Earth Observation Programme

June 2019

Presentation Content

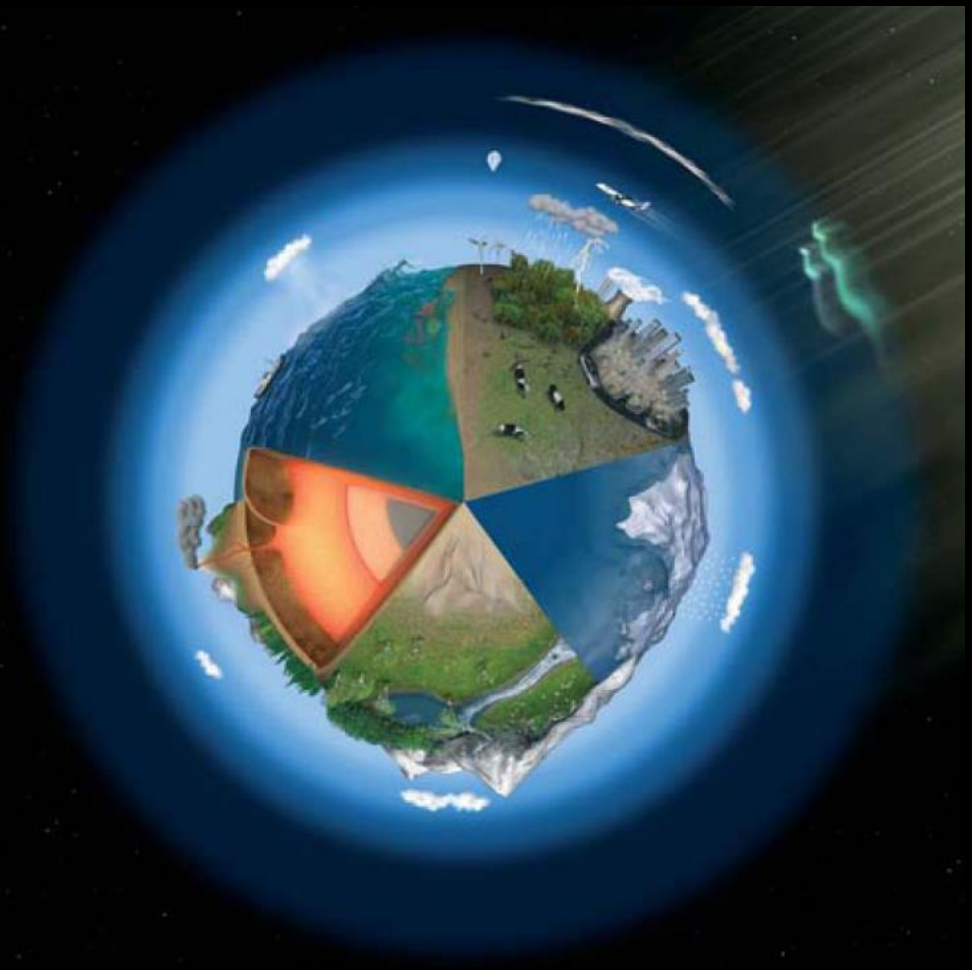
- Earth Observation Programme
- ESA Heritage SAR missions
- The Copernicus Sentinels
- Earth Observed by EO satellites (Achievements)
- Sentinel Data Access & Big Data Concepts


esa
EARTH
OBSERVATION
European Space Agency

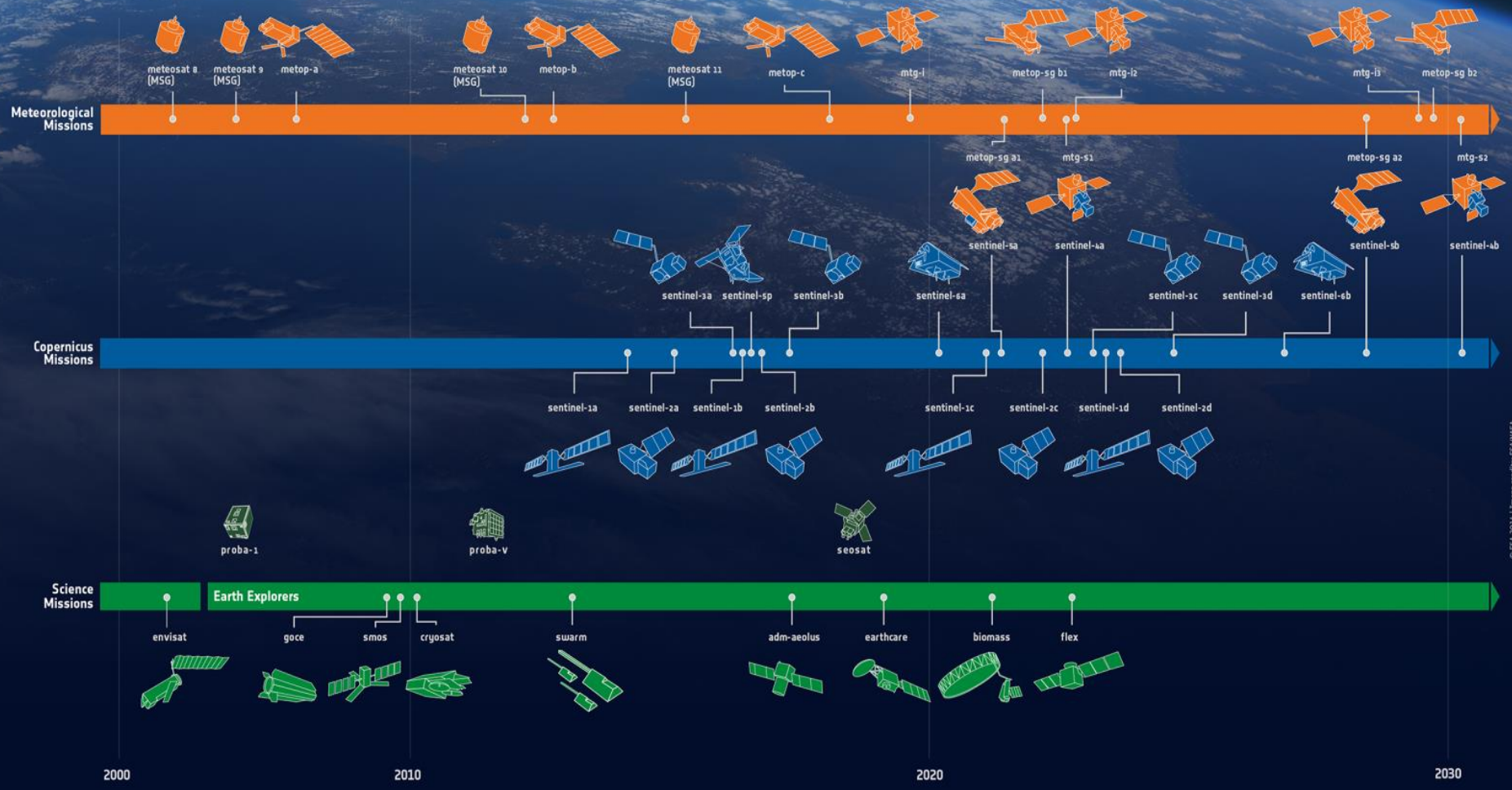
Why do we monitor Earth?

The only place where we can learn most of our planet is not found anywhere on Earth, but high above it!

In answer to key questions such as: How our planet works, Does it change and Why we must preserve it!

