

Overview of ESA Earth Observation Programmes: & Earth's extremes – Dynamic Cryosphere

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Mission Science Division

26/11/2017

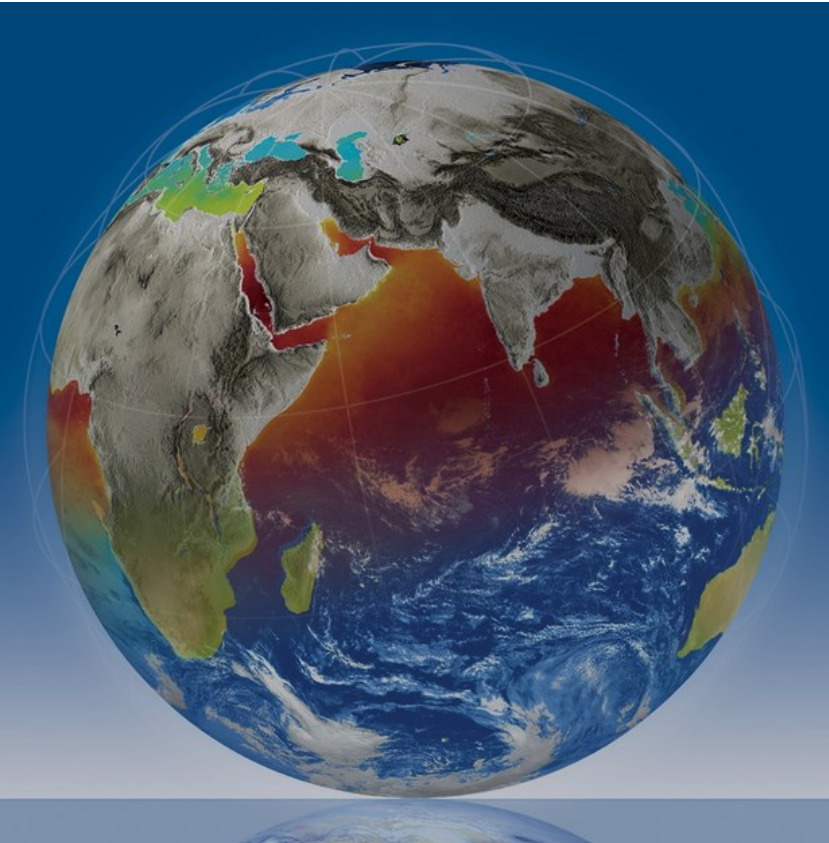
ESA's Living Planet Programme



- Science & Research
- Copernicus
- EarthWatch
- Meteorology

“Understanding the Earth system
and its processes”





Budget (2017)

- 1.6 B€

Personnel

- **554** = 320 ESA staff + 234 contractors
- **5 sites**: ESRIN, ESTEC, ECSAT, HQ, EBO

Four Programme lines

- Science & Research (EO Envelope)
- Copernicus (former GMES)
- EarthWatch
- Meteorology

**28 satellites in development;
12 satellites in operation**

ESA budget for 2017: by domain

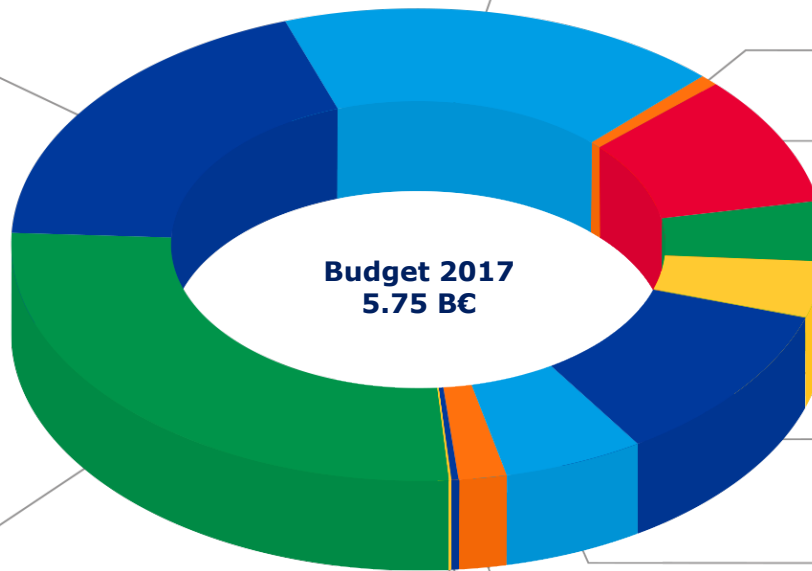
Navigation*
17.6%, 1,010.8 M€

Launchers*
18.9%, 1,088.4 M€

B€: Billion Euro
M€: Million Euro
***includes programmes implemented for other institutional partners**

Earth Observation*
26.9%, 1,543.3 M€

European Cooperating States Agreements
0.1%, 5.5 M€



Prodex
0.8%, 47.2 M€

Space Science
8.9%, 513.1 M€

Basic Activities
4.1%, 234.8 M€

Associated with General Budget
3.9%, 222.3 M€

Human Spaceflight
& Robotic Exploration
11.0%, 633.0 M€

Telecom & Integrated Applications*
5.6%, 319.0 M€

Technology Support*
2.0%, 114.3 M€

Space Situational Awareness
0.3%, 15.1 M€

ESA-DEVELOPED EARTH OBSERVATION MISSIONS



An aerial photograph of a vast, intricate river delta system, likely the Amazon. The water is a deep blue, branching out into a complex network of channels and distributaries that flow through a rugged, brownish landscape. The land appears to be a mix of forested areas and exposed earth or rock. In the upper right corner, there is a small, circular logo with a spiral pattern. A large, dark blue rectangular box with rounded corners and a white border is centered horizontally across the middle of the image, containing the word "Copernicus" in white text.

Copernicus

Sentinels: A New Generation Data Source



Sent-1A/B



Sent-2A/B



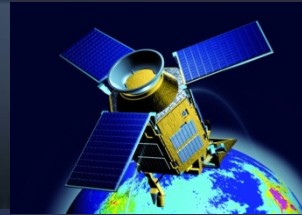
Sent-3A/B



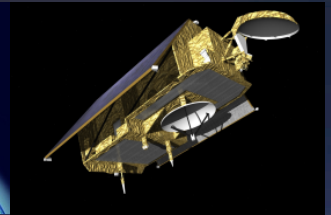
Sent-4A/B



Sent-5/5P



Sent-6A/B



- 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



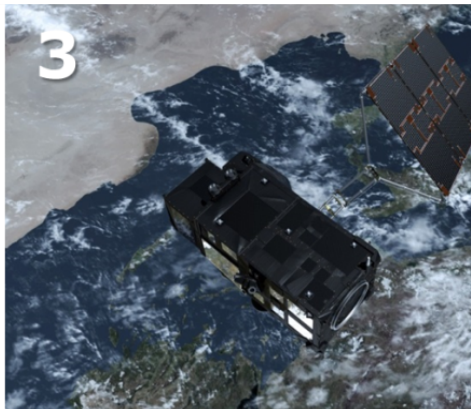
Copernicus – European Leadership in EO



1



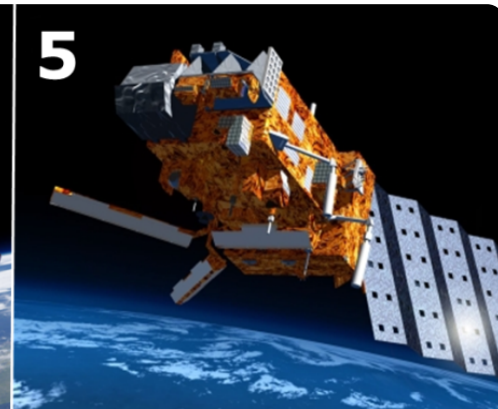
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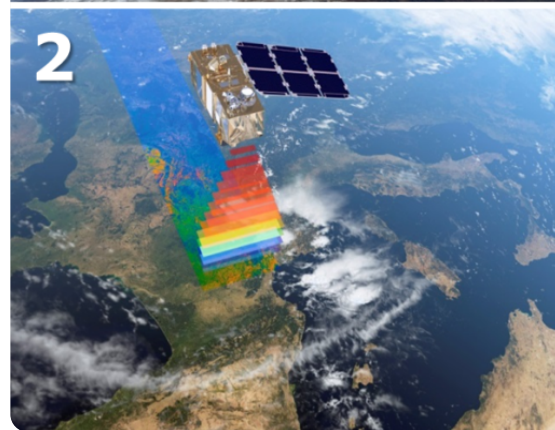
5p



