

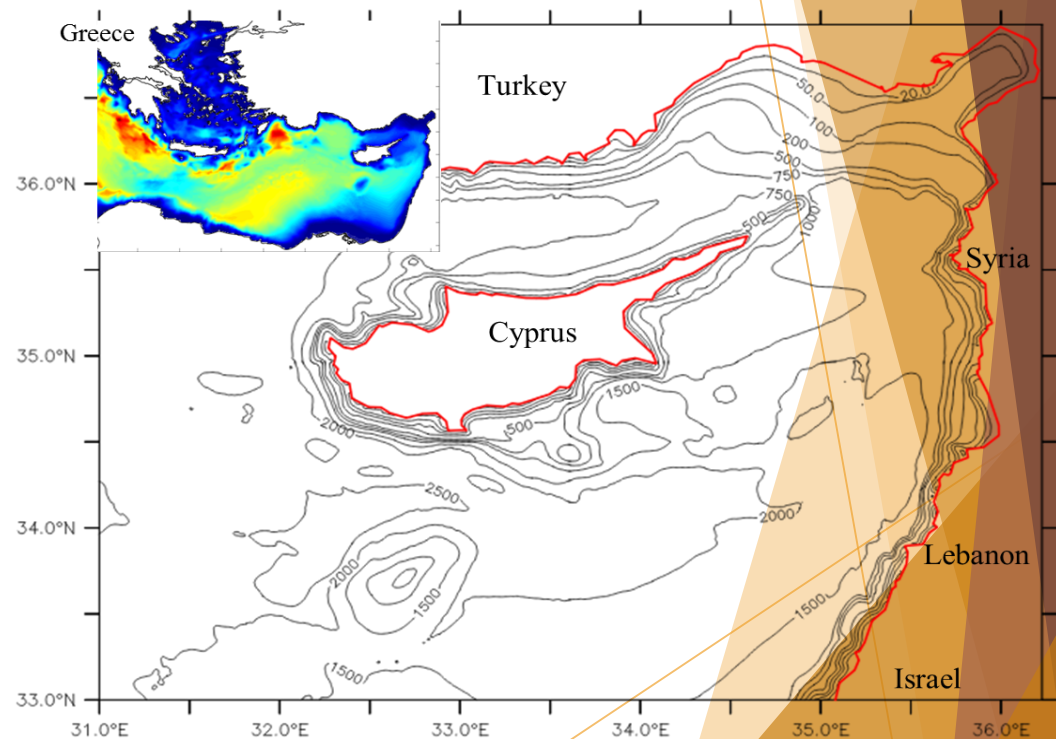
# Local Re-analysis of the Cyprus Basin: the impact of gliders and profiling floats on reproducing observed surface drifter tracks

- ▶ Anastasios Matsikaris, Dan Hayes
  - ▶ Oceanography Centre, University of Cyprus
- ▶ Pierre-Marie Poulain, Elena Mauri, Riccardo Gerin
  - ▶ OGS, Trieste
- ▶ 7<sup>th</sup> Euro-Argo Science Meeting, Athens, 22-23 October 2019

# Operational Data Assimilation of Gliders in Cyprus-Flow model

- ▶ Model used: Cyprus Coastal Ocean Model (CYCOM), based on the Princeton Ocean Model (POM).
- ▶ Nested within a regional model of the Eastern Mediterranean (ALERMO), which is in turn nested within the operational regional model of the Mediterranean (MFS).
- ▶ Horizontal grid spacing of 1.0 km, open southern and western boundaries at 33.0° N and 31.0° E, respectively.
- ▶ Longitude-latitude grid has dimension of 489 x 438 grid points. 24 vertical sigma levels, logarithmic near the top and bottom.
- ▶ Atmospheric forcing from the Skiron forecasting system of the University of Athens.

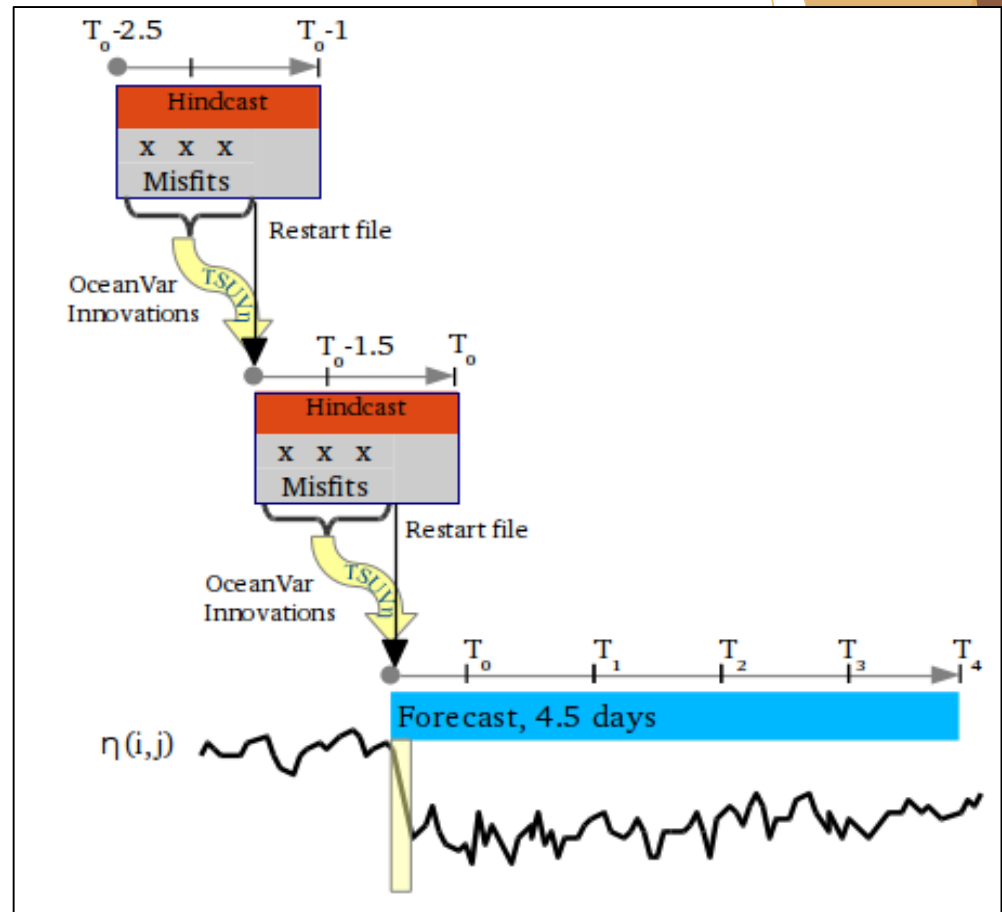
Domain and bathymetry of the CYCOM model and ALERMO model (inset).



# Operational Data Assimilation of Gliders in Cyprus-OceanVAR

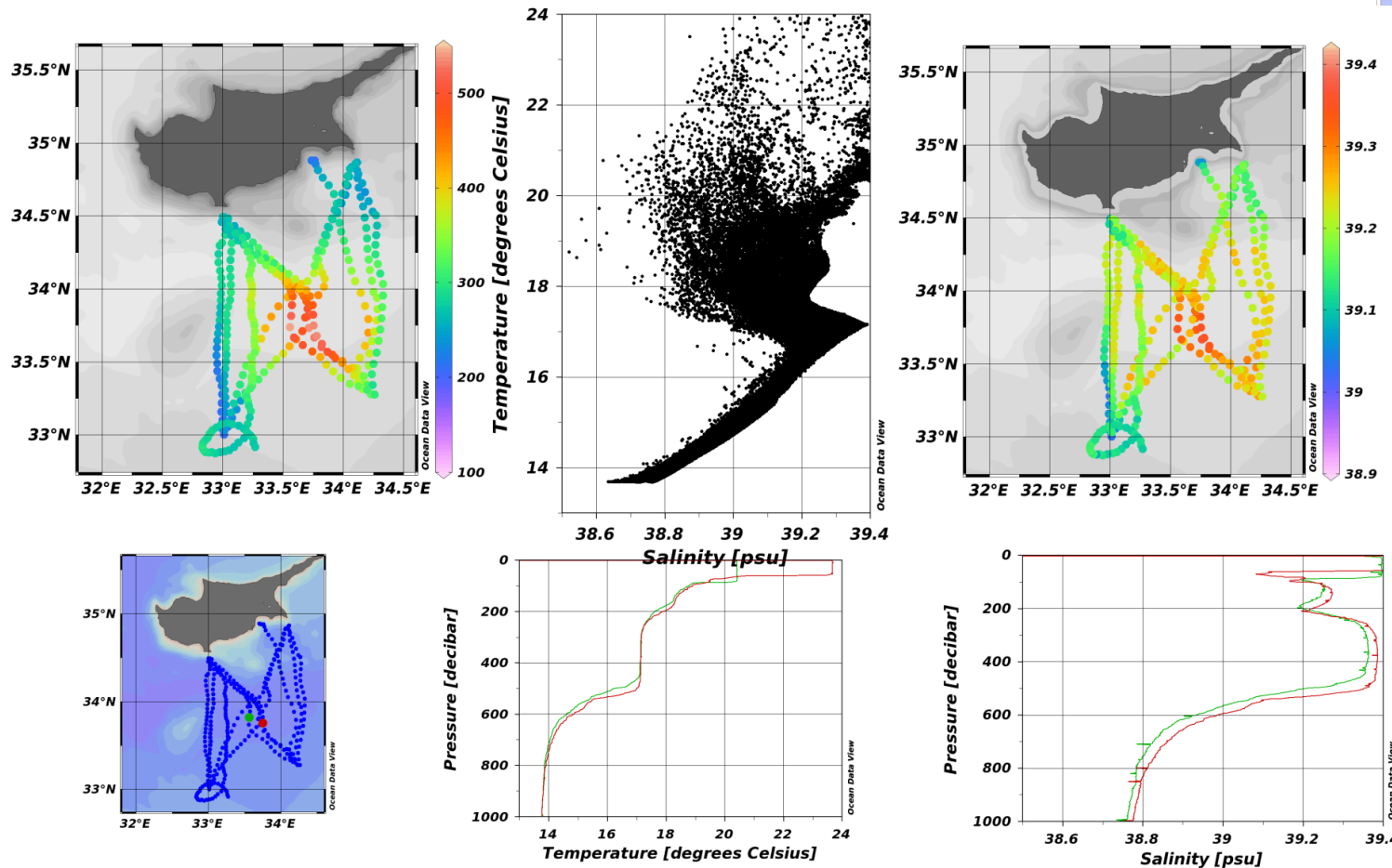
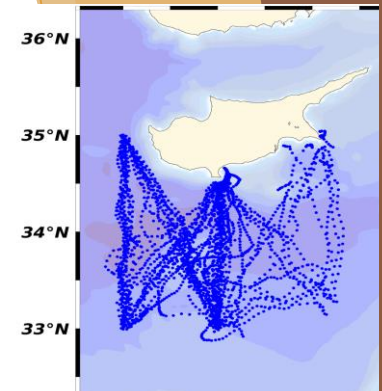
- ▶ Glider and float data were assimilated in the CYCOM model using OceanVar.
- ▶ OceanVar iteratively finds the minimum of the cost function of the analyzed state vector, written as the sum of the background error and observation error.
- ▶ This technique requires the computation of the vertical empirical orthogonal functions (EOFs) of the temperature and salinity anomalies from the monthly mean profiles at each model point.