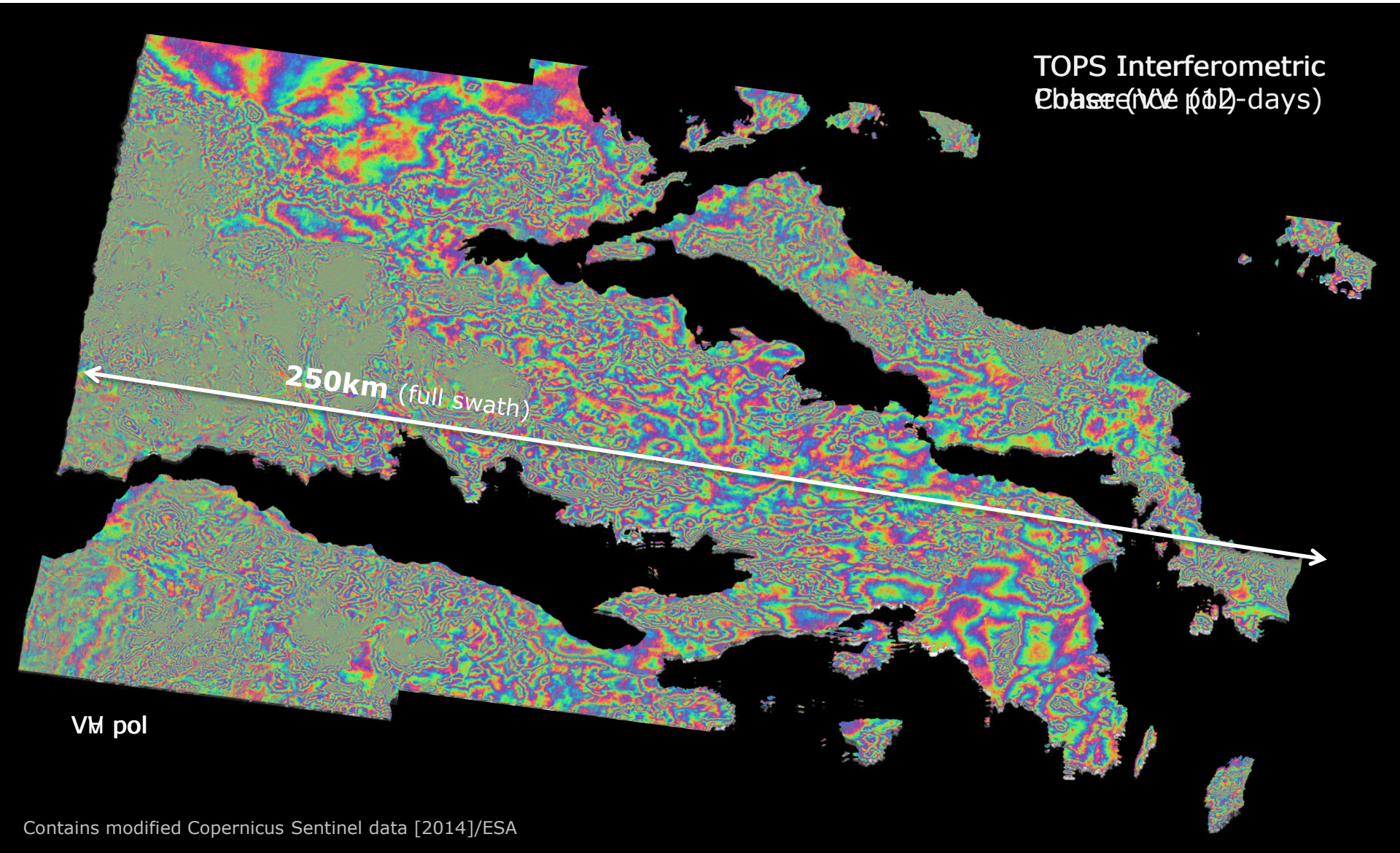


→ ESA-DEVELOPED EARTH OBSERVATION MISSIONS



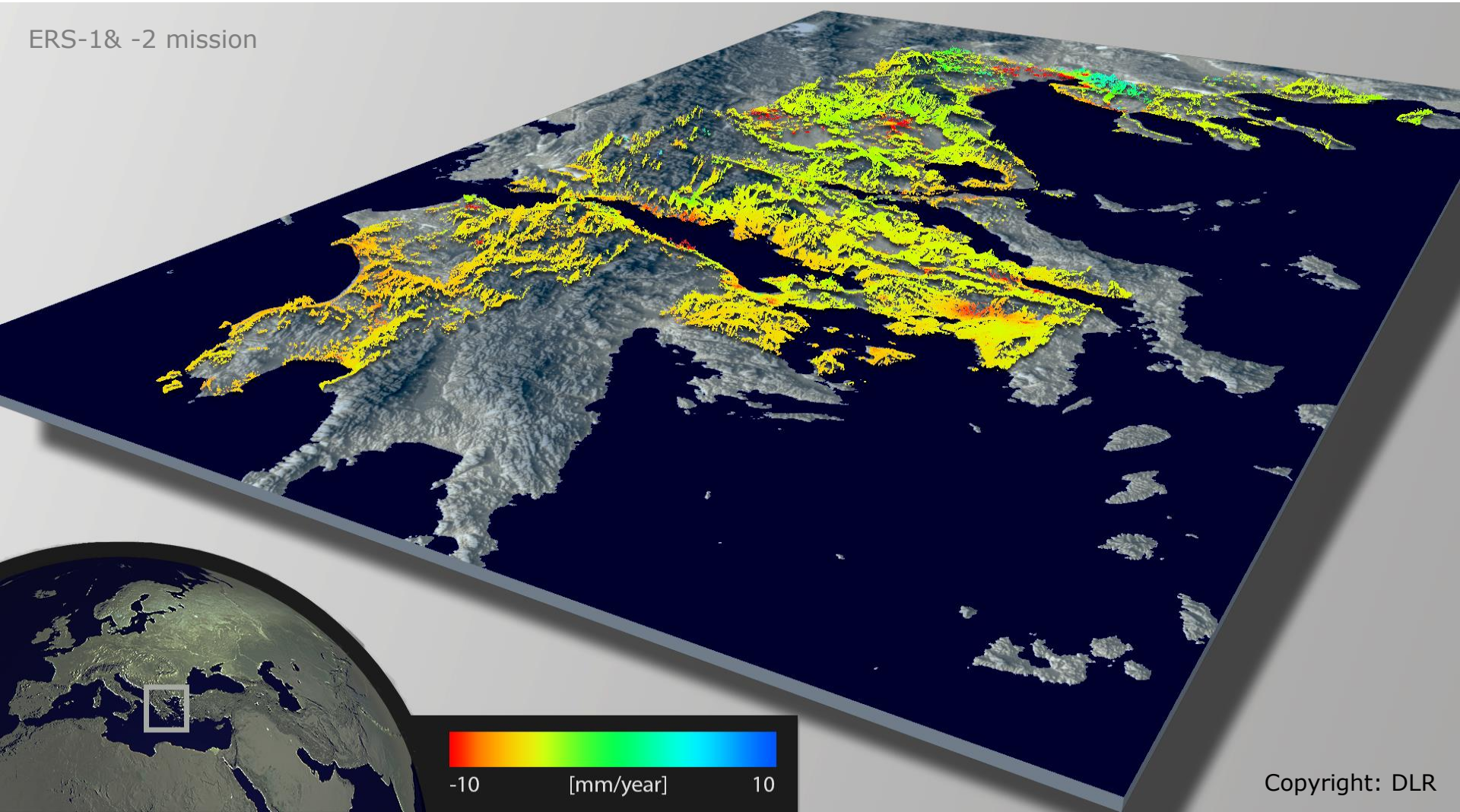
Sentinel-1 TOPS InSAR

http://step.esa.int

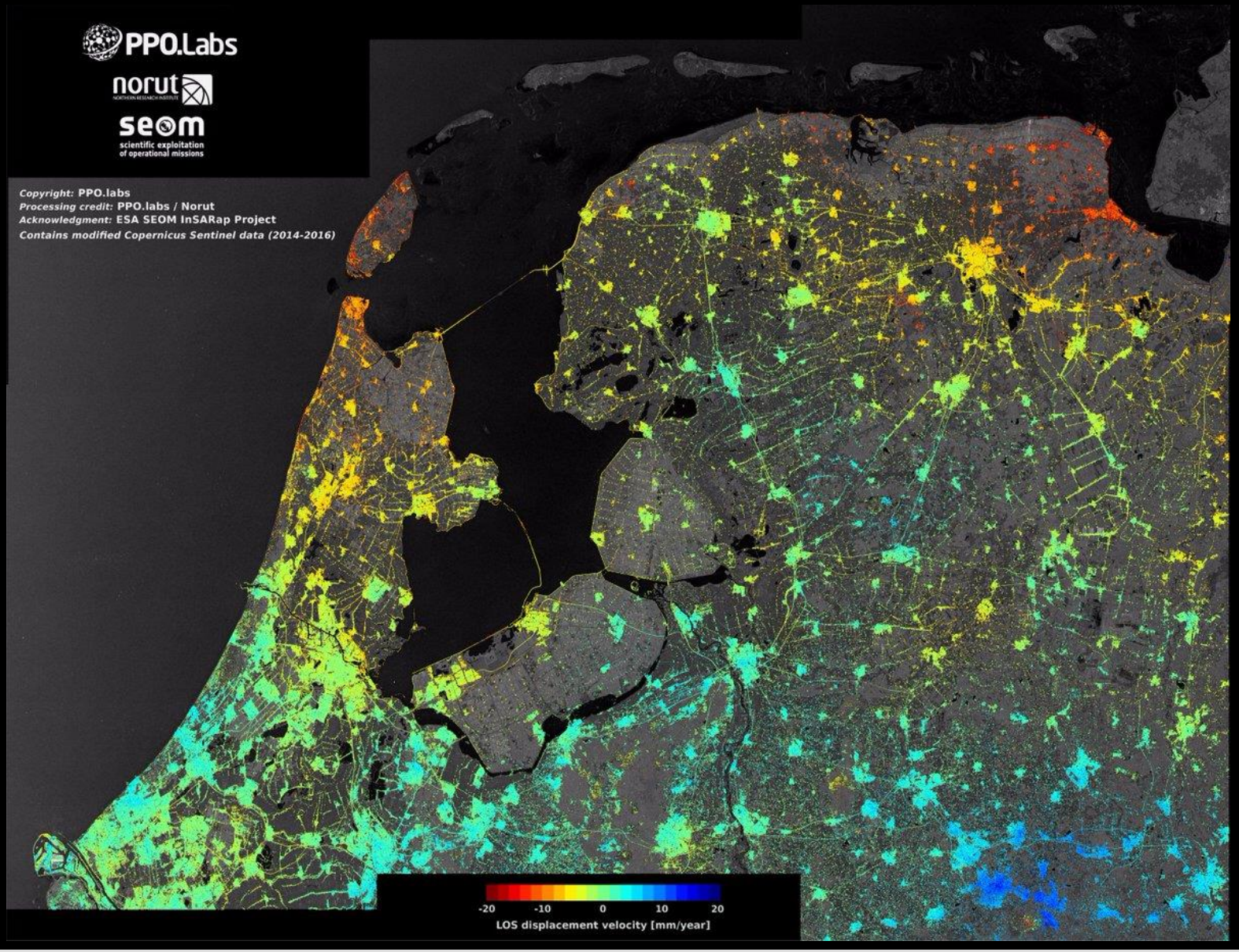


Wide Area Processing (WAP)
ESA's Terrafirma PSI Ground Displacement Products

Towards a pan-European information services for ground subsidence risk

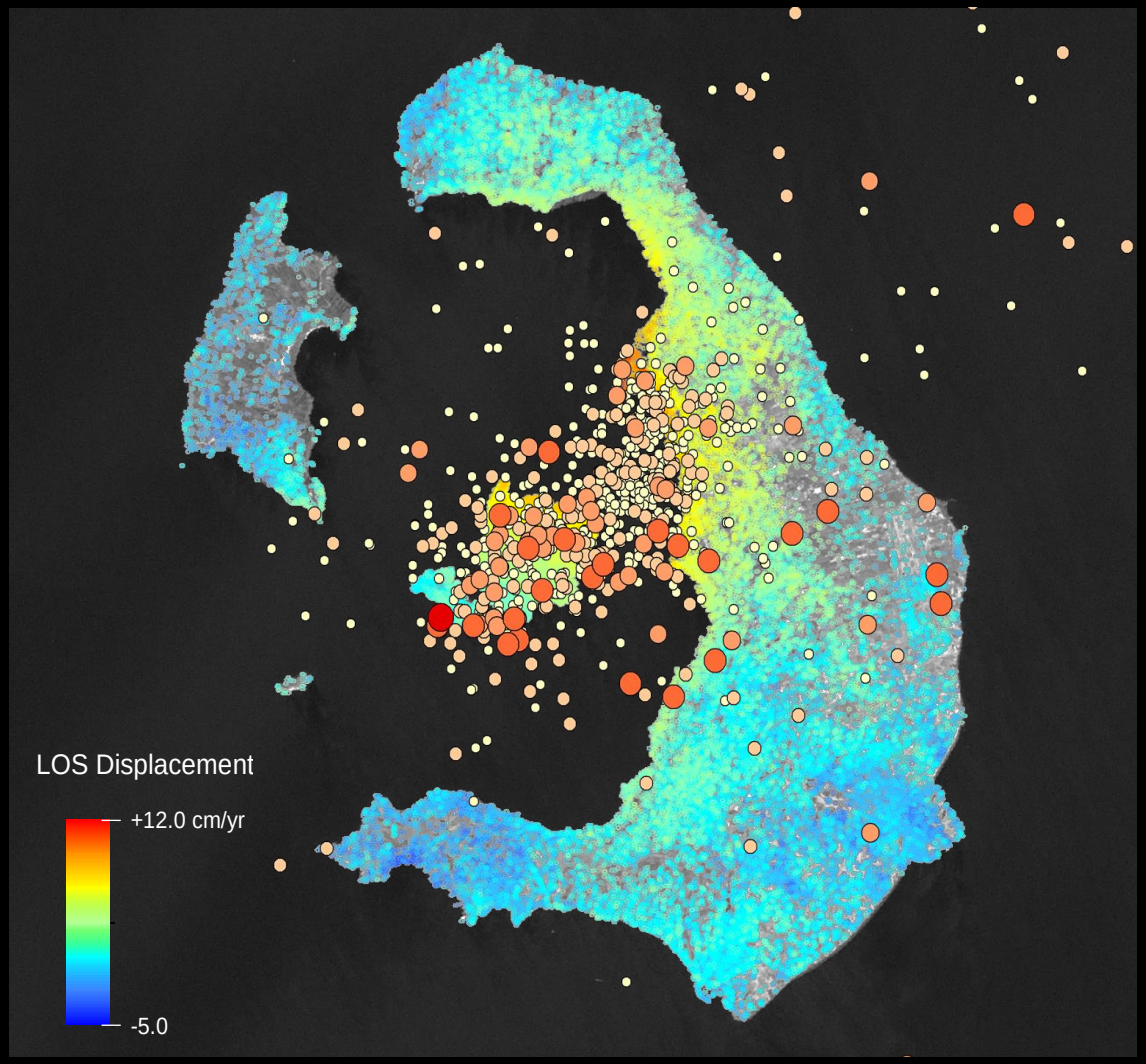


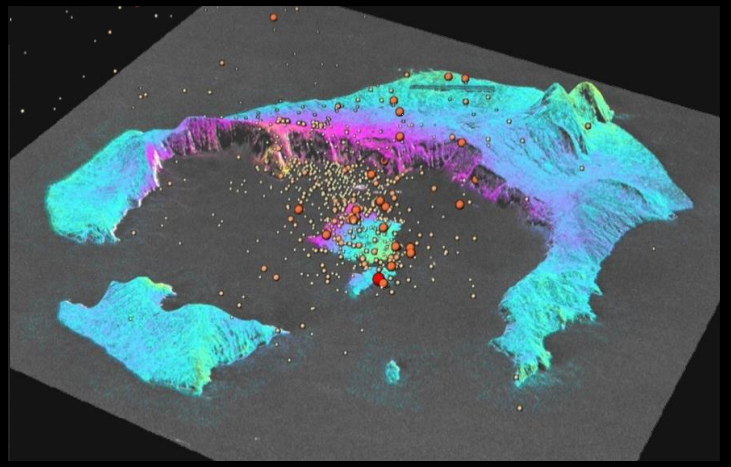
Country Level Results from Sentinel-1

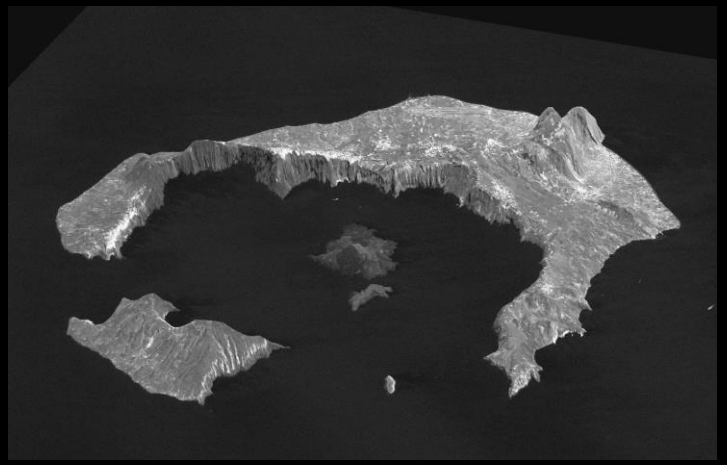


Volcano Breathing from Space

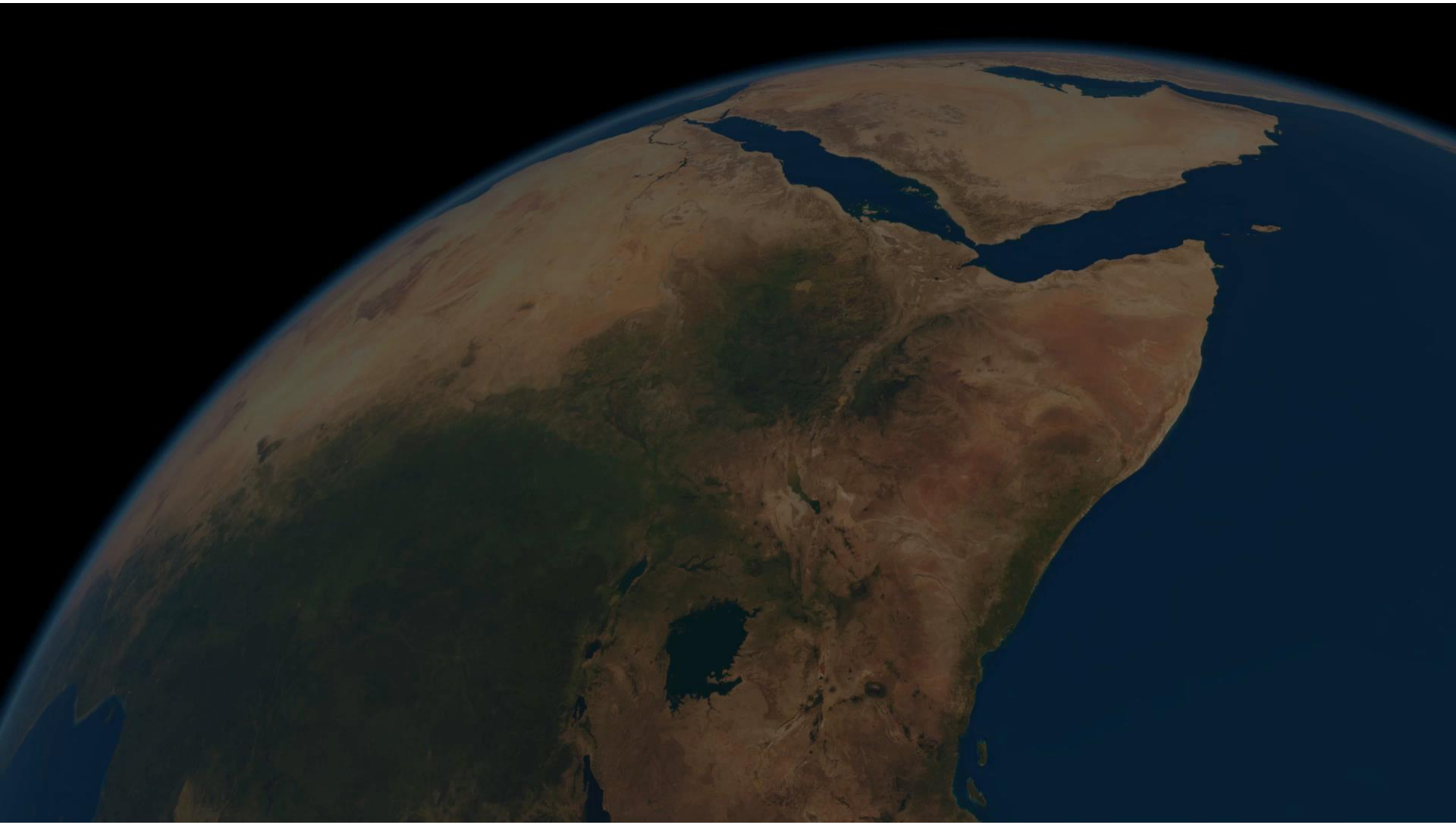
Unrest Episode of Santorini Volcano (Greece)







Monitoring the Great Rift Valley (Afar, Africa)



ESA Heritage SAR missions: ERS and ENVISAT

prepared by ERS/ENVISAT Teams

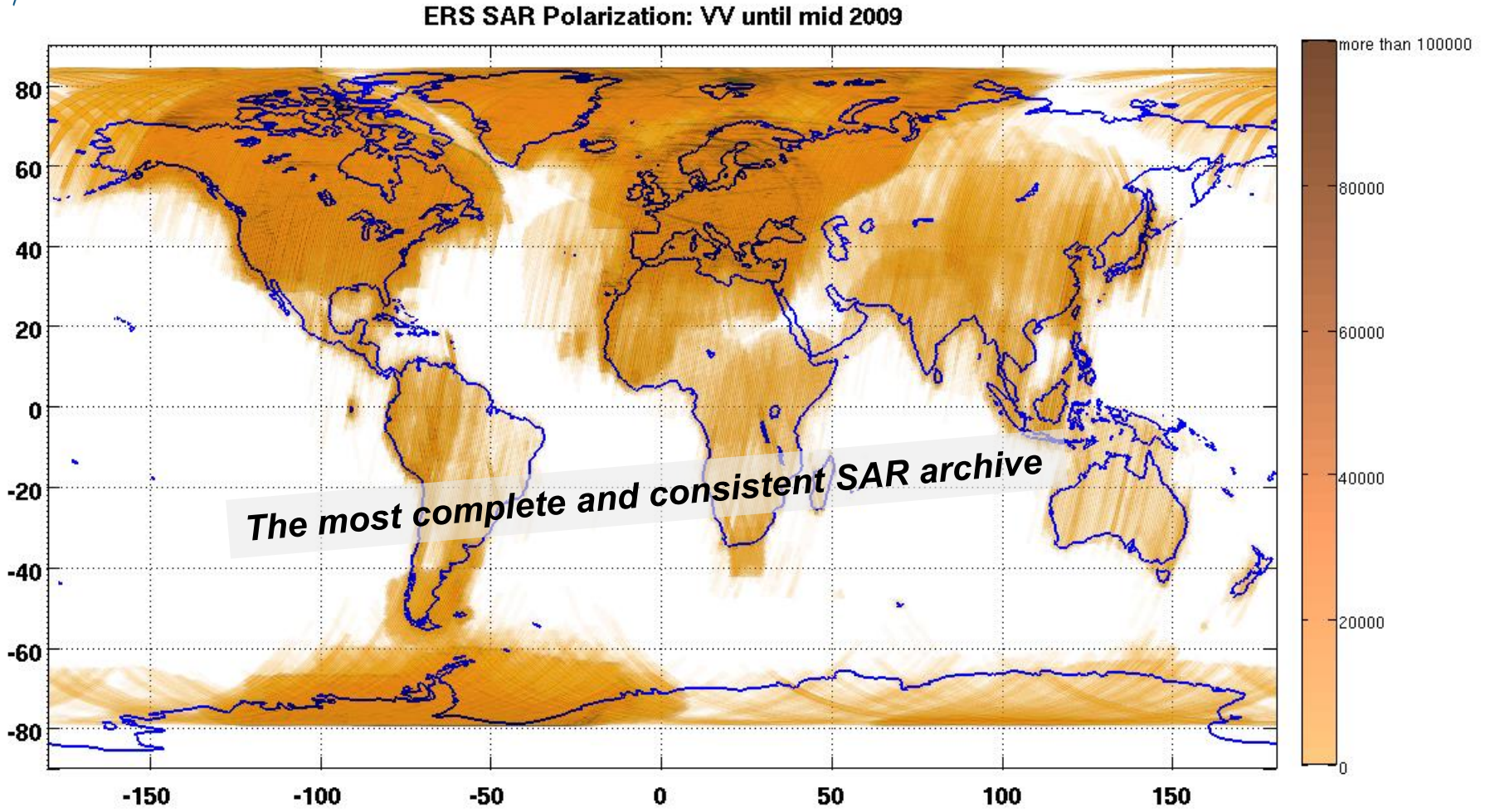
ESA and SAR Interferometry

For the last 25 years, ESA has been constantly supporting the SAR Interferometry (InSAR) communities with:

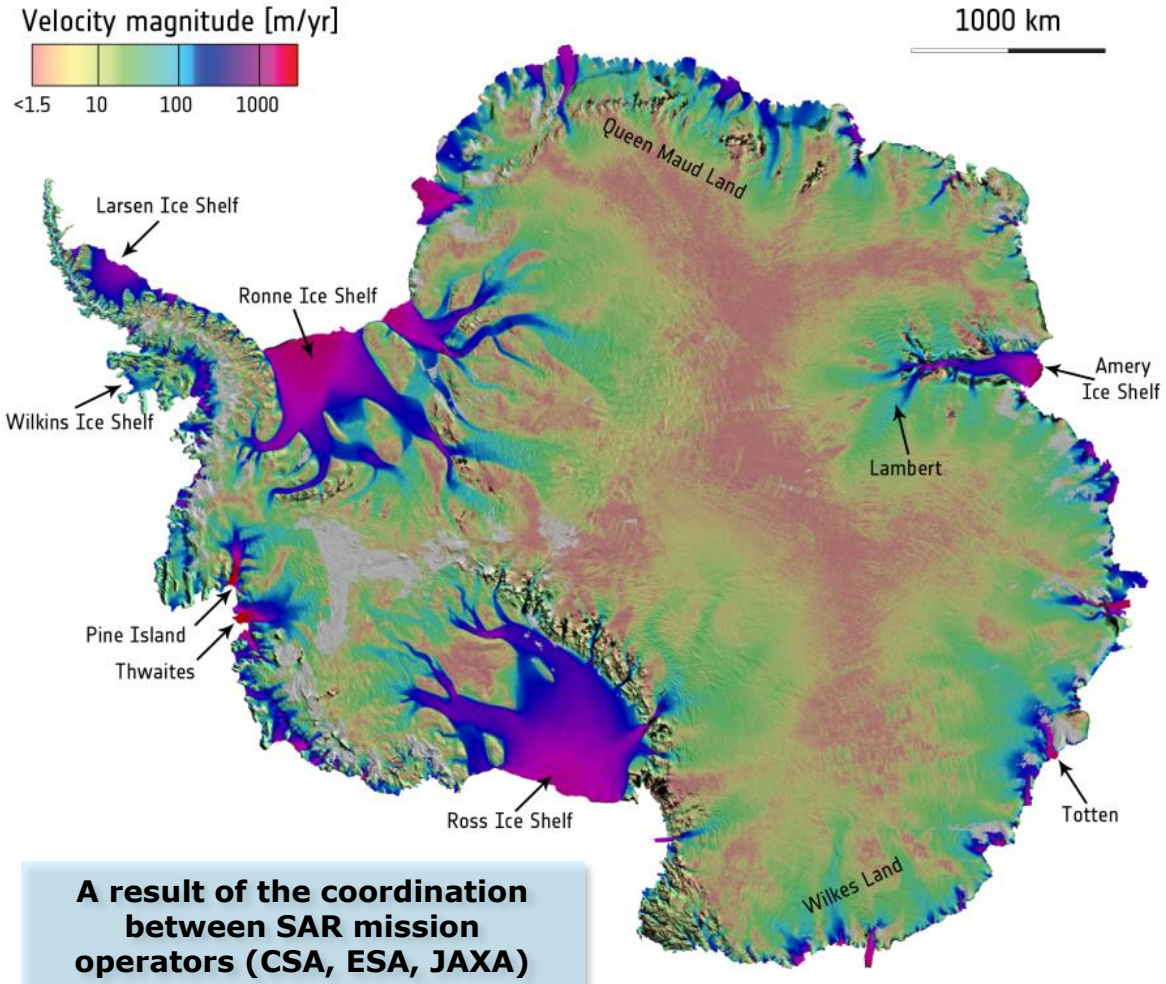
- the **provision of InSAR data**, through:
  - the development and operations of SAR satellites (ERS-1, ERS-2, Envisat)
  - a precise satellite orbital maintenance including InSAR tandem campaigns (ERS-1/ERS-2 tandem, ERS-2/Envisat tandem)
  - the development of a large and consistent InSAR data archive
  - a constant effort in facilitating the use of SAR data
- the **development of InSAR science and InSAR applications**,
- bringing together the InSAR communities through **Fringe & Living Planet workshops**.

ERS Missions → 20-years InSAR archive

1991-2011

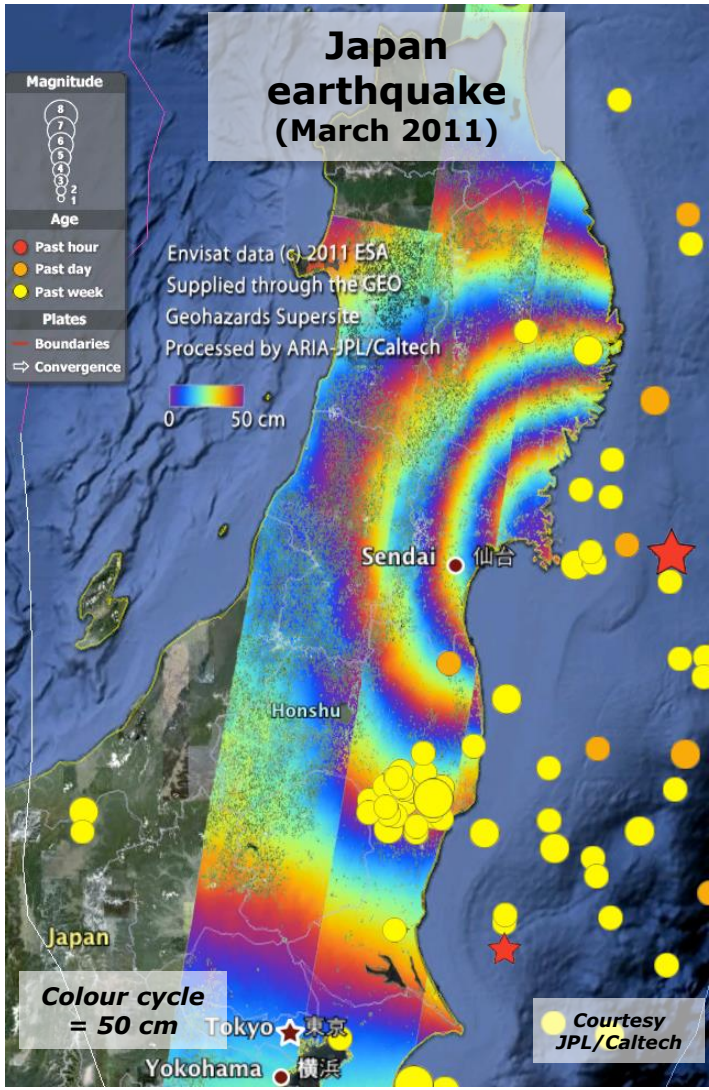


ENVISAT Mission - Large scale exploitation of InSAR



A result of the coordination between SAR mission operators (CSA, ESA, JAXA) during the *International Polar Year 2007-2008*

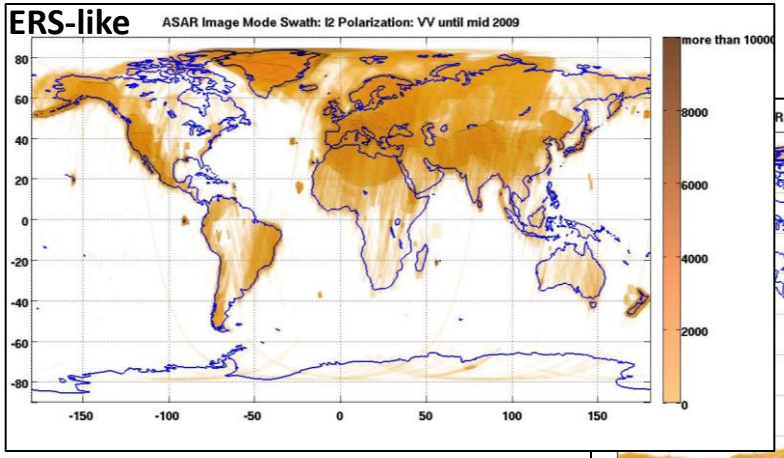
E. Rignot et al., Science, September 2011

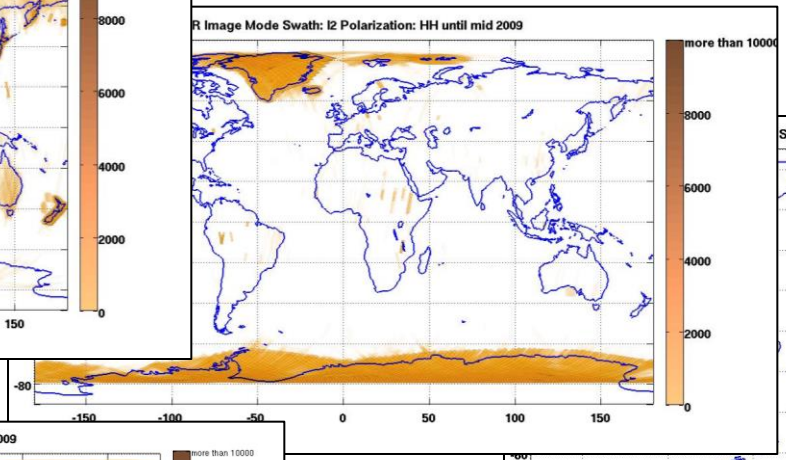


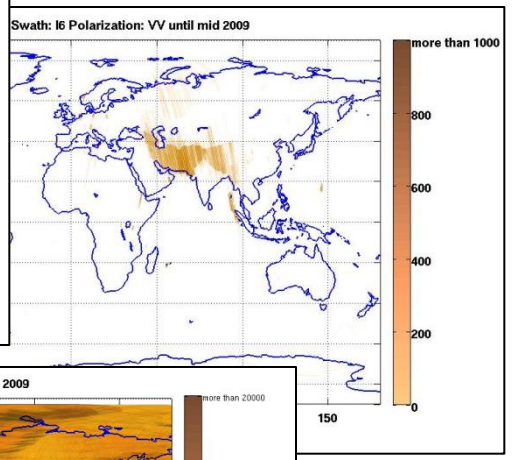
ENVISAT Mission - Large scale exploitation of InSAR

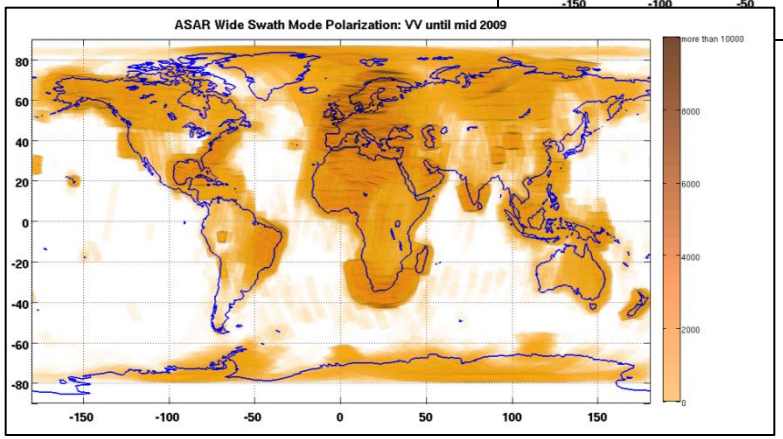
ENVISAT ASAR data

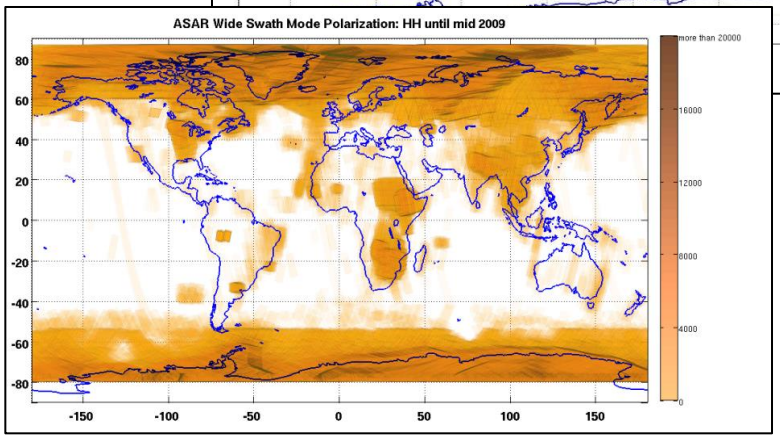
→ a large InSAR archive in different operating modes



