A?
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Engineering

E4230

# Microwave EO Instrumetation

*(5 cr)*

*Jaan Praks*
*Aalto University*

# Microwave EO and Climate Change

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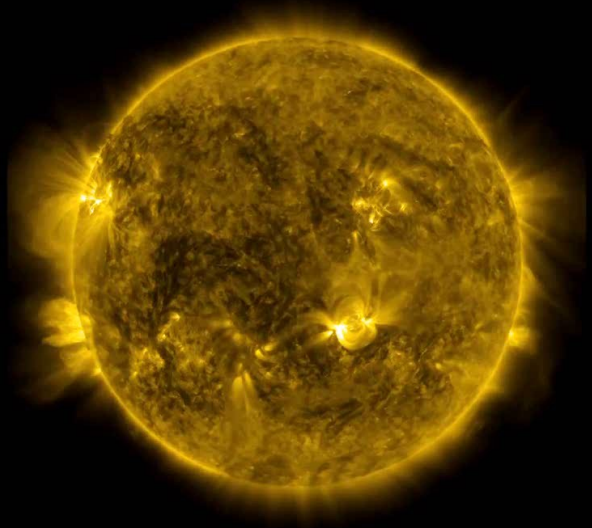

# Atmosphere

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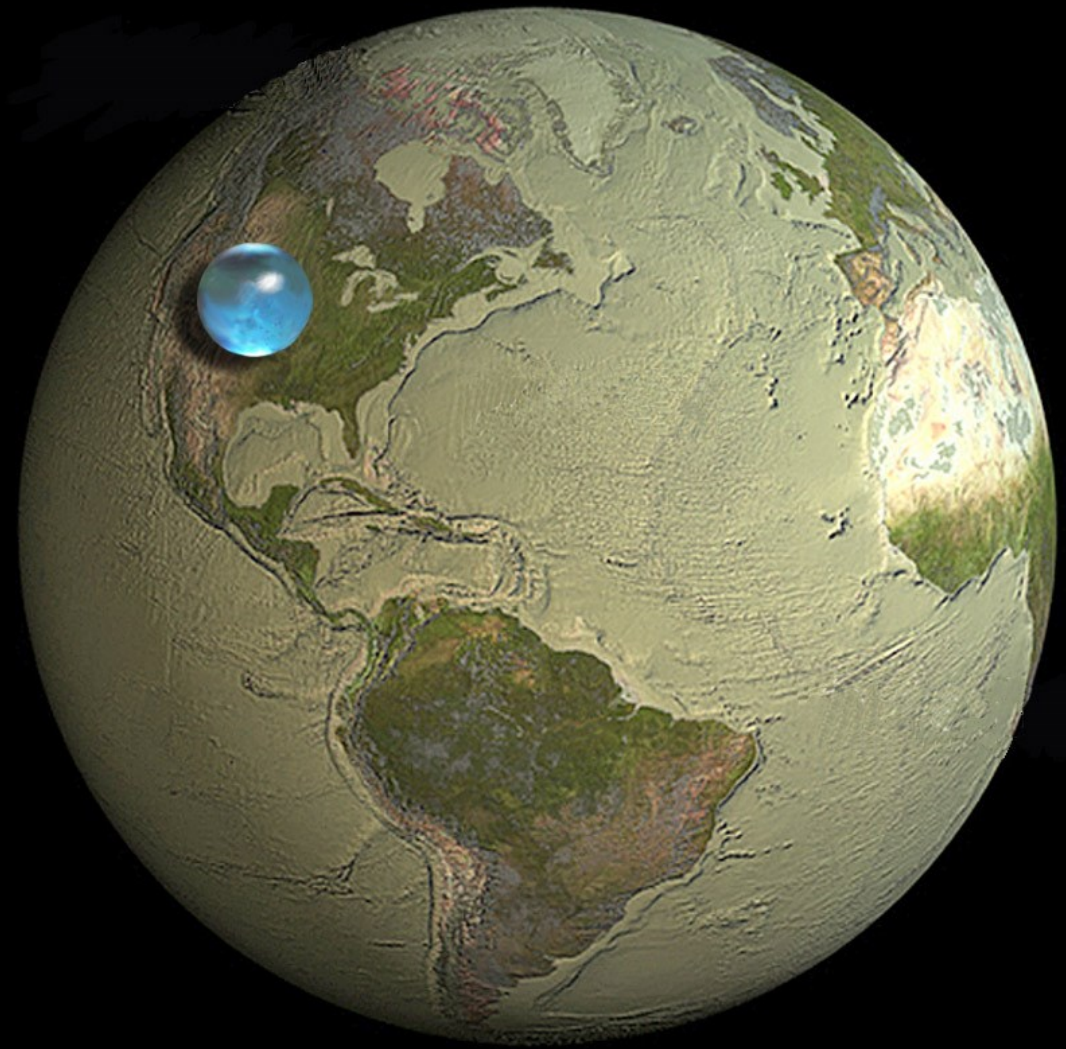
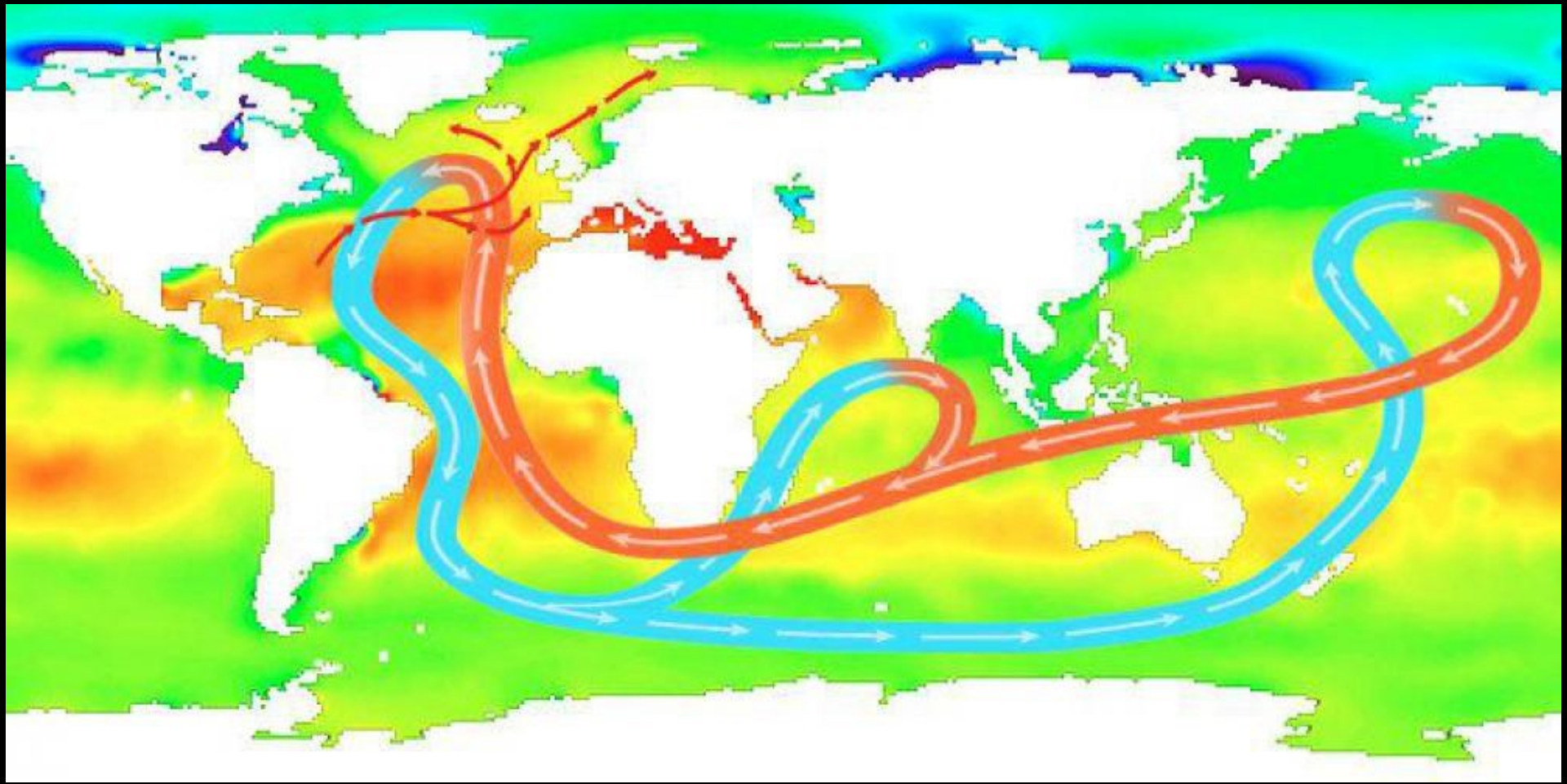
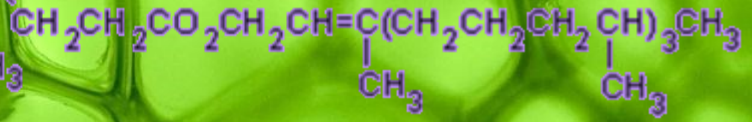
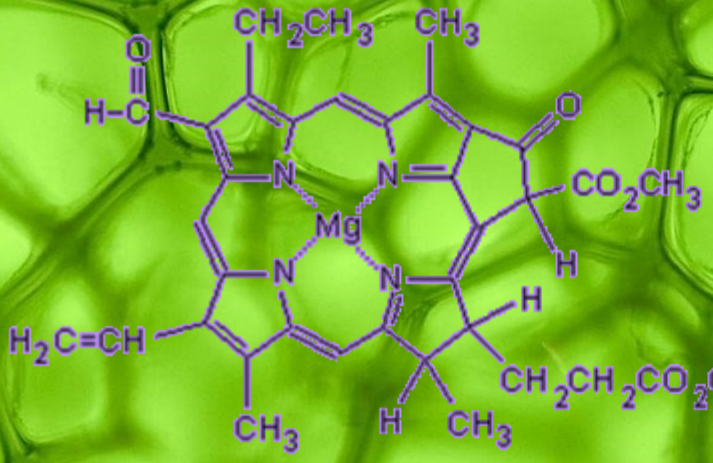
# Ocean



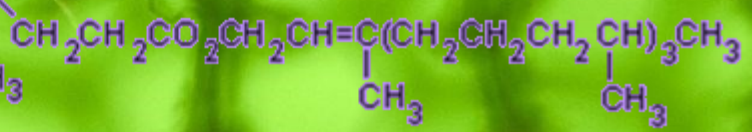


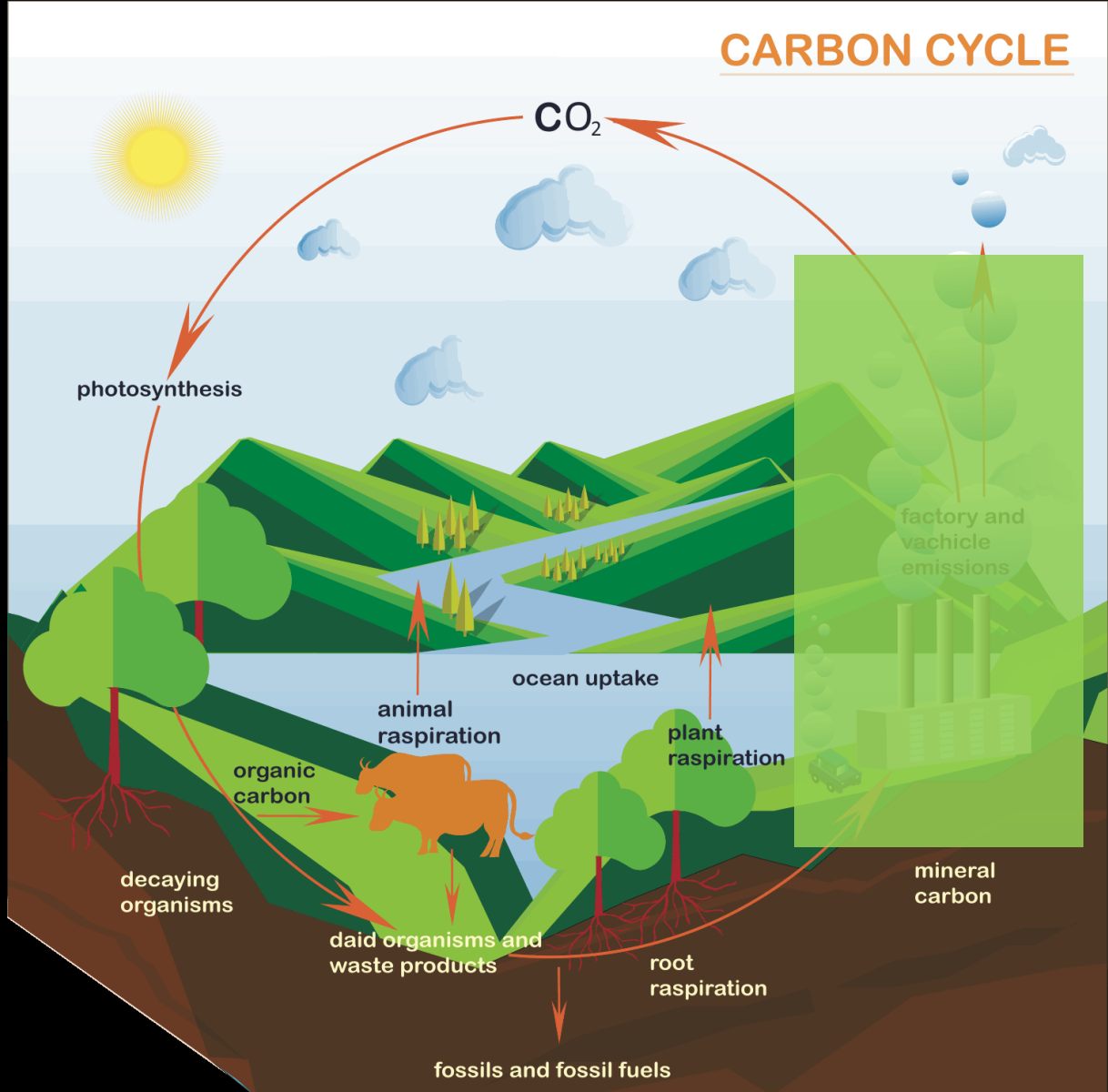

Chlorophyll a

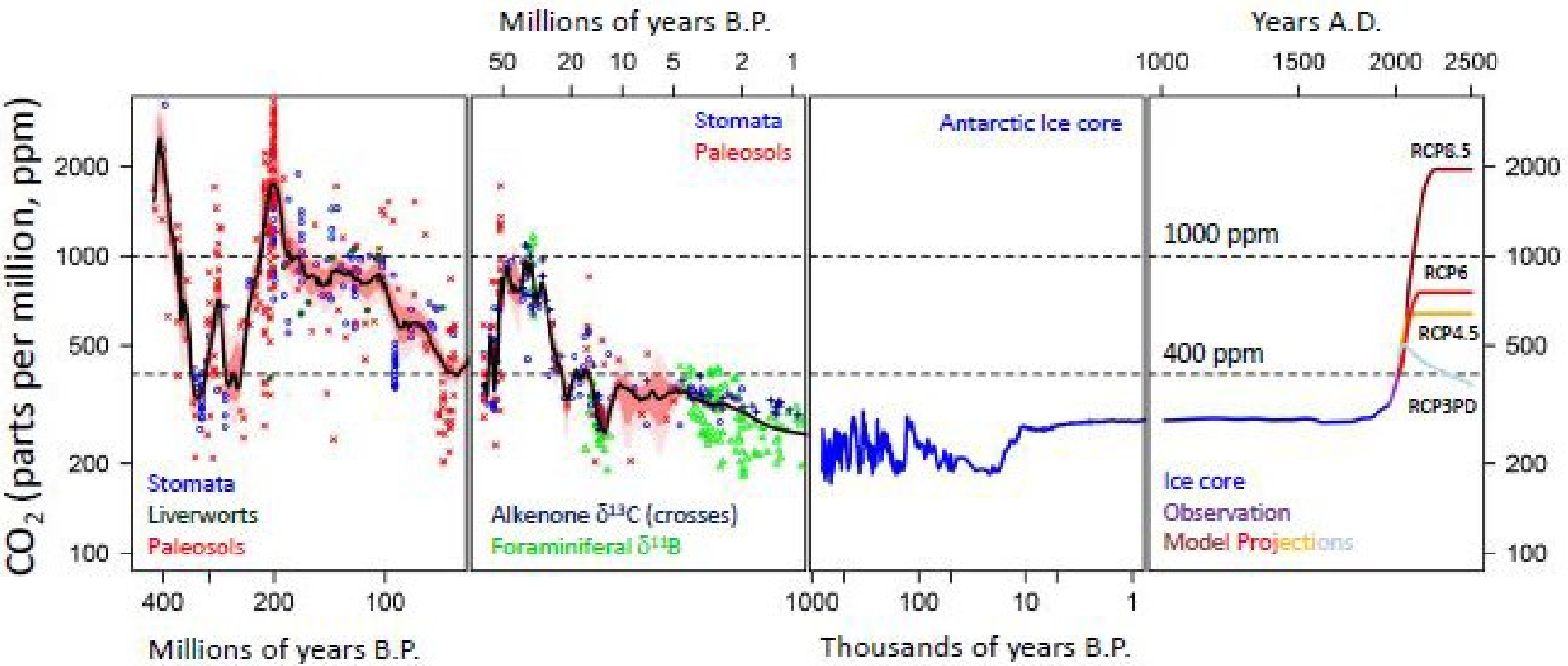



Chlorophyll b




CARBON CYCLE
$CO_2$
photosynthesis
factory and
vachicle
emissions
ocean uptake
animal
raspiration
plant
raspiration
organic
carbon
decaying
organisms
daid organisms and
waste products
root
raspiration
mineral
carbon
fossils and fossil fuels


Millions of years B.P.
50
20
10
5
2
1
Years A.D.
1000
1500
2000
2500
$CO_2$ (parts per million, ppm)
2000
1000
500
200
100
Stomata
Paleosols
Antarctic Ice core
RCP8.5
1000 ppm
RCP6
RCP4.5
400 ppm
RCP3PD
Stomata
Liverworts
Paleosols
Alkenone $\delta^{13}C$ (crosses)
Foraminiferal $\delta^{11}B$
Ice core
Observation
Model Projections
400
200
100
1000
100
10
1
Millions of years B.P.
Thousands of years B.P.

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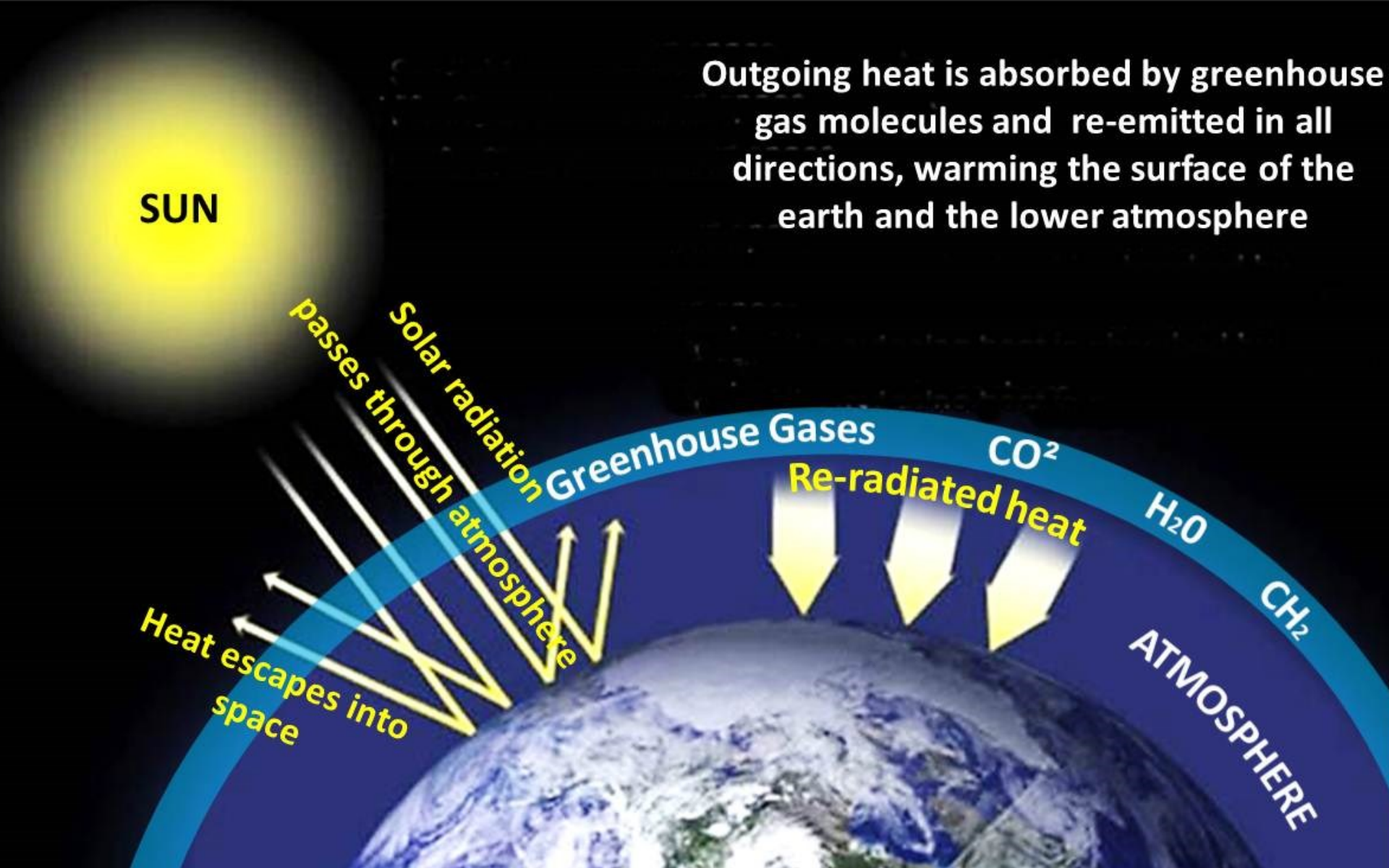
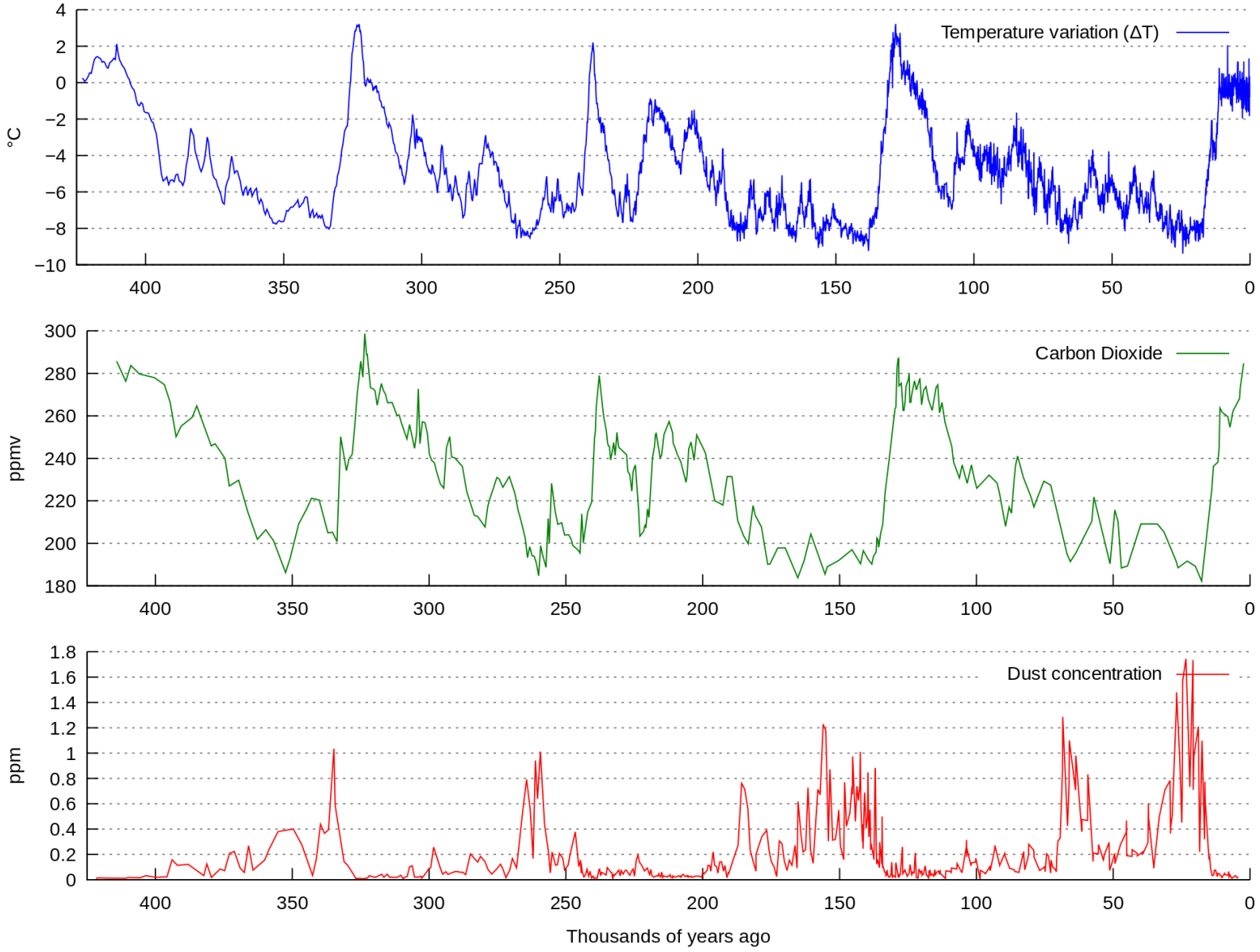
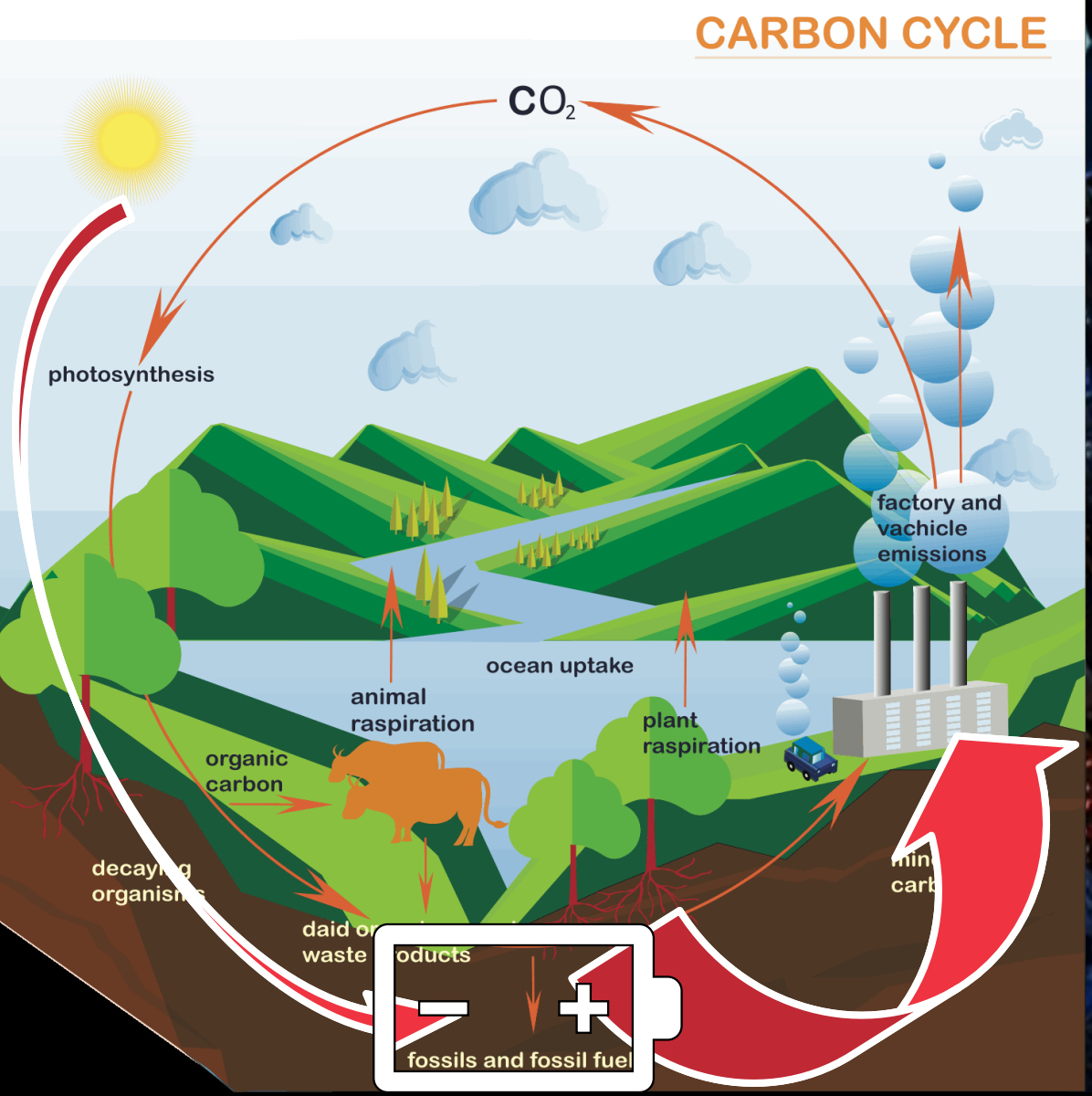
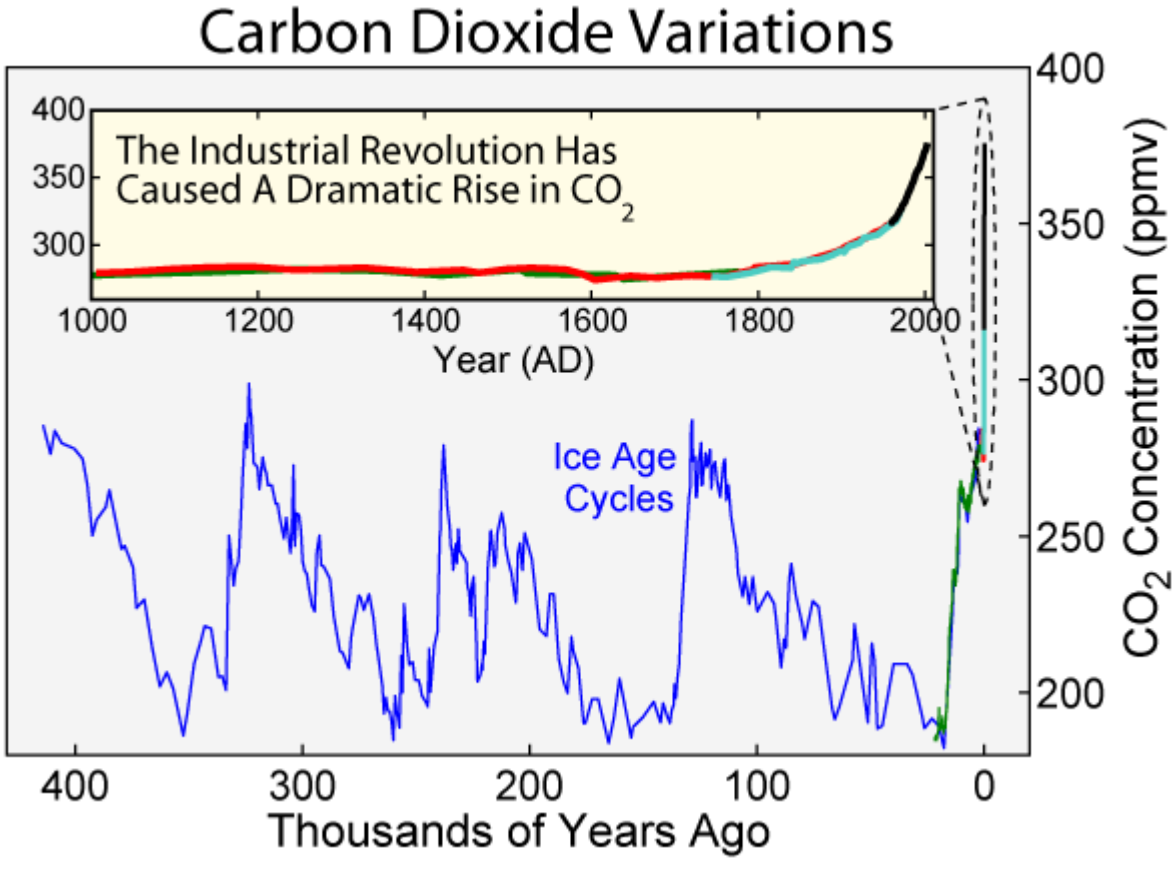
# $CO_2$ in atmosphere


