Sentinel-1 Mission Overview

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A global solution to geological hazards"
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Presentation Outline

- Copernicus / GMES context, the Sentinels
- Sentinel-1 Mission Overview, SAR Modes & Products
- Sentinel-1 Preliminary Observation Scenario, Sentinels Data Policy
- ESA Capacity-building, Training, SAR Toolboxes

Global Monitoring for Environment and Security (GMES): now called “Copernicus”

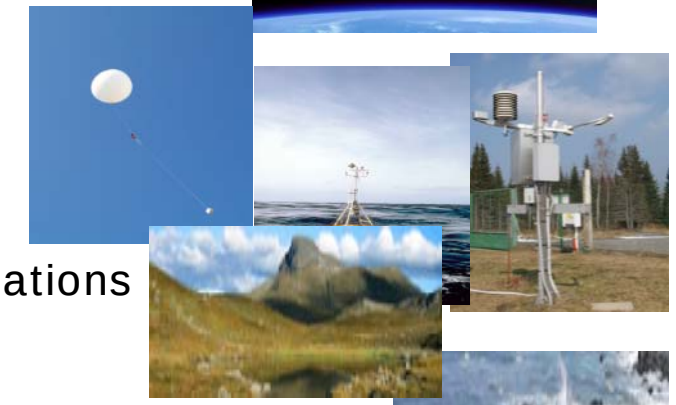
- EU/ESA co-funded program aiming at providing operational services based on Earth observation, and in-situ data.
- Provides relevant information to policy-makers, institutional EU + MS authorities (Core services), and local/regional users (Downstream services)

Space Component – developed & coordinated by ESA

- ✓ Sentinels
- ✓ Contributing (national) Missions

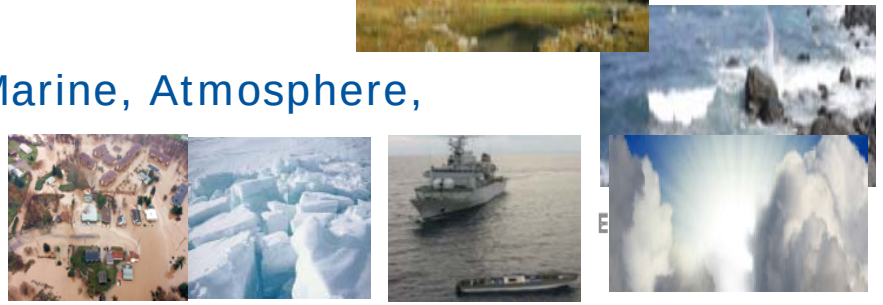
In-situ component – coordinated by EEA

- ✓ Observations mostly within national responsibility, with coordination at European level
- ✓ Air, sea- and ground-based systems and instrumentations



Service component – coordinated by EC

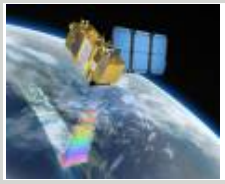
- ✓ Mapping and forecasting services: Land, Marine, Atmosphere, Emergency, Security and Climate Change



Copernicus dedicated missions: Sentinels

Sentinel-1 (A/B) – SAR imaging
All weather, day/night applications, interferometry

2014 /2015



Sentinel-2 (A/B) – Multi-spectral imaging
Land applications: urban, forest, agriculture,…
Continuity of Landsat, SPOT

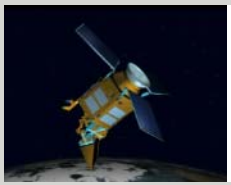
2014 /2016

Sentinel-3 (A/B) – Ocean and global land monitoring
Wide-swath ocean color, vegetation, sea/land surface temperature, altimetry

2014/2017

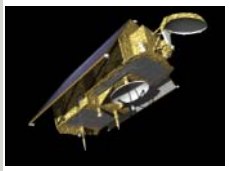
Sentinel-4 (A/B) – Geostationary atmospheric
Atmospheric composition monitoring, trans-boundary pollution

2019/2027



Sentinel-5 precursor/ Sentinel-5 (A/B) – Low-orbit atmospheric
Atmospheric composition monitoring

2015/2020/2027



Jason-CS (A/B) – Low inclination Altimetry
Sea-level, wave height and marine wind speed

