SMOS monitors Sea Surface Salinity for more than 15 years

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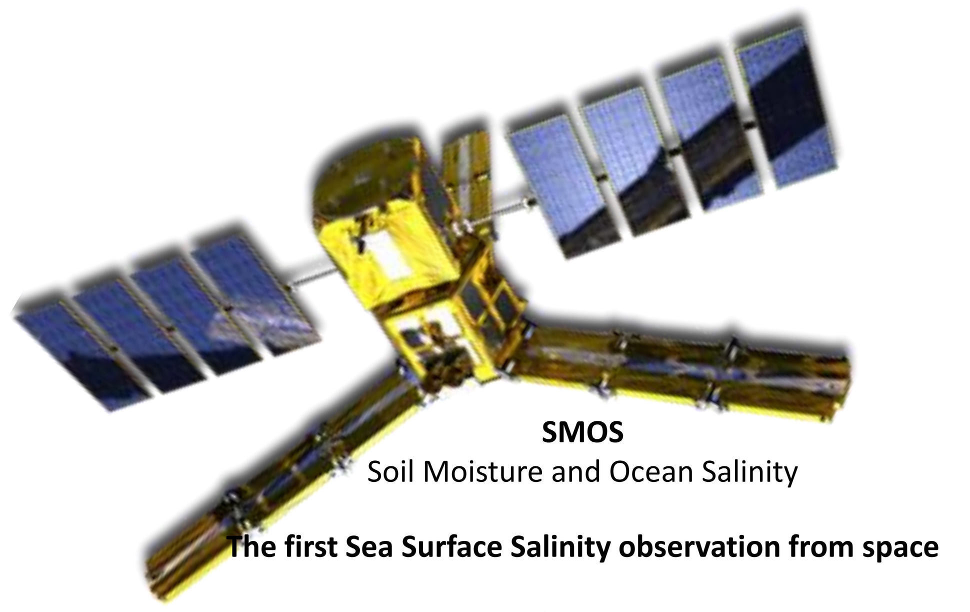
N. Rodriguez-Fernandez[5], and the SMOS and SMOS_HR TOSCA Ocean teams

See also oral presentation ‘Salinity’: Space session at the EU Digital Ocean Pavilion, Thursday June 5 2025, 10:30am-1:30pm

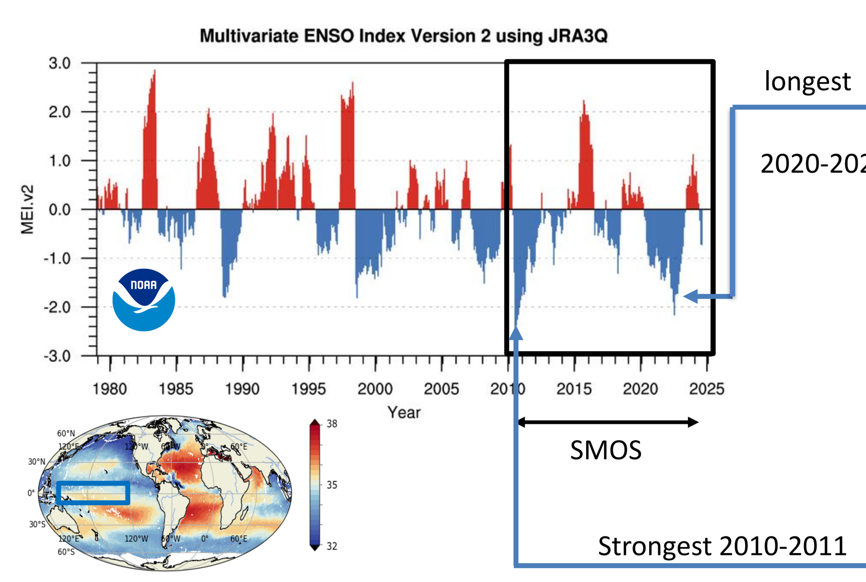
Unprecedent synoptic coverage of SSS at planetary scale related to climatic events : Monitoring of the two strongest & longest La Niña events since 1980