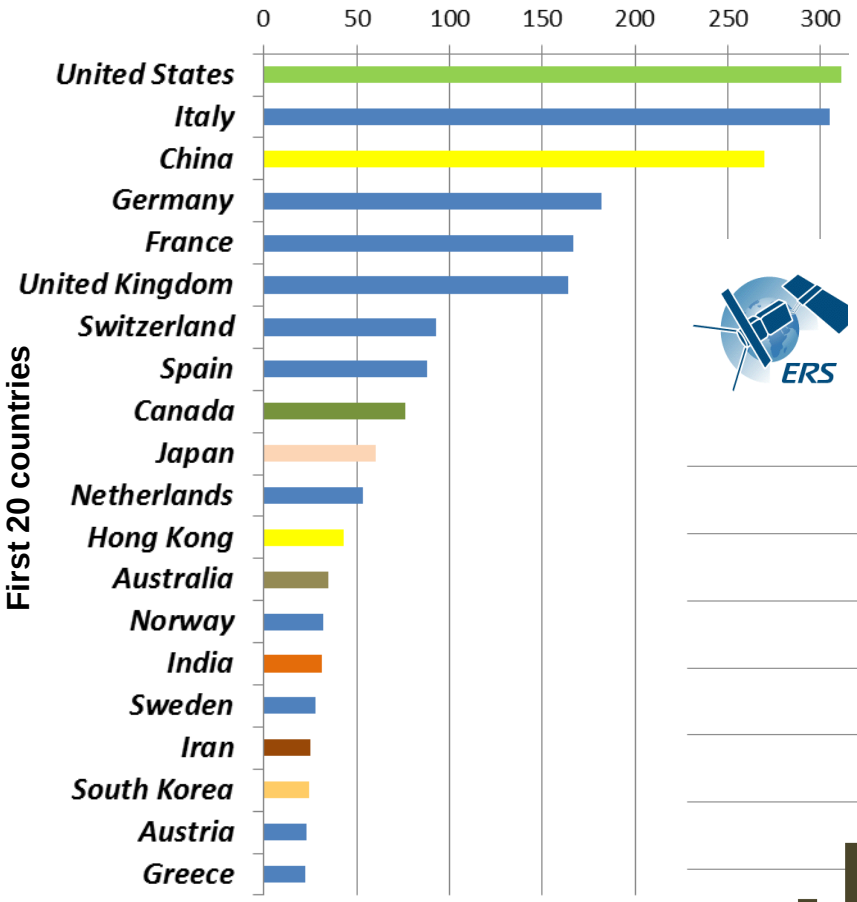






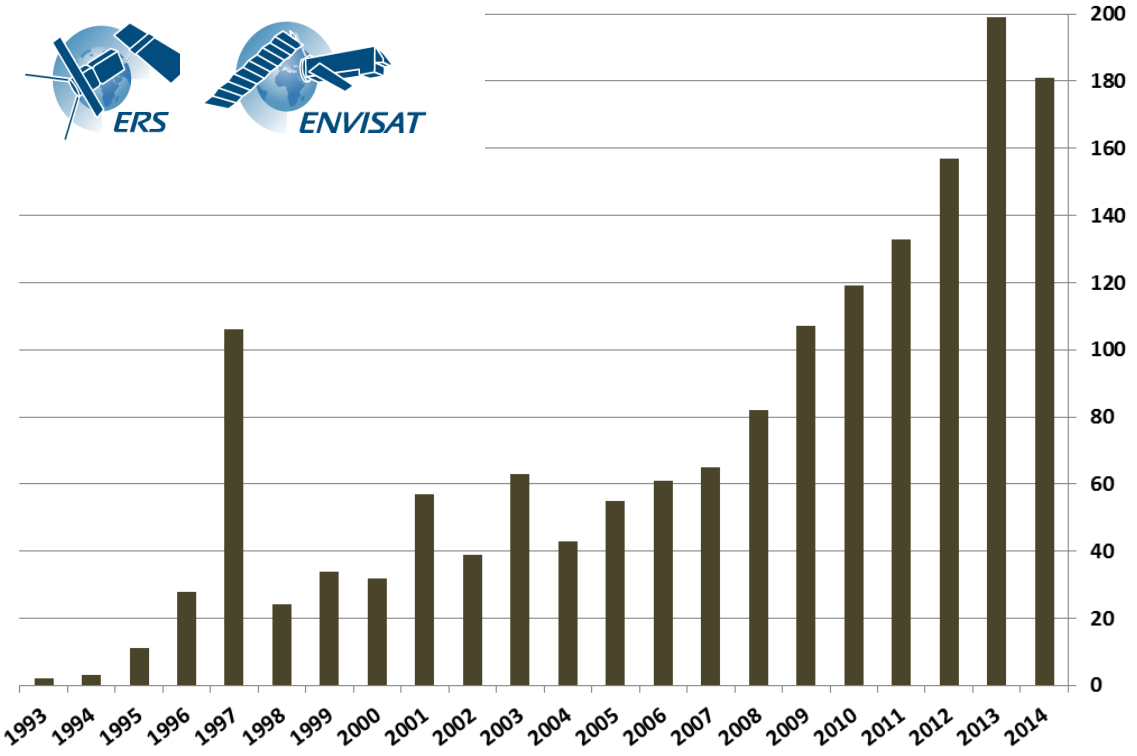


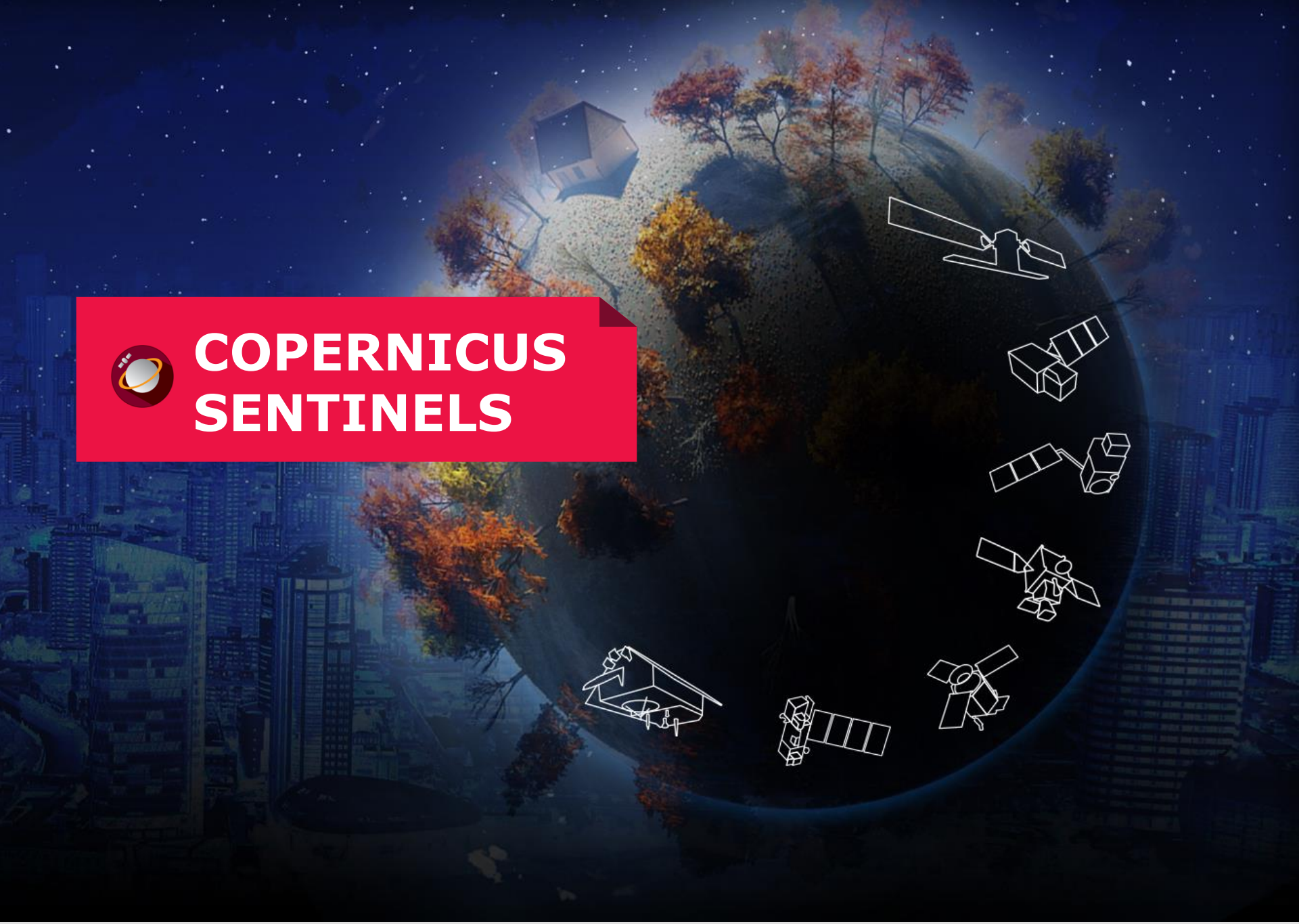
A large impact in the Scientific Literature



Scopus database, Journal papers with search on: “ERS or Envisat and SAR Interferometry”

Peer-reviewed journal papers based on SAR interferometry and on ERS or Envisat data




COPERNICUS
SENTINELS

Global monitoring for a safer world

Copernicus: an Earth observation programme for global monitoring for environment and security.

Led by the European Commission in partnership with ESA and the European Environment Agency, and responding to Europe's need for geo-spatial information services, it will provide autonomous and independent access to information for policy-makers, particularly for environment and security issues. ESA is implementing the space component: developing the **Sentinel** satellite series, its ground segment and coordinating data access.

ESA has started a **Climate Change Initiative**, for storage, production and assessment of essential climate data.

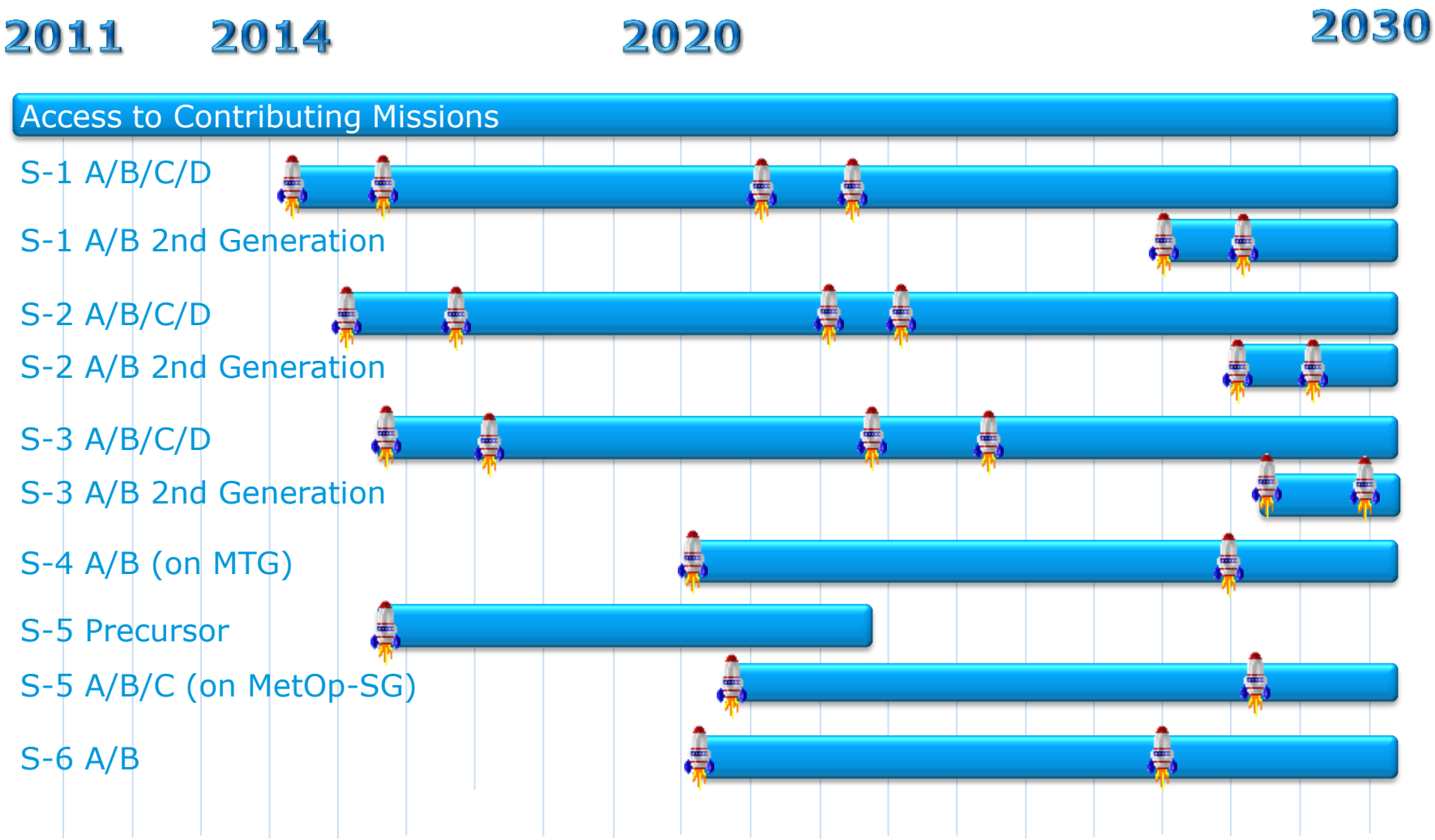
The Copernicus Programme

A Space Flagship Programme run by EU and ESA

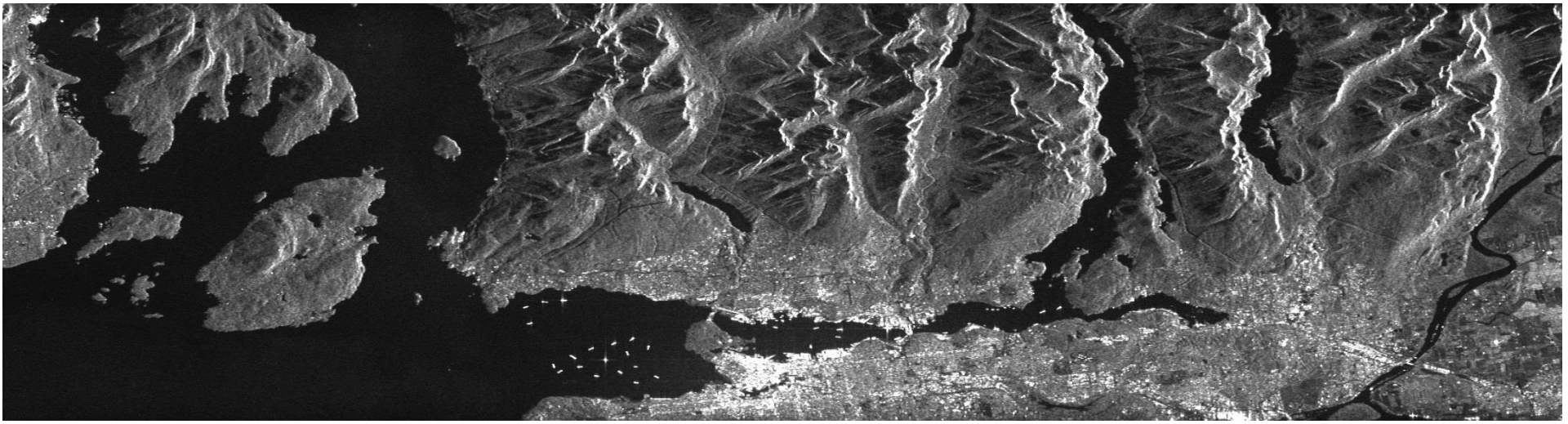
Dedicated satellites (“Sentinels”):

- **S1: Radar Mission**
- **S2: High Resolution Optical Mission**
- **S3: Medium Resolution Imaging and Altimetry Mission**
- S4: GEO Atmospheric Chemistry Mission
- S5P/S5: LEO Atmospheric Chemistry Missions
- S6/Jason-CS: Altimetry Mission

The Sentinel Family - Long Term Operational Plan

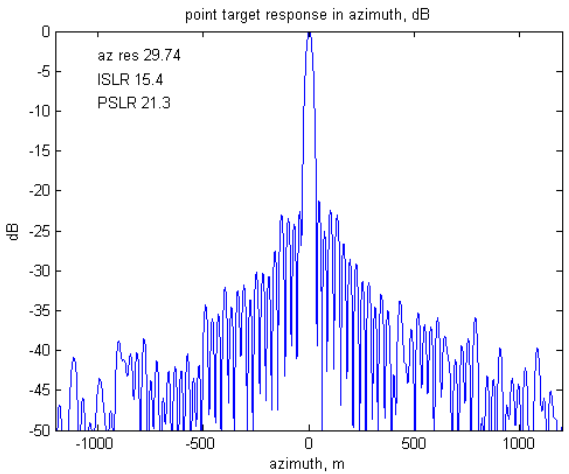


Sentinel-1 Simulated Products
First Radarsat-2 image in TOPS



The first RADARSAT-2 TOPS mode over Vancouver. (courtesy Radarsat-2 / MDA)

Point target analysis of a bright point around the airport



Launch of Sentinel-1A

- April 3, 2014
- Launch from French Guiana Space Base
- Soyuz-2 rocket
- New era in Earth Observation

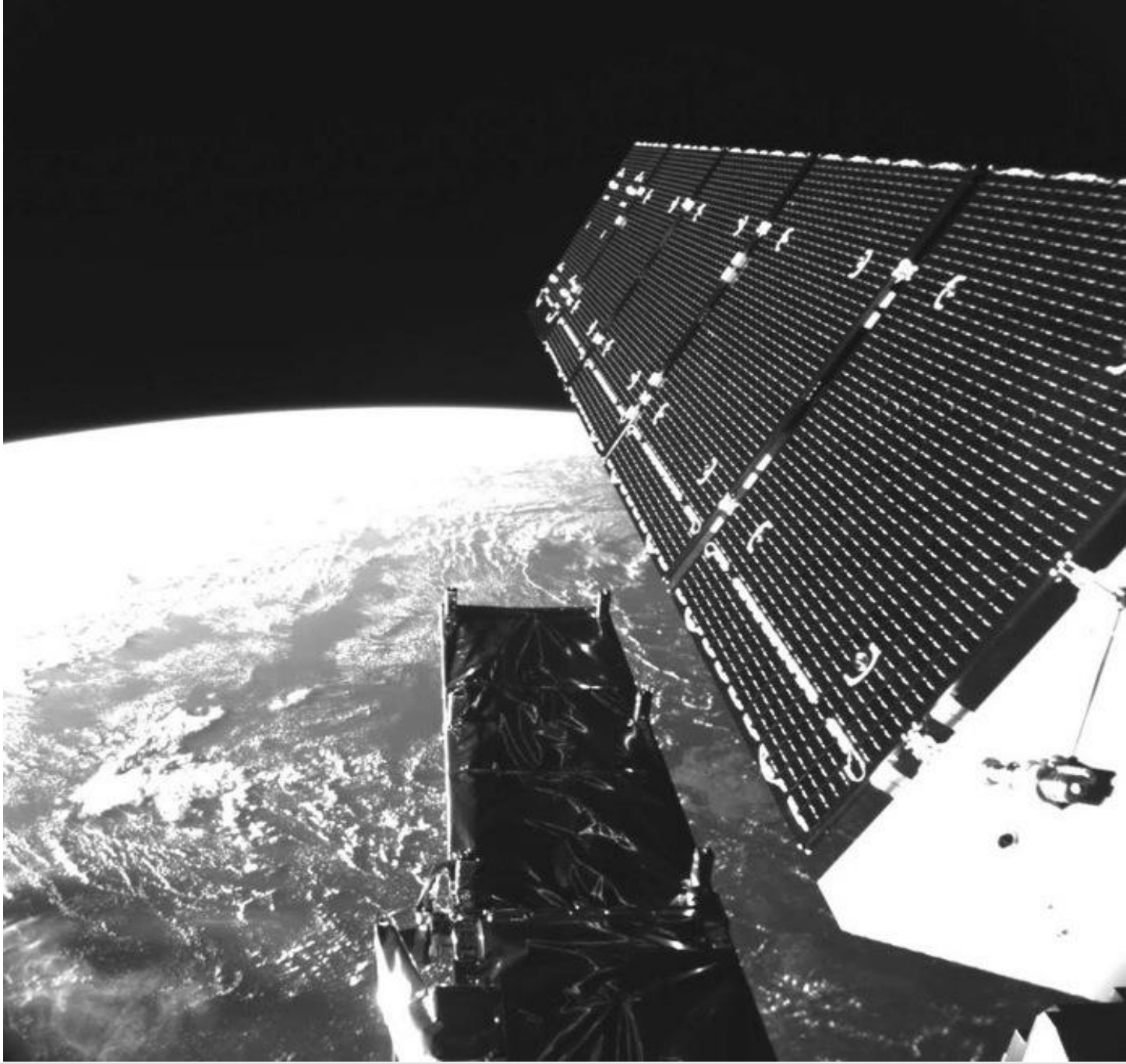
Launch of Sentinel-1A (3rd April 2014)

