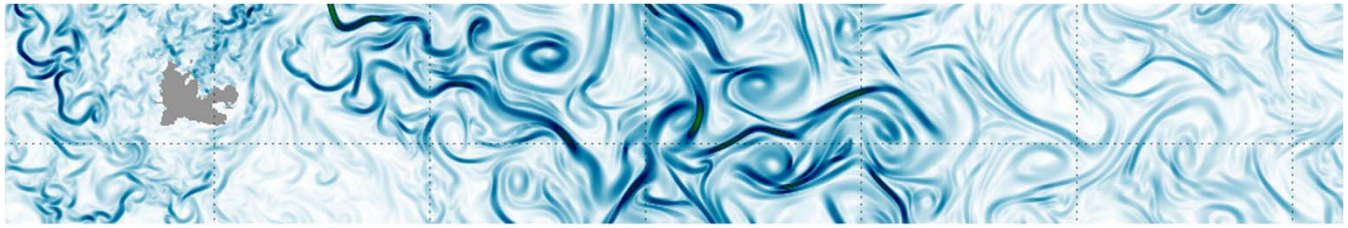
Dealing with spatially structured errors in SWOT data



MEOM team @ IGE, Grenoble

Metref, S., Cosme, E., Sommer, J. L., Poel, N., Brankart, J. M., Verron, J., Navarro, L. G. and Le Guillou, F.

17-20 June 2019 | Bordeaux, France

Two new inputs for SWOT

- **SWOT spatially structured error reduction method**

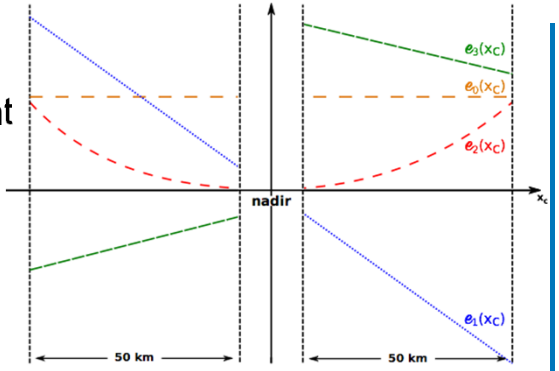
- **SWOT assimilation with spatially structured error reduction**

Error reduction method

Remove SWOT spatially structured errors with DA

SWOT errors

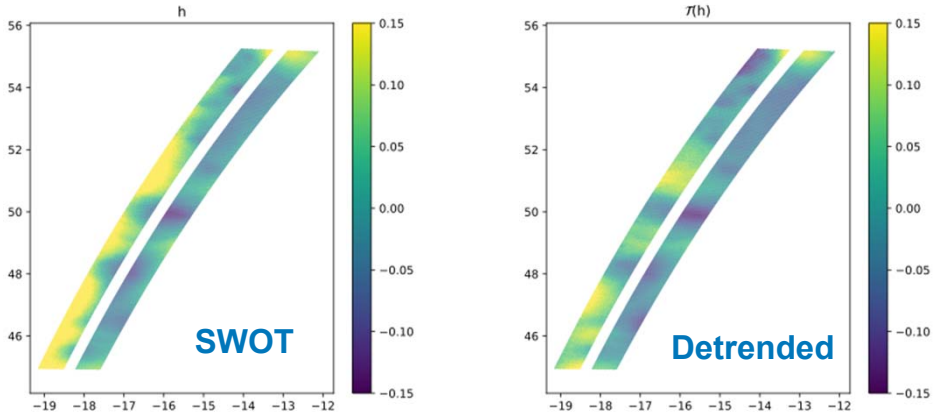
- Karin measurement
- Roll
- Baseline dilatation
- Phase
- Timing
- Wet troposphere



Detrending

$$\mathcal{T}(h(x_c)) = h(x_c) - \{\tilde{\alpha}_1 x_c + \tilde{\alpha}_2 x_c^2 + (\tilde{\alpha}_4 + \tilde{\alpha}_5 x_c)\chi_{[x_c<0]} + (\tilde{\alpha}_6 + \tilde{\alpha}_7 x_c)\chi_{[x_c>0]}\}$$

$\mathcal{T}$



Filtering method: *Metref et al., Remote Sens., 2019*

Data assimilation with static ensemble

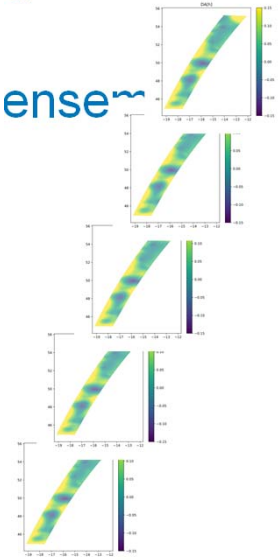
Ensemble:

High resolution SSH fields from a model interpolated on SWOT tracks

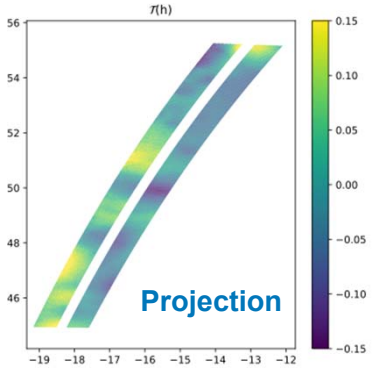
DA, recovering of large scale signal

d

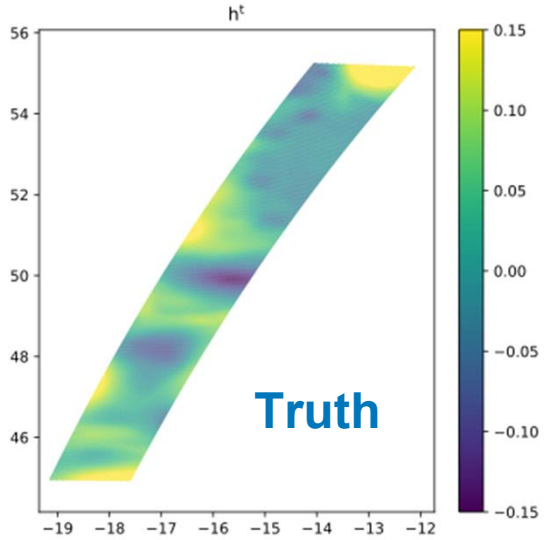
ense

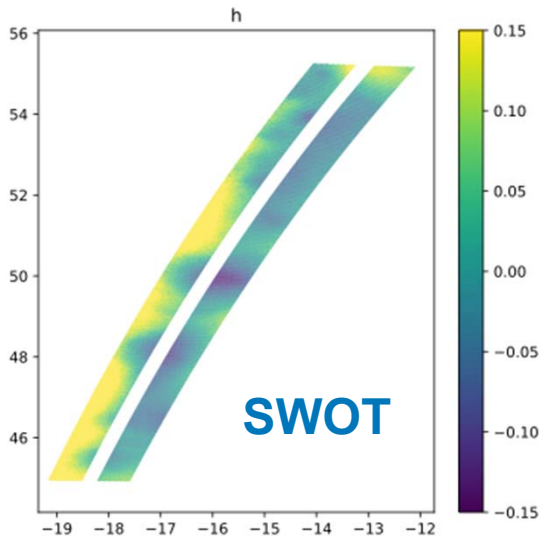


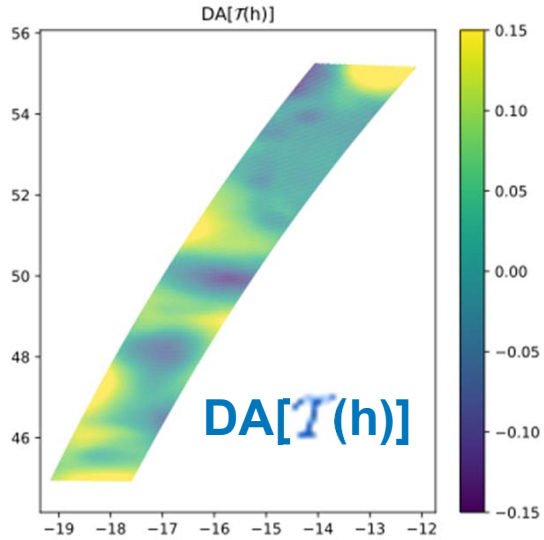
DA



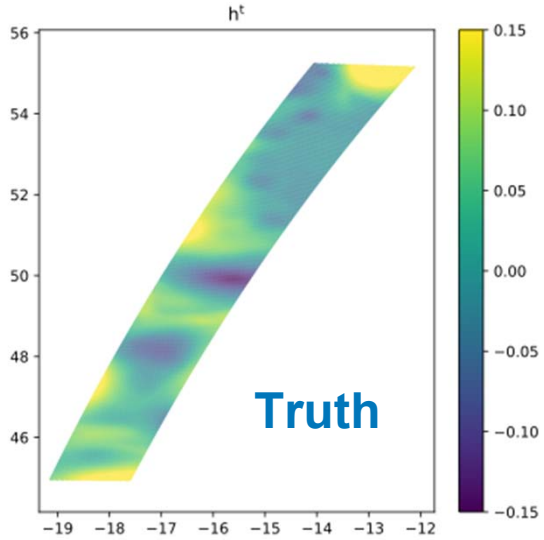
Representation of observation errors

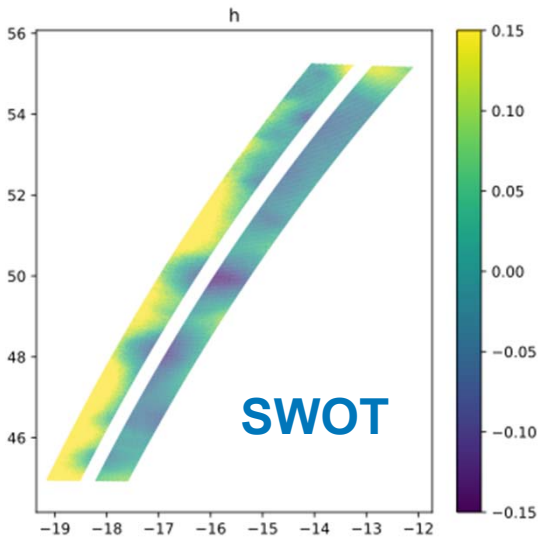


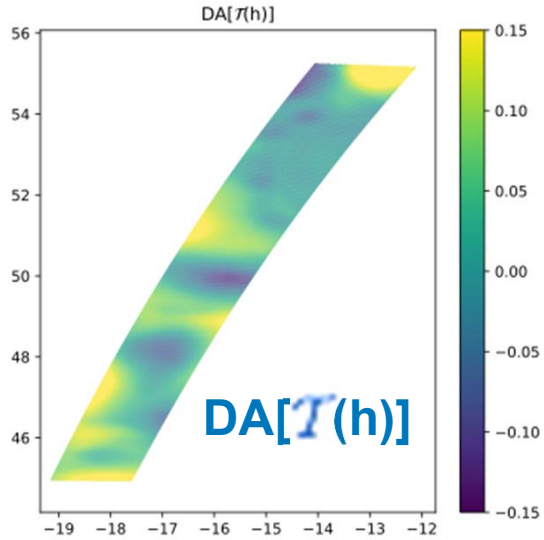




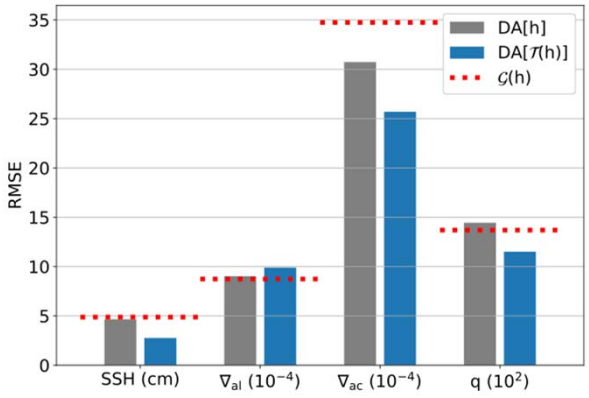
Representation of observation errors

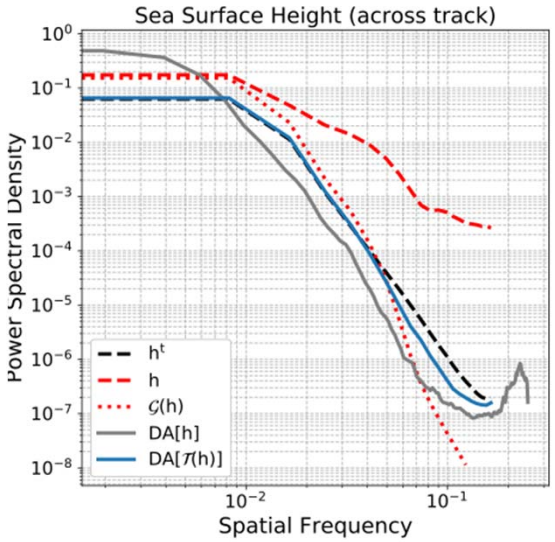


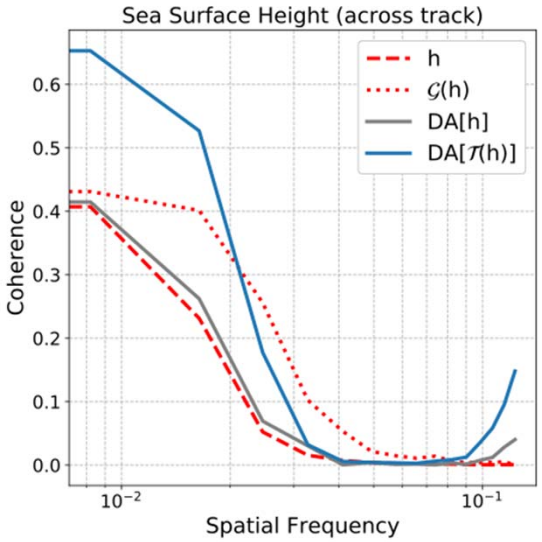




RMSE

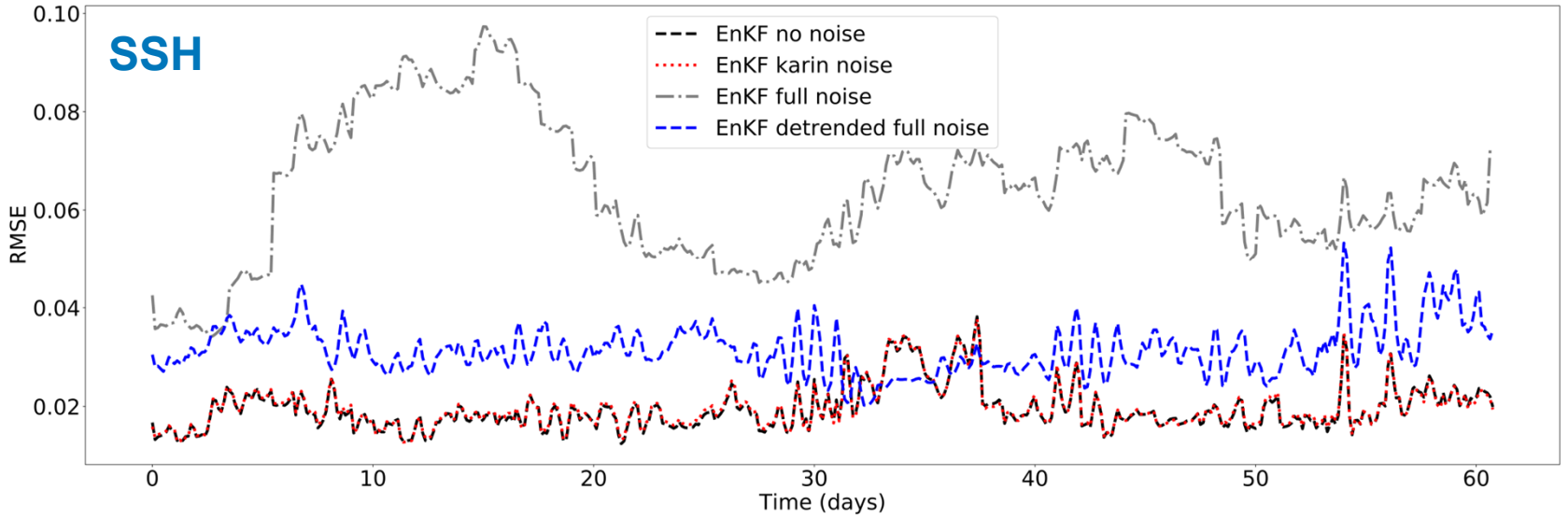






Detended-data assimilation

DA experiment: SSH mapping
Ref NATL60
OSMOSIS region
2 months (11/12 - 12/12)



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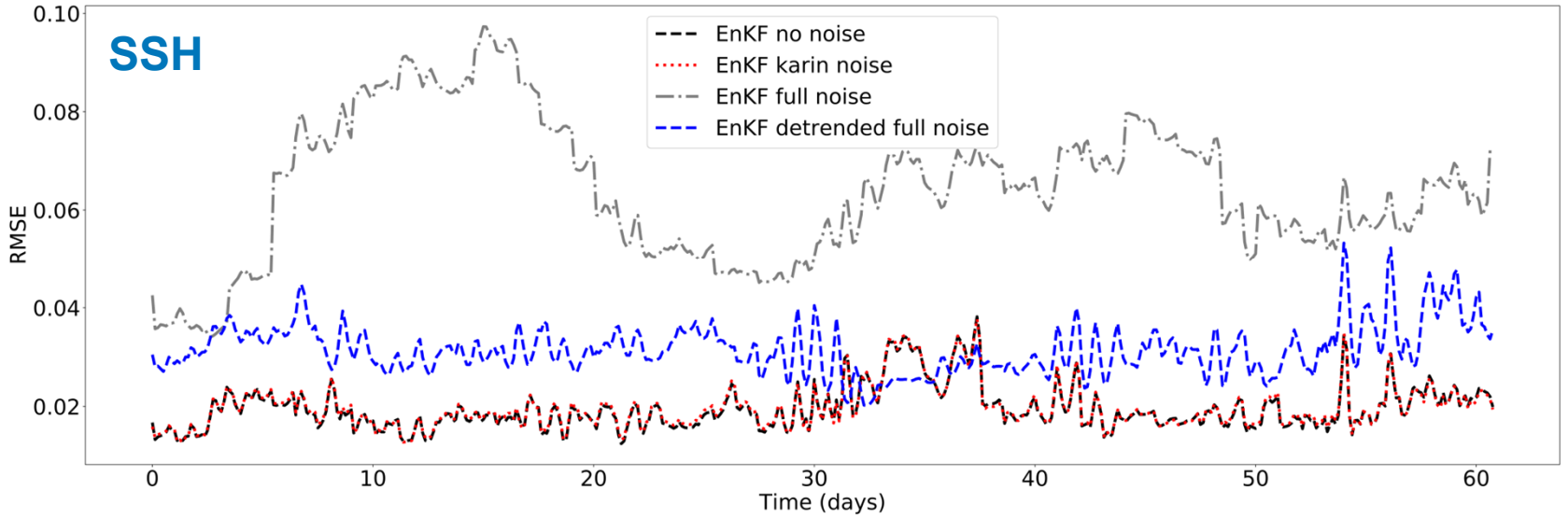

