Cooperation or coordination of underwater glider networks? An assessment from OSSEs in the Ligurian Sea

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1. Context

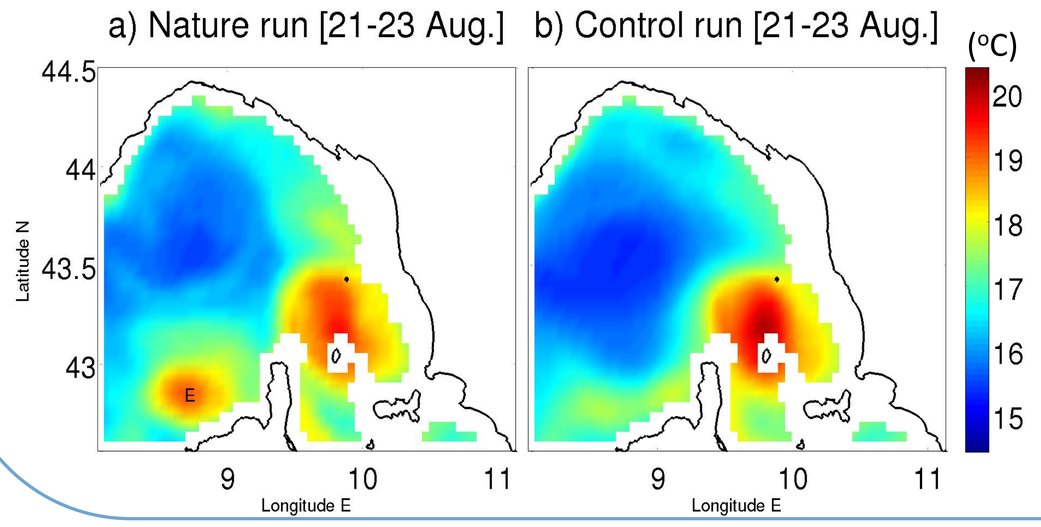
Underwater gliders are autonomous buoyancy-driven profiling platforms which trajectory can be controlled in near real-time through satellite communications while at the surface, opening the possibility for **adaptive sampling** procedures. Given their relative low operating cost, gliders might be deployed in small **fleets** so as to increase the extent of the observations. In that case, the **cooperation** between the platforms (i.e. the fact that the individual trajectories are driven by a common objective) can be expected to improve the efficiency of sampling missions compared to a naïve collective behavior.

This study implements Observing Systems Simulation Experiments (OSSEs) to evaluate the Ligurian Sea regional ocean temperature forecast performance of two levels of cooperation **(cooperative-unaware** and **cooperative-coordinated)** in a fleet of three gliders.

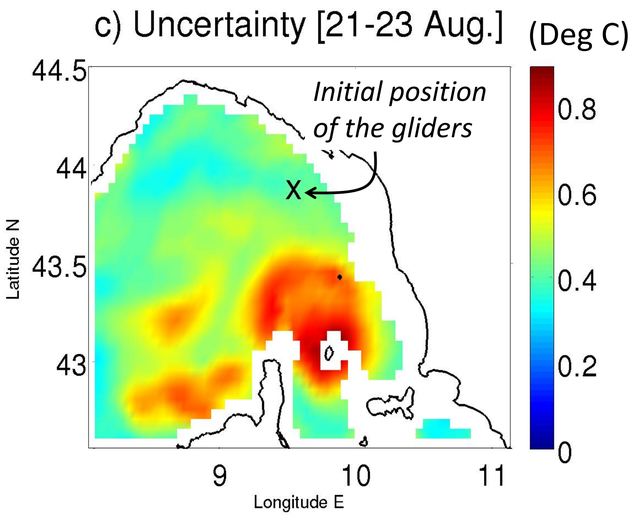
2. Methodology

Study area: **Ligurian Sea** (Western Mediterranean)
Model: Regional Ocean Modeling System (**ROMS**), 1.8-km resolution
Data assimilation: ensemble Kalman filter (**EnKF**)

- **OSSEs**: fraternal twin experiments
  → Main difference between nature and control runs: presence (absence) in the nature (control) run of a warm **anticyclonic eddy** off the north-western coast of Corsica Island.



- An **adaptive sampling** procedure is implemented to pilot the fleet of three gliders, based on an **optimal mission planning** run every 48h from 21 to 29 August 2010, aiming at minimizing the temperature model uncertainty predicted for the next two days.

