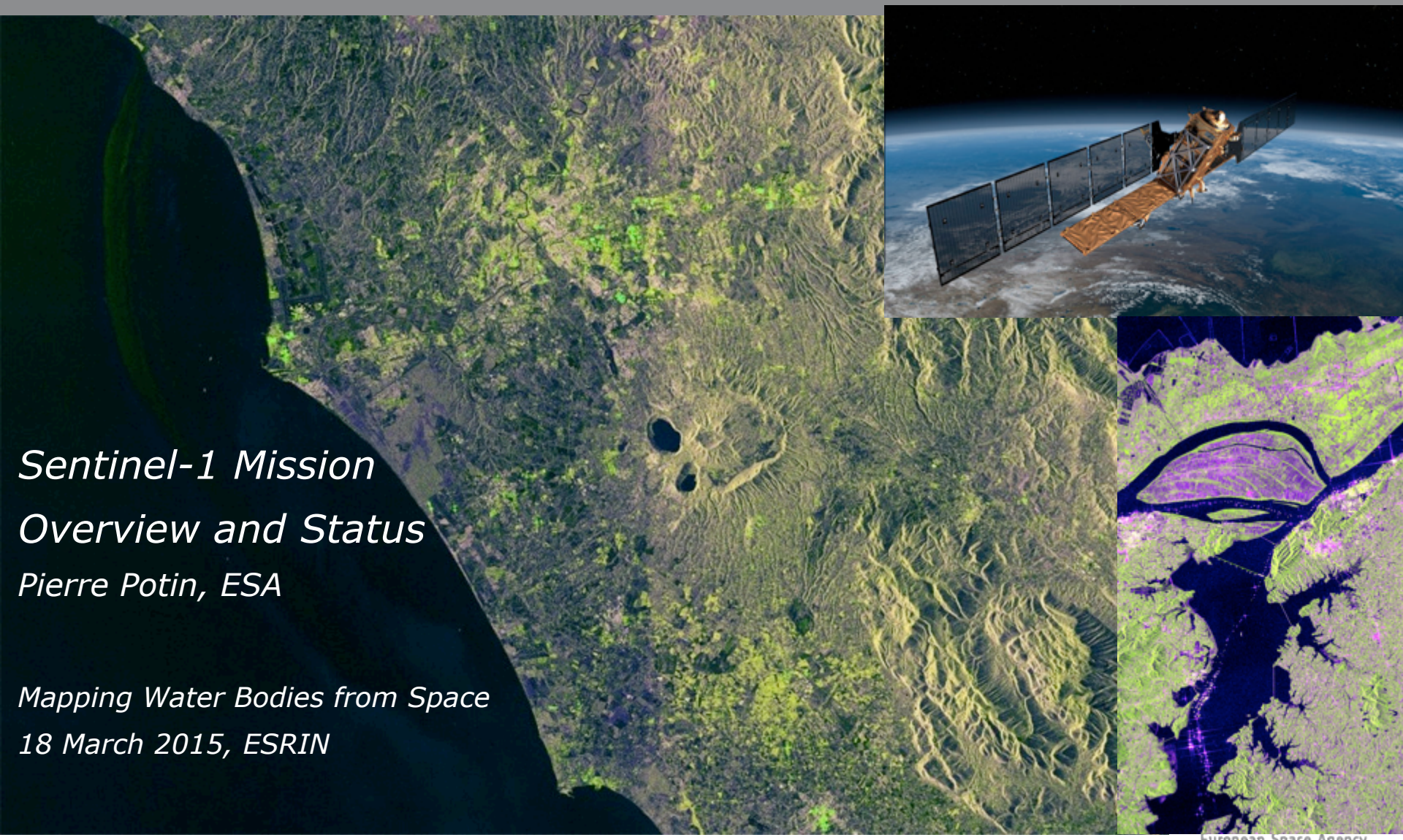


Sentinel-1 Mission Overview and Status

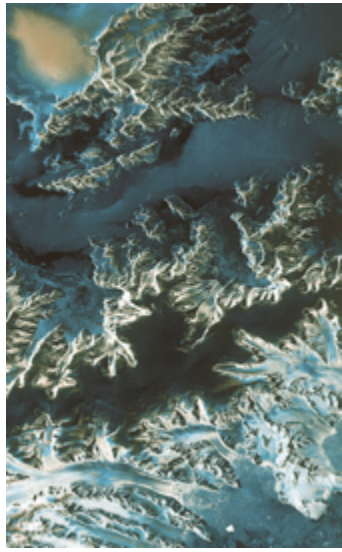
Pierre Potin, ESA

Mapping Water Bodies from Space

18 March 2015, ESRIN

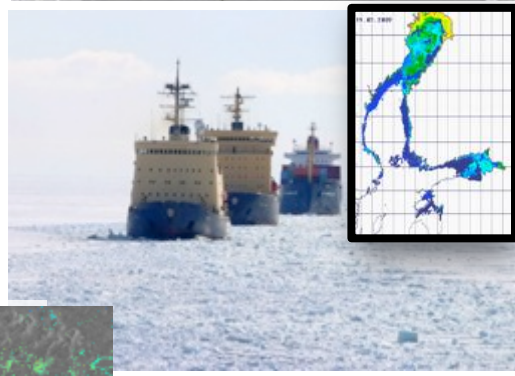
Sentinel–1 mission status

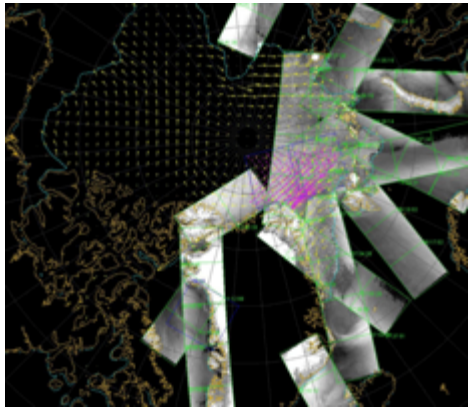
- ✓ Sentinel-1A launched on 3 April 2014 on Soyuz from Kourou
- ✓ Nominal orbit reached on 7 August 2014
- ✓ Sentinel-1A commissioning phased completed on 23 September 2014
- ✓ Sentinel-1A Operational Qualification phase on-going
- ✓ Data flow opened to all users worldwide since 3rd October 2014
- ✓ Satellite and ground segment status and performance are nominal
- ✓ Sentinel-1B satellite under procurement, launched foreseen in early 2016

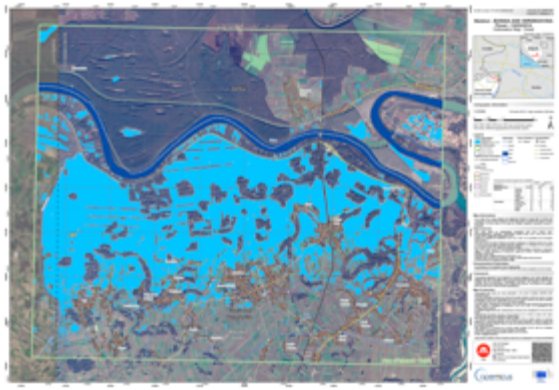


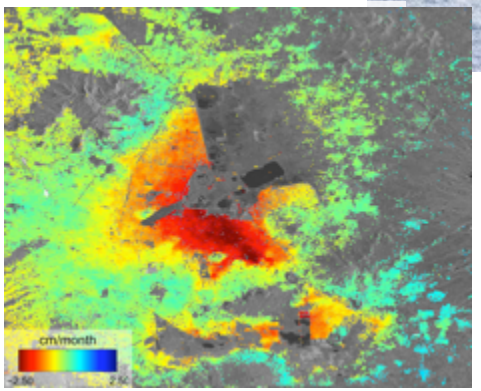
Sentinel–1: C-band SAR mission

- ✓ **Data continuity of ERS and ENVISAT missions**
- ✓ **Copernicus radar imaging mission for ocean, land, emergency**
- ✓ **Applications:**
  - monitoring sea ice zones and the arctic environment
  - surveillance of marine environment (e.g. oil spill monitoring)
  - maritime security (e.g. ship detection)
  - wind, wave, current monitoring
  - monitoring of land surface motion (subsidence, landslide, tectonics, volcanoes, etc.)
  - support to emergency / risk management (e.g. flooding, etc.) and humanitarian aid in crisis situations
  - mapping of land surfaces: forest, water and soil, agriculture, etc.



