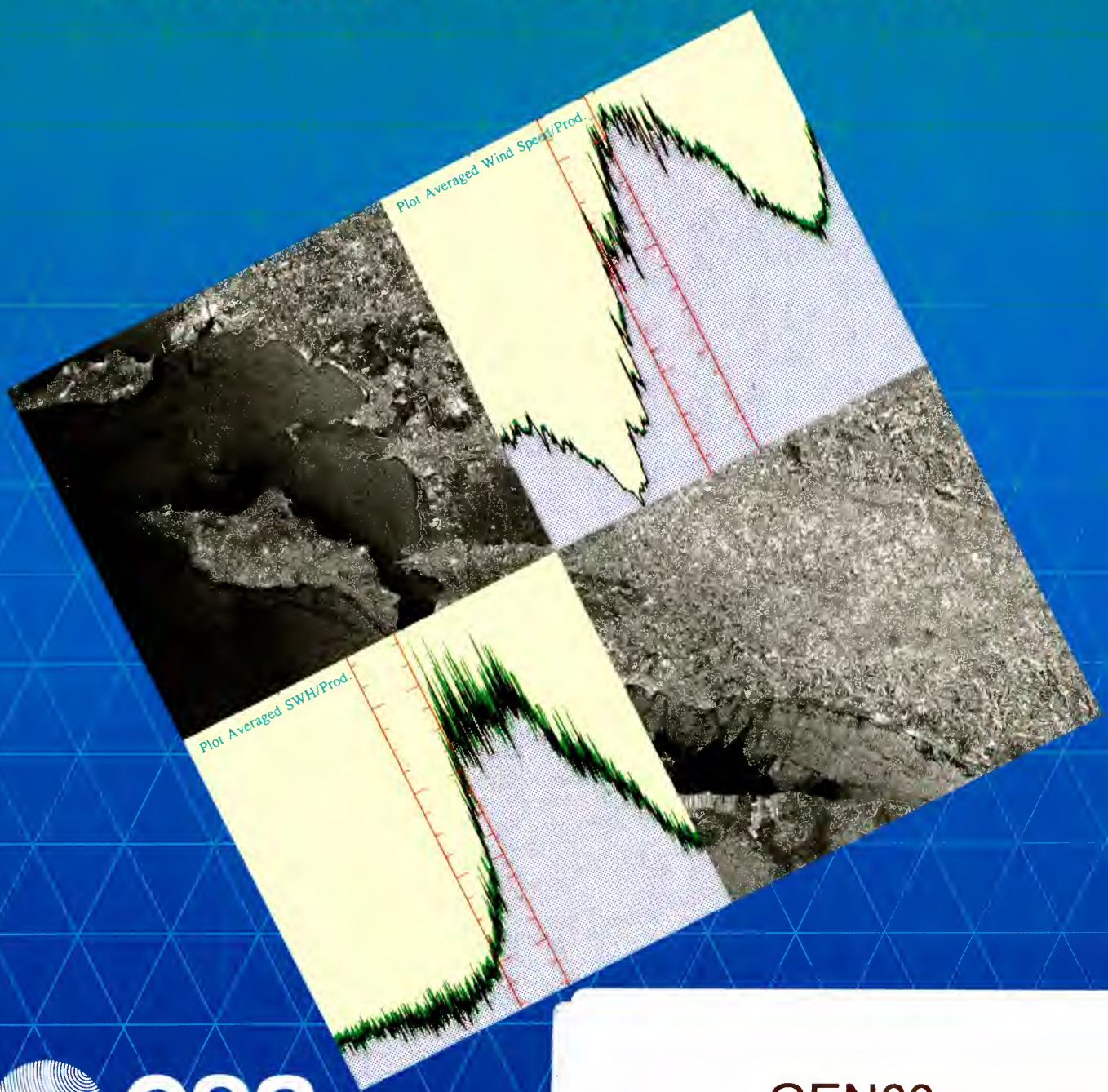
esa SP-1149

ESA ERS-1

PRODUCT SPECIFICATION



esa
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GEN03

Products

esa SP-1149
June 1992

ESA ERS-1 Product Specification

GENERAL INFORMATION

GENERAL INFORMATION

ERS-1 space segment

The first European remote sensing satellite (ERS-1) was launched by the European Space Agency (ESA) on 17 July 1991. In the three years of its expected lifetime the satellite sensors will provide systematic coverage of ocean and sea-ice areas on a highly repetitive basis allowing global monitoring for meteorological and environmental applications. Much of the data will be collected from remote areas such as the polar regions and the southern oceans, for which little comparable information has previously been collected. The nature of the satellite's orbit and its complement of sensors enables a global mission providing worldwide geographical and repetitive coverage, primarily oriented towards ocean and ice monitoring. An all-weather high resolution microwave imaging capability is also available over land and coastal zones within the regional coverage of a ground receiving station.

ERS-1 carries instrumentation consisting of a core set of active microwave sensors supported by additional, complementary instruments:

- **Active Microwave Instrument** (AMI) combining the functions of a Synthetic Aperture Radar (SAR) and a Wind Scatterometer. The SAR operates in image mode for the acquisition of wide-swath, all weather images over the oceans, polar regions, coastal zones and land. In wave mode the SAR produces imagettes (about 5 km x 5 km) at regular intervals for the derivation of the length and direction of ocean waves. The Wind Scatterometer uses three antennae for the generation of sea surface wind speed and direction measurements.

- **Radar Altimeter** (RA) provides accurate measurements of sea surface elevation, significant wave heights, various ice parameters and an estimate of sea surface wind speed.

- **Along Track Scanning Radiometer** (ATSR) combining an infra-red radiometer and a microwave sounder for the measurement of sea surface temperature, cloud top temperature, cloud cover and atmospheric water vapour content.

- **Precise Range and Range-rate Equipment** (PRARE) for the accurate determination of the satellite's position and orbit characteristics, and for precise position determination (geodetic fixing)*.

- **Laser Retro-reflectors** (LRR) allowing measurement of the satellite's position and orbit via the use of ground-based laser ranging stations.

** The joint DLR/ESA/Industry PRARE Failure Review Board has ascertained that PRARE suffered fatal radiation damage to its Random Access Memory, after a few hours of nominal operations, and therefore no signals will be received during the rest of the ERS-1 mission. An improved version of PRARE is being built for inclusion on ERS-2 in 1994.*

ERS-1 ground segment

The ERS-1 ground segment includes facilities for the satellite's control and operations, for reception, archiving and processing of the instrument data and provides services to satisfy user requirements for products. It consists of the following:

- **Earthnet ERS-1 Central Facility** (EECF) at ESRIN, Frascati, Italy, carries out all user interface functions, including worldwide cataloguing, handling of user requests, payload operation planning, scheduling of data processing and dissemination, quality control of data products and system performance monitoring.

- **Mission Management and Control Centre** (MMCC) at ESOC, Darmstadt, Germany carries out all satellite operations control and functional management, including overall satellite and payload operational scheduling.

- **ESA ground stations** at Kiruna (Sweden), Fucino (Italy), Gatineau and Prince Albert (Canada) and Maspalomas (Canary Islands, Spain), provide the main network for data acquisition and the processing/dissemination of Fast Delivery (FD) products.

- **National ground stations** around the world receive ERS-1 data by arrangements with ESA, extending the coverage potential of the high resolution SAR imaging mission.

- **Processing and Archiving Facilities** (PAFs) located in Germany, France, Italy and the UK are the main centres for the generation of off-line precision products and the archiving and distribution of ERS-1 data and products.

- **User centres and individuals,** such as national and international meteorological services, oceanographic institutes, various research centres and individual users.

The EECF drives the operations of most of the ground segment facilities, including providing activity schedules to the ground stations and processing and archiving centres. From the user's point of view, the EECF is the gateway to the ERS system and offers a set of system services to provide customers with an insight of the global catalogue of data products and the schedule for future operations, as well as product ordering services. The EECF comprises three main elements: Central User Service (CUS); Interface Sub-set (ISS); and Product Control Service (PCS). These services are explained in Chapter 8 of the ERS-1 System document and in the ERS-1 User Handbook.

The table below provides the complete list of ERS-1 ground receiving stations:

	Operational	*Planned*
Alice Spring, Australia	24 August 1991	
Aussaguel, France	April 1992	
Bangkok, Thailand		Autumn 1992
Cotopaxi, Ecuador	1 September 1991	
Cuiaba, Brazil	27 August 1991	
Fairbanks, Alaska, USA	6 August 1991	
Fucino, Italy	27 July 1991	
Gatineau, Canada	6 August 1991	
Hatoyama, Japan	15 August 1991	
Hobart, Australia	March 1992	
Hyderabad, India	18 August 1991	
Kiruna, Sweden	27 July 1991	
Kumamoto, Japan	15 August 1991	
Maspalomas, Canary Islands, Spain	1 August 1991	
O'Higgins, Antarctica, Germany	24 September	
Parepare, Indonesia		mid 1993
Prince Albert, Canada	6 August 1991	
Syowa, Antarctica, Japan	21 October 1991	
Tromso, Norway	3 August 1991	
West Freugh, UK	22 August 1991	

Contacts have been made between ESA and the following countries with a view to establishing further ground stations in:

- Israel
- Saudi Arabia
- South Africa
- Kenya
- Pakistan.

The low bit rate (LBR) mission (Radar Altimeter, Wind Scatterometer, ATSR, SAR in wave mode) is fully supported by the four stations of the ESA network: Kiruna, Maspalomas, Gatineau and Prince Albert. The data sensed by the LBR instruments is stored on the on-board tape recorders during each orbit and is dumped to one of the ESA network stations every orbit. For the high bit rate SAR data acquisition is only possible by a ground station in-sight of the spacecraft. Hence the network of regional acquisition stations includes stations all over the world.

The ERS-1 ground segment includes four Processing and Archiving Facilities (PAFs), located and managed as follows:

- **D-PAF:** *Deutsche Forschungsanstalt für Luft und Raumfahrt (DLR), Oberpfaffenhofen, Germany*
- **F-PAF:** *Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER), Brest, France*
- **I-PAF:** *Agenzia Spaziale Italiana (ASI), Matera, Italy*
- **UK-PAF:** *Defence Research Agency (DRA) RAE Farnborough, United Kingdom.*

The functions of the PAFs have been harmonised by ESA and each has an agreed area of responsibility for archiving and product generation. They will be responsible for:

- long-term archiving and retrieval of ERS-1 raw data, auxiliary information and relevant surface data
- generation and distribution of off-line geophysical and precision products
- support to long-term sensor performance assessment, calibration and geophysical validation, demonstration campaigns and pilot projects
- interfacing with the EECF for updating of the catalogue and supporting user services.

The PAFs will share the responsibility for product generation, in order to make efficient use of national expertise. It is intended that their operations should continue for 12 years after the launch of ERS-1. The services offered by each PAF are as follows:

- **D-PAF**
  - primary archive of raw data acquired by the German Antarctic Receiving Station at O'Higgins
  - primary processing centre for SAR precision and geocoded image data, higher level altimetry products and precision orbit calculations.
- **F-PAF**
  - primary archive for LBR data (SAR wave mode, Wind Scatterometer and Radar Altimeter) over the oceans and associated FD products
  - secondary archive of the global ATSR data set
  - primary processing centre for LBR data over oceans
  - processing centre for ATSR Microwave Sounder data
  - storage of relevant ESA provided campaign data.
- **I-PAF**
  - regional archive of SAR and LBR data (raw, processed and FD) acquired over the Mediterranean by the Fucino station
  - regional processing of SAR and LBR products for the Mediterranean.
- **UK-PAF**
  - primary archive for raw and processed SAR and ATSR data, LBR data over ice and land and SAR FD products
  - secondary archive for global LBR data
  - primary processing centre for SAR and LBR data over ice and land
  - primary processing centre for ATSR data
  - secondary processing centre for wave data products
  - storage of campaign data.

PAF products can be categorised as follows:

- **raw data products:** which are available at the PAFs a few days after acquisition. ESA raw data products are available for the SAR image mode, SAR wave mode and the Radar Altimeter.

- **FD products:** generated and distributed by the ESA ground stations within three hours from instrument observation. ESA FD products are available for the SAR image mode, SAR wave mode, Wind Scatterometer and the Radar Altimeter.
- **off-line products:** generated by the PAFs as ESA or national products and processed to various levels of precision. Off-line products include those from the SAR image mode, SAR wave mode, Wind Scatterometer, Radar Altimeter and ATSR.

User access to products and services

Users can access the ERS-1 services at the Earthnet ERS-1 Central Facility (EECF) located at ESRIN in Frascati (Rome, Italy), and view the ERS Global Activity Plan (GAP) for instrument observations. A user's product requirement can be satisfied either with data which has already been acquired by the satellite or with data from future data acquisitions. If the already planned future acquisitions do not meet the user's requirements, every attempt will be made by ESA to programme the necessary acquisition.

Users have access to the ERS-1 Central Catalogue, which provides information on the availability of data products and on planned acquisitions within the forthcoming few weeks. Users may contact the ERS-1 Help Desk by telephone, fax, telex or mail to obtain any information required prior to placing an order:

ERS-1 Help Desk
EECF
ESA/Earthnet Programme Office
ESRIN
CP 64
I-00044 Frascati
Italy.

Telephone:	(+39-6) 94180 600
Fax:	(+39-6) 94180 510
Telex:	610637 ESRIN I

The ERS Consortium (ERSC) is the official ESA distributor for ERS-1 products and users should submit orders to one of the ERSC Order Desks as follows:

- users in Europe, N. Africa and the Middle East: Eurimage ERS-1 Order Desk *(Middle East includes Syria, Lebanon, Iraq, Jordan, Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates, Oman and Yemen; users in Iran can contact either Eurimage or SPOT Image)*
- users in Canada and the United States: Radarsat International ERS-1 Order Desk
- users in other countries: SPOT Image ERS-1 Order Desk.

Note: The critical factor is the location of the user, not the geographical area for which the ERS-1 products are required.

Users can also submit orders through the sub-distributors of each of the ERSC partners; addresses of these can be obtained from the appropriate ERSC Order Desk.

Eurimage ERS-1 Order Desk
ESRIN
CP 64
I-00044 Frascati
Italy

Telephone:	(+39-6) 94180 478
Fax:	(+39-6) 942 6285
Telex:	610637 ESRIN I

Radarsat International ERS-1 Order Desk
275 Slater Street, Suite 1203
Ottawa, Ontario
Canada, K1P 5H9

Telephone:	(+613-238) 6413
Fax:	(+613-238) 5425
Telex:	053-3589

SPOT Image ERS-1 Order Desk
16 bis, Avenue Edouard Belin
BP 4359
31030 Toulouse Cedex
France

Telephone:	(+33-61) 539976
Fax:	(+33-61) 281 354
Telex:	53 2079 F SPOTIM

ACRONYMS AND ABBREVIATIONS

ACF	Auto-Correlation Function
A/D	Analogue / Digital
ADC	Analogue / Digital Converter
AMI	Active Microwave Instrument
ATSR	Along Track Scanning Radiometer
BIH	Bureau International de l'Heure
CCT	Computer Compatible Tape
CEOS	Committee on Earth Observation Satellites
CIS	Conventional Inertial System
CTS	Conventional Terrestrial System
ERS	European Remote Sensing Satellite
ERSC	ERS Consortium
ESA	European Space Agency
FD	Fast Delivery
FFT	Fast Fourier Transform
FM	Frequency Modulated
GCP	Ground Control Points
GEM	Goddard Earth Model
GRS1984	Geodetic Reference System 1984
HDDT	High Density Digital Tape
I	In-phase
ISLR	Integrated Side Lobe Ratio
LBR	Low Bit Rate
NMSF	Net Multiplicative Scaling Factor
N/S	North / South
PAF	Processing and Archiving Facility
PPTL	Processor Point Target Linearity
PRARE	Precise Range and Range-rate Equipment
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
OBRC	On Board Range Compression
OGRC	On Ground Range Compression
Q	Quadrature
QA	Quality Assurance
Q/L	Quick-look
RA	Radar Altimeter
RMS	Root Mean Square
SAR	Synthetic Aperture Radar
S/C	Spacecraft
SCATT	Scatterometer
SSH	Sea Surface Height
TBC	To Be Confirmed
TDT	Terrestrial Dynamic Time
TM	Telemetry
UPS	Universal Polar Stereographic
UTC	Universal Time Coordinate
UTM	Universe Transverse Mercator
WRS	World Reference System

REFERENCE DOCUMENTS

Reference 1 **SAR Data Products Format Standard.**
Revision 2.0, 10 March 1989.
CEOS SAR Data Standards Subgroup.

Reference 2 **ERS-1 SAR Products CCT Format.**
(ER-IS-EPO-GS-0506) Issue 1, 15 March 1990.

Reference 3 **ERS-1 Ground Stations Products Specifications for Users.**
(ER-IS-EPO-GS-0204) Issue 2.2, 8 May 1991.

Reference 4 **ERS-1 SAR FDC Product CCT Format.**
(ER-IS-EPO-GS-0506.2) Issue 1.1, 27 January 1992.
ANNEX B to Reference 2 Document.

Reference 5 **Specifications Techniques des Produits CERSAT.**
(C1-ST-000-CD000-02-IF) 15 February 1990.

Reference 6* **ERS-1 ALT Low Bit Rate Products CCT Format.**
(ER-IS-EPO-GS-0502) Issue 1.0, 3 April 1992.

Reference 7 **ATSR Format CCT Standardisation.**
(draft report in preparation, according to the CEOS SHARP format standards).

Reference 8 **The German PAF for ERS-1 – RAT Product Specification Document.**
(ERS-D-PSD-30000) Issue 1.1, 31 May 1990.

Reference 9 **The German PAF for ERS-1 – ERS-1 Standards used at D-PAF.**
(ERS-D-STD-31101).

* More detailed format description for each LBR product can be found in the following documents:

ERS-1 ALT CCT.
(ER-IS-EPO-GS-0503) Issue 1.0, 3 April 1992.
ERS-1 WSC CCT.
(ER-IS-EPO-GS-0504) Issue 1.0, in preparation.
ERS-1 SWM CCT.
(ER-IS-EPO-GS-0505) Issue 1.0, in preparation.

