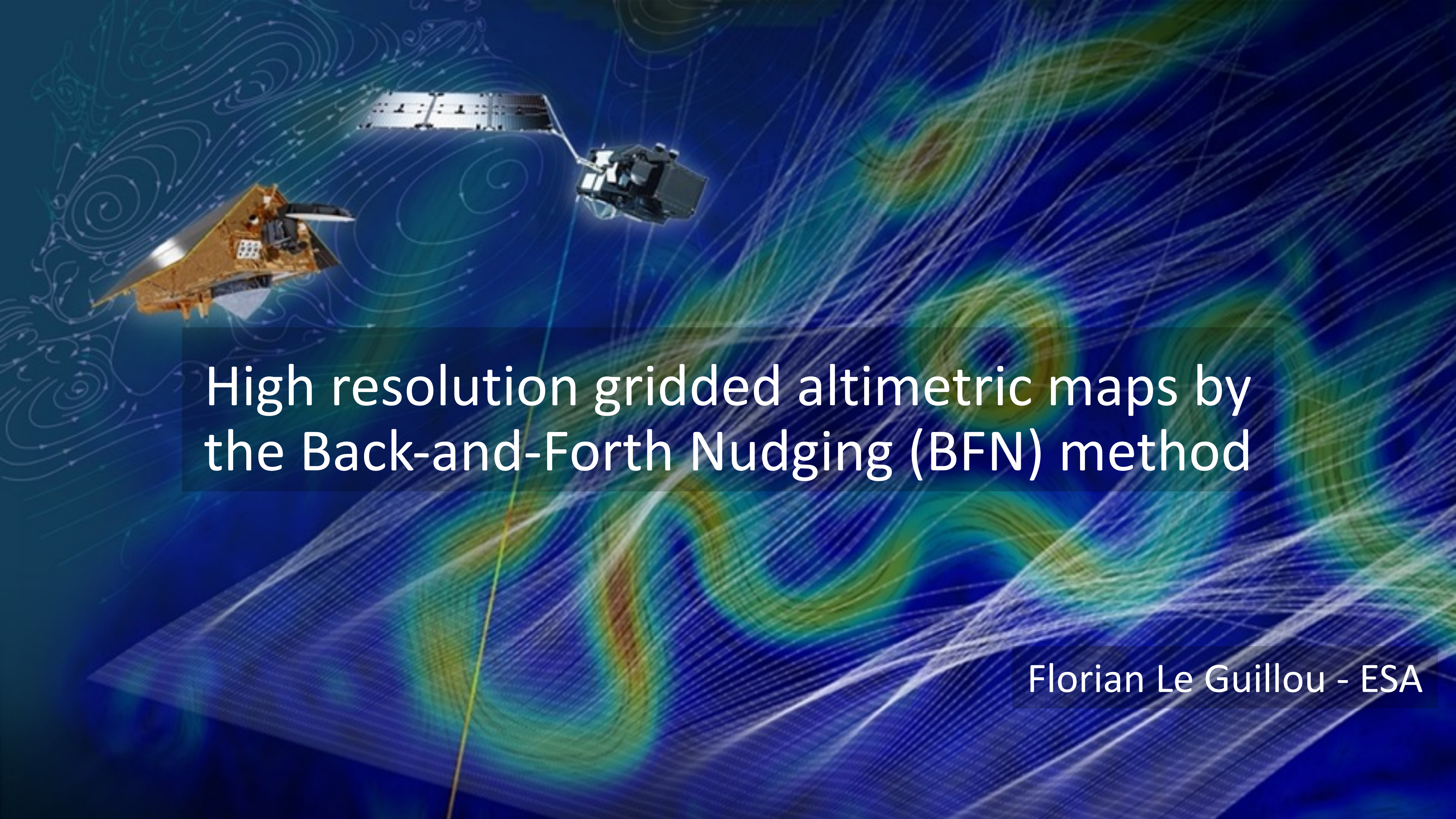
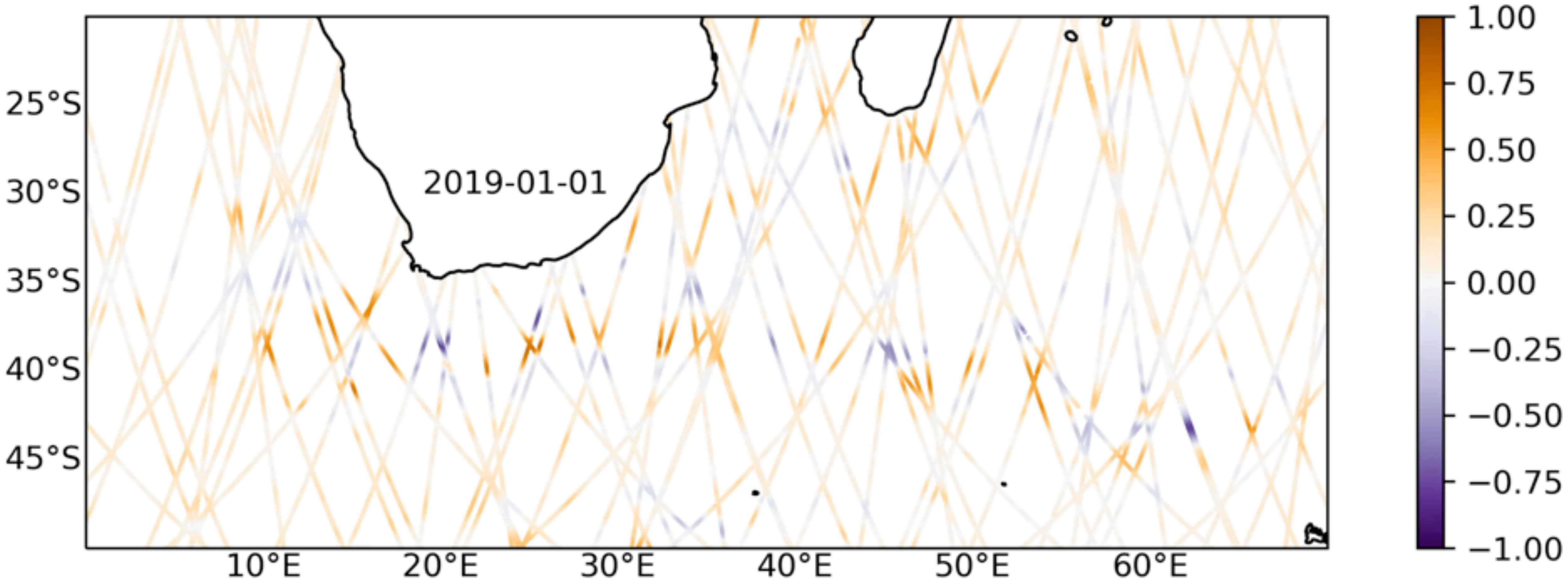


