Assimilation of HF radar currents in the Iroise Sea using EnOI

Impact on eulerian and lagrangian currents

GlobCurrent Workshop, IFREMER

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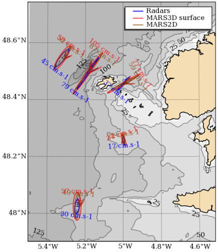
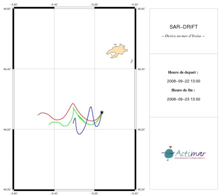
CONTEXT

- **Goal:** Progress toward assimilation HF radar currents in the Iroise Sea.
- **Iroise Sea:** Coastal region, macro-tidal forcing, strong inhomogeneities.
- **Applications:** Oil and object drifts, dispersion studies, navigation.
- **Special questions:**
  - Can we improve lagrangian currents?
  - How about assimilating a single radar?

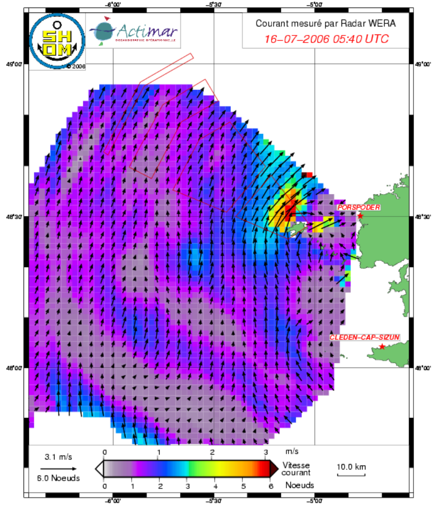
MARS M2 tide



Container release



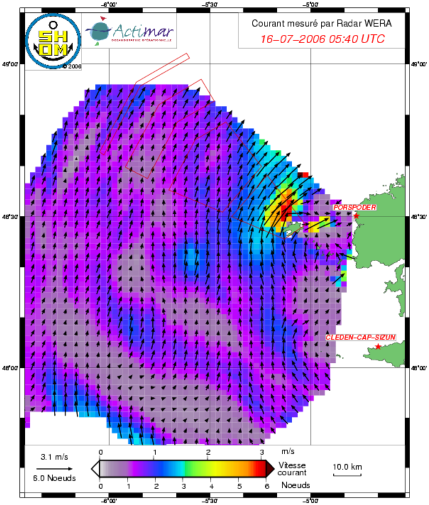
HF RADARS IN THE IROISE SEA



Emission

Reception

HF RADARS IN THE IROISE SEA

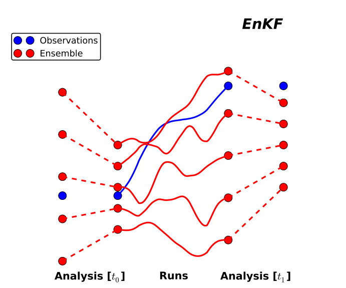


- Operated by Actimar for the SHOM since 2006.
- WERA 12.4 MHz.
- Reception: 16 antennas, BeamForming.
- Currents every 20 mn
- Gridded product: 2 km.

ENKF AND ENOI

Ensemble Kalman Filter

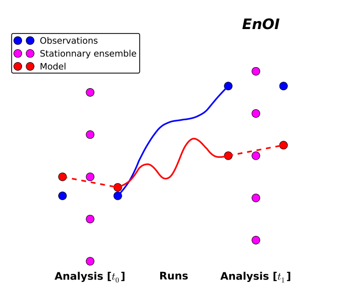
$$A^a = A^f + A'A'^T H^T (HA'A'^T + \Upsilon\Upsilon^T)^{-1}(D - HA^f)$$



- Several simulations.
- Hard to generate smart errors.

Ensemble Kalman Optimal Interpolation

$$\Psi^a = \Psi^f + \alpha A'A'^T H^T (\alpha HA'A'^T + \Upsilon\Upsilon^T)^{-1}(d - H\Psi^f)$$



- A single simulation.
- Stationary ensemble for errors.

$\Longrightarrow$ We choose EnOI for testing purpose, in passive assimilation mode (no restart).

MODEL

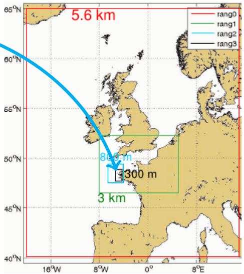
Source Preliminary tests with archived runs from PREVIMER (IFREMER, France).

Model MARS3D, rank 2 (800m resolution).

Performances In terms of currents: slightly too strong, especially near Ushant and west of Sein island.

