



## → MEASUREMENTS AND OBSERVATIONS IN THE 21st CENTURY CONFERENCE

# ESA's Earth Observation Programmes A focus on Hydrology

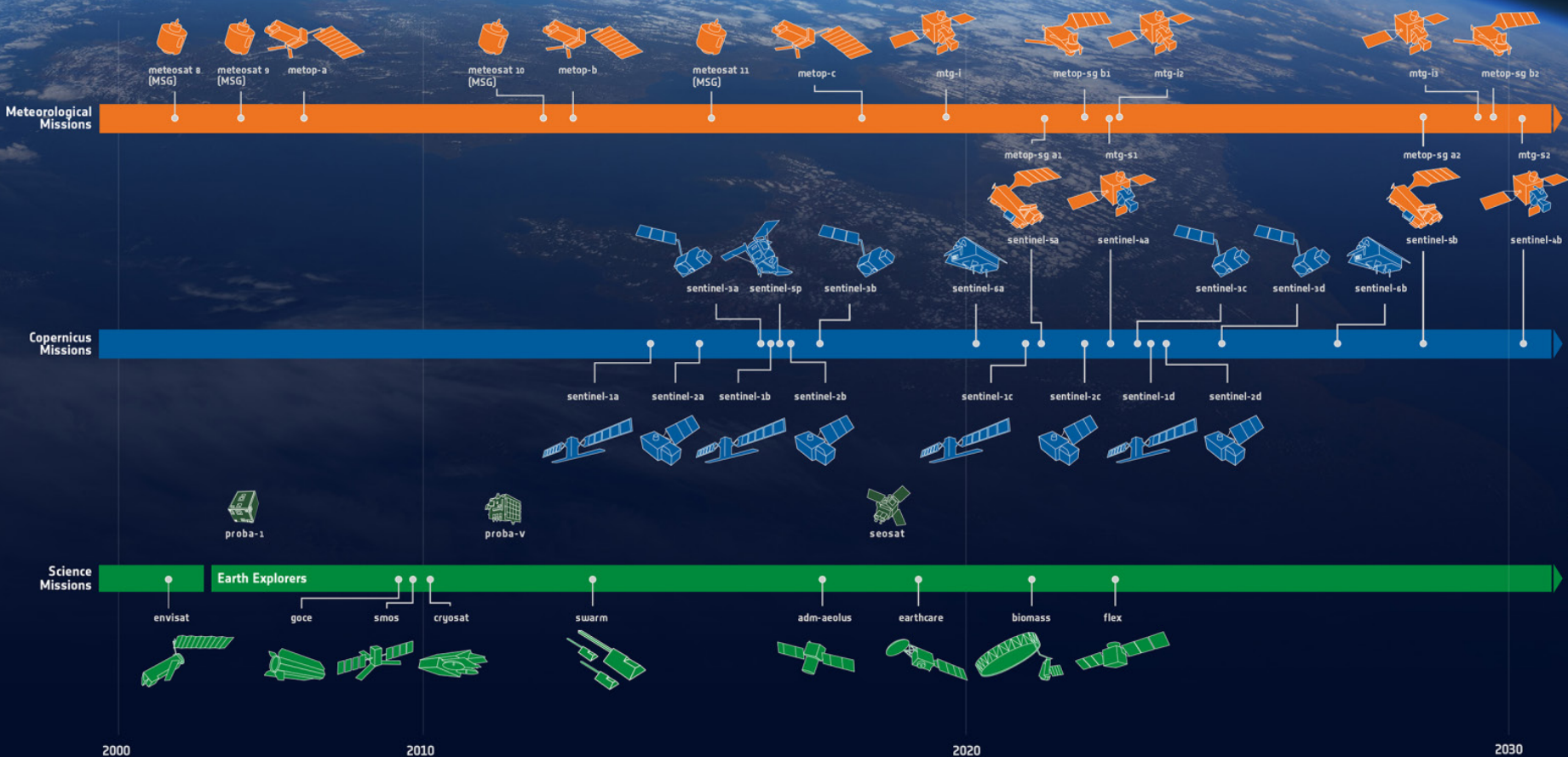
Jérôme Benveniste

Senior Advisor – European Space Agency

21 November 2016 | ESA-ESRIN | Frascati (Rome) Italy



# → ESA-DEVELOPED EARTH OBSERVATION MISSIONS



© ESA 2016 | Image credits: ESA/NASA

# Focus on Hydrology



# The Heritage: ERS and Envisat data

- ERS and Envisat missions 1991-2012
- More than 2 Petabytes of data
- Two decades of global change records
- Need for preservation, availability and exploitation



# Sentinel-1A

- 3 April 2014
- Kourou European spaceport
- Soyuz-2 rocket
- New era of Earth observation



# Sentinel-1B launch

- 25 April 2016
- Kourou
- Soyouz VS14



©2016 ESA - CNES - ARIANESPACE | Photo Optique Vidéo CSG





# Sentinel-1: The SAR Mission

- Sun-synchronous orbit at 693 km altitude
- Inclination: 98.18°
- 7 years lifetime
- Consumables for 12 years
- Mean LST: 18:00h at ascending node
- 12-day repeat cycle at Equator (with 1 satellite)
- 175 orbits/cycle
- 96h operative autonomy



# Aral Sea seen by Sentinel-1A

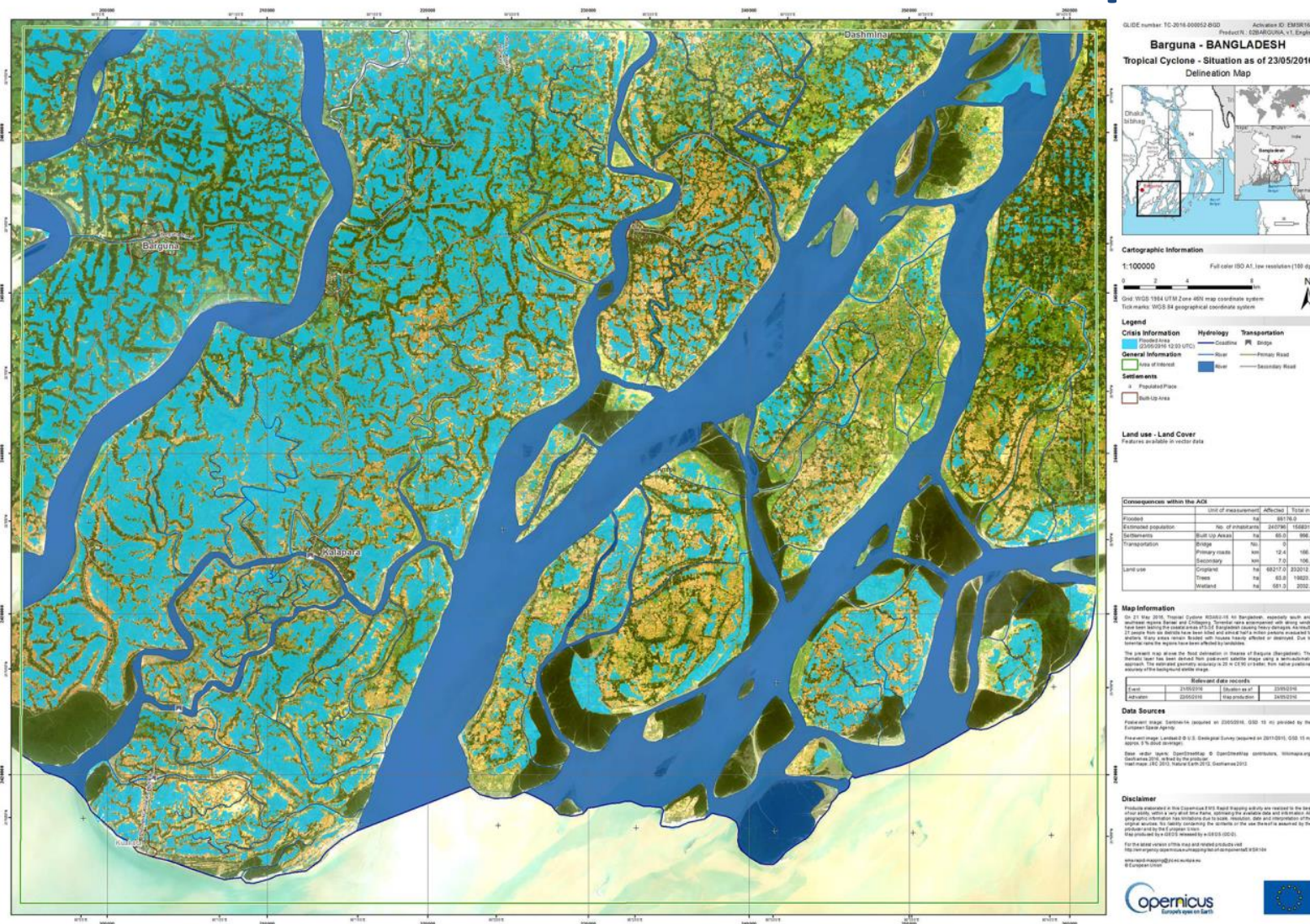
combining three radar scans from Sentinel-1A:  
red (17/10/14), green (28/12/14), blue (14/02/15).



