

XIX SELPER International Symposium

La percepcion remota y los sistemas espaciales en la era de la transformacion digital. Areas tematicas: Observación de la Tierra; Big Data y Transformación Digital, SW Desarrollos y Procesamiento de Datos, Aplicaciones Geoespaciales, Educación e Investigación.

EO Training: Sentinels for vegetation and natural disasters. Introduction to ESA Earth Observation

08 Nov 2021

Francesco Sarti, Amalia Castro Gomez

European Space Agency, Earth Observation Directorate

ESA UNCLASSIFIED - For Official Use





Speakers from:

ESA. NASA Arset. CONAE. CRECTEALC (Centro Regional de Enseñanza en Ciencia y Tecnología del Espacio para América Latina y el Caribe), Univ Tor Vergata, EO4IM

→ THE EUROPEAN SPACE AGENCY



The European Space Agency



° 22 Member States peaceful purposes

Over 80 satellites

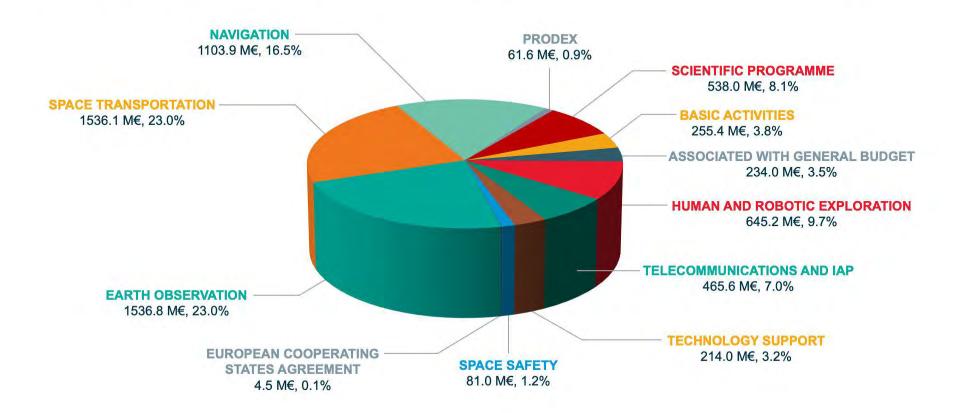
developed, tested, and operated since 1975

2020 Budget





ESA BUDGET BY DOMAIN FOR 2020: 6.68 B€





ESA EO Vision:





Taking the Pulse of our Planet

Our Mission



Develop world-class Earth Observation systems addressing scientific & societal challenges with European and global partners



ESA-Developed Earth Observation Satellites





Copernicus Dashboard



> 405.000

registered users

= tip of the iceberg

6 operational services













Land

Atmosphere

Ocean

Climate

Disaster

Security



250 TB satellite data distributed per day



full, free & open data policy

8 Copernicus Sentinels flying



S₅P



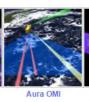


preparing Copernicus 4.0

Third Party Missions



























































IRS-1C

IRS-1D

JERS-1

KOMPSAT-1

KOMPSAT-2

SPOT

TerraSAR-X and TanDEM-X

UK-DMC

WorldView-1

WorldView-2





Landsat OLI/TIRS





Odin







Landsat TM/ETM





































The Earth Explorers Missions





Science: Earth Explorers



2018-present

eesa

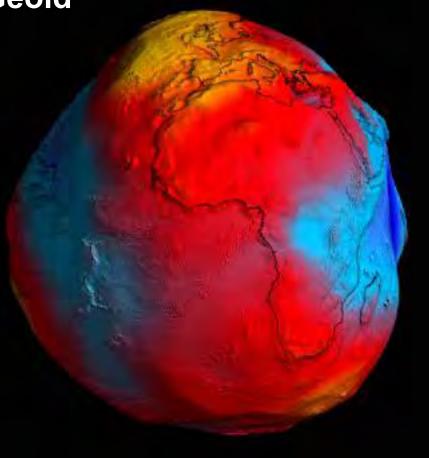
- Science driven programme
- Mission
 selection
 proposed by a
 peer committee
- On average one mission every 2 years





GOCE: Earth's Geoid





Most precise geoid ever produced

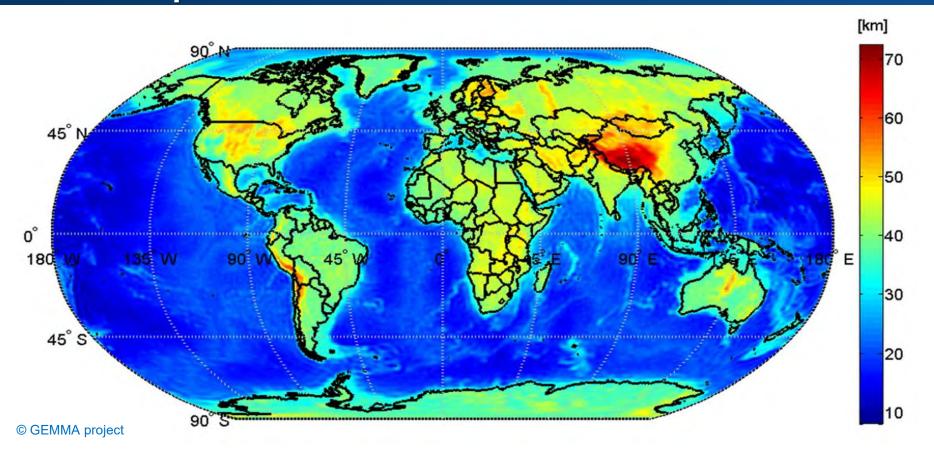
© ESA/HPF/DLR

→ THE EUROPEAN SPACE AGENCY



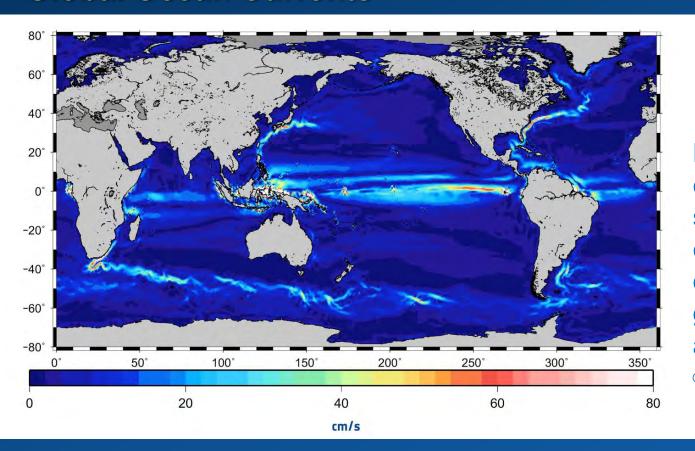
GOCE Maps Moho





Global Ocean Currents





Mean ocean circulation (mean speed of ocean currents in cm/s) derived from GOCE geoid & sea altimetry data

