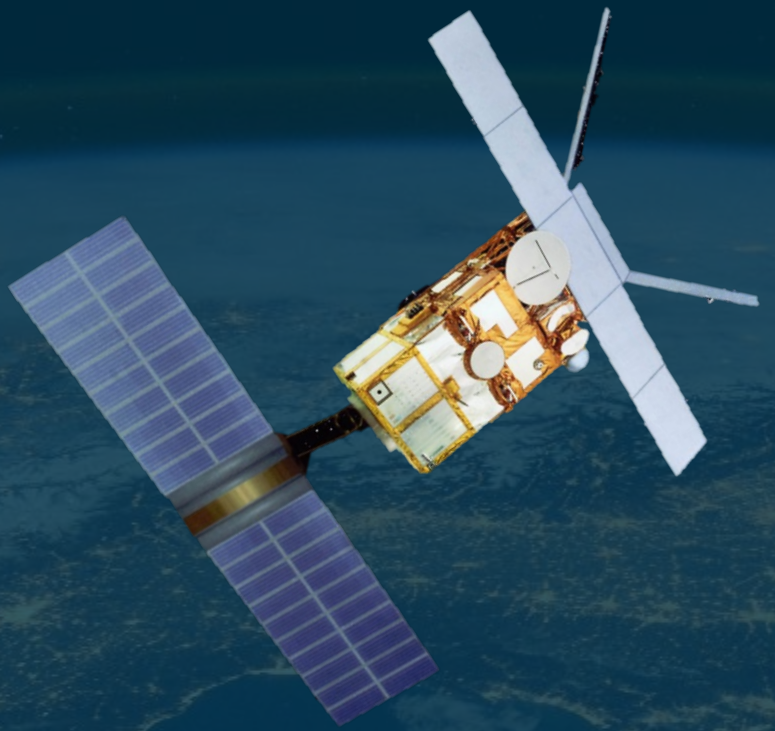


Valorization and Curation of the ESA ERS Missions

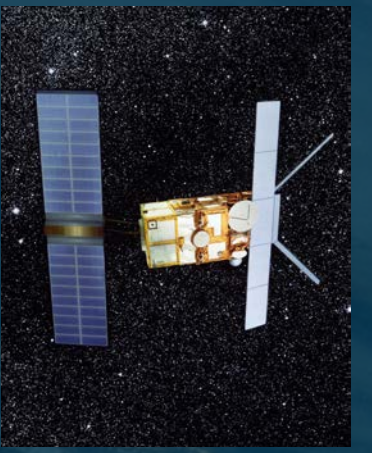
PV2023, 2-4 May 2023

Mirko Albani (ESA ESRIN)

European Remote-Sensing Satellites (ERS-1 and ERS-2)

ESA's first Earth observation mission dedicated to understanding our planet, the European Remote Sensing satellite (ERS-1), was launched on 17 July 1991. At the time, ERS-1 was one of the most sophisticated satellites ever developed and launched by Europe, paving the way for a new era in satellite technology to study the atmosphere, land, oceans and ice.

The satellite carried a comprehensive payload including an imaging synthetic aperture radar (SAR), a radar altimeter (RA) and other powerful instruments to measure ocean surface temperature and winds at sea. ERS-1 was then joined by ERS-2 in 1995 which carried an additional sensor for atmospheric ozone research – the Global Ozone Monitoring Experiment (GOME).



After the launch of ERS-2, the two satellites were linked in the first ‘tandem’ mission which lasted for nine months with the objective to to develop SAR interferometry applications. During this time the increased frequency of data available offered a unique opportunity to observe changes over a very short period of time, as ERS-2's track over the Earth's surface coincided exactly with that of ERS-1 24 hours earlier.

Heritage Value

The ERS Programme has provided a stream of data which has changed our view of the world in which we live. It has provided us with new insights on our planet, the chemistry of our atmosphere, the behavior of our oceans, and the effects of mankind's activity on our environment – creating new opportunities for scientific research and applications.

The success of ERS also paved the way for further Earth Observation missions such as Envisat and today's Copernicus Sentinel family of satellites, which evolved on ESA's heritage systems developed and launched onboard ERS-1 and ERS-2. Together, these three generations of missions provide a record of 30+ years of continuous observations of our Planet, supplying valuable long-term datasets for research and operational applications benefitting from long time-series analysis.

"*ERS Heritage data are still widely used today by scientists and researchers, as they provide a unique possibility to look back in time and better understand how our planet works, to learn more about how it is changing, also due to human activities, and what the impact on our lives can be*".

https://www.youtube.com/watch?v=Oi7U6Tc3sFg&t=13s

ERS Instruments

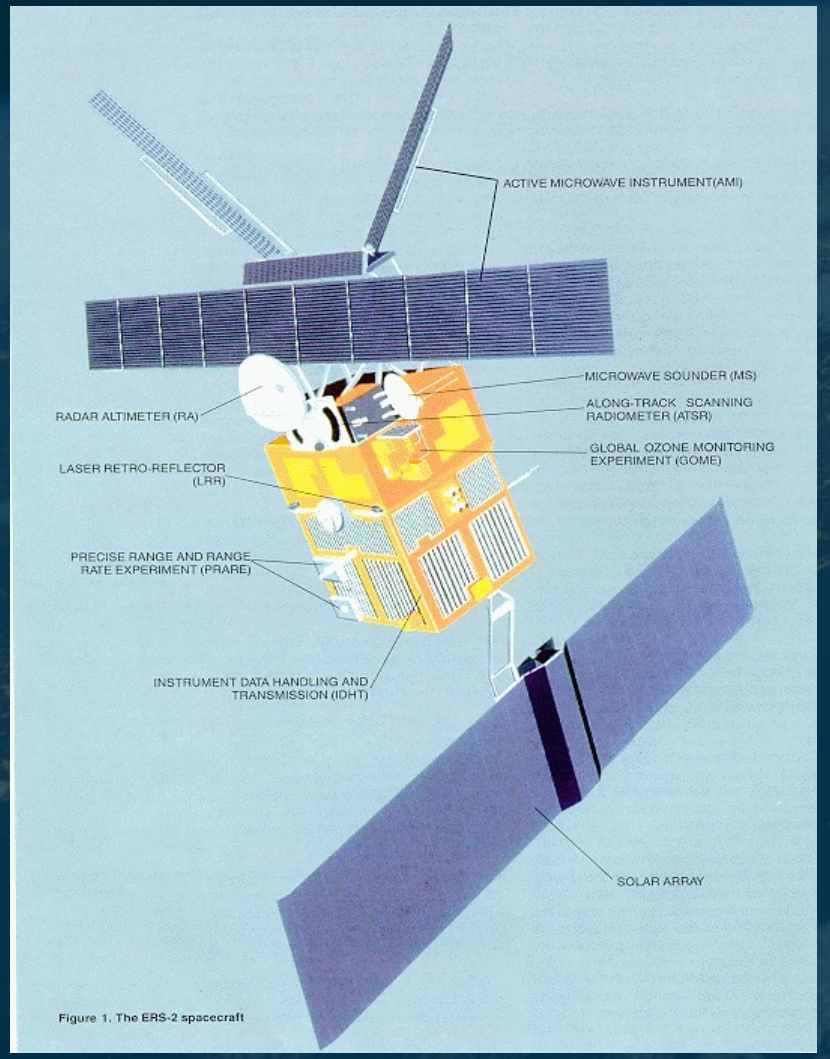


Figure 1. The ERS-2 spacecraft

Instrument - Imaging Spectrometers/Radiometers

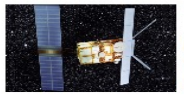
ATSR

The Along Track Scanning Radiometer (ATSR) on board ERS-1 and ERS-2 mission consisted of two instruments, an Infra-Red Radiometer and a Microwave Sounder.

Instrument - Positioning/Navigation

PRARE

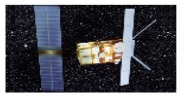
The Precise Range And Range-Rate Equipment (PRARE) was a microwave tracking system on board the ERS-1 and ERS-2 missions.



Instrument - Laser Ranging

LRR ERS

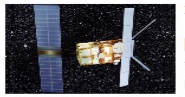
The Laser Retro-Reflector (LRR), on board the ERS-1 and ERS-2 missions, was an optical device for accurate satellite tracking from the ground to support instrument data evaluation.



Instrument - Scatterometers

SAR (ERS)

The Synthetic Aperture Radar (SAR) instrument aboard ERS-1 and ERS-2 was capable of high precision change detection of surface heights.



Instrument - Imaging Spectrometers/Radiometers

MWR (ERS)

The microwave radiometer (MWR) instrument on board the ERS-1 and ERS-2 missions provided measurements of the integrated atmospheric water vapour column and cloud liquid water content.

Instrument - Scatterometers

WS

The Wind Scatterometer (WS) instrument, on board the ERS-1 and ERS-2 missions, obtained information on wind speed and direction over the sea surface.

Instrument - Radar Altimeters

RA (ERS)

The Radar Altimeter (RA) was a Ku-band (13.8 GHz) nadir-pointing active microwave sensor, on board ERS-1 and ERS-2 missions, designed to measure echoes from ocean and ice surfaces.

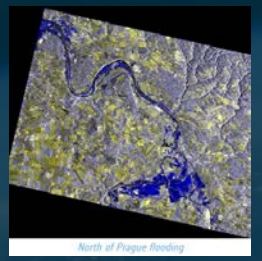
Instrument - Spectrometers

GOME

The Global Ozone Monitoring Experiment (GOME) was a nadir-scanning ultraviolet and visible spectrometer for global monitoring of atmospheric Ozone.

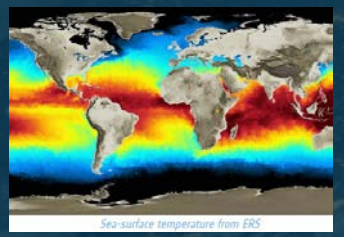
Applications (few examples)

Some examples of the many benefits that ERS data have brought to Science and Research over the years.



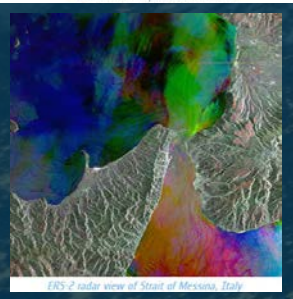
Floods

- ERS-2 was often used in the context of the International Charter on Space and Major Disasters, as in the cases of floods.



Sea and Land Surface Temperature

- ERS Along Track Scanning Radiometer (ATSR) was used to track water and land surface temperatures, which are crucial for climate change monitoring.



Land Cover classification and change detection

- ERS SAR data allowed the generation of large-scale land cover maps featuring seasonal variation of vegetation in support of forestry, agriculture monitoring and planning, and urban mapping applications.