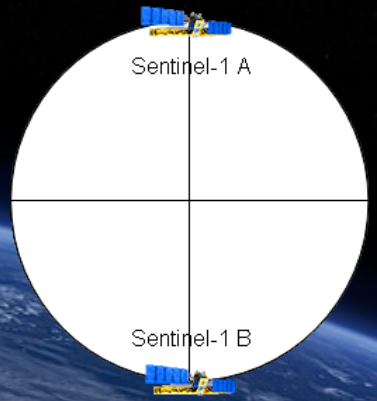






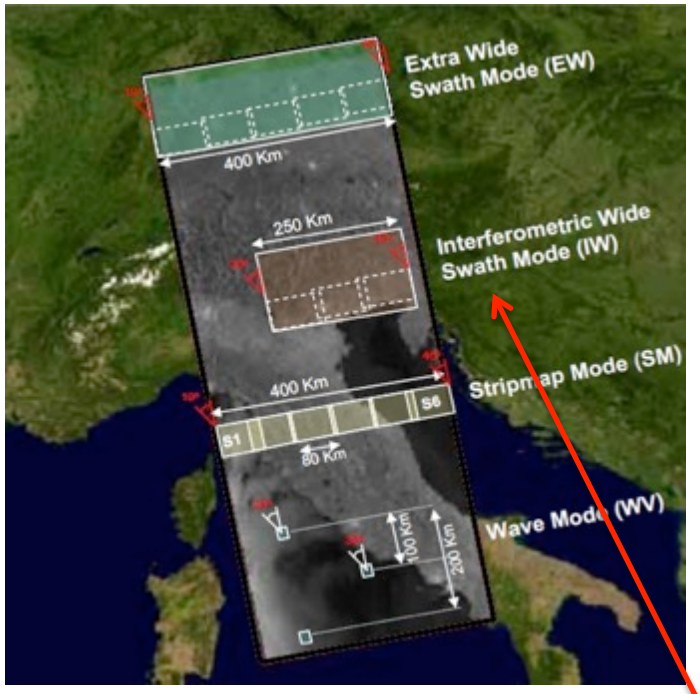
Sentinel-1: Mission Profile

- Mission based on 2 satellites
- C-band Radar instrument
- 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)
- 96h operative onboard autonomy



Sentinel-1 Operational Modes

Operational Modes



Resolution (1 look)	Swath Width	Polarisation
20 x 40 m²	> 400 km	HH+HV or VV+VH
5 x 20 m²	> 250 km	HH+HV or VV+VH
5 x 5 m²	> 80 km	HH+HV or VV+VH
5 x 5 m²	20 x 20 km² at 100 km spacing	HH or VV

Main mode over land

Image Acquisition in Interferometric Wide Swath mode (IW)

Terrain **O**bservation by **P**rogressive **S**cans (TOPS)

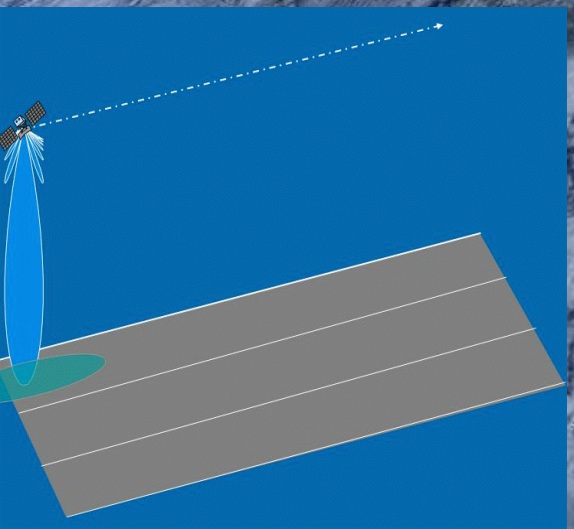
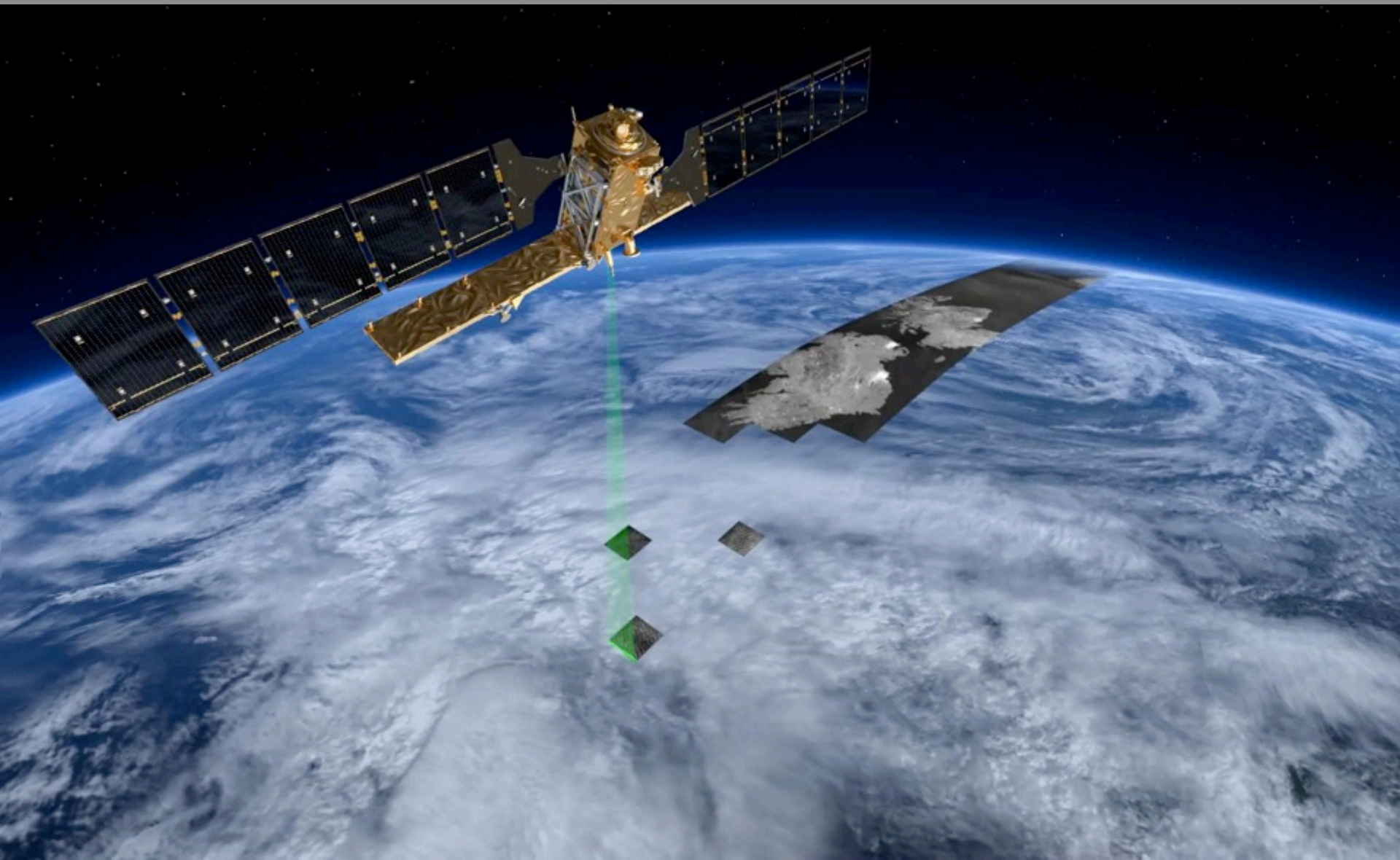


Image Acquisition in Wave Mode (VW) (used over open oceans)



Sentinel-1 Operational Products available to users

LEVEL-0 PRODUCTS

Compressed, unprocessed instrument source packets, with additional annotations and auxiliary information to support the processing.