High resolution gridded altimetric maps by the Back-and-Forth Nudging (BFN) method

Florian Le Guillou - ESA

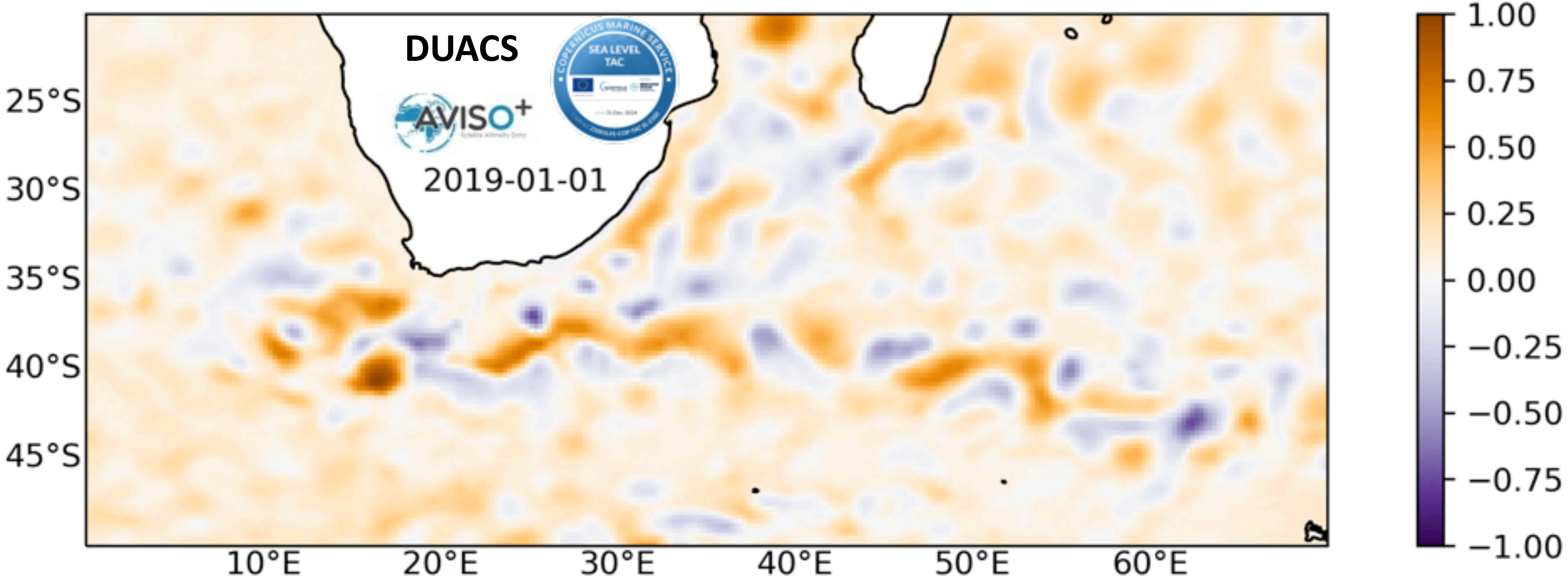
Ocean circulation estimated from altimetry

Several altimeters provide Sea Level Anomaly (**SLA**) observations along **one-dimensional tracks**



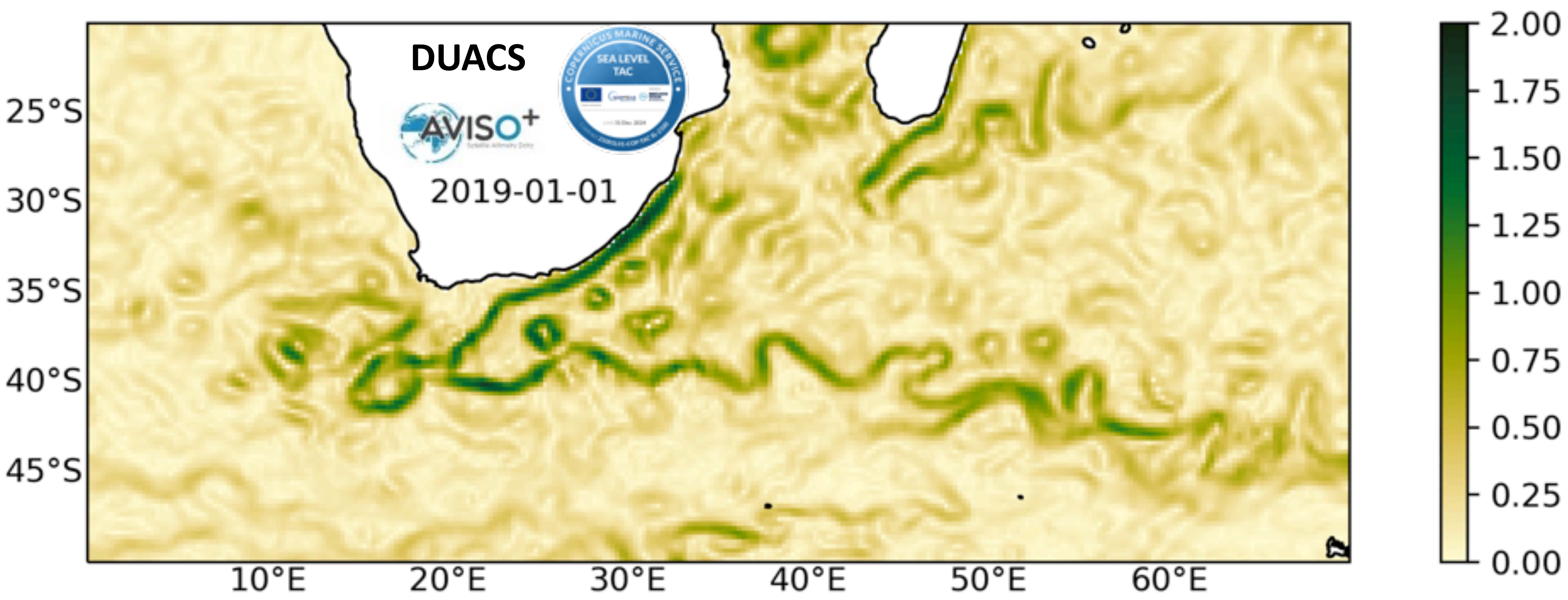
Ocean circulation estimated from altimetry

