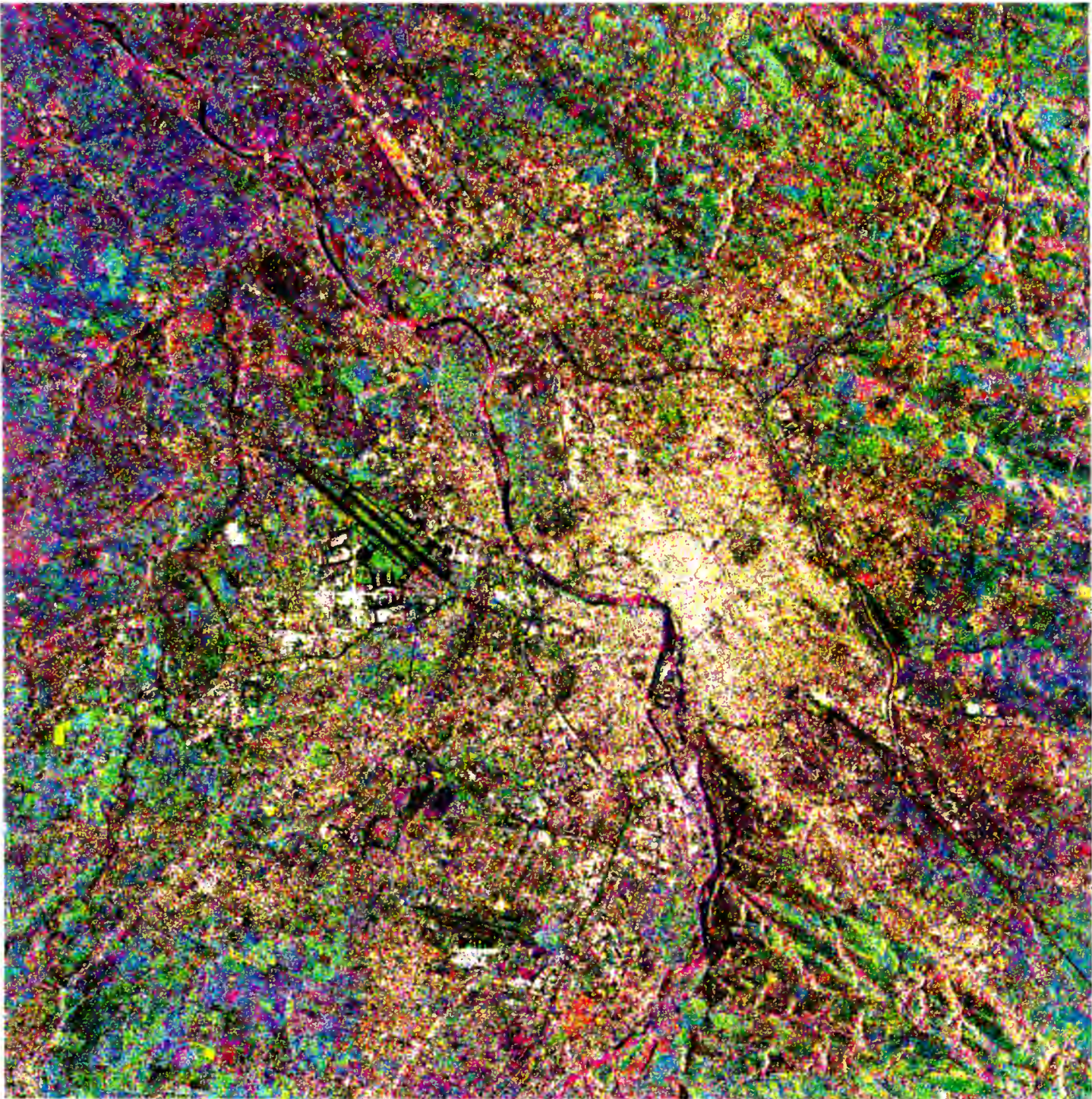


ERS-2 Commissioning Phase Review

26-27 October 1995 - ESRIN, Frascati - ITALY



ESA09



esa

ESRIN

ERS-2 Commissioning Review # 1

DAY 1 : Thursday 26 October

09H30	Registration	
10H00	Welcome	F.Roscian
10H10	Introduction	L.Emiliani
10H20	Commissioning phase objectives, planning and organisation	B.Marcorelles

PART 1 : Launch and flight operations

10H30	ERS-2 Launch and ESOC operations	ESOC (M.McKay)
	Manoeuvres and Orbit maintenance strategy	ESOC
10H45	Payload switch-On and verification	ESTEC (M.Canela)

11H00 Coffee Break

PART 2 : Satellite in-orbit performances

11H15	Satellite performances	ESTEC (M.Canela)
11H20	SCATT problem status report	ESTEC (J.Bosma)
11H50	Platform performances	MMS-F (B.Antonio)
12H10	Payload performances	DSF (J. Fernandez)
12H30	IDHT, Link Budget	ESOC (M.McKay)
12H45	Radar Altimeter	ALENIA (G.Angino)
		DORNIER (E.Schied)
		ESTEC (R.Francis)

13H15 Lunch break

14H15	SAR performances	MSS-UK (G.Cornelius)
14H30	GOME	ESTEC (J.Callies)
14H45	ATSR-2	RAL (D.Smith)
15H00	MWR	ESTEC (K.McMullan)
15H10	PRARE	Timetech (W.Schäfer)

PART 3 : Ground Segment performances

15H20	MMCC/MPS	ESOC (H. McKay)
15H30	Kiruna Station	ESOC (D. Mesples)
15H40	PAF status	ESRIN (B. Greco)

15H50 Coffee Break

16H10	LRDPF-REHOST	ESRIN (S. Coulson)
16H20	CUS/ISS	ESRIN (S. D'Elia)
16H30	Fucino/Maspalomas/Gatineau/P-A	ESRIN (G.M. Pinna)
16H40	Ground Stations Validation	ESTEC (M. Paganini)

PART 4 : Instrument Calibration Validation

17H00	RA/MWR Commissioning Strategy, and performances requirements Range, Wave and Wind MWR : Conclusions on final Bias and error Status on OPR validation	ESRIN J. Benveniste CETP (L. Eymard/S. Boukabara) ESRIN (J. Benveniste)
17H45	SAR Commissioning Strategy, and performances requirements Image mode: Raw data Corrections Products : FD PRI SLC Interferometric capability Wave mode	ESTEC E. Attema ESRIN (J. Sanchez) ESRIN (J. Sanchez) ESRIN (J. Sanchez) ESRIN (J. Sanchez) ESTEC (C. Buck) ESTEC (C. Buck) ESTEC (G. Brooker)

18H30 Cocktails

DAY 2 : Friday 27 October

09H00	GOME Commissioning Strategy and performances requirements Raw data Level 1 product Level 2 product GOME QA Geophysical validation status	ESTEC (J.Callies) ESTEC DLR (W.Balzer) DLR ESRIN (C.Zehner) ESTEC (E.Attema)
09H45	ATSR-2 commissioning Strategy Raw data Level 1 product Level 2 product Geophysical validation status	RAL (C. MatPow)
10H30	Coffee Break	
10H50	PRARE Instrument calibration	Timetech (W.Schäfer)
11H05	PRARE Validation and Ground Station Network	GFZ (Prof. Reigberg)
11H20	ERS-1/ERS-2 Tandem/Post Tandem Operation scenarios	ESA (G. Kohlhammer)
11H40	Conclusions	L.Emiliani
12H30	Lunch	

Day 1

ERS-2

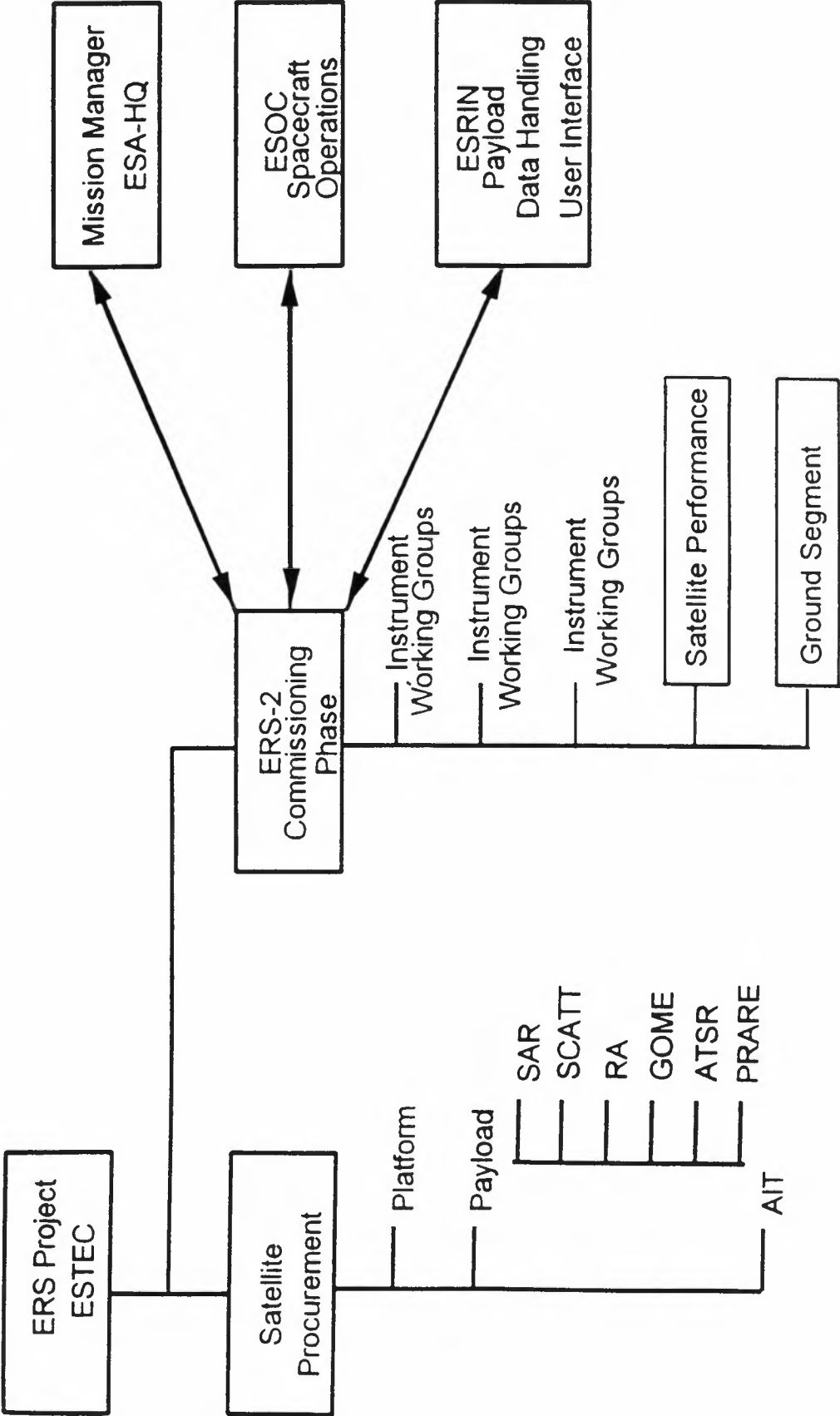
ERS-2 Commissioning Phase

B. Marcorelles
ESRIN, 26 October 1995

1. Commissioning Phase Objectives

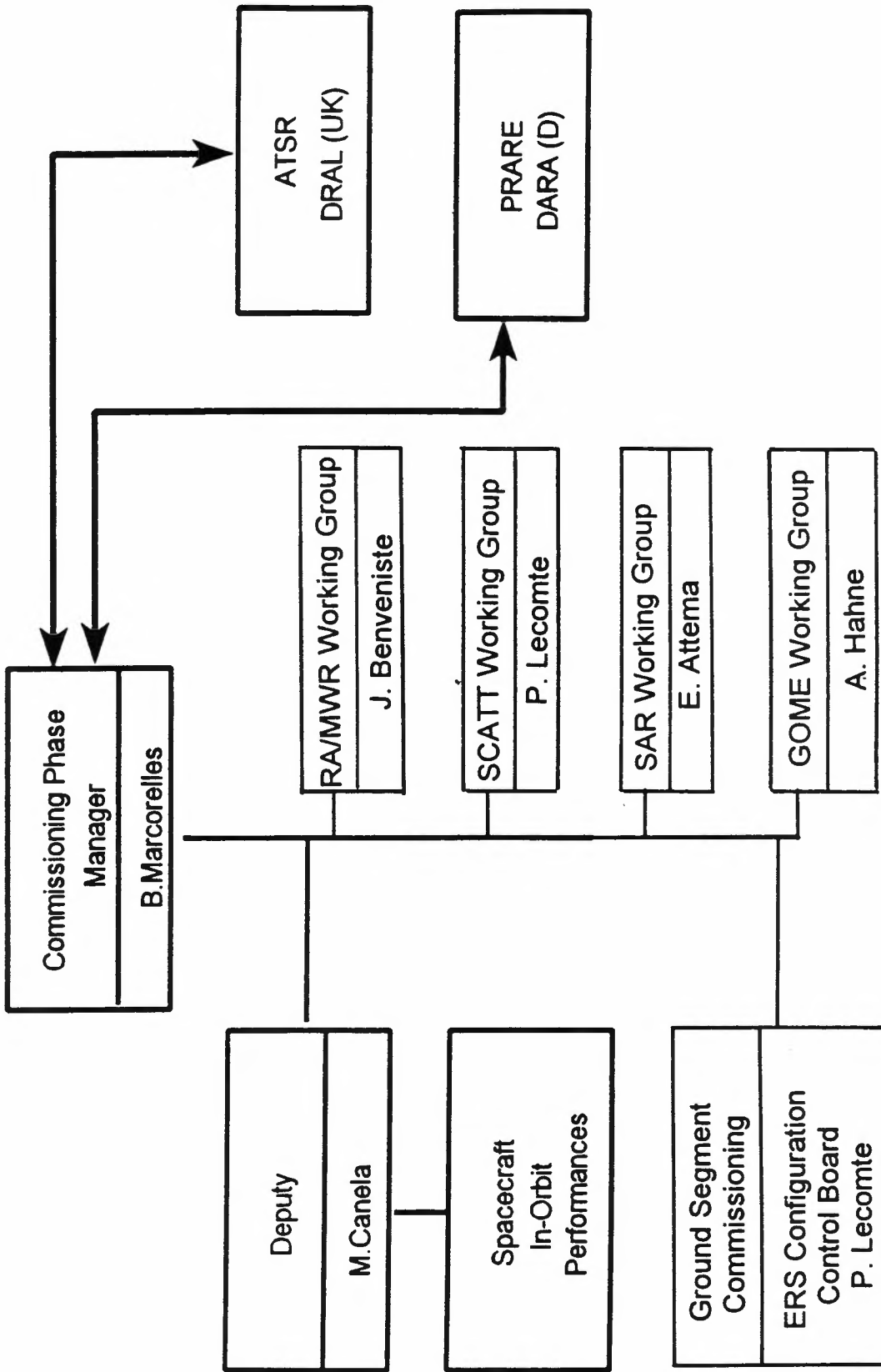
- **Instrument Commissioning Objectives:**
 - Instrument in-orbit performances
 - Engineering Calibration of each instrument
 - Validation of the raw data and products
 - Validation of Ground Segment processing and performances
- **Recurrent Instruments: SAR, RA, SCATT, MWR**
 - ERS-2 ready to ensure the nominal mission after 3 months of commissioning
 - Calibration/Validation report available after 6 months
- **New Instruments: ATSR-2, GOME**
 - Extended commissioning phase to 6 months

2. ESA Commissioning Organisation

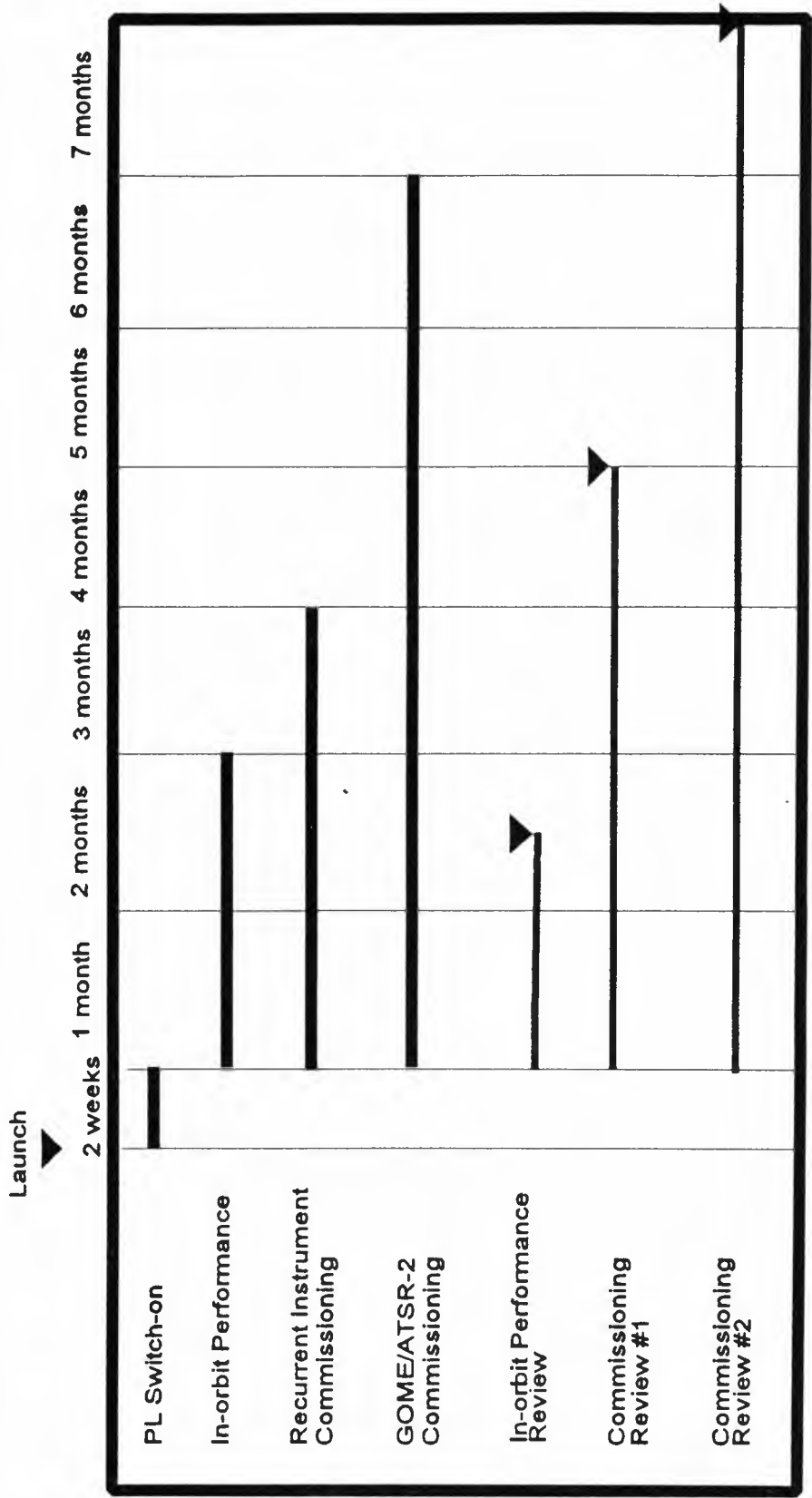


2. ESA Commissioning Organisation

(Continued)



3. Commissioning Phase Planning



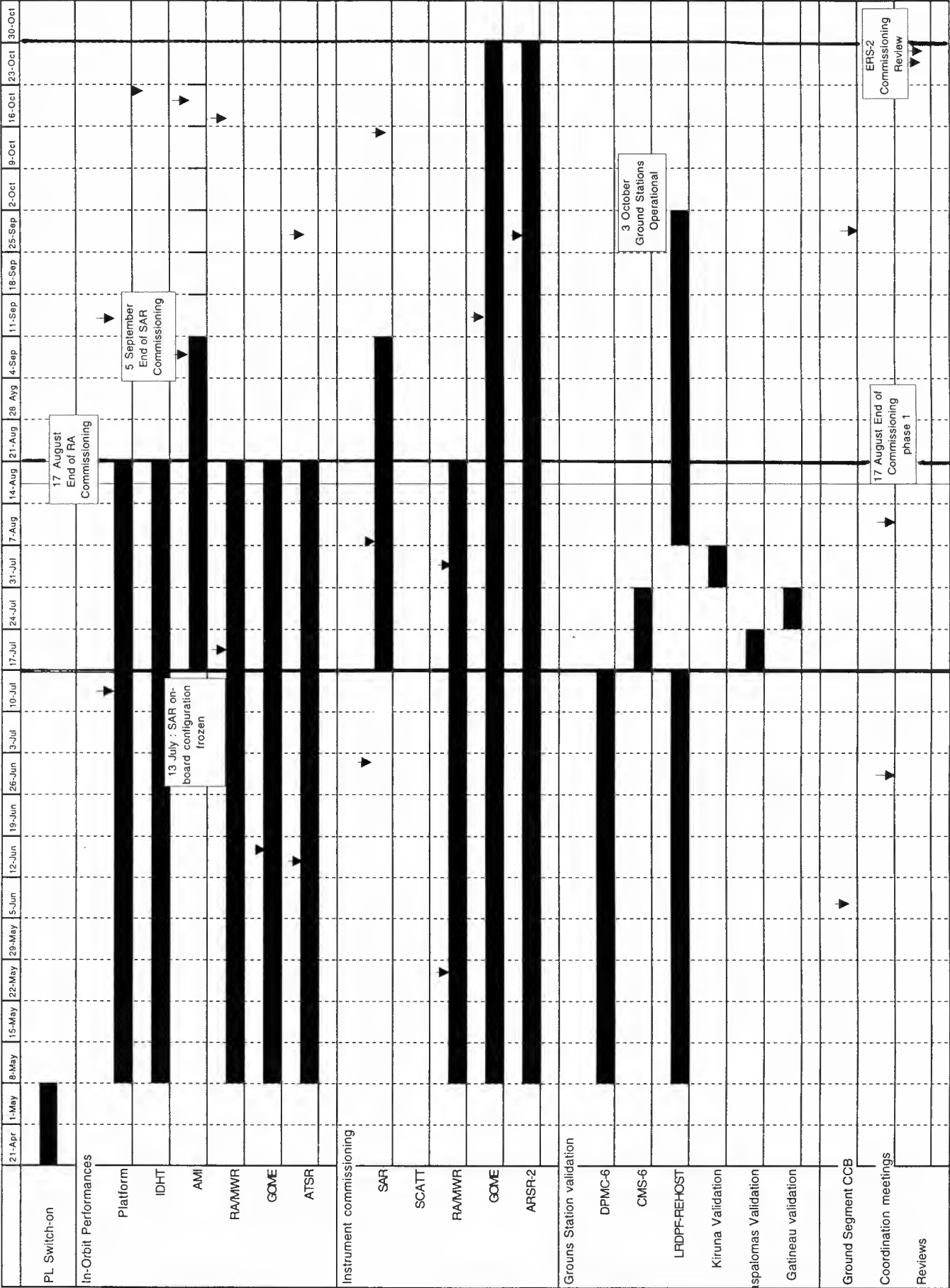
4. Commissioning Reviews

- **3 formal reviews were foreseen:**
 - **L+1 month: First ERS-2 Review**
 - "Platform and Payload in orbit performances"
 - "Preliminary Cal/Val results for instruments"
 - **L+4 months: Commissioning Review #1**
 - "Final in-orbit performances presentation"
 - "Recurrent instruments Cal/Val review #1 (RA, SCATT, SAR, MWR),"
 - "New instruments preliminary Cal/Val review (ATSR-2, GOME)"
 - **L+7 months: Commissioning Review #2**
 - "Final Commissioning Phase review all instruments"

5. Commissioning Phase Constraints

- SAR and SCATT: Same method as ERS-1 =
 - Transponder deployment
 - Rain forest used as natural site
- RA:
 - New strategy and new methodology due to non deployment of ground equipment
 - Cross calibration ERS-1 / ERS-2, TOPEX/ POSEIDON as a back-up
- Orbit is on a 35-days repeat cycle (3 days for ERS-1)
- ERS-1 and ERS-2 ground tracks absolute difference separated by a maximum of 200 meters
- Minimise manoeuvre during commissioning
- ATSR-2 and PRARE: Under responsibility of RAL and GFZ

Commissioning phase Planning



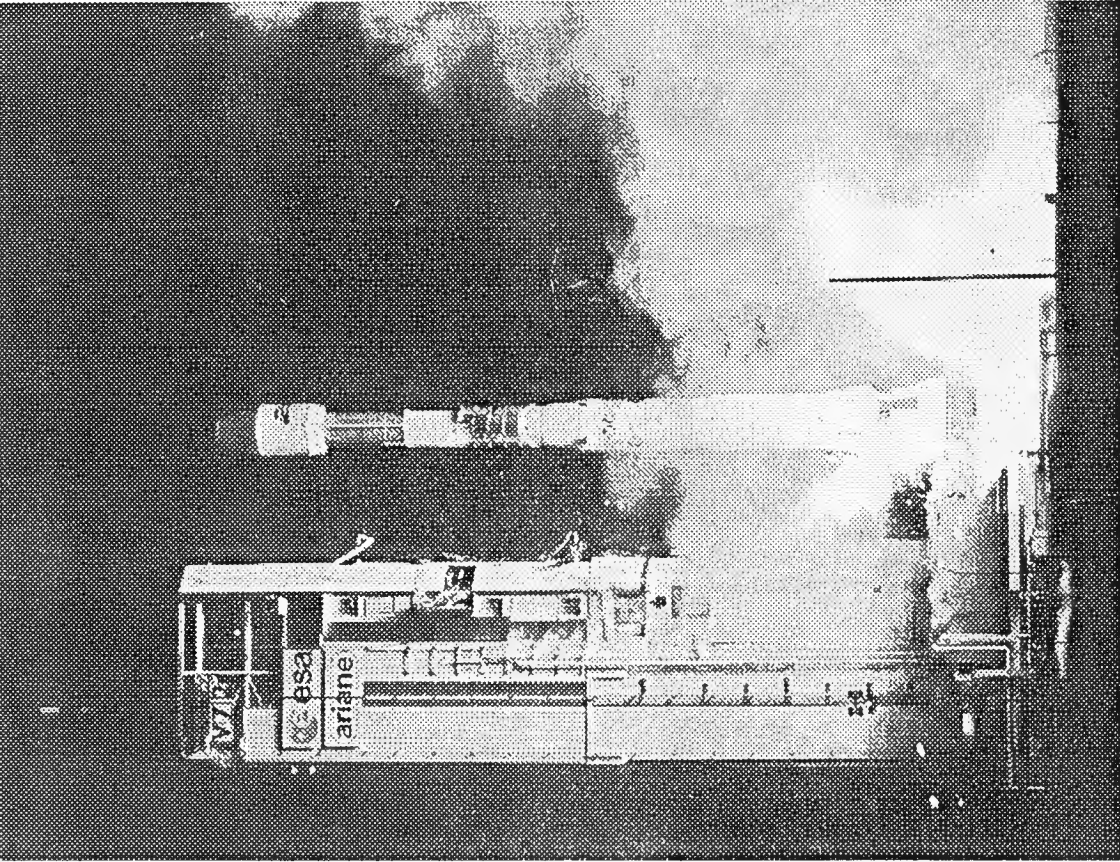
6. Commissioning Phase Main Events

- SCATT Commissioning not yet started!
- RA / MWR Commissioning nominal:
 - Operations successfully ended 17 August, after 3 cycles
 - Main results to be finalised mid November
 - ESA Validation Report to be issued at the end of 1995
- SAR Commissioning:
 - Started late due to SCATT problem
 - Final on-board configuration reached 13 July
 - Products accessible to users since 5 September
 - ESA Validation Report to be issued at the end of 1995
- Gome calibration operation successfully finished, geophysical validation on-going since 20 July
- ATSR-2 / PRARE: In progress

6. Commissioning Phase Main Events (continued)

- ERS-2 configuration operational in ground stations since 3 October
- PAF integration completed in June 1995
- PAF main products distribution status:
 - SAR PRI / SLC = since mid October in UK-PAF and D-PAF
 - OPR = under validation by RA-CWG, distribution will start in December 1995 in F-PAF
 - Other Products: Validation reports expected at the end of 1995, beginning of 1996





ERS-2 LAUNCH AND ESOC OPERATIONS

ERS-2 COMMISSIONING PHASE REVIEW

26 October 1995 ESRIN

M. Mc Kay



LAUNCH AND EARLY ORBIT PHASE

- **Successful Launch of ERS-2 on Ariane V-72 on**

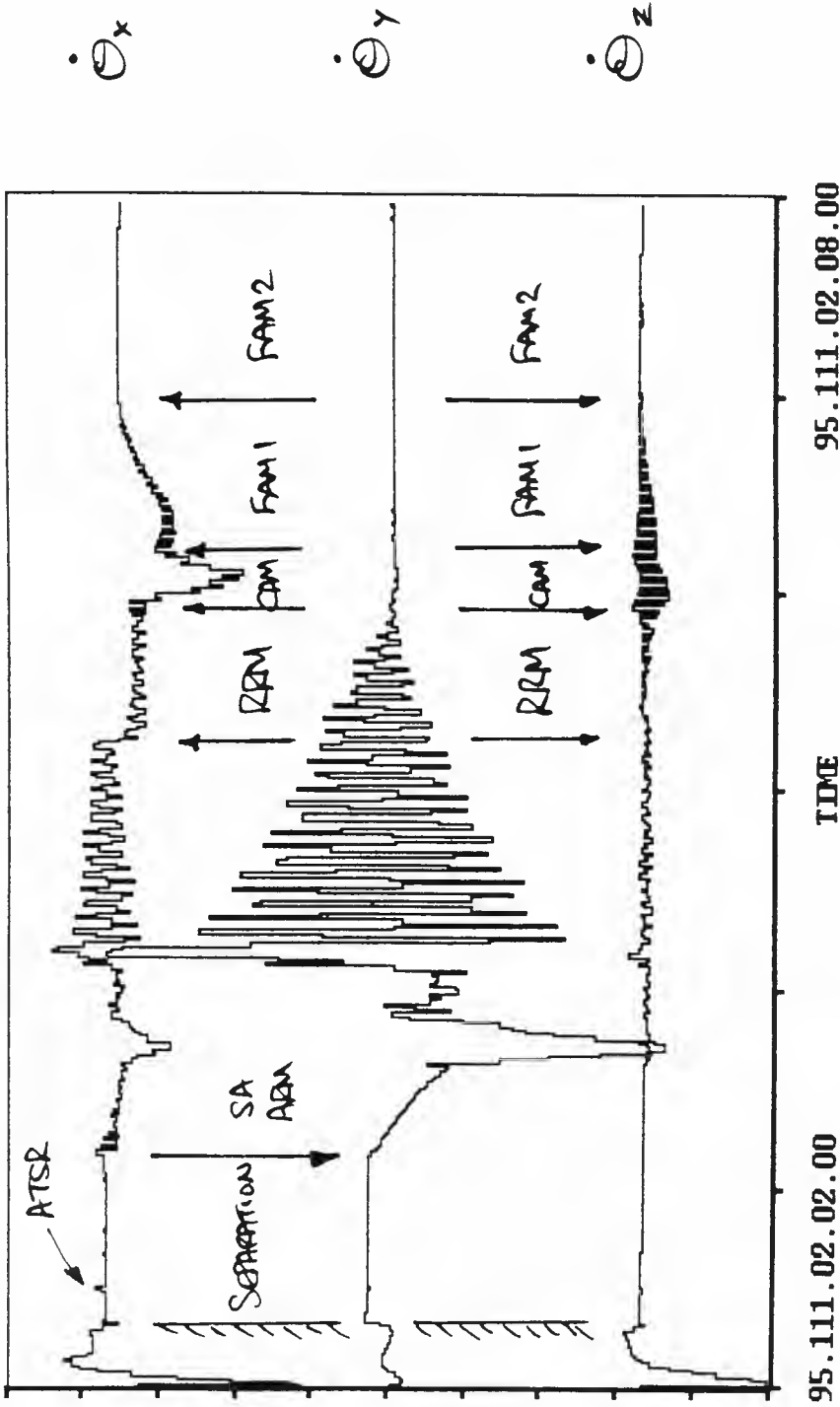
21st April 1995 at 01.44.06 UTC

- **Smooth Countdown**
- **Excellent Ascent Phase**
- **Excellent Separation Parameters with Good Rates and Orbit Injection**
- **Completion of Nominal Acquisition Sequence faster than expected**
- **Fine Pointing Mode Achieved at Separation + 3 hours 33 minutes**



Separation, Initial Deployments & Attitude Acquisition

ID	DESCRIPTION	VALUE	UNIT	MIN	MAX	LINE
0810C	CY RSOLVD X RATE	0.068349	DG/S	-2.500000	0.500000	
0813C	CY RSOLVD Y RATE	-0.005875	DG/S	-1.500000	1.500000	
0816C	CY RSOLVD Z RATE	0.013883	DG/S	-0.500000	2.500000	



ERS-2 COMMISSIONING PHASE REVIEW

26 October 1995 ESRIN

M. Mc Kay



LEOP DEPLOYMENTS

- **All Deployments completed within the Nominal Timeline**
- **ERS-1 retrieval data proved invaluable for monitoring, especially**
 - **SA Arm hinge shocks (4 latching)**
 - **SA Panels in conjunction with power monitoring**
- **SAR WING 1 MOTOR PHASE**
 - **High Wing 1 Initial Rates (possibly due to Wing 2 Spring)**
- **PAYLOAD PYROS VERIFICATION**
 - **All pyros, except SCATT Aft PEM Top Pyro, confirmed on A & B**



ORBIT MANOEUVRES

- 5 km Orbit Drop and Drift Start with 2 Orbit Control Manoeuvres (OCMs)
- 1 Out-of-Plane OCM Inclination Manoeuvre
- Drift Stop and Orbit Raising of 5km with 2 In-Plane OCMs
- ERS-2 in same orbit as ERS-1 with 1 day separation
- Mode Transition to YAW STEERING MODE
- All Mode transitions were nominal
- Consistent Manoeuvre Performance



AOCS Hardware Performance

- **Gyros**
 - Coherency and drift assessment are healthy
 - Gyro Spectra confirm good gyro health
 - Gyro Fine Blocking Surveillance enabled after 3 months
- **Thrusters**
 - Good Performance
 - Catalytis Bed Regeneration following cold starts
 - Thruster Pulse Miscounts following and OCM
- **Earth Sensors**
 - DES A & B consistent healthy noise with spikes
 - DES B Run-In completed



POWER & THERMAL STATUS

- **Power**
 - Solar Array and Batteries Nominal
 - Under Voltage Detection, UVD, occurring regularly
- **Thermal**
 - Stable Thermal conditions
 - Day Heating Only activated in October due to UVDs

LEOP GROUND SEGMENT

- Very Reliable Ground Station Network
- MMCC SCOS-B stable, reliable and performant
- Kiruna Station Acquisition and Processing for both Spacecraft



OPERATIONS STATUS

- Dual Operations from the same Control Room with the same Team
- Operation of ERS-1, ERS-2 and both processing chains at Kiruna
- Manual Scheduling of some activities to support Commissioning
- AMI Test Campaign Continuing
- Routine Gyros, Wheels & Thermal Verification

ANOMALIES

	PLATFORM	PAYLOAD	TOTAL
Pre-Launch	17	5	22
Post-Launch	4	28	32



ERS-2 COMMISSIONING REVIEW

ERS-2 PAYLOAD SWITCH-ON

October, 27, 1995

Miguel Canela

PAYLOAD SWITCH-ON

Phases and Objectives

- **Phase 1:**

To reach the minimum operational conditions

- . Instrument Control Units Switch-on
- . Instruments heating

- **Phase 2:**

To verify the nominal operational modes

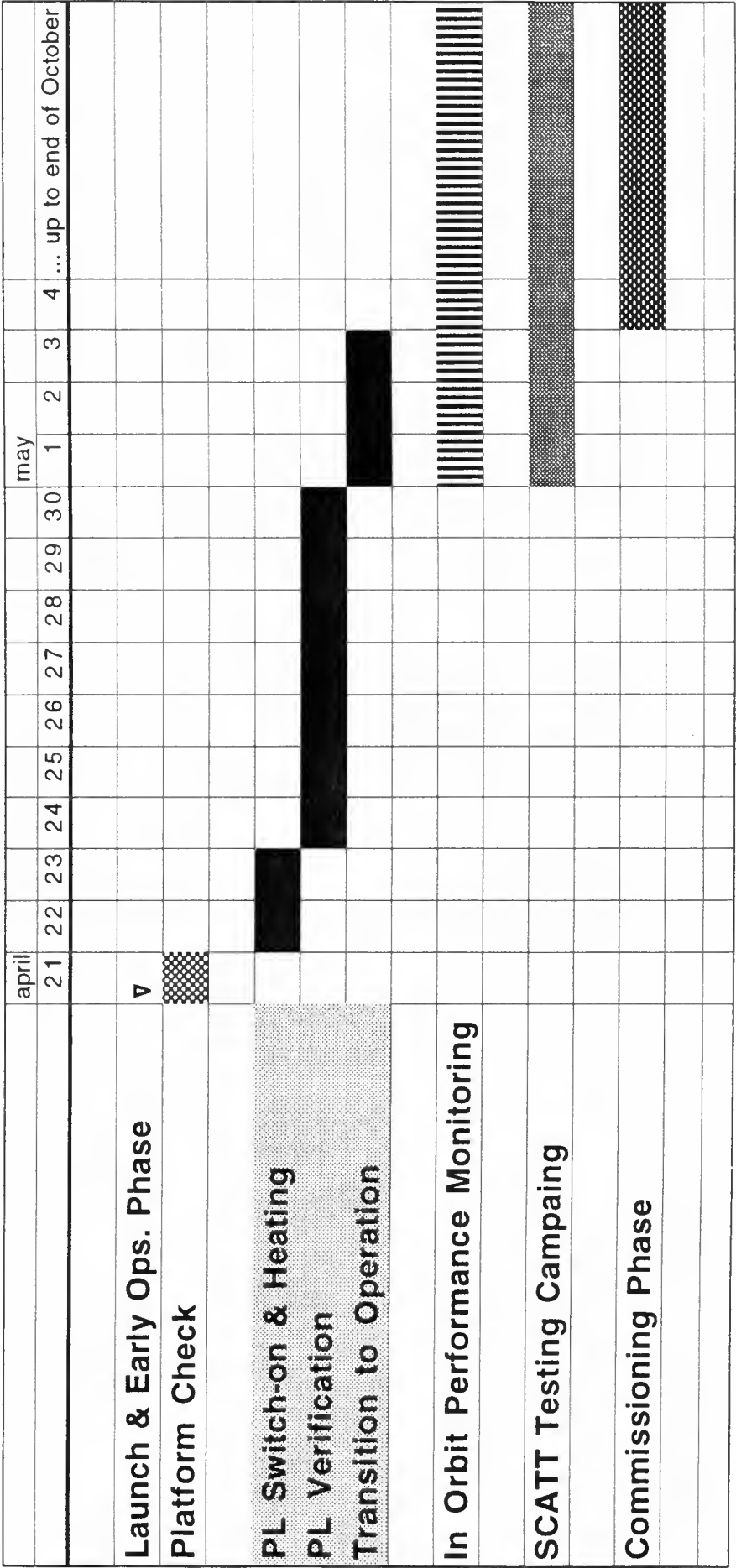
- . Instruments Functional check

- **Phase 3:**

Gradual transition to parallel operations

PAYLOAD SWITCH-ON

PLANNING OVERVIEW



PAYLOAD SWITCH-ON

Phase 1 (22, 23 april)

- **Step 1:**
 - . Instrument Control Units Switch-on:
IDHT, AMI, ATSR-2, RA
 - . transition from OFF to Stand By Mode
 - . loading of patches
- **Step 2:**
 - . Instruments heating:
to reach minimum operational temperature
 - . PRARE Switch-on

PAYLOAD SWITCH-ON Phase 1

PROBLEMS FOUND:

- IDHT Timing Synchronisation inconsistency
- ATSR-2 monitoring parameters inconsistency

These minor problems have been corrected

RESULTS:

- All activities successful and completed in time.
- Payload Status : NOMINAL

PAYLOAD SWITCH-ON Phase 2

Instrument verification

(24 -30 april)

- Individual Instrument functional check and Verification of all nominal operational modes
IDHT, ATSR-2, GOME, RA, AMI (outgazing)
- Start complete data recording and dump over Kiruna
- Use of manual commanding and specific timelines
- Measured values are given in the In Orbit Performance presentations

PAYLOAD SWITCH-ON Phase 2

IDHT VERIFICATION

(24, 25 april)

- LR Data Chain Test (link 1 - TWT 1)
- HR Data Chain Test (link 2 - TWT 3)
- HR & LR Data Chains Test
- TAPE RECORDERS CHECK
 - . 2 complete Tape record and playback
 - . Bit Error Check less than 10^{-7}
- Interference with gyros measurement
- Control by Mission Planning System

PAYLOAD SWITCH-ON Phase 2

ATSR-2 VERIFICATION

(26 april)

- **Infra Red Radiometer RUN-UP & no cooling**
 - . **Booster Heater check out**
 - . **Black Body Unit test**
 - . **Data compression check out**
 - . **Cooler outgasing: took 15 days**
- **Micro Wave Radiometer RUN-UP**
 - . **Scan Mirror rotation test**
 - . **Visible Channels gain setting**

PAYLOAD SWITCH-ON Phase 2

GOME VERIFICATION

(27 april)

- LED On for 2 minutes
- Mirror to LAMPCAL (167 deg), LAM On
- Mirror to DIFFPOS (180 deg), LAMP Of
- Coolers test
- Mirror heater On
- ADC CAL mode
- GOME SAVE MODE, Heater Off
- Mirror position test (nadir, rotating, darkview)

PAYLOAD SWITCH-ON Phase 2

RA VERIFICATION

(28 april)

- All operational modes tested:

Ice and Ocean Acquisition/tracking
Warm-up 2, SPSA On and Pause
Preset Ice and Ocean tracking

- Noise and Scanning Point Target test
- Checking of the following characteristics:

Transmit power, Receiver gain, I/F filter
shape, chirp slope, timing errors, SPTR half
power width, SPTR detailed shape, internal
delay, average noise floor & spurious signals

PAYLOAD SWITCH-ON Phase 2

AMI VERIFICATION

(29, 30 april)

- First test was SAR Image mode
- Second test was Wind mode
- Both tests failed due to a triggering of the receiver overload protection
- Investigations recommended to reduce the output power of the High Power Amplifier
- In this configuration, SAR Image and wave mode are succesfull and of good quality.
- But *Wind mode continued to fail.*

PAYLOAD SWITCH-ON Phase 2

- RESULTS of the functional check of all the operational modes for each instrument:
 - . IDHT and tape recorders: successfull
 - . ATSR-2 (IRR AND MWR): successfull
 - . GOME: successfull
 - . RA: successfull
 - . AMISAR: successfull
 - . AMISCATT: failed (*)
 - . PRARE: successfull
- All activities successfull and completed in time except for SCATT.
- Payload Status : NOMINAL except for SCATT
- (*) Details provided in specific presentation

PAYLOAD SWITCH-ON Phase 2

PROBLEMS FOUND:

- ATSR-IRR: Incoherence with Ground Segment on 3 expected parameter value
- ATSR-MWR: Too narrow limit settings of the MWR Gunn diode temperature
- These minor problems have been corrected
- AMI refuse mode

PAYLOAD SWITCH-ON Phase 3

Instrument operation

(1-3 may)

- **Progressive start of instrument operation**
 - ATSR-2, GOME, RA, AMI-SAR**
- **Start of the 35-day repeat cycle**
- **Start of the Instrument Performance monitoring and calibration**
- **Imaging over Kiruna and Fucino**
- **Operations and calibration for “A” side (exc AMI)**

PAYLOAD SWITCH-ON Phase 3 (1)

- All the Payload (except SCATT) is:
 - . scheduled by Mission Planning System
 - . operating nominally
- *IDHT*: Recorder A in use
 - . minor problem found in descoping results (already solved)
- *RA*: Performance measurements:
 - . ice/ocean,
 - . preset ice/ocean SPTR/noisecorrect functioning within specification and good matching with ERS-1

PAYLOAD SWITCH-ON Phase 3 (2)

- *ATSR MWR*: In nominal Operation Mode
- *ATSR IRR*:
 - . Performance measurements and adjustments give good functioning within specifications
 - . Science data are being produced regularly and very good quality images are available.
- *GOME*:
 - . Verification test going on (mirror, heater, cooler, ADC, safe mode...)
 - . Results show good performance

PAYLOAD SWITCH-ON CONCLUSIONS

- **RA, ATSR, GOME and AMI-SAR :**
 - Have been successfully verified and set in parallel operation managed by the MPS.
 - They have immediately undergone their commissioning.
 - The close In Orbit Performance Monitoring continued up to now.
- **AMI-SCATT:**
 - The testing campaign continued up to now

ERS-2 COMMISSIONING

**SATELLITE IN ORBIT
PERFORMANCES
ORGANISATION**

– October, 27, 1995

M.Canela

ERS-2 In Orbit Performances

- **MONITORING & ANALYSIS of the ENGINEERING PARAMETERS**
for all the satellite modules
- **SCIENTIFIC DATA:**
Analised by the commissioning working groups

ERS-2 In Orbit Performances

- **OBJECTIVES:**
- *To detect any deviation from specifications*
- *To control and characterise the evolution of the engineering aspects*
- *To implement corrective actions and operational precautions if needed*
- *To ensure coherency of the whole system*
- *To compare with ERS-1 performances*

ERS-2 In Orbit Performances

- *Strategy based on ERS-1 experience:*
 - *Intensive monitoring and analysis (daily and weekly) during firsts 3 months*
 - *Regular monitoring and medium term analysis (monthly) after 3 months*
- *Responsibles: ESTEC (ECC), ESOC (MMCC), ESRIN (PCS) and Manufacturers*

ERS-2 In Orbit Performances

- PLATFORM - MMS-T
- THERMAL - DSF / MMS-T
- POWER - DSF / MMS-T
- IDHT - DSF / LABEN
- SAR - DSF / MMS-UK
- RA - DSF / ALENIA
- ATSR - RAL
- MWR - SCHRAK / CETP
- PRARE - TIMETECH

ERS-2 In Orbit Performances

- **ENGINEERING PARAMETERS:**
 - *Inside especifications*
 - *Normal evolution:*
 - *far from threshols*
 - *similar or better behaviour than ERS-1*
- **SCATT:** *Monitoring will start immediately after end of investigation*

ERS-2 In Orbit Performances

- **PHASE E :**
 - Automatic routine monitoring
 - (per orbit, daily) (ESA)
 - Warnings and anomalies treatment
 - (when appear) (ESA + Industry On Rquest)
 - Monthly Performance analysis (ESA)
 - (plus quartely reporting)
 - Deep Performance analysis
 - (six-monthly) (ESA + Industry)

ERS-2

Commissioning Review Presentation

AMI SCATT Problem Status Report

Jack Bosma
D/OEE Directorate
ESA/ESTEC

ESRIN
26 October 1995

ERS-2 AMI SCATT Investigation - Period April - June 1995

- o investigation performed in the framework of the ERS-2 payload switch-on activity
- o status at first AMI switch-on:
 - instrument does not operate in either SAR or SCATT Modes with nominal High Power Amplifier (HPA) saturated gain setting. Switch-down of the instrument is activated by the Rx overload surveillance
 - action taken: reduce the AMI RF output power level by adjusting the upconverter drive gain to the minimum level possible. The 21 dB gain setting provides a 6 dB reduction in HPA RF input power and a 1.7 dB reduction in RF output power.
 - result: SAR Modes operational
SCATT Modes not achieved due to Rx overload activation

Note: there are no further adjustments of the RF output power built into the AMI instrument.

ERS-2 AMI SCATT Investigation - Period April - June 1995

In-orbit tests:

- various configuration changes to redundant units implemented, notably the Switch Matrix Controller, the RF subsystem, the High Power Amplifier and the SAR processor.
No change in SCATT mode behaviour
- further investigations include:
 - o link verification based on ground transponder measurements
 - o science data evaluation
 - o characterisation of Tx pulse received by ground antenna and storage scope.

ERS-2 AMI SCATT Investigation - Period April - June 1995

A first meeting of experts and the ERS-2 project team postulates the following failure scenarios:

Power leakage in the circulator assembly

The only single failure scenario in the Tx path that could explain a receiver overload condition for both SAR and SCATT modes is the possibility of ferrite/silica damage at one junction during launch and spread of debris through the circulator assembly. A detached tuning element could have a similar effect.

Both in-orbit data and ground truth measurements do not support the excessive return loss expected with a circulator assembly major damage. Laboratory tests performed later on flight representative hardware prove that only highly reflective materials e.g. metallic washers can provide adequate return loss.

Ferrite material does not provide sufficient loss.

This scenario has been given a low ranking as a plausible failure cause.

ERS-2 AMI SCATT Investigation - **Period April - June 1995**

Failure of the Rx overload protection

Both prime and redundant surveillances have been triggered in orbit, consequently a common failure mode is required. The following generic failures have been investigated:

- *systematic procedural error during calibration of the RX overload protection:*
Excluded later by Task Force work. Repeat exercises of the complete calibration procedure on the EM payload prove that the spread in RX threshold setting could not explain the in-orbit behaviour.
- *generic failure of attenuator.*
Excluded later by Task Force work. Extensive testing at component level of the Lot Date Code used for ERS-2 proves that the attenuators are extremely robust even during overtorquing and never shows a decrease in isolation required to explain the failure.
- *DC-offset and EMC susceptibility*
Excluded later by Task Force work. Design review with the manufacturer proves that the Rx overload detector is AC coupled. Furthermore extensive EMC tests have been successfully completed prior to launch at system level with flight attenuators installed.

This scenario has been given a low ranking as a plausible failure cause.

ERS-2 AMI SCATT Investigation = *Period April - June 1995***Timing Problem**

The most likely timing failure scenario involves the Wind Mode Enable signal generated by the SAR-P.

The WME signal activates the HPA, Rx and SAR junctions to either SAR Mode (clock wise) or SCATT Mode (anti-clock wise).

A single failure in the SAR-P WME signal (jitter or noise) could affect both SAR and SCATT modes.

In-orbit AMI operations with the re-configuration of the SAR-P to the redundant unit demonstrate no change in the instrument's behaviour.

No other single failure mode related to timing has been identified, consequently this scenario has a low ranking as a possible failure cause.

ERS-2 AMI SCATT Investigation - Period April - June 1995**Multipactor**

The actual circulator assembly flown on ERS-2 has been tested in 1988 and again in 1990.

During both tests the circulator assembly has been found to operate satisfactorily with a 3dB margin i.e. multipactor occurs at approximately 11 kW compared to the nominal operating level of 4.9 kW.

The lowest adjustable setting on the AMI provides an RF output power level of 3 kW.

Consequently a multipactor scenario requires adverse conditions as high pressure or contamination to explain the reduction in multipactor threshold necessary to obtain Rx overload conditions in Wind Mode at 3 kW. During this period of the investigation the multipactor scenario relies mainly on the evidence of the shape of one truncated pulse captured on ground during a Rx overload condition in Wind Mode.

More data is required in Rx overload conditions both in SAR and SCATT modes.

ERS-2 AMI SCATT Investigation = Period April - June 1995**Intermediate Status**

In view of the multipactor hypothesis it has been decided at this stage to allow for an extended in-orbit period of outgassing.

AMI SAR modes have been released for the ERS-2 Commissioning to maintain the planning for Tandem Operations with ERS-1.

No further attempts to operate Wind Mode have been planned during the outgassing period.

The return of the ERS-2 EGSE and flight spares allows to start an extensive investigation on the ground with flight representative hardware.

These decisions conclude the AMI investigations in the framework of the ERS-2 payload switch-on.

ERS-2 AMI SCATT Investigation - Period April - June 1995

7 June 1995 Set-Up of the AMI Task Force

Main Objective: Recovery of the AMI Wind Mode

Investigative means:

- o ground tests with flight spare/EM hardware to verify in-orbit performance as well as protection circuit behaviour;
- o ground tests with development hardware to perform failure simulations;
- o further in-orbit tests;
- o review of build standard and quality records
- o theoretical evaluation of the design contemplating on likelihood of failure mechanisms

ERS-2 AMI SCATT Investigation - Period April - June 1995

17 May - 24 June Extended Outgassing Phase:

- o Image and Wave Modes released for the nominal Mission Planning System with reduced power setting;
- o SCATT mode operation suspended to allow for an extended period of outgassing
- o Image Mode intermediately operated in Rx overload conditions to check for recovery effects due to continued RF power in SAR configuration.

3 July to 12 July:

- o preparations for AMI SAR Commissioning:
 - re-configuration AMI to all side A units, except for the HPA side B
 - reduction of Rx gain in Image by 4 dB
 - reduction of CAL attenuation in Image by 4 dB

ERS-2 AMI SCATT Investigation - Period June - July 1995

- o 24 June 1995 Re-Start of SCATT Test Campaign
- o no change in SCATT mode behaviour following extended outgassing phase
- o remaining AMI redundant units checked step by step notably the Power Conditioning Unit PCU, the Frequency Generator Equipment FGE, the Calibration Sub-System CAL-S/S unit and the SCATT Electronics SCATT-E unit . No change in SCATT mode behaviour
- o in-orbit tests in SAR and SCATT modes covering Rx overload conditions with extensive ground truth diagnostics

ERS-2 AMI SCATT Investigation **=** Period June - July 1995

Further Observations in-orbit during this Period

- o truncated pulses have been recorded several times in SCATT and SAR modes;
- o the falling edge of the truncated pulse shows a 4 dB initial drop for 1 microsec. in SCATT Mode before the Rx overload is activated;
- o one incident has been observed in SCATT Mode where a full pulse has been recorded with a power drop of 20 dB after 30 microsec. into the pulse;
- o these last observations tend to support a multipactor failure scenario.

ERS-2 AMI SCATT Investigation - Period June - July 1995

Main Observations in-orbit during this Period.

- o SAR modes proven to operate following the Mission Planning System in stable conditions with the minimum adjustable HPA output power level for more than 2 months.
- o Image Mode threshold for Rx overload activation is at 2.5 dB back-off on HPA input power. Evidence of recovery in Image.
- o The diagnostics of the Wind Mode anomaly is limited. The Rx overload protection always triggers on the first Tx pulse, the only exceptions recorded are on the first attempt on 1 May (7 pulses) and later on 10 May (2 pulses).

ERS-2 AMI SCATT Investigation - Period June - July 1995

Intermediate Status

- *in-orbit:*
 - o methods need to be developed to allow longer diagnostics of the WIND Mode

- *ground truth*
 - o ground truth requires further sophistication to allow multiple FORE/MID/AFT antennae coverage during Rx overload conditions

- *failure scenario*
 - o a multipactor failure fits some of the in-orbit observations, however more ground tests are required to understand the complex phenomena involved

ERS-2 AMI SCATT Investigation : Period August - October 1995**In-orbit**

- o method developed to by-pass the FORE antenna. Wind Mode is proven to operate in MID and AFT configurations with HPA input drive adjusted to minimum setting. Both housekeeping and science data indicate stable operations for MID/AFT up to the Rx overload activation on the first Tx pulse in the second FORE antenna cycle

Although this result is promising various attempts to derive an operating scenario-based on Wind Mode with no drive during the FORE antenna sequence are unsuccessful

- o SCATT Mode operated thru the HPA redundancy switch isolation with maximum HPA input drive and maximum Rx gain. Purpose of the test is to attempt a Wind Mode low power operation. The actual echo and cal pulse data obtained show that power levels are inadequate for any useful diagnostics
- o SCATT FORE antenna drive unit operated and confirmation obtained that antenna is firmly latched. No effect on Rx overload conditions
- o multiple ground truth measurements are obtained from FORE and MID antennae during a Rx overload condition. Although pulse shapes could support a multipactor behaviour, a number of tests would be required to allow a conclusive statement.

ERS-2 AMI SCATT Investigation**- Period August - October 1995****Multipactor Tests**

- o circulator assembly has been tested for multipaction in the FORE antenna configuration
- o multipaction occurred at 13 kW
- o at the start of multipaction isolation is lost in the FORE antenna junction during a short period < 1 microsec., coinciding with an increase in power in the other isolated ports i.e. at the AFT, MID, SAR and Rx junctions
- o the loss in isolation is immediately followed by a total reflection of the RF power back into the HPA
- o this behaviour could explain the Rx overload activation in-orbit as well as the loss in RF power during the Tx pulse.

ERS-2 AMI SCATT Investigation - *Period August - October 1995*

Multipactor continued

- o unexplained to date with a circulator assembly multipaction induced failure are
 - the origin for the drastic reduction in multipactor threshold
 - a source for the multi-failure scenario explaining also the different behaviour in SAR and SCATT modes
 - normal behaviour of the FORE antenna junction in clockwise direction
- o contamination is a possible candidate to meet the above conditions:
 - development tests performed in the past have proven that contamination can cause a significant degradation of the multipactor threshold
 - a spread in the deposit of contaminant could explain the difference in multipactor threshold in SAR and SCATT modes
 - continued operation of the SAR mode could burn-off the contaminant and explain the reported recovery effects
 - a multipactor test performed on a flight representative waveguide, using an ERS-2 suspect contaminant, showed no variations in multipactor threshold
 - a repeat test on a flight representative switch is presently in progress

ERS-2 AMI SCATT Investigation = Period August - October 1995

- o Status of Rx overload threshold checks in Image.
 - 10 May Rx overload at 3.0 dB back-off or 66.45 dBm (4415 W)
 - 12 May Rx overload at 3.0 dB back-off or 66.45 dBm (4415 W)
 - 18 May Rx overload at 3.5 dB back-off or 66.35 dBm (4315 W) *
 - 31 July Rx overload at 2.5 dB back-off or 66.65 dBm (4623 W)**
 - 8 August Rx overload at 1.0 dB back-off or 66.80 dBm (4786 W)

Notes:

- * HPA output set directly at 3.5 dB back-off
- ** Configuration RF S/S side A, HPA side B; all other measurements RF S/S side B, HPA side B

Conclusion:

The recovery of the AMI in Image Mode is confirmed. Since the start of the AMI Wave and Image Mode operations, the level of RF power that can be sustained in Image Mode has gradually increased

ERS-2 AMI In-Orbit Main Event - Period Sept. - Oct. 1995

22 September 1995 Major Break-Through.

- o EM payload tests demonstrate that the HPA redundancy switch can be operated as a power splitter and consequently a further reduction in HPA RF power on top of the nominal gain adjustment can be achieved.
- o a major step forward in the recovery of the SCATT is achieved with the successful in-orbit performance of a one minute Wind Mode operation based on the application of the above work-around
- o the work-around proves that the anomaly which leads to the Rx overload switch-down in Wind Mode is directly related to the RF output power level. This behaviour is similar to the anomaly in Image Mode, however unlike Image Mode the nominal gain adjustment is not capable to reduce the RF output power sufficiently to avoid the Rx overload switch-down
- o the intermediate switch position provides a potential work-around to reduce the RF power and to allow nominal Wind Mode operations

ERS-2 AMI SCATT Investigation - Period August - October 1995

29 September 1995 HPA intermediate state; long duration test

- o same test as 22 September, however 80 minutes Wind Mode duration planned.
Furthermore the UDC gain setting is used in Image Mode to compensate for the additional switch loss .

Test Result:

Following the re-positioning of the redundancy switch, Image Mode has been operated with incremental step increase of 0.5 dB on the UDC gain setting. The cal input peak power has been monitored and compared to the values with nominal switch setting used during Commissioning Phase.

A UDC setting of 24.5 dBm compensates for the additional switch loss in Image.

Wind Mode completed 1 hour and 7 minutes before the AMI has been switched-down due to Rx overload condition.

ERS-2 AMI SCATT Investigation - Period August - October 1995

**29 September 1995 HPA intermediate state; long duration test
(continued)**

Conclusion:

- the additional switch loss needed to achieve Wind Mode operations can be compensated in Image Mode by increasing the UDC gain setting to obtain the same RF output power as during the Commissioning Phase.
- the isolation loss in the selected intermediate switch position provides a RF output power that is on the threshold for Rx overload condition in Wind.
- a repeat test is required with another switch position to obtain a further decrease in output power and additional margin to the Rx overload condition.

ERS-2 AMI SCATT Investigation = Period August - October 1995

4 October 1995 HPA new intermediate state; long duration test

- o Same test as 29 September, except with a new switch position.

Test Results:

The Cal Input Peak Power is provided below:

switch position	Cal input peak power
nominal switch	4.60 dBm
intermediate state 29 Sept.	2.20 dBm
intermediate state 4 Oct.	1.34 dBm

The results prove that an additional 0.85 dBm reduction has been achieved.

Image Mode has been set to a UDC level of 25.5 dBm.

The Wind Mode result was unexpected with a Rx overload condition after 37 seconds.

X-band analysis indicates that the new switch position provides additional isolation loss reducing the RF output power, however the operating conditions are not stable. The Rx overload threshold is exceeded due to the standard deviation of the RF output power, which counteracts the reduction in overall level.

ERS-2 AMI SCATT Investigation - Period August - October 1995

4 October 1995 HPA new intermediate state; long duration test

Conclusions:

- the switch-position needs to be optimised to obtain an adequate margin against Rx overload condition in Wind Mode whilst maintaining stable operating conditions for the AMI
- new intermediate switch positions will be validated on the EM payload to establish RF power levels in between the settings of 29 September and 4 October
- further ground tests will be performed to characterise the stability of the intermediate switch position with respect to thermal and mechanical conditions
- also ground tests will be performed on the ERS HPA life test models to check the stability of the HPA design at low power operations

ERS-2 AMI SCATT Investigation - Period August - October 1995*Status prior to Commissioning Phase Review*

- o SAR Modes proven to operate following the Mission Planning System in stable conditions with 6 dB back-off on HPA input power since more than 4 months
- o Image Mode threshold for Rx overload activation presently 1.0 dB back-off on HPA input power. Recovery trend continues
- o a work-around using the HPA input switch as a power splitter provides sufficient RF power reduction to achieve for the first time Wind Mode operation
- o the additional switch loss needed to allow Wind Mode operations can be compensated in Image and Wave Modes to maintain the RF output power conditions of the SAR Commissioning

- o the switch-position needs to be optimised to obtain an adequate margin against Rx overload condition in Wind Mode whilst maintaining stable operating conditions for the AMI
- o X-band and S-band data over almost one orbit of Wind Mode with the work-around in place provided promising results showing that conditions were stable up to the Rx overload switch-down
- o Image and Wave Modes have operated for more than one day with the work-around in place. Quality control shows that products are comparable to those obtained during SAR commissioning
- o the objective remains to obtain an optimised switch setting and to release SAR and SCATT for continuous operations
- o following validation of the switch position stability based on EM payload testing, a new set of in-orbit tests are presently under preparation



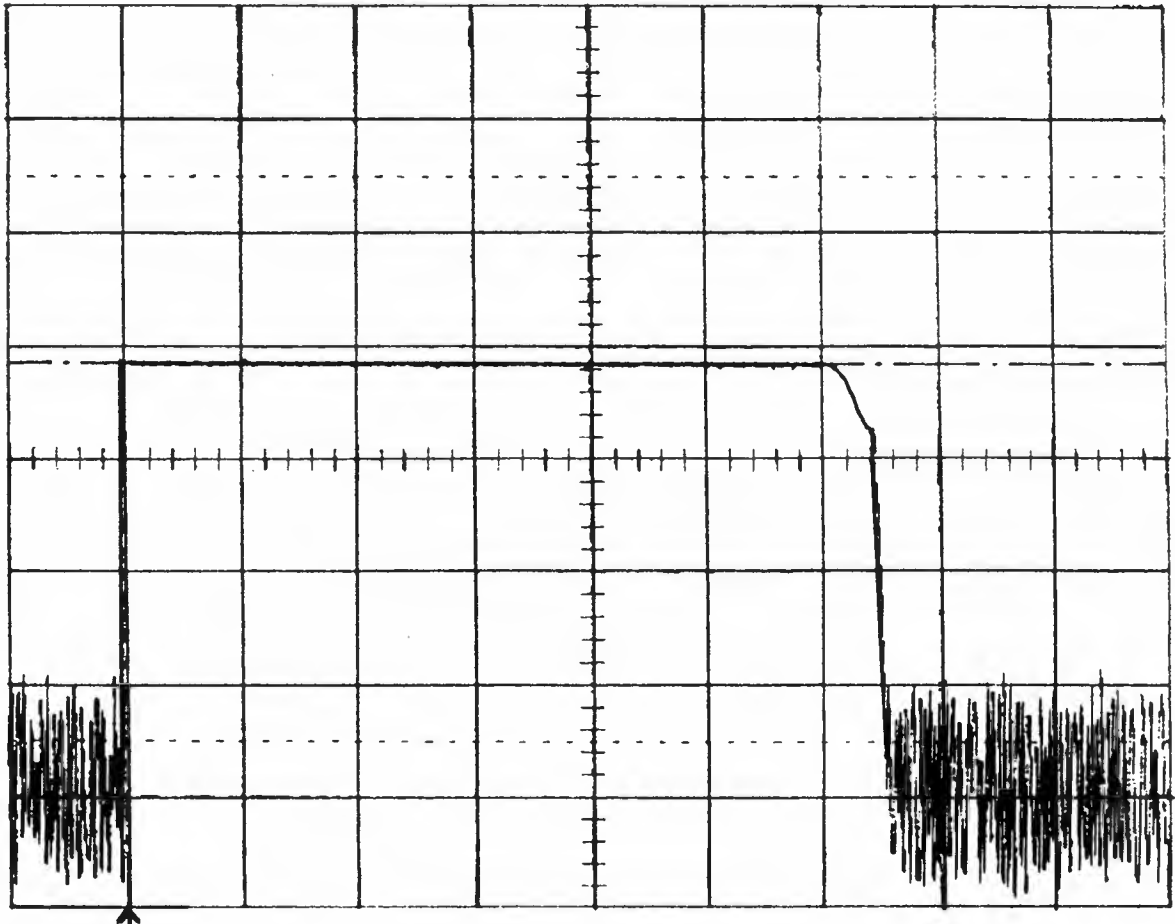
AMI WIND MODE INVESTIGATION

Test programme

- Diagnosis
 - In flight measurements
 - Component level measurements
 - Engineering model measurements
- Work-around solutions
 - Engineering model tests



AMI WIND MODE INVESTIGATION



Typical profile of switchdown during fore pulse transmission

Scales: time: 5 microseconds/div

power: 10 deciBels/div



AMI WIND MODE INVESTIGATION

Component and EM level diagnostic tests

- Pulse fall times under nominal and forced switchdown conditions
- Overload detector set up test
- Switch foreign body test
- Switch and switch matrix multipaction test



Results of component and EM level diagnostic tests

- Unable to reproduce wind mode switchdown characteristic under nominal and forced switchdown conditions
- Error margin of overload detector set up is insufficient to explain observed switchdowns
- The presence of metallic particles in contact with the ferrite puck of the switch can degrade the switch isolation significantly
- Tests on a single switch show that multipaction leads to a corona discharge which reduces the power transmitted by the switch and degrades the isolation and return loss of the device

Multipaction tests on the flight spare switch matrix show behaviour consistent with the performance observed in flight



AMI WIND MODE INVESTIGATION

Work-around tests

- Low power wind mode
- Reduced drive wind mode



AMI WIND MODE INVESTIGATION

Low power wind mode

Concept:

Drive HPA via the leakage path of an incorrectly oriented input redundancy switch

EM results:

Achieved 10 Watts output power sustained for 40 minutes operation

FM results:

Due to superior isolation of FM redundancy switch achieved only about 1 Watt output power sustained for only a few pulses



AMI WIND MODE INVESTIGATION

Reduced power wind mode

Concept:

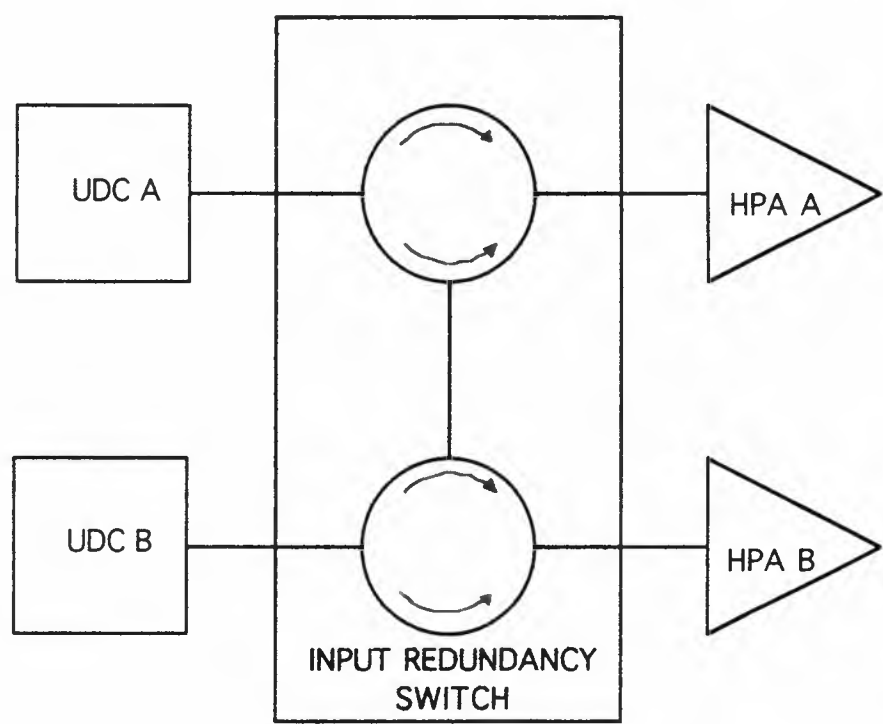
Redefine the HPA input redundancy switch as a variable attenuator

EM results:

Technique looks to be very promising

FM results:

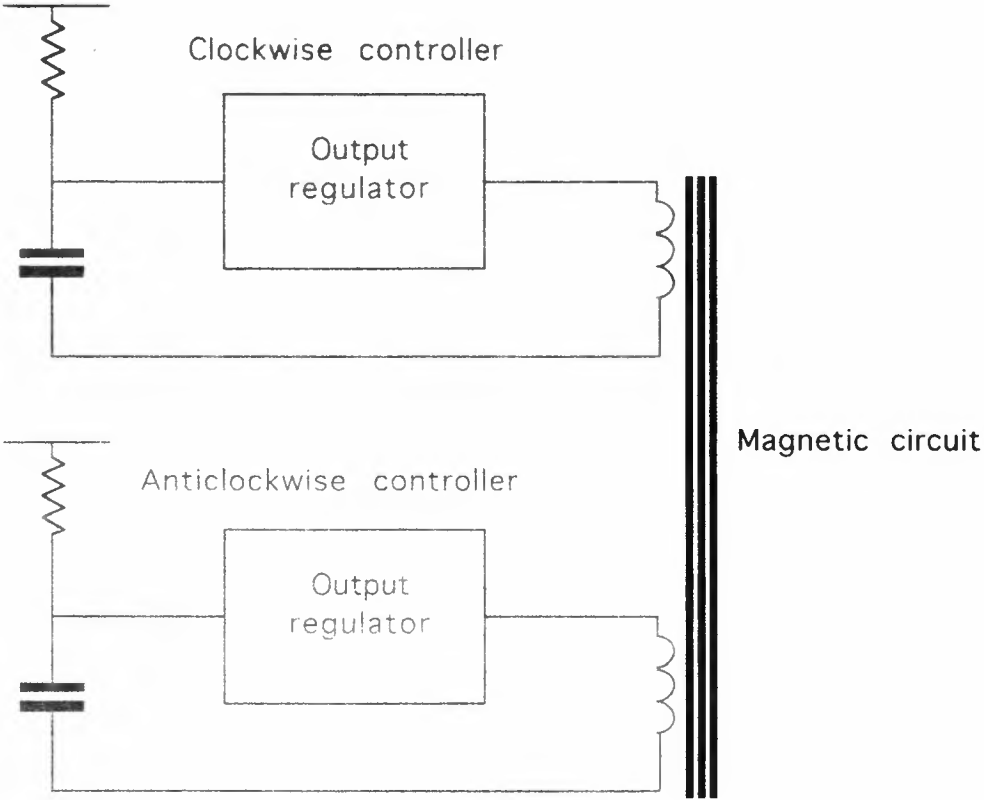
Still under investigation



HPA drive circuit cross strap concept



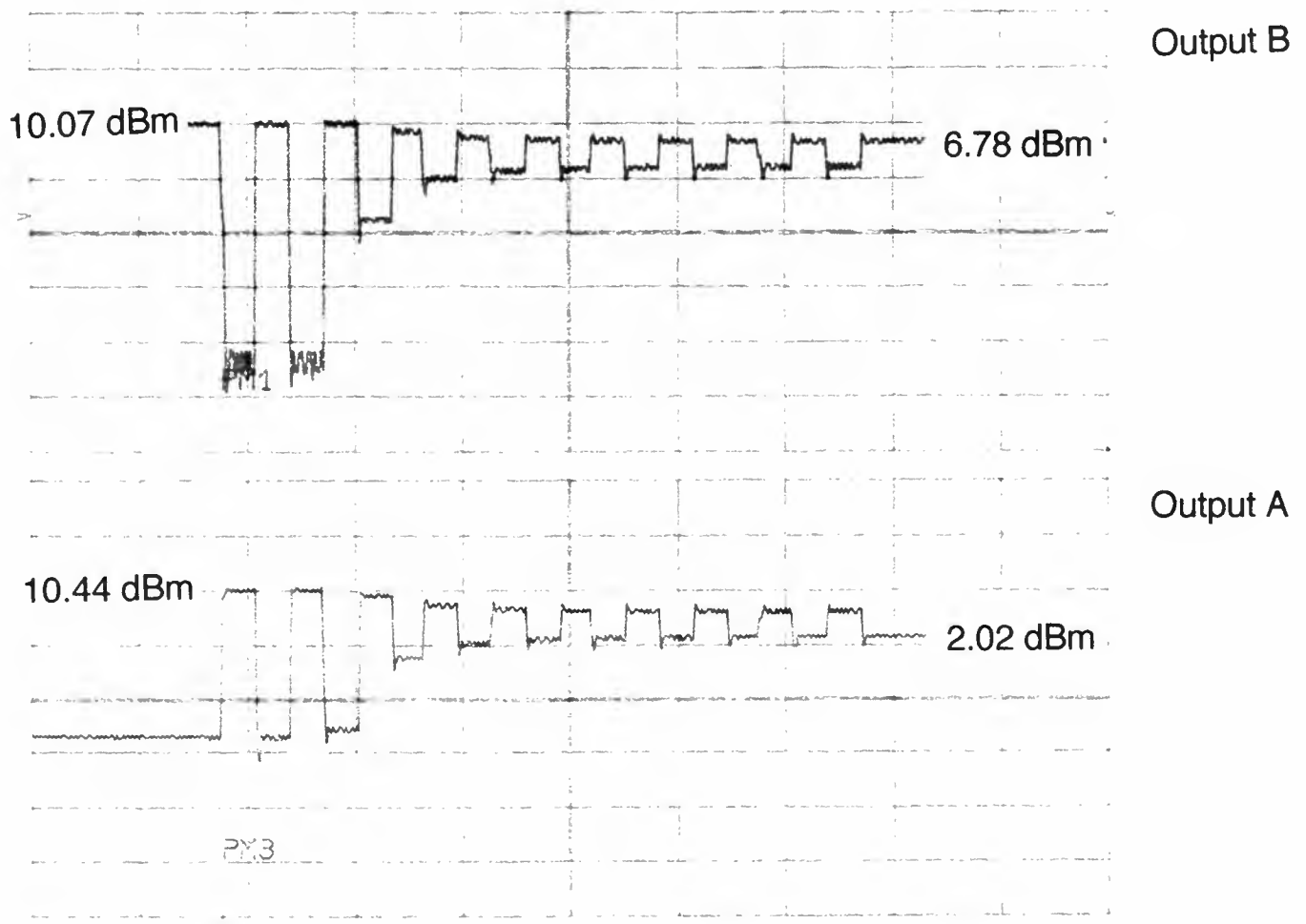
AMI WIND MODE INVESTIGATION



Circulator control concept



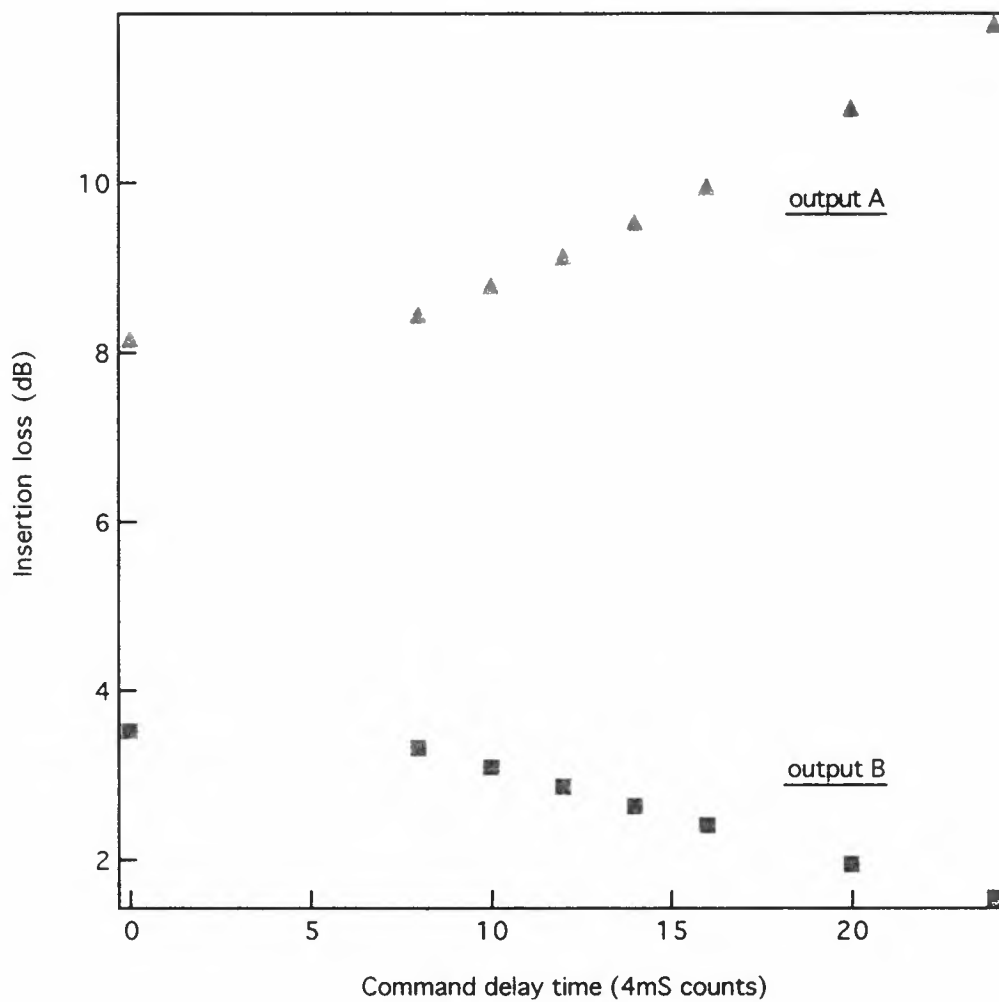
AMI WIND MODE INVESTIGATION



Insertion loss between redundancy switch A input and its A and B outputs over 20 switch operations with 8 count command delay time



AMI WIND MODE INVESTIGATION



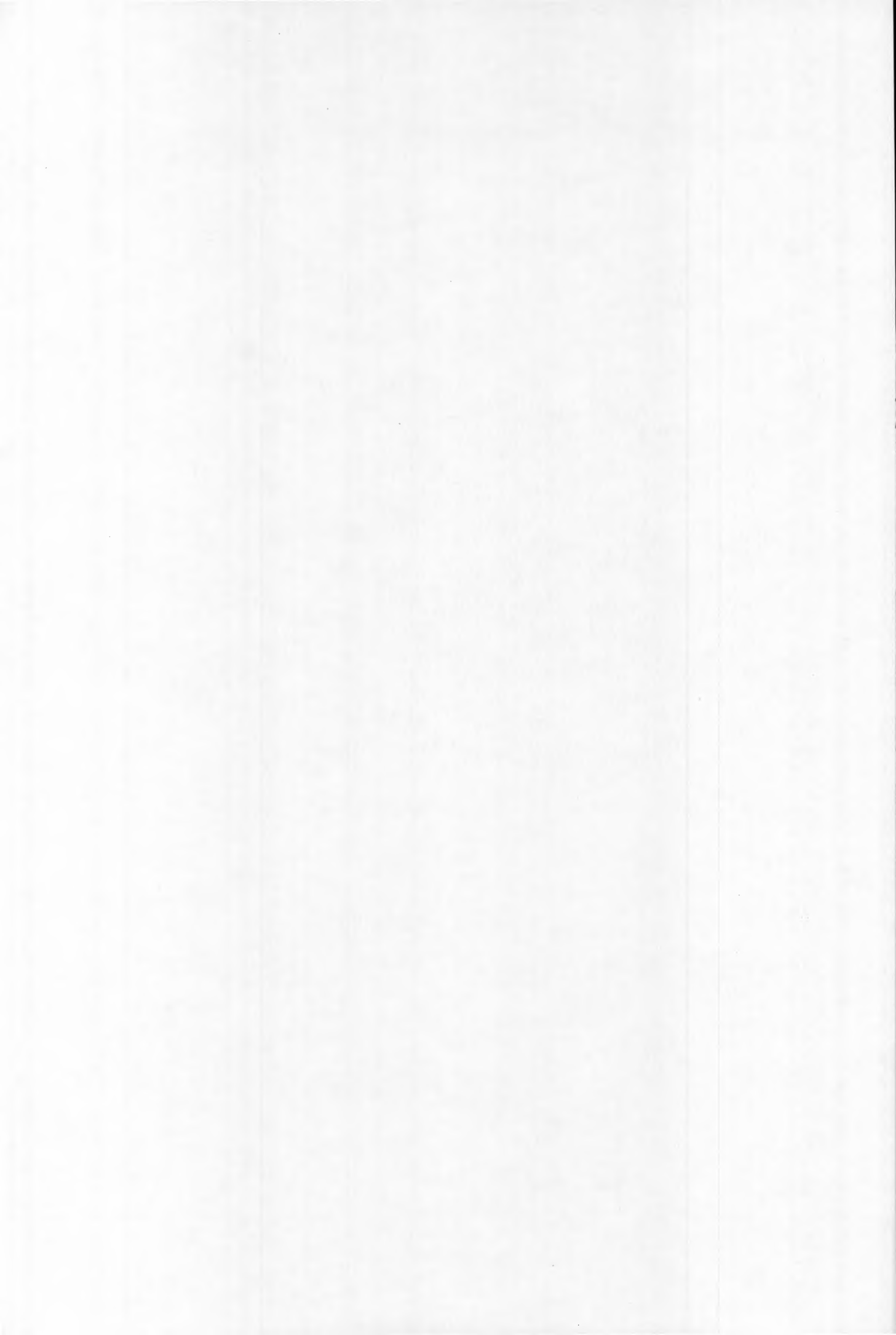
Switch insertion loss from input A to outputs A and B as a function of command delay time for 20 switching cycles



AMI WIND MODE INVESTIGATION

Preliminary conclusions

- It seems likely that the origin of the wind mode problem lies in multipaction in the switch matrix. The cause of this is currently unknown.
- Unconventional operation of the HPA input redundancy switch offers a means of adjusting the drive to the HPA which may lead to the operation of a sustained reduced power wind mode.



PLATFORM PERFORMANCES
ABSTRACT

ERS1/2 PLATFORM BUDGETS AND COMPARISON

- SOLAR ARRAY AGEING AND TREND ANALYSIS
- BATTERY PERFORMANCE
- THERMAL CONTROL DEGRADATION
- AOCS PERFORMANCE

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SOLAR ARRAY

ERS2 SOLAR ARRAY PERFORMANCE IS AROUND 2% ABOVE ERS1 S.A. AT BEGINNING OF LIFE AS MEASURED ON GROUND

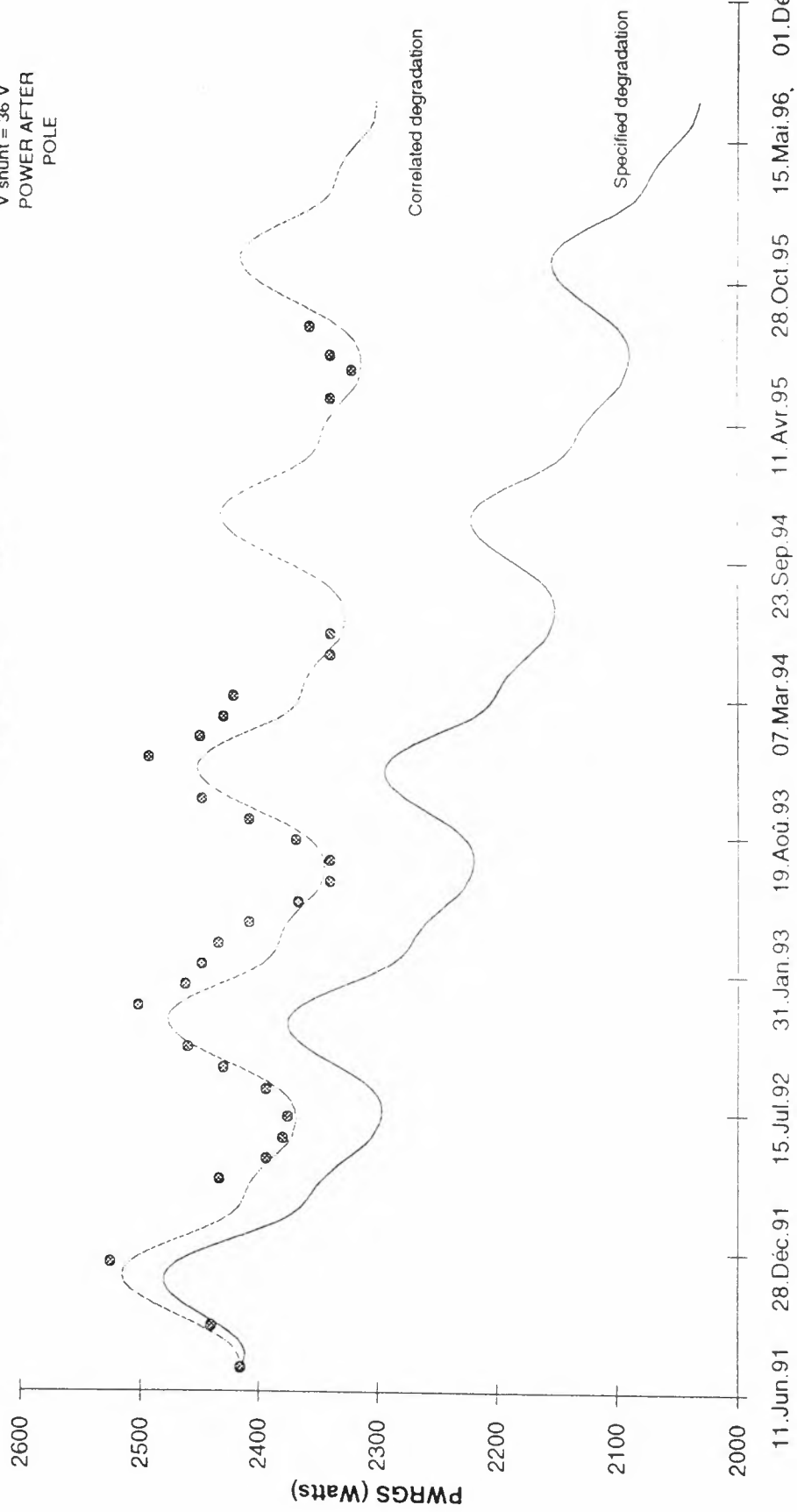
ERS1 OBSERVED DEGRADATION IS LESS THAN 2% SINCE BOL

ERS1 S.A. POWER WILL BE ABOVE 2300W AFTER 6 YEARS IN ORBIT
INSTEAD OF 2160W AFTER 2 YEARS

ERS1 SOLAR ARRAY

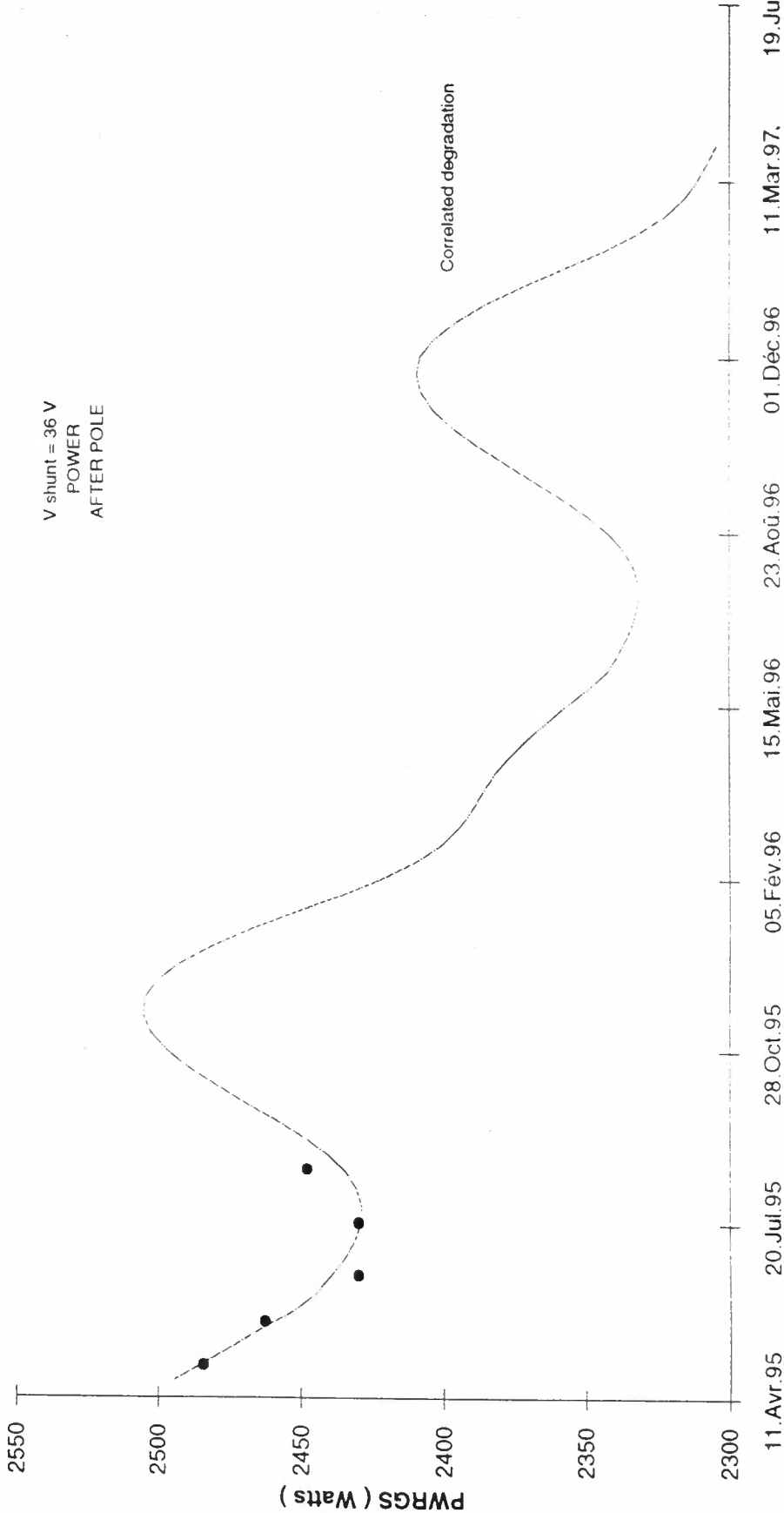
Puissance GS - Simulation des conditions de vol

V shunt = 36 V
POWER AFTER
POLE



ERS2 SOLAR ARRAY

Puissance GS - Simulation des conditions de vol



BATTERY AGEING
CELL FAILURE(1/3)

THE BATTERY AGEING DEPENDS ON D.O.D. AND AVERAGE TEMPERATURE OVER LIFETIME

THE TEMPERATURE IS MAINLY LINKED TO THE THERMAL COATING DEGRADATION OF THE BATTERIES COMPARTMENT RADIATOR

THIS DEGRADATION IS FOLLOWED THROUGH THE REJECTION CAPABILITY OF THE RADIATOR NORMALISED AT Tb=-4°C :

$$Pr = Pd + Ph$$
 with Pd =dissipated power and Ph =heating power

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BATTERY AGEING
CELL FAILURE(2/2)

THE ERS1/2 BATTERIES TEMPERATURES ARE CONTROLLED AROUND -4°C

THE AVERAGE TEMPERATURE EVOLUTION FOR THE NEXT 2 YEARS DUE TO THERMAL COATING DEGRADATION ALLOWS TO STAY CLOSE TO - 4°C

THE BATTERY AGEING / CELL FAILURE AT 20% DOD AND A TEMPERATURE OF 0°C ALLOWS A LIFETIME ABOVE 10 YEARS

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BATTERY AGEING
END OF DISCHARGE

THE SPECIFIED END OF DISCHARGE VOLTAGE IS 24V

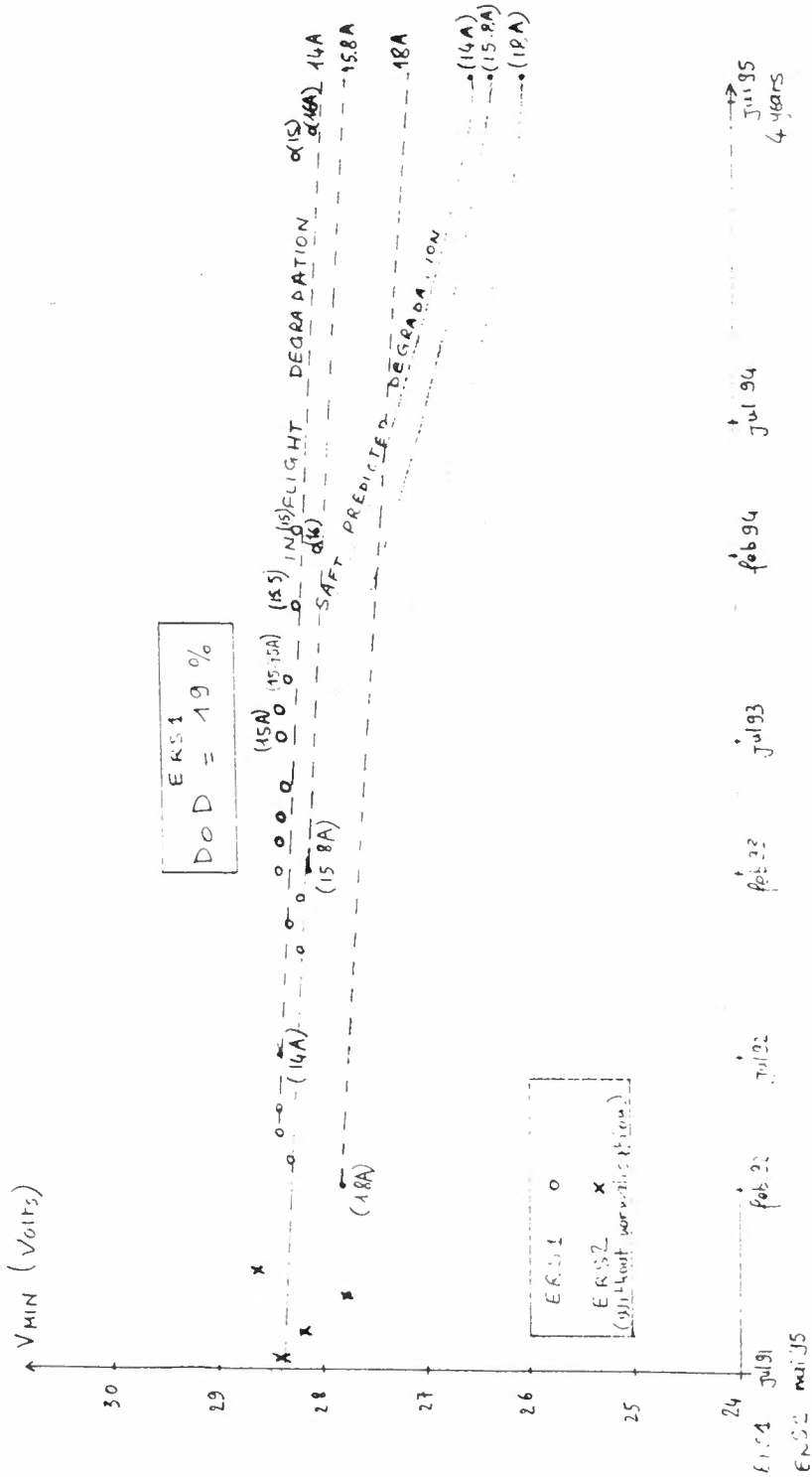
THE ERS1 MINIMUM VOLTAGE EVOLUTION HAS BEEN COMPARED TO
THE SAFT PREDICTION AFTER 4 YEARS IN ORBIT

THE ERS1 MINIMUM VOLTAGE IS ACTUALLY ABOUT 28.4V AT 15 A AFTER
4 YEARS IN-ORBIT

THE ERS2 MIN. VOLTAGE IS 28.4 V AT 15.5A , 19%DOD COMPARABLE TO
THE EXTRAPOLATED ERS1 BOL VALUE WAS 28.4 V AT 15.5A

BATTERY AGEING

END OF DISCHARGE



THERMAL CONTROL PERFORMANCE

THE ERS1/2 MEASURED VALUES COMPARED TO THE PREDICTIONS SHOWS GOOD THERMAL CONTROL BEHAVIOUR

ERS1 DEGRADATION IN 3 YEARS IS AROUND 2°C

ERS1/2 BOL VALUES ARE VERY CLOSED EXCEPT FOR :

- EAIM IN THE SAME AREA OF THE PRARE UNIT (ERS2:ON, ERS1:OFF)
- TRANSPONDER : ERS1: TXA ON , ERS2 : TXB ON

THE CONTROLLED LOOPS WORK IN THEIR THRESHOLDS AND ERS1/2 HAVE SIMILAR CYCLE RATIO: MAX 5CYCLES FOR EFB-Y

THERMAL CONTROL PERFORMANCE
UNITS TEMPERATURES

UNIT	ERS1 COLD CASE	ERS2 COLD CASE	ERS1 JUNE 92	ERS1 MAY 95	ERS2 MAY 95	ERS1 JUNE 95	ERS2 JUNE 95
GYRO Unit	21.2/22.6	21.2/22.6	25/27.31	25.8/28.5	26.2/28.5	25.8/28.1	26.5/28.5
Elec. STD1	5.9/7.15	7.1/8.5	7.5/10.97	8.57/12.58	6.07/10.65	8.2/11.9	6.8/10.6
EPRS	6.7/8.1	8.4/9.8	11.15/13.4 6	12.2/15	9.17/11.92	12.3/15.0	9.2/11.9
SADM			13.22/19.3 5	14.84/21.6 1	11.61/18.0 6	14.5/21.3	11.9/18.1
SADM Motor	15.4/18	16.9/20	16.8/18.4	18.4/20.38	15.6/18	18.4/20.4	16/18
SADM Elec	14.7/17.8	18.8/21.5	21.54/25.7 7	22.69/27.3 1	21.54/27.3 1	22.7/27.3	21.9/26.9
JSRU	12.6/20	13.9/21.7	14.84/22.9	-	-	15.2/23.9	13.9/21.9
PF/PDU	13.6/18.4	13.2/17.7	12.4/19.2	-	-	12.8/20.8	10.4/18.0
X Wheel	9.1/9.7	12.5/13.1	15.2/16	16.4/18	14.8/15.6	16.4/17.6	14.8/16.0
EMA	17/17.4	19.8/20.3	24.62/26.1 5	25.38/27.3 1	21.15/29.6 1	25.4/27.3	24.6/25.8
EAIM	15.2/15.6	18.5/18.9	17.42/18.3 9	17.74/19.6 8	19.35/22.5 8	18.1/19.7	20/22.6
OBC memory	20.8/21.1	21.4/21.8	21.54/22.6 9	22.31/23.8 5	20.38/23.4 6	22.7/23.8	21.5/23.1
Control Platform	11.1/11.8	13.2/14.1	16.8/18	18/20	14.8/17.2	18/19.6	16/17.2
Transponder 1	10.5/11.8	12.2/13.6	18.85/20.3 4	-	-	20/21.6	13.1/14.6
PRARE	9.7/10.3	7.7/8.75 600	110.8/11.5			11.9/12.7 (off)	23.2/24.8 (on)

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AOCS PERFORMANCE

ERS1/2 PERFORMANCE COMPARISON

DES MEASUREMENTS ON THE SAME ORBIT

WHEELS RATES

DSS UPDATINGS

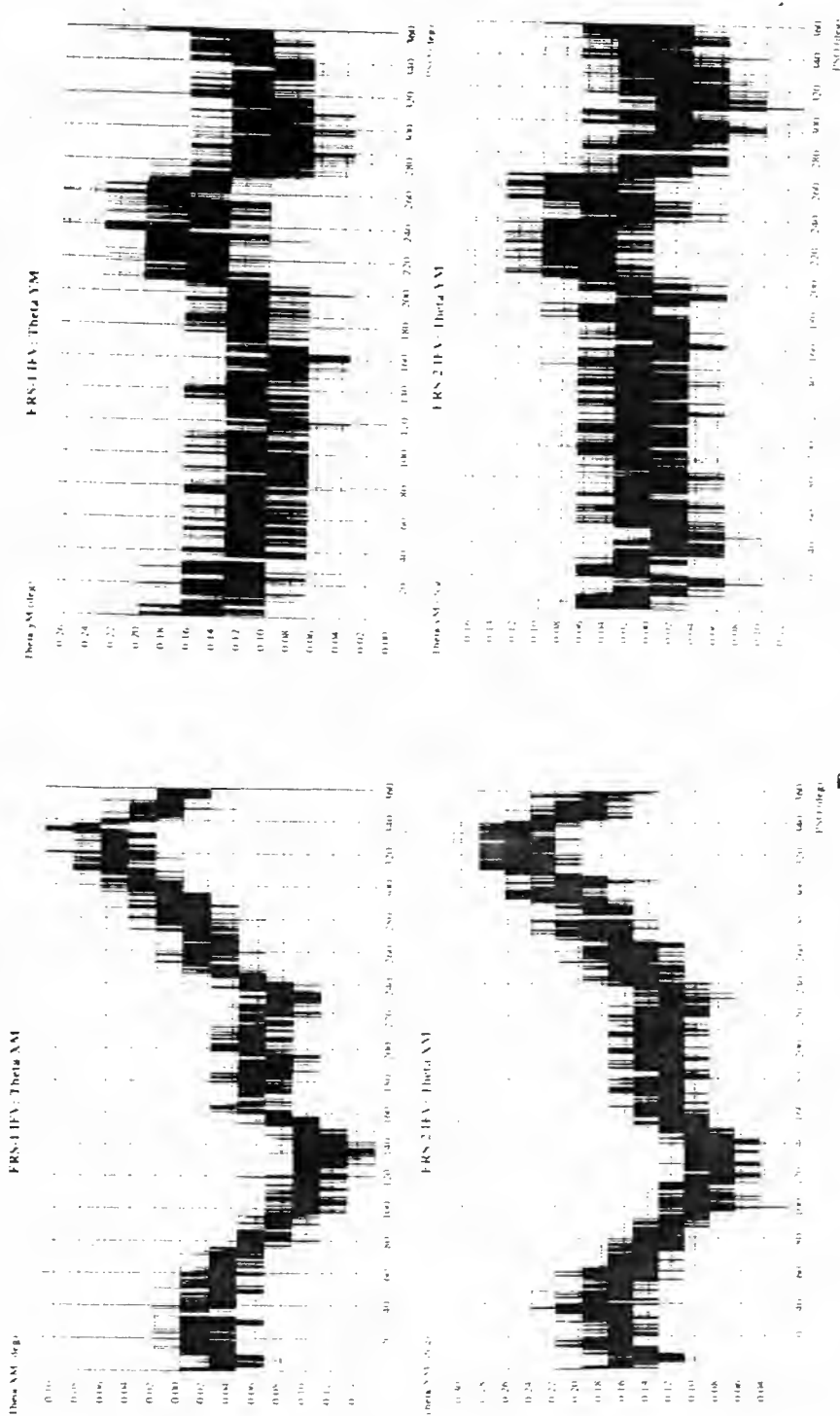
ERS2 ANALYSIS ON THE GYRO DATA

AOCS PERFORMANCE

DES MEASUREMENTS ON THE SAME ORBIT

-----> VERY CLOSE EVOLUTION BETWEEN ERS1 & ERS2

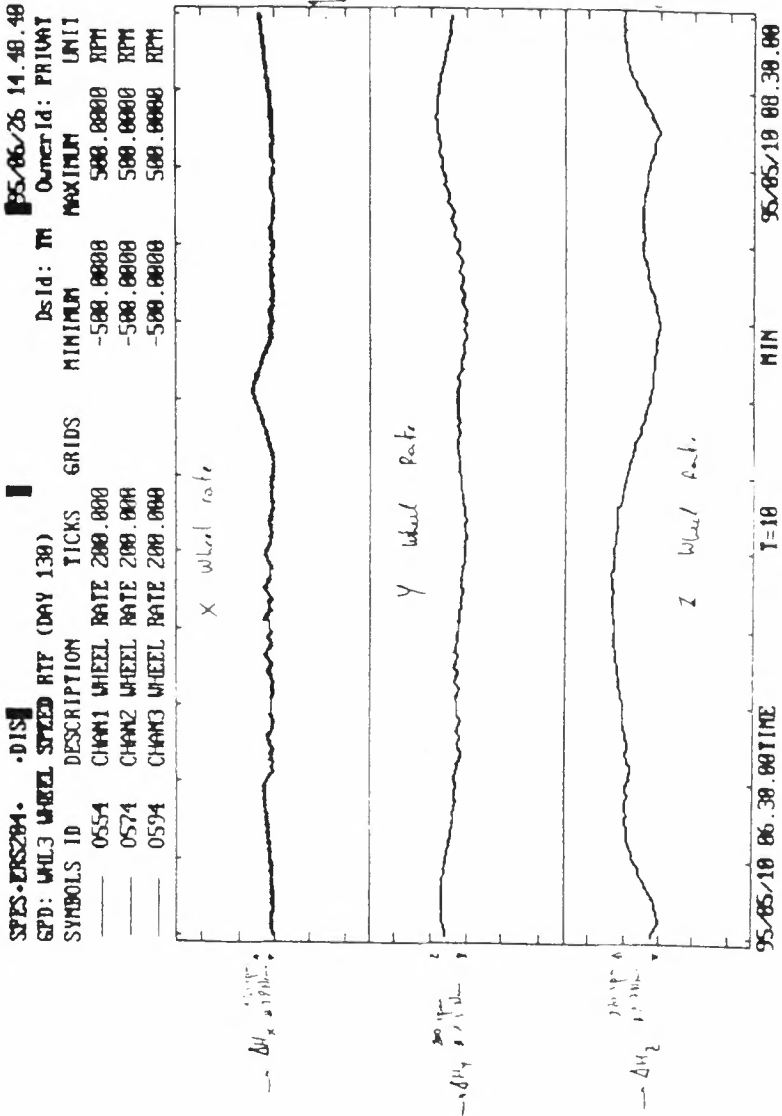
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AOCS PERFORMANCE

WHEELS RATES :

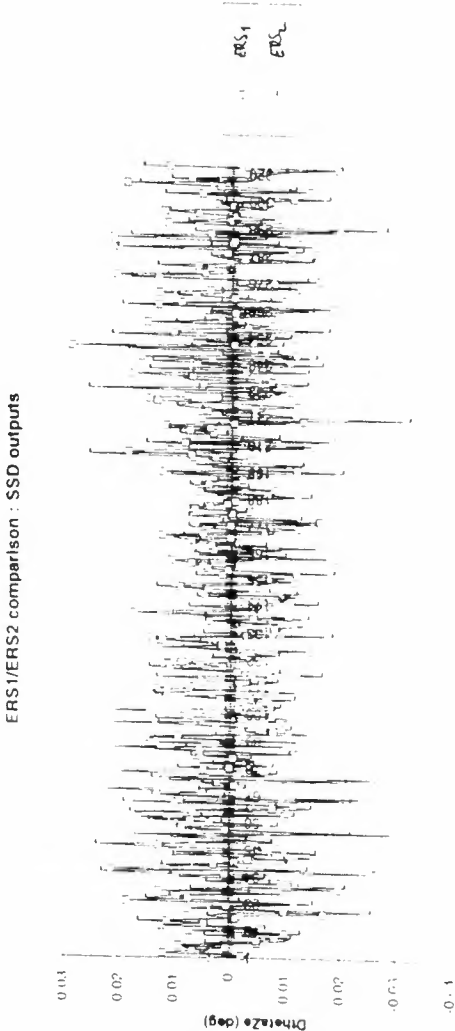
-----> NOMINAL EVOLUTION OVER ONE ORBIT



AOCS PERFORMANCE

DSS MEASUREMENTS

COMPARISON OF DSS OUTPUTS (θ_{ZM_0ZC}) OVER THE SAME PERIOD FOR ERS1&2 SHOWS GOOD CORRELATION AND PERFORMANCE : DISCREPANCY ARE EXPLAINED BY LUMINANCE EFFECTS DUE TO SENSITIVITY TO LONGITUDE : $|\theta_{ZM-0ZC}| < 0.03^\circ$



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AOCS PERFORMANCE

ERS2 ANALYSIS ON THE GYRO DATA

ANALYSIS OF THE FFT's FROM THE GYRO OUTPUT SAMPLES DURING HEALTH CHECK SHOW :

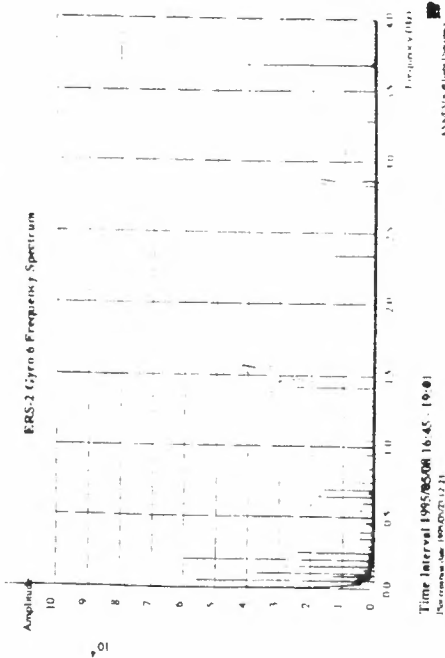
- SPIKES AT 1.4 HZ & 2.8 HZ ON GYRO 6 OUTPUTS WHEN GYRO 1,2,3,4 ON / GYRO 5&6 OFF
- SIMILARITY WITH ERS1 NOISE PHENOMENON: NOISE ON GYRO 6 WHEN GYRO 4 OFF , DISAPPEARING WHEN GYRO 4 ON

-----> NO IMPACT ON SYSTEM PERFORMANCE BUT HAS TO BE MONITORED

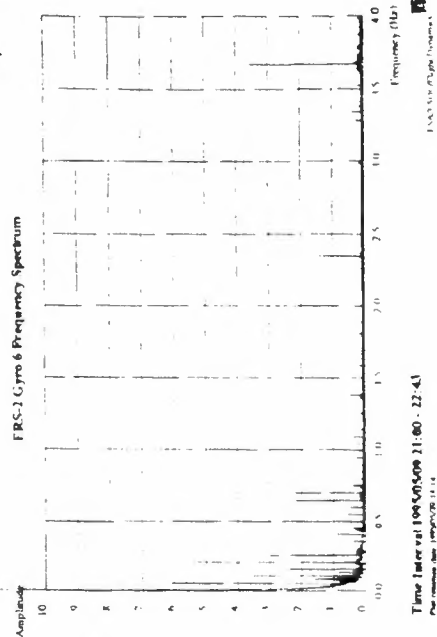
AOCS PERFORMANCE

ERS2 ANALYSIS ON THE GYRO DATA

GYRO 1, 2, 28G ON / 64KOS 485 OFF



GYRO 1, 2, 28G ON / 64KOS 3, 4, 5 OFF (Nominal Configuration)



ERS-2



Daimler-Benz Aerospace
Daimler Satellitensysteme GmbH

Payload Performances

ERS-2

Cool-down during LEOP

- all equipment well within operational temperature limits ($T \geq 5$ deg. C)
(requirement $T(PL) \geq$ min. non oper. limits)
- PL off mode with permanent day and night heating with LL and HL heaters
started nominally after SiADM release (at $H_0+2:12$)
- no heating required at SiAR- antenna and WSA motors during antenna
deployment

PEM Temperatures During PL-off Mode

Location	T/°C		
	ERS-2 (22.4.95)	ERS-1 (22.7.91)	ΔT /°C (ERS-2 /ERS-1)
RA Panel	13.6	11.1	2.5
HPA Panel	9.5	7.9	1.6
RF Access.	1.0	-5.3	6.3
AMI Panel	16.7	14.1	2.6
IDHT Panel	12.3	9.3	3.0
Cross Panel	11.8	10.1	1.7
Top Panel	7.5	5.0	2.5
AOCS	9.2	6.1	3.1
meas. PEM aver.	12.8	10.5	2.3
predic. PEM aver.	13.3	13.1	0.2

*) radiator still trimmed after final flight prediction in Kourou



PEM Temperatures During PL-off Mode

- o PL temperatures
 - very close to ERS-1 temperatures
 - well above min. oper. limits
 - well in line with predictions
- o high margins due to overall T/C design and increased heater bus voltage of ~34 V (orbit average heater power of 689 W)
- o high flexibility for instrument switch-on, verification and operation
(no thermal, power nor time constraints)

GOME Power Demand in PL-off and IDLE Mode

	measured	expected
PL off Mode: Heater power /W Heater Duty Cycle: FPA DDHU	11.5 at 34.0 V 100% 0%	13.1 W at 30.9V 100% 27%
IDLE Mode *)	19.5	17.5

*) within the accuracy of the current telemetry

Conclusions:

- same increased in-orbit battery voltage of ~34 V (orbit average) as observed on ERS-1 (analysis assumption was 30.9 V !)
- ==> heater duty cycles in-orbit different from predictions
- nevertheless predicted and measured temperatures in PL off mode are comparable due to similar heater power levels
- IDLE mode power consumption as expected

ERS-2



GOME Temperatures during PL Off Mode

Thermistors	Location	T/°C		T
		measured ¹⁾ at 34.04 V	predicted ²⁾ at BOL, SS, m-p 30.9 V	
S/C	optical bench	-12.7	-16.9	4.2
	DDHU	-10.5 (3)	-16.1 (4)	5.6
GOME	optical bench	-14 to -16	-16.9	1.9
	DDHU (PS)	-18.5 (3)	-16.1 (4)	-2.4
	Main Radiator	-29.1	-25.0	-4.1
	FPA detectors	-17.0	-17.6	0.6
	SUMA	-16.0	-16.5	0.5
	SUEA	-15.6	-17.9	2.3
	CU lamp	-15.6	-16.6	1.0
	CU PS	-16.8	-16.6	-0.2
	PU	-11.4	-16.5	5.1
	GOME average excl. rad.	-15.7	-16.8	1.1

(1) Telemetry only during ground coverage
==> limited validity of radiator temperature,
which varies ca. ± 5°C along the orbit
(2) Steady state, orbit average
(3) converter board
(4) baseplate

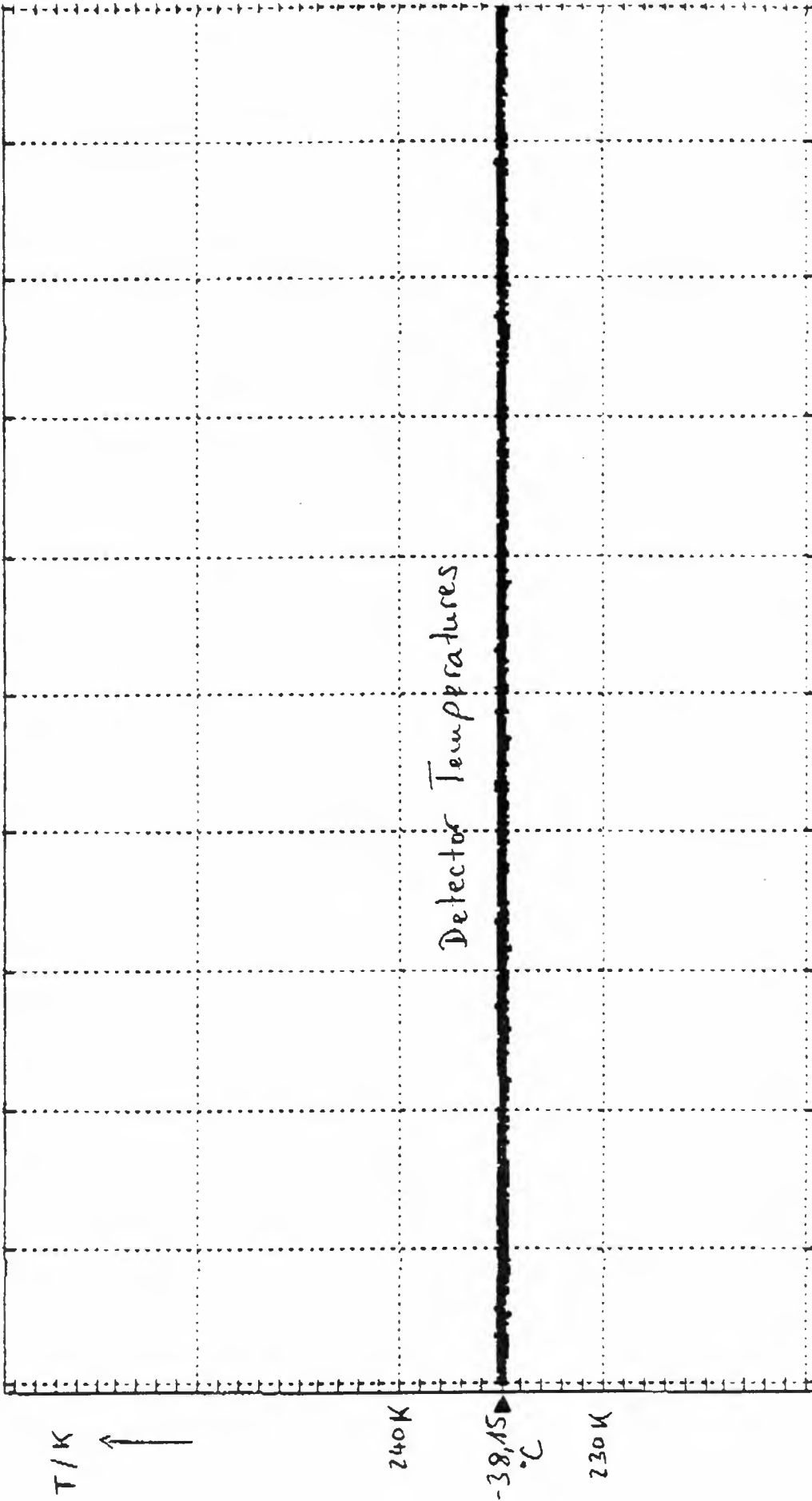
GOME Temperatures during Nominal Operation (CU off)

Thermistors	Location	Orbit Average T/°C		T /°C m-p
		measured	predicted for BOL, SS	
S/C	optical bench	7.9	1.4	6.5
	DDHU	27.4	27.6	-0.2
GOME	optical bench	5.4	1.8	3.6
	Input Telescope	6.1	1.0	5.1
	SUMA	4.5	2.2	2.3
	SUEA	7.3	1.8	5.5
	CU Lamp	5.2	2.9	2.3
	CU Power Supply	2.9	2.8	0.1
	PU	10.1	2.2	7.9
	average excl. rad.	5.9	2.1	3.8
	Main radiator	-27 to -18	-29 to -22	3
	Detectors	-38	-38	0

SPES-ERS104 • DIS 95/06/02 14.27.20

GPD: G001 GOME ,PA Temperatures OwnerId: PRIVAT

SYMBOLS ID	DESCRIPTION	TICKS	GRIDS	MINIMUM	MAXIMUM	UNIT
— V423	GM FPA1-TEMP1-S1	1.000	10.000	220.0000	260.0000	DEGR
- - V425	GM FPA2-TEMP1-S1	1.000	10.000	220.0000	260.0000	DEGR
- - - V427	GM FPA3-TEMP1-S1	1.000	10.000	220.0000	260.0000	DEGR
- - - - V429	GM FPA4-TEMP1-S1	1.000	10.000	220.0000	260.0000	DEGR



290.0000	DEGK
290.0000	DEGK
290.0000	DEGK

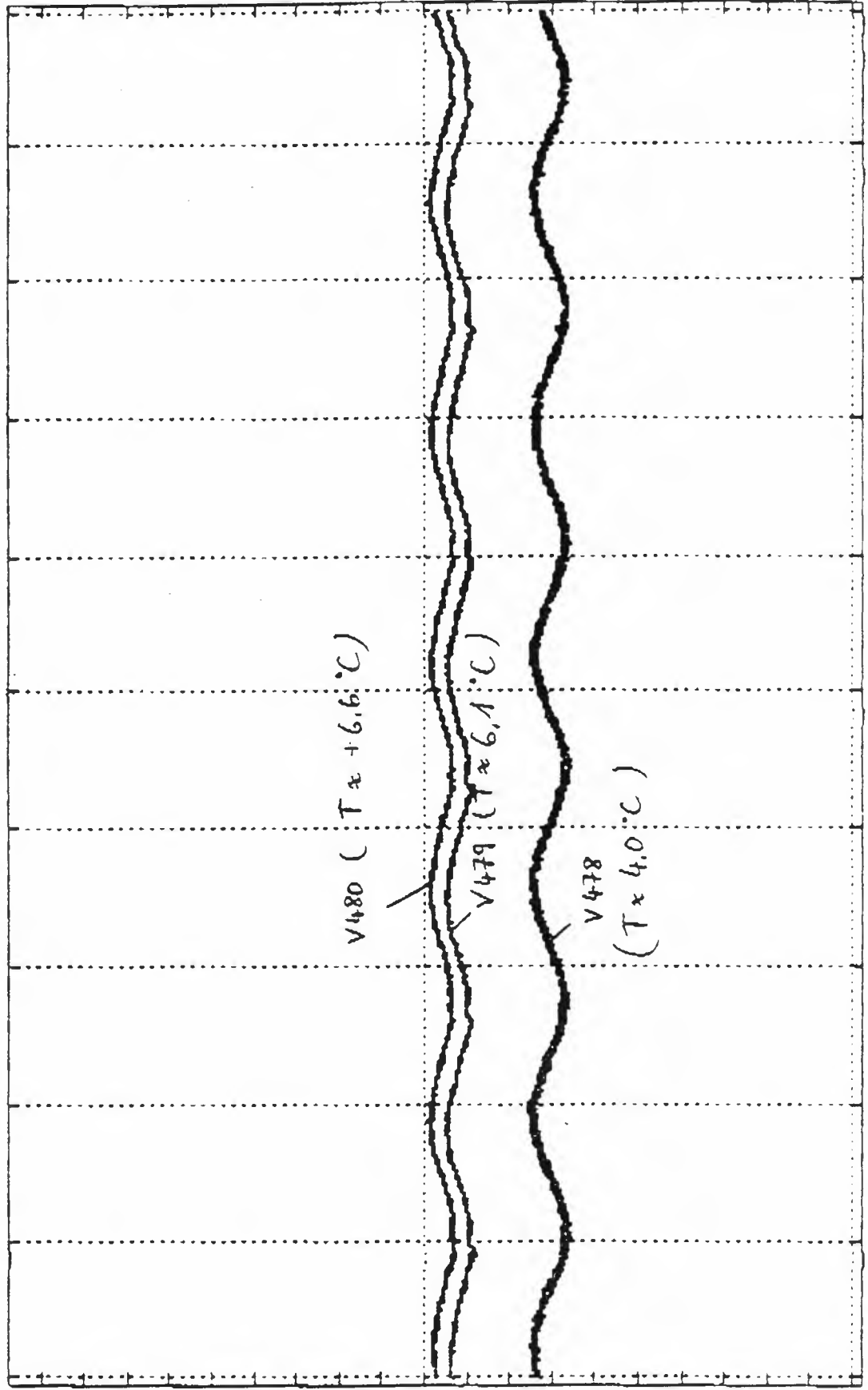
270.0000	MINIMUM
270.0000	MINIMUM
270.0000	MINIMUM

10.000	GRIDS
10.000	GRIDS
10.000	GRIDS

1.000	TICKS
1.000	TICKS
1.000	TICKS

TEMP4	DESCRIPTION
TEMP5	DESCRIPTION
TEMP6	DESCRIPTION

GM OPT.SYS	DESCRIPTION
GM OPT.SYS	DESCRIPTION
GM OPT.SYS	DESCRIPTION



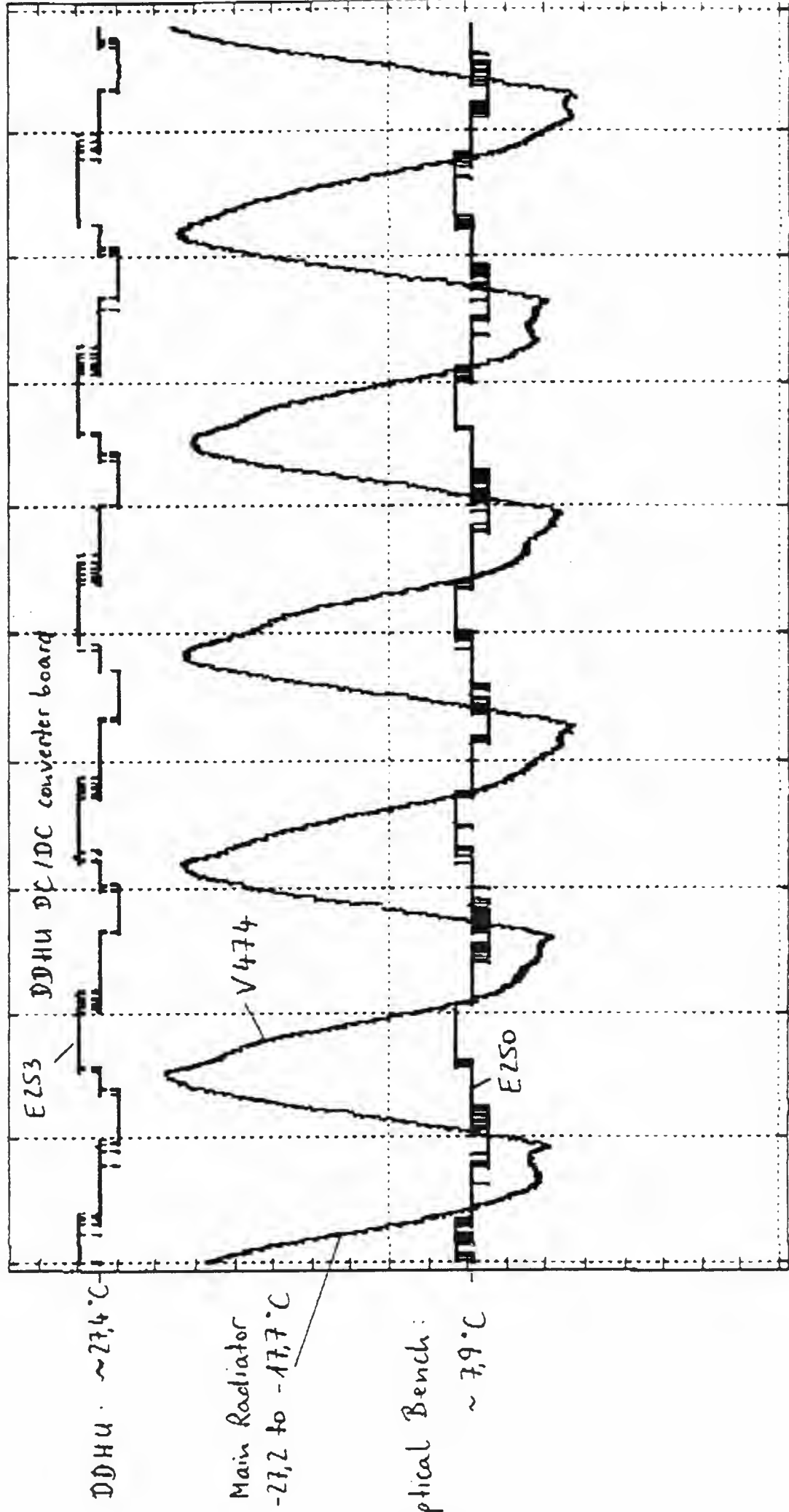
Orbital
Temperature
Variation
at GOME
Optical Bench

GPD: G006 GOME Radiator, Optical Bench and DDHU

DsId: TM

OwnerId: PRIVAT

SYMBOLS ID	DESCRIPTION	TICKS	GRIDS	MINIMUM	MAXIMUM	UNIT
---	V474 GM RADIATOR TEMP	1.000	10.000	240.0000	260.0000	DEGC
---	E250 TH GM OP BENCH T	1.000	10.000	0.0000	20.0000	DEGC
---	E253 TH GM DDHU TP	1.000	10.000	10.0000	30.0000	DEGC



T/°C and /K respect. (Note different scales !!)

Summary of GOME Performance

- Peltier control loops work perfectly for all 4 channels
- good correlation between predicted and measured temperatures
- slightly increased O/B temperature observed compared to predictions ($\Delta T \approx 3.8^\circ\text{C}$)
- ==> seasonal contribution (prediction for SS, measurement for 22.5.1995)
- ==> dissipation level:
 - prediction: 23.2 W (GOME BBM dissipations assumed in final flight predictions)
 - TV test measurement: 27.4 W
- ==> $\Delta Q = 4.2\text{ W}$ which corresponds to $\Delta T \approx 5^\circ\text{C}$



Summary of GOME Performance

- temperature offset of ≈ 1.3 °C between S/C and GOME internal thermistor at PDP
- radiator performance as predicted (!) $\Delta T \approx 3$ °C
- ==> fabulous result in the light of the very complex thermal environment (ATSR2 antenna) of the GOME main radiator
- temperature gradients on the O/B very stable along the orbit
- orbital variation exactly as predicted $\Delta T \approx \pm 0.5$ °C

ERS-2

Performance of T/C Hardware and Software

- heater and heater control system
 - heater branches and control hardware work correctly
 - OBC heater control software for PL and PF T/C loops operates nominally
 - heater control thresholds for control loop # 4 on AMI panel slightly adjusted
 - control loop # 2 on IDHT panel reveals 3 on/off switch cycles per orbit well within design goal of 5 switch-cycles per orbit
- radiators and heat pipes
 - work properly

ERS-2



PL Temperatures during Verification Phase

- Thermal control loops active
- PEM panel temperatures stabilised at temperature thresholds of heater control loops

Instrument	T aver/°C
RA	10 (-z)/ +5 (+z)
HPA TWT	4
HPA EPC	2
RF Access	-2
AMI	+5
ID	10 (-y)/8 (+y)
Tape Rec.	6
Calibr.	10
DEU	10
PDU	18
AOCS	9
GOME	11

Conclusion:

- same healthy thermal conditions as on ERS-1
 - extended instrument operation possible (AMI Image and IDHT Transmit mode)
 - sufficient power available
- =>same operational flexibility as ERS-1

Payload Switch-on period and commissioning:

- Except for AMI Scatt all instruments and subsystems were nominal and operated according to Mission Planning System (MPS) at ESOC
- AMI:
Image and Wave Mode operated correctly with 0.5 dB saturation power back-off
Neither Wind nor Wind Calibration Mode were maintained for more than a few transmit pulses due to auto switch-off upon "receiver overload" condition
- Operations/activities
AMI investigations are manifold and ongoing per AMI Task Force activities
ATSR and GOME calibration and on-line handling according to operational requests
RA calibration and nominal operations
PRARE: nominal operations

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ERS-2 AMI Wind Mode Anomaly

What happened?

During first payload switch-on, the AMI was shut down due to a triggering of the Receiver Overload protection circuit (in all modes) $\Rightarrow$ excessive receiver powers

First In-orbit Tests:

Redundancies changed $\Rightarrow$ no effect

HPA output power reduced by 1.7 dB $\Rightarrow$ image mode o.k.

Tests with transponders: the first Wind Mode Fore pulses caused the receiver overload to be triggered

On-Ground Tests:

EM AMI and EGSE set up at DORNIER:

Switching behaviour of receiver overload circuit: no major differences to the in-orbit results

Patch developed to overcome the Fore Wind Mode sequence:

Use the HPA input redundancy switch

Successfully tested on-ground $\Rightarrow$ applied in-orbit: Mid and Aft sequence o.k.!

New patch to overcome the Fore sequence permanently: switching speed o.k. but degrading switch performance after several cycles; switch was acting like an attenuator

This attenuation can be used to reduce the HPA power further: an attenuation of 2 ... 3 dB can be achieved

Verified on-ground: o.k.

Tested in-orbit, but not sufficiently stable to prevent a receiver overload

Tests with Flight Spare and with life test tube: check stability at low o/p powers

Multipaction Test at ESTEC facility:

Representative circulator set up showed that multipaction in one circulator causes the TX power to be reflected (at 6.8 kW)

If multipaction occurs in the Fore circulator, then power is routed to the receiver $\Rightarrow$ immediate switch-off due to receiver overload

Question: Which type of contamination is likely to reduce the multipaction threshold down to 1.7 kW?

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Intermediate summary:

- Wind mode is not yet operational; max. operation = 1 hr until auto switch-off
- Multipaction due to contamination could explain some of the failure characteristics
- During 1 hr Wind Mode the transmit power showed unexplained undulations: investigations ongoing
- Calibration Subsystem auto switch-off was likely caused by a relay in conjunction with a single event upset

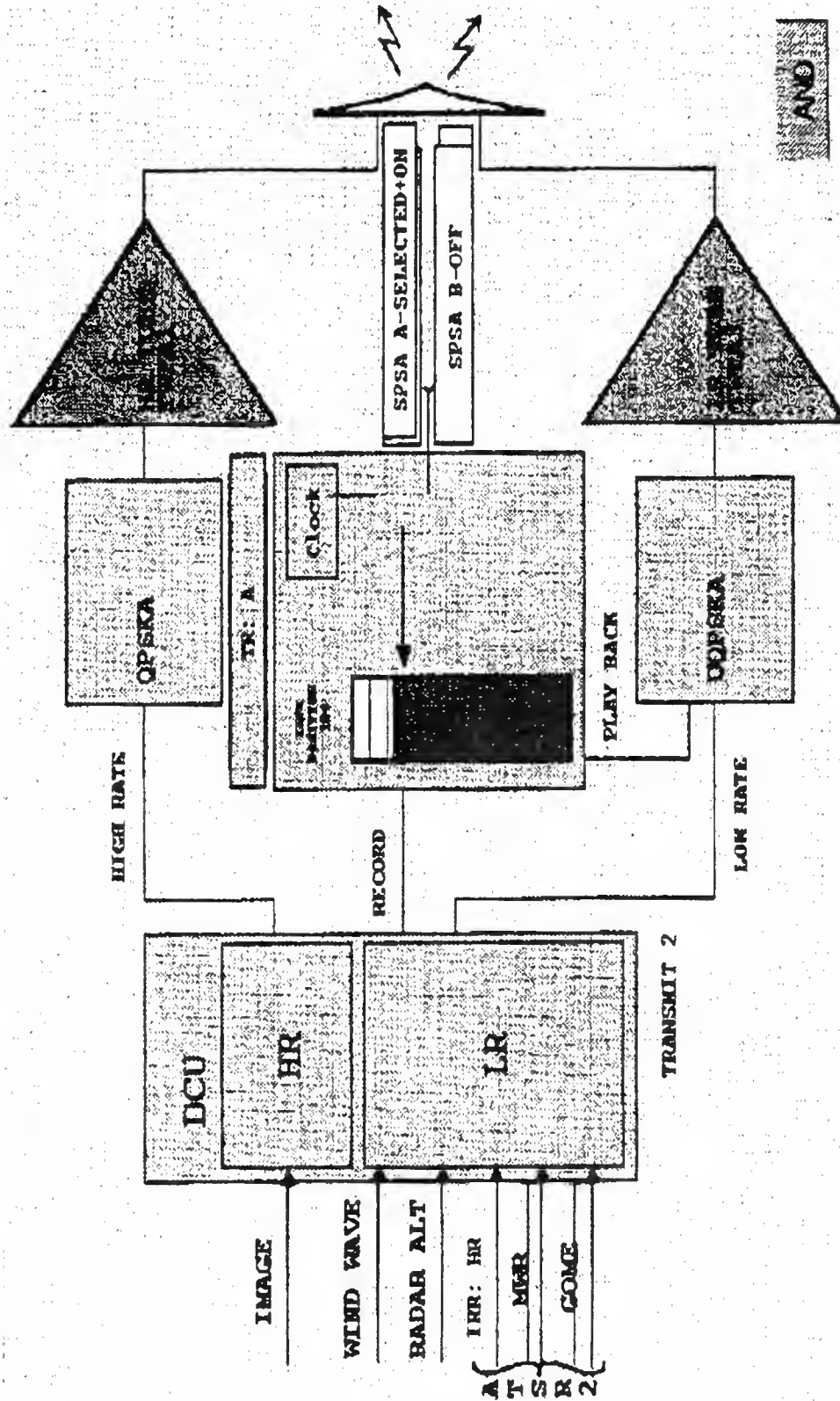
ERS-2



AMI main parameter trend in image mode (averages)

	june 95	july 95	aug.95
Q 402, HPA filament current, A	1.78	1.8	1.8
Q 403, HPA beam current, mA	96.55	96.55	96.55
Q 404, HPA cathode voltage, kV	-13.96	-13.96	-14
Q 405, HPA collector voltage, kV	-10.44	-10.445	-10.43
Q 407, Cal peak inp.power, dBm	4.72	4.64	4.68
Q 408, Cal peak outp. power, dBm	1.75	5.8	5.78
Q 408, Cal peak outp.power, wave, dBm	4.98	4.84	4.87
Q 409, FGE 5 GHz power, dBm	13.95	13.95	14

INSTRUMENT DATA HANDLING & TRANSMISSION



ERS-2 COMMISSIONING PHASE REVIEW

26 October 1995 ESRIN

M. Mc Kay



STATUS

- Nominal performance of the IDHT
- Travelling Wave Tube switchings reduced (~ 1/orbit)
- Tape units switched every 3 months
- Tape Pressures are continually monitored

4 Anomalies to date :

ANO-24	ICU Synchronisation Failure
ANO-34	Tape Recorder B μ cmd Failure
ANO-51	Mcmd Acknowledge Failure - Emergency Switch-Down
ANO-54	Analogue-Digital Converter Error on Initialisation



IDHT UNIT TEMPERATURES

ERS-1/2 S-Band Data	ERS-1	ERS-1	ERS-2
TM Parameter	Dec 92	Aug 95	Aug 95
I200/I203 TWT1/2 FIL	0.65 A	0.65 A	0.65 A
I201/I204 TWT1/2 HLX	0.35 mA	< 0.1 mA	0.45 mA
I202/I205 TWT1/2 EPC	11-21 C	10-28 C	11-20 C
I221 QPSK A TMP	16-26 C	16-27 C	20-25 C
I222 QPSK A +5V	~ 4 V	~ 4 V	~ 4 V
I225 UQPSK A TMP	15-27 C	15-27 C	16-26 C
I226 UQPSK A +5V	~ 4V	~ 4V	~ 4 V
I233 DCU A TMP1	21-36 C	20-36 C	20-36 C
I234 DCU A TMP 2	18.5-25 C	16.5-22 C	19.5-25 C
I231 DCU A SND V1	4 V	4 V	4 V
I232 DCU A SND V2	~ 4V	~ 4V	~ 4V
I206 TWT3 FIL CUR	0.65 A	0.65 A	0.65 A
I207 TWT3 HLX CUR	0.65mA	0.65mA	0.65mA
I208 TWT3 EPC TMP	11-25 C	11-28 C	11-21 C

Plot: 00023, Orbit: 002568
RMS at 1995 Day 290 11:38:06

ERS-2

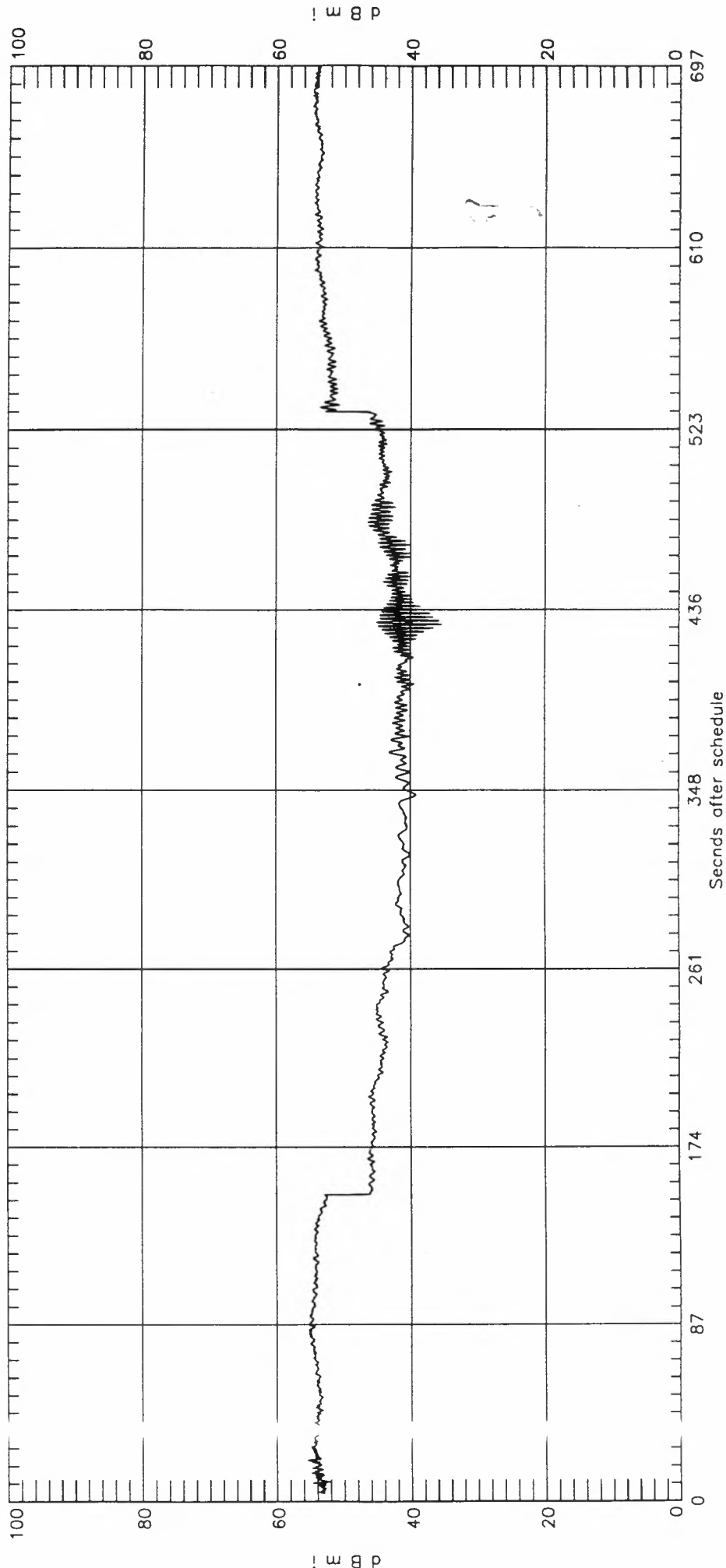
ESOC Mission Management and Planning Office - Plevel
Reference Measurement System

82: satellite EIRP X_band link 2 (RT), as received by demods

Valid measurement

Schedule time: 17-OCT-1995 11:38:06.000

Result file: RES505



ERS-1

Plot: 00003, Orbit: 22241
RMS at 1995 Day 289 11:38:03

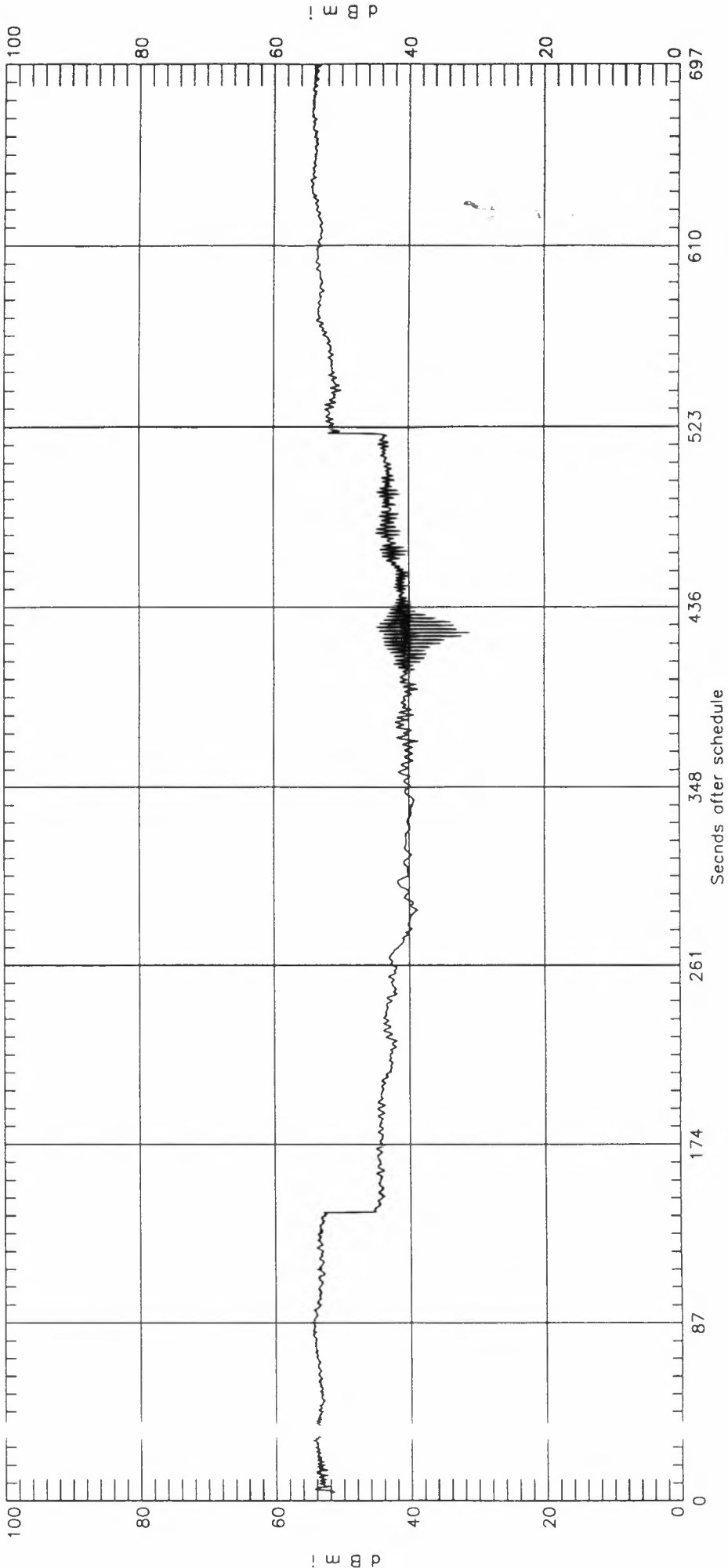
ESOC Mission Management and Planning Office - Plevel
Reference Measurement System

82: satellite EIRP X_band link 2 (RT), as received by demods

Valid measurement

Schedule time: 16-OCT-1995 11:38:03.000

Result file: RES481





Radar Altimeter S-Band Data Evaluation

**ERS-2 Commissioning Phase
First Review**

Presented by: F. Buscaglione

Frascati, 26/27 October 1995



Alenia Spazio S.p.A.