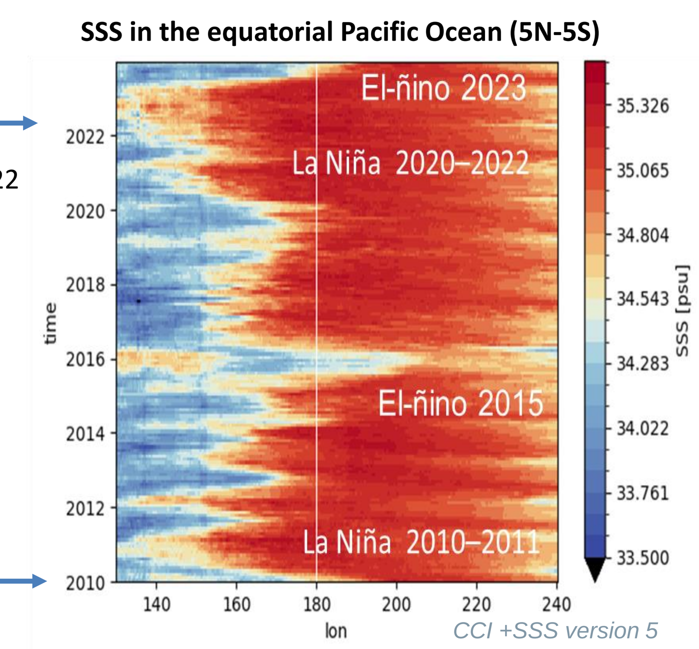


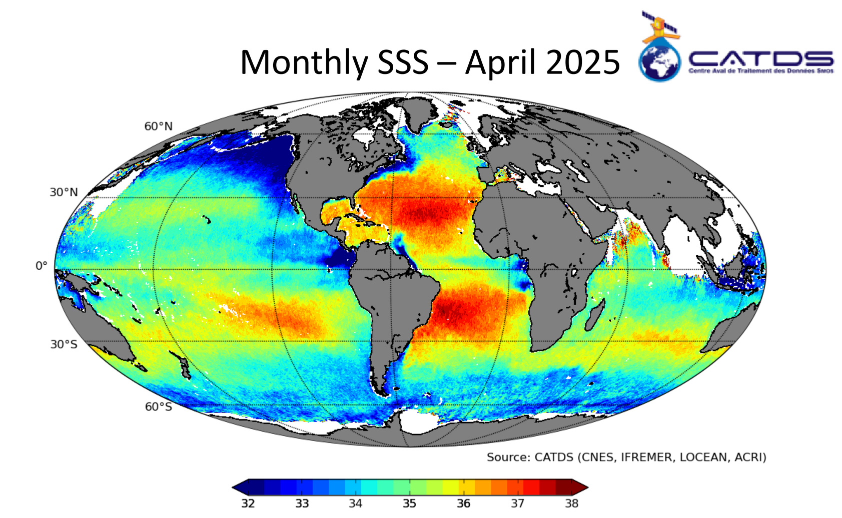
SMOS
Soil Moisture and Ocean Salinity

The first Sea Surface Salinity observation from space

ESA Earth Explorer (CNES PROTEUS platform)
~43km resolution/3 day global coverage





