

Earth Observation at ESA: New Developments

Fény-Tér-Kép
13 October 2017, Gárdony, Hungary

Zoltan Bartalis

European Space Agency (ESA ESRIN)
Directorate of Earth Observation Programmes
Science, Applications and Climate Department



The European Space Agency



Purpose of ESA



“To provide for and promote, for exclusively peaceful purposes, cooperation among European states in **space research and technology** and their **space applications.**”

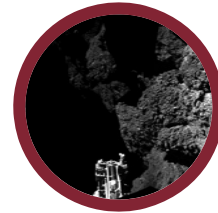
Article 2 of ESA Convention



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Activities

ESA is one of the few space agencies in the world to combine responsibility in nearly all areas of space activity.



space science



human spaceflight



exploration



earth observation



launchers



navigation



operations



technology



telecommunications



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Member States

22 ESA Member States:

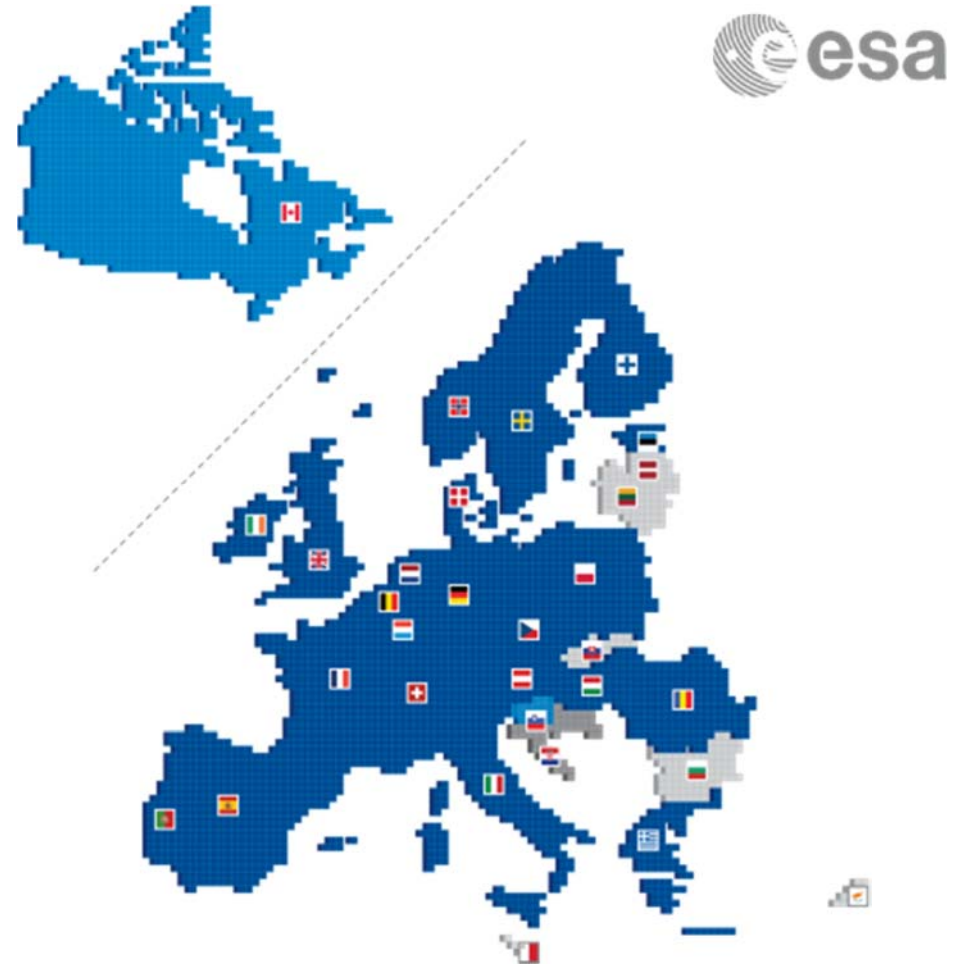
- 20 states of the EU (**AT, BE, CZ, DE, DK, EE, ES, FI, FR, IT, GR, HU, IE, LU, NL, PT, PL, RO, SE, UK**)
- Non-EU: **Norway** and **Switzerland**

Cooperation Agreements with ESA:

- **BG, CY, LV, LT, MT** and **SK**
- Discussions are ongoing with **Croatia**

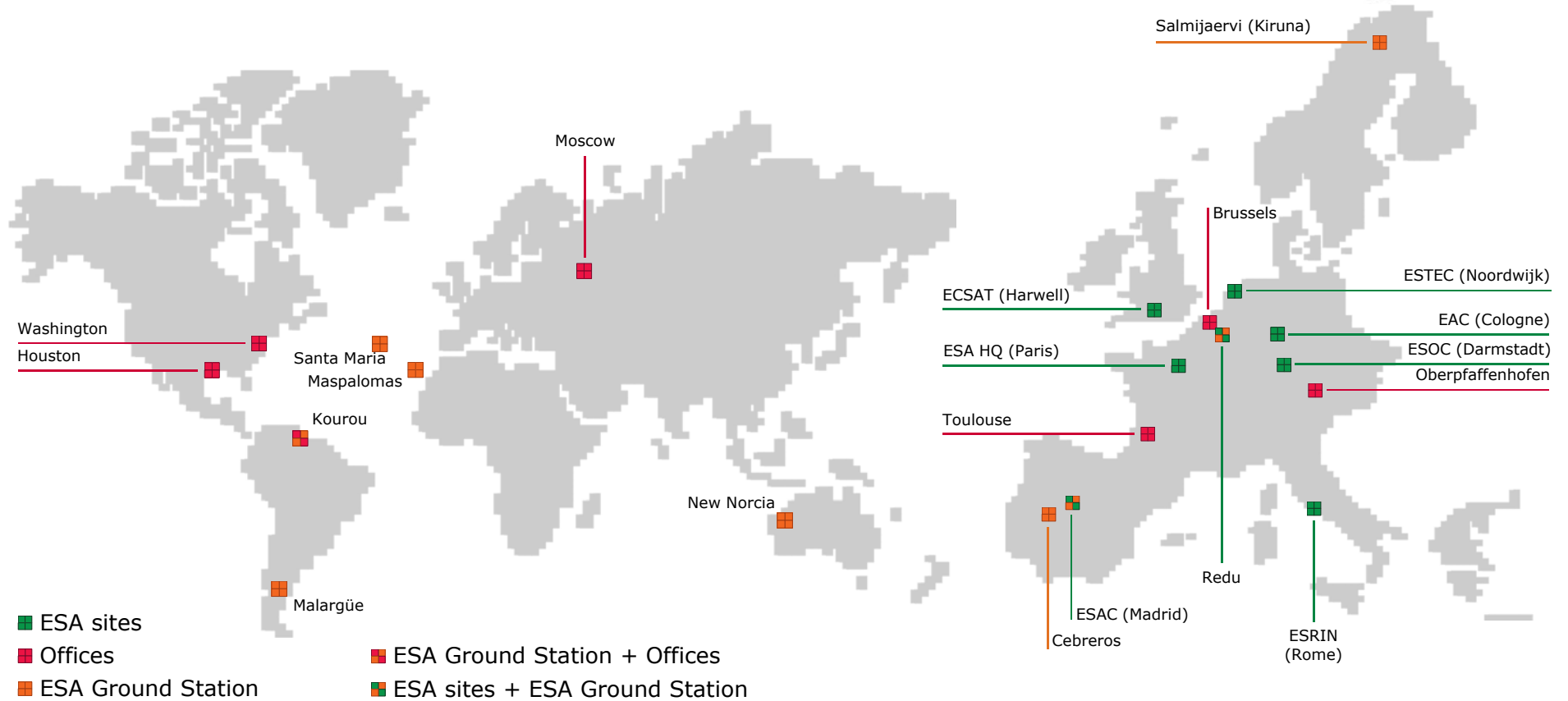
Slovenia is an Associate Member

Canada takes part in some programmes under a long-standing Cooperation Agreement



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ESA's locations

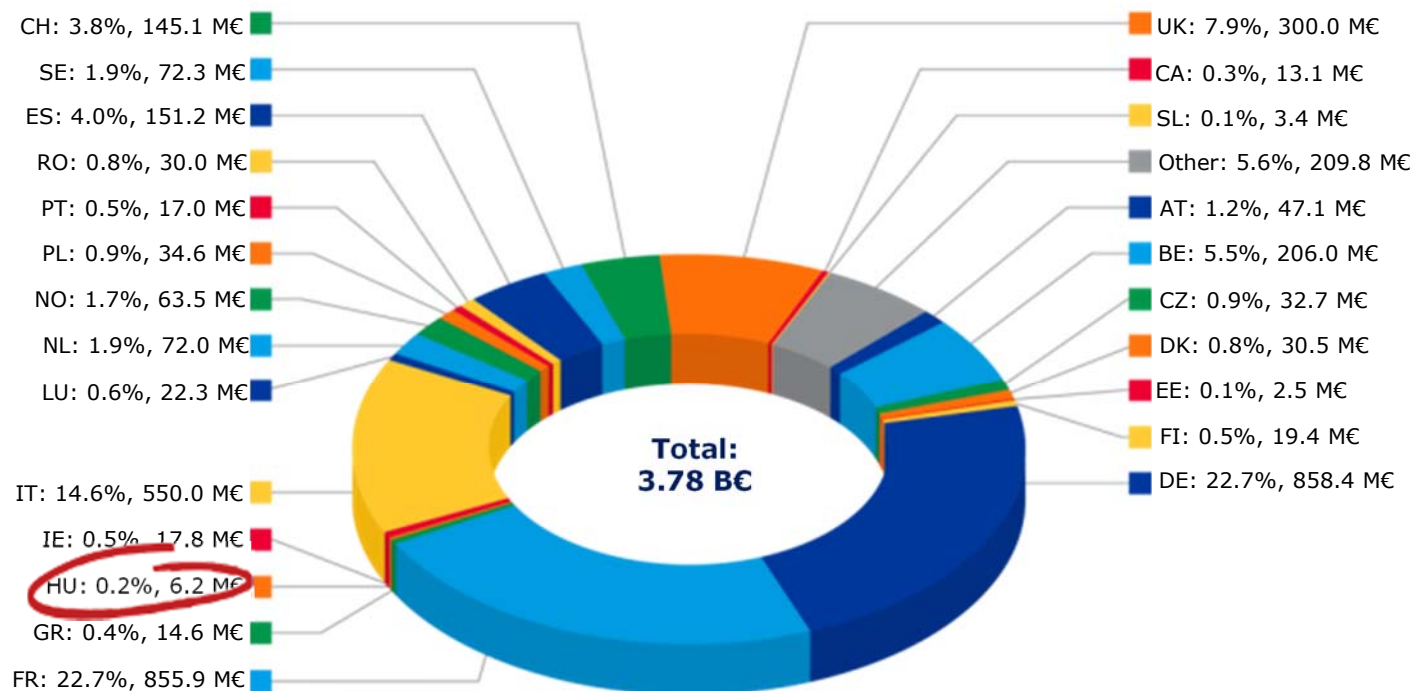


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ESA budget for 2017: 5.75 B€

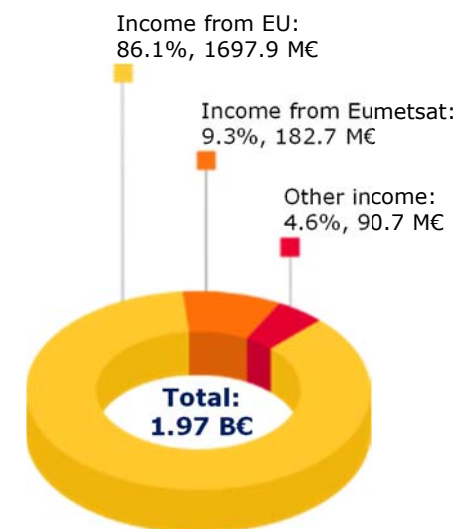


ESA Activities and Programmes



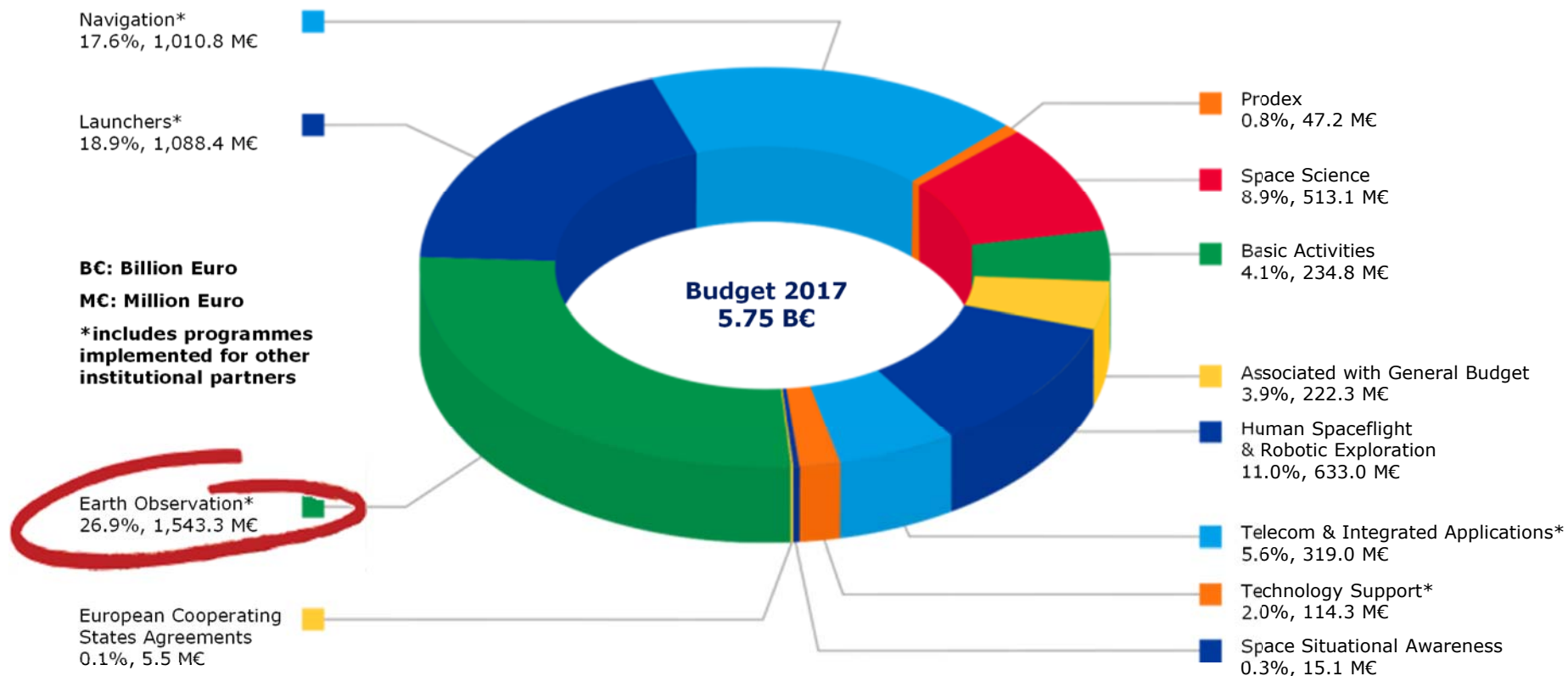
BC: Billion Euro M€: Million Euro

Programmes implemented for other institutional partners

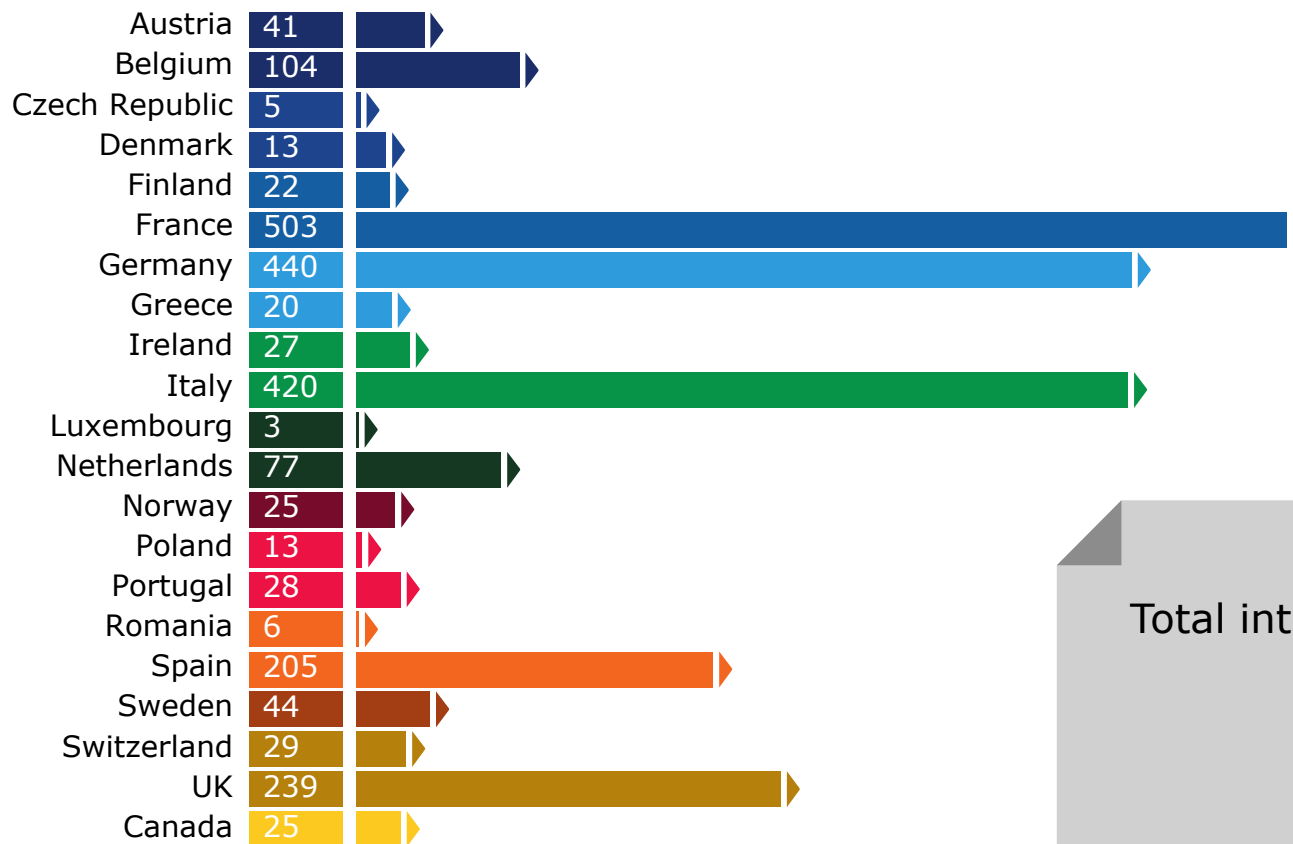


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ESA budget for 2017: by domain



Staff by nationality in 2016



Total international staff: 2289



ESA's industrial policy



About 85% of ESA's budget is spent on contracts with European industry.

ESA's industrial policy:

- Ensures that Member States get a fair return on their investment;
- Improves competitiveness of European industry;
- Maintains and develops space technology;
- Exploits the advantages of free competitive bidding, except where incompatible with objectives of the industrial policy.



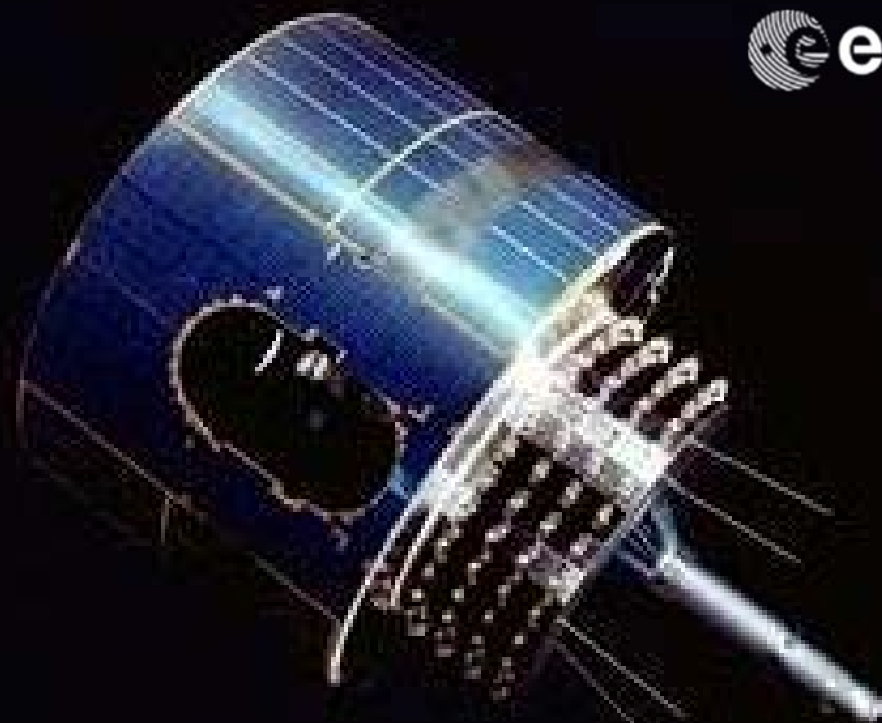


Earth Observation at ESA



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Meteosat-1 (1977)



ERS-1 (1991-2000)
ERS-2 (1995-2011)



Envisat (2002–2012)



ESA ESRIN: The Home of (Much of) ESA EO



ESRIN, in Frascati, Italy, is ESA's centre for Earth Observation where operations and exploitation of Earth Observation satellites are managed.

The world's largest database of environmental data for both Europe and Africa is managed from ESRIN.

Personnel on site (May 2017): 774

- 205 ESA staff (incl. YGTs and Fellows)
- 569 contractors

~50,000 visitors in 2016



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ESA-DEVELOPED EARTH OBSERVATION MISSIONS



ESA-DEVELOPED EARTH OBSERVATION MISSIONS



Meteosat-10
2017 Oct 12, 16:00 CET
Natural Color



Multi-Sensor
Precipitation
Estimate



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ESA-DEVELOPED EARTH OBSERVATION MISSIONS



Sentinels: A New Generation of Data Source



- Copernicus - European space flagship programme, led by the EU
- ESA is responsible for space component, Sentinel development, operation of some Sentinels, data buy from other partners, system evolution
- Sentinels – designed to monitor various elements of the Earth System in a fully operational manner
- Free, full and open data policy



Sentinel-1A/B



Sentinel-2A/B



Sentinel-3A/B



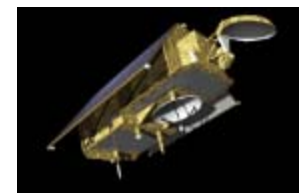
Sentinel-4A/B



Sentinel-5/5P



Sentinel-6A/B



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Overall programme
coordination:



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Sentinel Launches



	S1A/B: Radar Mission	3 Apr 2014 / 25 Apr 2016
	S2A/B: High Resolution Optical Mission	23 June 2015 / 6 March 2017
	S3A/B: Medium Resolution Imaging and Altimetry Mission	16 Feb 2016 / Q1 2018
	S4A/B: Geostationary Atmospheric Chemistry Mission	2021/2027
	S5P: Low Earth Orbit Atmospheric Chemistry Mission	13 Oct 2017
	S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission	2021/2027
	S6A/B: Altimetry Mission	2020/2025



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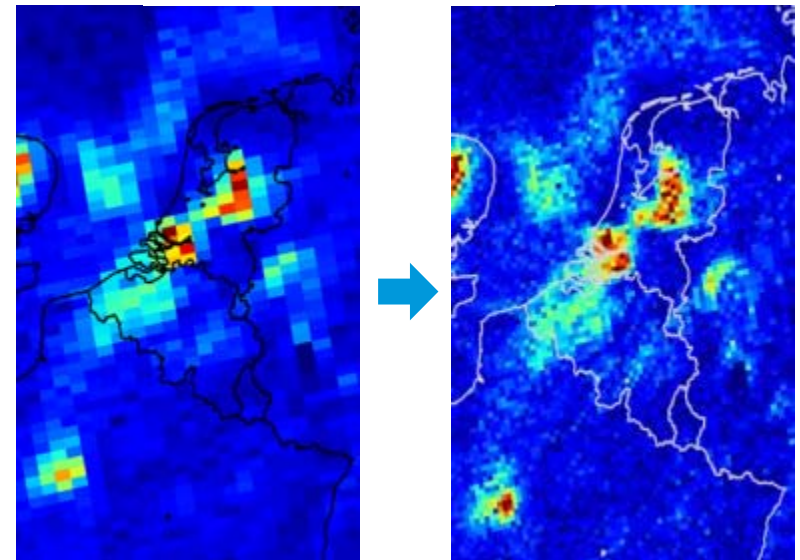
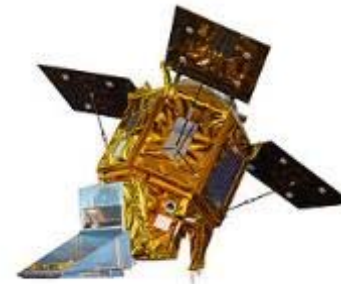
Atmospheric Monitoring with Satellites

Sentinel 5 Precursor (S-5P)

- Copernicus atmosphere mission in polar orbit
- Pre-operational mission focusing on global observations of the atmospheric composition for **air quality and climate**
- Payload: TROPOspheric Monitoring Instrument (TROPOMI)
 - jointly developed by The Netherlands and ESA
- Enhanced radiometric sensitivity and spatial resolution
- Launch: 13 October 2017 **(today!)**
- 7 year lifetime

Sentinel-5P Products

- Total column: O_3 , NO_2 , CO, SO_2 , CH_4 , HCHO
- Tropospheric column: O_3 , NO_2
- O_3 profile
- UV Aerosol Index & Aerosol layer height
- Clouds



Resolution improvement from OMI to TROPOMI
(NO_2 simulation)