6. GRAVITY FIELD MODELS

6. GRAVITY FIELD MODELS

A specification is available for the following gravity field model products:

DEFINITIONS

Definition 1 – Conventional Terrestrial System (CTS):
Z axis directed towards the mean pole as derived from the BIH pole series (ERP(BIH)87C02) covering the period January 1980 to October 1986. X axis fixed by allowing no net rotation about the Z axis with respect to the initial coordinates (SSC(DGFI)90L0X). Y axis completes the right-handed system.

Definition 2 – Conventional Inertial System (CIS):
This system is referred to the basic epoch 2000.01.01 12 hours designated J2000.0. The axes of the CIS are chosen in such a way that at the basic epoch J2000.0 they coincide in optimal approximation with the mean equatorial frame defined by the mean celestial pole (Z axis) and the mean vernal equinox (X axis).

Product name | *Product code*

Gravity Model First Generation — ERS-1.ORB.EGM1

DEFINITION

First generation of ERS-1 Gravity Field Models. ERS-1 gravity model provided as a set of fully normalised harmonic coefficients: $C(n,m)$, $S(n,m)$, appearing in the Earth geopotential U expansion:

$$U=(GM/r)\{1+\sum_{n=2}^{N}\sum_{m=0}^{n}(Re/r)\,Pnm(\sin(\theta)[\,C(n,m)\cos(m\phi)+S(n,m)\sin(m\phi)\,]\}$$

where:

GM	=	gravitational constant times mass of Earth and atmosphere
Re	=	mean equatorial radius of the Earth
r	=	distance of point P from Earth's centre of mass
θ	=	latitude of point P
ϕ	=	longitude of point P
$Pnm(x)$	=	associated Legendre polinomial of order n,m
$C(n,m)$, $S(n,m)$	=	fully normalised harmonic coefficients
N	=	truncation degree

DESCRIPTION

Input:

- pre-ERS-1 Earth gravity model
- ERS-1 laser range data
- tracking station survey ties
- a-priori degree variance models.

Algorithm:

Numerical integration of satellite's equation of motion and variational equations followed by a least square adjustment: reduction, accumulation, combination and solution of normal equation systems.

Output:

Spherical harmonic coefficients $C(n,m)$ and $S(n,m)$ of the expansion of the terrestrial potential U in spherical harmonics.

SPECIFICATIONS

Units: A-dimensional numbers.

Product geographical coverage: ERS-1 global coverage.

Spatial resolution: Spherical harmonic expansion of the geopotential with degree $n=2$ to $n=50$ and order $m=0$ to $m=50$.

Product location accuracy: Radial nominal accuracy = 1 m.

Reference system(s): CTS and CIS.[Definitions 1 and 2]

DATA VOLUME

0.25 Mbytes. 2500 parameters with associated error estimates.

MEDIUM

1600 bpi CCT, 6250 bpi CCT.

FORMAT

See Reference 8.

Product name *Product code*

Gravity Model Second Generation ERS-1.ORB.EGM2

DEFINITION
Second generation of ERS-1 Gravity Field Models provided as a set of fully normalised harmonic coefficients (see ERS-1.ORB.EGM1).

DESCRIPTION
Input:
- pre-ERS-1 Earth gravity model
- ERS-1 laser range data
- ERS-1.ORB.EGM1
- tracking station survey ties
- a-priori degree variance models.

Algorithm:
Numerical integration of satellite's equation of motion and variational equations followed by a least squares adjustment: reduction, accumulation, combination and solution of normal equation systems.
Output:
As ERS-1.ORB.EGM1.

SPECIFICATIONS
As ERS-1.ORB.EGM1.

DATA VOLUME
2500 parameters with associated error estimates. Volume = 0.25 Mbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 8.

6. GRAVITY FIELD MODELS

6. GRAVITY FIELD MODELS

A specification is available for the following gravity field model products:

DEFINITIONS

Definition 1 – Conventional Terrestrial System (CTS):
Z axis directed towards the mean pole as derived from the BIH pole series (ERP(BIH)87C02) covering the period January 1980 to October 1986. X axis fixed by allowing no net rotation about the Z axis with respect to the initial coordinates (SSC(DGFII)90L0X). Y axis completes the right-handed system.

Definition 2 – Conventional Inertial System (CIS):
This system is referred to the basic epoch 2000.01.01 12 hours designated J2000.0. The axes of the CIS are chosen in such a way that at the basic epoch J2000.0 they coincide in optimal approximation with the mean equatorial frame defined by the mean celestial pole (Z axis) and the mean vernal equinox (X axis).

Product name | *Product code*

Gravity Model First Generation — ERS-1.ORB.EGM1

DEFINITION

First generation of ERS-1 Gravity Field Models. ERS-1 gravity model provided as a set of fully normalised harmonic coefficients: C(n,m), S(n,m), appearing in the Earth geopotential U expansion:

$$U=(GM/r)\{1+\sum_{n=2}^{N}\sum_{m=0}^{n}(Re/r)^{n}\,Pnm(\sin(\theta))\,[\,C(n,m)\cos(m\phi)+S(n,m)\sin(m\phi)\,]\,\}$$

where:

GM	=	gravitational constant times mass of Earth and atmosphere
Re	=	mean equatorial radius of the Earth
r	=	distance of point P from Earth's centre of mass
θ	=	latitude of point P
ϕ	=	longitude of point P
Pnm(x)	=	associated Legendre polinomial of order n,m
C(n,m), S(n,m)	=	fully normalised harmonic coefficients
N	=	truncation degree

DESCRIPTION

Input:

- pre-ERS-1 Earth gravity model
- ERS-1 laser range data
- tracking station survey ties
- a-priori degree variance models.

Algorithm:

Numerical integration of satellite's equation of motion and variational equations followed by a least square adjustment: reduction, accumulation, combination and solution of normal equation systems.

Output:

Spherical harmonic coefficients C(n,m) and S(n,m) of the expansion of the terrestrial potential U in spherical harmonics.

SPECIFICATIONS

Units: A-dimensional numbers.

Product geographical coverage: ERS-1 global coverage.

Spatial resolution: Spherical harmonic expansion of the geopotential with degree n=2 to n=50 and order m=0 to m=50.

Product location accuracy: Radial nominal accuracy = 1 m.

Reference system(s): CTS and CIS.[Definitions 1 and 2]

DATA VOLUME

0.25 Mbytes. 2500 parameters with associated error estimates.

MEDIUM

1600 bpi CCT, 6250 bpi CCT.

FORMAT

See Reference 8.

Product name *Product code*

Gravity Model Second Generation ERS-1.ORB.EGM2

DEFINITION
Second generation of ERS-1 Gravity Field Models provided as a set of fully normalised harmonic coefficients (see ERS-1.ORB.EGM1).

DESCRIPTION
Input:
- pre-ERS-1 Earth gravity model
- ERS-1 laser range data
- ERS-1.ORB.EGM1
- tracking station survey ties
- a-priori degree variance models.

Algorithm:
Numerical integration of satellite's equation of motion and variational equations followed by a least squares adjustment: reduction, accumulation, combination and solution of normal equation systems.
Output:
As ERS-1.ORB.EGM1.

SPECIFICATIONS
As ERS-1.ORB.EGM1.

DATA VOLUME
2500 parameters with associated error estimates. Volume = 0.25 Mbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 8.

ESA ERS-1 PRODUCT SPECIFICATION

Request Form

The ESA ERS-1 Product Specification document has been structured to allow distribution in its entirety and by chapter. On this form you should record the product specifications you wish to receive. In addition to the specifications the pack sent to you will include a brief introduction to the ERS-1 space and ground segments, a list of acronyms and abbreviations and a list of references. Updates will be issued as product lists or specifications are modified. The following product specifications are available:

esa european space agency

SYNTHETIC APERTURE RADAR – IMAGE MODE ❑

SAR Annotated Raw Data	ERS-1.SAR.RAW
SAR Fast Delivery Image	ERS-1.SAR.UI16
SAR Fast Delivery Image Copy	ERS-1.SAR.FDC
SAR Single Look Complex Image	ERS-1.SAR.SLC
SAR Precision Image	ERS-1.SAR.PRI
SAR Ellipsoid Geocoded Image	ERS-1.SAR.GEC
SAR Terrain Geocoded Image	ERS-1.SAR.GTC01

SYNTHETIC APERTURE RADAR – WAVE MODE ❑

SAR Wave Annotated Raw Data	ERS-1.SWM.RAW
SAR Wave Fast Delivery Product	ERS-1.SWM.UWA
SAR Wave Fast Delivery Product Copy	ERS-1.SWM.FDC
SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC
SAR Wave Complex Image	ERS-1.SWM.CIT
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS

WIND SCATTEROMETER ❑

Scatterometer Fast Delivery Product	ERS-1.WSC.UWI
Scatterometer FD Product Copy	ERS-1.WSC.FDC
Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC
De-aliased Off-line Wind Fields	ERS-1.WSC.WNF

RADAR ALTIMETER ❑

Altimeter Annotated Raw Data	ERS-1.ALT.RAW
Altimeter Fast Delivery Product	ERS-1.ALT.URA
Altimeter Fast Delivery Product Copy	ERS-1.ALT.FDC
Off-line Intermediate Product	ERS-1.ALT.OIP
Ocean Product	ERS-1.ALT.OPR01
Sea Surface Height	ERS-1.ALT.SSH
Sea Surface Topography	ERS-1.ALT.TOP
Ocean Geoid	ERS-1.ALT.OGE

ORBIT ❑

Preliminary Orbit	ERS-1.ORB.PRL
Precise Orbit	ERS-1.ORB.PRC

GRAVITY FIELD MODELS ❑

Gravity Model First Generation	ERS-1.ORB.EGM1
Gravity Model Second Generation	ERS-1.ORB.EGM2

Tick box if you wish to receive the entire document ❑

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ORGANISATION:
ADDRESS:

POST CODE: COUNTRY:
TELEPHONE No.: TELEX No.:
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Please return form to:

ERS-1 Help Desk
EECF
Earthnet Programme Office
ESRIN
CP 64
I-00044, Frascati, Italy

telex: 610637 ESRIN I
telephone: ++39-6-94180600
fax: ++39-6-94180510

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esa european space agency

SYNTHETIC APERTURE RADAR – IMAGE MODE		❑
SAR Annotated Raw Data	ERS-1.SAR.RAW	
SAR Fast Delivery Image	ERS-1.SAR.UI16	
SAR Fast Delivery Image Copy	ERS-1.SAR.FDC	
SAR Single Look Complex Image	ERS-1.SAR.SLC	
SAR Precision Image	ERS-1.SAR.PRI	
SAR Ellipsoid Geocoded Image	ERS-1.SAR.GEC	
SAR Terrain Geocoded Image	ERS-1.SAR.GTC01	
SYNTHETIC APERTURE RADAR – WAVE MODE		❑
SAR Wave Annotated Raw Data	ERS-1.SWM.RAW	
SAR Wave Fast Delivery Product	ERS-1.SWM.UWA	
SAR Wave Fast Delivery Product Copy	ERS-1.SWM.FDC	
SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC	
SAR Wave Complex Image	ERS-1.SWM.CIT	
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS	
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS	
WIND SCATTEROMETER		❑
Scatterometer Fast Delivery Product	ERS-1.WSC.UWI	
Scatterometer FD Product Copy	ERS-1.WSC.FDC	
Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC	
De-aliased Off-line Wind Fields	ERS-1.WSC.WNF	
RADAR ALTIMETER		❑
Altimeter Annotated Raw Data	ERS-1.ALT.RAW	
Altimeter Fast Delivery Product	ERS-1.ALT.URA	
Altimeter Fast Delivery Product Copy	ERS-1.ALT.FDC	
Off-line Intermediate Product	ERS-1.ALT.OIP	
Ocean Product	ERS-1.ALT.OPR01	
Sea Surface Height	ERS-1.ALT.SSH	
Sea Surface Topography	ERS-1.ALT.TOP	
Ocean Geoid	ERS-1.ALT.OGE	
ORBIT		❑
Preliminary Orbit	ERS-1.ORB.PRL	
Precise Orbit	ERS-1.ORB.PRC	
GRAVITY FIELD MODELS		❑
Gravity Model First Generation	ERS-1.ORB.EGM1	
Gravity Model Second Generation	ERS-1.ORB.EGM2	
Tick box if you wish to receive the entire document		❑

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Earthnet Programme Office
ESRIN
CP 64
I-00044, Frascati, Italy

telex: 610637 ESRIN I
telephone: ++39-6-94180600
fax: ++39-6-94180510

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esa european space agency

SYNTHETIC APERTURE RADAR – IMAGE MODE ❑

SAR Annotated Raw Data	ERS-1.SAR.RAW
SAR Fast Delivery Image	ERS-1.SAR.UI16
SAR Fast Delivery Image Copy	ERS-1.SAR.FDC
SAR Single Look Complex Image	ERS-1.SAR.SLC
SAR Precision Image	ERS-1.SAR.PRI
SAR Ellipsoid Geocoded Image	ERS-1.SAR.GEC
SAR Terrain Geocoded Image	ERS-1.SAR.GTC01

SYNTHETIC APERTURE RADAR – WAVE MODE ❑

SAR Wave Annotated Raw Data	ERS-1.SWM.RAW
SAR Wave Fast Delivery Product	ERS-1.SWM.UWA
SAR Wave Fast Delivery Product Copy	ERS-1.SWM.FDC
SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC
SAR Wave Complex Image	ERS-1.SWM.CIT
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS

WIND SCATTEROMETER ❑

Scatterometer Fast Delivery Product	ERS-1.WSC.UWI
Scatterometer FD Product Copy	ERS-1.WSC.FDC
Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC
De-aliased Off-line Wind Fields	ERS-1.WSC.WNF

RADAR ALTIMETER ❑

Altimeter Annotated Raw Data	ERS-1.ALT.RAW
Altimeter Fast Delivery Product	ERS-1.ALT.URA
Altimeter Fast Delivery Product Copy	ERS-1.ALT.FDC
Off-line Intermediate Product	ERS-1.ALT.OIP
Ocean Product	ERS-1.ALT.OPR01
Sea Surface Height	ERS-1.ALT.SSH
Sea Surface Topography	ERS-1.ALT.TOP
Ocean Geoid	ERS-1.ALT.OGE

ORBIT ❑

Preliminary Orbit	ERS-1.ORB.PRL
Precise Orbit	ERS-1.ORB.PRC

GRAVITY FIELD MODELS ❑

Gravity Model First Generation	ERS-1.ORB.EGM1
Gravity Model Second Generation	ERS-1.ORB.EGM2

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ESA ERS-1 PRODUCT SPECIFICATION

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SAR Annotated Raw Data	ERS-1.SAR.RAW
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SAR Single Look Complex Image	ERS-1.SAR.SLC
SAR Precision Image	ERS-1.SAR.PRI
SAR Ellipsoid Geocoded Image	ERS-1.SAR.GEC
SAR Terrain Geocoded Image	ERS-1.SAR.GTC01

SYNTHETIC APERTURE RADAR – WAVE MODE ❑

SAR Wave Annotated Raw Data	ERS-1.SWM.RAW
SAR Wave Fast Delivery Product	ERS-1.SWM.UWA
SAR Wave Fast Delivery Product Copy	ERS-1.SWM.FDC
SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC
SAR Wave Complex Image	ERS-1.SWM.CIT
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS

WIND SCATTEROMETER ❑

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Scatterometer FD Product Copy	ERS-1.WSC.FDC
Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC
De-aliased Off-line Wind Fields	ERS-1.WSC.WNF

RADAR ALTIMETER ❑

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Altimeter Fast Delivery Product	ERS-1.ALT.URA
Altimeter Fast Delivery Product Copy	ERS-1.ALT.FDC
Off-line Intermediate Product	ERS-1.ALT.OIP
Ocean Product	ERS-1.ALT.OPR01
Sea Surface Height	ERS-1.ALT.SSH
Sea Surface Topography	ERS-1.ALT.TOP
Ocean Geoid	ERS-1.ALT.OGE

ORBIT ❑

Preliminary Orbit	ERS-1.ORB.PRL
Precise Orbit	ERS-1.ORB.PRC

GRAVITY FIELD MODELS ❑

Gravity Model First Generation	ERS-1.ORB.EGM1
Gravity Model Second Generation	ERS-1.ORB.EGM2

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6. GRAVITY FIELD MODELS

6. GRAVITY FIELD MODELS

A specification is available for the following gravity field model products:

DEFINITIONS

Definition 1 – Conventional Terrestrial System (CTS):
Z axis directed towards the mean pole as derived from the BIH pole series (ERP(BIH)87C02) covering the period January 1980 to October 1986. X axis fixed by allowing no net rotation about the Z axis with respect to the initial coordinates (SSC(DGFII)90L0X). Y axis completes the right-handed system.

Definition 2 – Conventional Inertial System (CIS):
This system is referred to the basic epoch 2000.01.01 12 hours designated J2000.0. The axes of the CIS are chosen in such a way that at the basic epoch J2000.0 they coincide in optimal approximation with the mean equatorial frame defined by the mean celestial pole (Z axis) and the mean vernal equinox (X axis).

Product name | *Product code*

Gravity Model First Generation — ERS-1.ORB.EGM1

DEFINITION

First generation of ERS-1 Gravity Field Models. ERS-1 gravity model provided as a set of fully normalised harmonic coefficients: $C(n,m)$, $S(n,m)$, appearing in the Earth geopotential U expansion:

$$U=(GM/r)\{1+\sum_{n=2}^{N}\sum_{m=0}^{n}(Re/r)^{n}\,Pnm(\sin(\theta))\,[\,C(n,m)\cos(m\phi)+S(n,m)\sin(m\phi)\,]\,\}$$

where:

GM	=	gravitational constant times mass of Earth and atmosphere
Re	=	mean equatorial radius of the Earth
r	=	distance of point P from Earth's centre of mass
θ	=	latitude of point P
ϕ	=	longitude of point P
$Pnm(x)$	=	associated Legendre polinomial of order n,m
$C(n,m)$, $S(n,m)$	=	fully normalised harmonic coefficients
N	=	truncation degree

DESCRIPTION

Input:

- pre-ERS-1 Earth gravity model
- ERS-1 laser range data
- tracking station survey ties
- a-priori degree variance models.