Outgoing heat is absorbed by greenhouse gas molecules and re-emitted in all directions, warming the surface of the earth and the lower atmosphere
SUN
Solar radiation passes through atmosphere
Heat escapes into space
Greenhouse Gases
CO²
Re-radiated heat
H₂0
CH₂
ATMOSPHERE

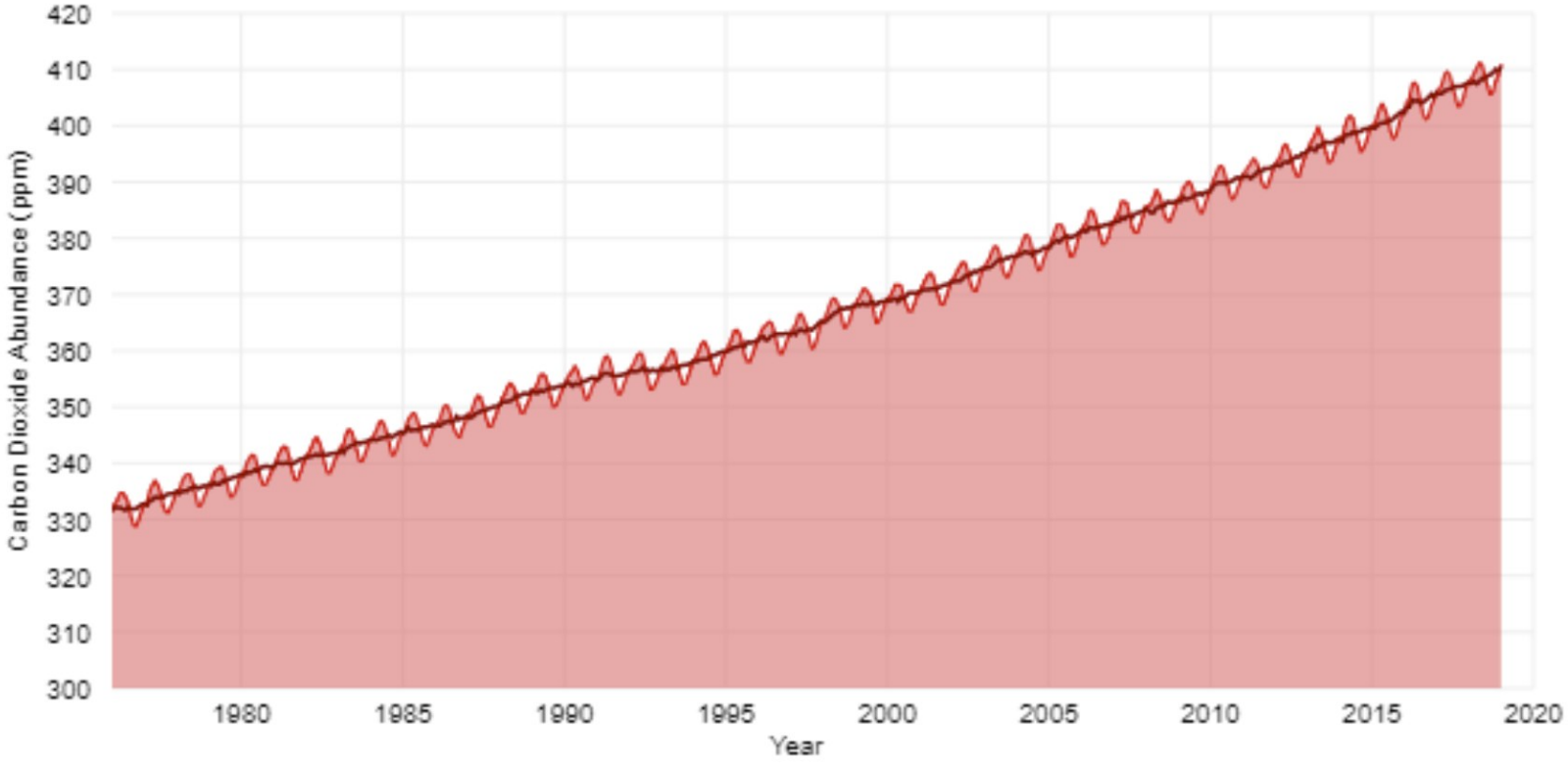

Temperature variation (ΔT)
°C
4
2
0
−2
−4
−6
−8
−10
400
350
300
250
200
150
100
50
0
Carbon Dioxide
ppmv
300
280
260
240
220
200
180
Dust concentration
ppm
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Thousands of years ago

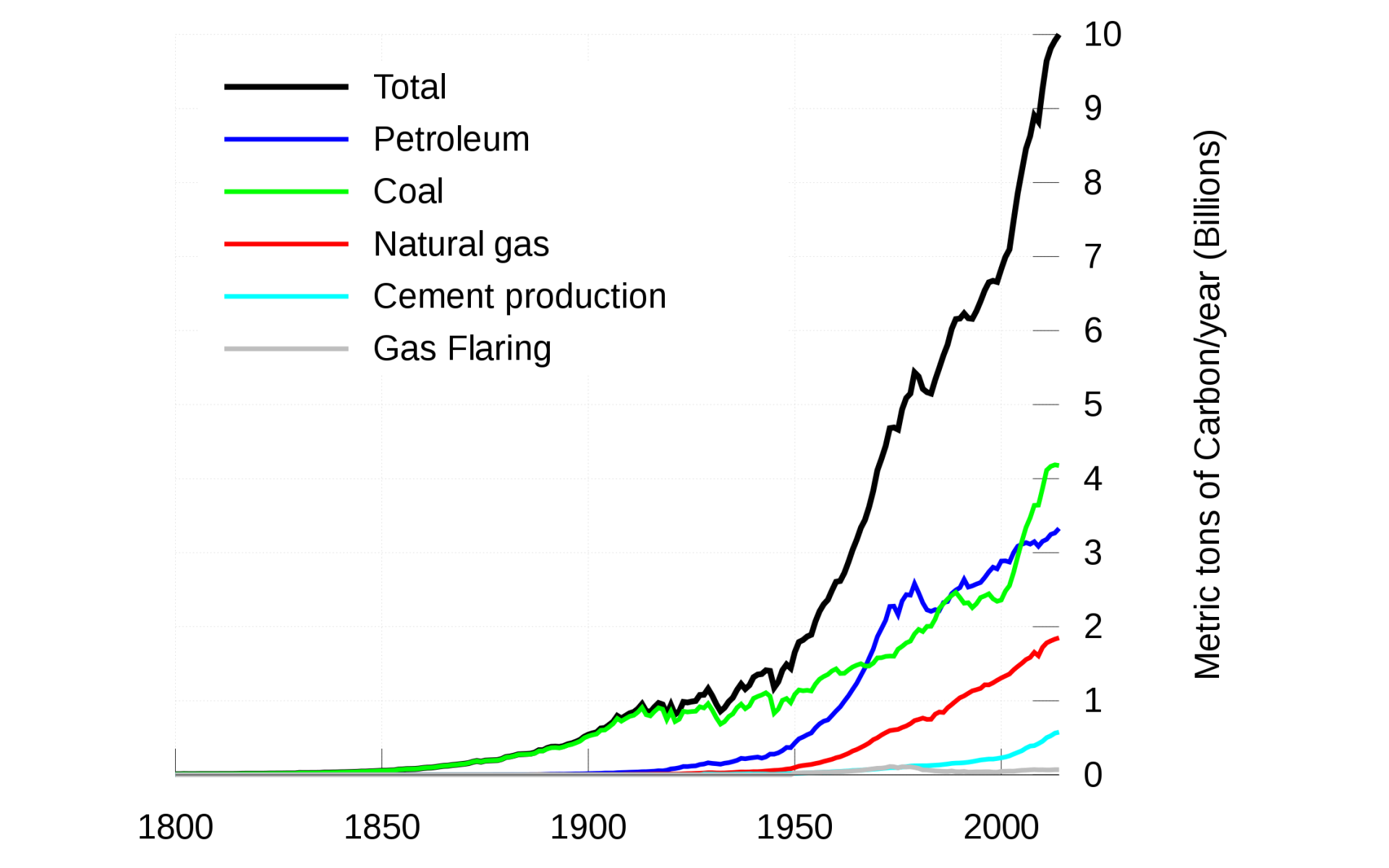



As ancient solar energy builds up civilization, the energy carrier, CO2, builds up in atmosphere.


Carbon Dioxide Variations
The Industrial Revolution Has Caused A Dramatic Rise in $CO_2$
400
350
300
1000
1200
1400
1600
1800
2000
Year (AD)
Ice Age Cycles
400
300
200
100
0
Thousands of Years Ago
400
350
300
250
200
$CO_2$ Concentration (ppmv)

# $CO_2$ emission development




Total
Petroleum
Coal
Natural gas
Cement production
Gas Flaring
10
9
8
7
6
5
4
3
2
1
0
Metric tons of Carbon/year (Billions)
1800
1850
1900
1950
2000

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# We had 400 ppm $CO_2$ in 3 mil years ago. Climate was warmer 2-3 degrees and ocean was higher 20 m.


Helsinki
St. Petersburg
Stockholm
Tallinn
Riga
Copenhagen
Dublin
Amsterdam
London
Brussels
Odesa
Black Sea

During Earth fauna mass extinction, the ruling species have disappeared.

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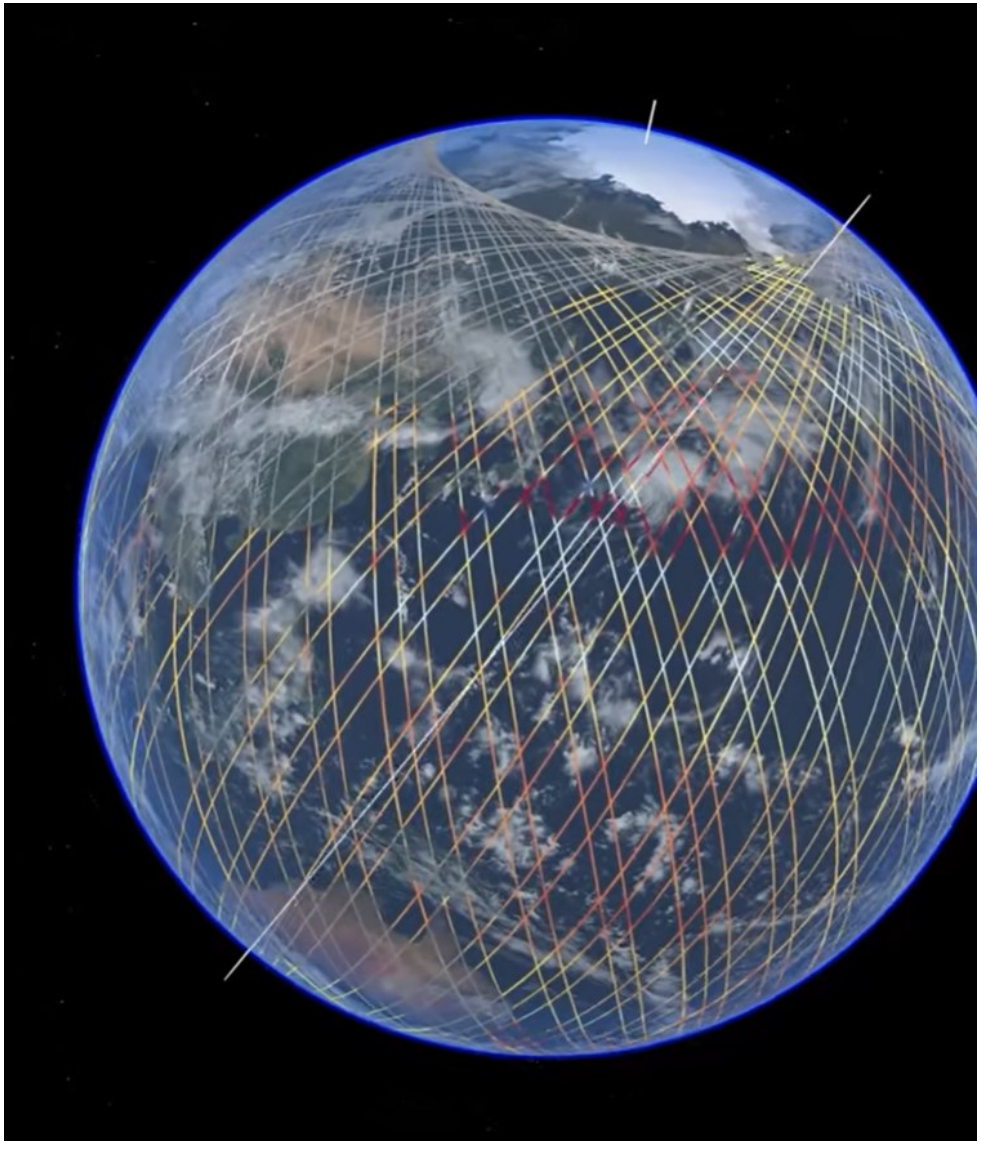
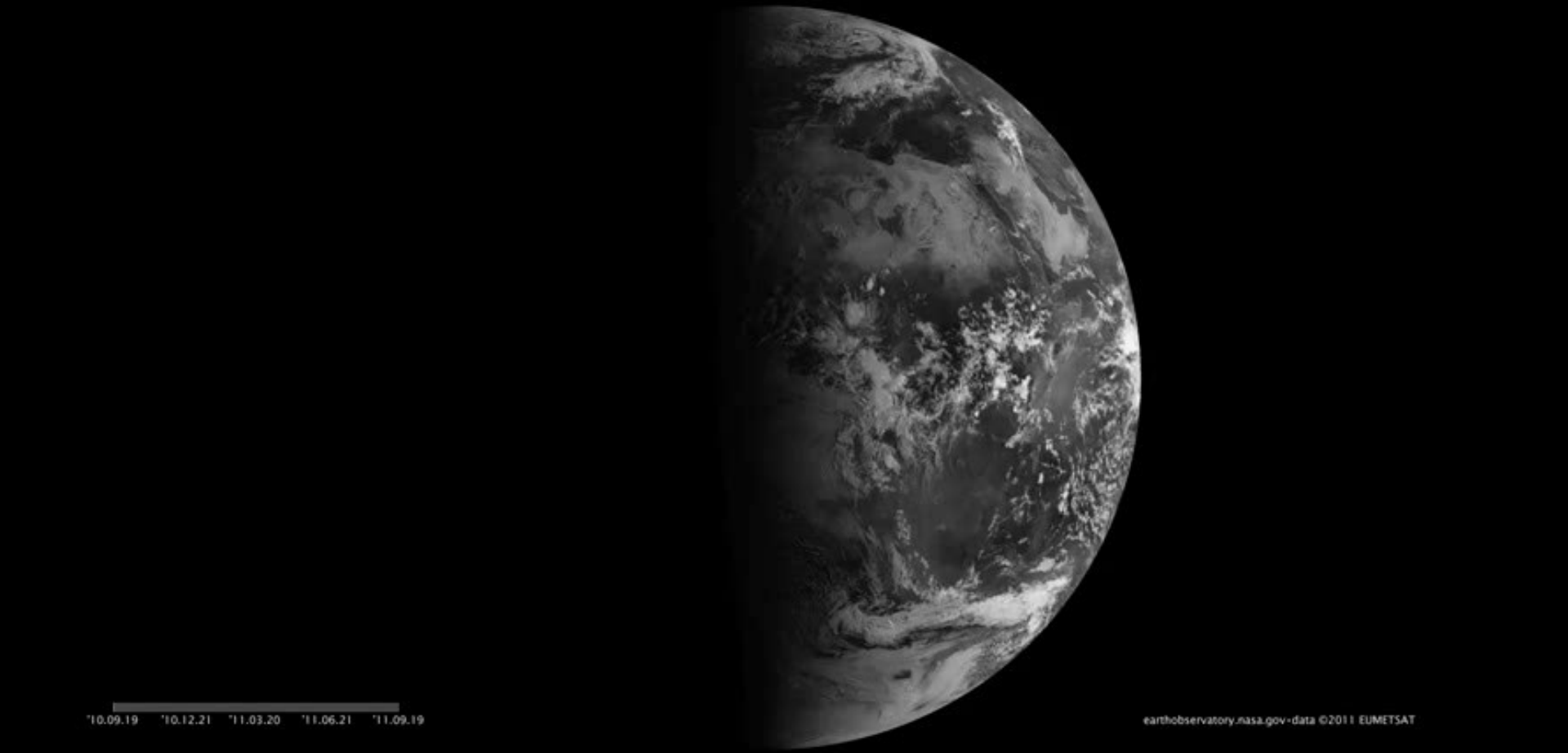
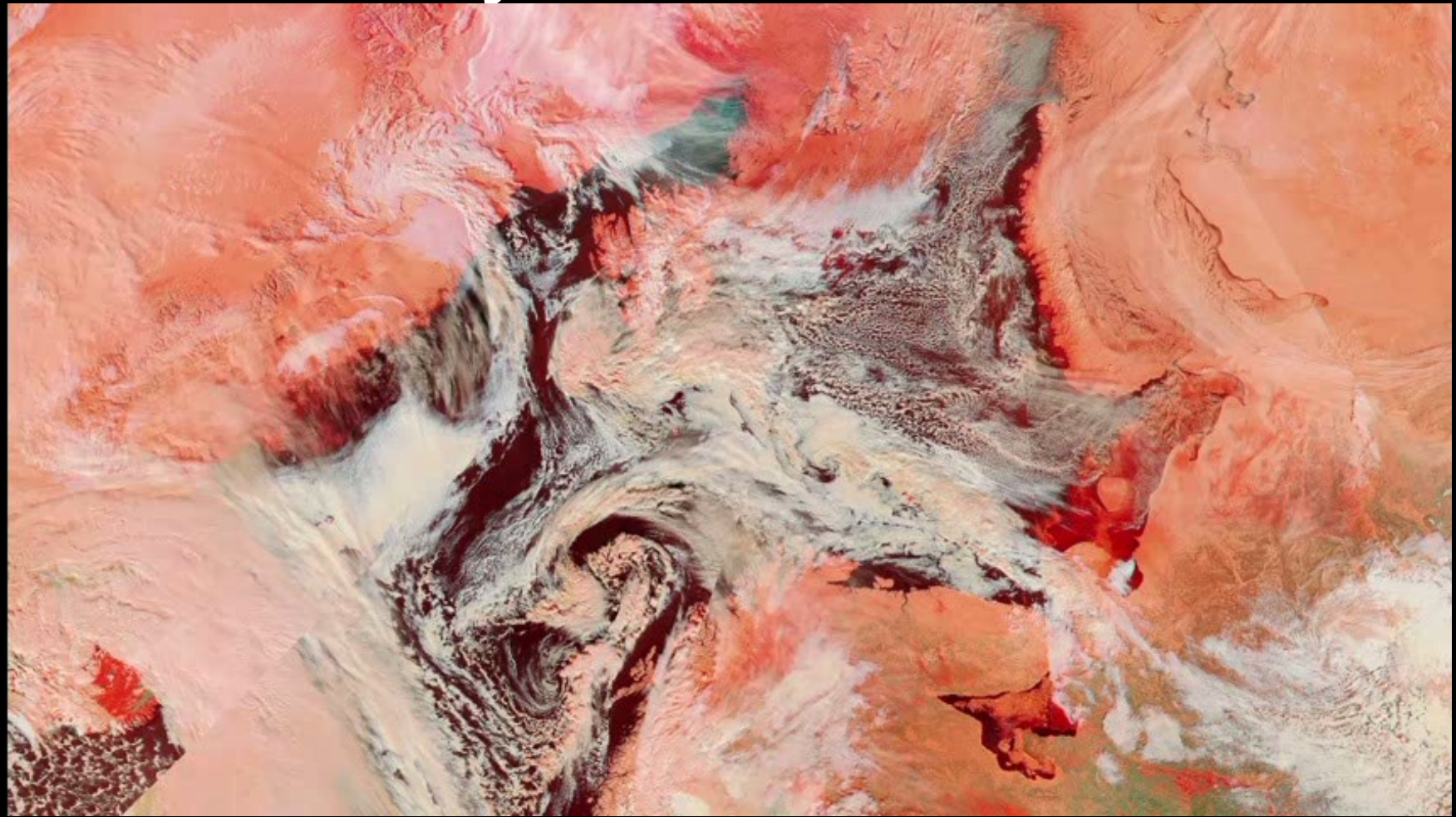
# Climate change and microwave EO



# North is dark…



# ….and cloudy



MODIS Arctic time lapse (Pekka Laurila)

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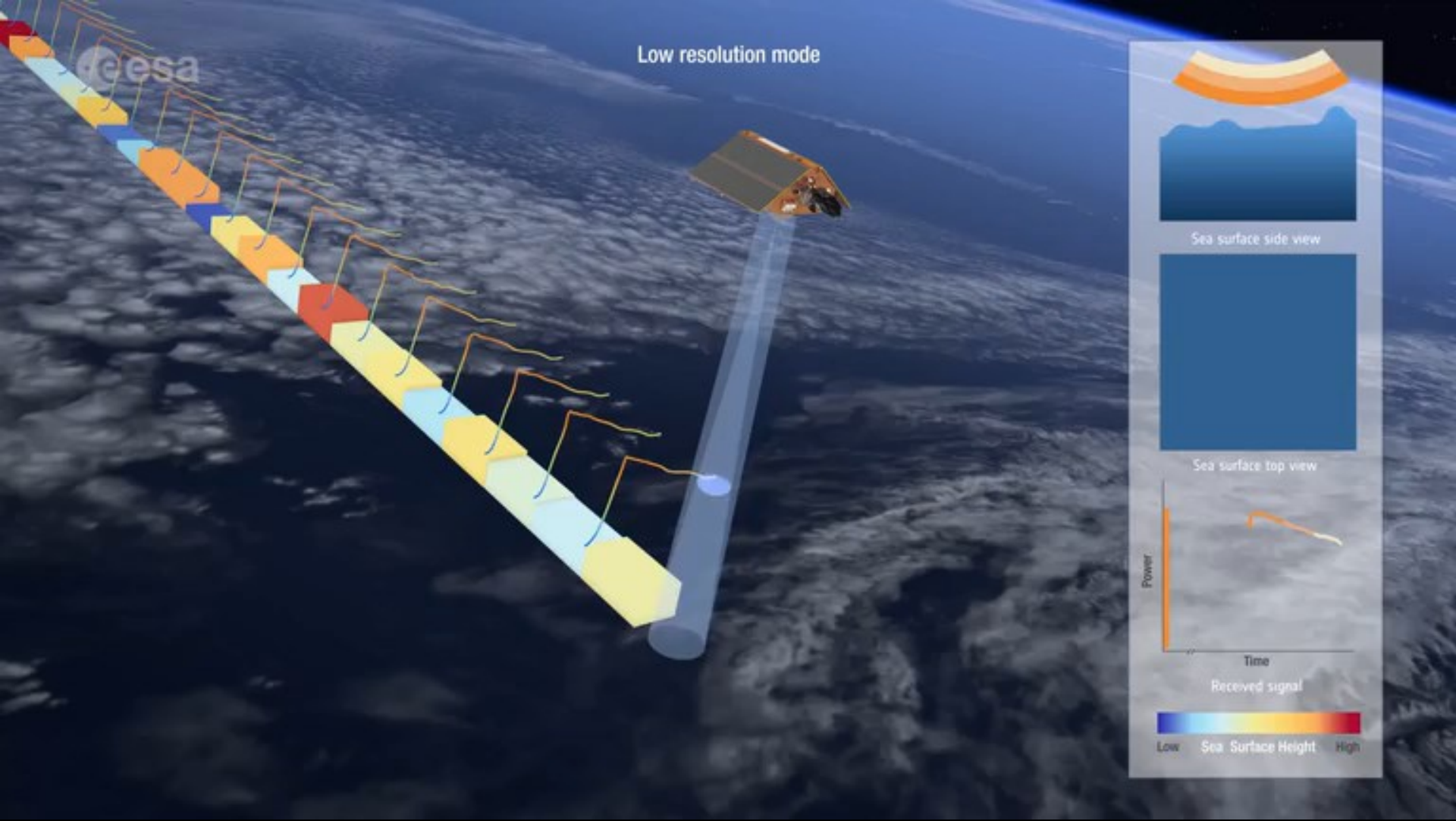
# European workhorses in space


esa
Low resolution mode
Sea surface side view
Sea surface top view
Power
Time
Received signal
Low
Sea Surface Height
High

# CryoSat-2

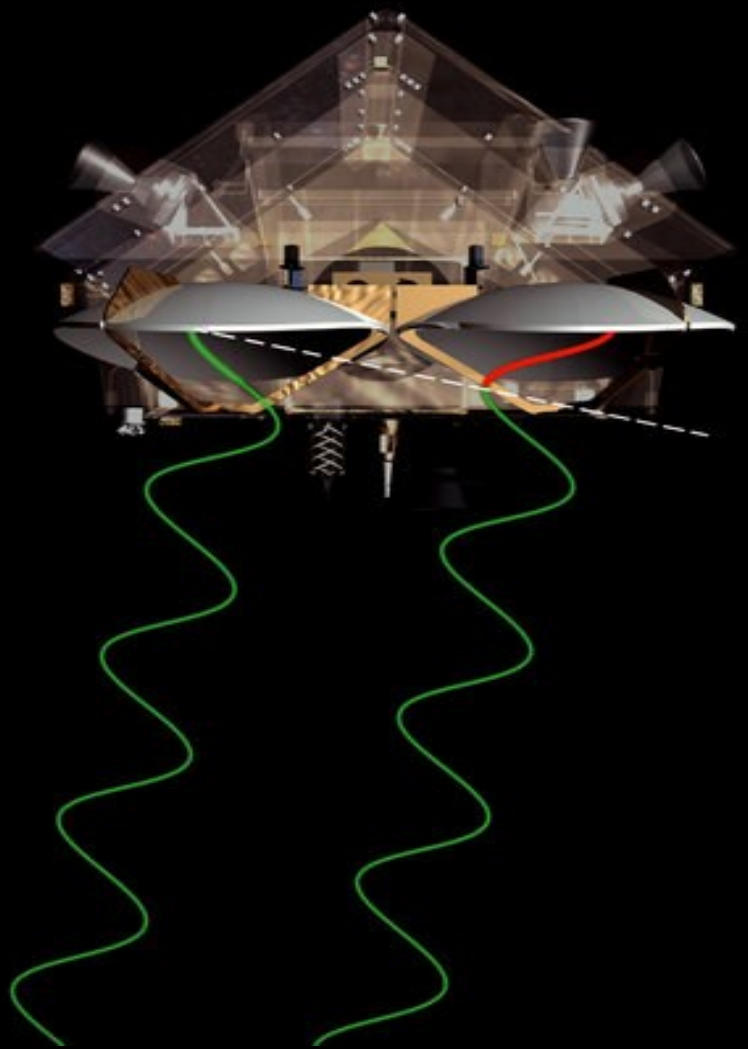
Measures ice thickness

Active Ku-band (13,7 GHz) advanced radar system

Launched 2010
Polar orbit (inclination 92º)
Period 99 min
Altitude 720 km
Mass 720 kg

Image: ESA

Advanced interferometric radar mode.

