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CENTRE NATIONAL D'ÉTUDES SPATIALES

LE CLIMAT ET L'APPORT DU SPATIAL

A. BLAZQUEZ

JOURNÉES JC2 CNES
16 OCT 2024

QUI SUIS-JE?

Formation

2005 Ingénieur aéronautique (ETSIAE, Madrid)

2020 Docteur en géodésie spatiale (Université de Toulouse)

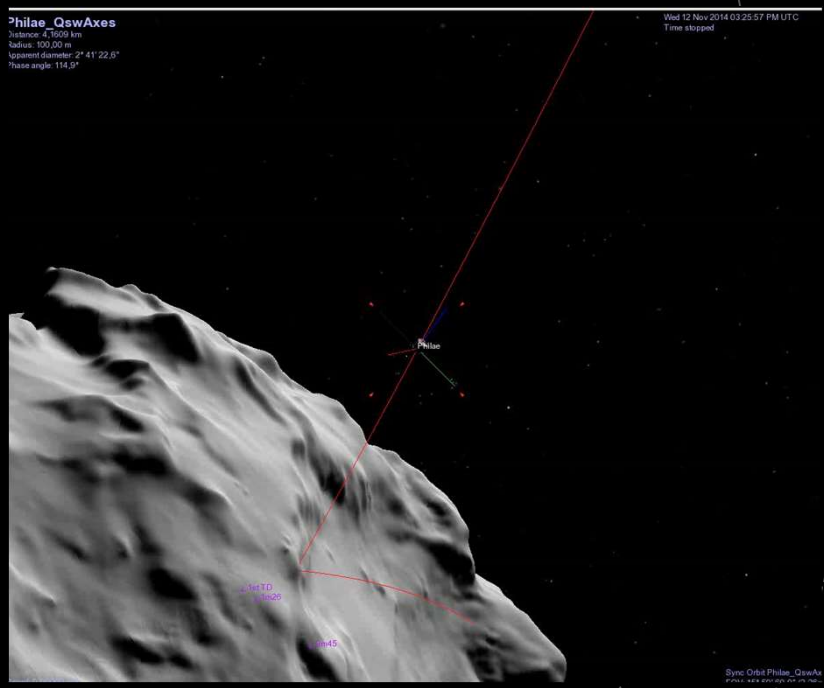
Expérience

2005 Stage Fin d'études au SUPAERO

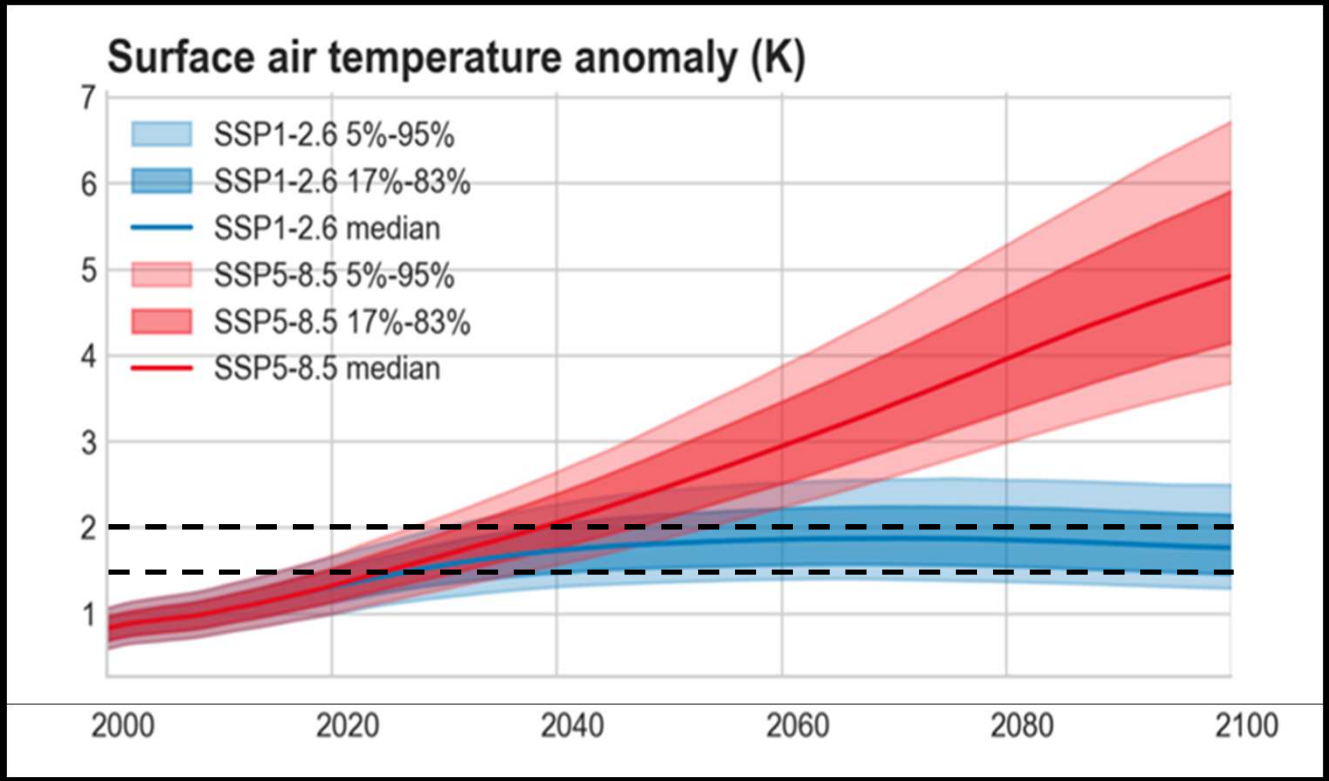
2006-2007 Ingénieur de développement COFRAMI

2007-2014 Ingénieur au CNES:
- Rentrée atmosphérique et études interplanétaires
- Participation à la mission Rosetta /Philae

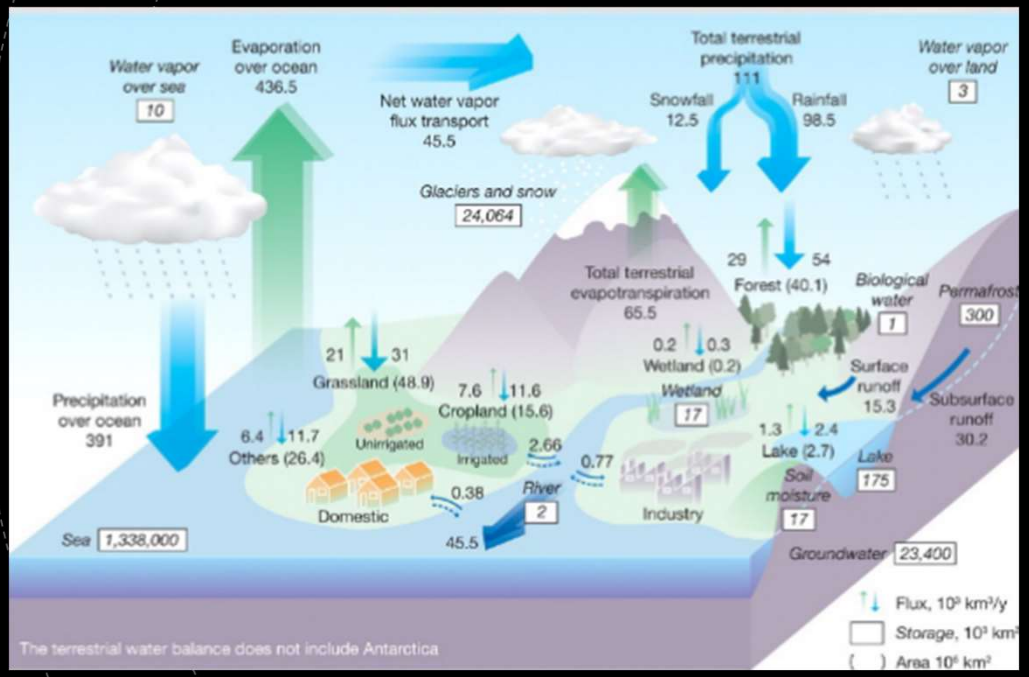
2015- Scientifique au LEGOS
- Géodésie spatiale, cycle de l'eau
- Niveau de la mer, climat



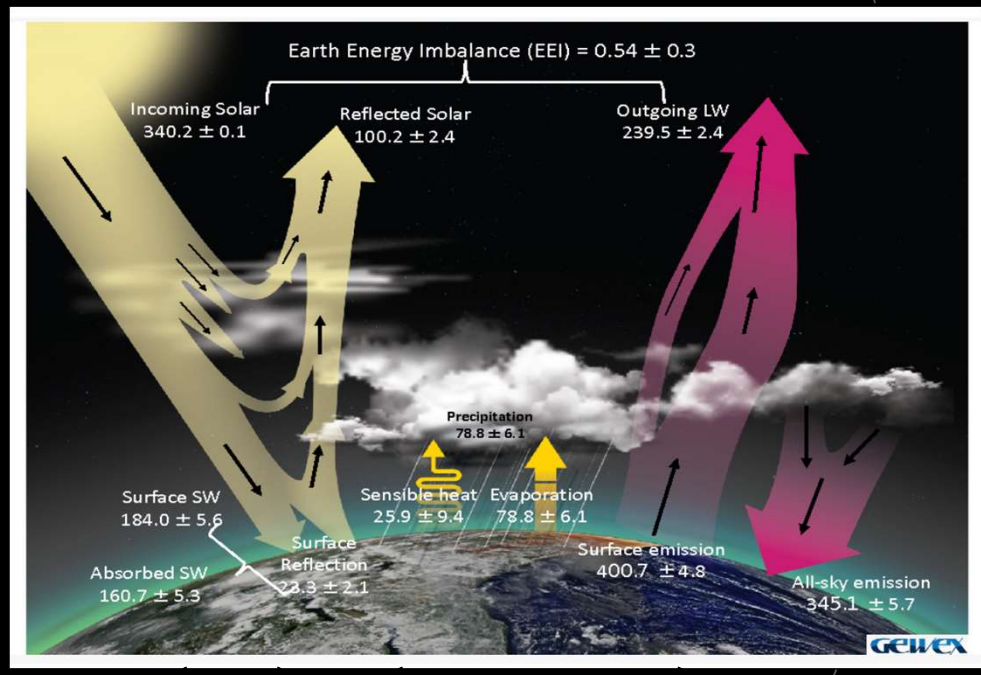
SONDAGE:


Surface air temperature anomaly (K)
SSP1-2.6 5%-95%
SSP1-2.6 17%-83%
SSP1-2.6 median
SSP5-8.5 5%-95%
SSP5-8.5 17%-83%
SSP5-8.5 median
7
6
5
4
3
2
1
2000
2020
2040
2060
2080
2100

LE CYCLE DE L'EAU ET L'ENERGIE

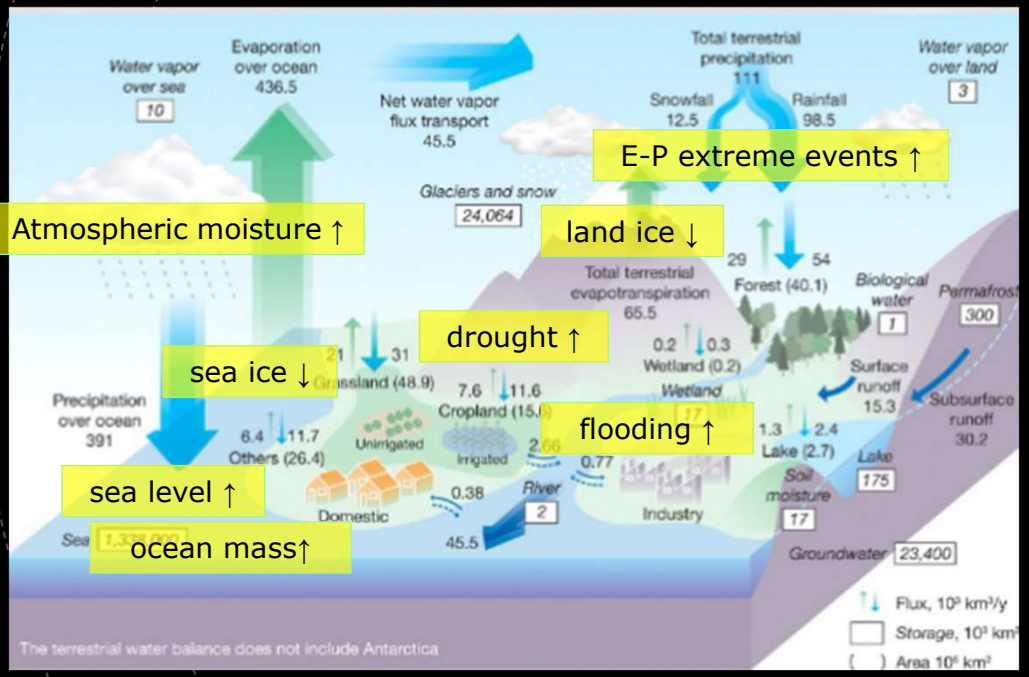


IPCC AR6



Stephens et al. 2023 BAMS

LE CYCLE DE L'EAU ET L'ENERGIE



Atmospheric moisture ↑

E-P extreme events ↑

land ice ↓

drought ↑

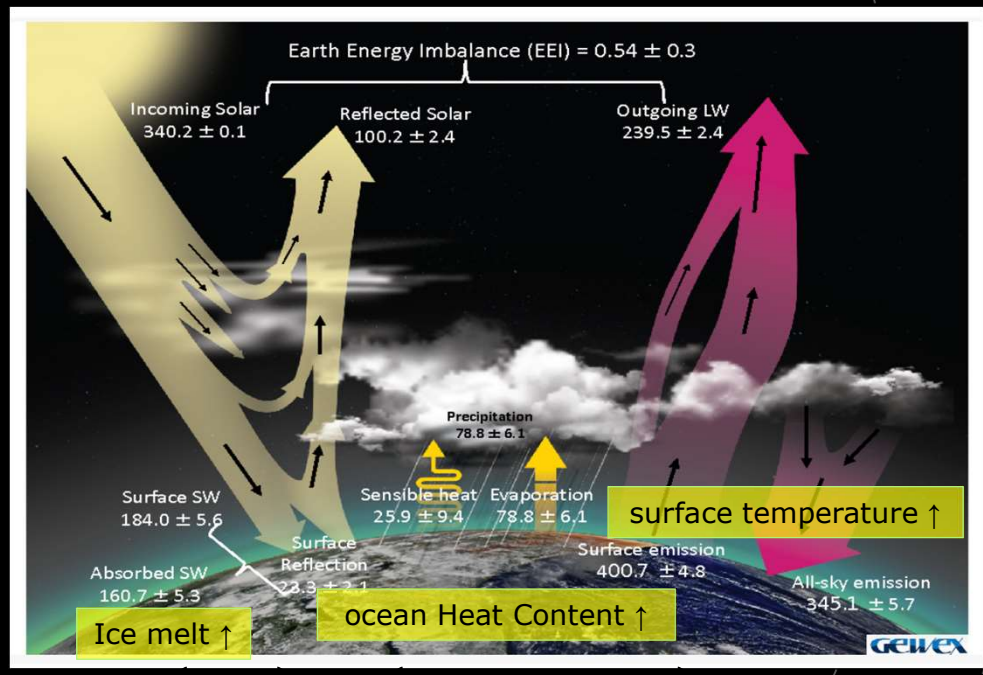
sea ice ↓

flooding ↑

sea level ↑

ocean mass↑

AR6 Figure 8.1b



surface temperature ↑

Ice melt ↑

ocean Heat Content ↑

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HOW TO OBSERVE LOCAL AND QUICK CHANGES IN A GLOBAL AND PERIODIC WAY?

Imagerie

Altimétrie

Gravimetry

Radiation

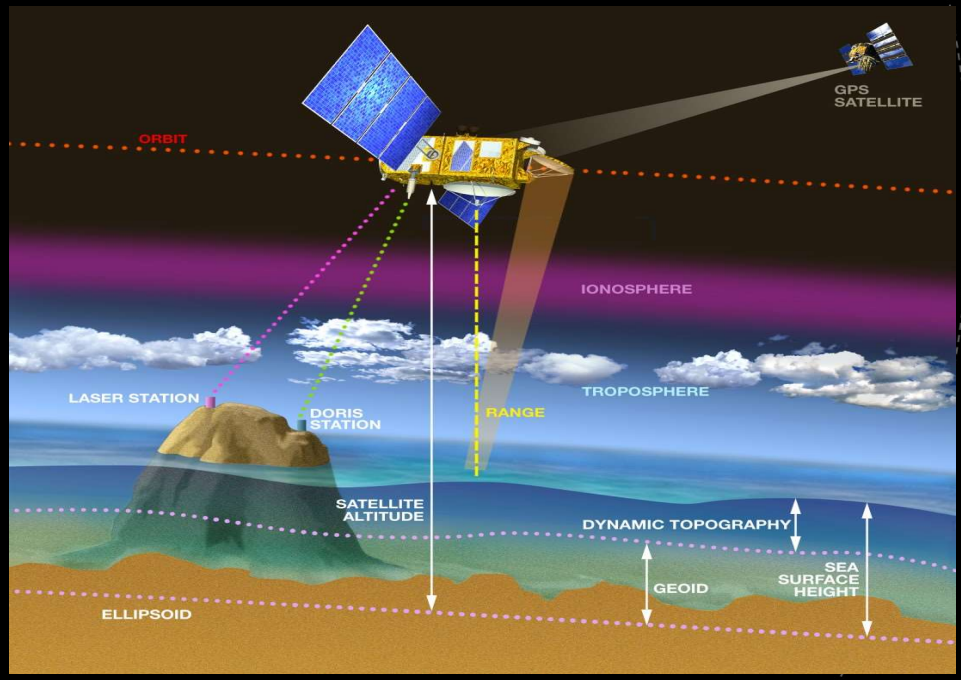
ALTIMETRIE SPATIALE

Time (t): the onboard altimeter measures the round-trip time between the satellite and the surface

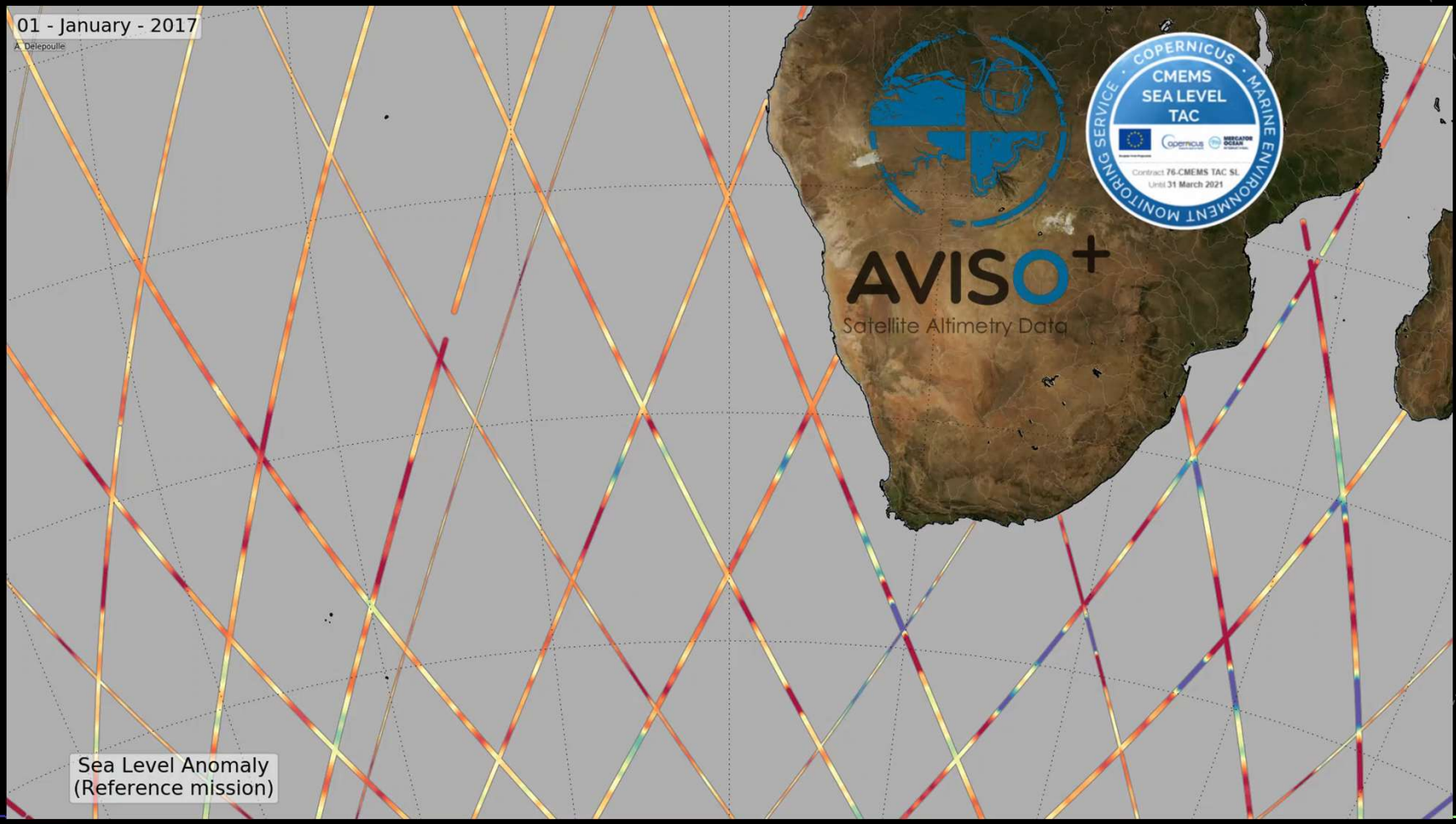
Range (R): the distance between the altimeter and the surface
$R=t/2c$ where c is speed of light

