Operational Assimilation of glider temperature and salinity in a mesoscale flow field: Eastern Mediterranean test case

D. Hayes[1],T. Rossides[1], H. Gildor[2] ,S. Dobricic[3]

[1]Oceanography Centre, University of Cyprus, Nicosia, Cyprus

[2]Hebrew University of Jerusalem, Israel

[3]Centro Euro-Mediterraneo sui Cambiamenti Climatici., Bologna, Italy

Introduction:

The objective of this study[1] is to increase the short term performance of ocean forecasts, in particular for surface currents. This would provide a significant improvement of predictive capacity for applications such as pollutant spreading or offshore operational safety. Quick and easy to deploy, gliders allow rapid improvement of model performance.

- An operational data assimilation system for the Eastern Mediterranean is described and evaluated for a 6-month twin experiment.
- Glider profiles of temperature and salinity are assimilated daily into a high resolution ocean forecast, after an initial spin up of one week.
- A control run is also carried out, identical except without assimilation of in situ data.

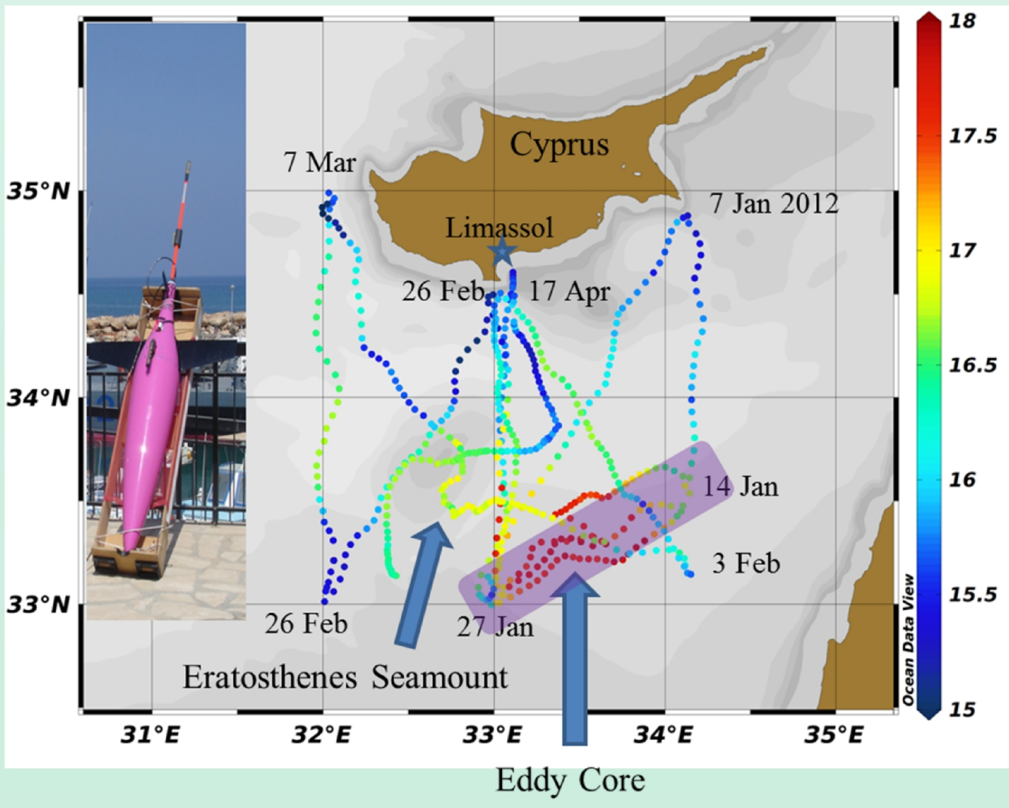


Figure 1. Cyprus glider (inset) and track of mission carried out from December 2011 to June 2012. Color represents temperature at 250 m depth during upcast. Cyprus eddy shows a warm core.