Table of Content

- Radar Altimeter dynamic variations
- Radar Altimeter orbital variations
- Radar Altimeter long trend analysis
- ERS-1 vs ERS-2 comparison
- Anomalies
- Conclusions

Radar Altimeter dynamic variations

- There are two classes of RA parameters which can be differentiated by their amplitude of variation around the orbit:
 - for one class variation are very small and therefore only long trend analysis is applicable
 - for the remaining parameters it is possible to observe an orbital variation; however, long trend analysis is still applicable on the parameter mean

Radar Altimeter orbital variations

- The parameters subject of the orbital variation are mainly those relevant to the Instrument temperatures
- The observed orbital variation of all these parameters shows a common behaviour
- The parameters that will be shown were continuously monitored through two consecutive orbits

Radar Altimeter orbital variations (cont'd)

ERS2 RA04

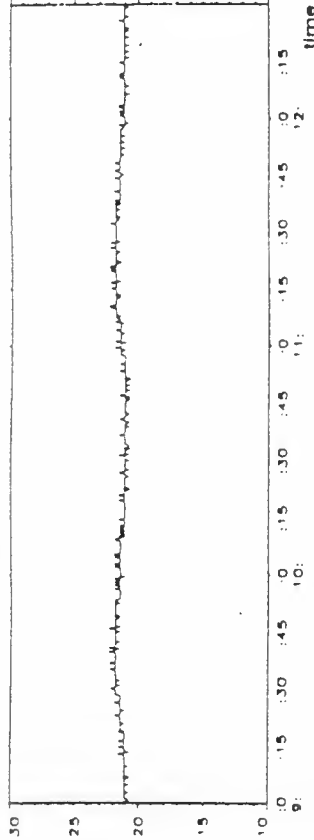
Start Date & Time 1995-264 09:00:02
End Date & Time 1995-264 12:29:54

ERS-2 R200,R201,R202,R214

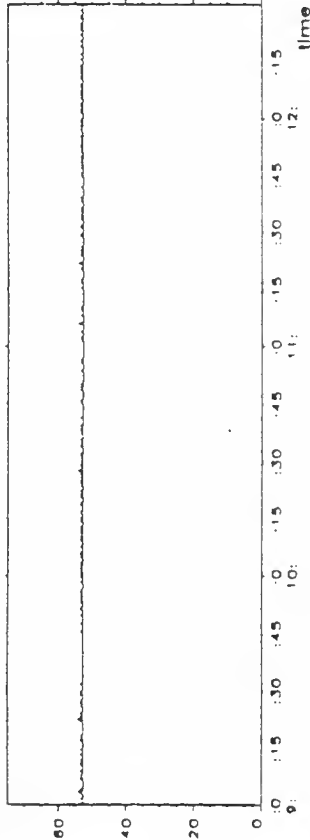
SPEVAL

R200 RA LVPS A/B TMP1
R201 RA LVPS A/B TMP2
R202 RA ICU A/B TMP
R214 RA HPA A TX PWR

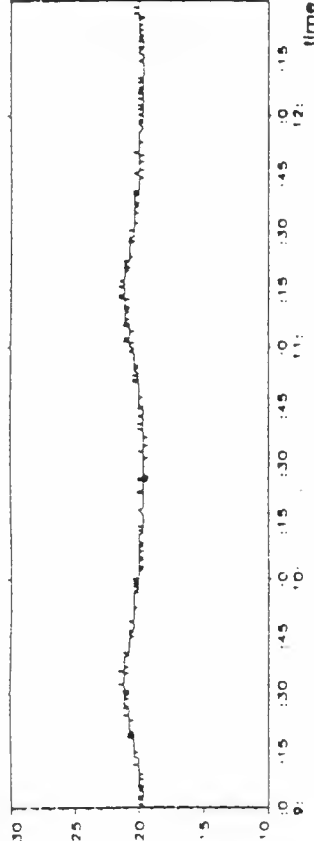
DEGC
R200



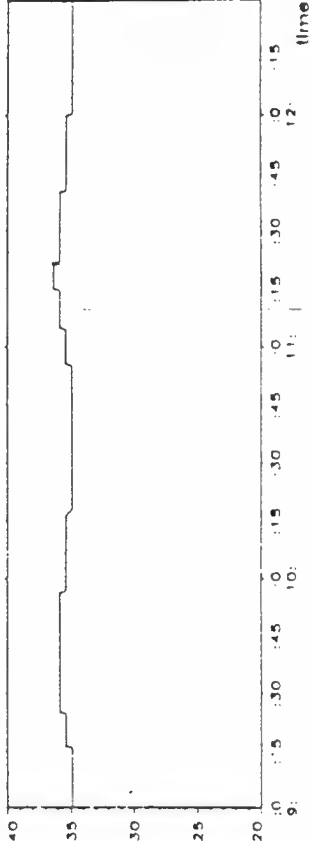
W
R214



DEGC
R201



DEGC
R202



Radar Altimeter orbital variations (cont'd)

ERS2 RA05

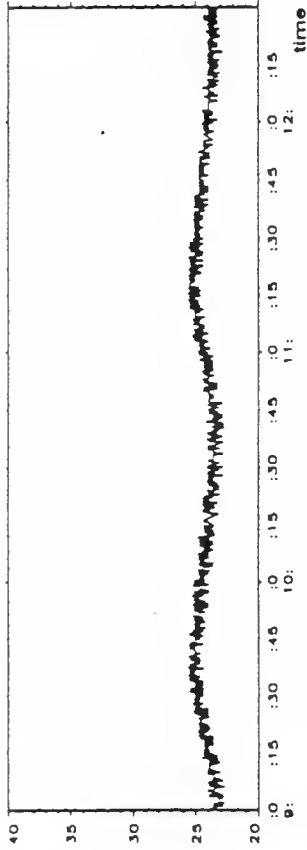
Start Date & Time 1995-264 09:00:02
End Date & Time 1995-264 12:29:54

ERS-2 R216,R218,R220,R224

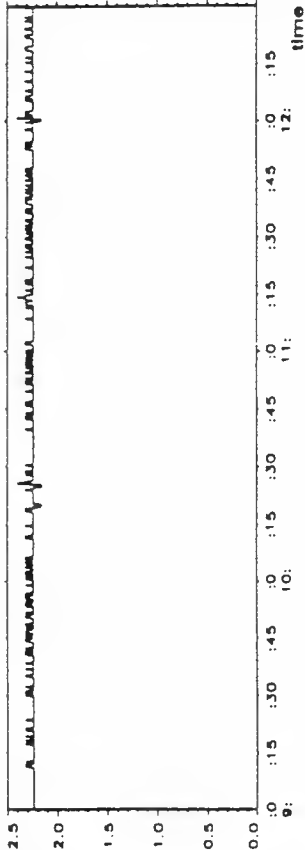
SPEVAL

----- R216 RA SP A I-CH TMP
----- R218 RA SP A Q-CH TMP
----- R220 RA MICRO-P A TMP
----- R224 RA HPA A HLX GUR

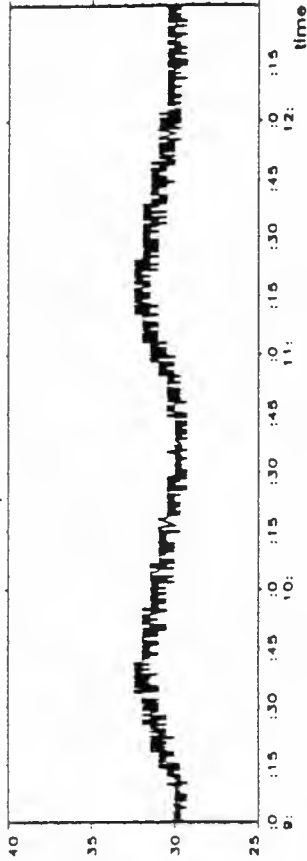
DEGC
R216



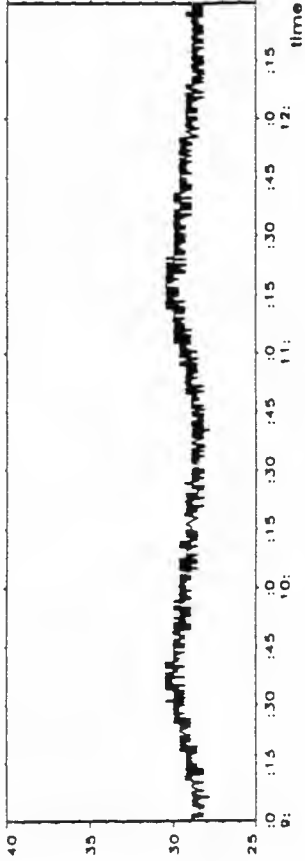
MA
R224



DEGC
R218



DEGC
R220



Radar Altimeter orbital variations (cont'd)

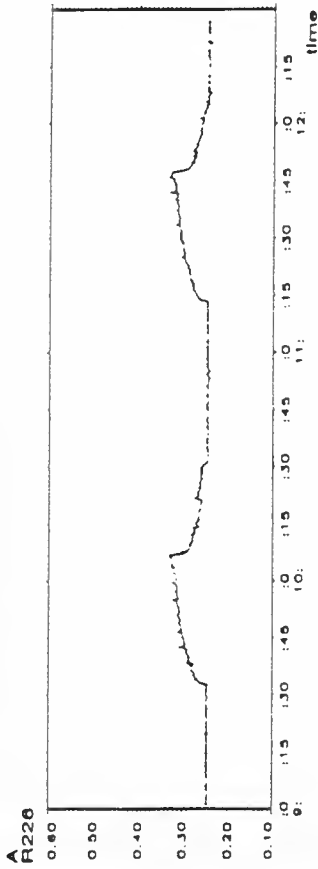
ERS2 RA06

Start Date & Time 1995-264 09:00:02
End Date & Time 1995-264 12:29:54

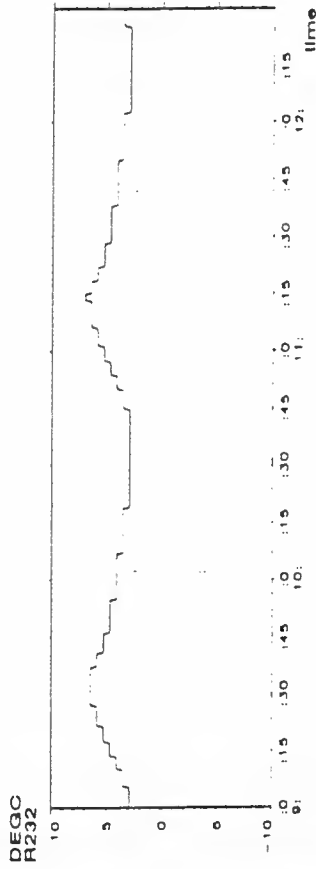
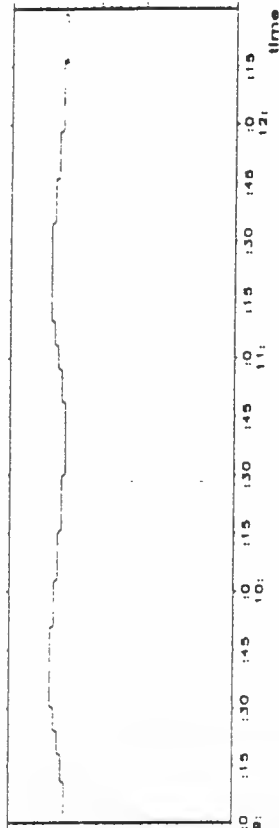
ERS-2 R226,R228,R230,R232

SPEVAL

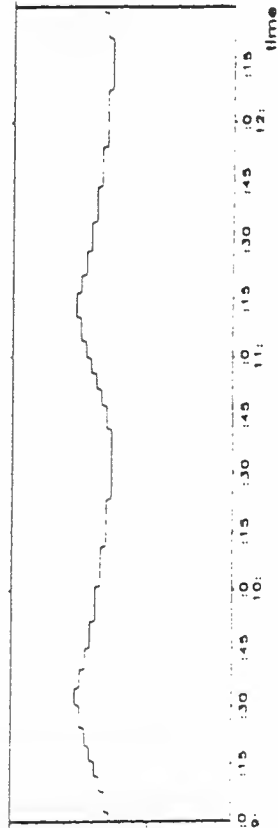
R226 RA PWR BUG A CUR
R228 RA EPO A H6 TMP
R230 RA TWT A H6 TMP
R232 RA MR A TMP



DEGC R228



DEGC R232

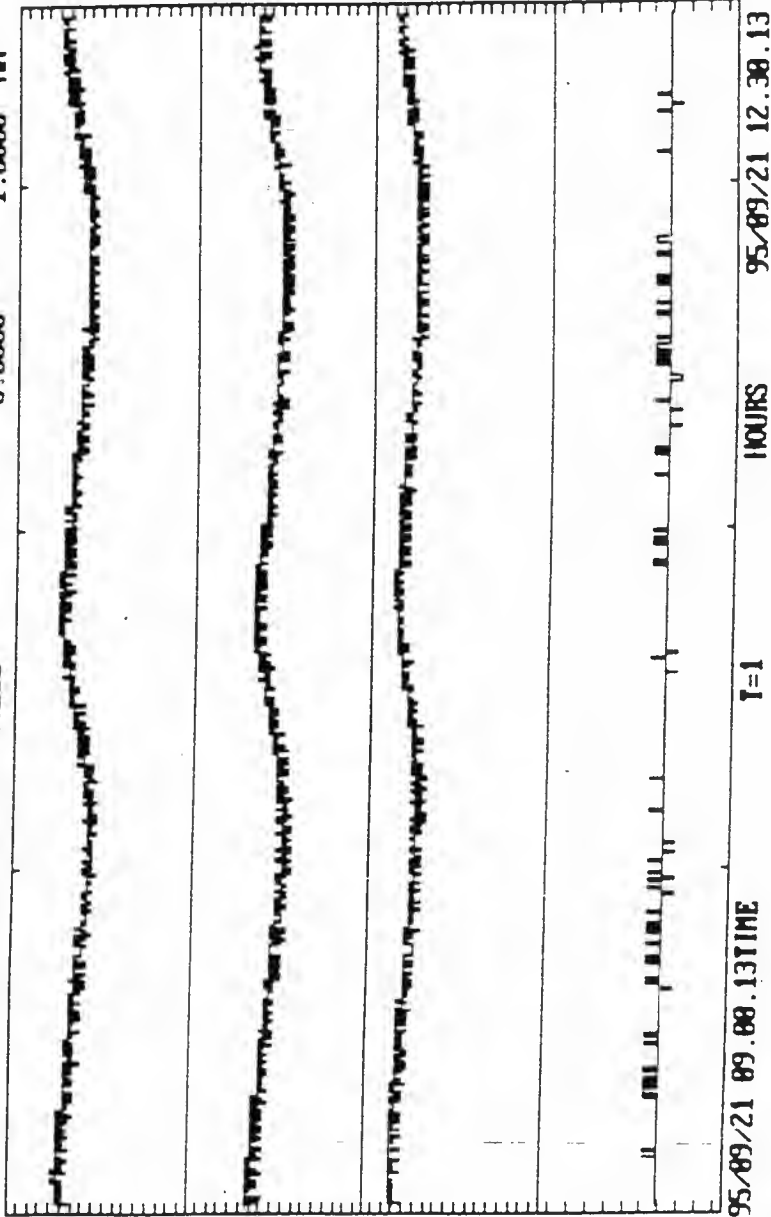


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Radar Altimeter orbital variations (ERS-1)

SYMBOLS ID	DESCRIPTION	TICKS	GRIDS	MINIMUM	MAXIMUM	UNIT
R216	RA SP A I-CH TMP	1.0000		25.0000	40.0000	DEGC
R218	RA SP A Q-CH TMP	1.0000		25.0000	40.0000	DEGC
R228	RA MICRO-P A TMP	1.0000		25.0000	40.0000	DEGC
R224	RA IPA A HLX CUR	0.200		0.0000	1.0000	MA



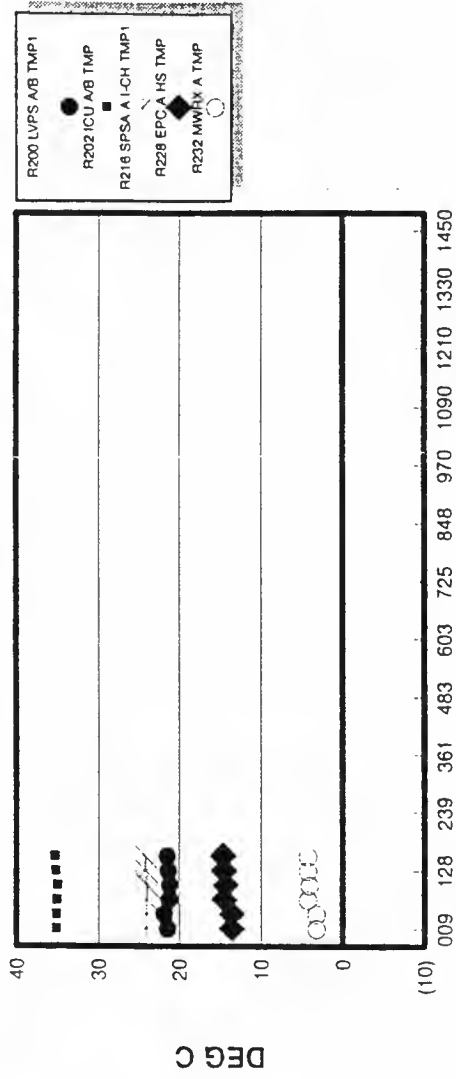
Radar Altimeter long trend analysis

- The RA long trend analysis can be preformed both on the orbital varying and on the orbital not-varying parameters
- The orbital varying parameters is averaged on 200 minutes on the 21st of every month since launch starting at 09:00:00 UTC each time
- An orbital not-varying parameters value is extracted every three days at 09:00:00 UTC since launch

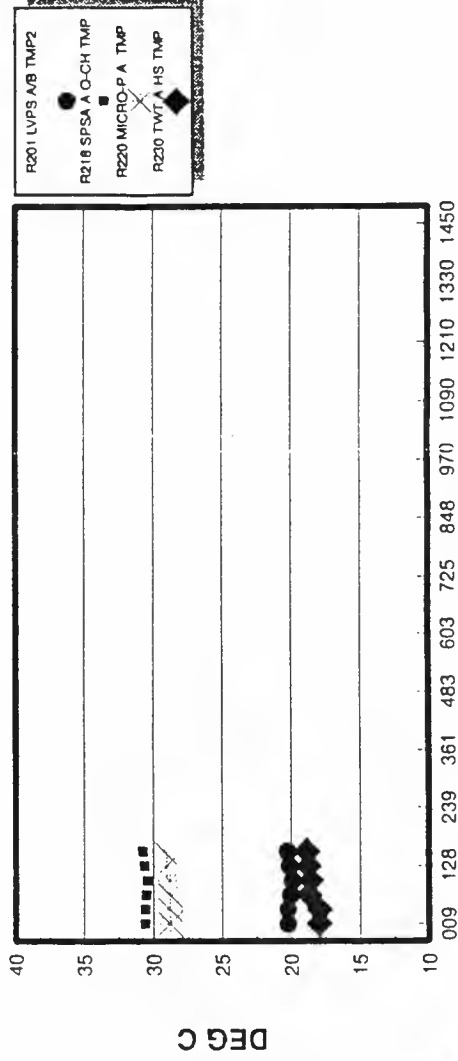
Radar Altimeter long trend analysis (cont'd)

- Orbital varying parameters:
 - Temperature:
 - After slight increase after launch for only few of them, all temperatures are quite stable
 - TWT parameters:
 - No evidence of trend can be identified due to the short observation period
- Orbital not-varying parameters:
 - So far no evidence of any trend can be identified with the exception of TWT filament current which increased after launch and then remain stable

Radar Altimeter long trend analysis (cont'd)

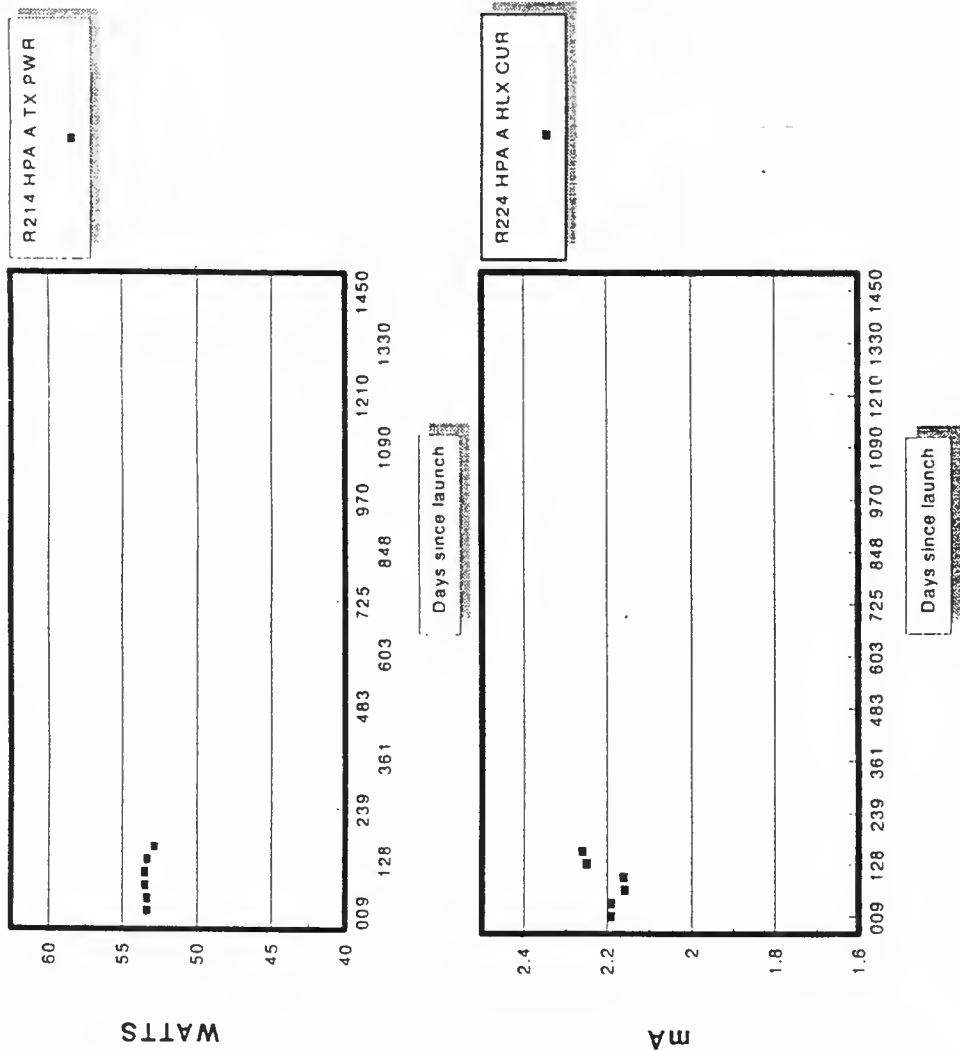


Days since launch

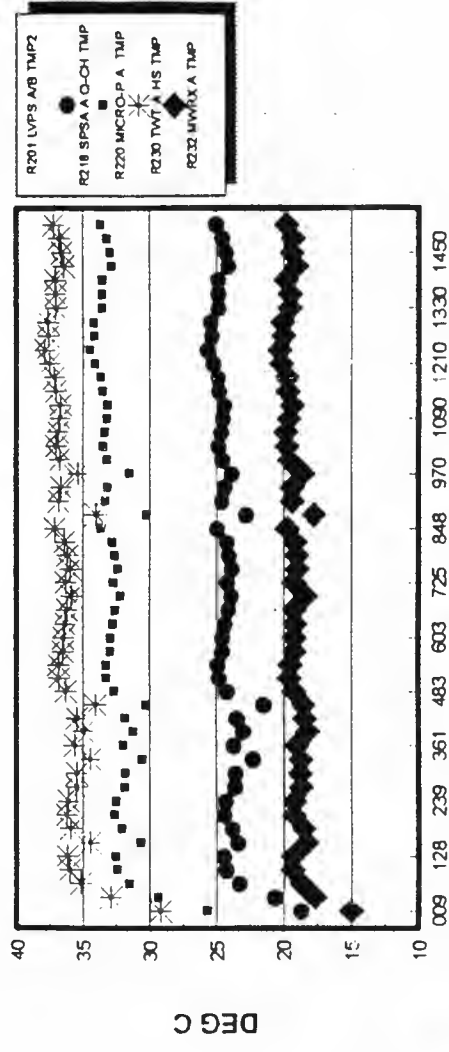
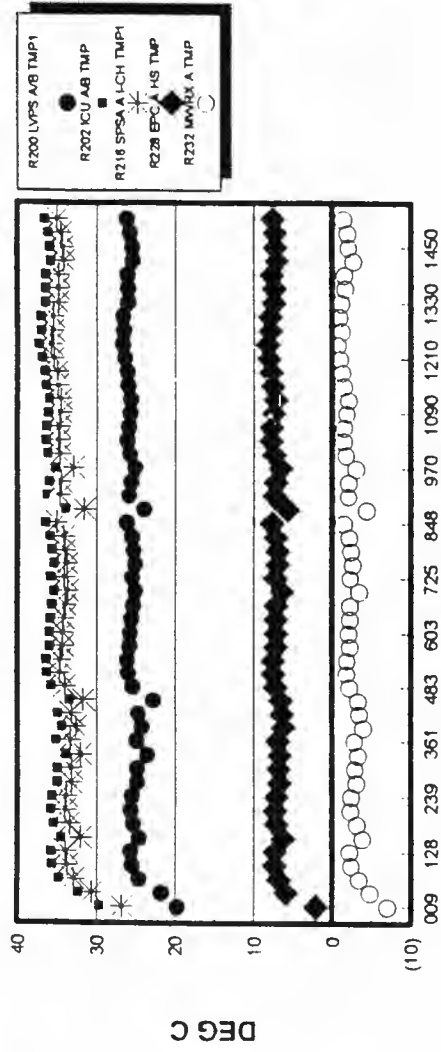


Days since launch

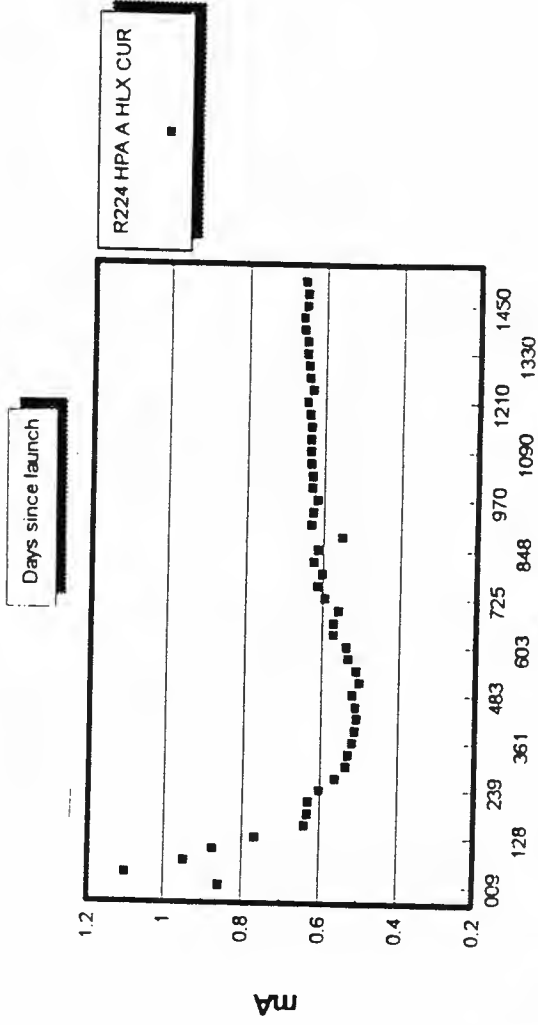
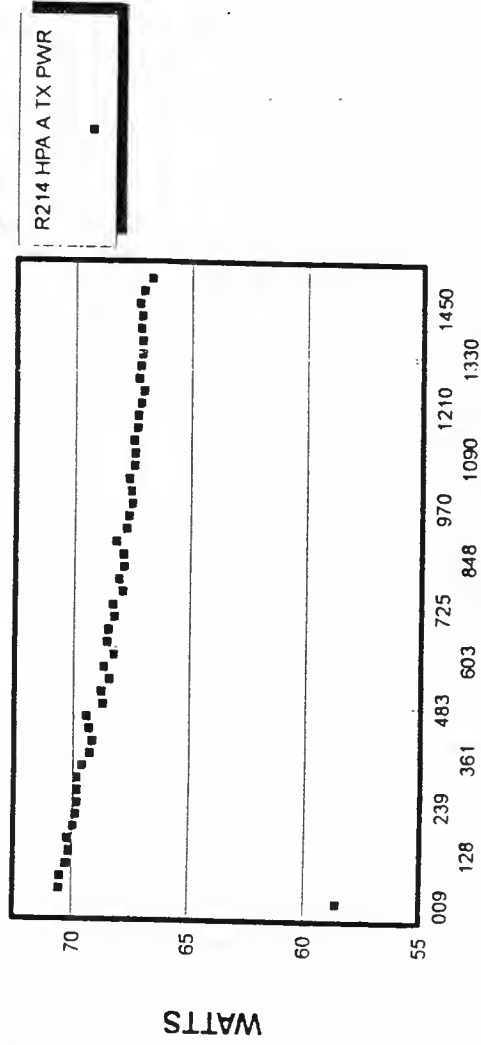
Radar Altimeter long trend analysis (cont'd)



Radar Altimeter long trend analysis (ERS-1)



Radar Altimeter long trend analysis (ERS-1)



Radar Altimeter long trend analysis (cont'd)

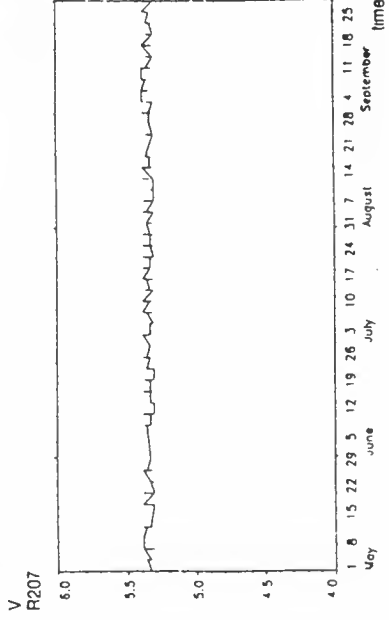
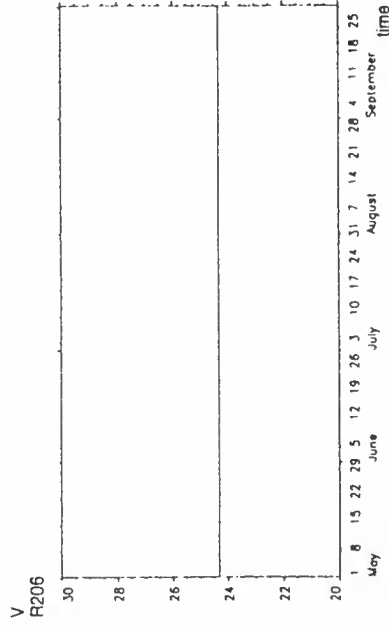
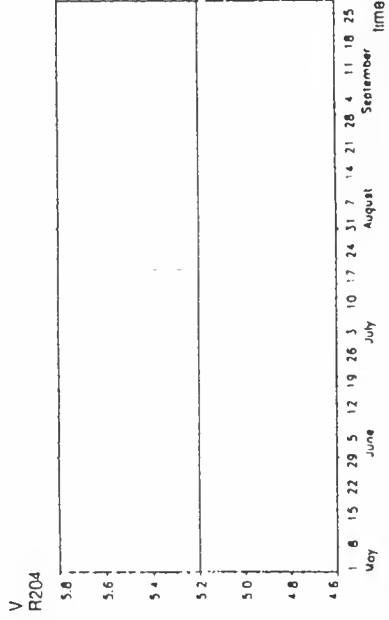
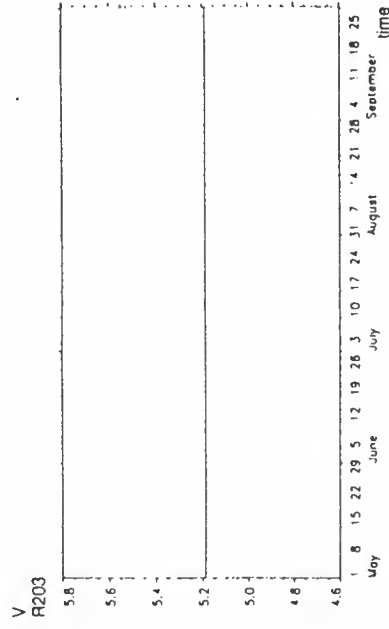
ERS2 RA02

ERS-2 R203 R204 R207 R206

Start Date & Time 1995-121 09:00:03
End Date & Time 1995-274 09:00:50

SPEVAL

----- R203 RA ICU A/B +5.2V
----- R204 RA MW A/B +5.2V
----- R206 RA USO A/B +24V
----- R207 RA SP A/B +5.2V



Radar Altimeter long trend analysis (cont'd)

ERS2 RA01ERS-2 R210

Start Date & Time1995-121 09:00:03

End Date & Time1995-274 09:00:50

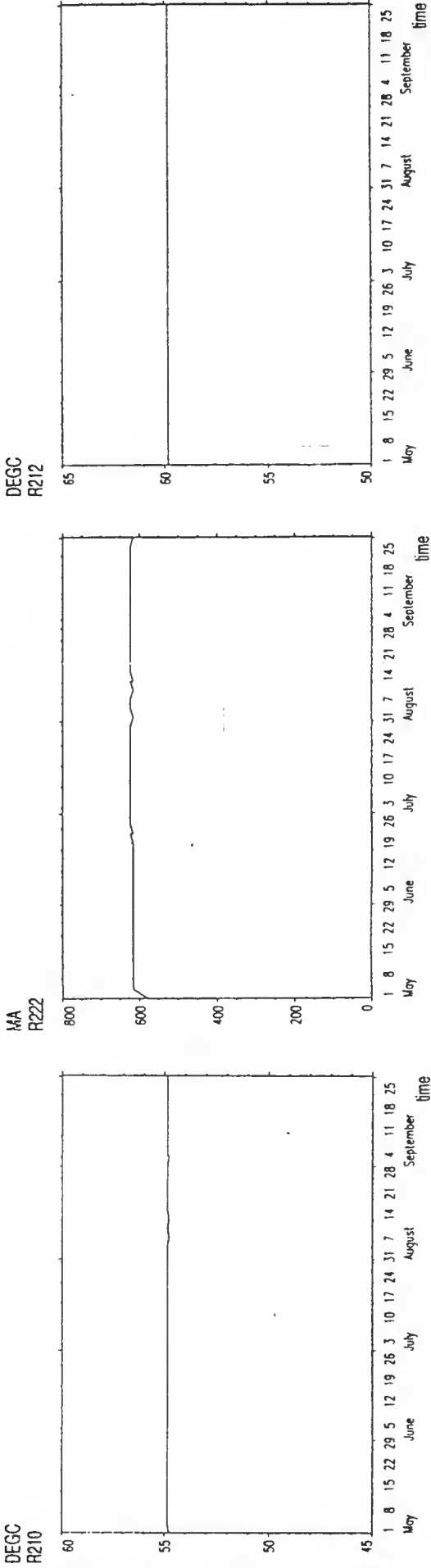
R212 R222

SPEVAL

— R210 RA USO A TMP

— R212 RA SAW A DL TMP

— R222 RA HPA A FIL CUR



Radar Altimeter long trend analysis (cont'd)

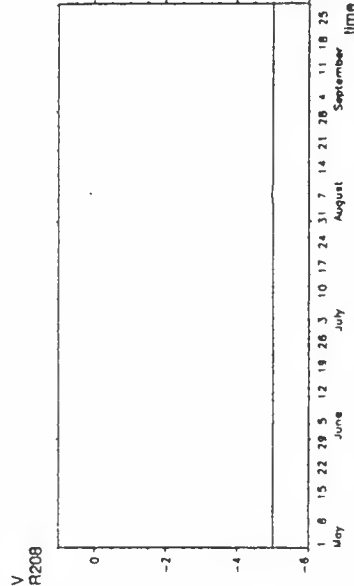
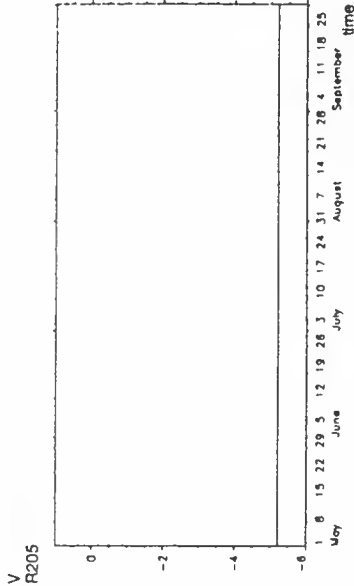
ERS2 RA03

Start Date & Time 1995-121 09:00:03
End Date & Time 1995-274 09:00:50

ERS-2 R205 R208 R209

SPEVAL

— R205 RA MW A/B -5.2V
— R208 RA SP A/B -5.2V
— R209 RA SP A/B -6.0V



Radar Altimeter long trend analysis (ERS-1)

SYMBOLS	ID	DESCRIPTION	TICKS	GRIDS	MINIMUM	MAXIMUM	UNIT
·	R283	RA ICU A/B +5.2V	0.500		0.0000	6.0000	V
·	R284	RA MW A/B +5.2V	0.500		0.0000	6.0000	V
·	R287	RA SP A/B +5.2V	0.500		0.0000	6.0000	V
·	R286	RA US0 A/B +24V	2.500		5.0000	30.0000	V

93/03/16	00.59.25	TIME	1=7	DAYS	95/12/11	00.58.25
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ERS-1 vs ERS-2 comparison

- The orbital varying parameters show a similar behaviour on ERS-1 and ERS-2 Radar Altimeters
- The long trend analysis comparison shows that the temperatures of ERS-2 Radar Altimeter present a smaller increase of value after launch before to reach a quite stable condition
- For the orbital not-varying parameters an exact overlapping of the curves is achieved

Anomalies

- The following type of the anomalies occurred:
 - RA Filling up with TYPE3 entries (no PEP status acquired)
 - Wrong IPC sent to SPSA (no ACK from SPSA to ICU)
 - ICU memory check violation (SEU)
 - SPSA memory check violation (SEU)
 - SPSA run time violation (task too long but operations are OK)
 - ICU unused memory fetch (SEU)

Conclusions

- Since switch-on the Radar Altimeter is properly working
- No failure occurred
- All parameters are well inside the expected ranges
- The Instrument shows operability in line with the design requirements and confirms the pre-flight tests
- The hardware behaviour is excellent and we can assume that it will meet the life time requirement as done by ERS-1 Radar Altimeter



Overview

- 1) Verification of RA on board parameters
- 2) Evaluation of actual in flight technical parameters
- 3) Quality of wave forms
- 4) Estimation of height measurement performance

Prepared:
E. Schied
Dornier Satellitensysteme GmbH



1) Verification of parameter settings

Several parameter settings are reflected in the source packets. The source packets have been analysed to verify the parameter setting macrocommand.

Result: All parameter settings have been found as expected.

Verification of acquisition parameters and acquisition function:

The 5 acquisition phases show the expected echo power levels, the transition from acquisition phase into the nominal tracking is smooth:

- the range accuracy is within about ± 1 m (for ocean mode)
- the power levels are correct within about ± 1 dB

Result:

There was no need for any on board parameter change so far.



2.) Derivation of actual in flight technical parameters

The derivation of the actual technical parameters is based mainly on the SPTR measurements (Scanning Point Target Response).

SPTR measurements:

- a small fraction of the transmit chirp is coupled directly into the receiver
- the signal is down converted with a replica of the chirp, the resulting "tone" has a frequency depending on the delay between transmit and receive chirp.
- the on board signal processor estimates the spectrum of the signal
- the evaluation software uses successive data blocks to reconstruct the detailed shape of the SPTR for different trigger settings.
- the detailed shape of the SPTR is analysed to extract technical parameters
- main technical parameters are e.g.: receiver gain, instrument internal delay, chirp slopes, point target response detailed shape and half power width, timing accuracy, IF filter shape

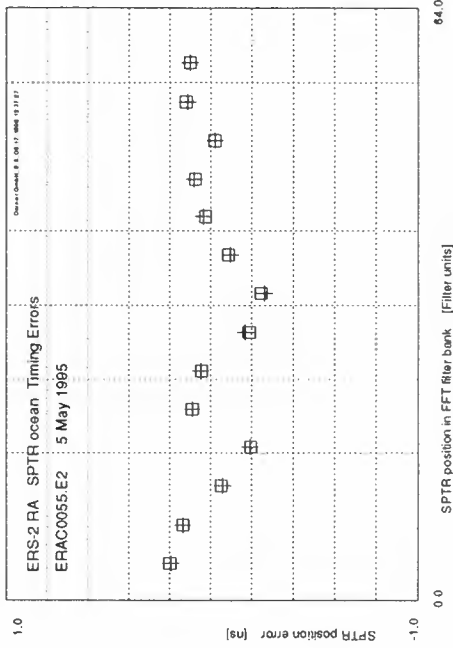
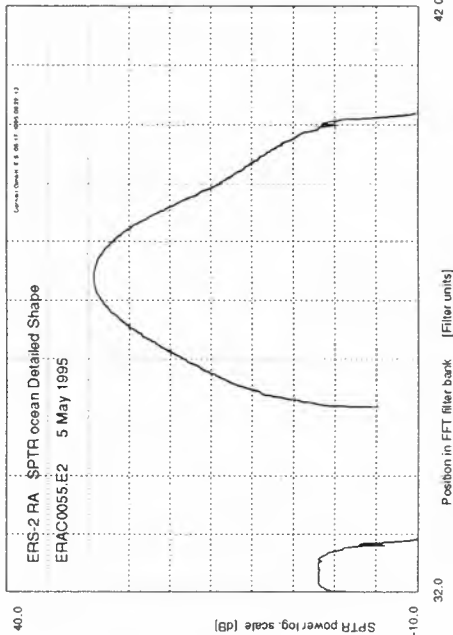
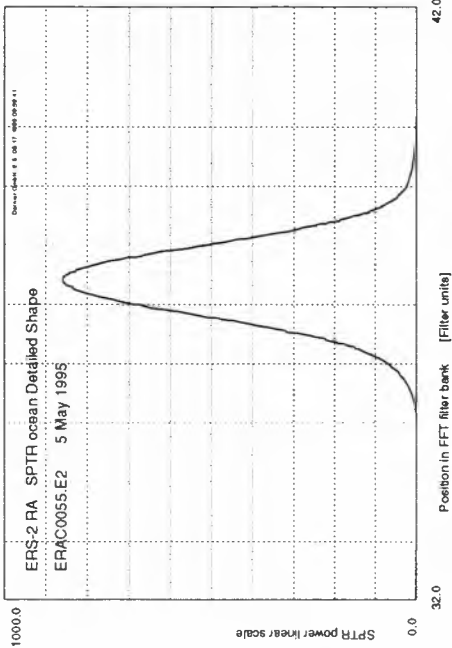
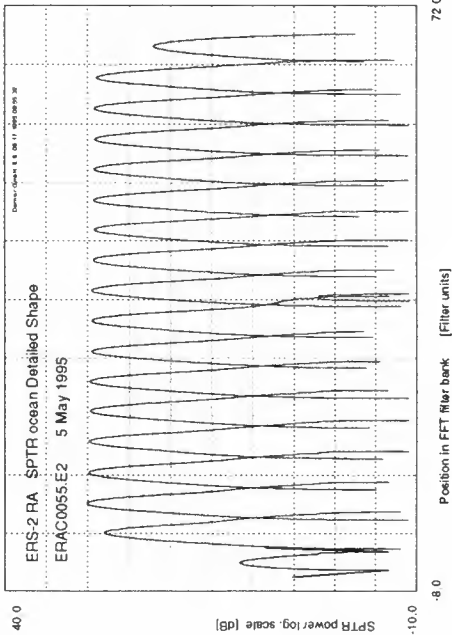
A similar technique is used to analyse the noise floor (PTN, Preset Tracking on the Noise)



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Radar Altimeter

ERS-2

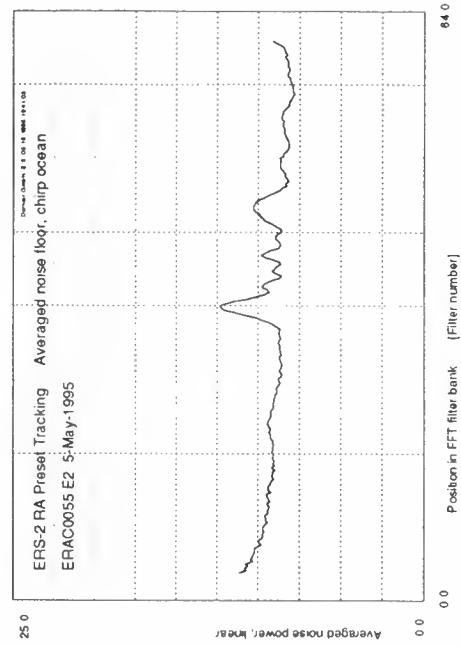
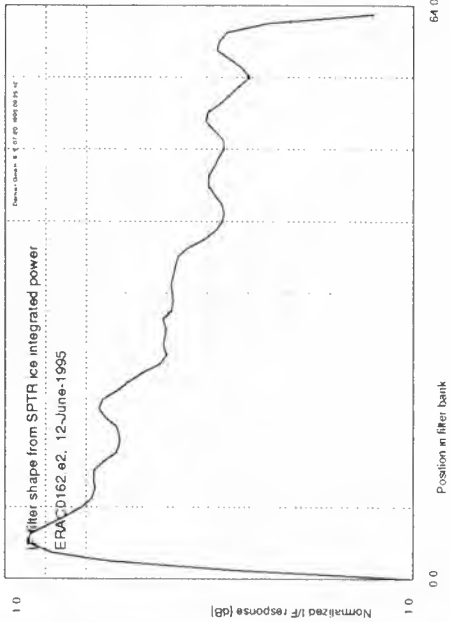
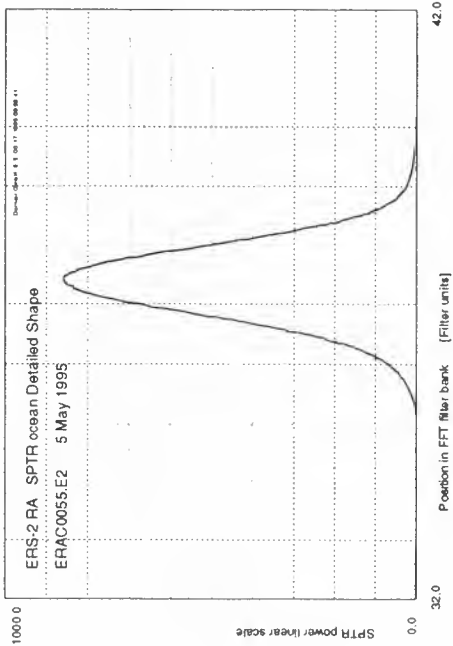
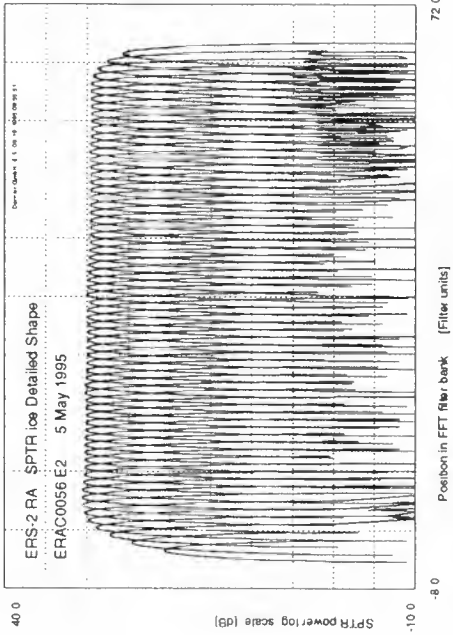




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Dornier

Radar Altimeter

ERS-2





Summary of technical parameter estimation:

Transmit power is unchanged compared to pre launch and stable

Receiver gain shows slight drift, but is compensated by internal calibration

Internal delay shows initially some drift, but is compensated by internal calibration

chirp slopes are stable since launch

IF filter is stable since launch

point target response detailed shape is stable since launch

receiver noise figure is stable since launch

spurious signals in the noise floor, quite stable - no impact on measurement accuracy
timing accuracy slightly improved since launch

Conclusions:

The technical parameters are well within the nominal ranges and are under close control.

The RA instrument provides good and stable measurements since the launch



3) Quality of wave forms

The wave forms are the basis for the on board parameter estimation and also for the precision products produced on ground. The quality of wave forms is the basis for correct measurements.

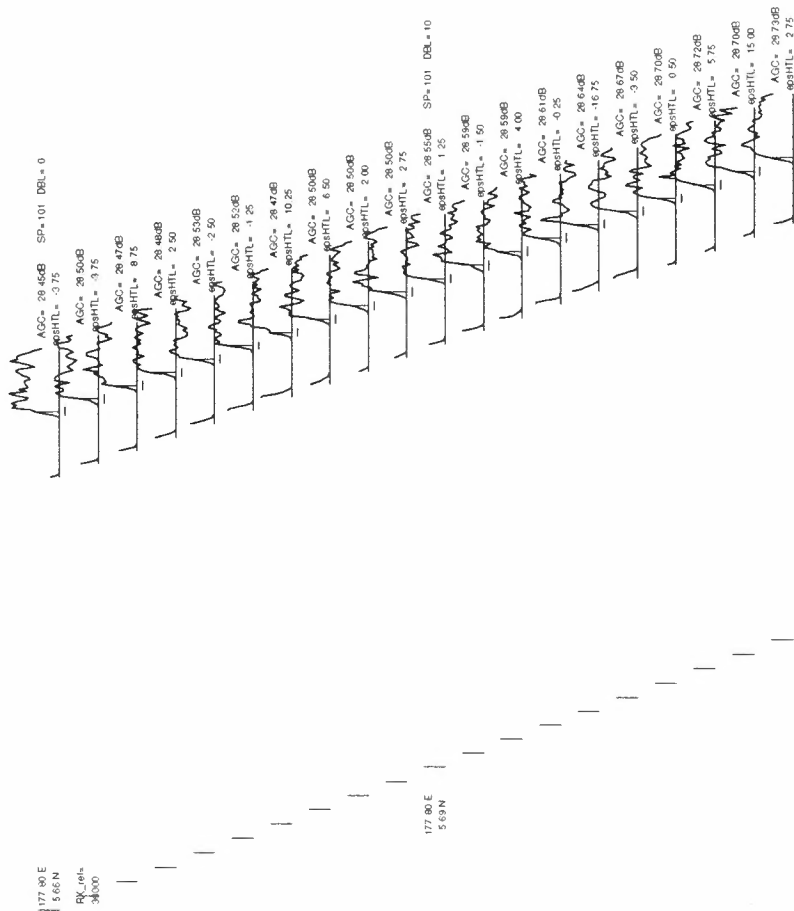
The quality of wave forms is difficult to prove. A plausibility check is based on statistical analysis, that is:

- mean values of wave form samples
- standard deviations of wave form samples
- distribution function of wave form samples



Radar Altimeter

ERS-2

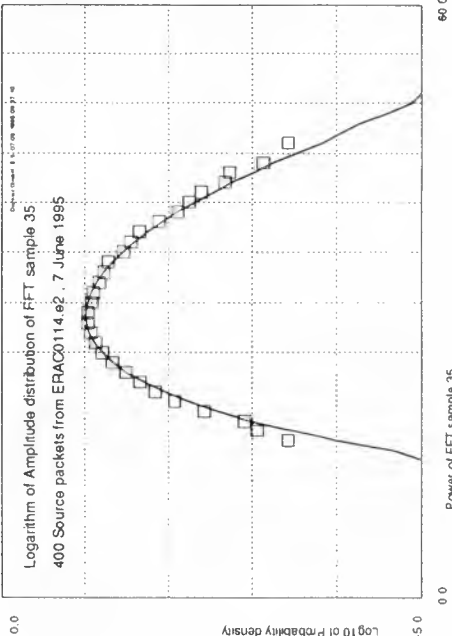
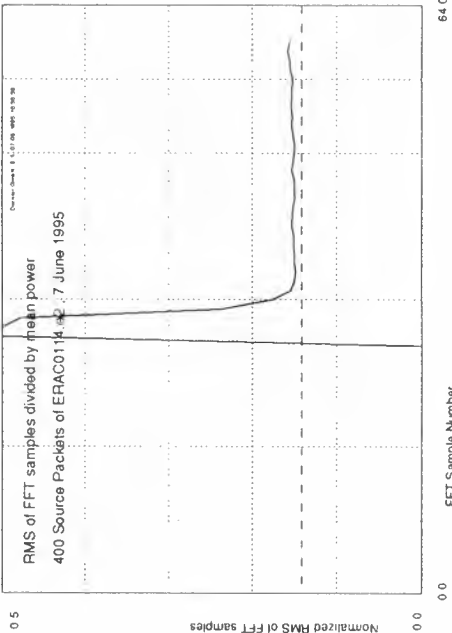
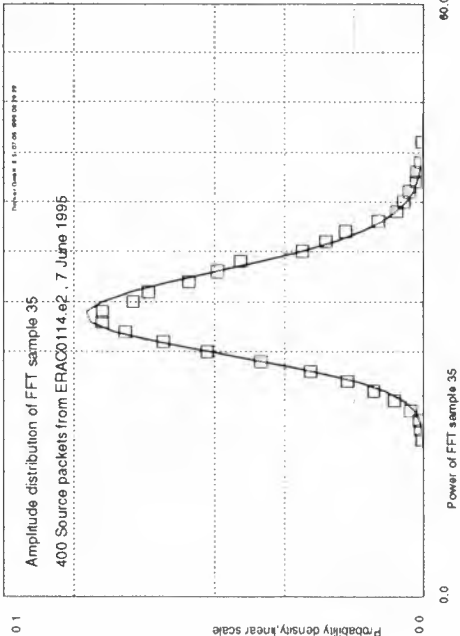
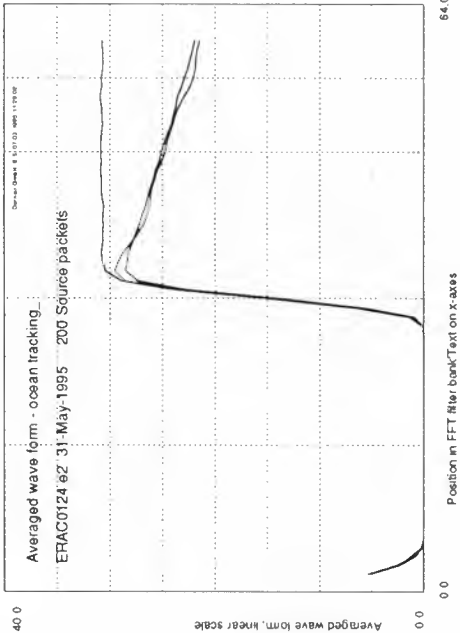




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Dornier

Radar Altimeter

ERS-2





Summary of wave form check

- The averages of the wave forms reflect the known instrument properties like filter shape and antenna pattern. There are visible no additional distortions.
- The standard deviations are close to the expected values
- The amplitude distribution function is close to the expected function
- There can be identified no anomalies in the wave forms (apart from the known truncation effect).

Conclusion:

- The wave forms are not distorted and provide a valid basis for the on board parameter estimation and the precision processing on ground.



4) Estimation of height measurement performance

- The altitude measurement accuracy (the "tracker noise" or so called random error or altitude resolution) is derived from the comparison of the altitude measurements obtained by ERS-1 and ERS-2 on the same ground track.
- The difference in the altitude measurements includes the tracker noise from both satellites plus any variation of the sea surface between the two measurements. The obtained result is therefore a worst case. It is assumed that both satellites have the same accuracy.

Results from altitude comparison:

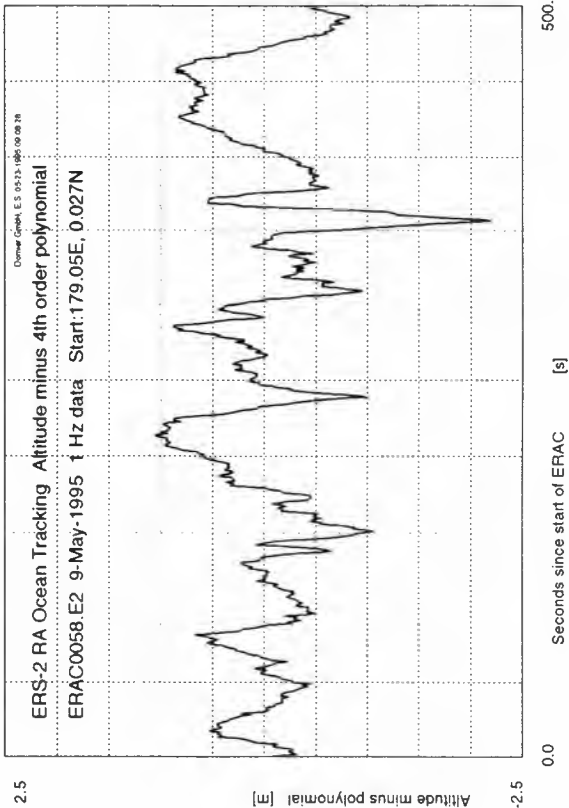
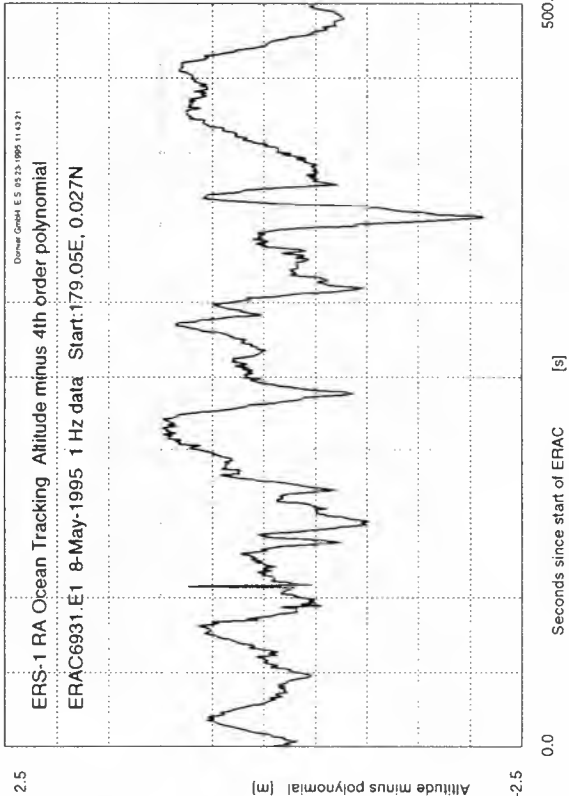
- The measured altitude difference is 6.7 cm rms.
- Time delay random error is better than **4.7 cm**.



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Dornier

Radar Altimeter

ERS-2



ERS-2 RA Instrument Performance

ESTEC Results

John O'Leary
Mònica Roca
Richard Francis

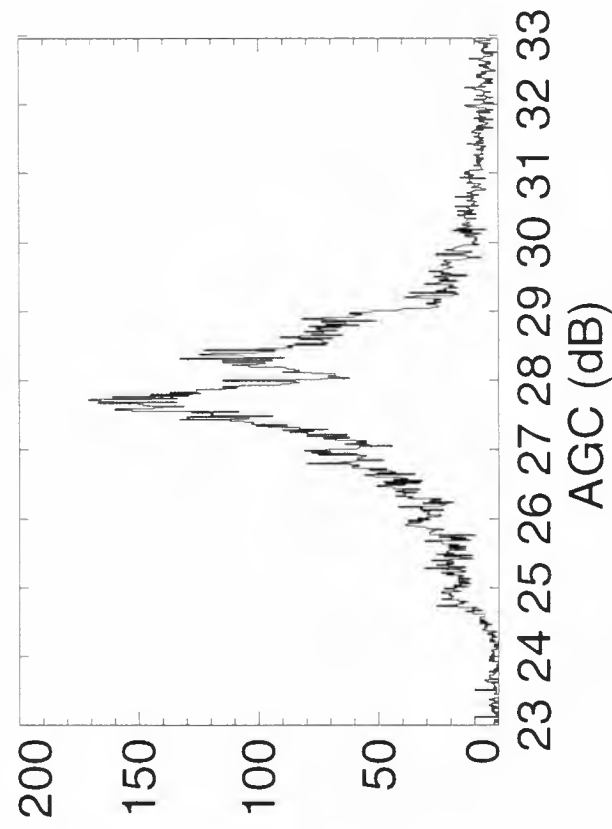


Look-Up Table (LUT) Changes

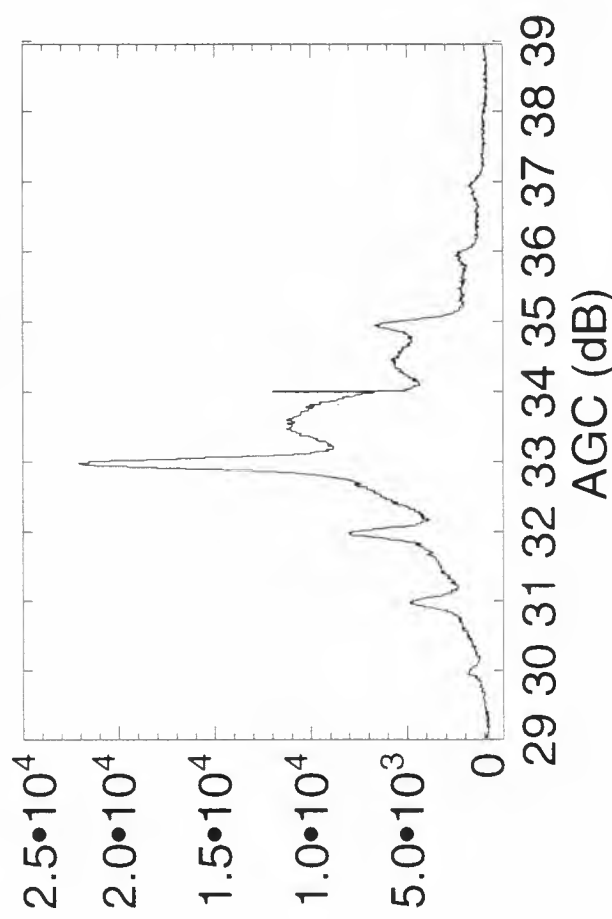
Date	Version	Parameter	Comment
21•4•95	10001	<i>all</i>	Launch version of all tables
20•5•95	10002	K1	measured chirp slope
		K2	measured SPTR width
	TAU_C_D	TAU_C_D	observed position of cal pulse
		HEIGHT_ALFA	doubled due to less frequent open-loop cal
		HEIGHT_BETA	on ERS-2
		LOOP_CAL_K1	wrong RXinit in initial table
23•5•95	10003	LOOP_CAL_K4	measured open loop cal power reference
		LOOP_CAL_KF	measured chirp slope
		HEIGHT_ALFA	removal of oscillation in height cal
6•7•95	10004	HEIGHT_BETA	due to wrong values
		TAU_C_D	better defined default value
	A_G_REF	A_G_REF	correction of sigma-zero histogram

Global AGC Distribution

ERS-2



ERS-1

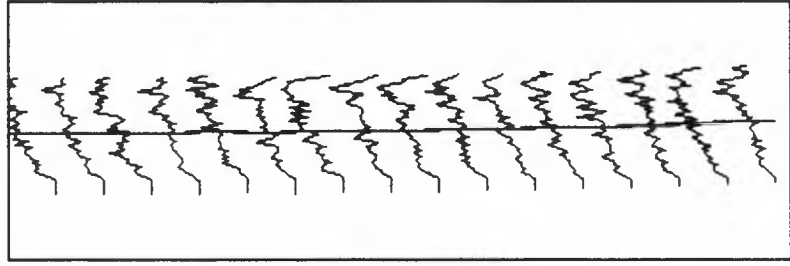
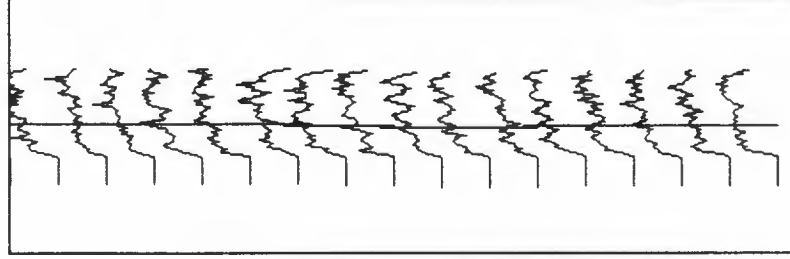
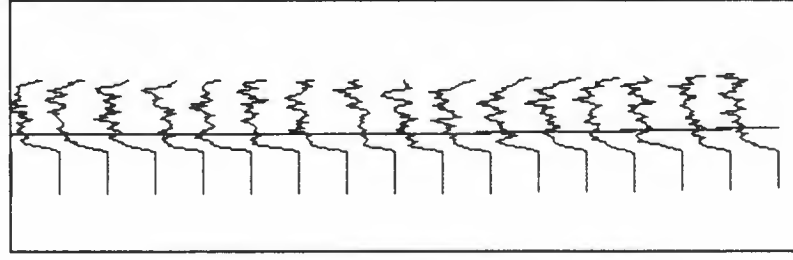
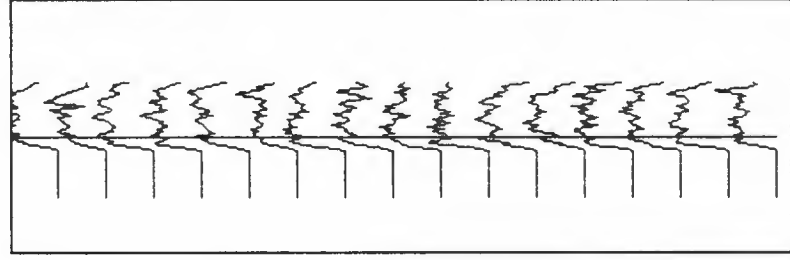
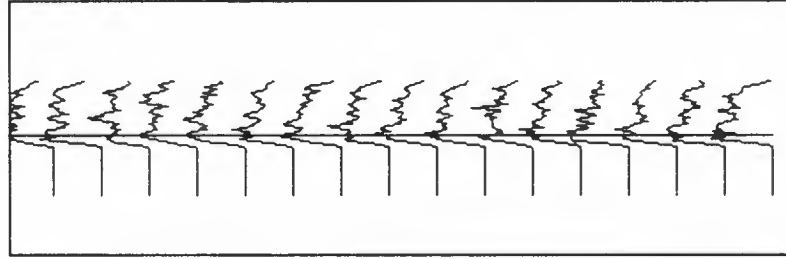


Mispointing Estimation

- RA is sensitive to off-nadir pointing errors (pitch and roll);
- Mispointing primarily degrades time-delay and sigma-zero measurement;
- RA performance out of specification for $\xi > 0.25^\circ$;
- Antenna pointing budget: 0.35° (3σ) – bias dominates;
- AOCS modified to allow small bias offset to be introduced;
- Consequent necessity to measure RA mispointing in-flight.

Mispointing

Mispointing induced by satellite roll-tilt mode (ERS-1)



Mispointing Results

Date	Pre-Averaged	Filtered	Comment
29•4•95	0.067°	0.068°	RA switch-on
6•5•95	0.061°		
9•5•95	0.030°		
25•5•95	0.067°	0.065°	
28•5•95	0.038°	0.043°	
31•5•95	0.046°	0.048°	
7•6•95	0.061°	0.059°	
10•6•95	0.066°	0.065°	
13•6•95	0.031°	0.033°	
23•6•95	0.078°	0.069°	

Note: Results are given to millidegrees for comparison between the methods.
Errors due to the IF filter shape limit the accuracy to about 0.08°



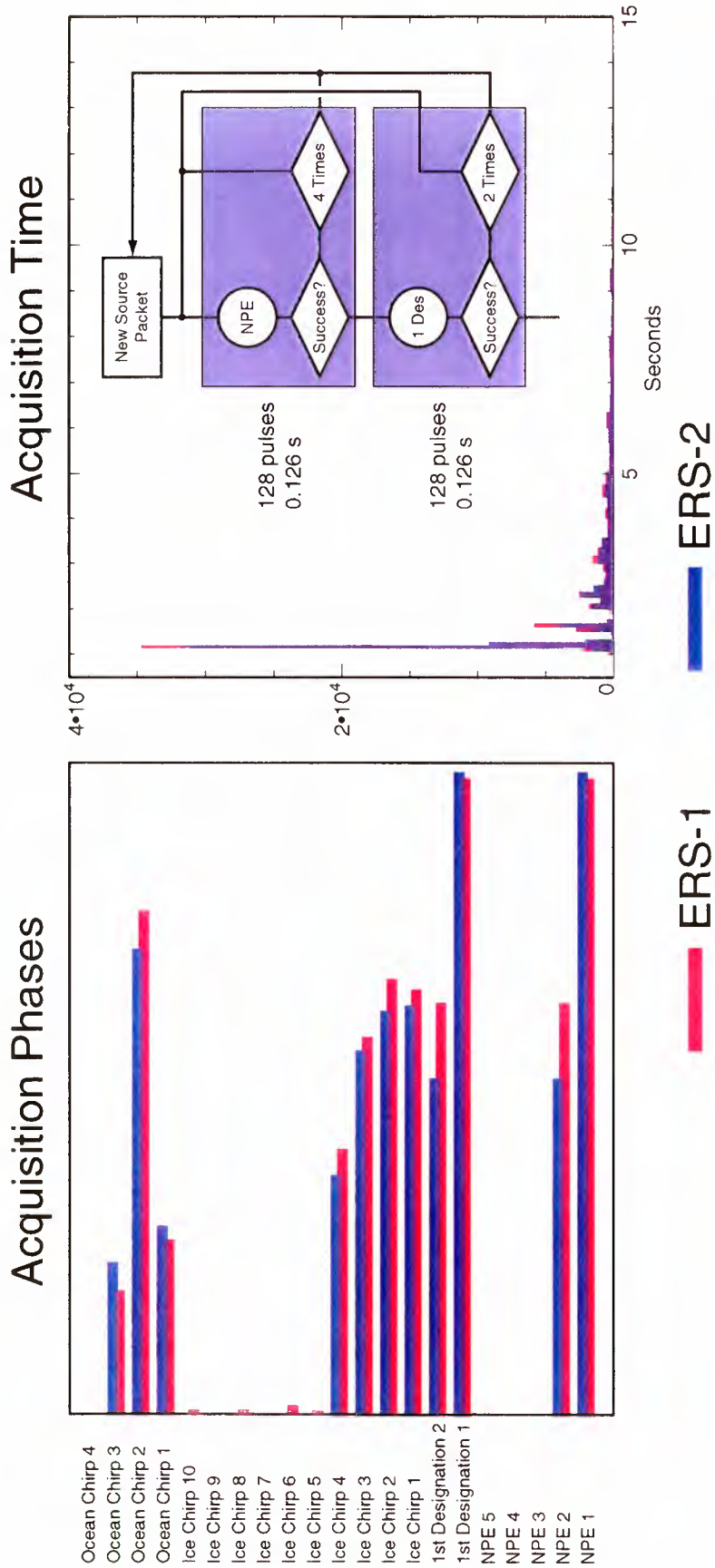
esa



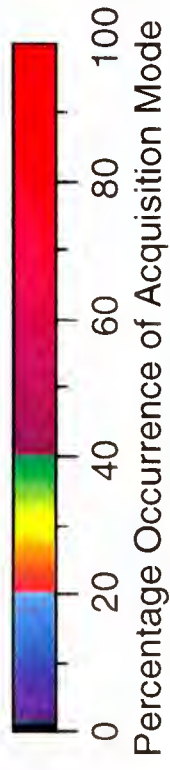
Conclusions

- Acquisition performance meets specifications;
- Acquisition and tracking have been improved since ERS-1 launch (same improvements for ERS-1);
- Height (time-delay) performance meets specifications (noise, calibrated stability);
- Sigma-zero meets specifications (noise, calibrated stability);
- Mispointing (pitch and roll) is extremely small, $\sim 0.05^\circ$, and does not significantly degrade performance (no bias needed in AOCS !).

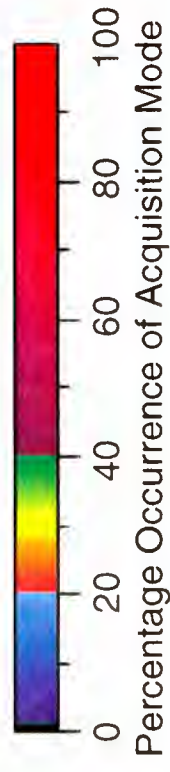
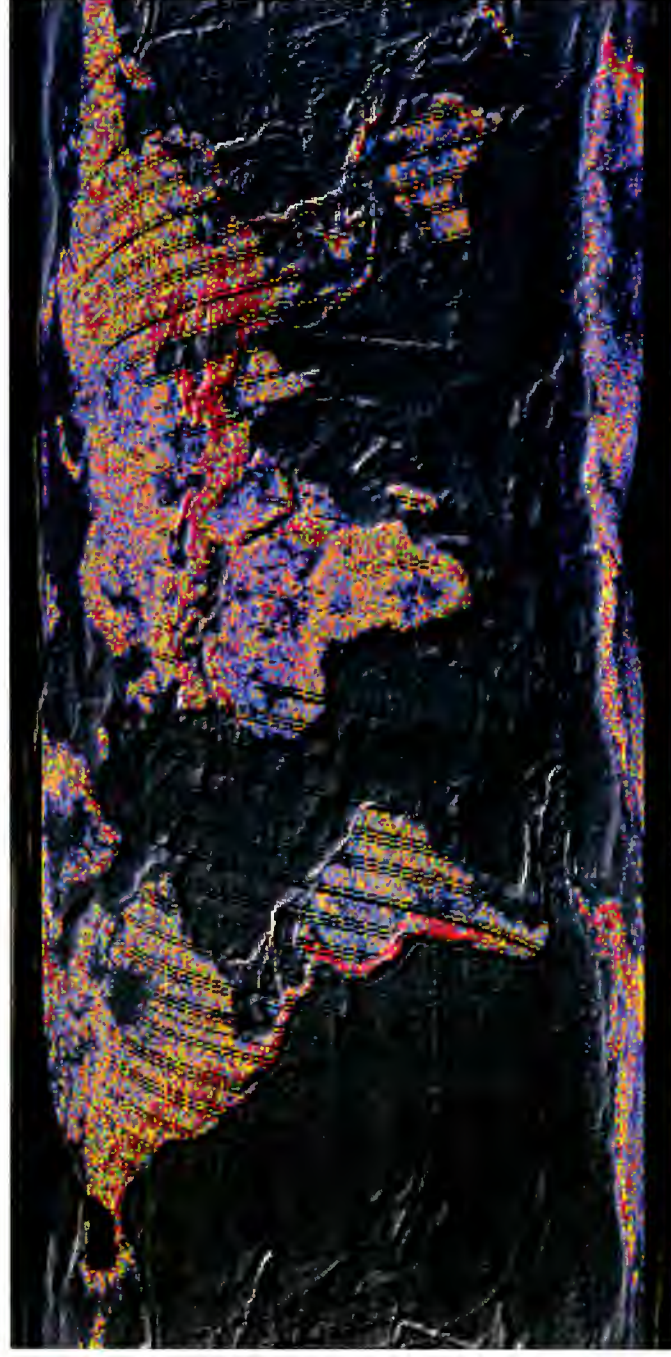
Acquisition Performance



Tracking Performance: ERS-1 September 1995

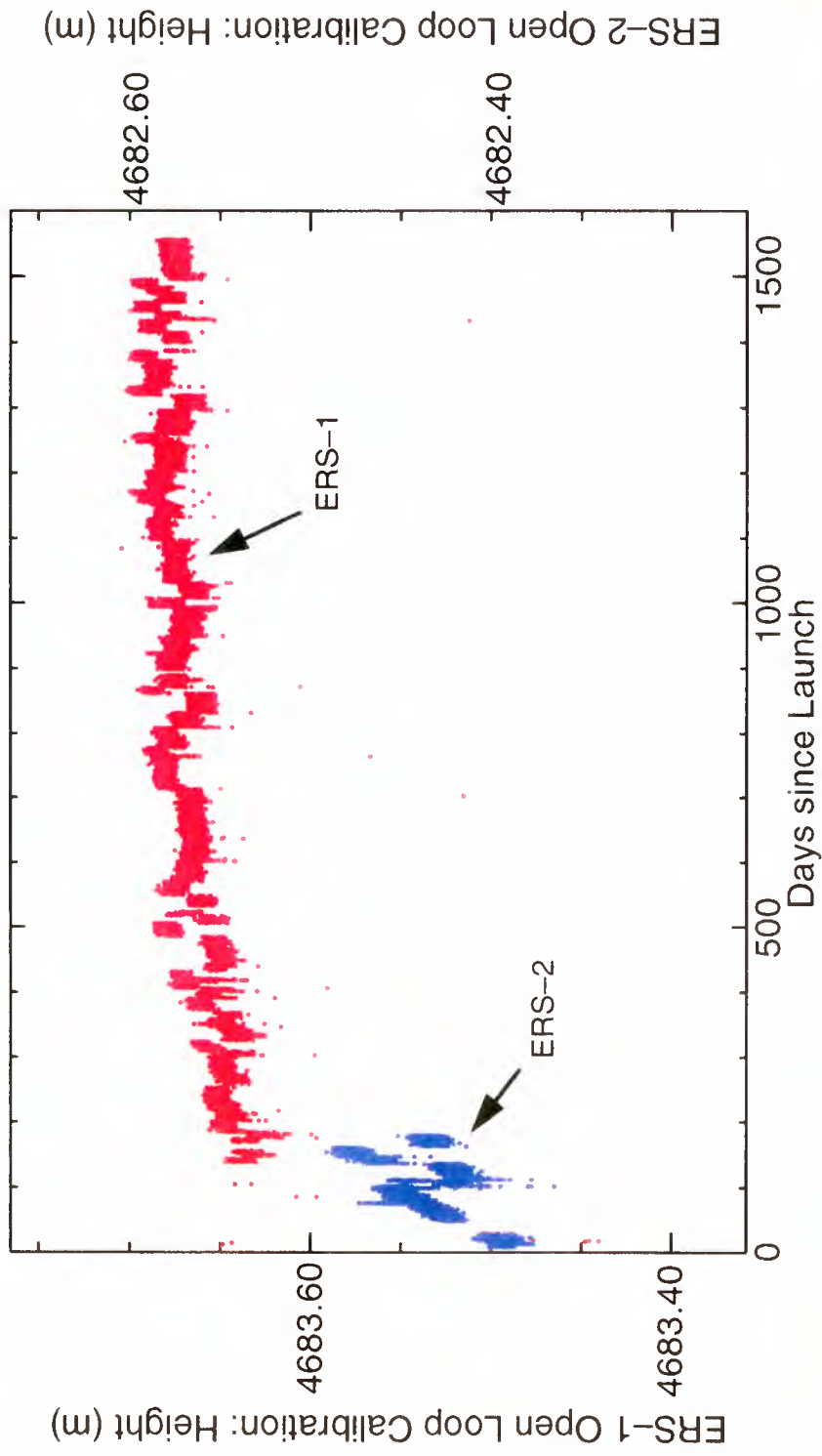


Tracking Performance: ERS-2 September 1995

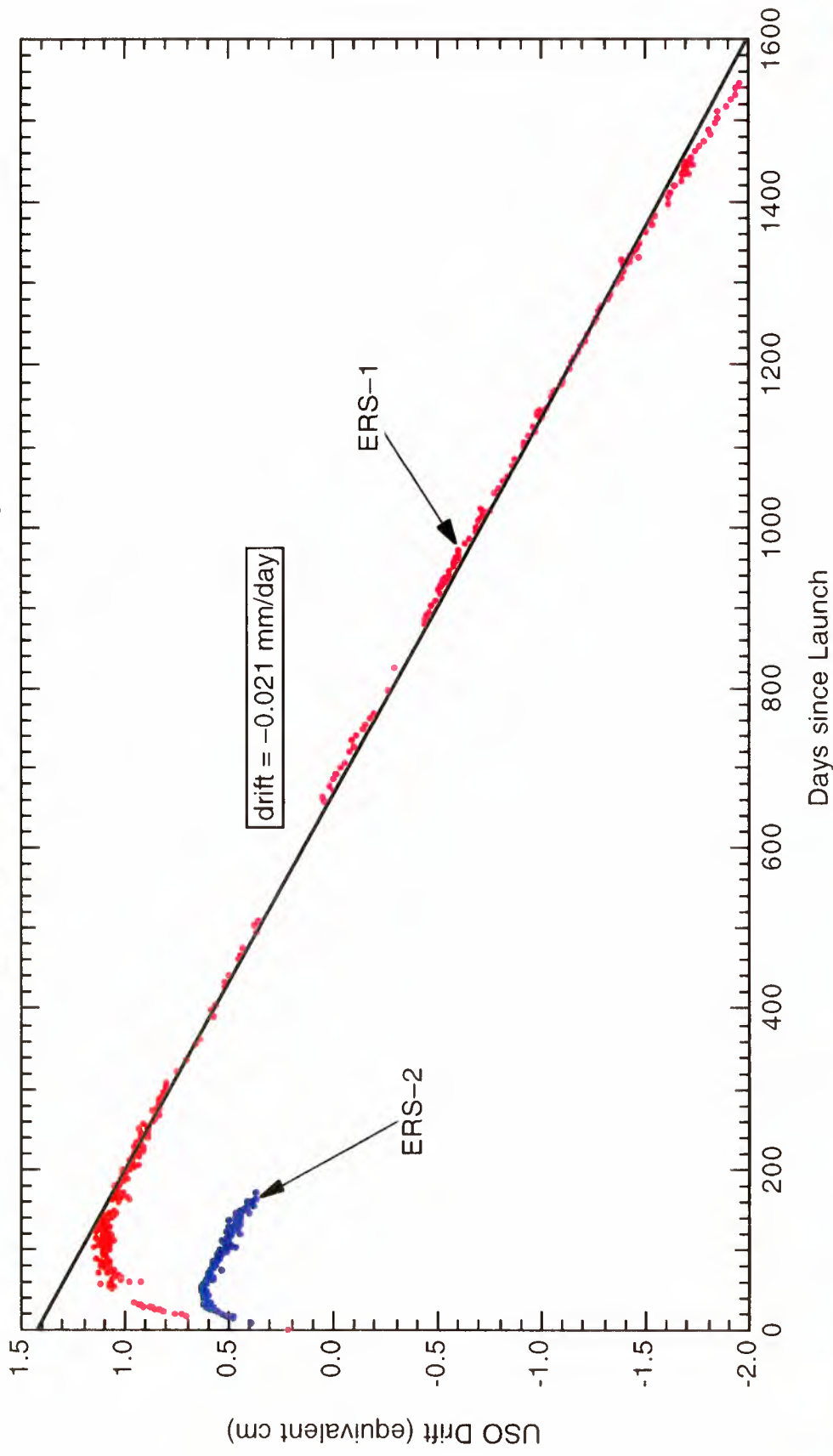




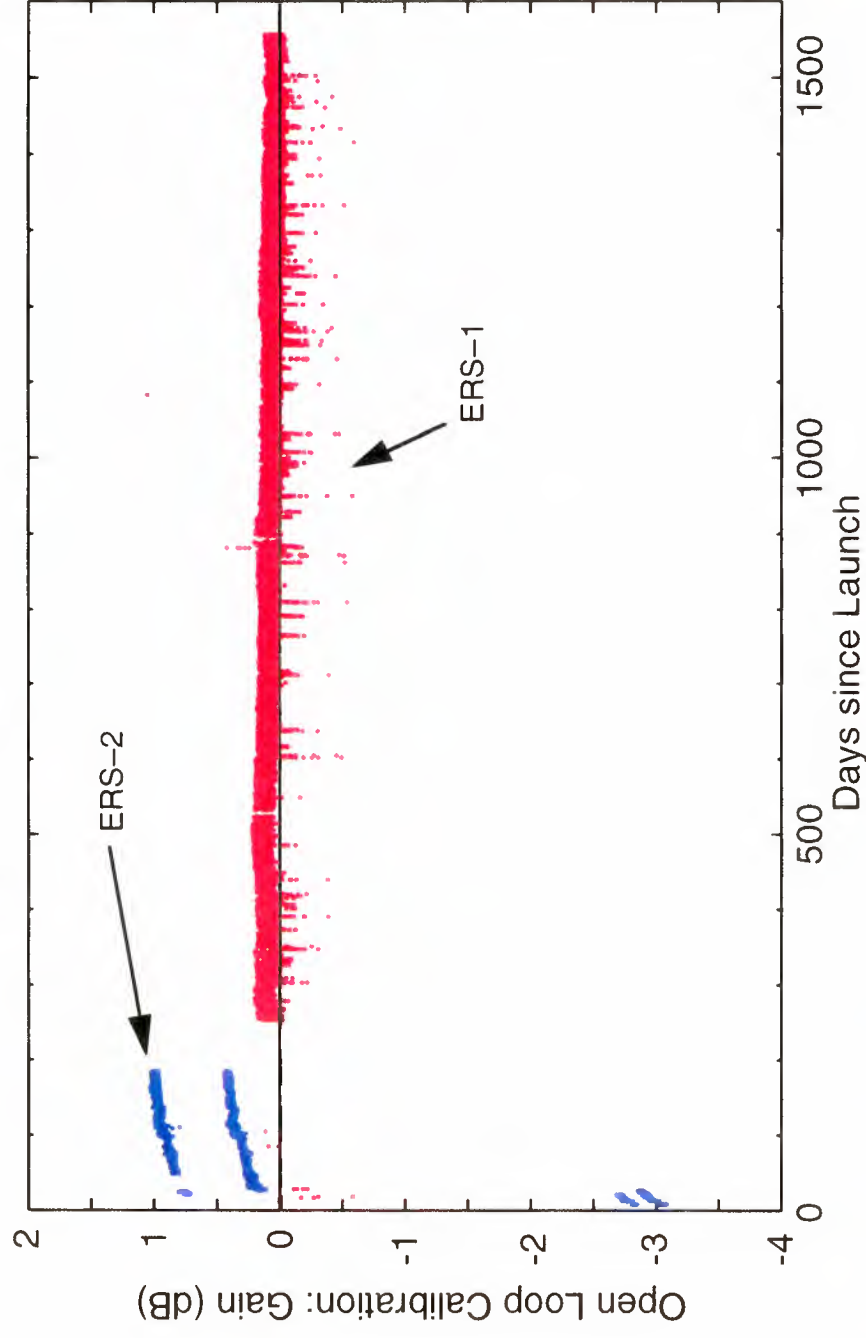
Height – Open Loop Calibration Stability



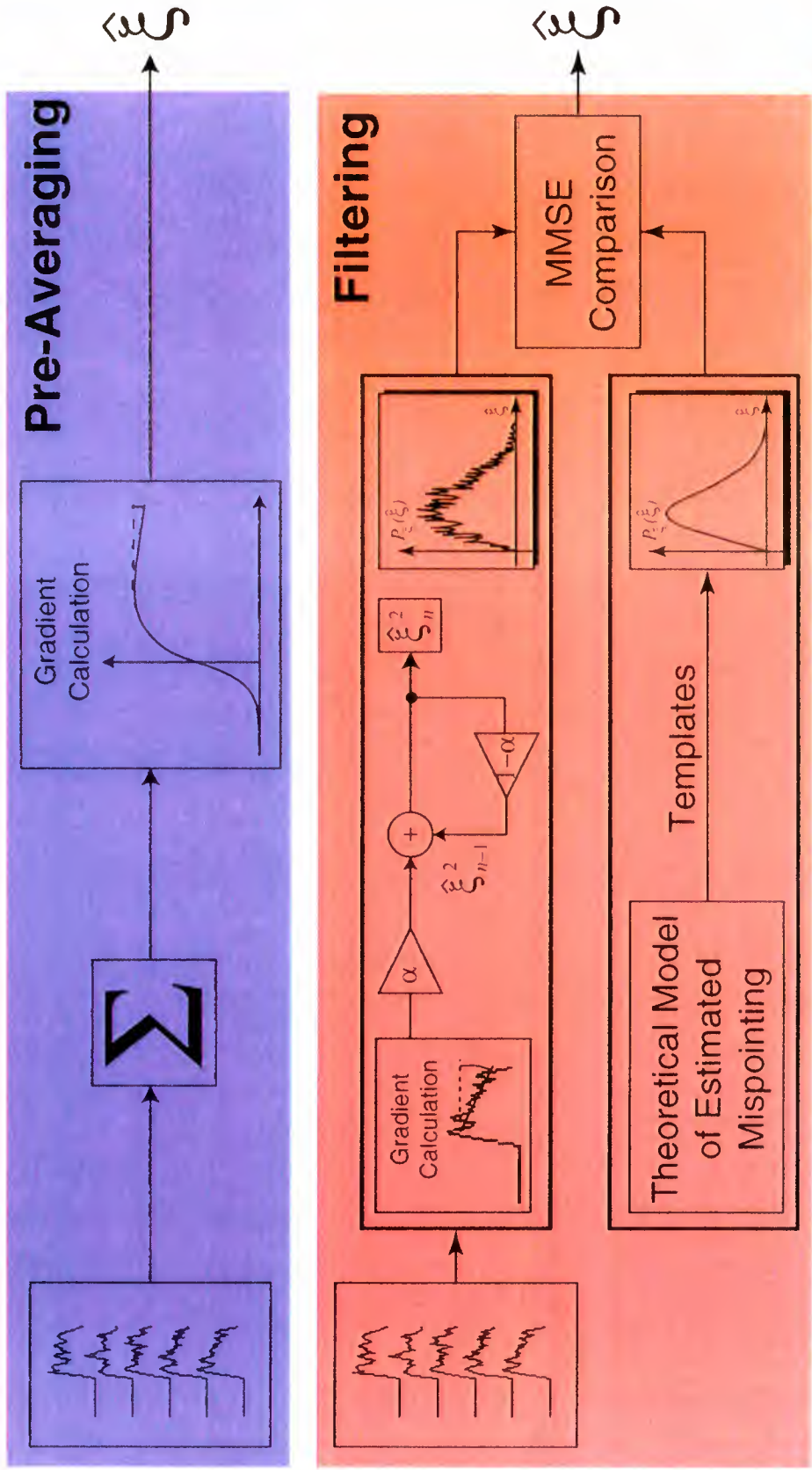
USO (Clock) Drift



Sigma-0 – Open Loop Gain Stability



Approaches to Mispointing Estimation



ERS-2 COMMISSIONING PHASE REVIEW OCTOBER 1995

ACTIVE MICROWAVE INSTRUMENT

AMI OPERATIONS

PRESENTED BY GRAHAM CORNELIUS of MATRA MARCONI SPACE UK

AMI-04.GRM

SCOPE

- AMI INITIAL CONFIGURATION
- SAFETY CHECK
- SUMMARY OF AMI ACTIVITIES
- INVESTIGATIONS
- DIAGNOSTIC TOOLS
- TELEMETRY - TREND ANALYSIS
 - COMPARISON WITH ERS-1
- HPA ARCING
- ANOMALY REPORTS
- CONCLUSIONS

AMI INITIAL CONFIGURATION

ALL SIDE A EQUIPMENTS SELECTED

(as ERS-1)

HPA HEATER VOLTAGE SET TO 95% (by Redundancy mcmd)

(as ERS-1)

FGE OVEN TEMP MONITORING RANGE SET (55 to 65°C)

(as ERS-1)

CAL S/S OPEN/CLOSED LOOP STATUS - INHIBIT MONITORING

(Cal does not power up to a known status)

(as ERS-1)

CAL S/S PEAK INPUT and OUTPUT POWER MONITORS - INHIBIT MONITORING

(due to occasional zero values and to occasional bit shifts)

(as ERS-1)

WIND/WAVE and WAVE - CYCLE TIME PATCH

(as ERS-1)

WIND/WAVE and WAVE - CYCLE TIME DURATION PATCH

(as ERS-1)

FOR SHORT STANDBY to HEATER TRANSITIONS (200 seconds)

)

* SET MONITOR - LOWER LIMITS OF ALL OVEN TEMPS SET TO LOW VALUE

)used on ERS-1

* SET MONITOR - TRANSITION DURATION to 200 seconds (Default is 4 hours)

)

AMI OPERATIONS

SAFETY CHECK

PRIOR TO RUNNING UP TO ACTIVITY MODES ON 'A' SIDE IF RADAR 'B' SIDE TAKEN TO HEATER MODE TO ENSURE ISOLATOR IN 'B' RECEIVE CHAIN IS IN A HIGH IMPEDANCE STATE.

200 SECOND STANDBY to HEATER TRANSITION USED.

ACTIVE MICROWAVE INSTRUMENT

SUMMARY OF AMI ACTIVITIES - 1

Launch of ERS-2	21-April-'95 (Day 111)
First Switch-on:	Standby 23-April-'95 (Day 113)
	Heater 24-April-'95 (Day 114)
First Activity Modes Attempted	30-April-'95 (Day 120)

SUMMARY OF AMI ACTIVITIES - 2

IMAGE mcmd:	Refuse Mode entered due to Rx OVERLOAD at start of mode
WIND mcmd:	Refuse Mode entered due to Rx OVERLOAD
AMI powered OFF/ON	(to reset and reload software, clear any SEUs etc)
IMAGE mcmd:	Refuse Mode entered (TDIF) due to Rx OVERLOAD at start of mode
UPCONVERTOR GAIN -	Reduced to minimum setting (21dBm) Normal setting: 27 dBm for HPA saturation 21dBm to HPA gives approx 1.7dBm less RF power
IMAGE mcmd:	IMAGE MODE ACHIEVED (low output power)

SUMMARY OF AMI ACTIVITIES - 3

WIND/WAVE mcmd:

Refuse Mode entered
due to Rx OVERLOAD at start of Wind.
Cal Stab and Wave operated correctly

IMAGE mcmds:

Several successful runs (including 10 min)

WIND/WAVE mcmd:

Refuse Mode entered
due to Rx OVERLOAD at start of Wind.
Cal Stab and Wave operated correctly

SWITCH MATRIX CONTROLLER B Side selected

WIND/WAVE mcmd:

Refuse Mode entered
due to Rx OVERLOAD at start of Wind.
Cal Stab and Wave operated correctly

SUMMARY OF AMI ACTIVITIES - 4

RF SUBSYSTEM B Side selected

WIND/WAVE mcmd: Refuse Mode entered
due to Rx OVERLOAD at start of Wind.
Cal Stab and Wave operated correctly

WAVE mcmd: Successful

IMAGE mcmds: Successful

WIND CAL mcmds: Refuse Mode entered
due to Rx OVERLOAD at start of Wind Cal .
Cal Stab operated correctly

UPCONVERTOR to HPA Switch set to 'wrong' position

SUMMARY OF AMI ACTIVITIES - 5

WIND CAL mcmd:	Wind Cal successfully operated via the Fore and Mid antennas, but failed due to HPA HI-VOLTAGE TOO LOW. ie the unrelated HPA internal control method.
IMAGE mcmd:	Successful - Fore antenna leakage measured by SAR TxP in Flevoland
WIND CAL mcmd:	Tx power measured by SAR TxP in Flevoland
ERS-1 measurements performed and compared to those of ERS-2	
IMAGE mcmds:	Performed at incrementing Upconverter Levels, to determine the level up to which the AMI will operate without tripping the Rx Overload.

SUMMARY OF AMI ACTIVITIES - 6

INTERIM CONCLUSIONS:

- a **IMAGE AND WAVE MODES - OPERATING SATISFACTORILY**
THESE MODES CAN BE USED IN MISSION PLANNING SYSTEM
- b **WIND MODE - NOT A SIMPLE FAILURE SCENARIO**
FURTHER INVESTIGATIONS REQUIRED

At this time, the AMI became subject to a formal Test and Diagnostic programme, under the auspices of the specially convened Task Force.

INVESTIGATIONS

POSSIBLE FAILURE SCENARIOS CONSIDERED DURING THIS PHASE

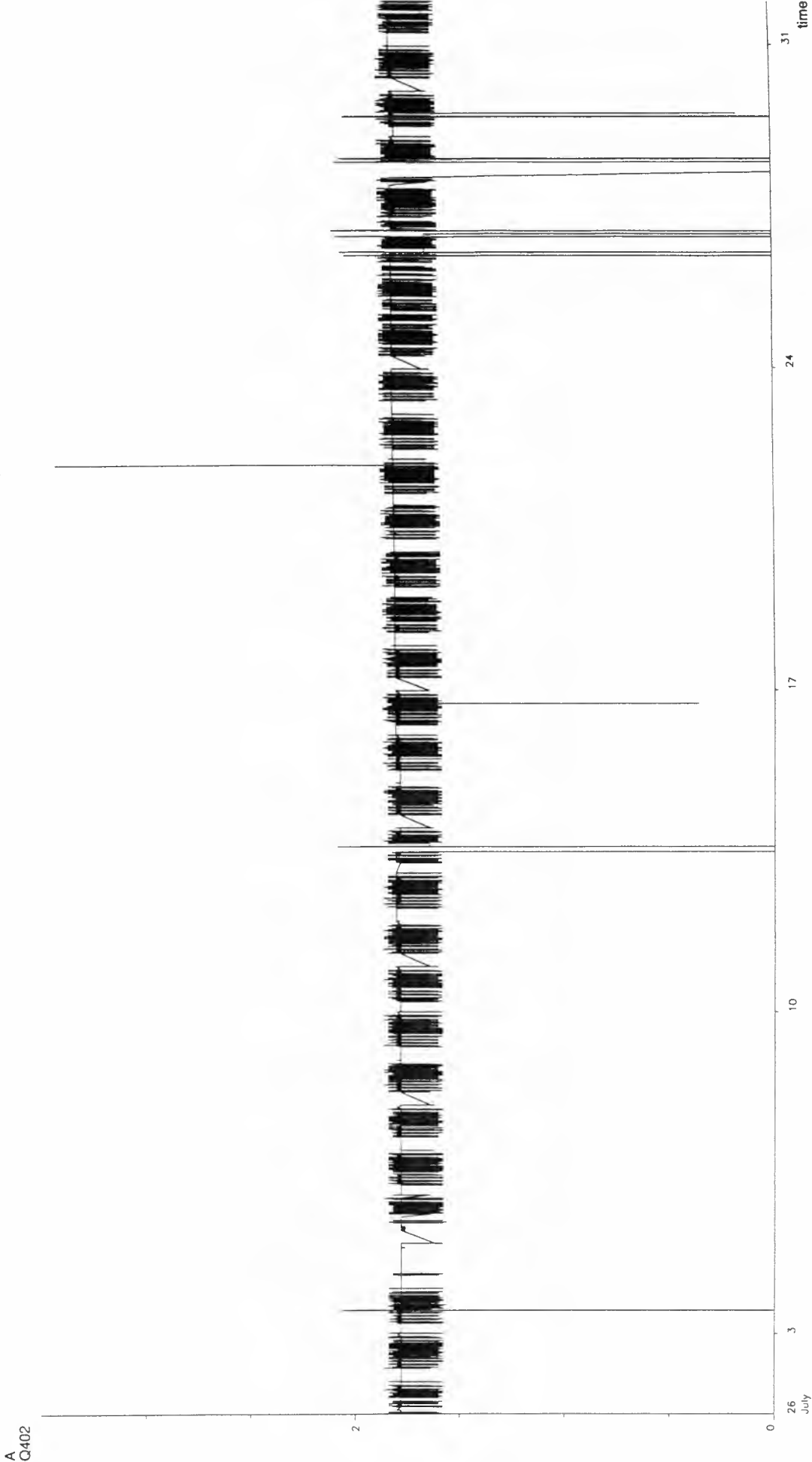
- | | |
|---|------------|
| - SINGLE EVENT UPSET IN SAR PROCESSOR | ELIMINATED |
| - FAILURE OF Rx OVERLOAD CIRCUIT IN RF S/S | ELIMINATED |
| - FALSE TRIGGERING OF Rx OVERLOAD CIRCUIT | |
| - FALSE TLM INDICATION OF Rx OVERLOAD | ELIMINATED |
| - INCORRECT THRESHOLD LEVEL SET (IN-LINE SOT ATTENUATORS) | |
| - SWITCH MATRIX CONTROLLER (SMC) NOT FULLY FUNCTIONAL | ELIMINATED |
| - EMC SPIKES ON CONTROL LINES TO SMC | ELIMINATED |
| - DAMAGED FORE ANTENNA CIRCULATOR IN CA | |
| - MULTIPACTION IN CIRCULATOR ASSEMBLY (CA) | |

DIAGNOSTIC TOOLS

- AMI REPORT AND REAL-TIME TELEMETRY FORMATS
- GROUND PROCESSING OF AMI SCIENCE DATA
- TDIF HIGH RATE SAMPLING OF UPB1 CURRENT AT 8Hz
- GROUND BASED MEASUREMENTS USING SAR AND SCATT TRANSPONDERS

ERS-2 AMI TWT Filament Current

Q402
Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41



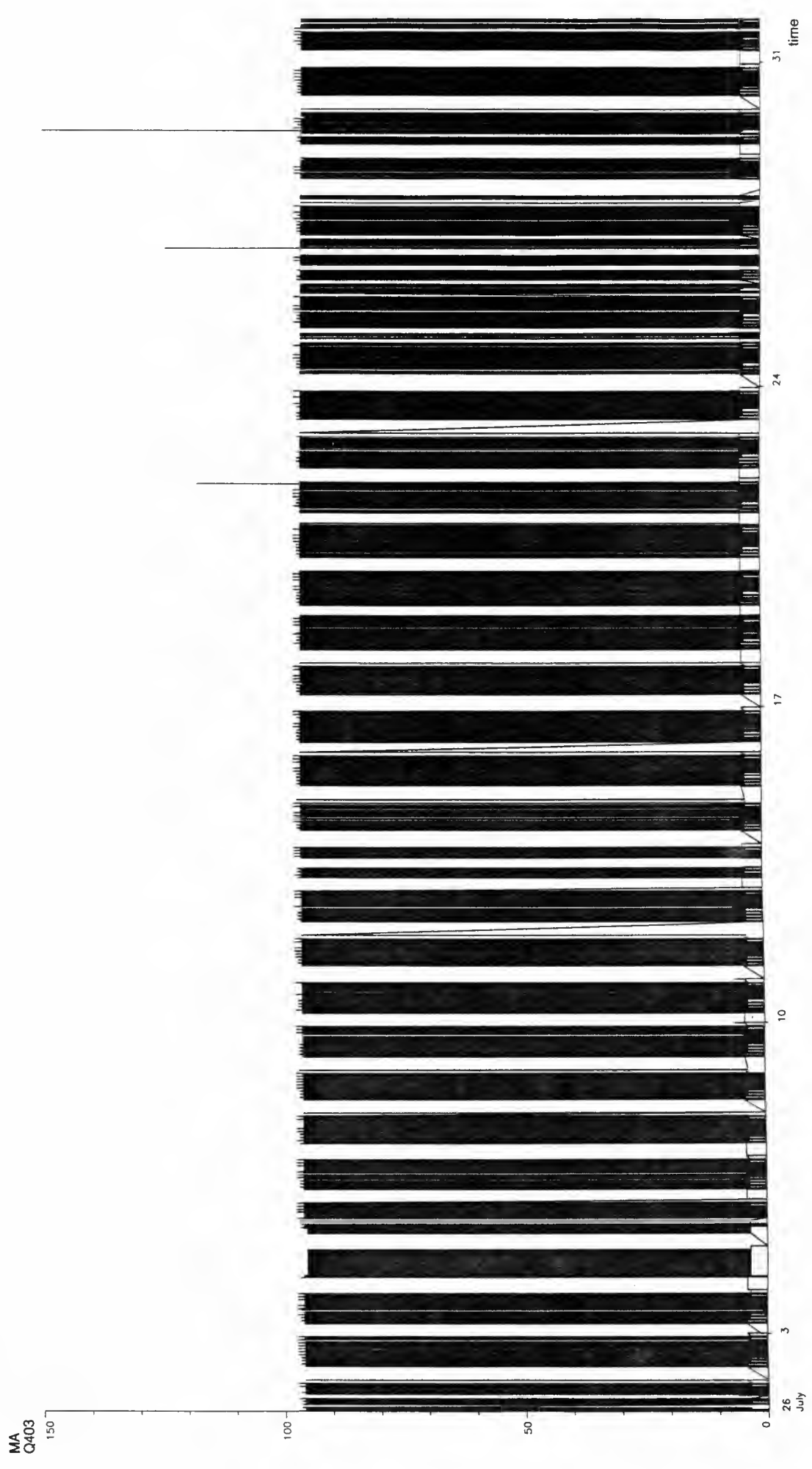
Q403

Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41

ERS-2 AMI TWT Beam Current

SPEVAL

Q403 TWT BEAM CURR A



Q404

ERS-2 AMI TWT Cathode Voltage

SPEVAL

Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41

Q404 TWT CATH VOLT A



Q405

ERS-2 AMI TWT Collector Voltage

SPEVAL

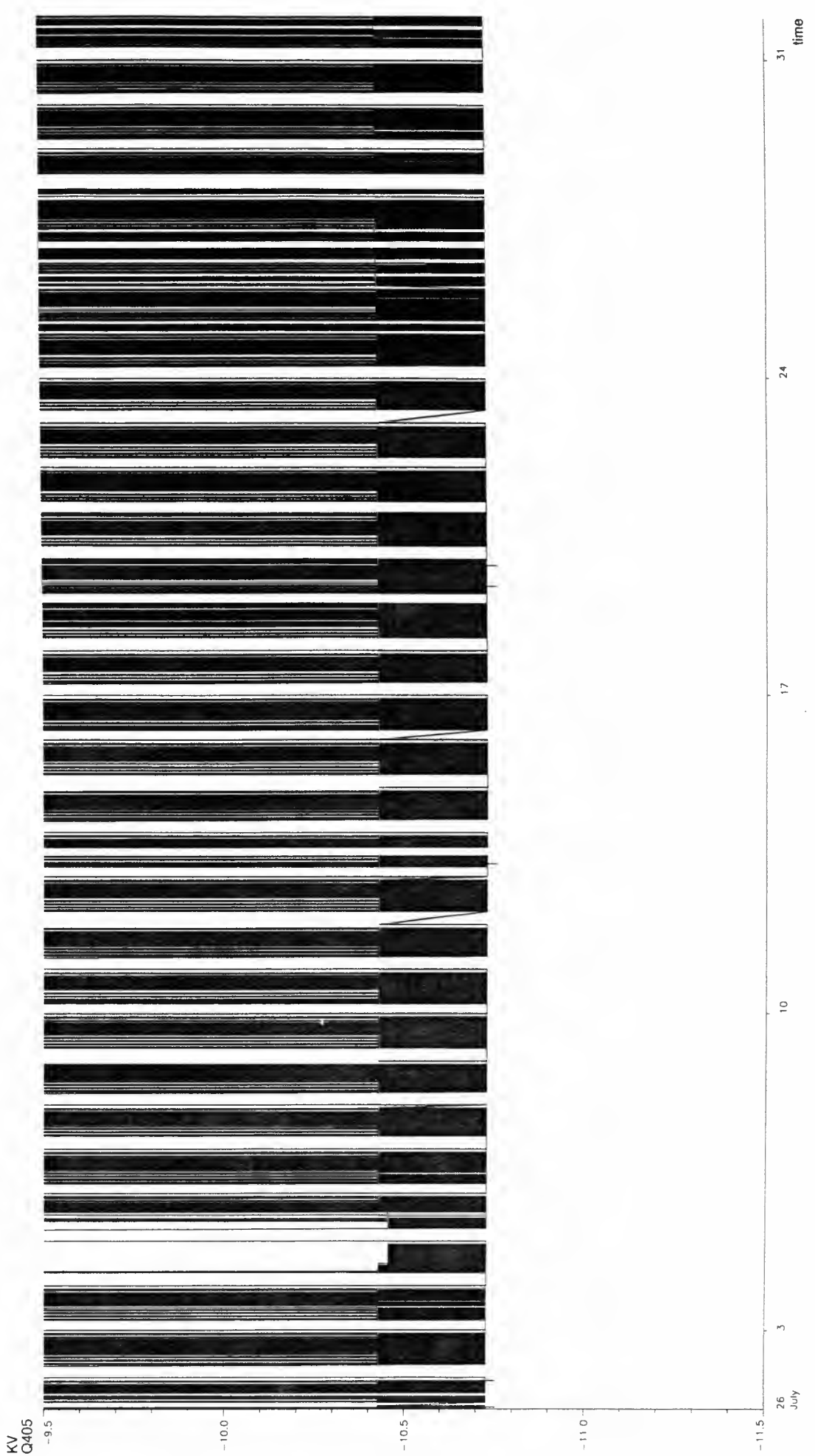
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1995-182 06:26:48

End Date & Time

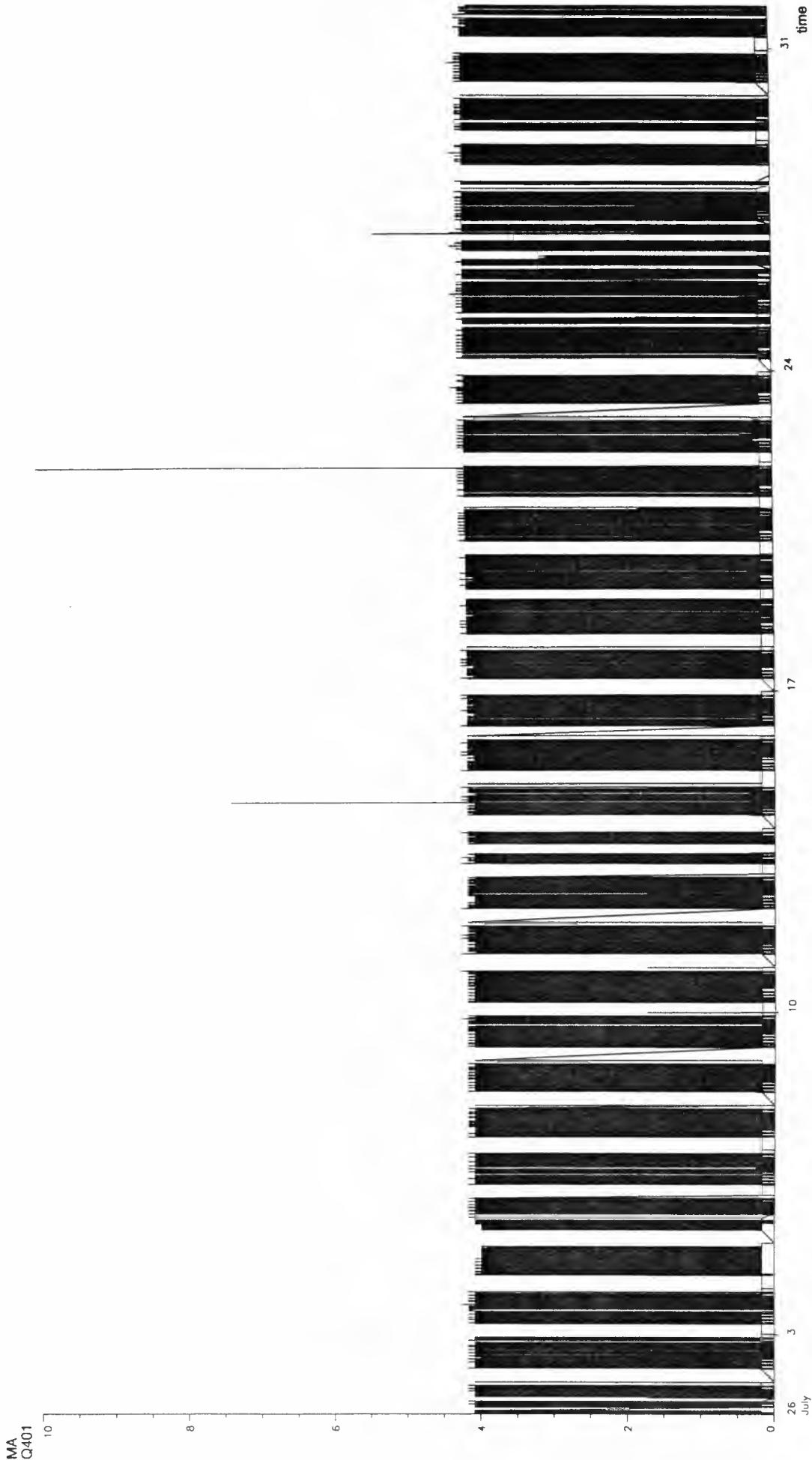
1995-212 22:34:41

Q405 TWT COLCTR VLT A



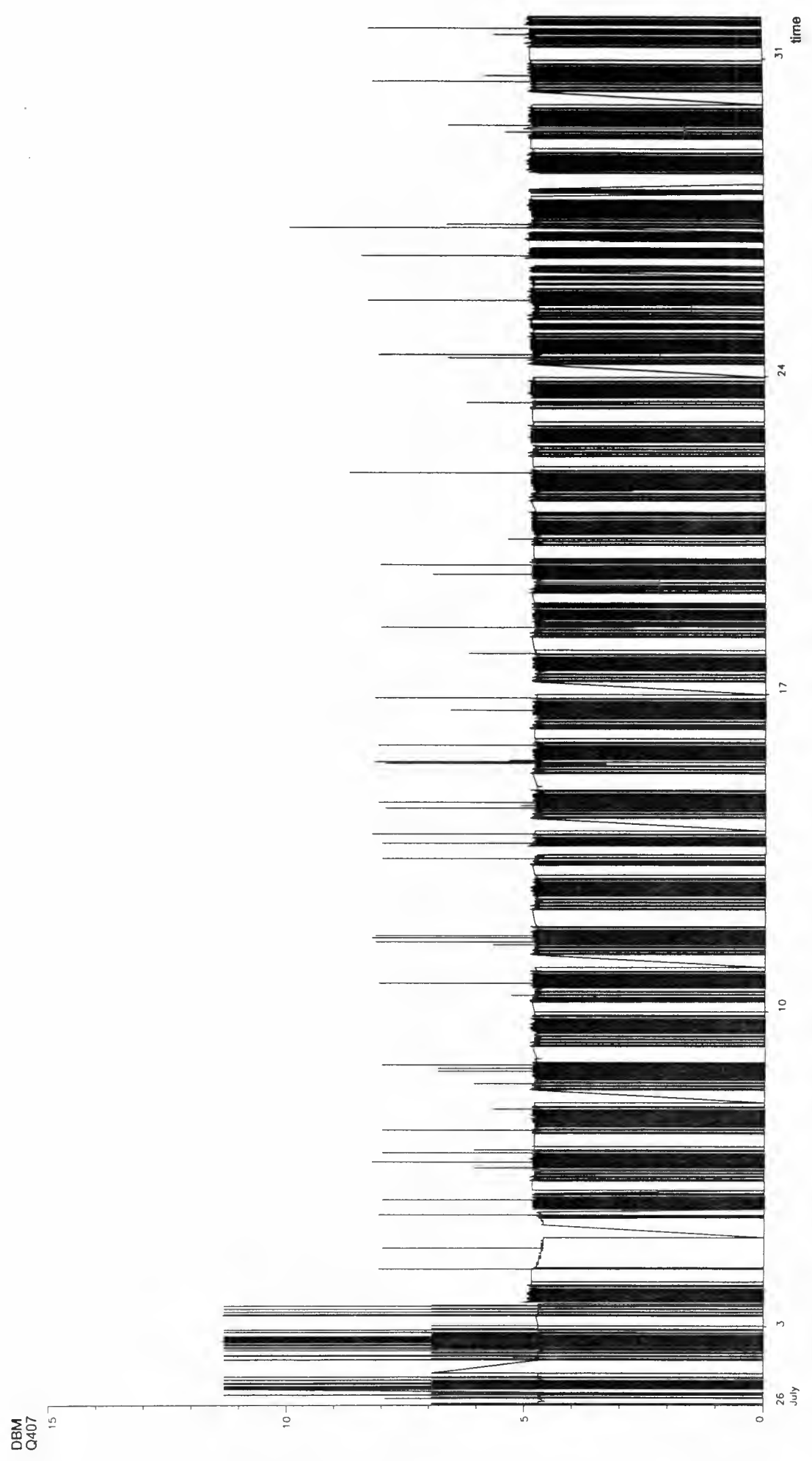
ERS-2 AMI TWT Ave Body Current

Q401
Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41



ERS-2 AMI Cal Input Peak Power

Q407
Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41



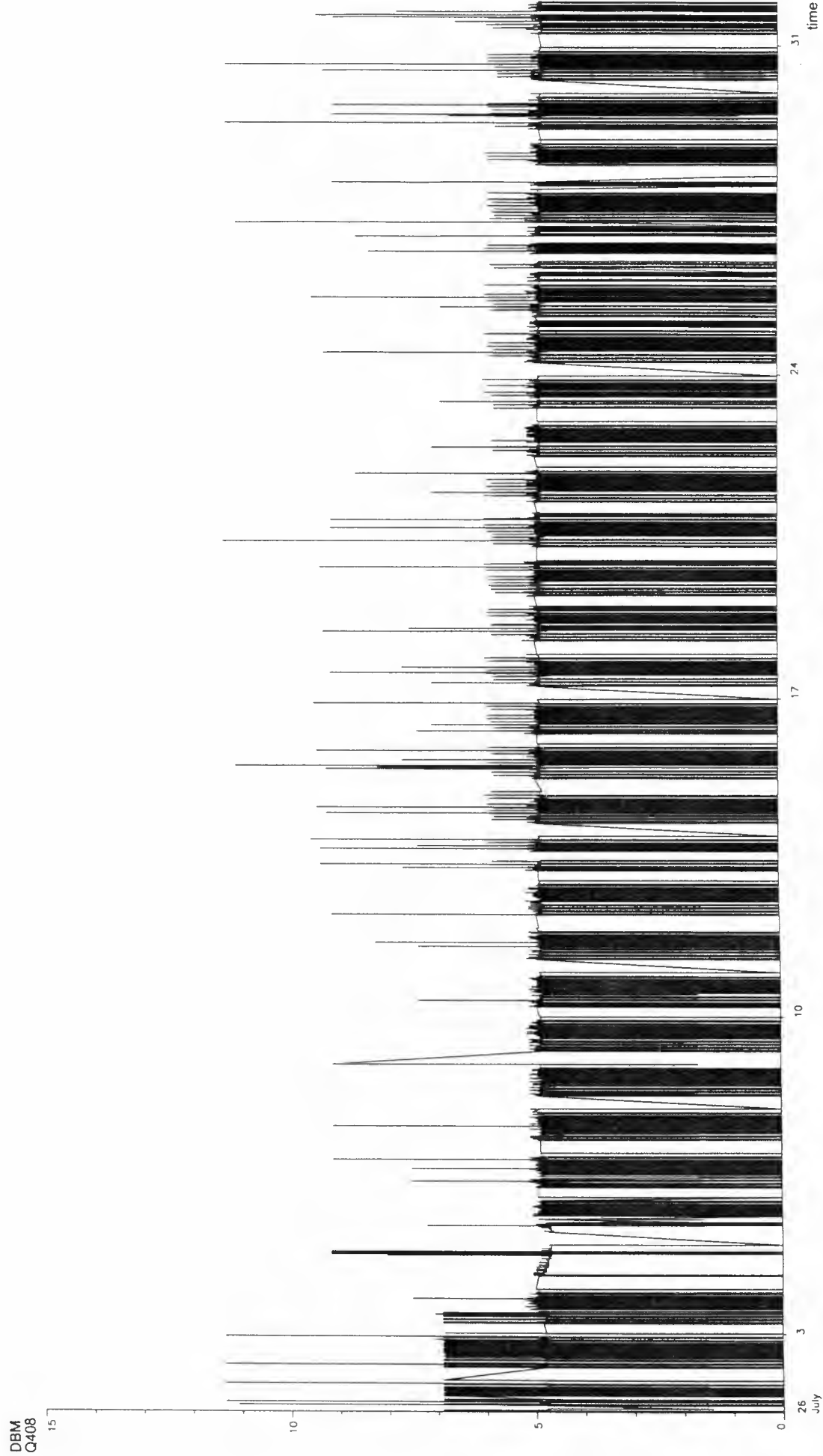
Q408

Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41

ERS-2 AMI Cal Output Peak Power

SPEVAL

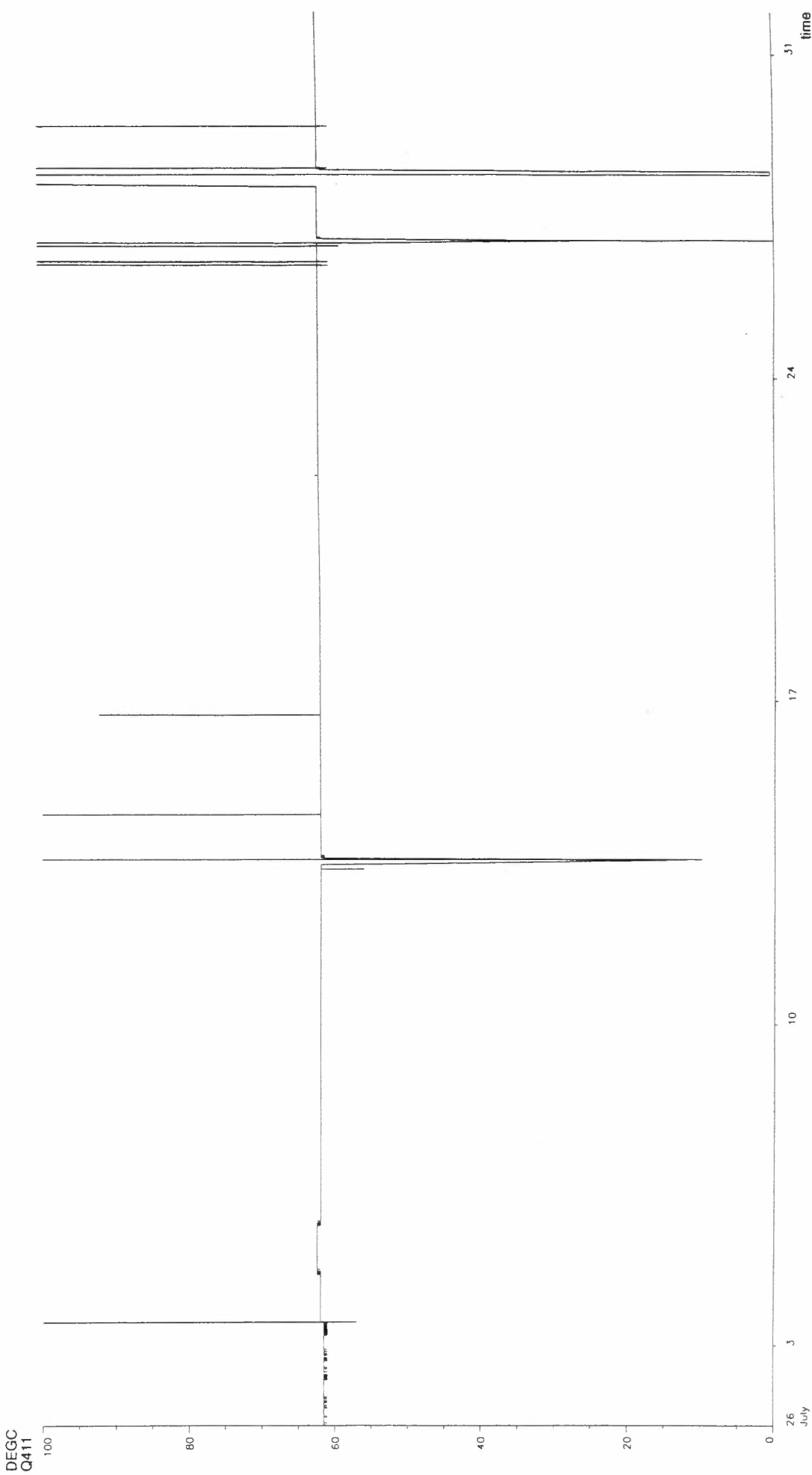
Q408 CAL OP PKPWR MON



ERS-2 AMI Cal Oven Temp

Q411
Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41

DEGC
Q411



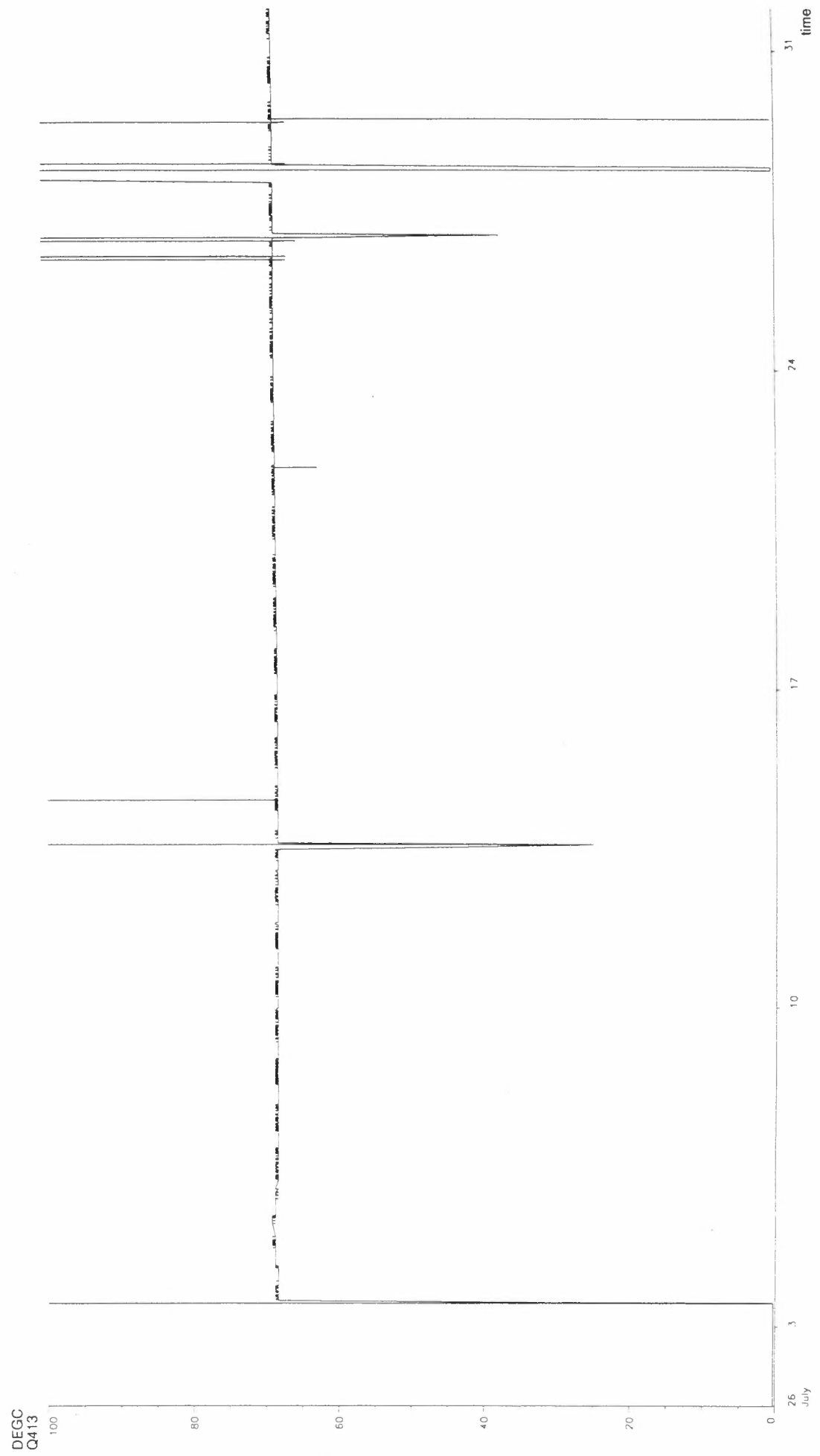
Q413

Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41

ERS-2 AMI IF Radar Oven Temp

SPEVAL

Q413 IFRD OVEN TEMP A



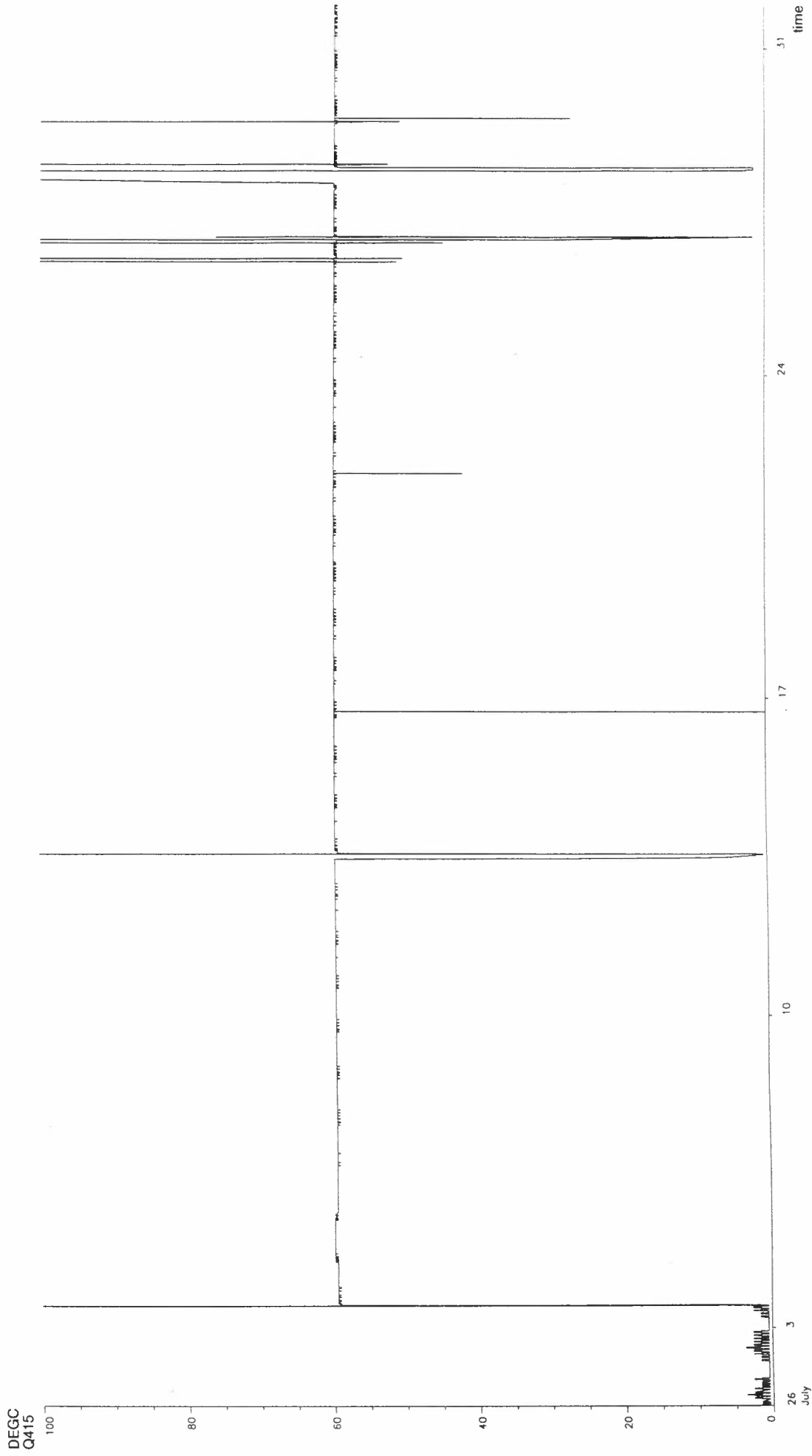
Q415

Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41

ERS-2 AMI Freq Gen Oven Temp

SPEVAL

Q415 FRGN OVEN TEMP A



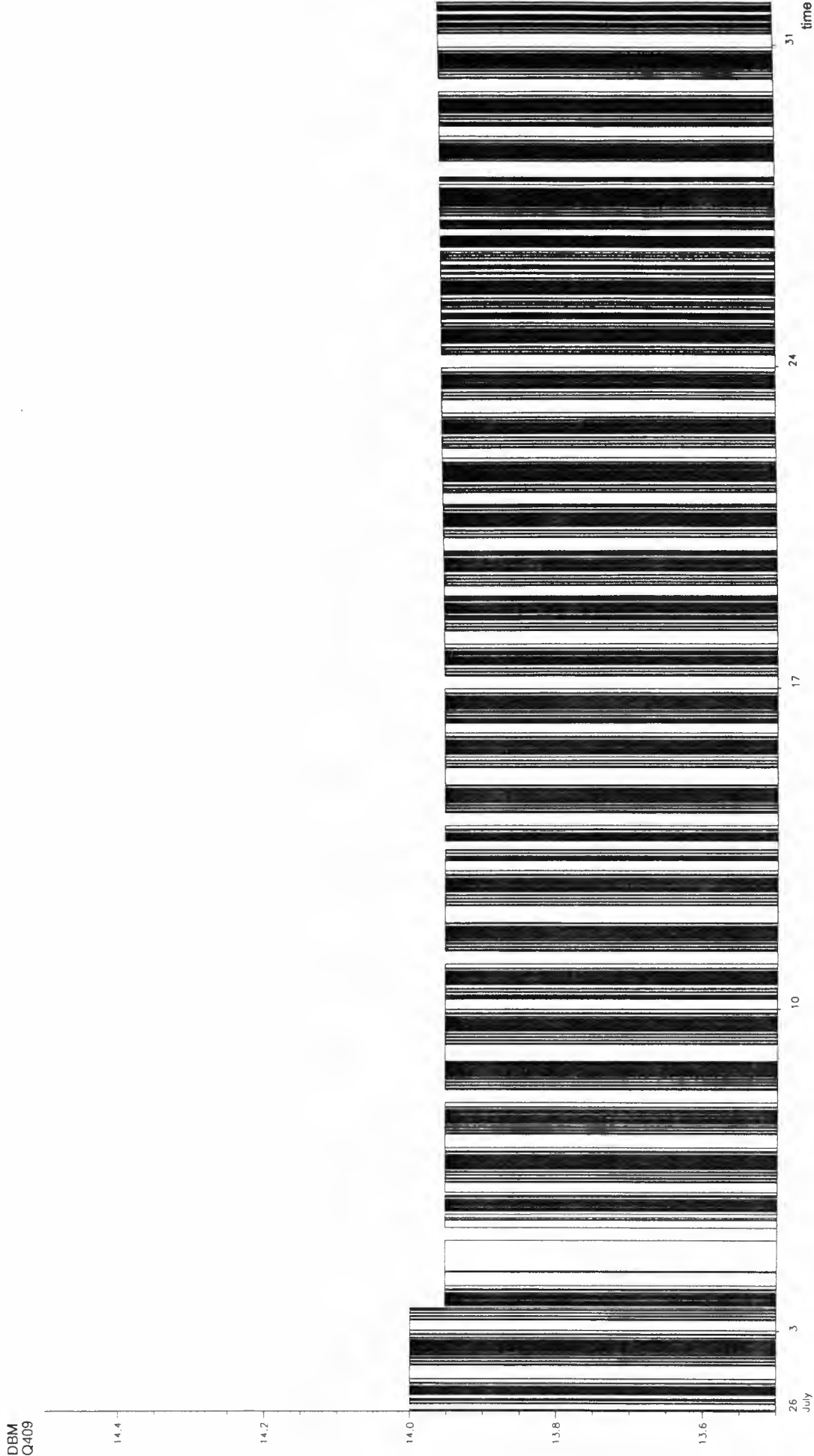
Q409

Start Date & Time 1995-182 06:26:48
End Date & Time 1995-212 22:34:41

ERS-2 AMI Freq Gen 5MHz Power

SPEVAL

Q409 FGN 5GHZ PWR A

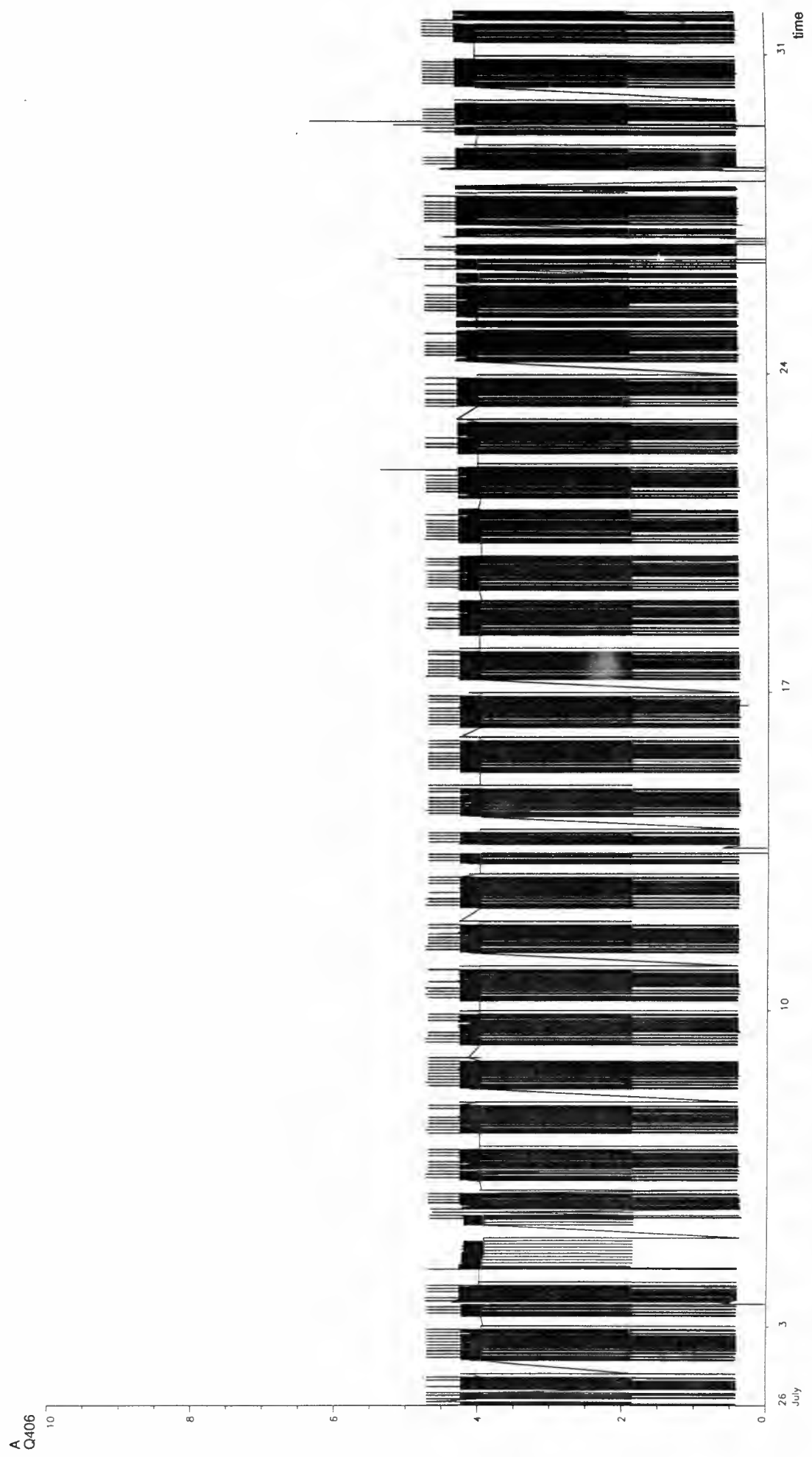


Q406

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End Date & Time 1995-212 22:34:41

