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

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Context & Approach:

- **Analog Data Assimilation**
  - AnDA (e.g., Lguensat & Tandeo, 2017).
  - Analog forecasting + Ensemble Kalman filter analysis
  - Data-driven approach where the analogs are searched via k-th nearest neighbours algorithm 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.

- **Application to Lorenz-63:**
  - 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).

- **Application to the reconstruction of gridded SSH**
  - 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.
  - The OCCIPUT dataset:
    - 50 members x 20 years of daily SSH at 1/4° resolution (e.g. Penduff et al., 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.

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.

References:
Lguensat et al., The analog data assimilation, MWR, 2017
Penduff et al., Ensembles of eddying ocean simulations for climate. CLIVAR Exchanges, 65(8-18-2), 2014
Bessières et al., Development of a probabilistic ocean modelling system based on NEMO 3.6: application at eddying resolution, GRL, 2017

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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.

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 1th reconstructed SSH with AnDA (left) and with OI (right).

Fig.: Daily 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.