EO Missions: Preservation, Discoverability and Valorisation

Heritage Data Programme (LTDP+)

CCI Collocation meeting

ESA-ESRIN, 5 October 2016

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ESA: Pioneers in Earth Observation

ESA has been dedicated to observing Earth from space ever since the launch of its first meteorological satellite, **Meteosat-1** in 1977

ESRIN is ESA's Earth Observation centre: the world's largest database of environmental data for Europe and Africa is managed from ESRIN

More than 25 years of continuous measurements from space available for many geophysical parameters: *LONG TIME DATA SERIES*

Need to:

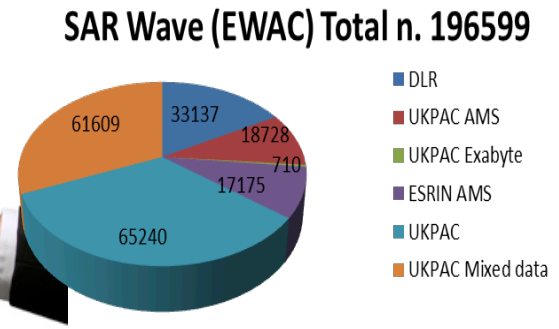
- ***Preserve, keep discoverable & accessible with latest technology***
- ***Continuously improve to ensure fitness for purpose and continuity / comparability with present and future missions data (e.g. Sentinels).***

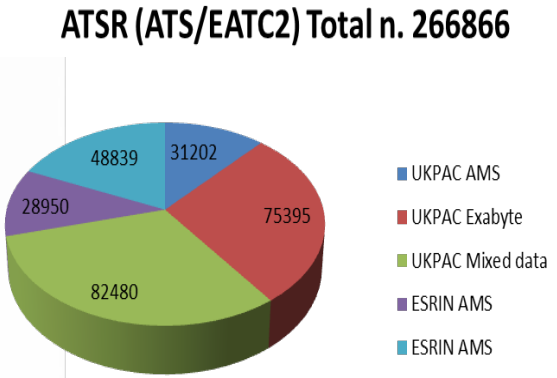
Long Term Data Preservation (LTDP) Programme

- The issue of preserving and keeping accessible ESA Heritage EO data was:
  - Recognised for the first time at ESA CMIN in 2008
  - Enlarged to *all heritage data from space* at ESA CMIN in 2012

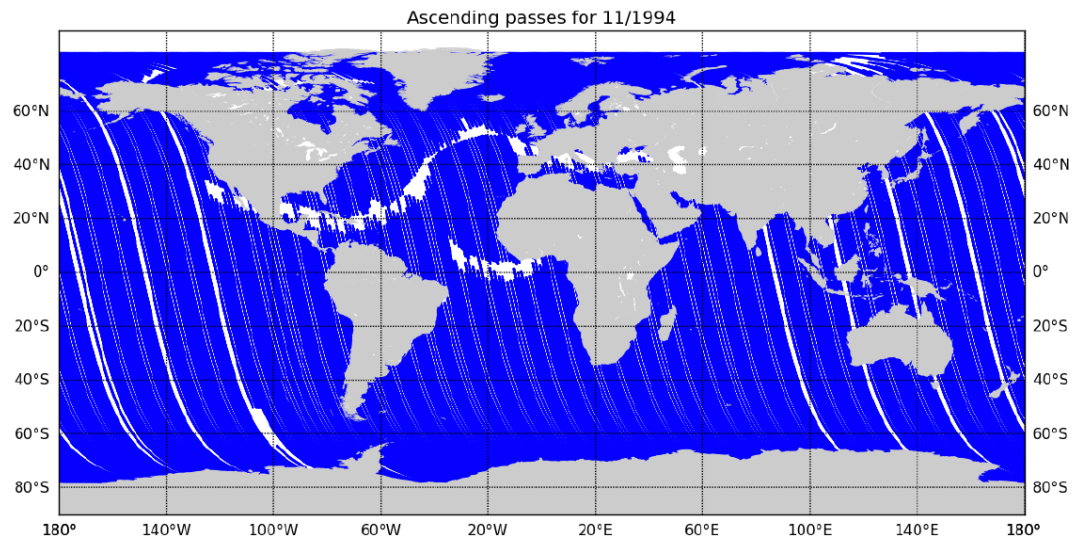
- The restricted budget envelope approved in 2012 forced to focus during 2013-2016 on a very *limited set of requirements*:
  - ***Preventing the unrecoverable loss*** of unique ESA heritage data holdings
  - Performing ***data consolidation & valorisation*** activities *for a selected subset of Earth Observation data*
  - Providing ***basic access*** and maintaining ***international cooperation*** on data preservation at a ***collaborative level***