Methods:

Glider Observations[2]

- A glider carried out a butterfly pattern from 2011/12/16 to 2012/06/01 and identified the Cyprus eddy (Fig. 1).
- Observations made to 1000 m (~8 hours and ~7 km between surfacings) with a non-pumped (CTD) (SBE-4 and SBE-5) and a dissolved oxygen sensor (SBE-43) Cyprus eddy identified (Fig. 2).

Cyprus Coastal Ocean Model[3]

- An operational flow forecasting system based on the Princeton Ocean Model.
- Driven by Skiron atmospheric forcing and Alermo initial and boundary conditions.
- Horizontal Resolution: 1 km, vertical resolution: 24 sigma layers.

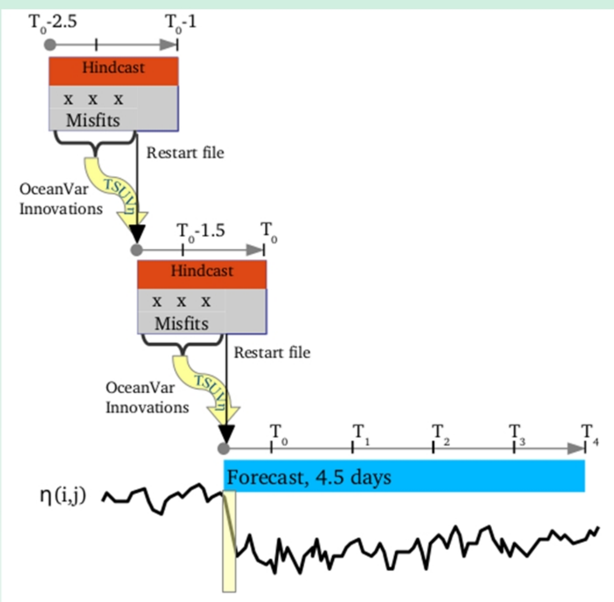


Figure 2. Operational forecast scheme for data assimilation. T_0 is 1200h GMT on the day of the operational run.

Data Assimilation *(OceanVar)*[4]

- Daily runs, with 2 1.5-day hindcasts in which misfits were computed based on available glider data. (Fig. 2)
- After each hindcast, correction fields were calculated by the 3DVAR OceanVar package.
- The corrections were introduced into the following hindcast (or forecast) in the first 20 steps.

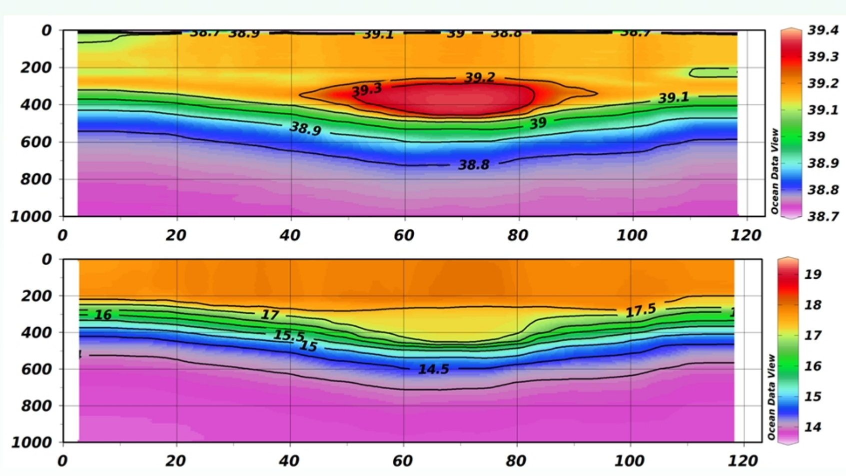


Figure 3. Vertical section of temperature (top) and salinity (bottom) in January 2012 through the Cyprus eddy region. Horizontalaxis is in kilometers from the western edge of the box in Fig.1

Results:

- RMS differences of the misfits between the temperature and salinity observations and the model background field at those locations (before any assimilation) were approximately 15% lower in the assimilative run.
- Assimilating temperature and salinity profiles produces large differences in the vicinity of Cyprus eddy between the control run and the data assimilative (d/a) run. The largest temperature and salinity differences are found at depths between 250 and 500 m, and the resulting misfits contain sharp vertical gradients (Fig.4)

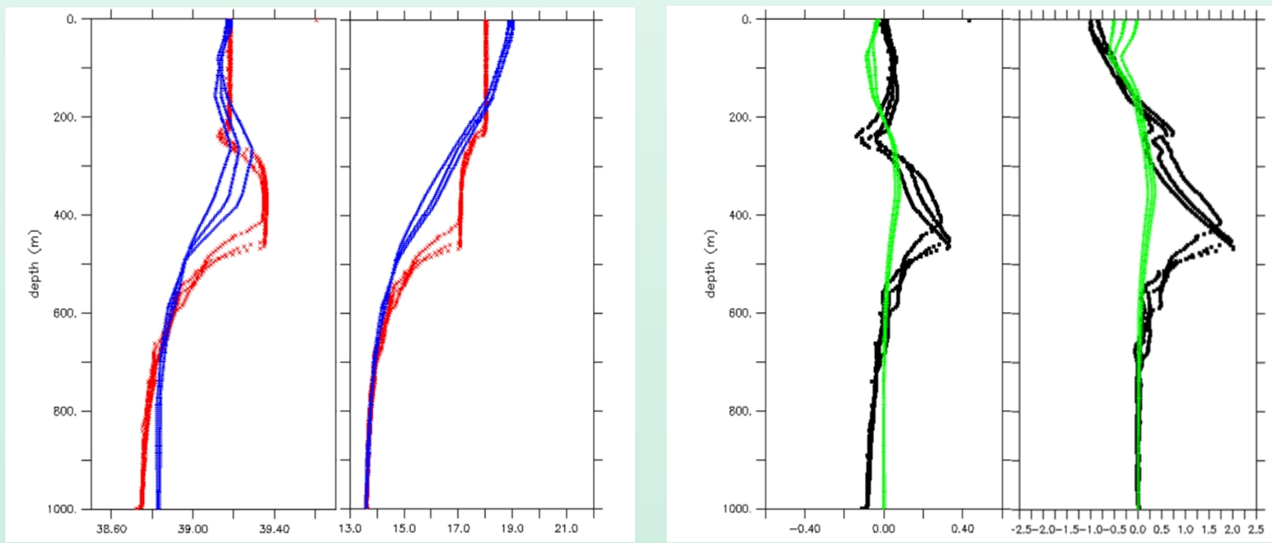
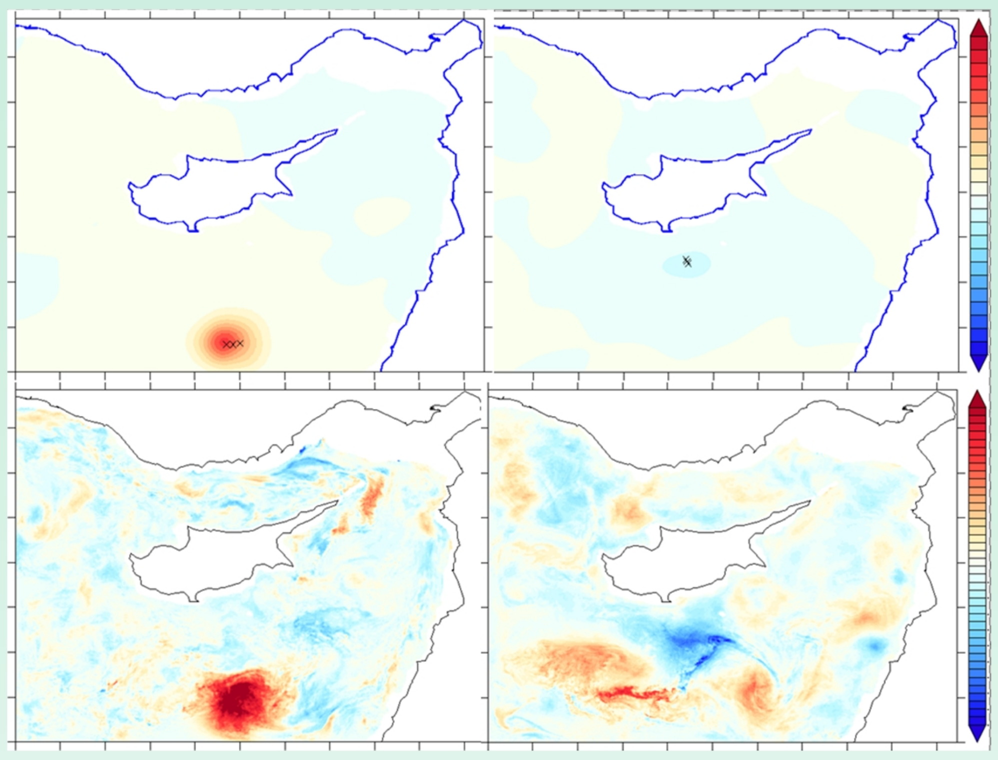


