ESA Earth Observation: Current status and latest results

Meeting of the European Space Sciences Committee

Maurice Borgeaud

Head of the Earth Observation Department
"Science, Applications and Climate"

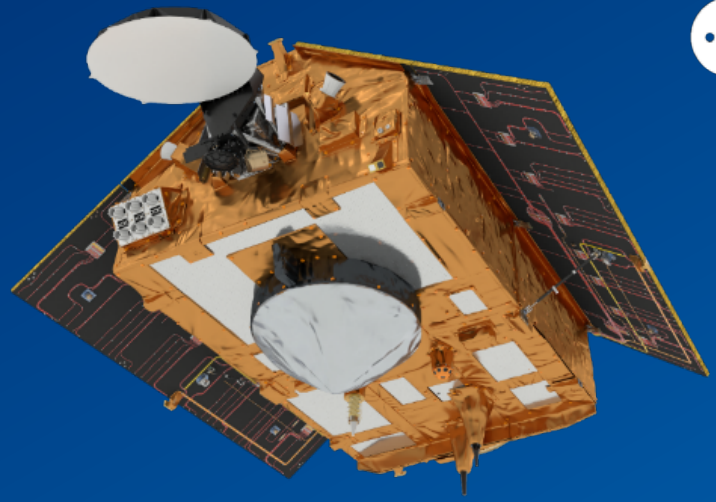
28 May 2021

ESA-Developed Earth Observation Satellites

16 in operation
37 under development
15 under preparation

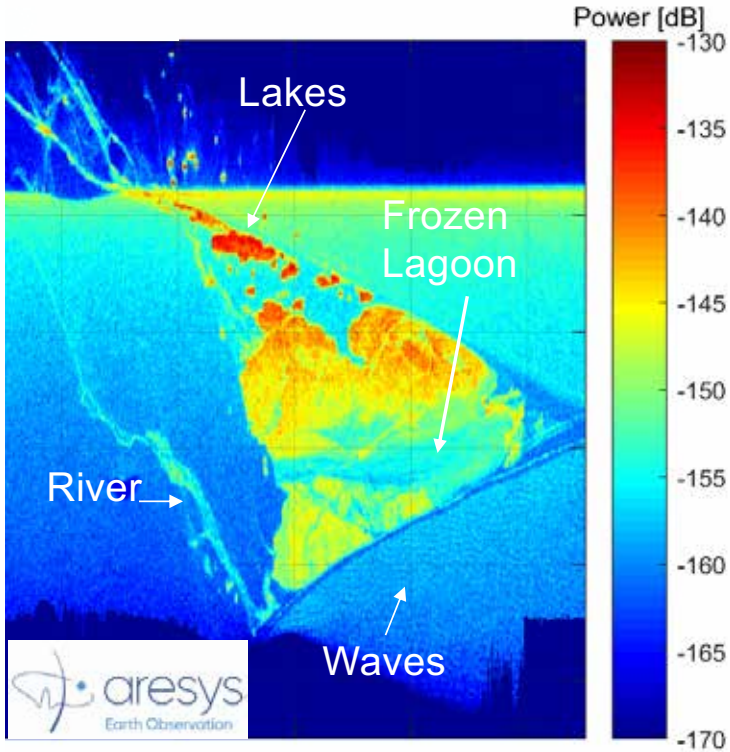
Sentinel-6 Michael Freilich

Launched successfully on 21 Nov. 2020



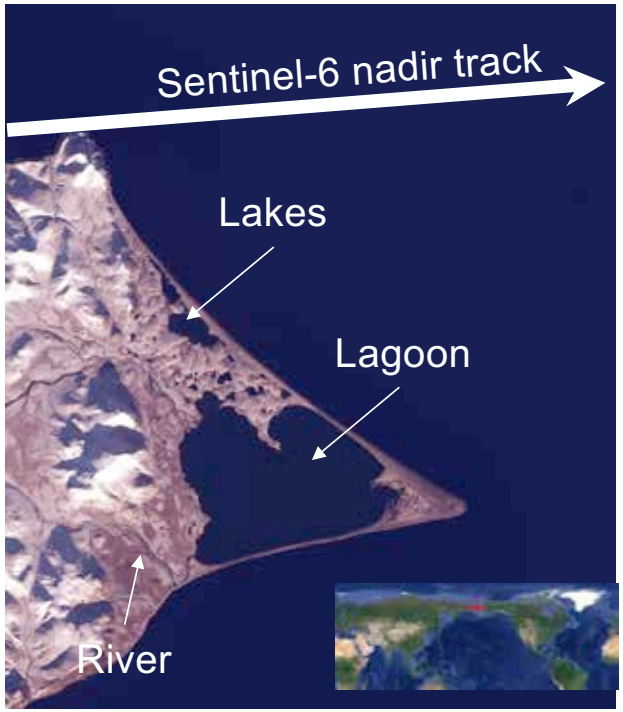
First Sentinel-6 across track SAR Range Image