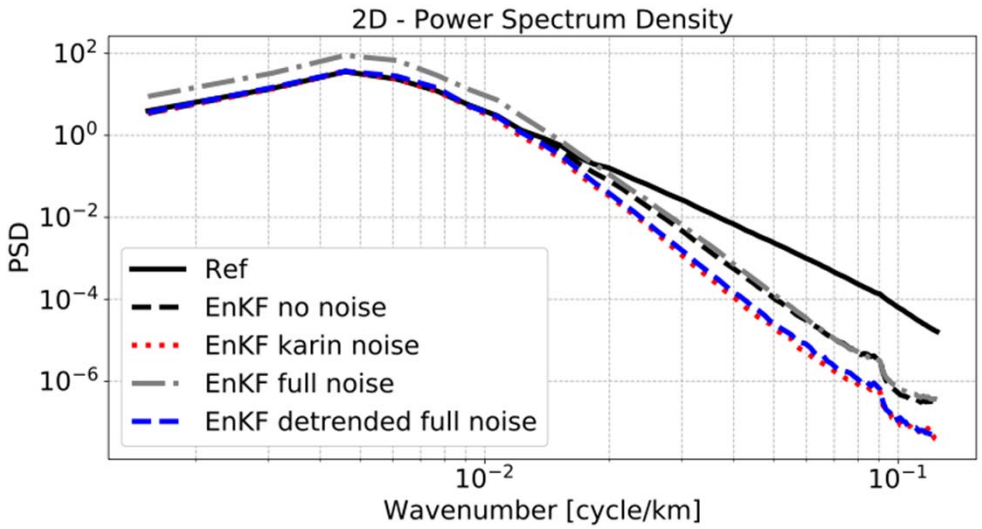

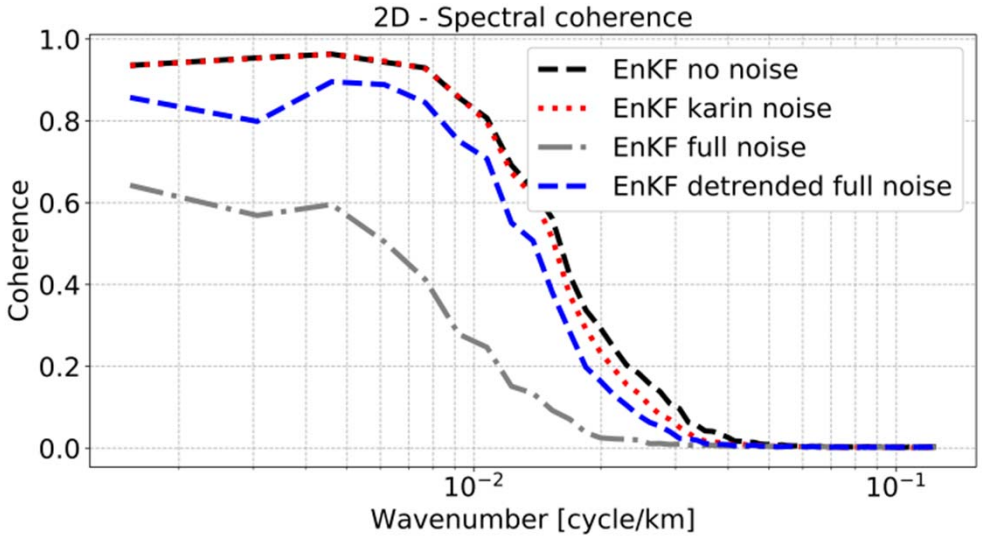

Summary

- **Methodology developed:**
  Metref, S., Cosme, E., Sommer, J. L., Poel, N., Brankart, J. M., Verron, J., & Navarro, L. G. (2019). Reduction of spatially structured errors in wide-swath altimetric satellite data using data assimilation. Remote Sensing, 11(11), 1336.

- **Incorporation in a DA scheme done (evaluation in progress)**

- **Methodological improvement (in progress)**

- **Comparison with DUACS for altimetry mapping (to be done)**

- **Method behavior with tide (to be done)**

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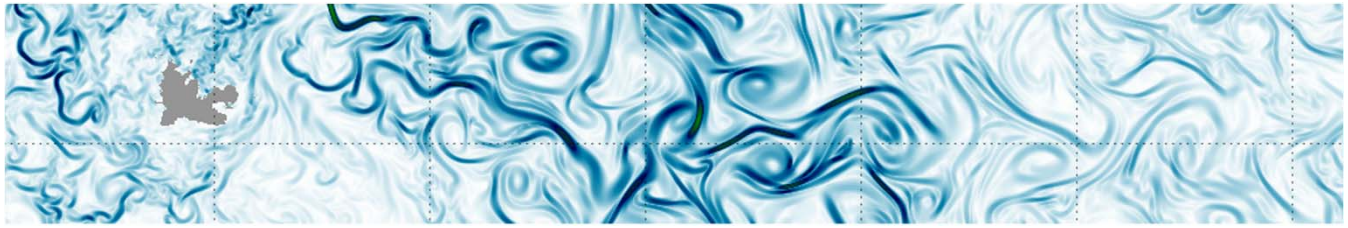
Mapping SSH from SWOT using simple data assimilation



IGE, Grenoble & CLS, Toulouse

Le Guillou, F., Cosme, E., Ubelmann, C., Metref, S., Ballarotta, M., Sommer, J. L., Verron, J., Navarro, L. G. and Le Guillou, F.

CLS COLLECTE LOCALISATION SATELLITES

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UNIVERSITÉ Grenoble Alpes

OceanNext Hydrosphere Data & Numerics

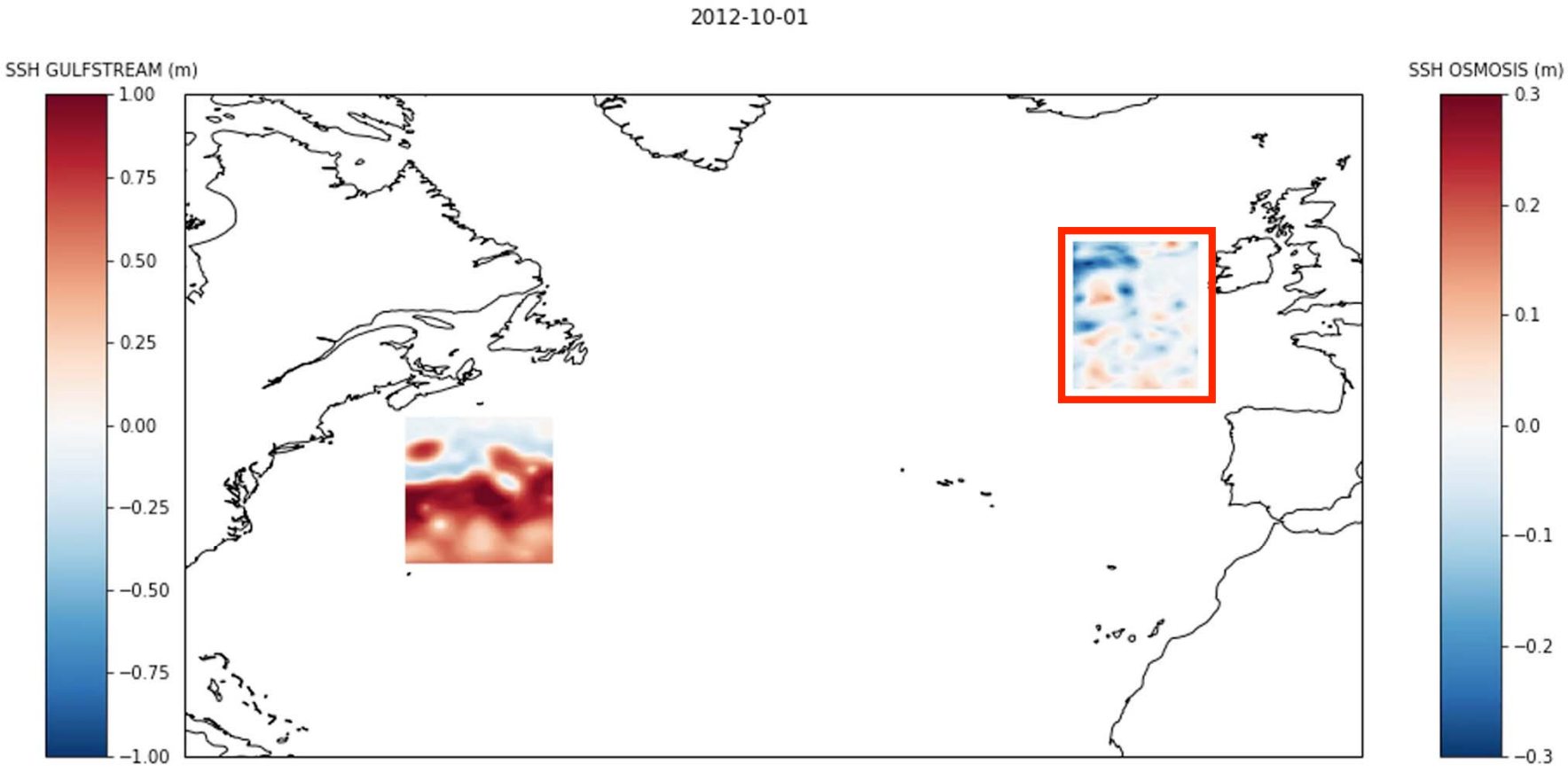
17-20 June 2019 | Bordeaux, France

OSSE FRAMEWORK: TWO STUDY CASES

Nature run: NEMO / NATL60

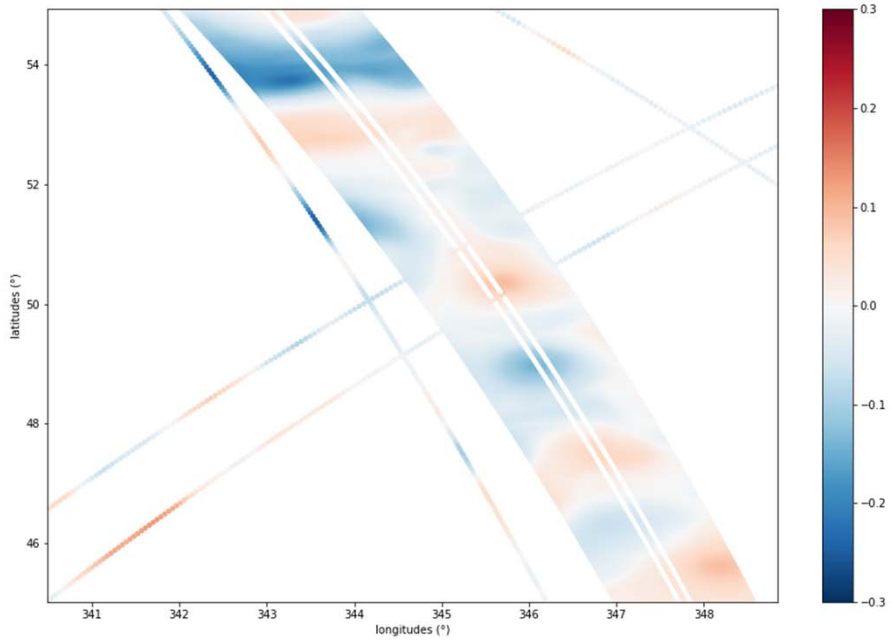
Domains: 10°x10°, res. 1/20°

Time period: 3 months, freq. 1h



DATA ASSIMILATION EXPERIMENTS

- Simulated observations: 4 nadirs & SWOT, without noise



Simulated observations projected on the state grid

- Data Assimilation (DA) algorithm:

Back and Forth Nudging (BFN)

along with **a 1 layer quasi-geostrophic model**

BACK AND FORTH NUDGING

Forward evolution

$$\begin{cases} \dfrac{\mathrm{d}X_k}{\mathrm{d}t} = AX_k + K(X_{\mathrm{obs}} - X_k), \\ X_k(0) = \widetilde{X}_{k-1}(0), \end{cases}$$