Operational forecast scheme for data assimilation, including hindcasts and forecasts:



# Glider Observations in Cyprus

Example of sub-basin eddy: intermediate depth

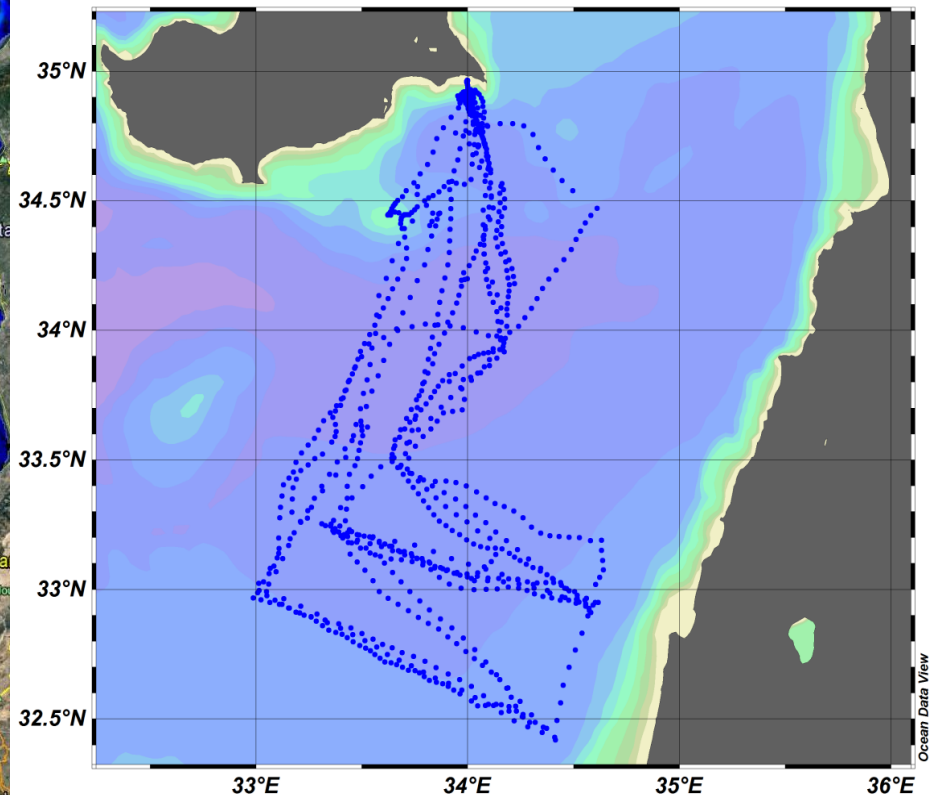
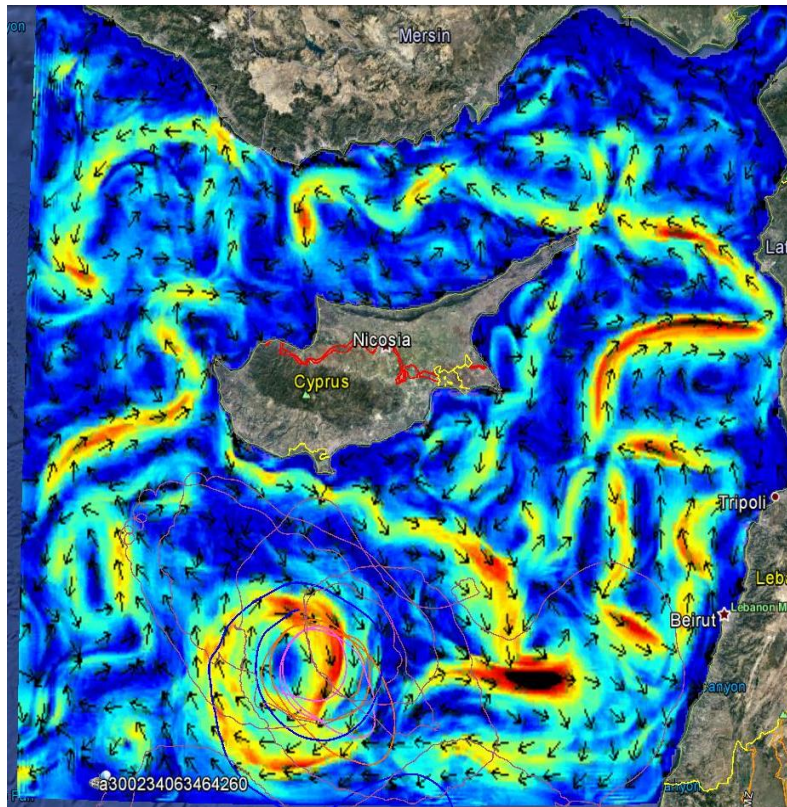


Oct 2010 to Feb 2011

# Circulation in the NE Levantine: CINE

## Operational Data Assimilation of Gliders in Cyprus

- Missing physics at mesoscale
  - Cyprus eddy-2017

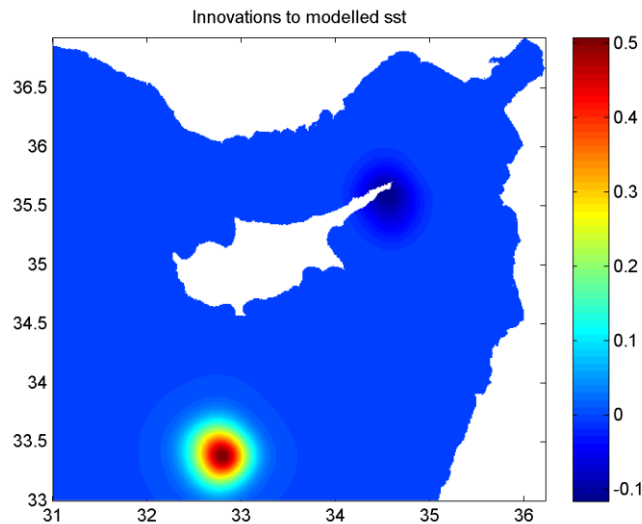


# January-March 2017 Reanalysis using floats and gliders

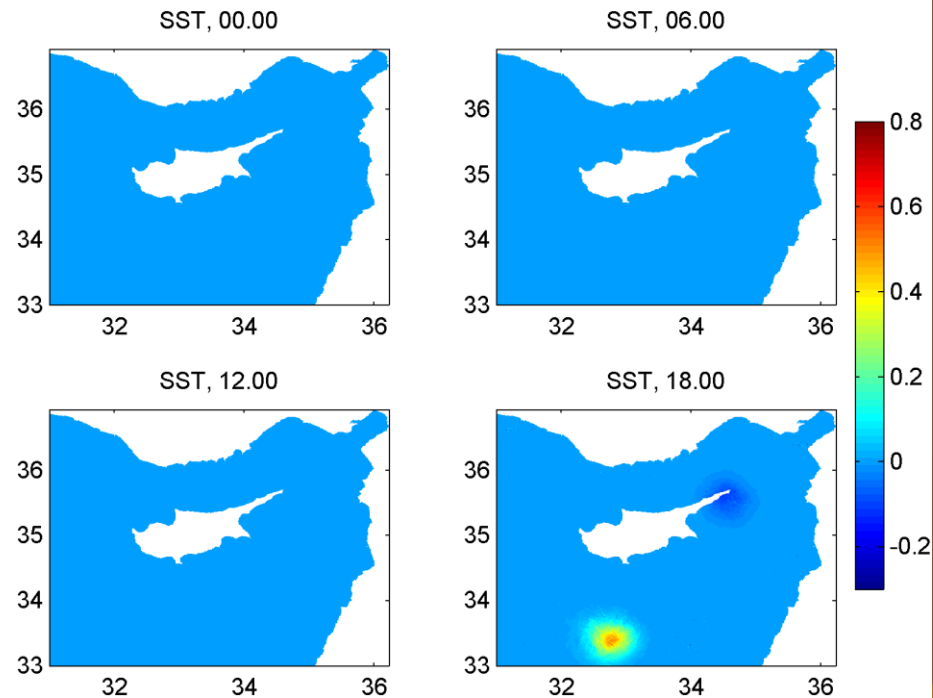
3 month hindcast of glider and float data assimilation:  
1 Jan to 31 Mar 2017

First day of assimilation, 04.01.17

Floats only



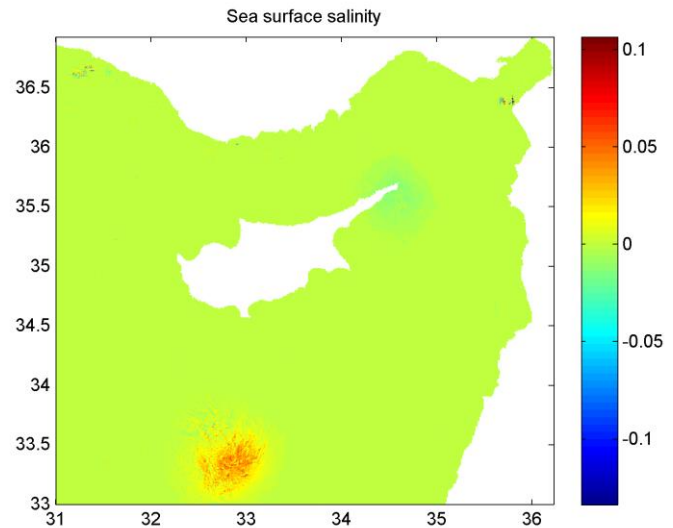
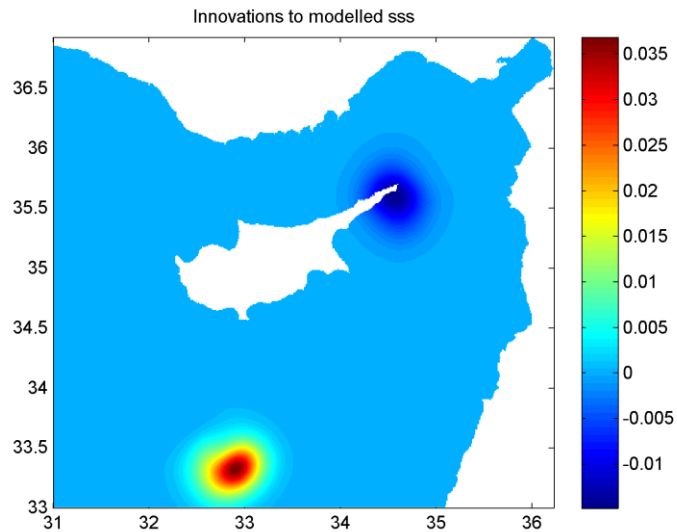
Sea surface temperature corrections (°C)  
for the previous day, 03.01.17