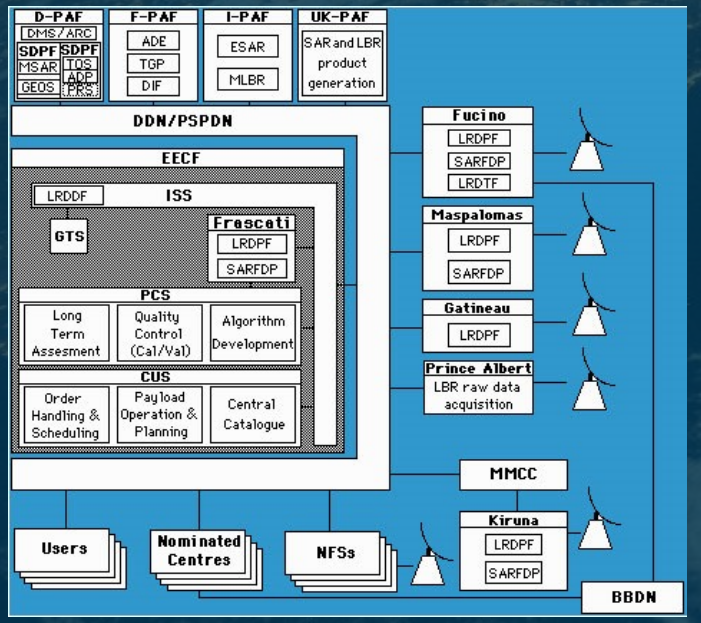
Ice Monitoring

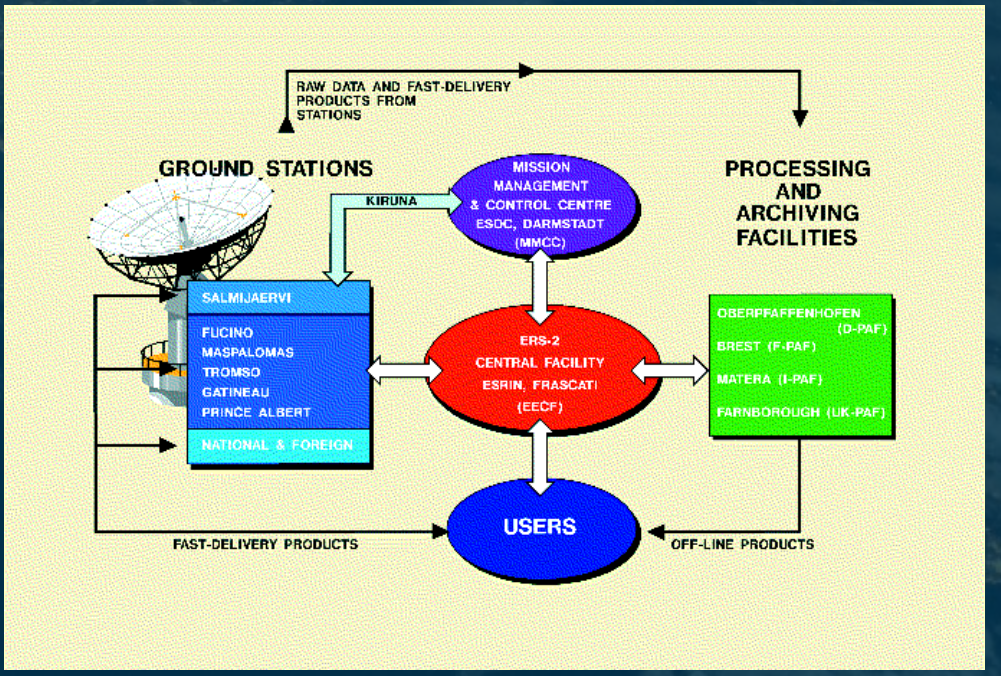
- ERS has allowed the tracking of changes in arctic sea-ice extent and the tracking of calving fronts in Greenland's largest ice streams.

ERS Ground Segment

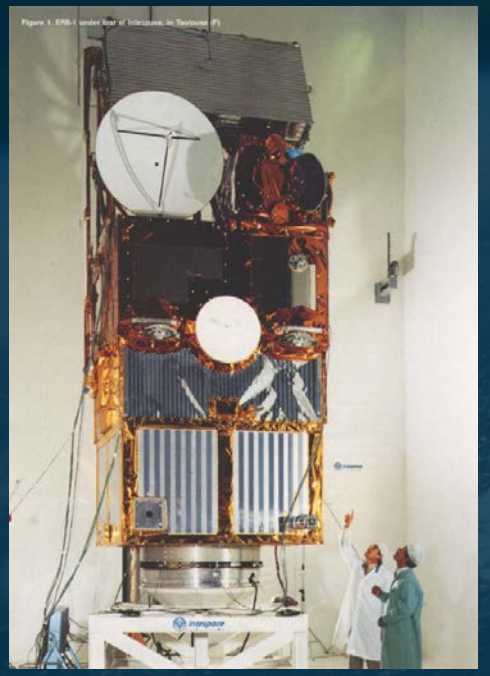
The characteristics of the ERS space segment in terms of its multi-sensor payload, orbit configurations and power requirements, imposed the implementation of a network of ground stations around the world to acquire the high bit rate SAR data (for which only direct readout was possible). In addition, facilities had to be provided to permit the downloading, once per orbit, of the on-board recorded low bit rate (LBR) data. The instrument data was sent to Processing and Archiving Facilities (PAFs) for archiving and off-line product generation and delivery to users.

The user interface and exploitation of the payload data was implemented at ESRIN by the Earthnet Programme Office (EPO); while the satellite planning and control functions, including the control of the Kiruna station were under the responsibility of ESOC in Darmstadt, Germany.

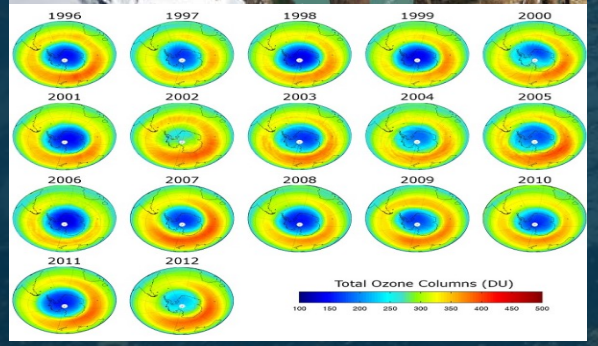




ERS-1 through pictures



ERS missions Achievements (few examples)



The Intergovernmental Panel on Climate Change (IPCC) published reports that detailed the intensifying impacts of climate change, including melting of the ice sheets, sea level rise, ocean warming and acidification. Observations from ERS and Envisat have proven critical for monitoring changes to the ice sheets, which together with glacier mass loss, are now the dominant contributors to global sea level rise. Picture: Upsala Glacier

ERS and Envisat provided high-quality information on the annual formation and recovery of the Antarctic ozone hole, as well as the health of the ozone layer blanketing the rest of the planet, from the mid-1990s until 2012. Data from the heritage missions have proven to be a vital resource, helping the international community to track the impacts of the Montreal Protocol. Picture: Antarctic ozone hole

Missions such ERS-1 pioneered datasets on Earth's surface using microwave, infrared and visible spectrum-based environmental monitoring and a comprehensive payload with several instruments including SAR and radar altimeter. Historically ERS datasets were called upon to monitor environmental and natural disasters such as flooding and earthquakes. However, to this day the ERS data acquired for some 20 years still provide invaluable land monitoring information and are continuously improved to build long time data series with newer missions.

ERS Mission End

ERS-1

Designed with a three-year lifespan, the ERS-1 satellite was operational for nine years, until on 10 March 2000 the satellite experienced an on-board attitude control system failure.

The satellite completed 45,000 orbits since its launch on 17 July 1991, and acquired more than 1.5 million individual SAR scenes.

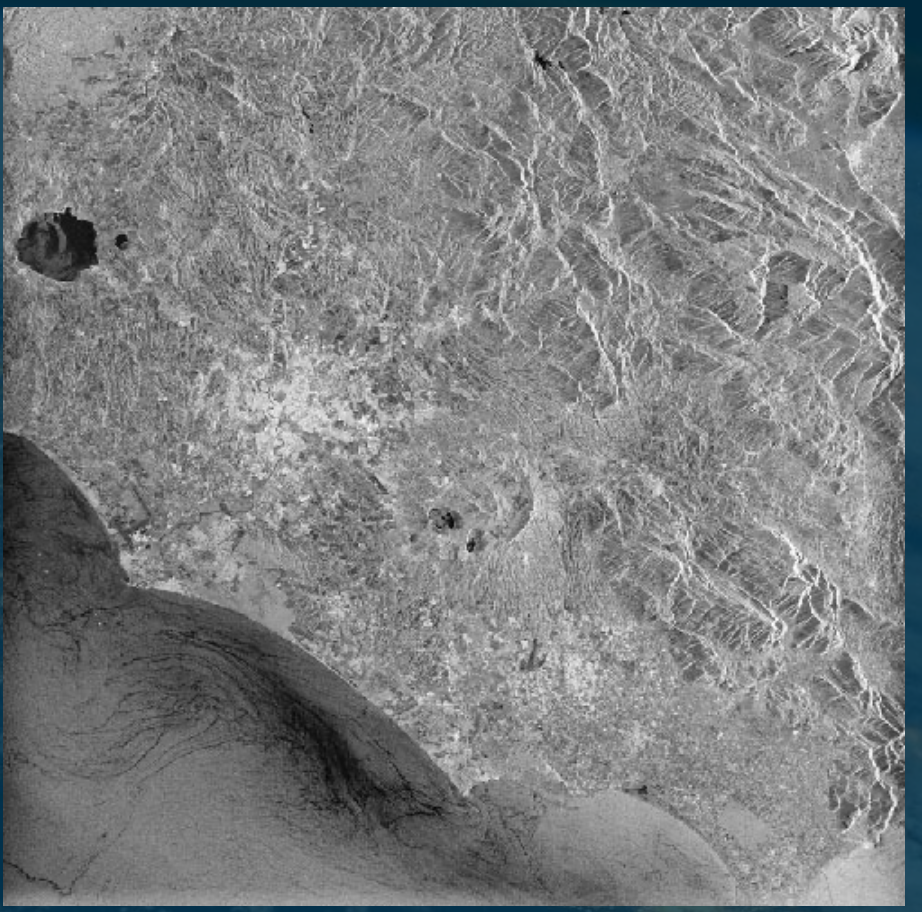
ERS-2

Designed to operate for three years, it greatly exceeded its design lifetime. In 2011, after 16 years of operations, the satellite was still functioning nominally but was running low on fuel, and the mission team decided to safely alter ERS-2's orbit in order to begin re-entry. This process was expected to take 15 years, during which the satellite would slowly descend and burn up in the atmosphere. The final command to ERS-2 was sent on 5 Sept to deactivate the instruments on board.

ERS-2 completed 85,000 orbits and travelled 3.5 billion km from 1995 to 2011. Together with ERS-1, the two satellites provided a large dataset of long-term observations that supported a range of applications.