Sentinel-1A Deployment

Sentinel-1A

4 April 2014

First ‘selfie’ from an Earth Observation Satellite



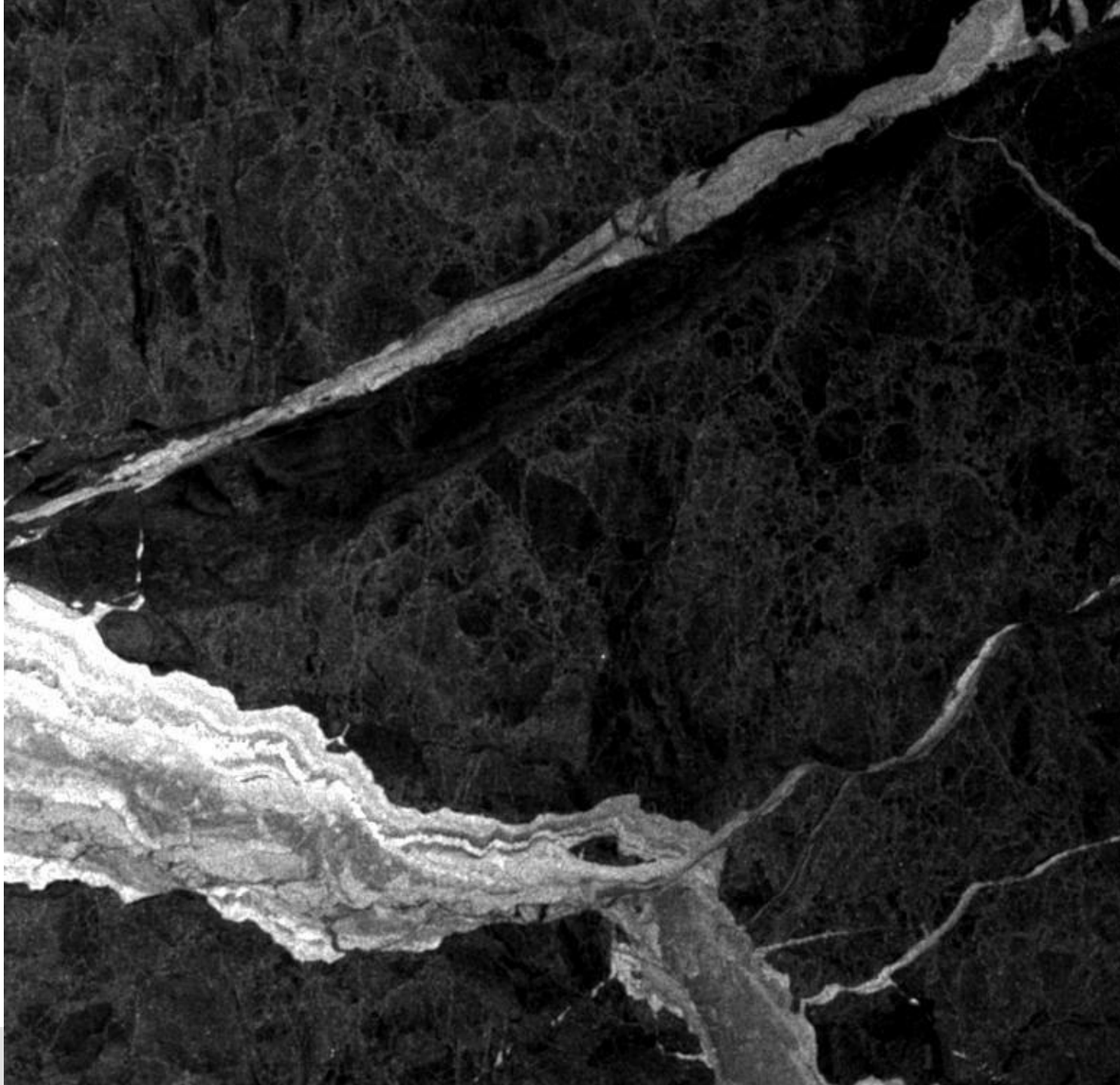
Sentinel-1A LEOP

Completed in three days as planned

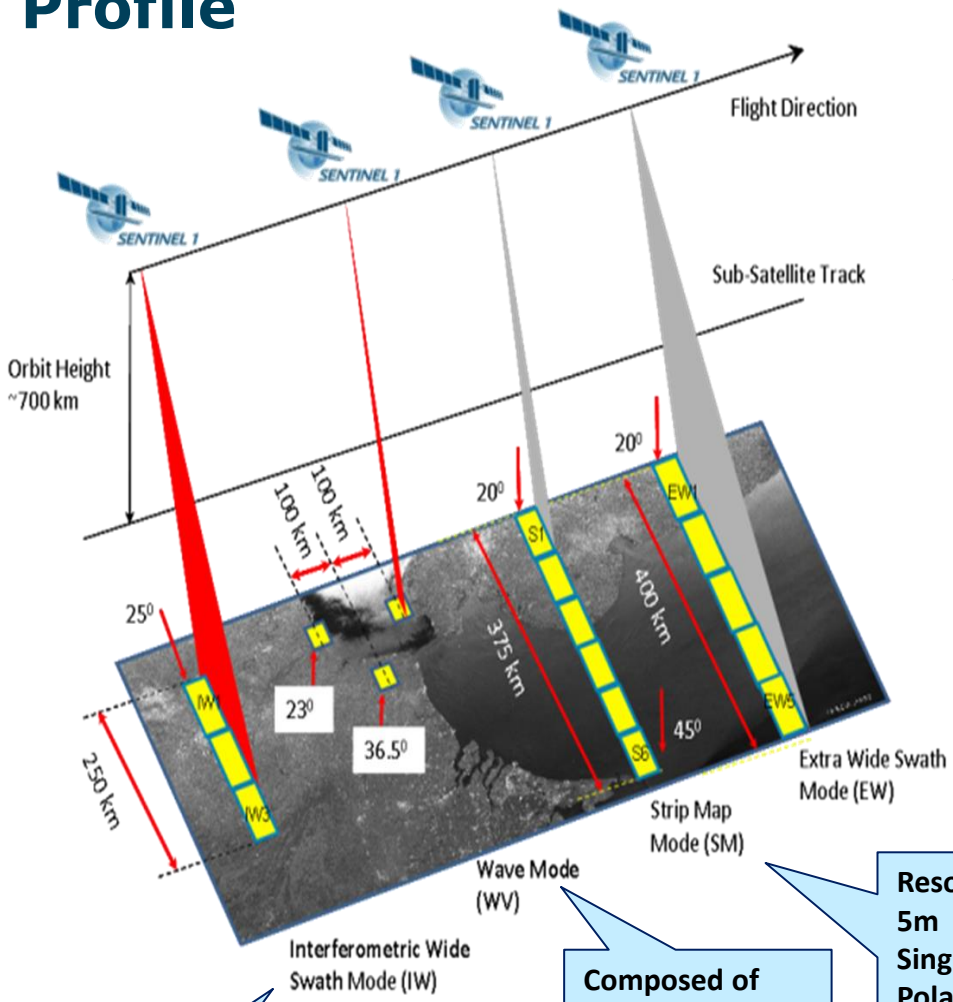
All s/s were switched on

First X-band downlink in Matera (I)

First SAR acquisition occurred on 6 April at L+62h33’
(WM over Svalbard)



Sentinel-1 Mission Profile



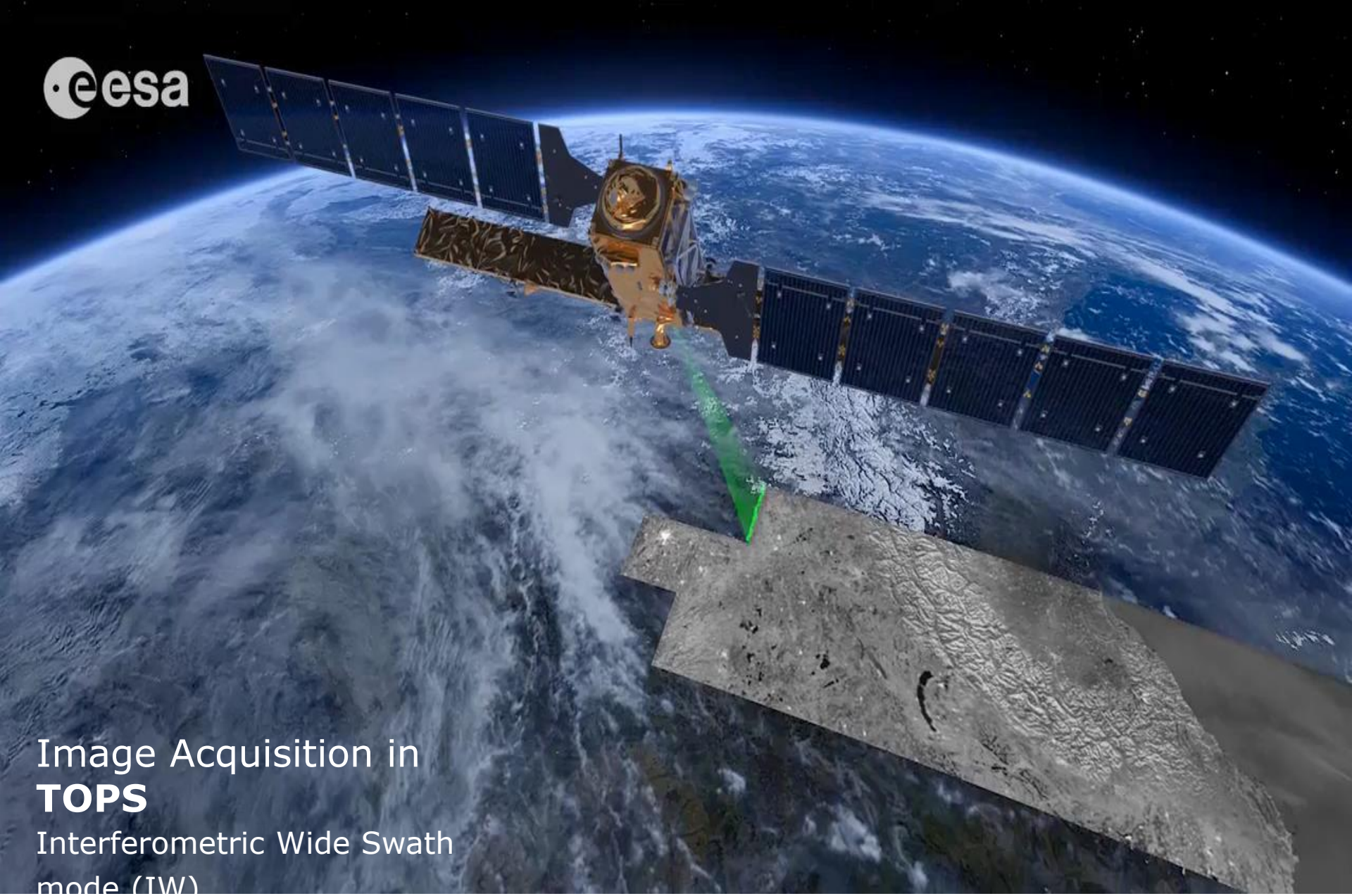
S-1 SAR can be operated in 4 exclusive imaging modes with different resolution and coverages.

Resolution: 20 x 40m
Single and dual Polarisation
Polar areas, and ocean relevant areas
Can be used for interferometry

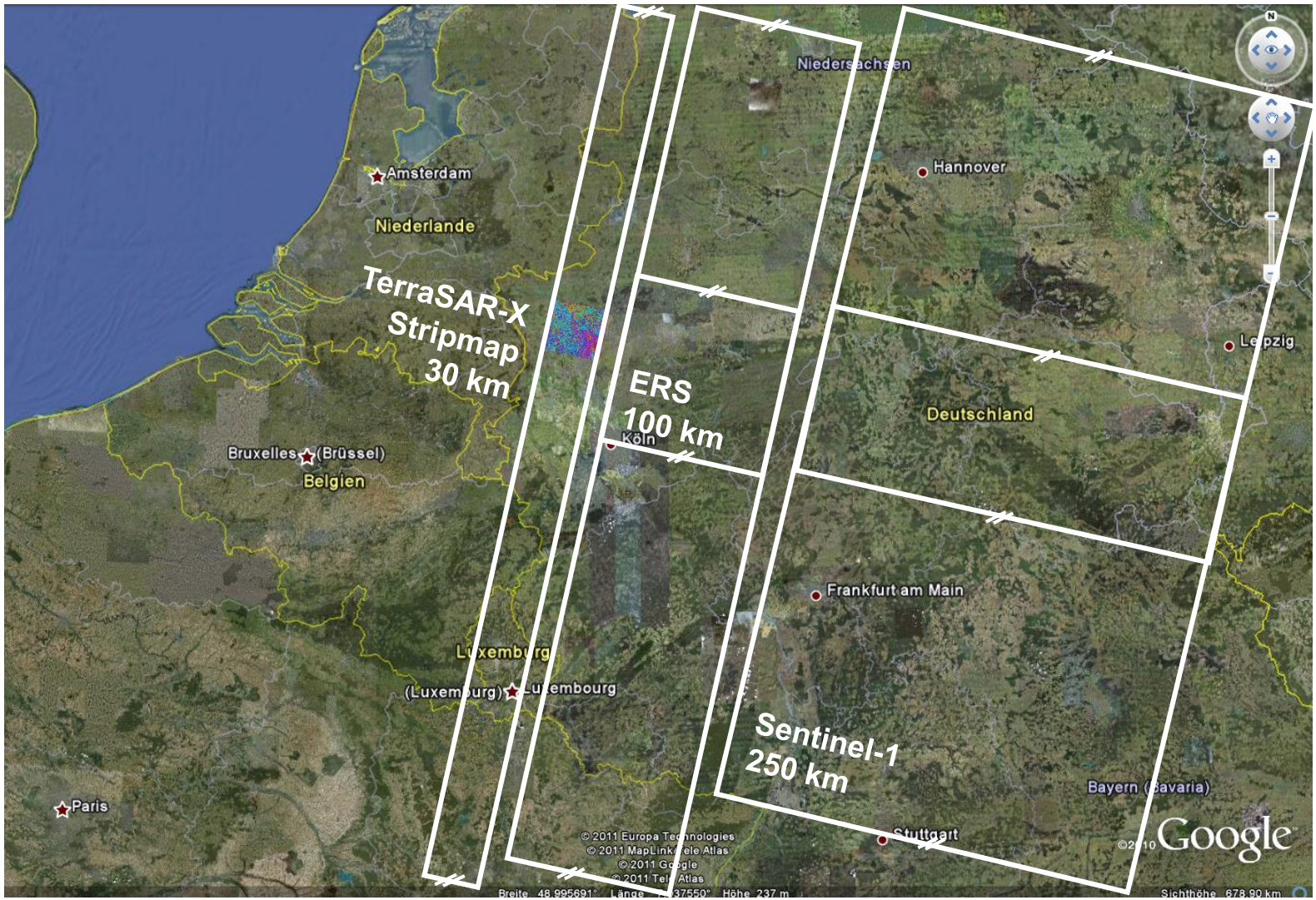
Resolution: 5m x 5m
Single and dual Polarisation
Emergency Services-Disater Monitoring

Composed of Stripmap imagettes
Single polarisation
Pre-defined mode over open oceans

Resolution: 5m x20m
Single and dual Polarisation
Pre-defined mode over Land

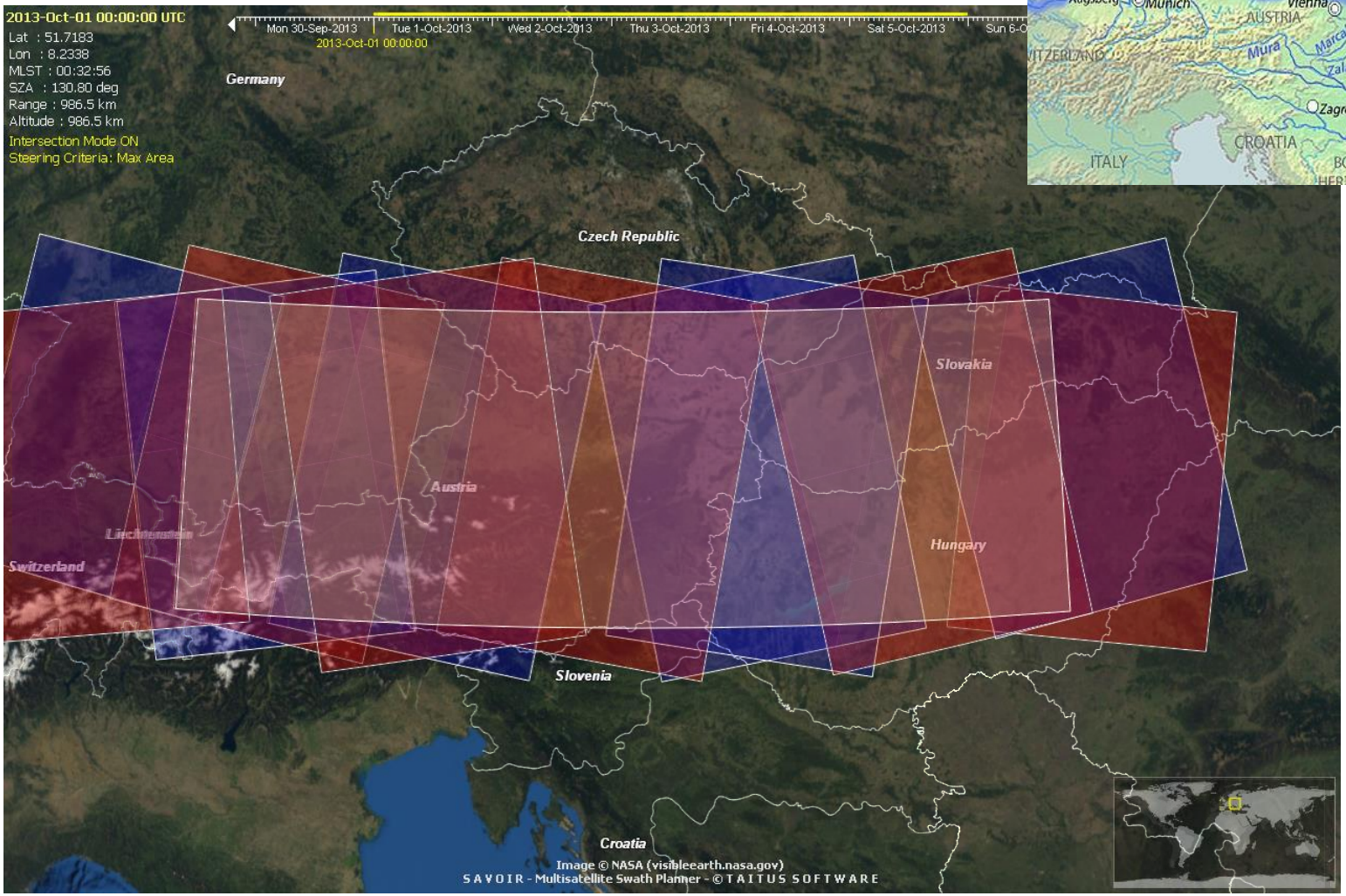

esa
Image Acquisition in
TOPS
Interferometric Wide Swath
mode (IW)

Sentinel-1 Swath Coverage



Sentinel-1 Improved Spatial Coverage

Sentinel-1 vs ENVISAT 5-day coverage

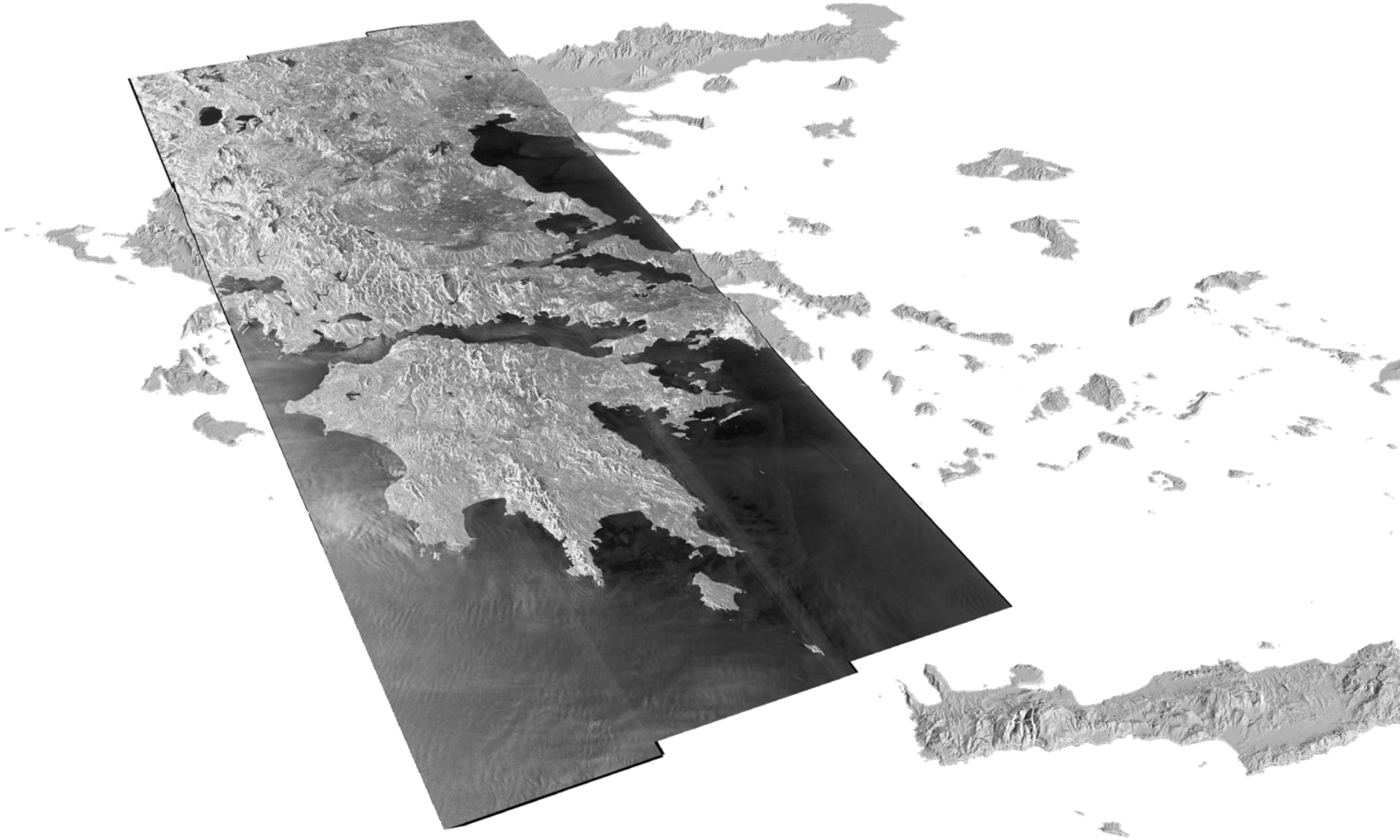


Until 2012:
ENVISAT

2014+:
Sentinel1A

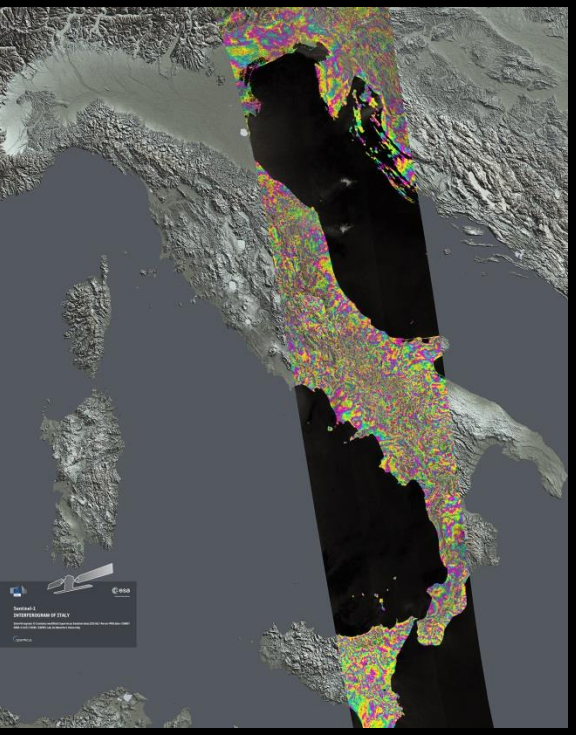
2016+:
Sentinel1A/B

Sentinel-1A TOPS over Greece (First Acquisitions)



Sentinel-1A

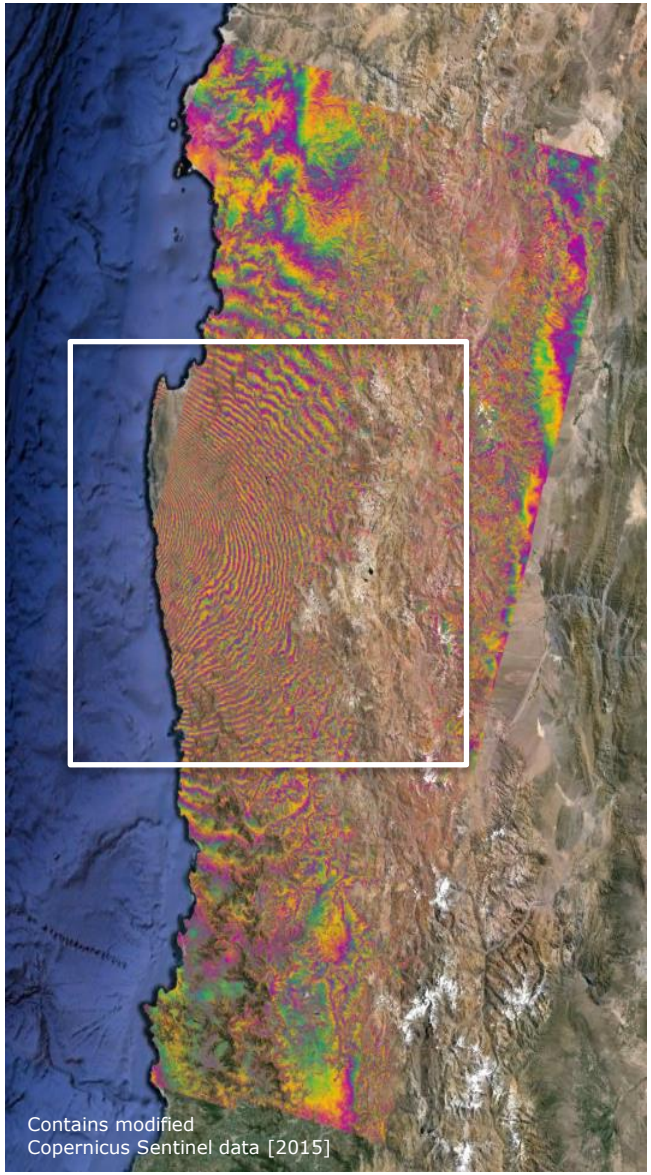
Italy (1200 Km)



Datatake (7 slices):

- IW mode
- Vertical Polarization
- Acq. Dates:
  - 09/08/2014
  - 21/08/2014

Sentinel-1 TOPS Interferometry



On September 16, 2015, an earthquake of **magnitude 8.3** occurred in Chile.