LEVEL-1 PRODUCTS

Level-1 Slant-Range Single-Look Complex Products (SLC):

Focused data in slant-range geometry, single look, containing phase and amplitude information.

Level-1 Ground Range Detected Geo-referenced Products (GRD):

Focused data projected to ground range, detected and multi-looked.
Data is projected to ground range using an Earth ellipsoid model, maintaining the original satellite path direction and including complete geo-reference information.

LEVEL-2 PRODUCTS

Level-2 Ocean products
Ocean wind field, swell wave spectra and surface radial velocity information as derived from SAR data.

Sentinel-1 Level 1 Operational Product characteristics

Acq. Mode	Product Type	Resolution Class	Resolution [Rng x Azi] [m]	Pixel Spacing [Rng x Azi]	No. Looks [Rng x Azi]	ENL
SM	**SLC**	-	**1.7 x 4.3 to 3.6 x 4.9**	**1.5 x 3.6 to 3.1 x 4.1**	1 x 1	1
	GRD	FR	9 x 9	4 x 4	2 x 2	3.9
		HR	23 x 23	10 x10	6 x 6	34.4
		MR	84 x 84	40 x 40	22 x 22	464.7
IW	**SLC**	-	**2.7 x 22 to 3.5 x 22**	**2.3 x 17.4 to 3 x 17.4**	1	1
	GRD	HR	20 x 22	10 x 10	5 x 1	4.9
		MR	88 x 89	40 x 40	22 x 5	105.7
EW	**SLC**	-	**7.9 x 42 to 14.4 x 43**	**5.9 x 34.7 to 12.5 x 34.7**	1 x 1	1
	GRD	HR	50 x 50	25 x 25	3 x 1	3
		MR	93 x 87	40 x 40	6 x 2	12
WV	**SLC**	-	**2.0 x 4.8 and 3.1 x 4.8**	**1.7 x 4.1 and 2.7 x 4.1**	1 x 1	1
	GRD	MR	52 x 51	25 x 25	13 x 13	139.7

- **For Ground Range Products, the resolution corresponds to the mid range value at mid orbit altitude, averaged over all swaths.**
- **For SLC SM/IW/EW products, the resolution and pixel spacing are provided from lowest to highest incidence angle. For SLC WV products, the resolution and pixel spacing are provided for beams WV1and WV2.**
- **For SLC products, the range coordinate is in slant range. All the other products are in ground range.**

Sentinel-1 Systematic acquisition & production concept

Visibility of observation scenario through Discovery Servic

Observation Scenario
(implementation of observation scenario within the available spacecraft and GS resource)

S1 Ground Segment

S1 regular commanding activity

Regular Satellite tasking

Regular Instrument sensing

Regular Data acquisition

DAP/ HLOP

Observation needs

COPERNICUS Users

Sentinel-1 Systematic acquisition & production concept

Regular access to operational S1 PDGS products for predefined data sets through Discovery and Download services

COPERNICUS Users

DAP/ HLOP

Systematic production needs

S1 Ground Segment

S1 systematic L0/ L1/L2 production rules

S1 data acquisition

S1 data downlink

Sentinel-1

GRD-MR NRT-1h (Data Set A)

GRD-MR NRT-3h (Data Set B)

WV L2-OCN NRT-3h (Data Set C)

GRD-MR Fast24 (Data Set D)

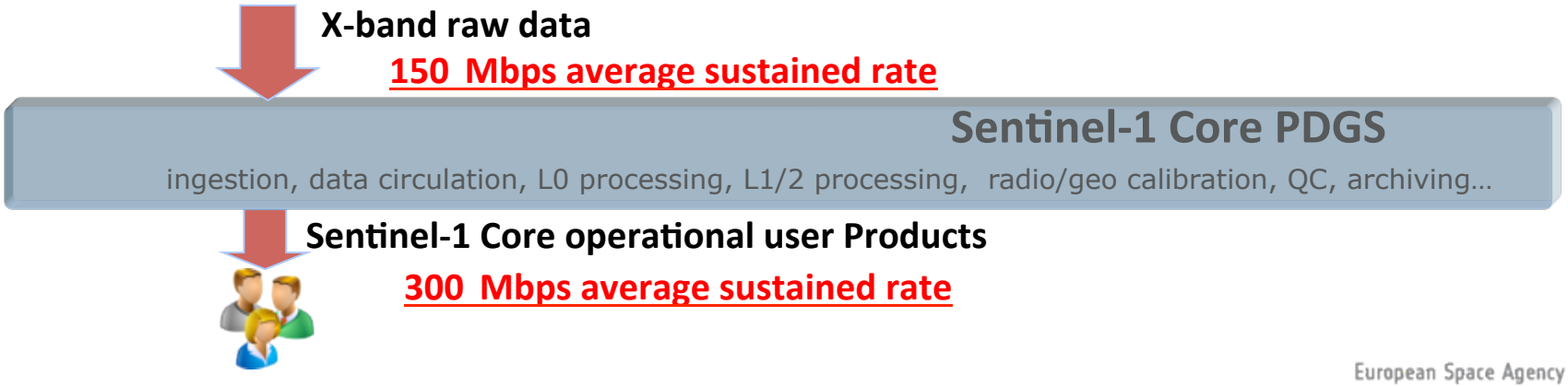
SLC Fast24 (Data Set E)

. . . .

Sentinel-1: un-precedent data volume

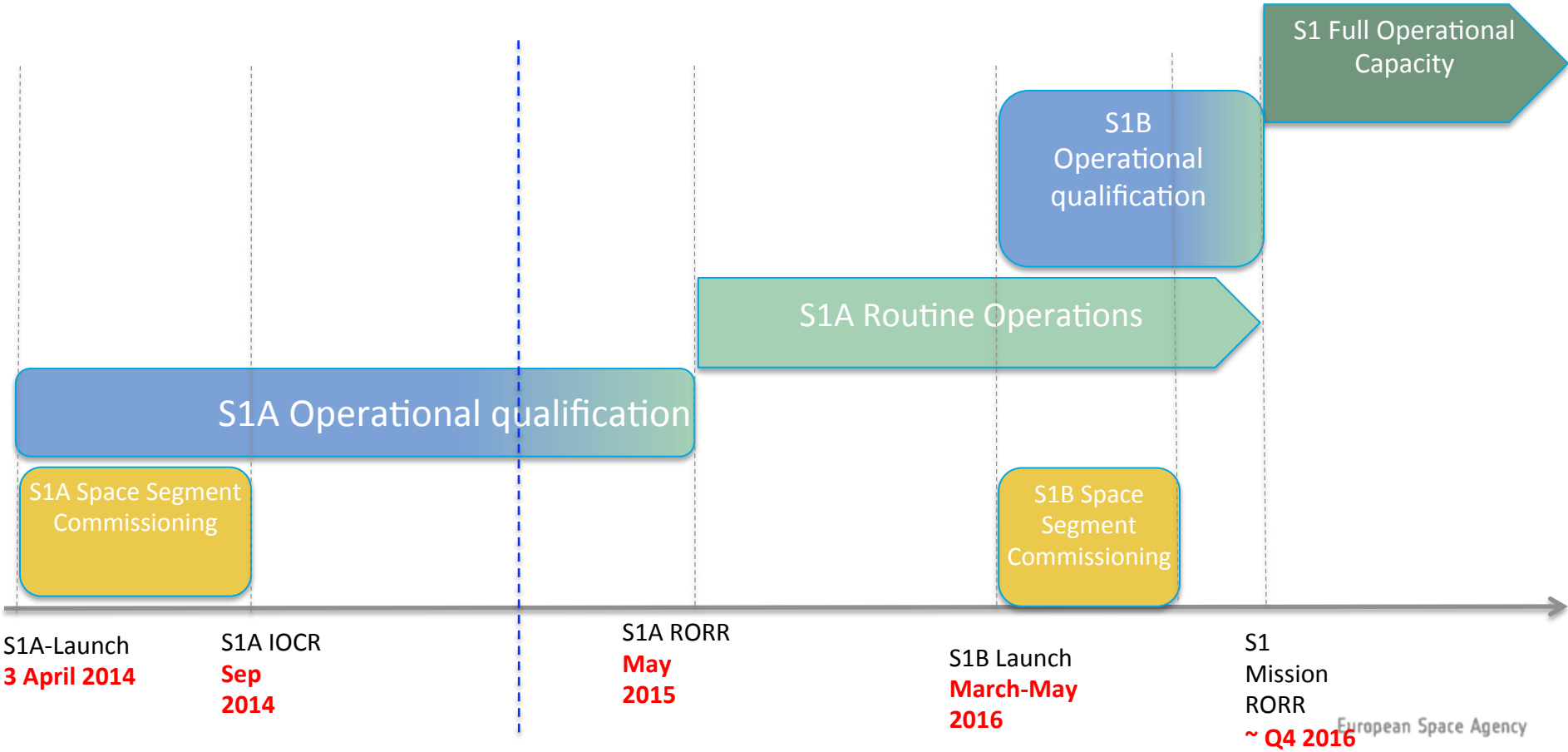
With the Sentinel-1 instrument characteristics and mission operations concept, data volume handling is a major challenge both for Ground Segment operations and also for user data access and management