ERS Mission: the beginning and the end

ERS-1 first image



ERS-2 last image over Rome

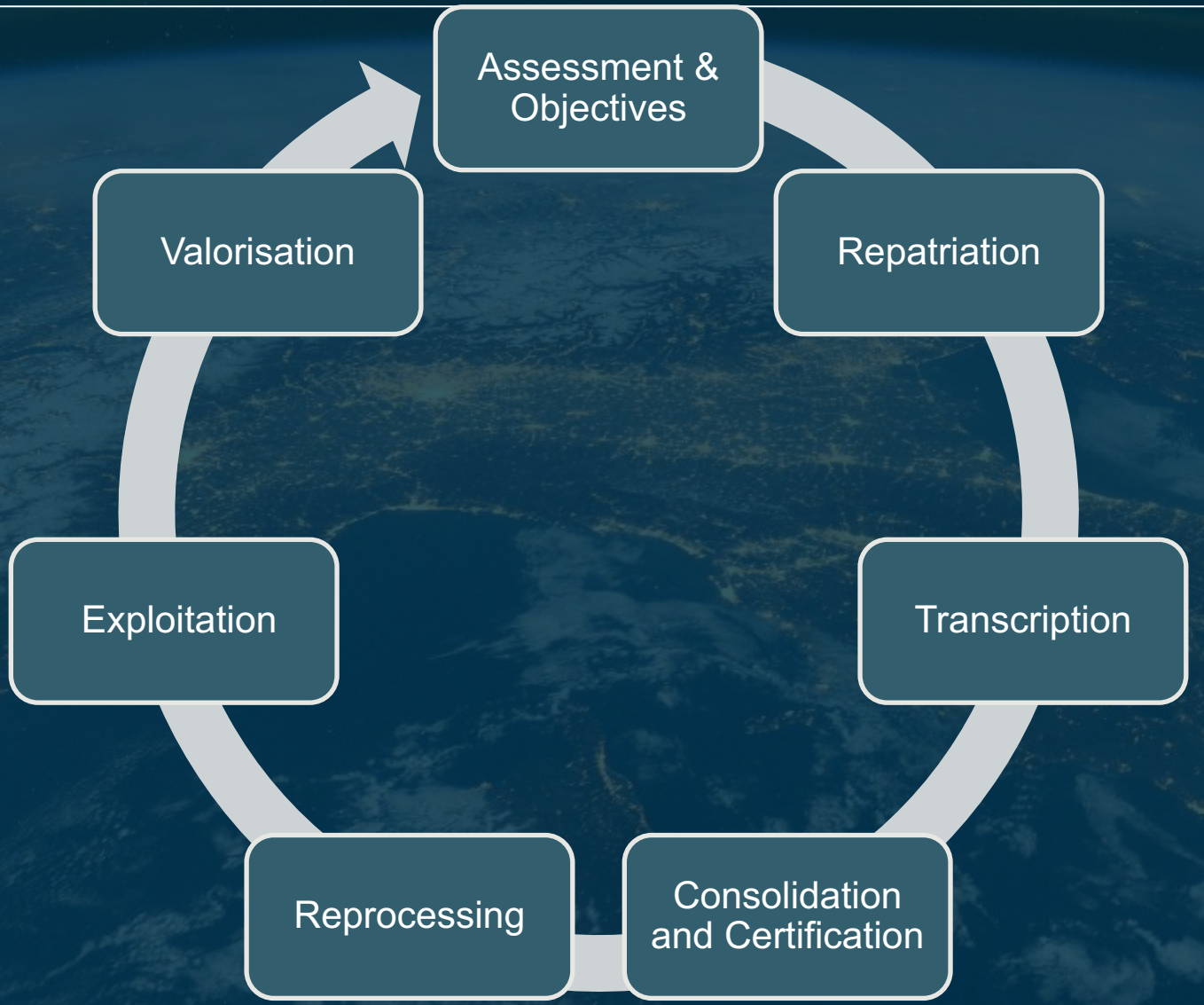
https://www.esa.int/Enabling_Support/Operations/ERS_satellite_missions_complete_after_20_years

Heritage Space Programme

Coordinated action to ensure preservation, access, curation and exploitation of ESA heritage space data & information

- Inter-Directorates
  Partners: EOP, SCI, HRE, OPS, DG Cabinet
- Covering 60+ ESA heritage missions including ERS, Envisat, GOCE, Rosetta, Planck, Herschel
- Ensuring data continuity with current/future missions in support to research & applications requiring long time data series (e.g. ***climate change***)
- Providing state of art preservation services (e.g. to support other ESA programmes)

ERS Preservation and Valorisation Effort



Assessment & Objectives

ESA UNCLASSIFIED - For Official Use

3 ANNEX A – APPRAISAL QUESTIONNAIRE

The Appraisal Questionnaire contains all information describing the mission/dataset, the appraiser, the appraisal date, and the responsibility of the appraisal.

1. The benefit resulting from ESA taking over the data custody, including the value of the mission data in terms of potential utilization for scientific and/or operational purposes:
   a. **Uniqueness:** type of sensor and characteristics, domain and variety of applications; specific and unique aspects of the mission as stand-alone data utilization potential;
   b. **Spatial and temporal complementarity:** data exploitation in conjunction with other data sources, in particular, ESA and national Earth Observation mission data; complementarity and gap filling of ESA and national missions data holdings;
   c. **Continuity** of services, research, and exploitation with on-going and future missions;
   d. **Data quality**;
   e. **Usefulness for research and application projects and potential future impact:** checked with different European user communities (e.g. Researchers, Public services, Value-adding Industry).
2. Accessibility and rights from European users and ESA point of view:
   a. **Open and free access conditions**: time-unlimited right for ESA to use and

	USABILITY					PRESERVATION		CURATION	
		MMP6 Data Validation	MMP7 Data Uncertainty	MMP8 Data Quality Control		MMP9 Data Preservation	MMP10 Data Verification	MMP11 Data Processing/Reprocessing	MMP12 Persistent & Resolvable Identifier
		1) Reference Data Representativeness - No validation 2) Reference Data Quality - No validation 3) Validation Method - No validation 4) Validation Results - No validation	1) Uncertainty Method: Uncertainty characterisation not performed, or method not documented. 2) Uncertainty Sources: Uncertainty characterisation not performed, or sources analysed not documented. 3) Uncertainty Values: No uncertainty information provided.	1) No control and monitoring check 2) No quality indicator in metadata 3) No procedures documentation		1) Uncontrolled storage location. 2) Only data are stored 3) Data Records archiving not managed 4) Relevant information on Product Details Assessment not made	No Data/Associated information integrity, authenticity and readability check	1) No reprocessing activities planned 2) Pre-flight calibration & characterisation not documented or information not available. 3) Post-launch calibration & characterisation not documented or not available. 4) Processing: Additional processing steps not documented.	No persistent and resolvable identifiers available
Level-1 Partially Managed	1) Advertising available 2) Catalogue search available at product level	Basic online services available for data and metadata access	1) Basic schema for automated data use 2) Data in documented standard file format. Non-standard naming conventions used.	1) Already existent mission documentation available and preserved for the long term 2) No link between mission documentation and data records	Product information available (not online)	1) Reference Data Representativeness: measurements assessed to be mostly representative of the satellite measurements 2) Reference Data Quality: single uncertainty for the entire dataset. 3) Validation Method: simple uncertainty estimated 4) Validation Results: Validation results show good agreement between satellite and reference measurements within uncertainties in most cases.	1) Uncertainty Method: Limited use of GUM approach, and/or, an expanded comparison to measurements by other sensors. 2) Uncertainty Sources: Most important sources of uncertainty included. 3) Uncertainty Values: Single uncertainty value provided for subsets of data	1) Basic data quality control and monitoring check 2) Minimal set of quality control procedures documented and available	1) Basic archiving for original data records preservation 2) Assessment of SW preservation 3) Product Details	Data Records/Associated information integrity basic check	1) Minor updates and bugs corrections of data records implemented 2) Data Records repackaging and/or reformatting 3) Pre-flight calibration & characterisation misses some important aspects 4) Post-launch calibration & characterisation misses some important aspects of instrument behaviour and/or is not entirely of a level of quality	1) Persistent identifier assignment only for particular Data Records Collections
Level-2 Managed	1) Detailed catalogue search available at product level 2) Product metadata oriented towards an international standard 3) Data Collection and Associated Information searchable. 4) International standard for Collection metadata	1) Simple Access Architecture through metadata 2) Data access system oriented towards an international standard	1) Use of non-proprietary international standards encodings for syntactic interoperability. 2) Periodically repackaging/reformatting of archived data. 3) Data in well-documented standard file format, community naming convention standards.	1) Documentation produced, published and well described 2) Link between mission documentation and data records created and managed	Dataset tested for presence of correct provenance metadata. Well described product information available online	1) Reference Data Representativeness: measurements assessed to be well representative of the satellite measurements 2) Reference Data Quality: full uncertainty information 3) Validation Methods assess satellite measurements 4) Validation Results show excellent agreement between satellite and reference measurements, within uncertainties.	1) Uncertainty Method: GUM approach to estimate measurement uncertainty with full breakdown of components and separated as Type A or B classification. 2) Uncertainty Sources: All important sources of uncertainty included. 3) Uncertainty Values: Total uncertainty per pixel is provided, with basic breakdown of key components no error-covariance.	1) Quality indicator post-processing available 2) Quality control procedures documented and available online			
Level-3 Fully Managed	1) International standard for Product metadata 2) International standard for Collection metadata 3) Catalogue accessible via international or community agreed standards protocol 4) Data policy available in metadata 5) Periodic updates of metadata in the catalogue 6) Quality indicator metadata available and discoverable 7) Search results relevancy. 8) Seamless transition	1) International standard for Data and metadata access system 2) Data policy available in the metadata. 3) Visualisation services 4) Reporting system 5) Hosted processing 6) Quick adoption to new technologies and standards evolution 7) Data and metadata accessible through a free and open access protocol	1) Accepted and Available semantic encoding standards for complete interoperability 2) Data and metadata uses FAIR-compliant vocabularies 3) Analysis Ready Data standard	1) Standards based metadata for documentation 2) Link between mission documentation and data records published	1) Automatic metadata generation for provenance documentation 2) Complete and updated data provenance available online	1) Reference Data Representativeness: Reference measurements independently assessed to be fully representative of the satellite measurements, covering the satellite's full range of measurements and with full assessment of uncertainties and carried out on a regular basis determined by product performance. 2) Reference Data Quality: full uncertainty and error-correlation information, assessed following the GUM and traceable to SI 3) Validation Methods assess satellite measurements and reference data w.r.t. their error- covariance and validates those uncertainties. 4) Validation Results show excellent agreement between satellite and reference measurements, within	1) Uncertainty Method: GUM approach to estimate measurement uncertainty, including a treatment of error-covariance. 2) Uncertainty Sources: All reasonable sources of uncertainty included. 3) Uncertainty Values: Uncertainties per pixel provided with error-covariance information for all appropriate components.	1) Data quality control fully compliant with an international standard 2) Quality indicator pre and post processing available in the metadata 3) Quality metadata assessed			

COMPONENTS	L0	L1	L2	L3
Metadata for Discovery	★	★	★	★
Online Access	★	★	★	★
Data Encoding	★	★	★	★
Data Documentation	★	★	★	★
Data Traceability	★	★	★	★
Data Validation	★	★	★	★
Data Uncertainty	★	★	★	★
Data Quality Control	★	★	★	★
Data Preservation	★	★	★	★
Data Verification	★	★	★	★
Data Processing/Reprocessing	★	★	★	★
Persistent & Resolvable Identifier	★	★	★	★

Long Term Preservation of Earth Observation Space Data

Earth Observation Preserved Data Set Content

Starting point for ISO/DIS 19165-2 Geographic information — Preservation of digital data and metadata —- Part 2: Content specifications for earth observation data and derived digital products

