How DBCP Data Contributes to Ocean Forecasting at the UK Met Office

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Contents

This presentation covers the following areas

- Introduction to Met Office Ocean Forecasting systems:
  - The FOAM system
  - The OSTIA system
- Deriving currents from buoy positions
- Equatorial benchmarking – comparisons with moored buoy data
- Global drifter-derived current analysis
- Conclusions
- (Future work and animations)

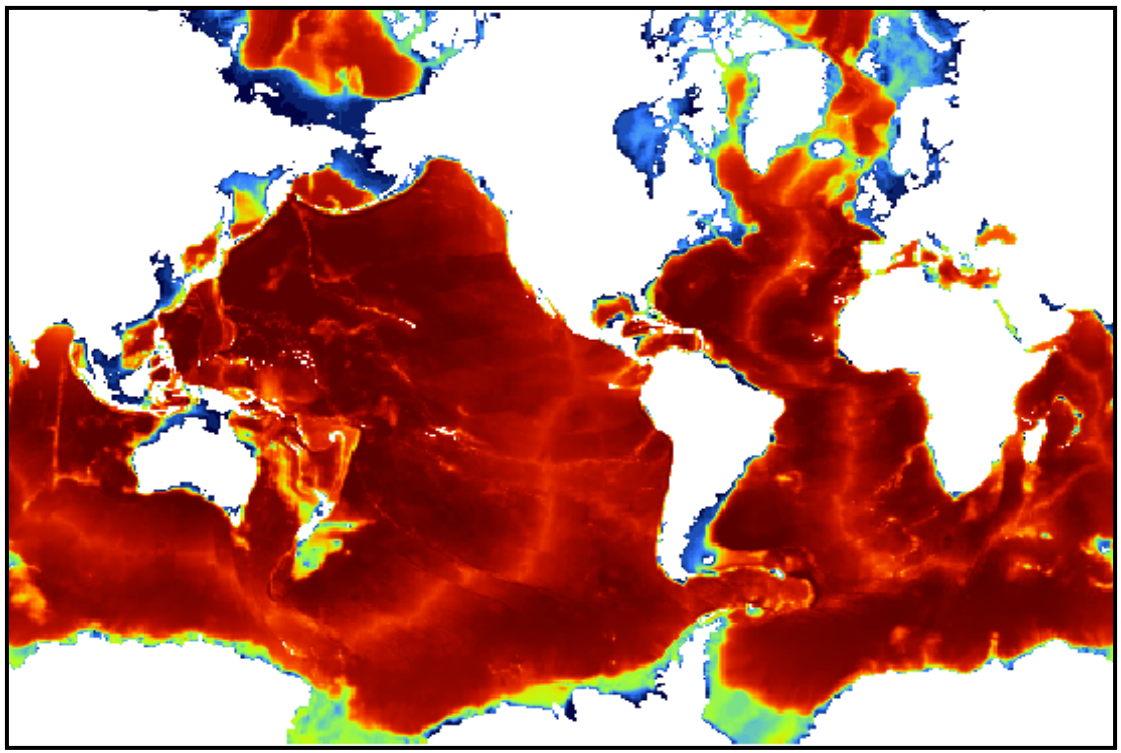
FOAM : Forecast Ocean Assimilation Model

A brief introduction

Forecasting Ocean Assimilation Model (FOAM)