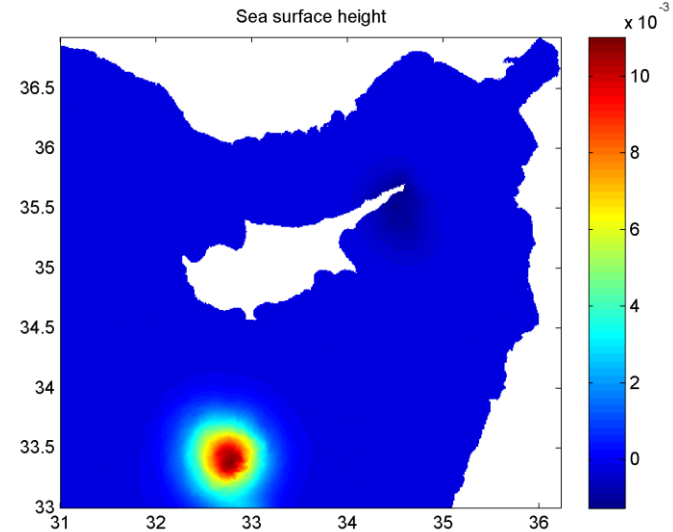
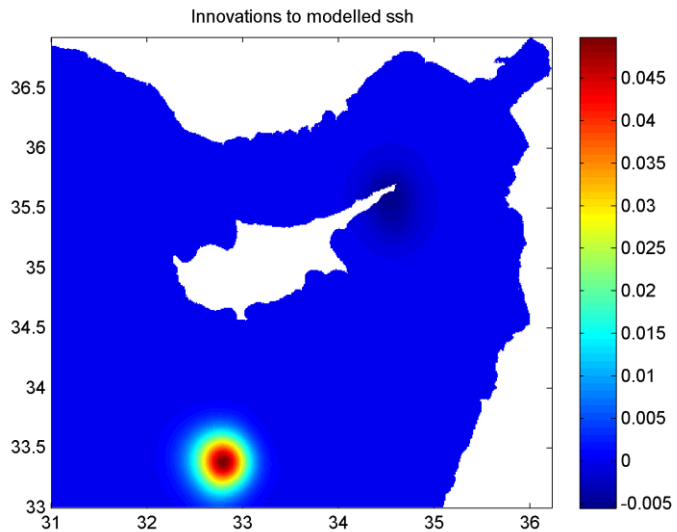
Modelled differences between runs with  
and without assimilation for 04.01.17



## First day of assimilation, 04.01.17



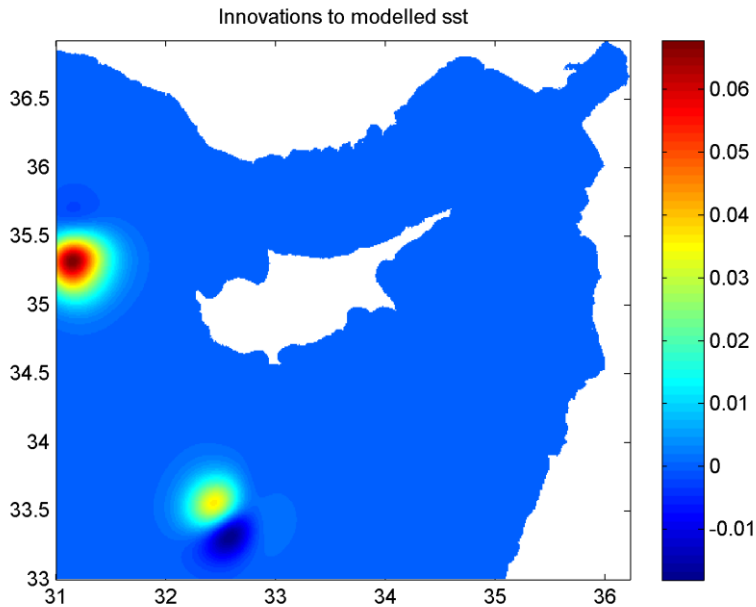
## Sea-surface salinity corrections (psu) and modelled DA differences



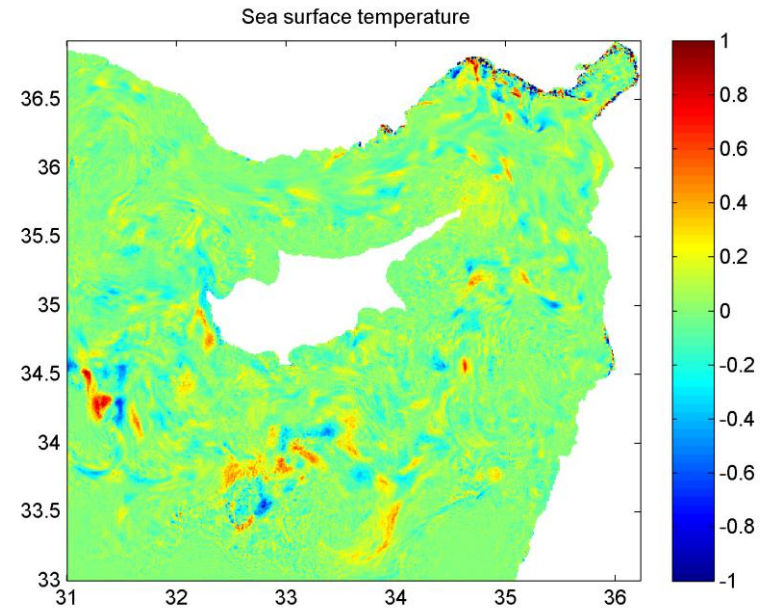
## Sea-surface height corrections (m) and modelled DA differences

After 10 days of assimilation, 15.01.17

Floats only



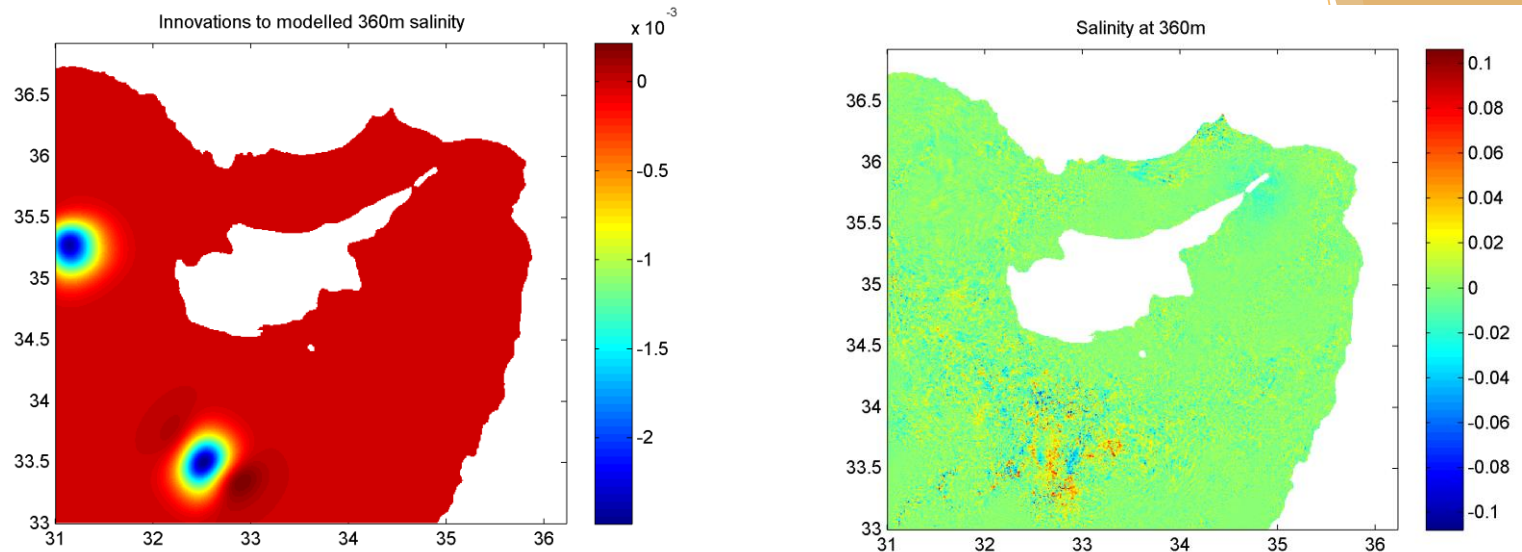
Sea surface temperature corrections (°C)  
for the previous day, 14.01.17



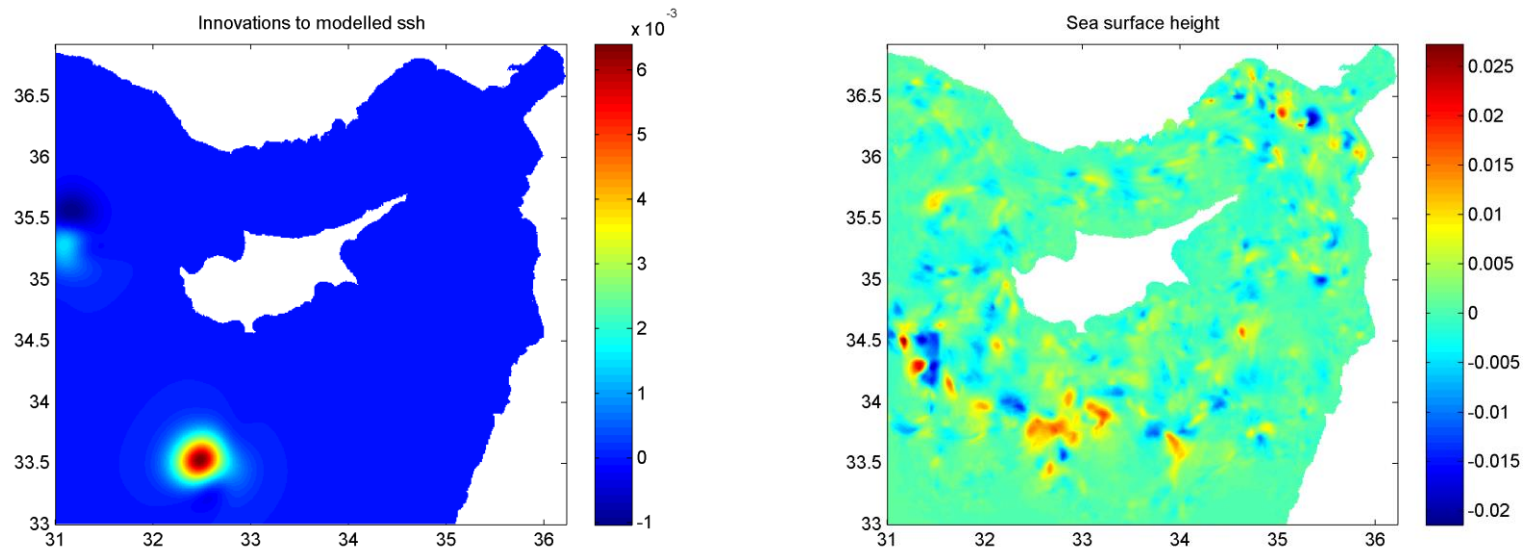
Modelled differences between runs with and  
without assimilation for 15.01.17