Heritage EO Data recovery and consolidation

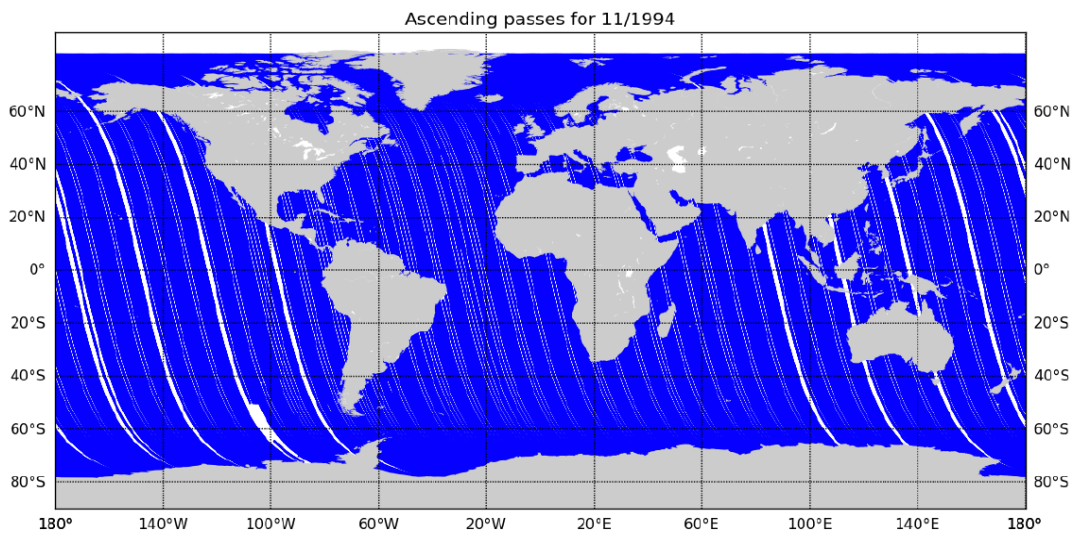




Consolidation example: ERS-1/2 Level-0 LBR Instruments and SAR Master Dataset Generation



ERS-1 ERAC LBR gaps visible in the limit of visibility of ground stations



Data gaps filled through re-transcription of 10000 HDDTs.

Heritage EO Data Knowledge Preservation

National Archiving centres shared by ESA

Knowledge Assets

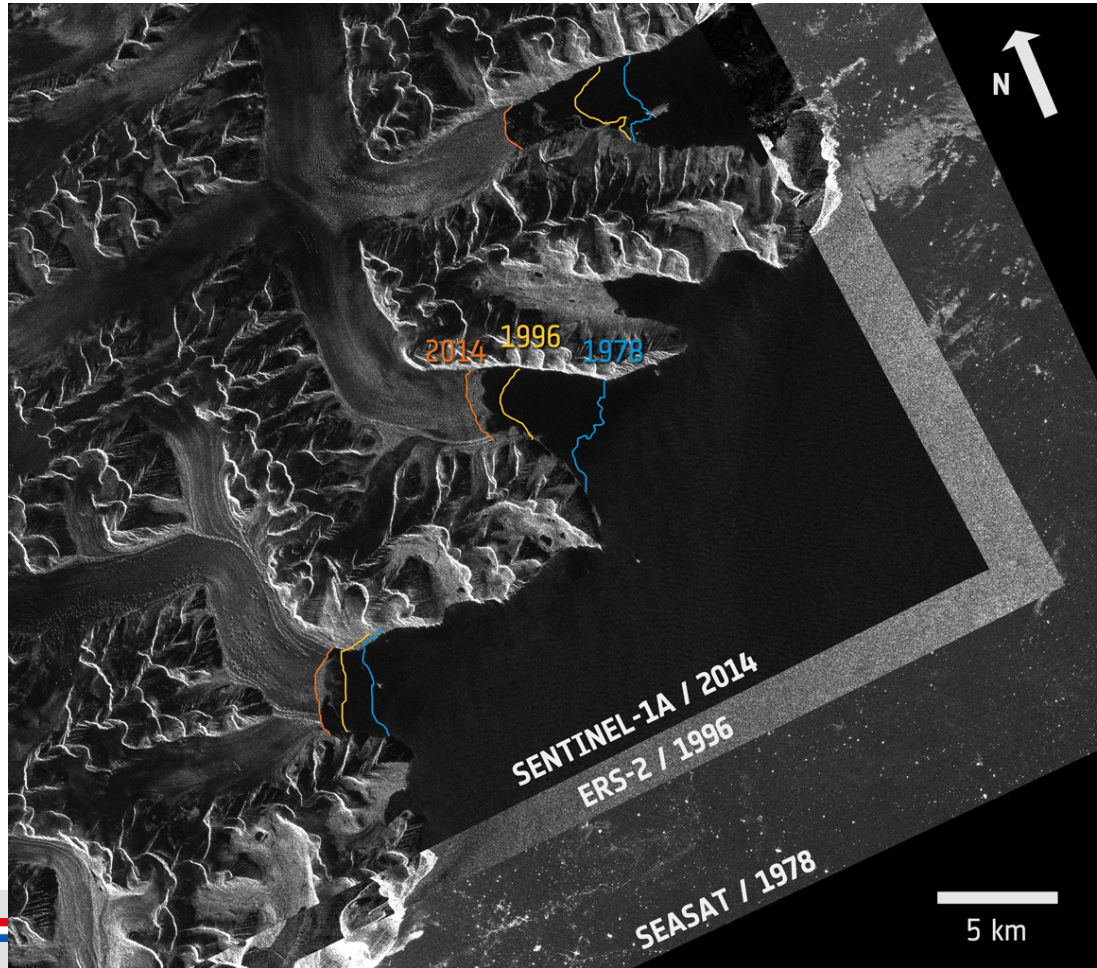
Knowledge Management System (KMS) and Media Archive (MA)

Valorisation example → SEASAT SAR data recovery:
→ Greenland glaciers as seen by 3 generations of radar missions

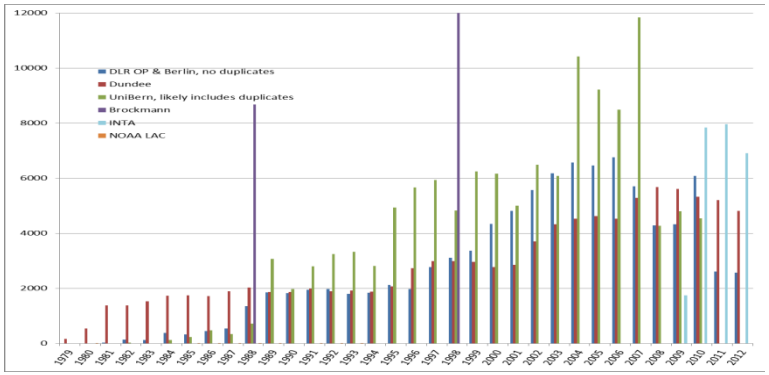
Seasat L-band SAR ESA data holdings (European coverage Jul-Oct 1978) fully recovered and accessible online for the first time ever. SEASAT, ALOS and JERS-1 data aligned to generate a long time data series in L-band.

