AATSR Validation Implementation Plan

PO-PL-GAD-AT-005 (3): Version 1
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Prepared by Marianne Edwards

Document Change Record

Issue	Date	Affected Pages	Comments

Contents

1 Scope of document

The AATSR validation plan is made up of three parts. The first part, validation principles and definitions (AD1), gives an overview of the AATSR validation programme and sets out the principles behind it. The second part, the AATSR measurement protocol (AD2) discusses the measurements needed for validation, and recommends the instrumentation and procedures that should be used. Both of these documents have been written with the help of the AATSR SAG.

This document forms part 3 of the AATSR validation plan, and describes in detail the activities that will be performed to validate the AATSR data products.

The validation implementation plan includes details of:

- The AATSR data products.
- Validation organisation.
- Validation activities that will make up the core validation programme, including the names of Principal investigators, instrumentation that will be used, geographical location and planned activities.
- The schedule of validation activities.
- The validation loop, describing what happens to the validation data once it has been collected.
- Longer term validation activities.

2 Applicable Documents

AD1	PO-PL-GAD-AT-005 (1)	AATSR Validation Principles and Definitions
AD2	PO-PL-GAD-AT-005 (2)	AATSR Validation Measurement Protocol
AD3	PO-PL-RAL-AT-0501	AATSR Commissioning Plan
AD4	PO-RS-GAD-AT-0001	AATSR Science Requirements
AD5	PO-TR-RAL-AT-0024	AATSR Infra-red radiometric calibration report – Issue 1
AD6	PO-TR-RAL-AT-0023	AATSR Visible radiometric calibration report – Issue 2
AD7	PO-PL-GAD-AT-0006	AATSR Ground Segment Development Plan
AD8		MERIS Cal/Val Implementation Plan
AD9	SVDS-02	SCIAMACHY Validation Handbook
AD10	PO-PL-ESA-GS-1092	Envisat Calibration and Validation Plan
AD11		AATSR Algorithm Verification Plan

3 Acronyms

AATSR	Advanced Along Track Scanning Radiometer
ADS	Annotation Data Set
AIMS	Australian Institute of Marine Science
A/O	Announcement of Opportunity
ASTER	Advanced Space borne Thermal Emission and Reflection radiometer
ATSR-2	Along Track Scanning Radiometer 2
AVHRR	Advanced Very High Resolution Radiometer
BADC	British Atmospheric Data Centre
BB	Black Body
BT	Brightness Temperature
Cb	CumuloNimbus
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DETR	Department of the Environment, Transport and the Regions
ESA	European Space Agency
EOS	Earth Observation Science
FOS	Flight Operations Support
GBR	Great Barrier Reef
GPS	Global Positioning System
ISAR	Infrared Sea surface skin temperature Autonomous Radiometer
JRC	Joint Research Centre
L	Launch
LST	Land Surface Temperature
M-AERI	Marine Atmosphere Emitted radiance Interferometer
MDS	Measurement Data Set
MODIS	Moderate Resolution Imaging Spectroradiometer
MPH	Main Product Header
NERC	Natural Environment Research Council
NDVI	Normalised Difference Vegetation Index
NWP	National Weather Prediction
OP	Operational Processor
PDS	Payload Data Segment
PI	Principal Investigator
PP	Prototype Processor
RAL	Rutherford Appleton Laboratory
SAG	Science Advisory Group
SISTeR	Scanning Infrared Sea Surface Temperature Radiometer
SODAP	Switch On and Data Acquisition
SPH	Specific Product Header
SST	Sea Surface Temperature
VDP	Validation Data Provider
VS	Validation Scientist

4 Validation requirements

The main objectives of the AATSR validation programme are to assess whether the AATSR instrument is returning global skin SST measurements and visible channel reflectances, which meet the scientific requirements of the mission in terms of accuracy. To meet these objectives, a number of validation activities will be carried out. Some of these are designated "core" activities, and are considered central to the validation programme. Other additional activities will be important for adding information and enhancing the core assessment made.

Validation can be considered in two phases: an initial validation period from launch (L) up until the validation workshop at L + 9 months, and ongoing validation during the remainder of the mission. These phases are described here.

4.1 Initial Validation

The first six months of the mission are known as the commissioning phase of the satellite. During this period, every instrument on the platform is switched on, data acquisition begins, and preliminary validation is carried out to assess the quality of the data received. As detailed in AD10, at the end of the commissioning phase, Level 1b data products are distributed to all users. Level 2 products are distributed to science AO PI's. At L + 9 months, a validation workshop will be held by ESA. This workshop will mark the end of the initial validation phase and the point at which all data become available to all users.

During the initial validation phase, the validation team will be considering the question; does the instrument meet its specifications? More specifically, the objectives are:

- To determine whether the AATSR instrument is returning an acceptable global skin SST (±0.3 K, as defined in AD4).
- To make an initial assessment of the quality of the AATSR SST data products, in a limited number of sites and seasons. Making timely use of any tandem ATSR-2/AATSR mission, this should include the determination of any bias difference between the measurements made by AATSR and those made by ATSR-2.
- To assess the accuracy of the AATSR data retrieved over land (as defined in AD4). Eventually this will include both the reflectance values returned by the visible channels and the temperatures retrieved from the thermal channels.

Sections 9 and 10 detail the validation activities that will be carried out to meet these objectives. Initial validation includes core and non-core validation activities.

4.2 Ongoing Validation

After the validation workshop, validation activities will continue. During the mission as a whole, the upper limits of achievable accuracy of the AATSR will be assessed. Specifically the aims of the on-going validation programme are:

- To make a detailed assessment of the quality of the AATSR SST data products in an increasing number of sites and seasons.
- To monitor the quality of the AATSR data products over the duration of the mission (for example, to investigate the success of the SST retrievals in varying conditions such as periods of high aerosol contamination following a volcanic eruption). This is essential for ensuring continuity of the climate record.
- To validate new AATSR products. Ongoing validation will seek to validate new products as they are developed and made operational.

Ongoing validation is described in Section 13. Core and non-core activities are included.

5. AATSR Data Products

Table 5-1 summarises the AATSR Data products.

After reception on the ground, the raw data are converted into a Level 0 product. This consists of a chronological sequence of records each containing a single instrument source packet, with each source packet representing one instrument scan. Level 0 data are processed to give, firstly, the Level 1b and then the Level 2 product. Level 0 data are not routinely available to users.

Product ID	Name	Description
ATS_NL__0P	Level 0 Product	• Instrument source packet data
ATS_TOA_1P	GBTR	• Full resolution top of atmosphere BT/reflectance for all channels and both views. • Product quality data, geolocation data, solar angles and visible calibration coefficients
ATS_NR__2P	GST	• Full resolution nadir-only and dual-view SST over sea • Full resolution 11 µm, BT and Normalised Difference Vegetation Index (NDVI) over land • Product quality data, geolocation data and solar angles
ATS_AR__2P	AST	• Spatially averaged ocean, land and cloud parameters • Spatially averaged top of atmosphere BT/reflectance
ATS_MET_2P	Meteo Product	• SST and averaged BT for all clear sea pixels, 10 arc min cell, for Meteo users
ATS_AST_BP	Browse Product	• 3 band colour composite browse image derived from L1b product. 4 km x 4 km sampling.

Table 5-1: Summary of AATSR data products

AATSR was designed primarily to measure sea surface temperature, precisely and accurately. The main aim of the validation programme is, therefore, to assess whether this is being achieved through validation of the Level 2 products. The ATS_NR_2P GST product contains full resolution nadir-only and dual view SST measurements over sea, whilst the ATS_AR_2P AST product contains ocean parameters that have been spatially averaged (over 50 and 17 km^2 grid cells, or half degree and 10 arcmin cells). The core validation activities will assess whether the SST measurements given in these Level 2 products are being measured to the accuracy and precision expected from the instrument design. Examination of the BT's in the Level 1b product will be an inherent part of this process.

Over land, the key parameter for validation will be the visible channel reflectance values in the Level 1b product. However, an AATSR LST retrieval is currently being prototyped for inclusion in the Level 2 products. Plans for the validation of this parameter will be added to this document at a later date.

The Meteo product (ATS_MET_2P) is designed for use by meteorological users in near-real-time, and will be validated by the Hadley Centre as part of their validation activities (see Section 9.1.1).

The browse product is intended to provide 3 band colour composite, quick-look images at coarse resolution. Derived from the L1b product, it is not covered specifically by validation activities.

6. AATSR Validation Organisation

As AATSR is an Announcement of Opportunity Instrument, the DETR is responsible for its calibration and validation throughout the mission. As part of this responsibility, an AATSR validation scientist (VS) has been appointed. The role of the VS is to ensure that the objectives outlined in Section 4 are achieved. The VS will coordinate and manage a validation programme for AATSR, ensuring validation data are collected and analysed in a timely manner. The validation activities that will be carried out are outlined in Sections 9 and 10, whilst information on what happens to the validation data once collected, is given when the Validation Loop is discussed in Section 13.

The AATSR VS is based at the Space Research Centre, University of Leicester, and works directly alongside the instrument PI, Professor David Llewellyn-Jones.

Contact details of the VS are:

Marianne Edwards
Earth Observation Science
Department of Physics and Astronomy
University of Leicester
University Road
Leicester, LE1 7RH
Tel: +44 116 2523521
Fax: +44 116 2525262
E-mail: mce1@le.ac.uk

6.1 The MERIS and AATSR Validation Team (MAVT)

In order to coordinate and manage the cal/val activities of the Envisat instrument, ESA have set up calibration and validation teams for the different payload instruments (see Figure 6.1-1). Guido Levrini of ESA ESTEC coordinates the cal/val programme as a whole.

AATSR has a calibration team (Figure 6.1-2), which focuses on the engineering aspects of the instrument commissioning and the verification of the data processing software. For validation, AATSR joins with MERIS to form the MAVT, the MERIS and AATSR Validation Team (Figure 6.1-3). MERIS and AATSR carry out similar validation measurements, and integration with the MERIS team is useful in that it ensures that AATSR validation activities are firmly integrated into the Envisat validation team. The MAVT is co-ordinated by Evert Attema at ESA ESTEC, helped by Paul Snoeij. Within the MAVT structure, AATSR activities are co-ordinated by the VS. Names listed in each column represent PI's that will be carrying out validation activities. In addition, a number of ESA observers are listed (P.Regner, P.Goryl, and H.Tait).

To aid administration and organisation within ESA, every validation activity is assigned a number. These numbers are 3 digits if the activity is an original AO response, or 4 digits if the activity is additional to the AO response. These numbers have been retained in this document for administrative purposes.

Information for the AATSR validation team is disseminated by the VS via the AATSR validation website, found at http://cerberus.cfs.le.ac.uk/aatsr/

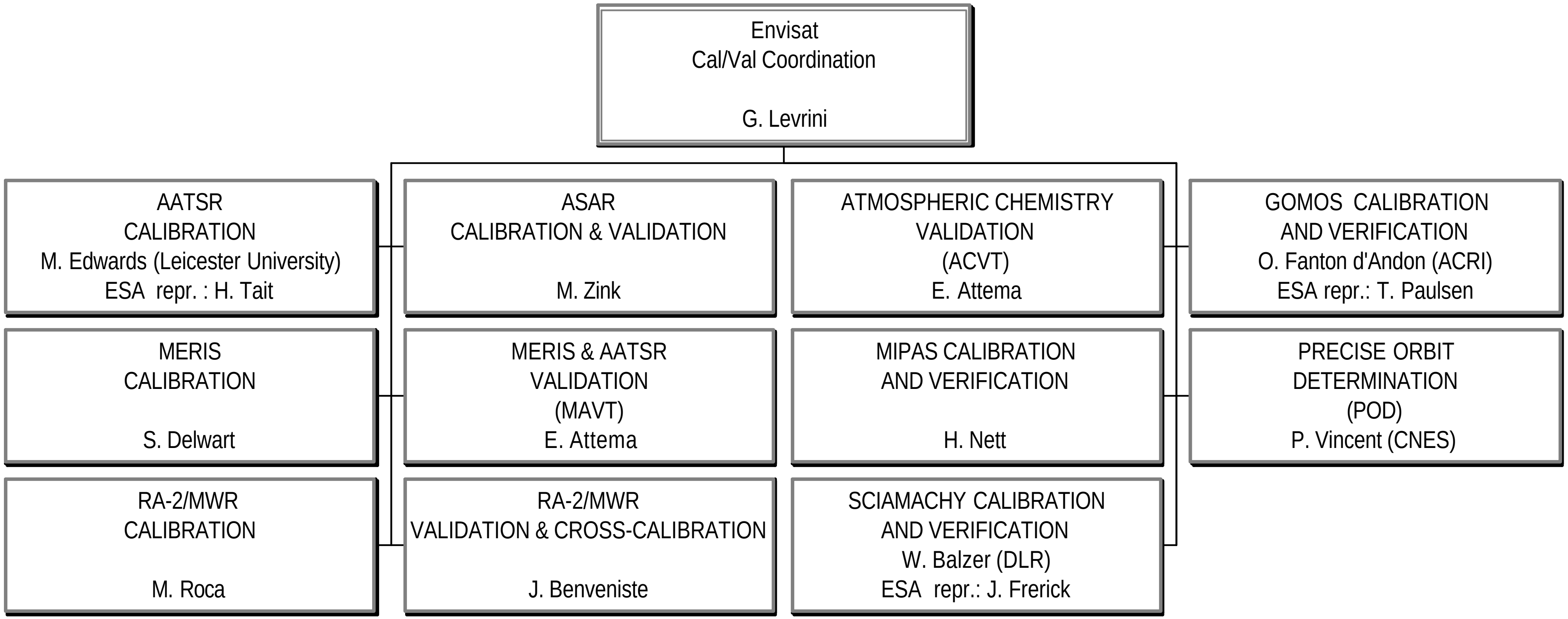


Figure 6.1-1 Organisation of the Envisat Cal/Val Programme

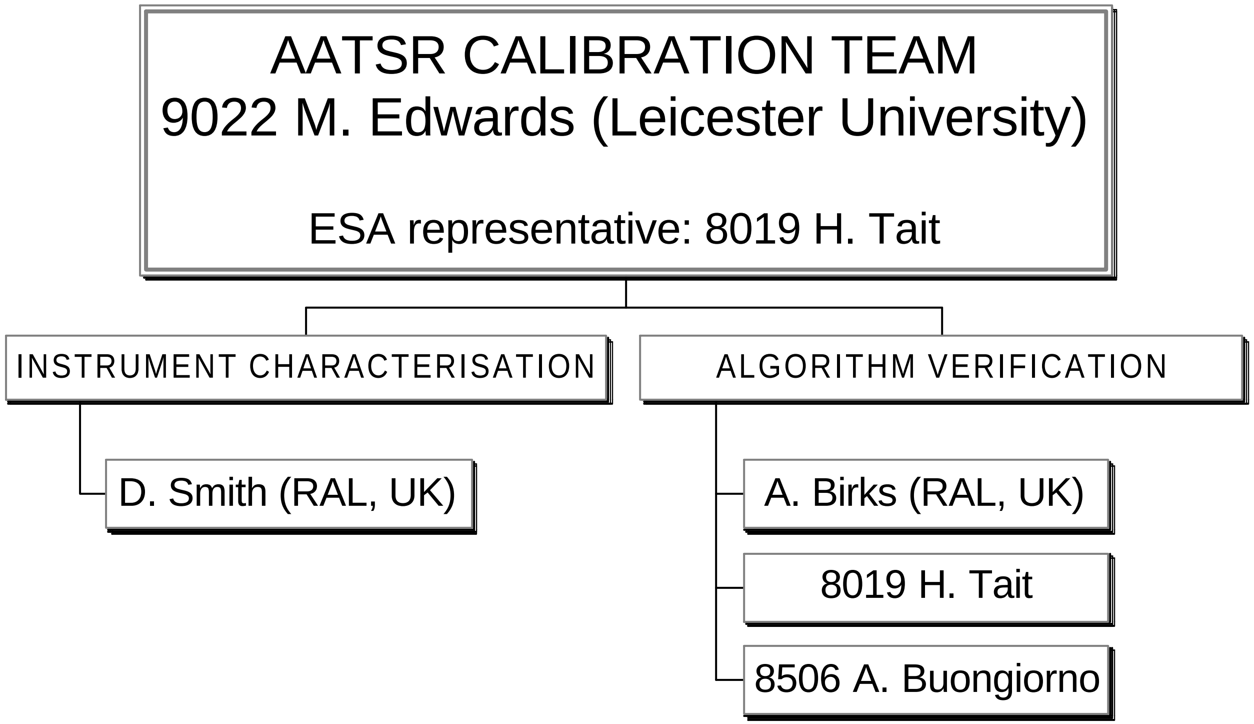


Figure 6.1-2 Organisation of the AATSR Calibration Team

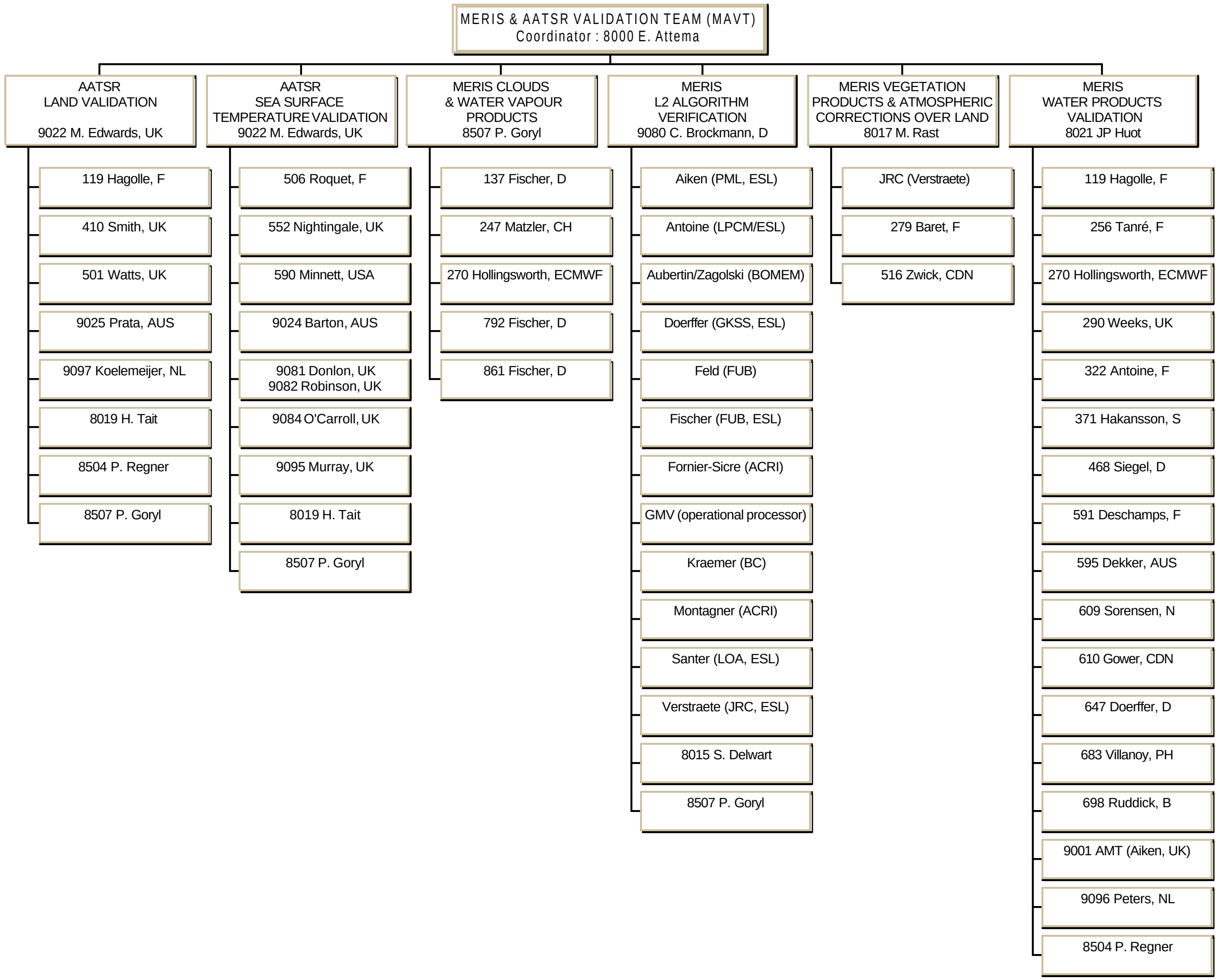


Figure 6.1-3: Organisation of the MERIS and AATSR Validation Team

7. Calibration

Most of the instruments on board Envisat require a series of activities post-launch to calibration the instrument. AATSR is slightly different in that it is self-calibrating. It has an on-board calibration system, which involves, for the thermal channels, the use of two specially designed and highly stable black-body reference targets, and, for the visible and near infra-red channels, a diffusely reflecting target that is illuminated once per orbit (for more information on AATSR calibration, see AD5 and AD6). As such, calibration of the instrument after launch is not required.