## After 10 days of assimilation, 15.01.17



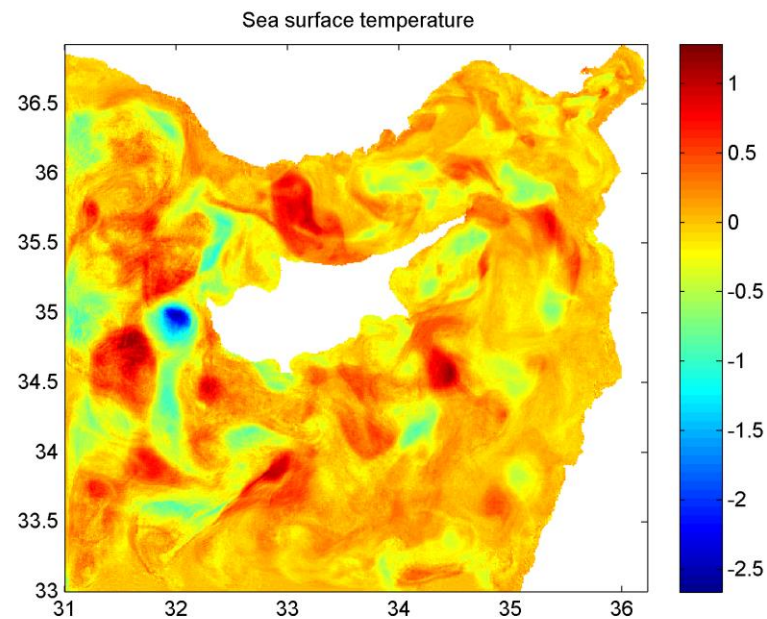
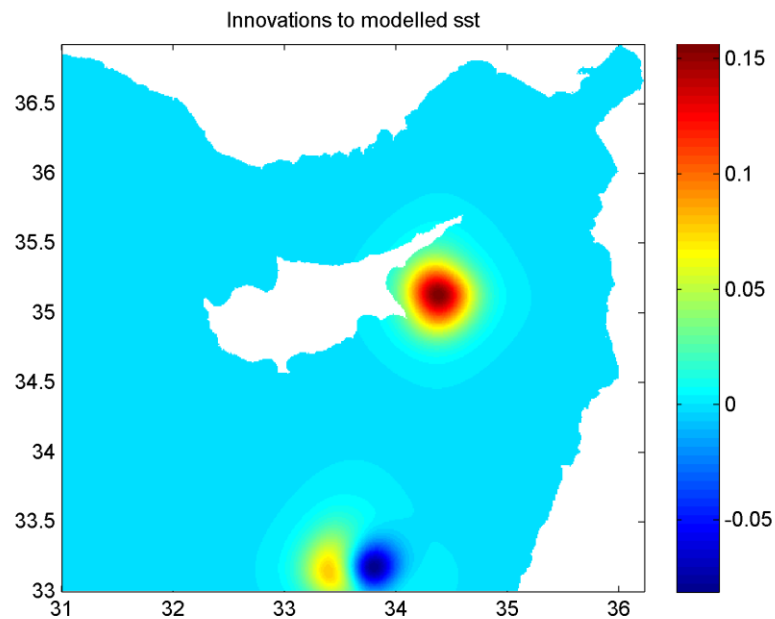
## 360m-depth salinity corrections (psu) and modelled DA differences



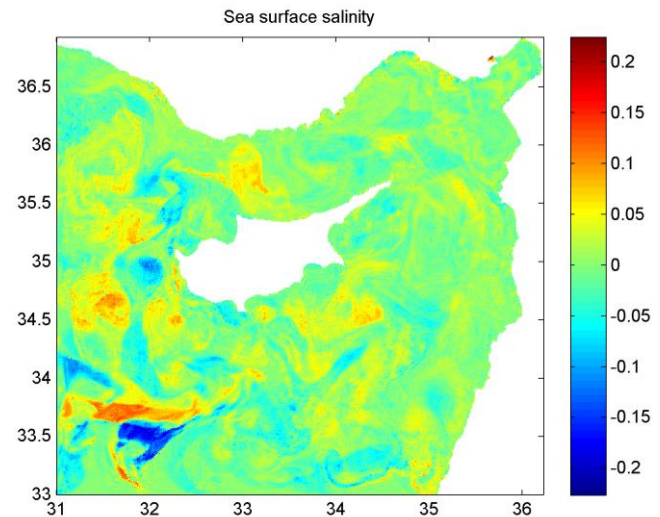
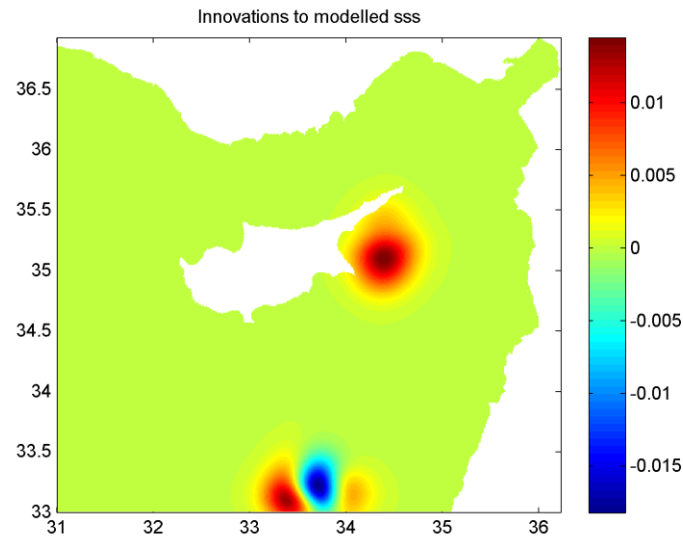
## Sea-surface height corrections (m) and modelled DA differences

End of second month of assimilation, 28.02.17

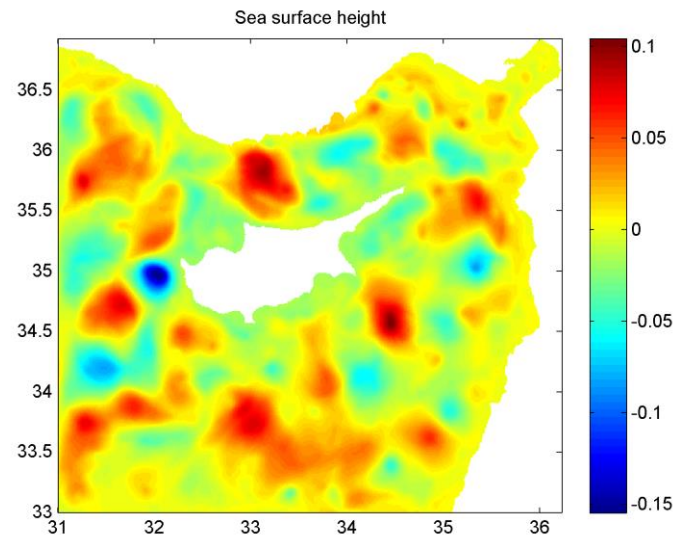
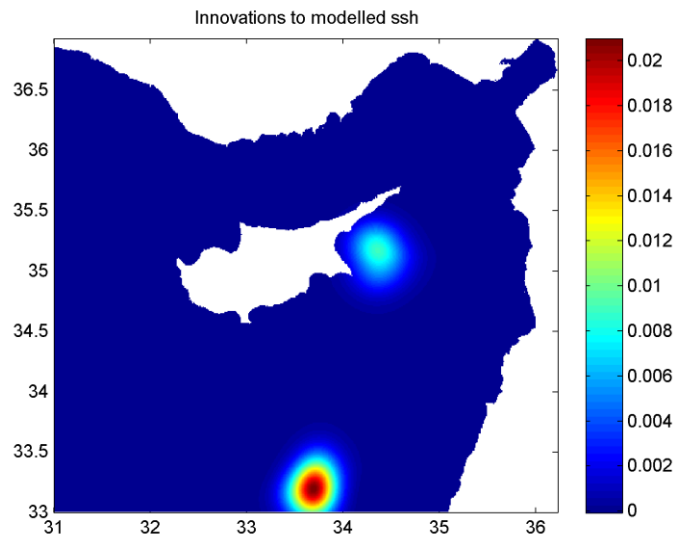
## Floats and Gliders



## End of second month of assimilation, 28.02.17



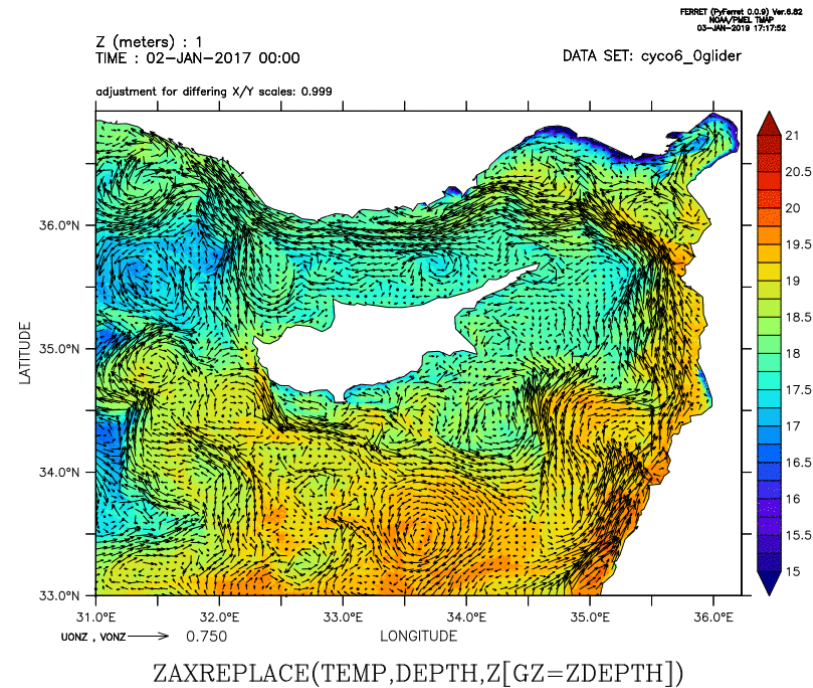
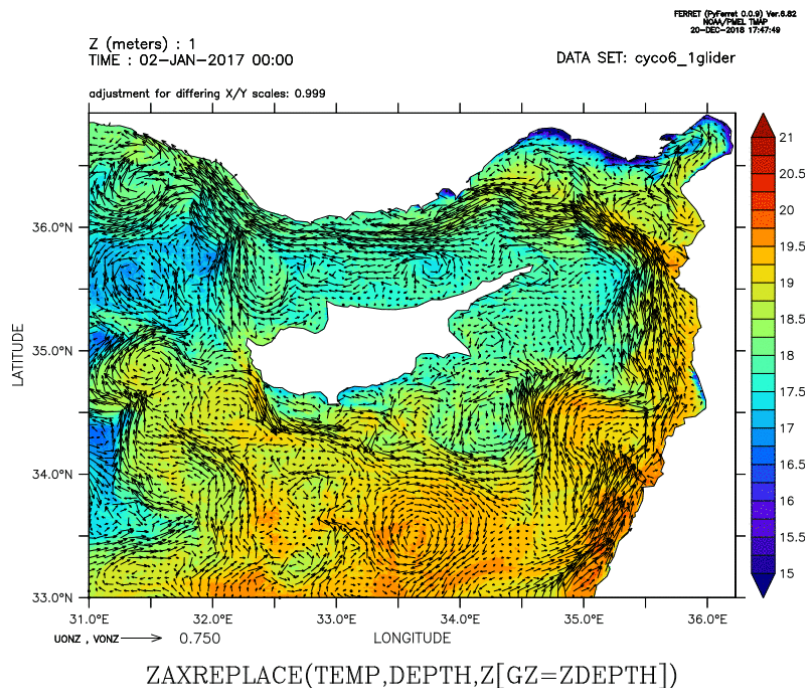
## Sea-surface salinity corrections (psu) and modelled DA differences



