GEO BLUE PLANET

Using remote sensing and modelling for coastal detection

Plenary session #3

Coastal Hazards

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NASA JPL

5^{th} Symposium | Accra, Ghana | 24 – 28 October 2022

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Using remote sensing and modelling for coastal detection.

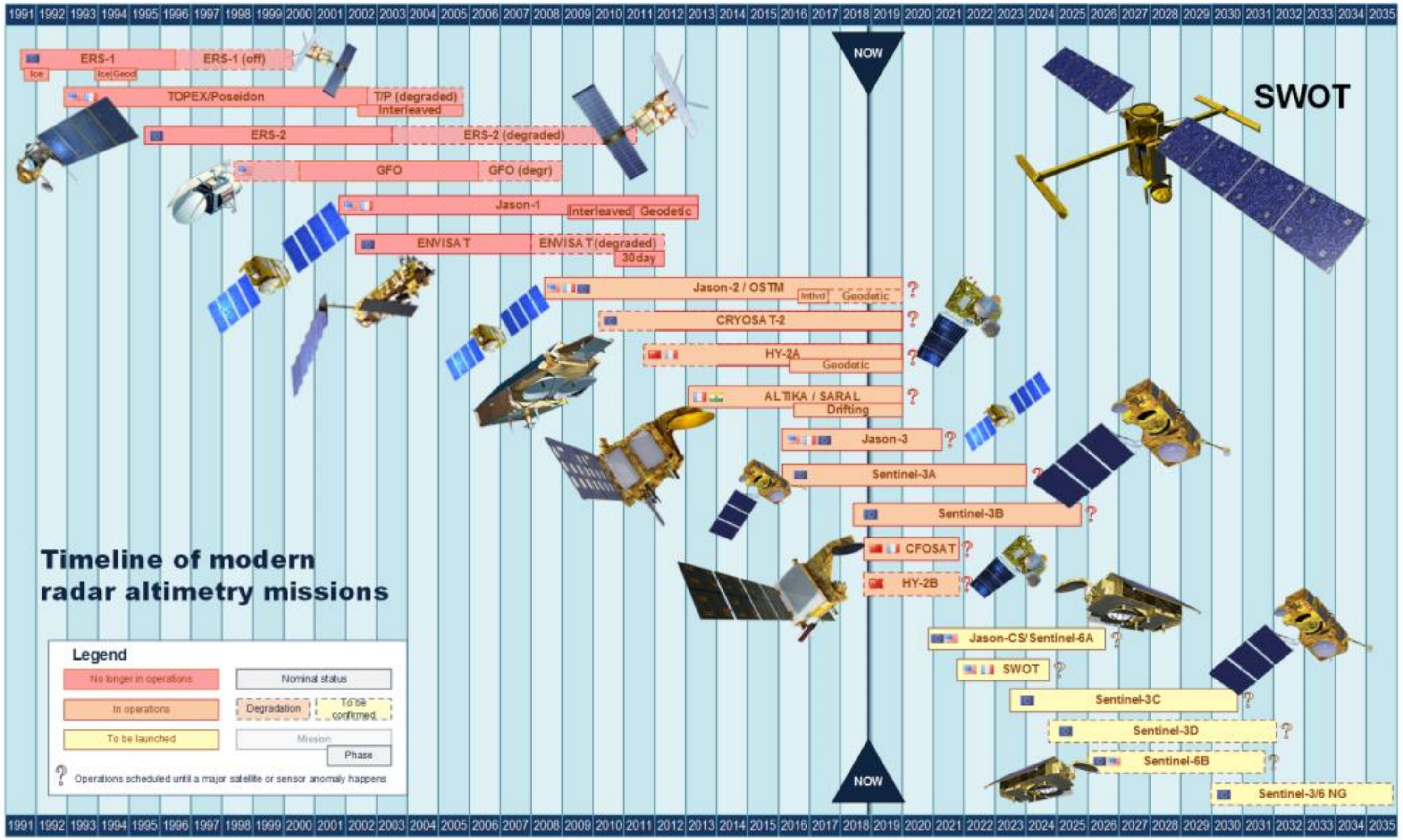
(1) Babette Christelle TCHONANG and (2) Pierre-Yves LE TRAON.

(1) NASA Jet Propulsion Laboratory

(2) Mercator Ocean international

Altimetry satellites

Providing sea level measurements since 1992



Chronology of altimetry missions (G. Dibarboure)

Major contribution of these measures:

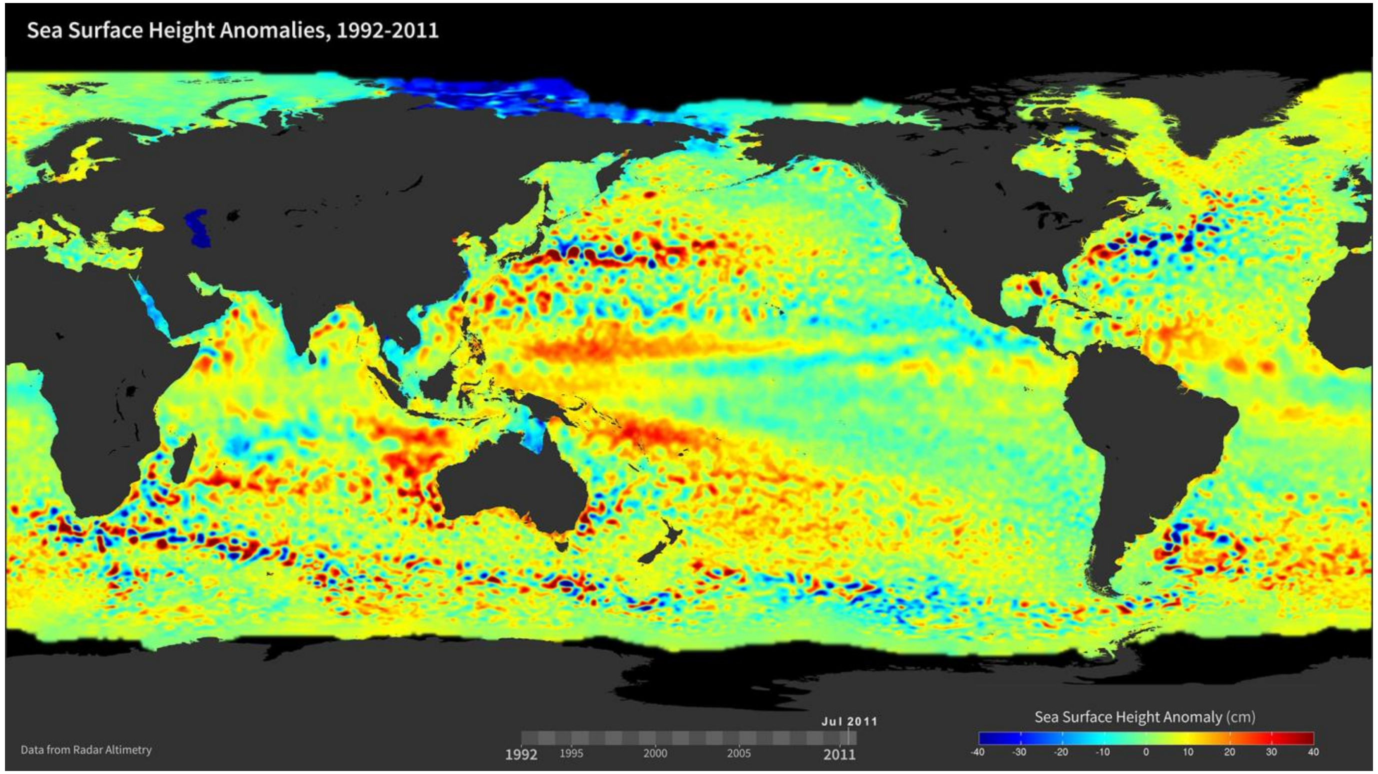
- **Understand**
- **Predict**
- **Modeling** … the global ocean (Le Traon et al., 2017)