However, as indicated in Figure 6.1-2, there will be specific activities to check and characterize the instrument post-launch. These activities should be completed before validation starts, and are detailed in AD4. The majority of these activities will be carried out during the AATSR SODAP in the first few weeks of the mission, although some will continue further into the commissioning phase after validation has started. At the end of the SODAP, there will also be some algorithm verification activities where data processing algorithms are verified and fine-tuned. These are discussed in Section 8.

The vicarious calibration of the visible channels, where visible channel data from AATSR are compared with data from other instruments, can be classified as either calibration or validation. Within the AATSR validation programme, vicarious cal/val is treated under the title of validation, and is described in Section 10.1.

8. Algorithm verification

The objectives of this activity are to "commission" the AATSR processors, characterise the performance of the algorithms and evaluate L1b and L2 product quality. A key feature of this work will also be evaluating, tuning and regenerating the AATSR processor auxiliary files.

Algorithm verification is one element within the overall AATSR calibration and validation plan. Work on algorithm verification will start immediately after the end of the AATSR SODAP. The results of algorithm verification will feed back into upgrades of the AATSR processing chain at the end of the Commissioning Phase. The target for completion of L1b algorithm verification is L+4 months. L2 algorithm verification should be completed by L+6 months.

The unit, system and acceptance tests, and the breakpoints designed for PP and OP testing and debugging will be used as a basis for these tests. This activity will also take advantage of AATSR and ATSR-2 parallel operations.

The AATSR algorithm verification activities will be described in detail in the AATSR Algorithm Verification Plan (AD 11) and will be designed to cover a representative range of geographical areas and viewing conditions. The L1b algorithm verification will focus on: product formats (MPH, SPH, MDS, ADS), telemetry unpacking, conversion and validation, visible calibration, IR calibration, geolocation, collocation of forward and nadir views, cloud flagging (including sun glint), performance of land/sea mask and cosmetic fill. The L2 algorithm verification will focus on: (MPH, SPH, MDS, ADS), interpolation of solar angles and pixel position from the L1b product, SST and NDVI retrieval at 1 km resolution, the spatial averaging process, and SST, NDVI and cloud parameters retrieval for spatially averaged cells. The Algorithm Verification Plan will give details of test objectives, test data, test procedures, test tools, expected test results or pass/fail criteria, and suggestions for corrective action in case of test failure (e.g. detailed breakpoint analysis).

At a number of points prior to launch, L0 data obtained directly from the AATSR instrument will be made available. Algorithm verification will include examination of the format of this Level 0 data to ensure that it is consistent with that expected by the data processing system. These data will be further tested by processing through the PP, in such cases where instrument and auxiliary file configurations allow.

These activities will be coordinated by ESA, conducted by RAL in their role as AATSR Expert Support Laboratory.

9. Initial Validation Activities: Validation of SST Products

For SST, validation concentrates on validating the Gridded Sea Surface Temperature Product, and the Spatially Averaged Sea Surface Temperature Product.

Validation falls into three groups:

- Early indication of gross errors in ASST
- Spot values for gridded data, taken using autonomous instrumentation
- Precision measurements

Measurements taken under these three headings vary in their frequency, global distribution and accuracy. They are all necessary, and considered "core" validation activities. Figure 9-1 details the PI's leading different projects involved in the three levels of SST validation. Ian Barton of CSIRO is listed several times as he will act as the contact point for all Australian projects. The administrative number of the activity is also listed.

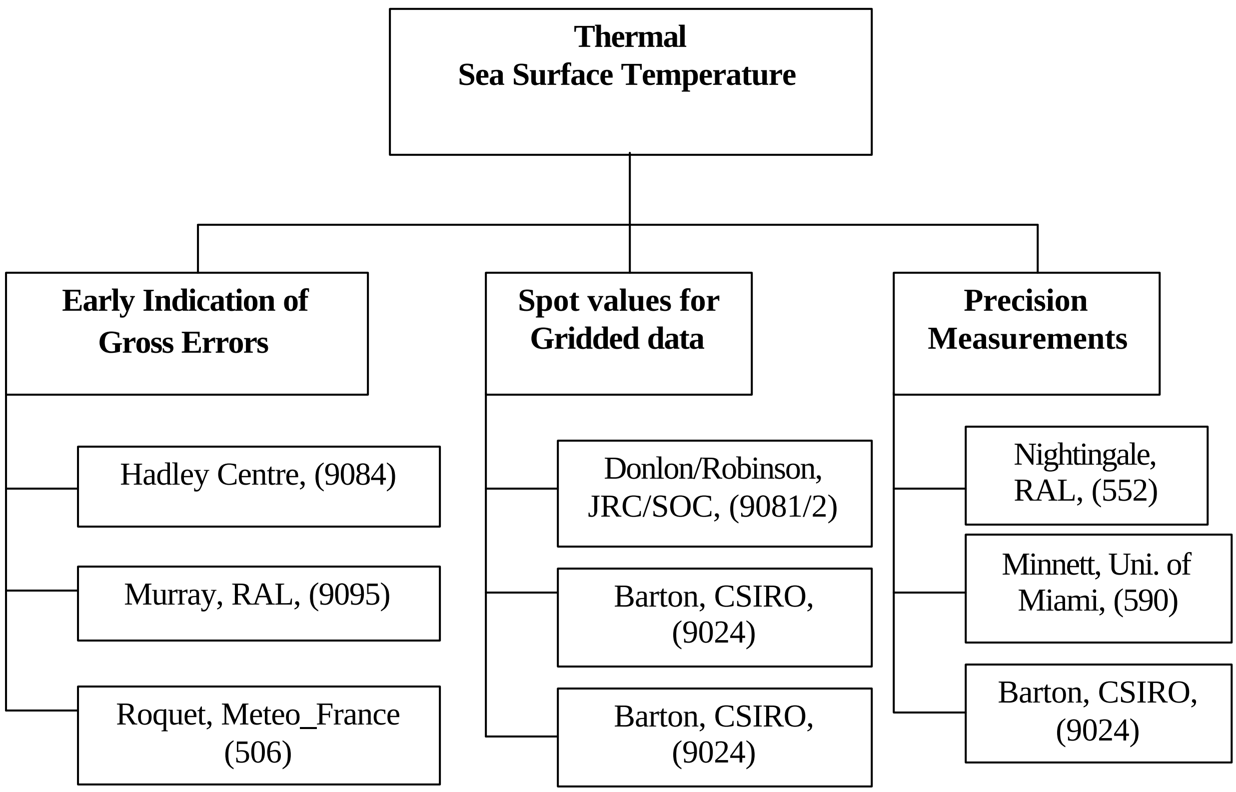


Figure 9-1: Levels of Validation for validating AATSR SST data products, and the PI's involved in each activity.

9.1 Level 1: Global Buoy Comparison including early indication of gross errors

Many of the early errors in SST's produced from ATSR-1 and ATSR-2 data were detected using systematic comparisons with buoy data and SST analysis fields. This is a good method of detecting gross errors in SST at an early stage, and is advantageous in that it can be carried out at a global scale and without field data collection campaigns.

9.1.1 Derivation of bulk SST from AATSR SST, and comparison to model SST's and buoy data, Met Office/Hadley Centre (9084)

The Met Office will derive bulk SSTs from the skin SSTs as described below and provide monitoring reports to DETR and ESA. The key staff involved in this activity are:

Principal Investigator (Contact): Roger Saunders
Satellite Applications, NWP Division
Met Office
London Road,
Bracknell
RG12 2SZ
roger.saunders@metoffice.com

Co-Investigators: Anne O'Carroll
Address as above
anne.ocarroll@metoffice.com

Lisa Horrocks
Address as above
lisa.horrocks@metoffice.com

9.1.1.1 Methodology

The Met Office will derive bulk SST from the AATSR observed skin SST, using surface wind and fluxes of heat and momentum from operational global NWP analyses. The skin to bulk correction will be applied to the near real time AST product.

It is planned, after careful monitoring, to assimilate the derived bulk SSTs into the new HadISST analysis scheme, along with in situ data, using Laplacian techniques and optimal interpolation, similar to the way in which AVHRR MCSSTs are assimilated. The HadISST analyses are globally complete SST and sea-ice monthly fields at 1° spatial resolution, available one month behind time.

The steps of the processing chain are:

1. Retrieve and decode AATSR near-real-time BUFR data
2. Compute skin SST's (10' × 10') from brightness temperatures
3. Combine (10' × 10') AST data into 0.5° × 0.5° data (if required)
4. Retrieve and interpolate (in space and time) the fluxes to drive the models of the skin effect and diurnal thermocline, and other fields required for quality control. This can be done over the full instrument swath.

5. Quality control incoming AATSR AST data.
6. Calculate value of delta-T (skin) from parameterisation of skin effect using model fluxes.
7. Calculate value of delta-T (sub-skin to 1m depth) from model of diurnal thermocline, using history of fluxes to set a diurnal thermocline flag if computations show a significant thermocline is likely.
8. Quality control output of skin and thermocline models.
9. Write out record of bulk SST, skin SST, latitude, longitude, time, across-track distance, delta-T's, quality control information, heat fluxes, brightness temperatures.
10. Retrieve buoy data and match in space and time with AATSR data. Produce NRT matchup file.
11. Retrieve offline buoy data (e.g. TOA array) and match with AATSR swath. Produce offline matchup file.

In addition to processing AATSR data in near real time, the same chain can also be used for processing ATSR-1/2 data, offline. The flexibility of using fluxes from an NWP model other than the Met Office's will be included (e.g. ECMWF reanalysis fields).

9.1.1.2 Deliverables to Validation Scientist

For validation purposes, including both gross and fine levels of quality control, the Met Office will provide the following to the VS:

- Time series of regional/global means (and standard deviation) of the difference between AATSR SSTs (both skin and bulk), and in situ observations. The in situ data are available as pentads at 5° spatial resolution for comparison with near real time satellite data. While AATSR versus in situ comparisons will be made weekly (or even daily), and potentially updated on the Hadley Centre website, statistics will be delivered to the VS on a monthly basis, as requested. The purpose of this comparison at the pentad resolution is to highlight sudden gross changes in the instrument performance.
- Monthly mean maps of the bias/standard deviation of the difference between AATSR bulk SST and HadISST. This will be a much finer comparison than the weekly checks, and will detect not only instrument problems but also levels of accuracy and any regional anomalies. Since the HadISST analysis fields take a month to complete, the results of this validation test can only be made available to the VS with at least one month's delay.
- Time series of a selected set of buoy minus AATSR SST (both skin and bulk). These will be updated monthly, as requested, and the difference data will also be uploaded to the NILU database.

The exact route of data delivery to the VS is TBD. Some of the data will be published on the external website. Examples of current monitoring plots for the ATOVS radiometers can be seen at: http://www.met-office.gov.uk/sec5/NWP/SRAG/Daily_ATovs_Monitoring/html/
The validation data will enter the validation loop.

9.1.1.3 Geographical Location

The Met Office will validate AATSR data over the oceans on a global scale subject to availability of global data from the satellite (i.e. no blind orbits), and the inevitable limitations of using in situ observations.

9.1.1.4 Data Requirements

- The Hadley Centre requires the ENVISAT AATSR Meteo Product (ATS_MET_2P) in Near Real Time (within 24 hours of measurement time).
- All orbits are required.
- Data will be obtained from ESA through a route TBD.

Address to where data should be sent:

Anne O'Carroll
Satellite Applications, NWP Division
Met Office
London Road,
Bracknell
RG12 2SZ
anne.carroll@metoffice.com

9.1.1.5 Interfaces

The PI and Co-Is will interface with a number of parties.

Interfaces	With whom	Reason	Timing
1	Validation Scientist	• For validation results and reports (in situ/satellite data matchups, maps etc.) • Participation in Data Quality Group	Monthly As required
2	DETR	• Participation in PSP/SAG	As required
3	ESA	• Receive AATSR Meteo Product	As required
4	NILU	• Buoy /satellite data matchups (small data volume)	Monthly
5	RAL	• Quality of Meteo product/validation	As required

9.1.1.6 Schedule

The Hadley Centre will work to the overall schedule outlined in Section 11. Up until launch, work will be carried out coding and updating the Met. Office AATSR Near-Real Time processor. The processor will receive cloud-cleared AATSR ABT data, calculate the skin SST, and apply the skin effect and diurnal thermocline models to estimate bulk SST.

9.1.2 Comparison of AATSR SST with buoy measurements, Murray (9095)

NB: The work of Dr Jo Murray of RAL in comparing AATSR SST measurements to buoy measurements is considered to have the scientific importance of a core activity. Funding constraints within DETR, however, mean that this activity will now be postponed until after the commissioning phase, in years 2 and 3.

Principal Investigator: Dr Jo Murray
Rutherford Appleton Laboratory
Chilton
Didcot
OX11 0QX

Co-investigators: Dr Chris Mutlow
RAL, as above.

9.1.2.1 Methodology

The work will compare AATSR data with buoy data, continuing work that has already been carried out with ATSR-2 data. AATSR data will also be intercompared with other satellite data, particularly those from microwave sensors such as the TMI and the AMSR-R.

The errors in the AATSR dataset will be identified and quantified, with particular attention paid to the spatio-temporal distribution of residual cloud contamination. The work is closely linked to that carried out by the UK Met. Office, and work will be carried out in conjunction with them.

9.1.2.2 Geographical Location

The work will be carried out on a global scale.

9.1.2.3 Data Requirements

- The following products are required:
  ATSR_AR_2P, full orbit product
- Data needed are offline.
- Transfer of data products via physical media.

9.1.3 ENVISAT/AATSR Matchup database for SST (506)

The objective of this work is to build a database including co-temporal and co-located AATSR and buoy observations. This database will provide a useful resource for the validation of SST algorithms under a wide range of atmospheric and oceanic conditions.

However, it is important to note that currently this project is limited only to establishing the database as the work is not fully funded and can only be performed by Meteo France on a best-efforts basis. The exploitation of the data in the database remains the subject of future work.

Principal Investigator: Herve Roquet
Meteo_France SCEM/CMS
Avenue de Lorraine B.P. 147
Lannion Cedex 22302
France
+33 296 056 764
+33 296 056 737
Herve.Roquet@meteo.fr

Co-Investigators: Alain Brisson, CMS
Pierre Le Borgne, CMS
Anne Marsouin, CMS

9.1.3.1 Methodology

Buoy measurements made at 0.5 m depth may not be considered ideal to validate satellite derived skin temperatures. Nevertheless, they are currently the only means of routinely validating surface temperature on a global scale, hence the usefulness of such a database.

The database will also include those data (in-situ measurements and NWP outputs) necessary to calculate the skin-bulk conversion, to support those users requiring satellite derived bulk temperatures and to evaluate the ability of AATSR to meet these requirements.

The database will be based on existing databases established at CMS for NOAA/AVHRR and GOES-8 data. There will be three categories of source data:

- In-situ measurements
- Numerical weather prediction model outputs
- Satellite data.

The buoy data will be collected routinely from a variety of sites across the world’s oceans and their quality will be assessed against climatological values. In situ data will include SSTs and other meteorological observations, when available. NWP model outputs will be included to provide air temperature and humidity profiles and near surface values, and wind estimates.

AATSR data will be extracted at the times and locations of the in-situ observations, for boxes of TBD size, centred at each in-situ location. Amongst other things, this will allow for various atmospheric correction smoothing techniques.

The database will support the following applications:

- Derivation, calibration and validation of SST retrieval algorithms in a wide range of oceanic and atmospheric conditions;
- The study of specific problems, such as the effects of atmospheric aerosols or skin-bulk conversions;
- Characterisation of the SST errors from satellite and buoy measurements, prior to use in other analysis and assimilation systems.

The development of the AATSR match-up data base will follow as closely as possible the content and format of the PATHFINDER AVHRR match-up data base, documented on http://www.rsmas.miami.edu/groups/rrsl/pathfinder/Matchups/match_index.html.

9.1.3.2 Geographical Location

Figure 9.1.3.2-1 shows the locations of the moored buoys to be used for this activity.