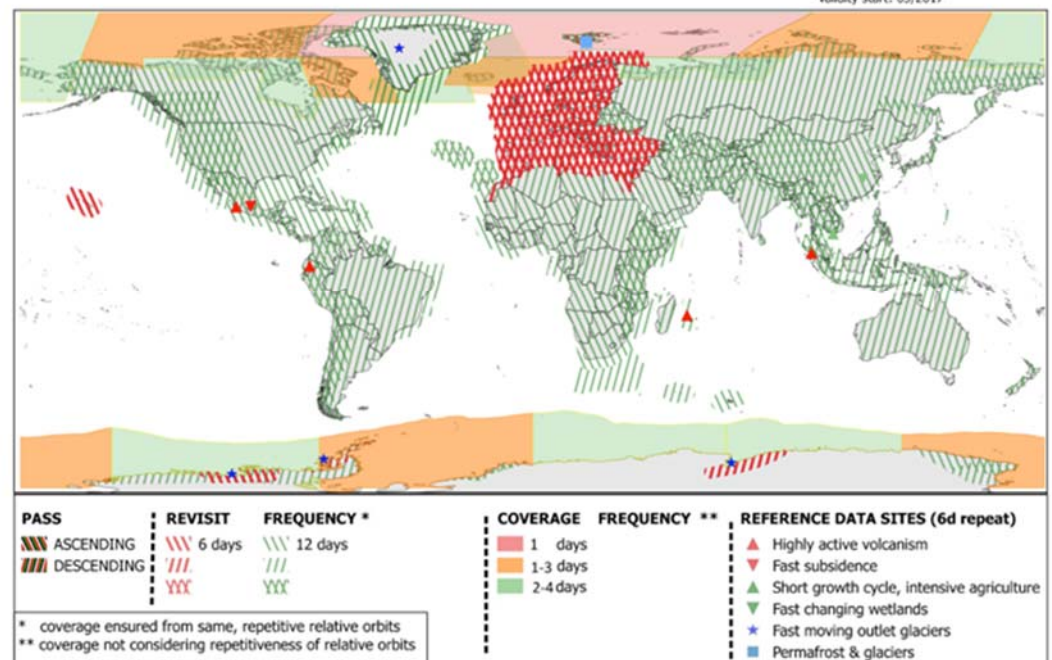
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Sentinel-1 Mission Status



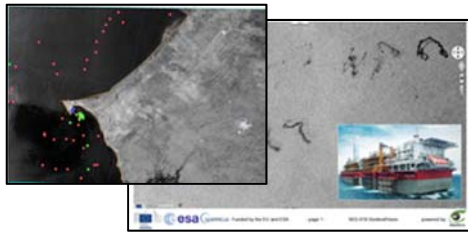
- Sentinel-1A and Sentinel-1B routine operations on-going, overall performance of satellites and ground segment is **nominal**, with high production throughput (11 TB/day)
- On-going actions for improving the Level 2 product component on Radial Surface Velocity through improved collection of on-board attitude information
- Support provided for various **activations** from the Copernicus Emergency Management Service and from the International Charter on Space and Major Disasters
- Sentinel-1 data **acquisition plan stable**

**Sentinel-1 Constellation Observation Scenario:
Revisit & Coverage Frequency**

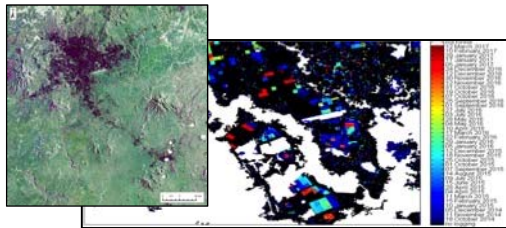


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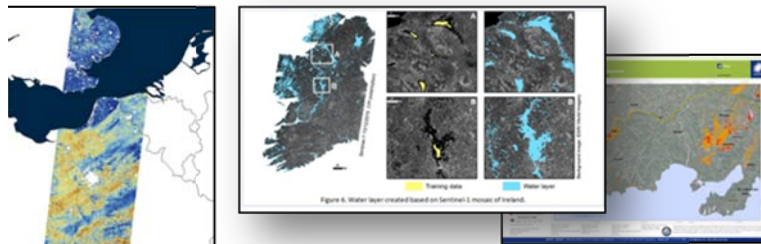
Sentinel-1 Applications



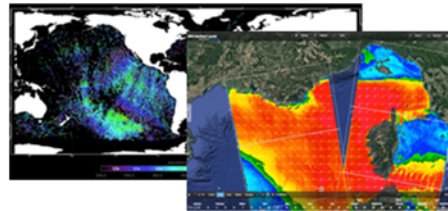
Maritime surveillance: oil spill monitoring, ship detection, illegal fisheries, etc.



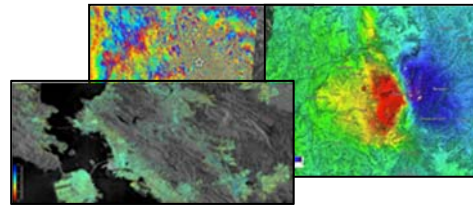
Land use, agriculture, forestry, logging, land classification, urban planning



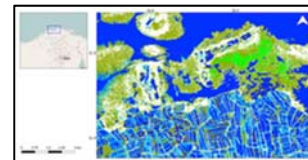
Emergency management



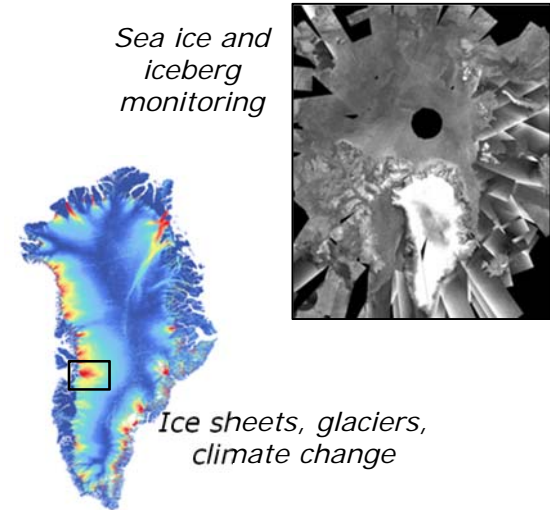
Sea state: wind, wave



Ground deformation: subsidence, landslides, earthquakes, volcanoes, infrastructure monitoring

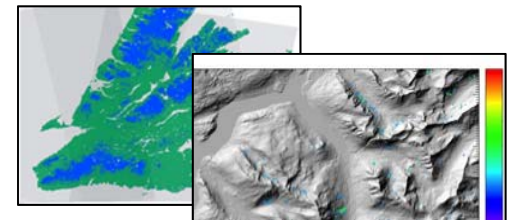


Soil moisture, wetlands



Sea ice and iceberg monitoring

Ice sheets, glaciers, climate change



Snow, permafrost, avalanches, ...



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Sentinel-1A GRD IW (VV), 2017 Oct 11



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Sentinel-2 Mission Status

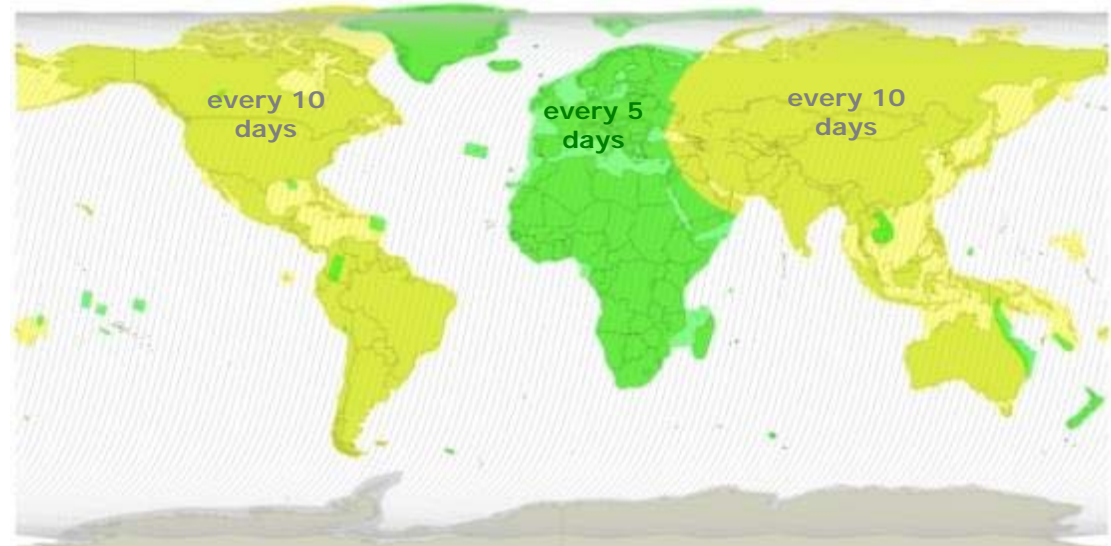
- Sentinel-2A and Sentinel-2B are operating **nominally**
- **Successful completion of the Sentinel-2B commissioning phase** was followed by opening of data access in early July.
- Sentinel-2B has reached the same observation pattern as Sentinel-2A, resulting in the current combined observation scenario shown on the right
- Feasibility study on **Sentinel-2 Level-2A** concluded that SEN2COR and MAJA algorithms for atmospheric correction are the most mature in Europe. Preparation for global systematic atmospheric correction with SEN2COR is on-going
- Products evolutions are being prepared with better cloud masks, with use of Global Reference Image and with raster based quality masks



Sentinel-2 Constellation Observation Scenario: Revisit Frequency

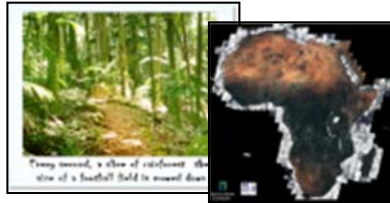


Validity start: July 2017



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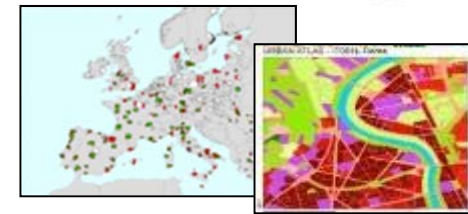
Sentinel-2 Applications



Forests & Carbon, Vegetation monitoring

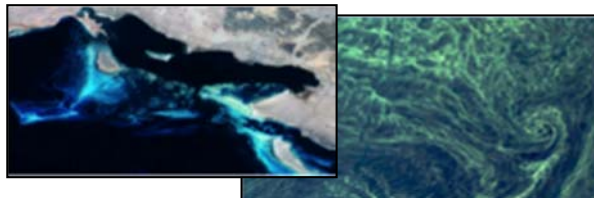
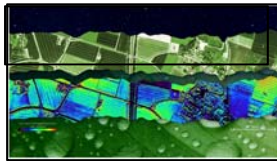


European land cover, human impact, high resolution layers

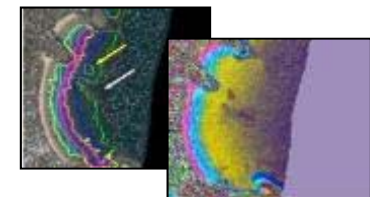


Regional to Urban Applications

Agriculture, fluorescence & biophysical parameters



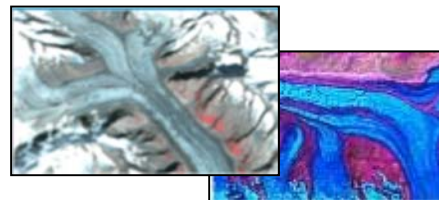
Water quality, Wetlands



Coastal zones/bathymetry



Emergency management



Glaciers & ice

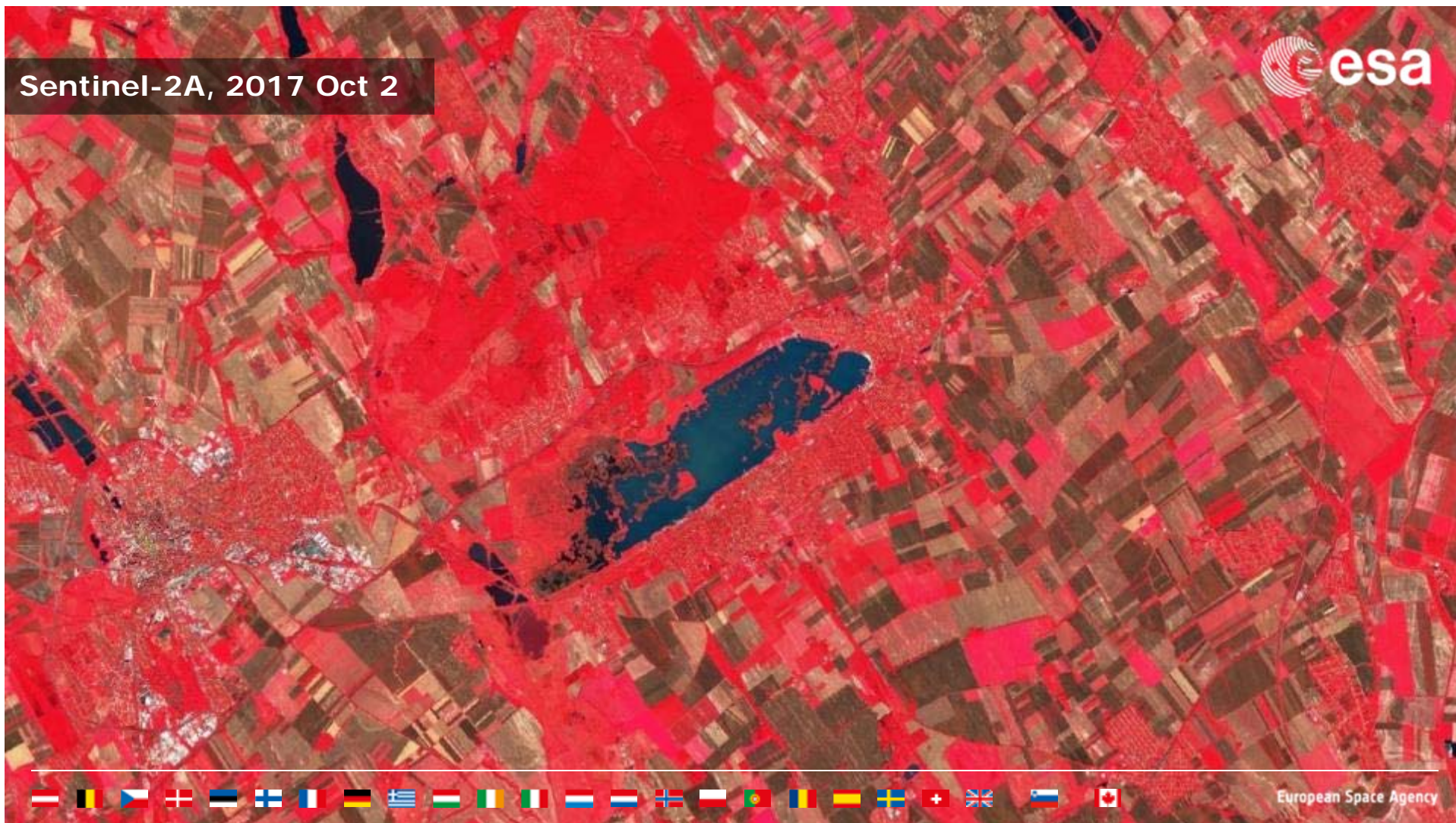


Geology & geomorphology



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Sentinel-2A, 2017 Oct 2



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Sentinel-3 Mission Status



- The Sentinel-3A mission is in the **ramp-up phase, moving towards full operational capacity**. The EUMETSAT-ESA Joint Routine Operations Readiness Review is planned for October 2017 with the aim to confirm the completion of the ramp-up phase and the readiness of the Sentinel-3A mission to start the full routine operations.
- The overall status of Sentinel-3A is **nominal**, with all instruments (OLCI, SLSTR, SRAL, MWR) performing nominally.
- The Payload Data Ground Segment (PDGS) is operating broadly as expected in the ramp-up phase, gradually moving towards full operational capacity. Some outages and data delays occurred due to recent upgrading of the PDGS systems in preparation of full operations and the on-going core data release. **OLCI and SLSTR Level 2 core data products over land and ocean were jointly released by EUMETSAT and ESA in July 2017** (all Level 1 and SRAL Level 2 core data products were released earlier in the ramp-up phase).
- Intense on ground **validation activities** are on-going to ensure the best possible user acceptance of the Sentinel-3A products.
- For Sentinel-3B commissioning phase, ESA and EUMETSAT have jointly elaborated a **Tandem phase** (agreed with the Commission) whereby Sentinel-3B will fly around 30 seconds apart from Sentinel-3A. The objective of the Tandem phase is to allow the best possible inter-calibration and inter-validation between the two missions. The Tandem phase is planned to last 4-5 months. Then during routine operations, the **orbit phasing** between Sentinel-3A and Sentinel-3B will be 140 degrees (instead of the initially foreseen 180 degrees).



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Sentinel-3A, 2017 Oct 11

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ESA-DEVELOPED EARTH OBSERVATION MISSIONS



Earth Explorers



These missions address critical and specific issues raised by the science community, while demonstrating the latest observing techniques.

- **GOCE** (2009–13) studying Earth's gravity field
- **SMOS** (2009–) studying Earth's water cycle
- **CryoSat-2** (2010–) studying Earth's ice cover
- **Swarm** (2013–) three satellites studying Earth's magnetic field
- **ADM-Aeolus** (2017) studying global winds
- **EarthCARE** (2018) studying Earth's clouds, aerosols and radiation (ESA/JAXA)
- **Biomass** (2021) studying Earth's carbon cycle
- **FLEX** (2022) studying photosynthesis
- **Earth Explorers 9 & 10** to be selected



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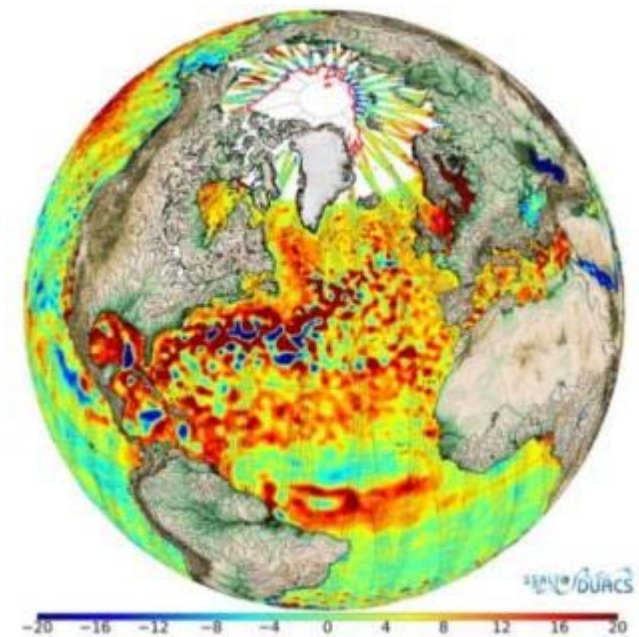
- Overall performance of CryoSat mission is **nominal**: the instrument performance continues to be excellent.
- A **new version of the CryoSat Ocean processor** (Baseline C) will enter in operations before end 2017 with noticeable improvements of ocean geophysical parameters consistent with other altimetry missions (e.g. Sentinel-3).
- The data processing of the KAREN validation campaign (Autumn 2016) embarking for the **first time Ka/Ku radars**, is underway with data quality being assessed.

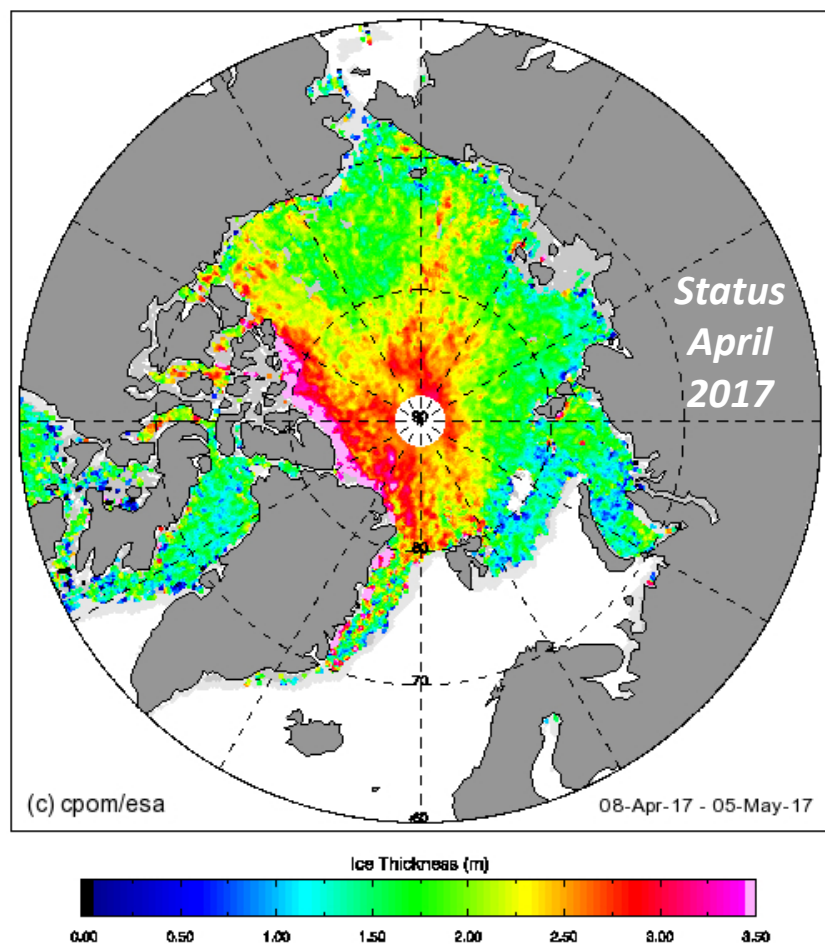
Average sea-surface topography mapped by CryoSat combined with data from other altimetry missions

Measurements at higher latitudes only possible thanks to CryoSat which also fills the gaps between ground tracks of other typical synchronous missions.

Red represent higher sea-level up to 20mm while blue represents lower areas up to -20mm.

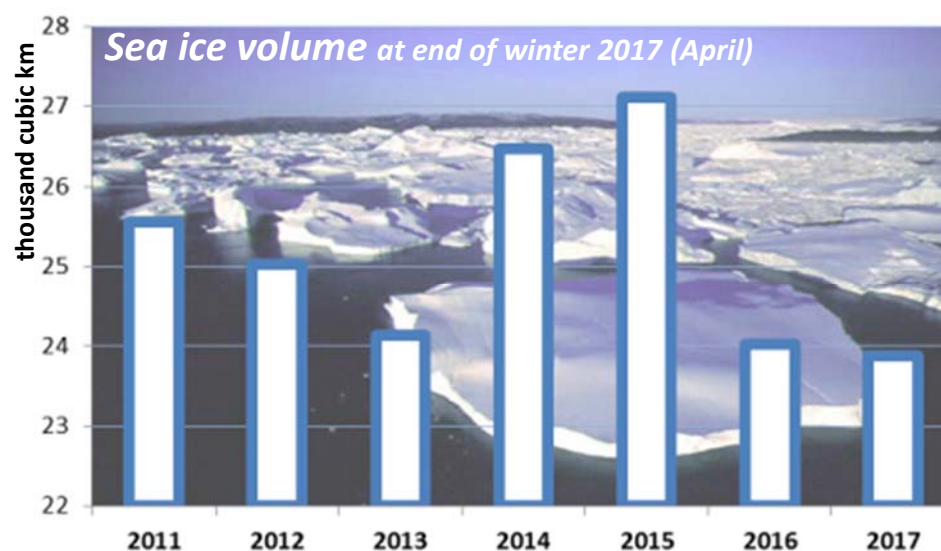
Credits: Salto/CNES/ESA





Arctic sea ice

→ *an historical minimum
for sea ice volume at end of winter 2017*



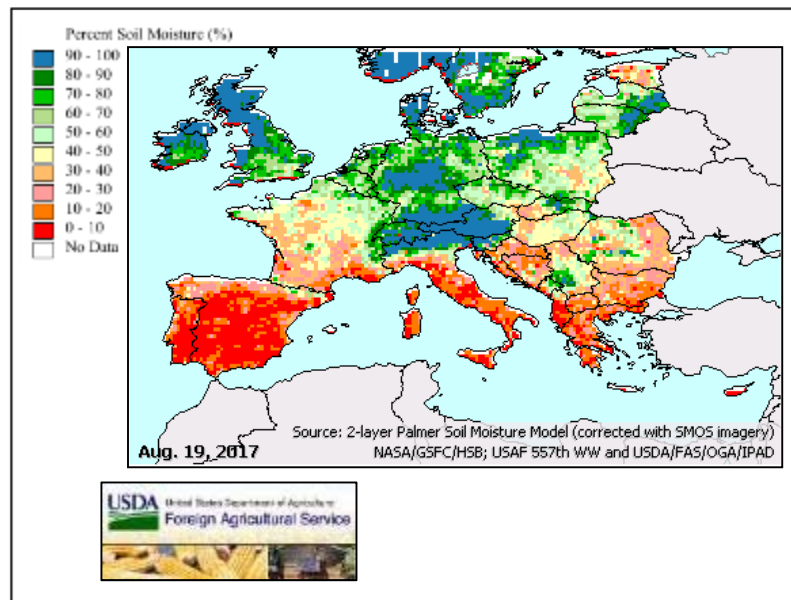
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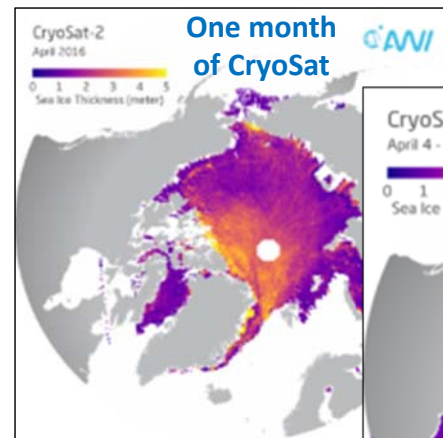
SMOS mission



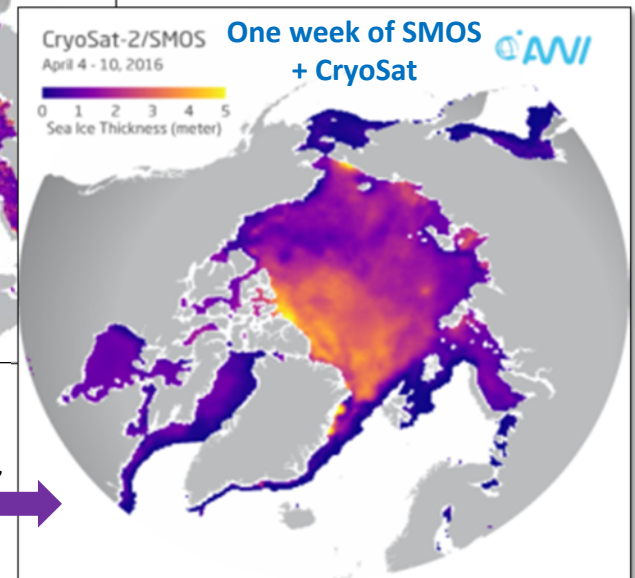
Percent soil moisture (mid-August 2017)



Combining both SMOS & CryoSat skills



Synergy ice product based on SMOS and CryoSat data, improving spatial and temporal coverage for thin sea ice as well as product structure and content



Ricker and Hendricks, AWI (D)



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Swarm mission



Changes in strength of Earth's magnetic field

Swarm witnessing the changes in strength of Earth's magnetic field

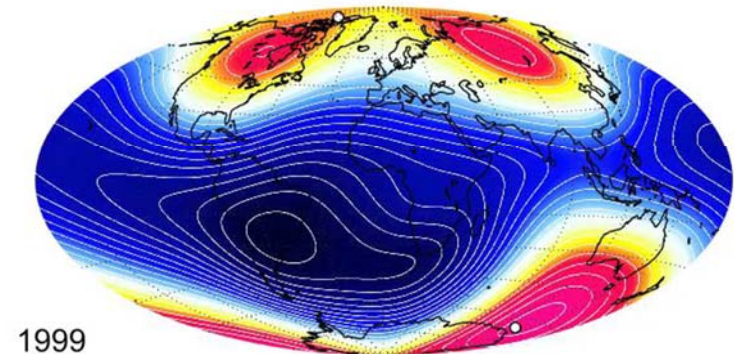
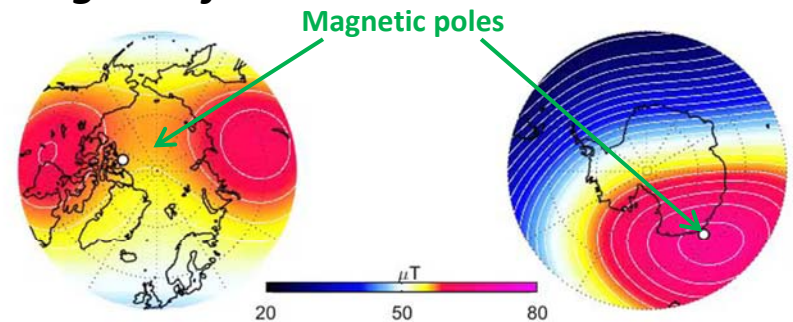
Changes of the strength of Earth's magnetic field between 1999 and 2016:

Blue → weak field

Red → strong field

The field has weakened by 3.5% at high latitudes over North America, while it has grown about 2% stronger over Asia.