- Systematic generation of **Level-0 products: about 1.5 TB per day** (both satellites) to be generated, real time quality checked and archived
- Systematic processing to **Level-1 products: about 1.7 TB per day** (both satellites) to be generated, real time quality checked and archived
- **To be disseminated to users with an on-line data access**

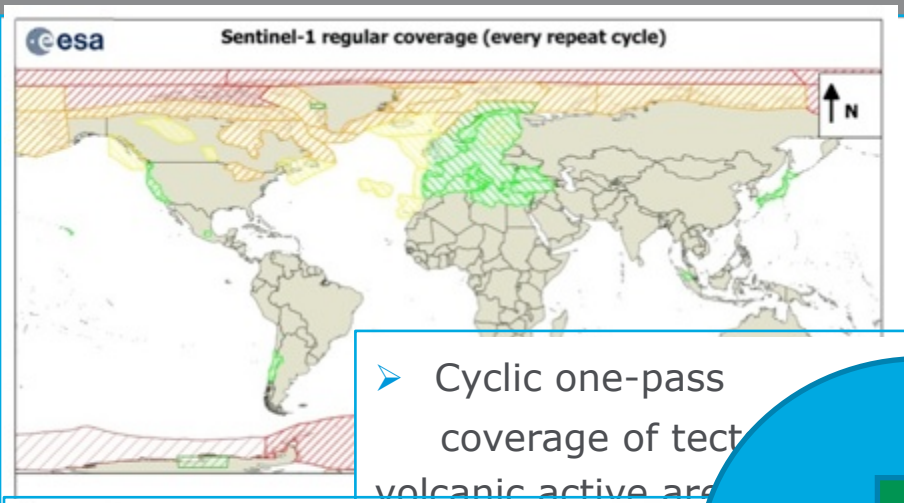


Operational qualification phase leading to the Routine Operations

Sentinel-1 full mission exploitation capacity based on the routine operations of the 2-satellite constellation
➔ gradually achieved

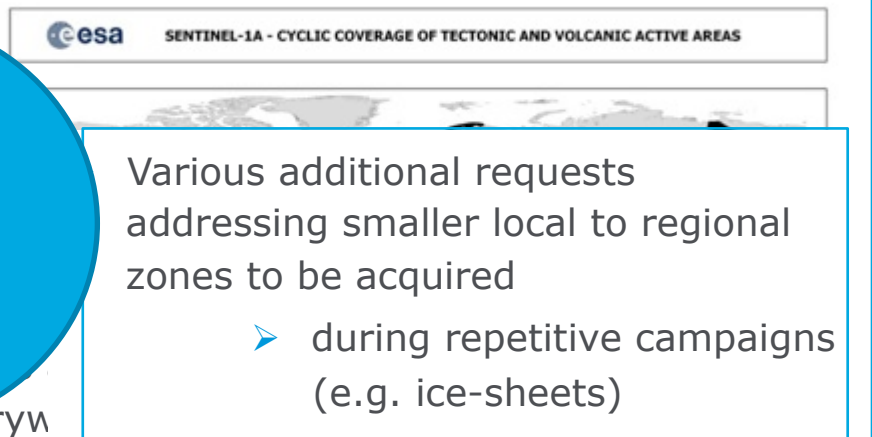


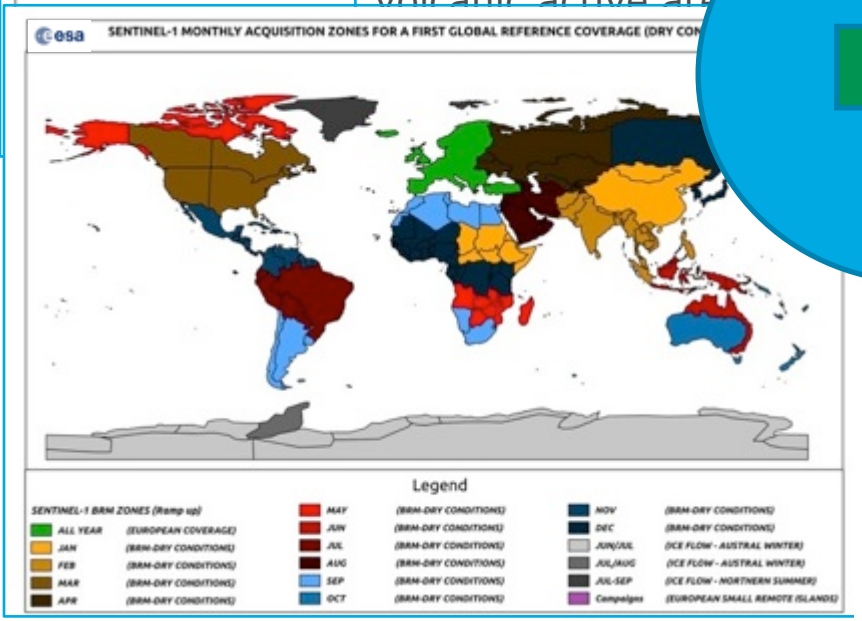
Sentinel-1A observation scenario - Approach for the Ramp-Up phase



- Consistent European coverage
- Sea-ice (focus European Arctic), sea state, maritime surveillance
- Major risk areas (tectonic and