A coseismic Sentinel-1 TOPS interferogram combining images acquired on 24th August and 17th September was computed.

Fringe pattern suggests about **140 cm** Line-of-Sight (LOS) ground displacement.

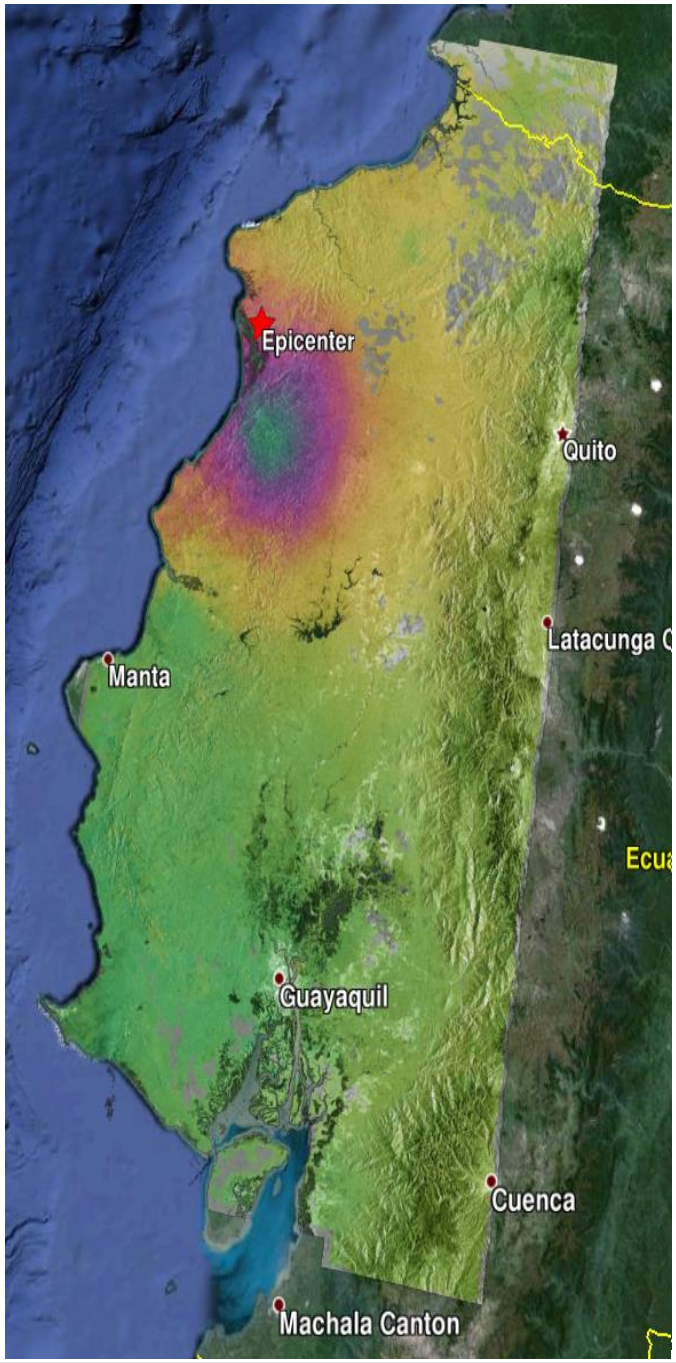
Results, interpretation and geophysical data available on INSARAP.org

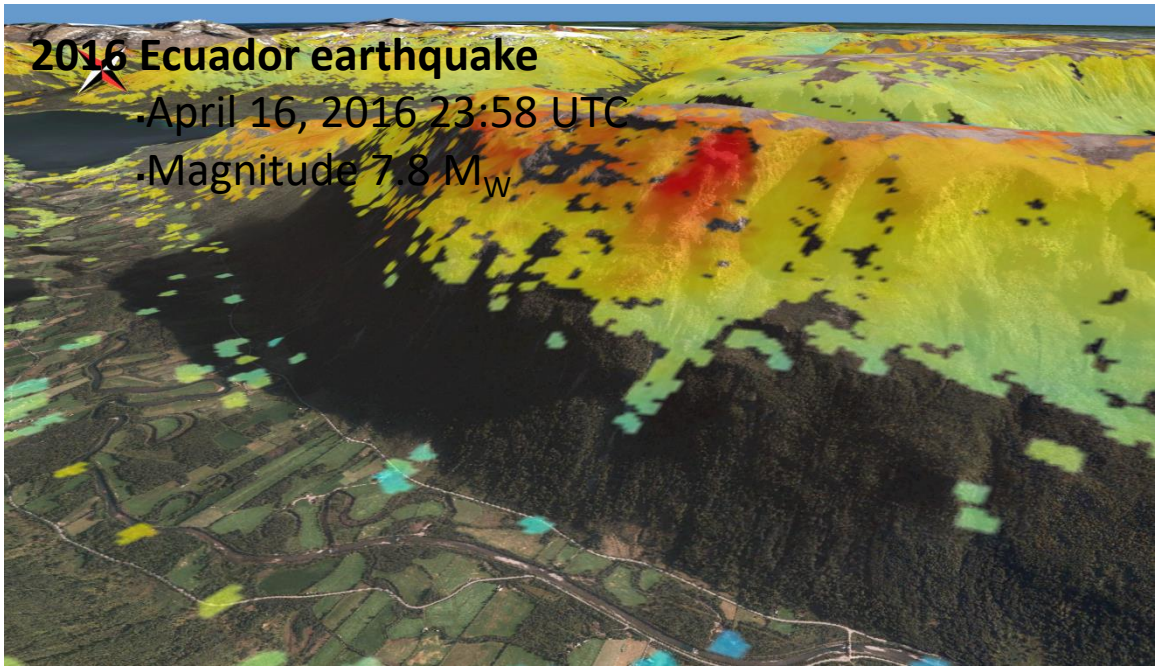
Project funded under ESA SEOM programme

seom
scientific exploitation of operational missions

2016 Ecuador Earthquake

NORUT/PPO.labs/Univ.Leeds –
ESA SEOM InSARAP study





Sentinel-1 D-InSAR

Average displacement velocity from 30 unwrapped interferograms
Data from snow free period:
Jun – Oct 2015

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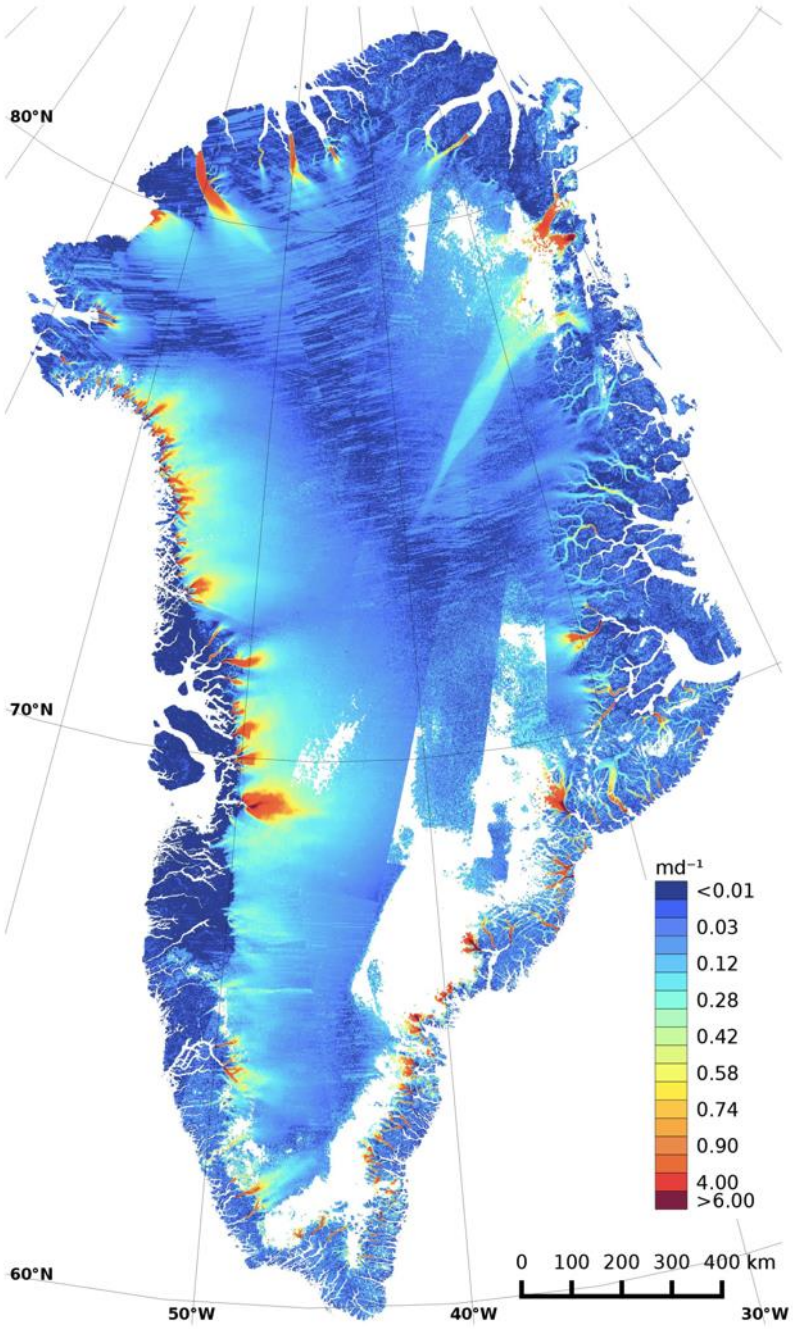
First Greenland Ice Sheet

Ice Surface Velocity Map based on Sentinel-1 data



Based on SLC products from Sentinel-1 Interferometric Wide (IW) Swath mode

Period: Jan-Mar 2015
(some scenes from Oct-Dec 2014)

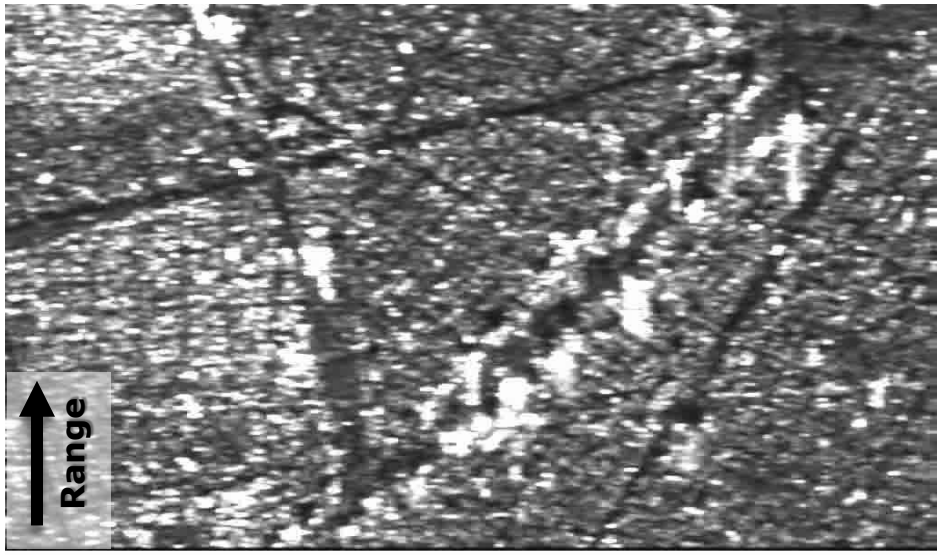
~ 800 scenes
~ 25 000 bursts
~ 2.7 TB of SLC data

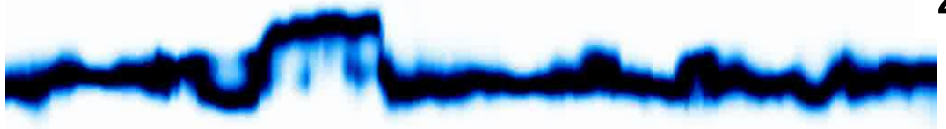
Offset tracking technique

Courtesy ENVEO IT Gmbh / ESA CCI Ice Sheets Project

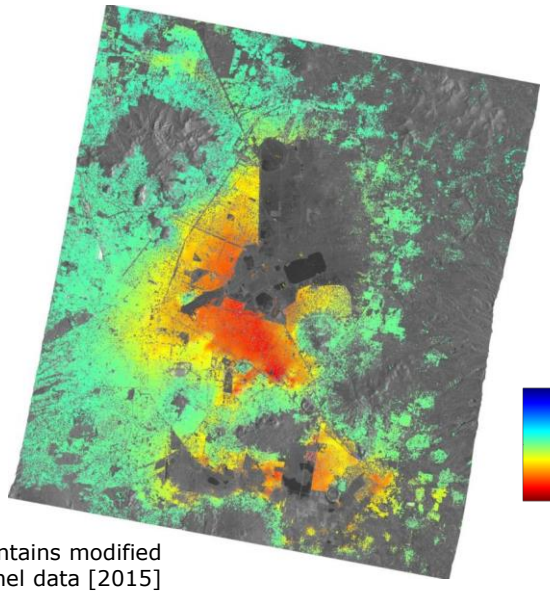
Sentinel-1 Tomography: Mexico City

DLR Microwaves and Radar Institute – ESA SEOM InSARAP study





250m



Contains modified
Copernicus Sentinel data [2015]

DLR

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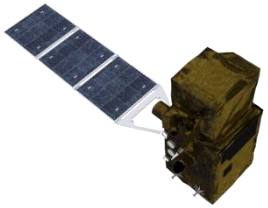
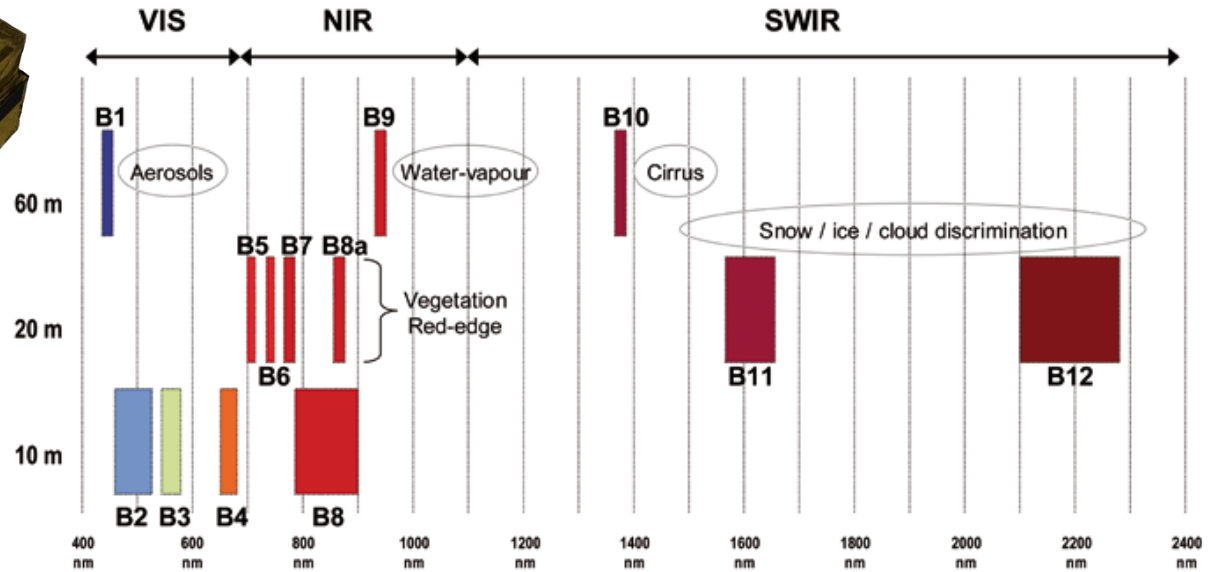
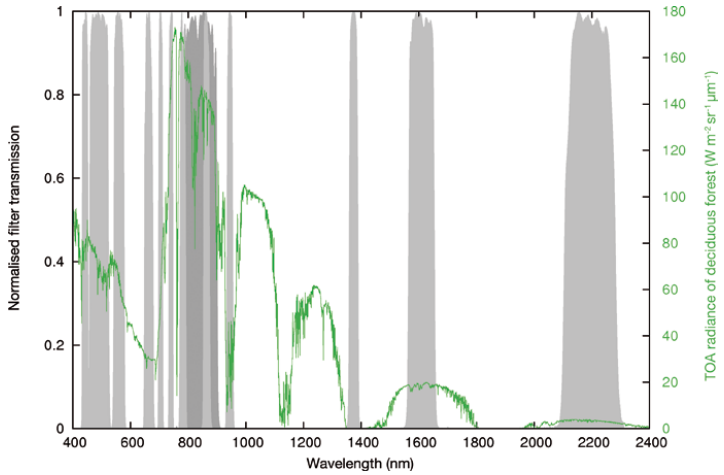
scientific exploitation
of operational missions

Sentinel-2 Multispectral Instrument (MSI)

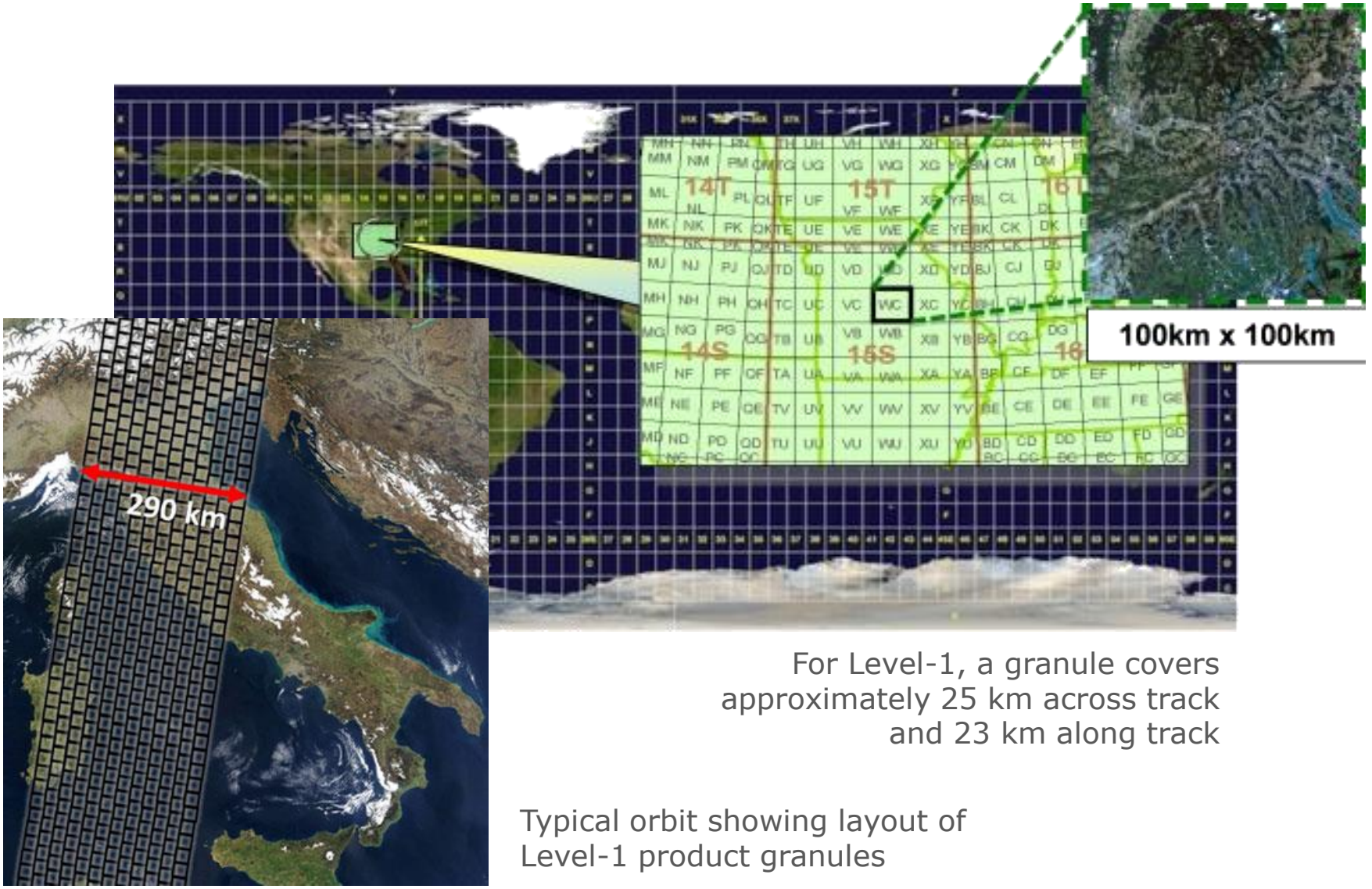




12	2190	180	0.1	1.5	24.5	100



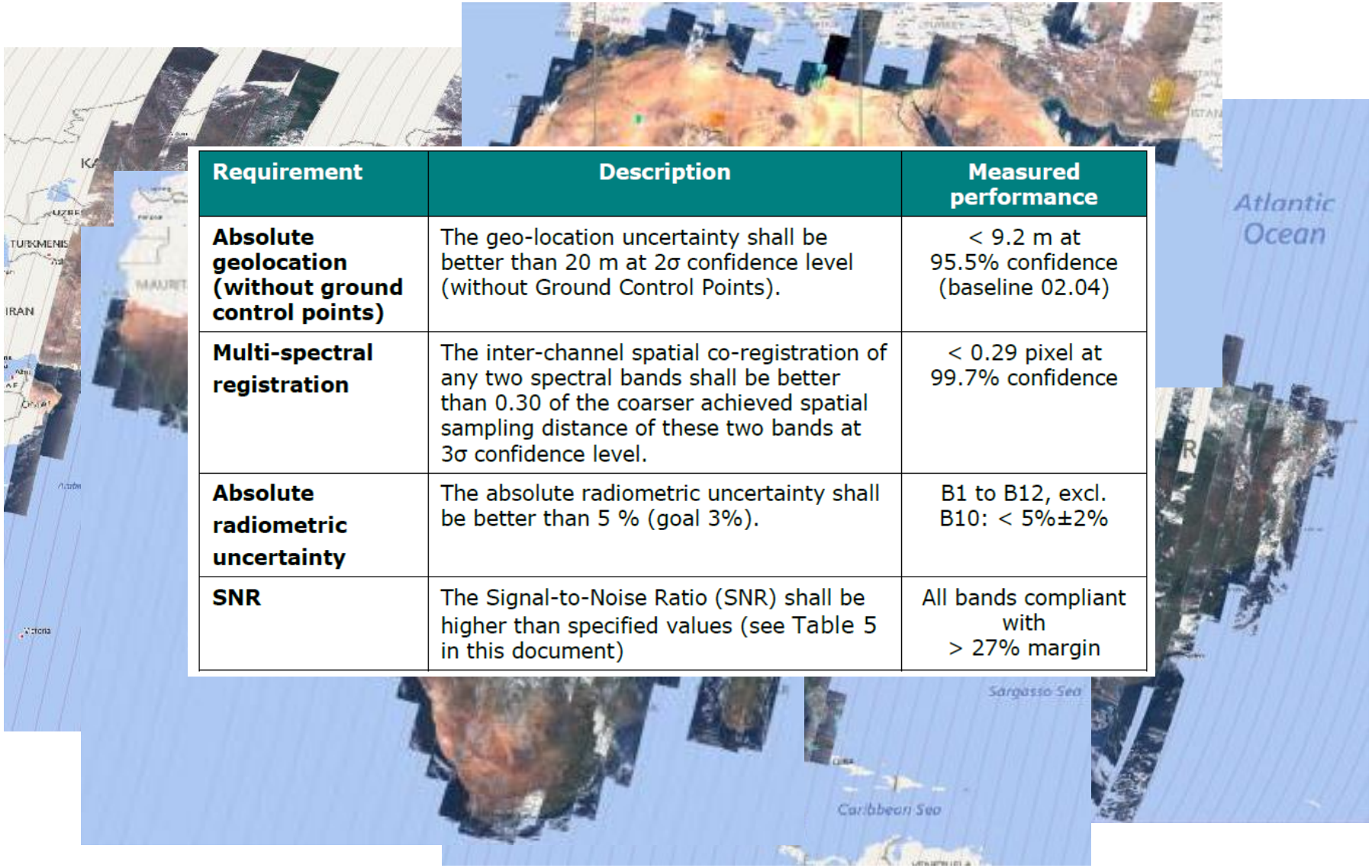
Sentinel-2 Level-1C Product Tiling



For Level-1, a granule covers approximately 25 km across track and 23 km along track