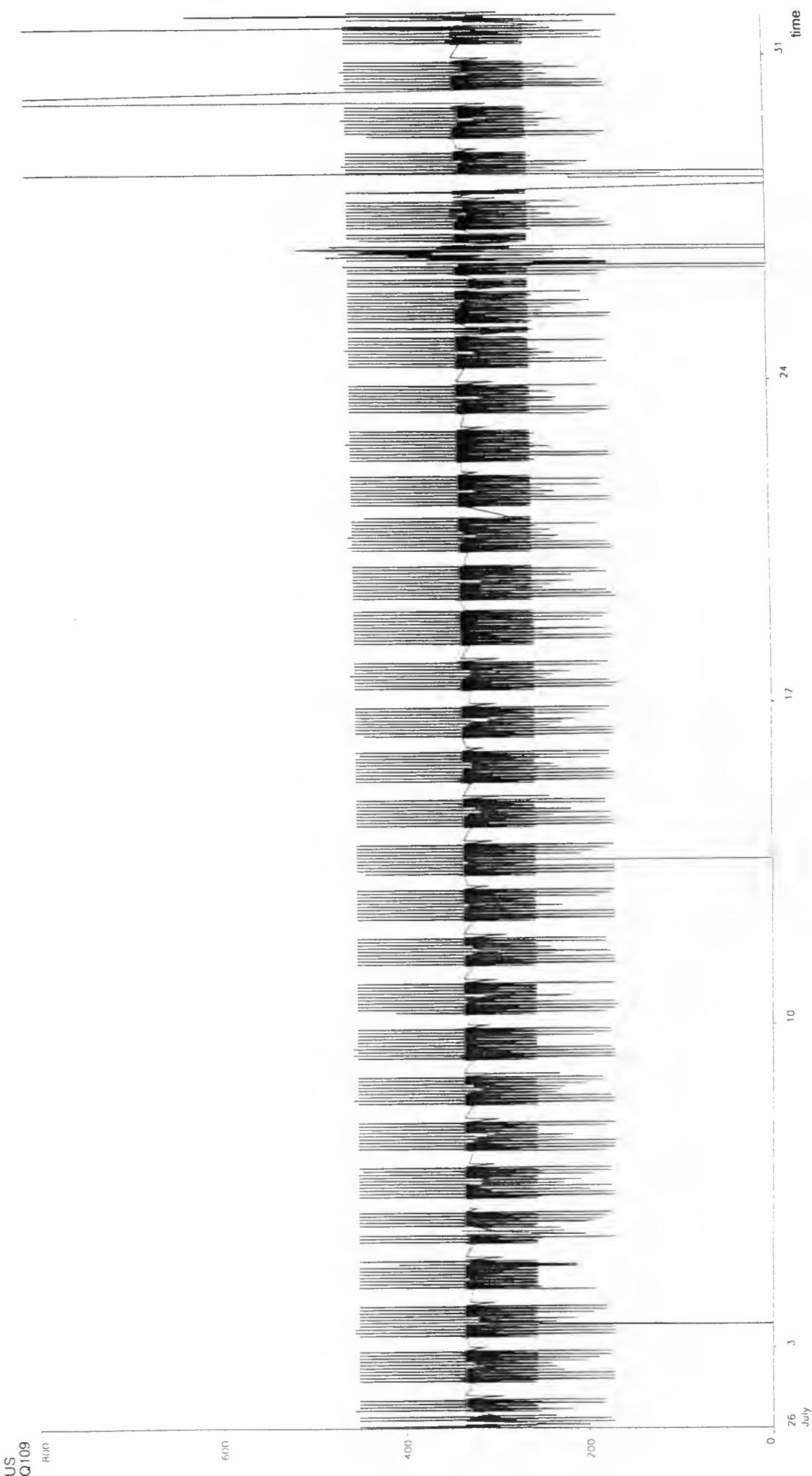
ERS-2 AMI PCU Output Current

SPEVAL
Q406 PCU OP BUS CUR A



ERS-2 AMI Sampling Window

Q109
Start Date & Time 1995-182 06:26:49
End Date & Time 1995-212 22:34:41



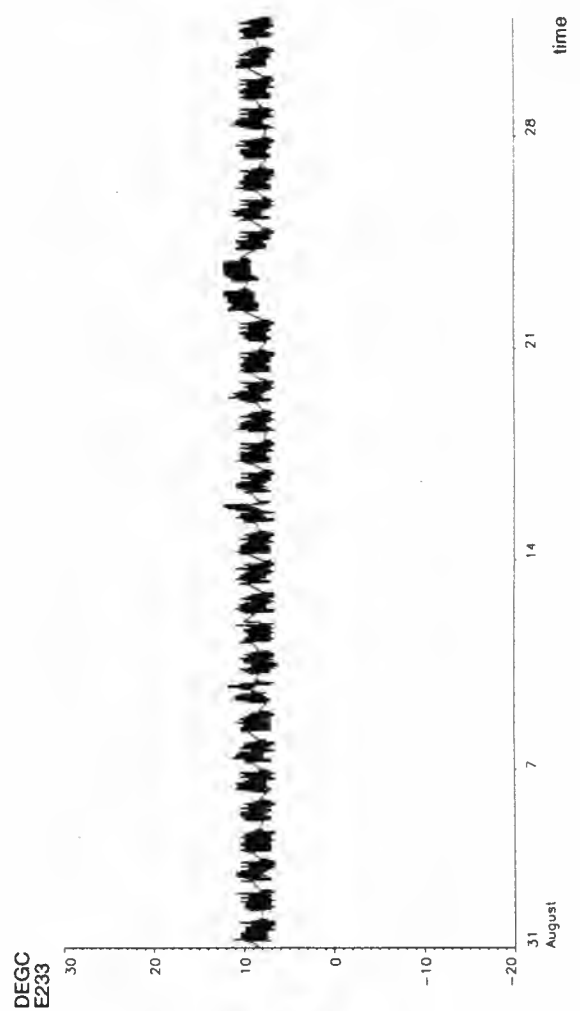
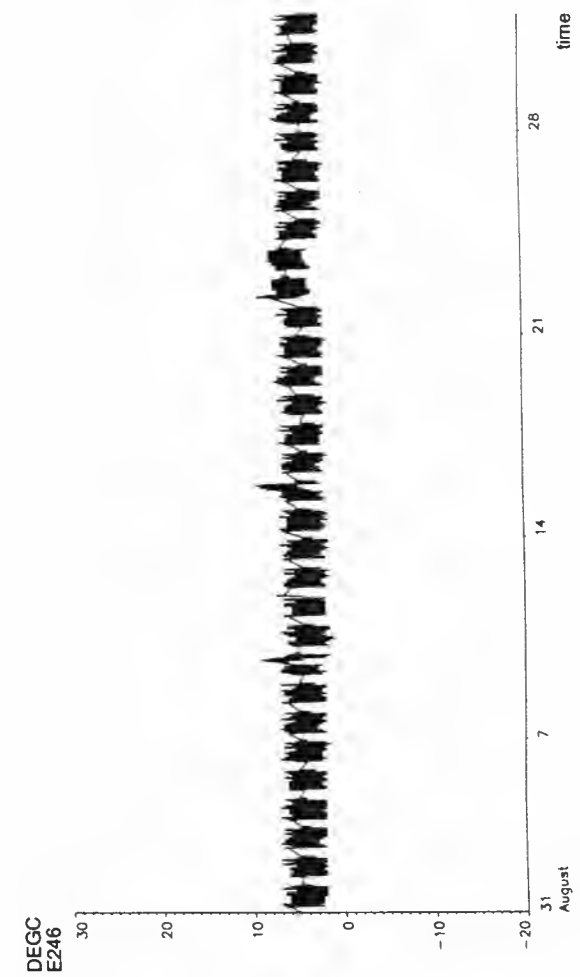
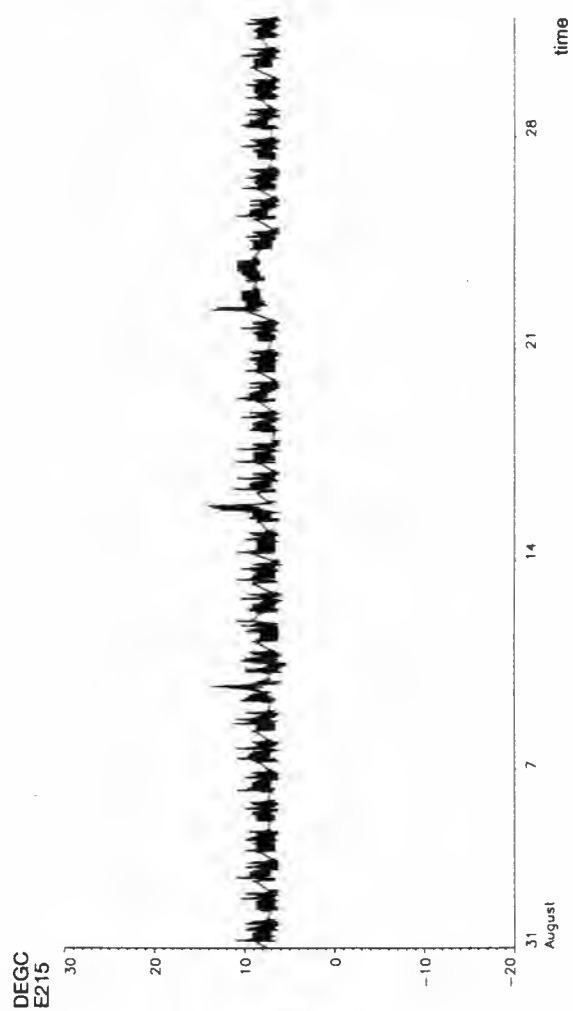
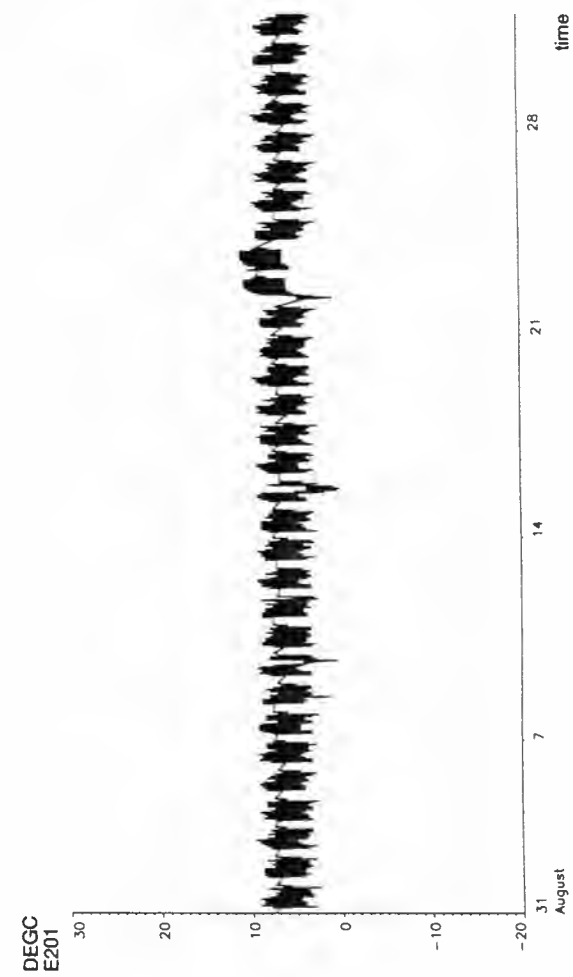
AMIT

Start Date & Time 1995-213 00:07:20
End Date & Time 1995-243 23:00:40

ERS-2 AMI Panel Temp

SPEVAL

- E201 TH AM SQ A/FG A
- E215 TH AM SCT PWR CD
- E233 TH AM PWR CD
- E246 TH AM RX RDCYSWT



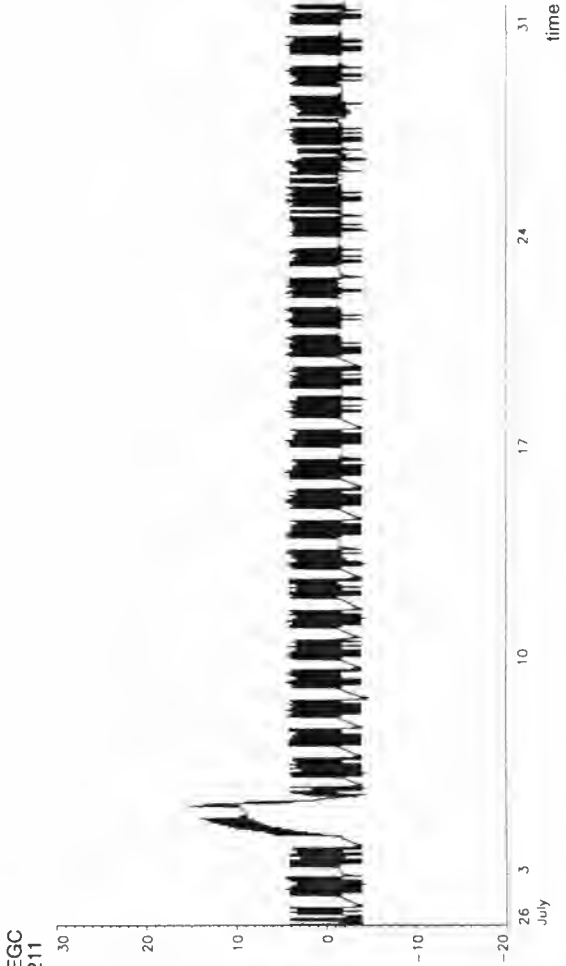
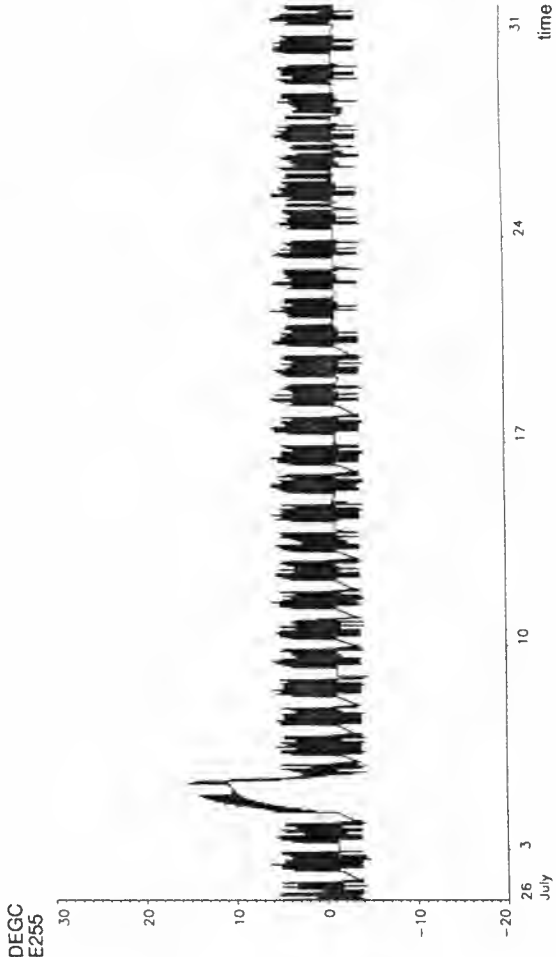
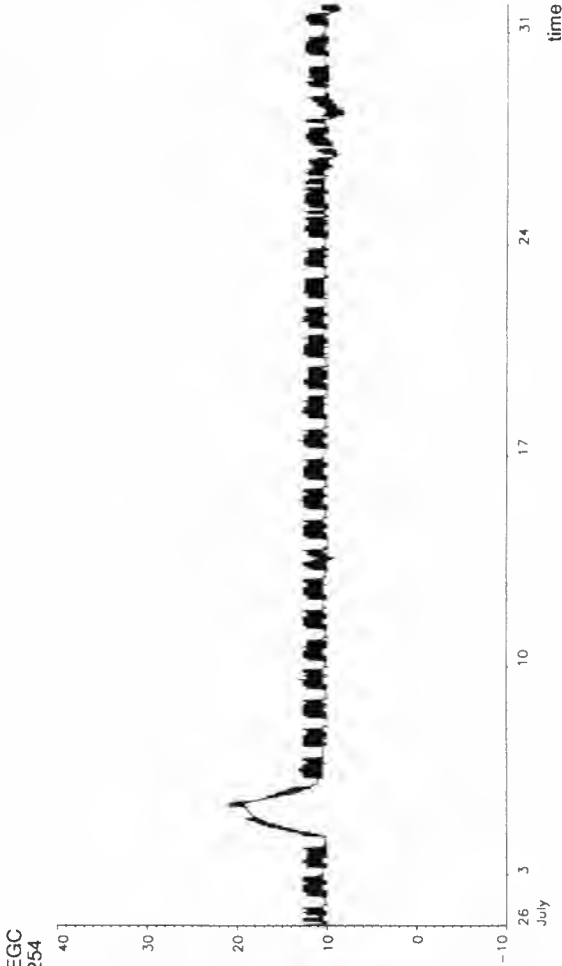
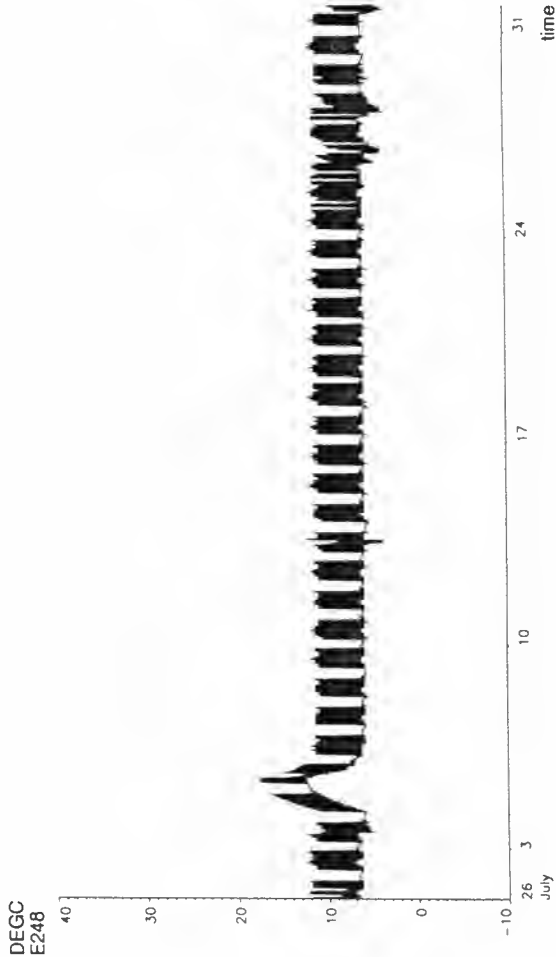
TOPT

Start Date & Time 1995-182 06:27:20
End Date & Time 1995-212 22:35:04

ERS-2 AMI Top Panel Temp

SPEVAL

- _____ E211 TH AM RFACC IS A
- _____ E248 TH AM SW MTR CT
- _____ E254 TH AM CIRCULATOR
- _____ E255 TH AM RFACC IS B

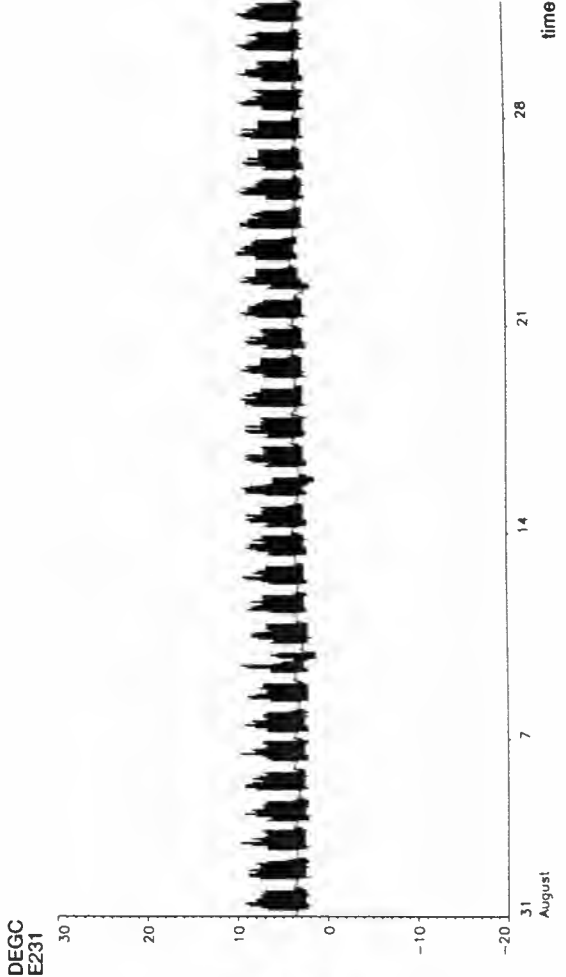
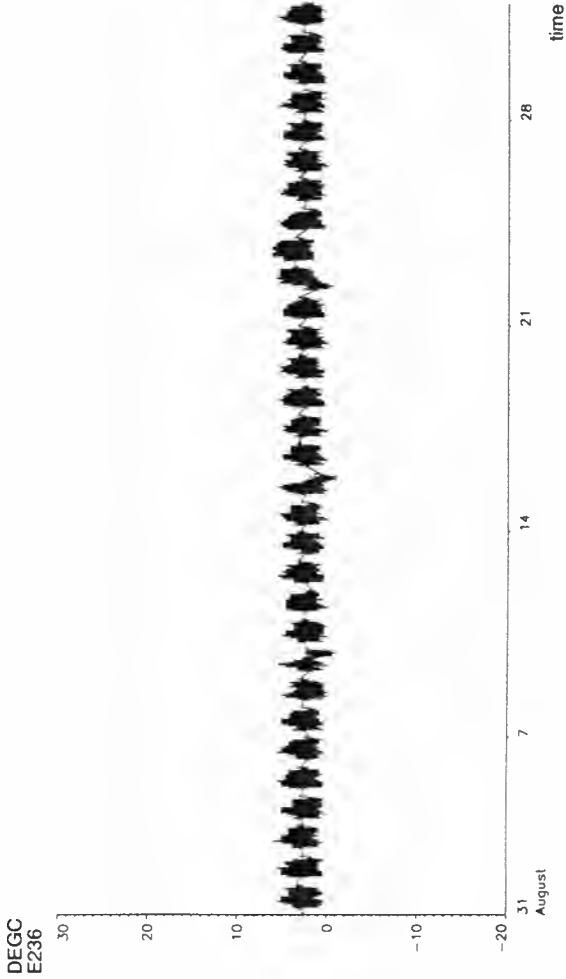
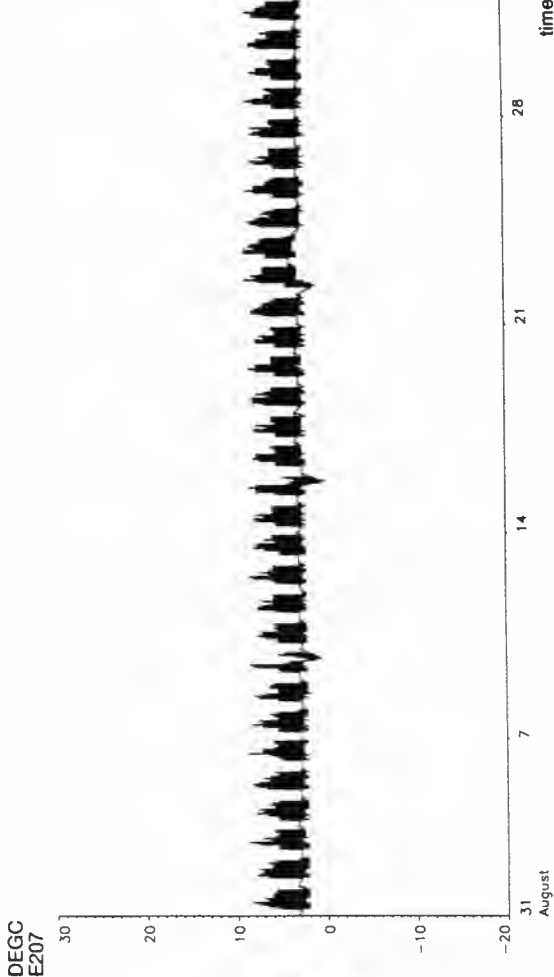
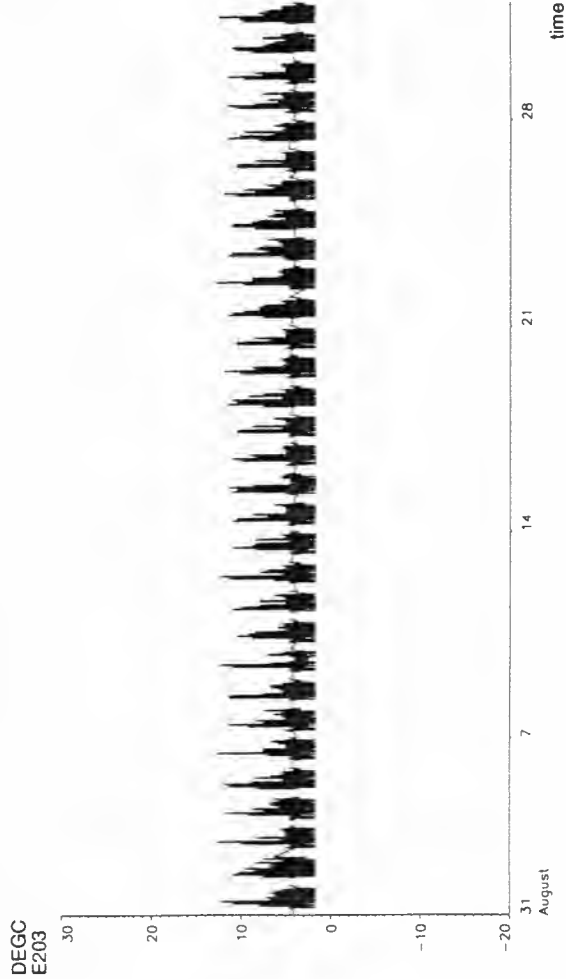


SPEVAL

- E203 TH AM TWT
- E207 TH AM COAX SW
- E231 TH AM EPC MID
- E236 TH AM EPC LOW

ERS-2 AMI HPA Panel Temp

HPAT
Start Date & Time 1995-213 00:07:20
End Date & Time 1995-243 23:00:40



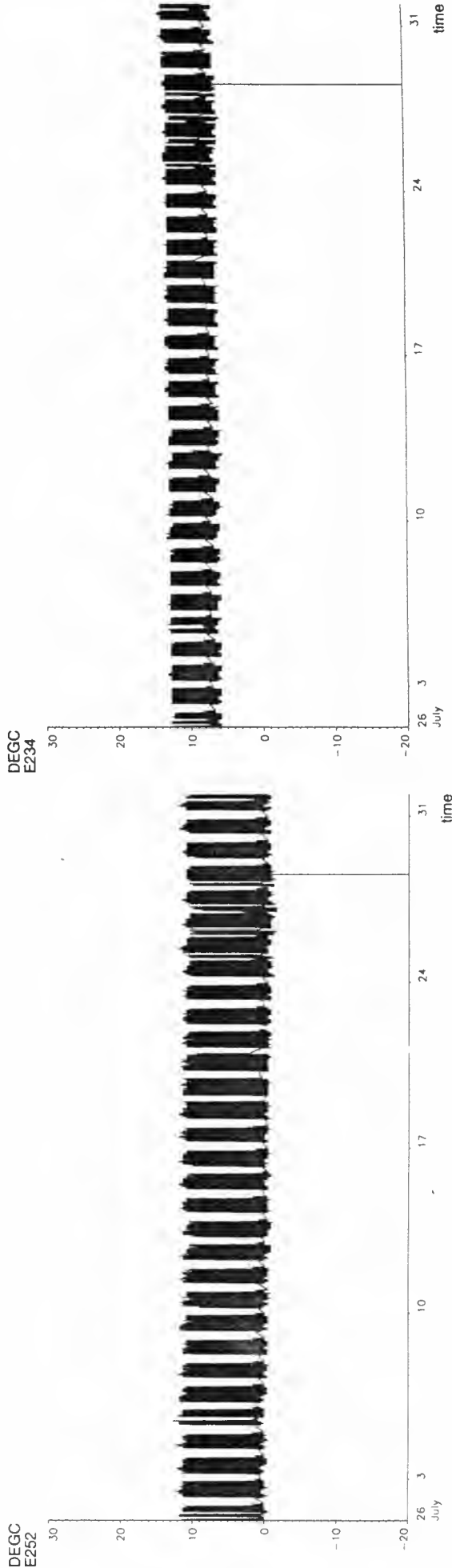
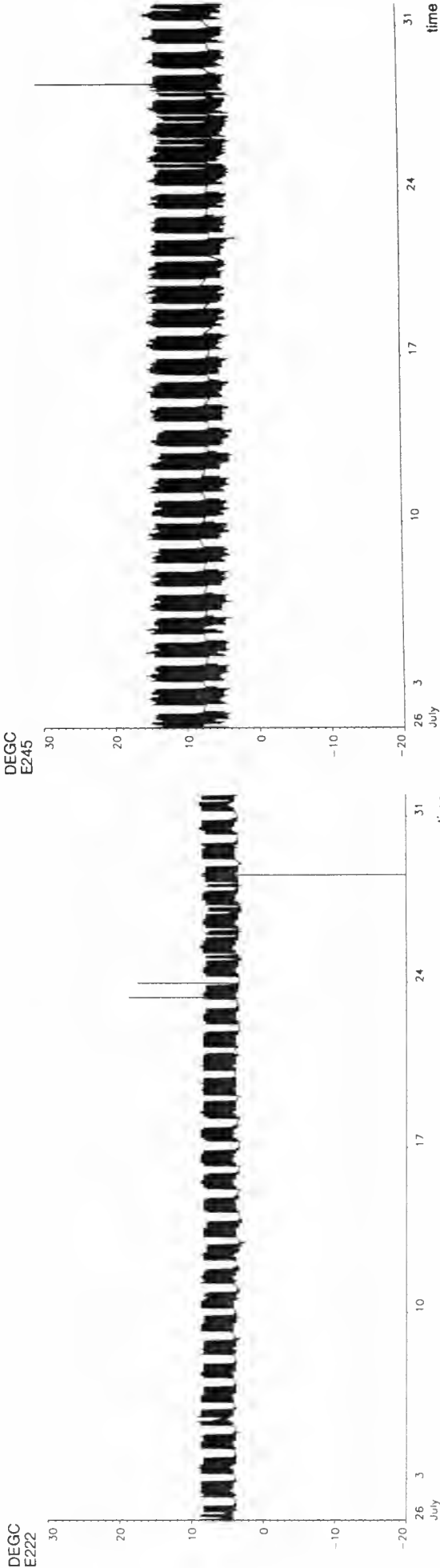
SPEVAL

E222 TH SARA MTR WNG1
E234 TH SARA MTR WNG2
E245 TH SARA HNG WNG1
E252 TH SARA HNG WNG2

ERS-2 AMI SAR Antenna Temp

SART

Start Date & Time 1995-182 06:27:20
End Date & Time 1995-212 22:35:04



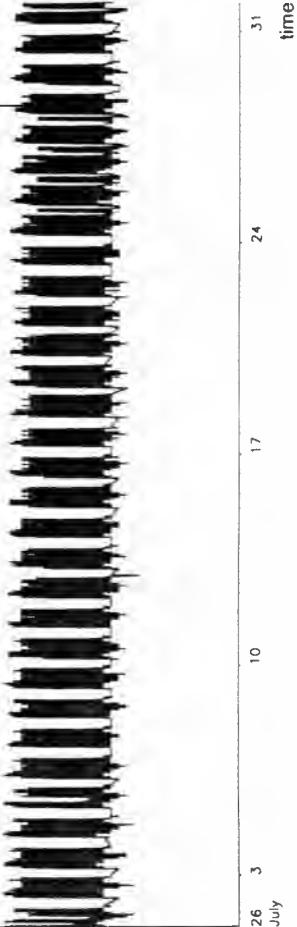
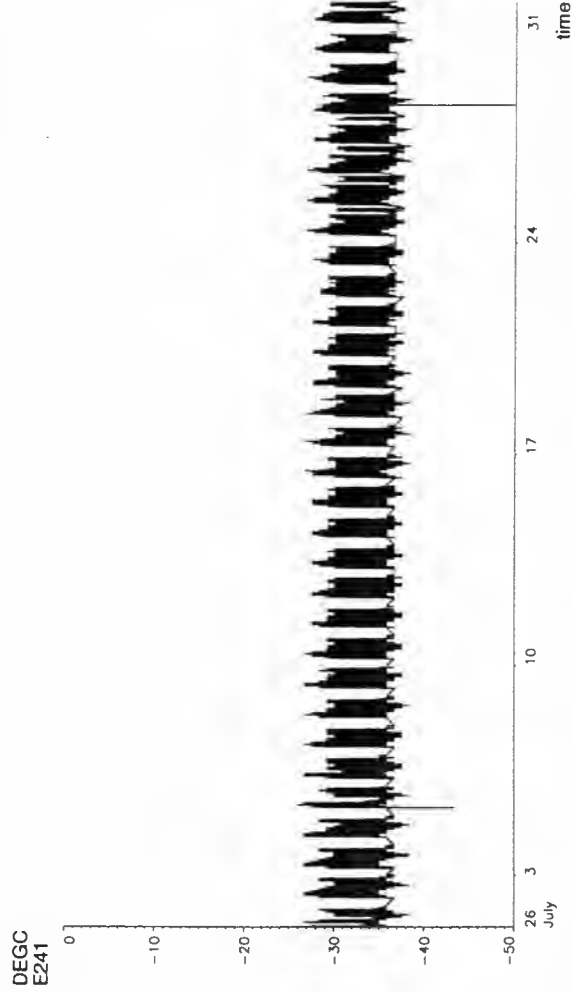
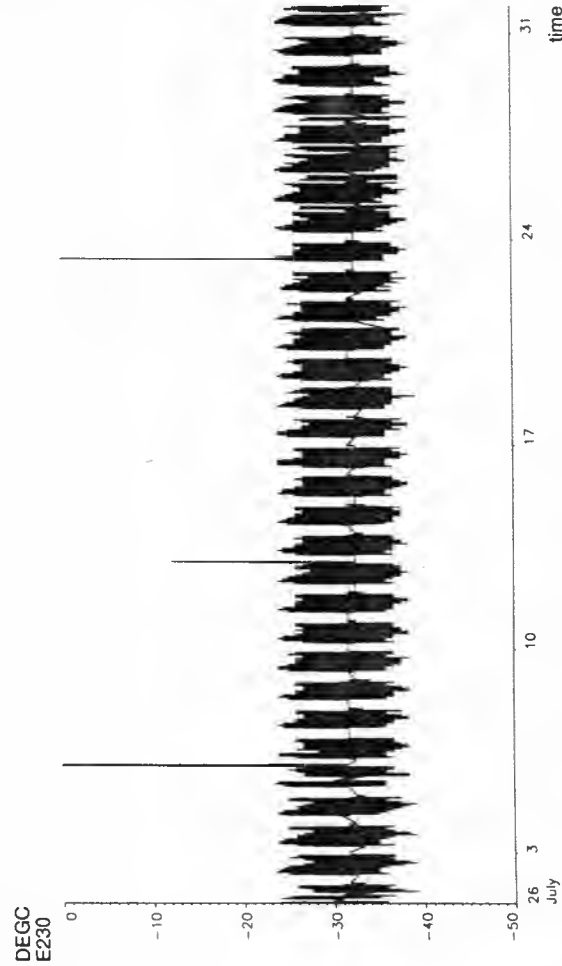
SCAT

Start Date & Time 1995-182 06:27:20
End Date & Time 1995-212 22:35:04

ERS-2 AMI SCATT Antenna Temp

SPEVAL

E230 TH FORA PANEL +Y
E241 TH MIDA PANEL
E251 TH AFTA PANEL -Y



ERS-2 COMMISSIONING PHASE REVIEW OCTOBER 1995

ERS-2 AMI PARAMETRIC TREND ANALYSIS 1/2
FOR FIRST MONTHS IN ORBIT

16-OCT-95

			Day Date	SVT 22.02.94	1/2 2/3.05.95	23 24.05.95	51 21.06.95	81 21.07.95	112 21-08-95
UPCONV GAIN	dB	IM		27.0	21.0	21.0	21.0	21.0	21.0
		WA		27.0	21.0	21.0	21.0	21.0	21.0
		WI		27.0	-	21.0	21.0	21.0	21.0
Q310 Rx ATTEN	dB	IM		11	15	15	15	19	19
		WA		e 15	15	15	15	15	15
		WI		18	-	-	-	-	-
Q301 CAL ATTEN	dB	IM		11	11	11	7	7	7
		WA		8	8	8	8	8	8
Q225 CAL LOOP ST		IM		OPEN	OPEN	OPEN	OPEN	OPEN	OPEN
		WA		CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED
Q407 CAL Pk I/P Pwr (dB/Dec)		IM		6.74	(80)	4.65(76)	4.75(78)	4.70(77)	4.70
		WA		-	-	4.75(78)	4.86(80)	4.75(78)	4.70
		WI		6.59	-	-	-	-	-
Q408 CAL Pk O/P Pwr (dB/Dec)		IM		3.53	(35)	1.69(33)	1.77(34)	5.75(96)	5.79()
		WA		-	-	4.84(78)	4.97(81)	4.84(78)	4.84(78)
		WI		6.58	-	-	-	-	-
Q401 AV BODY CURR 421	mA	IM		3.0	2.3	3.6	4.0	4.17	
		WA		-	-	-	-	-	
		WI		0.7	-	-	-	-	
		Gap		0.2		0.1	0.2	0.2	
Q402 FIL CURR 422	mA	IM			1.76		1.78	1.80	1.80
		WA			1.76		1.78	1.80	1.80
		WI			-		-	-	
Q403 BEAM CURR 423	mA	IM		97.2	100.7	96.6	96.6	96.6	96.6
		WA		-	-	-	-	-	-
		F/A - WI		22.1	-	-	-	-	-
		M - WI		15.2	-	-	-	-	-
		Gap		3.4	3.4	3.4	3.4	4.1	3.5
Q404 CATHODE V 424	-kV	IM		13.96	14.0	13.96	13.96	13.96	14.0
		WA		-	14.0	-	-	-	-
		WI		13.98	-	-	-	-	-
		Gap		13.98	-	14.00	14.00	14.00	14.0
Q405 COLLECT V 425	-kV	IM		10.37	10.5	10.45	10.43	10.43	10.4
		WA		-	10.5	-	-	-	-
		WI		10.3/10.5	-	-	-	-	-
		Gap		10.75	10.8	10.73	10.73	10.73	10.7

ERS-2 COMMISSIONING PHASE REVIEW OCTOBER 1995

ERS-2 AMI PARAMETRIC TREND ANALYSIS 2/2
FOR FIRST MONTHS IN ORBIT

16-OCT-95

	Day Date	SVT 22.02.94	1/2 2/3.05.95	23 24.05.95	51 21.06.95	81 21.07.95	112 21-08-95
Q406 PCU O/P CURR A IM		4.86	4.74	4.71	4.71	4.71	4.71
426	WA	-	-	3.95	3.95	3.98	3.98
	WI	5.30	-	-	-	-	-
	Gap	2.07	-	1.88	1.88	1.88	1.88
P131 PL1/UPB V	V	33.2	-	36.0/36.2	34.1/35.5	33.6/36.4	33.8/35.9
W001C PL1/UPB PWR W	W	902	736	720	730	730	730
	IM						
	WA	902	-	724	750	-	732
	WI	165/232	-	-	-	-	-
	Gap	66	65	65	69	70	65
Q409 FGE 5GHz Pwr Mon		13.95	14.0	13.95	13.95	13.95	14.0
Q411/412 CAL OVEN	C	/42.8	61.5			62.0	/62.0
Q413/414 IF RAD OVEN	C	/45.2	68.3			68.4/68.8	68.4/68.8
Q415/416 FGE OVEN	C	/59.8	59.4			59.0/59.4	59.0/59.4
Q419/420 EPC B/P	C	21/22	3			4/8	4/8
Q417/418 TWT B/P	C	21/22	8			1/11	1/11
E233 SAR/PCU	C	22/24	10			7/11	7/10
E246 Rx Red Sw	C	21/22	8			2/8	2/7
E201 SEQ/IF RAD/FGE-AC		21/23	5			3/9	2/9
E211 RF ACCs A	C	21/23	1			-4/5	-4/4
E255 RF ACCs B	C	21/23	-1			-4/6	-4/5
E248 SMC	C	22	5			5/12	6/12
REDUNDANCY CONFIGURATION		all A	all A	HPA B all else A	HPA B all else A	HPA B all else A	HPA B all else A

ERS-1 / ERS-2 AMI

PARAMETRIC TREND ANALYSIS COMPARISON
FOR FIRST MONTHS IN ORBIT

16-OCT-95

			ERS-2						ERS-1				
Day Date			SVT 22.02.94	1/2 2/3.05.95	23 24.05.95	51 21.06.95	81 21.07.95	112 21-08-95	SVT	1	71-79	102	132
ERS2-04.TLM 16-10-95													
UPCONV GAIN dB	IM		27.0	21.0	21.0	21.0	21.0	21.0					
	WA		27.0	21.0	21.0	21.0	21.0	21.0					
	WI		27.0	-	21.0	21.0	21.0	21.0					
Q310 Rx ATTEN dB	IM		11	15	15	15	19	19					
	WA		e 15	15	15	15	15	15					
	WI		18	-	-	-	-	-					
Q301 CAL ATTEN dB	IM		11	11	11	7	7	7					
	WA		8	8	8	8	8	8					
Q225 CAL LOOP ST	IM		OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN
	WA		CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED
Q407 CAL Pk I/P Pwr (dB/Dec)	IM		6.74	(80)	4.65(76)	4.75(78)	4.70(77)	4.70					
	WA		-	-	4.75(78)	4.86(80)	4.75(78)	4.70					
	WI		6.59	-	-	-	-	-					
Q408 CAL Pk O/P Pwr (dB/Dec)	IM		3.53	(35)	1.69(33)	1.77(34)	5.75(96)	5.79()					
	WA		-	-	4.84(78)	4.97(81)	4.84(78)	4.84(78)					
	WI		6.58	-	-	-	-	-					
Q401 AV BODY CURR 421 mA	IM		3.0	2.3	3.6	4.0	4.17						
	WA		-	-	-	-	-						
	WI		0.7	-	-	-	-						
	Gap		0.2		0.1	0.2	0.2						
Q402 FIL CURR mA 422	IM			1.76		1.78	1.80	1.80	1.74	1.72	1.74	1.74	1.74
	WA			1.76		1.78	1.80	1.80	1.74	1.72		1.72/1.74	1.72/1.74
	WI			-		-	-						
Q403 BEAM CURR mA 423	IM		97.2	100.7	96.6	96.6	96.6	96.6	99.3/100	100/100.7	99.3	98.6	99.3
	WA		-	-	-	-	-	-					
	F/A - WI		22.1	-	-	-	-	-					
	M - WI		15.2	-	-	-	-	-					
	Gap		3.4	3.4	3.4	3.4	4.1	3.5	4.1	4.1	4.1	4.1	4.1
Q404 CATHODE V -kV 424	IM		13.96	14.0	13.96	13.96	13.96	14.0	13.9	13.9	13.9	13.9	13.9
	WA		-	14.0	-	-	-	-	13.9	13.9	13.9	13.9	13.9
	WI		13.98	-	-	-	-	-					
	Gap		13.98	-	14.00	14.00	14.00	14.0	13.9	13.9	13.9	13.9	13.9
Q405 COLLECT V -kV 425	IM		10.37	10.5	10.45	10.43	10.43	10.4	10.1		10.1	10.1	10.1
	WA		-	10.5	-	-	-	-					
	WI		10.3/10.5	-	-	-	-	-					
	Gap		10.75	10.8	10.73	10.73	10.73	10.7	10.5	10.5	10.5	10.5	10.5
Q406 PCU O/P CURR A 426	IM		4.86	4.74	4.71	4.71	4.71	4.71	4.93	4.71/4.74	4.71	4.71	4.67/4.71
	WA		-	-	3.95	3.95	3.98	3.98					
	WI		5.30	-	-	-	-	-					
	Gap		2.07	-	1.88	1.88	1.88	1.88	2.1/2.2	1.88/1.94	1.88		1.98
P131 PL1/UPB V	V		33.2	-	36.0/36.2	34.1/35.5	33.6/36.4	33.8/35.9					
W001C PL1/UPB PWR	W IM		902	736	720	730	730	730					
	WA		902	-	724	750	-	732					
	WI		165/232	-	-	-	-	-					
	Gap		66	65	65	69	70	65					
Q409 FGE 5GHz Pwr Mon			13.95	14.0	13.95	13.95	13.95	14.0		14.2	14.2	14.2	14.2
Q411/412 CAL OVEN	C		/42.8	61.5			62.0	/62.0					
Q413/414 IF RAD OVEN	C		/45.2	68.3			68.4/68.8	68.4/68.8					
Q415/416 FGE OVEN	C		/59.8	59.4			59.0/59.4	59.0/59.4					
Q419/420 EPC B/P	C		21/22	3			4/8	4/8					
Q417/418 TWT B/P	C		21/22	8			1/11	1/11					
E233 SAR/PCU	C		22/24	10			7/11	7/10					
E246 Rx Red Sw	C		21/22	8			2/8	2/7					
E201 SEQ/IF RAD/FGE-A	C		21/23	5			3/9	2/9					
E211 RF ACCs A	C		21/23	1			-4/5	-4/4					
E255 RF ACCs B	C		21/23	-1			-4/6	-4/5					
E248 SMC	C		22	5			5/12	6/12					
REDUNDANCY CONFIGURATION			all A	all A	HPA B all else A	HPA B all else A	HPA B all else A	HPA B all else A	all A	all A	all A	all A	all A

ACTIVE MICROWAVE INSTRUMENT

ERS-2 HPA ARCING SUMMARY

DAYS AFTER FIRST
ACTIVITY MODES

I			
I			
V			
29	Day 148 28 May	WAVE OBRC	CATHODE VOLTAGE LOW
53	Day 172 21 June	WAVE OBRC	CATHODE VOLTAGE LOW
93	Day 212 31 July	WAVE OBRC	CATHODE VOLTAGE LOW

ACTIVE MICROWAVE INSTRUMENT

DAYS AFTER FIRST
ACTIVITY MODES

|
|
v

ERS-1 ARCING OCCURRENCES

17	24	31	33	37	44	53	62	64	77	77	90	92	105	107	113	125	125	136
<-----HPA AUTO RESTART ENABLED----->																		

ERS-2 ARCING OCCURRENCES

29	53	93
----	----	----

ARCING RATE:	ERS-1	1 ARC per 7 DAYS
	ERS-2	1 ARC per 55 DAYS

SUMMARY OF AMI ACTIVITIES

ANOMALY REPORTS - 1/2

DAYS AFTER FIRST
ACTIVITY MODES

V

1	Day 120	OR 27	RECEIVE OVERLOAD - REFUSE MODE	Ongoing
29	Day 148	OR 28	HPA ARC - REFUSE MODE	Expected Occurrence (seen on ERS-1)
31	Day 165	OR 31	OBDH PROCESSOR STOPPED	Attributed to SEU (seen on ERS-1)
75	Day 194	OR 36	AMI EMERGENCY SWITCHDOWN (EQ-SOL)	Attributed to SEU

SUMMARY OF AMI ACTIVITIES

ANOMALY REPORTS - 2/2

DAYS AFTER FIRST
ACTIVITY MODES

V

90	Day 209	OR 38	AMI FORMAT COUNTER ERROR Attributed to SEU (seen on ERS-1)
108	Day 227	OR 47	AMI FORMAT ACQUISITION ERROR Attributed to SEU (seen on ERS-1)
140	Day 259	OR 50	AMI FORMAT COUNTER ERROR Attributed to SEU (seen on ERS-1)
164	Day 283	OR 53	CAL S/S SIDE - A FAILS TO TURN ON Under Investigation

CONCLUSIONS OF AMI OPERATION

- 1. IMAGE AND WAVE MODES - AMI IS OPERATING CORRECTLY
(Reduced Power) AND WITHIN SPEC.
INSTRUMENT PARAMETERS ARE STABLE**
- WIND MODE - A LONG DURATION MODE HAS BEEN PERFORMED
(over 1 hour) BUT CURRENTLY NOT AVAILABLE FOR MPS**
- 2. POWER CONSUMPTION IS REDUCED COMPARED TO THAT OF
ERS-1 DUE TO REDUCED RF OUTPUT**
- 3. THERMAL CONDITIONS SIMILAR TO THOSE OF ERS-1**
- 4. HPA ARCING - CONSIDERABLY REDUCED COMPARED TO ERS-1**
- 5. ANOMALIES - RECEIVE OVERLOAD - MAJOR (WIND Mode)
ALL OTHERS ARE MINOR (Most seen on ERS-1)**

GOME IN-ORBIT PERFORMANCE

ESTEC / LTP:

A. Hahne

A. Lefebvre

J. Callies

TPD: GOME Team

ESTEC / NWP:

C. Caspar

26. / 27. October 1995

GOME IN-ORBIT PERFORMANCE

- > *Operations summary*
- > *Performance Verification*
 - * *thermal*
 - * *electrical*
 - * *electro-optical*
 - * *optical*
- > *Sun Measurements*
- > *Earth Shine Measurements*
- > *Conclusions*

GOME IN-ORBIT OPERATIONS MILESTONES | 1995

24 April	<i>Switch on to idle mode</i>
16 May	<i>Operation with cooled detectors</i>
	<i>Start of Comm. Phase 2 activities incl. noise analysis, dark signal mapping, LED measurements, diffuser monitoring.</i>
30 May	<i>Acquisition of first Sun Data (first shutter operation)</i>
13 June	<i>Start of Comm. Phase 3 activities:</i>
	<i>Optimisation of GOME macrocommand timelines</i>
18 July	<i>First Moon Calibration</i>
20 July	<i>Space Segment ready to start Geophysical Validation.</i>

GOME IN-ORBIT PERFORMANCE

GOME temperatures during nominal operation (Calibration Unit off)

<u>Location</u>	<u>orbit average in °C</u>	<u>22.5.95</u>
optical bench	5.4	
input telescope	6.1	
SUMA	4.5	
CU lamp	5.2	
polarisation meas. unit	10.1	
average	5.9	
detectors	-38°C	
radiator	-27° to -18 °C	

- Peltier control works perfectly for all 4 channels;
- temperature gradient on the optical bench very stable along the orbit
- orbital variation exactly as predicted $\Delta T \approx \pm 0.5^{\circ} C$

GOME IN-ORBIT PERFORMANCE

Electronic noise : *less than 2000 electrons*
 (better than specification)

Spikes, caused by radiation are introduced in the detectors. (Mostly) one diode (pixel) is affected. Height of the pulse is varying. Frequency is random. Probability is correlated to South Atlantic Anomaly but also present outside.

Filtering of these events in the ground processing is in preparation.

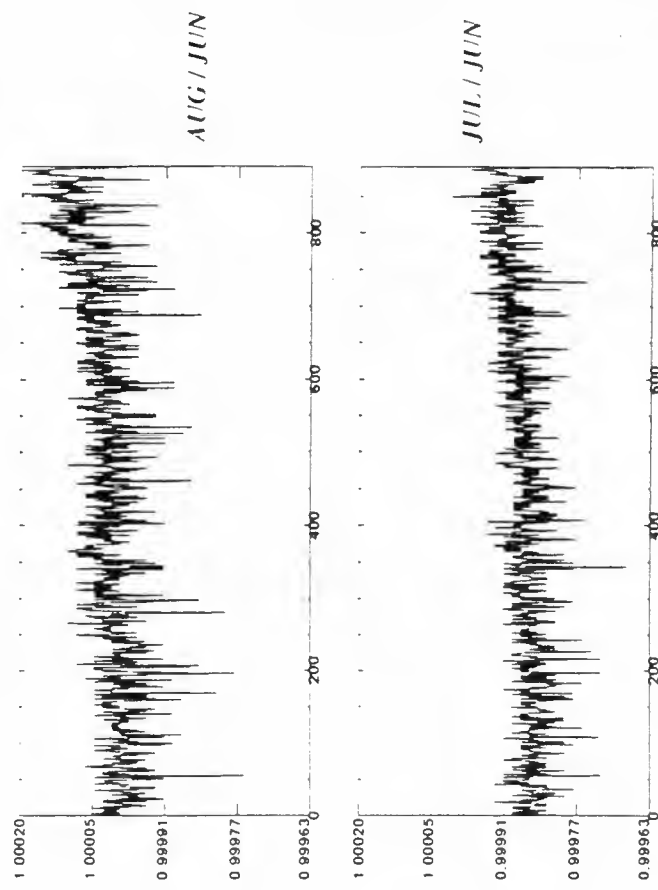
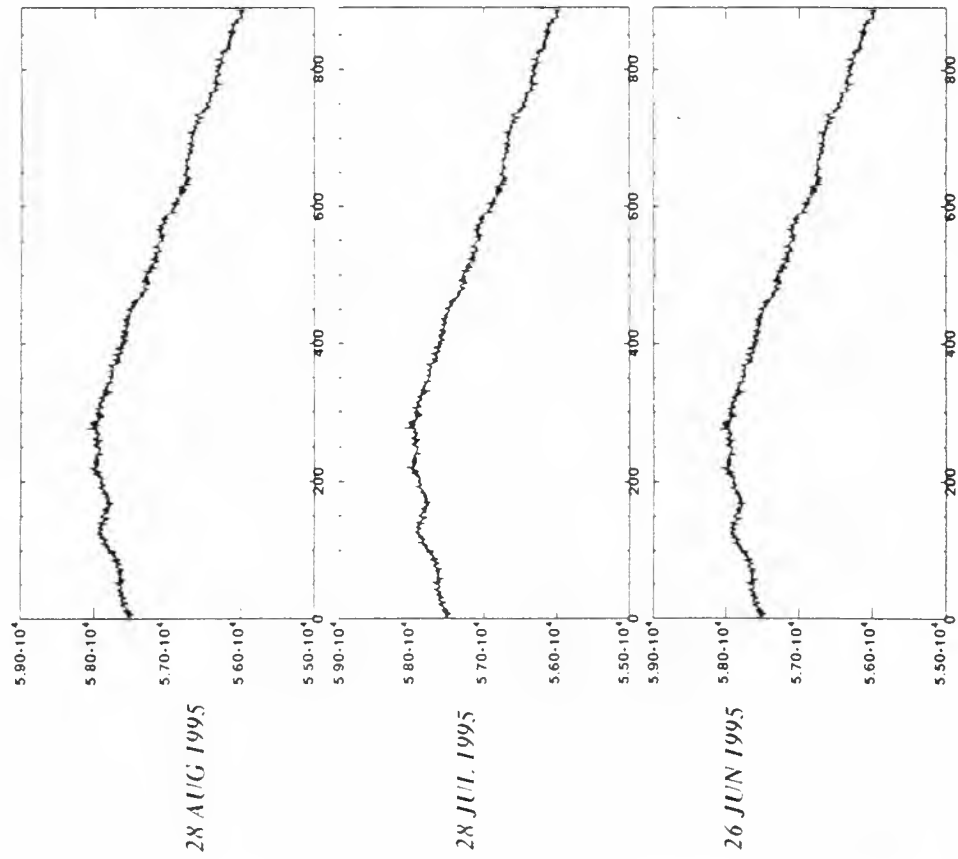
Scan Unit Performance:

- *dynamic errors (position and speed) are very similar to ground based testing.*
- *static behaviour is better than specification.*

GOME IN-ORBIT PERFORMANCE

Electro-optical:

- *Pixel gain stability better than 0.4% in all channels, in comparison with pre-flight data deviations are less than 0.05%.*
- *Stability of saturation levels in flight is extremely high.*
- *No dead pixel found.*



Stability check of saturation levels for channel 2
Each saturation level is obtained by averaging 64 successive LED measurements
No dark signal correction is performed

GOME IN-ORBIT PERFORMANCE

Optical:

Wavelength stability: change on-ground - in-orbit
(TV test)

CH1	CH2	CH3	CH4
0.07 nm	0.14 nm	0.18 nm	0.2 nm

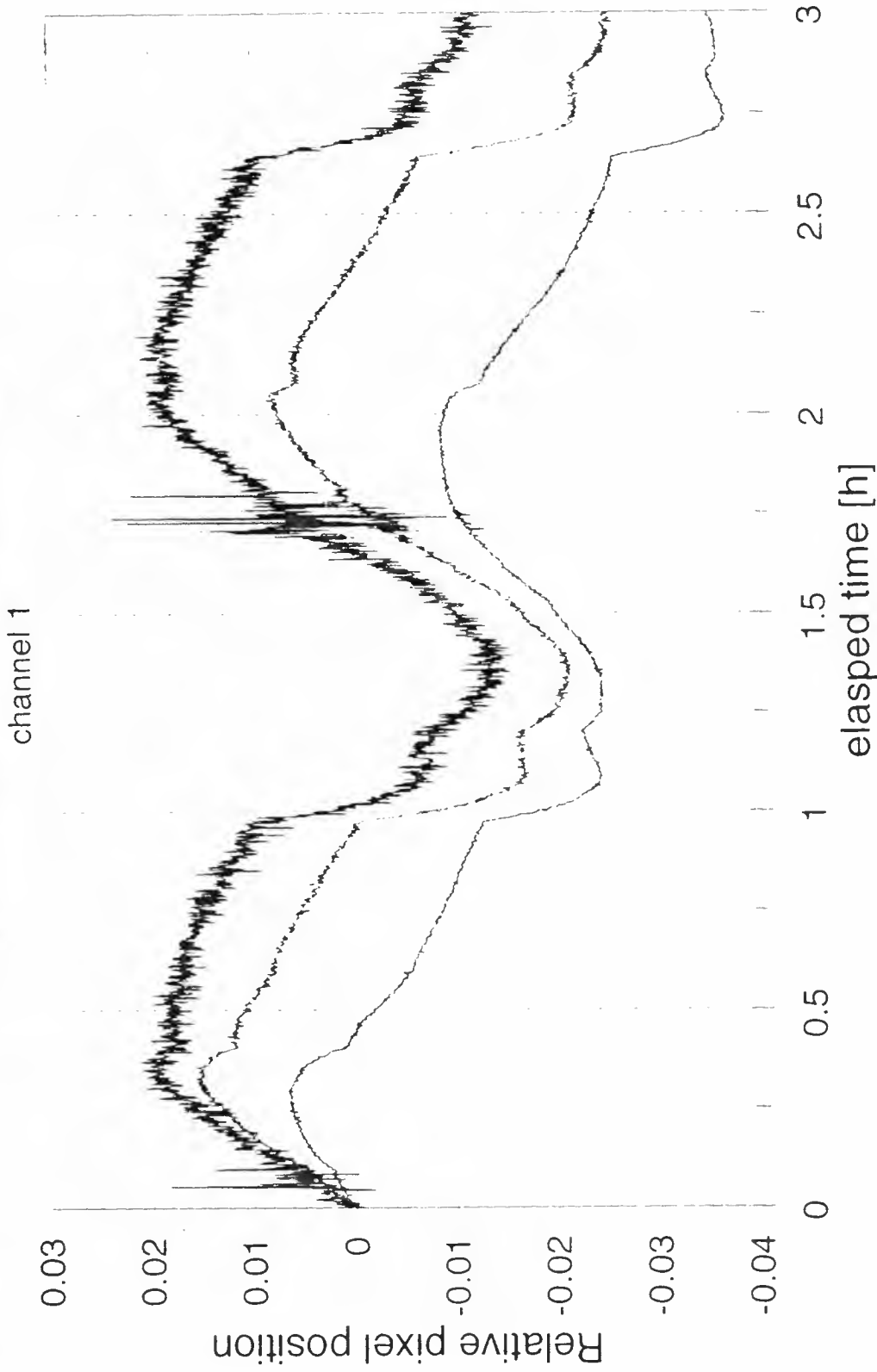
=> corresponding to a shift by 25 μm

Wavelength shift as function of orbital temperature variation

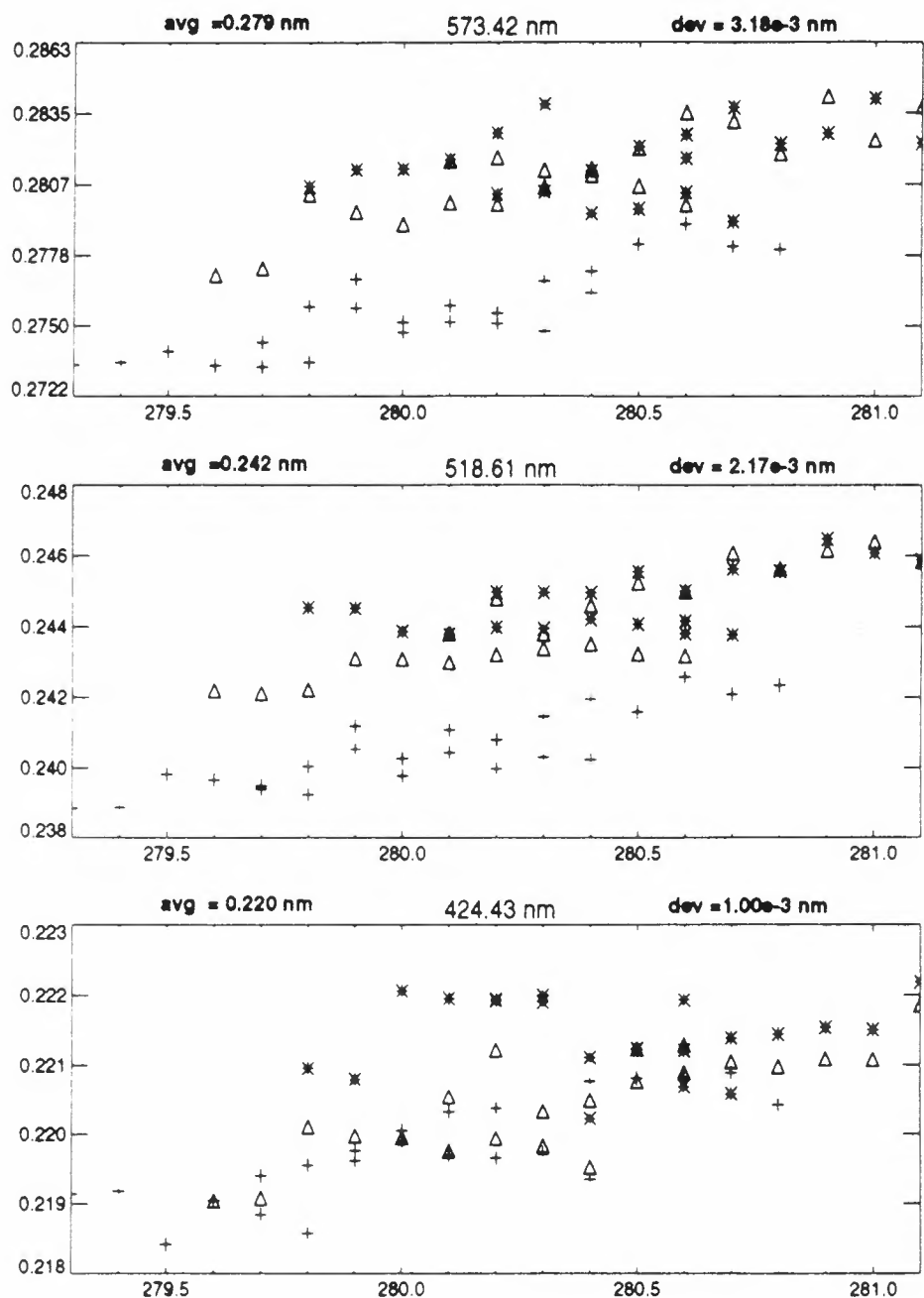
CH1	CH2	CH3	CH4
+/- 0.0023 nm	+/- 0.023 nm	+/- 0.0042 nm	+/- 0.0042 nm

=> corresponding to 1 / 50 of a pixel, required 1 / 10 of a pixel.

Spectral stability in orbit



CH 3 Slit Width stability vs. temperature and time
Gaussian approximation / 2*sigma values



26-JUN-1995

28-JUL-1995

28-AUG-1995



GOME IN-ORBIT PERFORMANCE

Sun Measurements:

- > *performed approx. on a daily basis*
- > *duration around 50 sec.*
- > *in-orbit stability mainly affected by a changing Etalon structure and out gassing of dichroic filter, but day to day variation (interval between sun measurements) likely not to cause any problem.*
- > *first comparisons with other in-orbit measurement indicate an initial degradation; investigations of what element is the cause and monitoring tool are under way.*

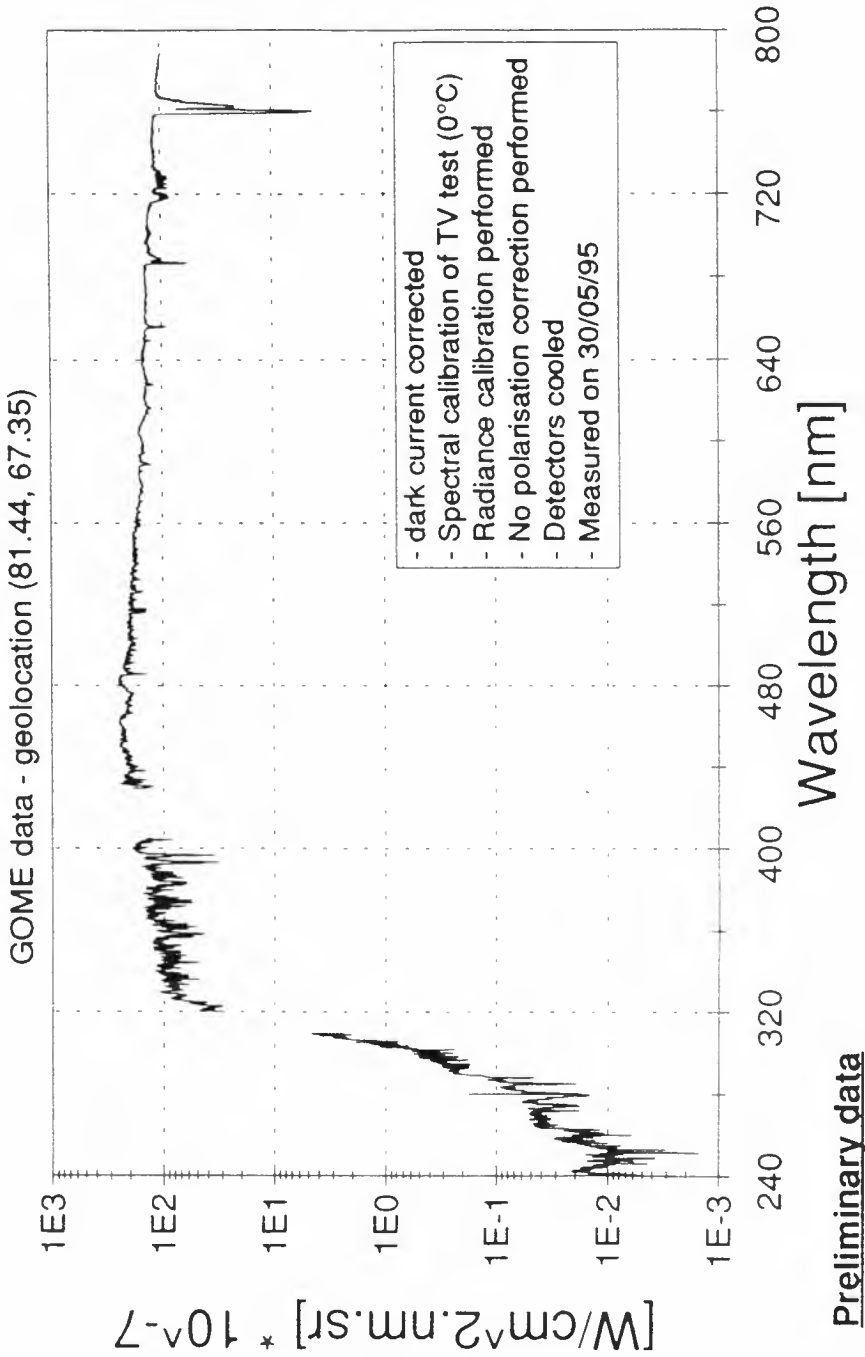
GOME IN-ORBIT PERFORMANCE

Earth Shine Measurements:

- > timeline controlled integration times to cope with different scene illumination
- > backscattered / reflected signal is higher than predicted in the visible, therefore saturation can occur with normal integration times of 1.5 sec.
- > immediate solution:
 - reduction of integration time at the expense of ground-coverage loss (data rate limited)
- > Future solution:
 - co-adding of detector readout (patch in preparation).

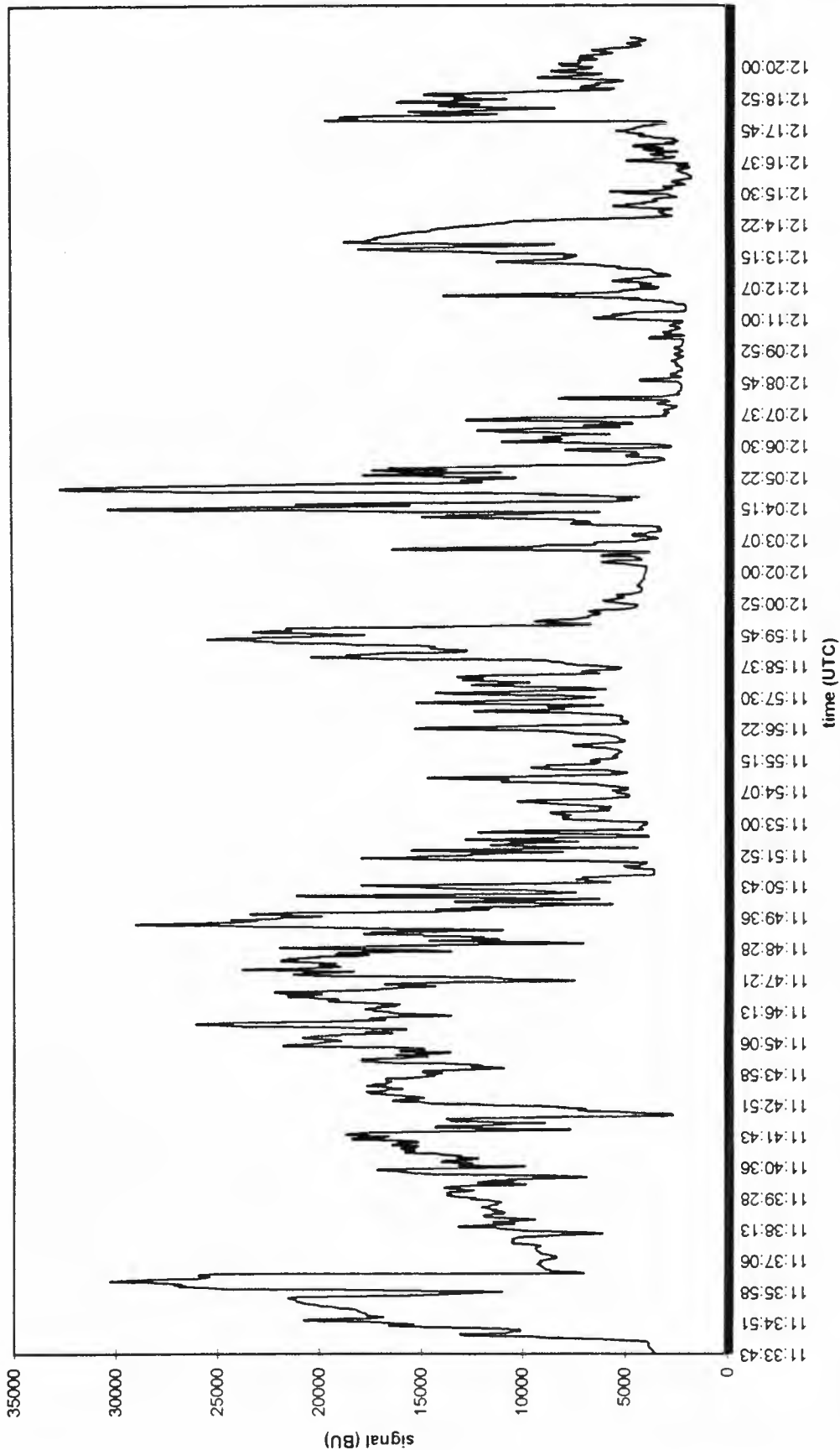
ERS-2 COMMISSIONING PHASE REVIEW

Earth radiance



ERS-2 COMMISSIONING PHASE REVIEW

GOME CH3 pixel 600 on 30.5.95 with 0.375 sec integration time



GOME IN-ORBIT PERFORMANCE

Anomalies:

- > *Radiation problem (spikes in spectra) can be identified and flagged in the ground processing. Single event upsets (2 so far) in DDHU SW can be resetted by instrument switch-off)*
- > *Saturated Detector Pixel (will be solved by co-adding patch).*
- > *Synchronisation of satellite clock disturbs GOME Timeline processing (GOME Timelines have to be interrupted prior to synchronisation).*

GOME IN-ORBIT PERFORMANCE

Conclusions:

- > *Despite the a.m. anomalies, all subsystems/functions are working well.*
- > *GOME was ready on 20/7/95 for the start of geophysical validation.*

ATSR-2 In Flight-Performance Review

Dr D.L.Smith

Space Science Department,

Council for the Central Laboratory of Research Councils

Rutherford Appleton Laboratory

Chilton Didcot, United Kingdom



ATSR-2 In Flight Performance

Contents

General Overview
Stirling Cycle Cooler
Scan Mechanism
Black Bodies
Visible Calibration System
Data Quality

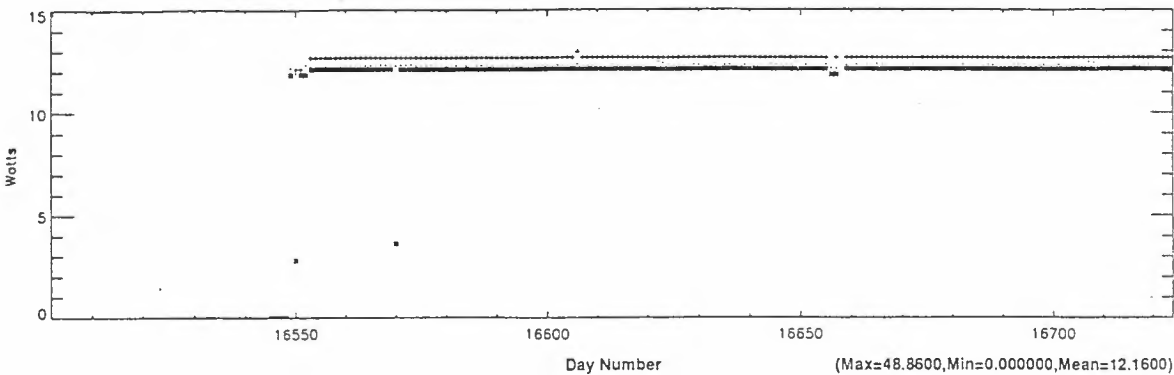
General

- Initial switch-on and functional test were completed with few problems.
- Visible channels active from instrument switch on.
- IR channels active from L+14. - detectors ~ 82 K
- Fore optics ~ 255 K
- 1.6 μ m cloud clearing + visible channel day/night switching thresholds optimised.
- Patch in preparation to correct default settings (gains, thresholds, limits), cooler and scan mirror control loop modifications + GOME transition flag correction.
- Pixel maps have been optimised to make best use of the clear views.

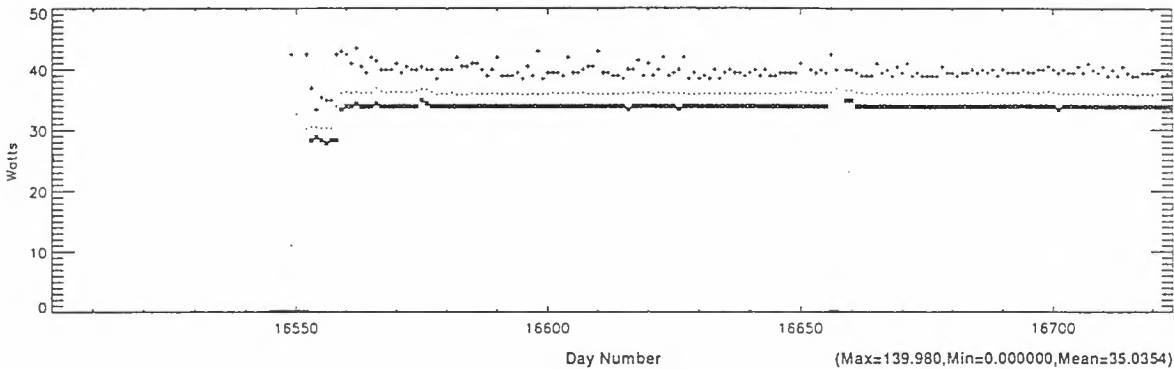


ATSR-2 In Flight Performance

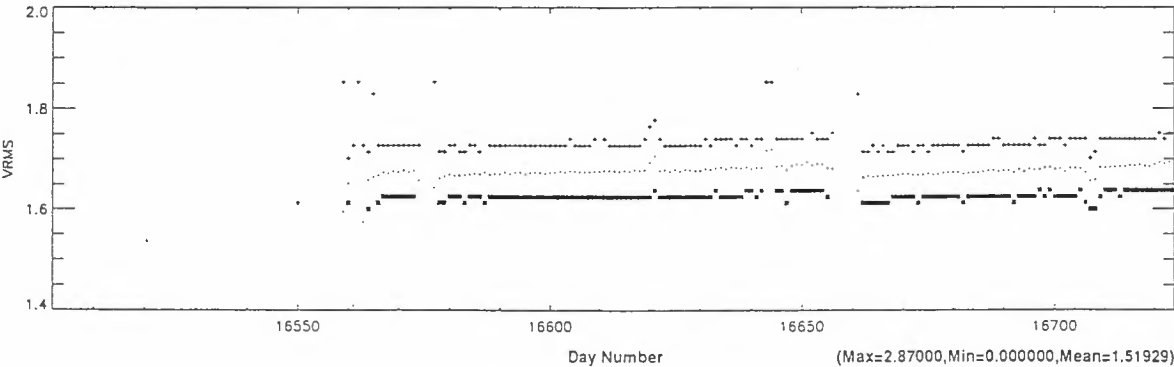
F901 (ATSR2): AT ICU POWER - Converter 2 Input Power Monitor



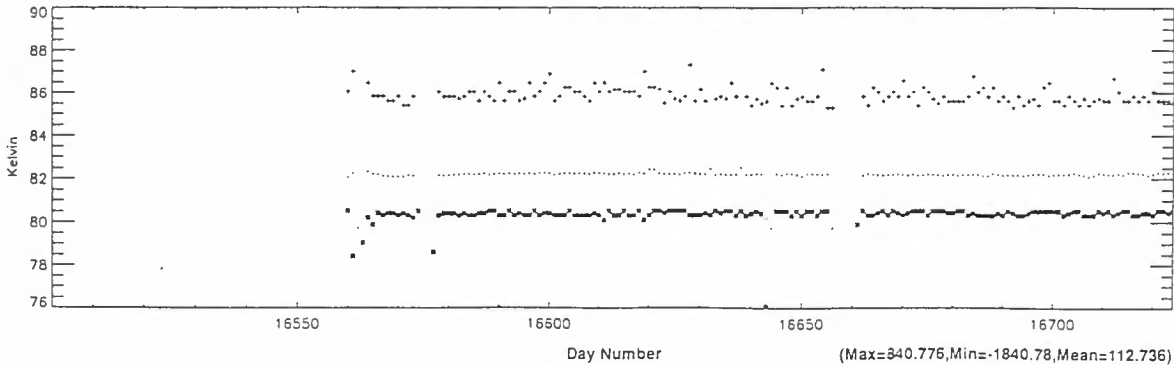
F900 (ATSR2): AT NOM ELEC PWR - Converter 1 Input Power Monitor



F702 (ATSR2): AT SCC C AMPL - SCC Compressor Amplitude



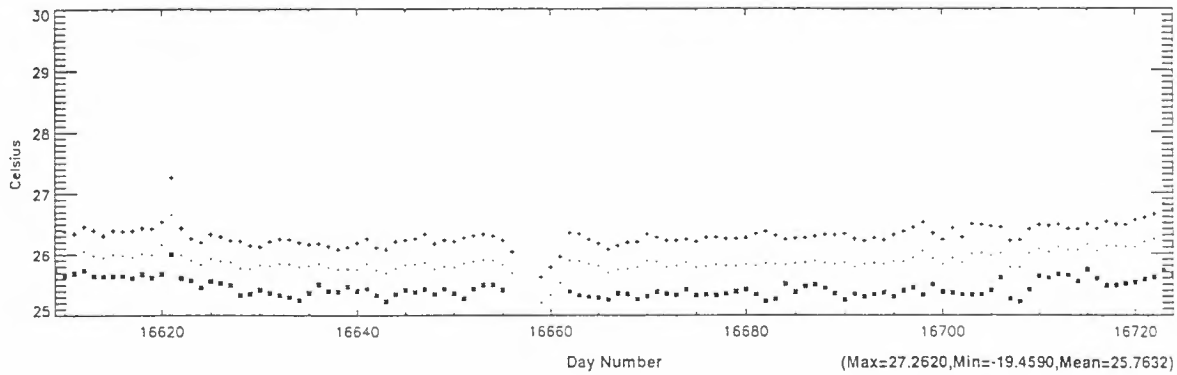
F566 (ATSR2): AT FPA BASE TEMP - FPA Baseplate detector temp



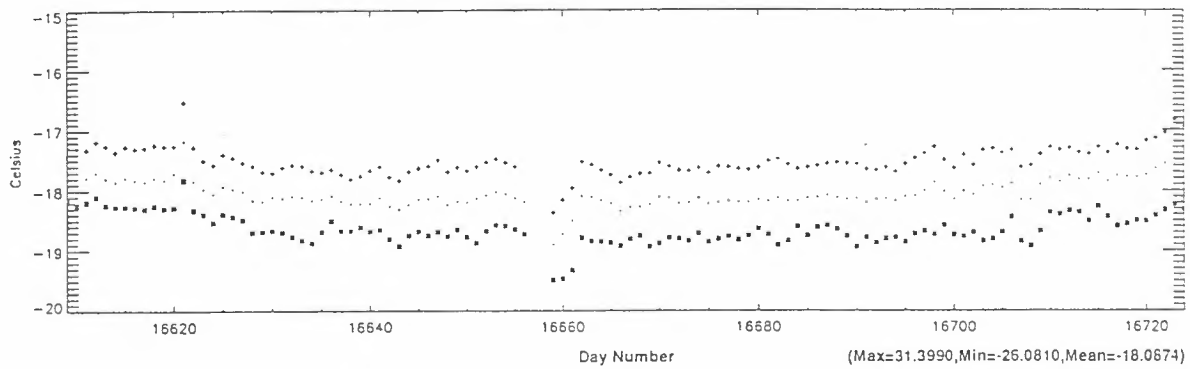


ATSR-2 In Flight Performance

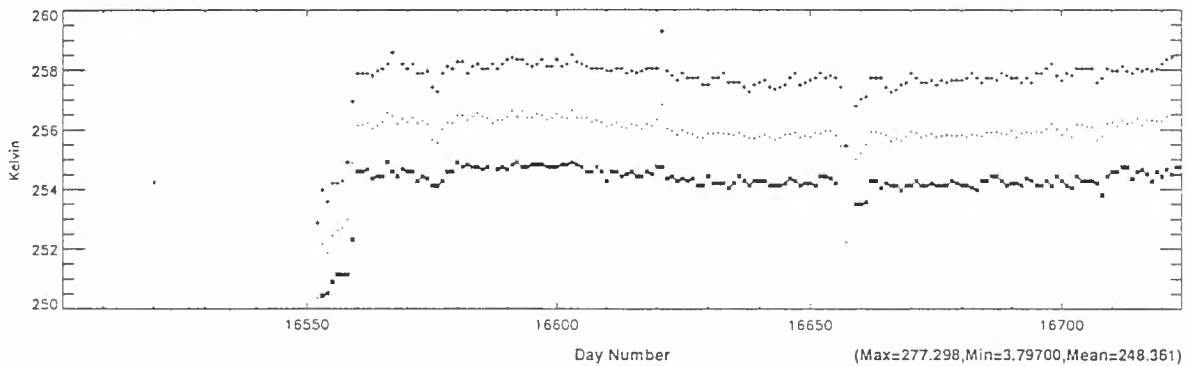
F018C (ATSR2): AT PXBB TEMP - +XBB Temperature 1



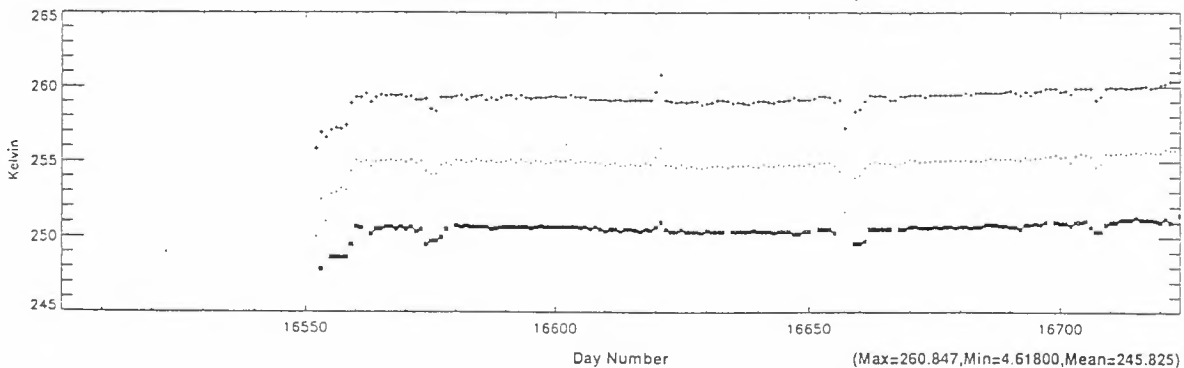
F019C (ATSR2): AT MXBB TEMP - -XBB Temperature 1



F551 (ATSR2): AT F STOP TEMP1 - Paraboloid mirr.aptre. stop temp



F555 (ATSR2): AT FPA BAFF TEMP - FPA Baffle Temperature





ATSR-2 In Flight Performance

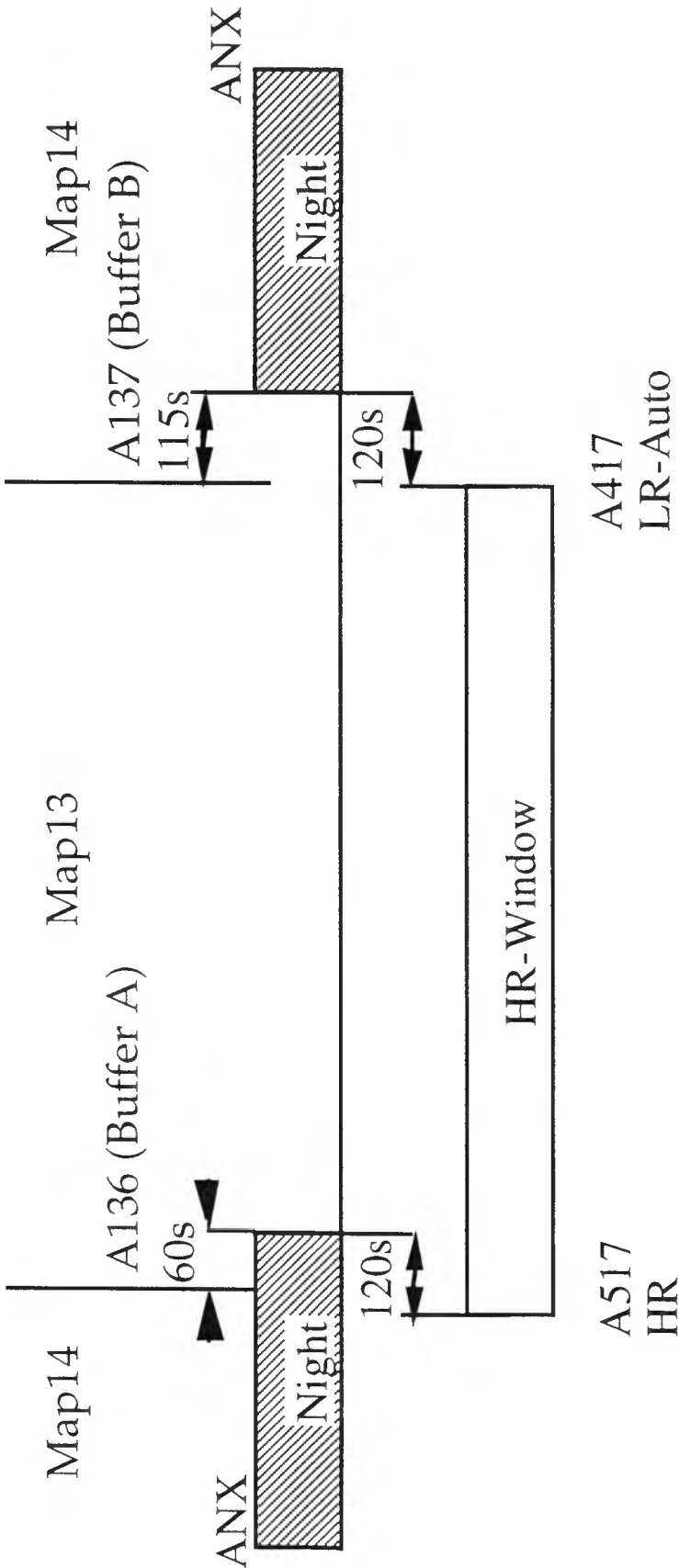
ATSR-2 Data Formatting

	IR	Visible	Usage
H-Rate	All ATSR-1 channels + 12bits	500km swath in both views + 12 bits.	Over land during daytime (see MPS)
Map 12	No Data	Full swath width + 12bit digitisation.	Outgassings
Map13	As for ATSR - 1	180km swath width + 12 bits	Daytime only during last 21 days of calendar month (see MPS).
Map14	As for ATSR - 1	670nm + 870 nm • Full swath + 8bits in Nadir • Alternate (Interlaced) pixels in Along-Track + 8bits 555nm • 300 km swath + 8bits in Nadir	Day + Night during first 9/10 days of calendar month. Nigh time only during remaining 21 days



ATSR-2 In Flight Performance

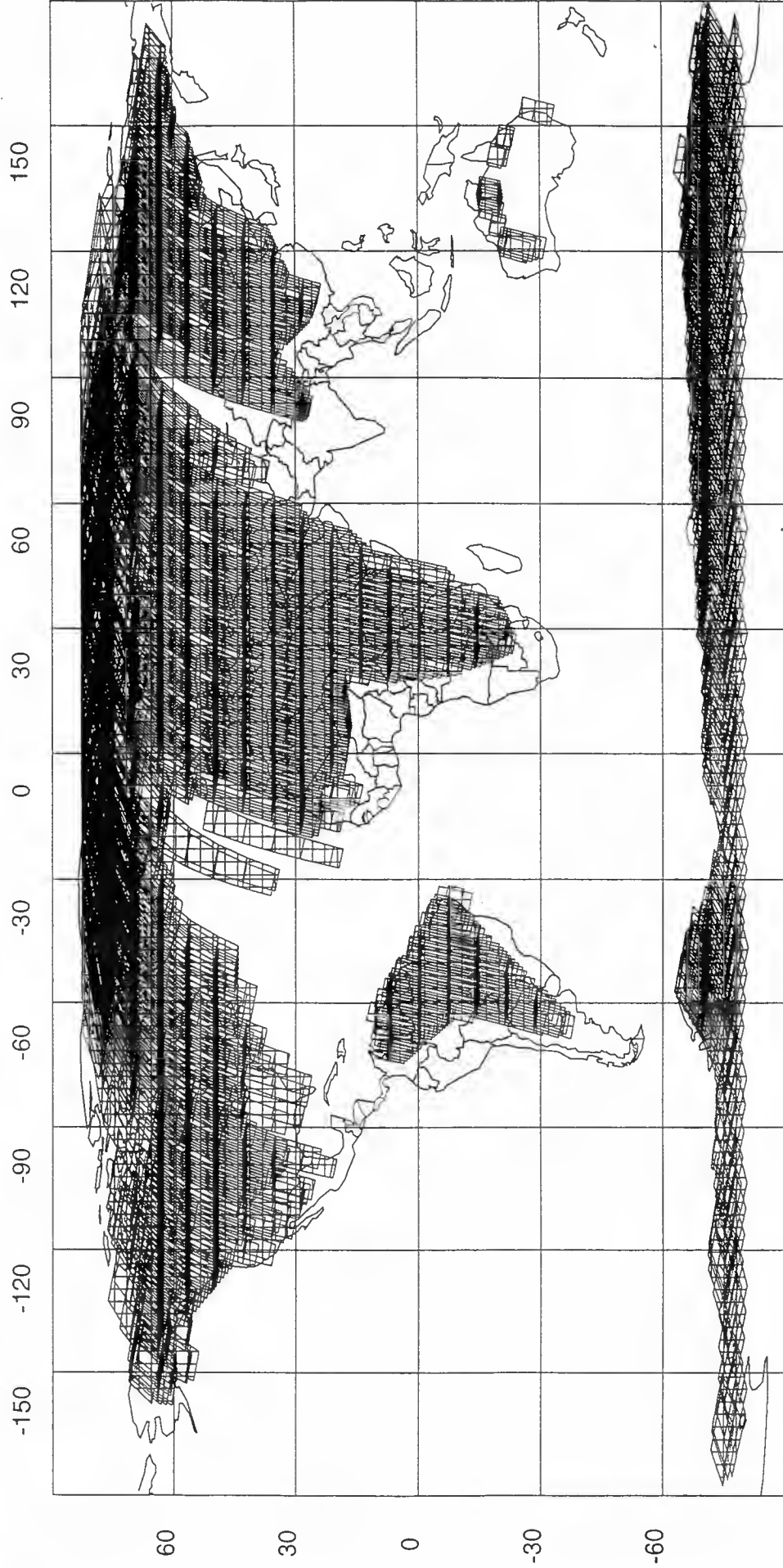
ATSR-2 MPS Scenario



Eclipse exit margin = -120s
Eclipse entry margin = -120s



ATSR-2 In Flight Performance



ATSR-2 H-Rate Coverage for
the month of September 1995
ESA/ESTEC/NW, ERS-2, 35-day repeat orbit (501), -71.723 deg First Orbit 1910 Last Orbit 2338



ATSR-2 In Flight Performance

Stirling Cycle Cooler

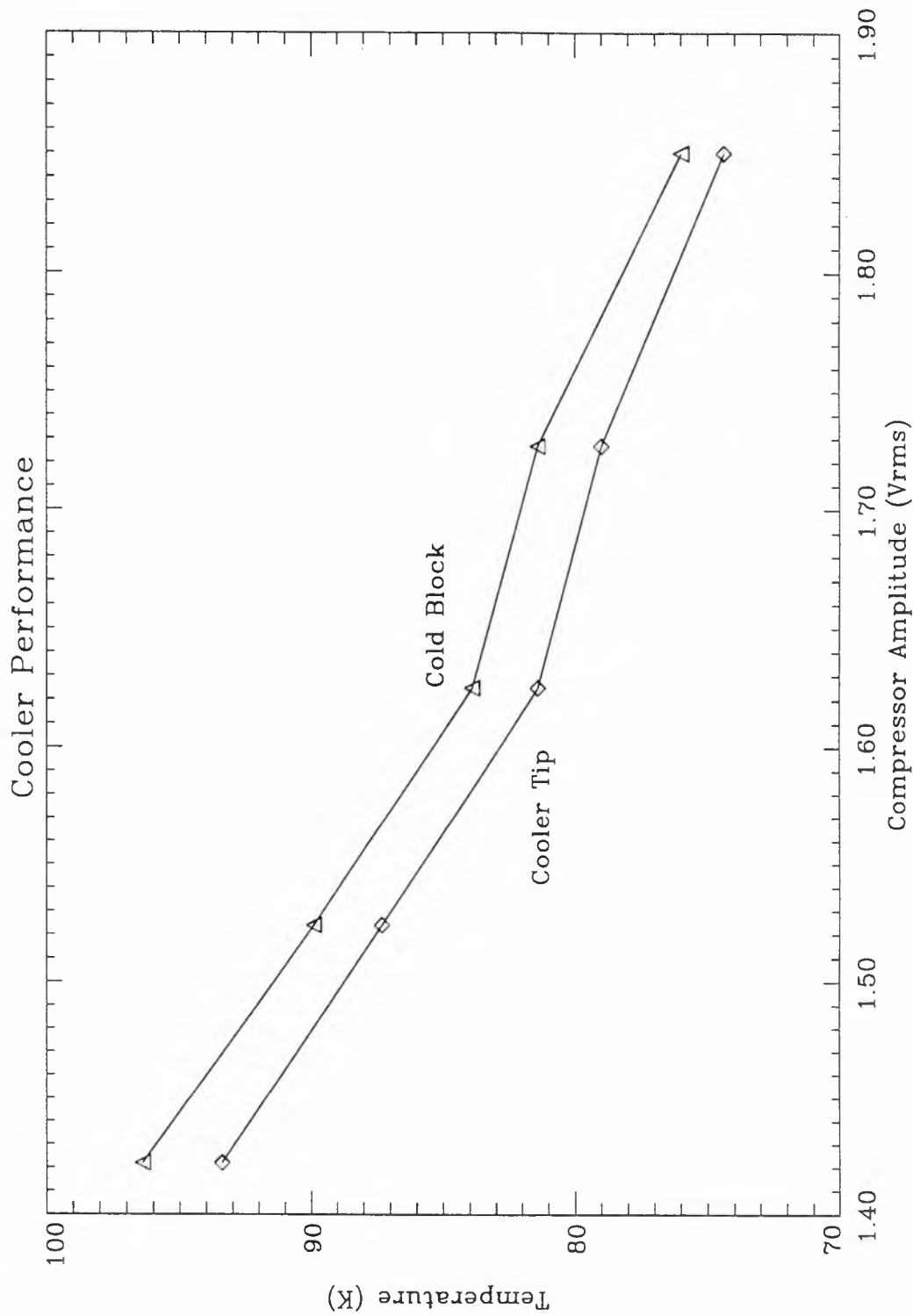
- Basic cooling performance evaluated by 9th May
- Turned on 4th May. Detectors cooled to 80K within 7hrs.
- Detectors stable to within $\pm 0.3\text{K}$ around an orbit (for ATSR-1 this was $\pm 1\text{K}$).
- The compressor amplitude forcing action has been tested. Requires software modification to enable control off different temperature sensor.
- So far 2 outgassings have been performed (19-22/5/95 and 9-13/8/95).

Outstanding Activities:

- Optimise forcing action
- Optimise Auto/Gain Offset Loop parameters (Period, Rate).



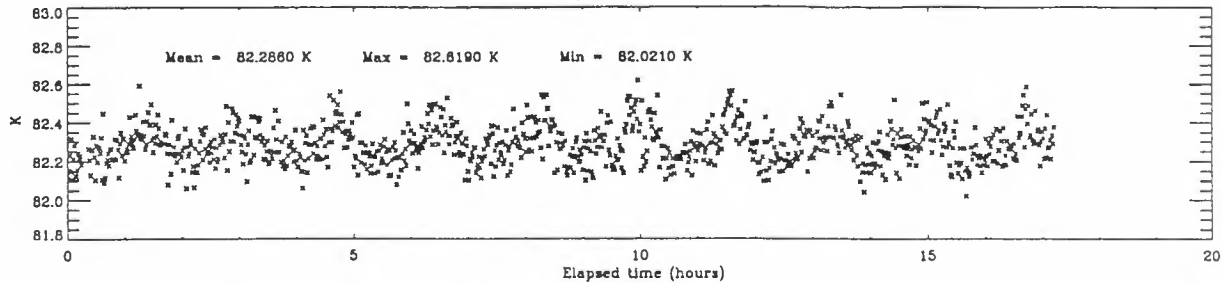
ATSR-2 In Flight Performance



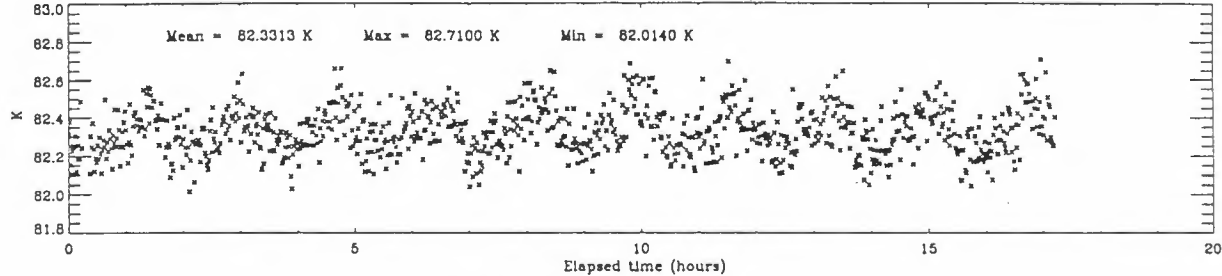


ATSR-2 In Flight Performance

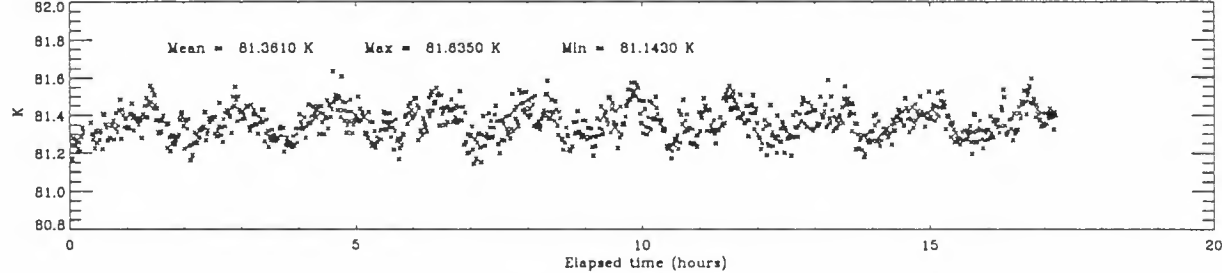
ATSR-2 10th September 1995
TM.Z 582 1.6 μ m Detector Temperature



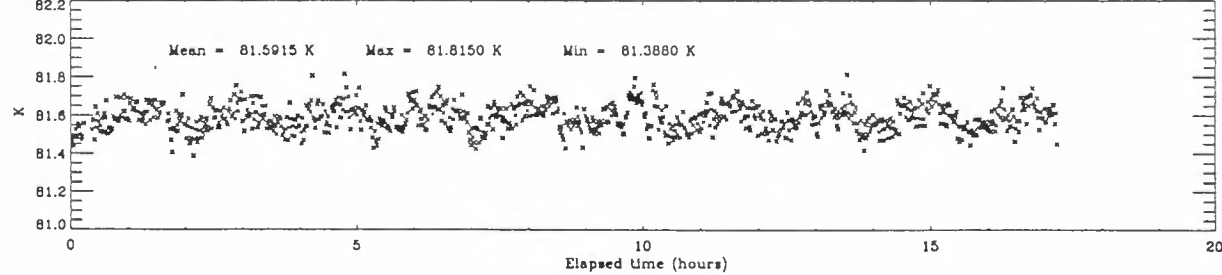
TM.Z 583 3.7 μ m Detector Temperature



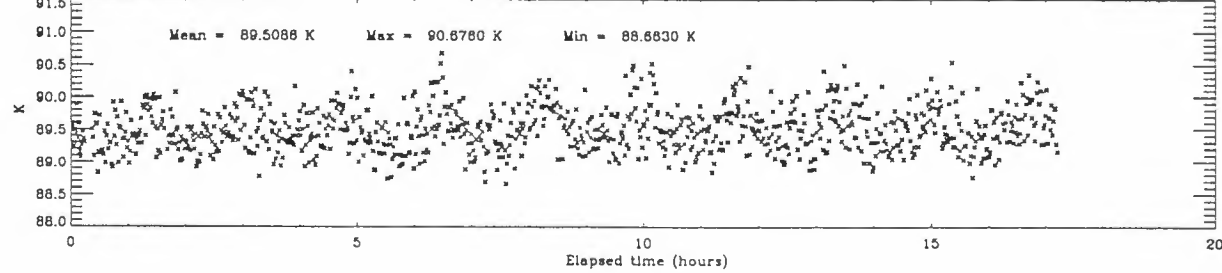
TM.Z 584 11 μ m Detector Temperature



TM.Z 585 12 μ m Detector Temperature

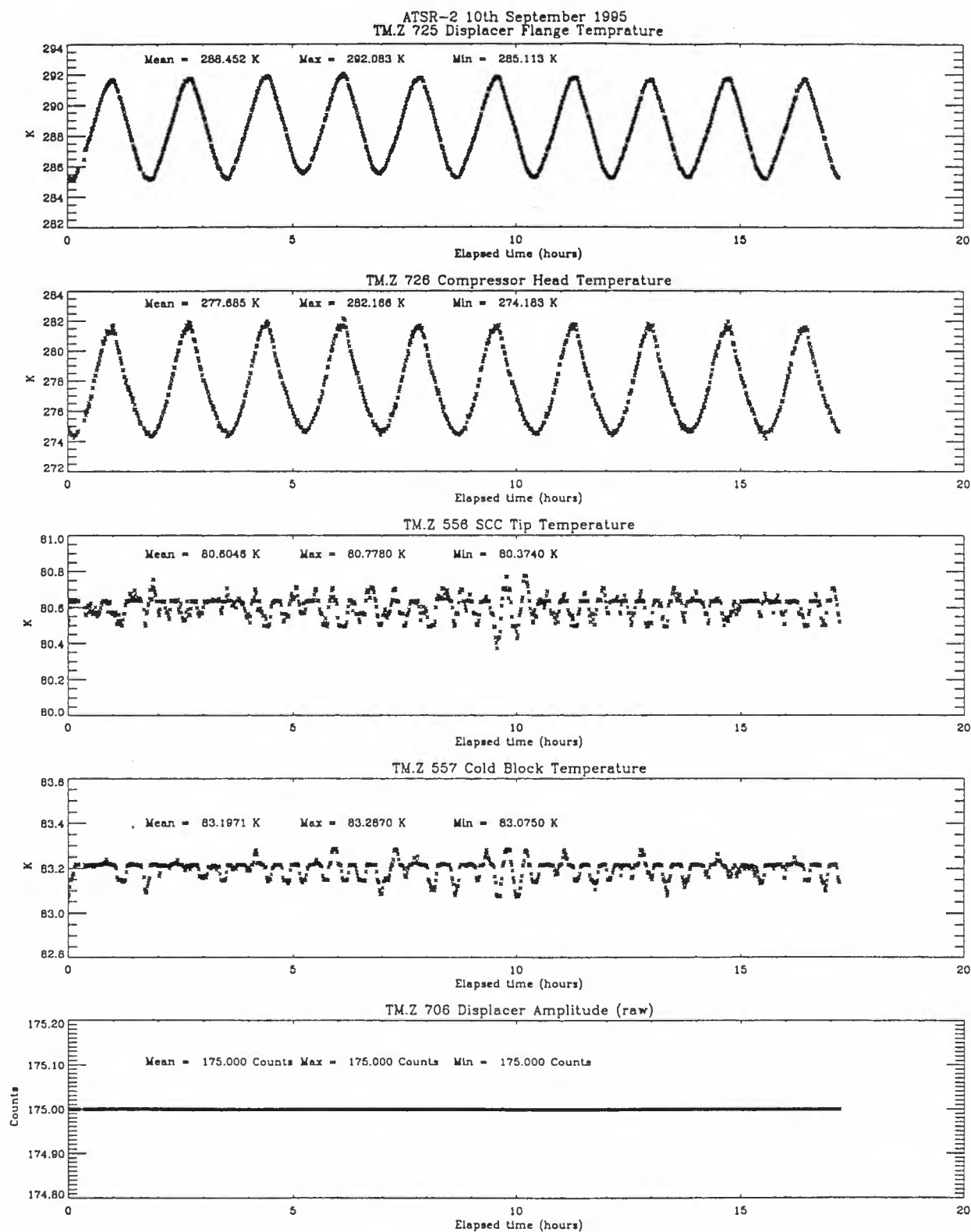


TM.Z 586 FPA Baseplate Temperature





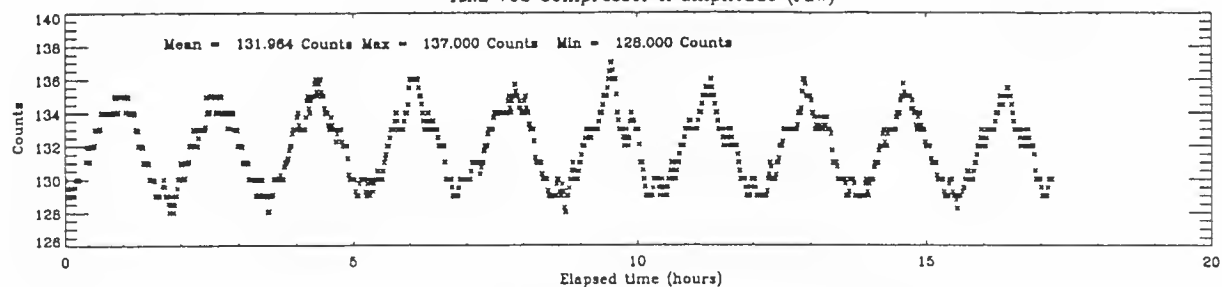
ATSR-2 In Flight Performance



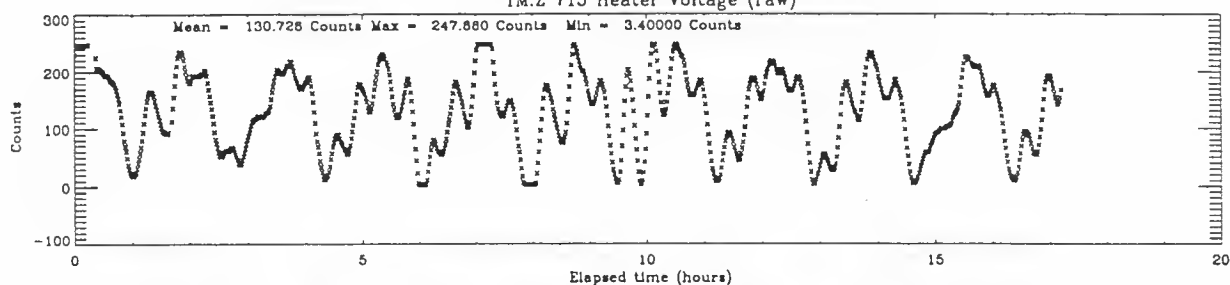


ATSR-2 In Flight Performance

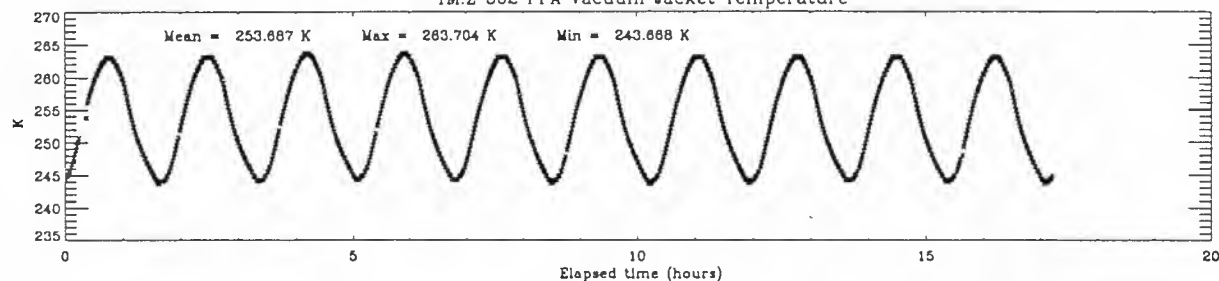
ATSR-2 10th September 1995
TM.Z 702 Compressor A amplitude (raw)



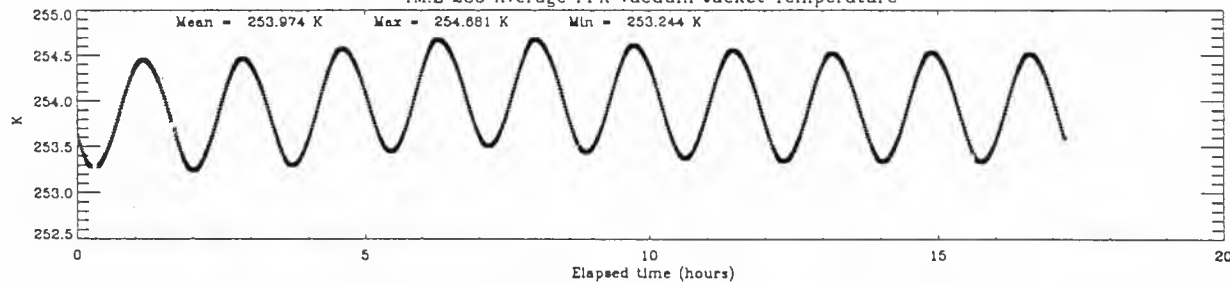
TM.Z 715 Heater Voltage (raw)



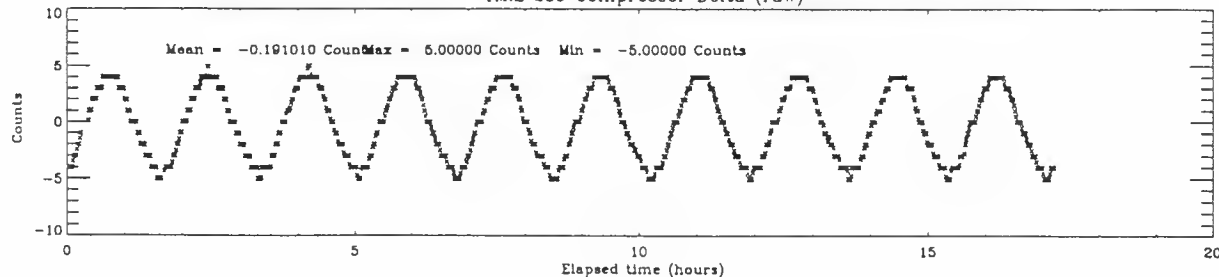
TM.Z 502 FPA Vacuum Jacket Temperature



TM.Z 288 Average FPA Vacuum Jacket Temperature



TM.Z 289 Compressor Delta (raw)





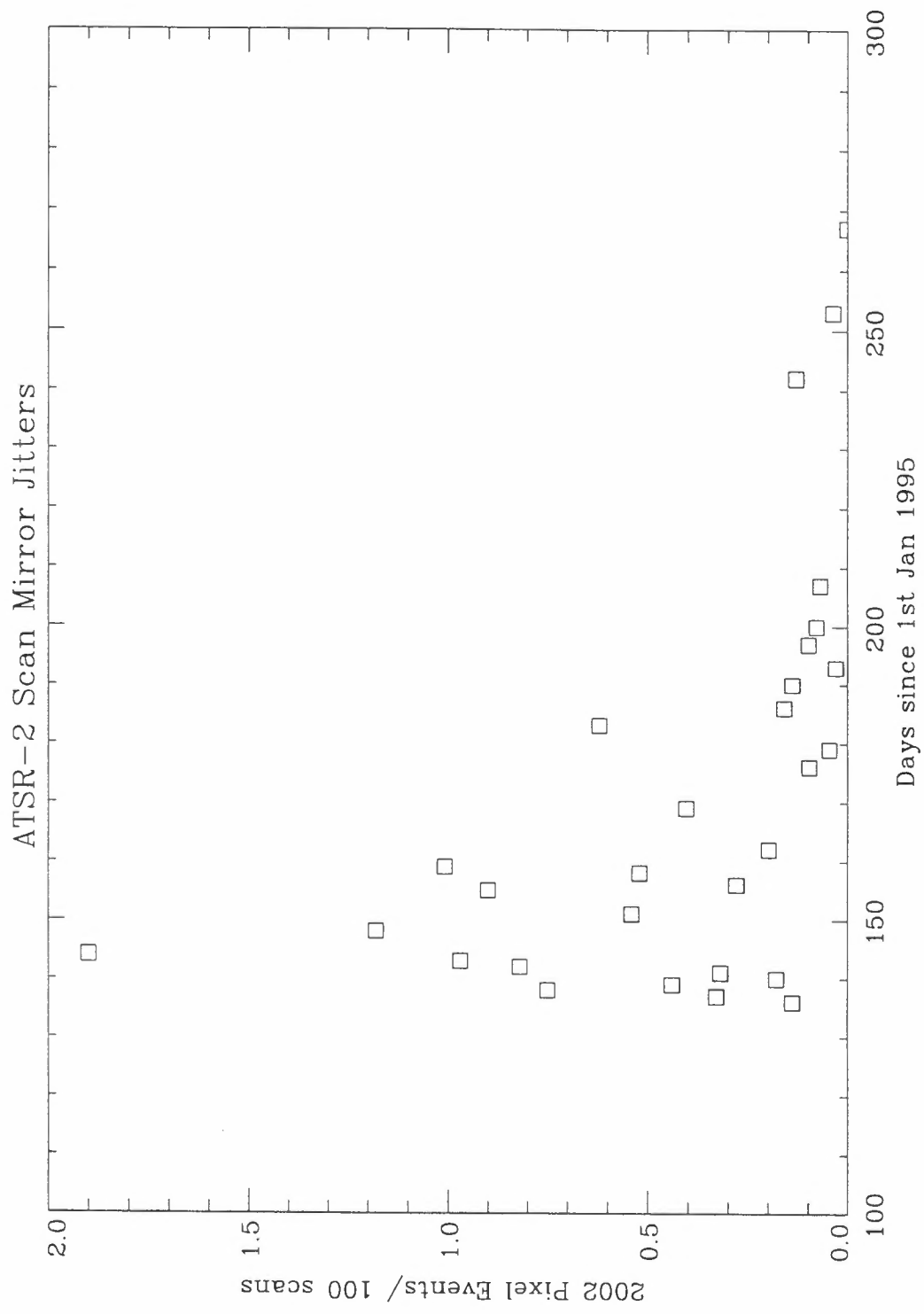
ATSR-2 In Flight Performance

Scan Mechanism

- Scan mechanism has been showing significant levels of 'Jitters' since launch. Effect clearly visible in along track images.
- Unable to maintain fine control of mechanism.
- Slight temperature excursions have been associated with 'bursts' of jitters.
- No obvious correlation with other PL activity.
- Probable cause is the wearing in of the mechanism bearings.
- Number of events detected by snapshot data has steadily decreased with very few events since mid September.



ATSR-2 In Flight Performance





ATSR-2 In Flight Performance

Black-Bodies

- Typical orbital temperature variation around $\pm 0.35\text{K}$ (hot BB) and $\pm 0.25\text{K}$ (cold).
- With detectors at 80K typical black-body pixel counts + NEATs are:-

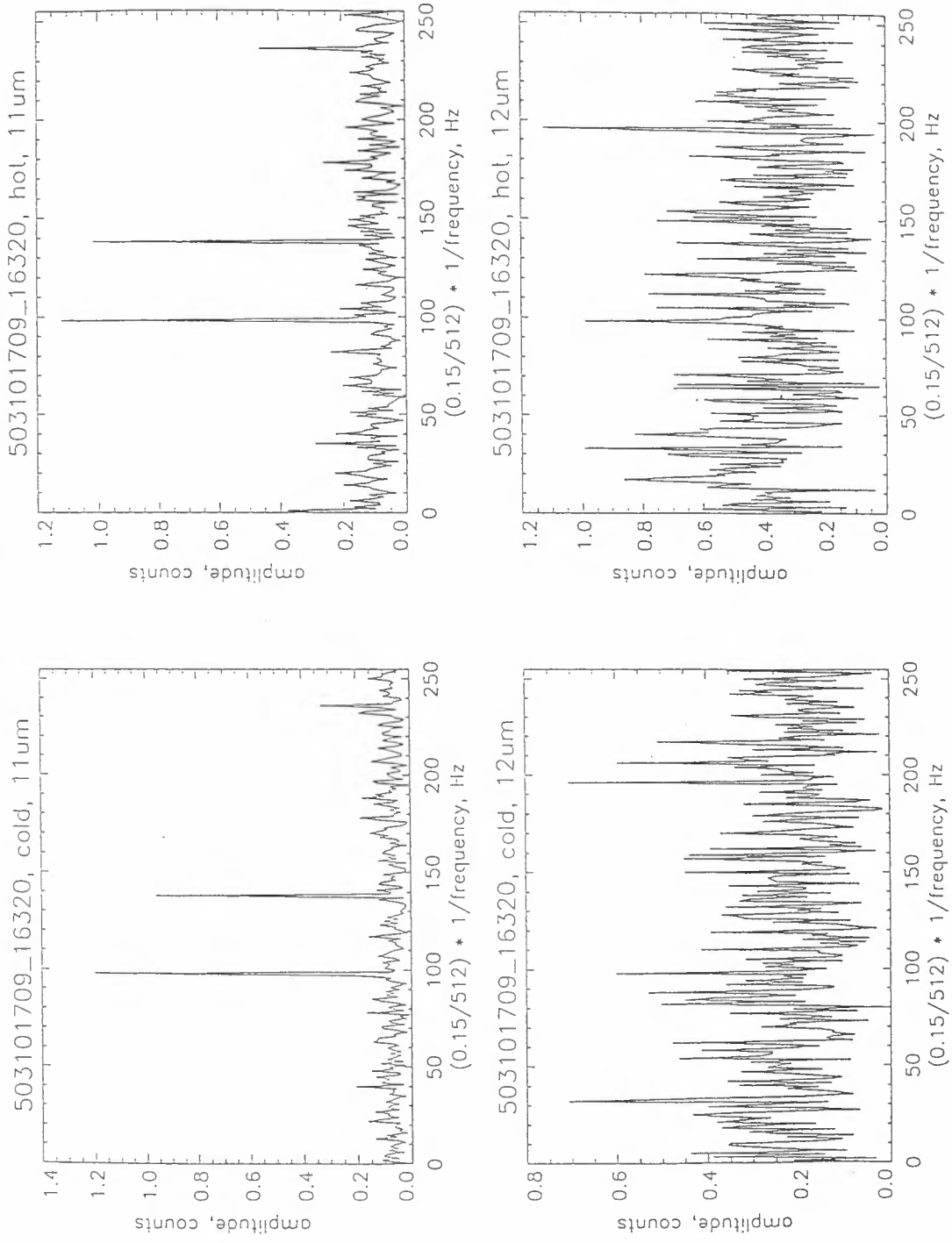
	+XBB (T= 297.1 K)		+XBB (T= 259.3K)	
	Counts	NEAT (K)	Counts	NEAT (K)
3.7 μm	2261	0.026	429	0.064
11 μm	2803	0.046	1361	0.044
12 μm	2935	0.036	1438	0.037
11-12 μm	140		80	

- Auto gain offset period of 512 scans ensures that 11-12 μm difference is positive for normal measurement range.
- The pixel noise due to cooler pick-up is insignificant.



ATSR-2 In Flight Performance

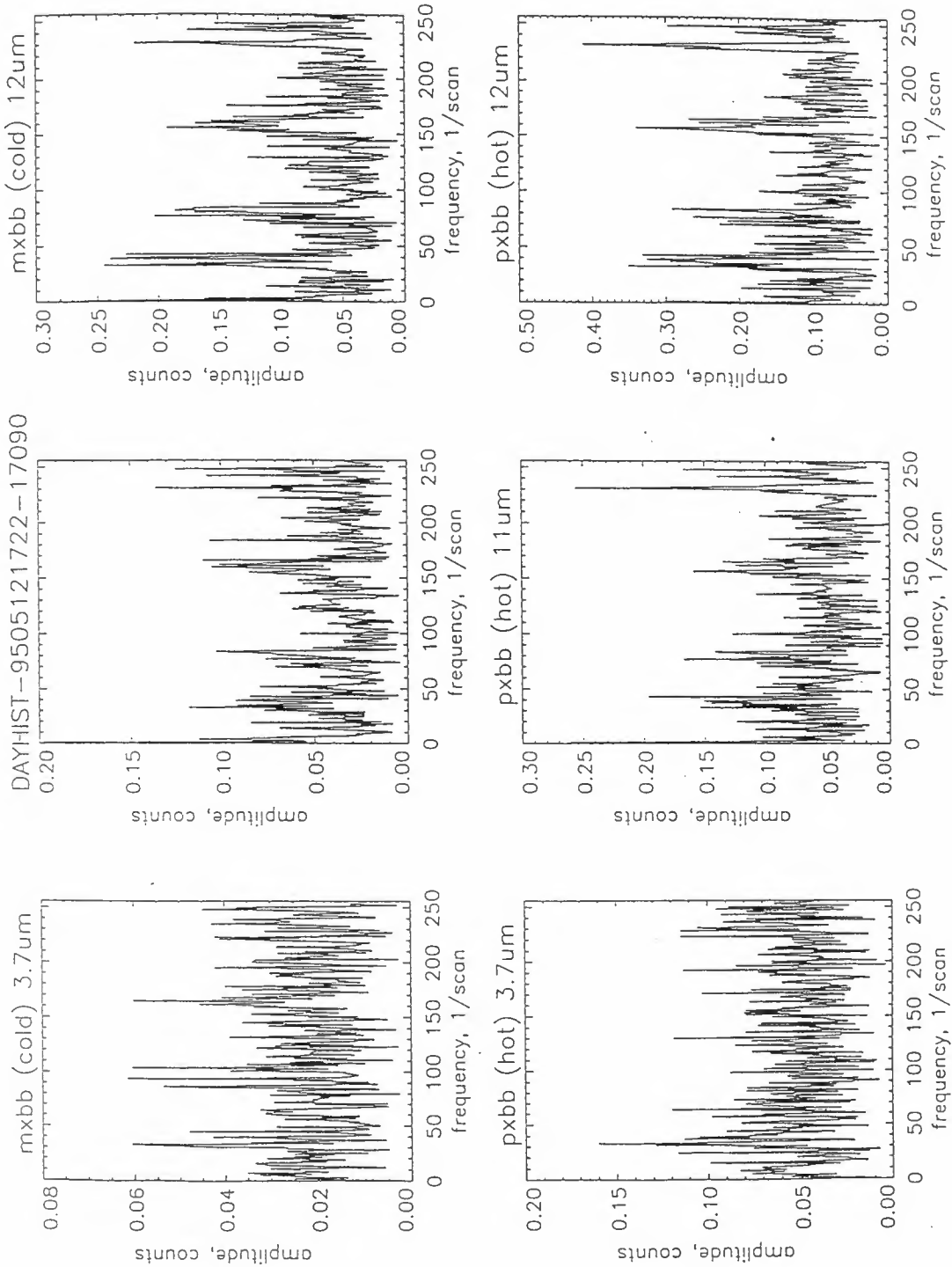
Cooler pick-up, ATSR-1





ATSR-2 In Flight Performance

Cooler pick-up, ATSR-2





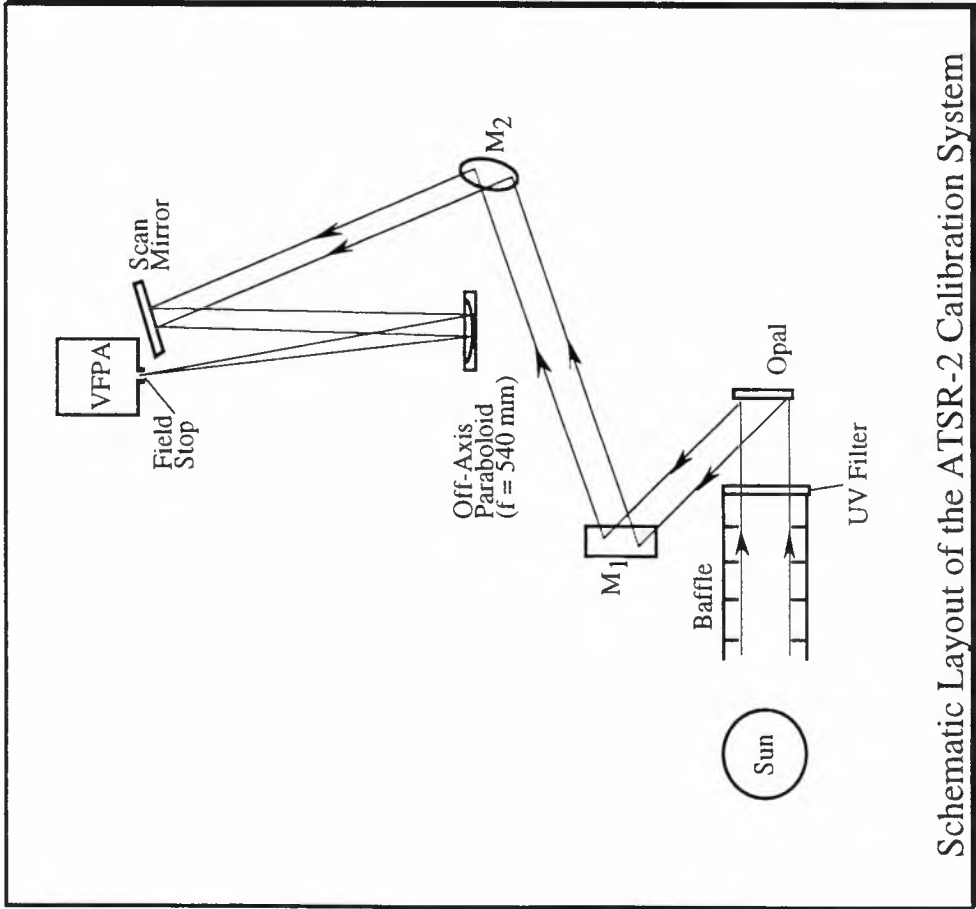
ATSR-2 In Flight Performance

- A test was performed to assess the radiometric performance of the targets by switching over the hot and cold black-bodies and comparing the cross-over times of the signals and baseplate temperatures.
- The effective temperature differences between the PRT measured temperatures and brightness temperatures were found to be:-

	+XBB	-XBB
3.7μm	-0.0047 K	0.0024 K
11μm	-0.0027 K	0.0010 K
12μm	-0.0015 K	0.0009 K

ATSR-2 In Flight Performance

Visible Calibration System (VISCAL)



Schematic Layout of the ATSR-2 Calibration System

Viscal throughput =

$$K_{\lambda} = \frac{A_{m2}}{A_{ATSR-2}} \cos(\pi/4) \tau_{uv,\lambda} r_{m1,\lambda} r_{m2,\lambda} R_{\lambda} (\pi/4)$$

where

A_{m2} = area of m2 footprint on opal

A_{ATSR-2} = Aperture area of ATSR-2

$\tau_{uv,\lambda}$ = transmission of uv filter at wavelength λ

$r_{m1,\lambda}$ $r_{m2,\lambda}$ = reflectance of mirrors m1 and m2

$R_{\lambda} (\pi/4)$ = radiance factor of opal

Ground Reflectance =

$$\frac{\pi I_{\lambda}}{I_{sun,\lambda}} = K_{\lambda} \frac{(C - C_{off})}{(C_{vcal} - C_{off})}$$



ATSR-2 In Flight Performance

- Visal at full solar illumination for ~ 30s.

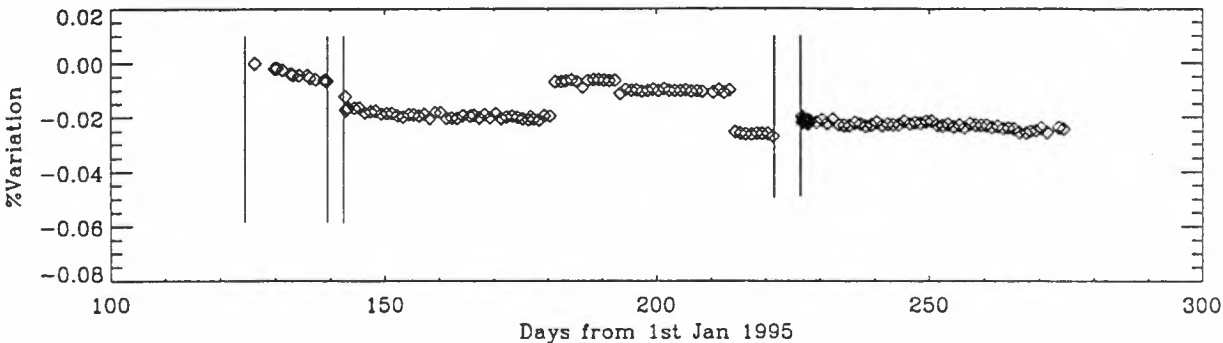
	1600nm	555nm	659nm	870nm
Mean background signal (from -XBB)	100±1	100±1	100±1	100±1
Typical Noise Levels at 12% albedo	< 2%	< 1%	< 1%	< 1%
Deterioration in signal over 3 months	<2%	<2%	<1%	<1%
Stability between successive orbits.	<0.1%	<0.1%	<0.1%	<0.1%

- Oscillations observed in 555, 659 and 870nm channels. Effect is due to build up of condensation on relay lens mounted on cold FPA.
- Period of oscillations gives indication of change in outgassing rate.

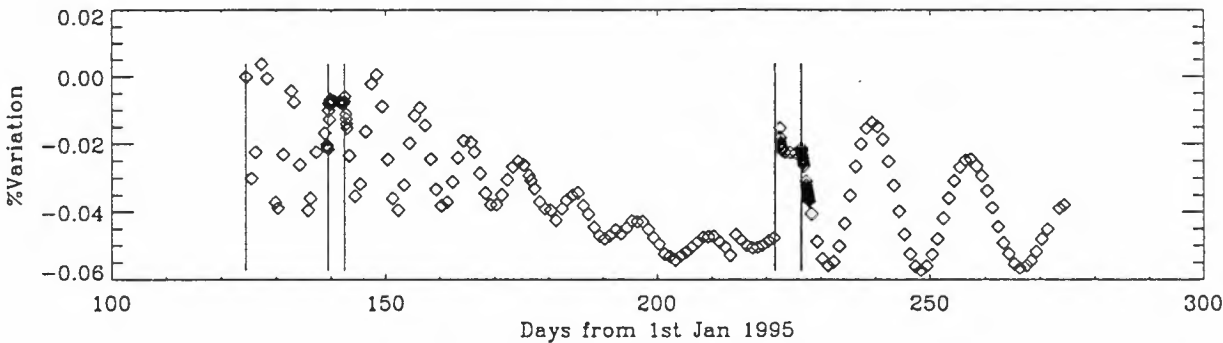


ATSR-2 In Flight Performance

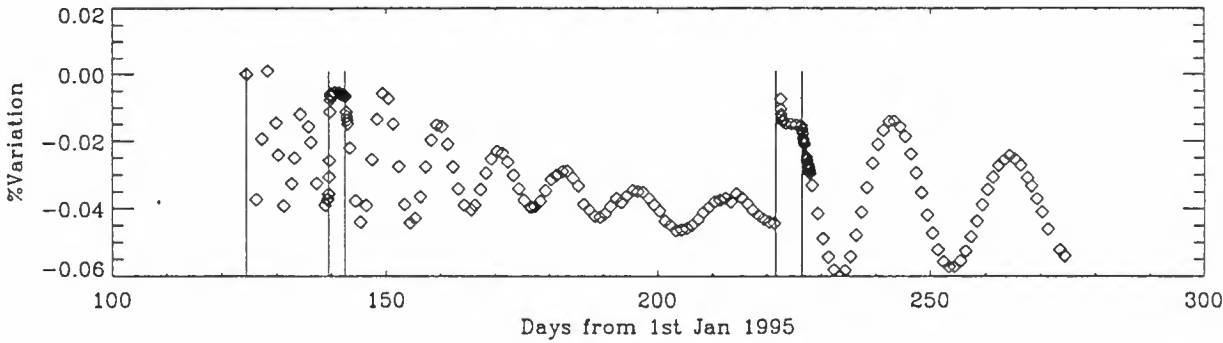
% Variation in Viscal Slope Since Launch (Adjusted for solar input)
1.6 μ m Channel



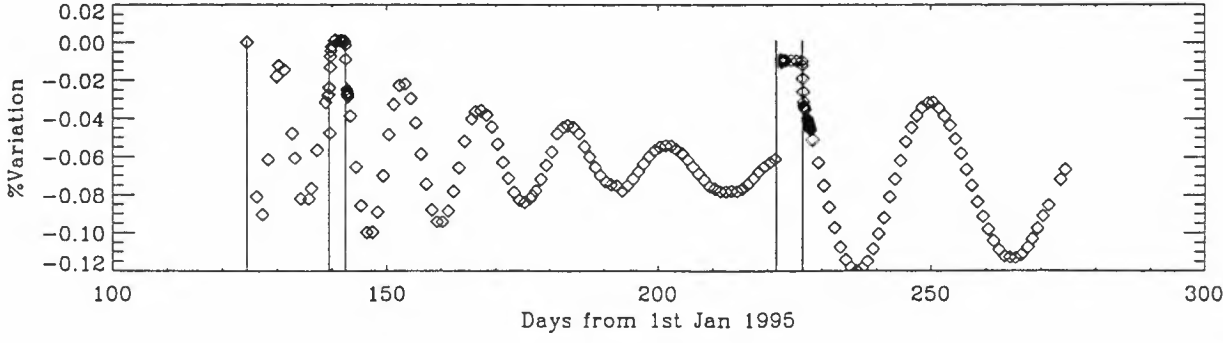
555nm Channel



659nm Channel

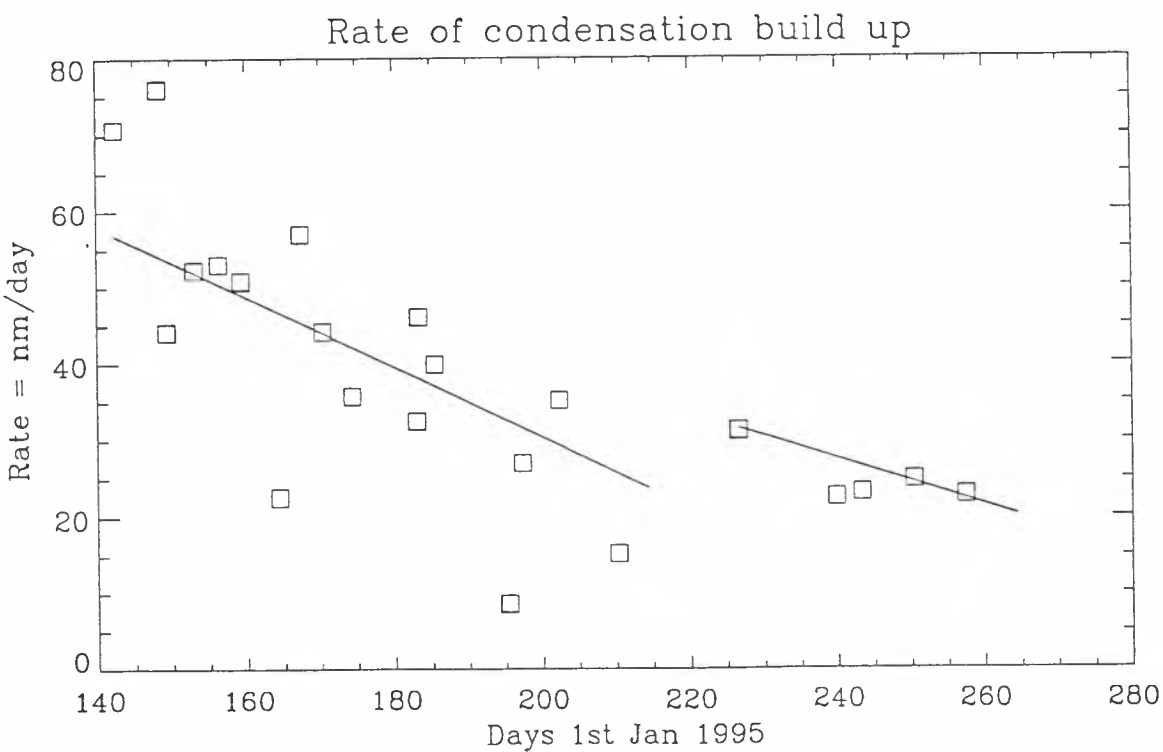
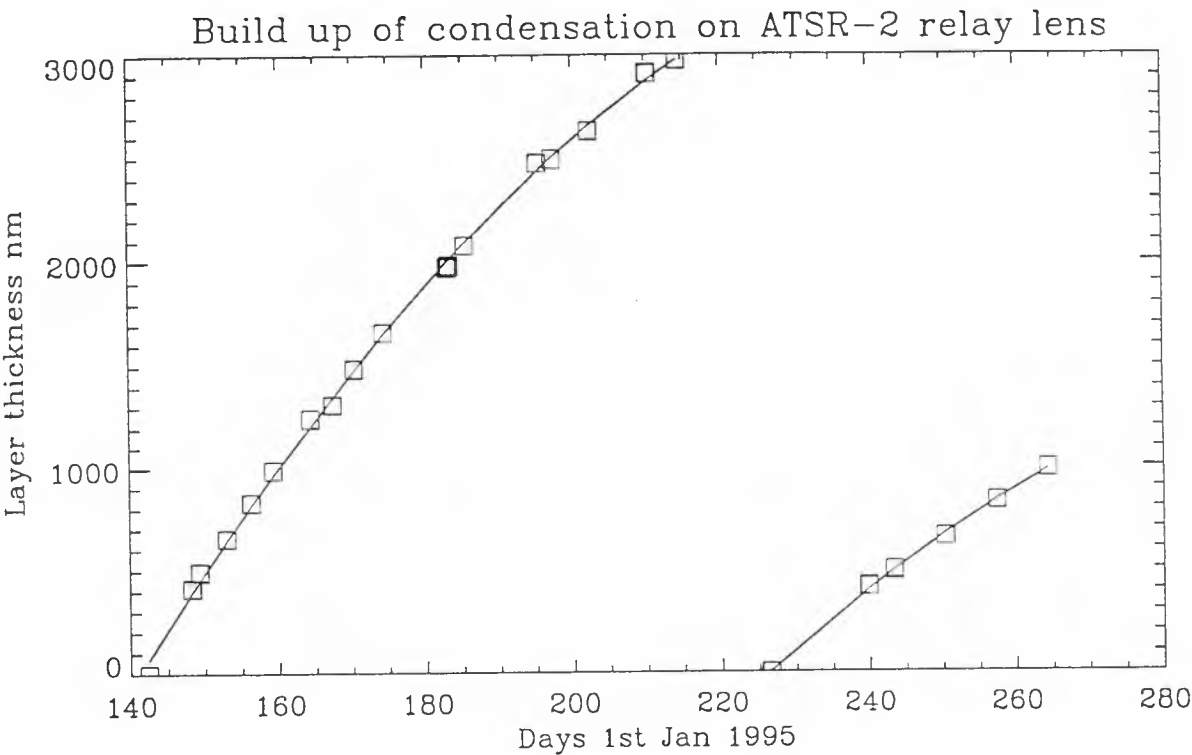


870nm Channel



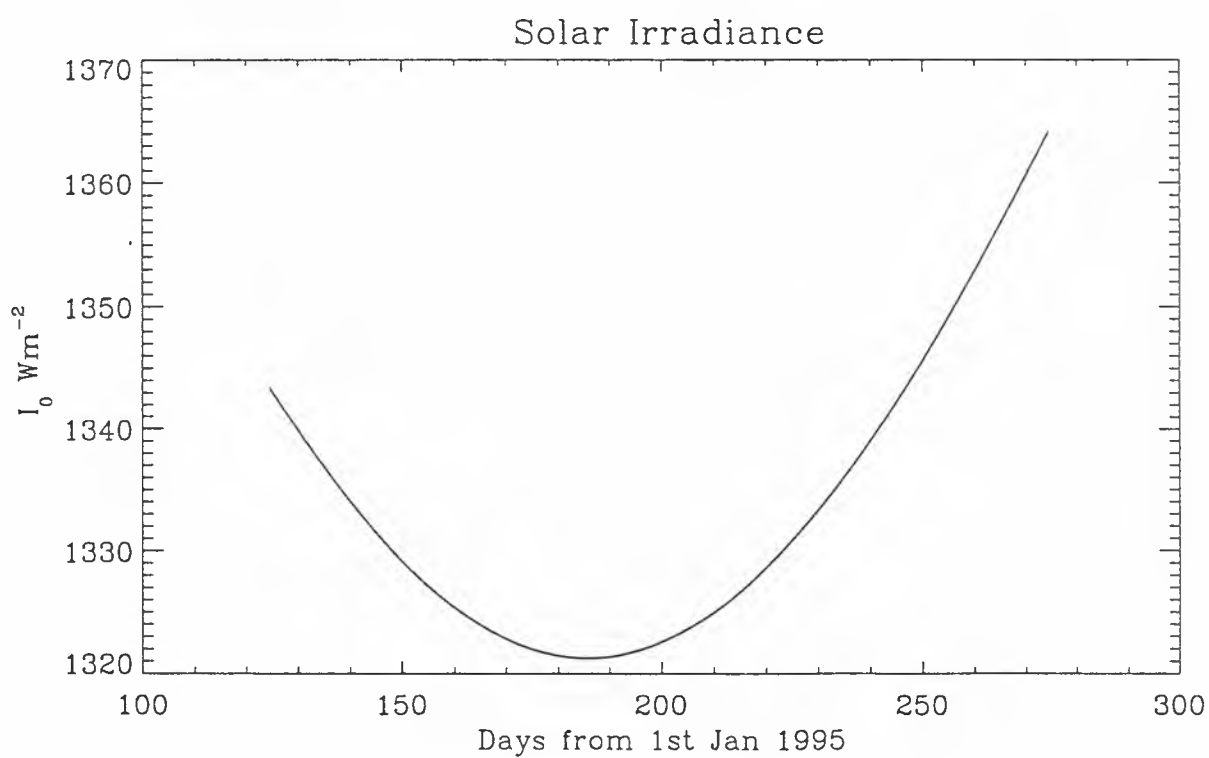
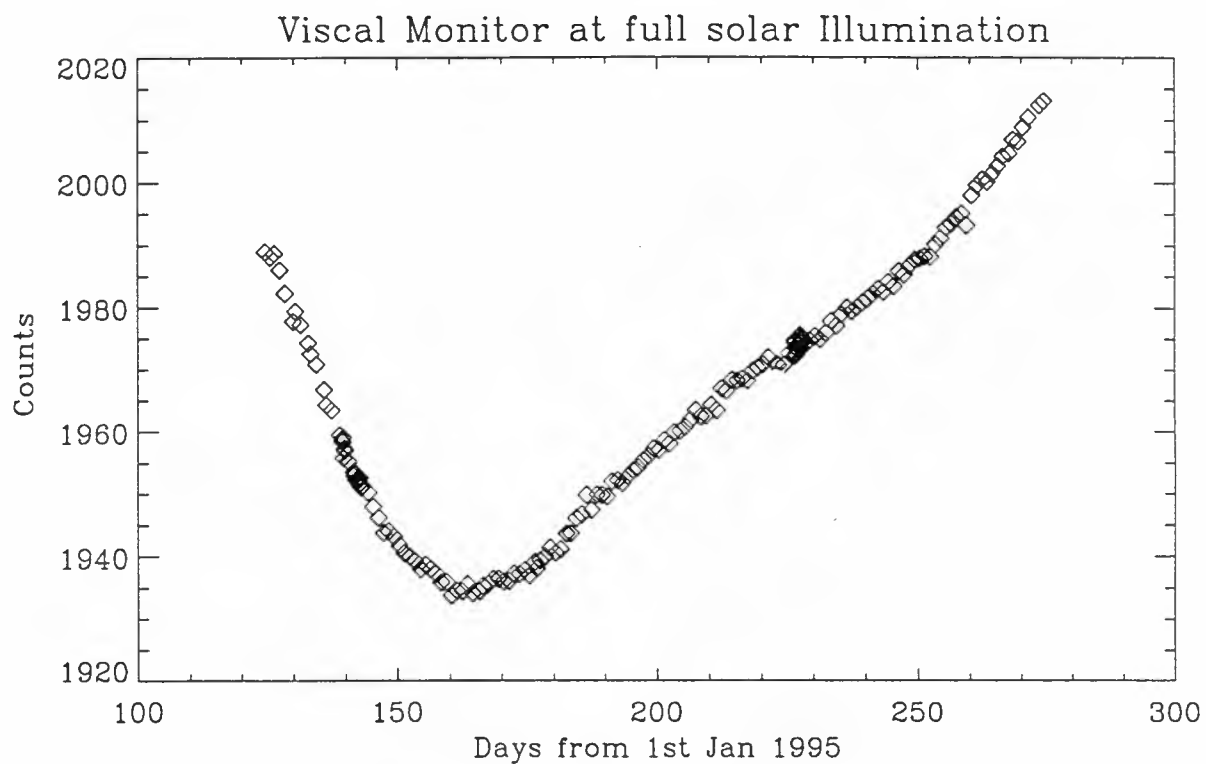


ATSR-2 In Flight Performance





ATSR-2 In Flight Performance





ATSR-2 In Flight Performance

Data Quality

- On the whole data packets are being down linked and transcribed with few anomalies.
- High rate data processing has been corrected though some refinements may be necessary
- A number of anomalies have detected which should be addressed:-

Corrupted packets - extra bits inserted causing isolated CRC errors.

Some instances of missing HR packets (H1 and H2).

Large burst of data errors on 18th May 1995 - ESRIN still to provide explanation.

MICROWAVE RADIOMETER (MWR-2)

F. Bosquillon (ESA/ESOC)
S. Boukabara (CETP)
W. Hoermanseder (Schrack Aerospace)
K.D. McMullan (ESA/ESTEC)



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MWR-2

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Objectives

- To measure near-nadir-viewing atmospheric brightness temperatures in the water vapour band at 23.8 GHz and the atmospheric window at 36.5 GHz to determine geophysical products such as water vapour and liquid water content.
- To determine an atmospheric height bias correction for the R.A. measurements from the above geophysical products.
- Secondary applications include monitoring of sea ice extent and evolution of polar ice over land.

