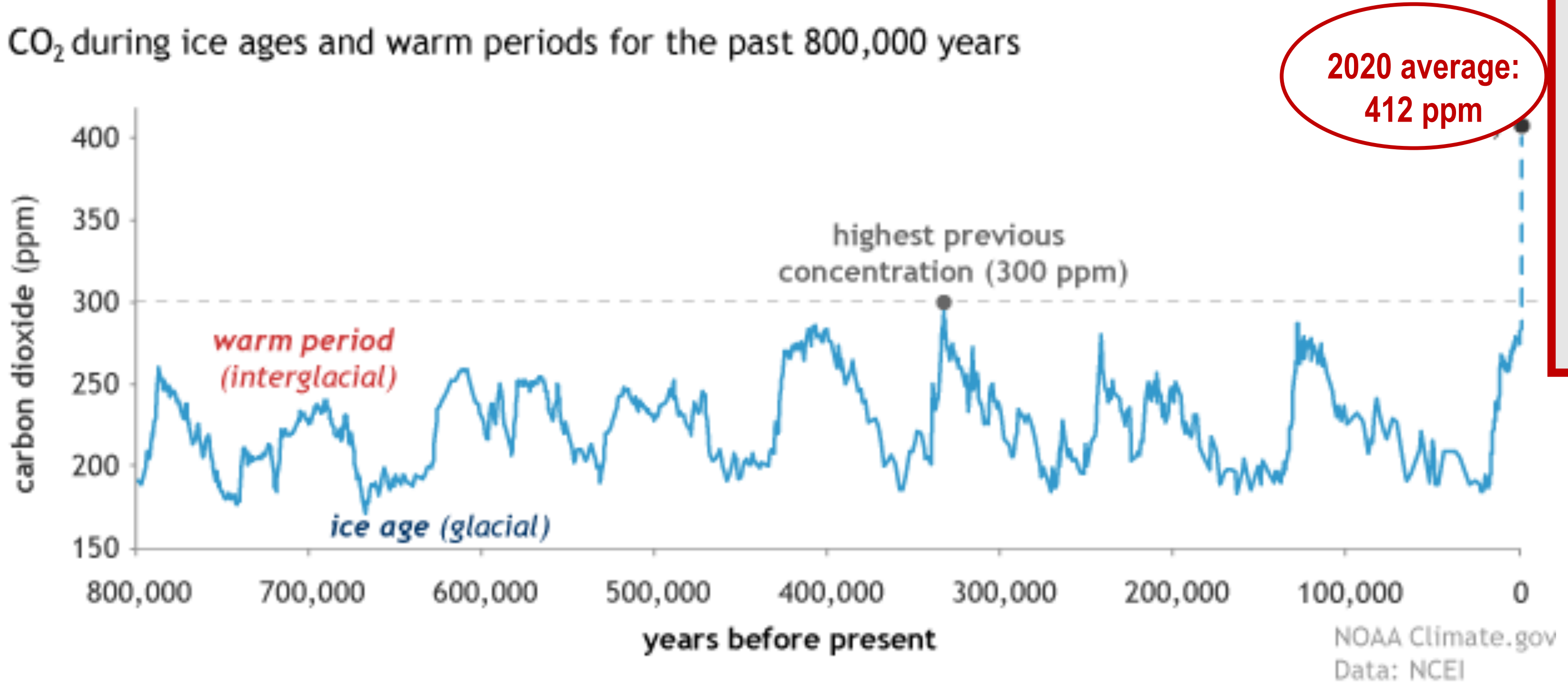
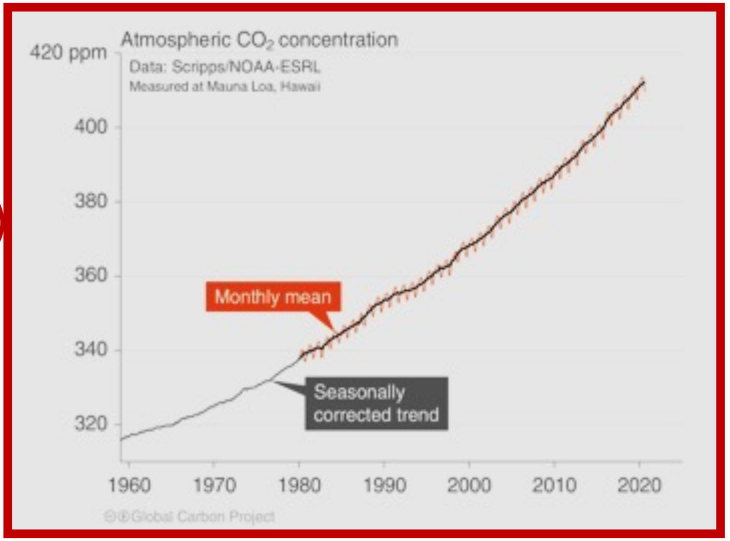
Brief overview of the contribution of satellites to the understanding of environment and its current changes

STÉPHANE CALMANT

IRD DEPUTY FOR FRENCH GUYANA

Atmospheric carbon dioxide concentration for the past 800 000 years

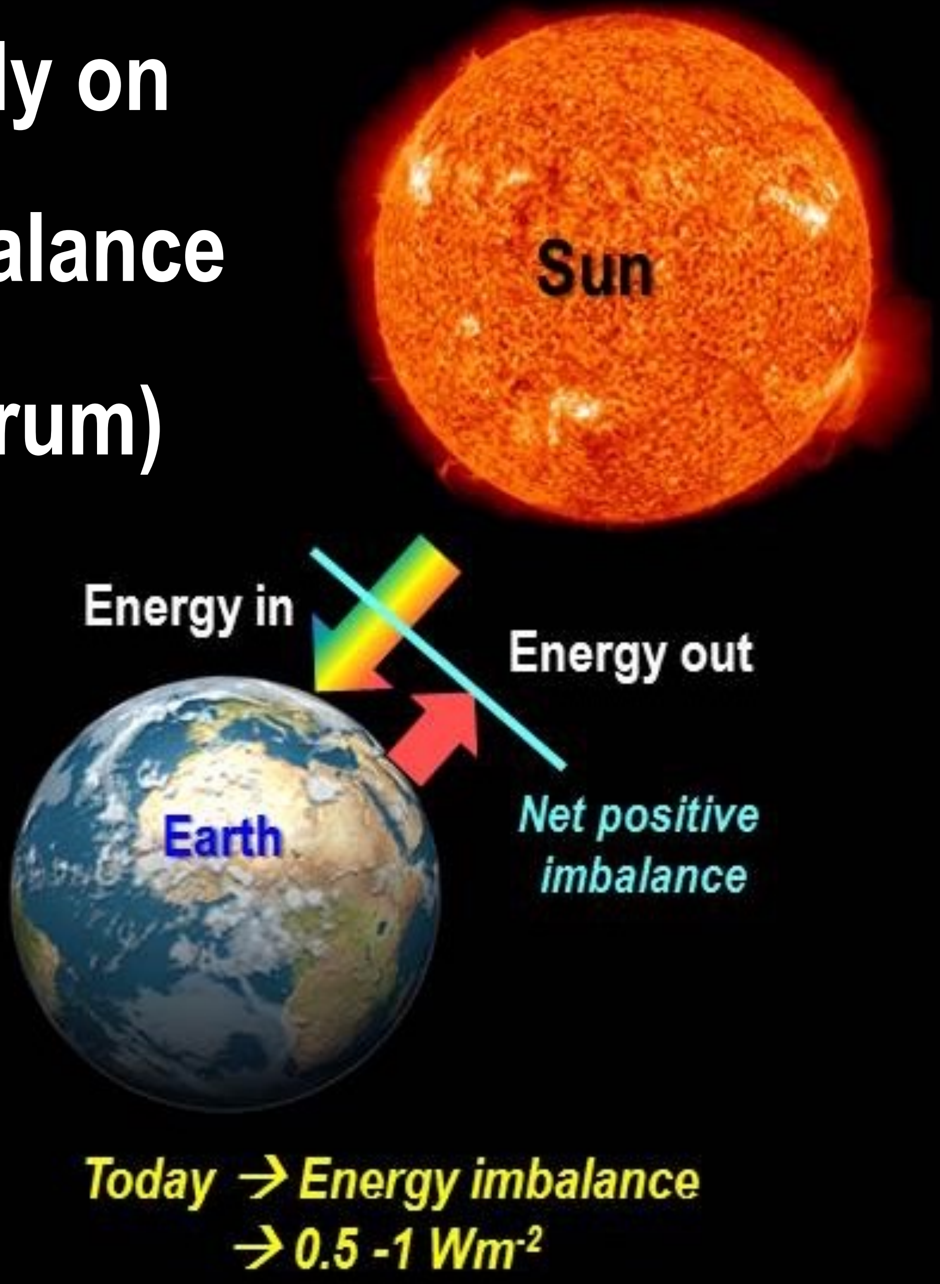




In 2020, atmospheric CO2 exceeded 410 ppm

Source: NOAA

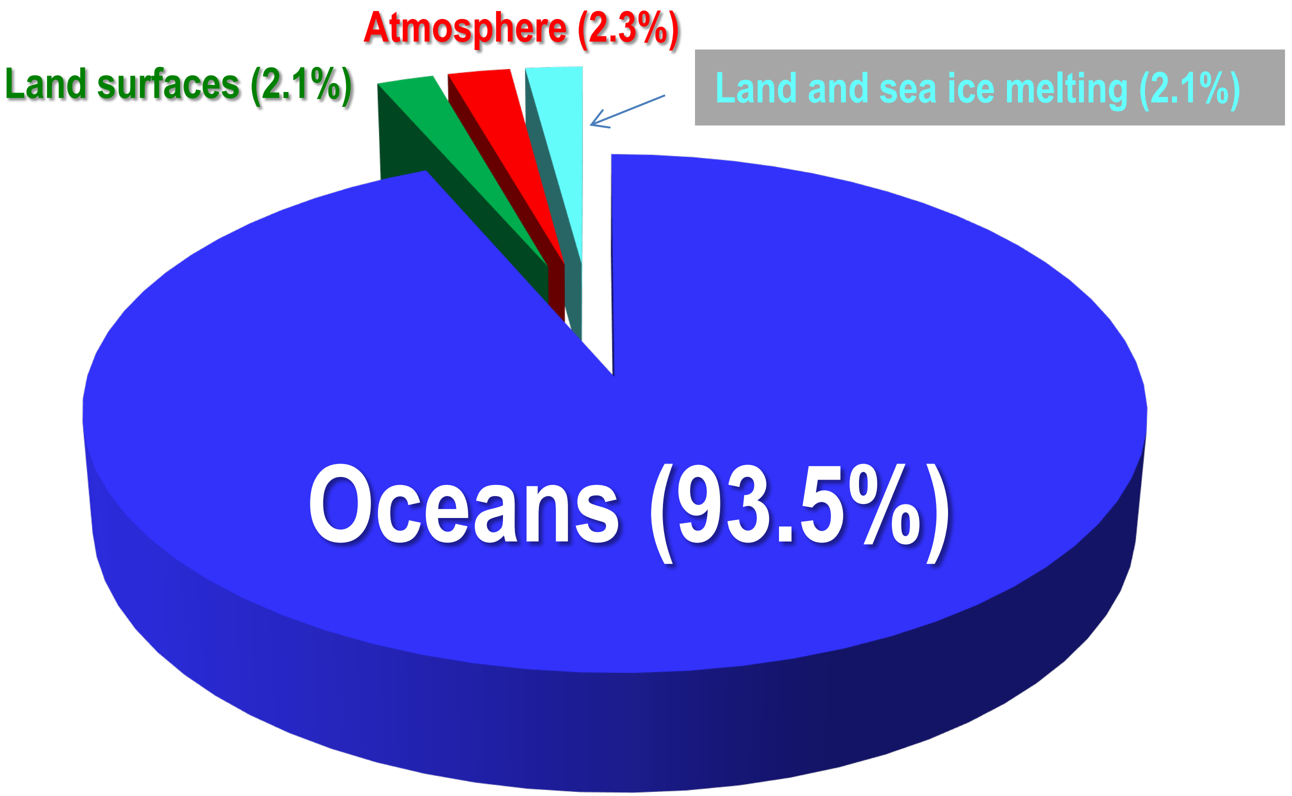
Climate changes rely on Earth's Energy Imbalance (wrt to past equilibirum)



IPCC, 2013

Heat excess in the system:

The ocean stores 93% of the additional heat trapped in the climate system by greenhouse gases emitted by human activities



IPCC AR5; Von Schuckmann et al., 2016

COP21 • CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

Art 7 (7c)

*Paris Agreement Article 7 (7c): Strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems.