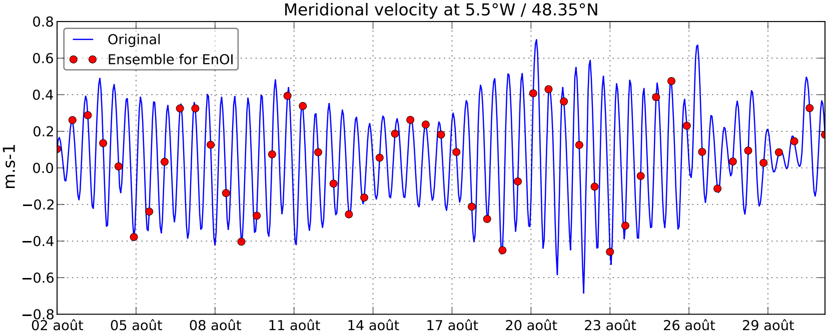
Testing period August 2009.

PREVIMER ranks



MODEL ERRORS

Ensemble for generating errors is built with en 14-hour undersampling of one month → ensemble of 50 members.



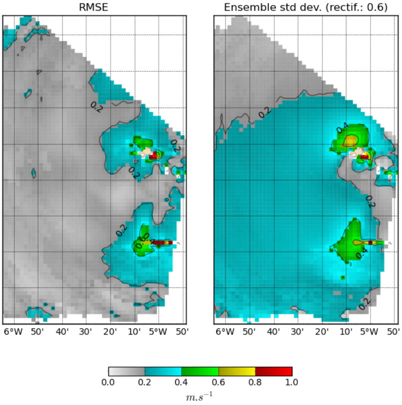
Undersampling a large period gives better results.

MODEL ERRORS

Consistency

Ensemble variance must be close to model errors for both radars.

Scaling with the rectification factor α $[\Psi^a = \Psi^f + \alpha \boldsymbol{A}'\boldsymbol{A}'^T\boldsymbol{H}^T(\alpha \boldsymbol{H}\boldsymbol{A}'\boldsymbol{A}'^T + \Upsilon\Upsilon^T)^{-1}(\boldsymbol{d} - \boldsymbol{H}\Psi^f)]$.



$\Rightarrow$ For both radars with use: $\alpha^{\frac{1}{2}} = 0.6$.

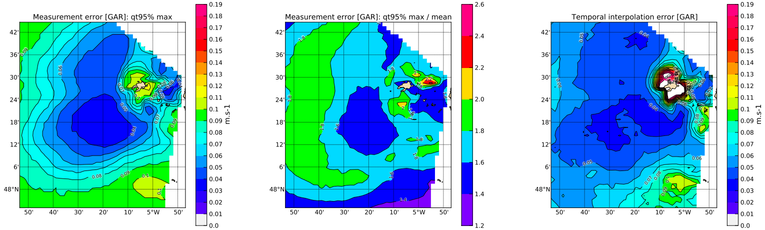
ERRORS

Radar errors

No need to generate an ensemble with EnOI.

Two sources of errors for observations:

- directly from radar measurements (mean or 95% quantile),
- ”interpolation“ errors.



Interpolation errors are weak except around islands.

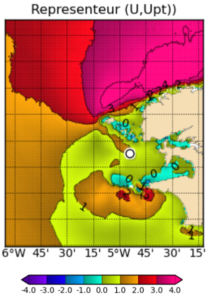
LOCALIZATION

Strong inhomogeneity + error assumptions.

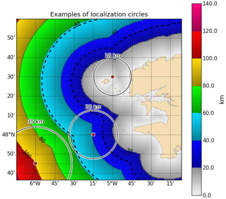
$\Rightarrow$ Localization to prevent unrealistic remote corrections (for the best or for the worst!).

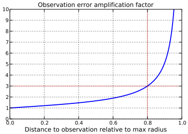
$\longrightarrow$ Correct a single model point with data within an appropriate radius.

Representer of U



Radius of selection





Error increases with radius.

PROJECTION OPERATOR H

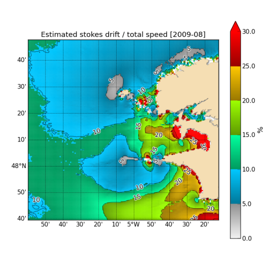
$$\Psi^a = \Psi^f + \alpha \boldsymbol{A}' \boldsymbol{A}'^T \boldsymbol{H}^T (\alpha \boldsymbol{H} \boldsymbol{A}' \boldsymbol{A}'^T + \Upsilon \Upsilon^T)^{-1} (\boldsymbol{d} - \boldsymbol{H} \Psi^f)$$

In three steps:

1. Add the Stokes drift.
2. Bilinear interpolation into the radar grid.
3. Projection of components onto the radial axis of the radar.