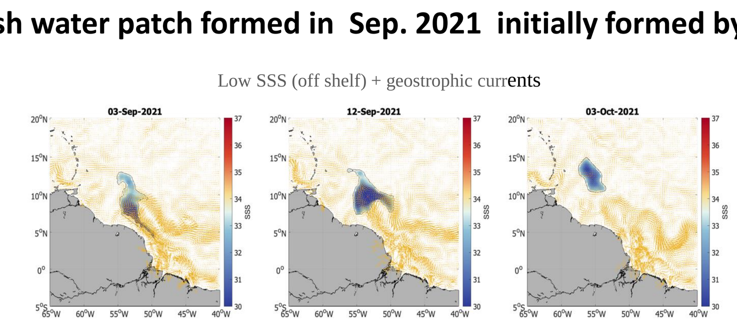


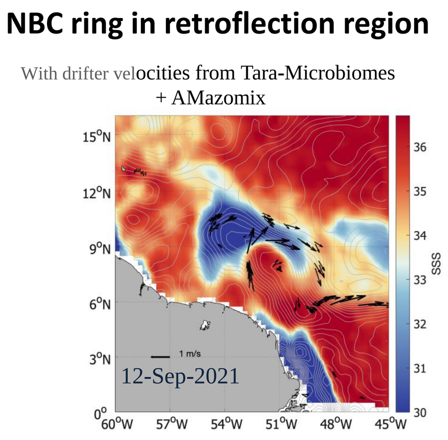
2010-01 — **15.5 years** — 2025-05

Unprecedent monitoring of eddying features related to freshwater fluxes

River plumes dynamics (relation between currents and fresh plume)

Fresh water patch formed in Sep. 2021 initially formed by an NBC ring in retroflection region





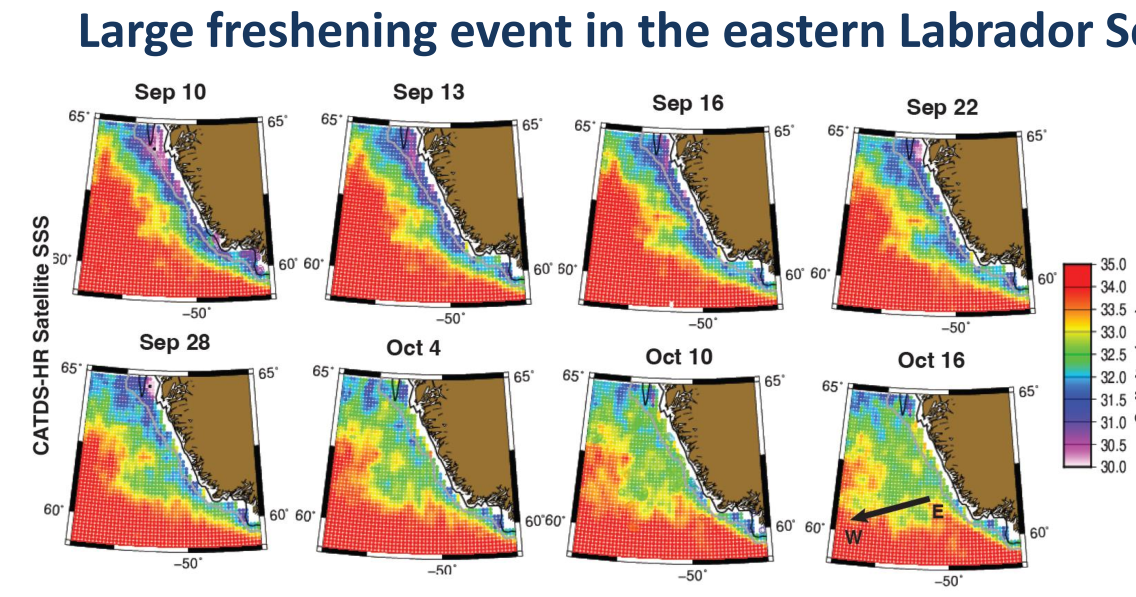
Such low SSS patches can interact with and reinforce strong cyclones (Balaguru et al. 2020; Reul et al. 2021)

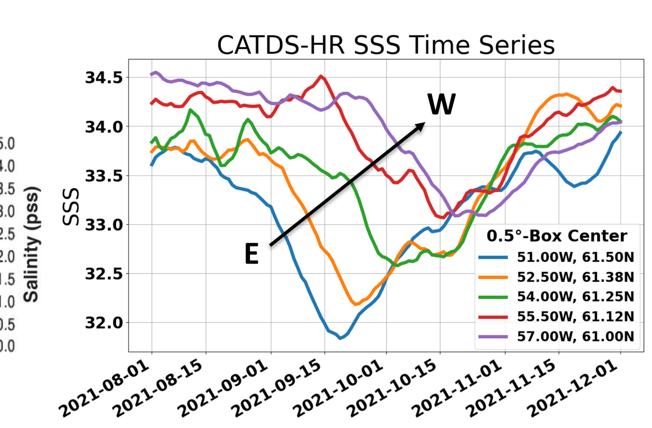
Initial area > 200 000 km²
freshwater transport of up to 0.5 Sv
Changes of SSS related to wind and deepening of fresh layer (from ~10 m to > 30 m)