5



2



4



6



Sentinel Launches



S-1



Radar

A



3 Apr. 2014

B



25 Apr. 2016

S-2



High
Resolution
Optical

A



23 Jun. 2015

B



6 Mar. 2017

S-3



Medium
Resolution
Optical &
Altimetry

A



16 Feb. 2016

B

2018

S-4



Atmospheric
Chemistry
(GEO)

A

2021

B

2027

S-5P



Atmospheric
Chemistry
(LEO)

A



13 Oct. 2017

S-5



Atmospheric
Chemistry
(LEO)

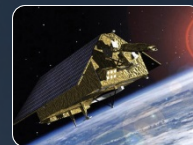
A

2021

B

2027

S-6



Altimetry

A








2020

B

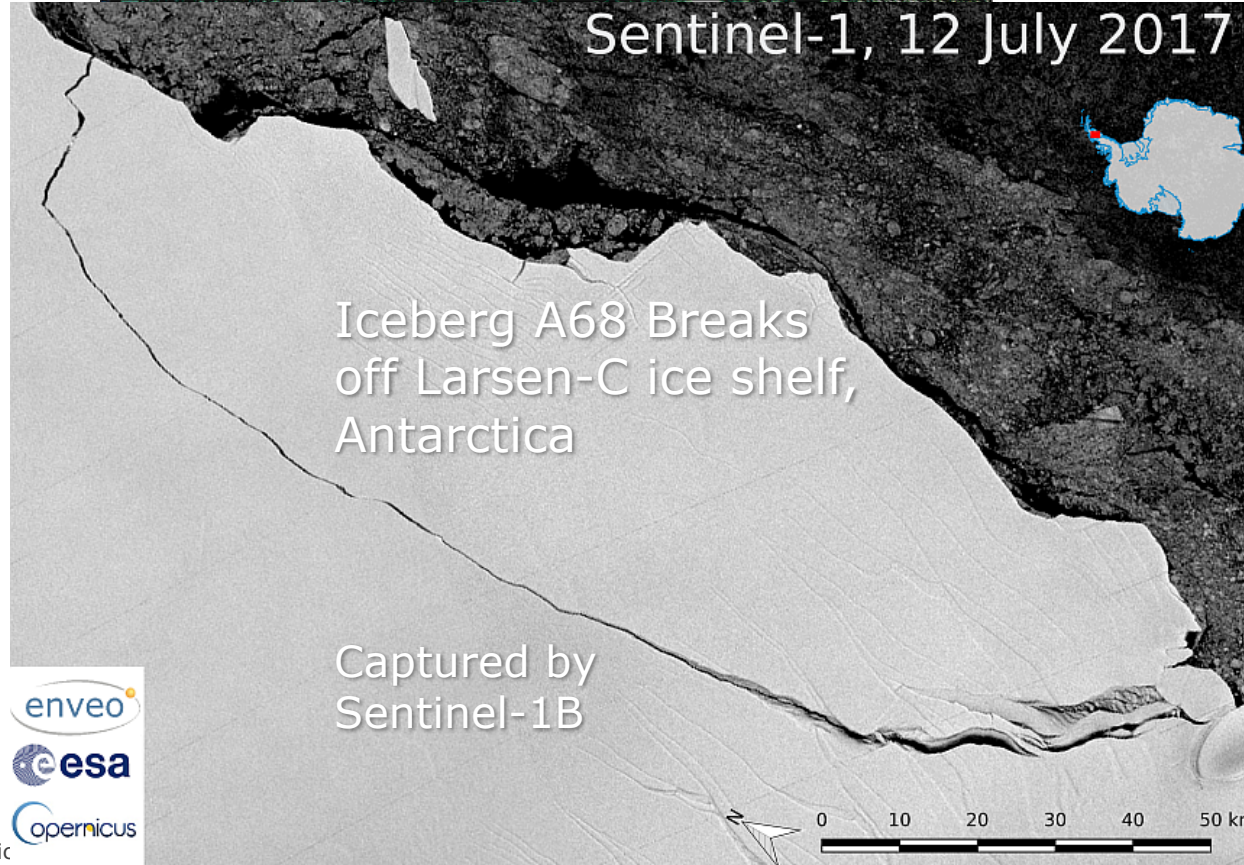
2025

Copernicus - 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 2016/2017
	S4A/B: Geostationary Atmospheric Chemistry Mission	2021/2027
	S5P: Low Earth Orbit Atmospheric Chemistry Mission	13 October 2017
	S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission	2021/2027
	S6A/B: Altimetry Mission	2020/2025