Altimetry satellites

❖ Integrated Multi-Mission Ocean Altimeter Data: 1992 -2011

- ✓ TOPEX/Poseidon (T/P)
- ✓ Jason-1 (J1)
- ✓ Ocean Surface Topography Mission/Jason-2 (OSTM)
- ✓ Jason-3 (J3)

$$anomalies = SSH(x,y,t_i) - \frac{1}{N}\sum_{i=1}^{N} SSH(x,y,t_i)$$



Combination of missions : at least 4 altimeters are needed

- ➢ Representation of large and mesoscale ocean dynamics (Chelton et al., 2011).
- ➢ Ocean analysis and forecasting system (Hamon et al., 2019).

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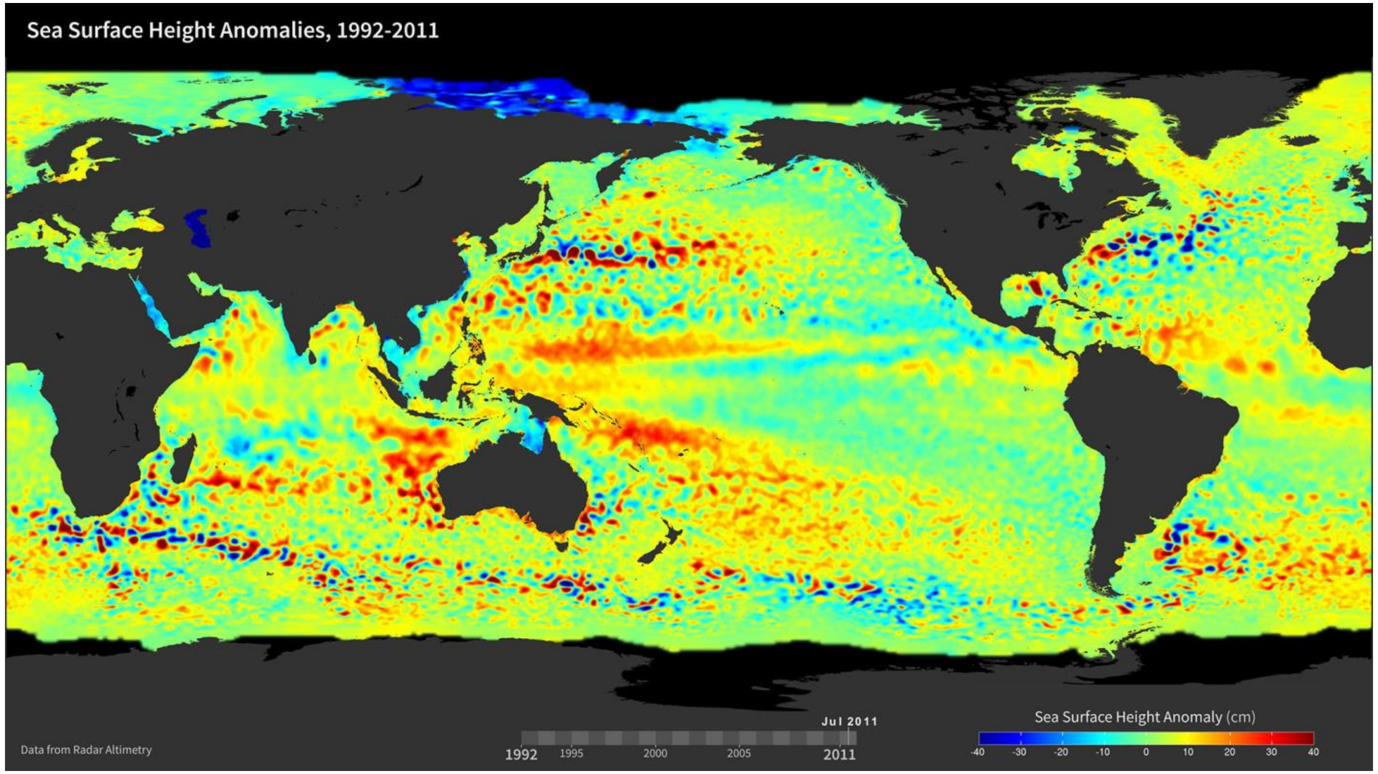