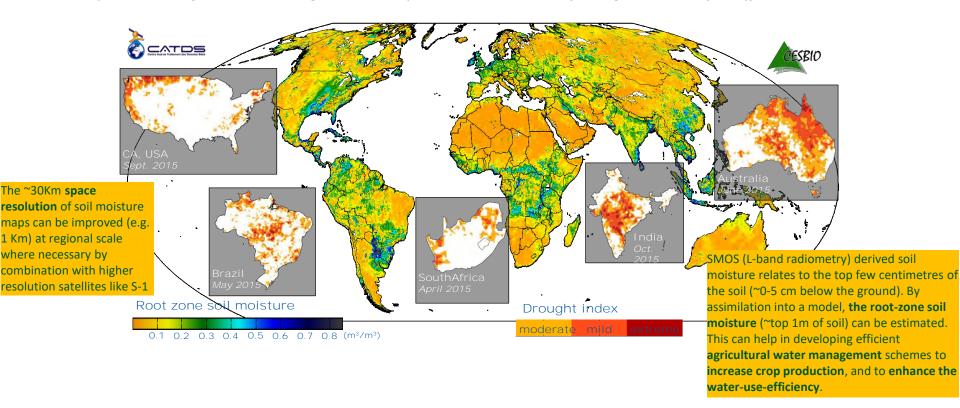
© ESA/CNES/CLS

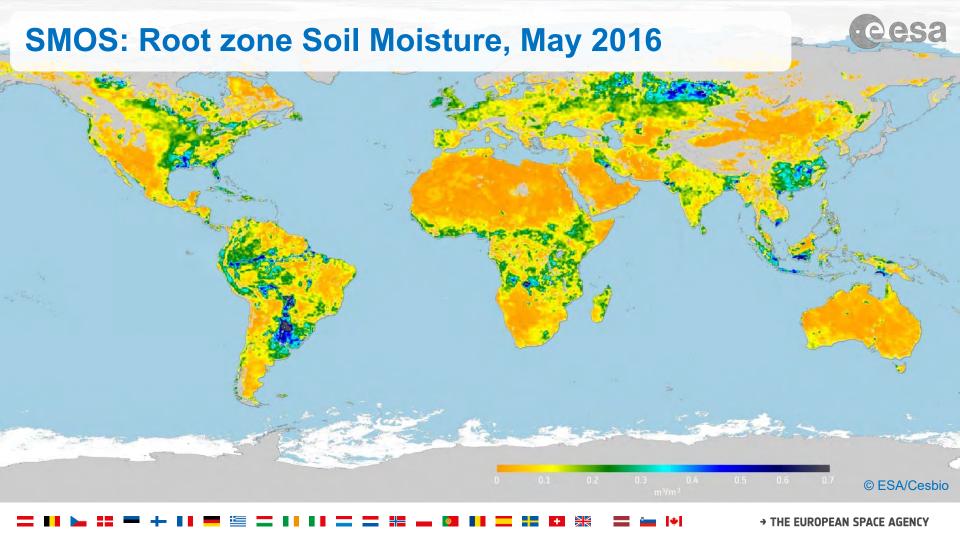


SMOS: Root zone Soil Moisture and major droughts (2015)



<u>Monitoring soil moisture in the root zone</u> allows detecting drought and provides information on the water available to plants, particularly relevant for semi-arid regions. <u>Water shortages can then be predicted several weeks before vegetation is likely to suffer</u>



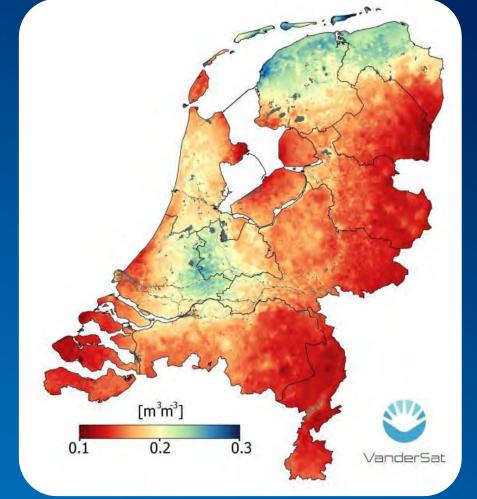


SMOS: Soil Moisture

The Netherlands

June 2017

© VanderSat















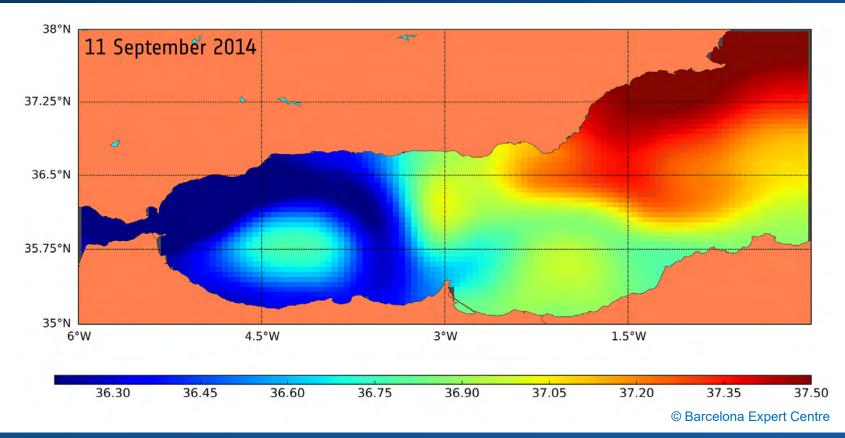






SMOS: Alboran Sea Salinity Changes







Antarctica Ice Melting Impact





West-Antarctic

Antarctic Peninsula

1990s

2010s

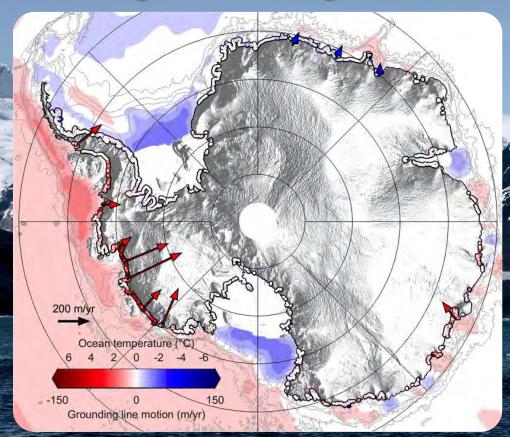
 $53_{\pm 29} \implies 159_{\pm 26}$

 $7_{\pm 13} \implies 33_{\pm 16}$

© Nature June 2018

Shifting Grounding Lines







Based on CryoSat data over six years (2010 – 2016)

© CPOM/Leeds/ESA

Glacier Decline
Cryosat

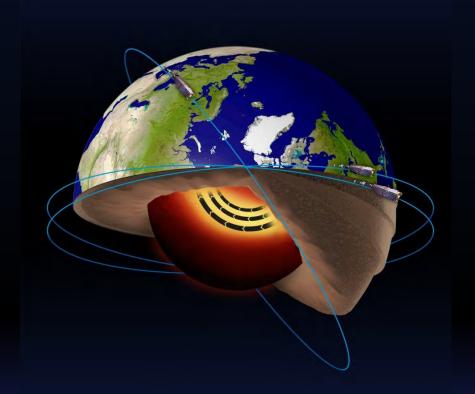






Swarm: Earth Core Discovery





Liquid Iron Jet Stream 3000 km beneath the surface

40 km / year

Jet stream is speeding up

© ESA/ATG Medialab

Swarm: Ocean Impact on Magnetism (magnetic tidal signals)



© ESA/Planetary Visions 2018

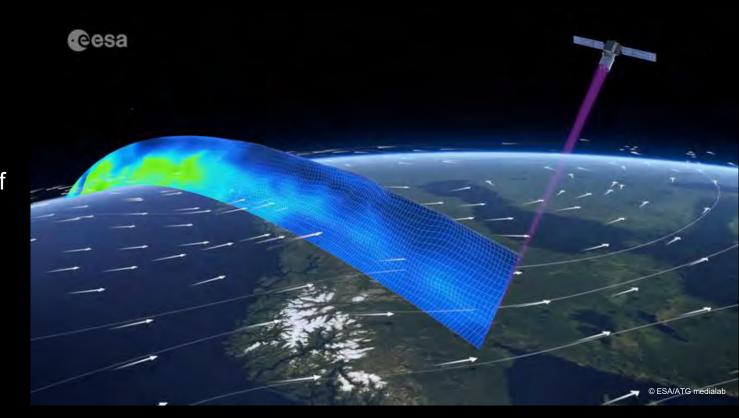


Aeolus addresses our 'Blind Spot'

esa

Wind

- Improving NWP Models' forecast accuracy
- Deepening
 Understanding of
 Climate Science
- Spurring insight into the atmospheric energy, water, aerosol and chemistry cycles