# Sentinel-1A: Flood Map

Bangladesh,  
May 2016

85 000  
hectares of  
flooded areas  
in light blue



Copyright: Copernicus  
Service information  
(2016) / Copernicus  
EMS / e-GEOS



# Sentinel-2



- Wide swath high resolution super-spectral imaging mission
- Land and Security Services
- Data continuity of Landsat and SPOT-type missions



# Sentinel-2A launch

- 22 June 2015
- Kourou
- Vega VV05



# Sentinel-2A: First images

Northwest Italy and  
Southern France

French Riviera

Po Valley



# Sentinel-2A: First images

Po Valley

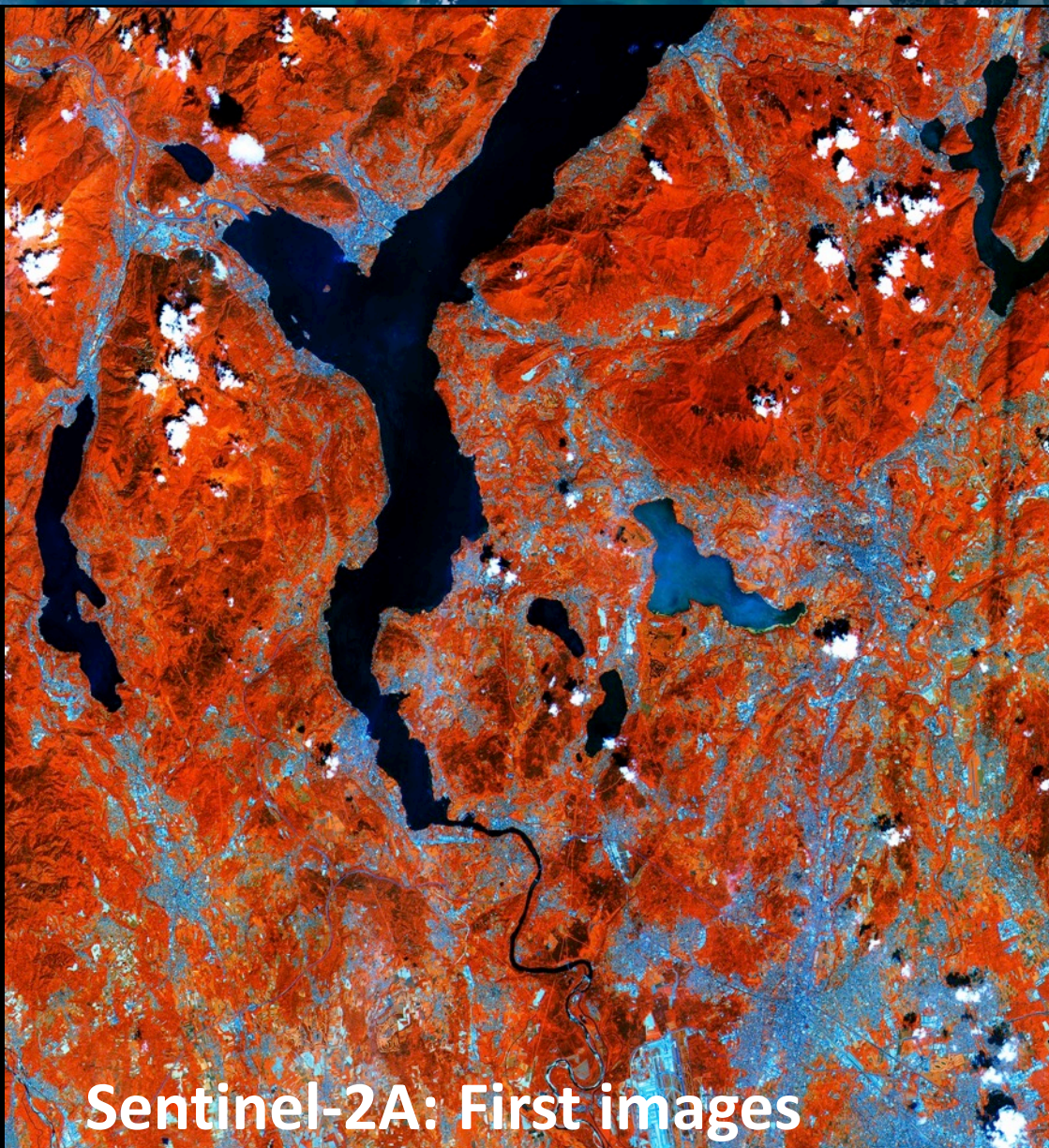




## Sentinel-2A: First images

Po Valley





27 June 2015,  
4 days after launch

**Sentinel-2A: First images**

Lago maggiore





27 June 2015,  
4 days after Sentin  
Lago maggiore



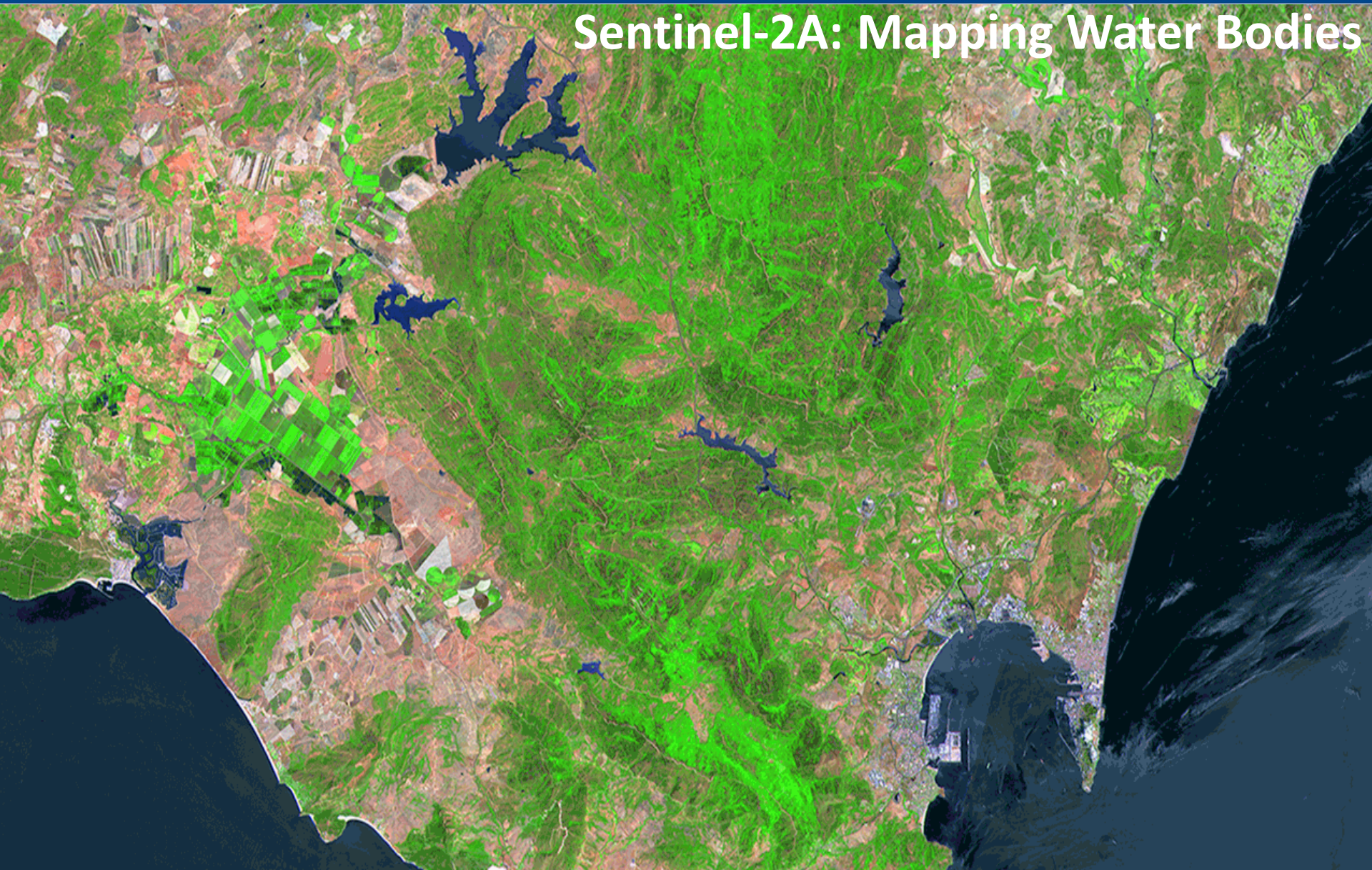


27 June 2015,  
4 days after Sentin  
Lago maggiore





# Sentinel-2A: Mapping Water Bodies





# Sentinel-3A

- Medium resolution imaging and altimetry mission
- Land and ocean applications

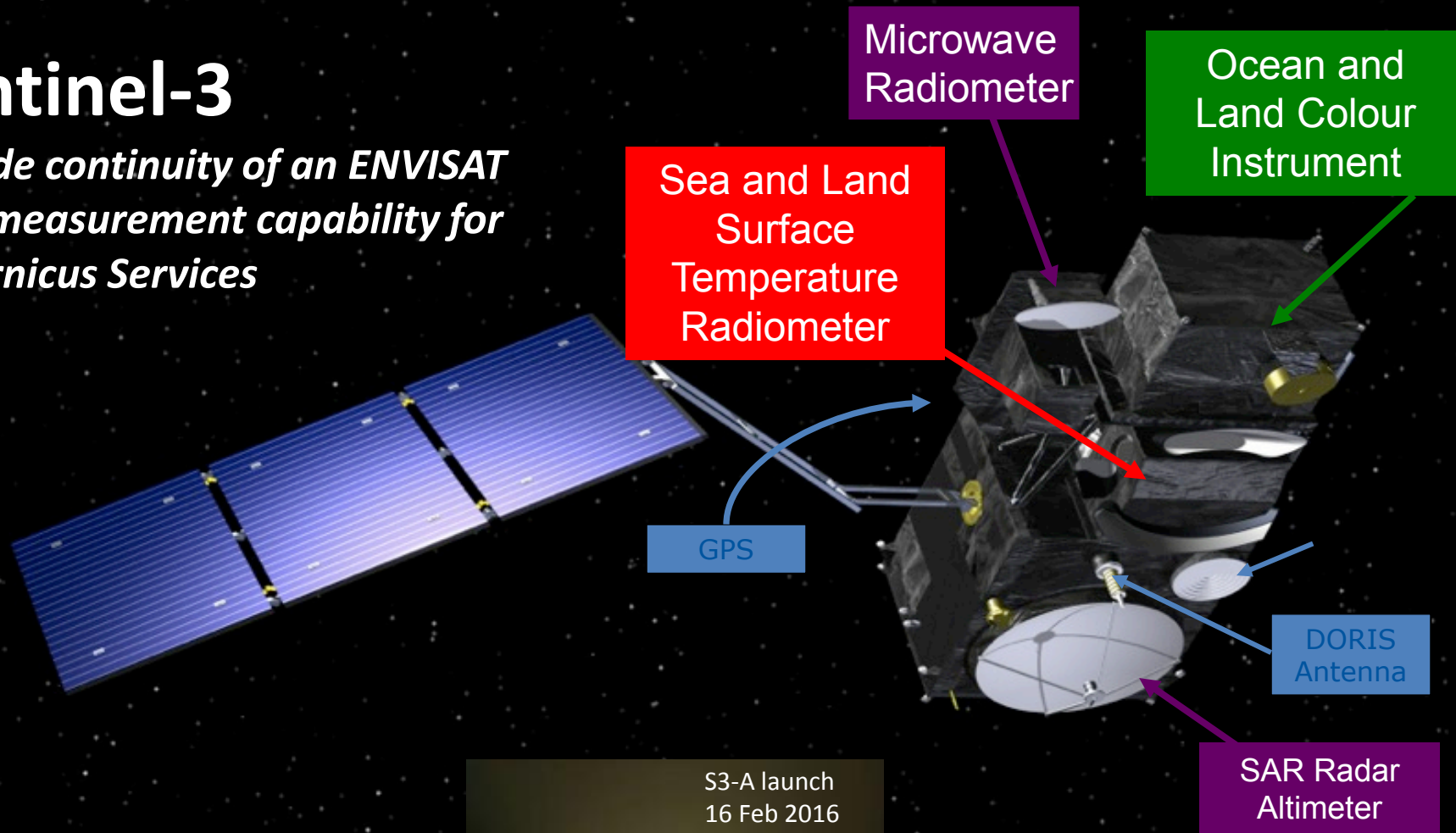


- Launched 16 February 2016



# Sentinel-3

*provide continuity of an ENVISAT type measurement capability for Copernicus Services*



S3-A launch  
16 Feb 2016

- Launch S-3A 16 February 2016
- Launch S-3B in 2017



# Sentinel-3A

## The River Nile

Sentinel-3's Sea and Land Surface Temperature Radiometer (SLSTR) measures the energy radiating from Earth's surface in nine spectral bands, including visible and infrared.