Systematic climate observations are fundamental to implementing the Paris agreement and monitoring its progress

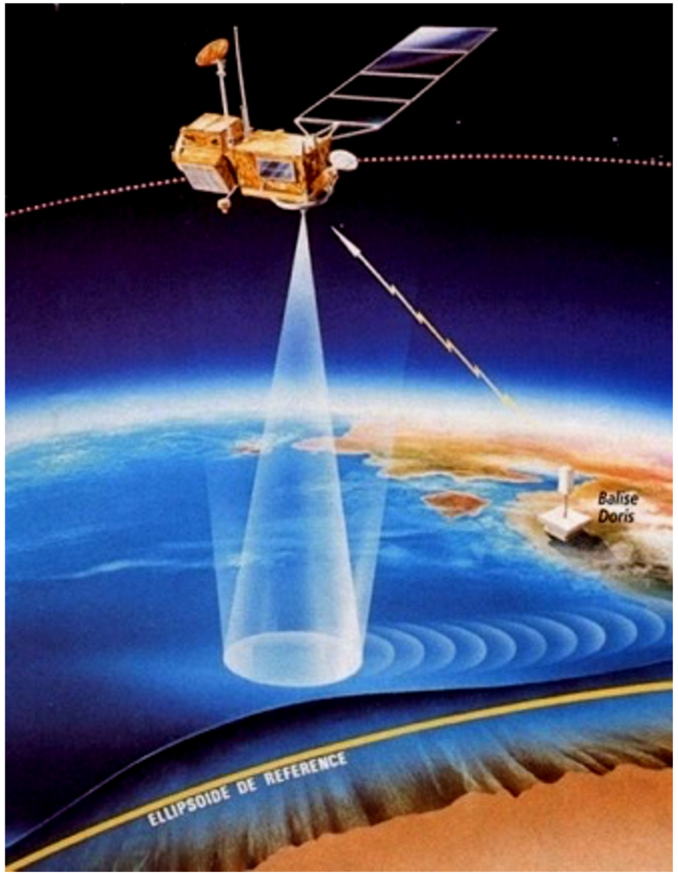
Systematic measurements : The key part played by the Satellites

Space-based observations provide a global perspective which contributes to improved understanding of the Earth system

→Dynamical interactions between atmosphere, ocean, land, ice and solid-Earth

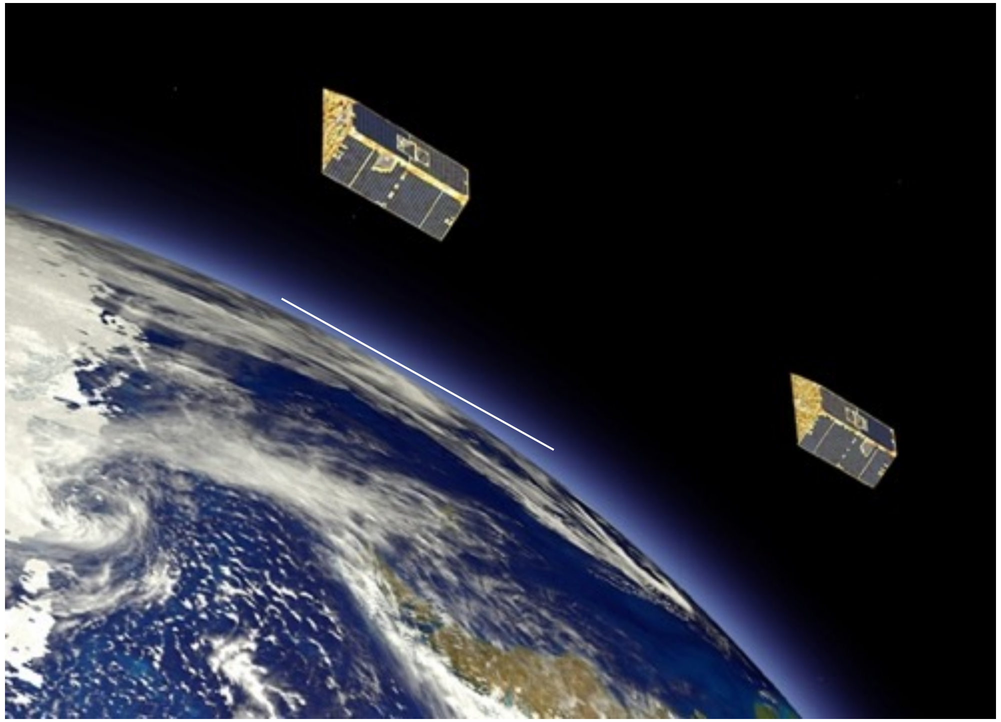
……. and human Society

Focus on two space techniques (other than sat imagery)

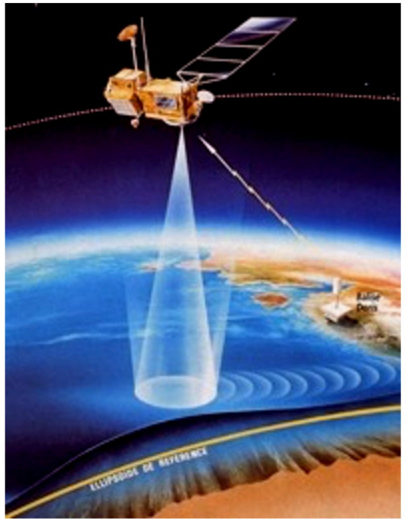


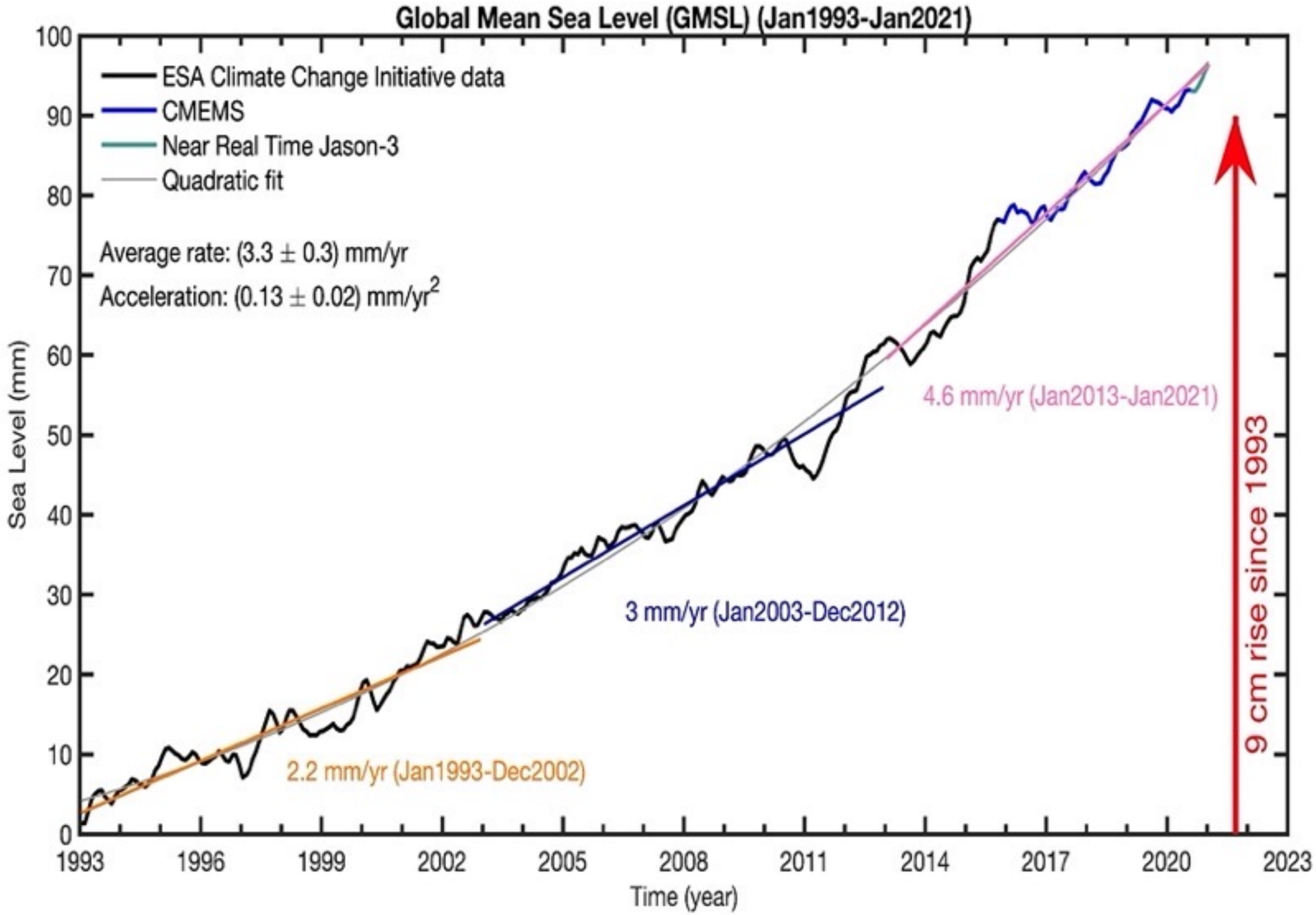
Satellite Altimetry missions (1992-)

Space Gravimetry mission (GRACE 2002-)

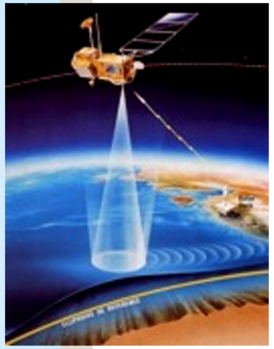


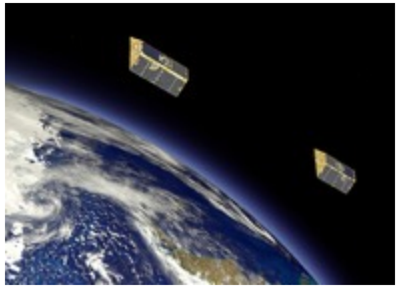
MEAN SEA LEVEL IS RISING FASTER AND FASTER



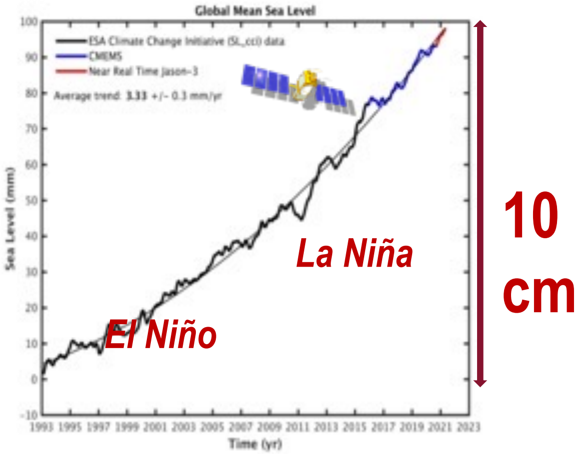


In terms of global mean→ 2 main causes of sea level rise…

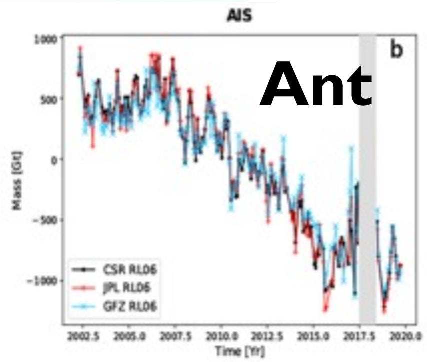


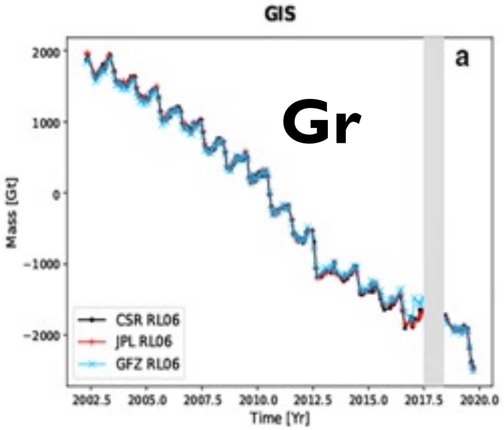


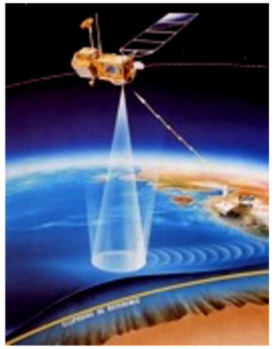
(1) Thermal expansion of sea water due to ocean warming (40% SLR)



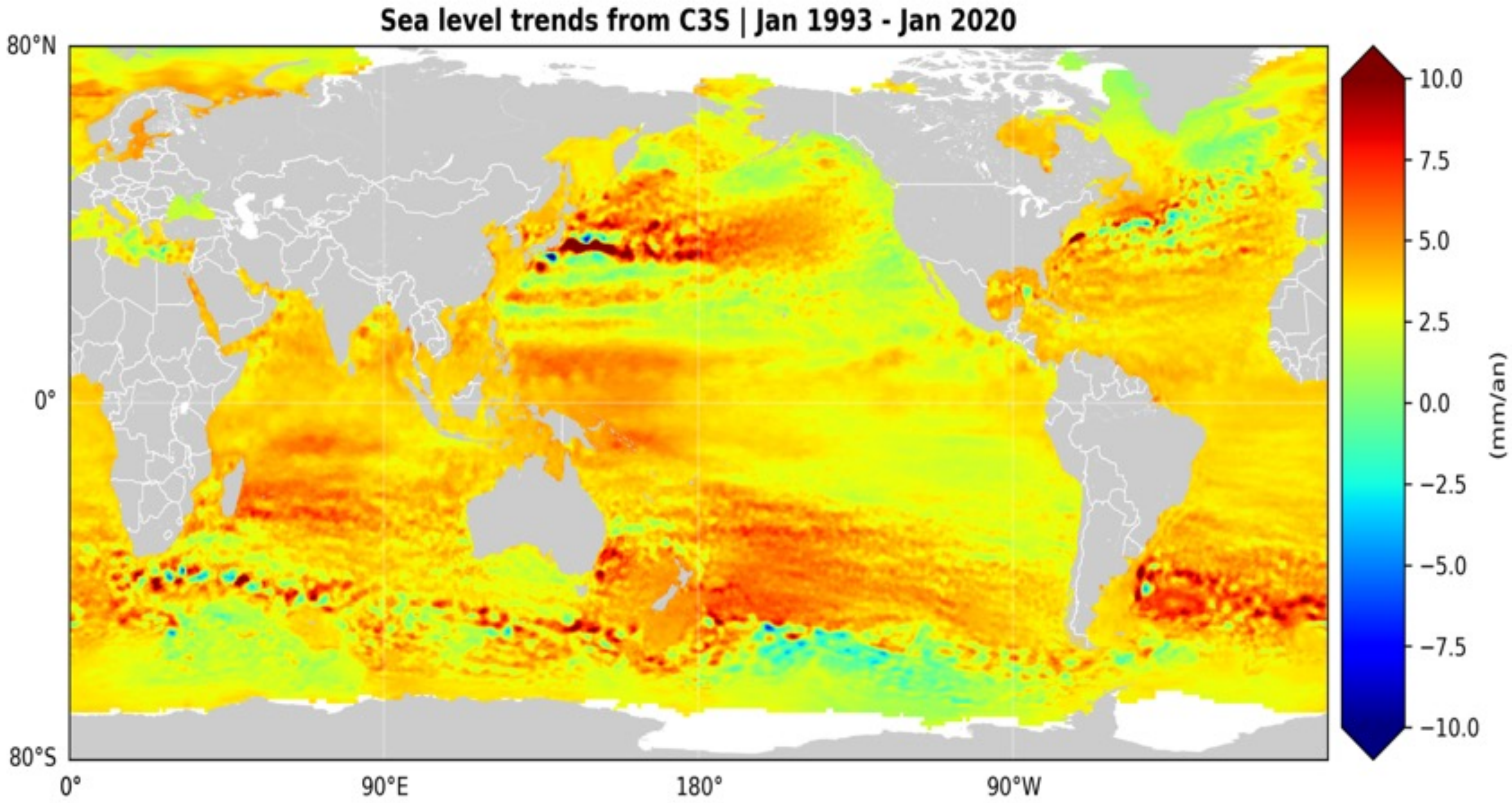
(2) Fresh water input due to land ice melt and terrestrial water storage changes
→ ocean mass increases (60% SLR)