Algorithm:

Numerical integration of satellite's equation of motion and variational equations followed by a least square adjustment: reduction, accumulation, combination and solution of normal equation systems.

Output:

Spherical harmonic coefficients $C(n,m)$ and $S(n,m)$ of the expansion of the terrestrial potential U in spherical harmonics.

SPECIFICATIONS

Units: A-dimensional numbers.

Product geographical coverage: ERS-1 global coverage.

Spatial resolution: Spherical harmonic expansion of the geopotential with degree $n=2$ to $n=50$ and order $m=0$ to $m=50$.

Product location accuracy: Radial nominal accuracy = 1 m.

Reference system(s): CTS and CIS.[Definitions 1 and 2]

DATA VOLUME

0.25 Mbytes. 2500 parameters with associated error estimates.

MEDIUM

1600 bpi CCT, 6250 bpi CCT.

FORMAT

See Reference 8.

Product name *Product code*

Gravity Model Second Generation ERS-1.ORB.EGM2

DEFINITION
Second generation of ERS-1 Gravity Field Models provided as a set of fully normalised harmonic coefficients (see ERS-1.ORB.EGM1).

DESCRIPTION
Input:
- pre-ERS-1 Earth gravity model
- ERS-1 laser range data
- ERS-1.ORB.EGM1
- tracking station survey ties
- a-priori degree variance models.

Algorithm:
Numerical integration of satellite's equation of motion and variational equations followed by a least squares adjustment: reduction, accumulation, combination and solution of normal equation systems.
Output:
As ERS-1.ORB.EGM1.

SPECIFICATIONS
As ERS-1.ORB.EGM1.

DATA VOLUME
2500 parameters with associated error estimates. Volume = 0.25 Mbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 8.

ESA ERS-1 PRODUCT SPECIFICATION
Request Form

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SAR Precision Image	ERS-1.SAR.PRI	
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SAR Terrain Geocoded Image	ERS-1.SAR.GTC01	
SYNTHETIC APERTURE RADAR – WAVE MODE		❑
SAR Wave Annotated Raw Data	ERS-1.SWM.RAW	
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Off-line Intermediate Product	ERS-1.ALT.OIP	
Ocean Product	ERS-1.ALT.OPR01	
Sea Surface Height	ERS-1.ALT.SSH	
Sea Surface Topography	ERS-1.ALT.TOP	
Ocean Geoid	ERS-1.ALT.OGE	
ORBIT		❑
Preliminary Orbit	ERS-1.ORB.PRL	
Precise Orbit	ERS-1.ORB.PRC	
GRAVITY FIELD MODELS		❑
Gravity Model First Generation	ERS-1.ORB.EGM1	
Gravity Model Second Generation	ERS-1.ORB.EGM2	
Tick box if you wish to receive the entire document		❑

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SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC
SAR Wave Complex Image	ERS-1.SWM.CIT
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS

WIND SCATTEROMETER ❑

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Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC
De-aliased Off-line Wind Fields	ERS-1.WSC.WNF

RADAR ALTIMETER ❑

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Altimeter Fast Delivery Product Copy	ERS-1.ALT.FDC
Off-line Intermediate Product	ERS-1.ALT.OIP
Ocean Product	ERS-1.ALT.OPR01
Sea Surface Height	ERS-1.ALT.SSH
Sea Surface Topography	ERS-1.ALT.TOP
Ocean Geoid	ERS-1.ALT.OGE

ORBIT ❑

Preliminary Orbit	ERS-1.ORB.PRL
Precise Orbit	ERS-1.ORB.PRC

GRAVITY FIELD MODELS ❑

Gravity Model First Generation	ERS-1.ORB.EGM1
Gravity Model Second Generation	ERS-1.ORB.EGM2

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SAR Single Look Complex Image	ERS-1.SAR.SLC
SAR Precision Image	ERS-1.SAR.PRI
SAR Ellipsoid Geocoded Image	ERS-1.SAR.GEC
SAR Terrain Geocoded Image	ERS-1.SAR.GTC01

SYNTHETIC APERTURE RADAR – WAVE MODE ❑

SAR Wave Annotated Raw Data	ERS-1.SWM.RAW
SAR Wave Fast Delivery Product	ERS-1.SWM.UWA
SAR Wave Fast Delivery Product Copy	ERS-1.SWM.FDC
SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC
SAR Wave Complex Image	ERS-1.SWM.CIT
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS

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Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC
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ORBIT ❑

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Precise Orbit	ERS-1.ORB.PRC

GRAVITY FIELD MODELS ❑

Gravity Model First Generation	ERS-1.ORB.EGM1
Gravity Model Second Generation	ERS-1.ORB.EGM2

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1. SYNTHETIC APERTURE RADAR IMAGE MODE

1. SYNTHETIC APERTURE RADAR – IMAGE MODE

Overview

The on-board SAR operated in image mode will obtain strips of high resolution imagery 100 km in width to one side of the satellite. The mid-swath depression, or incidence angle of the system in normal operation, will be 23°. However, for some experimental applications the roll tilt capability of the satellite will be used to vary this up to 35°.

The SAR image mode engineering parameters are as follows:

SAR antenna size:	10 m long, 1 m wide
frequency:	5.3 GHz (C band) ± 0.2 MHz
bandwidth:	15.55 ± 0.01 MHz
PRF range:	1640-1720 Hz (in 2 Hz steps)
long pulse duration:	37.1 ± 0.05 μs
compressed pulse length:	64 ns
peak power:	4.8 kW
polarisation:	linear vertical
signal sampling window:	299 μs (99 km telemetered swath)
A/D complex sampling:	18.96 Msamples/sec
I and Q quantisation:	5 bits for OGRC, 6 bits for OBRC
radiometric resolution:	2.5 dB at sigma-nought = -18 dB
swath location:	244.5 km to the right of the orbital track
swath width:	80.4 km (nominal within specifications) 102.5 km telemetered
incidence angle:	23° at mid-swath
data rate:	105 Mbps

SAR image mode products

A specification is available for the following SAR image mode products:

Product name | *Product code*

SAR Annotated Raw Data | ERS-1.SAR.RAW

DEFINITION
Decommutated raw SAR echo data suitable for input to a processor.

DESCRIPTION
Input:
- signal detected by the SAR instrument operating in image mode
- chirp replica and calibration pulses
- noise measurements
- system parameters
- orbital information as spacecraft parameters relating to the raw data set (see ERS-1.ORB.PRL and ERS-1.ORB.PRC)
- instrument parameters, etc..

Algorithm:
The product is generated via the following major operations:
- check on the spacecraft parameters to ensure normal operation during data generation
- analysis of instrument parameters to assess the correct instrument performance
- extraction and analysis of blocks of echo data to test the quality of the data.

Output:
- SAR raw data (I/Q channel samples) for an area of 100 km x 100 km, plus a 10% overlap in azimuth
- start/stop time of the data stream, orbit, quality indices, such as: missing lines flag, duplication lines flag, down link performance flag, calibration data, bit error rate, etc.. For more information see Reference 1.

SPECIFICATIONS
Units: Digital counts.
Product size: 5616 samples in range, 27000 samples in azimuth.
Product geographical coverage: ~100 km in ground range, ~110 km in azimuth.
Product location accuracy: The nominal accuracy is 0.9 km in range, 1 km in azimuth.
Axis orientation: The echo lines are in the range/azimuth system as defined by the spacecraft ground track and antenna beam pointing direction.
Presentation grid resolution: (as spacecraft and sensor dependent): Nominal spacing between data samples is 7.9 m in range, 3.9 m in azimuth.
Spacing between products: Data set centres are nominally spaced by 100 km on an azimuth heading parallel to the satellite nadir ground track.
Projection: Slant range projection.
Coordinate system: Bi-dimensional Cartesian ground range/azimuth grid defined by spacecraft orbit and antenna beam pointing.

DATA VOLUME
The samples are 8 bits I, 8 bits Q (the three most significant bits are set to zero); one sample is 16 bits. One data set is 5616 x 27000 x 2 bytes. Total volume of data set and CEOS superstructure is ~300 Mbytes.

MEDIUM
6250 bpi CCT, Exabyte cassette.

FORMAT
See Reference 1 and Reference 2.

REMARKS
Incidence angle at mid swath is 23° in nominal mode.

Product name | *Product code*

SAR Fast Delivery Image | ERS-1.SAR.UI16

DEFINITION
SAR fast delivery image.

DESCRIPTION
Input:
- signal detected by the SAR instrument operating in image mode
- chirp replica and calibration pulses
- noise measurements
- system parameters
- orbital information as spacecraft parameters relating to the raw data set
- instrument parameters, etc..

Algorithm:
The algorithm (range-doppler) performs most of the processing in slant-range azimuth frequency domain.

Output:
- SAR image of an area of about 100 km x 100 km
- frame centre observation time
- corners and frame centre locations
- ground velocity angle
- satellite altitude
- quality indices, noise level, etc..

SPECIFICATIONS
Units: Digital counts.
Product size: 5000 pixels in ground range, 6300 lines in azimuth.
Product geographical coverage: ~100 km in ground range, ~100 km in azimuth.
Product location accuracy: The nominal accuracy is 0.9 km in range, 1 km in azimuth.
Axis orientation: The axes are in the ground range/azimuth system as defined by the spacecraft ground nadir track and beam pointing direction – the origin is given in geodetic latitude and longitude.
Pixel size: 20 m in range, 15.8 m in azimuth.
Spatial resolution: <33 m in both range and azimuth.
Number of looks: Three looks.
Projection: Ground range projection on a curved Earth surface as given by the GEM6 Earth model.
Coordinate system: Bi-dimensional Cartesian ground range/azimuth grid defined by spacecraft orbit and antenna beam pointing.
Radiometric resolution: 3 dB.
Relative calibration: Gain normalisation.
Absolute calibration: None.

DATA VOLUME
The intensity at processor output is given in 16 bit one pixel = 2 bytes; one data set is 5000 x 6300 x 2 bytes = 63 Mbytes.

MEDIUM
Dissemination via high rate links.

FORMAT
See Reference 3.

Product name

SAR Fast Delivery Image Copy

Product code

ERS-1.SAR.FDC

DEFINITION
Off-line copy of ERS-1.SAR.UI16.

DESCRIPTION
As ERS-1.SAR.UI16.

SPECIFICATIONS
As ERS-1.SAR.UI16.

DATA VOLUME
Data set and CEOS superstructure is 63.7 Mbytes.

MEDIUM
6250 bpi CCT, Exabyte cassette.

FORMAT
See Reference 4.

Product name | *Product code*

SAR Single Look Complex Image — ERS-1.SAR.SLC

DEFINITION

Single-look, complex, slant-range, digital image generated from raw SAR image mode data with up-to-date (at time of processing) auxiliary parameters. Intended for ESA use in SAR quality assessment and calibration. Provides a basic meeting point for all SAR image mode processors of the ERS-1 ground segment. A minimum number of corrections and interpolations are performed on the data in order to allow the end-user maximum freedom to derive higher-level products. Complex output data is retained to avoid loss of information.

DESCRIPTION

Input:

- ERS-1 telemetry
- orbit, one of:
  - MMCC restituted orbit
  - ERS-1.ORB.PRL
  - ERS-1.ORB.PRC
- measured antenna patterns
- external calibration data (if available).

All processing parameters are derived from orbit and telemetry (e.g. I/Q channel characteristics, range / azimuth compression functions, noise / calibration pulse powers).

Algorithm:

There is no constraint on the algorithm to be used.

Output:

Digital data set plus annotations.

SPECIFICATIONS

Units: Complex pixels, arbitrary units: 16 bits I, 16 bits Q.

Pixel spacing: Natural spacing in both slant-range and azimuth – slant-range as for raw data (7.9 m), azimuth uniformly spaced in time at pulse repetition interval (PRI).[Note 1]

Product size: 2500 samples in range, 15000 samples in azimuth.[Note 2]

Data presentation: Product is written sequentially, range-line by range-line, on a first-line-in / first-line-out basis. The first sample of each range line is at near range. The same convention is used for FD SAR image products.

Product localisation: Referenced to frames of the WRS as follows. Given the zero-doppler range and azimuth times which delimit WRS full-scene image:

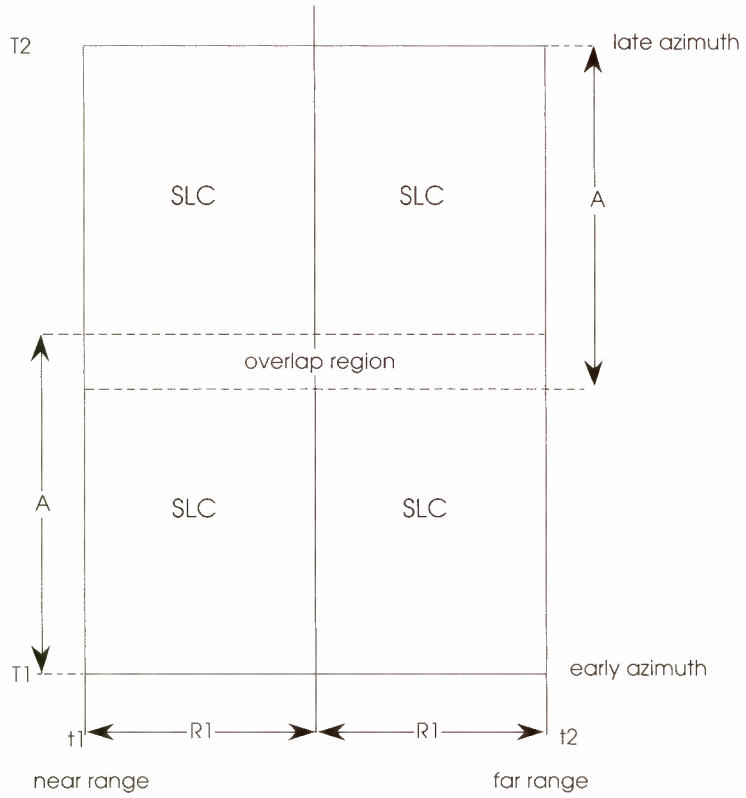
early azimuth	late azimuth	near range	far range
T1	T2	t1	t2

The nominal zero-doppler range and azimuth times which delimit each of the four quarter-scene SLC products are defined as follows:

early azimuth	late azimuth	near range	far range
T1	T1+A	t1	t1+R1
T1	T1+A	t1+R2	t1+R2+R1
T2-A	T2	t1	t1+R1
T2-A	T2	t1+R2	t1+R2+R1

where:
R1 = 2499 range sampling intervals (at 18.96 MHz)
R2 = 2500 range sampling intervals (at 18.96 MHz)
A = 1499 PRI
as illustrated in diagram.

reported in product annotations:
longitude and latitude of scene centre pixel and four corners.[Note 3]



Localisation accuracy: Mainly determined by accuracy of the orbit data used and datation accuracy.

Spatial resolution: As determined by range and azimuth processed bandwidths, nominally: slant range <10 m, azimuth <10 m.

Coordinate system: Slant-range, zero-doppler coordinates. [Definition 1]

reported in product annotations:

zero-doppler times of scene corners and centre pixels:

- zero-doppler range time of first, centre and last range pixels
- zero-doppler azimuth time of first, centre and last azimuth pixels

The reported range times are full two-way delay times.

Range spectral weighting: Hamming window (coefficient 0.75).

Number of looks: One look.

Look bandwidth: 0.82 x Pulse Repetition Frequency (null-to-null). If PRF is changed from scene-to-scene then look bandwidth changes accordingly.

Look spectral weighting function: Hamming window (coefficient 0.75) centred on estimated doppler centroid frequency.

Azimuth frequencies: The output data is left at doppler frequencies, i.e. not output at azimuth baseband.

Range cell migration artifact: Not more than -30 dB with respect to the main lobe.

Point target geometric mis-registration: ≤2 resolution lengths in range and in azimuth. [Definition 2]

Processor point target linearity: >0.95 over the linear dynamic range. [Definition 3]

Processor point target linear output dynamic range: OGRC 30 dB, OBRC 36 dB. [Definition 4]

Processor gain stability: Each SAR image mode processor shall be operated at known fixed gain at all times

reported in product annotations:

processor net multiplicative scaling factor [Definition 5]

Some optimisation of processor gains during the early mission may be unavoidable. [Definition 6]

Quality parameters:

reported in annotations:

The minimum set of flags and parameters is listed below [Note 4]

- SAR QA summary flags:
  - overall QA summary index (Value 0-9)
  - PRF code change flag (0 or 1)

- sampling window change flag (0 or 1)
- calibration system and receiver gain change flag (0 or 1)
- chirp replica quality flag (0 or 1)
- input data statistic flag (0 or 1)
- doppler centroid confidence measure flag (0 or 1)
- doppler centroid value flag (0 or 1)
- doppler ambiguity confidence measure flag (0 or 1)
- output data mean flag (0 or 1)

• SAR QA parameters:
- OGRC/OBRC flag (OGRC=0, OBRC=1)
- number of PRF code changes
- number of sampling window time changes
- number of calibration sub-system gain changes
- number of missing lines
- number of receiver gain changes
- 3-dB pulse width of (first) chirp replica ACF
- first side-lobe level of chirp ACF
- ISLR of chirp ACF function
- doppler centroid confidence measure (processor-specific)
- doppler-ambiguity confidence measure (processor-specific)
- estimated mean of I input data
- estimated mean of Q input data
- estimated standard deviation of I input data
- estimated standard deviation of Q input data
- calibration system gain
- first receiver gain read
- doppler ambiguity number

Internal calibration:

• raw data and replica corrections: applied in following sequence:
- bias correction applied to both I and Q channels
- gain imbalance correction applied to Q channel
- non-orthogonality correction applied to Q channel

• replica power estimation: measured as $Pr = \sum(i^2+q^2)$ over 704 samples of the extracted replica

• replica normalisation (OGRC): range compression filter is normalised to unity power after I/Q corrections and weighting function (none in case of ERS-1.SAR.SLC, has been applied to the extracted replica samples).
The replica normalisation factor Nr is calculated as: $Nr = \sum(i^2+q^2)$ where the sum is over all samples used to generate the matched filter. The replica normalisation is implemented by dividing each (I/Q) sample through by Nr. This normalisation accounts for Rx gain changes, AMI internal gain drifts and transmit power fluctuations. It is not applicable for OBRC data.