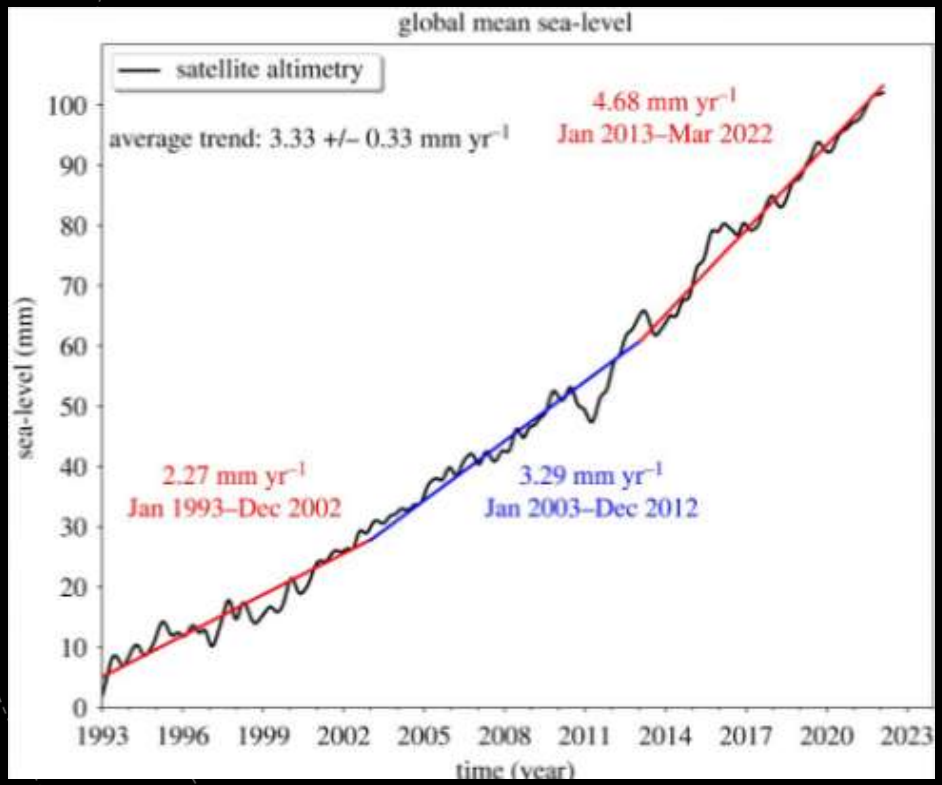
Altitude (h_{sat}): the position and height of the satellite is computed (GPS & DORIS system) relative to an arbitrary reference surface, an ellipsoid

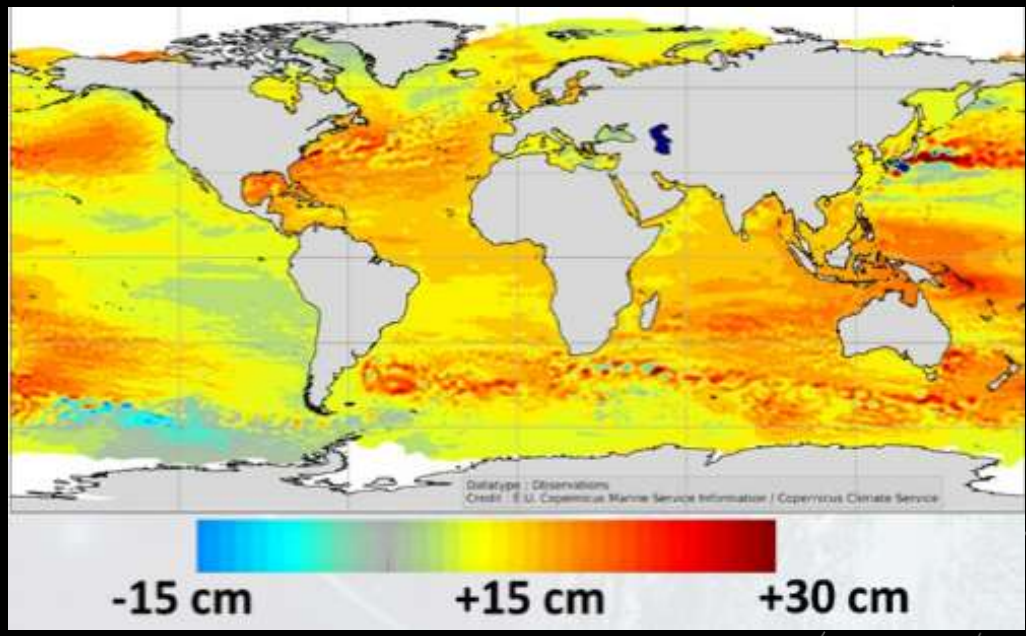
Sea surface height (SSH): height above a reference ellipsoid
$SSH = h_{sat} - R$



ALTIMETRIE SPATIALE







Cazenave et Moreira, 2022

E.U. Copernicus Climate Servicev

ALTIMETRIE SPATIALE

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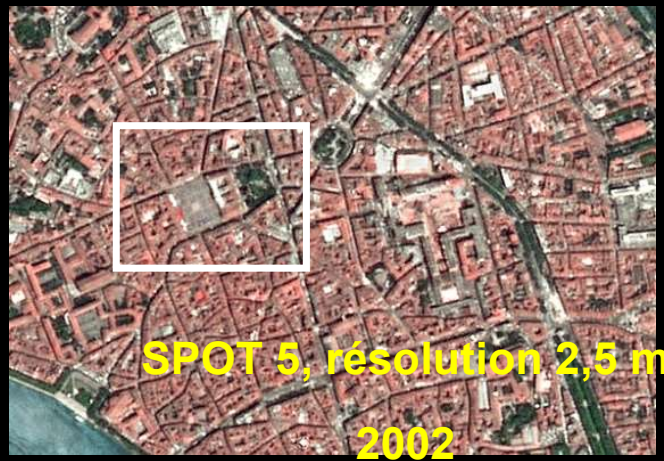
IMAGERIE SPATIALE