Stokes drift

Approximation with two second order polynoms of the 10-meter wind.

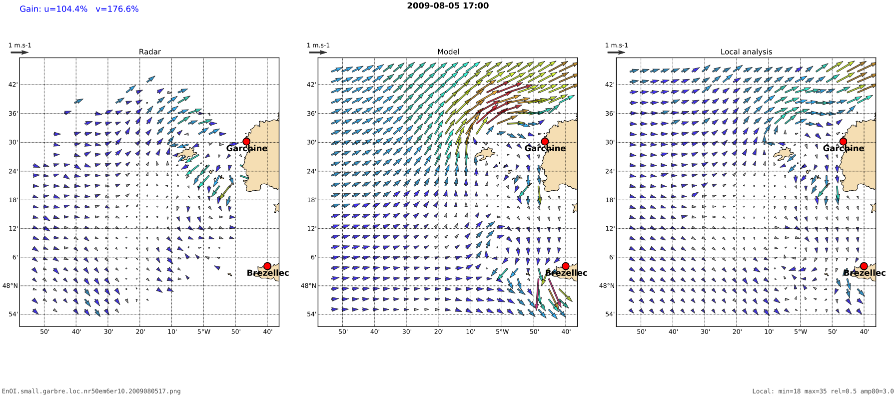


Ratio Stokes/total speed

EULERIAN CURRENTS

EXAMPLE

Local analysis with Garchine + Brezellec radars.

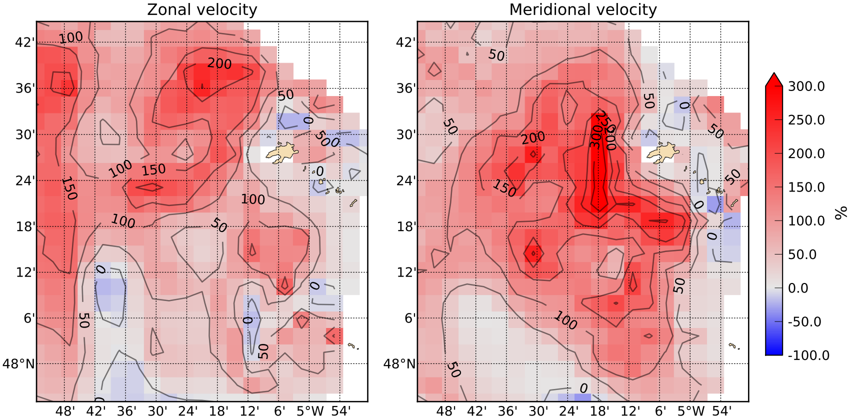


PERFORMANCES [1/4]

Temporal statistical performances for **local and global** analyzes of **1 or 2 radars**.

Gain over forecast [%] : $100\left(\frac{RMSE(forecast)}{RMSE(analysis)}-1\right)$ ($\rightsquigarrow <$ 0 means no gain).

Gain: Global analysis [Garchine+Brezellec]



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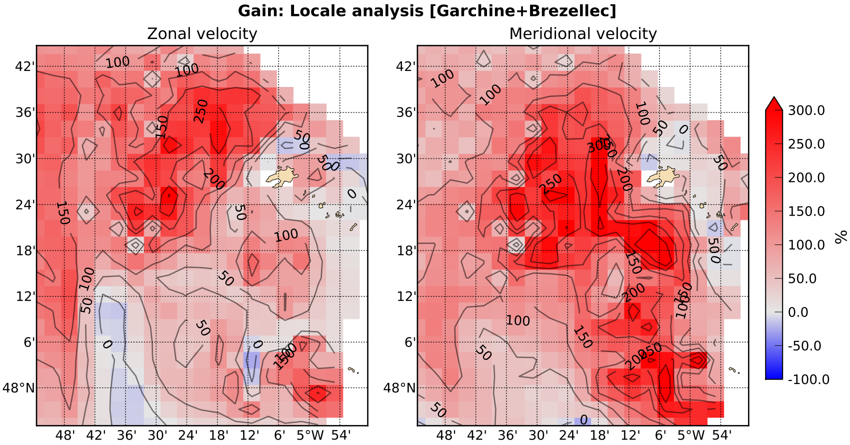

Localization: globally improves the correction

Performances [3/4]

