Assimilation of HF radar data in a regional model of the Ligurian Sea

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Introduction

We aim to verify how surface currents obtained by 2 WERA high-frequency radars can improve a regional model in the Ligurian Sea.
100 ROMS instances form an ensemble simulation. An observation operator extracts the radial currents (centered on the radars) from the hourly-averaged model forecasts,
An Ensemble Kalman filter is then used to assimilate the radial currents into the model,
Different test cases are run, and the model currents are somewhat improved by the radar data.
Without assimilating supplementary temperature data (from CTDs, ARGO or satellite), the temperature model field is not improved by assimilation the radar data.

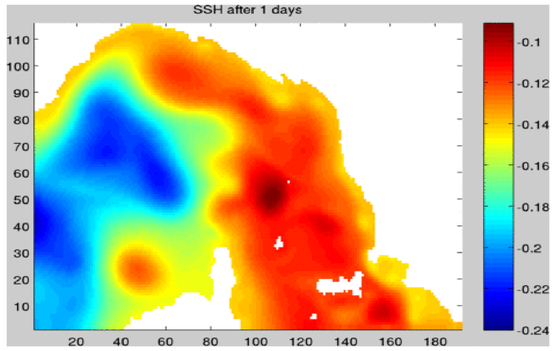
ROMS implementation

MODEL SETUP

- Simulation of the Ligurian Sea during the summer 2010 and MREA campaign
- ROMS: 1/60° horizontal resolution, 32 vertical level
- Open boundary conditions from the MFS model
- Atmospheric forcing fields from the COSMO model

MAIN FEATURES IN THE LIGURIAN SEA

- Eastern and Western Corsican Currents join and form the Northern Current
- Inertial oscillations (period ~17 hours)
- meso-scale



Ensemble generation

The ensemble members undergo perturbations of the uncertain aspects of the model:

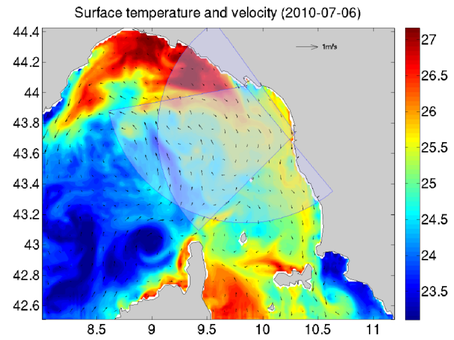
- Perturbed wind field
- Perturbed boundary condition
- Supplementary stochastic term in the velocity equation

The ensemble is spun up from unique initial condition during 1 week, after which members have separated and created mesoscale circulation features

Data and Observation Operator

AVAILABLE DATA DURING MREA10

- Two WERA high-frequency radar systems located in Insola de Palmaria and San Rossore, run by NATO Undersea Research Center (NURC, now CMRE)
- Radial currents are assimilated without reinterpolation on the Cartesian grid
- Azimuthal resolution of 6°
- Currents are averaged over 1 hour



- Also glider data, satellite SST

OBSERVATION OPERATOR: the HFradarExtract tool

- Extracts (averages) the radial currents from the model forecast upper layers:

$$u_{\mathrm{HF}} = \frac{k_b}{1-\exp(-k_b h)} \int_{-h}^{0} \mathbf{u}(z)\cdot\mathbf{e}_r \exp(k_b z)\,dz$$

- Smooths the currents in the azimuthal direction by a diffusion operator to filter scales smaller than 6 degrees

Data assimilation: OAK

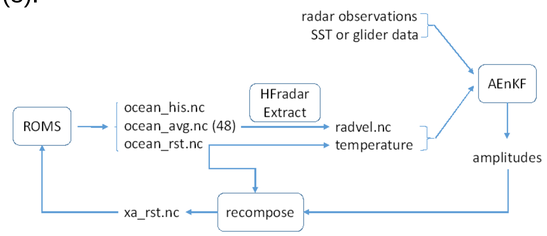
The Ensemble Kalman (EnKF) filter is used, where the state vector can contain:

- The model fields
- The model fields at different instants during a “window” (1); the filter becomes closely related to the Asynchronous EnKF
- The model fields and forcing fields (wind…)

Radar observations are spatially dense and not uncorrelated; we approximate this by increasing the observation error variance (2).

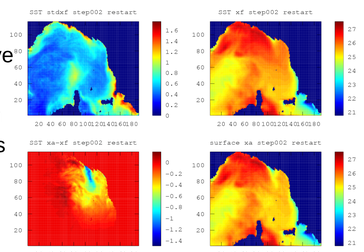
The impact of observations is limited in space by localization (3)

Different experiments are run to determine (1), (2), (3).



Multi-variate considerations

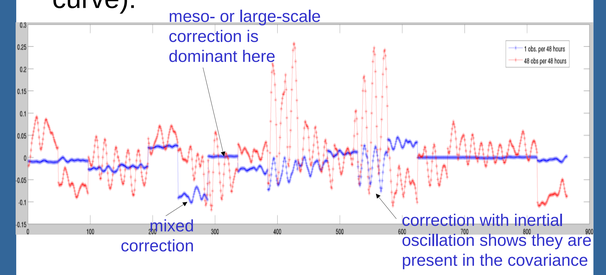
- assimilate radar currents, improve SST ?
- comparison with GHRSST images
- SST corrections have the right amplitude, **but**:
- rms SST error is not improved, similar result as Zhang et al 2010, Marmain et toi, 2014, Sperrevik et al 2015



- *work in progress:* also assimilate **T**
- The state vector is now multivariate and 4D (x,y,z,t)

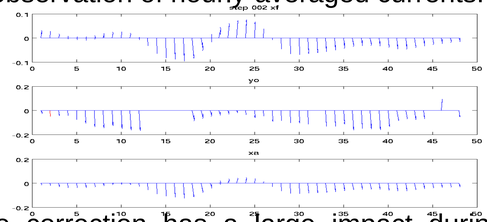
Time considerations

- The ensemble should represent variability at all spatial and time scales
- Instead of assimilating all data, assimilate just 2 radial velocities in 1 single point, 1 time per 48-hour window. The obtained correction at that particular location (blue curve):



- when assimilating data every hour, the correction and especially the inertial oscillation correction becomes more important (red curve)

- How long lasts the impact of 1 observation of hourly-averaged currents:



The correction has a large impact during ~10 hours advantage (necessity) of very frequent observations

Bibliography:
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Zhang W, Wilkin J, Arango H, *Towards an integrated observation and modeling system in the New York Bight using variational methods. Part I: 4DVAR data assimilation.* Ocean Modelling, 35, 2010