

# Sentinel-2: heading towards launch



**Bianca Hoersch (S2 Mission Manager)**  
**European Space Agency**

# Mission purpose



Consequently, a lot of subsequent the



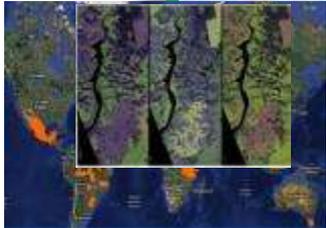
**Forests & Carbon, Vegetation monitoring/change (GEO-FCT/Tropforest project)**

**Land cover classification/CORINE IMAGE2006, IMAGE2009 etc. (Euromap, DMCii-Deimos, USGS)**

**Change detection: Urban Atlas (EUSI, SIRS)**

**Global Land cover & Land use (GLOBCover ESA)**

## A wide range of land applications



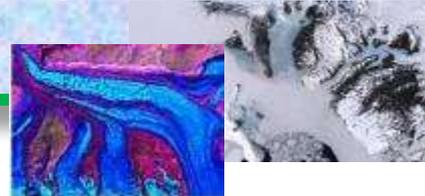
**Emergency management: flooding (SAFER, DLR)**



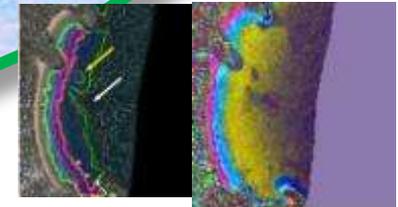
**Geology (USGS)**



**Glaciers & ice (LIMA Project)**



**Coastal zones/bathymetry (R. Merton et al.)**



## Mission profile

- ❑ **Two** Spacecraft operating in twin configuration
- ❑ Sun-synchronous orbit at **786 km, LTDN 10:30 AM**
- ❑ Multispectral instrument with **13** spectral bands (**VIS, NIR & SWIR**), at **10, 20** and **60 m** spatial resolution
- ❑ **290 km** swath width
- ❑ **5 days** repeat cycle at Equator (cloud free) with 2 satellites
- ❑ **7 years** design life time, consumables for 12 years
- ❑ Data transmission at **X band** plus **Optical** Communications via EDRS: **900 Gbytes/day** for processing with global systematic acquisition over land



# The multispectral benchmark

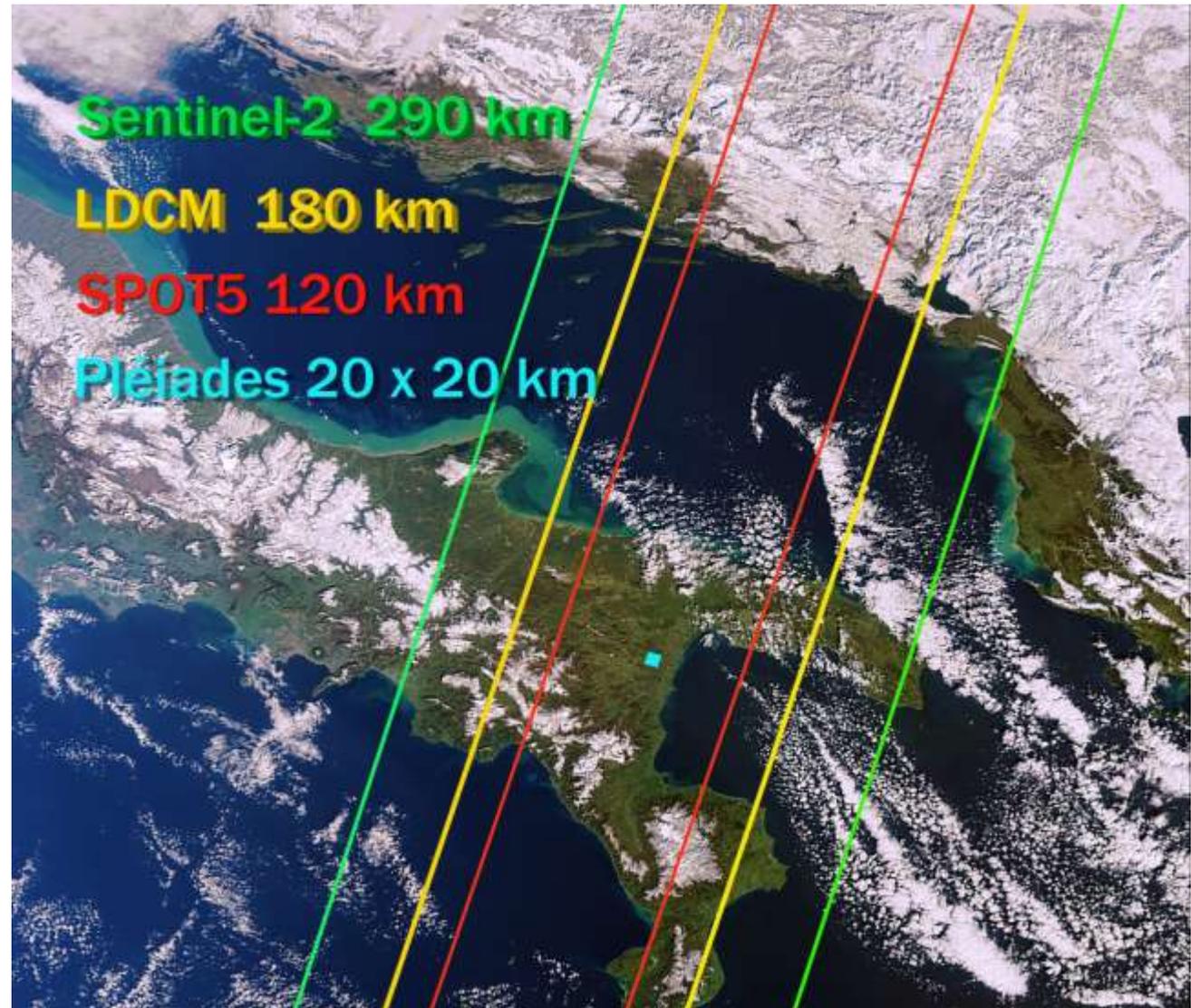


Coverage (d)	26	16	<b>5 (2 satellites)</b>
Swath (km)	60	185	<b>290</b>
Spectral bands	4+1	8+1	<b>13</b>
Resolution (m)	2.5	30,(15)	<b>10,20,(60)</b>