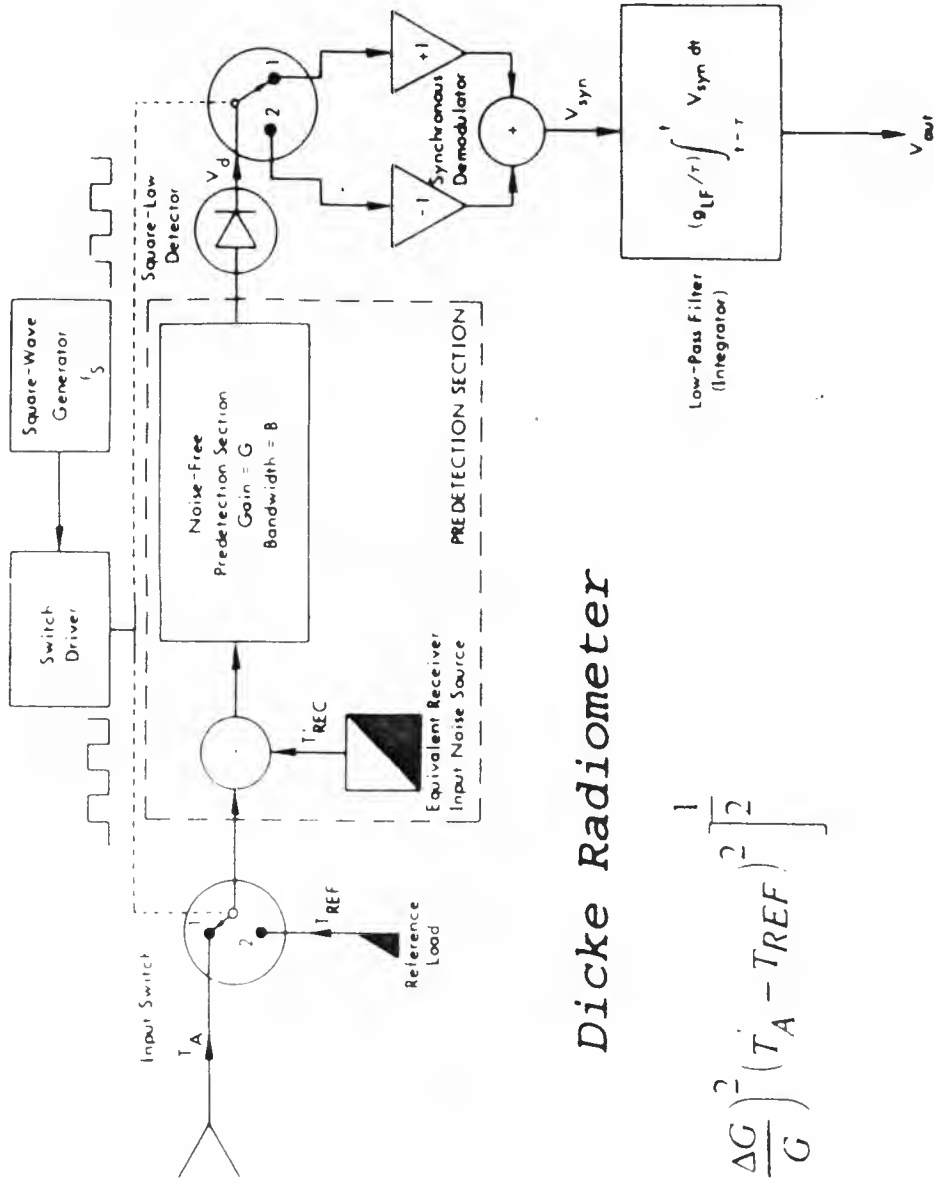


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Radiometer Type



Dicke Radiometer

$$\Delta T_{unbalanced} = \left[4\Delta T_{ideal}^2 + \left(\frac{\Delta G}{G} \right)^2 (T_A - T_{REF})^2 \right]^{\frac{1}{2}}$$

$$\Delta T_{ideal} = \frac{T_A + T_{REC}}{(B\tau)^{1/2}}$$

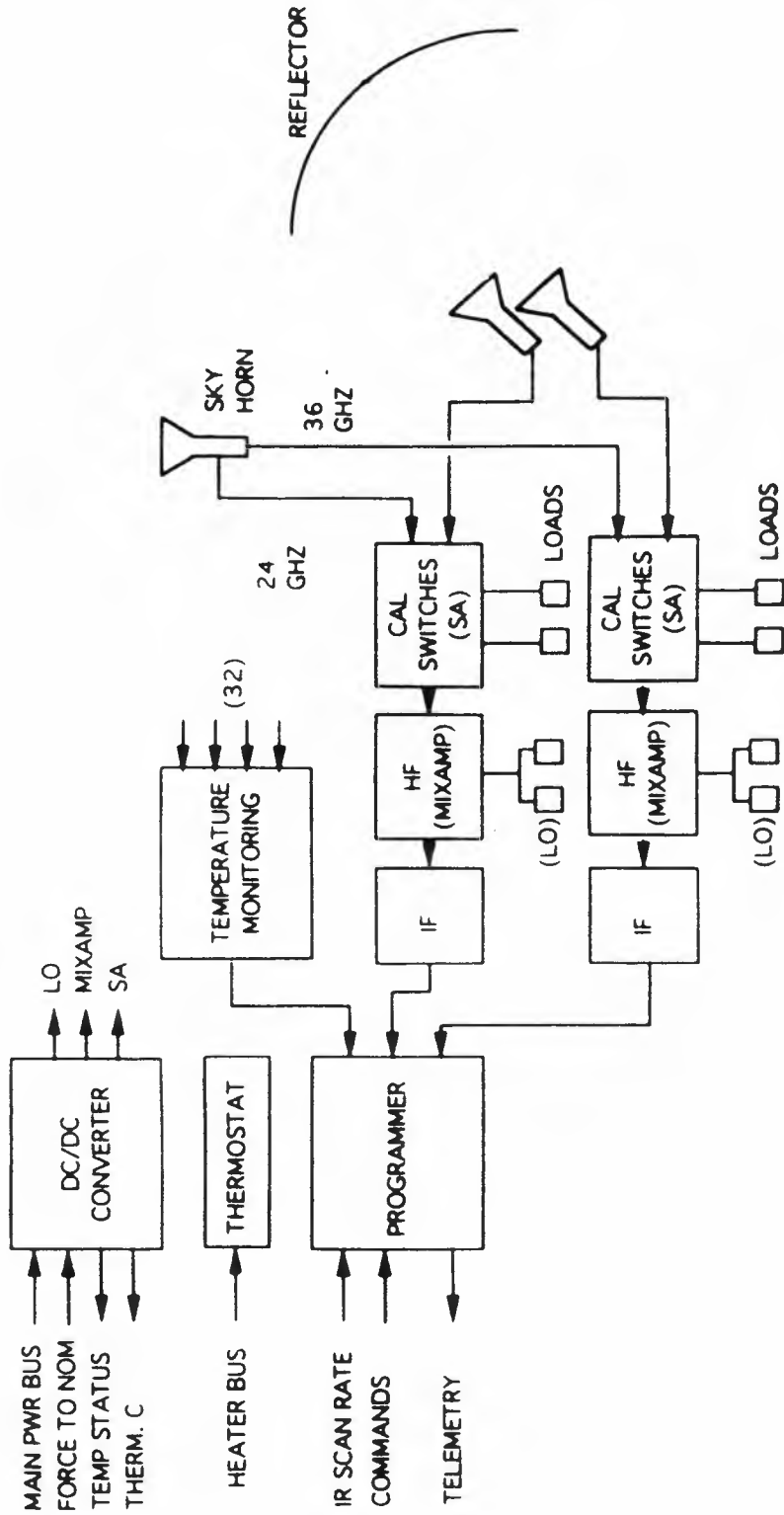


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Radiometer Block Diagram

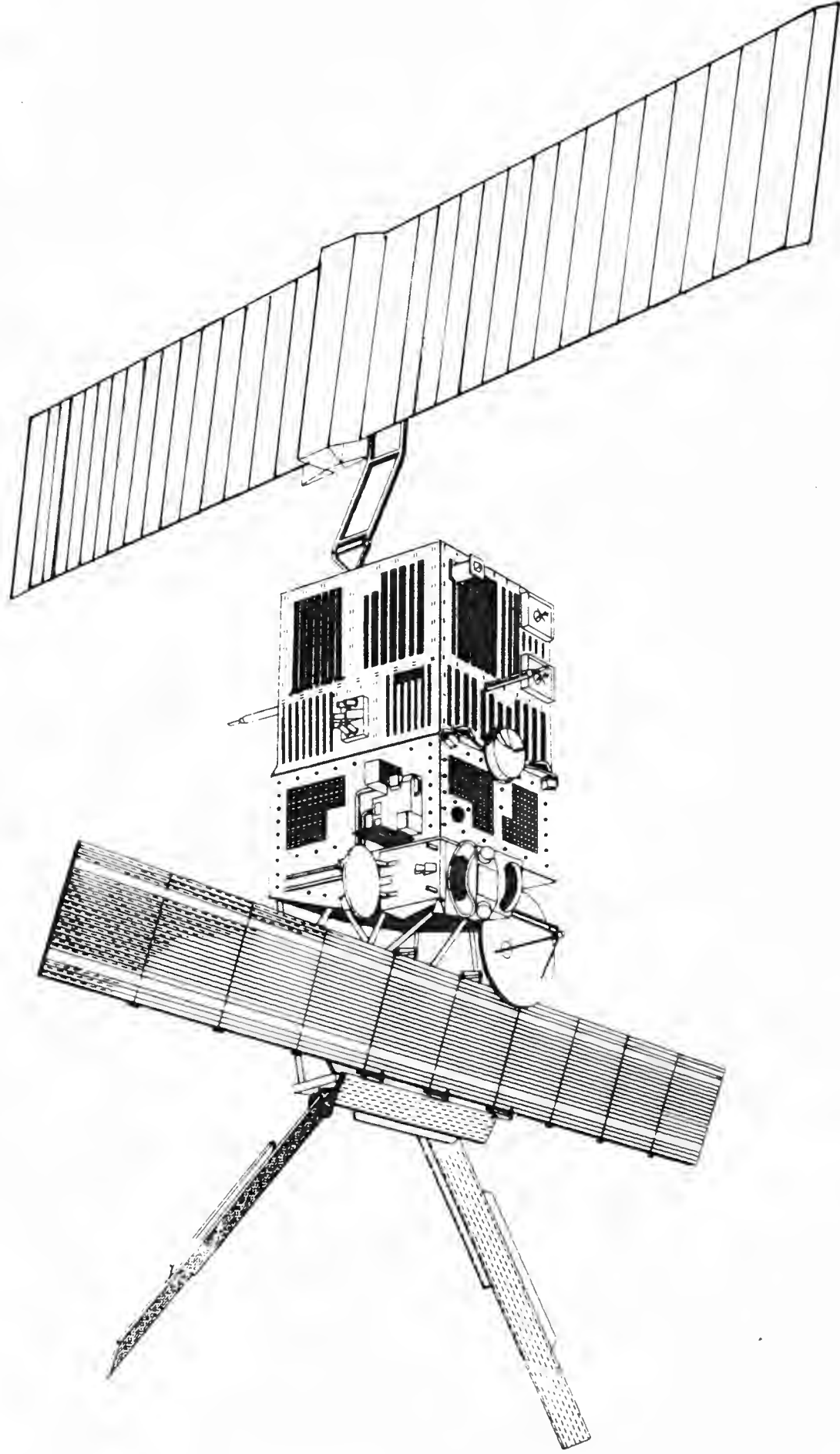




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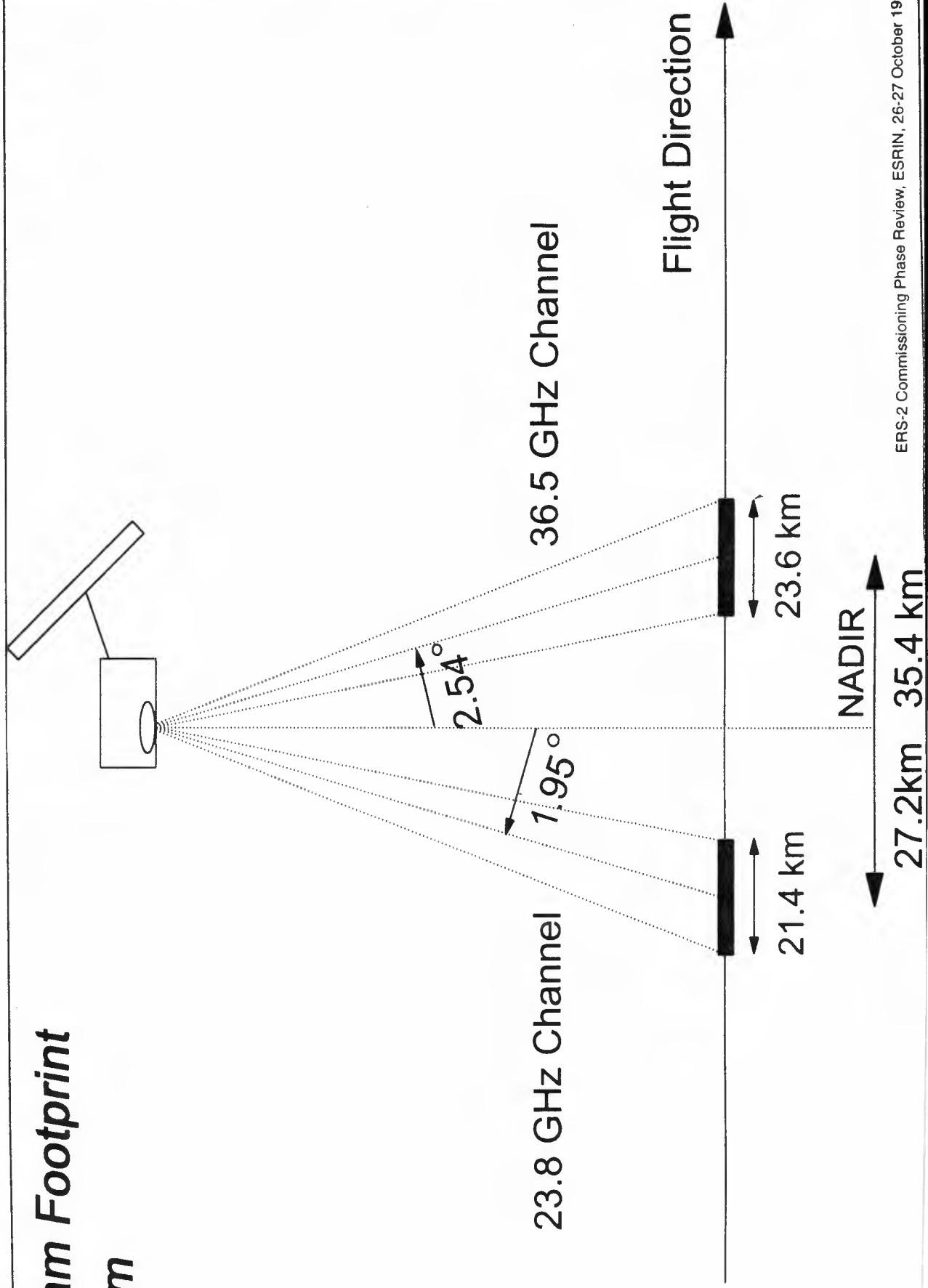


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**RF Beam Footprint
Diagram**

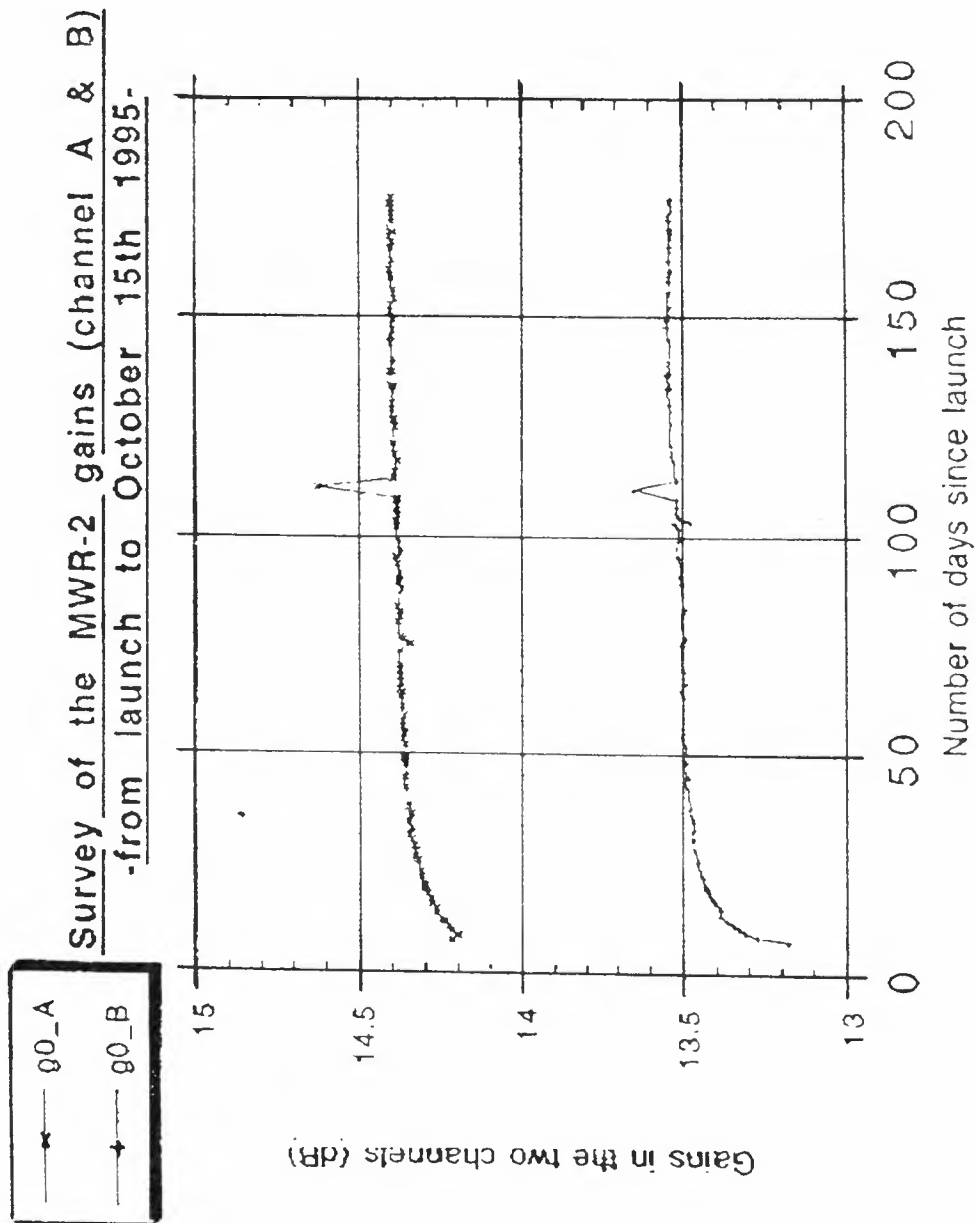




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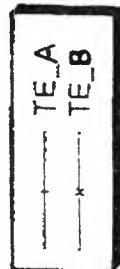




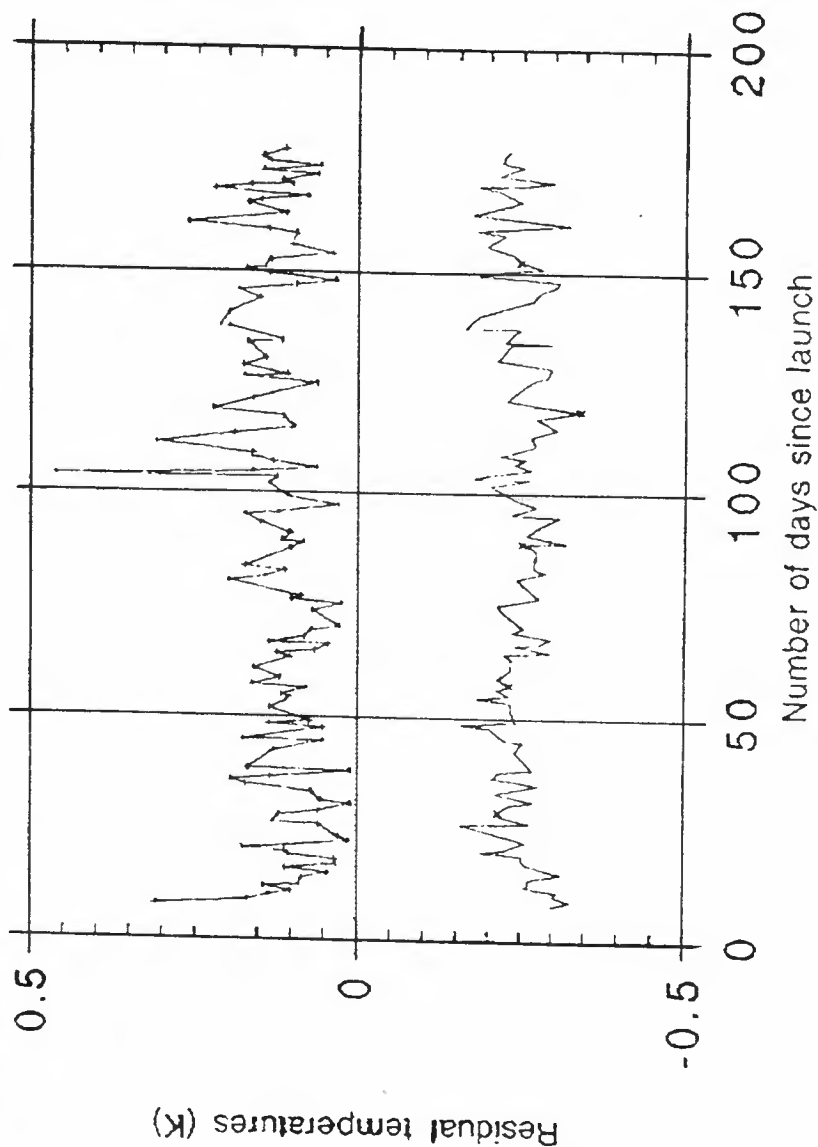
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Survey of the MWR-2 residual temperatures
(two channels) until October 15th 1995





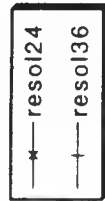
esa

MWR-2

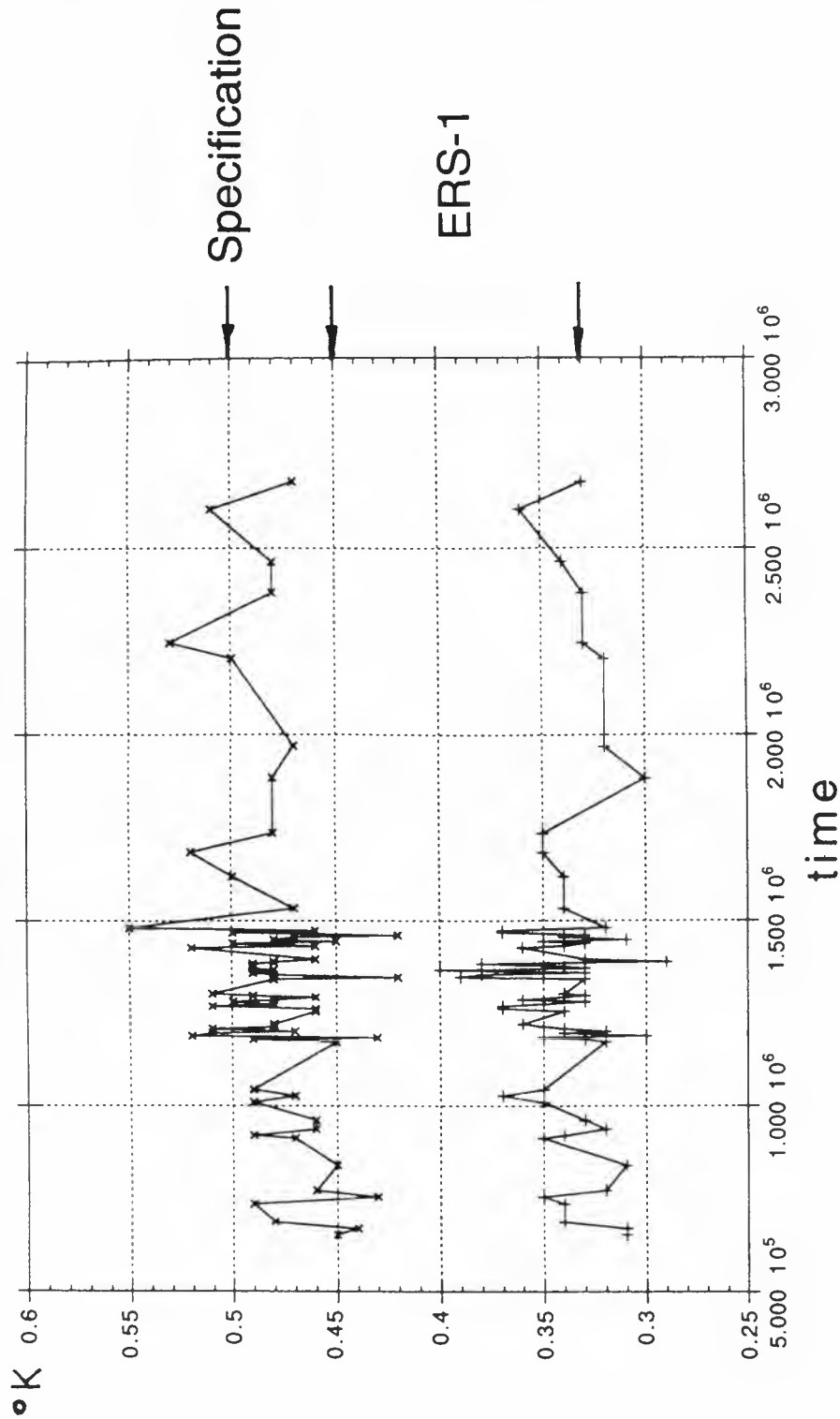
ERS-2

Radiometric Resolution

MWS RESOLUTION IN THE TWO CHANNELS (ΔT_{min})



28apr-21may-95_ERS2.Resol

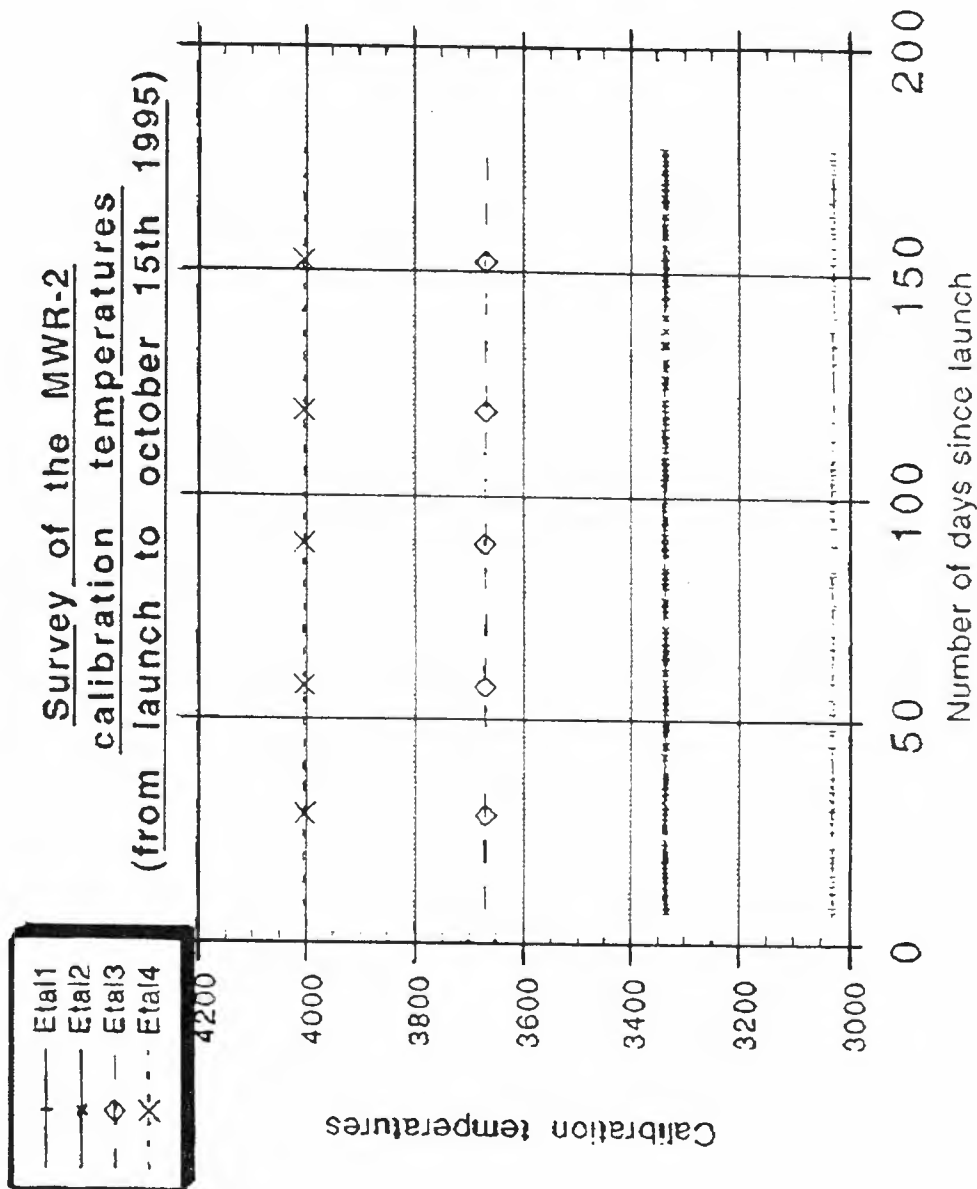




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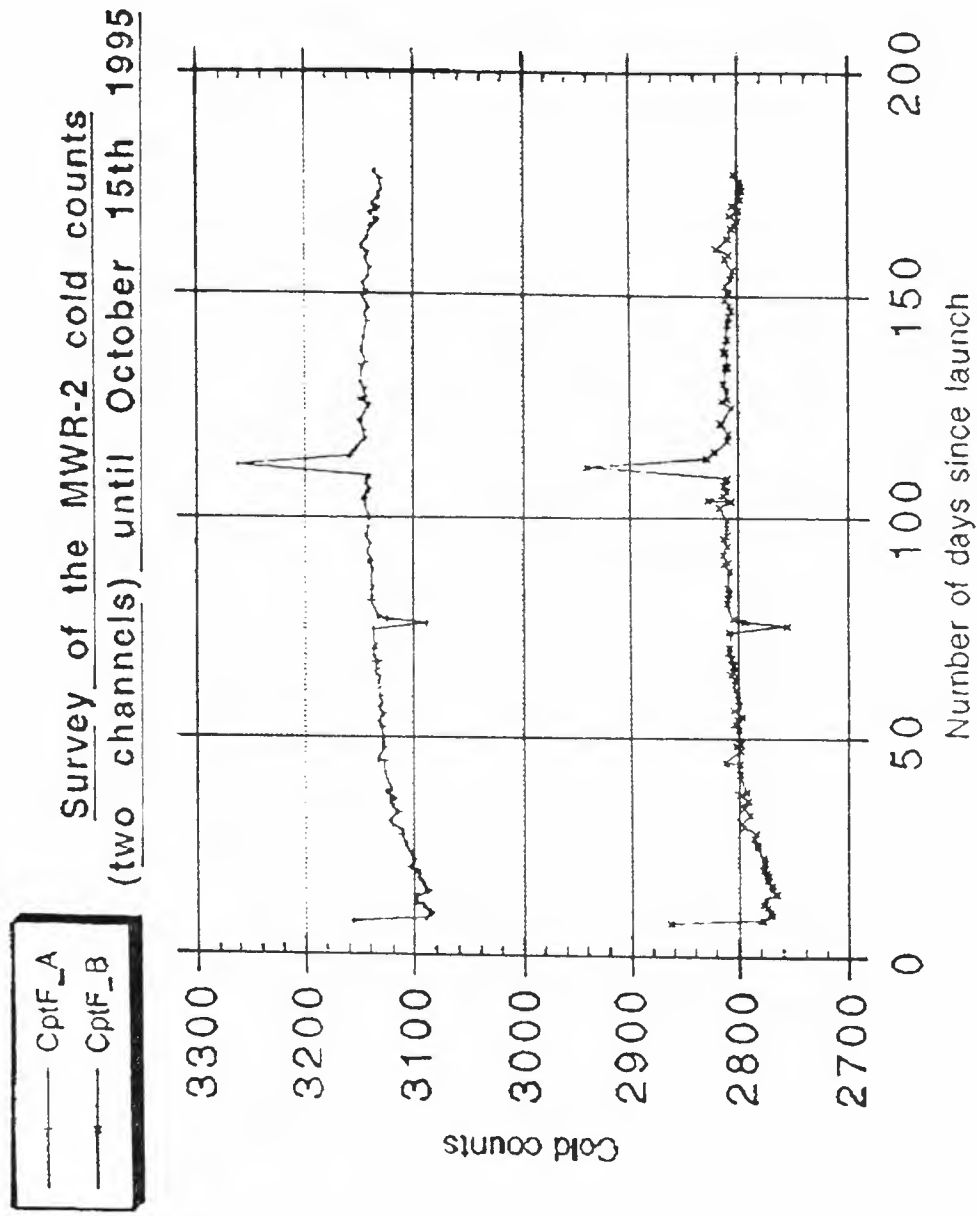




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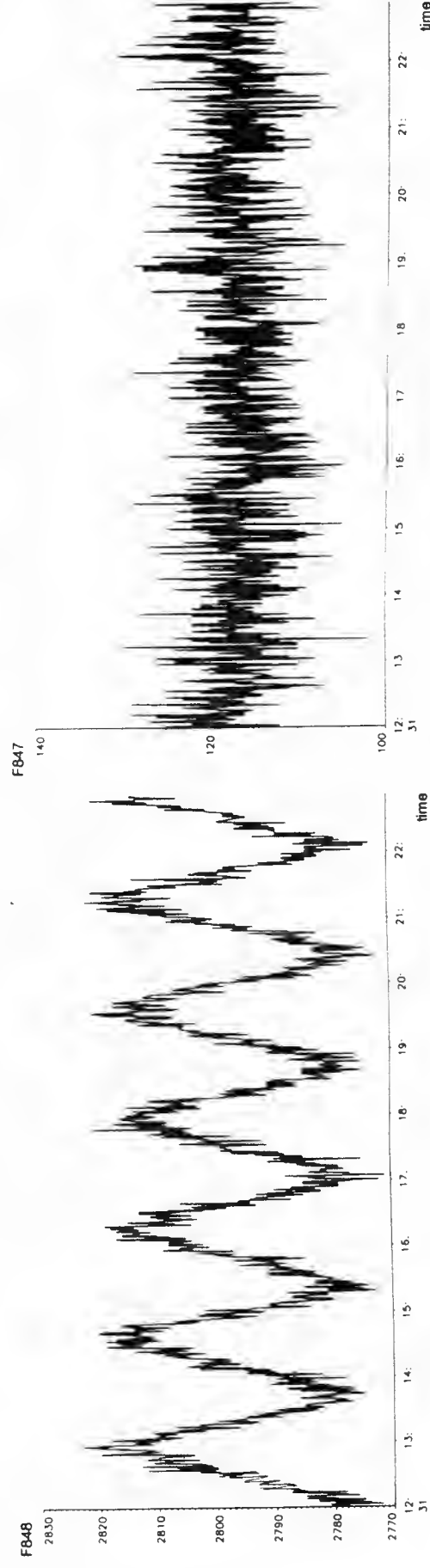
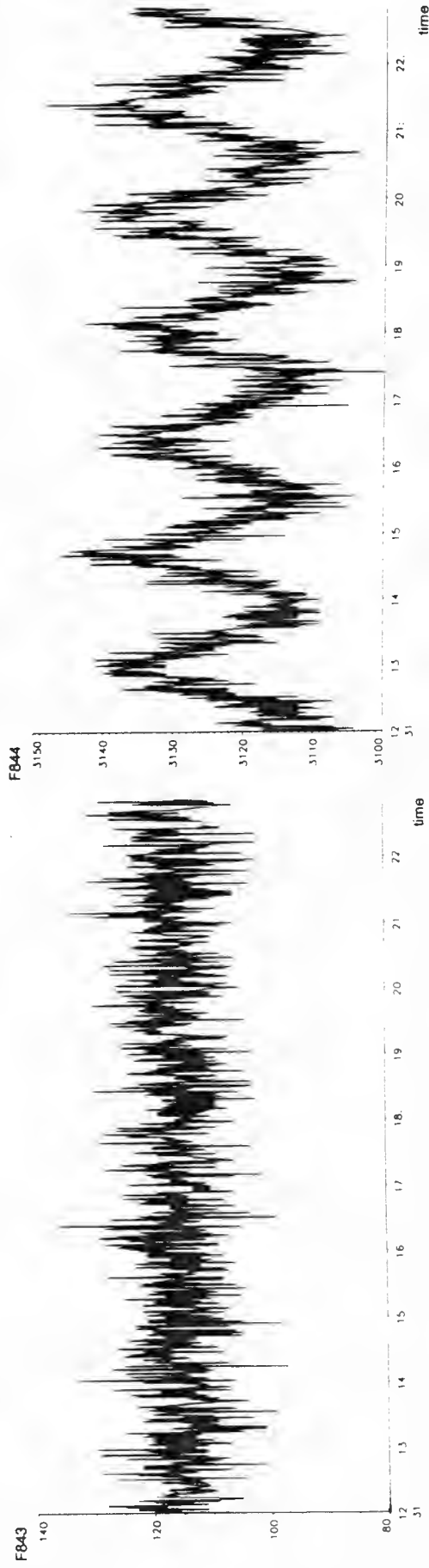
MWR-2

ERS-2

Time 1995-151 12:00:19 Start
Time 1995-151 22:51:47 End

Radiometric Calibration Temperatures

F843 AT HOT LOAD 23.8
F844 AT SKY HORN 23.8
F847 AT CAL HLD 36.5
F848 AT CAL SKRN 36.5





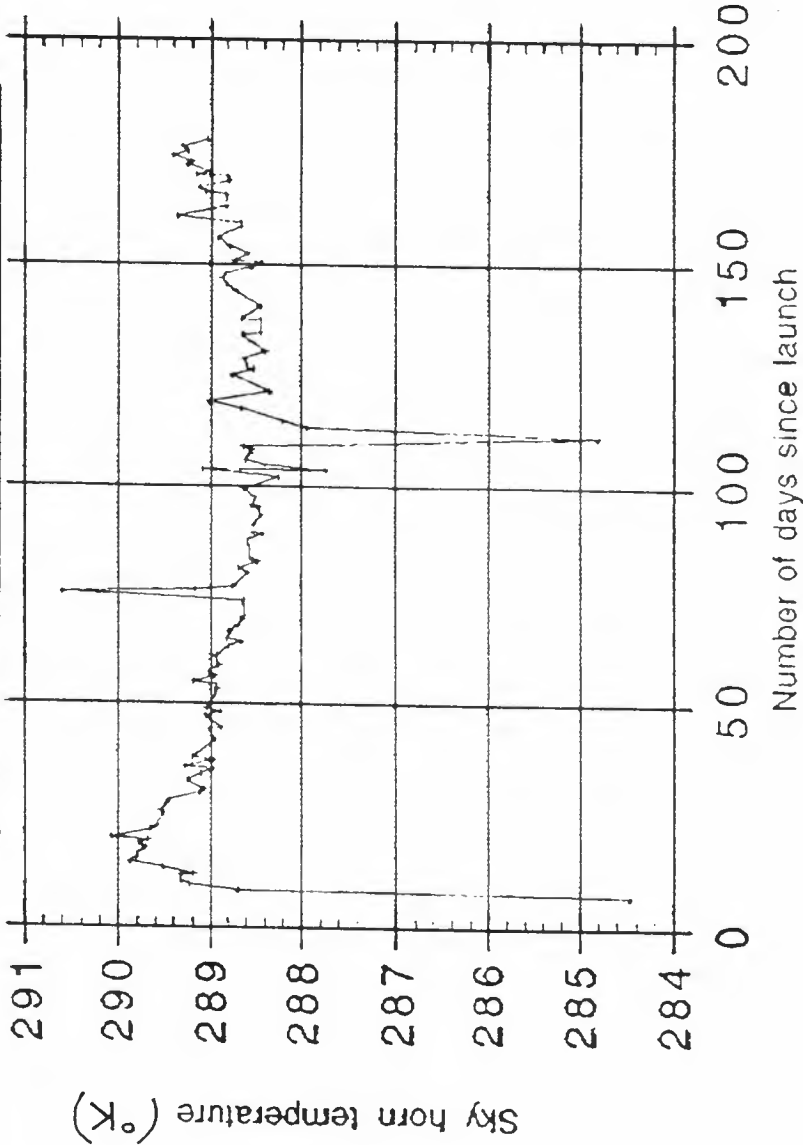
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MWR-2

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Survey of the MWR-2 sky horn temperature
(from launch to October 15th 1995)

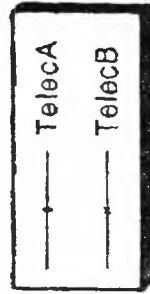




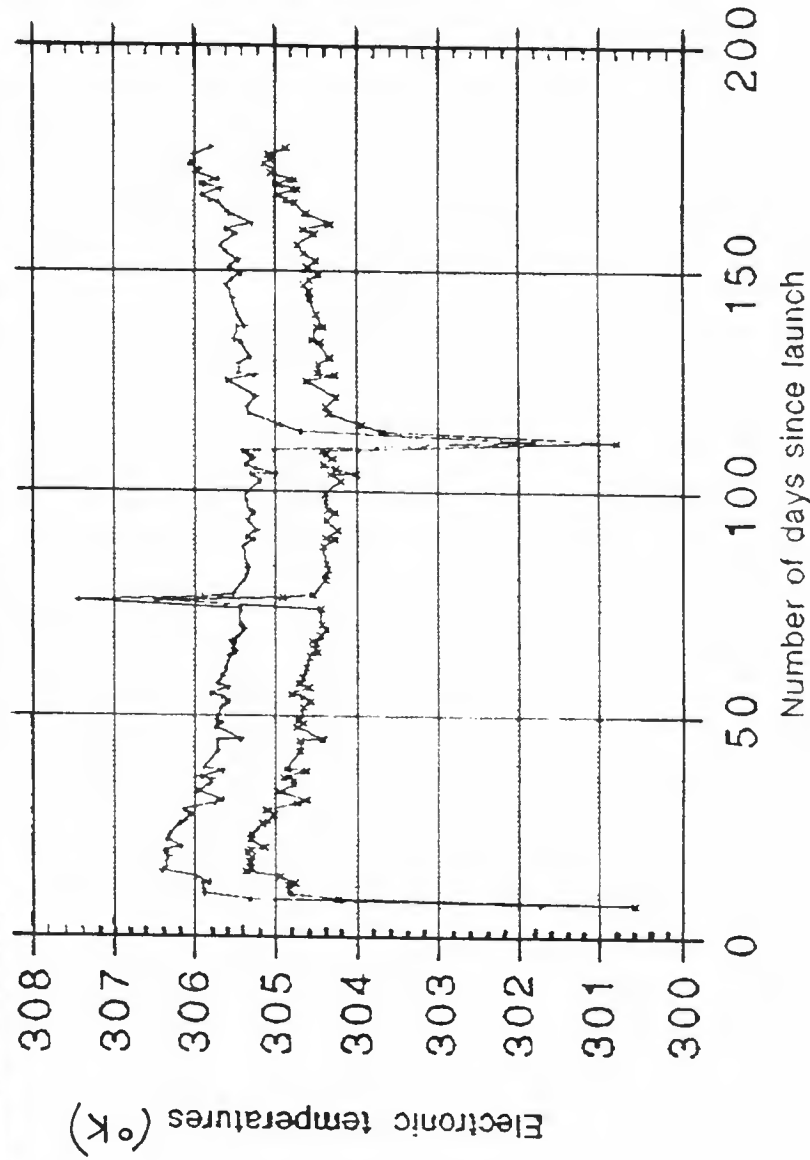
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MWR-2

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Survey of the MWR-2 electronic temperatures
(in the two channels) until October 15th 1995





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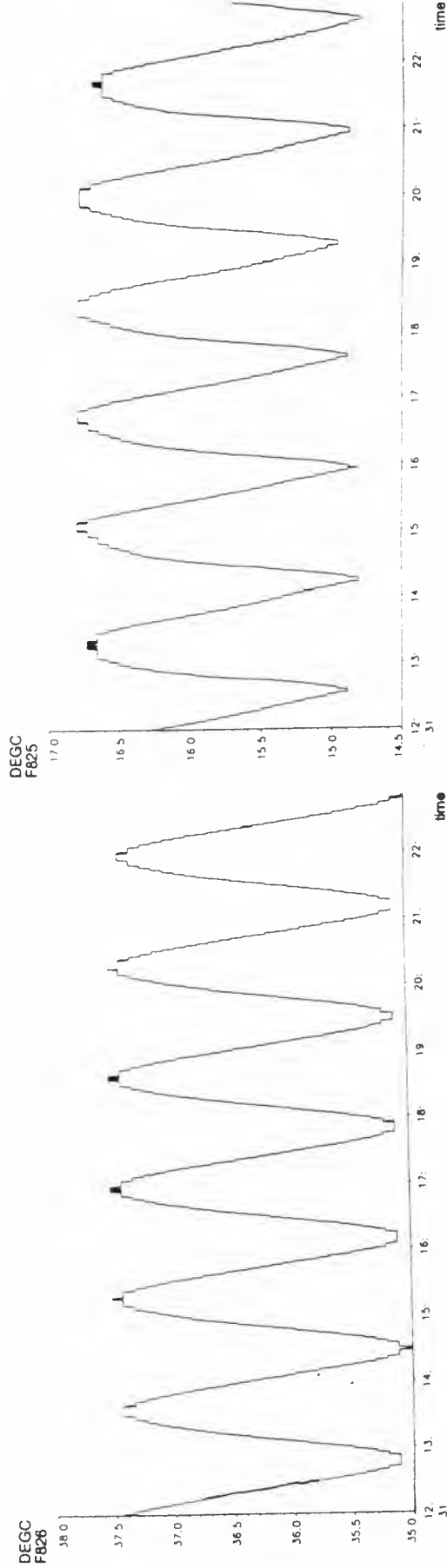
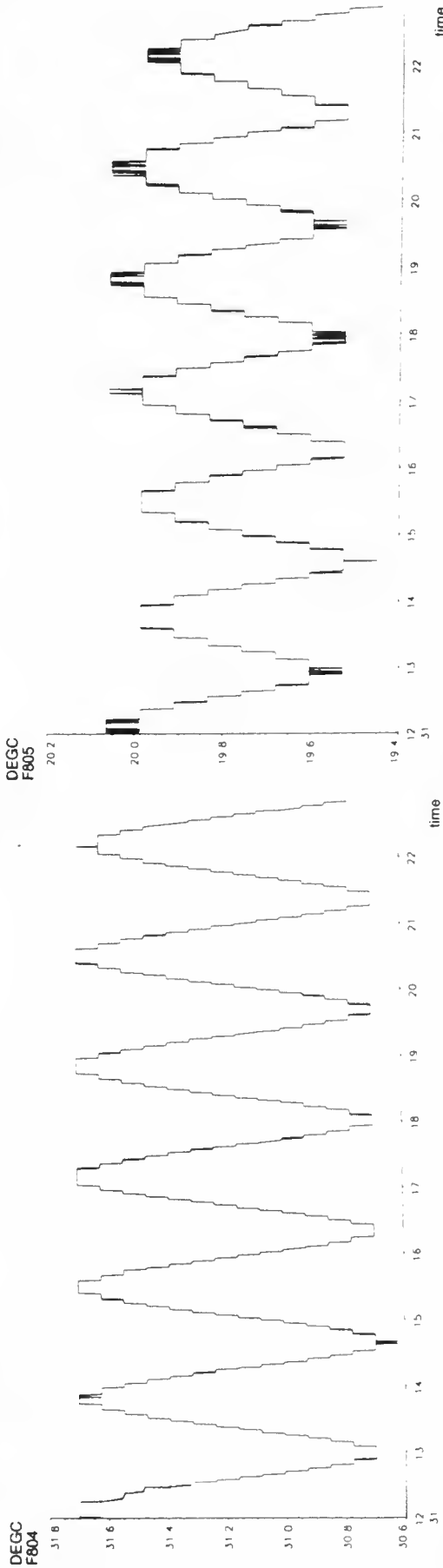
MWR-2

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Temperature Telemetries

Time 1995-151 12:00:19 Start
Time 1995-151 22:51:47 End

----- F804 AT T TA1 36.5
----- F806 AT T REF T1 23.8
----- F826 AT T SKYHORN
----- F828 AT T GUNN 23.8





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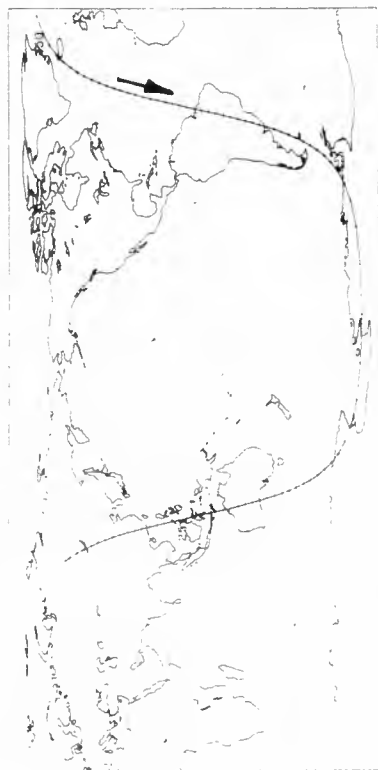
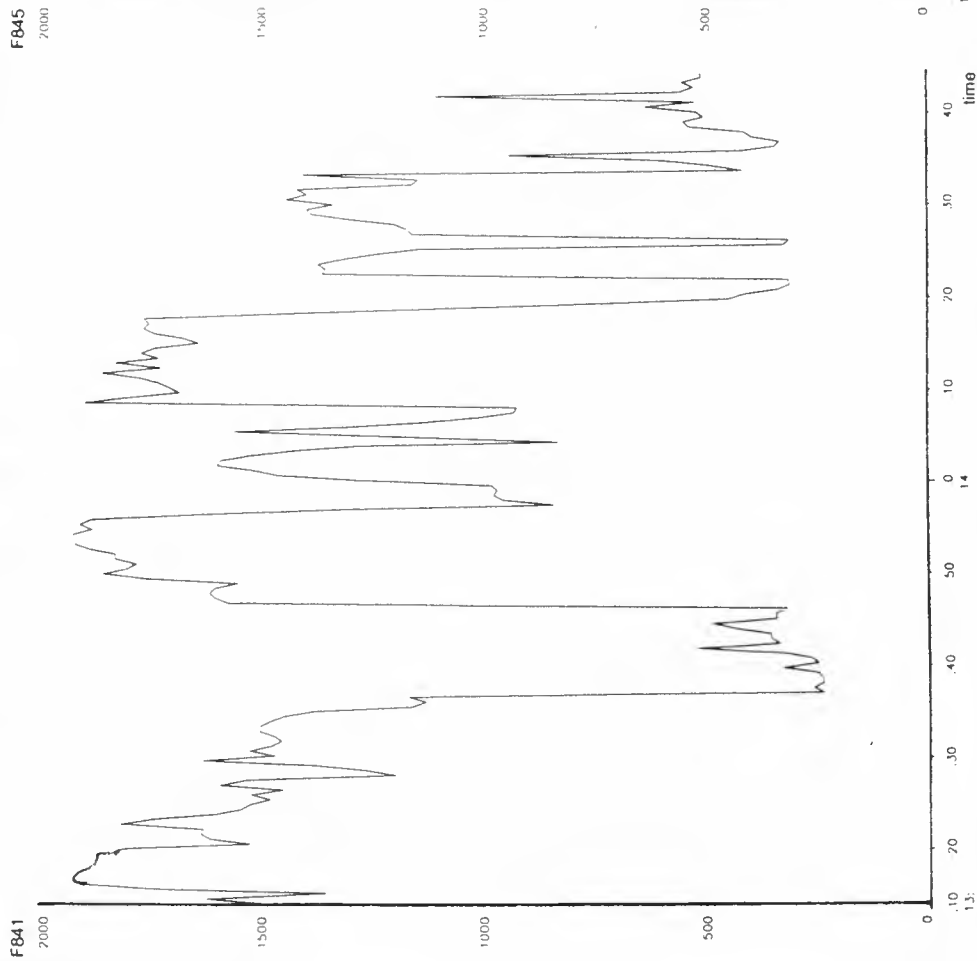
MWR-2

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Radiometric Measurements

Time 1995-128 13:14:11 Start
Time 1995-128 14:44:19 End

— F841 AT CAL MANT 23
- - - F845 AT CAL MANT 36





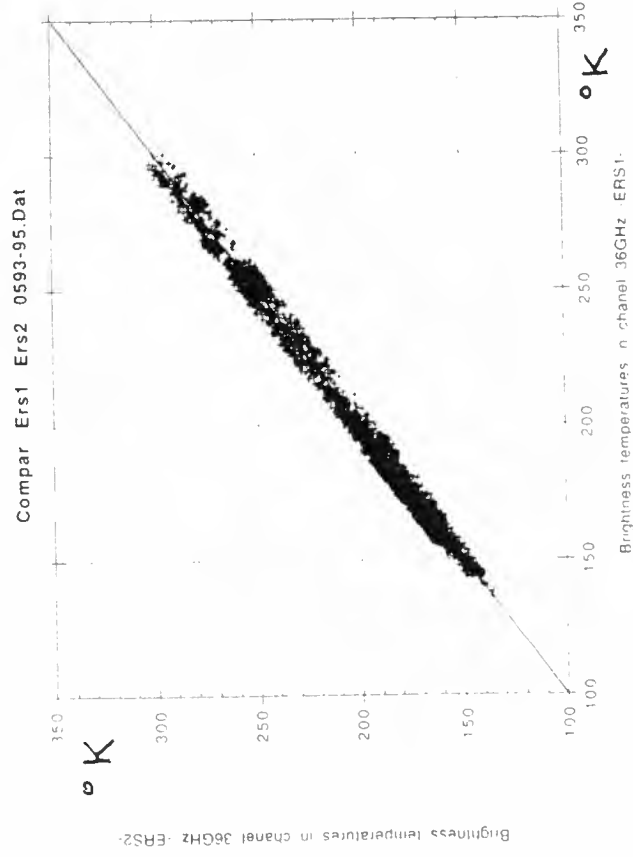
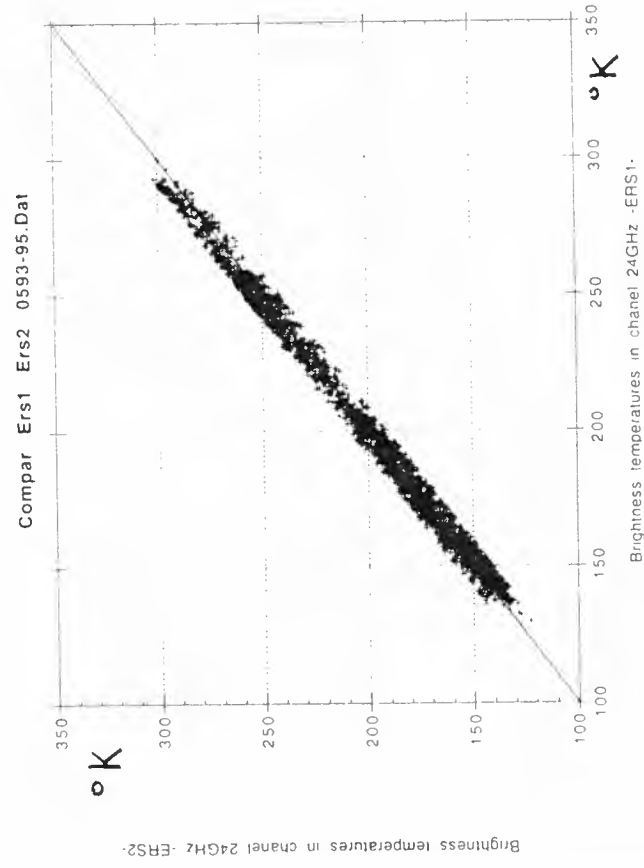
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MWR-2

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Comparison ERS1 - ERS2

- Elimination of points $\Delta T_b > 12K$
- 1 pt=data average in $1^\circ \times 1^\circ$ space
- ERS1 data of May 93 and ERS2 data of May 95





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MWR-2

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IN-ORBIT ANOMALY STATUS AND CONCLUSION

- Following switch-on on 27 April 1995, no in-orbit anomalies for MWR-2 have been recorded.
- In-orbit performance of MWR-2 is nominal and within specification, and comparable with the ERS-1 microwave radiometer.

ERS-2 Commissioning Review #1

PRARE

Wolfgang Schäfer, Martin Kufner
TimeTech GmbH

ESRIN, Frascati, 26 Oct 1995

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8. Conclusions 10

1. Instrument switch-on and initial operations

- Redundancy A switch-on was commanded by ESOC on April 26, 1995, 07h50.
- Initial parameters obtained from PF-TM showed nominal values
- After a warm-up period of 3 orbits, stable signals have been received at Stuttgart, Oberpfaffenhofen and Potsdam
- Subsequent commanding was performed by the PRARE command station at Stuttgart using the instrument's own signal links.
- All HK/TM parameters showed nominal and stable values.
- A step-by-step procedure was executed starting with low risk commands until the full set of parameters was loaded and until all major macro-commands were tested.
- Major instrument functions, which have been verified, include
 - Real time orbit prediction, checking of G/S visibility, G/S signal acquisition and tracking
 - Lock on ranging signal, lock on carrier signal
 - Reception and expansion of up-link commands
 - Data broadcast to ground stations
 - Data collection from ground stations
 - Dump of stored data upon request
- Dedicated G/S test configurations have been established to verify instrument performance and to obtain initial calibration values.
- After about ten days of operation, the system operated automatically and the most important system calibration parameters had been obtained.

2. Present instrument H/W and S/W status

- NO instrument H/W errors to report
- All telemetry values remain stable since instrument switch-on, including voltages, currents, transmitter power etc.
- The instrument temperature is stable at about 27 °C and to within 3 K with only very short excursions. This greatly eases instrument calibration, as there are only minor temperature effects to be compensated.
- The on-board clock, which is monitored by GFZ, shows the expected performance.
- Soft-error rate in data RAM, which is induced by protons, remains stable at about 4 soft-errors per day. These errors are automatically corrected on-board.
- The vital program RAM, which has been upgraded from the ERS-1 design using rad-hard circuits, is completely free of radiation-induced soft errors.
- On-board software operates flawlessly.
- Seven minor S/W patches have been implemented so far to correct for one error, which caused about 0.1 % data errors in the down link and the other patches are to correct for data corruption after solar array occultation.
- Another S/W patch was issued to reduce memory overhead by about 40 %, leaving more room for science data.
- Memory dump-rate is presently at 4 kBit/sec. It can be set by ground command to values from 2 up to 10 kBit/sec.

3. Command station operations

- Command station S/W was continuously updated to be compatible with on-board S/W and to improve data dump reliability, which was initially hampered by solar array occultations.
- Main task is to command the instrument and to initiate and receive data dumps.
- Up to now, 194 different macro-commands have been implemented and used.
- The EM is available at the command station to implement and verify S/W patches prior to uploading them into the instrument.
- Station is operating at a dump-rate of 4kBit/sec, being upgraded to 10 kBit / sec until mid December
- A commands history log and the image of the instrument configuration is maintained.
- From these records a daily report is prepared and issued to GFZ.
- Daily monitoring is performed of the on-board S/W and H/W status as well as of the memory status, i.e. percentage of used memory, amount of dump data, dump performance etc.
- Corrected problems:
 - data loss due to solar array occultation during night and day-time
 - computer overheating in July
 - data loss due to antenna rotator malfunctioning
- **Status:** Automatic and unattended operation. Operator intervention needed in case of unforeseen effects / events only.
- Uploading of station information and ephemeris data as well as the reception of dump data is performed on a routine basis.

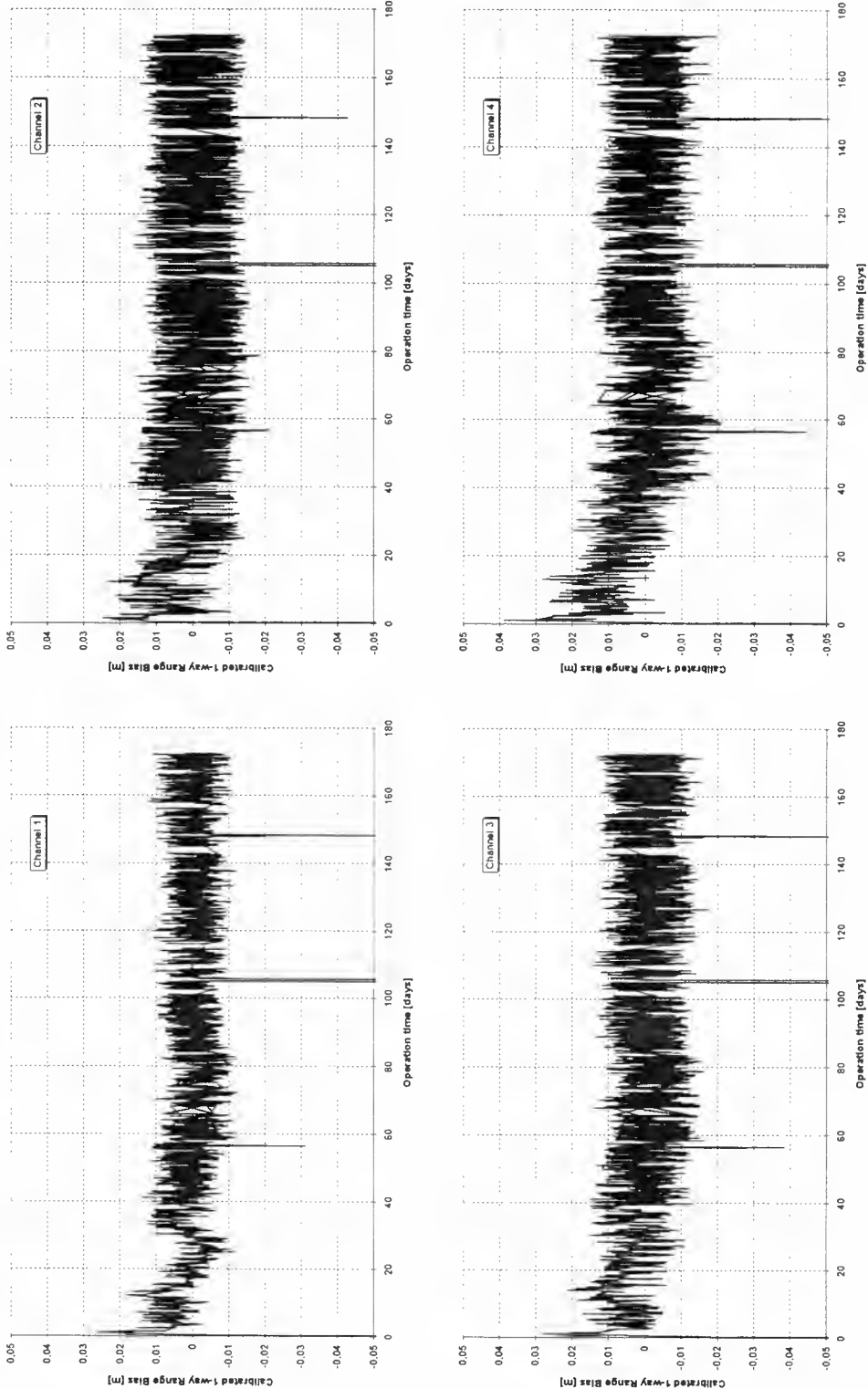
4. Instrument operational performance

- One instrument switch-off (4.5 hrs) by the PF occurred on August 8th, which caused interruption of otherwise continuous operation. Recovery time after this incident was about two days and the system was fully re-configured after about 7 days.
- Science data quality is partly reduced due to occultations by the solar array causing signal interruptions and due to signal scattering at the satellite structure. The effect is most dominant for stations at high latitudes and smallest at low latitudes.
- Mainly range-measurements are affected by scattering, whereas the influence on range-rate should be only about 1/1000 of the effect on range. The actual effect on range-rate is presently under investigation.
- Methods have been developed or are under development to reduce such errors by post-processing of science data.

Operations summary

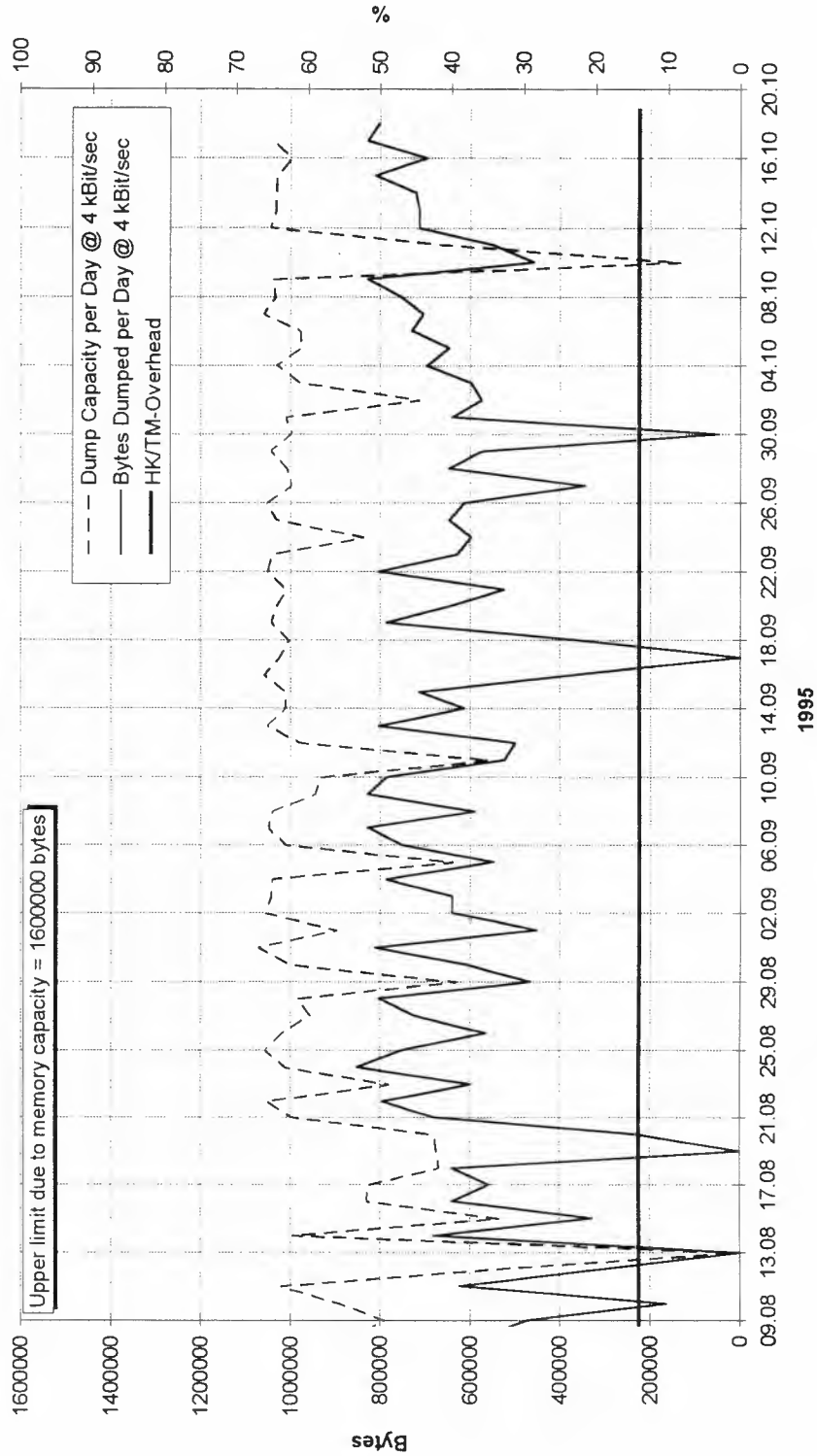
• Acquired passes at Stuttgart:	1100
• Total contact time:	157 hrs
• Macro-commands sent:	4300
• Commands rejected:	2
• Instrument S/W error counters:	0
• Amount of received data (TM and dump):	200 MBytes
• Amount of received science data:	92 Mbytes contained in 1450 dumps, data formatting overhead excluded.
• Instrument internal calibration runs:	3500 (this number approximately corresponds to the number of G/S contacts)

5. Instrument range stability, calibrated for temperature, four channels



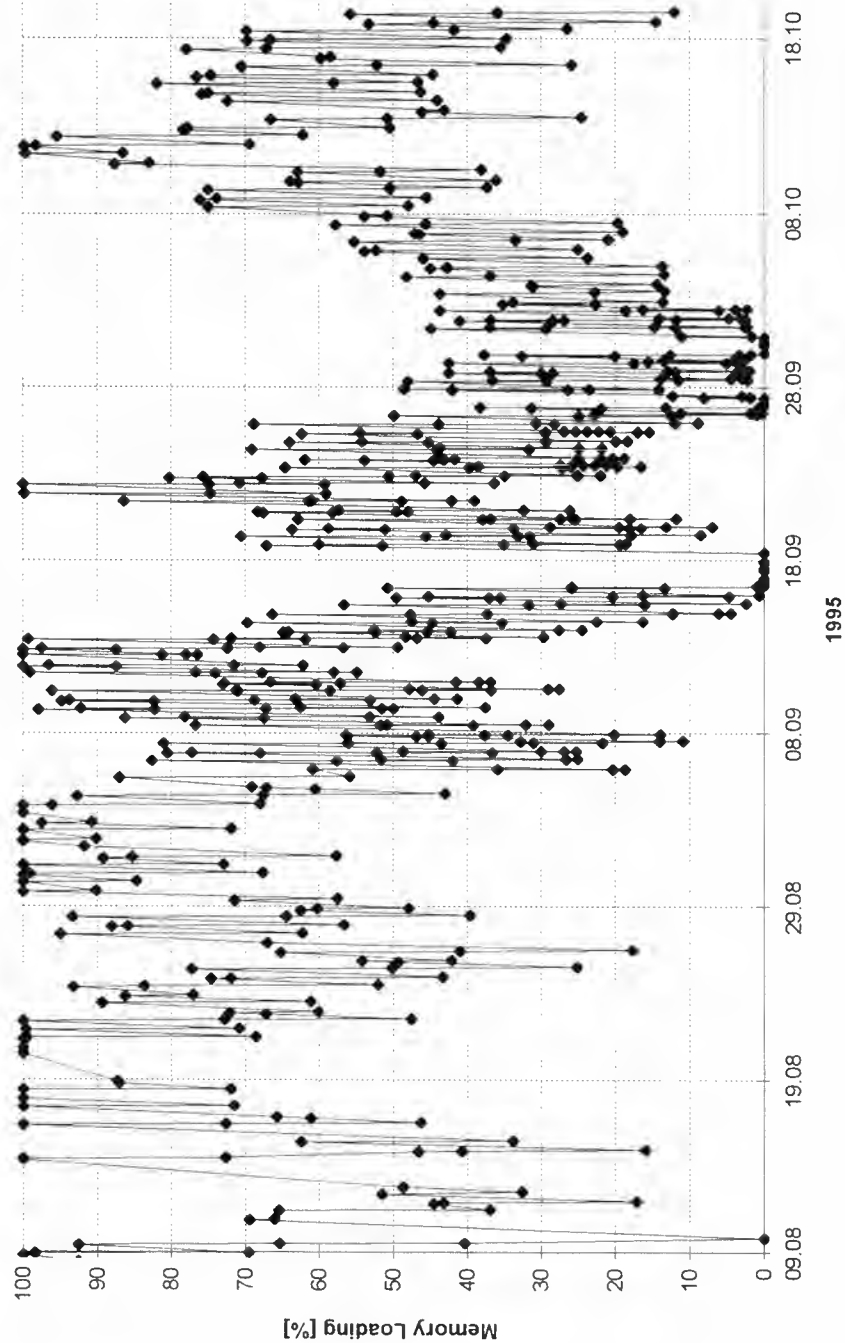
6. Data memory capacity and memory load factor

Data Dump-Capacity per Day



Notes: Dump capacity is the maximum amount of data, which actually could have been received, considering real command station performance
Bytes dumped is the actual amount of dumped data received, presently approx. 800 kBytes / day.
HK/TM overhead is due to continuous recording of H/K data
Upper limit due to memory capacity is estimated upon the planned ground segment configuration, taking into account higher dump rates.

7. Memory load factor versus operation time (from Aug 9th)



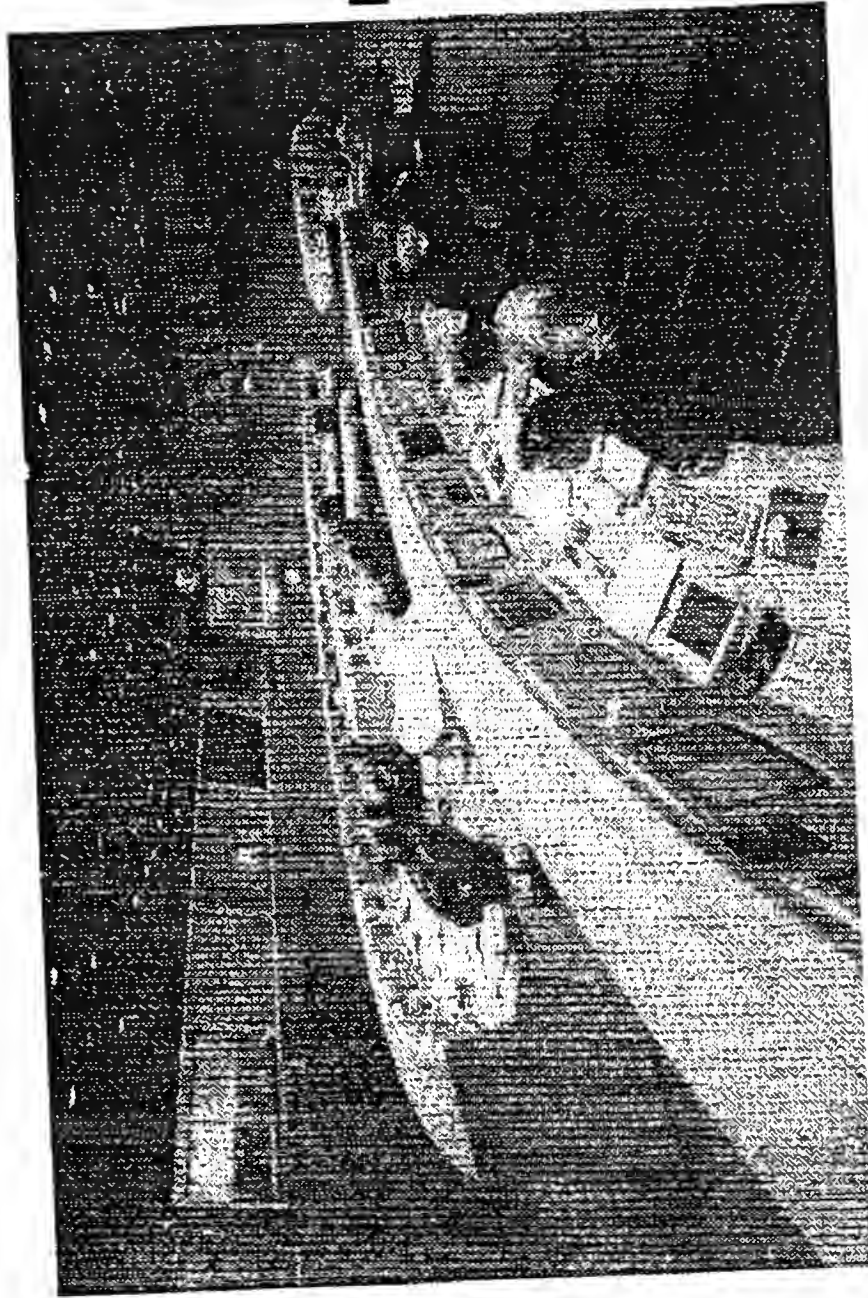
Notes: 100 % corresponds to the use of the total amount of data memory, i.e. about 512 kBytes.

This memory is used to collect data when satellite is out of visibility from Europe, i.e. during approx. twice 7 hrs of operation per day.

Peaks in August have been caused by dump interruptions from solar array occultations not properly accounted for in the command station S/W
Peak around Sept 20 was due to uploading of S/W patches, peak around Oct 11 was due to antenna rotator failure at the command station.

8. Conclusions

- After the instrument failure on ERS-1, several modifications have been implemented to improve its reliability.
- The objectives of these modifications have been fully achieved.
- Instrument H/W and S/W shows reliable operation and stable science data
- NO major instrument deficiencies have been discovered.
- Eight minor S/W patches have been implemented.
- Data dump problems induced by solar array occultations have been resolved.
- Data down-link and memory capacity is compatible with present G/S configuration. It will be further increased within the next two months using higher bit-rates.
- Overall performance of the instrument is as expected from a precursor flight on a Russian Meteor-3 satellite, although range- and range-rate data obtained from the instrument are somewhat affected by signal multi-path or scattering at the satellite structure.
- The effect of scattering on doppler measurements is expected to be about 3 orders of magnitude less than the effect on range.
- Methods have been developed to compensate or at least to minimise scattering-induced ranging errors.
- Reliable signal acquisition and tracking is achieved at elevation angles from below 2° up to overhead passes.
- **The instrument functions flawlessly and is ready to operate with the planned configuration of the ground station network.**



MISSION MANAGEMENT AND CONTROL CENTRE ESOC



ERS-2 COMMISSIONING PHASE REVIEW

M. Mc Kay

26 October 1995 ESRIN

MMCC

- SCOS-1B Control System is stable, reliable and performs well
- Move to more cost effective hardware end '95 for ERS-1 and early '96 for ERS-2
- Dual Operations moved to the new Earth Observation Control Room
- Flight Dynamics moved from mainframe to ORATOS on SUN w/s
- Mainframe Spacecraft Archive, SPES, will be replaced by SPEVAL based on Vax w/s with hard disk archive
- Fibre Optic Link from Kiruna Stn to ESRANGE Antenna in progress - removes the antenna as a single point failure
- Back Mini-Control System for Kiruna under integration testing



MISSION PLANNING

- System fully operational and supporting all mission operations
- New Database for Mission Parameters reducing s/w changes
- New Descoping for the IDHT tubes reduces the tube switchings
- Automatic Tape Changes scheduled every 3 months
- Support AMI Test Programme and multiple schedules
- Ground Station Scheduling now Database Driven
- ERS-1 MPS will be upgraded to run on the new ERS-2 system



SUMMARY

- **Launch was preceded by Redesign, Building, Integration, Testing, SVTs, SOVs and the Simulations Programme.**
- **This not only tested the Systems we were building but also the people building and testing them.**
- **The result was not only Confidence, but a TEAM.**
- **Demonstrated competence of European Industry.**

WE DID IT AGAIN !



ERS-2 Commissioning Phase Review
ESRIN, 26-27 Oct 1995

Kiruna Operations



esa

esoc/mod/amd

Presented by: D. Mesples

Kiruna Station Performance

- Over 1500 passes taken; Less than 10 affected by data loss.
- Complete FD production/dissemination within 3 hours in over 98% of orbits dumped over Kiruna.

PRODIS Operational Activities

- In accordance with Mission scenario.
 - Systematic HR and LR acquisition of up to 10 orbits of ERS-1 and ERS-2 data.
 - Systematic processing of ALL LR data acquired.
 - Processing of last daily orbit of Wave + generation of up to 3 UI16s.
 - All ERS-2 LR extracted products transcribed to Exabyte.
 - Dissemination of all FD within mission defined time window.

TTCDAF Operations Summary

- Tilt problem resolved at L+5 days.
 - No impact on P/L switch-on activities.
- FEC Tilt recommendation problem
 - 1 pass of ERS-2 data lost
 - s/w update conducted in week 42.
- Servo Computer unreliability:
 - Servo B crashes on average 3x /week
 - Running on Servo A

Kiruna Station Status Summary

- **TTCDAF**
 - Insignificant data losses due to various problems: Power outage, Servo Computer failure, FEC problem.
- **PRODIS**
 - Minor SGI LRDPF s/w anomalies still present resulting in minimal loss of data.
 - Transcription errors
 - Instrument header and extracted calibration products generation.

PRODIS Operations Summary

- DPMC-6
 - Minor problems outstanding
 - s/w upgrade in week 44/45
- SGI LRDPF
 - Operational since week 40
 - Majority of problems resolved with version 6.300.
- MMCC/MPS
 - Minor problems: No operational impact

Routine Phase Milestones

- SGI LRDPF Upgrade for Wave processing
 - April/May 1996
- DPMC-6 'spare' Installation
 - Pending
- HDDR redundancy
 - Pending ERS-2 w/s commissioning results
- ERS-1 LR Chain Upgrade

esrin

ERS GROUND SEGMENT

STATUS REPORT

Processing and Archiving Facilities

26-27 October 1995

MIP PAF's WORKPACKAGES STATUS

WP 2560	PAF integration	Completed for all PAFs DPAF: JAN 95 UKPAF: MAR 95 IPAF: MAR 95 FPAF: JUN 95
WP 2630	PAF EECF Interface test	Completed for all PAFs with the same functionality operational for ERS-1

MIP PAF's WORKPACKAGES STATUS

WP 3280	PAF Products Validation	SAR: nearly completed ALT: ongoing ATSR: it is assumed to be done at DRAL. GOME : it is assumed to be done by the ERS-2 Project. PRARE: calibration done by ERS-2 Project. PRARE inclusion into orbit computation yet to start ORBIT: Validation without PRARE completed
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PAF PRODUCTS VALIDATION STATUS

Product	Status	Validation Report
SAR.RAW	Validation completed at D-, I-, UK-PAF	End Nov
SAR.SLC	Validation completed at D-, I-PAF	End Nov
SAR.SLCF	<i>Validation ongoing at the UK-PAF (planned mid-Nov)</i>	End Nov
SAR.PRI	Validation completed at D-, I-, UK-PAF	End Nov
SAR.GEC	Validation completed at D-, I-PAF	End Nov
SAR.GTC	Validation completed at D-, I-PAF	End Nov
ALT.OPR	<i>Validation ongoing within the RA CWG</i>	<i>Mid-Dec</i>
ALT.WAP	<i>No real validation planned. Sample products given to major PI's (MSSL, GSFC)</i>	<i>TBC</i>

PAF PRODUCTS VALIDATION STATUS

Product	Status	Validation Report
ALT.SSH ALT.OGE ALT.TOP	<i>Validation to start after 6 months of OPR will be available. It will be done at D-PAF</i>	<i>OPR + 2 Months</i>
ORB.PRL ORB.PRC	Validation completed without PRARE data <i>Inclusion of PRARE data will be studied after PRARE cal/val</i>	Oct <i>Feb/Mar</i>
EGM	Validation completed at D-PAF	Oct
ATSR products	<i>Validation ongoing at DRAL. Expected completion: Nov 95</i>	<i>Expected: Nov 95</i>
GOM.TCD03 GOM.LVL13	<i>Validation ongoing under ERS-2 Project Control. Expected completion: Jan 96</i>	<i>Expected: Feb 96</i>

MIP PAF's WORKPACKAGES STATUS

WP 3410	D-PAF operations during Commissioning Phase	• Data reception, SAR screening, tracking data processing operational. • SAR production for testing done. • Additional Work carried out for the Commissioning Phase: • Sat.Laser Ranging stations coordination • PRARE stations coordination • support to ESA SAR cal/val • operational generation of Preliminary Orbit and QLOPR for ERS-2
WP 3420	F-PAF operations during Commissioning Phase	• Generation of Precise Orbit revision 2 started in Sep • Data reception , exabyte screening operational • OPR01 generation in support to PRC generation running • Generation of OPR02 for test/validation started after the reception of the Precise Orbit

MIP PAF's WORKPACKAGES STATUS

WP 3430	I -PAF operations during Commissioning Phase	• Data reception and SAR screening operational • SAR product generation for validation done
WP 3440	UK -PAF operations during Commissioning Phase.	• Data reception and SAR screening running. • Final upgrades on Order Handling Part completed in Oct • SAR product generation for validation done • Altimeter WAP processing starting now. Samples of data will be given to major PI's for verification • Additional Work carried out: • operational generation of TAMF files for the QLOPR as requested by Ra commissioning W.G.

PAF's ERS-2 STATUS

D-PAF

- **SAR ERS-2 status:**
 - Screening ongoing without backlog. 50 HDDT's/week are received from Kiruna
 - data distribution started (ALL PRODUCTS) on Oct 16th for the SAR acquisitions in the current configuration
 - Only exception GTC Photoproducts available since Oct 20th
- **Orbit/Altimeter ERS-2 status:**
 - QLOPR operational since 3rd May (support to RA CWG).
 - PRL orbits and Orbit Predictions operational since 24th Apr (support to RA CWG)
 - Precise Orbit revision 2 (without PRARE) generation started in September.

Validation completed, distribution can start beginning of Nov

 - Higher level products foreseen for validation after six months of OPR (in the course of 1996)
- **GOME status:**
 - exabytes only screened. The GDP expected to enter into ops in Feb 96 (ERS-2 Project activity)

PAF's ERS-2 STATUS

UK-PAF

- **SAR ERS-2 Status:**
 - Data distribution for PRI RAW can start on 16th Oct for PRI. SLCF start of distribution is planned for mid-Nov.
 - Screening backlog is about 330 HDDT's.
 - ERS-2 (and ERS-1) HDDT's from Kiruna covering Europe are now sent to DPAF only: UK-PAF screening load is reduced to 50/week (wrt to nominal capacity of 90-100/week), implying a backlog recovery throughput of 50/week.
- **LBR ERS-2 Status:**
 - SADIST Alpha procured and installed
 - SADIST-2 Processor Version 100 (non-operational) installed for experience building. Operational Processor v 200 is expected to be delivered end Nov (resp. of DRAL)
 - Altimeter exabytes are inventoried. Processing started mid Oct
 - No special validation ongoing: MSSL and GSFC will be asked to provide inputs at the start of the production.

PAF's ERS-2 STATUS

I-PAF

- **SAR ERS-2 status:**
 - No screening backlog
 - Distribution of SAR data acquired in the current configuration started Oct 16th (RAW, PRI, SLC, GEC)

PAF's ERS-2 STATUS

F-PAF

• LBR ERS-2 status:

- Exabyte Processing running. 15 media rejected so far (mainly from Kiruna). Very good situation wrt the ERS-1 start.
- Operations started end of June, the Backlog was recovered very rapidly
- OPR generation is OK. Cycles 1 2 done with the PRL (cycle 3 nearly ready). Cycles 1 2 done with the PRC. Kiruna Transcription Errors appear as data gaps.
- FD copying (ALT and Wave Mode) can start any moment
- OPR/VLC Distribution planned to start in December if green light is given by the validation team (validation exercise planned to end at the end of Nov)
- Regeneration of the early ERS-2 OPR is foreseen in 96 due to future improvements in the OPR ingredients (eg PRARE) and/or to fix of problems affecting the early data

PAF's ERS-2 FUTURE OUTLOOK

SAR

• ARCHIVE

- in UK space left until April, in D space left until April 96
- This problem should be solved by HDDT recycling, which is planned to start in Jan 96, after qualification of the SAR Transcription
- SAR Transcription & Q/L is planned to be installed at D-PAF before the end of 95
- I-PAF has built new space for the archive and proposes to ESA to re-develop the transcription and Q/L functionality in the E-SAR processor. Discussions are ongoing
- Q/L product is today archived on exabyte. Technically it could be offered to the users.
- ERS-2 data acquired before 12th July can be offered to users as "uncalibrated" or "experimental" data. SLC in particular could be useful

PAF's ERS-2 FUTURE OUTLOOK

SAR PROCESSOR MODERNISATION & HARMONISATION

- UK and D PAF will migrate to the VMP on DEC Alpha early 96. To achieve it the UKPAF needs an upgraded version of the ESRIN CPMF
- Alpha VMP will generate also the SLC-I product (specifications under work)
- UK-PAF has installed the same D-PAF Geocoding Processor to produce GEC's.
- I-PAF has upgraded the E-SAR SLC product to reach a Phase Preservation performance similar to the present VMP. The products can be offered for interferometry only if mixed among themselves
- I-PAF will migrate all HW to DEC Alpha by March 96 (proposal awaited for)
- I-PAF: GTC has been validated. Final details for production are being defined

PAF's FUTURE OUTLOOK

ALTIMETER & MWR & ORBIT PRODUCTS

• OPR/VLC

- Production can run with a throughput of 400% +
- Data generated so far appear of good quality. Validation expected to be completed by end Nov
- Algorithm changes are planned to the processor for the end of 95. This will put into question the continuity with the historical ERS-1 production. F-PAF could reprocess the 4 years of ERS-1 in two years, but this activity might be better planned in the framework of the LR HDDT transcription on DLT.

• ORBIT

- Production can run with a throughput of 300% +
- PRARE inclusion will be studied in Jan 96
- Algorithm changes already took place in March. Reprocessing of ERS-1 orbits will be considered in 96. and will be harmonised with the F-PAF

PAF's FUTURE OUTLOOK

ALTIMETER & MWR & ORBIT PRODUCTS

• WAP

- ERS-1 Geodetic Phase (Phases E & F) and Phase D under processing: completion expected end Nov
 - Production running at 400% rate
 - WAP version 3.0 passed acceptance and is distributed to PI's.
 - Transcription of historical Optical Disks to exabyte ongoing, completion planned for Nov.
- Exabytes delivered to MSSL and kept in NRSC archive to eliminate OD

•WAP Upgrading status:

- QA system will enter into operations in Jan 96 for ERS-1 and ERS-2
- MSSL generation of WAP-like products should start in Jan 96

PAF's FUTURE OUTLOOK

ATSR PRODUCTS

• UK-PAF houses two DEC Alpha's, for running both ERS-1 and ERS-2 processors

•ERS-1 status:

- PST backlog cleared
- High Res production awaiting for orders: capacity 1100 scenes/week. No archiving reports sent for historical data
- Raw Data are sent in ERS-2 format. A format converter ERS-2 -> ERS-1 will be provided to the UK-PAF not to discontinue operations

•ERS-2 status:

- Product & software validation assumed to be done by DRAL. It is expected that the software v 200 is delivered with full documentation set (eg operational documentation, user manual & validation report)
- New products are defined (GRIDDED/UNGRIDDED) and will be generated
- UKPAF will take care of CEOS formatting of products
- New SW harness will be implemented, since the SADIST-2 interfaces are different. It will be ready in March 96

PAF's FUTURE OUTLOOK

GOME PRODUCTS

- GOME development and cal/val assumed to be done by ESTEC & DLR
- It is expected that processor is delivered integrated in the D-PAF environment (part of it was tested in Jan 95)
- It is expected that operational processing starts in Feb 96
- It is expected that the User Documentation is provided for the two products (LVL13 and TCD03)
- It is expected that the user documentation includes a validation report

PAF's OUTSTANDING ISSUES

SAR

ARCHIVE/TRANSCRIPTION

- **D-PAF:** The transcription on D1 is to be organised with the same system of UKPAF. The data ingestion from D1 is to be synchronised with VMP migration DEC Alpha (no point in doing it for the VAX, which will be phased out in few months)
- **UK-PAF:** third shift in 96: necessary depending on the HDDT in-flow
- **I-PAF:** agreement ASI/ESA for the Transcription activities to be reached . Action is on ASI to provide a development proposal

PAF's OUTSTANDING ISSUES

LBR

- All PAF's: recovery of Kiruna Transcription faults, and retranscription of the early part of the mission: to be planned
- GOME processing/reprocessing: DLR has so far processed only BDDN data. Exabyte processing may need some further integration work, and operational procedures tuning
- F-PAF UK-PAF D-PAF: Kiruna produces sometimes two exabyte/day, while the PAFs expect one. All this is in-spec. We need to modify either the LRDPF or the three PAFs if the problem will persist
- F-PAF: imagette reprocessing capability exists at F-PAF, and could be used again in case of further Wave Mode algorithm evolution
- F-PAF: MWR data processing loses about 2% of data due anomalies in the ATSR-2 raw data files. DRAL is investigating. A modification to the MW processing algorithm is needed if the problem cannot be solved

ERS-2 LRDPF

Presentation Overview

- Background :-
 - System Requirements
 - H/W Configuration
 - Implementation & Test Strategy
- System Performance.
- FD Product Qualification Status.
- Raw Data Transcription Status.
- Future Developments

ERS-2 LRDPF Development Plan

- **Definition Phase (Mar-93 -> Aug-93)**
 - Requirements Analysis + Specification
 - Architectural Design
 - H/W Trade-Off
 - Acceptance Test + Integration Plan
 - External Interface Specification
- **Implementation Phase (Aug-93 -> Dec-94)**
 - Detailed Design; Implementation & Test
 - Pilot Deliveries to ESRIN
 - FAT + OSAT1 (against DPMC/CMS Simulator)
 - Integration into ESRIN reference System
- **Qualification Phase (Jan-95 -> Apr-95)**
 - Spacetec on-site support at ESRIN
 - Testing within FDPC Environment (ESRIN Reference Chain)
 - FD Product Comparison to old (ND) system (ERS-1 Wind + Altimeter)

ERS-2 LRDPF

High-level Requirements

- Re-Engineer Existing Functions (same algorithm)
 - Windscatt FD Product Generation
 - Altimeter FD Product Generation
 - Extracted Data Product Generation
- Add Mandatory Additional ERS-2 Functions
 - Ingestion of ERS-2 LR Telemetry (new LRFSI)
 - Re-construction of GOME + MW Science Packets
- Add Raw Data Transcription to Exabyte Cassette
- Add BDDN Product Dissemination
- Add FD Re-Processing from Transcription Exabyte
- System Configurable for ERS-1 or ERS-2

ERS-2 LRDPF

Industrial Organisation

- Spacetec (SPT), Norway : Prime Contractor
 - Overall System Responsibility
 - External Interfaces
 - Design Authority
 - Implementation of :-
 - Data Ingestion Sub-System (Custom LRFSI H/W)
 - Altimeter FD Product Generation
 - Extracted Calibration + Instrument Header Product Generation
 - Look-Up Table Handling
 - Raw Data Transcription
- Cap-Gemini-Sesa (CGS), Italy : Sub Contractor
 - Implementation of :-
 - Windsatt FD Product Generation
 - System User Interface (MMI)

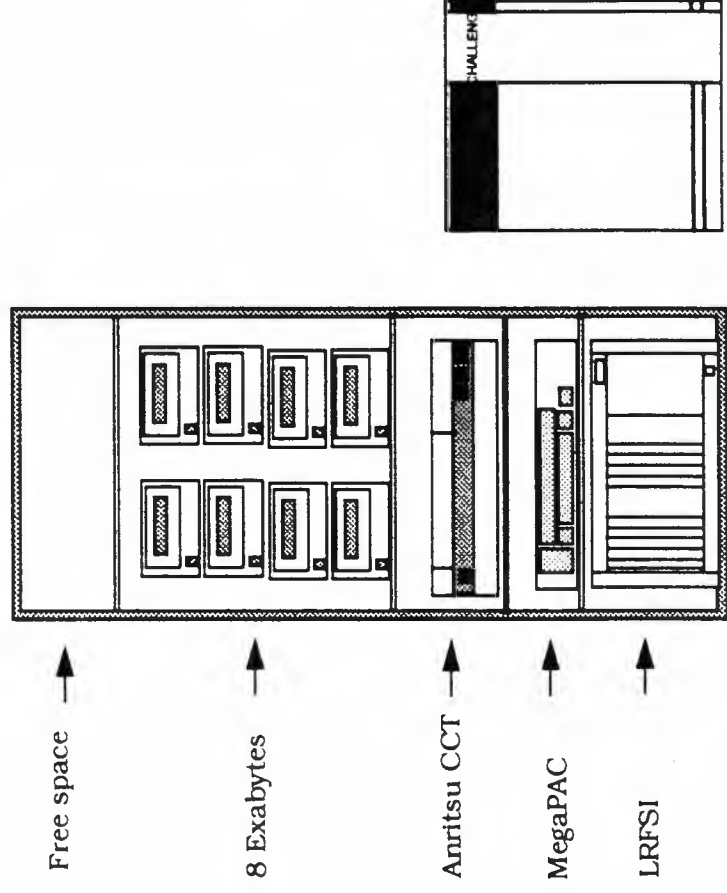
ERS-2 LRDPF

Hardware Platform

- ESA Decision Sep-93
- Silicon Graphics (SGI) Challenge L Server :-
 - 2 x CPU R4400 150 MHz 16 MFlops
 - 128 MB Memory, 6 x SCSI-2 F/W external Channels, 5 x VME64 slots
 - 1.2 + 8 GB Disk Bundle, 2 x IKON DR-11 DMA Boards (Data Ingest + Product Channel O/P)
- SGI Indy Workstation + 19 " Colour Monitor
- Peripherals :-
 - 8 x 5 GB 8mm Exabyte Drive with LCD Screen Doors
 - 1/2" Anritsu 6250 bpi CCT Tape Drive
 - N-ETH Megapac (X.25 Command Channel)
 - Local Event printer, report printer, label printer
 - External 19" Cabinet
- Data Ingestion Sub-System : Spacetec LRFSI :-
 - Off-the Shelf + Custom-Built VME Boards
 - 3 x CPU (Motorola)
 - S/W Application in ANSI C

ERS-2 LRDPF

System Physical Layout



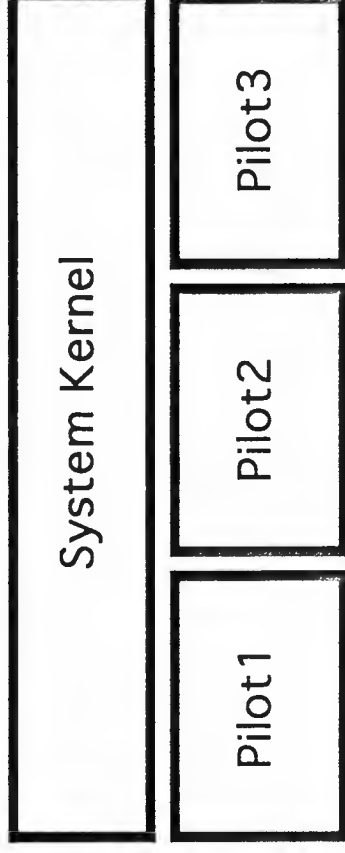
ERS-2 LRDPF

Hardware Rationale

- **Lowest Schedule Risk**
 - Available at the time of decision
 - Building Maturity (following early Onyx problems)
 - External DMA I/O drivers fully supported (VME64)
- **Technically Suitable**
 - Benchmarks -> Windscatt production : 35 mins
 - Large system I/O Bandwidth (1.2 GB/s system bus)
- **Clear Upgrade Path for CPU + RAM + Disk**
 - CPU Expandable (12 x R4400 or 6 x TFP)
 - Board Level upgrade to TFP Chip (300 MFlops)
 - Max RAM : 6 GB
 - Max Disk : 2.5 TB
- **Low Cost Development Platform Available**
 - Challenge M
 - Application S/W portable to Challenge L un-modified

ERS-2 LRDPF

Implementation Strategy



- Incremental System Builds (Pilots)
- Pilot 1 : Installation at ESRIN
- Pilot 2 : Installation at ESRIN & Kiruna
- Piloting Goals :-
 - Reduce Risk through Early Identification of Problems
 - Fixes fed back in to Development Path
 - Implementation of Key Functions Early
 - Support to ERS-2 Commissioning at Kiruna
 - Force Early Integration between CGS/SPT
 - Minimise Potential FAT/SAT Problems

ERS-2 LRDPF

Overall Test Strategy : Industry

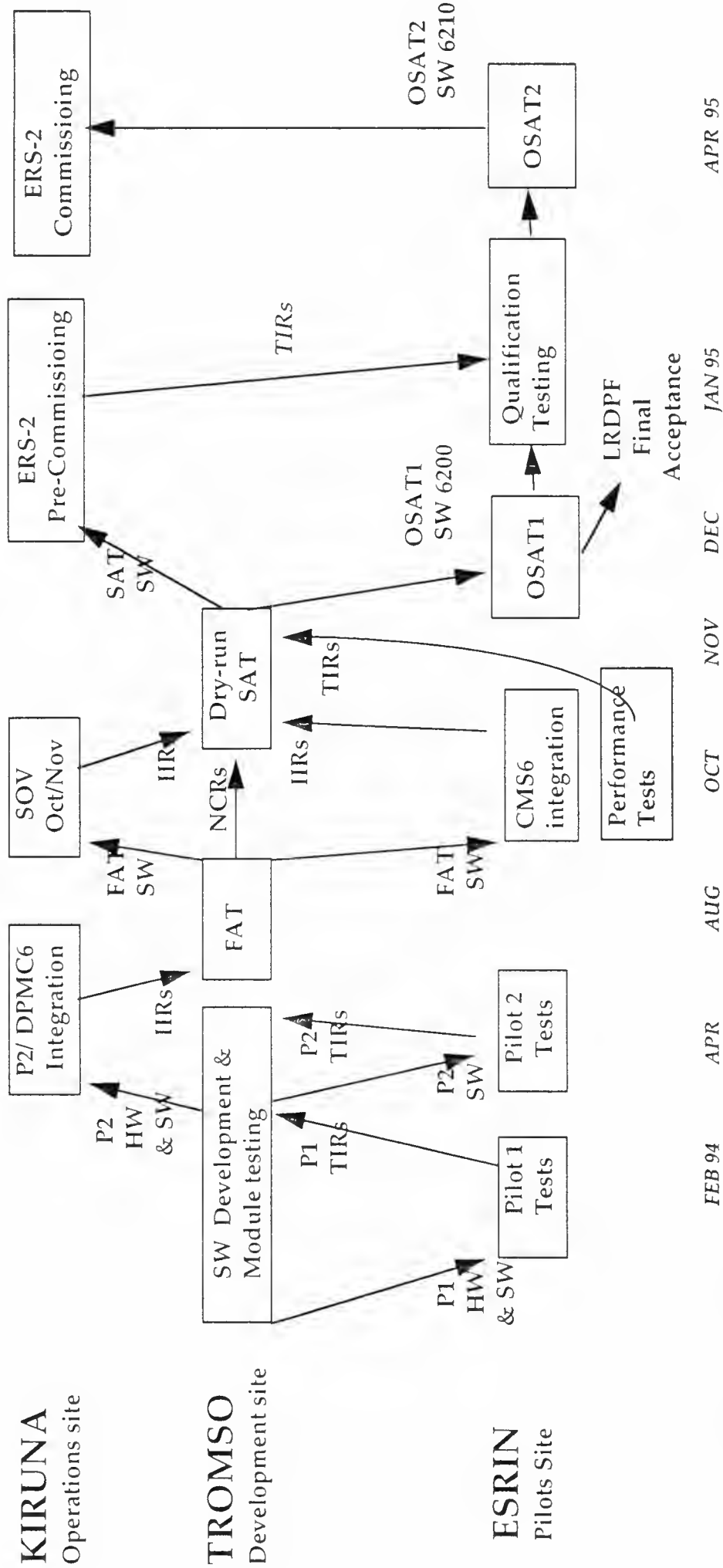
- **Algorithm Implementation Tests :-**
 - Dornier Test Data Comparison
 - For Windsatt Processing : raw data to sigma-0
 - 6 scenarios covered
 - ND LRDPF Comparison
 - For Windsatt : at specified breakpoints in algorithm + UWI product level
 - For Altimeter : at URA product level
- **Application Integration Tests :-**
 - First Integration at Pilot 1
 - Subsequent Integration prior tp CGS SAT
- **Formal Tests :-**
 - Internal FAT/SAT of MMI + Windsatt (CGS/SPT)
 - System FAT at Tromso
 - System OSAT1 at Esrin
- **LRDPF System Integration Tests :-**
 - Against CMS6 in FDPC environment at ESRIN

ERS-2 LRDPF

Overall Test Strategy : ESRIN

- **Functional Tests :-**
 - Verification of nominal execution
 - Under non-nominal conditions : Extensive error handling checks
- **Regression Tests :-**
 - Verification of fixes to Problems declared closed by Industry
 - Re-opening of TIR's / NCR's
- **Performance Tests :-**
 - End-End System throughput for various operational loads
- **Hardware Tests :-**
 - Laben LRFS + Spacetec LRFSI configuration
 - Exabyte device diagnostics
- **Reliability Tests :-**
 - Exabyte Device Robustness + Media Assessment
 - Realistic Transcription Operations
- **FD Product Comparison Tests :-**
 - Detailed field-by-field difference analysis ('delta' product)

ERS-2 LRDPF Development & Qualification Test Schema



ERS-2 LRDPF

System Performance Results

- **Scenario :-**
 - ERS-2 Science Test HDDT
 - Transcription to 7 Exabytes (Product configuration below)
 - Complete orbit of Wind + RA FD Product Generation + Dissemination to DPMC/CMS
 - Generation of 1.5 MB Instrument Header Products (all instruments) + Dissemination to CMS
 - Generation of 35 MB GOME + ATSR-2 E**C + Dissemination to BDDN
 - Archive to CCT of UWI, URA, E**I
- **Transcription :** **60 mins**
 - Product Generation + Write to Exabyte + Quality Check
 - ATSR-2, RA, GOME, MW, GH (380 MB total)
- **Windscatt (91 UWI) :** **40 mins**
- **Altimeter (85 URA) :** **1 min**
- **System Total Throughput :** **85 mins**
 - assuming Data Ingestion time of 25 mins (RT + PB).

ERS-2 LRDPF

Altimeter FD Product Qualification

- 2 Major (but compensating) Bugs discovered on ND,
- ERS-2 URA Products Compared from Parallel SGI/ND at Kiruna during Commissioning (identical LUTs/Schedules/Ingestion),
- Detailed Round-Orbit Plots + Cumulative Difference Statistics.
- Results (50 orbits, > 4000 products) :-
 - Altitude : Agrees to 1 cm
 - Wind Speed : Agrees to 1 cm/s
 - Wave Height : Agrees Exactly
 - Sigma-0 : Agrees to 0.01 db
 - All differences compatible with the reported resolution & occur on few DSR's only,
 - Very occasional outliers on Wind Speed + Sigma-0
- On-Going Work :-
 - small differences (< 1 cm) in std dev of Altitude
 - small differences (< 3) in peakiness count
 - # measurement blocks < 20 anomaly (occurs 1 in 10,000 DSR's)

• No Major Problems

Qualification Report

File: urand950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

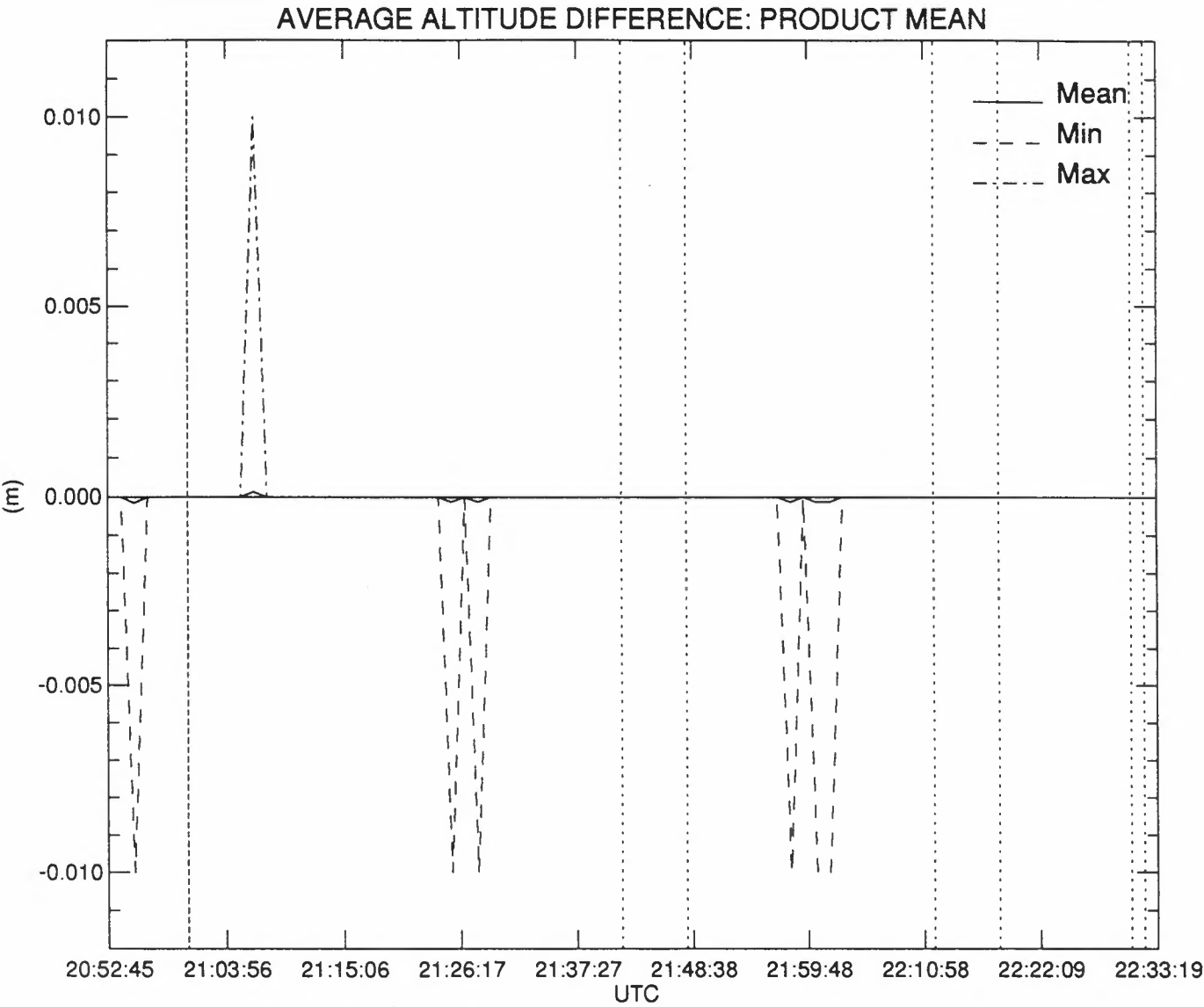
Last Product: 31-JUL-1995 22:33:19.154

File: urasg950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

Last Product: 31-JUL-1995 22:33:19.154



Total processed products = 81
Number of valid products = 65

On valid products:

- Mean = -1.05280E-05 (m)
- Min = -1.00000E-02 (m)
- Max = 1.00000E-02 (m)
- Std. Dev = 4.35805E-05 (m)

Qualification Report

File: urand950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

Last Product: 31-JUL-1995 22:33:19.154

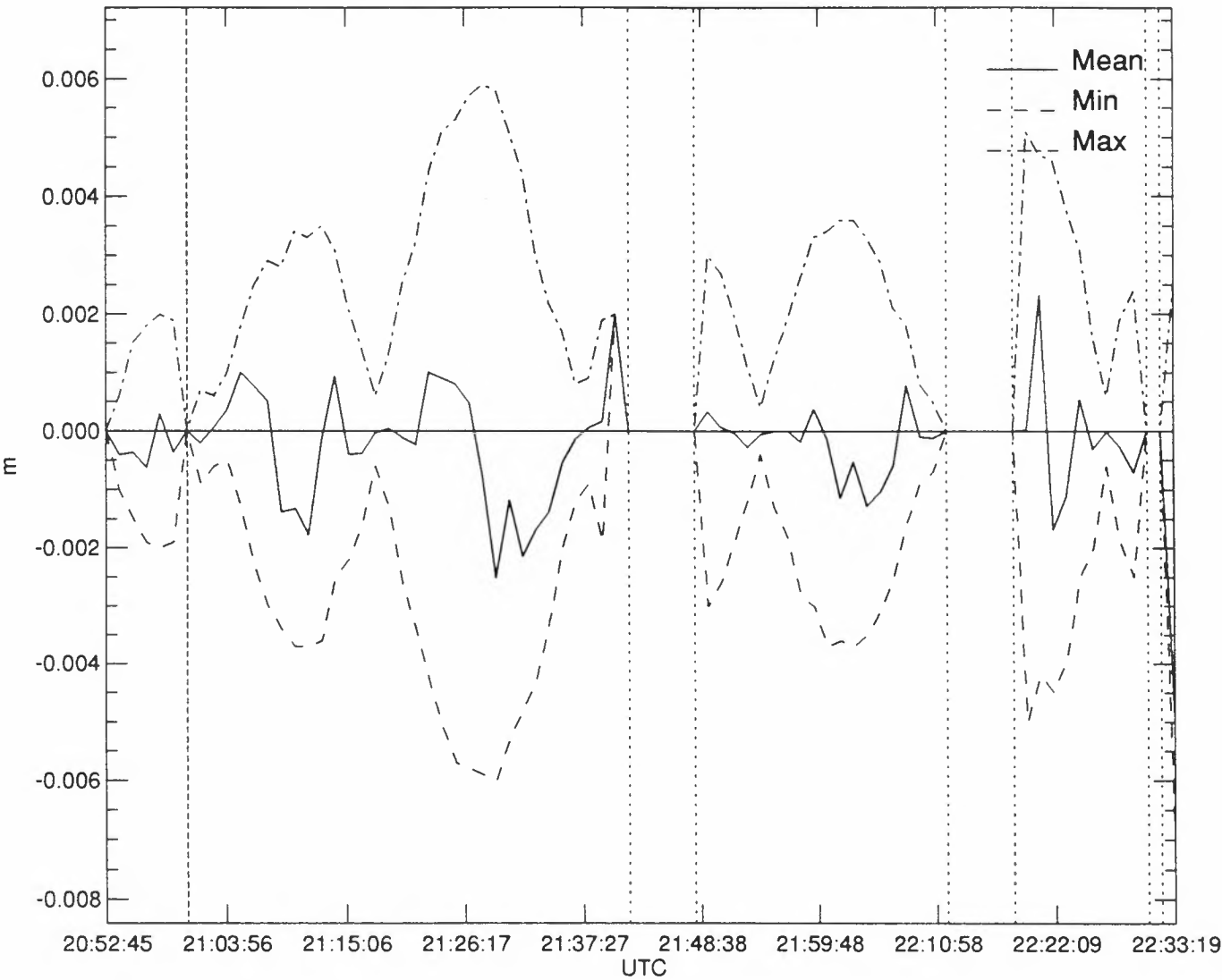
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Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

Last Product: 31-JUL-1995 22:33:19.154

STANDARD DEVIATION OF ALTITUDE DIFFERENCE: PRODUCT MEAN



Total processed products = 81

Number of valid products = 65

On valid products:

Mean = -2.88665E-04 (m)

Min = -7.10000E-03 (m)

Max = 5.90000E-03 (m)

Std. Dev = 1.04957E-03 (m)

Qualification Report

File: urand950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

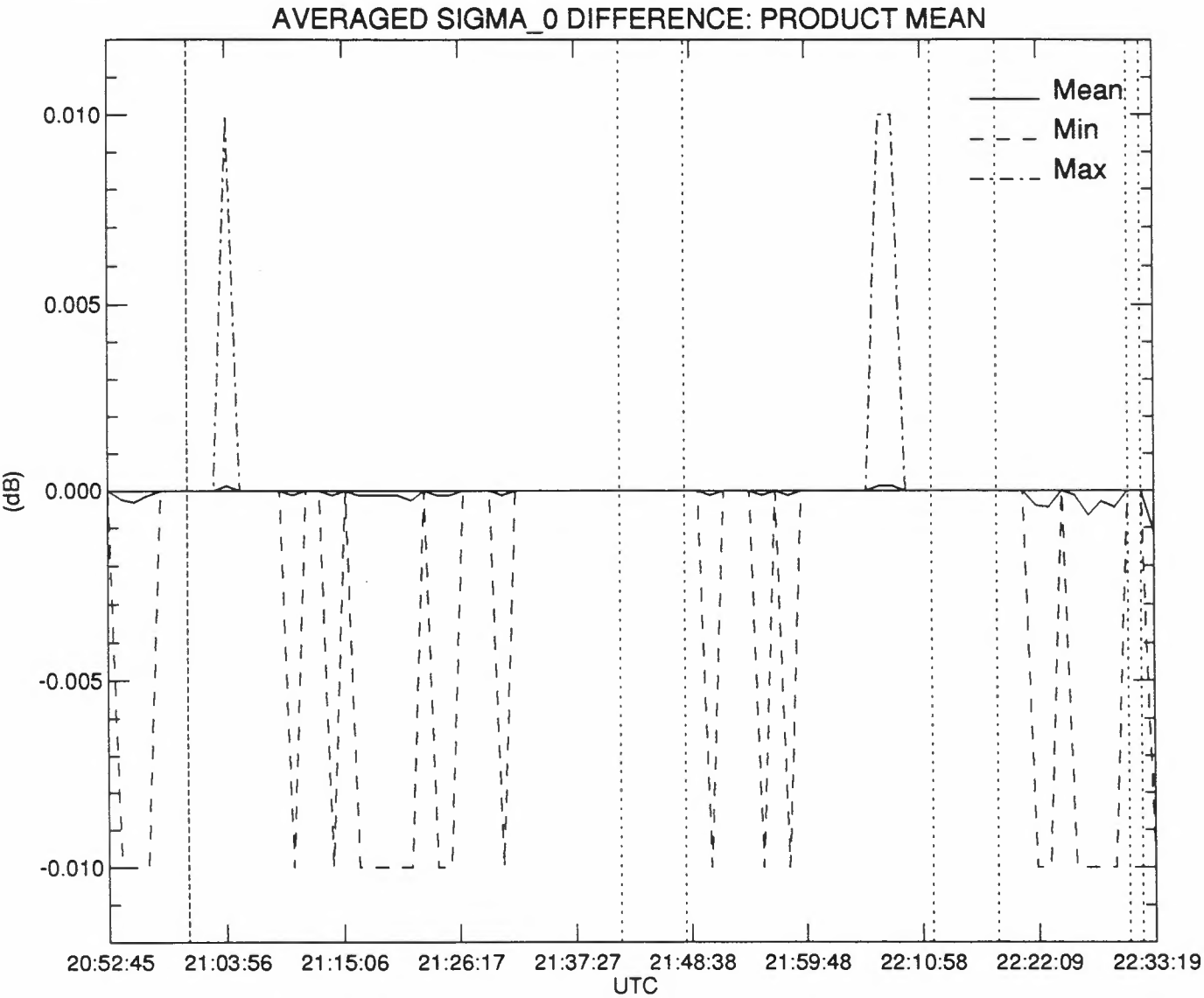
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Last Product: 31-JUL-1995 22:33:19.154



Total processed products = 81

Number of valid products = 65

On valid products:

Mean = -8.66078×10^{-5} (dB)

Min = -1.00000×10^{-2} (dB)

Max = 1.00000×10^{-2} (dB)

Std. Dev = 1.91909×10^{-4} (dB)

Qualification Report

File: urand950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

Last Product: 31-JUL-1995 22:33:19.154

File: urasg950731ksvp0008.e2

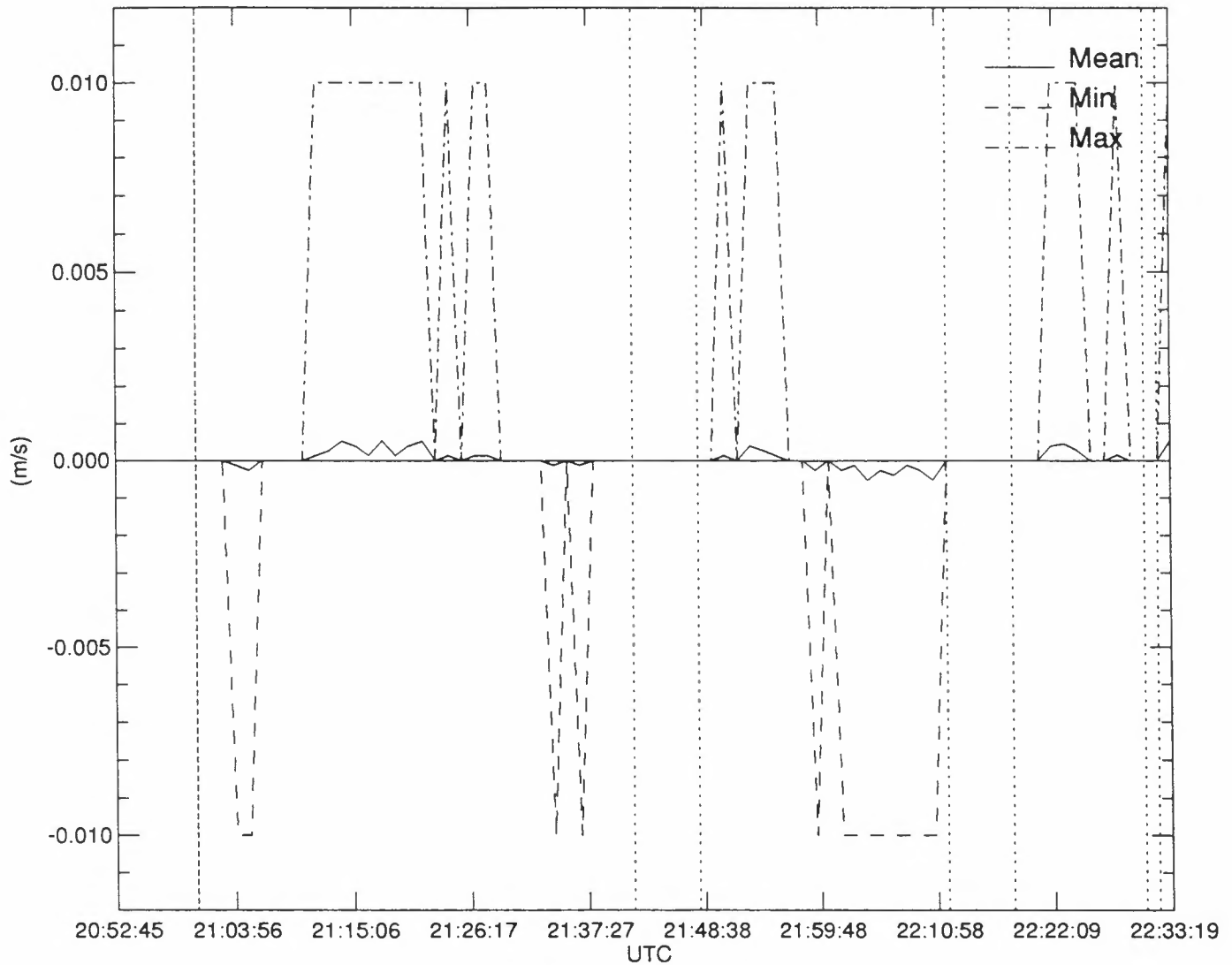
Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

Last Product: 31-JUL-1995 22:33:19.154

Page:11

AVERAGE WIND SPEED DIFFERENCE: PRODUCT MEAN



Total processed products = 81

Number of valid products = 65

On valid products:

Mean = $4.21187\text{E-}05$ (m/s)

Min = $-1.00000\text{E-}02$ (m/s)

Max = $1.00000\text{E-}02$ (m/s)

Std. Dev = $2.29790\text{E-}04$ (m/s)

Qualification Report

File: urand950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

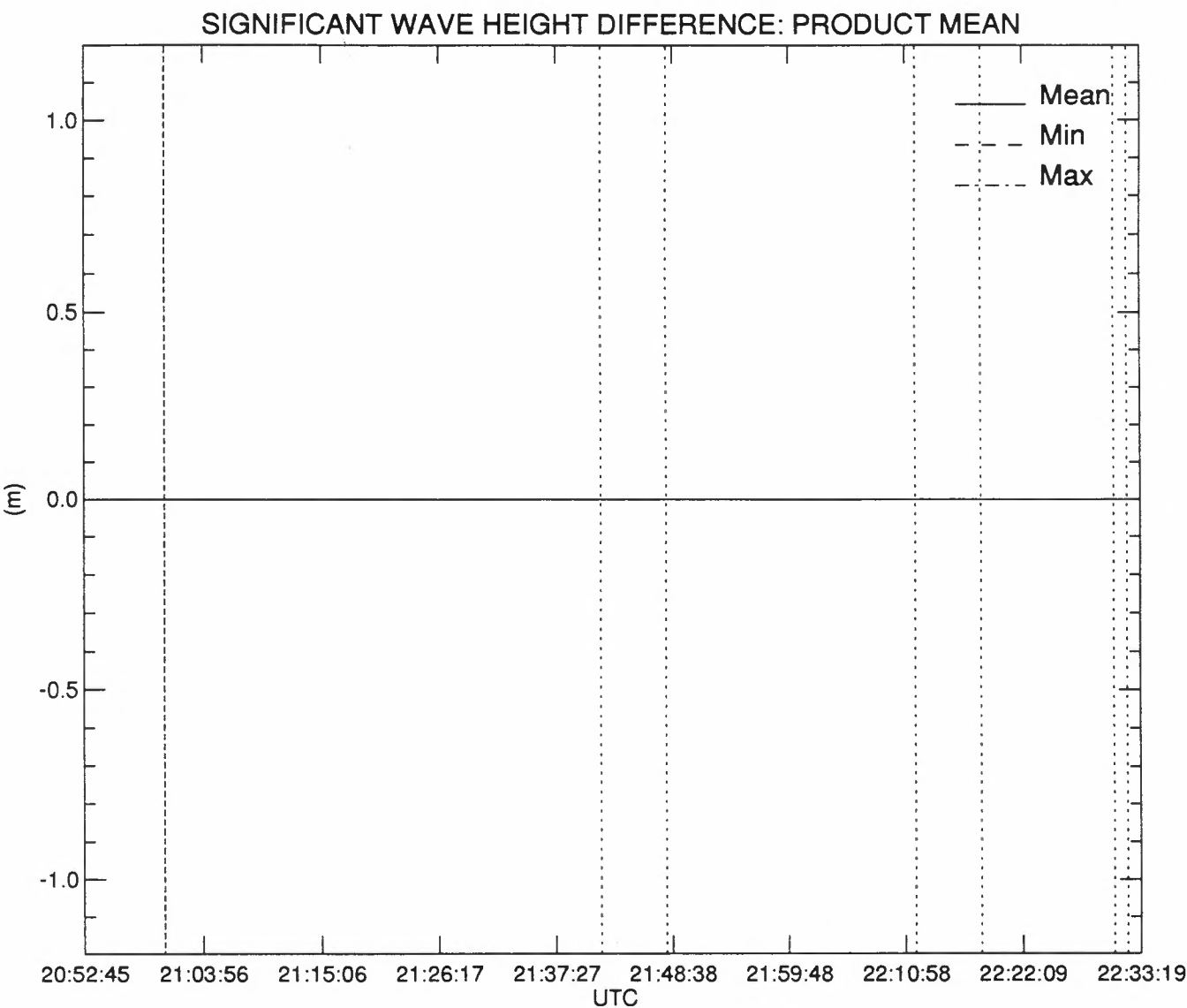
Last Product: 31-JUL-1995 22:33:19.154

File: urasg950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

Last Product: 31-JUL-1995 22:33:19.154



Total processed products = 81
Number of valid products = 65

On valid products:

Mean = 0.00000E+00 (m)

Min = 0.00000E+00 (m)

Max = 0.00000E+00 (m)

Std. Dev = 0.00000E+00 (m)

Qualification Report

File: urand950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

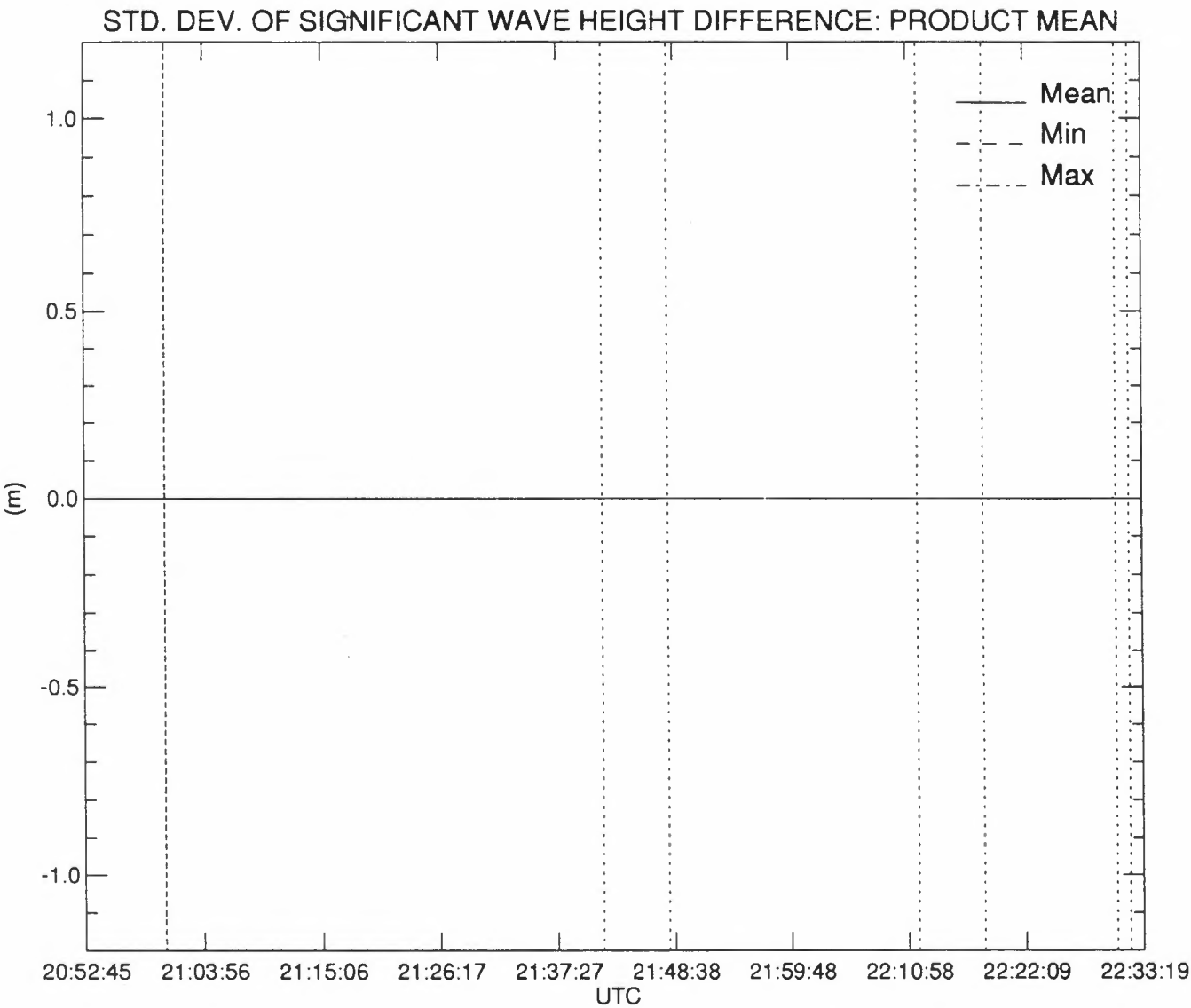
Last Product: 31-JUL-1995 22:33:19.154

File: urasg950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

Last Product: 31-JUL-1995 22:33:19.154



Total processed products = 81

Number of valid products = 65

On valid products:

Mean = 0.00000E+00 (m)

Min = 0.00000E+00 (m)

Max = 0.00000E+00 (m)

Std. Dev = 0.00000E+00 (m)

Qualification Report

File: urand950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

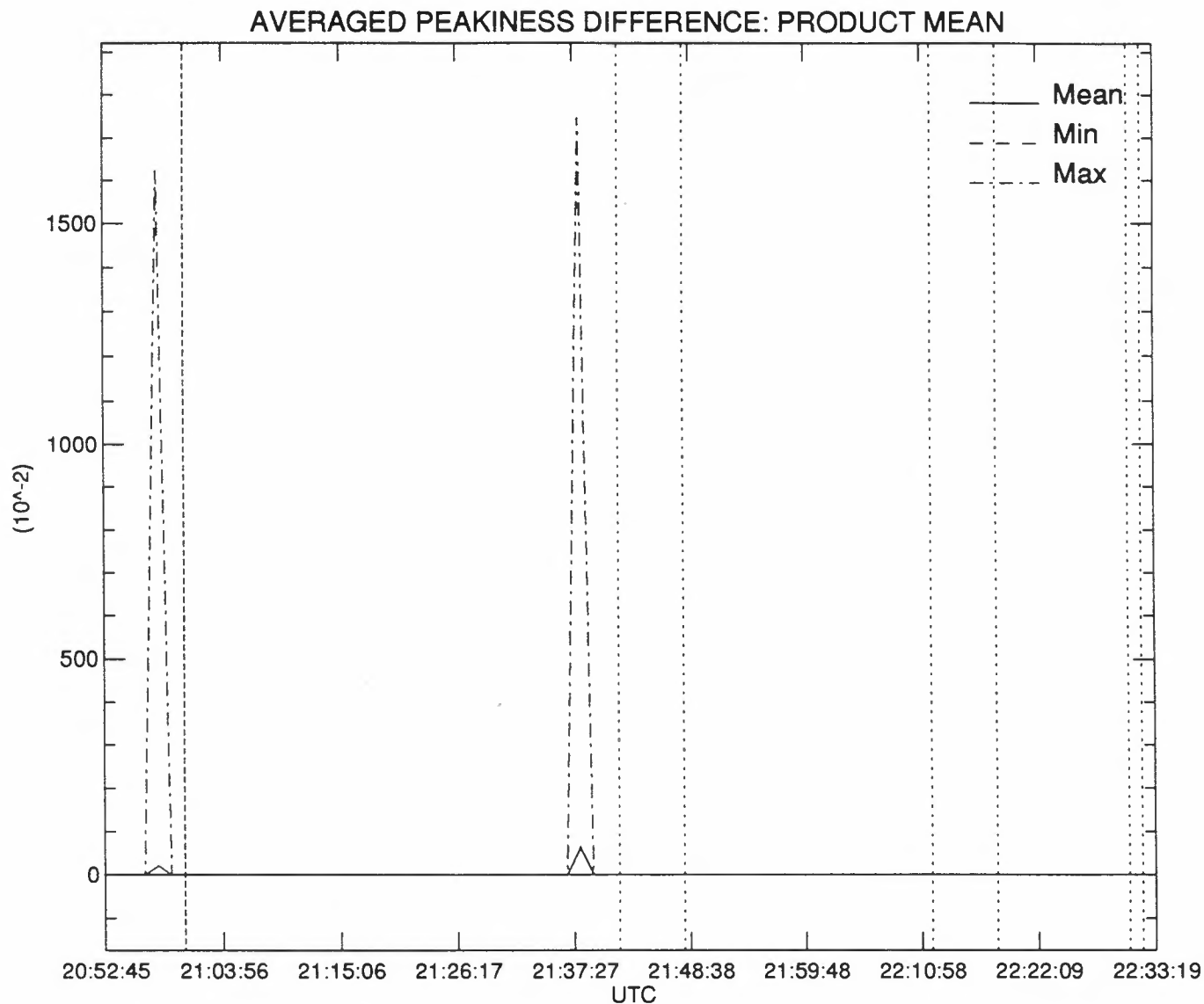
Last Product: 31-JUL-1995 22:33:19.154

File: urasg950731ksvp0008.e2

Number of Products: 81

First Product: 31-JUL-1995 20:52:45.461

Last Product: 31-JUL-1995 22:33:19.154



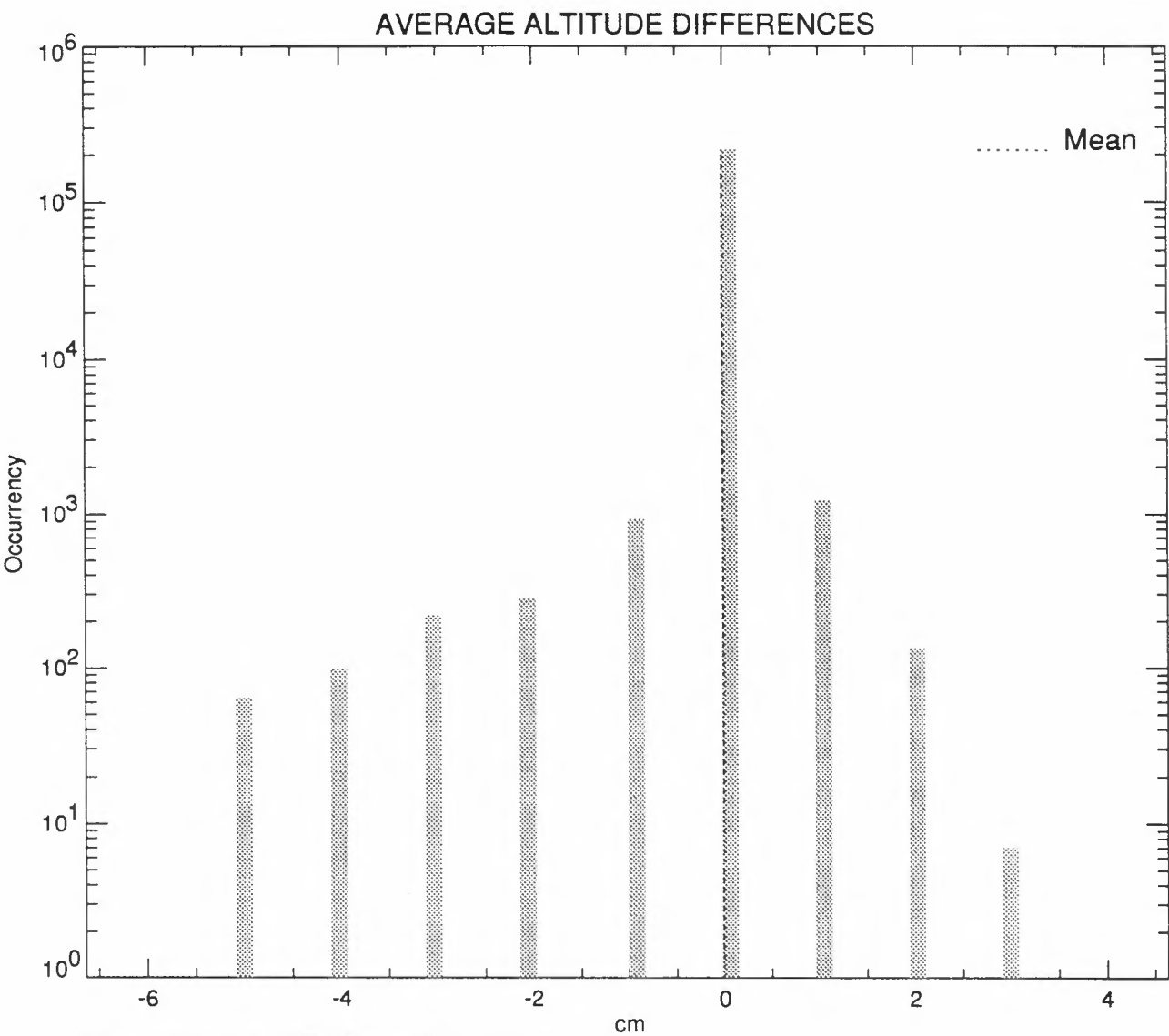
Total processed products = 81
Number of valid products = 65

On valid products:

- Mean = 1.31457E+00 (10⁻²)
- Min = 0.00000E+00 (10⁻²)
- Max = 1.74600E+03 (10⁻²)
- Std. Dev = 8.33996E+00 (10⁻²)

Re-Host LRDPF URA Qualification Report

Number of processed products: 4168
First Product: 10-JUN-1995 12:42:08.910 Last Product: 31-JUL-1995 22:33:19.154



Total number of DSRs = 320936

Number of valid differences = 217940

On valid differences :

Mean = -6.12095E-03 cm

Min = -5.00000E+00 cm

Max = 3.00000E+00 cm

Std. Dev. = 2.03021E-01 cm

% in [-20, +20] cm = 100

Mode = 0.00000E+00 cm

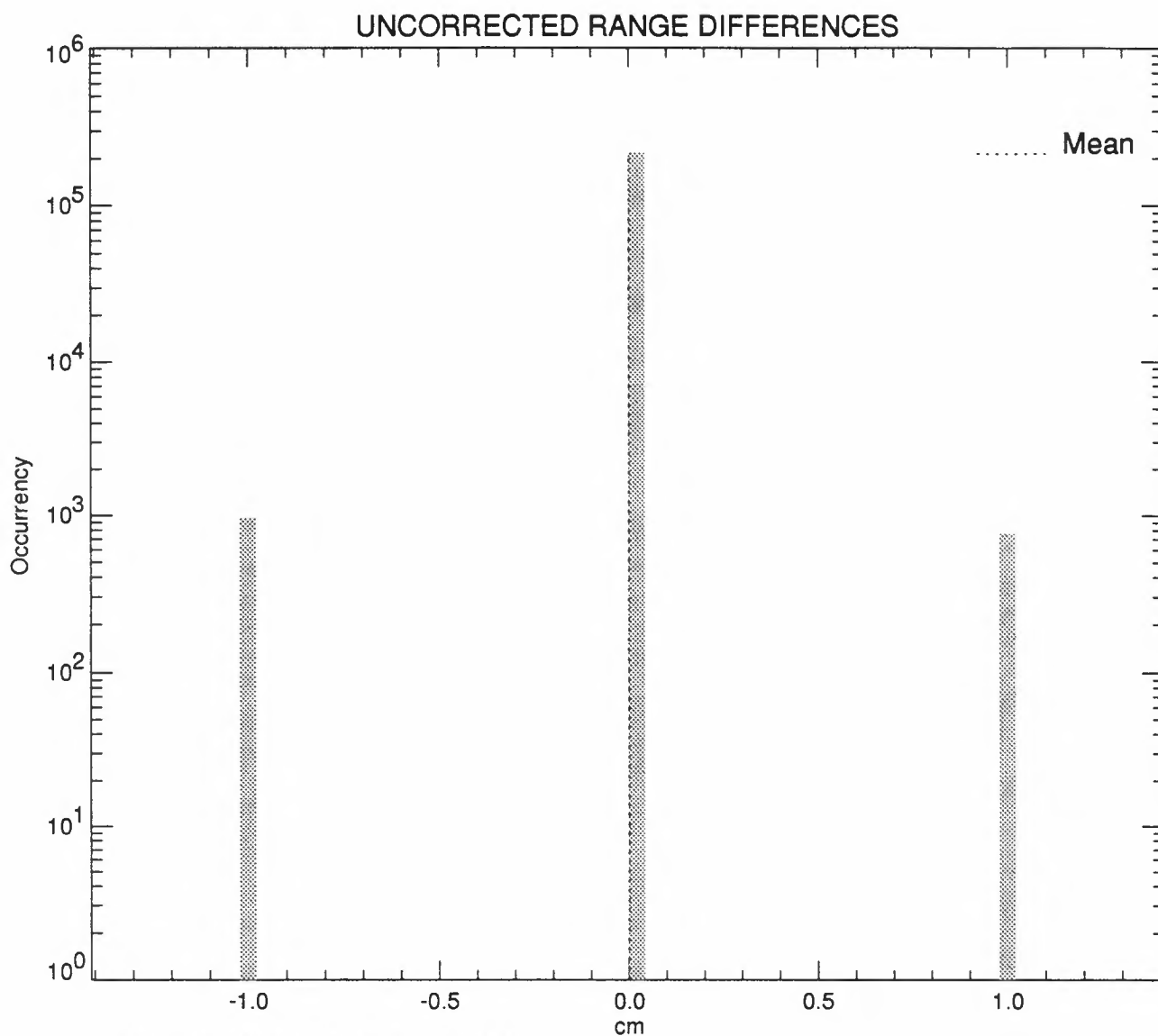
98% in [-1.63265E-03, 1.63265E-03] cm

Re-Host LRDPF URA Qualification Report

Number of processed products: 4168

First Product: 10-JUN-1995 12:42:08.910 Last Product: 31-JUL-1995 22:33:19.154

Page: 4



Total number of DSRs = 320936

Number of valid differences = 217940

On valid differences :

Mean = -9.40626E-04 cm

Min = -1.00000E+00 cm

Max = 1.00000E+00 cm

Std. Dev. = 8.88020E-02 cm

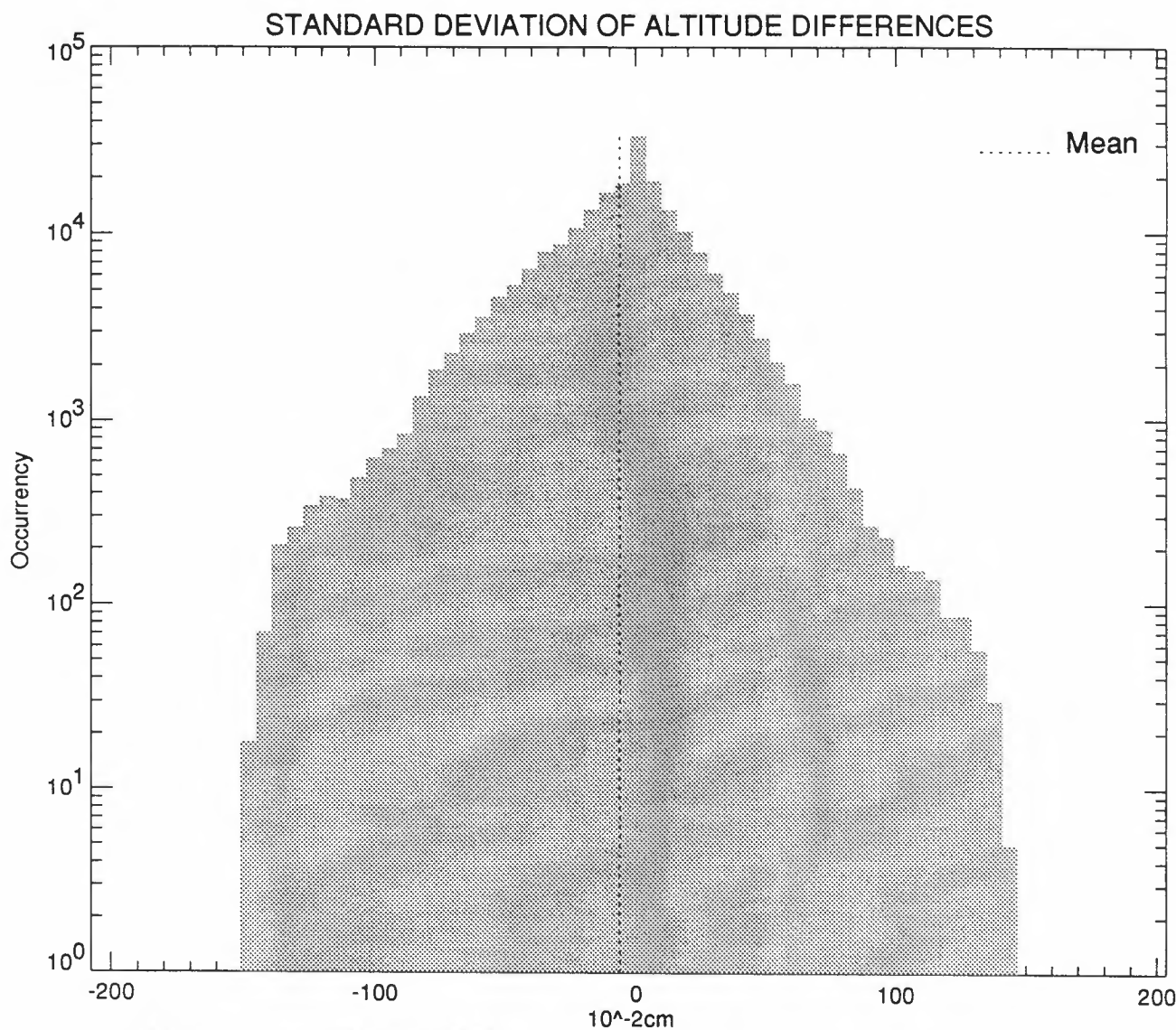
% in [-20, +20] cm = 100

Mode = 0.00000E+00 cm

99% in [-4.08163E-04, 4.08163E-04] cm

Re-Host LRDPF URA Qualification Report

Number of processed products: 4168
First Product: 10-JUN-1995 12:42:08.910 Last Product: 31-JUL-1995 22:33:19.154



Total number of DSRs = 320936

Number of valid differences = 217940

On valid differences :