Pléaides, résolution 70 cm

2011

IMAGERIE SPATIALE

RECONSTRUIRE LA 3D

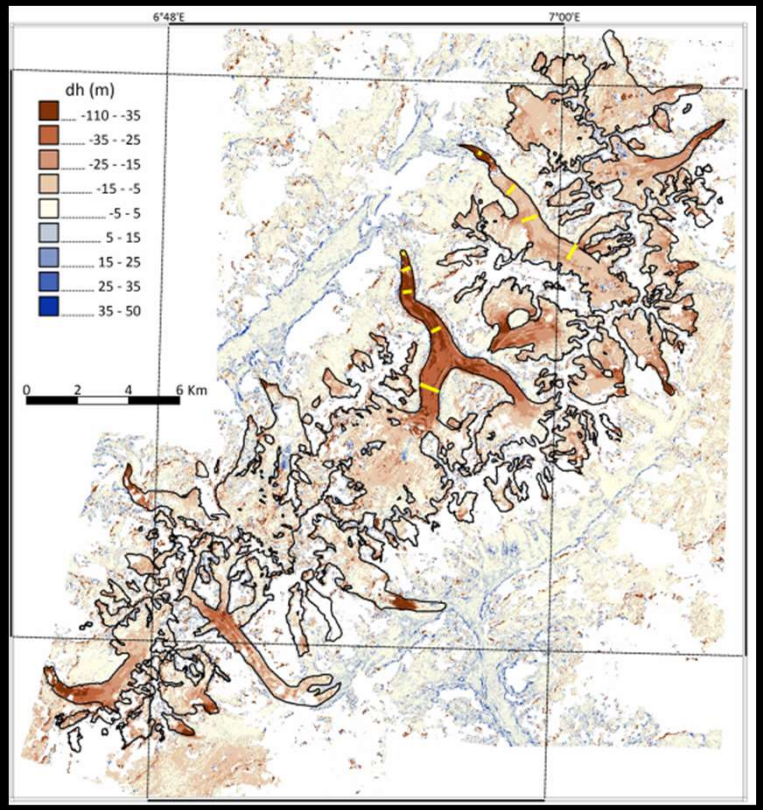
Quartier Sauzelongue, Toulouse

IMAGERIE SPATIALE

Mer de Glace

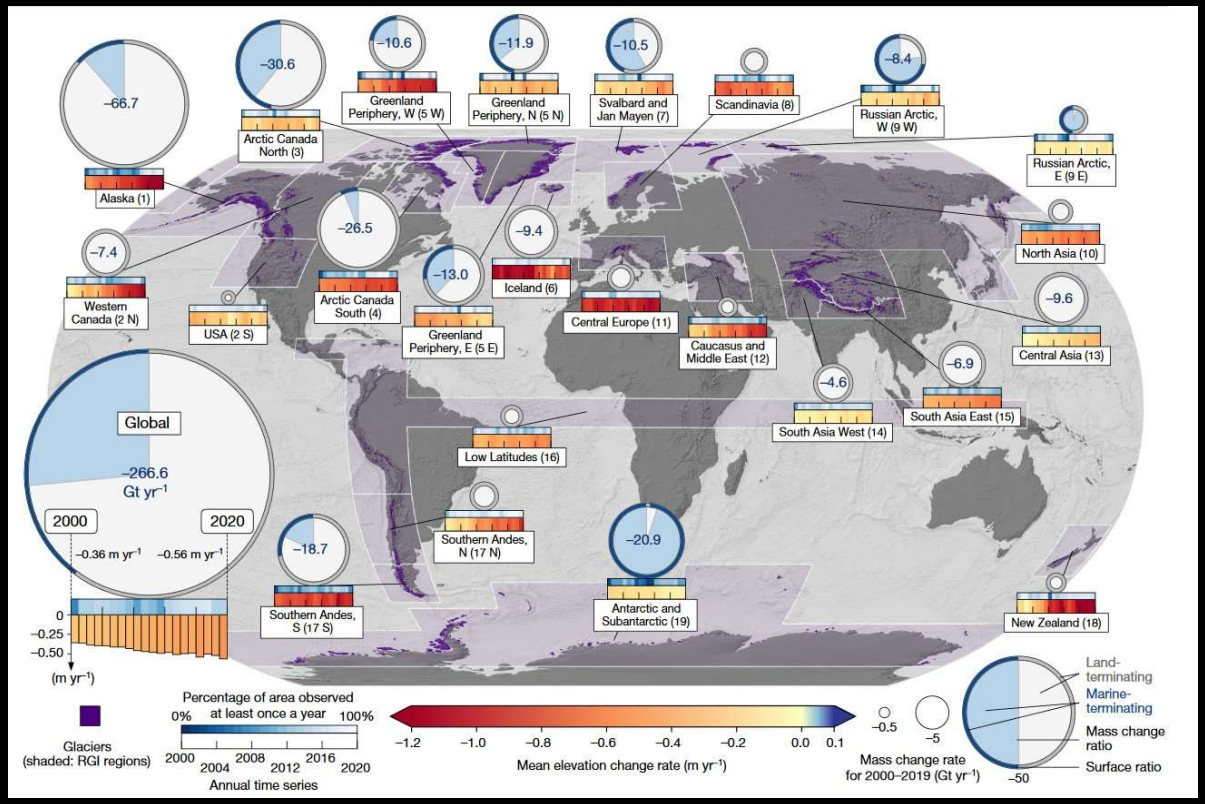
IMAGERIE SPATIALE

Elevation changes of glaciers in Mont-Blanc area between 2003 and 2012



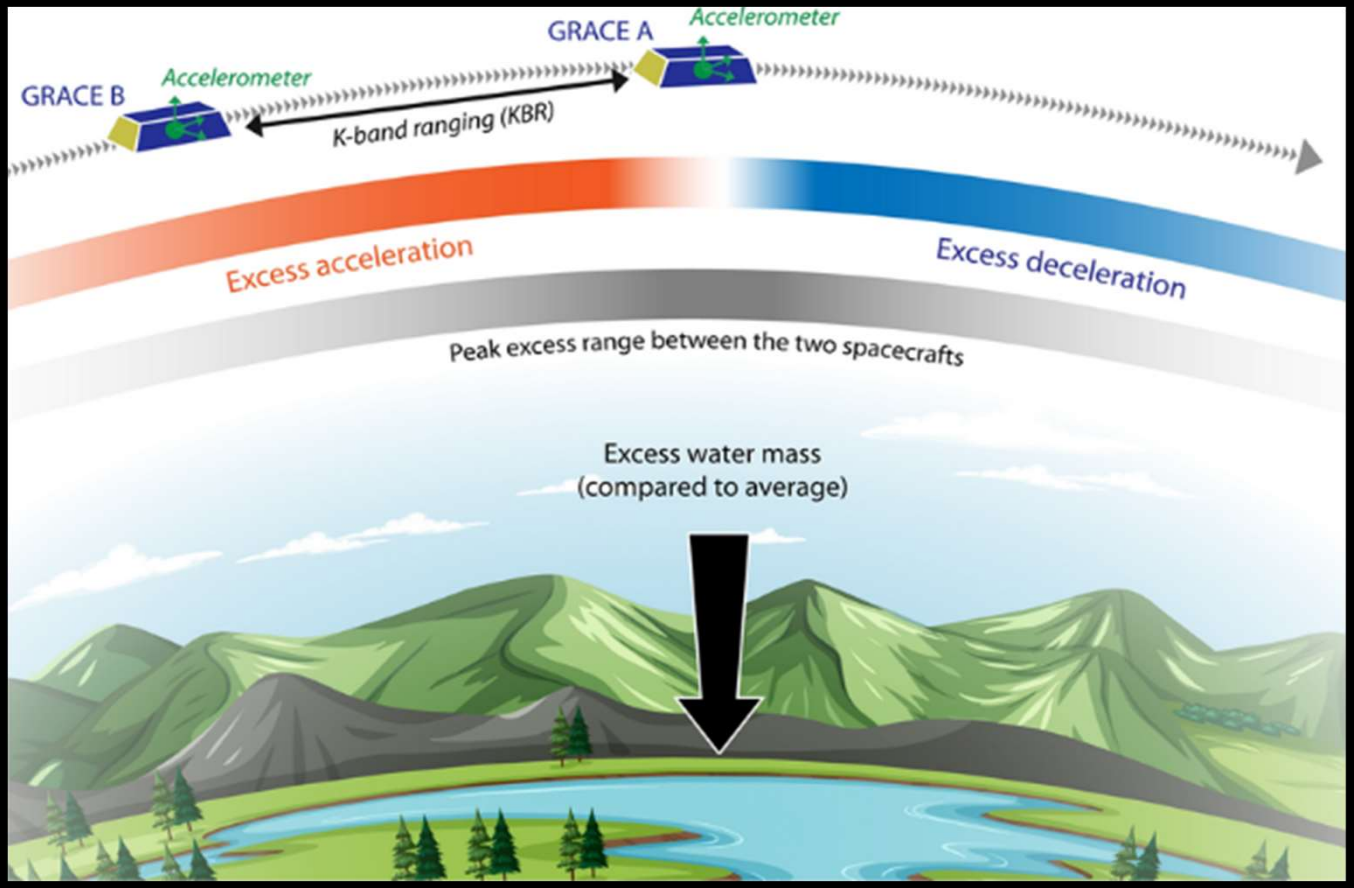
Berthier et al., TC, 2014

Glacier mass changes over the whole Earth from 2000 to 2020



Hugonnet et al.(2021)

GRAVIMÉTRIE SPATIALE



HUMPHREY et al. (2023)

GRAVIMÉTRIE SPATIALE

Level 1B data
Intersatellite range, GNSS, accelerometers, star tracker

→ Precise orbit determination → inversion → **Level 2 data** Gravity field → Post-processing → **Level 2b data** Gravity field

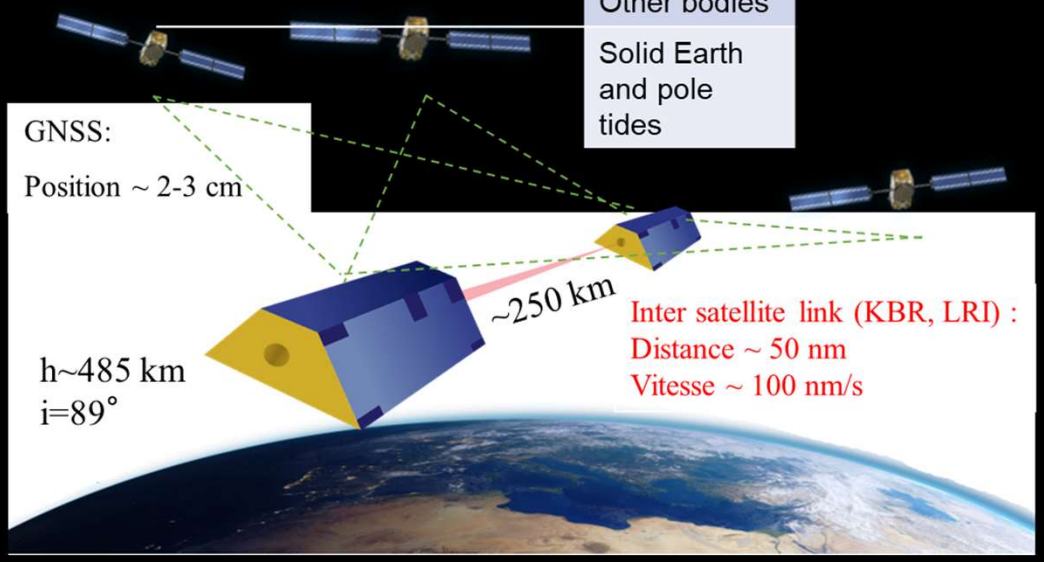
Dealiasing models	Geometrical models	Dynamical models
Atmospheric	SLR stations	Gravity
Oceanic	GPS	Ocean Tide
		Other bodies
		Solid Earth and pole tides

L2 corrections
Geocenter motion
Earth oblateness
Filtering

Post-processing

Solid-Earth corrections	Spatial limitations
GIA	Leakage and Gibbs effects
Earthquakes	