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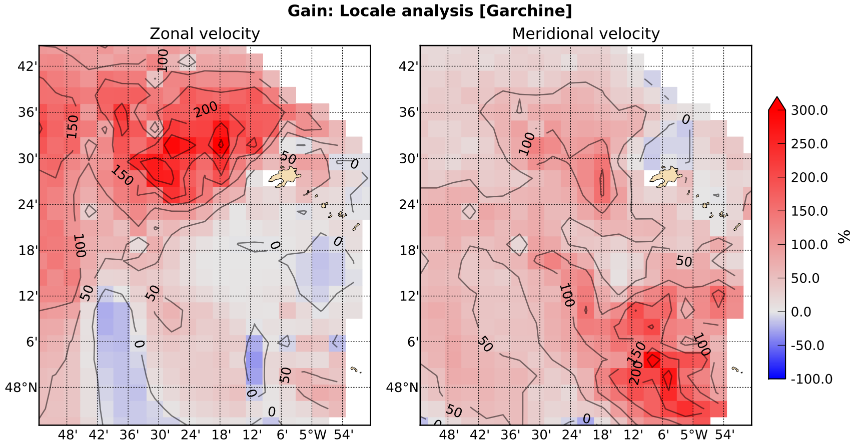

Assimilation a single radar: efficiency depends the direction of currents

Performances [4/4]

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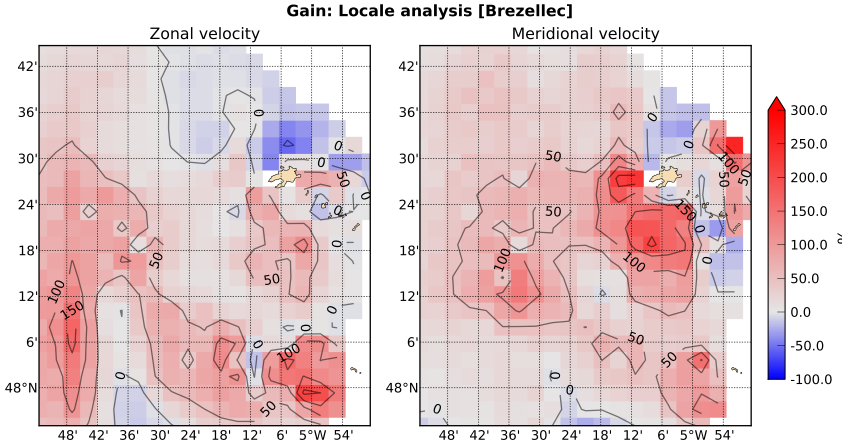
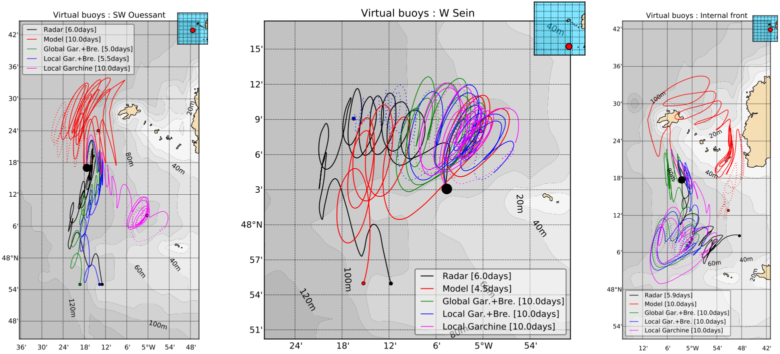


Assimilation a single radar: efficiency depends the direction of currents

LAGRANGIAN POINT OF VIEW

- Virtual drifters using hourly currents and an integration step of 1mn.
- Radar currents slightly filled using shapiro2D+shapiro1D.



⟶ Assimilation generally improves lagrangian simulations.

⟶ Gain of local analyses compared to global analyses is not that clear.

CONCLUSIONS AND PERSPECTIVES

EnOI assimilation

- Two WERA radars in the Iroise Sea.
- Ensemble based on large undersampling of MARS3D.
- Localization improves eulerian currents.
- Single radar: improvement depends on direction of currents.
- Strong effect from the lagrangian point of view.

Ongoing work

- Forecast efficiency.
- EnKF in active mode with smoother and IAU.
- Playing with initial conditions, drag coefficient, atmospheric forcing...
- Radar errors as an ensemble.
- Validation with surface drifters (and ADCP).
- Mediterranean Sea (microtidal).

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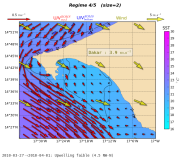
GLOBAL CURRENTS?

FOR COASTAL OPERATIONAL OCEANOGRAPHY

Dispersion study



SAR currents

- ✓ Offshore connections to coastal areas →
- ✓ High spatial resolution.
- ✗ Low temporal resolution.

Applications

- ✓ **Validation:** Mesoscale processes or upwellings.
- ✗ **Assimilation:** Low representativity, especially in tidal region.
- ✓ **Parameter optimization:** Potential application of assimilation.

Thank you