Comparison of images from Seasat on 16 August 1978, ERS-2 on August 1996 and Sentinel-1 on 20 August 2014 to map the retreat of two large glaciers in southeast Greenland over a 36-year period.

Retreat has been estimated at a rate of about 180 m/yr (top glacier) and 61.5 m/yr (bottom glacier)

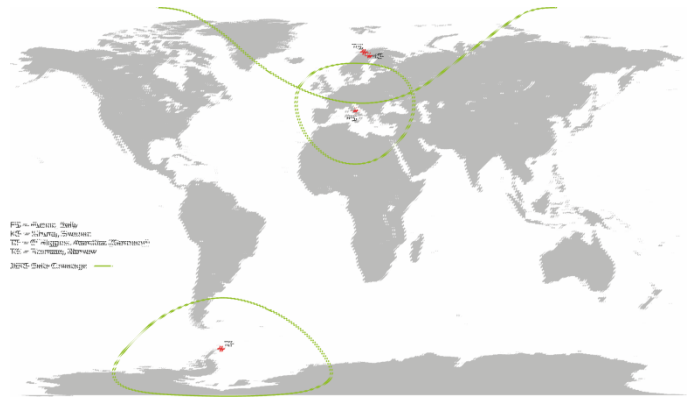


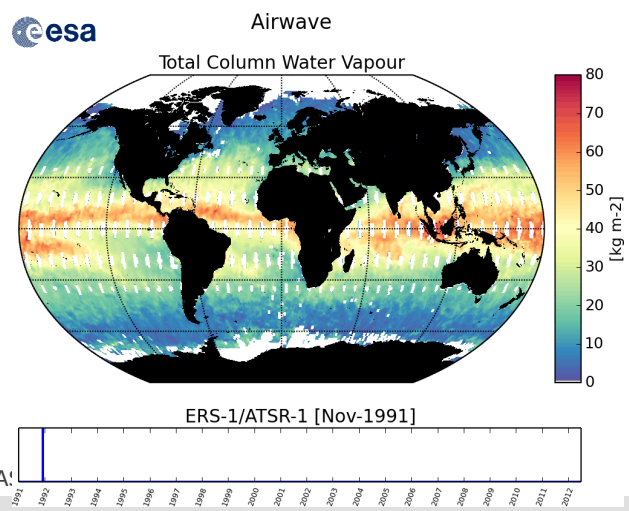
Valorisation pilots → AVHRR, JERS, ERS



Curation project for the generation of a the longest possible time series of AVHRR data over Europe.

Full reprocessing of JERS-1 L-band SAR and OPS data; alignment with SEASAT and ALOS data (L-Band SAR time series).





"Long Term Stability of the ATSR Instrument Series":

- Verify the Short Wave Infra-Red (SWIR) channel calibration across all three ATSR instruments, and prototype and validate revised methods as needed.
- Propose new scheme for cloud and Total Column Water Vapour (TCWV) retrieval.

Next to come

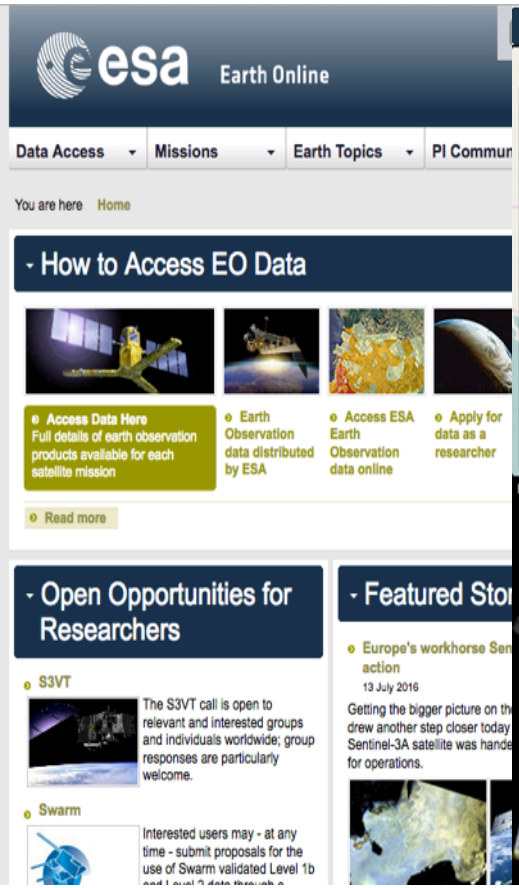
1. Marine Observation Satellites MOS-1 & MOS-1b
   - Feb 1987 – Nov 1995 & Feb 1990 – April 1996
   - MESSR (Multi-Spectral Electronic Self-Scanning Radiometer)
   - VTIR (Visible and Thermal Infrared Radiometer)

