Analog data-driven strategies for the reconstruction of altimeter-derived SSH fields

IMT Atlantique
Bretagne-Pays de la Loire
École Mines-Télécom

OSTST, Miami, October 2017

ABSTRACT

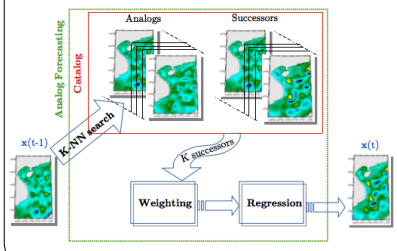
In this work, we investigate the potential of data-driven strategies to benefit from large-scale simulation/ renalysis datasets with a view to improving the reconstruction of sea level anomalies. We develop an analog data assimilation model for the spatio-temporal interpolation of along-track satellite altimeter data. We demonstrate that a multi-scale decomposition associated with a patch-based representation of the 2D fields can lead to significant improvement compared with optimal interpolation and EOF-based interpolation techniques for case-study region in the South Chinae Sea.

Keywords— SSH, along-track altimetry, data-driven methods, analog data assimilation

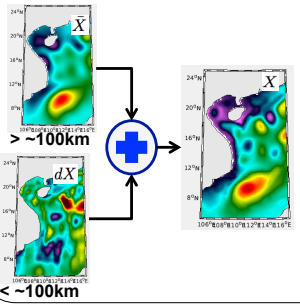
Analog data assimilation (AnDA)

We recently introduced the analog data assimilation (AnDA) [1] as a **data-driven « model-free » assimilation model**. Given a reference catalog of exemplars, it plugs **an analog forecasting model into a classic Ensemble Kalman filter or smoother**. The analog data assimilation can reach state-of-the-art reconstruction performance when the catalog of exemplars is large enough.

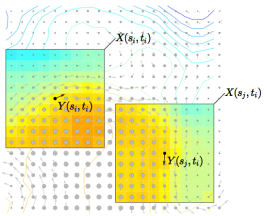
Analog forecasting



Two-scale decomposition



Patch-based representation



Patch-based AnDA

AnDA may not apply to high-dimensional fields, such as 2D SSH field, due to the curse of dimensionality. We then consider the following **two-scale decompositon of the SSH field**

$$X = \bar{X} + dX + \xi$$

with **an EOF-based representation of each patch of the detail field** dX:

$$dX(\mathcal{P}_s, t) = \sum_{k=1}^{N_E} \alpha_k(s,t) EOF_k$$

As sketched on the left, the large-scale component is estimated using and optimal interpolation. We then apply AnDA to each patch location. Overall, we apply a spatial averaging over overlaping patches to derive the reconstructed field.

Numerical experiments (OSSE) in the South China Sea

Observing System Simulation Experiment:

- **Simulation data:** OGCM, 1979-2012, 3-daily, 1/10°
- **Real along-track data:** Jason2, Cryosat2, Saral/AltiKa, HY-2A along-track altimeter positions in 2014
- **Simulated along-track data**: simulation of noisy and noise-free along-track data from 1979 to 2012 using real along-track positions

Experimental setup: training data (1979-2011), test on 2012 data

Evaluation procedure: RMSE and correlation w.r.t. the groundtruth

Benchmarked models: Optimal Interpolation (OI), VE-DINEOF, direct application of AnDA at the regional scale (G-AnDA), proposed patch-based AnDA (PB-AnDA)

Reconstruction performance (noise-free case)

	RMSE	ρ
OI	0.026	0.81
VE-DINEOF	0.023	0.85
G-AnDA	0.020	0.89
PB-AnDA	**0.013**	**0.96**

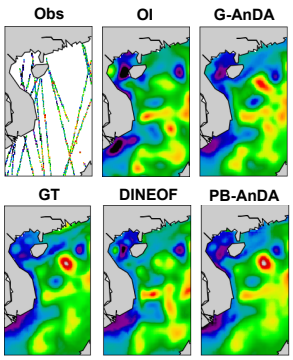
Reconstruction performance (noisy case, σ=0.03)

	RMSE	ρ
OI	0.066	0.41
VE-DINEOF	0.060	0.45
G-AnDA	0.039	0.67
PB-AnDA	**0.032**	**0.71**

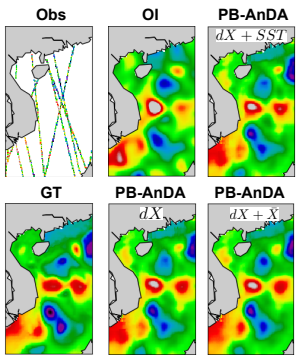
Using additional regression variables (σ=0.03)

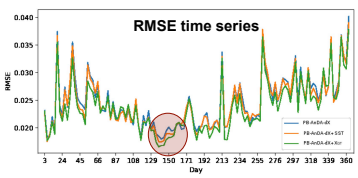
	RMSE	ρ
PB-AnDA-dX	0.032	0.41
PB-AnDA-dX+SST	0.031	0.45
PB-AnDA-dX+X	0.029	0.67
PB-AnDA-dX+X^{GT}	**0.026**	**0.71**

Reconstruction example using different methodes



AnDA models with different regression variables





Conclusion and Future work

This study demonstrates **the relevance of data-driven strategies for the reconstruction of SLA fields from along-track altimetry data**. We report significant improvement for the proposed patch-based analog assimilation scheme compared to state-of-the-art models.

Future work comprises the evaluation of the proposed framework for different case-study regions especially regarding its sensitivity to key parameters (e.g., the catalog of exemplars) and other altimeter-derived sampling patterns, including **future altimetry mission** (e.g., SWOT).

Authors

Redouane Lguensat, Ronan Fablet
IMT Atlantique, Lab-STICC, Brest, France

Tianfeng Li, Ge Chen
OUC, Qingdao, China

Bertrand Chapron
Ifremer, LOPS, Brest, France

Acknowledgments

This work was supported by CNES (OSTST project MANATEE), labex Comnlabs (project SEACS), Teralab (project TIAMSEA) and ANR (project EMOCEAN) and GIS Bretel.

References

[1] R. Lguensat, P. Tandeo, P. Aillot, R. Fablet. The Analog Data Assimilation. Monthly Weather Review, 2017..

[2] R. Fablet, P. Viet, R. Lguensat. Data-driven Methods for Spatio-Temporal Interpolation of Sea Surface Temperature Images. IEEE Trans. on Computational Imaging, 2017.

More details from:

R. Lguensat, P. Viet, M. Sun, G. Chen, F. Tenglin, B. Chapron, R. Fablet. Data-driven Interpolation of Sea Level Anomalies using Analog Data Assimilation. https://hal.archives-ouvertes.fr/hal-01609851.

Associated code

Python code available from https://github.com/rfablet

Contact ronan.fablet@imt-atlatntique.fr

Webpage perso.telecom-bretagne.eu/ronanfablet