CEOS-WGISS
Data Stewardship Interest Group

Doc. Ref.: CEOS/WGISS/DSIG/EOPDSC
Date: September, 2015
Issue: Version 1.0

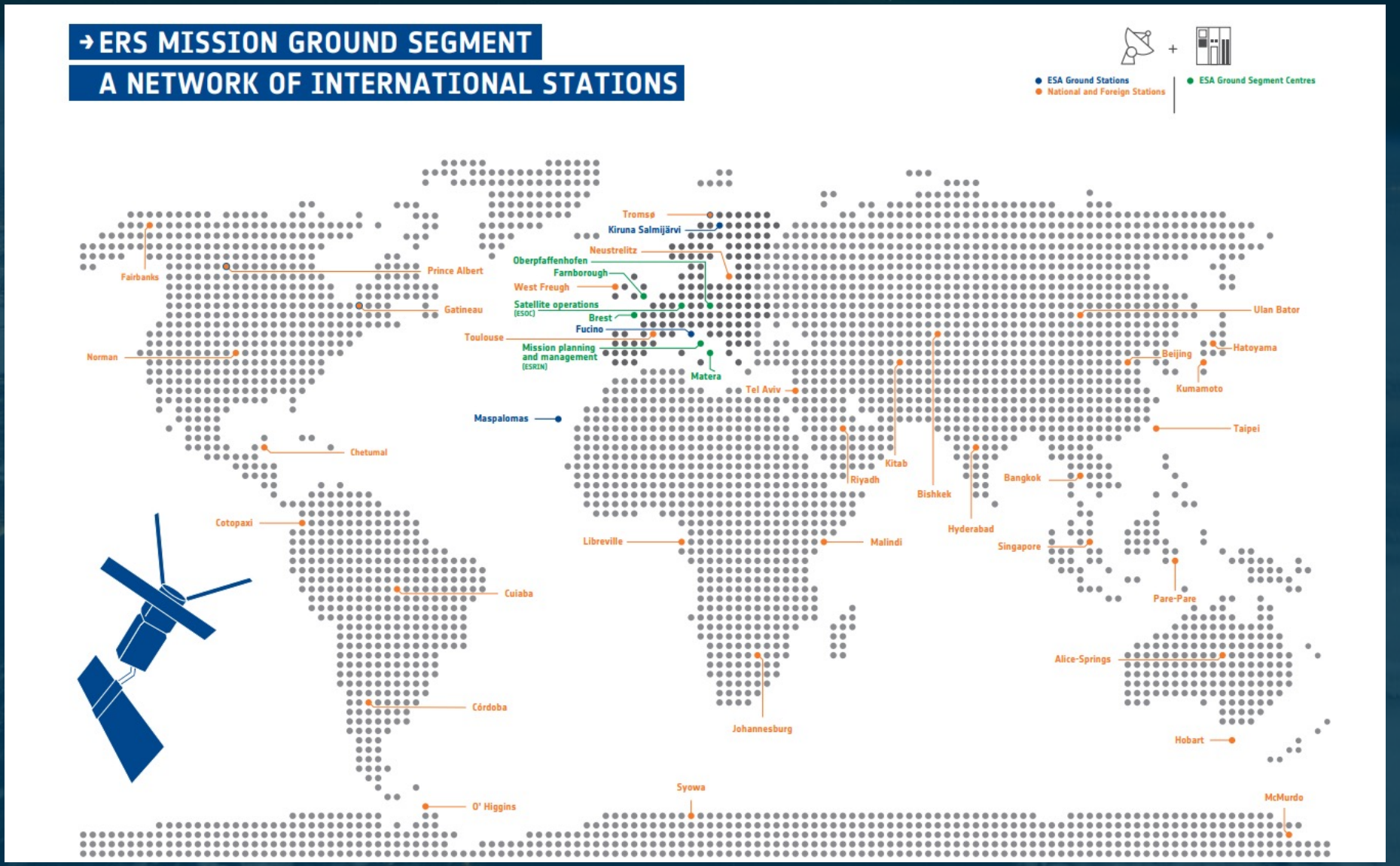
Repatriation

Two main streams:

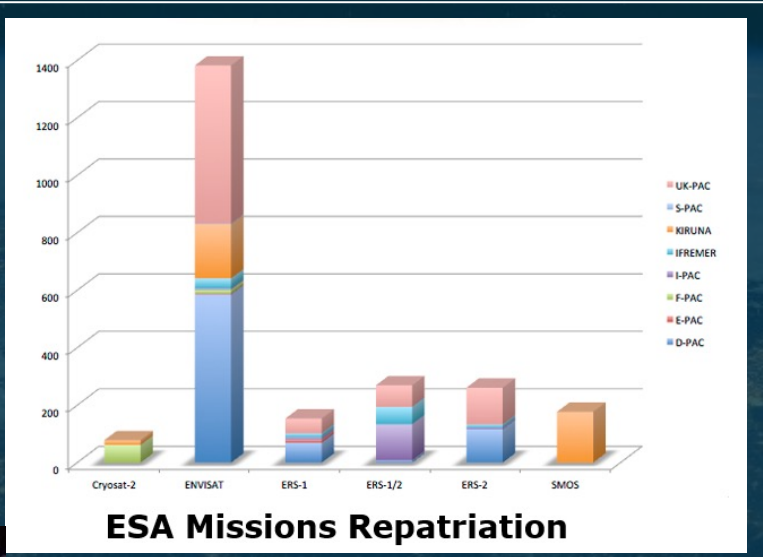
- Phase-out project in 2015 to repatriate from ESA Ground Stations and Processing Archiving Centers (LBR & HR SAR);
- National and Foreign stations repatriation (HR SAR), still ongoing

Focus of the ERS Repatriation projects:

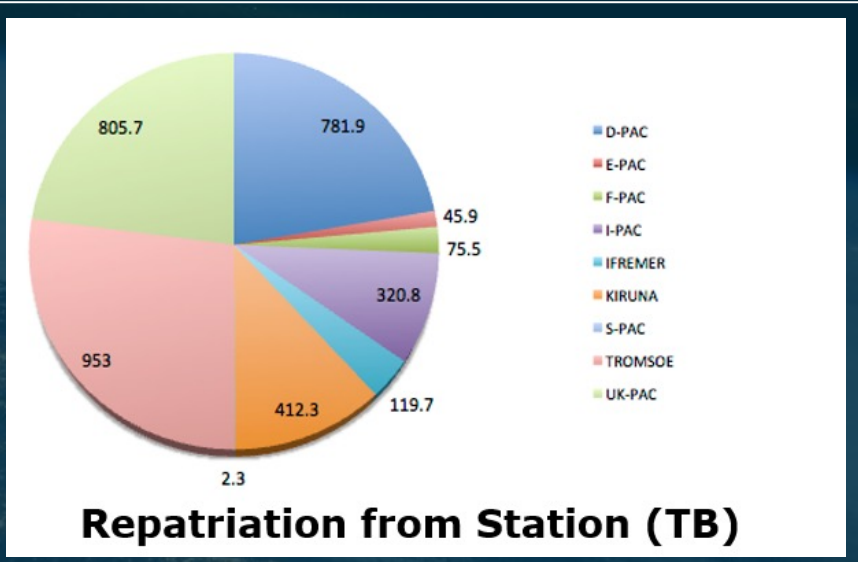
- Data
- Associated Information
- Software
- Hardware
- Media



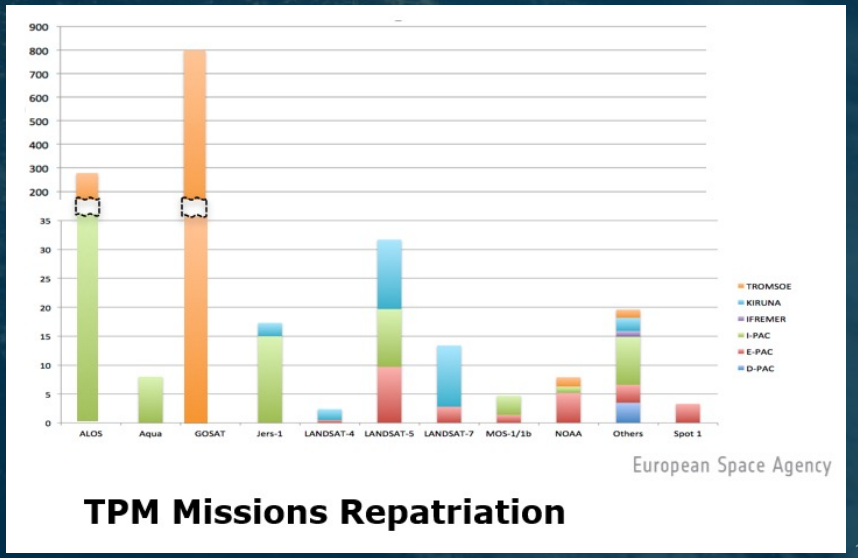
Repatriation Phase-out project: Data



ESA Missions Repatriation



Repatriation from Station (TB)



TPM Missions Repatriation

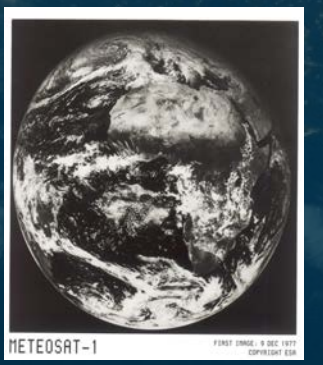
Repatriation Phase-out project: Associated Information

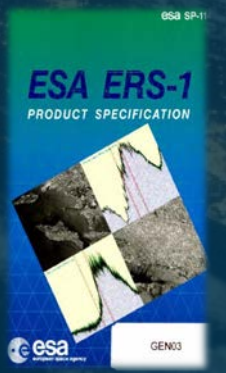
Focus on Information (e.g. documents, databases, etc.) associated with EO data and needed to allow their usability and understandability from broader user communities now and in the future.

- More than 800 kg total weight of non-digital information identified for repatriation, to be digitised and ingested into the Space Data Information Preservation Archive;
- Temporarily stored in Fiano Warehouse (near Rome);
- More that 25 GB (~ 9000 items) of missions information digital objects to be ingested into the Space Data Information Preservation Archive.





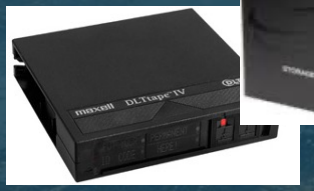





Repatriation Phase-out project: Media Assets





Different Media:

- HDDT
- Sony D1
- Optical Disk
- Exabyte
- LTO
- LTO2
- NAS
- T10000B

ESRIN Tape Archive Capacity before repatriation:

- 5550 Optical Disks
- 50000 Exabyte
- 70000 DLT
- 3600 HDDT

Half full of existing media

Media with (possibly) unique data repatriated from facilities :

- UK-PAC: ~14015 media
- Maspalomas: ~11560 media
- Tromsoe/Svalbard: ~620 media
- IFREMER: ~430 media
- Kiruna: ~170 media
- Matera: ~1160 media
- D-PAC: ~700 media

ERS2 Media Conclusion – Updated 29/04/2016 esa

Internal Distribution Only

Table 2: Summary of ERS2 Media to Keep / Dispose

Facility	Keep (Note 1)	Dispose (Note 1)
UK-PAF	• ERS2 SAR (D1 #1752) / (DLT #2700) • All ERS2 LBR L0 media shipped from ESRIN &/or Matera (N.B. This shall include the DLT media generated at the additional stations after the onboard tape recorder failure). • The UKPAF equivalent copy of the ERS2 LBR media shipped from ESRIN&/or Matera media which failed in the data extraction in UK (approx. EXA & DLT #750) • T10000 media containing ERS2 SAR / LBR Data	• ERS2 WAP (EXA #2694) • ERS2 LBR L0 media (EXA #16420) originally circulated from stations of KS, GS and MS) excluding the UKPAF equivalent copy of ERS2 LBR ESRIN&/or Matera failed media present at the facility.
F-PAF	• The FPAF equivalent copy of the ERS2 LBR media ESRIN&/or Matera media which failed in the data extraction in UK present at the facility (approx. EXA #450).	• ERS2 LBR L0 media (EXA #15468) originally circulated from stations of KS, GS and MS) excluding the FPAF equivalent copy of ERS2 LBR ESRIN&/or Matera failed media. • ERS2 IWA L1 (EXA #14343)
Matera / Fucino	• ERS2 LR HDDTs (currently 15568 will be reduced significantly within June (expected to be < 5000) when open questions and analysis are closed out and the analysis has been done on all instruments. (Note 2) • ERS2 SAR D1 / DLTs until SAR consolidation is completed.	-/-
ESRIN	• VMS Backups EXA& DLT (ERS1 / ERS2) • Missing inventory lists (EXA #2700, DLT #9400 DLT, LTO #90) • All ERS2 LBR / SAR Media • T10000 media containing ERS2 SAR / LBR Data	-/-
KIRUNA	• ERS2 LR HDDTs (currently #25941 can potentially be reduced to < 5000 when questions raised (see earlier slides) are closed out and the analysis has been done on all instruments. Recommendation is to keep the media until at least end 2016.	-/-
DLR	• ERS SAR media (Pending SAR information which will be based on level of consolidation of SAR data and comparisons with ESA catalogue). N.B This shall include T10000 media containing ERS2	• ERS2 LBR L0 media origi stations of KS, GS and M

