Science Status: Ocean, Coasts, and Cryosphere

Ocean PIs

Thanks to WG leads for their contributions!

SWOT-ST Meeting
14-17 October 2025, Arcachon

Science Status: Ocean, Coasts, and Cryosphere

F. d'Ovidio, T. Farrar, L.-L. Fu

Dedicated session this afternoon

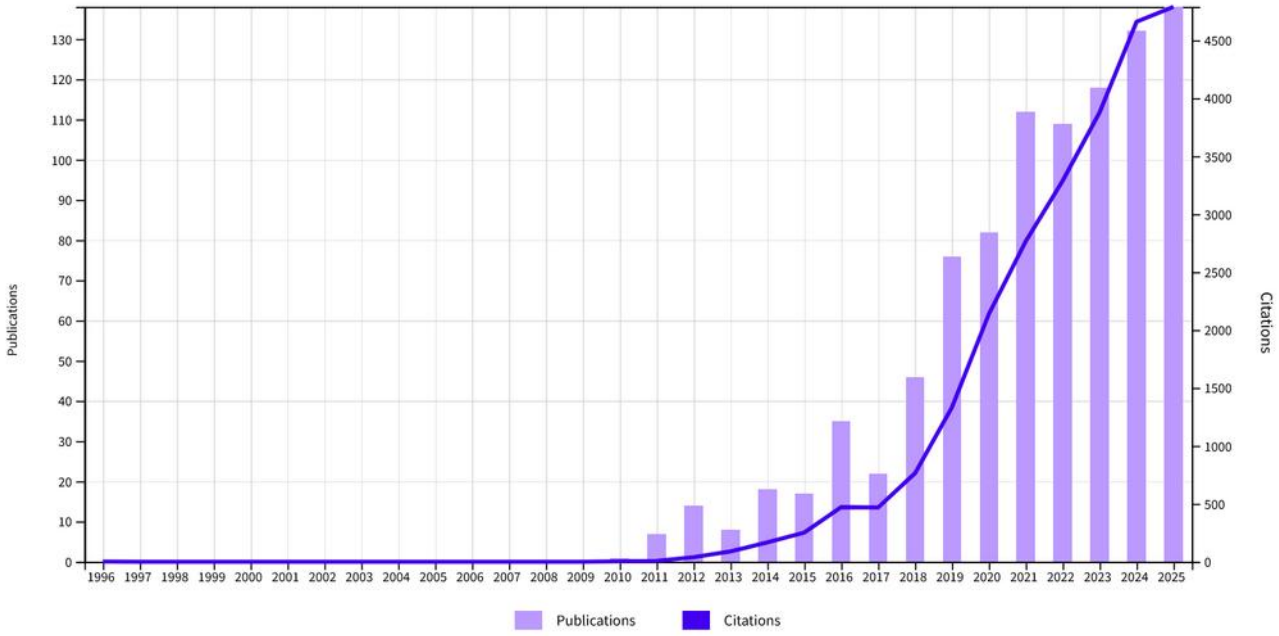
SWOT-ST Meeting
14-17 October 2025, Arcachon

Disclaimer

Too many beautiful results! This is not an exhaustive or even a representative account of what the SWOT ocean community is doing

Some bibliometrics

Articles citing Durand et al., (2010), Biancamaria et al. (2016), or Morrow et al. (2019) (Web of Science)