Backward evolution

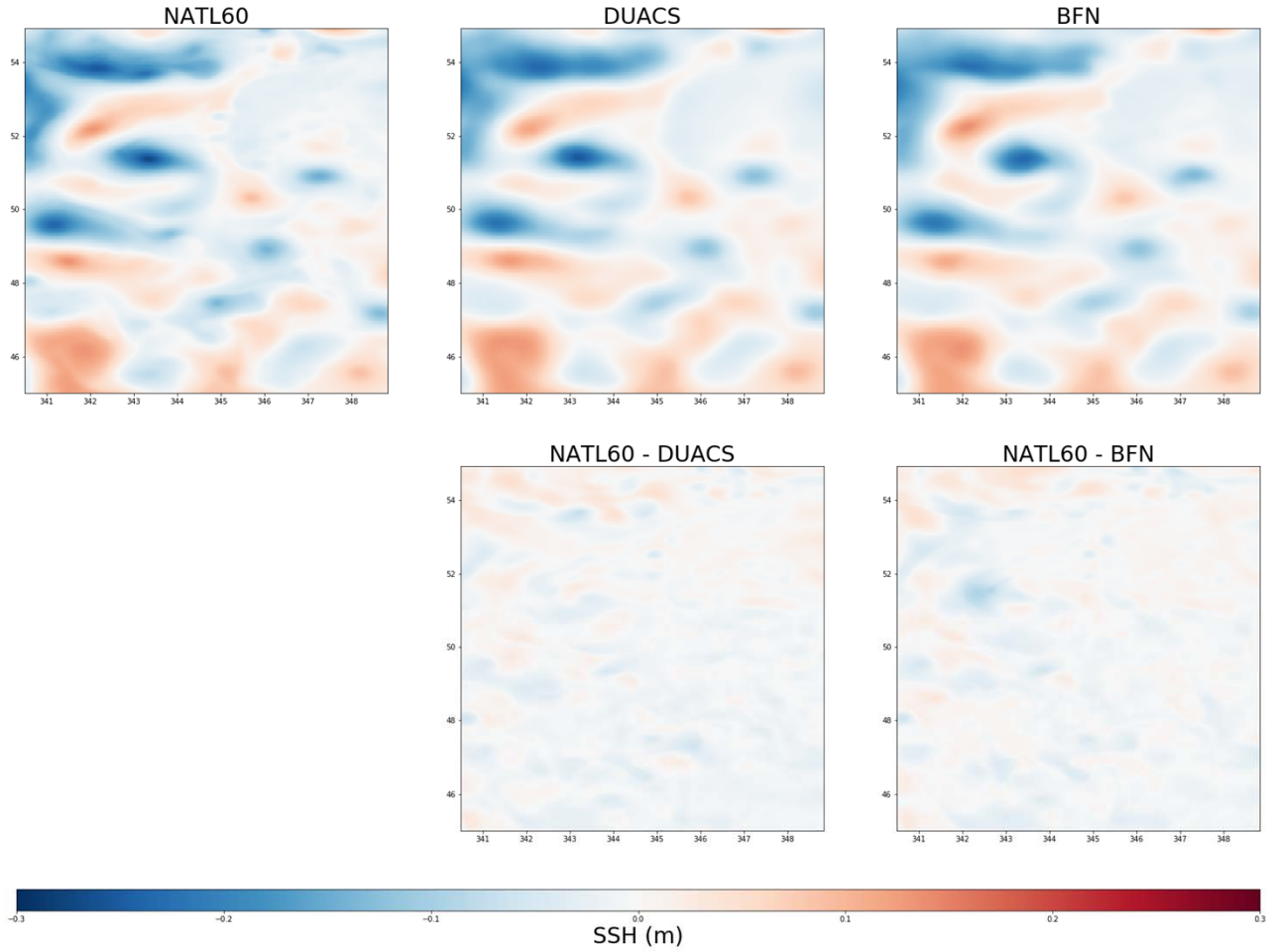
$$\begin{cases} \dfrac{\mathrm{d}\widetilde{X}_k}{\mathrm{d}t} = A\widetilde{X}_k - K(X_{\mathrm{obs}} - \widetilde{X}_k), \\ \widetilde{X}_k(T) = X_k(T), \end{cases}$$

- The algorithm converges to a smoothed trajectory which best fits the observations and the model.