Monitoring Larsen-C Ice Shelf with Sentinel-1



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26/11/2017 | Slide 11

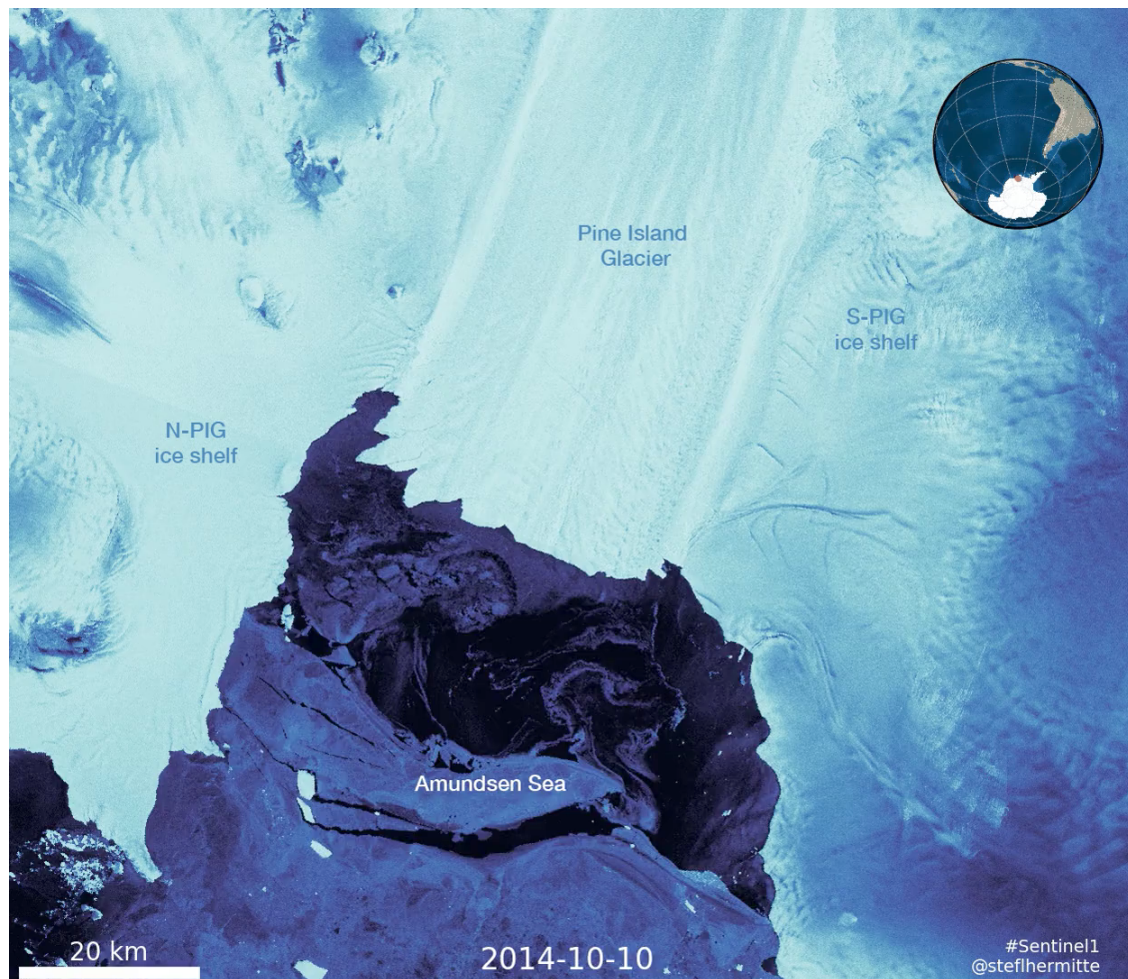


European Space Agency

Glacier Flow

Pine Island Glacier (PIG) West Antarctic Ice Sheet

Sentinel-1B
2014-2017



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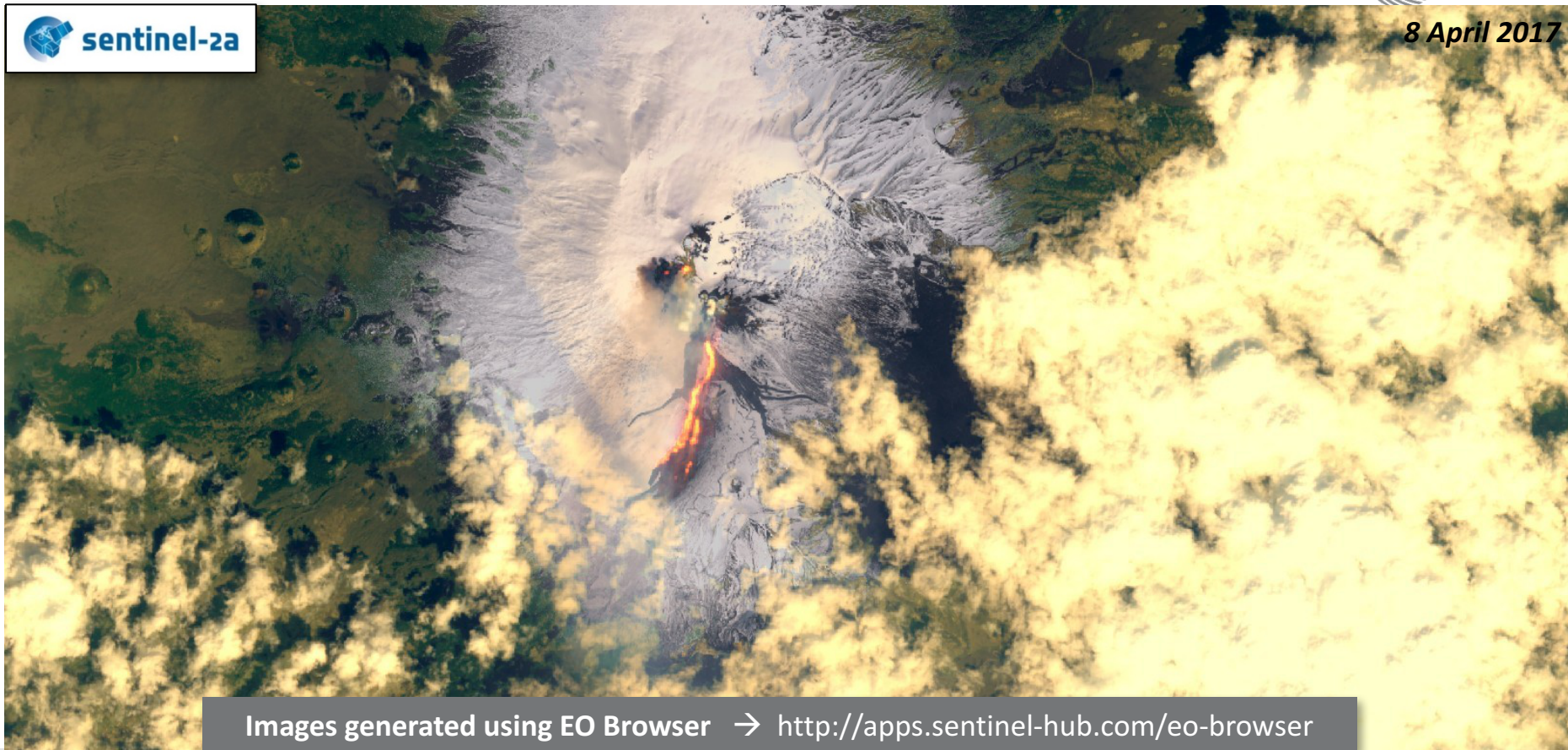


European Space Agency

Sentinel-2: Mt Etna Eruption (March – April 2017)