2018/2023

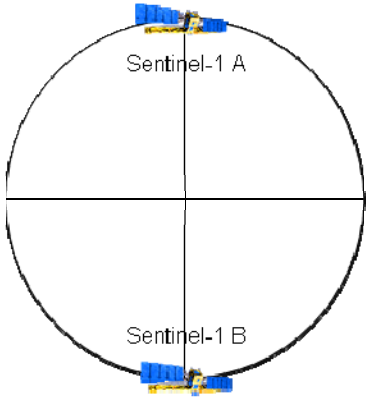
European Space Agency

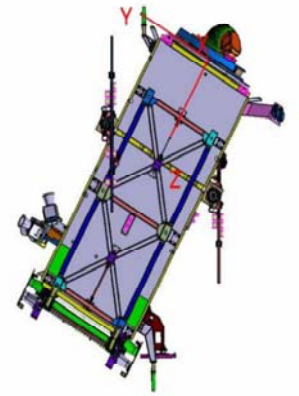
Sentinel–1: C-band SAR mission

- ✓ **Data continuity of ERS and ENVISAT missions**
- ✓ **Dedicated Copernicus radar imaging mission for ocean, land and emergency services**
- ✓ **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.)
  - mapping of land surfaces: forest, water and soil, agriculture, etc.
  - support to emergency / risk management (e.g. flooding, etc.) and humanitarian aid in crisis situations