• calibration pulse processing: average calibration pulse power measured by compressing calibration pulse with nearest replica

• noise power estimation: measured as per calibration pulse by compressing valid noise signals and averaging

• AMI system gain monitoring: AMI gain settings are reported in product annotations

• ADC power transfer non-linearity: not done

• noise subtraction: not done

reported in product annotations: [Note 5]

• internal calibration data time tag (UTC)

• number of valid calibration pulses

• number of valid noise pulses

• number of valid replicas (always 1)

• first sample in replica

• mean calibration pulse power

• mean noise power

• range compression normalisation factor

• replica power.

Absolute calibration: No compensation for:

- antenna elevation gain pattern
- range spreading loss (R**3)

computed and reported in product annotations:

- incidence angle at first range pixel
- incidence angle at centre range pixel
- incidence angle at last range pixel [Note 6]

reported in product annotations:

Externally supplied absolute calibration parameters:

- normalisation reference range Ro km (set to 0 for ERS-1.SAR.SLC)
- antenna elevation gain pattern
- absolute calibration constant K (scalar)
- upper bound K (+3 standard deviation)
- lower bound K (-3 standard deviation)
- processor noise scaling factor
- date on which K generated
- K version number X.Y.

DATA VOLUME

Data set and CEOS superstructure is 150.2 Mbytes.

MEDIUM

6250 bpi CCT, Exabyte cassette.

FORMAT

See Reference 1 and Reference 2.

NOTES

Note 1:

On-ground azimuth spacing in metres depends on Earth-satellite relative velocity and PRI. Velocity varies by approximately 2% around orbit and PRI is fixed within AMI imaging sequence.

Note 2:

Referred to as a 'quarter-scene' or quadrant corresponds to approximately one-half (range) by one-half (azimuth) of a full-scene image. Nominal spatial extent in slant-range is 19.76 km, i.e. half the range swath. Exact spatial extent in azimuth varies with Earth-satellite relative velocity and PRI (approximately 59.7 km for PRI = 1690 Hz, velocity = 6725 ms^{-1}).

Note 3:

A 'range-line' refers to a line of image pixels all at constant zero-doppler azimuth time (horizontal in the product localisation diagram). For the two near-range quadrants: the zero-doppler range time of the first range pixel of both quadrants is nominally identical to that of the WRS full-scene image. For the two early-azimuth quadrants: the first range-line of both quadrants nominally coincides with the first range-line of the WRS full-scene image. For the two late-azimuth quadrants: the last range-line of both quadrants nominally coincides with the last range-line of the WRS full-scene image. For the two far-range quadrants: each is contiguous with the corresponding near-range quadrant. The SLC products overlap in the azimuth direction about WRS full-frame centre. They do not overlap in the range direction. The specification is limited to a definition of the quadrant time delimiters with respect to some known WRS full-scene time delimiters, as required to process the full-scene. Definition of T1, T2, t1 and t2 is beyond the scope of this product specification. Any definition of quadrant designators (1, 2, 3 and 4) or their geographical organisation, as may be used in a catalogue is explicitly excluded from this product specification.

Note 4:

In case of any parameter or flag not being available, or not known, its value is reported as 0. PAF products may include additional parameters and flags specific to their processor algorithm. QA flags are set by comparison of the corresponding QA parameters with pre-defined thresholds applied by PAFs. The convention for QA flag setting is that value 0 indicates nominal conditions (e.g. no change in parameter or thresholds not crossed) and value 1 indicates non-nominal conditions. The value of the 'overall QA summary index' is the sum of values of the nine lower-

level QA flags. For this index the value 0 indicates all-nominal QA conditions and a non-zero value gives a count of non-nominal QA conditions. Unless otherwise stated the listed quality parameters and flags are as defined for the SAR Fast Delivery products. The reported raw data means are estimated after biases due to encoding have been removed, i.e. the nominal value is 0 for all modes. Doppler centroid and doppler FM rates used for processing are reported in the annotations as processing parameters.

Note 5:
The internal calibration parameters are identical to those reported by PAFs to EECF in the HDDT_QA_REPORT via the EECF-PAF interface. They are only reported in the product annotations if the internal calibration signals are present on HDDT. They may be derived from AMI internal calibration signals acquired either before, or after, the scene image data. The reported internal calibration time tag is that of the first format (or source packet) of calibration data used.

Note 6:
The incidence angles are computed on the basis of orbit and a reference Earth model (e.g. GEM6). Terrain slope effects are excluded. If externally supplied absolute calibration parameters are not available then they are set to 0. The externally supplied absolute calibration parameters are planned to be derived as a result of external calibration campaigns and analysis. Availability depends on deployment of resources and duration of campaigns and analysis. The values, if and when available, are expected to vary from product-type to product-type, may vary from processor to processor, and may exhibit some time-dependence. In the K version number X.Y, X will refer to a K update implemented across the ERS-1 ground segment, and Y will refer to an upgrade only implemented at the source PAF (as may arise in the case of local software updates). The processor noise scaling factor is nominally that factor which, when multiplied by the reported mean noise power (see internal calibration), gives the noise power at centre range in the same (arbitrary) units as the image power.

DEFINITIONS

Definition 1 – Zero-doppler coordinates:
A general class of SAR image coordinate systems is specified by a one-to-one mapping of target range into image x coordinates, and a one-to-one mapping of absolute time into image y coordinates. The zero-doppler image coordinate system is further specified by the property that the focused energy of any point target appears in the image at that pixel whose range and absolute time are exactly those of the target when the doppler frequency is 0. This corresponds to the closest point of approach between target and sensor. Assuming perfect yaw steering each image range-line thus represents, at a fixed time, the intersection of the Earth's surface with that plane which contains both the satellite and the sub-satellite point and which is also orthogonal to the Earth-satellite relative velocity vector. This is to be distinguished from 'beam-centred' image coordinates in which the absolute time and range are those of the target when at beam centre.

Definition 2 – Point target geometric mis-registration:
This is the mis-registration of a point target's energy from its assumed zero-doppler location caused by approximations in the SAR processor. Mis-registration due to orbit or terrain height is not included.

Definition 3 – Processor point target linearity:
The processor point target linearity is measured by the coefficient of correlation of the regression of output point target peak power over input point target power. It is measured within the point target linear output dynamic range.

Definition 4 – Processor point target linear dynamic range:
This is the range of the output powers over which the processed point target peak power is linearly proportional to input point target power.

Definition 5 – Processor net multiplicative scaling factor (NMSF):
A SAR processor may provide the option to multiplicatively scale the data at one or more stages of the processing. It is assumed here that any adjustment of SAR processor gain will be implemented by adjustment of such scaling factors. The NMSF is the product of all such adjustable

multiplicative factors applied to the data. In the case of a processor with no such scaling factor this parameter shall always be reported as 1 in the product annotations.

Definition 6 – SAR processor gain:
SAR processor gain is defined as the intercept of a linear regression of point target power (measured in dB) output over point target power (dB) input to the processor. This is equivalent to the power in dB of the image point target response arising when raw data from a point target specified as being of 0 dB power is processed. The actual numerical value of the processor gain depends on the definition of point target power in the raw data and in the image. The product specification for ERS-1.SAR.SLC implies only that, for a given SAR processor, the processor gain, whatever its particular numerical value, does not vary with time. This assumes processor point target linearity to be within specification. Effects due to errors in doppler parameter estimates or due to the AMI ADC setting are excluded. The so-defined gain is range-invariant. When measuring processor gain using simulated raw data, any range varying gains or losses present in the raw data or compensated in the processor must be properly accounted for.

Product name *Product code*

SAR Precision Image ERS-1.SAR.PRI

DEFINITION

Multi-look, ground range, digital image generated from raw SAR image mode data using up-to-date (at time of processing) auxiliary parameters and corrected for antenna elevation gain and range spreading loss. ERS-1.SAR.PRI has been specified for users wishing to perform applications-oriented analysis. It is intended for multi-temporal imaging and to derive radar cross sections. Engineering corrections and relative calibration are applied to compensate for well-understood sources of system variability. Absolute calibration parameters, if available, will be provided in the product annotations, but this depends on external calibration activities.

DESCRIPTION

Input:

- ERS-1 telemetry
- orbit, one of:
  - MMCC restituted orbit
  - ERS-1.ORB.PRL
  - ERS-1.ORB.PRC
- measured antenna patterns
- external calibration data (if available).

All processing parameters are derived from the orbit and telemetry (e.g. I/Q channel characteristics, range and azimuth compression functions, noise and calibration pulse powers).

Algorithm:

There is no constraint on the algorithm to be used.

Output:

Digital image plus annotations.

SPECIFICATIONS

Units: Amplitude in arbitrary units (16 bits per pixel).

Product size: 8000 pixels in ground range by at least 8200 pixels in azimuth.

Product geographical coverage: 100 km in ground range, at least 102.5 km in azimuth.

Pixel size: 12.5 m ground range, 12.5 m azimuth.

Data presentation: Product is written sequentially, range-line by range-line, on a first-line-in / first-line-out basis. The first sample of each range line is at near range. The same convention is used for FD SAR image products.

Product localisation: As applicable WRS

reported in product annotations:

longitude and latitude of scene centre pixel and four corners.

Localisation accuracy: Mainly determined by accuracy of the orbit data used and datation accuracy.

Spatial resolution: As determined by range and azimuth processing parameters, nominally ground range <33 m, azimuth <30 m.

Coordinate system: Zero-doppler coordinate system projected onto ground-range. Same slant-to-ground range projection used for all range lines of a single image.

Range spectral weighting: Hamming window (coefficient 0.75).

Number of looks: Three non-overlapping looks.

Look spectral weighting: Hamming window (coefficient 0.75).

Look bandwidth: 320 Hz null-to-null.

Look spacing and numbering convention:

- look 1: covers low absolute frequencies
- look 2: centred at the estimated doppler centroid
- look 3: covers high absolute frequencies.

The looks are exactly contiguous in frequency. The total processed bandwidth is 960 Hz

Look weighting factor: No weighting factor applied. This is equivalent to unity weighting for all looks.

Look detection and summation: Looks are over-sampled before detection. Looks are power-detected and summed with no weighting. The summed result is square-rooted when written to product.

Range cell migration artifact: Not more than -30 dB with respect to the main lobe.

Processor point target linearity: As ERS-1.SAR.SLC.

Processor point target linear output dynamic range: As ERS-1.SAR.SLC.

Processor gain stability: As ERS-1.SAR.SLC.

Quality parameters: As ERS-1.SAR.SLC.

Internal calibration: As ERS-1.SAR.SLC.

Absolute calibration: Image compensated for:

- antenna elevation gain pattern
- range spreading loss (1/R**3)
  (each range cell normalised with respect to 847 km slant range)

reported in product annotations:

Externally supplied absolute calibration parameters:

- as ERS-1.SAR.SLC, except:
  - reported K values (if available) are different
  - normalisation reference range Ro is 847 km.

DATA VOLUME

Data set and CEOS superstructure is 131.3 Mbytes.

MEDIUM:

6250 bpi CCT, Exabyte cassette, photographic print.

FORMAT

See Reference 1 and Reference 2.

Product name | *Product code*

SAR Ellipsoid Geocoded Image — ERS-1.SAR.GEC

DEFINITION

Geocoded SAR image generated from raw SAR image mode data with the best available instrumental corrections applied, precisely located and rectified on to a map projection. The projection will be UTM for latitudes within (-80°, +84°) and UPS for the remaining latitudes. The GRS1984 reference ellipsoid will be used. Geocoded data sets can be used by the scientific or commercial community which will refer the actual SAR data to geographic/cartographic locations. Applications which benefit from geocoded products include ice monitoring, mapping large forest and agricultural areas, etc.. Engineering corrections and relative calibration are applied to compensate for well-understood sources of system variability. Absolute calibration parameters, if available, will be provided in the product annotations, but this depends on the outcome of external calibration activities.

DESCRIPTION

Input:

- ERS-1 telemetry
- measured antenna pattern
- ERS-1 SAR range and azimuth processed data
- orbit, best one of:
  - MMCC restituted orbit
  - ERS-1.ORB.PRL
  - ERS-1.ORB.PRC
- external calibration data (if available)
- external data as: coarse global digital elevation model for the ellipsoid shift.

All processing parameters are derived from the telemetry data (e.g. I/Q channel characteristics, range and azimuth compression functions, noise and calibration pulse powers) and restituted orbit.

Algorithm:

Resampling with mapping by piecewise approximated mapping functions. Inclusion of image rotation and utilisation of mono-dimensional resampling schemes. This part describes only the step from SAR slant range image to SAR ground range image projected onto a geographical map.

Output:

- SAR geocoded data
- annotation parameters.

SPECIFICATIONS

Units: Amplitude in arbitrary units.

Product size: 9100 to 12000 pixels in grid easting, 9100 to 12000 pixels in grid northing.

Product geographical coverage: ~100 km square rotated according to map grid.

Product location accuracy: With respect to reference ellipsoid: ±150 m in grid easting/northing.

Axis orientation: Origin is given in geodetic latitude/longitude, axis in grid easting/northing.

Pixel size: 12.5 m for both easting and northing.

Spatial resolution: <30 m in both grid easting and grid northing.

Projection: SAR slant range image to a curved Earth surface as given by the GRS1984 Earth model, followed by a transformation to a specific map (UTM, UPS).

Coordinate system: Two dimensional coordinate system based on the specific map.

Radiometric resolution: 3.5 dB.

Range spectral weighting function: Hamming window.

Number of looks: Three non-overlapping looks.

Look spectral weighting functions: Hamming window (coefficient 0.75).

Look bandwidth: 320 Hz null-to-null.
Look spacing and numbering convention:

- look 1: covers low absolute frequencies
- look 2: centred at the estimated doppler centroid
- look 3: covers high absolute frequencies.

The looks are exactly contiguous in frequency. The total processed bandwidth is 960 Hz.
Look weighting factor: No weighting factor applied. This is equivalent to unity weighting for all looks.
Look detection and summation: Looks are over-sampled before detection. Looks are power-detected and summed with no weighting. The summed result is square-rooted when written to product.
Range cell migration artifact: Artifact on the look-summed product shall not contribute more than -30 dB with respect to the main lobe.
Processor point target linearity: As ERS-1.SAR.PRI.
Processor point target linearity: As ERS-1.SAR.PRI.
Processor gain stability: As ERS-1.SAR.PRI.
Quality parameters:

reported in product annotations:

- parameters already specified in ERS-1.SAR.PRI.
- QA summary flags:
  - automatic QA performed flag
  - interactive/visual QA performed flag
  - QA procedure type identifier
  - product quality indicator (0...9)
- QA parameters:
  - nominal error for geocoding in northing/easting in metres on ground
  - nominal error for geocoding along/across track in metres on ground
  - maximum UTM-zone geometric extension in metres
  - ellipsoid additional reference height in metres.

Internal calibration: As ERS-1.SAR.PRI.
Absolute calibration: As ERS-1.SAR.PRI, image compensated for:

- antenna elevation gain pattern
- range spreading loss (1/R**3)
  (each range cell normalised with respect to 847 km slant range)

reported in product annotations:
Externally supplied absolute calibration parameters:

- as ERS-1.SAR.SLC except:
  - reported K values (if available) are different
  - normalisation reference range Ro is 847 km.

DATA VOLUME

The intensity at processor output is given in 16-bit one pixel = 2 bytes, one data set is from 165.62 Mbytes (9100 x 9100 x 2 bytes) to 288 Mbytes (12000 x 12000 x 2 bytes). Data set and CEOS superstructure is 165.8 to 288.2 Mbytes.

MEDIUM

6250 bpi CCT, Exabyte cassette, photographic print.

FORMAT

See Reference 1 and Reference 2.

Product name | *Product code*

SAR Terrain Geocoded Image — ERS-1.SAR.GTC01

DEFINITION

Geocoded SAR image generated from raw SAR image mode data with the best available instrumental corrections applied, precisely located, corrected for terrain variations and rectified on to a map projection. Projection, applications and calibration as for ERS-1.SAR.GEC, with the addition that the SAR inherent geometric distortion, due to terrain height variations and SAR side-looking geometry, is restituted to the highest possible degree, to achieve map reference in regions of layover and shadow. Digital elevation models and ground control points are used to improve the geocoded product.

DESCRIPTION

Input:

- ERS-1 telemetry
- measured antenna pattern
- orbit, best one of:
  - MMCC restituted orbit
  - ERS-1.ORB.PRL
  - ERS-1.ORB.PRC
- external calibration data (if available)
- external data as: digital elevation model (DEM) and ground control points (GCP).

All processing parameters are derived from the telemetry data (e.g. I/Q channel characteristics, range and azimuth compression functions, noise and calibration pulse powers) and restituted orbit. [Note 1]

Algorithm:

The algorithms use a precision SAR image generated in slant range together with the DEM of the imaged area. Together with the basic satellite orbit information the DEM is used to derive 'artificial' Ground Control Point chips. These GCPs are generated by simple simulation techniques and are used to adjust the geometry of the slant range image and the DEM itself, if necessary. The adjusted geometry refines the SAR imaging model for the subsequent resampling with the DEM. The resampling takes into consideration the modified SAR imaging model, the cartographic projection formula (with datum shifts) and the individual terrain height (derived from the DEM). No radiometric modifications due to terrain slope-effect are foreseen.

Output:

- SAR geocoded data
- annotation parameters.

SPECIFICATIONS

Units: Amplitude in arbitrary units.
Product size: 9100 to 12000 pixels in grid easting, 9100 to 12000 pixels in grid northing.
Product geographical coverage: About 100 km square rotated according to map grid.
Product location accuracy: With respect to reference ellipsoid: ±150 m in grid easting/northing.
Axis orientation: Origin is given in geodetic latitude/longitude, axis in grid easting and grid northing.
Pixel size: 12.5 m for both easting/northing.
Spatial resolution: <30 m in both grid easting and grid northing.
Projection: SAR slant range image to a curved Earth surface as given by the GRS1984 Earth model, followed by a transformation to a specific map (UTM, UPS).
Coordinate system: Two dimensional coordinate system based on the specific map.
Radiometric resolution: 3.5 dB.
Range spectral weighting function: Hamming window.
Number of looks: Three non-overlapping looks.
Look spectral weighting functions: Hamming window (coefficient 0.75).