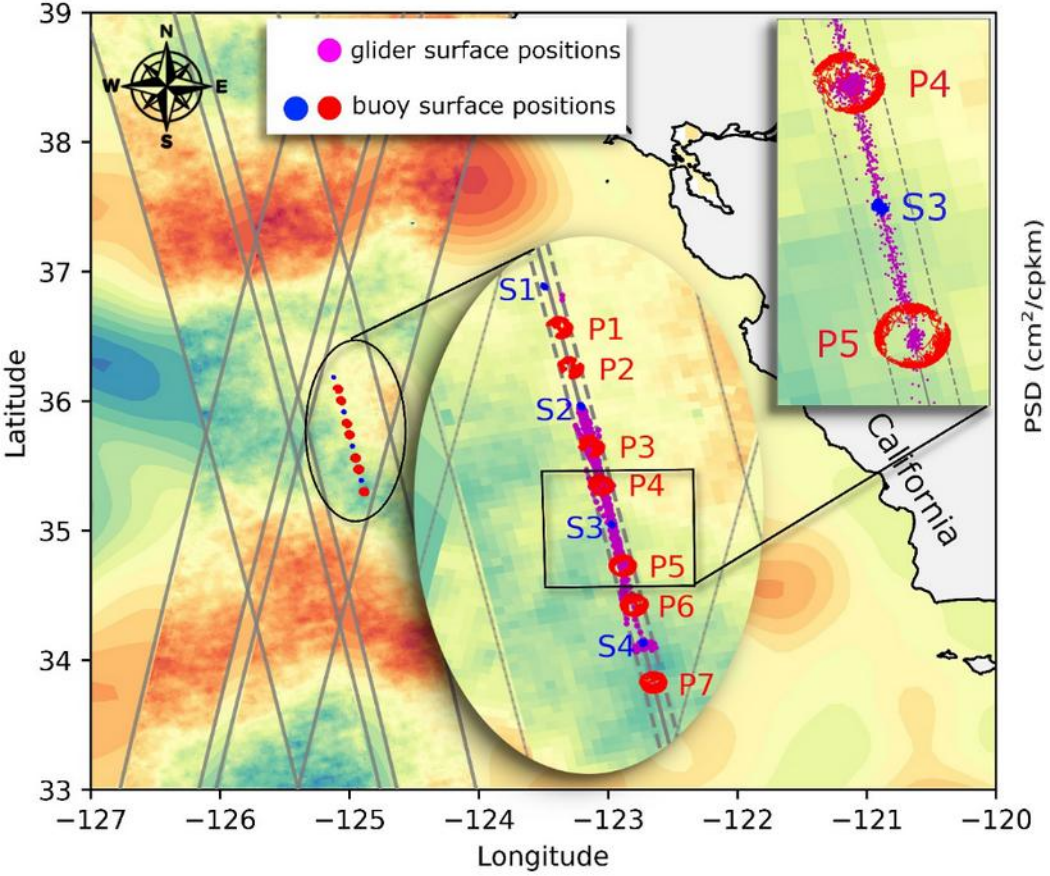


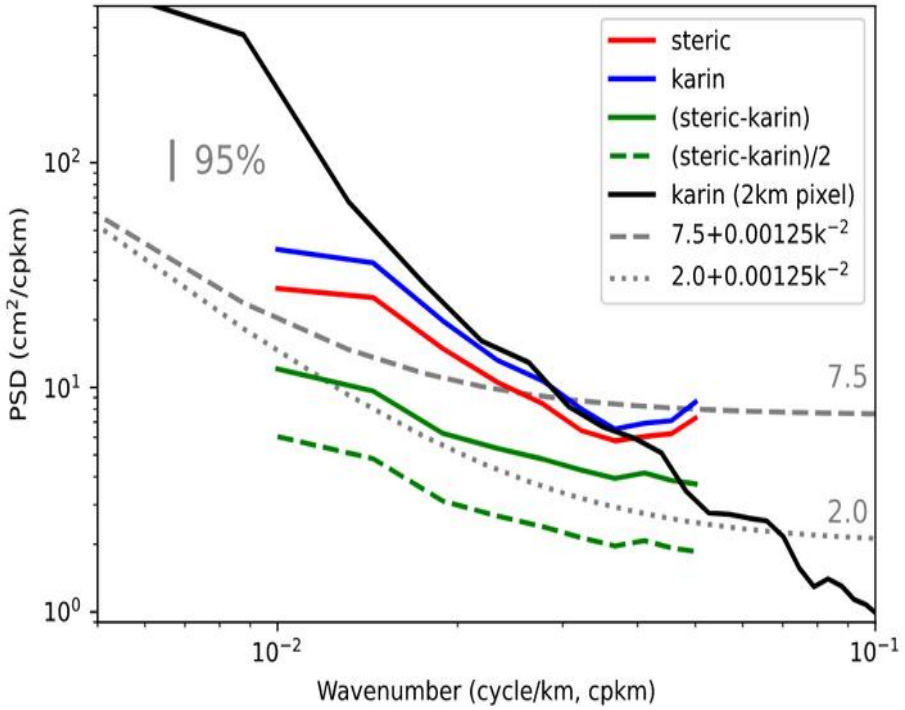
This workshop: 325 abstracts

OSM-2026: 62 abstracts at the SWOT session


Regional Validation

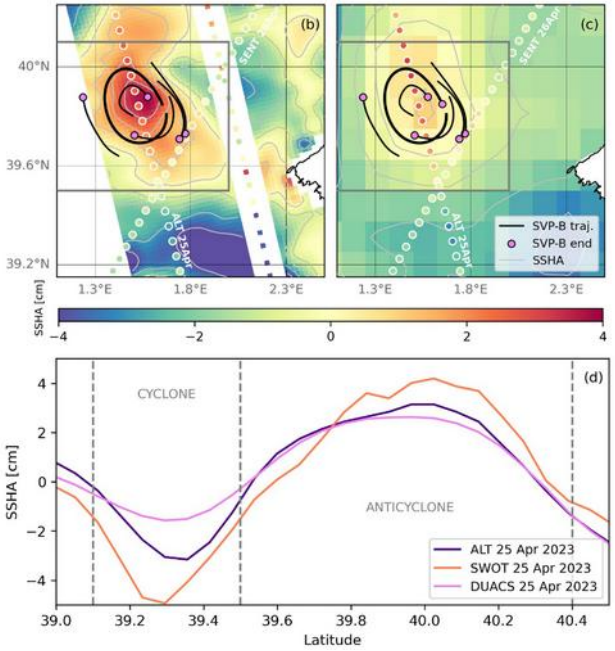
Validation of science requirements





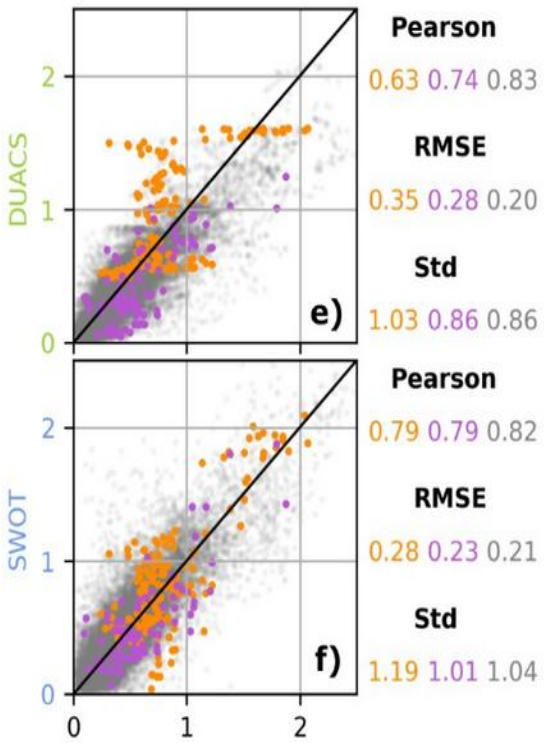
Wang et al., 2024

Other examples of regional validation



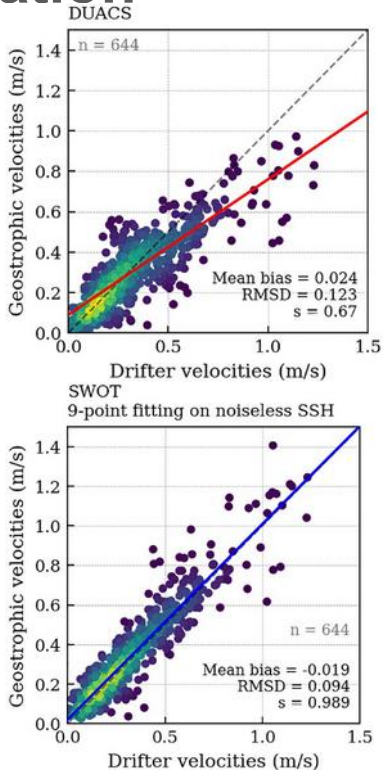
NW Mediterranean

Verger-Miralles et al. 2025



Agulhas

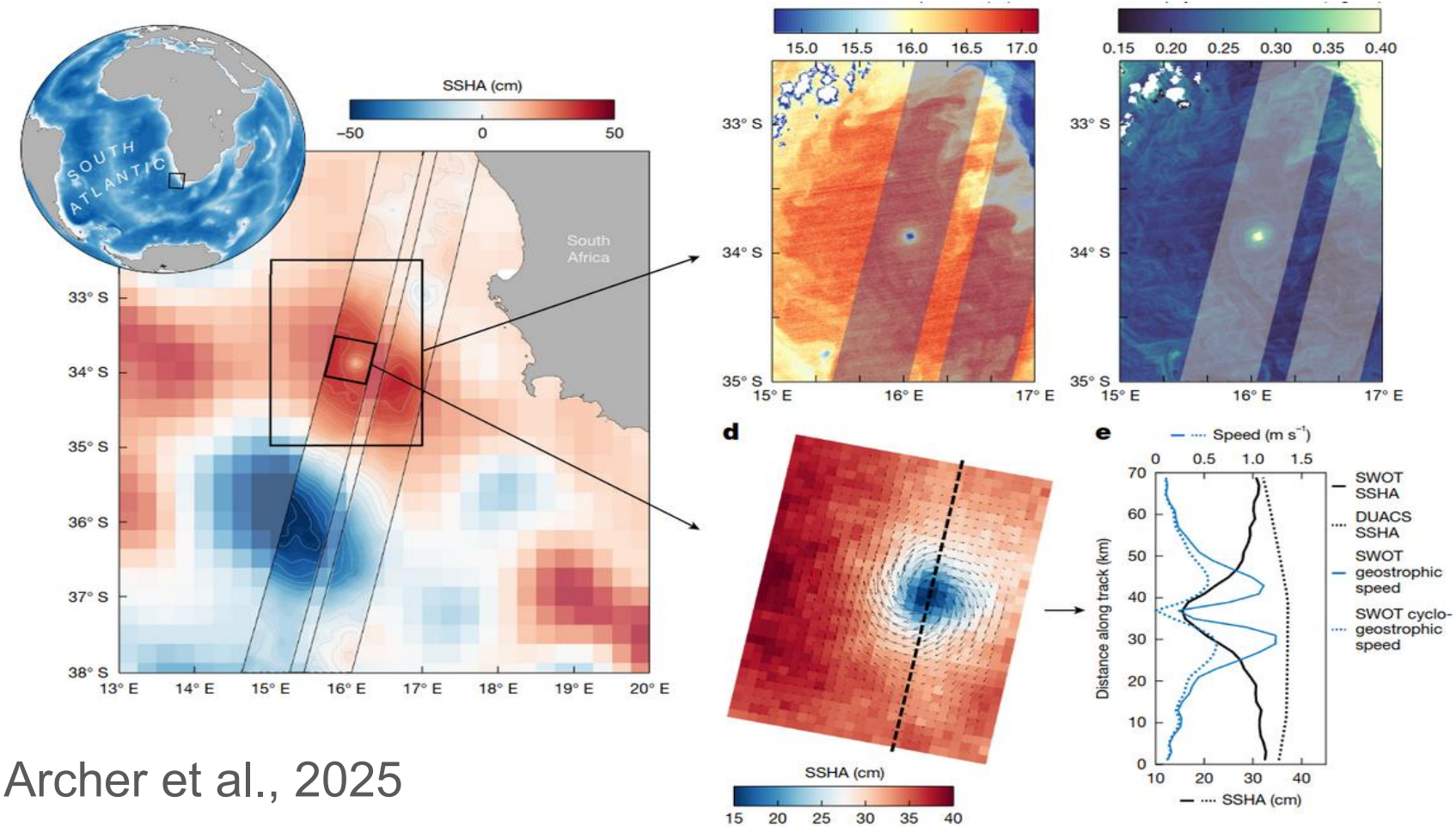
Coadou-Chaventon et al. 2025



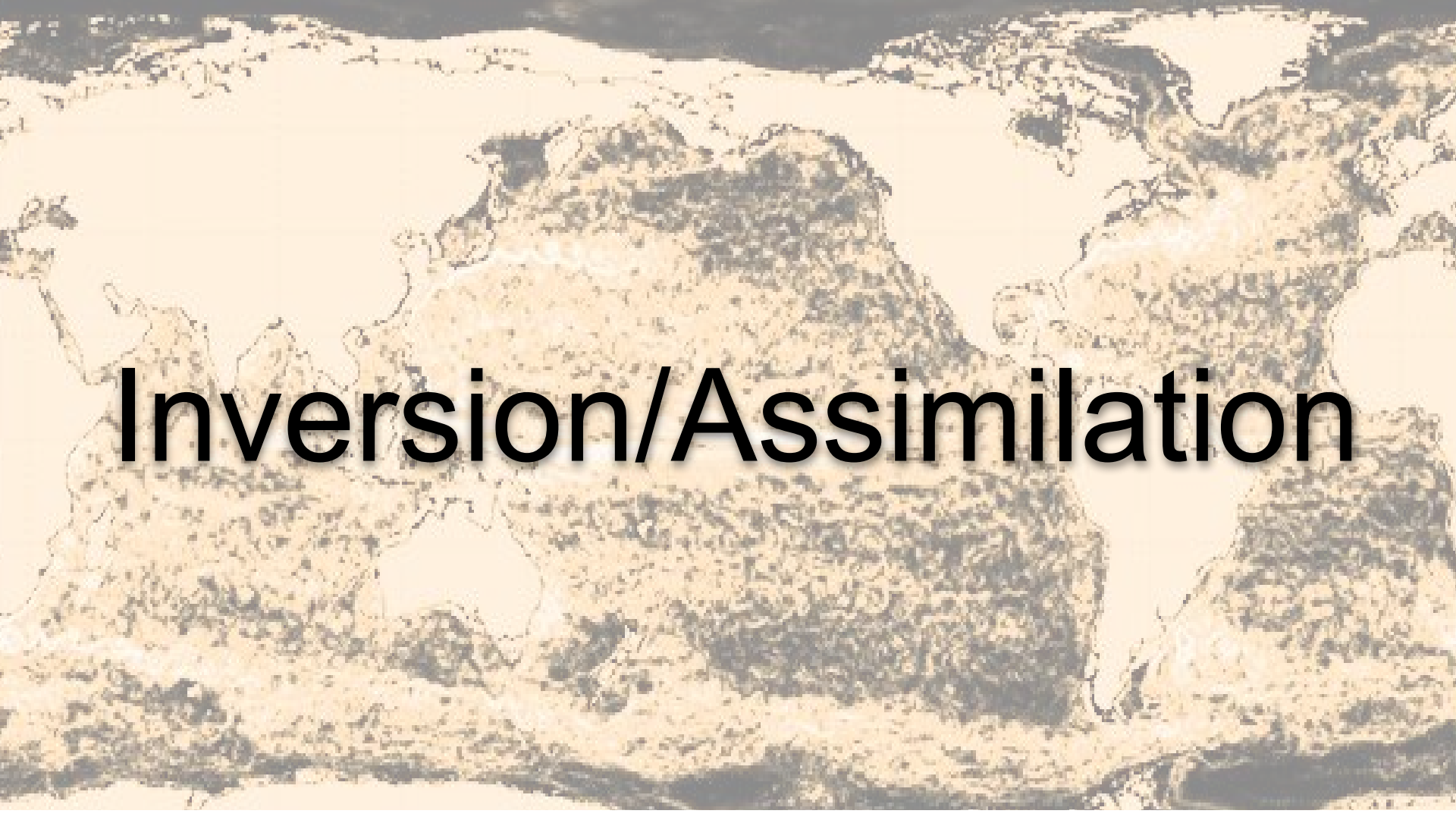
Antarctic Circumpolar Current

Tranchant et al. 2025

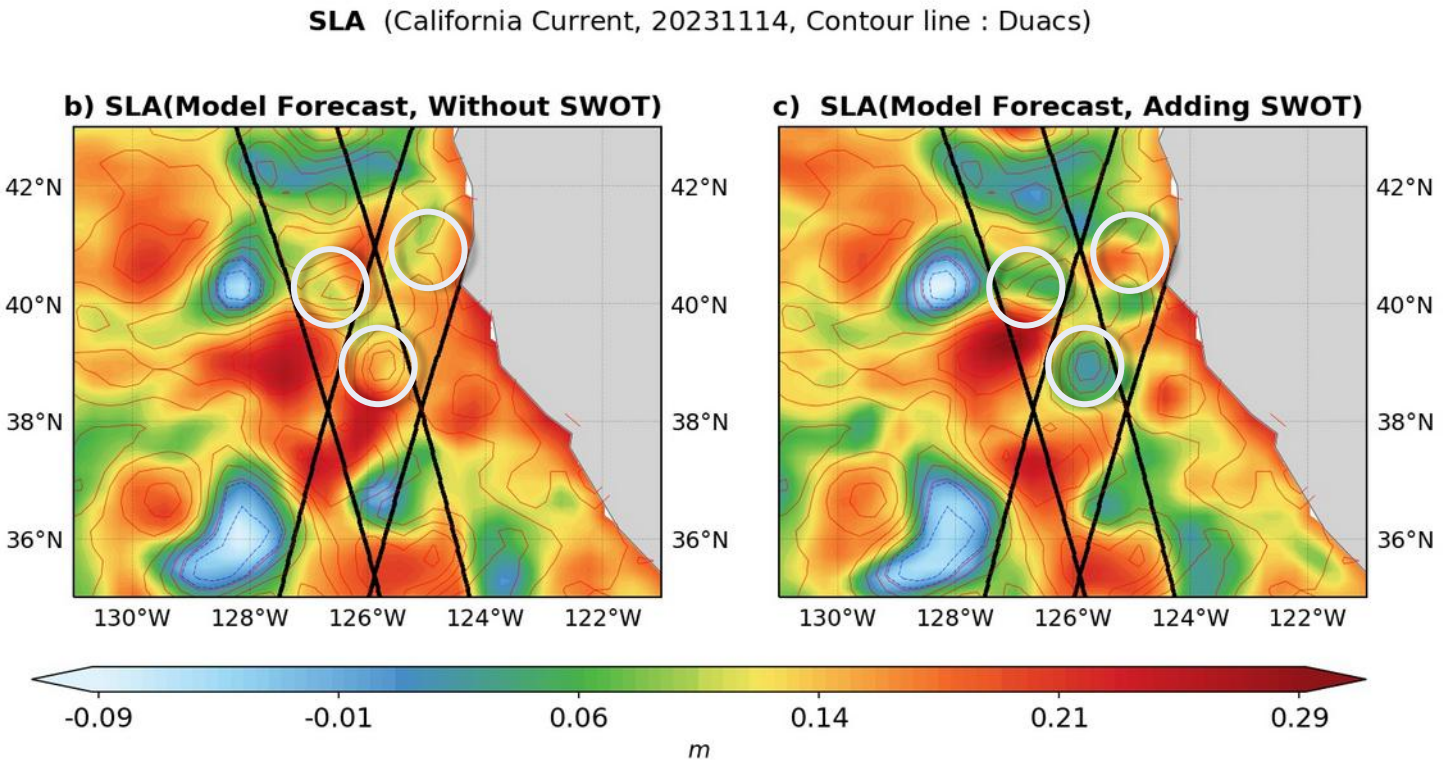
Going beyond the mesoscale



Archer et al., 2025

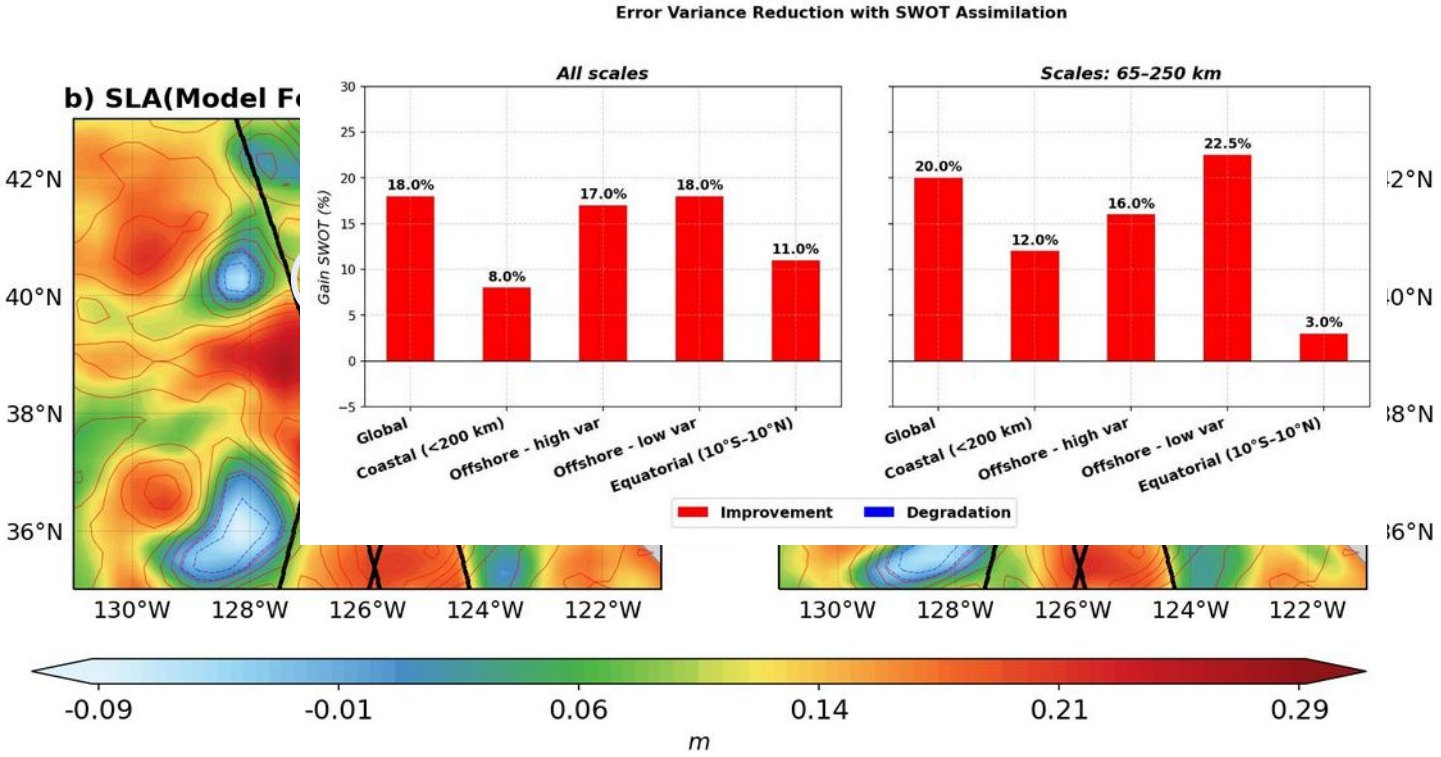

Inversion/Assimilation

Effects of including SWOT in assimilation (MERCATOR)

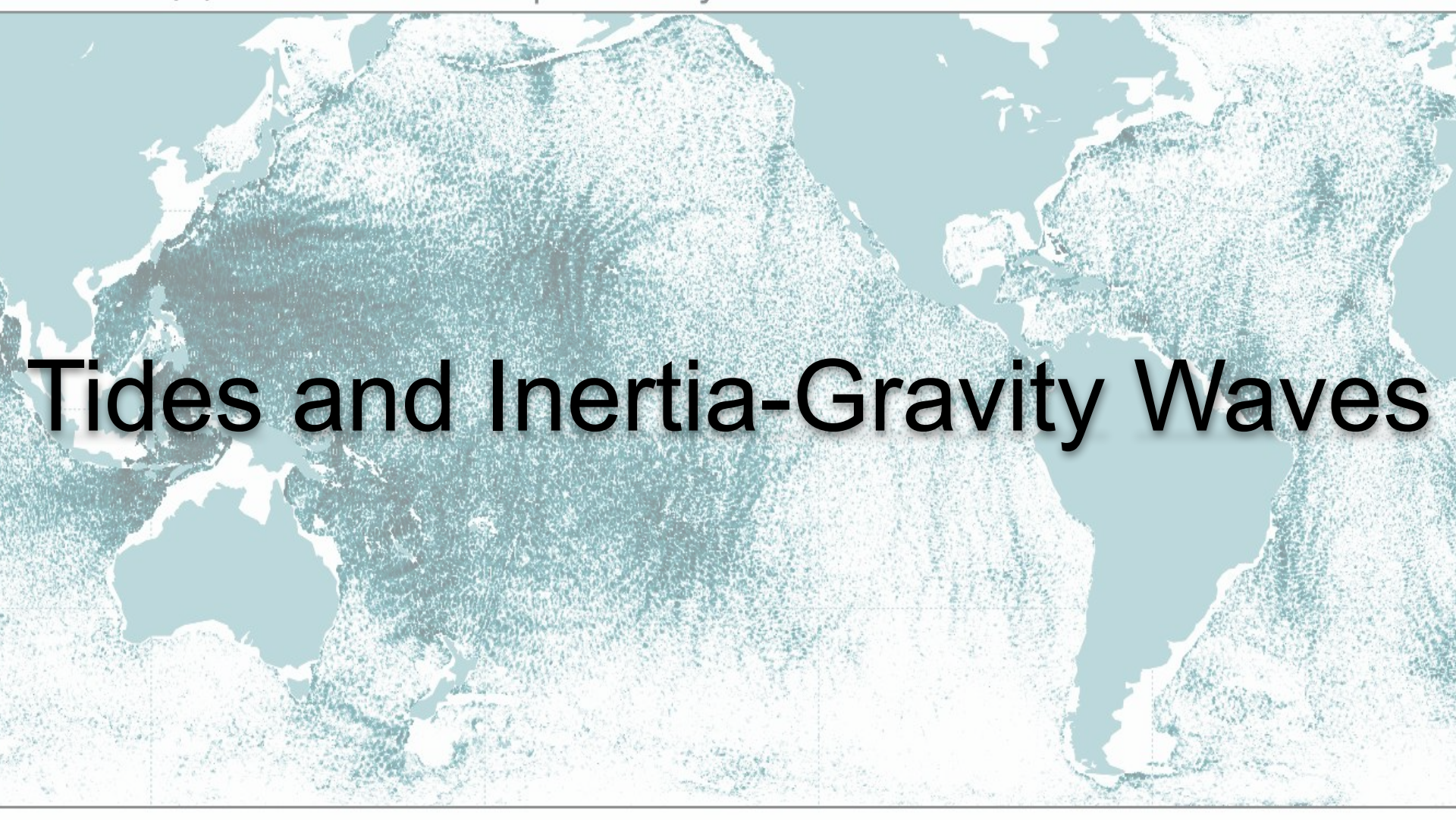


See M. Benkiran, E. Fouchet, P.-Y. Le Traon and E. Rémy talks/posters

Effects of including SWOT in assimilation (MERCATOR)