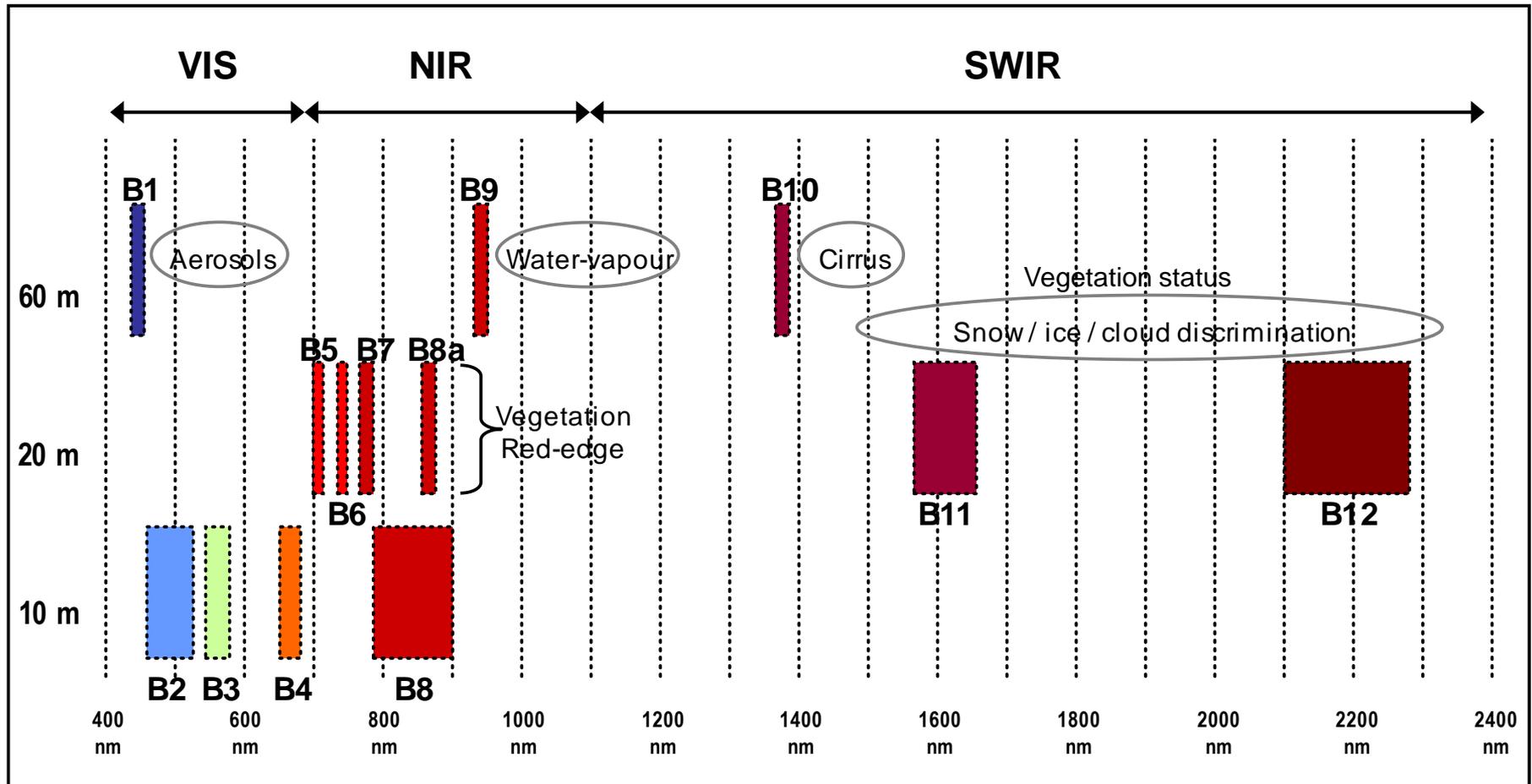
**Sentinel-2  
(A+B):**

**Full Earth  
Coverage  
(at Equator)  
in 5 days**

**Sentinels are  
complementary  
to High-Res  
commercial and  
national missions**

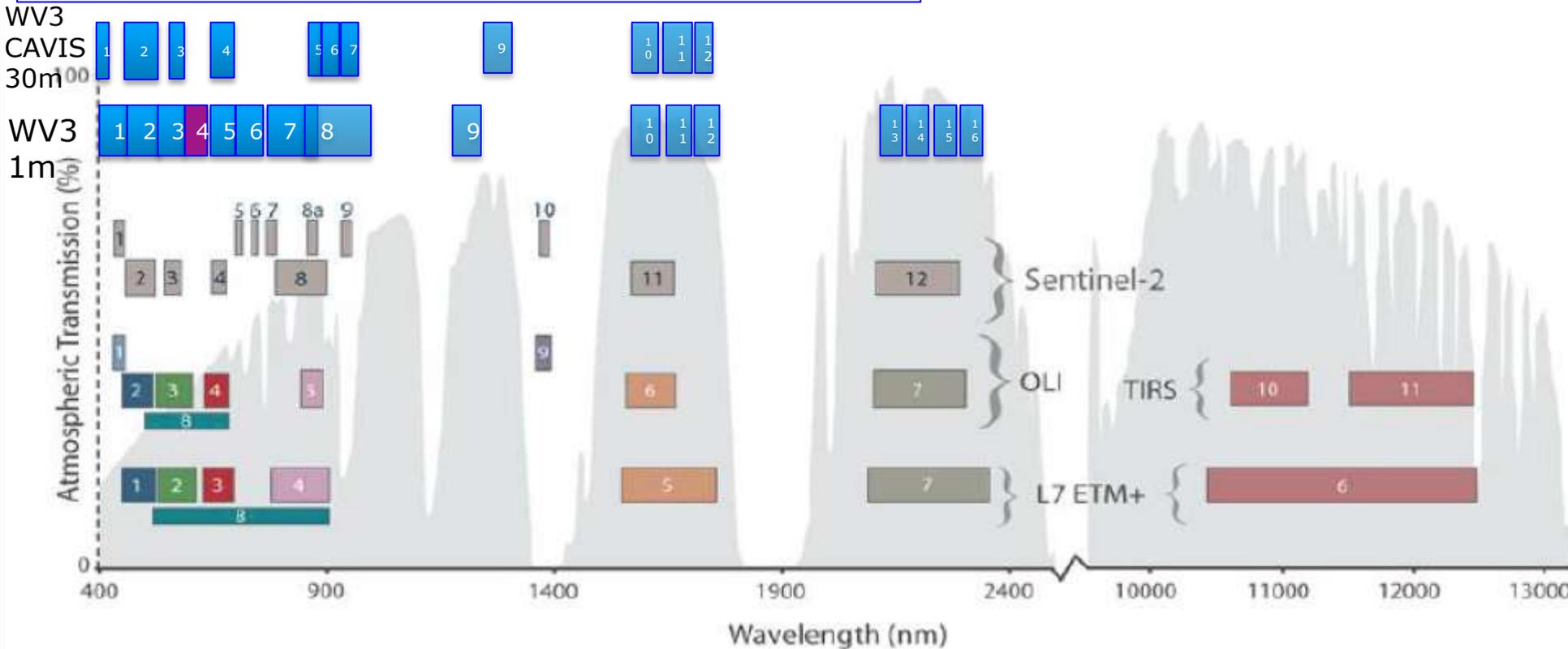
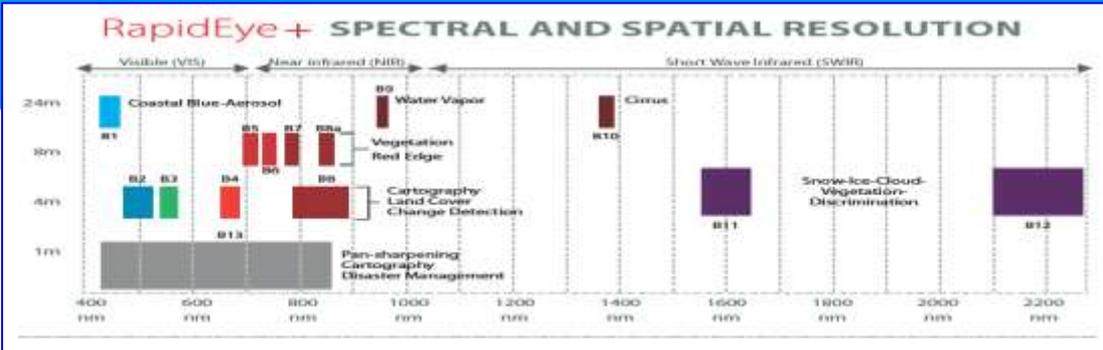


# Sentinel-2 spectral diversity



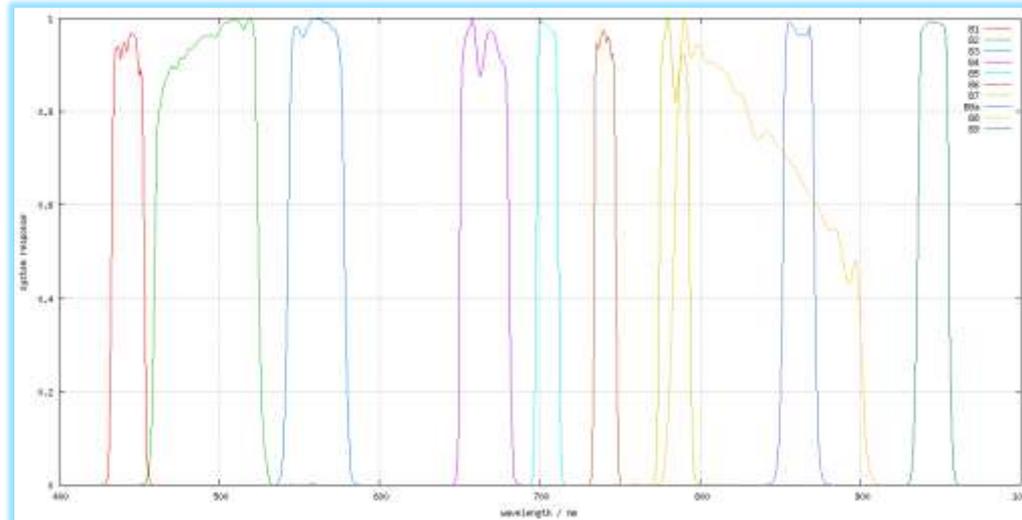
**13 spectral bands: unprecedented for vegetation analysis, correction of atmospheric perturbations & land classification**

# Comparison S2-L8-WV3-RE+ spectral bands



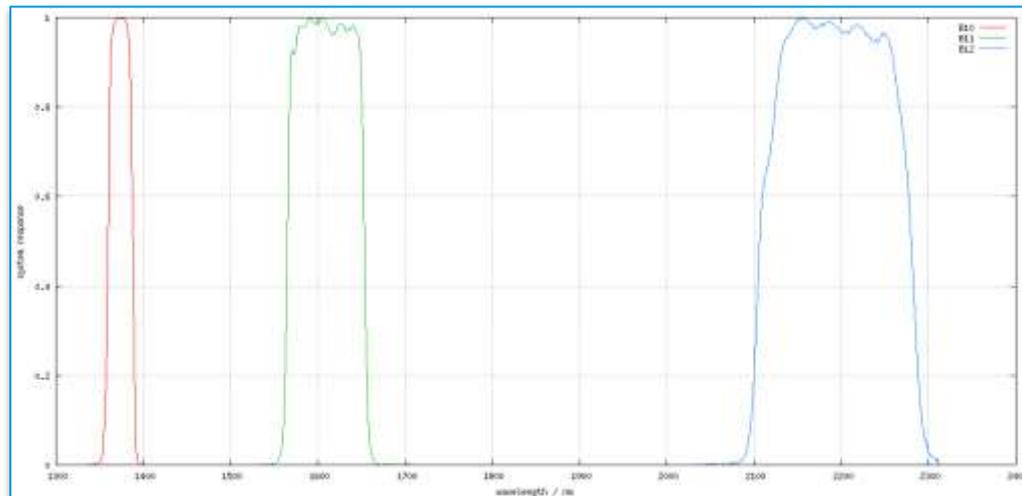
# Spectral response

## VNIR channels



Band #	Center $\lambda$ nm	Spectral Width $\Delta\lambda$ nm
B1	443	20
B2	490	65
B3	560	35
B4	665	30
B5	705	15
B6	740	15
B7	783	20
B8	842	115
B8a	865	20
B9	945	20