Look bandwidth: 320 Hz null-to-null.

Look spacing and numbering convention:

- look 1: covers low absolute frequencies
- look 2: is centred at the estimated doppler centroid
- look 3: covers high absolute frequencies.

The looks are exactly contiguous in frequency. The total processed bandwidth is 960 Hz.

Look weighting factor: No weighting factor applied. This is equivalent to unity weighting for all looks.

Look detection and summation: Looks are over-sampled before detection. Looks are power-detected and summed with no weighting. The summed result is square-rooted when written to product.

Range cell migration artifact: Artifact on the look-summed product shall not contribute more than -30 dB with respect to the main lobe.

Processor point target linearity: As ERS-1.SAR.PRI.

Processor point target linear output dynamic range: As ERS-1.SAR.PRI.

Processor gain stability: As ERS-1.SAR.PRI.

Quality parameters:

reported in product annotations:

- parameters already specified in ERS-1.SAR.PRI
- QA summary flags:
  - automatic QA performed flag
  - interactive/visual QA performed flag
  - QA procedure type identifier
  - product quality indicator (0...9)
- QA parameters:
  - nominal error for geocoding in northing/easting in metres on ground
  - nominal error for geocoding along/across track in metres on ground
  - maximum UTM-zone geometric extension in metres
  - land percentage of scene
  - DEM resolution in degrees
  - percentage of DEM availability in scene
  - coarse DEM resolution in degrees
  - percentage of coarse DEM availability in scene
  - total number of measured GCP
  - individual GCP description:
    - row and column of image coordinate
    - height from DEM (optional)
    - northing and easting of map reference coordinate
    - map derived terrain height (optional)
    - measured residual
  - root mean square geometric residual of whole image
  - average vector of whole image
  - average vector magnitude
  - vector magnitude standard deviation
  - percentage of layover pixels in scene
  - percentage of shadow pixels in scene
  - threshold for a 'dark' pixel in layover areas
  - percentage of 'dark' (error) pixel in layover areas
  - threshold for a 'bright' pixel in shadow areas
  - percentage of 'bright' (error) pixel in shadow areas
  - radiometric mean and standard deviation of layover areas
  - radiometric mean and standard deviation of shadow areas.

Internal calibration: As ERS-1.SAR.PRI.

Absolute calibration: As ERS-1.SAR.PRI, image compensated for:

- antenna elevation gain pattern
- range spreading loss (1/R**3)

(Each range cell normalised with respect to 847 km slant range)

reported in product annotations:

Externally supplied absolute calibration parameters:

- as ERS-1.SAR.SLC except:
  - reported K values (if available) are different
  - normalisation reference range Ro is 847 km.

DATA VOLUME

The intensity at processor output is given in 16-bit one pixel = 2 bytes, one data set is from 165.62 Mbytes (9100 x 9100 x 2 bytes) to 288 Mbytes (12000 x 12000 x 2 bytes). Data set and CEOS superstructure is 165.8 to 288.2 Mbytes.

MEDIUM

6250 bpi CCT, Exabyte cassette, photographic print.

FORMAT

See Reference 1 and Reference 2.

NOTE

Note 1:

The DEM is presented in a raster format, with a grid size of 12.5 m or 25 m to meet the requirements for the geocoding algorithm. The data will give the terrain height in 16-bit binary notation in metres. The data are annotated with map projection reference, datum and orientation.

SAR image of the Southern Atlantic Coast of France with the estuary of the Gironde, which has been widened by the Bay of Biscay's strong tides. A light wind is accentuating the local sea currents, with the more sheltered areas appearing black. On the Ile d'Oléron (upper left corner), there is a parallel series of pine-covered dunes at the southern tip that continues on mainland. The bright line on the nearby shoreline is due to breaking waves, suggesting a moderate swell. The ERS-1 SAR instrument's resolution does not allow small-scale farming features to be detected, but the dark homogeneous zones can be identified as extensive wet grassland. The agglomeration of bright spots in the river bend in the top centre of the image is the town of Rochefort.

2. SYNTHETIC APERTURE RADAR WAVE MODE

2. SYNTHETIC APERTURE RADAR – WAVE MODE

Overview
The Synthetic Aperture Radar can be operated in wave mode. The primary purpose is to measure directional wave spectra – wave energy as a function of the directions and lengths of waves at the ocean surface – from the backscattered radiation from sample areas. For this function the SAR collects data at spatial intervals of either 200 km (nominally) or 300 km anywhere within the swath available to the SAR mode (100 km wide) in steps of approximately 2 km.

The SAR wave mode engineering parameters are as follows:

SAR antenna size:	10 m long, 1 m wide
frequency:	5.3 GHz (C band) ± 0.2 MHz
bandwidth:	15.55 ± 0.01 MHz
PRF range:	1640-1720 Hz (in 2 Hz steps)
long pulse duration:	37.1 ± 0.05 μs
compressed pulse length:	64 ns
peak power:	4.8 kW
polarisation:	linear vertical
A/D complex sampling:	18.96 MSamples/sec
I and Q quantisation:	2 bits for OGRC (5 km telemetered data) 4 bits for OBRC (10 km telemetered data)
radiometric resolution:	2.5 dB at sigma-nought = -18 dB
swath location:	programmable anywhere within SAR swath
swath width:	5 km x 5 km every 200-300 km for OGRC between 9.6 km (far swath) and 12 km (near swath) for OBRC
incidence angle:	23° at mid-swath
data rate:	15 Mbps

SAR wave mode products
A specification is available for the following SAR wave mode products:

Product name | *Product code*

SAR Wave Annotated Raw Data | ERS-1.SWM.RAW

DEFINITION
SAR wave annotated raw data.

DESCRIPTION
Input:
Raw wave mode SAR data.
Algorithm:
Remove telemetry frames, telemetry quality checks, demultiplex SAR wave data, demultiplex auxiliary information, merge data sources and time order.
Output:
- SAR wave raw data (I/Q channel samples)
- start/stop time of the data stream, orbit, quality indices, as:
  - missing lines flag
  - duplication lines flag
  - down link performance flag
  - calibration data
  - bit error rate, etc..

SPECIFICATIONS
Units: Digital counts.
Product size:
- 2384 x 528 samples each of 4 bits I, 4 bits Q for OBRC
- 2384 x 1056 samples each of 2 bits I, 2 bits Q for OGRC.

Product geographical coverage: Approximately 5 km x 5 km.
Spacing between products: 200/300 km along track.
Projection: Slant range.
Coordinate system: None.

DATA VOLUME
One data set is 2384 x 528 bytes = 1.258 Mbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT, Exabyte cassette.

FORMAT
See Reference 5 and Reference 6.

Product name | *Product code*

SAR Wave Fast Delivery Product — ERS-1.SWM.UWA

DEFINITION
Power spectrum of an imagette.

DESCRIPTION
Input:
- raw wave mode SAR data
- GEM6 Earth model.

Algorithm:
The product is generated through the following major steps:
- generation of an image using the image mode algorithm (see ERS-1.SAR.UI16) with no modifications
- extraction of power spectrum by using a 512 x 512 FFT in Cartesian coordinates
- averaging and conversion to polar coordinates.

Output:
Power spectrum.

SPECIFICATIONS
Units: Digital counts.
Product size:
- 12 amplitude levels in logarithmic form corresponding to spatial wavelengths between 100 m and 1000 m
- 12 angular sectors between 0° and 180°; overlapping 15°.

Product geographical coverage: 5 km x 5 km.
Spacing between products: 200/300 km along track.
Projection: Slant range.
Coordinate system: Polar.
Relative calibration: None.

DATA VOLUME:
508 bytes. The intensity level is given in 8 bits. One data set is made of:
- one main product header (128 bytes)
- one specific product header (232 bytes)
- one product data set record (12 x 12 + 2 bytes).

MEDIUM:
Dissemination via low rate links.

FORMAT
See Reference 3.

Product name | *Product code*

SAR Wave Fast Delivery Product Copy — ERS-1.SWM.FDC

DEFINITION
Copy of ERS-1.SWM.UWA product.

DESCRIPTION
As ERS-1.SWM.UWA.

SPECIFICATIONS
As ERS-1.SWM.UWA.

DATA VOLUME
3 kbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 5 and Reference 6.

REMARKS
As ERS-1.SWM.UWA.

Product name *Product code*

SAR Wave Intermediate Product Copy ERS-1.SWM.IPC

DEFINITION
SAR wave mode imagette at level of FD processing. The image consists of: 320 pixels (azimuth) x 400 pixels (range) for OGRC data, 320 pixels (azimuth) x 600 pixels (range) for OBRC data.

DESCRIPTION
Input:
- ERS-1 telemetry
- orbit, one of:
  - MMCC restituted orbit
  - ERS-1.ORB.PRL
  - ERS-1.ORB.PRC
- measured antenna patterns
- GEM6 Earth model.

Algorithm:
Generation of an image using the image mode algorithm (see SAR fast delivery product) with no modifications.
Output:
SAR imagette.

SPECIFICATIONS
Units: Digital counts.
Product geographical coverage: 6.47 km in range, 5.12 km in azimuth.
Spacing between products: 200/300 km along track.

DATA VOLUME
OGRC ~260 kbytes, OBRC ~390 kbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 5 and Reference 6. As far as the quality of the image processing is concerned there is no difference between image mode and wave mode.

Product name | *Product code*

SAR Wave Complex Image | ERS-1.SWM.CIT

DEFINITION

Three-look, complex, slant-range, digital image generated from raw SAR wave mode data with up-to-date (at time of processing) auxiliary parameters. Intended for ESA use in SAR quality assessment and calibration. Provides a basic meeting point for all SAR wave mode processors of the ERS-1 ground segment. Product has been conceived as a possible starting point for development of spectra retrieval algorithms. A minimum number of corrections and interpolations are performed on data in order to allow the end-user maximum possible freedom to derive higher-level products. Complex data is retained in order to avoid possible loss of information.

DESCRIPTION

Input:

- ERS-1 telemetry
- orbit, one of:
  - MMCC restituted orbit
  - ERS-1.ORB.PRL
  - ERS-1.ORB.PRC
- measured antenna patterns.

All processing parameters are derived from the orbit and telemetry (e.g. I/Q channel characteristics, range/azimuth compression functions, noise, calibration pulse powers).

Algorithm:

There is no constraint on the algorithm to be used.

Output:

Three complex looks, plus annotations.

SPECIFICATIONS

Units: Complex pixels, arbitrary units: 16 bits I, 16 bits Q.

Pixel spacing: Natural spacing in both slant-range and azimuth:

- slant-range: as for raw data (7.9 m)
- azimuth: uniformly spaced in time at 2 x PRI.

On-ground azimuth spacing in metres depends on Earth-satellite relative velocity and Pulse Repetition Interval. Velocity varies by approximately 2% around orbit. PRI is fixed within an AMI wave mode sequence. The azimuth pixel spacing is twice that of ERS-1.SAR.SLC

Product size: Each look: 512 samples in range x 1024 samples in azimuth. Spatial extent in slant-range is exactly 4 km, corresponding to roughly 12 km on the ground. Exact spatial extent in azimuth varies with Earth-satellite relative velocity and PRI (approximately 8 km for PRI = 1690 Hz, velocity = 6725 ms^{-1}).

Data presentation: Product is written sequentially, range-line by range-line, on a first-line-in / first-line-out basis. The first sample of each range line is at near range. Looks are written sequentially in order 1, 2, 3. The first-in first-out convention is used for the FD wave mode processor.

Product localisation: As determined by SAR operational parameters. The SAR can be programmed to acquire wave cells at intervals of either 200 or 300 km along track. The imaged area is programmable within the range swath in steps of approximately 2 km.

reported in product annotations:

Longitude and latitude of scene centre pixel and four corners.

Localisation accuracy: Mainly determined by accuracy of the orbit data used and datation accuracy.

Axis orientation: North direction measured clockwise from azimuth direction.

Spatial resolution: As determined by range and azimuth processed bandwidths, nominally slant range <10 m, azimuth <30 m.

Coordinate system: Slant-range, zero-doppler coordinates. Zero-doppler times of four corners and centre pixel as ERS-1.SAR.SLC.

Range spectral weighting: None applied.

Number of looks: Three contiguous looks.

Look alignment: The looks are aligned so that a correctly look-registered image is formed by detecting each look and summing together pixel number (i,j) of each look.

Look spectral weighting: Rectangular window centred on look centre-frequency.

Look bandwidth: 0.25x PRF. If PRF is changed from scene to scene then look bandwidth changes accordingly.

Look spacing and numbering convention:

- look 1: covers low absolute frequencies
- look 2: centred at the estimated doppler centroid
- look 3: covers high absolute frequencies.

Looks are non-overlapping, exactly contiguous in frequency.

Look weighting factor: No weighting factor applied. This is equivalent to unity weighting for all looks.

Azimuth frequencies: Each complex look is output at azimuth baseband frequency. This is equivalent to frequency translation in azimuth by minus the centre-frequency of each look.

Extent of fully correlated imagette:

The imagette contains a region of fully correlated (full quality) pixels surrounded by a region of partially correlated pixels. This is a trapezium with two sides parallel to the image azimuth axis. The fully correlated region is thus designated by four azimuth ordinates and two range abscissae.

reported in product annotations:

Limits of fully correlated (full quality) region:

- range pixel number: near range
- range pixel number: far range
- azimuth pixel number: near range, early azimuth
- azimuth pixel number: near range, late azimuth
- azimuth pixel number: far range, early azimuth
- azimuth pixel number: far range, late azimuth

The above specified boundary pixels lie inside the fully correlated region.

Range cell migration artifact: Not more than -30 dB with respect to the main lobe.

Processor point target linearity: As ERS-1.SAR.SLC.

Processor point target linear output dynamic range: OGRC: 9 dB, OBRC: 23 dB.

Processor gain stability: Each wave mode processor shall be operated at a known fixed gain at all times. Some optimisation of wave mode processor gains during the early mission may be unavoidable.

Quality parameters: As ERS-1.SAR.SLC.

Internal calibration: As ERS-1.SAR.SLC.

Absolute calibration: Not mandatory. If parameters provided in annotations then as ERS-1.SAR.SLC.

DATA VOLUME

6.4 Mbytes.

MEDIUM

1600 bpi CCT, 6250 bpi CCT.

FORMAT

See Reference 5 and Reference 6.

Product name *Product code*

SAR Wave Detected Image Spectrum ERS-1.SWM.DIS

DEFINITION
Imagette and power spectrum.

DESCRIPTION
Input:
- raw wave mode SAR data
- GEM6 Earth model.

Algorithm:
The product is generated through the major following steps:
- generation of an image using the image mode algorithm (see ERS-1.SWM.UWA) with no modifications
- extraction of power spectrum by using a 512 x 512 FFT in Cartesian coordinates.

Output:
Detected imagette and imagette power spectrum.

SPECIFICATIONS
Units: Digital counts.
Product size:
- 12 amplitude levels in logarithmic form corresponding to spatial wavelengths between 100 m and 1000 m
- 12 angular sectors between 0° and 180°; overlapping 15°.

Product geographical coverage: 5 km x 5 km.
Spacing between products: 200/300 km along track.
Coordinate system: Polar.
Relative calibration: None.

DATA VOLUME
1.6 Mbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 5 and Reference 6.

Product name *Product code*

SAR Wave Imagette Power Spectrum ERS-1.SWM.IPS

DEFINITION
Precise power spectrum of an imagette.

DESCRIPTION
Input:
- ERS-1.SWM.DIS
- GEM6 Earth model.

Algorithm:
The spectrum obtained in product ERS-1.SWM.DIS is analysed to determine the regions where the energy is located. The analysis is performed by crossing the spectrum with planes at decreasing energy values and by determining the crossing regions between these planes and the spectrum. The surfaces determined in this way are further analysed to deduce the main peaks parameters.

Output:
A power spectrum with the following main parameters:
- wavelength corresponding to the maximum peak value
- wavelength corresponding to the weighted peak mean
- angle between peak axis and north
- minimum and maximum wave-number.

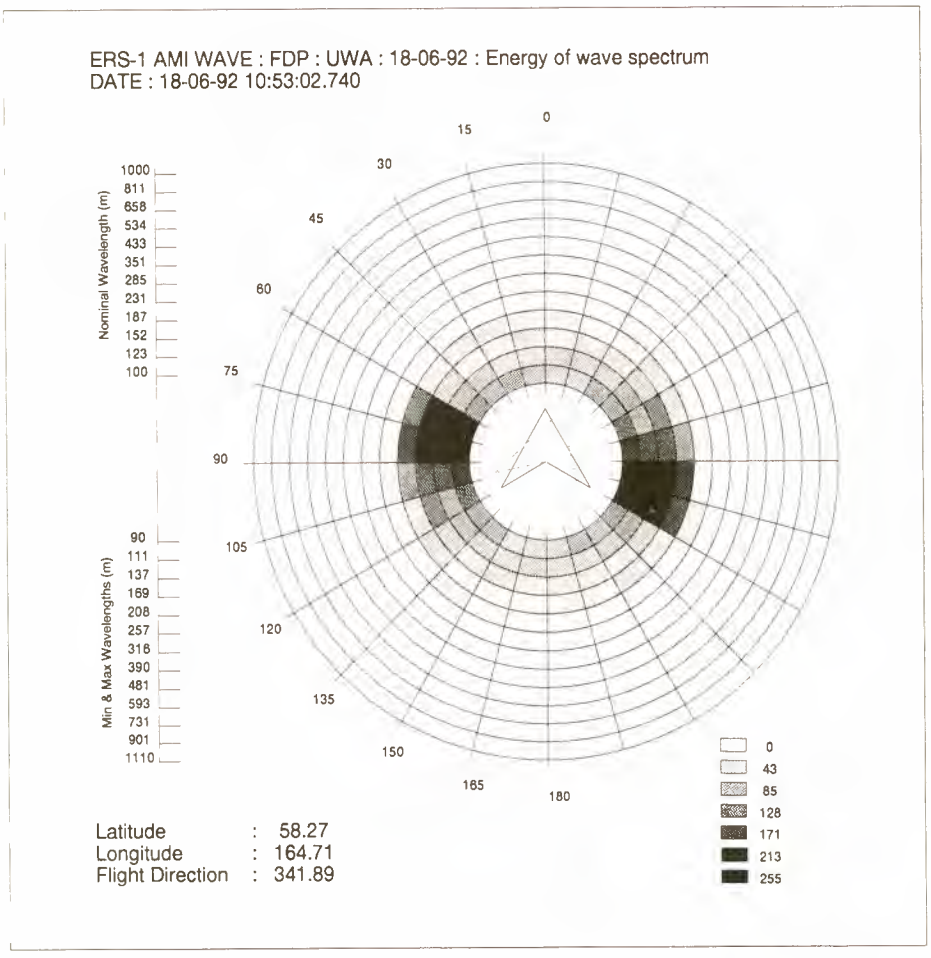
SPECIFICATIONS
Product size:
- 12 amplitude levels in logarithmic form corresponding to spatial wavelengths between 100 m and 1000 m
- 12 angular sectors between 0° and 180°; overlapping 15°.