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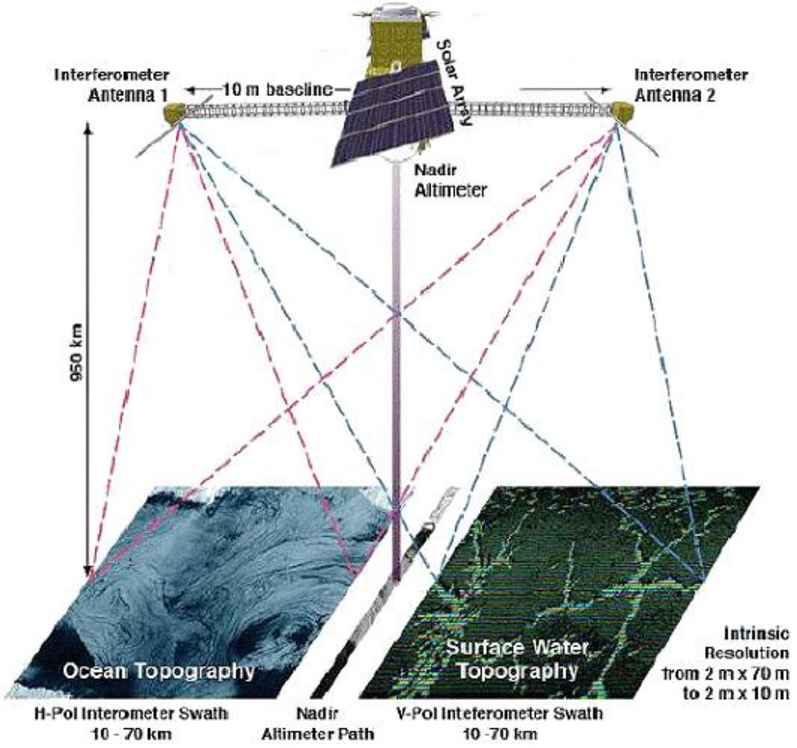
Limitation : **spatial resolution**

- Distance between tracks too large
- Representation of wavelengths > 200 km only

The future SWOT mission

- **Mission developed in the framework of the cooperation between NASA and CNES with contributions from the space agencies of Canada and the United Kingdom.**
  - **Launch: early December 2022**
  - **Brings together two communities: Oceanographers and hydrologists focused on a better understanding of the world's oceans and its terrestrial surface waters**



Principle of operation of the SWOT satellite ©NASA

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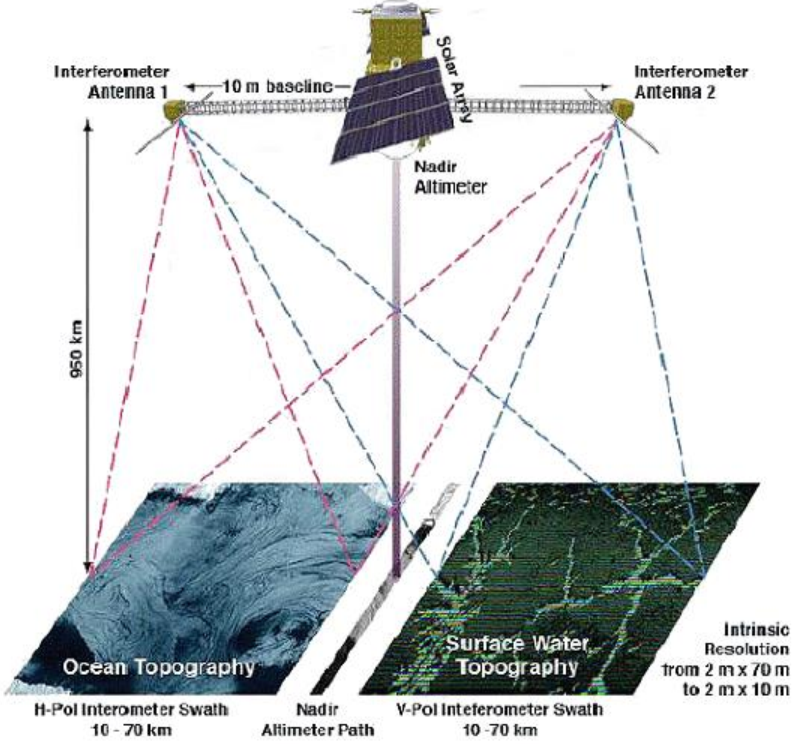
Measurement characteristics:

- **Mowings: 2X 60 km wide**
- **Repeat cycle: ~=21 days**
- **Revisit time: 10 days at the equator to a few days at the poles,**
- **Orbit not synchronized with the sun with an inclination of 78°**



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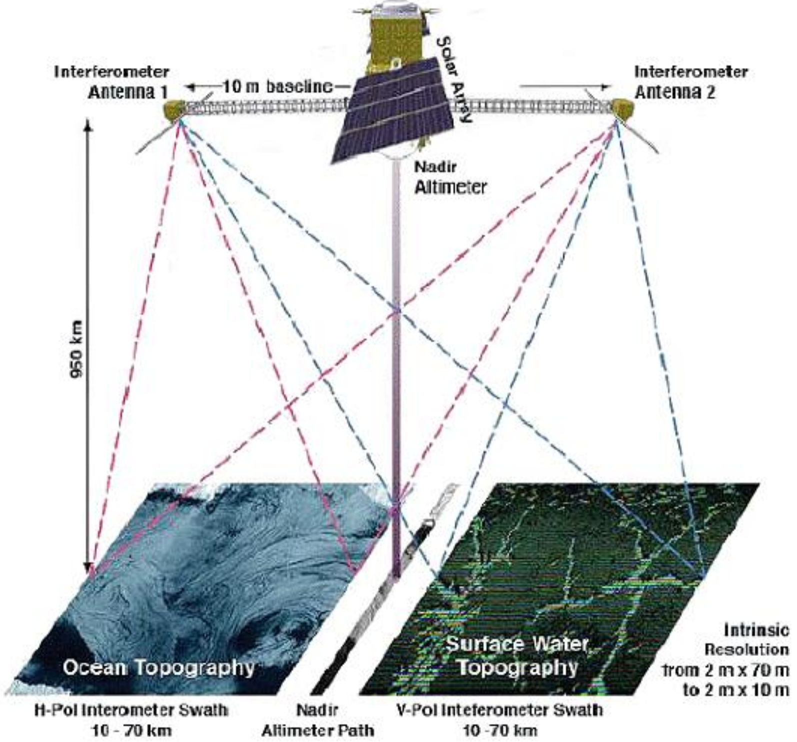
- **2D sea level measurement (SSH)**
- **Unprecedented spatial resolution up to 15 km**
- **Larger spatial coverage of data**
- **Representation of ocean mesoscale and sub-mesoscale variability (Wang et al., 2019)**