See M. Benkiran, E. Fouchet, P.-Y. Le Traon and E. Rémy talks/posters



Tides and Inertia-Gravity Waves

Validation of internal tides detected by SWOT off Amazonian coast

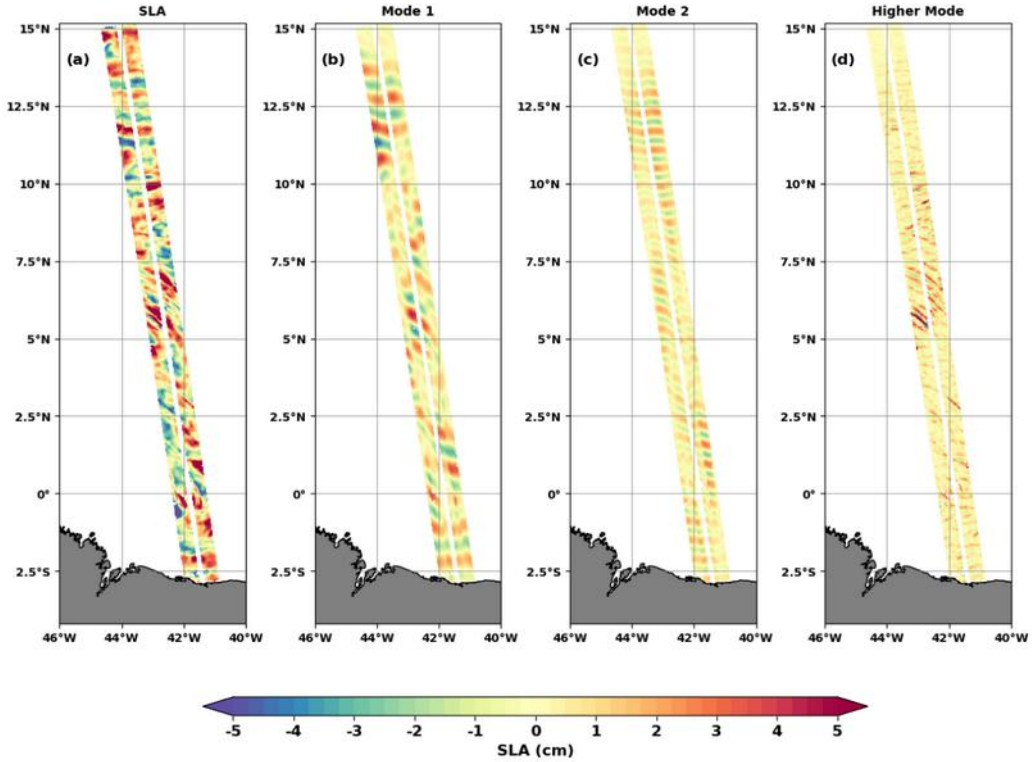
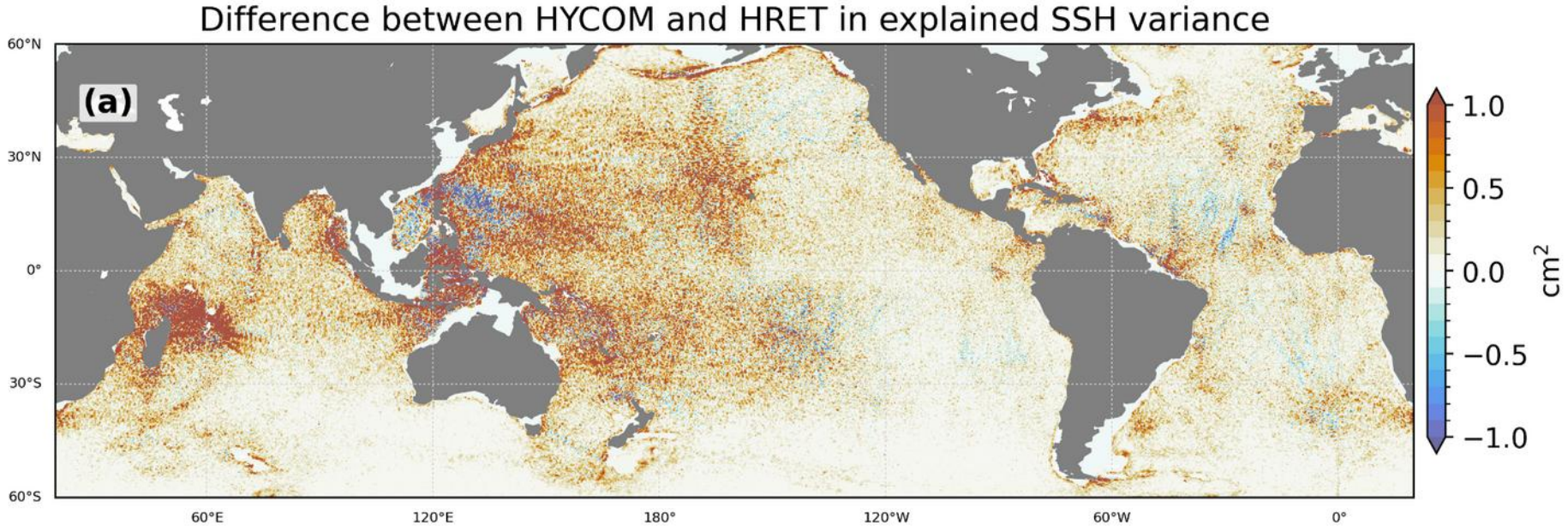


Figure 2. Snapshot of SWOT SLA on 8 April 2023. **(a)** Total SLA, **(b)** mode 1 FFT-filtered SLA (180–90 km), **(c)** mode 2 FFT-filtered SLA (80–60 km), and **(d)** higher-mode FFT-filtered SLA (50–2 km).

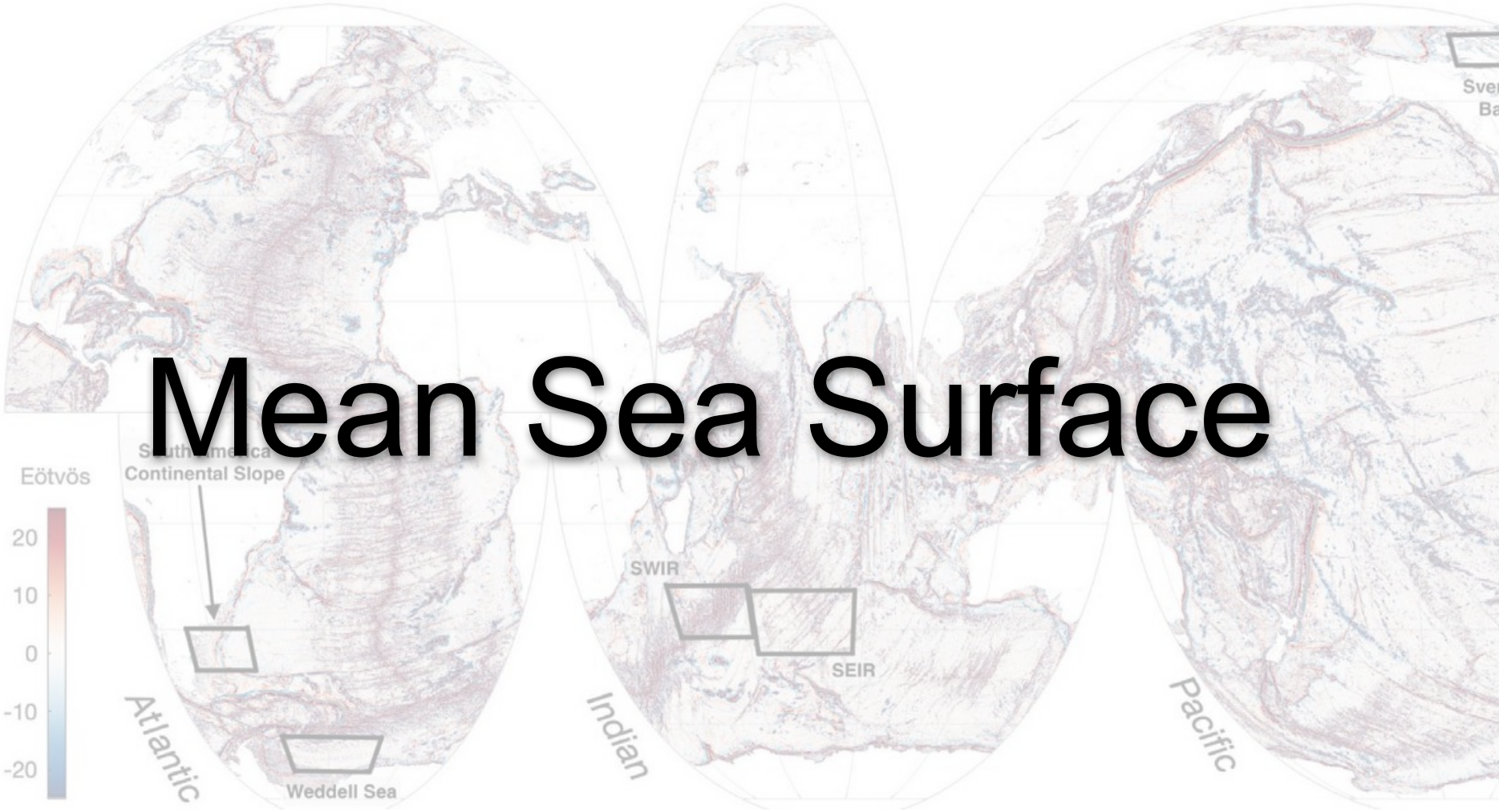
Tchilibou et al., 2025

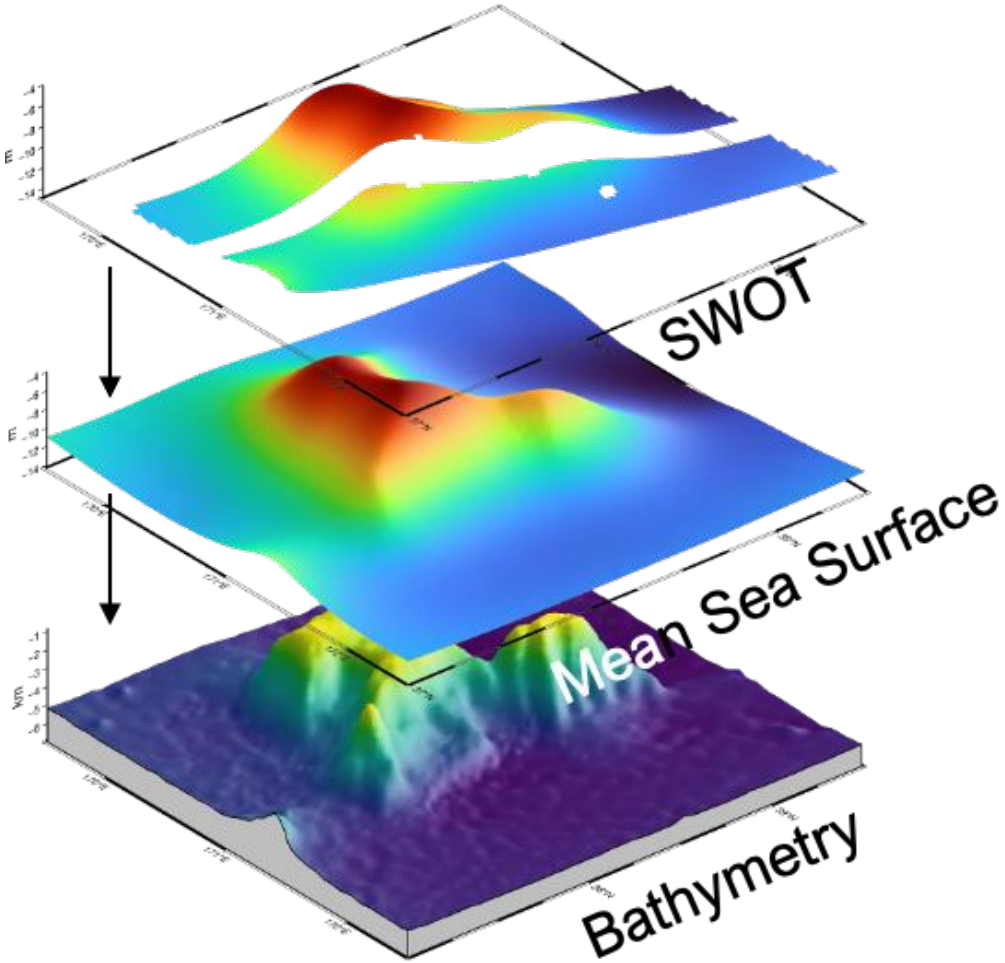
SWOT-models comparisons: HYCOM does 20% better than HRET in a one-on-one comparison



See Yadidya and Arbic presentation

Mean Sea Surface



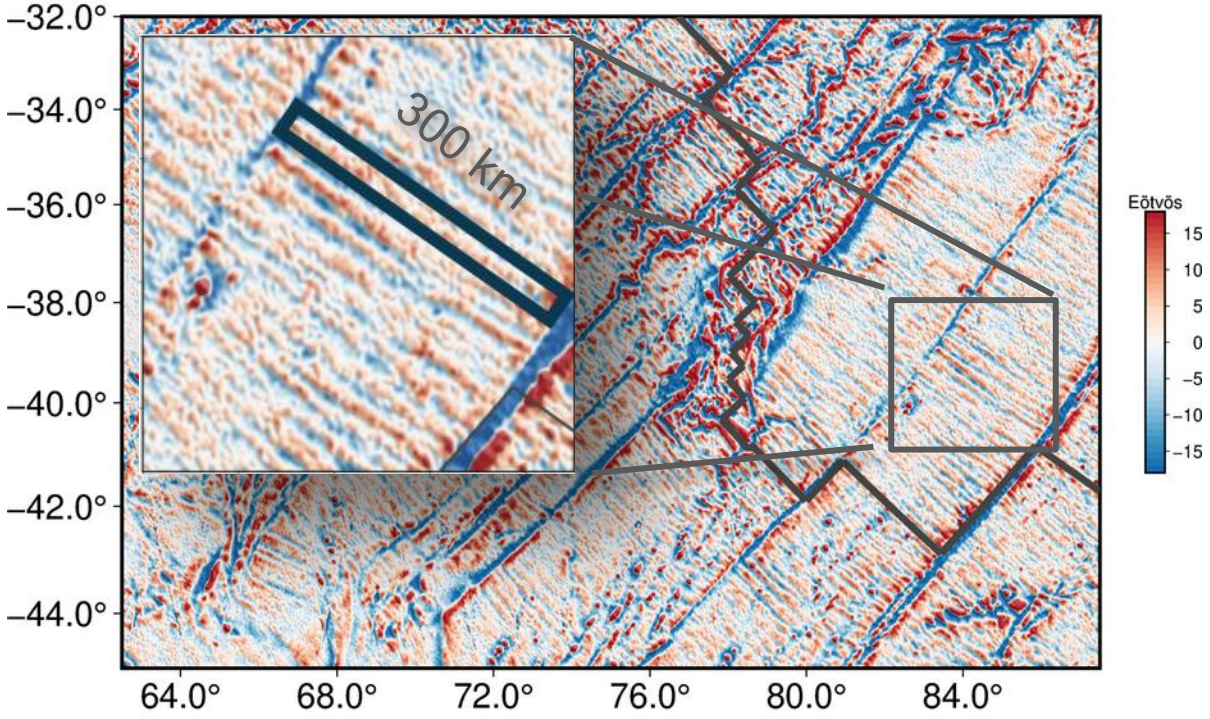


Marine gravity field, mean sea surface (MSS), and bathymetry greatly improved

- geodetic signals in models down to ~8 km wavelength,
- and oceanographic and altimetric noise.
- MSS, gravity and bathymetry improvements are unfortunately non-uniformly distributed over the oceans due to two diamond gaps in the SWOT observations increasing towards the Equator.

