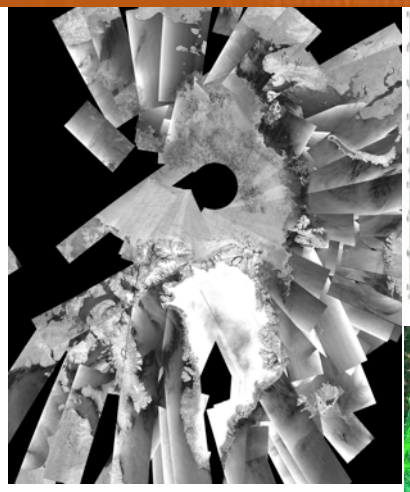
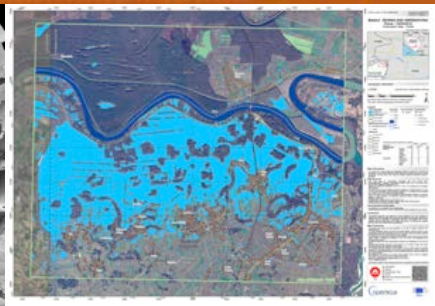
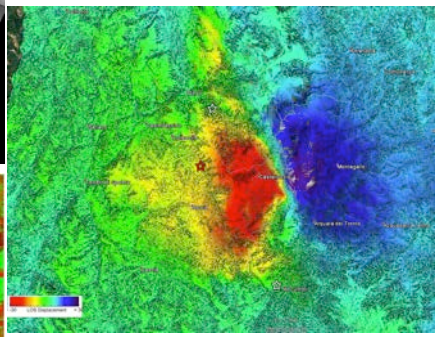
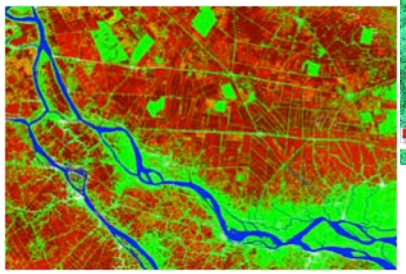
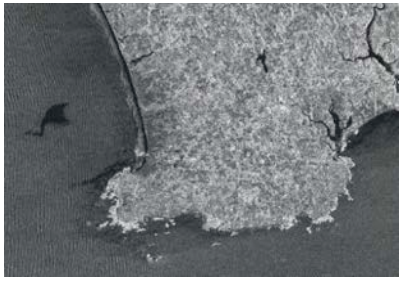
→ WORLDCOVER 2017 CONFERENCE
14–16 March 2017| ESA–ESRIN | Frascati (Rome), Italy
European Space Agency

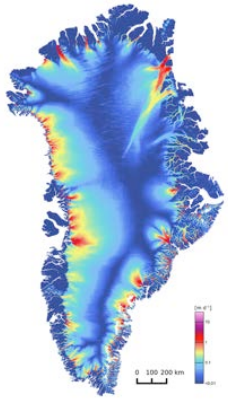












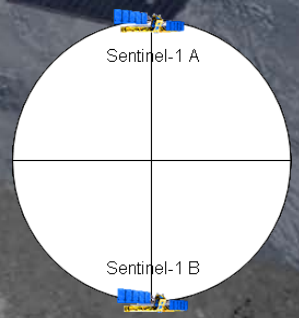
SENTINEL-1 Mission Status

Pierre Potin
Sentinel-1 Mission Manager
ESA

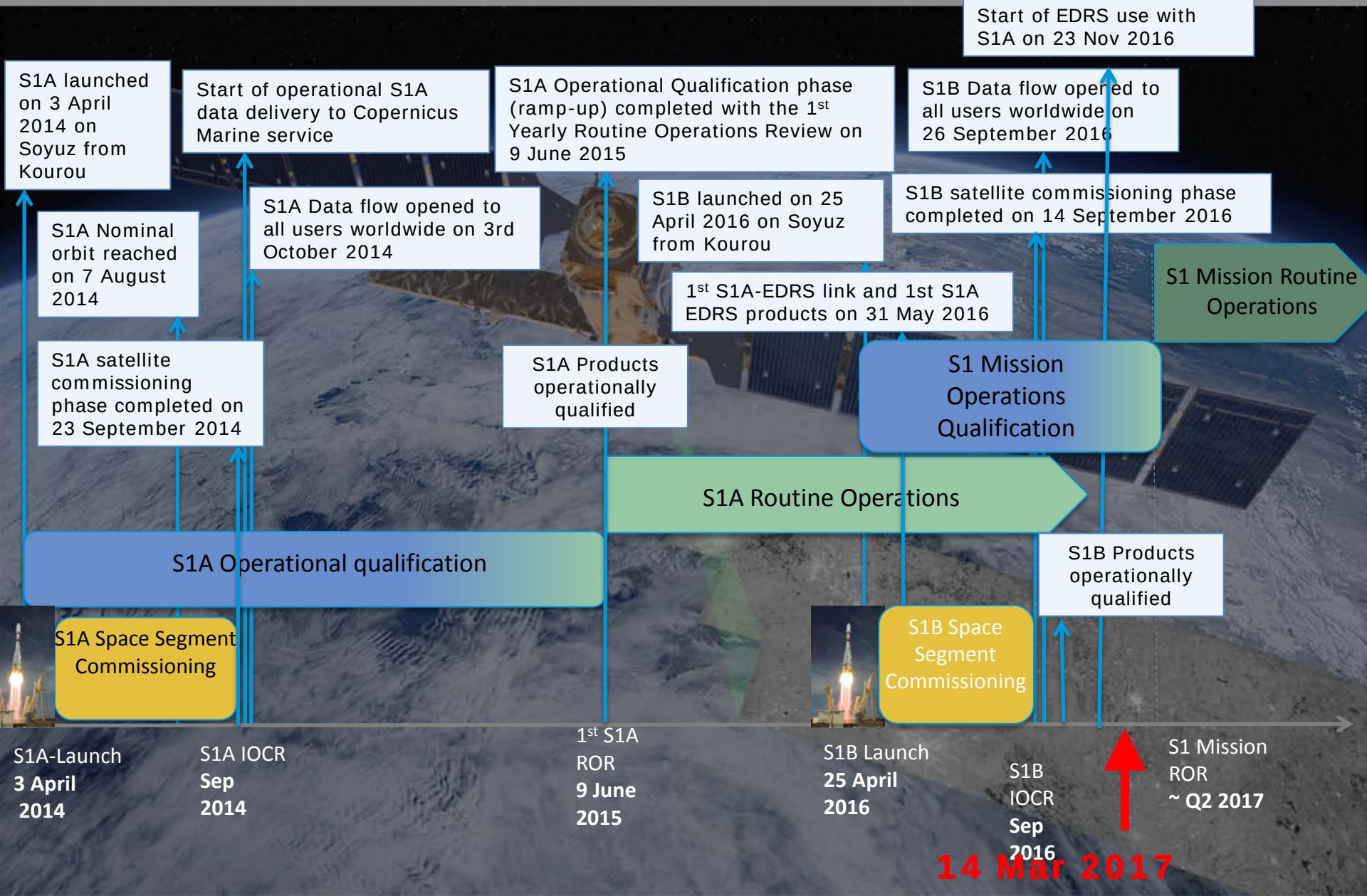
Sentinel-1: Mission Profile

Copernicus radar imaging mission for ocean, land, emergency

- Part of the Copernicus Programme led by the European Union
- Mission based on 2 identical satellite units (S1A & S1B) and a highly performing ground segment
- Main satellites characteristics:
    - C-band Radar instrument
    - Instrument duty cycle of 25min/orbit in HBR modes and 75min/orbit in LBR
    - 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 (6 days with 2 satellites)
- Instrument operations based on a predefined observation scenario
- Systematic data processing with open & free data data access
- Gradual increase of the mission operational capacity from the S1A launch up to the mission constellation routine operations