The 1D altimetric observations are optimally interpolated in space/time to provide gridded SSH maps



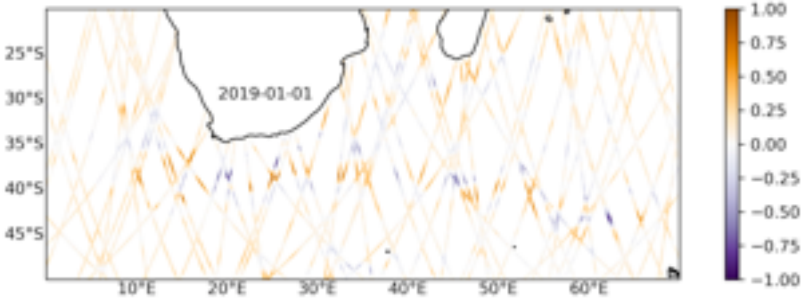
Ocean circulation estimated from altimetry

The surface currents are derived using the **geostrophy assumption**

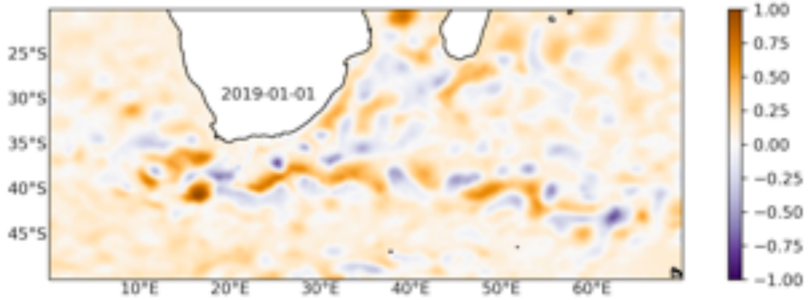


Limits of the operational DUACS products

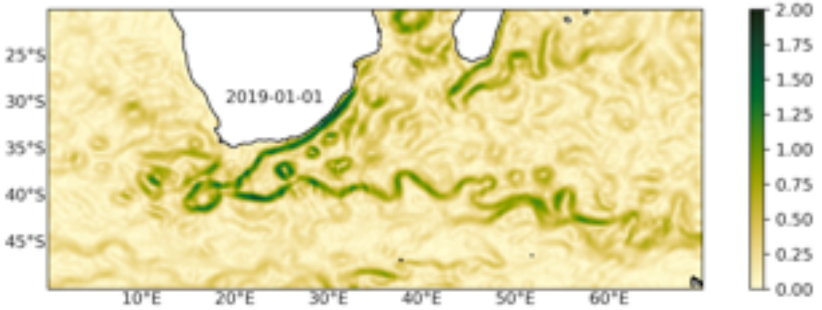
Along-track SLA



Mapped SLA



Surface currents



Optimal (linear) interpolation

Geostrophy assumption

Limit: Space-time resolution limited to 200km – 10 days (*Ballarotta et al., 2019*)

Challenge: Improve the mapping algorithm to take into account non linear dynamics

Opportunitiy: Add non linear dynamical constrain in the mapping procedure (e.g. *Ubelmann et al. 2015* and **this talk**)

Limit: Only the geostrophic circulation is estimated

Challenge: Include ageostrophic processes (e.g. Ekman, tidal, inertial currents)

Opportunity: Use other spaceborne and/or *in situ* observations, e.g. Drifters (**next talk** by Clement Ubelmann)

The Back-and-Forth-Nudging (BFN) method

*Quasi-Geostrophic (**QG**) dynamics*

$$\left.\begin{aligned} q &= \frac{g}{f}\nabla^2\eta - \frac{f}{H_e}\eta \\ \frac{\partial q}{\partial t} &+ u_g\frac{\partial q}{\partial x} + v_g\frac{\partial q}{\partial y} = 0 \end{aligned}\right\} \quad \frac{\partial \eta}{\partial t} = \mathcal{M}(\eta, t)$$