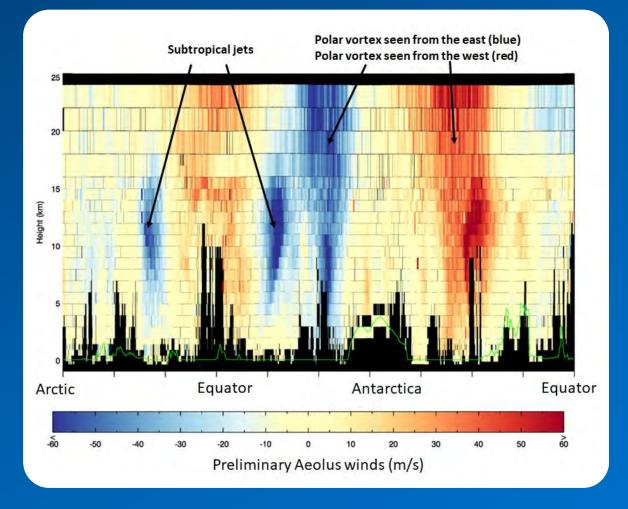


Aeolus





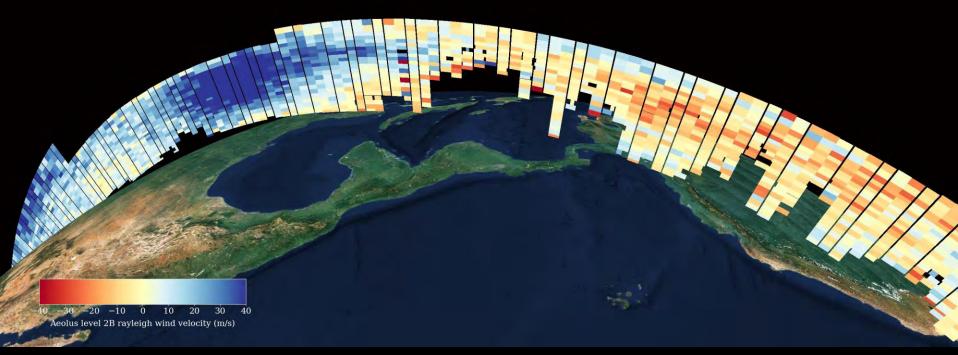
© ESA/ECMWF



Aeolus data is operational and impactful



Aeolus gauges hurricane Lota wind velocities 17 November 2020

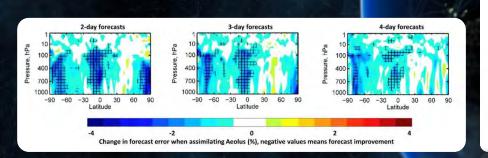


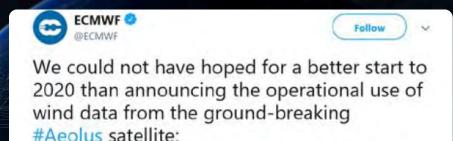
Aeolus Data is now operational



Aeolus

Data is now operationally used by ECMWF in its Numerical Weather Prediction models



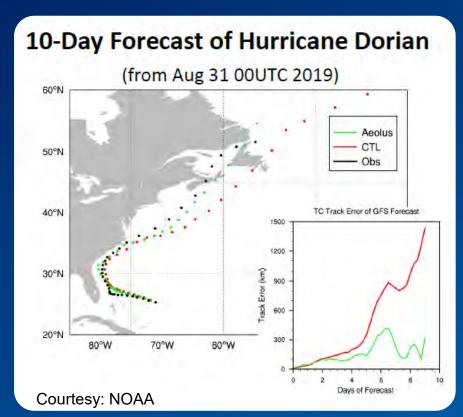


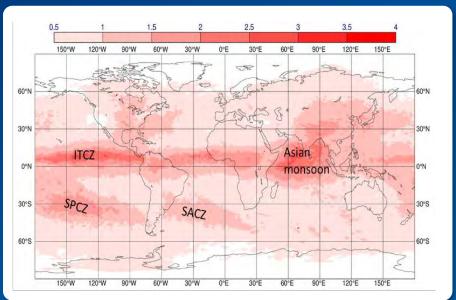
ecmwf.int/en/about/media... A big thank you to @esa @ESA_EO for making Aeolus happen, and Happy New Year to all.



Aeolus data is operational and impactful







Positive impact (red) when assimilating Aeolus winds from 4 April to 19 August 2020 (M. Rennie – ECMWF)



Upcoming Earth Explorers



6

EarthCARE

- Clouds, aerosols & radiation
- High performance lidar tech.
- Partnership with JAXA
- Launch planned 2023

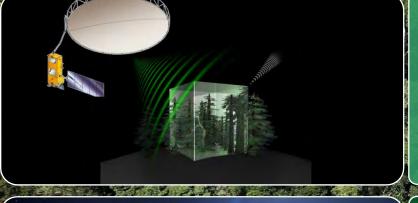






Further Earth Explorers





7 Biomass

- Forest biomass & height estimates
- First P-band SAR in space
- Launch planned 2023

FLEX

- Vegetation fluorescence, indicator of photosynthesis
- Launch planned 2024

Earth Explorer 9 selected: FORUM



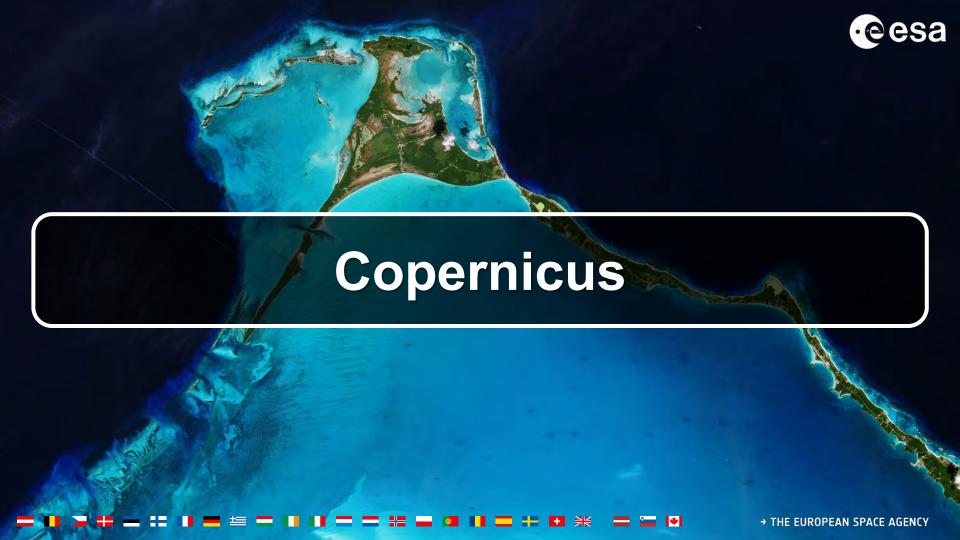


Key for climate science

By measuring radiation emitted by Earth into space, FORUM will provide new insight into the planet's radiation budget and how it is controlled

Covers Earth's top-of-atmosphere emission spectrum from 6.25 – 100 micrometer with a spectral resolution of 0.5 cm⁻¹





Copernicus – a new Phase in EO



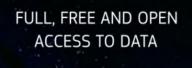
European Earth Observation System

- Led by the EU
- EU-ESA Collaboration

European response to global needs:

- to manage the environment
- to mitigate the effects of climate change
- to ensure civil security

European independence, contribution to global system (GEOSS)



SECURITY





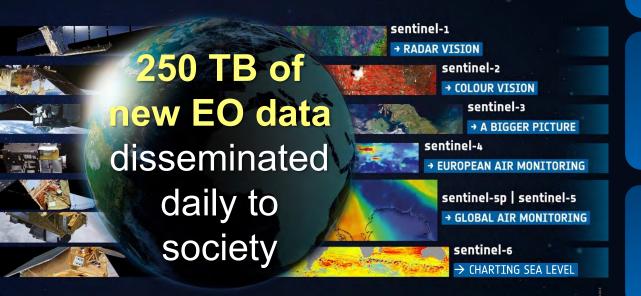


European Copernicus Programme



Global leadership in Earth Observation

Excellent EU-led cooperation with ESA



Benefits EU-interests, science & applications 67-131 B€ value by 2035

Boost European competitiveness & tech innovation

Big data, Al, cloud comp.