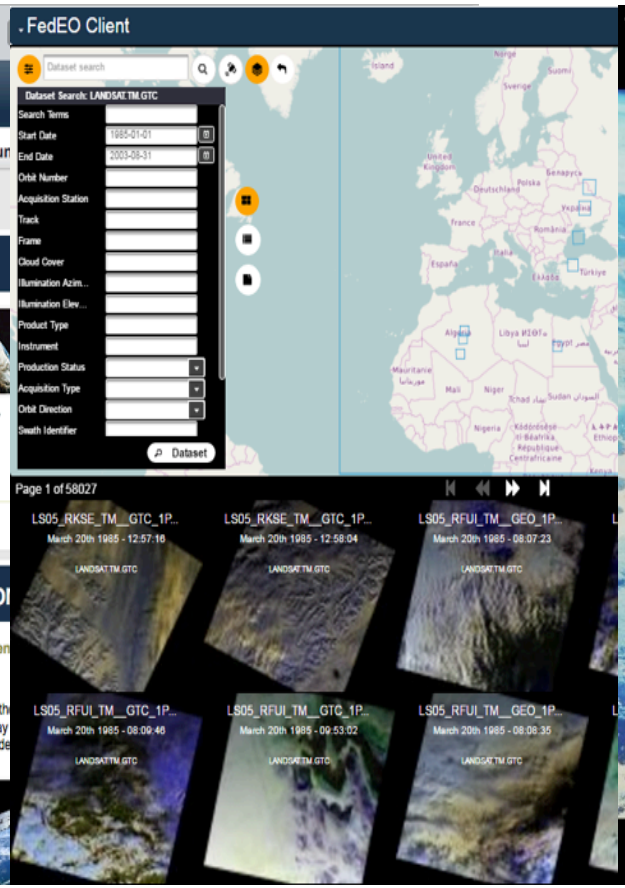
2. Nimbus-7
   - Nov 1978 – Jun 1986
   - Coastal Zone Color Scanner (CZCS)

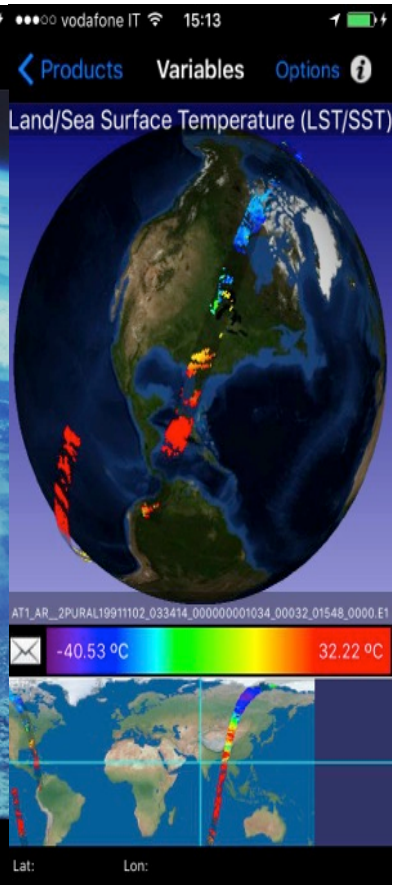
3. Adeos-1
   - Aug 1996 – Jun 1997
   - OCTS (Ocean Colour and Temperature Scanner)

4. SPOT-1 & SPOT-2
   - Feb 1986 – Dec 1990 & Jan 1990 – Jun 2009)
   - HRV (High Resolution Visible) & HRVIR (High Resolution Visible IR)

Heritage EO Assets Discovery and Access







Cooperation in CEOS and GSCB for heritage data recovery

Data Set	Mission(s)	Sensor(s)	Mission Owner	Data Set Location
Ozone profiles from 30 to 110 km	EURECA	ORA	ESA	Belgian Institute for Space Aeronomy (TBC)
Grille vertical profiles	Spacelab 1; ATLAS-1	Grille (Infrared Spectrometer)	Spacelab 1: NASA-ESA ATLAS-1: NASA	Belgian Institute for Space Aeronomy (TBC)
Deuterium and Hydrogen atomic concentrations	ATLAS-1	ALAE	NASA	Unknown (Sensor Owner: CNRS)
Solar spectral irradiance	Spacelab 1; EURECA; ATLAS missions	SOLSPEC	Spacelab 1: NASA-ESA EURECA: ESA ATLAS missions: NASA	Institut Pierre Simon Laplace (TBC)
ESMR data sets from the polar regions	Nimbus-5	ESMR	NASA	NASA (NSIDC - National Snow & Ice Data Center)
ESMR Imagery of Brightness Temperature on 70 mm Film	Nimbus-5	ESMR	NASA	GSFC - Goddard Earth Science Data and Information Services (GES DISC)
SeaSat SMMR data	SeaSat	SMMR	NASA/JPL	JPL Physical Oceanography DAAC