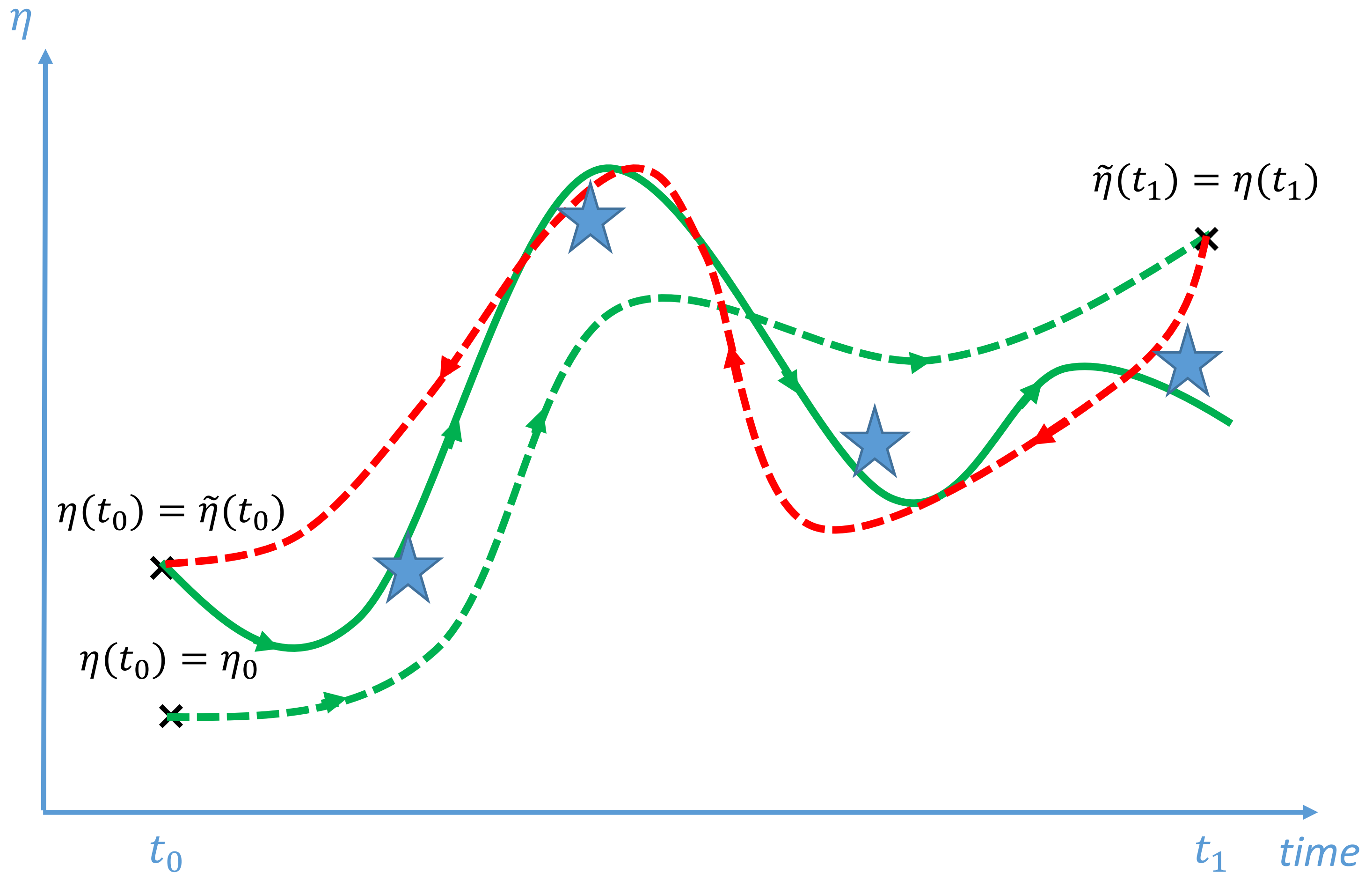
Forward nudging

$$\begin{cases} \eta(t_0) = \eta_0 \\ \dfrac{\partial \eta}{\partial t} = \mathcal{M}(\eta, t) + K(\eta^{obs} - \eta) \end{cases}$$

Backward nudging

$$\begin{cases} \tilde{\eta}(t_0) = \tilde{\eta}_0 \\ \dfrac{\partial \tilde{\eta}}{\partial t} = \mathcal{M}(\tilde{\eta}, t) - K(\eta^{obs} - \tilde{\eta}) \end{cases}$$

Let's consider some observations η^{obs} over $[t_0, t_1]$



Experimental set-up

Study region: retroflexion of the Agulhas Current

Time periods: 2010-2019

Input dataset: all available altimetry data

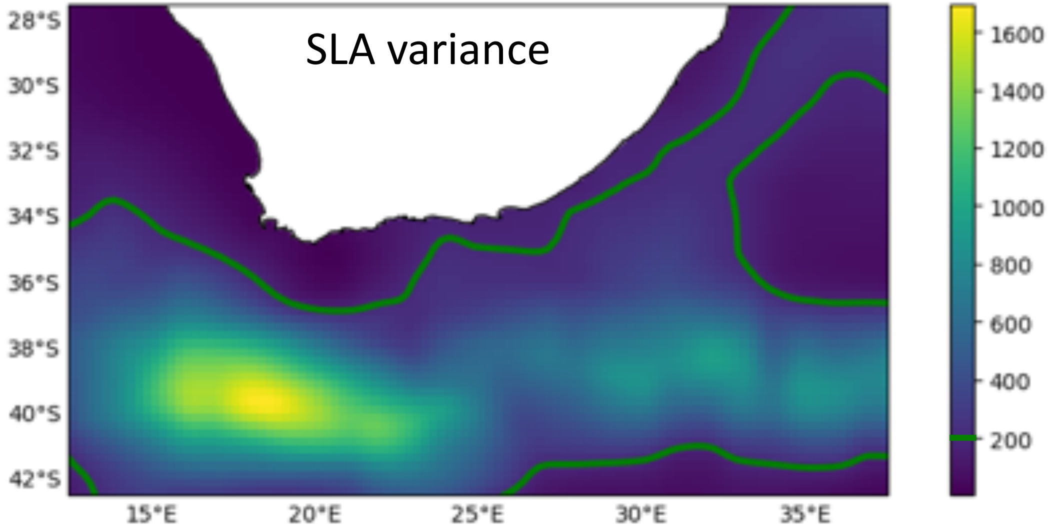
Methods: DUACS & BFN-QG

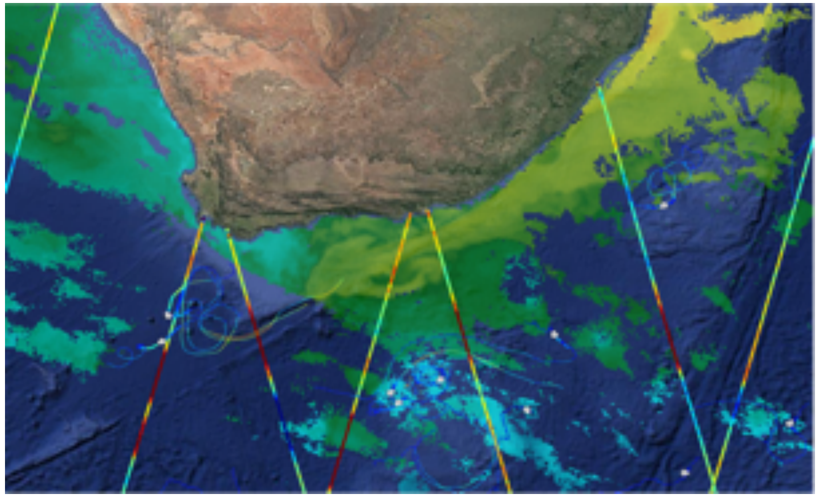
Independent dataset for validation:

SLA from SARAL/AltiKa, removed from the input dataset (only for year 2019)

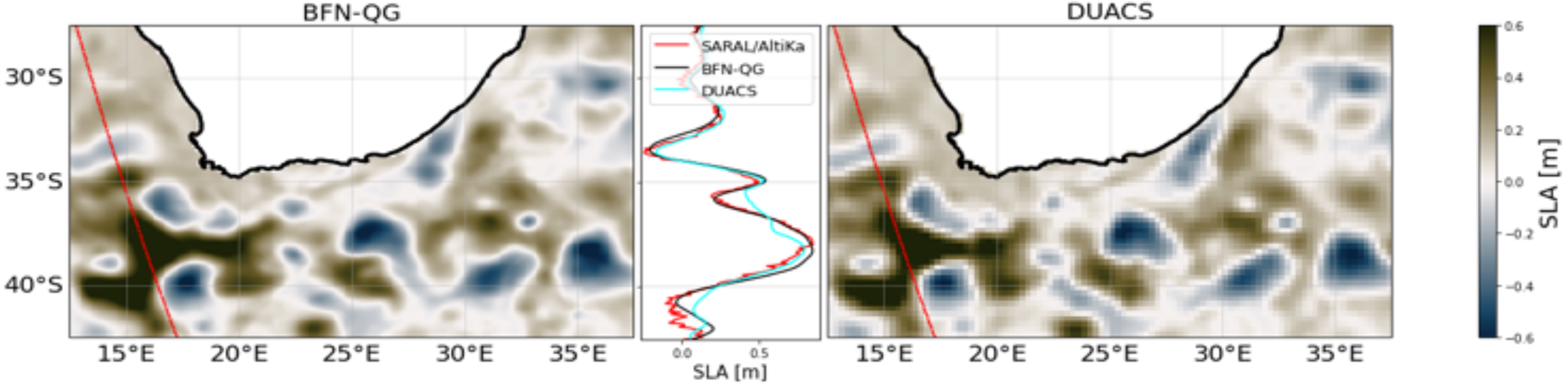
SST Seviri L3C (Eumetsat)

Drifters 15m drogue (Coriolis, CMEMS)



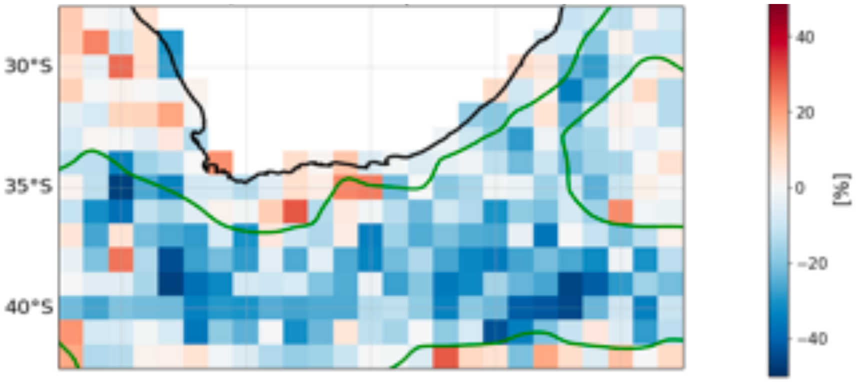


Results: performances in SLA mapping



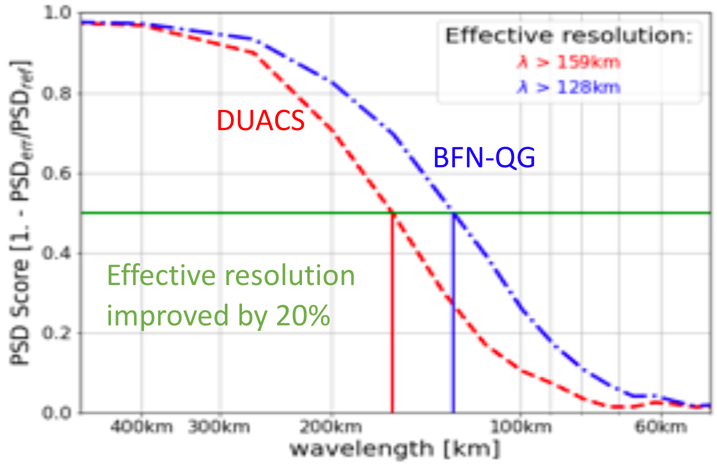
$$RMSE_{map} = \sqrt{SLA_{map}{}^2 - SLA_{SARAL}{}^2}$$