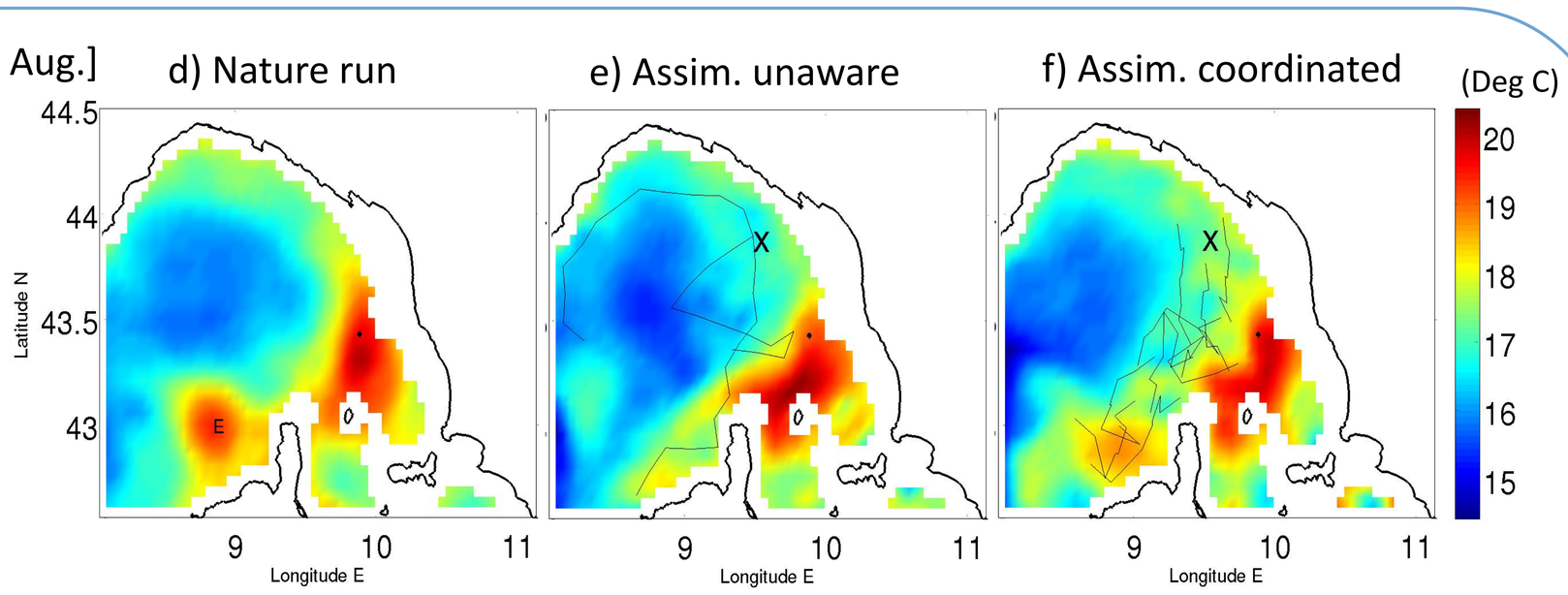


Figures : Initial surface-to-100m-depth 48-h averaged temperature of (a) the nature and (b) control runs. (c): associated uncertainty.

- Two levels of cooperative control of the glider fleet are considered:
  1) **unaware** (the gliders are independently free to fly in any part of the domain)
  2) **coordinated** (the platforms are constrained to fly in a triangular formation maintaining a 25-km distance between each other).

3. Results

- The uncertainty estimate (Fig c) properly captures the dynamical area off Corsica and the adaptive sampling procedure satisfactorily directs the gliders towards this area (Fig e and f).
- In the cooperative-unaware scenario (Fig e), one of the platforms monitors the area of the eddy on 27 August, but without really crossing the core of the structure. This is insufficient for the model to reproduce the eddy during the following prediction cycle. No statistical improvement with respect to the control simulation is found in this scenario.



Figures : Surface-to-100m-depth 48-h averaged temperature of (d) the nature run, (e) cooperative-unaware, and (f) coordinated fleet assimilated solutions for the period 27-29 Aug. The glider trajectories are represented by the fine black lines in (e) and (f).

- The improved coverage provided by the coordinated triangular formation leads to a better representation of the mesoscale structure, even if not exactly at the right position (Fig f). In this case, the Root-Mean-Square Error is reduced by 40 % in the area around the eddy.

4. Conclusions

- The adaptive sampling procedure based on the predicted model uncertainty (EnKF) allows to direct the gliders towards model error hot spots associated with ocean mesoscale variability.
- The resulting glider fleet sampling allows the insertion of missing eddies in a high-resolution model after data assimilation provided that the platforms maintain a geometrical formation (**coordinated** fleet configuration) allowing to collect information along different directions across the mesoscale structure.

References

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- *EnKF:* Evensen et al., 2003, Ocean Dyn., 53, 343-367.
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