- Cyclic one-pass coverage of tect
volcanic active ar



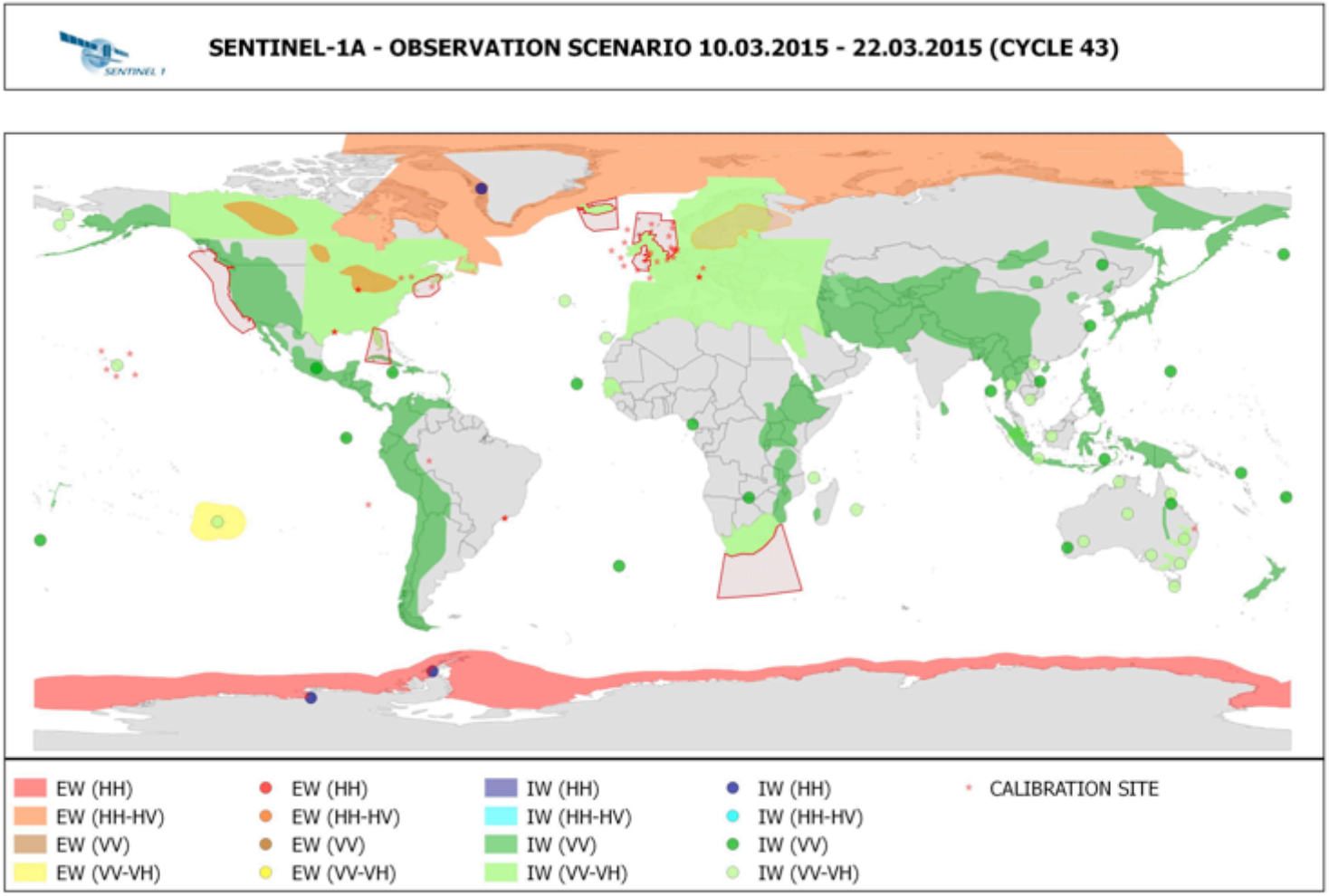


- IWS moc
- One pass
- Fulfil req
requests
reference

Various additional requests addressing smaller local to regional zones to be acquired

- during repetitive campaigns (e.g. ice-sheets)
- with medium frequency
- considering seasonal constraints
- to be gradually introduced into the routine observation scenario

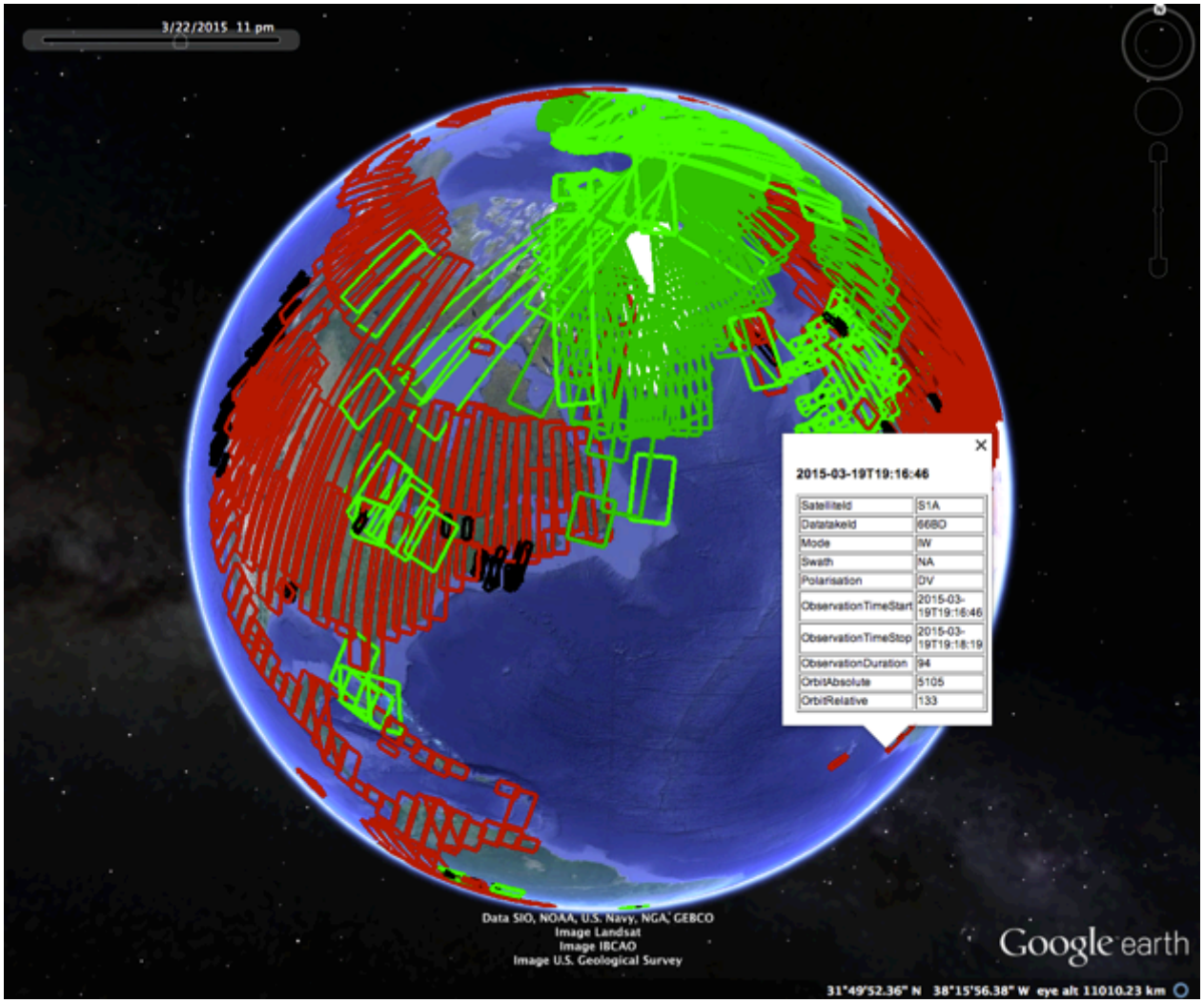
Sentinel-1A observation scenario
(one 12-days repeat cycle: from 10 to 22 March 2015)