Sentinel-6 MF



(a) LRM (b) Fully Focussed SAR Range image
30 Nov 2020

Sentinel-2B

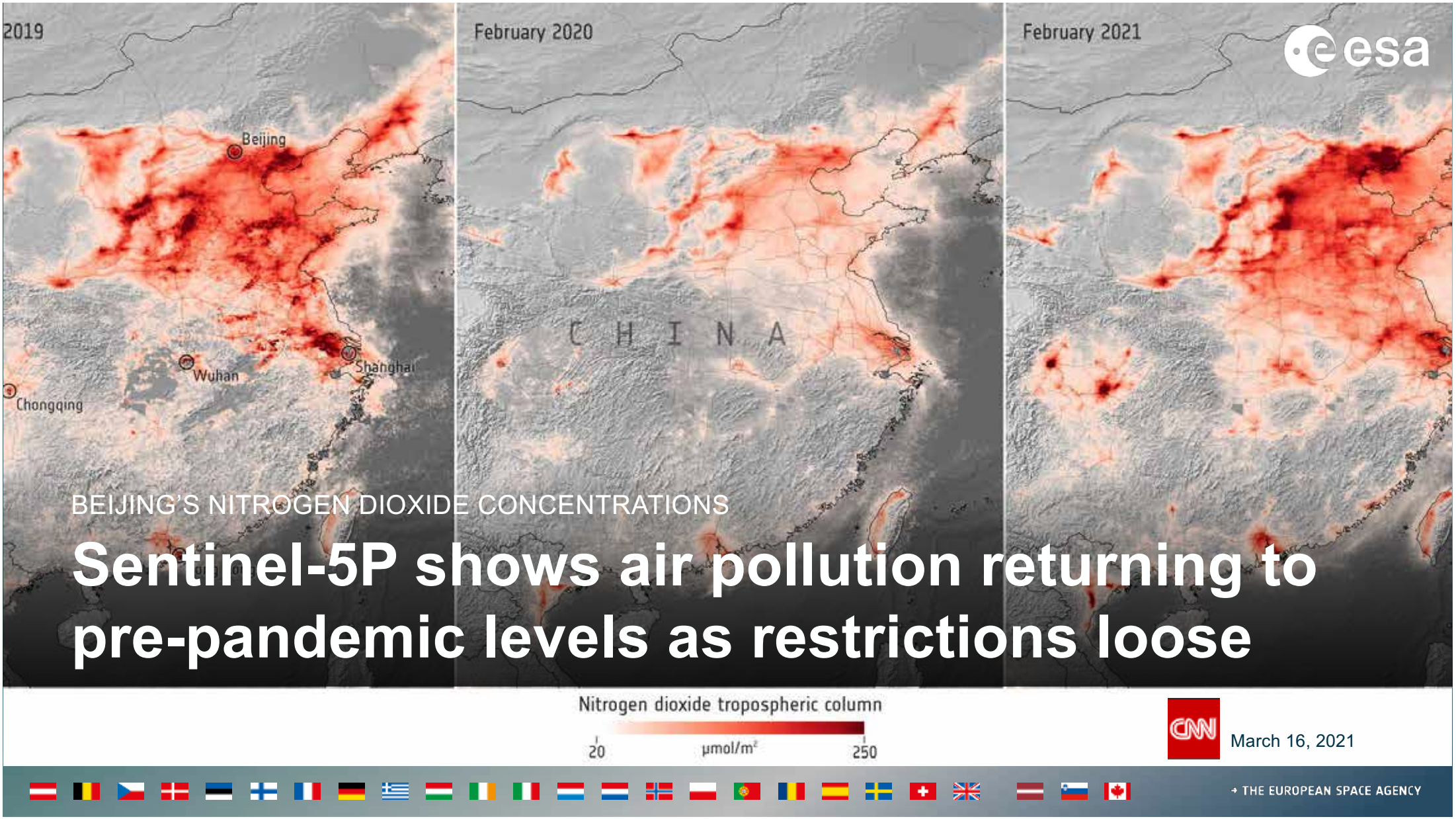


10m, Ozero Nayvak peninsula, Russia
19 October 2020

Sentinel-1B

Interferometric Wide Swath
29 Nov 2020

Sentinel-5P SO_2 emission measurements during April 2021 of "La Soufrière" volcano in Saint Vincent


2019
February 2020
February 2021
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Beijing
Wuhan
Shanghai
Chongqing
CHINA
BEIJING'S NITROGEN DIOXIDE CONCENTRATIONS
Sentinel-5P shows air pollution returning to pre-pandemic levels as restrictions loose
Nitrogen dioxide tropospheric column
20
µmol/m²
250
CNN
March 16, 2021
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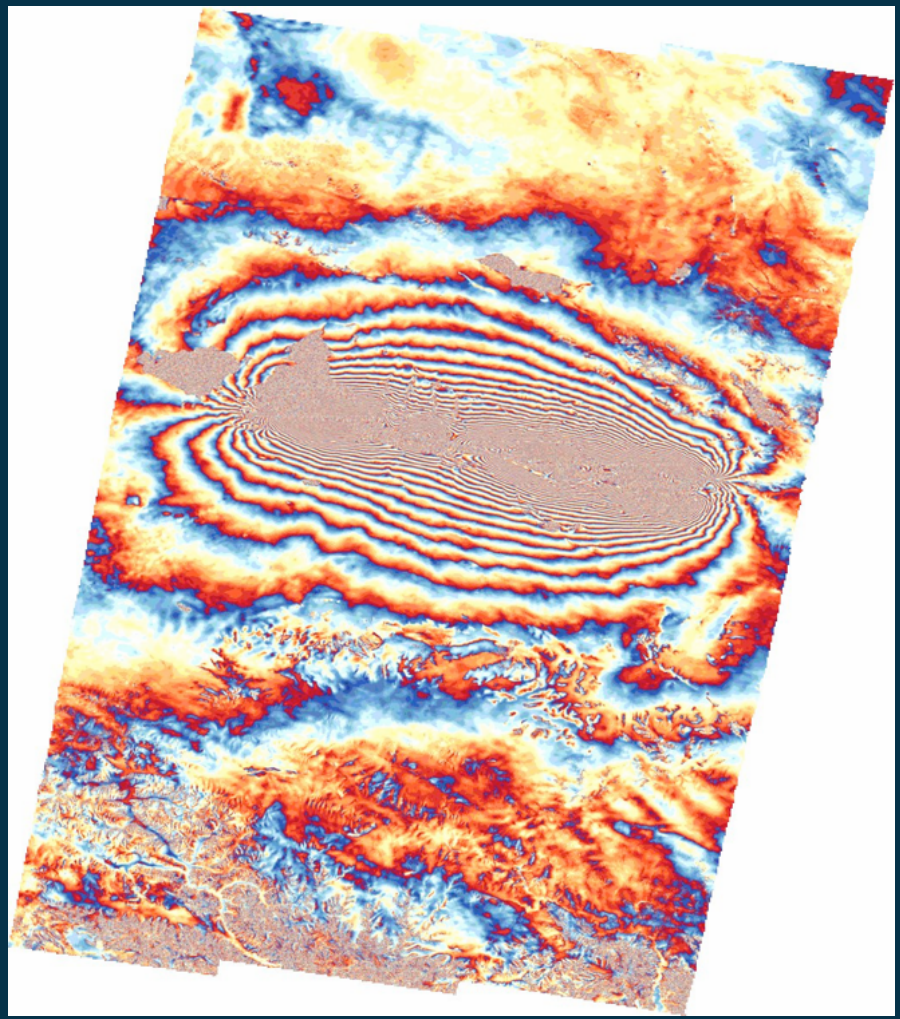
Sentinel-1

