Inserting SWOT/KaRIn images in the multi-mission altimeter constellation products

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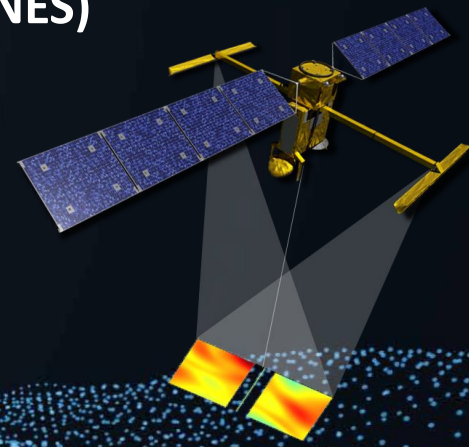
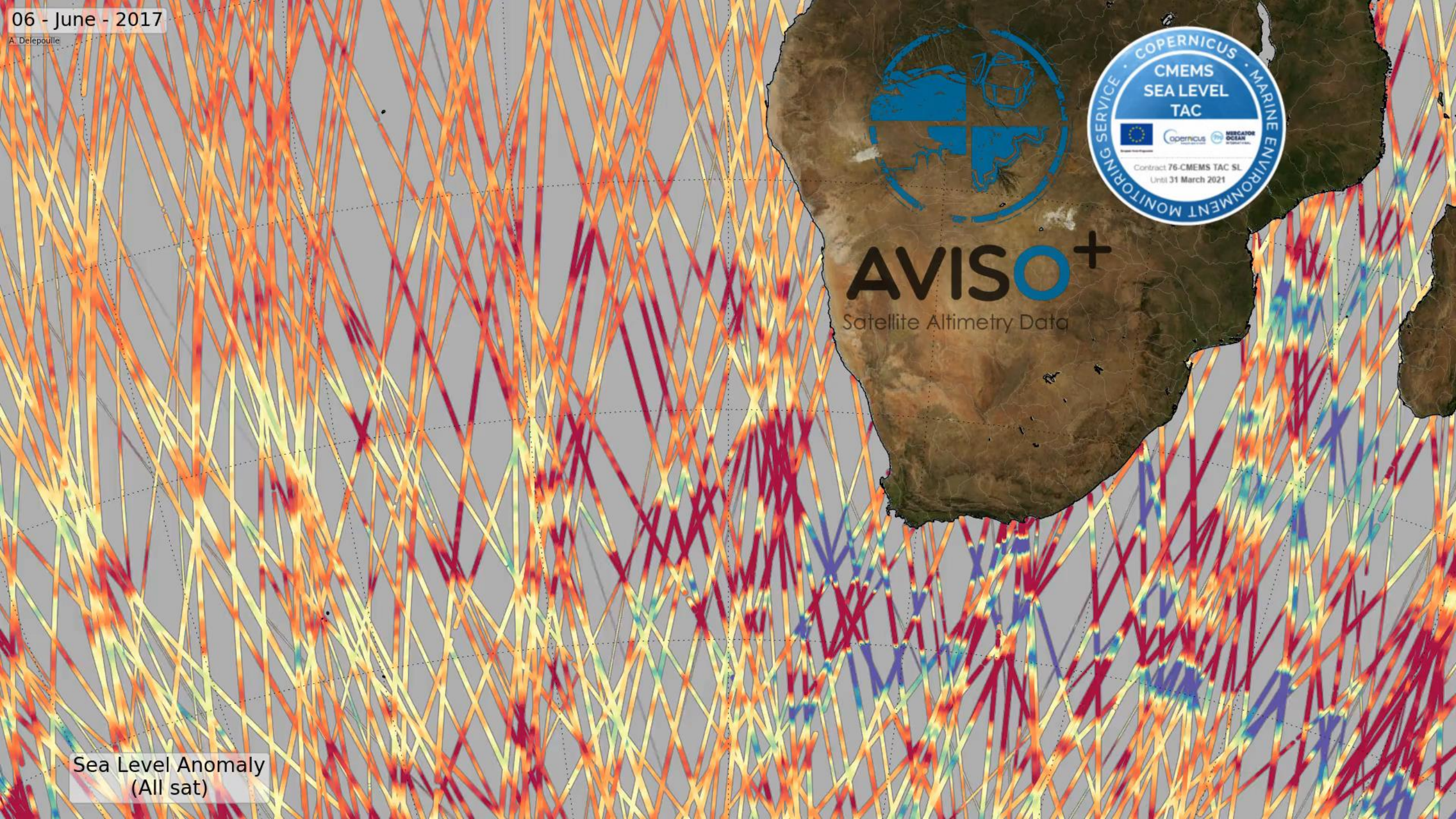
G Dibarboure (CNES)



OSTST Meeting, PUERTO RICO, Nov. 7 to Nov. 11, 2023


06 - June - 2017
A. Delepoulle
COPERNICUS
CMEMS
SEA LEVEL
TAC
MARINE ENVIRONMENT MONITORING SERVICE
Contract 76-CMEMS TAC SL
Until 31 March 2021
AVISO+
Satellite Altimetry Data
Sea Level Anomaly
(All sat)

Mapping approaches for the past 20 years (non-exhaustive)