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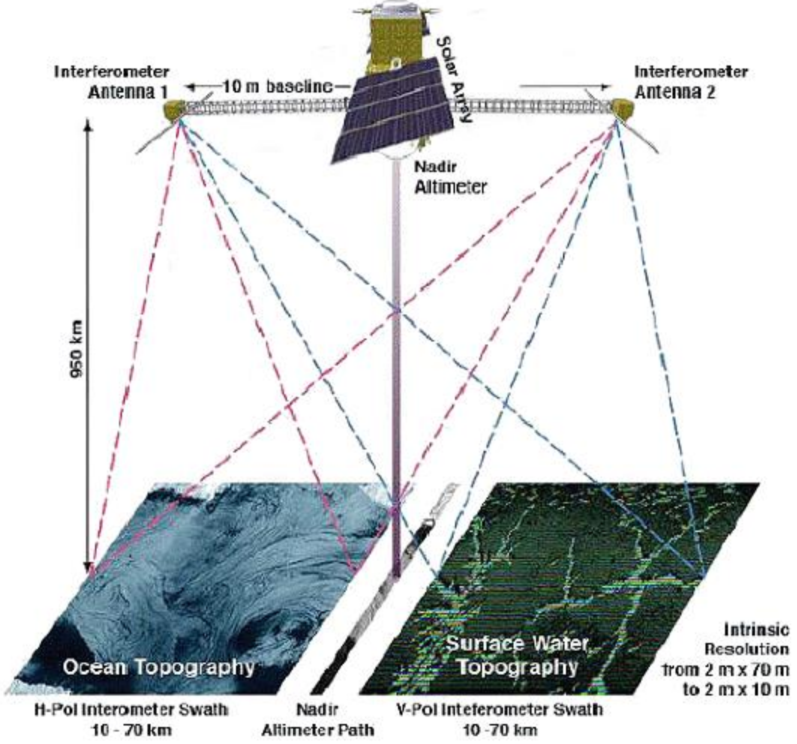
Limitation: Time resolution ➔ not sufficient to capture small scales that evolve rapidly over time

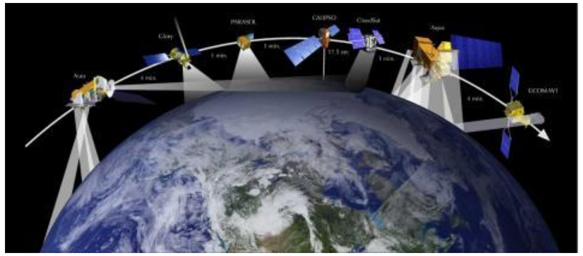


Principle of operation of the SWOT satellite ©NASA

The future SWOT mission

What impact will SWOT have on operational oceanography at the global and coastal levels?

Global ocean data



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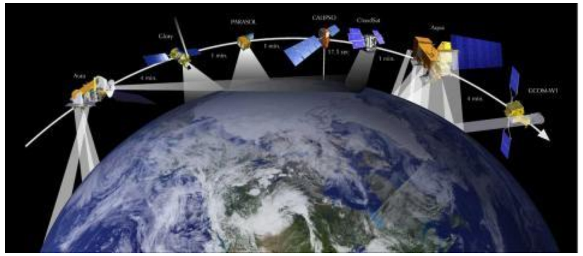

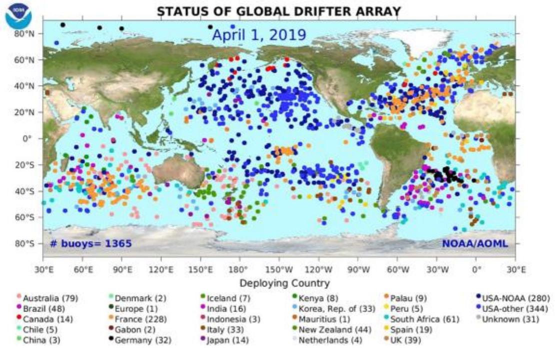

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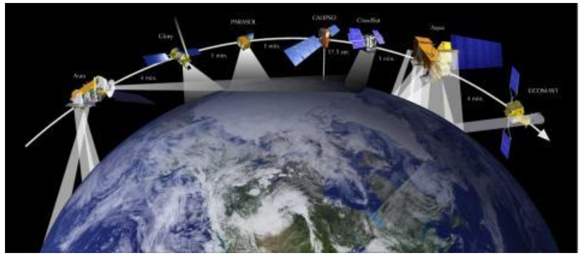