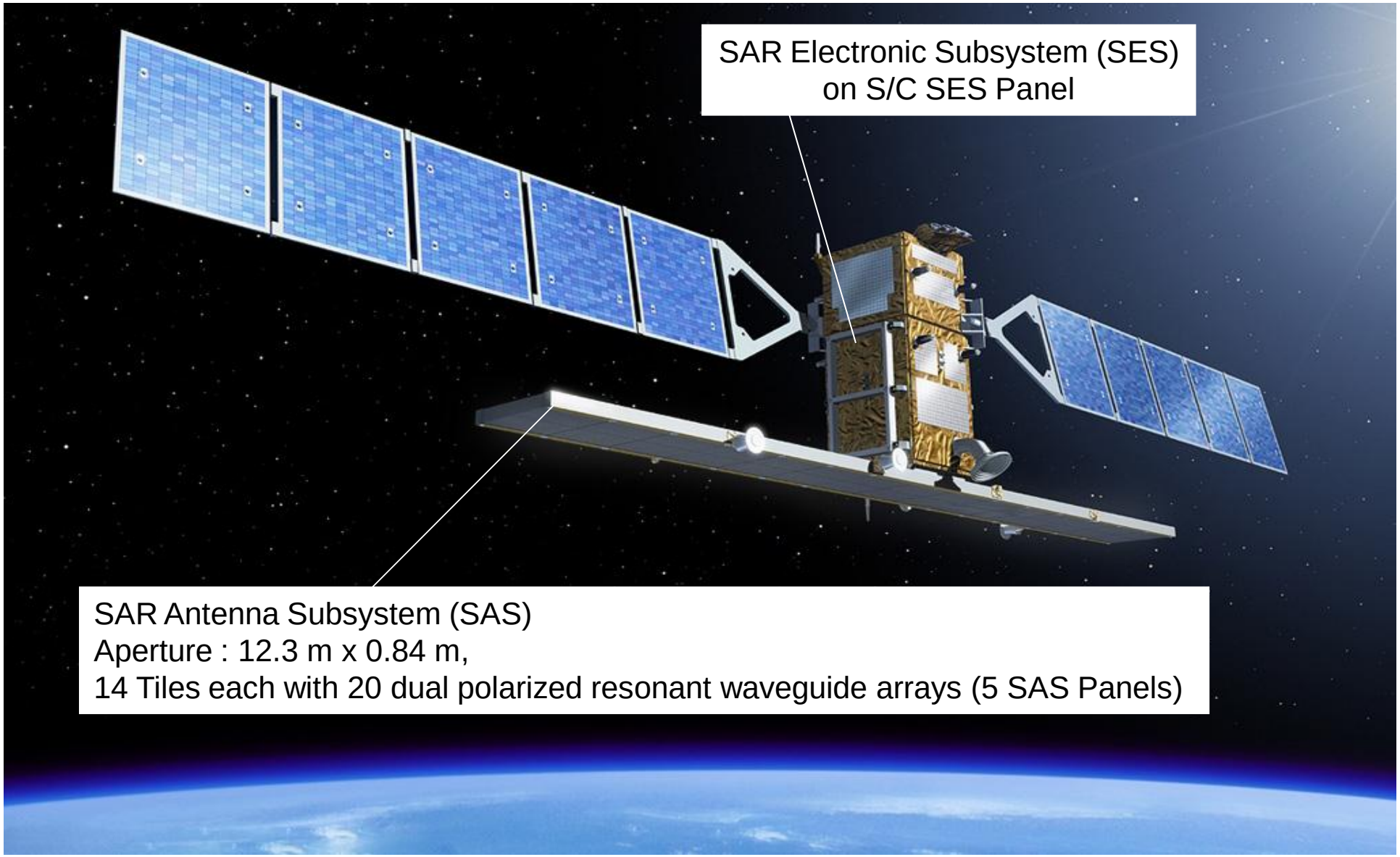
Sentinel-1 Mission Facts

- C-Band Synthetic Aperture Radar Payload (at 5.405 GHz)
- Constellation of two satellites (A & B units)
  - Launch of Sentinel-1A scheduled for early 2014 (Sentinel-1B launch indicatively mid 2015, subject to EC funding)
  - 7 years design life time with consumables for 12 years
- Near-Polar sun-synchronous (dawn-dusk) orbit at 698 km
  - 12 days repeat cycle (1 satellite), 6 days for the constellation
  - Both Sentinel-1 satellites in the same orbital plane (180 deg phased in orbit)
  - Orbital tube 100m
- Duty cycle: 25 minutes of High Bit Rate imaging per orbit
  - On-board data storage capacity (mass memory) of 1400 Gbit
  - Two X-band RF channels for data downlink with 2 X 260 Mbps
  - On-board data compression using Flexible Dynamic Block Adaptive Quantization (FDBAQ)
  - Optical Communication Payload (OCP) for data transfer via laser link with the GEO European Data Relay Satellite (EDRS)