## Sentinel-3A

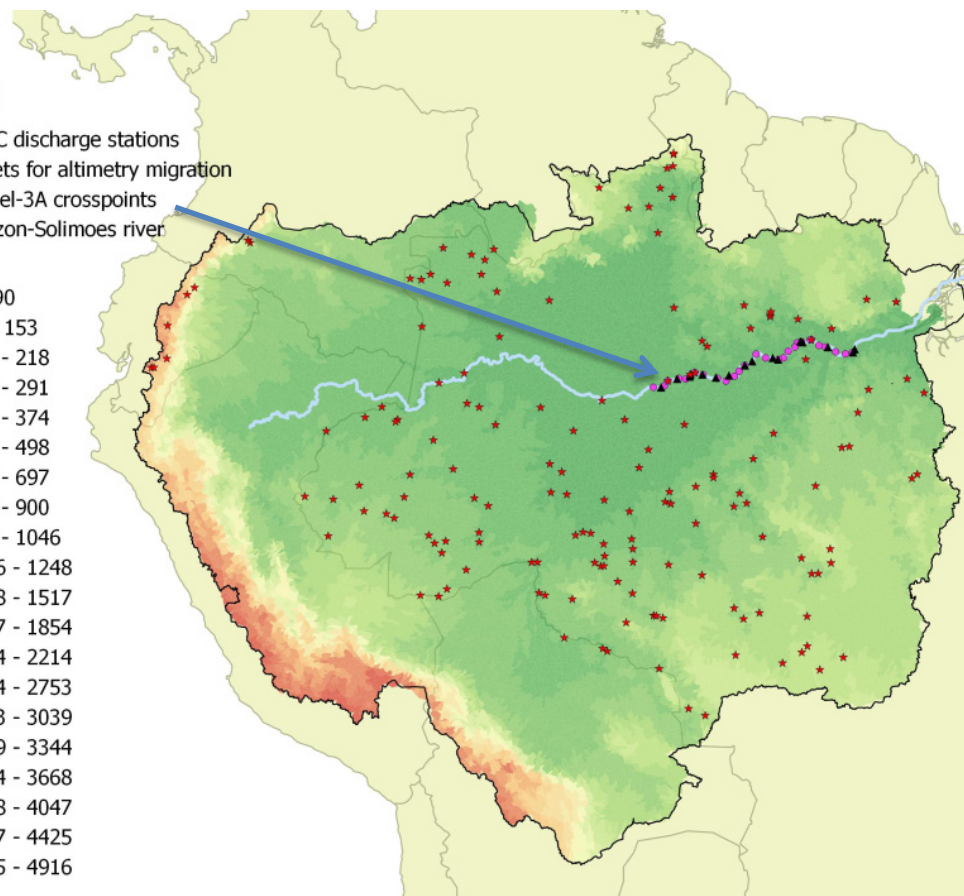
The Sentinel-3 Radar Altimeter measures river stage to derive discharge

### Legend

- ★ GRDC discharge stations
- Outlets for altimetry migration
- ▲ Sentinel-3A crosspoints
- Amazon-Solimoes river

### Elevation

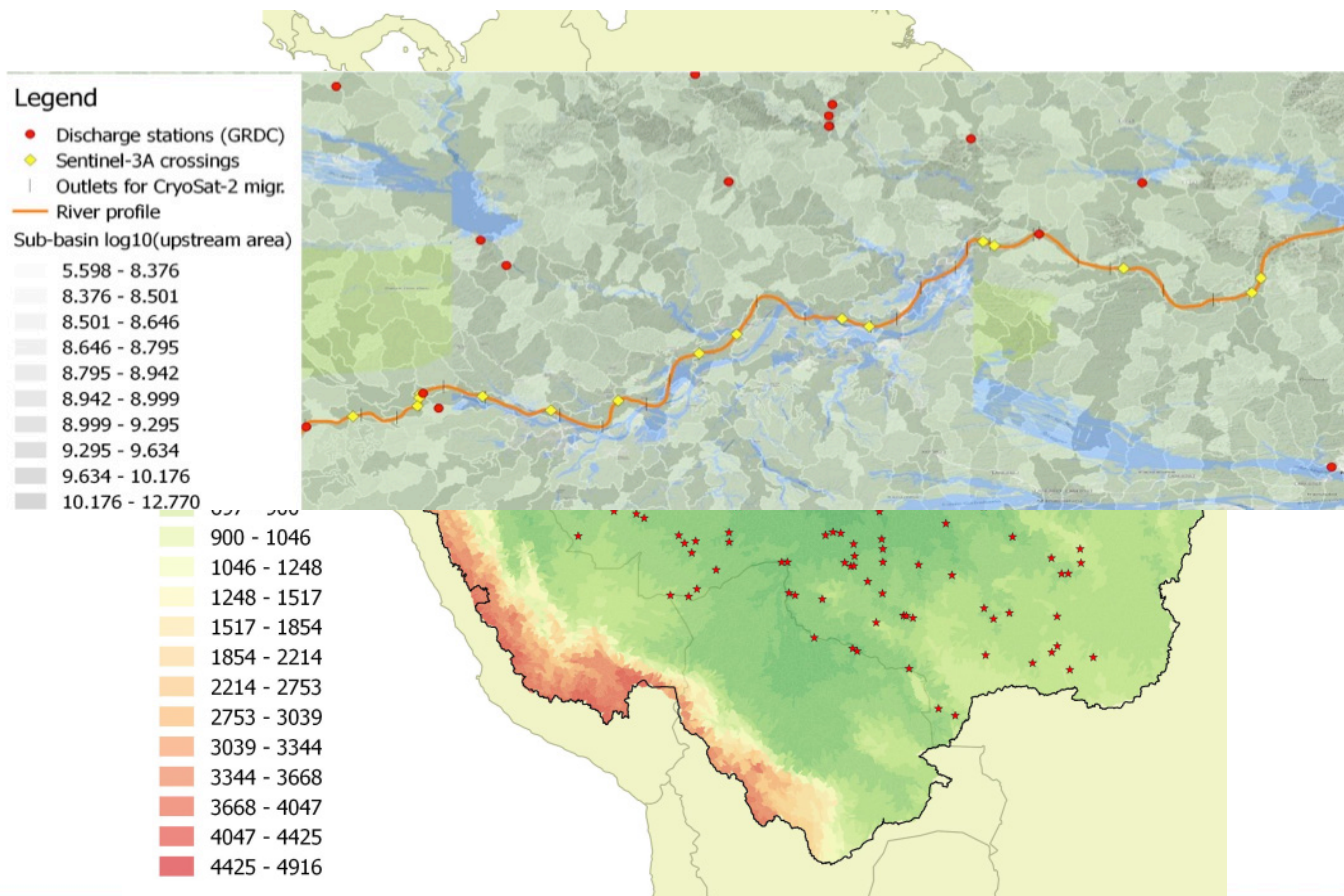
1 - 90
90 - 153
153 - 218
218 - 291
291 - 374
374 - 498
498 - 697
697 - 900
900 - 1046
1046 - 1248
1248 - 1517
1517 - 1854
1854 - 2214
2214 - 2753
2753 - 3039
3039 - 3344
3344 - 3668
3668 - 4047
4047 - 4425
4425 - 4916