## SWIR channels

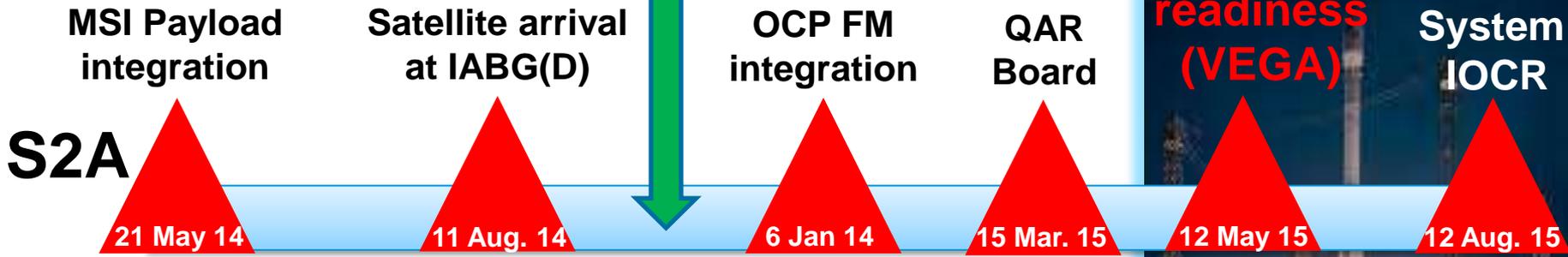


✓ **Compliant Spectral stability**

Band #	Center $\lambda$ nm	Spectral Width $\Delta\lambda$ nm
B10	1375	30
B11	1610	90
B12	2190	180

# 6 months to launch

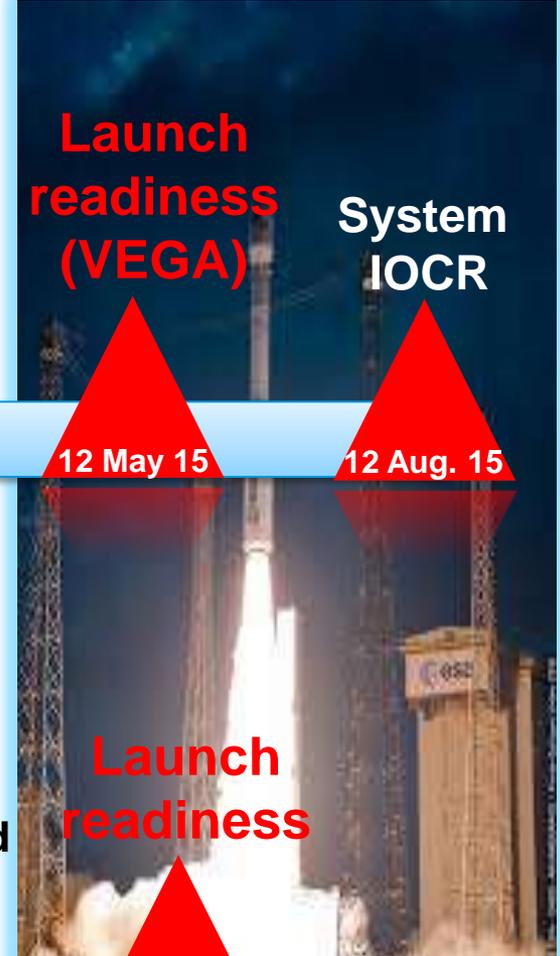
status 19<sup>th</sup> Nov. 2014



Payload integration, Satellite final functional tests ✓

Satellite environmental qualification tests\*

\* :  
**Sine qualification tests** ✓  
**Acoustic tests** ✓  
 TB-TV tests  
 EMC Radiated



Courtesy: Airbus Defense and Space





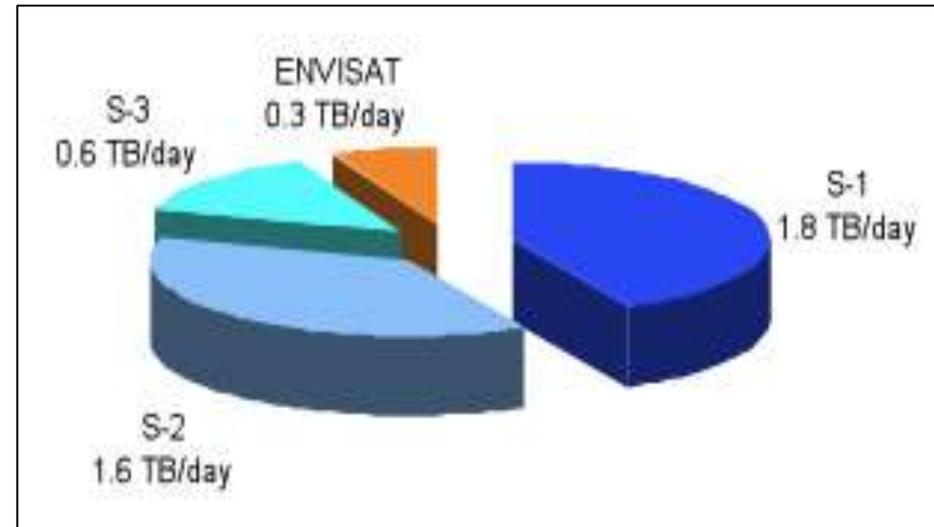
# **An ESA unified space segment and mission management**

## Sentinel Data Policy = **FREE and OPEN access**

- Joint COM/ESA **Sentinel Data Policy Principles** have been prepared in 2009 - adopted by ESA MSs in Sep 2009
- ESA approved **Sentinel Data Policy**. Main principles of Sentinel data policy:
  - **Open** access to Sentinel data by anybody and for any use
  - **Free** of charge data licenses
  - Restrictions possible due to technical limitations or security constraints
- **EU Delegated Act** on Copernicus Data and Information Policy has been published on 12 July 2013 (C(2013)4311, final)

Sentinel-1, Sentinel-2, Sentinel-3  
acquire data:

- continuously,
- over much wider swaths,
- at improved resolutions,
- in more spectral bands than any of their 'predecessors'



Sentinels-1/-2/-3 (A+B) generate, together, more than **13 times the volume of data** generated by the 10 instruments on board Envisat, the largest European EO satellite ever