$$Gain/Loss = \frac{RMSE_{BFN} - RMSE_{DUACS}}{RMSE_{DUACS}}$$



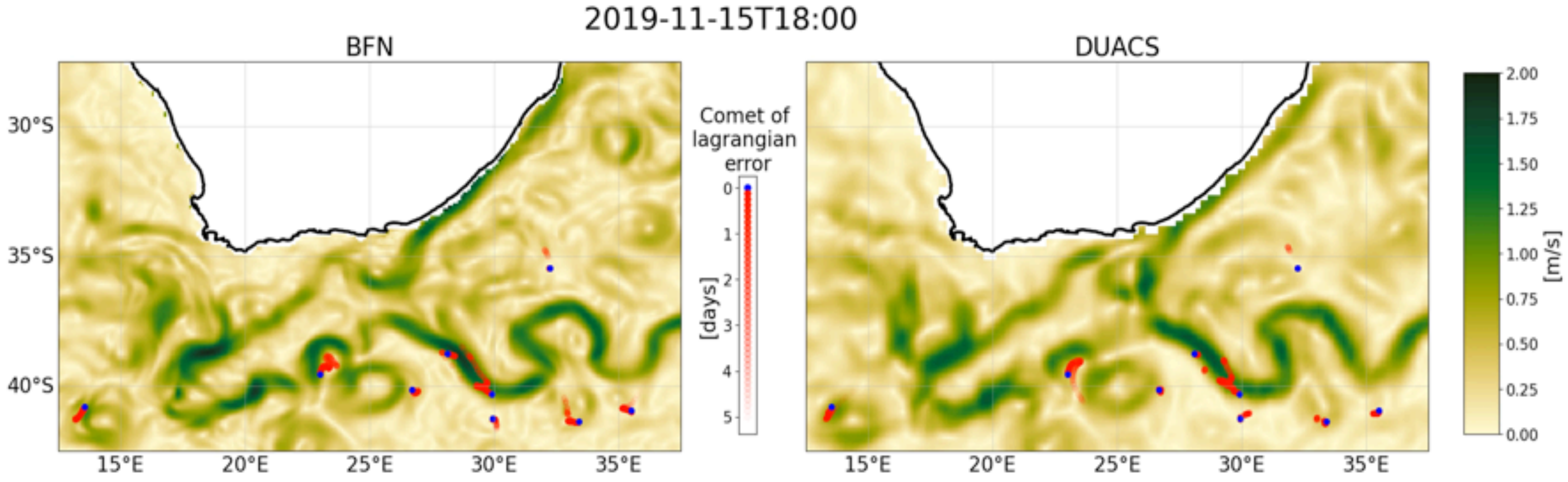
Average reduction of error ~10%

Spectral diagnostics



Results: performances in ocean currents retrieval

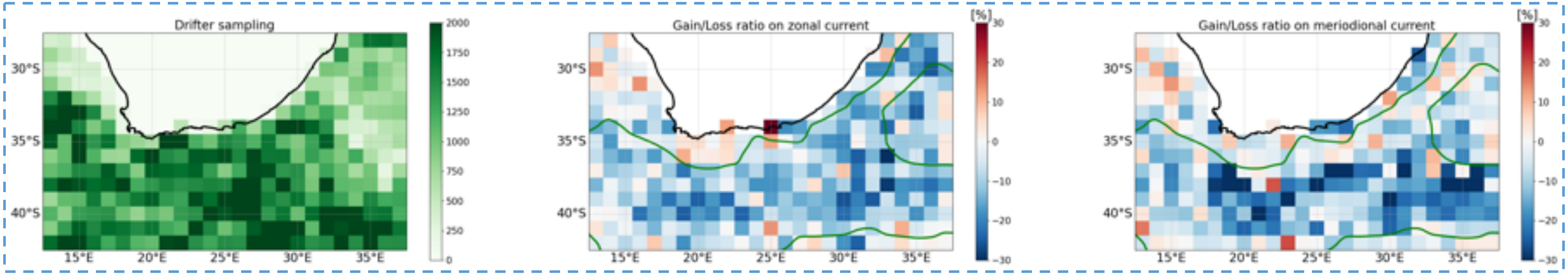
Comparisons with Drifter data



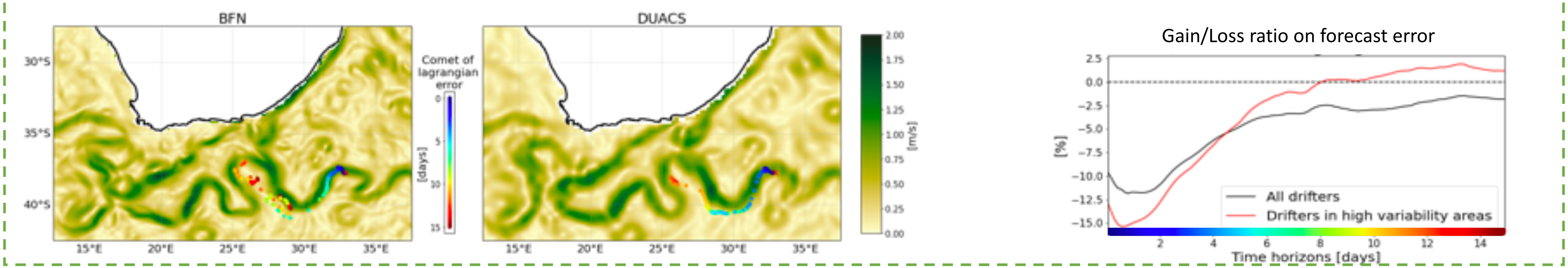
Results: performances in ocean currents retrieval