## Sea-surface height corrections (m) and modelled DA differences

# Total 3-month hindcast of glider and float data assimilation animations

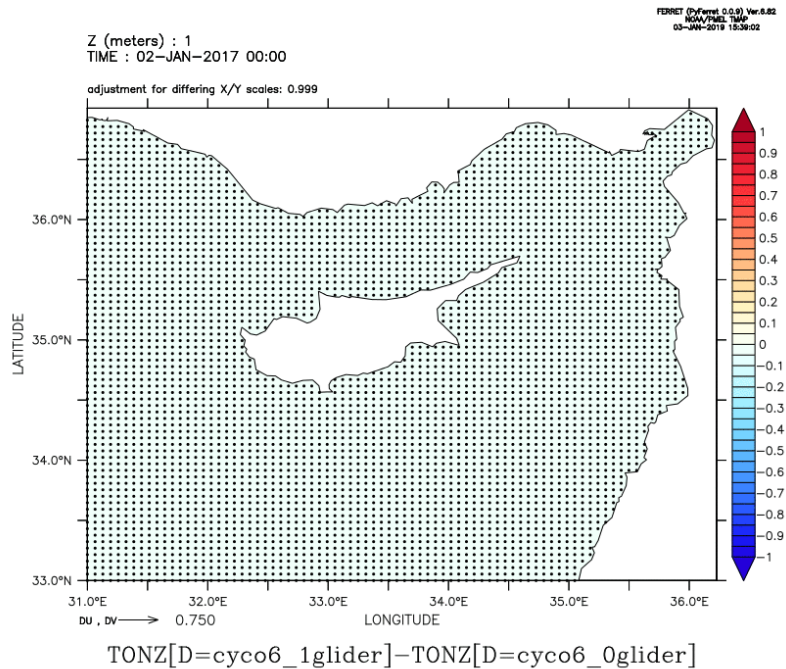
## Qualitative Comparisons: Surface Temp. and Velocity



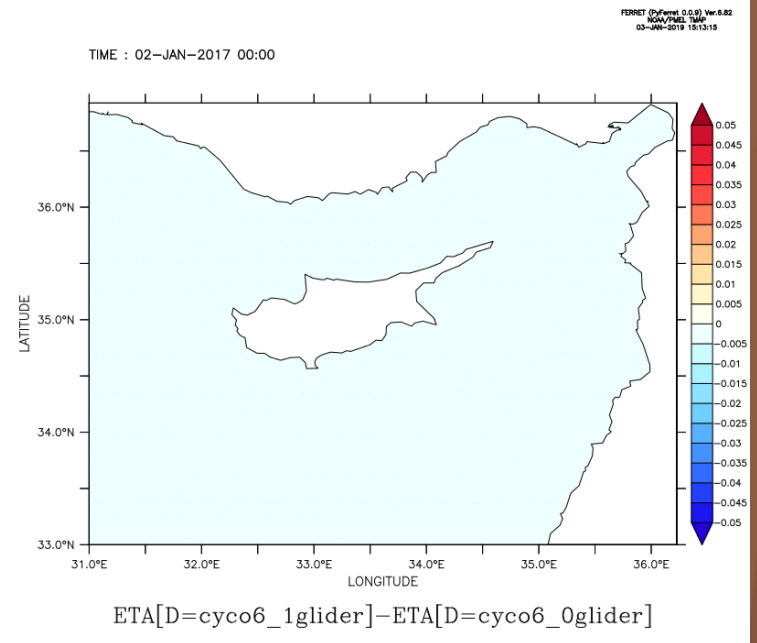
- Significant differences of data assimilation (LEFT) with control run (RIGHT).
- The Cyprus anticyclonic eddy near Eratosthenes SM is more pronounced in the DA run.



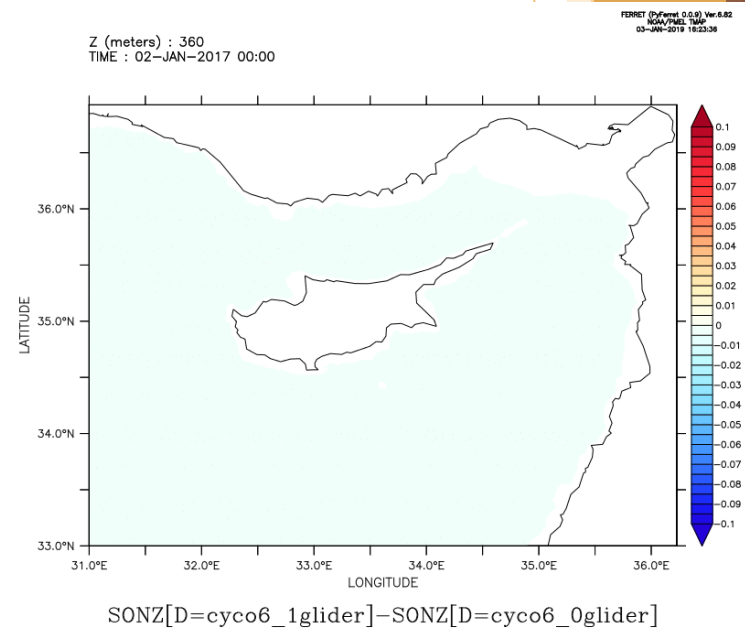
# Animated differences between runs with and without assimilation