The South Atlantic Anomaly (region with the weakest magnetic field) has moved westward and further weakened by ~2%.



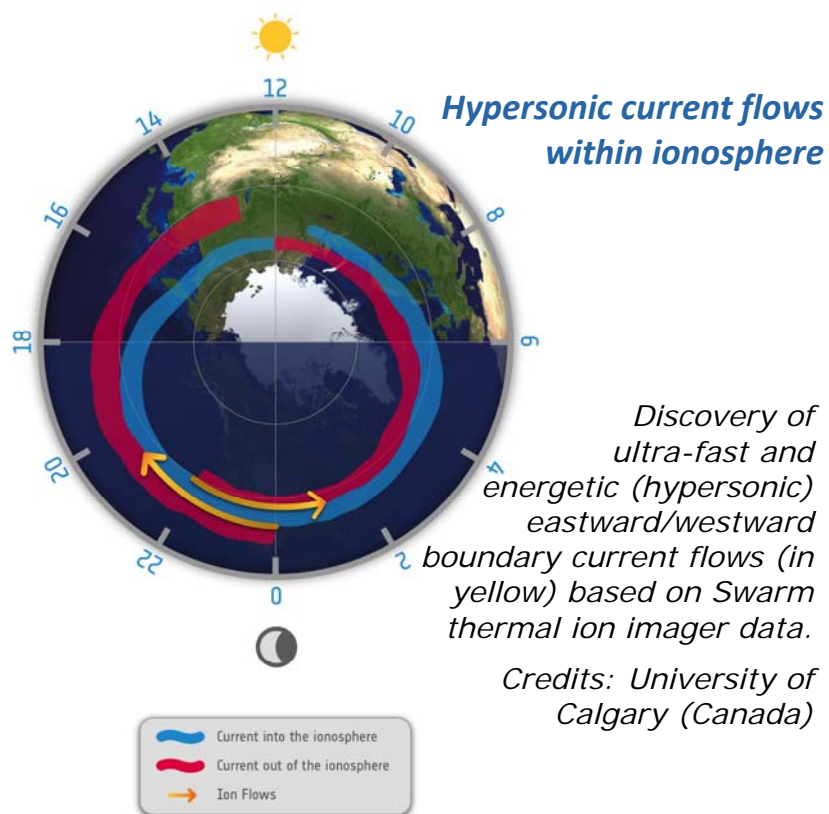
Animation courtesy of DTU Space (Swarm, CHAMP and Ørsted data)



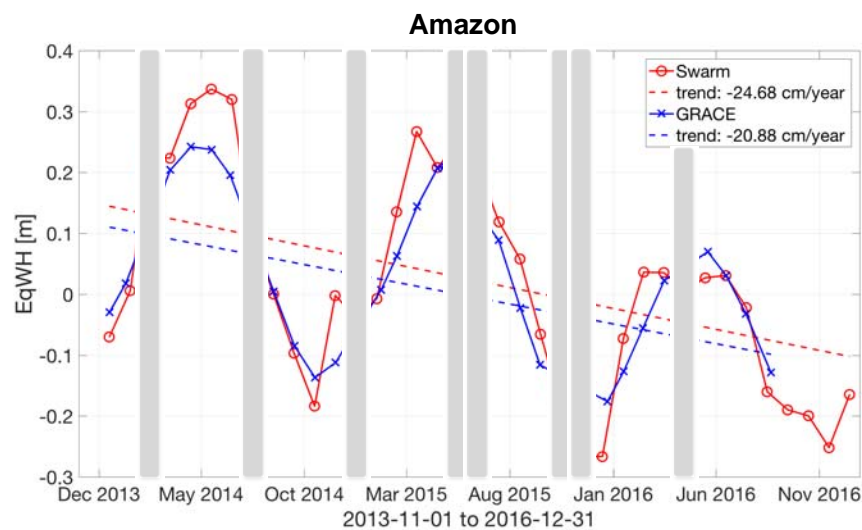
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Swarm mission



3-years mass transport process for the Amazon basin



Swarm as an observing platform for mass transport processes – comparison with GRACE for the Amazon basin

Credits: J. Texeira, Delft University of Technology (NL)



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Earth Observation at ESA: Programmatics



ESA's Earth Observation Envelope Programme (EOEP)



"EOEP-5 Block 4" also known as **"EO Science for Society"**

Objectives:

- Foster scientific excellence
- Pioneer new EO applications
- Stimulate downstream industry growth
- Support international responses to global societal challenges

Built on successes of previous exploitation activities:

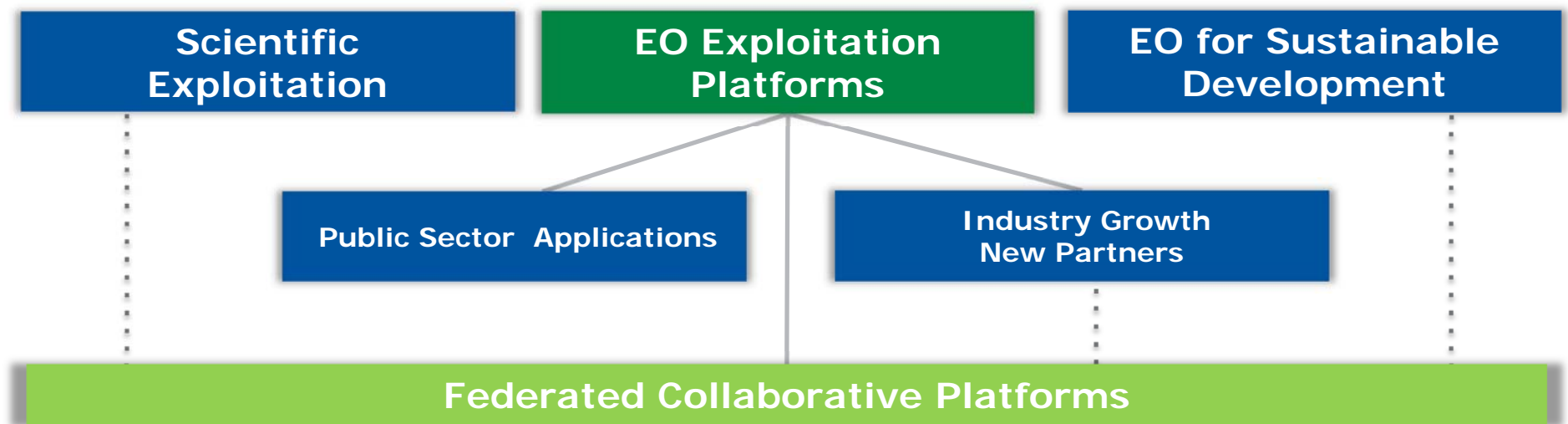
- adapting them to the new European EO context
- responding to recommendations of EOEP-4 programmatic and scientific review

eo science for society



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EO Science for Society: Components

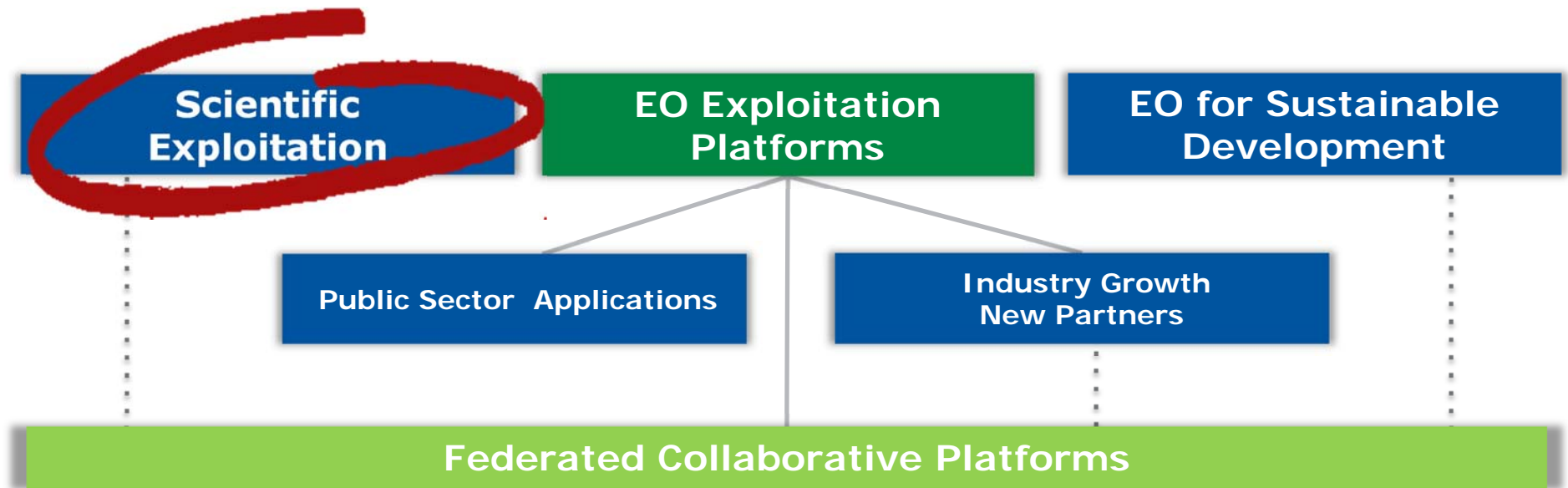


New: Some 10% of the budget assigned via **open calls** to support industry/user initiatives.



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EO Science for Society: Components



New: Some 10% of the budget assigned via **open calls** to support industry/user initiatives.



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Finding and Engaging the (Young) Talents



Education, training, and capability building

- to develop the scientific expertise and technical skills that fuel innovation
- adapted to take account of the specific needs and priorities of new and/or smaller ESA member states



Cryosphere Training, Svalbard
June 2018



Land Training, Gödöllő
September 2017



OceanTraining, Porto
September 2017



EO Open Science, Frascati
September 2017 - @EO_Open_Science



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Land Training Course 2017, SZIU, Gödöllő



eoscience.esa.int/landtraining2017

seom
scientific exploitation of operational missions

esa

SEOM ESA

NAVIGATION

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- SATELLITES and INSTRUMENTS
- ORGANISING COMMITTEE
- VENUE and LOGISTICS
- LINKS
- CONTACT POINTS

Land Training 2017 > Home

+ 7th ADVANCED TRAINING COURSE ON LAND REMOTE SENSING
4-9 September 2017 | Szent István University | Gödöllő, Hungary

**** Training course summary ****

Background

As part of the *Scientific Exploitation of Operational Missions (SEOM)* programme element, the European Space Agency (ESA) organised an Advanced Land Training Course devoted to train the next generation of Earth Observation (EO) scientists to exploit data from ESA and operational EO missions (e.g. the Sentinels) for science and applications development.

A total of 78 post graduate-level, PhD students, post doctoral research scientists and users from Europe, Canada and from other continents attended the 6-day course, which was held at:

- [Szent István University \(SZIU\), Hungary](#)
- **from 4 to 9 September 2017.**

Objectives

The Advanced Land Training Course aimed at:

- **Training the next generation of European and Canadian Principal Investigators (PIs).**

Highlights

Szent István University Gödöllő Campus
Released: 28/08/2015

Shaping Next-Generation Scientists
Released: 06/03/2015

Sentinel-1A mosaic over Hungary
Released: 06/03/2015

Budapest from the ISS
Released: 24/01/2017

Space Agency

Land Training Course 2017, SZIU, Gödöllő



eoscience.esa.int/landtraining2017

Tuesday 5 September 2017			Lecturers		
Kostas Papathanassiou DLR, Germany	Introduction to SAR and InSAR		Zoltán VEXERDY , Szent István University, Hungary		
Michael Foumelis BRGM, France	ESA SNAP Sentinel-1 Tools		Eric POTTIER , Université de Rennes 1, France		
Eric Pottier Université de Rennes 1, France	SAR Polarimetry		Laurent FERRO-FAMIL , Université de Rennes 1, France		
Eric Pottier, Laurent Ferro-Famil Université de Rennes 1, France	Introduction to PolSARpro Toolbox		Ahmad AL BETAR , CESBIO, France		
Costas Cartalis University of Athens, Greece	Advanced Optical and Thermal Applications		Wolfgang Dorigo , Vienna University of Technology, Austria		
Ana Ruxecan Brückmann Consult GmbH, Germany	ESA SNAP Sentinel-3 Tools, OLCI and SLSTR Data		Participants		
Wednesday 6 September 2017			Michael MUNK ANDERSEN , Aarhus University, Denmark		
Lorenzo Bruzzone University of Trento, Italy	Multitemporal Analysis		Anna BERNINGER , RSS GmbH / LRU Munich, Germany		
Michael Foumelis BRGM, France	Multitemporal Analysis using ILU Products		Alexandre BEVINGTON , University of Northern British Columbia / Government of British Columbia, Canada		
Alessandro Marin Selenix s.r.l. ESA ESRIN, Italy	Cloud Computing and the ESA Exploitation Platforms		István BOZSÓ , Hungarian Academy of Sciences, Geodetic and		
Kostas Papathanassiou DLR, Germany	Forest Retrievals using SAR				
Laurent Ferro-Famil, Eric Pottier Université de Rennes 1, France	Forest Retrievals using SAR				
			Best poster award in the category "Radar Remote Sensing"		
			Vivien PACSKÓ , Eötvös Loránd University, Hungary	Numerical characterization of time series data derived from H/A/alpha decomposition of Sentinel-1 images	
			Best poster award in the category "Optical Remote Sensing"		
			Marta MILCZAREK , Polish Academy of Sciences, Space Research Centre, Poland	Sentinel Water Mask (SWM) - new index for water detection on Sentinel-2 images	
			Best poster award in the category "Agriculture and Synergistic Applications"		
			Odysseas VLACHOPOULOS , National Observatory of Athens, Greece	Synergy of Satellite EO data with Unmanned Aircraft Systems (UAS) and other smart platforms for precision farming: The case of vineyards in Greece	
			Best poster award in the category "Urban Applications"		
			Albert CARBONELL , Barcelona Regional S.A., Spain	Barcelona Urban Heat Island characterization and modeling	
			Best poster award in the category "Hydrology and Climate Change"		
			Ingmar NITZE , AWI Helmholtz Centre for Polar and Marine Research, Germany	Landsat-based trend analysis of lake dynamics across northern permafrost regions	
			Thais ALMEIDA LIMA , University of British Columbia, Canada	Detecting selective logging in the Brazilian Amazon: a pilot test with Sentinel-2A data	
			Bence AMBRUS , Budapest University of Technology and Economics, Hungary	Uplift analysis in the city of Bóbingen using PS-InSAR	
			Michael Munk ANDERSEN , Aarhus University, Denmark	Space herding	
			Zane ATSTAJA , Rural Support Service, Latvia	Sentinel-1 data use for monitoring of agricultural activities	
			Iván BARTON , University of Sopron, Faculty of Forestry, Hungary	Treefall gap detection on Sentinel-2A satellite images in the Börzsöny mountains	
			Márta BELENYESI , Government Office of the Capital City Budapest, Hungary	Retrospective analysis of long-term landscape evolution based on archive satellite imagery and historical maps	
			Anna Luisa BERNINGER , RSS GmbH / LMU Munich, Germany	Tropical canopy height and above ground biomass estimation in Central Kalimantan, Indonesia with the use of Pol-InSAR data - first results	
			Alexandre BEVINGTON , Univ. of Northern British Columbia / Gov. of British Columbia, Canada	Large area glacier change for western Canada over 45 years of satellite imagery	

ESA EMITS Invitation To Tender System



emits.esa.int

esa emits

ENTITIES LOGIN ESA Home Page Industry Information Entity Registration Service Desk Help

ESA Open Invitation To Tender [EN]

AO8996

Title: EO FOR SUSTAINABLE DEVELOPMENT GOALS

Open Date: 01/08/2017

Closing Date: 27/10/2017 13:00:00

Status: ISSUED

Reference Nr.: 27.155.10

Prog. Ref.: EO-Science for Socie

Budget Ref.: EO-Science for Socie

Special Prov.: AT+BE+CZ+DK+EE+FI+FR+DE+GR+IE+IT+LU+NL+NO+PL+PT+RO+ES+SE+CH+GB+CA+SI

Tender Type: C

Price Range: 200-500 KEURO

Products: Satellites & Probes / Other

Technology Domains: Others

Establishment: ESRIN

Directorate: Directorate of EO Programmes

Department: Science, Applications & Climate Dep.

Division: Data Applications Division

Contract Officer: Boisard, Nathalie

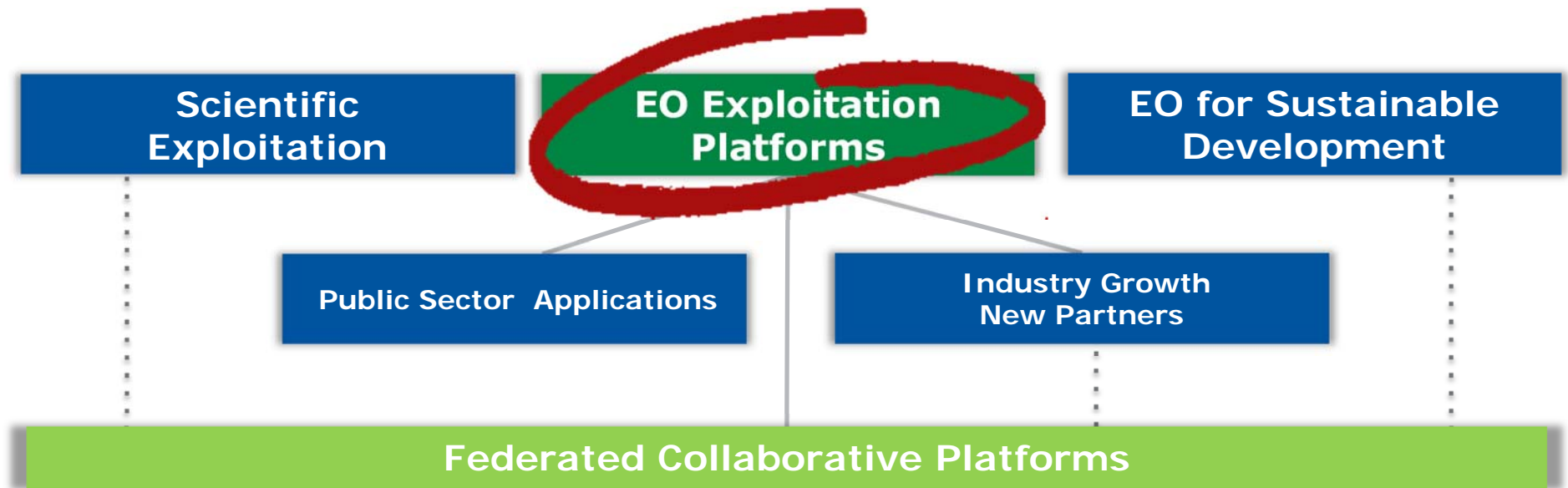
Industrial Policy Measure: N/A - Not apply

Last Update Date: 10/10/2017

Update Reason: Loaded a new Clarification(English version)

In September 2015, the UN General Assembly ratified the 2030 Agenda on Sustainable Development, a new transformative, integrated and universal agenda that aims to end poverty, promote prosperity and peoples well-being while protecting the environment. In total, 17 Sustainable Development Goals (SDGs) and 169 Targets have been adopted by the world leaders and will guide new norms through which countries will manage, monitor progress and communicate on the 3 interconnected components of sustainable development: economic growth, social inclusion and environmental sustainability. A robust monitoring mechanism for the implementation of the SDGs requires a solid framework of indicators to track progress, inform policy and ensure accountability of all stakeholders. A global framework of 230 indicators for the monitoring of the Goals and Targets has been proposed by the UN Statistical Commission as a voluntary and country-led instrument to be officially adopted by the Economic and Social Council (ECOSOC). Satellite Earth Observations and Geospatial Information are essential elements that can

EO Science for Society: Components



New: Some 10% of the total budget will be assigned via **open calls** to support industry/users initiatives.

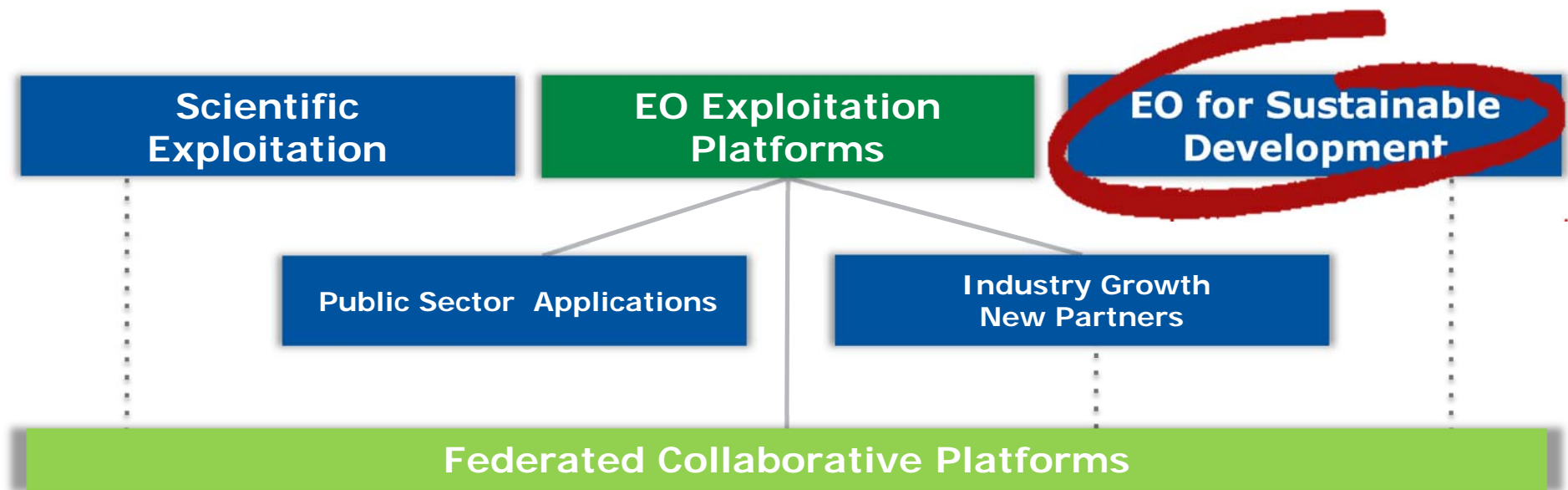


European Space Agency



European Space Agency

EO Science for Society: Components



New: Some 10% of the total budget will be assigned via **open calls** to support industry/users initiatives.