# S2 Products Summary

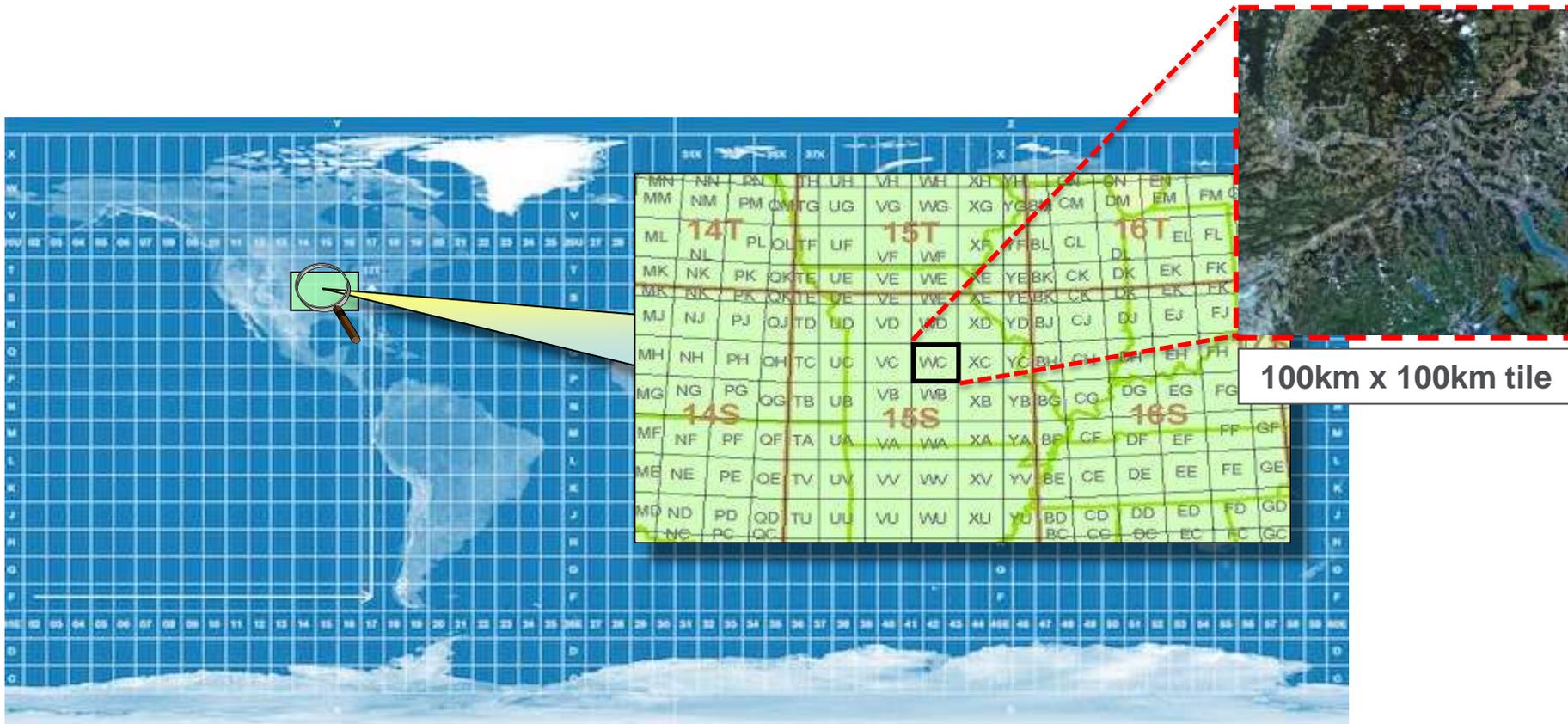
Name	High-level Description	Production	Preservation Strategy	Volume
<b>Level-1B</b>	Top-of-atmosphere radiances in sensor geometry	Systematic	Long-term	~27 MB (each 25x23km <sup>2</sup> )
<b>Level-1C</b>	Top-of-atmosphere reflectances in cartographic geometry (UTM/WGS84)	Systematic	Long-term	~500 MB (each 100x100km <sup>2</sup> )
<b>Level-2A</b>	Bottom-of-atmosphere reflectances in cartographic geometry	On user side (using Sentinel-2 Toolbox)	-	~600 MB (each 100x100km <sup>2</sup> )

# Level-1C / Tiling

Very similar to  
Landsat L1T



- Cartographic Reference System: UTM (with 6°x8° grid zones).
- Each grid zone is split into ~100x100km<sup>2</sup> UTM "Tiles".



1. Bottom-of-atmosphere (BOA) reflectances in cartographic geometry (UTM/WGS84).

2. Products additionally include:

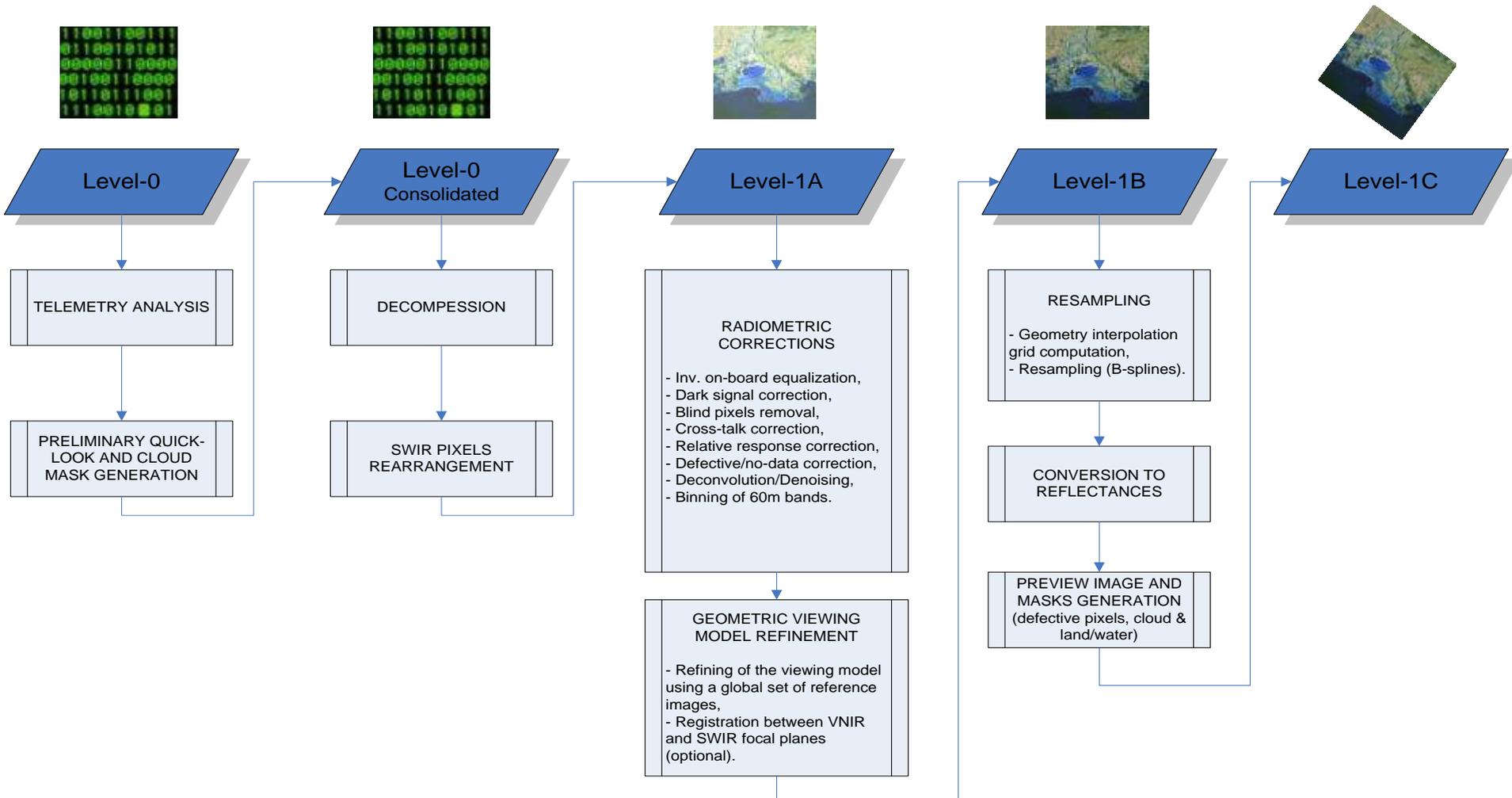
This product is initially offered as part of the Sentinel-2 toolbox:  
<https://earth.esa.int/web/sentinel-tbx/sentinel-2-toolbox>

→ The possibility of making a standard core product systematically available from the Sentinels core ground segment is currently being explored. Joint assessment with CNES, DLR, EC/JRC (and US) planned

- c. Slope effect correction.
- d. BRDF effect correction.