Initial draft list complied through user feedback

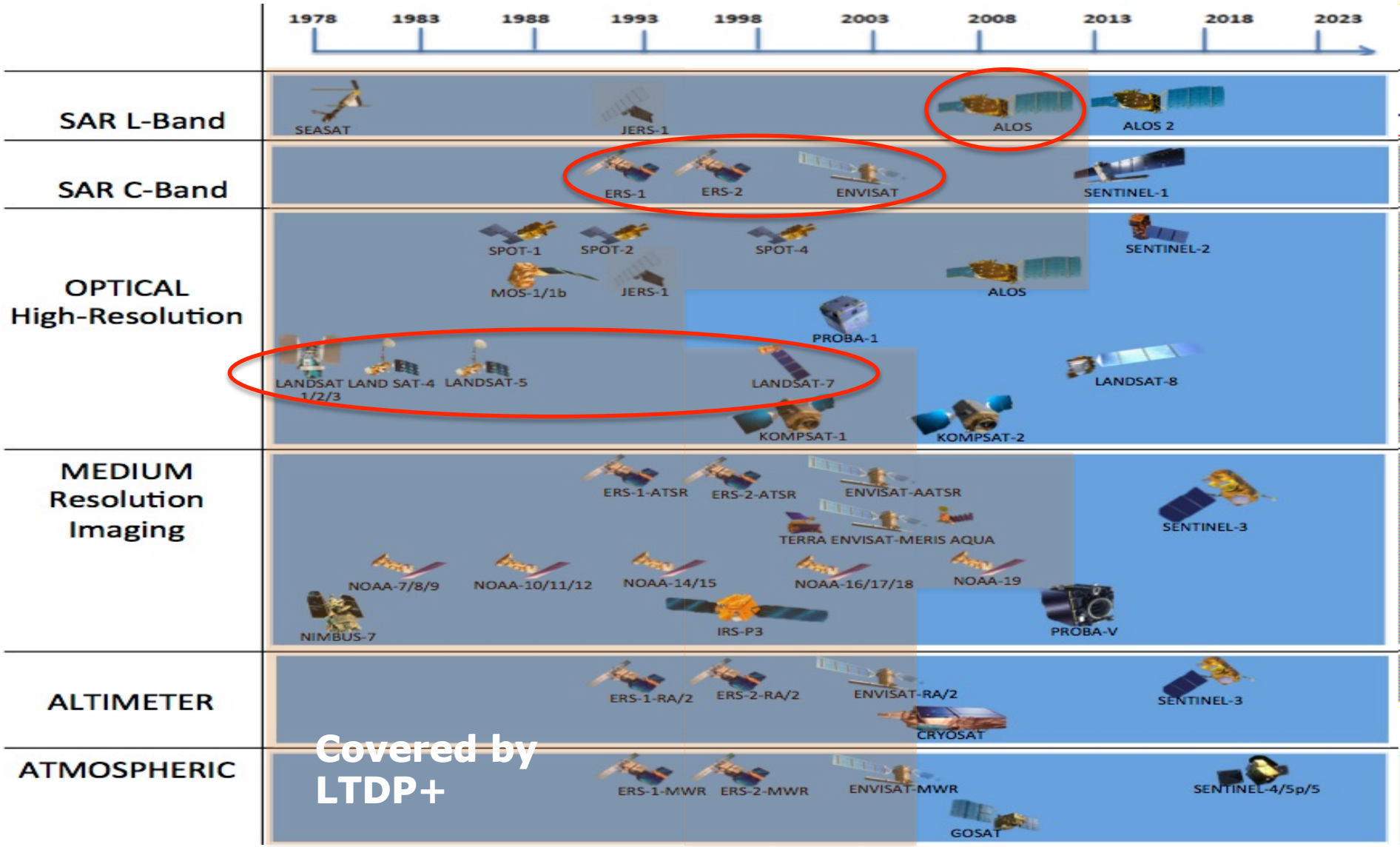
CEOS WGClimate requested to help in identifying additional datasets of interest for ECVs generation (and extension back in time) which were acquired in the past but are not accessible today.

Heritage Data Programme LTDP+ → proposed at CM-16

- ***Basic Activity*** within ESA DG proposal for the Level of Resources (2017-2021)
- Will be implemented in cooperation ***across four ESA Directorates*** (EOP, SCI, HRE, OPS) and with data owners and users in MSs
- ***Will consolidate and extend*** LTDP programme achievements to:
  - secure ***state-of-art preservation of all ESA heritage data assets*** and associated information, and to prevent loss of data from (non-ESA) missions at risk and judged of European interest
  - ensure continuous ***quality improvement and valorisation of data from a growing number of Earth Observation missions to maximise usability and impact,*** to provide continuity with current & future missions, and to enable multi-disciplinary applications
  - ensure heritage ***data discoverability and accessibility*** to users relying on latest ICT technology to facilitate exploitation and broader data use
- Will consist of ***Joint Activities*** coordinated by D/EOP, and of ***Specific Activities*** implemented independently by each directorate

heritage data programme
ltdp+

ESA EO Long Time Data Series (excerpt)



Heritage Data Programme (LTDP+) EO Specific Implementation Activities → the elements

1.Data preservation

*Secure **preservation of all:***
*- **ESA heritage data assets &** associated information*

Prevent loss of *non-ESA EO data* at risk and judged of European long-term interest

International Cooperation

2.Data improvement and valorisation

*Ensure **quality improvement of EO heritage data** for continuity with current/ future missions, multi-disciplinary applications & broader data use*

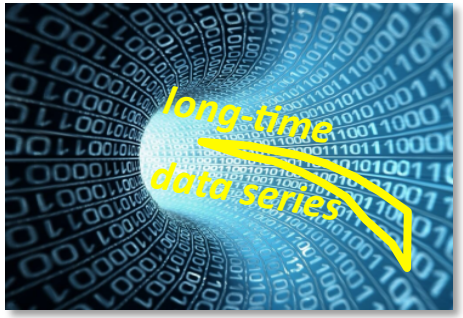
Build **long time series of coherent data &** data collections for specific applications (e.g. reprocessing)

Generate **Fundamental Level 1 Data Records (FDRs)** combining archived data assets (heritage and current) from National & ESA EO Missions

3.Data discoverability & accessibility

*Ensure **data accessibility and usability** relying on latest ICT, tools and services as expected by users.*

Ensure maximum possible valorisation (e.g. data analytics), including through Exploitation Platforms.



Fundamental Data Records (FDRs) in the frame of the Heritage Data Programme (LTDP+)

- Generation and management of ***Fundamental Earth Observation Data Records (FDRs)*** needed for land, marine, atmosphere, solid Earth and climate research.

  → combination of heritage and current data from ESA and national EO missions

- *A FDR is defined as a unified and coherent set of single sensor type re-calibrated and inter-satellite calibrated Level 1 data*.