Mean = -6.28447E+00 10^-2cm

Min = -1.48000E+02 10^-2cm

Max = 1.44000E+02 10^-2cm

Std. Dev. = 3.30859E+01 10^-2cm

% in [-10, +10]10^-2cm = 37

Mode = 0.00000E+00 10^-2cm

60% in [-2.20490E+01, 2.20490E+01]10^-2cm

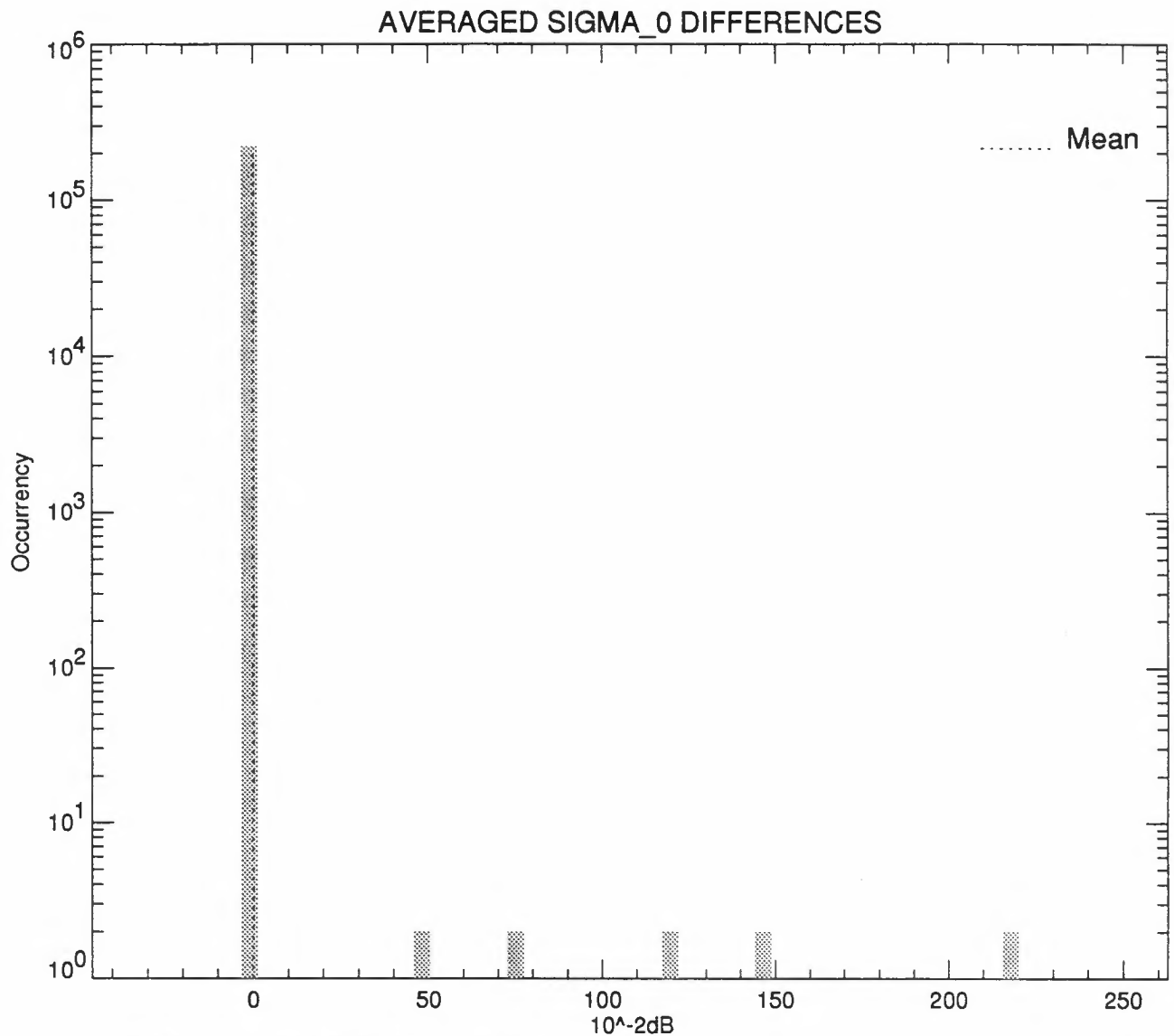
90% in [-5.70299E+01, 5.70299E+01]10^-2cm

Re-Host LRDPF URA Qualification Report

Number of processed products: 4168

First Product: 10-JUN-1995 12:42:08.910 Last Product: 31-JUL-1995 22:33:19.154

Page: 6



Total number of DSRs = 320936

Number of valid differences = 219821

On valid differences :

Mean = 1.21690E-02 10⁻²dB

Min = -1.00000E+00 10⁻²dB

Max = 2.18000E+02 10⁻²dB

Std. Dev. = 1.29133E+00 10⁻²dB

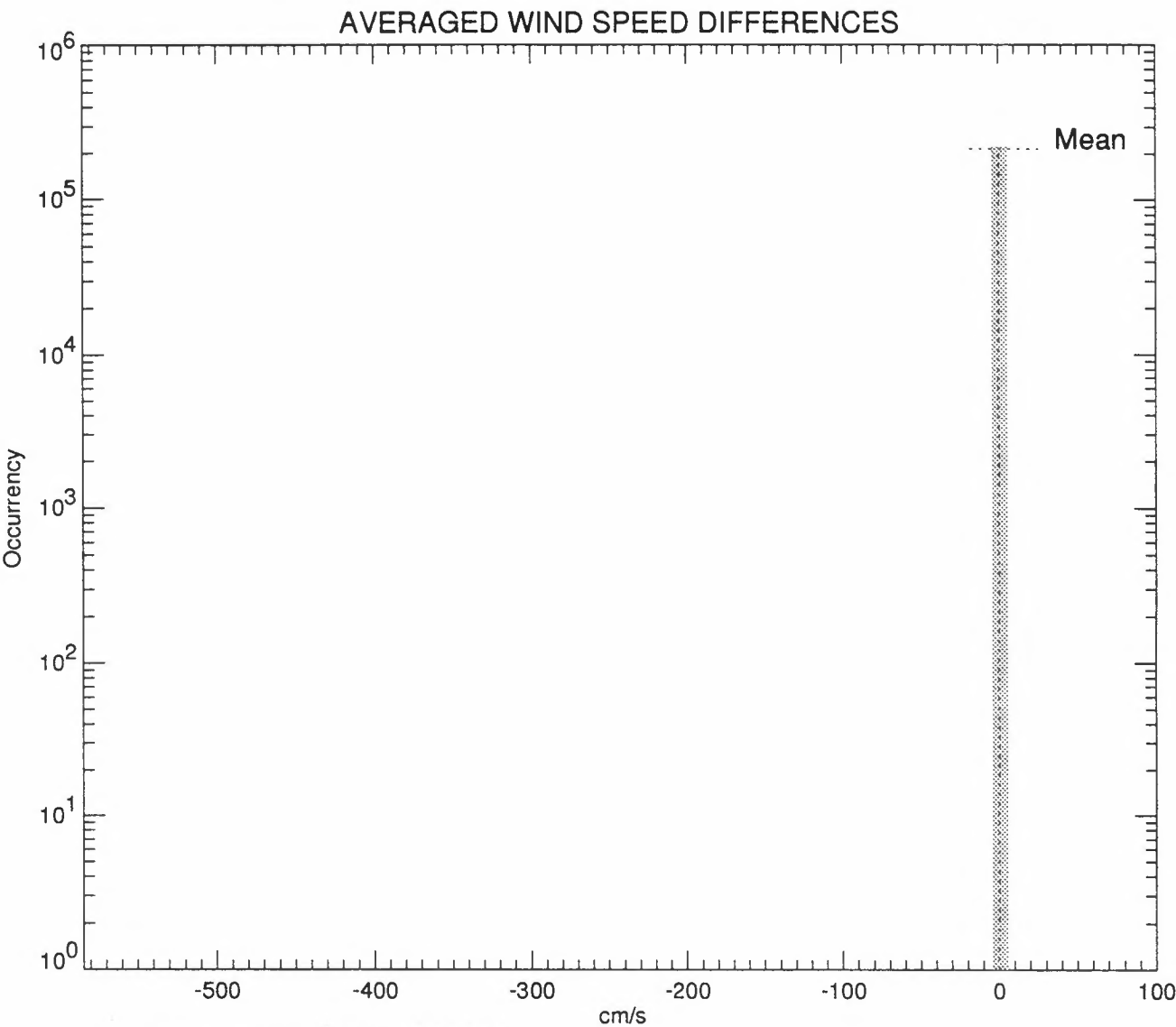
% in [- 1, + 1]10⁻²dB = 99

Mode = 0.00000E+00 10⁻²dB

98% in [-4.46939E-02, 4.46939E-02]10⁻²dB

Re-Host LRDPF URA Qualification Report

Number of processed products: 4168
First Product: 10-JUN-1995 12:42:08.910 Last Product: 31-JUL-1995 22:33:19.154



Total number of DSRs = 320936

Number of valid differences = 219816

On valid differences :

Mean = -1.93025E-02 cm/s

Min = -4.85000E+02 cm/s

Max = 1.00000E+00 cm/s

Std. Dev. = 2.24033E+00 cm/s

% in [- 1, + 1] cm/s = 99

Mode = 0.00000E+00 cm/s

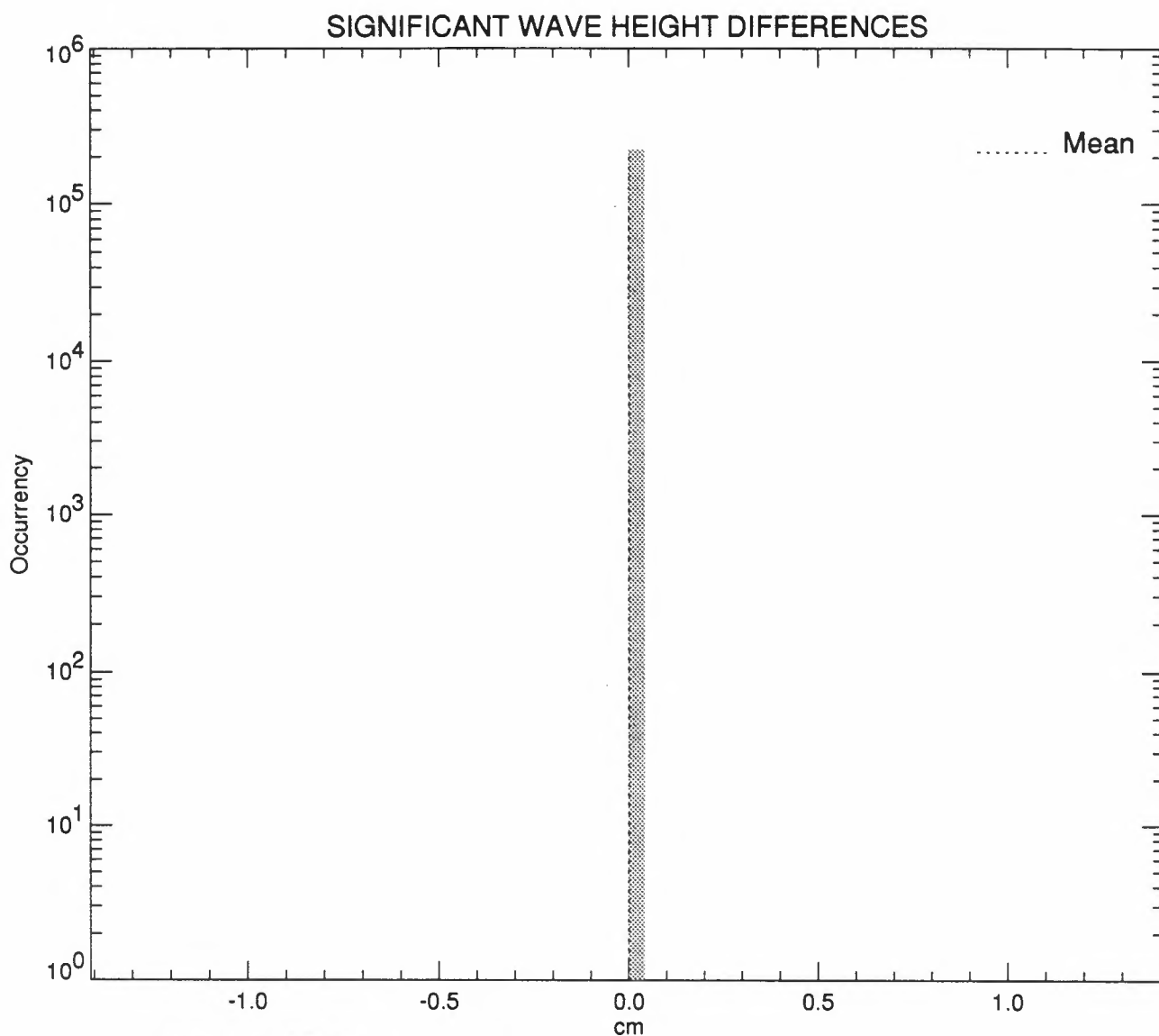
98% in [-9.91837E-02, 9.91837E-02] cm/s

Re-Host LRDPF URA Qualification Report

Number of processed products: 4168

First Product: 10-JUN-1995 12:42:08.910 Last Product: 31-JUL-1995 22:33:19.154

Page: 8



Total number of DSRs = 320936

Number of valid differences = 219821

On valid differences :

Mean = 0.00000E+00 cm

Min = 0.00000E+00 cm

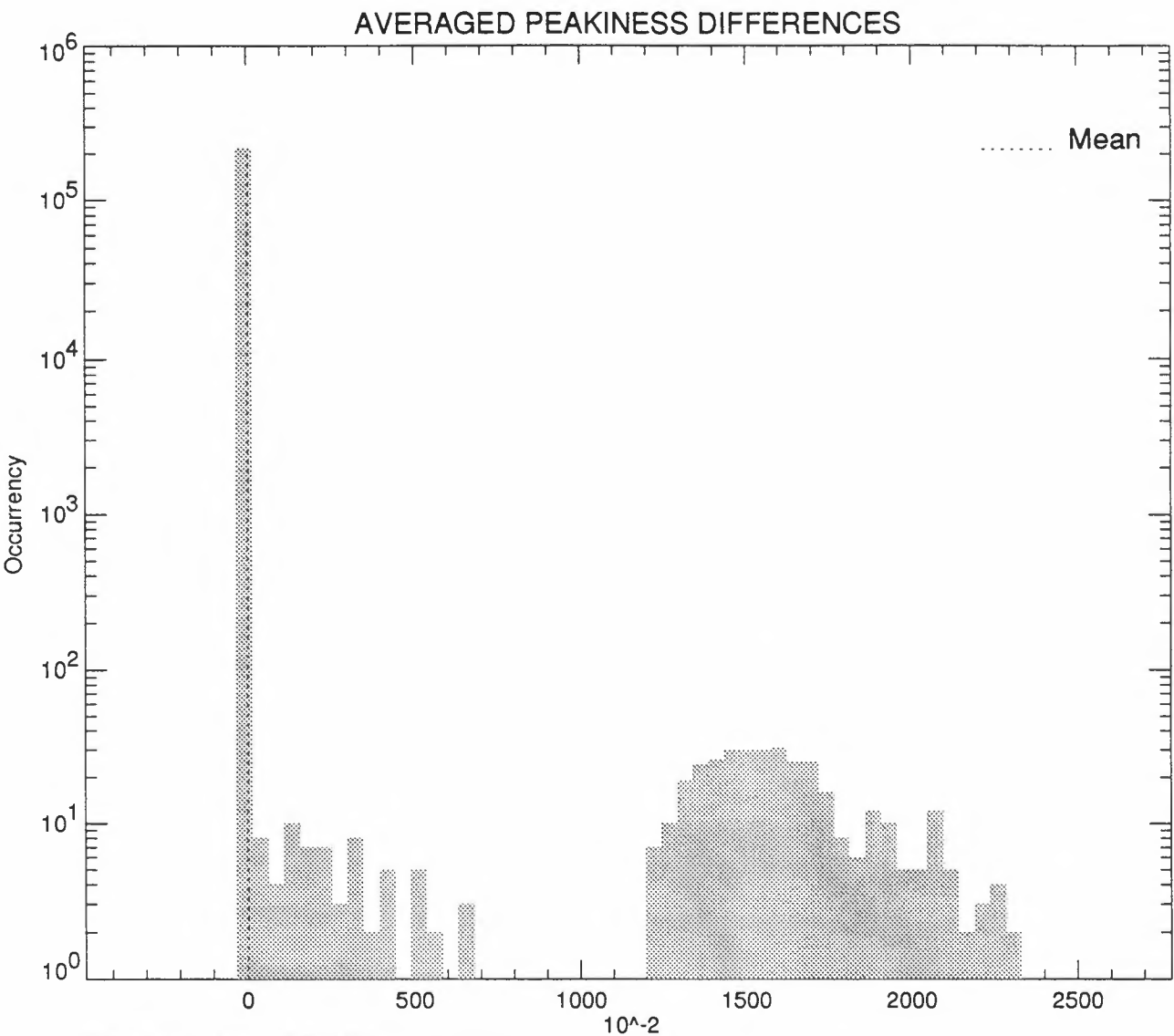
Max = 0.00000E+00 cm

Std. Dev. = 0.00000E+00 cm

% in [- 1, + 1] cm = 100

Re-Host LRDPF URA Qualification Report

Number of processed products: 4168
First Product: 10-JUN-1995 12:42:08.910 Last Product: 31-JUL-1995 22:33:19.154



Total number of DSRs = 320936

Number of valid differences = 217978

On valid differences :

Mean = 2.64880E+00 10⁻²

Min = -8.00000E+00 10⁻²

Max = 2.30900E+03 10⁻²

Std. Dev. = 6.52054E+01 10⁻²

% in [- 1, + 1] 10⁻² = 99

Mode = 0.00000E+00 10⁻²

99% in [-4.72857E-01, 4.72857E-01] 10⁻²

ERS-2 LRDPF

Windscatt FD Product Qualification

- Sigma0 -> Wind
- Tested 18 months ago (Pilot 1); same Wind Speed & Direction METEO Comparison Statistics as per ND.
- Raw Data -> Sigma0
- No ERS-2 (yet!), Limited (< 5) ERS-1 full orbits at ESRIN,
 - Results :-
 - Agreement to 0.00005 db on all beams but some nodes at 0.1 db difference after South Pole Crossing (No impact on Wind),
 - 60 % within 0.005 db , 90 % within 0.01 db,
- Raw Data -> Wind
- Results :-
 - Wind Speed : 90 % within 0.5 m/s, occasional outliers at 2 m/s
 - Wind Direction : 80 % within 2 deg, occasional outliers at 180 deg
 - Differences could be due to product generation conditions (not same)
 - Further Investigation :-
 - Parallel SGI / ND Production at Fucino

No Major Problems (but limited Data Set)

ERS-1 Wind Scatterometer Products (UWI)

First Product : 06-FEB-1994 18:21:13.774 : ORBIT : 13399.4193

Last Product : 06-FEB-1994 19:35:03.954 : ORBIT : 13400.1543

Total Products Processed : 63

Day : 37

Page : 5

UWI GLOBAL ACQUISITIONS : STATISTICS

Total number of nodes	=	22743
-----------------------	---	-------

On Total of nodes :

No valid sigma naught	=	0	0.00%
Only one valid sigma naught	=	570	2.51%
Only two valid sigma naught	=	76	0.33%
Three valid sigma naught	=	22097	97.16%

On Three valid sigma naught :

Three Beams - ARCING	=	0	0.00%
Three Beams - KP	=	0	0.00%
Three Beams - LAND	=	6212	28.11%
Three Beams - LOW WIND	=	2200	9.96%
Three Beams - LOW PROB	=	173	0.78%
RANK 1 < 10 nodes	=	2	0.01%
Checksum Flag	=	0	0.00%
Three Beams - OK	=	13510	61.14%

On Three Beam OK :

AMB. REM. auto. mode	=	0	0.00%
AMB. REM. meteo after auto.	=	10235	75.76%
AMB. REM. meteo only	=	1971	14.59%
AMB. REM. compatability	=	722	5.34% (95.69%)
RANK 1 auto. mode	=	0	0.00%
RANK 1 meteo after auto.	=	0	0.00%
RANK 1 meteo only	=	582	4.31% (4.31%)

ERS-1 Wind Scatterometer Products (UWI)

First Product : 06-FEB-1994 18:21:13.774 : ORBIT : 13399.4193

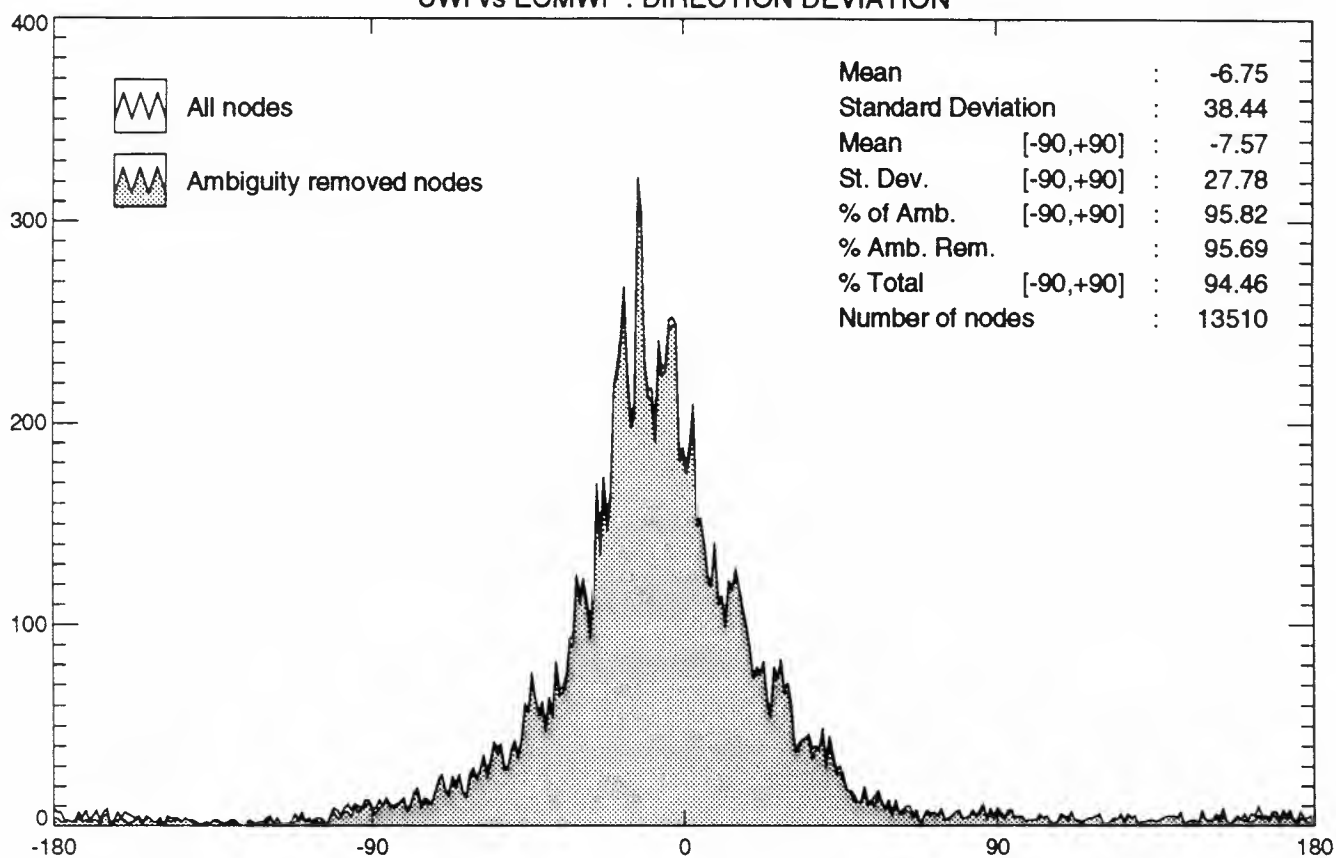
Last Product : 06-FEB-1994 19:35:03.954 : ORBIT : 13400.1543

Total Products Processed : 63

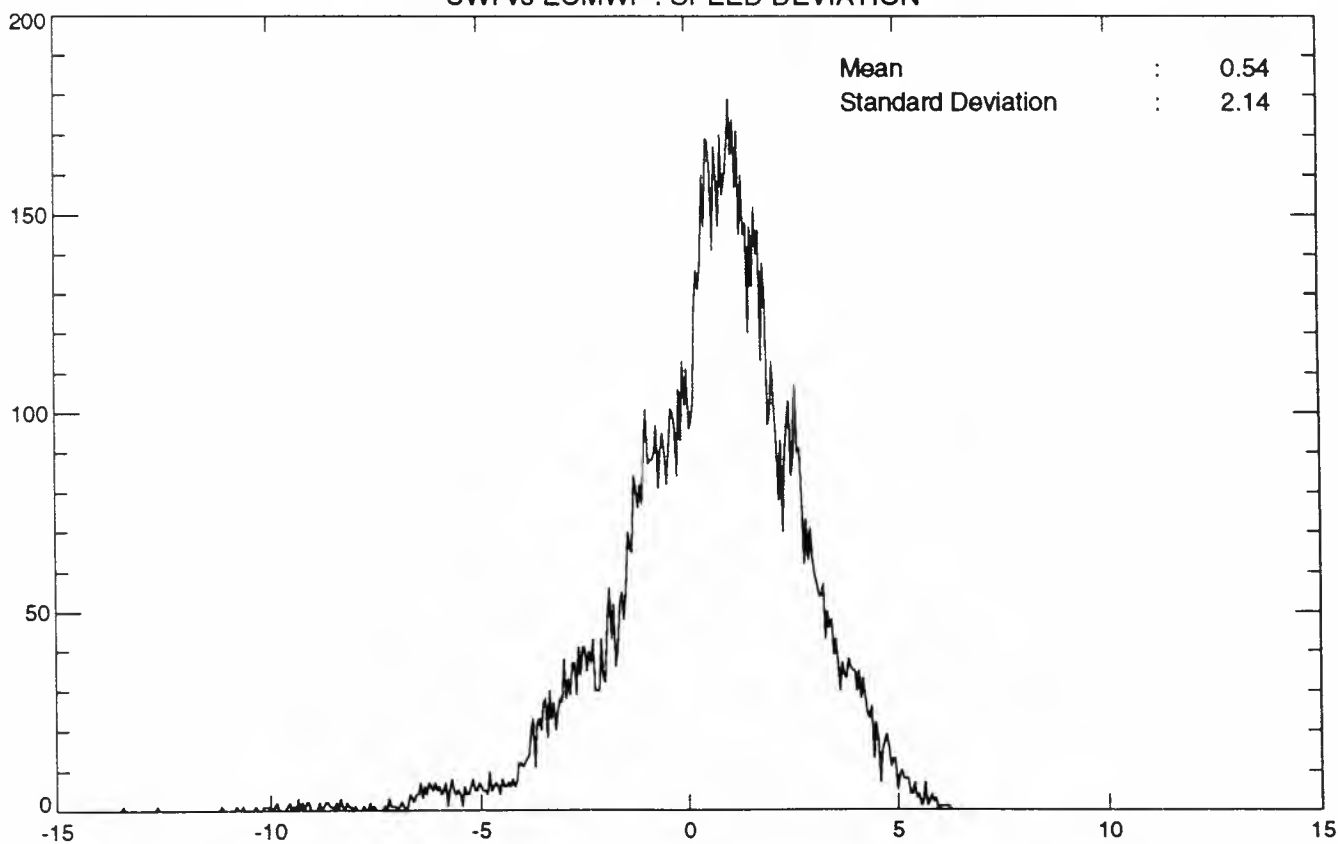
Day : 37

Page : 6

UWI vs ECMWF : DIRECTION DEVIATION



UWI vs ECMWF : SPEED DEVIATION



ERS-1 Wind Scatterometer Products (UWI)

First Product : 06-FEB-1994 18:21:13.774 : ORBIT : 13399.4193

Last Product : 06-FEB-1994 19:35:03.954 : ORBIT : 13400.1543

Total Products Processed : 63

Day : 37

Page : 5

UWI GLOBAL ACQUISITIONS : STATISTICS

Total number of nodes	=	22743
-----------------------	---	-------

On Total of nodes :

No valid sigma naught	=	0	0.00%
Only one valid sigma naught	=	570	2.51%
Only two valid sigma naught	=	76	0.33%
Three valid sigma naught	=	22097	97.16%

On Three valid sigma naught :

Three Beams - ARCING	=	0	0.00%
Three Beams - KP	=	0	0.00%
Three Beams - LAND	=	6212	28.11%
Three Beams - LOW WIND	=	2219	10.04%
Three Beams - LOW PROBA	=	160	0.72%
RANK 1 < 10 nodes	=	1	0.00%
Checksum Flag	=	0	0.00%
Three Beams - OK	=	13505	61.12%

On Three Beam OK :

AMB. REM. auto. mode	=	865	6.41%	
AMB. REM. meteo after auto.	=	11925	88.30%	
AMB. REM. meteo only	=	130	0.96%	
AMB. REM. compatability	=	0	0.00%	(95.67%)
 RANK 1 auto. mode	=	0	0.00%	
RANK 1 meteo after auto.	=	583	4.32%	
RANK 1 meteo only	=	2	0.01%	(4.33%)

ERS-1 Wind Scatterometer Products (UWI)

First Product : 06-FEB-1994 18:21:13.774 : ORBIT : 13399.4193

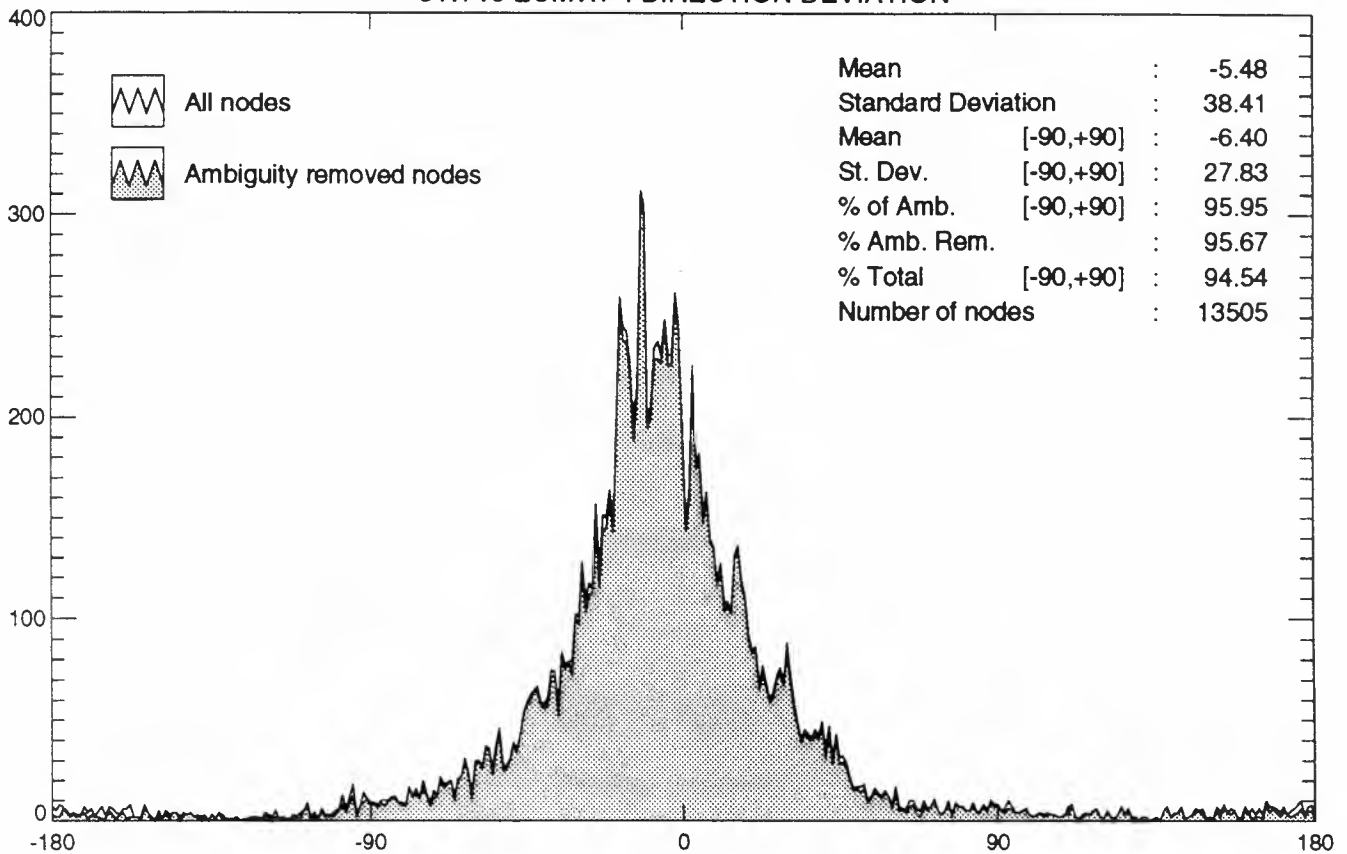
Last Product : 06-FEB-1994 19:35:03.954 : ORBIT : 13400.1543

Total Products Processed : 63

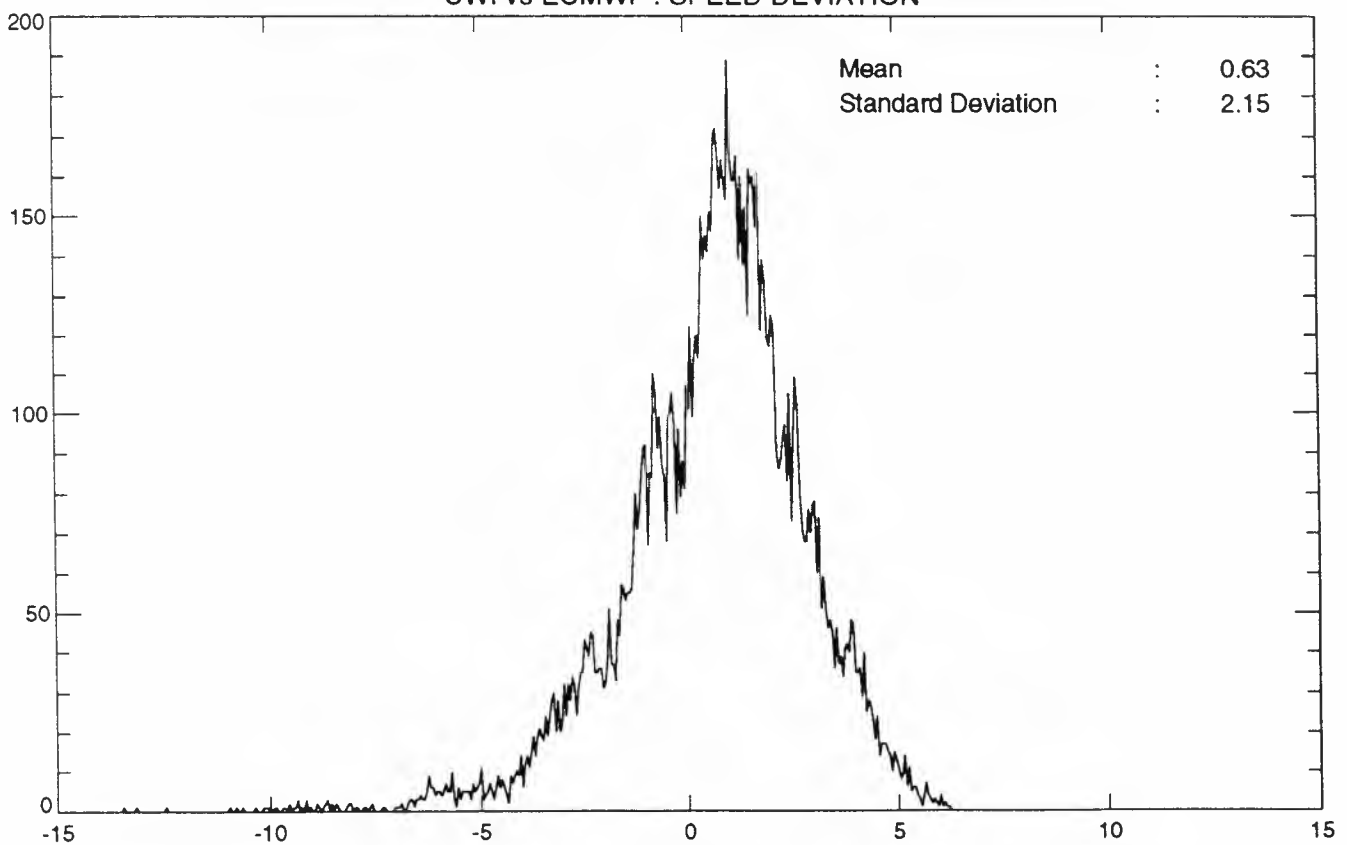
Day : 37

Page : 6

UWI vs ECMWF : DIRECTION DEVIATION



UWI vs ECMWF : SPEED DEVIATION



Qualification Report

File: uwi__950726ksep1001.e1

Number of Products: 70

First Product: 26-JUL-1995 08:11:39.002

Last Product: 26-JUL-1995 09:33:49.347

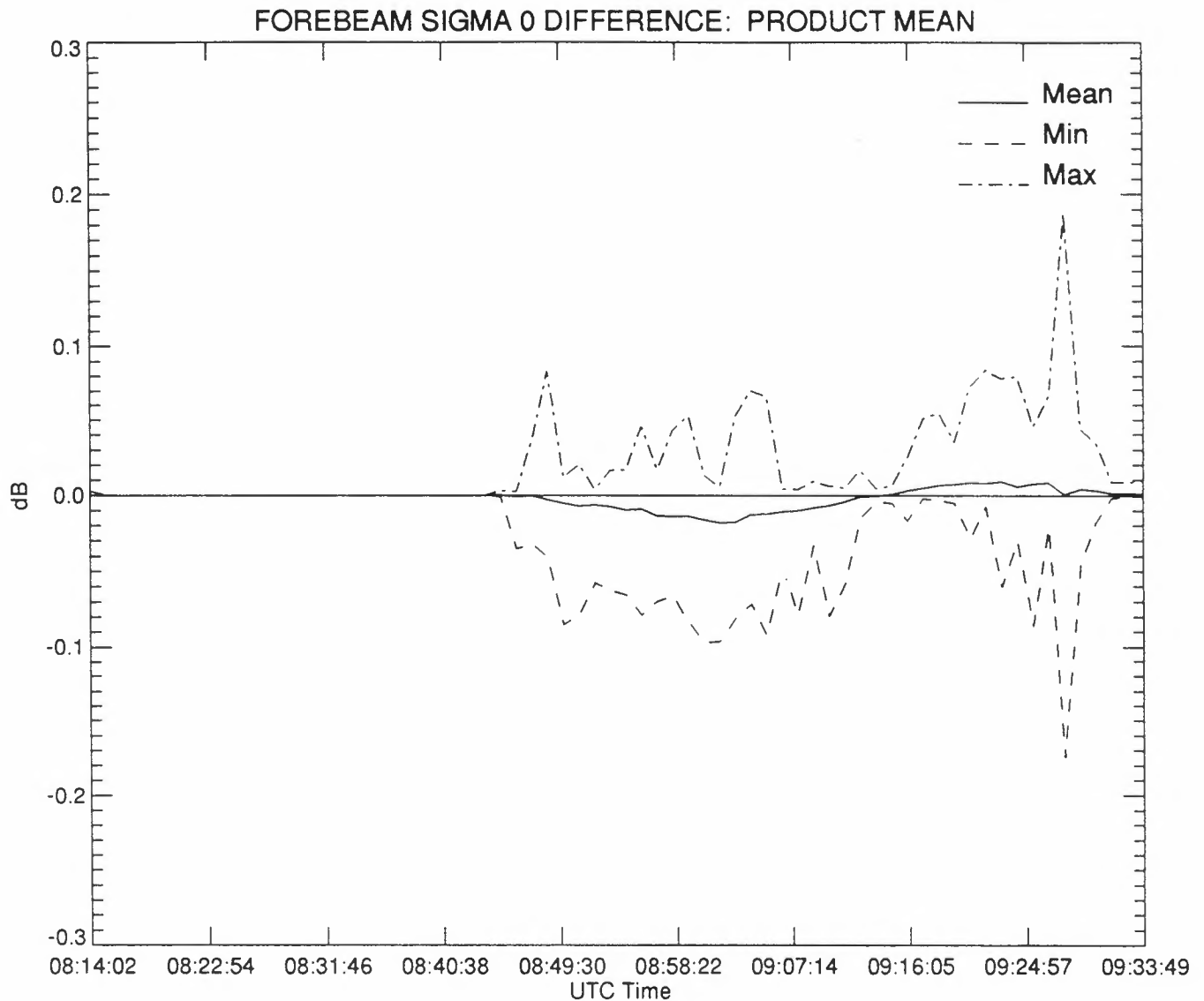
File: uwi__950929esep0000.e1

Number of Products: 69

First Product: 26-JUL-1995 08:14:01.943

Last Product: 26-JUL-1995 09:35:00.810

Page:12



Total processed products = 68

Number of valid products = 68

On valid products:

Mean = -1.88716×10^{-3} (dB)

Min = -1.74350×10^{-1} (dB)

Max = 1.87639×10^{-1} (dB)

Std. Dev = 6.38695×10^{-3} (dB)

% in $[-5.0 \times 10^{-5}$ dB, $+5.0 \times 10^{-5}$ dB] = 38.0

Qualification Report

File: uwi__950726ksep1001.e1

Number of Products: 70

First Product: 26-JUL-1995 08:11:39.002

Last Product: 26-JUL-1995 09:33:49.347

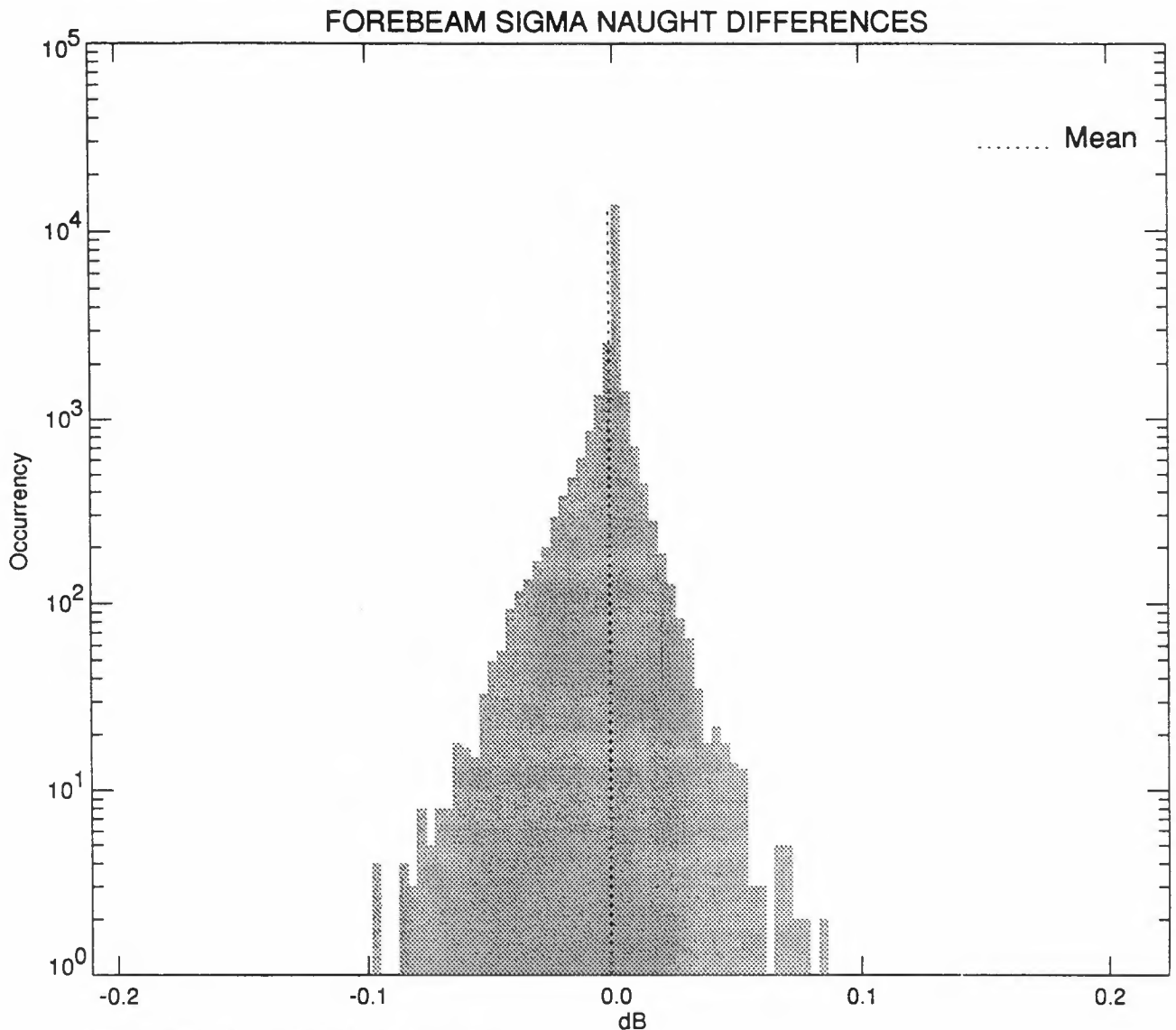
File: uwi__950929esep0000.e1

Number of Products: 69

First Product: 26-JUL-1995 08:14:01.943

Last Product: 26-JUL-1995 09:35:00.810

Page:15



Total number of nodes = 24548

Number of valid sigma naught differences = 24548

On valid sigma naught differences :

Mean = -1.88716×10^{-3} (dB)

Min = -1.74350×10^{-1} (dB)

Max = 1.87639×10^{-1} (dB)

Std. Dev. = 1.12723×10^{-2} (dB)

% in $[-5.0 \times 10^{-5} \text{ dB}, +5.0 \times 10^{-5} \text{ dB}] = 39.0$

Mode = 1.21458×10^{-3} (dB)

60% in $[-1.33745 \times 10^{-3} \text{ dB}, 3.76657 \times 10^{-3} \text{ dB}]$

90% in $[-1.63784 \times 10^{-2} \text{ dB}, 1.88071 \times 10^{-2} \text{ dB}]$

Qualification Report

File: uwi__950726ksep1001.e1

Number of Products: 70

First Product: 26-JUL-1995 08:11:39.002

Last Product: 26-JUL-1995 09:33:49.347

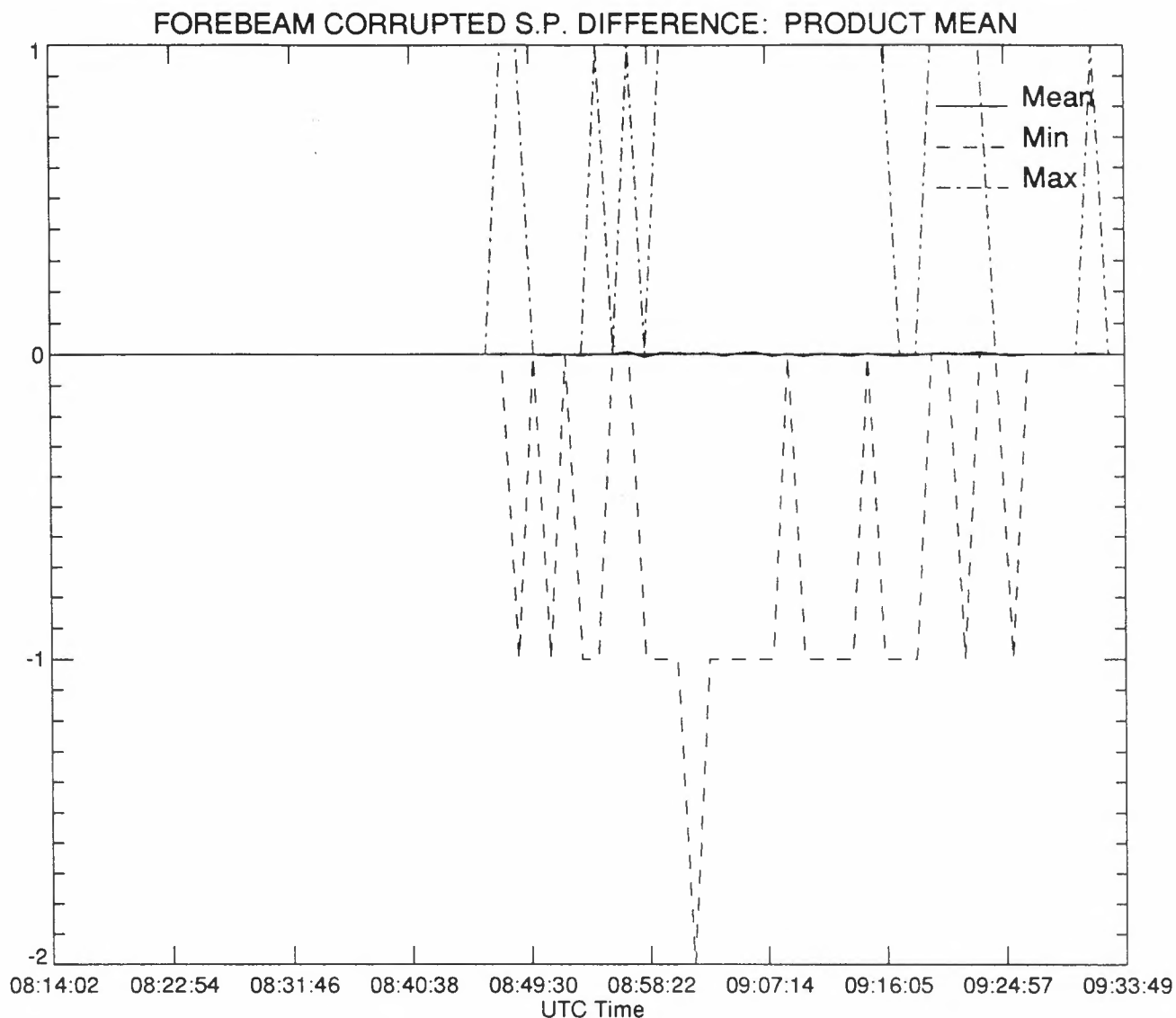
File: uwi__950929esep0000.e1

Number of Products: 69

First Product: 26-JUL-1995 08:14:01.943

Last Product: 26-JUL-1995 09:35:00.810

Page:18



Total processed products = 68

Number of valid products = 68

On valid products:

Mean = 4.07365E-04

Min = -2.00000E+00

Max = 1.00000E+00

Std. Dev = 3.21996E-03

Qualification Report

File: uwi__950726ksep1001.e1

Number of Products: 70

First Product: 26-JUL-1995 08:11:39.002

Last Product: 26-JUL-1995 09:33:49.347

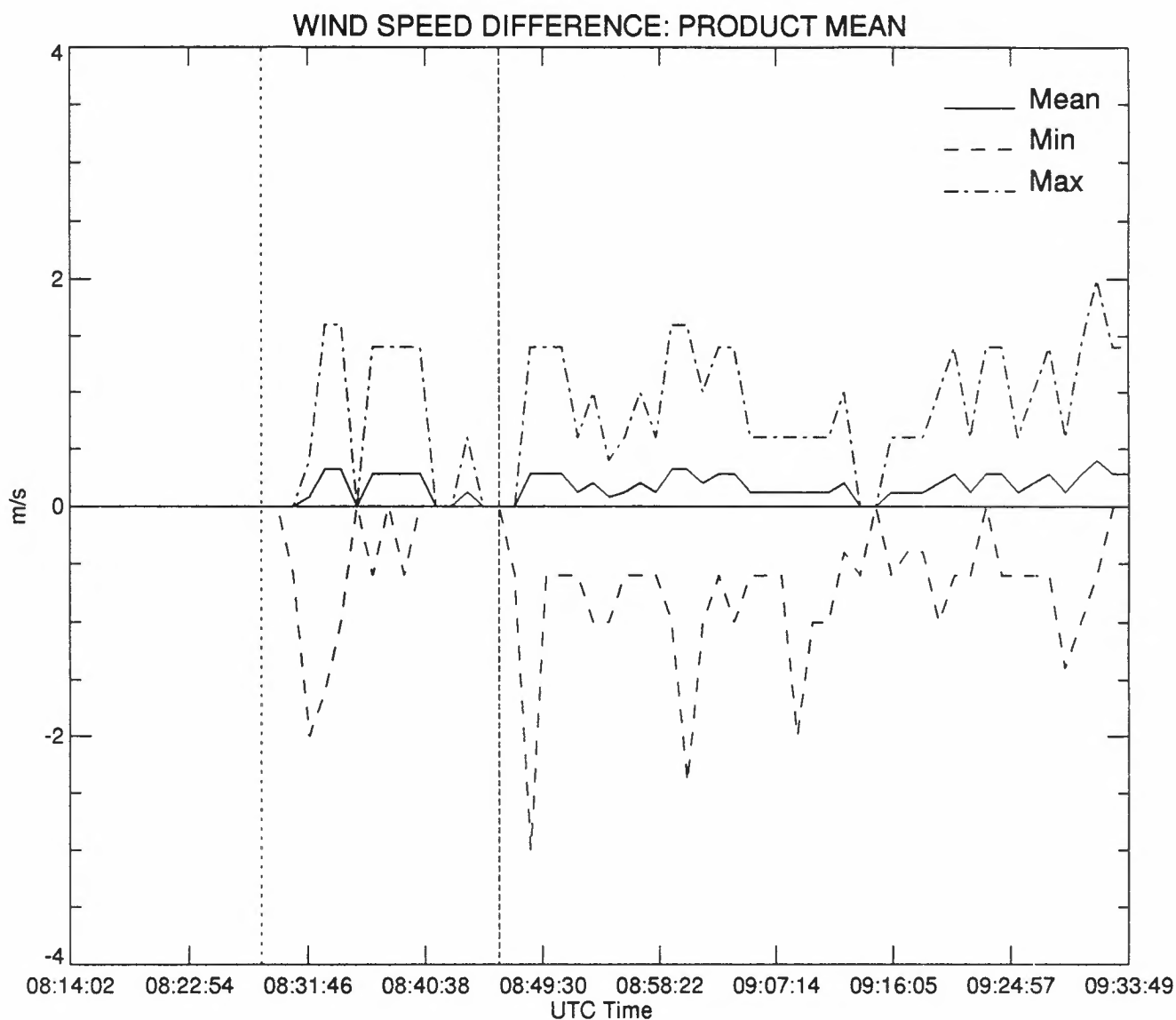
File: uwi__950929esep0000.e1

Number of Products: 69

First Product: 26-JUL-1995 08:14:01.943

Last Product: 26-JUL-1995 09:35:00.810

Page:21



Total processed products = 68

Number of valid products = 54

On valid products:

Mean = 1.74815E-01 (m/s)

Min = -3.00000E+00 (m/s)

Max = 2.00000E+00 (m/s)

Std. Dev = 1.11334E-01 (m/s)

% in [- 1m/s, + 1m/s] =100.0

Qualification Report

File: uwi__950726ksep1001.e1

Number of Products: 70

First Product: 26-JUL-1995 08:11:39.002

Last Product: 26-JUL-1995 09:33:49.347

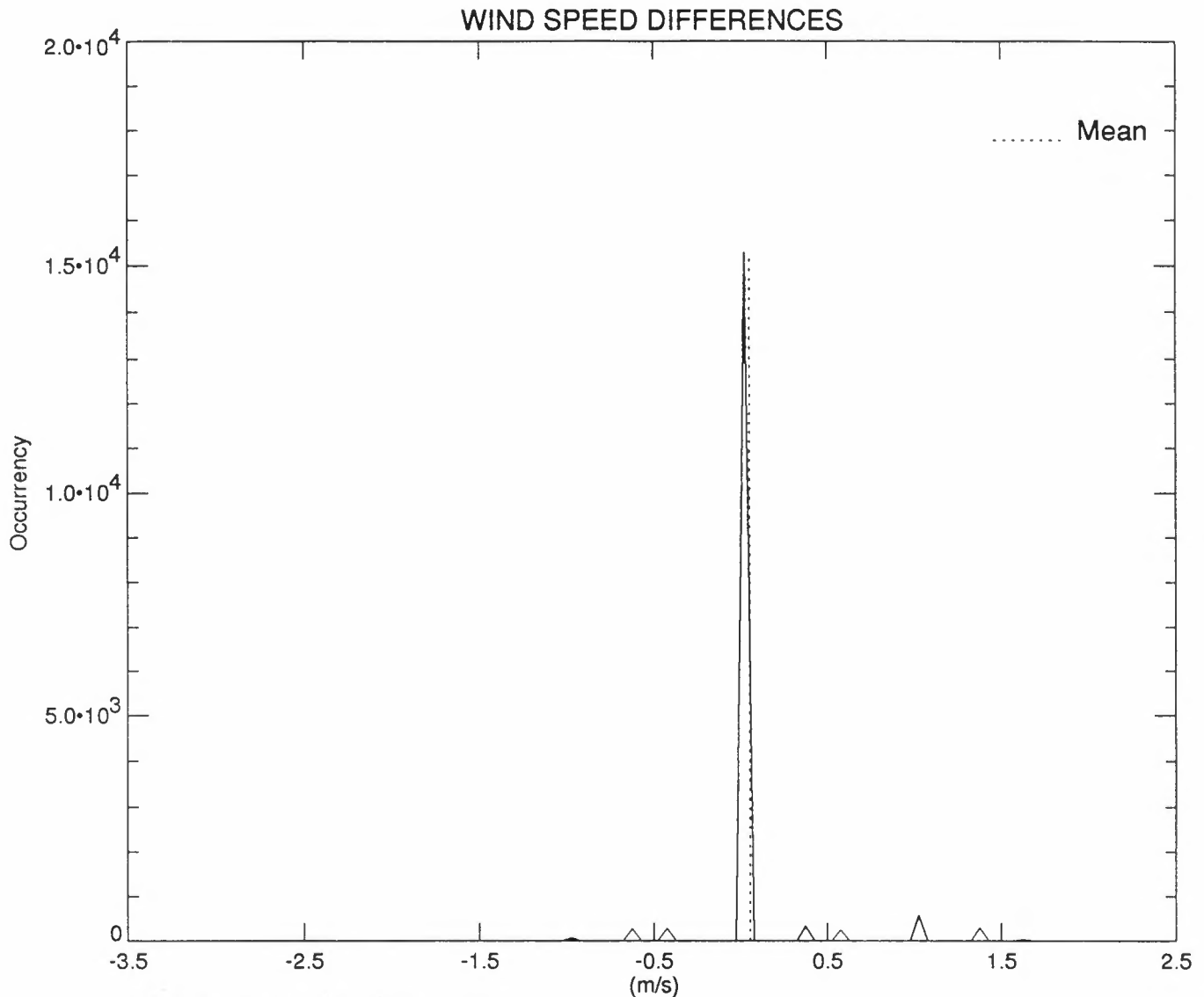
File: uwi__950929esep0000.e1

Number of Products: 69

First Product: 26-JUL-1995 08:14:01.943

Last Product: 26-JUL-1995 09:35:00.810

Page:22



Total number of nodes = 24548

Number of valid wind speed differences = 17360

On valid wind speed differences :

Mean = $5.37790\text{E-}02$ (m/s)

Min = $-3.00000\text{E+}00$ (m/s)

Max = $2.00000\text{E+}00$ (m/s)

Std. Dev. = $2.96782\text{E-}01$ (m/s)

% in [- 1m/s, + 1m/s] = 94.0

Mode = $2.50000\text{E-}02$ (m/s)

88% in [$-1.10595\text{E-}08\text{m/s}$, $5.00000\text{E-}02\text{m/s}$]

91% in [$-4.00497\text{E-}01\text{m/s}$, $4.50496\text{E-}01\text{m/s}$]

Qualification Report

File: uwi__950726ksep1001.e1

Number of Products: 70

First Product: 26-JUL-1995 08:11:39.002

Last Product: 26-JUL-1995 09:33:49.347

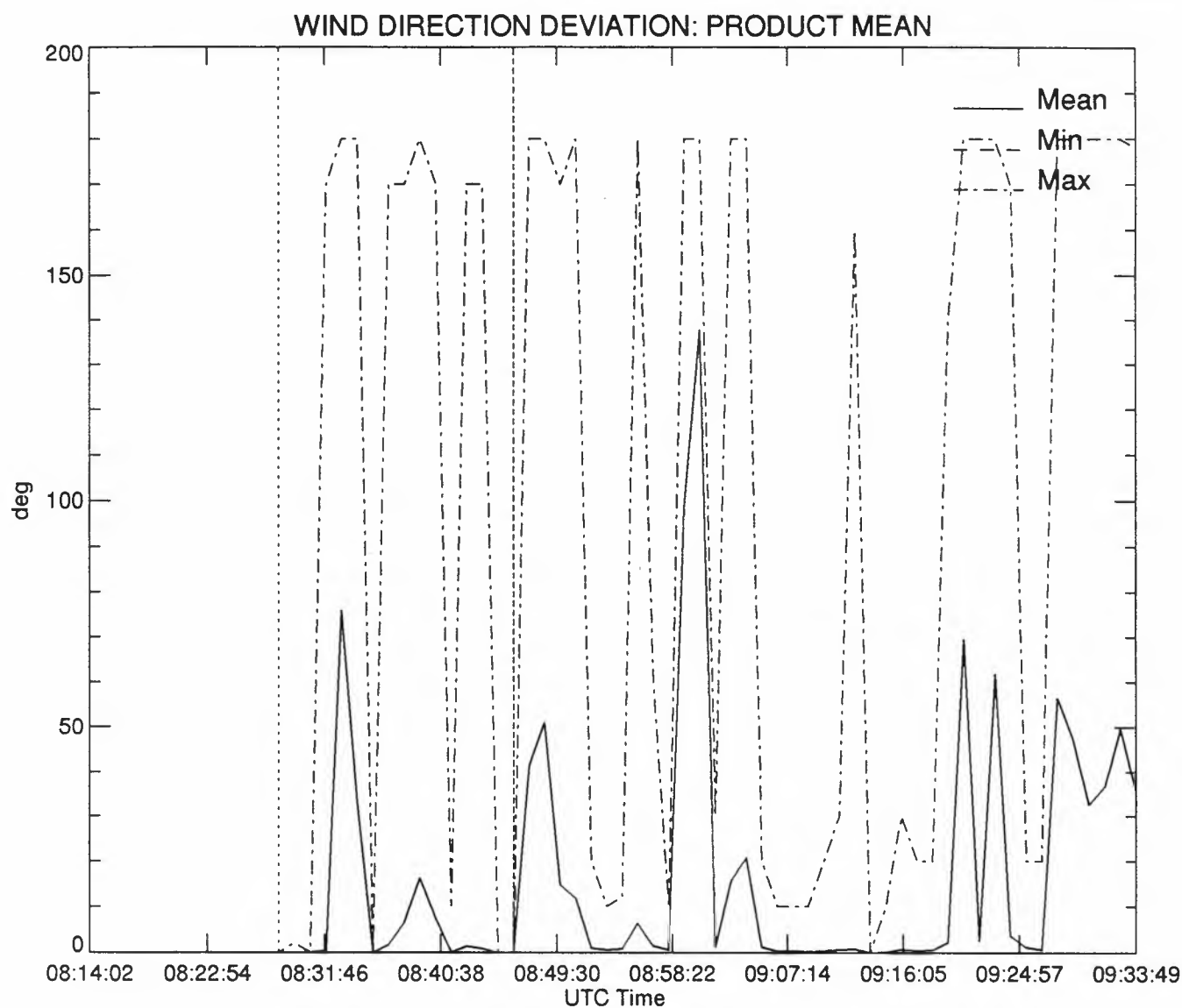
File: uwi__950929esep0000.e1

Number of Products: 69

First Product: 26-JUL-1995 08:14:01.943

Last Product: 26-JUL-1995 09:35:00.810

Page:23



Total processed products = 68

Number of valid products = 54

On valid products:

Mean = 1.76641E+01 (deg)

Min = 0.00000E+00 (deg)

Max = 1.80000E+02 (deg)

Std. Dev = 2.90457E+01 (deg)

% in [-10deg, +10deg] = 64.0

Qualification Report

File: uwi__950726ksep1001.e1

Number of Products: 70

First Product: 26-JUL-1995 08:11:39.002

Last Product: 26-JUL-1995 09:33:49.347

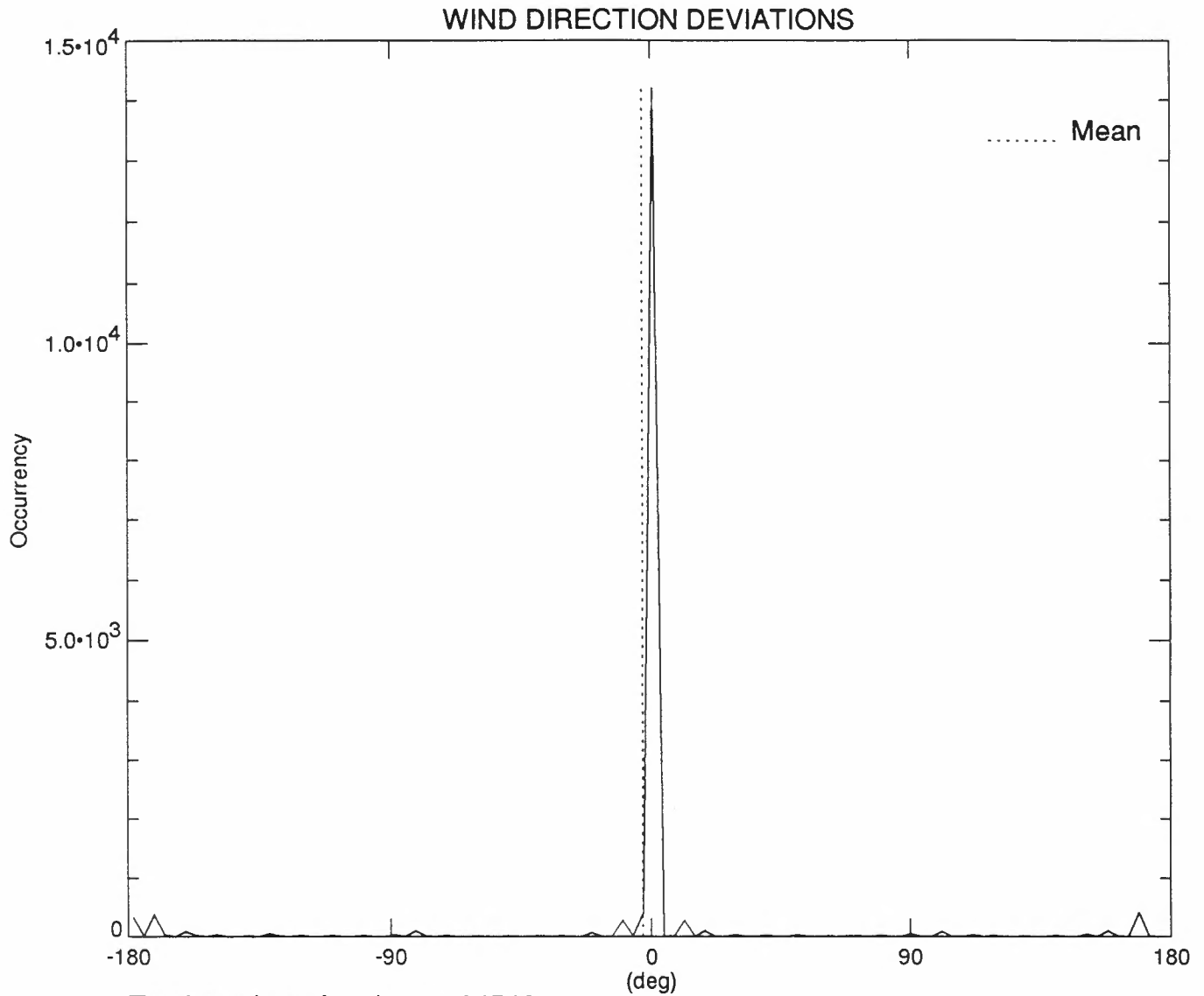
File: uwi__950929esep0000.e1

Number of Products: 69

First Product: 26-JUL-1995 08:14:01.943

Last Product: 26-JUL-1995 09:35:00.810

Page:24



Total number of nodes = 24548

Number of valid wind direction deviations = 17360

On valid wind direction deviations :

Mean = -2.99 (deg)

Min = -180.00 (deg)

Max = 178.00 (deg)

Std. Dev. = 51.49 (deg)

% in [-10deg, +10deg] = 84.0

Mode = 7.90001E-01 (deg)

80% in [-3.33990E-02deg, 1.61340E+00deg]

90% in [-8.84229E+01deg, 9.00028E+01deg]

ERS-2 LRDPF

Raw Data Transcription Performance

- > 2000 orbits Transcribed at Kiruna
- 2000 x 5 EXAs x 4 Instruments = > 40,000 EXA Writes
- 16 EXA Anomaly Reports from PAF's (< 0.0004 %)
 - Probably all Hard Media Write Events
 - Moving from SONY to Exabyte Corporation Media may improve Failure Rate.

ERS-2 LRDPF

Conclusions

- 6 months ERS-2 Parallel Operations with ND at KIR,
 - » (Transcription to PAF's , FD Products to ESRIN)
- 6 months ERS-2 MAS + GAT Transcription at ESRIN,
- 3 Weeks ERS-1 Full FD Operations & ERS-2 Transcription at MAS + GAT,
 - » Wind + Altimeter FD Products to User Community
- FD Wind + Altimeter Products in Good Shape

No Major Problems

ERS-2 LRDPF : Future Development

AMI Wave FD Processing

• Rationale :-

- ALL ERS LR Data Processing on same platform
- KIR : RT Wave FD for ERS-2 + additional SAR Image processing capacity
- MAS : additional SAR Image processing capacity
- GAT : De-commission SARFDP
- Benefit of Wave Mode Re-Processing Capability
- Invest in Wave Application S/W (same rationale as per LRDPF)

• Development :-

- Spacetec / MDA / CGS
- Re-Engineering of Existing SARFDP Algorithm
- Upgrade of Wave Algorithm to Revised Spec (Project)
- RA Upgrade : Technical clarifications + decision needed from Project
- H/W Upgrade of SGI Platform (CPU / Memory / Disk)

• Schedule :-

- | | | |
|-----------------|---|-----------|
| • KO | : | 06-JUL-95 |
| • Reqmts Review | : | 07-SEP-95 |
| • Design Review | : | 09-NOV-95 |
| • FAT | : | FEB-96 |
| • SAT | : | APR-96 |

ERS-2 COMMISSIONING REVIEW #1

ERS USER SERVICES

ESRIN October 26-27, 1995

USERS SERVICES



CUS, ISS and BDDN UPGRADES

▪ Global Requirements:

- **support full (planning, acquisition, production and dissemination) ERS-2 exploitation**
(for both the on-board instruments, including GOME and ATSR-2, and the ground segment facilities)
- **in parallel with full ERS-1 exploitation**
- **keeping the increase in personnel to a minimum**
(=> enhance performance)
- **being ready before the ERS-2 launch**
(in order to handle ERS-2 Commissioning Requests)

US **ERS** SERVICES



CUS, ISS and BDDN UPGRADES (cont.)

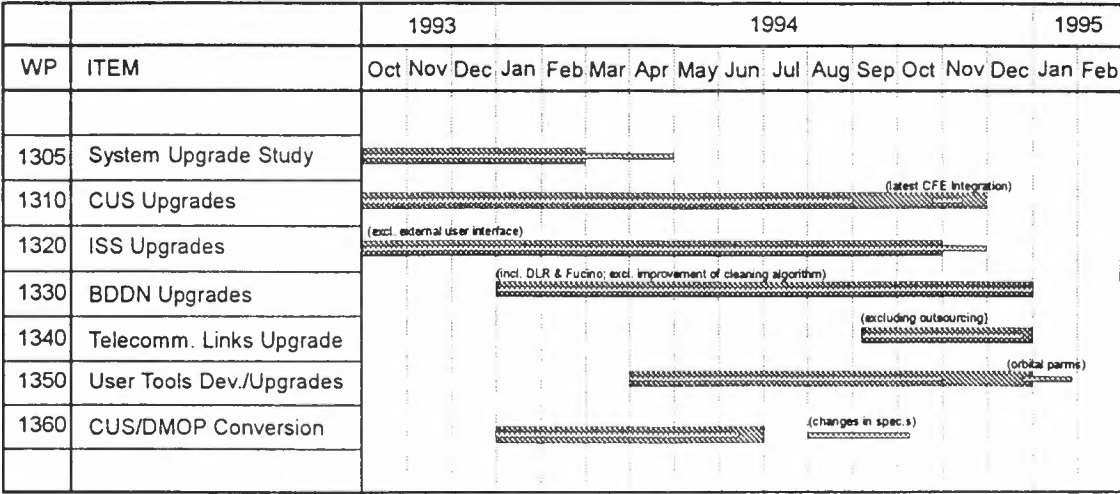
▪ Achievements:

- **all upgrades successfully completed on schedule**
(including links, but excluding those included in the Outsourcing contract, which were anyway covered by back-ups)
- **operationally used starting from November '94 through January '95**
- **with two man/year less**
(one in maintenance and one in Help Desk)
- **understaffed area identified in Mission / Production Planning**
(particularly critical for Tandem)

US **ERS** SERVICES



MAJOR WORK PACKAGES



SYSTEM UPGRADE STUDY RESULTS

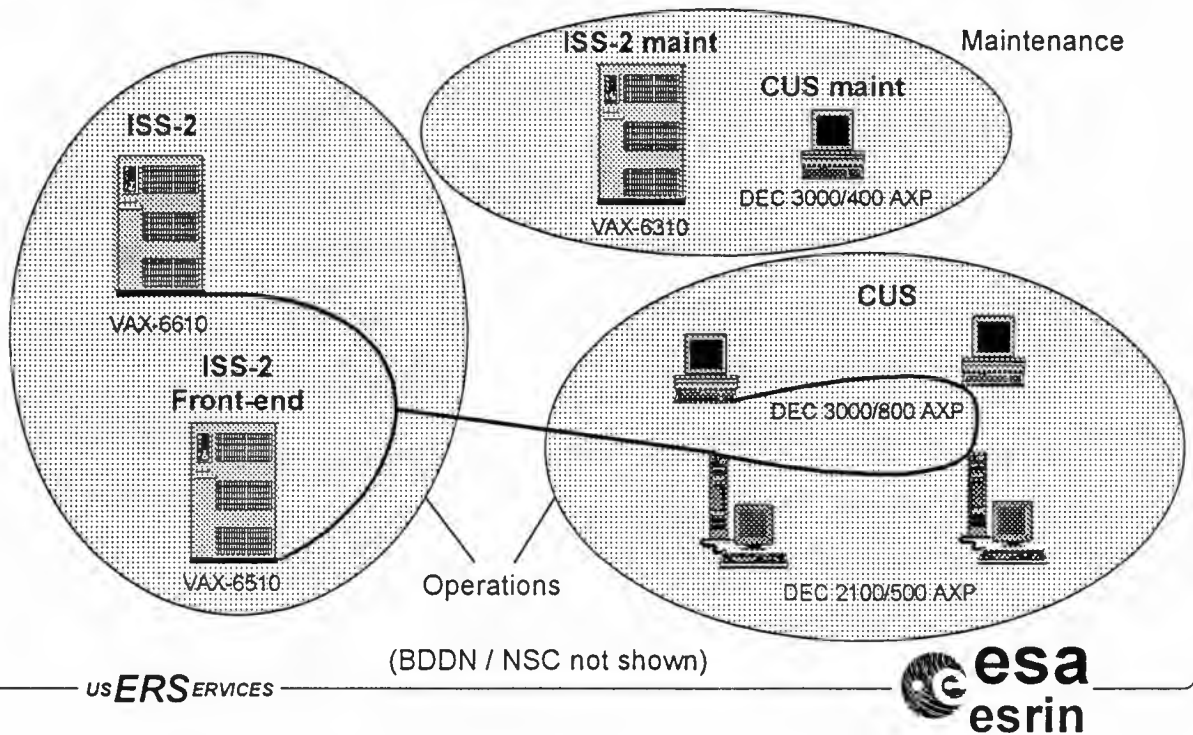
- ▶ CUS:

- keep current HW/SW (*baseline configuration*)
 - prepare in parallel an *Alpha platform*
 - separate maintenance environment
- ▶ ISS:

- do not migrate to Alpha
 (telecomm. packages not yet reliable)
 - enhance HW (double traffic)
 - separate operational from user traffic
 - separate maintenance environment
- ▶ BDDN-NSC:

- keep current HW/SW

CURRENT SYSTEM CONFIGURATION



CUS ALPHA PLATFORM

• Configuration:

- client/server architecture based on OpenVMS 6.1 & ORACLE 7.0.16
- interchangeable DEC 2100 model 500 AXP servers
- shared RAID-5 disk subsystem
- duplicate fast back-up system
- internal user access via Alpha work-stations and X terminals
- looser link with ISS (no more clustered and not sharing disks with CUS)

• Key Features:

- high performance
- high availability
- up to date technology (open to enhancements, lower maintenance cost, etc.)
- faster VAX computers released for ISS use

usERS SERVICES

esa
esrin

CUS UPGRADES

- ▶ **Multi-satellite Support:**

- User Request Handling
- Mission Planning
- Ground Station Schedule Generation (incl. station availability per satellite)
- Catalogue Access / Query (across satellites)
- Production Planning
- PAF Interface

- ▶ **New DMOP Conversion Software**

- ▶ **Support for GOME and ATSR2**

- ▶ **New CFE Integration**

- ▶ **Global Products Catalogue Integration**

US **ERS** SERVICES



ISS UPGRADES

- ▶ **Multi-satellite Support:**

- Handle different files and different interfaces for ERS-1 and ERS-2

- ▶ **Multi-machine Support:**

- Split the load per mission or file groups on different machines
- Run a test/commissioning environment in parallel to the operational one

- ▶ **Separate interactive access:**

- Improve security of operational traffic against external user access

- ▶ **Database re-organisation:**

- ISS ORACLE Packages to be moved to CUS

- ▶ **External Packages Integration:**

- MMAN (ESOC), FAD-2 (MDA), BUFR (UK Met. Office)

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BDDN UPGRADES

► Transmit Station upgrades:

- Multi-mission: SAR FD interface with CMS/DPMC
- Integration with re-hosted LRDPF
- DMA switch for Kiruna

► NSC Upgrades:

- Multi-mission: file interface and dissemination scheduling
- Default dissemination scheduling using distribution list (GOME and Microwave Sounder)
- Multiwindow dissemination scheduling versus product and mission
- BDDN TS disk cleaning algorithm Upgrade

► BDDN Receiving Station installation in DLR

US ERS SERVICES



LINKS' UPGRADES

- Telecomm. links were upgraded outside or within the Outsourcing contract

LINK	from (Kbps)	to	Upgrade	Outsourcing migration/upgrade
- ITAV	2.4	9.6	Dec. 21, '94	Aug. 8, '95
- BRACKNELL	9.6	9.6	N/A	July 26, '95
- MASPALOMAS	9.6	64	Mar. 13, '95	N/A
- D-PAF	9.6	19.2	N/A	May 22, '95
- F-PAF	19.2	48	N/A	May 22, '95
- UK-PAF	9.6	19.2	N/A	July 13, '95

- Upgrade of Maspalomas' link was required to improve overall reliability (not directly related to ERS-2)

US ERS SERVICES



COMMISSIONING PHASE SUPPORT

- ERS-2 SAR production for CAL/VAL, Interferometry, PR
- Set-up and maintenance of an on-line server for GOME data
- Creation and maintenance of on-line information and documentation:
 - general information and descriptions
 - commissioning activities (plans, manoeuvres, etc.)
 - sensor status and results (in particular for GOME and interferometry)
 - SAR images (first and PR ones, one per member state, etc.)
- Various support activities:
 - preparation of articles
 - manning stands at public events (e.g. Le Bourget and IGARSS '95)
 - preparation of special leaflets and CD-ROMs
- Extension of DESCW (multi-mission DESC version for Windows) for ERS-2

HW / SW PROBLEMS

- ESTEC provided CFI:
 - still one unresolved problem (some times, at high latitudes, error -105 received)
 - no adequate maintenance service provided by ESTEC
- EECF - MMCC Interface:
 - ERS-2 Restituted DMOP not received with regular delay (often > 3 days)
 - A few details to be adjusted in PEP / DMOP, require now manual intervention (ERS-1 and ERS-2 Wind and Wave sensing to be merged in a new mode - TBC; rejected sensing segments are accepted when resubmitted; DMOP contains some zero duration link activities)
- Outsourcing Contract:
 - Two full blackouts of the BT network for a total of 42 hours in August (no major operational impact thanks to back-ups)
 - D-PAF link still with low reliability (ESANET used again since October 13)

FUTURE ACTIONS

► GOME:

- system still to be transferred to operations
- preliminary info provided to Help Desk by project
- commissioning activities fully supported through online information
- to be prepared a document (based on the PB one) on:
 - products** levels 1 and 2
 - media** controlled on-line access and CD-ROM
 - costs** on-line access free-of-charge; off-line distribution via yearly subscription with 100% overhead plus shipment
 - order procedure** via ESRIN and/or Eurimage
- to be prepared and distributed a user note

► ASTR-1/2:

- set-up catalogue and ordering procedure
- set-up production

ESA Ground Stations

ERS-2 Commissioning Review
ESRIN - 26/27 October 1995

Gian Maria Pinna - DEX/EF

ERS-2 Stations Upgrade

Stations were upgraded following the guidelines from the Project MIRD and the relative ESRIN MIP

- New Control & Monitoring System (CMS6)
 - New Low Rate Data Processing Facility (LRDPF2)
 - Enhanced SAR Fast Delivery Processor (SAR FDP)

 - CMS6 : Fuc / Mas / Gat
 - SAR FDP : Fuc / Mas / Gat (Wave)
 - LRDPF2 : Fuc / Mas / Gat
 - Upgraded CMS2 : Pal
-

ESRIN FDPC Stations

Commissioning Phase

- CMS6 operated during Commissioning Phase only at Fucino
 - SGI-LRDPF not operated during Commissioning Phase
 - Needed LRDPF pre-operational phase at Maspalomas and Gatineau (two weeks)
-

Commissioning Phase

Operations

- Fucino
 - ◆ ERS-1 Nominal Operations (new chain)
 - ◆ ERS-2 Operations (new chain)
 - ◆ ERS-2 URA Re-processing on ND-LRDPF
 - Maspalomas/Gatineau
 - ◆ ERS-1 Nominal Operations (old chain)
 - ◆ ERS-2 Acquisition (manual)
 - Prince Albert
 - ◆ ERS-1 Nominal Operations (new chain)
 - ◆ ERS-2 Acquisition (new chain)
-

[illegible]

Commissioning Phase Performance

		Planned	Transmitted	Acquired	Processed
Fucino	ERS-1	490	478	473	473
	ERS-2	453	407	400	400
Maspalomas	ERS-1	394 (HR&LR)	384 (HR&LR)	379 (HR&LR)	375 (HR&LR)
	ERS-2	369 (HR&LR)	346 (HR&LR)	343 (HR&LR)	155 (HR)
Gatineau	ERS-1	331	315	312	302
	ERS-2	334	312	309	-
Prince Albert	ERS-1	139	126	125	125
	ERS-2	139	129	128	-

2-May / 3-Oct 1995

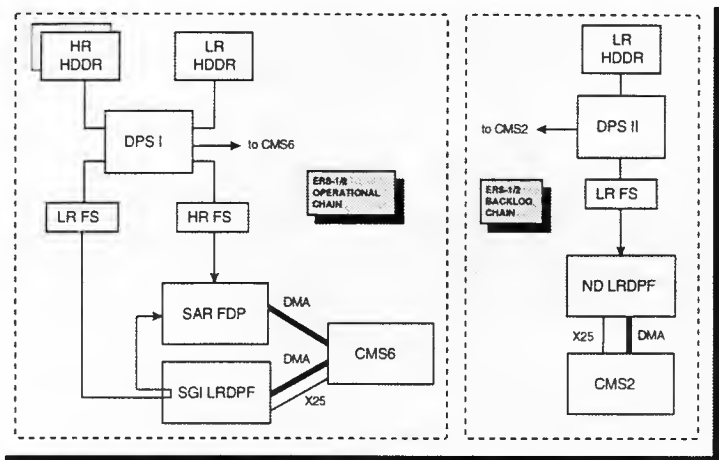
		Planned	Transmitted	Acquired	Processed
Fucino	ERS-1	490	478	473	473
	ERS-2	453	407	400	400
Maspalomas	ERS-1	394 (HR&LR)	384 (HR&LR)	379 (HR&LR)	375 (HR&LR)
	ERS-2	369 (HR&LR)	346 (HR&LR)	343 (HR&LR)	155 (HR)
Gatineau	ERS-1	331	315	312	302
	ERS-2	334	312	309	-
Prince Albert	ERS-1	139	126	125	125
	ERS-2	139	129	128	-

2-May / 3-Oct 1995

Stations Configuration

Routine Phase

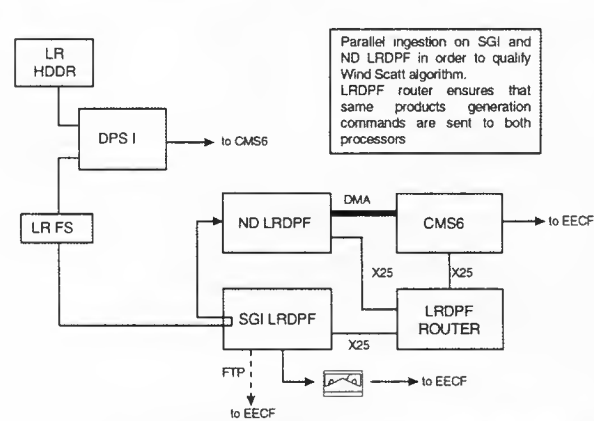
FUCINO



Stations Configuration

Routine Phase

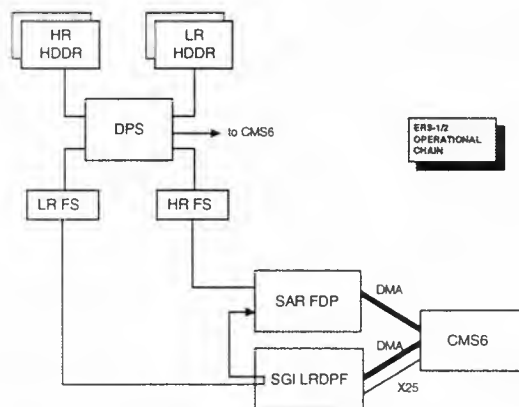
FUCINO (Scatt qualification)



Stations Configuration

Routine Phase

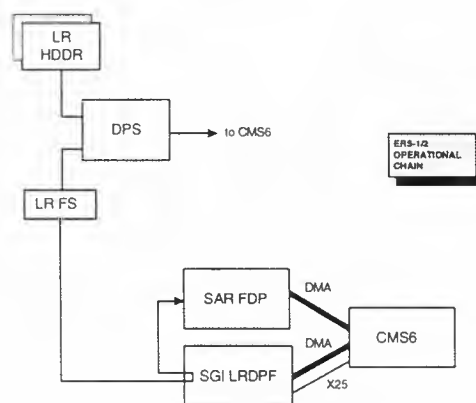
MASPALOMAS



Stations Configuration

Routine Phase

GATINEAU



Stations Spares

- Redundant LR and HR HDDR
 - Spare Data Path Switcher
 - Spare HR and LR FS
 - LRDTF Spacetec LR FS upgraded to Laben
 - Spare LRFSI
 - Spare LRDPF DMA boards
 - Spare Exabyte drives
-

Tandem Operations

- FUCINO
 - ◆ ERS-1/2 HR Acquisition
 - ◆ ERS-1/2 SAR Processing
 - ◆ ERS-1/2 Re-processing or Re-transcription
 - ◆ ERS-1 LR Raw Data Transcription (Kiruna passes)
 - MASPALOMAS
 - ◆ ERS-1/2 HR and LR Acquisition
 - ◆ ERS-1/2 SAR and LR Processing
 - ◆ ERS-1/2 LR Raw Data Transcription
-

Tandem Operations (continued)

- GATINEAU
 - ◆ ERS-1/2 LR Acquisition
 - ◆ ERS-1/2 LR Processing
 - ◆ ERS-1/2 LR Raw Data Transcription
 - ◆ ERS-1/2 LR Backlog Processing (Prince Albert)
 - ◆ ERS-1/2 LR Raw Data Backlog Transcription (Prince Albert)
 - PRINCE ALBERT
 - ◆ ERS-1/2 LR Acquisition
-

LR Raw Data Archives

Status

- More than 20000 ERS-1/2 LR HDDTs are archived at Fucino station (5000 at I-PAF)
 - About 30 HDDTs / day increment
 - Available space for no more than 3 months
 - HDDTs to be recycled (?)
- ☛ Solution must be found quickly
-

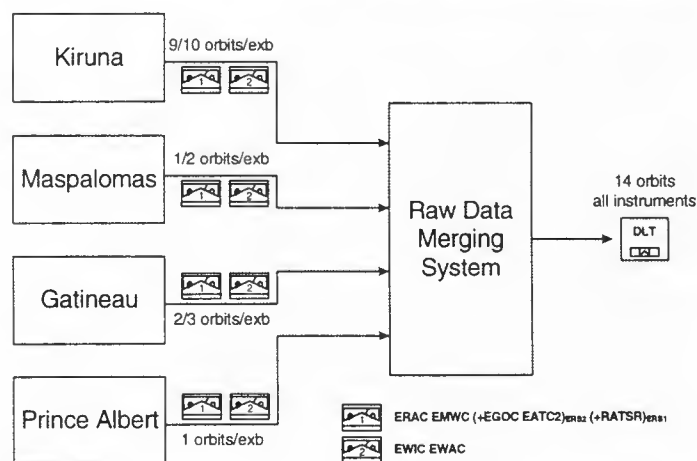
LR Raw Data Archives

Strategies

- LR Raw Data Transcription on DLT of ERS-1 historical archive - one day, all instruments per cassette (20 GB)
- Merging of ERS-1 and ERS-2 transcription exabytes on DLT
- Transfer and storage of HDDTs
- Re-processing from DLT

LR Raw Data Archives

Operations



LR Raw Data Archives

Costs

- Workstation + DLT Drives + Exabyte Drives
 - Development of Data Merging System
 - Media Costs (DLT)
 - Operations Costs (1h / HDDT)
 - Planned Workload: ~3 years
-

Conclusions

- ✓ Stations preparation and upgrade completed
 - ✓ ERS-2 Commissioning activities impact on ERS-1 operations minimal
 - ↳ Only concern is archives status and transcription activities
-

GROUND STATIONS VALIDATION

Marc PAGANINI ESTEC/NWO

GROUND STATIONS VALIDATION

- ☐ OBJECTIVES
- ☐ GROUND STATIONS VALIDATION PLANNING
- ☐ KIRUNA CONFIGURATION
- ☐ MASPALOMAS CONFIGURATION
- ☐ GATINEAU CONFIGURATION
- ☐ FUCINO CONFIGURATION
- ☐ ROUTINE OPERATIONS
- ☐ INTEGRATION TESTS
- ☐ INTEGRATION/VALIDATION TESTS RESULTS
- ☐ PROSPECTIVE CONFIGURATION

OBJECTIVES

- ☐ Four elements had to be integrated and validated during commissioning :
- | DPMC-6 | installed at Kiruna |
|--------------|--|
| CMS-6 | installed at Fucino, Maspalomas and Gatineau |
| CMS-5.1 | installed at Prince Albert |
| LRDPF-rehost | installed at Kiruna, Fucino, Maspalomas and Gatineau |
| SAR-2 | installed at Kiruna, Fucino, Maspalomas and Gatineau |
- ☐ Routine Operations during 3 months (starting on L + 2 weeks) :
- DPMC-6, LRDPF-rehost and SAR-2 (image/wave) at Kiruna.
 - CMS-6, SAR-2 (image) at Fucino.
 - CMS-5.1 at Prince Albert.
- ☐ Integration/validation tests in the Kiruna, Maspalomas and Gatineau stations :
- these tests were representative of nominal ERS-2 operations with limited ERS-1 operations.
 - the configuration of these ground stations were as close as possible to the post-commissioning configuration.
 - the successful completion of these tests drove the decision to operate the DPMC-6/CMS-6 and the LRDPF-rehost in all stations (except for the ERS-1 chain in Kiruna).
- ☐ Target day of the change-over (post-commissioning configuration) : **L + 3.5 months** (end of August).



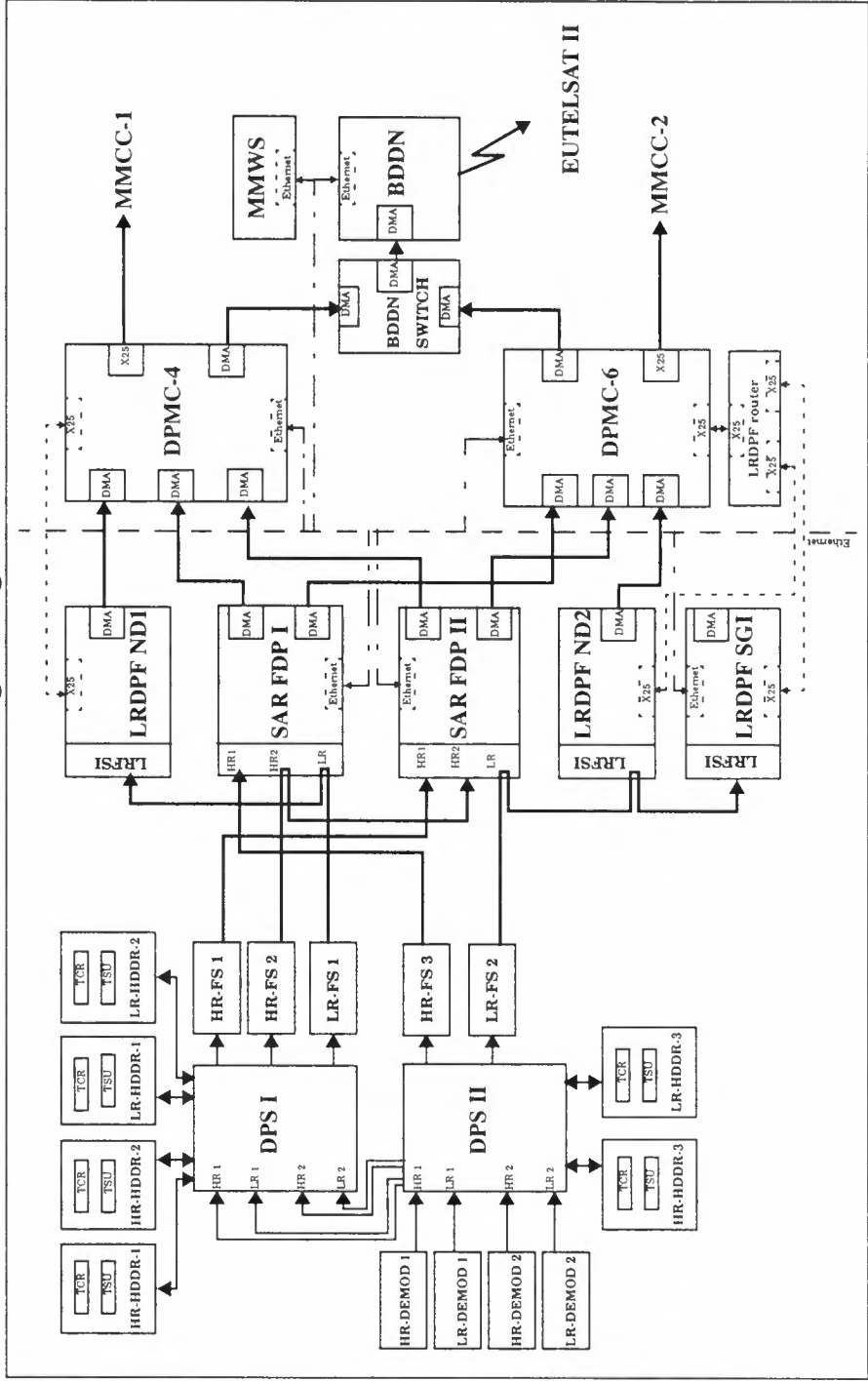
GROUND STATIONS VALIDATION PLANNING

		21-Apr						8-May						17-Jul	24-Jul	31-Jul
		week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	week 10	week 11	week 12	week 13	week 14	week 15
DPMC-6	KS															
	FS															
CMS-6	MS, GS															
	PS															
CMS-5.1	KS, FS															
	MS, GS															
LRDPF-rehost	KS, FS															
	MS, GS															
SAR-2	KS, FS															
	MS, GS															
integration / validation	KS															
	MS															
	GS															

KS : Kiruna station GS : Gatineau station PS : Prince Albert station
MS : Maspalomas station FS : Fucino station

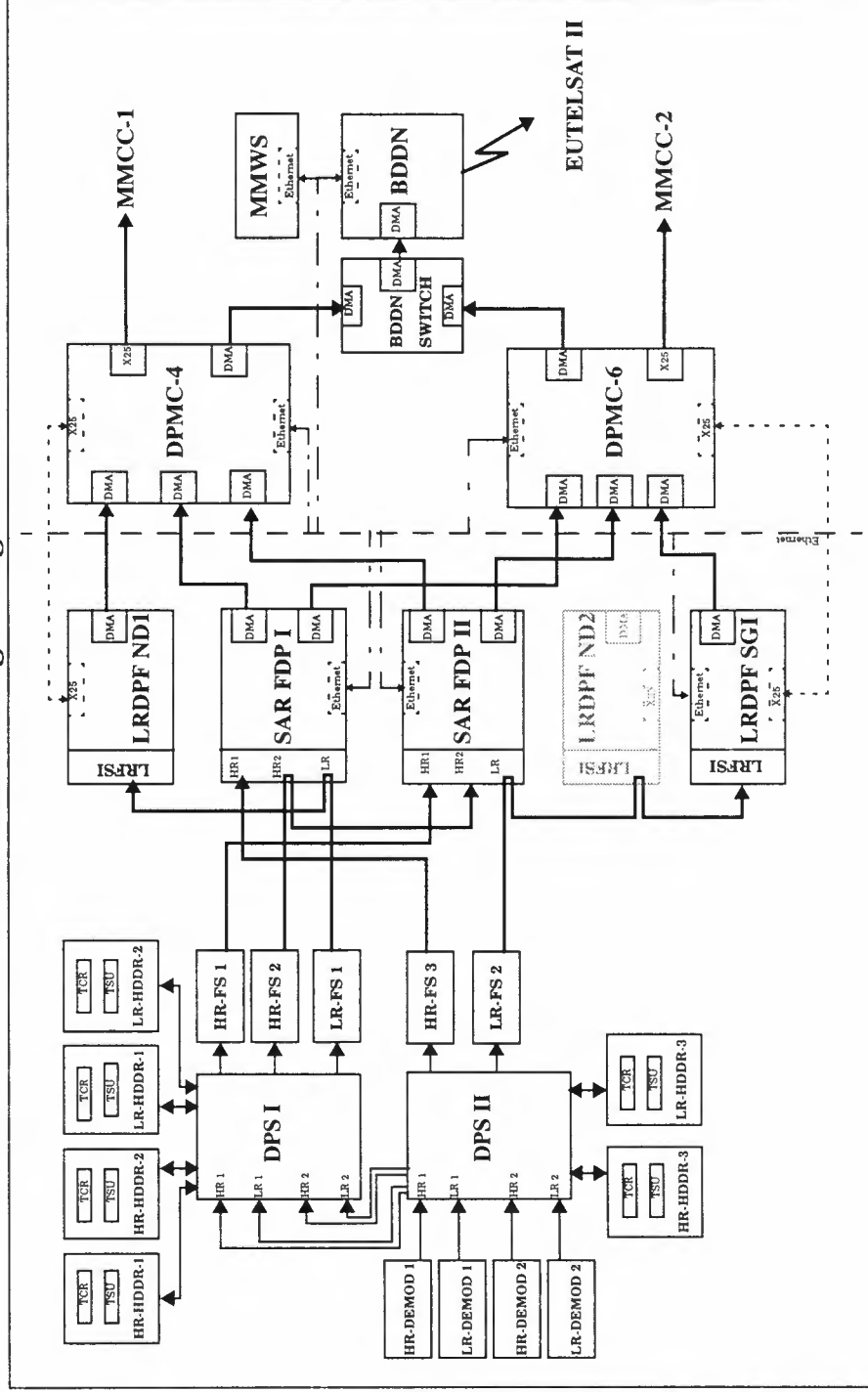
KIRUNA CONFIGURATION (1/2)

Commissioning configuration



KIRUNA CONFIGURATION (2/2)

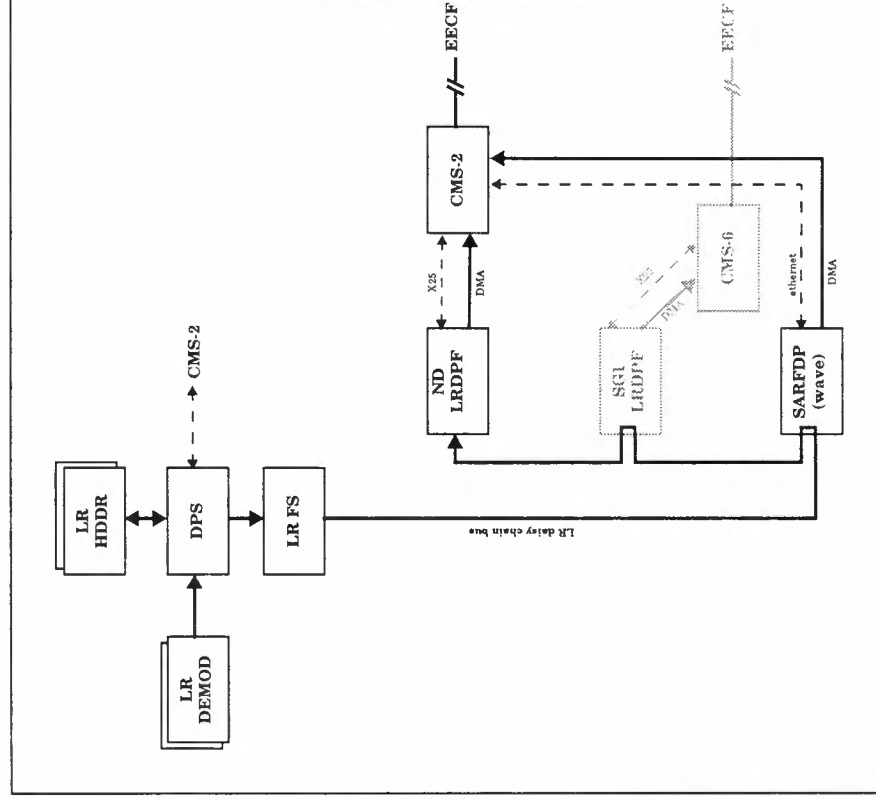
Post-commissioning configuration



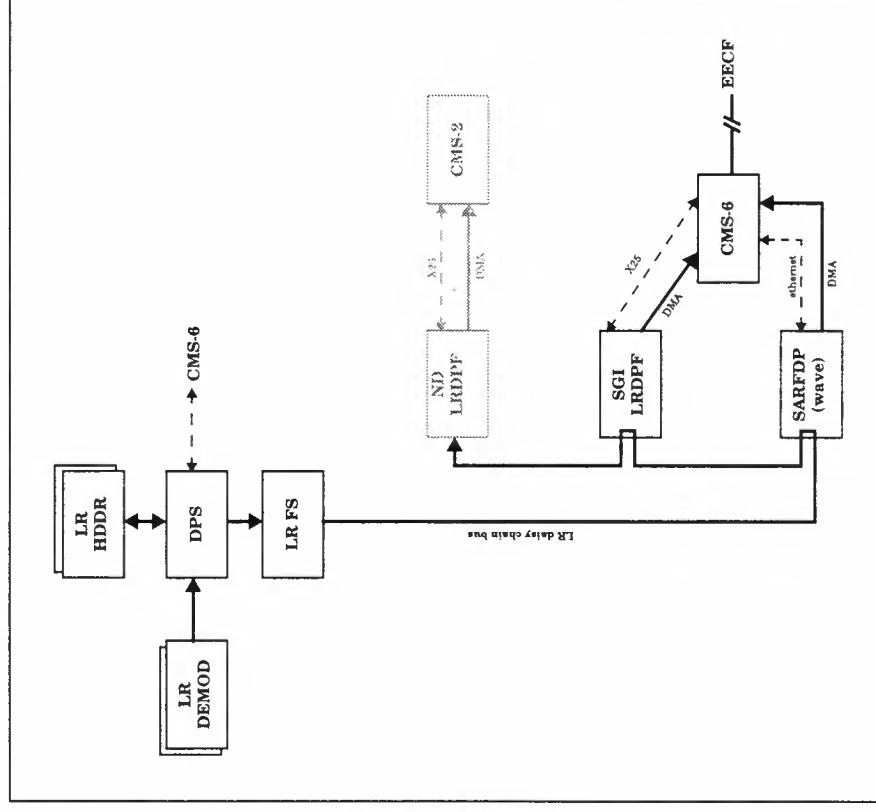
The diagram illustrates the architecture for processing HR and LR images. It starts with input blocks for HR and LR images, each with an HDDR (High-Dynamic-Range) component. These feed into a DFS (Dynamic Frequency Selection) block. The HR path then goes through an HR DEMOD block, while the LR path goes through an LR DEMOD block. Both paths then feed into HR FS and LR FS (Frequency Selection) blocks. These feed into HR LRD (Low-Rate Decoder) and LR LRD blocks, which are connected to HR LRDPF and LR LRDPF (Low-Rate Decoder with Phase Filtering) blocks. The HR LRDPF block is connected to the HR delay chain bus, which feeds into the HR FS block. The LR LRDPF block is connected to the LR delay chain bus, which feeds into the LR FS block. Both HR FS and LR FS blocks feed into the CMS-6 block. The CMS-6 block is connected to the SGI LRDPF (Super-Resolution Image Low-Rate Decoder with Phase Filtering) block. The SGI LRDPF block is connected to the SARFDP (Super-Resolution Adaptive Frequency Domain Processing) block. The SARFDP block is connected to the EECF (Enhanced Edge-Centric Feature) block. The SARFDP block also has a feedback loop to the SGI LRDPF block. The SARFDP block is connected to the DMA (Direct Memory Access) block, which feeds into the EECF block. The EECF block is connected to the HR delay chain bus, which feeds into the HR FS block. The EECF block is also connected to the LR delay chain bus, which feeds into the LR FS block.

GATINEAU CONFIGURATION

Commissioning configuration

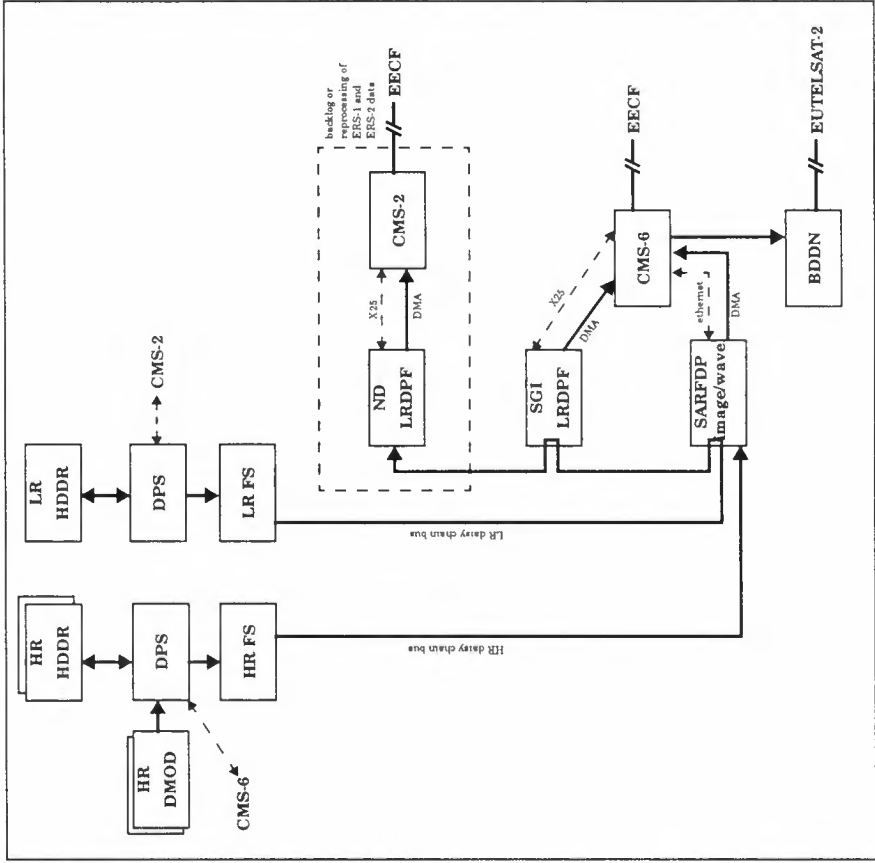


Post-commissioning configuration

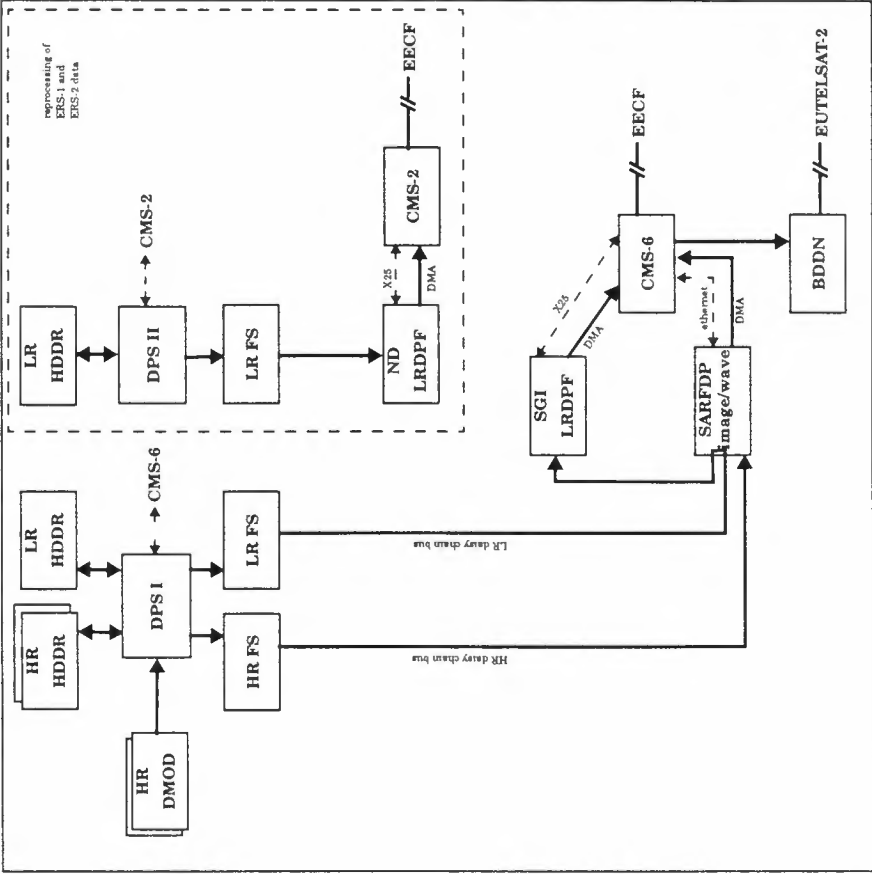


FUCINO CONFIGURATION

Commissioning configuration



Post-commissioning configuration



ROUTINE OPERATIONS

The following new/upgraded systems have been routinely operated during the commissioning phase :

☐ KIRUNA station

LRDPF-rehost	ERS-2	◆ nominal operations except products dissemination to the DPMC-6 ◆ systematic FD products generation and storage on Exabyte ◆ systematic level-0 products transcription on Exabyte ◆ systematic level-0 products dissemination though the BDDN
DPMC-6	ERS-2	◆ nominal operations except dissemination of ERS-2 LR products from LRDPF-rehost
SAR-2	ERS-2	◆ image and wave FD products generation and dissemination (1 orbit/day)
BDDN	ERS-1 / ERS-2	◆ dissemination of UI16, UILR, EGOC and EMWC products

☐ FUCINO station

CMS-6	ERS-1 / ERS-2	◆ nominal operations
SAR-2	ERS-1 / ERS-2	◆ image FD products generation and dissemination
BDDN	ERS-1 / ERS-2	◆ nominal operations

☐ PRINCE ALBERT station

CMS-5.1	ERS-1 / ERS-2	◆ nominal operations
----------------	---------------	--

INTEGRATION TESTS (1/2)

- ☐ The integration/validation tests aimed at verifying that the Kiruna, Maspalomas and Gatineau ground stations can support the post-commissioning scenario.
- ☐ Full end-to-end tests involving all elements of the ERS ground segment (CUS, MPS, MMCC, EECF + stations) were organised.
- ☐ All the LR HDDTs acquired during the integration tests were later processed in backlog at Fucino (ERS-1) and at Esrin (ERS-2) on the LRDPF-ND for RA commissioning.

☐ L + 13 weeks (17-20 July 1995) : MASPALOMAS integration tests

16	17	18	19	20	21	
						◆ station configured with the CMS-2 / LRDPF-ND / SARFDP (wave/image)
						◆ station configured with the CMS-6 / LRDPF-SGI / SARFDP (wave/image)
						◆ ERS-1 data processed in real time and disseminated nominally to the users
						◆ ERS-2 data processed and disseminated in backlog to privileged users
						◆ ERS-2 data processed in real time and disseminated nominally to privileged users
						◆ ERS-1 data processed and disseminated in backlog to users

INTEGRATION TESTS (2/2)

☐ L + 14 weeks (24-27 July 1995) : GATINEAU integration tests

23	24	25	26	27	28	
						◆ station configured with the CMS-2 / LRDPF-ND / SARFDP(wave)
						◆ station configured with the CMS-6 / LRDPF-SGI / SARFDP(wave)
						◆ ERS-1 data processed in real time and disseminated nominally to the users
						◆ ERS-2 data processed and disseminated in backlog to privileged users
						◆ ERS-2 data processed in real time and disseminated nominally to privileged users
						◆ ERS-1 data processed and disseminated in backlog to users

☐ L + 15 weeks (2 August 1995) : KIRUNA integration tests

30	31	1	2	3	4	
						◆ ERS-2 chain configured with the DPMC-6 / LRDPF-ND / LRDPF-SGI / SARFDP (backlog)
						◆ ERS-2 chain configured with the DPMC-6 / LRDPF-SGI / SARFDP (real time)
						◆ (router between DPMC-6 and LRDPFs removed, LRDPF-ND powered down)
						◆ ERS-2 LR data processed (LRDPF-SGI) and disseminated in real time
						◆ ERS-2 SAR data (image/wave) processed (SARFDPs) and disseminated in real time

INTEGRATION/VALIDATION TESTS RESULTS

- ☐ a few NCRs were open as a result of the integration tests performed in the ground stations and of the LRDPF-rehost acceptance tests performed on the ESRIN reference system.
- ☐ The change-over date was bound to the closure of the most critical NCRs raised on the LRDPF-SGI and on the CMS-6.
- ☐ List of most critical NCRs :

CMS-6	NCR-122	◆ corruption of the FAD CYCLIC COUNTER configuration files
	NCR-135	◆ FAD2 unable to close some product files
LRDPF-rehost	NCR-124	◆ MMI problems in the UWI products display
	NCR-127	◆ errors related to transcription (command sequencing in multi-reel transcription, tape labels handling)
	NCR-137	◆ problems with wind direction of the UWI products (ND <-> SGI) (180 degree difference with same ambiguity removal)
	NCR-138	◆ incorrect handling of the meteo tables

- ☐ All critical NCRs closed with the release of the new LRDPF-SGI S/W (version 6.300) and of the new CMS-6 S/W (version 6.200).
- ☐ New DPMC-6 S/W release (version 6.200) to be installed early november.
- ☐ Change-over effective on **October 3**, first orbit dumped over Kiruna.

PROSPECTIVE CONFIGURATION

- ☐ The CMS stations configuration is OK.
- ☐ The Kiruna station configuration is not fully appropriate for a tandem scenario :
 - the SARFDP processors can not satisfy both ERS-1 and ERS-2 missions in real time :
 - they must be shared between ERS-1 and ERS-2, in wave and image modes.
 - the ERS-1 LR data are still processed on the LRDPF-ND with its inherent drawbacks :
 - maintainability of the Norsk computer,
 - lack of commonality of the LR processing since the ERS-1 data acquired in the CMS stations are processed on the LRDPF-rehost,
 - no ERS-1 LR transcription can be performed at the station.

☐ Future modifications foreseen :

STATION	MISSION	MODIFICATION	TARGET DATE
KS, FS	ERS-1 & ERS-2	♦ DLT drive for LR level-0 products archiving	early 96
KS, MS, GS, FS	ERS-1 & ERS-2	♦ wave processor on the LRDPF-rehost	April 96
KS	ERS-1	♦ LRDPF-rehost + DPMC-6 integration	still to be approved

ERS-2 Radar Altimeter & Microwave Radiometer Commissioning Working Group presentation: CAL/VAL Strategy and First Results

Jérôme Benveniste

ESRIN DPE/OM

Chairman, ERS-2 RA & MWR CWG

ESRIN, 26-27 October 1995



OVERVIEW

- **RA & MWR-2 CALVAL:-**
 - Principle and strategy
 - A Commissioning Working Group has been constituted
 - Objectives
 - Cross-calibration with ERS-1
 - Methods
 - Different methods used to consolidate result
 - First results
 - Relative Range bias $\approx 2.0 \text{ cm} \pm 2 \text{ cm}$ (ERS-2 longer)
 - Relative SWH
 - Relative Wind Speed
 - MWR-2 (cf. CERP presentation)



Calibration of ERS-2 RA

- Calibration of ERS-2 relative to ERS-1
 - No absolute on-site calibration
- What to calibrate?
 - Range
 - Sigma_o , wind speed
 - Significant wave height
- With what (relative) precision?



Calibration of ERS-2 relative to ERS-1

- **Methods**
 - Global
 - » Crossover
 - » Repeat track analysis
 - » Comparison with models (wind, wave)
 - Local
 - » Natural targets
 - » Buoys
- **Redundancy to consolidate results**



CONTRIBUTIONS for RA and MWR-2 CAL/VAL

	01	02	NP	SST	EE	ETE	CT	EB	OF	IM	WW1	WW2	IP	MWR
JRCOC											X			
MSSL										X				
POL/ASTON					X	X			X					
DUT	X	X	X	X	X	X	X							
D-PAF/GFZ	X	X	X	X	X	X	X					X		
CLS				X	X	X	X	X						X
IFREMER												X		
IfEN					X	X	X							
DORNIER													X	
ESOC	X	X	X	X	X	X								
CETP														X
ECMWF											X			
DNMI											X			

The Calibration/Validation strategy is in ER-TN-ESA-GS-0408



Auxiliary instruments

- Calibration of the ERS-2 RA shall not depend on other on-board instruments (being calibrated)
 - ATSR/M
 - PRARE



Operational requirements

- **ERS-1/2 relative phasing (short: 1 day lag)**
 - Cross-track distance < 200 m
- **Data Acquisition:**
 - Ice/ocean mode strategy
 - Descoping
- **ERS-1/2 Data requirements**
 - ERAC
 - URA
 - QLOPR (preliminary orbit)
- **External data requirements**
 - Laser tracking
 - ECMWF -> UK-PAF: TAMF -> ESRIN & DPAF



Data Flow

- Problem with the UK-PAF TAMF files
 - bug -> one month delay
 - 10 day-files missing
- Kiruna-only coverage not adequate for crossover solutions -> Backlog re-processing of non-KS URAs by ESRIN (last global QLOPR delivered on 9/10)

<viewgraphs from PF>



ULTRA STABLE OSCILLATOR

(prepared by C. LOIAL DEX/EM ESRIN)

(reviewed by J. BENVENISTE, DPE/OM ESRIN)

USO DEFINITION

One of the critical elements of the Radar Altimeter system is the Ultra Stable Oscillator (USO) as it clocks the range measurement.

The USO frequency is measured on ground during the passes over the Kiruna station and it is used at 15 Mhz to drive the bit clock during the replay of the tape recorder.

The frequency is thus directly recoverable on-ground from the real-time bit-synchroniser on the ground station and comparing it with an atomic frequency standard.

9 to 10 files a day are sent to ISS at ESRIN from the Kiruna station via the MMCC (Mission Management and Control Center) for both satellites.

The USO value (in figure 1) is received in ESRIN PCS :

- on a weekly basis on tuesdays for ERS-1 (on a daily basis after an RA event)
- on a daily basis for ERS-2 during the beginning of the mission

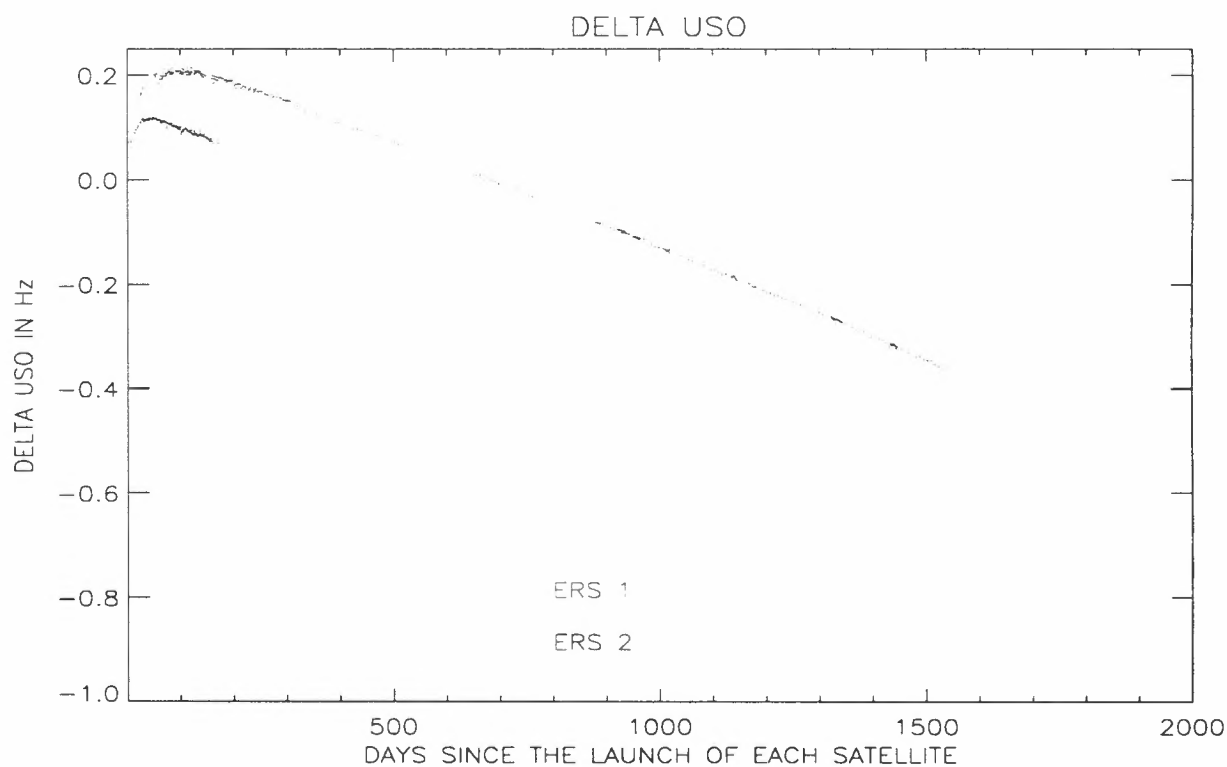


Figure 1 : ERS- 1/2 DELTA USO PLOTTING

USO DATABASE

A USO database since both satellite launches is updated every day and a user file generated from this database is available at ESRIN.

File naming convention :

USO_ERS_YYMMDD_CCCC.TXT

with :

YY : YEAR
MM : MONTH [1,12]
DD : DAY [1,31]
CCCC : CYCLIC COUNTER [1,9999]

The file contains :

- 'HEADER FILE' : 100 lines FIXED PORTION
(USO definition and format description)
- ERS-1 USO DATA RECORD : VARIABLE PORTION
- ERS-2 USO DATA RECORD : VARIABLE PORTION

Format description :

Headers and data records are separated by a "@@@@@@@@@@" line.

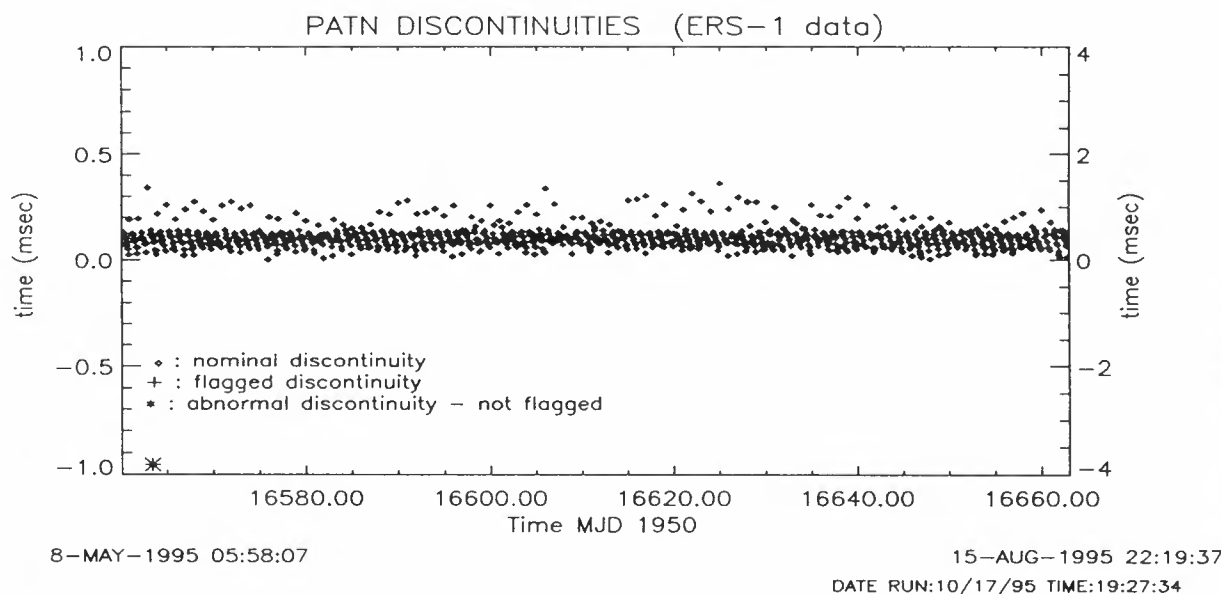
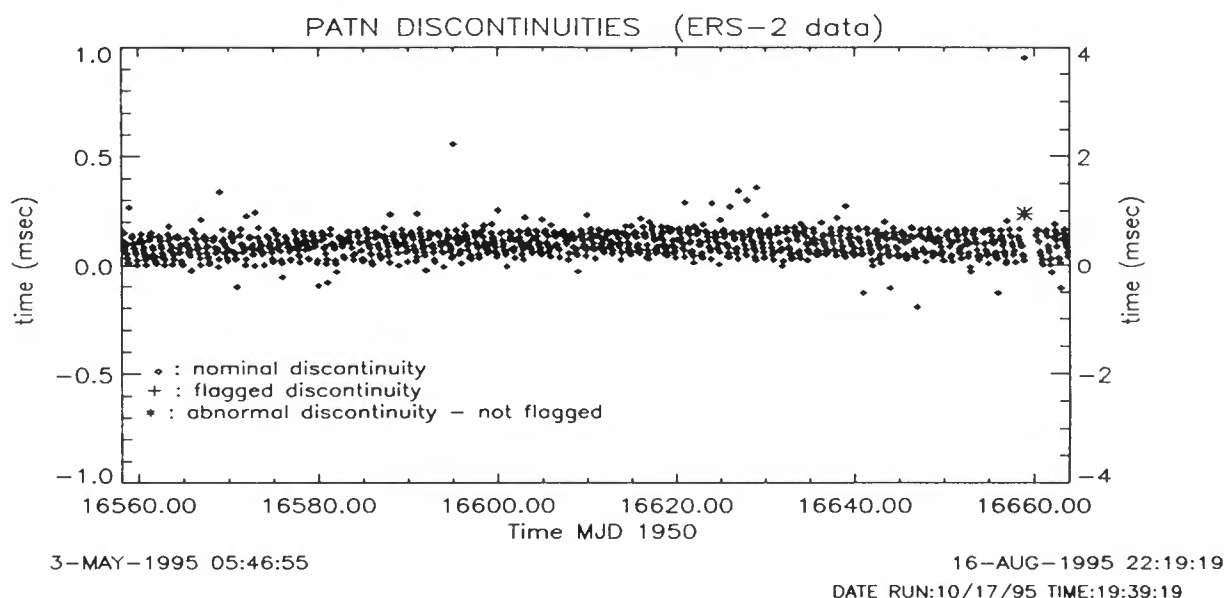
* Header starts with "@@@@@@@@@@", contains 100 lines inclusive. The next block starts "@@@@@@@@@@" characters.

* ERS-1/2 USO data records are separated by a "@@@@@@@@@@" line. The different fields of the ERS-1/2 data record are :

Date	: date of the USO measurement
Day	: days number from the satellite launch.
USO (Hz)	: USO measured value (Hz)
DeltUSO (Hz)	: USO (Hz) - 15000000 Hz
Time	: time of the USO measurement (HH:MM:SS.SSS) (the default value is 99:99:99.999)

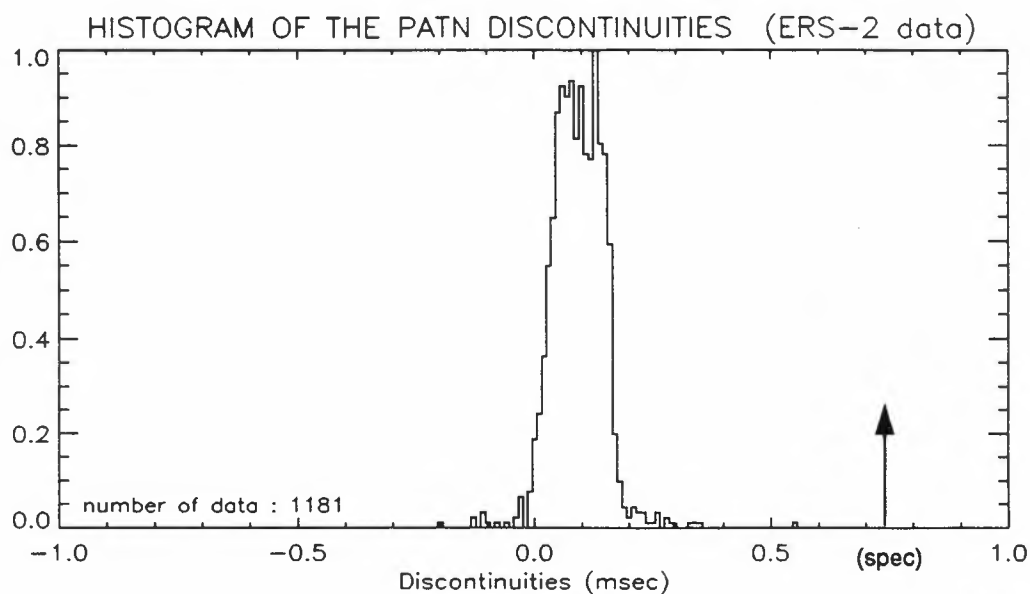
Please note that there is no quality flag and that some USO frequency values are clearly outliers.

UTC/SBT Time Correlation Monitoring

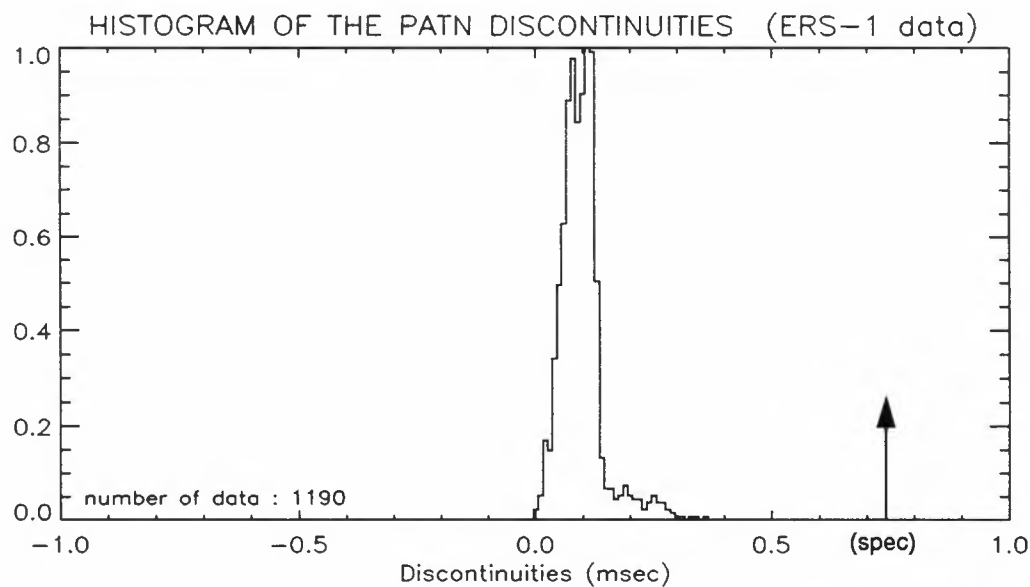


UTC/SBT Time Correlation Monitoring

(cnt'd)

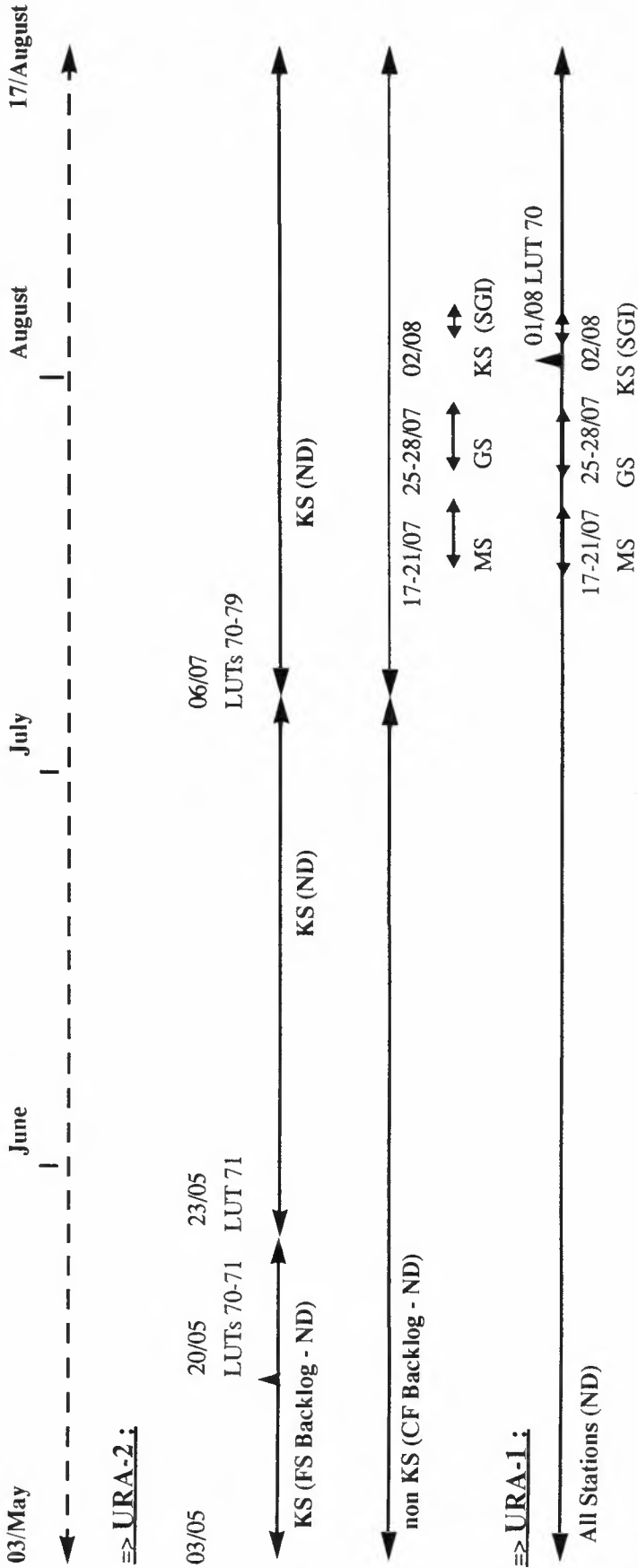


DATE RUN:10/17/95 TIME:19:39:19



DATE RUN:10/17/95 TIME:19:27:34

ERS-2 RA & MWR COMMISSIONING PHASE
URA FAST DELIVERY PRODUCTION SUMMARY

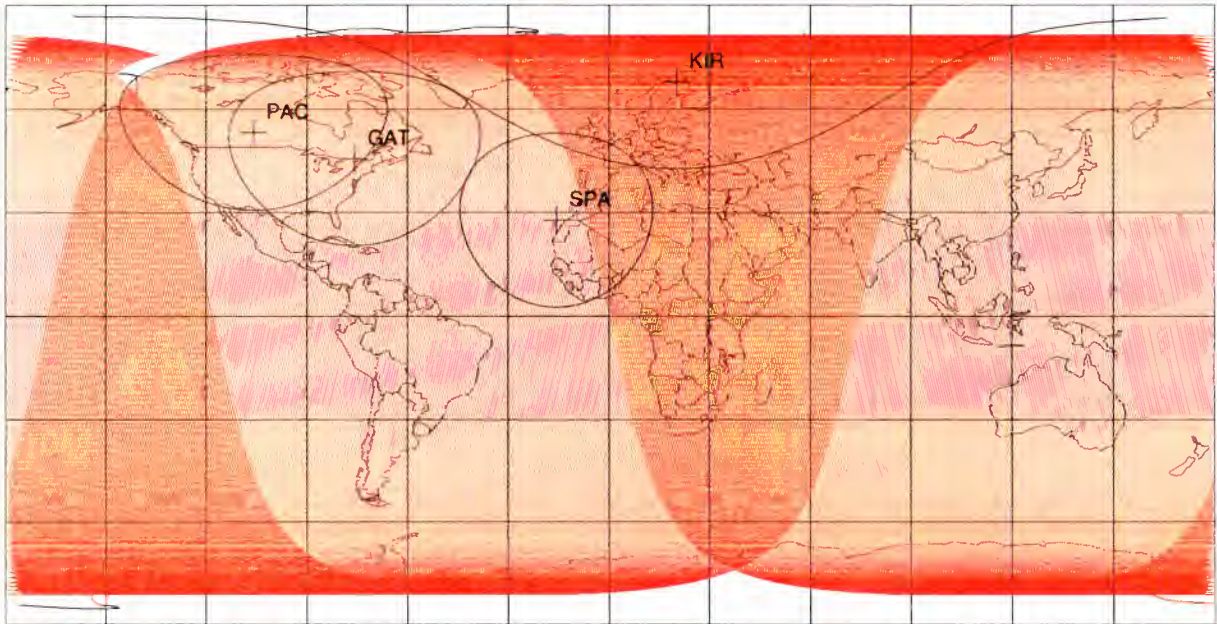


ERS-1 AND ERS-2 URA FAST DELIVERY PROCESSING AND BACKLOG PROCESSING NOMINAL

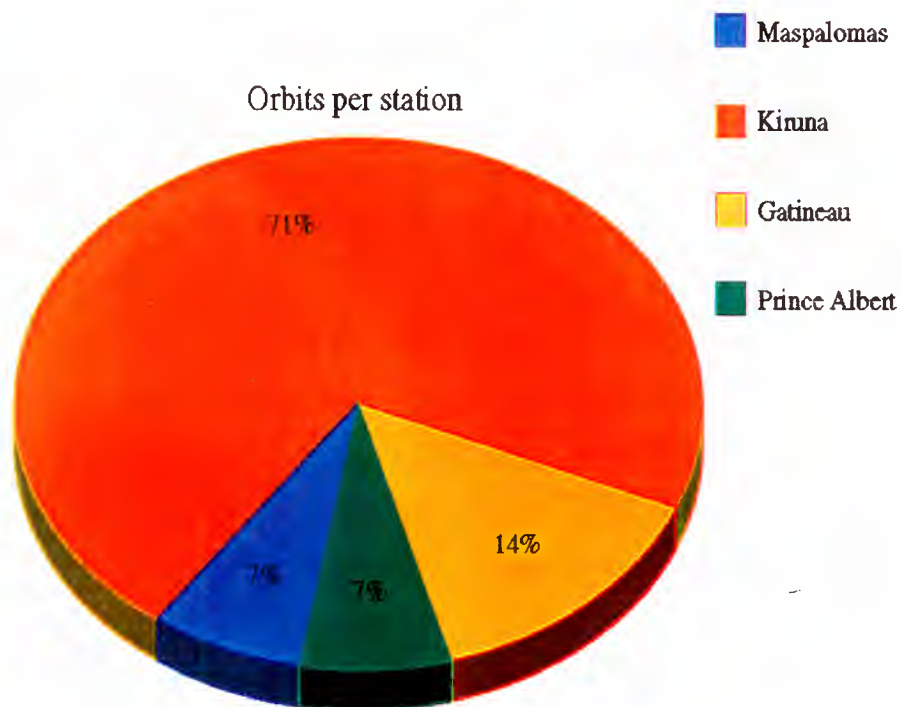
Pending Action : ERS-1 RA data processed on the LRDPF-SGI to be processed on the LRDPF-ND
(Data from the Integration & Validation Tests Period of the ground stations in ERS-2 nominal configuration)

RA Acquisition/Processing strategy:

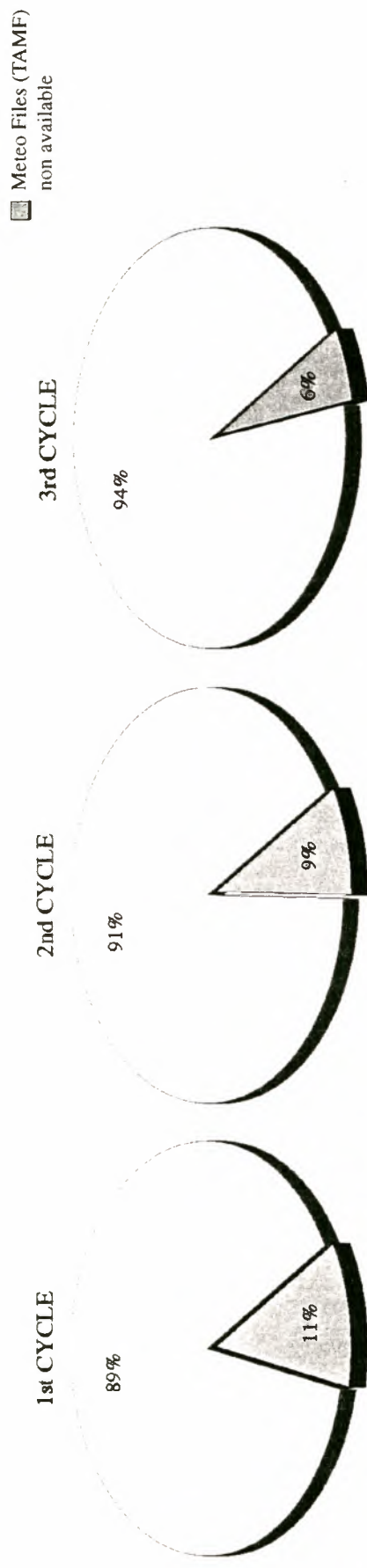
KIRUNA station coverage:



Non-Kiruna ERS-2 Fast Delivery Products (URA) processed in backlog:



Global QLOPR Production (D-PAF):



- Processed data from all stations
- New Ocean Tide Model (**FES95.1**, Le Provost, 1995)
- New Gravity Model (**PGM055**)
- Last QLOPR delivered on 9/10/96.

ERS-2 Commissioning Phase Data Requirements Status:

Data Availability:

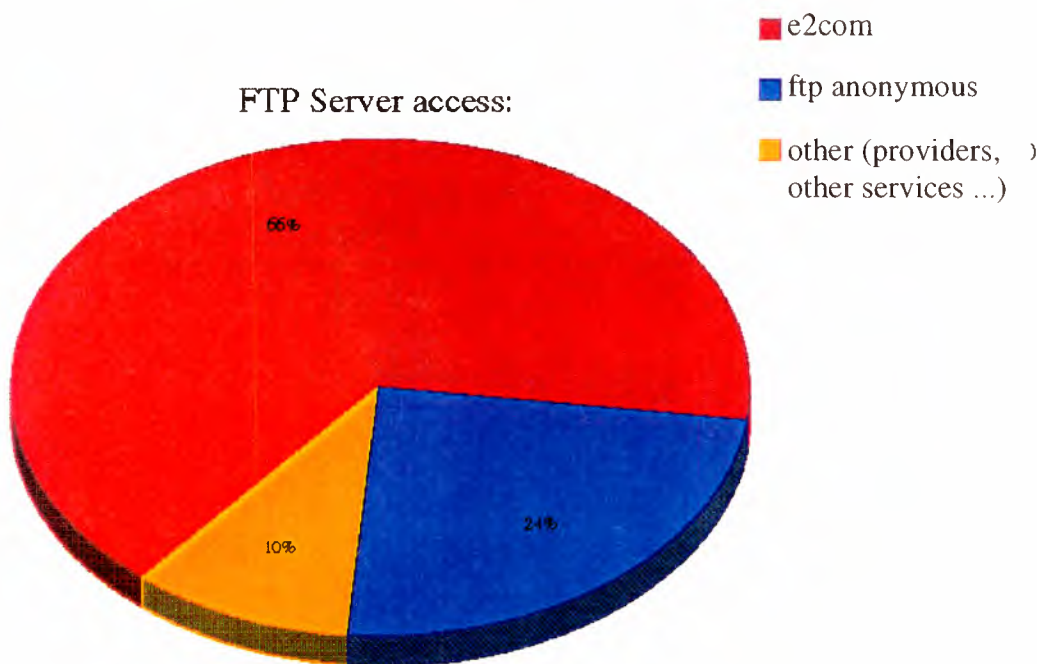
All Data required for the ERS-2 RA and MWR Commissioning phase were available on ESRIN and D-PAF FTP Servers.

Dissemination Efficiency:

All institutes were provided with their requested data.
No complaints received.