O. Andersen and WG leads

“1 year of SWOT data offers more detailed information than 30 years of nadir altimetry”



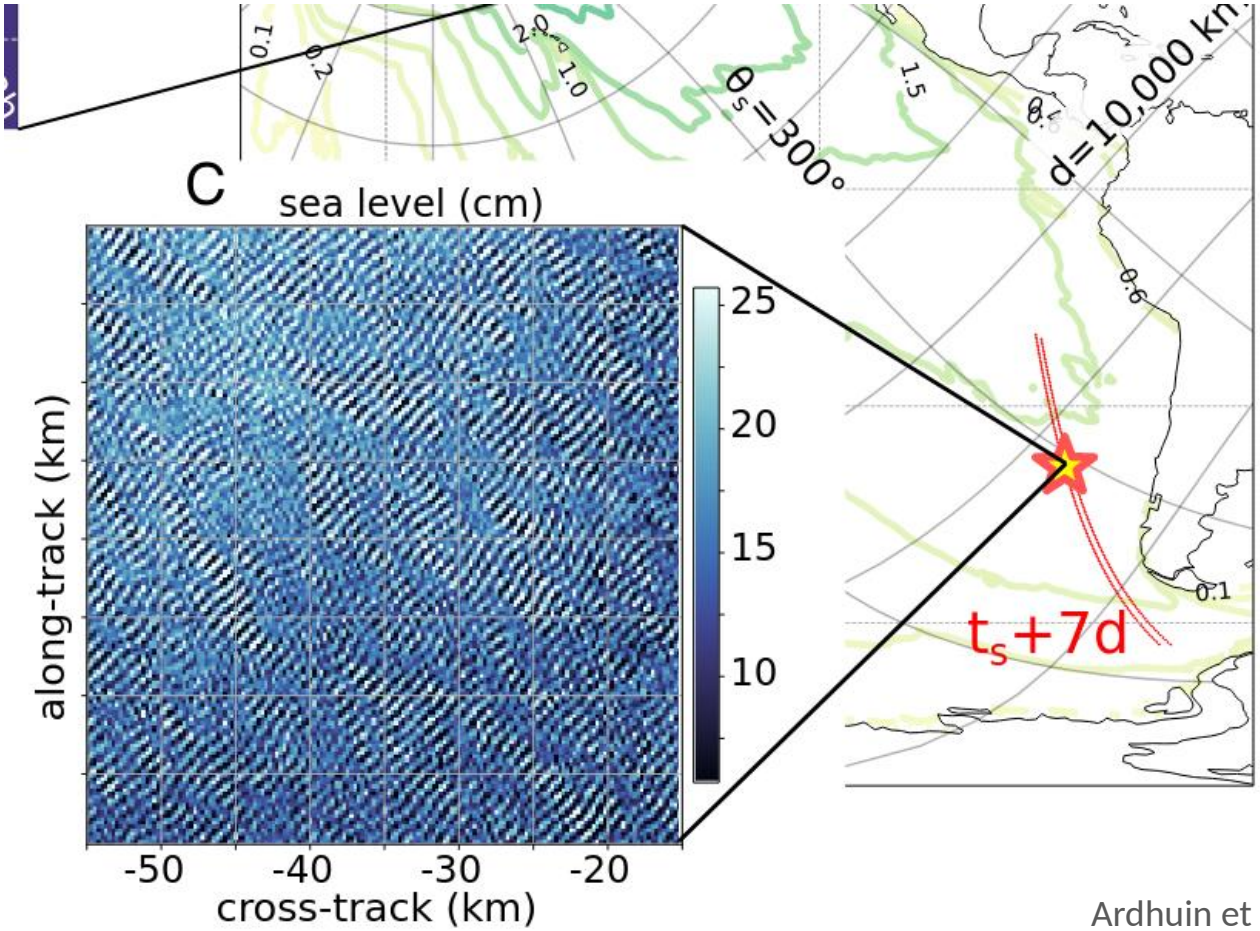
Example: Individual abyssal hills are now visible

- Can be used to refine plate reconstruction models
- to inform local tectonic and volcanic history of formative ridge
- for modeling internal tide conversion

Yu et al. Science, 2024; MSS WG Leads

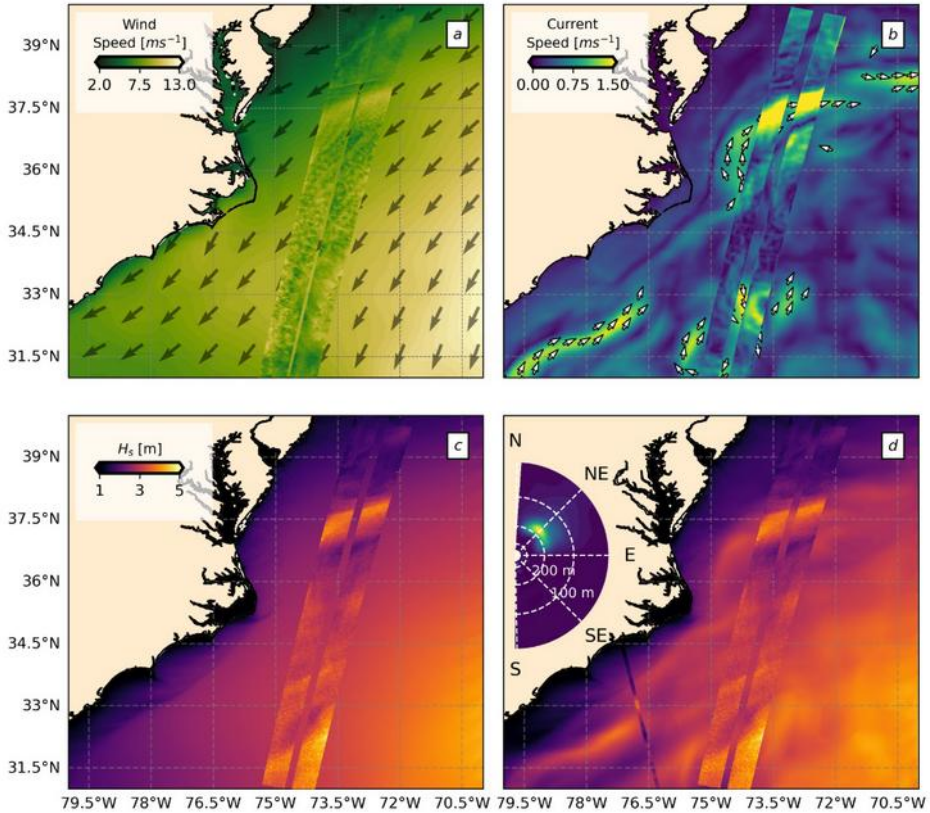

Wind and waves

Example of swell detected by SWOT after the passage of a storm



Ardhuin et al. 2025a, 2025b

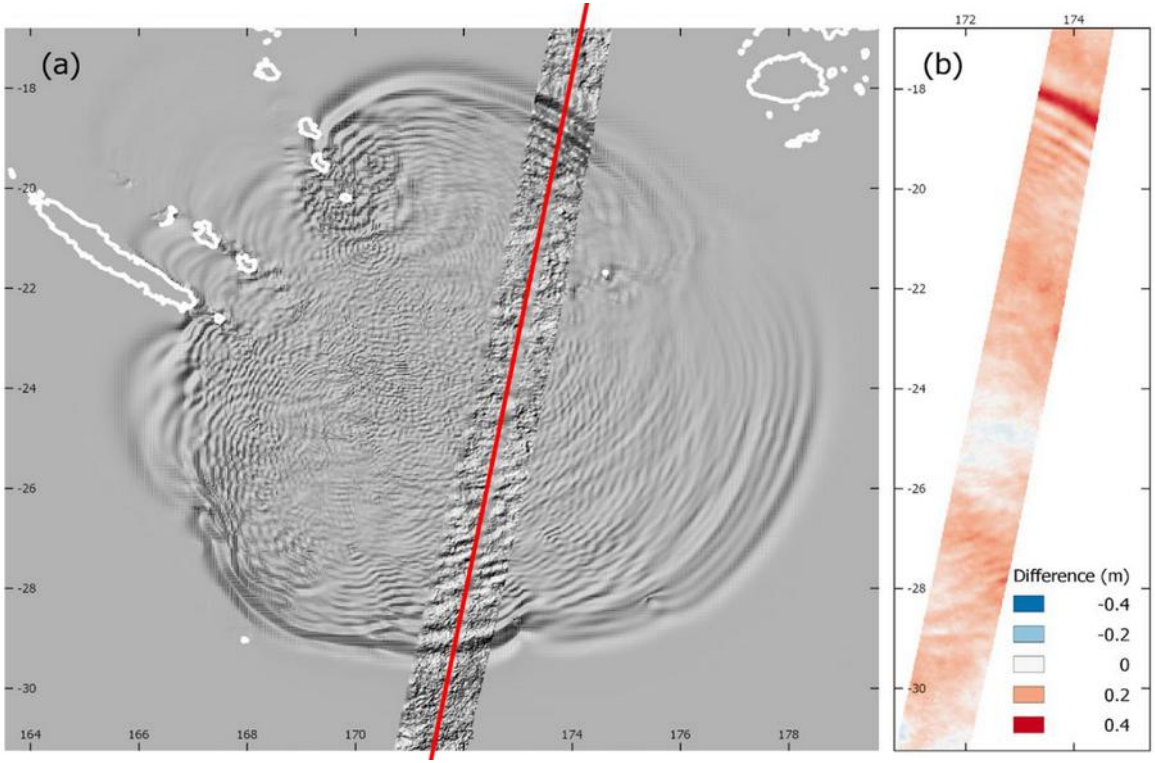
SWOT's concomitant high-resolution wave data and SSH **“represent a transformative advance in understanding Hs gradients”**, Villas Bôas et al. 2025



- Improvement of sea state operational models (navigation safety).
- Exploration of sea state gradients coupled to air-sea processes.

Villas Bôas et al. 2025

2D detection of tsunami's signal



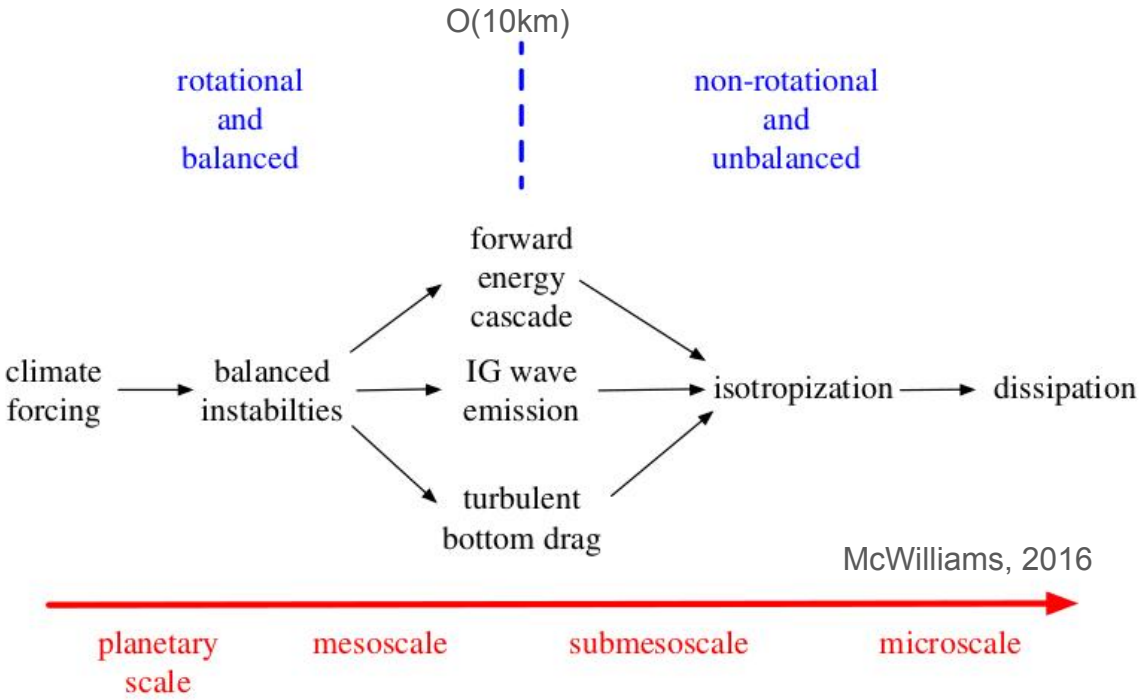
Roger et al. 2025

- Synergies of SWOT with seismic networks
- Model improvement for tsunami generation, propagation, and dissipation
- More reliable and quantitative tsunami early warning

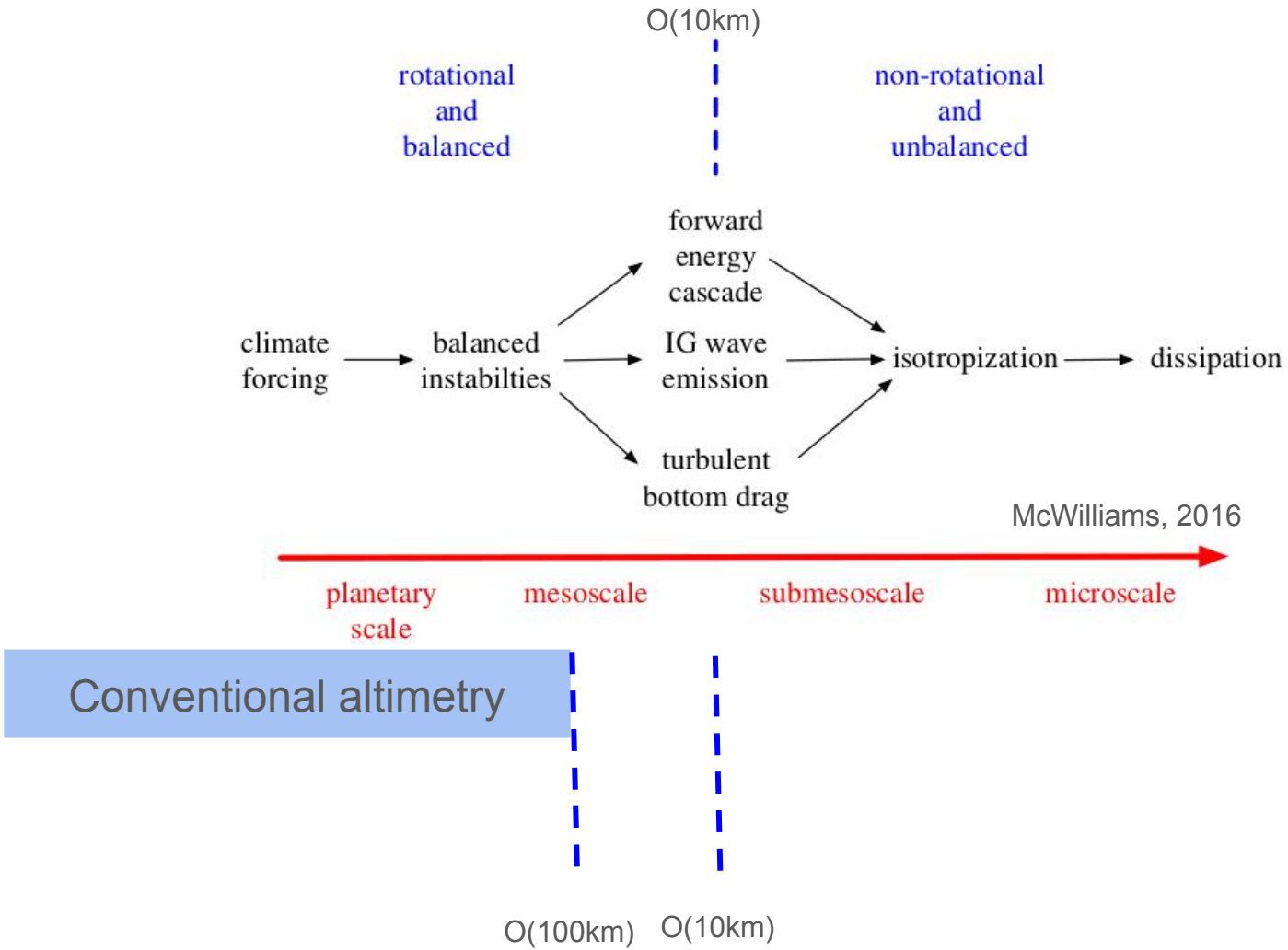
Some challenges and perspectives

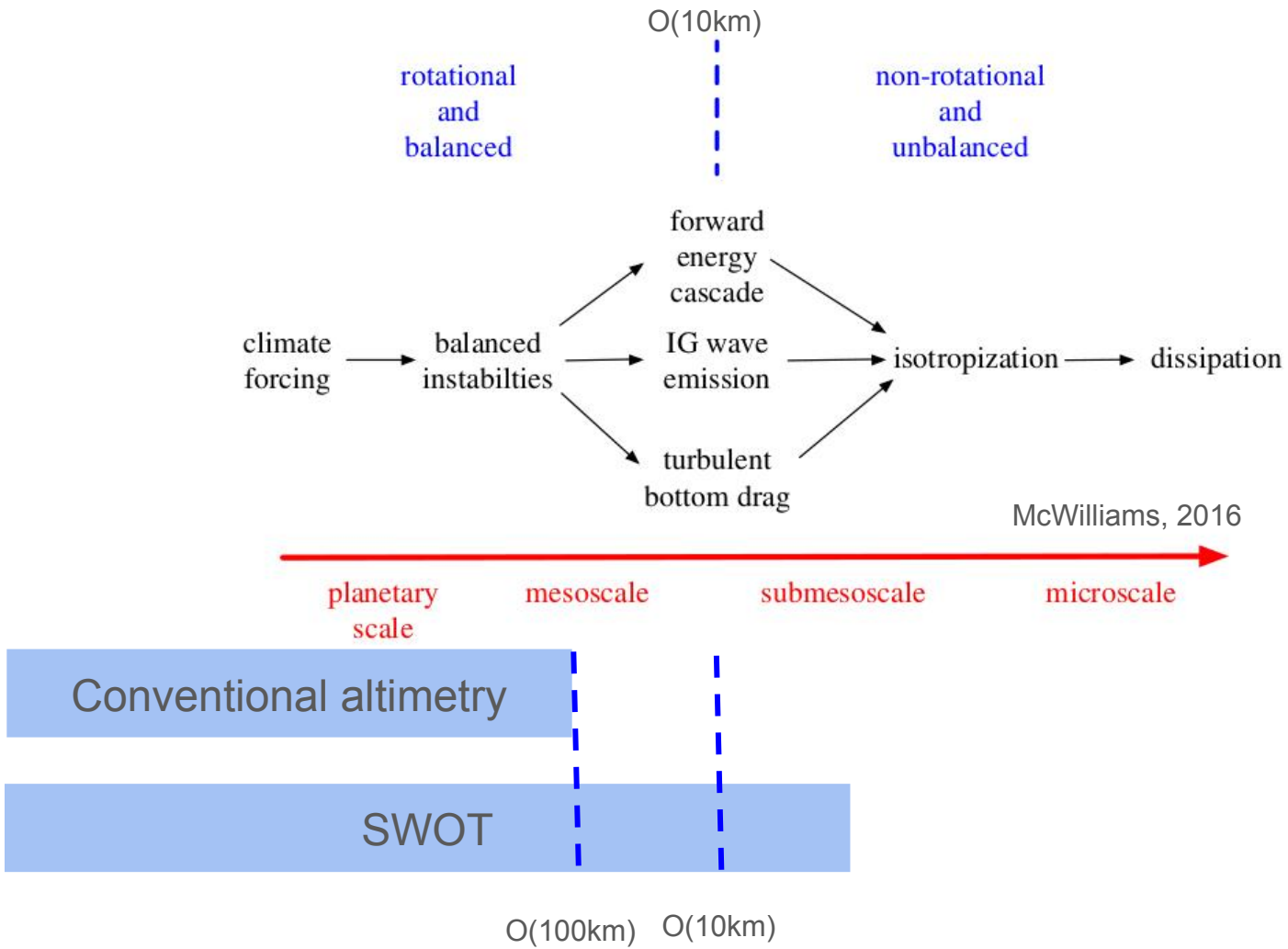
SWOT-ST Meeting
14-17 October 2025, Arcachon