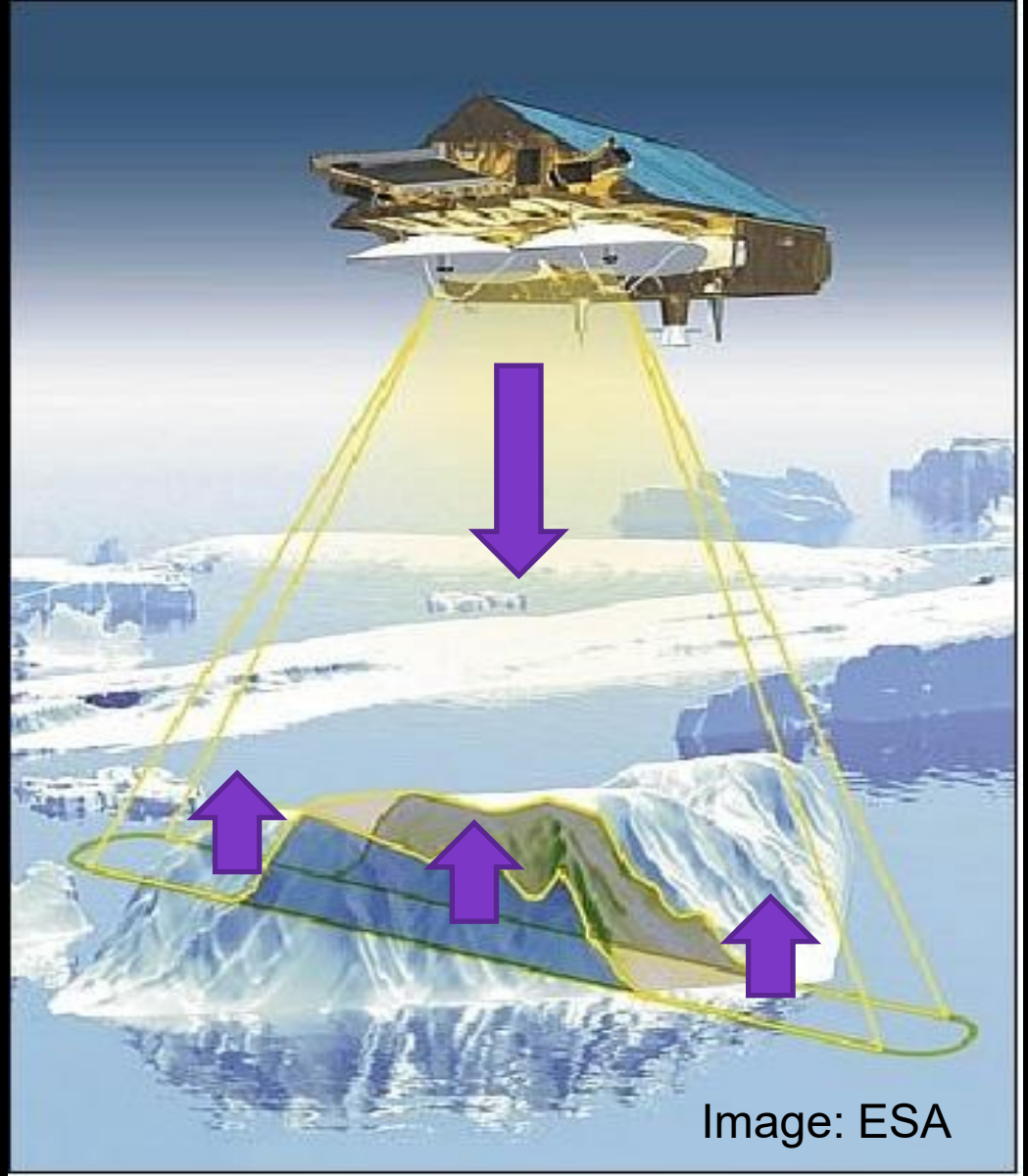


Active Microwave Instrument

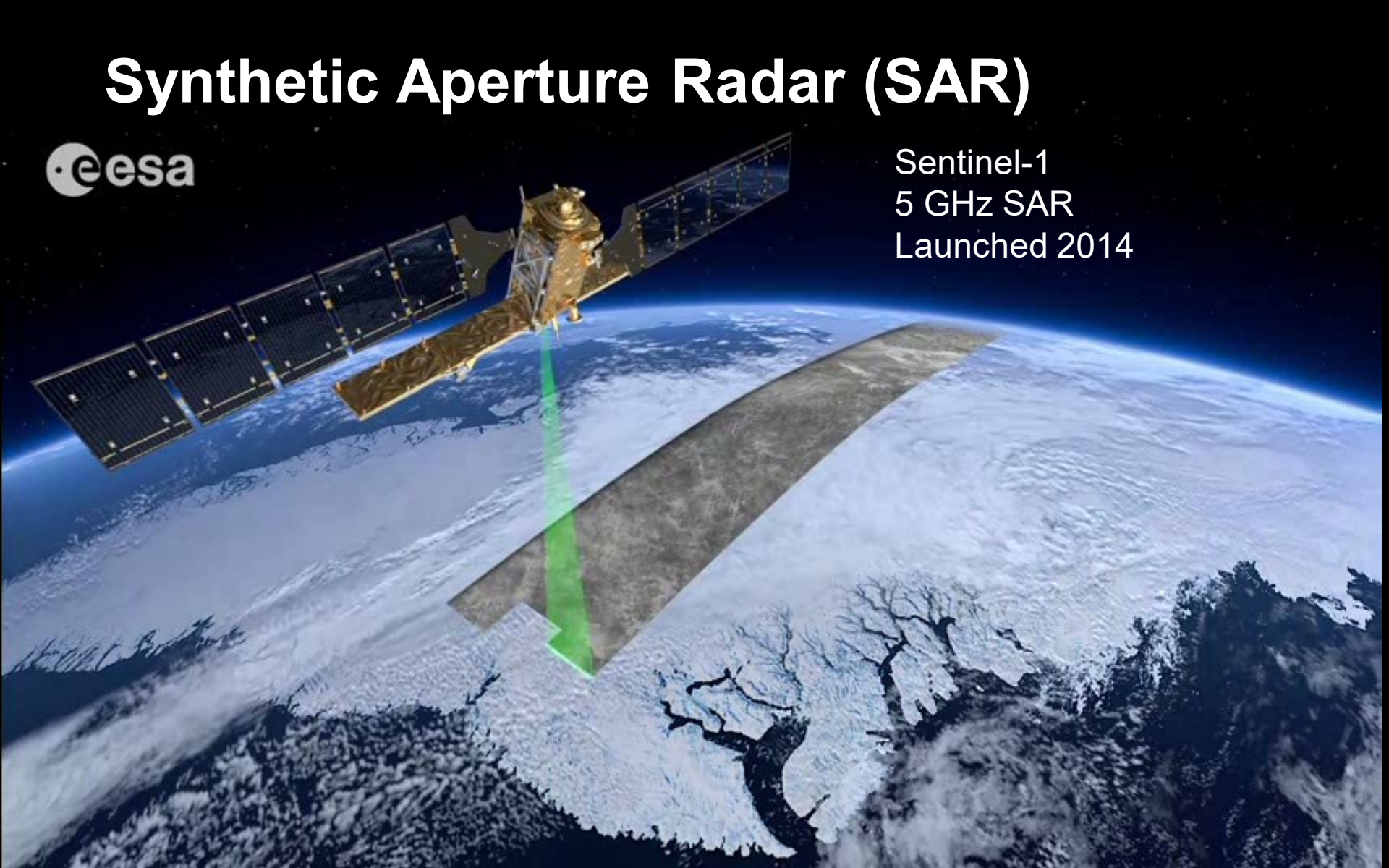
Measures ice thickness

Ku-band (13,7 GHz)
Radar altimeter
Dedicated for distance measurements

Three different measurement modes



# Synthetic Aperture Radar (SAR)



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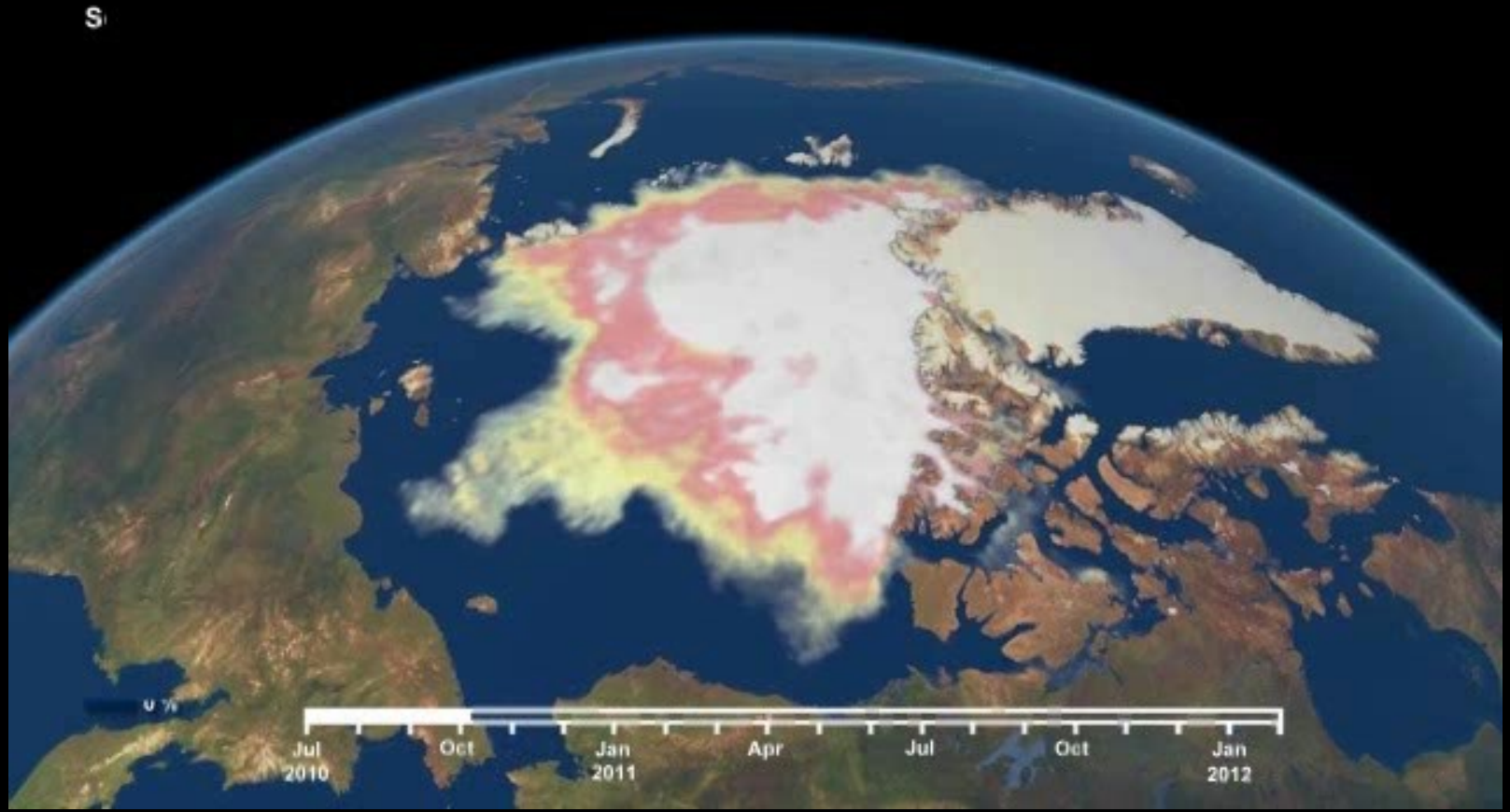
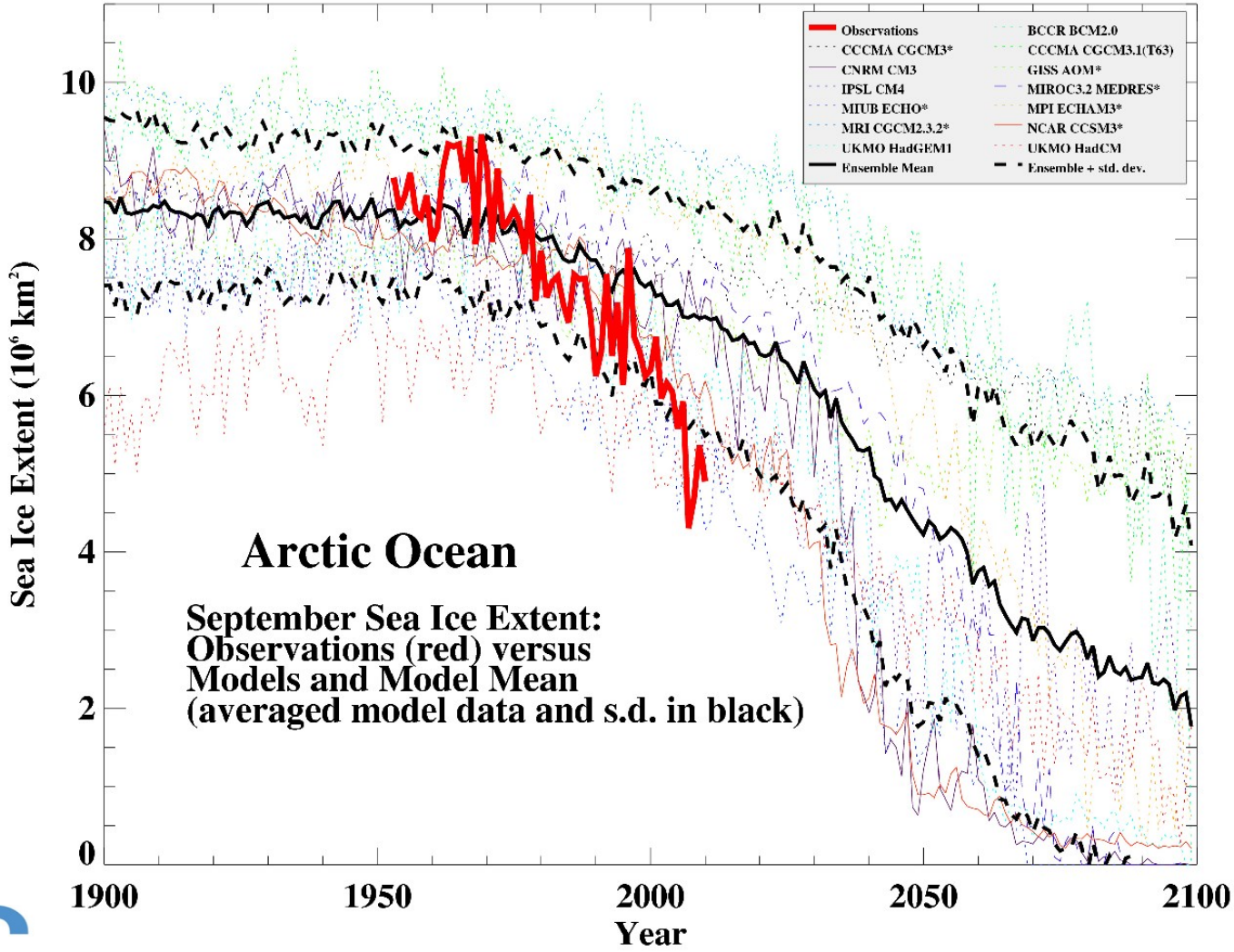
# Ice Cover and ice extent

# The sea ice thickness from SMOS



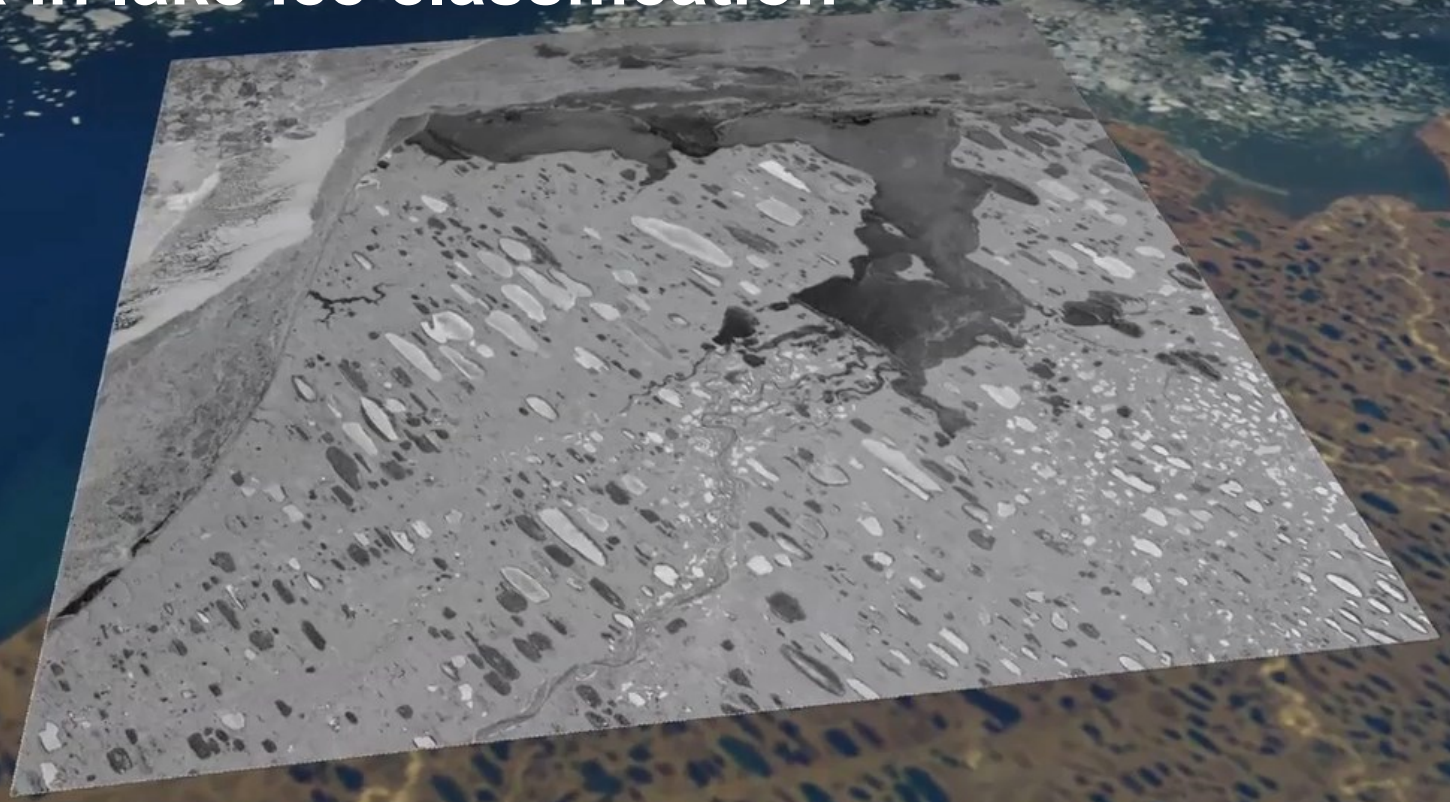

University of Hamburg / KlimaCampus / CliSAP / Institute of




INTERGOVERNMENTAL PANEL ON climate change

ERS-1 SAR

# SAR in lake ice classification



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# Glaciers


esa
Jakobshavn Glacier flow
07-2017

Credit: ESA

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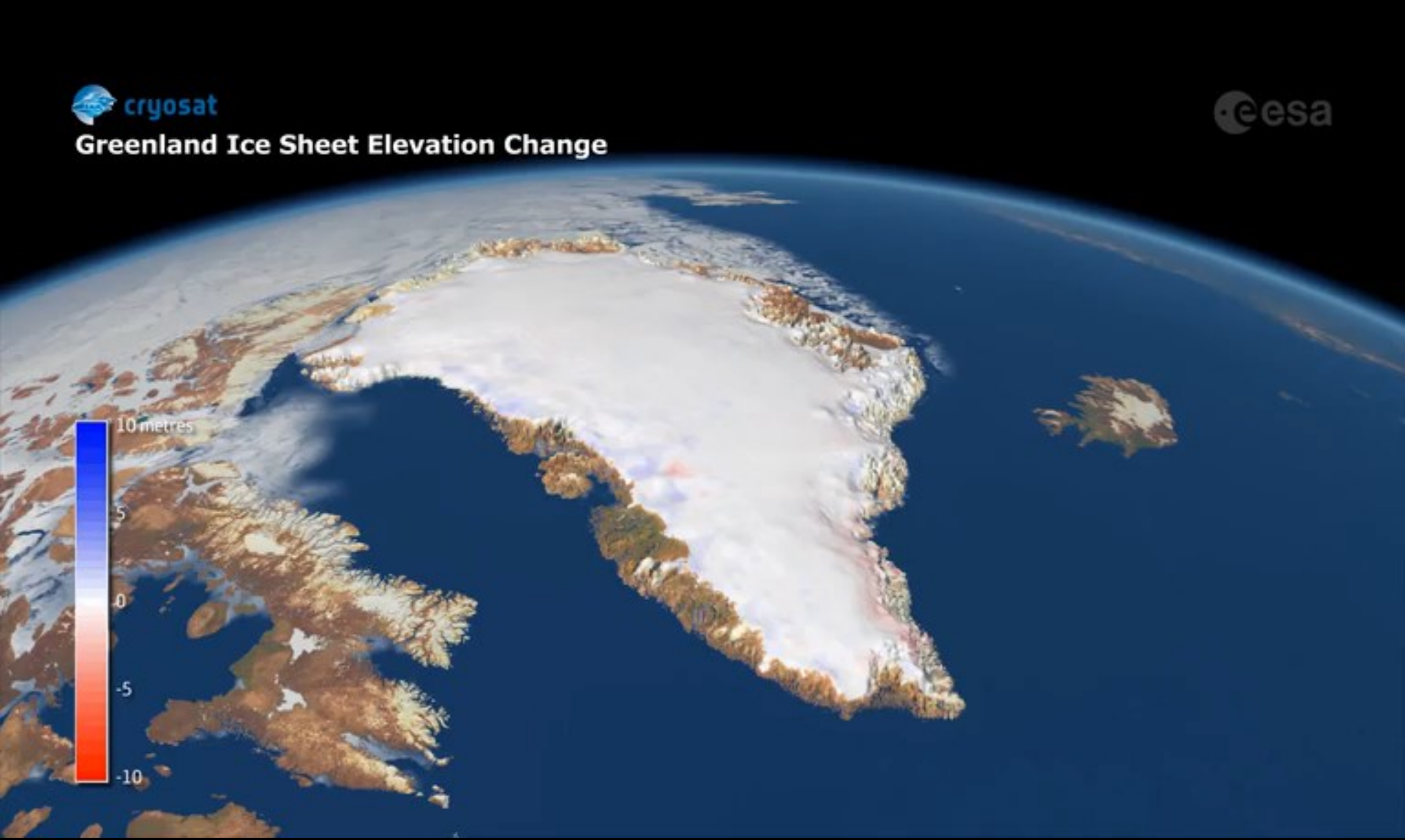
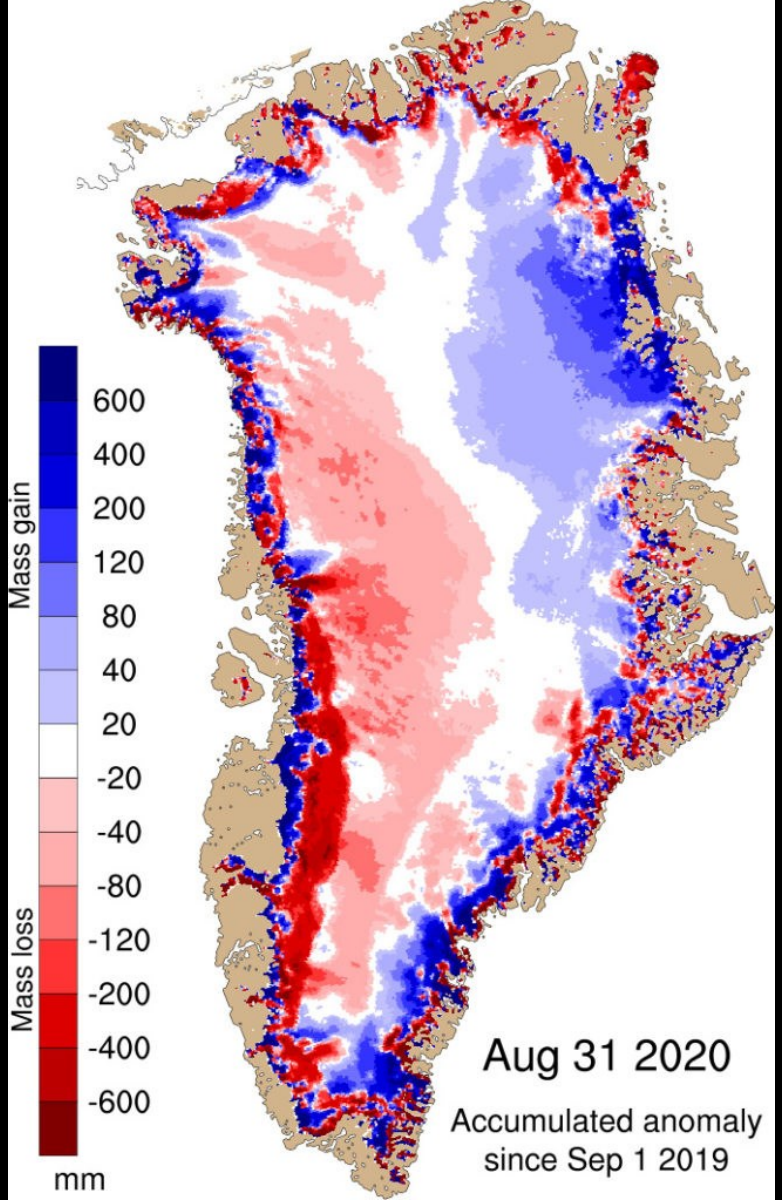
# Greenland


cryosat
Greenland Ice Sheet Elevation Change
esa
10 metres
5
0
-5
-10




Credit: DMI Polar Portal.