Sentinel Expansion missions will support **European Green Deal**

Copernicus Sentinel Status







Radar

S-2



3 Apr. 2014

В 25 Apr. 2016

> C 2022

D > 2024



High Res. Optical

A 23 Jun. 2015

В 6 Mar. 2017

> C 2022

D > 2025 **S-3**



Medium Res. Optical & **Altimetry**

16 Feb. 2016

В 25 Apr. 2018

> C 2023

D > 2025 **S-4**



Atmospheric Chemistry (GEO)

A 2023

> В 2030

S-5P



Atmospheric Chemistry (LEO)

13 Oct. 2017

S-5



Atmospheric Chemistry (LEO)

A 2023

> В 2030

C 2037 **S-6**



Altimetry

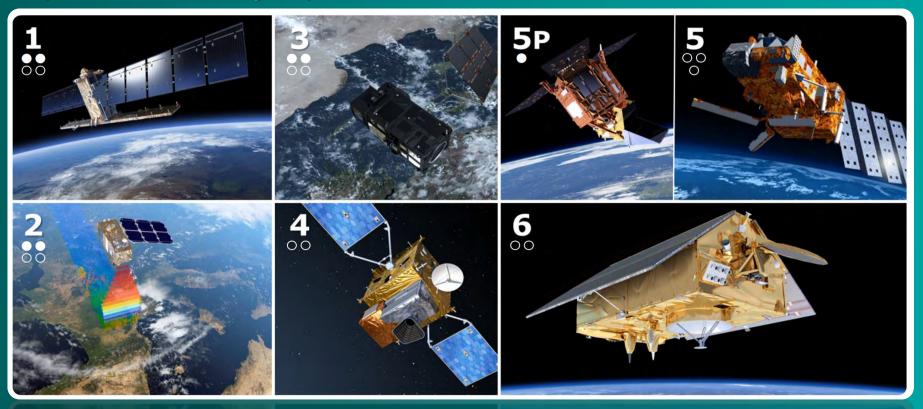
MF 21 Nov. 2020

> В 2025

The Big Data Revolution

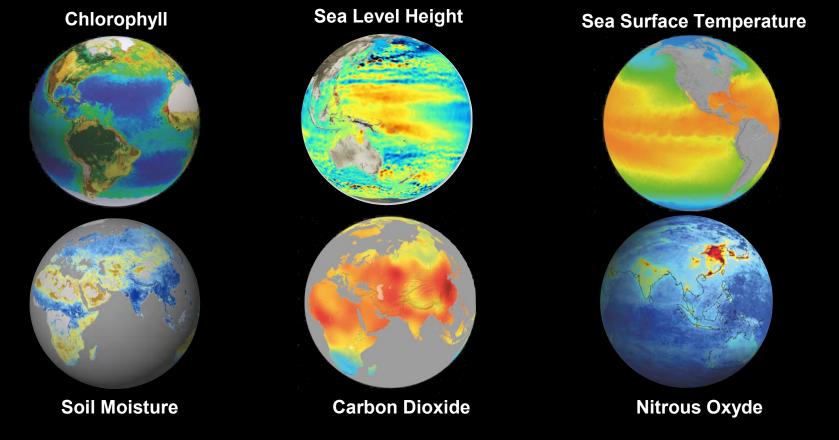


Copernicus is the largest producer of EO data in the world



Global & System View by Copernicus





Copernicus Sentinel Satellites





Sentinel 1 (A/B/C/D) **SAR Imaging**

All weather, day/night applications, interferometry



Sentinel 2 (A/B/C/D) **Multispectral Imaging**

Land applications: urban, forest, agriculture, ... Continuity of Landsat, SPOT



Sentinel 3 (A/B/C/D) Ocean & Global Land Monitoring Wide-swath ocean colour, vegetation, sea/land surface temperature, altimetry



Sentinel 4 (A/B) **Geostationary Atmospheric** Atmospheric composition monitoring, pollution; instrument on MTG satellites



Sentinel 5 (MF/B/C) & Precursor **Low-Orbit Atmospheric**

Atmospheric composition monitoring; instrument on MetOp-SG satellites



Sentinel 6
Jason CS (A/B)

Altimetry reference mission

Contributing Missions are key to Copernicus



Optical High & Very High Resolution

DMC

Pléiades

RapidEye

WorldView









Deimos-2

s-2 SPOT (HRS)

SkySat

Doves









Synthetic Aperture Radar

Cosmo SkyMed

Radarsat

TerraSAR-X Tandem-X







Optical Medium & Low Resolution

SPOT PROBA-V





and many more ...

Altimetry

Cryosat

Jason





Atmosphere

MetOp

MSG





ESA buys large volumes of non-ESA EO data

Copernicus Sentinel Data Policy



Sentinel data are available:

- √ Free, Full and Open*
- ✓ Over very long term
- ✓ Systematically, Operationally



Legal notice on the use of Copernicus Sentined Data and Service Information

* **ESA Sentinel Data Policy** (Sep 2013) and **EU Delegated Act** on Copernicus Data and Information Policy (Dec 2013)

ESA and COPERNICUS Earth Observation DATA ACCESS (see



dedicated presentation available)

- ESA (ERS & ENVISAT and EEs) and ESA TPM Missions and data access
 - HERITAGE Missions (ENVISAT, ERS) and EEs
 - Access to ESA and ESA TPM and Visualization tool
 - Data policy and EO Sign In registration
 - Access via EO-CAT
 - Other data access mechanism examples (free and restricted)
 - EEs access, AOs and visualization tool
- Access to Copernicus Sentinels Data (focusing on Copernicus hub)
 - Data Policy and use typologies (focusing on scientific users)
 - Sentinel Data data hub (registration, search and download)
 - Sentinel 3 and EUMETSAT CODA hub
 - DIAS and other hubs to access Sentinels data
- RUS service introduction
 - (small video)
- ESA Toolboxes and App



DIAS – Creating an EO Data Ecosystem

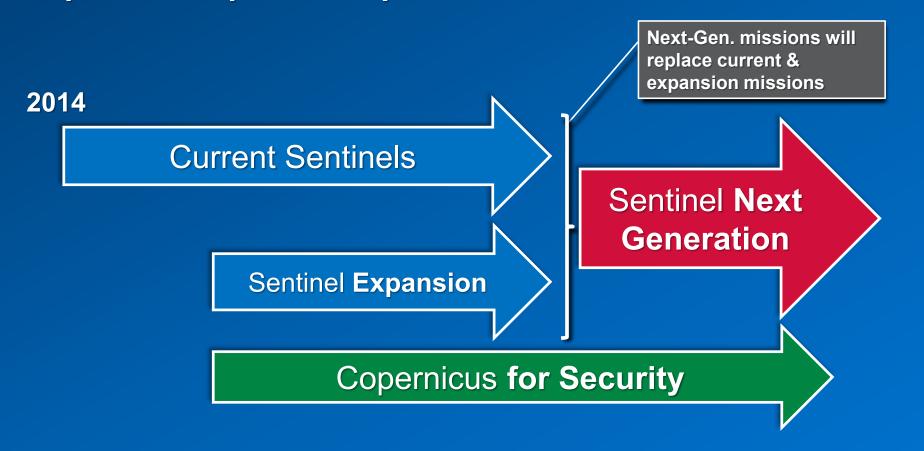




- Copernicus Data and Information
 Access Services (DIAS)
- Common DG-GROW-ESA approach to EO data exploitation with Copernicus at its core
- Started in June 2018

Copernicus Space Component Evolution

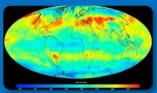




Copernicus: Sentinel Expansion Missions, under study @esa

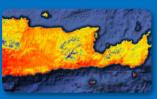


CO2M - Anthropogenic CO₂ Monitoring



Causes of Climate Change

LST – Land Surface Temperature Mission



Agriculture & Urban Management

CRISTAL – Polar Ice & Snow Topography



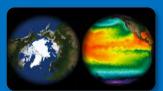
Effects of Climate Change

CHIME – Hyperspectral Imaging Mission



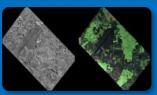
Food Security, Soil, Minerals, Biodiversity

CIMR – Passive Microwave Radiometer



Sea: Surface Temp. & Ice Concentration

ROSE-L – L-band SAR Mission



Vegetation & Ground Motion & Moisture

CO₂M

Anthropogenic CO₂ Monitoring Mission







CIMR – Science and Applications

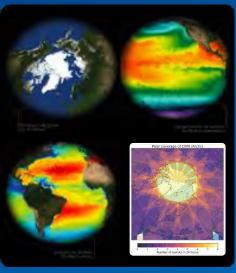


Polar Oceans are fundamental to understanding the global environment

Support the EU Arctic Policy

- Measure the Polar regions every ~6 hours with 95% global daily coverage
- Enhance all Copernicus Services





Monitoring many polar ocean parameters

Sea Ice Concentration, Sea Surface Temperature, thin Sea Ice Thickness, Sea Surface Salinity, Wind Speed, Snow Water Equivalent, Soil Moisture