ace Agency

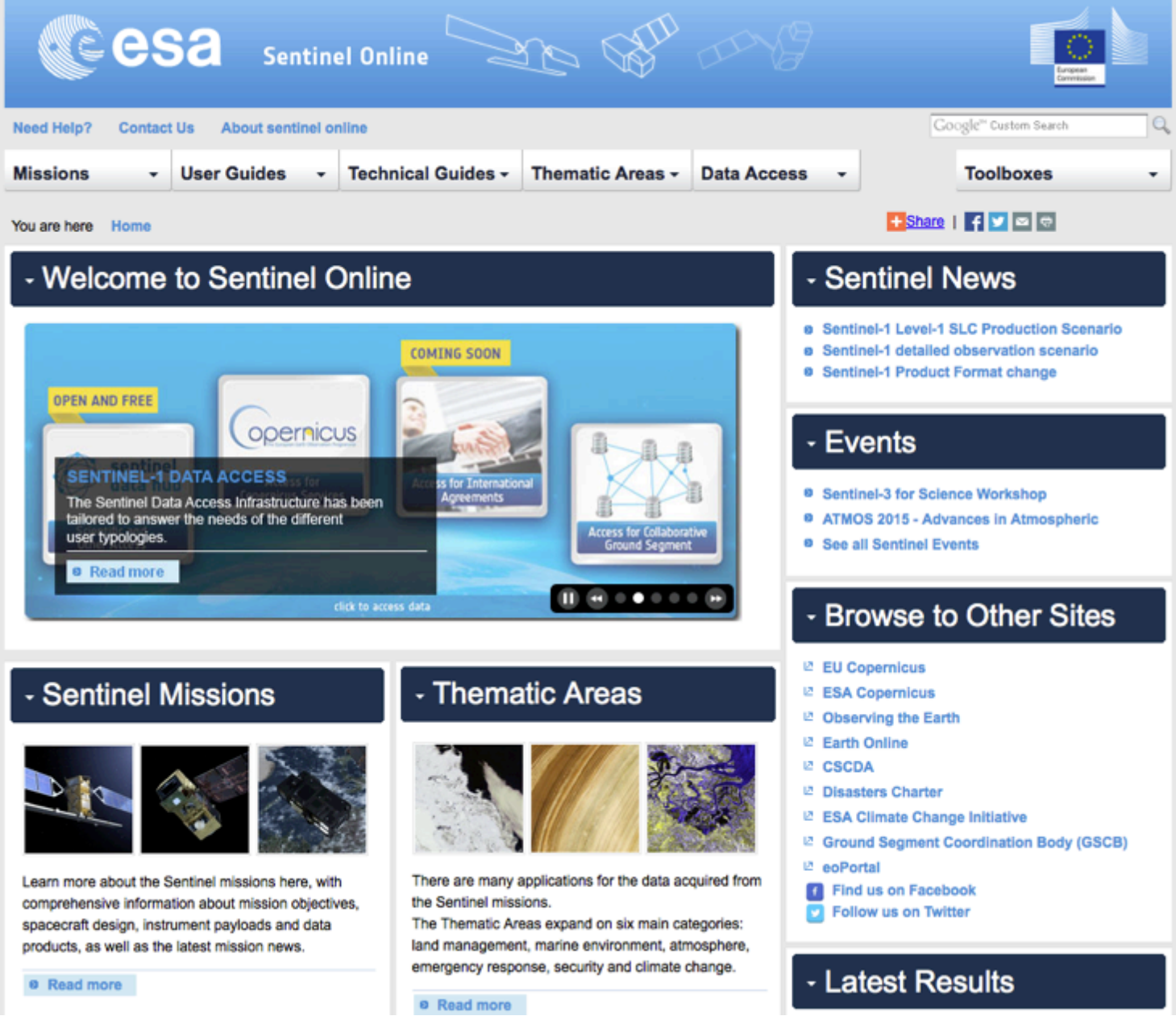
https://sentinel.esa.int/web/sentinel/missions/sentinel-1/observation-scenario

Sentinel-1A acquisition segments
(one 12-days repeat cycle: from 10 to 22 March 2015)



European Space Agency

https://sentinel.esa.int/web/sentinel/missions/sentinel-1/observation-scenario/acquisition-segments

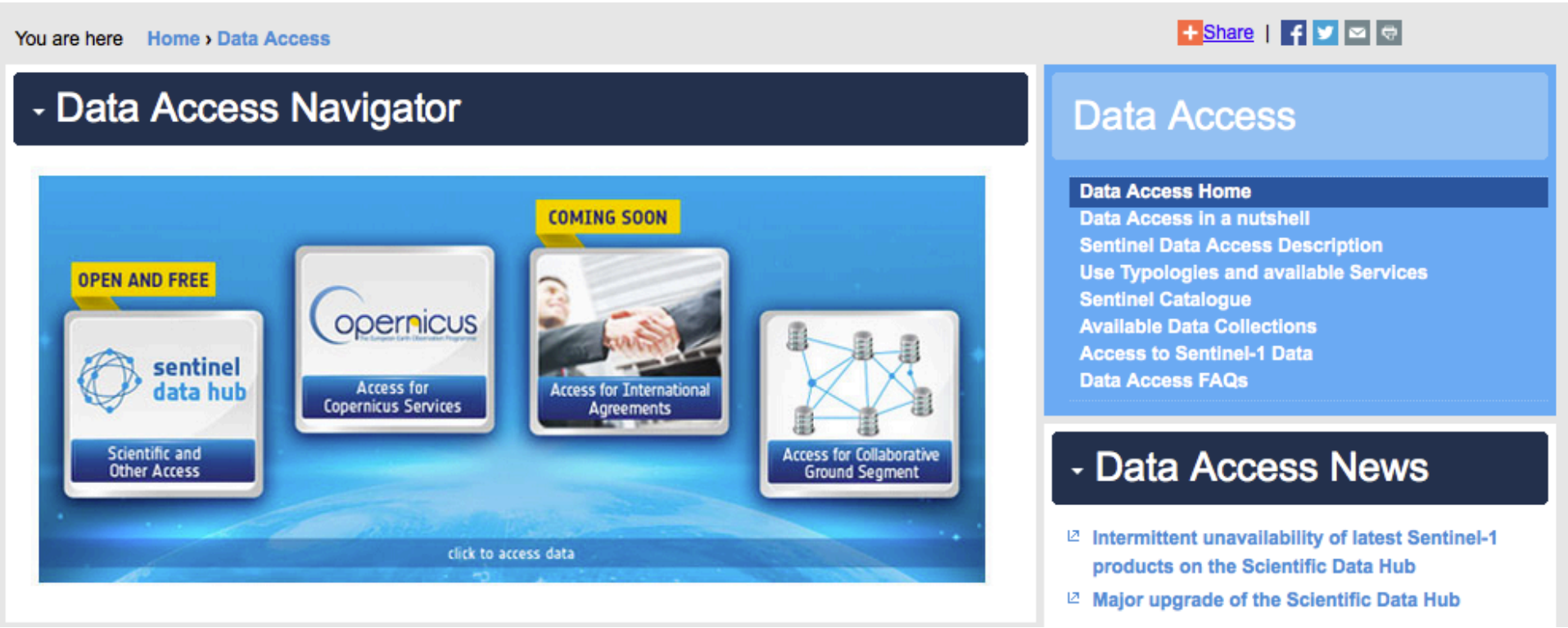


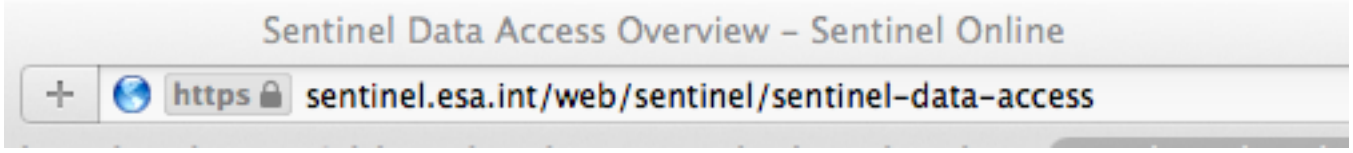
esa

http://sentinel.esa.int

European Space Agency

Sentinel Data Access Landscape





Open & Free 'Science and Other' Data Access – Initial Operations

- Open and Free access
- Terms and Conditions for Sentinel data use and distribution published
- Self Registration and Sample Products open since S-1A launch
- Routine Data flow opened on 3rd October
- Rolling Archive
  - target of latest 2 months data at least (not operated yet, today 5.5 months of data available…)
  - no timeliness guarantee
- Quota restriction of 2 concurrent downloads to ensure bandwidth availability for all users

“Scientific / Other use” access to Sentinel-1

Register and login to: **https://scihub.esa.int/**

Sentinel-1 Scientific Data Hub

Overview | Search | Profile | Cart | About

Welcome cstewart ! Logout

Search

Search | advanced search

Request done : (footprint:"Intersects(POLYGON((20.392373046874 43.33390890325 9,29.730751953124 43.33390890325 9,29.730751953124 48.37882076186,20.392