European Space Agency

ESA Collaboration with IFIs in EO



- Since 2008, 65 small-scale demonstrations of EO-based environmental information in support of multilateral bank development projects
- Responding to specific geospatial information needs
 - **Land:** urban infrastructure, land cover, forest, crops, soil erosion, inland water
 - **Marine:** oil spills, fishing, coral reefs, coastal change, sea level height, ocean currents
 - **Risk:** floods, land motion/subsidence, landslides, seismic
- MoUs and secondments in place with the World Bank and Asian Development Bank



European Space Agency

A Dedicated Programme of Work Required: EO4SD



EO4SD – Earth Observation for Sustainable Development – An ESA initiative for *large-scale* exploitation of satellite data in support of international development. Engaging various IFIs and their client states. Currently running (2016–2018):



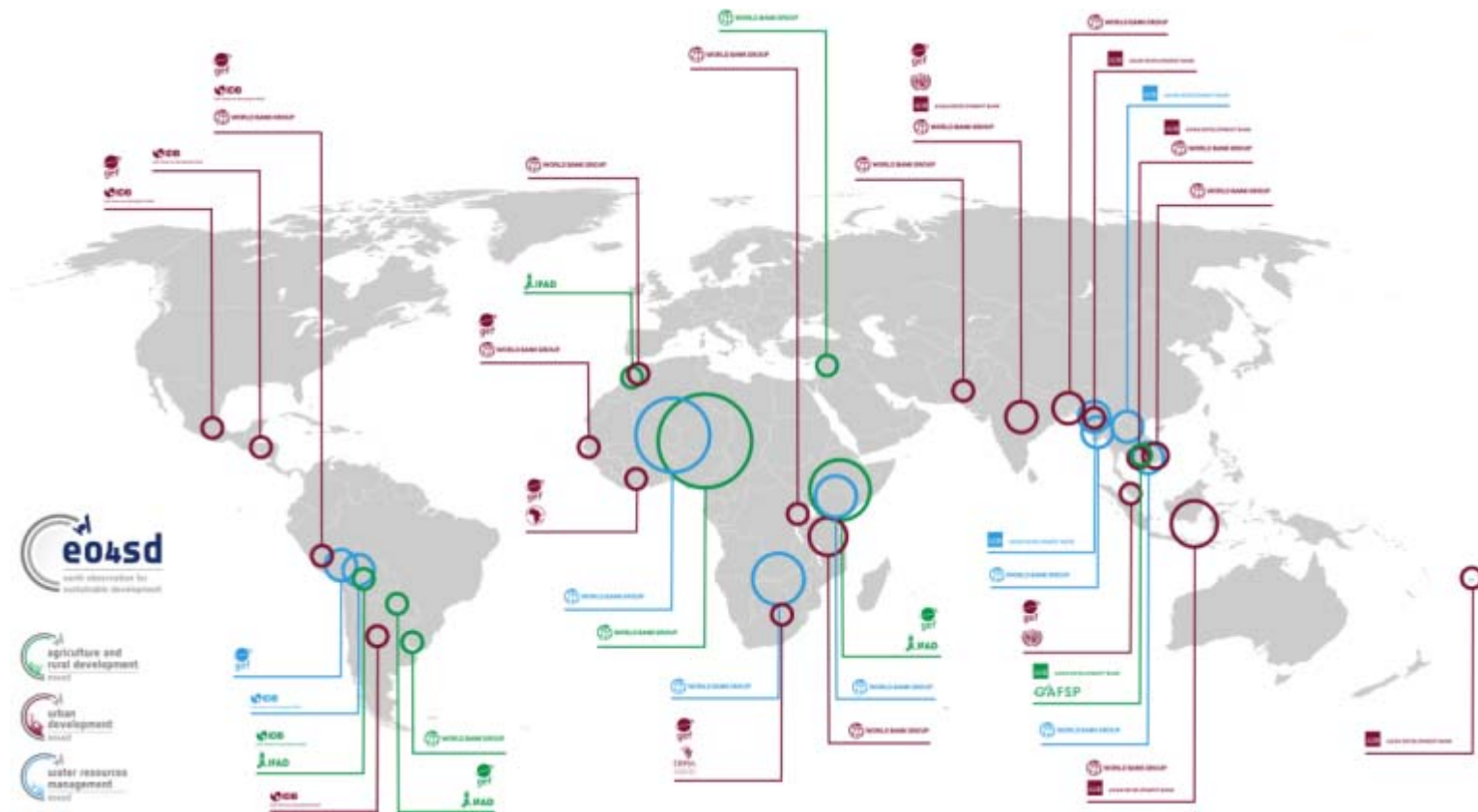
More thematic areas under preparation to start 2017.

Key questions:

- What EO-based information is most needed?
- How can it be used in Official Development Assistance (ODA) activities and working practices?
- What benefits does this information deliver to stakeholders (IFIs and their client states)? Do the benefits justify the costs?
- How can EO-based information be established on a long-term, sustainable basis?

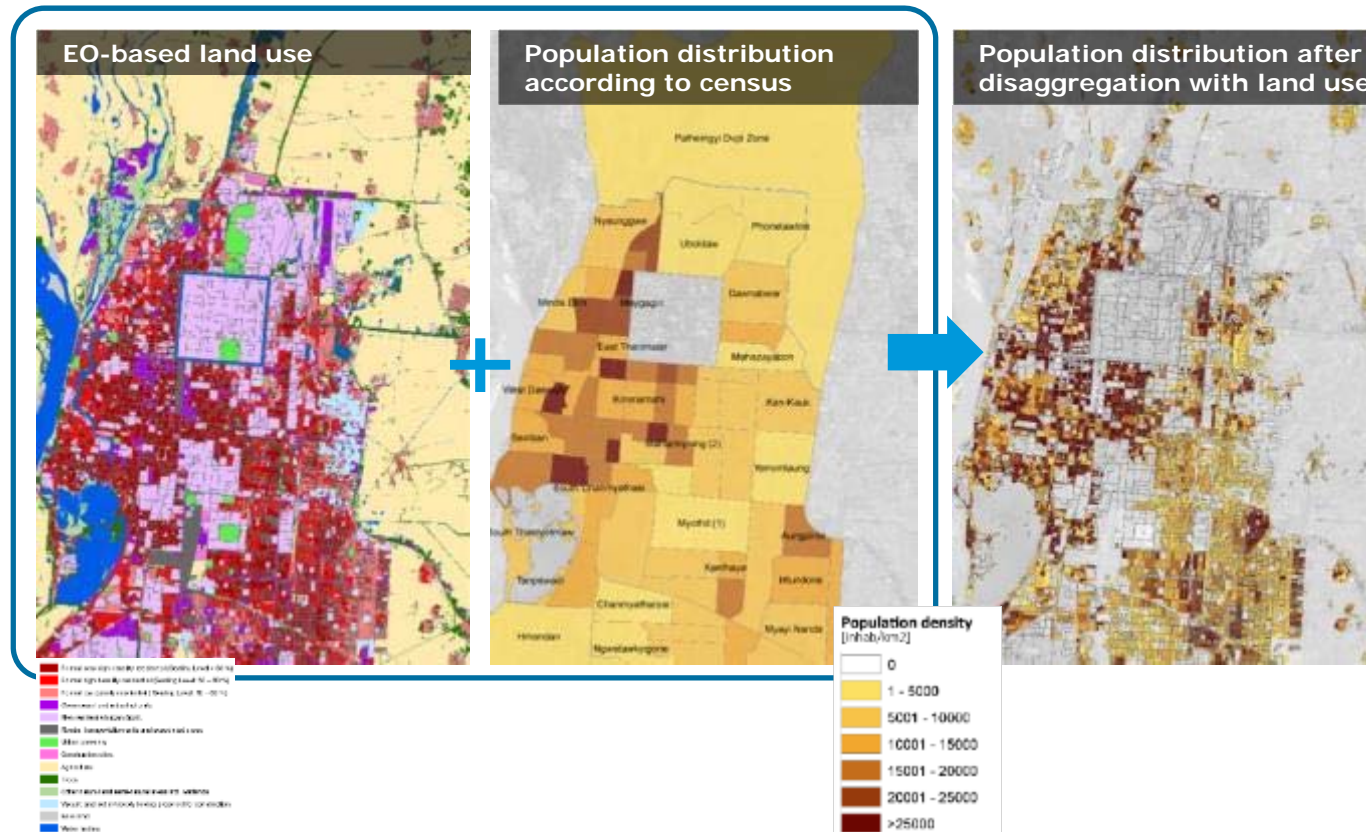


EO4SD – Presently Active Projects



European Space Agency

Example: Population Distribution Mapping, Mandalay



The spatial distribution of land cover types inside each administrative division holds valuable additional information on population distribution.

Knowing the type of urban fabric (residential or nonresidential) allows for further refinement of census data (e.g. work/home, day/night).

Processing: GISAT.



European Space Agency

Earth Observation and the SDGs



SDGs with major opportunities for EO data

Earth Observation potential contribution to the SDG Targets and Indicators

Target Contribute to progress on the Target yet not the Indicator per se										Goal	Indicator Direct measure or indirect support						
								1.4	1.5		1.4.2						
								2.3	2.4	2.c		2.4.1					
								3.3	3.4	3.9	3.d		3.9.1				
										5.a		5.a.1					
6.1	6.3	6.4	6.5	6.6	6.a	6.b					6.3.1	6.3.2	6.4.2	6.5.1	6.6.1		
								7.2	7.3	7.a	7.b		7.1.1				
										8.4							
								9.1	9.4	9.5	9.a		9.1.1	9.4.1			
								10.6	10.7	10.a							
11.1	11.3	11.4	11.5	11.6	11.7	11.b	11.c				11.1.1	11.2.1	11.3.1	11.6.2	11.7.1		
								12.2	12.4	12.8	12.a	12.b		12.a.1			
								13.1	13.2	13.3	13.b		13.1.1				
								14.1	14.2	14.3	14.4	14.6	14.7	14.a	14.3.1	14.4.1	14.5.1
15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9					15.1.1	15.2.1	15.3.1	15.4.1	15.4.2	
										16.8							
17.2	17.3	17.6	17.7	17.8	17.9	17.16	17.17	17.18			17.6.1	17.18.1					

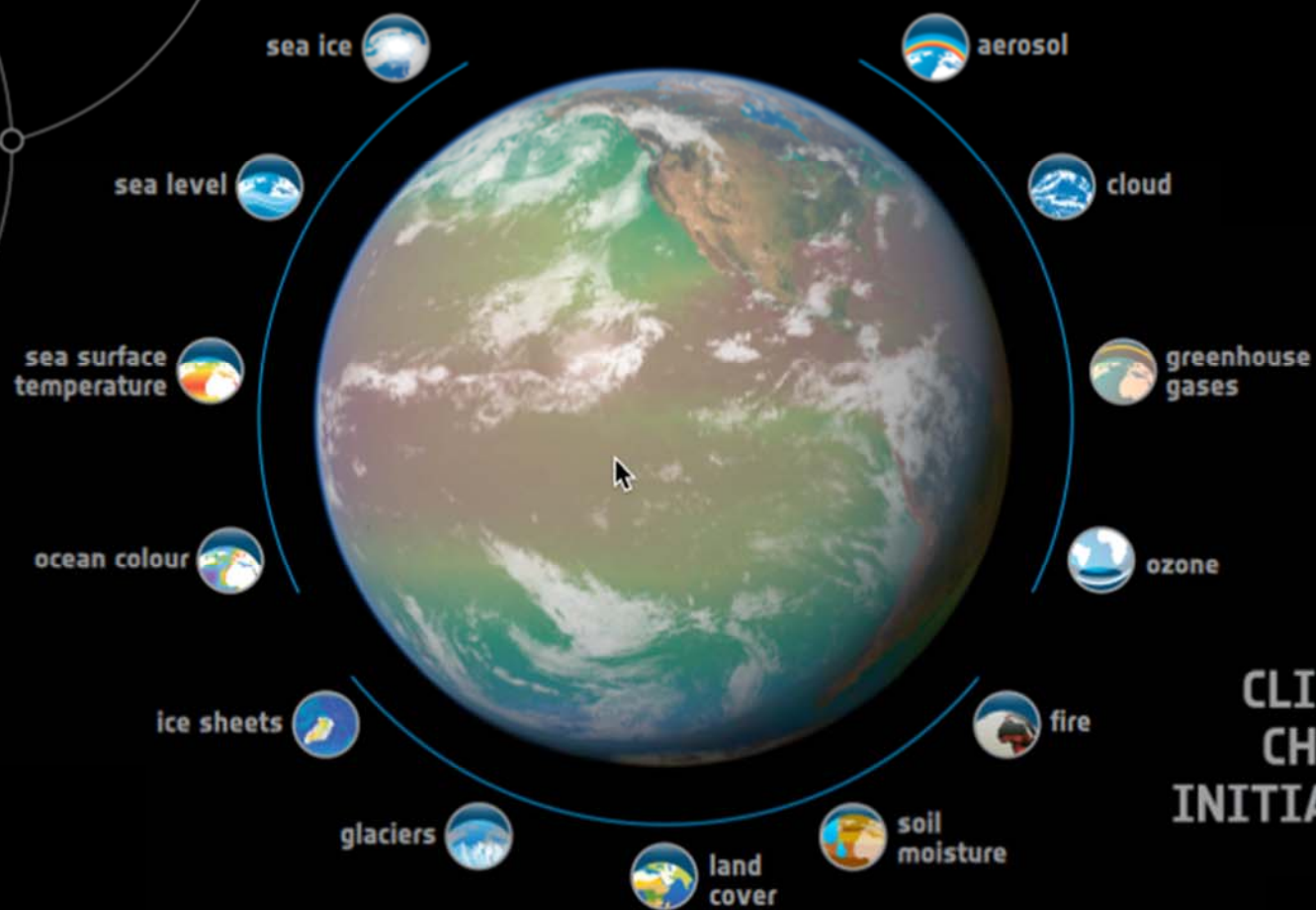
Analysis performed by the GEO EO4SDGs initiative



European Space Agency

ESA Climate Change Initiative



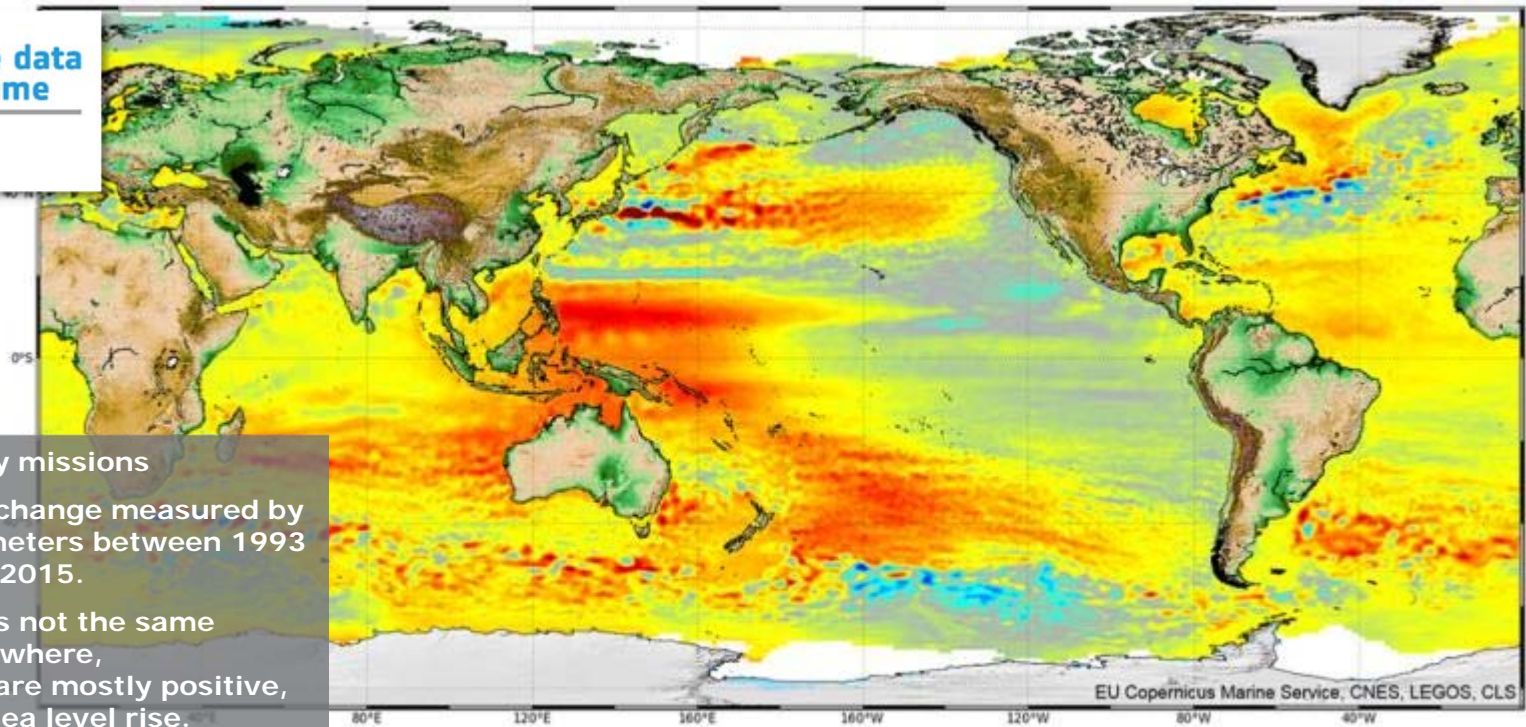


CLIMATE CHANGE INITIATIVE

Sea Level Trends



heritage data
programme
ltdp+



Altimetry missions

Regional sea level change measured by satellite radar altimeters between 1993 and 2015.

The change is not the same everywhere, and the numbers are mostly positive, indicating sea level rise.



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Paradigm Shift for Earth Observation?



Evolving IT Possibilities: New Developments for EO



- New companies (not traditionally space-related) becoming active in space (Google, Amazon, etc.)
- Easy data access
- 7 billion cell phones worldwide
- Social media
- Crowdsourcing
- Cloud computing, big data analytics

Time for a paradigm shifts in EO programmes?

- "never say never"
- "fail fast, fast forward"
- Act when 90% ready, risks management
- Time is the only non-renewable resource
- Clear vision-driven implementation
- Access to venture capital



Election Pope Benedict XVI



Election Pope Francis



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#FutureEO



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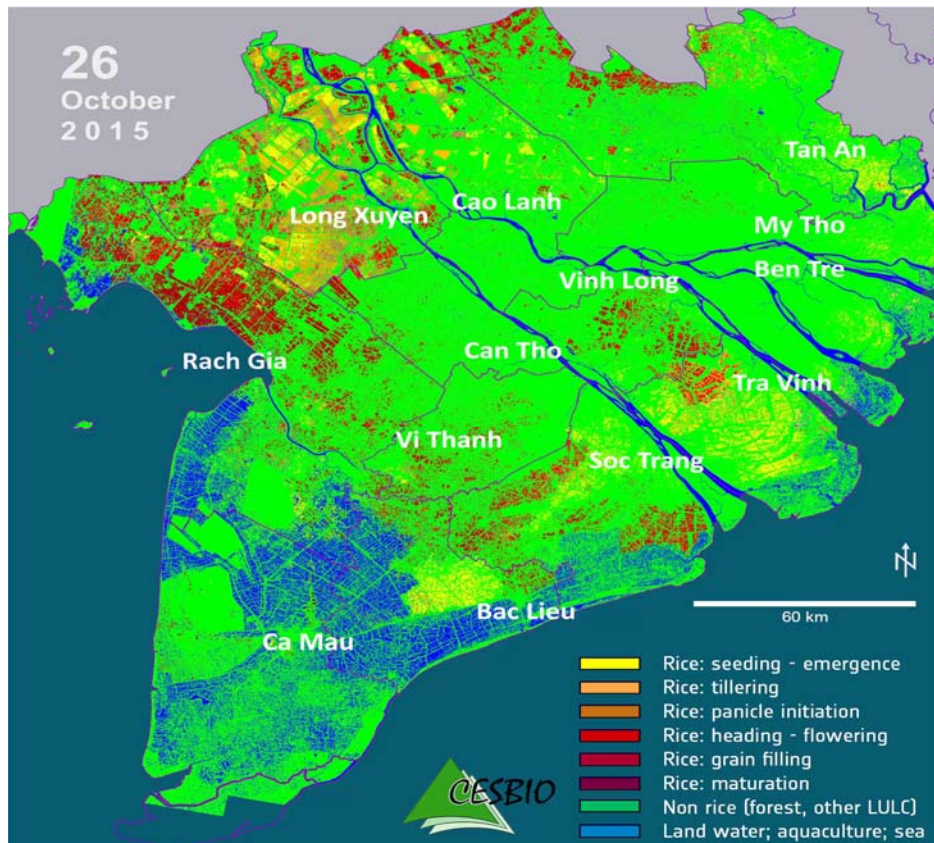


Sentinel-1 Results



European Space Agency

Monitoring of Crop Stages



Winter-Spring Rice 2015/16

- March 2015: 1.7 million ha rice
- March 2016: 1.4 million ha rice
- 16.5% loss in rice area due drought and salt water intrusion caused by El Niño
- 976,000 people affected, 67 million USD estimated damage
- Based on unprecedented Sentinel-1 time series

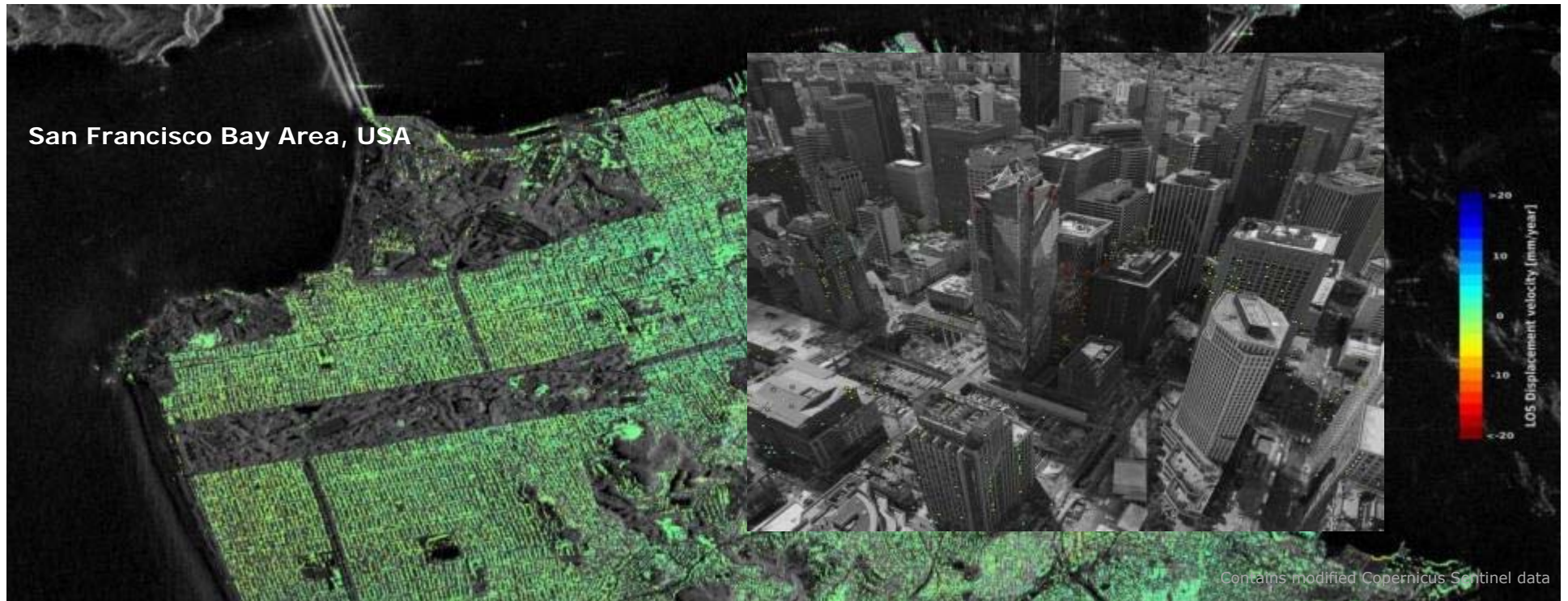


The Mekong Delta, Vietnam
300 km x 300 km, 20 m resolution



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Subsidence Monitoring



<http://insarap.org>

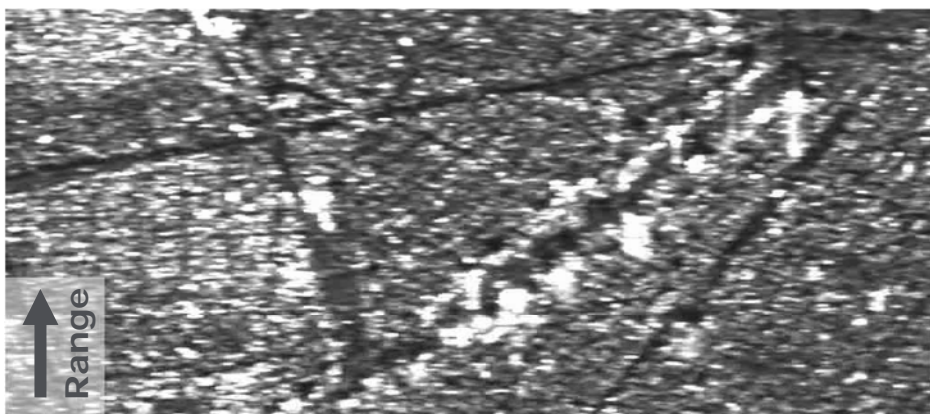


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SAR Tomography



Mexico City



250m

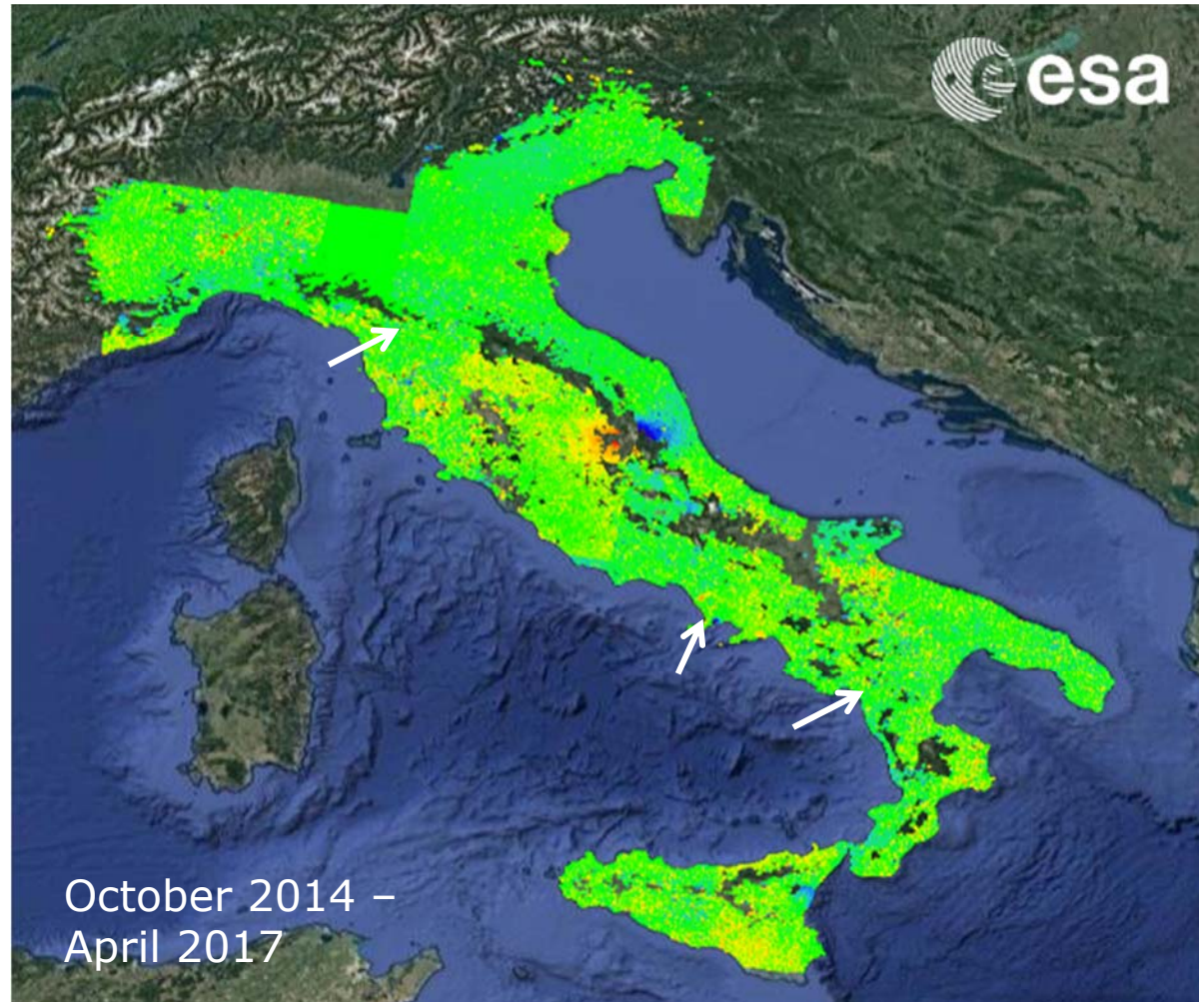
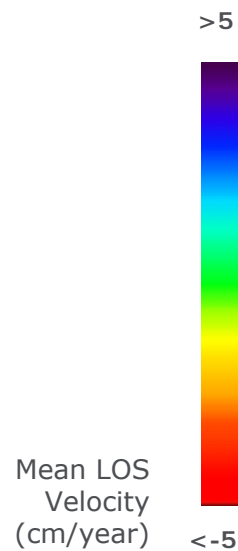
03.10.2014 – 04.09.2015
28 processed images