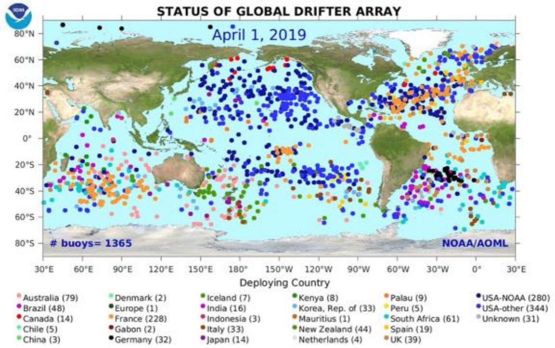

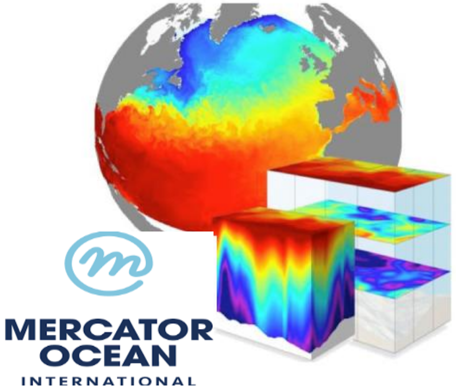

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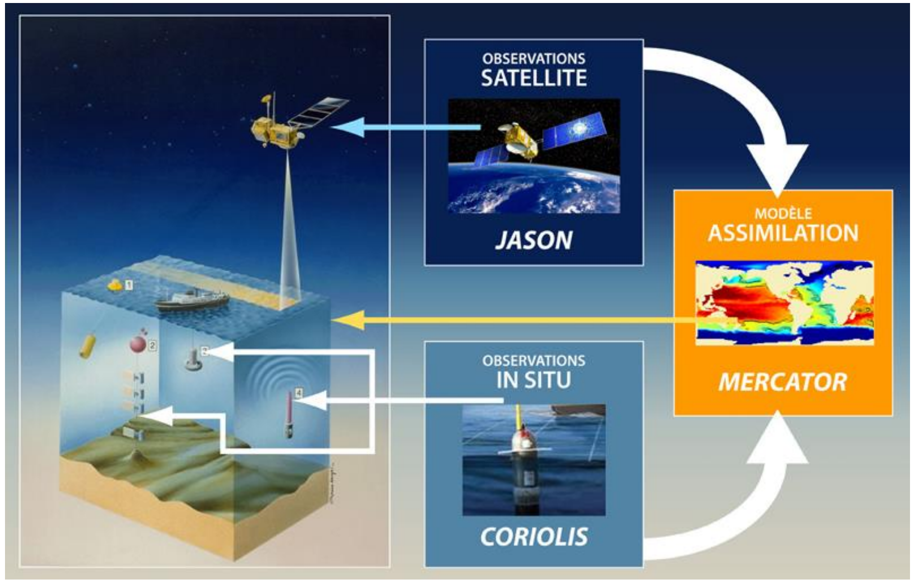
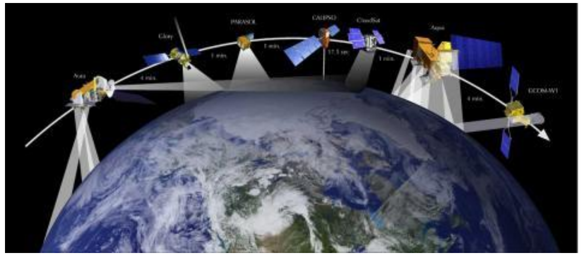
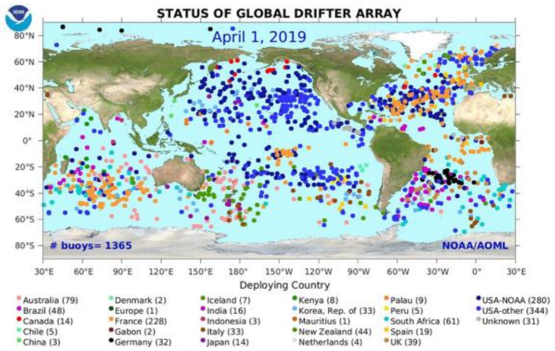
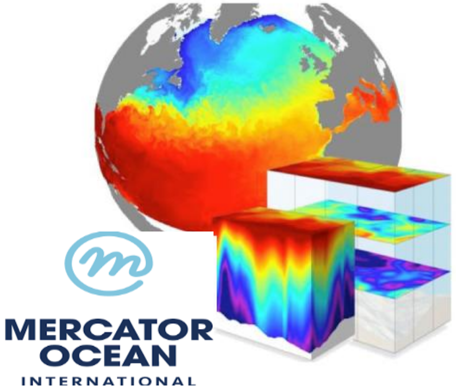


Data assimilation: combine **satellite and in situ observations and high-resolution numerical models** to provide an efficient approach to best-estimate the true state of the ocean in space and time.



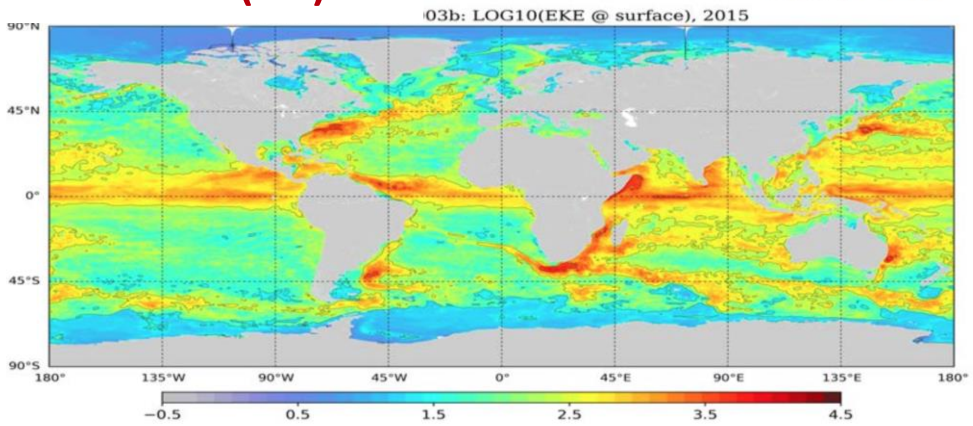




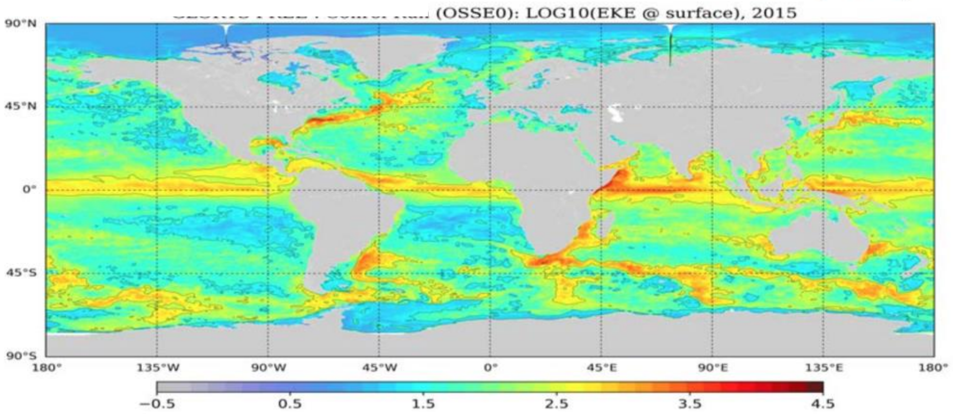
PhD work: impact of SWOT on ocean analysis and forecasting

Step 1: Simulate NR and FR (≠ oceanic state).

Nature Run (NR) EKE (2015)



Free Run (FR): OSSE0 EKE (2015)



Step 2: Generate synthetic obs

NR: synthetic observations

- **In-situ: position /date = obs. CORA4 of Coriolis**
- **SST: 1/4° weekly card L4**

Satellite observations:

- 3 Nadir: Jason3, Sentinel 3A et 3B ➔ 3cm error
- SWOT ➔ KaRIn noise (JPL' simulator, 7km X 7km)

Assimilation system: SAM2 (système d'assimilation mercator)
Assimilation cycle: 7 days