LSTM

Land Surface Temperature Monitoring Mission



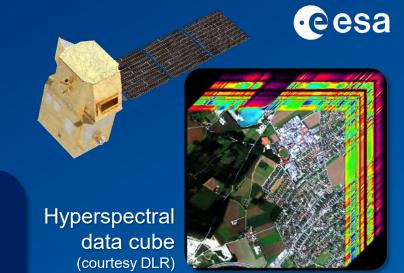


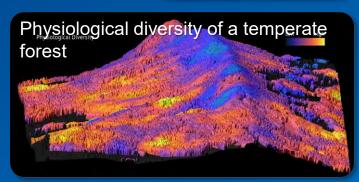
Support agriculture management services, water and food security

CHIME – Science and Applications

Support the **European Green Deal** and EU environmental policies

- Sustainable agricultural and biodiversity management, sustainable mining and environmental preservation
- Through <u>routine hyperspectral</u> <u>measurements</u>
- Support food security, agriculture, soil management





(Airborne imaging spectroscopy APEX data - Schaepman, Jehle et al. 2015)



ROSE-L

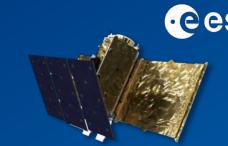
Radar
Observing
System for
Europe L-band



Better services for disasters & geohazards, forests & agriculture management

ROSE-L – Science and Applications

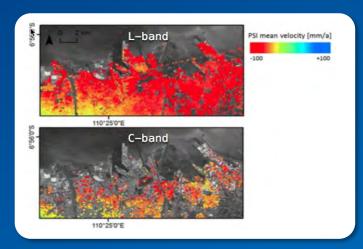
Improve services for Disasters & Geohazards, Forests, Agriculture and high-resolution monitoring of Arctic & Cryosphere



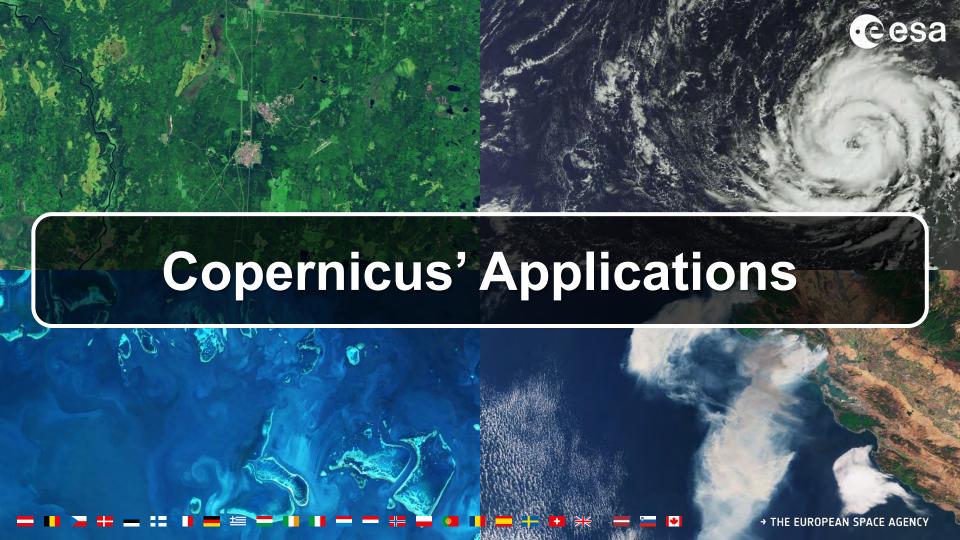
- L-band SAR has strong all-weather capabilities
- Improve disaster
 mitigation: earthquakes
 and volcanoes,
 landslides, flooding etc.
- Land use and agriculture as well as snow and ice applications



Temporal variations in Soil moisture & Crop type



Mapping fast subsidence rates of Semarang (Indonesia) using point scatterers at L-band & C-band

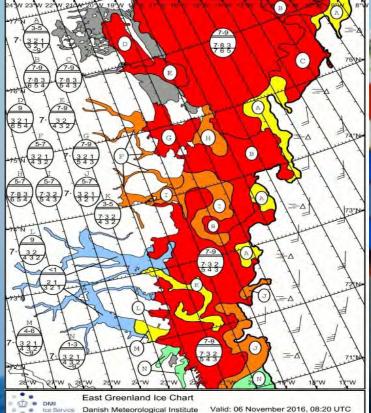








Safe & Efficient Shipping





East Greenland Ice Chart

Based upon Sentinel-1 A & B data

© DMI

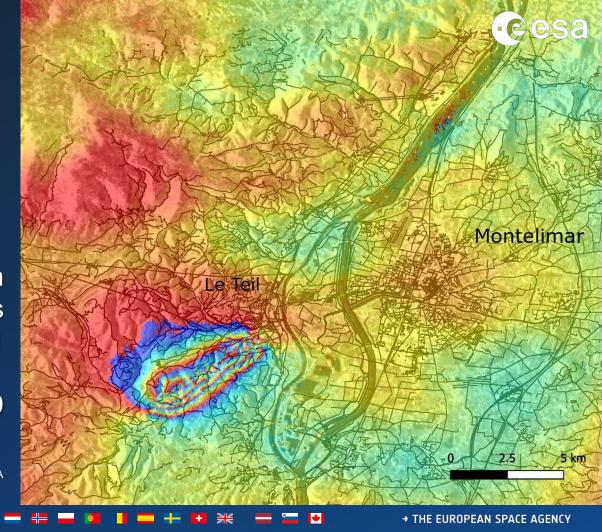


Earthquake in France, ground displacement

Interferogram
Based on Copernicus
Sentinel-1

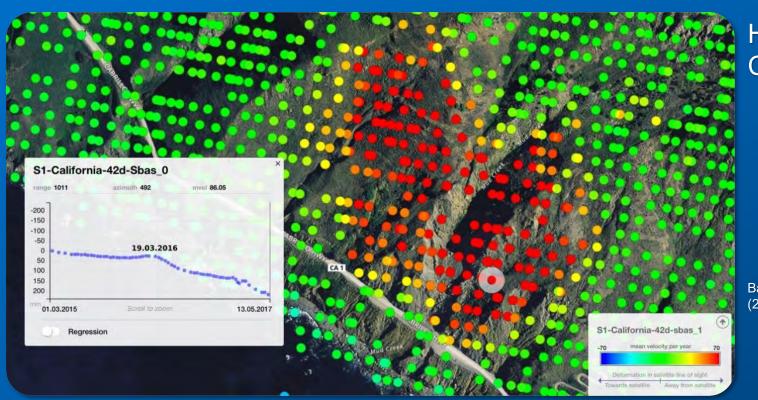
6 and 12 November 2019

Contains modified Copernicus Sentinel data (2019), processed by ESA



Landslides



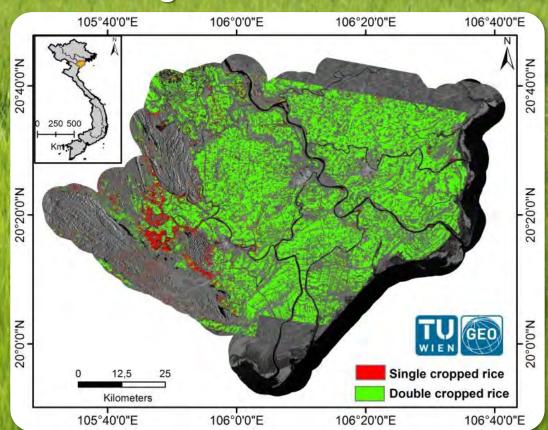


Highway 1 California U.S.