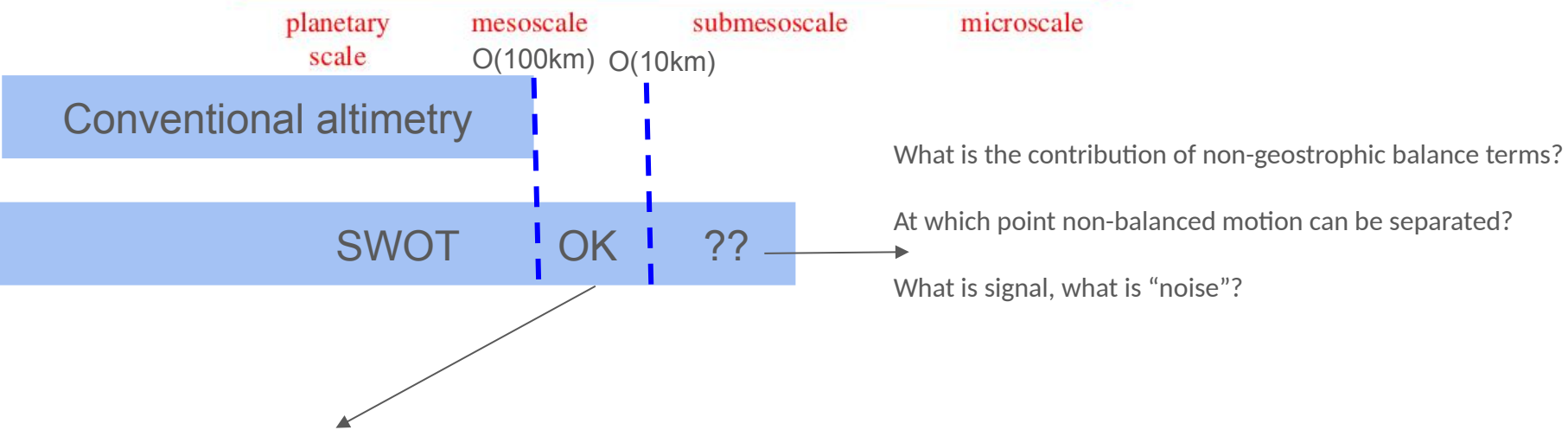

1. Velocities



Key processes for the redistribution of energy, matter, and properties


O(10km)
rotational
and
balanced
non-rotational
and
unbalanced
forward
energy
cascade
climate
forcing
balanced
instabilties
IG wave
emission
isotropization
dissipation
turbulent
bottom drag
McWilliams, 2016
planetary
scale
mesoscale
submesoscale
microscale
Conventional altimetry
O(100km)
O(10km)


O(10km)
rotational and balanced
non-rotational and unbalanced
forward energy cascade
climate forcing
balanced instabilties
IG wave emission
isotropization
dissipation
turbulent bottom drag
McWilliams, 2016
planetary scale
mesoscale
submesoscale
microscale
Conventional altimetry
SWOT
O(100km)
O(10km)


planetary scale
mesoscale
O(100km)
O(10km)
submesoscale
microscale
Conventional altimetry
SWOT
OK
??
What is the contribution of non-geostrophic balance terms?
At which point non-balanced motion can be separated?
What is signal, what is “noise”?
Geostrophic equilibrium + tides

planetary scale | mesoscale O(100km) | submesoscale O(10km) | microscale

Conventional altimetry

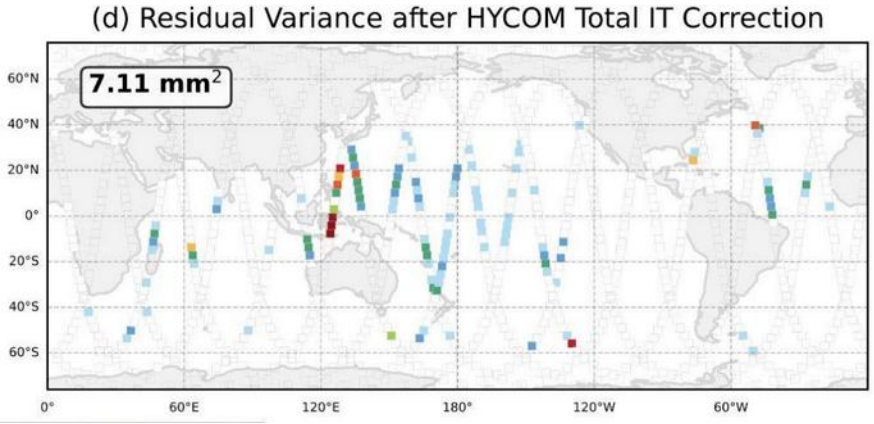
SWOT | OK | ??

What is the contribution of non-geostrophic balance terms?

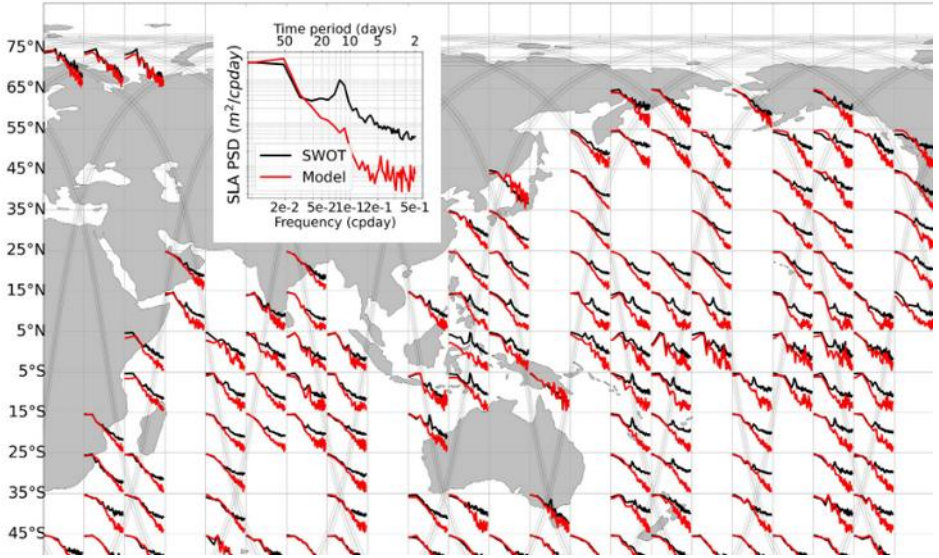
At which point non-balanced motion can be separated?

What is signal, what is “noise”?

Synergies with high resolution models



B. Arbic talk



Fauchet et al. 2025

planetary scale | mesoscale O(100km) | O(10km) | submesoscale | microscale

Conventional altimetry

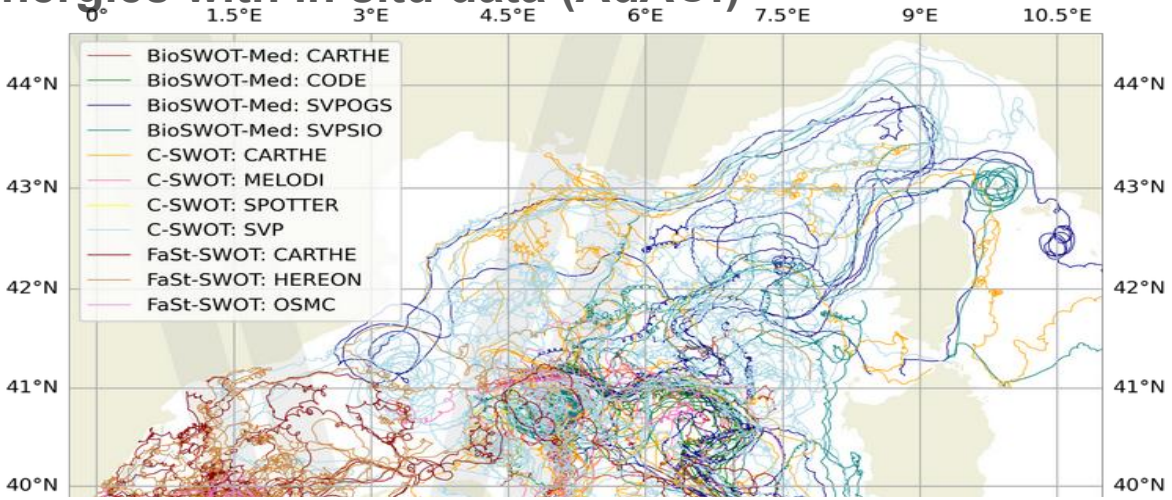
SWOT | OK | ??

What is the contribution of non-geostrophic balance terms?

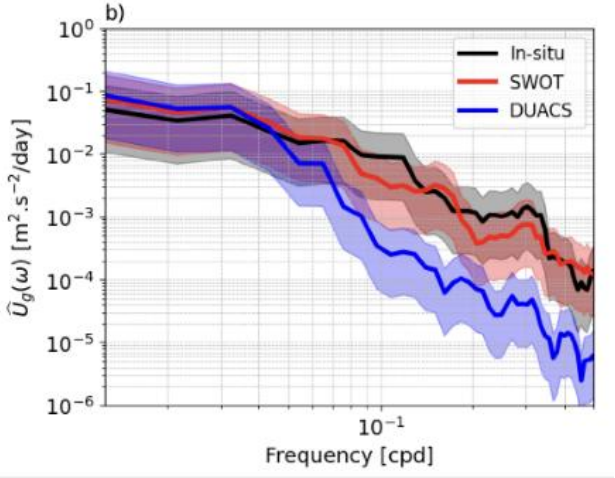
At which point non-balanced motion can be separated?

What is signal, what is “noise”?

Synergies with in situ data (AdAC!)

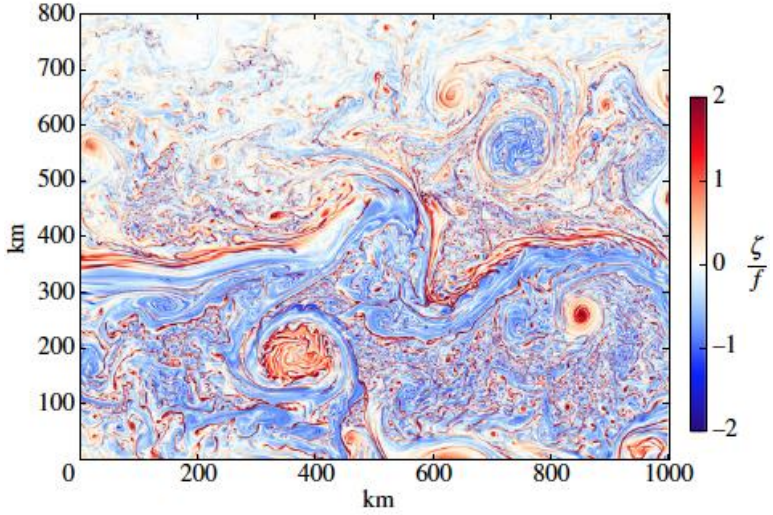


Demol et al. 2025, submitted



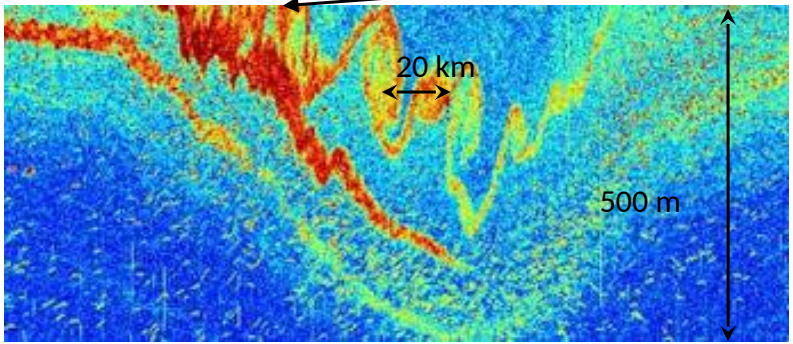
Cho et al. 2025, submitted

Prelaunch Mission Goal: Vertical transport of heat and water properties in the ocean



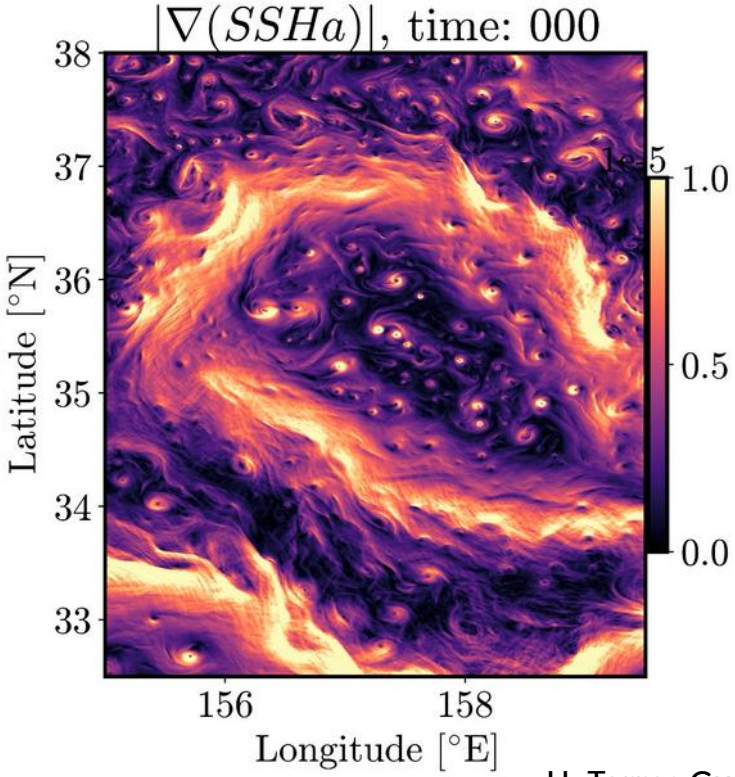
Vorticity at the surface in the Gulf Stream (McWilliams, 2016)