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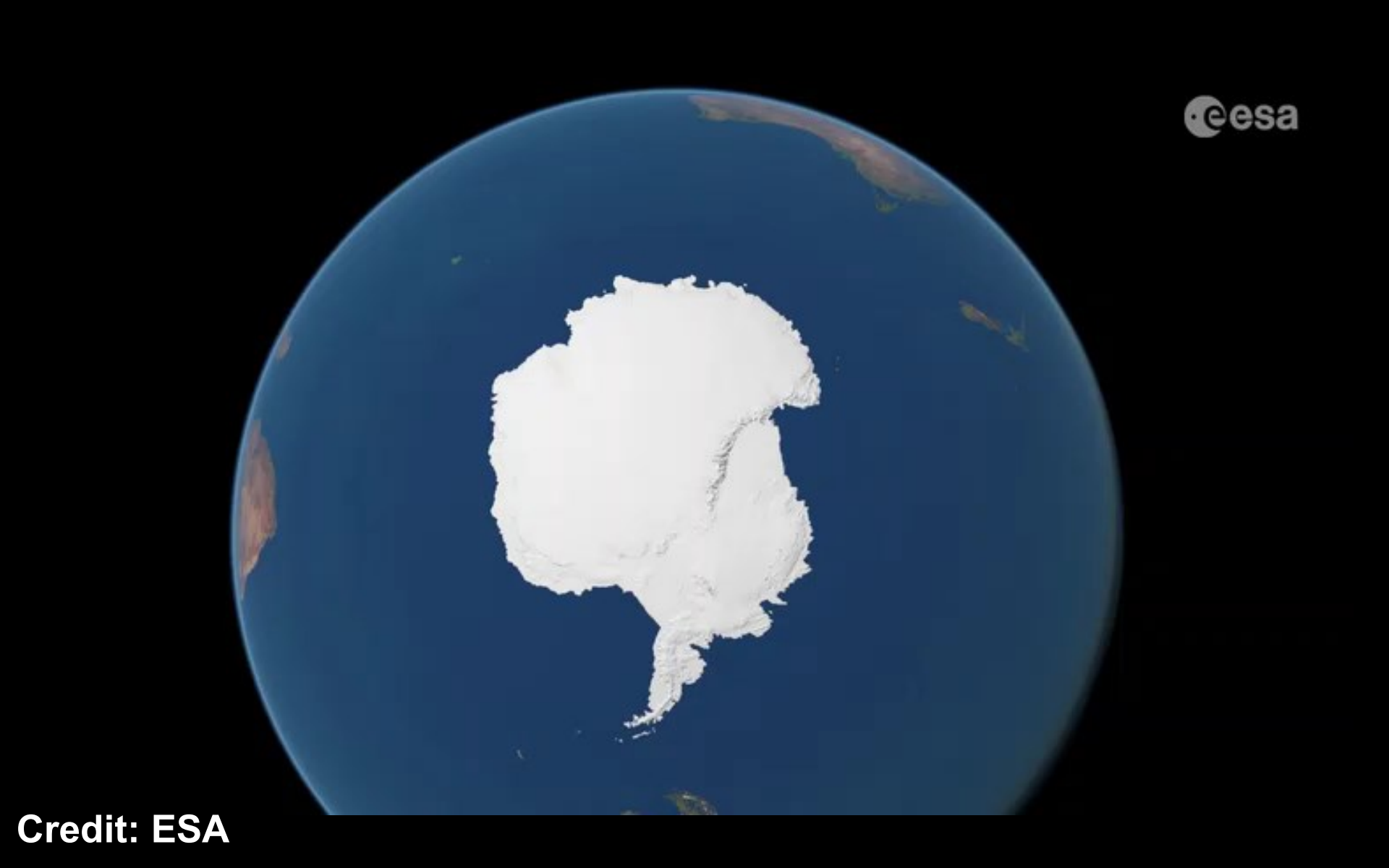
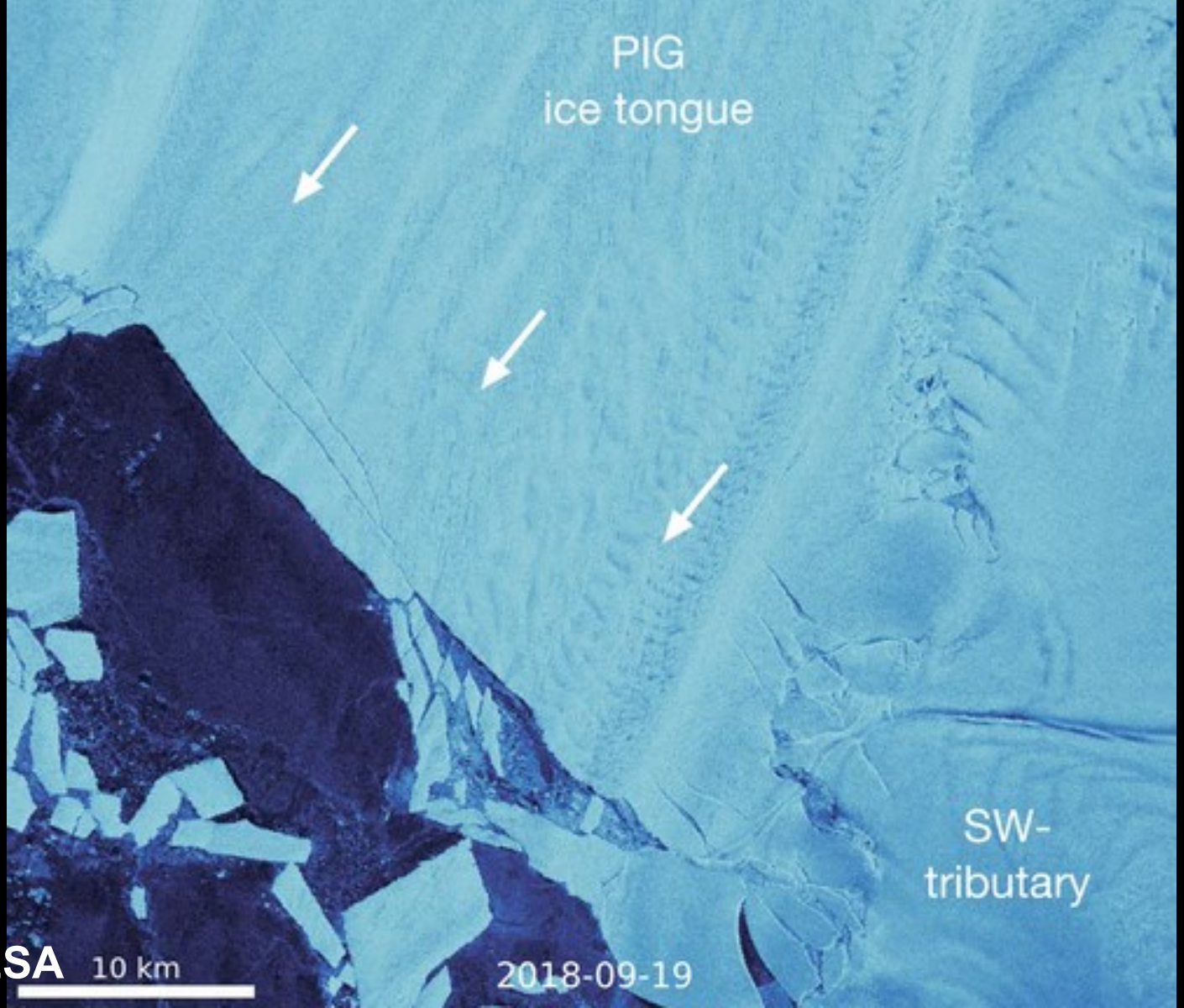
# Antarctica

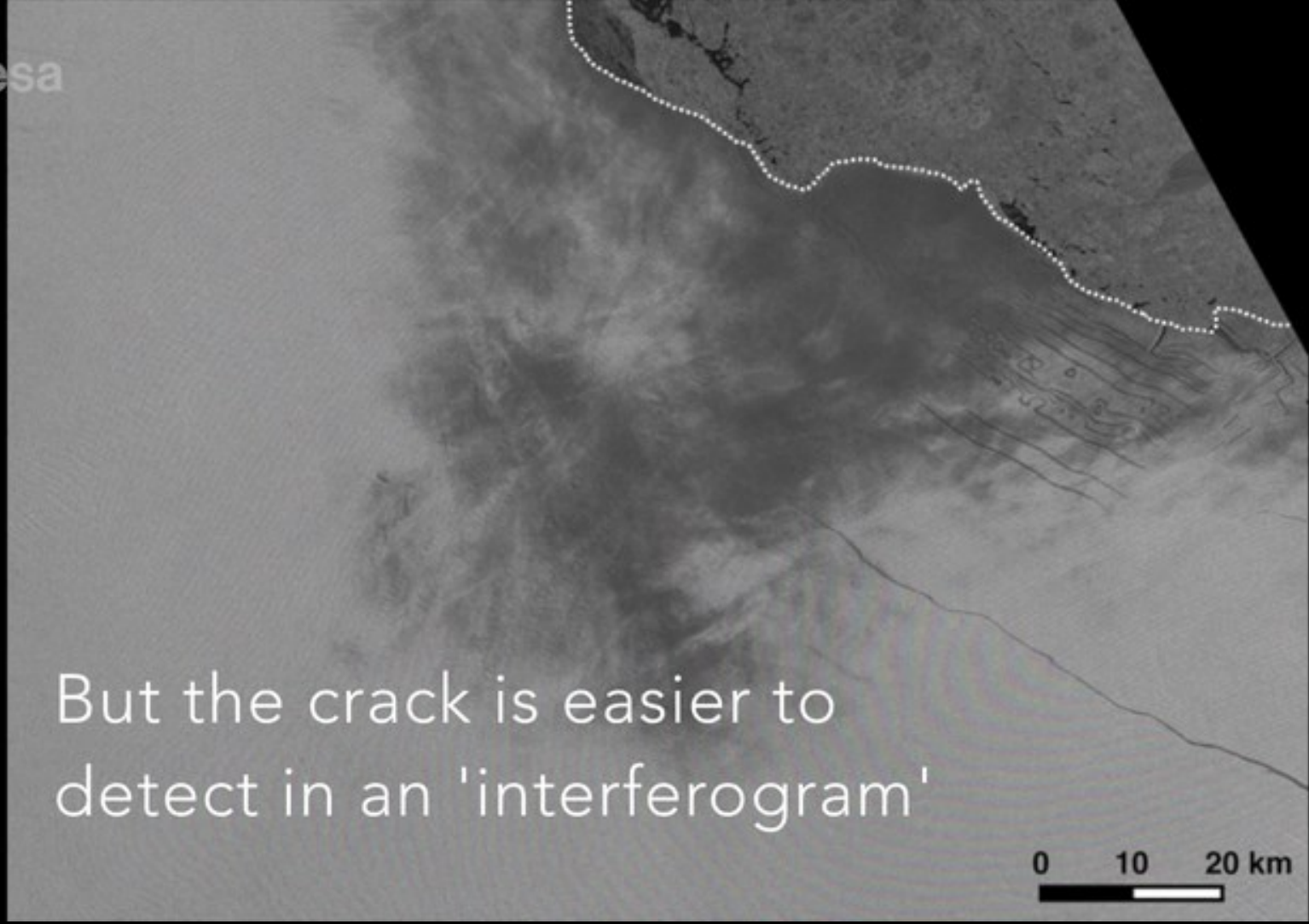


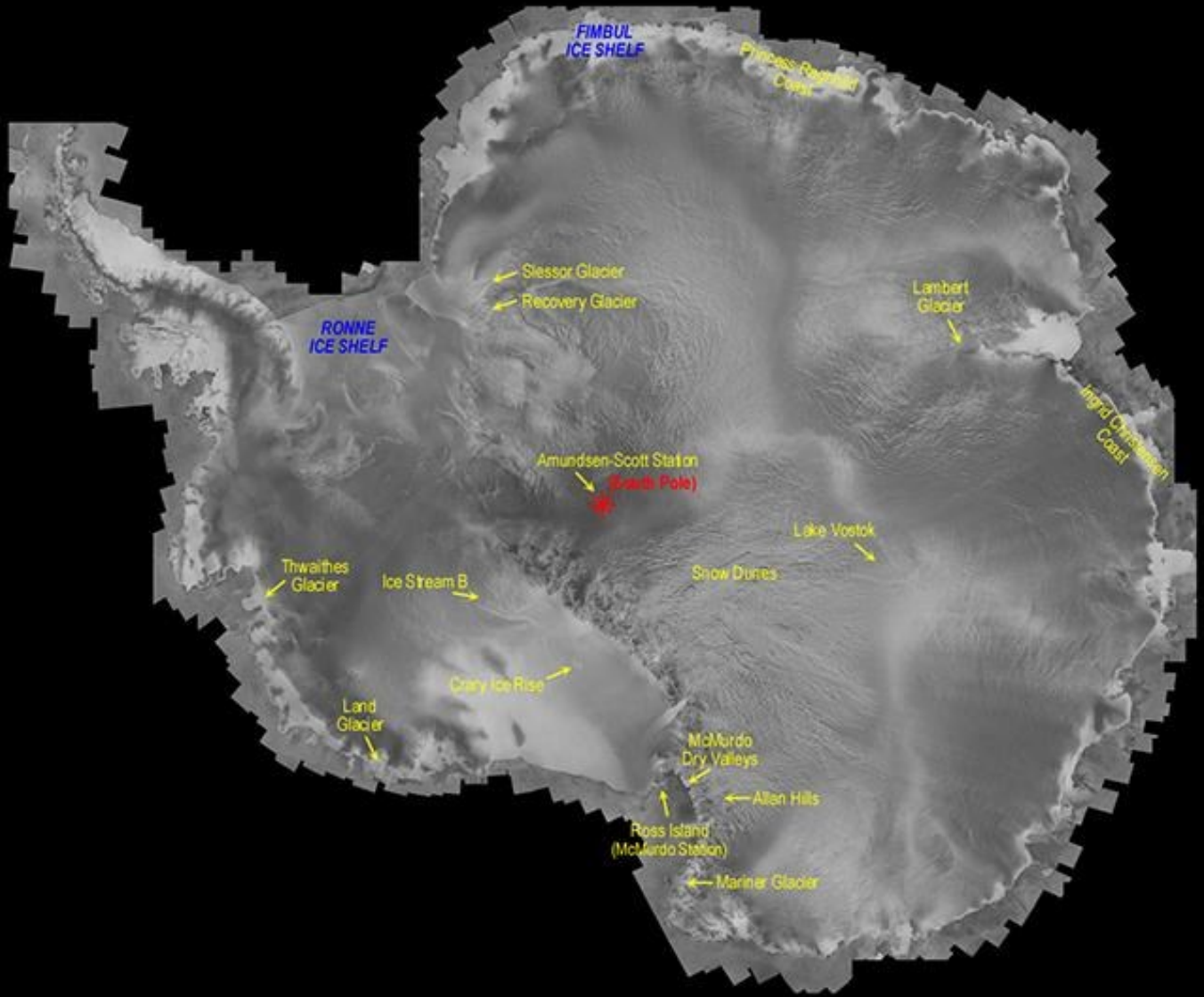

Credit: ESA



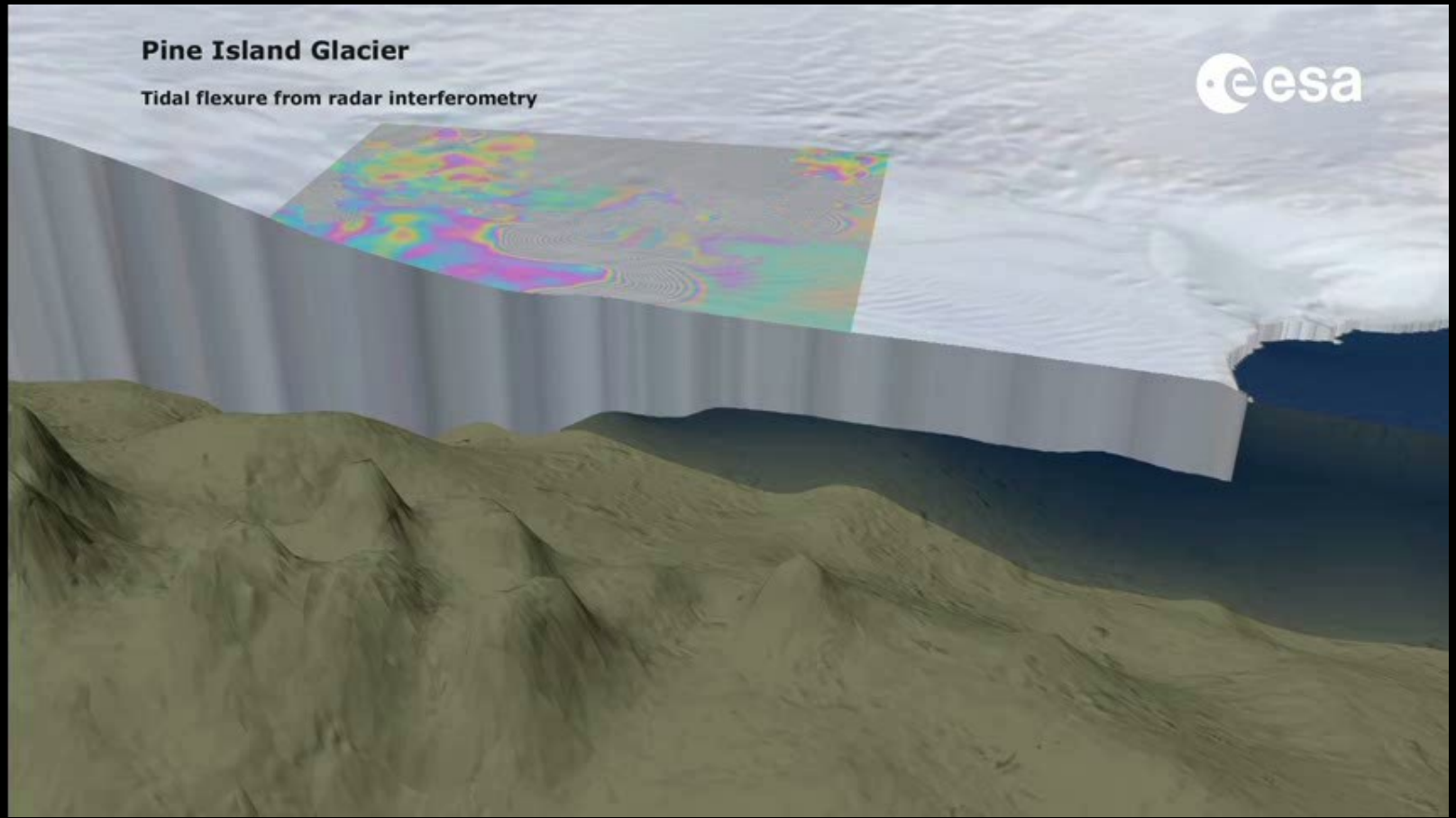

Credit: ESA


Credit: ESA

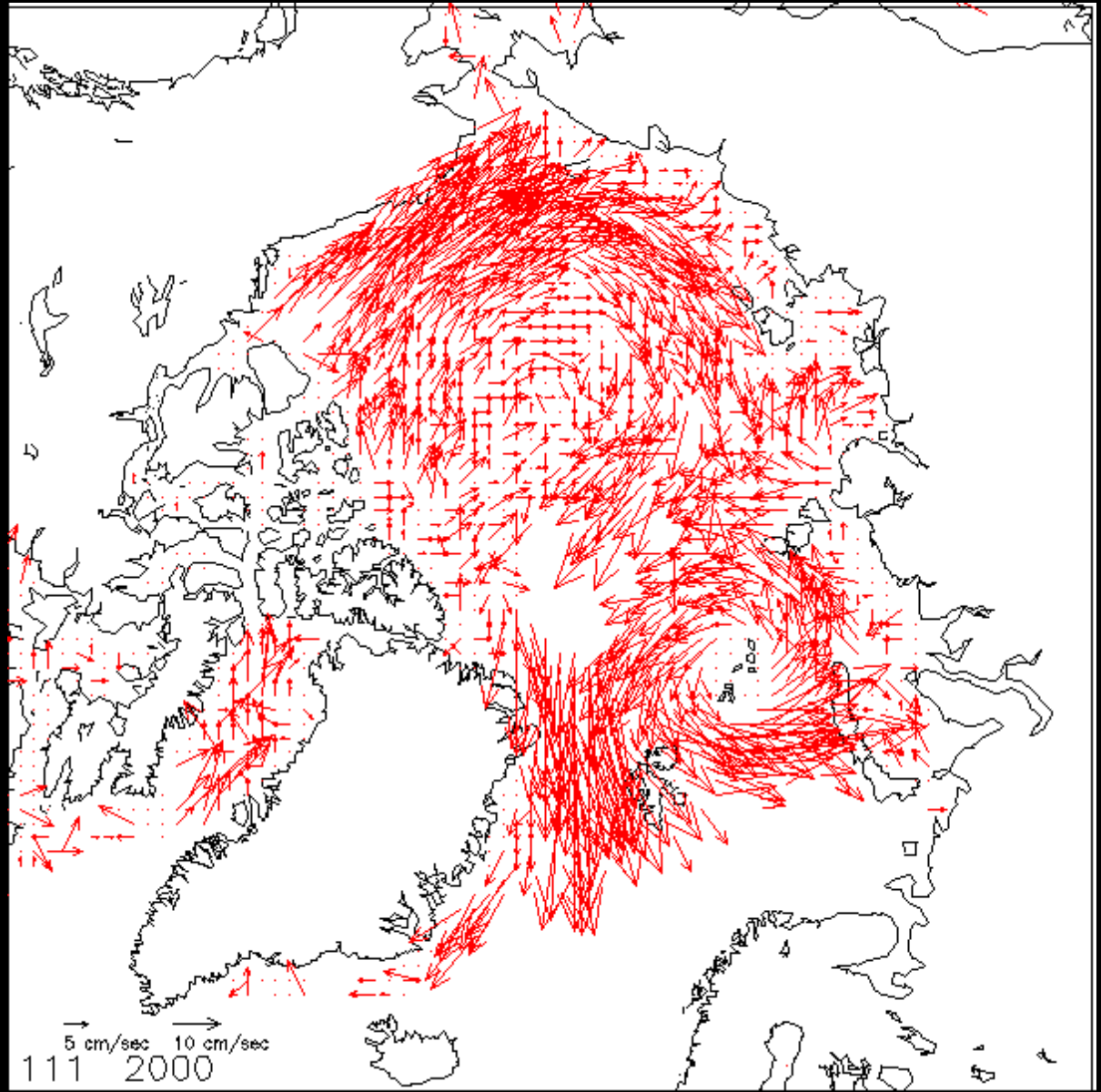

esa
But the crack is easier to
detect in an 'interferogram'
0
10
20 km


FIMBUL
ICE SHELF
Princess Ragnhild
Coast
Slessor Glacier
Recovery Glacier
RONNE
ICE SHELF
Lambert
Glacier
Ingrid Christensen
Coast
Amundsen-Scott Station
(South Pole)
Lake Vostok
Thwaithes
Glacier
Ice Stream B
Snow Dunes
Crary Ice Rise
Land
Glacier
McMurdo
Dry Valleys
Allan Hills
Ross Island
(McMurdo Station)
Mariner Glacier

# SAR interferometry in height detection



Ice Motion from Passive Microwave: SMMR, SSM/I, SSMIS, and AMSR-E



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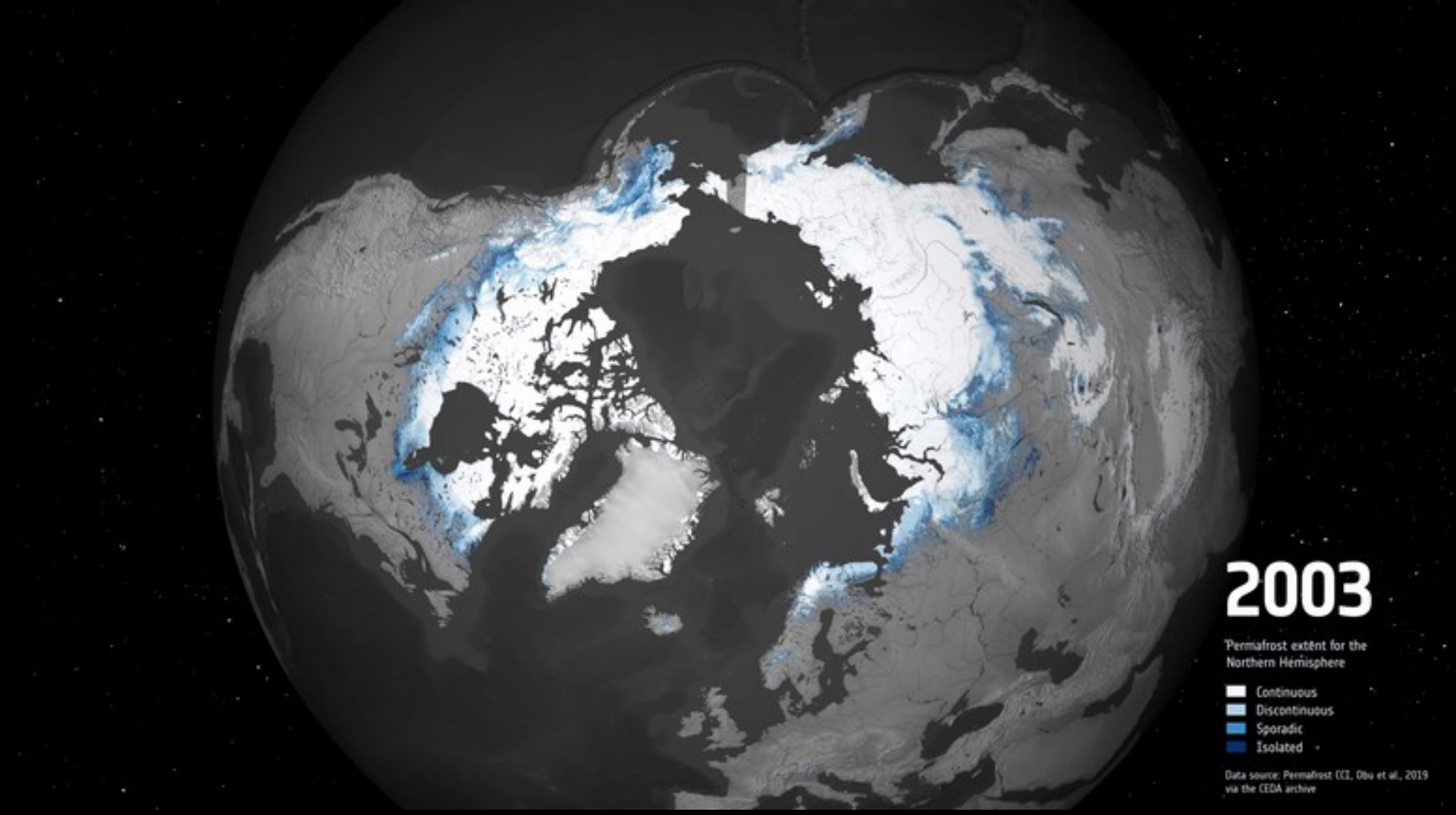
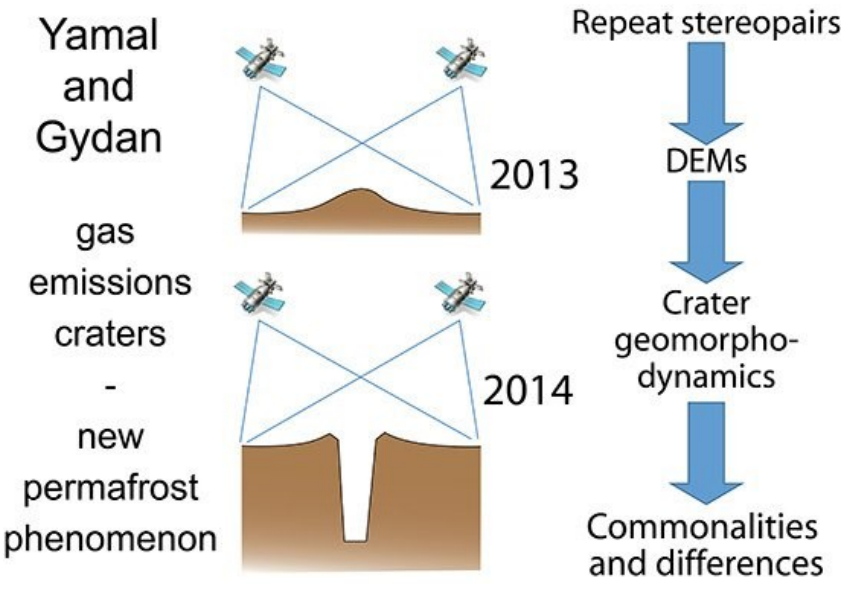
# Perma-frost


2003
Permafrost extent for the Northern Hemisphere
Continuous
Discontinuous
Sporadic
Isolated
Data source: Permafrost CCI, Obu et al., 2019 via the CEDA archive