8 April 2017

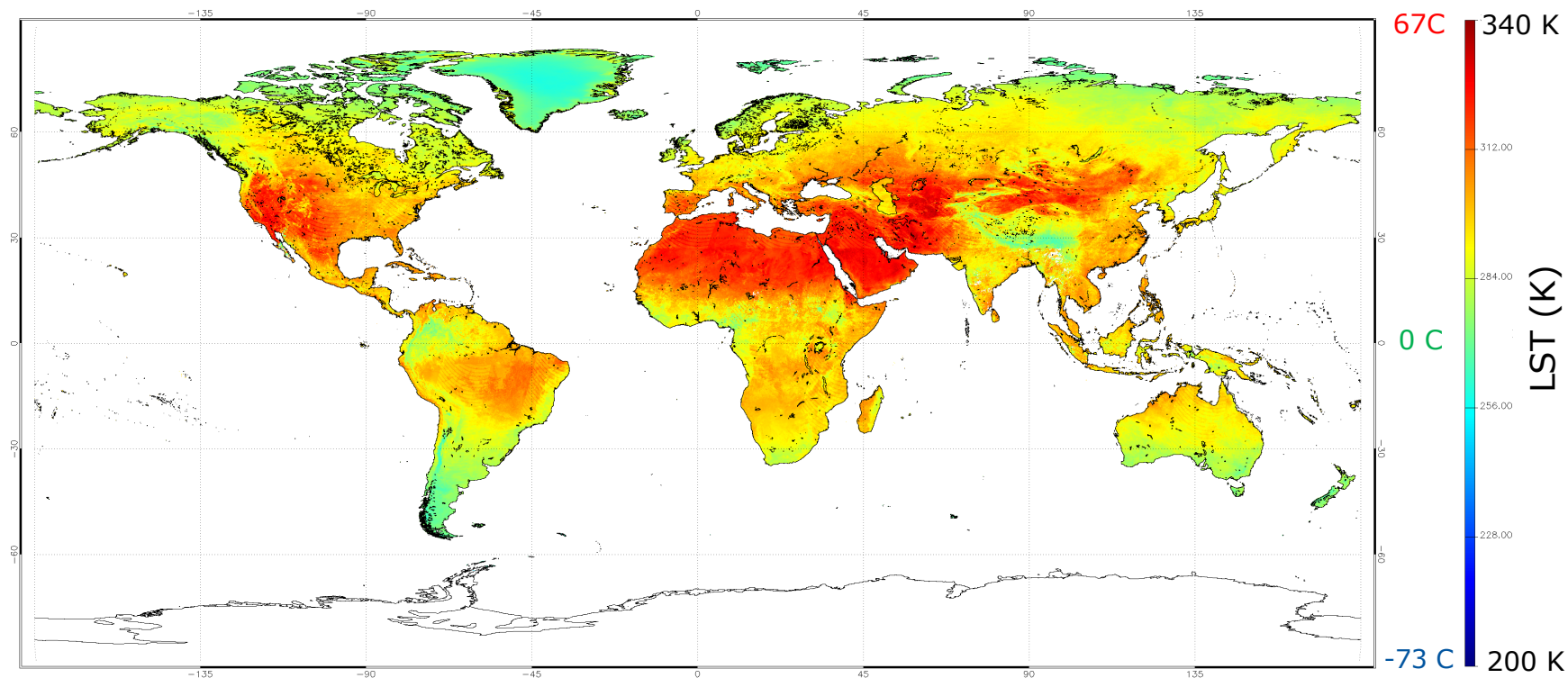


Images generated using EO Browser → <http://apps.sentinel-hub.com/eo-browser>



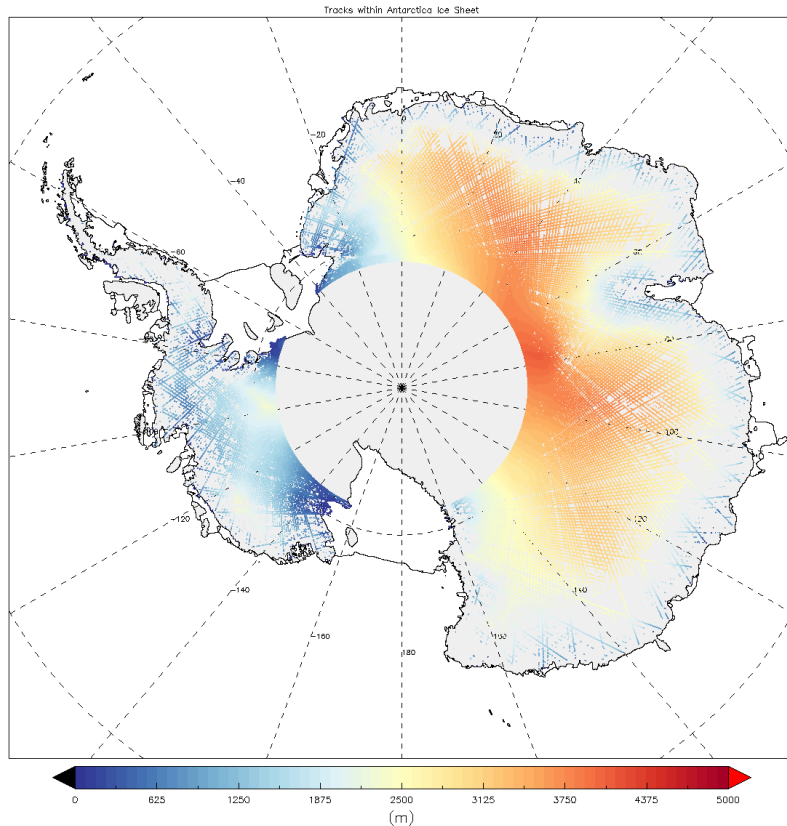
European Space Agency

Sentinel-3: Land Surface Temperature (LST)



Copyright: contains modified Sentinel-3A data (2016)
Processed by UK National Centre for Earth Observation/University of Leicester