Regional rates of sea level change (1993-2020) (mm/yr)

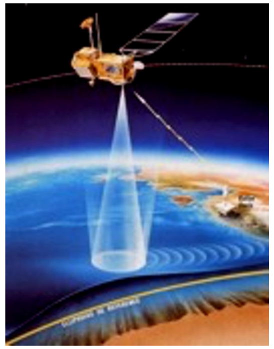


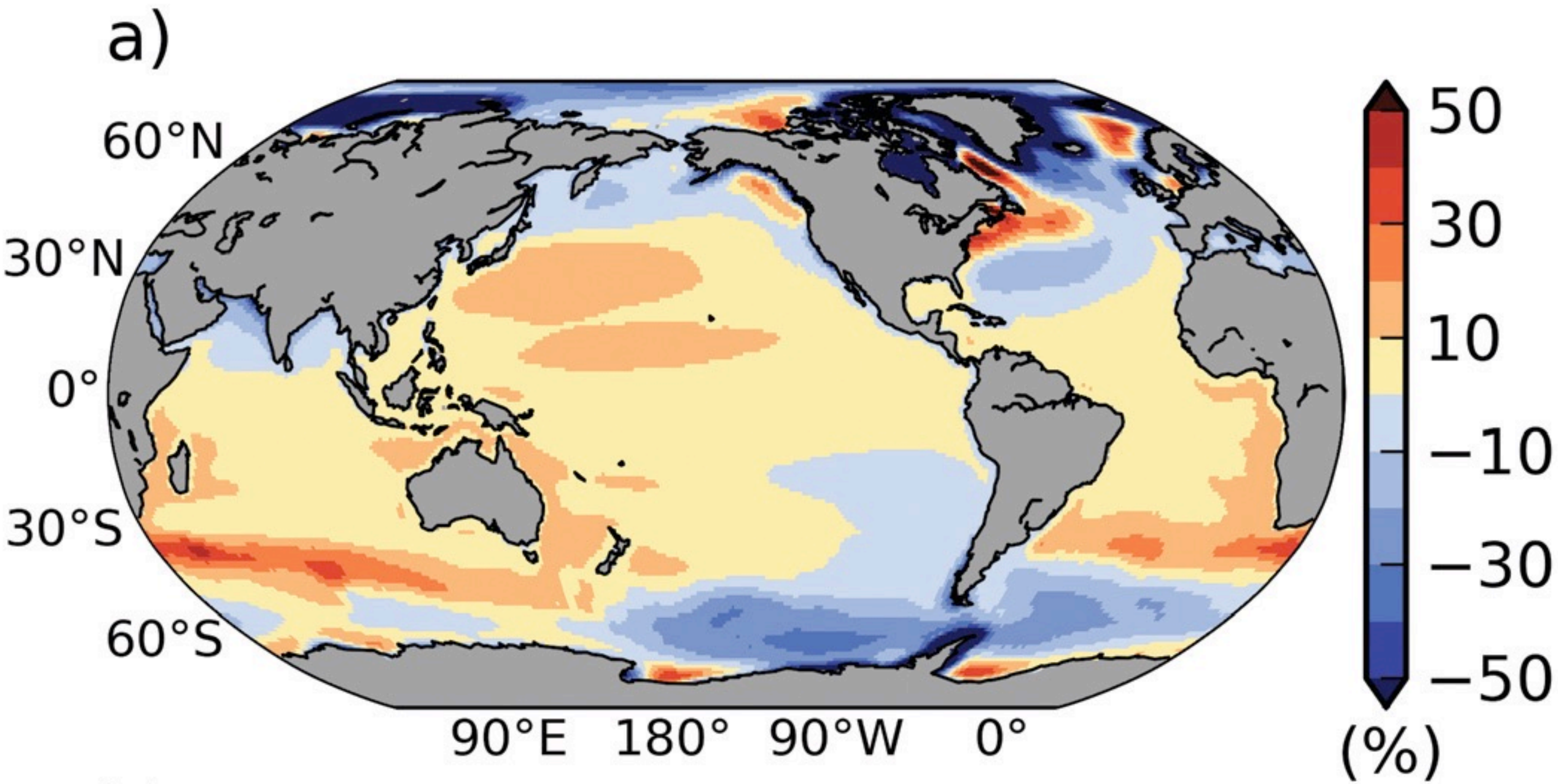
Spatial trend patterns amplify the global mean rise

→ Regional rates can be up to 2-3 times larger than the global mean sea level rise

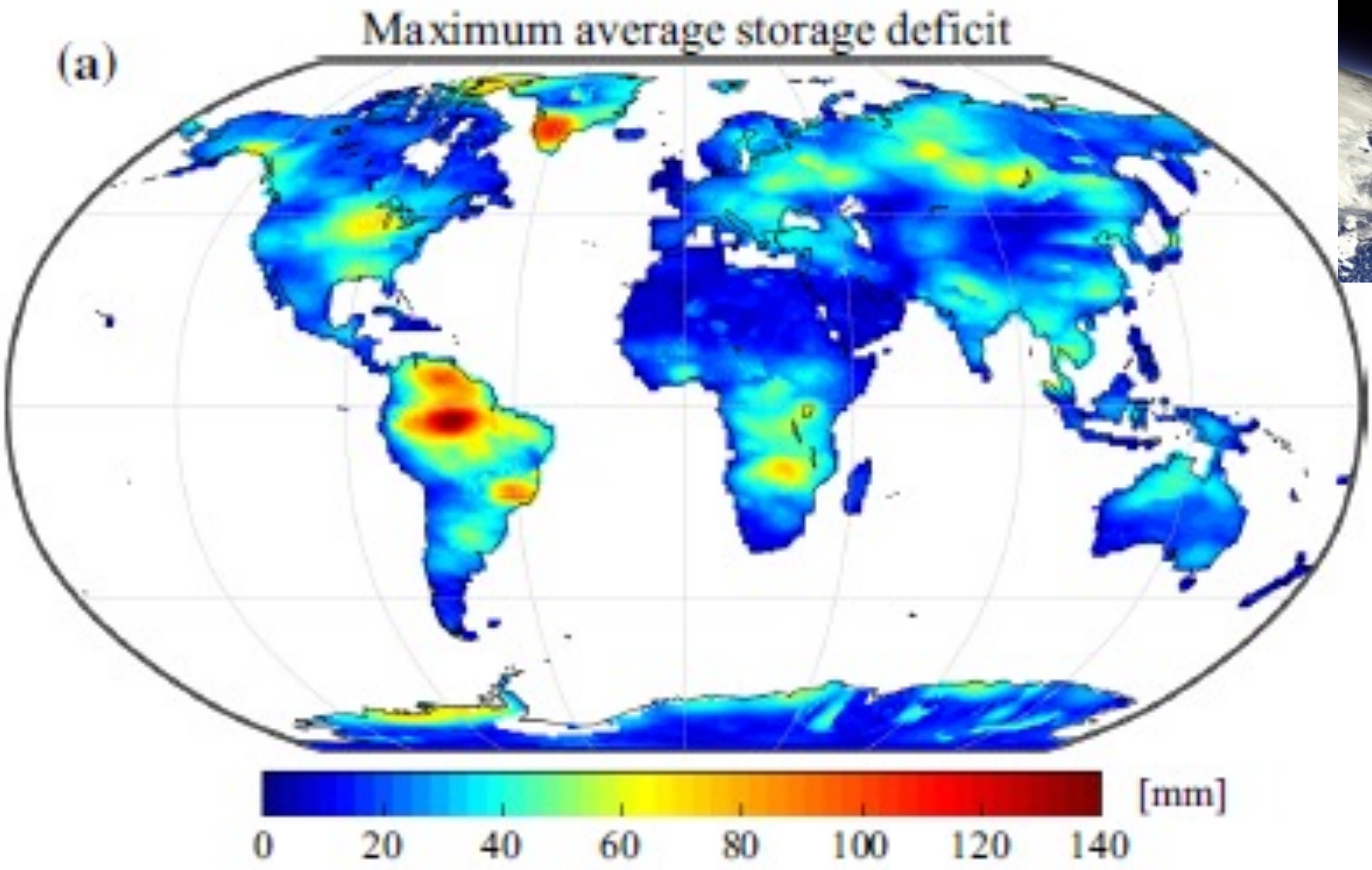
Regional Variability of the SLR in 2100 [difference to mean in %]

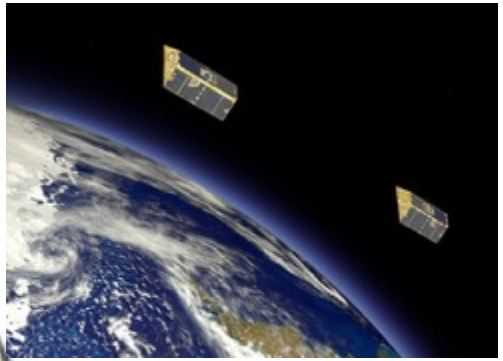
(same for all GIEC scénarios)





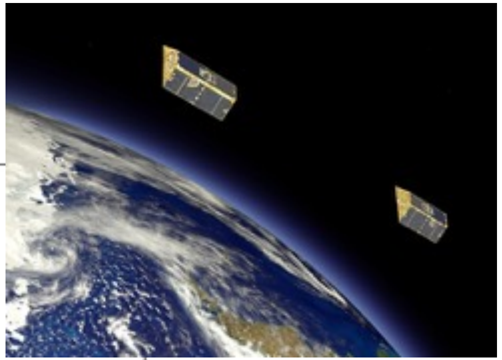
Average water storage deficit over 2002-2015 from GRACE