Display 1 to 23 of 23 products

S1A_IW_GRDH_1SDV_20141004T044457_20141004T044522_002675_002FBB_10EC
https://scihub.esa.int/dhus/odata/v1/Products('19043ecc-4b49-408a-b2b9-be251c5dd9fa')/$value
Date : 2014-10-04T04:44:57.460Z, Instrument : SAR-C, Mode : IW, Satellite : Sentinel-1, Size : 1 GB

S1A_IW_GRDH_1SDV_20141004T044522_20141004T044547_002675_002FBB_1551
https://scihub.esa.int/dhus/odata/v1/Products('6359f2bc-42f8-47cc-bf4e-46b7df638d86')/$value
Date : 2014-10-04T04:45:22.460Z, Instrument : SAR-C, Mode : IW, Satellite : Sentinel-1, Size : 1 GB

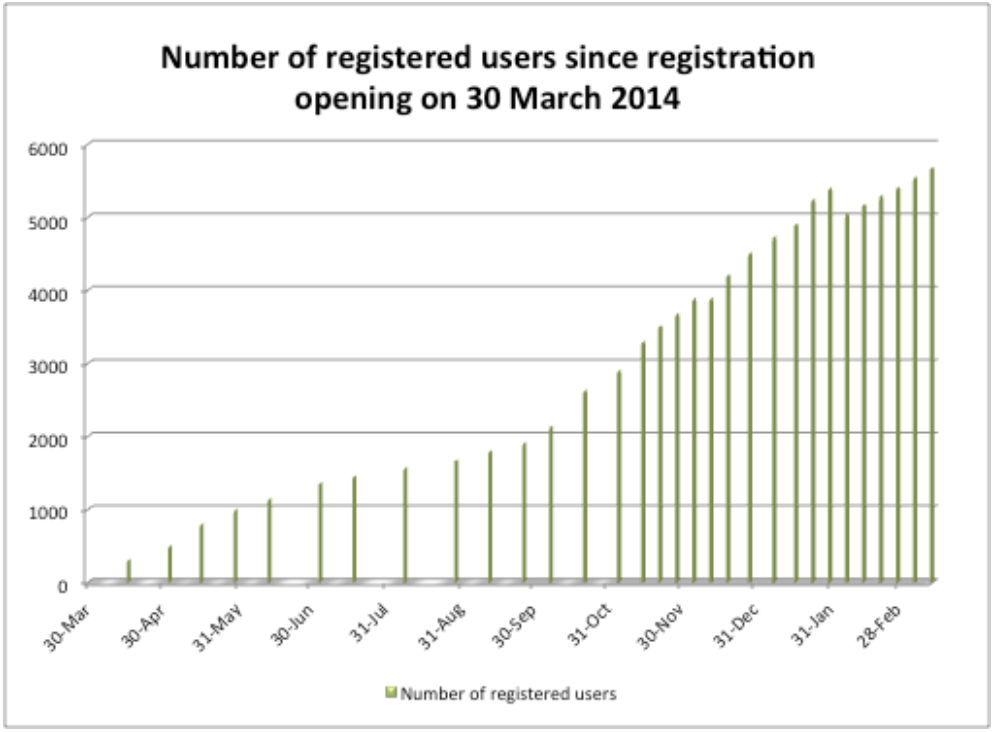
S1A_IW_GRDH_1SDV_20141004T044547_20141004T044612_002675_002FBB_FD20
https://scihub.esa.int/dhus/odata/v1/Products('5b4c06d2-206e-4de6-ad2f-07bc10bbe5c0')/$value
Date : 2014-10-04T04:45:47.460Z, Instrument : SAR-C, Mode : IW, Satellite : Sentinel-1, Size : 1 GB

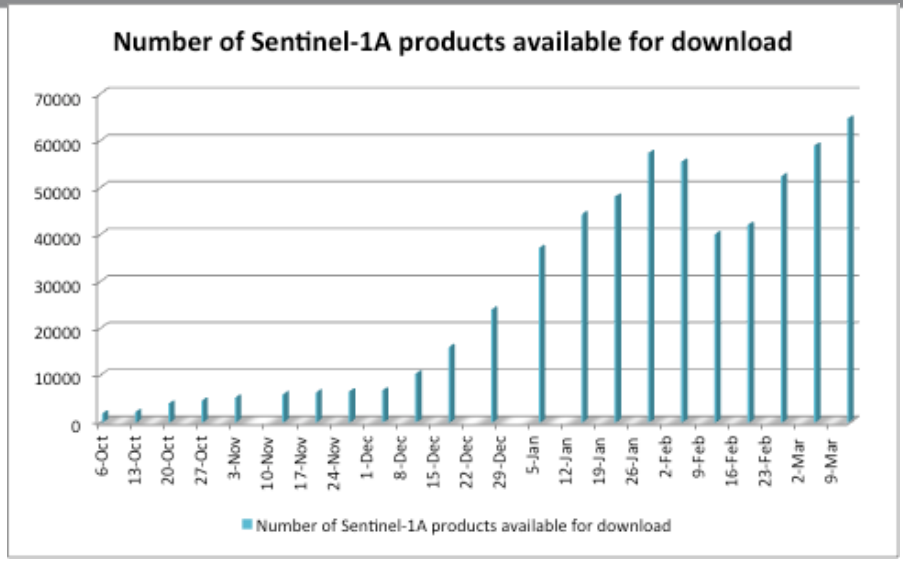
S1A_IW_GRDH_1SDV_20141004T044612_20141004T044637_002675_002FBB_925F
https://scihub.esa.int/dhus/odata/v1/Products('188eada4-1ab4-4ece-a182-879334d023d9')/$value
Date : 2014-10-04T04:46:12.460Z, Instrument : SAR-C, Mode : IW, Satellite : Sentinel-1, Size : 1 GB

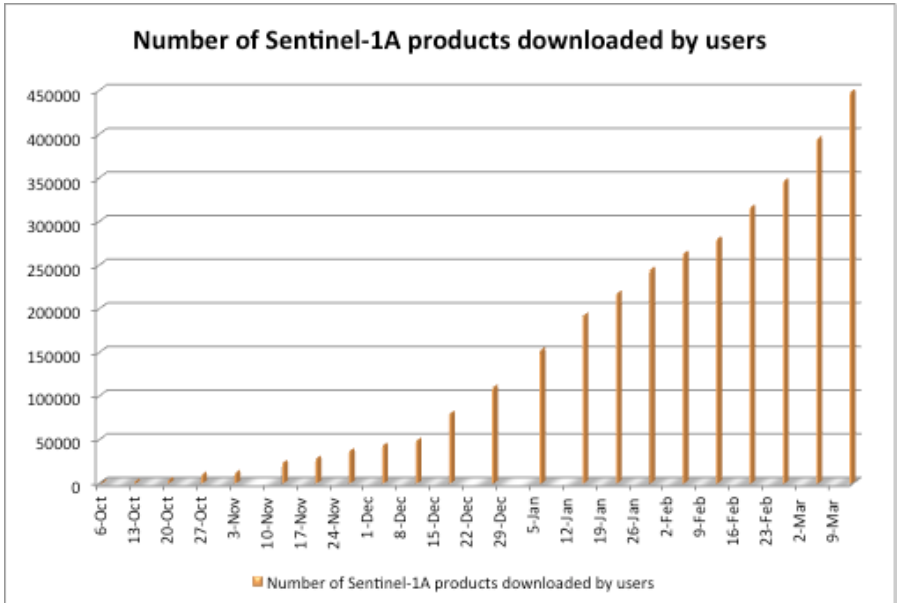
Sentinel-1 User and Data Statistics ("Scientific / Other Use" data hub)

By 12 March 2015:

- ✓ **5676 registered users**
- ✓ **64673 products available for download**
- ✓ **448293 products downloaded by users, representing about 580 TB of data**