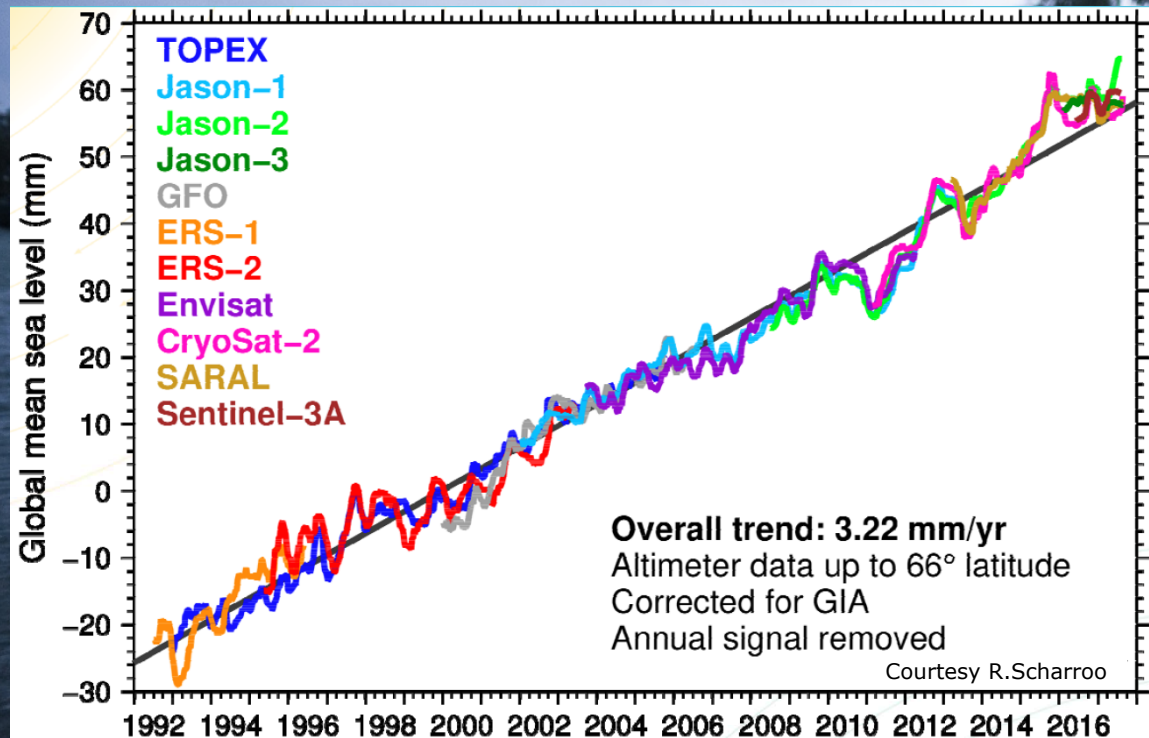
Land Ice Elevation and Volume Change



Sentinel-3A measures
the Antarctic ice sheet surface
elevation and topography

Based on Copernicus Sentinel data (2015),
Processed by UCL-MSSL

Rising Sea Levels

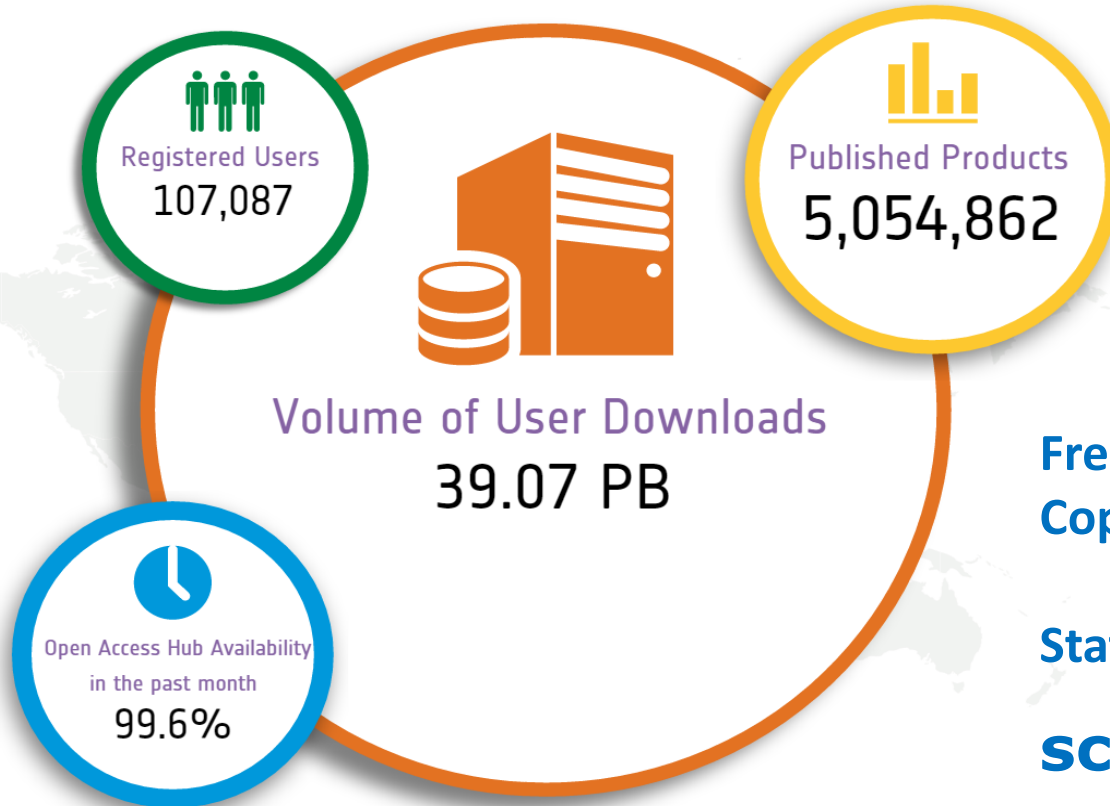


Mean Sea
Level Rise (cm)

Satellite Altimetry Sea
Level Data:

- Sentinel-3 and
- Sentinel-6 (>2020)

Sentinel Open Access Data Hub



**Free and open access to
Copernicus products**

Statistics as of 17 Nov. 2017

scihub.copernicus.eu

Copernicus: Economic Benefits

The **global geospatial analytics market** was valued at US\$ 27.42 bn in 2015 and is projected to reach **US\$ 72.21 bn by 2020**

Increase by factor 3 in 5 y

Research and Markets, 2016

based on free and open data policy



1 € spent by European tax payer on Copernicus results in **public return of up to 10 €**

Ratio 1:10

"The Socio-Economic Benefits of GMES"
ESPI report 39, November 2011

Meteosat 9

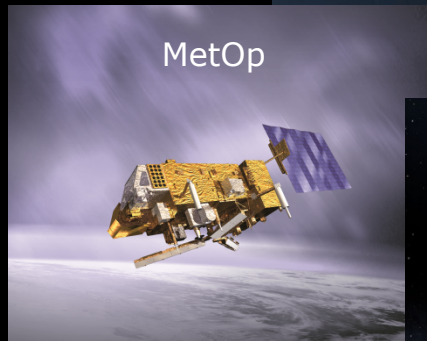
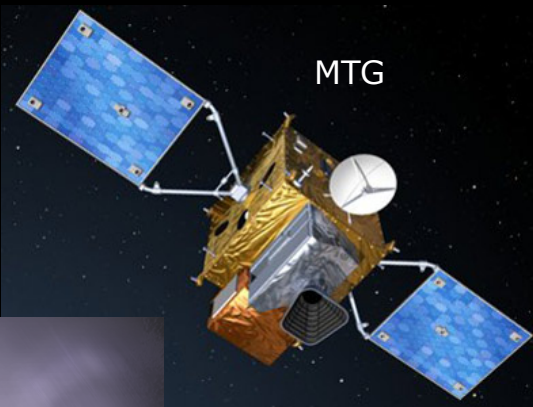


Meteorological Missions

19 Sept. 2012

Meteorological Missions

- ESA develops prototype satellites, and, on behalf of EUMETSAT, procures recurrent satellites
- EUMETSAT operates the satellites
- Currently Meteosat Second Generation (MSG) in GEO and MetOp in LEO orbit
- Meteosat Third Generation (MTG) and MetOp Second Generation under development for launch in next decade





The Earth Explorers

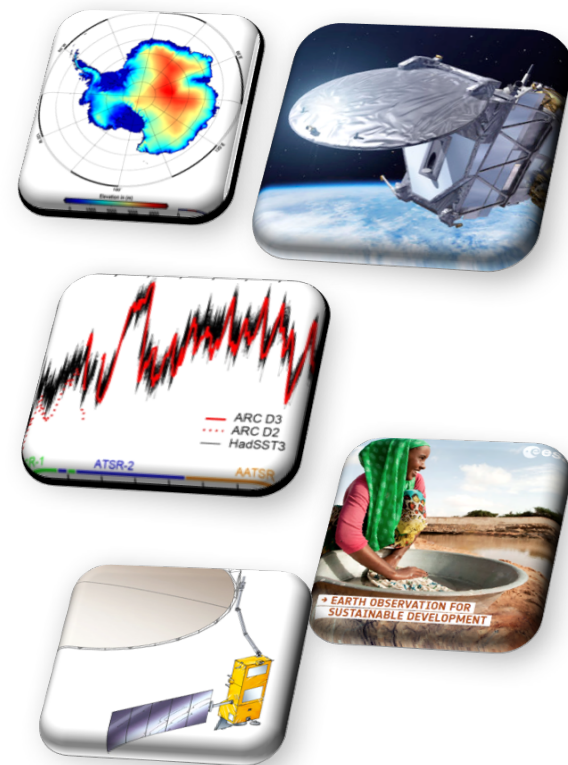
Research Missions

EOEP-5 (2017-2021)



Earth Observation Envelope Programme (EOEP): EO backbone Programme:

- Prepares all Research Missions (Earth Explorers) and future mission concepts
- From pre-development to research/data exploitation
- Enhances competitiveness of European industry
- Addresses scientific and societal challenges (climate, water, food, SDG, etc.)
- Drives scientific excellence and innovation
- Brings EO to all levels of society



Earth Explorers: EO Science Missions



GOCE	2009 – 2013
SMOS	2009 – Present
CryoSat	2010 – Present
SWARM	2013 – Present
Aeolus	2018
EarthCARE	2019
Biomass	2021
FLEX	2022
EE9 (SKIM/FORUM)	2025

Upcoming Earth Explorers



Aeolus

- Global observations of wind profiles
- Assimilation into Numerical Weather Prediction models for improved atmospheric forecasting
- Launch planned for 2018



EarthCARE

- Global observations of clouds, aerosols and radiation
- Launch planned for 2019
- Cooperation with JAXA