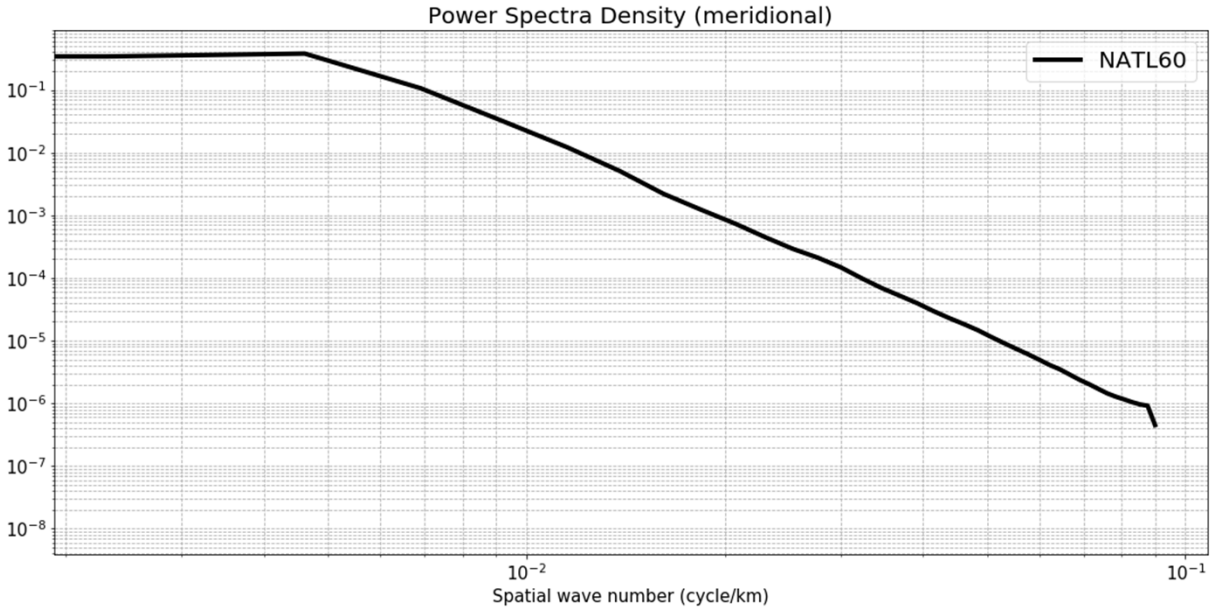
MAPPING PERFORMANCE: COMPARISON WITH DUACS PRODUCTS

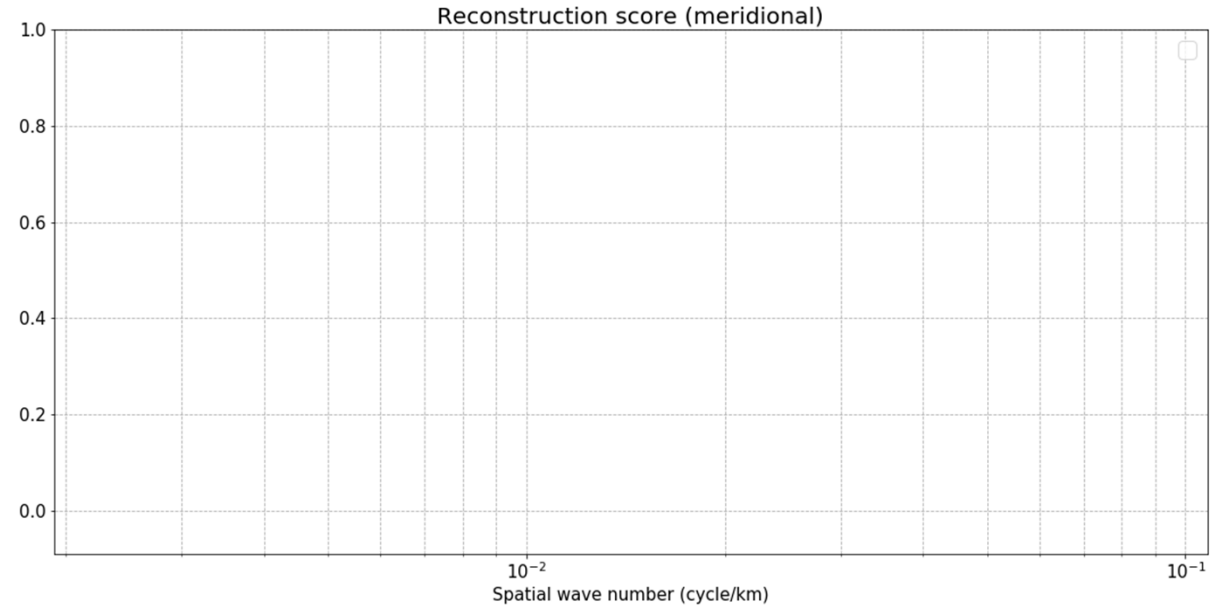
SSH snapshots

Comparison with NATL60

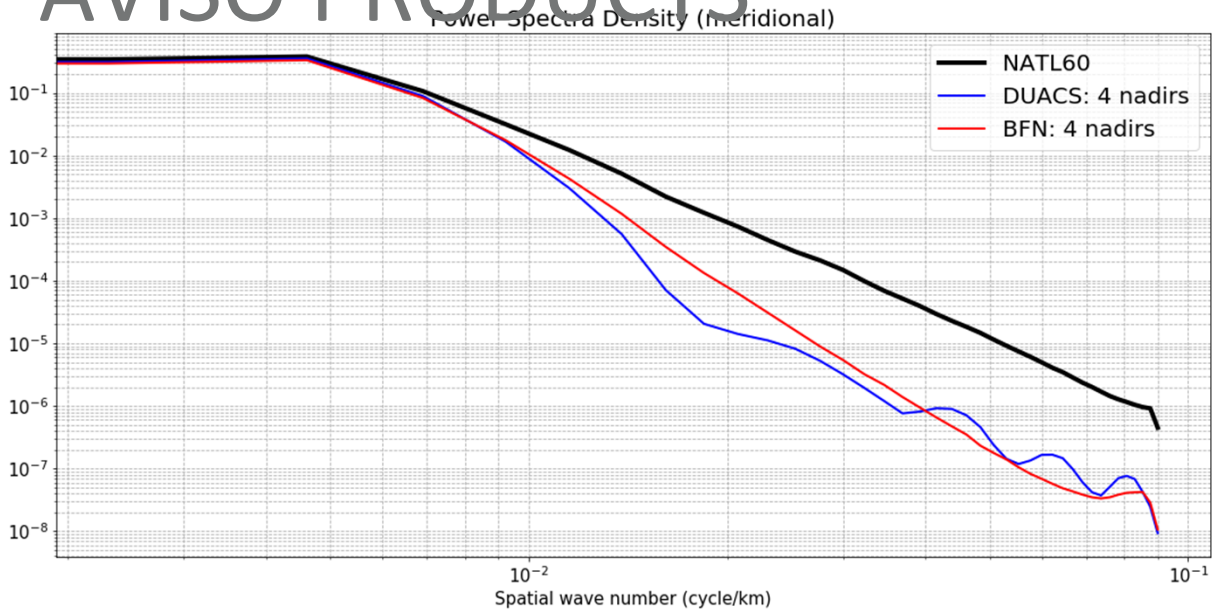


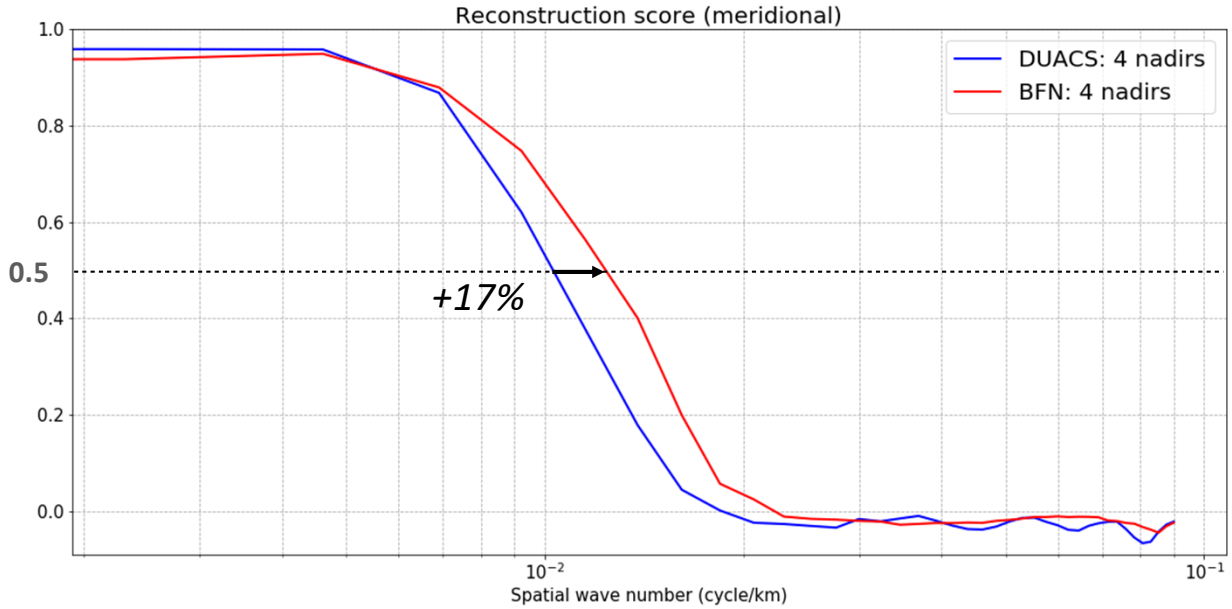
MAPPING PERFORMANCE: COMPARISON WITH AVISO PRODUCTS





MAPPING PERFORMANCE: COMPARISON WITH AVISO PRODUCTS

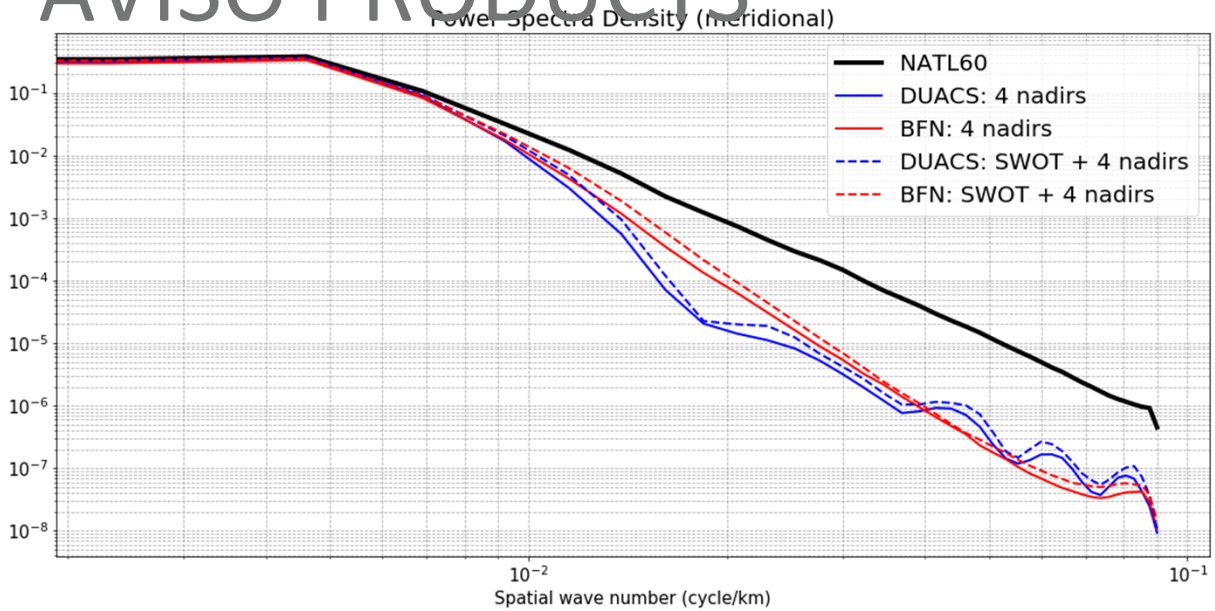


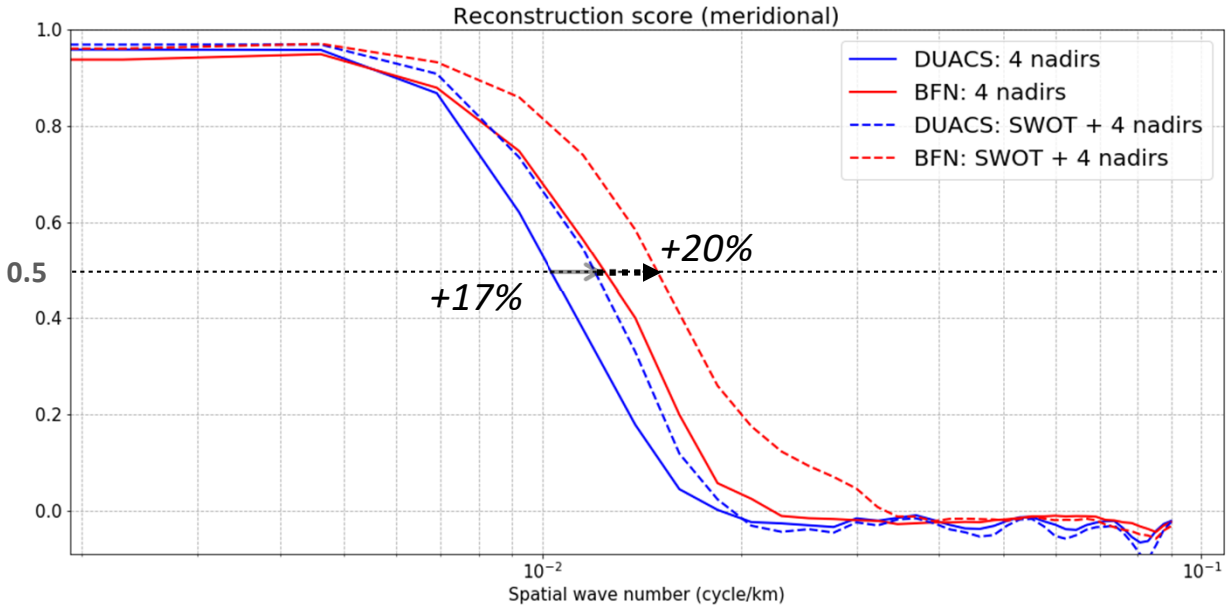


Gain in effective resolution

- DA: **17%**

MAPPING PERFORMANCE: COMPARISON WITH AVISO PRODUCTS





Gain in effective resolution

- DA: **17%**
- SWOT: **20%**

SUMMARY & PERSPECTIVES

- Data assimilation framework:
  - Nadir and swath altimetry data
  - BFN with simple model (QG)

- Both SWOT data and DA improve the effective resolution of the AVISO maps

- Propagator seems to limit the reconstruction performance:
  - Need to improve the propagator to interpolate SWOT data much more efficiently

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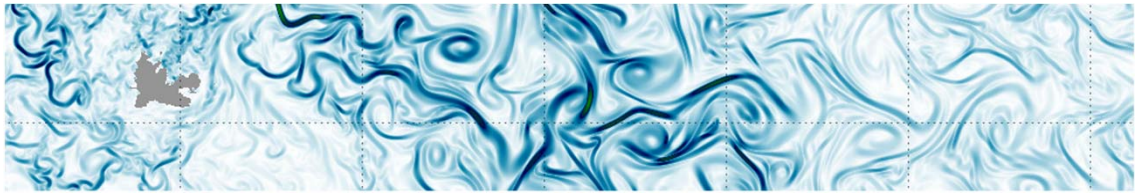
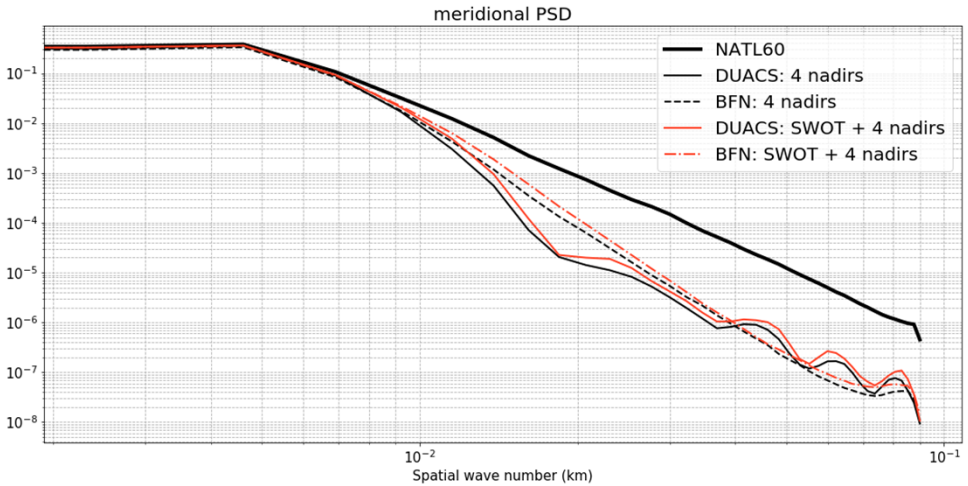
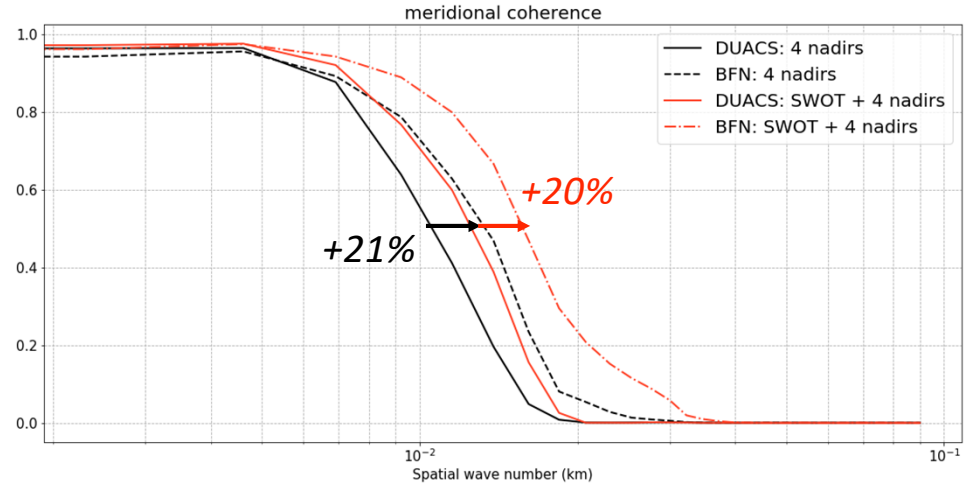
Thank you !