Weekly Mission Status Reports available 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 45

Reference Period: 3 March 2015 – 9 March 2015

Mission status

- The Sentinel-1A operational qualification phase is on-going. The first yearly Routine Operations Review is planned early June 2015
- The opening of the Sentinel-1 data flow to all users took place on 3rd October. Data can be accessed from: https://sentinel.esa.int
- 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 before the end of the ramp-up phase. See an overview at: https://sentinel.esa.int/web/sentinel/missions/sentinel-1/observation-scenario
- The use of Sentinel-1A data by the pre-operational precursor of the Copernicus Marine Environment Monitoring Service MyOcean for sea-ice and iceberg monitoring activities is on-going
- Sentinel-1A responded to an activation from the International Charter Space and Major Disasters for an eruption of the Villarrica Volcano in Chile. See more at: https://www.disasterscharter.org/web/guest/activations/-/article/volcano-in-ch-19
- 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
- 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 detailed observation plan in the form of instrument acquisition segments will from now on regularly be published through KML files on Sentinel Online at: https://sentinel.esa.int/web/sentinel/missions/sentinel-1/observation-scenario/acquisition-segments
- The areas where acquired data is systematically processed to Level-1 SLC products have been extended on 4 March. The current SLC production can be consulted at: https://sentinel.esa.int/web/sentinel/missions/sentinel-1/production-scenario
- By mid-March, a slight change in the Level-1 and 2 product format specification will be introduced. More details at: https://sentinel.esa.int/web/sentinel/missions/sentinel-1/news/-/article/sentinel-1-level-1-2-product-format-specifications-version-2-9-released
- By 5 March:
  - A total of 5541 users have self-registered
  - Since the opening of the regular data flow on 3 October:
    - about 62000 products are currently available on-line for download
    - 394498 product download have been made by users, corresponding to 521 TB of data
- The overall operations mission performance is nominal

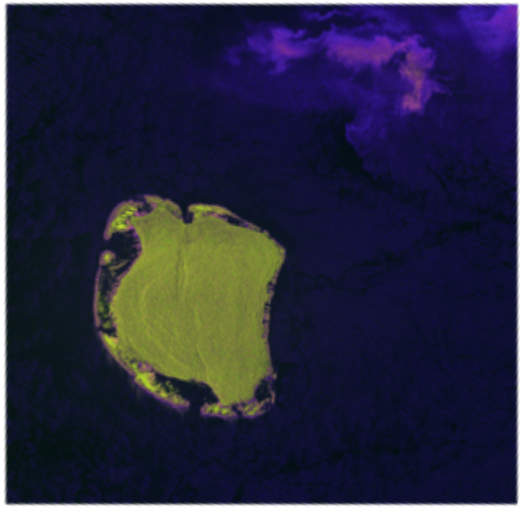
Outlook

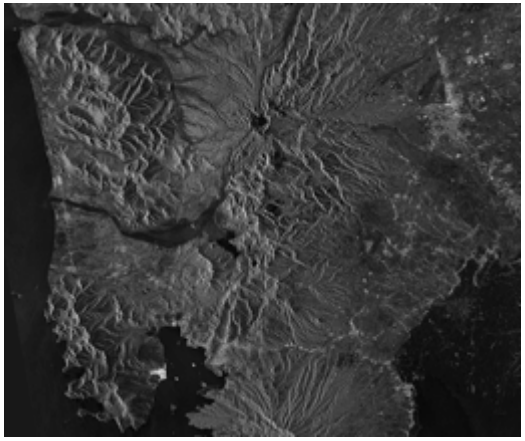
- Continuation of ramp-up mission operations

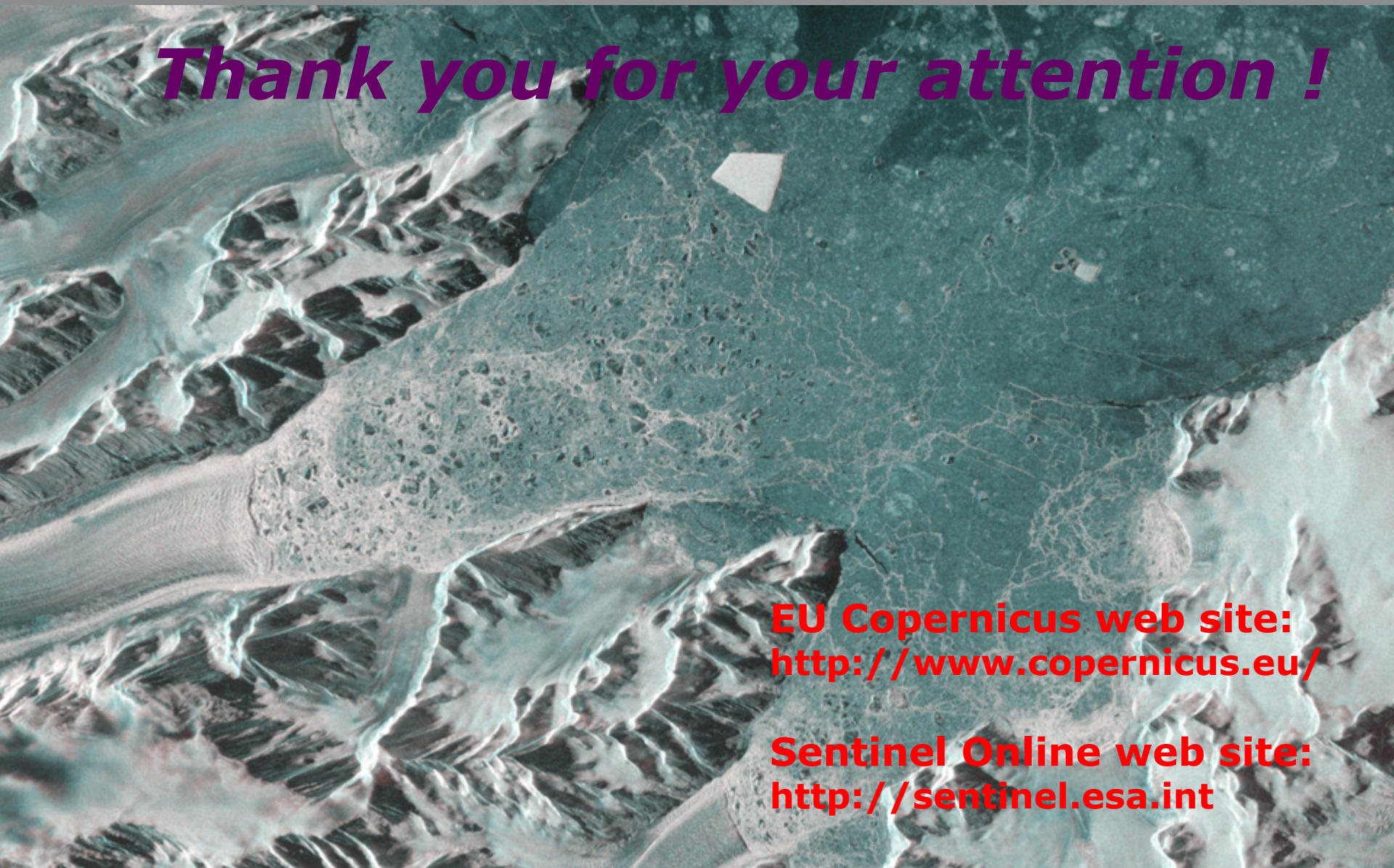
Report prepared by the ESA Sentinel-1 Team -

Concluding remarks

- ✓ Mission overall in a very good status
- ✓ Various elements of the system operating nominally
- ✓ Mission capacity currently being further increased (incl. observation and production scenarios)
- ✓ Very high expectations from the various user communities (operational services, science, value-adding, etc.)
- ✓ Applications in various thematic domains already demonstrated
- ✓ Outstanding efforts made by various teams !







Thank you for your attention !

EU Copernicus web site:
http://www.copernicus.eu/

Sentinel Online web site:
http://sentinel.esa.int