Dynamic Cryosphere

Courtesy M. Drinkwater - ESA

CryoSat

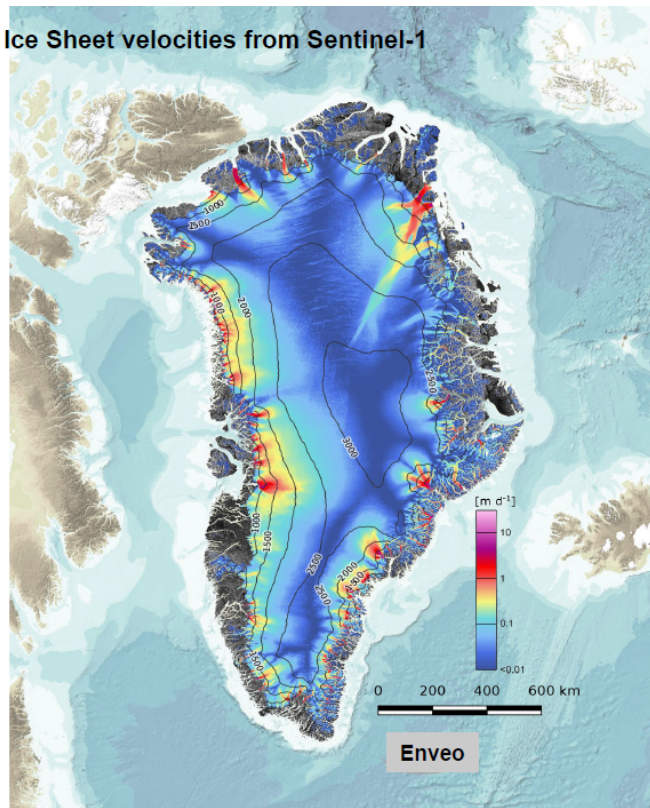
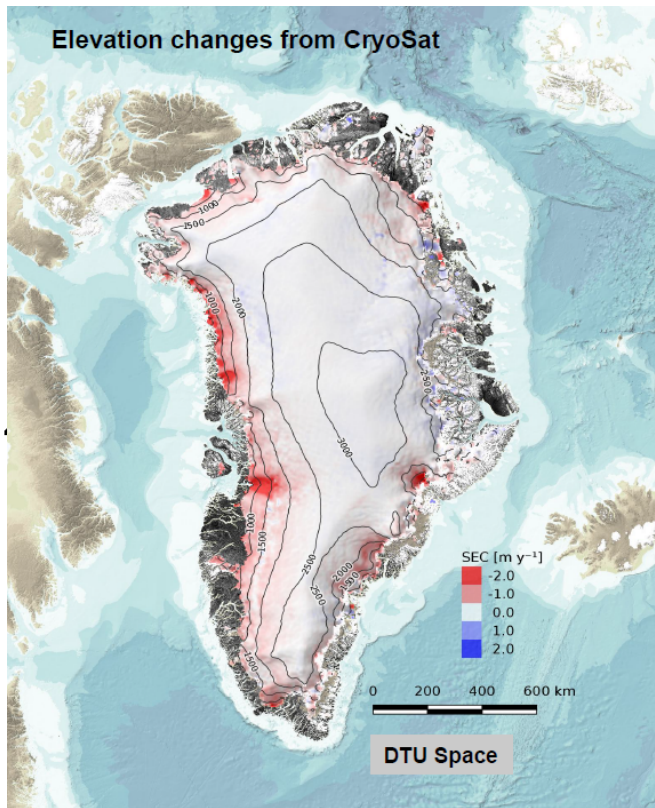


Third Earth Explorer
Launched 8 Nov. 2010

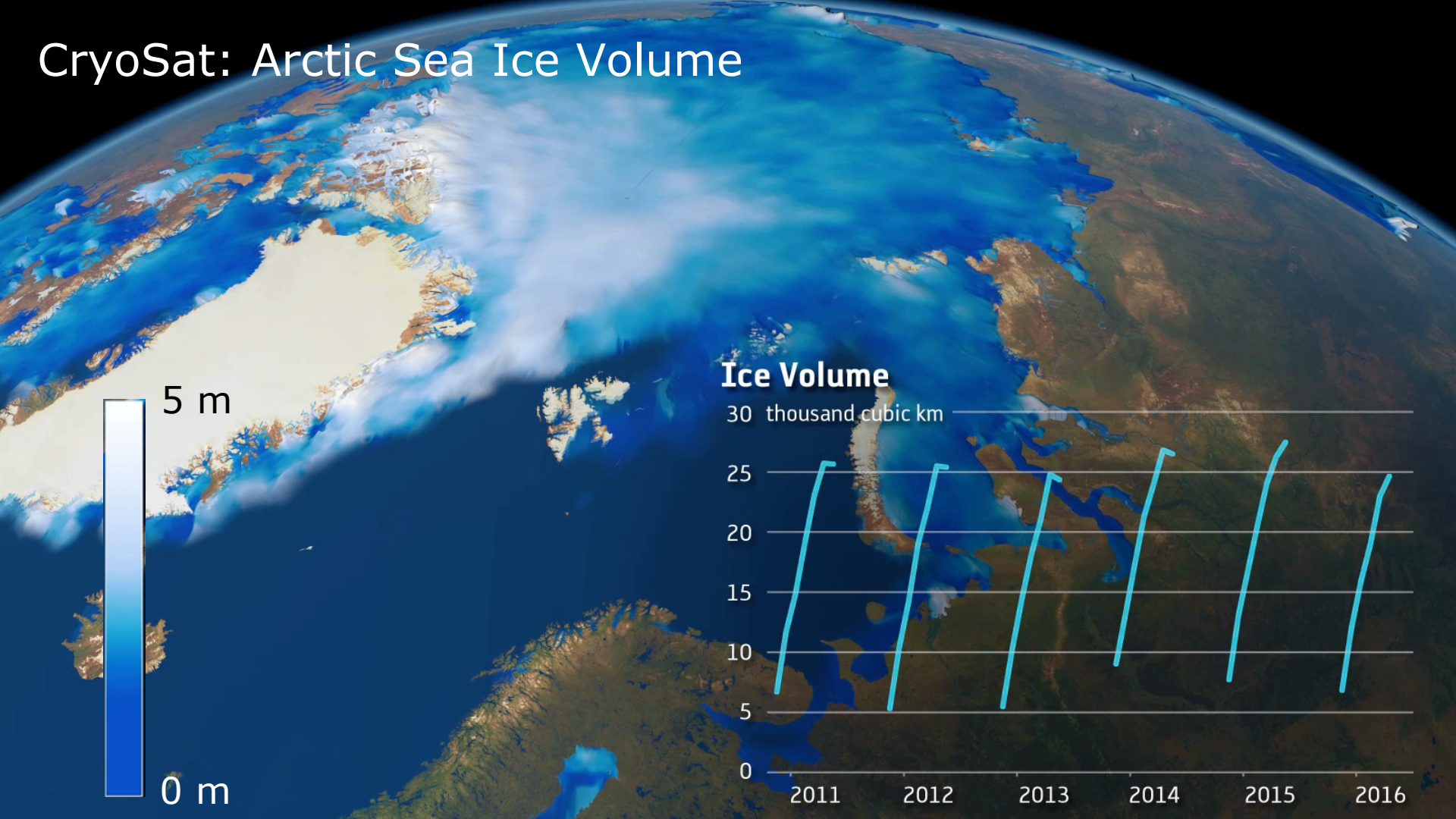
Ice Elevation and Ice Thickness
(cm-level changes)