Product geographical coverage: 5 km x 5 km.
Spacing between products: 200/300 km along track.

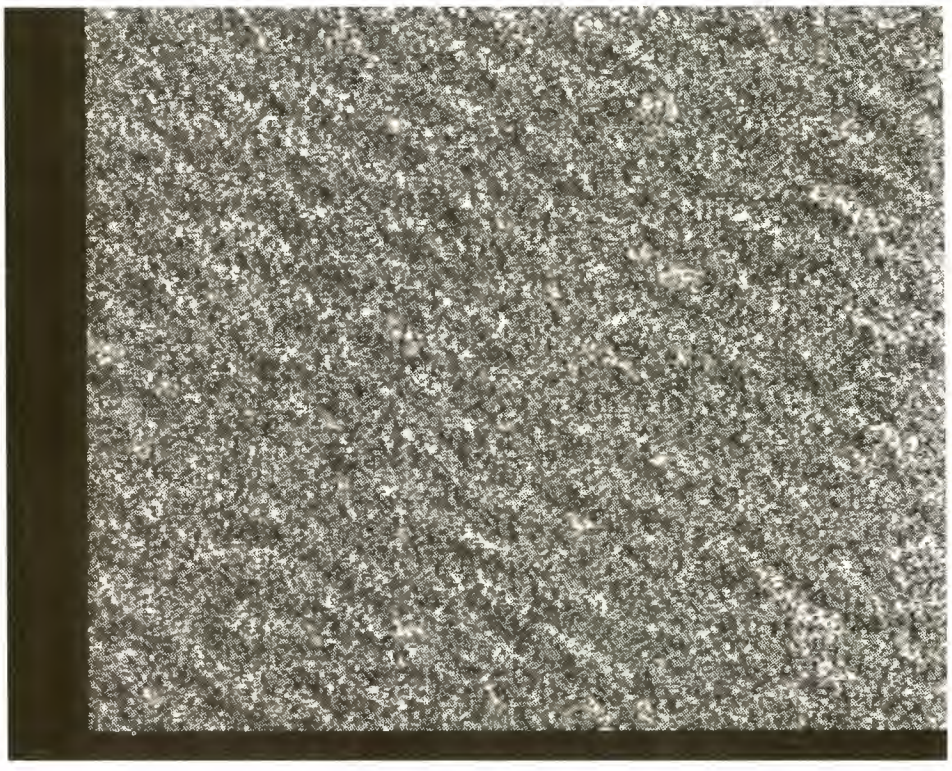
DATA VOLUME
2.5 kbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 5 and Reference 6.



SAR Wave Spectrum: Fast-Delivery Wave-Mode Spectrum showing a wave group propagating with short wavelengths diagonally with respect to the satellite flight direction



SAR Wave Imagette: SAR Wave-Mode Imagette showing wave patterns propagating across the image

3. WIND SCATTEROMETER

3. WIND SCATTEROMETER

Overview

The purpose of the Wind Scatterometer is to obtain information on wind speed and direction at the sea surface. These wind vectors can then be incorporated into models, global statistics and climatological data sets. The Wind Scatterometer measures the echo power of a signal transmitted by the satellite and returned from the ocean surface. The echo power is affected by the surface wind conditions. Three antennae are used to obtain information about the wind at the ocean surface. Each antenna points in a different direction, and hence for a particular point on the ocean surface three echo power values, obtained from three different angles, are used to calculate the surface wind vectors.

The Wind Scatterometer engineering parameters are as follows:

antennae parameters:	*Fore*	*Mid*	*Aft*
aspect angle:	45° ± 5°	0° ± 5°	-45° ± 5°
length:	3.6 m	2.5 m	3.6 m
dynamic range:	42 dB	42 dB	42 dB
pulse length:	130 μs	70 μs	130 μs
number of pulses for 50 km:	256	256	256
frequency:	5.3 GHz (C band) ± 52 KHz		
bandwidth:	15.55 ± 0.01 MHz		
peak power:	4.8 kW		
polarisation:	linear vertical		
I and Q quantisation:	8 bits each		
swath location:	200 km – 700 km to side of orbital track		
swath width:	400 km within specifications 500 km telemetered		
incidence angle range:			
fore beam:	25° at node 1, 59° at node 19		
mid beam:	18° at node 1, 47° at node 19		
aft beam:	25° at node 1, 59° at node 19		
data rate:	105 Mbps		

Wind Scatterometer products

A specification is available for the following Wind Scatterometer products:

Product name *Product code*

Scatterometer Fast Delivery Product ERS-1.WSC.UWI

DEFINITION
Sigma-nought triplets extraction and wind field processed at fast delivery specifications.

DESCRIPTION
Input:
- AMI wind mode raw data
- noise measurements
- system/instrument parameters
- orbital information as spacecraft state vectors at closest ascending node
- system calibration
- UTC correction.

Algorithm:
Echo instrumental corrections, noise subtraction, sigma-nought calculation, internal calibration, wind model fitting, ambiguity removal, etc..

Output:
- wind speed
- wind direction
- sigma-nought triplets
- latitude/longitude
- quality indices
- noise level, etc..

SPECIFICATIONS
Units: Wind speed: m/s; wind direction: degrees; backscattering coefficient: $1/10^2$ dB.
Product size: 19 grid points in ground range, 19 grid points in azimuth.
Product geographical coverage: ~500 km in ground range, ~500 km in azimuth.
Product location accuracy: The nominal accuracy is 5 km in range, 5 km in azimuth.
Axis orientation: The axes are in the ground range/azimuth system as defined by the spacecraft ground nadir track and beam pointing direction. The origin is given in geodetic latitude and longitude.
Spatial resolution: 50 km in ground range direction, 50 km in azimuth direction.
Projection: Ground range projection on a curved Earth surface as given by the GEM6 Earth model.
Coordinate system: Bi-dimensional Cartesian ground range/azimuth grid defined by spacecraft orbit and antenna beam pointing.
Radiometric resolution: 2 dB (quantisation resolution).
Relative calibration: Closed loop.
Absolute calibration: None.

DATA VOLUME:
- header = 176 bytes
- ancillary data = 166 bytes
- data set (361 x 46) = 16606 bytes
- total volume = 16948 bytes.

MEDIUM
Dissemination via low rate links.

FORMAT
See Reference 3.

REMARKS
The generated wind field corresponds to a stable wind field referred to a height of 10 m.

Product name

Scatterometer FD Product Copy

Product code

ERS-1.WSC.FDC

DEFINITION
Copy of ERS-1.WSC.UWI.

DESCRIPTION
As ERS-1.WSC.UWI.

SPECIFICATIONS
As ERS-1.WSC.UWI.

DATA VOLUME
18 kbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 5 and Reference 6.

Product name *Product code*

Scatterometer Extracted Wind Copy ERS-1.WSC.IWC

DEFINITION
Wind field processed at fast delivery specifications.

DESCRIPTION
Input:
- AMI wind mode raw data
- noise measurements
- system/instrument parameters
- orbital information as spacecraft state vectors at closest ascending node
- system calibration
- UTC correction.

Algorithm:
Echo instrumental corrections, noise subtraction, sigma-nought calculation, internal calibration, wind model fitting, ambiguity removal, etc..

Output:
- wind speed
- wind direction
- latitude/longitude
- quality indices
- noise level, etc..

SPECIFICATIONS
Units: Wind speed in m/s; wind direction in degrees.
Product size: 19 grid points in ground range, 19 grid points in azimuth.
Product geographical coverage: 500 km in ground range, 500 km in azimuth.
Product location accuracy: The nominal accuracy is 5 km in range, 5 km in azimuth.
Axis orientation: The axes are in the ground range/azimuth system as defined by the spacecraft ground nadir track and beam pointing direction. The origin is given in geodetic latitude and longitude.
Spatial resolution: 50 km in ground range direction, 50 km in azimuth direction.
Projection: Ground range projection on a curved Earth surface as given by the GEM6 Earth model.
Coordinate system: Bi-dimensional Cartesian ground range/azimuth grid defined by spacecraft orbit and antenna beam pointing.
Radiometric resolution: 2 dB (quantisation resolution).
Relative calibration: Closed loop.
Absolute calibration: None.

DATA VOLUME
9 kbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 5 and Reference 6.

REMARKS
The generated wind field corresponds to a stable wind field referred to a height of 10 m.

Product name | *Product code*

De-aliased Off-line Wind Fields | ERS-1.WSC.WNF

DEFINITION
Off-line wind field with direction ambiguity removal.

DESCRIPTION
Input:
- sigma-nought triplets
- noise measurements
- system/instrument parameters
- orbital information as spacecraft parameters relating to the raw data set (5 days restituted orbit, see ERS-1.ORB.PRL)
- system calibration
- UTC correction
- predicted or analysed wind fields from meteorological offices.

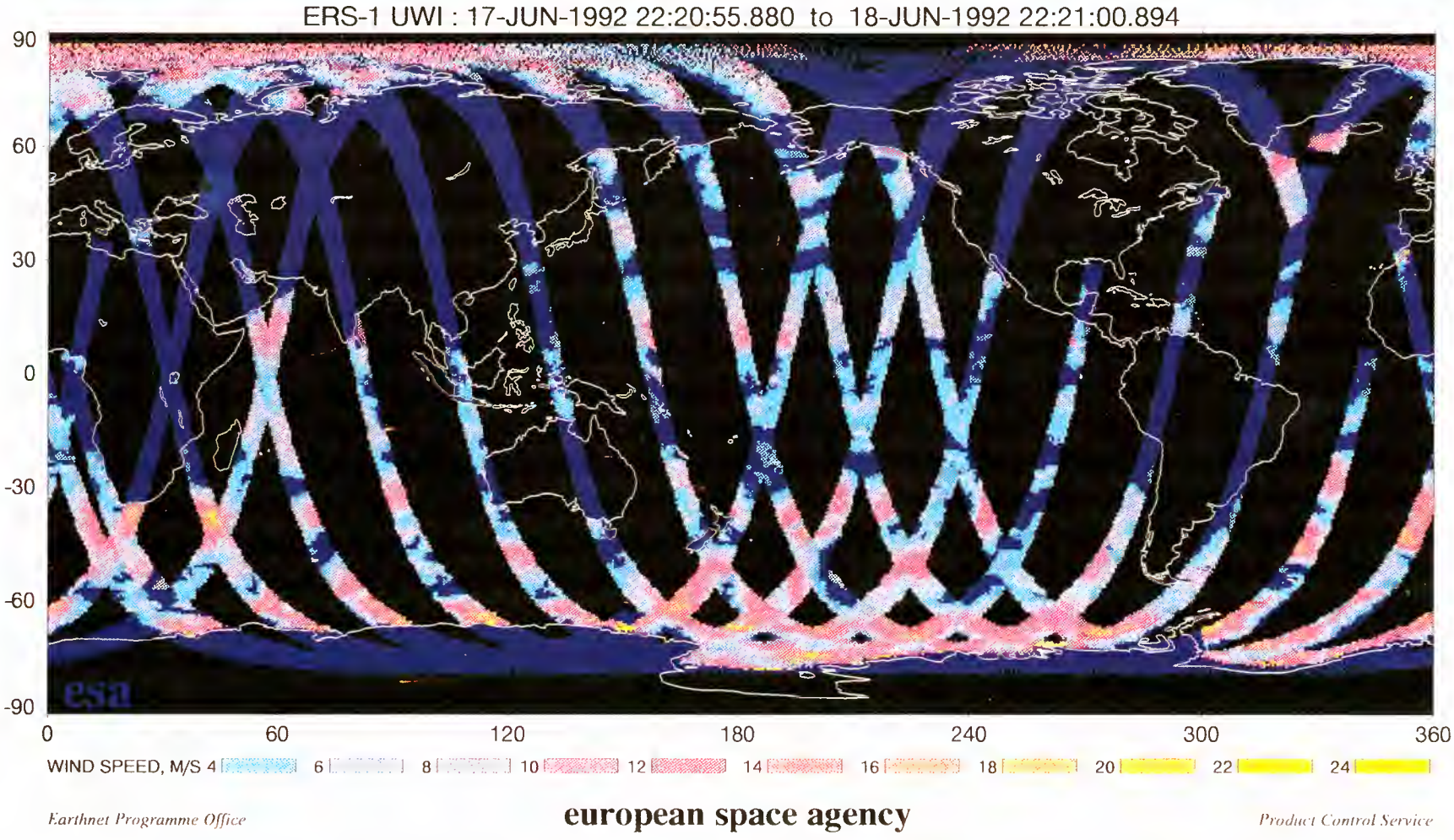
Algorithm:
Scattering model fitting, solution rank evaluation, ambiguity removal, etc..
Output:
- wind speed
- wind direction
- latitude/longitude
- quality indices, noise level, etc..

SPECIFICATIONS
Units: Wind speed in cm/s; wind direction in degrees.
Product size: 19 grid points in ground range, 19 grid points in azimuth.
Product geographical coverage: 500 km ground range, 500 km azimuth.
Product location accuracy: The nominal accuracy is 5 km in range, 5 km in azimuth.
Axis orientation: The axes are in the ground range/azimuth system as defined by the spacecraft ground nadir track and beam pointing direction. The origin is given in geodetic latitude and longitude.
Spatial resolution: 50 km in ground range, 50 km in azimuth.
Projection: Ground range projection on a curved Earth surface as given by the GEM6 Earth model.
Coordinate system: Bi-dimensional Cartesian ground range/azimuth grid defined by spacecraft orbit and antenna beam pointing.
Relative calibration: Closed loop.
Absolute calibration: None.

DATA VOLUME
20 kbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 5 and Reference 6.



Colour-coded chart of ocean-surface wind speeds measured by the ERS Scatterometer on 18 June 1992

4. RADAR ALTIMETER

4. RADAR ALTIMETER

Overview

The Radar Altimeter provides high precision measurements of the distance from the satellite to the surface. Over oceans and smooth ice sheets, accuracies significantly better than 10 cm are achieved, under normal conditions. Over ice a special mode is available with coarser resolution (4 times) and more agility. These performances correspond to one second averages of the measurements, which is equivalent to an along track spacing of about 7 km. With precise knowledge of the orbit, the absolute elevation of ocean and ice surfaces can be extracted for use in geodesy, ocean circulation, ice topography etc.. A major objective of the Radar Altimeter is to measure the height of ocean waves derived from the echo shape; additionally the wind speed can be determined from the echo power. These quantities, averaged over an area several kilometres across the sub-satellite track, will be used as one-second averages. The Radar Altimeter will provide global measurements (up to latitude 82° N/S) of wave height, extending to regions which previously had no regular observations.

The Radar Altimeter engineering parameters are as follows:

backscattering coefficient:	0.7 dB
echo waveform samples:	64 x 16 bits at 20 Hz
beam width:	1.3°
RF frequency:	13.8 GHz
pulse duration:	20 μs
pulse repetition frequency:	1020 Hz
power peak:	50 W
bandwidth	
ocean mode:	330 MHz
ice mode:	82.5 MHz
internal calibration cycle duration:	150 ms

Altimeter products

A specification is available for the following Radar Altimeter products:

Product name | *Product code*

Altimeter Annotated Raw Data — ERS-1.ALT.RAW

DEFINITION
Annotated uncorrected altimeter measured data, sensor telemetry parameters and sensor characteristics.

DESCRIPTION
Input:
Available data for the altimeter, sensor parameters, orbit information (see ERS-1.ORB.PRL and ERS-1.ORB.PRC).
Algorithm:
Reconstructed source packets, telemetry quality checks, demultiplex altimeter data, merge data sources and time order.
Output:
- raw waveforms
- uncorrected altimeter measured data, i.e.:
  - time delay with respect to the transmitted pulse
  - slope of the echo leading edge
  - power level of the echoed signal
- sensor parameters
- internal calibration data
- preliminary restituted orbital parameters related to the raw altimeter data set.

SPECIFICATIONS
Units: Time delay in clock-periods, echo power in digital counts, slope in counts/ns.
Product geographical coverage: 500 km along track.
Spatial resolution: 350 m.
Coordinate system: Geographical latitude and longitude.

DATA VOLUME
Approximately 256 kbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT, Exabyte cassette.

FORMAT
See Reference 5 and Reference 6.

REMARKS
The data are taken at a rate of 20 per second.

Product name | *Product code*

Altimeter Fast Delivery Product — ERS-1.ALT.URA

DEFINITION
Satellite altitude, wind speed at nadir and significant wave height.

DESCRIPTION
Input:
- altimeter raw data at repeat rate of 20 Hz
- atmospheric pressure on a 1° x 1° presentation grid
- sensor parameters
- closed loop calibration data
- orbital information as spacecraft parameters relating to the raw data set.

Algorithm:
The product is generated via the following major operations:
- conversion delay-altitude, considering the propagation in free space – the altitude is estimated correcting the measured time delay by:
  - applying a scaling factor (derived from open loop calibration) from telemetry units to seconds and adding the on-ground calibration term
  - carrying out additional correction to compensate for the IF-filter ripple
  - including the correction factor derived from closed loop calibration
- significant wave height correction using a look-up table
- doppler correction
- correction for atmospheric effects, in terms of delay and backscattering using a bi-dimensional look-up table and interpolating
- backscattering altitude correction
- internal calibration.