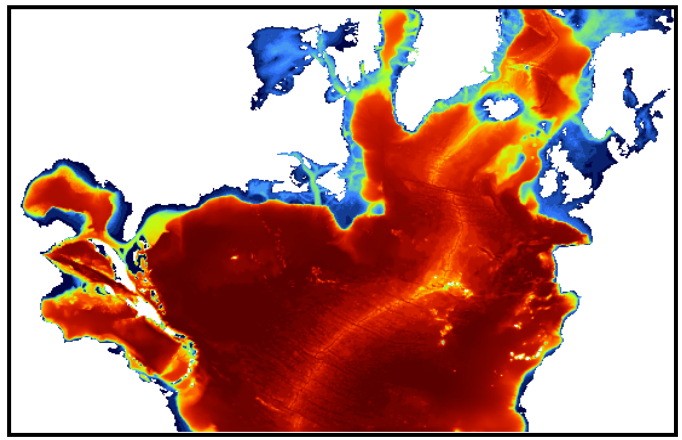
- Daily analyses and forecasts out to 6 days
- NEMO ocean model (with a linear free surface) coupled to LIM2 seaice model
- Surface forcing using 3-hourly NWP fluxes
- Assimilation of satellite and in-situ observations of temperature, salinity, SSH and seaice concentration
- Distribution of information to the UK Navy and MyOcean project
- Provides lateral boundary conditions for the UK shelf seas models as well as other external organisations.

FOAM Configurations

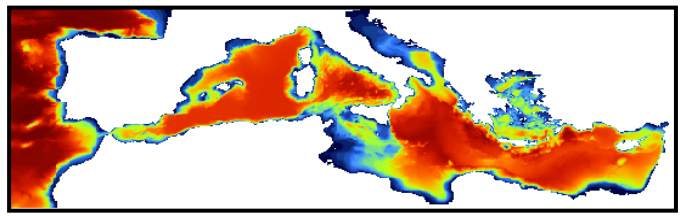


1/4˚ Global (**orca025**)

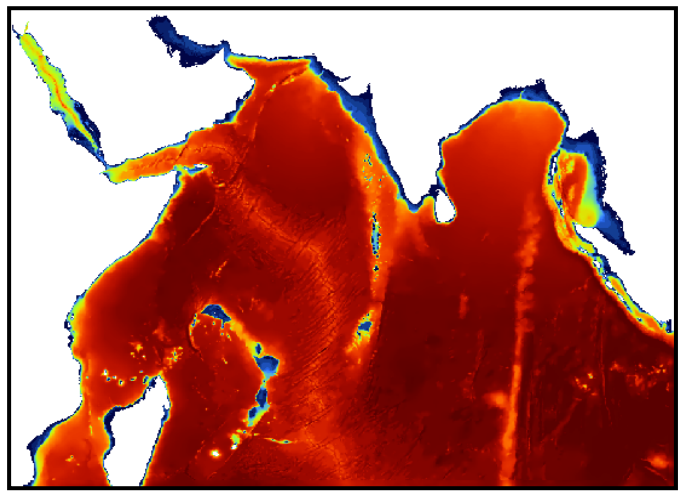
Provides lateral boundary conditions for the regional models