Level 3 data
water mass anomalies for hydrology, cryosphere, oceanic studies



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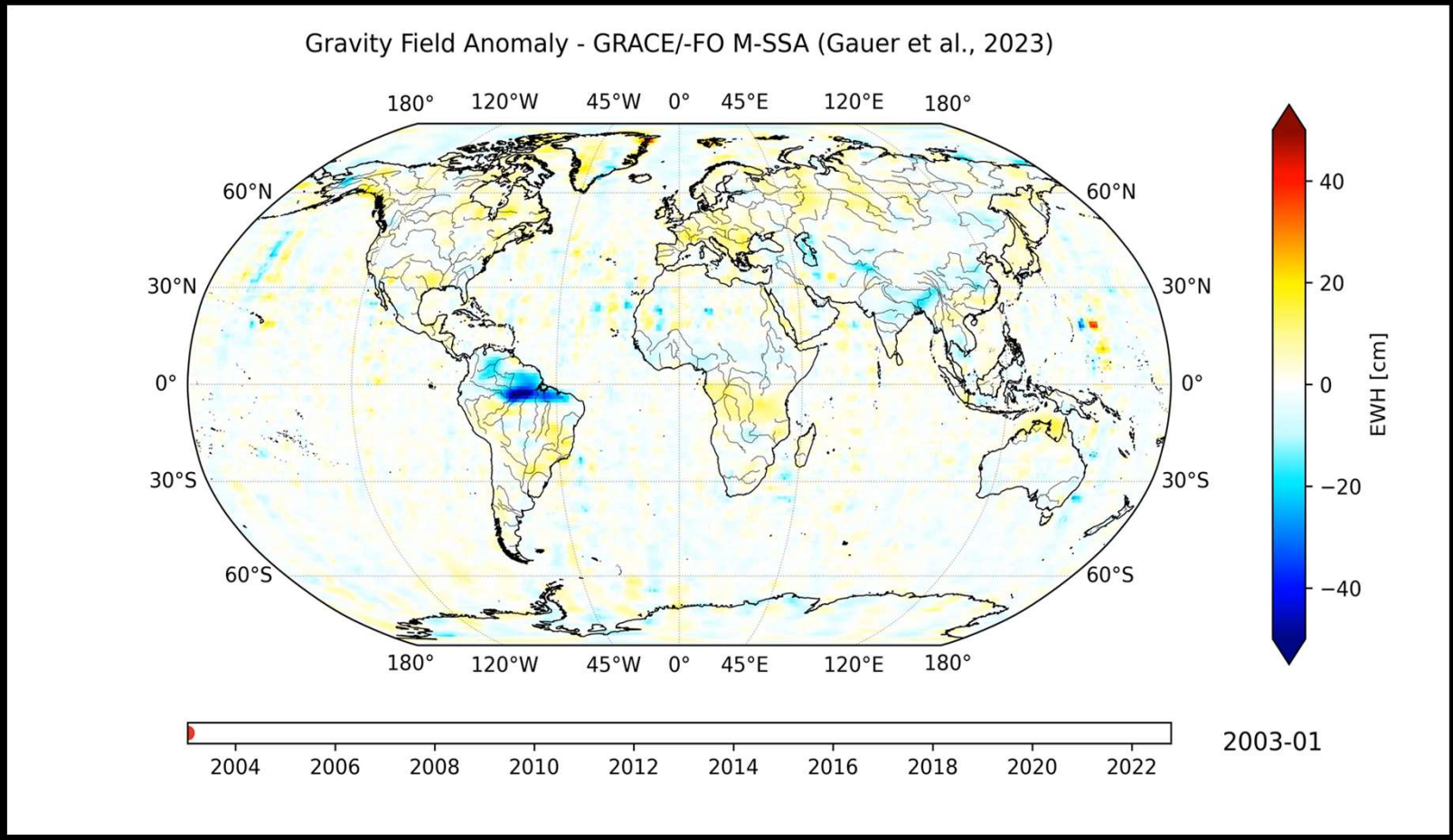
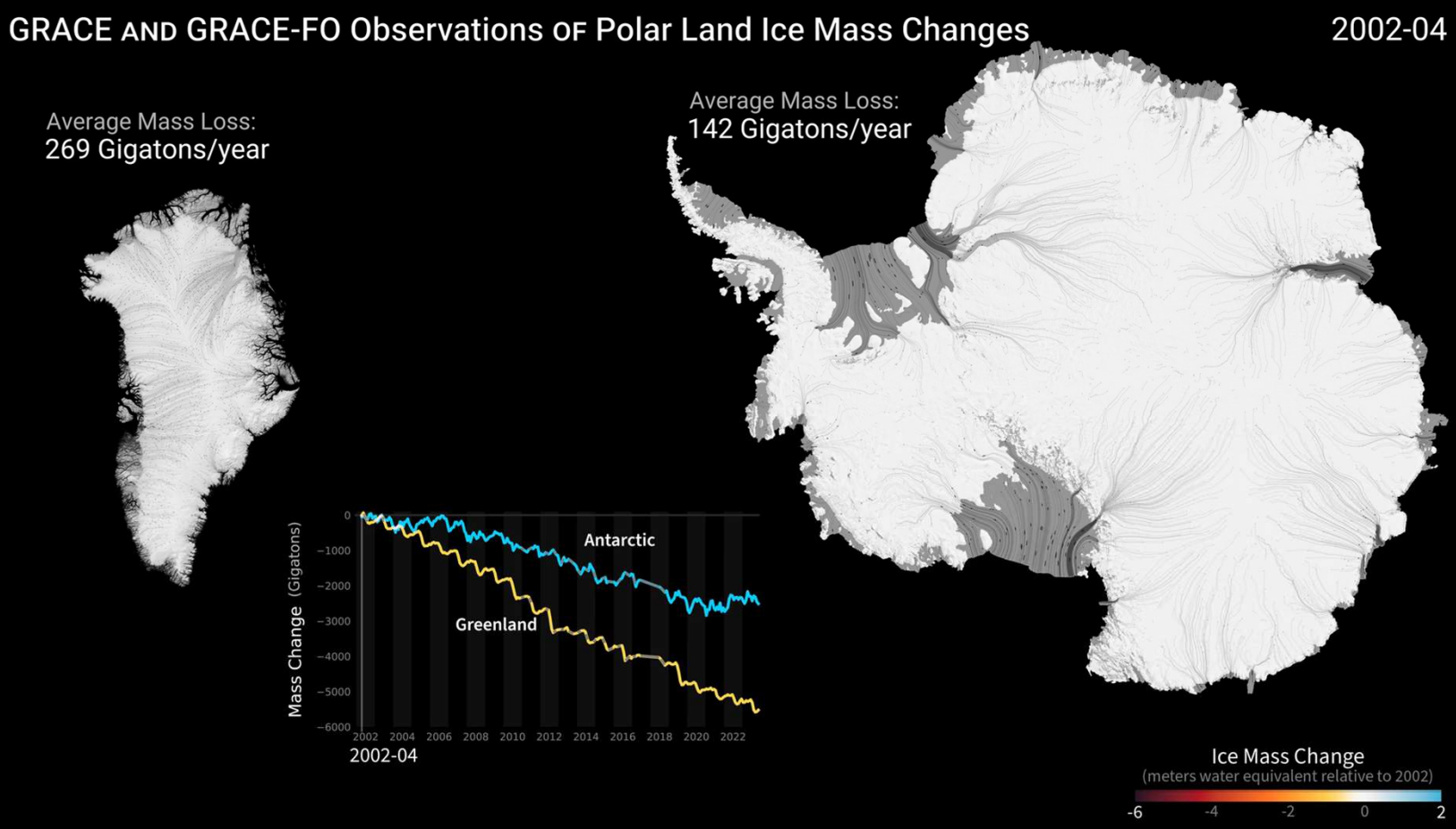
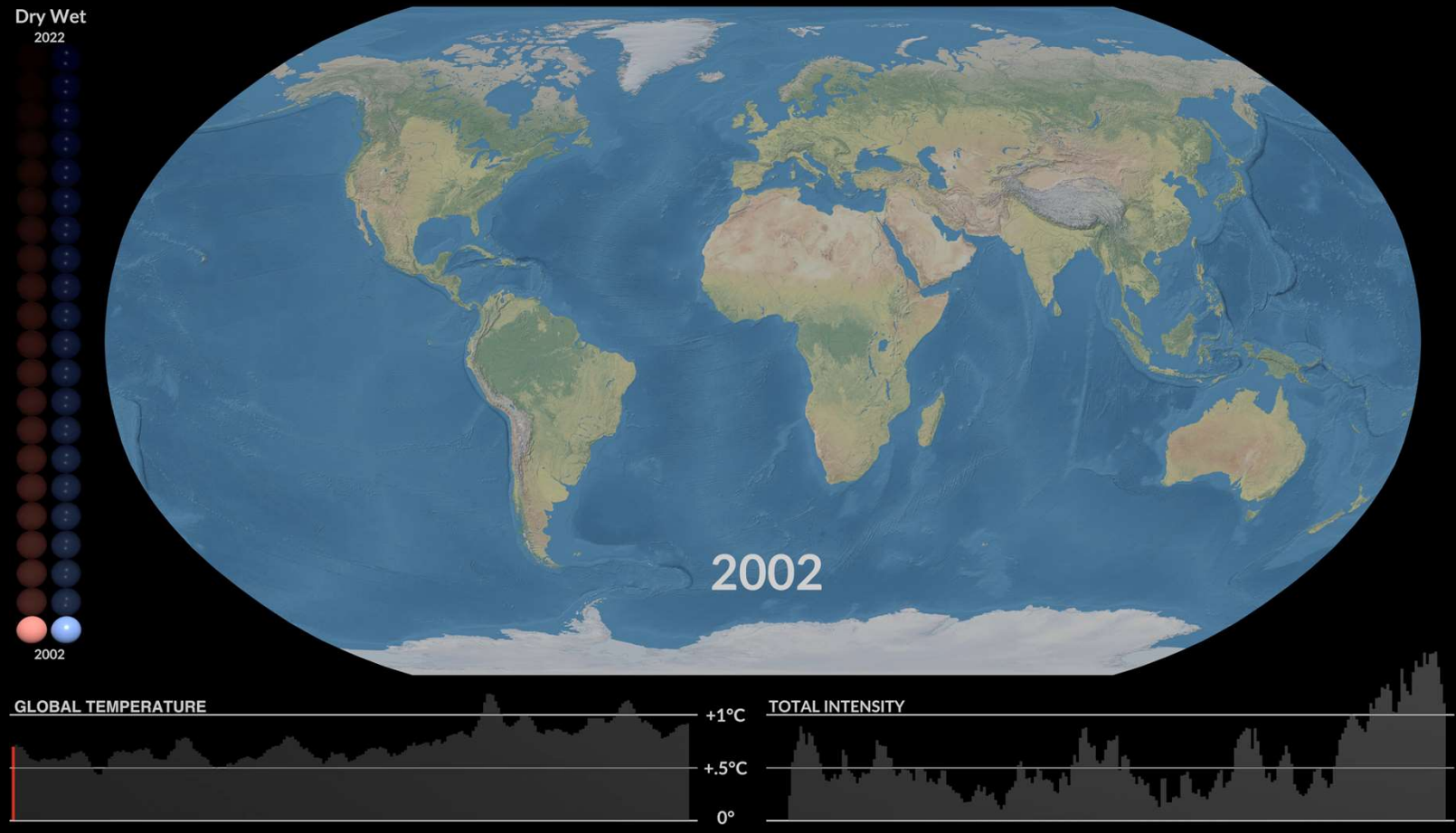


LM. Gauer (IPGP)