- Mw 7.3 Earthquake
- Southern Qinghai, China, 21 May 2021
- Descending pass interferogram
- 6-day repeat (using both S1A and S1B) in both geometries, descending pass interferogram



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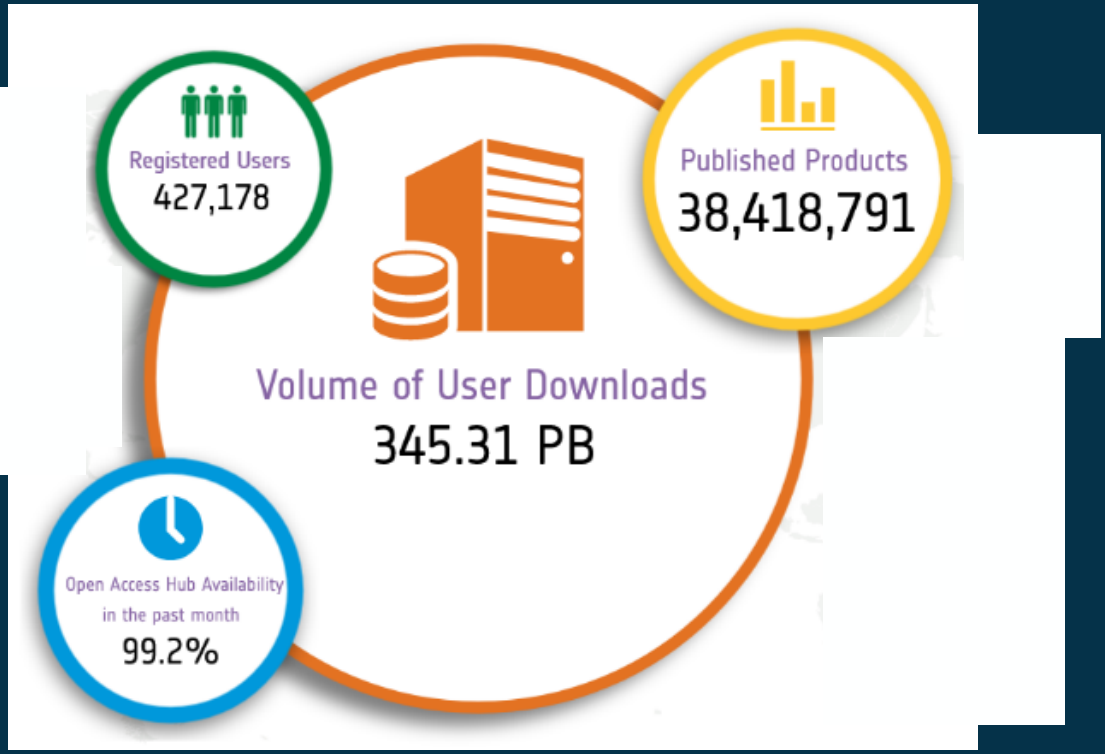
A-76: The world's largest iceberg

The world’s largest iceberg, dubbed A-76, has calved from Antarctica.

This animation uses images from the Copernicus Sentinel-1 mission and shows the giant slab of ice breaking off from the Ronne Ice Shelf, lying in the Weddell Sea, on 13 May 2021

Sentinel user demand → continuous increase



Overall **archive exploitation ratio** is growing (*ratio of published products vs downloaded products for all ESA hubs*)

	May 2021	2018 values
Sentinel-1	1:15	1:12
Sentinel-2	1:13	1:12
Sentinel-3	1:11	1:8
Sentinel-5P	1:27	1:9

Statistics beginning May 2021

Copernicus Sentinel Expansion Missions (~~HPCM's~~)

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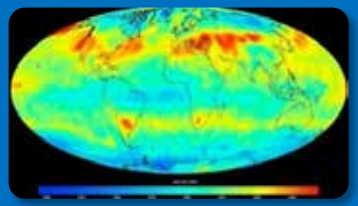
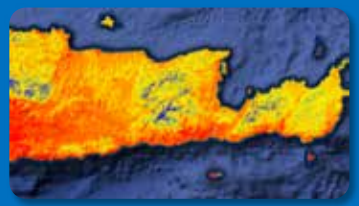
CO2M - Anthropogenic CO_2 Monitoring



Causes of Climate Change

LST – Land Surface Temperature Mission



Agriculture & Urban Management

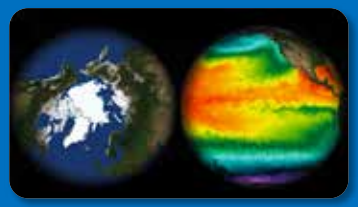
CRISTAL – Polar Ice & Snow Topography

Effects of Climate Change

CHIME – Hyperspectral Imaging Mission

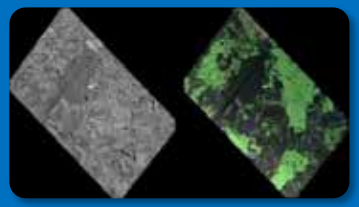
Food Security, Soil, Minerals, Biodiversity