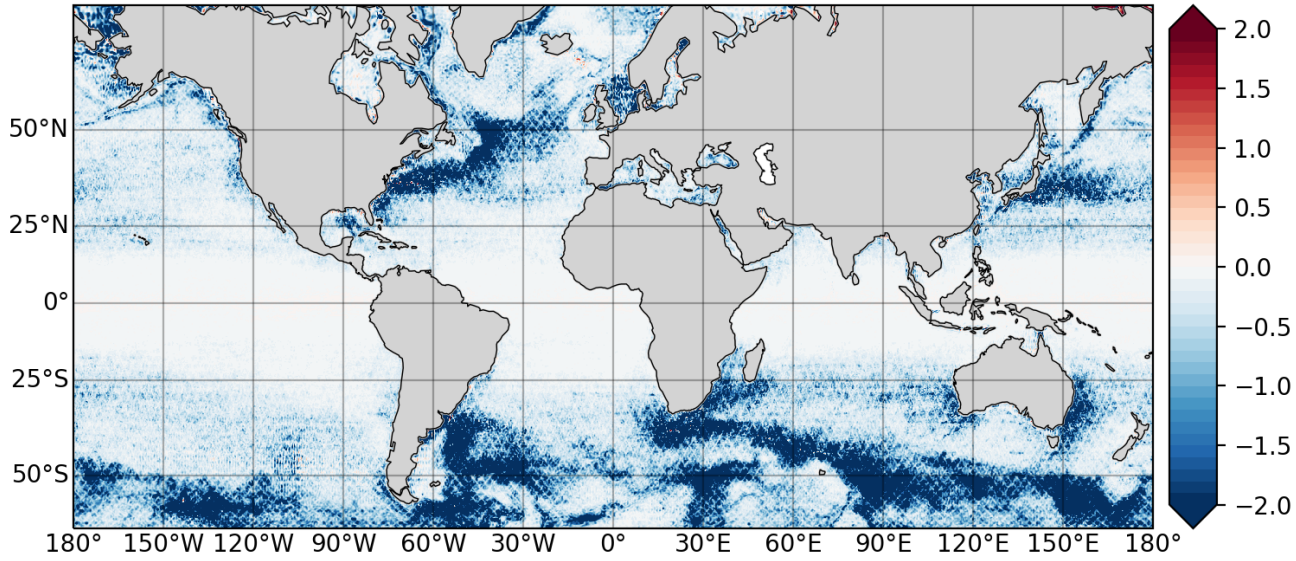
Le Traon, 1998, An Improved Mapping Method of Multisatellite Altimeter Data **Pujol et al, 2012**, Using High-Resolution Altimetry to Observe Mesoscale Signals, **Taburet et al, 2019**, DUACS DT2018: 25 years of reprocessed sea level altimetry products	**Objective Analysis**
Zlotnicki, 2019, MEaSUREs Gridded Sea Surface Height Anomalies Version 1812.	**Kriging**
Ubelmann, 2021, Reconstructing Ocean Surface Current Combining Altimetry and Future Spaceborne Doppler Data **Ballarotta, 2023**, Improved global sea surface height and currents maps from remote sensing and in situ observations **Bellemin Laponnaz et al, 2022**, High resolution SSH mapping with future satellite mission swot,	**Multiscale mapping (MIOST)**
Lilly et al, 2023, Optimal parameters formapping along-track altimetry	**Local Polynomial Fitting**
Ubelmann et al, 2015, Dynamic interpolation of sea surface height and potential applications for future high-resolution altimetry mapping, JAOT **Rogé et al, 2017** Using a dynamical advection to reconstruct a part of the SSH evolution in the context of SWOT, application to the Mediterranean **Ballarotta et al, 2020**, Dynamic Mapping of Along-Track Ocean Altimetry: Performance from Real Observations	**Dynamic interpolation - simplified QG**
Archer, 2020, Increasing the Space–Time Resolution of Mapped Sea Surface Height From Altimetry	**3D var**
Le Guillou, 2021, Mapping Altimetry in the Forthcoming SWOT Era by Back-and-Forth Nudging a One-Layer Quasigeostrophic Model **See Florian «forum» presentation**	**BFN-QG – simplified QG**
Fablet et al., 2021, End-to end physics-informed representation learning for satellite ocean remote sensing data:Applications to satellite altimetry and sea surface currents.	**Data driven (4Dvarnet)**
Martin, 2023 Synthesizing Sea Surface Temperature and Satellite Altimetry Observations Using Deep Learning Improves the Accuracy and Resolution of Gridded Sea Surface Height Anomalies **Xiao, 2023,** Reconstruction of Surface Kinematics From Sea Surface Height Using Neural Networks	**Data driven & Multisensor**