GRAVIMÉTRIE SPATIALE



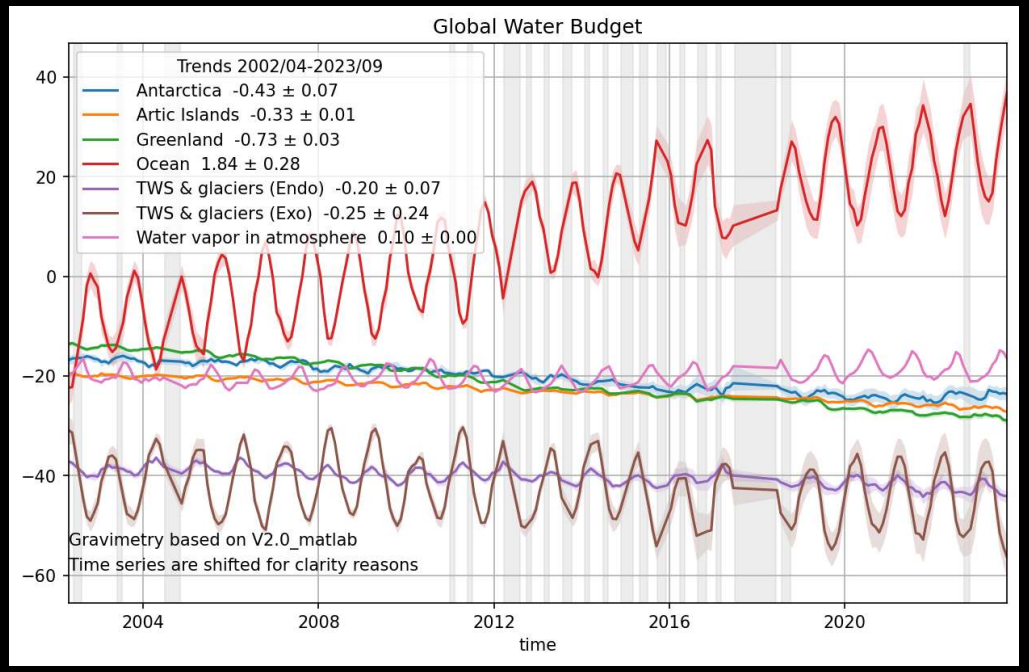
F. Landerer (NASA/ JPL Caltech)

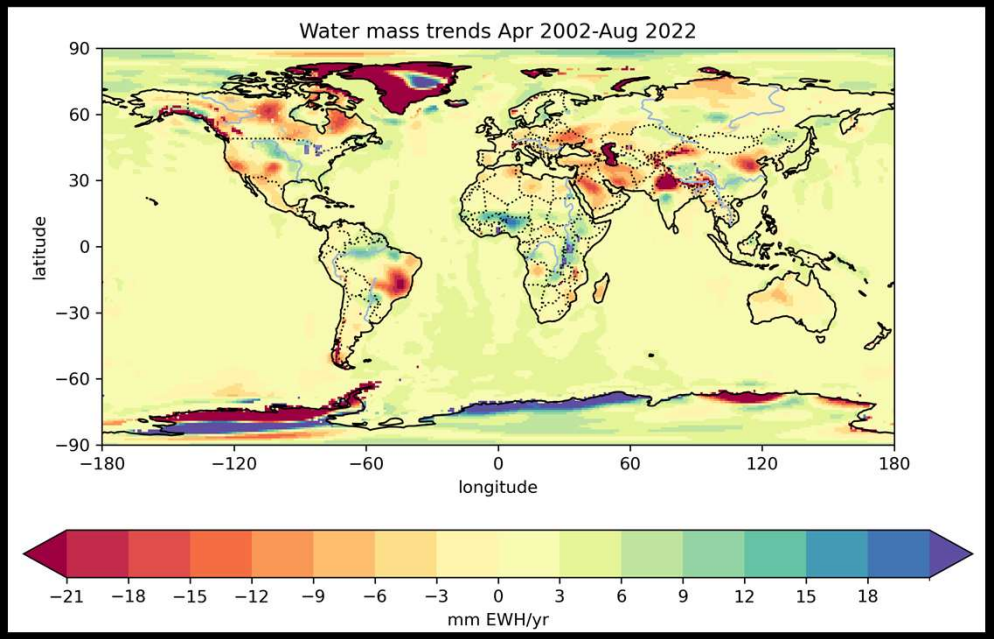


M. Rodell (NASA/ JPL Caltech)

GRAVIMÉTRIE SPATIALE

Bilan Global d'eau





$$\Delta M_{Ocean} + \Delta M_{Atm} + \Delta M_{Cryosphere} + \Delta M_{LWS} = 0$$

where: $\Delta M_{Cryosphere} = \Delta M_{Greenland} + \Delta M_{Antarctica} + \Delta M_{Glaciers}$

$\Delta M_{LWS} = \Delta M_{LWS\ ENDO} + \Delta M_{LWS\ EXO}$

Update from Blazquez et al 2018

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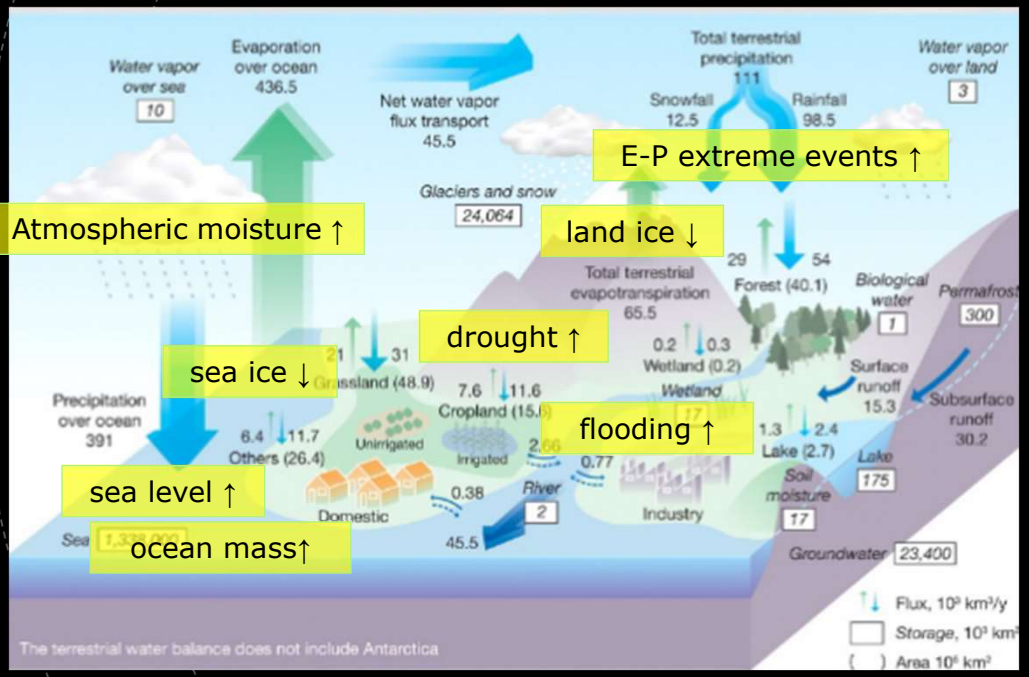
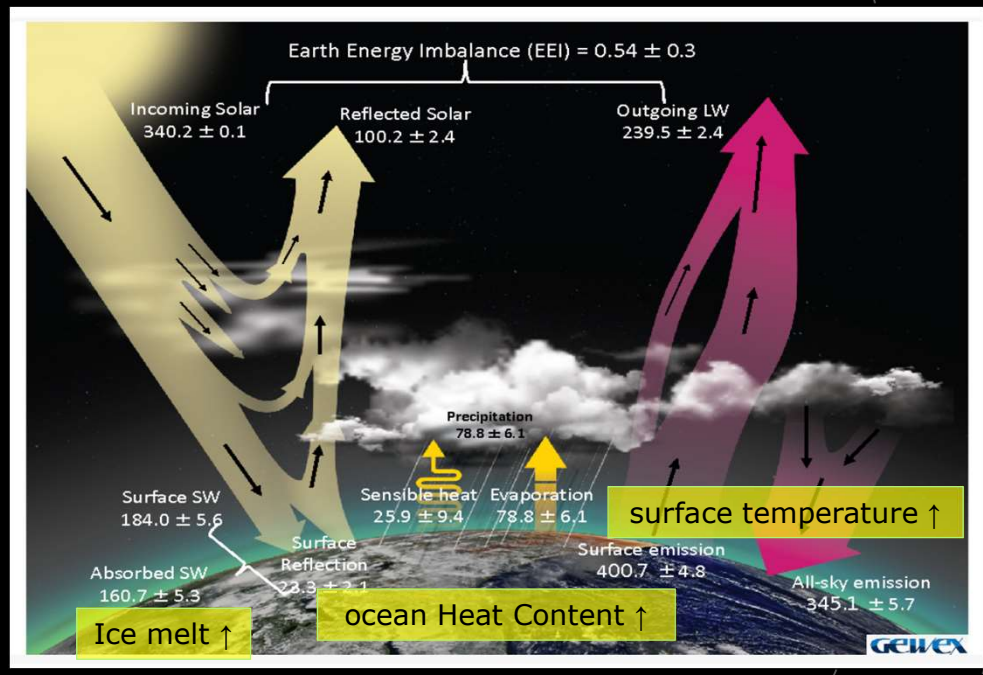
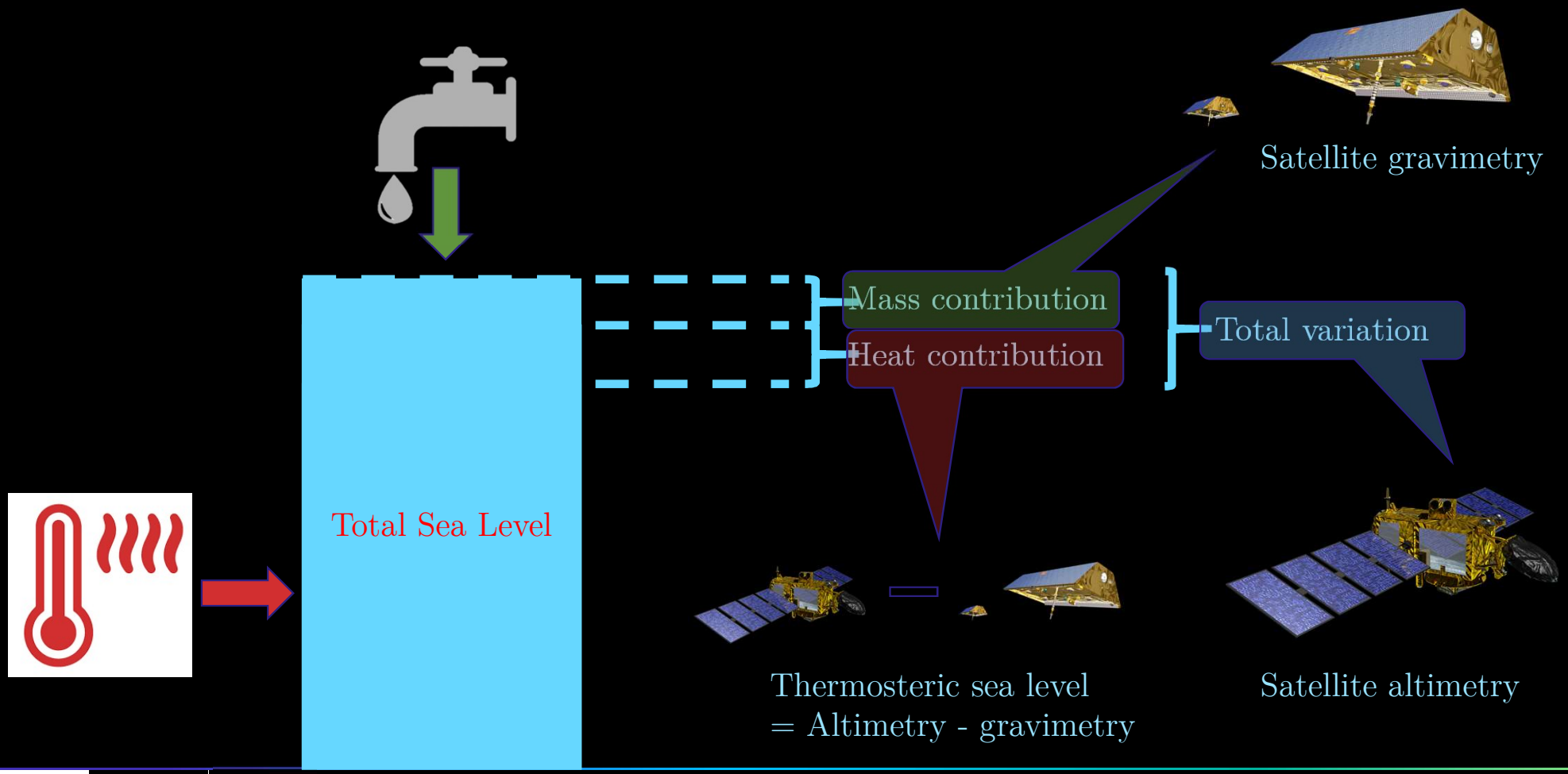