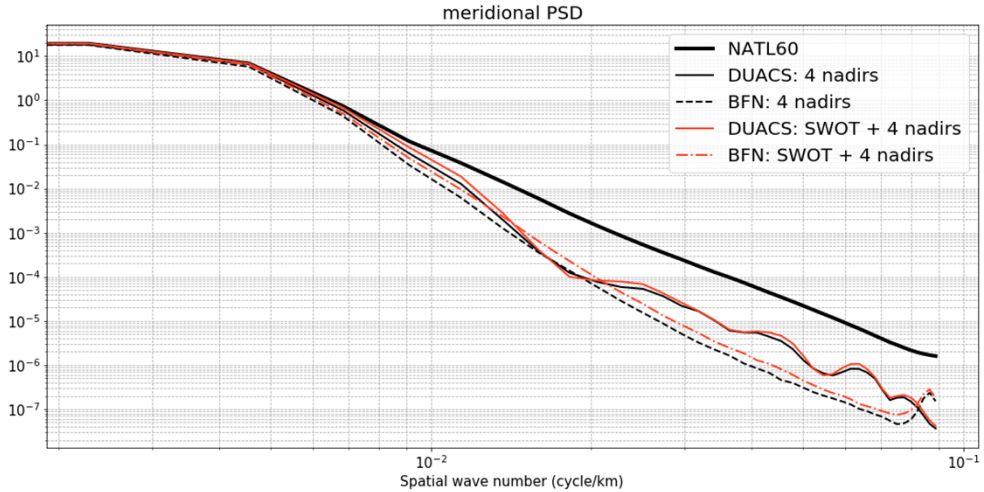
MAPPING PERFORMANCE: COMPARISON WITH AVISO PRODUCTS

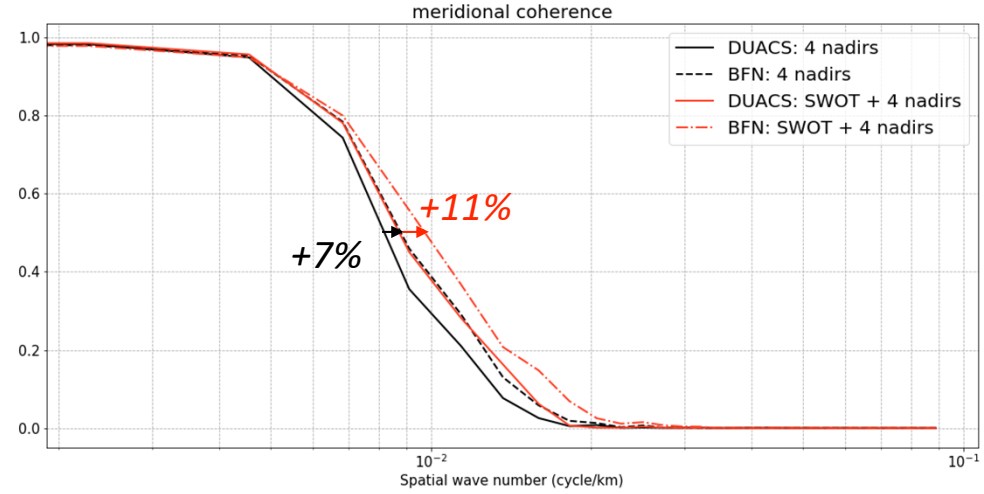
OSMOSIS





GULFSTREAM

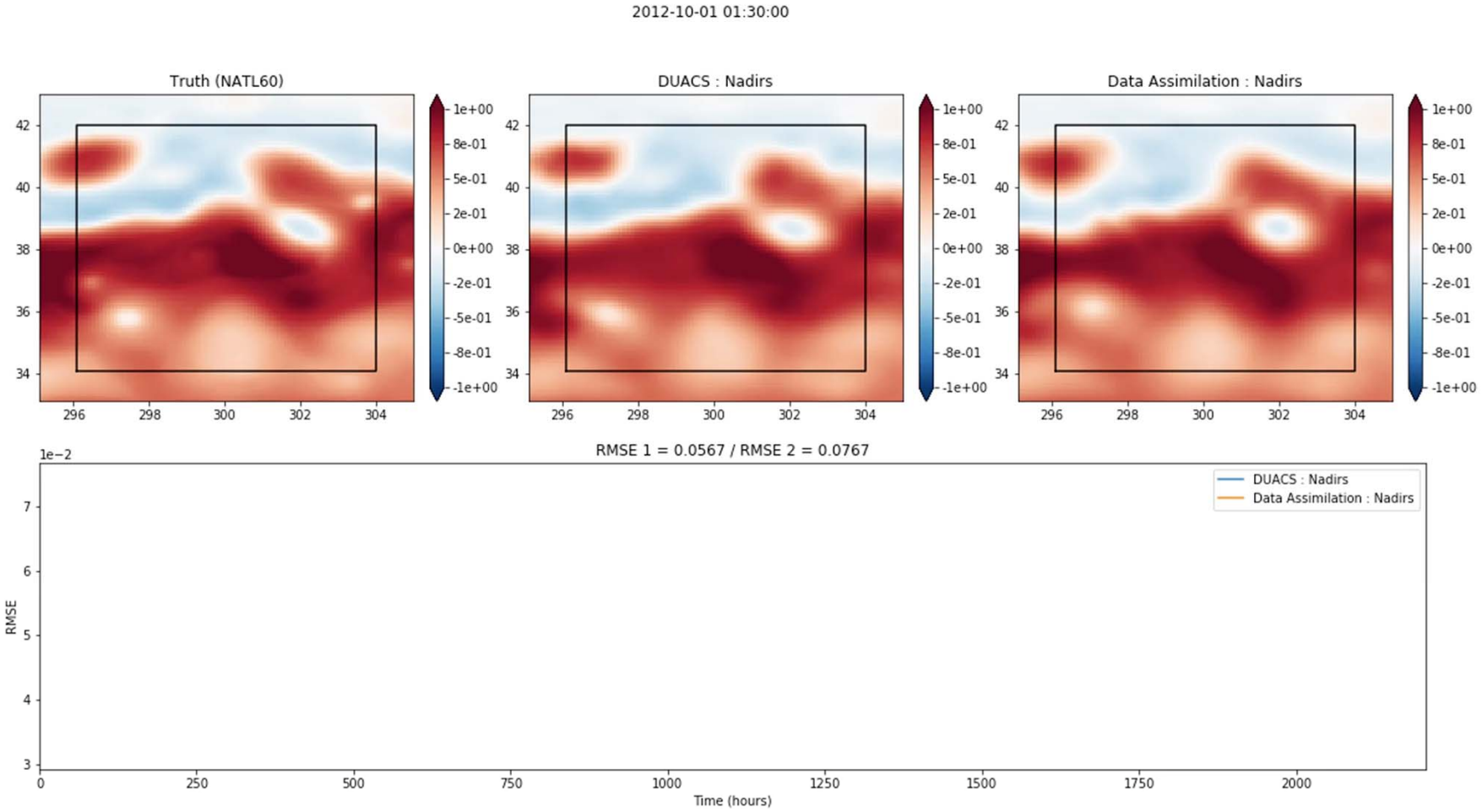




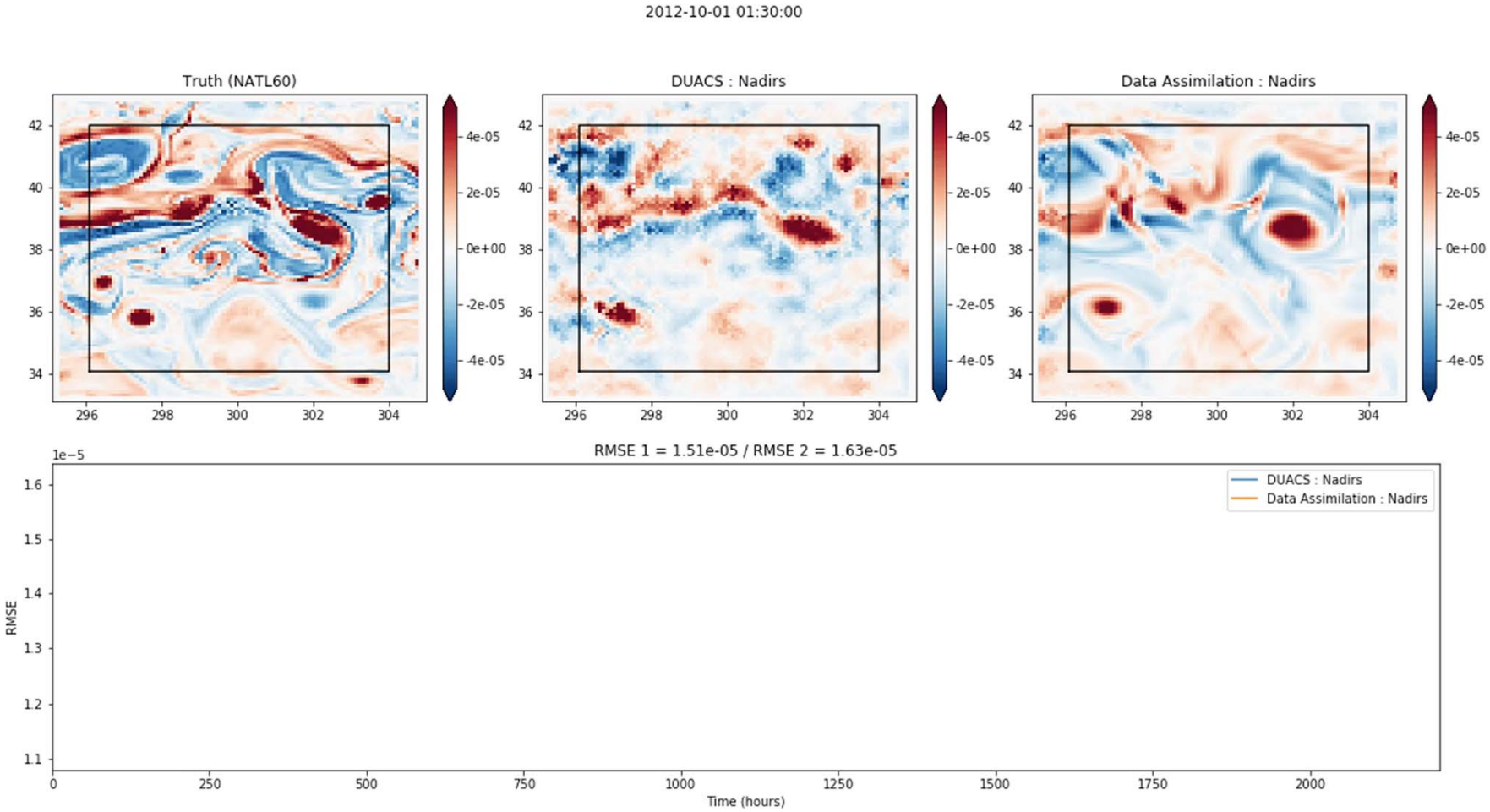
BAROTROPIC MODEL

- AIM : $SSH_{i+1} = M(SSH_i)$
- 1) Stream function $\Psi_i = \frac{g}{f} SSH_i$
- 2) Potential vorticity $PV_i = E(\Psi_i) = \beta y + \nabla^2 \Psi_i - \frac{1}{L_d^2} \Psi_i$
- 3) Forecast $PV_{i+1} = PV_i + dt \times J(\Psi, PV_i)$
- 4) Inversion of (2) $\Psi_{i+1} = E^{-1}(PV_{i+1})$
- 5) Forecasted SSH $SSH_{i+1} = \frac{f}{g} PV_{i+1}$