Specific preparation of SWOT ingestion through OSSE

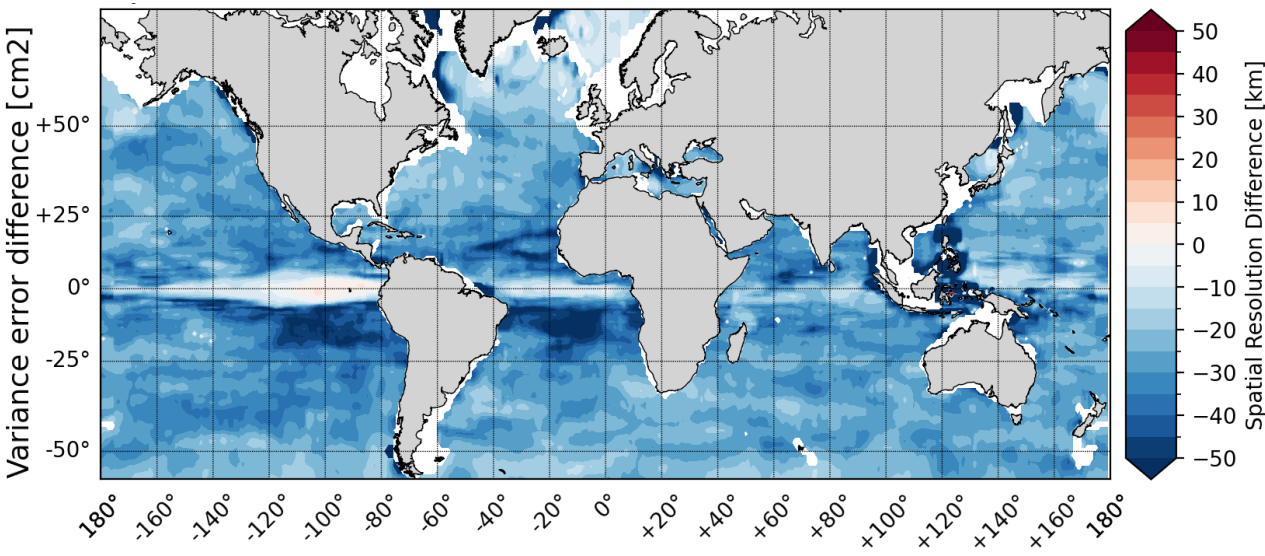
Bellemin Laponnaz et al, 2022, High resolution SSH mapping with future satellite mission swot (OSTST 2022)

- OSSE using MIOST (Multiscale Mapping). MIOST is still R&d algorithm but will be the official/ operational algorithm in DUACS in 2025
- The experiment consisted in the comparison of the performances of **a [3 nadir] map to [3 nadir+swot]**

Mapping Error reduction with SWOT (cm2)



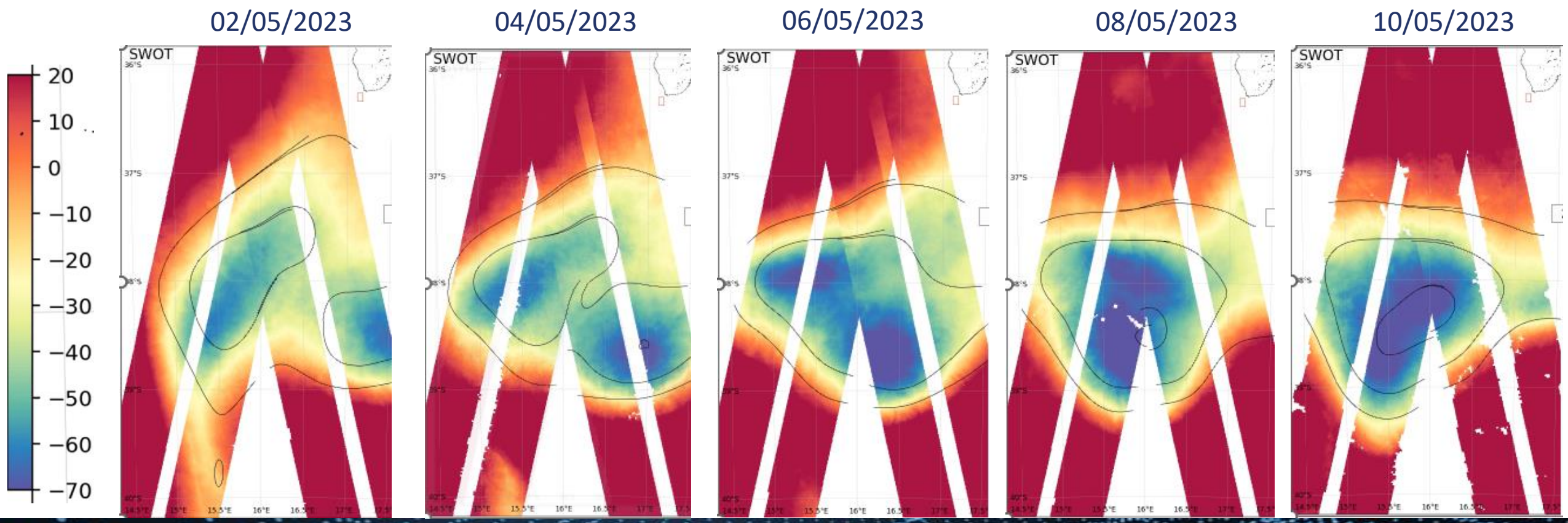
Resolution increase with SWOT (km)



Real SWOT Data available: OSE now possible

- SWOT performances are oustanding (*see OSTST talks from Lee Fu, Jimbo wang*)
- 1-day Level 2 products have been entirely reprocessed by JPL (>3month). Several weeks of 21-day also available
- Complementary Level 3 products have been developed (*see OSTST talk from Clement Ubelmann)*