Sentinel-1 Mission Phases



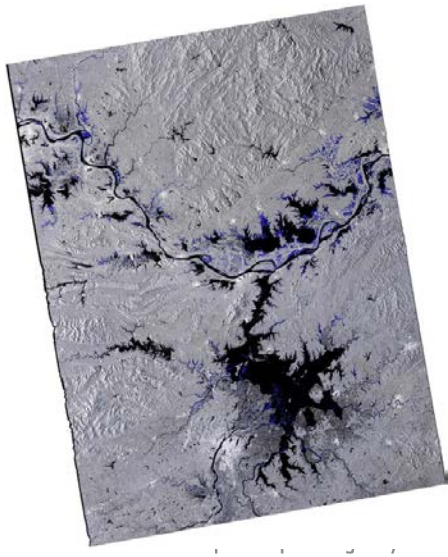
Sentinel-1 mission status

➢ Sentinel-1 **nominal routine operations continue**

- Sentinel-1B core products distributed to all users since end September 2016
- Data routinely provided to Copernicus Services
- On-going support to various activations from the Copernicus Emergency Management Service and International Charter Space and Major Disasters
- EDRS-A start of services to Sentinel-1A on 23 November 2016, focusing on end-to-end operational service validation. Use of EDRS service being progressively increased as part of routine operations

➢ **Sentinel-1 constellation currently generates nearly 10 TB of products daily** (against a formal specification of 3 TB)

- Expected to be further increased with the use of EDRS for Sentinel-1B and the 4th core X-band station



➢ **Upcoming Milestones**

- Start of gradual increase of Quasi Real Time observations
- Sentinel-1 Constellation Mission Operations Review: May 2017

Sentinel-1 observation scenario Main components & thematic domains

Agriculture

European coverage

Forestry

Calibration/validation

Maritime surveillance

Global land mapping

Emergency

Tectonic active areas and volcanoes / landslides and subsidence

PR actions (infrequent)

Security

Sea state

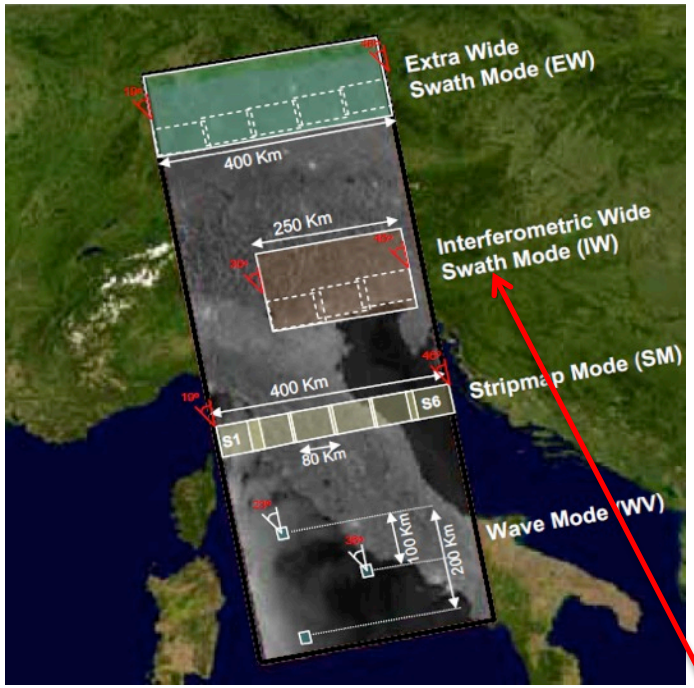
Sea-ice, icebergs, lake-ice

Ice sheets, glaciers, permafrost and snow

Sentinel-1 observation scenario
SAR Operational Modes

Sentinel observation scenario main objective is to
establish a predefined stable conflict free observation plan

Operational Modes

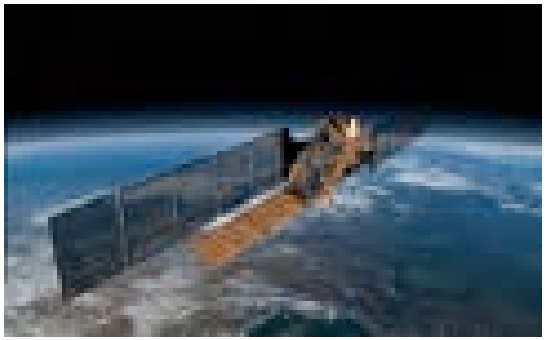


GRD Level 1 product resolution	Swath Width	Polarisation
50m (3 ENL)	> 400 km	HH+HV or VV+VH
20m (5 ENL)	> 250 km	HH+HV or VV+VH
9m (4 ENL)	> 80 km	HH+HV or VV+VH
50m (140 ENL)	20 x 20 km² at 100 km spacing	HH or VV

Main mode over land and coastal areas

European Space Agency

Sentinel-1 Constellation Observation Scenario



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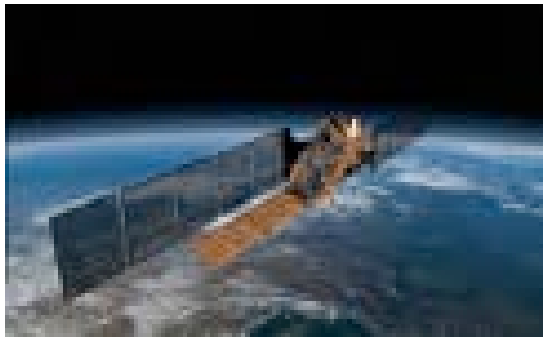


➔ The use of Sentinel-1B, similarly to Sentinel-1A, allows to increase the observations volume by a factor 2 overall

➔ Sentinel-1 constellation observation scenario considered already very stable

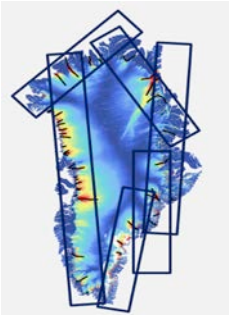
➔ Allows the user community to define own activities with stable observation patterns

Sentinel-1 Constellation Observation Scenario - Main enhancements with inclusion of Sentinel-1B -

- Increase of revisiting frequency for operational monitoring services, in particular Copernicus marine environment service and maritime surveillance services

- European coverage increase by a factor 2, ie 6-day cycle in both ascending and descending, in IW dual-polarisation VV+VH

- Interferometry every 6 days for relevant areas and applications, for instance:
  - for fast moving glaciers (Greenland margins and “supersites” in Antarctica)
  - areas subject to large subsidence



- Increase of global land mapping frequency for land cover applications in particular, that require short revisit time