Credit: ESA

# Gas emission craters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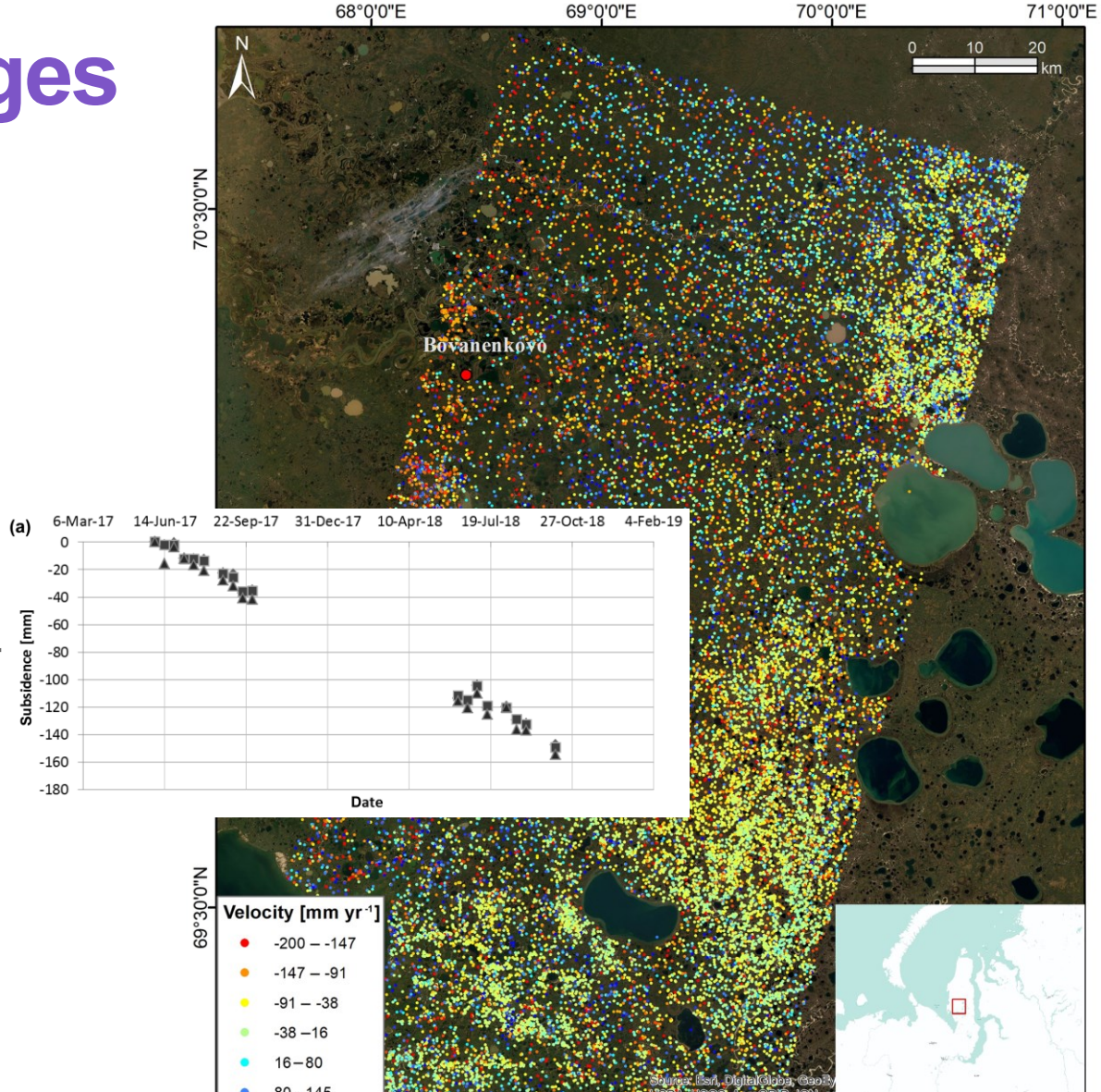
https://doi.org/10.3390/rs9101023

# Surface changes

SAR Interferometry
InSAR
DINSAR

https://doi.org/10.51
s-382-183-2020

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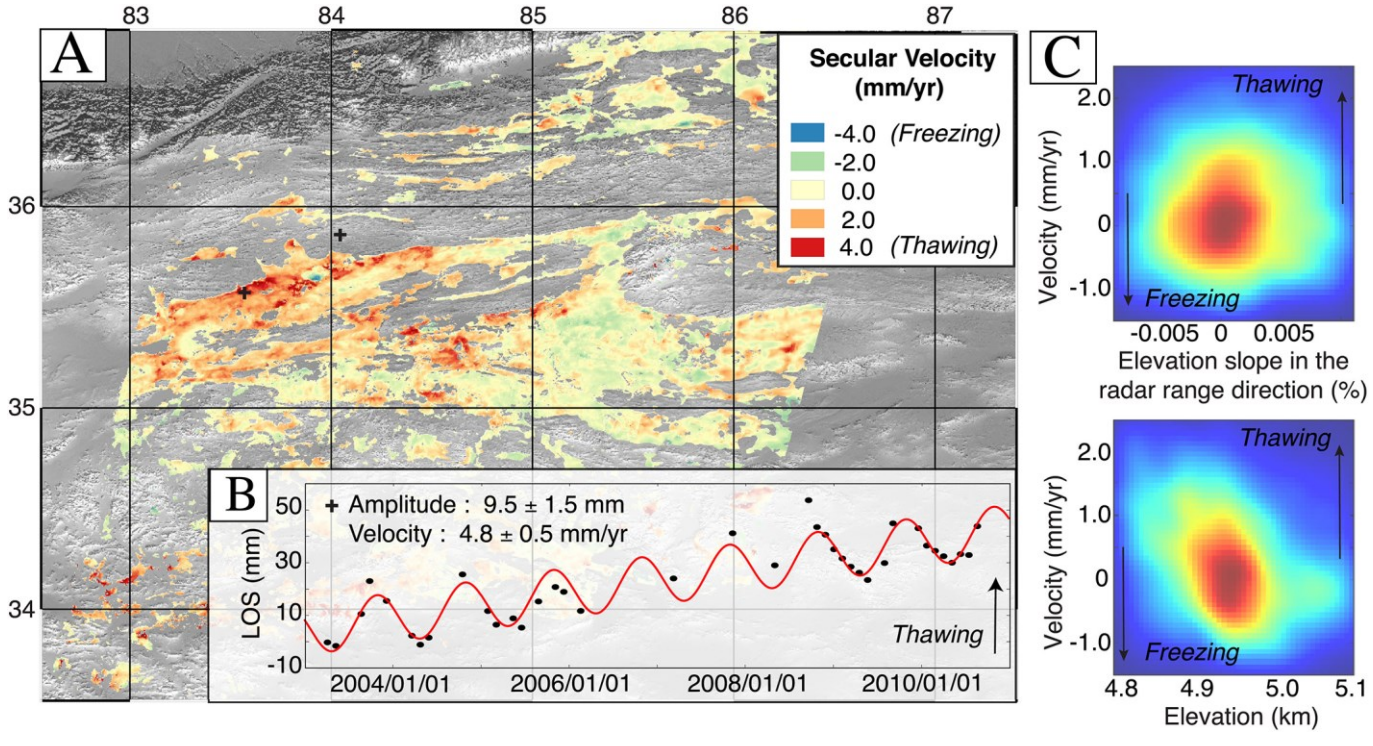
# Large-scale InSAR monitoring of permafrost freeze-thaw cycles on the Tibetan Plateau

Simon Daout
Marie-Pierre Doin
Gilles Peltzer
Anne Socquet
Cécile Lasserre

First published: 09 January 2017
https://doi.org/10.1002/2016GL070781
Citations: 33

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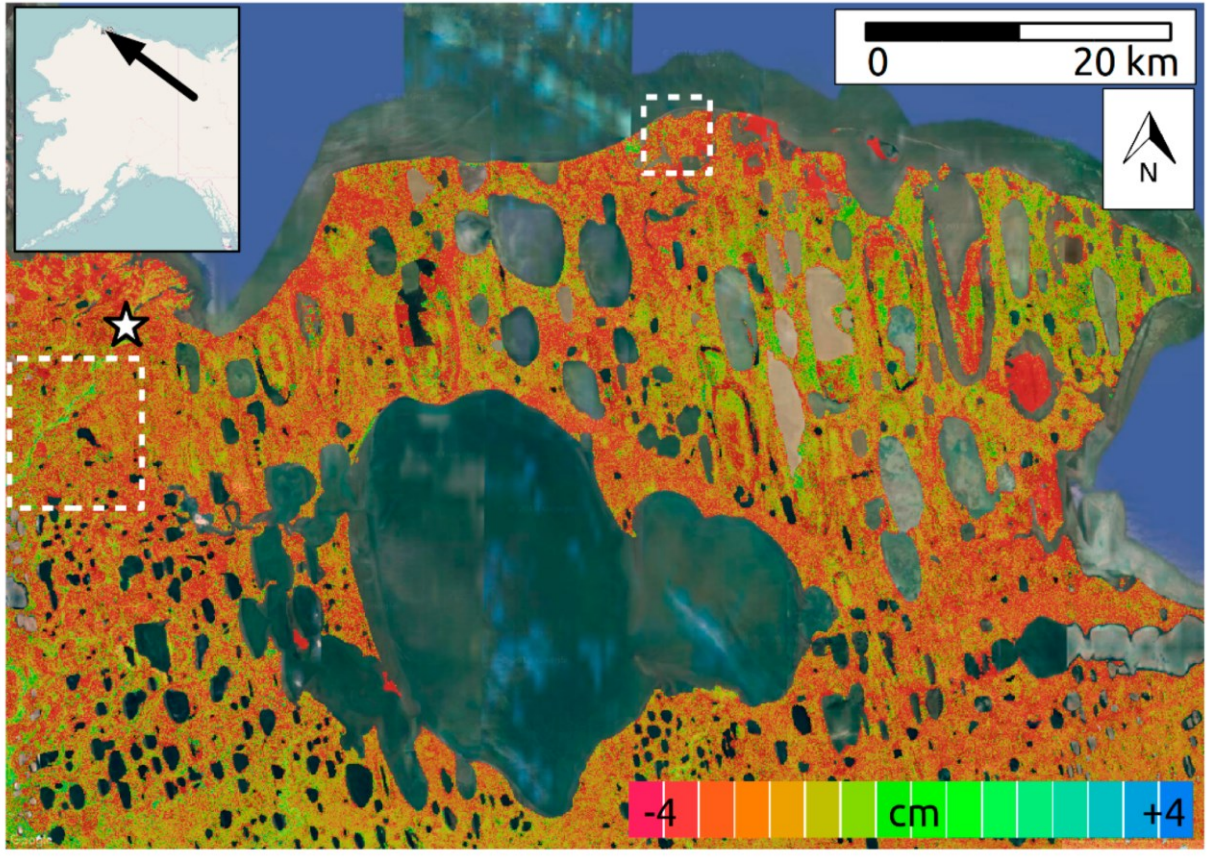
# Sentinel-1 SAR Interferometry for Surface Deformation Monitoring in Low-Land Permafrost Areas

**Tazio Strozzi, Sofia Antonova, Frank Günther, Eva Mätzler,Gonçalo Vieira,Urs Wegmüller,Sebastian Westermann and Annett Bartsch**

https://doi.org/10.3390/rs10091360

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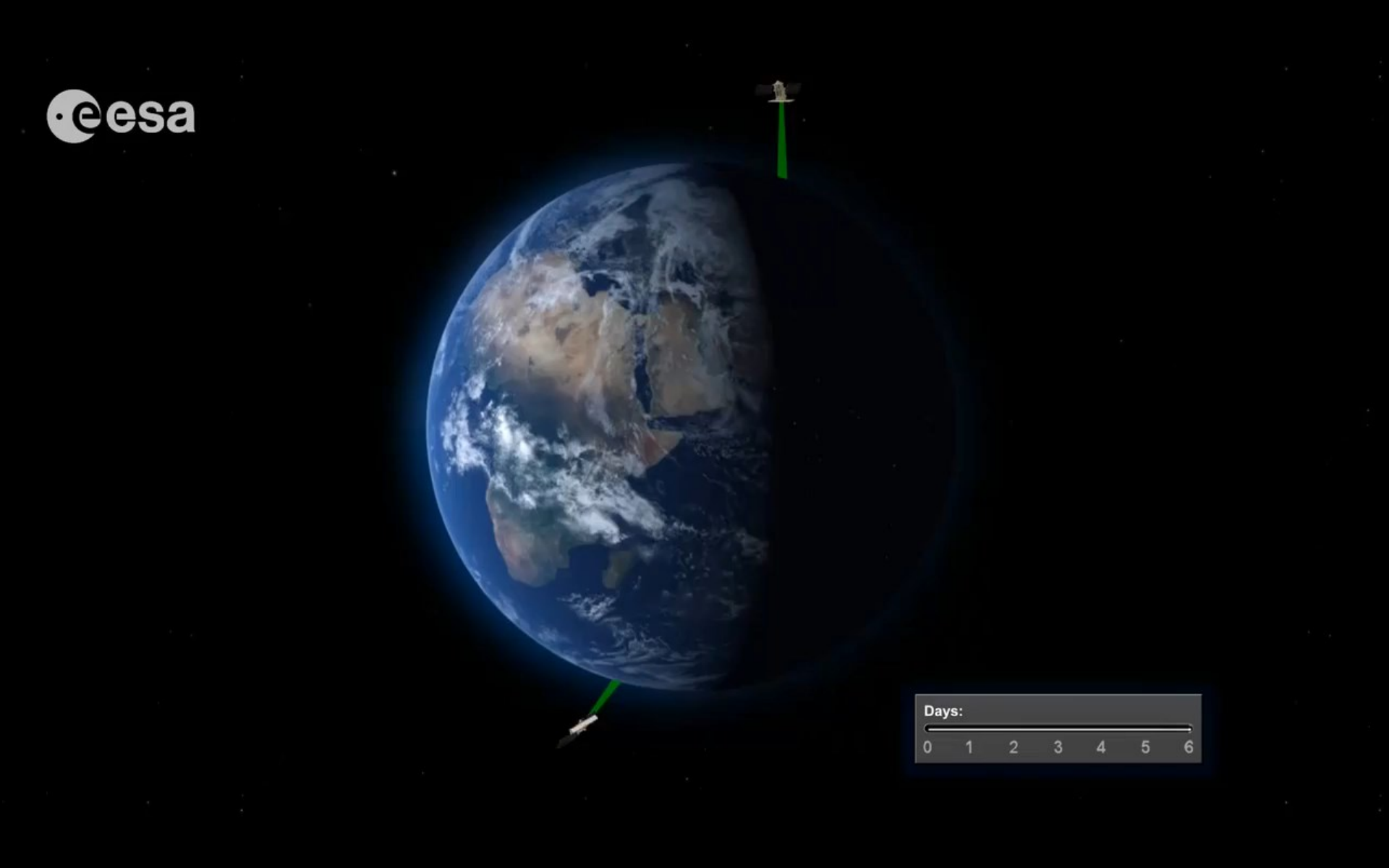
esa
Days:
0 1 2 3 4 5 6

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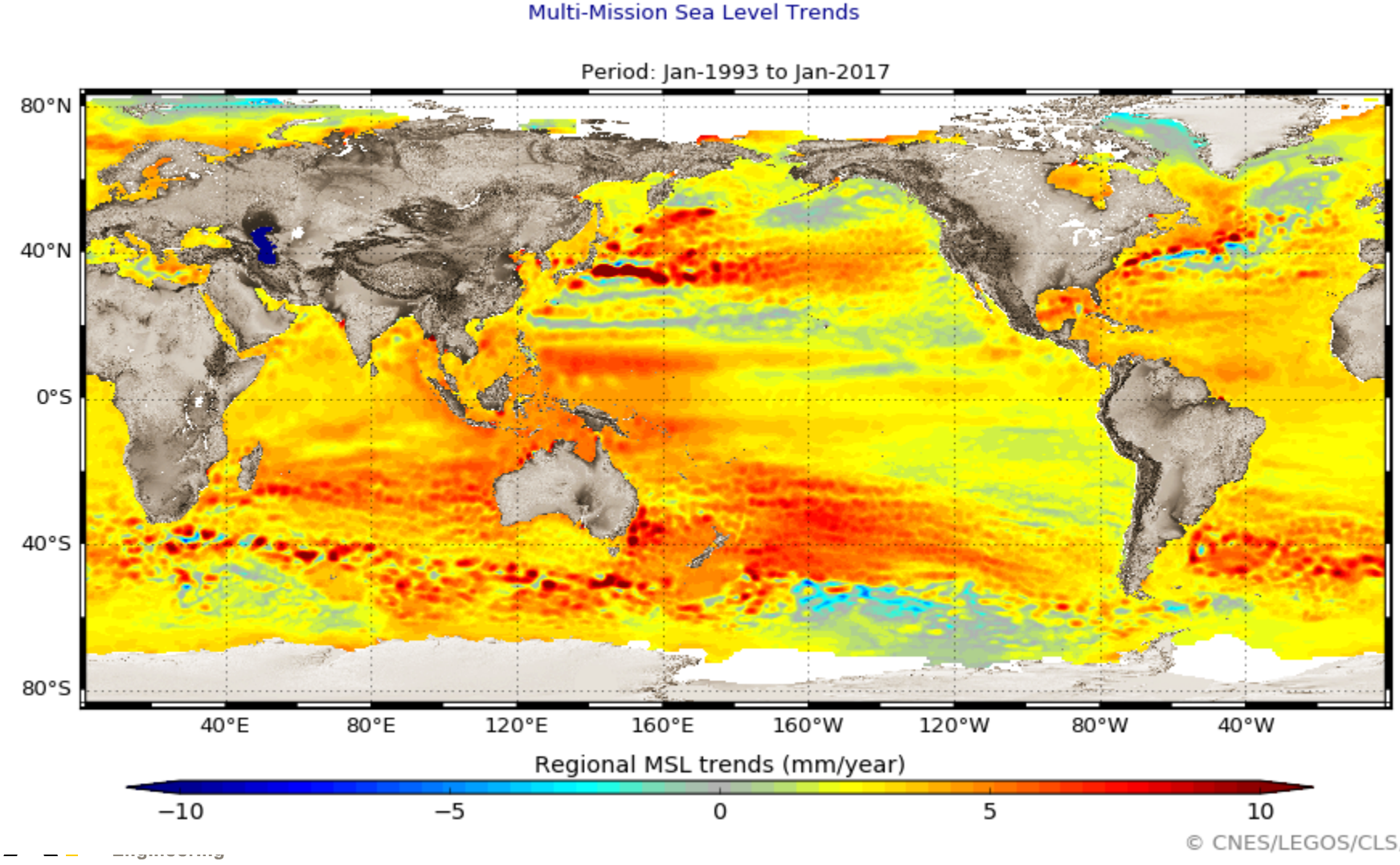
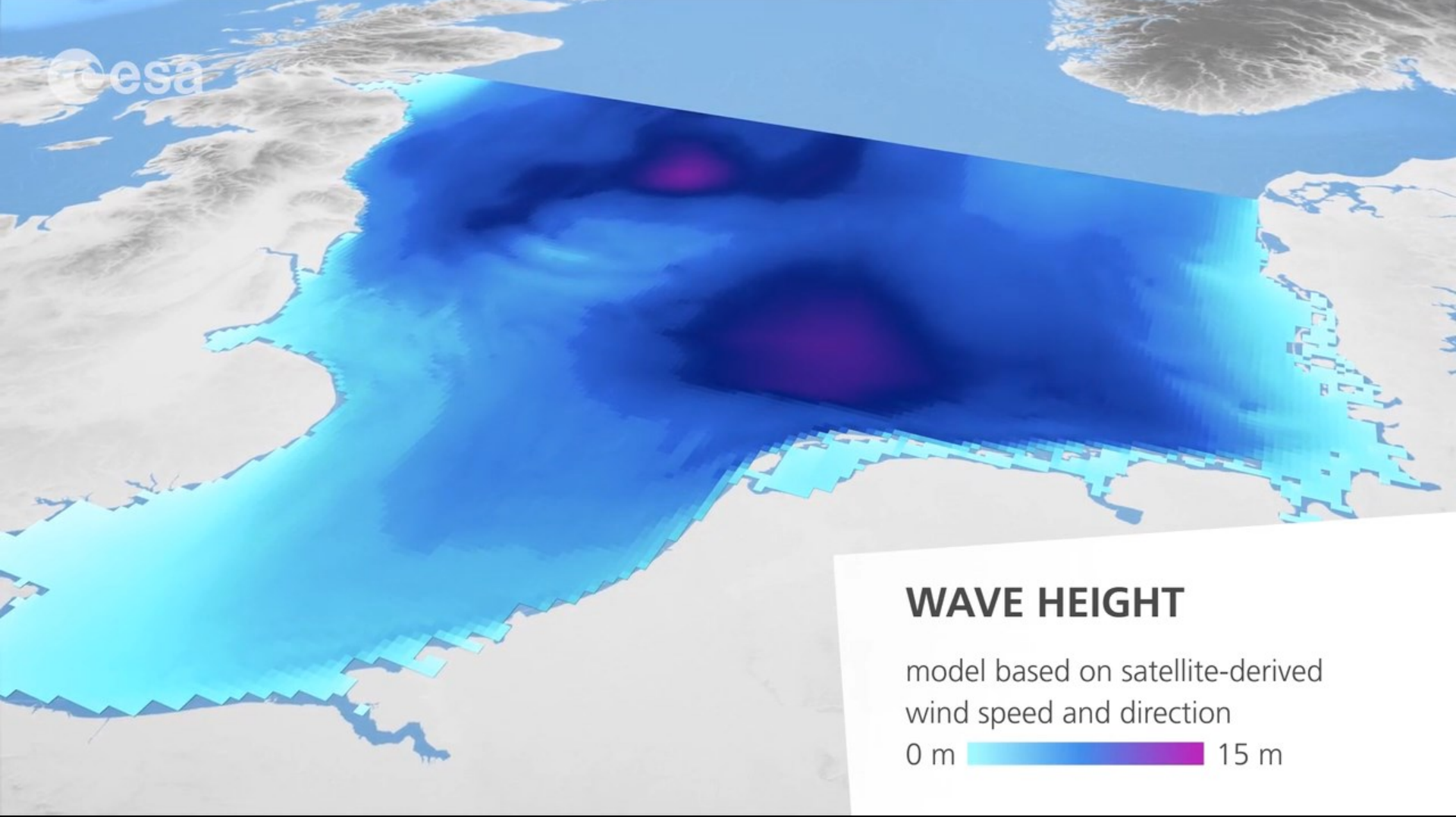
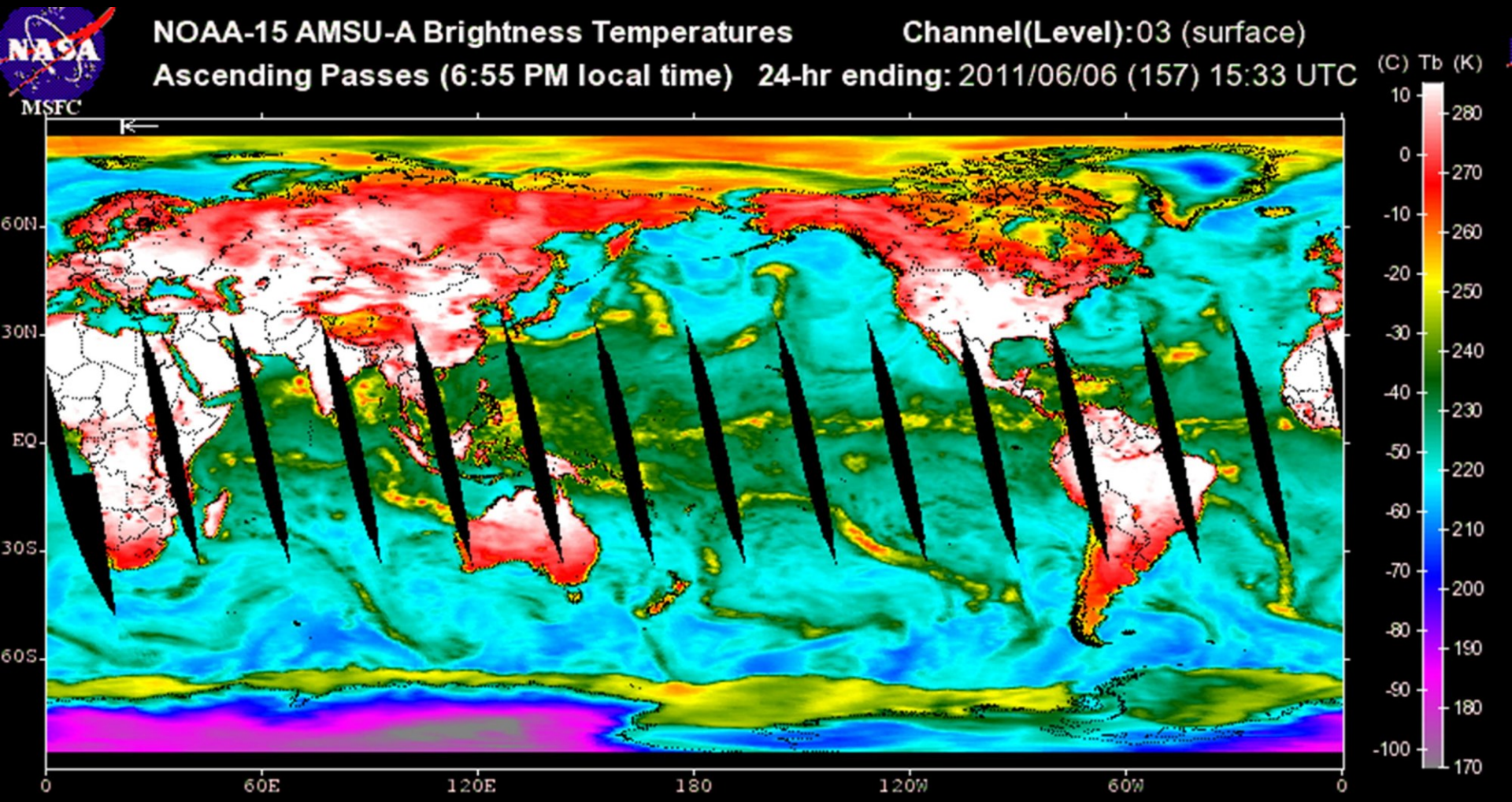
# Ocean


Multi-Mission Sea Level Trends
Period: Jan-1993 to Jan-2017
80°N
40°N
0°S
40°S
80°S
40°E
80°E
120°E
160°E
160°W
120°W
80°W
40°W
Regional MSL trends (mm/year)
−10
−5
0
5
10
© CNES/LEGOS/CLS, 2017


esa
WAVE HEIGHT
model based on satellite-derived
wind speed and direction
0 m
15 m

Credit: ESA

Credit: ESA


NOAA-15 AMSU-A Brightness Temperatures
Channel(Level):03 (surface)
Ascending Passes (6:55 PM local time)
24-hr ending: 2011/06/06 (157) 15:33 UTC
MSFC
(C) Tb (K)
10 280
0 270
-10 260
-20 250
-30 240
-40 230
-50 220
-60 210
-70 200
-80 190
-90 180
-100 170
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0