AR6 Figure 8.1b

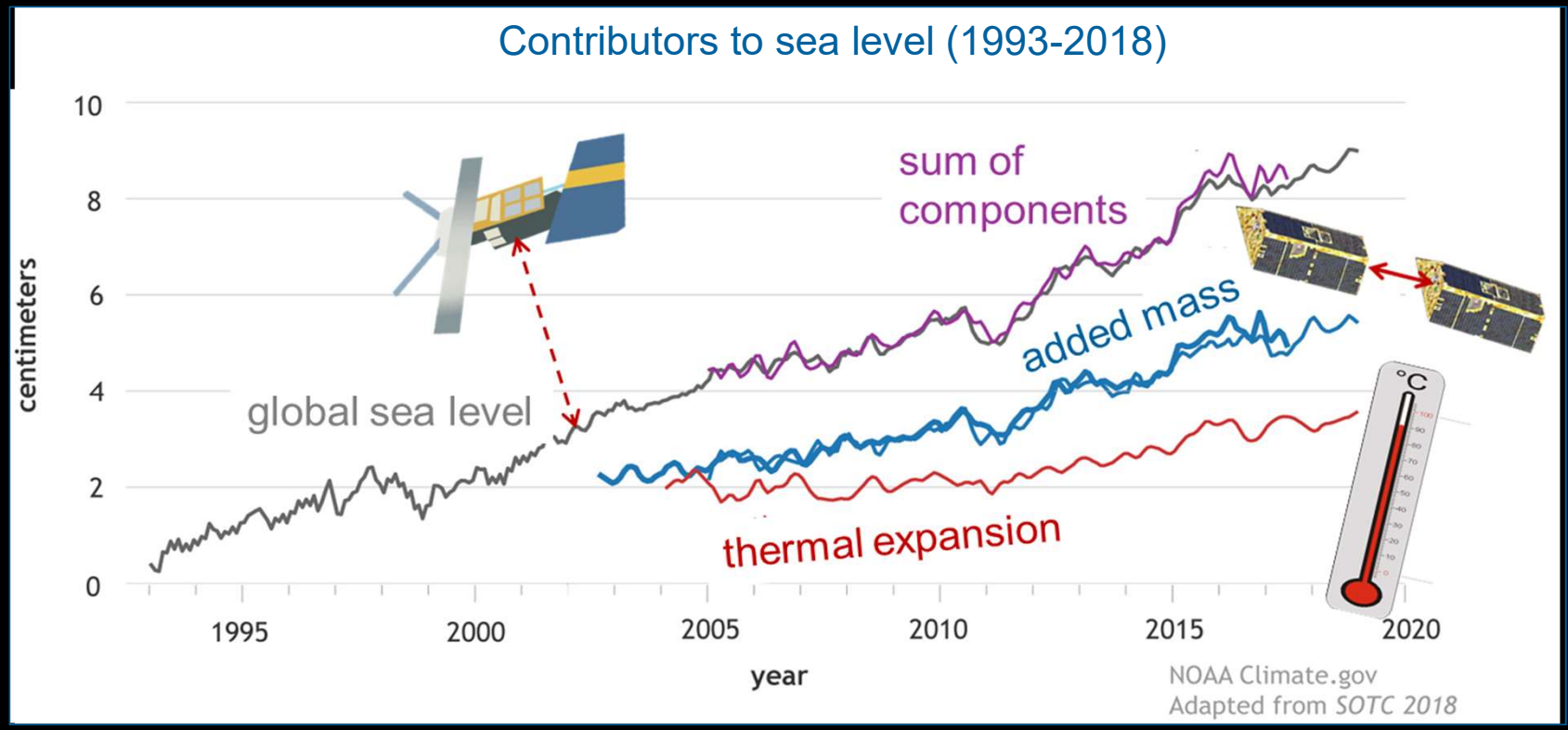


Stephens et al. 2023 BAMS

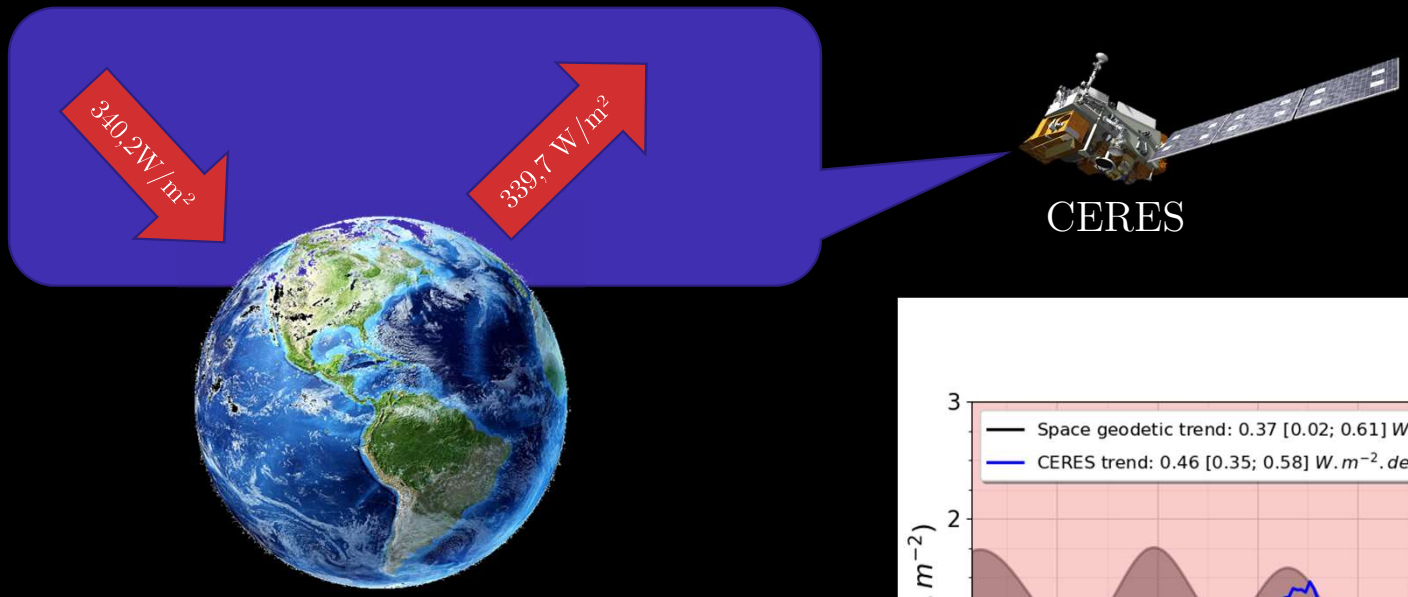
BILAN NIVEAU DE LA MER



BILAN NIVEAU DE LA MER

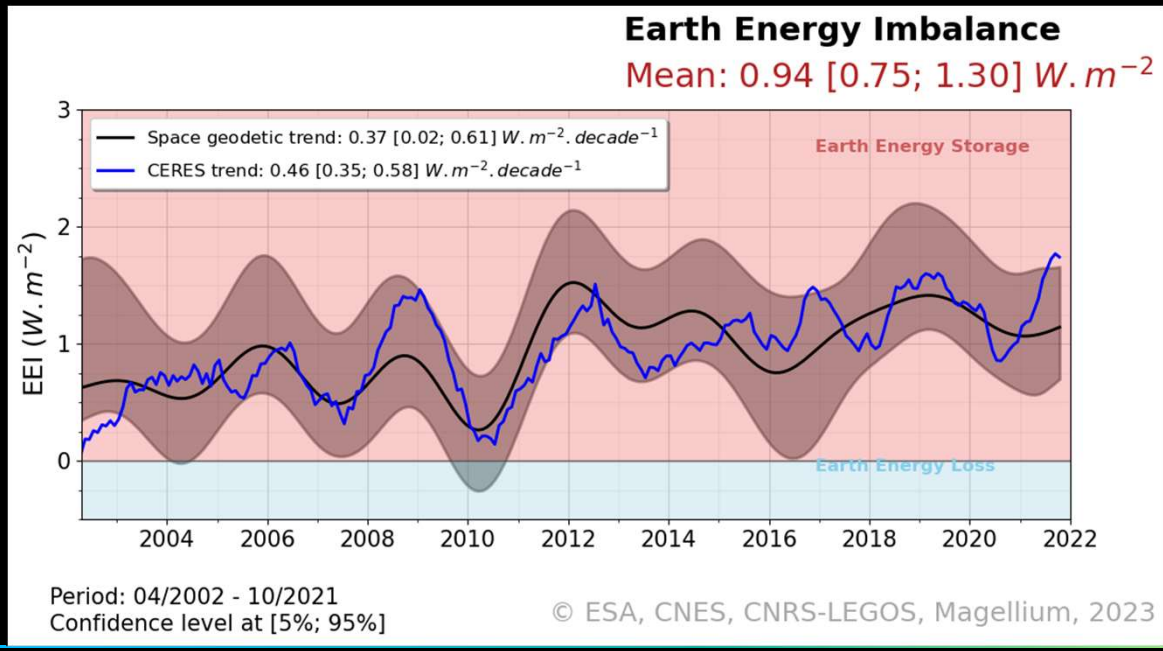


Measuring the Ocean heat uptake



CERES

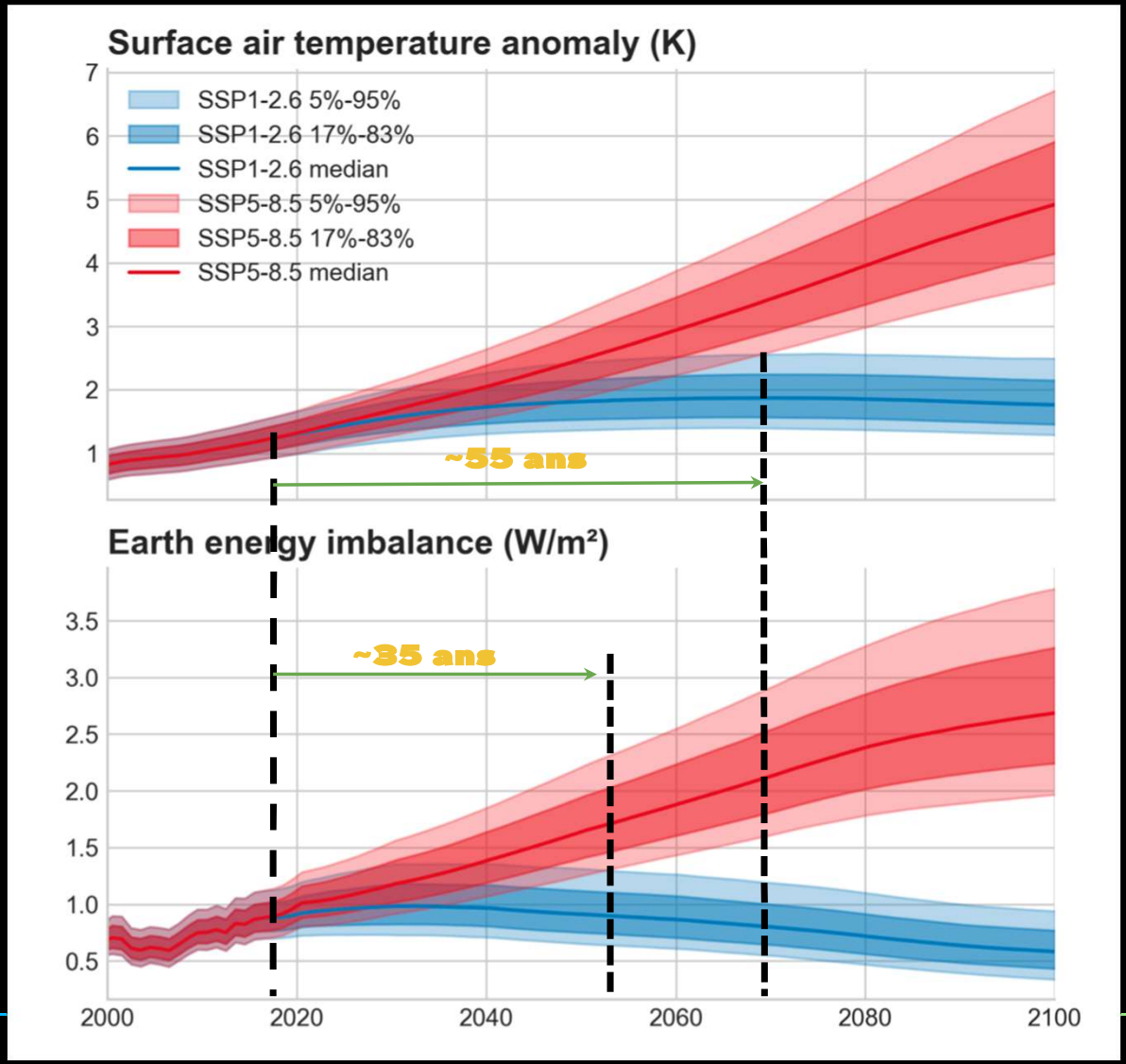
Absorbed = **EEI** = 0,54 +-0,3 W/m²
90% goes into the ocean



Ocean heat uptake :

$$OHU = \frac{dOHC}{dt} = 0{,}90 * EEI$$