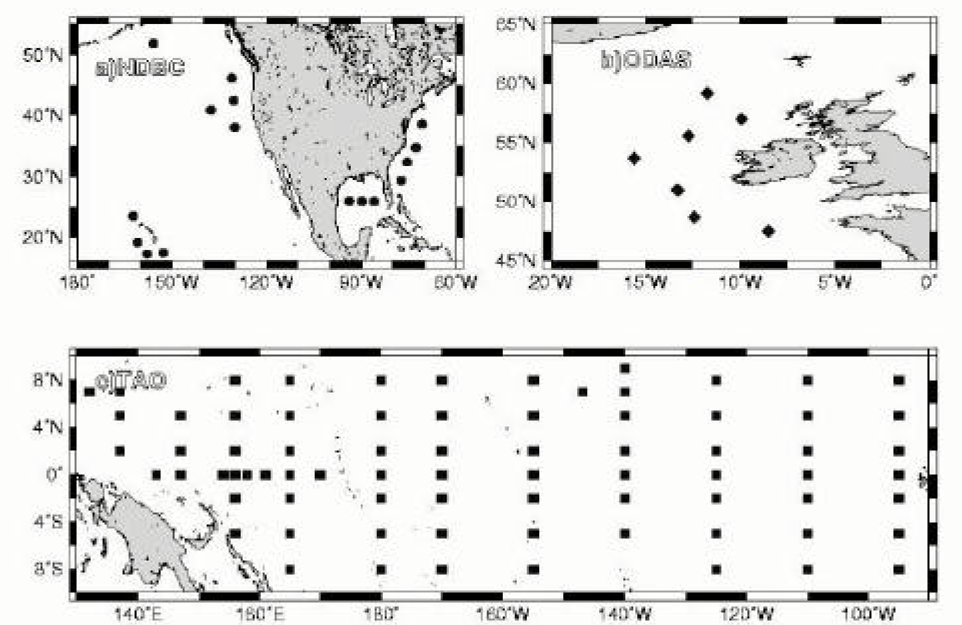


Figure 9.1.3.2-1 Location of buoys used to create a matchup database for SST

Table 9.1.3.2-1 gives the locations of the European meteorological buoys.

Identifier	Latitude	Longitude
62029	48.70	-12.40
62081	51.00	-13.30
62105	54.90	-12.60
62106	57.00	-9.90
62108	56.60	-13.20
62163	47.50	-8.50
64045	59.10	-11.40
61001*	43.40	7.80

Table 9.1.3.2-1 Locations of the European Meteorological Buoys

* Indicates an additional buoy, not shown in Figure 9.1.3.2-1, which has been moored in the Mediterranean Sea, and will be of particular interest due to more frequent cloud free conditions in this region.

Exact location information for the NOAA and TOGA arrays is TBD.

9.1.3.3 Data Requirements

512 x 512 km scenes of the following products are required routinely over each buoy location.

- ATS_TOA_1P (Level 1B TOA BT/reflectance)
- ATS_NR__2P (Level 2 SST 1 km resolution)
- Data will be delivered off-line. There is no NRT requirement.
- Transfer of data products will be via weekly batches delivered on CD-ROM.

The use of the RA-2/MWR product RA2_MWG_2P for water vapour content is currently being investigated.

Address to where data should be sent: Herve Roquet
Address as above

The default method of obtaining AATSR data for this work will be via the ENVISAT USF. PERL scripts provided by the USF will be used to set up a standing order for 512 x 512 km scenes over each site.

9.1.3.4 Interfaces

Interfaces	With whom	Reason	Timing
1	USF	To order ENVISAT Products	TBC
2	Validation Scientist	Receive updates on the status of AATSR Cal/Val activities. Send validation results, and report progress of work.	TBC

9.1.3.5 Schedule

This work will follow the overall validation schedule outlined in Section 11. In particular, prior to the ENVISAT launch, preparatory activities will focus on:

- The second ENVISAT cal/val rehearsal
- Familiarisation with the AATSR product format
- Building the input and output interfaces around the database

Following the release of products to cal/val PIs, the database will be built on a routine basis as AATSR data are received at CMS. Initially data will be collected for 6 months to ensure a representative data set. This 6 month dataset will be made available to investigators from other scientific teams a few months later, following the completion of quality control procedures.

9.2 Level 2: 'Spot values for gridded data'

Validation will also take place using autonomous measurements from instruments on board ships of opportunity. These will provide spot values for validating SST gridded data (GSST).

9.2.1 Infrared Sea surface skin temperature Autonomous Radiometer (ISAR-5-IR) system (552)

One of the instruments that will be used for Level 2 validation is the ISAR, designed by Dr Craig Donlon of JRC, and developed in conjunction with Southampton University.

Principal Investigator: Professor Ian Robinson
Southampton Oceanography Centre
University of Southampton
School of Ocean and Earth Science
Waterfront Campus
European Way
Southampton
SO14 3ZH
isr@soc.soton.ac.uk

Co-Investigators: Dr Craig Donlon,
CEC-Joint Research Centre
Space Applications Institute
Marine Environment Unit (TP272)
Via Enrico Fermi
I-21020
Italy
Craig.Donlon@jrc.it

9.2.1.1 Instrumentation

ISAR is a precision, autonomous, self-calibrating infrared radiometer, capable of measuring in situ sea surface temperature (SSST) accurate to ± 0.1K rmse. The ISAR-5 radiometer uses two precision calibration black body (BB) cavities to maintain the radiance calibration of a solid state infrared detector having a spectral window of 9.6-11.5µm. All ISAR-5 target views are made using a single route optical path via a protective scan drum arrangement that allows the target view to be accurately positioned over a range of 180°. The BB apertures are completely sealed from direct water ingress using a patent pending shutter mechanism triggered by an optical rain sensor that completely seals the ISAR-5 from the external environment. This is important in order to protect the instrument on deployments of up to 3 months.

The ISAR-5 system has been designed from the outset to provide a total solution to the needs of satellite validation work. It has a dedicated fully configurable RS-485 port that can be used to connect other sensors required to place the radiometer measurements into an ocean-atmosphere context. Included in these measurements are: bulk SST determined from a hull mounted (mounted on the internal hull) sensor, wind speed and wind direction, solar radiation, humidity and, long wave radiation. The maximum deployment of an ISAR instrument is 3 months although experience suggests that the ISAR, like any other oceanographic instrument, should be thoroughly checked at 1 month intervals for problems and replaced as required.

9.2.1.2 Methodology

Two ISAR instruments will be developed, and used in tandem. At any one time, one ISAR will be deployed on a merchant ship collecting data, and the second will be returned to the laboratory for service, maintenance and re-calibration.

- As the vessel continues normal operating duties, ISAR will provide measurements of SST at 3-minute intervals. The SST data will be derived as an integrated average over a 1 minute period and include full correction for sky reflections at the sea surface, calibration and ancillary engineering data.

- If possible, data collected will be fed in near real time to SOC using the ship's e-mail system. An automatic tape backup of each days data will be made every night. Complete data download will depend on access to the ship and may incur a delay of up to 3 months depending on vessel operations.

- AATSR data will be ordered in advance, corresponding to ISAR's geographic and temporal position.

- High resolution (1 km) AATSR data contemporaneous with valid ISAR data are required to perform a satisfactory validation study. Matchup's between SST measurements collected by ISAR and cloud free AATSR imagery will be made at SOC. These data will be e-mailed to the VS, and enter the 'validation loop'. Relevant ISAR and corresponding data will be posted to the NILU database.

9.2.1.3 Geographical Location

In the first instance, ISAR will be installed on the Brittany Ferry, the Val De Loire. This operates between Portsmouth and Le Havre. Negotiations have already underway with Brittany Ferries, and ISAR should be installed for testing during the second rehearsal before launch, April/May 2001.

While initial deployments of ISAR will focus on the European area (Celtic Sea, Bay of Biscay and E. Channel), negotiations will continue with ferry companies/merchant ships operating over a wider geographical coverage. It may be possible to operate both ISAR's simultaneously on separate ferries although there is a risk that both ISAR's sustaining damaged due to extreme weather resulting in no validation data being available for as repair or replacement is undertaken.

Following the successful activities in the European area, additional ships operating regular, long-haul intercontinental passages will be sourced. Ideally these should operate from Southampton or Portsmouth facilitating access to the ship, and call to places where project contacts are available to provide maintenance and support to the ISAR system. Target calls include Miami, USA (University of Miami, RSMAS, Dr. P. Minnett), Seattle, USA, (University of Washington, APL, Dr. A. Jessup), Hobart, Tasmania (CSIRO, Dr. I. Barton). It will be a priority to ensure these passages include a broad range of atmospheric and oceanic conditions although the constraints of ship and passage availability may preclude optimal passage routes.

9.2.1.4 Planned Validation Activities

During the first validation rehearsal in October/November 2000, the prototype ISAR (ISAR-01) successfully collected data for a 4-week continuous period. Following this initial deployment, it was calibrated against a standard black body and performed to specification. ISAR-01 will participate in the 2nd Radiometer inter-calibration exercise planned at the University of Miami in late Spring 2001. Following this, it is foreseen that ISAR-01 will be installed on the Val De Loire Ferry for initial sea trials. However, it should be noted that due to delays in contractual arrangements, ISAR-02 is unlikely to be complete and available for deployment until October 2001.

Although it may be possible to provide a near real time ISAR data product via e-mail communication, for final validation post processing of all ISAR data will be required before matching to AATSR data. In addition, each AATSR scene will require careful interpretation to ensure that contemporaneous data are cloud free. Experience suggests that one of two modes of AATSR data acquisition are preferred:

a) All data for a given (rectangular) area are archived and sent to the PI. This mode may work well for small areas such as that in which the Val de Loire will operate. While there will be considerable redundant data in this mode, it will ensure that all data are available for validation and provide a regular and simple data order to the PAF. This method will allow validation results to be published most rapidly.

b) ISAR data are processed and quality controlled. Corresponding AATSR data are ordered based on quick look inspection for ISAR data. Quick look data can be archived and sent to the PI in the same way as method (a) above. AATSR scenes that are considered adequate for validation can then be ordered as required.

Experience suggests that additional data requests are often necessary due to ship deviations from the spatial and temporal arrangements submitted to the PAF. This will be addressed as necessary.

9.2.1.5 Data Requirements

- The following AATSR data products are required:
  512 x 512 scenes of ATS_TOA_1P, brightness temperature and SST products for all passes covering track of ferry operating in English Channel/Celtic Sea/Bay of Biscay.
  ATS_NR_2P
  ATS_AR_2P
- Transfer of data products via physical media.
- Data volume: 2 scenes, twice per day, for 6 months during commissioning phase.
- Data needed are offline.
- Data from other instruments would be helpful, such as wind speed from the radar altimeter, and products from MERIS, for understanding water types and atmospheric aerosol loading.

Address to where data should be sent

Profess or Ian Robinson
Southampton Oceanography Centre
University of Southampton
School of Ocean and Earth Science
Waterfront Campus
European Way
Southampton
SO14 3ZH

9.2.1.6 Interfaces

The PI will interface with a number of parties.

Interfaces	With whom	Reason	Timing
1	Validation Scientist	• Help with cruise planning, instrument installation and running, data acquisition. • Help with NILU submission • Send validation results (in situ/satellite data matchups) • Participation in Data Quality Group	Pre and post launch As required Monthly As required
2	ESA USF	• Order and receive AATSR data • Order and receive radar altimeter, and MERIS data (TBC).	As required As required
3	NILU	• Submission of in situ/satellite matchups	TBC

9.2.1.7 ISAR Schedule

Robinson/Donlon will work to the overall schedule outlined in Section 11. In terms of the two ISAR instruments, the schedule is as detailed in Table 9.2.1.7-1:

	Date	**Activity**
ISAR-1	Feb-May 2001	Final system configuration following 4 week autonomous test at SOC
	May 2001	Final instrument calibration at BNL
	May-June 2001	Instrument validation at Miami radiometer workshop
	June-July 2001	Installation of ISAR system (ISAR + Ocean and atmosphere sensors) on M/V Val de Loire
	August 2001	Trialling of AATSR validation operations in English Channel, Celtic Sea, and Biscay, in collaboration with Brittany Ferries.
	October/November 2001	Commencement of validation data collection
ISAR-2	April-June 2001	Instrument procurement and construction phase
	July 2001	Calibration and validation phase
	August 2001	Deployment in tandem with ISAR-1 aboard Val de Loire

Table 9.2.1.7-1 Schedule for ISAR-1 and ISAR-2 activities

9.2.2 The Rottnest Island Ferry in Perth, Barton (9024)

Validation measurements are being collected by an infrared radiometer fitted to a passenger ferry that operates on a daily basis between the Perth coast and Rottnest Island, 25km offshore.

Principal Investigator: Dr Ian Barton
CSIRO Marine Research
GPO Box 1538
Hobart, Tasmania 7001
Ian.Barton@marine.csiro.au

Co-Investigator: Mr Alan Pearce
CSIRO Marine Research
PO Box 20, North Beach
Western Australia WA 6020
Alan.Pearce@marine.csiro.au

9.2.2.1 Instrumentation

The Rottnest Island passenger ferry carries a TASCO infrared radiometer (HORIBA IT-340), which is housed in a well-sealed tube located in a semi-protected area near the bridge of the ferry, as well as a PRT sensor in the engine intake system for “bulk” temperature measurements. As the ferry makes the 25 km return trip between Hillarys Marina and Rottnest Island, both the TASCO and the PRT temperatures are recorded together with date/time and a GPS position. A second infrared radiometer has been installed at the CSIRO laboratories near the coast to sense the downwelling sky radiance and thereby allow for the reflected sky radiance correction.

Data are automatically logged onto a datalogger at 10-second intervals and are downloaded onto computer on a weekly to fortnightly basis. From time-to-time, the objective lens of the radiometer requires replacement due to salt corrosion. The infrared radiometers are calibrated against an accurate portable black body at about monthly intervals, and the bulk temperature device is calibrated against a standard thermometer. At times when the conditions are not suitable, the radiometer system can be covered to avoid excess spray. The facility will shortly be upgraded to overcome some of the operational problems, which have been experienced.

Wind measurements are also available from shore weather stations at Hillarys Marina and Rottnest Island.

9.2.2.2 Methodology

1 **Instrument installation:** The TASCO radiometer is fitted to the Rottnest Island passenger ferry SeaFlyte, with a clear beam view of the sea. It samples in the 8 to 12 µm range.
2 **Validation Data Collection:** The ferry travels daily between Hillarys Marina and Rottnest Island (32°S), with different schedules in summer and winter. On a typical daily

schedule, the ferry departs at 0900 and 1430 daily, with a travel time to the Island of 40 minutes. On the transect, the datalogger records both TASCO and PRT measurements at 10-second intervals, and after downloading, 1-km averages are computed along the track.

3 **Data Download:** Once a week or fortnight, the instrumentation is checked and maintained, and data are downloaded.

4 **Satellite data ordering and collection:** AATSR will be ordered from the ESA User Services Facility in advance, depending on the geographic and temporal location of ISAR instruments.

5 **In situ/satellite data matchups:** High resolution (1km) AATSR data contemporaneous with valid TASCO data are required to perform a satisfactory validation study. Matchups between SST measurements collected by the TASCO and cloud free AATSR imagery will be made at Marmion. These data will be emailed to the validation scientist, and will enter the 'validation loop'. Validation reports will be sent to the VS on a monthly basis.

9.2.2.3 Geographical Location

Validation measurements will be collected in Perth, Australia, along the Hillarys - Rottnest Island transect (25 km). Only daytime data will be collected. This is located at 31.8° S, 115.8°E to 32.0°S, 115.5°E. Figure 9.2.2.3-1 shows a map of the transect along which validation data will be collected.

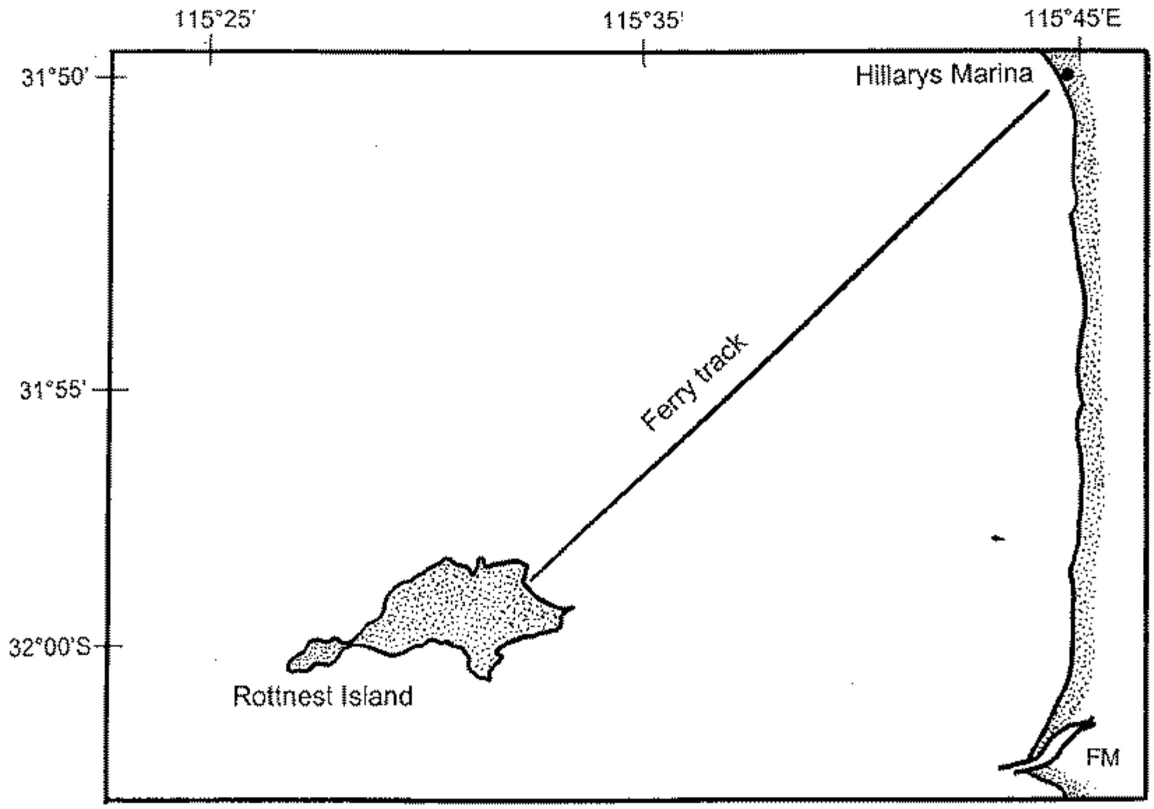


Figure 9.2.2.3-1 Ferry transect along which validation data will be collected with the TASCO radiometer

9.2.2.4 Planned Validation Activities

The TASCO radiometer is already installed on the Rottnest Island Ferry although an upgrade is currently being planned. This will remain on the ferry collecting daily measurements during the commissioning phase of ENVISAT.