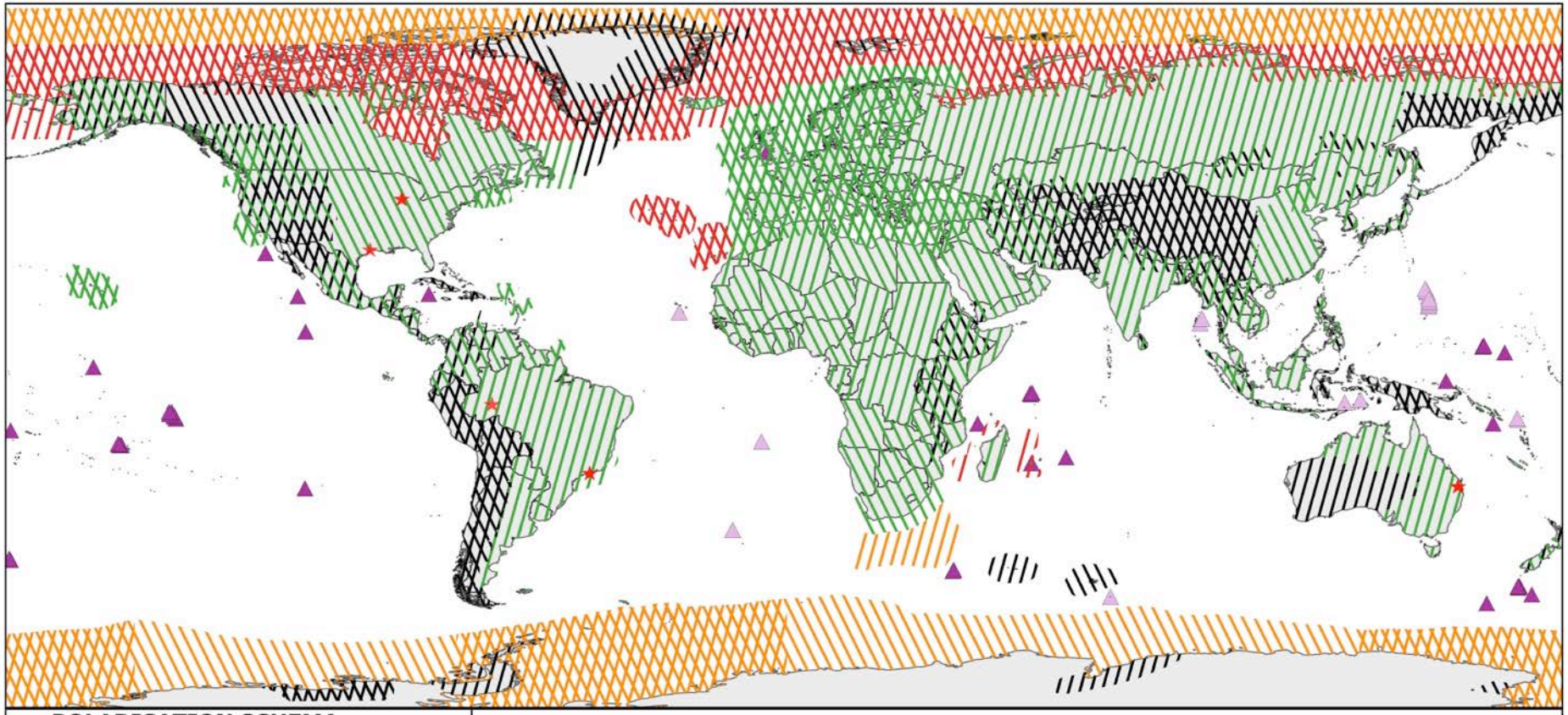
  ➔ Full mapping of global land areas every 12 days at least (except Antarctica and Greenland, subject to specific campaigns), with a combined use of S1A and S1B

European Space Agency

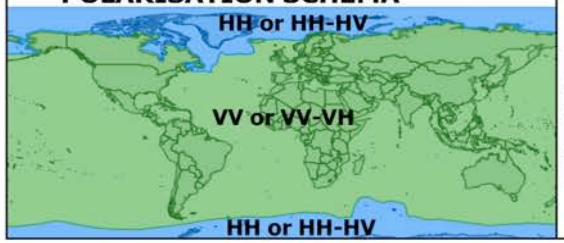
Sentinel-1 Constellation Observation Scenario: Mode - Polarisation - Observation Geometry

sentinel-1

validity start: 10/2016



POLARISATION SCHEMA



MODE / POLARISATION

- IW mode / dual polarisation
- IW mode / single polarisation
- EW mode / dual polarisation
- EW mode / single polarisation

- SM mode / dual-polarisation
- SM mode / single-polarisation

PASS

- ASCENDING
- DESCENDING

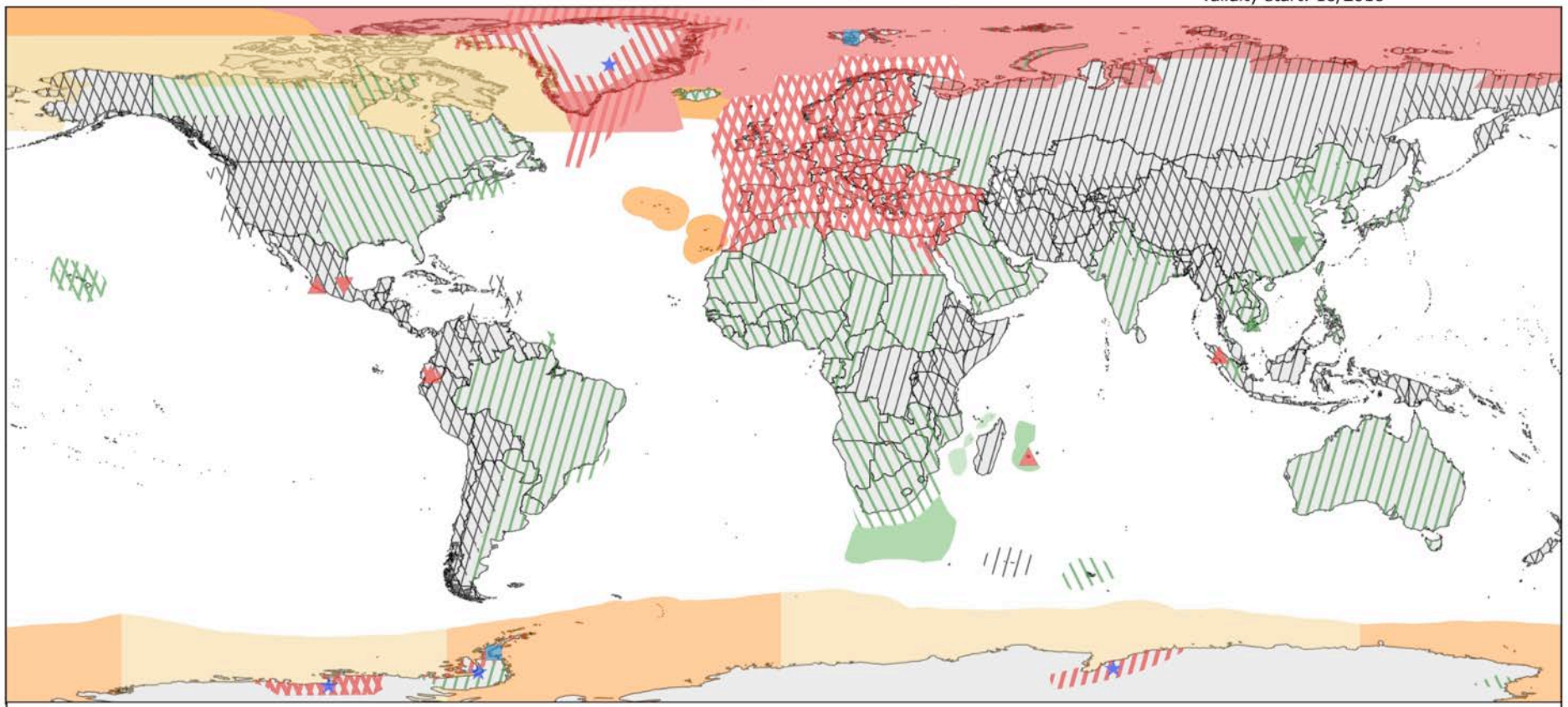
Calibration Site

(locally different modes or polarisations possible)

