Assessment of Some New Developments to the Met Office Ocean Forecasting System FOAM Using Comparisons to Ocean Current Data

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Outline

* Met Office FOAM system intro
* Global models Orca025/Orca12
* North West Shelf models AMM7 / AMM15
* MDT comparing CNES-CLS13 and CNES-CLS18 (beta)
* Summary and Recommendations
FOAM INTRODUCTION
Forecast Initialisation: *Operational FOAM*

- **Global** - ¼ degree resolution
- **Mediterranean** - 1/12 degree resolution
- **Indian Ocean** - 1/12 degree resolution
- **North Atlantic** - 1/12 degree resolution
- **UK shelf** - -1.5km resolution - Physics only
- **UK shelf** - -7km resolution - Physics and Biogeochemistry
In situ measurements valid for one day on 14th Jan 2019.

- Temperature profiles (Argo, moored buoys, XBTs, CTDs, marine mammals, gliders)
- Salinity profiles (Argo, moored buoys, CTDs, gliders)
- In situ SST data (ships, moored and drifting buoys)
Satellite observations are less sparse but still do not sample all the time/space scales we’re interested in, and don’t measure the sub-surface ocean directly.

Satellite measurements valid for one day on 14th Jan 2019.
Global Forecasting Ocean Assimilation Model (FOAM) consists of:

- NEMO ocean model – 75 levels – 1 metre top level thickness
- CICE ice model
- NEMOVAR data assimilation
  - Using 3D-VAR
  - State vector - Temperature, salinity, SSH, velocities, sea ice concentration
  - Includes and SST and SSH bias correction scheme
  - First guess at appropriate time (FGAT)
  - Multivariate balance
  - Diffusion operator used to model the background error correlations
  - Incremental Analysis Update (IAU) step used to nudge the increments into the model
- Assimilates satellite and in-situ SST, altimeter SLA, in-situ temperature and salinity profiles and satellite sea ice concentration – nearly 2 million daily observations.
Velocity capabilities in FOAM

The obs oper in NEMO can compare to velocity data online – we don’t do this

Various methods for offline comparison are employed:
Visual comparisons to other products e.g. GlobCurrent, statistics against drifters, against moorings, HF radar.

NEMOVAR is capable of assimilating velocity data (and generating balanced density and SSH increments) but we don’t do so at the moment.
ORCA12
Surface velocities (m/s) in the Gulf Stream region. The velocities are all a 5 day average from 07/07/2013 to 11/07/2013

- Better resolution of main currents
- Improved North Atlantic current
- Resolving a series of eddies below the Gulf Stream
- Gulf stream separation is too far North – model or data assimilation?
Surface velocities (m/s) in the Kuroshio region. The velocities are all a 5 day average from 07/07/2013 to 11/07/2013

- Simulate the two eddies below the Kuroshio current.
- Good representation of this loop current
AMM7, AMM15
Impact of assimilating profiles and altimeter obs in AMM7

New system with assimilation of SST, SLA, and T/S profiles

Large reduction (>25%) in T/S RMS errors compared to v8 system.
Assimilation of SLA also introduces eddy-scale features to our analyses which compares well with altimeter-derived surface current estimates.

Left: Mean surface currents for January 2015 from AMM7v8 and v9 and from observation-derived current products.

Right: Depth profile of temperature (left) and salinity (right) innovation statistics from AMM7 v8 (grey) and v9 (black) averaged over full domain and 2-year period.

King et al., 2018, Ocean Modelling

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Upcoming changes: increasing model resolution

Recently upgrading the ocean model component to the 1.5km resolution AMM15

- Higher resolution, slightly smaller domain.
- Higher resolution bathymetry and coastline.
- No change in vertical resolution.

- Allows for fine detail of flow speed and variability.

- Can now begin to resolve mesoscale eddies and internal tides.

*Graham et al., 2018, GMD*
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Comparison to HF radar in the German Bight
Tidal current bias
Higher resolution SLA dataset now available from CLS/Aviso

Standard dataset provided at 1Hz resolution (~7km along-track), experimental product available at 5Hz resolution (~1.5km), but with (improved) filtering to remove more of the high-frequency noise.

In principle, resolution of new product is better matched to AMM15, but we currently use unfiltered product.

In general, we might expect RMSE to increase with higher resolution dataset.
NEW MDT
Mean Dynamic Topography testing

MDT used to convert sea level anomaly data to dynamic sea surface height for assimilation and comparison with models

Testing new CNES-CLS18 beta MDT compared to CNES-CLS13 MDT


Velocity could be a useful independent assessment.
CNES-CLS13 vs CNES-CLS18 MDT

Surface Current m/s

CLS13

CLS18

GlobCurrent

Std dev current
CNES-CLS13 vs CNES-CLS18 MDT

Surface Current m/s

CLS13

CLS18

GlobCurrent

Std dev current

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Statistical assessment model compared to drifter velocity

Would be useful but difficult to use results in practice

Main issue is uneven spatial coverage

Dec 2015 – number of obs in a 5 degree bin.

Not really sampling where we want
SUMMARY AND OUR RECOMMENDATIONS
Summary

• Ocean currents are interesting!
• ...Both to us and to our customers
• Would like to do more assessment of currents. But this is not something we do regularly preferring to assess against T+S, SST, SLA
• The existing observations are not really sufficient to do a thorough assessment as they spatially and temporally sparse.
• We are therefore very interested in any ways of improving spatial coverage including any future space based observations
Recommendations

For assessment

- Spatial coverage: uniform or focused in high variability locations
- Swath data (L2/L3) or point observations are fine
- Full depth interesting, but...
- Surface currents are useful – 1 m model top level thickness

For (potential) data assimilation

- Errors
- Timely data (<6h preferably)
CLS13 Dec 2015 current speed and u-cmpt std dev
CLS18 December current speed and u-cmpt std dev

Plots of velocity