Figure 4. Profiles of model (blue) and glider (red) temperature(left) and salinity (right) for day 49 (23 January 2012) (top), used to calculate the respective misfits (black) and corrections (green) on day 50 (bottom). Note that the corrections are 3-D fields, and only the profile through the glider location is shown here.

- The observations differ greatly from the model at day 50, because the glider encountered the core of the eddy (Fig 4).
- Significant corrections are produced by OceanVar using the above misfits and resulting model differences the following day at 360 m (Fig. 5, left).
- When the glider is outside the eddy, say day 175, salinity differences at 360 m are smaller. They are still visible throughout the domain, and are larger near the eddy region (Fig 5., right).

Figure 5. Corrections to salinity and glider profile locations (symbol x) for day 49 (23 January 2012) and day 174 (27 May 2012) at depth 360 m only. Difference in salinity at 360 m between the data assimilative run and control run for day 50 (left) 15 and day 175 (right).



Conclusions:

- A single glider was able to improve the ocean state estimate (Fig. 6).
- Future improvements: update of the vertical EOF used in OceanVar based on a re-analysis including all glider missions since 2009, increasing domain to African coast, and increasing vertical resolution.

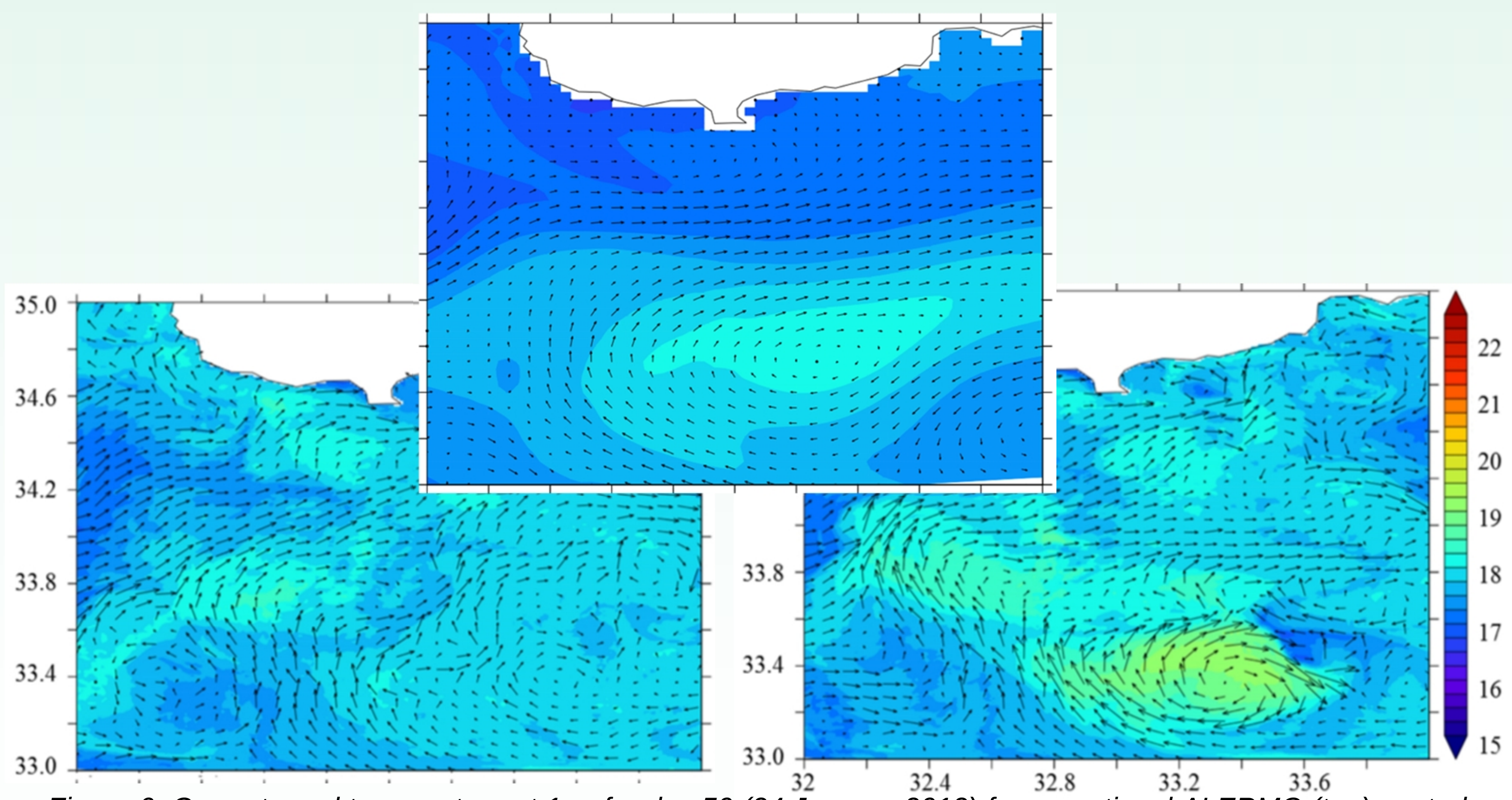


Figure 6. Currents and temperature at 1 m for day 50 (24 January 2012) for operational ALERMO (top) control run (left) and data assimilative run (right). Cyprus eddy is at 33.5°N, 33.5°E. Identical scales are used.

References:

1. Hayes, D.R., Dobricic, S., Gildor, H., 2016. Operational Assimilation of glider temperature and salinity in a mesoscale flow field: Eastern Mediterranean test case. Ocean Science Discussions 2016, 1–27. doi:10.5194/os-2016-43.
2. Hayes, D.R., 2016. Physical oceanography from Seaglider mission CNCY201114910. Oceanography Center, University of Cyprus, Nicosia, doi:10.1594/PANGAEA.859003.
3. Zodiatis, G., Lardner, R., Hayes, D.R., Georgiou, G., Sofianos, S., Skliris, N., Lascaratos, A., 2008. Operational ocean forecasting in the Eastern Mediterranean: implementation and evaluation. Ocean Science 4, 31–47. doi:10.5194/os-4-31-2008.
4. Dobricic, S., Pinardi, N., 2008. An oceanographic three-dimensional variational data assimilation scheme. Ocean Modelling 22, 89–105.doi:http://dx.doi.org/10.1016/j.ocemod.2008.01.004.

Acknowledgements:

- University of Athens: George Kallos, Sarantis Sofianos
- Funding: FP7-GROOM, Cyprus RPF and UCY-YPOKINOUMODA.