- Example of an eddy interaction in the Aghulas current using SWOT L3



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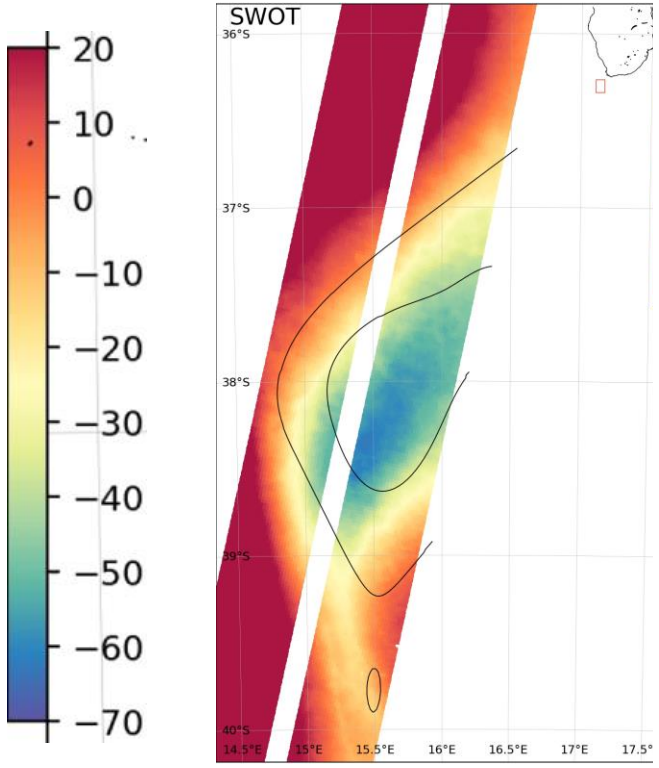
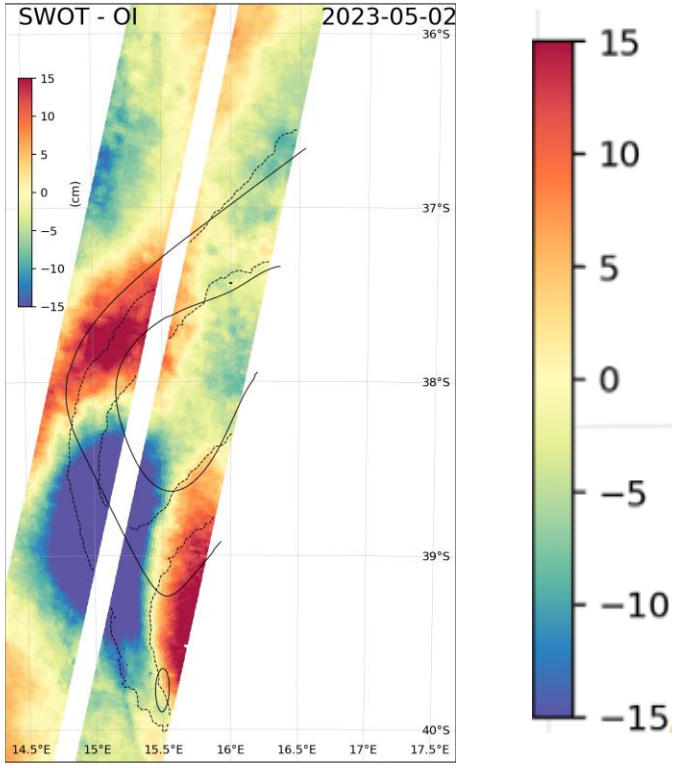
L3 [SWOT] (cm)



Next step is ingesting SWOT in the mapping

L3 [SWOT] – L4 [Nadirs] (cm)