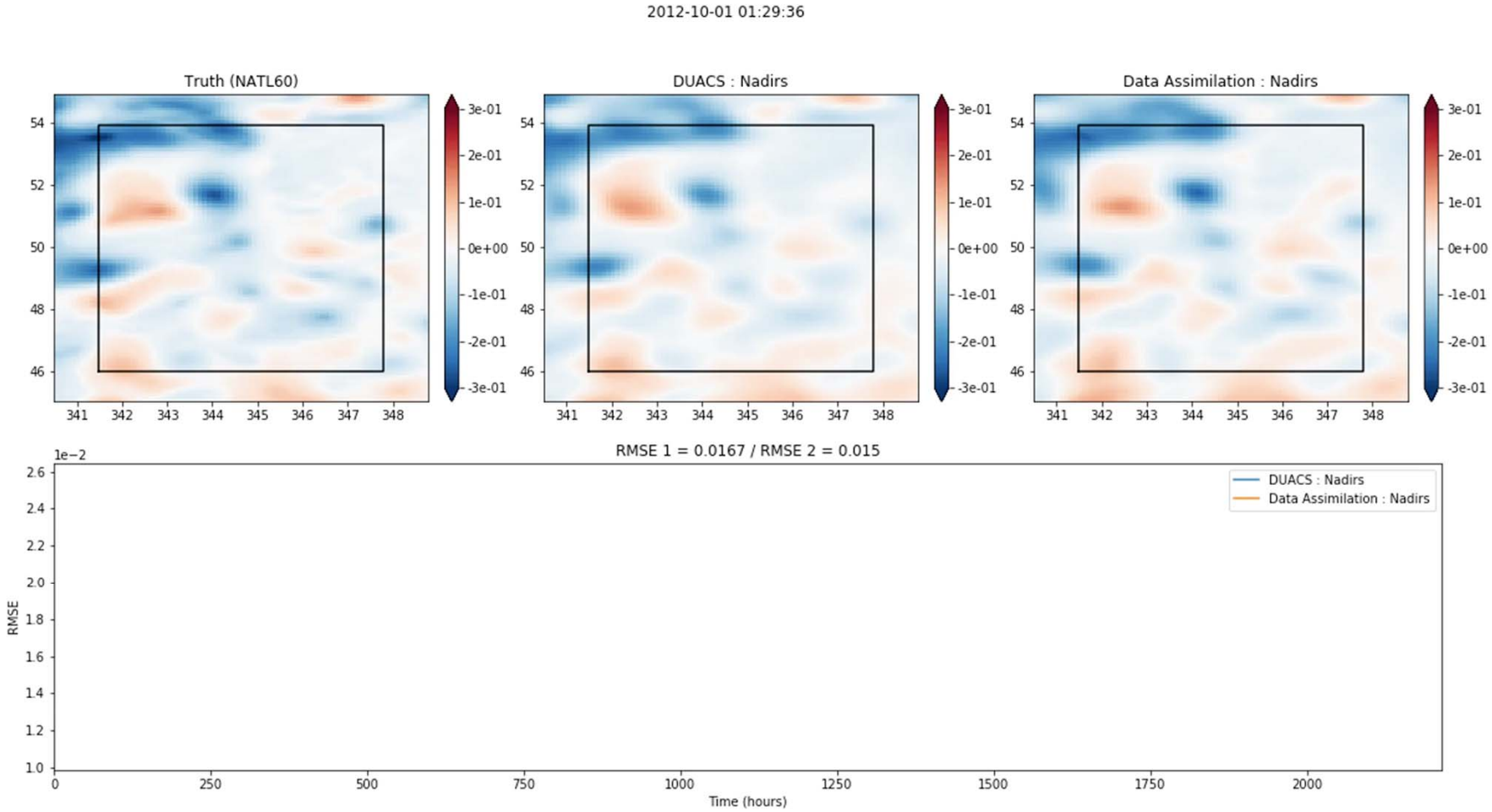
MOVIE: DUACS VS BFN, NADIRS, GULFSTREAM



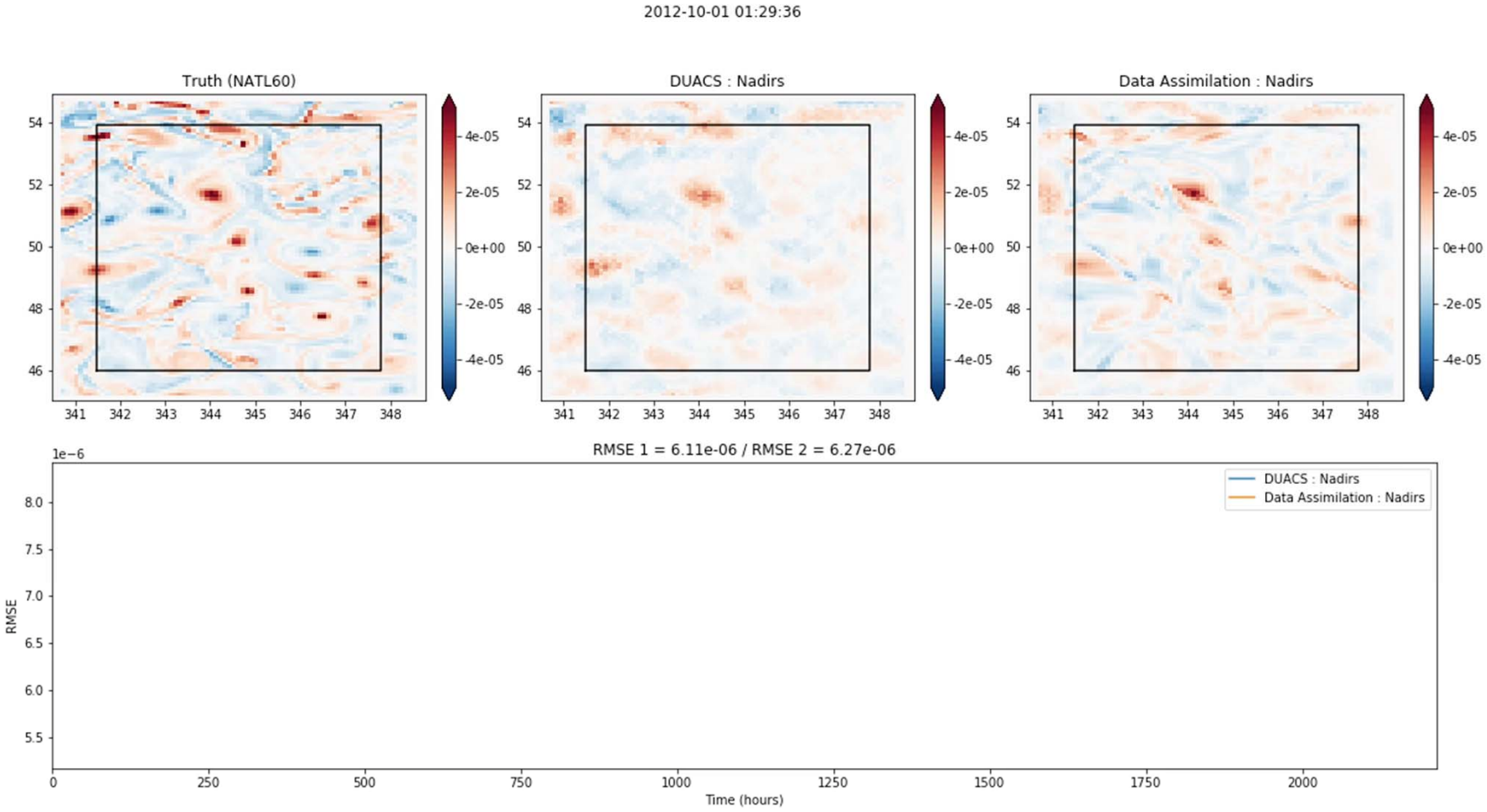
MOVIE: DUACS VS BFN, NADIRS, GULFSTREAM



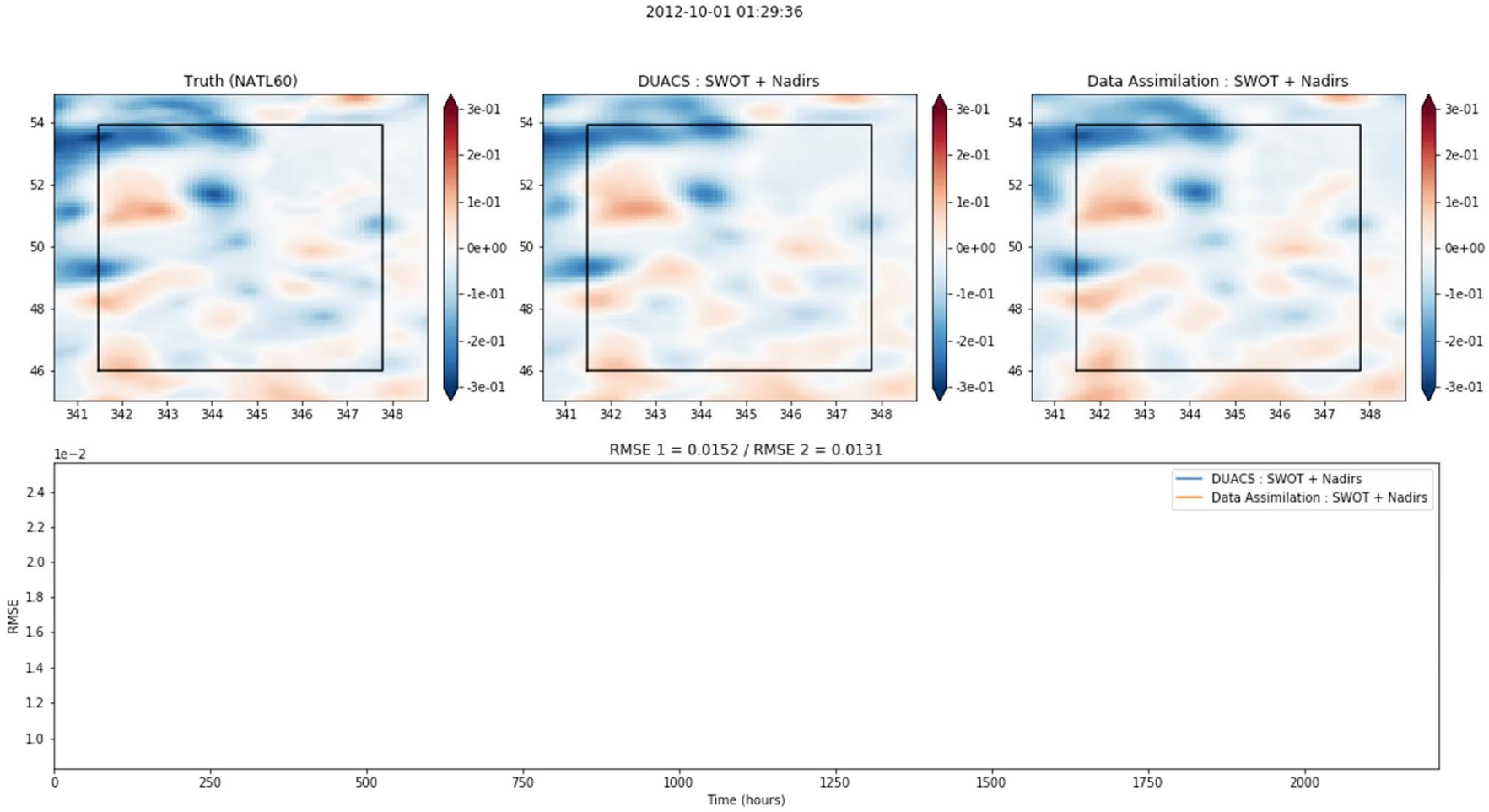
MOVIE: DUACS VS BFN, NADIRS, OSMOSIS



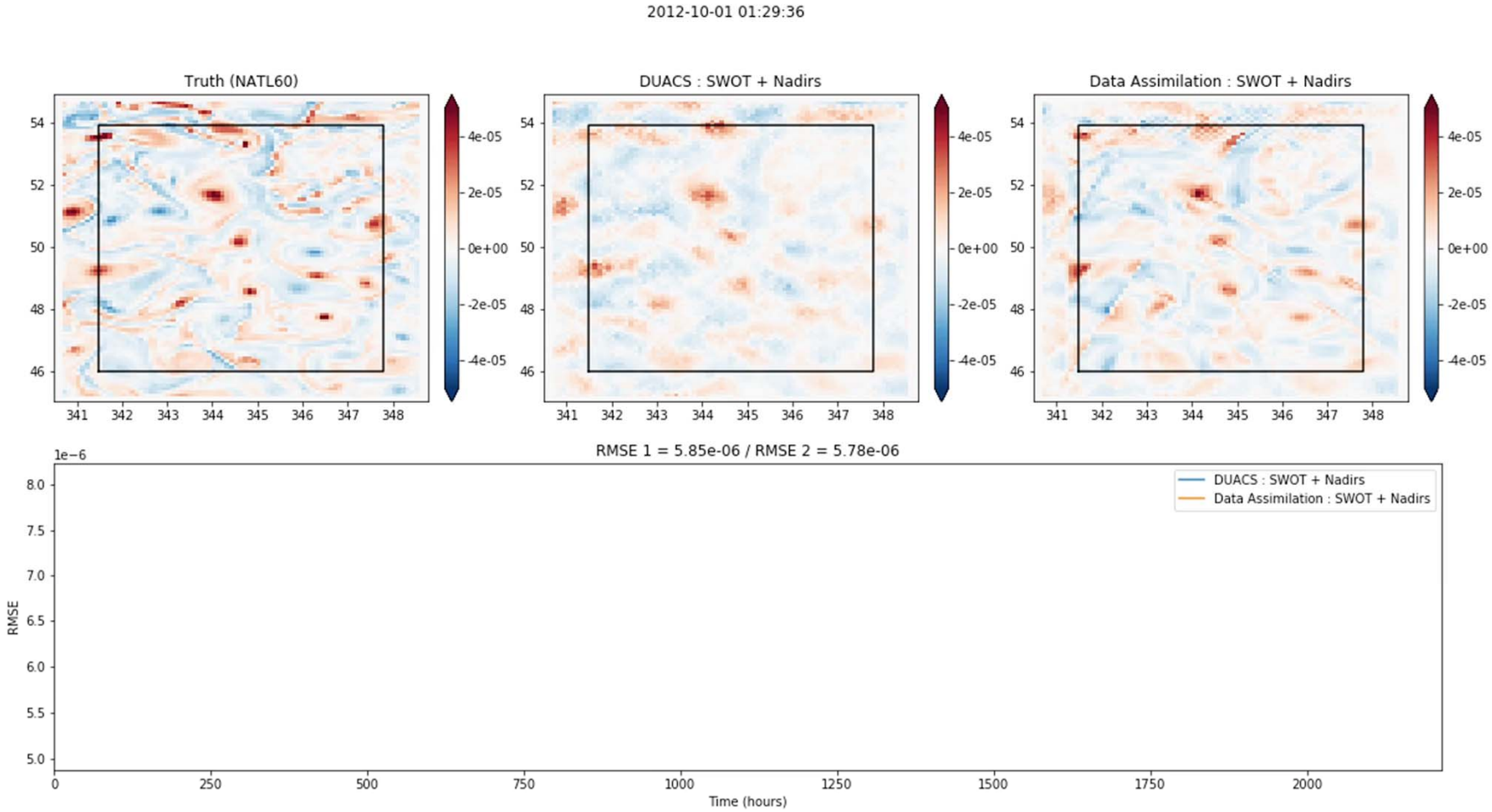