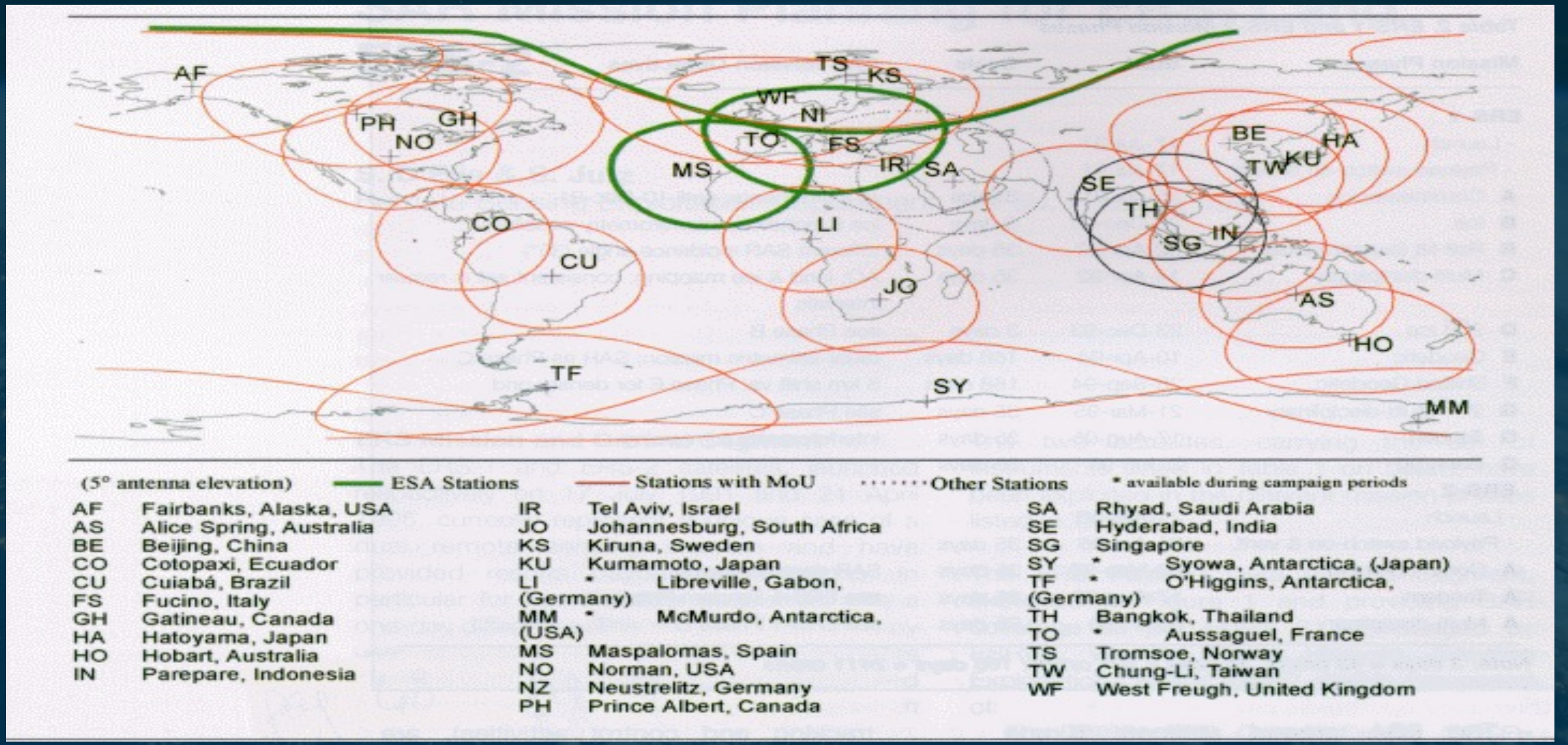

Repatriation Phase-out project: Hardware Assets

ESA Asset id	Hostname	Description	TYPE	Used for ESA ops	USE	Mission	Legacy media type	Dismissio n impa	Remark	Manufacturer	Date of purchase	Serial_number	Model	Possible destination
COD.ESRIN.8762		SIGNAL GENERAROR 2022D	ACQ	YES					1E+07	MARCONI	21/12/2004	119216/023	52022-00	
CODICE ESRIN 40068972		CIEL SERIAL TX/RX	ACQ CIEL	YES					1E+07	CIEL GMBH	01/08/2007	703205	CPCI 270	
COD.ESRIN.9645		CPCI SERIAL RECEIVER	ACQ CIEL	YES	NOT USED				1E+07	CIEL	08/10/2001	99251009	CPCI	
ESRIN.02599		CPCI SERIAL RECEIVER	ACQ CIEL	YES					1E+07	CIEL	08/10/2001	99482024	CPCI	
ESRIN.11066		MASTERIZZATORE/STA MPANTE	CD PRINTER	YES	NOT USED				1E+07	RIMAGE	04/08/2006	U058545	RAS7	
ESRIN.11372		CDR PRINTER	CD PRINTER	YES	NOT USED				1E+07	RIMAGE	13/07/2006	5305026	CDPRS-II	
ESRIN.11025	ex pfs-nas-ma.eo.esa.int	COMPUTER XEON 3GHZ DOPPIO PROCESSORE	PC	YES					1E+07	HEWLETT PACKARD	06/10/2006	8022KJ4B2T	PROLIANT	
COD.ESRIN.10201		CD MASTERING SYSTEM	CD PRINTER	YES	NOT USED				1E+07	RIMAGE	14/06/2005	U032386	CDPR-PC	
COD.ESRIN.10201		MASTERIZZATORE	CD PRINTER	YES	NOT USED				1E+07	RIMAGE	04/07/2005	U031929	RAS4	
NEPTUNE.564554		MASTERIZZATORE/STA MPANTE	CD PRINTER	YES	NOT USED				1E+07	RIMAGE	19/11/2004	U041825	RAS7	
NEPT.ID 702573	storage1-ip	STORAGETEK 6410 ARR	DATA STORAGE	YES					1E+07	SUN	10/12/2008	0751EGQ116	9843	
NEPT.ID 702775	storage1-ip	STORAGETEK 6410 ARR	DATA STORAGE	YES					1E+07	SUN	10/12/2008	0812DHG0K8	9843	
NEPT.ID 702823	storage1-ip	STORAGETEK 6410 ARR	DATA STORAGE	YES					1E+07	SUN	10/12/2008	0812DHG0HD	9843	
COD.ESRIN.10049		CD MASTERING SYSTEM	CD PRINTER	YES	NOT USED				1E+07	RIMAGE	24/07/2006	U030171	CDPR-PC	
COD.ESRIN.10049		MASTERIZZATORE	CD PRINTER	YES	NOT USED				1E+07	RIMAGE	24/07/2006	U030214	RAS4	
NEPT.ID 755542	CSDS-01	CIEL SERIAL TX/RX	ACQ CIEL	YES		Landsat 1-5 MSS, MOS	HDDT		1E+07	CIEL GMBH	03/10/2008	80403	CPCI 270	
ESRIN.7362	HDDR#1	HDDR	RACK PENNY & GILES	YES		ERS-1/2 LR	HDDT		1E+07	PENNY & GILES	04/04/2007	832	SE 9000	Of potential interest for data re-processing
CODICE ESRIN.9494	mpsctr2-fuc	WORKSTATION	WORKSTATION	YES	NOT USED				1E+07	SILICON GRAPHICS	26/10/2001	0800690C623D	O2	Repatriation in progress for LTDP
COD.ESRIN.10268		WORKSTATION	WORKSTATION	YES	NOT USED				1E+07	SILICON GRAPHICS	14/06/2005	080069100E71	O2	Repatriation in progress for LTDP
COD.ESRIN.09358		WORKSTATION	WORKSTATION	YES					1E+07	SILICON GRAPHICS	14/06/2005	08006B95A4F0	O2	To be disposed of at the end of operations
COD.ESRIN.09430		WORKSTATION	WORKSTATION	YES					1E+07	SILICON GRAPHICS	14/06/2005	69D1AA1	CMNA018	To be disposed of at the end of operations
COD.ESRIN.0294		TTL-ECL-CONVERTER	ECL	YES		Landsat 1-5 MSS, MOS	HDDT		1E+07	ACS	21/12/2004	MAESA001	TTL-ECL	Of potential interest for data re-processing
ESRIN.4834 asset 2200000011		HDDR	RACK SCHLUMBERGER	YES		MOS			1E+07	ENERTEC-SCHLUMBERGER	04/04/2007	40	ML 2601	Of potential interest for data re-processing

Repatriation of Hardware:

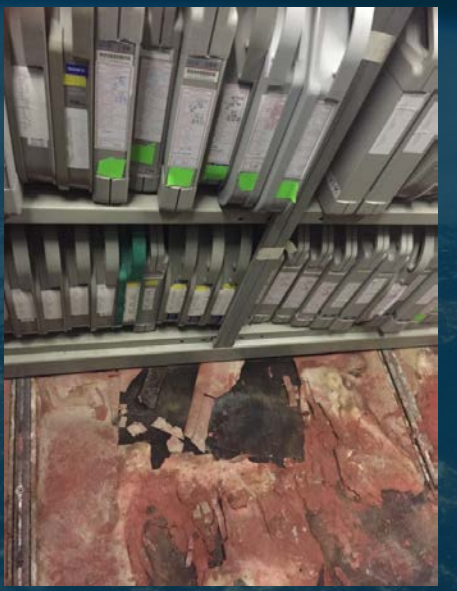
- D-PAC: 20 items
- Maspalomas: 23 items
- Tromso: 6 items
- Svalbard: 5 items
- Kiruna: 23 items
- UK-PAC: 104 items
- Matera: 29 items
- F-PAC: 1 item

Repatriation from National & Foreign Station: on-going



Repatriation Memories

Repatriation Memories



Transcription

The EO Heritage Media Archive located at ESRIN and the warehouse in Fiano store today several thousand legacy media containing data from ESA and TPM missions that could be potentially re-transcribed with the goal of filling gaps in the available datasets. In addition the content of several hundred tapes is unknown.

Full inventory of the available tapes has been finalized and priorities for transcription projects defined. Projects implemented through services provided by industry (when available) or through set-up of dedicated transcription chains at ESRIN.

Transcription chains being set-up at ESRIN:

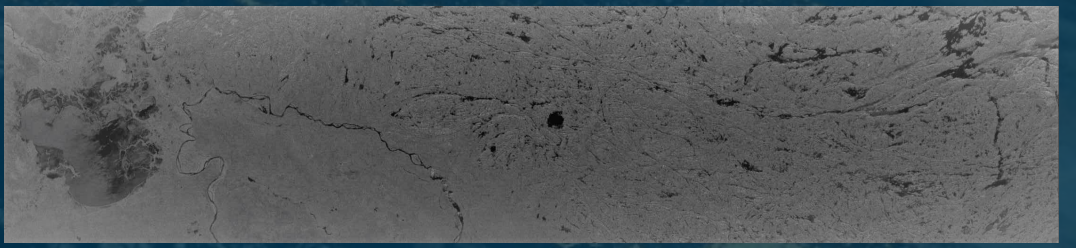
- CS-DIS chain able to transcribe data from missions like Landsat, ERS, MOS and MODIS by connecting suitable HW media readers to the chain (e.g. HDDT, DLT, Exabyte, D1)
- ERS specific transcription chains for data acquired at ERS Foreign Stations (e.g. CCMEO)
- NOAA AVHRR and NIMBUS-7 Optical Disk Chains

Ongoing transcription projects with industry (examples)

- Re-transcription of about 6.5 thousand heritage tapes (HDDTs) containing ERS-1/2 low-rate data for additional gap filling in the master datasets is ongoing at the Matera station in Italy. Activities are currently halted due to a failure with the HDDT reader. Additional tapes will be shipped to Matera from the external warehouse outside ESRIN in the next quarters, pending repair work on the faulty HDDT hardware.