CIMR – Passive Microwave Radiometer



Sea: Surface Temp. & Ice Concentration

ROSE-L – L-band SAR Mission



Vegetation & Ground Motion & Moisture

A Multi-year Financial Framework partnership agreement (MFF) between ESA and EC largely completed and should be finalised in the coming months

Science: Earth Explorers

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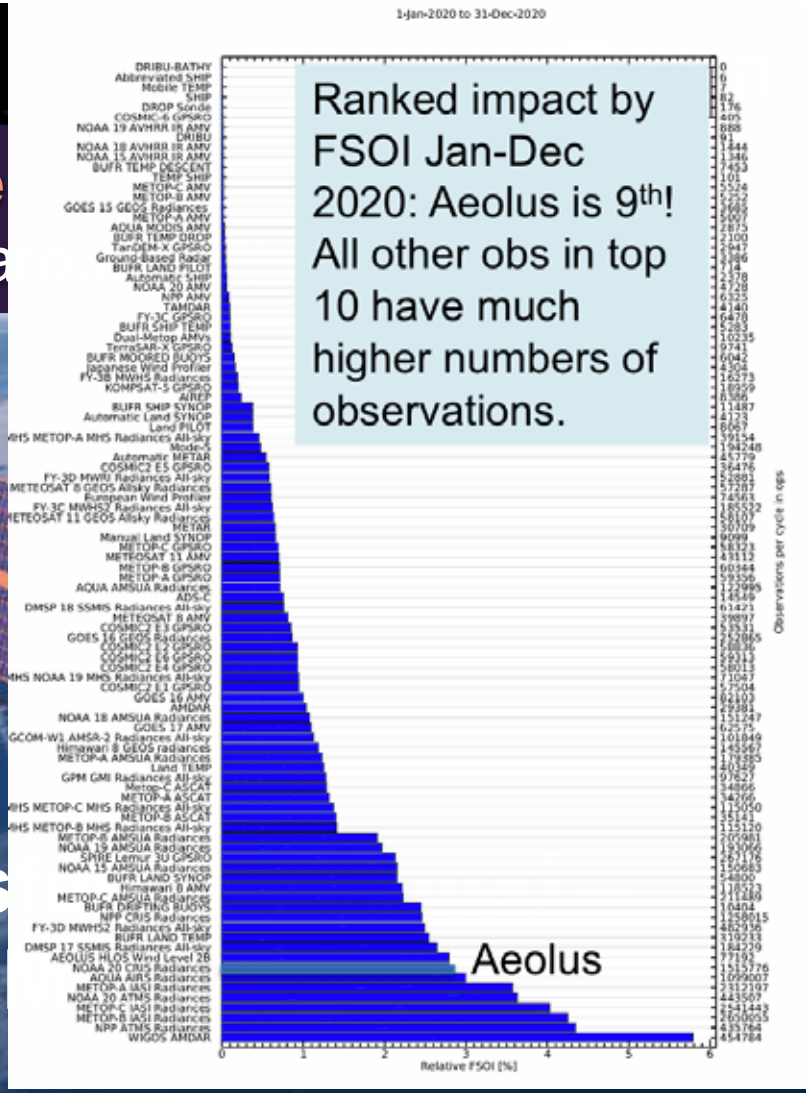
Laser e
Stable a

AEOLUS LASER - SPECIAL CALIBRATION ACTIVITIES UNDERWAY

Recovery activities were success
Products available again since 3



© ECMWF – Clear and positive impact

FutureEO – Earth Explorer Progress

Earth Explorer 9 FORUM in Phase B1

Earth Explorer 10

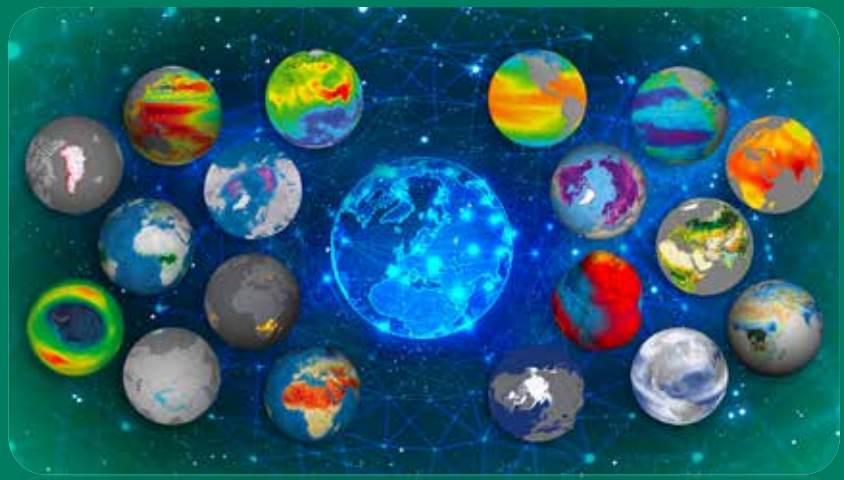
- 3 Candidates in Phase 0
- PBEO selected one candidate for ph. A

Harmony

Earth Explorer 11

15 Proposals received on 4/12/20

PB-EO decision on 10/6/21 for up to 4 missions to enter ph A

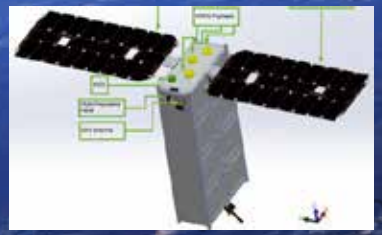


Scout Missions

- New approach for EO missions to faster and cheaper missions
- Main drivers: 3 years from ph A to launch and costs < 25 M€

ESP-MACCS

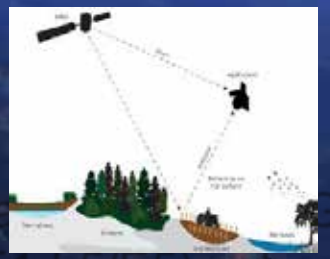
Earth System Processes Monitored in the Atmosphere by a Constellation of Cube Sats.