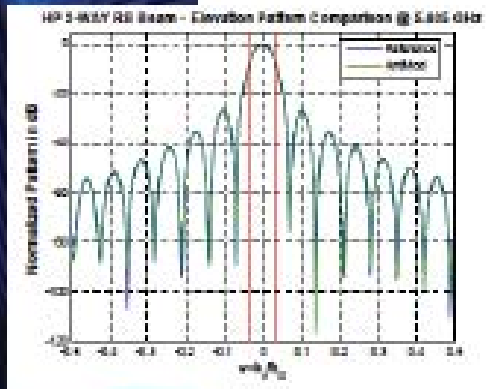


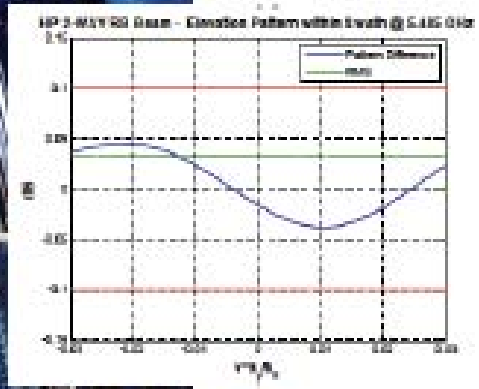
Sentinel-1 Spacecraft – SAR elements



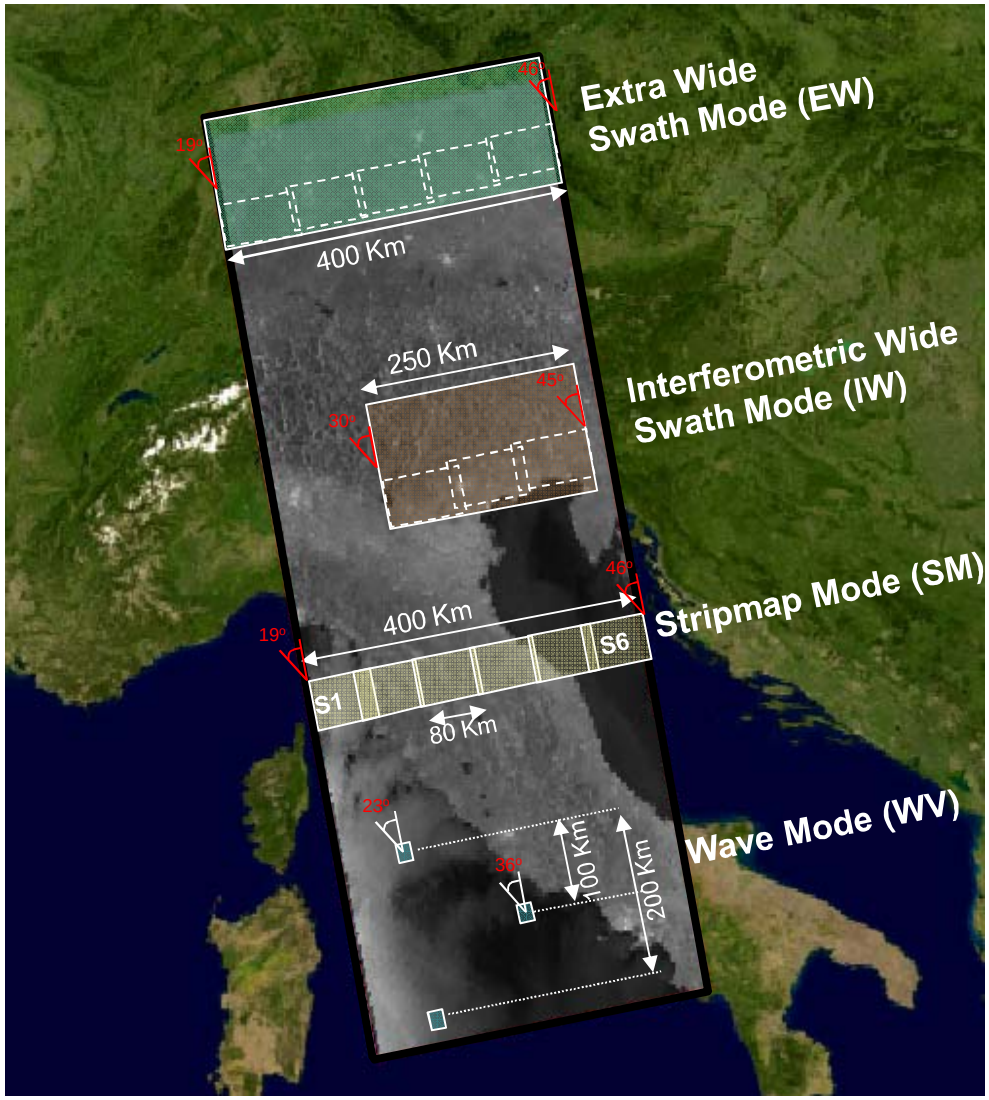
Sentinel-1A platform

Sentinel-1A SAR Antenna





Sentinel-1 SAR Modes



Sentinel-1 SAR can be operated in 4 exclusive imaging modes with different resolution and coverage:

Mode Rate	SAR Mode
High Bit Rate (HBR)	IW
	EW
	SM (S1 → S6)
Low Bit Rate (LBR)	WV

Polarisation schemes for IW, EW and SM:

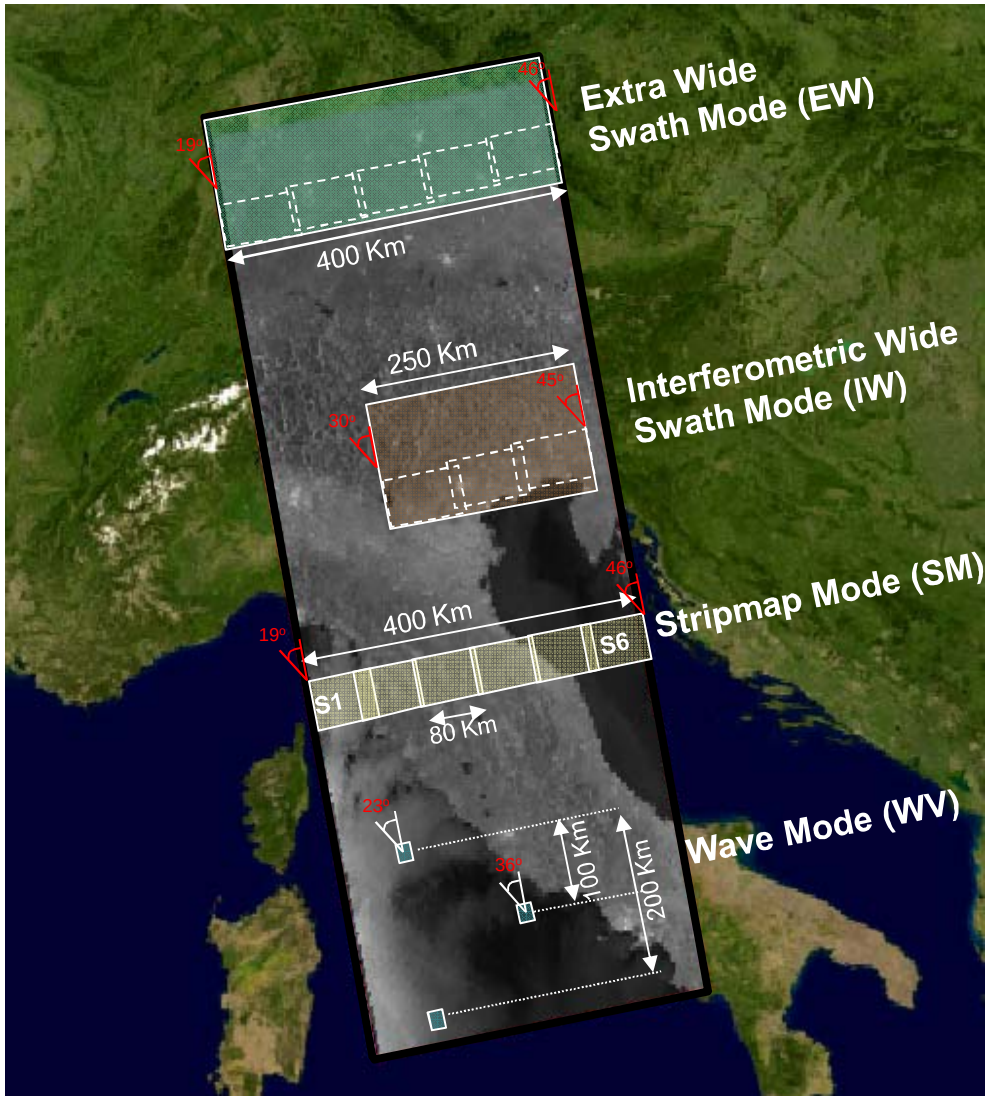
- single polarisation: HH or VV
- dual polarisation: HH+HV or VV+VH

For Wave mode: HH or VV

For all of these operating modes, the same family of products is available to the users.