# Level-1C / Algorithm

See F. Gascon tomorrow



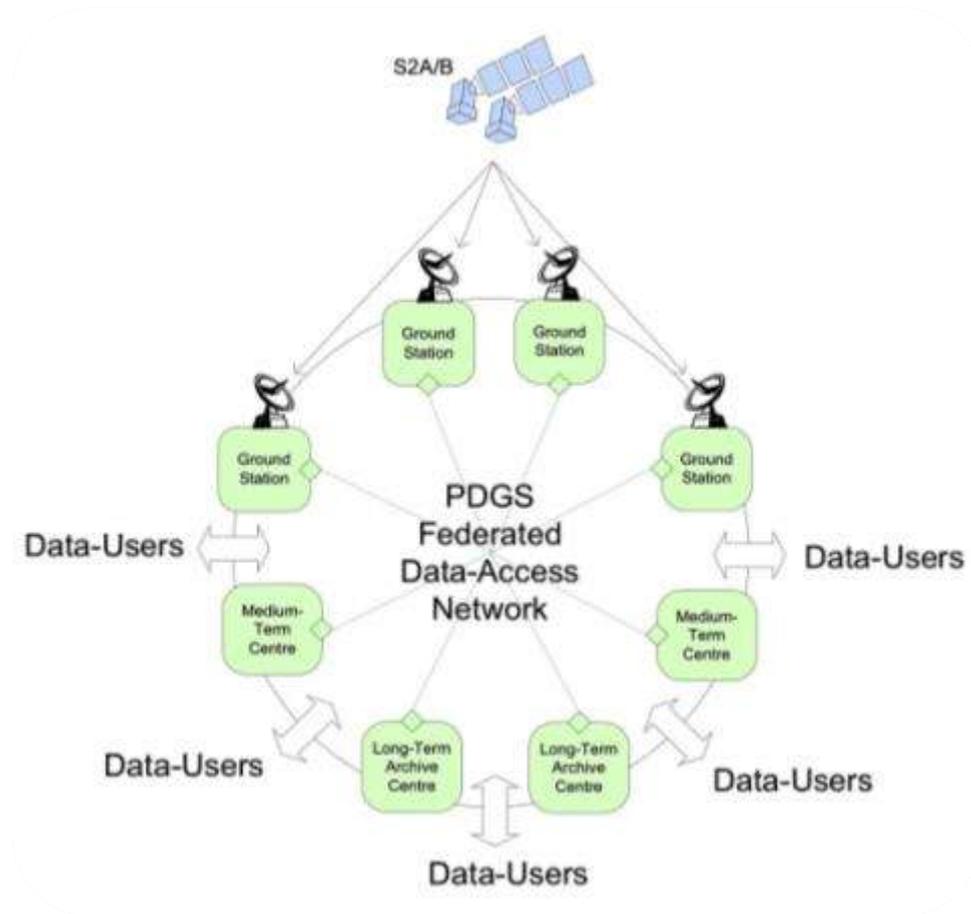
# Level-1C / Data Quality Targets



Radiometric Data Quality	
Absolute radiometric uncertainty	3 % (goal) , 5 % (threshold)
Inter-band relative radiometric uncertainty	3%
Linearity knowledge accuracy	1%
Modulation Transfer Function (MTF)	0.15 to 0.3 (for 10m bands) <0.45 (for 20 & 60m bands)
Geometric Data Quality	
Absolute geolocation uncertainty	20m $2\sigma$ (threshold) 12.5m $2\sigma$ (goal) with GCPs
Multi-temporal registration	0.3 pixel $2\sigma$ (goal) with GCPs
Multi-spectral registration (for any couple of spectral bands)	0.3 pixel $3\sigma$

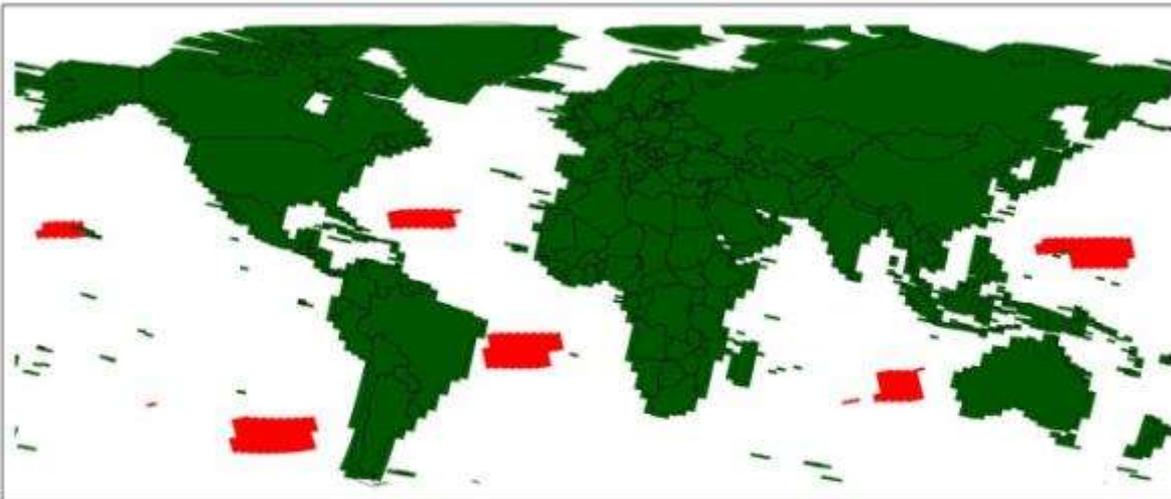
## Ground Segment

- Data processed by Core GS within **3-24 hours** after acquisition
- X band data downlink with instrument data rate of **490 Mb/s** (after onboard wavelet compression)
- **Laser Communication** through geo terminal (can be operated simultaneously with the X band subsystem)
- **900 GB** per day: cloud-free images will be further processed



## EFFECTIVE COVERED AREA AT THE END OF THE RAMP UP PHASE (FULL OPERATIONALITY)

derived from simulated swath - cleared for lead in/out datatakes



### Legend

Acquisition Area

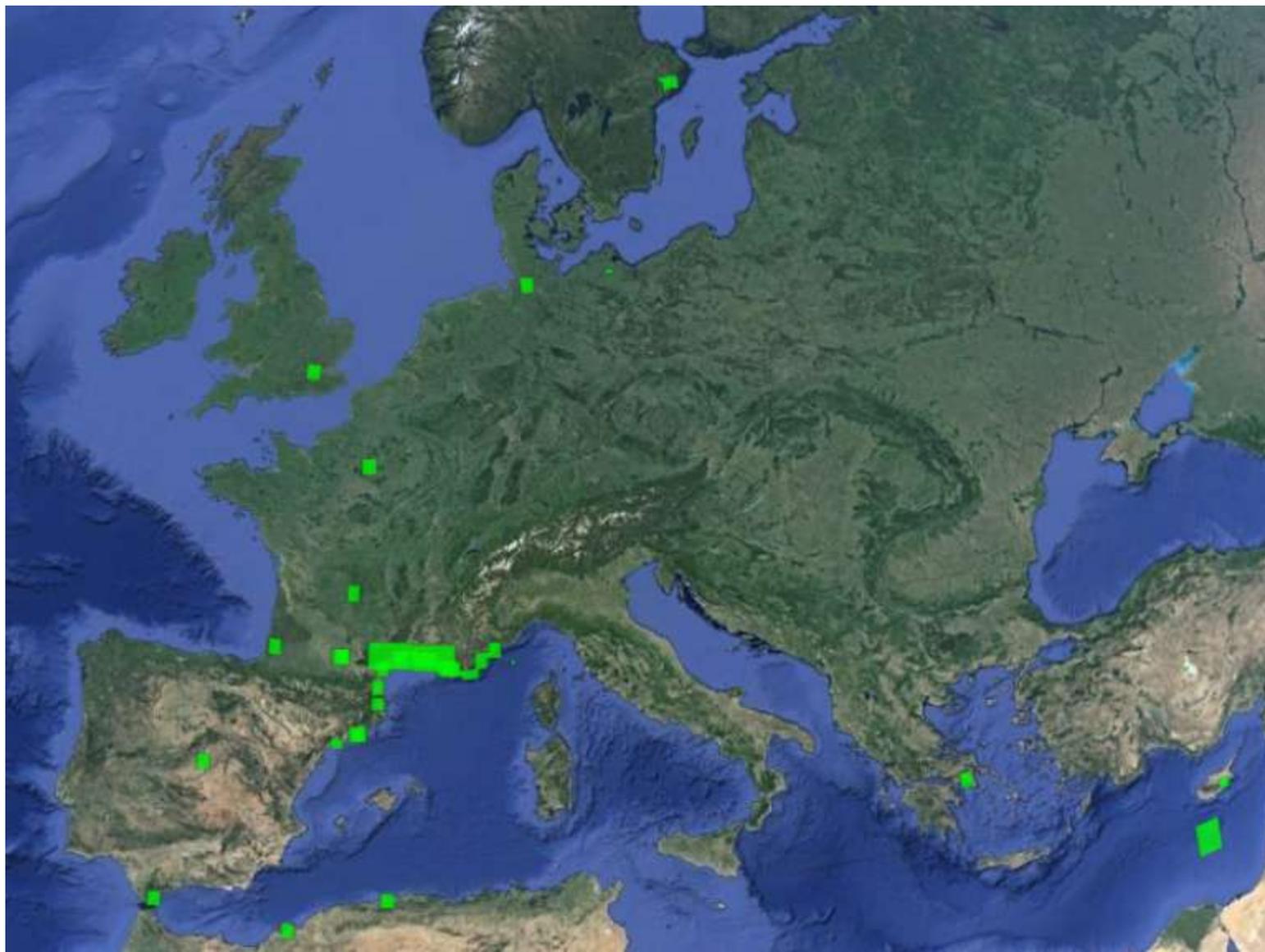
■ Regular

■ Calibration Purposes (outside the regular acquisition area)