Sentinel-1 Constellation Observation Scenario: Revisit & Coverage Frequency

sentinel-1

validity start: 10/2016



PASS
- ASCENDING
- DESCENDING

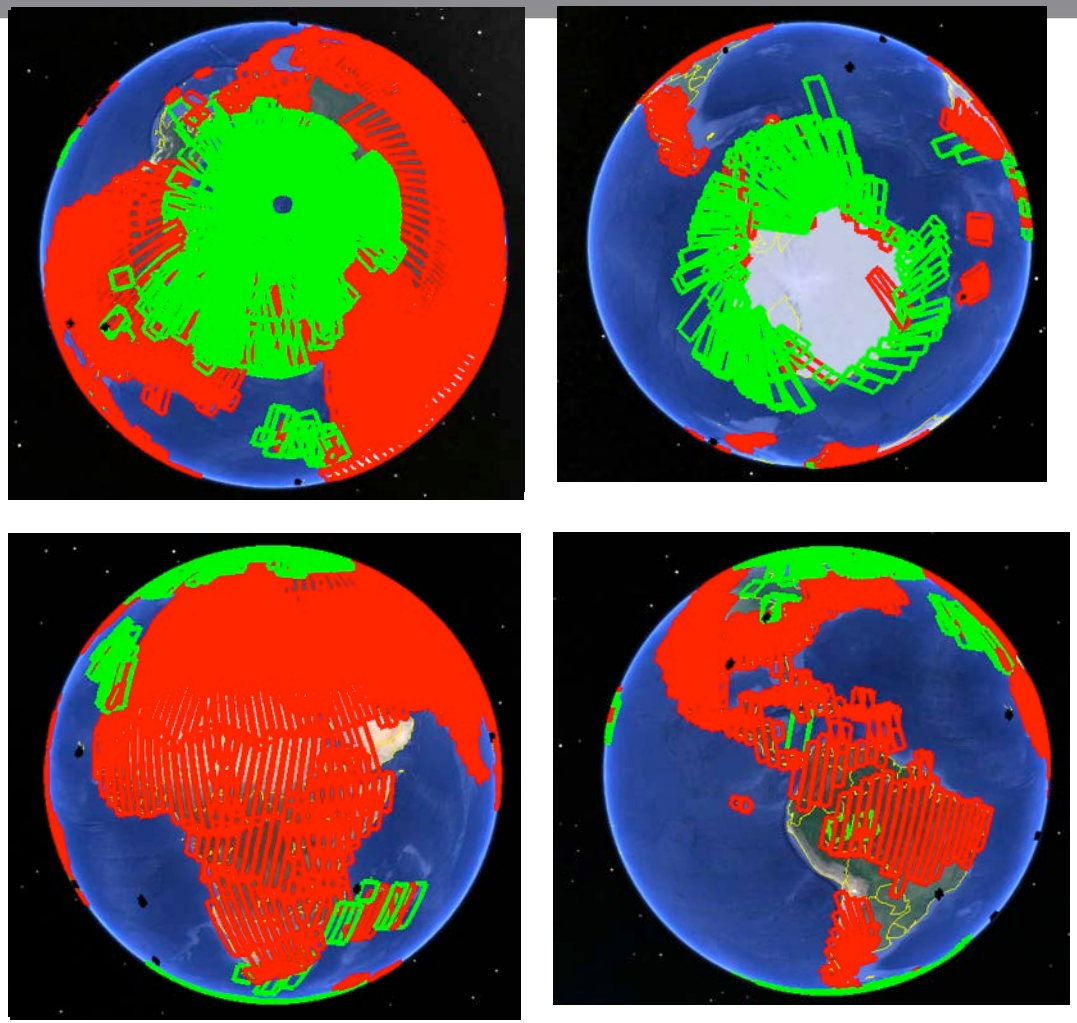
REVISIT FREQUENCY *
- 6 days
- 12 days
- 24 days

COVERAGE FREQUENCY **
- 1-2 days
- 3 days
- 6 days
- 12 days

REFERENCE DATA SITES (6d repeat)
- Highly active volcanism
- Fast subsidence
- Short growth cycle, intensive agriculture
- Fast changing wetlands
- Fast moving outlet glaciers
- Permafrost & glaciers

* coverage ensured from same, repetitive relative orbits
** coverage not considering repetitiveness of relative orbits

Sentinel-1 Constellation Observation Scenario
Detailed acquisitions



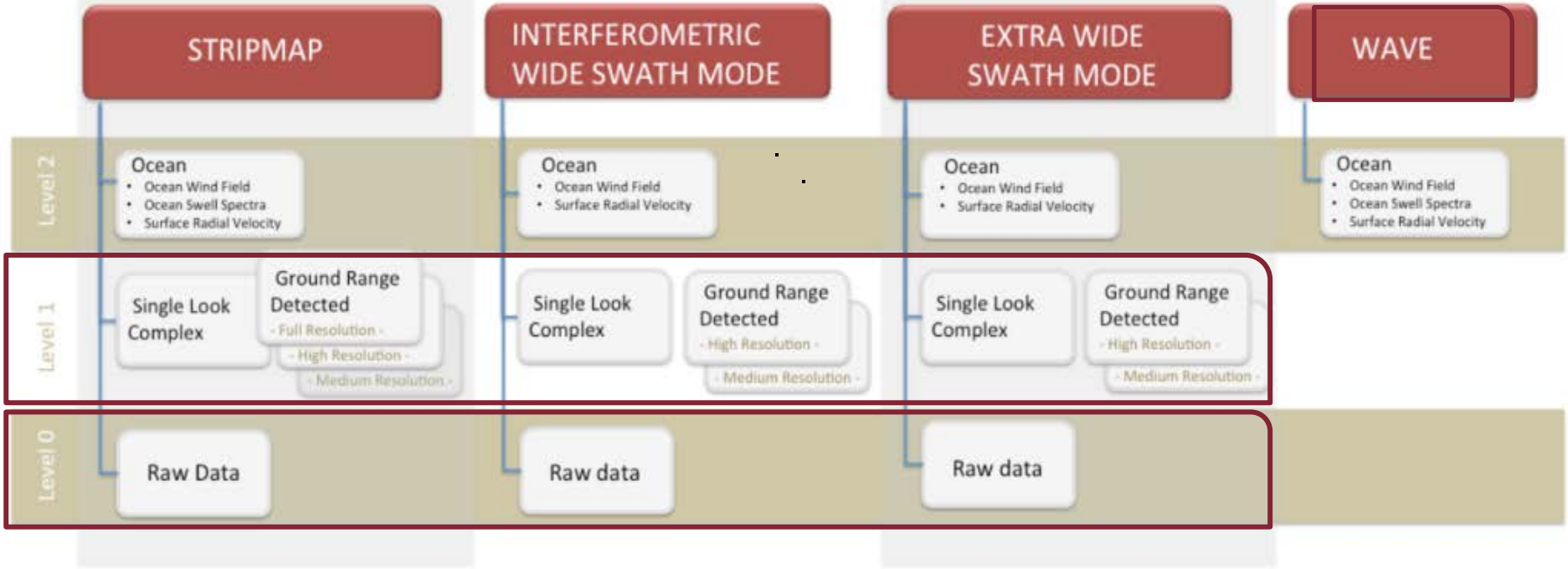
KML files providing detailed information on the planned acquisitions regularly published on Sentinel Online

https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario/acquisition-segments