9.2.2.5 Data requirements

- The following AATSR data products are required:
  ATS_TOA_1P
  ATS_NR_2P
- Transfer of products via physical media.
- Data volume: 512 x 512 scenes of ATS_TOA_1P and ATS_NR_2P for every daytime pass over the ferry transect.
- Data needed are offline.

Address to where data should be sent

Dr Ian Barton
CSIRO Marine Research
GPO Box 1538
Hobart, Tasmania 7001
Ian.Barton@marine.csiro.au

9.2.2.6 Interfaces

The PI will interface with a number of parties.

Interfaces	With whom	Reason	Timing
1	Validation Scientist	• Help with NILU submission • Send validation results (in situ/satellite data matchups) • Participation in Data Quality Group	As required. Monthly As required
2	USF	• Order and receive AATSR Data	TBC
3	NILU	• Weekly uploads of ferry data, approx. 50 Kbytes.	Weekly

9.2.2.7 Schedule

Validation data collection on board the Rottnest Island Ferry will follow the overall validation schedule described in Section 11.

9.2.3 The wave-piercing ferry in Townsville, Barton (9024)

Validation measurements will be collected using an infrared radiometer fitted on a wave-piercing catamaran ferry.

Principal Investigator: Dr Ian Barton
CSIRO Marine Research
GPO Box 1538
Hobart, Tasmania 7001
Ian.Barton@marine.csiro.au

Co-Investigator: Dr William Skirving
PMB No. 3
Townsville MC
Queensland 4810
w.skirving@aims.gov.au

9.2.3.1 Instrumentation

An infrared radiometer system, based on an Everest radiometer, has been developed by the Australian Institute of Marine Science (AIMS). It has in-built black body targets, and is installed on the Pure Pleasure Ferry (Figure 9.2.3.1-1), which operates between Townsville and Kelso reef on the Great Barrier Reef. The ship design allows an almost vertical view of the sea surface which is undisturbed by the ferry's wake. A view of 30 degrees to the vertical is used to ensure that reflections from the ship do not contaminate the reflected sky radiance. The ferry also carries a bulk temperature measuring system, and surrounding buoys provide measures of air and sea temperature, wind and solar radiance every 30 minutes. Currently, the sky radiance is calculated using an atmospheric transmission model with radiosonde data from Townsville airport, which is close to the coast. Radiosondes are launched at approximately 0900 local time daily.

AIMS are working on a new radiometer system, which is based on the old system but has advanced features such as advanced black body units and a same-day data collection capability via an automated mobile phone. This should be ready in time for AATSR launch.

Figure 9.2.3.1-1: The 'Pure Pleasure Ferry' that operates between Townsville and the Kelso Reef, and carries an infrared radiometer designed to collect measurements for the calculation of sea surface temperature.

Figure 9.3.2.1-2: The Everest Radiometer fitted to the bow of a catamaran operating from Townsville to the Great Barrier Reef.

9.2.3.2 Methodology

1. **Instrument installation:** The Everest radiometer is fitted to the bow of the Pure Pleasure Ferry.
2. **Validation Data Collection:** The Ferry travels from Townsville to Kelso Reef, a distance of 90 km at between 9.00 and 11 am every day, 5 or 6 days a week. On the transect, the radiometer records measurements at 8-14µm wavelengths, at single

waveband intervals. The system averages over one minute. A bulk SST measurement, a pyrgeometer output and local radiosondes give an emissivity correction.

3. **Data Download:** Once a week, the instrumentation is checked and maintained, and data are downloaded daily.
4. **Satellite data ordering and collection:** AATSR will be ordered from the ESA User Services Facility in advance, depending on the geographic and temporal location of ISAR instruments.
5. **In situ/satellite data matchups:** High resolution (1km) AATSR data contemporaneous with valid Everest data are required to perform a satisfactory validation study. Matchups between in situ SST measurements and cloud free AATSR imagery will be made at AIMS. These data will be e-mailed to the validation scientist, and will enter the 'validation loop'. Validation reports will be sent to the VS on a monthly basis.

9.2.3.3 Geographical Location

Validation measurements will be collected on a 90km transect between the Australian coast at Townsville and the Great Barrier Reef. This is at 19.2 S to 18.5 S along 147.0 E. During the austral winter months, this area has an extremely low level of cloud cover, which will ensure that many data coincidences between ship and satellite data occur.

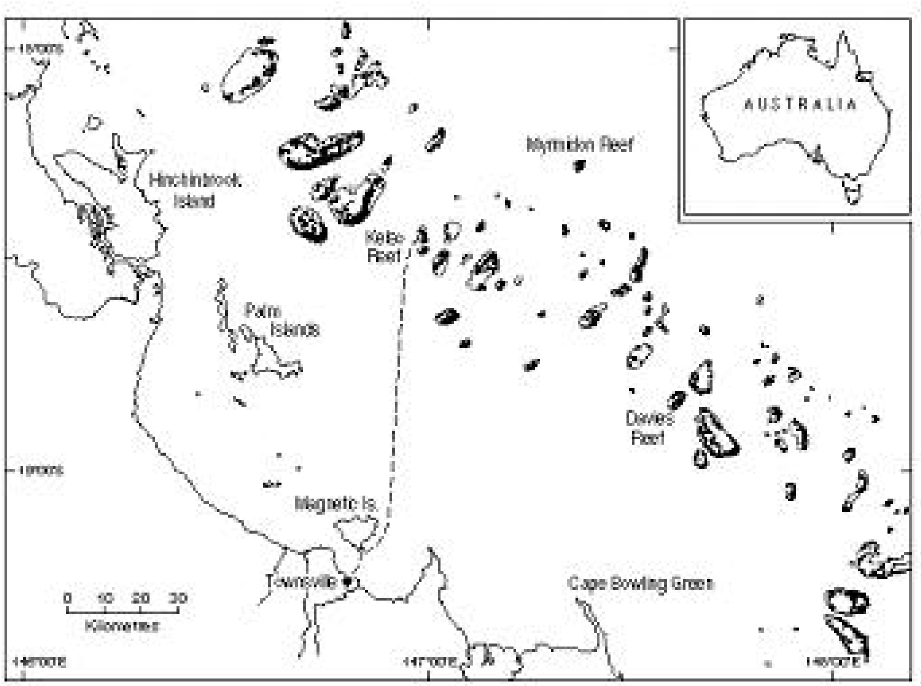


Figure 9.2.3.3-1 Location of the validation activities operating from Townsville to the Great Barrier Reef.

9.2.3.4 Planned validation Activities

Data from the Everest radiometer are already being collected and used for the validation of SST measurements from ATSR-2. This activity will continue with AATSR on ENVISAT.

9.2.3.5 Data requirements

- The following AATSR data products are required:
  ATS_TOA_1P
  ATS_NR_2P
- Transfer of products via physical media.
- Data volume: 512 x 512 scenes of ATS_TOA_1P and ATS_NR_2P for every daytime pass over the ferry transect.
- Data needed are offline.

Address to where data should be sent

Dr Ian Barton
CSIRO Marine Research
GPO Box 1538
Hobart, Tasmania 7001

9.2.3.6 Interfaces

The PI will interface with a number of parties.

Interfaces	With whom	Reason	Timing
1	Validation Scientist	• Help with NILU submission • Send validation results (in situ/satellite data matchups) • Participation in Data Quality Group	As required. Monthly As required
2	USF	• Order AATSR Data • Receive AATSR Data	TBC
3	NILU	• Weekly uploads of ferry data, approx. 50 Kbytes. • Downloads of data from other validation exercises.	Weekly As required

9.2.3.7 Schedule

Validation data collection from Townsville will follow the overall validation schedule described in Section 11.

9.3 Level 3: Precision Measurements

On the third level, validation will take place using radiometers, specifically designed to take measurements of a high precision. These instruments are generally not autonomous and as a consequence, provide fewer data points and a limited coverage. Data, however, are very accurate, and supplements information given from Level 1 and Level 2 validation activities.

9.3.1 SISTeR, Nightingale (552)

SISTeR has been used to validate SST measurements from ATSR-2 for a number of years, and this activity is considered part of the core AATSR validation programme. However, financial constraints within DETR mean this work is not currently funded for the commissioning phase. This matter is under review. TBC.

SISTeR is a precision radiometer developed by Dr Tim Nightingale of RAL. It has been used for the validation of ATSR and ATSR-2 data, and will be involved in making measurements for validating AATSR. For more information on SISTeR, see http://www.atsr.rl.ac.uk/validation/, and the references listed below.

Principal Investigator: Dr Tim Nightingale
Space Science and Technology Department
Rutherford Appleton Laboratory
Chilton, Didcot
Oxon, OX11 0QX
T.J.Nightingale@rl.ac.uk

Co-Investigators: Dr Chris Mutlow, RAL
Dr Marianne Edwards, University of Leicester
Dr Craig Donlon, JRC

9.3.1.1 Instrumentation

The Scanning Infrared Sea surface Temperature Radiometer, SISTeR, is a compact and flexible, self-calibrating radiometer, specifically designed for research in a maritime environment. It measures approximately 20 x 20 x 40 cm, and weighs about 20kg. SISTeR is shown in Figure 8.3.1.1-1.

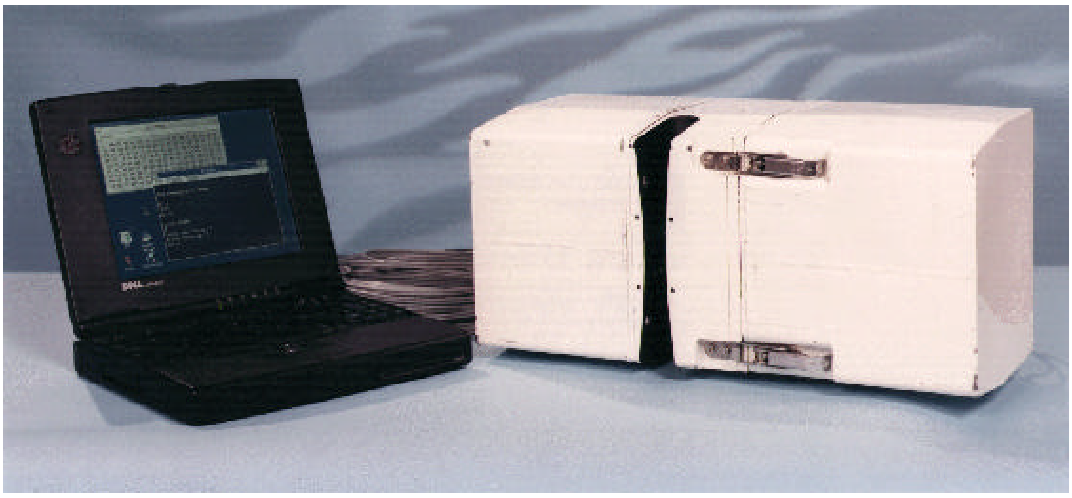


Figure 9.3.1.1-1: The SISTeR radiometer and supporting equipment (taken from http://www.atsr.rl.ac.uk/validation/sister/sis_inst/)

The instrument is divided into three compartments containing the foreoptics, the scan mirror and reference black bodies, a small format PC with signal processing and control electronics. The foreoptics compartment contains a DLATGS pyroelectric detector and preamplifier, mounted onto an assembly containing a concentric 6-position filter wheel and a black rotating chopper. The filter wheel contains three narrow-band filters centred at 3.7µm, 10.8µm and 12.0µm, matching those in the ATSR instruments. The beam is chopped at 100Hz, a compromise between the optimum noise performance of the detector and a fast filter response in the signal processing chain. The main optical element is an ellipsoid mirror, by which the detector can view a 45° scan mirror through an anti-reflection coated ZnSe window.

All external radiance measurements are calibrated using two internal black bodies, operated at ambient temperature and at a programmable increment (typically 10 K) above ambient temperature. Each black body contains an embedded rhodium iron thermometer and is calibrated complete against a standard thermometer. External views can be programmed in fine increments at angles in a range spanning 180° from nadir to zenith.

9.3.1.2 Methodology

1. **Instrument development and testing:** SISTeR has been used on a number of validation campaigns already, collecting validation data points for the ATSR-2 instrument. Between deployments, the instrument undergoes extensive cleaning and maintenance, and calibration activities.

2. **Organisation of cruises/negotiation with ships-of-opportunity:** Negotiations with ships-of-opportunity take place, making use of both pre-existing contacts and new opportunities. Cruise availability and the participation of SISTeR are confirmed. Ancillary instruments that will be needed are identified, and acquired (by purchase, loan or hire).

3. **Instrument packing and shipping:** SISTeR is packed and arranged for shipping, with all required documentation, at times and places agreed with the cruise operator.

4. **Installation:** The SISTeR is generally mounted as far forward and as high as possible on the host ship, so that it is clear of "green water" and spray, and can view undisturbed water forward of the bow wave. Where possible, the viewing angle to the

sea is kept within the range 15° - 40° from nadir. The instrument also requires a clear view to the sky at the complementary angle from zenith.

The SISTeR is equipped with a quick release mount and is provided with a small turret, to which a mating bracket is attached. The turret should be mounted on a horizontal surface with a pattern of eight holes. A small horizontal platform, with the pattern pre-drilled, is also available and can be attached to handrails with U-bolts.

The SISTeR requires 24V DC power and serial data connections. Instrument data are logged remotely on a laptop PC. Waterproof power supplies, serial modems and cable sets are available for runs of 100m or more with terminations for a variety of mains outlets.

5. **In situ data collection:** The SISTeR makes continuous measurements throughout the cruise, unless severe weather prevents data collection (in this instance, the instrument is covered to protect it). Typically, SISTeR radiances are sampled every 0.8s with the 10.8µm filter. Skin SSTs are calculated from the upwelling ocean radiance samples, corrected for a small reflected sky radiance term with the complementary sky samples. Over a flat sea surface and for a narrow filter function, the upwelling radiance can be approximated closely as

$$R\_up = B(SST) + (1 - e)\, R\_down$$

where R_*up* and R_*down* are the upwelling sea and complimentary downwelling sky radiances, e is the emissivity of the sea surface and B(T) is the Planck function, each integrated over the instrumental filter function and field of view. R_*up* and R_*down* are measured directly by the SISTeR, and so the term B(SST) and hence the skin SST can be retrieved from these. The data are analysed on board and are available at the end of the cruise for comparison to satellite data. If urgently required, small amounts of data can usually be supplied whilst at sea. Supporting measurements of local meteorological parameters, bulk sea surface temperature and balloon-sonde profiles of atmospheric state will provide a valuable context for the skin SST data.

SISTeR Operation: All aspects of the SISTeR instrument, from the scan mirror position to the detector signal are accessible through variables defined in a C library. Control programs of arbitrary complexity can be written, but generally just a few lines of code are needed to define a scan sequence. When a control program is running, the complete instrument state is transmitted over a serial link to a laptop ground station after every measurement. All SISTeR measurement sequences contain repeated measurements of its two internal black bodies. In addition, to calculate the skin SST, the SISTeR is programmed to make measurements both of upwelling radiances from the sea surface and complementary downwelling sky radiances.

In the SISTeR longwave channels, the measured noise temperature for a 1 second sample at typical SSTs is less than 30mK. Measurements of an external CASOTS black body before, during and after a typical one-month validation campaign showed that the SISTeR calibration remained repeatable to better than 20mK, even though the scan mirror finish had deteriorated noticeably over the same period.

6. **Satellite data ordering and collection:** AATSR data will be order from the ESA User Services Facility in advance, depending on the cruise track.

7. **In Situ/satellite data matchups:** High resolution AATSR data contemporaneous with valid SISTeR data are required to perform a satisfactory validation study. Matchups between SST measurements collected in situ and cloud-free AATSR data will be made by Tim Nightingale at RAL. These data will be reported to the validation scientist, and will enter the validation loop. After the AATSR SODAP, and during the commissioning phase (2-6 months after launch), validation reports will be be sent to the VS on a monthly basis. Post-commissioning, validation reports will be sent bi-monthly. The PI will be invited to participate in the Data Quality Group as appropriate.

9.3.1.3 Geographical Location

Ideally, SISTeR will collect data on a global scale. Precise location will depend on the cruises that can be undertaken, and the availability of funding and berths.

9.3.1.4 Planned Validation Activities

a. **Indian Ocean:** The NERC vessel, the Charles Darwin, will be in the Indian Ocean from 16th November 2001 to 14th December 2001. It will travel from Muscat, Oman to Durban. The straight transect will take 15 days, and any remaining time can be spent directing the boat as required (i.e. to cover as many as possible ENVISAT/ERS-2 overpasses). Adrian New at Southampton Oceanography Centre has expressed an interest in being Principal Scientist for the cruise, working closely alongside Leicester University and RAL to optimise the cruise for ENVISAT validation. At the present time, the cruise is being assessed for the probability of cloud cover, and the coincidences of ERS-2/ENVISAT overpasses.

b. **AMT:** The Atlantic Meridional Transect operates taking supplies down to Antartica. SISTeR has participated in the AMT twice before, once in 1996 and once in 1998 (see http://www.atsr.rl.ac.uk/validation/index.shtml). In 1998, the Rutherford Appleton Laboratory, in collaboration with the Colorado Center for Astrodynamics Research (CCAR, USA), the Southampton Oceanography Centre (SOC, UK), and the European Joint Research Centre (JRC, Italy), made a series of atmospheric and oceanic measurements from the RRS James Clark Ross, along a transect from Grimsby in UK to the Falkland Islands. These measurements were made as a part of the Atlantic Meridional Transect/Radiometric Observations of the Sea Surface and Atmosphere (AMT-7/ROSSA98) joint experiment, operated by the Plymouth Marine Laboratory (PML, UK) and the British Antarctic Survey (BAS, UK). The AMT will run again in September 2001.

NB: Due to the new launch date of Envisat, both of these cruises are now outside the timeframe needed for validation, occurring before the Envisat launch and the end of the AATSR SODAP. Due to this reason, no cruises are currently scheduled, but work investigating cruise opportunities in early 2002 is being carried out.

9.3.1.5 Data Requirements

- The following AATSR data products are required:
  ATS_TOA_1P
  ATS_NR_2P

ATS_AR_2P

- Approximately 20 overpasses per cruise
- No requirement for NRT data

Address to where data should be sent:

Dr Tim Nightingale
Rutherford Appleton Laboratory
Chilton
Didcot
OX11 0QX

9.3.1.6 Interfaces

The PI will interface with a number of parties:

Interfaces	With whom	Reason	Timing
1	Validation Scientist	• Help with cruise planning, instrument installation and running, data acquisition. • Help with NILU submission • Send validation results (in situ/satellite data matchups) • Participation in Data Quality Group	As required Monthly As required
2	USF	• Order AATSR Data • Receive AATSR Data	As necessary < 3 weeks, post data take
3	NILU	• Upload SISTeR data, meteorological data, balloon-sondes, bulk temperature data • Download additional wind speed data	Post-cruise

9.3.1.7 Schedule

There are currently no validation cruises planned for SISTeR but work investigating opportunities is continuing. Any activities that do take place will fit into the overall validation schedule outlined in section 11.