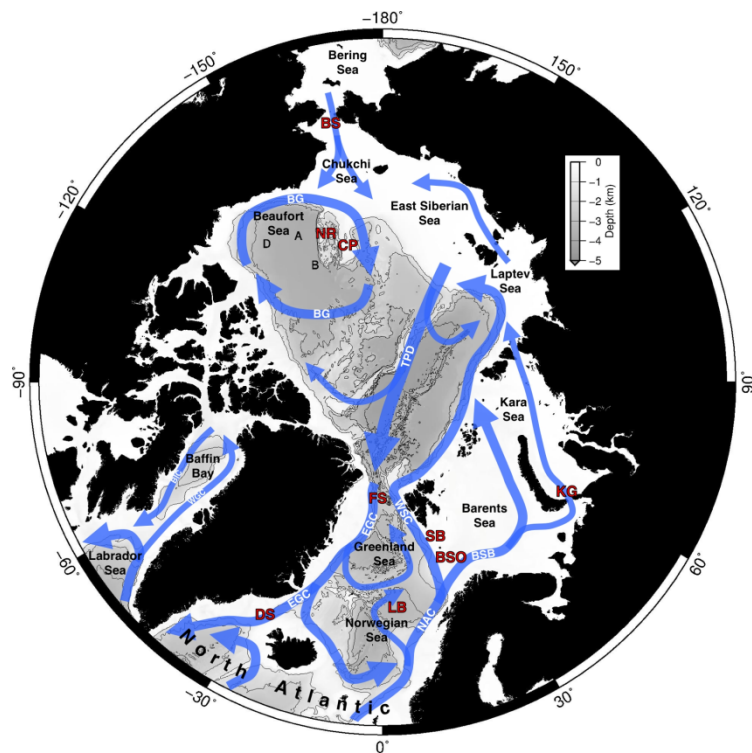
Greenland Ice Sheet Elevation and Dynamics