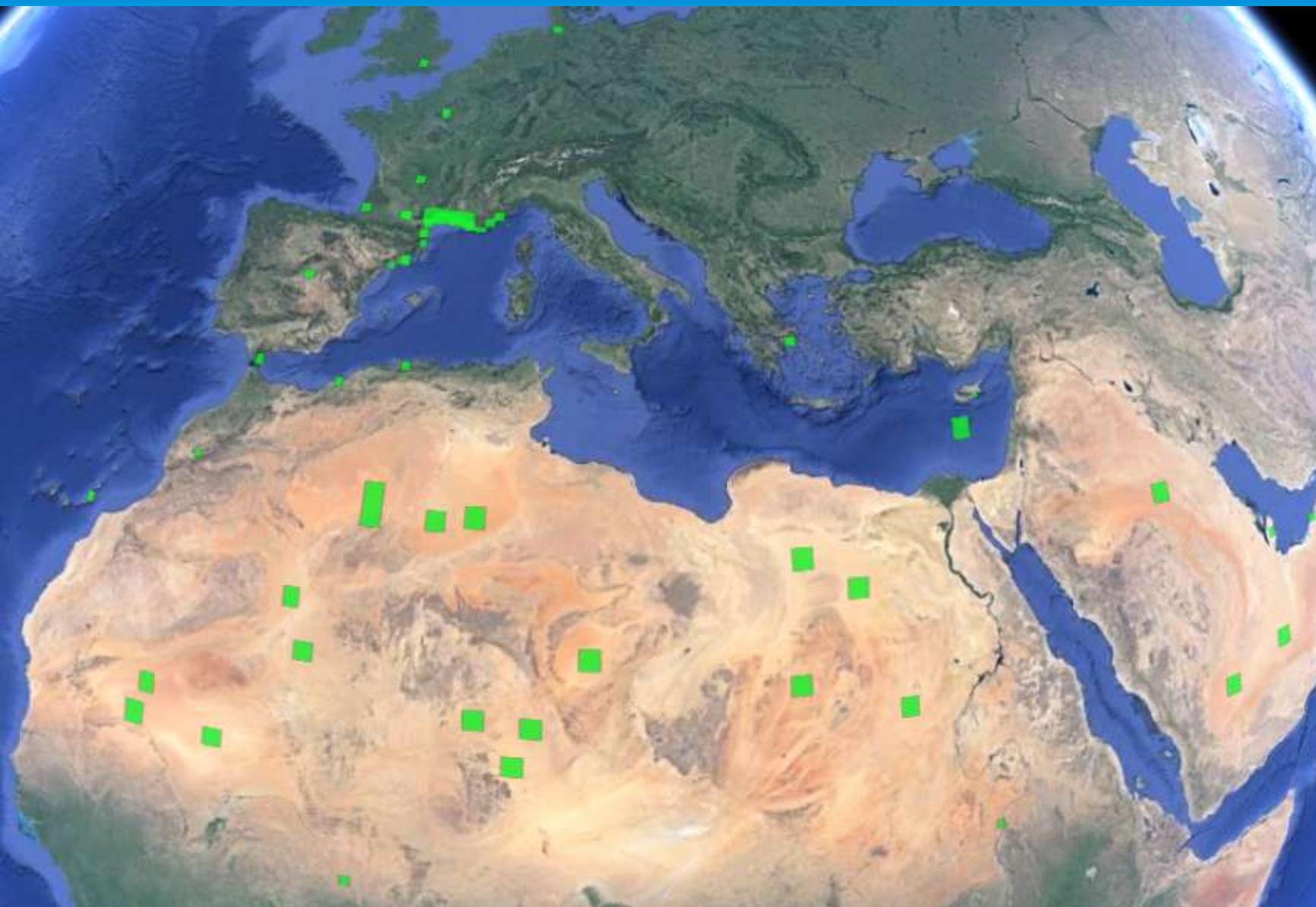
Baseline in full operations is systematic acquisition of:

- ✓ All land surfaces ( $-56^{\circ}$  and  $+84^{\circ}$  latitude);
- ✓ Major (greater than 100 km<sup>2</sup> size) and EU islands;
- ✓ Coastal (20km off the coast)
- ✓ inland waters, Mediterranean Sea and all closed seas;
- ✓ Cal/Val sites.

