

Analog forecasting (AnDA) and large-ensemble ocean simulations to improve satellite-derived gridded products

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Analog forecasting (AnDA) and large-ensemble ocean simulations to improve satellite-derived gridded products.

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3DA:
A CMEMS project

COPERNICUS · MARINE ENVIRONMENT MONITORING SERVICE · Service Evolution
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1 Context & Approach:

- **Investigate AnDA as an alternative, data-driven method to interpolate along-track satellite altimetry data (CMEMS-3DA project).**
- **Approach: Twin experiment based on the OCCIPUT large-ensemble global ocean simulation.**

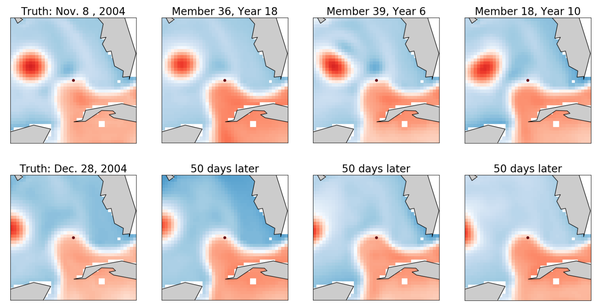


*Fig.: Examples of SSH daily snapshots from 4 members of the OCCIPUT ensemble illustrating different states of the simulated loop current and shredded eddy in the **Gulf of Mexico**.*

- **The OCCIPUT dataset:**
  - 50 members x 20 years of daily SSH at 1/4° resolution (e.g. Penduff et all, 2014, Bessières et al 2017).
  - Member #1 of the ensemble is taken as the truth.
  - Along-track AVISO-like pseudo-observations are extracted from this truth for 2004.
  - The 49 members and 19 years left are used as the historical catalog.

- **Goal:**
  - Reconstruct AVISO-like gridded products from along-track SSH,
  - Compare AnDA with Optimal Interpolation methods.

2 Analog Data Assimilation

AnDA (e.g., Lgensat & Tandeo, 2017).

→ **Analog forecasting + Ensemble Kalman filter analysis**

- Data-driven approach where the analogs are searched via k-th nearest neighbours algrorithm in a historical catalog.
- AnDA can be seen as an Optimal Interpolation with a physically-constrained covariance structure.
- In this project, AnDA performs the analog search in the EOF space.

3 Application to Lorenz-63:

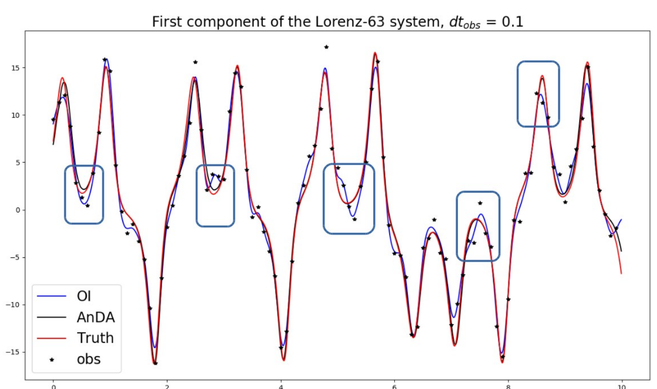


Fig.: Reconstruction of the first component of the Lorentz-63 model with AnDA and OI.

AnDA outperforms OI because:

- It uses past trajectories to produce realistic reconstructions.
- It uses an adaptive covariance structure (i.e. AnDA "knows" when the reanalysis is good or less good).

4 Application to the reconstruction of gridded SSH

Example results from a Twin Experiment in the Gulf of Mexico region:

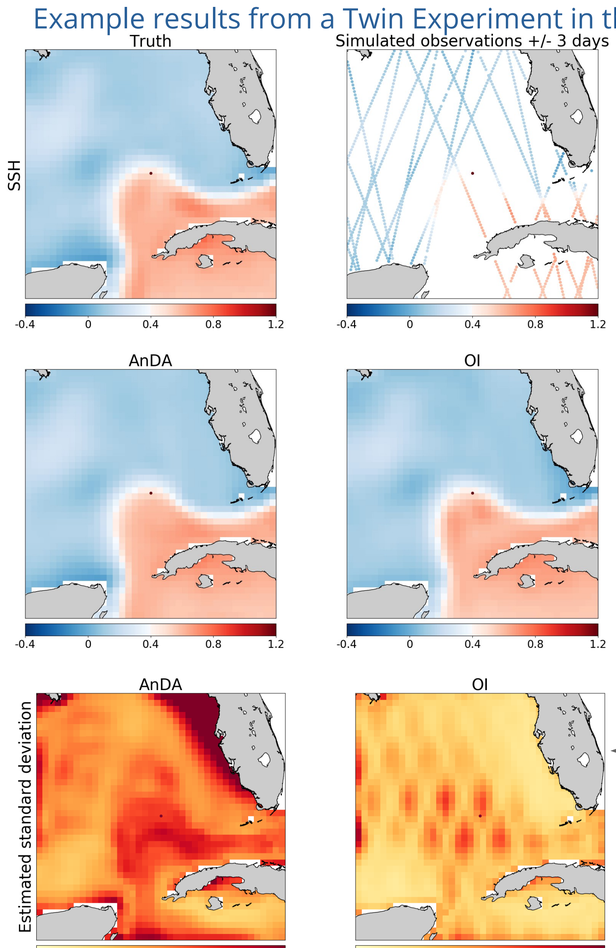


Fig. Daily snapshot of SSH in 2004 in the Gulf of Mexico from the Truth (OCCIPUT simulation member #1, left) and extracted along-track pseudo-obs (right).

Fig. Daily snapshots of th reconstructed SSH with AnDA (left) and with OI (right).

Fig. Estimated standard deviation from AnDA (left) and OI (right) reconstructions.

Fig. Snapshot of the absolute error of the reconstructed SSH with AnDA (left) and OI (right)

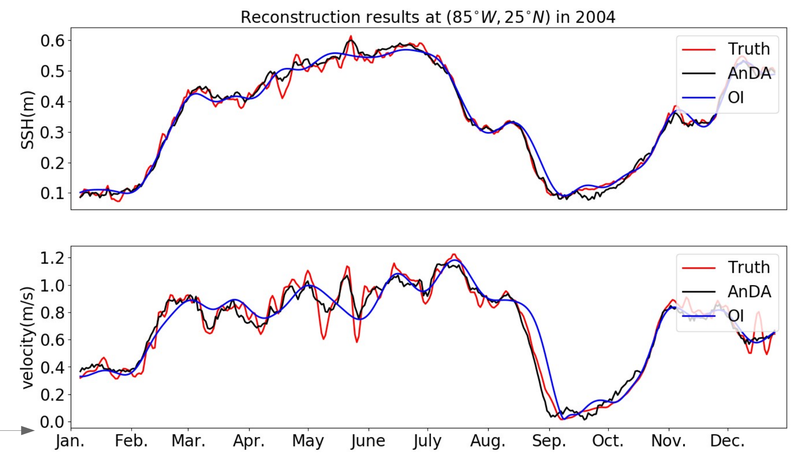
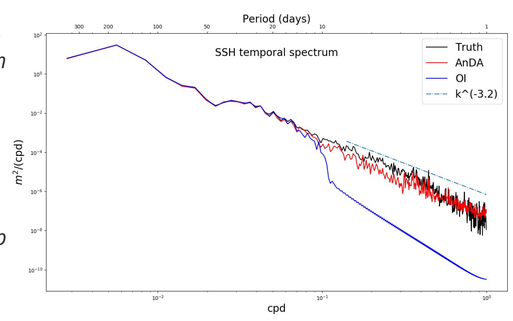


Fig. Timeseries of the True and reconstructed SSH and velocity from AnDA and OI methods at an example gridpoint in the loop current (85W, 25N) in 2004.

Fig.Temporal spectrum of the True and reconstructed SSH from AnDA and OI in 2004, computed at gridpoints, then averaged over the loop current region.



5 Conclusions:

- AnDA is able to capture high-frequency SSH signals better than OI (e.g. Florida coastal waves).
- AnDA produces realistic SSH trajectories, with a reconstructed variance less sensitive to observational sampling than OI.
- AnDA is significantly dependent on the catalog (its size, resolution, realism, etc).

- Further work is on-going to investigate how AnDA behaves in a "cousin" experiment (pseudo-obs taken from a higher-resolution simulation than the OCCIPUT catalog) and with real observations.

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