Olivier et al. 2024

Anticyclonic circulation induced around the patch (over 10 cm higher sea level due to low SSS in 12 m -layer)

Large freshening event in the eastern Labrador Sea in Sept. 2021

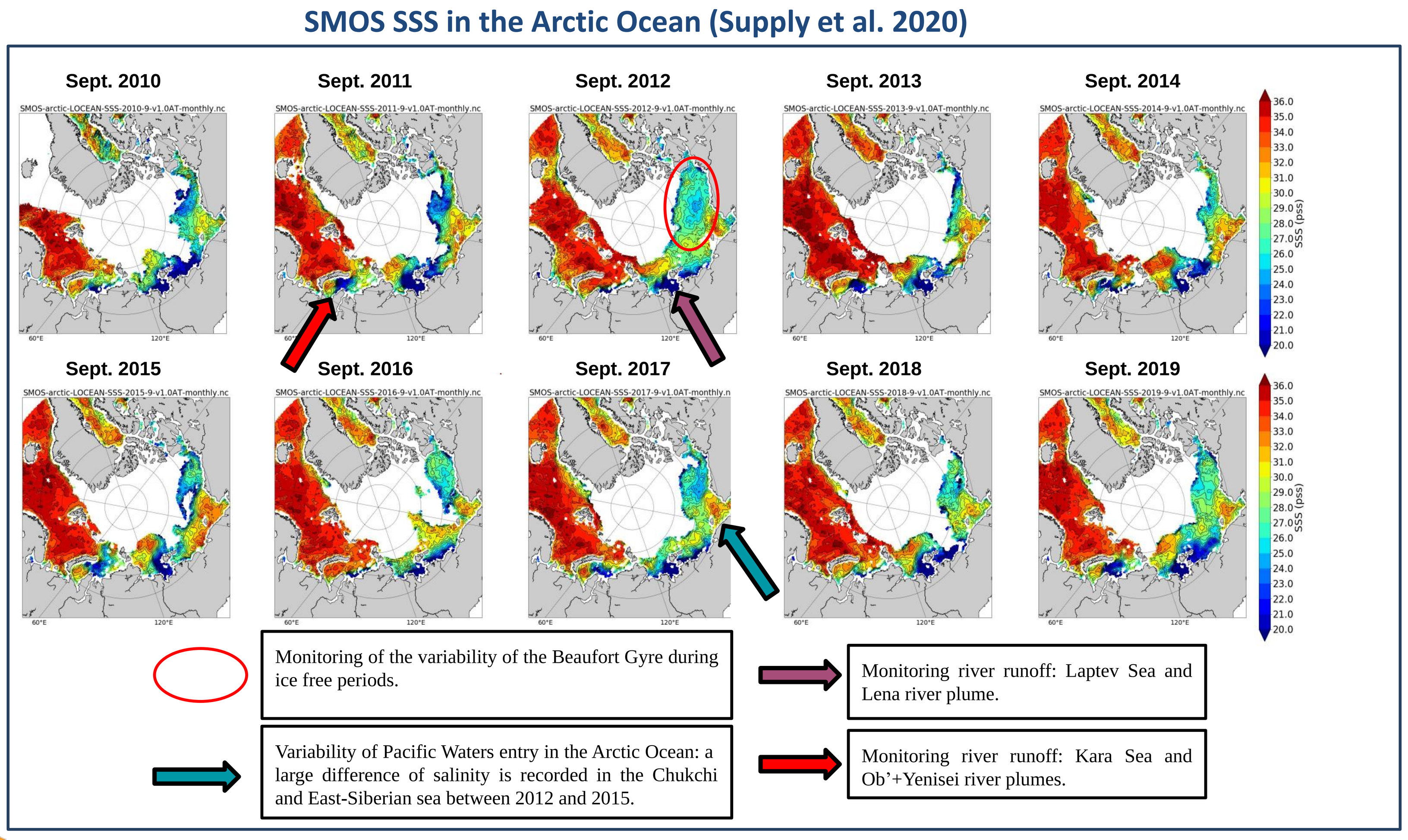




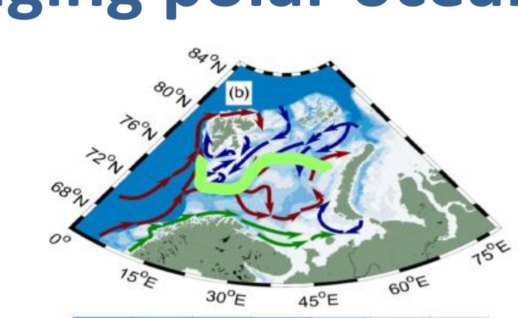
Usually, freshwater masses coming from Greenland meltwater and Arctic polar surface water remain on Greenland coastal shelf. A **strong anomalous event was detected in Fall 2021**. If mixed offshore, these freshwater masses have **the potential to stratify the Labrador