# Sentinel-3A

The Sentinel-3 Radar  
Altimeter measures river  
stage to derive discharge



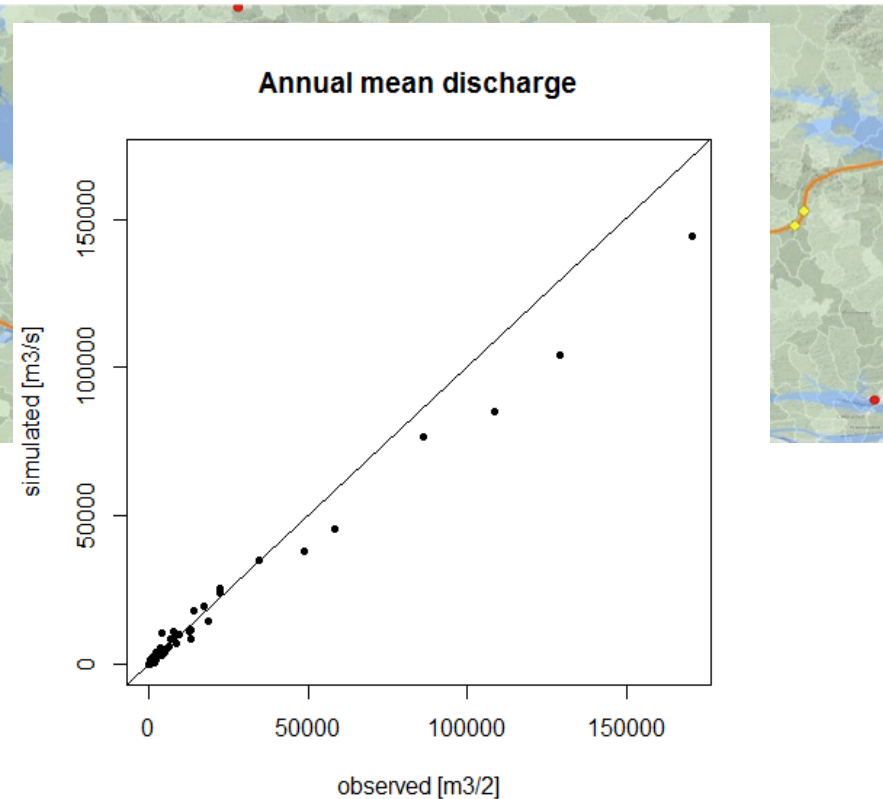


# Sentinel-3A

The Sentinel-3 Radar  
Altimeter measures river  
stage to derive discharge

## Legend

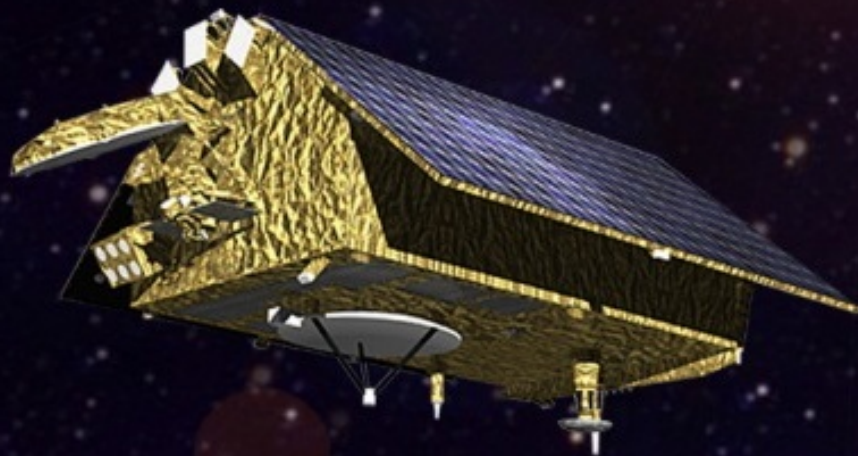
- Discharge stations (GRDC)
  - Sentinel-3A crossings
  - | Outlets for CryoSat-2 migr.
  - River profile
- Sub-basin log<sub>10</sub>(upstream area)
- |                 |
|-----------------|
| 5.598 - 8.376   |
| 8.376 - 8.501   |
| 8.501 - 8.646   |
| 8.646 - 8.795   |
| 8.795 - 8.942   |
| 8.942 - 8.999   |
| 8.999 - 9.295   |
| 9.295 - 9.634   |
| 9.634 - 10.176  |
| 10.176 - 12.770 |





# Sentinel-6 / Jason-CS – Radar Altimetry

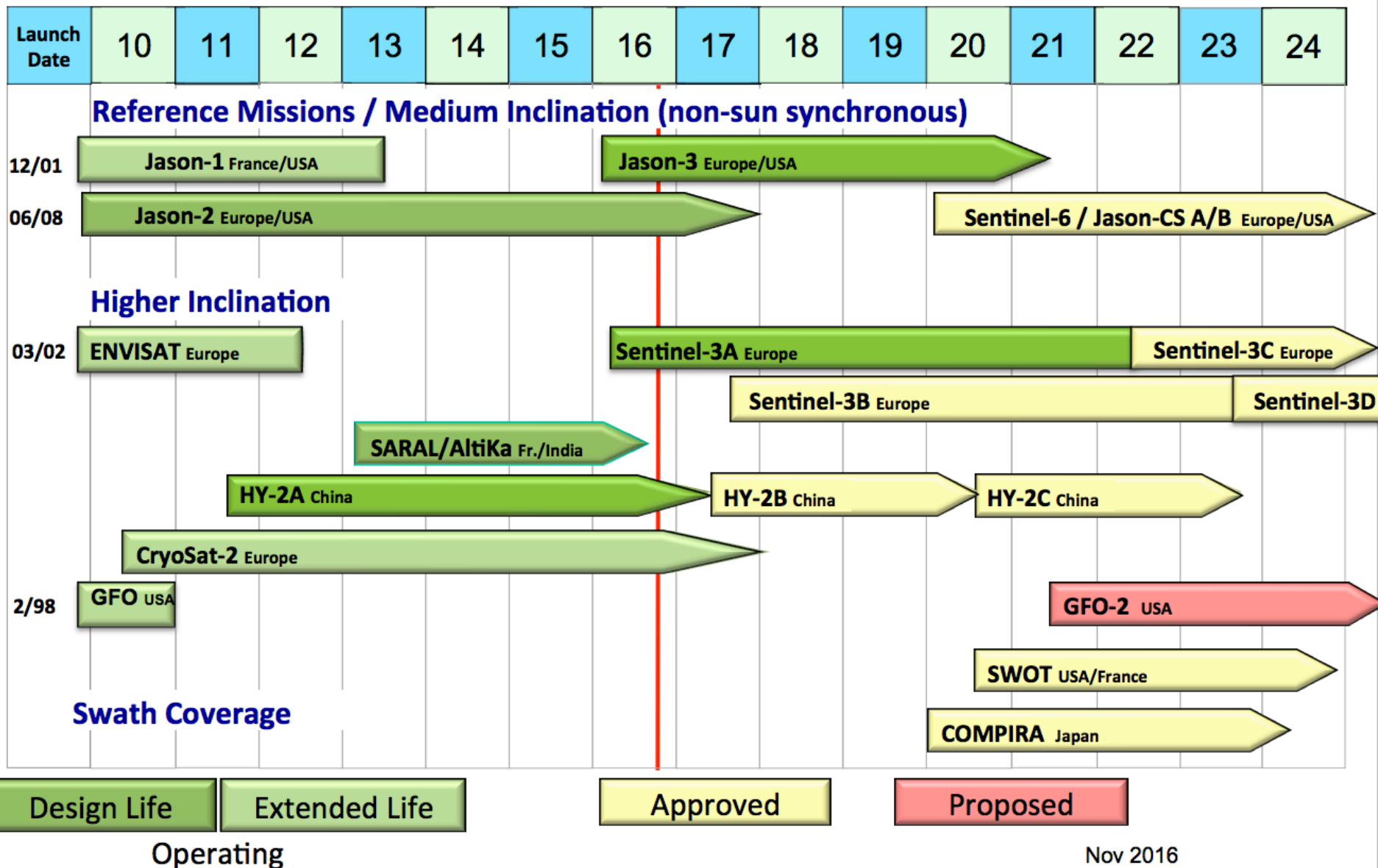
Sentinel-6 will pursue in 2020 the reference mission started in 1992 by TOPEX/Poseidon followed by Jason-1, -2, -3



CryoSat and Sentinel-3 heritage  
Interleaved high and low resolution modes



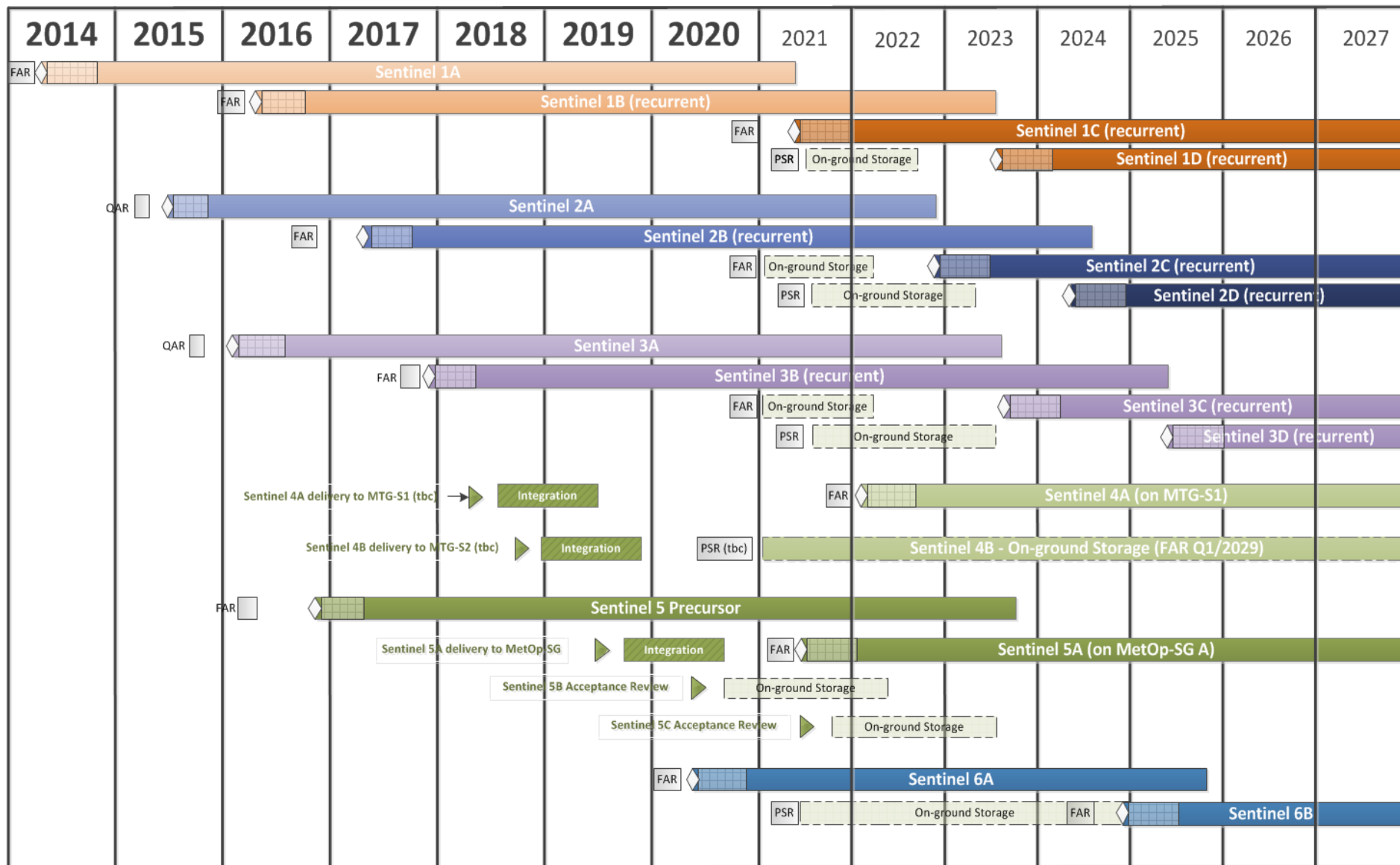
# Radar Altimetry Missions



Nov 2016



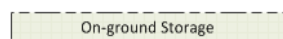
# Sentinel Schedule



Legend:



Qualification Acceptance Review (QAR)  
Flight Acceptance Review (FAR) or  
PreStorage Review (PSR)



Tentative launch date



In-orbit Commissioning

Status: 7 June 2016





Sentinel Online



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Missions

User Guides

Technical Guides

Thematic Areas

Data Access

Toolboxes

You are here [Home](#) > [Data Access](#)

[Share](#) | [f](#) [t](#) [e](#) [r](#)

## - Data Access Navigator



## - Data Access at Your Fingertips

The free, full and open data policy adopted for the Copernicus programme foresees access available to all users for the Sentinel data products, via a simple pre-registration.

### Who needs to register:

Registration is open to all users via simple on-line self-registration accessible via the [Sentinels Scientific Data Hub](#).

Member States requiring data for not register on this service, they

Following registration, the user c data. Please note that the full operational qualification of the products is not yet completed.