9.3.1.8 References

C.J. Donlon, T. Nightingale, L. Fielder, G. Fisher, D. Baldwin and I.S. Robinson 1999: The calibration and intercalibration of sea-going infrared radiometer systems using a low cost blackbody cavity, *J. Atmos. Oceanic Technol.*, **16**, 1183-1197.

C.J. Donlon and T.J. Nightingale, 2000: Effect of atmospheric radiance errors in radiometric sea-surface skin temperature measurements. *Applied Optics*, **39**, 2387-2392.

9.3.2 M-AERI, Minnett (590)

Global Validation of AATSR SST's will be validated using precision measurements taken with the M-AERI, as described in A/O proposal 590. The work is done in conjunction with validation activities for the infrared sensors on the EOS platforms (ASTER and MODIS) and the AVHRR series.

Principal Investigator: Dr Peter Minnett
Rosenstiel School of Marine and Atmospheric Science
Meteorology and Physical Oceanography
University of Miami
4600 Rickenbacker Causeway, Miami 33149
pminnett@rsmas.miami.edu

Co-Investigators: Dr Otis Brown, RSMAS-MPO
Dr Jim Butler, NASA GSFC
Dr Craig Donlon, JRC
Dr Bill Emery, University of Colorado
Dr Bob Evans, RSMAS-MPO
Dr Simon Hook, NASA JPL
Dr Andy Jessup, University of Washington
Dr Carol Johnson, NIST Gaithersburg
Dr Bob Knuteson, University of Wisconsin
Dr Frank Palluconi, JPL
Dr Joe Rice, NIST Gaithersburg

Dr Goshka Szczodrak, RSMAS-MPO
Dr Gary Wick, University of Colorado

9.3.2.1 Instrumentation

The primary instrument that will be used to collect validation measurements is the M-AERI (Marine Atmosphere Emitted radiance Interferometer). The M-AERI is a robust, accurate, self-calibrating, sea-going Fourier-transform interferometric infrared spectroradiometer that is deployed on marine platforms to measure the emission spectra from the sea surface and marine atmosphere (Minnett *et al*. 2001). The environmental variables derived from the spectra include the surface skin temperature of the ocean, air temperature and surface emissivity. Use of the M-AERI for the validation of satellite-derived surface temperature fields, and the study of the physics of the skin layer has been extensive. The instrument has been deployed on numerous research cruises. In January 2000, it could be reported that on no occasion had data collection been terminated by an instrument failure (Minnett *et al*., 2001). Other radiometers, operated by some of the the Co-Investigators, will provide data in a similar fashion to the M-AERI. While not providing the spectral information available from the M-AERI, these instruments make measurements in spectral intervals defined by filters that correspond to the window channels of the AATSR. These radiometers are also well calibrated to provide accurate skin SST from ships.

The key instrument parameters of the M-AERI system are given in Table 9.3.2.1.

Scan Time	1 second in each direction
Spectral Coverage	5.5-18.2µm, 550-1800 cm^{-1} 3.3-5.5µm, 1800-3000 cm^{-1}
Spectral Sampling	0.48 cm^{-1}
Instrument field-of-view	45 mrad (full angle)
Dimensions	116 cm L x 71 cm W x 76 cm H
Mass (sensor)	93 Kg
Power (system)	1 kW maximum (approx.)

Table 9.3.2.1 Key instrument parameters of the M-AERI system

The M-AERI operates in the range of infrared wavelengths from 3 to 18 µm, measuring spectra with a resolution of 0.5 cm^{-1}. Two infrared detectors are used to achieve this spectral range, and these are cooled to 78K by a Stirling cycle mechanical cooler to reduce the noise equivalent temperature different to levels well below 0.1K. The M-AERI includes two internal black body cavities for accurate real-time calibration. A scan mirror directs the field of view from the interferometer to either of the black body targets to the environment from nadir to zenith. The mirror is programmed to step through a pre-selected range of angles, viewing either the atmosphere or the sea surface. The interferometer integrates measurements over a pre-selected time interval, usually a few tens of seconds, to obtain a satisfactory signal to noise ratio, and a typical cycle of measurements (two view angles to the atmosphere, one to the ocean, and calibration measurements) takes about 5 minutes. Pitch and roll sensors on the M-AERI mean the influence of the ship's motion on the measurements can be determined.

Instrument Operation: The M-AERI runs continuously under computer control, except for a brief period at midnight UTC when the computer reboots and undertakes some housekeeping tasks. This ensures that there is enough disk space for the new day's data. In the event of a shortage in disk space, the system will automatically delete the oldest day's data. It is thus important that an operator saves data to CD or tape on a regular basis to prevent data loss. Some data loss will occur in the event of heavy rain or sea spray. The mirror must remain clean and dry in order for the M-AERI to provide the required measurements. A rain sensor ensures that the mirror is moved into a 'safe' position in the event of light rain and spray. During heavy rain, the M-AERI is covered for protection.

Data Flow: In addition to interferometer data, a comprehensive set of housekeeping data are collected from the blackbody subsystem, the mirror controller, the environmental monitors (temperature, humidity, pressure and precipitation), a global positioning system location and an inclinometer. The housekeeping data are sampled (200 average sample) and recorded at 5 second intervals. These are invaluable for validation and data analysis.

9.3.2.2 Methodology

In the following discussion, the operational methodology given here for the M-AERI, will be applied, where appropriate, to the radiometer deployments organized by the Co-Investigators.

1. **Instrument development and testing**: the M-AERI has now been used on a number of data collection exercises, and is considered proven in its ability to measure SST to an accuracy of <0.1K. Periodically the M-AERI is brought together with similar instruments, such as those of the Co-Investigators and the SISTeR (UK) and the DAR011 (Australia), for cross-comparisons and calibration checks against reference black body targets.

i. **Intercalibration at Miami, 1998**: One such inter-comparison took place in the form of a workshop, held at RSMAS in March 1998. The purpose of the workshop was to provide a framework in which investigators using infrared radiometers, spectrometers and imaging devices could come together to compare instruments, calibration targets and measurement protocols. This would ensure consistent and accurate datasets for future use in validating infrared retrievals of surface temperature over land and sea.

   An instrument platform to support remote sensing and meteorological instruments was constructed on the roof of the marine science centre at RSMAS. A 15m high meteorological tower next to the instrument platform provided data on wind speed and direction, air temperature and humidity, downwelling long and short wave radiation. Floats in the water in front of the building provided a near surface in situ surface temperature. Instruments were compared to each other and to internationally recognised black body calibration targets.

   Results of the 1998 inter-comparison workshop can be found at http://www.rsmas.miami.edu/ir and has been reported by Kannenberg and Palluconi, 1998 (Kannenberg, R., and F. Palluconi, Joint Rosenstiel School of Marine and Atmospheric Science (RSMAS) Committee on Earth Observation Satellites (CEOS) Validation Workshop, The Earth Observer, 10 (3), 38-42, 1998; http://eospso.gsfc.nasa.gov/eos_observ/5_6_98/may_jun98.html). Comparing M-AERI to a blackbody maintained by the National Institute of Standards and Technology, for example, an error analysis indicated that the absolute accuracy of M-AERI sea surface skin temperatures does indeed meet or exceed the design goal of 0.1C absolute accuracy (Minnett *et al*., 2001).

ii. **Intercalibration at Miami, 2001.** A second international infrared radiometry workshop and inter-comparison will take place at the Rosenstiel School of Marine and Atmospheric Science, University of Miami, from May 29 to June 1, 2001. The workshop, coordinated by Dr P. Minnett of RSMAS and Dr Ian Barton of CSIRO, will build on the first workshop and in addition to laboratory facilities, a NIST-certified blackbody calibration target and roof-top platform, will include one or two days on the R/V Walton-Smith. This will ensure the radiometers can operate accurately and consistently under sea conditions, as well as in the laboratory.

Table 9.3.2.2-1 details the candidate infrared radiometers for the second inter- comparison.

Instrument	Institution	P.I
M-AERI	RSMAS, U.Miami	P.Minnett
SISTeR	RAL, UK	T.Nightingale
DAR011 & DAR010	CSIRP, Australia	I.Barton & F.Prata
CIRIMS	APL, U. Washington	A. Jessup
ISAR-5	JRC, EEC	C.Donlon
New radiometer	AIMS, Australia	W.Skirving
New radiometer	NOAA, U. Colorado	J.Shaw & W.Emery
Off-the-shelf radiometers, e.g. TASCO's, Everests, Heimanns	Various	Frank Palluconi *et al.*
Infrared imagers	APL, U.Washington	A.Jessup

Table 9.3.2.2-1 Candidate instruments for the Miami Intercomparison, May 2001

The candidate black bodies for the inter-comparison are given in Table 9.3.2.2-2.

Instrument	Institution	P.I
NIST-Certified/NIST designed black body target	RSMAS, U.Miami	P.Minnett
NIST-Certfied/NIST designed black body target	APL, U.Washington	A.Jessup
CSIRO Portable black body	CSIRO, Australia	A.Barton
CASOTS Black body	JRC, EES	C.Donlon
JPL black body calibrator	NASA-JPL's	Frank Palluconi

Table 9.3.2.2-2 Candidate Blackbodies to be used during the Miami Intercomparison, May 2001.

2. **Organisation of Cruises/ Negotiation with ferries/ships-of-opportunity.** RSMAS has 3 M-AERI instruments that will be used on validations. Specific details of campaigns are mentioned in Section 9.3.2.4. Recent negotiations have led to the installation of a M-AERI on the Royal Caribbean cruise ship, the 'Explorer of the Seas', in October 2000. Continuing negotiation and international liaison has enabled participation in cruises worldwide in the past, and this will continue throughout 2001/2002.

3. **Installation.** Once negotiations are completed, the M-AERI is installed on the vessel.

4. **In Situ Data Collection.** As the vessel continues normal operating duties, the M-AERI makes measurements as described above. On shorter cruises such as the weekly cruise of the Explorer of the Seas, the instrument can be left to run almost autonomously, with little technical assistance needed. Data are downloaded on a weekly basis as the boat comes into port in Miami. On longer cruises, a dedicated technician/scientist accompanies the instrument on the cruise, maintaining it and ensuring data are collected.

   Interferometer and housekeeping data are collected together. The merged data stream is recorded in a customized data format (DMW, developed at the University of Wisconsin). After creation of the DMW format data files, a sequence of FORTRAN language modules are executed. 5 processing steps are performed on the raw data.

   - A correction for detector nonlinearity is applied to the longwave band.

- The forward and backward Michelson scans for each of the longwave and shortwave bands are calibrated individually.
- The forward and backward scans are averaged for each band.
- A finite field of view correction is applied to each calibrated spectrum.
- The spectra are resampled to a standard wave-number scale common to all M-AERI systems.

5. **Satellite data ordering and collection:** AATSR will be ordered from the ESA User Services Facility in advance, depending on the geographic and temporal location of M-AERI and filter radiometers.

6. **In situ/satellite data matchups:** High resolution (1km) AATSR data contemporaneous with valid M-AERI and radiometer data are required to perform a satisfactory validation study. Matchups between SST measurements collected by M-AERI and cloud free AATSR imagery will be made at RSMAS. Similar measurements made by the Co-Investigators will be collated at RSMAS. These data will be e-mailed to the VS, who will be responsible for their analysis and for feeding them into the 'validation loop'. Validation reports will be sent to the VS on a monthly basis.

9.3.2.3 Geographical Location

Ideally, M-AERI and other instruments will validate SST measurements from AATSR on a global scale. Particular attention will be paid to capturing the full range of atmospheric variability from the polar to equatorial zones. For the ocean, emphasis will be placed on deployments on long trans-oceanic quasi-meridional sections in the Pacific and Atlantic Oceans, and targeted campaigns in regions of known 'difficult' conditions, such as the outflow of continental aerosols.

As explained in Section 9.3.2.4, at the present time, possible validation activities include validation data collection in the East Caribbean, Pacific and Arabian Seas.

9.3.2.4 Planned Validation Activities and Specific Cruises

RSMAS has three M-AERI instruments, which will be used on validation campaigns. The deployment of each of these instruments for 2001 is shown in Figure 9.3.2.4-1. With a launch date of October 2001, deployments in December are significant for AATSR validation. Deployments for 2002 have not been decided yet.

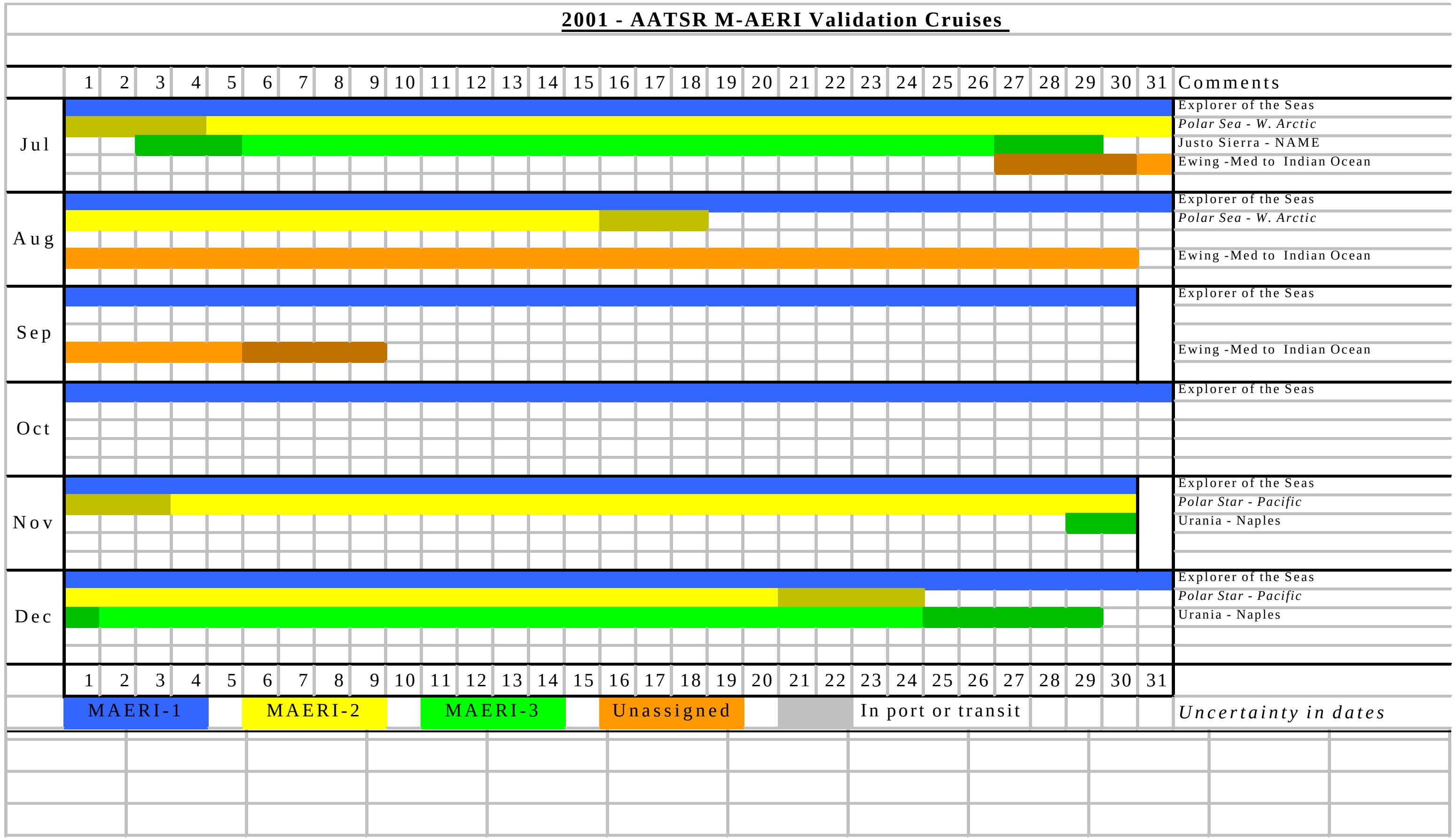


Figure 9.3.2.4-1 MAERI validation cruises for AATSR, 2001

- **Royal Caribbean Cruise Line Ship**

One of the M-AERI instruments is deployed on board the Royal Caribbean 'Explorer of the Seas' Cruise ship. Beginning on 28th October 2000, Explorer of the Seas sails a weekly seven-night eastern Caribbean itinerary from Miami, down to Haiti, Puerto Rico, US Virgin Islands, Nassau in the Bahamas and back across the Gulf Stream. The ship docks in Miami every Saturday allowing scientists to download data and maintain the instrument. The M-AERI was installed on the ship in November 2000, and the collection of sea surface temperature measurements is already underway. Experience throughout the pre-launch period should ensure the successful collection of validation points throughout the commissioning and post-commissioning phases. For more details see http://www.rsmas.miami.edu/rccl/.

- **Research Vessels/Ships of opportunity**

The other two M-AERI instruments will be deployed episodically on research vessels and ships of opportunity throughout the commissioning and post-commissioning phases of ENVISAT.

USCGC Polar Star: Planned activities during the ENVISAT mission include a continuing series of deployments on US Coast Guard ice-breakers on trans-Pacific sections from Seattle to Australia (USCGC Polar Star as identified in Table 9.3.2.4-1). These are made twice each year as the ship goes south to assist in the re-supply of US Antarctic stations. These sections take between four and twelve weeks, depending on the route and the other work being done in the Pacific, and cover a wide range of mid-latitude, tropical and equatorial conditions. Usually these ships do an additional cruise in the Arctic in the boreal summer, which provide an opportunity to make measurements in polar conditions. More information on the polar star can be found at: http://www.polarstar.org/.

Project name	Ship	Departure Date	Departure Port	Arrival Date	Arrival Port	Comments
Royal Carribean	Explorer of theSeas	Every Saturday	Miami	Every Saturday	Miami	7 day cruises in Eastern Carribean. Saturday to Saturday.
North American Monsoon Expt.	R/VJusto Sierra	6 July 2001	Veracruz, Mexico	26 July 2001	Veracruz, Mexico	Western Carribean
Western Arctic	U SCGC Polar Sea	Early July?	Seattle	Mid August?	Seattle	
Eastern Mediterranean, Red Sea, Gulf of Aden and Arabian Sea.	R/V Ewing	31 July	Pireus	5 Sept	Djibouti	May continue on to Perth, Western Australia.
MODIS Initialisation Cruise	R/V Thomas G.Thompson	21st November	San Diego	16th December	Seattle	Off Baja California.
Pacific Transect	USCGC Polar Star	? November	Seattle	? December 2001	Australian Port	
Western Mediterranean	R/V Urania (details) (picture)	2 December	Naples	24 December	Naples	Collaboration with Institute of Atmospheric Physics, Rome.