- Repatriation from INPE of 800 HDDT tapes containing unique ERS SAR data acquired at Brazilian stations to ESRIN and then to Matera for transcription.

- Several hundred D1 media containing unique ERS SAR data from Canadian stations were identified at CCMEO and about 400 passes are being extracted through a resumed chain and repatriated to ESRIN. One sample has been successfully ingested in the CS-DIS legacy processing environment at ESRIN to generate the corresponding L0 data products.



- Projects with other missions (AVHRR, NIMBUS, SPOT)

- Identification and evaluation of potential additional ERS SAR L0 data to be repatriated from other National Foreign Stations will be carried out after the completion of the repatriation of media from INPE.

Consolidation and Certification

Data repatriated, data transcribed and data already available and archived at ESRIN were used as input to a ***Consolidation and Certification*** process, mostly carried out in 2016-18, which analysed the level of completeness of all ERS instruments datasets to generate “Level-0 Master Datasets”

ERS Data Screening

- Creation of Master, Segregated and Corrupted listing files
  - Corrupted products: Issue observed reading the ADF
  - Segregated products: Issues observed during the consistency checks or duplicate products (not unique in terms of temporal coverage - start date-time / end date-time)
  - Master products (Unique or overlapped products with the most recent creation date)
- Gap analysis & completeness computed using satellite first acquisition/last acquisition as full nominal coverage.
- Creation of final Master listing file

ERS Data Cleaning and Master Data Set Generation

- “Removal” of corrupted files
- Alignment and harmonisation of the data coming from different sources (e.g., file naming, format, packaging)
- Merging of Data into a single Master Data Set

ERS Master Data Set Verification

- Final gaps identified against actual consolidated dataset

Consolidation and Certification Results

ERS SAR Master consolidation overall results	2016	2022
Estimated completeness ERS-1 (data coverage vs recorded unavailabilities)	82%	95%
Estimated completeness ERS-2 (data coverage vs recorded unavailabilities)	88%	97%

Sensor / Type of product	Estimated completeness % (data coverage vs recorded unavailability's)
RA / ERAC	97.82%
MWR / EMWC	97.83%
SWM / EWAC	93.56%
WSC / EWIC	96.06%
ATSR-1 / RATSR	99.50%
Telemetry / EGH	96.69%

Sensor / Type of product	Estimated completeness % (data coverage vs recorded unavailability's)
RA / ERAC	96.53%
MWR / EMWC	97.56%
SWM / EWAC	84.62% (*)
WSC / EWIC	86.16% (*)
ATSR-2 / EATC-2	91.51%
GOME / EGOC	98.95%
Telemetry / EGH	82.74%

Reprocessing

Reprocessing activities are performed with the goal to:

- Improve data quality (e.g. new algorithms, new auxiliary files)
- Align heritage mission dataset to new missions (e.g. Sentinels) using new IPFs/algorithms to generate long time data series (e.g. climate)
- Change data format to facilitate usability and better exploit modern technologies/tools (e.g. Data Cubes);
- Ensure compliance to CEOS Analysis Ready Data (ARD) specifications.

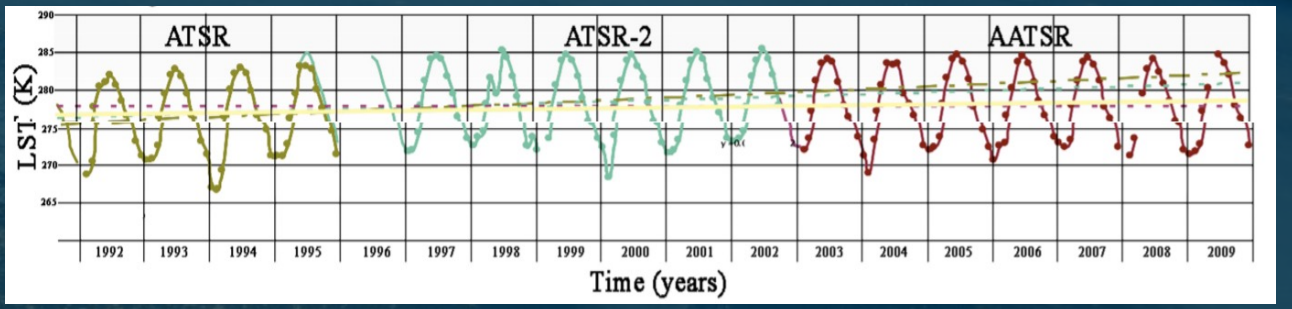
Mission	Instrument	Product type	
ERS	AMI/SAR	SAR_IMM_1P	
ERS	AMI/SAR	SAR_IM__BP	
ERS	AMI/Scatterometer	WSC_ASP_15	
ERS	AMI/Scatterometer	WSC_ASH_2P	
ERS	AMI/Scatterometer	WSC_ASN_2P	
ERS	AMI/Scatterometer	WSC_HEY_1P	
ERS	AMI/Scatterometer	WSC_UWI_2P	
ERS	ATSR-1/2	ATS_TOA_1P/AT_1_RBT	
ERS	ATSR-1/2	ATS_TOA_1A	
ERS	AMI/SAR	SAR_IMM_1P	Snow-CCI

ERS Full (Re)processing activities

Reprocessing (examples)

ATSR-1/2, Fast v2.05, 4th reprocessing completed

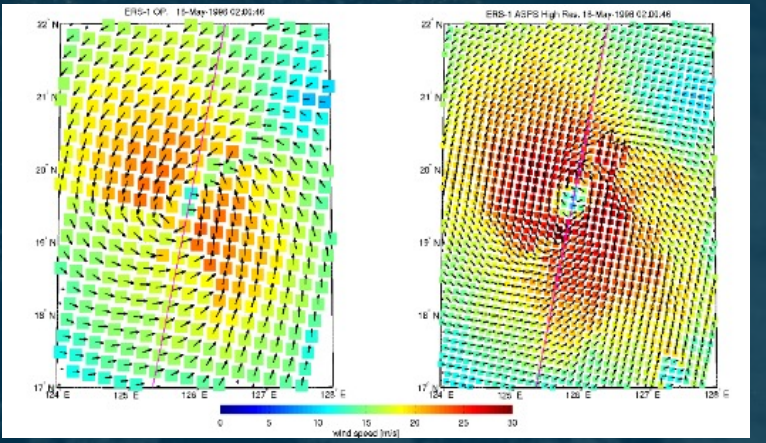
- Harmonisation with Envisat AATSR and Sentinel-3 SLSTR
- Ortho-geolocation (toward ARD)
- Calibration, incl. 12 micrometers correction
- Cloud Masking
- Uncertainties



Land Surface Temperature ATSR-1, ATSR-2, (A)ATSR time series

ERS-1/ERS-2 SCATT ASPS v10.04 L1/L2 Reprocessing completed

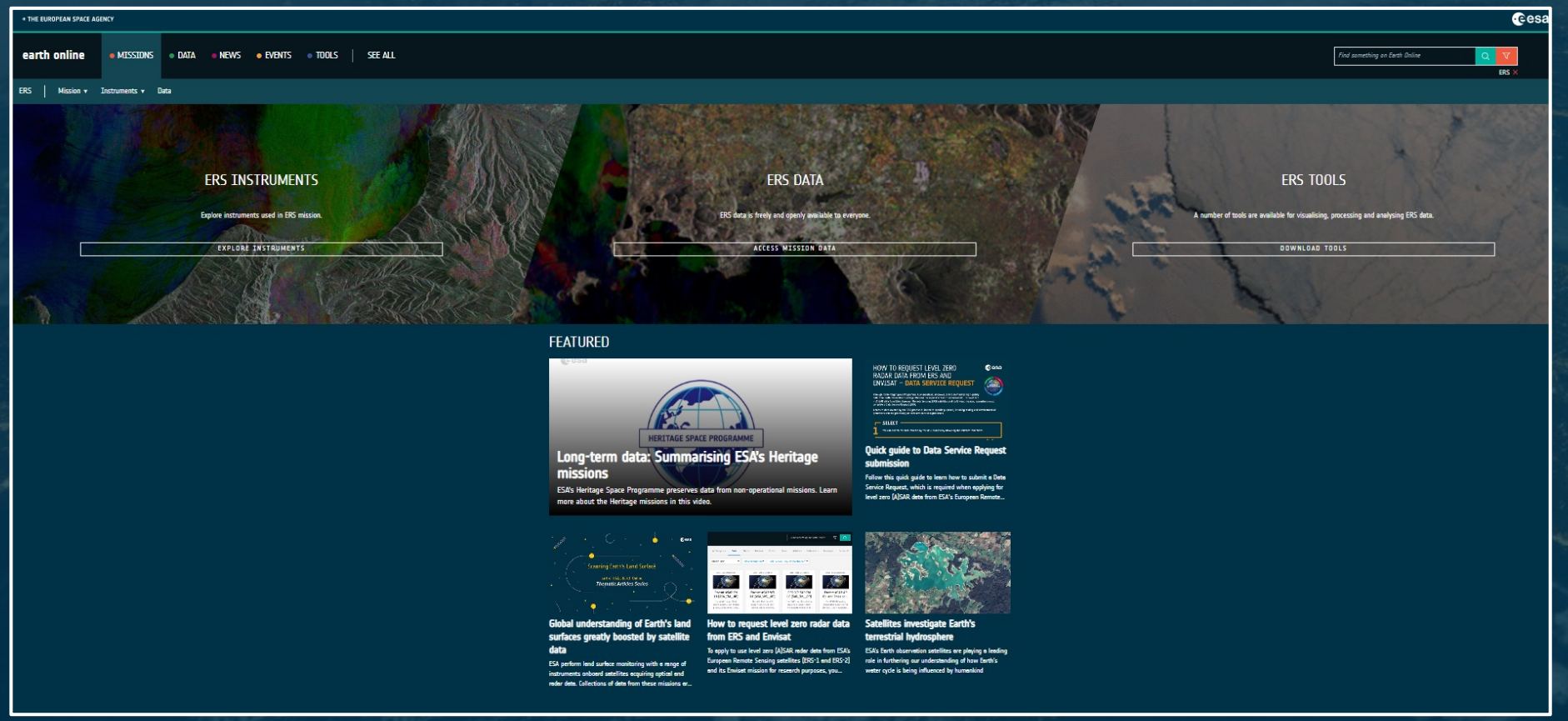
- Incl. Re-fined calibration of the 3 backscattering measurements, CMOD5N geophysical forward model, Sea-ice probability, sea-ice flag



ERS-1 *observation of Typhoon Bart occurred on May 1996: left picture is from ERS-1 operational product (UWI) with 25 km grid spacing; right image is from high resolution product (ASPS H) with 12.5 km grid spacing (from 2017 EUMETSAT Meteorological Satellite Conference – S. Pinori)*