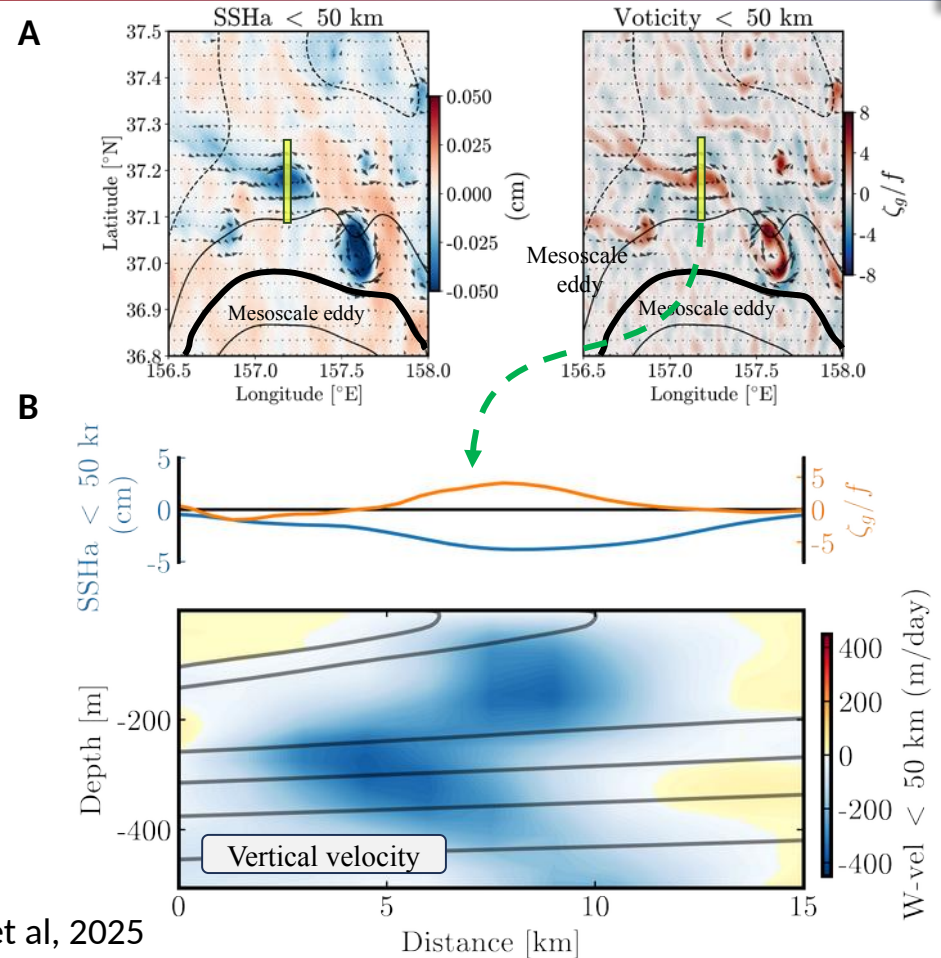
Sea surface height variations are observed by SWOT for estimating ocean currents at depths.



Submesoscale cyclones coupling the surface and deep ocean from model

Simulated SSH gradients after removing IGWs

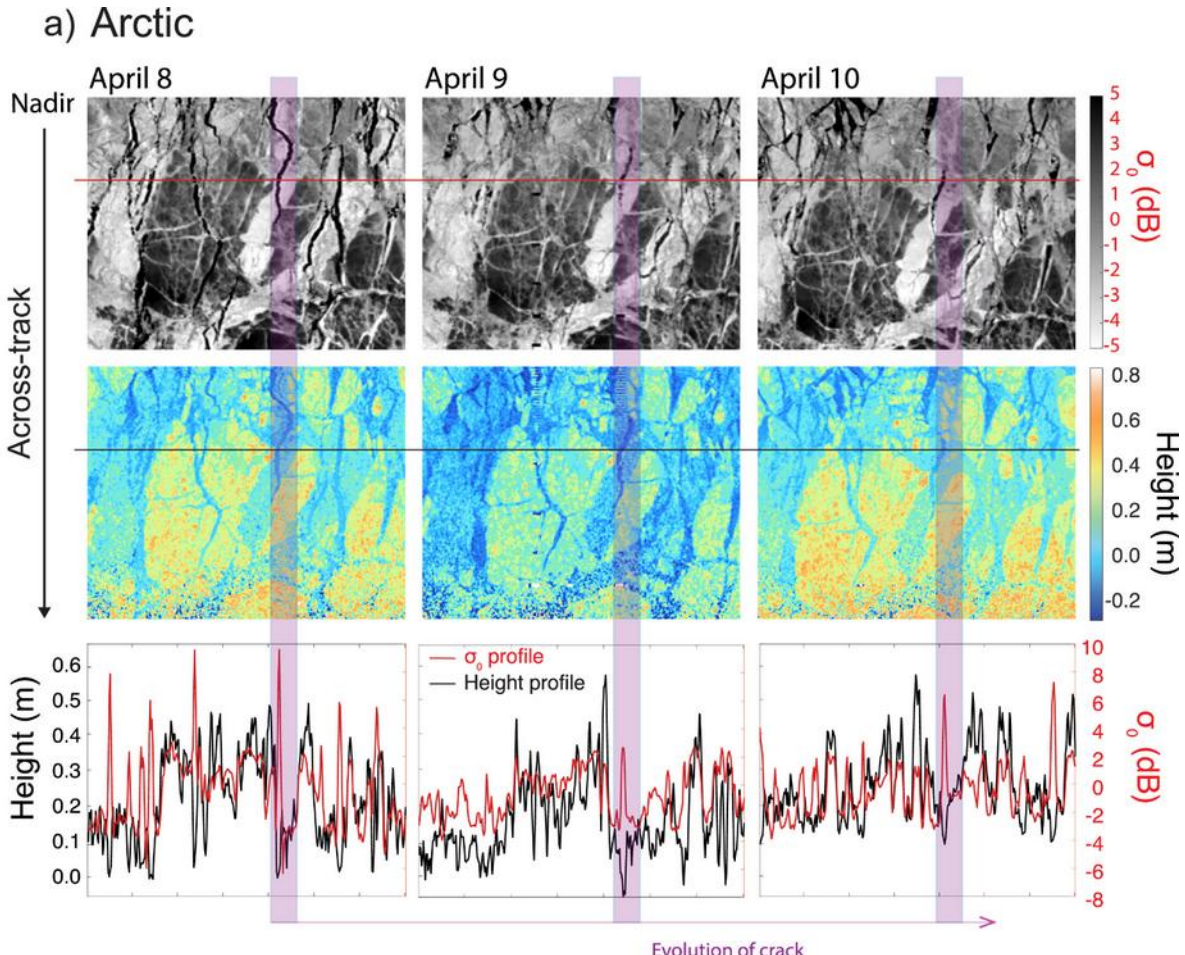




H. Torres Gutierrez et al, 2025

2. Sea ice

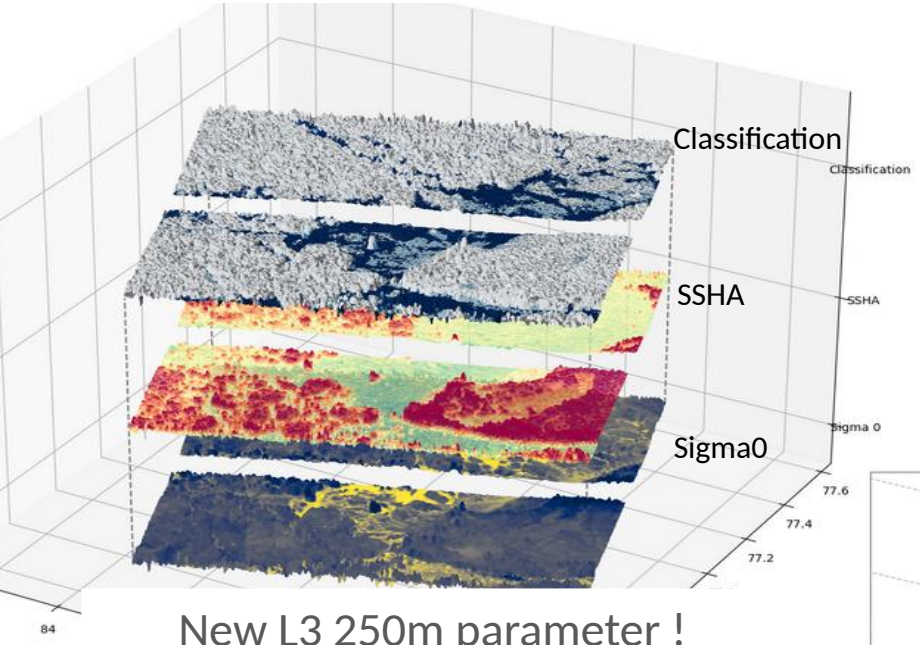
Sea ice surface and height detection

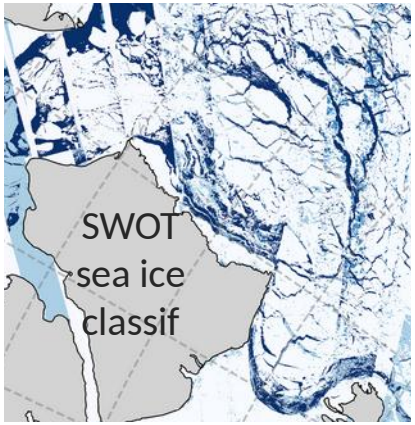


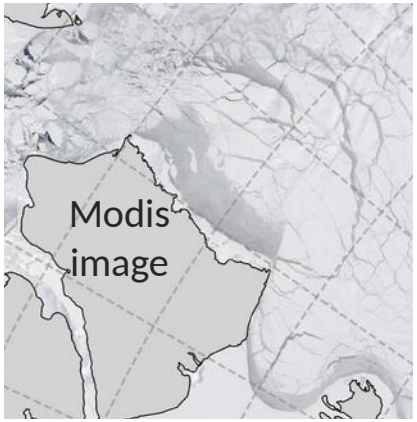
Kacimi et al. 2025

SWOT SPIceSea: sea ice classification

Jestin et al., The Cryosphere, submitted

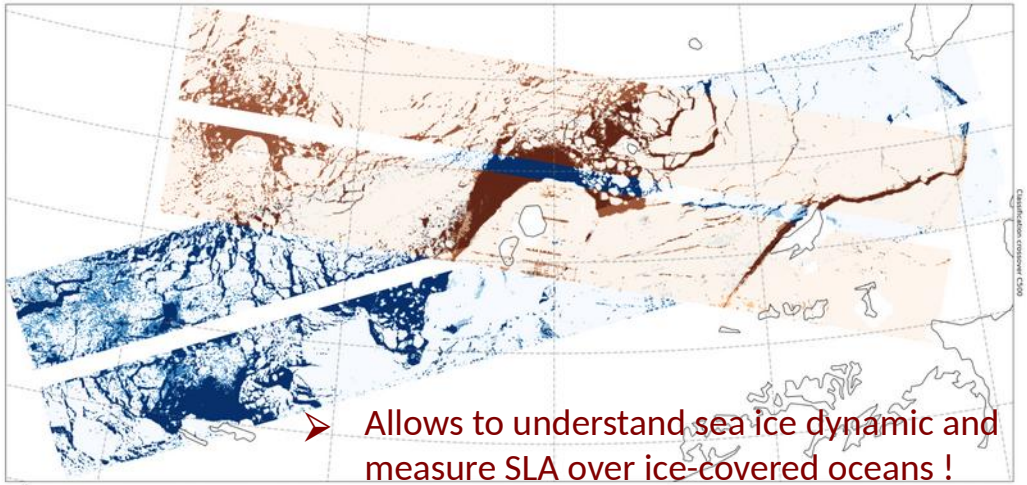






New L3 250m parameter !

surface type	flag
ocean (including leads and polynyas)	#0
probable ocean	#18
probable ice	#19
ice pack, ice floes	#20

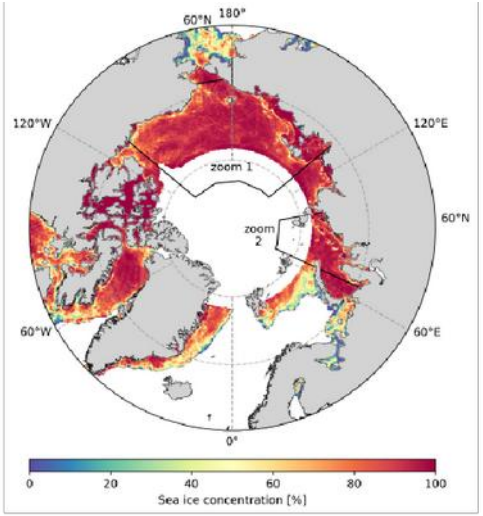


➢ Allows to understand sea ice dynamic and measure SLA over ice-covered oceans !

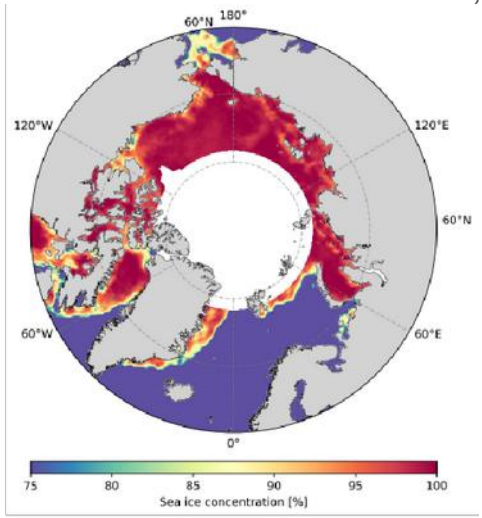
SWOT SPIceSea: sea ice **concentration**

Jestin et al., The Cryosphere, submitted

SWOT sea ice concentration



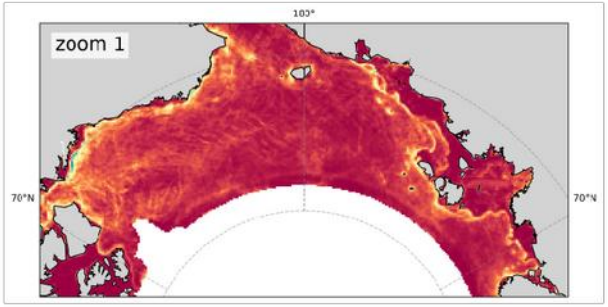
(a) Concentration derived from classification



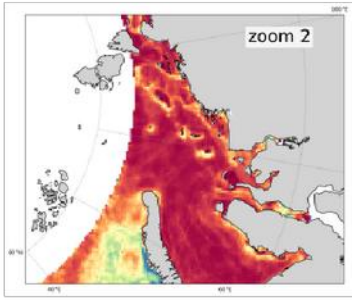
(b) OSI SAF concentration

OSI-SAF/Copernicus reference product

SWOT sea ice concentration (zooms)



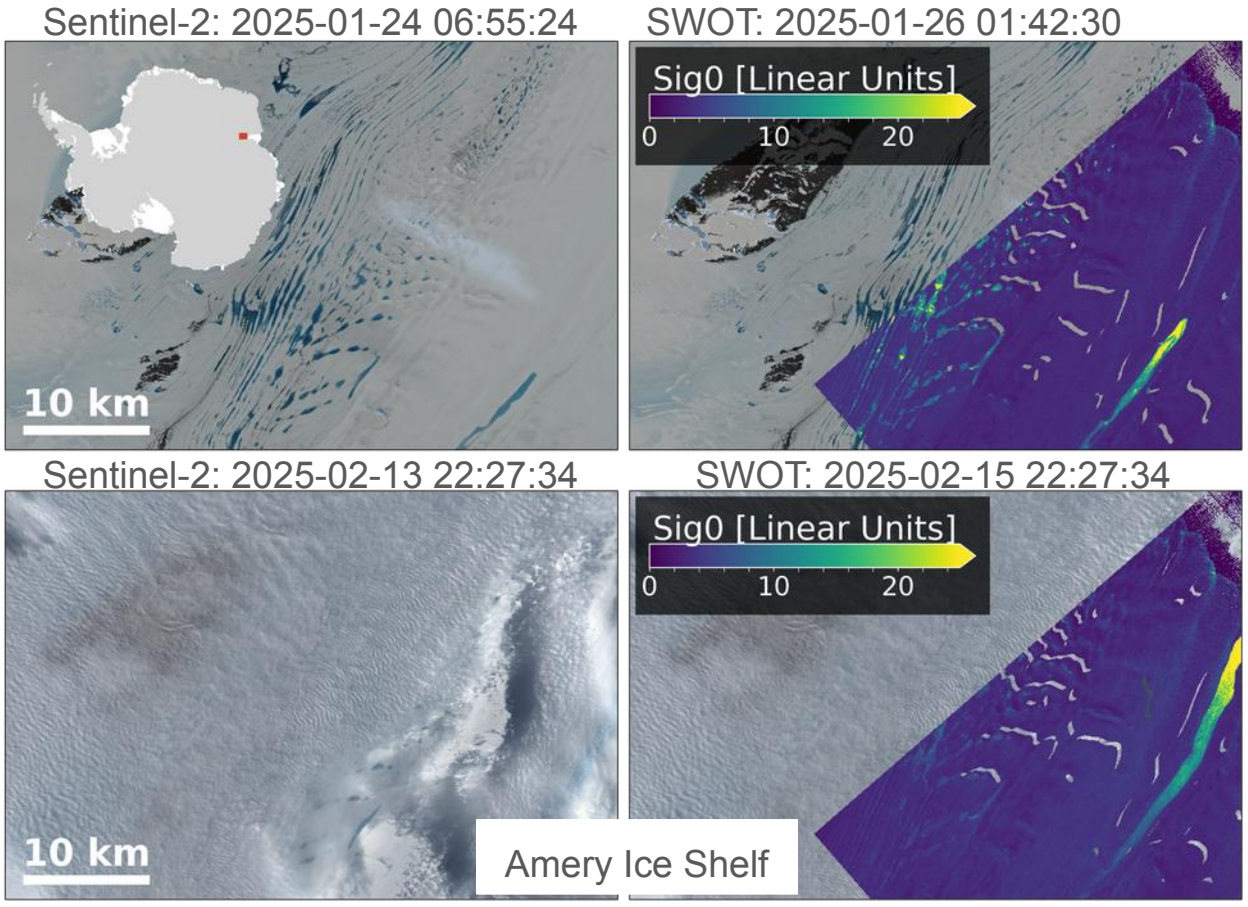
(c) North of Alaska and East Siberia



(d) Kara sea islands

➢ Towards an unprecedented improvement in sea ice concentration !