  → basis for higher level products and parameters generation

- FDR must be maintained in the long term → better characterization, recalibration, science knowledge evolution, format change, algorithm change, alignment with new missions, etc

- FDRs must be accessible and usable with latest ICT and tools

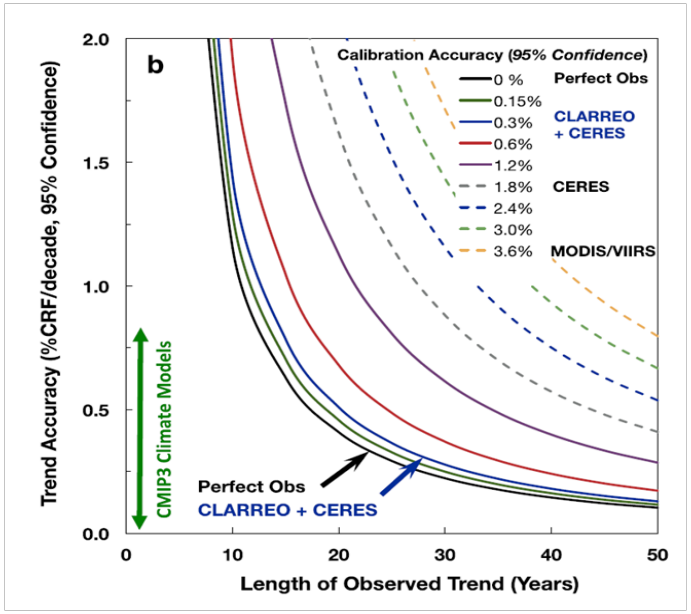
FDR - Fundamental Data Record – illustration 1
Long term, quality, traceable characterisation, accuracy

LTDP+ → Making Heritage DATA usable for Societal Challenges

How the length of the time series required to detect a significant climate trend for a particular climate variable increases with decreasing accuracy of the satellite observations.
The figure shows the dramatic effect of instrument accuracy on both climate trend accuracy and the time to detect trends (Wielicki, et al., 2013). For example, it would take at least 12 years of **perfect observations** to detect a trend of 0.8% per decade in cloud radiative forcing.

The Three Laws of Climate Change (Bruce Wielicki NASA)

Accuracy, Accuracy, Accuracy



Higher Accuracy Observations
→
narrowed uncertainty
15 to 20 years earlier

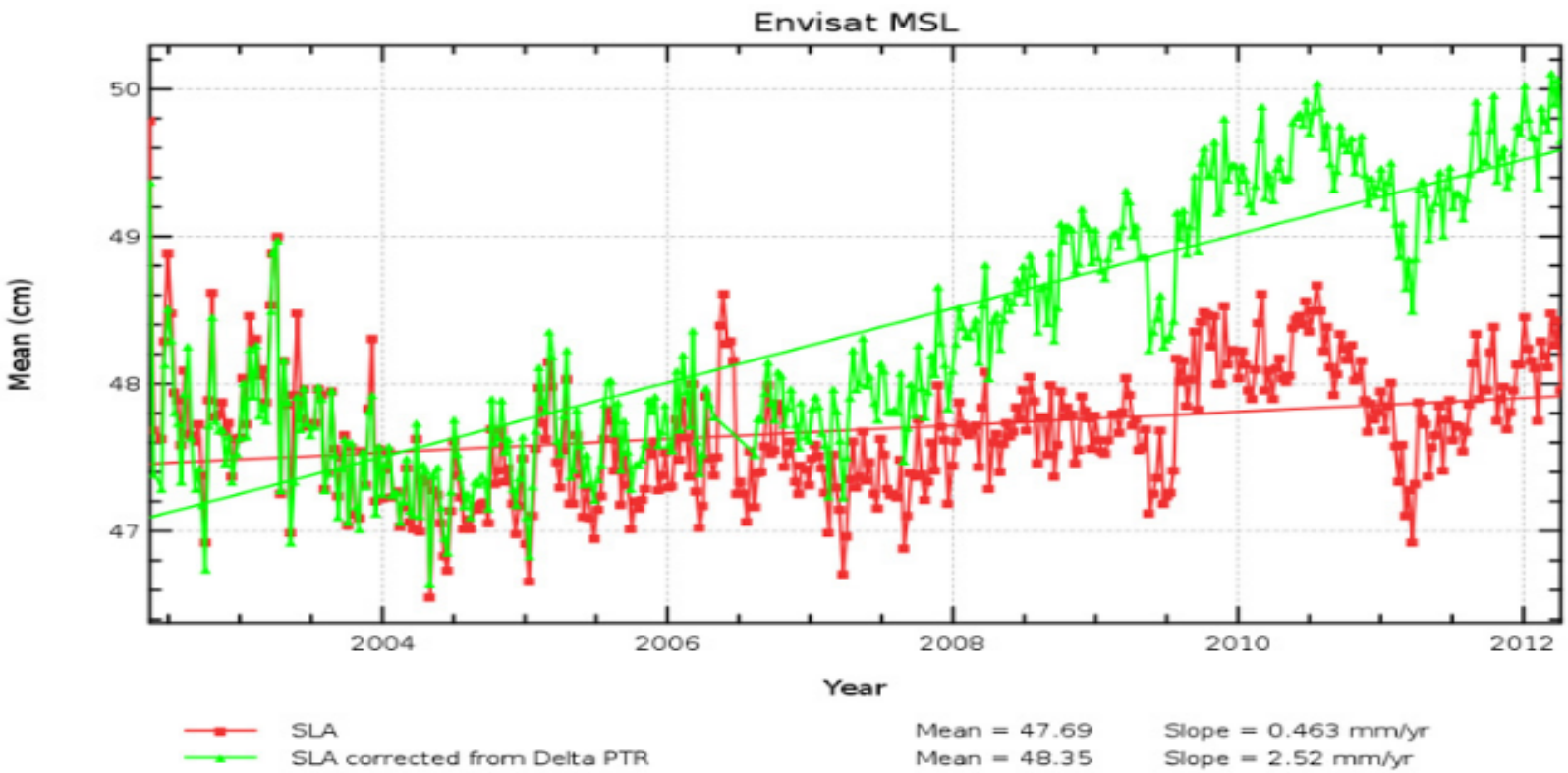
→ ***HUGE ECONOMICAL IMPACT For Society***

Ref: ***WCRP Climate Sensitivity, and Challenge Workshop, March 23-28, 2014***
Bruce Wielicki

FDR - Fundamental Data Record – illustration 2
Long term, quality, traceable characterisation, accuracy