Based on Sentinel-1 data (2015–17), processed by Norut

Monitoring Rice Yields







Based on Sentinel-1 Data

© TU Wien, GEO

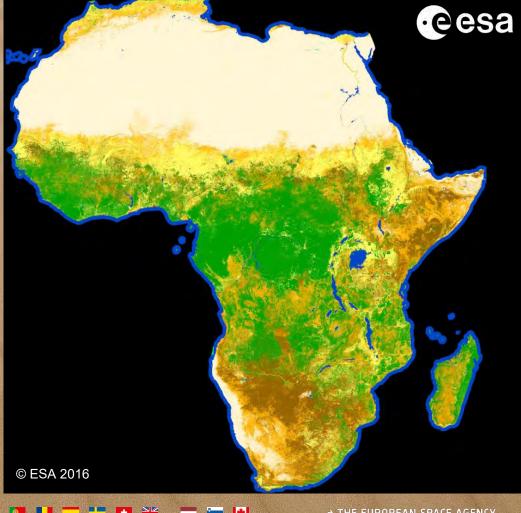




Land Cover Typology

180.000 Sentinel-2A images Dec. 2015 – Dec. 2016





Agricultural Land Use



Distinguishing 15 crop types Germany

Mixed Sentinel-2 and Landsat-8 Data



© Humboldt University Berlin

P. Griffiths















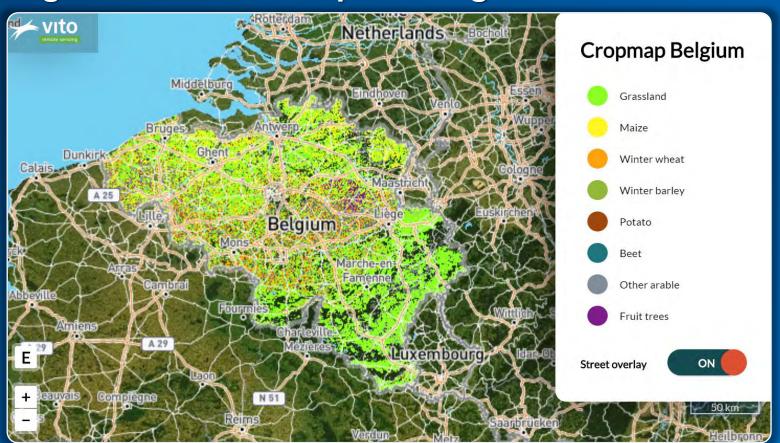






Agricultural Landscape in Belgium

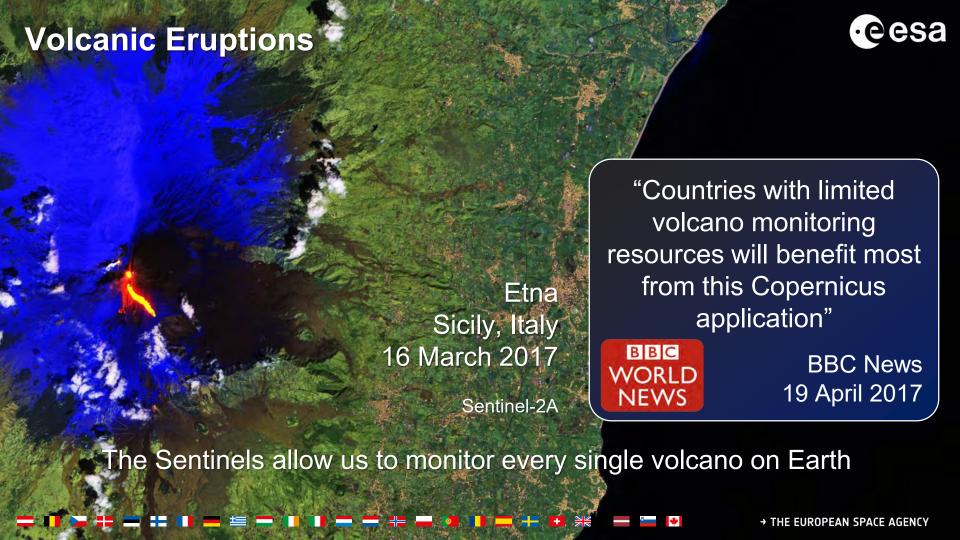




Based on Sentinel-1 & Sentinel-2 Data

1 Jan. – 15 June 2018

© VITO





Forest Fires in Urban Areas

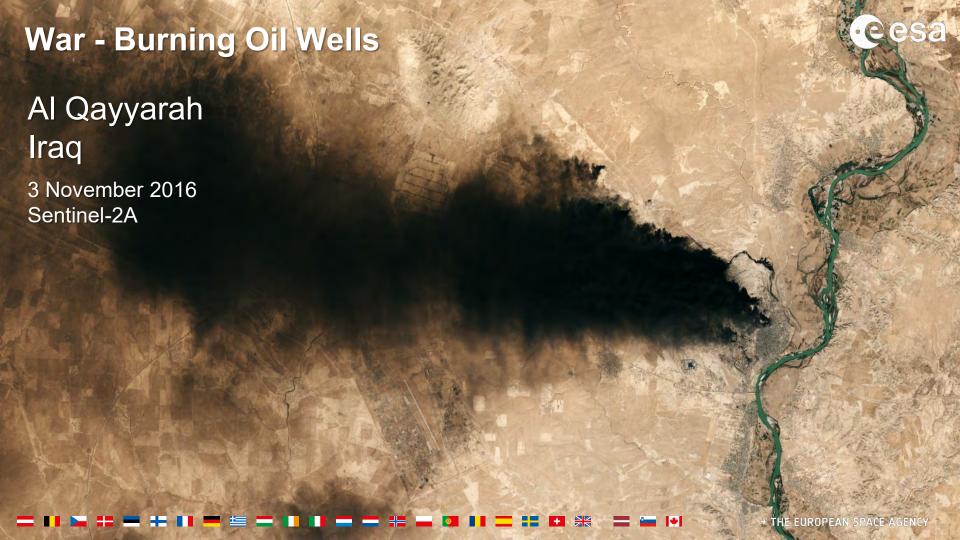


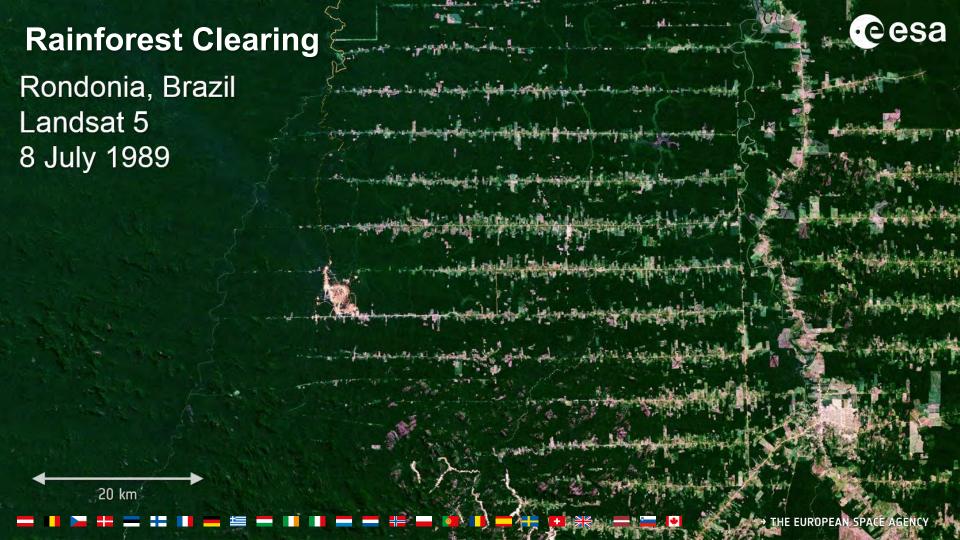


Mount Vesuvius Naples, Italy

Sentinel-2B 12 July 2017











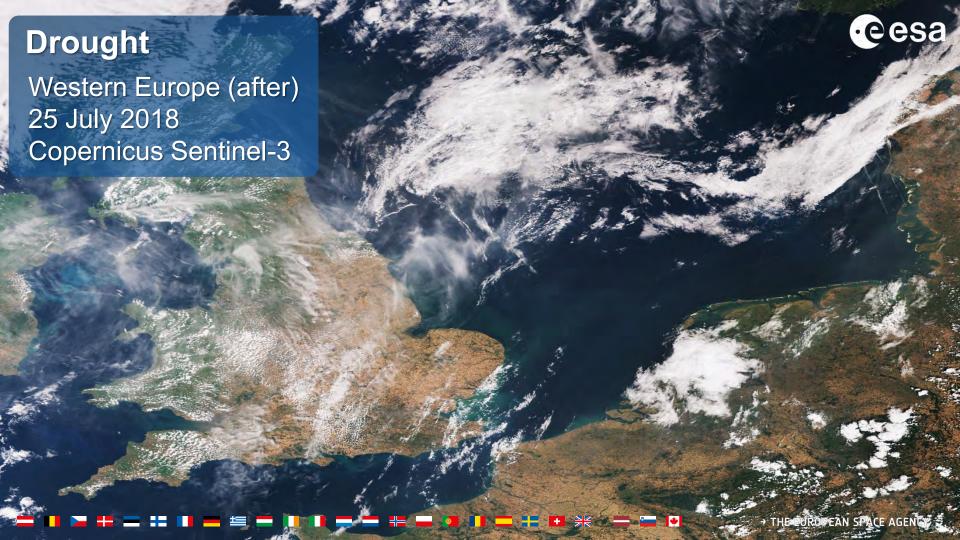
Attica before and after floods
Copernicus
Sentinel-2