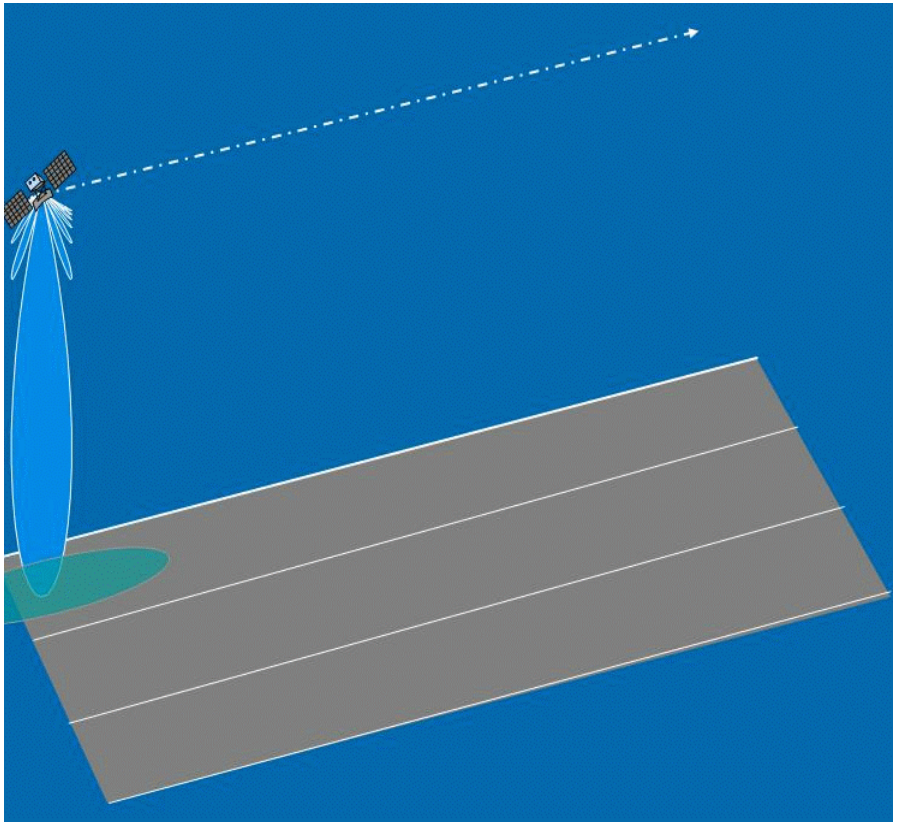
European Space Agency

Sentinel-1 IW & EW are TOPS-modes



Terrain **O**bservation by **P**rogressive **S**cans

- The beam is swept forward in the direction of travel
- Results in time-varying Doppler centroid
- Requires adaptation of InSAR processing chains



Sentinel-1 SAR Modes Performance

Mode	Access Angle	GR Single Look Resolution	Swath Width	Polarisation
Strip Map (SM)	20-45 deg.	Range 5 m Azimuth 5 m	> 80 km	HH or VV or HH+HV or VV+VH
Interferometric Wide Swath (IW)	> 25 deg.	Range 5 m Azimuth 20 m	> 250 km	HH or VV or HH+HV or VV+VH
Extra Wide Swath (EW)	> 20 deg.	Range 20 m Azimuth 40 m	> 400 km	HH or VV or HH+HV or VV+VH
Wave mode (WM)	23 deg. & 36.5 deg.	Range 5 m (TBC) Azimuth 5 m (TBC)	> 20 x 20 km Vignettes at 100 km intervals	HH or VV

For All Modes	
Radiometric accuracy (3 σ)	**1 dB**
Noise Equivalent Sigma Zero	**-22 dB**
Point Target Ambiguity Ratio	**-25 dB**
Distributed Target Ambiguity Ratio	**-22 dB**

Sentinel-1 ESA Operational Products

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, burst-by-burst, single look, containing both 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.