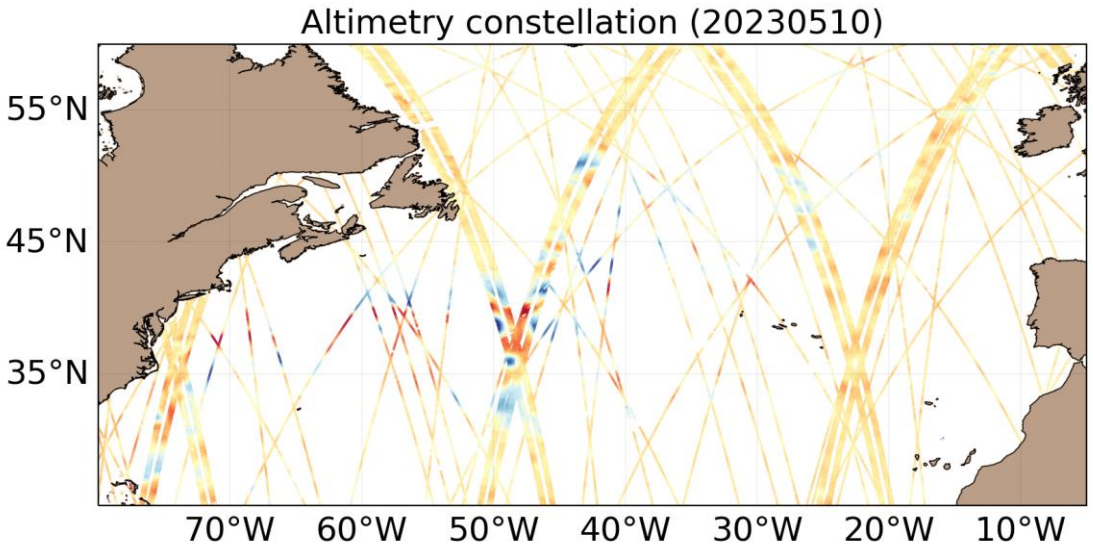


OSE Experimental design

Experiments

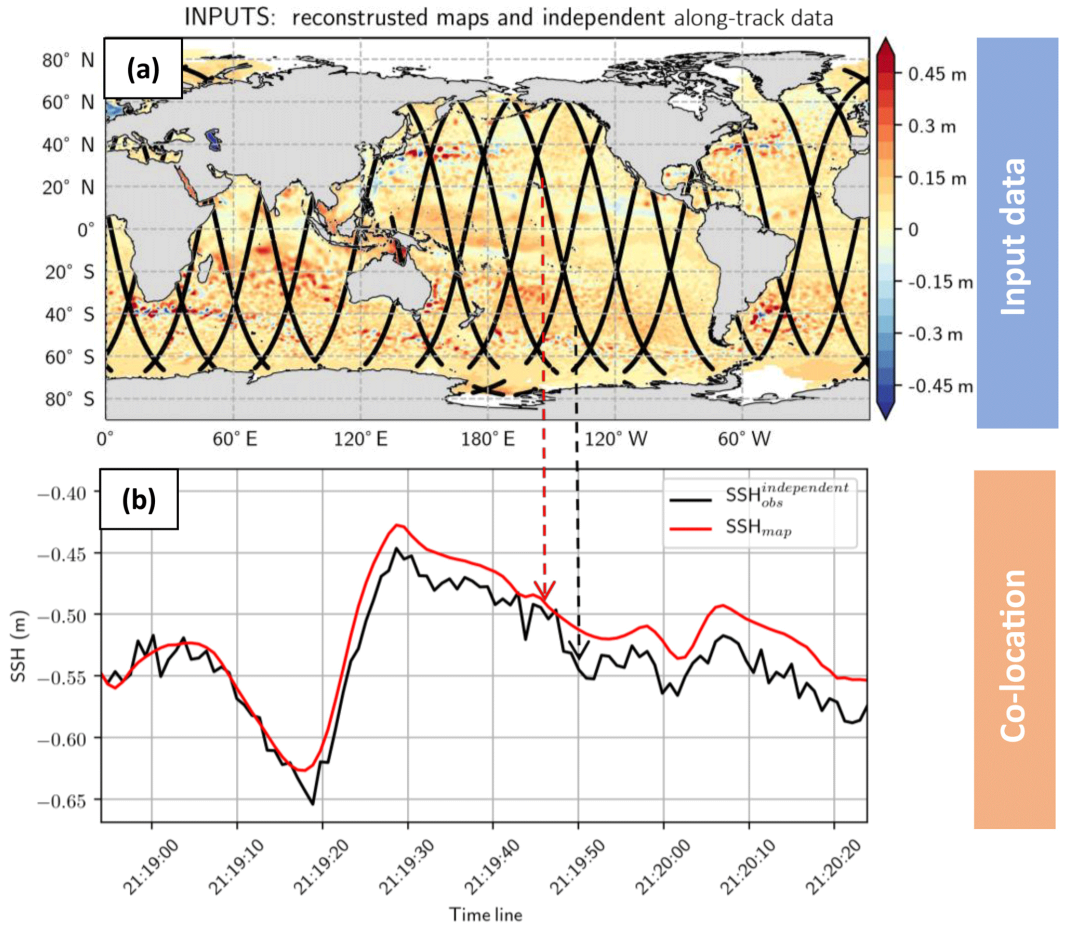
- Experiments carried out in Delayed-Time mode (past & future observations) from 2023-05-01 to 2023-07-01:
  - **EXP#1**: Cryosat-2, HaiYang-2B, Sentinel-3A, Sentinel-3B, Sentinel-6, Jason-3 => **L4 [Nadirs]**
  - **EXP#2**: Cryosat-2, HaiYang-2B, Sentinel-3A, Sentinel-3B, Sentinel-6, Jason-3 + **SWOT Karin:** => **L4 [Nadirs+SWOT]**

- 2 method tested **MIOST** (Global) & **4Dvarnet** (North Atlantic)