Sea-surface temperature differences

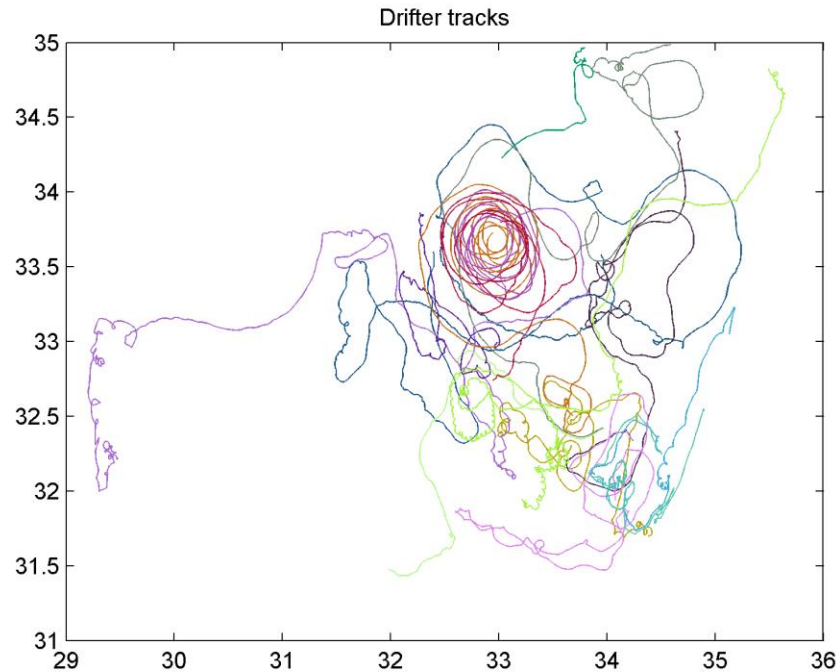


Sea-surface height differences

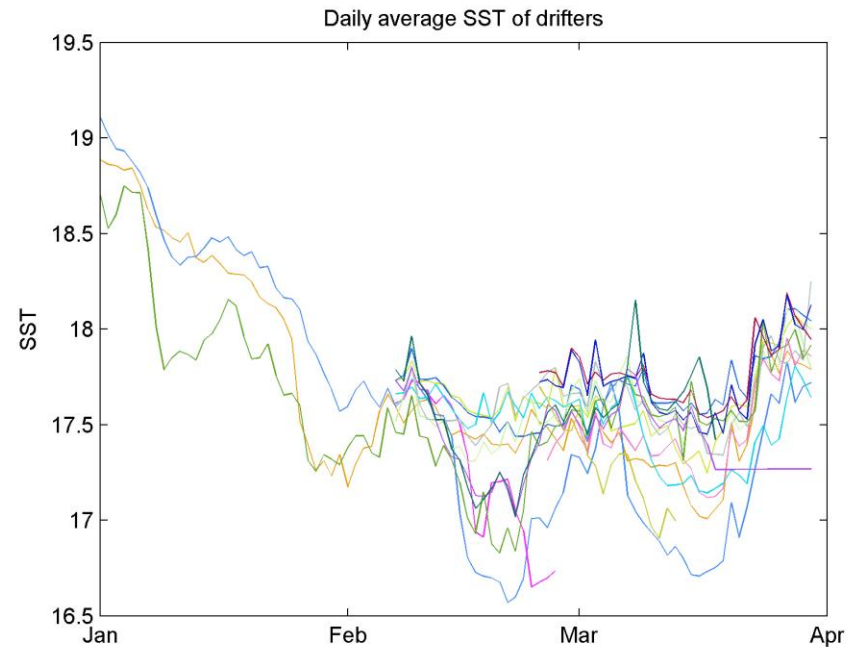


360m-depth salinity differences

# Network of surface drifter tracks in the basin



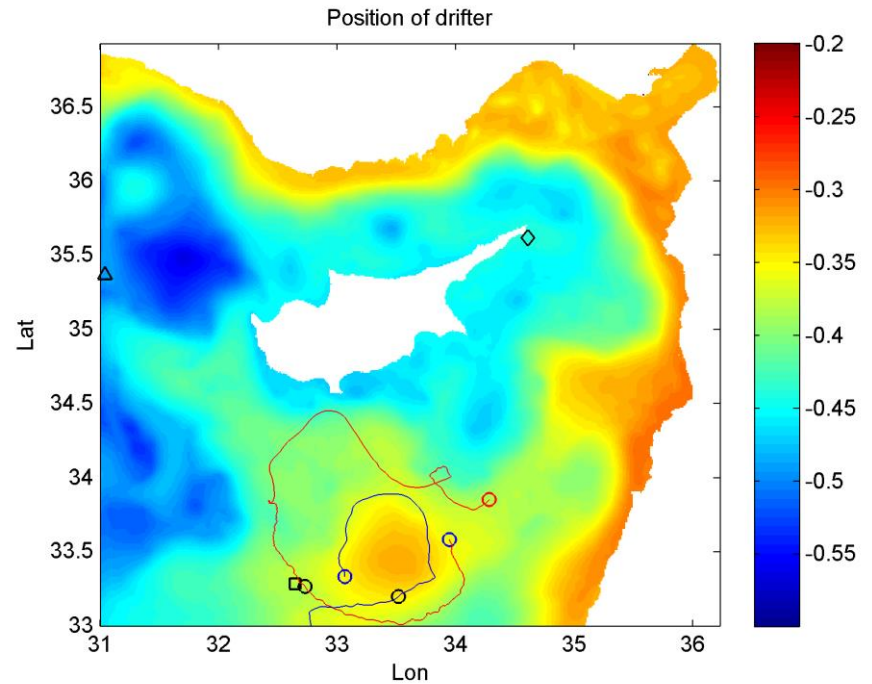
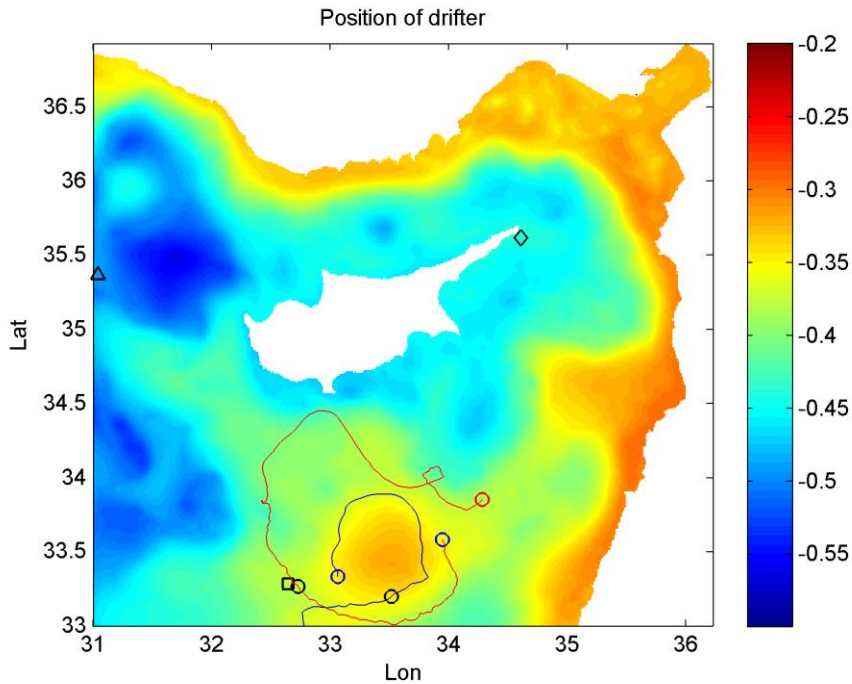
Track of all drifters in the Eastern Med for the 3-month period



Sea surface temperature recorded by the drifters (daily averages)

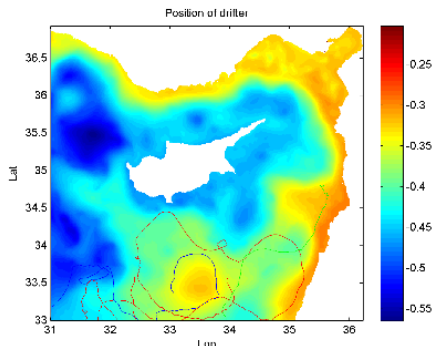


# Modelled sea surface height and drifters' tracks: 12.01.17



Assimilation run

No-assimilation run

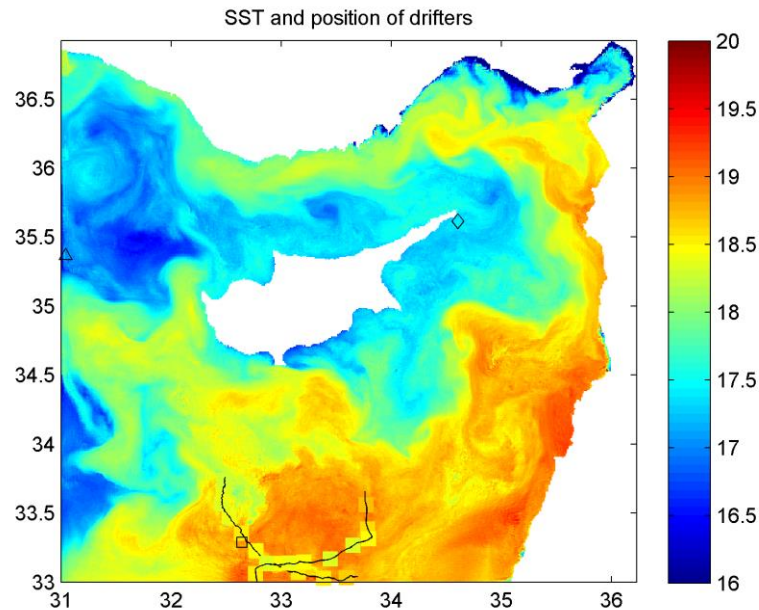


- Only 2 drifters were around in January. Drifters tracks, shown for all of January, start from the blue circle and end at the red circle, with black circle showing the current position of the drifter.
- No gliders or floats were present the day before the run, but black triangle, square and diamond show the floats' positions 2, 3 and 4 days before respectively.
- Very slight differences between the 2 runs, but DA seems to perform slightly better in the region of the Cyprus eddy.

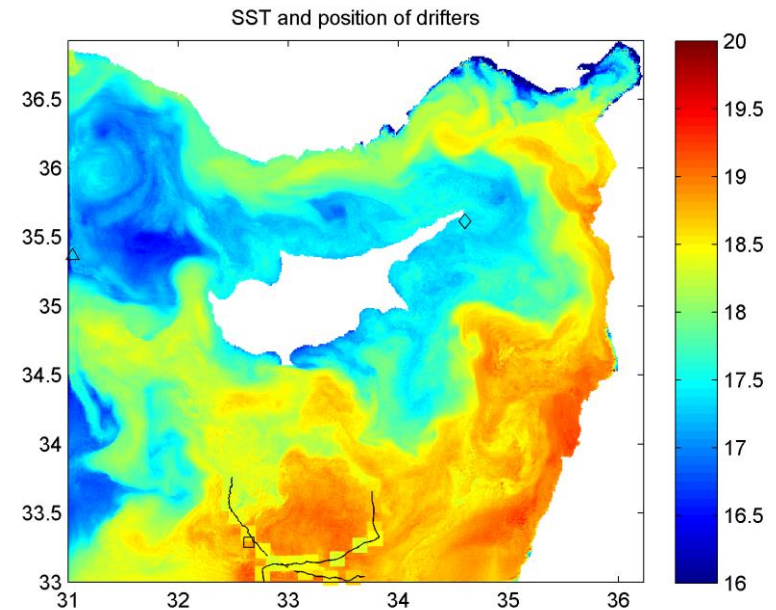
Da run, drifters for all 3 months

# Modelled sea surface temperature and drifters' temperatures

12.01.17, 12.00, 6-hour average



Assimilation run

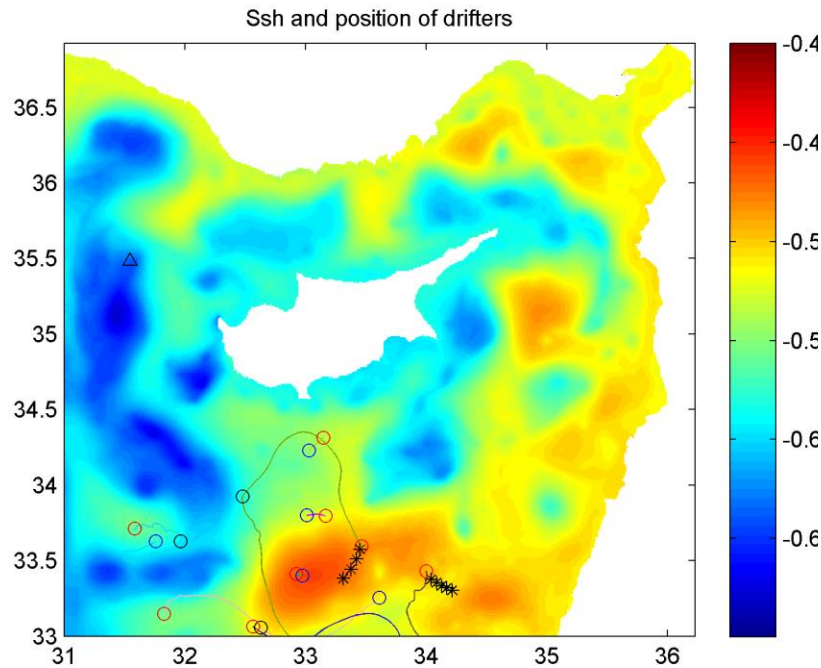


No-assimilation run

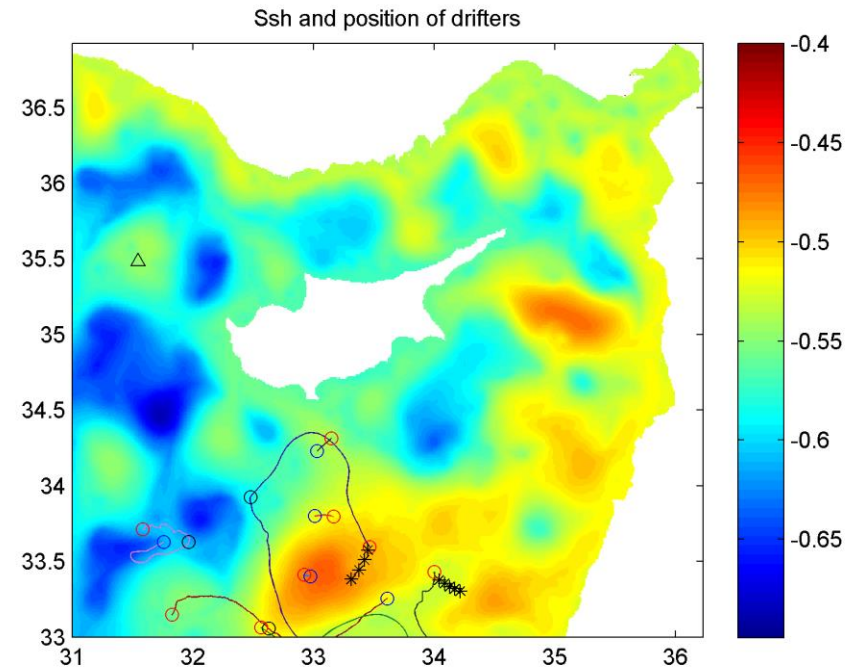
- Drifters' SSTs shown for the ten days around the date of the run (7-17/01/17), in square boxes (transparent borders) along the drifter tracks, for the same time period as the model (09.00-15.00 averages).
- Black triangle, square and diamond show floats' positions 2, 3, 4 days before, resp..
- For every drifter trajectory, the RMSE between the model's and the drifter's SSTs at the above points were calculated.
  - Average RMSE for all drifters: DA: 0.3392 Vs No DA: 0.3246
- Very similar RMSEs; could be expected as only 1 float was close to the drifters' area.