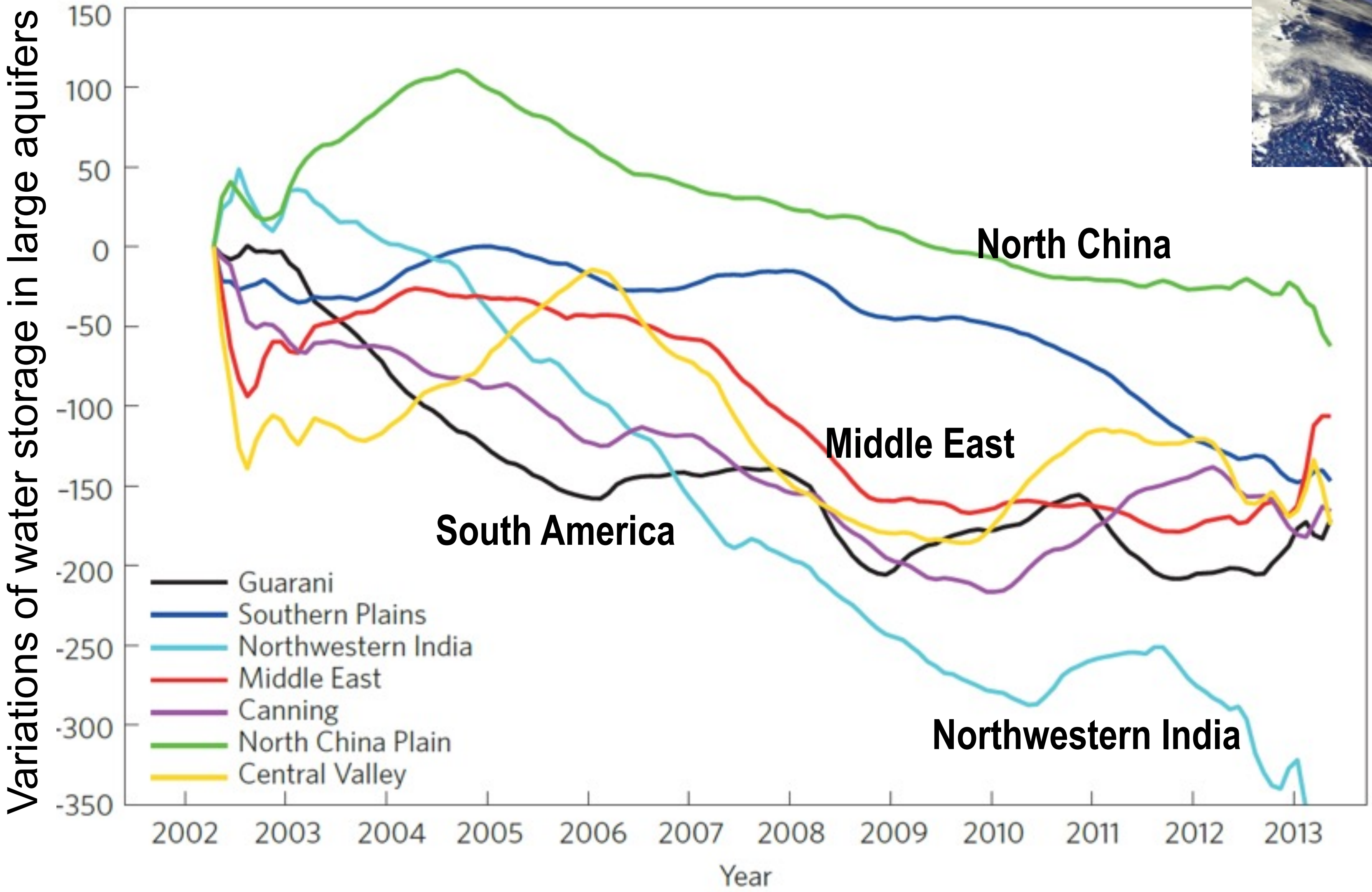




Humphrey et al., 2016

Temporal change in water storage in a few large aquifers from GRACE

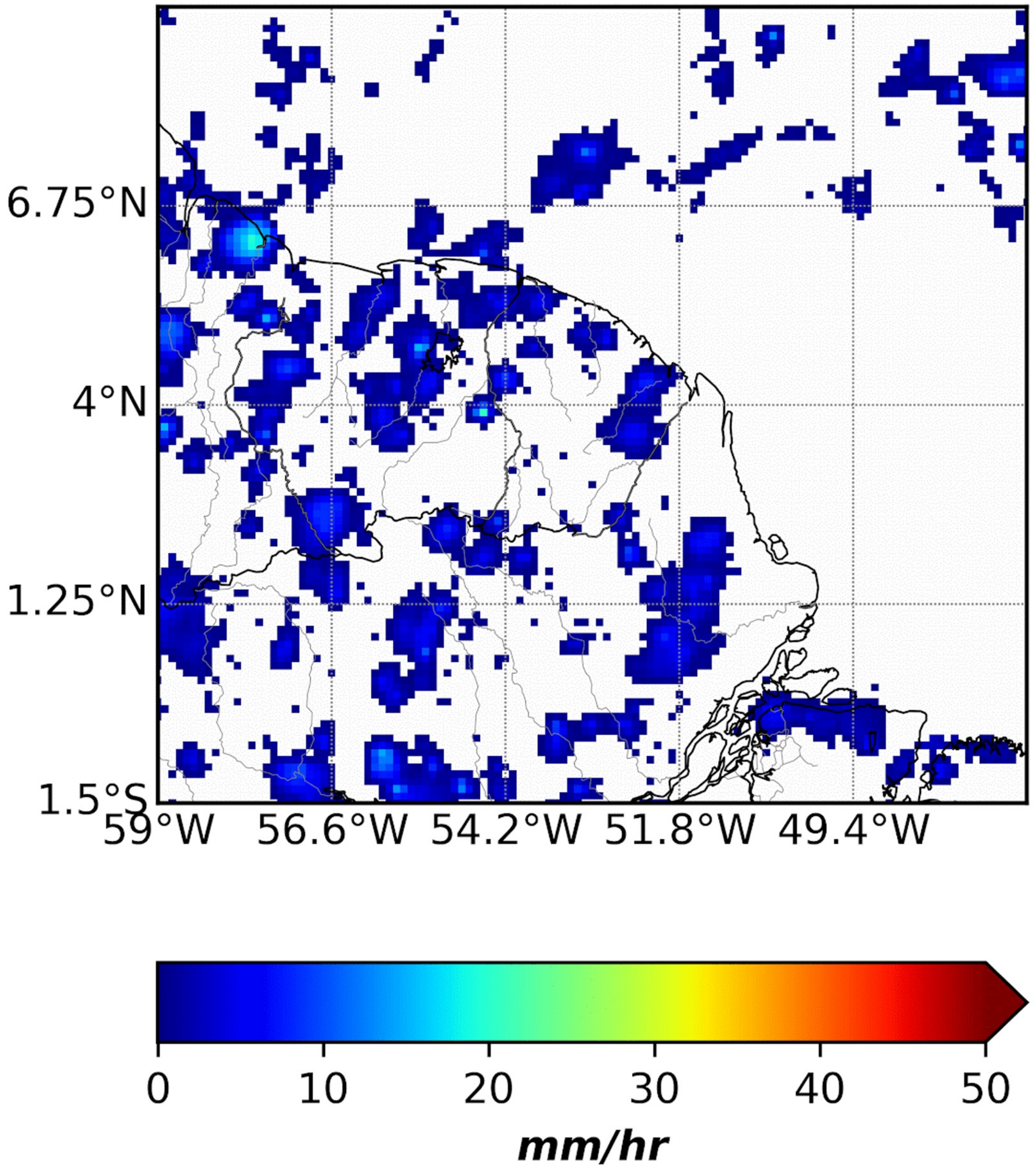


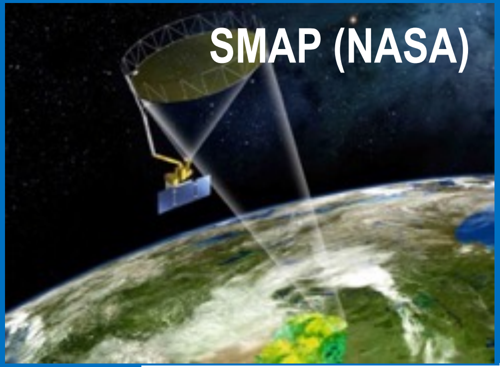


Famiglietti et al., 2014

GPM Constellation Status
Suomi NPP
(NASA/NOAA)
GPM
Core Observatory
(NASA/JAXA)
MetOp B/C
(EUMETSAT)
JPSS-1
(NOAA)
Megha-Tropiques
(CNES/ISRO)
NOAA 18/19
(NOAA)
DMSP F17/F18/
F19/F20
(DOD)
GCOM-W1
(JAXA)

IMERG V06C Early - precipitationCal
2022-09-01 19:00:00 - 19:29:59 UTC

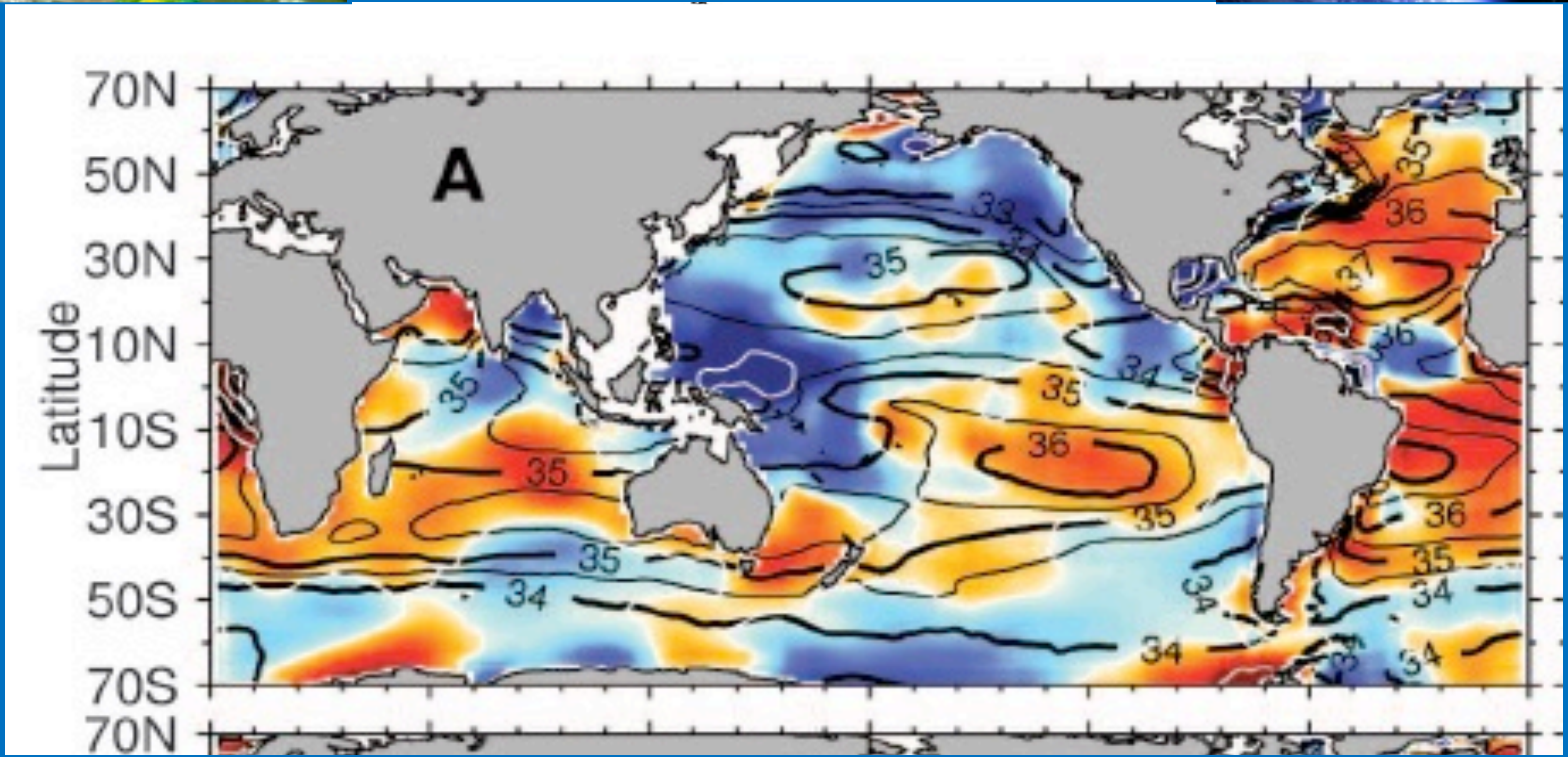




Sea Surface Salinity (SSS)