Typical orbit showing layout of Level-1 product granules

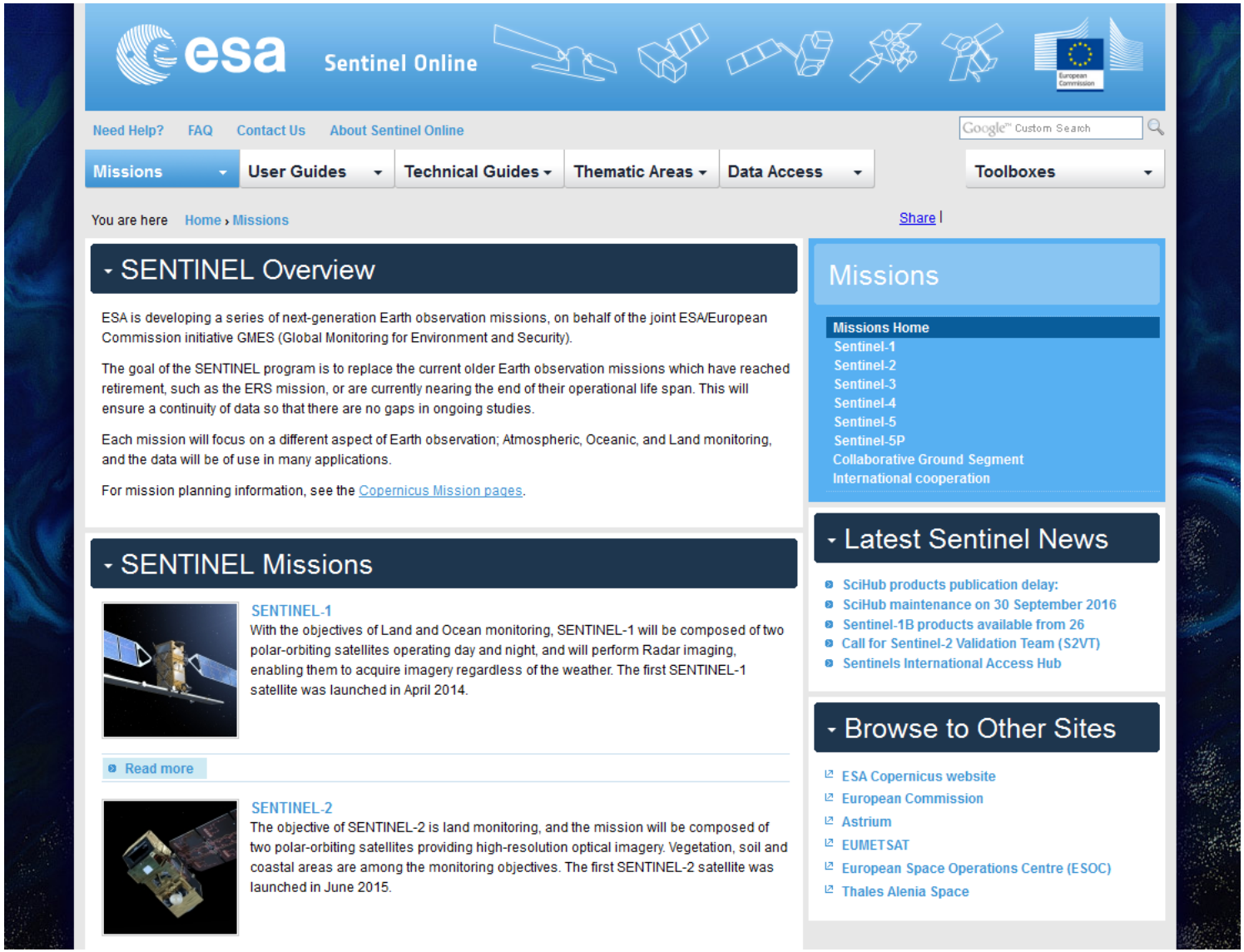
Sentinel-2 | Measured Product Performances

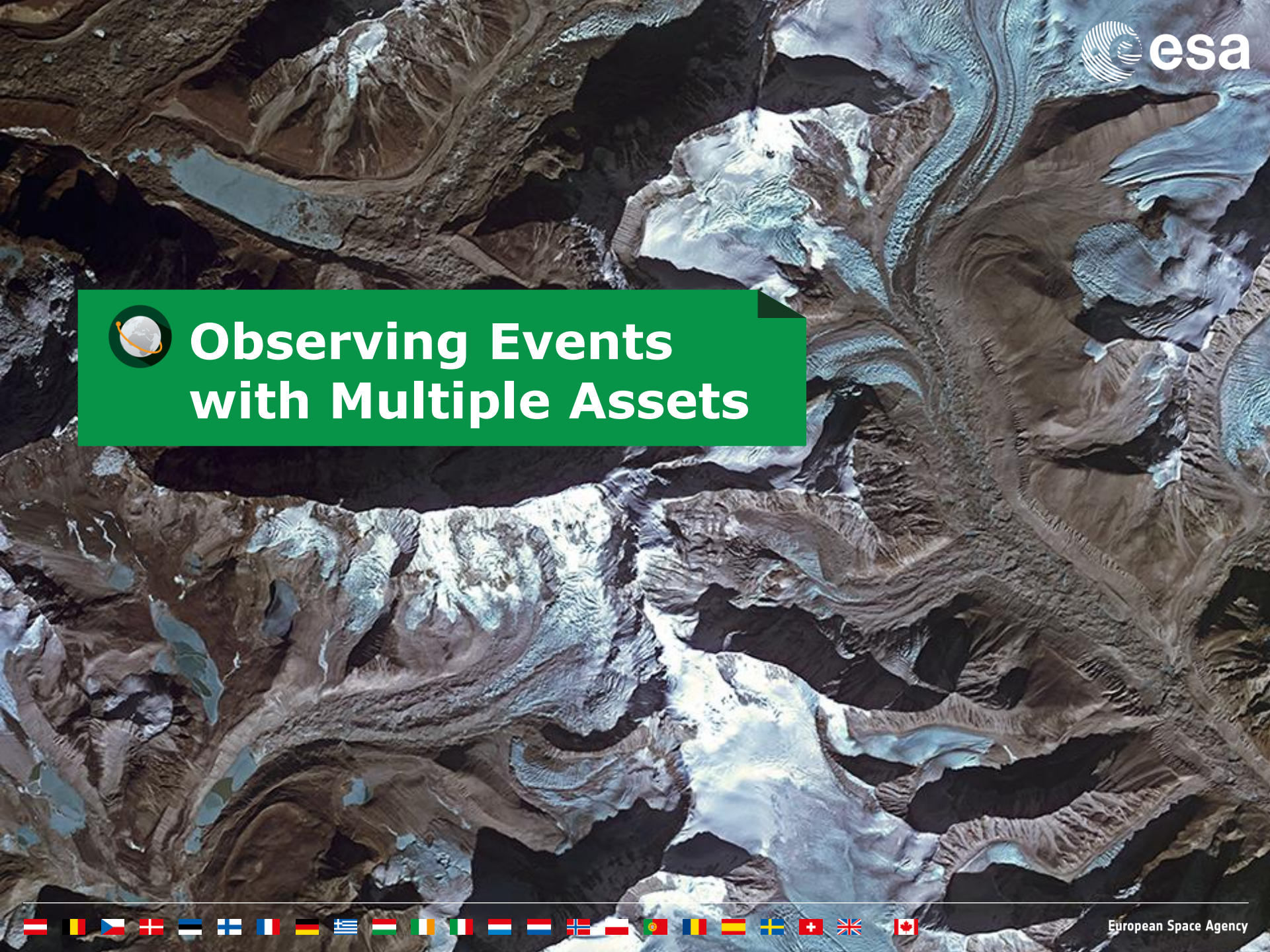


Requirement	Description	Measured performance
Absolute geolocation (without ground control points)	The geo-location uncertainty shall be better than 20 m at 2σ confidence level (without Ground Control Points).	< 9.2 m at 95.5% confidence (baseline 02.04)
Multi-spectral registration	The inter-channel spatial co-registration of any two spectral bands shall be better than 0.30 of the coarser achieved spatial sampling distance of these two bands at 3σ confidence level.	< 0.29 pixel at 99.7% confidence
Absolute radiometric uncertainty	The absolute radiometric uncertainty shall be better than 5 % (goal 3%).	B1 to B12, excl. B10: < 5%±2%
SNR	The Signal-to-Noise Ratio (SNR) shall be higher than specified values (see Table 5 in this document)	All bands compliant with > 27% margin

Sentinel Online | The Official Sentinel Website

https://sentinel.esa.int/web/sentinel/home

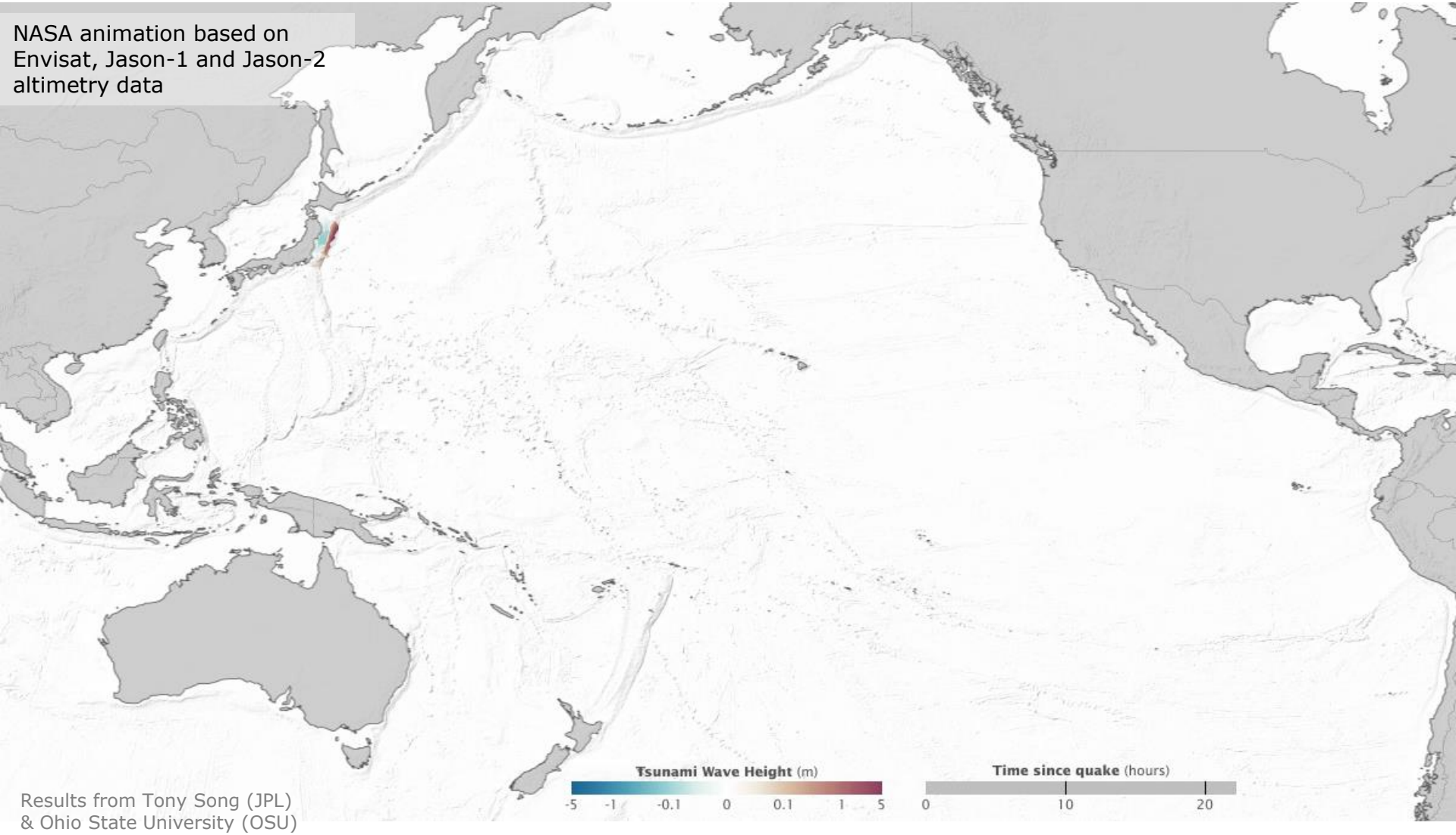




Observing Events with Multiple Assets

Observing an event with many assets

→ Tohoku-Oki earthquake (2011)



Observing an event with many assets

→ Tohoku-Oki earthquake (2011)

After 18 hours, the tsunami reaches Antarctica and destabilizes the Sulzberger ice shelf

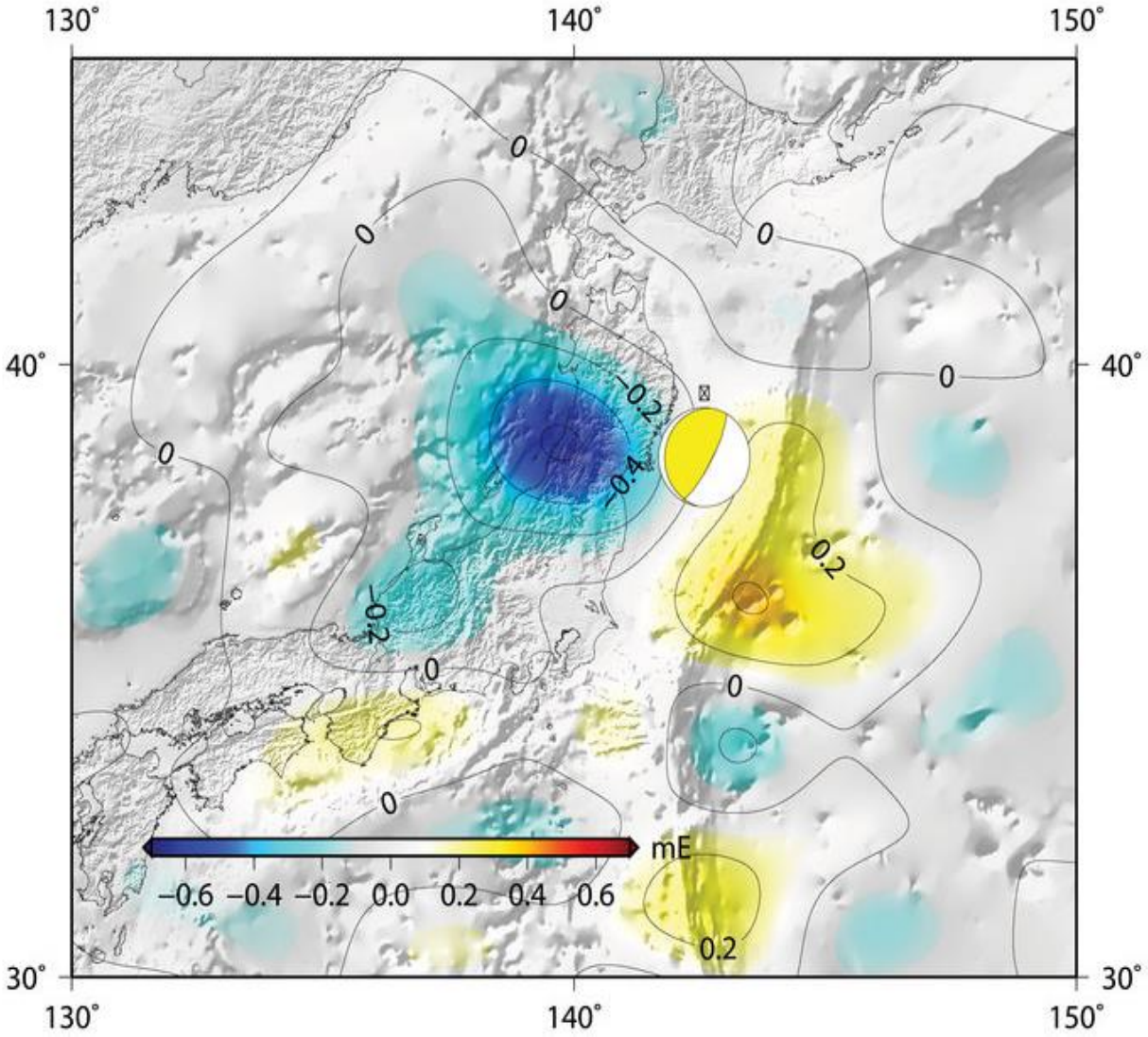
ENVISAT

5 km

Brunt, K.M et al., Antarctic ice-shelf calving triggered by the Honshu (Japan) earthquake and tsunami, Journal of Glaciology, July 2011.

Observing an event with many assets

→ Tohoku-Oki earthquake (2011)

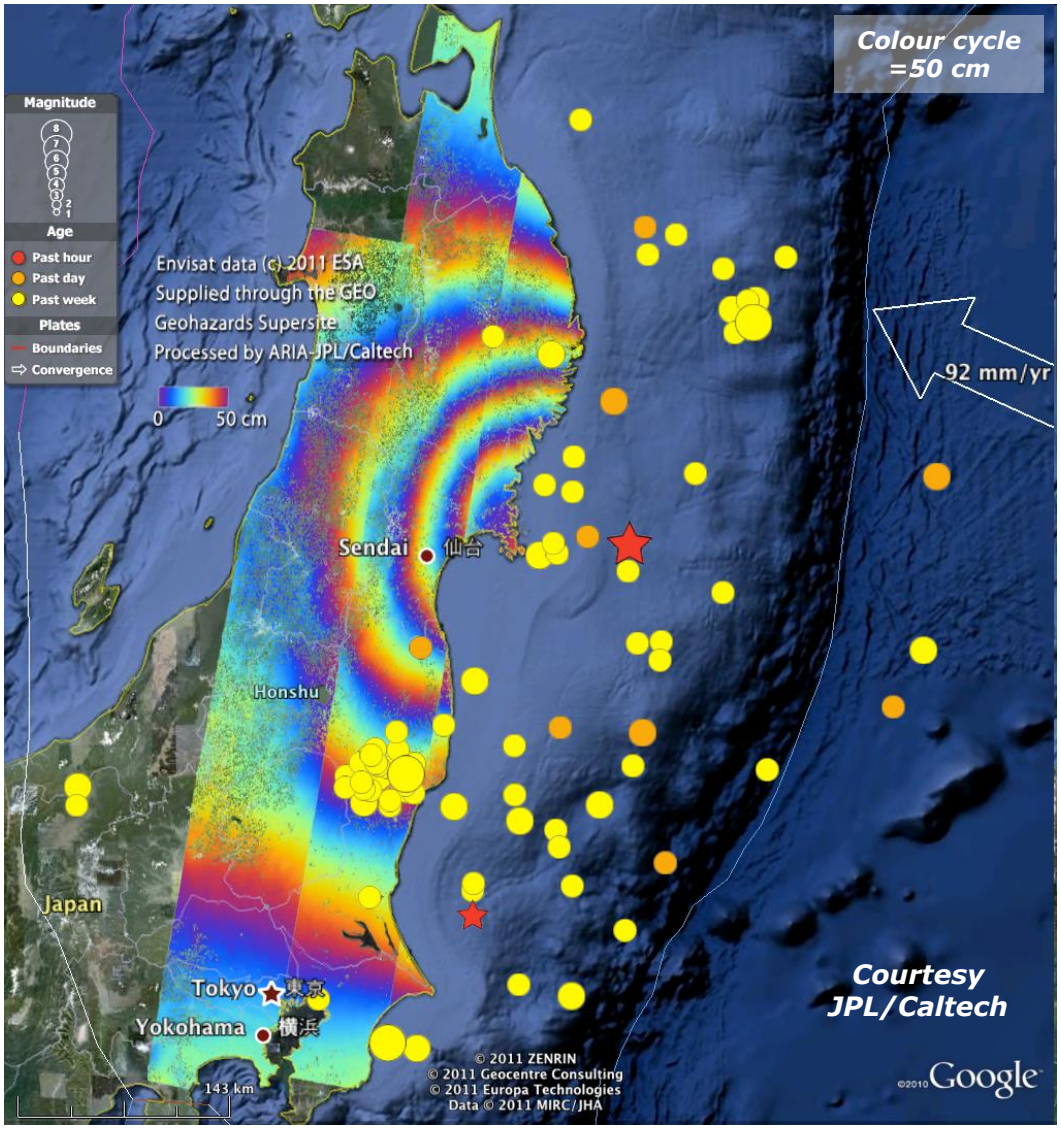


Observing an event with many assets

→ Tohoku-Oki earthquake (2011)