Earth System Processes Monitored in the Atmosphere based on Sun occultation.
Three 8U cubesats with
HIROS (Heterodyne TIR Spectrometer)
+ HSDI (VIS NIR Hyperspectral Solar Disk Imager)

HydroGNSS

GNSS-R to measure biomass, soil moisture, permafrost, wind speeds



Dual circular pol. GPS/Galileo dual freq. (L1/E1-L5/E5) coherent channel generating Delay Doppler Maps (DDM).
45 kg SSTL-21 platform with upgraded GNSS-R FPGA receiver

Meteorological Missions status

MTG

- MTG-I PFM QAR, June 2022
  Earliest launch Q4 2022
- MTG-S PFM QAR, May 2023
  Earliest launch Q4 2023

MetOp-SG

- Satellite-A1:FAR = Oct. 2023, Launch = Jan. 2024;
  - Schedule recovery measures investigated to return to launch in 2023. Driver for launch is METimage PFM delivery (Mar. 2023).
- Satellite-B1:FAR = Jul. 2024, Launch = Oct. 2024.

Aeolus Follow-on

- Aeolus FO preparatory activities ongoing
- Instrument improvement based on Aladin experience.
- Preliminary assessment of orbit altitude: 360 km during 7-y lifetime

AWS

- Mission Preparation Activities study successfully completed in Dec.
- Phase B/C/D/E proposal evaluated and Contract Proposal approved unanimously by Participating States
- Negotiations with industry successfully completed. Phase B/C/D/E activities kicked-off on 1 Feb. 2021
- EUMETSAT will be involved in the AWS development and assumptions for a future cooperation regarding an operational AWS Constellation

understanding the variations of the global Earth energy-water cycle at regional and global scales through satellite observations and modelling approaches

Winner Team Award:
Leader Luca Brocca

Winner Individual Award:

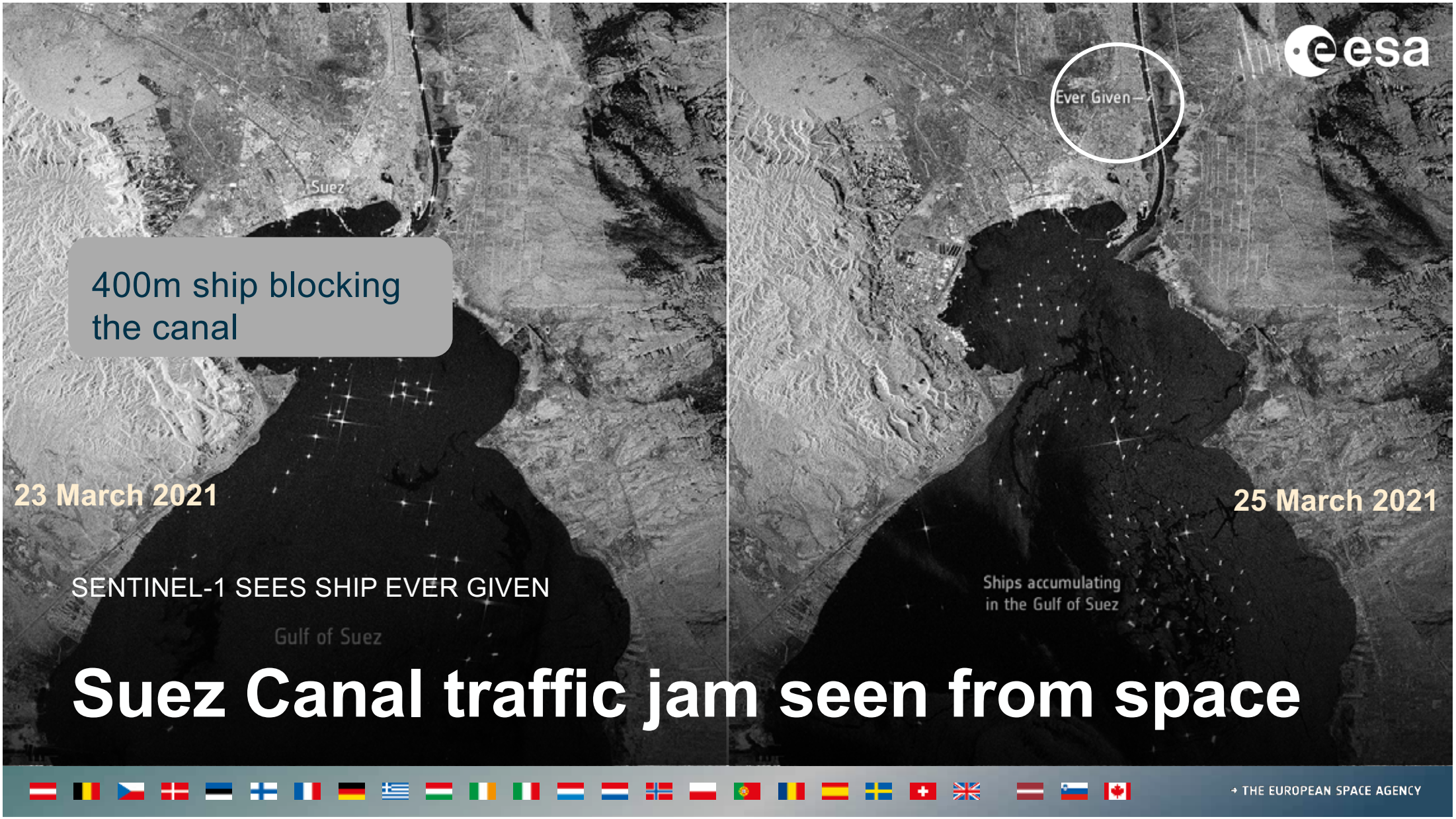
Benoît Meyssignac

pioneering studies on the assimilation of satellite soil moisture products into hydrological modelling