Red → P decreases

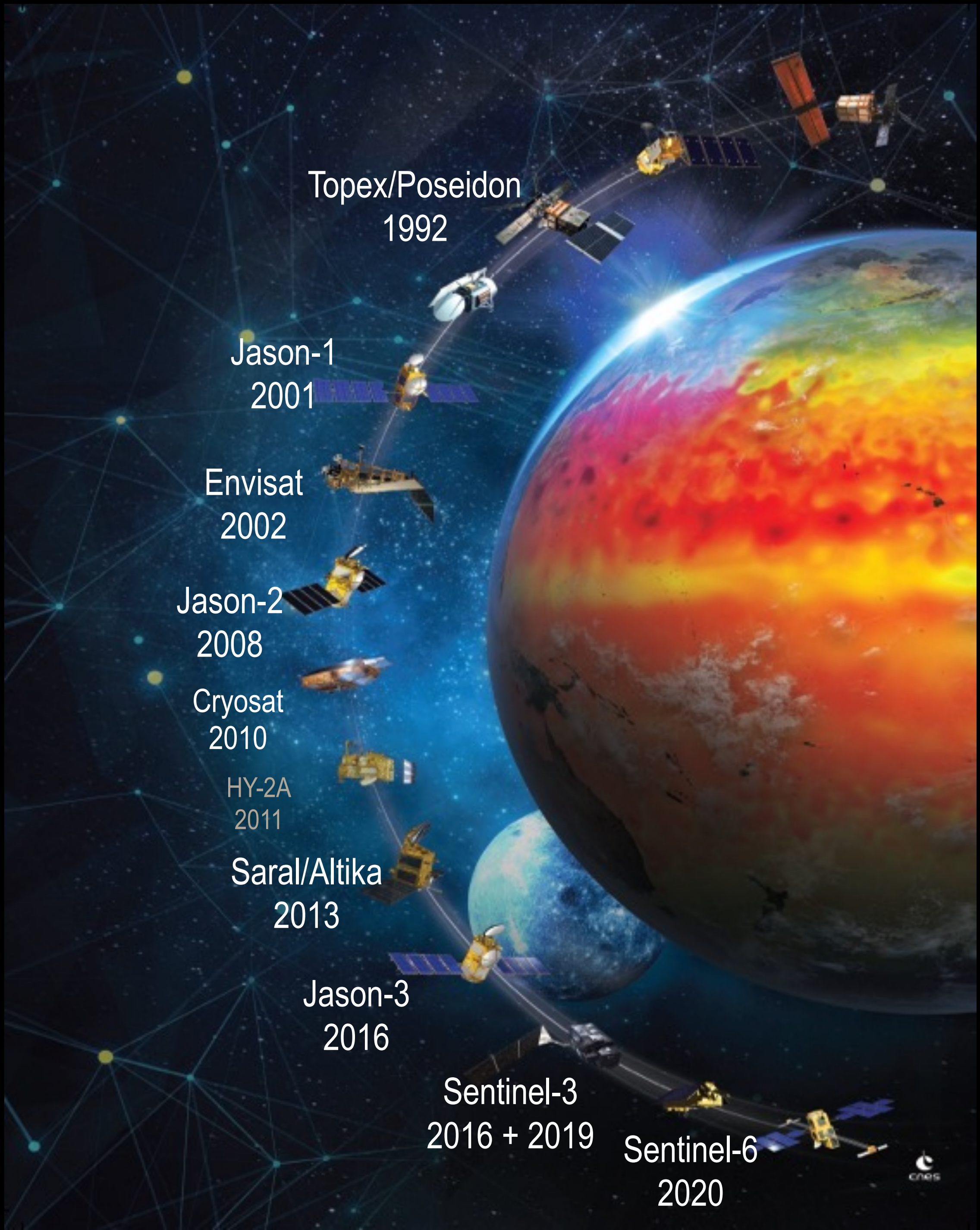
Blue → P increases

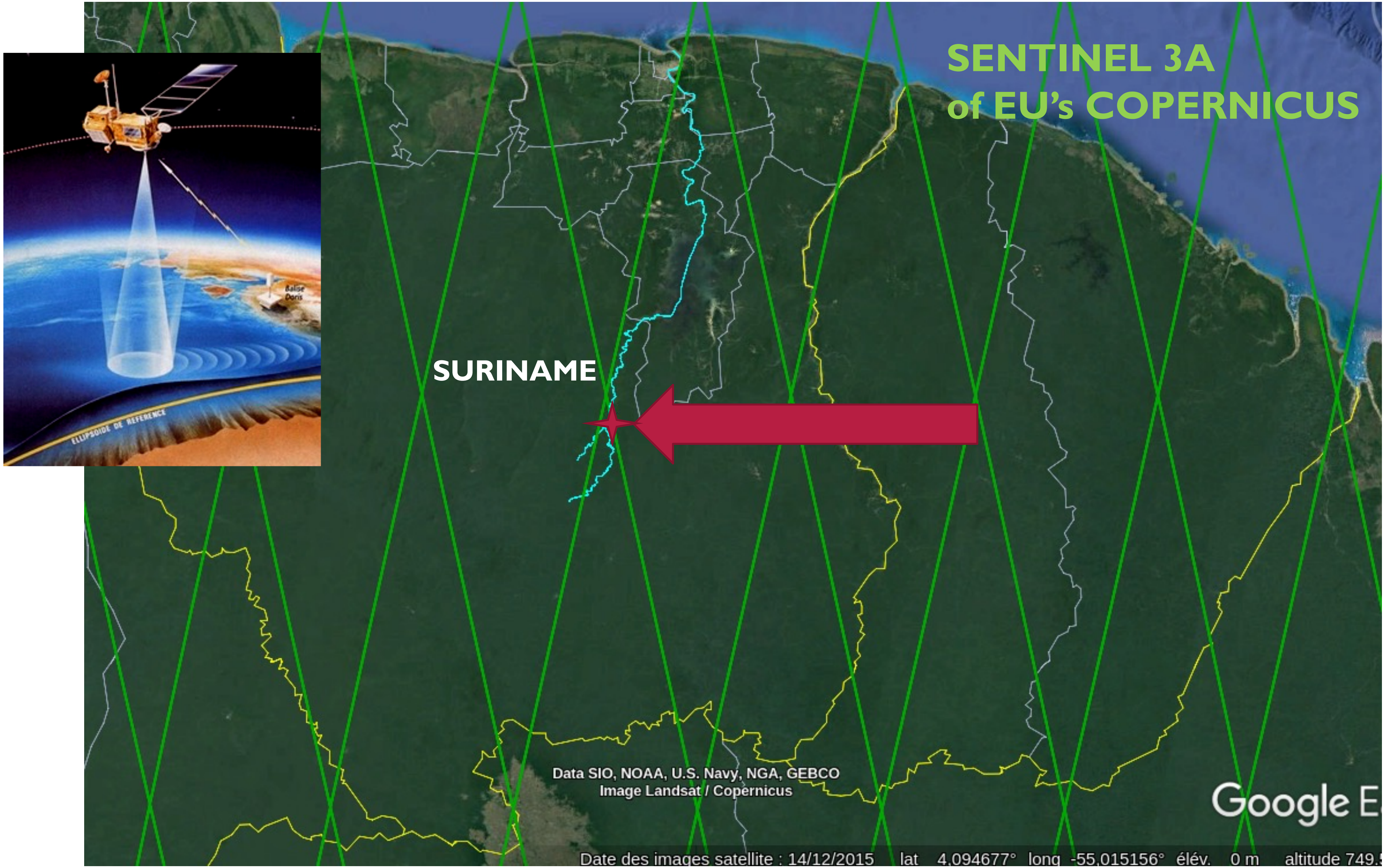


Sea surface salinity: trends over 1950 - 2000

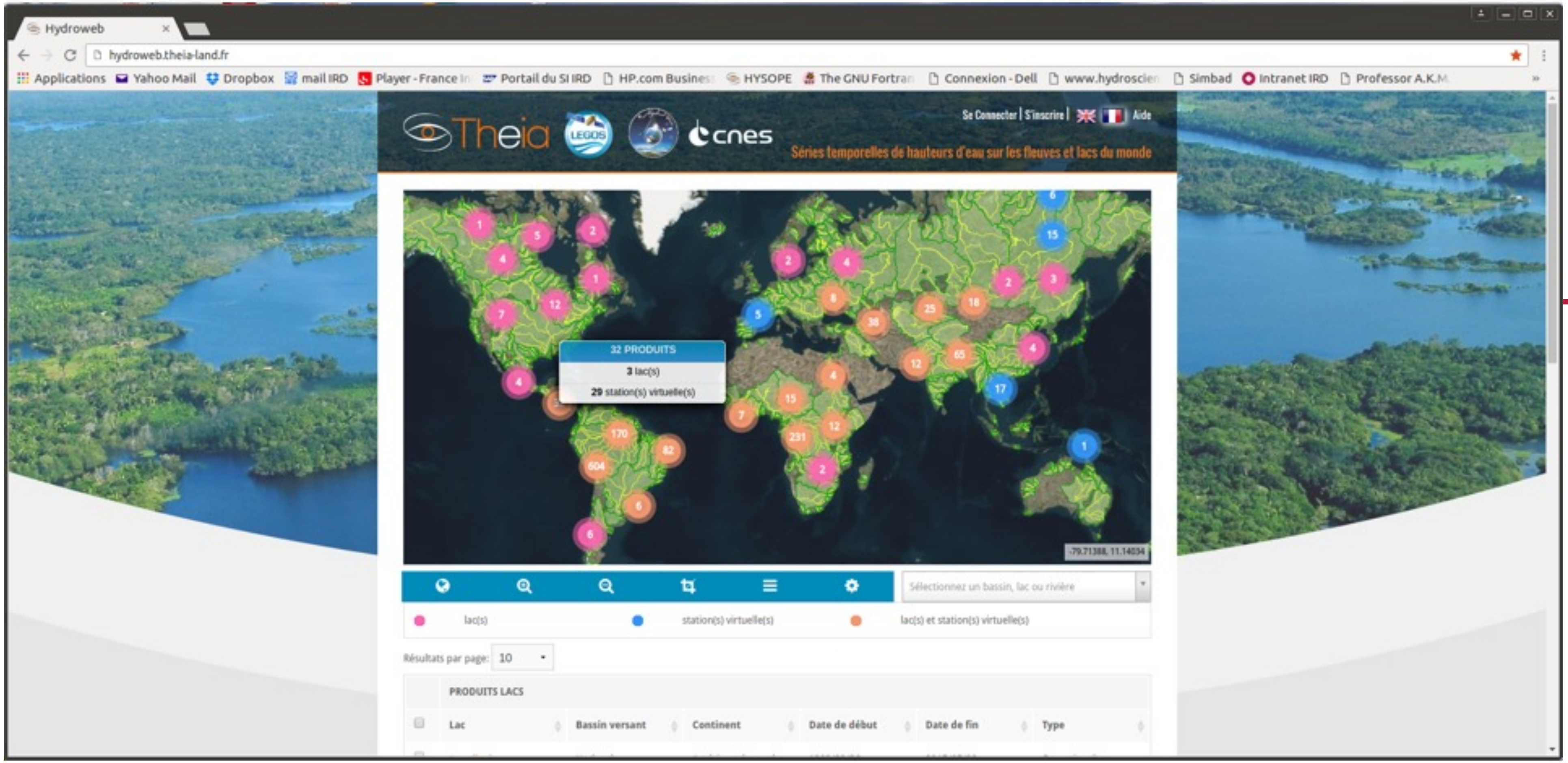
→ Evidence of an intensification of the water cycle

High Accuracy Altimetry

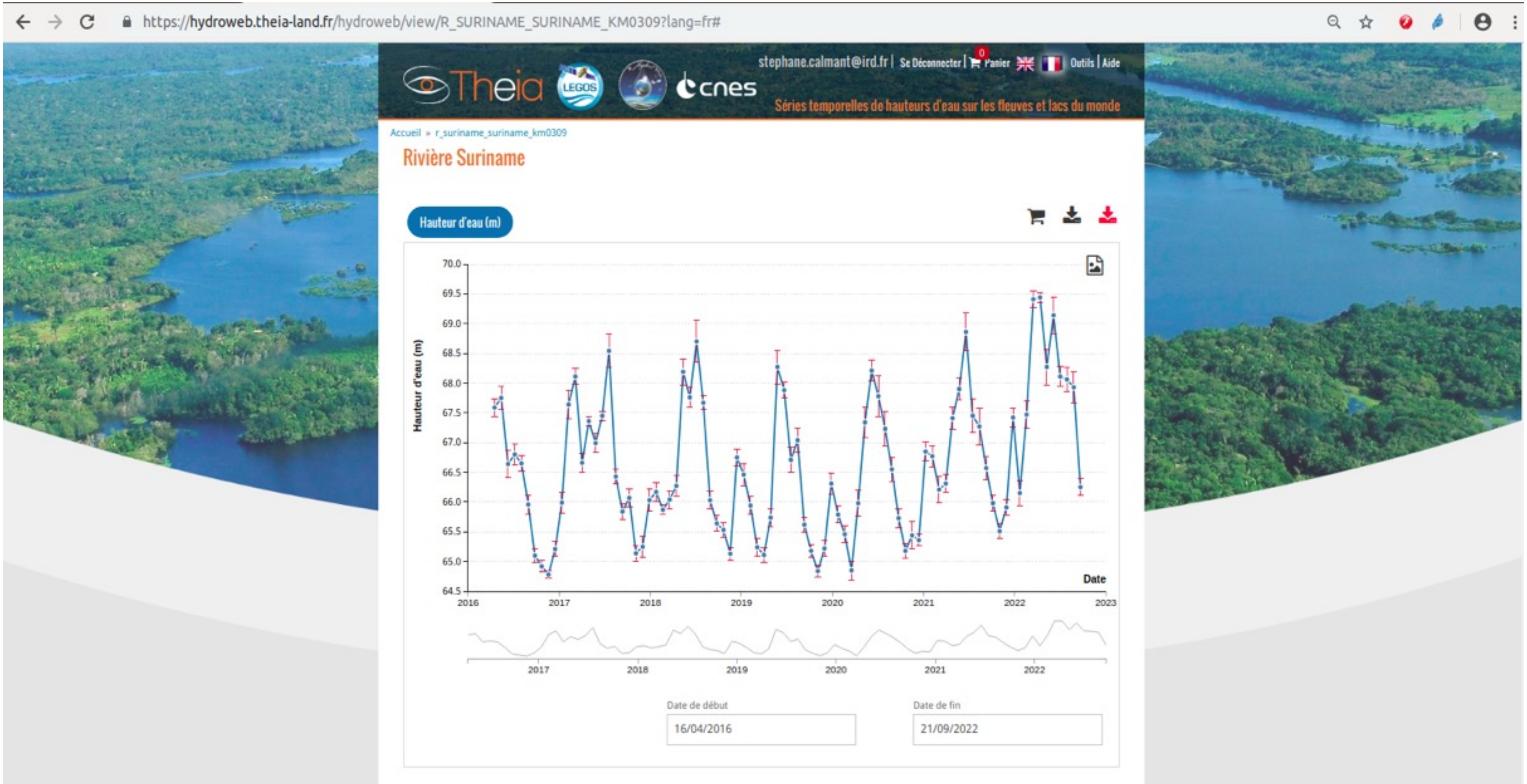



SENTINEL 3A
of EU's COPERNICUS
SURINAME
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Google E
Date des images satellite : 14/12/2015 lat 4.094677° long -55.015156° élév. 0 m altitude 749.

Hydroweb



Hydroweb
hydroweb.theia-land.fr
Applications
Yahoo Mail
Dropbox
mail IRD
Portail du SI IRD
HYSOPE
Connexion - Dell
Simbad
Intranet IRD
Theia
cnes
Se Connecter | S'inscrire | Aide
Séries temporelles de hauteurs d'eau sur les fleuves et lacs du monde
32 PRODUITS
3 lac(s)
29 station(s) virtuelle(s)
Sélectionnez un bassin, lac ou rivière
lac(s)
station(s) virtuelle(s)
lac(s) et station(s) virtuelle(s)
Résultats par page: 10
PRODUITS LACS
Lac
Bassin versant
Continent
Date de début
Date de fin
Type

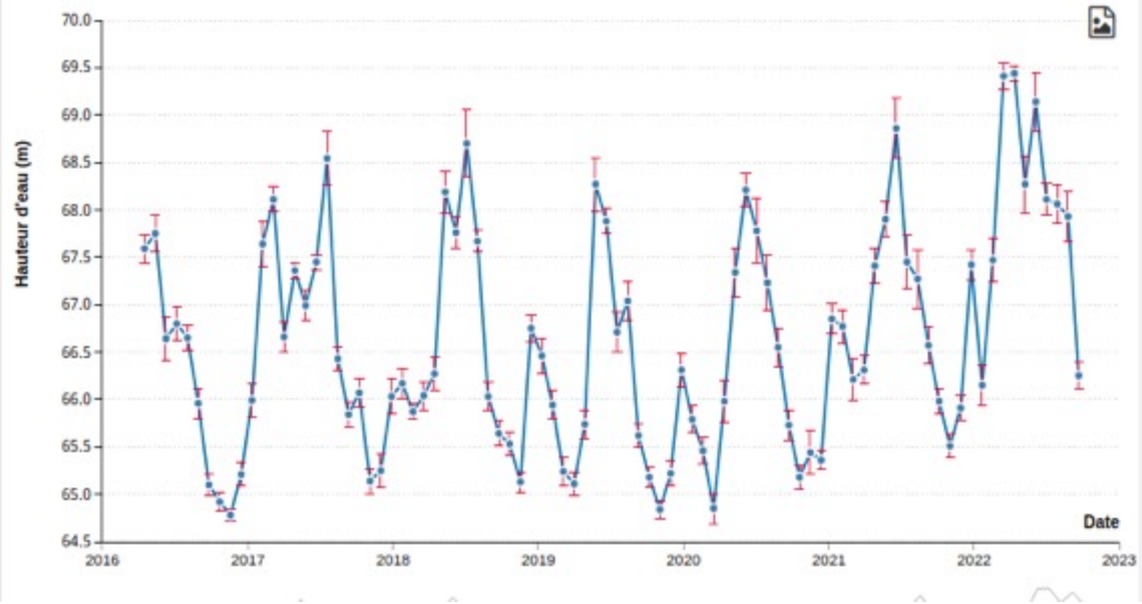

https://hydroweb.theia-land.fr/hydroweb/view/R_SURINAME_SURINAME_KM0309?lang=fr#
Theia
LEGOS
cnes
stephane.calmant@ird.fr | Se Déconnecter | Panier | Outils | Aide
Séries temporelles de hauteurs d'eau sur les fleuves et lacs du monde
Accueil » r_suriname_suriname_km0309
Rivière Suriname
Hauteur d'eau (m)
Hauteur d'eau (m)
70.0
69.5
69.0
68.5
68.0
67.5
67.0
66.5
66.0
65.5
65.0
64.5
Date
2016
2017
2018
2019
2020
2021
2022
2023
Date de début
16/04/2016
Date de fin
21/09/2022

Limitations :