Table 9.3.2.4-1: Possible AATSR Validation Cruises in 2001 for the M-AERI

Figure 9.3.2.4-2 shows the tracks of past and planned M-AERI cruises. This figure is regularly updated and is available at http://www.rsmas.miami.edu/ir/maeri_cr.gif.

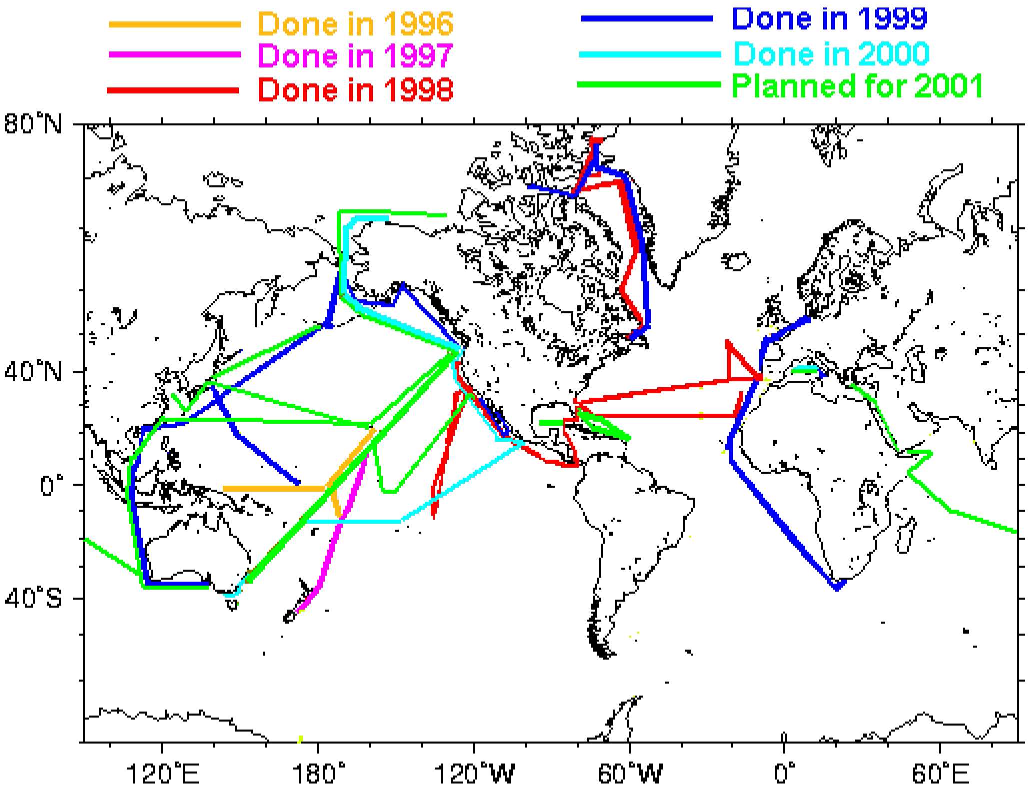


Figure 9.3.2.4-2: Schematic representation of the cruises, completed and planned, for the University of Miami's M-AERI systems

9.3.2.5 Data Requirements

- The following data products are required:
  ATS_TOA_1P full resolution or ATS_NR_2P full resolution
  512 x 512 scenes coincident with ship tracks

- Data needed is offline, just after validation cruises. Some data (that covering the Royal Caribbean cruise track) is required continuously. No Near-Real-Time data are required.

- Primarily scenes products located over the ships are required. Additionally full orbits of data for comparison with AVHRR Pathfinder and MODIS are needed.

Address to where data should be sent:

Dr Peter Minnett
Rosenstiel School of Marine and Atmospheric Science
Meteorology and Physical Oceanography
University of Miami
4600 Rickenbacker Causeway, Miami 33149
pminnett@rsmas.miami.edu

9.3.2.6 Interfaces

The PI will interface with a number of parties.

Interfaces	With whom	Reason	Timing
1	Validation Scientist	Help with cruise planning, instrument installation and running, data acquisition. Help with NILU submission Send validation results (in situ/satellite data matchups) Participation in Data Quality Group	As required Monthly As required
2	USF	Order AATSR Data Receive AATSR Data	As necessary
3	NILU	Upload one small file per day per M-AERI instrument when operating. Download other cruise validation data (i.e from SISTeR, ISAR, DAR011).	TBC As required

9.3.2.7 Schedule

Validation data collection using the M-AERI will follow the schedule outlined in Section 11, and Figure 9.3.2.4-1.

9.3.3 DAR011, Barton (9024)

Validation activities from Hobart are being conducted by Dr Ian Barton, CSIRO. A precision radiometer, the DAR011, will be operated on board research ships-of-opportunity, such as the RV Franklin.

Principal Investigator: Dr Ian Barton
CSIRO Marine Research
GPO Box 1538
Hobart, Tasmania 7001
Ian.Barton@marine.csiro.au

9.3.3.1 Instrumentation

The instrument being used for validation measurements is the DAR 011 radiometer, built by CSIRO (see Figure 9.3.3.1-1). This instrument benefits from a long heritage and performs extremely well. The instrument was calibrated against the USA NIST standard in 1998, and further calibration and comparison against other standards and instruments are planned. The DAR011 radiometer was operated alongside the M-AERI instrument on the USCGC Polar Star during March 2000, and good agreement between the two instruments was found. Bulk temperature is obtained from a well-calibrated thermosalinograph, which operates continuously. Full meteorological data are available including radiosonde launches at satellite overpass times when the skies are free of clouds.

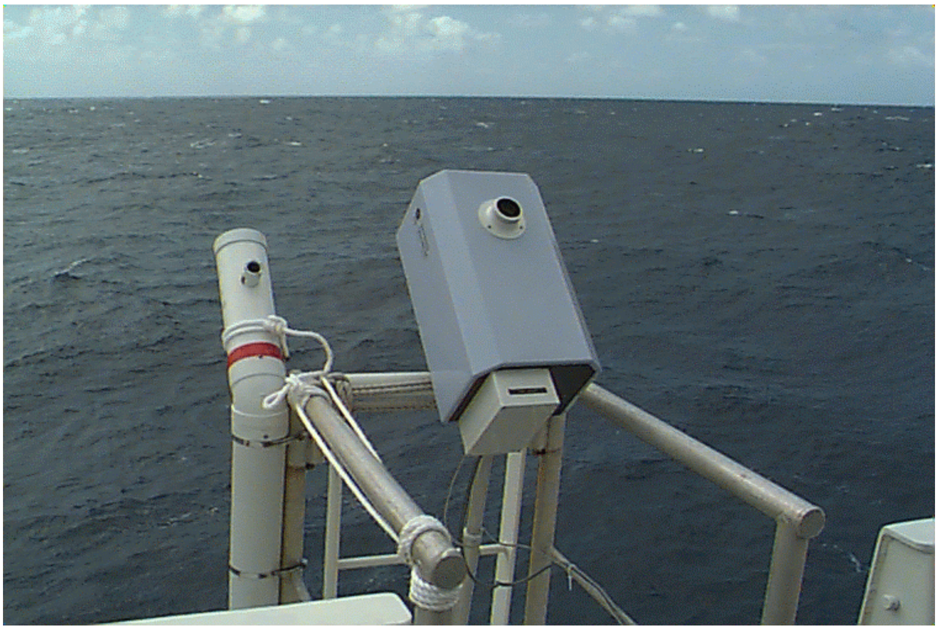


Figure 9.3.3.1-1: The DAR011 radiometer, mounted on the RV Franklin, used for validation activities based in Hobart. (Photograph from CSIRO)

9.3.3.2 Methodology

1. **Instrument development and testing**: the DAR011 has now been used on a number of data collection exercise. It was involved in the intercalibration exercise in Miami in 1998, and will be involved in the second exercise in 2001.

2. **Organisation of Cruises/ Negotiation with ferries/ships-of-opportunity.** The Research Vessel, the Franklin, operates in Australian waters. It has a full complement of oceanographic and meteorological instrumentation that provides the supporting marine and atmospheric data needed for analysis. The frequency of cruises is determined by berth availability, ship schedule and funds to cover travel, ship time and at-sea allowances.

3. **Installation.** Once negotiations are completed, the DAR011 is installed on the vessel.

4. **In Situ Data Collection.** The DAR011 makes continuous measurements throughout the cruise. Radiosondes are launched as satellite overpass times when the sky is free of clouds. The radiometer views the sky on a regular basis to ensure that an accurate correction can be applied to account for the non-unity emissivity of the sea surface. The data are analysed on board and are available at the end of the cruise for comparison to satellite data. If required urgently, small amounts of data can be usually supplied via the internet whilst at sea.

5. **Satellite data ordering and collection:** AATSR will be ordered from the ESA User Services Facility in advance, depending on the geographic and temporal location of DAR011 instrument.

6. **In situ/satellite data matchups:** High resolution (1km) AATSR data contemporaneous with valid DAR011 data are required to perform a satisfactory validation study. Matchups between SST measurements collected in situ and cloud free AATSR imagery will be made at CSIRO, Hobart. These data will be e-mailed to the validation scientist, and will enter the 'validation loop'. After the AATSR SODAP and during the commissioning phase (2-6 months after launch), validation reports will be sent to the VS on a monthly basis.

9.3.3.3 Geographical Location

Cruises usually occur in Australian waters - but on occasion, data will be collected from areas some distance from Australia. Cruises will be targeted that promise a high probability of clear skies, typically cruises in tropical waters during the months of June to October, when the monsoon activity is north of the equator and clear skies are frequent. Following launch of ENVISAT, it is anticipated that there would be three to six two-week cruises per year. Prior to launch, the instruments and data collection techniques will be tested through one or two shorter cruises per year.

9.3.3.4 Planned Validation Activities

Three cruises of the RV, the Franklin had been planned for the latter half of 2001, but with the new Envisat launch date of October 2001, all these validation data collection opportunities are now too early. Current negotiations are seeking berths on the later cruises in late 2001/early 2002.

9.3.3.5 Data Requirements

- The following AATSR data products are required:
  ATS_TOA_1P
  ATS_NR_2P
- Transfer of products via physical media is acceptable.
- Data volume: 512 x 512 scenes of ATS_TOA_1P and ATS_NR_2P of all passes covering the ship tracks: 6-10 weeks of operation anticipated per year.
- Data needed are offline.

Address to where data should be sent

Dr Ian Barton
CSIRO Marine Research
GPO Box 1538
Hobart, Tasmania 7001

9.3.3.6 Interfaces

The PI will interface with a number of parties.

Interfaces	With whom	Reason	Timing
1	Validation Scientist	• Help with NILU submission • Send validation results (in situ/satellite data matchups) • Participation in Data Quality Group	As required Monthly As required
2	USF	• Order AATSR Data • Receive AATSR Data	As necessary
3	NILU	• 2 Mbytes of data submitted at the end of every cruise. • Download of wind data for research vessel track.	At the end of every cruise

9.3.3.7 Schedule

The validation activities from Hobart will follow the overall validation schedule outlined in Section 11, with specific cruise occurring as is detailed in Table 9.3.3.4-1.

10 Validation of the visible channels

Validation of the visible/near infrared channels of the AATSR instrument, in the GBTR product, will be carried out over land and cloud (Koelemeijer and Watts). Two types of validation fall into this group: vicarious validation and validation using ground measurements taken during field campaigns.

Figure 10-1 gives the names of PI's leading different project involved in the validation of visible/near infrared channels of AATSR, together with their project ID number. The work by Smith and Prata is considered core validation activities. The work of Koelemeijer, Hagolle and Watts is being carried out primarily for the validation of other instruments (for SCIAMACHY and MERIS). It is not considered core AATSR validation activities, although data from these activities will be useful for initial AATSR validation and their work is included here.

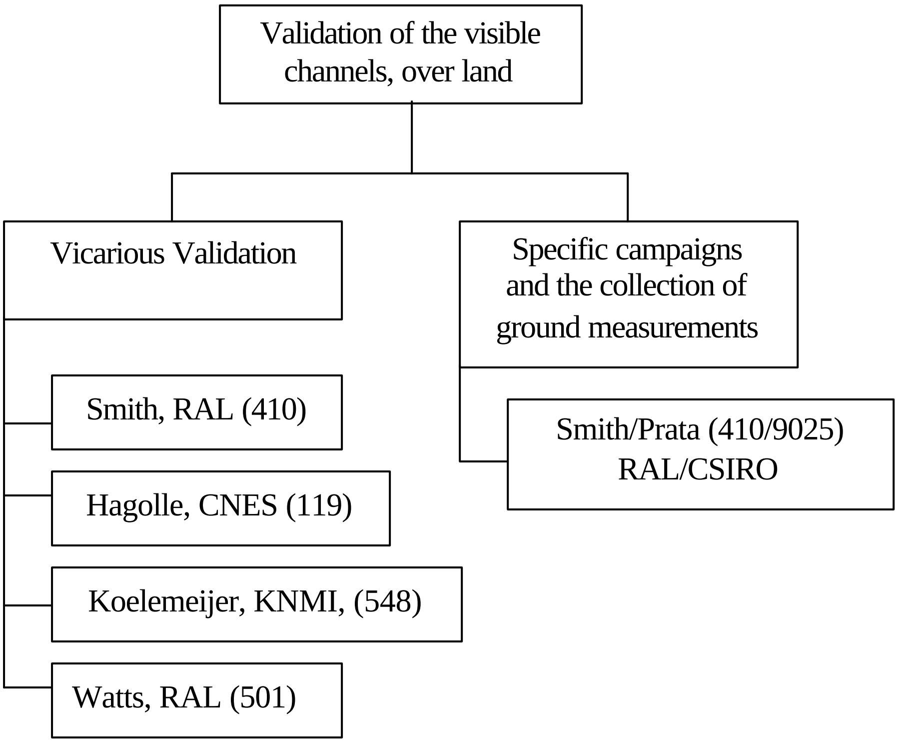


Figure 10-1: PI's involved in validation of the AATSR visible/near infrared channels

10.1 Vicarious Validation

Vicarious validation is where top-of-atmosphere (TOA) radiances from AATSR are compared to TOA measurements from similar sensors, for a range of stable sites. At the present time, there are four projects that will do vicarious validation for AATSR.

10.1.1 Vicarious Inter-Calibration of AATSR and MERIS using terrestrial targets, Smith (410)

Principal Investigator: Dr David Smith
Rutherford Appleton Laboratory
CCLRC, Chilton
Didcot, Oxfordshire
OX11 0QX

Co-Investigators: Dr Chris Mutlow, RAL
Dr Carina van Eijk, Institute of Applied Physics
Dr C.R.Nagaraja Rao, NOAA/NESDIS
Dr Fred Prata, CSIRO Atmospheric Research

10.1.1.1 Methodology

Smith will compare AATSR- and MERIS top-of-atmosphere radiances for a range of desert regions and Greenland ice, and monitor the long-term stability of the instruments. This will lead to a robust characterisation of the in-orbit performance of the instruments and the on-board calibrators. Using similar channels on AATSR and MERIS enables direct comparisons of the instrument calibrations to be made, Figure 10.1.1.1-1. The measurements will be particularly useful to check for any across track variations in the calibration of MERIS. The results will also be compared against the existing ATSR-2 data for the same scenes. In-situ measurements provided by CSIRO over Australian sites will validate the top-of-atmosphere measurements (see Section 10.2.1).

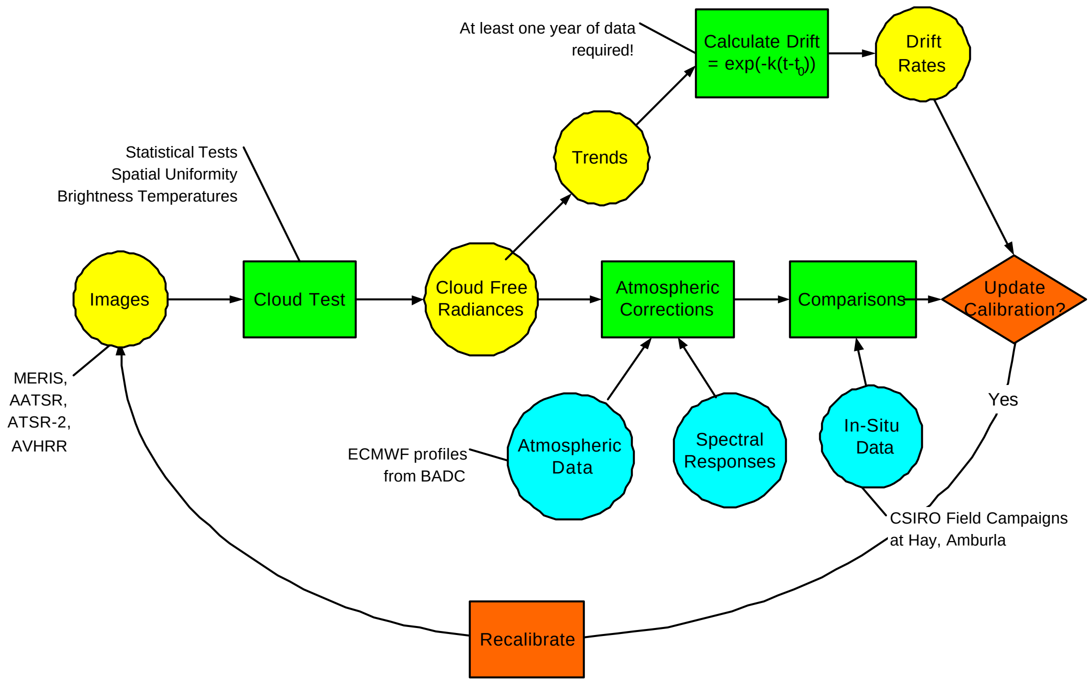


Figure 10.1.1.1-1 Intercomparison scheme for AATSR, ATSR-2 and MERIS.

10.1.1.2 Geographic Locations

Table 10.1.1.2-1 gives the latitudes and longitudes of the main regions to be studied. Other sites may be required as the investigation progresses.