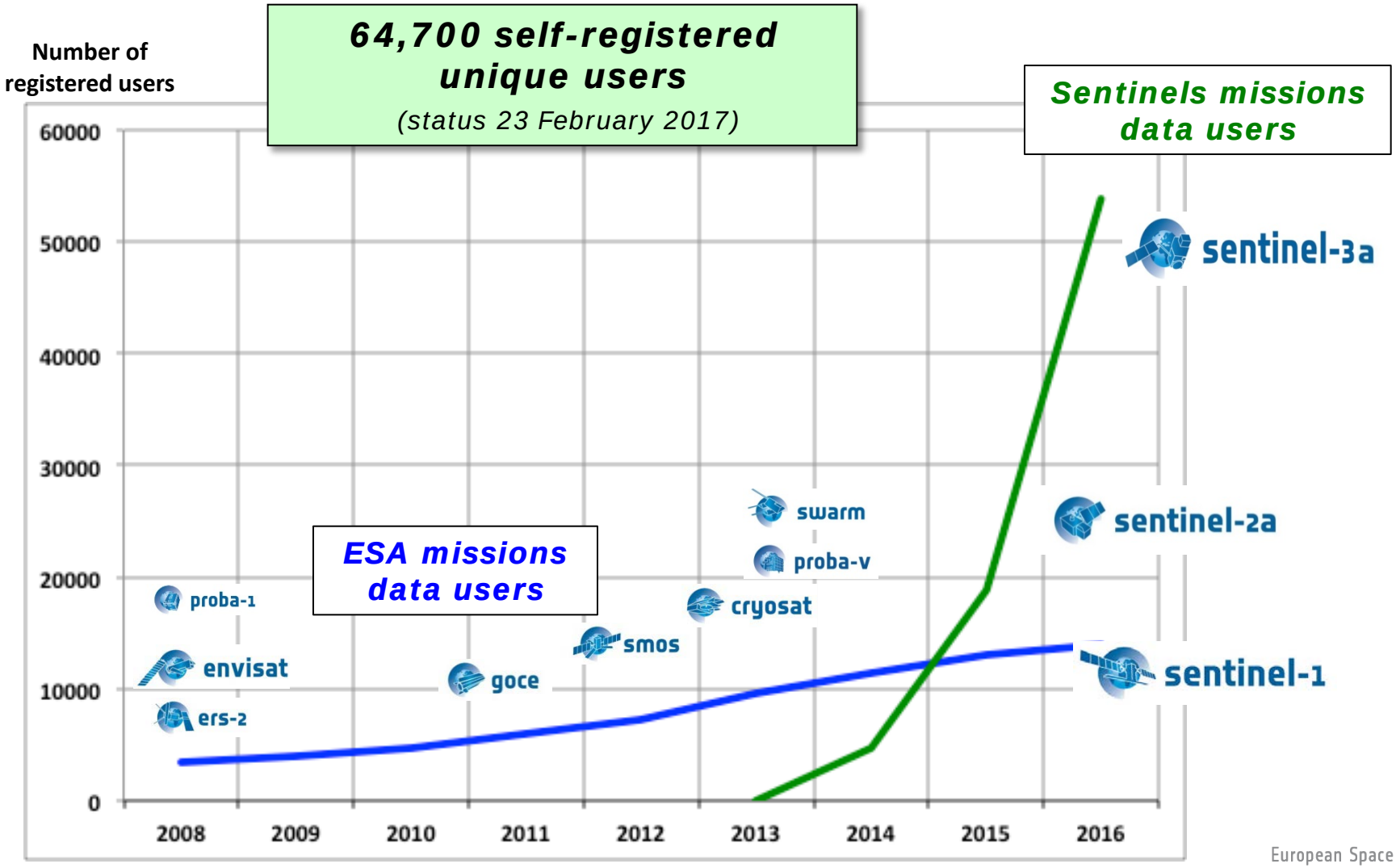
Sentinel-1 Production Scenario

All Sentinels acquired data are systematically downlinked and processed to generate the core products within 24 hours from sensing:

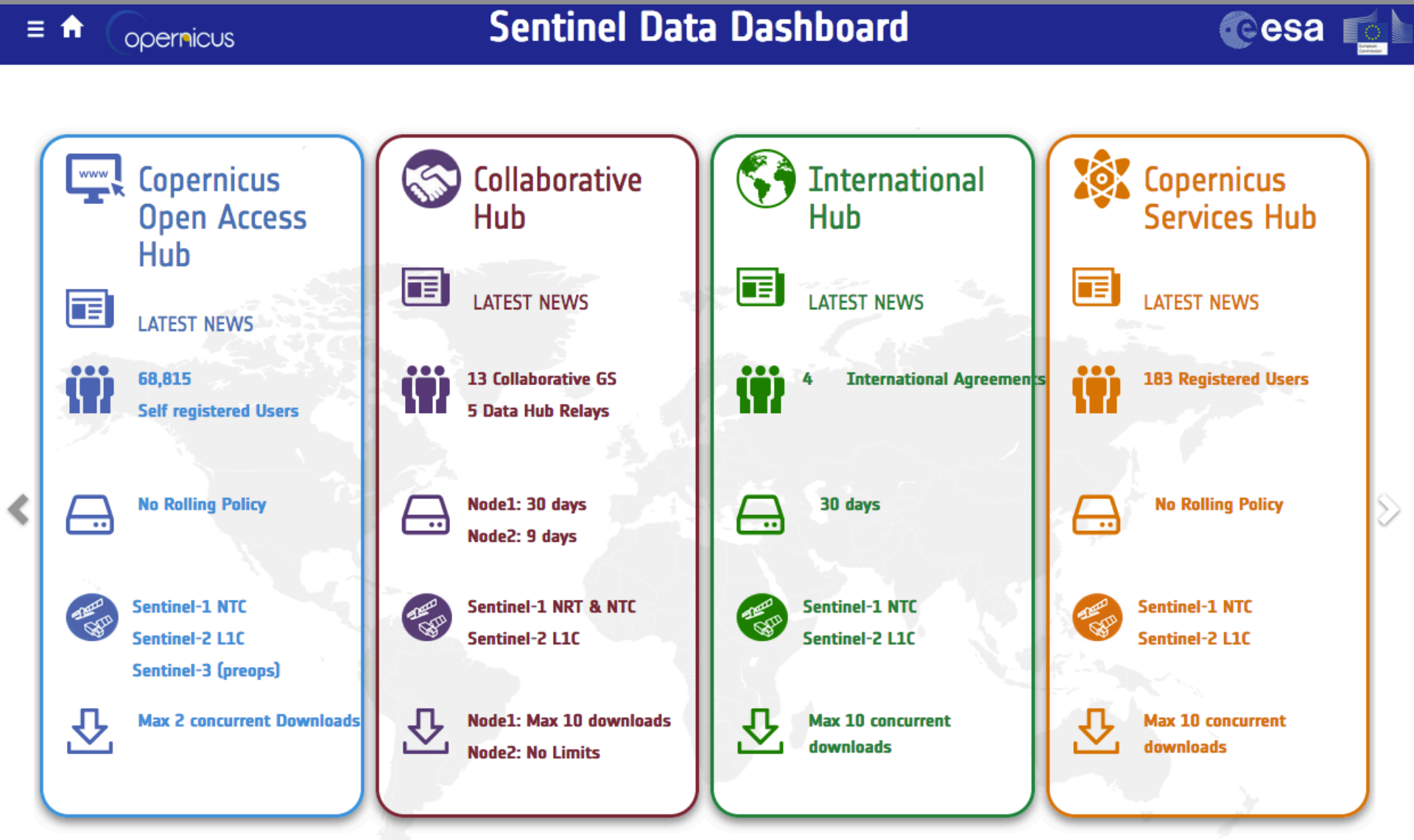
- **L0 products**
- **L1 GRD**
- **L1 SLC (initially over selected regional areas, since July 2015 over all land masses)**