Preliminary Sentinel-1 Observation Scenario

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For observation of land motion

Sentinel-1 observation scenario objectives

Implement a pre-defined and conflict-free observation plan, aiming at fulfilling, to the maximum feasible extent, the observation requirements from:

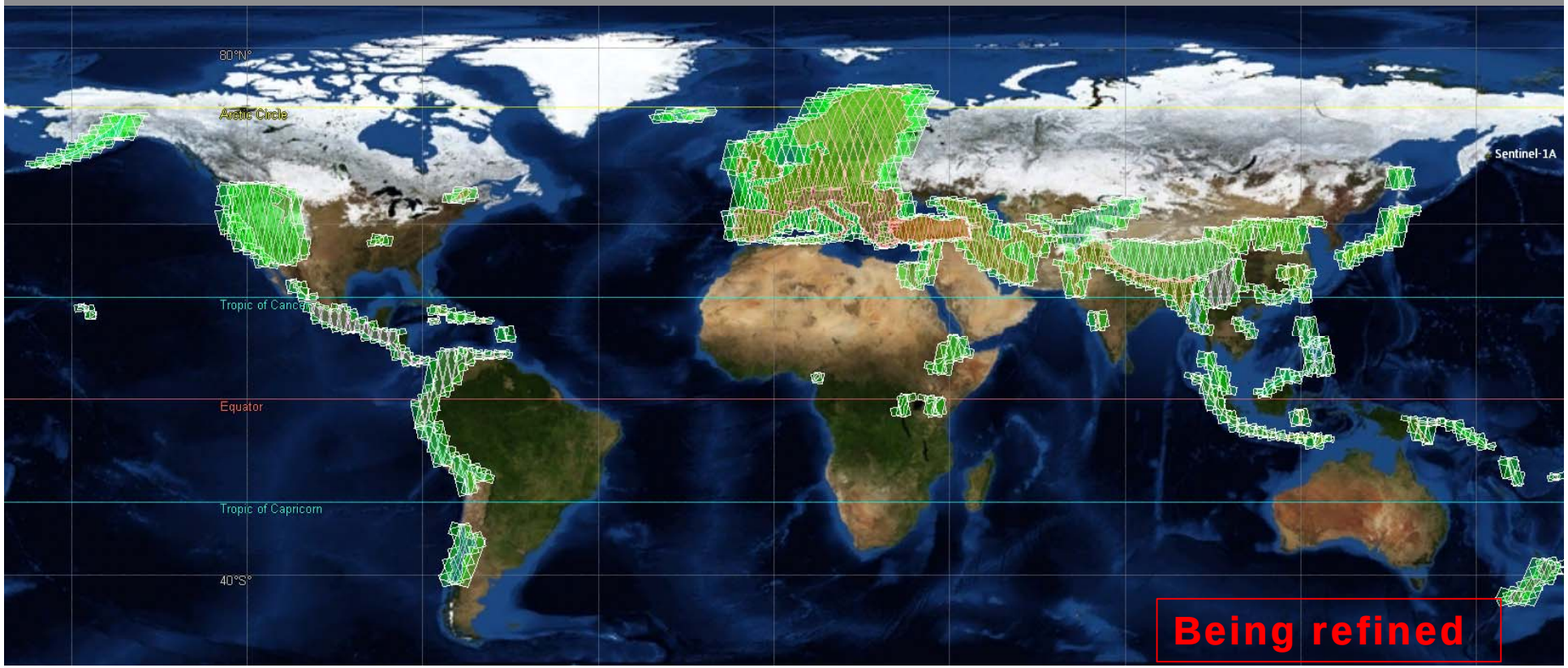
- The mission requirements
- The Copernicus services
- The use by ESA / EU Member States

In addition, on best effort basis and in order to ensure some continuity of ERS/ENVISAT, requirements from the science community are also considered, as well as contributions to international cooperation activities.

→ Need to find *a priori* the solutions on the potential conflict among users (e.g. different SAR operation modes / polarisation required over same geographical area)
→ Clear priority given to Copernicus use, National services and use by ESA/EU Member States

→ The aim is to image all land-masses on a regular basis.
→ The pre-defined mode over land is IWS
→ The Full Operations Capacity is reached with the 2-satellite constellation + the European Data-Relay Satellite (EDRS).