Output:
- UTC time of measurement
- geodetic latitude and longitude
- wind speed estimate averaged over 1 second
- significant wave height estimate averaged over 1 second
- satellite altitude estimate averaged over 1 second
- product confidence data.

SPECIFICATIONS
Units: Wave height: m; wind speed; m/s; significant wave height: m.
Product geographical coverage: 500 km.
Product location accuracy: Nominal accuracy is 1 km along track, 15 m across track.
Axis orientation: The axes are defined as the spacecraft ground nadir along and across track directions. The origin is given in geodetic latitude and longitude.
Coordinate system: Geographical latitude and longitude.
Relative calibration: Open loop and closed loop calibration.

DATA VOLUME
6.776 kbytes.

MEDIUM:
Dissemination via low rate links.

FORMAT
See Reference 3.

Product name

Altimeter Fast Delivery Product Copy

Product code

ERS-1.ALT.FDC

DEFINITION
Copy of ERS-1.ALT.URA.

DESCRIPTION
As ERS-1.ALT.URA.

SPECIFICATIONS
As ERS-1.ALT.URA.

DATA VOLUME
10 kbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 5 and Reference 6.

Product name *Product code*

Off-line Intermediate Product ERS-1.ALT.OIP

DEFINITION
System corrected altimeter measurements taken over the ocean. Altimeter altitude over the ellipsoid surface, backscattering and echo slope.

DESCRIPTION
Input:
- altimeter raw data
- acquisition date and time
- calibration data
- system/instrument parameters
- orbital information as spacecraft parameters relating to raw data set (see ERS-1.ORB.PRL).

Algorithm:
All parameters are re-estimated on-ground from waveforms (using a MLE derived algorithm for ocean mode only), averaged over 1 second, calibrated and corrected for instrumental errors.
Output:
- height over the ellipsoid
- height standard deviation
- height instrumental correction
- on ground estimated backscattering coefficient
- on ground estimated backscattering coefficient standard deviation
- on ground estimated backscattering coefficient instrumental corrections
- significant wave height (H 1/3)
- H 1/3 standard deviation
- H 1/3 instrumental corrections
- height vertical speed
- antenna mispointing
- instrument status
- UTC time
- quality indices.

SPECIFICATIONS
Units: Height: mm; backscattering coefficient: $1/10^2$ dB; significant wave height: cm; noise level: $1/10^2$ dB; antenna mispointing: mdeg.
Parameters accuracy: Height: 4.5 cm; backscattering coefficient: 0.2 dB; significant wave height: 3% (for ocean mode only).
Product geographical coverage: 520 km along track.
Product location accuracy: Nominal accuracy is 15 m along track, 5 m across track.
Axis orientation: The axes are defined as the spacecraft ground nadir along and across track directions. The origin is given in geodetic latitude and longitude.
Coordinate system: Geographical latitude and longitude.
Relative calibration: Open loop and closed loop calibration.
Absolute calibration: Applied.

DATA VOLUME
15 kbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 5 and Reference 6.

Product name | *Product code*

Ocean Product | ERS-1.ALT.OPR01

DEFINITION

Geophysically corrected altimeter measurements over the ocean, including all engineering and geophysical corrections due to the troposphere, the ionosphere and the electromagnetic bias. In addition, the surface altitude over the ellipsoid is calculated, correcting for the surface elevation due to tides and geoid. All the geophysical corrections are supplied together with the uncorrected measures, to allow the user the possibility of applying different corrections.

DESCRIPTION

Input:

- altimeter off-line product
- atmospheric pressure
- ATSR – Microwave Sounder brightness temperatures
- solar activity index
- system/instrument parameters
- orbital information as spacecraft parameters relating to the raw data set, (see ERS-1.ORB.PRL), etc..

Algorithm:

- height computation assuming free space propagation
- height correction for the additional delay due to:
  - ionosphere electron content
  - dry atmosphere effect, wet atmosphere effect
  - barotropic effect
  - ocean tide, Earth tide
  - electromagnetic bias
- sigma-nought correction for the atmosphere liquid water content
- wind speed model fitting
- significant wave height computation from restituted data.

Output:

- satellite altitude over the ellipsoid corrected for geophysical errors
- height estimate including:
  - dry tropospheric correction
  - wet tropospheric correction (from meteo fields)
  - wet tropospheric correction (from ATSR – Microwave Sounder data)
  - ionospheric correction
  - electromagnetic bias correction
  - external corrections
  - ocean tide elevation over the ellipsoid
  - Earth tide elevation over the ellipsoid
  - ocean loading tide
- height variance
- surface range
- wind speed at nadir
- wind speed variance
- significant wave height
- significant wave height variance
- quality indices
- output from ERS-1.ALT.OIP

The product consists of one record per source packet in tracking mode; acquisition and calibration mode source packets will originate blank products. [Note 1] The significant wave height is derived from re-tracking.[Note 2]

SPECIFICATIONS

Units: Height: mm; wind speed: cm/s; significant wave height: cm; antenna mispointing: mdeg.

Parameters accuracy:

- satellite altitude + surface range: 60 cm (as 50+10)
- wind speed: 2 ms (TBC)
- significant wave height: 3%.

Product geographical coverage: 520 km along track.

Product location accuracy: Nominal accuracy is 15 m along track, 5 m across track.

Coordinate system: Geographical latitude and longitude.

Absolute calibration: Applied.

DATA VOLUME

Approximately 12 kbytes.

MEDIUM

1600 bpi CCT, 6250 bpi CCT.

FORMAT

See Reference 5 and Reference 6.

REMARKS

The product parameters can be derived from data acquired at either 1 Hz or 20 Hz.

NOTES

Note 1:

Corrections derived from ATSR – Microwave Sounder data are also supplied in terms of water vapour/liquid water content and altitude corrections. One product covers a full revolution over the ocean surface (orbit discontinuities because of ice/land are admitted). This product is intended to be massively generated over all sea surfaces. Data in acquisition mode do not contribute to the measures, but their occurrence is flagged and dummy data are used to fill the record. The orbit state vectors are provided as auxiliary data.

Note 2:

Significant wave height is derived from re-tracking. Standard deviation is calculated for the following parameters: altitude, sigma-nought and significant wave height, with the formula:

$$std = \mathrm{sqrt}\left(\sum_{i=1}^{N} \frac{[\, p\,(i) - pm\,]^2}{N - 1} \right)$$

where `p(i)` is the ith value of the parameter of interest within the source packet, and `pm` is the mean value. Only valid values of the parameters contribute to the standard deviation. Dry tropospheric correction is derived from the analysed meteo fields, using the Saastamoinen formula. The meteo fields are provided globally.

Wet tropospheric correction from the meteo fields is derived from integrated water vapour content included in the meteo fields. The correction should use the Smith and Weintraub model (1953). Wet tropospheric correction from ATSR – Microwave Sounder is a linear combination of the ATSR brightness temperatures. Coefficients are to be determined.

Electromagnetic bias correction (Lipa and Barrick formula) is used. Sigma-nought correction due to liquid water is calculated from ATSR – Microwave Sounder data when available; otherwise it is set to 0. Ocean tide elevation over the ellipsoid (Schwiderski model) is used. Earth tide elevation over the ellipsoid: Sun and Moon positions at the time are calculated. Then the total tide is derived.

Ocean Product with PRC Orbit

ERS-1.ALT.OPR02 is an improved version of the ERS-1.ALT.OPR01 product. Orbital information from product ERS-1.ORB.PRC is used.

Product name | *Product code*

Sea Surface Height | ERS-1.ALT.SSH

DEFINITION
Global set of point values of the sea surface height (SSH) above the reference ellipsoid. The product will be available as long period (stationary) SSH.

DESCRIPTION
Input:
- altimeter ocean record product (ERS-1.ALT.OPR02)
- precise ERS-1 orbit (see ERS-1.ORB.PRC)
- land/ocean mask.

Algorithm:
- screening of corrected altimeter range data
- altimeter cross-over analysis for orbital radial errors removal
- computation of the heights above ellipsoid
- interpolation over a regular grid.

Output:
- time period
- grid spacing
- reference ellipsoid
- sea surface height at each grid node
- RMS estimate associated to sea surface height at each grid node
- quality indices, etc..

SPECIFICATIONS
Units: Sea height and RMS estimate in m.
Parameters accuracy: Expected sea height: approximately 10 cm.
Parameter resolution: Sea height: 1 cm.
Product geographical coverage: Global ERS-1 coverage. Due to the ERS-1 inclination the latitude θ will be limited to the interval $-81.5° \leq \theta \leq +81.5°$.
Axis orientation: The axes are defined as the spacecraft ground nadir along and across track directions. The origin is given in geodetic latitude and longitude.
Reference system: The ellipsoid referred to is that of the Geodetic Reference System 1980 (GRS80).
Coordinate system: Geographical latitude and longitude.
Maximum grid spacing: Approximately 11 km at the equator.

DATA VOLUME
The global data set (latitudes between -81.5° and +81.5° and a basic grid spacing of 2 m x 2 m) the data set volume is 94.36 Mbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT, contours plots, synthetic relief photos.

FORMAT
For CCT see Reference 8.

REMARKS
The ERS-1.ALT.SSH data are computed on a global scale and can be made available to users on global geographical coverage or on any region whose geographical extension is a multiple of blocks of 500 km x 500 km. Parameter values are set to -999.99 on nodes where no sea surface heights are available.

Product name | *Product code*

Sea Surface Topography | ERS-1.ALT.TOP

DEFINITION

The sea surface topography provides a coarse estimate of the structural deviations $h(\phi,\theta)$, between the geoid and the mean sea surface, in terms of a normalised surface spherical harmonic series of the form:

$$h(\phi,\theta) = \sum_{n=2}^{N} \sum_{m=0}^{n} \{ [A(n,m)\cos(m\phi) + B(n,m)\sin(m\phi)] Pnm(\sin(\theta)) \}$$

where:

- ϕ = geographic longitude of point P on the sea surface
- θ = geographic latitude of point P on the sea surface
- $Pnm(x)$ = associated Legendre polynomial of order nm
- $A(n,m)$, $B(n,m)$ = fully normalised harmonic coefficients
- N = truncation degree (N will be in the interval 6-15)

DESCRIPTION

Input:

- ERS-1.ALT.SSH
- ERS-1.ORB.EGM1 / ERS-1.ORB.EGM2.

Algorithm:

- calculation of differences between the stationary SSH and estimates of long wavelength geoidal features from satellite-only gravity field models
- spectral filtering.

Output:

- spherical harmonic coefficients $A(n,m)$ and $B(n,m)$ of the expansion of the structural deviations $h(\phi,\theta)$, between the geoid and the mean sea surface
- quality indices, etc..

SPECIFICATIONS

Units: $A(n,m)$ and $B(n,m)$ in m.

Parameters accuracy: Expected $h(\phi,\theta)$ (sea-geoid deviation) approximately 60 cm.

Product geographical coverage: Global ERS-1 coverage. Values of $h(\phi,\theta)$ determined over land do not have any physical meaning. In addition, the harmonic series should only be used within the latitude range of $-81.5° \leq \theta \leq +81.5°$.

Spatial resolution: Spherical harmonic expansion limited by N (6-15). Corresponding half wavelength distance at the Earth's surface is 180°/N or some 20000/N km.

Reference system: Values of $h(\phi,\theta)$ do not refer to an absolute reference surface. The relationship to geoid heights HG and sea surface heights $H(\phi,\theta)$) is such that H=HG+h.

Coordinate system: Geographical latitude and longitude.

DATA VOLUME

0.2 Mbytes.

MEDIUM

1600 bpi CCT, 6250 bpi CCT, plots.

FORMAT

See Reference 8.

Product name | *Product code*

Ocean Geoid | ERS-1.ALT.OGE

DEFINITION
Point values of geoid heights above the reference ellipsoid. The heights are provided for the nodes of a regular equi-angular 1° x 1° Earth fixed grid.

DESCRIPTION
Input:
- most recent stationary ERS-1.ALT.SSH product
- global dynamic topography models
- satellite derived gravity fields
- marine surface gravity data
- Earth's gravity field derived from ERS-1 data (ERS-1.ORB.EGM1/2).

Algorithm:
- datum determination for oceanographic models of the dynamic topography
- calculation of differences between the stationary sea surface heights and estimates of the dynamic topography corrected for datum deficiencies
- evaluation of Stoke's integral in ocean areas using marine gravity data
- evaluation of altimetry independent geoid heights, derived from long wavelength components of gravity field models (ERS-1.ORB.EGM1/2)
- spectral combination of all geoid height estimates, weighted according to their error estimates.

Output:
- time period
- grid spacing
- reference ellipsoid
- geoid heights at each grid node
- quality indices (e.g. height rms estimate, etc.).

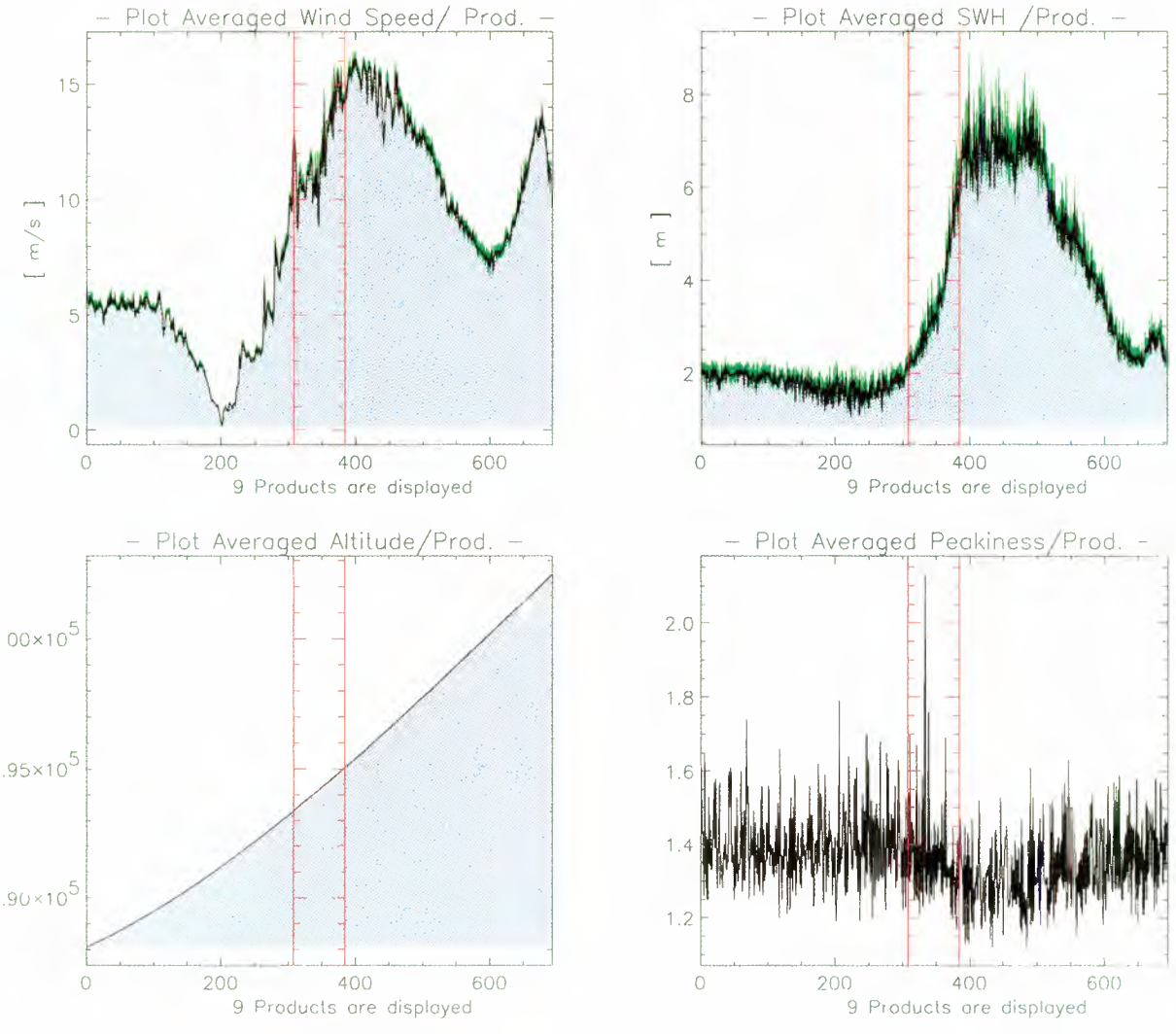
SPECIFICATIONS
Units: Geoid height in m.
Parameters accuracy: Expected geoid height: approximately 30 cm.
Parameter resolution: Geoid height: 1 cm.
Product geographical coverage: Global ERS-1 coverage. Due to the ERS-1 inclination the latitude θ will be limited to the interval $-81.5° \leq \theta \leq +81.5°$.
Reference system: The ellipsoid referred to is that of the Geodetic Reference System 1980 (GRS80).
Coordinate system: Geographical latitude and longitude.

DATA VOLUME
For the global data set (i.e. for latitudes between -81.5° and +81.5°) and for the basic grid spacing of 1° x 1° the data set volume is 0.95 Mbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT, contour plots, synthetic relief photos.

FORMAT
See Reference 8.

REMARKS
The reference ellipsoid and the normal gravity, the geoid heights refer to, are those of the Geodetic Reference System 1980 (GRS80). The ERS-1.ALT.OGE data are computed on a global scale and can be made available to users on global geographical coverage or on any region whose geographical extension is a multiple of blocks of 500 km x 500 km. Parameter values are set to -999.99 on nodes where no sea surface heights are available.



Radar Altimeter: Plots of wind speed, wave height, satellite altitude and peakiness parameters from Fast-Delivery Altimeter products relating to the Southern Atlantic

5. ORBIT

5. ORBIT

A specification is available for the following Orbit products:

DEFINITIONS

Definition 1 – Conventional Terrestrial System (CTS):
Z axis directed towards the mean pole as derived from the BIH pole series (ERP(BIH)87C02) covering the period January 1980 to October 1986. X axis fixed by allowing no net rotation about the Z axis with respect to the initial coordinates (SSC(DGFI)90L0X). Y axis completes the right-handed system.