Istituto di Ricerca per la Protezione Idrogeologica

TEAM AWARD AND INDIVIDUAL AWARD

Winners of ESA-EGU EO Excellence Award announced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Suez
Ever Given
400m ship blocking the canal
23 March 2021
25 March 2021
SENTINEL-1 SEES SHIP EVER GIVEN
Gulf of Suez
Ships accumulating in the Gulf of Suez
Suez Canal traffic jam seen from space
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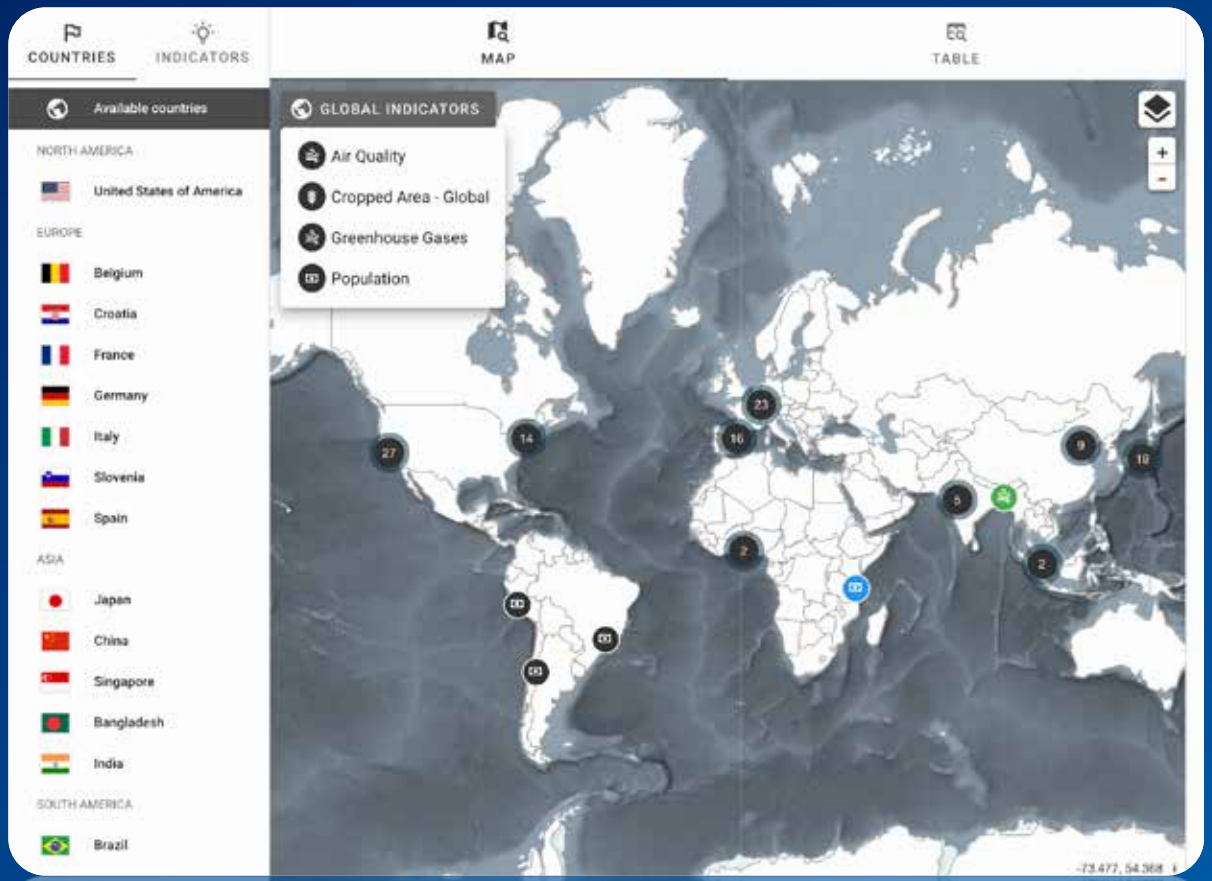
ESA-NASA-JAXA Dashboard - eodashboard.org



Trilateral Dashboard extended with NASA and JAXA until June 2021

Towards a Digital Twin of our solid Earth

Results from 3Dearth project team: 3dearth.uni-kiel.de

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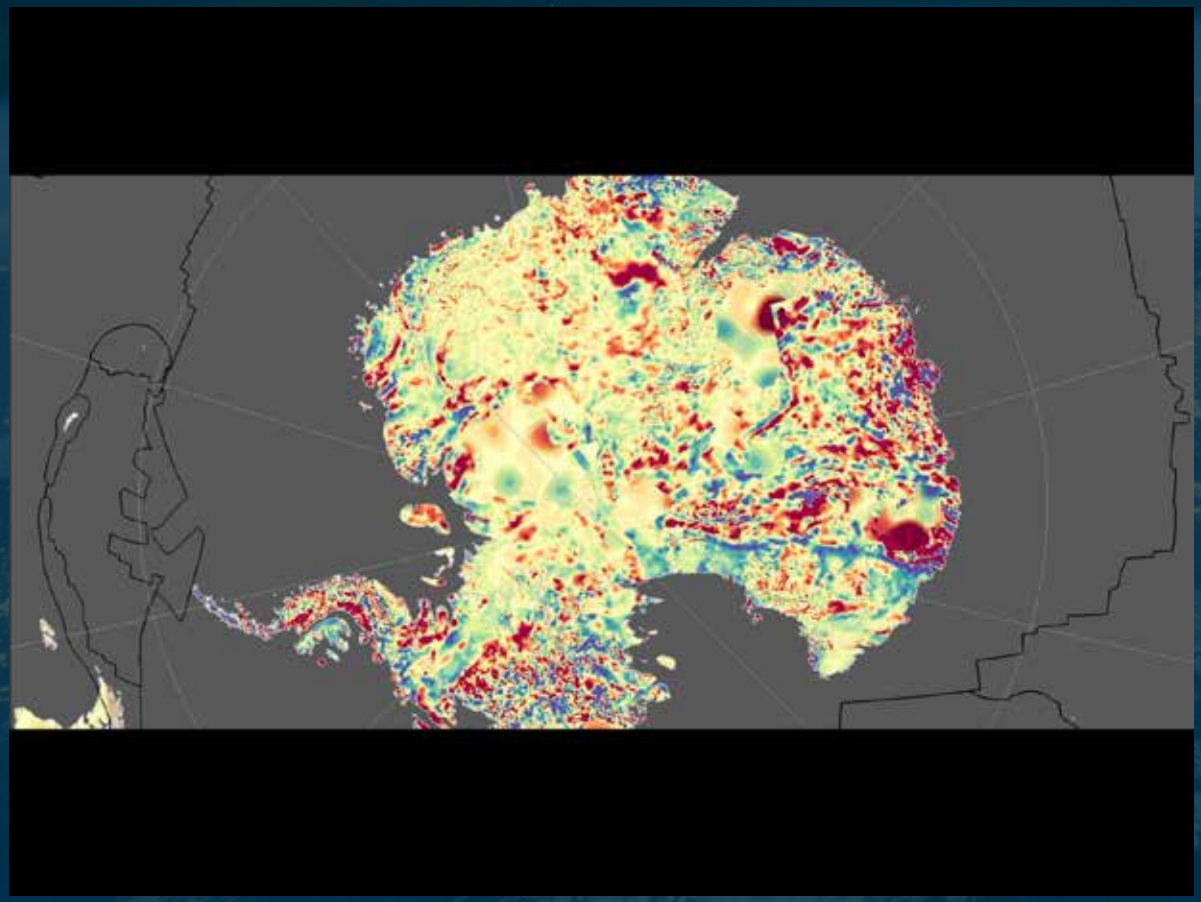
Terrestrial geophysics allows us to listen to the beat of earthquakes and sketch out Earth's interior structure