Service Reliability:

Access to the ESRIN ftp server from May to August 96 (4 months):



Results

<viewgraphs from institutes>

(results are preliminary, more processing and reporting in November. Range calibration results are pending verification of distance between RA antenna and CoG)



ECMWF / ERS-1 Comparison
Altimeter Windspeeds
GLOBAL 1.5° SEP 1995

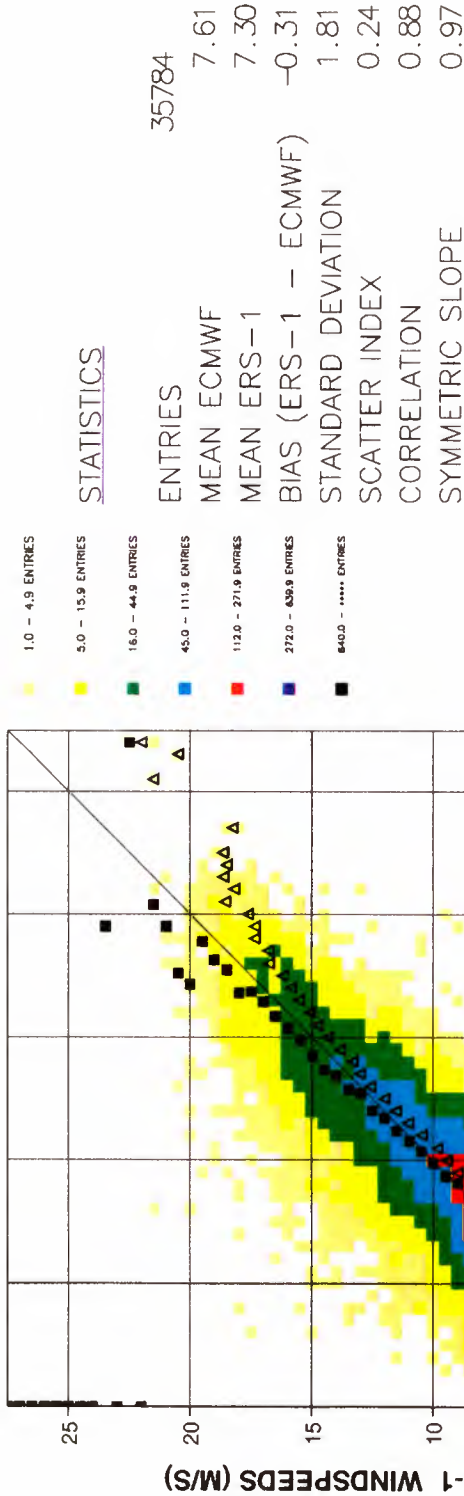


Figure 6: Comparison of ECMWF wind speed results with ERS-1 radar altimeter wind speed data for September 1995. The squares denote the mean values in the x-direction and the triangles in the y-direction.

ECMWF / ERS-2 Comparison
Altimeter Windspeeds
GLOBAL 1.5° SEP 1995

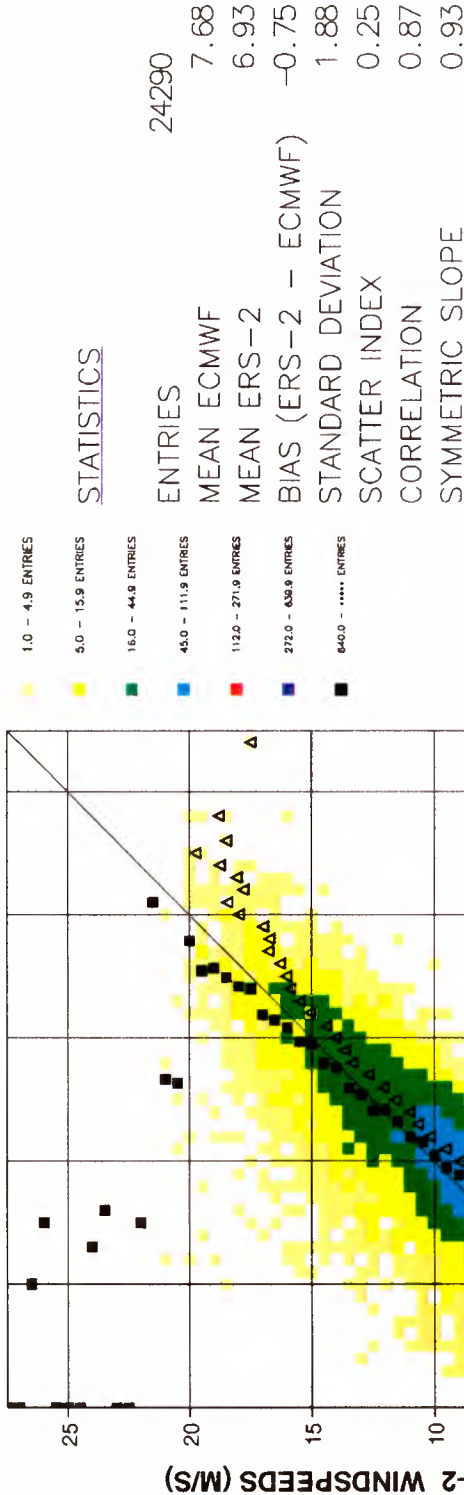


Figure 7: Comparison of ECMWF wind speed results with ERS-2 radar altimeter wind speed data for September 1995. The squares denote the mean values in the x-direction and the triangles in the y-direction.

WAM / ERS-1 Comparison
Altimeter Waveheights
GLOBAL 1.5° SEP 1995
(model field: fg, ERS-1 alt. assimilation: on)

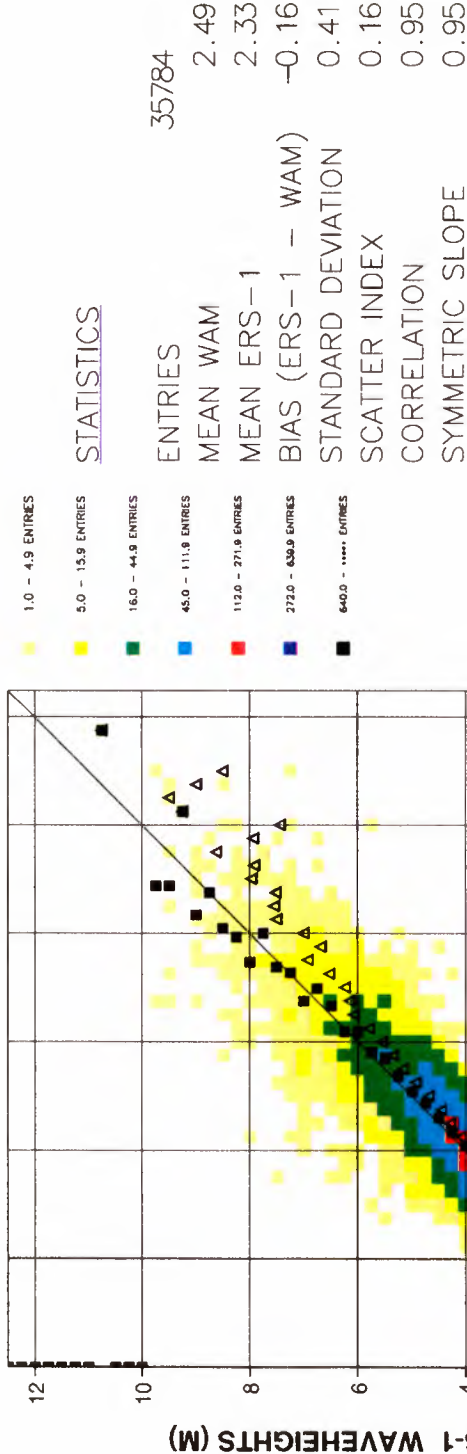


Figure 10: Comparison of ECMWF wave height results with ERS-1 radar altimeter wave height data for September 1995. The squares denote the mean values in the x-direction and the triangles in the y-direction.

WAM / ERS-2 Comparison
Altimeter Waveheights
GLOBAL 1.5° SEP 1995
(model field: fg, ERS-1 alt. assimilation: on)

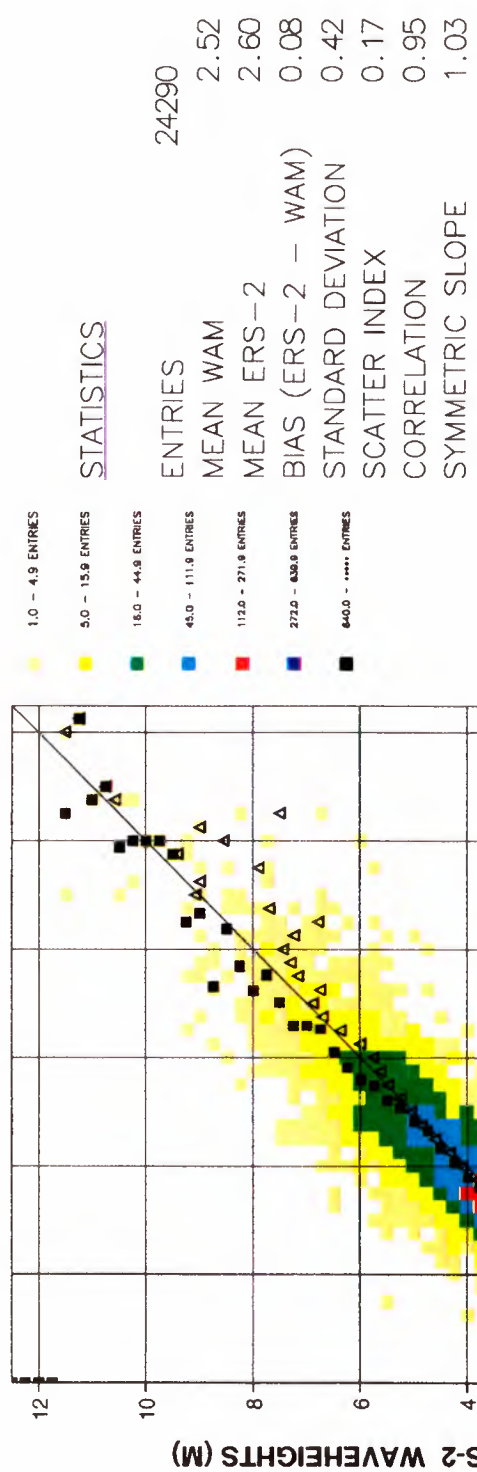


Figure 11: Comparison of ECMWF wave height results with ERS-2 radar altimeter wave height data for September 1995. The squares denote the mean values in the x-direction and the triangles in the y-direction.

IFREMER CONTRIBUTION TO THE ERS-2 RADAR ALTIMETER COMMISSIONING PHASE

SIGNIFICANT WAVE HEIGHT AND BACKSCATTER COEFFICIENT AT ERS-1 / 2 and TOPEX-POSEIDON GROUNDTRACK CROSSING POINTS

Preliminary results

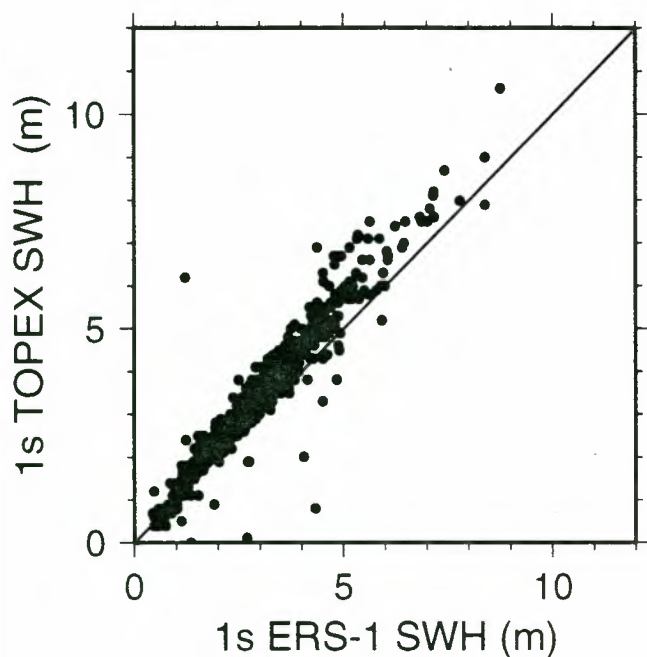
Pierre Queffeuilou
Département d'Océanographie Spatiale
IFREMER, BP 70, 29280 Plouzané, France
Tel (33) 98 22 42 94 Fax (33) 98 22 45 33
e-mail pierre.queffeuilou@ifremer.fr

- individual 1 second ERS and TOPEX POSEIDON altimeter cells
- closest approach
 - less than 10 km
 - less than 1 hour
- first results for the following time periods:

TP CYCLE	T/P	TIME	ERS-1	ERS-2
97	POSEIDON	03.05.95 - 12.05.95		
98	TOPEX	12.05.95 - 22.05.95	X	X
99	TOPEX	22.05.95 - 01.06.95	X	X
100	TOPEX	01.06.95 - 11.06.95	X	X
101	TOPEX	11.06.95 - 21.06.95		X
102	TOPEX	21.06.95 - 01.07.95		X
	POSEIDON	01.07.95 - 01.07.95		
103	POSEIDON	01.07.95 - 11.07.95		
104	TOPEX	11.07.95 - 21.07.95	X	X

- to be completed
 - with TOPEX and POSEIDON data
 - till the end of ERS-2 cycle number 4 (17 August) corresponding to TP cycle number 107
 - analysis of result accuracy due to time and space variability

SIGNIFICANT WAVE HEIGHT



ERS-1 TOPEX

n = 520

mean 3.03 m 3.47 m

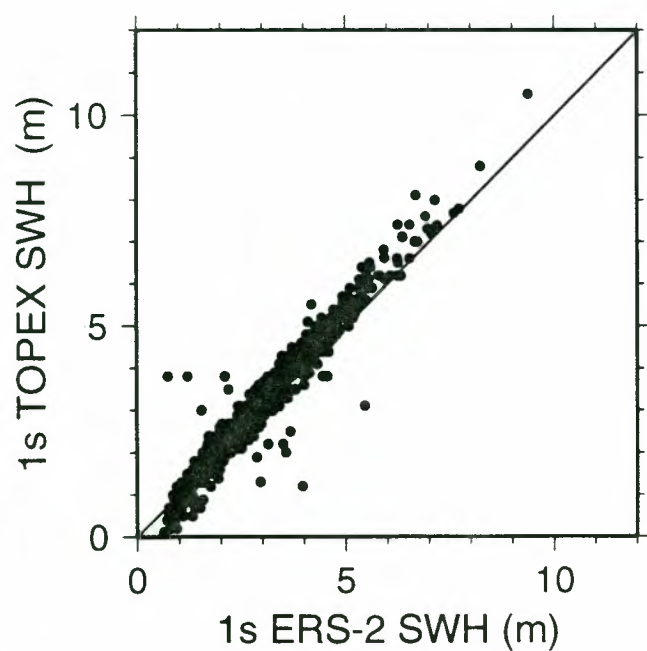
std 1.49 m 1.72 m

$$SWH_T = A * SWH_{ERS1} + B$$

$$A = 1.10 \quad B = 0.14$$

ERS-1 minus TOPEX

mean -0.45 m; std 0.53 m



ERS-2 TOPEX

n = 854

mean 2.73 m 2.86 m

std 1.36 m 1.51 m

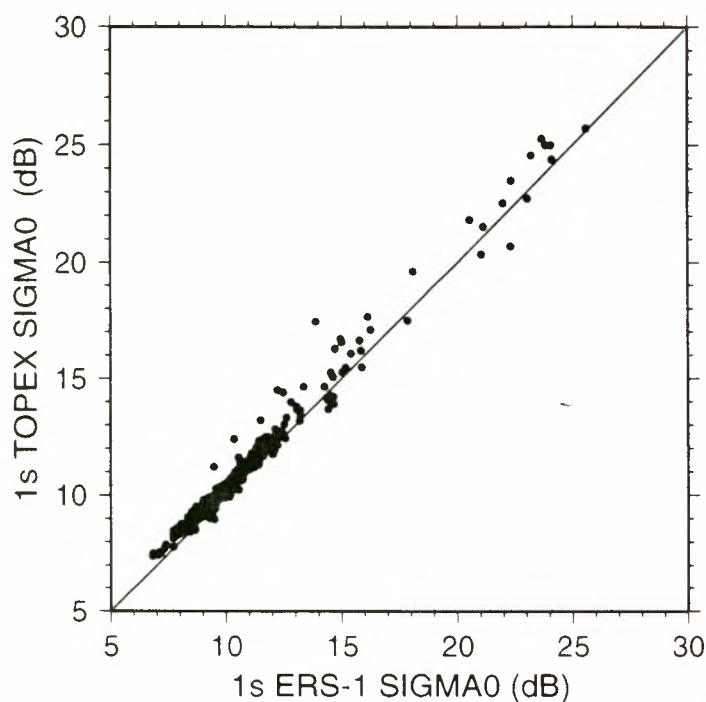
$$SWH_T = A * SWH_{ERS2} + B$$

$$A = 1.08 \quad B = -0.10$$

ERS-2 minus TOPEX

mean -0.13 m; std 0.38 m

BACKSCATTER COEFFICIENT



ERS-1 TOPEX

n = 521

mean 10.69 dB 11.08 dB

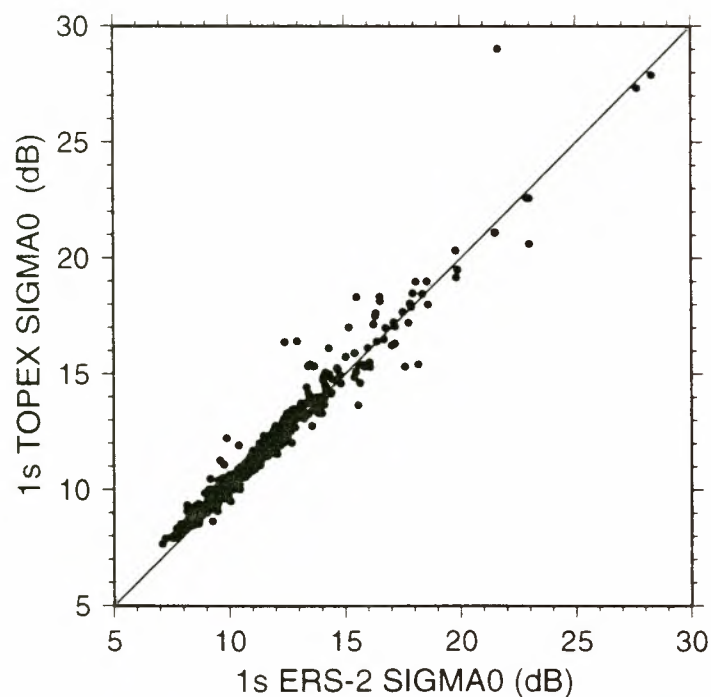
std 2.49 dB 2.56 dB

$$\text{Sigma0}_T = A * \text{Sigma0_ERS1} + B$$

$$A = 1.02 \quad B = 0.22$$

ERS-1 minus TOPEX

mean -0.39 dB; std 0.36 dB



ERS-2 TOPEX

n = 858

mean 11.23 dB 11.47 dB

std 2.20 dB 2.21 dB

$$\text{Sigma0}_T = A * \text{Sigma0_ERS2} + B$$

$$A = 0.98 \quad B = 0.49$$

ERS-2 minus TOPEX

mean -0.25 dB; std 0.48 dB

1/6

12/10/95

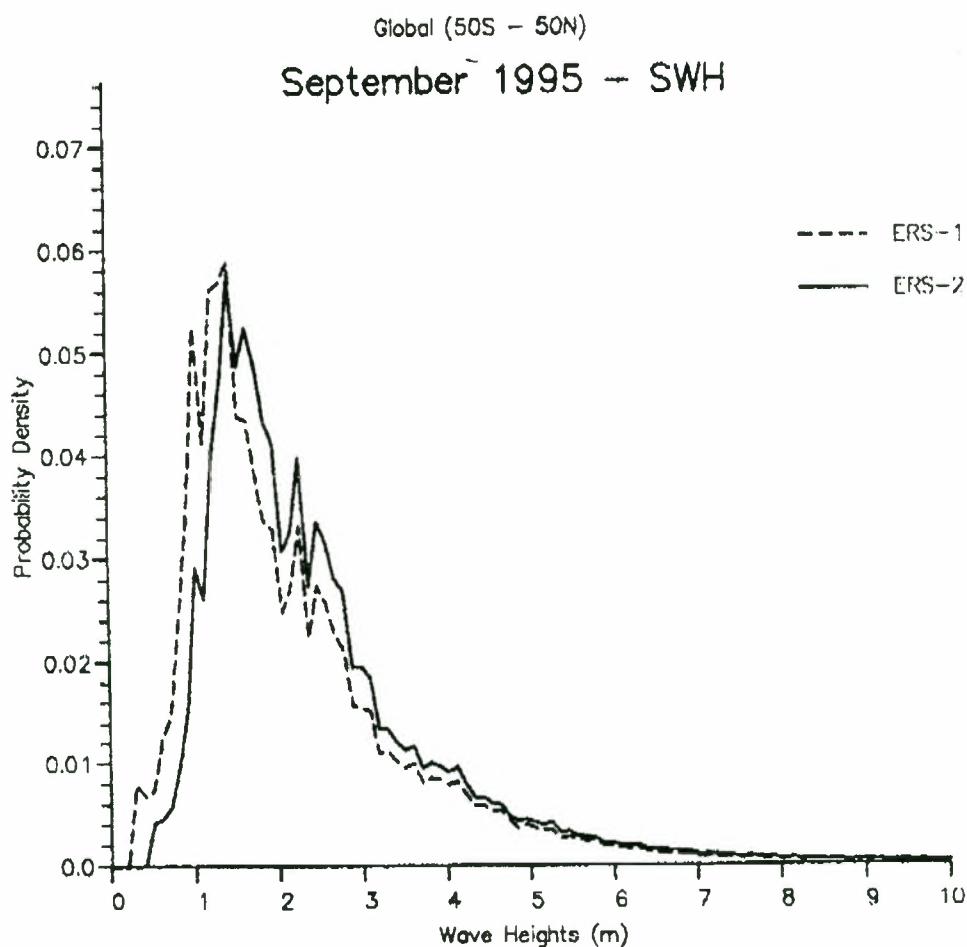
C TO JEROME BENVENISTE

ESRIN

FAX +39 6 941 80321

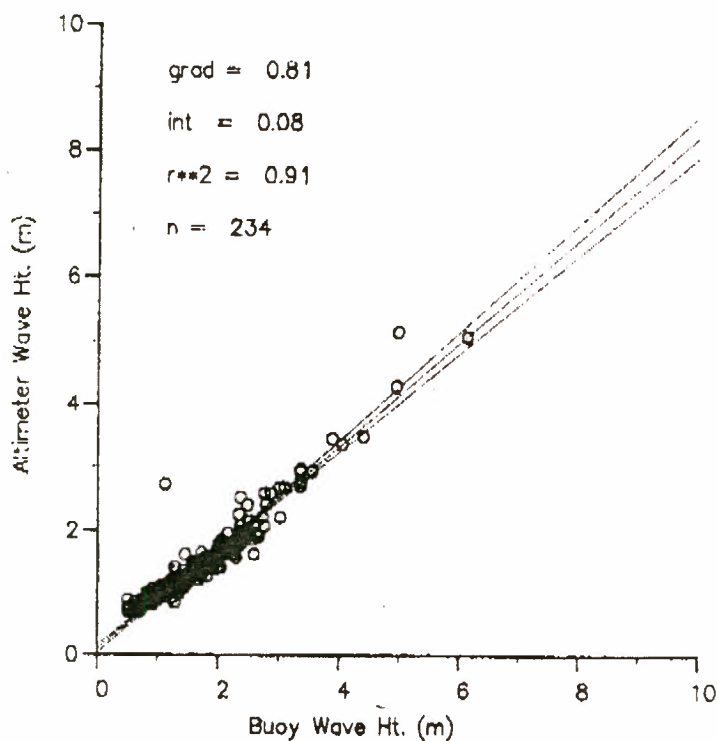
FROM DAVID COTTON, SOUTHAMPTON

+44 1703 596400



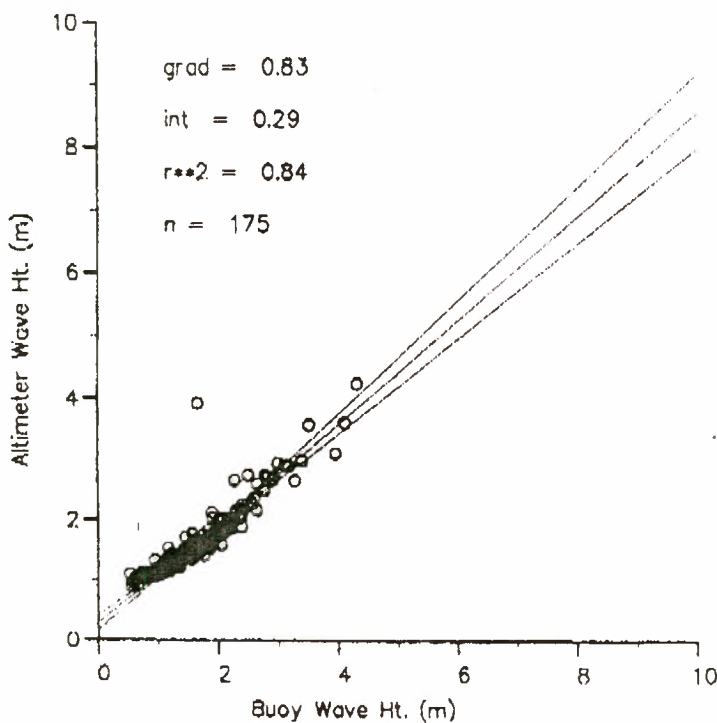
Altimeter/Buoy Overflight – Wave Height

May–Sept 1995 ERS–1



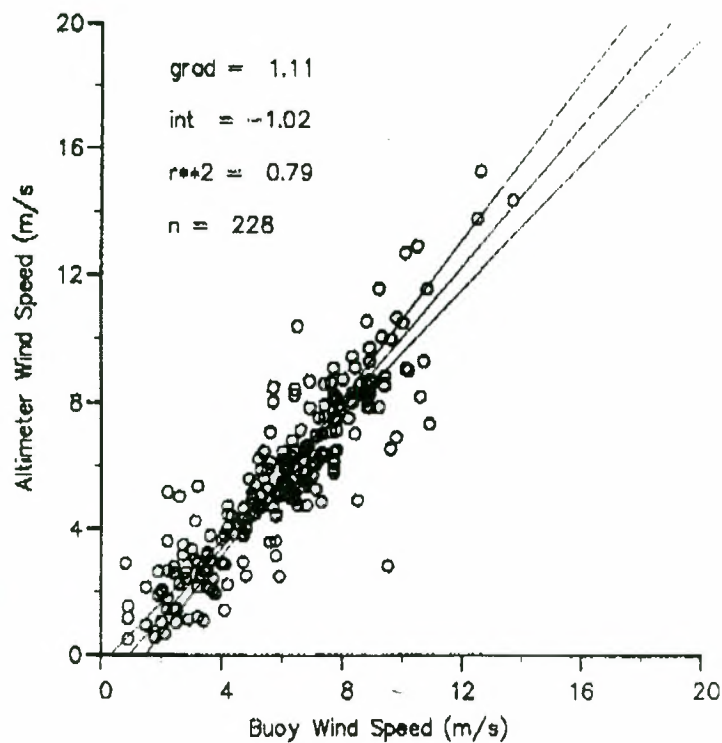
Altimeter/Buoy Overflight – Wave Height

May–Sept 1995 ERS–2



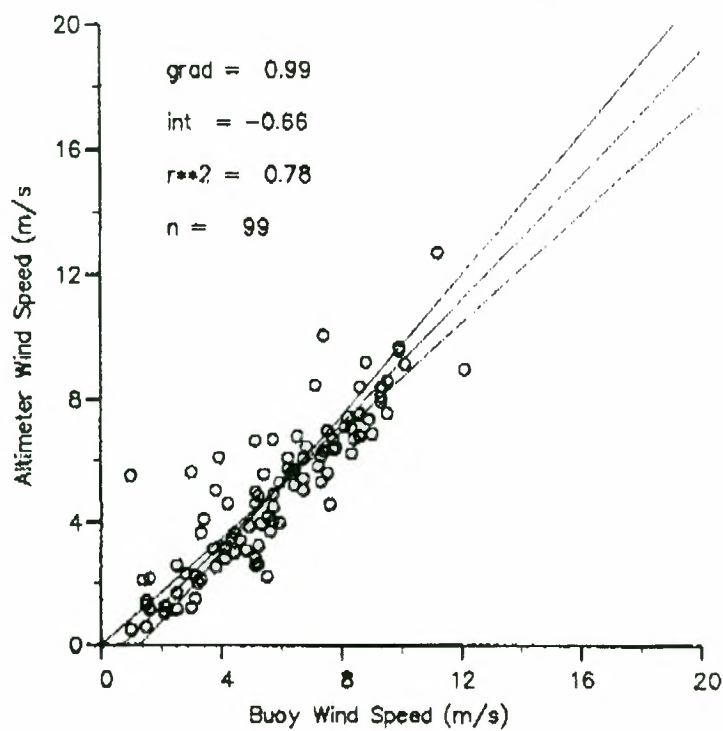
Altimeter/Buoy Overflight - Wind Speed

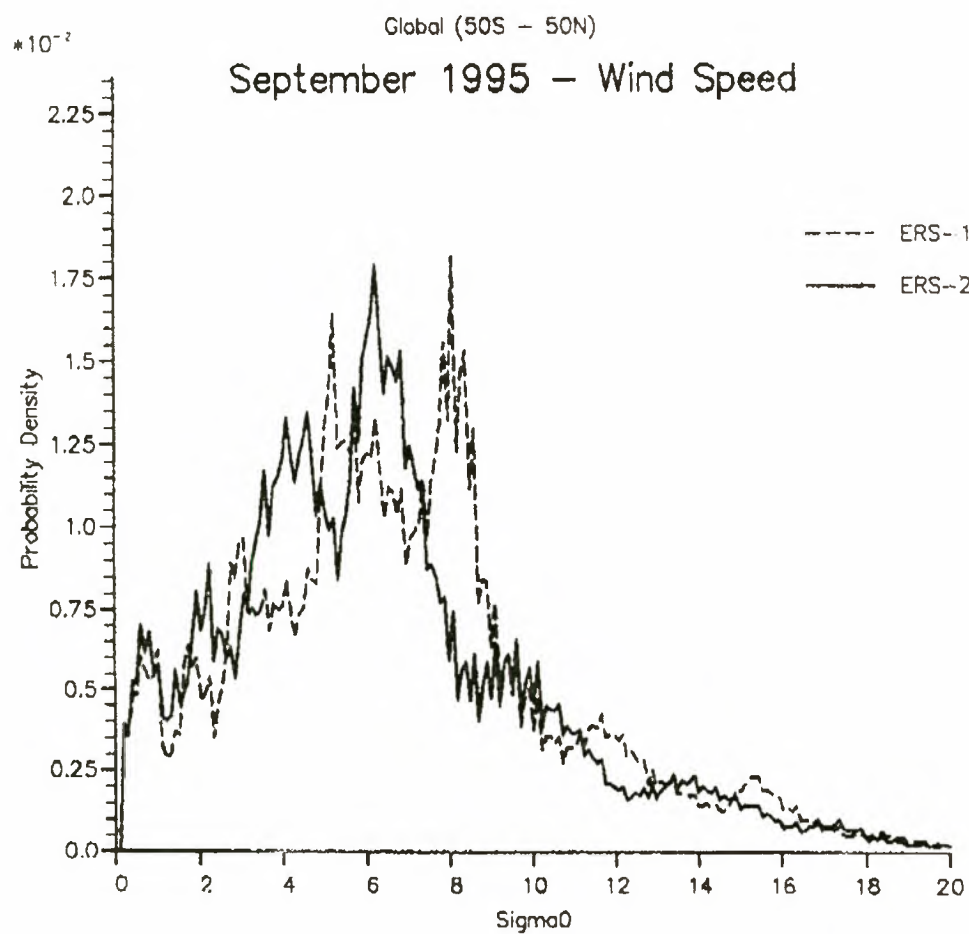
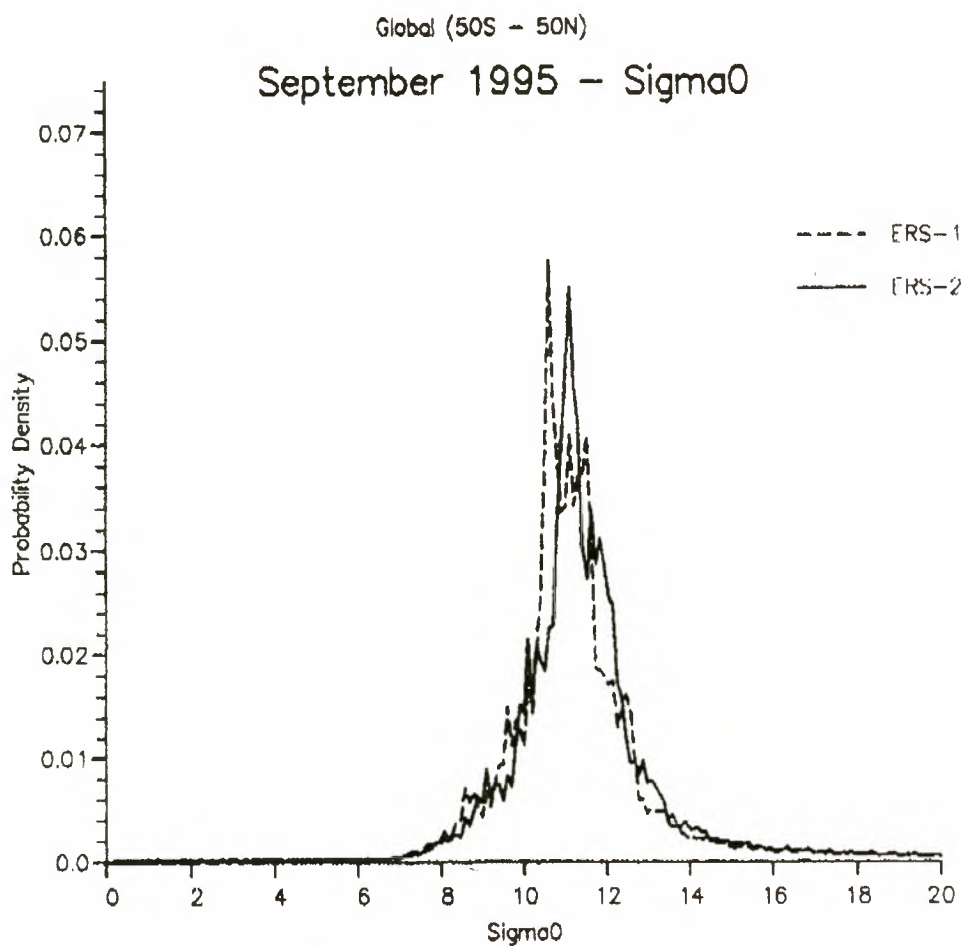
May - Sept 1995 ERS-1



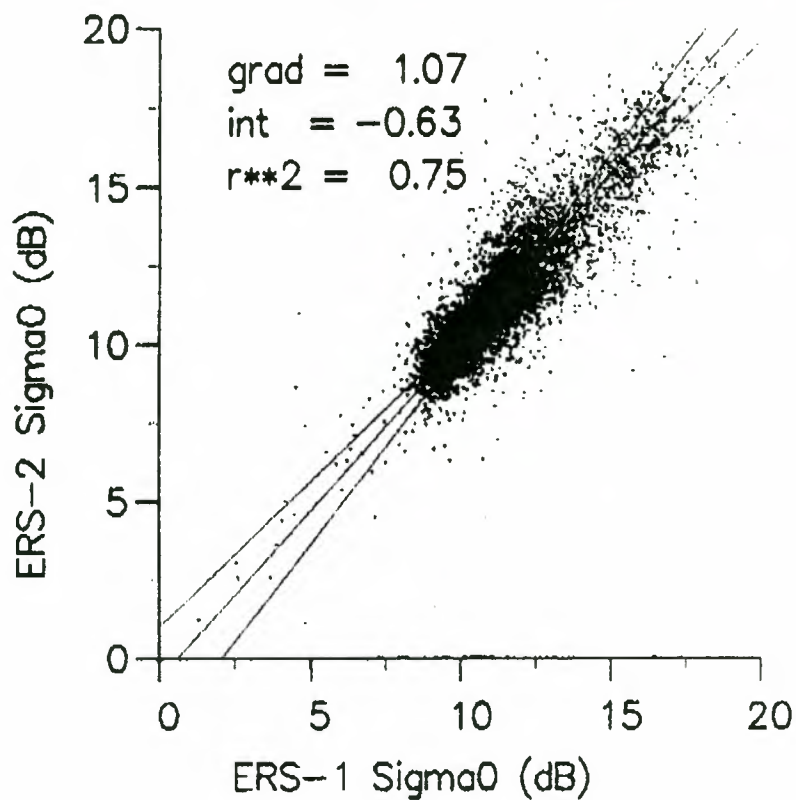
Altimeter/Buoy Overflight - Wind Speed

July-Sept 1995 ERS-2

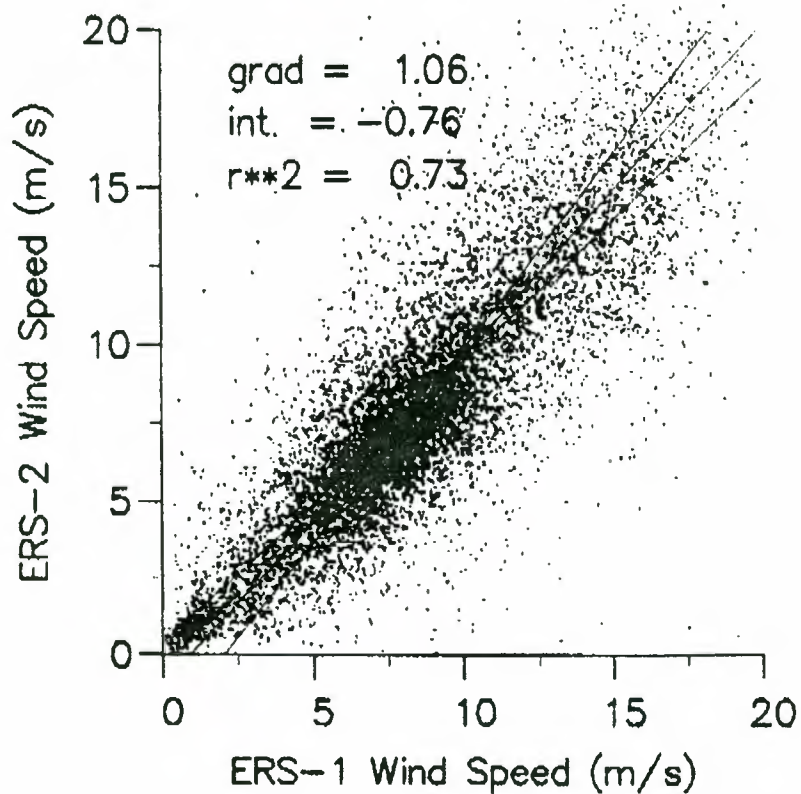




September Sigma0



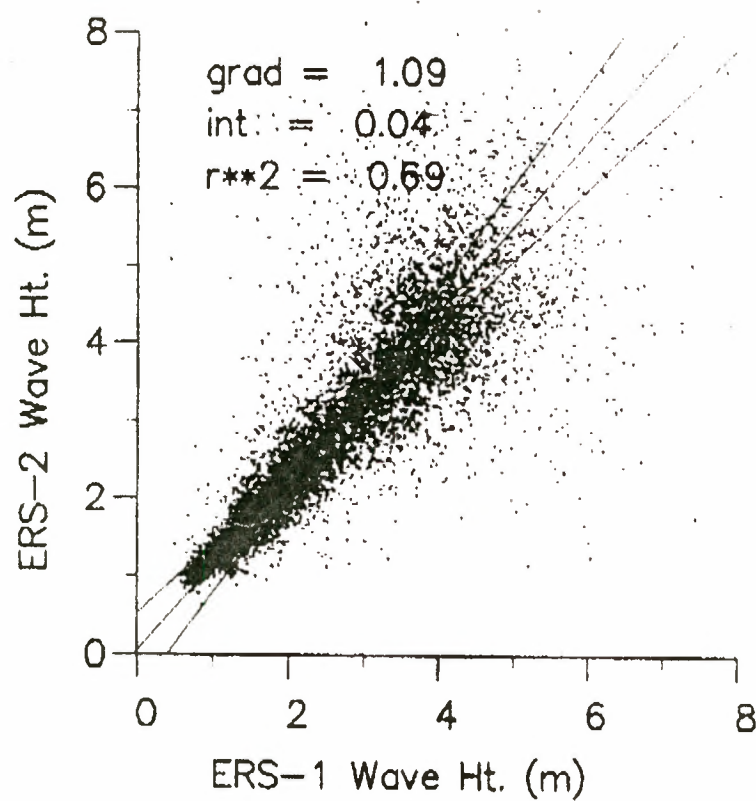
September Wind Speed



JILLOME BENVENISTE

616

September Sig. Wave Ht.

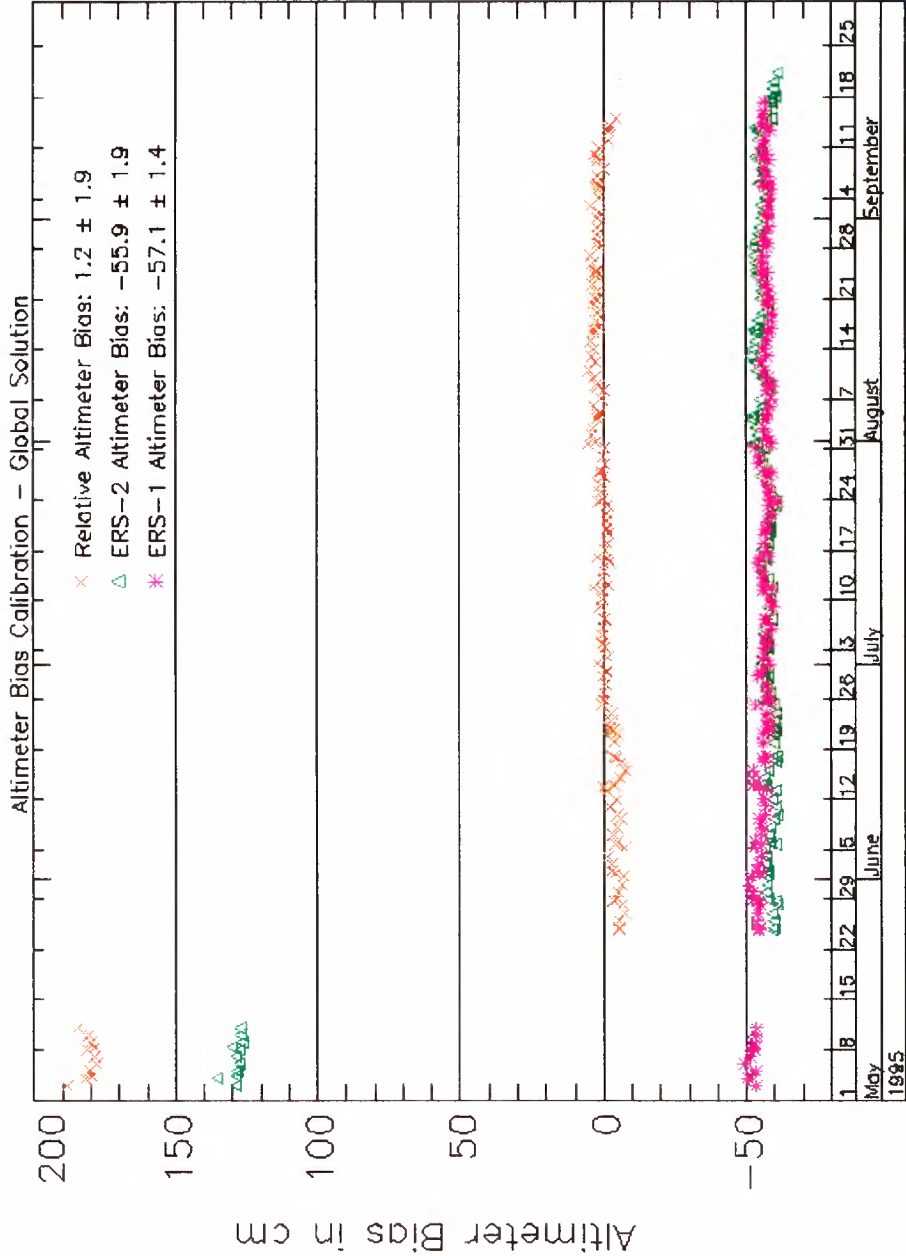




ERS-2 Altimeter Calibration at ESOC

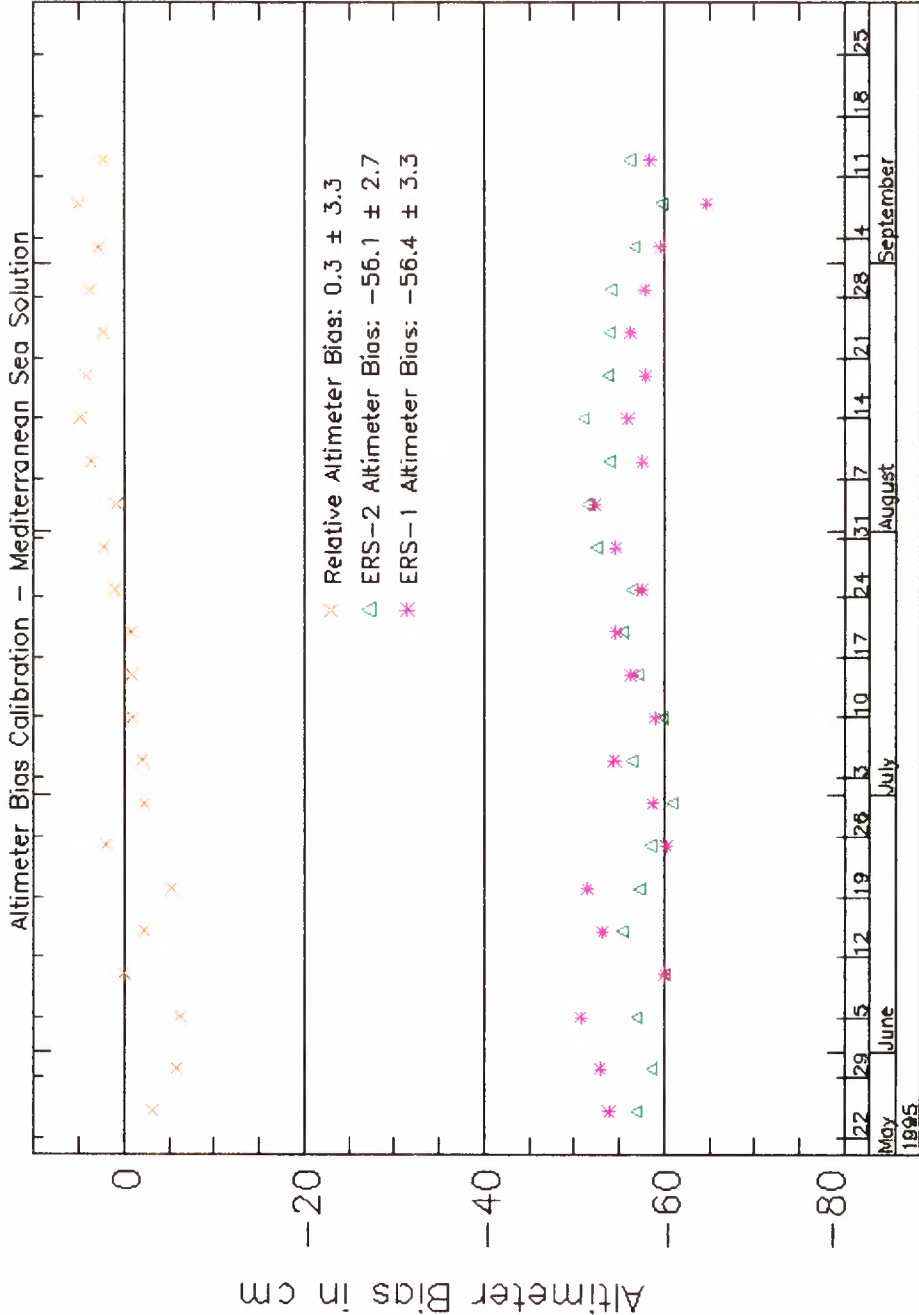


Global Calibration



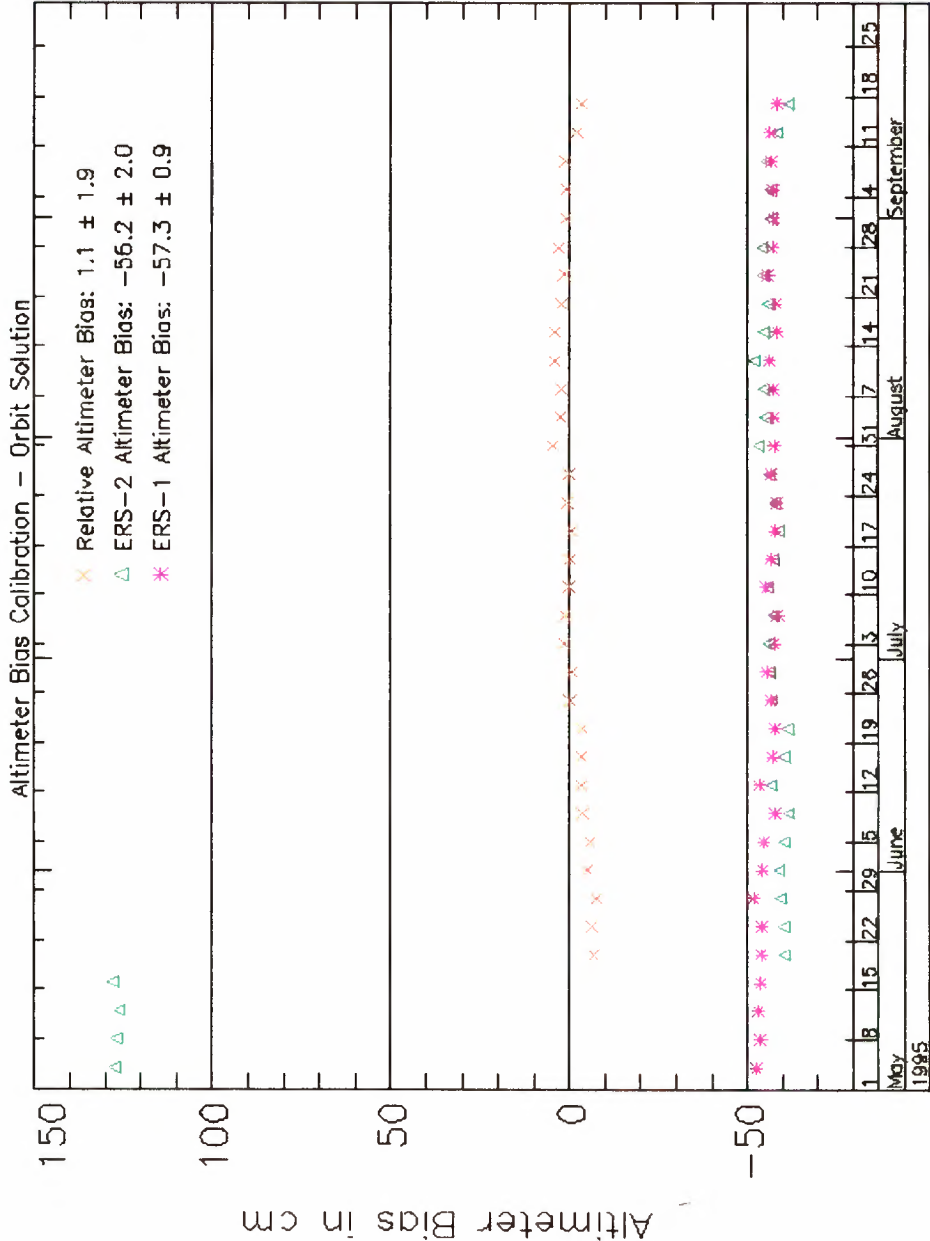


Local Calibration in the Mediterranean Sea





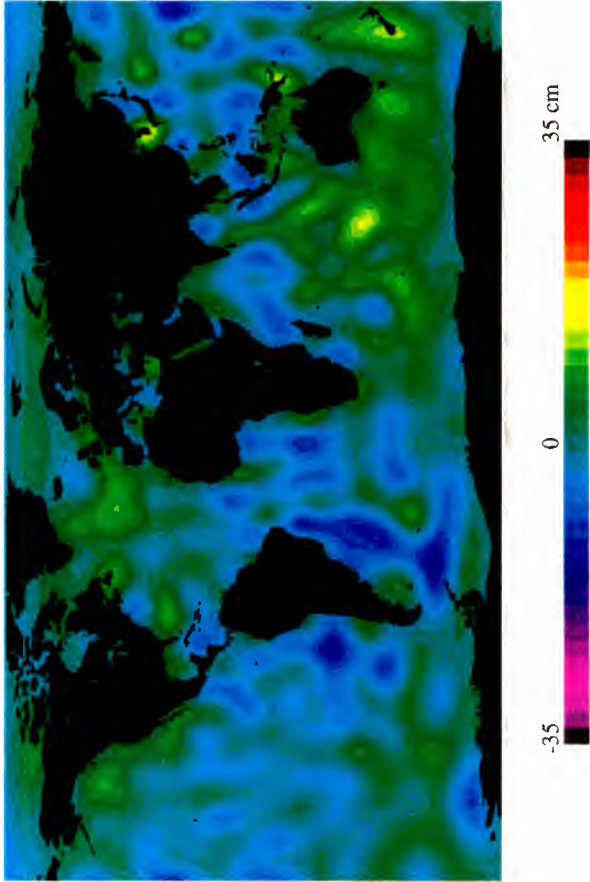
Global Calibration, Orbit Solution



Sea Surface Differences

ERS-2 & ERS-1 Sea Surface Topography differences

Mean value: 0.6 cm , rms= 3.6 cm



Month	ERS-2	ERS-1	ERS-2 - ERS-1
June	-56.0	-56.1	0.1
July	-57.2	-57.8	0.6
August	-54.5	-57.2	2.7

Conclusions

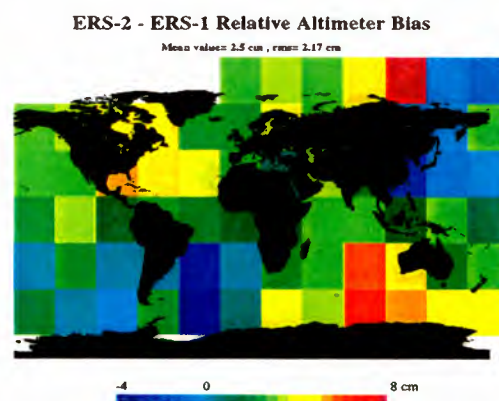
- Four different methods have been used at ESOC for the relative ERS-2 altimeter calibration:

Method	Relative bias (cm)	Sigma (cm)
Global solution	1.20	± 1.90
Mediterranean solution	0.30	± 3.30
Orbit solution	1.10	± 1.90
Sea Surfaces differences	1.10	± 1.10

- A weighted fit between all the methods considered will determine the final value of the bias:

$$\text{Relative altimeter bias} = 1.02 \pm 0.17 \text{ cm}$$

- To evaluate the systematic part of the error introduced in the estimation a set of local calibrations have been performed.



- The combination of the non-systematic and systematic errors will provide the final uncertainty:

$$\text{Relative altimeter bias} = 1.02 \pm 2.18 \text{ cm}$$

Crossover time lag	Number of points	Mean/Standard deviation of (ERS2-ERS1) SSH difference.
no threshold	39393	-1.7/16.2
< 10 days	19254	-1.8/15.7
< 5 days	10737	-1.8/14.5
< 1 day	2436	-2.4/13.8

Table 5 Results from ERS-1/ERS-2 crossover analysis for cycle 3, as function of crossover time lag. Units are cm.

Cycle Nb	Number of points	Mean/Standard deviation of (ERS2-ERS1) SSH difference.
1	352678	-2.3/9.7
2	780432	-2.2/8.7
3	702348	-1.9/8.6
4	796223	-5.1/10.3
All	2631681	-3.1/9.4

Table 6 Results from ERS-1/ERS-2 repeat-track analysis. Units are cm.

Cycle No	Number of crossovers	ERS-1		Number of crossovers	ERS-2	
		mean of SSH difference (cm)	Standard deviation (cm)		Mean of SSH difference (cm)	Standard deviation (cm)
1	4172	-0.62	16.84	3241	-1.57	15.20
2	25643	-0.69	15.89	15854	-1.98	15.12
3	24405	-0.58	15.26	14224	-0.74	14.11
4	31279	-0.10	15.41	16134	-1.00	14.55
All	85499	-0.44	15.59	49453	-1.08	14.66

Table 2 - Results from ERS-1/ERS-1 and ERS-2/ERS-2 crossover statistics

Cycle No	Number of crossovers	Mean/Standard deviation of (ERS2-ERS1) SSH difference		
		fully corrected.	without inverse barometer	without added sea-state bias
1	7331	-1.9/17.1	-2.2/18.8	-1.0/17.1
2	42557	-1.6/19.6	-1.6/22.3	-0.7/19.7
2	39393	-1.7/16.2	-1.6/19.4	-0.9/16.2
4	47322	-4.7/20.1	-4.8/22.1	-3.9/20.1
All	136603	-2.7/18.7	-2.8/21.3	-1.9/18.7

Table 4 Results from ERS-1/ERS-2 crossover analysis. Units are cm.

figure 1

ERS1 CYCLE 2, TOPEX CYCLES 98 A 101

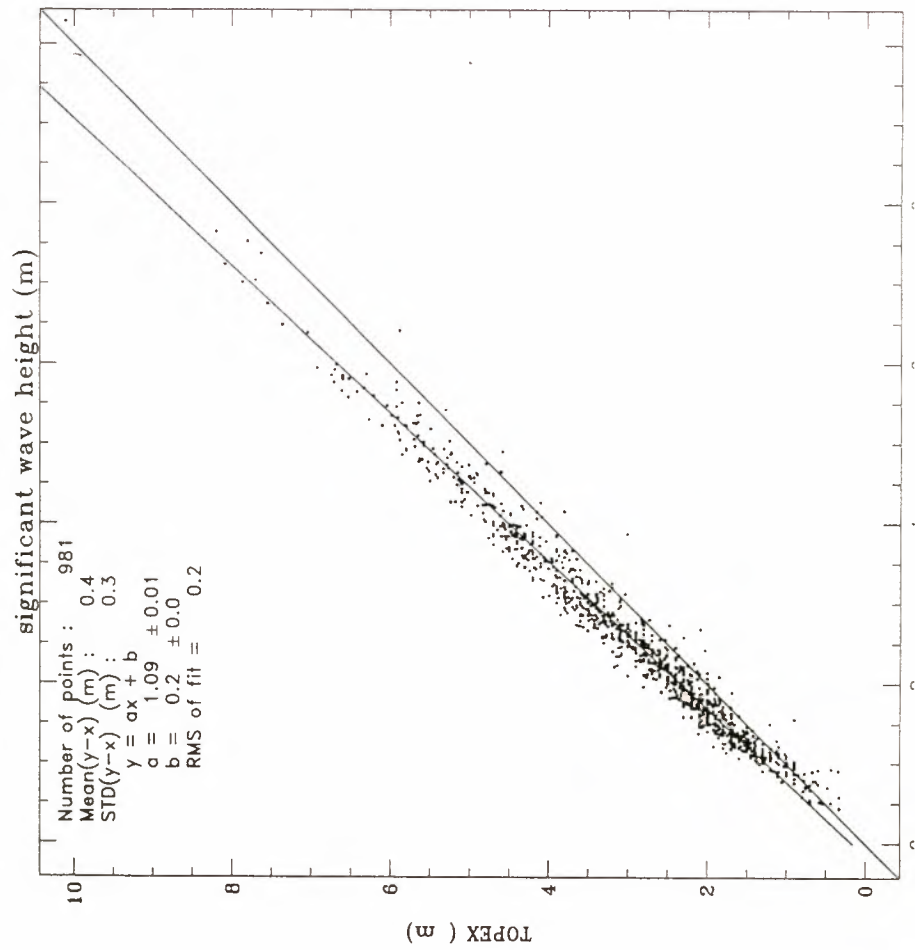
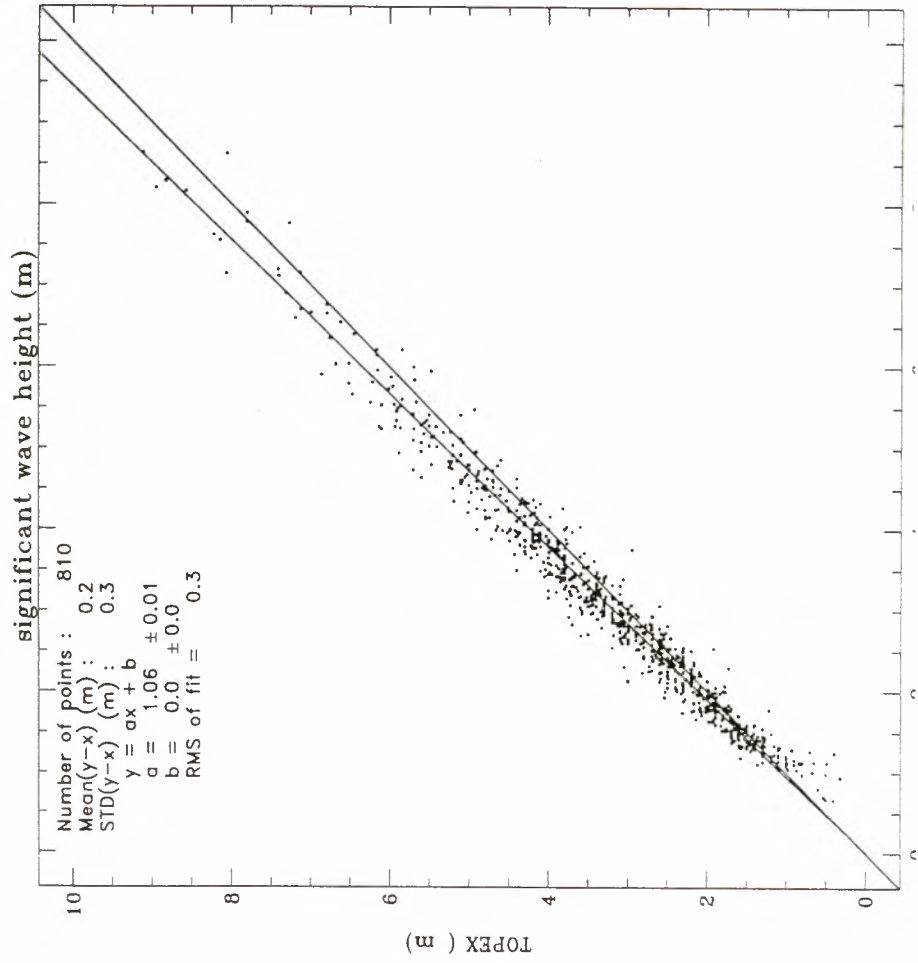
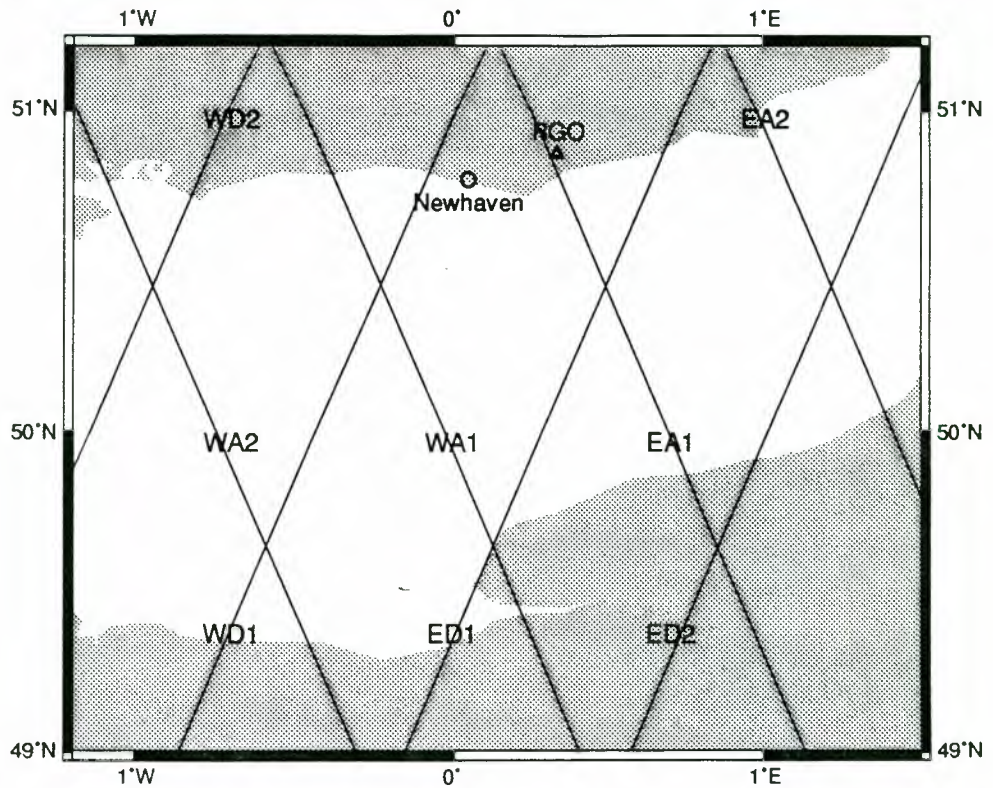


figure 2

ERS2 CYCLE 2, TOPEX CYCLES 98 A 101

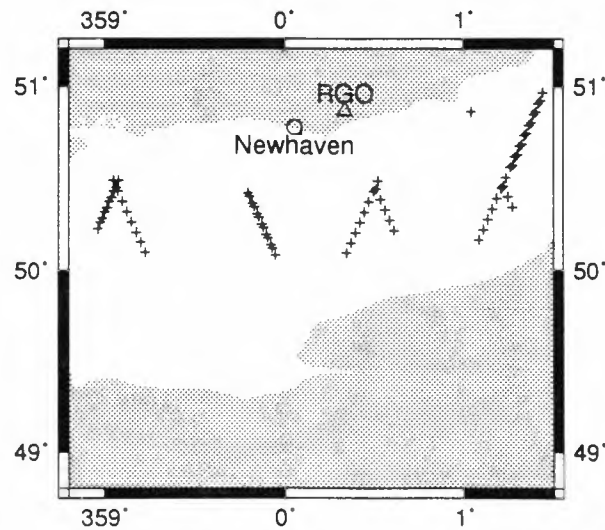


Groundtracks over The Channel

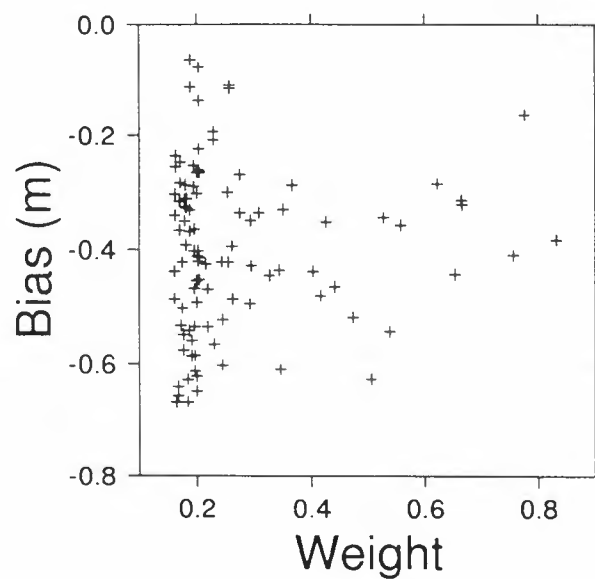


This is the calibration site for the short-arc in situ calibration campaign. It shows the tide gauge (Newhaven) used for sea-surface elevation measurements and the laser ranger of the the Royal Greenwich Observatory (RGO) used for short-arc radial orbit correction. The eight passes considered are shown on the map. Each was assigned an identifier according to whether it was east or west of the gauge, was ascending or descending and whether it was amongst the closest four to the gauge or the farthest four. Thus pass 'EA1' is east of the tide gauge, an ascending pass and amongst the four closest passes to the gauge.

ERS-2 calibration point distribution

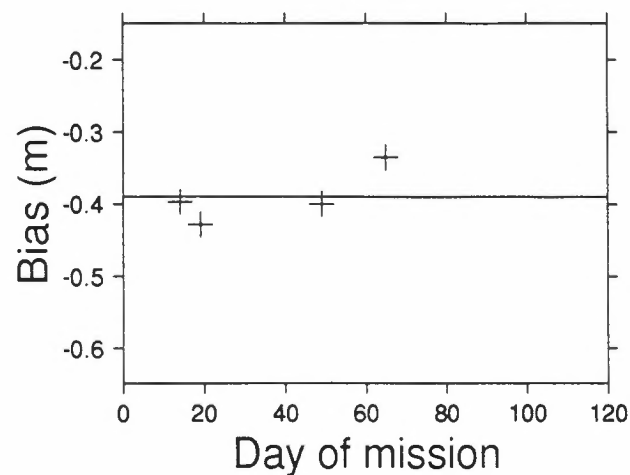


ERS-2 bias distribution by weight

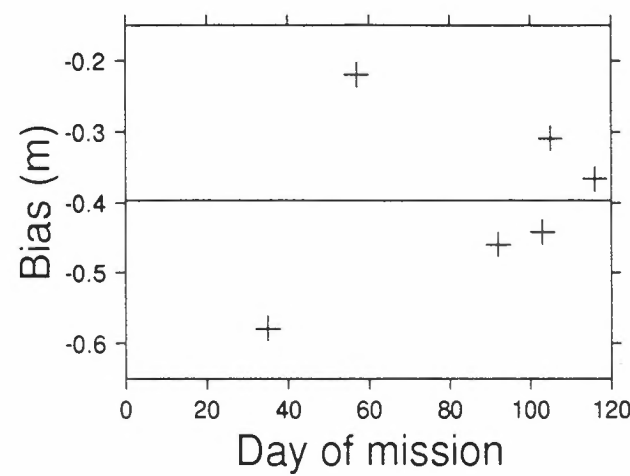


This shows the distribution of calibration points for ERS-2 only. Below the geographical distribution is the distribution by weight. Weight is inversely proportional to distance so the closest ones have largest weight and a smaller spread. Note that spurious calibration points corrupted by proximity to land are rejected and not shown here.

ERS-2 biases (near passes)

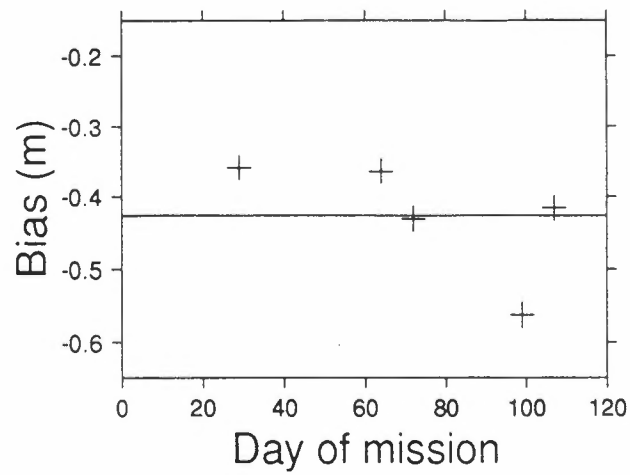


ERS-2 biases (far passes)

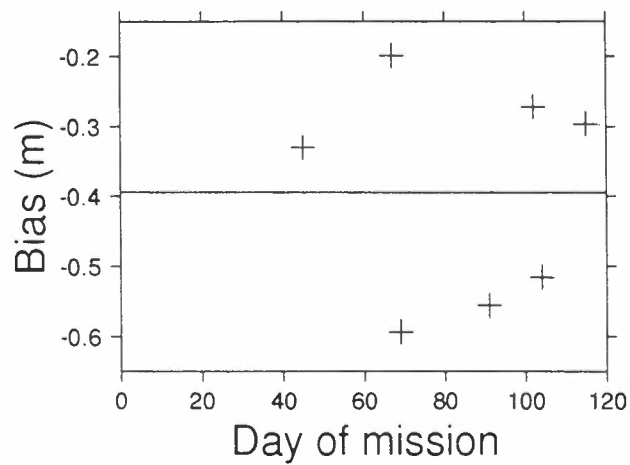


The mean bias is -39.0 cm for the nearest passes and -39.6 cm for the furthest passes.

ERS-1 biases (near passes)



ERS-1 biases (far passes)



The mean bias is -42.6 cm for the nearest passes and -39.4 cm for the furthest passes.

Data Type	Satellites	SSB (% SWH)		Rel bias (cm)	
		ERS-1	ERS-2	ERS-1	ERS-2
DXO	T/P - ERS-1	-5.54	—	34.7 ⁽¹⁾	—
	T/P - ERS-2	—	-5.71	—	34.2 ⁽¹⁾
	ERS-1 - ERS-2	-5.32	-5.18	—	-0.6 ⁽²⁾
SXO	ERS-1 - ERS-2	-5.64	—	—	—
	ERS-2 - ERS-2	—	-5.12	—	—
RP	ERS-1 - ERS-2	-5.52	-5.57	—	-0.8 ⁽²⁾

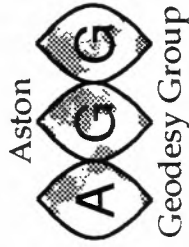
⁽¹⁾ Relative to TOPEX altimeter

⁽²⁾ Relative to ERS-1 altimeter

No T/P SSB solved for (assume Gaspar 4 parameter model is accurate).

ERS-2 altimeter bias approx 0.5–1.0 cm less negative than ERS-1.

DXO = Dual satellite crossover
 SXO = Single satellite crossover
 RP = Repeat pass



Sea State + Relative Bias Determination

Satellites used TOPEX/POSEIDON
 ERS-1
 ERS-2

Period analysed MJD 49838 — 49875
 (1 May — 7 June 1995)

Altimetry used ERS-1 and ERS-2 quicklook data
 TOPEX/POSEIDON GDR data

Corrections used CSR 3.0 tidal model (ocean + loading)
 Pole tide
 Inverse barometer
 Gaspar 4 parameter model SSB model for T/P
 (Sea state bias removed for ERS-1 + ERS-2)
 Centres of gravity corrected for (ERS-1 + ERS-2)
 all other corrections as supplied

ERS-2 Commissioning Working Group

RA Ice-Mode Cross Calibration



MSSL

Climate Physics
Group

Methodology and data processing: goal is 5cm accuracy cross calibration

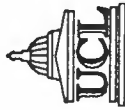
- Mission constraints forbid generation of a full cycle of ice mode data over ocean
- Hence must use collinear track analysis over deep ocean, with a few carefully selected orbits
- We may use the coincident ground track of ERS-1&2, but there will be at least 1 day separating them in time
- Ocean should be reasonably stationary over this time, but:
- We must fully compensate for orbit, ionospheric, atmospheric, tidal and geoid effects
- No ice-mode data available from Fast Delivery processing
- Therefore we must use 20Hz waveform data processed by ESA, which has engineering-level corrections applied
- MSSL have built a geophysical processing chain with the following components:

$$height = h_{orbit} - h_{raw} + \Delta h_{retrack} - \Delta h_{doppler} + \Delta h_{iono} + \Delta h_{dry} + \Delta h_{wet} - \Delta h_{solid_tide} - \Delta h_{loading_tide} - \Delta h_{ocean_tide} - \Delta h_{geoid} + \Delta h_{cog}$$

- Orbits can be generated from D-PAF or Delft orbit data
- Atmospheric corrections are derived from UK-PAF TAMF files
- Ionospheric corrections are from the University of Texas IONO90 model
- Tides are enhanced Schwiderski at present, UOT model will be substituted shortly.
- Geoid is OSU91a
- Other corrections can be plugged in if required

ERS-2 Commissioning Working Group

RA Ice-Mode Cross Calibration

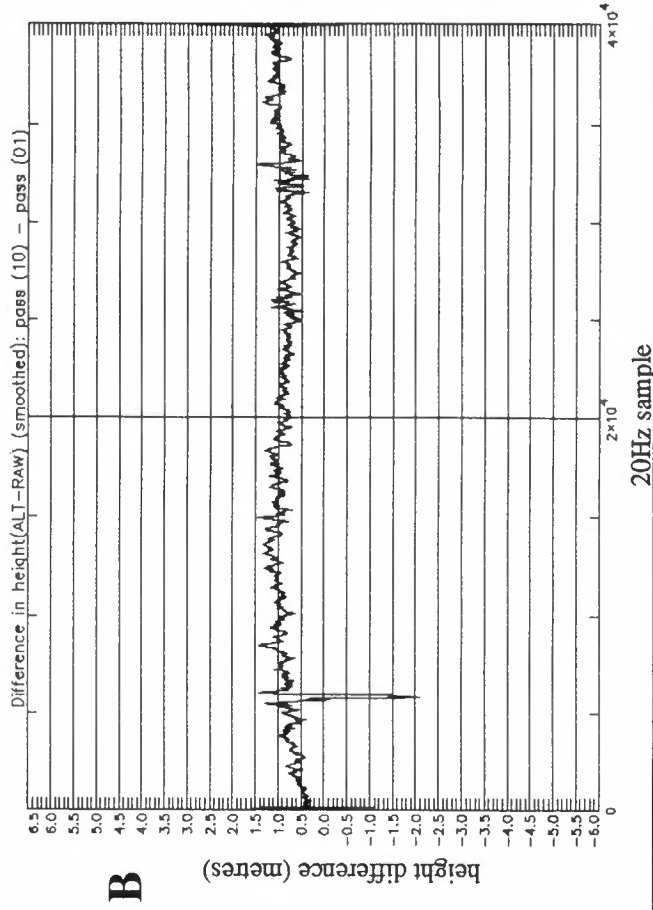
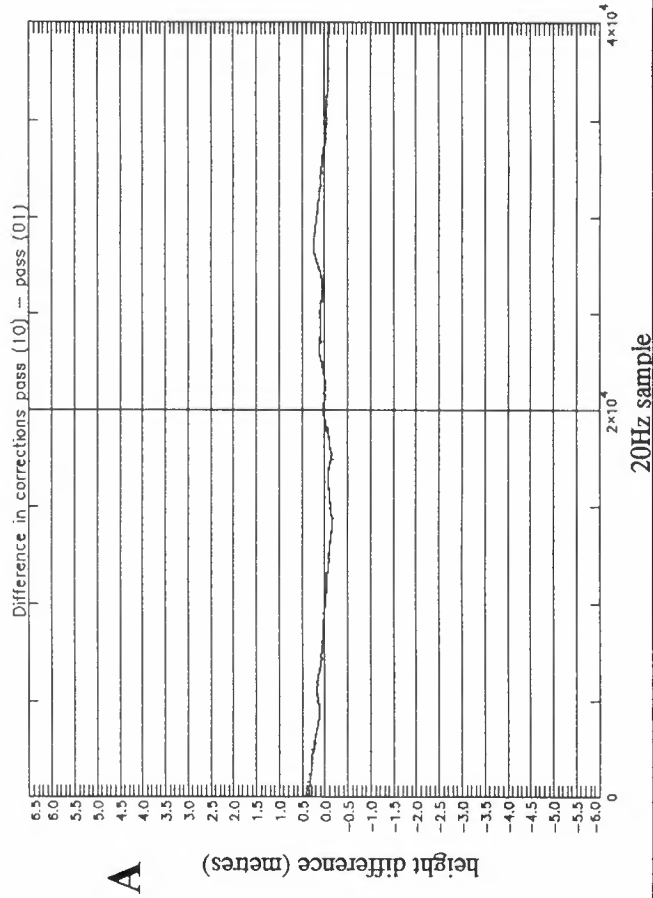


MSSL

Climate Physics
Group

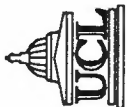
Showing that the bias is in the data, rather than MSSL processing:

- The corrections, tides and geoid were computed separately for each mission's collinear ground track
- The corrections etc were differenced in order to look for a bias.
- Plot A shows the difference plot, revealing structure plus approximately zero mean
- Hence correction processing cannot be contributing a constant 1 metre offset
- The (Delft) orbit altitude was used to convert range to uncorrected height
- The uncorrected and untracked heights for each mission were differenced
- The 1 metre offset is apparent (Plot B), and does not go away when data are retracked (to cm precision)
- Audit of ESA low-level processing and characterisation data in progress - not yet clear whether artefact or instrumental effect



ERS-2 Commissioning Working Group

RA Ice-Mode Cross Calibration

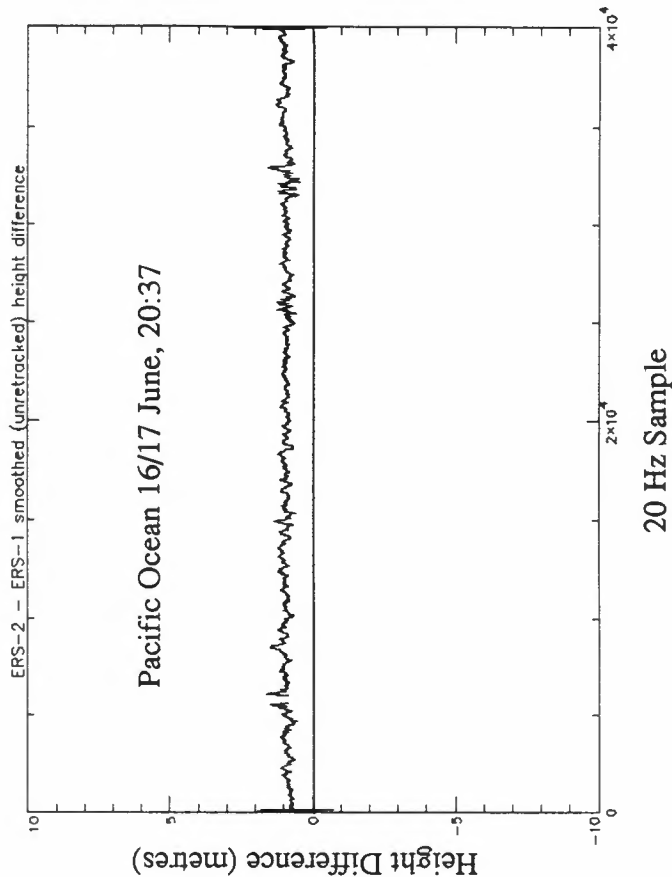


MSSL

Climate Physics
Group

Preliminary Result: ERS-2 RA ice mode range measurement shows ~1 metre height bias relative to ERS-1

- Collinear, dual mission pairs show an approximate bias of 1 metre over the major oceans,
- We have shown that the bias must be in the input data as supplied by ESA
- It has not yet been established whether the effect is instrumental, or a low-level processing issue
- It has not yet been established which mission is 'wrong'
- ERS-TOPEX crossovers will be used to investigate further, once ESA processing audit completed



ERS-2 Commissioning Working Group

RA Ice-Mode Cross Calibration

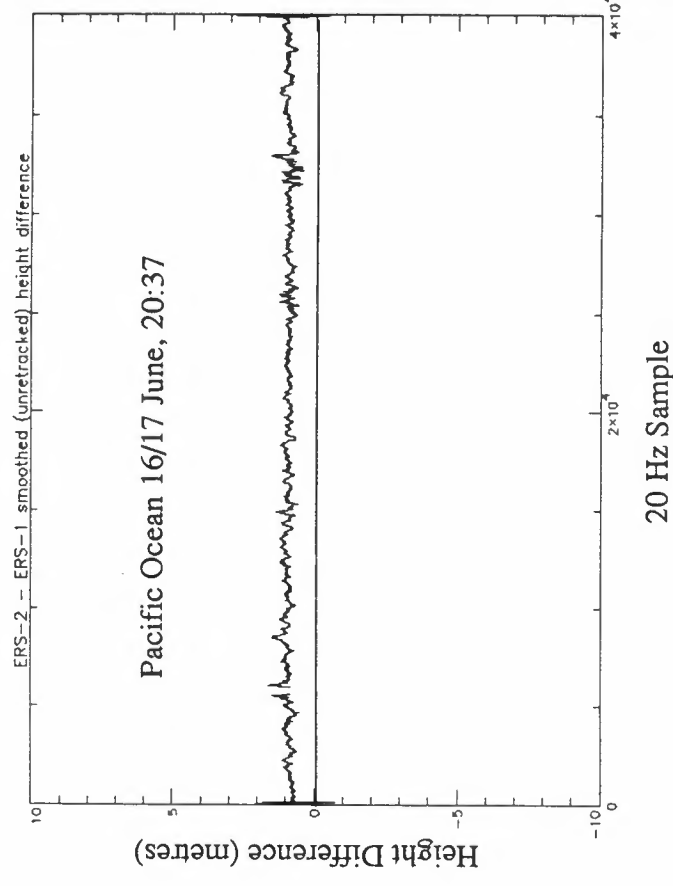


MSSL

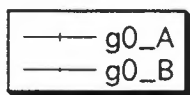
Climate Physics
Group

Summary: - with current data provided by ESA:

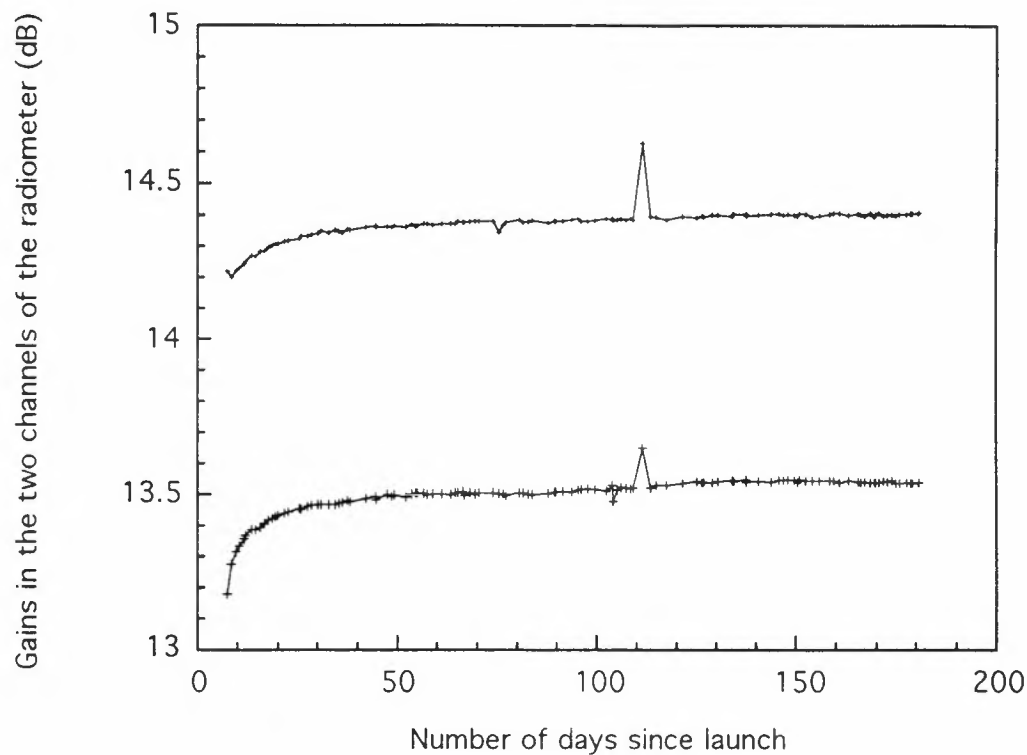
- MSSL have processed the provided data as collinear, 2-mission, ground track pairs with 1 day separation
- Data have been corrected for engineering biases, atmospheric, ionospheric, tide, & geoid effects
- Collinear-track height differences show a 1m bias over major oceans
- Investigation shows 1m bias is in the input data
- Currently not clear whether a low-level data processing or instrumental effect



**STATUS OF THE MICROWAVE RADIOMETER
AND THE VALIDATION OF ITS RESULTS**



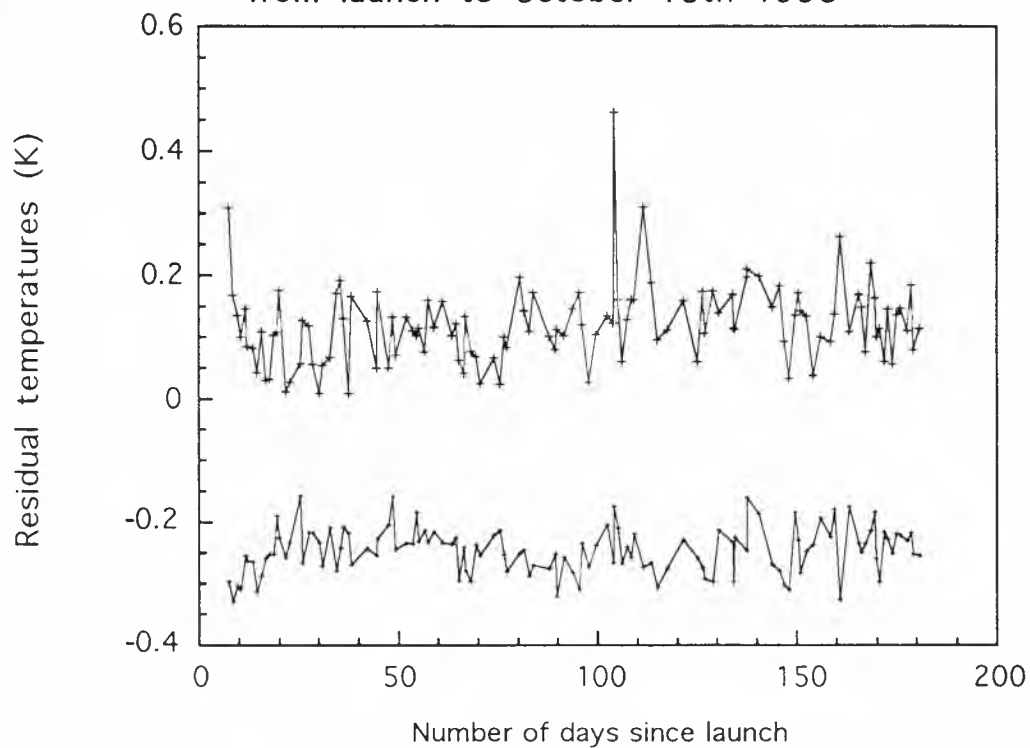
Survey of the MWR-2 gains (channel A &B)
from launch to October 18th 1995



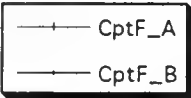
The gains have been stabilised since the 50th day.



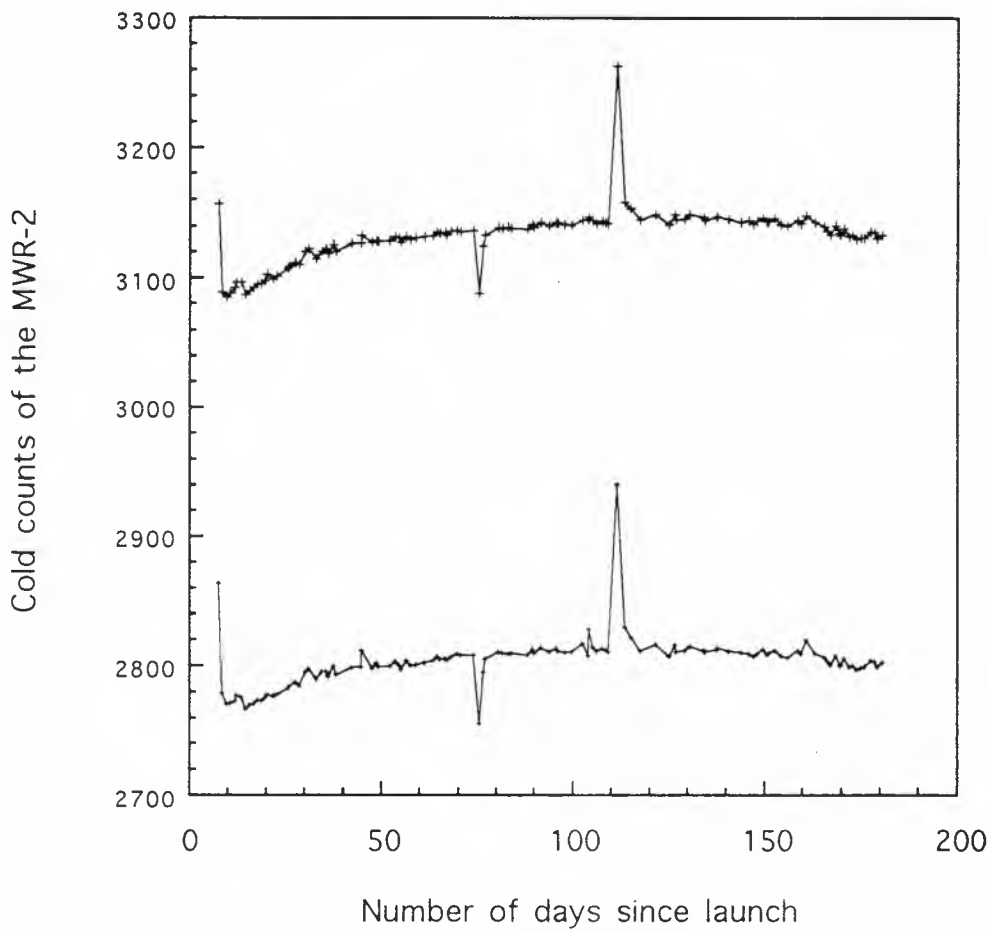
Survey of the MWR-2 residual temperatures (channel A &B)
from launch to October 18th 1995



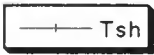
The residual temperatures are in their normal range ($< 1\text{K}$)



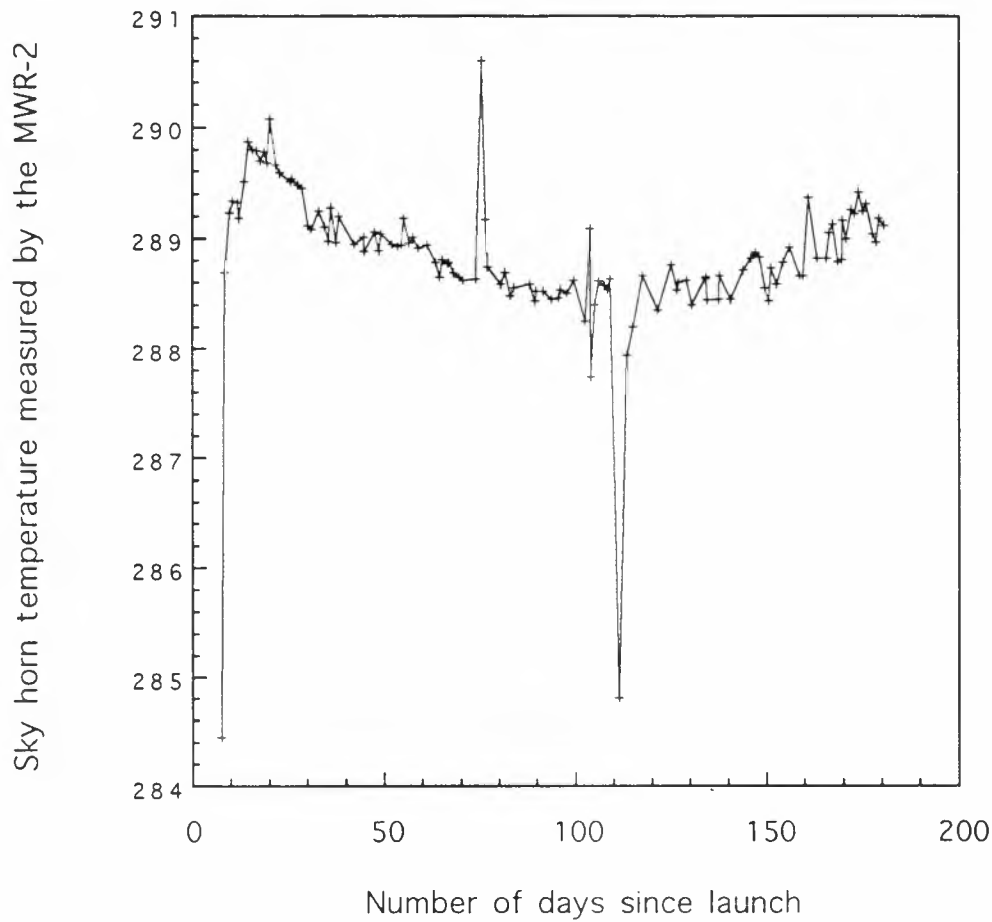
Survey of the MWR-2 cold counts (channel A &B)
necessary for the calibration -from launch to October 18th 1995-



The cold counts are in their normal range, the half annual cycle has been done.



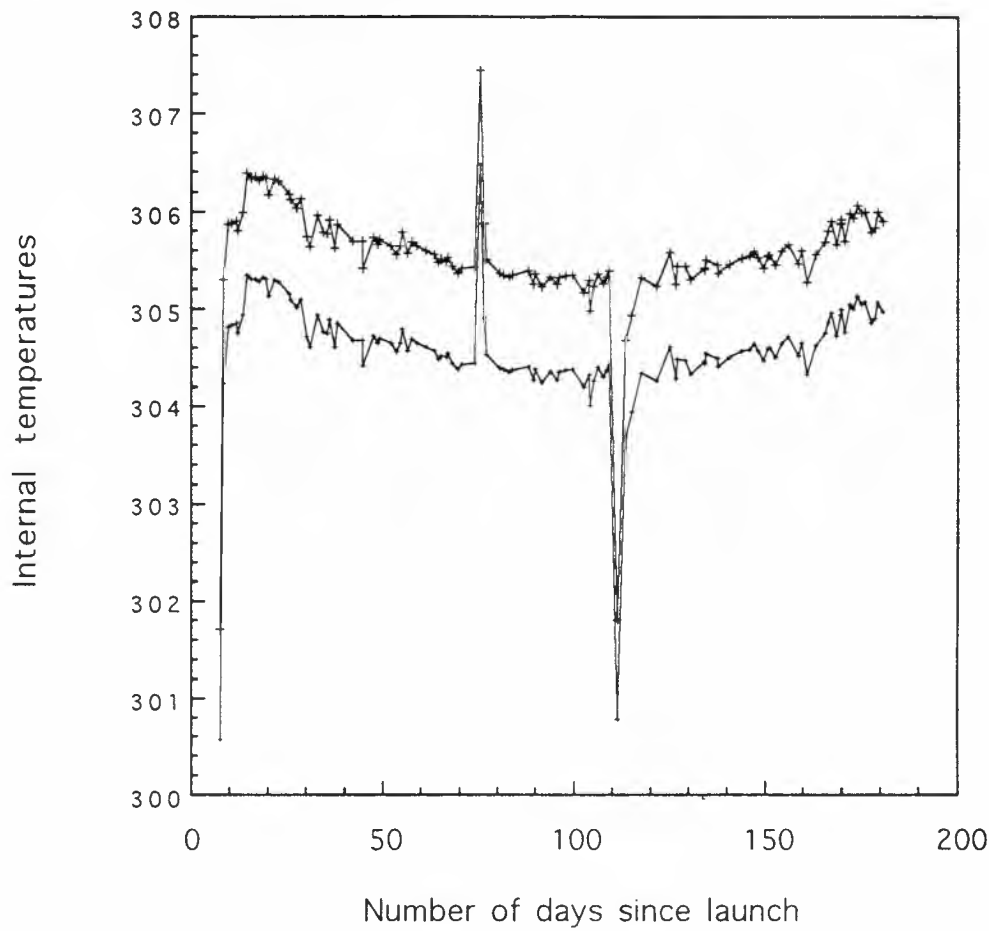
Survey of the MWR-2 sky horn temperature (channel A &B)
necessary for the calibration -from launch to October 18th 1995-



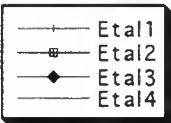
The variation of the sky horn temperature is in its normal range, the half of the annual cycle has been done



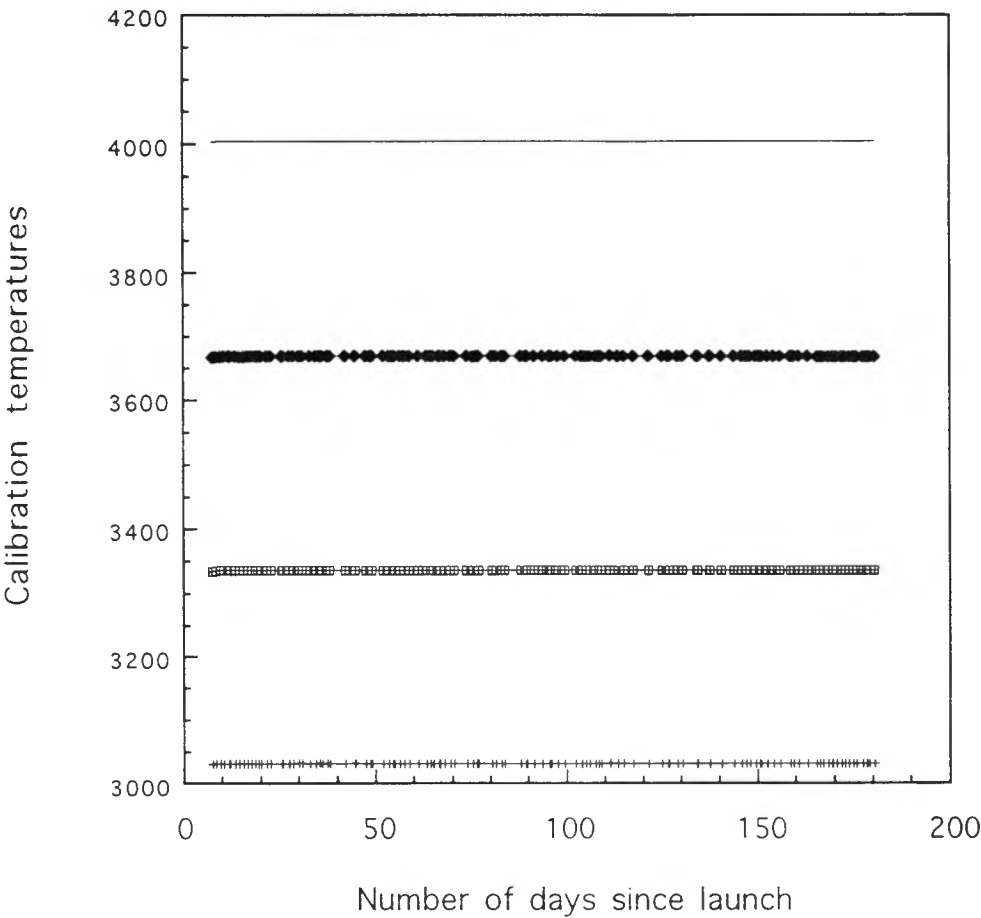
**Survey of the MWR-2 internal temperatures
necessary for the calibration -from launch to October 18th 1995-**



**The variation of the internal temperatures is in its normal range, the
half of the annual cycle has been done**



Survey of the MWR-2 calibration temperatures
(from launch to October 18th 1995)



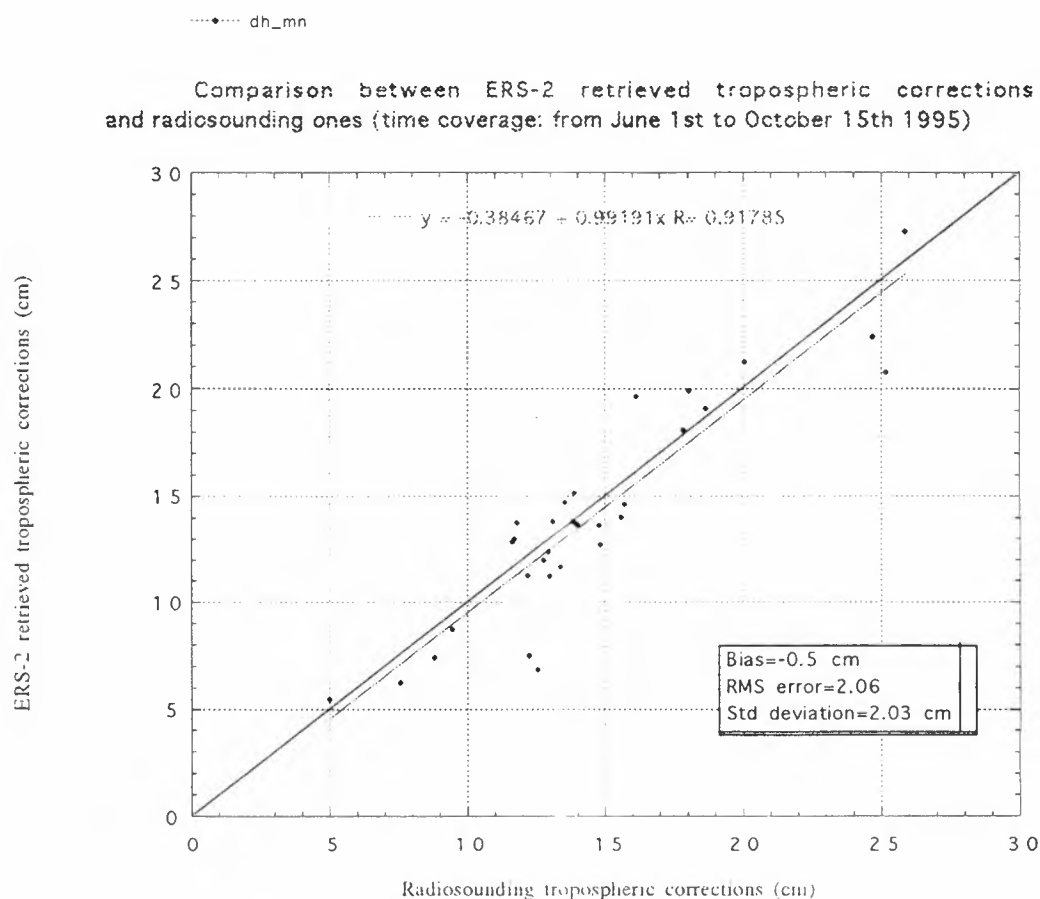
These temperatures serve to do the conversion between the values of the resistances measured and the temperatures (in K). They are perfectly constant.



Comparison of performances ERS-1/ERS-2

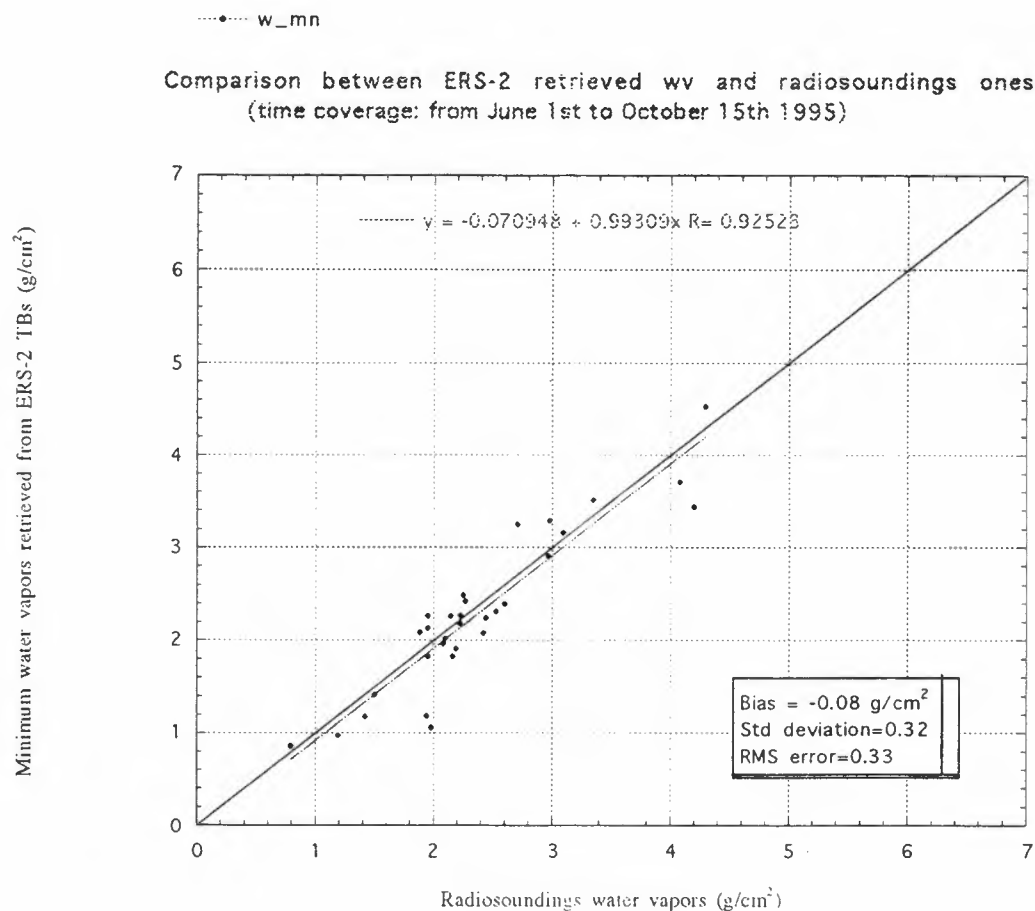
		ERS-1	ERS-2
	Time necessary for warming up	- Around one week after the switch on	- Around three days after switch on
	Time of all parameters stabilization	- One month	- 50 days
*warning	Discard between stabilized measured gain and ground estimated one, chanel A	- ≈ 0.2	- ≈ 0.4
*warning	Discard between stabilized measured gain and ground estimated one, chanel B	- ≈ 0.1 (after calibration correction)	- ≈ 0.2
	Residual temperatures (terms of bias)	- Chanel A: $\approx - 0.2$ - Chanel B: $\approx - 0.5$	- Chanel A: ≈ 0.1 - Chanel B: $\approx - 0.25$
	Hot load chanel A	- In a solar cycle: between 117 and 120	- Until now, stabilized on 116
	Cold load on chanel B	- In a solar cycle: between 2800 and 3000	- In a solar cycle: between 3100 and 3200
	Radiometric resolution	- In a solar cycle: between 0.4 and 0.5	- Until now, stabilized on 0.48
	Sky horn temperature	- In a solar cycle: between 290 and 295	- Around 290
	Electronic temperature	- In a solar cycle: between 305 and 308 (chanel A)	- Around 306.5

Comparison with radiosounding measurements



The coincident radiosoundings are not so much but show perfectly that the results of the MWR-2 are quite good (retrievals of the geophysical parameters using the brightness temperatures). The same result has been obtained with ATSR/M but three years after.....

Comparison with radiosounding measurements



The same result is obtained with the water vapors.

Conclusions

<TBW>

- **URA AND QLOPR VALIDATED**
 - Fine tuning of Wind and Wave Calibration values possible/ pending (TBDecided)
- **Final results with Quick-look data in December**
 - > SP-xxx Report



Further tasks of RA & MWR-2 CWG

- **Consolidate calibration results using OPR**

- This exercise is highly beneficial due to the precision of the off-line OPR compared to quick-look data.
- It will significantly increase of accuracy and robustness of ERS-2 RA Calibration due to:
 - » Use of calibrated ancillary data (MWR)
 - » precise orbit
 - » waveform re-tracking
 - » denser data set to stabilise the cross-calibration results
 - » robust estimate of E-M bias
- It will provide the final calibration values fit for a long term time series of ERS altimetric Geophysical Data Records.





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ERS-2

SAR Commissioning

Evert Attema
ESA/ESTEC/NWA

SAR Commissioning



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Contents of the Presentation

- The SAR Commissioning Working Group
- Tasks of the SARCWG
- Overview of Results
- Future Actions

SAR Commissioning



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The SAR Commissioning Working Group

– Experts from ESA and Industry, Fruitful

Collaboration

– External support

- ECMWF
- DNMI
- IFREMER
- TNO
- DRA

SAR Commissioning

Tasks of the SACWG (1)

- Production of Commissioning Plan
- Gain Setting for Image & Wave Modes
- Data Acquisition, Transponder & Corner Reflector Operations
- Organisation of External Support
- Data Analysis
 - Calibration Factors
 - Antenna Pattern Correction
 - Wave Mode Transfer Function
 - Geophysical Validation



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Tasks of the SACWG (2)

- Verification of
 - Stability
 - Dynamic Range
 - Interferometry
 - PAF Product Validation
- Recommendations
 - Method for the Calculation of the Calibration Constant
 - Antenna Pattern Interpolation Method
 - Data Release
 - Attitude Bias for Tandem Mission
 - Future Work

SAR Commissioning

Overview of Results

- Planning (ER-TN-ESA-GO-0404 April 1995)
- Gain Setting
- Calibration Constant, Antenna Pattern Correction, Wave Mode Transfer Function
- Geophysical Validation (Inputs from DNNMI)
- Verification of Stability & Dynamic Range
- Verification of Interferometry
- Release of Products
- Recommendations



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Future Actions

- More Data to Confirm Stability and Update Data Calibration if Required
 - Reduced SAR Data Set due to AMI Wind Mode Tests
- Production of SAR Commissioning Report

SAR Commissioning



ERS2 SAR Commissioning Review (26/27 October 1995)

Image Mode

J. Sánchez

Contents

- 1. Introduction
- 2. ERS-2 AMI On-Board Settings And SAR Stability
- 3. ERS2 SAR Image Mode Raw Data
 - 3.1 Raw Data Statistics
 - 3.2 Chirp Replica
 - 3.3 Noise
- 4. Off Line Products
 - 4.1 Calibration
 - 4.2 SLC & PRI
- 5. Conclusion

PRODUCT ID : 2013003 (class 2006) VI

(51.92 , 6.07) (52.11 , 4.70)

NORTH VECTC

ACQUISITION : 4-AUG-1995 10:35: 1.414

: corners

GENERATION : 9-AUG-1995 17:07:16.350

(52.81 , 6.43) (53.01 , 5.03)

ERS2 PRI REFERENCE IMAGE. FLEVOLAND. 4-AUG-1995. ALL CORRECTIONS APPLIED.

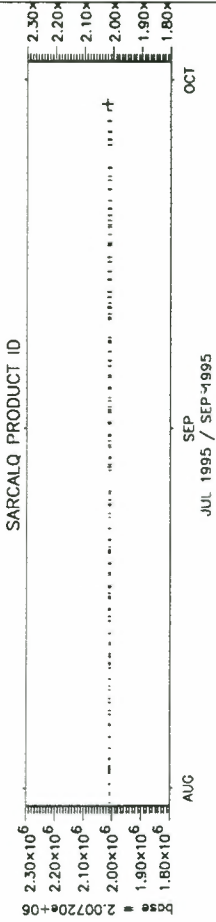
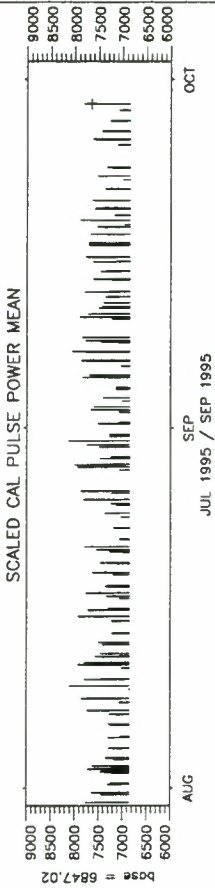
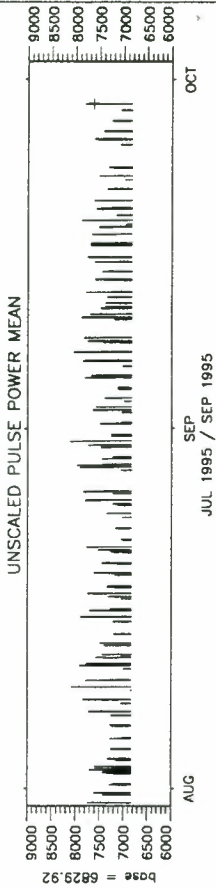
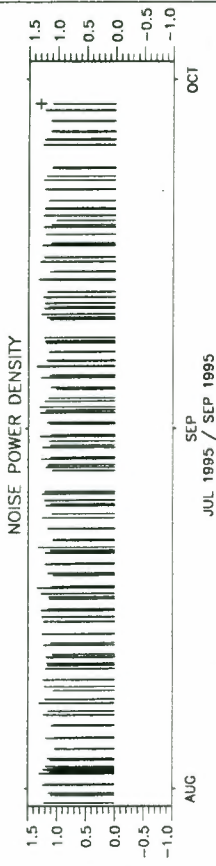


ERS2 AMI On-Board Settings and Stability

- The Receiver Attenuation has been increased 4 dB for ERS2 in order to avoid the Analogue to Digital Converter saturation effect existing for ERS1.
- The ERS2 SAR stability monitored since July the 14th up to September the 29th shows a stability comparable to ERS1.

Calibration Pulse Trends Analysis Report

Product type: UNID Product class: 0 Station: ALL Database: ERS-2				
Trends analysis from 14-JUL-1995 11:27:01 to 28-SEP-1995 21:28:12				
Number of values retrieved: 245				
Parameter name	trend detected	mean value	std dev	
noise power density	none	1.13387	0.131365	
sarcalq product id	positive	2.01490e+06	3847.79	
scaled cal pulse power mean	none	7391.21	268.737	
unscaled pulse power mean	none	7373.07	268.705	



ERS2 SAR Image Mode Raw Data

- Statistical Analysis of ERS2 SAR Image data has proven that the ERS2 AMI Receiver Analogue to Digital Converter has been optimised to work in the linear part of his Power Transfer Function.
- The Comparison with ERS1 has identified a shift of -250 Hzs for the ERS2 Doppler Frequency in near range.
- ERS2 Chirp Replicas are of good quality. The Power levels are lower than for ERS1, reflecting the decreasing in transmitted power due to the AMI anomaly.

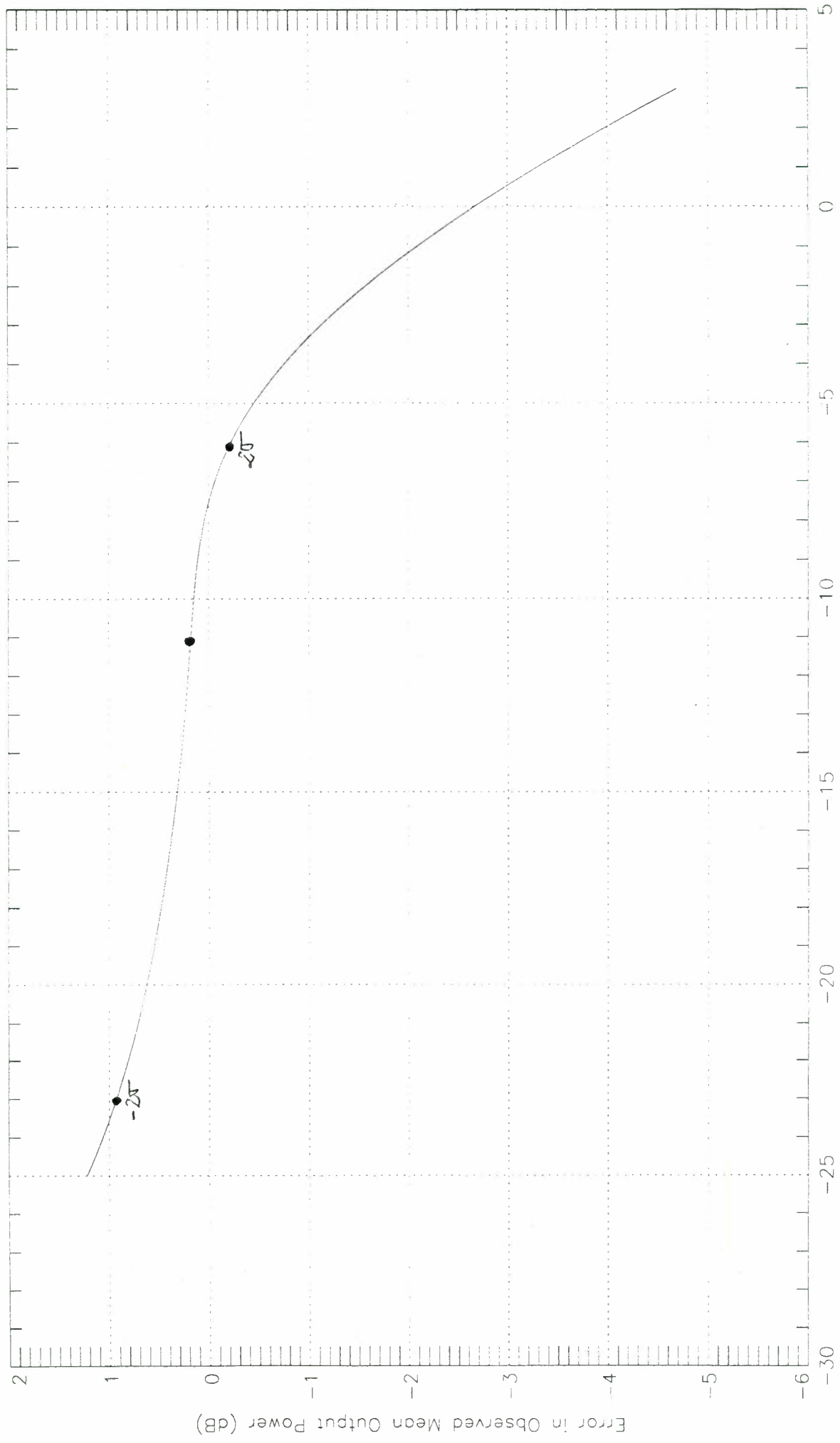
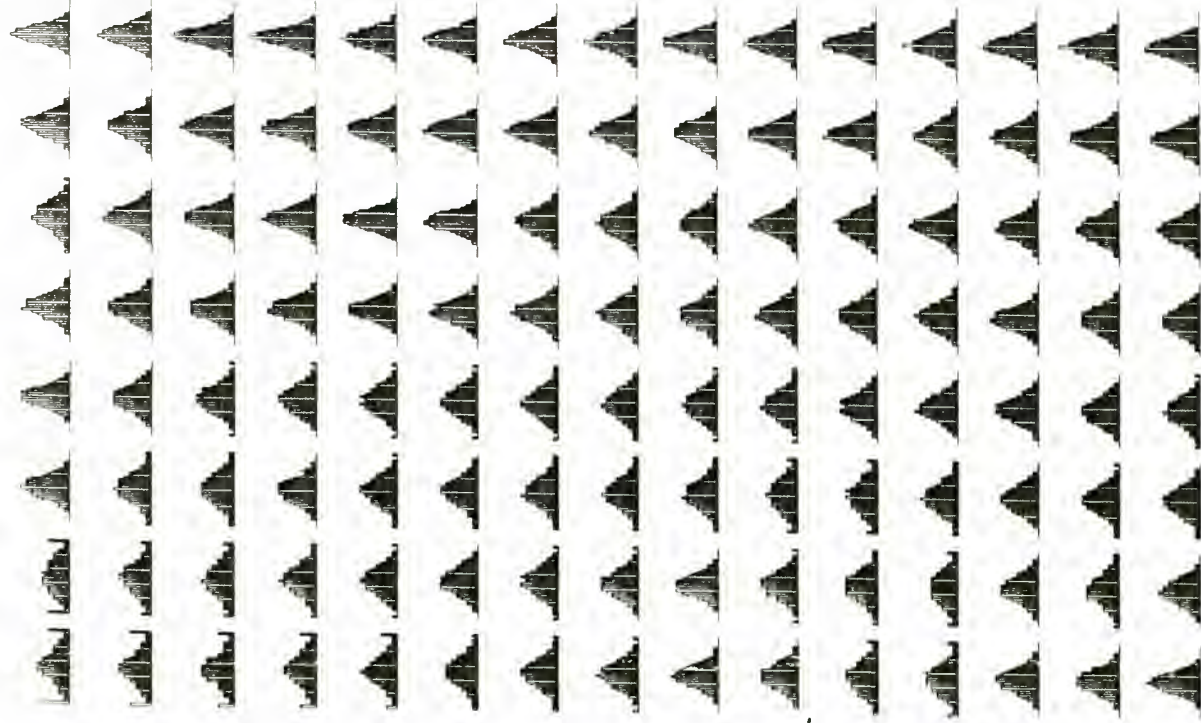
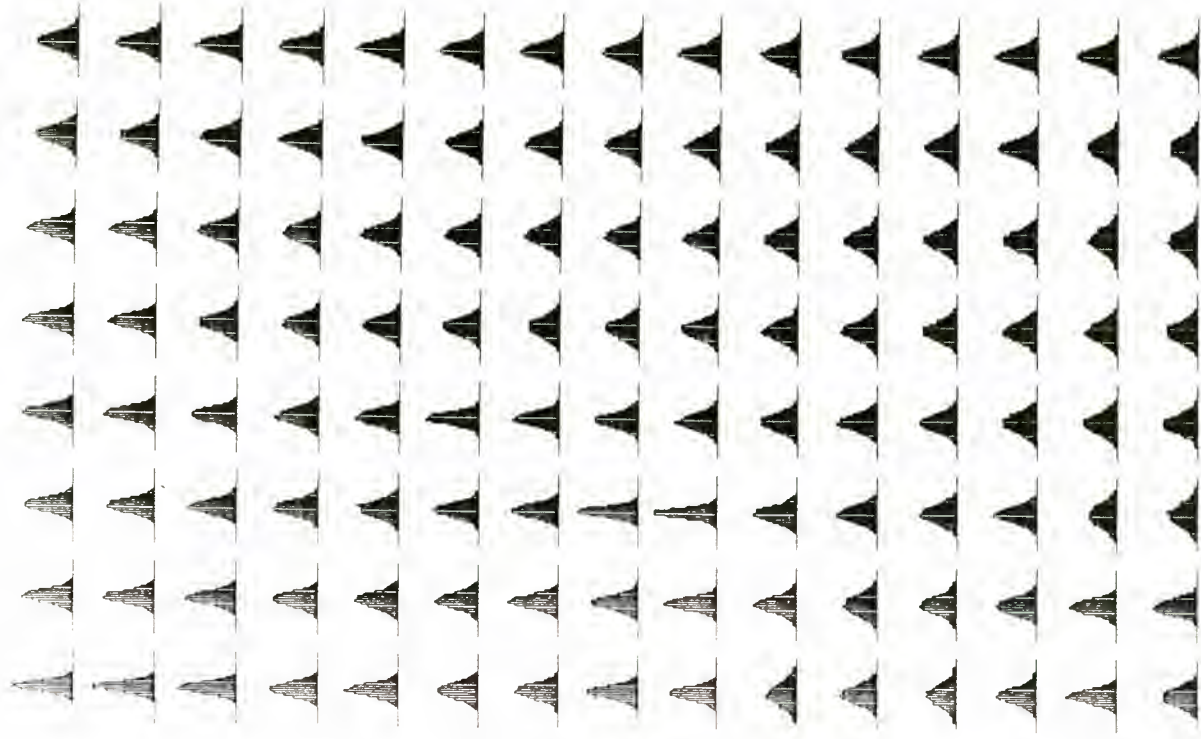


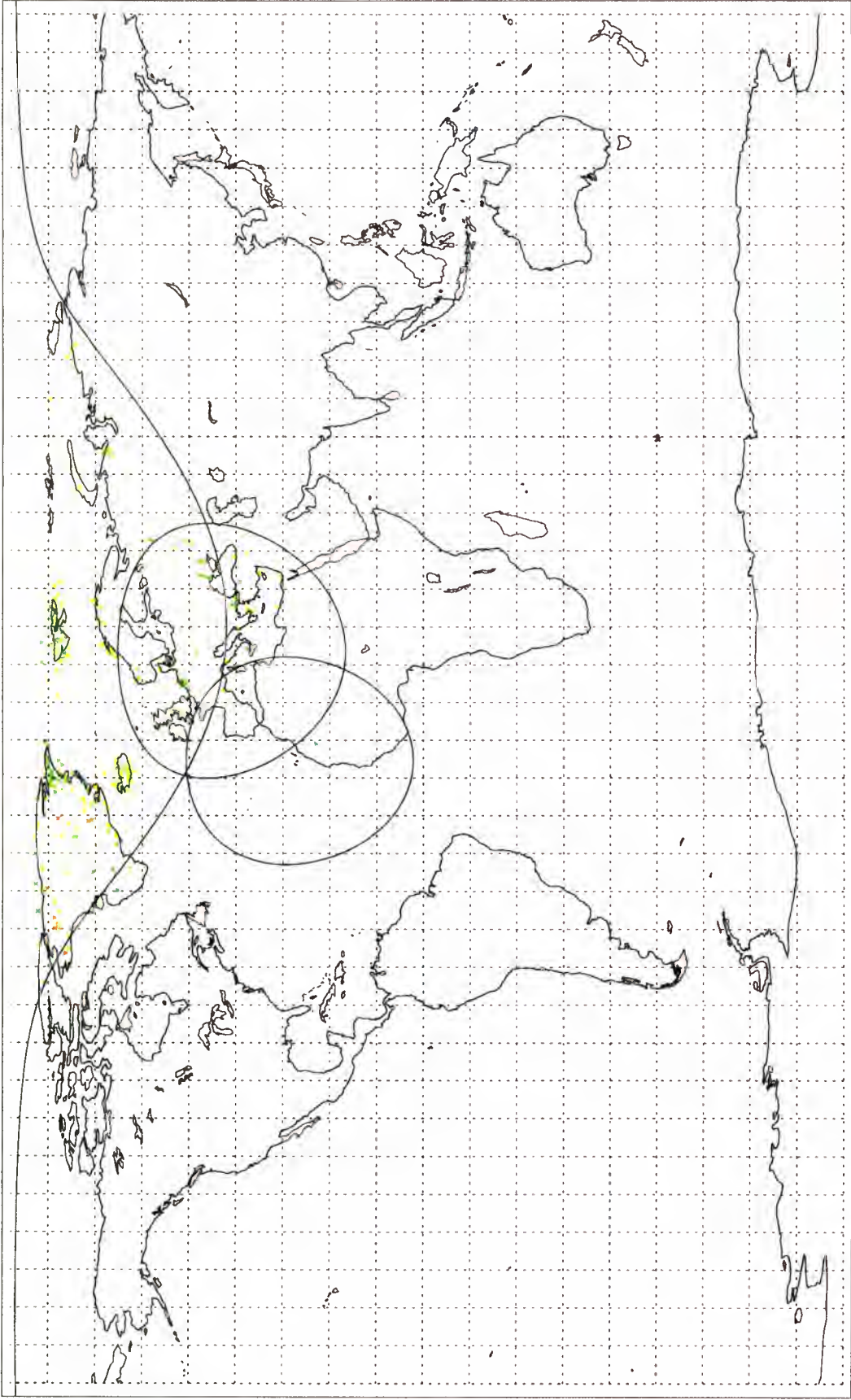
Figure 1. ERS-2 Power Transfer Function Image Mode. Ambient Temp. Chain A Thermal Vacuum Test



ERS-2.SAR.PRI Histograms of ADC Quantisation Levels for
Flevoland (Orbit 885, Frame 1053, 21st June 1995)
Maximum Vertical Scale = 10%



ERS-2.SAR.PRI Histograms of ADC Quantisation Levels for
Flevoland (Orbit 1508, Frame 2547, 4th August 1995)
Maximum Vertical Scale = 10%

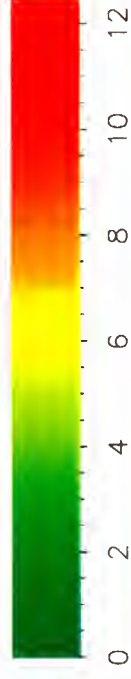


Date: 16-Oct-1995

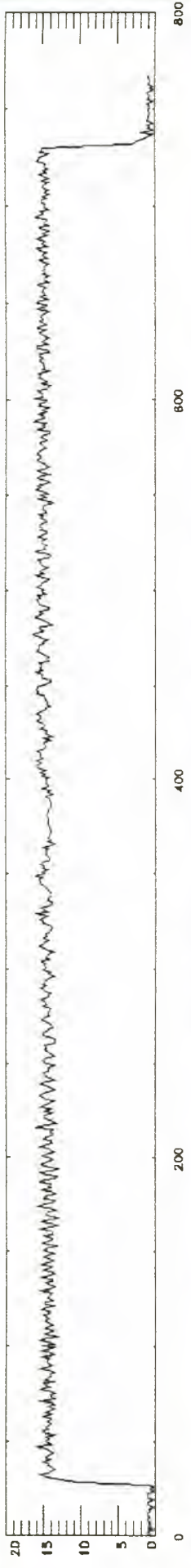
Title: ERS2 SAR (Image Mode) | Channel Std Dev

Author: Jose Ignacio Sanchez (ESRIN/DEX/EM)

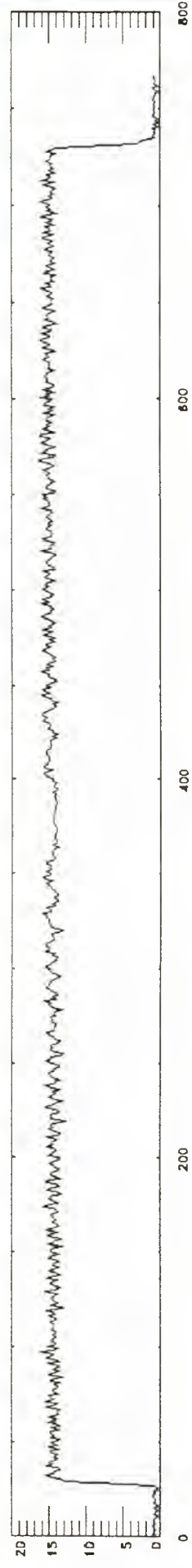
color scale



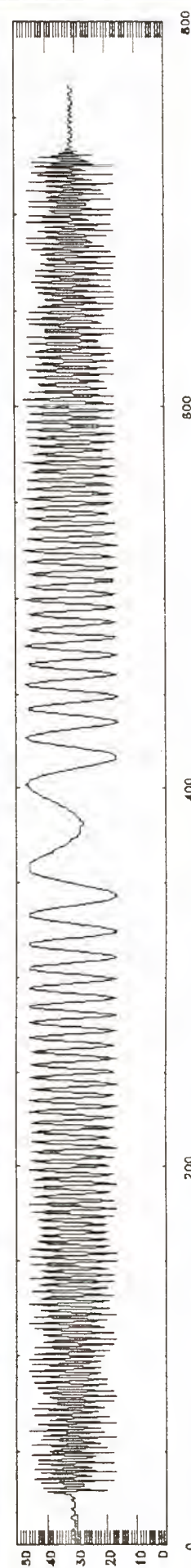
Sample Two



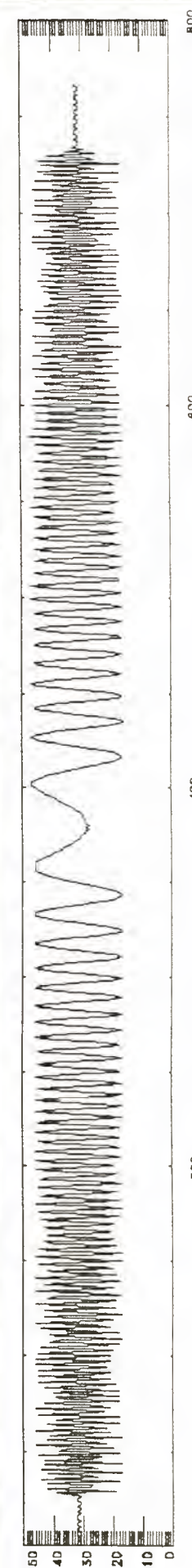
Sample One



Sample Two



Sample One



ERS2 SAR (Image Mode) receiver energy levels (ERS1 levels in the same period in brackets)

- ERS2 SAR Mean Noise Power: 0.53 dB (2.79 dB)
- ERS2 SAR Mean Replica Power: 51.92 dB (52.9dB)
- ERS2 SAR Mean Cal. Pulse Power: 38.68 dB (38.59 dB)

ERS2 Noise Equivalent σ^0 :

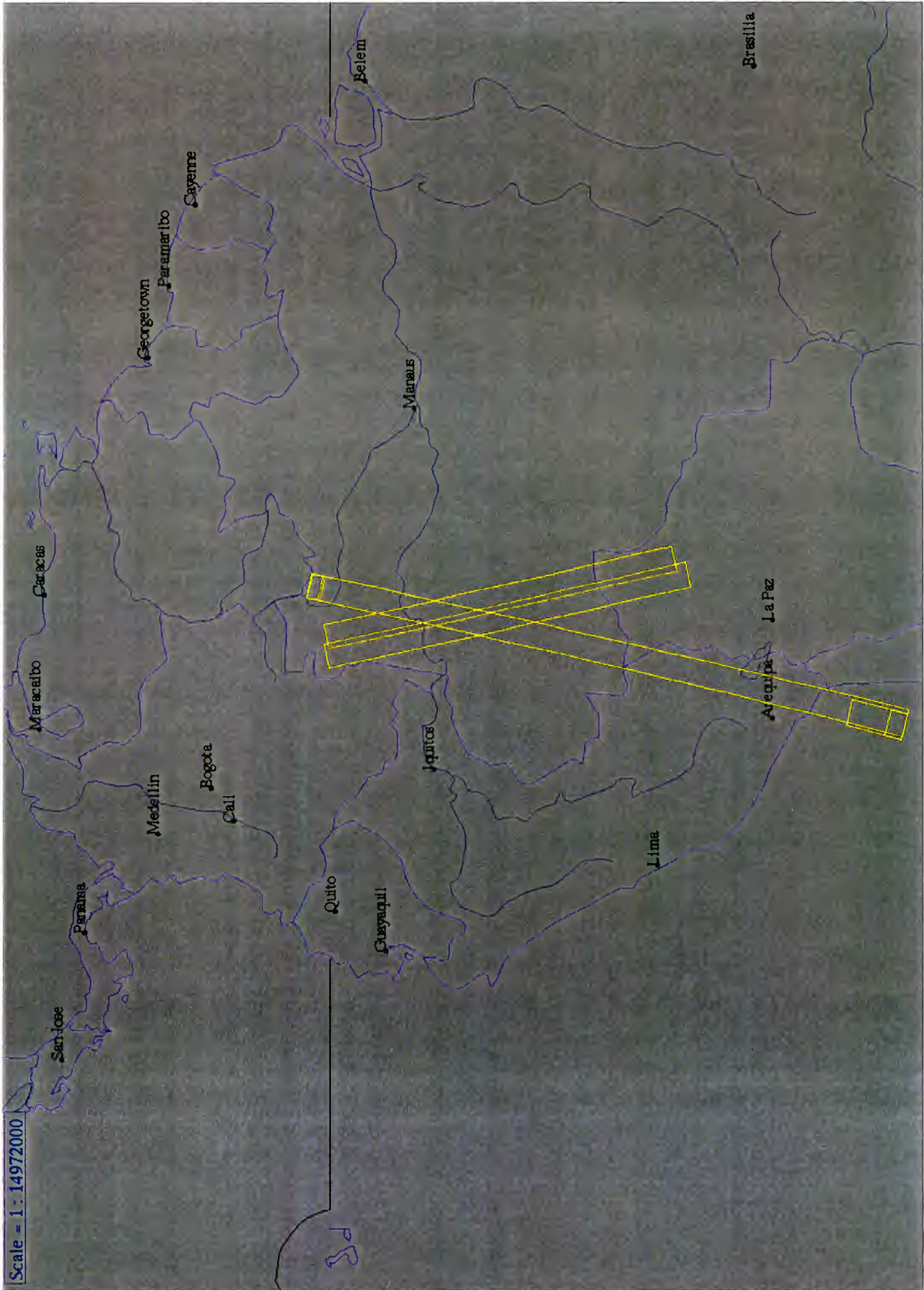
-24.8 dB (-25.5 dB)

ERS2 Doppler Shift respect ERS1:

-250 Hz

ERS2 SAR Image Mode Off Line Products & Calibration

- The ERS2 Range Antenna Pattern has been calculated using SAR data acquired over the Brazilian tropical forest and used to correct ERS2 SAR Image data.
- The ERS2 Range Antenna Pattern is almost identical to the ERS1 Range Antenna Pattern.
- SLC and PRI products are of good quality, comparable to ERS1. The Calibration Constants have been calculated using the transponders deployed in Flevoland.