22 and 25 November 2019

Contains modified Copernicus Sentinel data (2019), processed by ESA, CC BY-SA 3.0 IGO

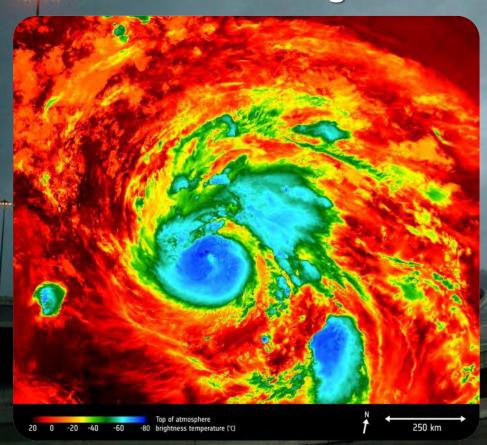
→ THE EUROPEAN SPACE AGENCY





Hurricane Monitoring





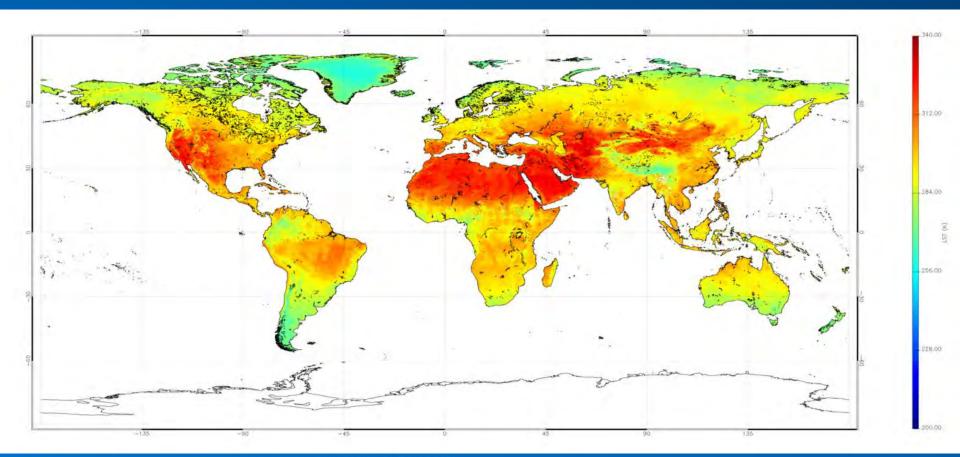
< Temperature at the top of Harvey as the storm approaches Texas</p>