OSSE: Observing System Simulation Experiment

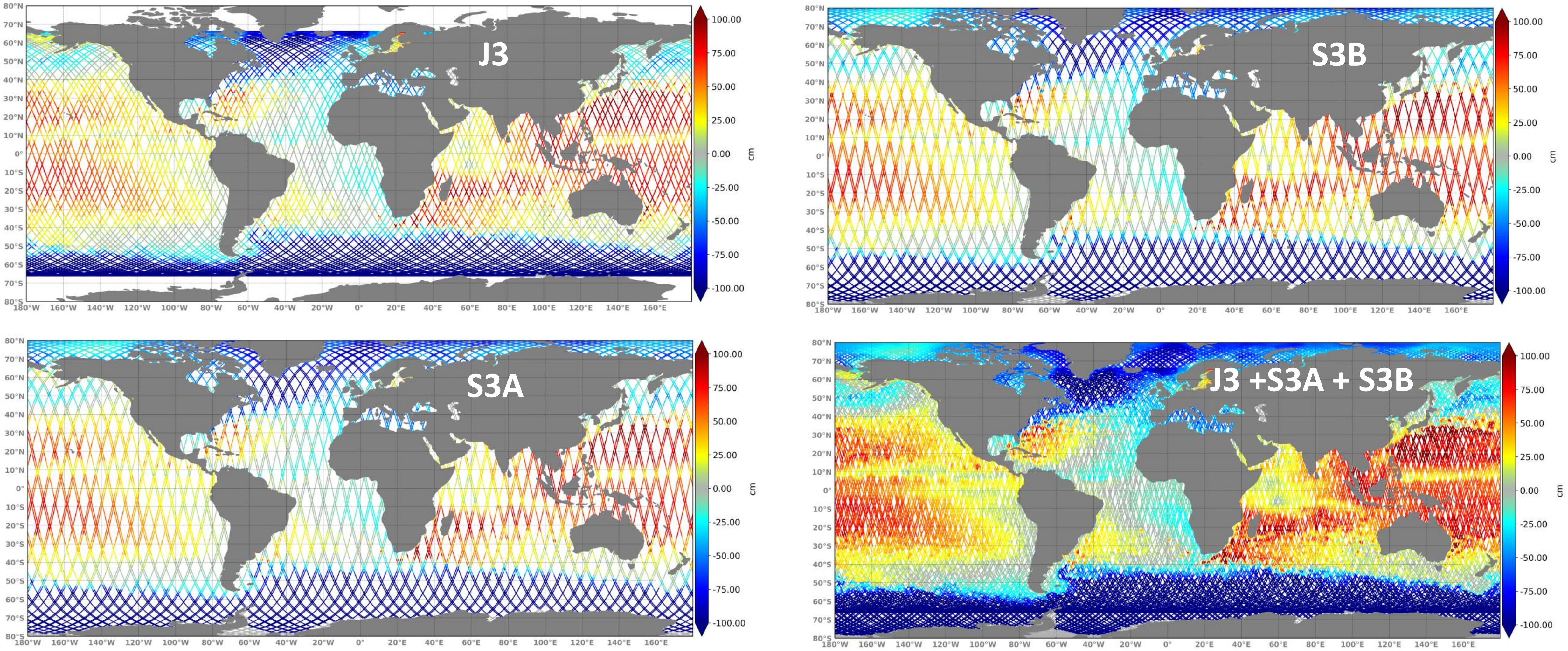
Step 3: Assimilate the obs in the FR

OSSE1 (3Nadir),
OSSE2 (SWOT), OSSE3 (SWOT + 3Nadir)