Land Motion Areas - Current Observation Scenario for the Ramp-Up Phase



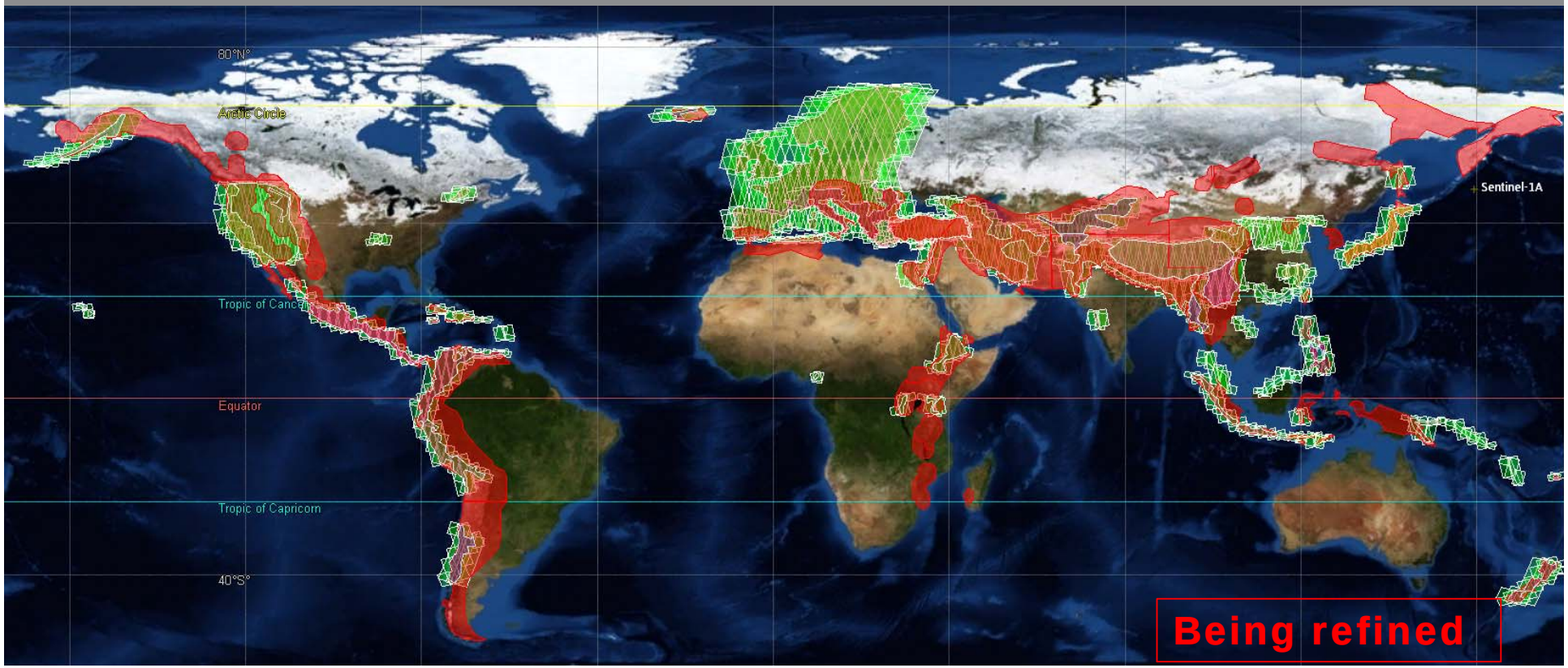
Tectonic Areas consist of:

- Land motion Areas Europe, acquired in IWS, polarization VV and
- Global Land motion Areas, acquired in IWS, polarization HH

Observation frequency:

- Ascending and descending acquisitions, every 2nd cycle (once every 24 days)

Land Motion Areas - Possible Extension of the Observation Scenario



Possible extension of the observation scenario (red zones):

- Feasibility is being evaluated through satellite acquisition planning simulations
- Whether this can be realised depends on experience gathered during the ramp-up phase
- More imaging resources available after launch of S-1B
- A procedure is in place for regular updates of the observation scenario during routine operations

Sentinel Data Policy

Sentinel Data Policy
=
full and open access to Sentinel data to all users

- Aim for maximum availability of data & corresponding access services
- Support to increasing demand of EO data for
  - → implementation of environmental policies
  - → climate change initiatives

In practical terms:

- Anybody can (has the right to) access acquired Sentinel data
- Licenses for the Sentinel data are free of charge
- Online access with simple user registration, for free, within the technical and financial limits (available operations budget)
- Datasets over selected supersites (for example Etna) will be made available early
- More information will be available next week in *The Living Planet Symposium*

Sentinel-1 Concluding remarks

- The Sentinel-1 mission will provide continuity to ERS and ENVISAT C-band SAR with improved performance and revisiting times

- Sentinel-1 will be operated with a predefined routine observation plan currently under definition, fulfilling in priority the requirements from the Copernicus services and from the ESA / EU Member States

- Main tectonic areas will be covered in both ascending and descending acquisitions every 24 days. (preliminary plan!)

- Towards a free and open access to Sentinel data for all users, within technical and budget constraints / restrictions.

ESA Capacity-Building: Training Courses

ESA organises a large number of EO training at several levels:

- **Eduspace** – a website for secondary schools and schoolteachers
- **EO Summer School** – for Early Career Scientists. A two-week intensive course organised every two years in *ESA-ESRIN, Frascati, Italy*.
- **Advanced EO Training for PIs** – a series of regular one week long advanced thematic training courses.
  - *Advanced Ocean Training Course:* 2006, 2009, **2013**
  - *Advanced Training Course on Land Remote Sensing*: 2007, 2009, 2011, 2013
  - *Advanced Atmospheric Training Course:* 2008
  - *Advanced Course on Radar Polarimetry*: 2011, 2013
- **"Tiger" Training Courses** – capacity-building in Africa
- **Other Training Courses** are organised on an ad hoc basis.