LTDP+ → Enabling 1st step in the transformation of DATA into Information and Knowledge

Mean Sea Level
Example with Envisat

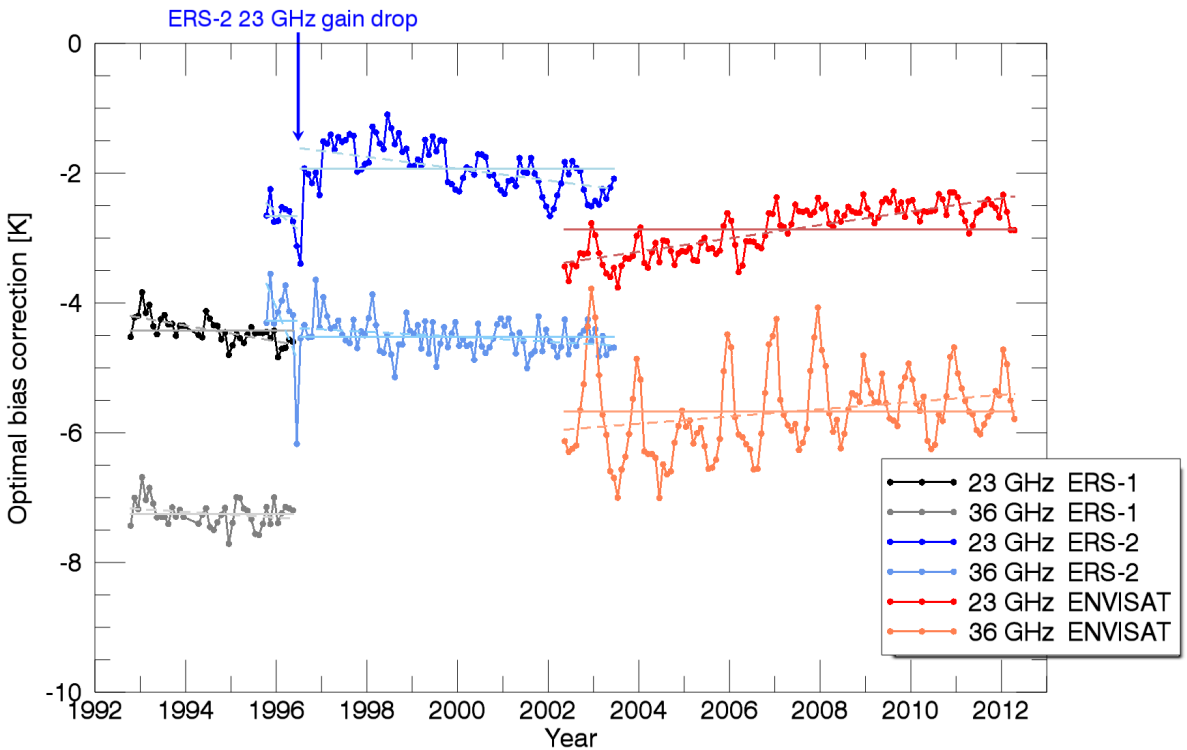


FDR - Fundamental Data Record – illustration 3
Long term, quality, traceable characterisation, accuracy

LTDP+ → Heritage EO DATA is bridging past, present & future (of SPACE 4.0)

ERS/Envisat MWR Recalibration and Water Vapour FDR Generation

- Calibration discontinuities between the three MWRs instruments (ERS-1, ERS-2, Envisat) on the order of 2 K were identified and corrected for.
- Inter-calibration approach developed needed for ERS-1, ERS-2, Envisat, **<u>and Sentinel-3.</u>**

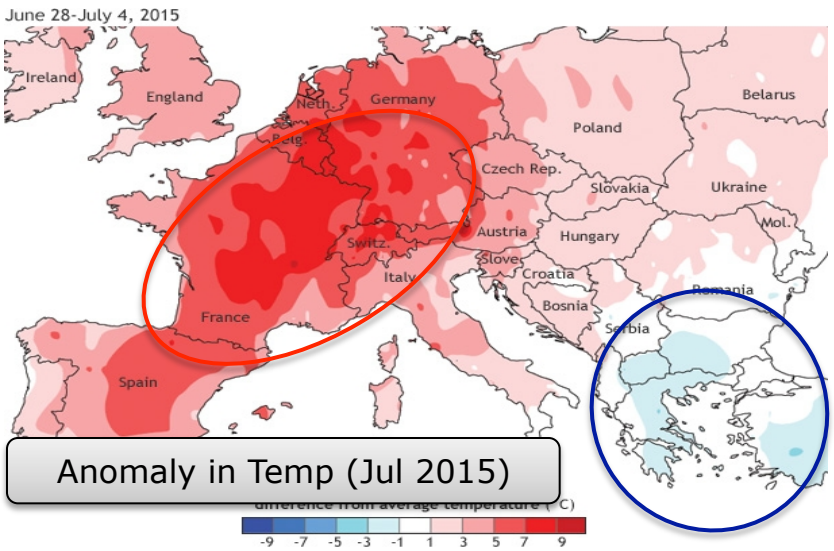


→ Inter-calibration is of crucial importance for the generation of FDRs.