sea and inhibit convection**. *(Reverdin et al. 2025, JAOT in rev., Foukal et al. 2025, in prep.)*

The changing polar oceans

SMOS SSS in the Arctic Ocean (Supply et al. 2020)



Arctic CATDS CEC V2 available at CATDS; operational Arctic SSS available @CATDS in 2026



Oziel et al., (2016)

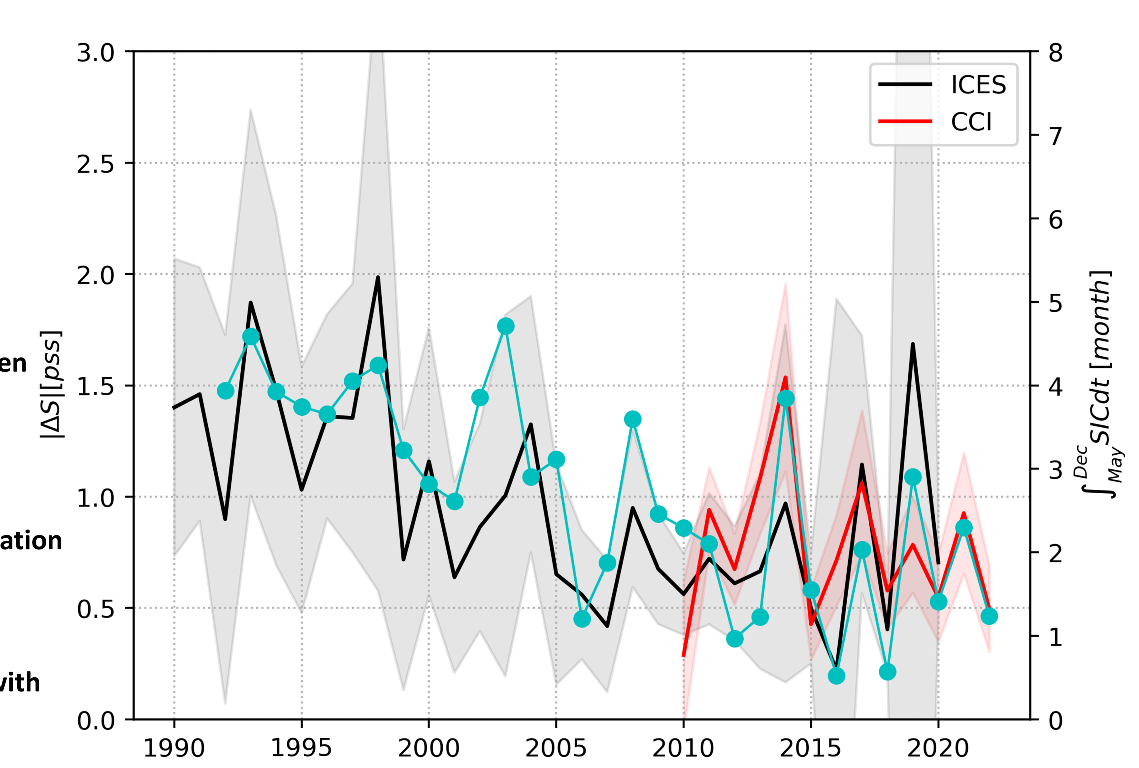
Barents Sea : hotspot of Atlantification of the Arctic Ocean
Strong impact on the Polar Front, the natural frontier between the Atlantic and Arctic Ocean hydrological, biogeochemical, ecological, and sea ice conditions