**Sentinel.esa.int**

## - Data Access Overview

The Copernicus Space Component (CSC) Ground Segment data dissemination implements the Copernicus Data Policy,

## Data Access

### Data Access Home

- [Sentinel Data Access Description](#)
- [Use Typologies and available Services](#)
- [Sentinel Catalogue](#)
- [Available Data Collections](#)
- [Access to Sentinel Data](#)

## - Data Access News

- [New Sentinel-2 products available in the Scientific Data Hub](#)
- [Sentinel-2 data access upgrade to be performed on Scientific Data Hub](#)
- [Major upgrade of the Sentinels Scientific Data Hub](#)

## - Key Resources

- [Sentinels Scientific Data Hub](#)
- [CSCDA Website](#)
- [Data Access Portfolio](#)
- [Legal notice for Sentinel Data](#)
- [Access to data from Copernicus missions](#)
- [Status](#)
- [Quick Look Portal](#)
- [Copernicus Operations concept and Sentinel data access](#)



# EO Open Science 2.0



Open Science 2.0 describes the on-going systematic changes in doing research and organising science, driven by rapid advances in ICT and Digital Technologies.

- More Global Collaboration (e.g. Open Science)
- More Data-intensive Science (e.g. Big Data analytics)
- More Actors & Communities involved (e.g. Citizen Science)
- More Transparency, Scrutiny of results (e.g. Open Access Journals)
- New ways to publish (e.g. Social Media, Executable Papers)
- New ways to educate (e.g. Massive Online Open Courses: 16.000 participants)





# Sentinel Data Statistics

- free and open access

[sentinels.copernicus.eu](https://sentinels.copernicus.eu)

Users and Products Statistics:  
(status 31 March 2016)

- **28,923 registered users** on Sentinel Scientific Data Hub
- more than **473,000** Sentinel-1 products available for download
- **3,893,103** Sentinel-1 image downloads, representing **4.67 PB of data**



# Science – the Earth Explorers

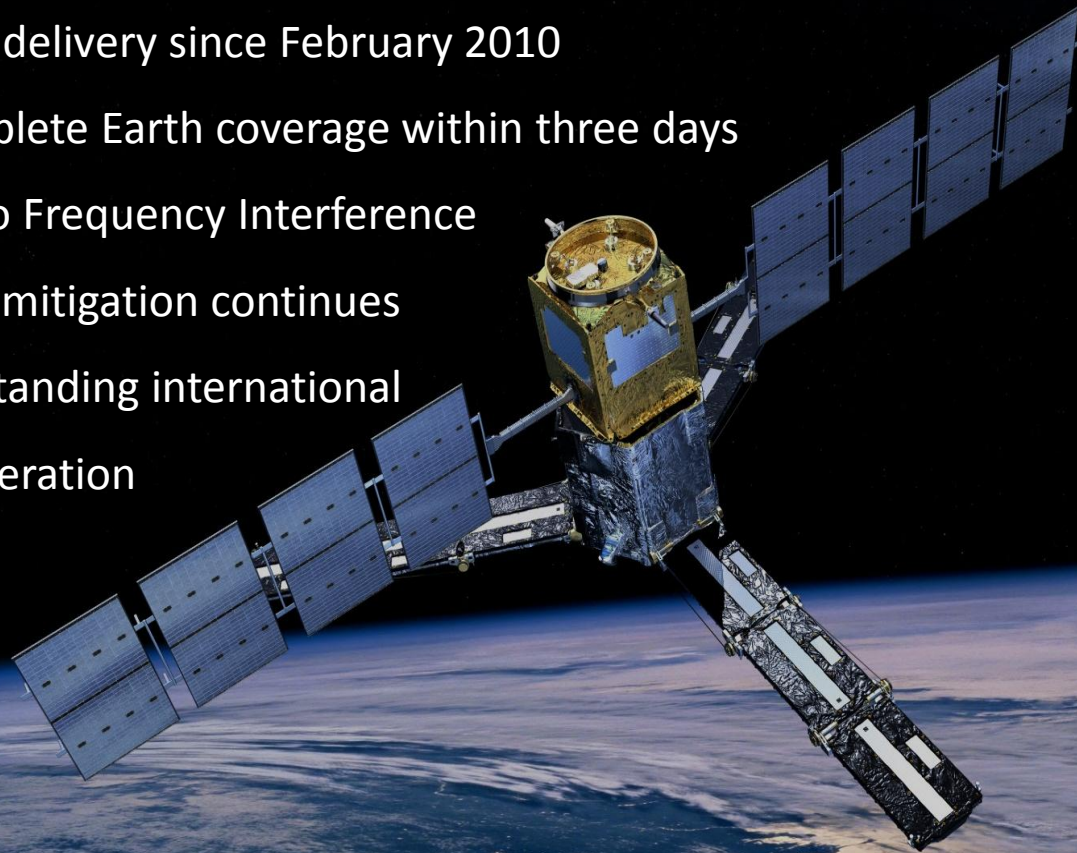


Earth Explorers launched so far



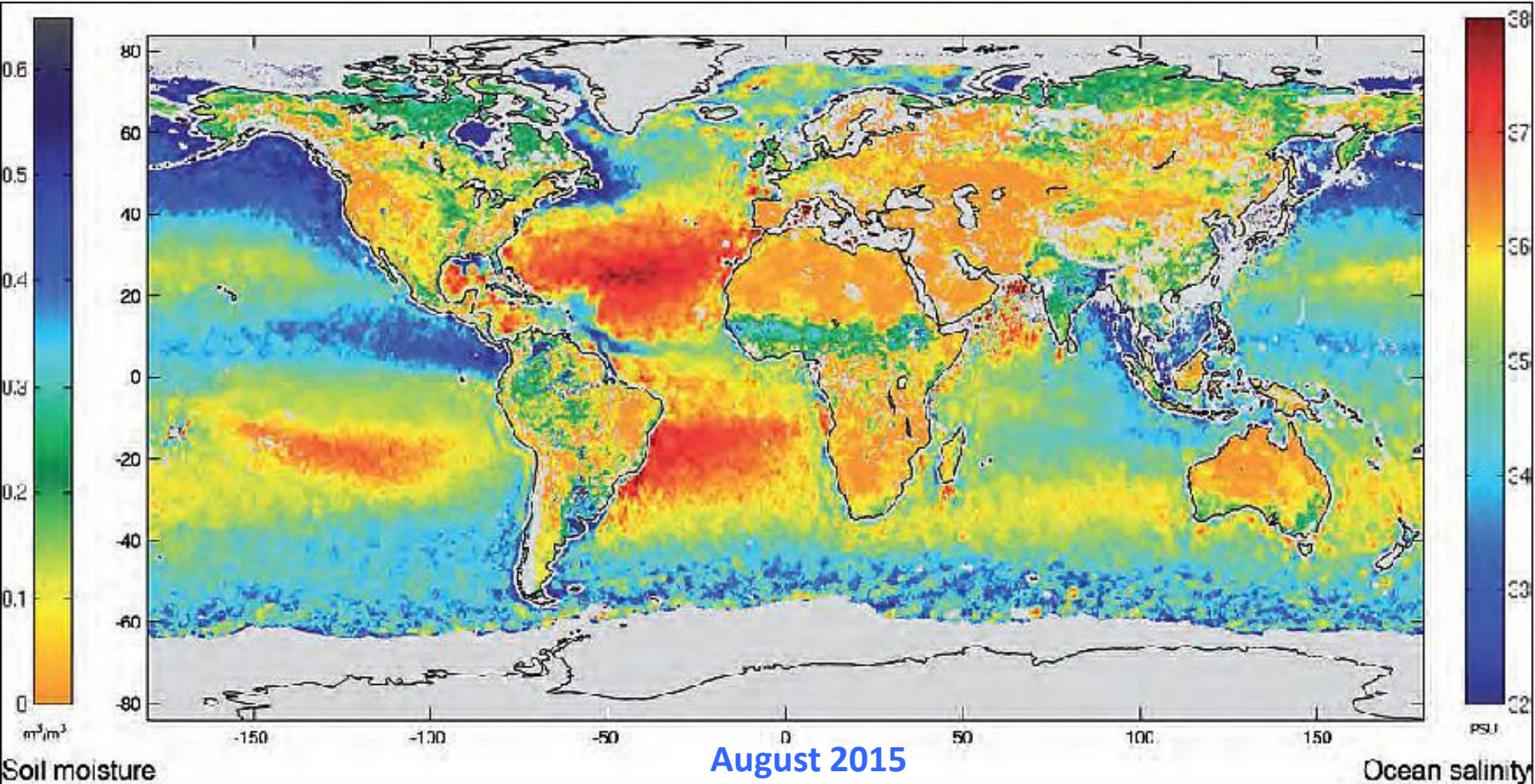
## SMOS – Soil Moisture and Ocean Salinity

- Data delivery since February 2010
- Complete Earth coverage within three days
- Radio Frequency Interference (RFI) mitigation continues
- Outstanding international cooperation
- Mission extension until 2017