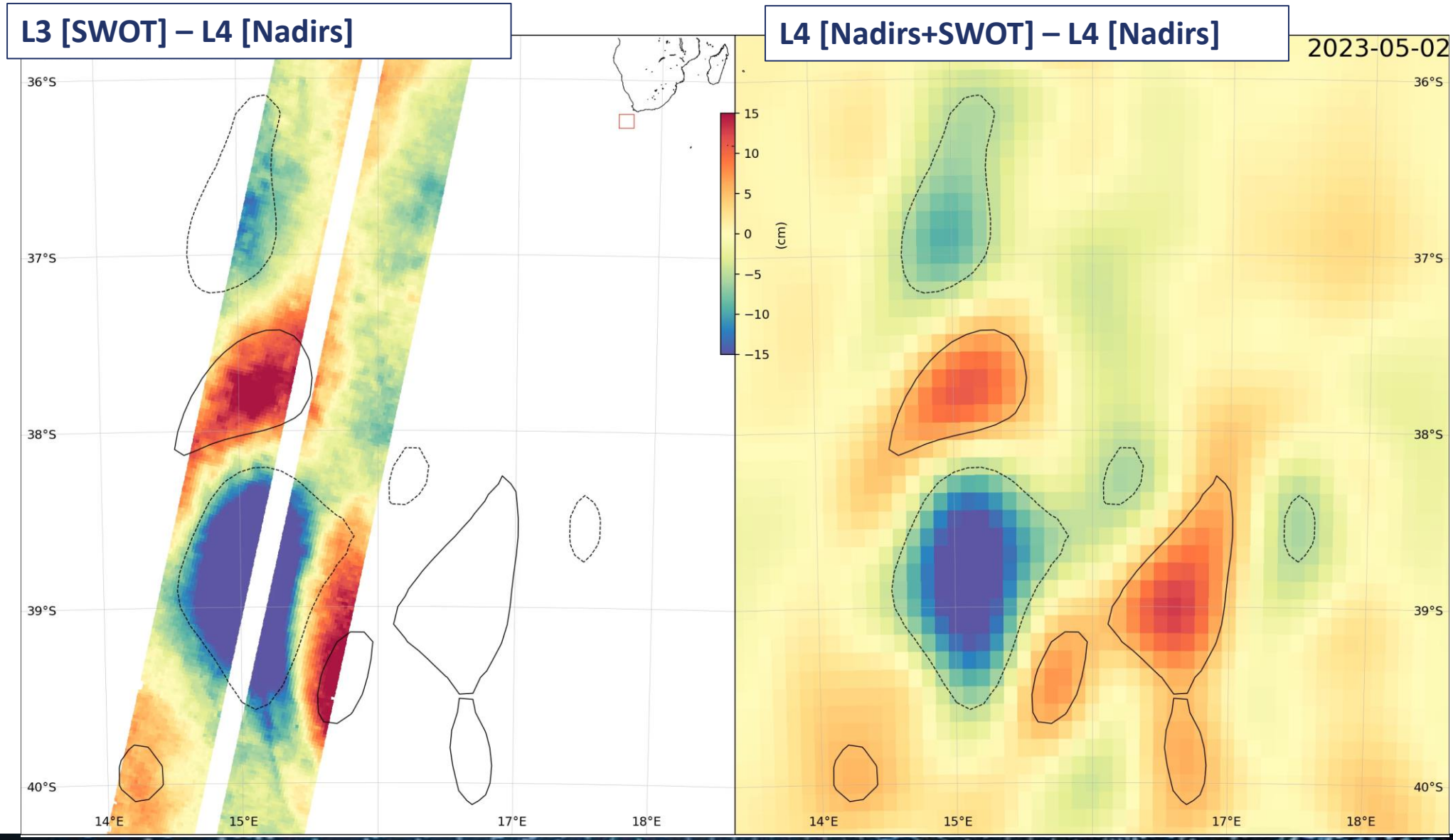


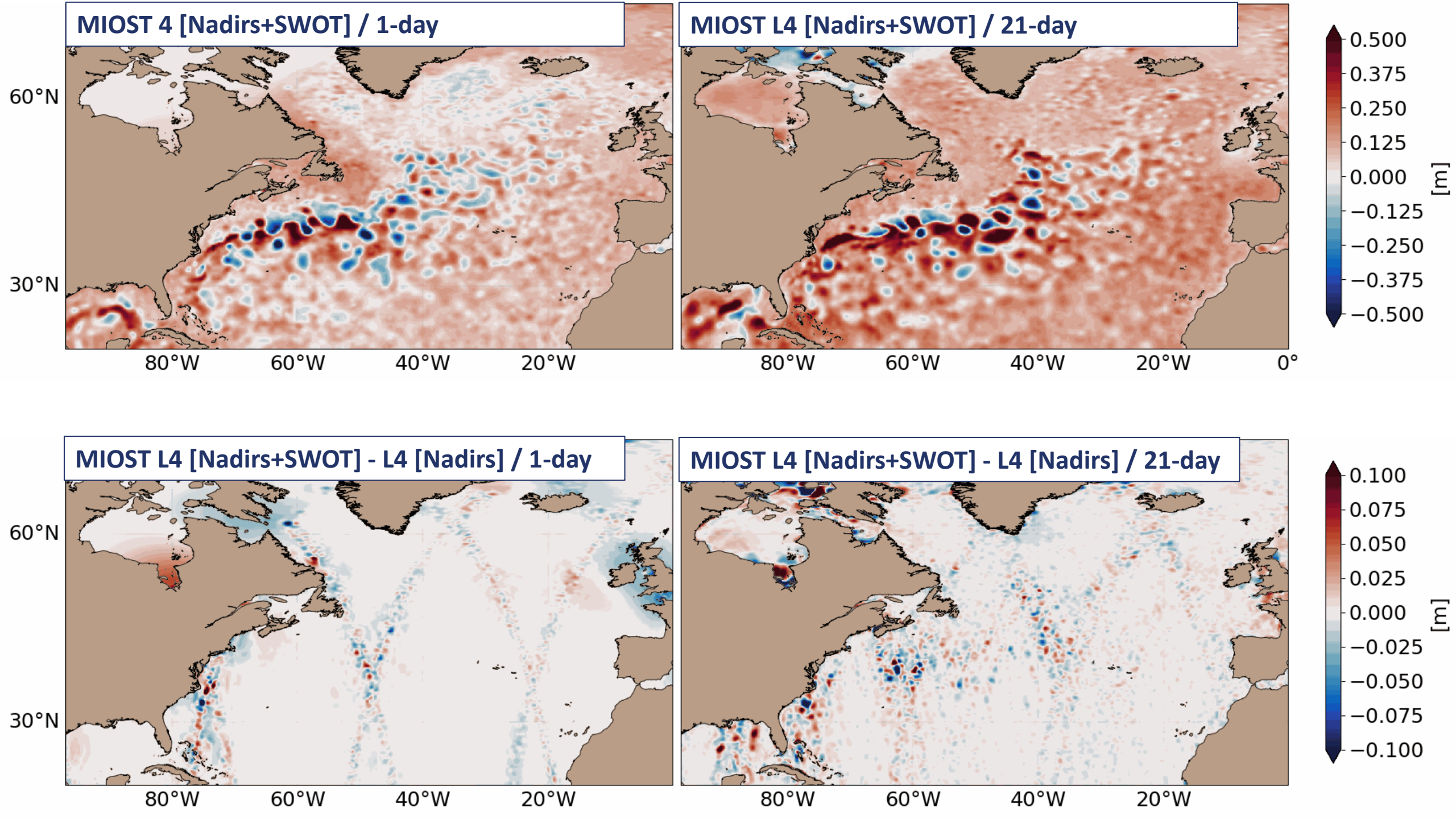
Assessment

- Visual assessment
- Comparison to Saral/Altika kept as independent measurements.



Performances of MIOST L4 [Nadirs+SWOT] / 1-day

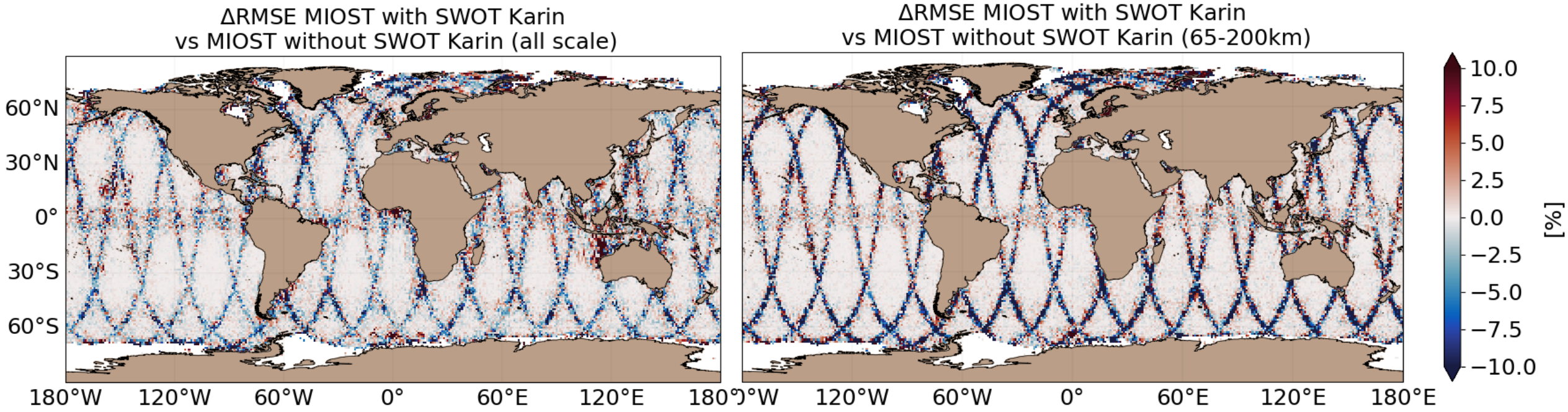



MIOST 4 [Nadirs+SWOT] / 1-day
MIOST L4 [Nadirs+SWOT] / 21-day
MIOST L4 [Nadirs+SWOT] - L4 [Nadirs] / 1-day
MIOST L4 [Nadirs+SWOT] - L4 [Nadirs] / 21-day
60°N
30°N
80°W
60°W
40°W
20°W
0°
0.500
0.375
0.250
0.125
0.000
−0.125
−0.250
−0.375
−0.500
0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.100
[m]

Performances of MIOST L4 [Nadirs+SWOT] / 1-day

	offshore (> 200km) & high var (> 0.02m2)		offshore (> 200km) & low var (<0.02m2)	
	In swath [%]	Near swath [%]	In swath [%]	Near swath [%]
ALL SCALE	-9.83	-4.03	-2.05	-1.03
65-200km	-16.85	-6.89	-5.97	-2.34