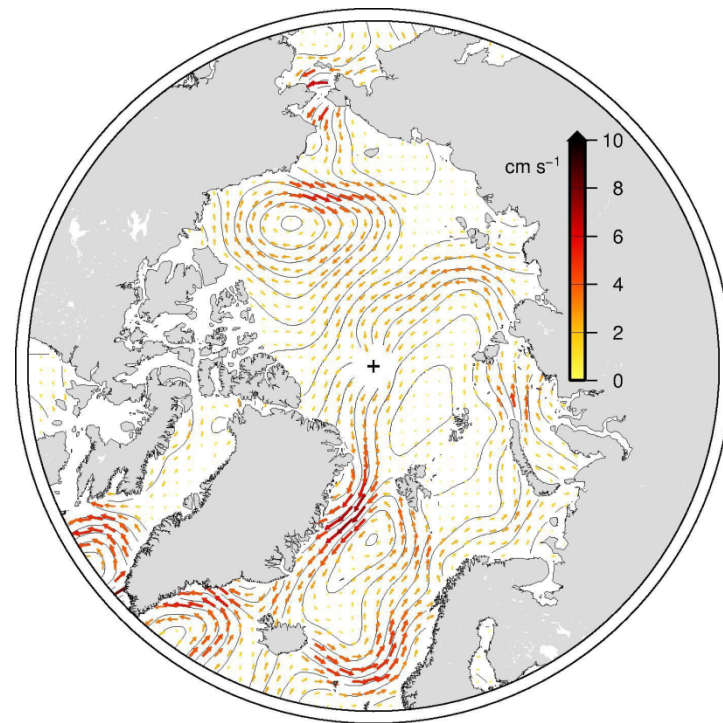
CryoSat: Arctic Sea Ice Volume



CryoSat-2: Arctic Ocean Circulation

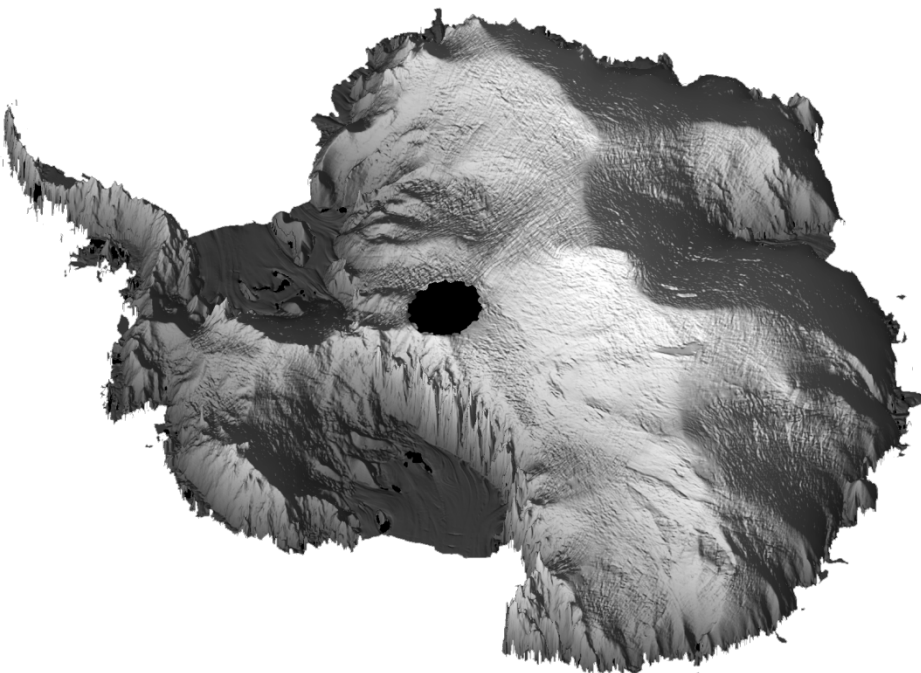


Courtesy Armitage et al. (2017), TC

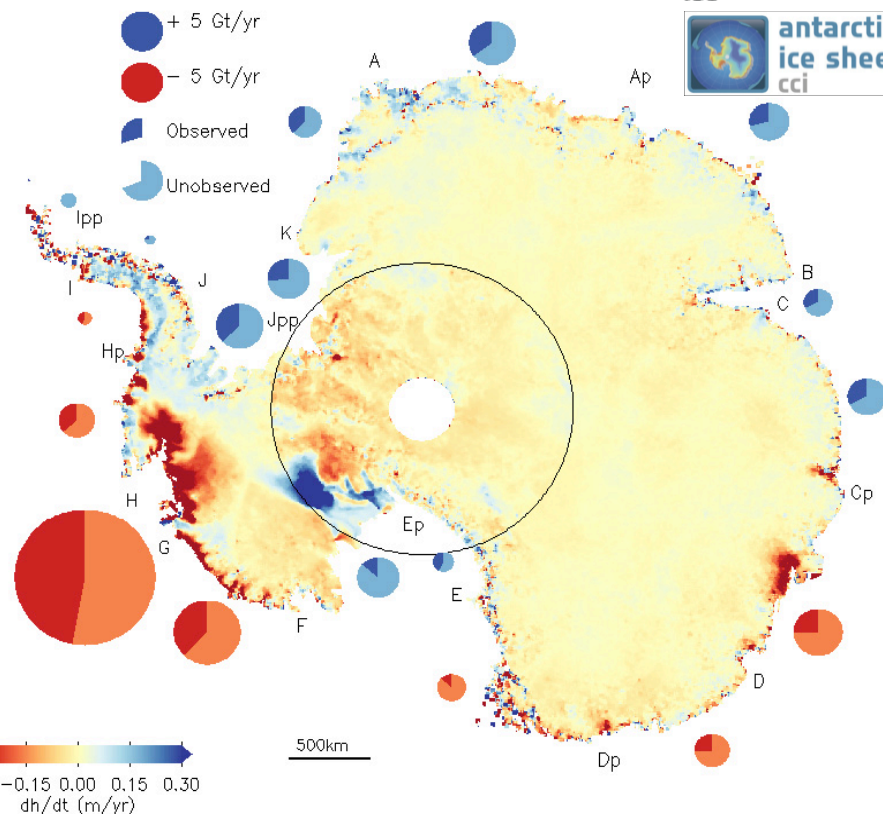


Courtesy Armitage, from CryoSat data

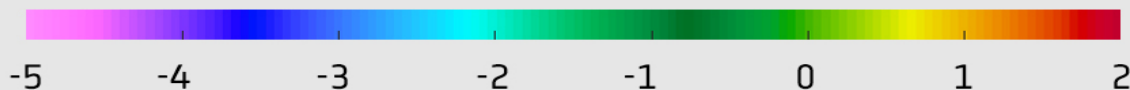
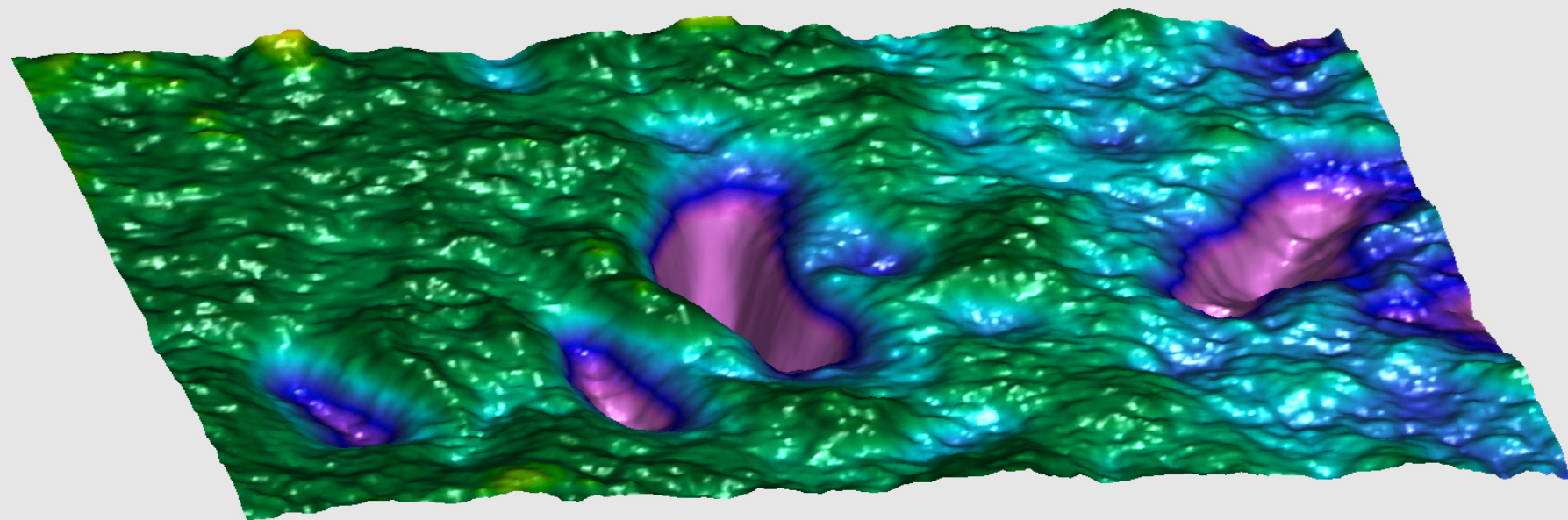
Antarctic Ice Mass Loss



- CryoSat Digital Elevation Model
- 2 km grid resolution



CryoSat: Antarctic Lake Outbursts



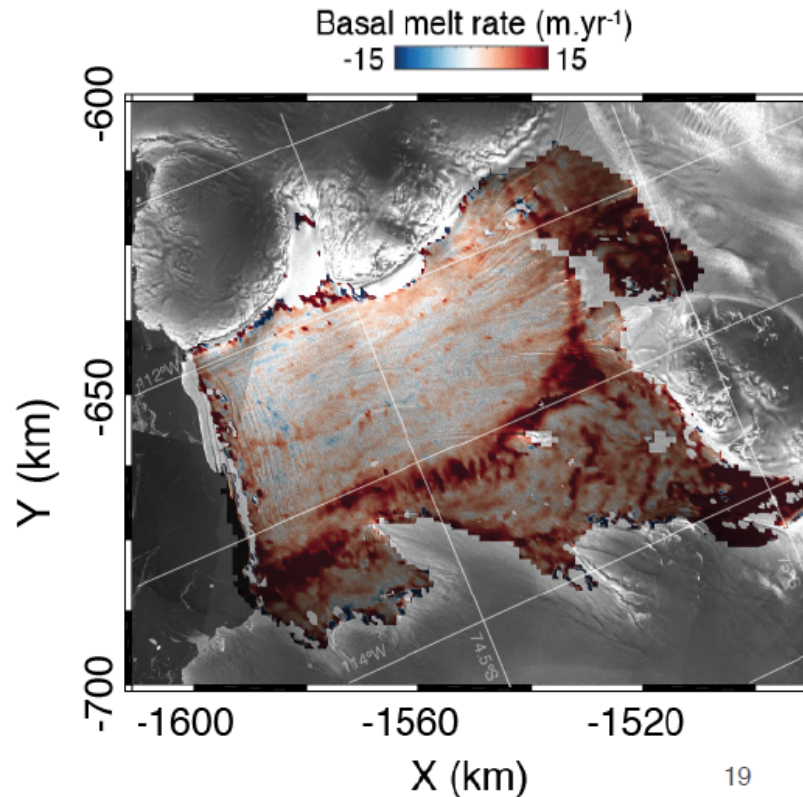
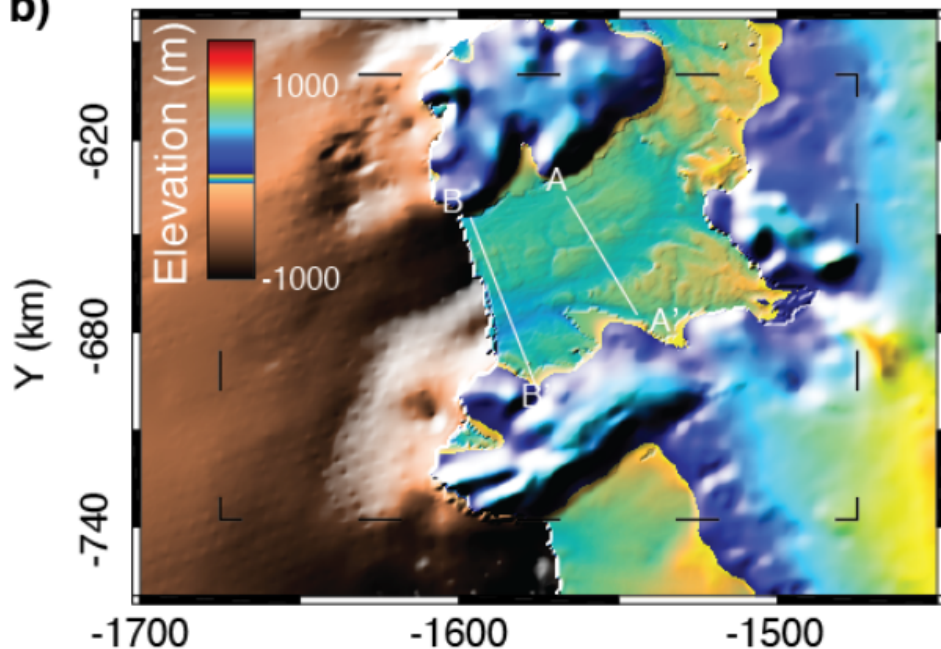
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Gourmelen

Elevation change (m)

CryoSat: Ice Shelf Submarine Canyons

Dotson Ice Shelf, Antarctica

b)



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we develop world class Earth Observing systems