## SMOS – Soil Moisture and Ocean Salinity

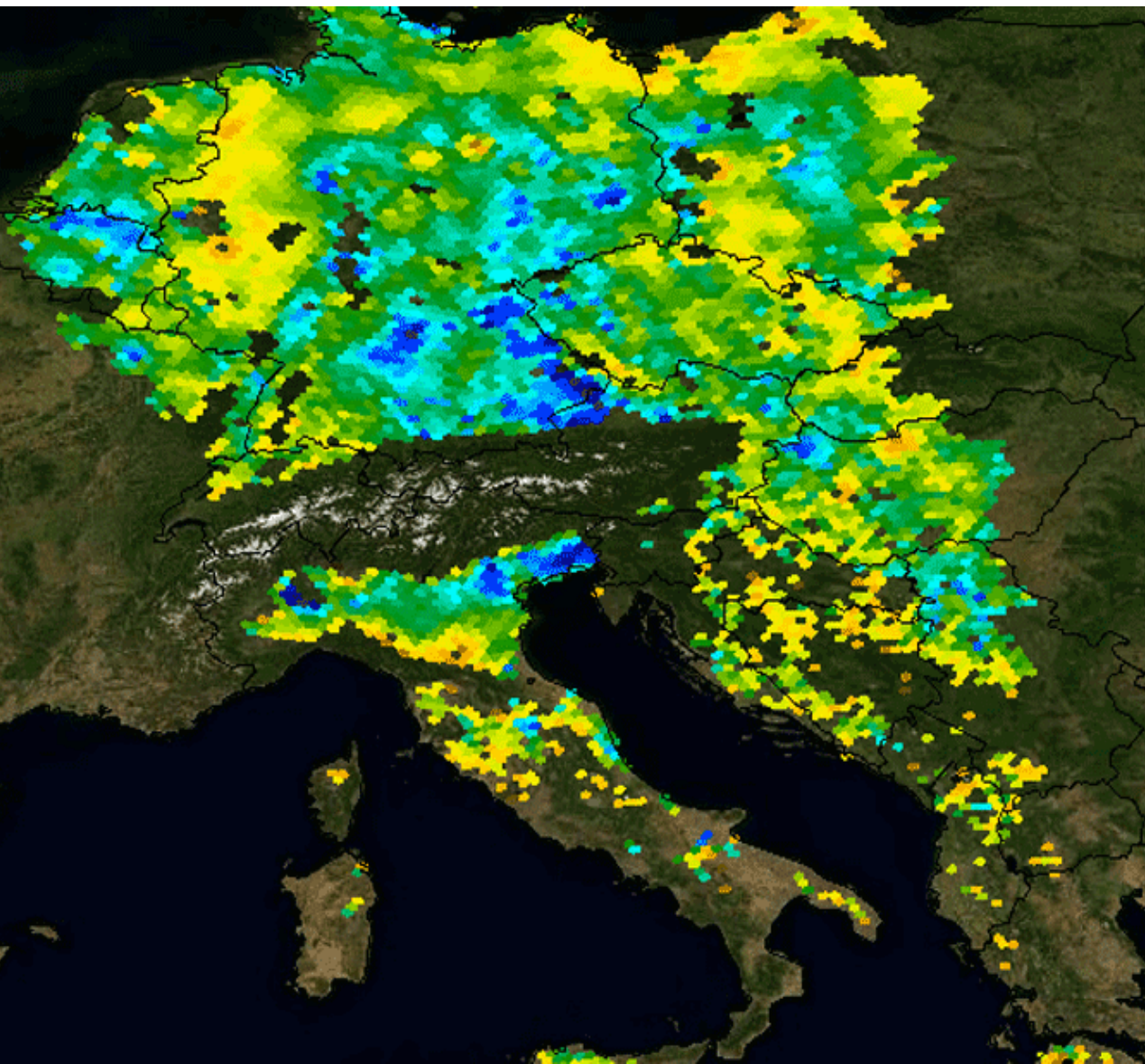




## SMOS – Hydrology

- SMOS provides soil moisture conditions
- May 2013: saturated soils in Central Europe
- Immediate run-off and subsequent flooding through additional rain

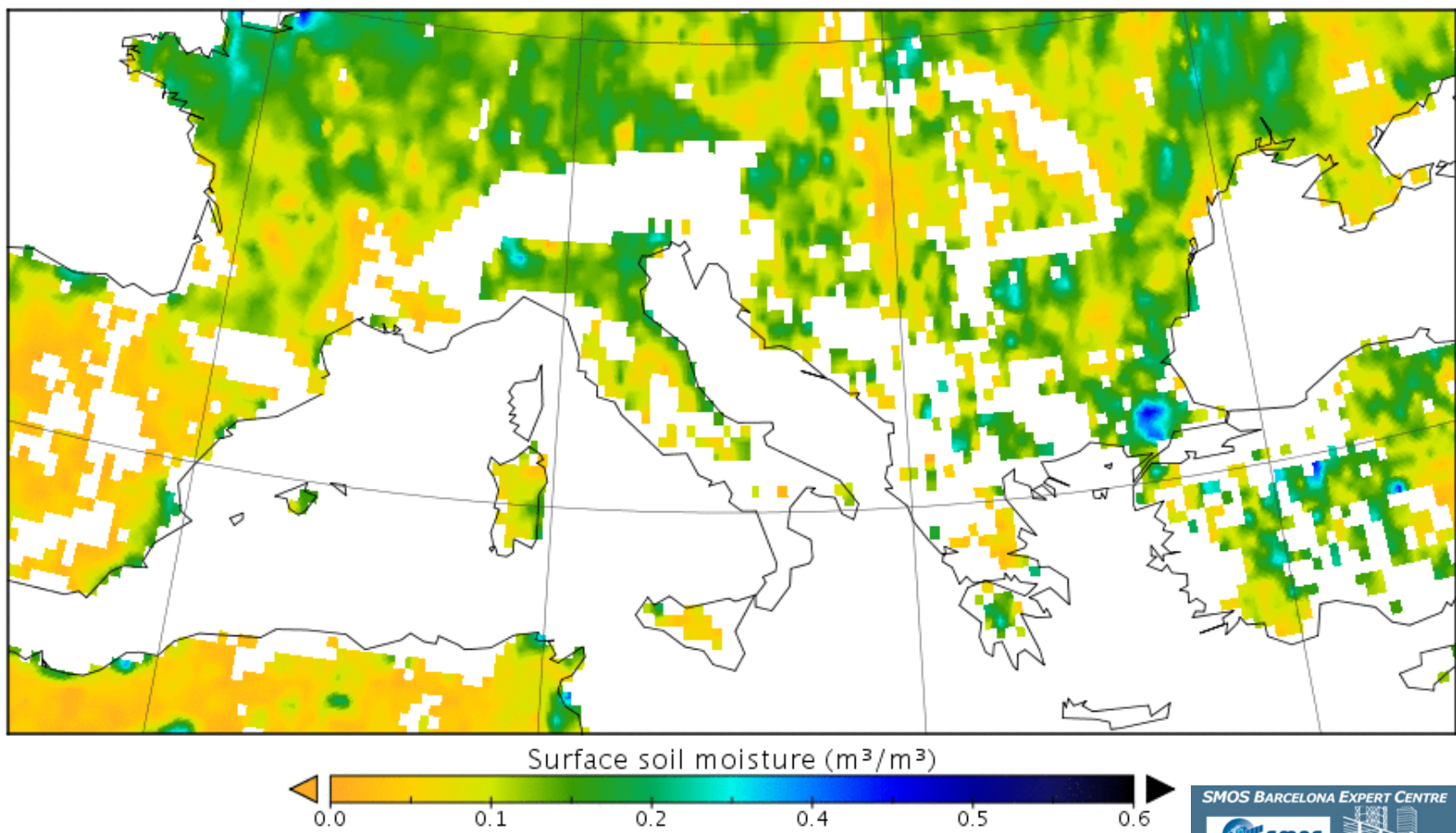
31 MAY 2013





# SMOS – Hydrology

Surface soil moisture (10–11–12 May 2014)



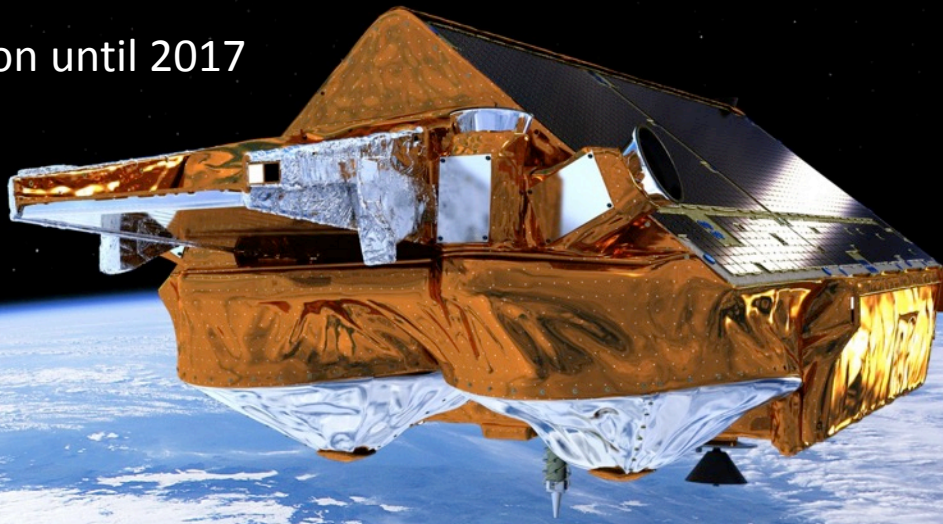


## CryoSat: The Ice Mission

- First interferometric altimeter in space
- Global sea ice thickness measurements
- Data used for ice research,
  - but increasingly also for oceanography
  - and *inland water (river stage, lake level)*
- Mission extension until 2017



© Thinkstock by Getty Images





# River Level from CryoSat

Bercher et al., 2013

Mekong River

396 km

© 2013 Cnes/Spot Image  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

©2010 Google

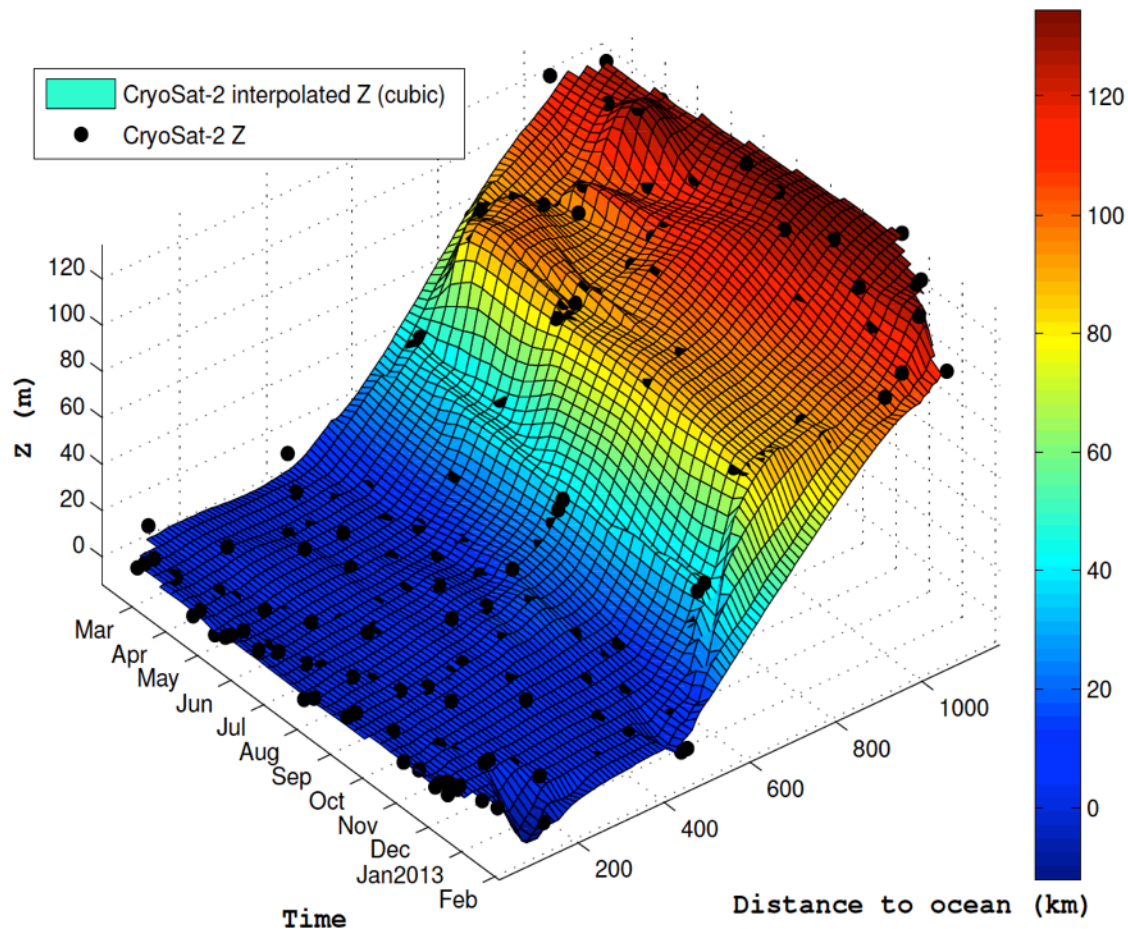
lat 14.150767° long 101.641231° elev. 122 m