European Space Agency

Country-Level DInSAR

Parallel Small BAseline Subset
(P-SBAS) DInSAR algorithm:
Towards national-scale DInSAR
analysis

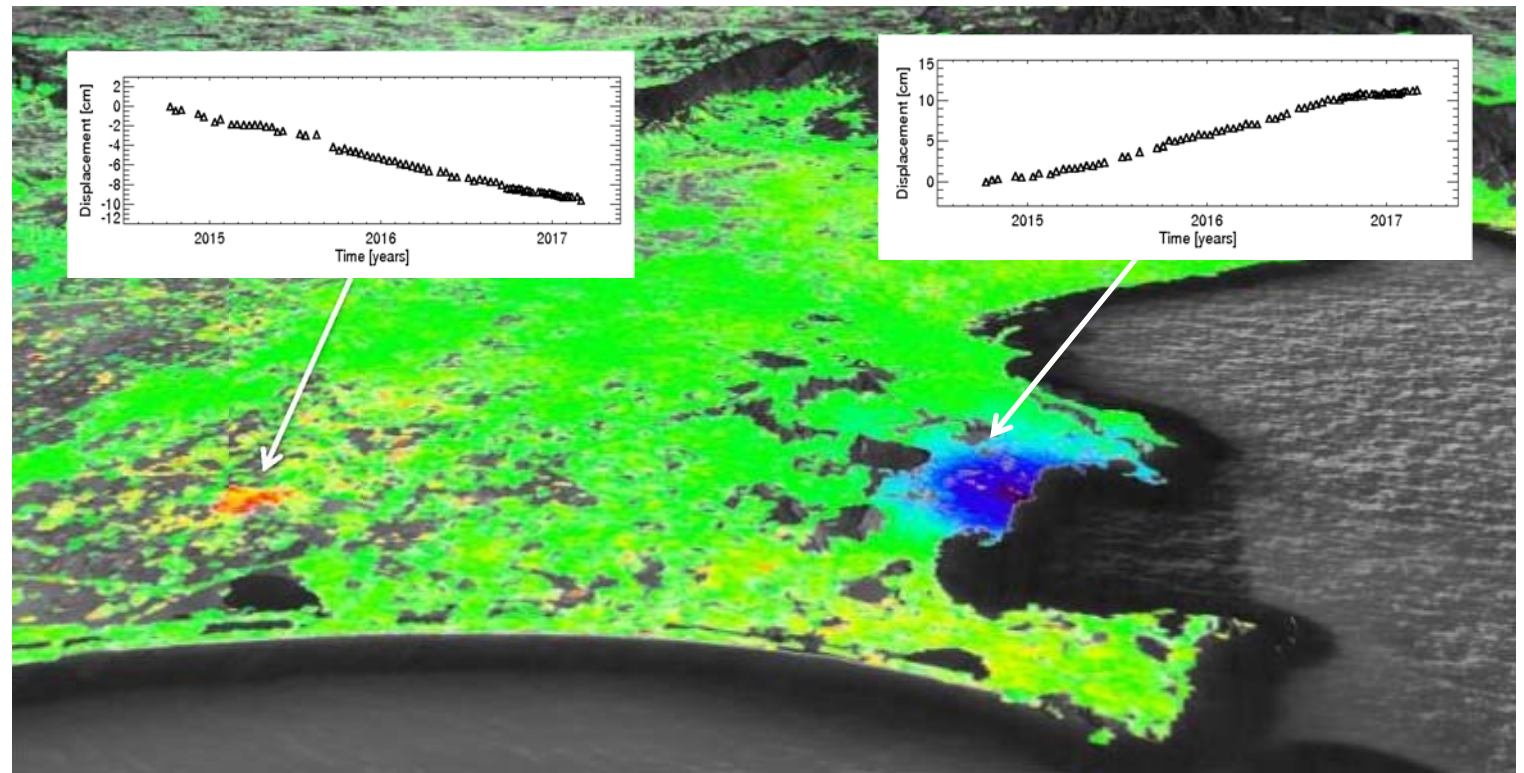
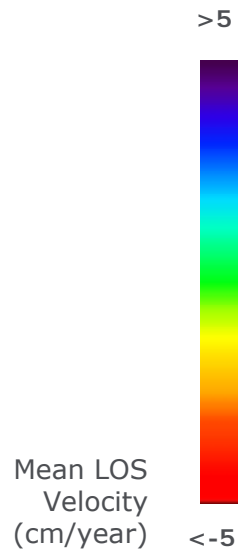


European Space Agency

Country-Level DInSAR



Volcanic activity,
Campania

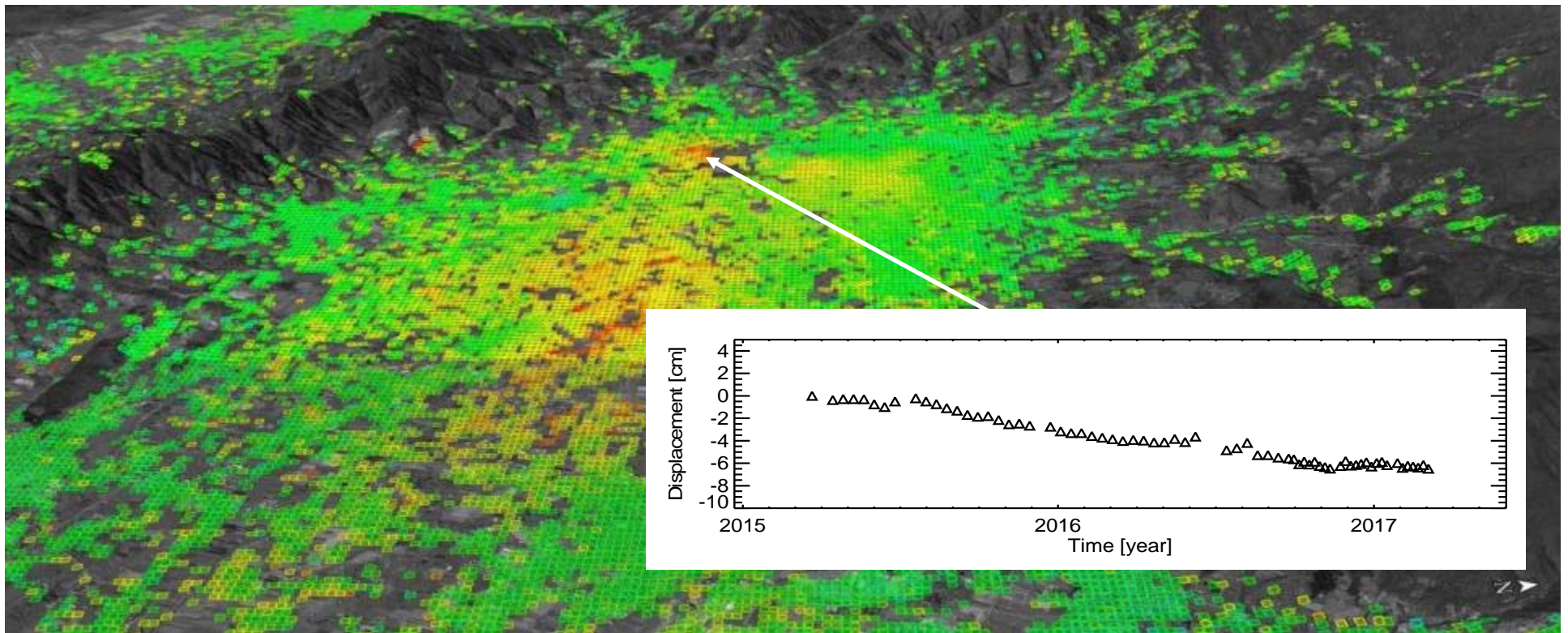


European Space Agency

Country-Level DInSAR



Pistoia, Tuscany: Subsidence due to water extraction

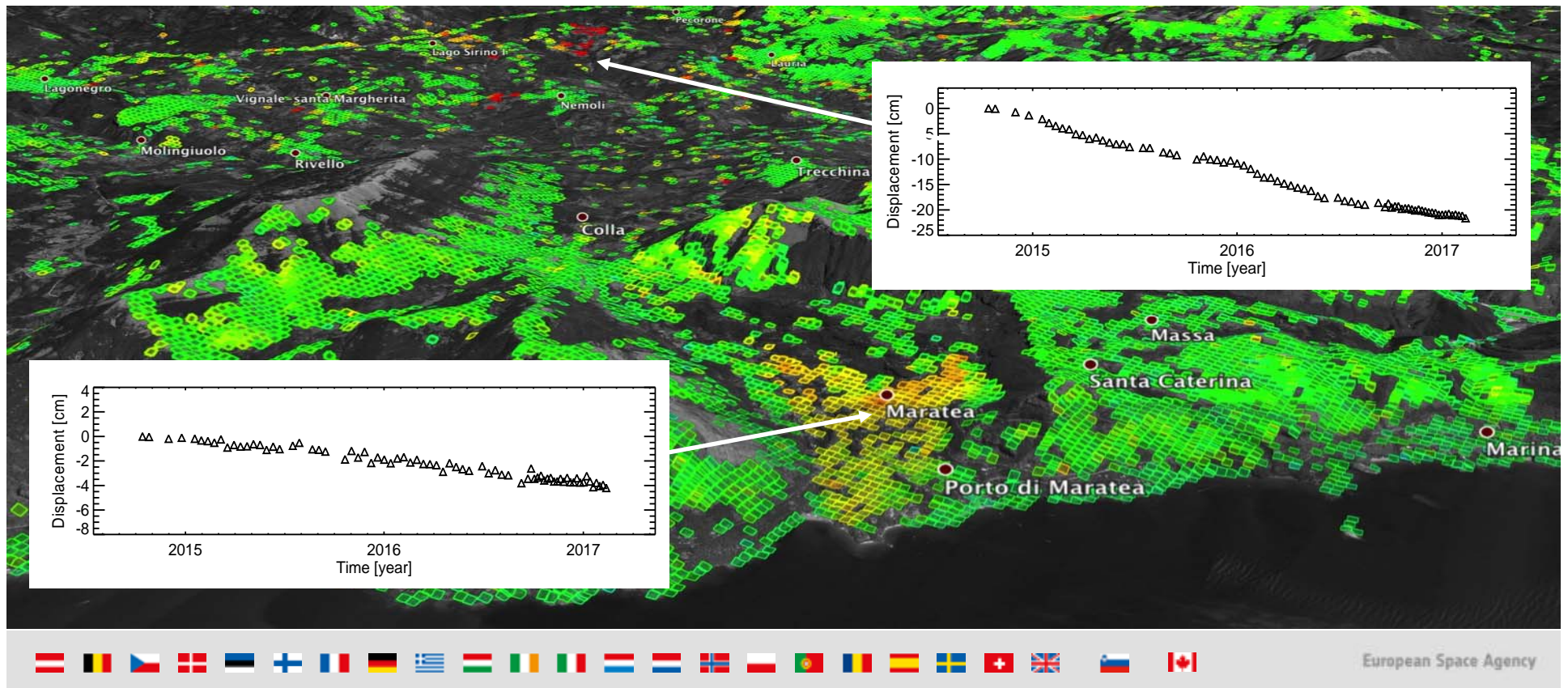


European Space Agency

Country-Level DInSAR



Maratea, Basilicata: Subsidence due to landslides

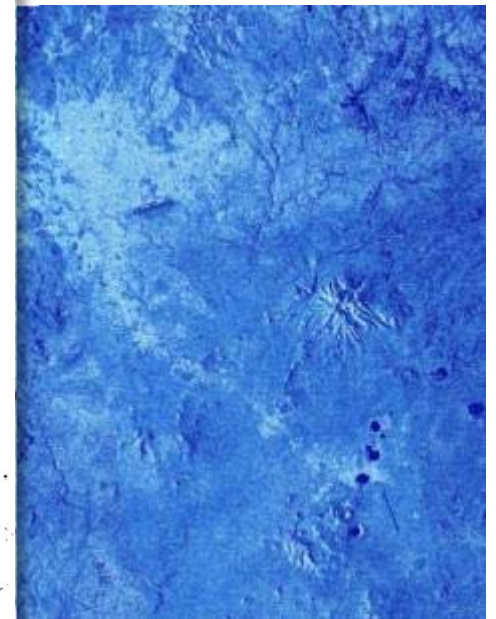
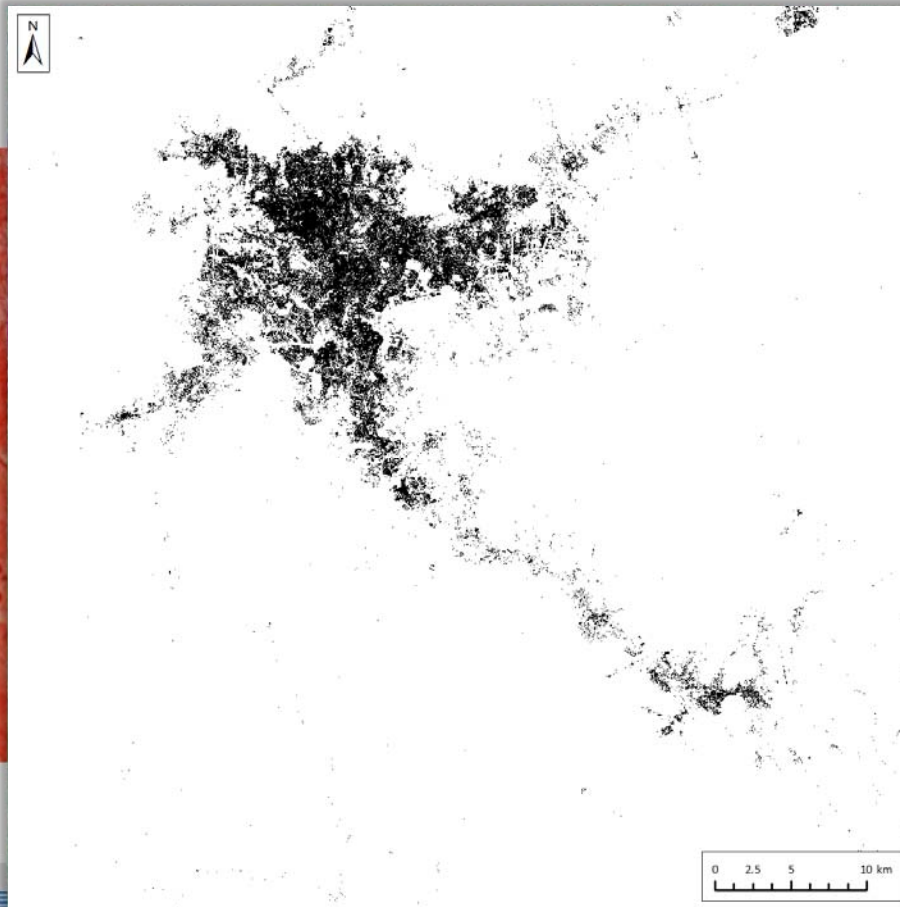


Global Urban Footprint

Addis Ababa, Ethiopia



σ^0 max

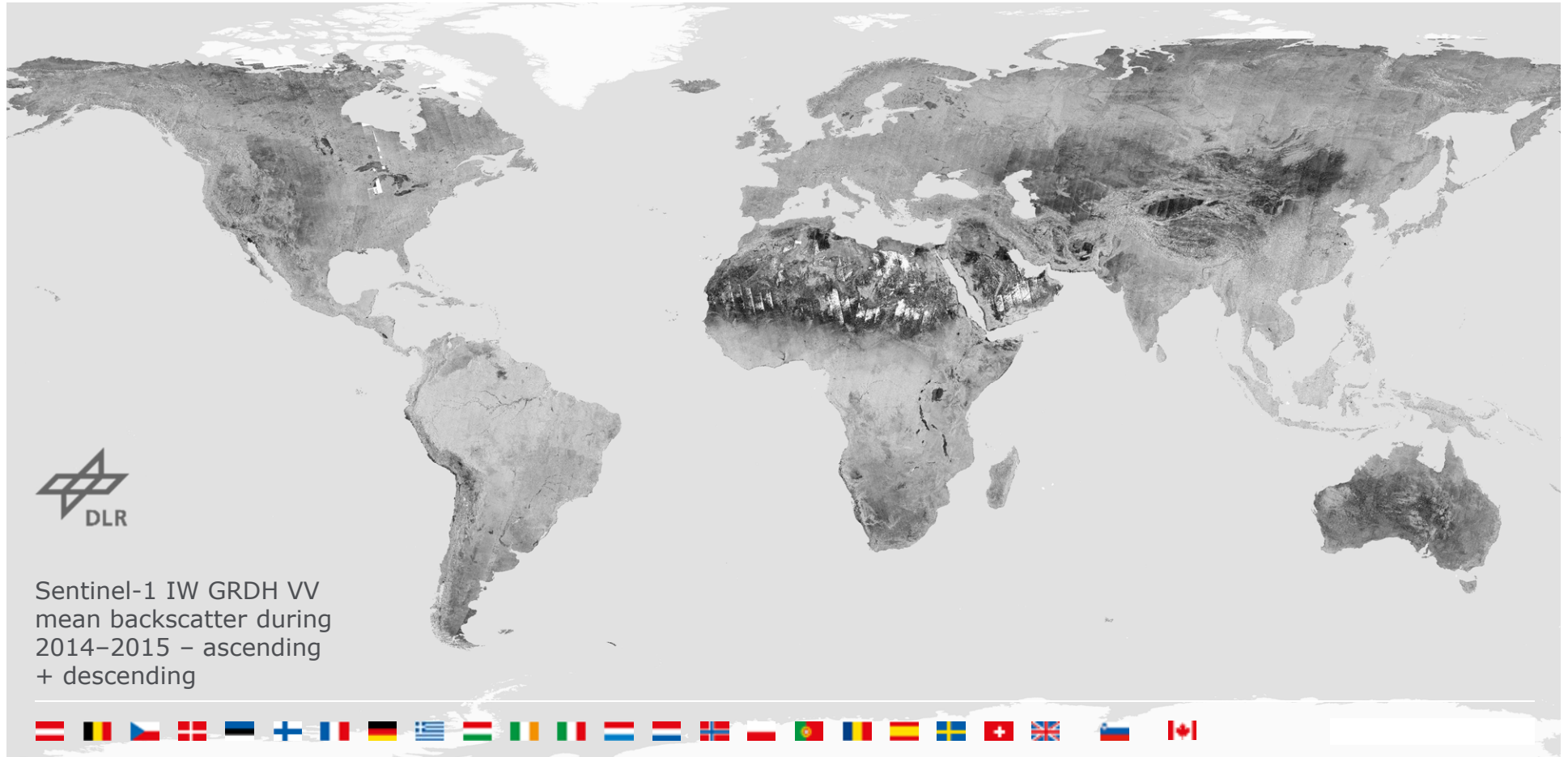


σ^0 standard deviation



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Global Urban Footprint



Global Urban Footprint

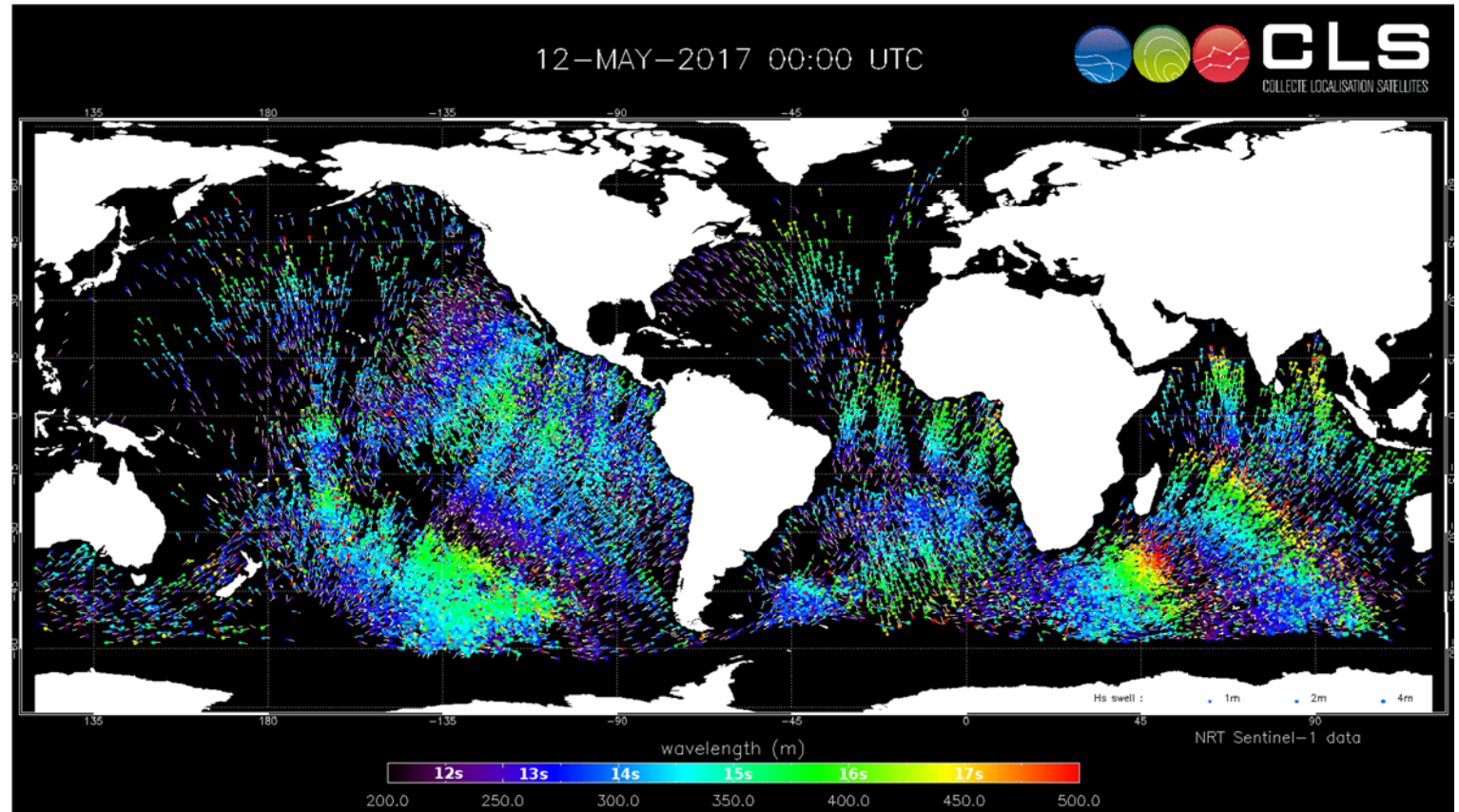


European Space Agency

Global Near-Real Time Swell Tracking



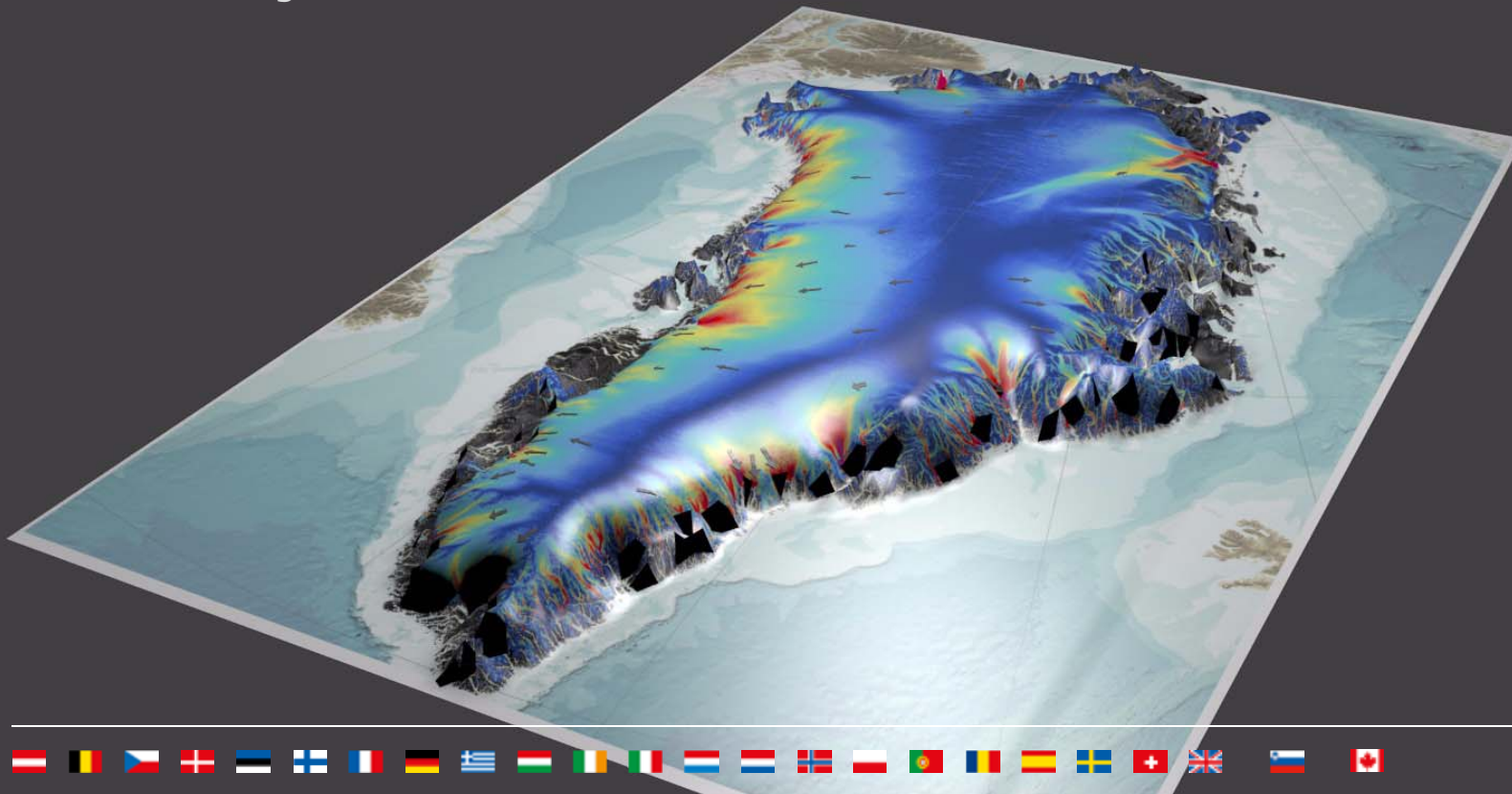
Sentinel-1A and
Sentinel-1B
Wave Mode over
10 days