Watching ice shelves crack open: Meltwater and crevasse evolution from SWOT



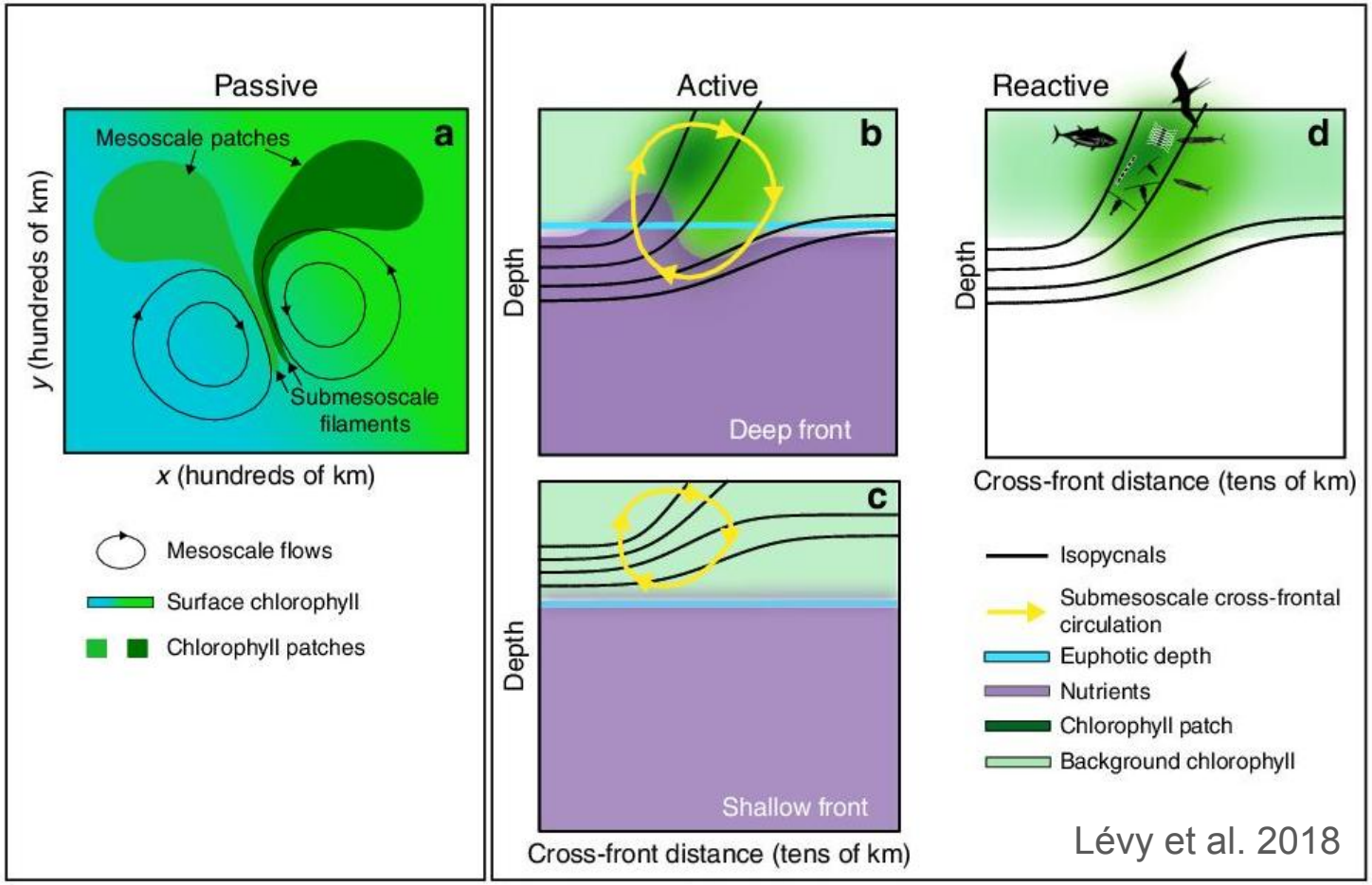
Ka-band backscatter detects water-filled crevasses, even if cloudy

Simultaneous height and backscatter measurements provide novel dataset for monitoring crevasse evolution

Zachary Katz
zachary_katz@mines.edu
COLORADO SCHOOL OF MINES

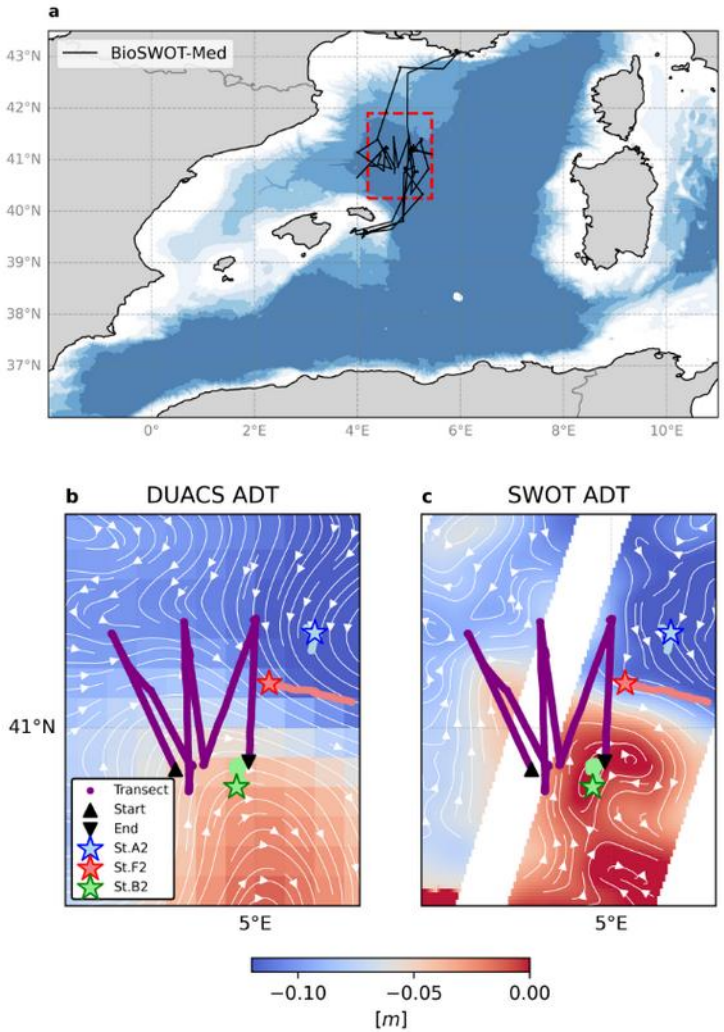

3. Biology

Testing paradigms of biophysical coupling needs SWOT precision

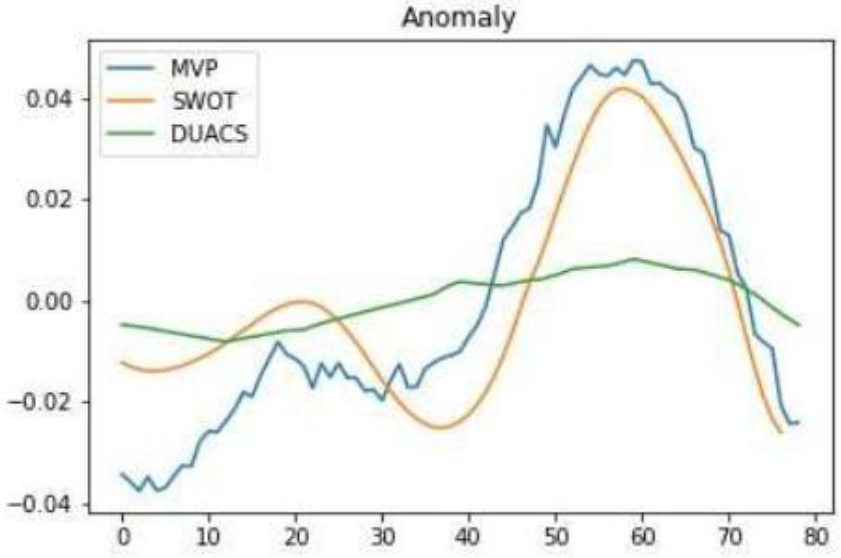


Lévy et al. 2018

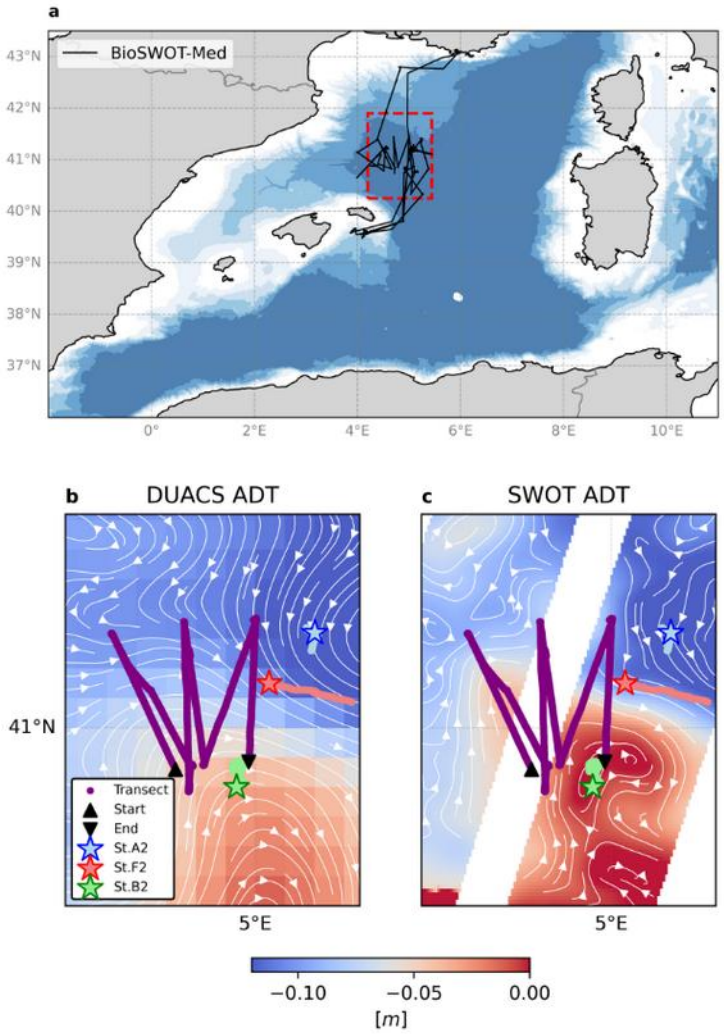
BIOSWOT-Med
Bottom-up effect of an eddy at SWOT scales



CalVal

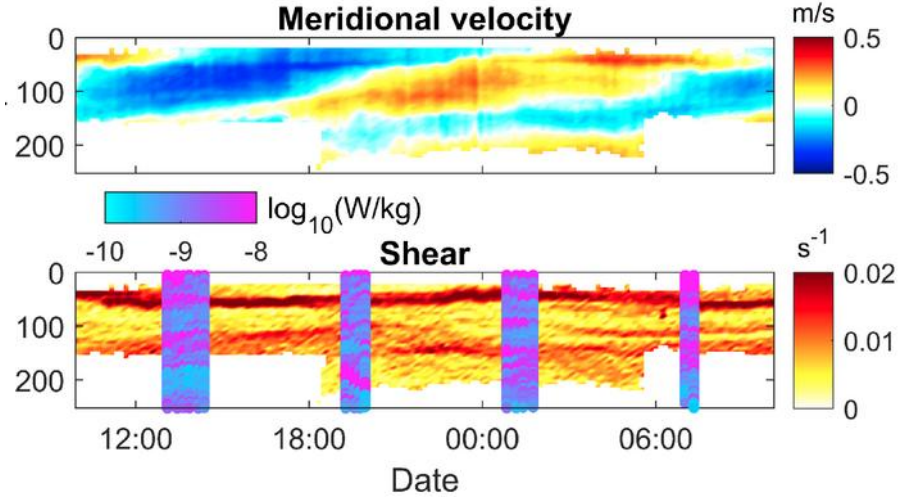


Rousselet et al. in prep.