Definition 2 – Conventional Inertial System (CIS):
This system is referred to the basic epoch 2000.01.01 12 hours designated J2000.0. The axes of the CIS are chosen in such a way that at the basic epoch J2000.0 they coincide in optimal approximation with the mean equatorial frame defined by the mean celestial pole (Z axis) and the mean vernal equinox (X axis).

Product name | *Product code*

Preliminary Orbit | ERS-1.ORB.PRL

DEFINITION
Satellite ephemerides (position and velocity vectors) every two minutes, derived from quick-look laser and Radar Altimeter fast delivery ranges.

DESCRIPTION
Input:
- quick-look laser tracking data
- altimeter fast delivery data
- measurement model data
- reference frame model data
- dynamical model data
- orbital elements at initial epoch.

Algorithm:
- numerical integration of satellite's equations of motion and variational equations
- reduction of observations and iterative least squares adjustment.

Output:
- time tags with respect to J2000.0
- spacecraft position every 2 min
- spacecraft velocity every 2 min
- attitude vectors every 2 min.

SPECIFICATIONS
Units: Position: mm; velocity: μm/s; attitude parameters: millidegrees; time in Julian Days since 2000.01.01 12 hrs in Terrestrial Dynamic Time (TDT).
Product geographical coverage: ERS-1 global coverage.
Spatial resolution: About 950 km.
Product location accuracy: Radial nominal accuracy = 3 m.
Reference system(s): CTS and CIS.[Definitions 1 and 2]
Time resolution: 120 seconds.
Product sizing: 7-day arc.

DATA VOLUME:
1250 kbytes per week.

MEDIUM
Packet switching network.

FORMAT
See Reference 8.

REMARKS
The preliminary orbits are based on a less dense and not necessarily fully corrected set of tracking data (e.g. quick-look data) as compared to the finally available data set, on partly less accurate models and, if necessary, for processing time reduction, on less complex numerical procedures. These orbits are an improvement on the initial knowledge of the orbit, but do not provide the optimal fit to the real spacecraft motion. This information is used for the spatial location of the on-board sensors and the prediction of the ERS-1 orbit over the following days. ERS-1.ORB.PRL is available 1 or 2 days after request.

Product name | *Product code*

Precise Orbit | ERS-1.ORB.PRC

DEFINITION
Satellite ephemerides position and velocity vectors every 30 s, derived from full rate laser tracking data.

DESCRIPTION
Input:
- laser tracking data
- measurement model data
- reference frame model data
- dynamical model data
- orbital elements at initial epoch.

Algorithm:
- numerical integration of satellite's equations of motion and variational equations
- reduction of observations and iterative least squares adjustment.

Output:
- time tags with respect to J2000.0
- spacecraft position every 30 s
- spacecraft velocity every 30 s
- attitude vectors every 30 s.

SPECIFICATIONS
Units: Position: mm; velocity: μm/s, attitude parameters: mdeg; time in Julian days since 2000.01.01 12 hrs in Terrestrial Dynamic Time (TDT).
Product geographical coverage: ERS-1 global coverage.
Spatial resolution: About 225 km.
Product location accuracy: Radial nominal accuracy = 1 m.
Reference system(s): CTS and CIS.[Definitions 1 and 2]
Time resolution: 30 seconds.
Product sizing: 7-day arc.

DATA VOLUME
5 Mbytes per week.

MEDIUM
1600 bpi CCT, 6250 bpi CCT, Exabyte cassette.

FORMAT
See Reference 8.

REMARKS
The precise orbits are based on a data reduction process in which all the available tracking data, corrections, transformations and dynamical models are taken into account together with the most precise numerical procedures. These orbits represent the best achievable approximation of the real orbital motion according to the tracking data and the 'state of the art' on satellites dynamical motion models. ERS-1.ORB.PRC is available 1 or 2 days after request.

6. GRAVITY FIELD MODELS

6. GRAVITY FIELD MODELS

A specification is available for the following gravity field model products:

DEFINITIONS

Definition 1 – Conventional Terrestrial System (CTS):
Z axis directed towards the mean pole as derived from the BIH pole series (ERP(BIH)87C02) covering the period January 1980 to October 1986. X axis fixed by allowing no net rotation about the Z axis with respect to the initial coordinates (SSC(DGFII)90L0X). Y axis completes the right-handed system.

Definition 2 – Conventional Inertial System (CIS):
This system is referred to the basic epoch 2000.01.01 12 hours designated J2000.0. The axes of the CIS are chosen in such a way that at the basic epoch J2000.0 they coincide in optimal approximation with the mean equatorial frame defined by the mean celestial pole (Z axis) and the mean vernal equinox (X axis).

Product name | *Product code*

Gravity Model First Generation — ERS-1.ORB.EGM1

DEFINITION

First generation of ERS-1 Gravity Field Models. ERS-1 gravity model provided as a set of fully normalised harmonic coefficients: C(n,m), S(n,m), appearing in the Earth geopotential U expansion:

$$U=(GM/r)\{1+\sum_{n=2}^{N}\sum_{m=0}^{n}(Re/r)\,Pnm(\sin(\theta)[\,C(n,m)\cos(m\phi)+S(n,m)\sin(m\phi)\,]\}$$

where:

GM	=	gravitational constant times mass of Earth and atmosphere
Re	=	mean equatorial radius of the Earth
r	=	distance of point P from Earth's centre of mass
θ	=	latitude of point P
ϕ	=	longitude of point P
Pnm(x)	=	associated Legendre polinomial of order n,m
C(n,m), S(n,m)	=	fully normalised harmonic coefficients
N	=	truncation degree

DESCRIPTION

Input:

- pre-ERS-1 Earth gravity model
- ERS-1 laser range data
- tracking station survey ties
- a-priori degree variance models.

Algorithm:

Numerical integration of satellite's equation of motion and variational equations followed by a least square adjustment: reduction, accumulation, combination and solution of normal equation systems.

Output:

Spherical harmonic coefficients C(n,m) and S(n,m) of the expansion of the terrestrial potential U in spherical harmonics.

SPECIFICATIONS

Units: A-dimensional numbers.

Product geographical coverage: ERS-1 global coverage.

Spatial resolution: Spherical harmonic expansion of the geopotential with degree n=2 to n=50 and order m=0 to m=50.

Product location accuracy: Radial nominal accuracy = 1 m.

Reference system(s): CTS and CIS.[Definitions 1 and 2]

DATA VOLUME

0.25 Mbytes. 2500 parameters with associated error estimates.

MEDIUM

1600 bpi CCT, 6250 bpi CCT.

FORMAT

See Reference 8.

Product name *Product code*

Gravity Model Second Generation ERS-1.ORB.EGM2

DEFINITION
Second generation of ERS-1 Gravity Field Models provided as a set of fully normalised harmonic coefficients (see ERS-1.ORB.EGM1).

DESCRIPTION
Input:
- pre-ERS-1 Earth gravity model
- ERS-1 laser range data
- ERS-1.ORB.EGM1
- tracking station survey ties
- a-priori degree variance models.

Algorithm:
Numerical integration of satellite's equation of motion and variational equations followed by a least squares adjustment: reduction, accumulation, combination and solution of normal equation systems.
Output:
As ERS-1.ORB.EGM1.

SPECIFICATIONS
As ERS-1.ORB.EGM1.

DATA VOLUME
2500 parameters with associated error estimates. Volume = 0.25 Mbytes.

MEDIUM
1600 bpi CCT, 6250 bpi CCT.

FORMAT
See Reference 8.

ESA ERS-1 PRODUCT SPECIFICATION

Request Form

The ESA ERS-1 Product Specification document has been structured to allow distribution in its entirety and by chapter. On this form you should record the product specifications you wish to receive. In addition to the specifications the pack sent to you will include a brief introduction to the ERS-1 space and ground segments, a list of acronyms and abbreviations and a list of references. Updates will be issued as product lists or specifications are modified. The following product specifications are available:

esa european space agency

SYNTHETIC APERTURE RADAR – IMAGE MODE		❑
SAR Annotated Raw Data	ERS-1.SAR.RAW	
SAR Fast Delivery Image	ERS-1.SAR.UI16	
SAR Fast Delivery Image Copy	ERS-1.SAR.FDC	
SAR Single Look Complex Image	ERS-1.SAR.SLC	
SAR Precision Image	ERS-1.SAR.PRI	
SAR Ellipsoid Geocoded Image	ERS-1.SAR.GEC	
SAR Terrain Geocoded Image	ERS-1.SAR.GTC01	
SYNTHETIC APERTURE RADAR – WAVE MODE		❑
SAR Wave Annotated Raw Data	ERS-1.SWM.RAW	
SAR Wave Fast Delivery Product	ERS-1.SWM.UWA	
SAR Wave Fast Delivery Product Copy	ERS-1.SWM.FDC	
SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC	
SAR Wave Complex Image	ERS-1.SWM.CIT	
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS	
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS	
WIND SCATTEROMETER		❑
Scatterometer Fast Delivery Product	ERS-1.WSC.UWI	
Scatterometer FD Product Copy	ERS-1.WSC.FDC	
Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC	
De-aliased Off-line Wind Fields	ERS-1.WSC.WNF	
RADAR ALTIMETER		❑
Altimeter Annotated Raw Data	ERS-1.ALT.RAW	
Altimeter Fast Delivery Product	ERS-1.ALT.URA	
Altimeter Fast Delivery Product Copy	ERS-1.ALT.FDC	
Off-line Intermediate Product	ERS-1.ALT.OIP	
Ocean Product	ERS-1.ALT.OPR01	
Sea Surface Height	ERS-1.ALT.SSH	
Sea Surface Topography	ERS-1.ALT.TOP	
Ocean Geoid	ERS-1.ALT.OGE	
ORBIT		❑
Preliminary Orbit	ERS-1.ORB.PRL	
Precise Orbit	ERS-1.ORB.PRC	
GRAVITY FIELD MODELS		❑
Gravity Model First Generation	ERS-1.ORB.EGM1	
Gravity Model Second Generation	ERS-1.ORB.EGM2	
Tick box if you wish to receive the entire document		❑

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ESRIN
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I-00044, Frascati, Italy

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ESA ERS-1 PRODUCT SPECIFICATION

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esa european space agency

SYNTHETIC APERTURE RADAR – IMAGE MODE		❑
SAR Annotated Raw Data	ERS-1.SAR.RAW	
SAR Fast Delivery Image	ERS-1.SAR.UI16	
SAR Fast Delivery Image Copy	ERS-1.SAR.FDC	
SAR Single Look Complex Image	ERS-1.SAR.SLC	
SAR Precision Image	ERS-1.SAR.PRI	
SAR Ellipsoid Geocoded Image	ERS-1.SAR.GEC	
SAR Terrain Geocoded Image	ERS-1.SAR.GTC01	
SYNTHETIC APERTURE RADAR – WAVE MODE		❑
SAR Wave Annotated Raw Data	ERS-1.SWM.RAW	
SAR Wave Fast Delivery Product	ERS-1.SWM.UWA	
SAR Wave Fast Delivery Product Copy	ERS-1.SWM.FDC	
SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC	
SAR Wave Complex Image	ERS-1.SWM.CIT	
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS	
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS	
WIND SCATTEROMETER		❑
Scatterometer Fast Delivery Product	ERS-1.WSC.UWI	
Scatterometer FD Product Copy	ERS-1.WSC.FDC	
Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC	
De-aliased Off-line Wind Fields	ERS-1.WSC.WNF	
RADAR ALTIMETER		❑
Altimeter Annotated Raw Data	ERS-1.ALT.RAW	
Altimeter Fast Delivery Product	ERS-1.ALT.URA	
Altimeter Fast Delivery Product Copy	ERS-1.ALT.FDC	
Off-line Intermediate Product	ERS-1.ALT.OIP	
Ocean Product	ERS-1.ALT.OPR01	
Sea Surface Height	ERS-1.ALT.SSH	
Sea Surface Topography	ERS-1.ALT.TOP	
Ocean Geoid	ERS-1.ALT.OGE	
ORBIT		❑
Preliminary Orbit	ERS-1.ORB.PRL	
Precise Orbit	ERS-1.ORB.PRC	
GRAVITY FIELD MODELS		❑
Gravity Model First Generation	ERS-1.ORB.EGM1	
Gravity Model Second Generation	ERS-1.ORB.EGM2	
Tick box if you wish to receive the entire document		❑

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esa european space agency

SYNTHETIC APERTURE RADAR – IMAGE MODE		❑
SAR Annotated Raw Data	ERS-1.SAR.RAW	
SAR Fast Delivery Image	ERS-1.SAR.UI16	
SAR Fast Delivery Image Copy	ERS-1.SAR.FDC	
SAR Single Look Complex Image	ERS-1.SAR.SLC	
SAR Precision Image	ERS-1.SAR.PRI	
SAR Ellipsoid Geocoded Image	ERS-1.SAR.GEC	
SAR Terrain Geocoded Image	ERS-1.SAR.GTC01	
SYNTHETIC APERTURE RADAR – WAVE MODE		❑
SAR Wave Annotated Raw Data	ERS-1.SWM.RAW	
SAR Wave Fast Delivery Product	ERS-1.SWM.UWA	
SAR Wave Fast Delivery Product Copy	ERS-1.SWM.FDC	
SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC	
SAR Wave Complex Image	ERS-1.SWM.CIT	
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS	
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS	
WIND SCATTEROMETER		❑
Scatterometer Fast Delivery Product	ERS-1.WSC.UWI	
Scatterometer FD Product Copy	ERS-1.WSC.FDC	
Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC	
De-aliased Off-line Wind Fields	ERS-1.WSC.WNF	
RADAR ALTIMETER		❑
Altimeter Annotated Raw Data	ERS-1.ALT.RAW	
Altimeter Fast Delivery Product	ERS-1.ALT.URA	
Altimeter Fast Delivery Product Copy	ERS-1.ALT.FDC	
Off-line Intermediate Product	ERS-1.ALT.OIP	
Ocean Product	ERS-1.ALT.OPR01	
Sea Surface Height	ERS-1.ALT.SSH	
Sea Surface Topography	ERS-1.ALT.TOP	
Ocean Geoid	ERS-1.ALT.OGE	
ORBIT		❑
Preliminary Orbit	ERS-1.ORB.PRL	
Precise Orbit	ERS-1.ORB.PRC	
GRAVITY FIELD MODELS		❑
Gravity Model First Generation	ERS-1.ORB.EGM1	
Gravity Model Second Generation	ERS-1.ORB.EGM2	
Tick box if you wish to receive the entire document		❑

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ESA ERS-1 PRODUCT SPECIFICATION

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esa european space agency

SYNTHETIC APERTURE RADAR – IMAGE MODE ❑

SAR Annotated Raw Data	ERS-1.SAR.RAW
SAR Fast Delivery Image	ERS-1.SAR.UI16
SAR Fast Delivery Image Copy	ERS-1.SAR.FDC
SAR Single Look Complex Image	ERS-1.SAR.SLC
SAR Precision Image	ERS-1.SAR.PRI
SAR Ellipsoid Geocoded Image	ERS-1.SAR.GEC
SAR Terrain Geocoded Image	ERS-1.SAR.GTC01

SYNTHETIC APERTURE RADAR – WAVE MODE ❑

SAR Wave Annotated Raw Data	ERS-1.SWM.RAW
SAR Wave Fast Delivery Product	ERS-1.SWM.UWA
SAR Wave Fast Delivery Product Copy	ERS-1.SWM.FDC
SAR Wave Intermediate Product Copy	ERS-1.SWM.IPC
SAR Wave Complex Image	ERS-1.SWM.CIT
SAR Wave Detected Image Spectrum	ERS-1.SWM.DIS
SAR Wave Imagette Power Spectrum	ERS-1.SWM.IPS

WIND SCATTEROMETER ❑

Scatterometer Fast Delivery Product	ERS-1.WSC.UWI
Scatterometer FD Product Copy	ERS-1.WSC.FDC
Scatterometer Extracted Wind Copy	ERS-1.WSC.IWC
De-aliased Off-line Wind Fields	ERS-1.WSC.WNF

RADAR ALTIMETER ❑

Altimeter Annotated Raw Data	ERS-1.ALT.RAW
Altimeter Fast Delivery Product	ERS-1.ALT.URA
Altimeter Fast Delivery Product Copy	ERS-1.ALT.FDC
Off-line Intermediate Product	ERS-1.ALT.OIP
Ocean Product	ERS-1.ALT.OPR01
Sea Surface Height	ERS-1.ALT.SSH
Sea Surface Topography	ERS-1.ALT.TOP
Ocean Geoid	ERS-1.ALT.OGE

ORBIT ❑

Preliminary Orbit	ERS-1.ORB.PRL
Precise Orbit	ERS-1.ORB.PRC

GRAVITY FIELD MODELS ❑

Gravity Model First Generation	ERS-1.ORB.EGM1
Gravity Model Second Generation	ERS-1.ORB.EGM2

Tick box if you wish to receive the entire document ❑

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- Issue 1.1 18 May 1989
- Issue 2.0 15 March 1991
- Issue 2.1 19 August 1991
- Issue 3.0 1 June 1992 (this issue)

It is aimed at providing relevant information for the description of the products that are generated from the data telemetered by the ERS-1 payload instruments at ESA facilities, i.e. the ESA ERS-1 ground stations or Processing and Archiving Facilities (PAFs).

> **NOTE:**
>
> This document is meant to be dynamically updated, as a consequence of the on-going tuning of the ERS-1 ground segment, and in particular of the PAFs, and of their evolution. Updates in the on-board instruments' performance during the satellite life-time may also necessitate changes. Hence, modifications to the product lists and/or to the product specifications may be expected.

The document starts with a brief introduction on the ERS-1 space segment, ground segment, and user access to products and services, then continues with a number of chapters, one per instrument. Every chapter gives a summary of the instrument characteristics, followed by the available product specifications. Lists of acronyms/ abbreviations and references are also included at the end of the document. The document has been structured to allow an easy update and its distribution by instrument. A request form is available.

This document is part of a series about ERS-1. The others in the series are:

- **ERS-1 System**
  The ERS-1 System (ESA-SP-1146) provides detailed information on ERS-1, including the satellite, instruments, ground facilities and data services.

- **ERS-1 User Handbook**
  The ERS-1 User Handbook (ESA-SP-1148) provides information on ordering and details on accessing the ERS-1 catalogue, which notifies users of the availability of data, products and of planned acquisitions.