Scale = 1 : 14972000

PRODUCT ID : 2024903 (class 2006) VI

(-5.40 , 292.74) (-5.20 , 291.89)

NORTH VECTC

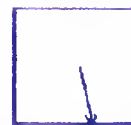
ACQUISITION : 18-JUL-1995 14:46:52.004

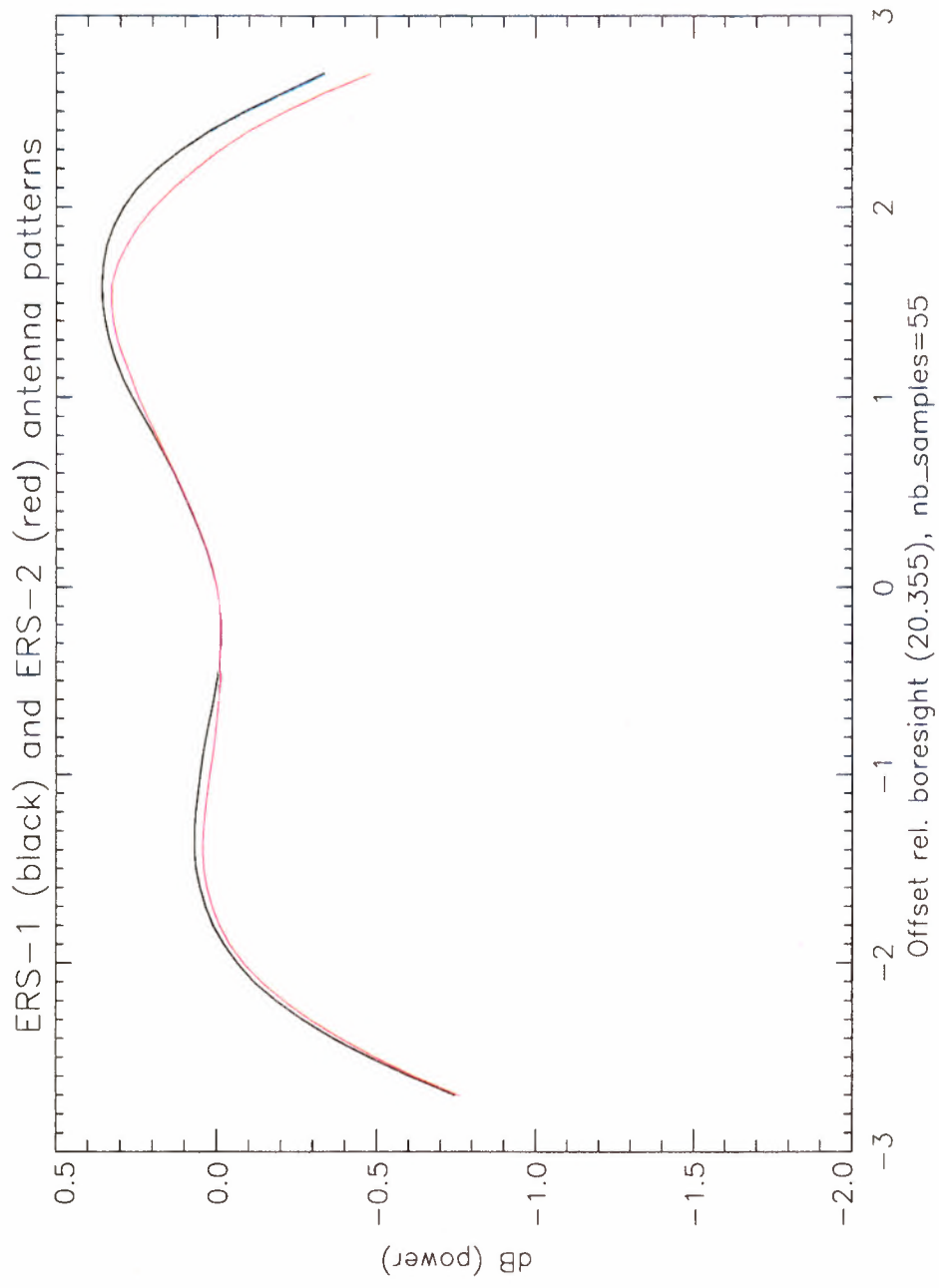
: corners

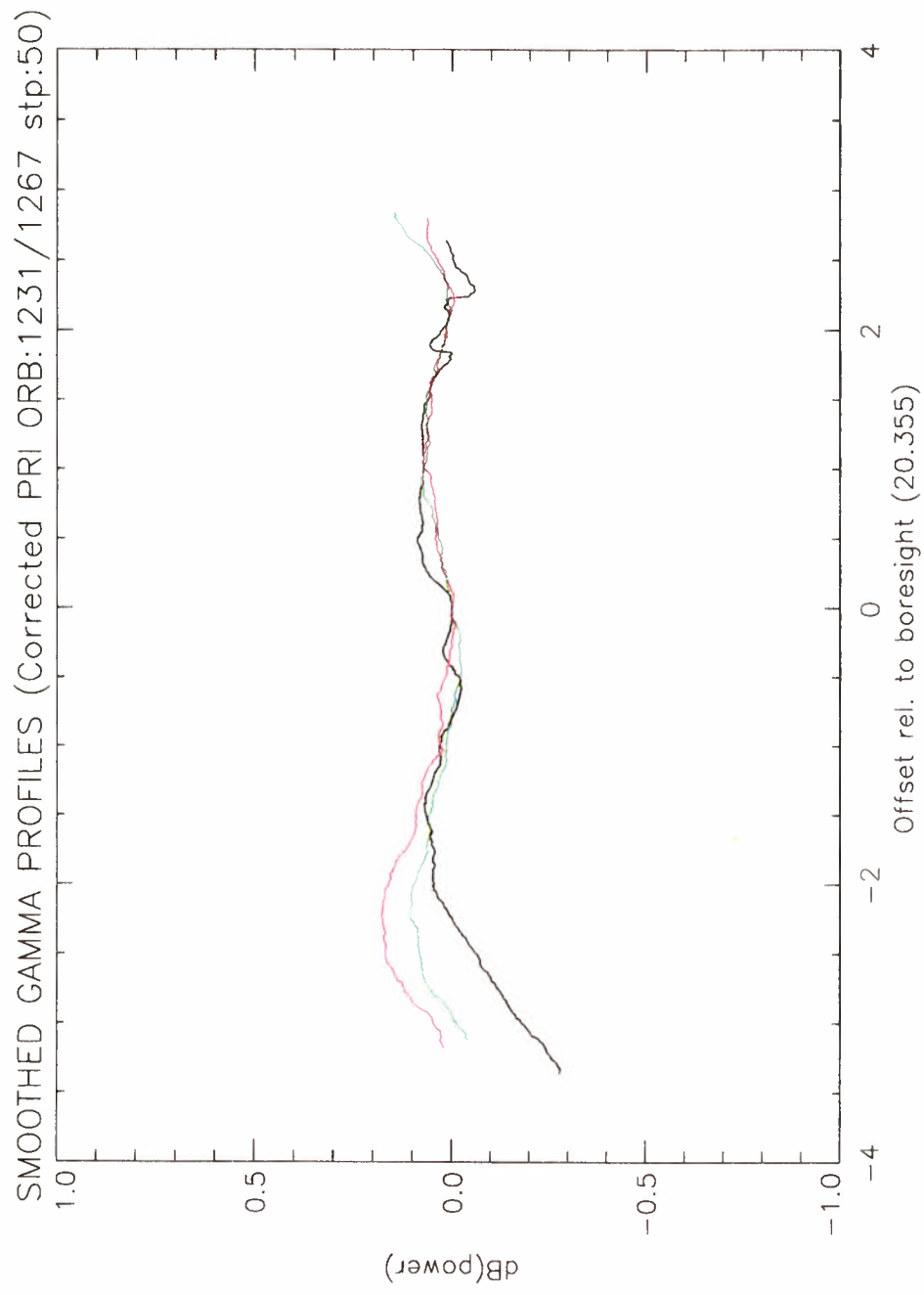
GENERATION : 14-SEP-1995 08:34:50.280

(-4.49 , 292.94) (-4.29 , 292.09)

ERS-2 PRI image acquired over the Amazonian rainforest







ERS2 SAR Image Mode Quality Characteristics (Reference image, August the 4th 1995)

- Visual inspection identified no artifacts or problems
- Location Accuracy

Range	256 m
Azimuth	52 m

PRI

- Point Target Analysis

Range resolution	23.5 m
Azimuth resolution	21.7 m
Range PSLR	-18.5 dB
Azimuth PSLR	-15 dB
ISLR	-9.3 dB

- Distributed Target Analysis

Radiometric resolution	2 dB
------------------------	------

$K = 59.75 \text{ dB}$

SLC

- Point Target Analysis

Range resolution	9.7 m
Azimuth resolution	5.4 m
Range PSLR	-21.6 dB
Azimuth PSLR	-27.3 dB
ISLR	-12.6 dB

- Distributed Target Analysis

Radiometric resolution	3.1 dB
------------------------	--------

$K = 49.7 \text{ dB}$

ERS2 SAR Image Mode Noise Equivalent σ^0

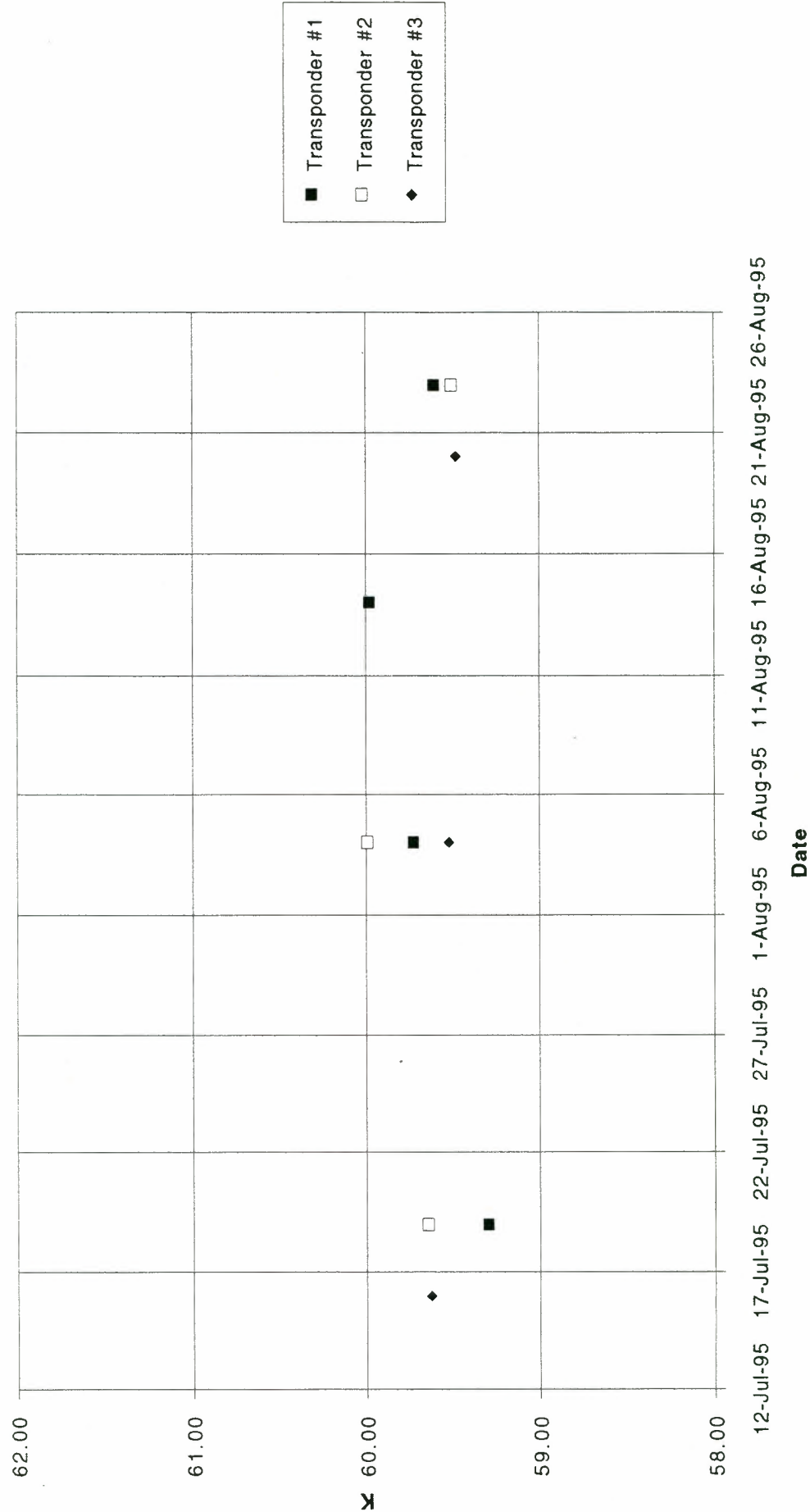
-24.8 dB

(-25.5 dB for ERS1)

ERS2 SAR Image Mode Azimuth Ambiguity Ratio

-27.14 dB

ERS2 PRI VMP Calibration Constant (59.75 dB).



Conclusion

- The ERS2 SAR On-Board Gain Settings, in Image Mode, have been optimised respect to the ERS1 SAR.
- The ERS2 SAR Products have a good quality, similar to ERS1 SAR products
- The ERS2 SAR radiometric stability measured during the Commissioning Phase is as good as the ERS1 SAR radiometric stability.



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estec

ERS-2 SAR COMMISSIONING

European space research
and technology centre

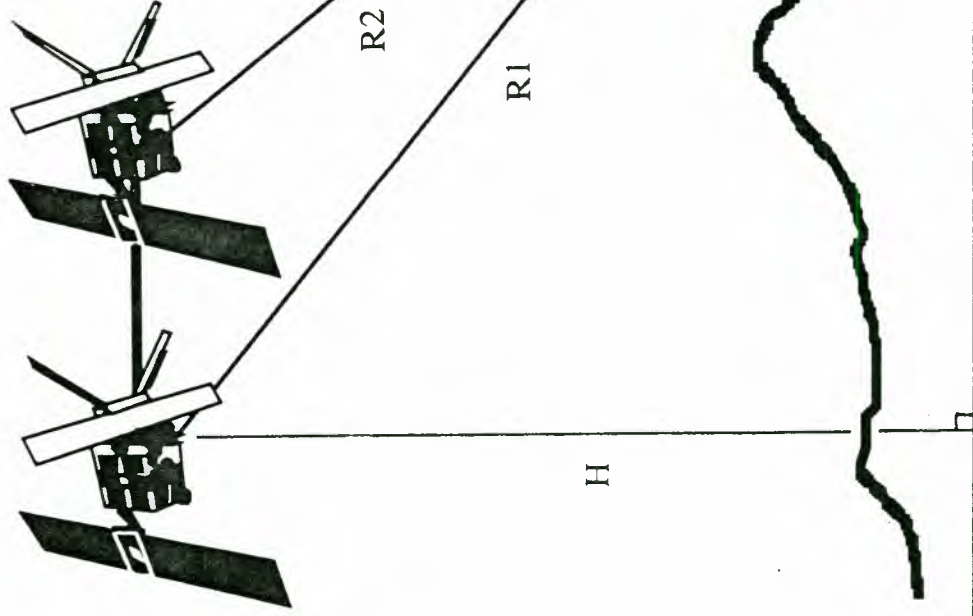
ERS-2 / ERS-1 SAR INTERFEROMETRY

Christopher H Buck

ESA/ESTEC - XRI

Interferometric SAR Concept

ERS-1 <- Baseline -> ERS-2



The two satellites are separated spatially by the "Baseline"

The altitude "H" can be determined from the orbit parameters.

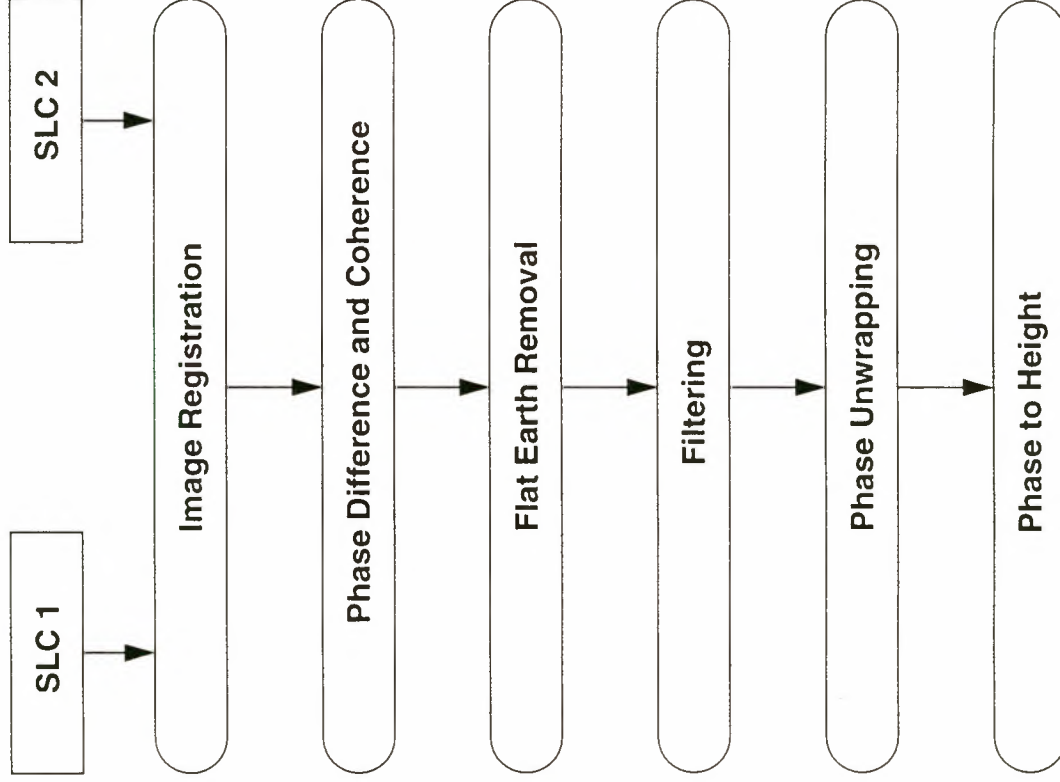
Due to the different path lengths of R1 and R2 the phase of the return signal at ERS-1 and ERS-2 will be different. Using this difference, the baseline and altitude of the satellite it is possible through trigonometry to calculate the height of the target "h".

Subtracting the phase information of one image from the other produces a Phase Difference Image or Interferogram.

From this it is possible to produce a model of the terrain.

Mean Sea Level

Interferometric SAR Processor at ESTEC



Input is two Single Look Complex images where care has been taken to preserve the phase information

The two images are registered, starting from identifiable features, to within 1/32 pixel

By subtracting the phase the interferogram is generated. The coherence map gives an indication of the quality

The interferogram is remixed to remove the fringes associated with the flat terrain response

Filtering is performed to reduce noise

The modulo 2π of the image is removed by adding up the phase across the fringes

Taking account of the geometry (baseline, altitude) a Digital Elevation Map DEM of the scene is generated



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estec

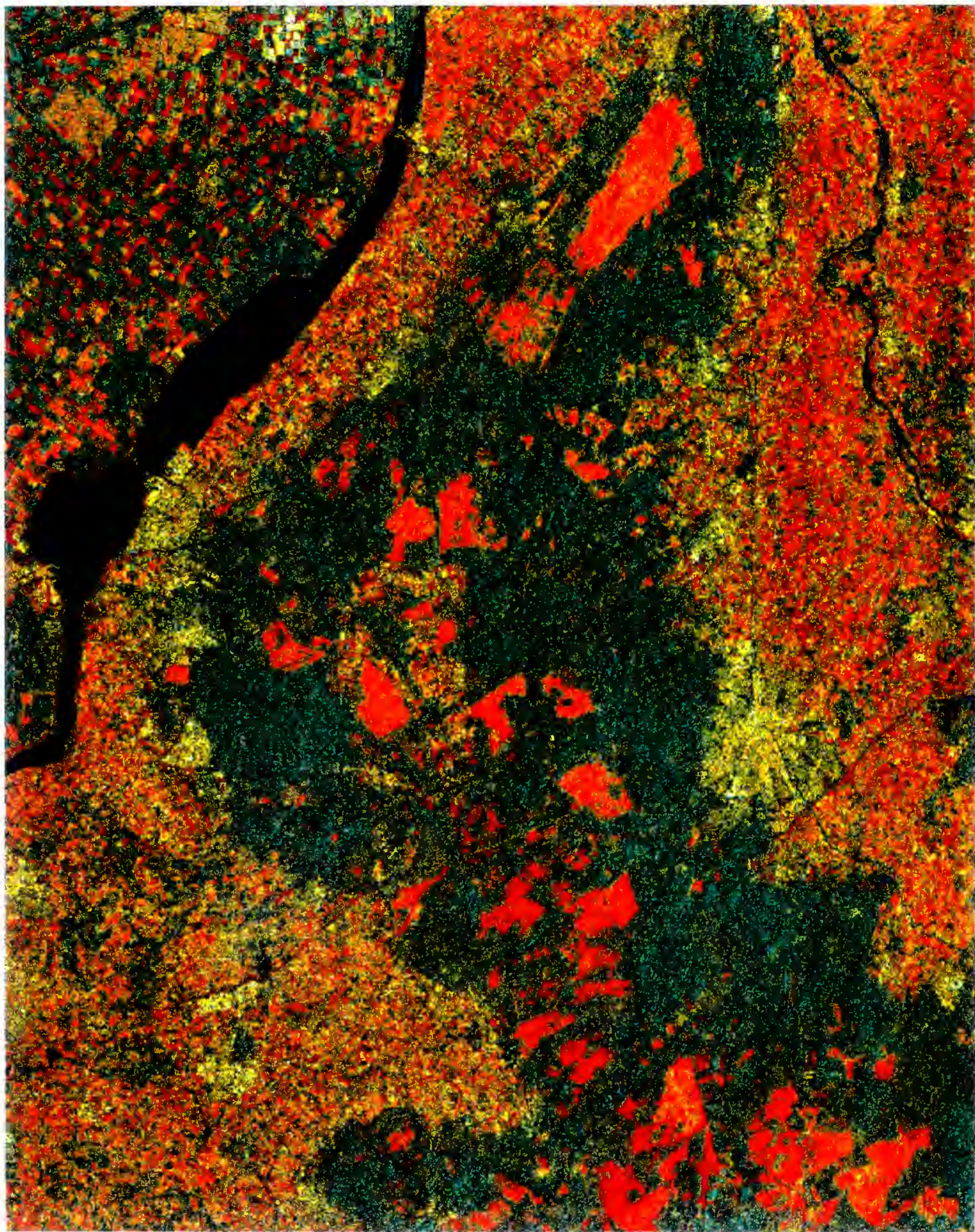
ERS-2 / ERS-1 SAR Interferometry

european space research
and technology centre

Test Site Flevoland - Flat Terrain

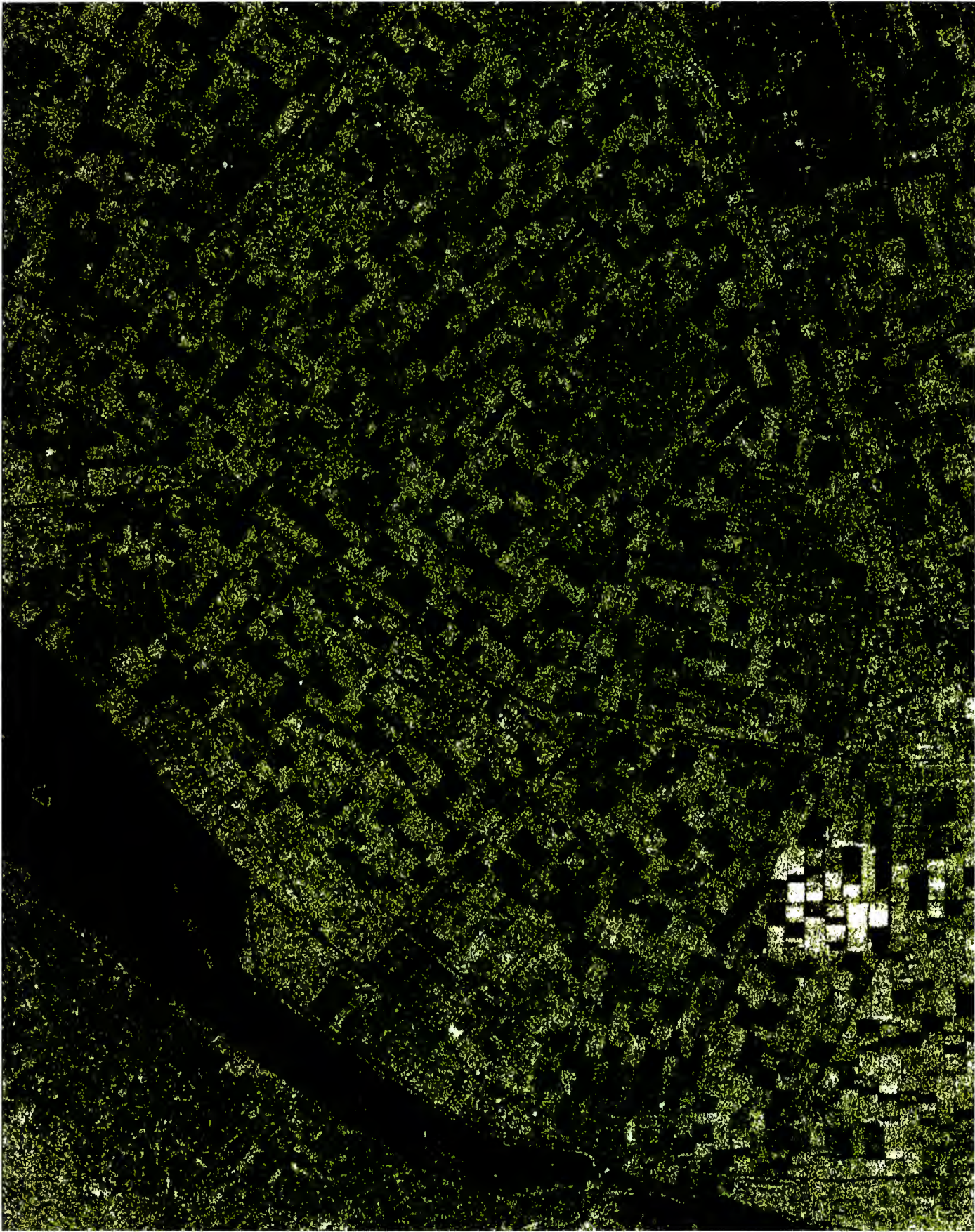
Satellite	ERS-1	ERS-2
Date	29-06-96	30-06-95
First coefficient of Doppler Centroid. (Corresponds to the pointing of the antenna)	510.0 Hz/sec	298.5 Hz/sec
Difference in Doppler (i.e. pointing difference between ERS-1 & 2)	212.5 Hz/sec	
Baseline (spatial distance between ERS-1 & 2)	~160m	

ERS-1/ERS-2 29 & 30 June '95
Flevoland & Hoge Veluwe (NL)



Red = coherence
Green = average intensity
Blue = difference in intensity

ERS-2 SINGLE LOOK COMPLEX INTENSITY IMAGE → I LOOK IN RANGE, S LOOKS IN AZIMUTH (NL) 30 JUNE 98

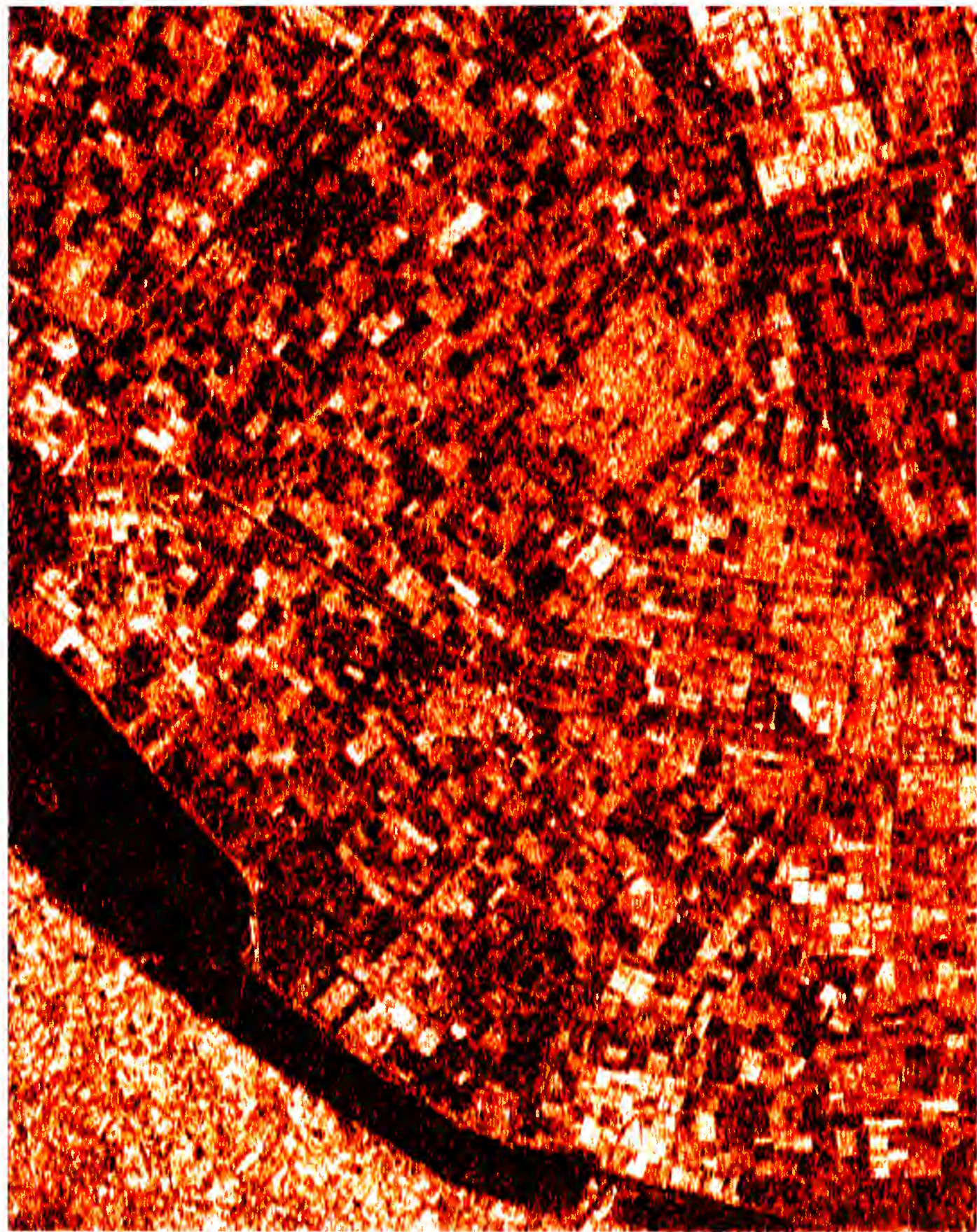


4000 Pixels AZIMUTH →

CH BUCK ESTEC / XRI

1000 Pixels RANGE →

ERS-1/ERS-2 MODULUS OF COHERENCE IMAGE FLEVOLAND (NL) 21 & 20 JUNE 19

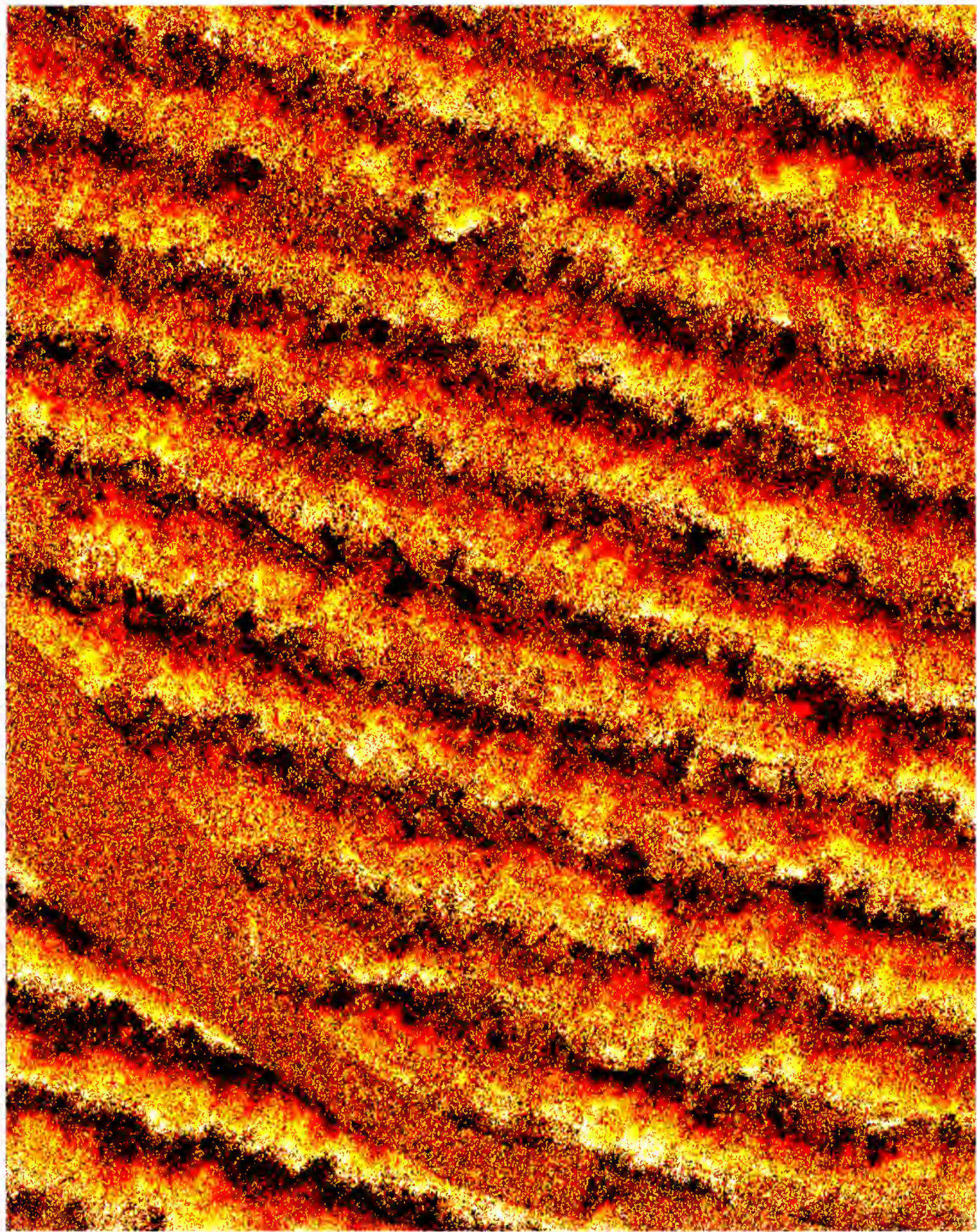


→ AZIMUTH

CH BUCK ESTEC/XRI

RANGE →

ERS-1/ERS-2 PHASE DIFFERENCE IMAGE CLEVELAND (NL) 29 & 30 JUNE 93

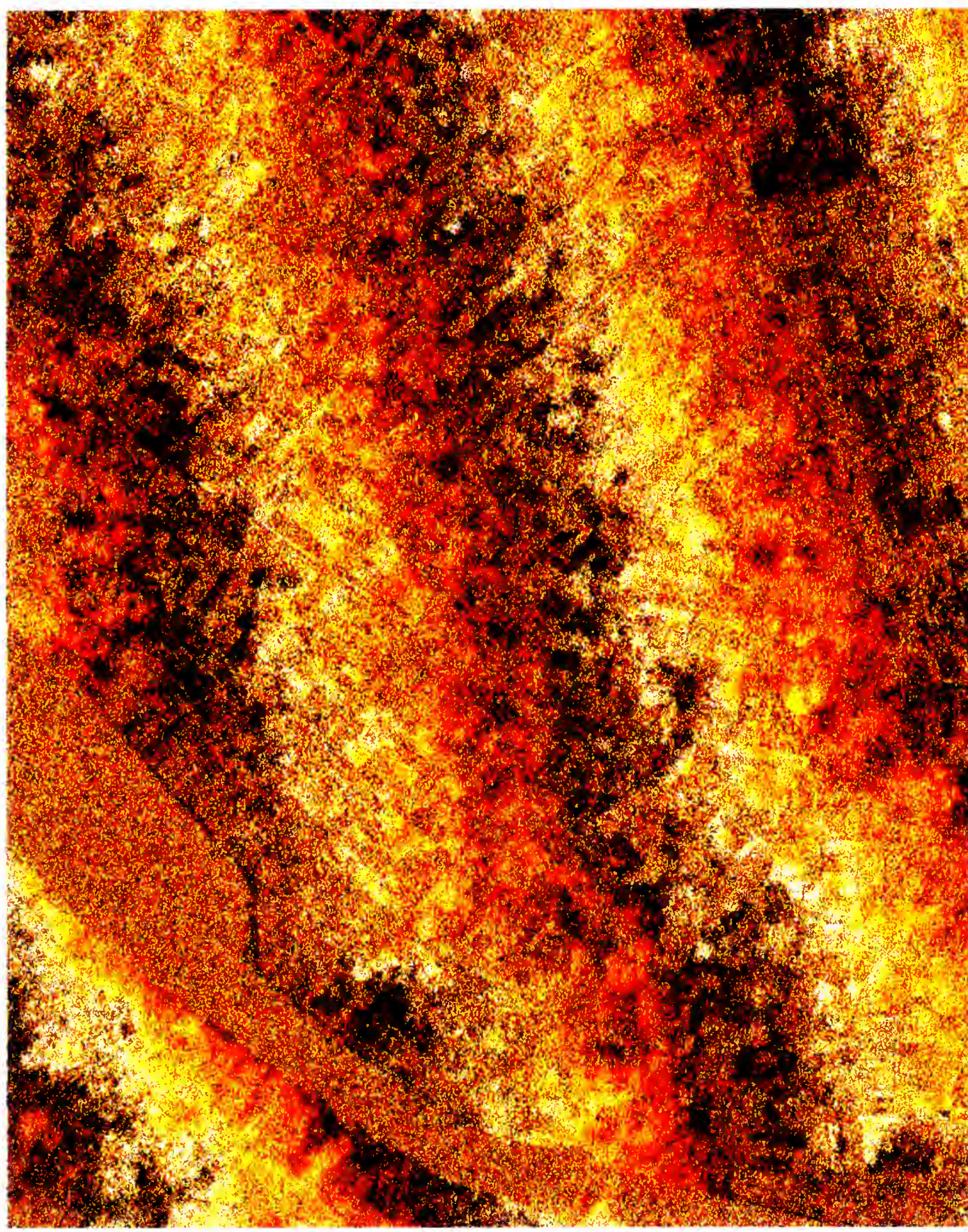


→ AZIMUTH

CH BUCK ESTEC / XRI

→ RANGE

ERS-1/ERS-2 BASEBAND (FLAT EARTH REMOVED) PHASE DIFFERENCE IMAGE 29 & 30 JUNE '95

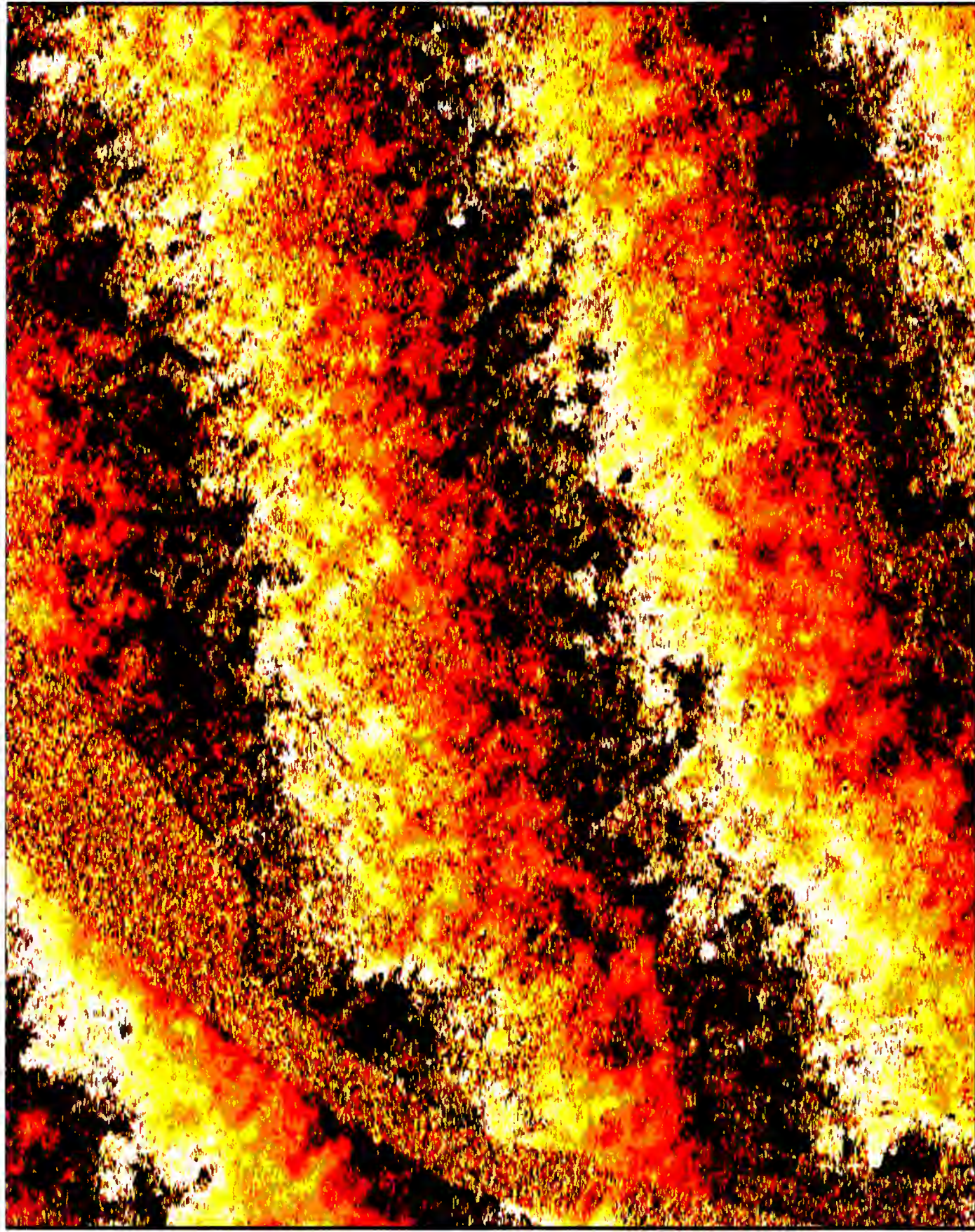


→ AZIMUTH

C H BUCK ESTEC/XRI

RANGE →

ERS-1/ERS-2 FILTERED ISAREBAND IMAGE (5x11 BOX CAR) 29830 JUNE 9'S

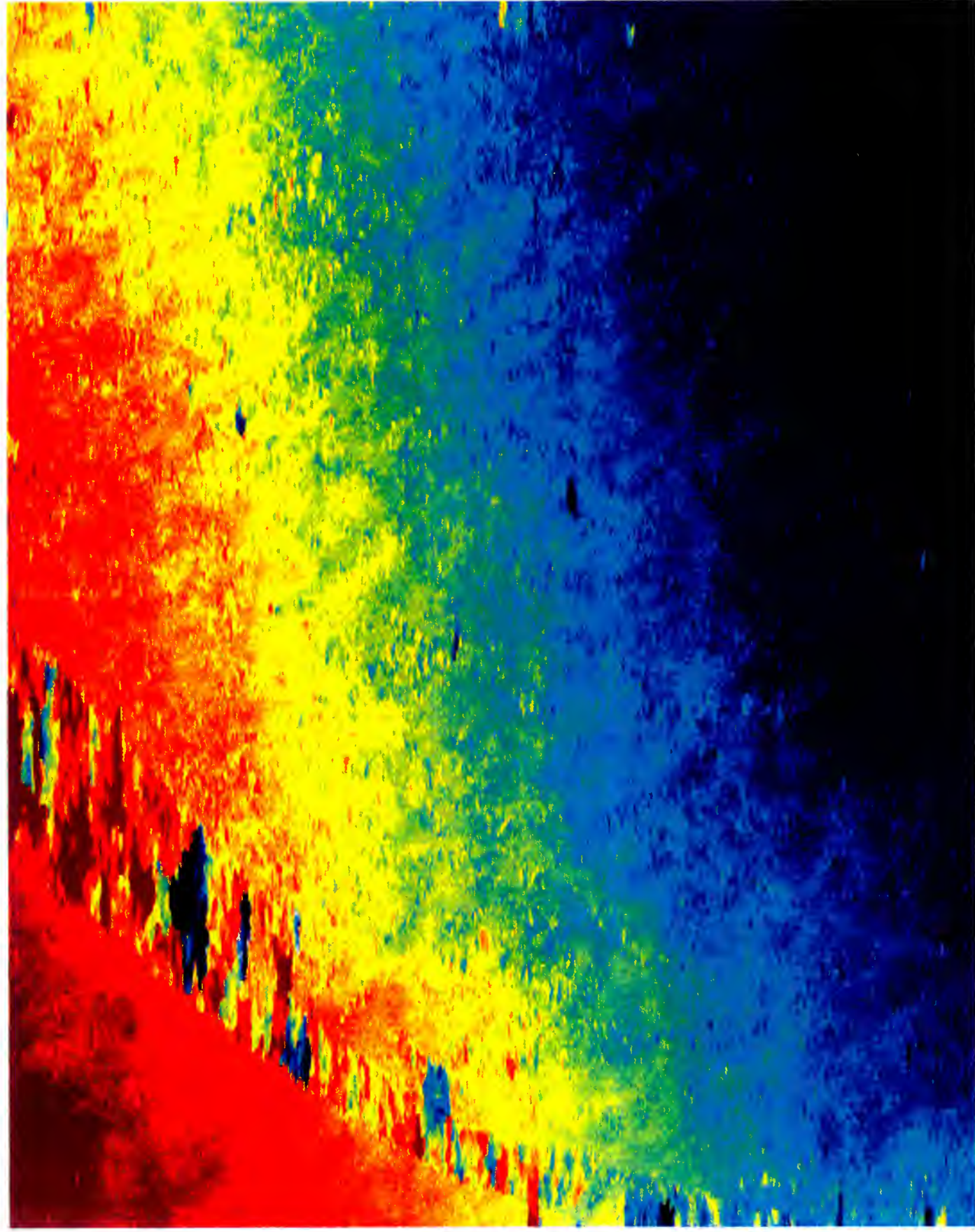


→ AZIMUTH

CHUCK ESTEC/XRI

PAIRS →

ERS-1 / ERS-2 UNWRAPPED 1-HASE 1-DIFFERENCE IMAGE CLEVELAND (NL) 29 & 30 JUNE 95

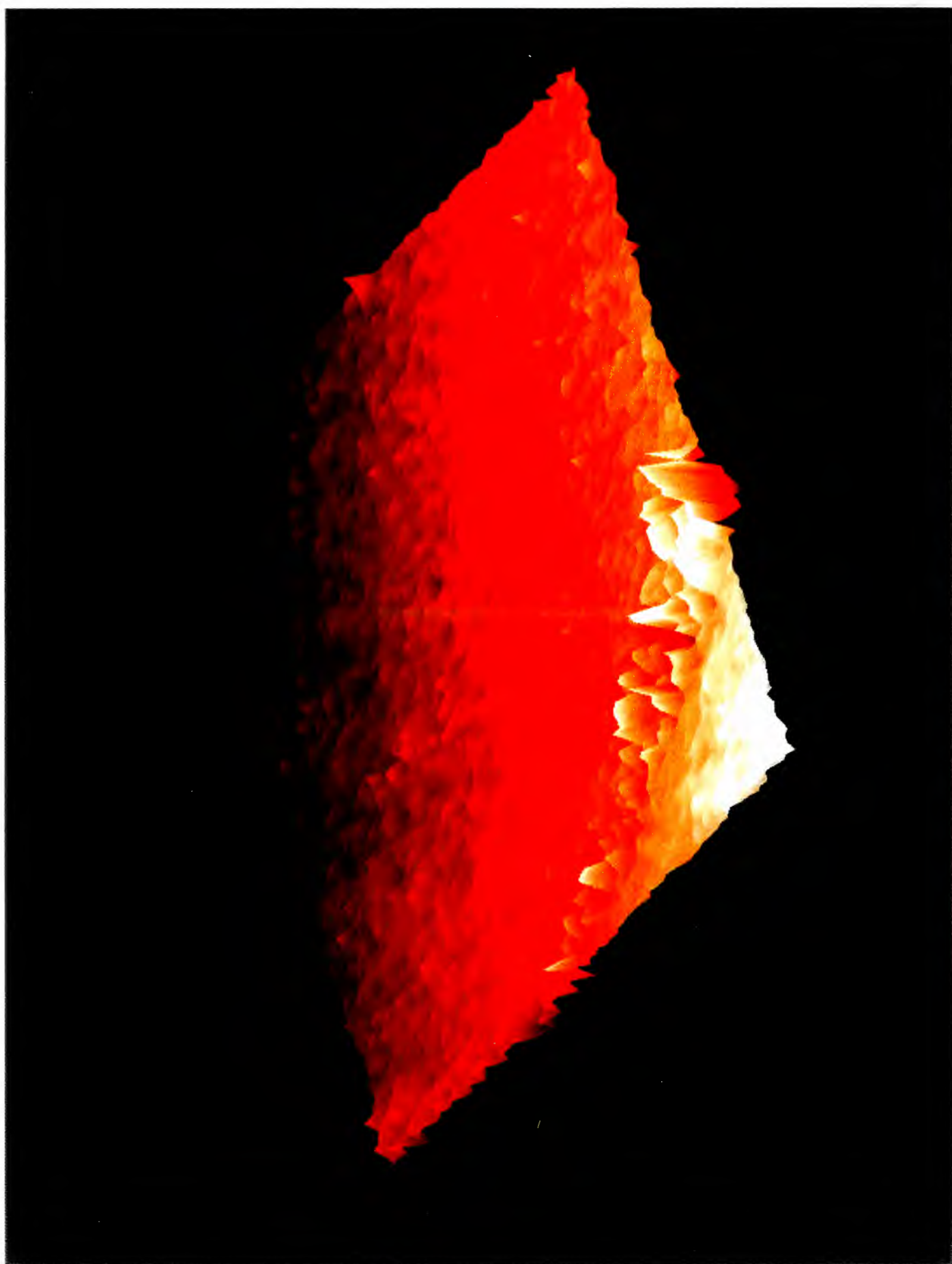


→ AZIMUTH

C H BUCK ESTEC / XRI

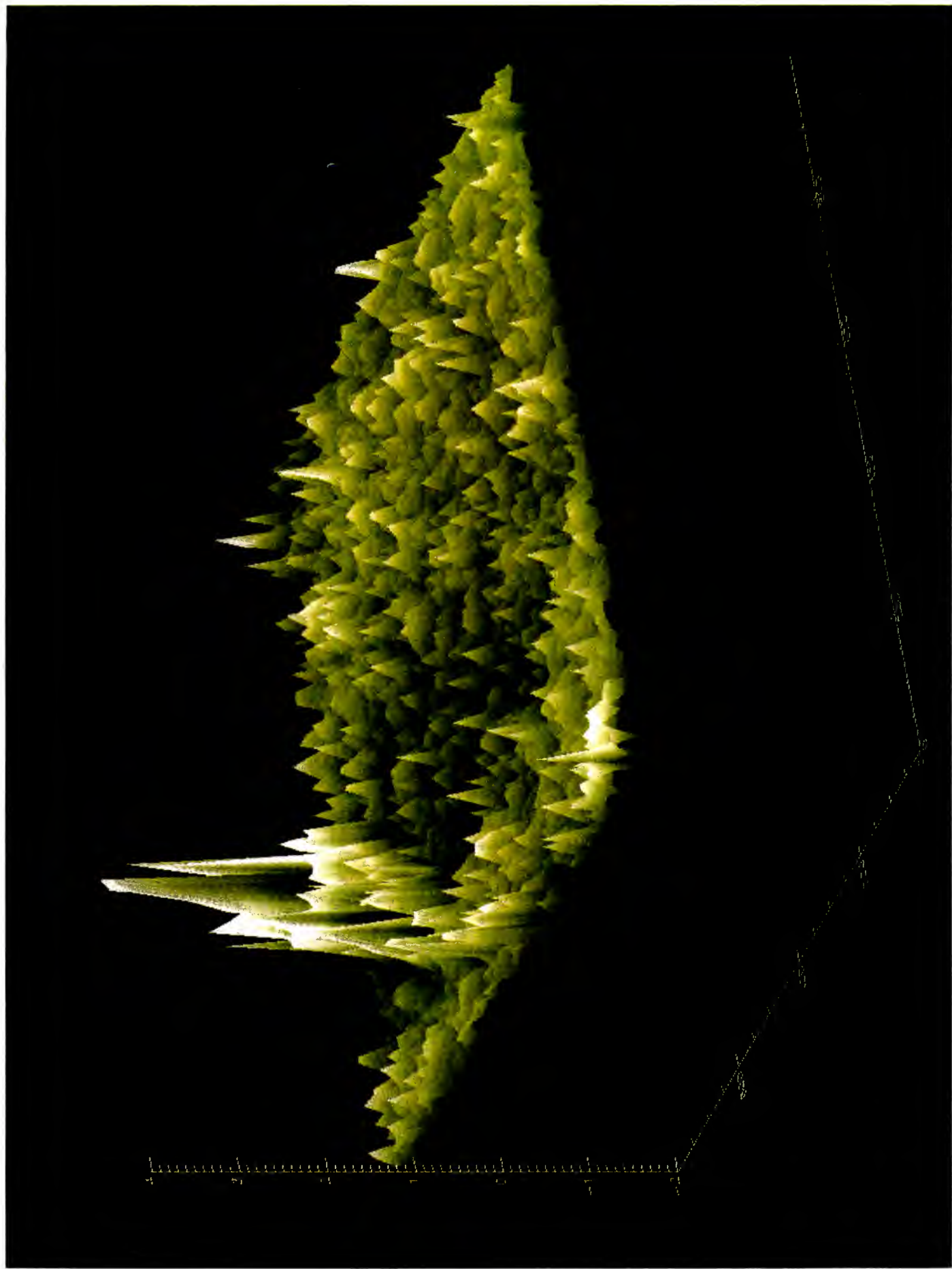
RANGE →

ERS-1/ERS-2 UNWRAPPED PHASE PROJECTION CLEVELAND (NC) 29 & 30 JUNE 95

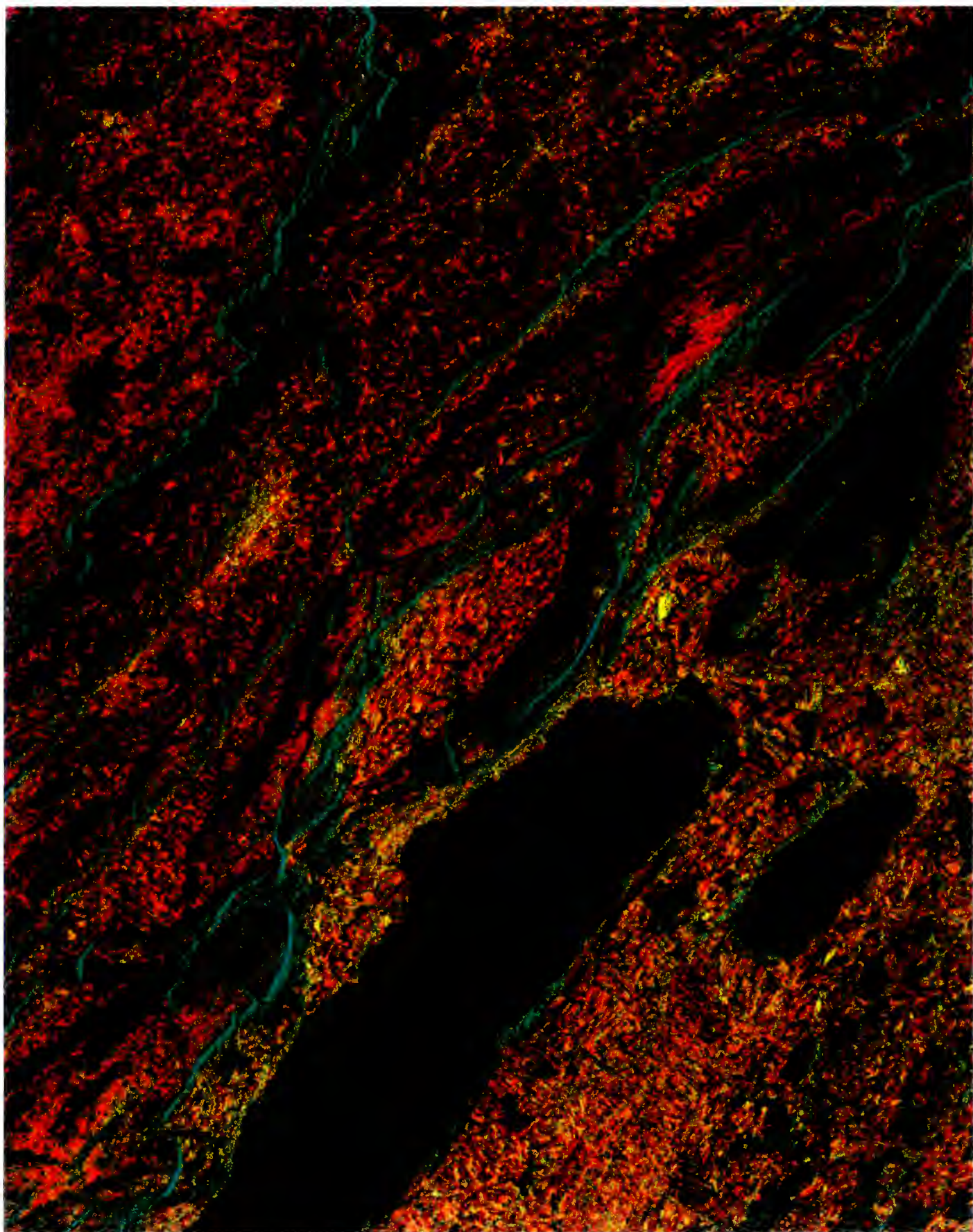


CH BULL FSTER 1x01

ERS-1/ERS-2 UNWRAPPED PHASE PROJECTION FLEVOLAND (NL) 29 & 30 JUNE 95



ERS-1/ERS-2 COMPOSITE IMAGE NEUCHÂTEL (CH) 5 & 6 JULY '95



CH BUCK ESTEC / XRI

RED = COHERENCE
GREEN = AVERAGE INTENSITY
BLUE = DIFFERENCE IN INTENSITY



esa
estec

ERS-2 SAR COMMISSIONING

European space research
and technology centre

ERS-2 FAST DELIVERY PRODUCT (UI16) CALIBRATION

Christopher H Buck

ESA/ESTEC - XRI



ERS-2 Fast Delivery Product (UI16)

European space research
and technology centre

CALIBRATION RESULTS

Calibration Factor Estimation from Corner Reflectors deployed in Flevoland

(Calibration RCS values used: FEL-TNO 40.54 dBm2 / JPL 44.14 dBm2)

Satellite	ERS-1	ERS-2	ERS-2	ERS-1	ERS-2
Target / Date	13-08-95	14-08-95	30-08-95	17-09-95	18-09-95
1 JPL	44.45	43.91	44.67	43.22	42.88
2 TNO	40.19	40.18	40.32	39.91	39.84
3 JPL	45.15	45.81	45.82	44.99	46.42
4 TNO	39.73	39.67	39.61	38.49	38.79
5 TNO	39.62	39.59	39.24	41.84	41.04
6 JPL	42.75	42.34	41.49	*	*
7 TNO	39.78	40.20	40.49	40.96	40.43
8 JPL	45.69	45.26	44.46	45.20	45.21

Absolute Calibration Factor at Mid Swath (23.00 deg)

Satellite	13/14-08-95	29/30-08-95	17/18-09-95	Average	Difference
ERS-1	73.49	**	73.65	73.57	
ERS-2	69.64	70.05	69.83	69.84	3.73

* missing reflector, ** processor problem

SAR Wave Mode Commissioning

Guy Brooker, Thomas Mayer, Bertyl Duesmann

☐ WAVE MODE INTRODUCTION

☐ STRATEGY

☐ RAW DATA VALIDATION

- Gain Setting
- Chirp Replica
- Noise

☐ SAR IMAGETTE

- Transponder measurements
- System Transfer Function
- Localisation
- Stability

☐ WAVE SPECTRA

- Spectra
- Geophysical Validation

☐ CONCLUSIONS

WAVE MODE INTRODUCTION

- ❑ ERS SAR Wave mode product
 - Imagette
 - Small SAR Image
 - 5km in Azimuth
 - 5km in range in On Ground Range Compression, OGRC (2 bit samples)
 - 10km in range in On Board Range Compression, OBRC (4 bit samples)
 - OBRC is used operationally
 - Wave spectrum
 - Spectrum of ocean surface
 - Sampled into 12 by 12 polar bins
 - 0 to 180 degrees in direction
 - 100 to 1000m wave lengths
- ❑ Commissioning Acquisitions and processing
 - Nominal acquisition in OBRC Wave Mode (NB not Wind/Wave)
 - 1 orbit processed per day. Full day processed on 2-AUG-1995.
 - 1 orbit OGRC acquired on 4-JUL-1995 (orbit 1069).
 - Full day of OGRC on 23-AUG-1995.

STRATEGY

- ☐ Validation
 - Raw Data and processed products are examined in fine detail
 - Ensure that instrument and processing are functioning nominally, within expected limits.
- ☐ Absolute Calibration
 - Calibration Constant
 - System Transfer Function
 - Localisation
- ☐ Comparison with ERS-1
- ☐ Stability
 - Chirp Replica
 - Noise
 - Mean Image level
- ☐ Geophysical Validation

RAW DATA VALIDATION Gain Setting

Set to nominal ERS-1 values

- ☐ Receiver attenuation 15 dB
- ☐ Calibration system attenuation; open loop
 - OGRC 20 dB
 - OBRC 23 dB

Due ERS-2 AMI overload shutdown the upconverter gain on ERS-2 is different to ERS-1 setting.

- ☐ ERS-1 Upconverter gain 27 dB
- ☐ ERS-2 Upconverter gain 20 dB

On July 13th 1995 Image mode gains were changed to compensate for the new upconverter gain setting, wave mode gains were not altered.

Final setting TBC when AMI Task Force investigation is complete.

RAW DATA VALIDATION Chirp Replica & Noise

☐ Chirp

- Comparable with image mode, and ERS-1
- Nominal MMCC chirp used for cross correlation.
- Chirp index stable at 31.

☐ Noise

- Comparable with image mode, and ERS-1
- Stable

☐ Raw Data

- Comparable with ERS-1
- Mean I & Q levels
 - daily average stable 0.06
 - daily range ± 0.2
- Standard deviation of I & Q
 - daily average stable 3.5
 - daily range ± 3

SAR IMAGETTE Transponder measurements (1/4)

TNO deployed transponder in Vlaardingen, Netherlands.

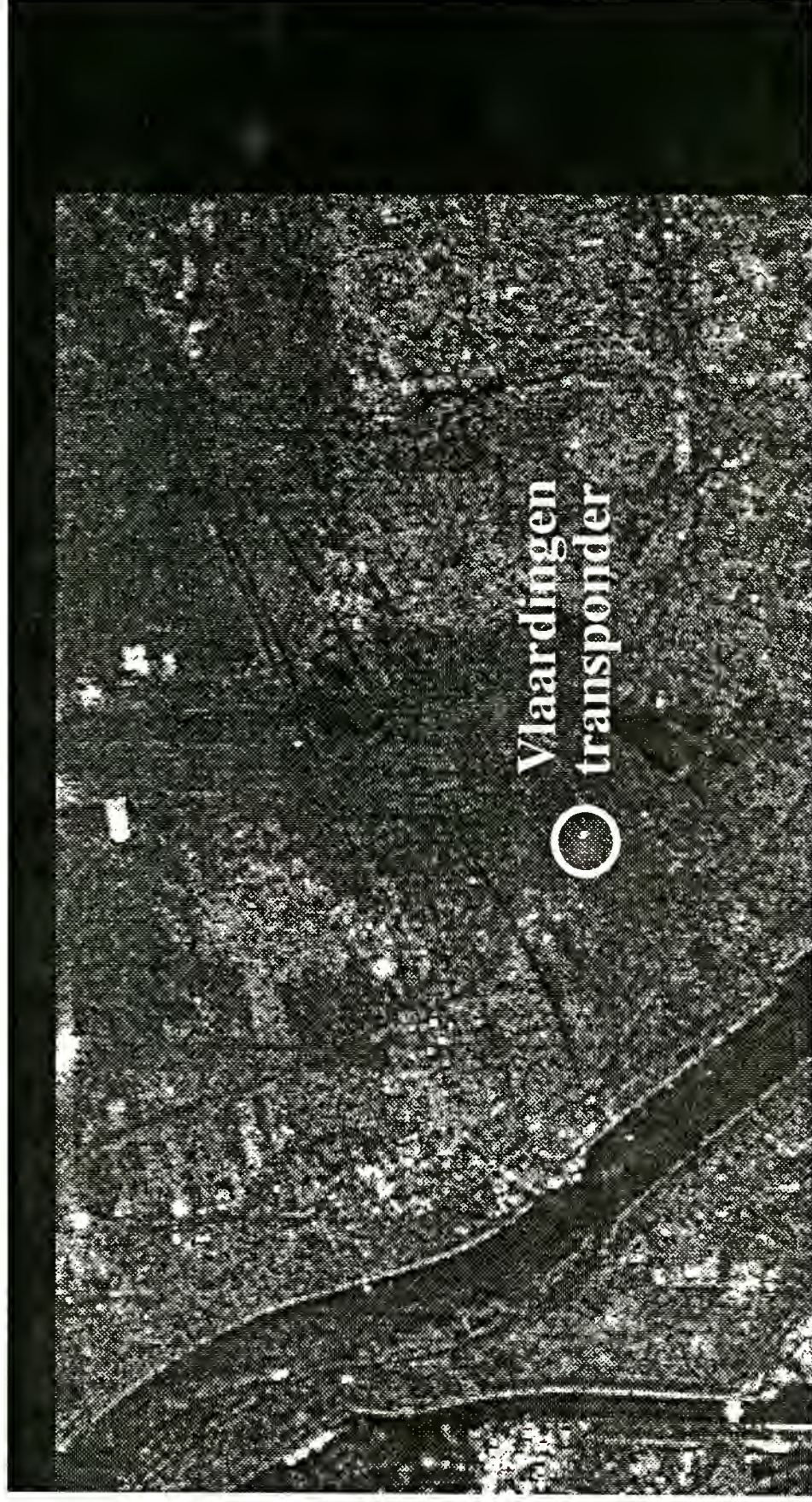
Wave acquisitions made in OBRC

- ☐ ERS-1 28-JULY-1995 21:46:41
- ☐ ERS-2 29-JULY-1995 21:46:44

Point target measurements of the resulting imagettes gives

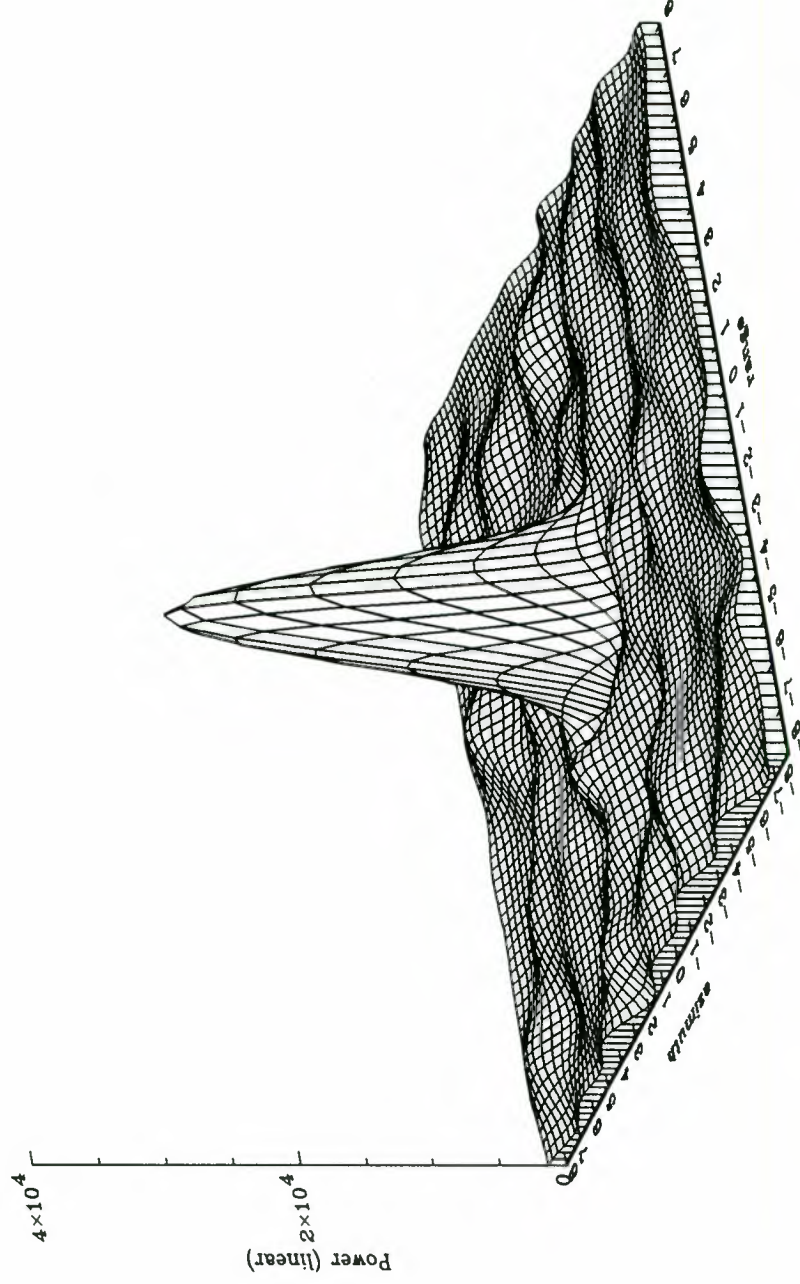
- ☐ Resolution
- ☐ Approximate calibration constant
- ☐ Localisation accuracy

SAR IMAGETTE Transponder measurements (2/4)



SAR IMAGETTE Transponder measurements (3/4)

Zoom interpolation : 17x17 pixels



SAR IMAGETTE Transponder measurements (4/4)

RESOLUTION	ERS-2	ERS-1
Azimuth Resolution	21.38 m	22.37 m
Range Resolution	26.97 m	26.55 m

CALIBRATION CONSTANT	
At Mid Swath 23°	76.32
	75.49

Imagette size	
Azimuth	5.14 km
Range	10.15 km

Transponder	
Incidence angle	22.92°
Radar Cross Section	42.0 dB

Assuming flat antenna pattern.
Imagette centred approximately at mid SAR swath

SAR IMAGETTE System Transfer Function (1/2)

The primary objective of the AMI wave mode is to observe the ocean surface, and derive wave spectra from those observations.

The system response to ocean surface wave modulations is non-linear.

The response function can be fitted by

- hamming function in azimuth

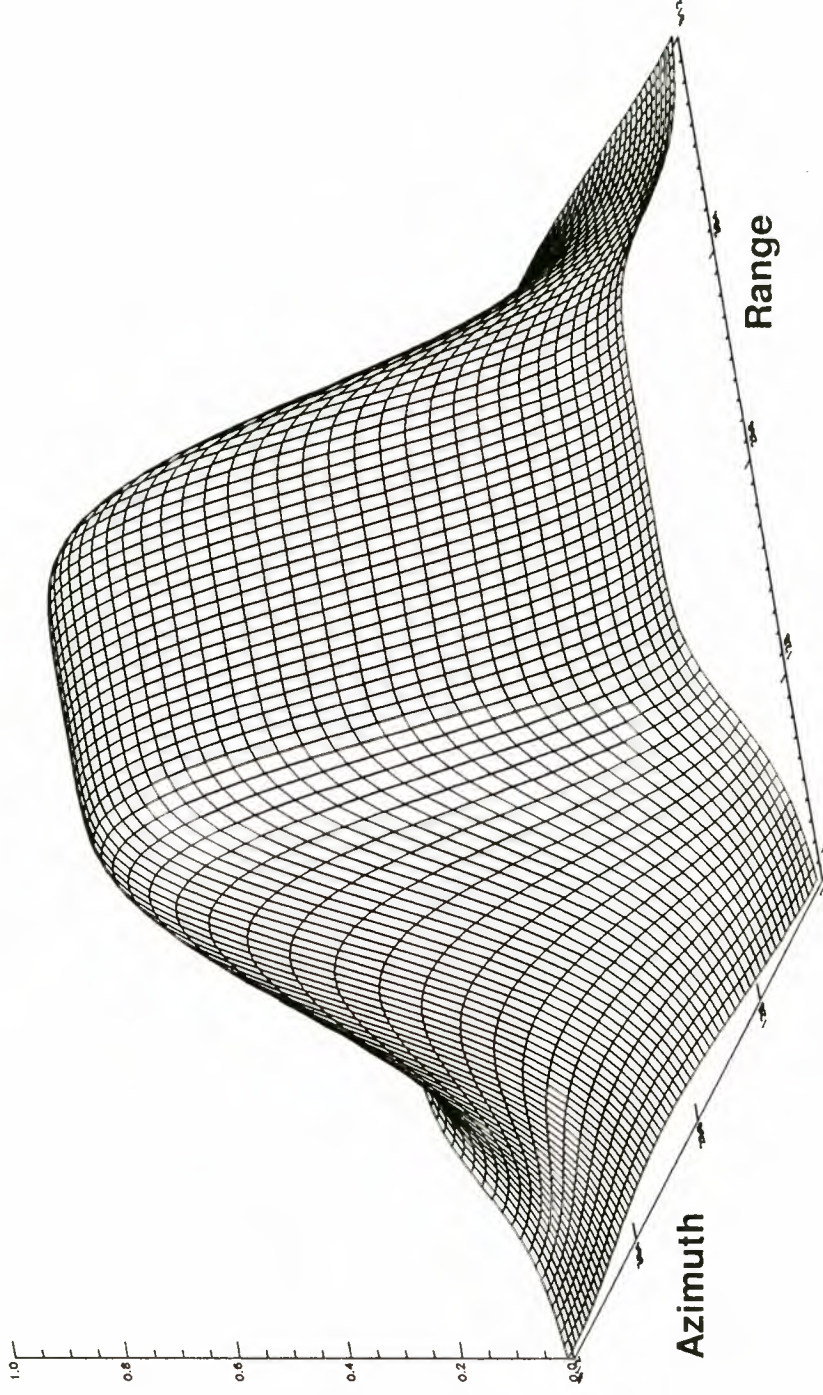
$$STF_{azimuth}(k_a) = \alpha - (1 - \alpha) \cos(\delta y \cdot k_a)$$

- butterworth function in range

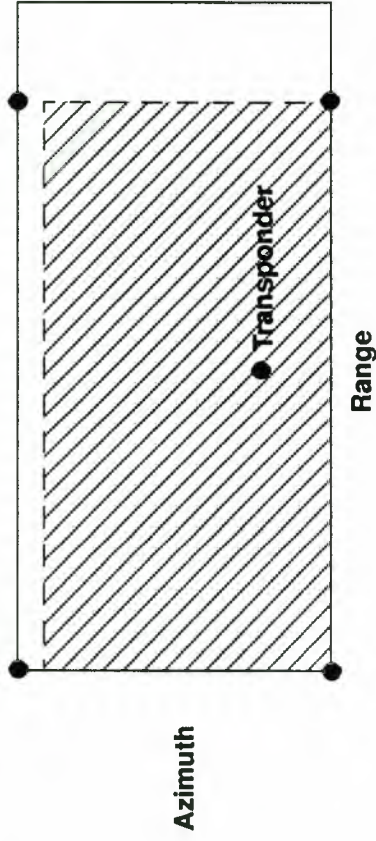
$$STF_{range}(k_r) = \frac{1}{\left(1 + \left(k_r \cdot \frac{65}{2\pi}\right)^6\right)}$$

IFREMER have derived an initial estimate of the ERS-2 STF. This has been found to be identical to ERS-1 in range, and almost equivalent in azimuth. $\alpha = 0.595$ for ERS-2, $\alpha = 0.59$ for ERS-1

SAR IMAGETTE System Transfer Function (2/2)



SAR IMAGETTE Localisation



Transponder location in Image

Pixel in imagette (range, azimuth)

258, 91

Location computed from Image corners

51.9190°N 4.2903°E

Range from predicted orbit used in processing

852.061 km

True Transponder location

Location measured by non-differential GPS $\pm 40\text{m}$ 51.9188°N 4.2870°E

Range from restituted orbit

851.963 km

Localisation Differences(range, azimuth)

226 m, 40m

SWST table offset change accounts for $\sim 100\text{m}$.

SAR IMAGETTE Stability

☐ Imagette mean

- daily average stable 2400
- daily range 1000..4200

☐ Imagette Standard Deviation

- daily average stable 1280
- daily range 0..2400

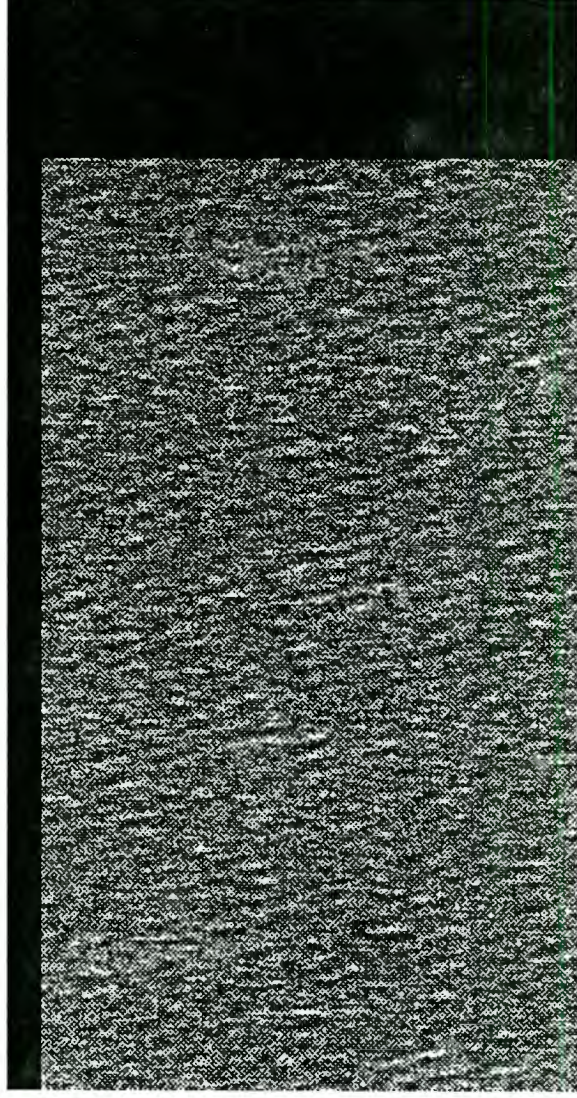
☐ Doppler mispointing

- Difference between expected doppler and measured doppler
-350 Hz

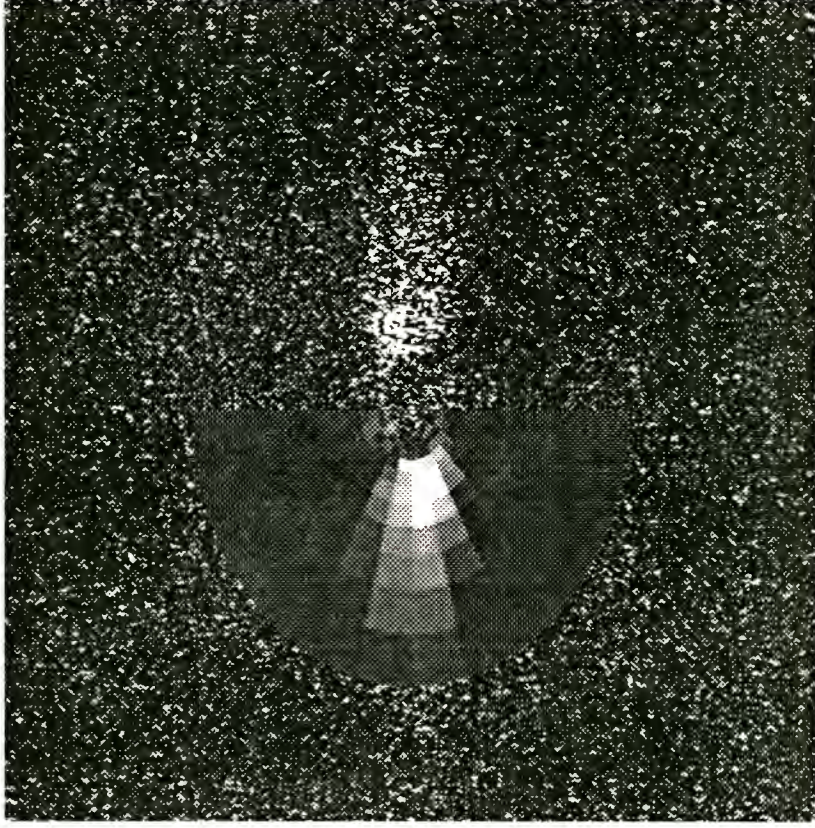
WAVE SPECTRA (1/3)

This product exhibits wave energy travelling in the range direction.

Date (UTC)	29-JUL-1995 21:21:55.249
Location	-35.974° N, 26.681° E
Mode	OBRC (320 x 600)
Image size	301 Azimuth, 510 Range



WAVE SPECTRA (2/3)



WAVE SPECTRA (3/3)

- ☐ Geophysical Validation begun.
- ☐ Initial results show similar quality to ERS-1
- ☐ New wave algorithm development in progress.
 - Re-host on LRDPF
 - Use of calibration constant
 - Use of Static Transfer Function
 - Cleaner application of signal processing methods
 - Shifting wavelength scale to 60m..750m (rather than 100m..1000m)
 - Computation of Azimuthal Clutter Cutoff
=> wind speed measurement

CONCLUSIONS

- ☐ Wave mode shown to be working well.
- ☐ Results comparable with ERS-1.
- ☐ Gain setting may need to be adjusted once AMI task force complete
- ☐ New wave algorithm is eagerly anticipated by wave user community

Day 2

GOME COMMISSIONING/VALIDATION*ESTEC / LTP:**A. Hahne**A. Lefebvre**J. Callies**ESTEC / NWP:**C. Caspar**ESTEC / VR:**E. Attema**P. Wursteisen*

GOME COMMISSIONING

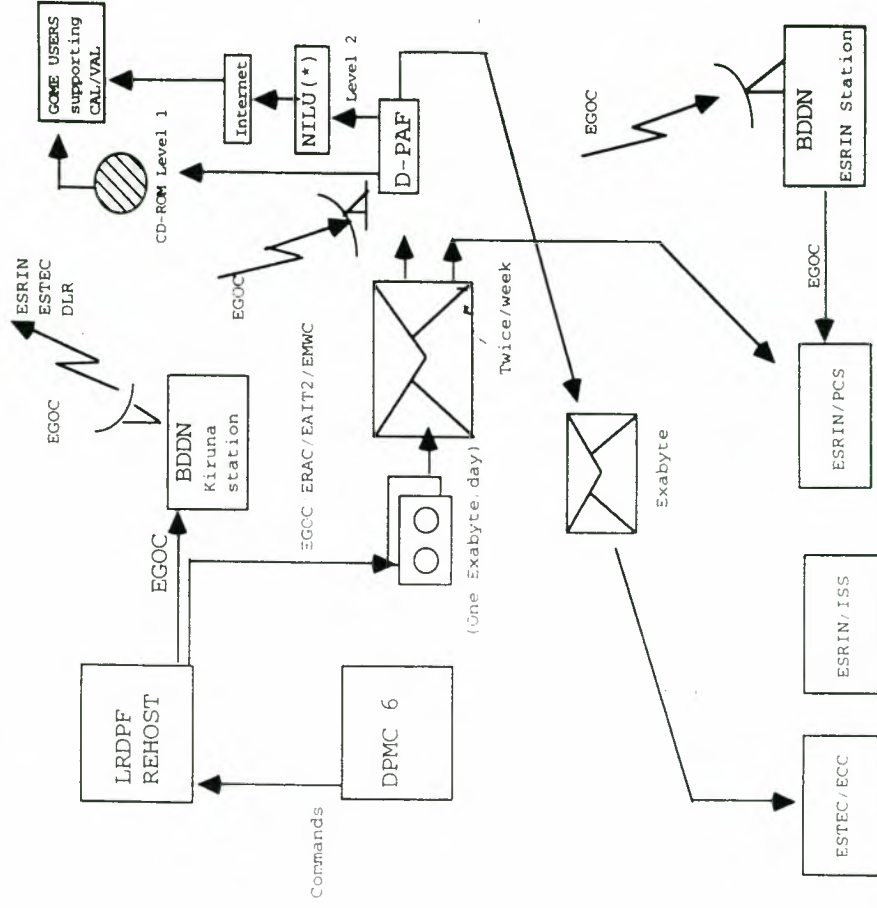
- > *Data flow during commissioning/validation phase*
- > *Strategy*
- > *Products*

GOME COMMISSIONING STRATEGY

- > *Raw data are distributed to ESRIN / ESTEC / DLR via BDDN*
 - > *DLR processor output is sent to NILU (Norwegian Institute for Air Research) for access by the validation PI's. (PI's of level 1 product get a CD)*
 - > *Validation PI's feed back the results of their analyses in validation meetings.*
 - * *first mtg on 8.6.95 for irradiance data*
 - * *second mtg on 14/15.9.95 for all products.*
- on-going activity.*

ERS-2 COMMISSIONING PHASE REVIEW

ERS-2 GOME DATA CIRCULATION - COMMISSIONING PHASE



(*) NILU: Norwegian Institute for Air Research

GOME COMMISSIONING

Level 0 data: raw data

Level 0 data -> 1 processing converts raw data into time corrected, geolocated, wavelength and radiometrically calibrated spectra.

By using ground-based (keydata) and in-orbit calibration parameters.

On-ground calibration performed by TPD (NL) resulted in a set of key parameters, derived for the in-orbit situation (polarisation dependancy, radiance response, spectral resolution, etc.)

An update of some keydata for the true in-orbit situation has been performed (using sun measurements).

GOME COMMISSIONING

Level 1 data:

sun irradiance

earth radiance

Level 1 -> 2:

*derives total column ozone data using
differential optical absorption spectroscopy
(including cloud fitting and air mass
factor calculation)*

Level 2 data:

total column ozone data.

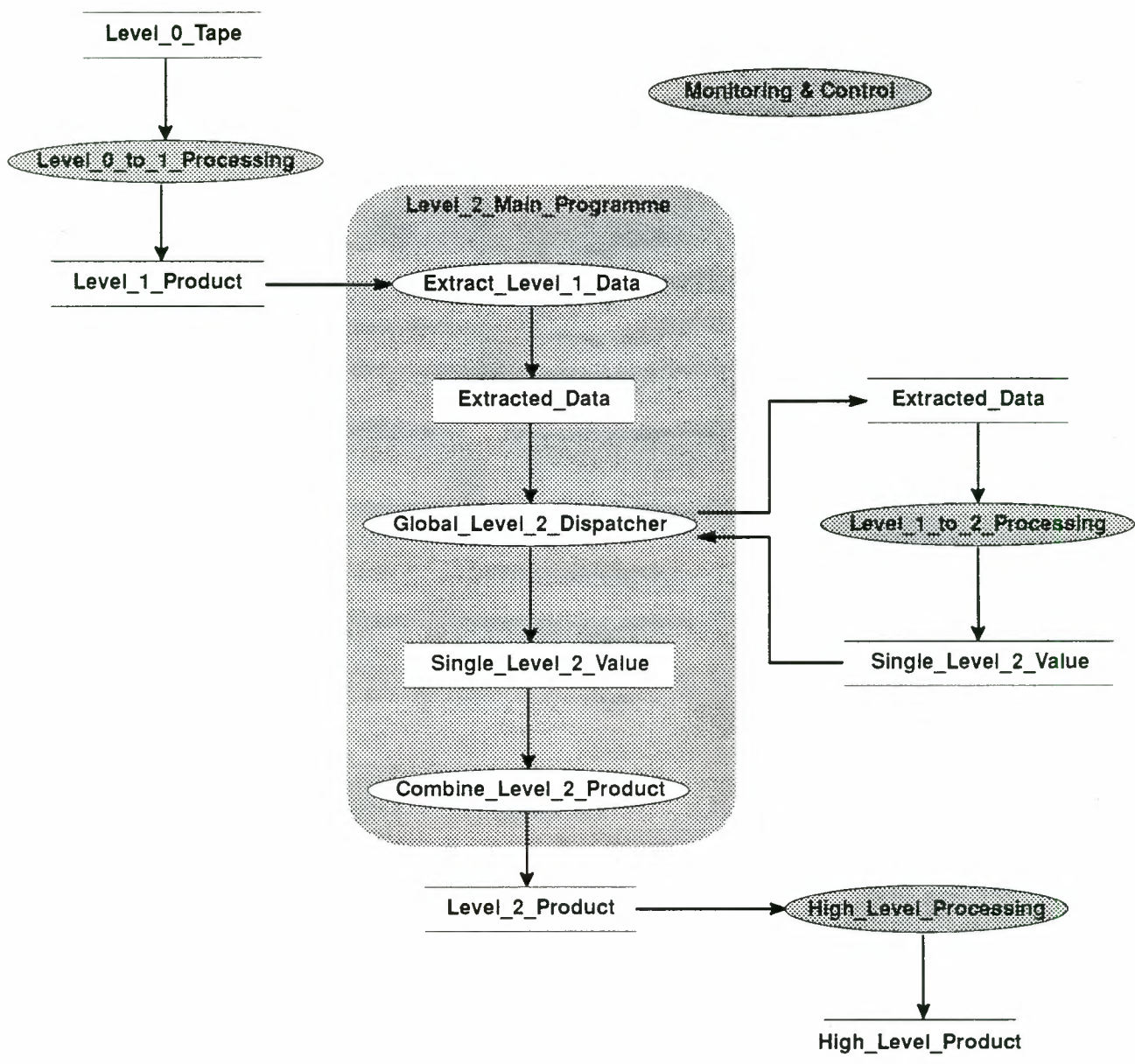
First ERS-2 Commissioning Review

ESRIN, Frascati

26./27. October 1995

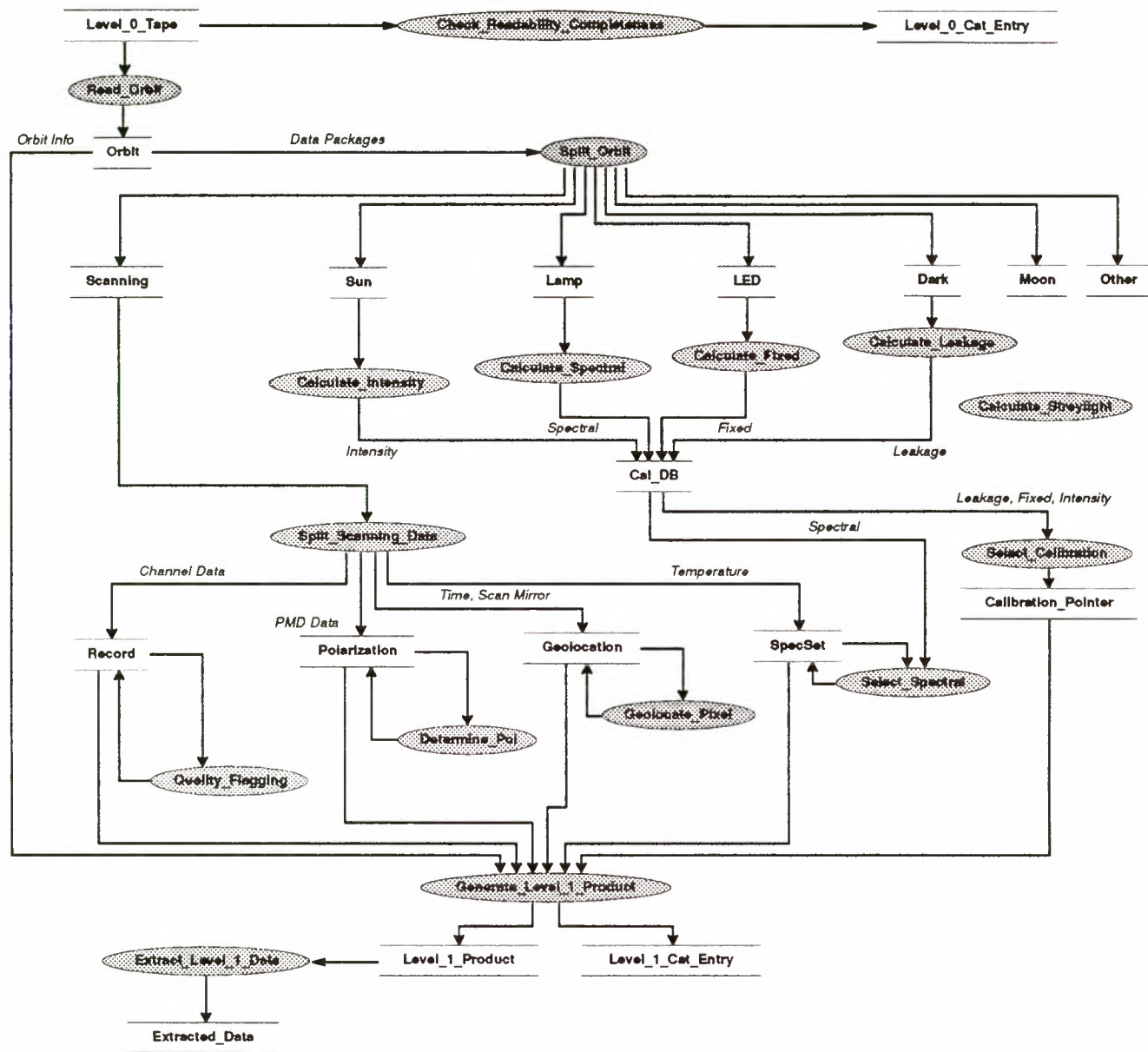
GOME Data Processor

Overall System (Functional Model)



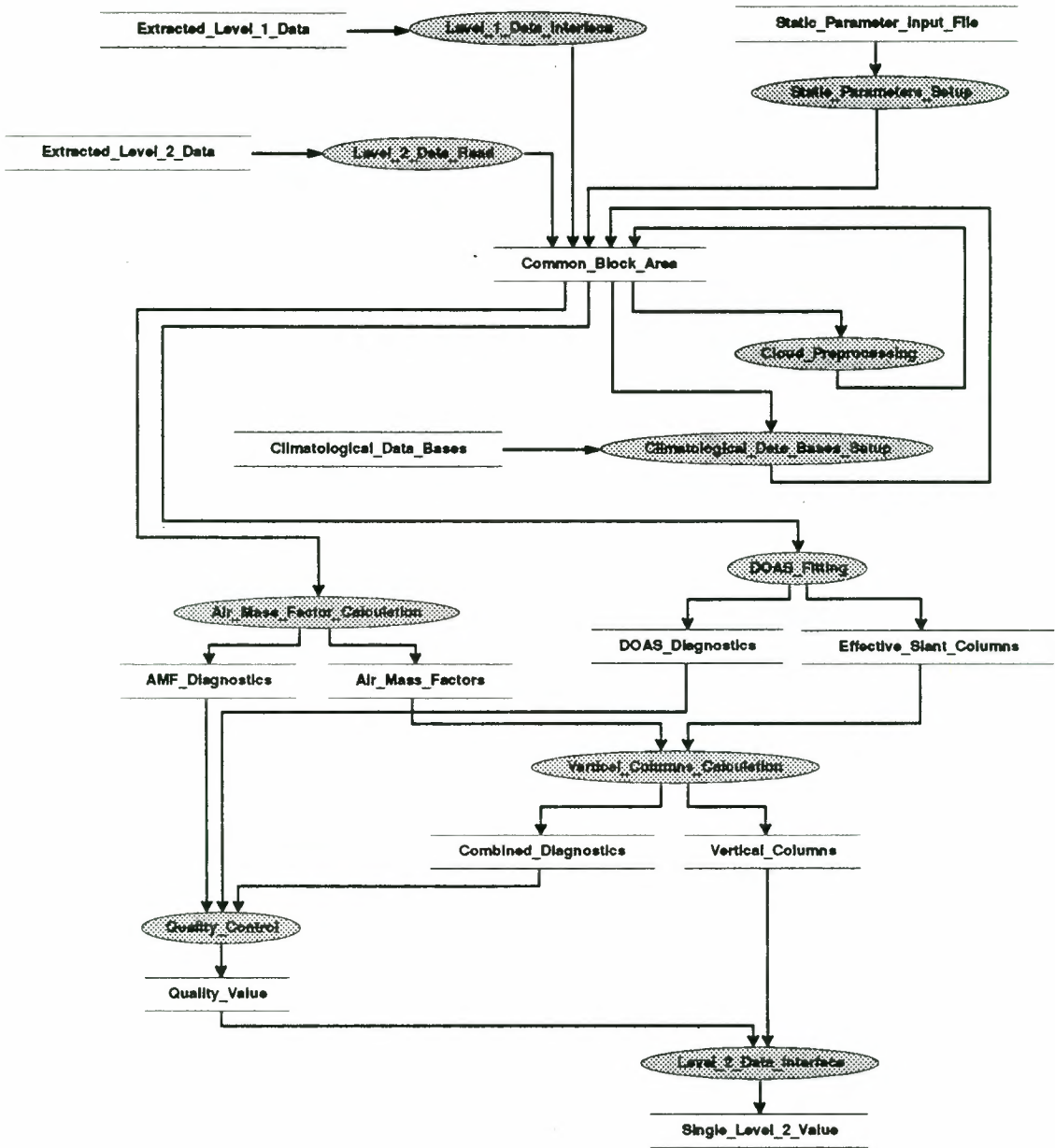
GOME Data Processor

Level 0 to 1 Processing (Functional Model)



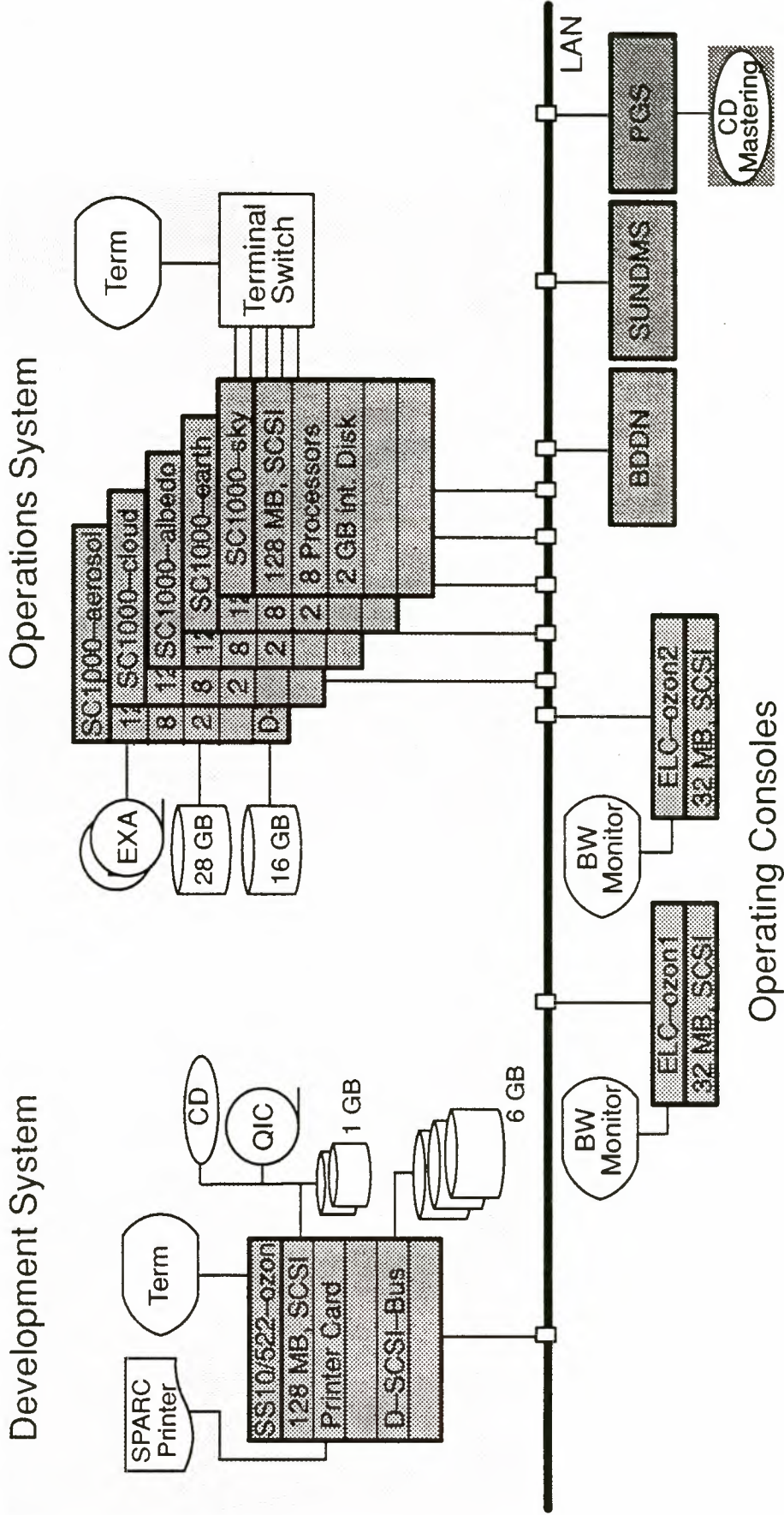
GOME Data Processor

Level 1 to 2 Processing (Functional Model)



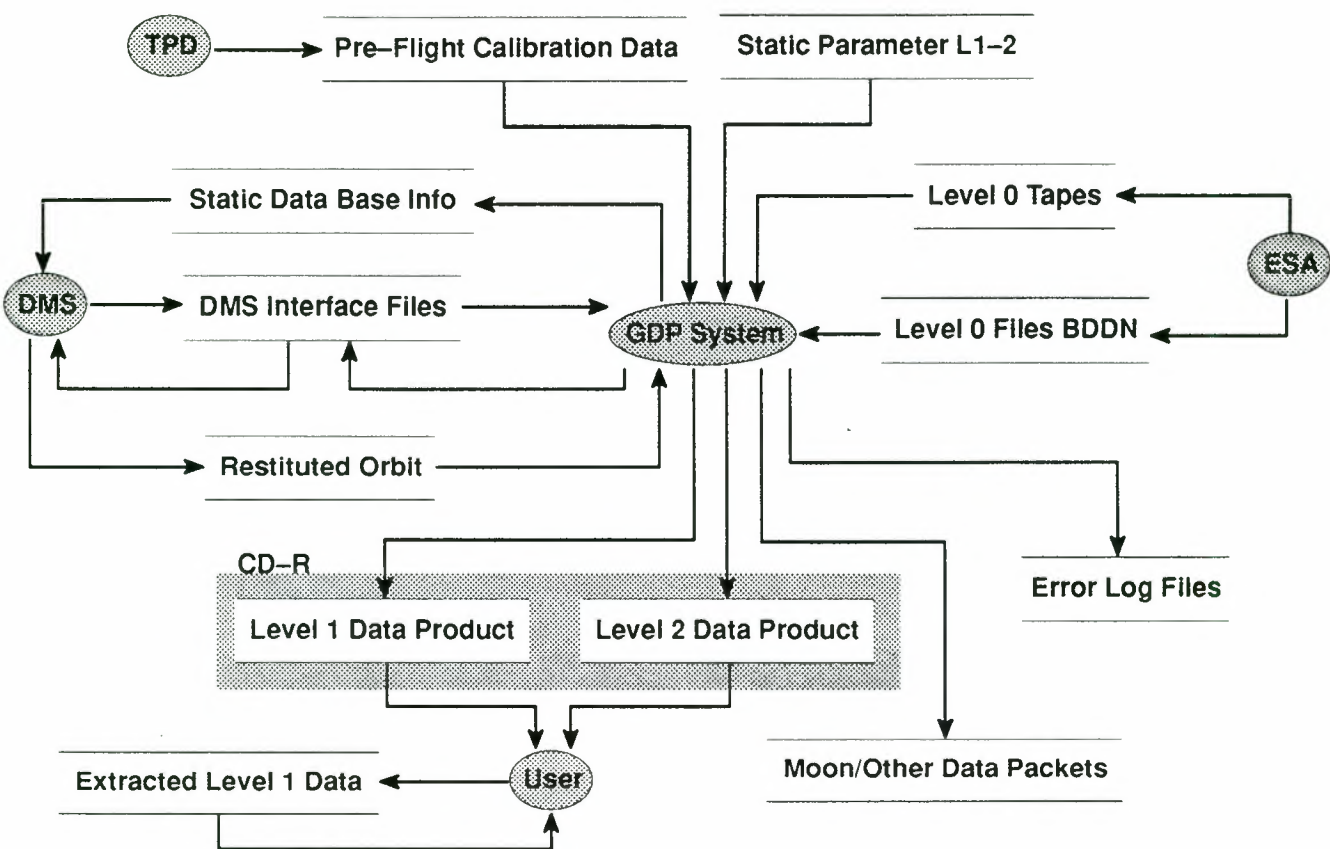
GOME Data Processor

Hardware Configuration for the Operation Phase



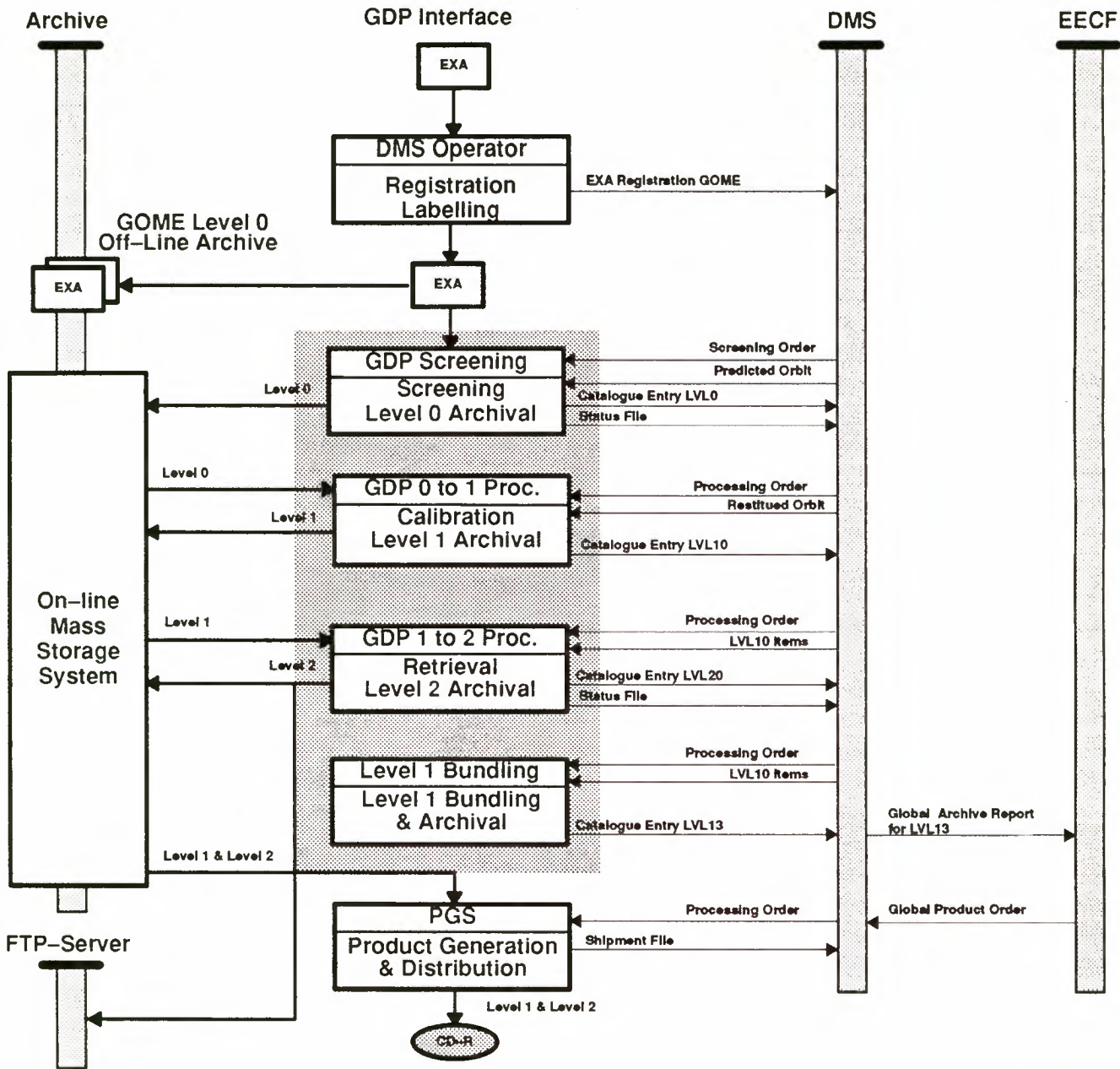
GOME Data Processor

GDP Interfaces



GOME Data Processor

DMS Interface



GOME Data Processor

Proposed GOME Data Products

Product Name	System	Delay from Observation	Processing Time	maximal Frequency	Product Frame	Product Size	Internal Storage	Shipment Media
GOM.LEVL1	GDP	1 week after reception of raw data	1/2 hour	max 40 products per day	1 orbit	16 MB	juke box	CD-R (ca. 35 orbits per CD-R)
GOM.TCDO3	GDP	1 day after reception of raw data	1/2 hour	max 40 products per day	1 orbit	650 kB	juke box	FTP-Server

GOME Data Processor – Level 0 to 1 Processing

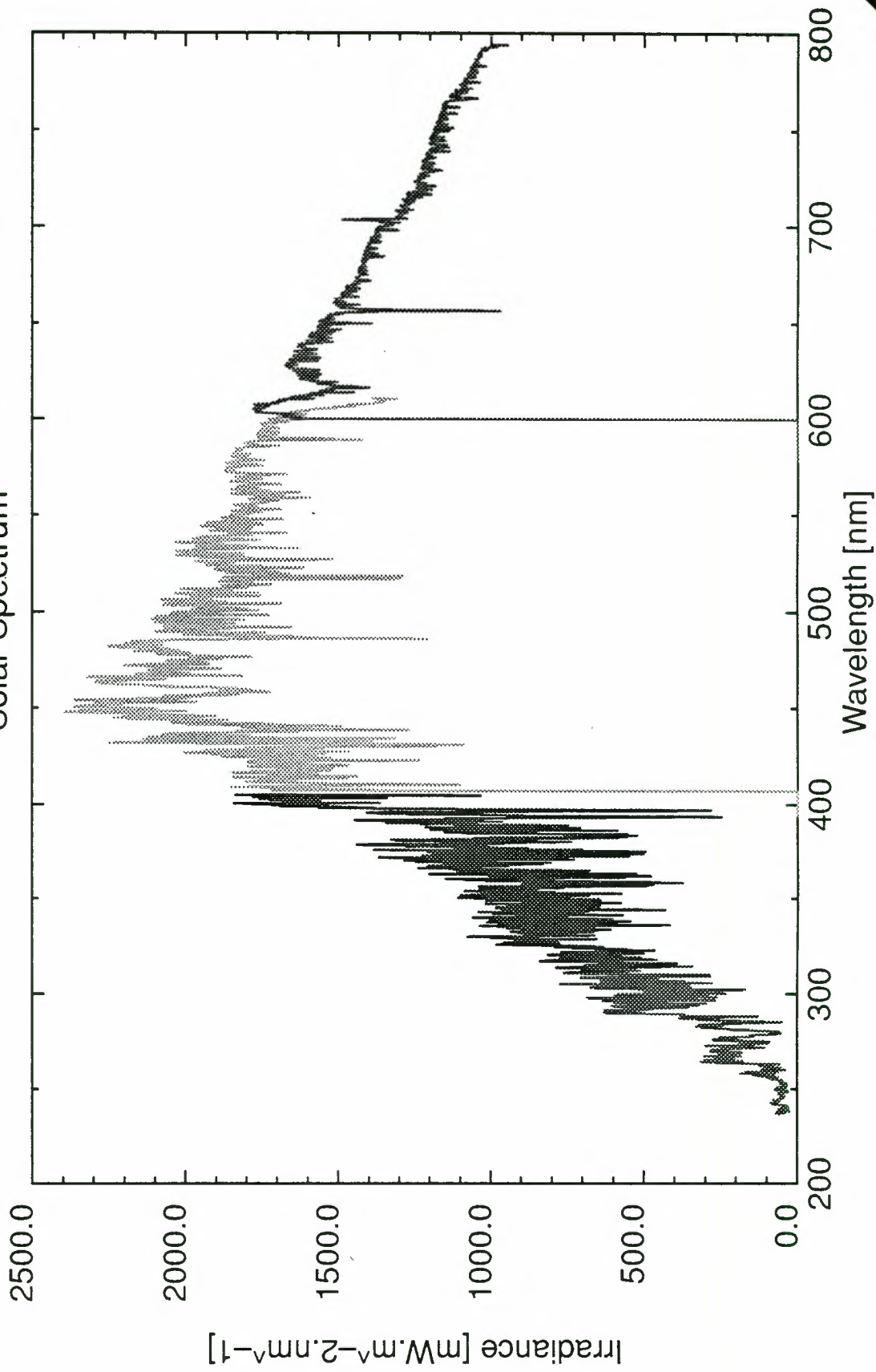
Status

- Processor is operational; only minor updates and are fixes required (see below)

Open Issues

- Geolocation to be validated with ESA orbit propagator
- Polarisation correction also for channel IA
- Implementation of module Quality Flagging (Hot Pixel Assessment and Wavelength Check)
- Change of Level 1 data product format concerning Sun and Moon measurements
- Extraction of calibration data from the Level 1 data product

GOME Level 0 to 1 Processing Solar Spectrum



Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V.

GOME Data Processor

RGB Composite of the PMD data



GOME Data Processor – Level 1 to 2 Processing

Status

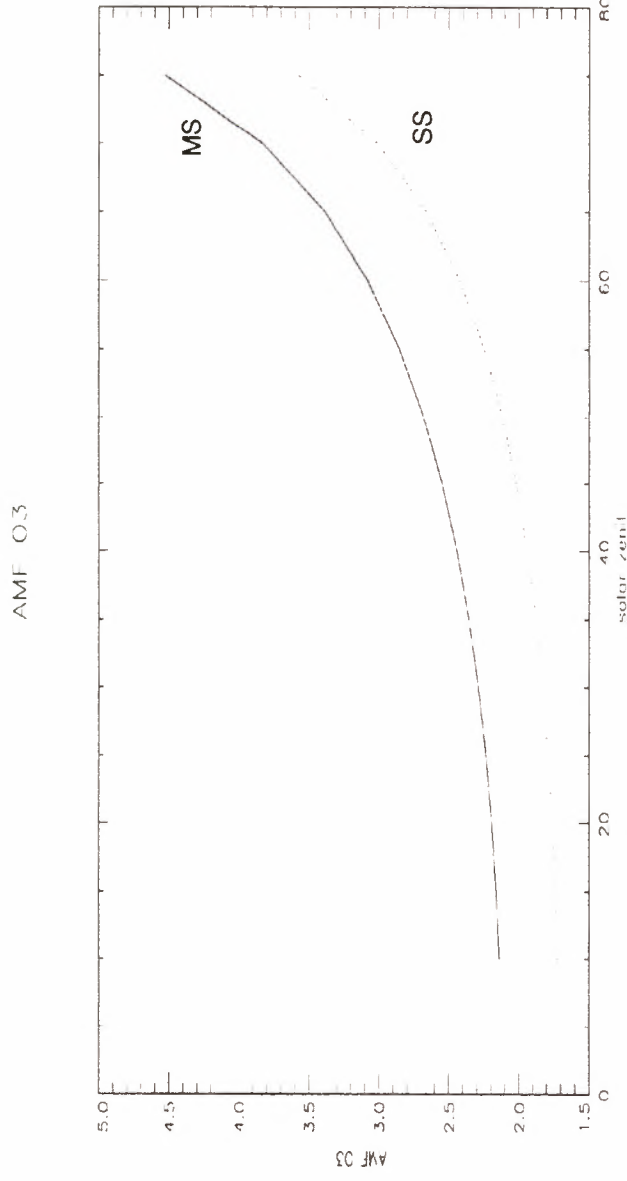
- DOAS fitting in visible gives reasonable results, further improvements are still possible
- Multiple-scattering correction tables in preparation
- Operational processing of orbits from 23.–25. July 1995

Open Issues

- Definition of DOAS fitting window in visible
- Definition of Main VCD entry (UV, VIS or best choice)
- Application of multiple-scattering correction tables

GOME Data Processor

Single-Scattering / Multiple-Scattering Comparison – AMF O₃ GOMEtran – First Results



Wavelength: 330nm

Geolocation: mid-latitude Line-of-Sight: 0

Azimuth: 0

Albedo: 20%

Aerosol: rural, background

➡ MS results ~25% higher than SS values

GOME Data Processor

Single-Scattering / Multiple-Scattering Correction Table Generation

Parameter Variation

Parameter Name	Parameter Values	Number
Wavelengths	330, 437, 520	3
Solar Zenith Angles	10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 91, 93	14
Line-of-Sight Angles	0, 5, 10, 15, 20, 25, 30, 35	8
Albedo	5, 20, 30, 50, 75, 95	6
Ground altitude	0.0, 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0	9

- 18144 MS caluculations = 2600 h = 3.6 month
- 18144 SS caluculations = 50 h

GOME Data Processor

Condensed Comments & results reported to DFD

- η observed in radiance/irradiance
- Total column of ozone from TOMS and GOME "is about the same" with multiple scattering correction applied
- GOME shows only 92% of the SSBUV solar irradiance
- there is a difference between the end of channel 1A and the beginning of an averaged channel 1B
- request for PMD solar irradiance and more detailed sun measurement results
- PMD earth-shine radiance: New algorithmic approach proposed by John
- lunar data request
- fitting window moving for DOAS algorithm in the visible and windows with gaps are required

GOME Data Processor

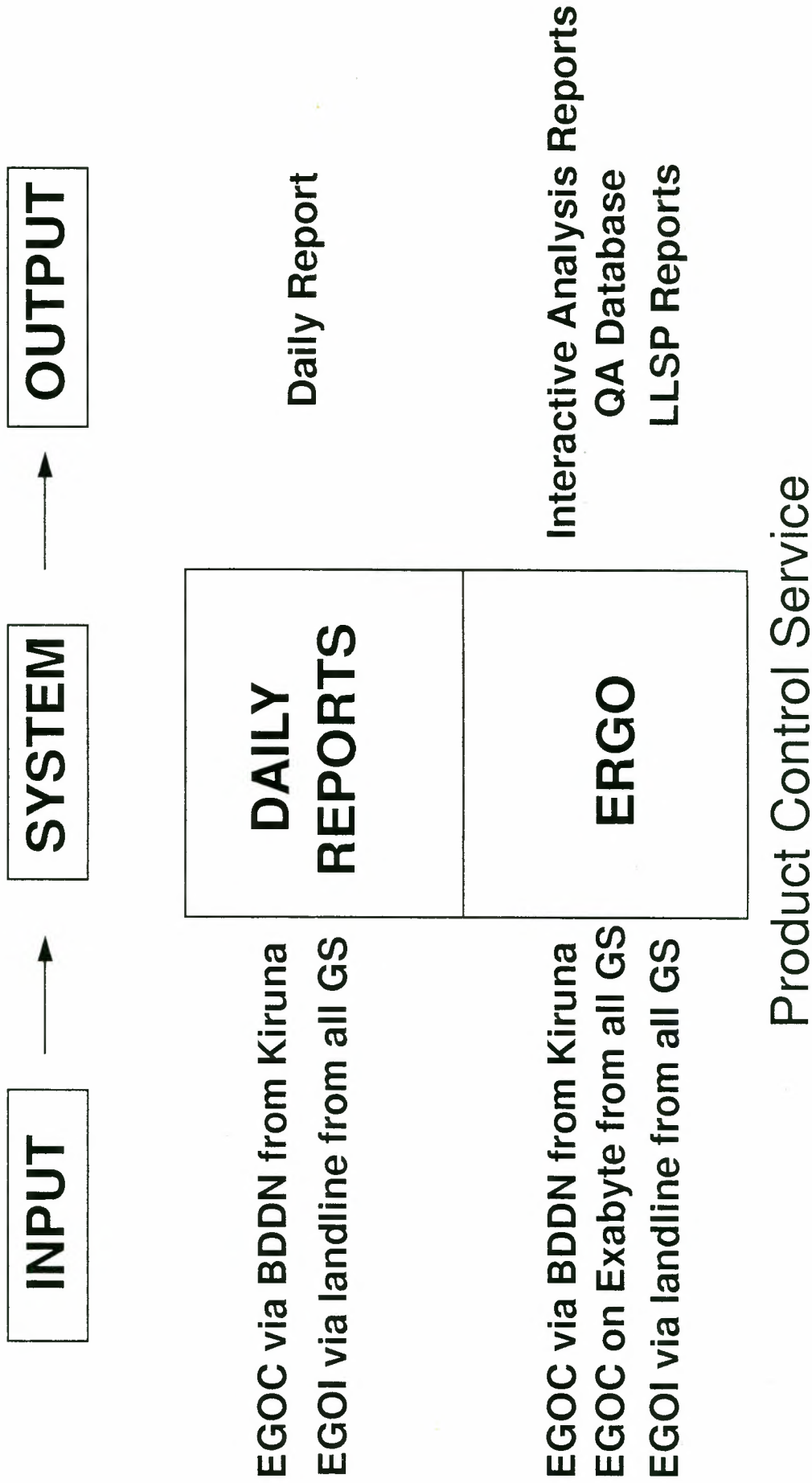
Future Activities

- Update of the processors; see later
- Regular distribution of GOME data products
- Assistance for the validation PIs still on-going
- Update of AD and SVVP documentation data packages
- Preparation of software user manuals
- Preparation of Acceptance Test Review Data Package (ATR/DP)
- Organisation of the Acceptance Test Review

ESRIN ERS-2 Mission Implementation Plan Tasks for the GOME Instrument:

- Development of a software system to monitor GOME instrument performance and the quality of GOME raw data products
- Support to the GOME project team at ESTEC during Commissioning phase
- Operational QA/LLSP during lifetime of the mission

GOME Quality Assurance Tools at ESRIN:



Daily Reports Tool

- **Anomalies**
- **Data Availability and Integrity**
- **Instrument Status and Health Parameters**
- **Resolution ~ 2 minutes**
- **4 Stations**
- **With EGOIs will be Near Real Time**
- **Selected Raw Detector Data**

Daily Reports Activities

- Check Production
- Identify Anomalies
- Investigate if Necessary (QA Tools)
- Report to ESTEC
- Selected Pages on FTP Server (as requested by ESTEC and DLR)

ERS-2 Global Ozone Monitoring Experiment Data

First Product : 13-OCT-1995 05:19:24.767 : ORBIT : 2507.2177

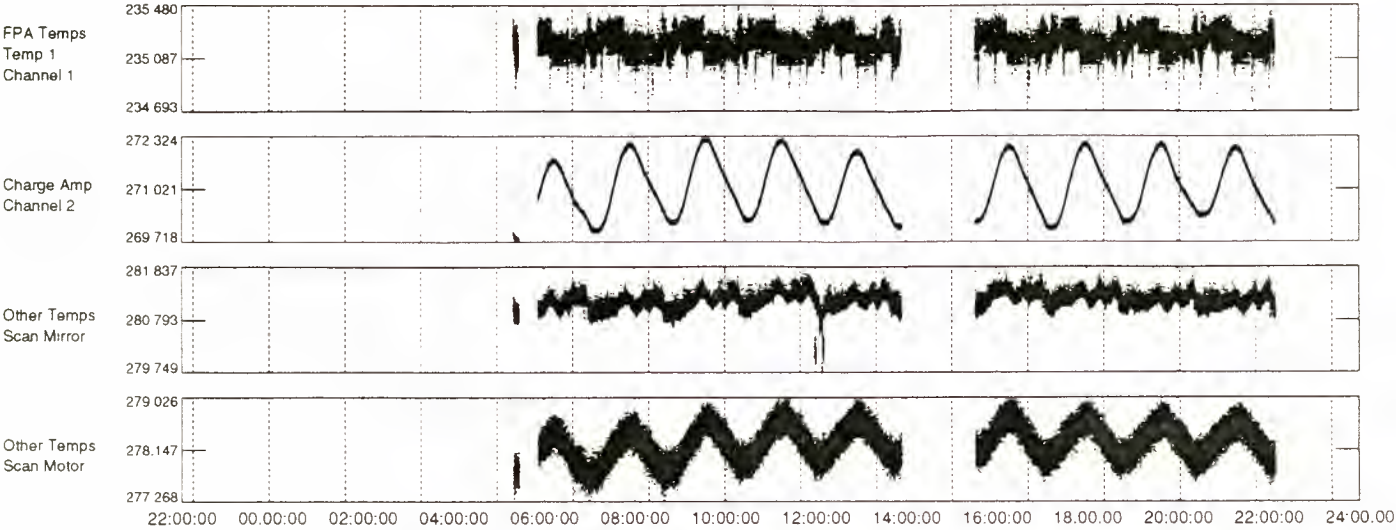
Last Product : 13-OCT-1995 22:08:44.756 : ORBIT : 2517.2510

Total Products Processed : 35354

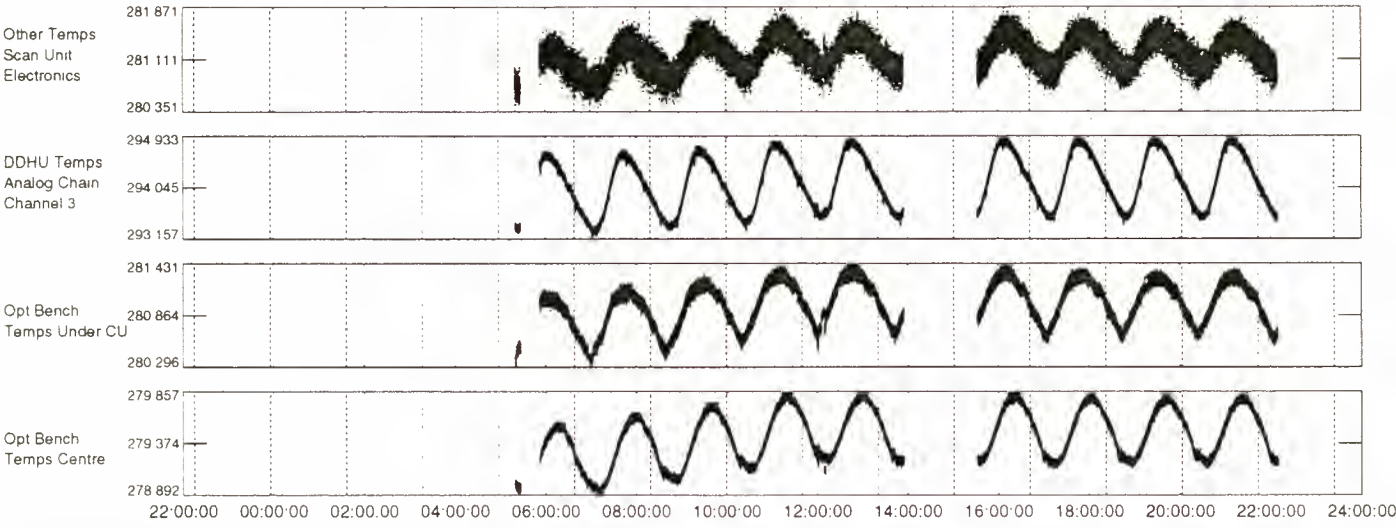
Day : 286

Page : 9

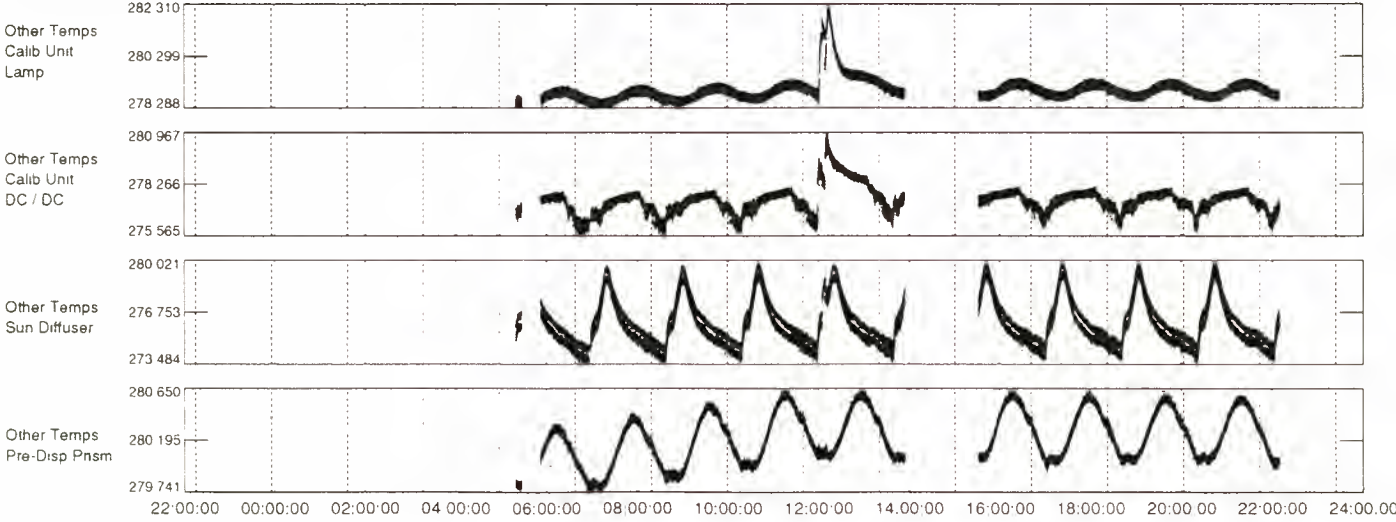
GOME GLOBAL ACQUISITIONS : SELECTED TEMPERATURES A



GOME GLOBAL ACQUISITIONS : SELECTED TEMPERATURES B



GOME GLOBAL ACQUISITIONS : SELECTED TEMPERATURES C



ERS-2 PRODUCT REPORTS (EGOC) : ANOMALY LOG

First Product : 13-OCT-1995 05:19:24.767 : ORBIT : 2507.2177

Last Product : 13-OCT-1995 22:08:44.756 : ORBIT : 2517.2510

Total Products Processed : 35354

Day : 286

Page : 11

Software Version Number is: 6 3 0 0

All software versions are the same.

Threshold Table Number is: 11000

All threshold table versions are the same.

First Virtual Separation of Channel 1 is: 880

Crossover pixel for Channel 1 remained constant.

First Virtual Separation of Channel 2 is: 191

Crossover pixel for Channel 2 remained constant.

Source Packet Counter is:

Non-contiguous at: 13-OCT-1995 05:51:54.982

The total number of occurrences of the above error was: 5

Null products received: 91

EGOC_951013075237.E2;1 : CORRECTLY READ

EGOC_951013094250.E2;1 : CORRECTLY READ

EGOC_951013112329.E2;1 : CORRECTLY READ

EGOC_951013130054.E2;1 : CORRECTLY READ

EGOC_951013143924.E2;1 : CORRECTLY READ

EGOC_951013175702.E2;1 : CORRECTLY READ

EGOC_951013211419.E2;1 : CORRECTLY READ

EGOC_951013225207.E2;1 : CORRECTLY READ

GAP : 05:26:53.314 - 05:51:54.982 : 1000 source packets missing AT KIRUNA

GAP : 05:54:11.493 - 05:54:14.493 : 1 source packet missing AT KIRUNA

GAP : 06:56:10.396 - 06:58:07.407 : 77 source packets missing AT KIRUNA

GAP : 07:14:00.005 - 07:14:39.009 : 25 source packets missing AT KIRUNA

GAP : 13:53:59.580 - 15:31:51.205 : 3913 source packets missing AT KIRUNA

Extracts Of Raw Detector Data For QA

Quicklook at Key Signals of Instrument (2 of 4 Detectors)

Extracted Detector Windows

- **318 nm; 331 nm** (5 pixels)
- **665 nm; 780 nm** (3 pixels)

Will be available at ESRIN within 24 hours of acquisition.

ERS-2 Global Ozone Monitoring Experiment Data

First Product : 21-JUL-1995 00:47:35.742 : ORBIT : 1302.1157

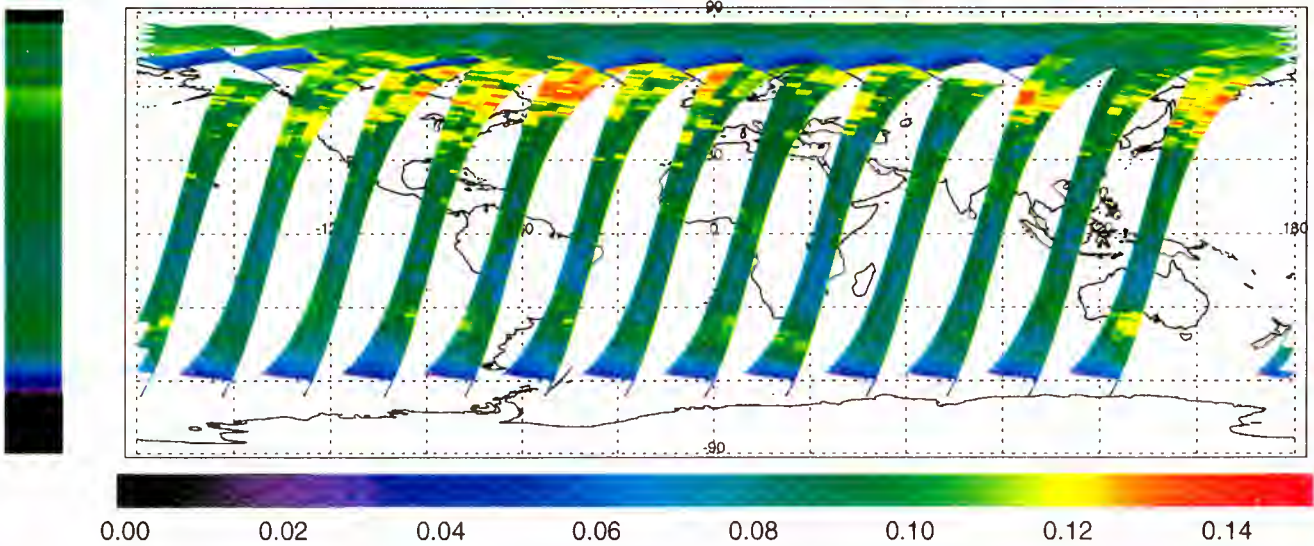
Last Product : 21-JUL-1995 22:48:29.206 : ORBIT : 1315.2460

Total Products Processed : 52507

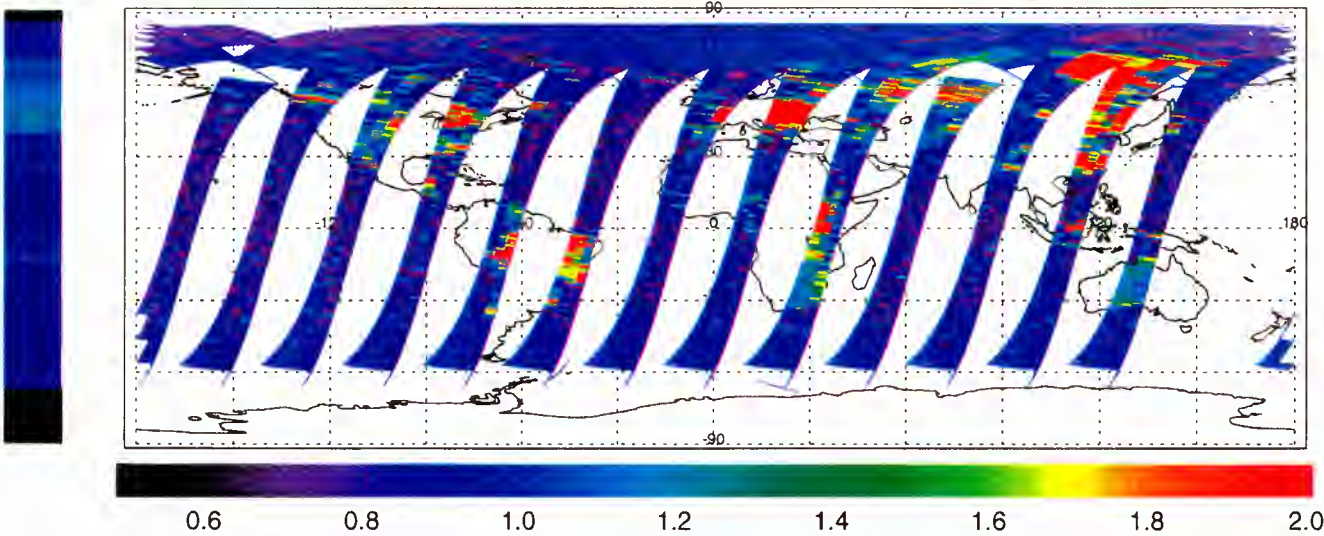
Day : 202

Page : 13

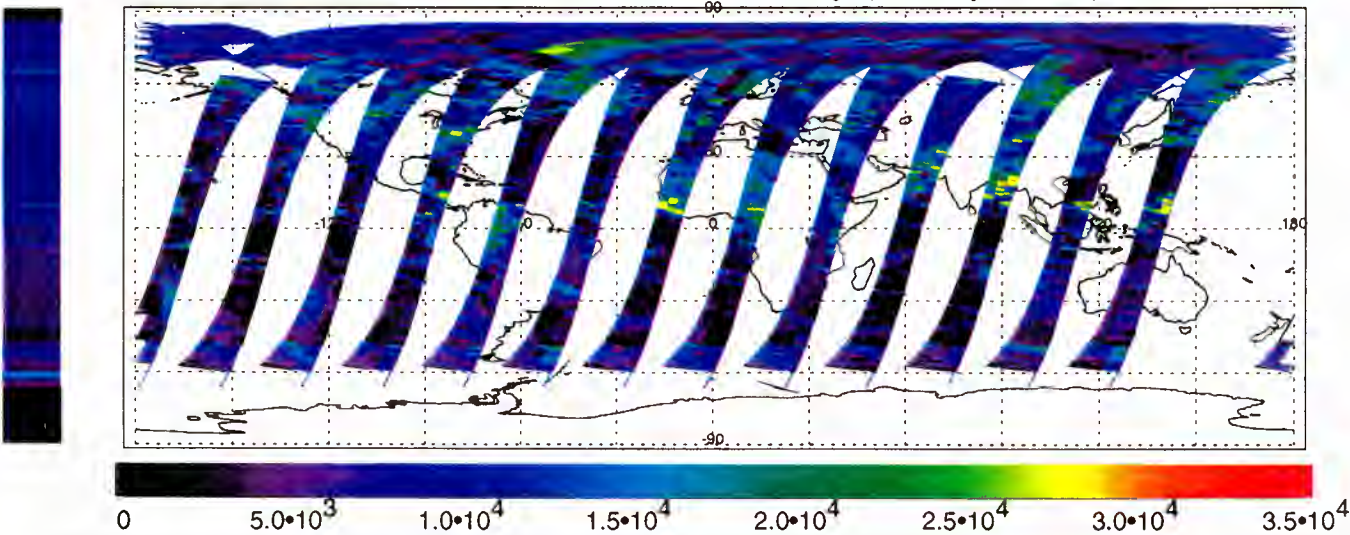
331/318 nm Uncalibrated Line Ratio, SZA Dependence Removed



780/665 nm Uncalibrated Line Ratio Log 10



780 nm Uncalibrated Intensity (Binary Units)



Extended RASCALS for GOME QA (ERGO) - FUNCTIONS:

- Automated and Interactive EGOT and EGOC Analysis
- QA Database
- Long Loop Sensor Performance Analysis
- 3 Days Maps
- Calibration Processing
- Exabyte Dump

ERGO Activities:

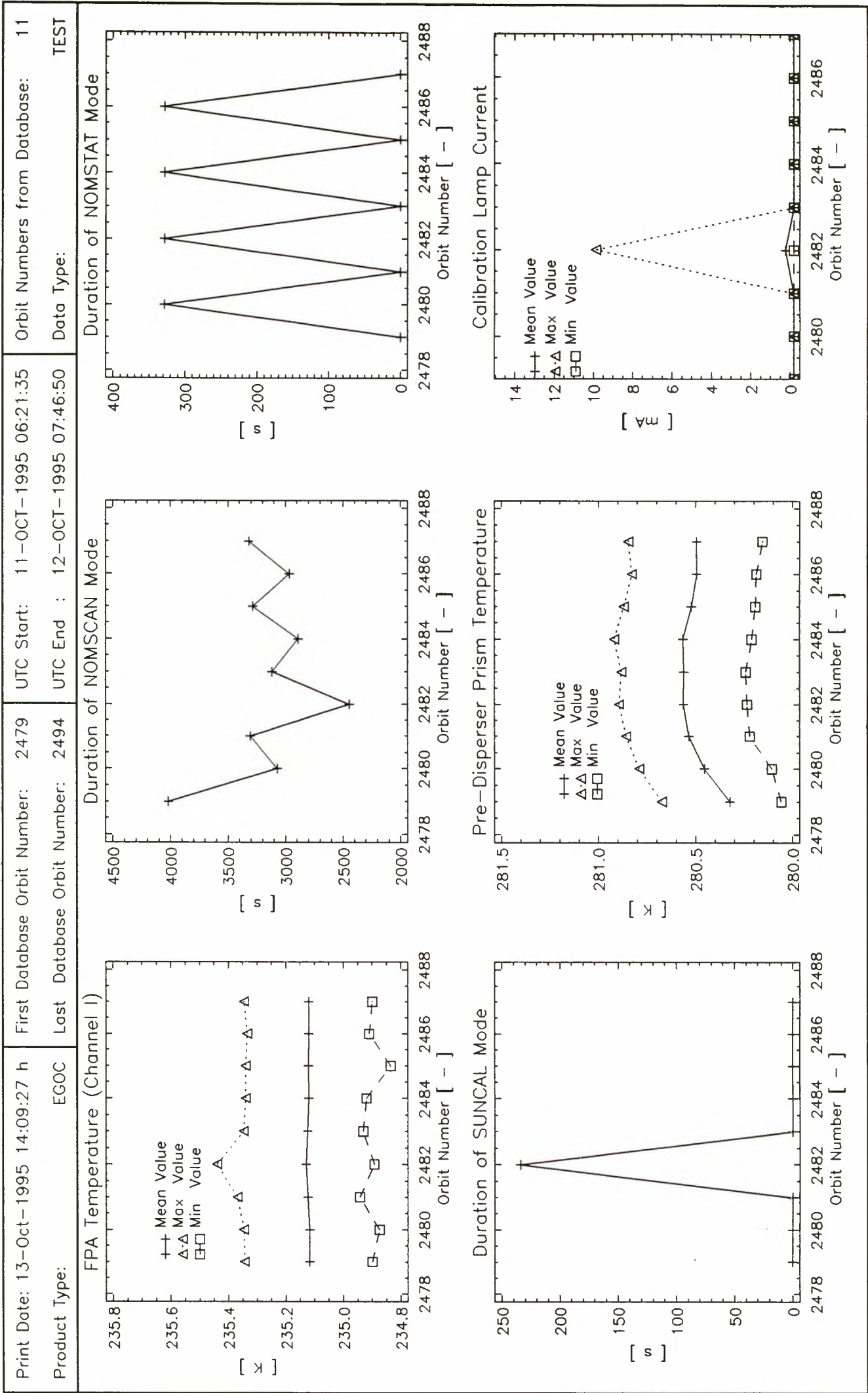
- Activities during Commissioning Phase:

- Detailed Investigations of Anomalies detected by the Daily Reports
- Anomalies in the on-board software detected (e.g. scan motor current)
- Instrument health parameters routinely monitored (e.g. temperatures, detector noise, lamp calibration behaviour in orbit)
- Instrument mode and timeline execution routinely monitored (e.g. moon calibration)
- Anomalies detected and investigated (e.g. saturation, data gaps)
- Patch to on-board software verified

- Future Activities:

- Inclusion of requested (by DLR) QA-reports on the FTP server at ESRIN
- Monitoring of calibration parameters
- Plots of selected parameters over 3 days (global coverage - RGB compositions)

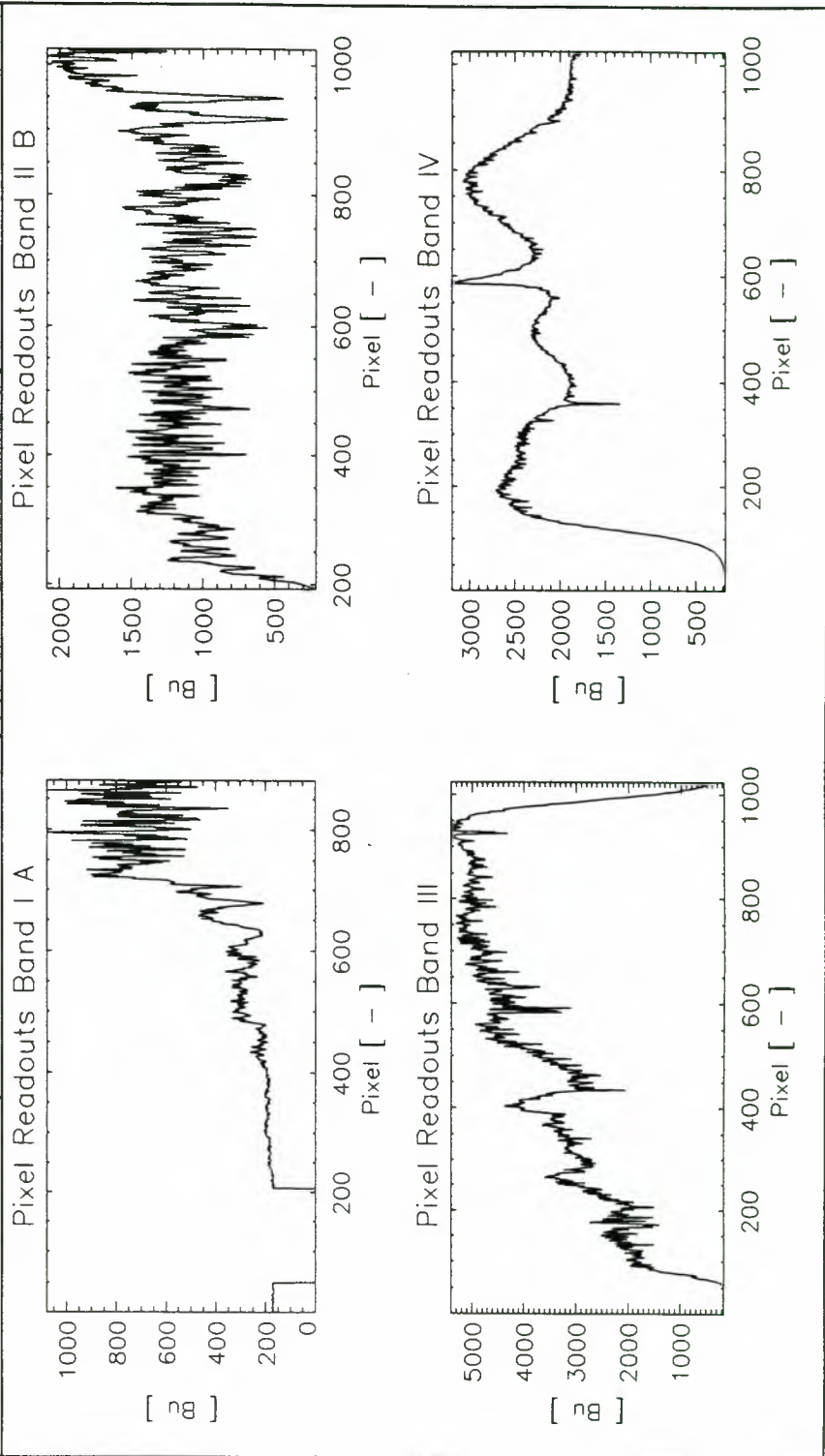
COME -- LONG LOOP ANALYSIS -- PARAMETER



4 GOME (Raw Data) Spectral Bands - Moon Observation

GOME – EGOC ANALYSIS – PARAMETER

Print Date: 09-Aug-1995 11:08:12 h	File Name: EGOC_950718115234.E2;1	UTC Start: 18-JUL-1995 09:31:39	Product Number: 2900 of 3991
Station ID: Kiruna Station (KS)	File Date: 18-07-1995 Orbit:1264	UTC End : 18-JUL-1995 11:11:25	Time: 18-JUL-1995 10:44:08.920



CONCLUSIONS:

- **ESRIN GOME QA tools qualified and operational**
- **Support during Commissioning to the GOME Project team at ESTEC**
- **The software systems are ready for normal operations**
- **Long-term Interaction with user and scientists (GSAG) essential**
- **Useful experience for QA/LLSP on future missions**



ERS-2

GOME Geophysical Validation

Evert Attema
ESA/ESTEC/NWA

GOME Validation





esa

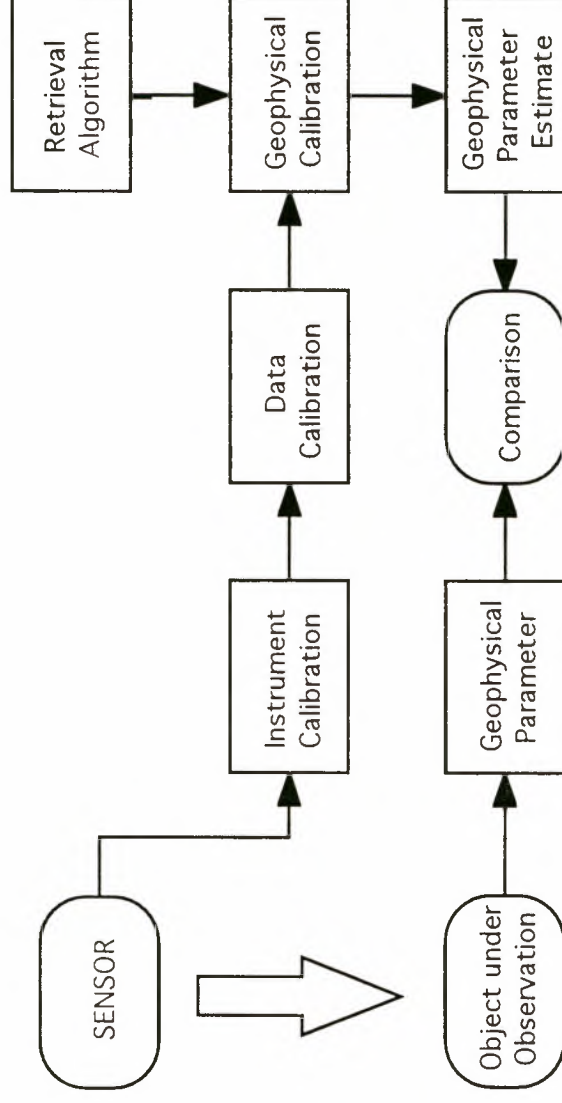
ERS-2

Contents of the Presentation

- Principle of Geophysical Validation
- The Geophysical Validation Team
- Time Table of Activities
- Current Status
- European In-Situ Data Collection Stations
- Preliminary Data Analysis

GOME Validation

Principle of Geophysical Validation





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The Geophysical Validation Team

- Composition
 - 19 teams (B,CH,D,F,I,N,NL,NZ,UK,USA)
- Tasks
 - comparison of in-situ data from ground stations and other satellite with GOME data products
 - Feedback to instrument calibration and algorithm update
 - accuracy statement at the end of commissioning
 - recommendation for release of data

GOME Validation

Time Table of Activities

- Team Meetings
 - Sun Spectrum meeting 8 June 1995
 - First Validation meeting 14/15 September 1995
 - Second Validation meeting 20/21 November 1995
 - Final Workshop 24-26 January 1996
- Data Collection
 - Blind (w/o GOME) in-situ data collection : July-October 1995, extension requested to end 1995
- Data Analysis
 - Limited number of orbits, no polarisation correction
 - Regular distribution of reprocessed data by end October



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Current Status

- Three Month of In-Situ Data in NILU Data Base
- Joint S/W Development by Investigators
- Data Analysis about to Commence

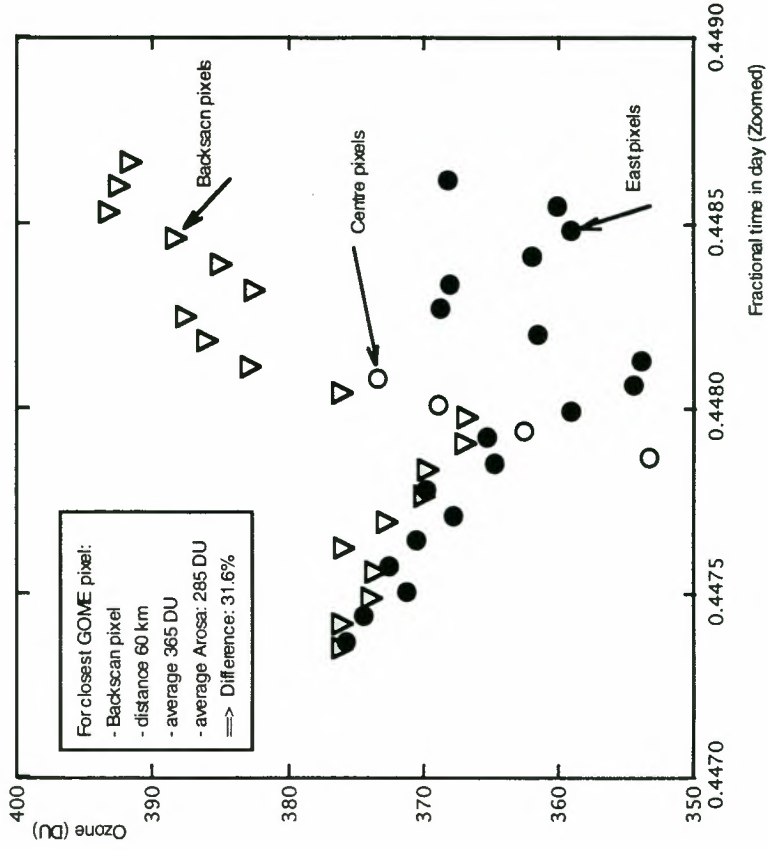
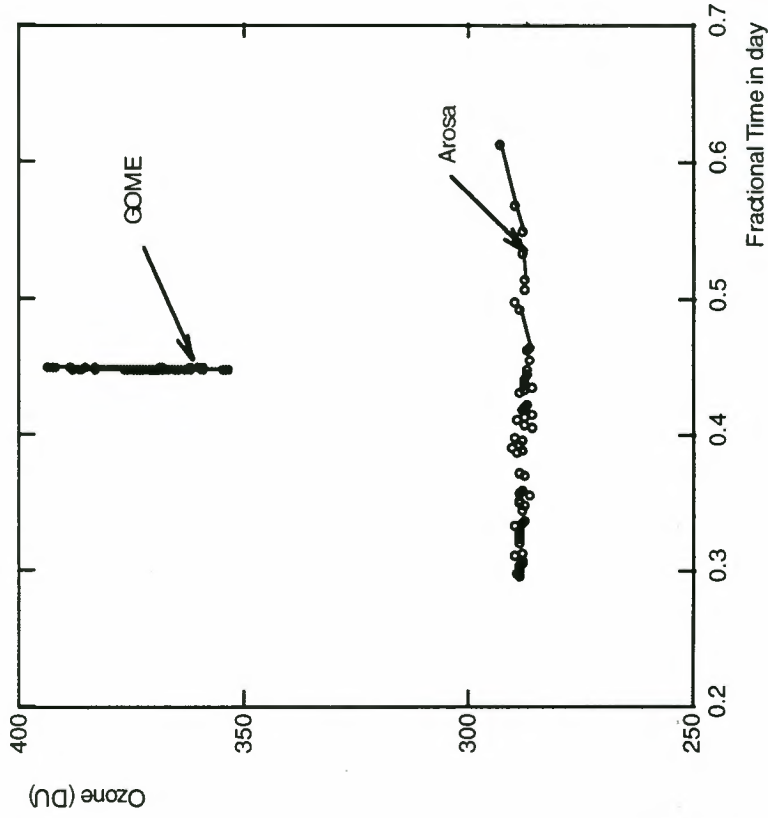
GOME Validation





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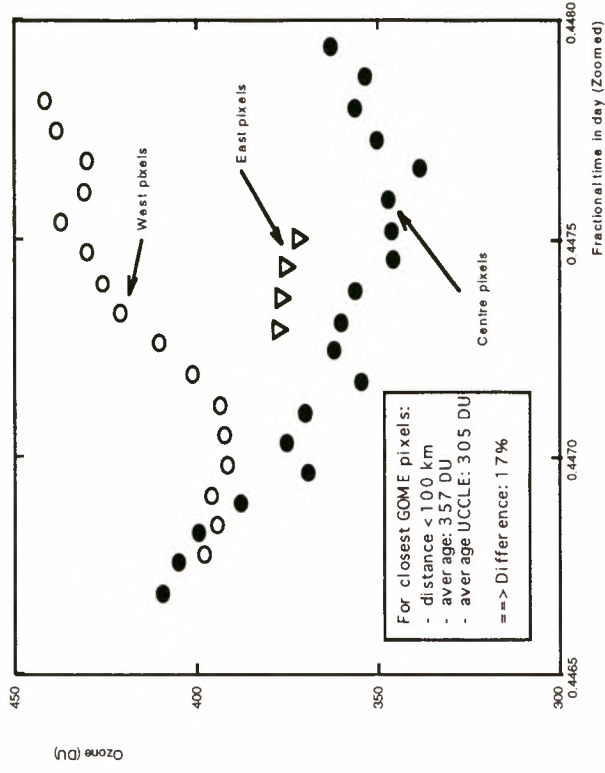
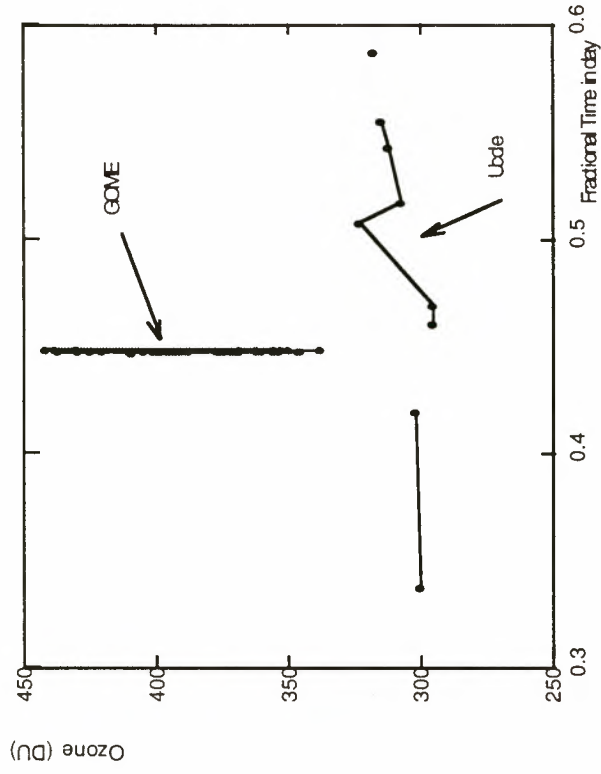
AROSA Station, 22 July 1995





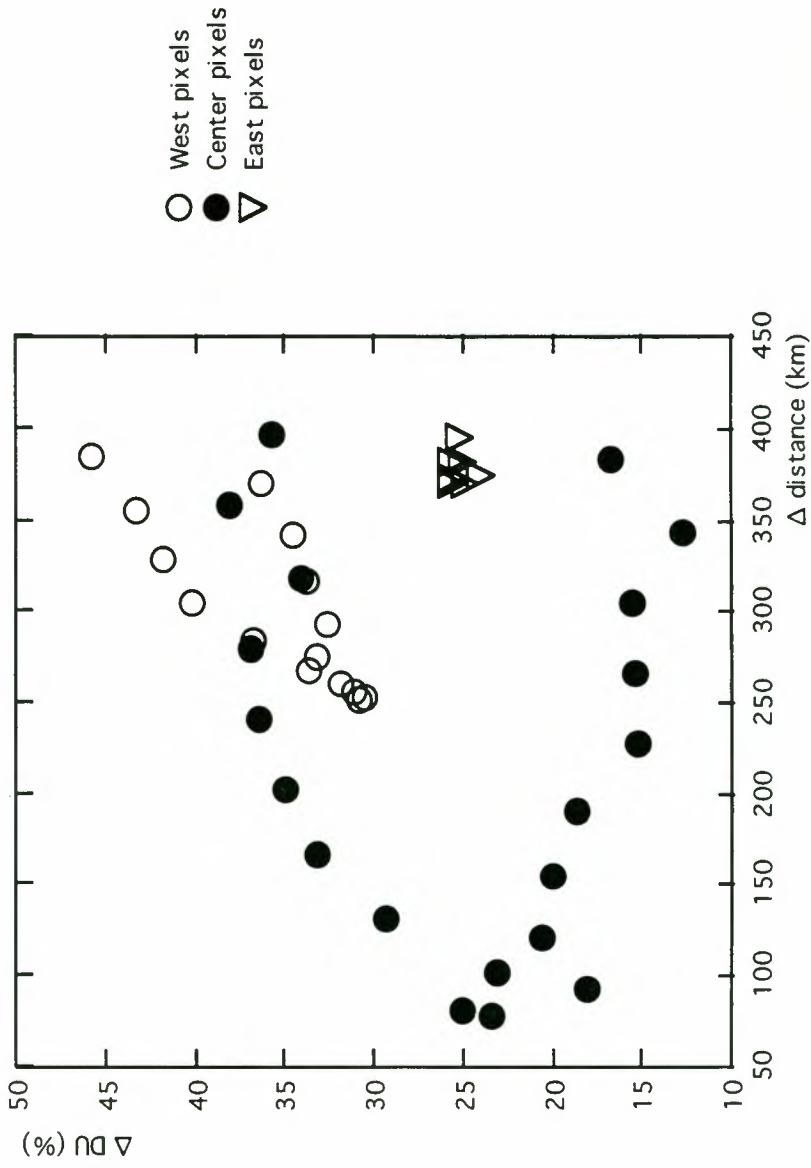
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UCCLE Station, 22 July 1995

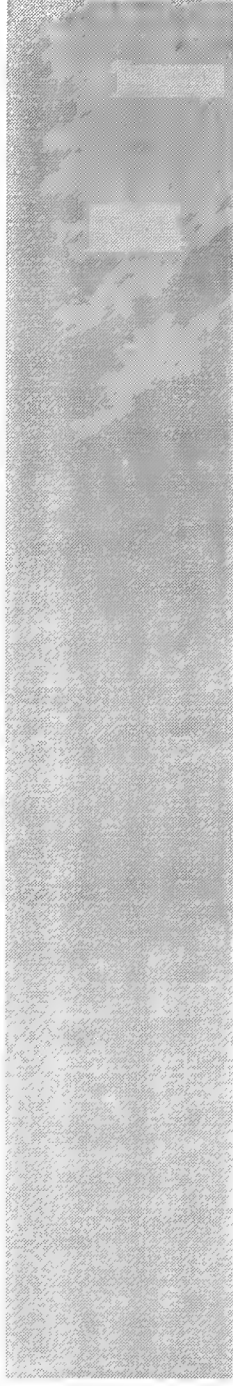


GOME Validation

De BILT Station, 22 July 1995



Difference DU (%) vs distance from station (km)



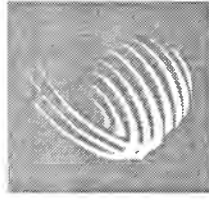
ATSR-2

Ground Segment Commissioning & Calibration Validation

Dr. Chris Mutlow

ATSR-1 Principal Investigator & ATSR-2 Project Scientist

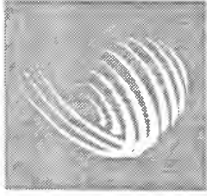
Council for the Central Laboratory of Research Councils
Rutherford Appleton Laboratory
Chilton, Didcot, United Kingdom



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Contents of Presentation

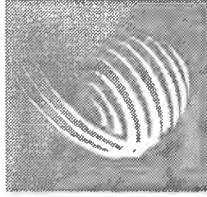
-
- Introduction
 - ATSR-2 Instrument & the data products from ATSR-2
 - Commissioning/Calibration and Validation Strategy
 - Pre-flight & in-flight
 - Products validation
 - Raw data
 - Level 1 product
 - brightness temperatures
 - Visible TOA uncorrected reflectances
 - Level 2 products
 - Sea Surface Temperature
 - Geophysical Validation
-



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The ATSR-2 instrument

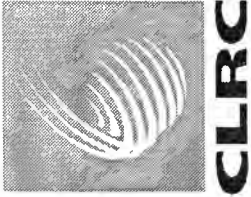
- ATSR-2 is the enhanced version of the ATSR instrument for ESA's ERS-2 satellite.
- ATSR-2 continues the SST climate record started by the ATSR-1 instrument, so has the same four IR channels as ATSR-1 (i.e. 1.6, 3.7, 10.8 and 12 μm).
- ATSR-2 includes new visible channels for vegetation remote sensing:
 - 0.56 μm (green)
 - 0.67 μm (red)
 - 0.87 μm (near-IR)



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The ATSR-2 instrument *cont.*

- Limited data rate on ERS-2 so ATSR-2 has a complex set of operating modes to maximise the collection of visible channel data
 - High rate (max. 60 min/orbit) when scatterometer not in wind/wave mode gives all visible channel data to 12-bits
 - Low rate
 - narrow swath with high digital res. (i.e. 180km & 12-bit)
 - wide swath with low digital res. (i.e. 500 km & 8-bit)
- Improved IR digital resolution over ATSR-1 at night
 - at night all ATSR-2 IR channels at 12-bit resolution (cf. ATSR-1 where some channels were only 11-bits)
 - daytime IR data same formatting as ATSR-1.