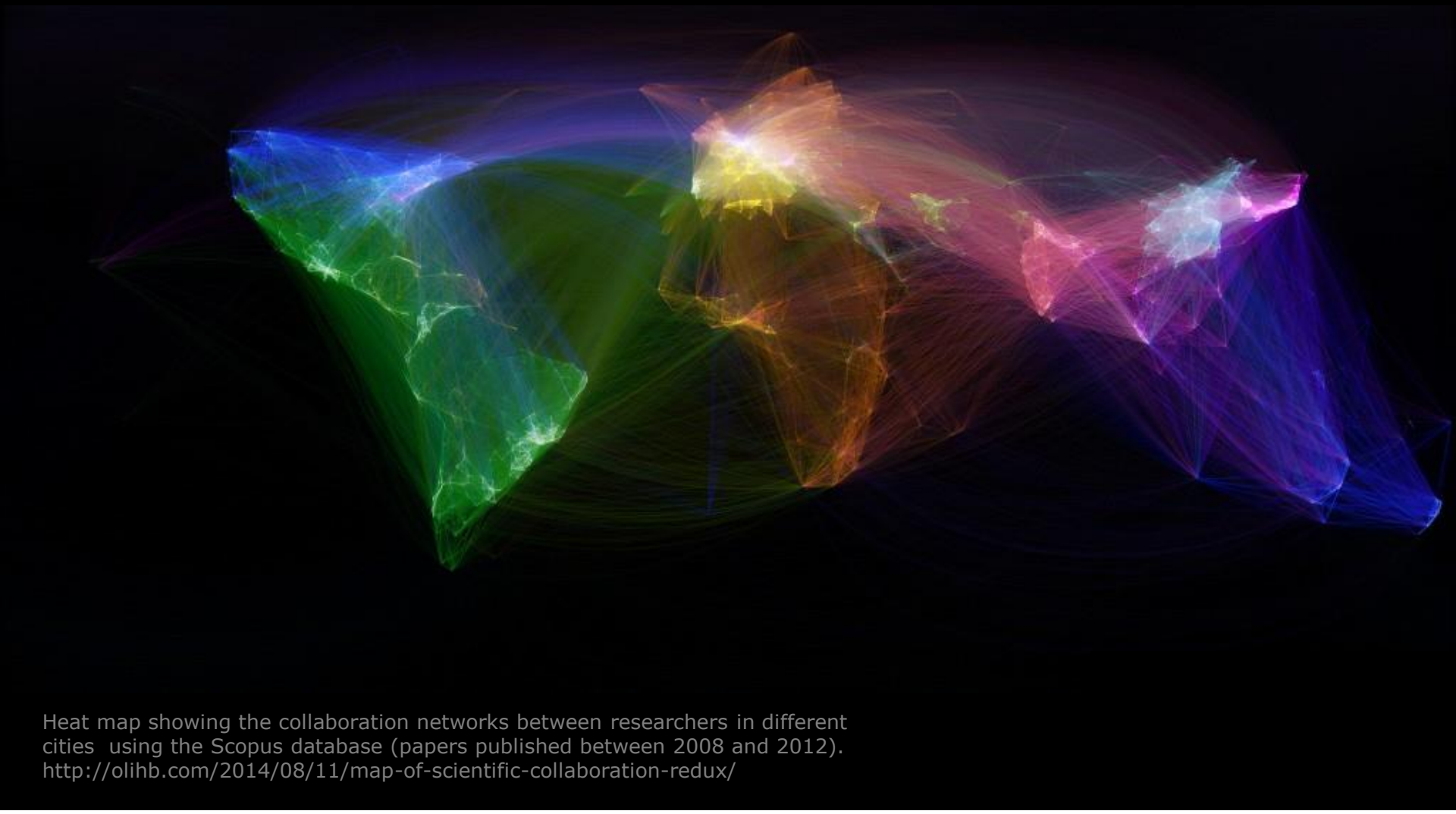
Observing an event with many assets

→ Tohoku-Oki earthquake (2011)



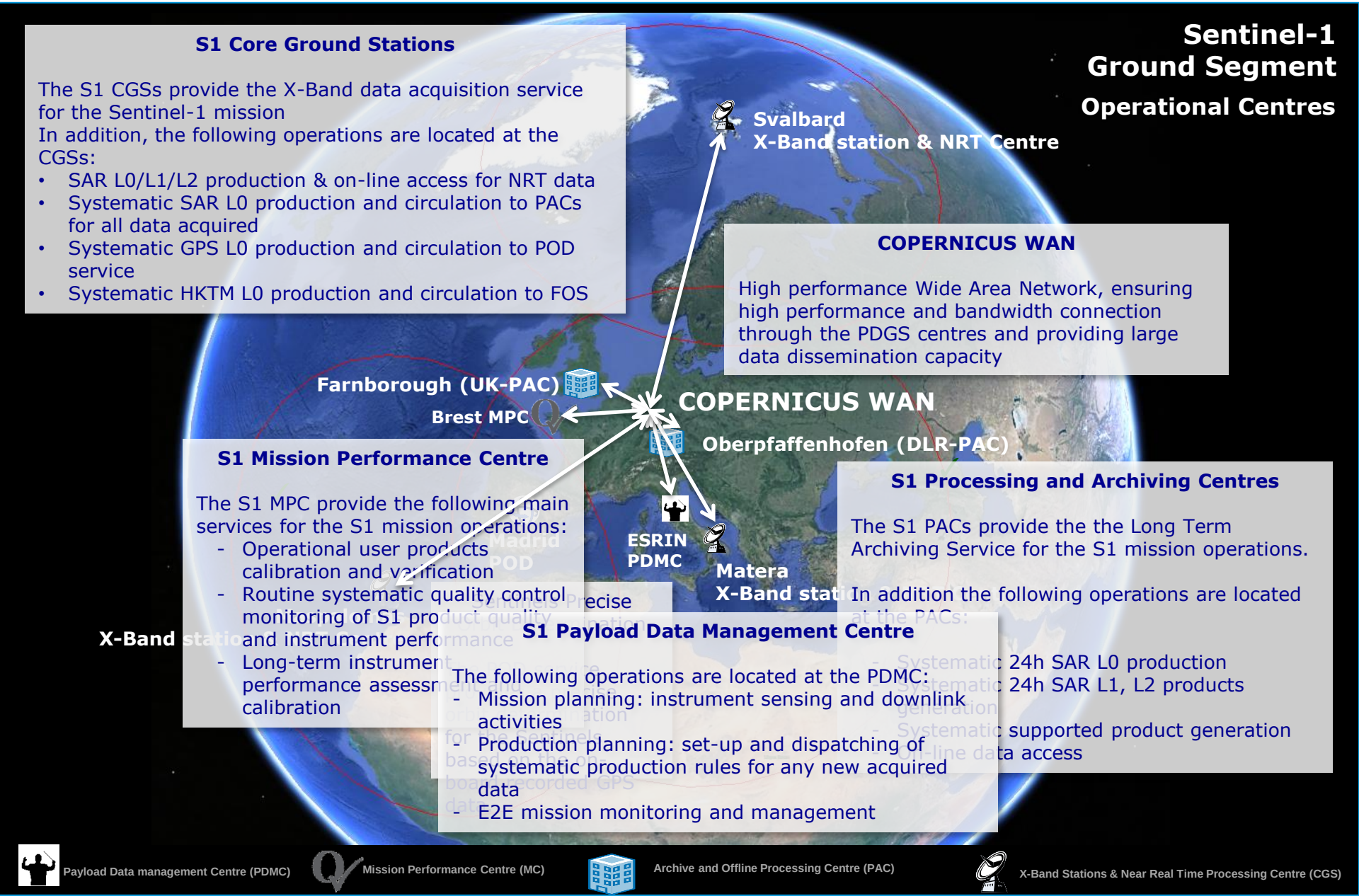
Thanks to the background data acquisitions (several pre-seismic acquisitions in February 2011), it was possible to generate an ENVISAT ASAR interferogram (combining with several post-seismic acquisitions in March 2011) which provided a detailed estimation of the terrain movement on a very large scale.

Sentinel Data Access



Heat map showing the collaboration networks between researchers in different cities using the Scopus database (papers published between 2008 and 2012).
http://olihb.com/2014/08/11/map-of-scientific-collaboration-redux/

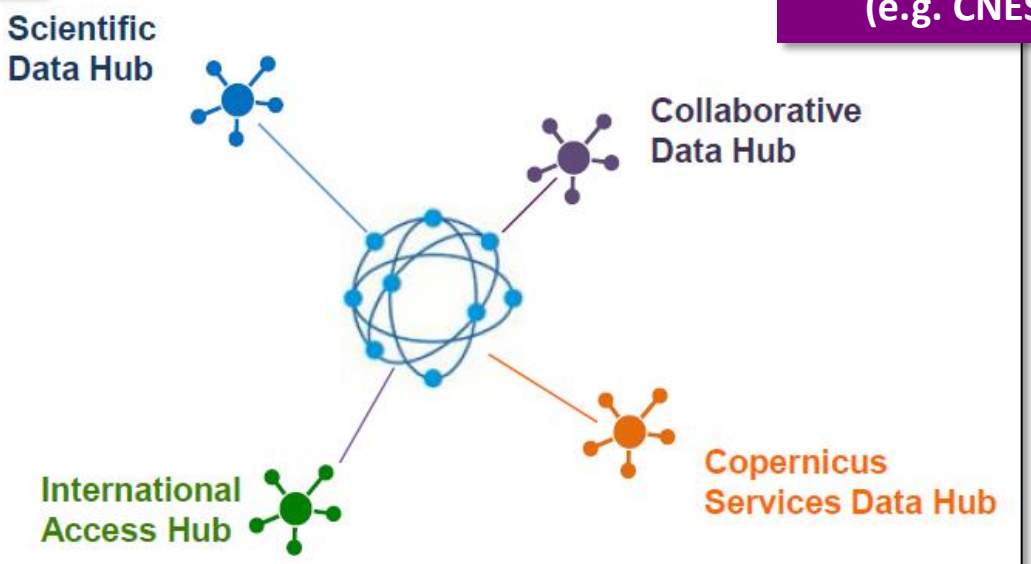
Sentinel Ground Segment Overview



ESA operated Sentinel Data Hubs

The open access Sentinel Data Hub, for *anyone*

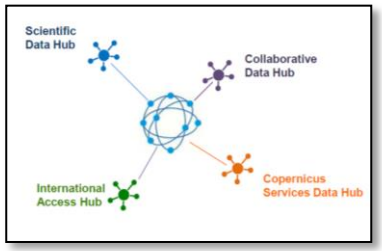
Sentinel data access, for *European partners* (e.g. CNES, DLR)



Sentinel data access, for *international partners* (e.g. NASA)

Sentinel data access, for *Copernicus services* (e.g. marine, land)

Sentinel Data Hubs - Latest Configuration



ESA operated Sentinel Data Hubs

Open Data Hub

Self Registration

> 36,600 Users

No Rolling Policy Applied

Sentinel-1A NTC
Sentinel-2A L1C
03-Oct-2014
16-Nov-2015

Max 2 Concurrent Downloads

Collaborative Data Hub

11 Collaborative Users
4 Data Hub Relay Users

Node 1: 30 days
Node 2: 9 days

Sentinel-1A NRT & NTC
Sentinel-2A L1C

Node 1: Max 10 downloads
Node 2: No limits

International Access Hub

4 Users

30 Days

Sentinel-1A NTC
Sentinel-2A L1C[1]

No specific threshold

L1C[1] coming soon

Copernicus Services Data Hub

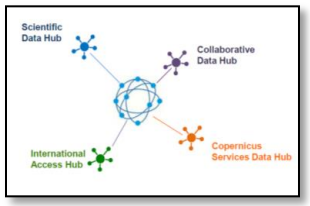
copernicus space component data access

108 Users

No Rolling Policy Applied

Sentinel-1A NRT & NTC
Sentinel-2A L1C
01-Dec-2015

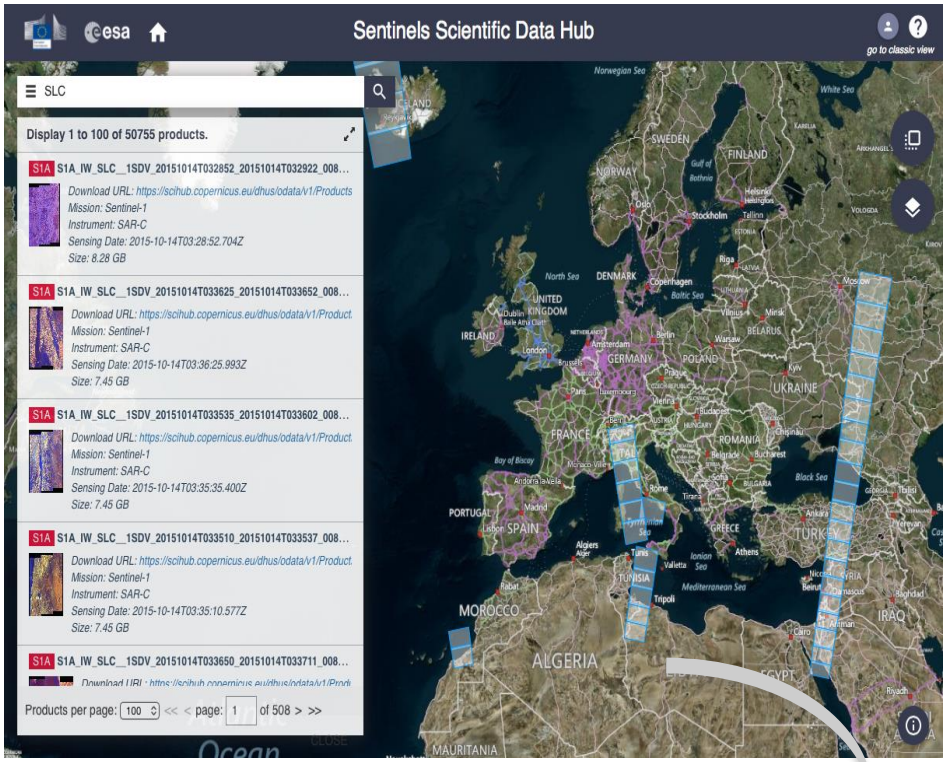
Max 10 concurrent downloads



Copernicus Open Data Hub

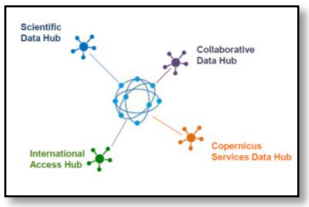
The open access data hub for anyone

esa



scihub.copernicus.eu

- ✓ Simple self registration
- ✓ Currently all data generated since October 2014 is available online
- ✓ APIs provided for automatic downloads via scripts
- ✓ Quota restriction of 2 concurrent downloads to ensure bandwidth availability for all users
- ✓ Single user can engage up to 500 Mbps output network bandwidth

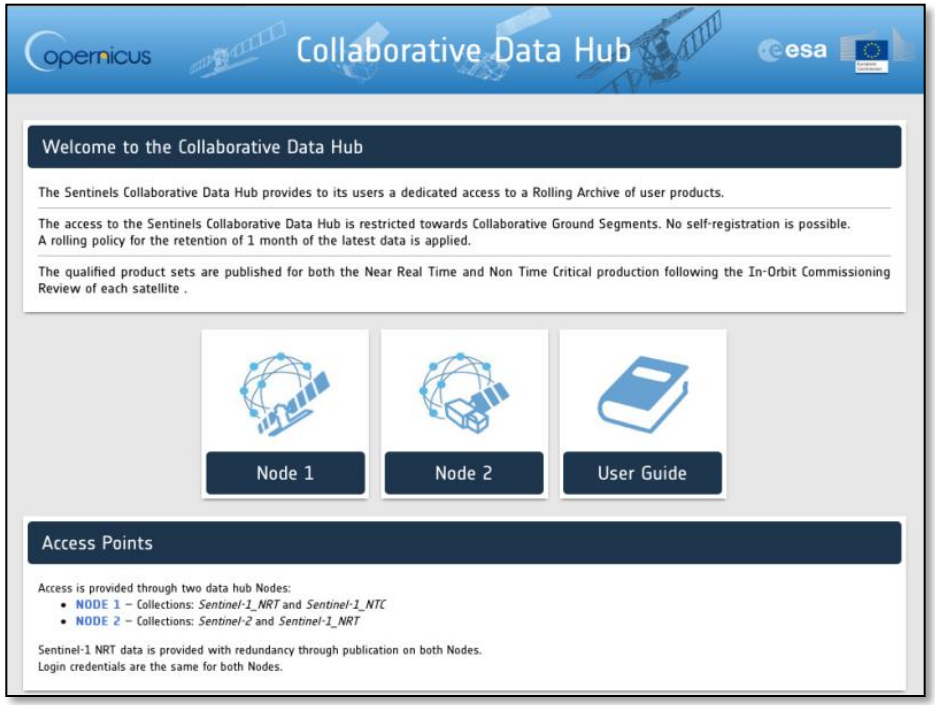


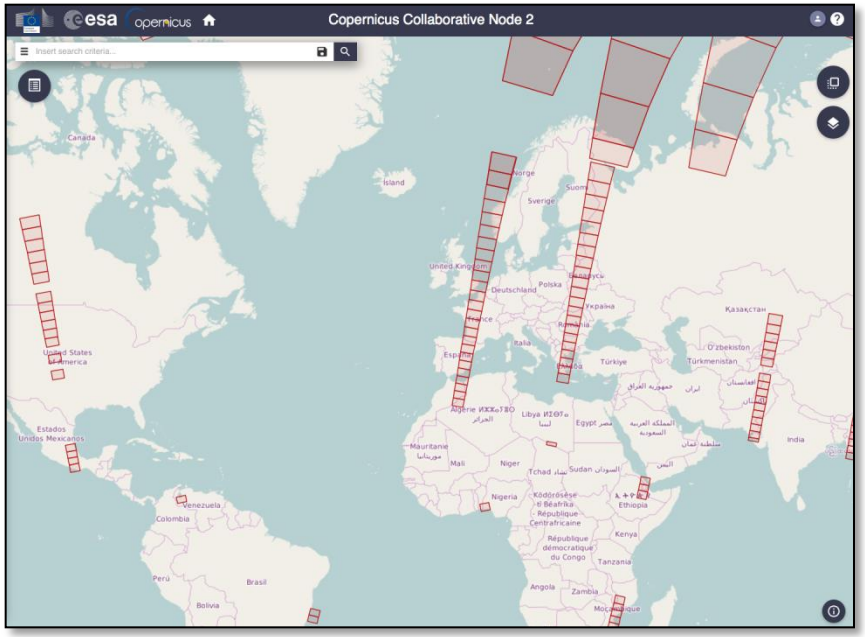
Collaborative Ground Segment Data Hub

colhub.copernicus.eu

Data Centre infrastructure in operations since January 2015:

- 11 accounts enabled, one per Participating States with formalised Collaborative Ground Segment agreements
- No restrictions in simultaneous downloads

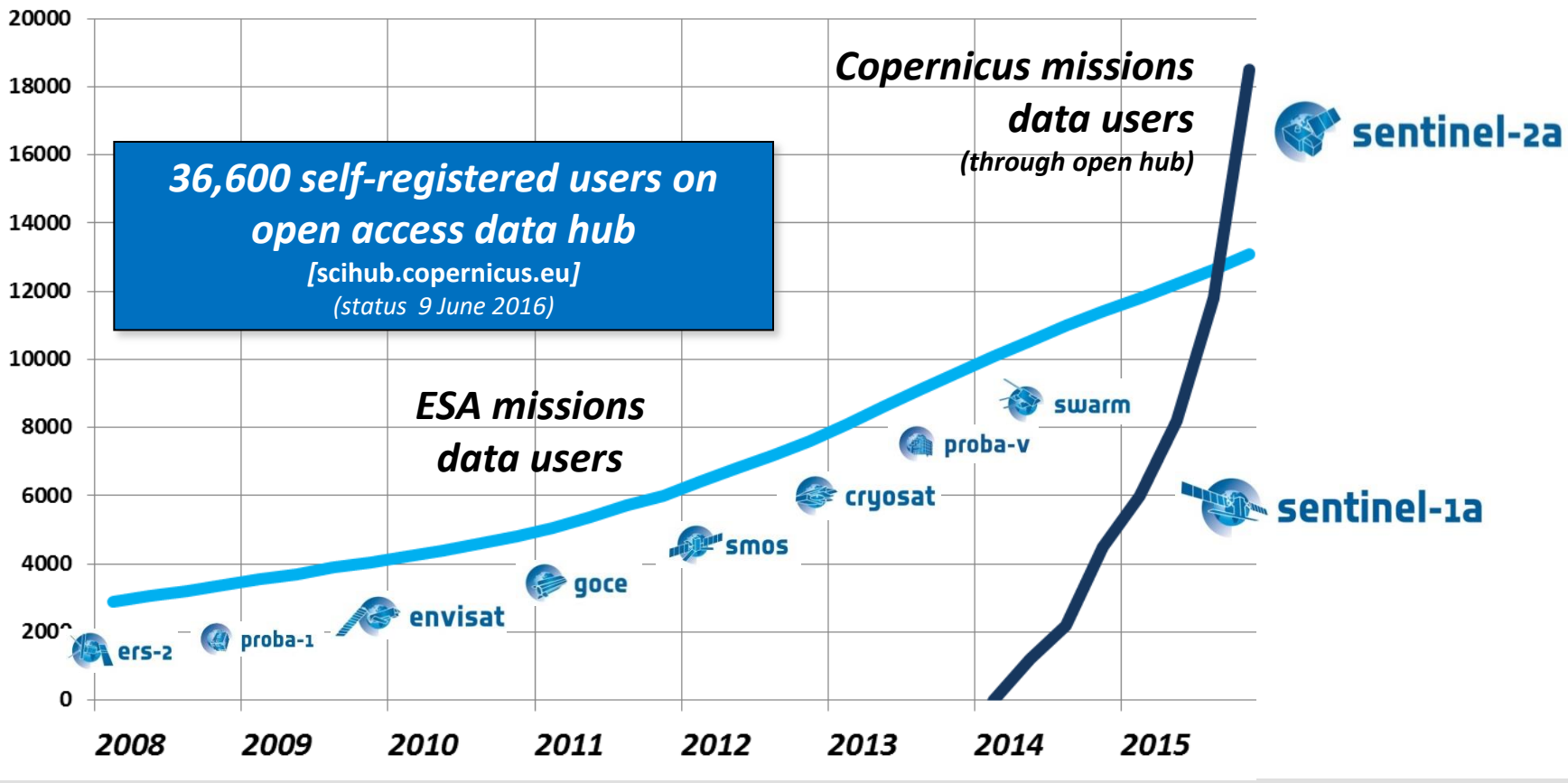




Sentinel data

Users registration on Open Access Data Hub

A steady sharp increase of users
as a consequence of Data Policy and Mission Operations Concept:
systematic observation, acquisition, processing and dissemination



Weekly Mission Status Reports published online

https://sentinel.esa.int/web/sentinel/missions/sentinel-1/mission-status

sentinel-1

→ RADAR VISION FOR COPERNICUS

Mission Status Report 1

Reference Period: 3 April - 7 April 2014

Mission Status

- Sentinel-1A was successfully launched from Kourou on 3 April 2014, 21:02 UTC
- The Launch and Early Orbit Phase (LEOP) was successfully performed according to the planned timeline and declared closed on 6 April at 16:00 UTC
- The Commissioning Phase has started

Satellite

The LEOP covered the main following key activities:

- Deployments of the solar panels (including. rotation) and of the Synthetic Aperture Radar (SAR) antenna
- Achievement of Satellite Nominal Mode and AOCS Nominal Pointing Mode
- Switch ON and initial checks of the spacecraft sub-systems
- First operations of the X-Band Transmitter and the SAR instrument (3 min of Wave mode)

In addition, a collision avoidance manoeuvre was performed on 5 April

Ground Segment

- The Flight Operations Segment performed nominal during the complete 3 days of LEOP
- First X-band data acquisition took place at the Matera ground station on 6 April, early morning
- First SAR instrument data acquisition was performed on 6 April. The related measurement was successfully processed at UK-PAC
- The FOS and the PDGS were declared ready to support the commissioning phase

Outlook

- Start of platform and payload commissioning activities
- First SAR acquisitions driven by the operational PDGS mission planning system are planned to start on 9 April, as part of the initial verification and calibration activities
- Start of orbit manoeuvre sequence to acquire the target reference orbit.