Comparisons with Drifter data

Diagnostics on Eulerian velocities



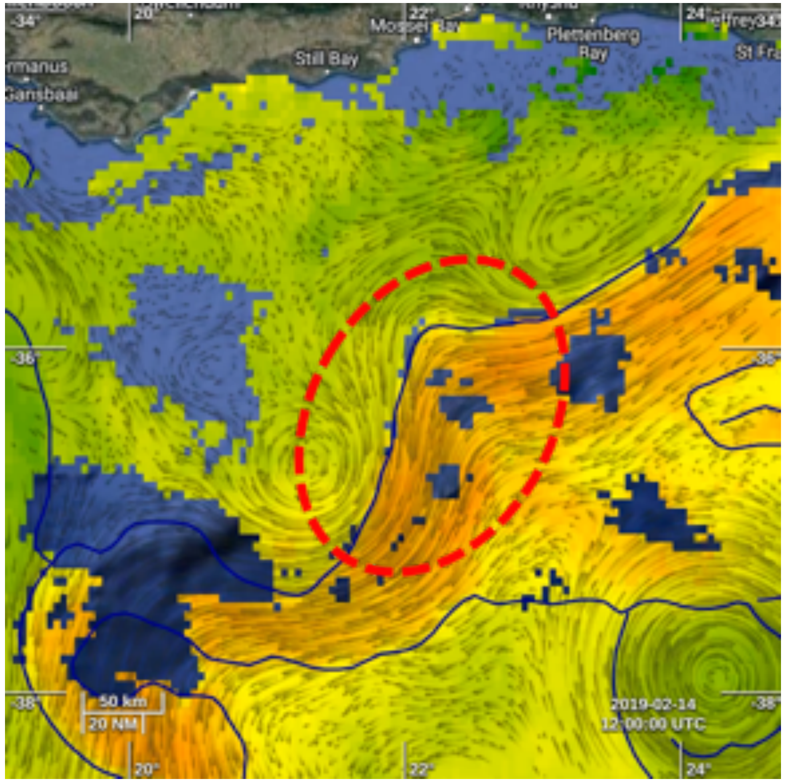
Diagnostic on Lagrangian velocities



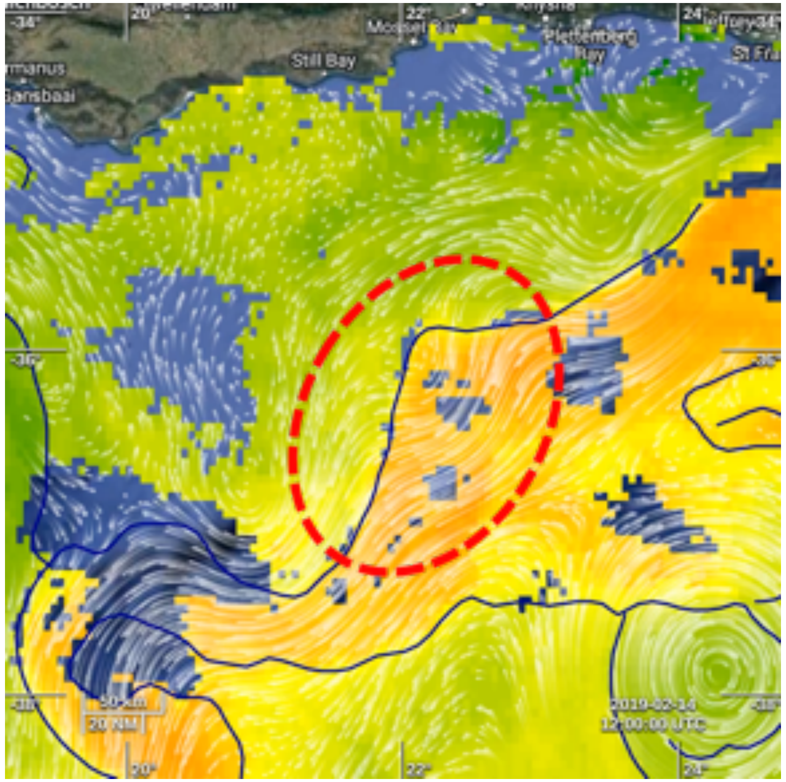
Results: performances in ocean currents retrieval

Comparisons with SST data

BFN-QG



DUACS



For quantitative assessment, see Lucile Gautier's talk this afternoon

Conlusions and perspectives

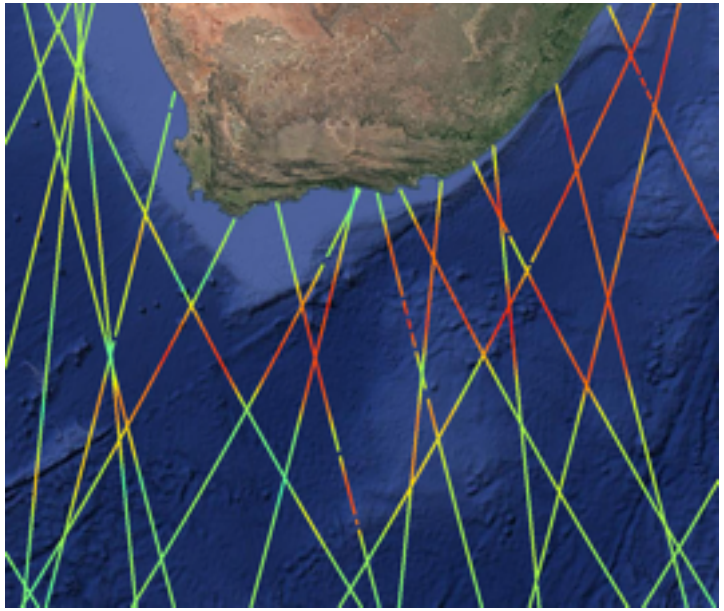
- BFN-QG improves the quality of SLA/currents retrievals in the Agulhas current
  - Space resolutions of SLA maps improved by 20%
  - Both Eurelian zonal/meridional currents improved by 10%
  - Lagrangian prediction improved for lead times < 5-10 days

- What remains to be improved:
  - Performances depend on the dynamical regime (where QG assumptions hold)
  - SLA only gives the geostrophic currents