Altitude 1545,15 km



# River Level from CryoSat

CryoSat-2 SAR - Mekong river water level  $Z(x,t)$



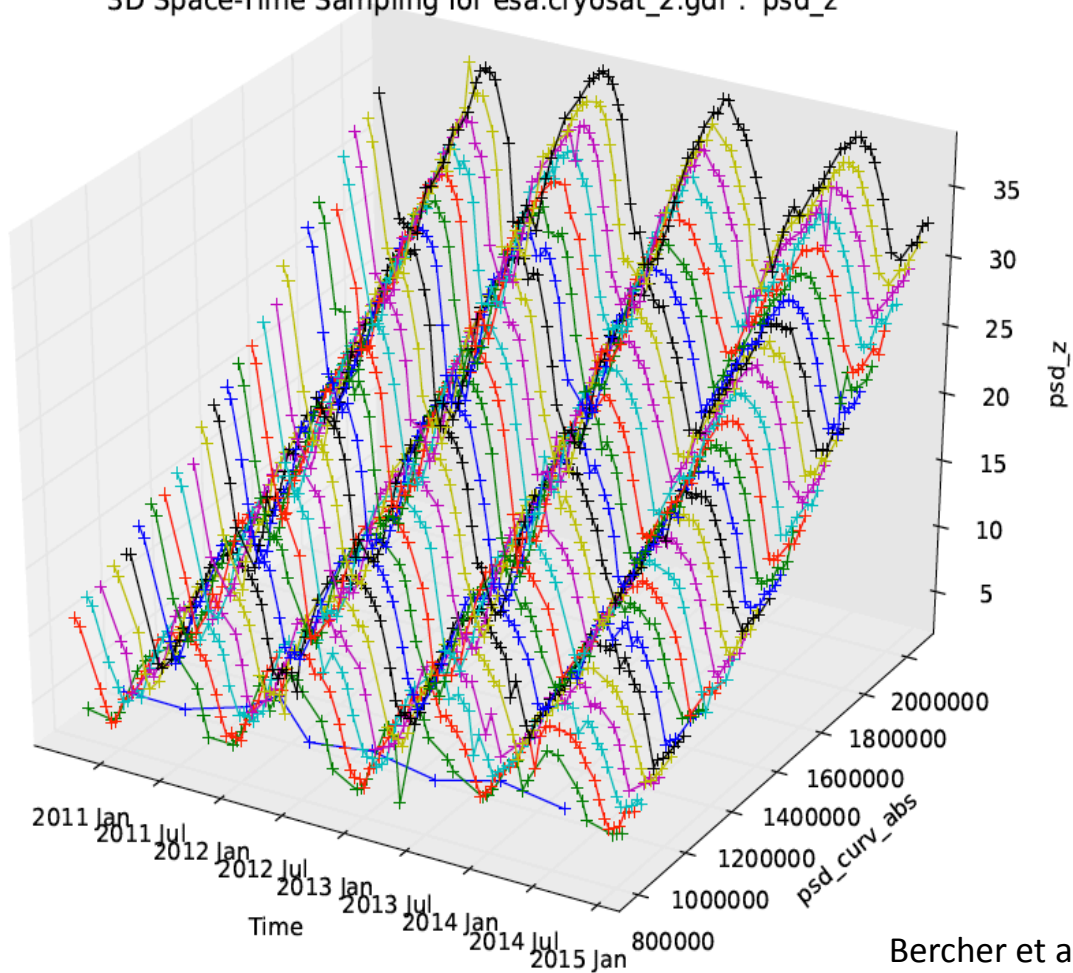
Bercher et al., 2013



# River Level from CryoSat

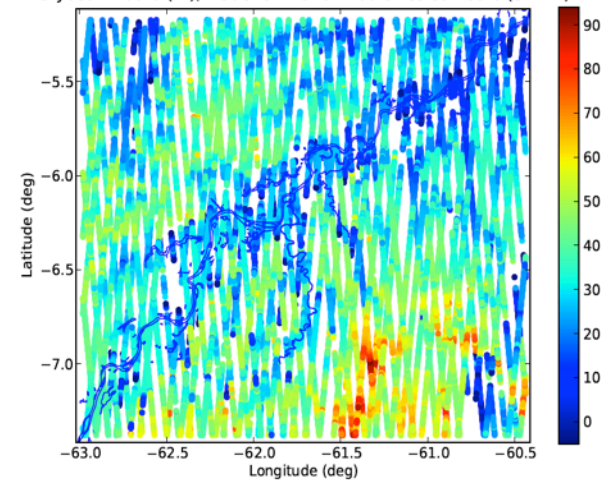
## Madeira River

3D Space-Time Sampling for esa.cryosat\_2.gdr : 'psd\_z'



Map of CryoSat-2 measurements

CryoSat-2 data (m), Madeira river & tributaries contours (SWBD)



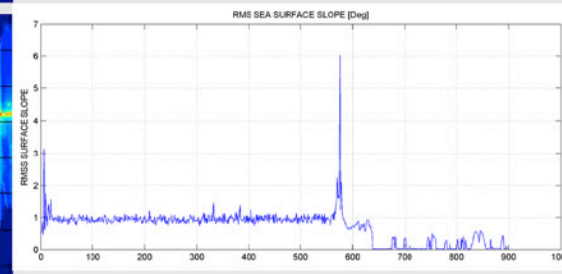
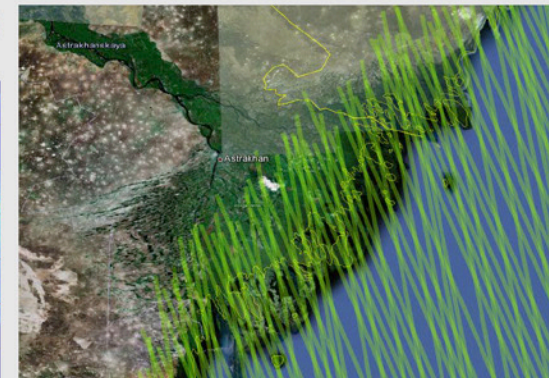
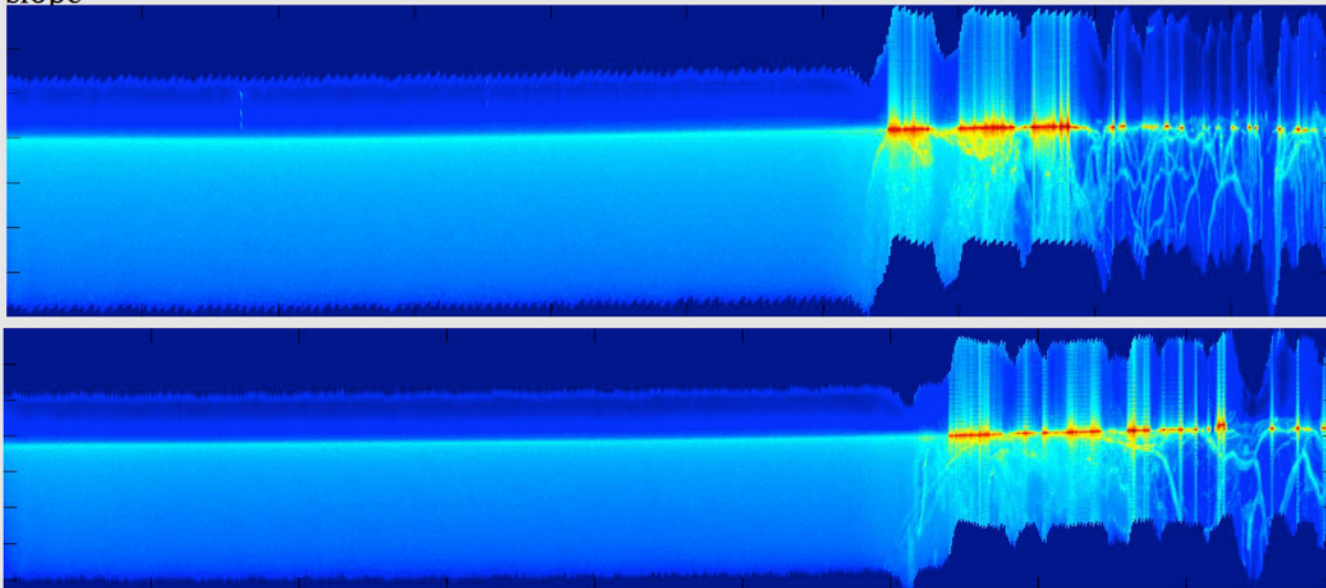
Bercher et al., 2015



## River Level from CryoSat

### PASSES OVER VOLGA'S DELTA (WETLAND)

In passes at the Volga's Delta, the stagnant waterways and the muddy sand banks are clearly recognizable and distinguishable by mean of the scattered power and surface rms slope

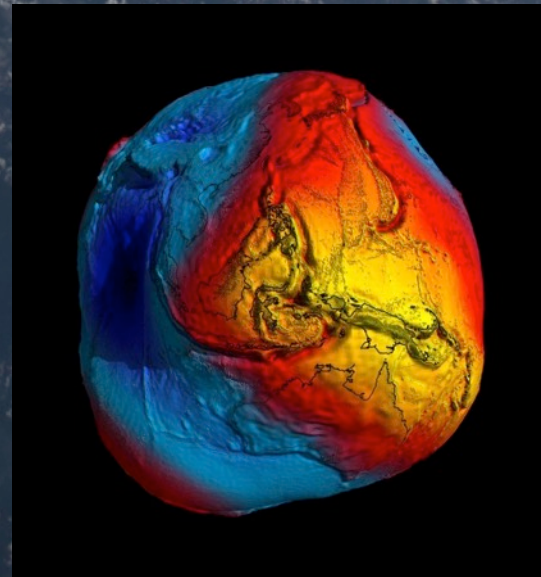


Dinardo et al., 2015



# GOCE: Gravity and Ocean Circulation

- First gradiometer in space
- Best geoid ever
- 5<sup>th</sup> version of geoid (July 2014), including all GOCE measurements
- End of mission declared 21 October 2013 following depletion of Xenon fuel
- Re-entry 11 November 2013