Sentinel data - Users Registration Evolution

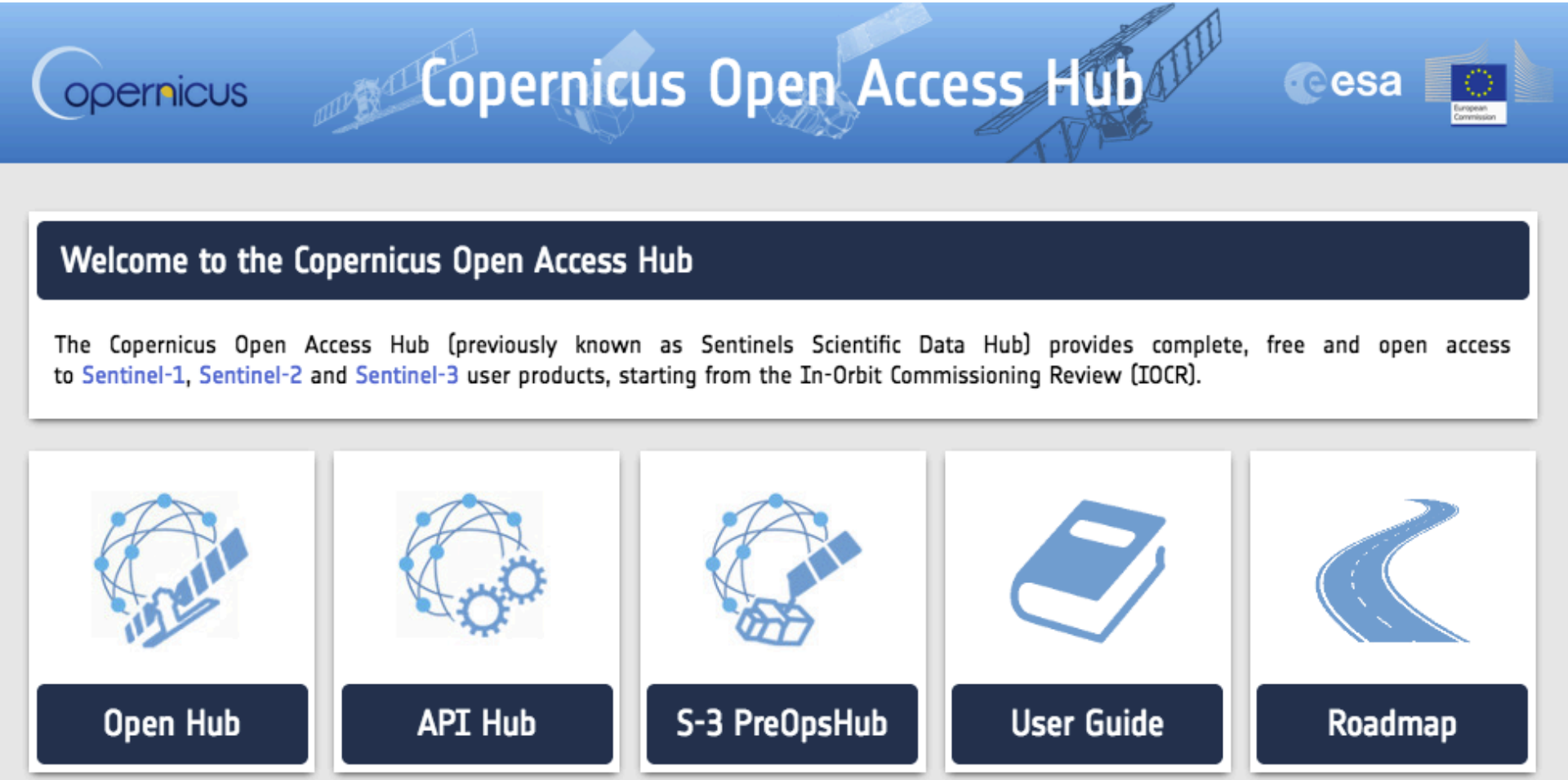


Sentinel Data Hubs – Latest Configuration



Sentinel Open (Scientific) Hub

https://scihub.copernicus.eu/

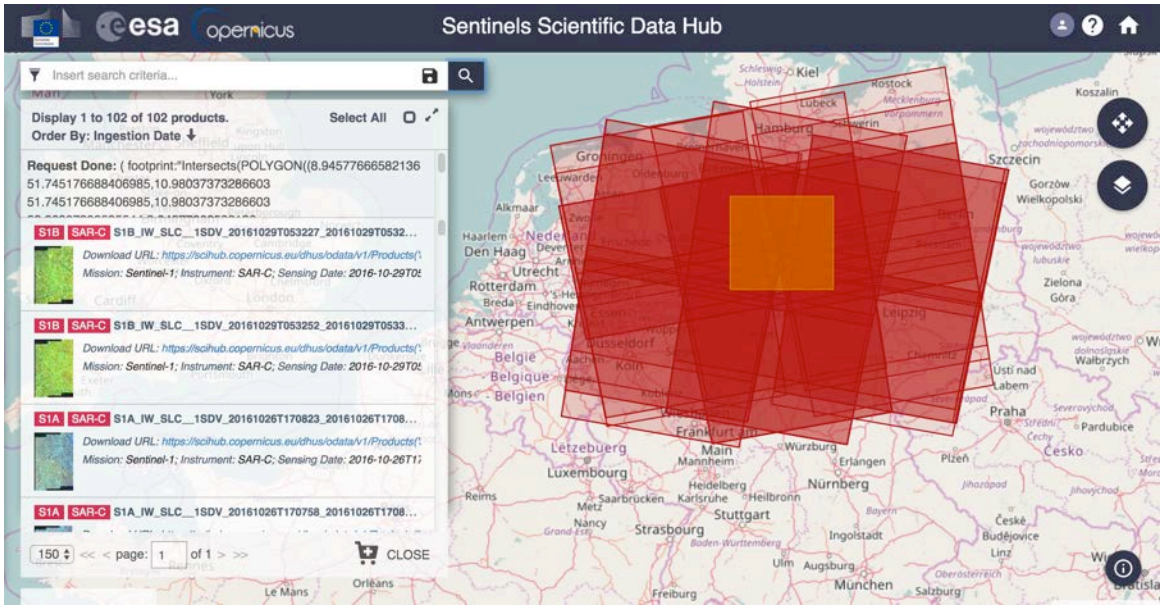


Sentinel-1 mission operations and data access concepts: Foster the development of SAR-based applications