European Space Agency

Ice Sheet Monitoring

Routine observations of
ice sheet margins

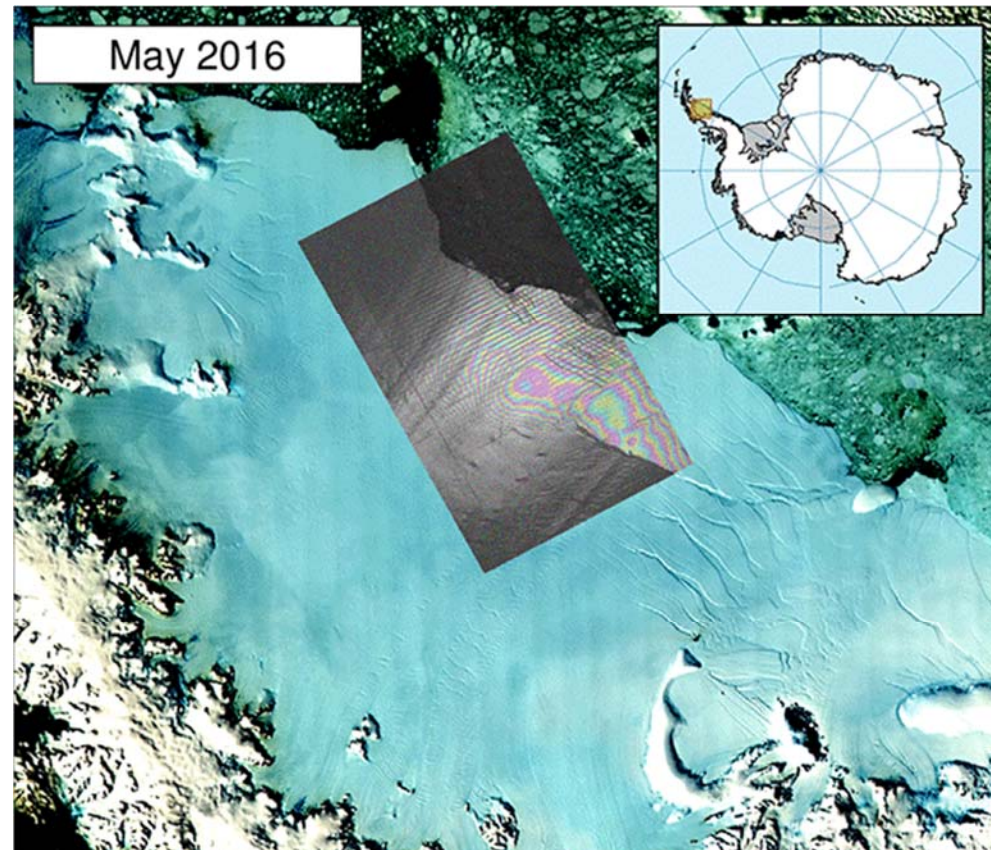


European Space Agency

Ice Shelf Monitoring: Larsen-C



- Seemed relatively stable until January 2016
- In January 2017 alone it travelled 20 km, reaching a total length of about 175 km
- As the crack grew, it branched off towards the edge of the shelf
- On July 12 part of the ice shelf had finally broken away

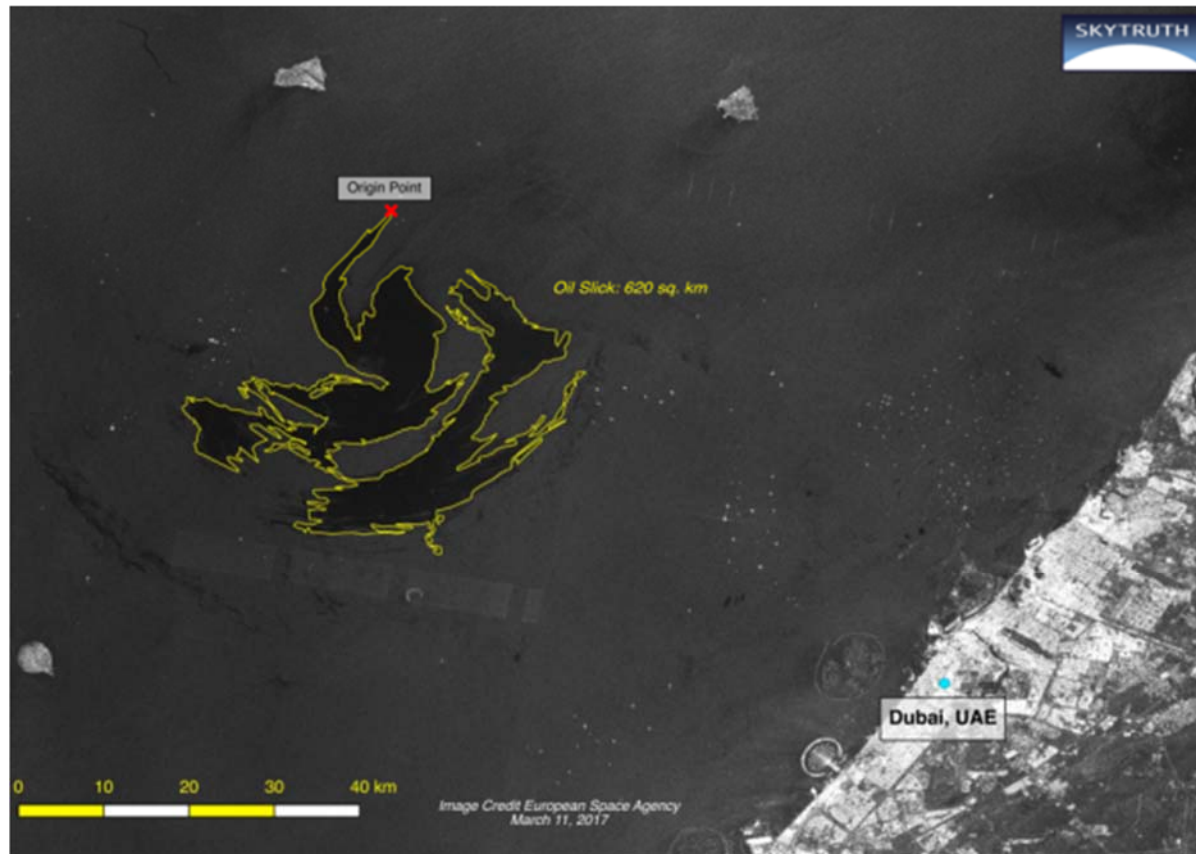


0 25 50 75 100 km



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Oil Spill Monitoring

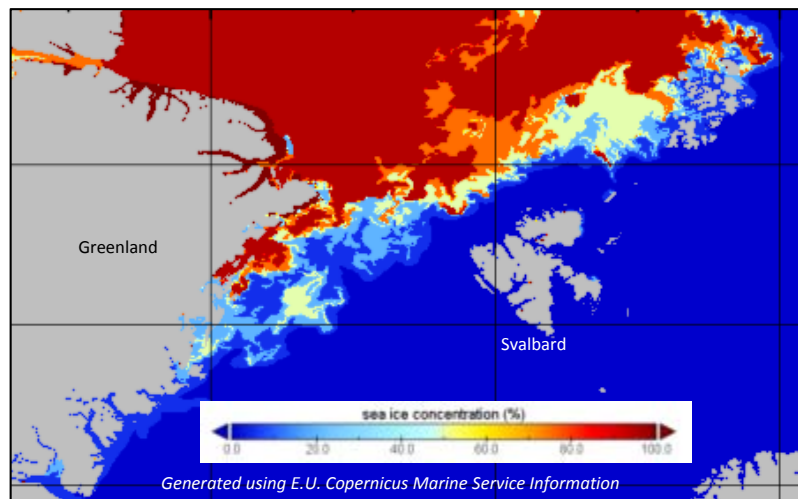


European Space Agency

Sentinel-1: Results from Operational Services

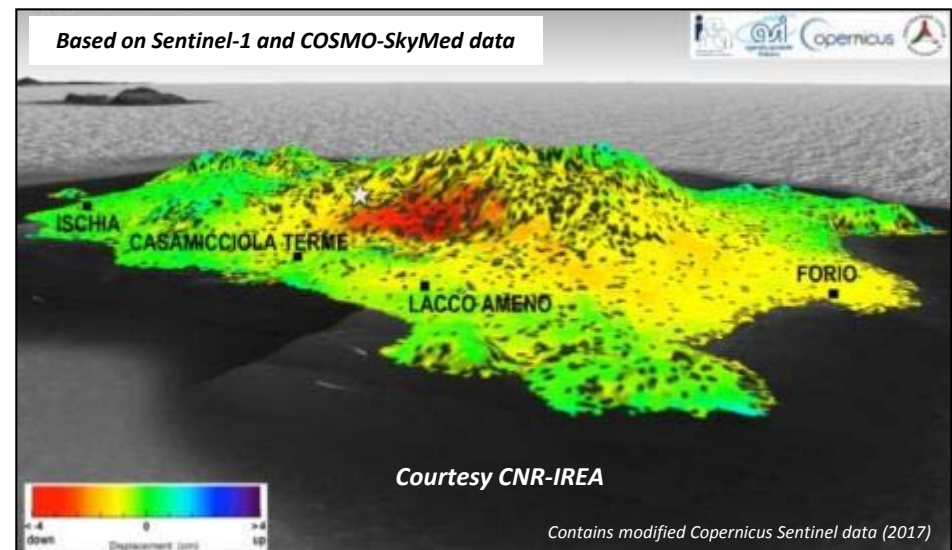


*High resolution sea ice concentration charts
(early September 2017)*



The Copernicus Marine Environment Monitoring Service provides daily high resolution sea ice concentrations derived from Sentinel-1 mission data.

*Ischia island (Italy)
Map of displacements following the 21 August earthquake (Md 4.0)*



One of the objectives of the Italian Civil Protection is to obtain quickly information from its competence centres (in this case CNR-IREA and ASI) on ground movements and deformations due to earthquakes.



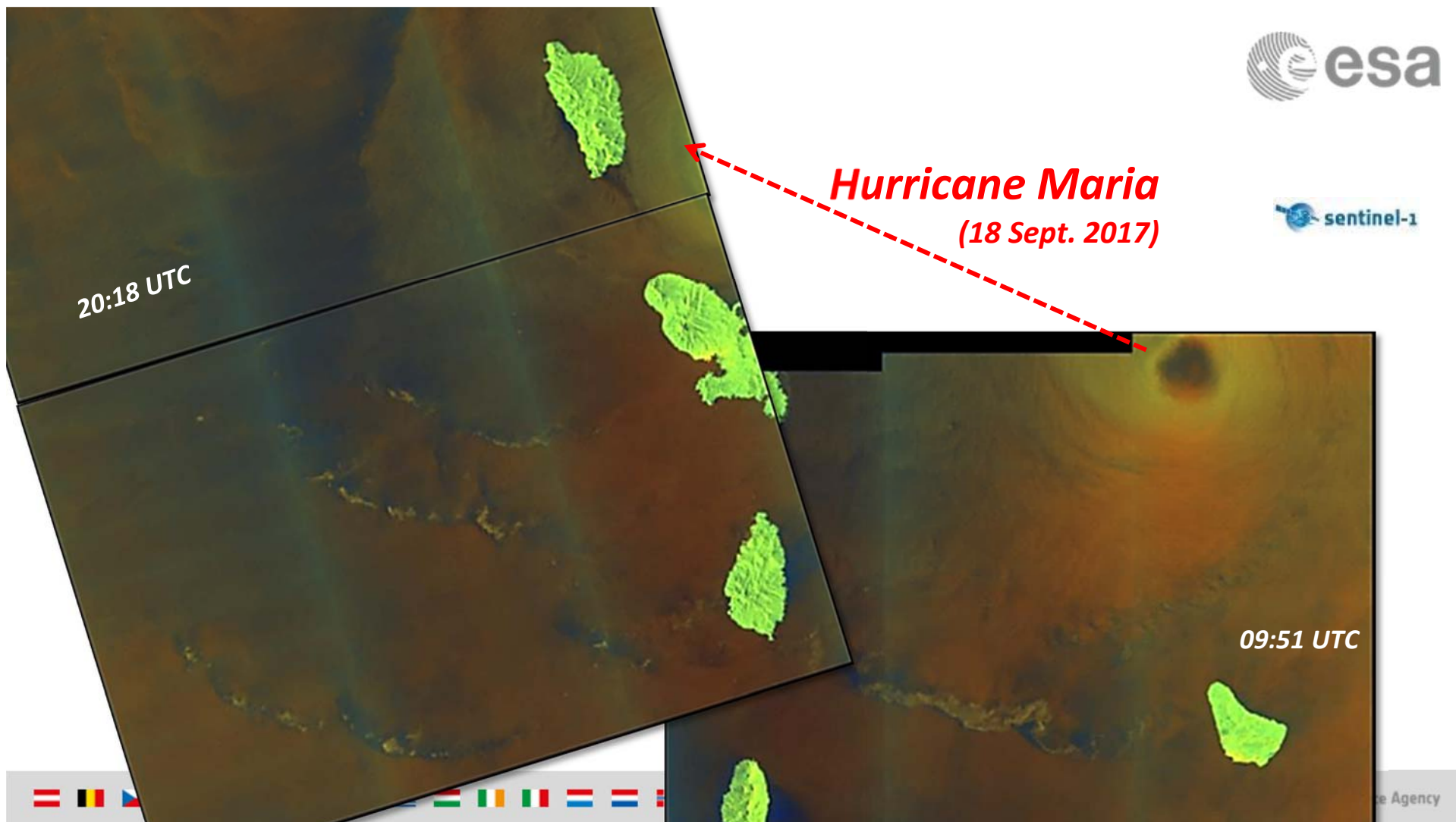
European Space Agency



Hurricane Maria
(18 Sept. 2017)

09:51 UTC

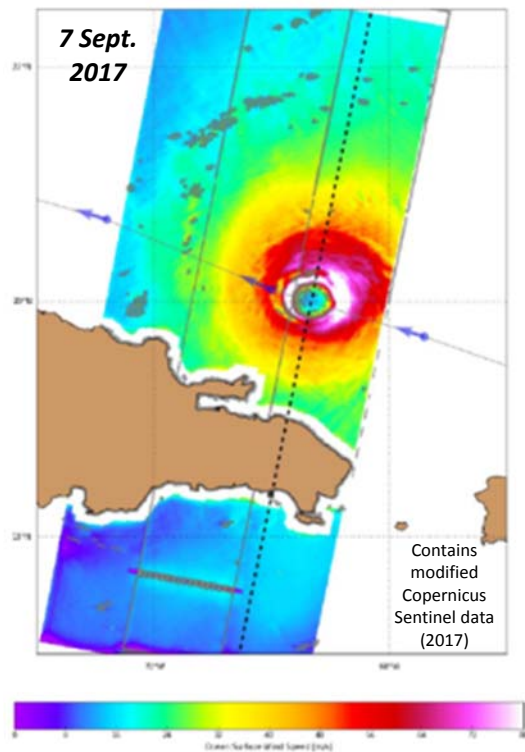
20:18 UTC



Sentinel-1: More Results from Science Teams

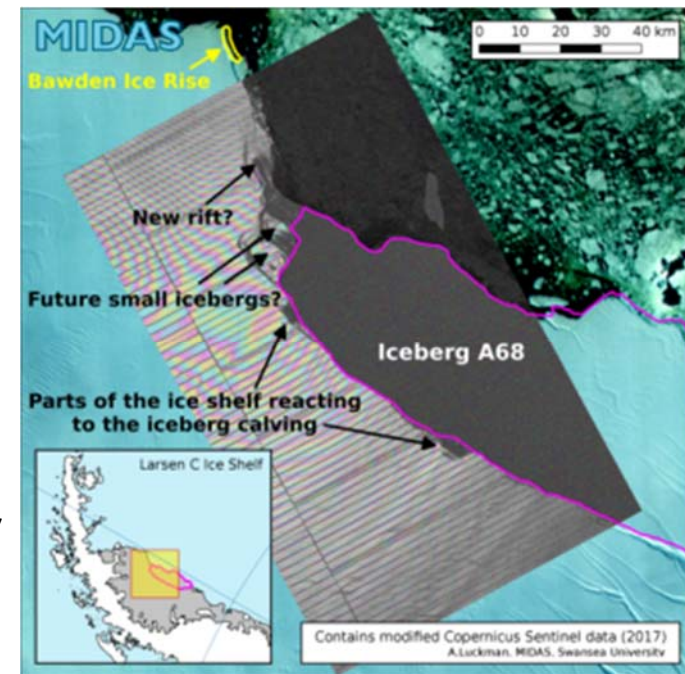


Experimental wind field of Irma hurricane



Courtesy
IFREMER
(F)

Larsen-C ice shelf calving in July 2017



Courtesy
Swansea
University
(UK)

See also paper in *Nature Climate Change*:
"Impacts of the Larsen-C Ice Shelf calving event", Univ. of Leeds (UK)



European Space Agency



Sentinel-2 Results

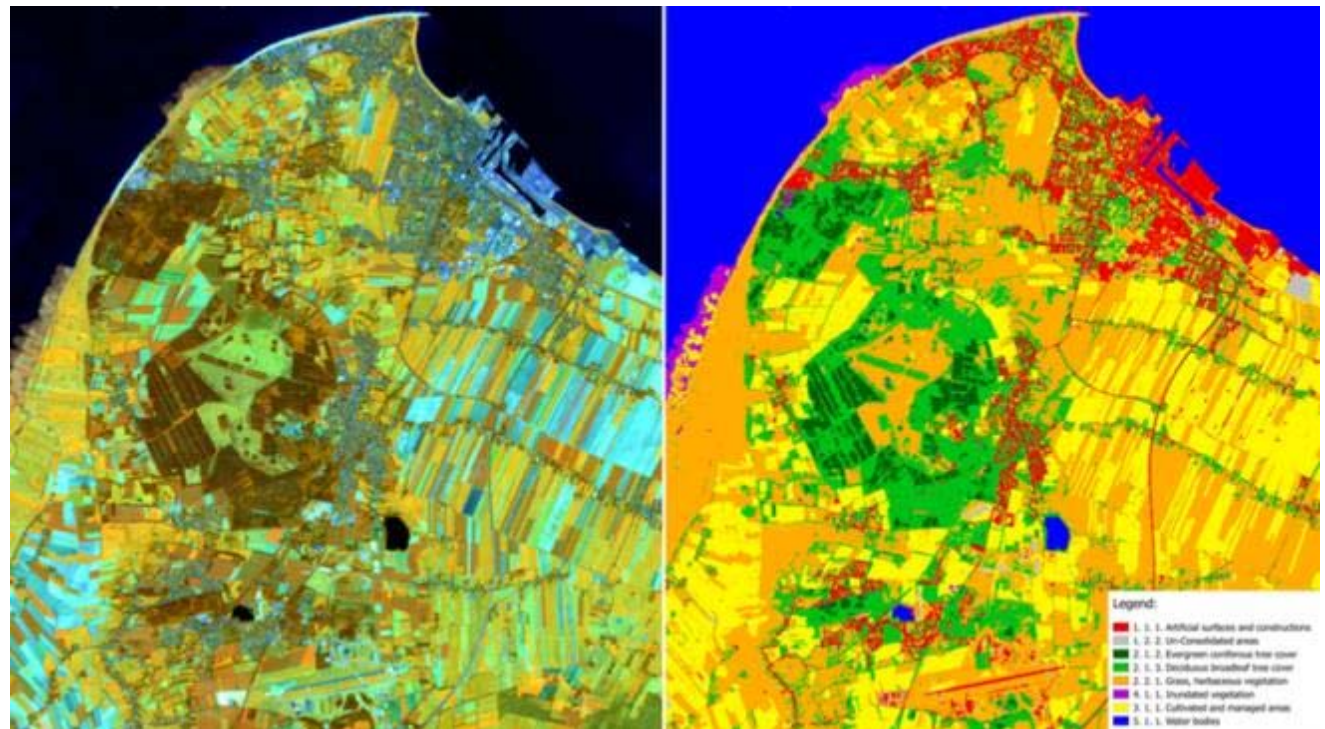


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Global Land Cover



- Advanced land cover classification strategies to exploit the new capabilities of Sentinel-2 in view of generating global land cover maps



Space Research Centre
Polish Academy of Sciences



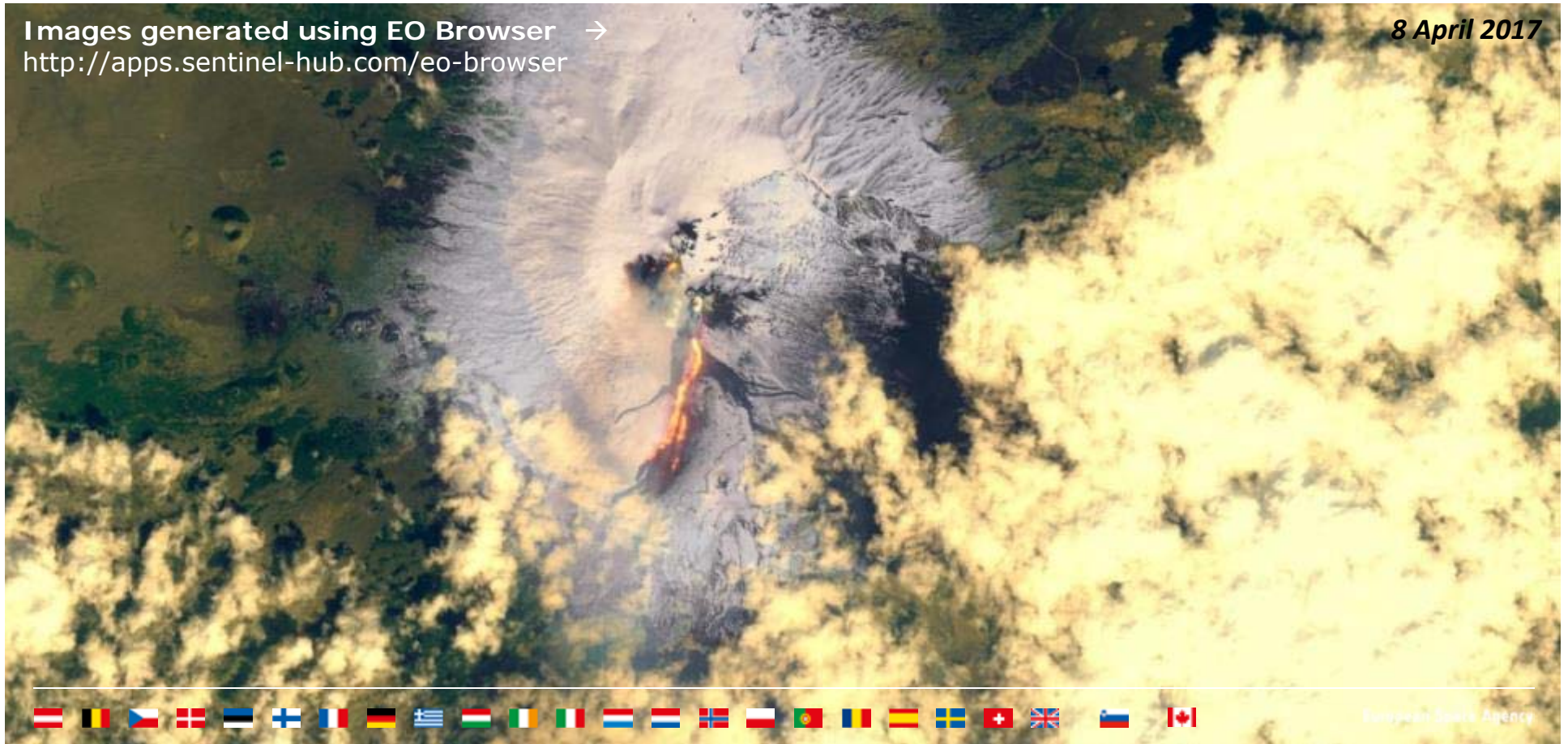
European Space Agency

Mount Etna Eruption, March–April 2017



Images generated using EO Browser →
<http://apps.sentinel-hub.com/eo-browser>

8 April 2017



European Space Agency

Endorsement of Copernicus for Use within the CAP



- Commissioner P. Hogan:
"...already Paying Agencies using data of the Sentinels ... In the near future satellite monitoring of parcels could replace most of the OTSC – this kind of simplification is very much in my plans..."