Type	Site Name	Longitude Range	Latitude Range
Desert	Algeria – East	7°10’E-8°10’E	29°49’N - 30°49’N
	Algeria - East	0°42’E - 1°42’E	30°30’N - 31°18’N
	Arabia	46°16’E – 47°16’E	18°23’N - 19°23’N
	Dunhuang	94°01’E – 94°30’E	40°02’N - 40°17’N
	Libya 1	12°31’E – 13°31’E	23°55’N - 24°55’N
	Libya 2	10°49’E – 11°49’E	25°59’N - 26°59’N
	Libyan Desert (Sudan)	28°W-29°W	21°N-23°N
	Sonora	114°18’W-113°54’W	31°54’N-32°06’N
Ice	Greenland	35°W-45°E	70°N-77.5°N
Australian Sites	Hay, NSQ	145.292°E	34.382°S
	Amburla, NT	133.119°E	23.285°S
	Thangoo, WA	122.26°E	18.10°S

Table 10.1.1.2-1 Geographic Location of the sites used for Vicarious Validation

10.1.1.3 Data Requirements

Tables 10.1.1.3-1 to 4 detail the data required.

Source	From	Type of Data	Channels	Date From	Date To	Delay	Delivery Mode	Comments
AATSR	LRAC	Level 1b	All	Launch	End Mission	< 3wks	Physical Media	Standing Order
MERIS	LRAC	Level 1b	520, 560, 620, 665, 681, 865, 890nm	Launch	End Mission	< 3wks	Physical Media	Standing Order

Table 10.1.1.3-1 Envisat Products Required for vicarious validation (410)

Source	From	Type of Data	Channels	Date From	Date To	Delay	Delivery Mode	Comments
MERIS	ESA	Spectral Response Functions	520, 560, 620, 665, 681, 865, 890nm	-	-	-	FTP	-

Table 10.1.1.3-2 MERIS Auxiliary Products required for vicarious validation (410)

Source	From	Type of Data	Channels	Date From	Date To	Delay	Delivery Mode	Comments
ECMWF	BADC	GRIB	-	Launch	End Mission	< 1wk	FTP	-

Table 10.1.1.3-3 ECMWF data required for vicarious validation (410)

Source	From	Type of Data	Channels	Date From	Date To	Delay	Delivery Mode	Comments
AATSR	DETR/ RAL	Spectral Response Functions	All	-	-	-	FTP	-
ATSR-2	RAL	GBT	All	Launch	End ERS-2 Mission	< 3wks	FTP/ EXABYTE	Standing Order
ATSR-2	RAL	Spectral Response Functions	All	-	-	-	FTP	-
TOMS	BADC	Ozone Profiles	-	Launch	End Mission	< 1wk	FTP	-

Table 10.1.1.3-4 Additional data required for vicarious validation (410)

10.1.1.4 Interfaces

The PI will interface with a number of parties.

Interfaces	With whom	Reason	Timing
1	Validation Scientist	• Send validation results • Participation in Data Quality Group	Monthly As required
2	USF	• Order and receive AATSR data • Order and receive MERIS data	As necessary
3	CNES	• Exchange of MERIS/AATSR data over desert sites	
4	NILU	• Uploading of data	TBC
5	BADC		

10.1.1.5 Schedule

The vicarious validation work of Smith will follow the overall validation schedule outlined in Section 11.

10.1.2 Validation of MERIS calibration using natural targets, Hagolle (119)

A limited amount of vicarious calibration of the AATSR visible channels will be undertaken as part of the MERIS calibration activities. The primary aim of this activity is to validate and monitor the absolute calibration of MERIS using a variety of natural targets, including stable desert sites. However, over desert sites it is also possible to conduct vicarious calibration of the AATSR visible channels and perform cross calibration between MERIS, AATSR and other sensors.

Details of the MERIS calibration exercise using natural targets are contained in AD8 (the MERIS Cal/Val Implementation Plan). The AATSR aspects of this work are described here. It is important to note that this work is not central to CNES' activities and is only designed to compliment the MERIS calibration. Therefore it is a lower priority task for CNES and will be performed on a best efforts basis.

Principal Investigator: Olivier Hagolle
CNES
18 Avenue E. Berlin
Toulouse CEDEX 4
31401
France
Tel 33 561282135
Fax 33 561273167
Olivier.Hagolle@cnes.fr

Co-Investigators: TBD

10.1.2.1 Instrumentation

This method uses the characterisation of the properties of 20 desert sites that was obtained with POLDER 1 instrument. Given the very good stability with time of these sites, no in-situ measurement is needed for this method. Measurement protocols are not applicable for this work.

10.1.2.2 Methodology

Twenty desert sites in North Africa and Arabia have been selected for their spatial uniformity and temporal stability, using Meteosat data. The sites are quite lambertian and the directional variations of their reflectance has been monitored using POLDER data. Since POLDER data makes a very complete sampling of the directional conditions, it is nearly always possible to find a POLDER acquisition with solar and viewing angles very close to the angles of any sensor measurement. POLDER can thus be used as a transfer radiometer to make cross calibrations between sensors, even if they do not have the same scanning geometry.

The main error sources are the aerosols and the variation of the site reflectance: aerosols can modify the top of atmosphere reflectance of the desert sites, but it is expected that after averaging a lot of measurements, the aerosol effect will mainly affect the results as a noise and not as a bias. The cross-calibration results could also be affected by long term variations of the desert sites reflectance, but averaging the results for 20 desert sites reduces the eventual variations. Since 1996, CNES has been collecting desert sites data from many sensors. These data are gathered in an ORACLE database: for the moment, the available data are:

SeaWiFS, AVHRR (NOAA14,15,16)
MODIS, MISR
POLDER 1, SPOT 1,2,3,4, VGT,

The desert sites can be used in the following ways:

- To compare the absolute calibration of AATSR with the calibration of MERIS and other sensors
- To check the stability of the instrument calibration as a function on time.

10.1.2.3 Geographic Locations

The desert sites are given in Table 10.1.2.3-1.

Site Name	Lat centre (°)	Long centre (°)	Lat_min	Lat_max	Long_min	Long_max
Arabia1	18.88	46.76	18.38	19.38	46.26	47.26
Arabia2	20.13	50.96	19.63	20.63	50.46	51.46
Arabia3	28.92	43.73	28.42	29.42	43.23	44.23
Sudan1	21.74	28.22	21.24	22.24	27.72	28.72
Niger1	19.67	9.81	19.17	20.17	9.31	10.31
Niger2	21.37	10.59	20.87	21.87	10.09	11.09
Niger3	21.57	7.96	21.07	22.07	7.46	8.46
Egypt1	27.12	26.1	26.62	27.62	25.6	26.6
Libya1	24.42	13.35	23.92	24.92	12.85	13.85
Libya2	25.05	20.48	24.55	25.55	19.98	20.98
Libya3	23.15	23.1	22.65	23.65	22.6	23.6
Libya4	28.55	23.39	28.05	29.05	22.89	23.89
Algeria1	23.8	-0.4	23.3	24.3	-0.9	0.1
Algeria2	26.09	-1.38	25.59	26.59	-1.88	-0.88
Algeria3	30.32	7.66	29.82	30.82	7.16	8.16
Algeria4	30.04	5.59	29.54	30.54	5.09	6.09
Algeria5	31.02	2.23	30.52	31.52	1.73	2.73
Mali1	19.12	-4.85	18.62	19.62	-5.35	-4.35
Mauritania1	19.4	-9.3	18.9	19.9	-9.8	-8.8
Mauritania2	20.85	-8.78	20.35	21.35	-9.28	-8.28

Table 10.1.2.3-1 Desert Sites used for vicarious validation by Hagolle (119)

10.1.2.4 Data Requirements

Systematic use of every AATSR Level 1b ATS_TOA_1P product acquired over these sites

The default method of obtaining AATSR data for this work will be via the ENVISAT USF. PERL scripts provided by the USF will be used to set up a standing order for 512x512 km scenes over each site and to regularly download these products. The extraction of the suitable calibration points from the AATSR products will be performed manually by CNES.

Under AO 410, RAL will also be requesting data over certain desert sites and performing a similar extraction of relevant pixels (see Section 10.1.1). For those sites, which coincide between the two projects, the possibility of performing the data retrieval and extraction for both projects at RAL using modified ATSR-2 routines is being investigated. These routines will read in AATSR products, locate calibration sites, detect cloudy pixels and output cloud free reflectances (nominally in HDF format).

10.1.2.5 Interfaces

Interfaces	With whom	Reason	Timing
1	RAL	Overlap with work of AO410, collaboration regarding MERIS, and AATSR data over desert sites.	TBC
2	USF		TBC
3	Validation Scientist	Receive updates on the status of AATSR Cal/Val activities. Send validation results, and report progress of work.	TBC

There are no plans for CNES to upload data to or download data from NILU.

Where AATSR results are reported at ENVISAT events such as the Commissioning Review and the Validation Workshop, they shall be covered under the general reporting for MERIS AO 119.

10.1.2.6 Schedule

The work of Hagolle at CNES will follow the overall validation schedule detailed in Section 11. Additional schedule details are provided in Table 10.1.2.6-1.

October 2000 – July 2001	• Development of calibration tools • Explore plans for collaboration with RAL
August 2001	• Operational qualification of the tools
October 2001	• ENVISAT launch
December 2001	• End of AATSR SODAP • Reception of first AATSR L1b products (or extracted data) at CNES
January 2002	• First results
March 2002	• End of ENVISAT Commissioning Phase • Report results of AATSR/MERIS cross calibration from first few months of data at ENVISAT Commissioning Review
June 2002	• Report further results of AATSR/MERIS cross calibration at ENVISAT Validation Workshop

Table 10.1.2.6-1 Schedule details for the work of Hagolle (A0 119)

10.1.3 Intercomparison of AATSR with MERIS and SCIAMACHY, Koelemeijer (548)

The work outlined in AO 548 is primarily concerned with the validation of SCIAMACHY Level 2 products, namely, polarization, radiances, cloud and aerosols. It also, however, involves the use of MERIS and AATSR data for inter-comparison with SCIAMACHY data, and is included here for completeness. A more detailed description of the work can be found in the SCIAMACHY validation handbook (AD9).

Principal Investigator: P.Stammes

Co-investigators: Dr Robert.Koelemeijer (Contact)
K.N.M.I
P.O. Box 201
3730 AE De Bilt
The Netherlands
Tel: +31 30 2206 467
Fax: +31 30 2210 407
koelemei@knmi.nl

10.1.3.1 Methodology

The SCIAMACHY instrument measures the Earth's radiance between 240-1750nm, 1940-2040nm and 2265-2380nm. The spectral resolution is wavelength dependent, varying between 0.2 and 1.5nm. The measurements are performed in an alternating limb nadir mode such that an atmospheric volume is first observed in limb, and after 435 seconds, observed in nadir view. Solar and lunar occultation measurements are performed when possible. For radiometric calibration, an internal white light source can be observed as well as the sun and the moon. The default swath width of SCIAMACHY is 960km.

This work will compare normalised radiances of SCIAMACHY acquired in nadir mode to those of AATSR and MERIS. The normalised radiance is proportional to the ratio of the Earth's reflected radiance to the solar irradiance perpendicular to the solar beam. To this end, the AATSR and MERIS pixels will be collocated with the SCIAMACHY ground pixel, and averaged over the SCIAMACHY ground pixel. The SCIAMACHY normalised radiances will be convoluted with the instrument response functions of AATSR and MERIS. For the comparison, a partly cloudy scene over the ocean will be used, such that a large dynamic range is covered. The inhomogeneity of the scene allows confirmation of the positioning and geolocation of the instruments. A similar approach was successfully applied to GOME and ATSR-2 data (Koelemeijer *et al.*, 1998).

To assess SCIAMACHY degradation during its lifetime, SCIAMACHY normalised radiances acquired over a number of Saharan sites will be analysed (in conjunction with Hagolle, AO 119).

A second objective of this activity is cloud validation. The SCIAMACHY level 2 cloud products will consist of cloud cover fraction, cloud optical thickness, and cloud top pressure. These cloud properties will be compared to cloud properties derived from MERIS and AATSR data. Cloud top pressure retrieval from SCIAMACHY employs the oxygen A-band, i.e. similar as MERIS. AATSR cloud top pressures will be derived by converting cloud top temperatures to pressures using atmospheric temperature profiles from the European Centre for Medium-range Weather Forecasts (ECMWF) model. A similar comparison was performed regarding effective cloud fractions and cloud top pressures derived from GOME and ATSR-2 [Koelemeijer and Stammes, 1999; Koelemeijer *et al*., 2000].

10.1.3.2 Geographic Location

TBC

10.1.3.3 Data Requirements

- The following AATSR data products are required:
  ATS_TOA_1P
- Data volume: half orbit ATS_TOA_1P on request, and 512 X 512 scenes of ATS_TOA_1P over desert sites.
- Timing: < 3 weeks delivery after data take.
- Transfer of products via physical media.

Address to where data should be sent:

Robert Koelemeijer
Address, as above.

10.1.3.4 Interfaces

TBD

10.1.3.5 Schedule

Koelemeijer will follow the overall validation schedule outlined in Section 11.

10.1.3.6 References

Koelemeijer, R.B.A., Stammes, P., and Watts, P.D., 1998, Comparison of visible calibrations of GOME and ATSR-2, *Remote Sensing Environment*, 63, pp 279-288

Koelemeijer, R.B.A., and Stammes, P., 1999, Validation of global ozone monitoring experiment cloud parameters using oxygen A-band measurements from the Global Ozone Monitoring Experiment, *J.Geophy.Res.*, 104, 18, pp 801-814

Koelemeijer, R.B.A., Stammes, P., Hovemnier, J.W., and de Haah, J.F., 2000, A fast method for retrieval of cloud parameters using oxygen A-band measurements from the Global Ozone Monitoring Experiment, in press.

10.1.4 MERIS/AATSR calibration using Arctic Stratus and Tropical CumuloNimbus clouds, Watts (501)

Philip Watts of RAL will provide calibration of the reflectance channels of the AATSR and MERIS instruments using cloud targets. Two methods and corresponding cloud types are utilised in conjunction with a multiple scattering plane parallel cloud model and NWP data to aid definition of atmospheric conditions.

This work is funded by ESA as an activity for MERIS, and hence calibration of the MERIS instrument is the main priority. Calibration of AATSR reflectance channels will also take place however. The work is described in AD8 (the MERIS Cal/Val implementation plan).

Principal Investigator:

Philip D Watts
Rutherford Appleton Laboratory
Chilton
Didcot
OX11 0QX
Tel: 01235 445170
Fax: 01235 445848
p.d.watts@rl.ac.uk

Co-Investigators:

David Smith, RAL
A.J.Baran, Met. Office

10.1.4.1 Methodology

Two methods of calibrating AATSR data are used.

In the first method, Arctic stratus clouds are used to absolutely calibrate 0.55, 0.67, 0.87 and 1.6µm AATSR channels, using a comparison of nadir and along track reflectances and knowledge of the bi-directional reflectance distribution function.

In the second method, deep convection clouds in the tropical regions are used to intercalibrate the 0.55, 0.67, and 0.87 µm channels by comparison of nadir view data and correction for residual above-cloud atmospheric effect. The target reflectance is more or less insensitive to the underlying surface or overlying atmosphere when a very deep cloud over ocean is observed. Radiative transfer models provide an estimate of the ratio between expected reflectances at non-absorbing wavelengths.

For both methods, the following analysis steps are needed:

a) Selection of suitable target areas within the imagery

For the arctic stratus method, a suitable target is one that conforms closely to the plane-parallel model, is water cloud, contains a range of optical depths around ô = 4, overlies blue water ocean and does not include strong sunlight geometry. These requirements are identified through both automated and non-automated methods.

For tropical deep convection, a suitable target is optically thick and geometrically deep, covers a large area, is illuminated at high solar angles, and lies over the ocean. Again automated and non-automated methods are used.

b) Prediction of the expected reflectance ratios (along track/nadir in stratus case, channel to channel in the tropical Cb case)

For both methods, expected reflectance ratios are calculated using a fast cloud-atmosphere-surface radiative transfer model developed for cloud parameter inversion as part of a study for SEVIRI.

c) Generation of calibration factors by comparison to measured ratios, and quality control of analysis fit.

10.1.4.2 Geographic Location

Using clouds as calibration targets mean that is hard to specify data over a specific geographic area. The presence and location of clouds is highly variable. . To achieve a reasonable number of targets in a given time period, a large area must be defined.

The MERIS Calibration plan details a strategy for defining the geographic location needed. In summary, the single best search region for the arctic stratus clouds is the North Atlantic/North Norway region. For tropical deep convection clouds, the most useful areas are the Western Pacific and the Eastern Indian Ocean, with the convection moving seasonally with the intertropical convergence zone.

10.1.4.3 Data Requirements

- The following AATSR data products are required:
  ATS_TOA_1P
- Data are required systematically over specific cloud locations.
- Transfer of products via physical media

10.1.4.4 Interfaces

TBD

10.1.4.5 Schedule

Watts will follow the overall validation schedule outlined in Section 11.

10.2 Specific Campaigns and the collection of ground measurements

In addition to the validation of the visible and near-infrared channels using vicarious methods, these channels can also be validated over land using dedicated field campaigns and the collection of ground measurements.

10.2.1 Ground data collection in Australia, Prata (9025)

Fred Prata of CSIRO has been undertaking radiometric measurements over land for a number of years, at three sites in Australia – Thangoo, Amburla and Hay. These three sites represent different environmental conditions and land cover types. Continuing work with ATSR and ATSR-2, ground measurements taken at sites in Australia will be compared with data from AATSR. Prata is named as a co-investigator on the proposal by Smith (410), and will work in collaboration with him.

Principal Investigator: Dr Fred Prata
CSIRO Atmospheric Research
PMB 1 Aspendale
Vic. 3195
Australia

Co-Investigators: TBC

10.2.1.1 Instrumentation

A number of instruments will be used including ground-based spectrometers, sun photometers, radiosonde equipment and aircraft mounted spectrometers.

10.2.1.2 Methodology

Validation conducted by Prata will take the form of specific campaigns and long term monitoring.

The validation methodology will be similar to that used for the ATSR-2 Atmospheric Correction Experiment (ACEX). The surface measurements and atmospheric data collected at the satellite overpass time were fed into a radiative transfer code (MODTRAN 3B) and TOA reflectances calculated for comparison with the ATSR-2 reflectances. The accuracy of this method of validation was limited by the spatial sampling of the ground-based reflectances. During the AATSR validation, the sampling problem will be overcome by the use of spectrometers flown aboard aircraft.