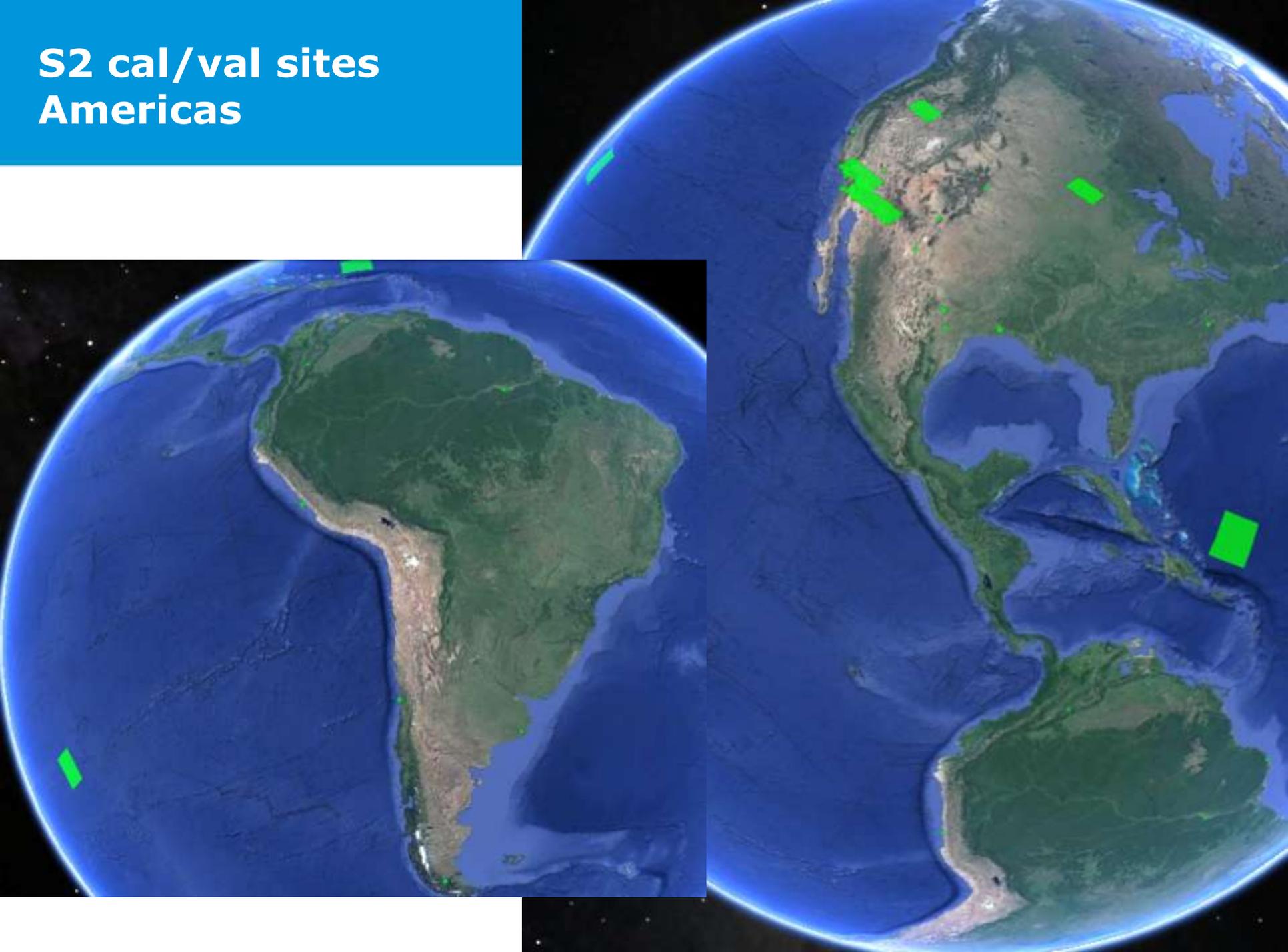
# S2 cal/val sites Europe



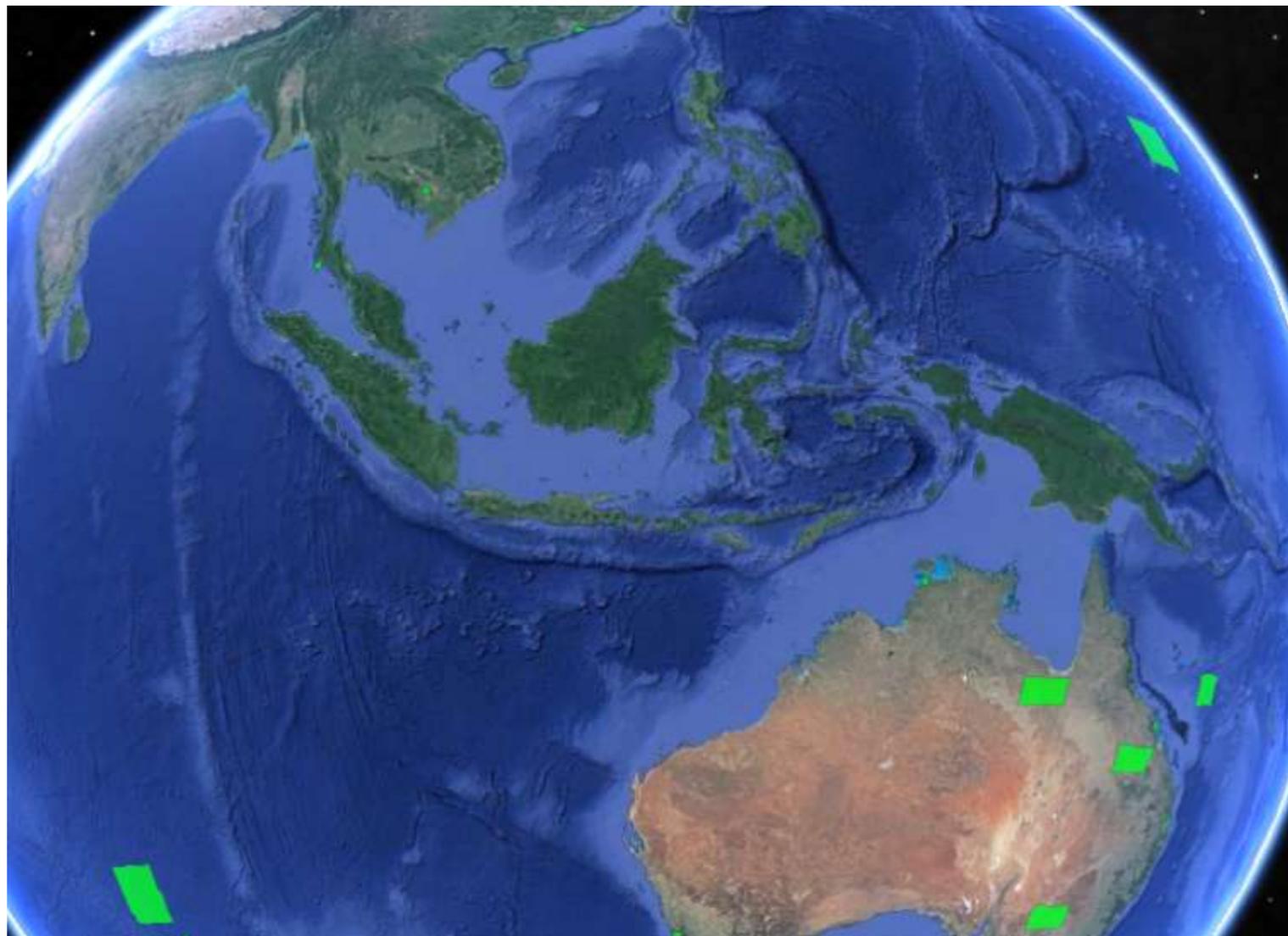
# S2 cal/val sites Europe-Africa



# S2 cal/val sites Americas



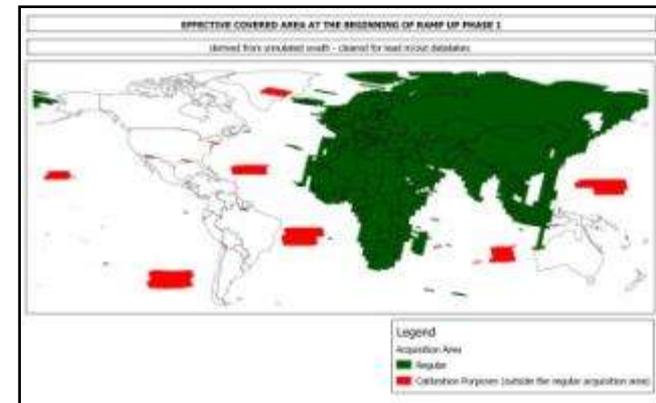
# S2 cal/val sites South East Asia/Australia



# Sentinel-2 ramp-up

Like for Sentinel-1, a gradual ramp-up will be defined for Sentinel-2, increasing/improving gradually the service to users in a stepwise approach, e.g.

- Gradual increase of acquisition capacity could start with a reduced observation scenario for few months
- Ensuring from the start coverage of global Cal/Val needs
- Ensuring as early as possible COPERNICUS CORE datasets needs for Europe/Africa, mostly systematically
- Ensuring maximum coverage/orbit length for generation of a global reference image (GRI), which is required to produce highest accuracy L1C products...this may take up to 9 months to produce the GRI



# Main drivers of the S2 ramp-up observation scenario



1. Mission requirements
  - a. Mission instrument & check-out needs in E1 and E2
  - b. Incl. cal/val sites and cross-comparison with other missions
  - c. First ~9 months: GRI production, world is defined in 8 blocks
  - d. S1-S2-S3 cross-comparison: land, coastal and ocean sites
2. Copernicus Services needs
  - a. European land: 2 cloudfree coverages of Europe May to Sep 2015, 2016 etc.
  - b. Global land: systematic acquisition of all land masses = gradual build-up starting in 2015
  - c. Marine, tbc:
  - d. Emergency, Security etc.
3. ESA/ (EU)Member State (urgent) needs
4. Other users urgent needs

# USE TYPOLOGIES



**Copernicus Services**

**Copernicus Core & Downstream Services**

Other EU needs assimilated to Copernicus services  
e.g. EMSA, EEA, EUSC, JRC

<b>Scientific /Other use</b>		<div style="background-color: #0070C0; color: white; padding: 5px; border-radius: 5px;">Science use</div>	<div style="background-color: #0070C0; color: white; padding: 5px; border-radius: 5px;">Public Value Adding use</div>	<div style="background-color: #0070C0; color: white; padding: 5px; border-radius: 5px;">Commercial Value Adding use</div>
<b>MSs CollIGS</b>		<div style="background-color: #FFFF00; padding: 10px; border-radius: 10px;"> <p><b>ESA/EU Member States needs (Collaborative GS)</b></p> <p><b>ESA funded R&amp;D projects</b></p> </div>		
<b>Int'l Agreements</b>		<div style="background-color: #0070C0; color: white; padding: 10px; border-radius: 10px;"> <p><b>International Agreements</b></p> </div>		

# Data access – 4 categories of users



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



esa Sentinel-1 Scientific Data Hub

Welcome to the Sentinel-1 Scientific/Other use Data Hub

The Sentinel-1 Scientific Data Hub provides free and open access to a Rolling Archive of Sentinel-1 Level 0 and Level 1 user products. Products are available for the following Sentinel-1 acquisition modes:

- Strip Map (SM)
- Interferometric Wide Swath (IW)
- Scan Area Swath (SAS)

Level 0 products and Level 1 Ground Range Detected (GRD) products are available for all performed acquisitions. Level 1 Single Look Complex (SLC) products are available for acquisitions performed over specific regions of interest.

The S-1 Scientific Data Hub Rolling Archive maintains the latest 2 months of products for download via HTTP. The target of a 4 month rolling archive will be reached in progression starting from a rolling period of 2 weeks commencing on the 27<sup>th</sup> of October.

A maximum of 2 concurrent downloads per user is allowed in order to ensure a download capacity for all users.

The Sentinel-1 Level 1 products are preliminary quality. Operational product qualifications, including absolute rad.

esa

EUROPEAN SPACE AGENCY

Enter the Hub

Latest News

- 20-10-2014 - Data Hub Maintenance
- 14-10-2014 - Data Hub Maintenance
- 09-10-14 Maintenance Window 5
- Initial opening of the Sentinel-1
- SendHub web site activation and OMA\* (OP-01)

Terms and Conditions for the Use and Distribution of Sentinel-1 Data

Agreed by and between:

The European Space Agency, hereinafter referred to as ESA or the Agency

and

the User

Whereas the Agency, under the ESA - EU (SM) Agreement (2014)02 (02) is charged with managing the SM/1 Space Component (SC) Programme;

Whereas the access to information is governed by:

- ESA's Sentinel Data Policy (SDAP) (ES/DIR/2014\_04) (hereinafter referred to as the SDAP) and this agreement (the User) for the Sentinel-1 Data Component (SDC) (hereinafter referred to as the SDC); and
- The Commission Delegated Regulation (EU) No 1219/2012 of 12 July 2012 supplementing Regulation (EU) No 924/2012 of the European Parliament and of the Council on the European Earth Monitoring Programme (EMEP) by establishing requirements and breaking conditions for SDC's users and defining criteria for monitoring access to SDC's selected data and SDC's service information);

Whereas the present Terms and Conditions for the use and distribution of Sentinel-1 Data govern Sentinel-1 data which has not been otherwise "transferred";

Whereas the User has obtained or intends to obtain such Sentinel-1 Data via a European data distribution platform, minor rules, about acquisition from the Sentinel-1 satellite, the SDC or other online services providing Sentinel-1 data or by any other means or in order to transfer data from another source or legal service;

The parties agree, that the User shall be granted the right to use and distribute the Sentinel-1 data according to the following Terms and Conditions:

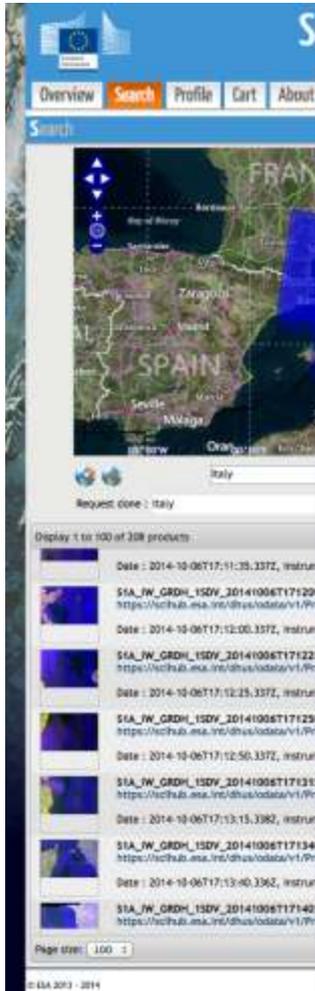
1. Definitions

- ESA: the Agency under the ESA - EU (SM) Agreement
- User: means any public or private entity or natural person having accepted these Terms and Conditions in order to use, either publicly or privately, Sentinel-1 data;
- Sentinel-1 data: means all data and products, generated on the basis of observations acquired by sensors, flown on the Sentinel-1, in the Sentinel-1 Payload systems, downloaded by EU in the frame of the ESA Space Component;
- Primary Product: Sentinel-1 Data means any original Sentinel-1 Data including open and instrument data;
- Derived Products: are products derived from Primary Products utilizing a data transformation to the original sensor observation and do not include a significant intellectual or creative contribution made by the User for the purpose of these Terms and Conditions; Allowed Products means - for satellite - but are not limited to, geospatial metadata, images, orthorectified images, mosaics and mosaic images, mosaics and mosaics of sub-satellite data;
- Derivative Works are products derived from primary products in a form or format which do not have a creative contribution with the original sensor observation and which contain a significant intellectual or creative contribution made by the User; For the purpose of these Terms and Conditions, Derivative Works include - for satellite - but are not limited to, and are not limited to, registration, registration metadata, orthorectification etc.

Version 1.0.1 July 2014

1. Open and Free T&C's published
2. Self Registration and Sample Products open since S-1A launch
3. Routine Data flow opened on 3<sup>rd</sup> October
4. Rolling Archive
  - a. target of latest 2 months data
  - b. achievement of full population will be progressive
  - c. no timeliness guarantee
5. Quota restriction of 2 concurrent downloads to ensure bandwidth availability for all users

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



*"By using Sentinel data, the User is deemed to have accepted these Terms and Conditions"*



## → TERMS AND CONDITIONS FOR THE USE AND DISTRIBUTION OF SENTINEL DATA

Agreed by and between:

The European Space Agency, (hereinafter referred to as ESA or the Agency)

and

the User

Whereas the Agency, under the ESA – EC GMES Agreement [ESA/LEG/382] is charged with managing the GMES Space Component (CSC) Programme;

Whereas the access to Sentinel data is governed by

- ESA's Sentinel Data Policy [ESA/PB-E0(2013)30, rev.1] formulating guidelines for a free and open access to Sentinel data and thus providing the basis for the GMES Space Component (GSC) Draft Operations Concept [ESA/PB-E0(2010)56, rev.1], and
- [The Commission Delegated Regulation (EU) No 1159/2013 of 12 July 2013 supplementing Regulation (EU) No 911/2010 of the European Parliament and of the Council on the European Earth monitoring programme (GMES) by establishing registration and licensing conditions for GMES Users and defining criteria for restricting access to GMES dedicated data and GMES service information.]

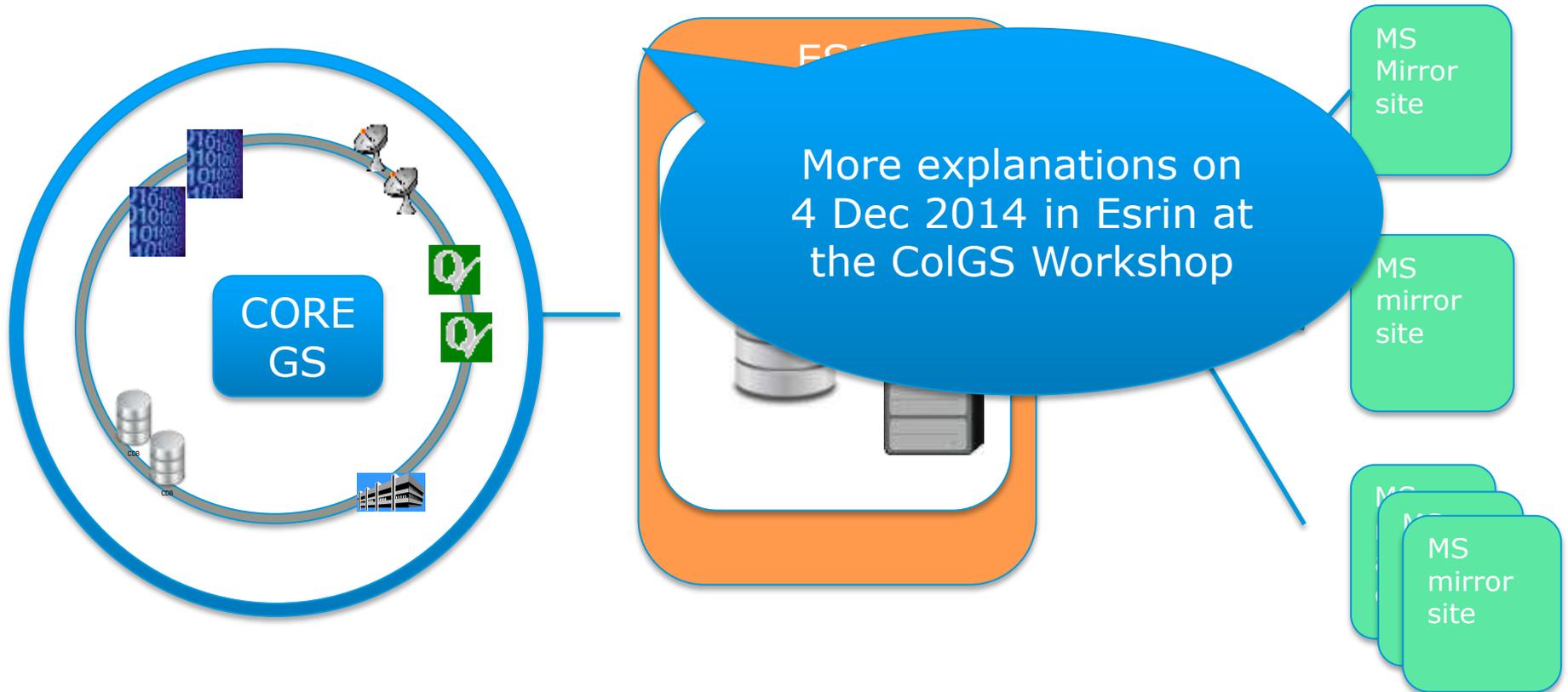
Whereas the present Terms and Conditions for the use and distribution of Sentinel data govern Sentinel data which has not been assessed "sensitive".

Whereas the User has obtained or intends to obtain such Sentinel data via a Copernicus data dissemination platform, mirror sites, direct acquisition from the Sentinel satellite, via EDRS or other online services providing Sentinel data or by any kind of transfer of or access to Sentinel data from whatever natural or legal person,

The parties agree, that the User shall be granted the right to use and distribute the Sentinel data according to the following Terms and Conditions:



# Rolling Archive Access for Collaborative Partners – Context



# Mission-specific collaboration S2-L8 on a mission-to-mission basis in Phase E2



After pre-launch calibration, other types of collaboration such as

- Post-flight Validation campaigns and cross-validation
- Joint out-of-baseline observation campaigns such as e.g.
  - over some regions for tbd time  $< x$  degree sun angle,
  - joint Antarctica campaigns
  - nighttime observations campaign for global volcanoes
  - Coral reefs or other natural features special campaigns
  - Etc....
- Joint /fused/synergy products?...follow-up of ROSES (NASA), USGS exploitations and SEOM/DUE (ESA), and linked to it joint exploitation workshops
- DEM usage and sharing
- GRI usage by L8, comparison between L8 GCP database with S2 GRI
- Etc

# Topics covered?



- ✓ **Products:** Addressed, more detail tomorrow in FGascon talk
- ✓ **Global DEM:** PlanetDEM as current baseline, may evolve
- ✓ **Collaborative ground segment:** Principles addressed, more details on 4 Dec 2014 at Esrin
- ✓ **Toolbox development:** S2 toolbox available,
- ✓ **Cooperation with USGS,** inter-calibration of Sentinel-2 MSI and Landsat-8 OLI sensors, etc.: Addressed

A detailed view of the Sentinel-2 satellite in orbit above Earth. The satellite's main body is gold-colored and complex, with various instruments and antennas. Two large, rectangular solar panel arrays are extended from the main body, each covered in a grid of dark solar cells. The Earth's surface below shows a mix of blue oceans, white clouds, and brown and green landmasses.

Thank you for your  
attention

[http://www.esa.int/Our\\_Activities/Copernicus/Sentinel-2](http://www.esa.int/Our_Activities/Copernicus/Sentinel-2)

<http://sentinel.esa.int>