# GOCE: A Wealth of Applications

Geoid

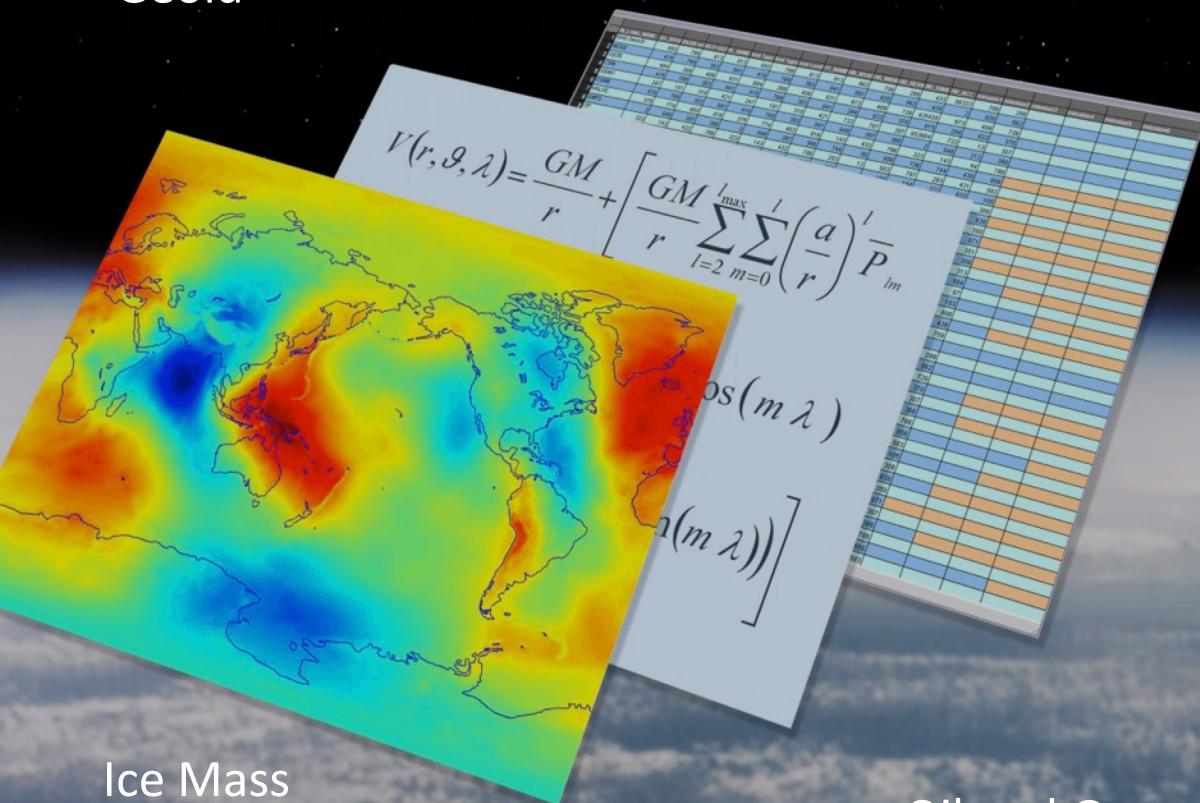
Gravity Anomalies

Topography

Altimetry

Positioning

Unified Height Systems



Ice Mass Balance

Mean Ocean Circulation

Oil and Gas Exploration

Post Glacial Rebound



# Proba-V

- Minisatellite tracking global vegetation growth
- Observation on an “always on” basis
- Launched in May 2013 on 2<sup>nd</sup> VEGA flight as part of the VERTA programme
- Multiple guest payloads
- Data delivery since December 2013
- Mission extension up to May 2018





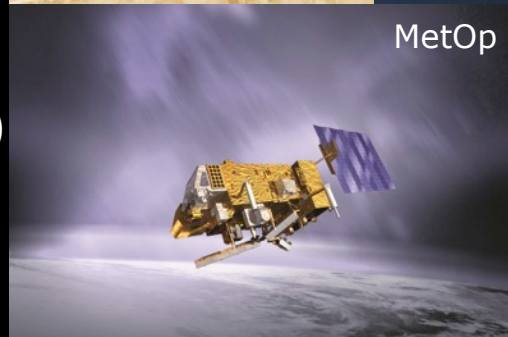
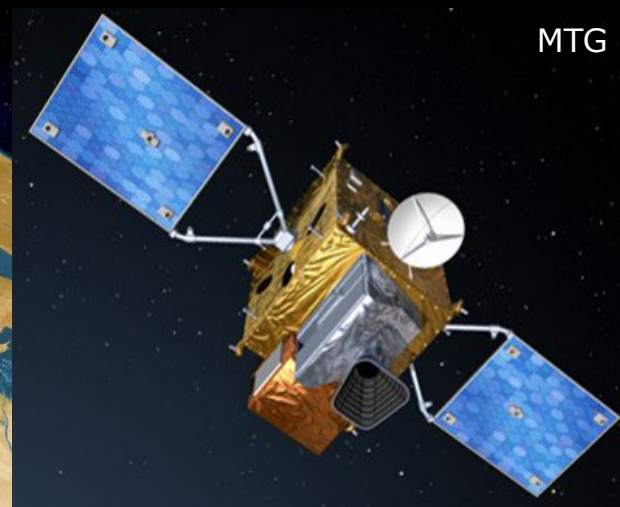


© ESA-BELSPO 2015, produced by VITO



## Meteorological Missions

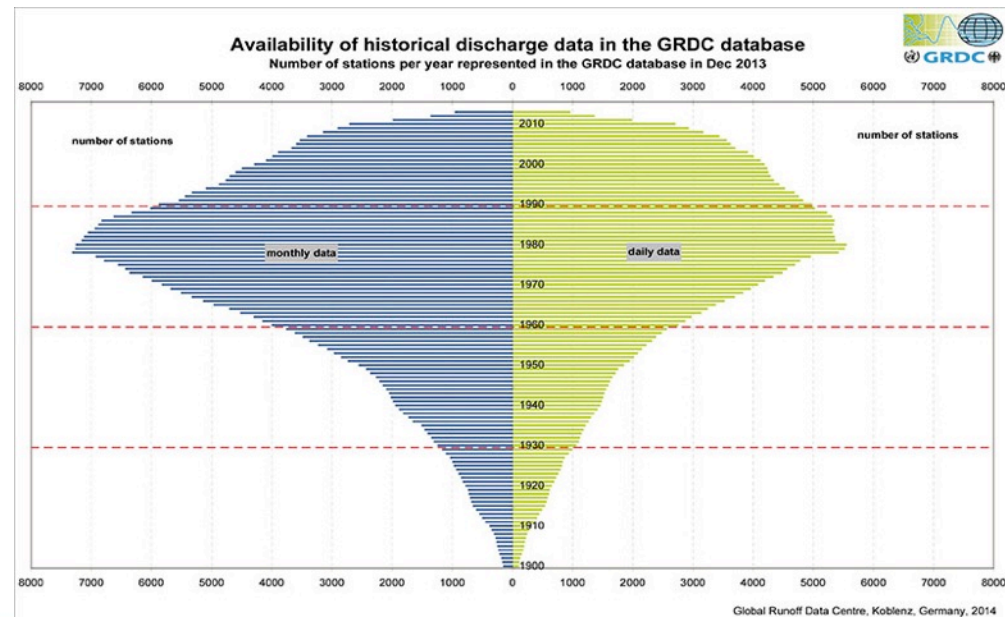
- ESA develops prototype satellites and, on behalf of EUMETSAT, procures recurrent satellites
- EUMETSAT operates the satellites
- Currently Meteosat Second Generation (MSG) missions in GEO and MetOp missions in LEO
- MeteoSat Third Generation (MTG) and MetOp Second Generation under development
- MSG-4 launched 15 July 2015






- With increasing demand, water resource challenges have increased in complexity
- Need to improve applications used for water resources decision-making processes
- Need to extract more information in large quantities from river basins over large spatial domains and time periods
- Data on water quantity, water quality and water uses are scarce in developing countries and deteriorating in some countries

- Many EO applications exist and new data platforms and applications are added every year
- Nevertheless our problems aren't solved yet...





## There are some caveats too...

- Remote Sensing provides indirect estimation
- Need for ground truth
  -  !!
- Reliability / error margin not always clearly defined
- Different reliability for different purposes and scales
- Still gaps and challenges for widespread operational application (including capacity building)





# Sustainable Development Goals



TRANSFORMING OUR  
WORLD:  
THE 2030 AGENDA FOR  
SUSTAINABLE  
DEVELOPMENT

**1** NO  
POVERTY



**2** ZERO  
HUNGER



**3** GOOD HEALTH  
AND WELL-BEING



**4** QUALITY  
EDUCATION



**5** GENDER  
EQUALITY



**6** CLEAN WATER  
AND SANITATION



**7** AFFORDABLE AND  
CLEAN ENERGY



**8** DECENT WORK AND  
ECONOMIC GROWTH



**9** INDUSTRY, INNOVATION  
AND INFRASTRUCTURE



**10** REDUCED  
INEQUALITIES



**11** SUSTAINABLE CITIES  
AND COMMUNITIES



**12** RESPONSIBLE  
CONSUMPTION  
AND PRODUCTION



**13** CLIMATE  
ACTION



**14** LIFE  
BELOW WATER



**15** LIFE  
ON LAND



**16** PEACE, JUSTICE  
AND STRONG  
INSTITUTIONS



**17** PARTNERSHIPS  
FOR THE GOALS





# Earth Observation for Sustainable Development

- EO is essential for environmental monitoring at regional, national and transboundary scale
- Mature tools & EO products are available for consistent & transparent assessment of water resources
- Capacity building of EO know-how is required for successful uptake

**Good Basis for supporting the implementation & monitoring of the 6th S.D. Goal “Ensure availability and sustainable management of water and sanitation for all”**





**Thank you for your attention**





# Copernicus Water resources management





# Managing water resources

Water is essential for life. The need to grow more and more food places huge demands on available freshwater. With water scarcity an increasing issue, it is important to manage this precious resource.