Not everywhere :

hence it can happen that it is not

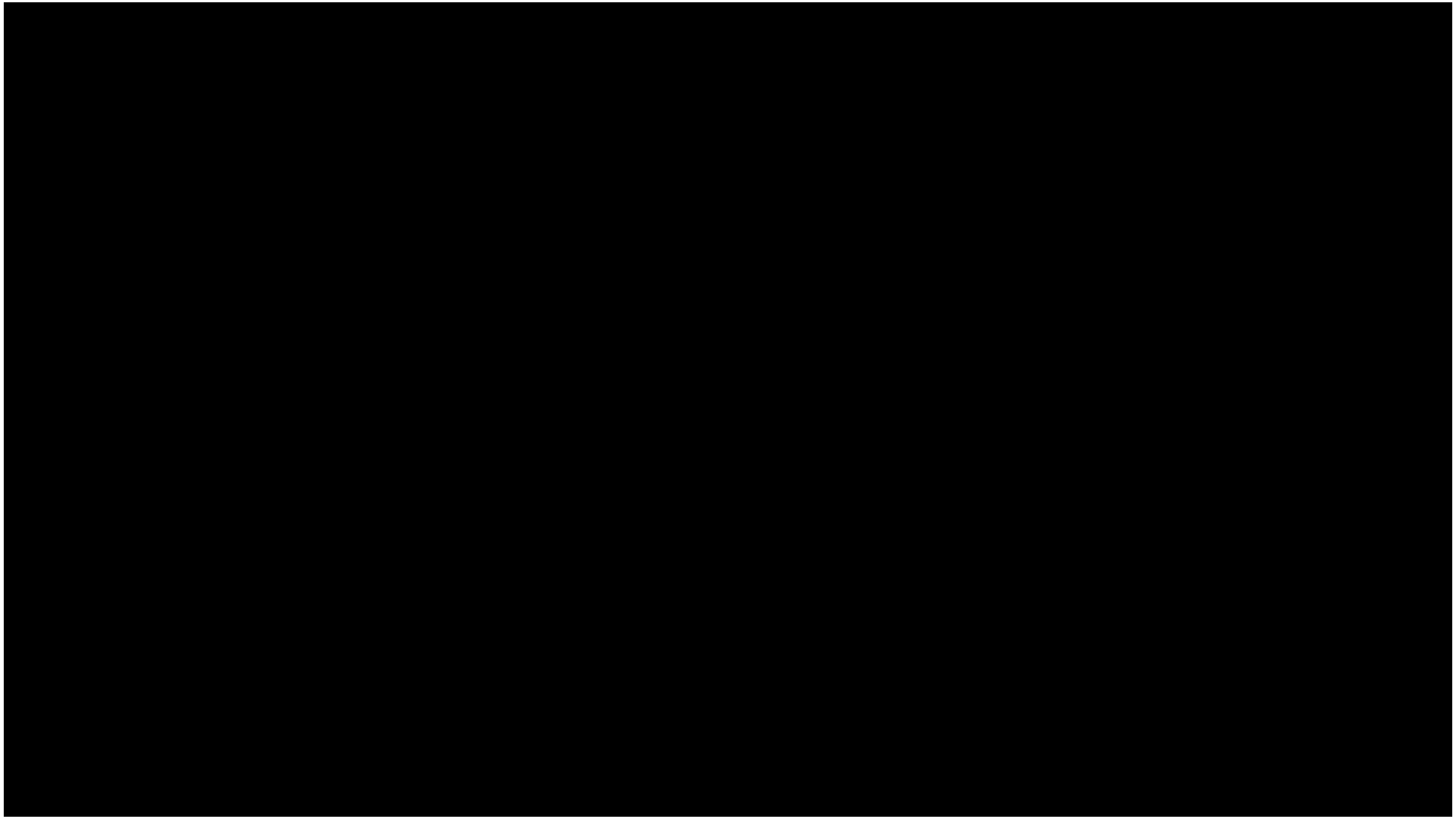
sampling the very place that you want



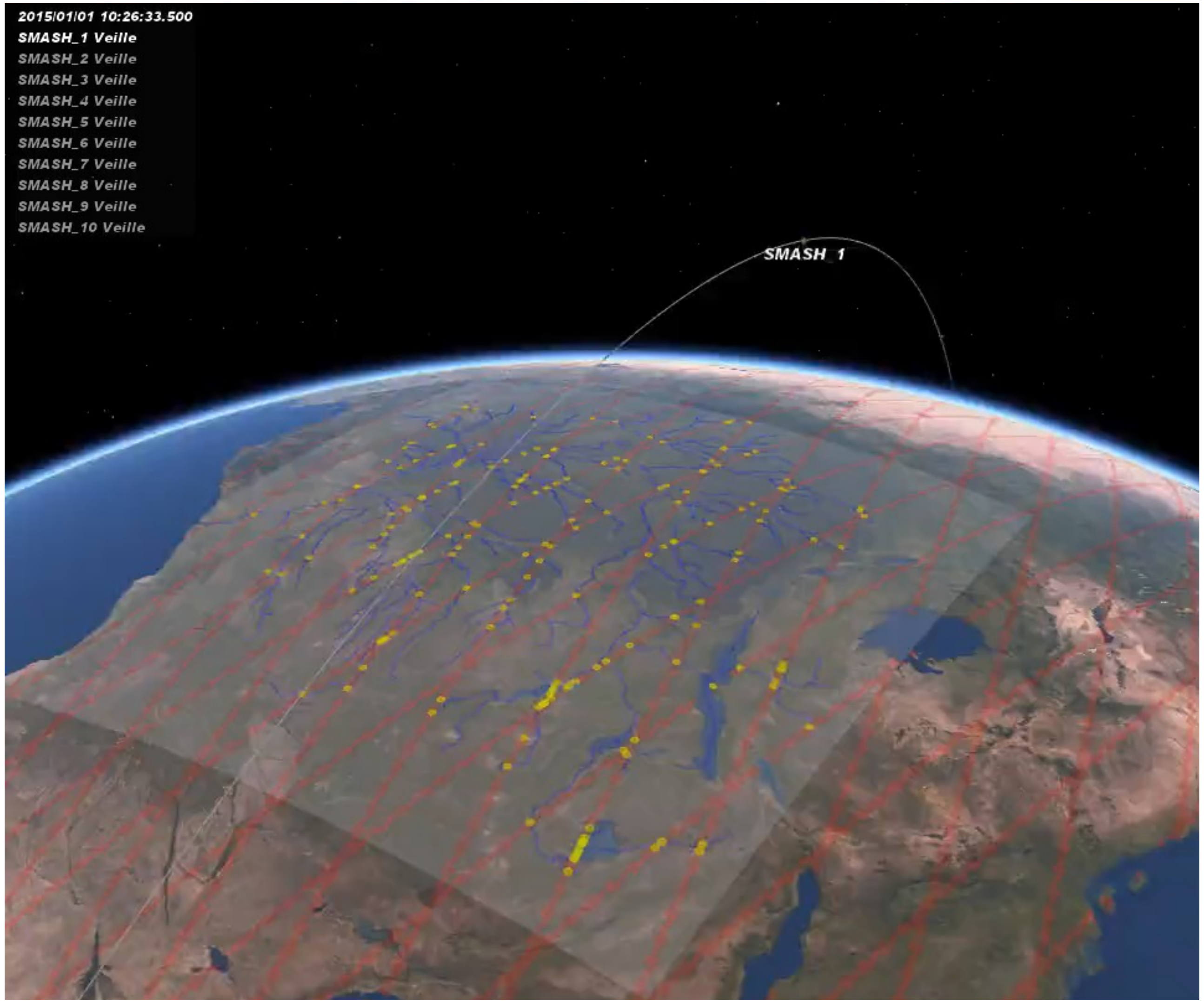
Not every day:

It may miss important rapid variations

SWOT (CNES/NASA) : global coverage of Earth waters



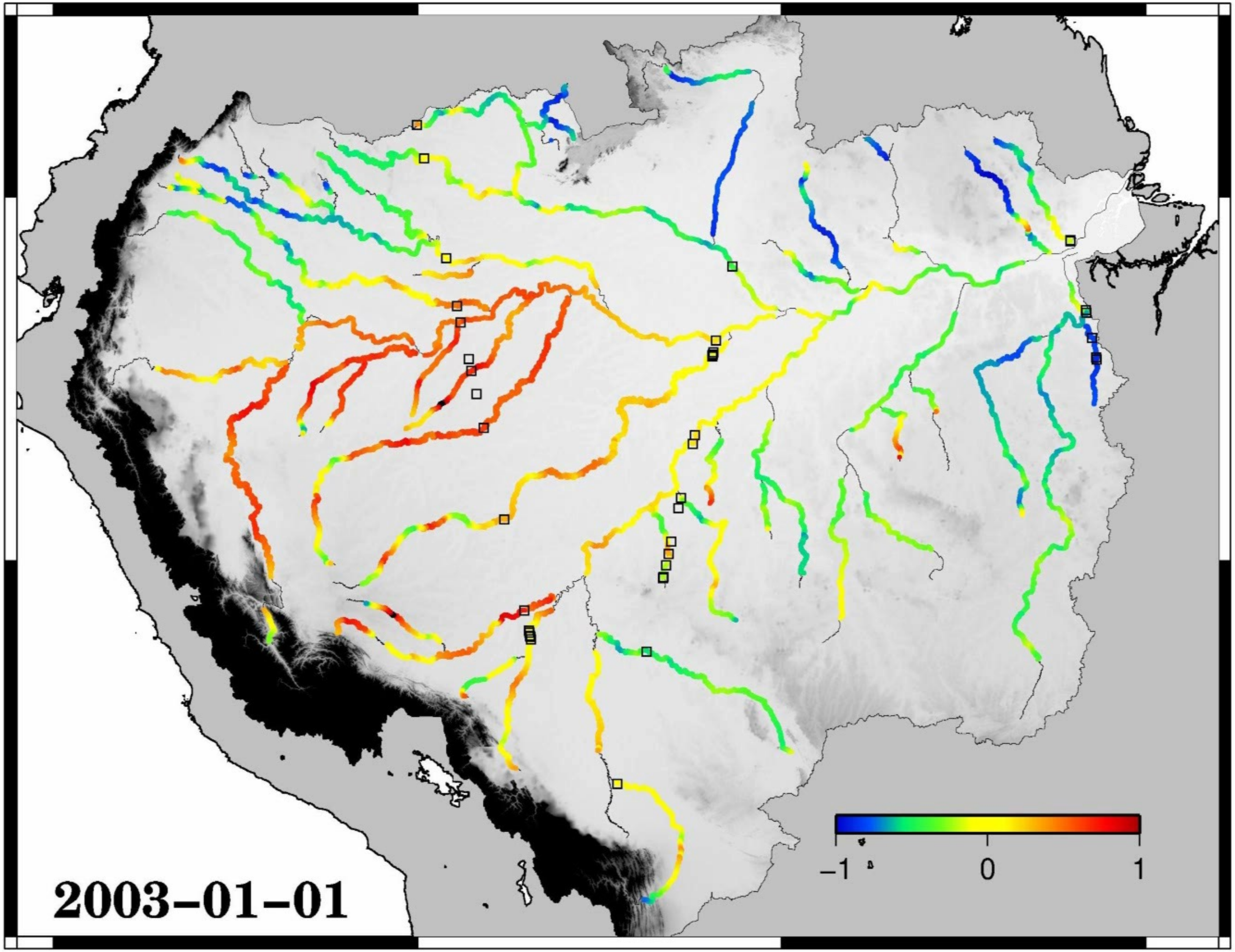
SMASH : a Constellation for daily hydrometry worldwide



- 10 µ satellites in the same orbit plane
- 40k pre-defined targets for better efficiency
- worldwide
  - NRT delivery of the water levels
  - Free access
  - Daily measurements
  - σ = 10 cm

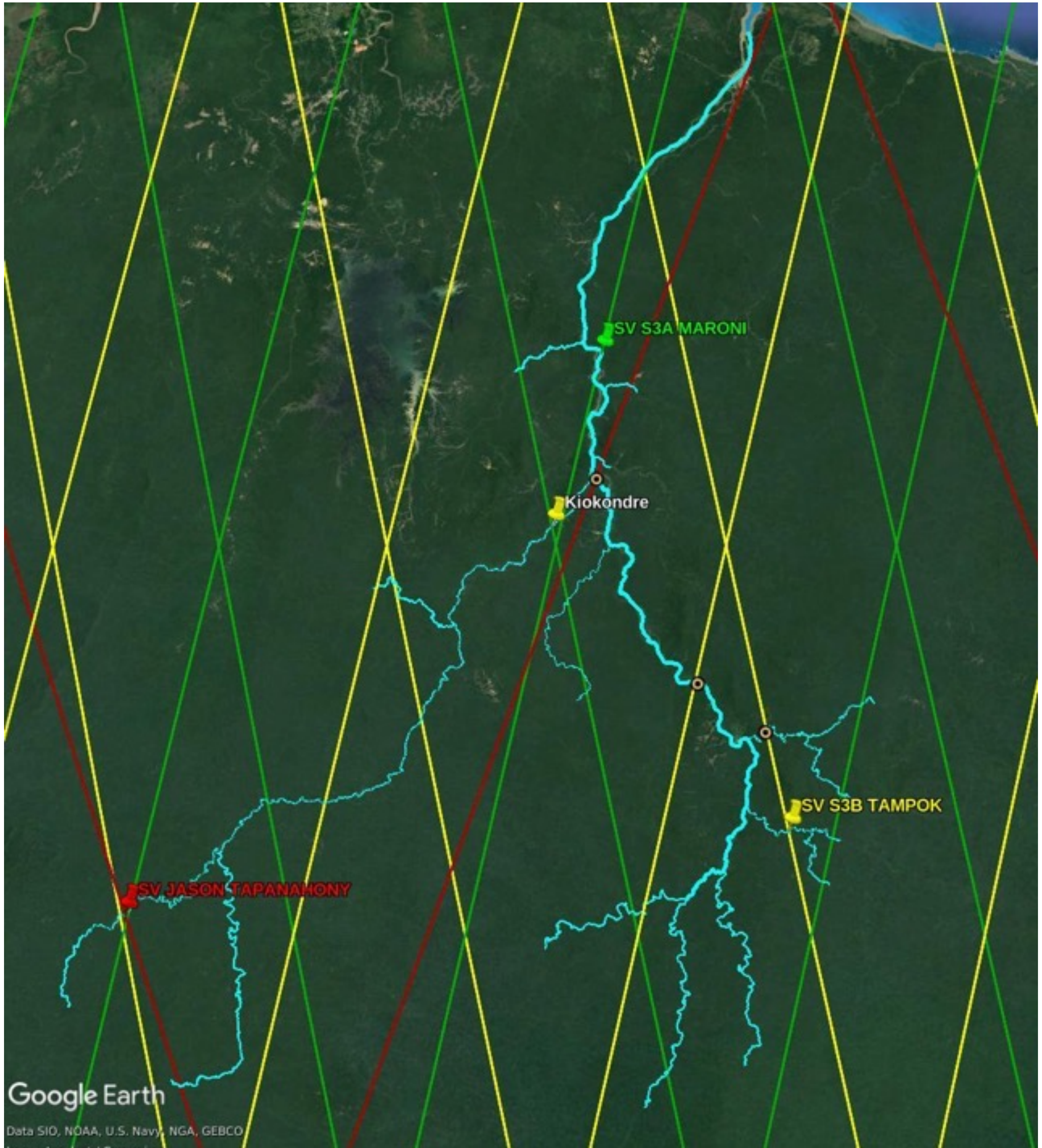
Special thanks to A. Cazenave, French Academy of Sciences