# Modelled sea surface height and drifters' tracks

20.02.17



Assimilation run



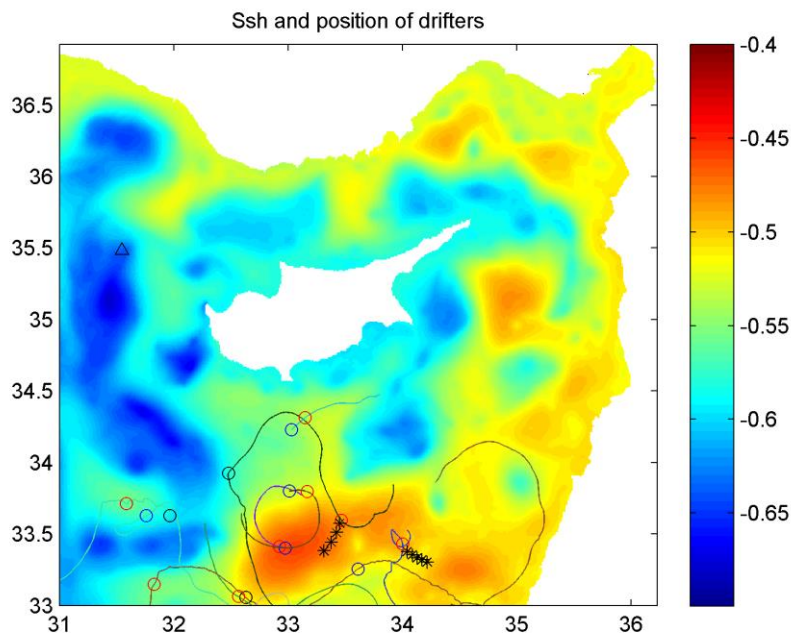
No-assimilation run

- Drifter tracks shown for the ten days around the date of the run.
- Drifters tracks start from the blue circle and end at the red circle, with black circle showing the current position of the drifter.
- Black stars show the gliders' positions the day before the run. Black triangle shows the float's position the day before the run.
  - Stronger eddy in the assimilation run

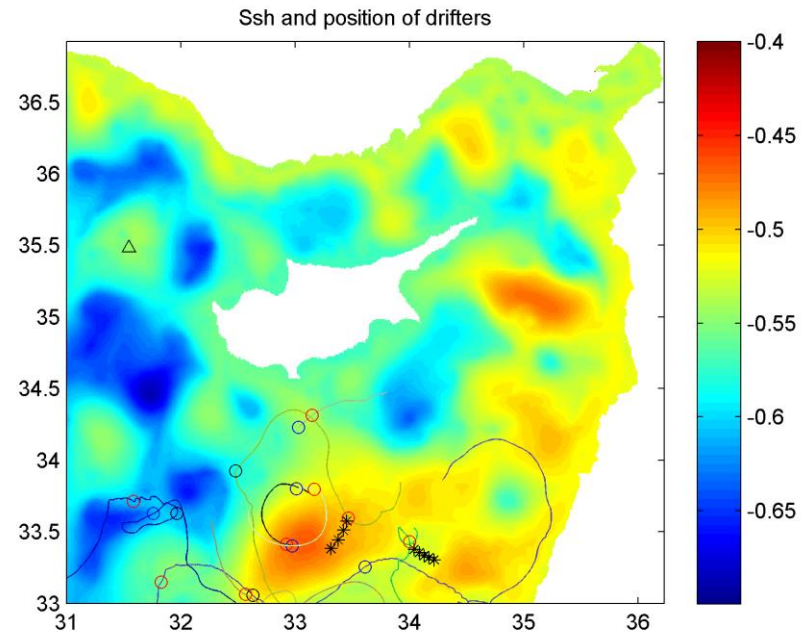


# Modelled sea surface height and drifters tracks

20.02.17



Assimilation run

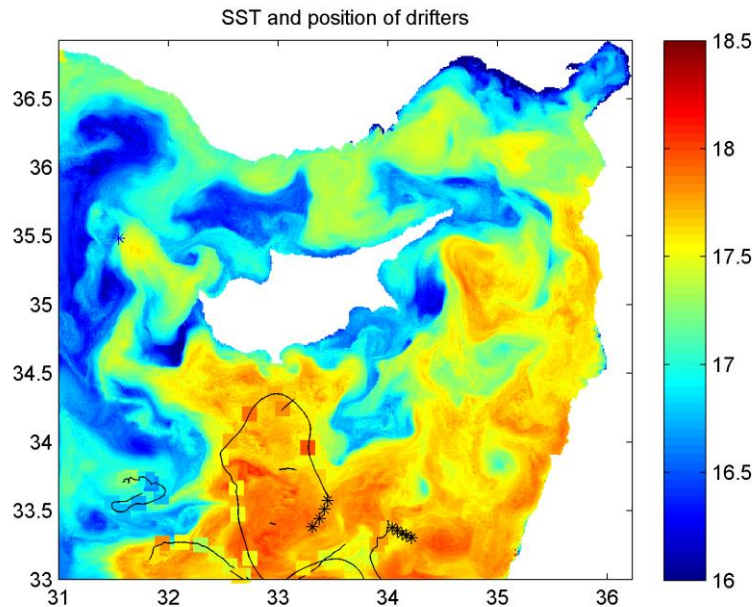


No-assimilation run

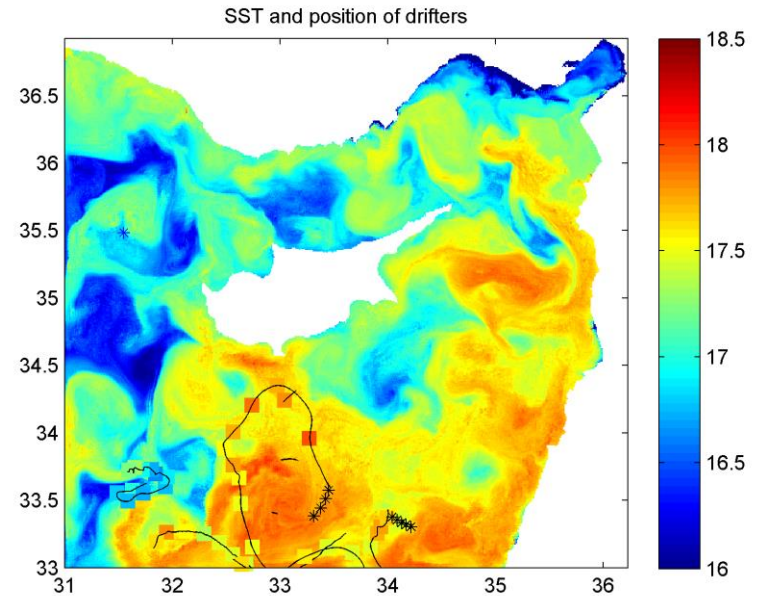
- *Drifters tracks shown for all of February.*
- Drifters tracks start from the blue circle and end at the red circle, with black circle showing the current position of the drifter.
- Black stars show the gliders' positions the day before the run. Black triangle shows the float's position the day before the run.
  - Stronger eddy in the assimilation run

# Modelled sea surface temperature and drifters' temperatures

20.02.17, 12.00, 6-hour average



Assimilation run

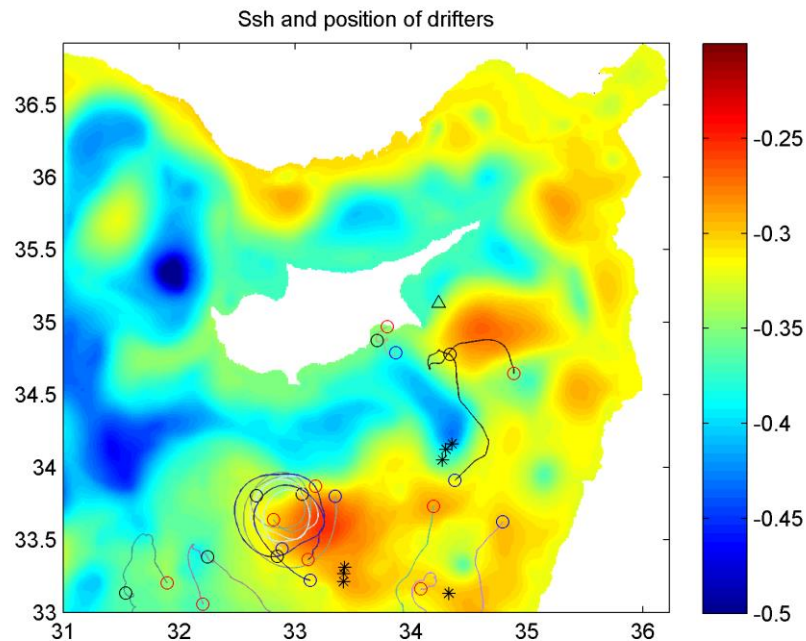


No-assimilation run

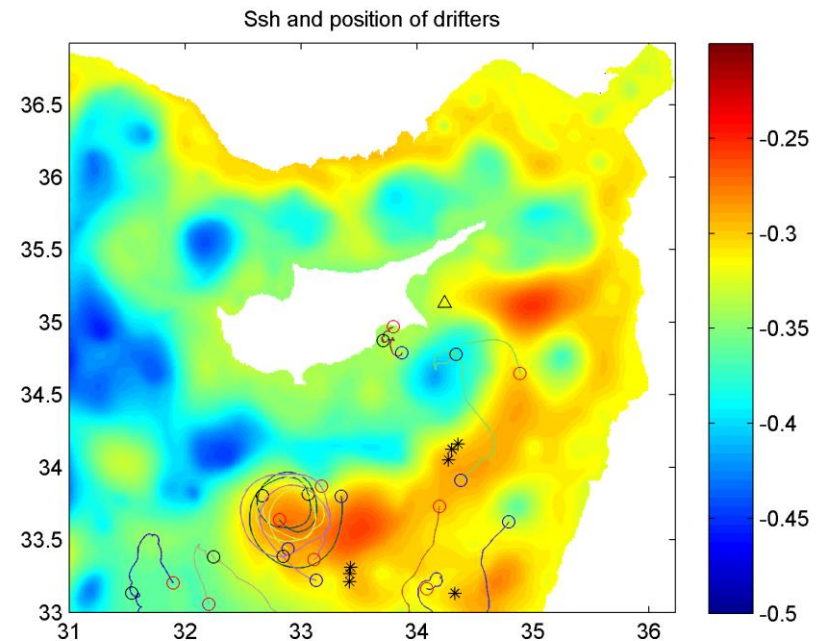
- Drifters' SSTs shown for the ten days around the date of the run, in square boxes (transparent borders) along the drifters' tracks, for the same time period as the model (09.00-15.00 averages).
- Black stars show the gliders' positions the day before the run. Blue star shows the float's position the day before the run.
  - Average RMSE for all drifters: DA: 0.2253 Vs No DA: 0.2642

# Modelled sea surface height and drifters' tracks

10.03.17



Assimilation run



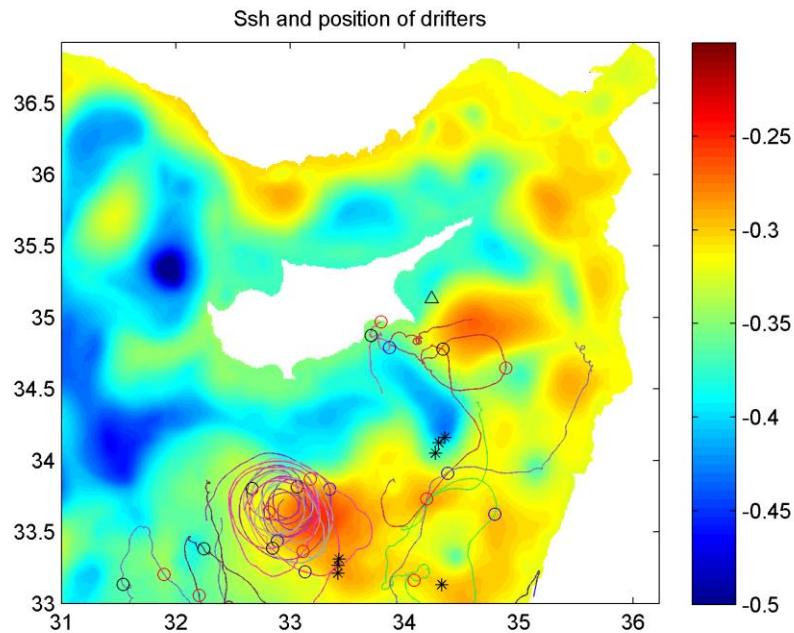
No-assimilation run

- Drifter tracks shown for the ten days around the date of the run.
- Drifters tracks start from the blue circle and end at the red circle, with black circle showing the current position of the drifter.
- Black stars show the gliders' positions the day before the run. Black triangle shows the float's position the day before the run.
- Eddy is moving to the west during the experiment. Da run seems to follow the drifters more closely.