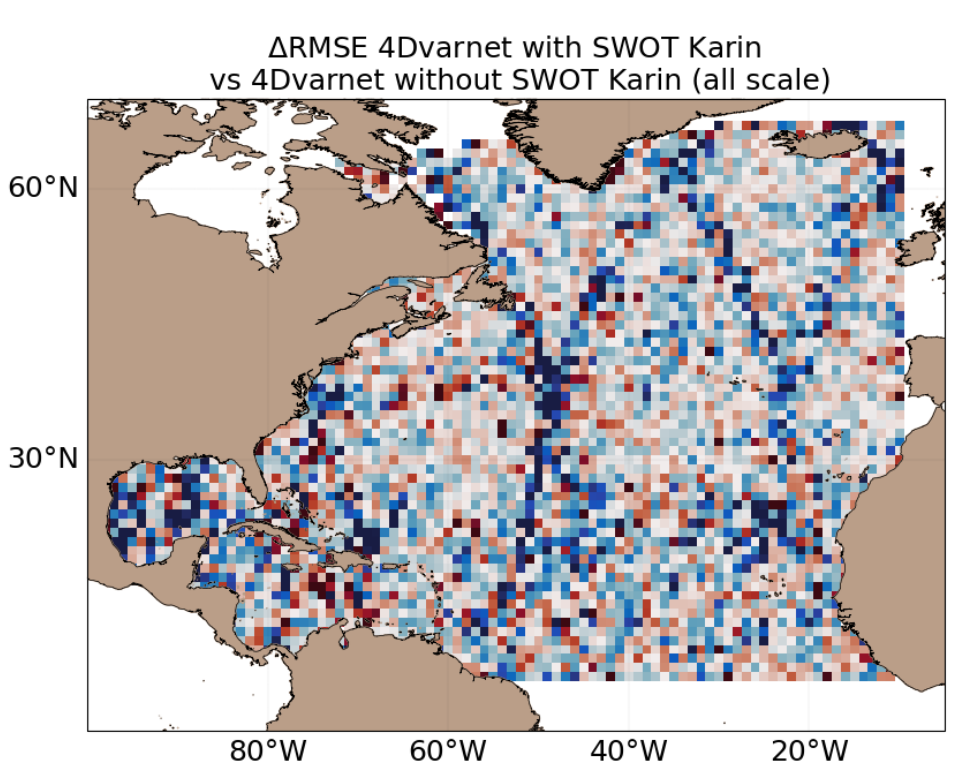
Improved with Karin **Degraded with Karin**

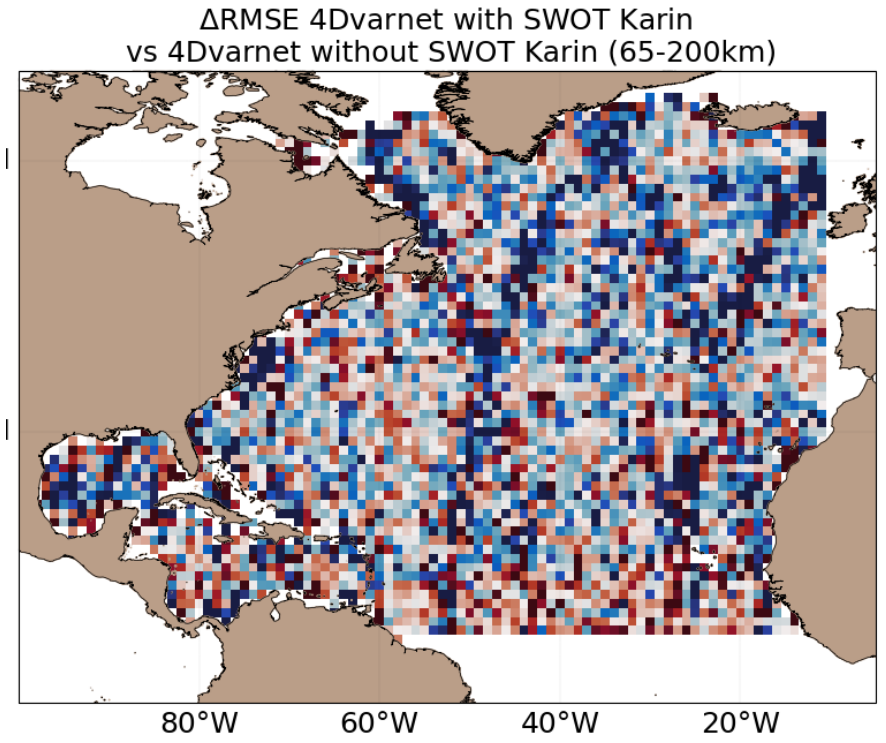


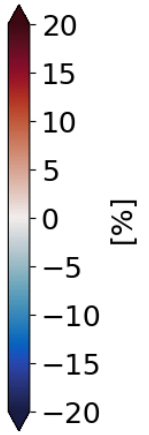
Performances of 4DVArnet L4 [Nadirs+SWOT] / 1-day

Data driven « 4DVarnet »

	offshore (> 200km) & high var (> 0.02m2)		offshore (> 200km) & low var (<0.02m2)	
	In swath [%]	Near swath [%]	In swath [%]	Near swath [%]
ALL SCALE	-17.46	-4.79	-5.34	-3.92
65-200km	-18.09	-6.45	-6.79	-6.74







Improved with Karin

Degraded with Karin

Conclusion & Perspectives

- Two mapping methods (MIOST & 4Dvarnet) were tested to reconstruct the ocean surface topography using Level-3 SWOT Karin data and nadirs observations.
- The experiments indicate that the **systems behave well ingesting Karin** data in addition to the current **nadir constellations**.
- Based on these preliminary results, the **contribution of Karin** is a **reduction of 15-20% in RMSE** (Root Mean Square Error) in energetic regions, and approximately **8% reduction elsewhere.** Test on a longer period needed to consolidate
- **Data driven methods are very promising**
- With the refinement of the resolution **the wave/mesoscale separation become crucial**
- **“Data challenge” frameworks are ready** for Global/Regional mapping with Karin, so that different groups can intercompare their mapping and propose validation methods

  https://ocean-data-challenges.github.io/