The first validation campaign will take place shortly after ENVISAT launch during the AATSR commissioning phase. The exact timing of the campaign will depend on selection of optimum weather conditions. Within 6 months, a second campaign will take place to establish the reproducibility of the validation results and to check on the stability and performance of the AATSR onboard calibration system. It is likely that these campaigns will take place at the Hay site, but consideration will be given to conducting the campaigns at Amburla. (TBD Prata)

The Amburla site is well-suited to validation because of its homogeneity, stability and because it is an instrumented site. The most important aspect of validation at this site will be the ability to determine the site's spectral reflectance stability. For this purpose upwelling spectral irradiances should be monitored at the site. Overflights of the site using a video camera system approximately once per month are desirable. The spectral BRDF of the site should be measured at least once, from the air if funding permits, during the monitoring period.

10.2.1.3 Geographical Location

Validation work will be carried out at three locations in Australia – Uardry, Amburla and Thangoo.

- Uardy

Hay plains, New South Wales, Australia
Lat. -34.396, Long. 145.303
Altitude: 100m above MSL

Uardry is a semi-arid grasslands site located on the vast Hay plains some 50 kilometres east of the township of Hay. The site and surrounding region are dry land grazing properties (mainly sheep) characterised by large treeless expanses of natural vegetation located on extremely flat and homogeneous natural terrain. The overlying atmosphere is characterised by a semi-arid climate with low amounts of water vapour and aerosols. Regular winter/spring rainfall provide seasonal vegetative growth. The site has moderate column amounts of water vapour (typically 10 to 30 kg m^{-1}) and aerosol optical depth (typically 0.03 at 0.5 micron). Instruments monitor continuously at several points the surface radiation budget components (broadband shortwave and longwave fluxes, downwelling and upwelling), meteorological parameters, and in clear daytime skies the aerosol optical depth, column ozone and water vapour amounts.

- Amburla

Tanami Desert, Northern Territory, Australia
Lat. -23.385, Long. 133.119
Altitude: 620m above MSL

Amburla is an arid desert site located on a long flat plain (approximately 30 km x 12 km) characterised by a red soil with a sparse cover of Mitchell grass. The site, which is located 100 kilometres northwest of Alice Springs, is used for cattle and camel grazing. Ephemeral vegetative growth following heavy tropical thunderstorm activity or slow-moving rainband activity, may be significant but is uncommon. The site has moderate column amounts of water vapour (typically 5 to 40 kg m^{-1}) and aerosol optical depth (typically 0.03 at 0.5 micron). The site is instrumented to continuously monitor at several points the surface radiation budget components (broadband shortwave and longwave fluxes, downwelling and upwelling) and meteorological parameters.

- Thangoo

Thangoo is uniform over an area of at least 3 km x 3 km and characterised by a hot and humid monsoonal summer climate, a warm to hot and relatively dry winter climate, and significant aerosol loading in spring and early summer due to large uncontrolled bushfires. A location at the southern extent of the ITCZ (inter- tropical convergence zone) is planned to minimise monsoonal activity (cloud) and maximise the summer day-to-day atmospheric variability (aerosol and water vapour). Continuous monitoring at several points will include the surface radiation budget components (broadband shortwave and longwave fluxes, downwelling and upwelling), meteorological parameters, and in clear daytime skies, the aerosol optical depth, column ozone and water vapour amounts.

10.2.1.4 Planned Validation Activities

Measurements are being undertaken at the three validation sites on a continuous basis. During the commissioning phase, validation reports will be made available on a monthly basis (TBC Prata). It is hoped that dedicated campaigns will be undertaken to complement the continuous measurements (TBC Prata).

10.2.1.5 Data Requirements

- The following AATSR data products are required:
  ATS_TOA_1P
- Transfer of products via physical media.
- The data needed are offline.

Address to where data should be sent:

Dr Fred Prata
Address as above.

10.2.1.6 Interfaces

TBD

10.2.1.7 Schedule

The work of Prata will fit into the schedule of Smith (Section 10.1.1), and the overall validation schedule outlined in Section 11.

11 Schedule for validation activities

In terms of a schedule for validation activities, there are a number of important milestones that affect all validation activities. This section describes events, which are applicable to all activities. Milestones specific to any one activity have been included in the section relevant to that activity.

Figure 11-1 details the top-level schedule information. These are then described in more detail.

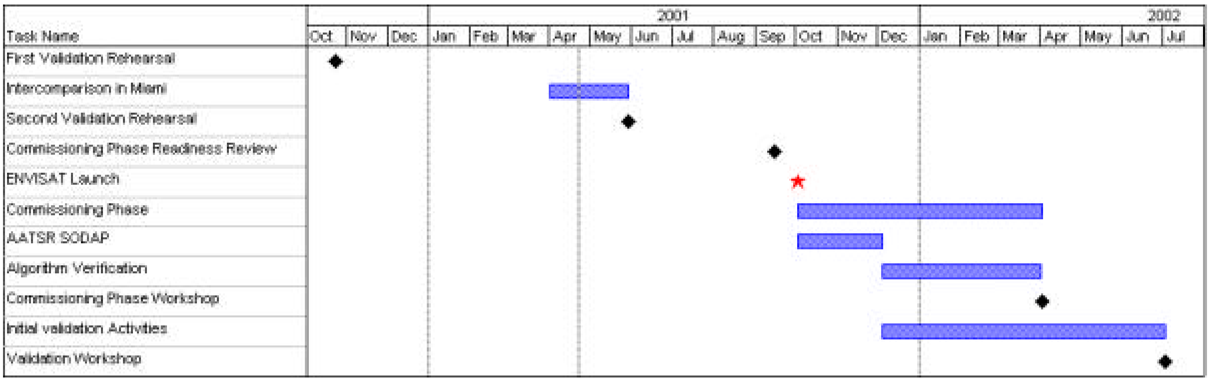


Figure 11-1: Validation Schedule

- **Validation Rehearsals (1 and 2)**

The first validation rehearsal took place from the 24th October to the 3rd November 2000. This was an opportunity for ESA and VDP's to test communication channels and data handling software. Each PI had a list of tasks, which he/she was required to perform. These are summarised in Table 11-1.

Rehearsal Task	
Test Communication Channels	• Sign up with NILU, download and upload validation data from NILU • Order and download Envisat data • Contact the ESA helpdesk
Test validation data handling software	• Test local data handling software
Verify data quality control procedures	• Install software and test: EnviView, data dictionary tool, mission CFI and S/W libraries, TIME library, ESOV
Produce a written report	

Table 11-1: Tasks performed by PI's during the first rehearsal

The second rehearsal will give PI's another opportunities to familiarise themselves with the tools available, data ordering system etc. More details TBC.

- **Miami Intercomparison:** This is described in detail in Section 9.3.2.

- **Launch:** At the present time, Envisat is scheduled for launched on 2nd October 2001.

- **SODAP:** Following launch, there is a Switch On and Data Acquisition Phase, the characterisation of the instrument in-orbit performance and validation of the ground segment procedures and engineering tools. Current estimates put the SODAP for AATSR at L + 9 weeks (TBC). After review of the results of the planned commissioning activities and subsequent instrument reconfiguration, the SODAP will be declared complete and the formal validation phase will commence.

- **Commissioning Phase Workshop:** This will take place at L + 6 months, and will mark the end of the commissioning phase of Envisat.

- **Validation Workshop:** This will take place at L + 9 months. Each PI will be required to present validation results collected and conclusions drawn.

12 Data Requirements

In order to ascertain satellite data requirements during the commissioning phase, and the logistics of data distribution and circulation, Hannah Tait (ESA ESTEC) has been compiling a spreadsheet of validation data requirements. The current version of this spreadsheet can be found in Annex A. This spreadsheet is primarily to aid ESA in planning, and is constantly evolving and changing as plans develop and requirements change. Subsequent updates and more details of data requirements can be obtained directly from Hannah Tait, and she should be notified of any additions or modifications to the current estimates.

Contact details:

Hannah Tait
ESA ESTEC
Keplerlaan 1
Postbus 229
2200 AG Noordwijk
The Netherlands
Tel: +31 71 565 5918
Hannah.Tait@esa.int

13 The Validation Loop

The validation loop, as described here, is in a draft format, and is currently being circulated for comments and input from DETR, ESA and validation data providers.

The AATSR Validation Loop describes what happens to validation data, collected by Validation Data Providers (VDPs). An outline of the validation loop is given in Figure 12-1.

1. Following ENVISAT Launch, and the AATSR Switch On and Data Acquisition Phase (SODAP), AATSR data will become available to AATSR validation data providers (VDP's). VDP's will inform the Validation Scientist (VS) of any planned campaigns, and the VS will ensure that the Flight Operations Support team are aware of these campaigns in their planning. This will ensure that the data will be collected at that time, if this is possible, or that the VDP is informed in advance of the non-availability of the instrument. VDP's will order and receive AATSR data, collect in situ measurements and perform in situ/satellite matchups. VDP's will submit validation data to the NILU database.

2. Following the SODAP, for the remainder of the Commissioning Phase, once a month, VDP's will send the VS information files containing the in situ/satellite matchups plus any analysis/comments they have. If validation data are unavailable on a monthly basis, the VDP's will still send a short report detailing progress, and expectation of the timing of results.

3. During commissioning, ESA will perform algorithm verification, and will report results to the VS. The VS will report results of the algorithm verification to the VDP's, and will incorporate results into the validation reports passed to the AATSR Data Quality Group (DQG).

4. The VS will coordinate validation activities, collating all the results received, and analysing them. If the validation data reveal anomalies and errors, the VS will investigate possible sources of error, by asking VDP's to check their data, and seeking advice from the PP team, the FOS team and the PDS team. If thought necessary, investigations by the various specialist teams may take place at this stage on a limited scale. In this way, a basic level of quality assurance will be applied to take place. Reports will be sent to members of the DGQ on a regular basis.

5. The DQG will meet as required (i.e. whenever there is a significant input of validation results). Meetings will be convened by the VS, and chaired by the PI (or Project Scientist). The DGQ will be made up of people with experience and expertise in validation and the AATSR instrument. These will include the PI, the Project Scientist, the VS and the FOS Manager. Depending on the validation report under review, additional experts may be invited to attend. DETR, ESA, and NERC will have full visibility of the group and can attend meetings, if desired.

6. The DQG will review the validation reports, and decide what, if any, further action is needed. They may authorise further investigations (into the validation data collected, the data processing chain, the instrument etc). The VS will coordinate any further investigations, and report back to the DQG.

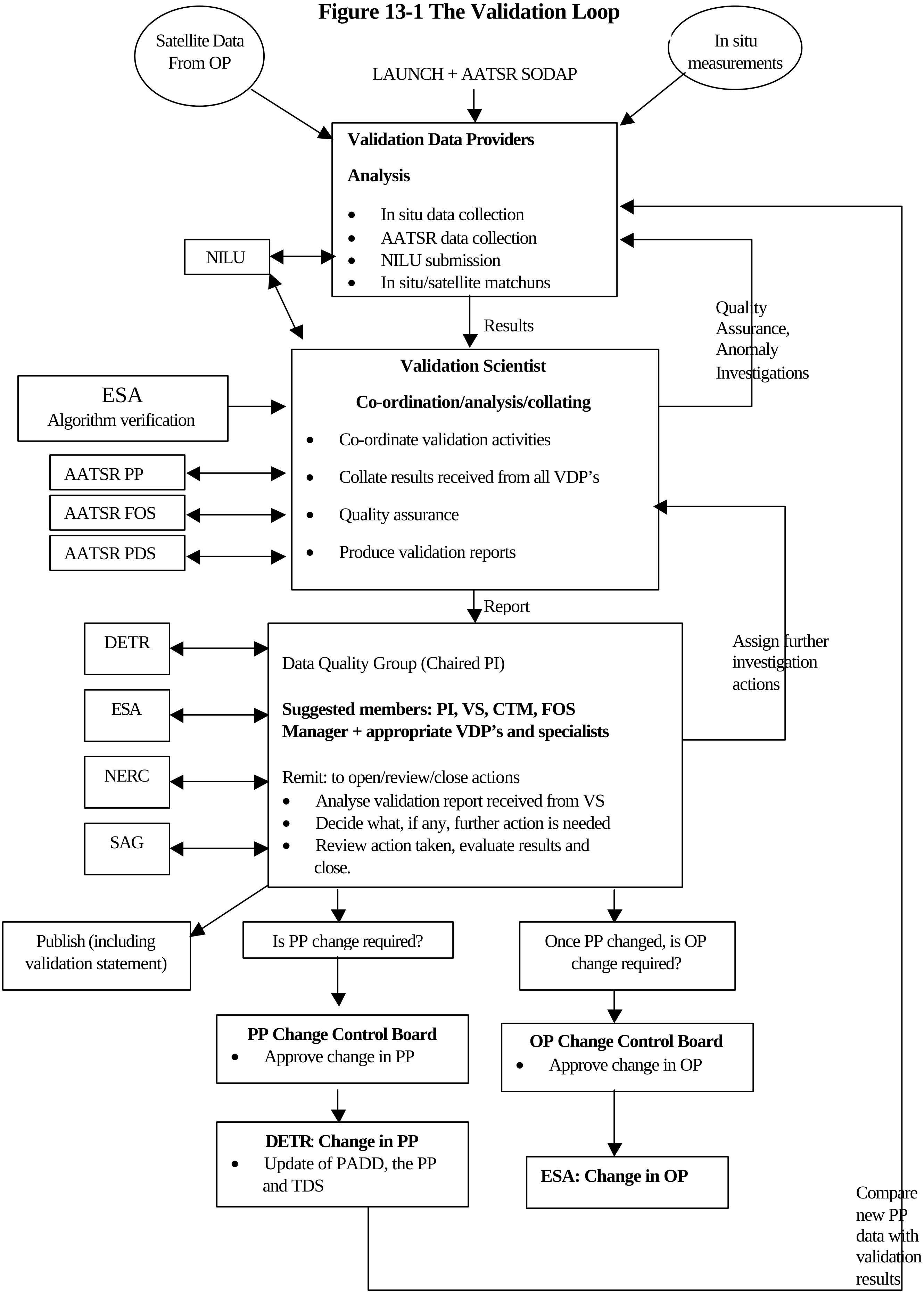
7. If a change to the data processing is recommended by the DQG, this change will first be tested with the PP using the further investigation loop via the VS. If results of the test confirm that a change in the operational system is needed, recommendations to permanently change the PP are passed to DETR. A Change Control Board (ESA, DETR, PI, SAG) meets to approve the change. If a change is approved, DETR updates the PADD, the PP and the TDS. New data from the PP are provided to the VDP's, and tested against validation results.

8. Following successful testing, a change in the OP is made, and the validation loop begins again.

9. Statements about the status of validation activities and AATSR product quality will be made by the DQG on a regular basis and published on the AATSR validation website.

10. Following the commissioning phase, the validation loop will continue, although it is envisaged that meetings of the DQG will be held less frequently.

Figure 13-1 The Validation Loop



14 Future Validation Activities

As described in Section 4, the objectives of the AATSR validation programme are extended post-commissioning to include:

- Validate AATSR SST products in an increasing number of sites and seasons.
- Monitor long-term data product quality.
- Validate new products.

Many of the activities detailed as initial validation activities will continue, whilst additional activities will be conducted by the wider scientific community through new contacts and collaboration.

14.1 Continuation of Commissioning Phase Activities

Table 14.1-1 gives an indication of the continuation of commissioning phase activities after the validation workshop at L + 9 months. Year 2 and 3 represents one and two years from L + 9 months respectively.

ID No.	Activity	Post-commissioning
9084	Global buoy comparison, including early indication of gross errors.	Continuation of activities throughout years 2 and 3.
9095	Murray	Work for years 2 and 3, pending availability of funding (TBC)
506	Roquet: ENVISAT/AATSR Matchup database for SST	TBC
9081/2	Robinson/Donlon: ISAR	Continuation of activities throughout years 2 and 3, pending availability of funding. Deployment of ISAR 1 and 2 in more geographic areas. (TBC)
9024	Barton: Rottnest Island Ferry, Perth	Continuation in years 2 and 3, pending availability of personnel and funding (TBC)
9024	Barton: Pure Pleasure Ferry, Townsville	Continuation in years 2 and 3, pending availability of personnel and funding (TBC)
552	Nightingale: SISTeR	Possible activities in years 2 and 3, pending the availability of funding (TBC)
590	Minnett: M-AERI	Continuation in years 2 and 3, pending availability of cruises and funding (TBC)
9024	Barton: DAR011	Continuation in years 2 and 3, pending availability of cruises and berths (TBC)
410	Smith: Vicarious inter-calibration of AATSR and MERIS using terrestrial targets	Planned continuation of long term monitoring of desert sites, pending availability of funding. (TBC)
119	Hagolle	TBC
548	Koelemeijer	TBC
501	Watts	TBC
9025	Prata	Planned continuation of field data collection (TBC)

Table 14.1-1 Continuation of initial validation activities, post the validation workshop at L + 9 months.

14.2 Additional external validation

Table 14.2-1 lists ESA A/O proposals that have been categorised as 'Science' proposals, and which include validation work. These PI's will receive data when it is released for general use at the end of the commissioning phase. (NB Some listed projects use AATSR data, but only as a means of validating data from MERIS. Nevertheless, these may make interesting contributions and have been included here for completeness).

Validation Activity, AO Project No.	Parameter investigated (in relation to AATSR)
889 (Rao)	SST using in-situ ship and buoy data
656 (Kwarteng)	Atmospheric Aerosol
647 (Doerffer)	SST
247 (Matzler)	Surface Temperature, Atmospheric Parameters
595 (Parslow)	SST
861 (Fischer)	Cloud optical thickness, and cloud albedo
609 (Sorensen)	Atmospheric parameters
864 (North)	Aerosol Opacity and land surface bi-directional reflectance

Table 14.2-1: Additional post-commissioning validation projects, not included in the core validation programme

In addition to these AO science proposals, it is hoped that validation data will come from the wider scientific community. Initial contact has already been made with several groups with a view to future collaboration regarding validation work. These include a group at Cranfield University interested in validation over land, the NASA validation team, and the Hyperspectral Task team at the Earth Observation Centre in Canberra.

14.3 New Products

A number of products are being discussed for AATSR data. As mentioned in Section 5, an AATSR land surface temperature product is being prototyped for inclusion in the L2 products. Further products, which could be developed, might include a cloud and aerosol product. If new products are developed, validation will be carried out post-commissioning to validate the parameters derived.

15 Development of the AATSR Validation Implementation Plan

The AATSR Validation Implementation Plan is a working document, and will evolve over time as plans develop. Issues that will be developed further for the next issue of the plan include:

- Plans for validation of the land surface temperature product.
- More detailed descriptions of PI interfaces, and deliverables to the VS and ESA.
- Data analysis – work of the VS in data analysis, particularly in relation to the validation loop.
- Details and results of the 2^{nd} validation rehearsal.
- Further details of possible collaborations for future validation work.

Annex A

See additional file, Data-Distribution_AATSR_xx.xls