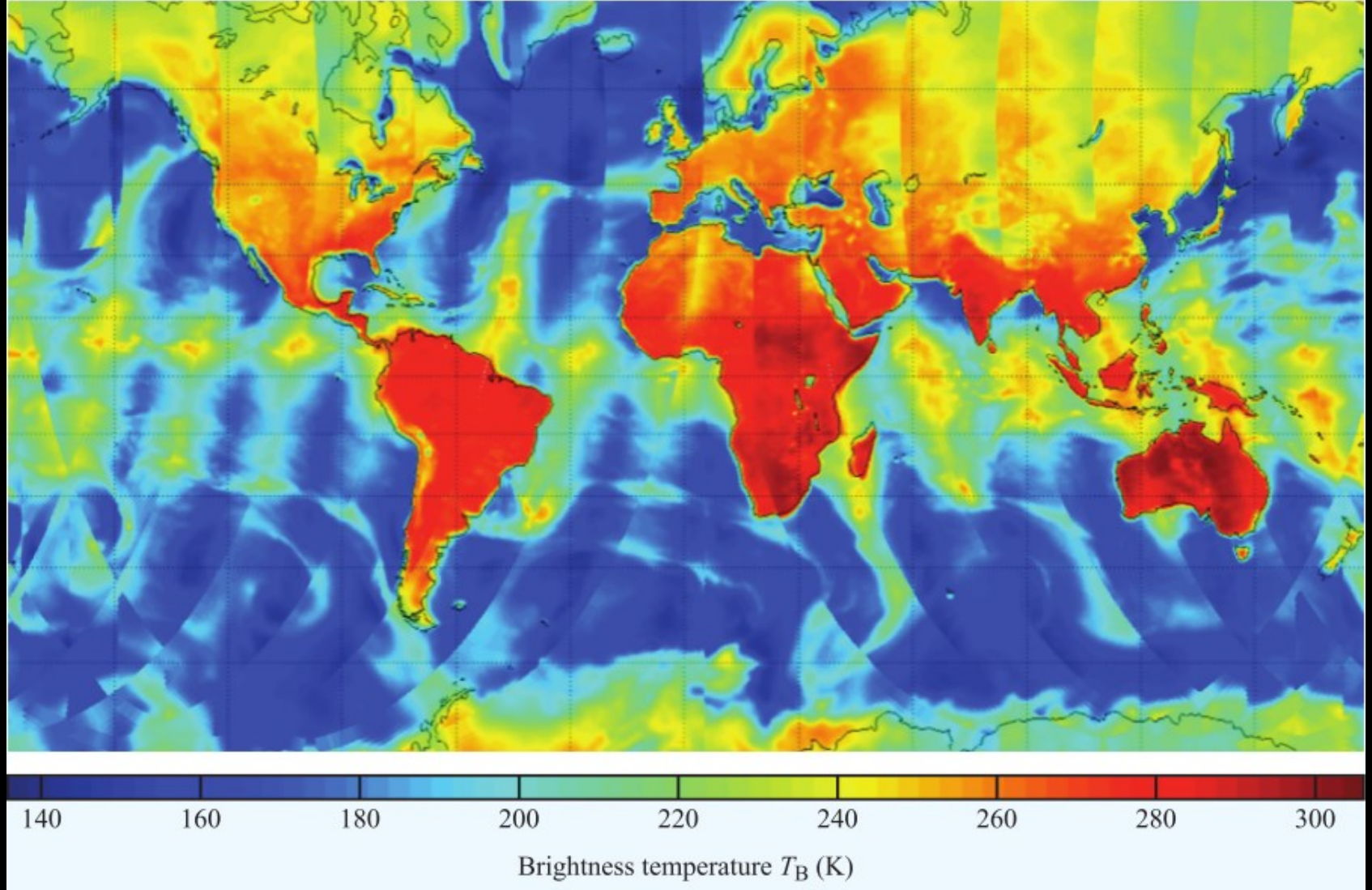
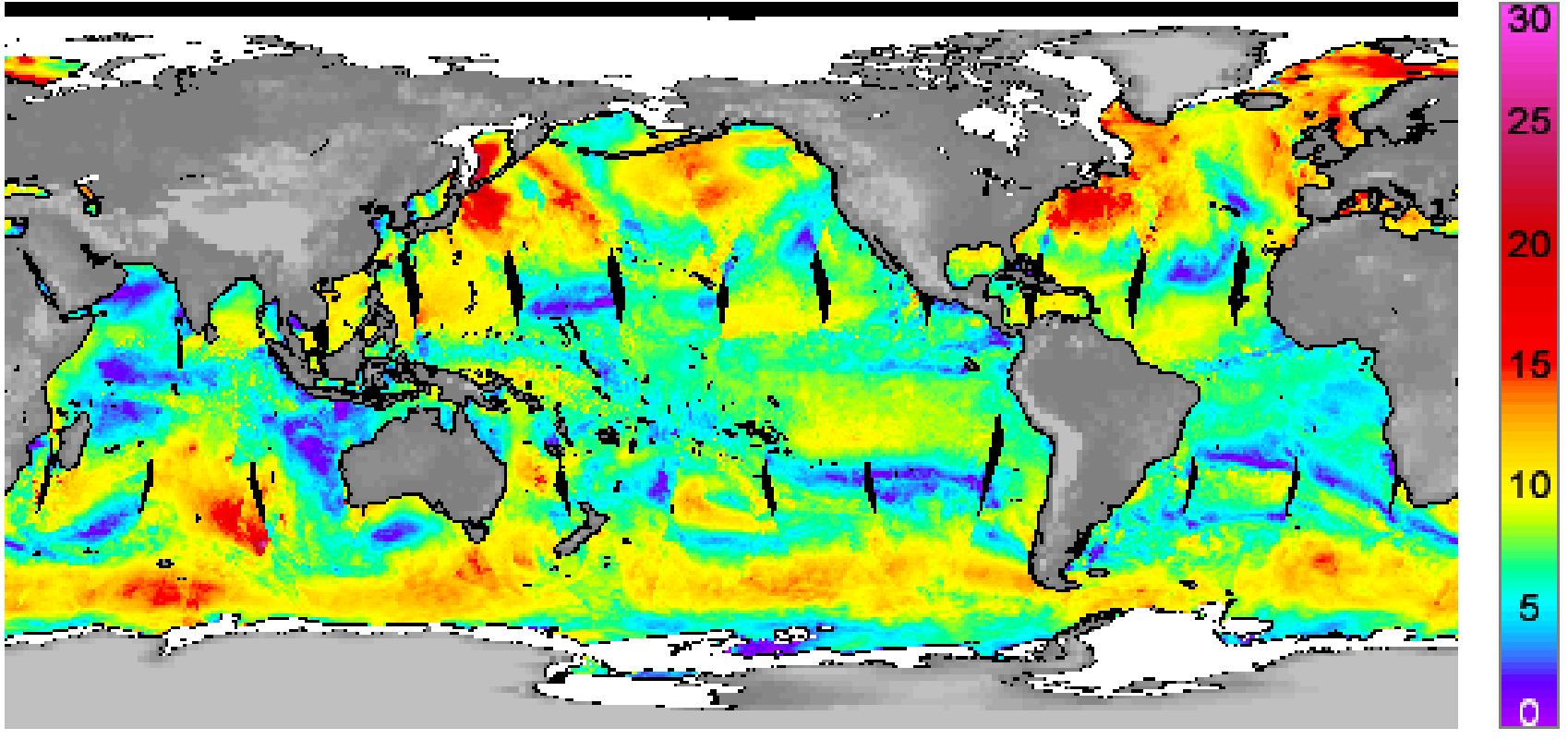
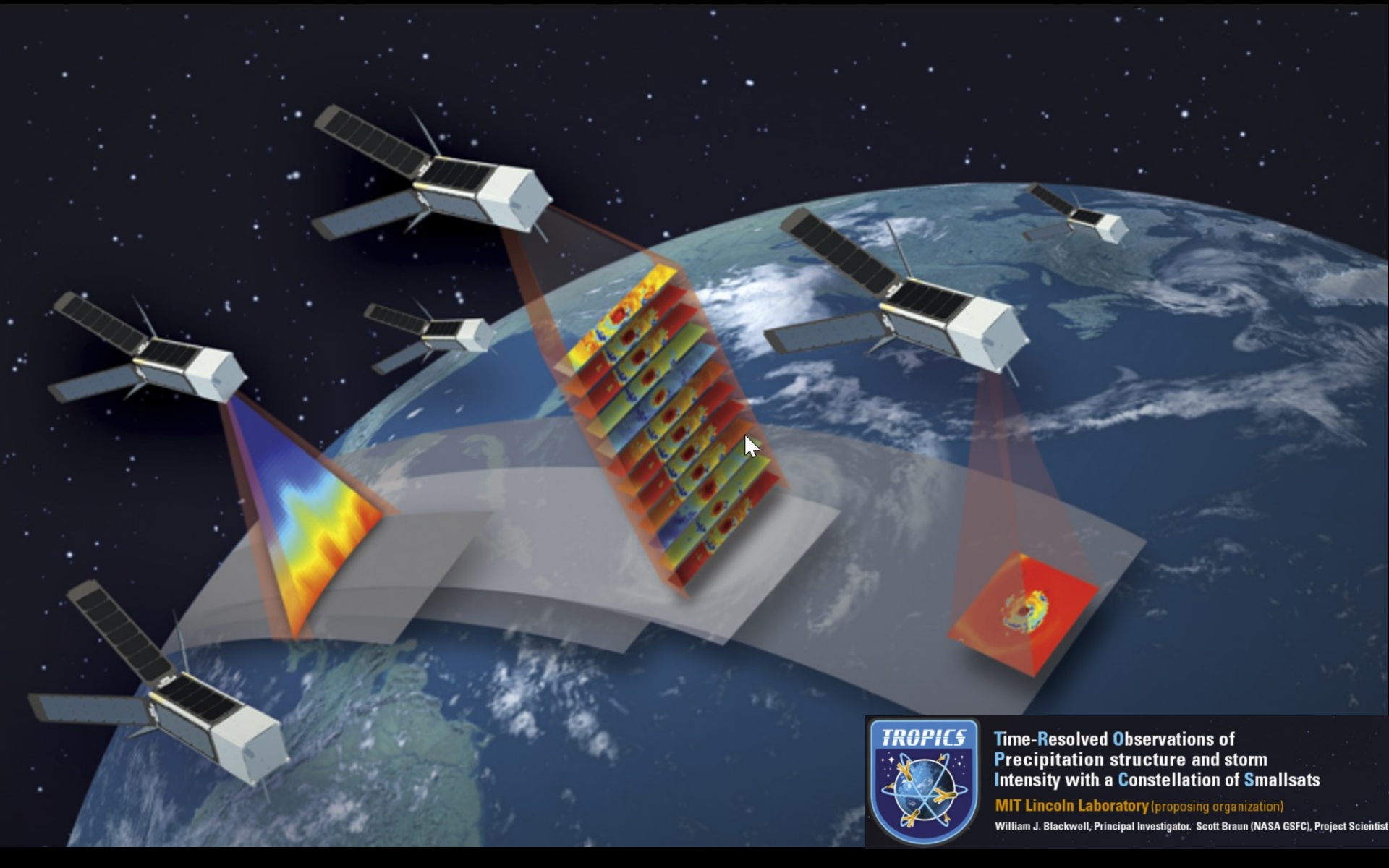



**Figure 9-32:** A global mosaic of ATMS 23.8 GHz brightness temperatures observed on December 16, 2011.

# Average of 3 days ending: 2015/02/03, WindSat, version 7.0.1

**Surface Wind Speed (m/s)**




TROPICS
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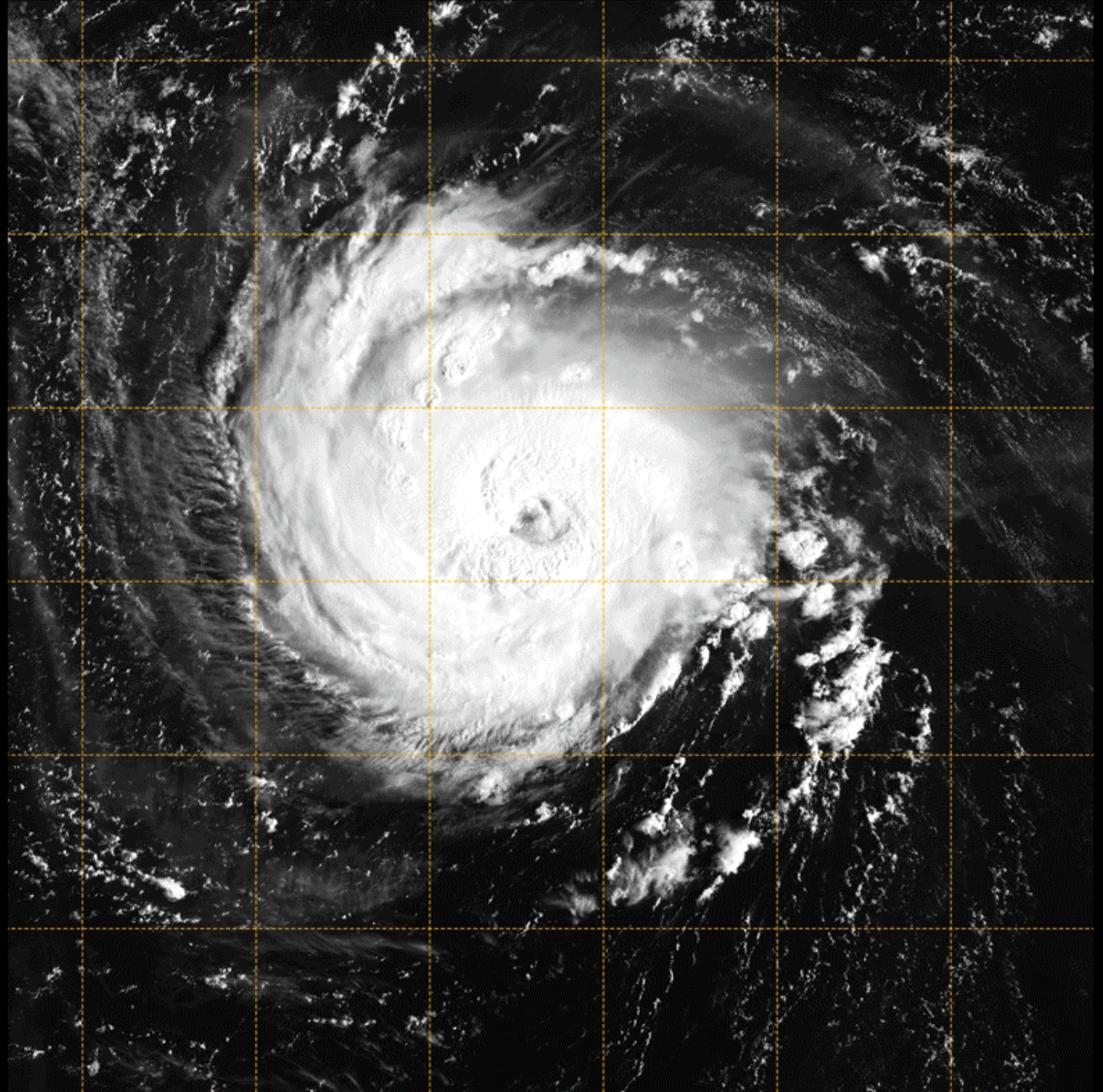

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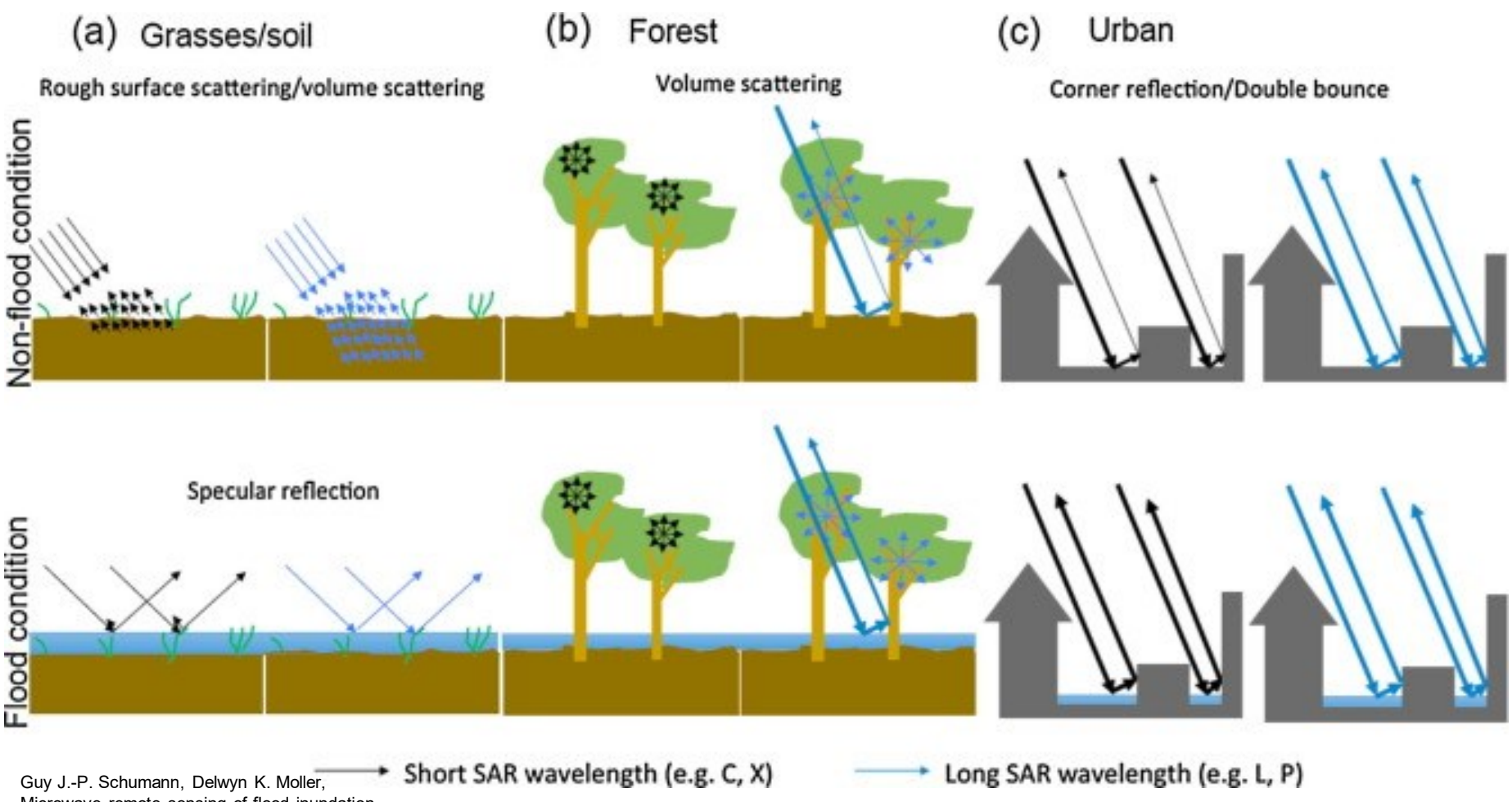
# Floods



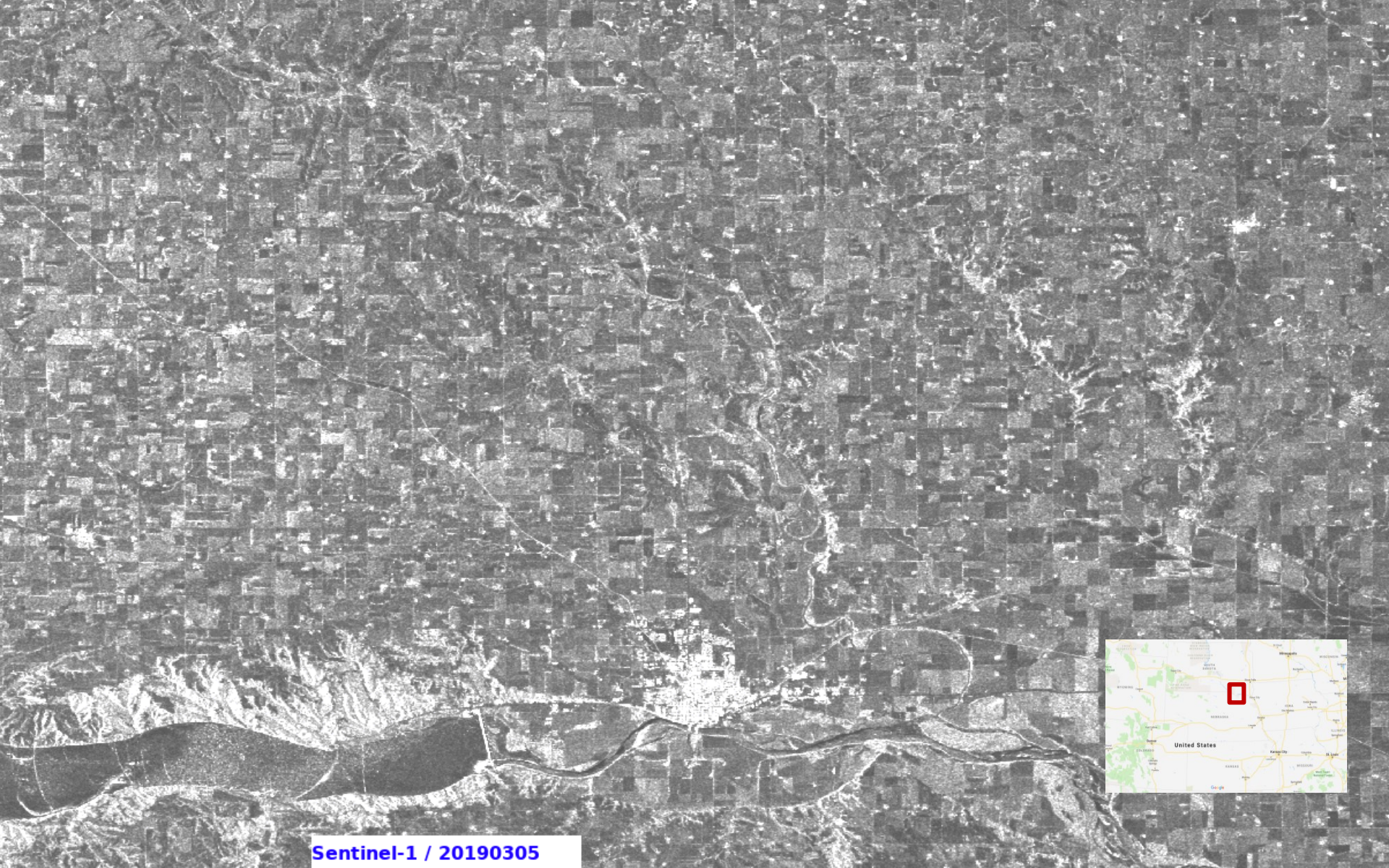

Guy J.-P. Schumann, Delwyn K. Moller,
Microwave remote sensing of flood inundation,
Physics and Chemistry of the Earth, Parts A/B/C,
Volumes 83–84,
2015,
Pages 84-95,
ISSN 1474-7065,
https://doi.org/10.1016/j.pce.2015.05.002.
(http://www.sciencedirect.com/science/article/pii/S1474706515000406)

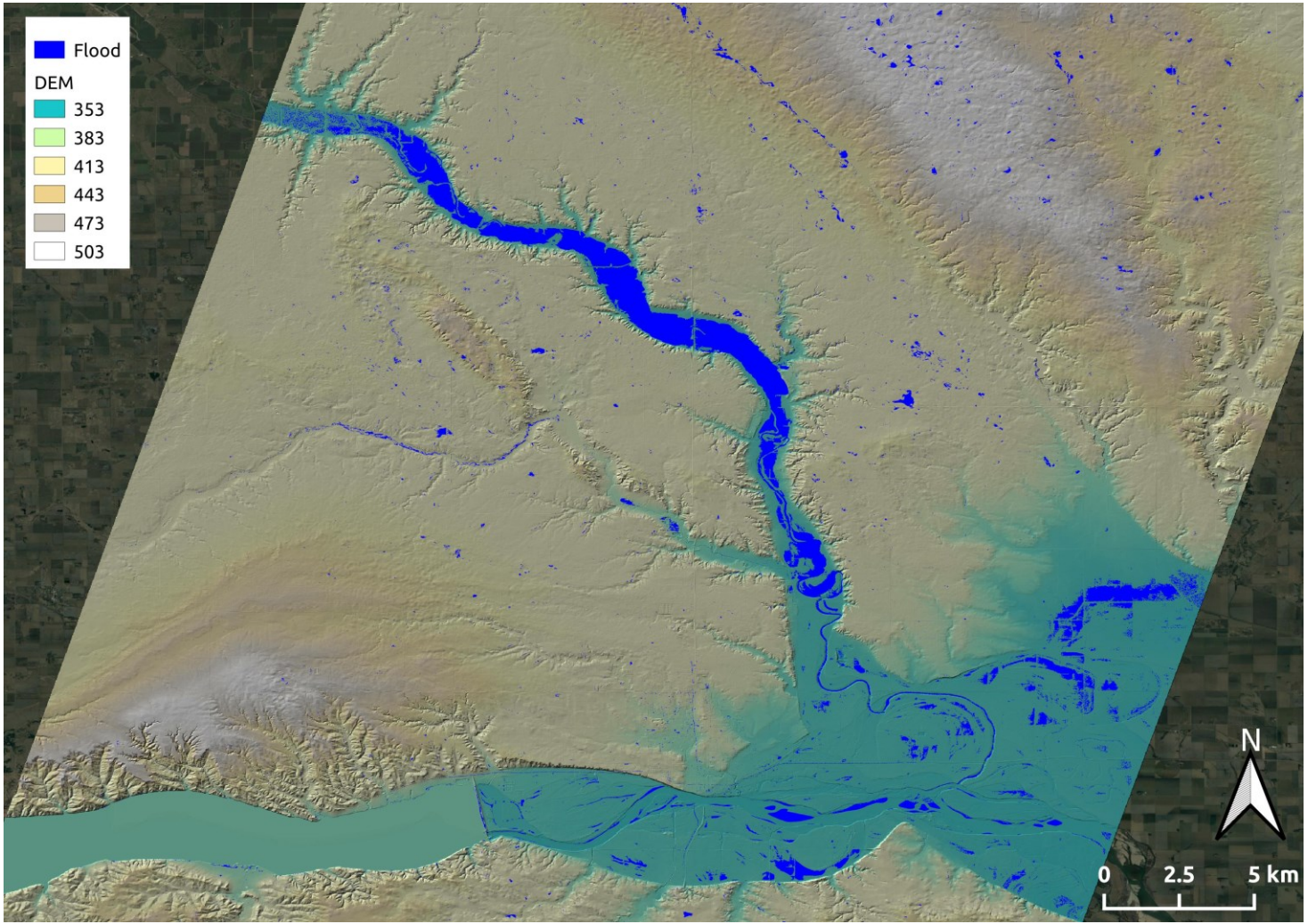
FLOOD SITUATION

## YANKTON, USA

Event ID: 103068, taken on 3/19/2019 5:32:31 PM (UTC)
Sensor Mode: LEFT_26.6
Orbit Direction: DESCENDING
Look Angle: 26.2
Center coordinates (LAT, LON): 42.9044, -97.3614


ICEYE


Sentinel-1 / 20190305
United States




X2

FLOOD SITUATION

**YANKTON, USA**

Event ID: 103068, taken on 3/19/2019 5:32:31 PM (UTC)
Sensor Mode: LEFT_26.6
Orbit Direction: DESCENDING
Look Angle: 26.2
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ICEYE


Florida
Grand Bahama
Great Abaco


Crystal Inn
SPEED LIMIT 35


Bahamas
Road network data © OpenStreetMap contributors
ICEYE

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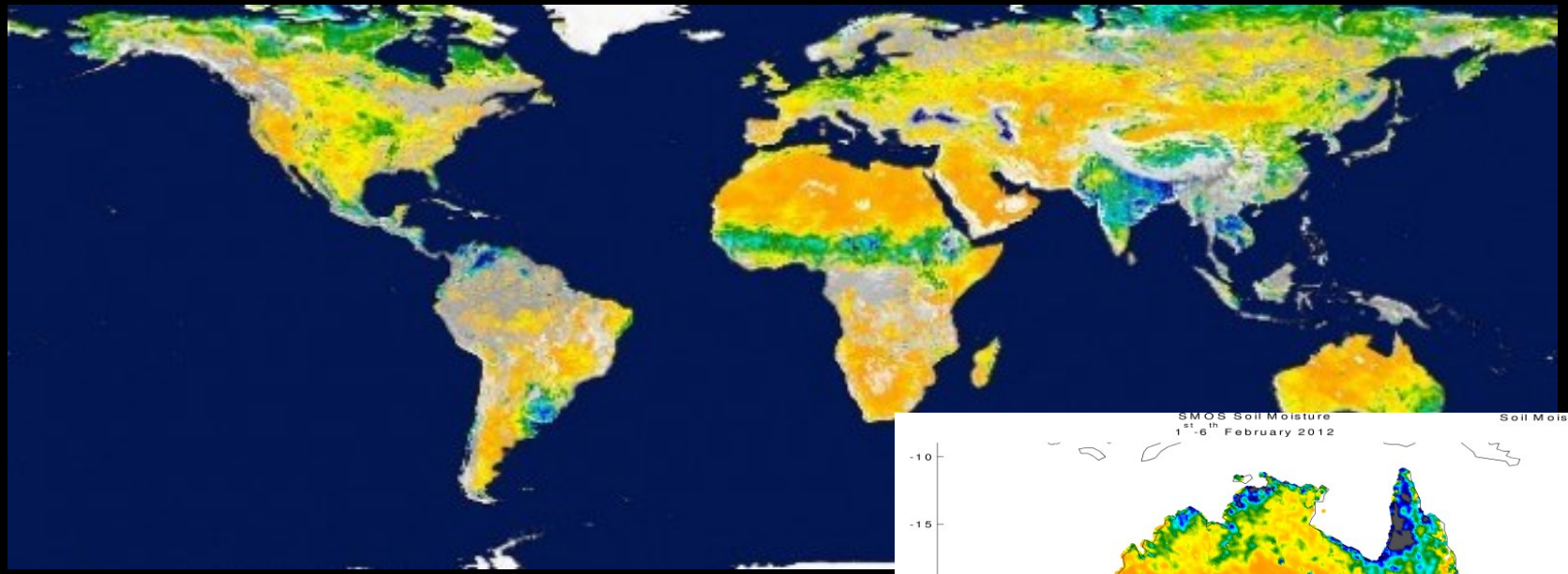
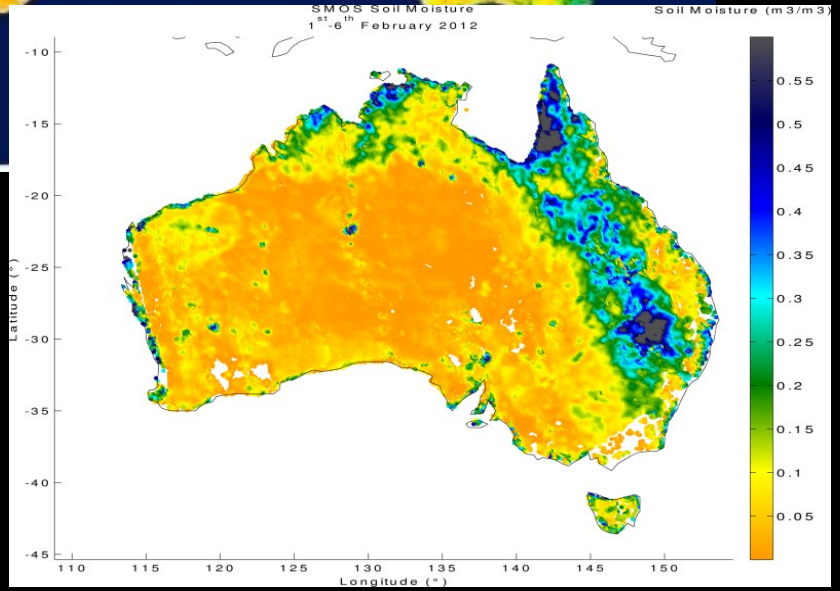
# Droughts