MEASURING EEI VS AIR TEMPERATURE ANOMALY



Meyssignac et al. (2023)

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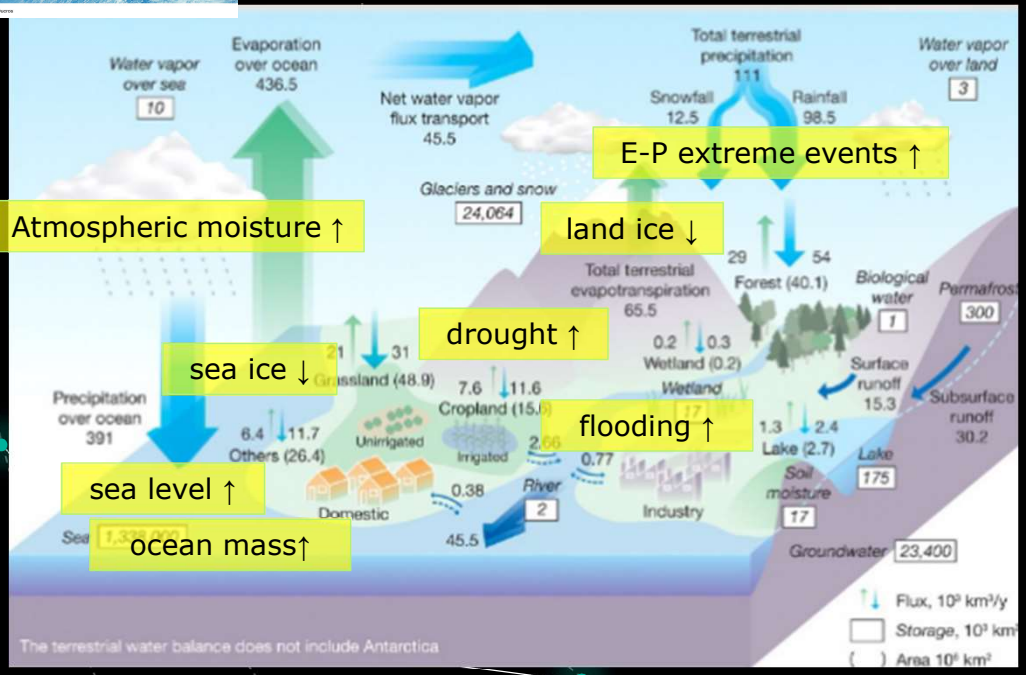


Atmospheric moisture ↑

E-P extreme events ↑

land ice ↓

drought ↑

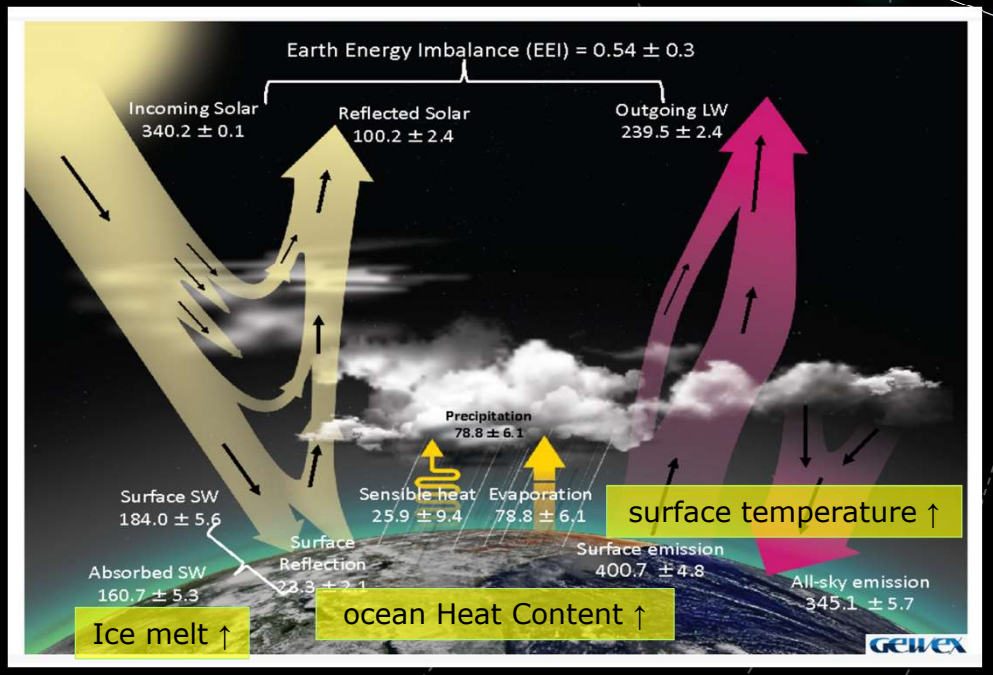
sea ice ↓

flooding ↑

sea level ↑

ocean mass↑

AR6 Figure 8.1b



surface temperature ↑

Ice melt ↑

ocean Heat Content ↑

Stephens et al. 2023 BAMS