Antarctica’s magnetic link to ancient neighbours

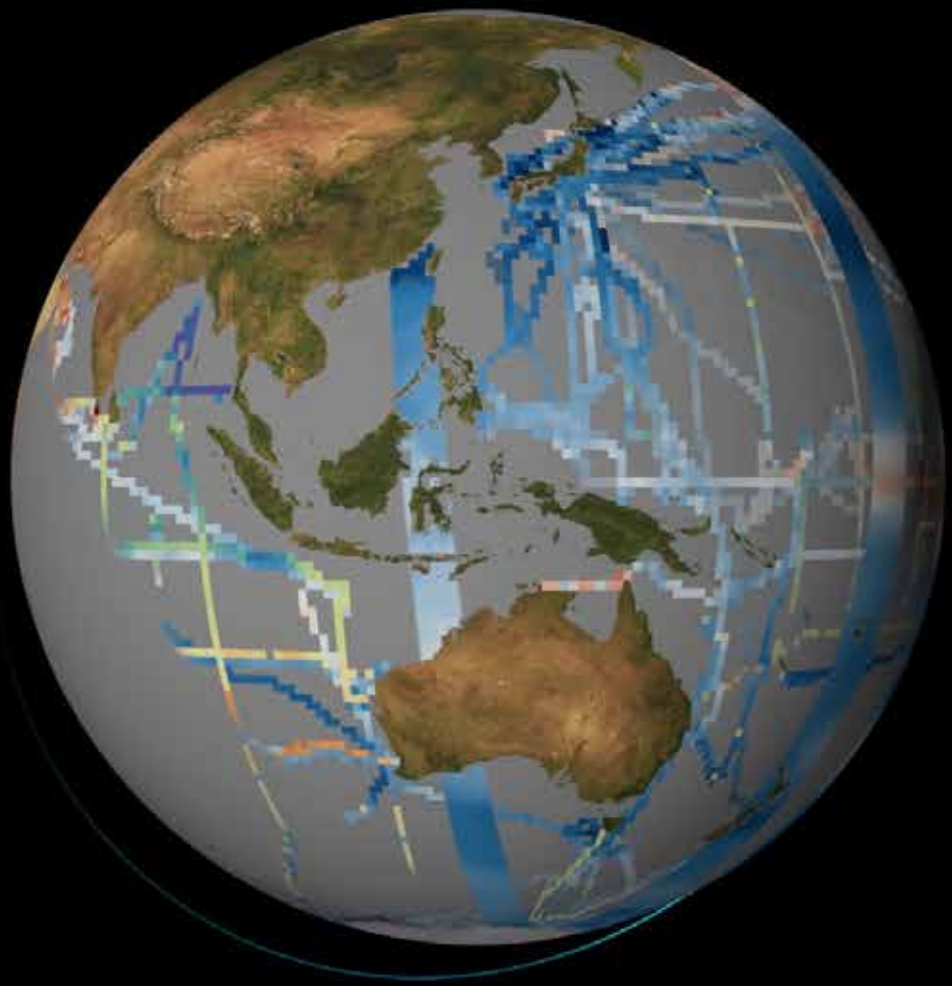


The new study shows that combining satellite and aeromagnetic data provides a key missing link to connect Antarctica’s hidden geology with formerly adjacent continents, namely Australia, India and South Africa – keystones of Gondwana.

A novel 20+ years of ocean acidification dataset

Results from OceanSODA team: esa-oceansoda.org

Satellite observations can be used to fill in the gaps by measuring related parameters such as ocean temperature, salinity and chlorophyll content.