Access and Exploitation

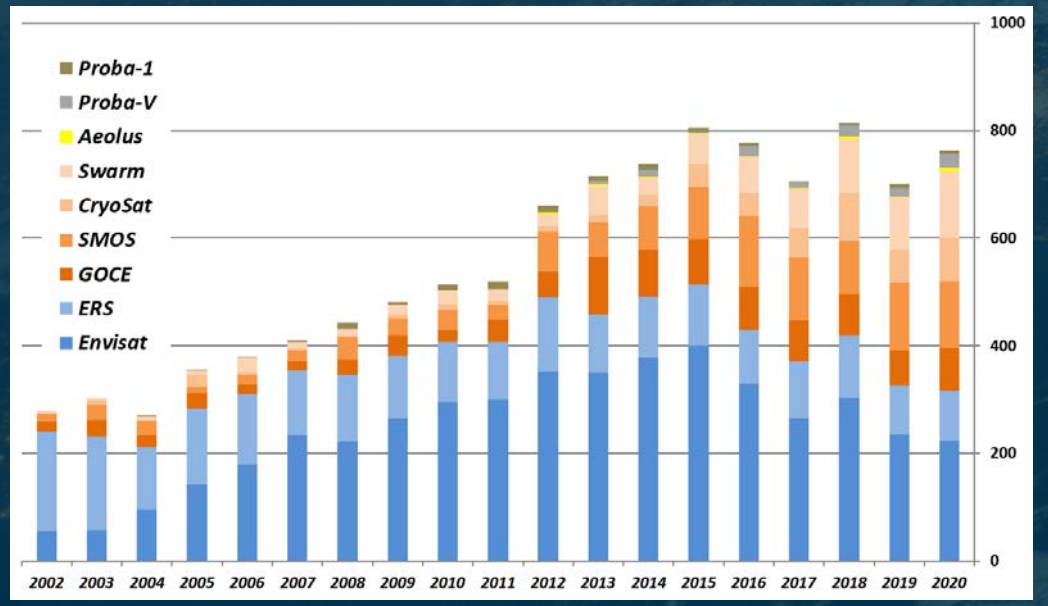
All ERS data products are accessible through the ESA catalogue and dissemination systems on an open and free basis for all users in accordance with ESA Earth Observation Data Policy, together with tools for their exploitation.



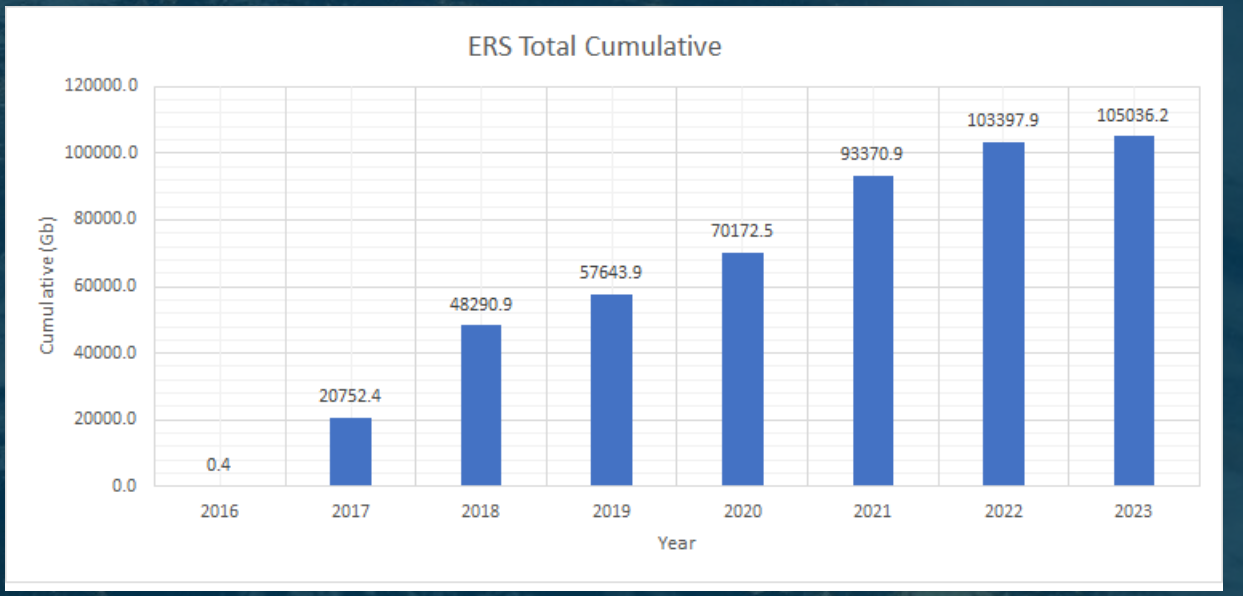
For each available ERS datasets a Landing Page is generated and published on the ESA EO Web Site with the relevant Digital Object Identifier (DOI).

Data and Users

During their lifetime, ERS data supported over 5000 projects producing some 4000 scientific publications. Archived data still to this day provide us with a wealth of information. They are maintained accessible and are continuously improved in the frame of the ***Heritage Space Programme*** to build long time data series with successor missions like Envisat, Earth Explorers and the Copernicus Sentinels.



Publications

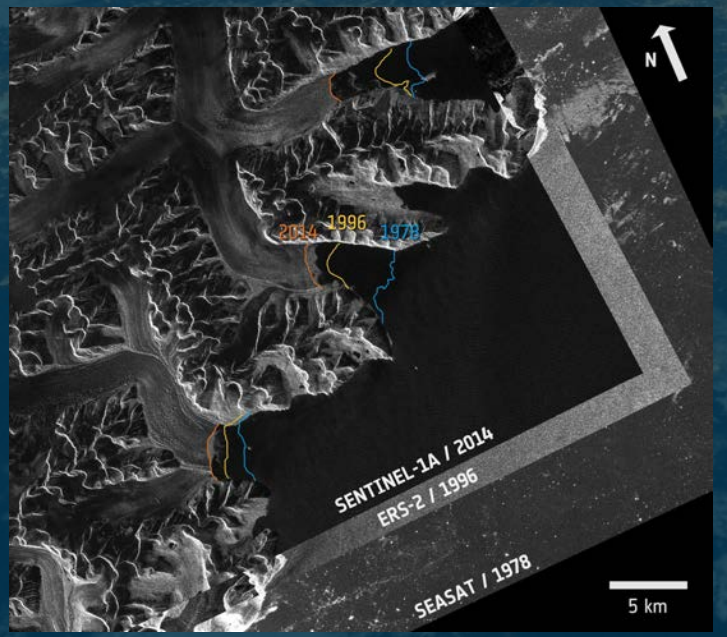


ERS Data download in the recent years

https://earth.esa.int/eogateway/missions/ers/data

ERS data use: 36 years of radar vision

Comparing data from three generations of radar missions – Seasat, ERS and Sentinel-1 – the retreat of two large glaciers in southeast Greenland over a 36-year period is evident in the image below.
This preliminary analysis shows that the effects of climate change on the world's second largest ice sheet have had a major impact over the past three decades. The glaciers show significant retreat, with the upper glacier receding by about 5.5 km over the past 36 years. This melt is contributing to sea-level rise and the release of more freshwater into the North Atlantic.



The efforts to retrieve, consolidate and reprocess the ESA Seasat and ERS SAR data holdings were carried out under the Heritage Space Programme.

Valorisation

Several ***Valorisation*** activities have and are still being implemented to improve quality of ERS data using new algorithms and processors in alignment with newer missions (e.g. Sentinels). Beside improvement of single datasets, innovative approaches for data valorization are being implemented through the concepts of Fundamental Data Records (FDR) and Analysis Ready Data (CEOS-ARD).

A FDR is a unified and coherent set of single sensor type re-calibrated and inter-satellite calibrated Level1 data. The FDR concept allows to ensure long-term preservation and valorisation of data, to improve calibrations and uncertainty estimates and reduce multi-mission bias. It facilitates data harmonisation, interoperability and continuity, and is a transparent and fully documented approach supporting new applications and services for a wider user community.

CEOS Analysis Ready Data (CEOS-ARD) are satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis with a minimum of additional user effort and interoperability both through time and with other datasets.

ESA FDR4* projects

- Generating ESA-specific **multi-mission long-term datasets**
- Relevance for several applications and ESA Climate activities

Fundamental
Sensor data
(Level 1)

FDR

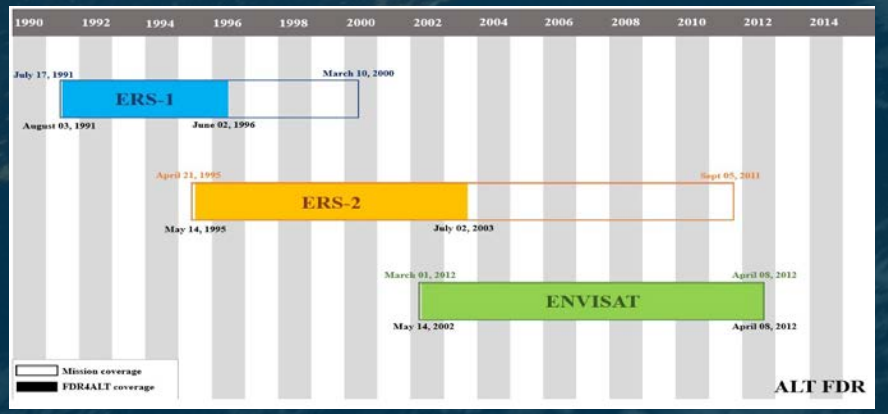
TDP

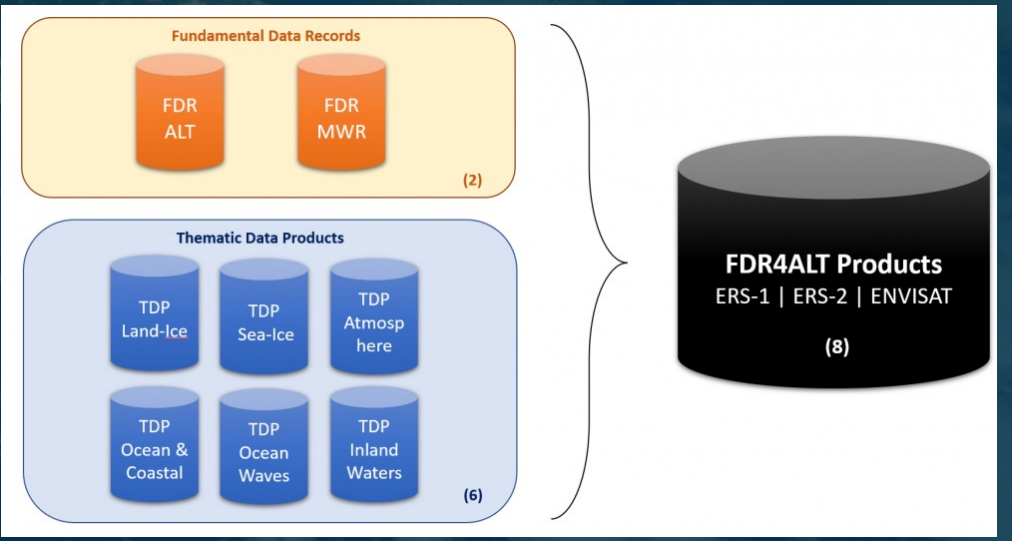
Thematic
Geophysical parameters
(Level 2+)

- Two **projects** started in 2019 with 3-year duration
  - **for Altimetry: FDR4ALT** https://www.fdr4alt.org
  - **for Atmospheric Composition: FDR4ATMOS** https://atmos.eoc.dlr.de/FDR4ATMOS