- SPARES

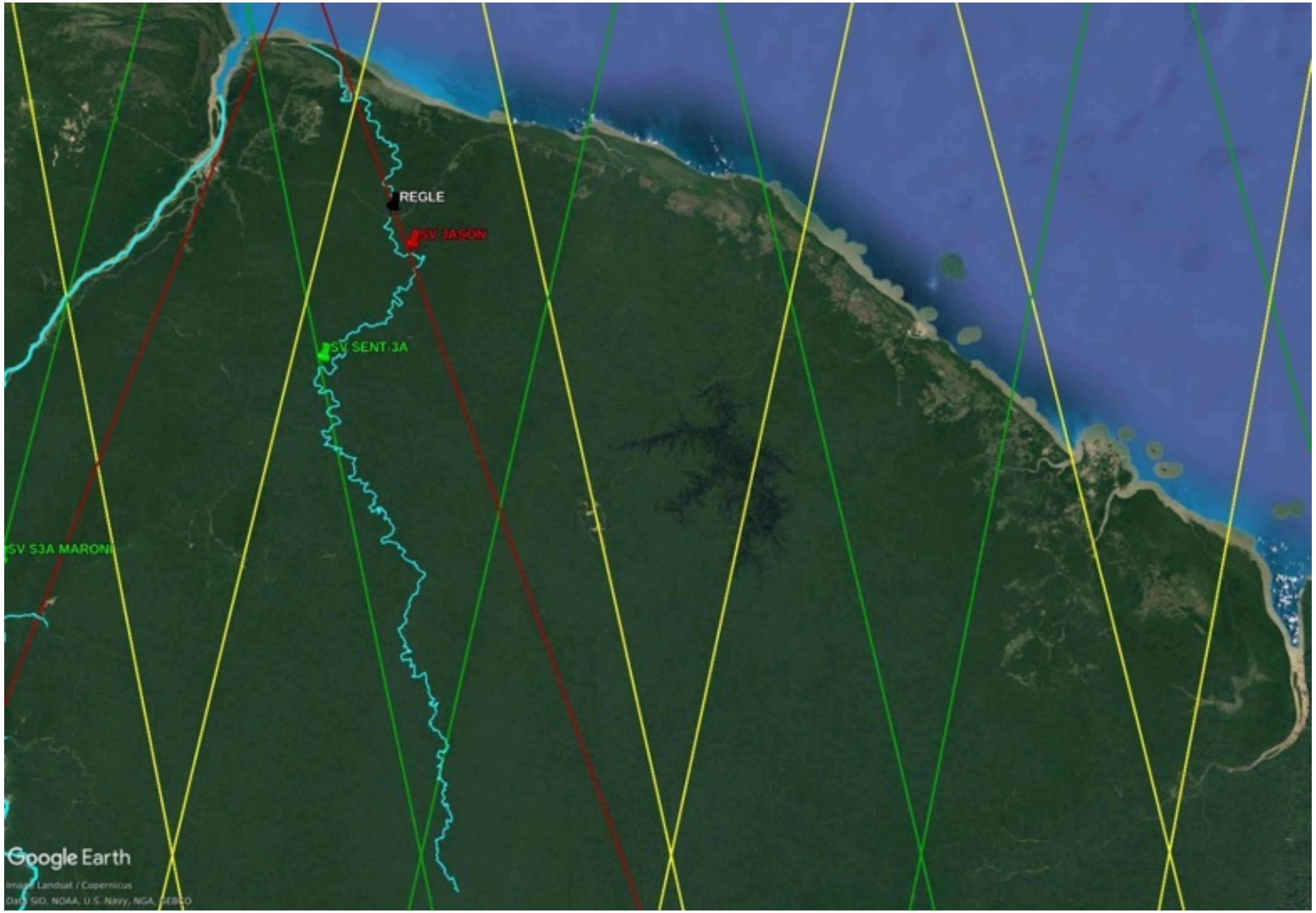


−1
0
1
2003–01–01

Un grand fleuve transfrontalier de Guyane : le Maroni

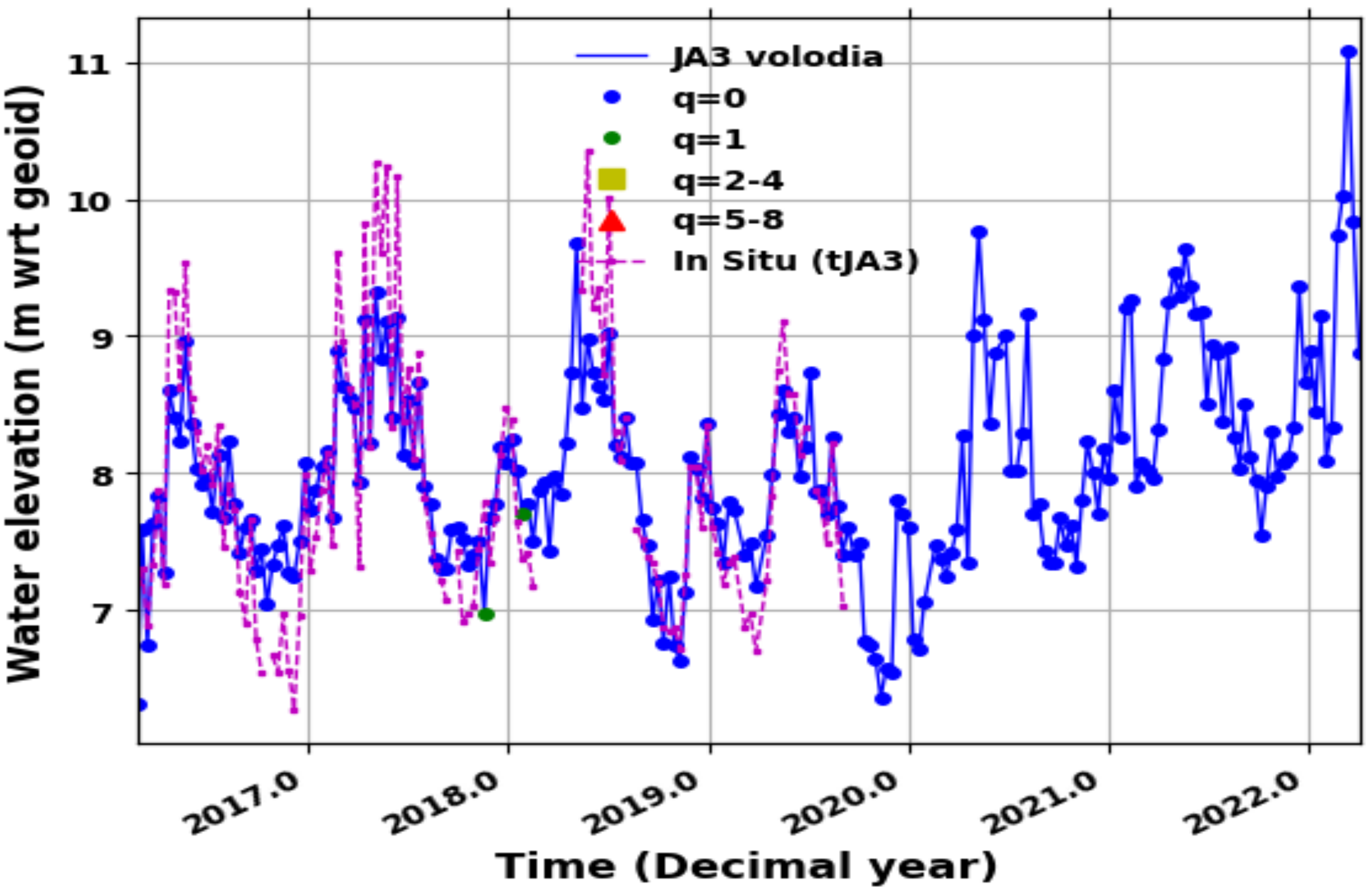


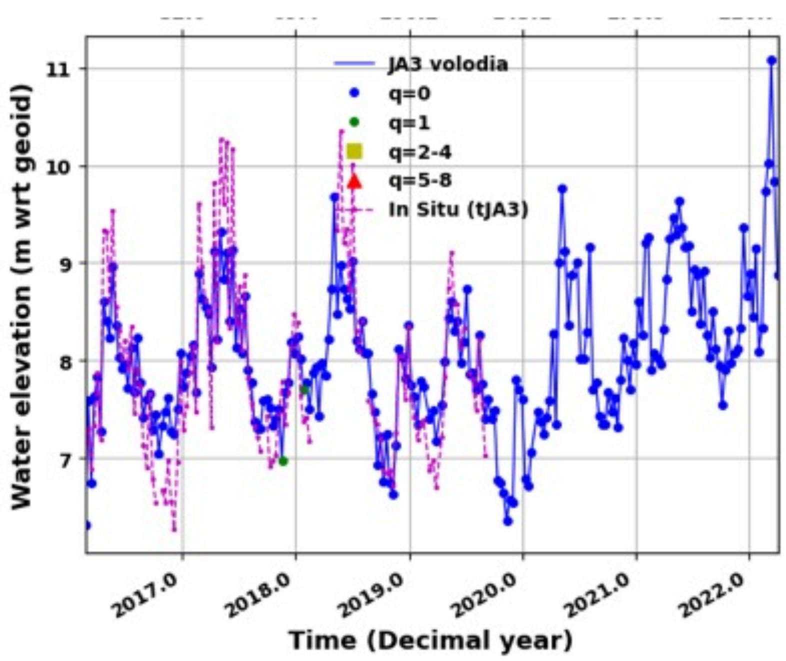
Un petit fleuve cotier de Guyane : la Mana

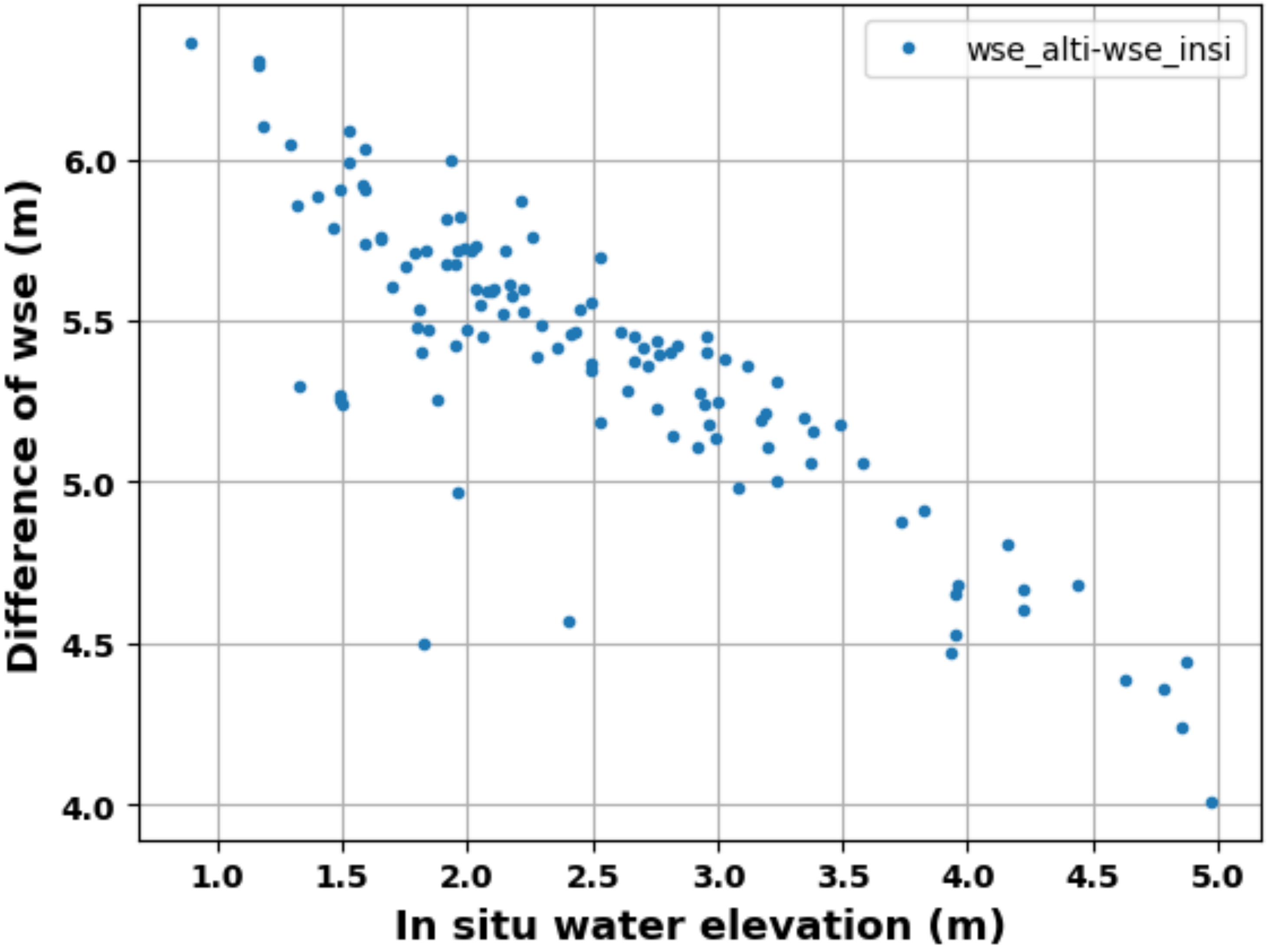


Jason-3 VS


REGLE


JA3 volodia
q=0
q=1
q=2-4
q=5-8
In Situ (tJA3)
Water elevation (m wrt geoid)
11
10
9
8
7
2017.0
2018.0
2019.0
2020.0
2021.0
2022.0
Time (Decimal year)