Cryosat based 10 years Glacier Mass Balance – Alaska / Himalayas

Results from CryoTop/Mont. Glaciers team: cryosat-mtg.org

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COOPERATION BETWEEN GOOGLE EARTH, ESA, EC, NASA AND US GEOLOGICAL SURVEY

Sentinel-2 satellite imagery key to powering Google Earth's new timelapse

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Interactions ESA-EOP with ESSC

- Prof. Chris Rapley
  - appointed as (ad personam) Member of ACEO (ESA Advisory Committee on Earth Observation) since Nov. 2020 (after Athena Coustenis's departure)
  - chaired the agenda item of the ACEO meeting (5-7 May 2021) dealing with the recommendation for the EE11 candidate missions to enter phase 0
  - will report ACEO findings to PBEO on 10/6/2021
- Dr. Sindy Sterckx appointed as (ad personam) Member of the International Science Panel for the EOEP-5/FutureEO-1 Programmes
- ESA/EOP looking forward to the ESSC recommendation for the CM-22 Earth Observation programmes proposals

Questions from ESSC linked to EO (1)

The ESA CCI programme has been extremely successful and useful (it is very envied by our colleagues in the US). But beyond the ECV monitoring phase (that needs to continue), it may be time to go further, in particular to focus on the impacts of global changes and investigate how EO can help (defining for example **a series of impact indicators** that could be observed from space). What is your (ESA) opinion on that issue?

- Reference to a changing climate is often given only by rising global temperature but not suffiicient
- To counter this, GCOS has proposed 7 indicators which cover the most relevant domains of climate change: temperature and energy, atmospheric composition, ocean and water as well as the cryosphere, https://gcos.wmo.int/en/global-climate-indicators
- These are used by WMO as the base for their annual reporting for the state of the climate.
- The indicators are of course by definition ECVs, but simply a down selection of the all ECVs.
- The use of cross-ECV's is also considered of paramount importance to answer key questions such as
  - closure of the sea level budget
  - NASA-ESA IMBIE (Ice sheet mass balance intercomparison exercise)

Questions from ESSC linked to EO (2)

EO would greatly **benefit of small satellites constellations** (Cubesats, etc.). This would help increasing the spatio-temporal resolution of some measurements (e.g., for monitoring river runoff with daily resolution, coastal zones changes, extreme events...). What is the position of ESA on that issue? Are there plans to complement the Sentinel programme by Small Sat missions for some EO applications not reachable by conventional means?

- Already in 2014-2016, ph AB1 for a small radar companion satellite to fly with SAOCOM-1a in bistatic mode
- Since 2017, ESA/EOP intensively following the development of "*New Space*"
- Setup of the Phi-Lab
- Launch of PhiSat (CubeSat) satellites in 2020 with AI chip on an EO satellite
- Development of prototype AWS (Arctic Weather Satellite) for 40 M€ that should be taken over by EUMETSAT with a constellation of 16 satellites
- Start a new SCOUT series of satellites (3 years development and cost < 25 M€)
- At the end, it still remains that large infrastructures (EO satellites) would be needed to
  - Fostering a free/full/open data policy
  - Key scientific and societal questions pushing the frontiers of science/technology do require large/expensive satellites (ex. recent evaluation of the EE11 missions ideas)
  - Ensure proper cross-calibration with (less performing) smaller satellites

Questions from ESSC linked to EO (3)

Does ESA consider exploiting synergies (and team up) with the private sector to fly small-sat constellations also for measuring other variables such as greenhouse gases (CO2, methane)? Such measurements would support Europe's reporting duties with respect to its own mitigation efforts but more importantly respond to its mandate of capacity building under the UNFCCC Paris Agreement, especially since such measurements would greatly increase the spatial coverage of greenhouse gas information in the global South.

- ESA very active with small-sat actors (Planet, ICEYE, Spire)
- ICEYE radar data will be offered in the frame of the ESA Third party missions (decided at last PBEO)
- Both ICEYE and PLANET data are now used in the operations of the International Space and Major Disasters founded by ESA/CNES/CSA in 2000
- In the frame of the MFF-2 (EC multi-annual financial framework 2021-2027) budget, a substantial amount is allocated to data buy from (small-sat) commercial actors in the frame of the Copernicus programme.
- Very recent discussions with Planet to use the synergy of S5P, CO2M and CarbonMapper
- Agreement with GHGSat (Iris) to provide via ESA 5% of the new satellite measurements to the scientific community for free

Questions from ESSC linked to EO (4)

Copernicus is a widely recognized European success (also envied by non-Europeans) but it remains unclear who are really the users and what they do with the data/products. The data/products from the Sentinel missions are no doubt top level (in particular for scientific applications) but it is not completely clear if they fully respond all categories of end user's needs (in particular those of decision makers). These products are defined by scientists only. But the end users should be in the loop since the beginning of the process. What is the strategy of ESA on that process?

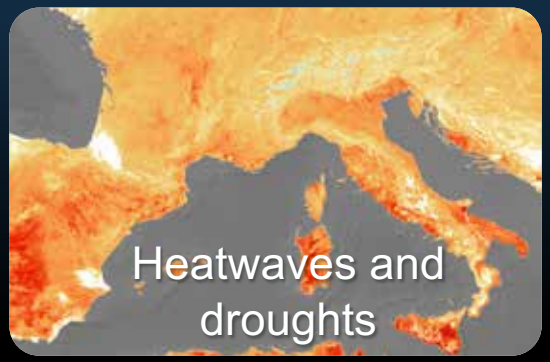
- "… *The main users of Copernicus services are policymakers and public authorities who need the information to develop environmental legislation and policies or to take critical decisions in the event of an emergency, such as a natural disaster or a humanitarian cri*sis…"

  ref: https://www.copernicus.eu/en/about-copernicus/copernicus-detail
- Copernicus designed to answer the needs of the European Commission sectorial policies (not the science community). However the main users of the Copernicus (particularly Sentinel's) are scientists
- EC in full control of the Copernicus users requirements process
- Different as the Earth Explorer process which is entirely under ESA control and are based on Calls for Ideas to the science community

EOP – Strategic challenges towards CM-22

Measure, model and predict the climate and biodiversity crises

EO is key in understanding
our natural world and its complexity
and to address key societal challenges



Develop next generations of EO missions & systems

- Maintain European EO leadership
- System of systems architecture
- Push frontiers of tech & scientific knowledge

Multiply the societal value of EO

Fully deploy disruptive innovation …

… boost EO economy & commercialisation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Thank you for your attention