ATSR-2 - New Products ungridded 1-km image

- High resolution ungridded^{*}, geolocated scans of data from each of the IR channels for both the forward and nadir views. The product contains 512 scans.
 - infrared brightness temperatures for 3.7, 10.8 and 12 μ m channels
 - uncorrected visible reflectances (i.e. not atmospherically corrected) for 0.56, 0.67, 0.87 and 1.6 μ m channels.

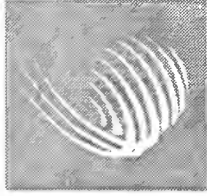
* These products have been retained in scan co-ordinates (i.e. in the instrument co-ordinate system) to make them more useful to the land community.



ATSR-2 - New Products gridded 1-km image

- High resolution gridded^{*}, geolocated and co-located images for both the forward and nadir views (spatial resolution nominal 1km nadir and 2km in forward view). Product covers 512 x 512 km.
 - Brightness temperature.
 - uncorrected visible channel reflectances
 - Sea surface temperature & cloud clearing information.
 - vegetation product.

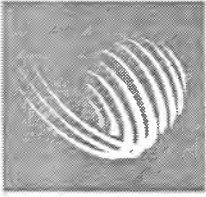
* This product is on a 1km grid and the forward and nadir views for the same scene are in the product.



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ATSR-2 - New Products spatially-averaged products

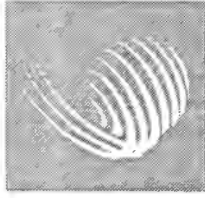
- These products are spatially averaged over 30 arc-minutes and 10 arc-minutes of latitude and longitude, both resolutions are present in each product.
 - spatially-averaged composite brightness temperature.
 - sea surface temperature - ATSR-2's main climate product.
 - cloud product.
 - land surface temperature.
 - vegetation (*under development*)
 - aerosol using dual view (*under development*).



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Strategy

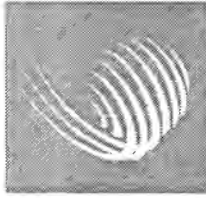
-
- Instrument design
 - high-signal to noise
 - stability
 - in-flight calibration
 - Careful pre-flight calibration using upgraded version of ATSR-1 facility
 - Product Q/A & validation
 - In-flight calibration and cross-calibration with ATSR-1
 - Validation of geophysical data products
-



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ATSR-2 Pre-Launch Calibration

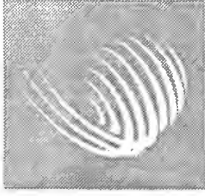
- To ensure the instruments were well calibrated both ATSR-1 and ATSR-2 were subjected to a rigorous pre-flight calibration
 - radiometric and linearity checks over the full range of scene temperatures
 - consistency checks around the whole scan
 - stability under simulated BOL, EOL and orbital conditions.
 - field of view determination
 - spectral testing
 - Same test facility used for calibration of both instruments
 - pre-launch calibration of the visible channels
-



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ATSR-2 In-Flight Calibration

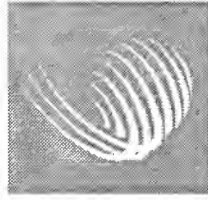
-
- ATSR-1 & 2 include two high precision, ultra-stable blackbody calibration targets - one cold and one hot - spanning the range of expected SST.
 - around orbit ΔT less than 0.5K
 - blackbodies temperatures interchanged periodically through the mission to ensure they provide consistent results
 - ATSR-2 has an on-board visible calibration system allowing it to view the sun each orbit to provide a calibration reference.
 - ATSR-2 views the sun via a Russian Opal diffuser.
 - the Opal is protected by an optical glass window.
 - already discussed in presentation on ATSR-2 in-flight commissioning
-



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Raw Data

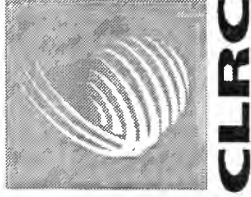
- ATSR Processing system performs considerable amount of data Q/A to check the raw data as it is read
 - testing of software with data collected during ground testing
 - timing consistency
 - duplicate packets
 - missing packets
 - checksum errors
 - detection of instrument anomalies
 - flagging of non-nominal orbits (i.e. when geolocation may be less reliable)



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ATSR-2 Ground Processing Software Status

- Current version has basic processing up to the level 2 products implemented. However, this is not final release so has the following caveats.
 - BT product currently in final stages of validation
 - Visible channels calibrated using pre-flight values
 - Cloud algorithm still being refined
 - ATSR-1 processing capability not yet included
 - modifications still required to flag scan mirror jitters
 - Initial release of software to UK PAF for testing purposes has been completed
 - Software ready for delivery to Tromsø for testing.
-



Level 1 Product validation

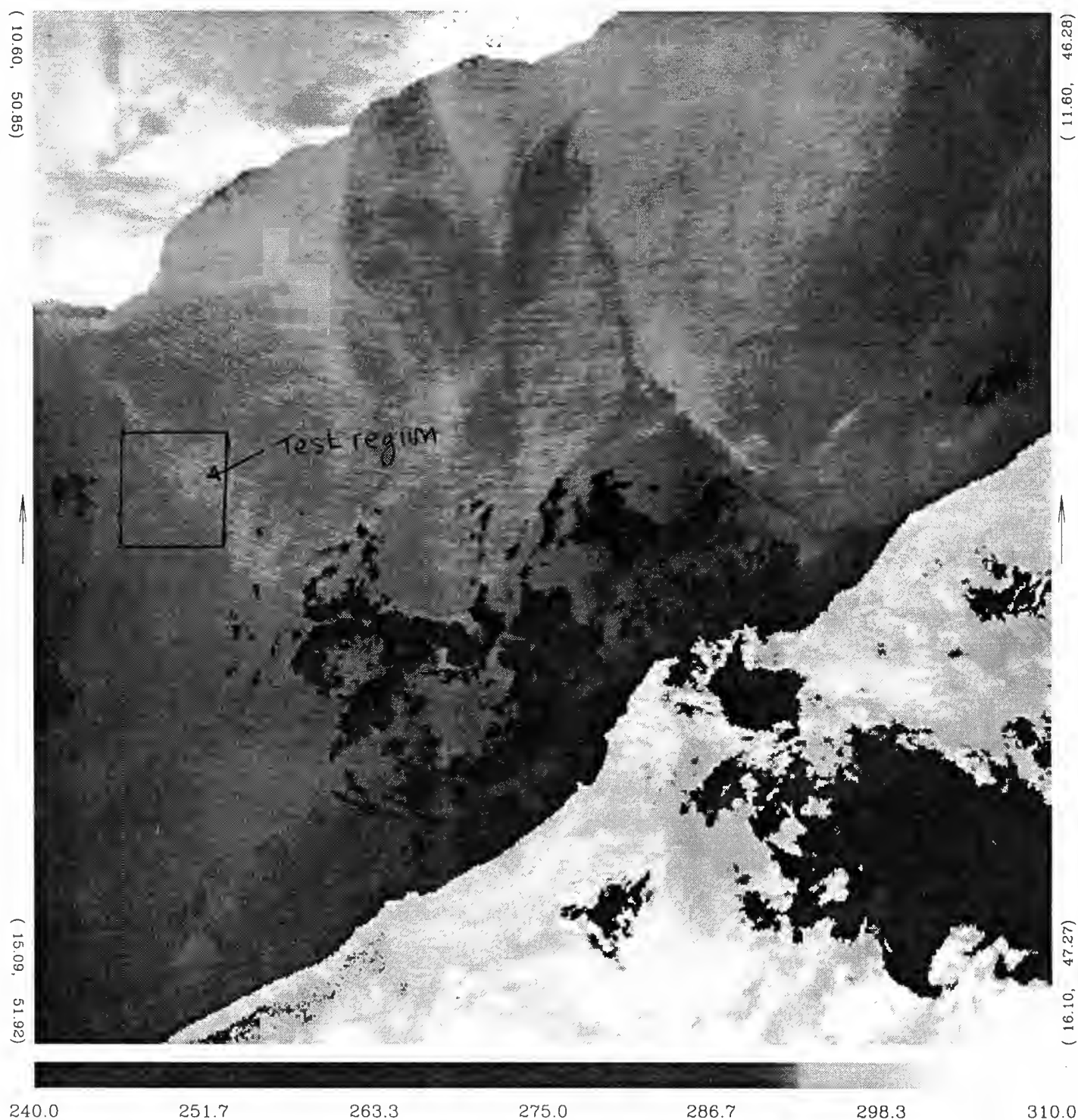
-
- Brightness temperature images currently in the last stages of validation
 - RAL expect to declare them ready of general use by mid-November.
 - flagging of scan mirror jitters still to be included
 - Procedure involves a comparison of ATSR-1 and ATSR-2 images separated by one day.
 - tests of image co-location/geolocation using coastlines
 - comparison of brightness temperatures in uniform areas of the image
 - Campaign data is then used to provide geophysical validation for the brightness temperatures and the visible radiances. (*see later slides*)
-



Sample Level 1 validation

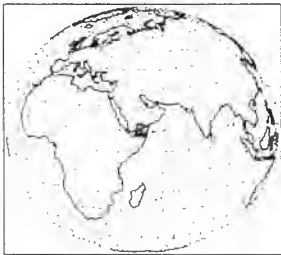
-
- Images of Red Sea
 - ATSR-1 image collected on 19th August 1995
 - ATSR-2 image collected on 20th August 1995
 - Results of comparison after correction of different starting locations for the image
 - pixel to pixel geolocation/colocation in the range 0.01 to 0.03°
 - higher noise level on the ATSR-1 image
 - BTs in marked area agree better than 0.08 to 0.3°C despite being collected 1 day apart
 - This result indicates that the ATSR-1 and ATSR-2 instruments and their processing schemes agree well in all the images we have tested to date.
-

ATSR-1 Test image



ATSR nadir view 11.0 μ m brightness temperature
Histogram equalised between 240 and 310 degrees Kelvin

The product file is RAL_LRDTF\$508190635_18500_51003_A600.BT
The colour table is MONO.RGB
COPYRIGHT ESA/EPSRC/RAL 1994



ATSR-2 Test Image



Collected 20/08/95

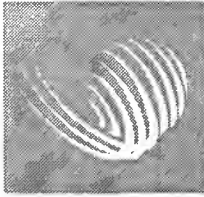
Histogram Equalised between 240 and 310 degrees Kelvin

©ESA/RAL/NERC



Level 2 Product Validation

- The validation of the SST and ASST products from ATSR-2 will get underway within the next few weeks
 - once the optimisation and testing of the new ATSR-2 cloud algorithm is completed.
 - the algorithm is at an advanced stage of development
- The validation of these products is described on the following slides.



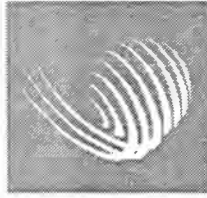
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Geophysical Validation

- The ATSR 1 and 2 instruments carry in-flight calibration targets so are self-calibrating (with the exception of the 1.6 μ m channel on ATSR-1) so we only use campaigns for validation of the data.
 - The aims of this validation procedure are
 - verify ATSR-1 and 2 meet their design goals for accuracy and precision (infrared and visible) in-flight conditions
 - verify ATSR-1 & 2 radiometric calibration (both visible and infrared) are consistent with pre-launch calibration
 - test radiative transfer model used in the retrieval process
 - understand the effects of spatial sampling and scene variability
 - test of the long-term stability of the system using external data
-

ID	Task Name	Duration	Start	Finish	Q2 '96			Q3 '96			Q4 '96			Q1 '97			Q2 '96			Q3 '96			Q4 '96			Q1 '97		
					A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
1	SATE	20d	01/05/95	27/05/95																								
2	SATE-2	15d	18/09/95	06/10/95																								
3	RACE (Nova Scotia)	21d	14/08/95	11/09/95																								
4	SUDOFEX	326d	01/09/95	29/11/96																								
5	MUBEX	34d	17/07/95	31/08/95																								
6	ACE 1	23d	01/11/95	01/12/95																								
7	CGBAP Cape Grim	524d	17/04/95	17/04/97																								
8	CSIRO Hay Site	522d	17/04/95	15/04/97																								
9	ATSR-1 Inter comparisons	53d	17/05/95	28/07/95																								
10	TOGA TOA Comparisons	522d	17/04/95	15/04/97																								
11	La Crau	17d	03/07/95	25/07/95																								
12	Zimbab	36d	29/09/95	17/11/95																								

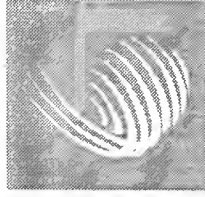
Project: ATSR-2 Validation Date: 26/09/95	Task	Milestone	Rollled Up Task	Rollled Up Progress
	Progress	Summary	Rollled Up Milestone	



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ATSR-2 Campaigns

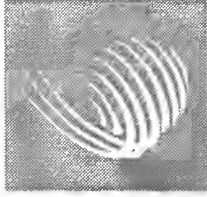
-
- A series of ATSR-2 campaigns are planned during the mission to address various aspects of the geophysical validation.
 - *see schedule*
 - Some of these campaigns have already taken place
 - MUBEX SST validation Mutsu Bay, Japan in July/August
 - SATE-1 and 2 with the UK MRF aircraft
 - Visible calibration over the La Crau site in the S. France
 - Zimbabwe campaign now underway
 - Long-term ATSR-1 & 2 validation in Australia at a number of land sites
 - Long-term monitoring and cross-calibration of ATSR-1 & 2 SST data using TOGA TOA Array
-



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Status of ATSR-2 Validation

- Basic validation of the ATSR-2 level 1 and 2 products against validated ATSR-1 equivalent products underway, level 1 almost complete.
 - Initial ATSR-2 level 1 data sets are being prepared .
 - Analysis of ATSR-2 validation campaign data will start once the ATSR-2 cloud algorithm is optimised
 - Data from MuBEX already being analysed, although bad weather reduced the number of co-incidences.
 - Software for the intercomparison of ATSR-1 and 2 SST and ASST data is already.
-

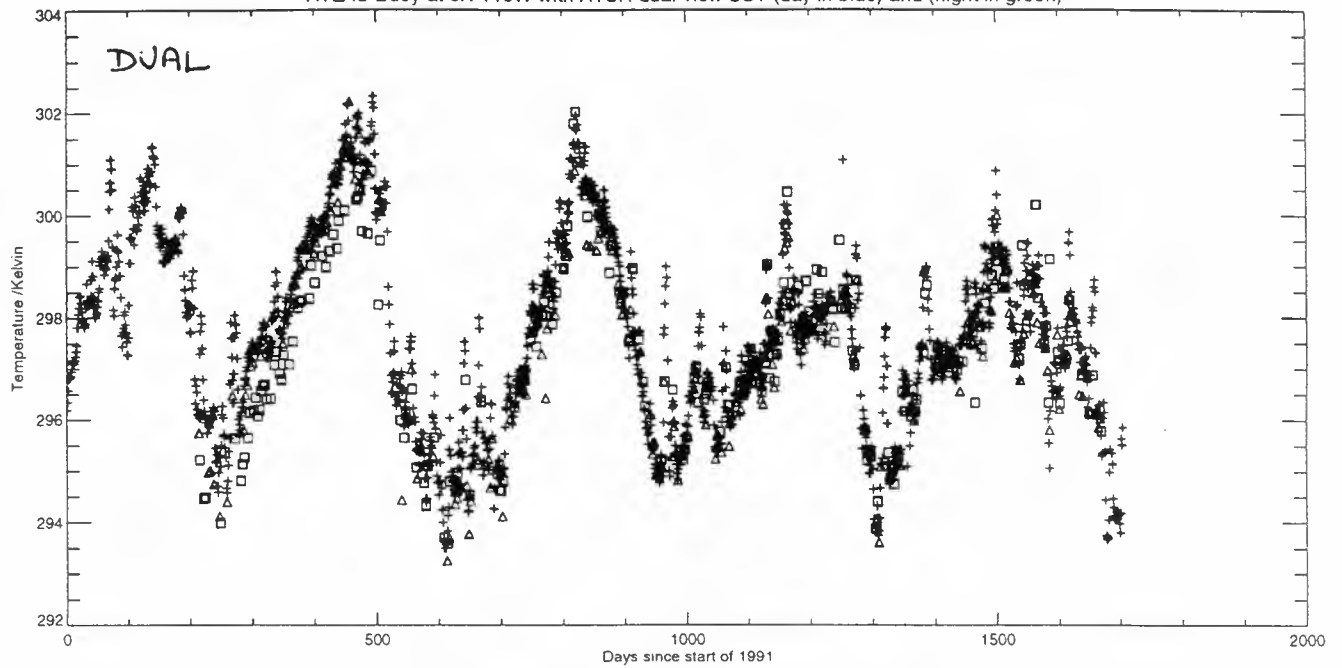


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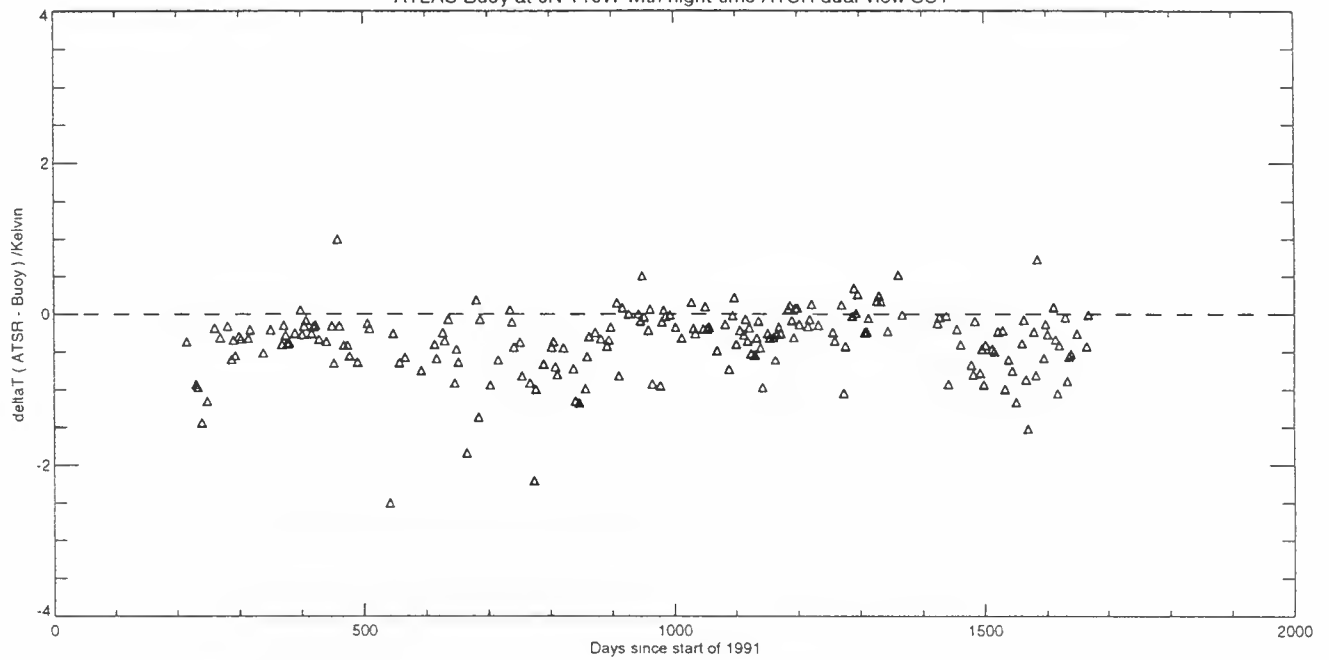
Example of long-term consistency of Spatially-averaged SST ATSR-1 data

-
- Following figures show a comparison of ATSR-1 spatially-averaged SST data with SST observed by TOGA TAO buoy at 0°N 110°W
 - crosses are buoy observations averaged over 1 day (provided by NOAA PMEL)
 - triangles are ATSR-1 night-time SST retrieval
 - squares are ATSR-1 day-time SST retrieval
 - Comparisons shown from the nadir-only retrieval and the dual view retrieval
 - Comparisons show very good agreement between ATSR-1 and the buoy, despite no correction for skin-bulk difference.
 - dual-view retrieval closer to the buoy than nadir-only
 - dual view retrieval less susceptible to Mt. Pinatubo aerosol
-

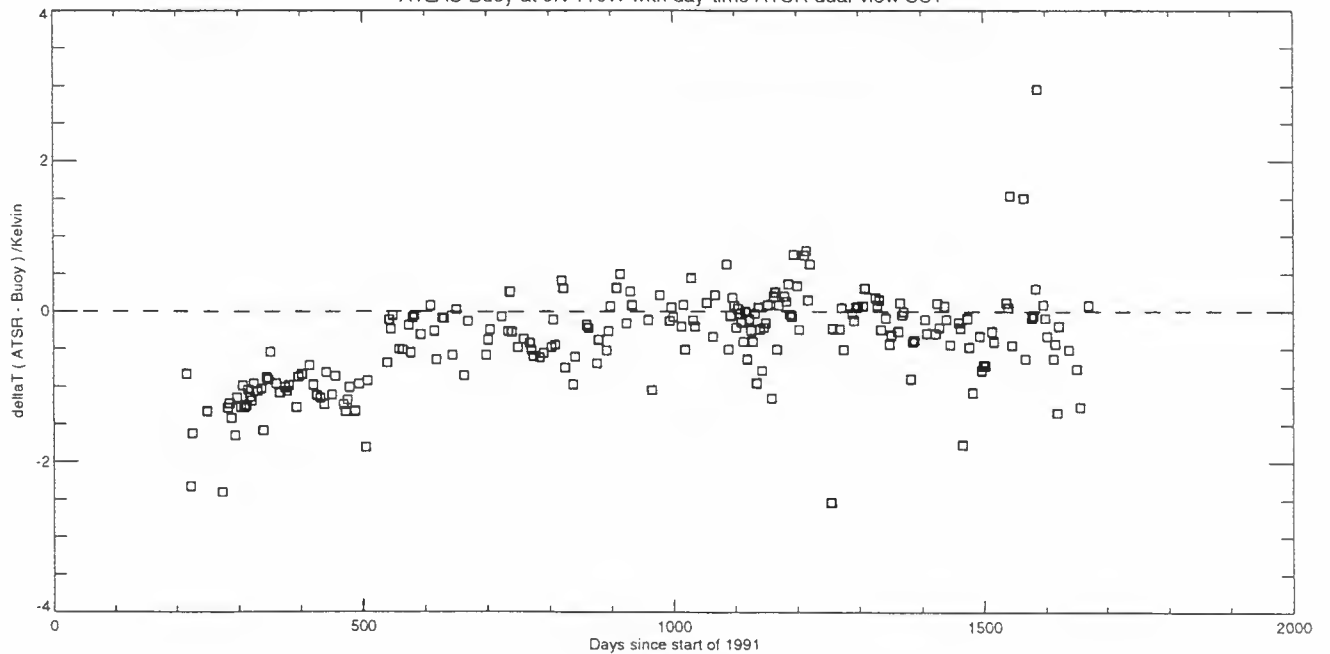
ATLAS Buoy at 0N 110W with ATSR dual-view SST (day in blue) and (night in green)

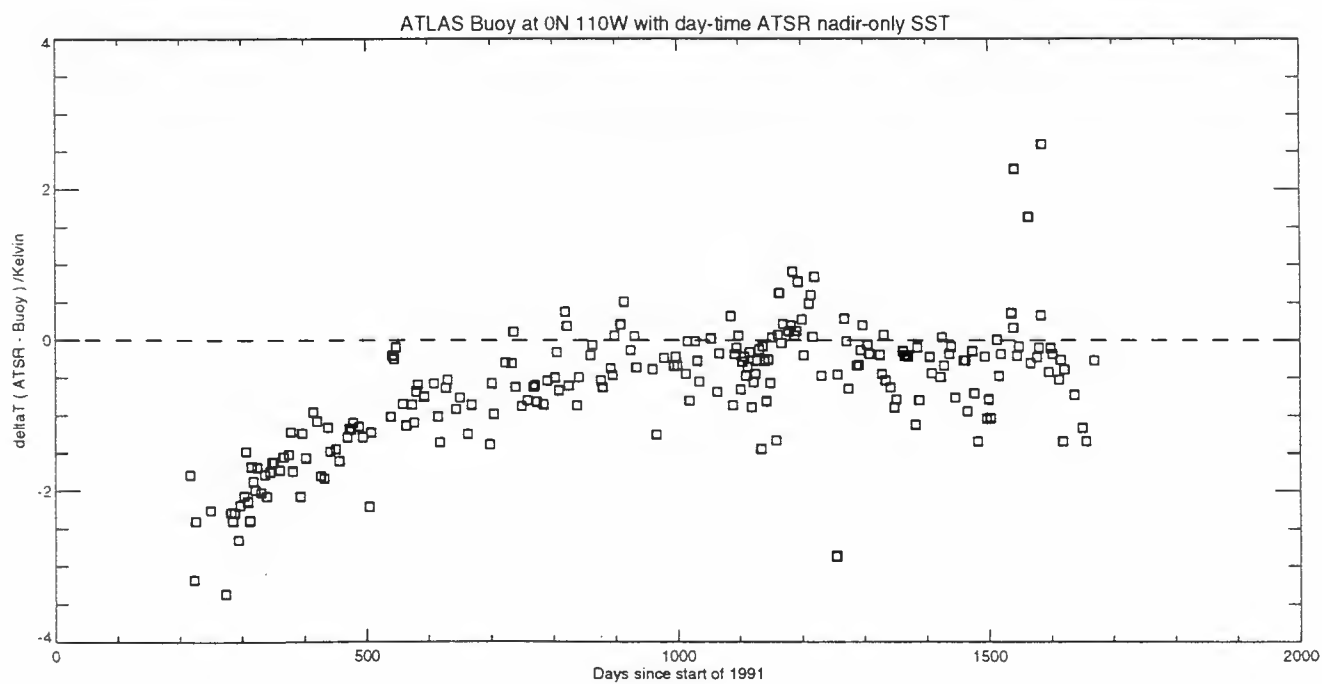
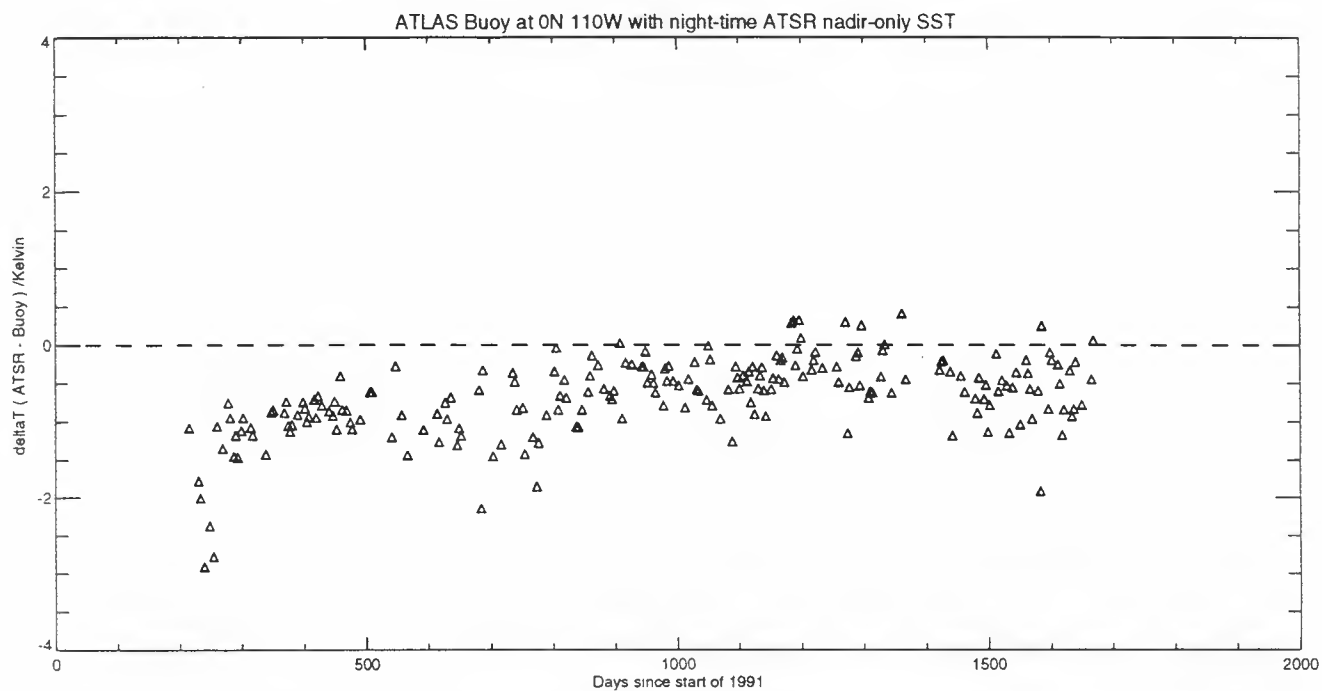
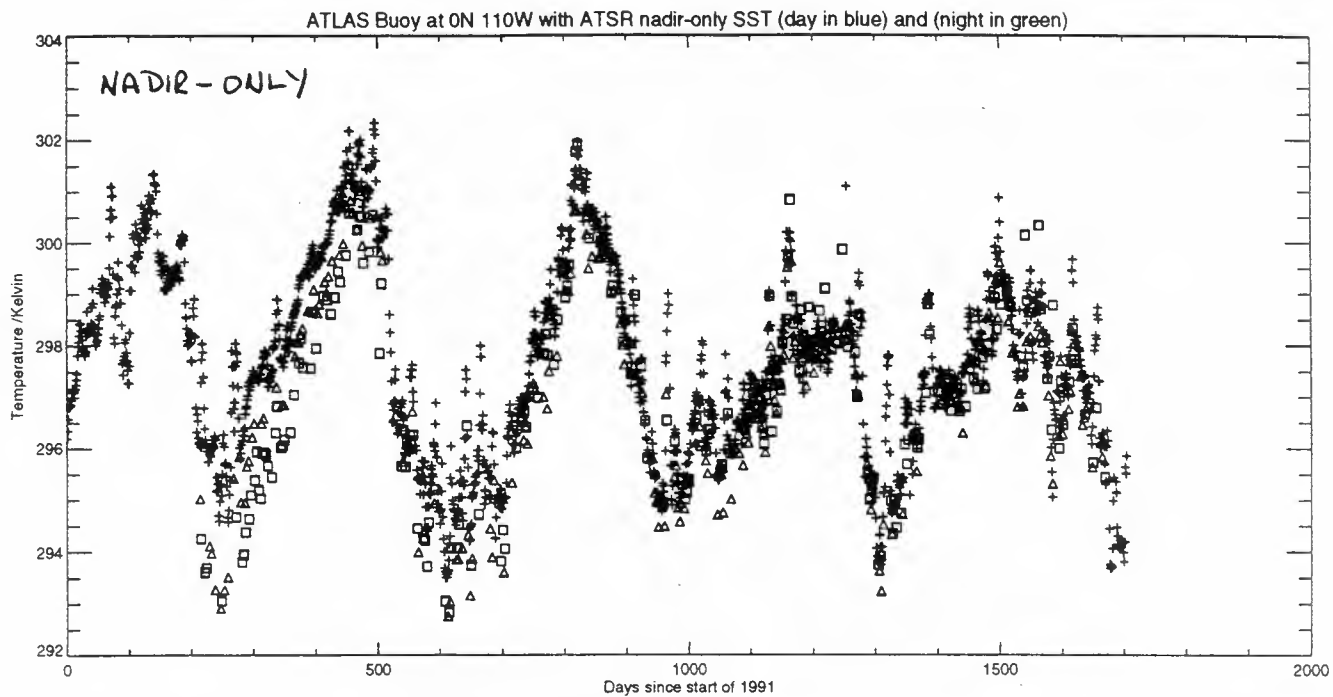


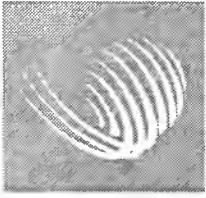
ATLAS Buoy at 0N 110W with night-time ATSR dual-view SST



ATLAS Buoy at 0N 110W with day-time ATSR dual-view SST



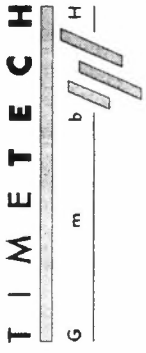




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Conclusions

- Data from ATSR-2 shows lower noise than ATSR-1 data
- ATSR-2 ground processing software complete and validated to level 1.5, expected release date mid-November
- Level 1.5 products from ATSR-2 cross validate well with ATSR-1 products.
- ATSR-2 cloud algorithm near completion and SST data expected to be released to validators within the next month.
- Expect release of validated SST products early in the new year
- Expect release of ATSR-2 visible channel data calibrated using the VISCAL unit early in the new year



ERS-2 Commissioning Review #1

PRARE Instrument Calibration and Validation

Wolfgang Schäfer, Martin Kufner
TimeTech GmbH

ESRIN, Frascati, 26/27 Oct 1995

Table of Content

1. Available data and analysis methods	3
2. Calibration and corrective parameters	4
3. Examples of data evaluation, range versus doppler comparison	5
4. Internal delay calibration	8
5. Channel-to-channel range bias	10
6. Instrument Calibration Status	11
7. Conclusions	12

1. Available data and analysis methods

- Calibration values are derived from instrument design characteristics
pre-launch data gathered during thermal and TV test campaigns
in-orbit monitoring of routine data, H/K and science data
dedicated test-sequences on-board activated upon ground command
automatic instrument internal calibration using the built-in calibration transponder after each G/S contact
- Dedicated configurations of ground stations have been used like:
all channels tracking one single station, which excludes station and signal path induced effects
tracking of closely located stations at a distance of about 160 m, which excludes signal path induced effects
- Analysis S/W is available to
cross check range and range rate using “differenced range versus integrated doppler” (DRVID) in a single channel
compare results from different channels or closely co-located G/S
automatically plot of orbital parameters, satellite configuration, H/K parameters and science data to detect correlations
- Functional verification is performed by comparison of predicted G/S contact time (from 0° to 0° elevation) to the actually obtained number of data from a G/S. This verifies the combined S/C and G/S operational performance.

2. Calibration and corrective parameters

- **Range** measurements
 - are corrected for instrument internal characteristics (like time-tagging of measurements, data averaging etc.)
 - The instrument internal delay is derived from calibration translator data available after each G/S contact and from instrument temperature
 - Corrections to the instrument internal delay are further applied using
 - range versus signal doppler calibration
 - range versus signal amplitude calibration
 - Range is corrected for the actual frequency of the on-board clock
- **Doppler** measurements are stable by design of the instrument due to the two-way nature of the measurements
 - the only correction is due to the frequency of the on-board clock
- Monitoring of the on-board **clock** is continuously performed by GFZ using a dedicated time system located at Oberpfaffenhofen. A two-way method is used, which allows to separate between orbit errors and clock errors.

3. Examples of data evaluation, range versus doppler comparison

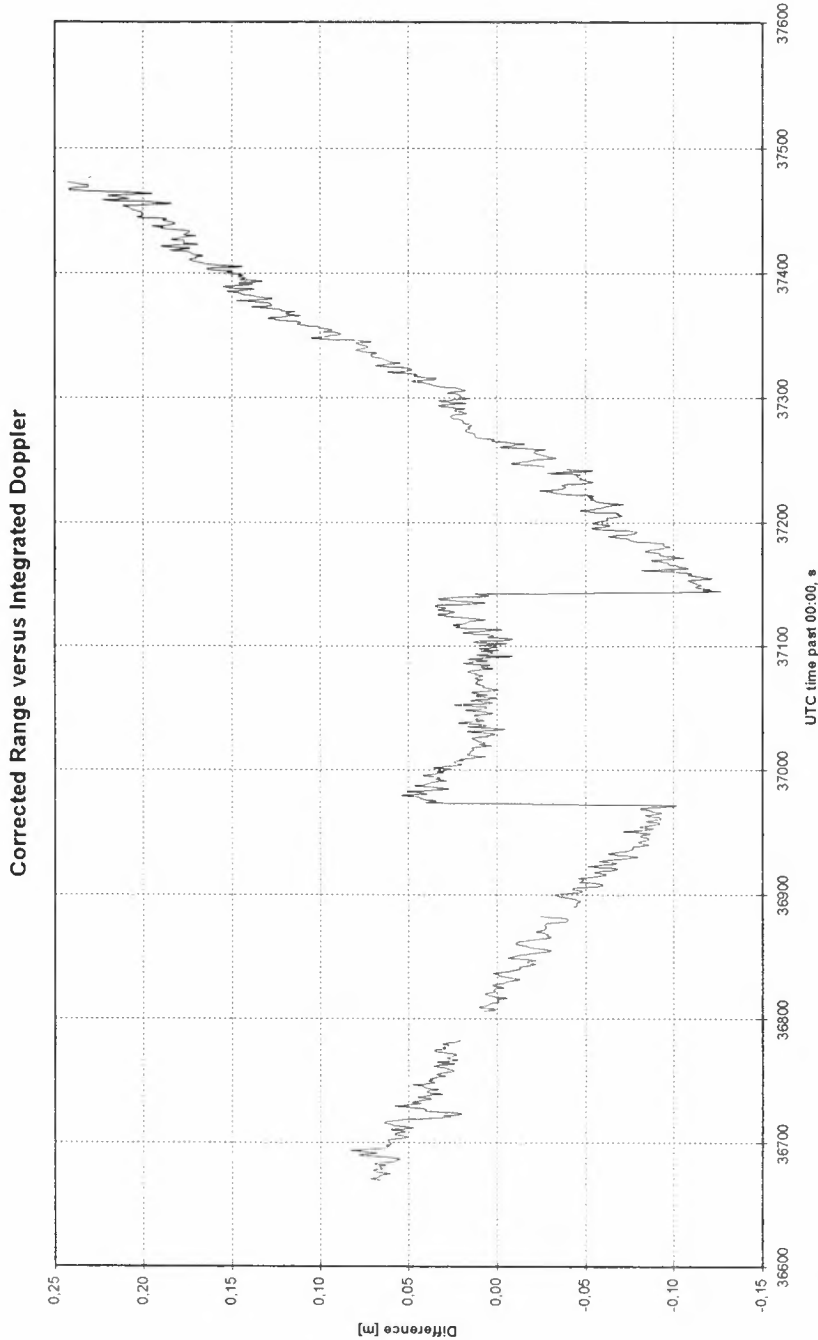


Fig 3-1:

- difference due to ionosphere is clearly visible
- noise of the range measurement is less than 2 cm (noise on carrier phase can be neglected)
- range jump introduced by G/S during power level reduction at close distances can be clearly detected

Corrected Range and Integrated Doppler, polynomial approximation
(pass : Potsdam 17.05.1995 10:12)

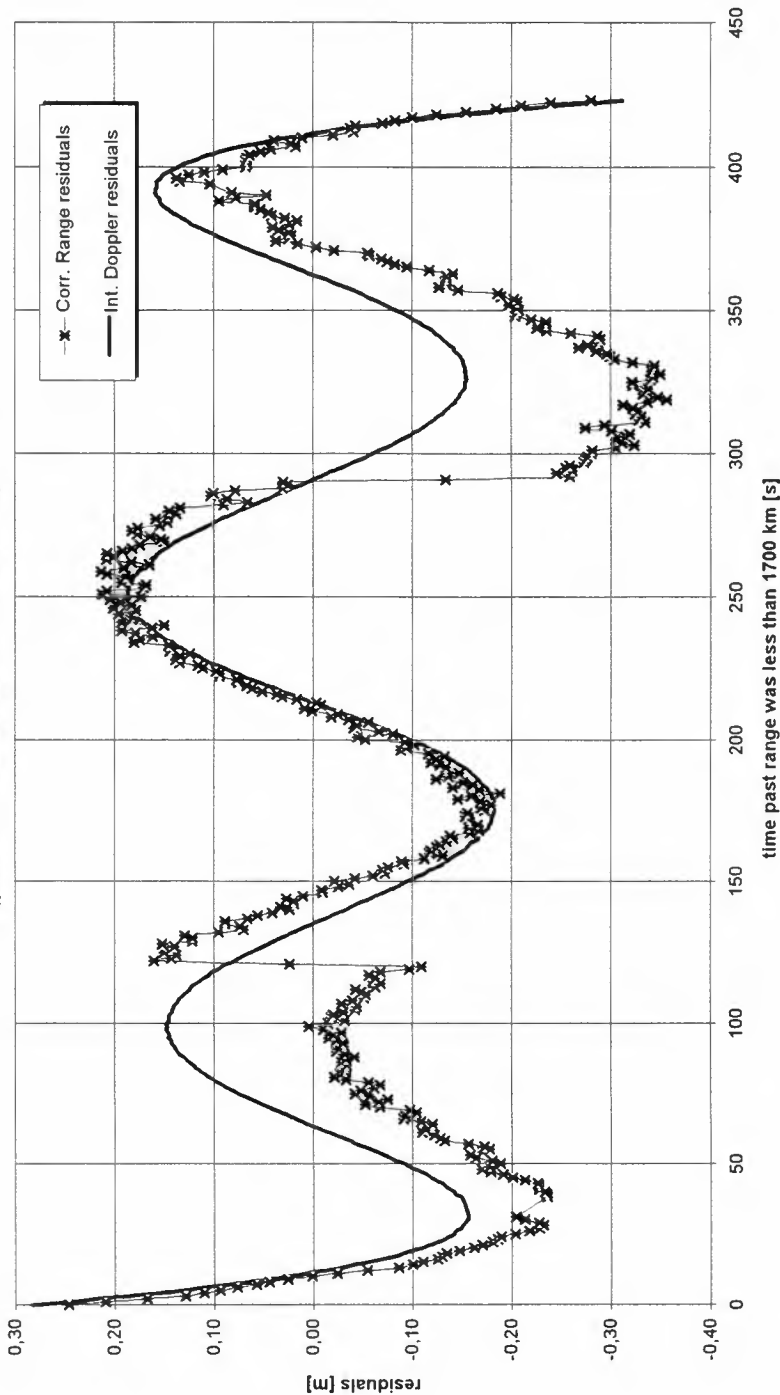


Fig 3-2:

- same range and range-rate data as in Fig. 3-1. (seconds 36850 ... 37300)
- range jump introduced by G/S during power level reduction at close distances can be clearly detected
- integrated doppler shows very low noise, which cannot be detected at this scale
- there are no cycle slips, even not at the points of range jumps
- DRVID method is a valuable tool to verify instrument stability and for detailed analysis

Difference between integrated doppler from two co-located stations at Potsdam

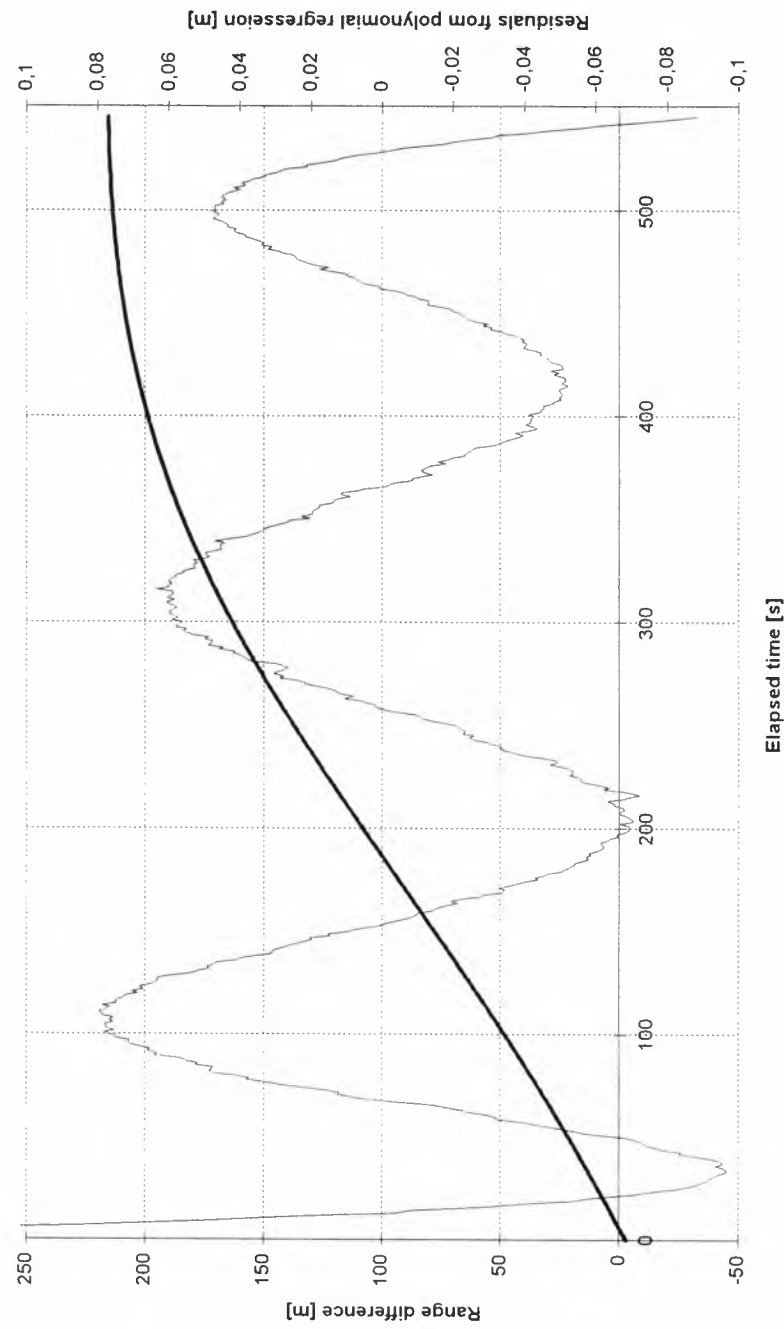


Fig 3-3: - Difference between integrated doppler obtained from two stations located at Potsdam (left scale)
- Residuals after regression demonstrate the level of noise in range-rate data (right scale)

4. Internal delay calibration

Averaged Box Temperature of PRARE-2 A

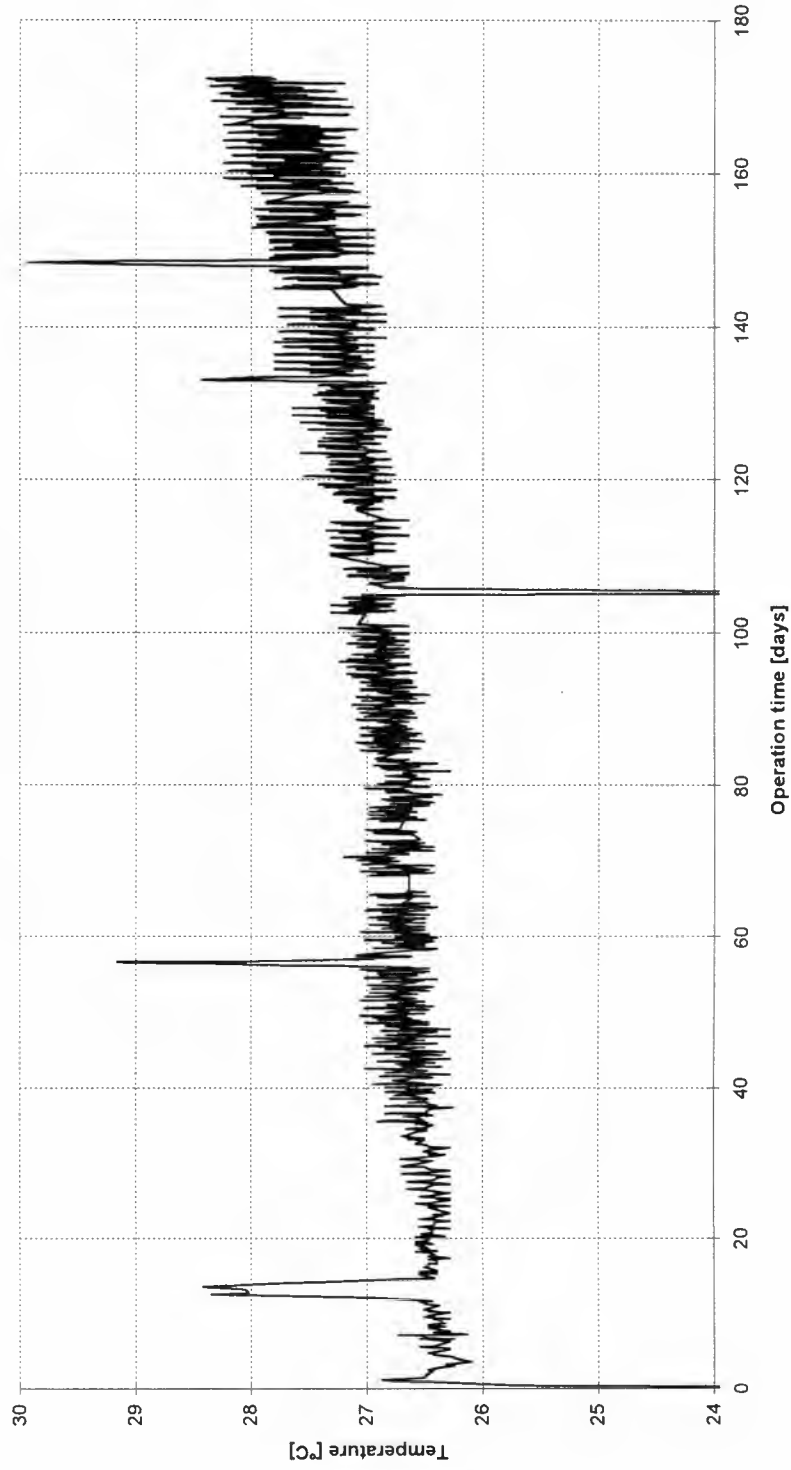


Fig. 4-1: Instrument temperature during internal calibration runs. Note higher excursions at right, where more stations at different locations are participating. Low peak due to switch-off on Aug 8th.

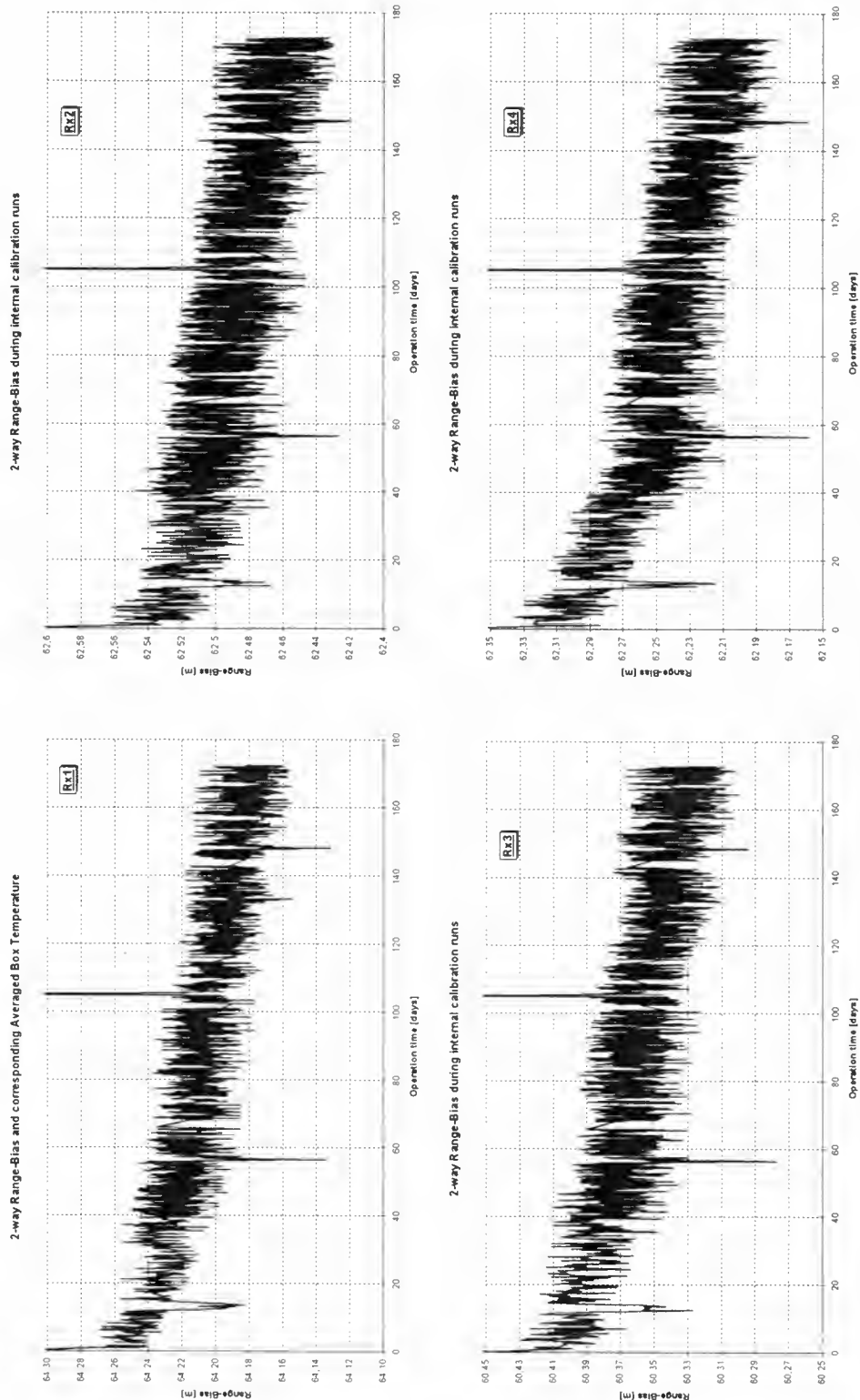


Fig. 4-2: Instrument internal delay calibration (about 3400 runs) show strong correlation between internal delay and box temperature. This allows to derive correction values directly from box temperature, which provides even higher precision than from internal range calibration alone. Corrected values have been presented in part I of this meeting.

5. Channel-to-channel range bias

- After application of all corrections derived from pre- and in-flight data, there are residual biases in between channels.
- These biases are stable for each location, from which multi-channel test are available.
- The biases show so far unexplained differences, when results from different stations are compared (highest number of passes are obtained from stations at **Bangalore** and **Greenbelt**)

Diff between Channels:		1 - 4		1 - 4		2 - 4		2 - 4		3 - 4		3 - 4		1 - 3		1 - 3		2 - 3		2 - 3		1 - 2		1 - 2	
Station	Passes	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev	Mean	StDev
Bangalore	80	-17,2	1,1	-5,6	1,0	-2,4	1,1	-14,8	1,2	-3,2	0,9	-11,7	0,9	-11,7	0,9	-11,7	0,9	-11,7	0,9	-11,7	0,9	-11,7	0,9	-11,7	0,9
Greenbelt	28	-14,4	1,2	-4,5	0,8	-2,1	0,9	-12,1	1,3	-2,2	0,8	-9,6	0,8	-9,6	0,8	-9,6	0,8	-9,6	0,8	-9,6	0,8	-9,6	0,8	-9,6	0,8
Oberpf.	6	-17,4	1,8	-5,3	1,5	1,6	0,4	-18,3	1,8	-6,7	1,0	-11,7	1,4	-11,7	1,4	-11,7	1,4	-11,7	1,4	-11,7	1,4	-11,7	1,4	-11,7	1,4
Potsdam	4			-4	1,2	0,6	0,7	-11,5		-4,5	0,9	-7,5	0,9	-7,5	0,9	-7,5	0,9	-7,5	0,9	-7,5	0,9	-7,5	0,9	-7,5	0,9
Weighted Average		-16,0		-5,1		-2,0		-13,8		-3,0		-10,8		-10,8		-10,8		-10,8		-10,8		-10,8		-10,8	

Values in cm

• **Corrective actions**

1. The receiver channel exhibiting the smallest effect has been assigned the highest priority by ground command.
2. Additional multi-channel tests are continuously performed at Greenbelt, Hartebeesthoek and Bangalore.
3. Further “single” stations (i.e. Hawaii, Tahiti) will be used as well as soon as they will be installed.

6. Instrument Calibration Status

Calibration activity	Status	Remarks
Range versus doppler in 4 channels	issued 04/08/95	derived from in-flight calibration, re-calibrated Oct 18, stable to within 1 mm
Range versus temperature	issued 04/08/95	derived from in-flight operations, continuously updated according to temperatures actually experienced by the instrument
Range versus channel AGC	issued 04/08/95	derived from ground testing
Range versus input AGC	none	effect is very minor, nothing detected so far
Channel-to-channel range bias	issued 23/10/95	stable for each G/S, still some unexplained G/S location dependent differences.
Doppler calibration	N.A.	defined by design. The only correction is due to the actual frequency of the internal clock, which is continuously monitored at Oberpfaffenhofen.

7. Conclusions

- Long-term monitoring of instrument internal delay shows slight, un-modelled drift during the first 4 weeks of operation in the order of about 2 cm. It is stable to within about 1 cm thereafter.
- A recent re-calibration of the most dominant correction, which is range versus doppler, compares to about 1 mm to values obtained 8 days after launch.
- Range noise is as predicted from the link budget. It is in the order of 2 cm for most parts of the orbit.
- Remaining inter-channel differences of up to 18 cm after calibration have been accounted for by additional channel-to-channel biases. These values are stable over time to within about 1.2 cm.
- There are still some station-location dependencies on the channel-to-channel biases in the order of about 3 cm. This effect is under investigation.
- The channel showing the highest bias has been assigned the lowest priority. Data from most stations are now from "stable" channels. Continued multi-channel tests will be performed to get more confidence in the calibration values.
- Doppler data show very smooth behaviour. They can be used to detect and correct for range-"jumps" and possibly also for multipath- or scattering-induced errors in range data.
- The instrument shows no cycle slips, i.e. the received doppler cycles are integrated by the instrument without errors under normal receiving conditions.
- Residuals from doppler are still under investigation. Polynomial fits and channel-to-channel comparison show very low noise (less than 0.1 mm/s). There could be still systematic effects which can only be detected by comparison of doppler-data to the real orbit.

Instrument calibration values are available for all known effects.

ERS-1/2 Tandem Mission

ERS-2 Commissioning Review
26-27 Oct 1995



Tandem Mission Formal Documents

- ESA/C(94)150, ESA/PB-EO(94)44 rev.2
ERS-1/2 'Tandem' Exploitation
- ESA/PB-EO/DOSTAG (95)02: The ERS Tandem Mission: Status
and Plans
- ESA/EOPAG(94)12 ERS-1 and ERS-2 operation plan during
Commissioning Phase
- DOSTAG Presentations and Chairman's Reports
ESA/PB-EO(95)76, ESA/PB-EO(95)53
- ESA/PB-EO-DOSTAG(95)11: Revised Tandem Scenario
- ESA/PB-EO-DOSTAG(95)16: ERS Tandem Exploitation

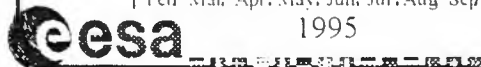
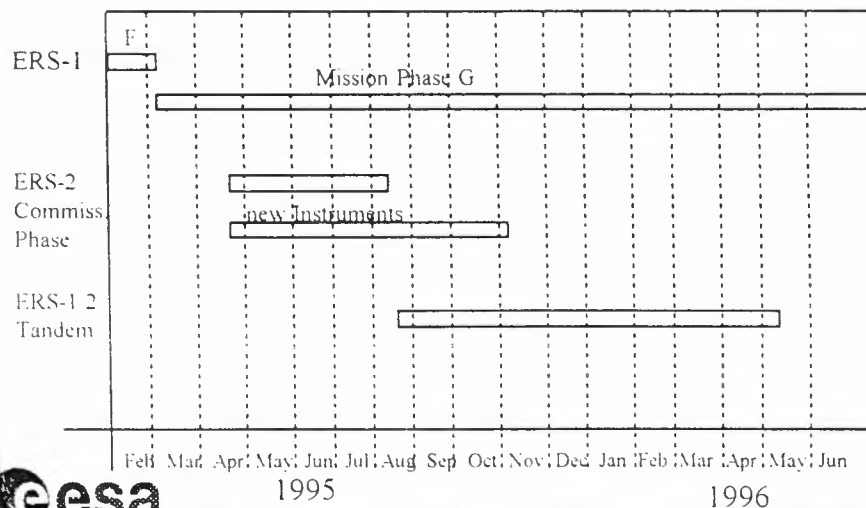


Tandem Mission Main Objectives

- Increased spatial and temporal sampling
 - for Interferometry and monitoring of all surface changes
- Complementary use of instruments
 - SAR/WSC conflicts at coast line
 - Different Instruments covering the same area on ground (e.g ATSR/SAR or WSC/RA)
- Extension of ERS-2 lifetime

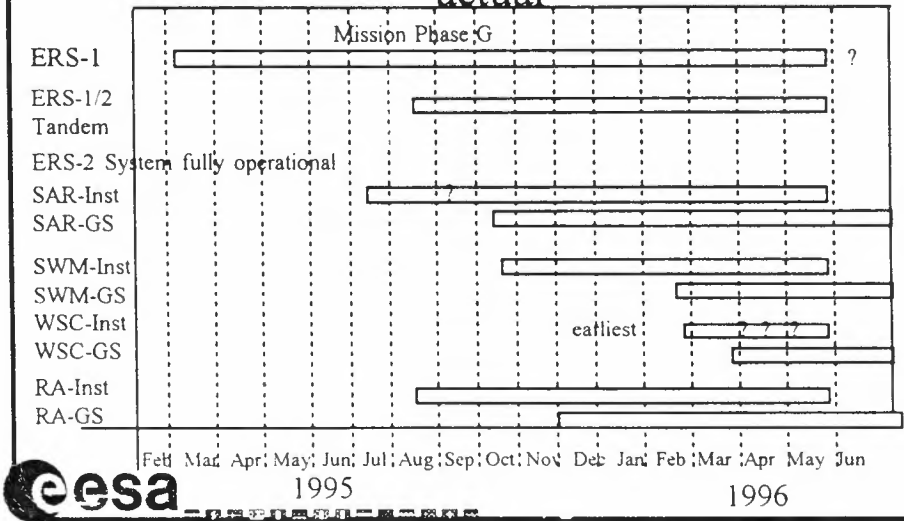


ERS-1/2 Mission Phases



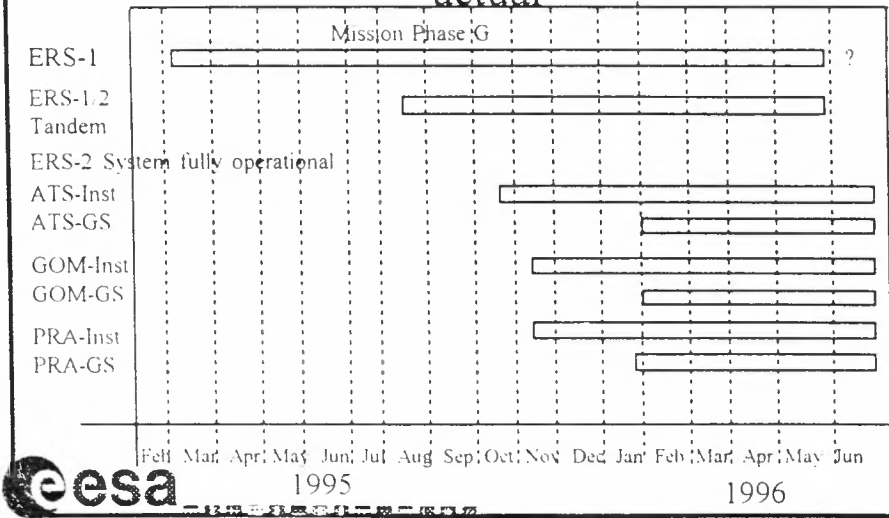
ERS-1/2 Mission Phases

actual



ERS-1/2 Mission Phases

actual



Tandem Mission Orbit Scenario

- 1 day offset of the same track between ERS-1 and ERS-2
 - ERS-1 is first
 - 30 min offset in the same orbital plane
- optional: 8 day offset of the same track between ERS-1 and ERS-2
 - implementation tbc (e.g. at the end of the nominal tandem phase)



Tandem Mission Operational Requirements

- Orbit Maintenance:
 - max. across track separation E1/E2 80m to 250m
 - deadband at high latitudes 400 m
 - deadband at the equator 1000 m
 - orbit crossings in high latitudes
 - dedicated high latitude campaign with across track separation of about 120m at high latitudes



Tandem Mission Operational Requirements

- Frequency of Acquisitions
 - about 5 SAR acquisitions/global land surface area (e.g. 2 ERS-1, 3 ERS-2)
 - also ascending acquisition pairs for areas with steep slopes (reduction of layover effected areas)



Tandem Mission Usable Data

- all acquired data since beginning of ERS-2 commissioning phase, because
 - for interferometry 'phase information' rather than radiometry is used (gain setting is irrelevant)
 - during commissioning the orbit maintenance was within the specifications for the tandem phase



Tandem Mission Implementation

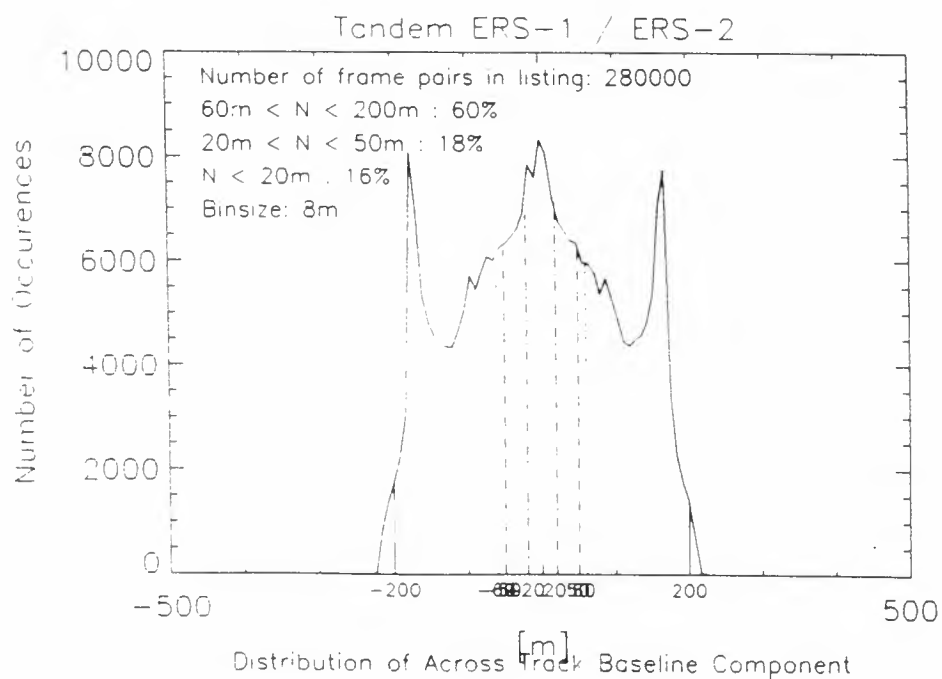
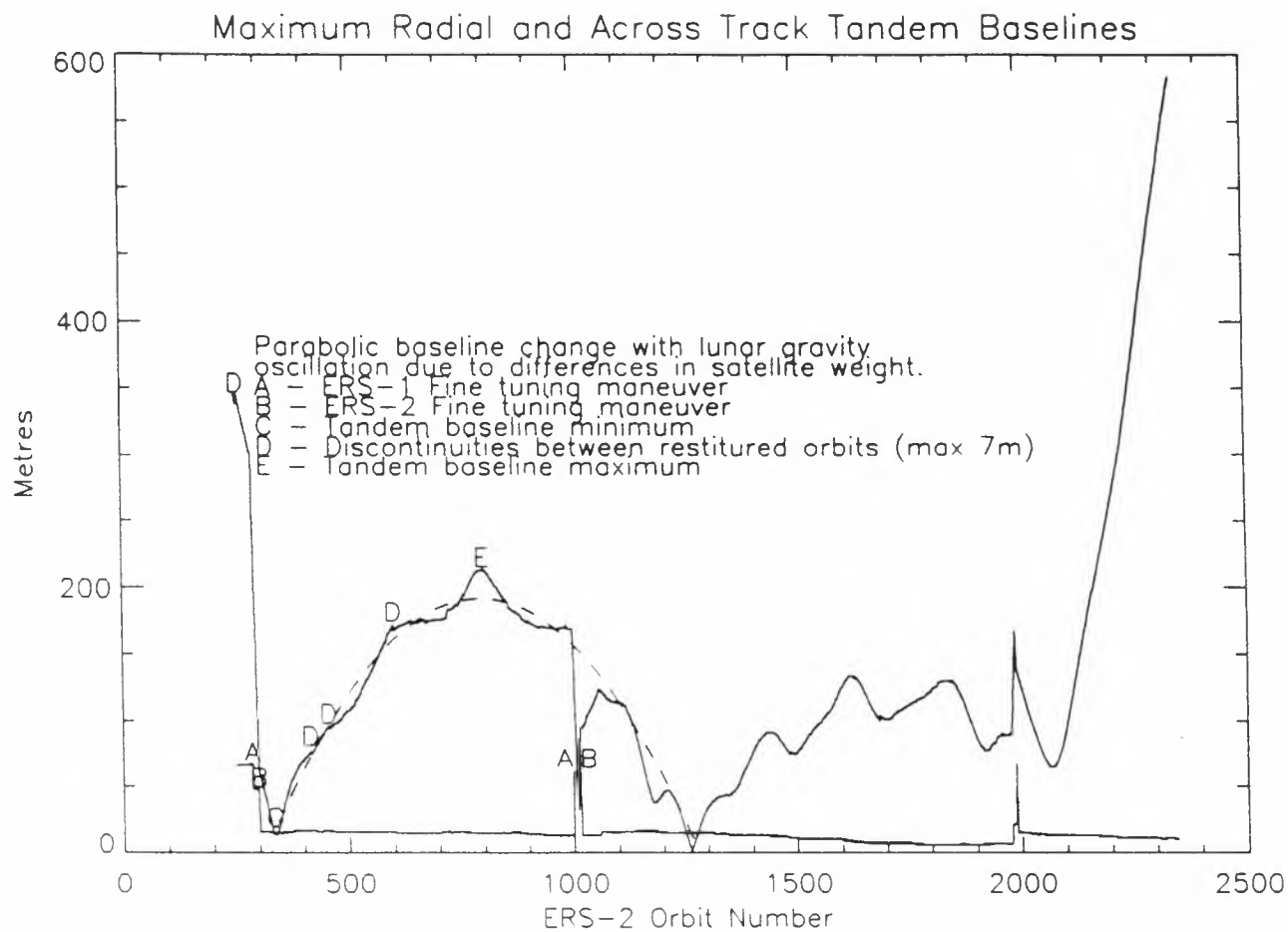
- Acquisition user requests accepted for ERS-1 or ERS-1/2 pairs only (not for ERS-2)
- ERS-1/2 baseline planning focussed on full station coverages
(Detailed Planning prepared by DEX-Mission Planner)

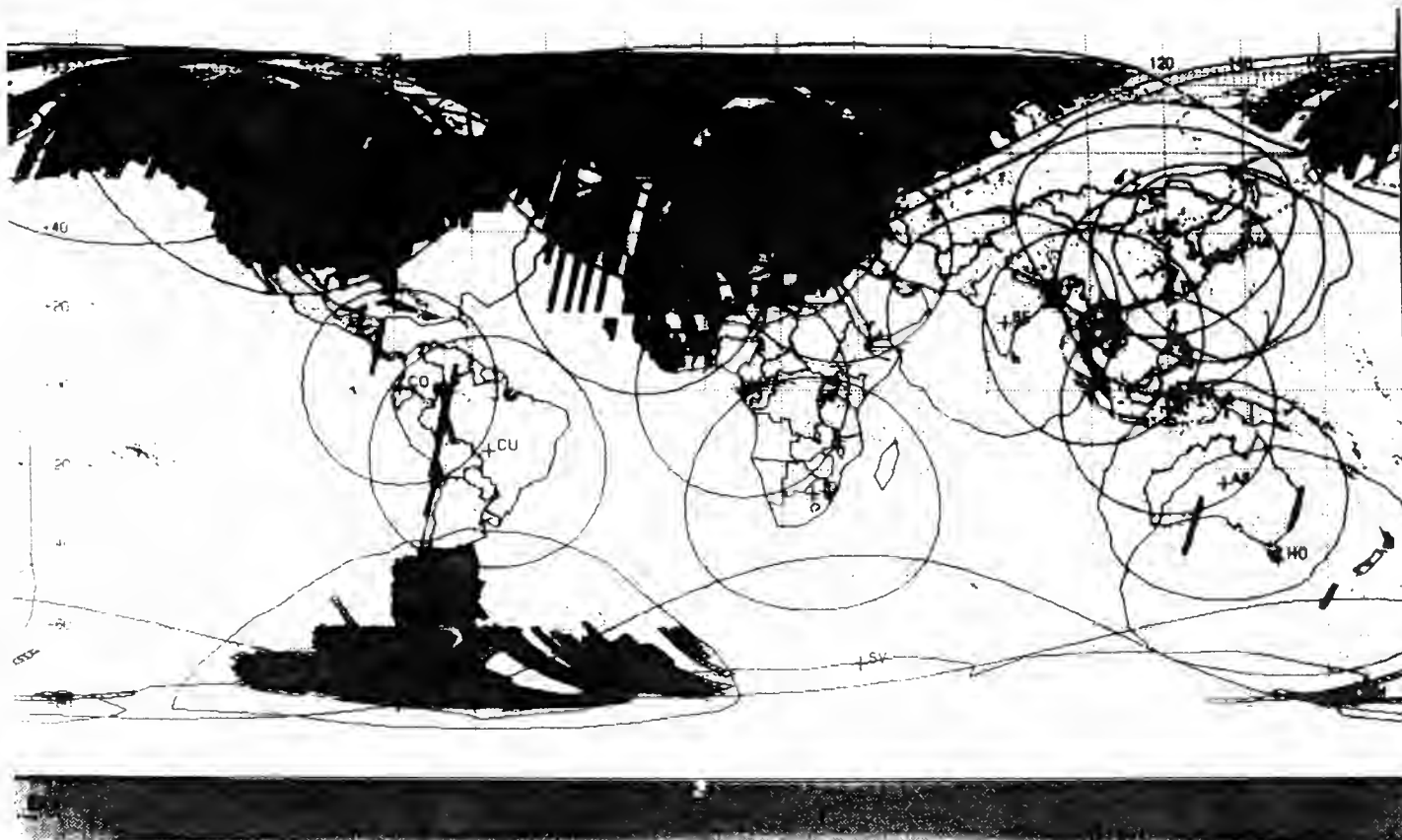


Tandem Mission Implications

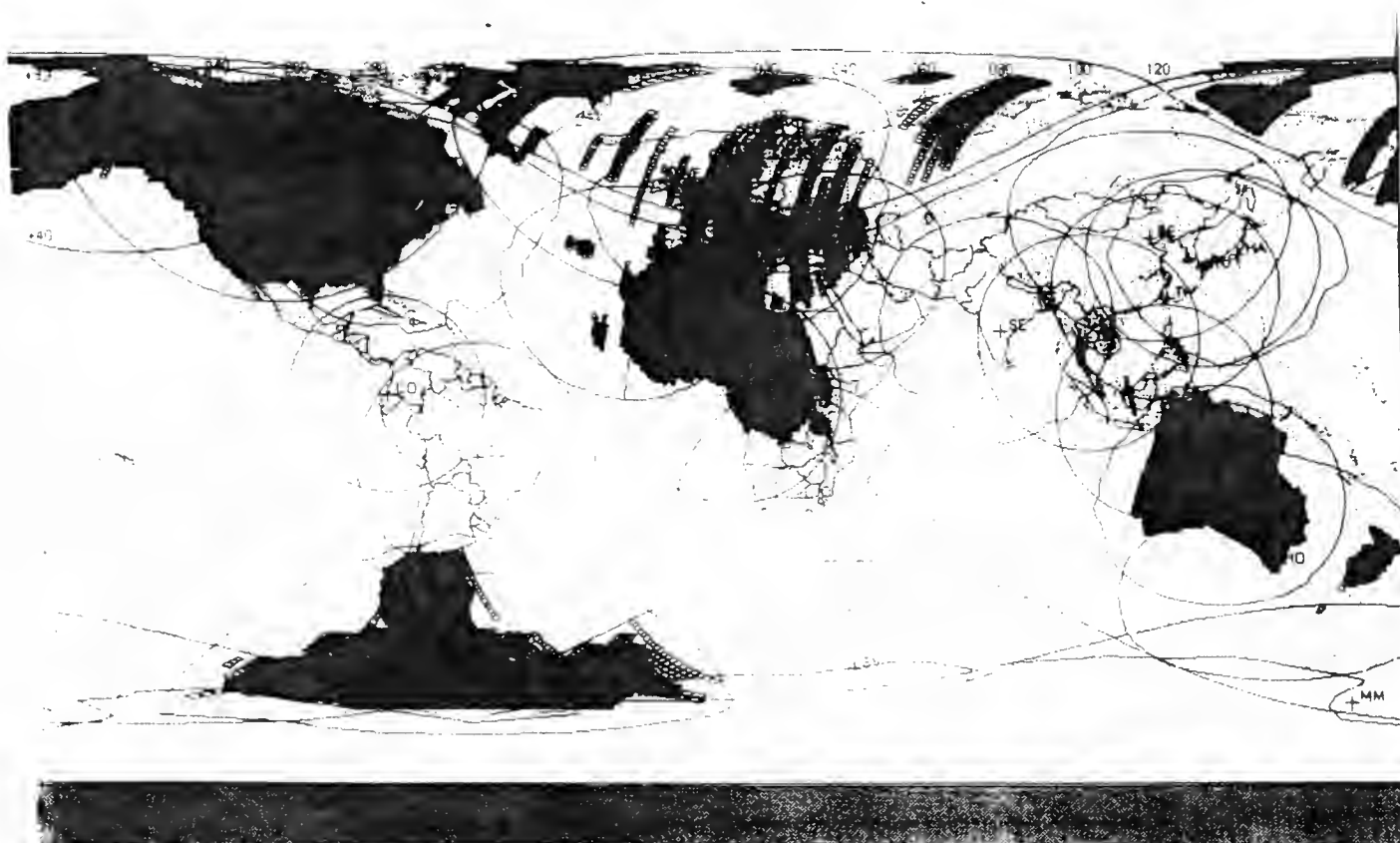
- Ground Stations: increased acquisition frequency (consumables, workload, conflicts with other satellites etc)
- PAFs: increased requirements on tape screening, cataloguing archiving,
- Data Policy: provision of (5) full data sets to foreign stations without access fee





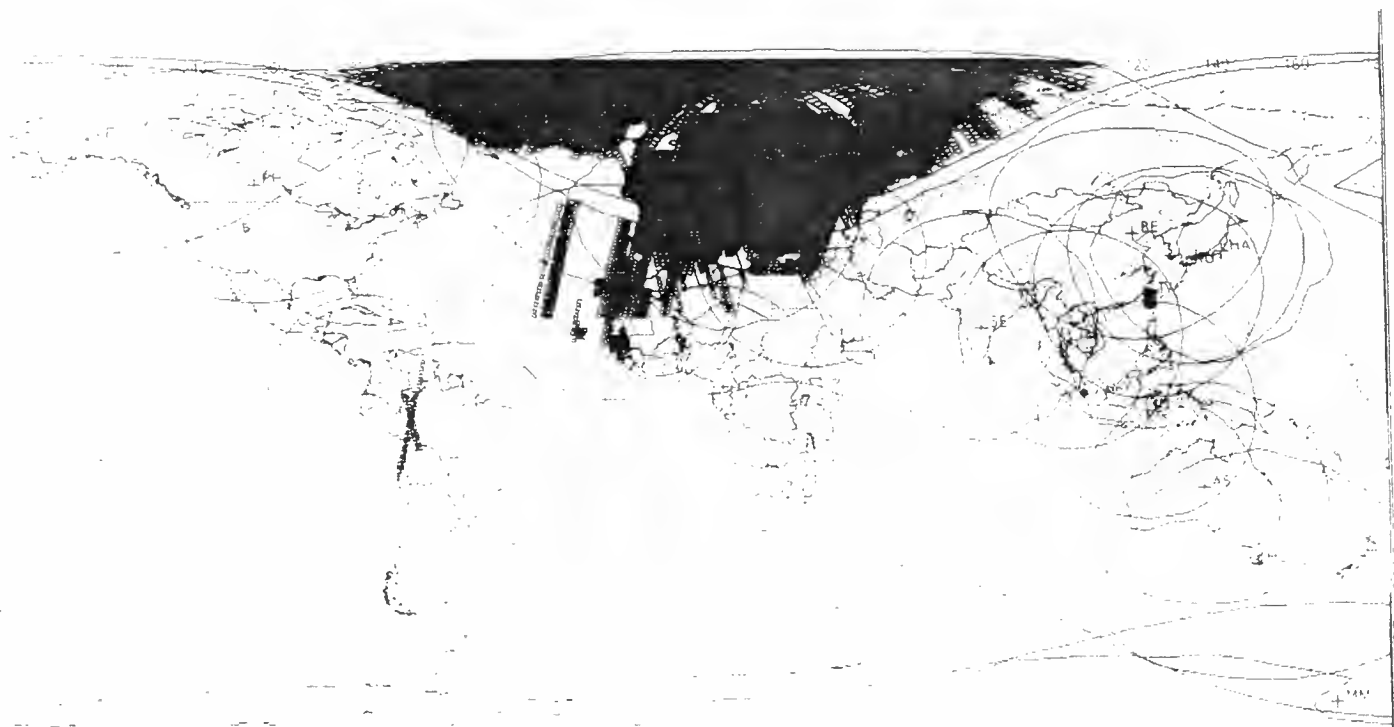


ERS-2 13 00 25 34 05





ERS-1 PLANNING FROM 12-JUL-85 TO 30-OCT-85 (orbits 20861-22449)



ERS-2 PLANNING FROM 21-APR-95 TO 12-JUL-95 (orbits 1-1187)

Evaluation of SAR Interferometry with 2 satellites

- During Commissioning Phase Interferograms using data from both satellites have been successfully generated within ESA
- products (not validated) over selected test sites have been distributed to Fringe users participating in the validation who also confirm the feasibility of the methodology
- Accuracy and some corrections (e.g. antenna mispointing) are under investigation in further detail and eventually corrected

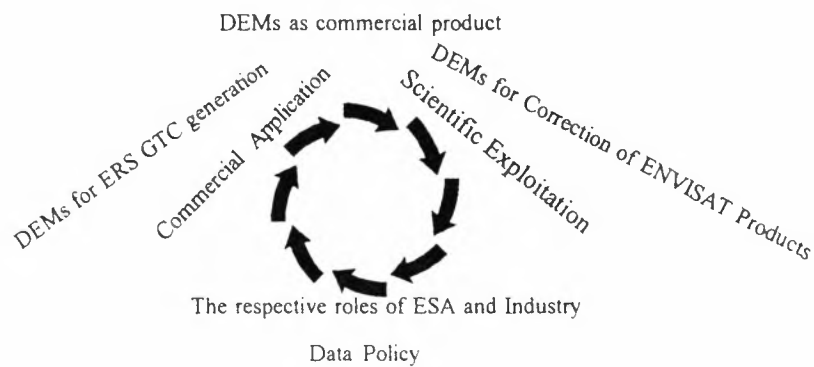


Auxiliary Data for Tandem Exploitation (Interferometry)

- ESA Responsibility
 - restituted orbit information with high precision
 - ERS-1/ERS-2 system parameters (antenna mispointing)
- User Responsibility
 - rough DEMs
 - GCPs
 - Meteorological Data



Tandem Mission Exploitation



Post Tandem Mission Options

- Extensions of Tandem
 - no baseline planning over NFS
- Tandem for LBR only
 - Discontinue SAR operations of either ERS-1 or ERS-2
- ERS-1 in 'keep alive'
 - WSC data availability to be confirmed
- ERS-2 in 'keep alive'
 - no GOME, PRARE, ATSR-2 data



PRARE Ground Station Network Commissioning Phase Report

Ch. Reigber, S. Bedrich, F. Flechtner, Ch. Förste, F. H. Massmann, J. C. Raimondo

**GeoForschungsZentrum Potsdam, Div. Recent Kinematics and Dynamics of the Earth,
Telegraphenberg A17, D-14473 Potsdam**

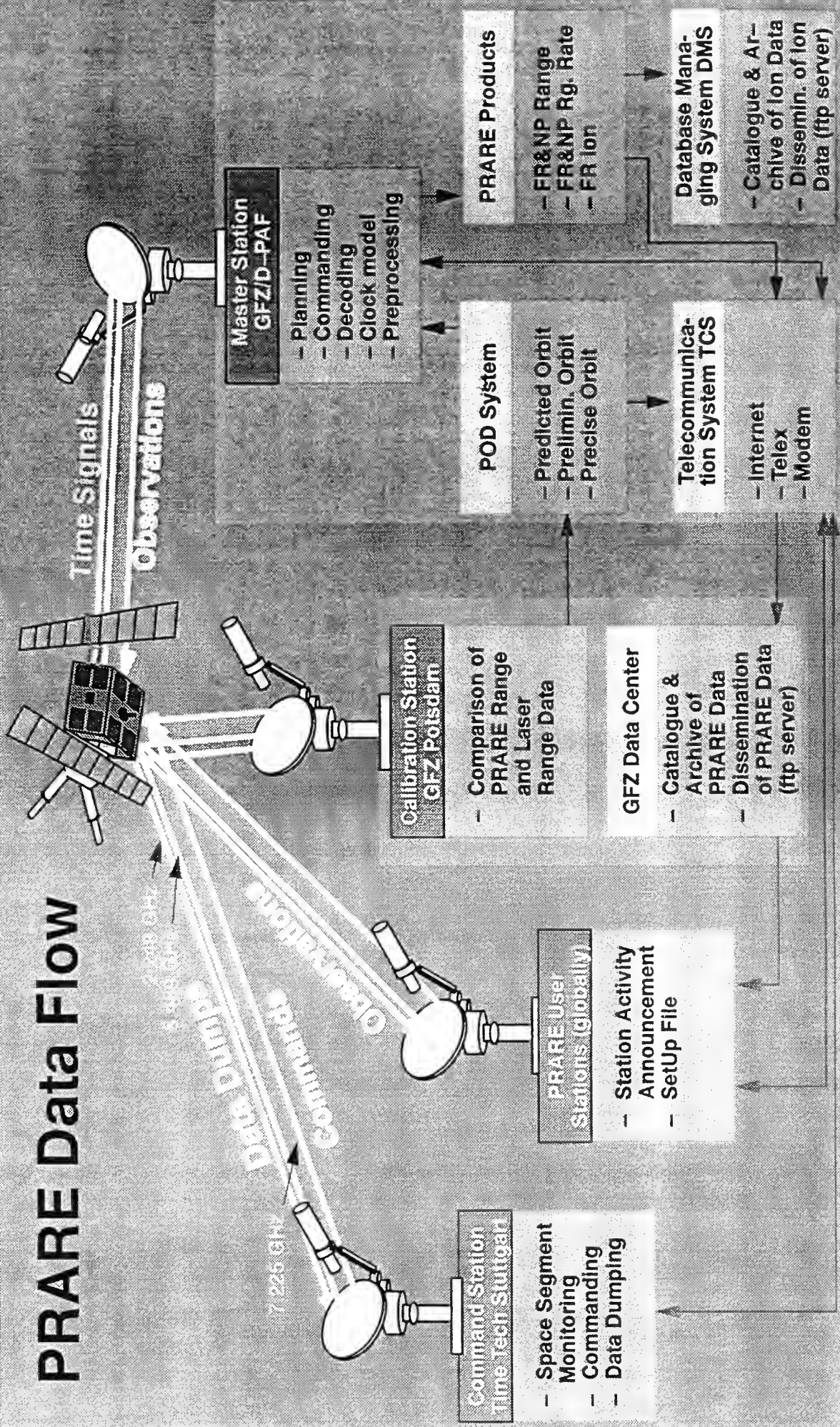
First ERS-2 Commissioning Review, October 26/27, 1995, ESRIN, Frascati, Italy



GFZ's Responsibilities in PRARE Ground Segment

- Ground Control Segment:
 - provide and operate PRARE Master Station including Time System in Oberpfaffenhofen
 - provide and operate Calibration Station (3rd generation Laser plus PRARE) in Potsdam
- Ground Station Network:
 - coordinate tracking activities of global network
 - generate Level-1 PRARE products (FR & NP range, FR & NP doppler, FR ion)
 - archive and distribute scientific data to owners and investigators

PRARE Data Flow



Status PRARE on ERS-2: Ground Station Network

- Master Station Oberpfaffenhofen is fully operational since beginning of mission; backup available for securing onboard clock monitoring:
 - all acquired data dumps are continuously preprocessed
 - routine generation of clock models PRARE—time vs. UTC
- Calibration Station Potsdam is fully operational; 161 calibration passes acquired up to now
- Present ground station network consists of 12 stations. Extension to 15 stations foreseen for November/December 1995.



Status PRARE on ERS-2: Data Processing

- All PRARE data are preprocessed until week 40 in a revision 3 version (commissioning phase solution) and are made available to station owners on the GFZ Potsdam/Data Centre ftp server
- PRARE data archiving and distribution facility at GFZ/DC is fully operational
- PRARE data were validated on the basis of the following products:
 - range and time bias values from external calibration of PRARE data vs. Laser data
 - PRC orbits including PRARE data
 - station coordinates from PRARE data

=> All tests show high quality of PRARE data



PRARE Data Access

- PRARE products are accessed using GFZ FTP server ("ftp.ftp.gfz — potsdam.de")
- Data are stored in UNIX compressed form using a defined directory structure:

/pub/home/kg/PRARE/mission/weekwwyy_r/ttt_ss_yyww_rev.r.Z

with:

mission = {METEOR3, ERS2}
ww = no. of week {1 ... 53}
yy = year {94, 95, ...}
r = revision {0 ... 9}
ttt = type of data {FRR, FRD, NPR, NPD, ION}
ss = ground station serial id {1 ... 29}
.Z = UNIX — compressed

- Access to PRARE products is password protected !

PRARE Station Network

Status October 23, 1995

Location	S/N	Owner	in operation since week
Oberpfaffenhofen	02	GFZ	18
Buddinge/Narsarsuaq	06	UC	30 – 36 / 38
Greenbelt	12	DUT	26
Honefos	13	SK	35 – 41
Weilheim	16	GFZ	42
Hartebeesthoek	17	GFZ	22
Bangalore	19	GFZ	29
Kitab	20	GFZ	25
Potsdam – 0	21	GFZ	19 – 41
Ulaan Bataar	22	GFZ	27
Potsdam – 1	24	GFZ	20 – 38 / 41
Maracaibo	25	DGFI	22 – 33
Leipzig/O'Higgins	26	IfAG	36 – 39 / 41
Herstmonceux	28	POL	25

GFZ
D-PAF

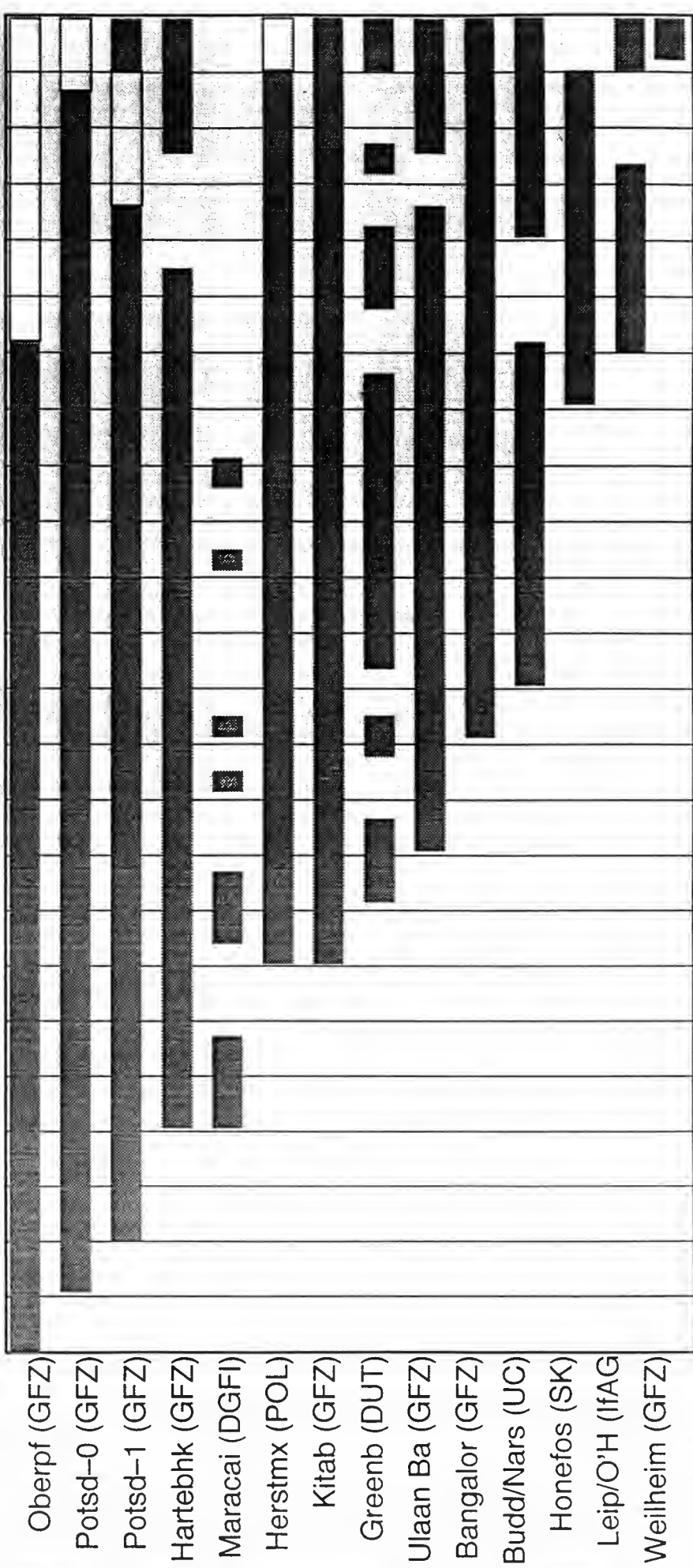


GEO FORSCHUNGS ZENTRUM POTSDAM

PRARE G/S Network Status

May 2, 1995

October 23, 1995



■ = active □ = passive

Week in 1995

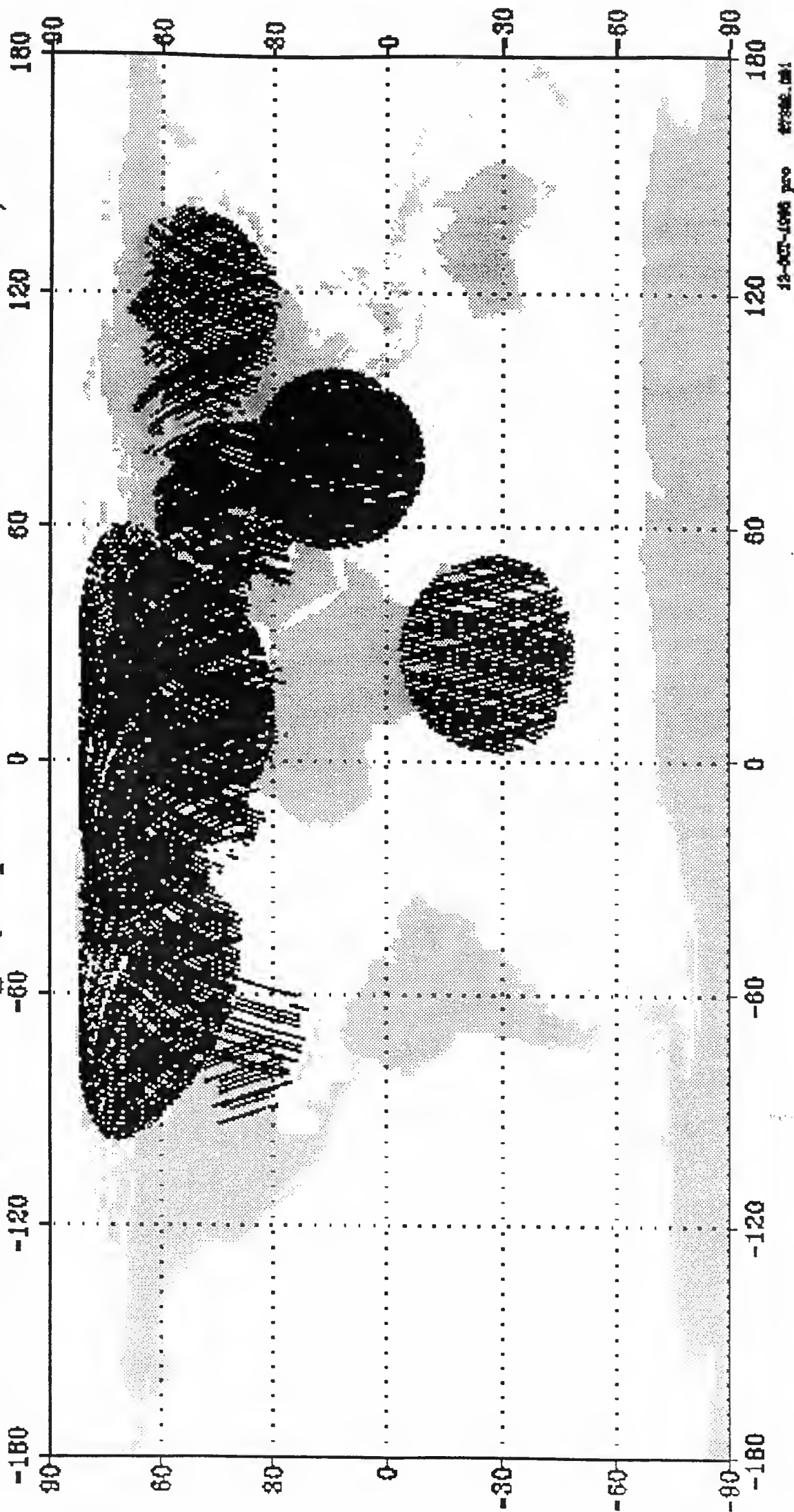
GFZ

D-PAF



GFZ Potsdam / D-PAF

ERS-2 PRARE Tracking (September 4 - October 09 1995)

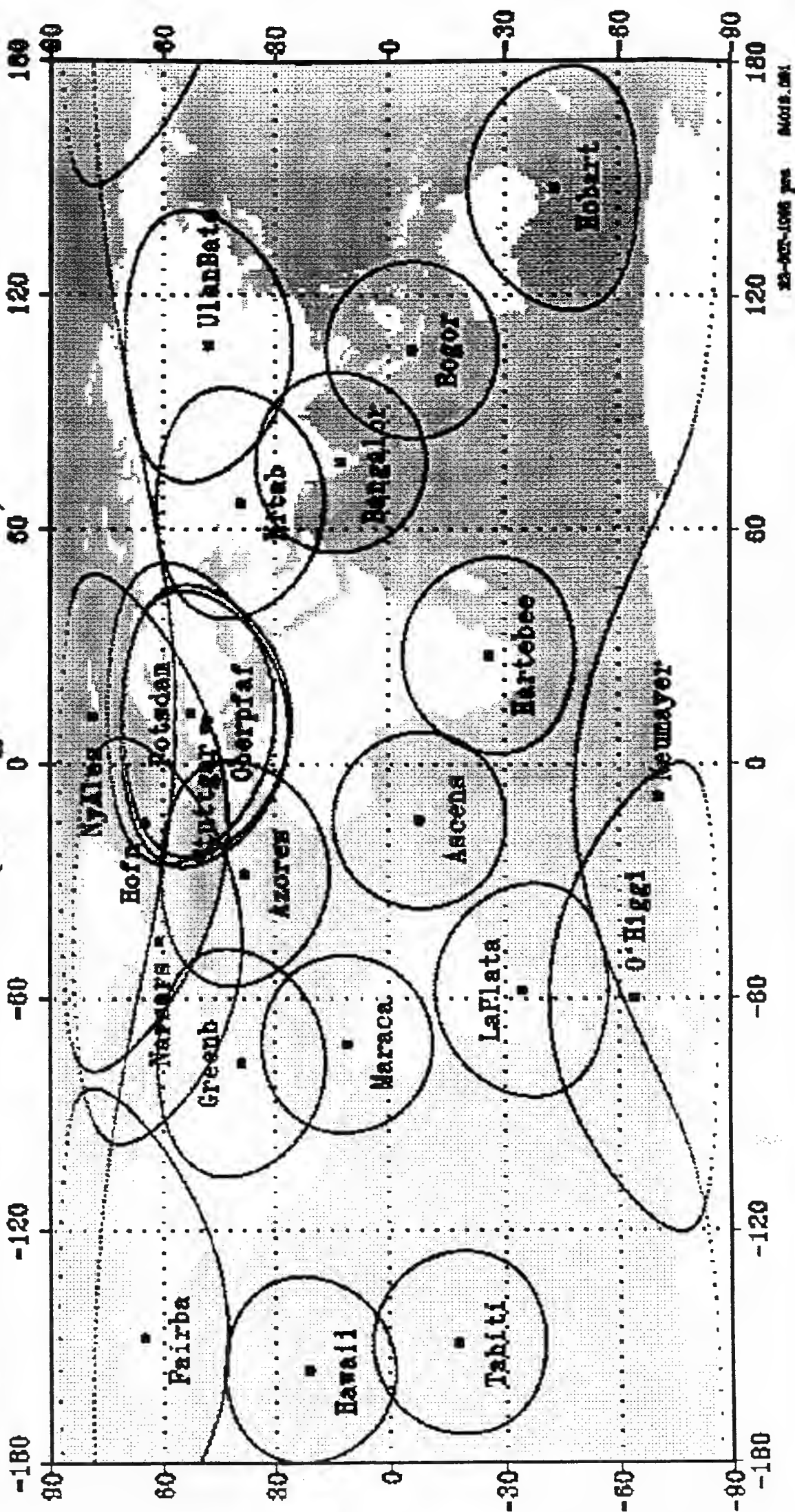


12-OCT-1995 00:00 47382.000



GPZ Potsdam /D-PAF

ERS-2 PRARE MEX Network (5 deg. cut-off)



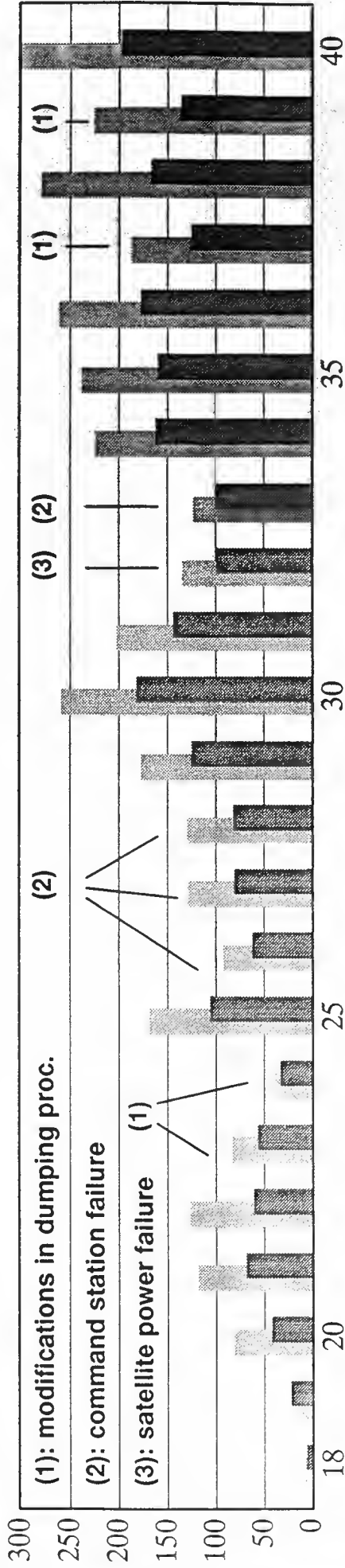


GEO FÖRSCHUNGS ZENTRUM POTSDAM

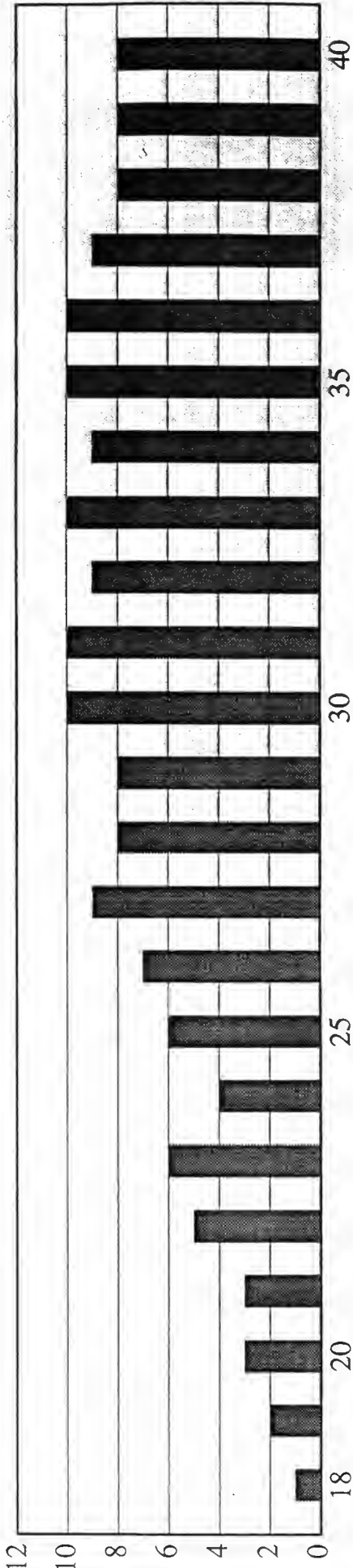
No. of PRARE/ERS-2 Doppler and Range Passes / No. of G/S

Passes

(Rev. 3)



Stations



GFZ

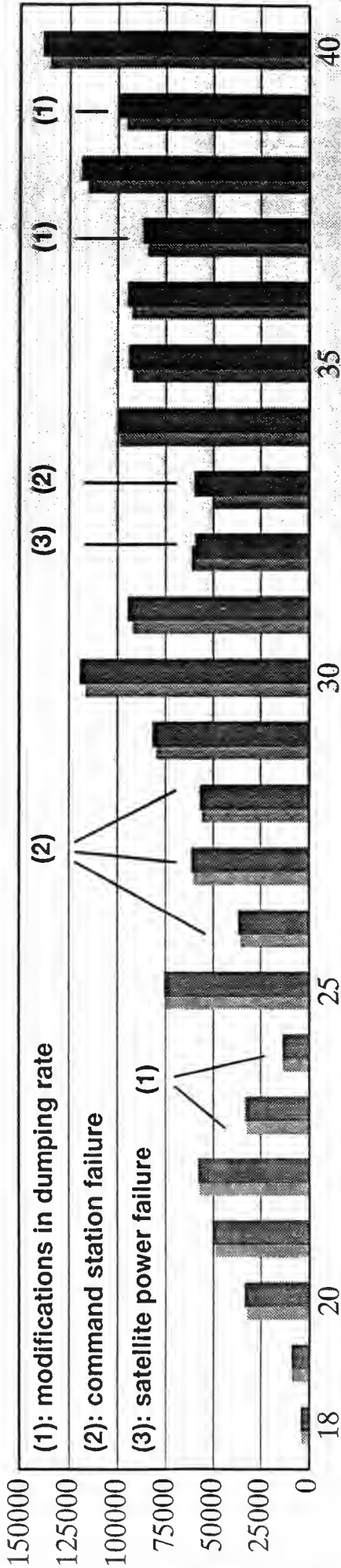
D-PAF



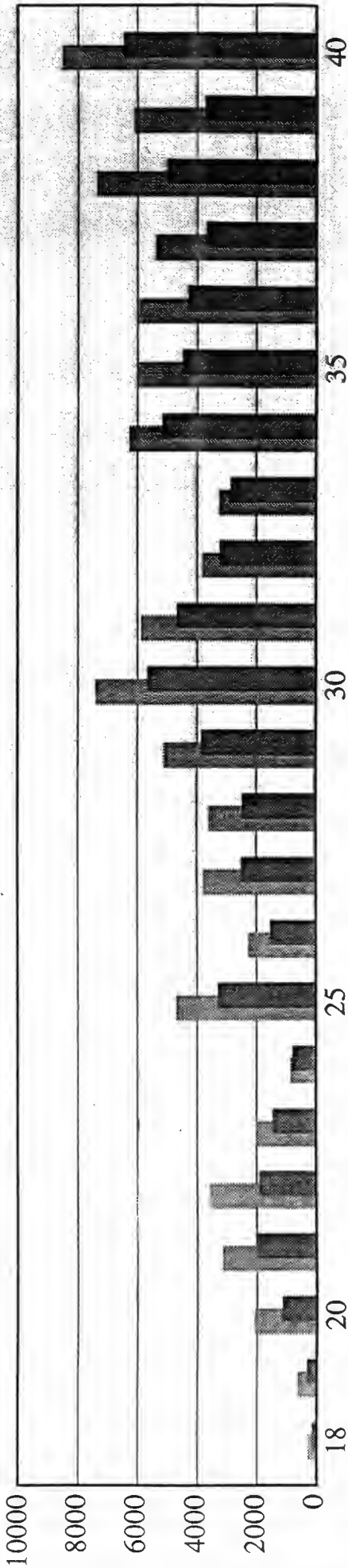
No. of PRARE/ERS-2 Doppler and Range FR&NP Observations

(Rev. 3)

FR



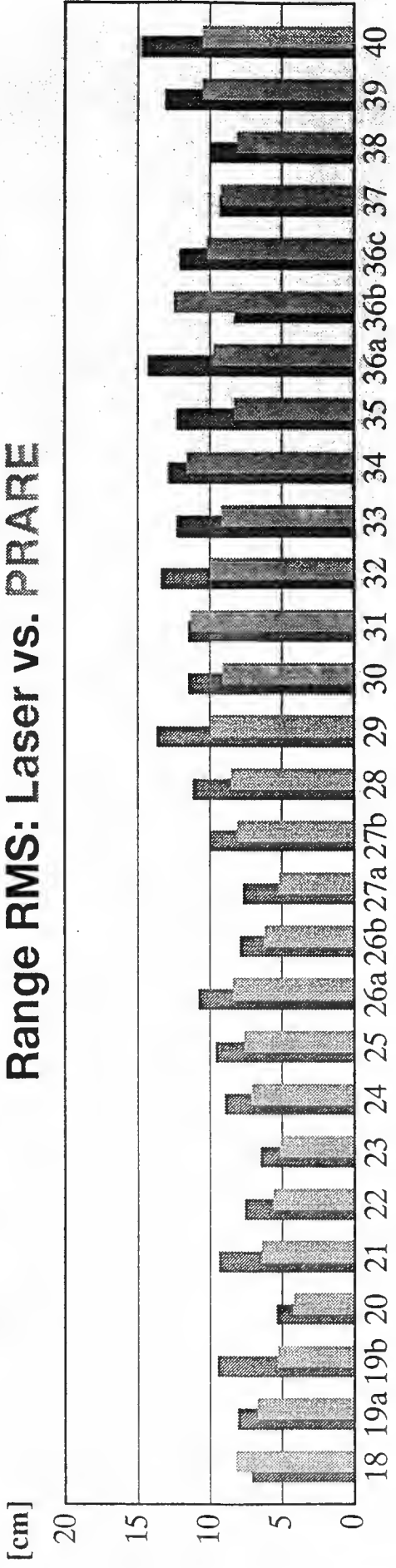
NP



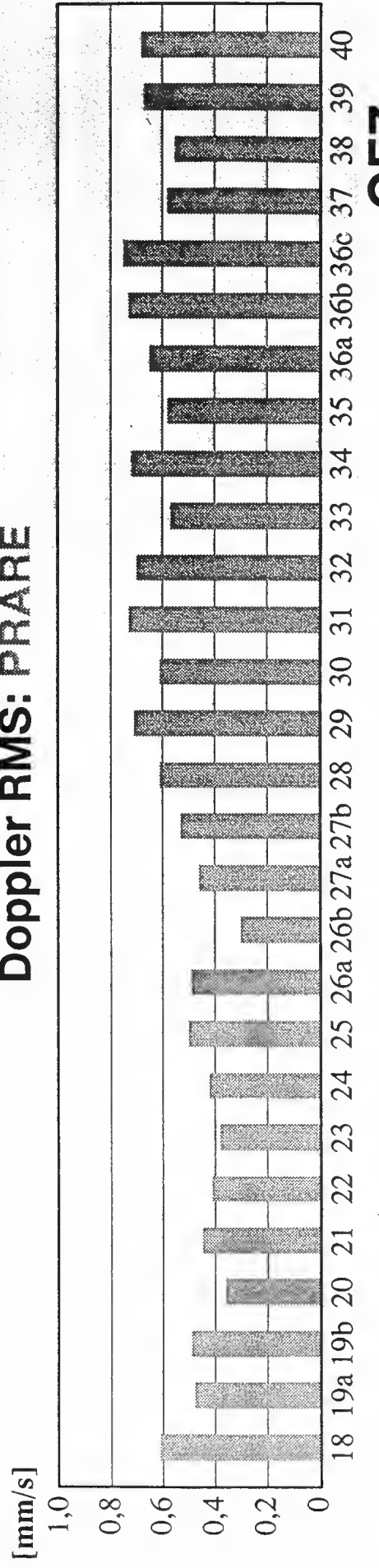


ERS-2 Orbital Fit Results, Rev. 3 (I)

Range RMS: Laser vs. PRARE



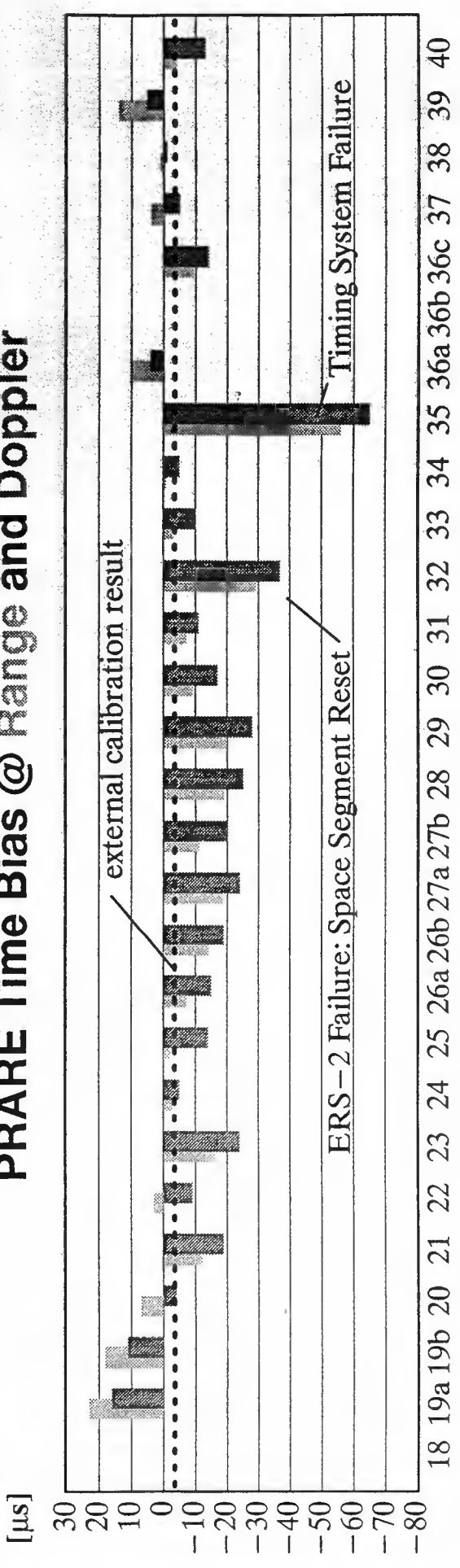
Doppler RMS: PRARE





ERS-2 Orbital Fit Results, Rev. 3 (II)

PRARE Time Bias @ Range and Doppler





External Calibration of PRARE Range Data from ERS-2 (Results at Potsdam)

Stations	Number of Passes	Range Bias [cm]	Time Bias [μ sec]	Correlation between Range and Time Bias
1) SLR – PRARE				
7836 – 7730	60	3.6 ± 0.8	-7.5 ± 2.0	0.21
7836 – 7740	32	0.3 ± 0.7	-1.5 ± 2.0	0.14
2) PRARE – PRARE				
7730 – 7740	326	-0.9 ± 0.1	0.4 ± 0.2	0.04



Coordinate adjustment from ERS-2 PRARE Range data

1) Analysis strategy:

- | | |
|------------------------------------|---|
| Elevation cut-off angle: | 5 degrees |
| PRARE related adjusted parameters: | Time bias per week |
| | Range bias per station |
| | Tropospheric zenith path delay per pass |

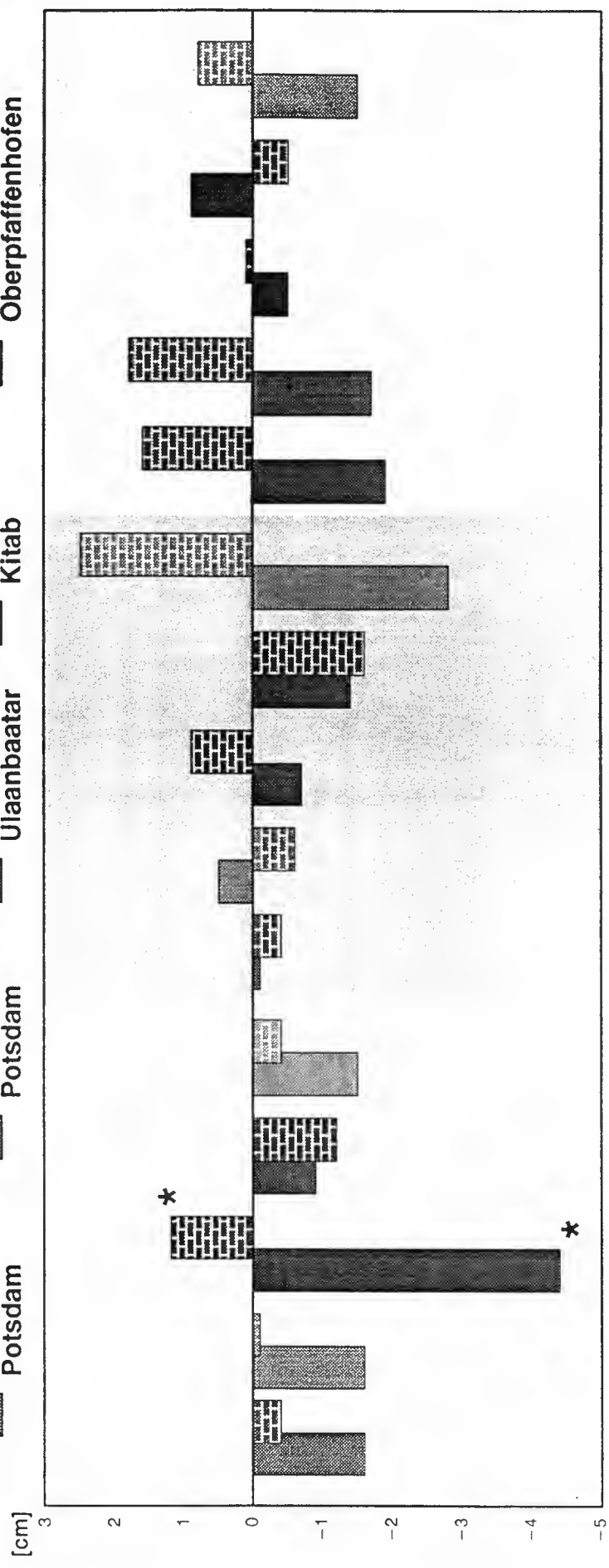
2) Difference between the GPS/terrestrial measured and PRARE solved differential coordinates between the two Potsdam PRARE stations 7730 and 7740

Included data time span	Δ North [cm]	Δ East [cm]	Δ Height [cm]
95/05/15 – 95/08/06	+ 0.04	– 0.17	– 8.3



Repeatability of coordinate adjustment from PRARE Range Data (ERS-2)

Differences between two 8-week solutions to a 16-week solution



* Ulaanbaatar: Inaccuracy of the North component due to trees very close in the north (meanwhile the trees have been cut down)



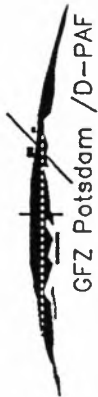
PRARE on ERS-2: Problem Areas (I)

- Onboard antenna arrangement leads to multipathing
- Space segment calibration still insufficient (2-6 cm uncertainty in range), no final range/channel correction provided up to now by ESA. Joint GFZ/TimeTech investigation under way; solution due date November 10
- Ground station power reduction at high elevation angles leads to jumps in range of up to several 10 cm (under investigation by Nortel DASA, TimeTech and GFZ; solution due date November 10)
- Relative X/S ground station calibration under final investigation by Nortel DASA and GFZ (solution due date November 10)
- IMIA between ESA/DARA not yet signed, but a red-marked copy has been agreed in a joint DARA/ESA/GFZ meeting on October 16, 1995

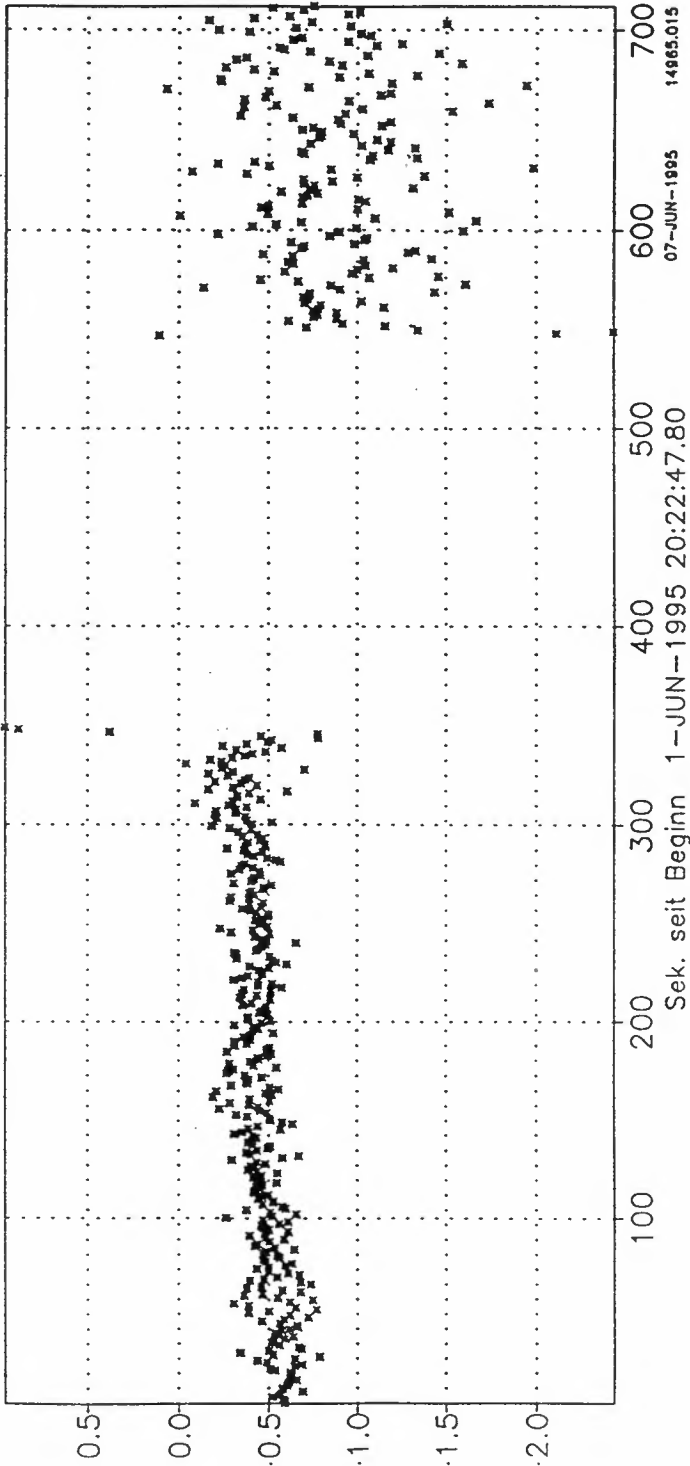
PRARE on ERS-2: Problem Areas (II)

- Raw data dumping:
 - Dump rate still 4 kb/sec (not sufficient for handling the full ground station network)
 - Increase of dump rate to 10 kb/sec will be implemented by TimeTech until end of November and verified until mid of December 1995
 - Dump data will only be received at C/S in Stuttgart
- Document describing M/S and C/S interfaces (dump data availability, SLP and ephemeris upload) is under preparation (draft version: November 17, final version: November 30, 1995)

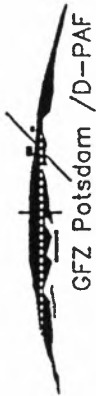
ERS-2 Range Multipath Example



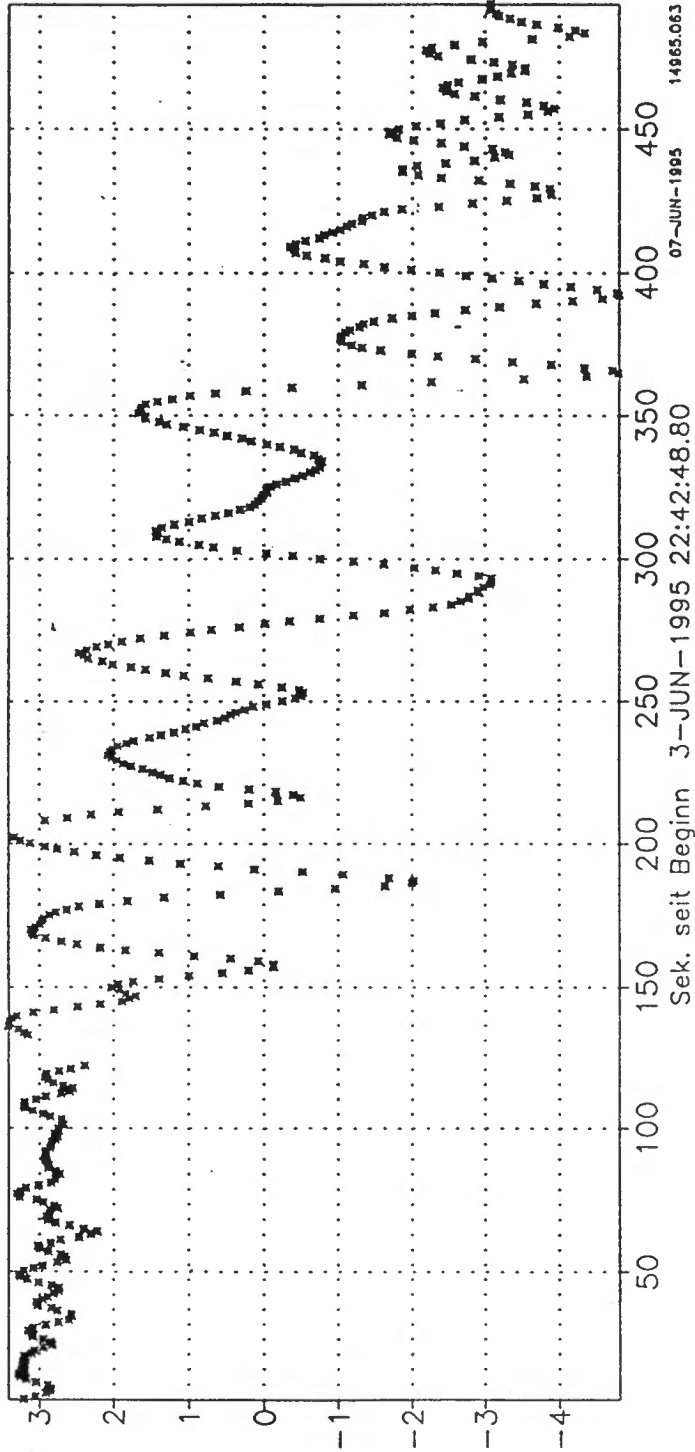
Range Residuen [m] 77360201_015 Oberpf1



ERS-2 Range Multipath Example



Range Residuen [m] 77302104_026 Potsdam





Multi Channel Tests Results [cm]

Station	Channel						
		0-1	0-2	0-3	1-2	1-3	2-3
O'hofen (9.-10.5.)		-24.8	-38.3	-36.4	-13.1	-10.2	2.5
Potsdam-0 (12.-15.5.)		-14.7	-24.2	-	-9.0	-7.3	1.3
Bangalore (14.-17.8.)		-24.3	-30.1	-34.3	-5.7	-9.8	-3.9
Greenbelt (17.-18.8.)		-18.5	-24.9	-27.5	-6.3	-8.8	-2.5
		-20.6 ±4.8	-29.4 ±6.5	-32.7 ±4.7	-8.5 ±3.4	-9.0 ±1.5	-0.7 ±3.0

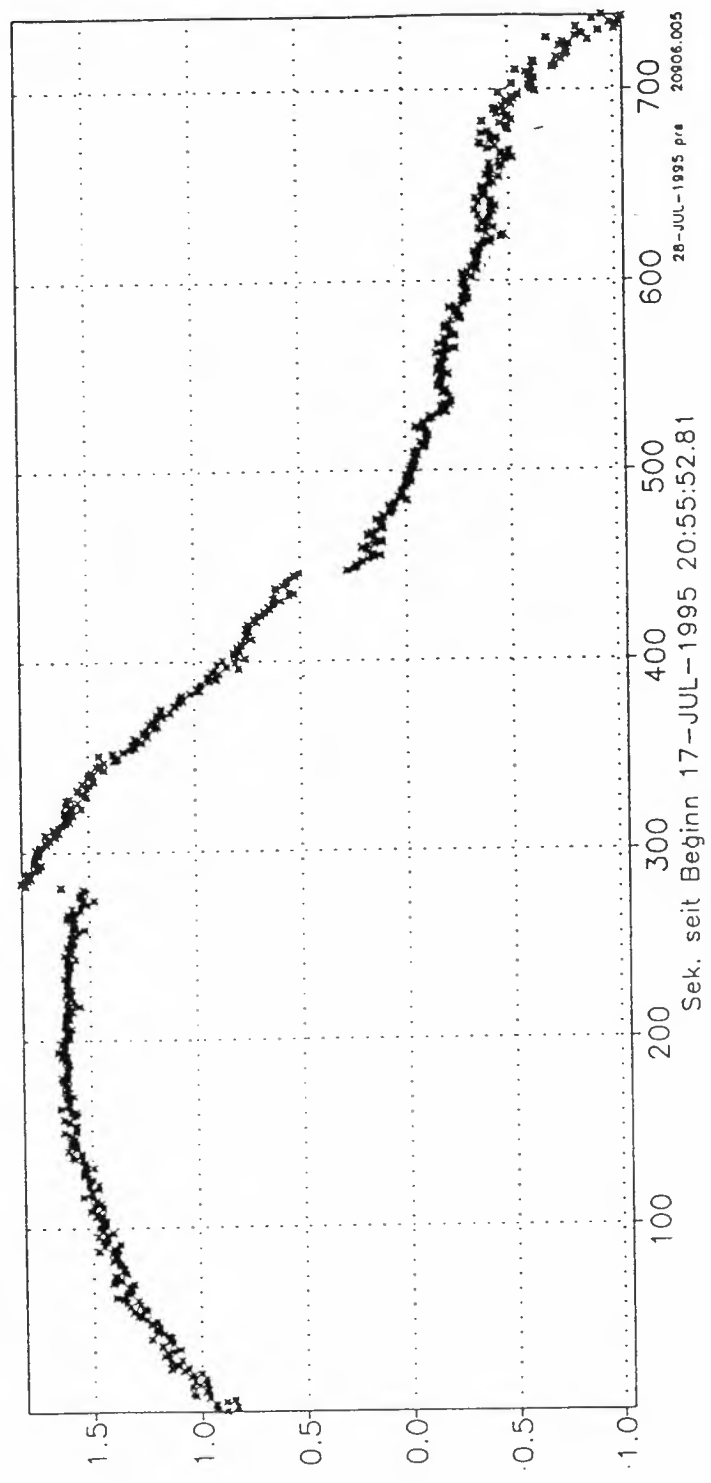
=> Differences between channels are not constant [redacted] with station

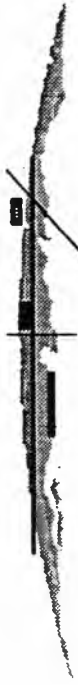
=> Uncertainty in range/channel correction about 1.5 to 6.5 cm



PRARE range jumps due to ground station power reduction

Range Residuen [m] 77141701_004 Hartebe





Conclusions

- A 12 station PRARE MEX network is in place and will grow up to 15 stations until end of 1995
- Master and Calibration station are fully operational since beginning of the mission
- All data evaluations (PRC, external calibration, station coordinates determination) show high quality of the PRARE data
- Still existing problems (space segment calibration, X/S G/S calibration, G/S power reduction, increase of dumping rate) will be solved until end of November 1995
- Multipathing needs modeling effort
- PRARE commissioning phase extended until November 30, 1995