European Space Agency

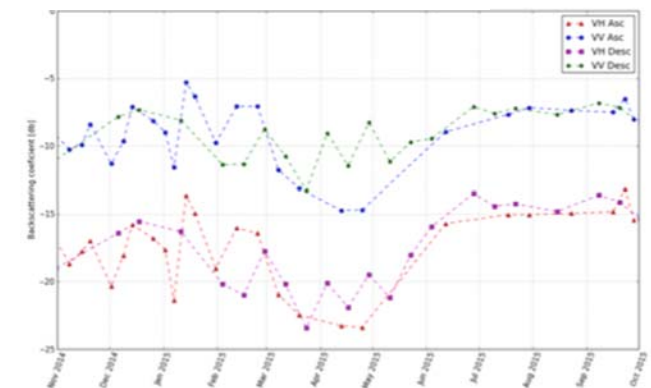
Dynamic National Crop Type Mapping



- *Sen4CAP* – S-1/2 time series for Land Parcel Identification System of the Czech CAP – machine learning



Sentinel-1 time series

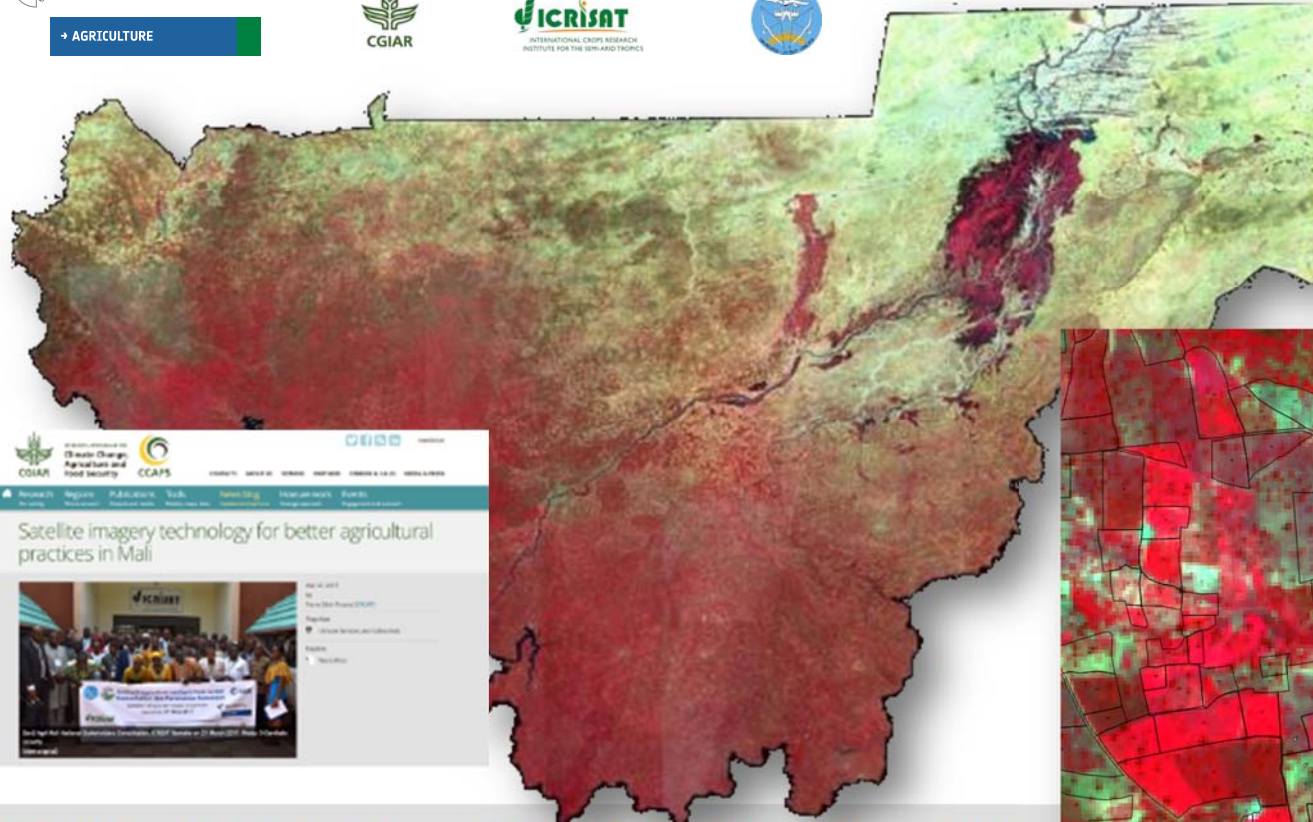


European Space Agency

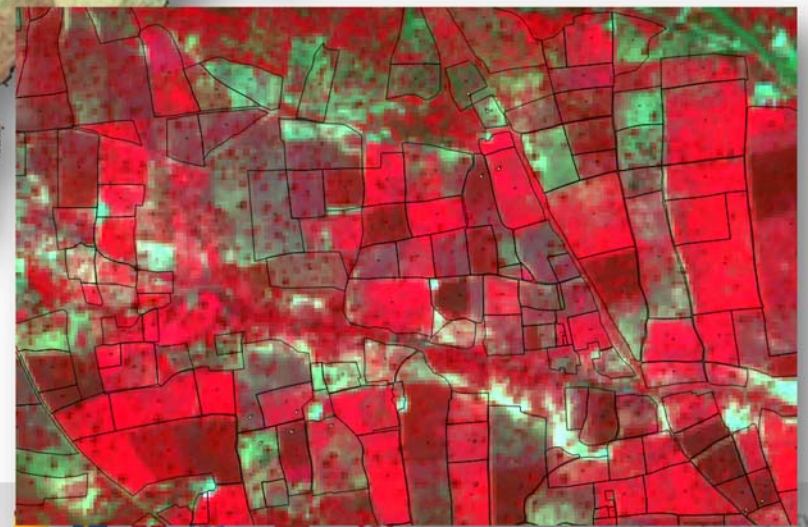
Mali Food Security: National statistics, Crop Damage



→ AGRICULTURE



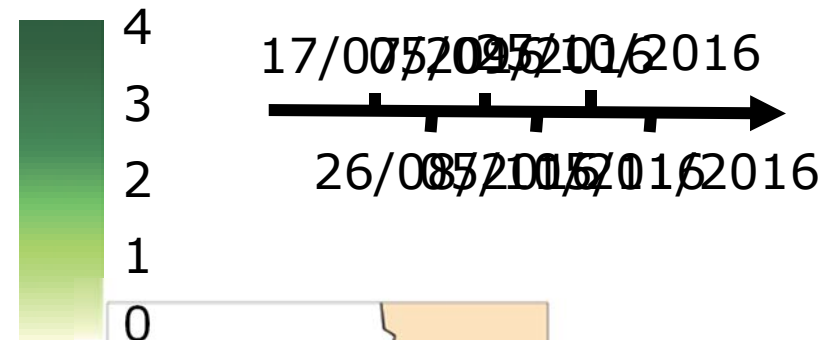
2016 Oct 5–Nov 25



Mali: Monitoring the Growth of Cotton



→ AGRICULTURE



17/00572016
26/0872016
17/0972016
16/1072016



Koutiala



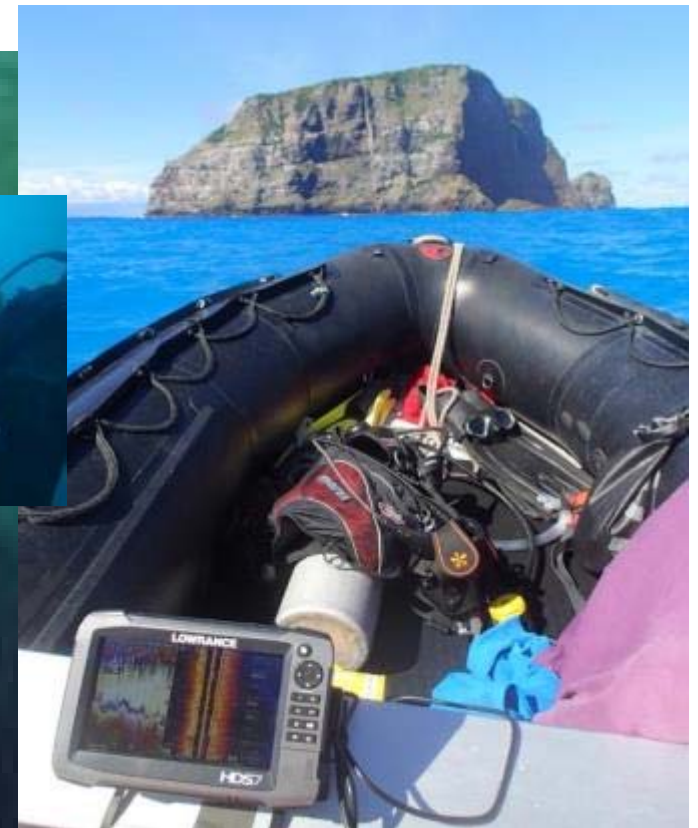
European Space Agency

Coral Reef Monitoring



Marquesas Islands, French Polynesia

February 2017



Contains modified Copernicus Sentinel data [2017],
Sen2Coral project, Dr. John Hedely

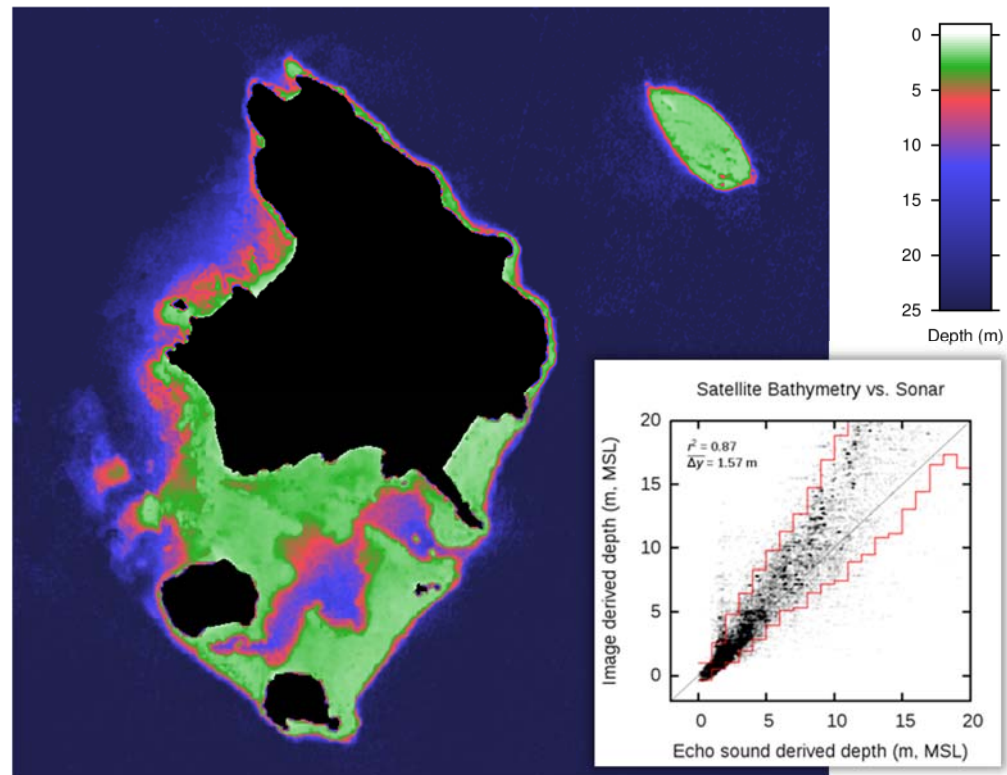


European Space Agency

Shallow Water Bathymetry



Lizard Island, Great Barrier Reef



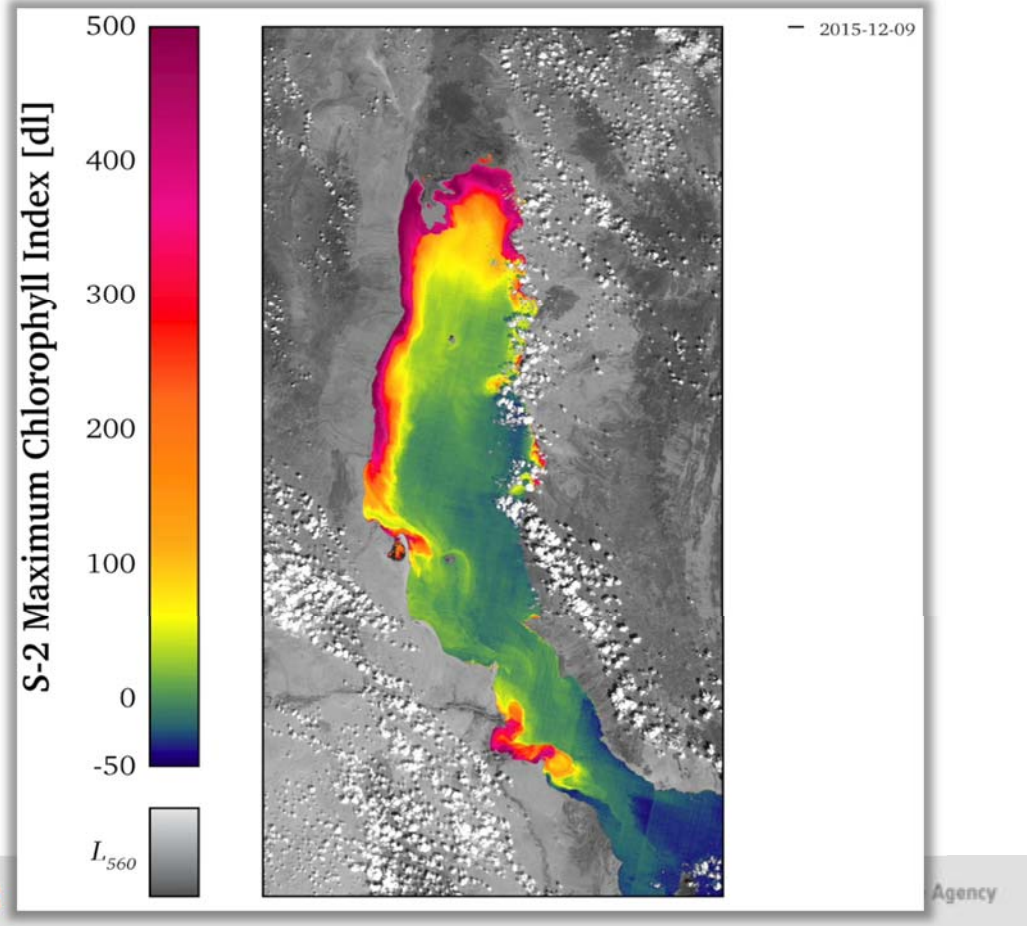
European Space Agency

Water Quality Monitoring

Lake Turkana, Ethiopia



Getintravel

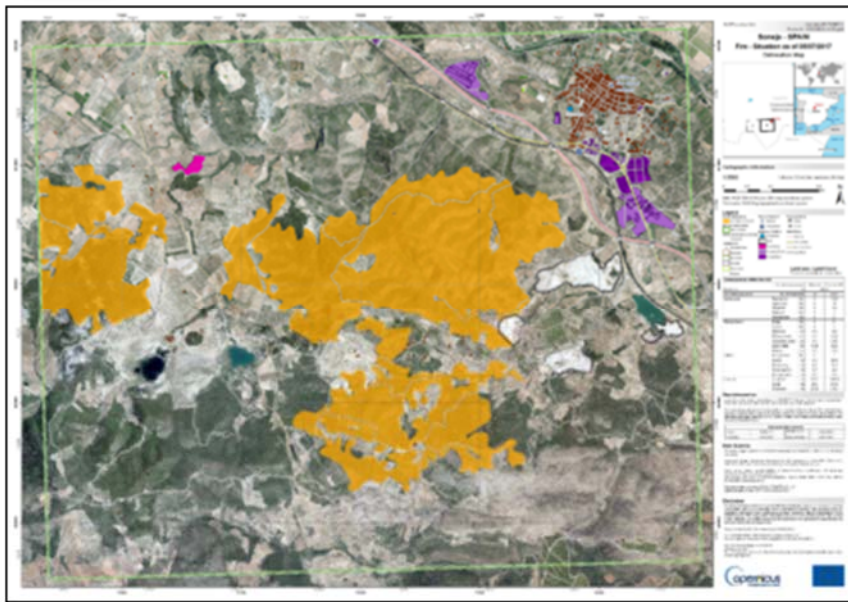


Agency

Sentinel-2: More Results

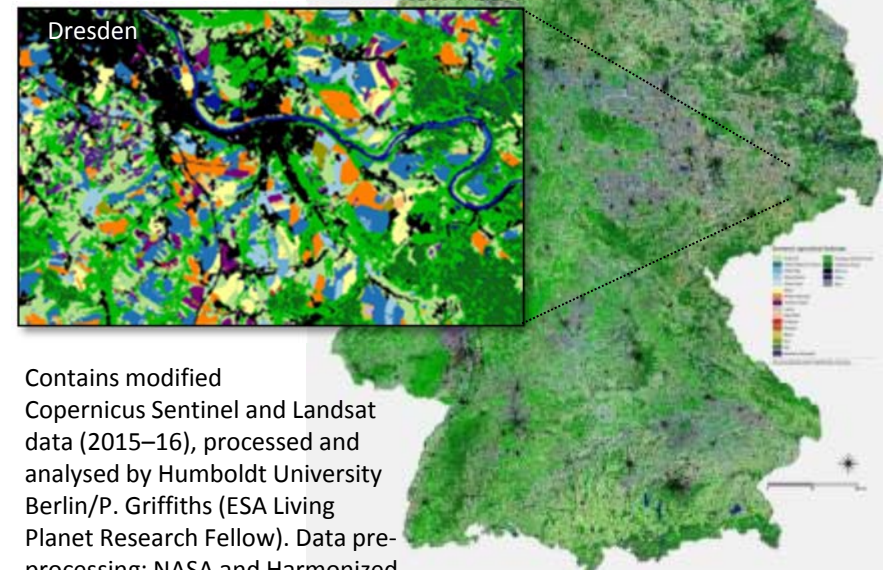


Forest Fires in Castellón Province (E)



Activation EMSR211 of Copernicus Emergency Management Service

*Land-cover classification
map of Germany
(based on Sentinel-2
and Landsat-8 data)*

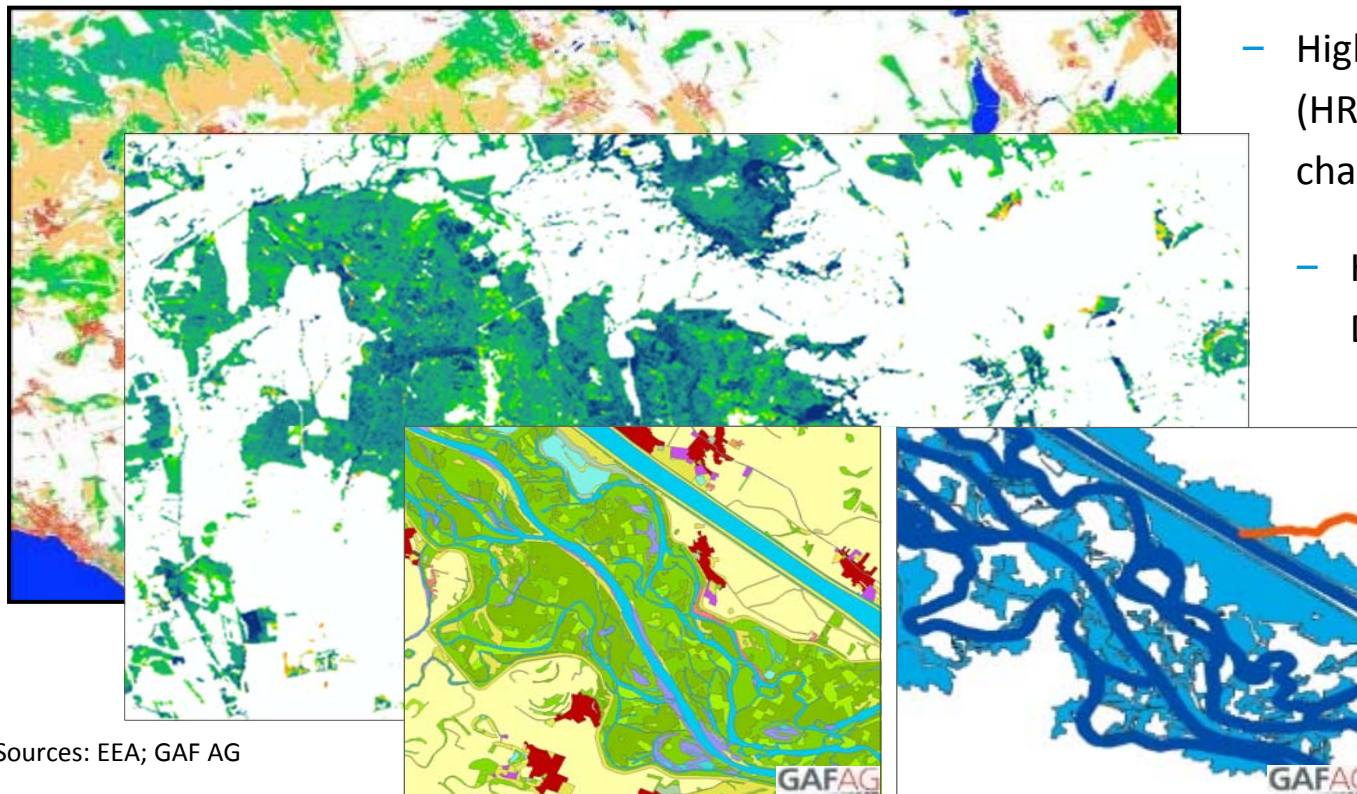


Contains modified
Copernicus Sentinel and Landsat
data (2015–16), processed and
analysed by Humboldt University
Berlin/P. Griffiths (ESA Living
Planet Research Fellow). Data pre-
processing: NASA and Harmonized
Landsat–Sentinel initiative



European Space Agency

Sentinel-2: Copernicus Land Monitoring Services



- High-resolution Layers (HRL) with land cover/ use characteristics
- HRL Forest: Tree Cover Density [%]
- European Riparian Zones

Sources: EEA; GAF AG



European Environment Agency



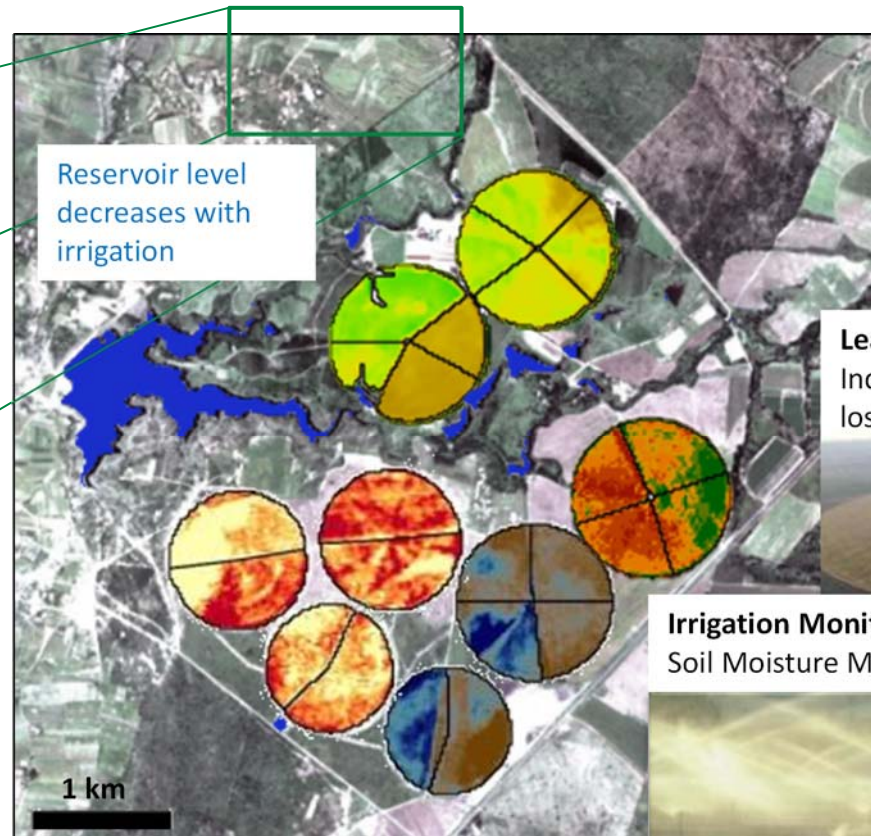
European Space Agency

Sentinel-2 Time-Series for Agriculture e.g. in Africa

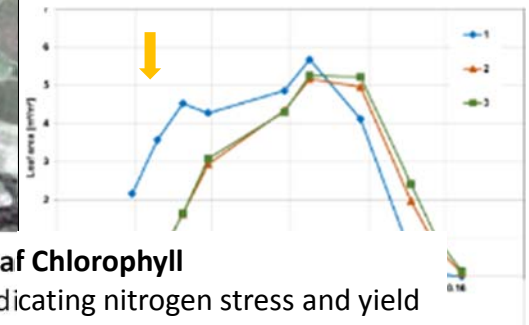
Spatial resolution of S-2 now also allows monitoring of small holder farms.



Free, open and transparent Sentinel data & IT-platforms (e.g. ESA's FS-TEP) promote more sustainable and more productive agriculture everywhere on the Globe, in industrialized and developing countries.