Sea Surface Salinity (SSS) gradient provides a better identification of the Polar Front rather than the SST gradient in Summer

Interannual SSS changes in September are mainly explained by the surface freshwater flux associated with the local melt of the sea ice imported into the region.

Kolodziejczyk et al., in rev., 2025

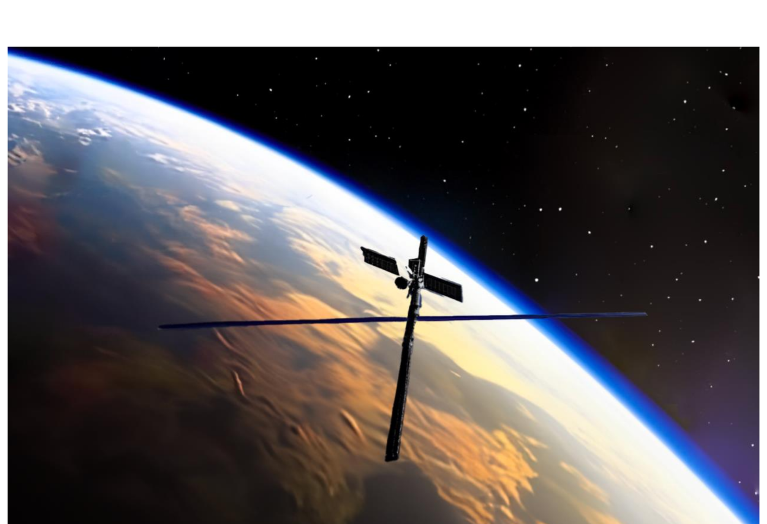
Polar Front surface thermohaline properties in the Barents Sea



September-October absolute SSS difference between north and south of the polar front between 1990-2022 for ICES in situ data (black), CCI+SSS (SMOS+Aquarius+SMAP, red), and the May to December ice cover equivalent duration (green dots).

CryoRad mission idea (ESA EE12) : SSS monitoring in cold waters: poster (# 1181)

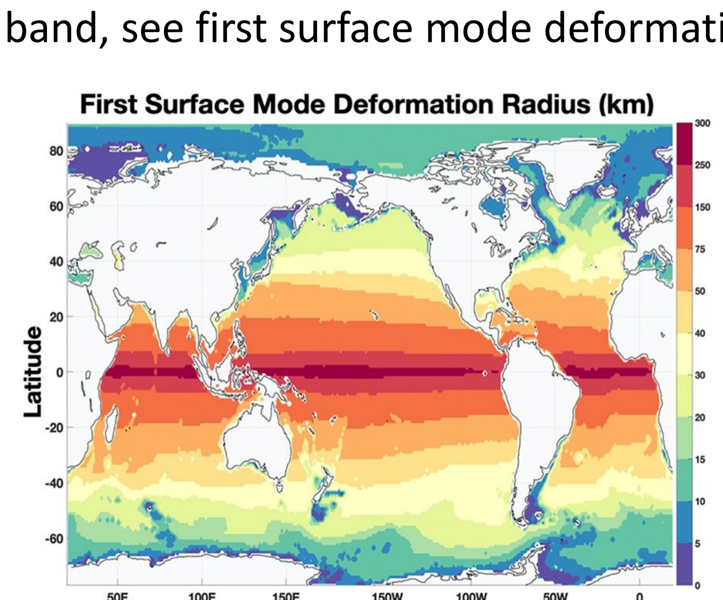
SMOS-HR/FRESCH : ~10km spatial resolution every ~ 3days