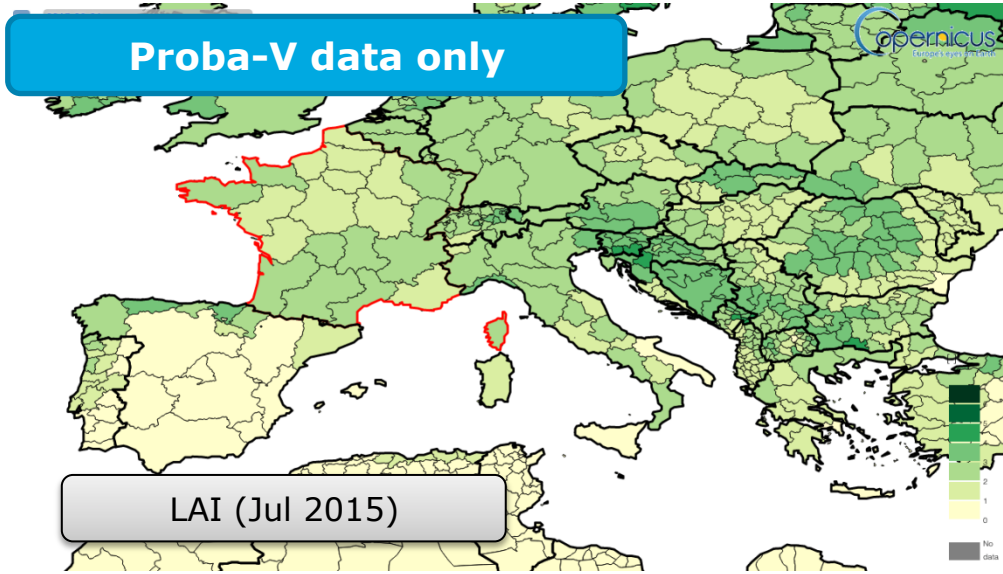
FDR - Fundamental Data Record – illustration 4
Long term, quality, traceable characterisation, accuracy

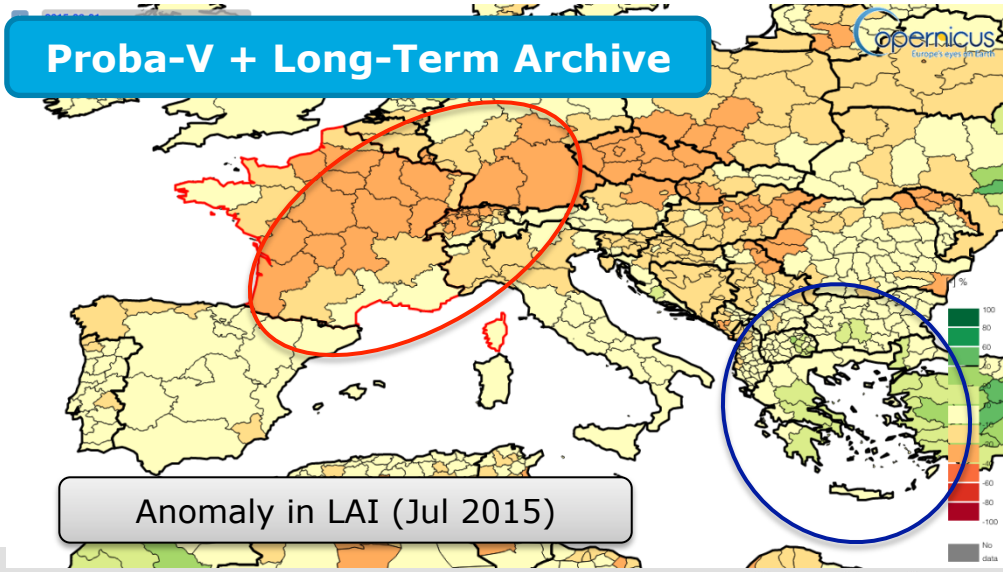
SPOT-VGT – Proba-V Added Value of Long-Term Archive

- Long-Term Archive of accurately calibrated and characterized products is needed not only for climate, but also for operational applications
- Impact of 2015 Europe heat wave could be detected only if we analyze Proba-V data with respect to the averaged values from SPOT-VGT 15 years' archive



Anomaly in Temp (Jul 2015)





Fundamental Data Records (FDRs) in the frame of the Heritage Data Programme (LTDP+)

ESA EO data holdings can be used to build the following FDRs:

1. **Radar Altimeter data series**: ERS, Envisat, CryoSat, Jason(s) (providing continuity with Sentinel-3);
2. **Passive Microwave Radiometers data series**: ERS, Envisat, Jason(s) (providing continuity with Sentinel-3);
3. **Atmospheric Chemistry and Composition (nadir-viewing) data series**: ERS/MetOp GOME/GOME-2, Terra-MOPPIT, Envisat SCIAMACHY, OMI, GOSAT (providing continuity with Sentinel-5P/4/5);
4. **Atmospheric Chemistry and Composition (profilers/limb) data series**: Envisat SCIAMACHY, GOMOS, MIPAS, ODIN-OSIRIS, ODIN-SMR, ACE-FTS, ACE-MAESTRO, MetOp IASI (providing continuity with Sentinel-5P/4/5);
5. **Medium Resolution Optical SWIR-TIR data series**: ERS ATSR, Envisat AATSR, NOAA AVHRR, Aqua & Terra MODIS (providing continuity with Sentinel-3);
6. **Medium Resolution Optical data series**: ERS ATSR, Envisat AATSR / MERIS, NOAA AVHRR, Aqua & Terra MODIS (providing continuity with Sentinel-3);
7. **High Resolution Optical data series**: Landsat, Spot, MOS-1/1b, JERS-1, ALOS, Proba-1 (providing continuity with Sentinel-2);
8. **C-band Scatterometer data series**: ERS, MetOp;
9. **C-band SAR data series, including wave mode data**: ERS, Envisat, Radarsat (providing continuity with Sentinel-1);
10. **L-Band SAR data series**: Seasat, JERS-1, ALOS.

Conclusions

- Preservation and valorisation of science and environmental data from space missions constitute a major challenge but above all **a great opportunity**.

  → Data are the only remaining assets once a mission is ended

- Data is more than ever today's fuel for information.

- Data from the past is the essential piece for elaborating information on evolution, ultimately to increase our knowledge and prospects for the future.

LTDP+ activity has the ambition to serve these goals

Thank you for your attention !!!

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"Know and Valorize the past to manage the future"

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