Step 4: Compare to NR

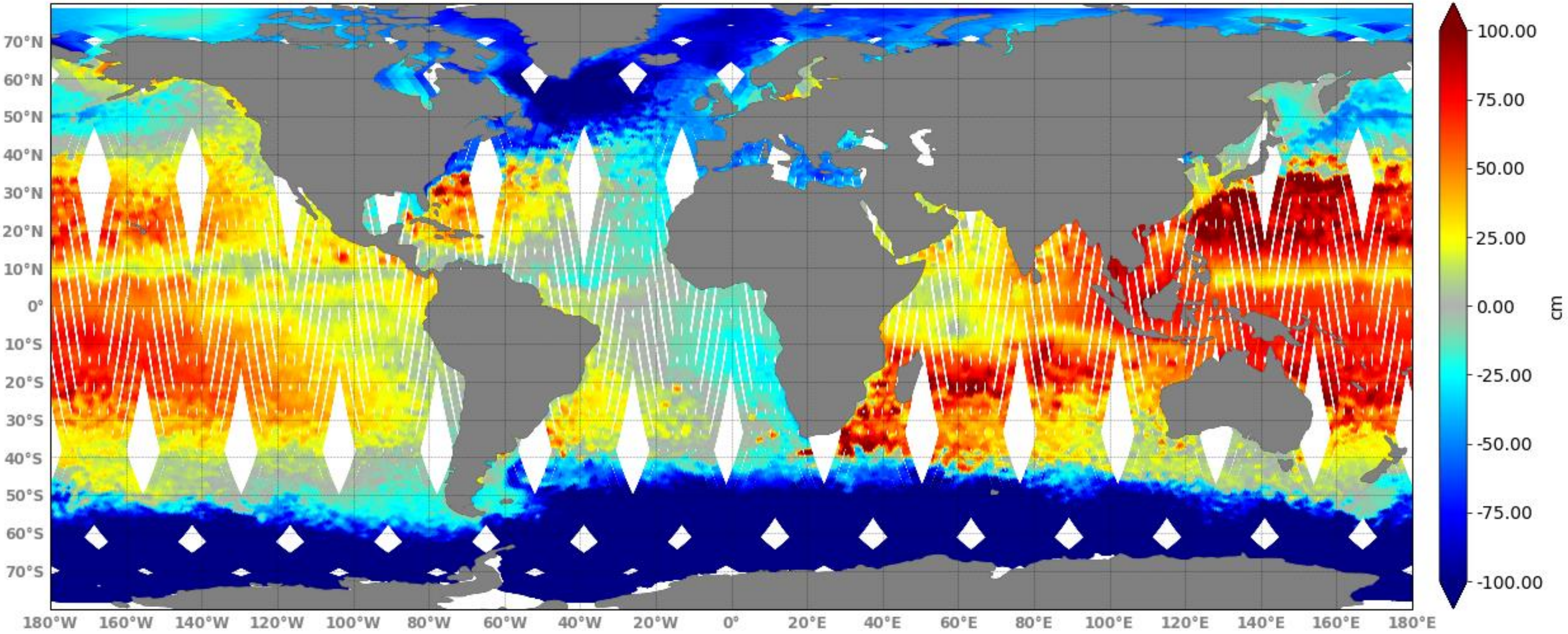
Simulation of observations

❖ **Nadir altimeters: 01-07/01/2015: simulated SSH data**



Simulation of observations

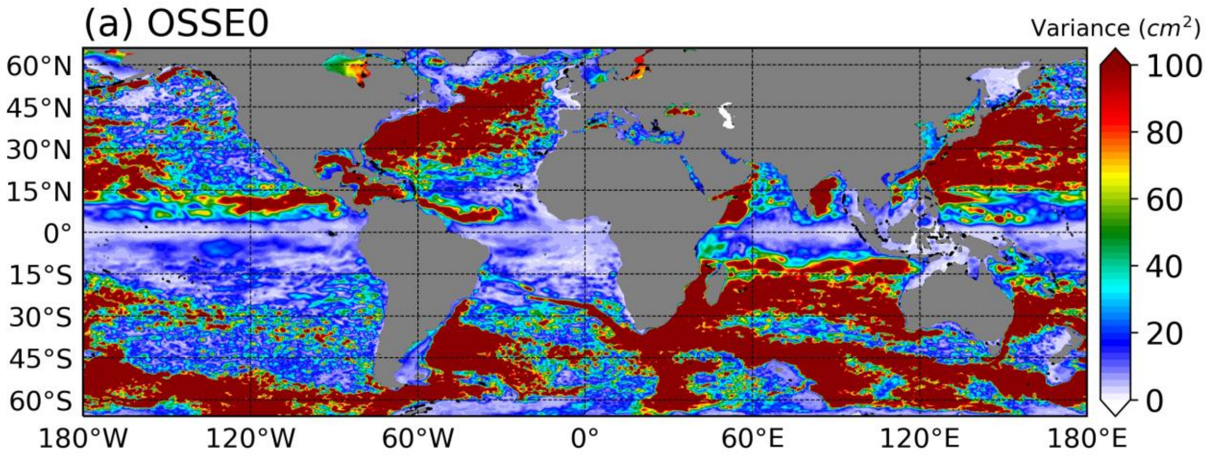
- ❖ **The SWOT satellite: 01-07/01/2025: simulated data from SSH**

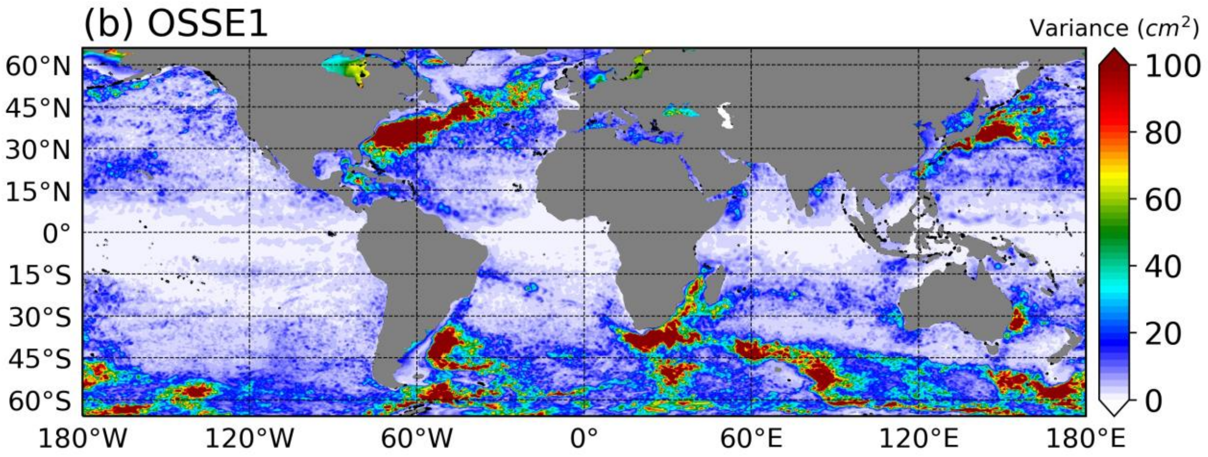


Results: Impact on SSH (Sea Surface Height)

OSSE0 ➔ FR
OSSE1 ➔ 3 Nadir

❖ **SSH analysis error variance (NR –OSSE0,1)**





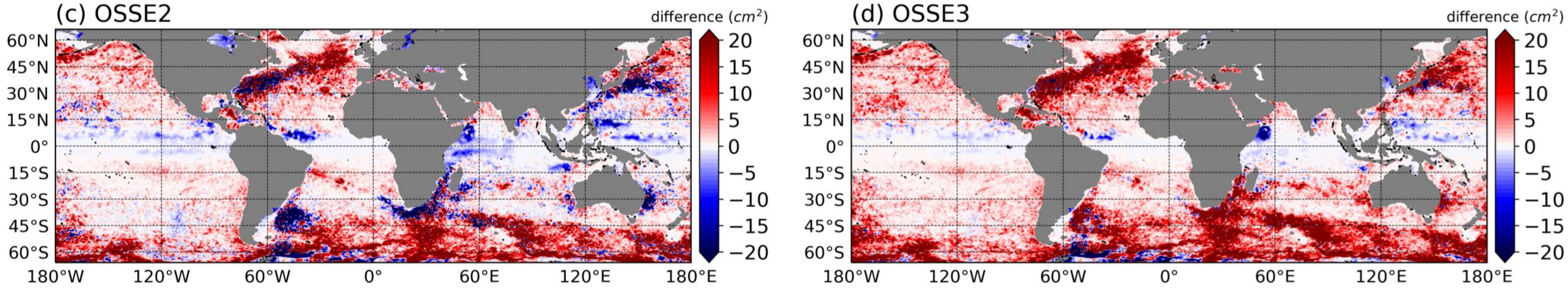
- **OSSE0:** high error value almost everywhere ➔ **NR and FR are decorated**

- **OSSE1:** considerable reduction of the analysis error

Results: Impact on SSH (Sea Surface Height)

- **Difference: Var SSH(OSSE1) – Var SSH(OSSE2, 3)**
- **Color red (blue) ➔ improvement (degradation)**

OSSE1 ➔ 3 Nadir
OSSE2 ➔ SWOT
OSSE3 ➔ SWOT + 3 Nadir



- **OSSE2:** SSH improvement in high latitudes ➔ **high data density**
- **OSSE2:** SSH degradation in the equatorial band, and western edge currents ➔ **fast dynamic < 21 days**
- **OSSE3:** reduction or significant suppression of the degradation observed in OSSE2