Crop Growth Monitoring



Leaf Chlorophyll

Indicating nitrogen stress and yield losses



Irrigation Monitoring Soil Moisture Mapping



www.vista-geo.de

Sentinel-2: Monitoring Infrastructure

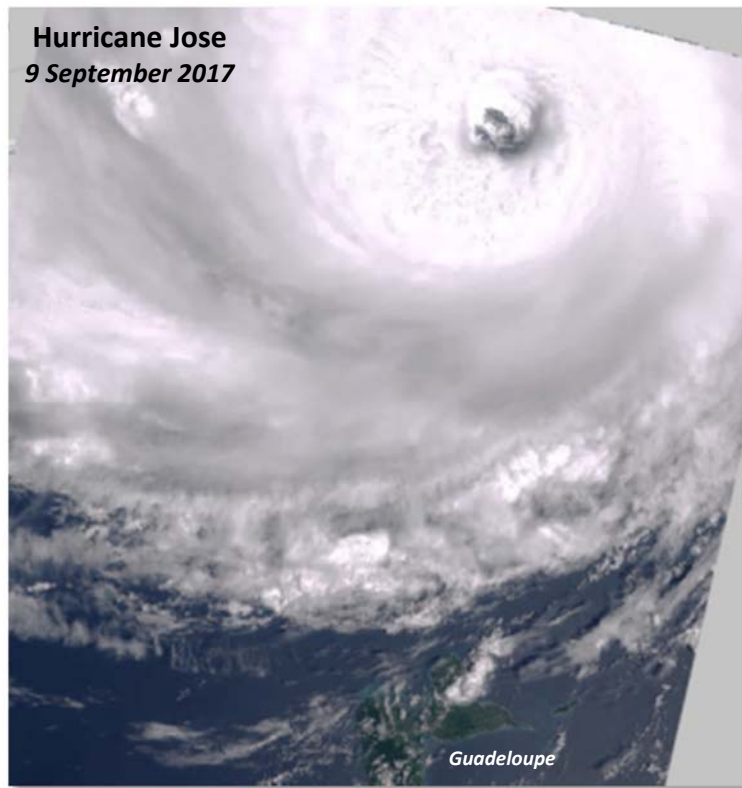


Yavuz Sultan Selim
Bridge, Istanbul

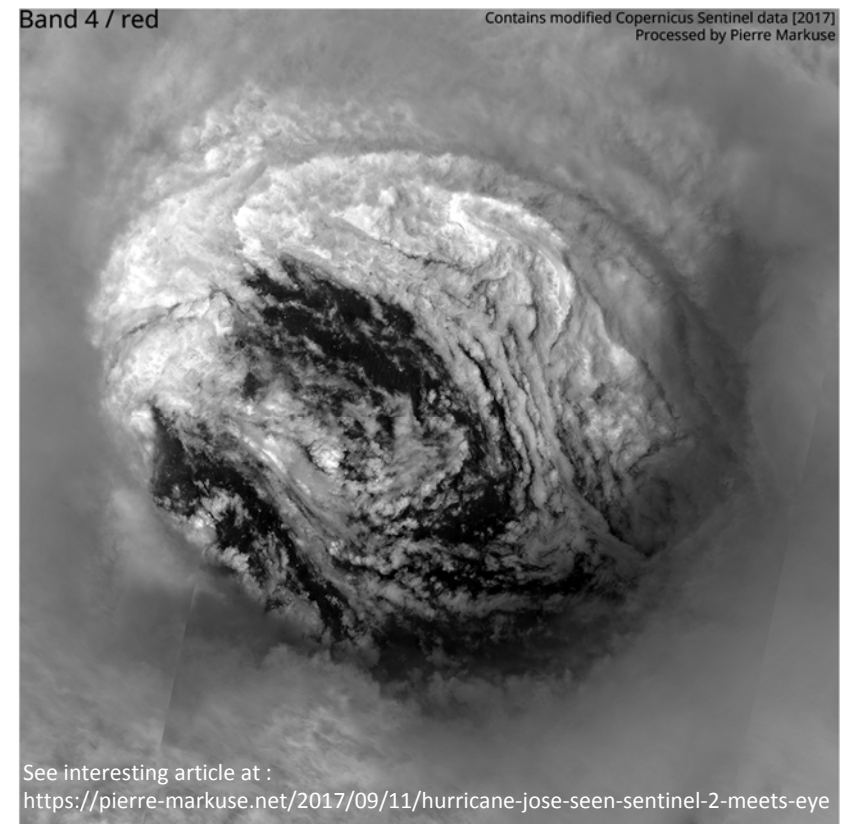


European Space Agency

Sentinel-2: Monitoring Hurricane Jose

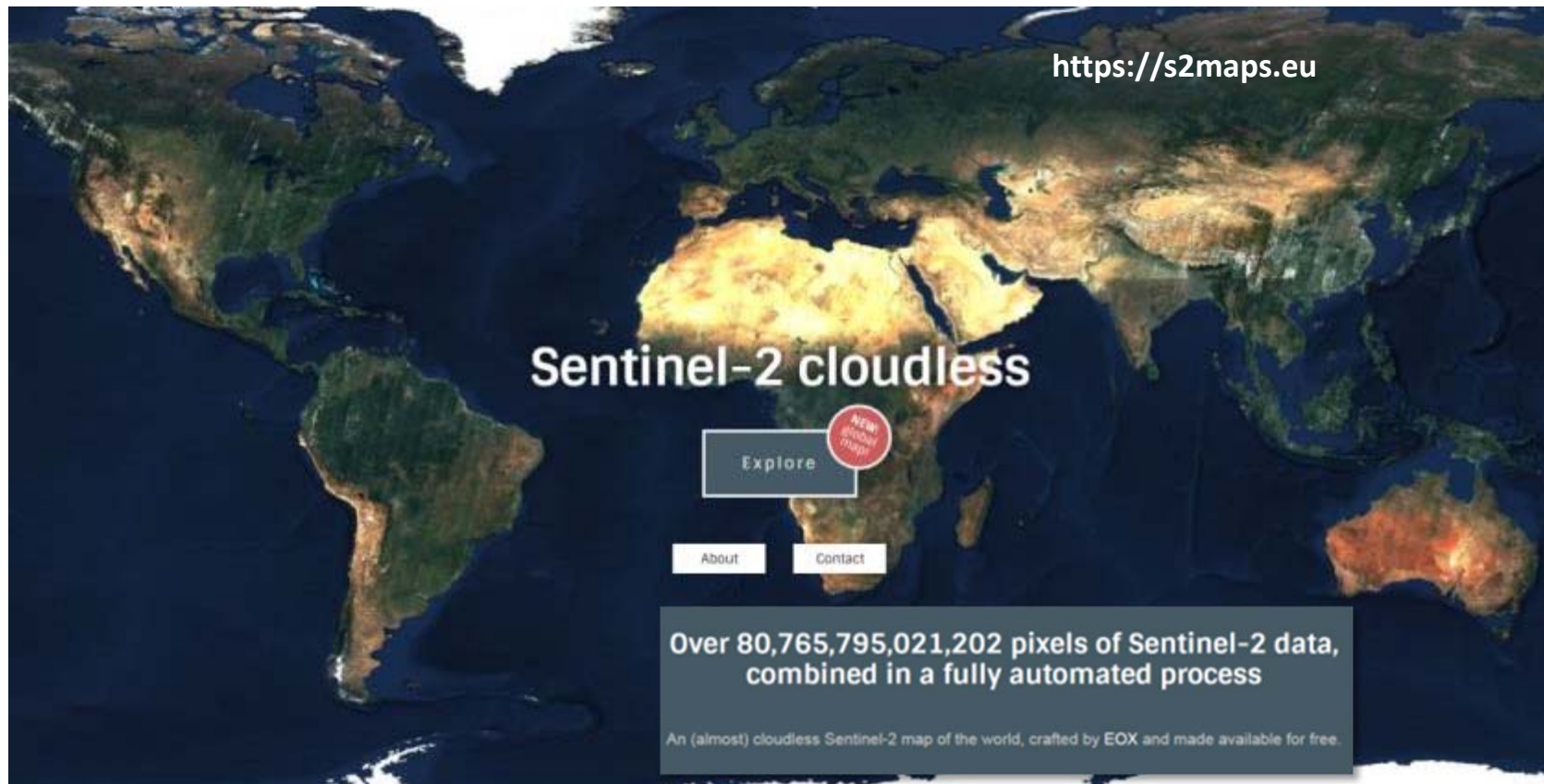


Contains modified Copernicus Sentinel data (2017)



European Space Agency

Sentinel-2: Cloudless World Map



European Space Agency



Sentinel-3 Results



European Space Agency

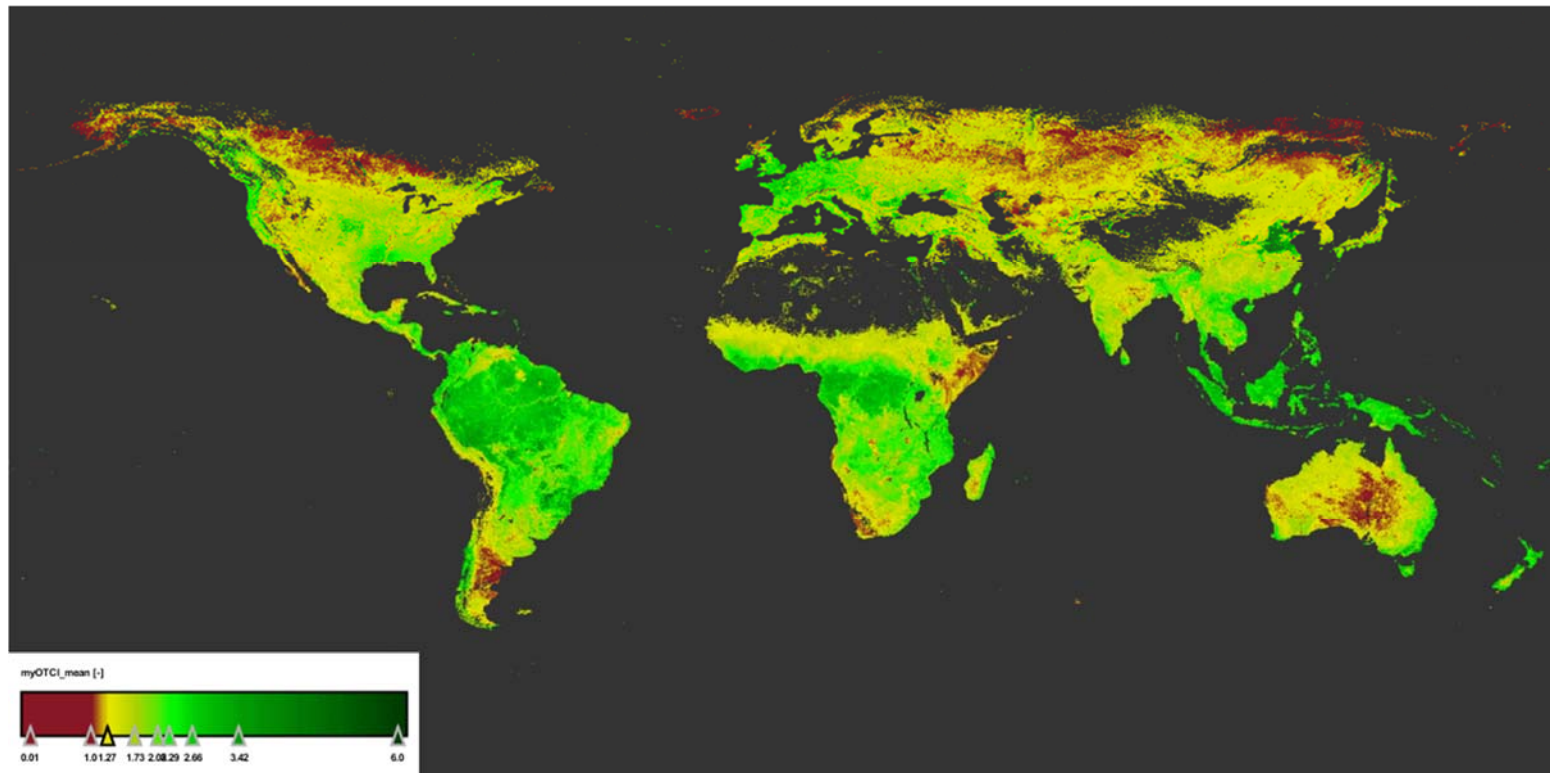
Monitoring Chlorophyll Index



1 April–27 May 2017

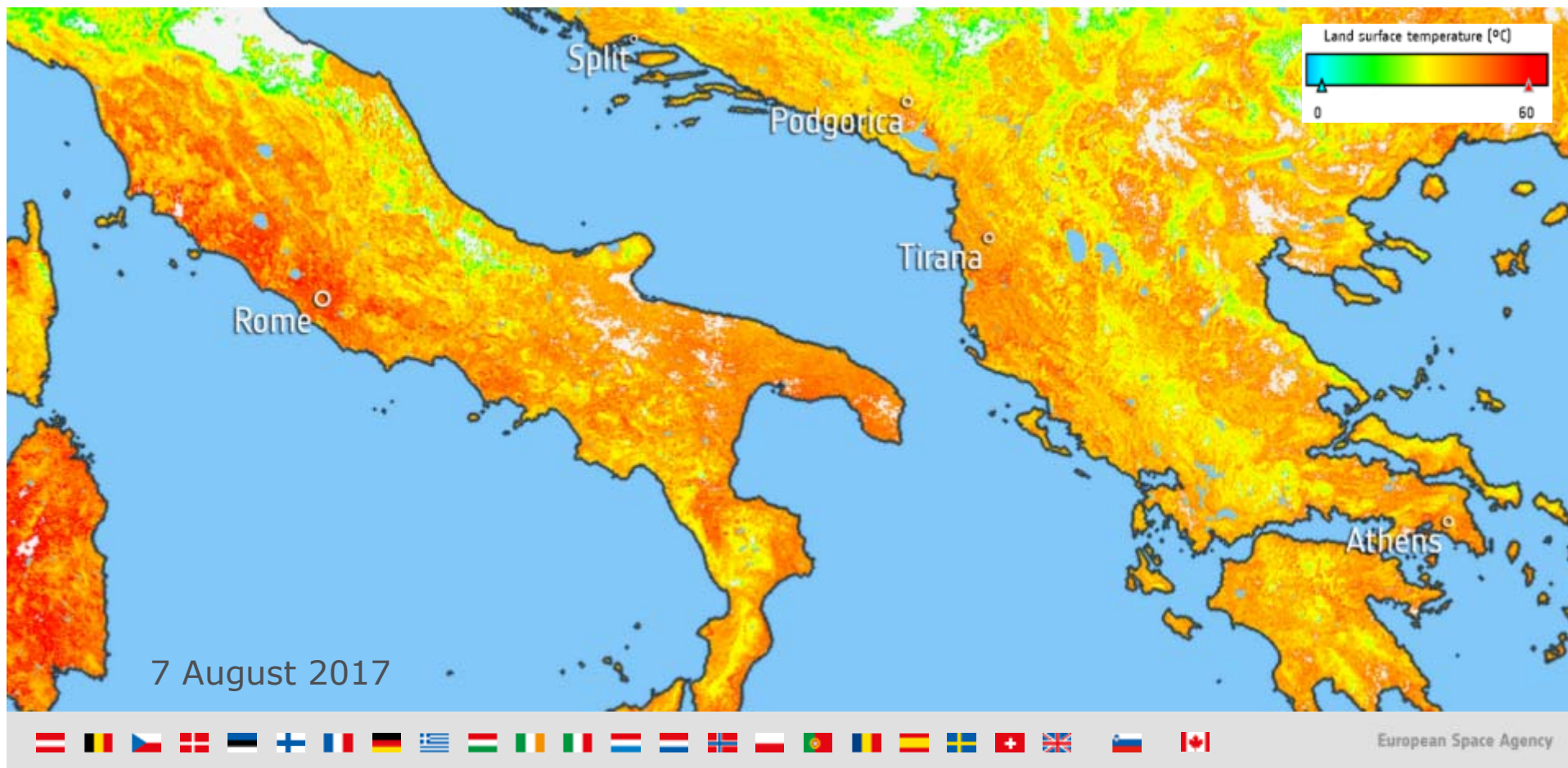
UNIVERSITY OF
Southampton


BROCKMANN
CONSULT



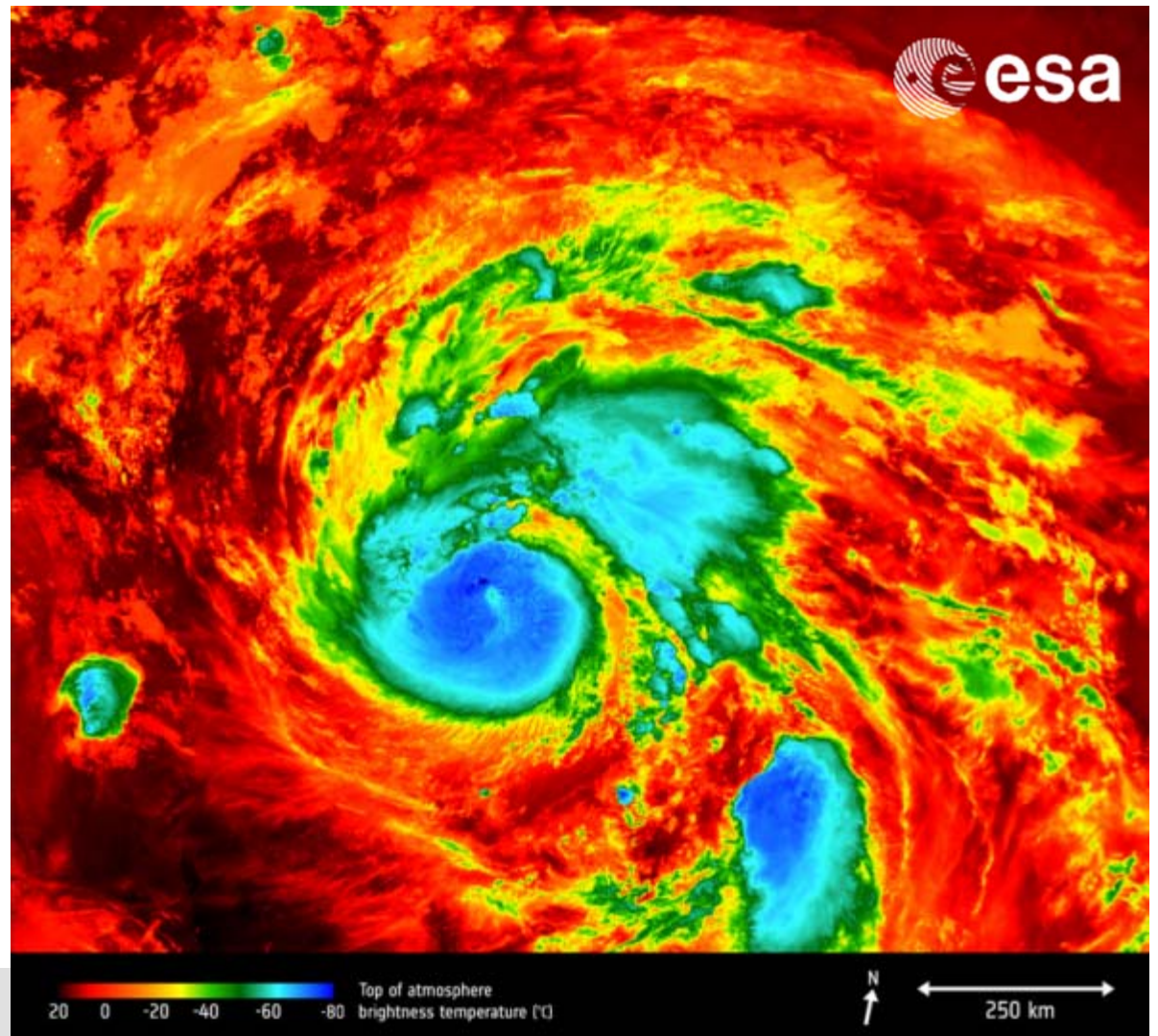
European Space Agency

Monitoring Heatwaves



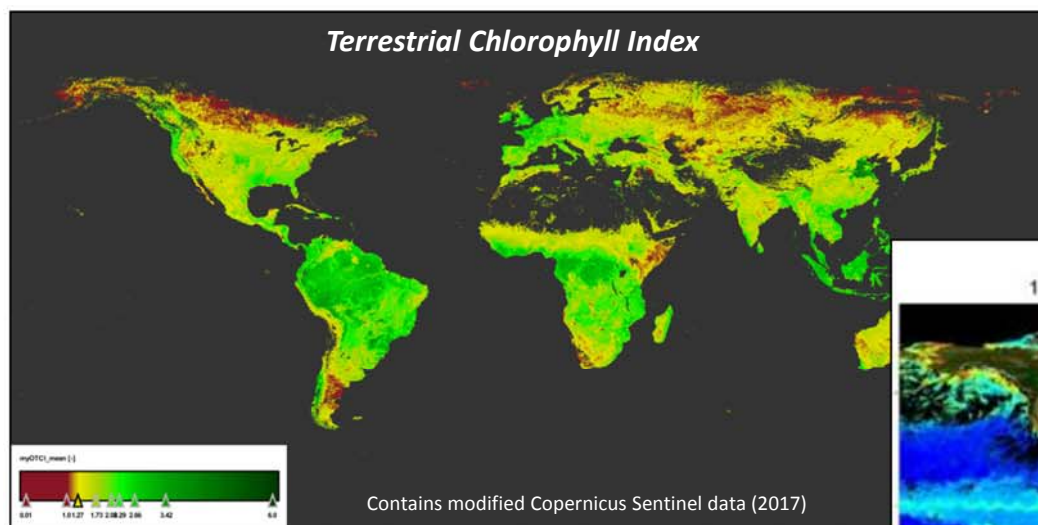
Hurricane Harvey

25 August 2017



Sentinel-3 mission

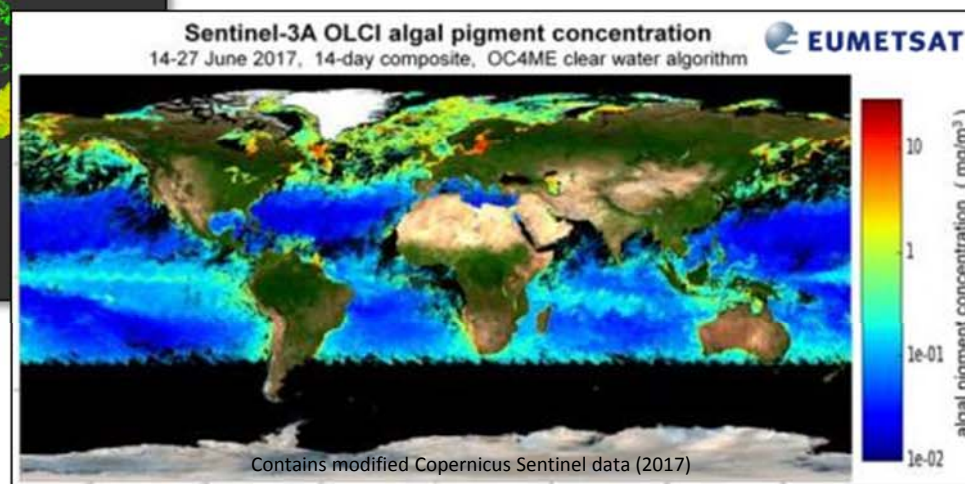
Some results from OLCI validation teams

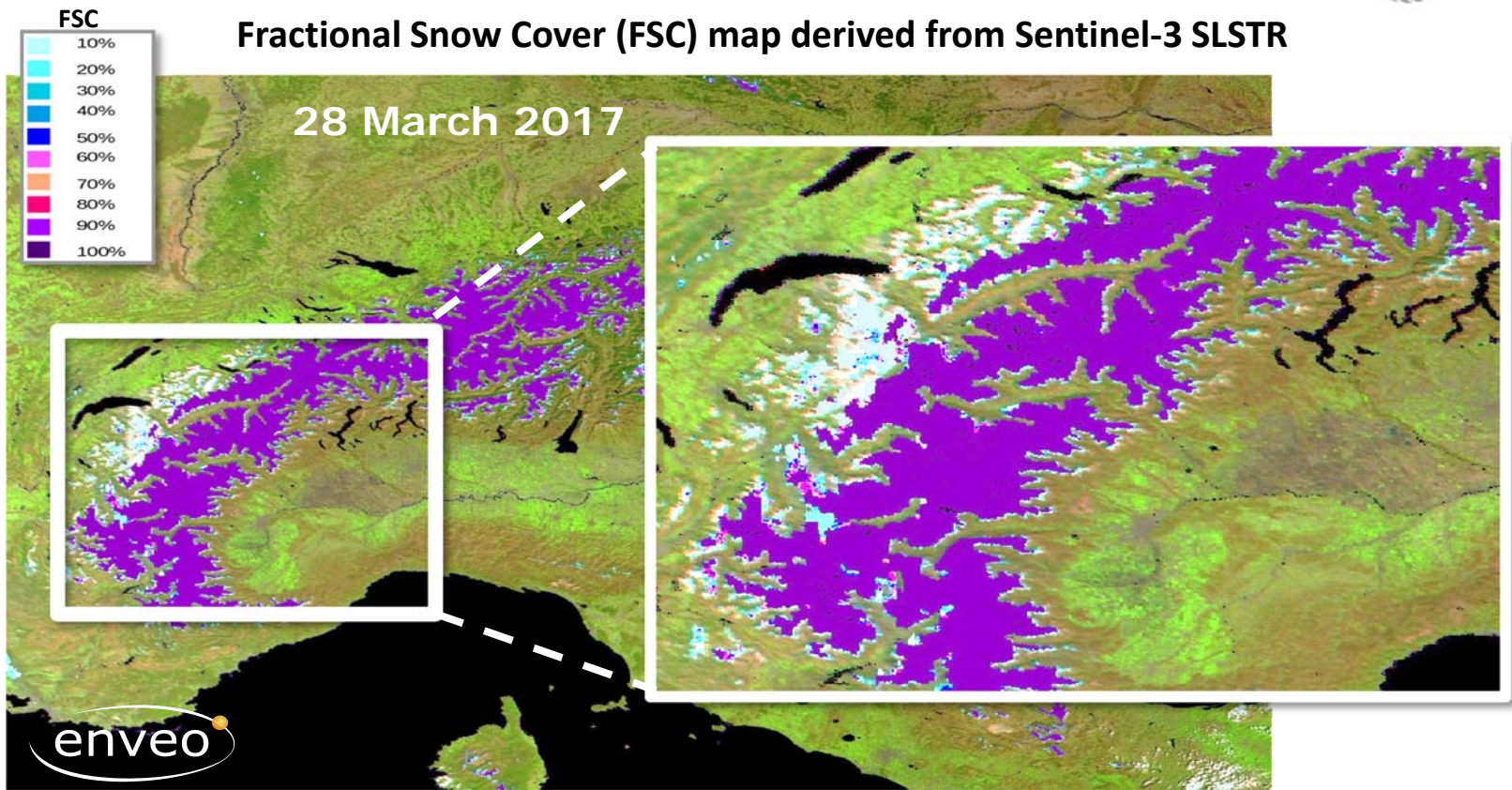


The animation shows how chlorophyll, which is essential in photosynthesis, changed around the world between 1 April and 27 May 2017.

*Animation processed by University of Southampton–J. Dash/
Brockman Consult (S3-MPC)*

Sentinel-3 OLCI Level 2 products were released in July 2017 simultaneously by Eumetsat (for ocean) and ESA (for land)





Contains modified Copernicus Sentinel data (2017)