Report prepared by the ESA Sentinel-1 Team -

sentinel-1

→ RADAR VISION FOR COPERNICUS

Mission Status Report 57

Reference Period: 26 May 2015 – 1 June 2015

Mission status

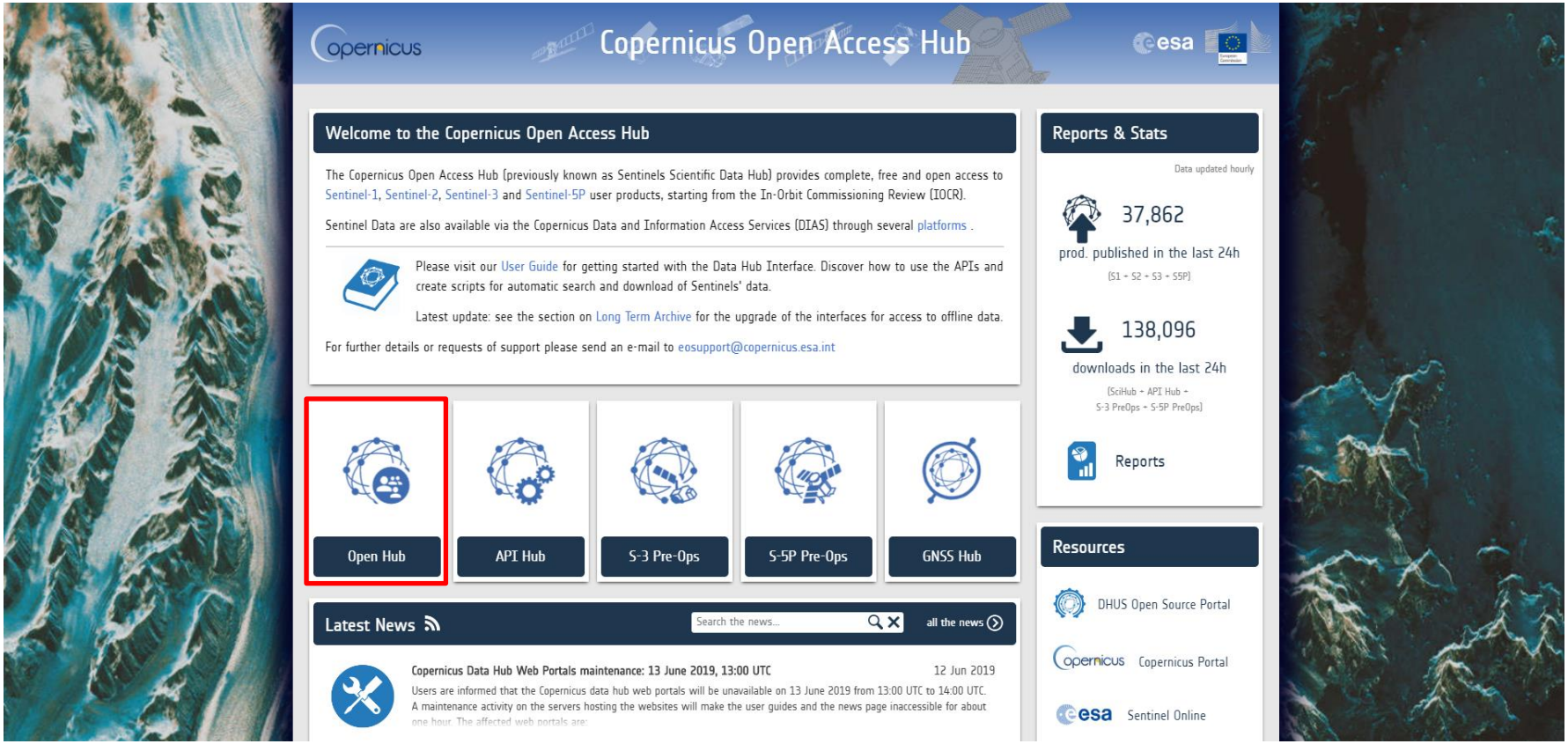
- The Sentinel-1A operational qualification phase is on-going. The first yearly Routine Operations Review is planned on 9 June 2015
- The opening of the Sentinel-1 data flow to all users took place on 3rd October. Data can be accessed from: https://sentinels.copernicus.eu
- The implementation of the ramp-up observation scenario is on-going, including in particular the coverage of a first set of Copernicus Services areas of interest, of European land and coastal waters, of a set of global tectonic/volcanic areas, as well as of other specific targets worldwide for various applications. The observation plan is gradually complemented with observations outside the above areas to achieve a full mapping of all land areas worldwide (Antarctica excluded) before the end of the ramp-up phase. The dedicated campaign for Antarctica ice sheet monitoring has started and will run till early October 2015 indicatively. See an overview of the observation scenario at: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario
- The detailed observation plan in the form of instrument acquisition segments is published on Sentinel Online at: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario/acquisition-segments
- The use of Sentinel-1A data by the Copernicus Marine Environment Monitoring Service for sea-ice and iceberg monitoring activities is on-going
- Sentinel-1 products were used by authorities in Alaska for monitoring a major flood. More information at: https://sentinel.esa.int/web/sentinel/missions/sentinel-1/news/-/article/sentinel-1-monitors-alaskan-flood
- The Sentinel-1A spacecraft is in a stable state, operating in Nominal Mission Mode (NMM), with all sub-systems working on prime units. The Flight Operations Segment (FOS) ensuring the monitoring, control and commanding of the satellite is operating nominally. Orbit control manoeuvres are performed once a week typically
- A planned satellite unavailability took place on 28 May from 06:30 UTC to 13:30 UTC in order to perform an on-board maintenance activity. No SAR acquisitions were performed during this period
- The Sentinel-1A – Alphasat TDP-1 inter-orbit link characterisation phase is on-going
- X-Band data acquisitions are routinely performed over Matera, Svalbard and Maspalomas X-band core stations. The acquired data are circulated within the PDGS, systematically processed to Level-0 and Level-1 products and archived. Level-2 product operational qualification is on-going
- Operations are performed regularly at the Processing and Archiving Centres (DLR-PAC and UK-PAC). All other PDGS operational services (i.e. Mission Performance, Precise Orbit Determination, Wide Area Network) are operating nominally
- The areas where acquired data are systematically processed to Level-1 SLC products are gradually being extended. The SLC production scenario description has been updated and can be consulted at: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/production-scenario
- By 28 May, a total of 7461 users have self-registered; 1,071,399 product download have been made by users, corresponding to 1,31 PB of data.
  At the time of publishing this report, about 145,000 products are available on-line for download
- The overall operations mission performance is nominal

Outlook

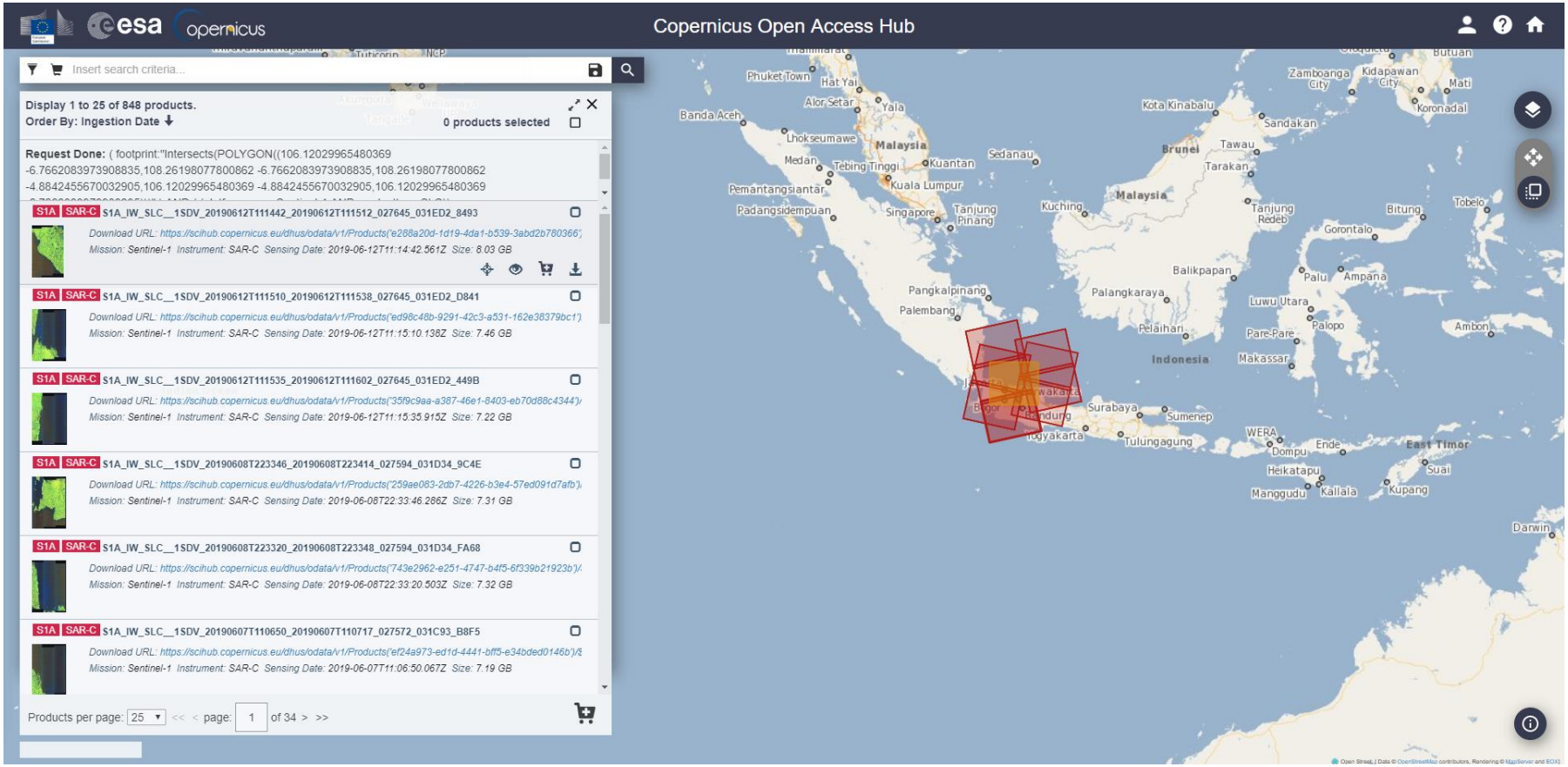
- Continuation of ramp-up mission operations

Report prepared by the ESA Sentinel-1 Team -

Copernicus Open Access Hub | https://scihub.copernicus.eu

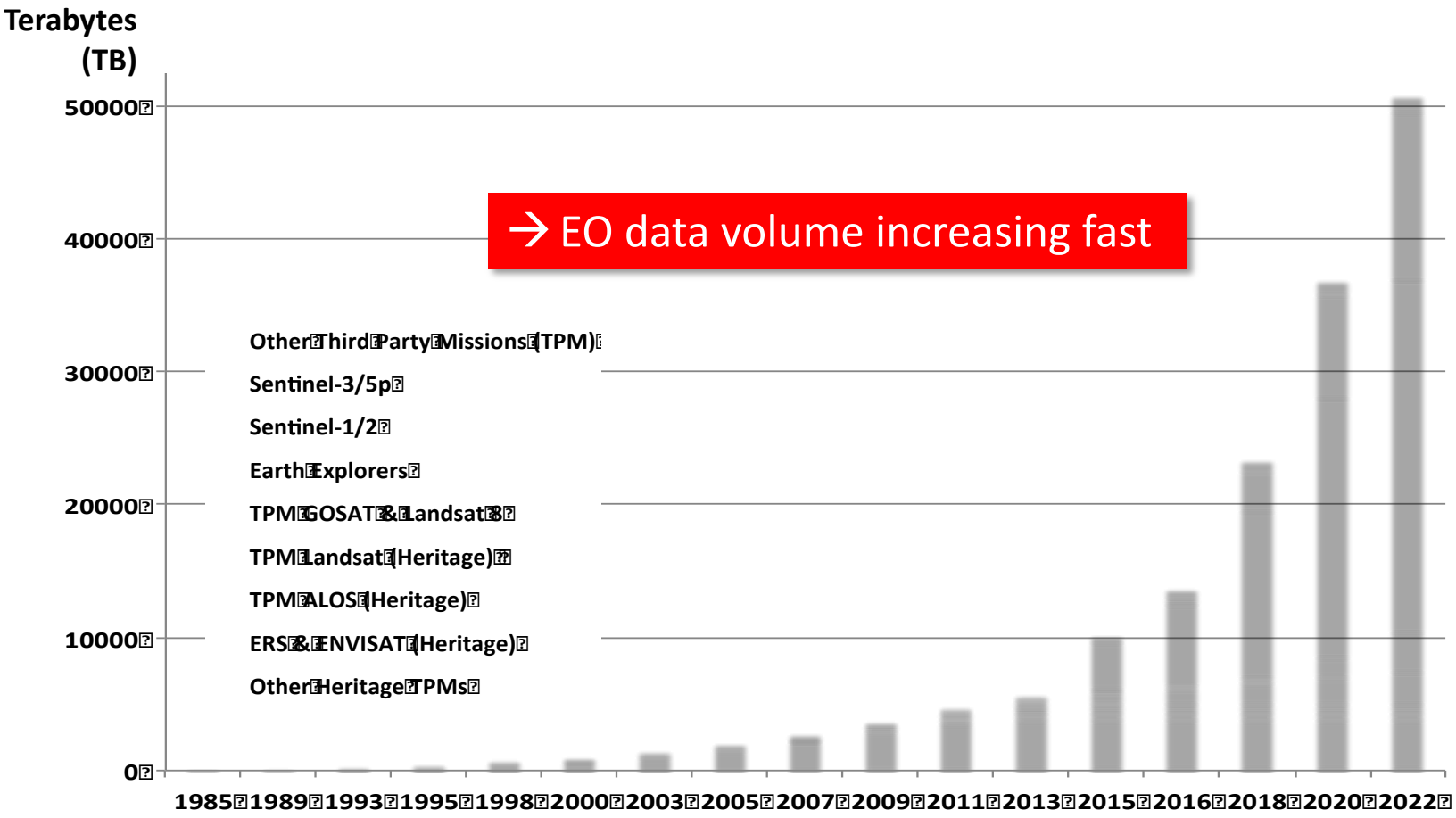


Copernicus Open Access Hub | https://scihub.copernicus.eu

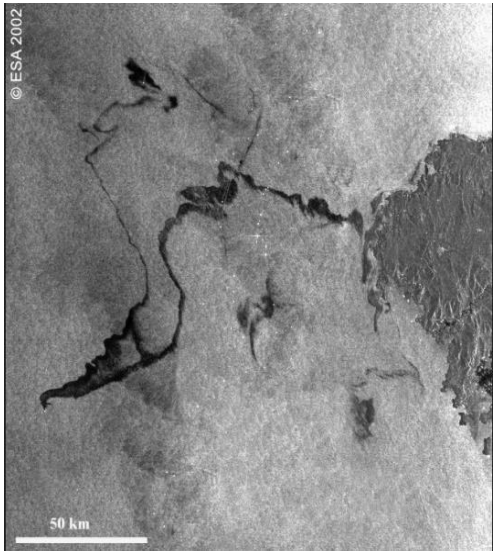


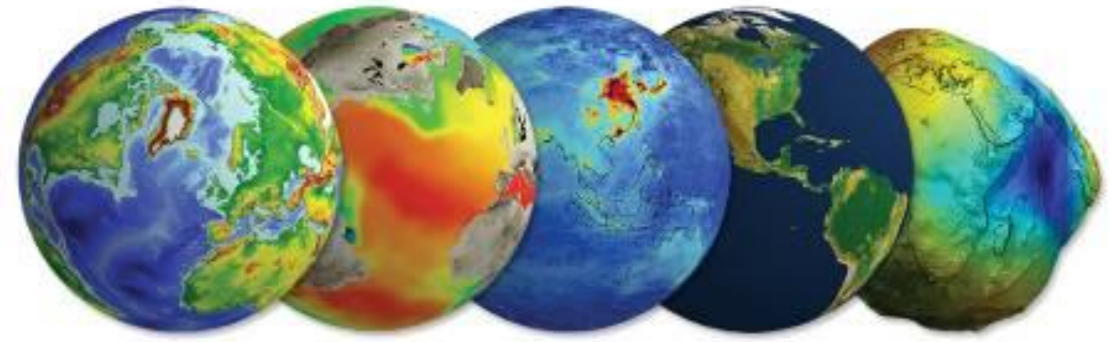
Big Data

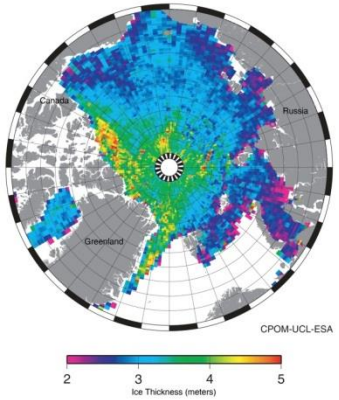
→ *increasing volume of EO data*

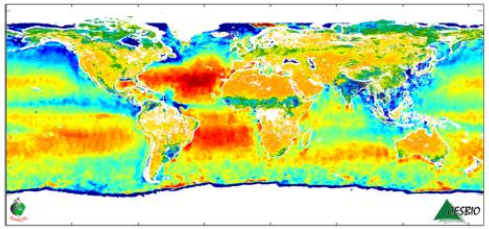


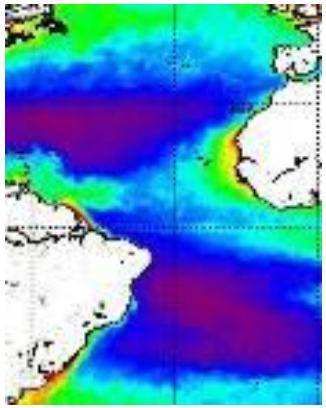
Big Data - Increasing **diversity** of EO data
Increasing **diversity** of usage of EO data









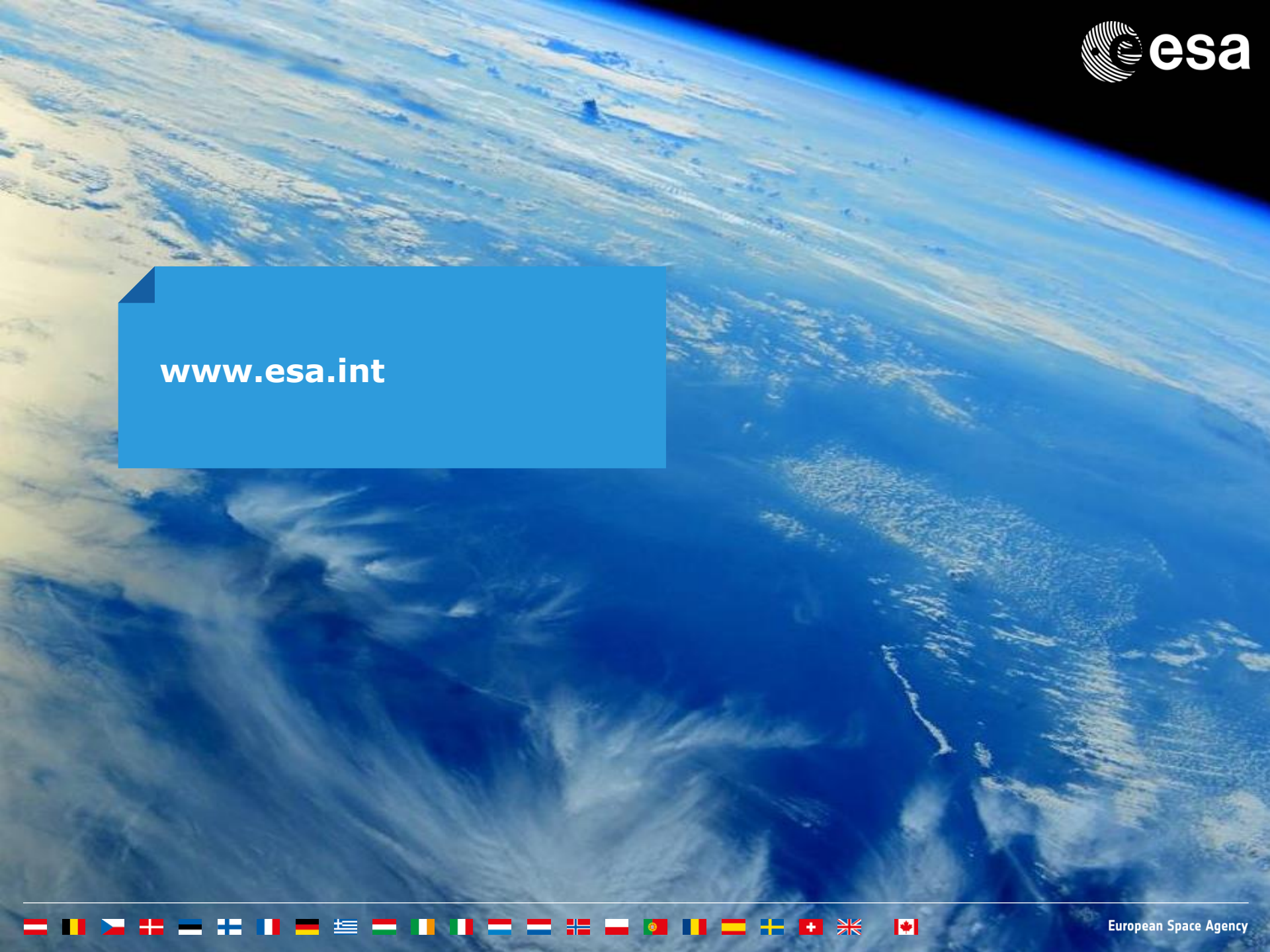


Take-home Messages

We are at the **golden era of EO** with numerous missions providing imagery for several application domains, including the Copernicus Sentinels with the open and free data policy.

Ever **increasing volume and diversity of data** impose innovative concepts for both data storage and processing capacity, currently addressed by cloud-based platform solutions.

Apart from pure technical developments, value adding and generation of **Analysis Ready Data** (ARD) within an **interoperable ecosystem** are crucial steps to properly address modern community needs.


www.esa.int