Based on Sentinel-3A data 25 August 2017

© BY-SA 3.0 IGO

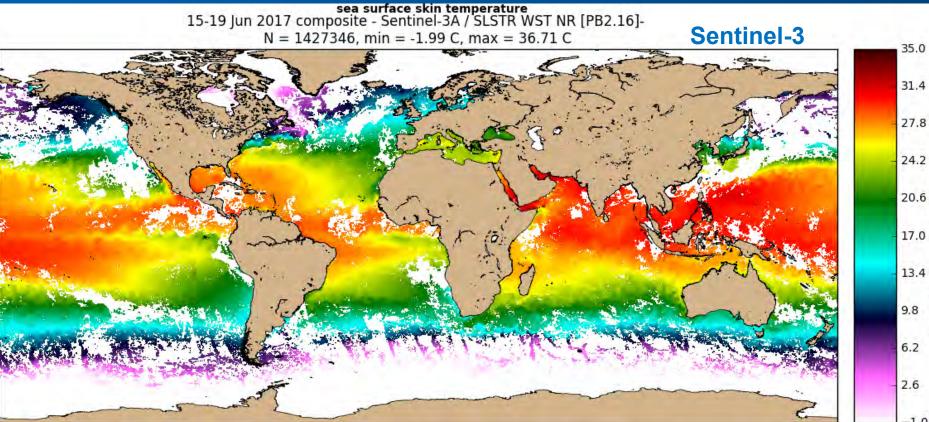
Earth Surface Heat





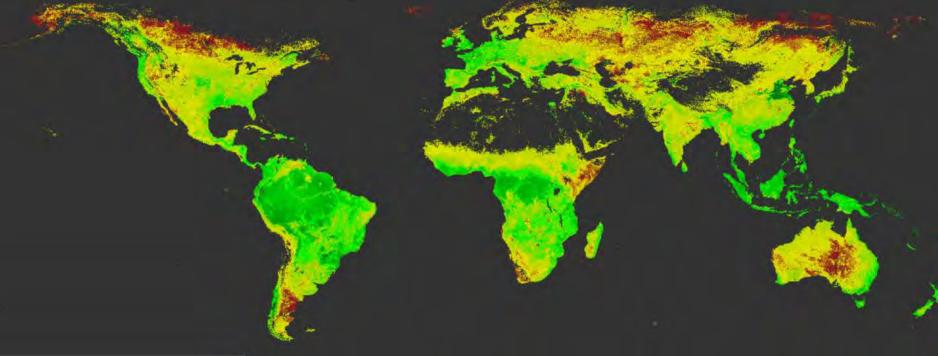
Sea Surface Temperature

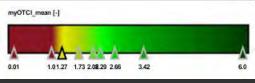






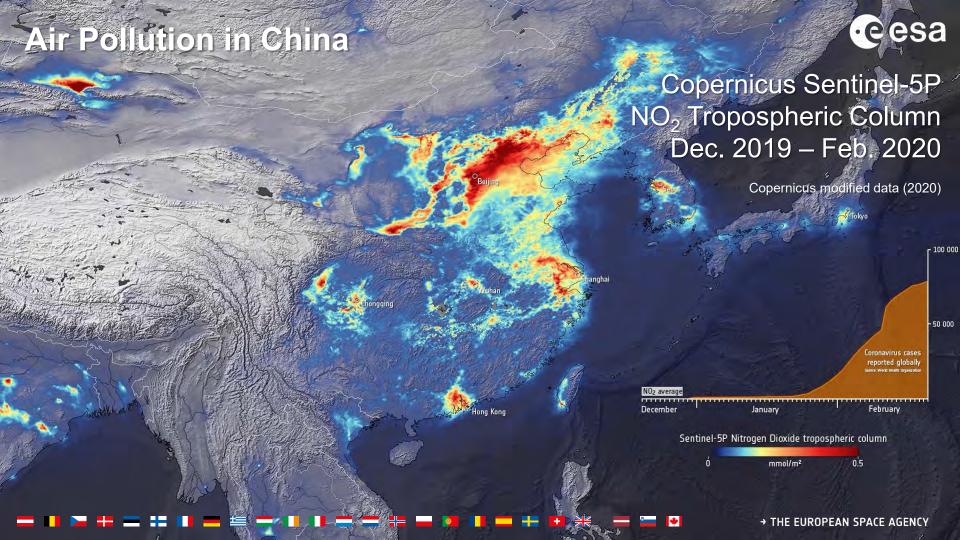


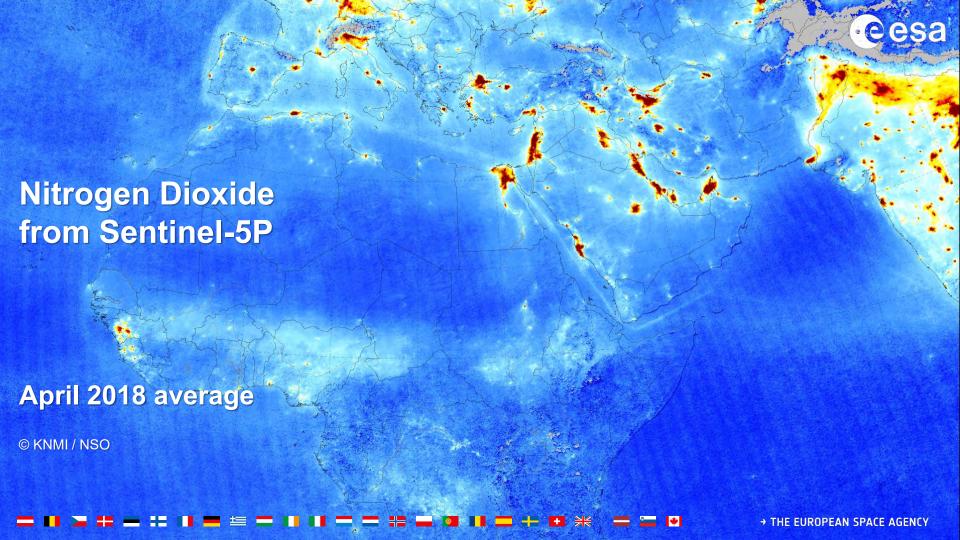




Vegetation Index
Based upon Copernicus Sentinel-3A data (2017)
© University of Southampton–J. Dash/Brockman Consult (S3-MPC)

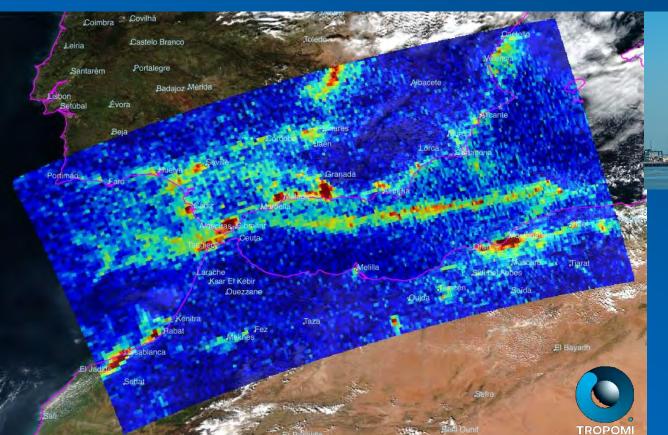






Shipping Lanes: Air Pollution

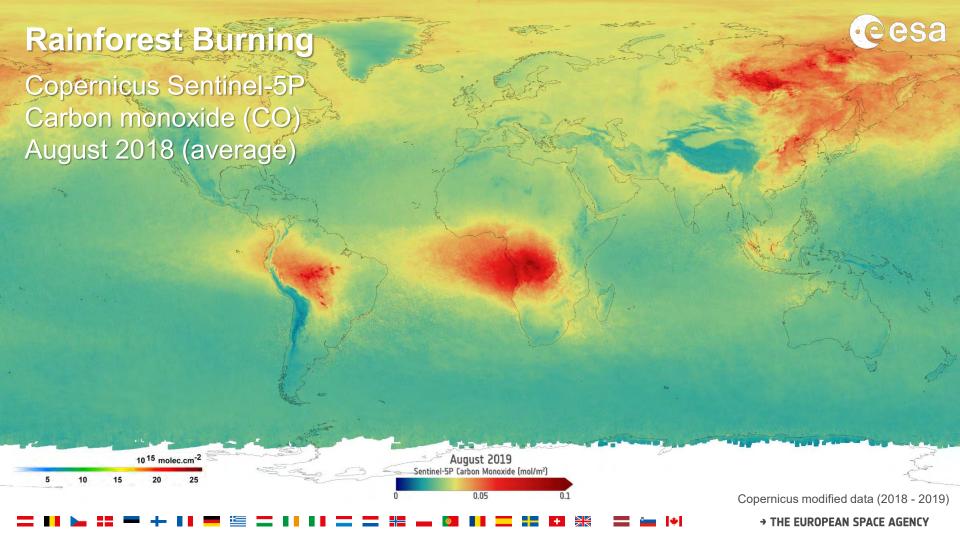






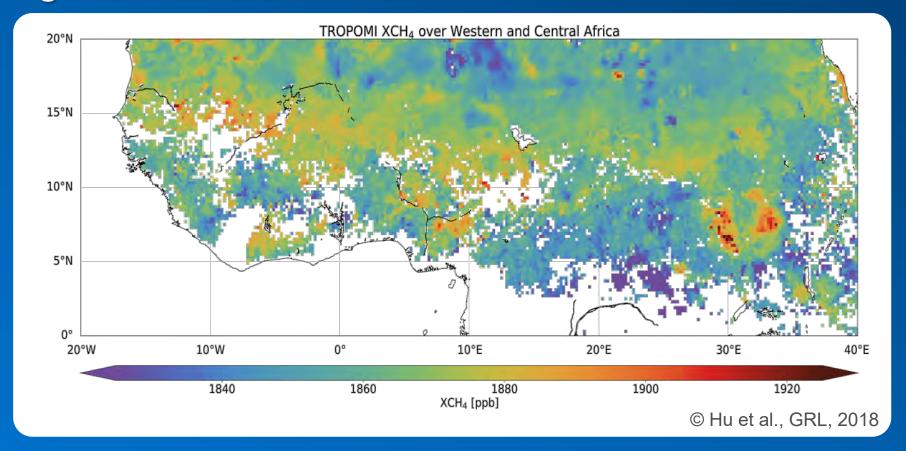
© KNMI / NSO / ES





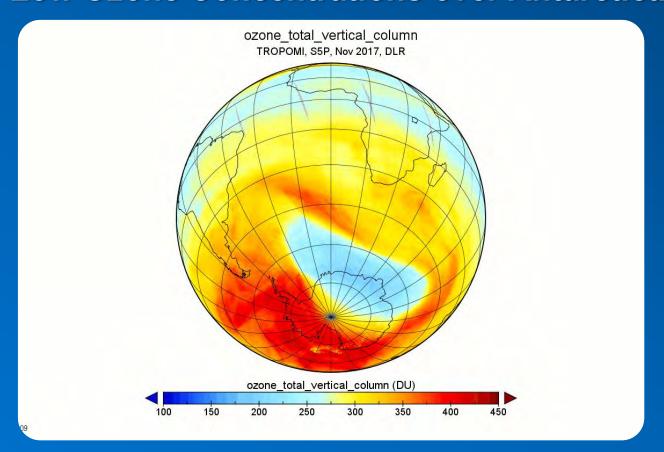
Regional Scale methane over Africa





Low Ozone Concentrations over Antarctica





November 2017 Sentinel-5P

© DLR

Training & Education https://eo4society.esa.int/training-education/







→ ADVANCED COURSE ON RADAR POLARIMETRY 2019 22-25 January 2019 | ESA-ESRIN | Frascati (Rome), Italy





A NEW ONE: Impact of COVID-19 measures on Atmospheric Composition

How did COVID-19 affect the atmosphere? Learn about the ICOVAC project and its findings

MORE INFO



A NEW ONE FO from Space: The Cryosphere

Learn about the role of satellite 'Earth observation' (EO) technology in monitoring the Earth's Cryosphere and the data it produces

MORE INFO



A NEW ONE Land in Focus

A series of online learning materials suitable for anybody interested in the potential of remote sensing technologies for applications over land surfaces.

MORE INFO



eesa

Echoes in Space

Echoes in Space is suitable for anybody interested in getting an Introduction to Radar images or looking to dive into the topic

MORE INFO



The Frozen Frontier Monitoring the Greenland Ice Sheet from Space

You'll look at the measurements made possible by Earth. Observation (EO) satellites like Cryosat, the technologies and techniques involved, the data generated, and its uses and challenges

Please consult/view freely all published material/videos of recent ESA EO training courses, as well as MOOCs, by navigating through

https://eo4society.esa.int/trainingeducation/

As well as RUS/Copernicus training: https://rus-copernicus.eu/portal/therus-offer/training/



Farth Observation from Space: the Optical View

An Introduction to optical Earth observation: monitoring our planet from satellites, using photography, imaging in various wavelengths, lidar and other optical sensing technologies

MORE INFO



Earth Observation: Disruptive Technology and New Space

A series of interviews with leading experts across Earth Observation and related technologies

MORE INFO



MORE INFO

















Thank you for your attention!

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