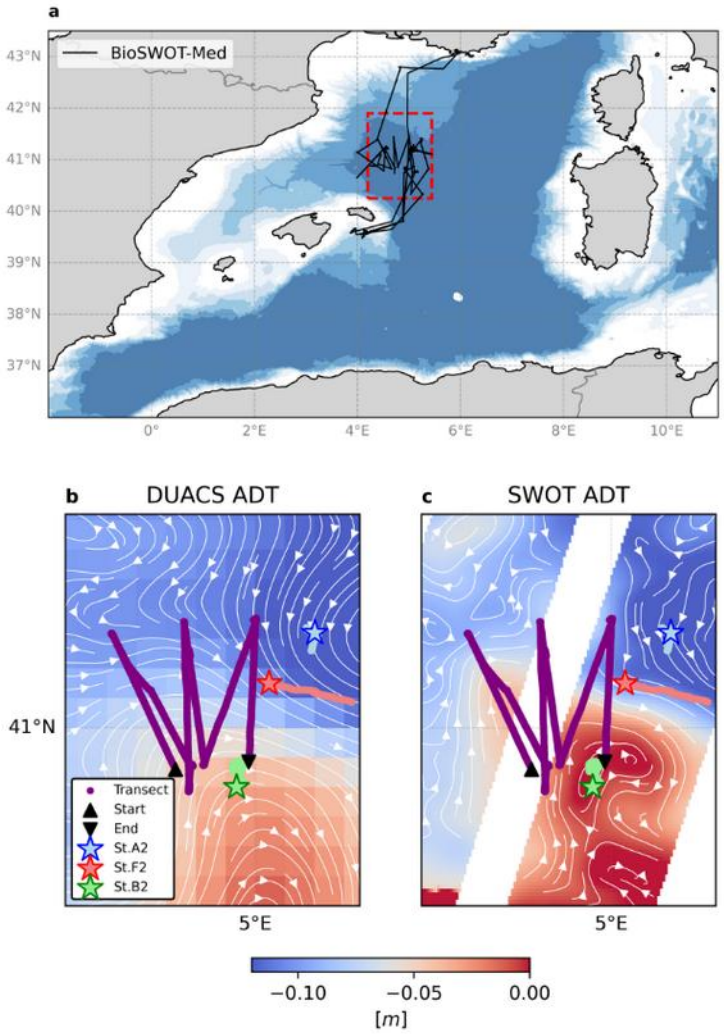


BIOSWOT-Med
Bottom-up effect of an eddy at SWOT scales

Trapping of internal waves

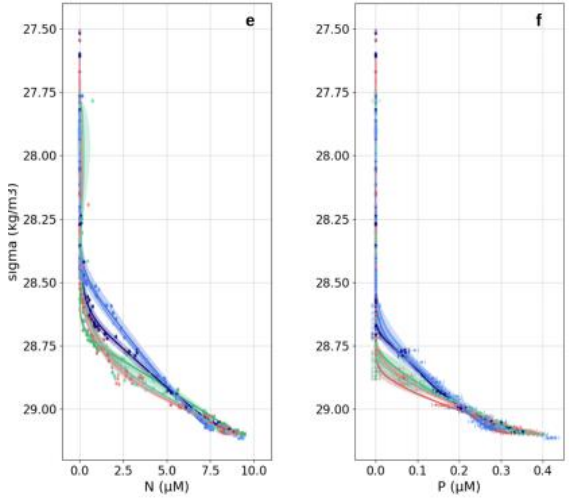


Rolland et al. under revision



BIOSWOT-Med
Bottom-up effect of an eddy at SWOT scales

Modulation of the nutrient field



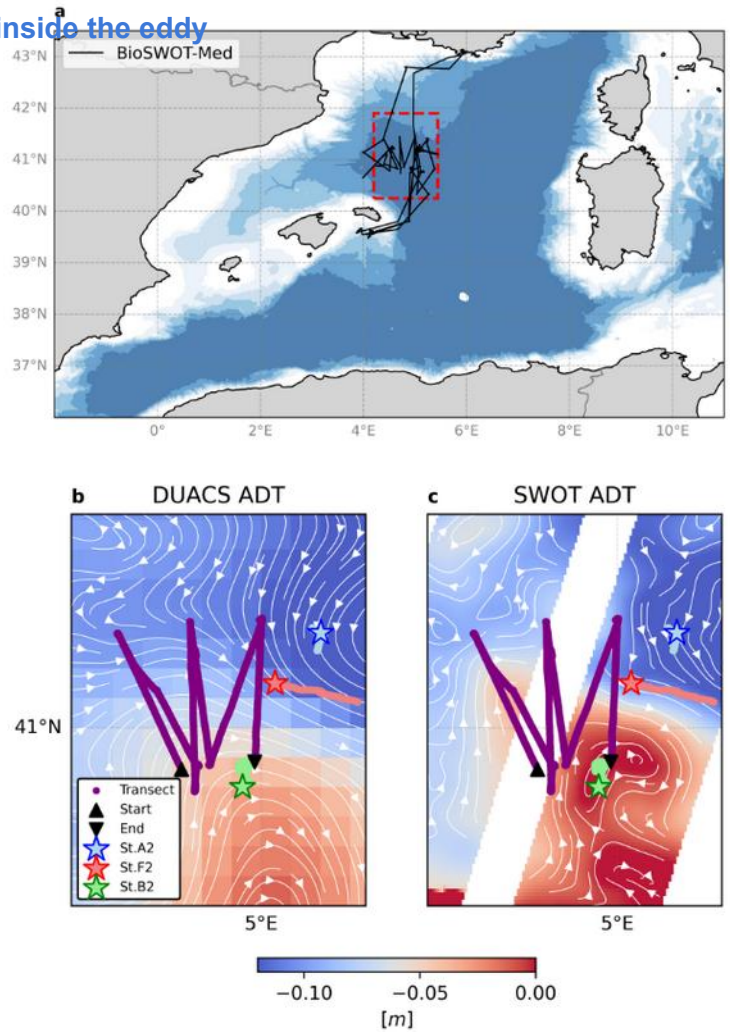
inside the eddy

outside the eddy

frontal region

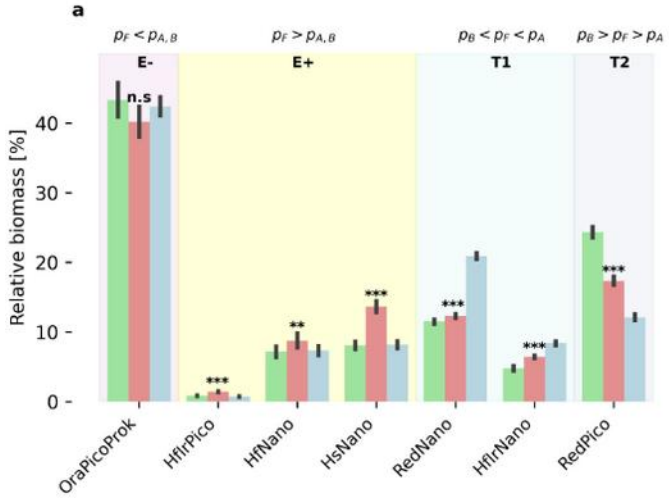
Joel et al. submitted

inside the eddy



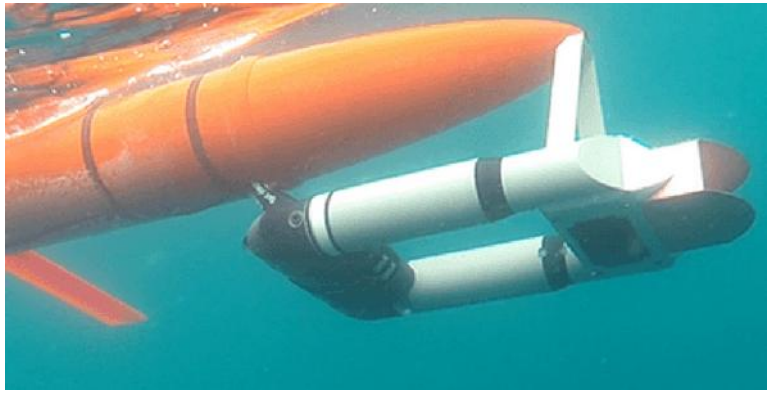
BIOSWOT-Med
Bottom-up effect of an eddy at SWOT scales

Modulation of the phytoplankton community



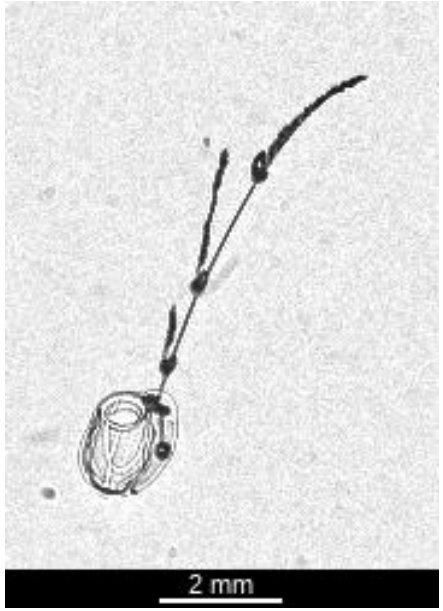
inside the eddy
outside the eddy
frontal region

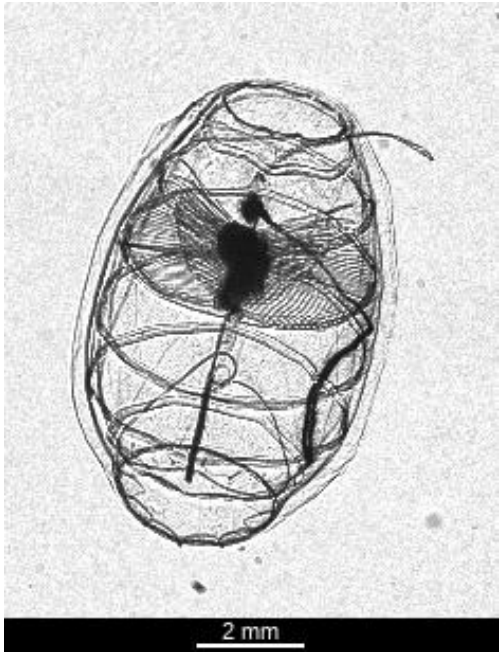
Oms et al. under revision

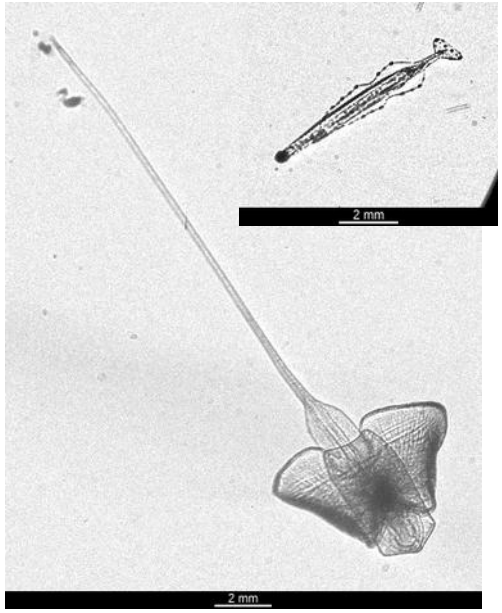


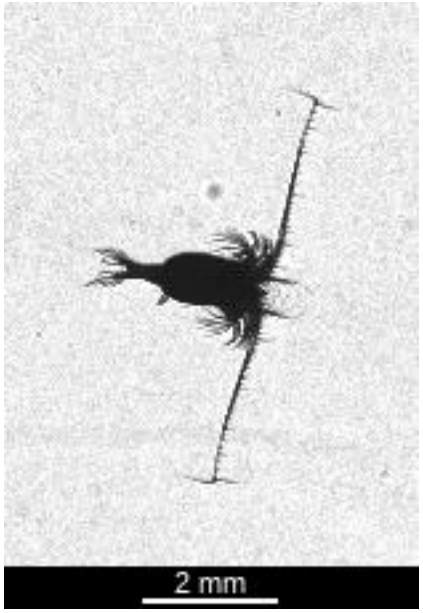
BIOSWOT-Med
Bottom-up effect of an eddy at SWOT scales

Ongoing study on the impact on zooplankton

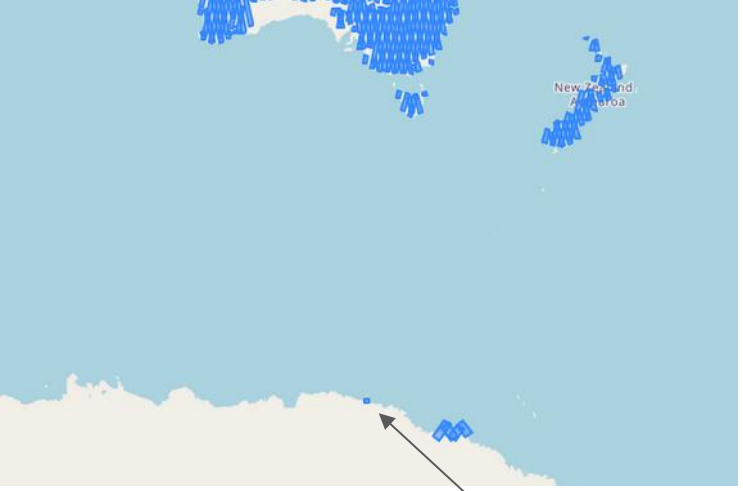








Images courtesy of M. Ohman (Scripps)



November 2025: a CNES-funded collaboration with a Weddell seal for cross-validating freeboard estimation!

Sara Labrousse, LOCEAN-IPSL, program IPEV 1182

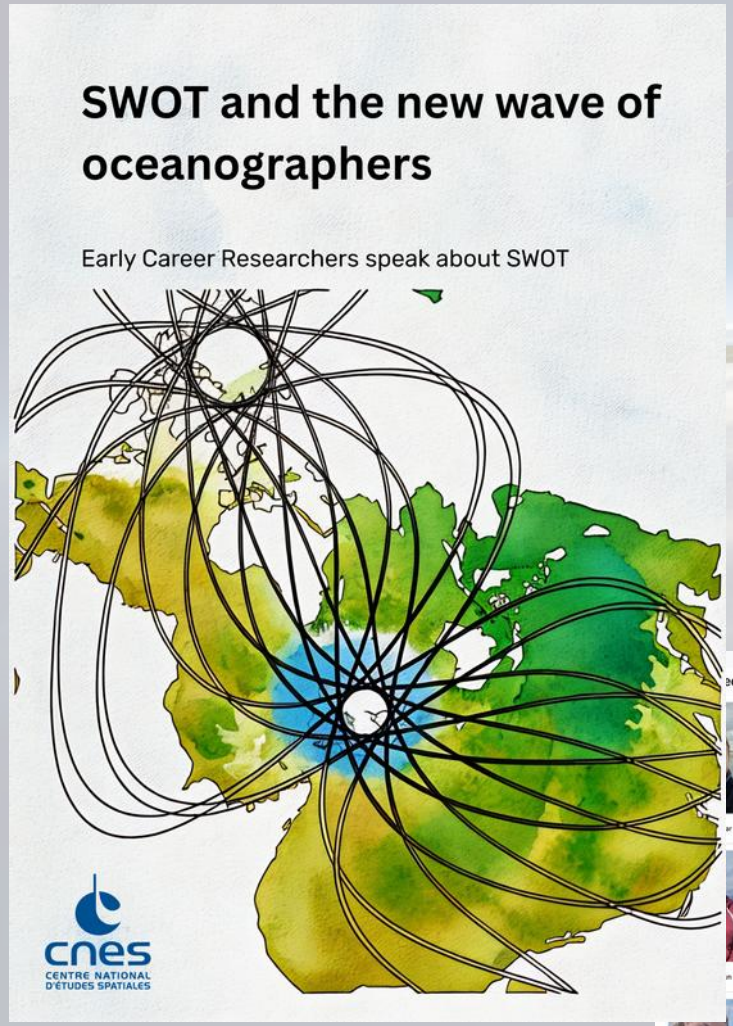
Thank you and enjoy the meeting!

F. d’Ovidio, T. Farrar, L.-L. Fu

Sara Labrousse, LOCEAN-IPSL, program IPEV 1182

Some announcements

SWOT-ST Meeting
14-17 October 2025, Arcachon



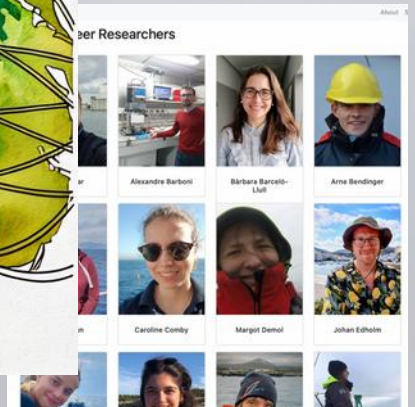
If you are Early Career:

We want to hear what you think about SWOT!

More than 50 interviews to SWOT ECR already collected for Oceanography in an eBook.

Next edition will include hydrology, DEC, and the cryosphere. Please contact:

tosca.ballerini@thalassa.one



Post-launch community paper (Oceanography)

At O(100) papers in the past two years, it's time to review how SWOT confirmed, infirmed, and transformed what we know about the ocean mesoscale and submesoscale

Tentative title: "Ocean mesoscale and submesoscale as seen by the SWOT satellite mission"

Introduction and Conclusions -> Ocean Science Leads

Sections -> 3-5 pages for each Working Group, coordinated (written) by WG Leads

Journal: Progress in Oceanography ?

We need your feedback

SWOT-ST meetings are great opportunities for discussing community feedback and recommendations for our space agencies. Here are some possible points of discussion that we would like you to keep in mind during this week.

What is your preferred product lifecycle? (Any update as soon as there are some new features, one year or more,..)

How far would you like to push model-trained AI for denoising SWOT observations?

Please free to contact the Science Leads for any other community question that you feel can be relevant to raise!

SWOT-ST Meeting
14-17 October 2025, Arcachon