The Copernicus Sentinel data policy ensures **open and free on-line access to Sentinel-1 products**, stimulating SAR based applications in the operational and scientific domains, providing equal opportunities to all users and facilitating the undertaking of new value-added activities

Scientific Hub

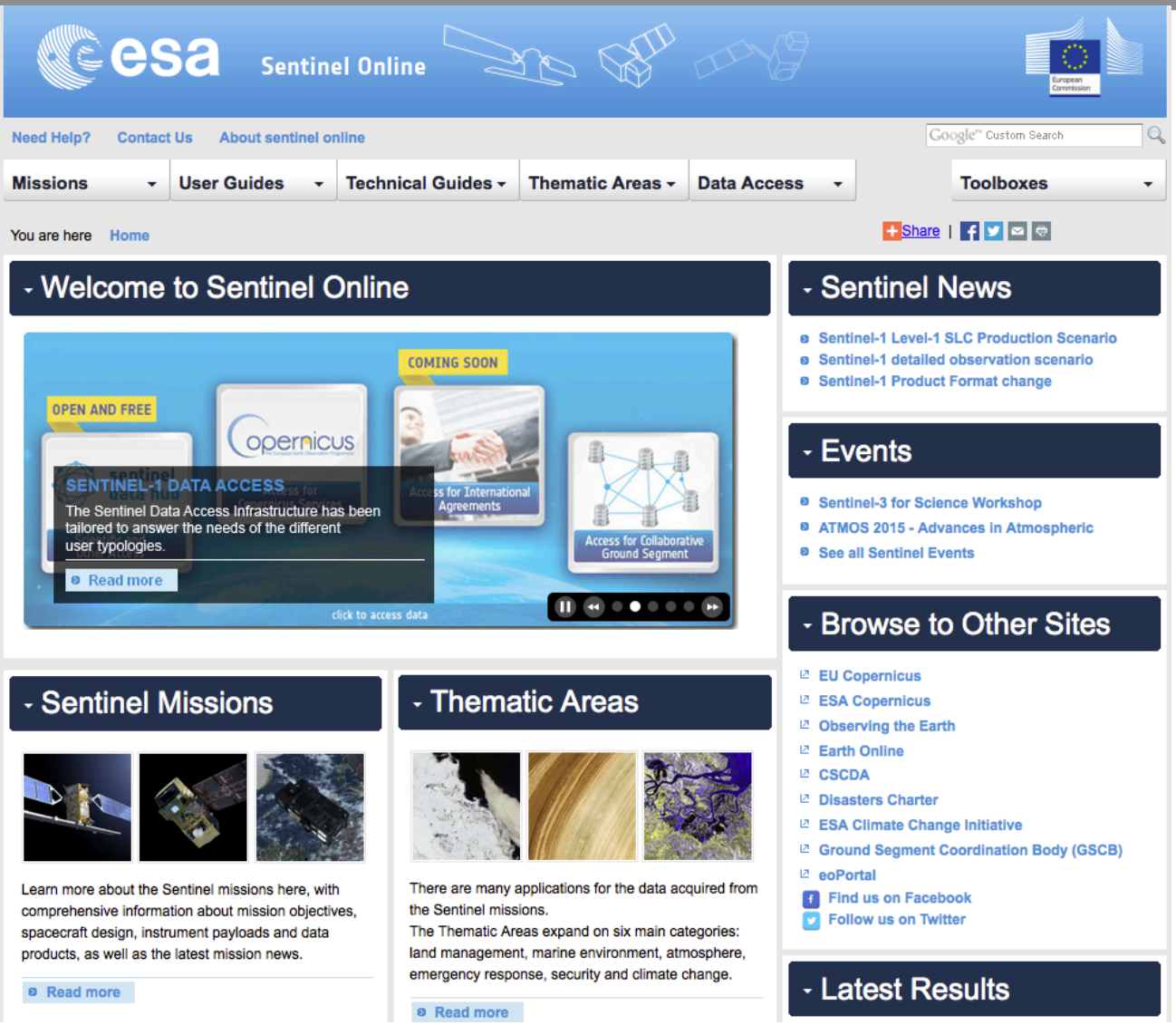
- Access through self-registration
- Automated download scripting capability and dedicated API-Hub
- Restriction on concurrent downloads



Today, more than 1 Million Sentinel-1 products are available on-line for download, representing more than 1 PB of data.

The complete mission archive has been downloaded more than 7 times

Sentinel Online web portal



http://sentinels.copernicus.eu

Sentinel-1 related documentation and technical notes are available

Weekly Mission Status Reports published online
(145 reports issued since S1A launch)

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 -

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sentinel-1

→ RADAR VISION FOR COPERNICUS

Mission Status Report 145

Reference Period: 28 February 2017 – 6 March 2017

Mission status

- The Sentinel-1A and Sentinel-1B routine operations are on-going
- The Sentinel-1 observation scenario supports the systematic coverage of Copernicus Services areas of interest, of European land and coastal waters, of global tectonic/volcanic areas, as well as of other specific areas worldwide for various applications. The observation plan also includes a regular mapping of all land areas worldwide, with a frequency largely increased with Sentinel-1B in operations. Starting on 26 September 2016, the Sentinel-1 observation plan is implemented with the combined use of Sentinel-1A and Sentinel-1B
- World maps providing a high level description of the overall Sentinel-1 constellation observation scenario, in terms of SAR modes, polarisation, observation geometry, revisit and coverage frequency are available at: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario
- The detailed observation plan in the form of instrument acquisition segments, for both Sentinel-1A and Sentinel-1B is published at: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario/acquisition-segments
- The operational use of Sentinel-1 data by the Copernicus Marine Environment Monitoring Service for sea-ice and iceberg monitoring activities is on-going
- The European Maritime Safety Agency (EMSA) operationally uses Sentinel-1 imagery in quasi-real time in the CleanSeaNet services; operations with EMSA service providers local stations are on-going
- The use of the EDRS-A service by Sentinel-1A is on-going as part of the routine operations, allowing to further increase the overall mission capacity
- The Sentinel-1B optical link commissioning using Alphasat TDP-1 is on-going
- Both Sentinel-1A and -1B spacecraft are in a stable state, operating in Nominal Mission Mode (NMM). The Flight Operations Segment (FOS) ensuring the monitoring, control and commanding of the satellites is operating nominally. Orbit control manoeuvres are performed once a week
- X-Band data acquisitions are routinely performed over Matera, Svalbard and Maspalomas X-band core stations. The acquired data are circulated within the Payload Data Ground Segment (PDGS), systematically processed to Level-0 and Level-1 products and archived
- Wave Mode data are regularly acquired over open oceans, systematically processed to Level-2 OCN products and made available. Sentinel-1 IW and EW Level-2 OCN products over regional ocean areas are available on the Data Hubs. The operational qualification of Level-2 OCN products is on-going (geophysical validation of the Radial Surface Velocity component)
- 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
- By 2 March 2017, a total of 68,838 users have self-registered on the Sentinels Scientific Data Hub; 7,098,763 product download have been made by users, corresponding to about 8.4 PB of data. More than 1.1 million Sentinel-1 products are available on-line for download, representing 1.6 PB of data. Statistics of last 24 hours are available in real time at the Data Hub home page: https://scihub.copernicus.eu