MOVIE: DUACS VS BFN, NADIRS, OSMOSIS



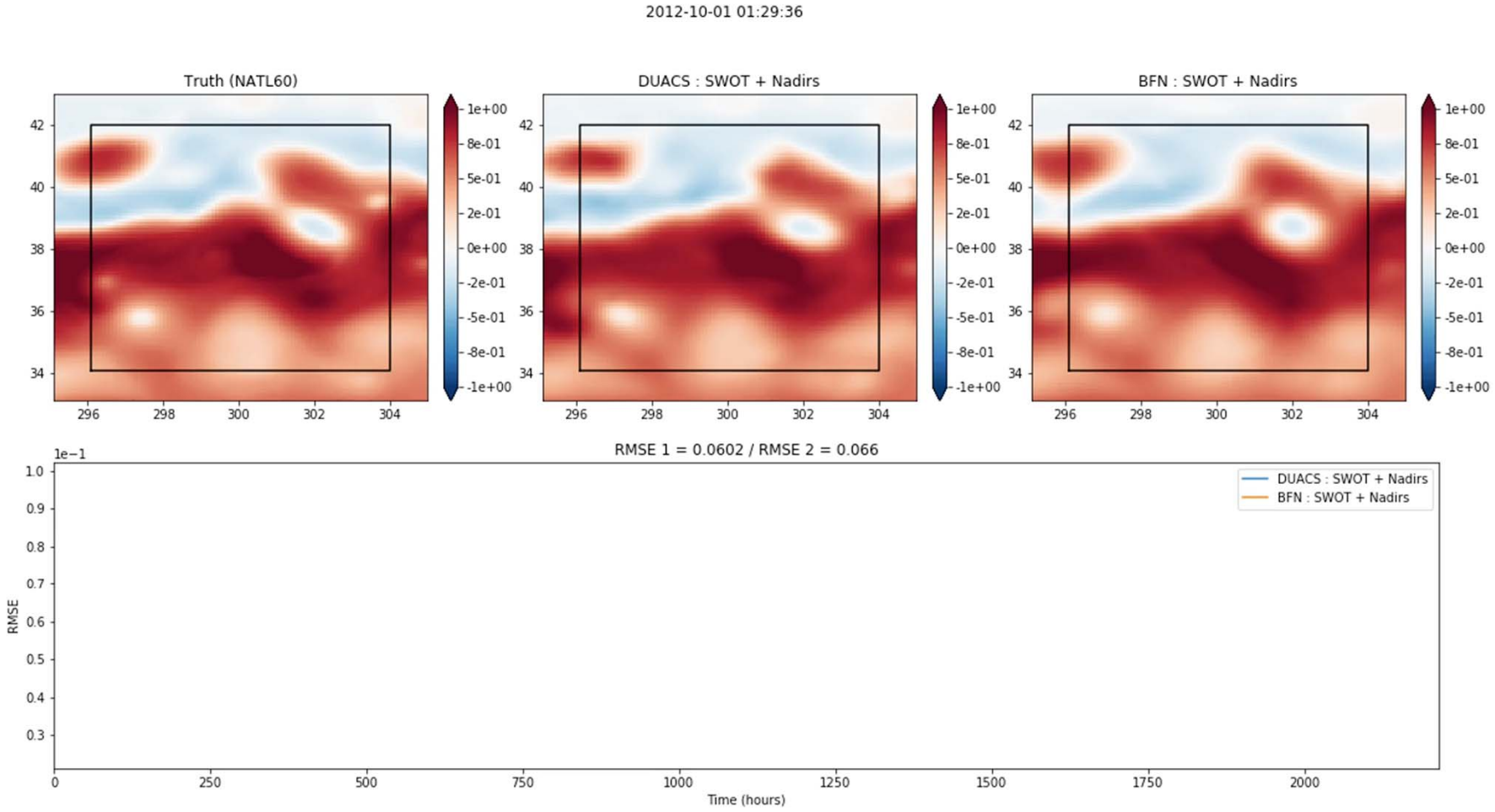
MOVIE: DUACS VS BFN, SWOT & NADIRS,



MOVIE: DUACS VS BFN, SWOT & NADIRS,



MOVIE: DUACS VS BFN, SWOT & NADIRS,



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