# Global Soil Moisture

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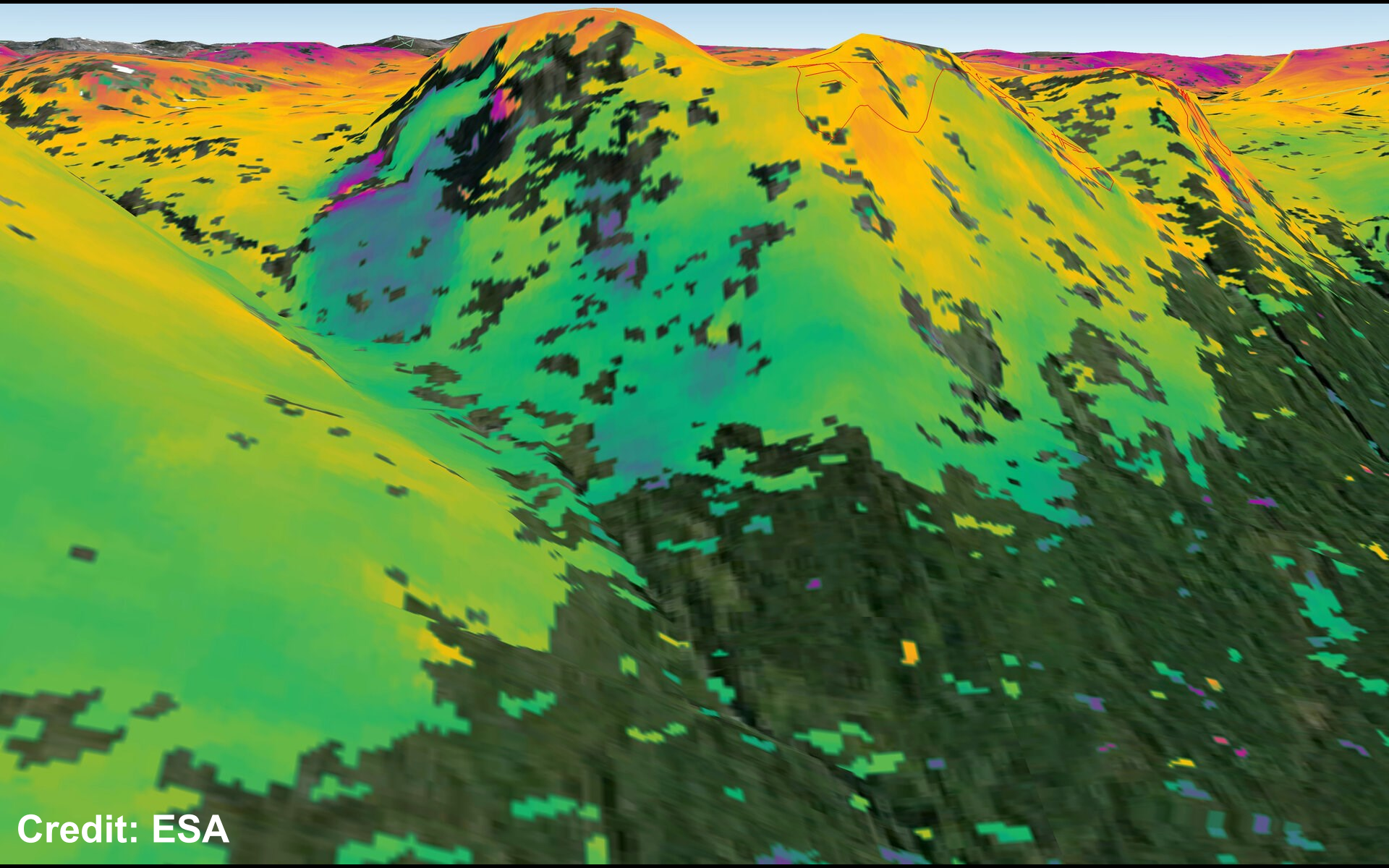
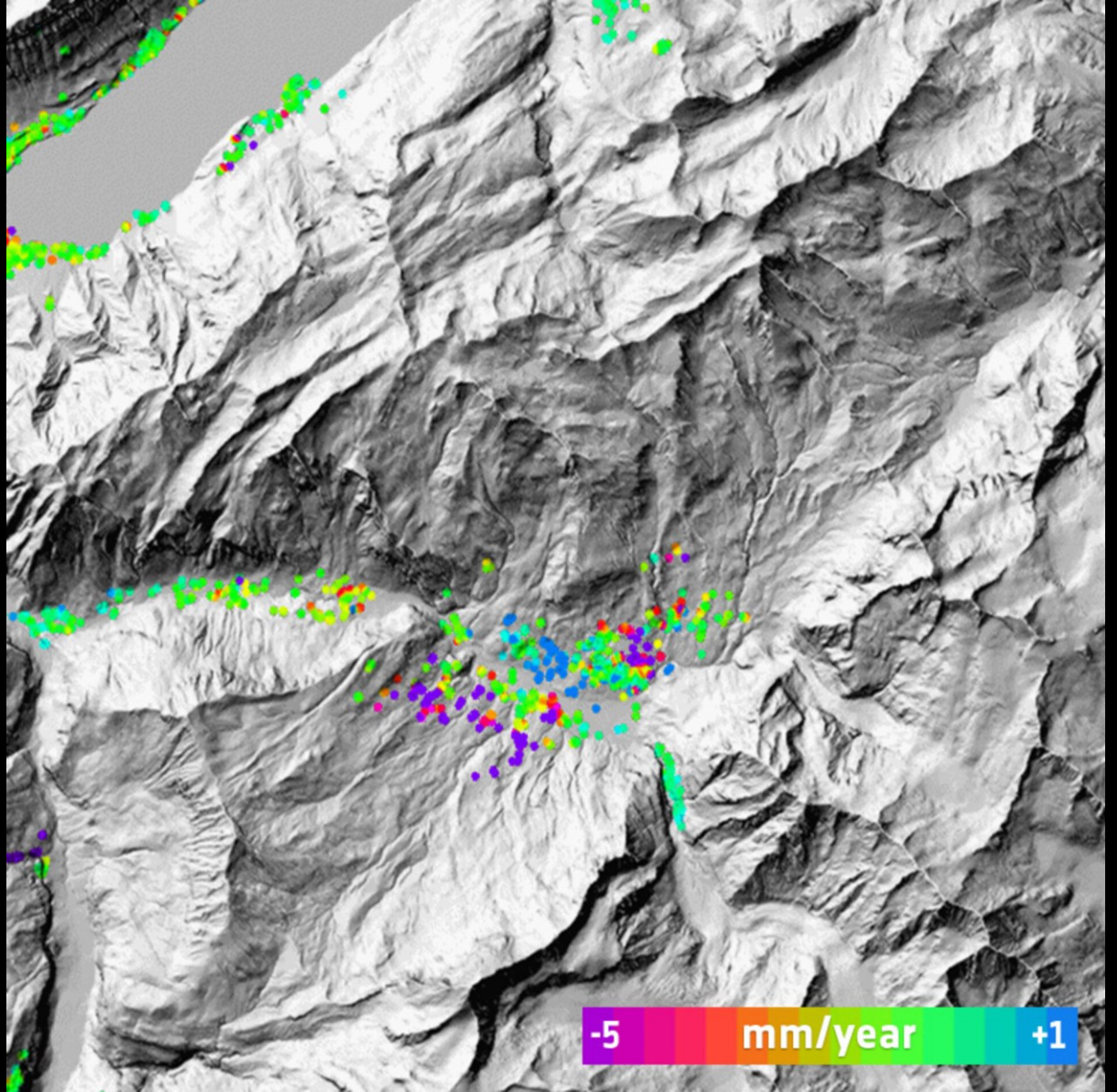
# Land-slides


Credit: ESA

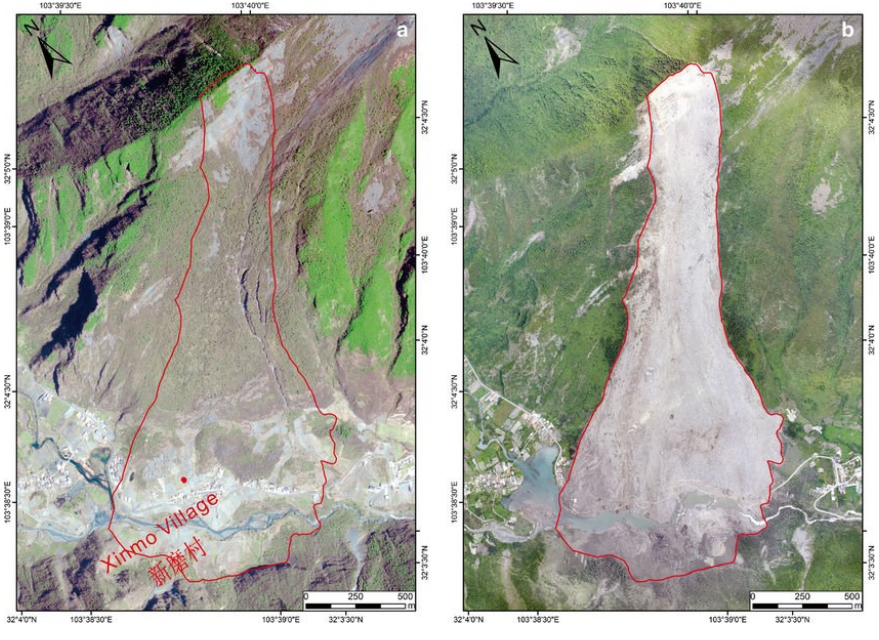


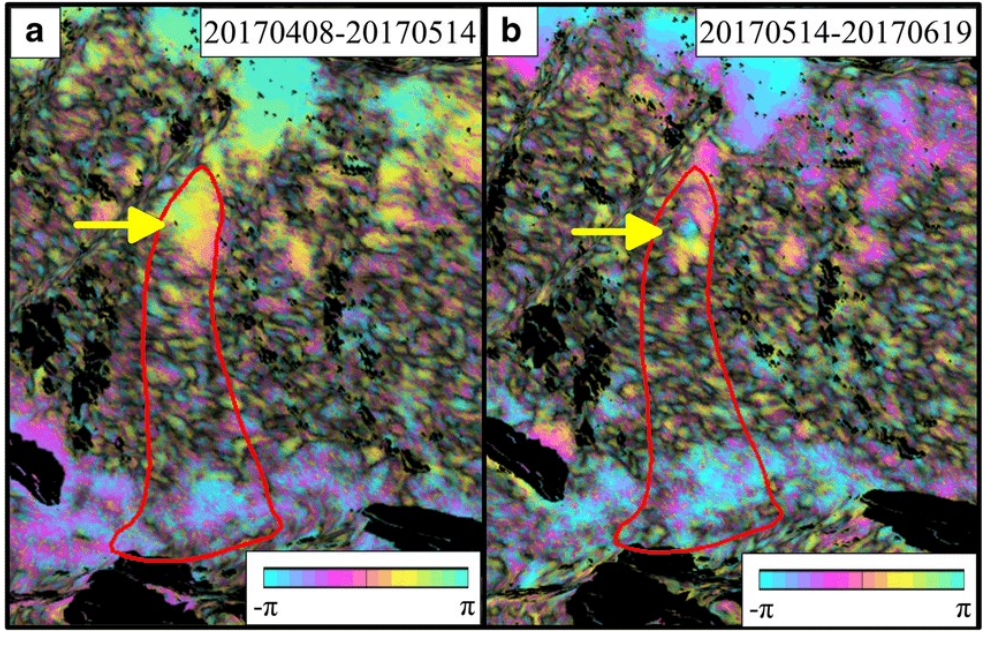

Credit: ESA

# Failure mechanism and kinematics of the deadly June 24th 2017 Xinmo landslide, Maoxian, Sichuan, China

Article
Full-text available
Oct 2017

Xuanmei Fan
Qiang Xu
Gianvito Scaringi[...]
Hans-Balder Havenith

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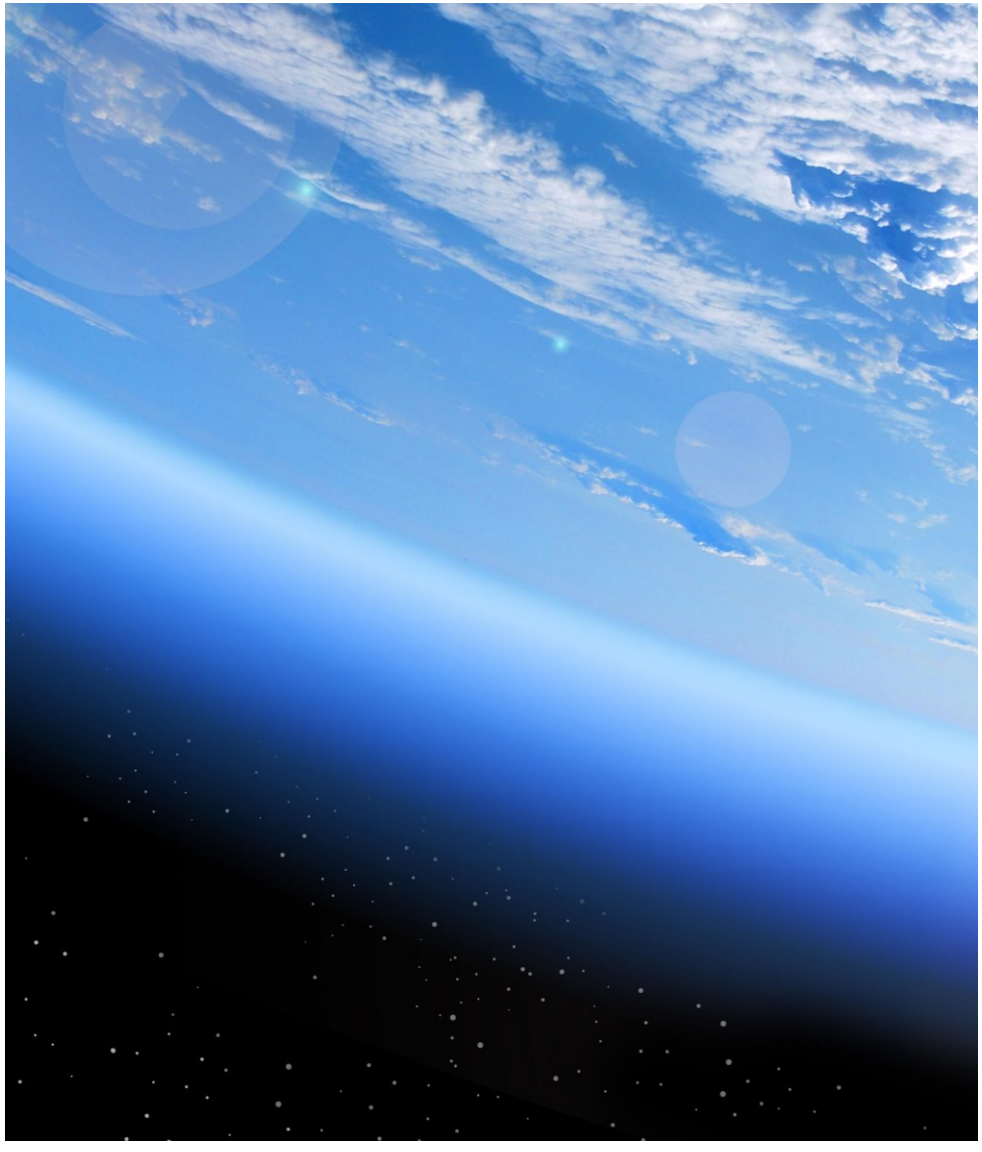
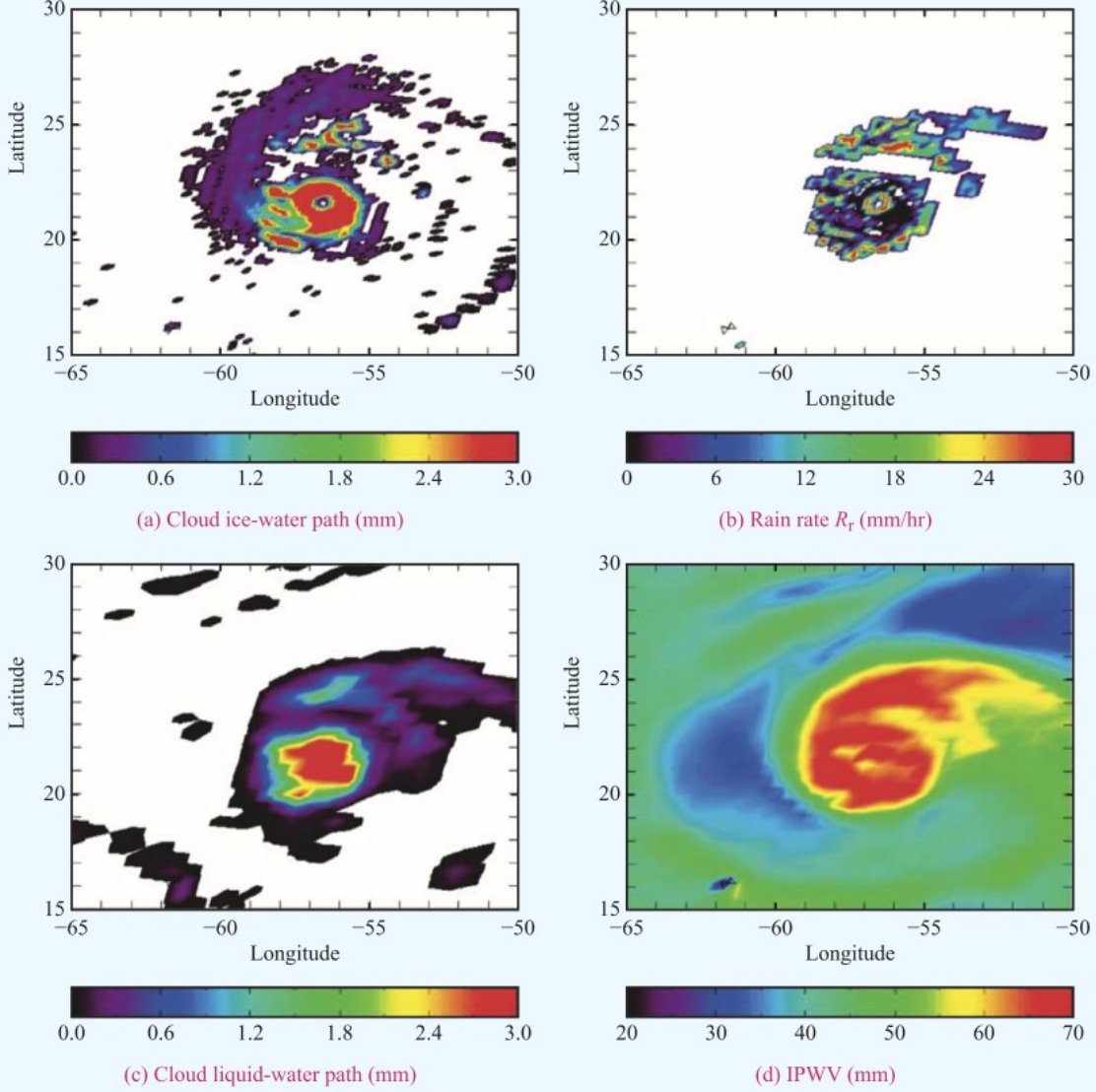
# Atmosphere




Microwave Radiometer (MWR) by Radiometrics.
Water vapor and liquid water measurements at frequencies: 23.8 and 31.4 GHz



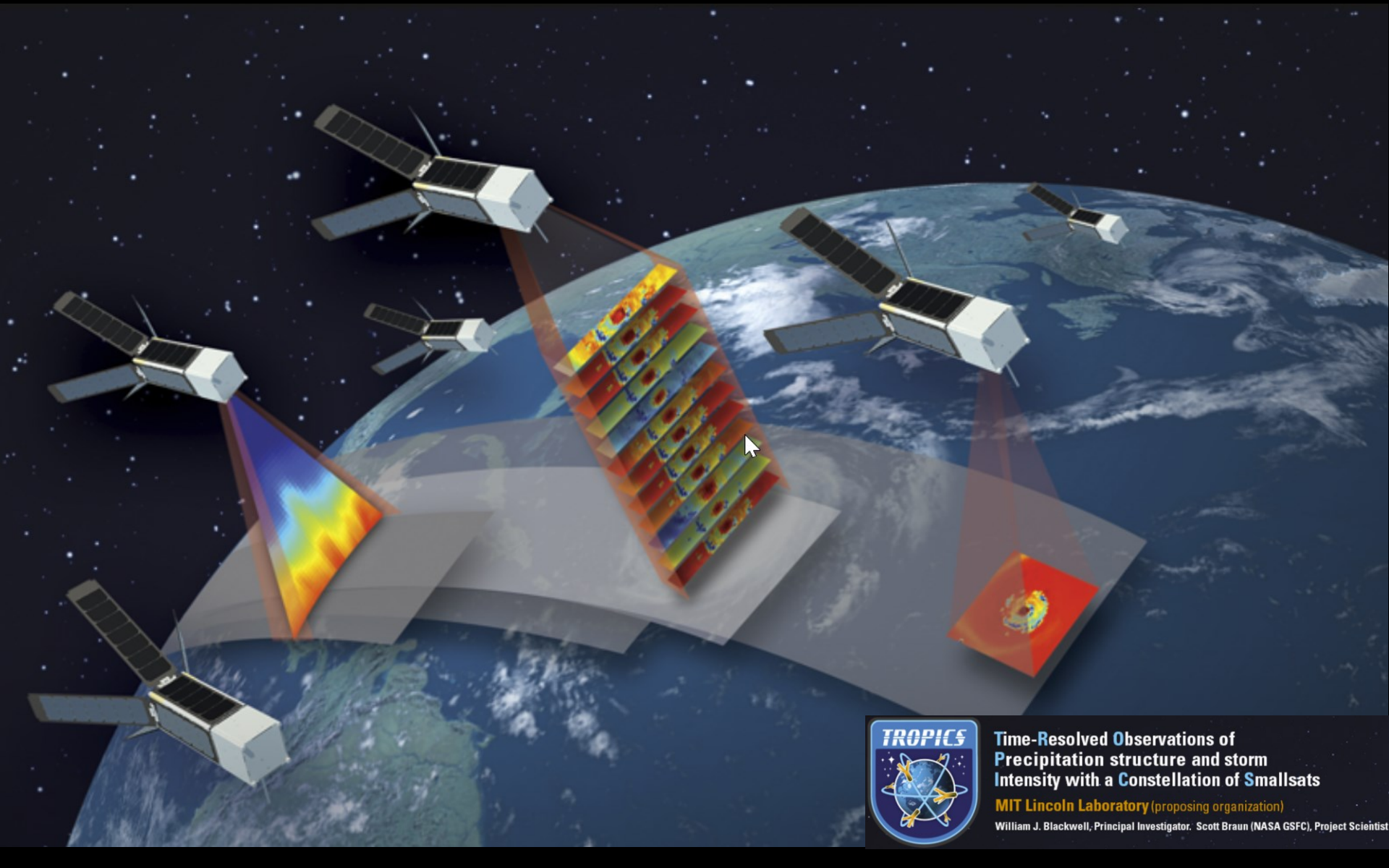

(a) Cloud ice-water path (mm)

(b) Rain rate $R_r$ (mm/hr)

(c) Cloud liquid-water path (mm)

(d) IPWV (mm)

**Figure 9-39:** AMSU-retrieved (a) ice-water path, (b) surface rain rate, (c) cloud liquid water, and (d) integrated precipitable water vapor (IPWV) for Hurricane Isabel on September 12, 2003 [Liu and Weng, 2005].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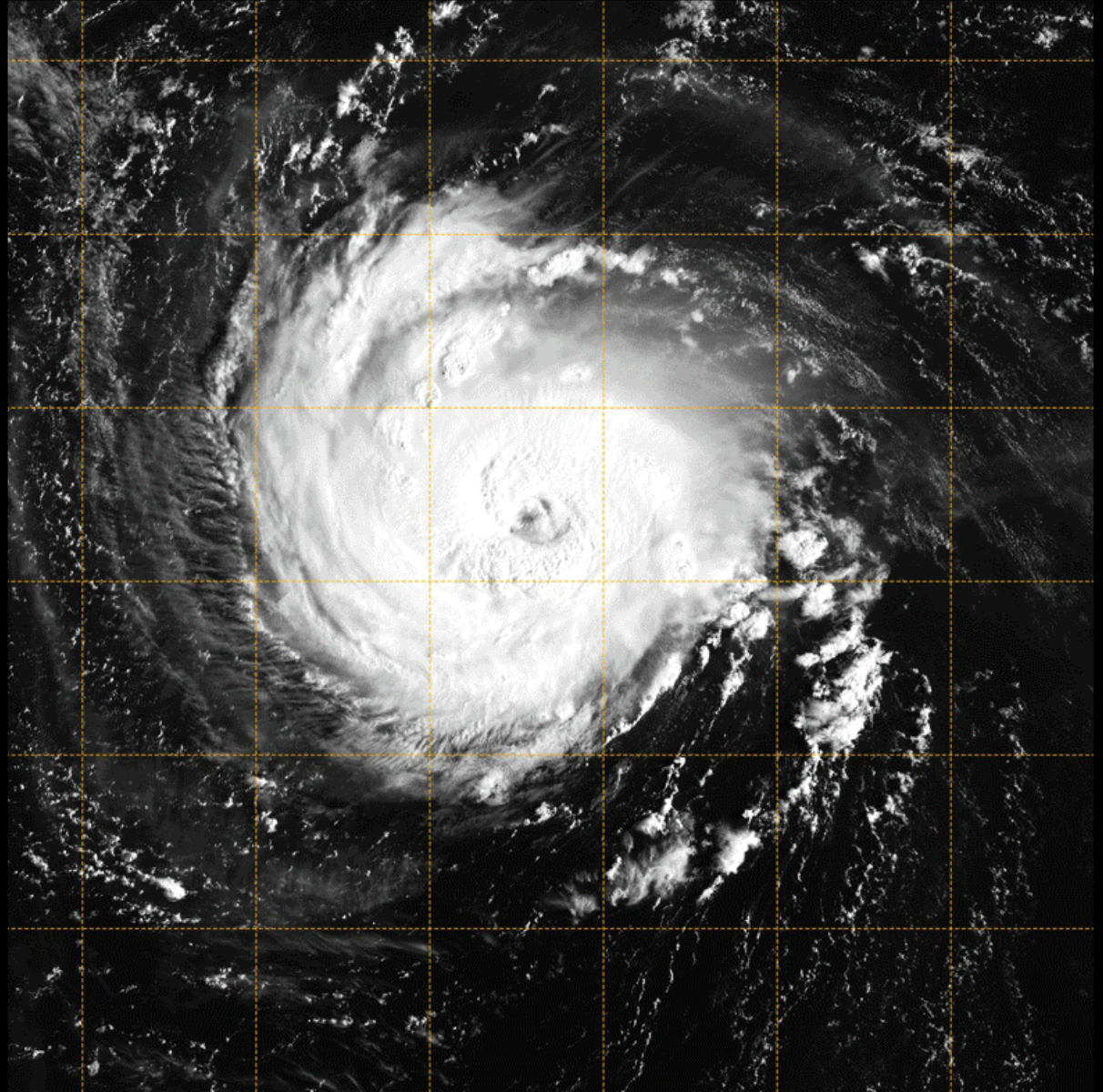
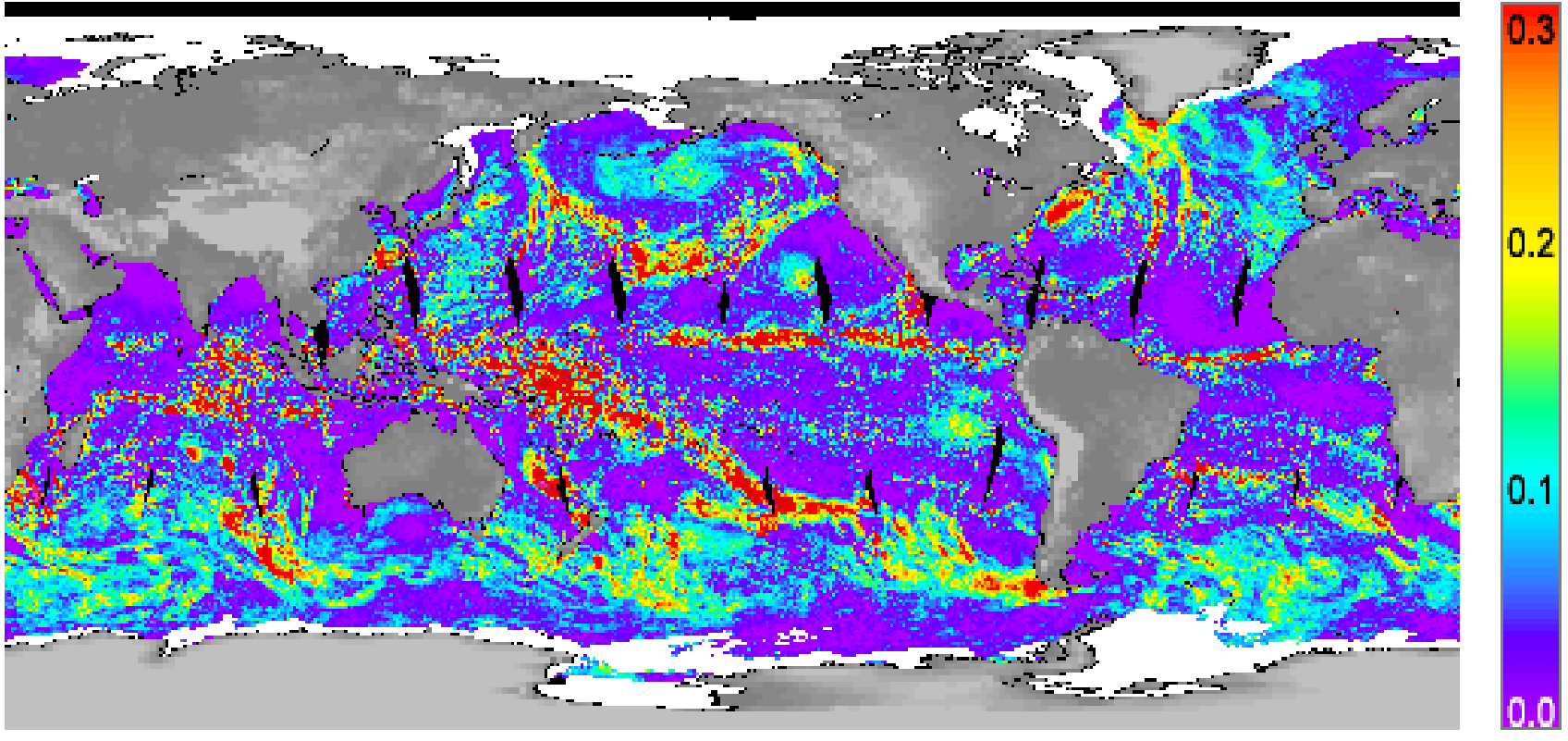