Outlook

- Continuation of Sentinel-1 constellation routine operations

Report prepared by the ESA Sentinel-1 Team

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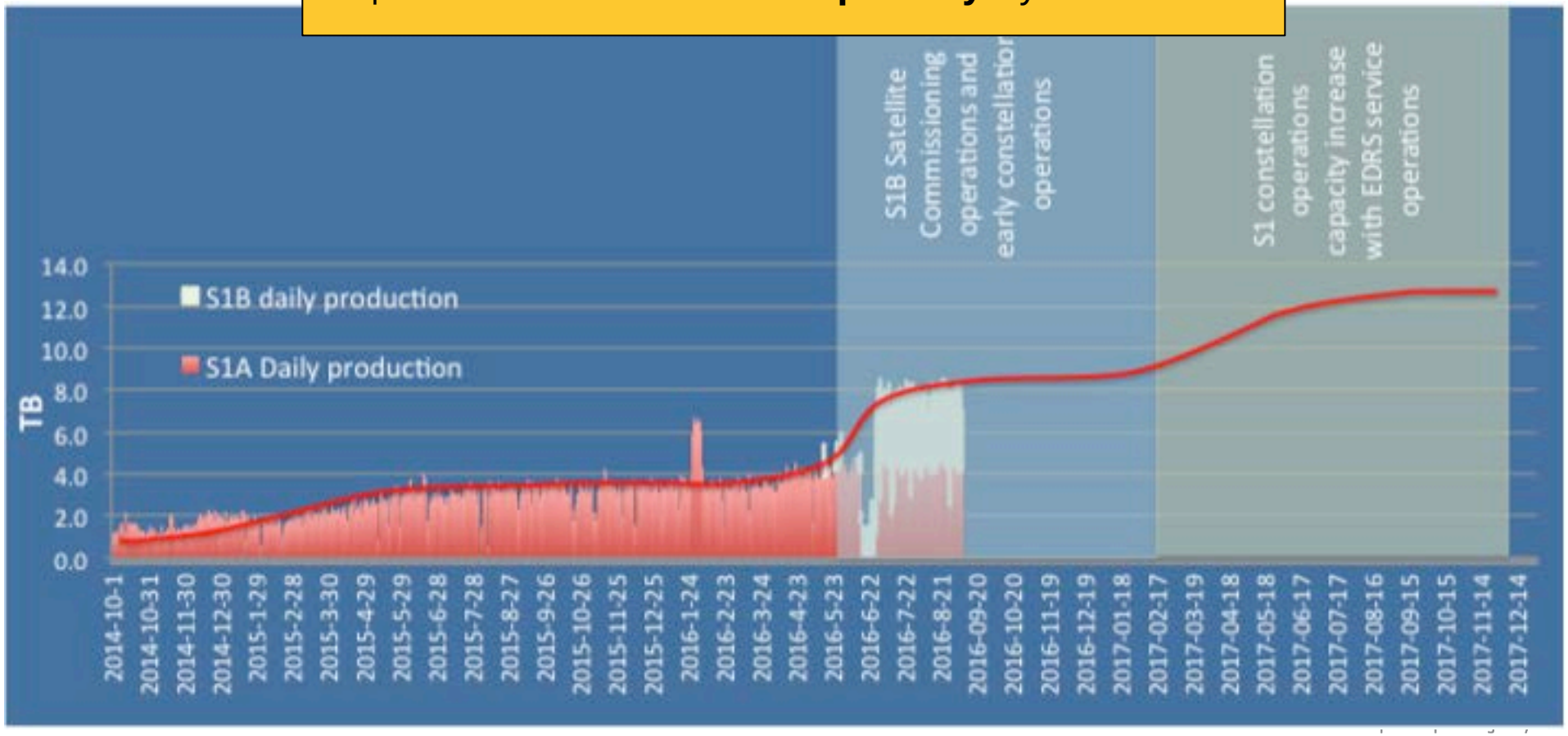
Sentinel-1 mission capacity evolution - 2017

The Sentinel-1 mission total daily production will further increase in coming months

A **conservative forecast** projects the daily mission production to reach **~12 TB per day** by end 2017

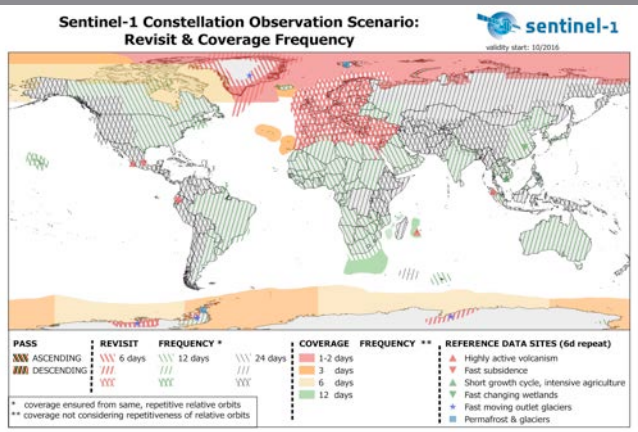


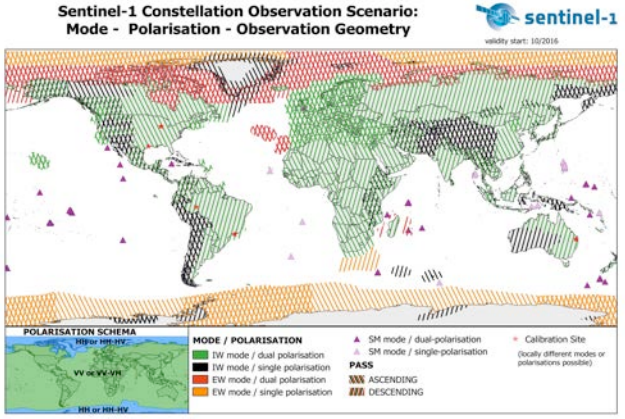
Sentinel-1 mission operations: concluding remarks

- The Sentinel-1 mission operations provide:
  - the technical suitability,
  - the adequate revisit and global coverage,
  - the long-term perspective,
  - the data access conditions,

  ➔ to move SAR applications into the operational domain, at national/regional/continental/global scale

- The unprecedented data volume generated by the Sentinel-1 mission represents today a challenge for its massive exploitation





S1 for Rice Monitoring

Monitoring of Crop Stages

Winter-Spring Rice 2015/16

- March 2016: 1.4 Million ha rice
- March 2015: 1.7 Million ha rice
- **16.5% loss in rice area** due drought and salt water intrusion caused by El Nino
- 976.000 people affected, 67 Mil. $ estimated damage

- Based on unprecedented S1 timeseries

The Mekong Delta, Vietnam
300 km x 300 km, 20 m resolution

GEOGLAM Global Agricultural Monitoring

Asia-RiCE Crop Estimation and Monitoring

V.A.S.T

European Space Agency

CSC Missions Management On-Line

Copernicus Programme: copernicus.eu

Sentinel Online: sentinels.copernicus.eu

CSC Data Access: spacedata.copernicus.eu

ESA Sentinel app: available for iOS and Android