Concept:
- L-Band interferometric radiometer with antenna array optimized for high resolution

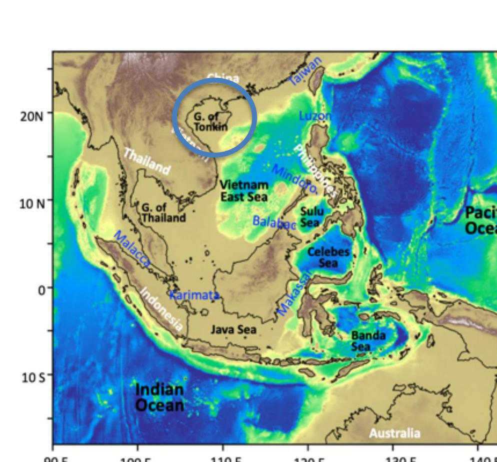
Programmatic:
- SMOS-HR CNES phase A Ok,
- FRESCH mission idea recommended for resubmission to ESA Earth Explorer 13

General Rationale:
- Get as close as **10km from the coast and ice** (only ~40km with SMOS):
  - **cover ~ 90 % of the surface of continental plateau** (only 50 % with SMOS)
- Detection of **small scale features, filaments** (SMOS resolution limits eddies structure detection outside tropical band, see first surface mode deformation on figure below)

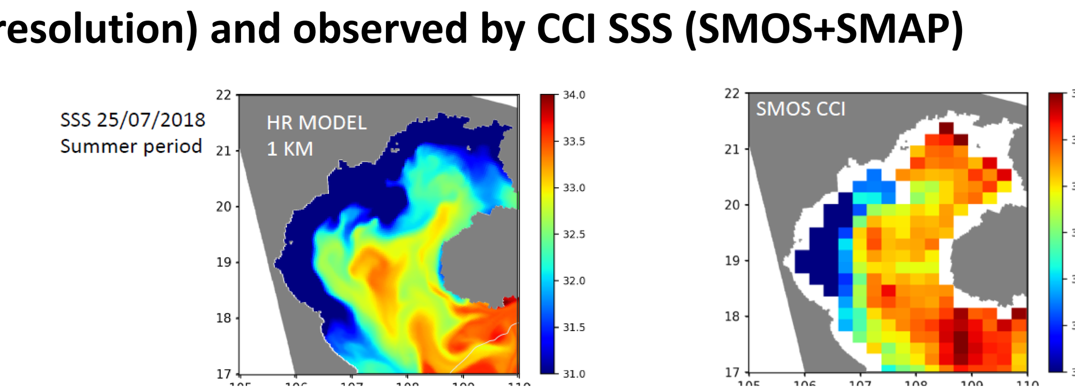


Scales of mesoscale eddies (1st baroclinic Rossby radius of deformation (km)(Lacasce and Groeskamp, 2020). SMOS-HR => mesoscale features at much higher latitude than SMOS.

River-ocean continuum : Red River Delta – Gulf of Tonkin:
- Southeast Asia : a hot spot of water masses transformation and transport
- Understand the processes (typhoons, wind, geostrophy, ENSO) that trigger the variability at different scales of water and sediment transport along the river - estuary – ocean continuum



Plume and Ocean SSS dynamics simulated by the Symphonie model (1km resolution) and observed by CCI SSS (SMOS+SMAP)



Need for SMOS-HR/FRESCH to monitor SSS (and density) in the River-Ocean continuum

Some References: Olivier et al. 2024, https://doi.org/10.1016/j.rse.2024.114165; Boutin et al. 2023, doi :10.1007/s10712-023-09798-5; Supply et al. 2020, https://doi.org/10.1016/j.rse.2020.112027; Reul et al., 2020: https://doi.org/10.1016/j.rse.2020.111769; Balaguru et al. 2020, https://doi.org/10.1175/BAMS-D-19-0303.1; Reul et al. 2021, https://doi.org/10.1029/2020GL091478.

Acknowledgements
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