Proposed future work

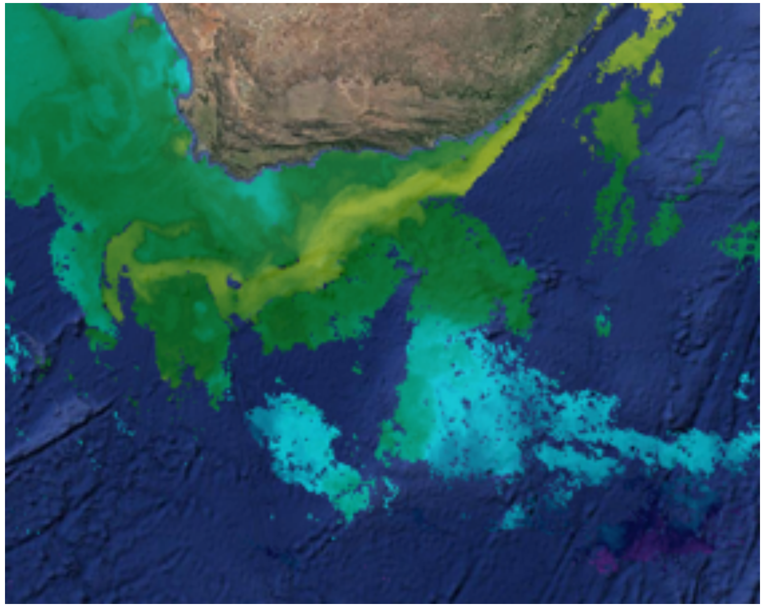
Multi-sensors assimilation

Altimetry



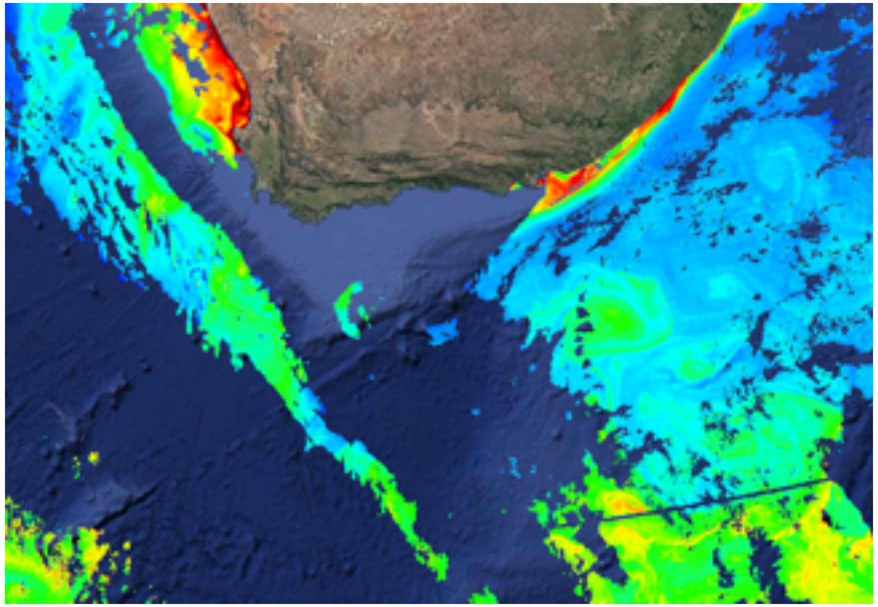
$$\frac{\partial q}{\partial t} + \boldsymbol{U_g} \cdot \nabla q = 0$$

Sea Surface Temperature

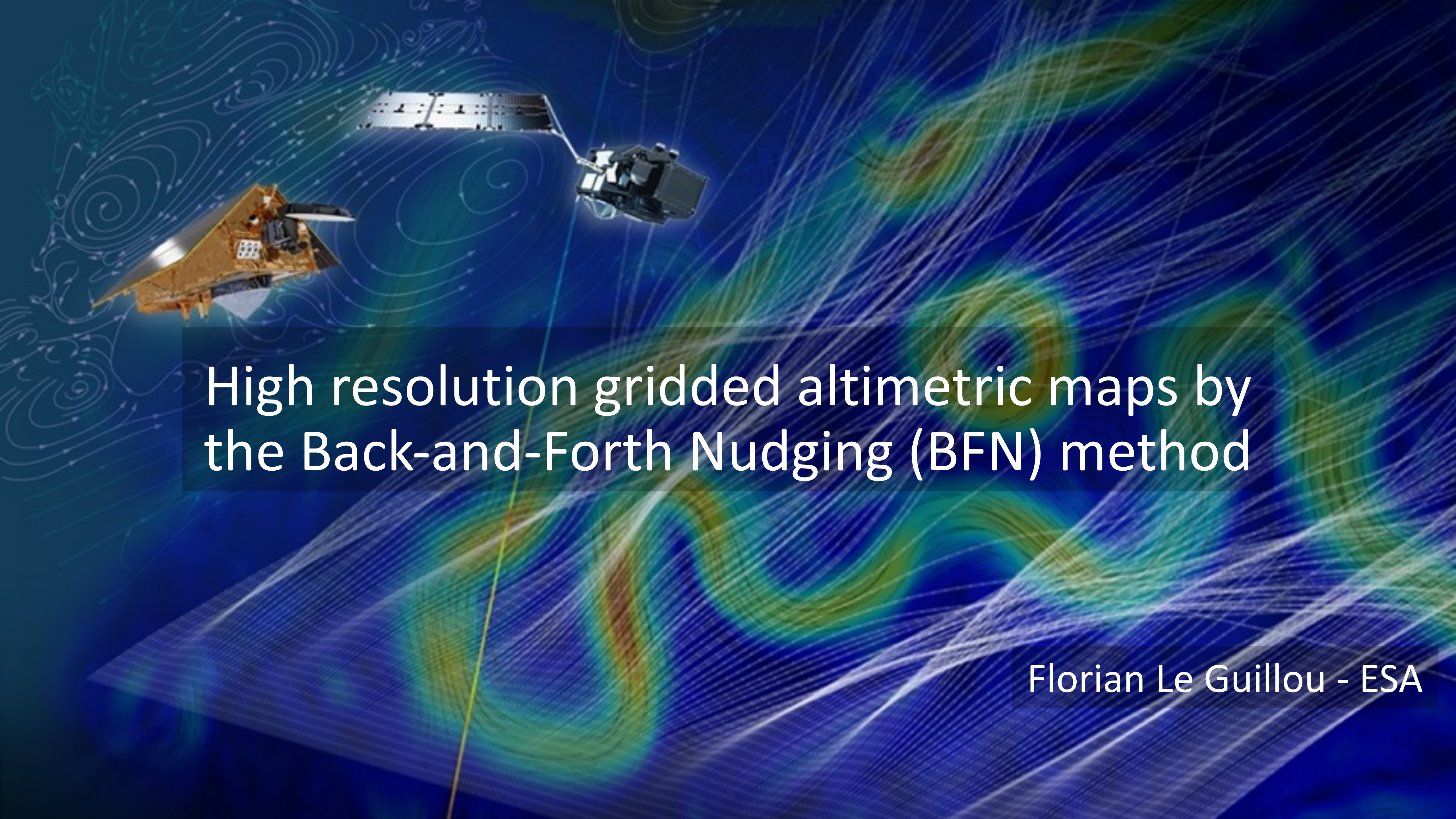


$$\frac{\partial SST}{\partial t} + (\boldsymbol{U_g} + \boldsymbol{U_a}) \cdot \nabla SST = F_{SST}$$

Ocean Color



$$\frac{\partial Chl}{\partial t} + (\boldsymbol{U_g} + \boldsymbol{U_a}) \cdot \nabla Chl = F_{Chl}$$



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