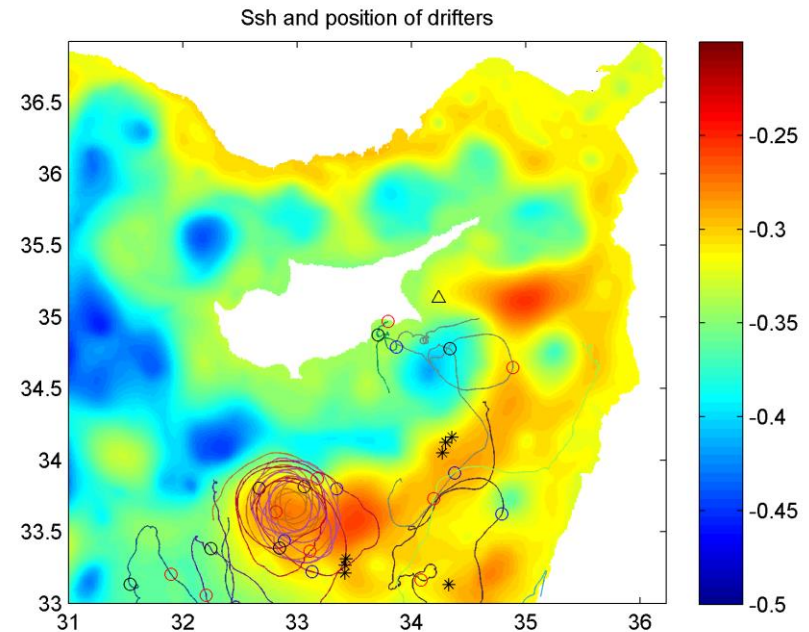


# Modelled sea surface height and drifters' tracks

10.03.17



Assimilation run

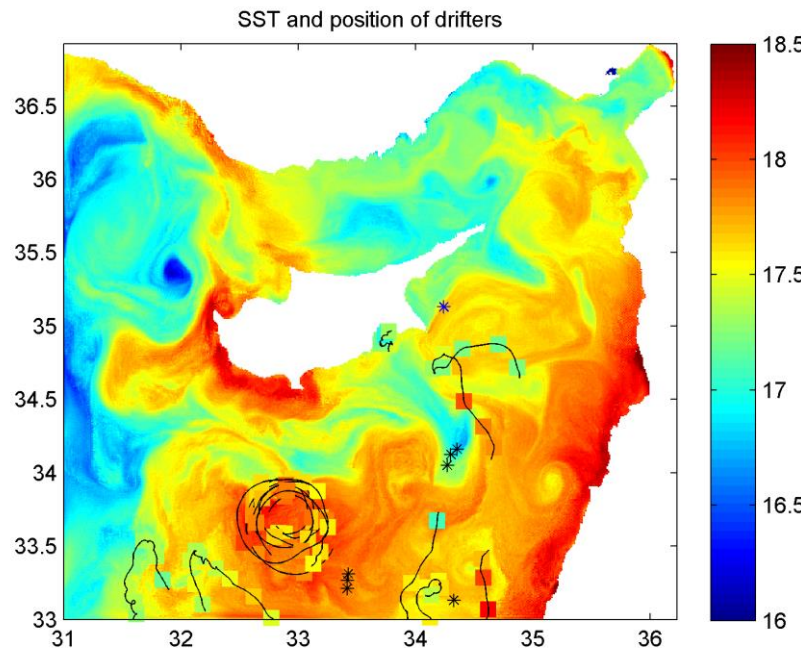


No-assimilation run

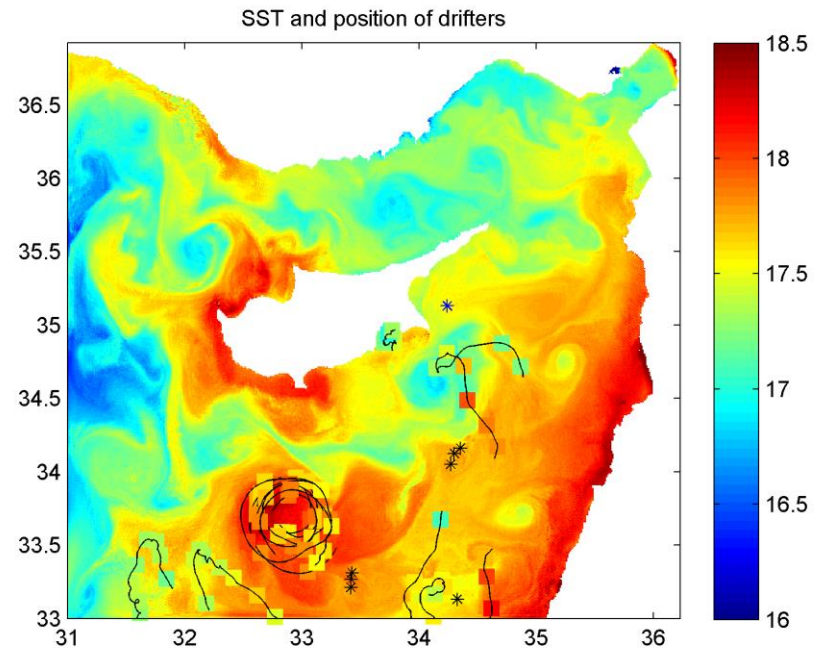
- *Drifter tracks shown for all of March.*
- Drifters tracks start from the blue circle and end at the red circle, with black circle showing the current position of the drifter.
- Black stars show the gliders' positions the day before the run. Black triangle shows the float's position the day before the run.
- Eddy is moving to the west during the experiment. Da run seems to follow the drifters more closely.

# Modelled sea surface temperature and drifters' temperatures

10.03.17, 12.00, 6-hour average



Assimilation run

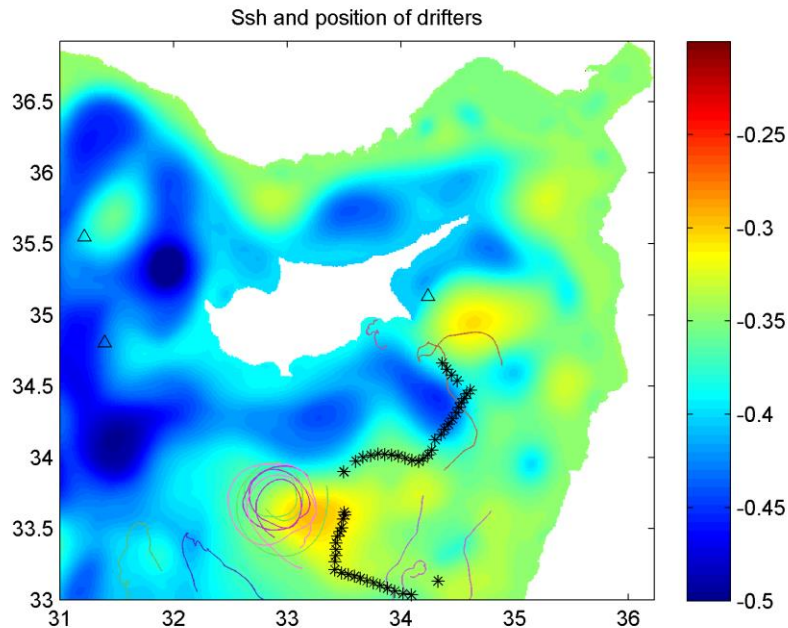


No-assimilation run

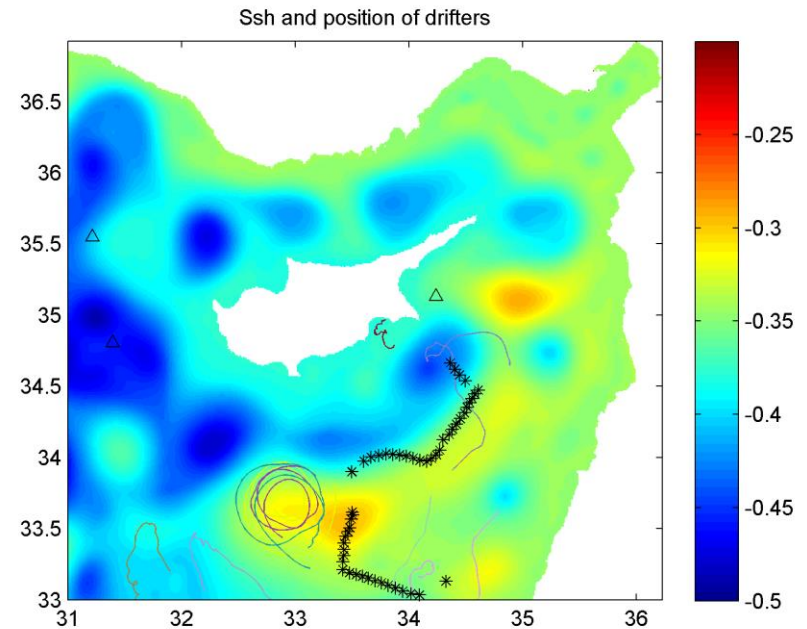
- Drifters' SSTs shown for the ten days around the date of the run, in square boxes (transparent borders) along the drifters' tracks, for the same time period as the model.
- Black stars show the gliders' positions the day before the run. Blue star shows the float's position the day before the run.
- Average RMSE for all drifters: DA: 0.2813 Vs No DA: 0.3258

# Modelled sea surface height and drifters' tracks

Average modelled SSH for the week 07-14.03.17



Assimilation run



No-assimilation run

- Drifters tracks shown for the ten days around the week of the run.
- Black stars show the gliders' positions during the week (minus 1 day). Black triangles show the floats' positions.
- *Weekly average* patterns are more uniform than the instantaneous ones, but the averaging has possibly removed some information.
- DA performs better in the region of the eddy. The eddy is moving to the west during the course of the experiment.

# Future Plans

- Hindcast at high resolution (since Argo era 2002, glider era 2009, to present).
- Expand to African coast to eliminate open boundary on the south.
- Update EOFs.
- Increase vertical resolution (often only 1 point in core of eddy).





Thanks for your attention.  
Any questions?