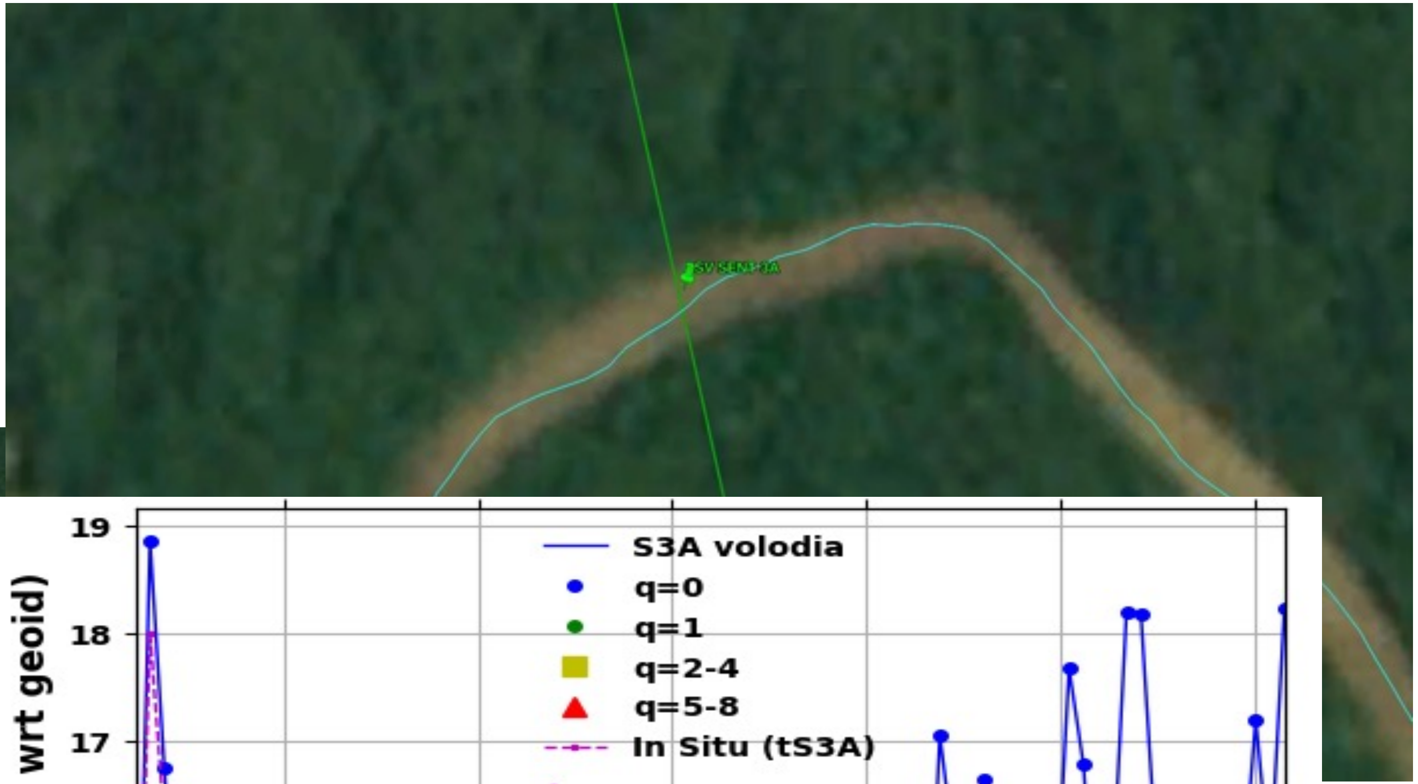




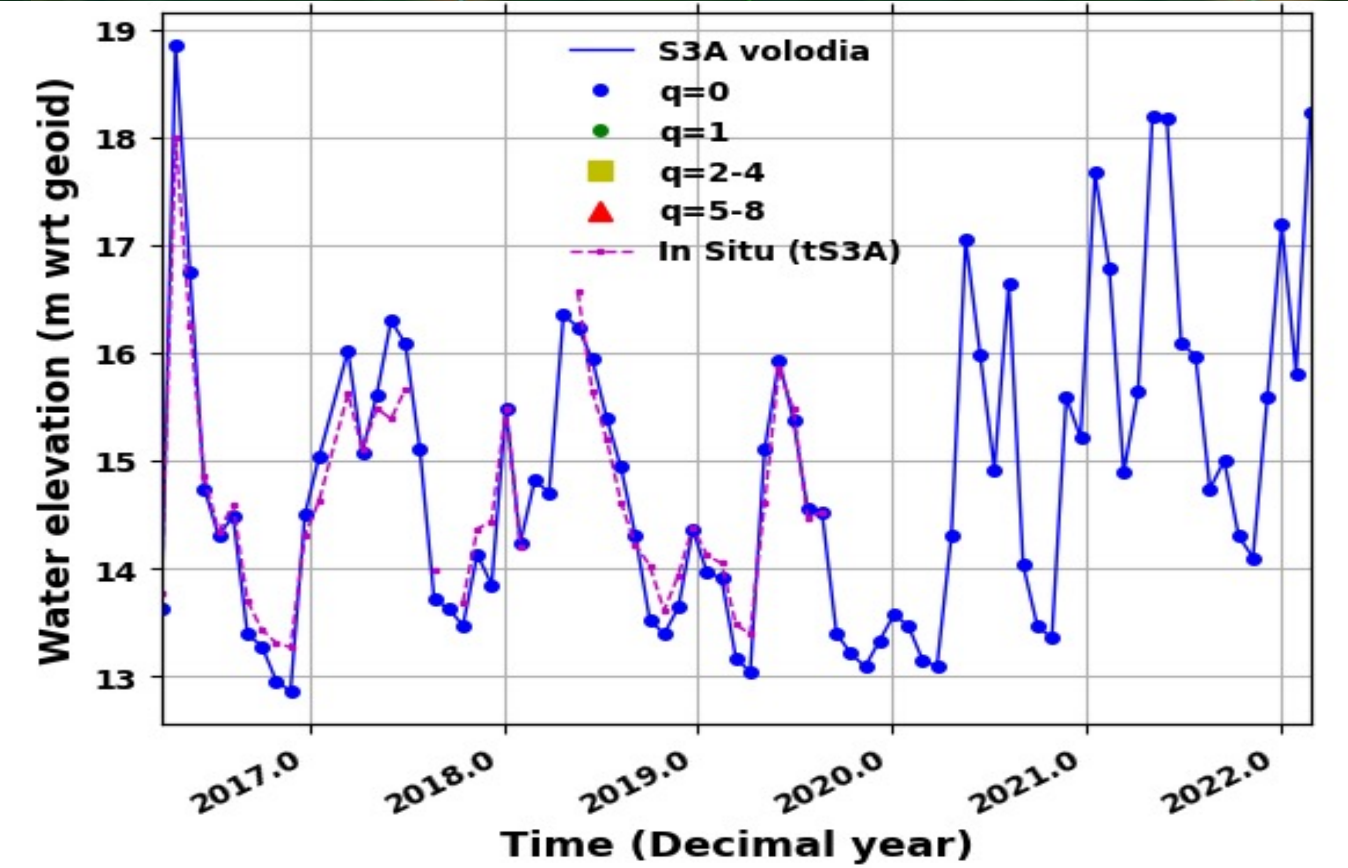
Differences rely on different reach widths, not on errors

SENTINEL 3A

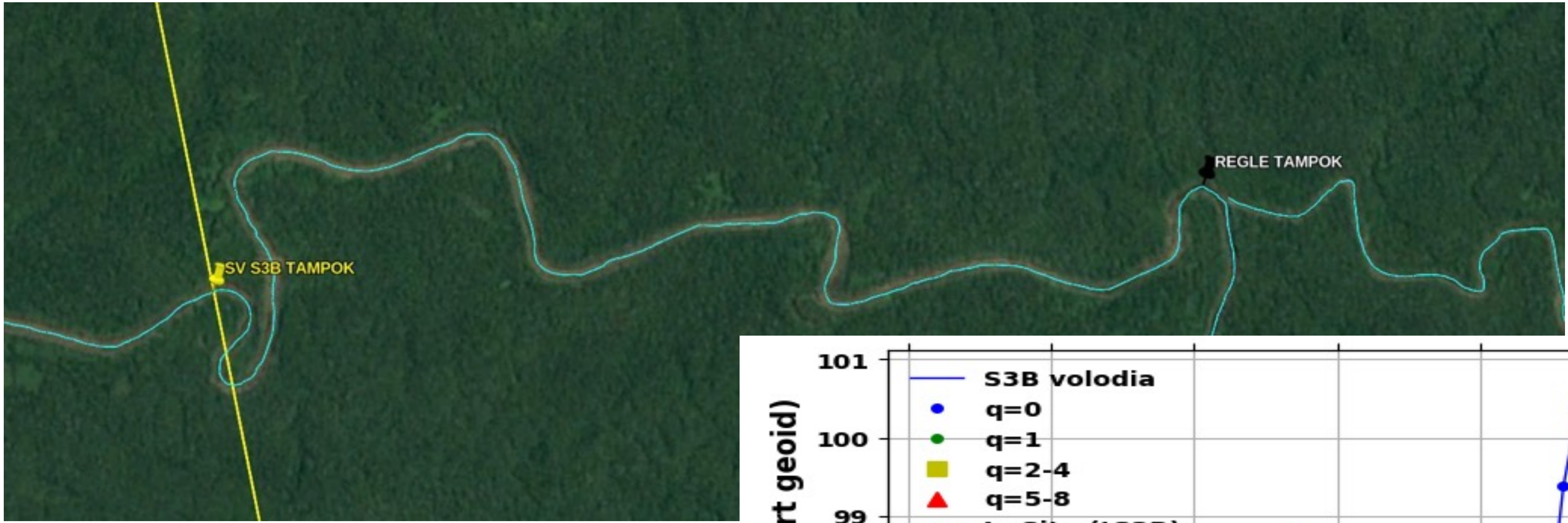
SV SENT-3A
Google Earth

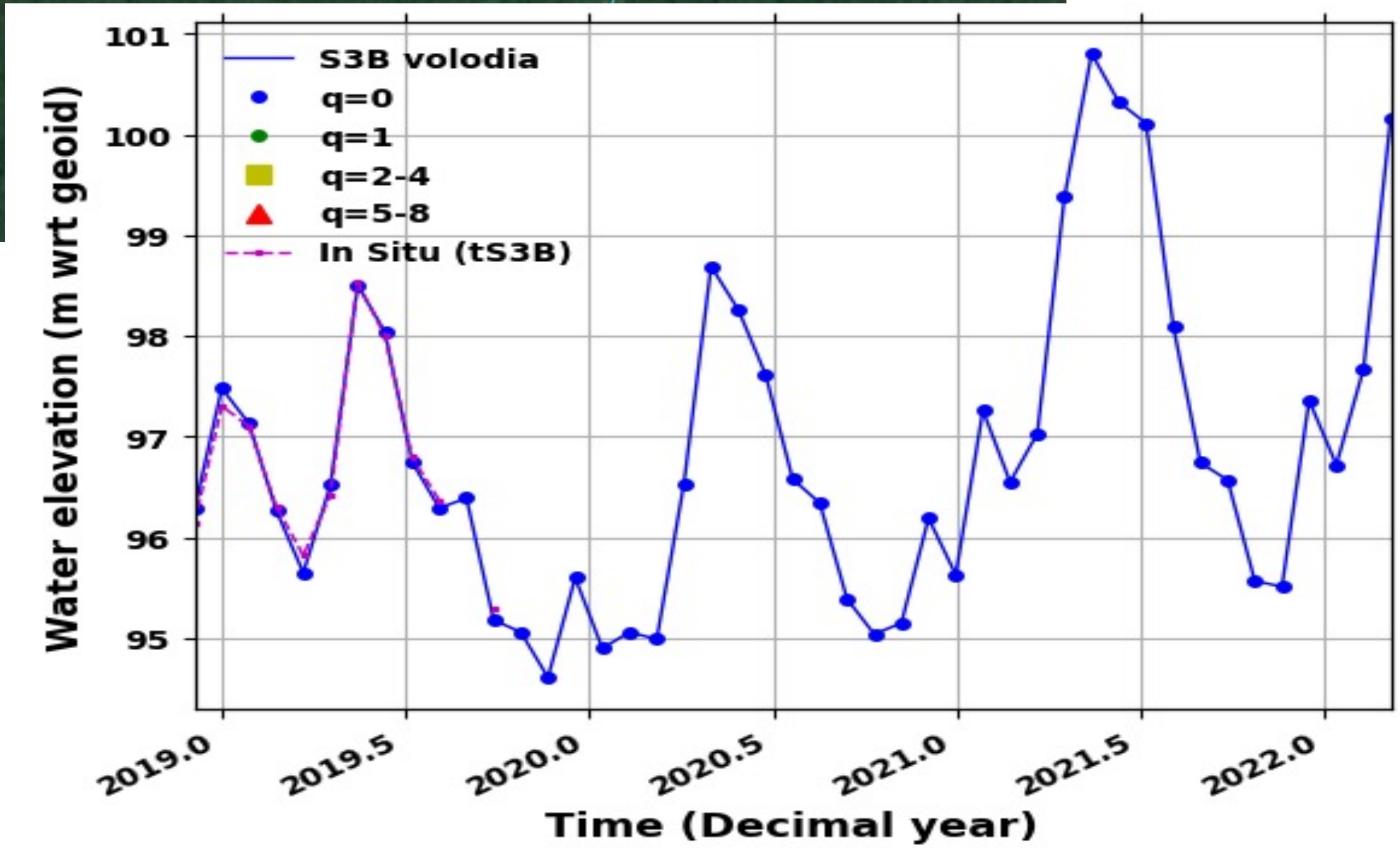


SV SENT-3A



S3A volodia
q=0
q=1
q=2-4
q=5-8
In Situ (tS3A)
Water elevation (m wrt geoid)
13
14
15
16
17
18
19
2017.0
2018.0
2019.0
2020.0
2021.0
2022.0
Time (Decimal year)





SV SENTINEL on
The Tampok tributary

Rio Pardo (Amazon Basin)