ESA NEST & Sentinel-1 Toolboxes

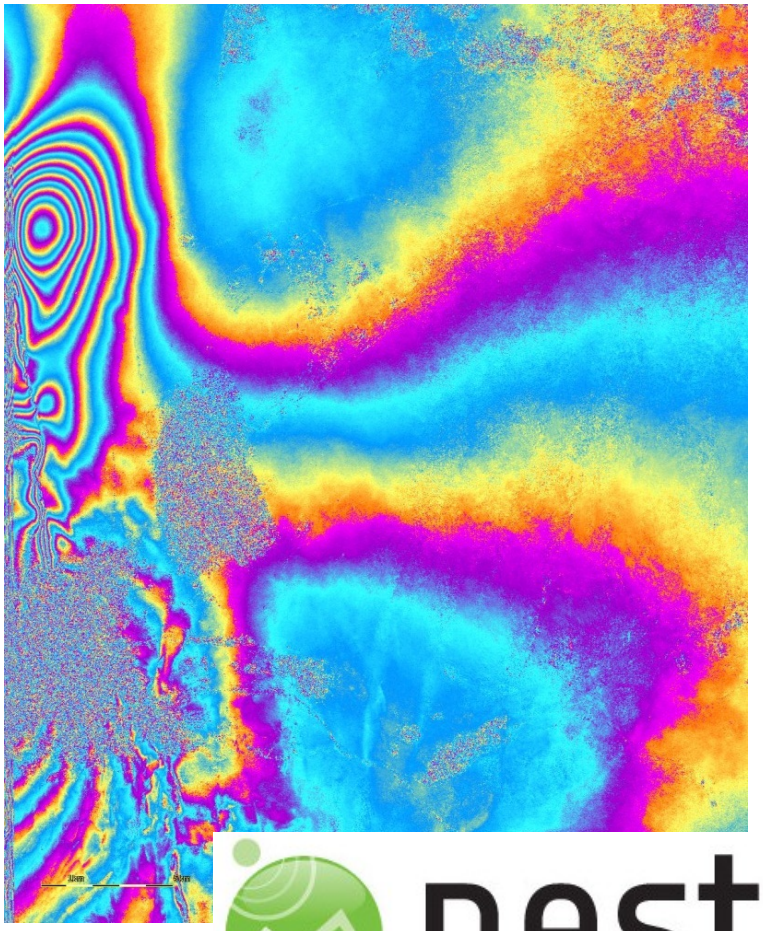
Next ESA SAR Toolbox: A free, open-source multi-mission SAR and InSAR toolbox.

InSAR functionality in NEST 5A:

- Co-registration, resampling, spectral and phase filtering
- Interferogram and coherence-image generation
- Spectral and Phase Filtering
- Topographic phase removal, DEM generation and DEM assisted co-registration
- Optimal Master selection
- Integrated Unwrapper + Bridge to 3rd party Unwrapper (SNAPHU)
- DEM generation and DEM assisted co-registration
- (3-4 passes) DInSAR
- ERS-Envisat Cross-InSAR

Sentinel-1 Toolbox will be based on NEST 5A

- Full SAR and InSAR support including InSAR with TOPS
- Development will start in Q4 2013



nest
next esa sar toolbox

Thank You!

Process for collecting and implementing the Sentinel observation requirements

Group	Source of Requirements
GMES services and GMES use	Extrapolation of GMES Data Access Data Warehouse requirements Direct discussions with GMES services and EU Agencies (e.g. EMSA)
National services and use by ESA and EU Member States	Discussions with Member States Delegations Reply to Collaborative Ground Segment questionnaire (in the framework of the GOCG)
Scientific use, on-going projects, continuity of ERS/ENVISAT	Recommendations from scientists at key SAR workshops (FRINGE, SEASAR), Sentinel-2 and -3 workshops, SEN4SCI, etc. ESA GSE Projects (e.g. Polar View, MARISS, Terrafirma, GMFS, etc.) Glob-series projects, CCI, SEOM, etc. Extrapolation of ERS/ENVISAT projects
International Initiatives, International cooperation	GEO/CEOS (e.g. FCT, GFOI, Geo-hazard Supersites), IGOS, FAO, REDD, PSTG, IICWG, GCOS, CliC, TIGER, DRAGON, etc. Requests from international partners (e.g. US (NOAA / NASA / USGS), Australia, China, etc.)
Other use including use for commercial value-adding	EARSC, etc.