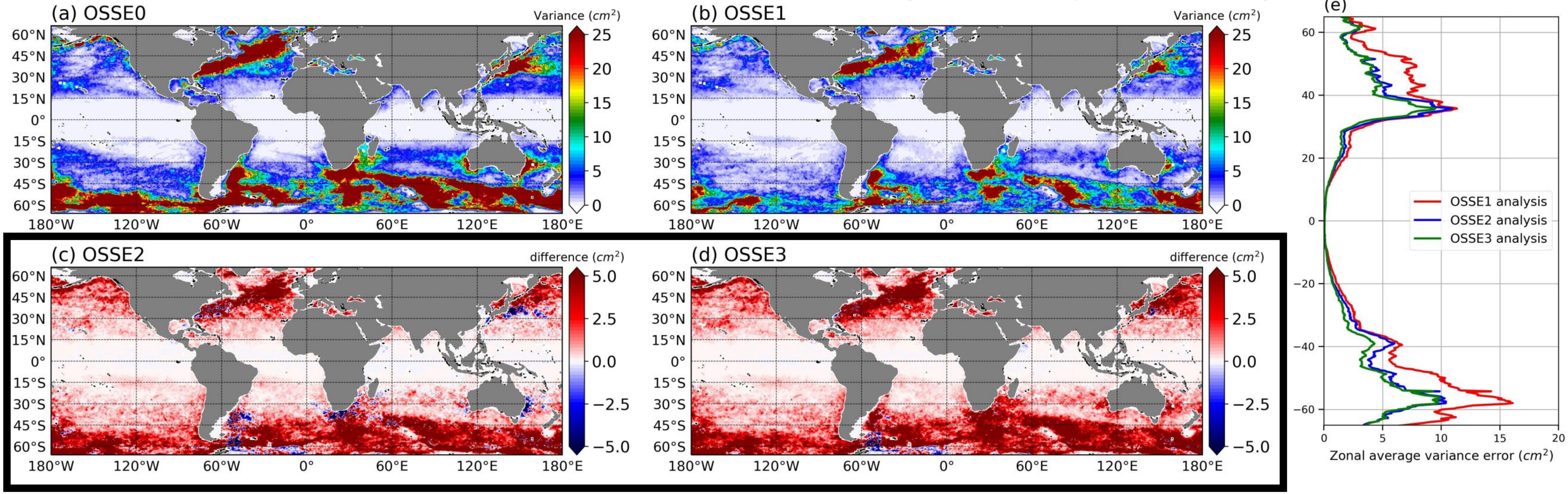
The joint assimilation of SWOT and 3nadir observations provided the best performance almost everywhere.

Results: Impact on SSH filtered at 200 km

- ❖ **SSH error variance: OSSE0 and 1**
- ❖ **Difference: Var Error OSSE1 - Var Error OSSE2 and 3**

✓ **Equatorial band ➔ signal < 200 km is weak**

✓ **High latitude ➔ space-time coverage of SWOT is denser**



Tchonang et al., 2021

By excluding equatorial and tropical regions (+/- 20°), OSSE3 reduces the global error of OSSE1 in the analyses by about 40%.

OSSE1 ➔ 3 Nadir

OSSE2 ➔ SWOT

OSSE3 ➔ SWOT + 3 Nadir

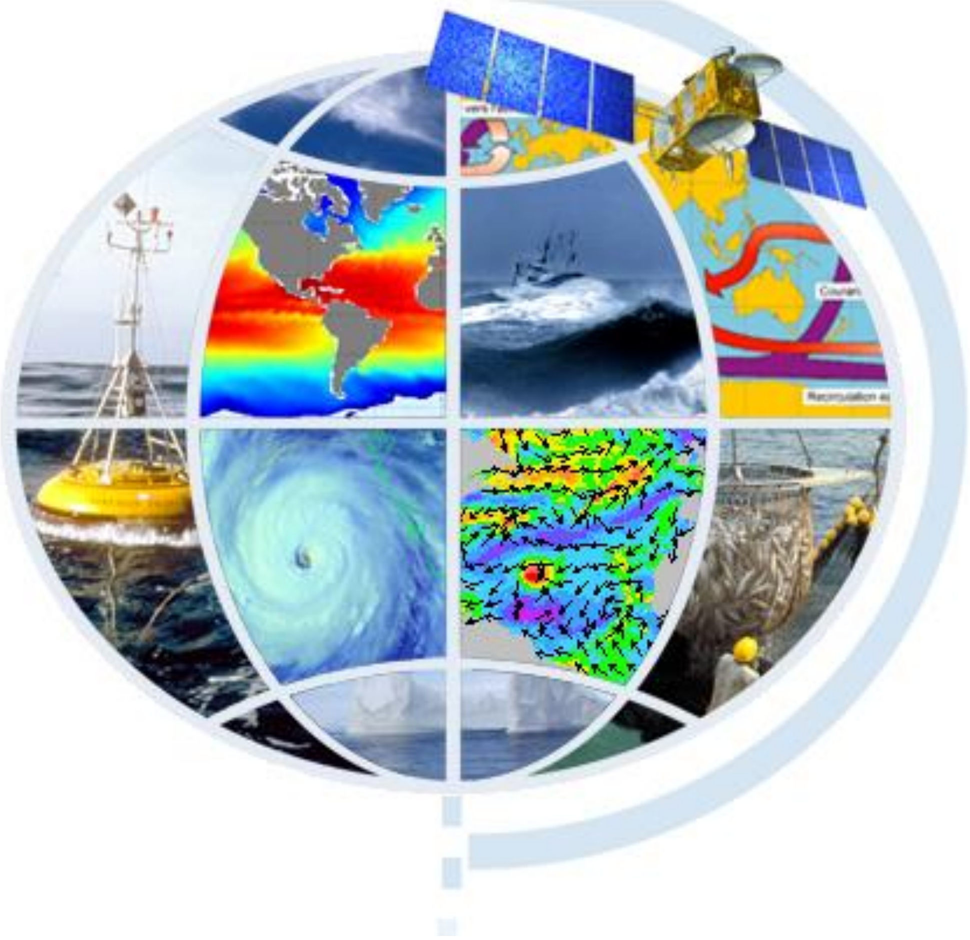
Take home message

- ✓ **SWOT observations will allow assimilation systems to constrain spatial scales beyond what is currently achievable using a constellation of nadir altimeters.**
- ✓ **SWOT observations will have a significant improvement in the quality of ocean analyses and forecasts, therefore it will bring an breakthrough in operational oceanography.**

Applications of operational oceanography.

An integrated approach to describe and forecast the ocean in real time

- Warnings about coastal floods, storm impacts, harmful algal blooms and contaminants
- Electronic charts, sea state conditions, optimum routes for ships
- Prediction of primary productivity, ocean currents, ocean climate variability
- Modelling of and response to oil spills and dredging



Thank You.
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Contact: Tchonang@jpl.nasa.gov