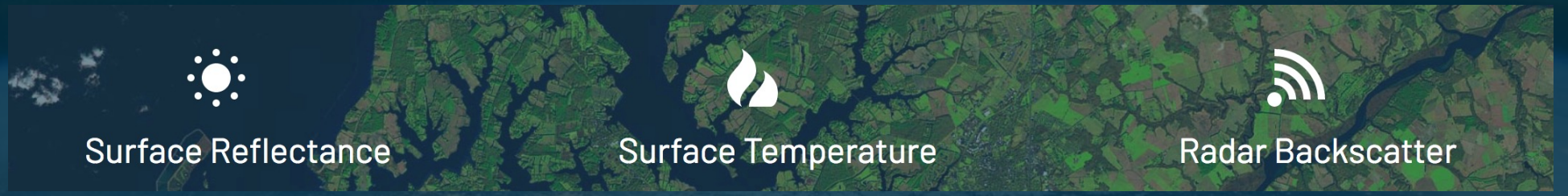
Key aspects

- Pursue **harmonization** of different sensors and improve calibrations
- **Uncertainty characterization** based on EO metrological guidelines
- Target a **wider user community**
- Allow **interoperability** and continuity towards current & future missions





CEOS Analysis Ready Data



CEOS-ARD SR	CEOS-ARD ST	CEOS-ARD NRB
Sentinel-2 Proba-V MERIS	Sentinel-3 (A)ATSR	Sentinel-1 (A)SAR

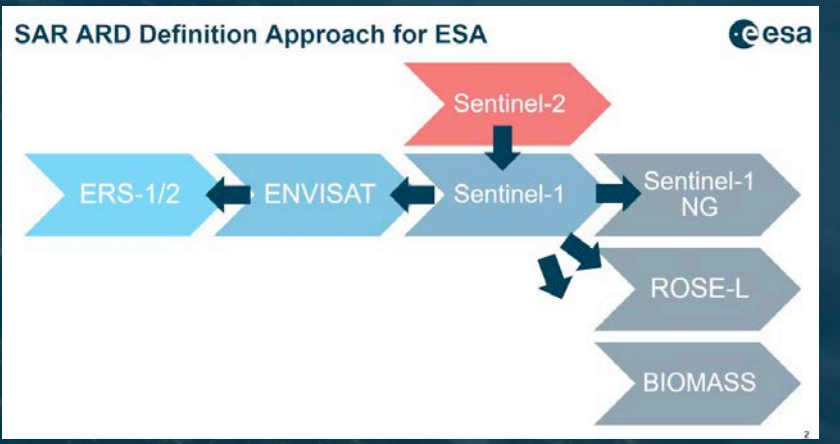
CEOS: «Analysis Ready Data are satellite data that have been processed to a minimum set of requirements and organised into a form that allows immediate analysis with a minimum of additional user effort and interoperability both through time and with other datasets.»

ERS and Envisat Surface Reflectance, Surface Temperature and Radar products specifications have been assessed against the CEOS Analysis Ready Data (ARD) specifications to identify potential improvement activities to allow data from ESA Heritage Missions to become compliant with CEOS ARD requirements.

Analysis Ready Data Projects for ERS/Envisat

SAR ARD Project (example)

- Alignment of CEOS ARD products for ERS/Envisat (A)SAR to those of an under development enhanced Sentinel-1 product
- Calibrated with RTC (Radiometrically Terrain Corrected), denoised, projected over Copernicus DEM, geolocated ➔ *Immediate analysis!*
  - *Challenge for ERS:* **Geometric Accuracy Improvement Study** using PATN Time Correlation File
- Same gridding / tiling system, and Copernicus 30m DEM than Sentinel-1 ➔ *Interoperability!*
- Cloud-Optimised GeoTIFF, VRT, XML and STAC ➔ *Cloud-computing compliant!*
- Open source processor (prototype and operational) ➔ *Open science compliant*



Lessons Learned

Plan for long term preservation from the Mission Concept Stage / Phase A, to ensure that preservation policies and approaches are applied since the beginning and followed throughout the mission lifetime.

→ Better results, reduced cost

Ensure that a measured and monitored process is achieved for data archiving, data migration/transcription, data consolidation and quality control (e.g. following CEOS guidelines)

Preservation:

1. Properly preserve data (more than one copy) and ensure archive technology migration.
2. When data are stored on media, properly preserve the main information (e.g. start/stop date and time, orbit number, path, etc.) throughout the entire mission lifetime.
3. Preserve other data associated information (e.g. station acquisition reports, inventories, etc.) and software in line with internationally recognized standards and Best Practices.

Lessons Learned

4. Physical Media Archives (if media available) must be a well controlled environment (humidity, temperature, etc.).

5. Maintain functionality of media reading/transcription chains (hardware and software) including spare parts for old technologies for the media available in the archive (or potentially coming from other sources).

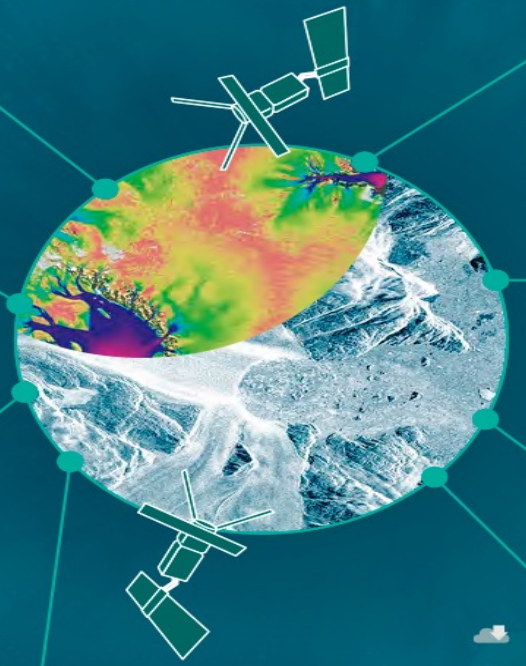
6. Media refreshment is recommended (if data kept on media): performed for ESA missions and some TPMs (e.g. HDDTs → DLTs/Exabytes). However, we have identified some media (e.g. Pegasus tapes containing Landsat data), for which the reader is missing.

7. Think twice before disposing original media after transcription: in case of data loss (e.g. due to a failed transcription), data can still be rescued from these media. This was possible in several cases with ESA and TPM missions data in the recent years (thank to the fact that original media and transcription chains were kept).

Celebrating 30 years of ERS

What?

The **European Remote Sensing (ERS)** satellite programme was composed of two missions, **ERS-1** and **ERS-2**



When?

Launched on **17 July 1991** and **21 April 1995**, on Ariane-4 rockets from Europe's Spaceport in Kourou, French Guiana, with same sun-synchronous polar orbit at about 780 km altitude

Applications

The satellites circled Earth **over 120,000** times in total, continuously observing and monitoring our planet's land, atmosphere, oceans and ice caps, while supporting scientific research, operational services and applications in several domains

Heritage Value

Both satellites far exceeded their design life of **three years**, with ERS-1 ending in 2000 and ERS-2 in 2011. Today data are accessible and enhanced as part of the **Heritage Space Programme**, together with data from other missions

Instruments

ERS-1 and ERS-2 were the most advanced and complex satellites of their time, delivering an **enormous volume of data** to Earth through a comprehensive set of instruments, including:

- An imaging synthetic aperture radar (**SAR**)
- A radar altimeter (**RA**)
- A water vapour measuring microwave radiometer (**MWR**) and a temperature-measuring radiometer (**ATSR**)
- An ozone monitoring spectrometer (**GOME**) – on ERS-2 only

Built by?

Designed and built by an international consortium of European industries led by **DSS (Dornier Satelliten Systeme GmbH)**

Data and Users?

ERS data supported **over 5,000** projects producing some **4000** scientific publications. Archived heritage data still provide a wealth of information, and are continuously improved to build harmonised, long time data series with successor missions like Envisat and Copernicus Sentinels

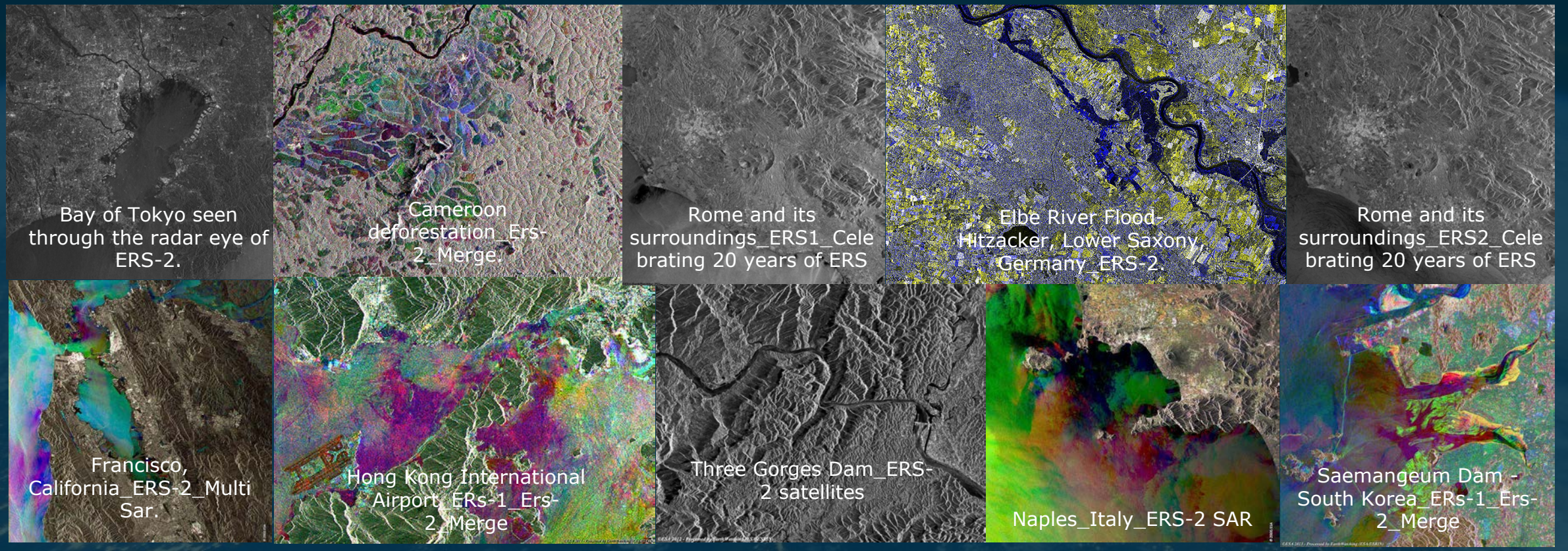
Innovation

A tandem mission was implemented following the launch of ERS-2, which shared the **same orbit** as ERS-1. This enabled an accurate, **three-dimensional digital map** of Earth's land surfaces and allowed to detect small changes on Earth's surface with a range precision of 1 cm, opening **new fields of applications**.

Data Access

https://earth.esa.int/eogateway/missions/ers/data

For more information visit:
https://earth.esa.int/eogateway/missions/ers


Bay of Tokyo seen through the radar eye of ERS-2.
Cameroon deforestation_Ers-2_Merge.
Rome and its surroundings_ERS1_Celebrating 20 years of ERS
Elbe River Flood-Hitzacker, Lower Saxony, Germany_ERS-2.
Rome and its surroundings_ERS2_Celebrating 20 years of ERS
Francisco, California_ERS-2_Multi Sar.
Hong Kong International Airport_ERs-1_Ers-2_Merge
Three Gorges Dam_ERS-2 satellites
Naples_Italy_ERS-2 SAR
Saemangeum Dam - South Korea_ERs-1_Ers-2_Merge

Thank you !!!!!