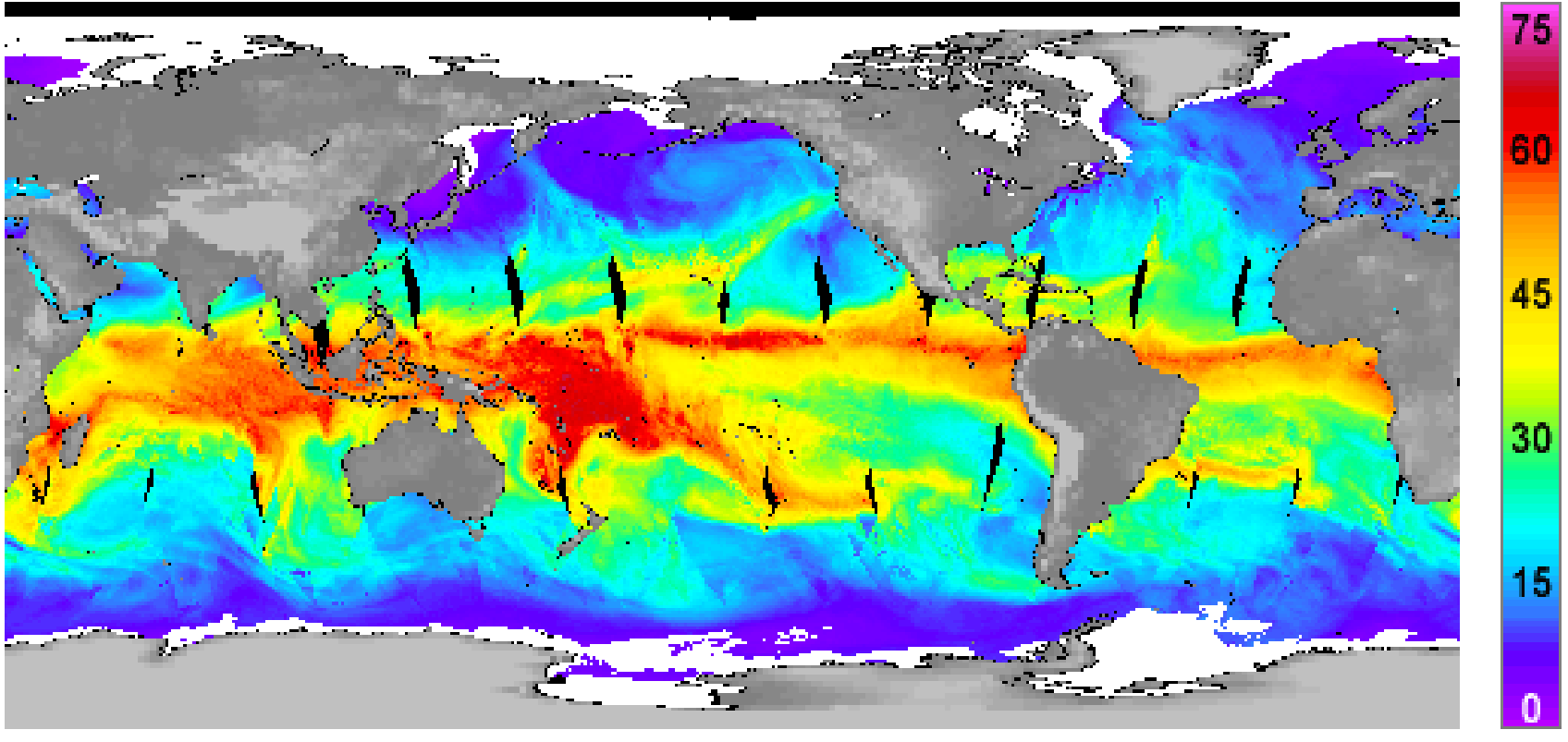
# Average of 3 days ending: 2015/02/03, WindSat, version 7.0.1

**Cloud Liquid Water(mm)**



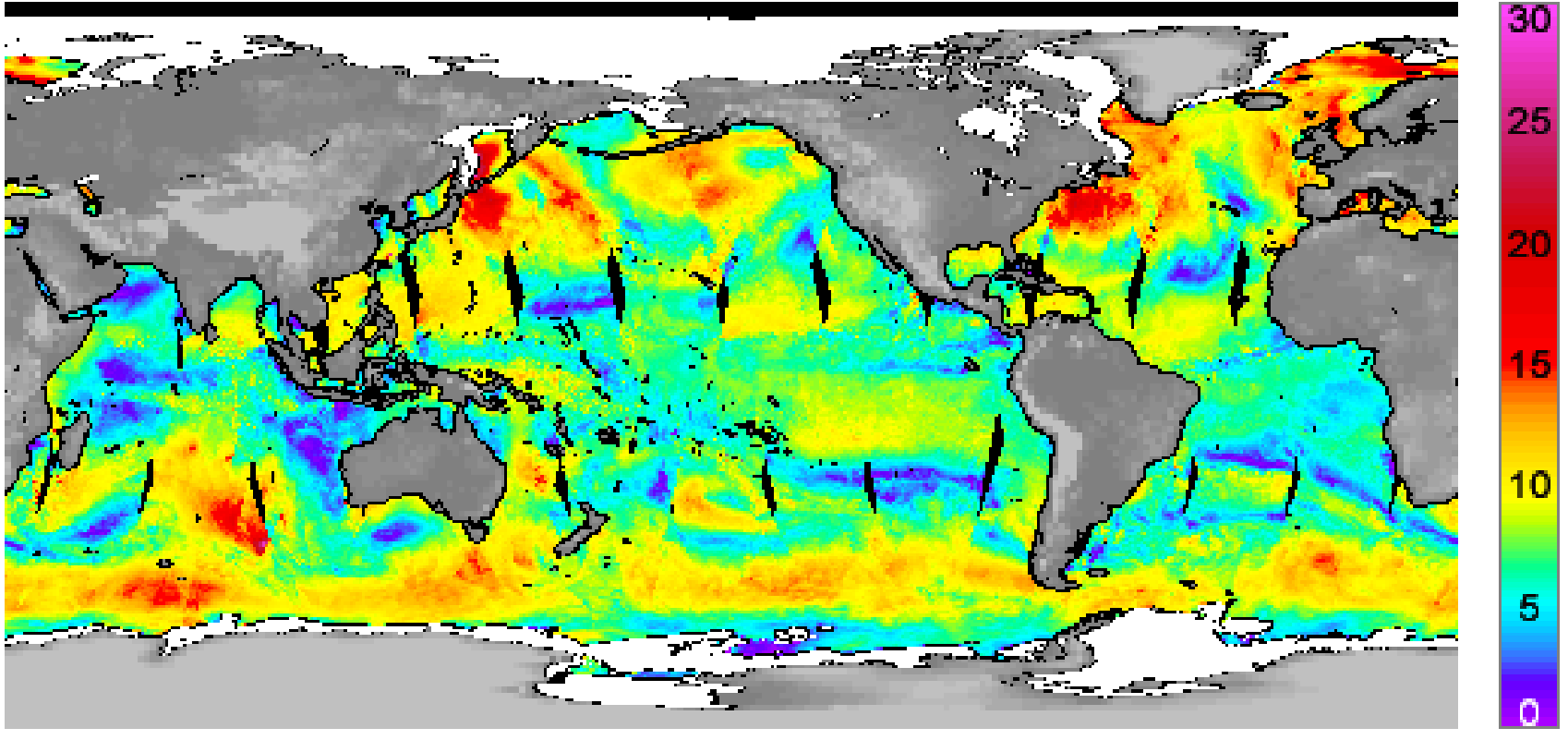
# Average of 3 days ending: 2015/02/03, WindSat, version 7.0.1

**Atmospheric Water Vapor (mm)**



# Average of 3 days ending: 2015/02/03, WindSat, version 7.0.1

**Surface Wind Speed (m/s)**



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# Debunking Q&A

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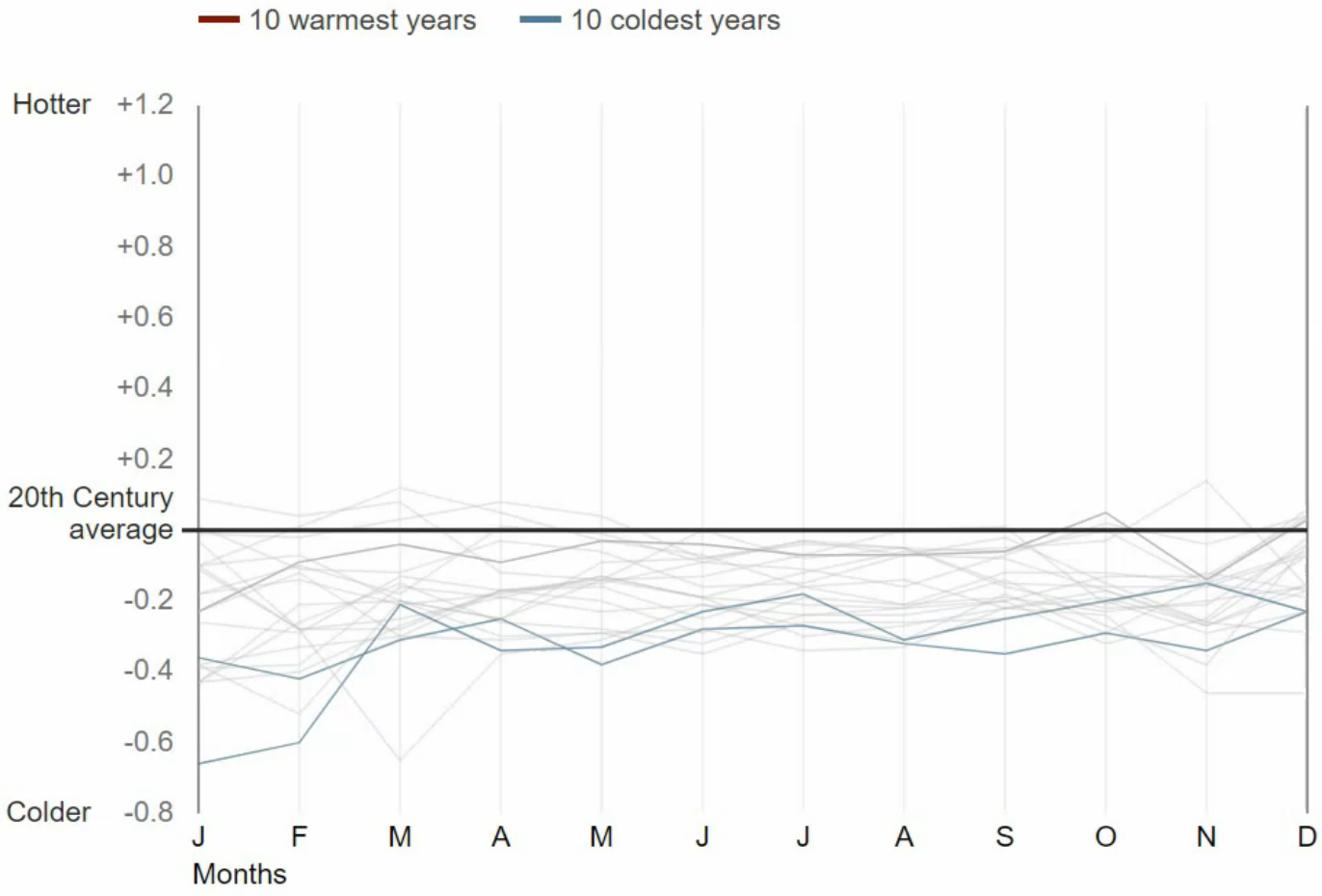
# There is no change!

*There is.*

# How years compare with the 20th Century average

## 1900



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# Not our fault?

*Is not a relevant question*


DETROIT

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# We cannot do anything!

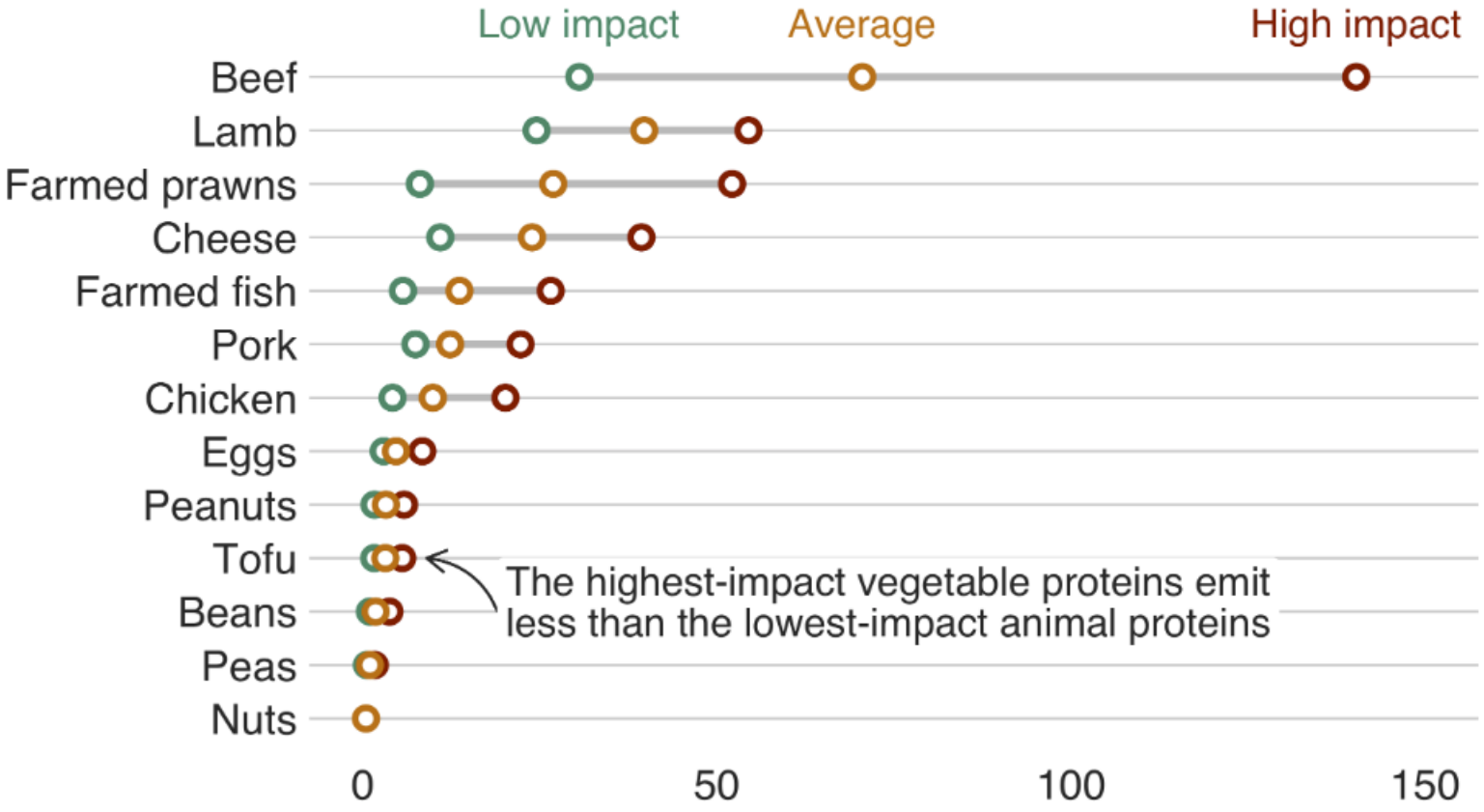
*Only we can. This is our only hope.*

# Greta Thunberg


SKOLSTREJK
FÖR
KLIMATET

# Beef has the biggest climate impact

## Greenhouse gas emissions per kilogram




Source: Poore & Nemecek (2018), Science

BBC

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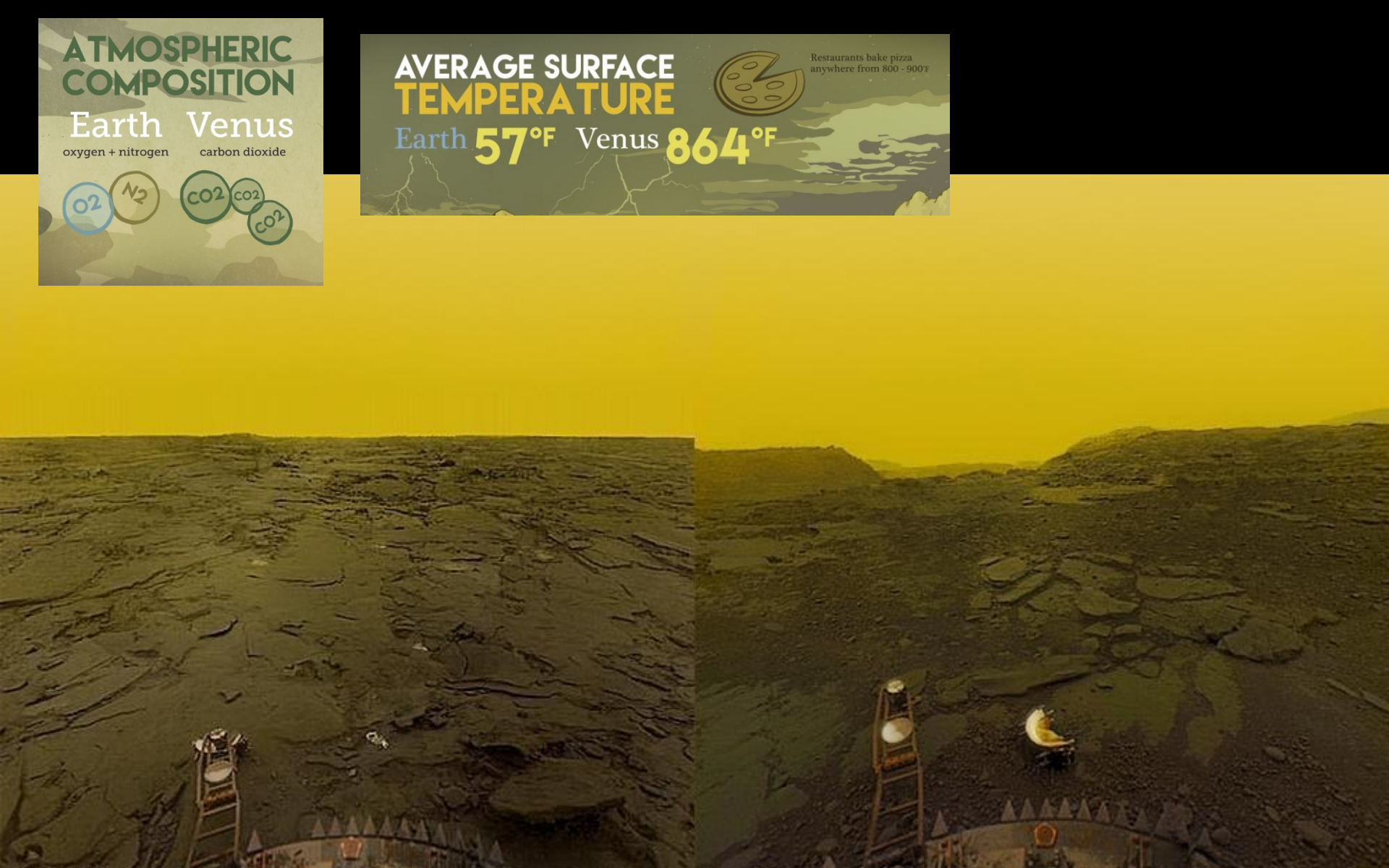
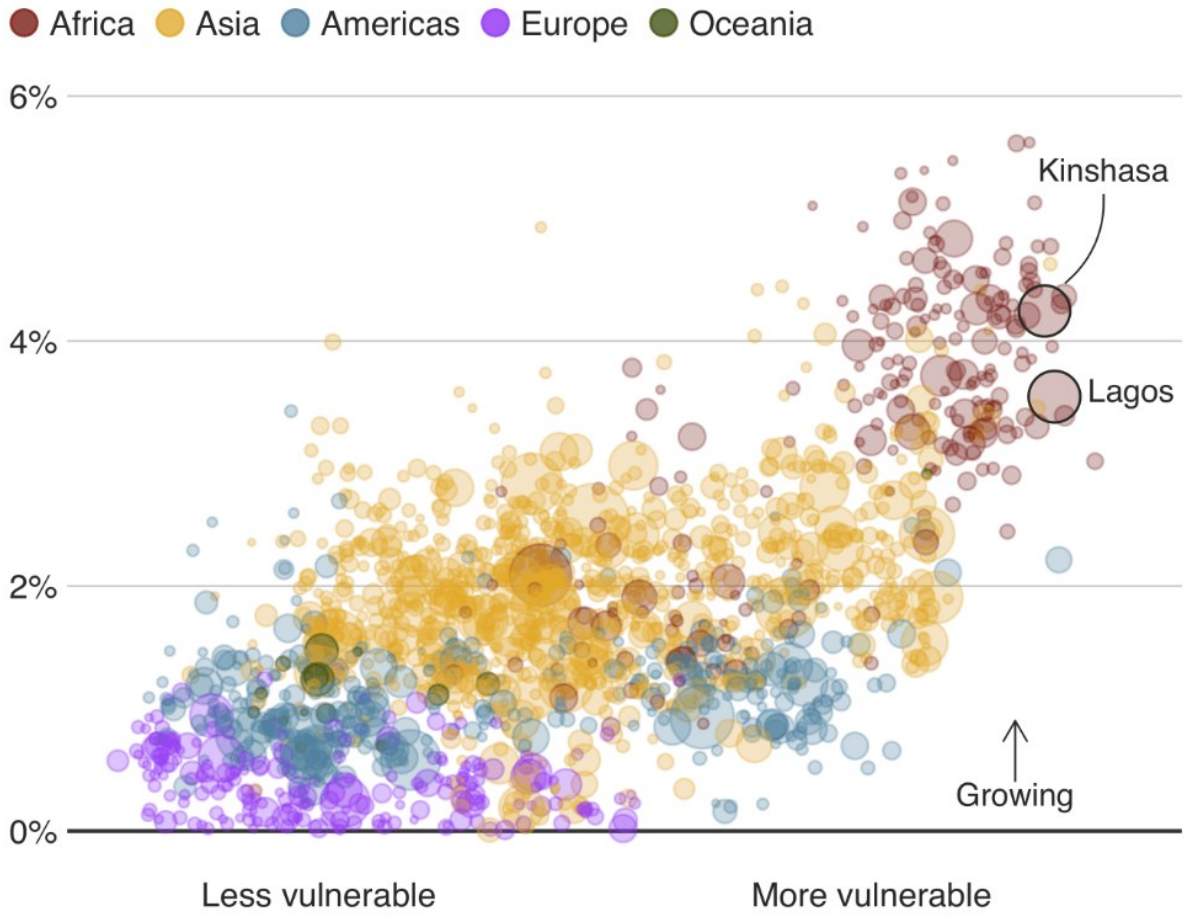
# It is good that it will get warmer!

*To certain extent, but even this is very expensive.*


ATMOSPHERIC COMPOSITION
Earth
oxygen + nitrogen
Venus
carbon dioxide
O2
N2
CO2
CO2
CO2
AVERAGE SURFACE TEMPERATURE
Earth 57°F
Venus 864°F
Restaurants bake pizza anywhere from 800 - 900°F

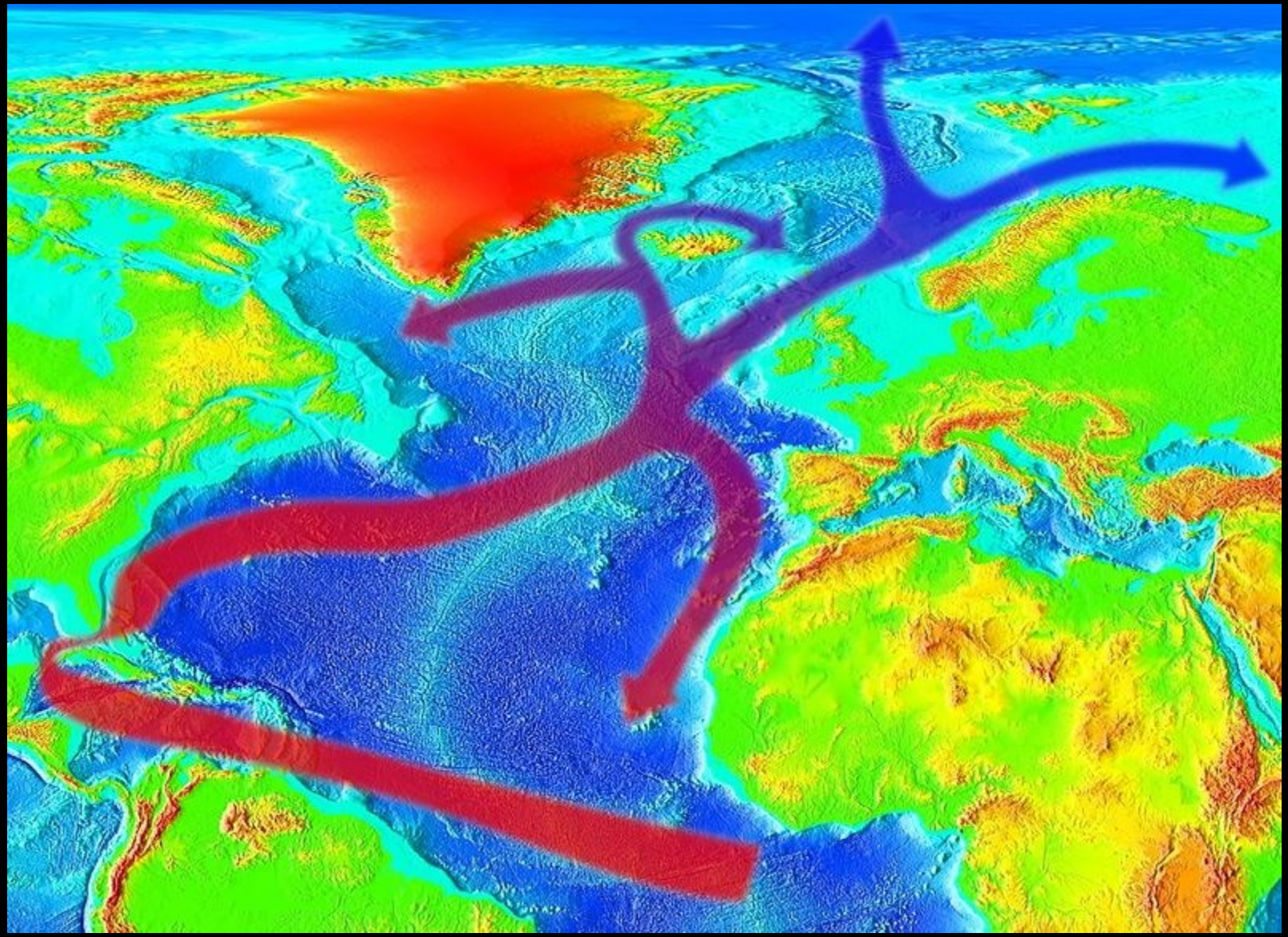
# Fast-growing cities face worse climate risks

Population growth 2018-2035 over climate change vulnerability




Source: Verisk Maplecroft. Circle size represents current population.

BBC



61° 13′N, 149° 54′W, **Anchorage** · Alaska

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# Is it all money and conspiracy?

A?

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# Base your actions on facts and you might have a chanche to affect the reality.

.

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# What to do?

# Let’s think some actions!

- Fusion reactor research. Civilization needs clean energy.
- Promote nuclear power, promote Onkalo.
- Better legislation for nuclear waste transport.
- Solar energy.
- Energy storage. Hydrogen technologies?
- Better waste management.
- Alternatives for concrete.
- CO2 capture.
- Vote the right people!

# Let’s think some actions!

- **Education, especially girls and women.**
- **European green deal. Taxation and carbon trade.**
- **Promoting the big picture thinking.**