1/12˚ North Atlantic



1/12˚ Mediterranean



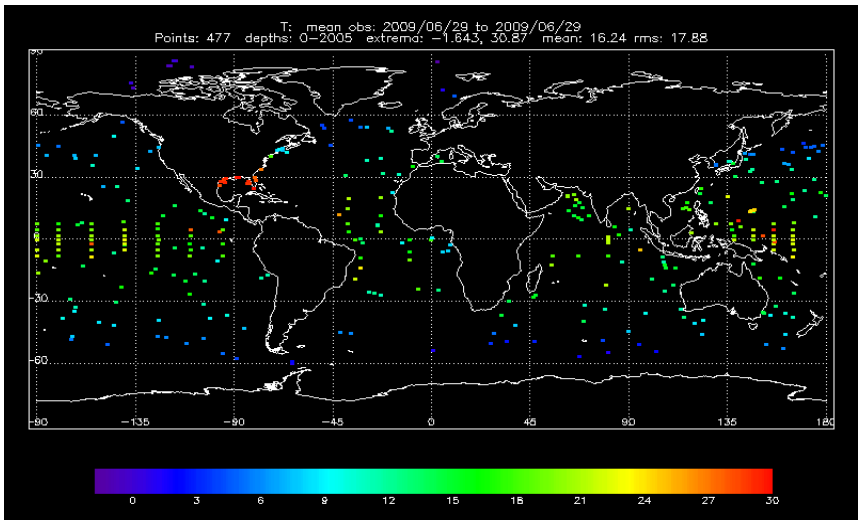
1/12˚ Indian Ocean

FOAM Data assimilation

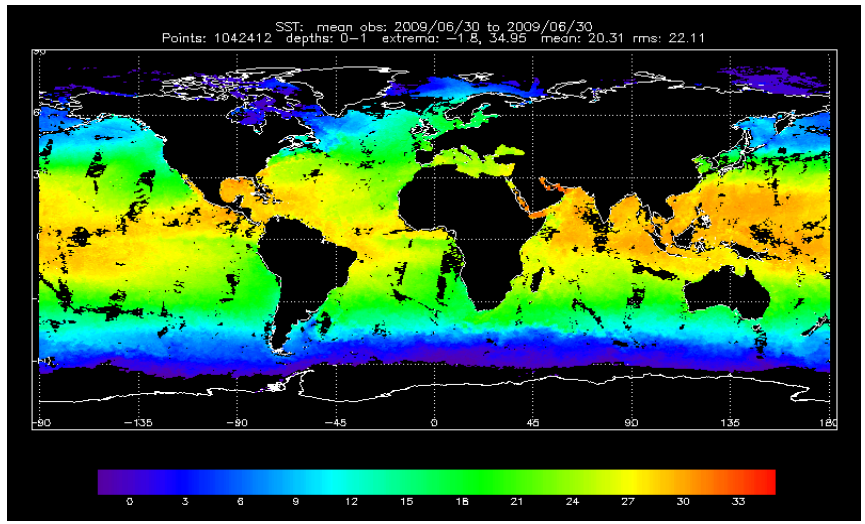
- Data is assimilated using a multi-scale Optimal Interpolation (OI) scheme
- Including a first-guess-at-approximate-time (FGAT) method for calculating model-observation differences
- Two 24-hour assimilation cycles are performed each day. This 48-hour observation window allows us to include much more data into the FOAM system
- DBCP buoys (along with other in-situ SST observations) and data from the Advanced Along-Track Scanning Radiometer (AATSR) are used as a reference to correct biases in the satellite SST data.

FOAM Data assimilation

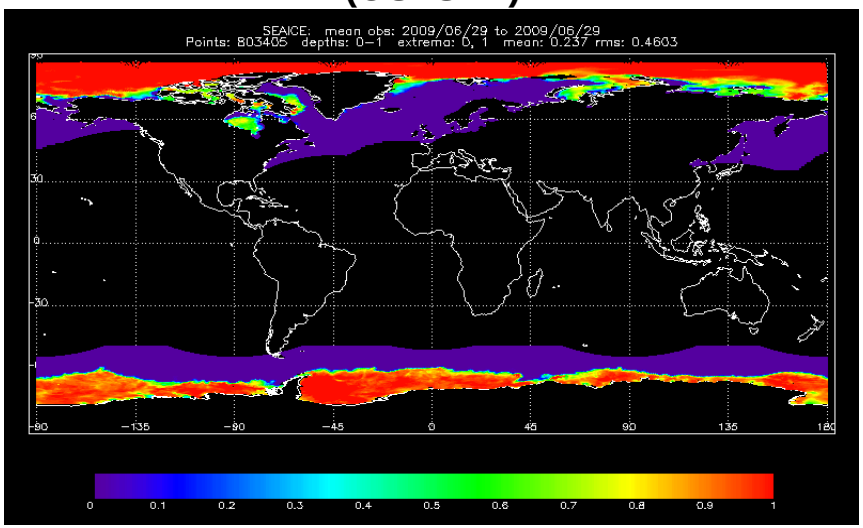
Temperature and salinity profiles
(Argo floats, XBTs, CDTs, buoys,…)



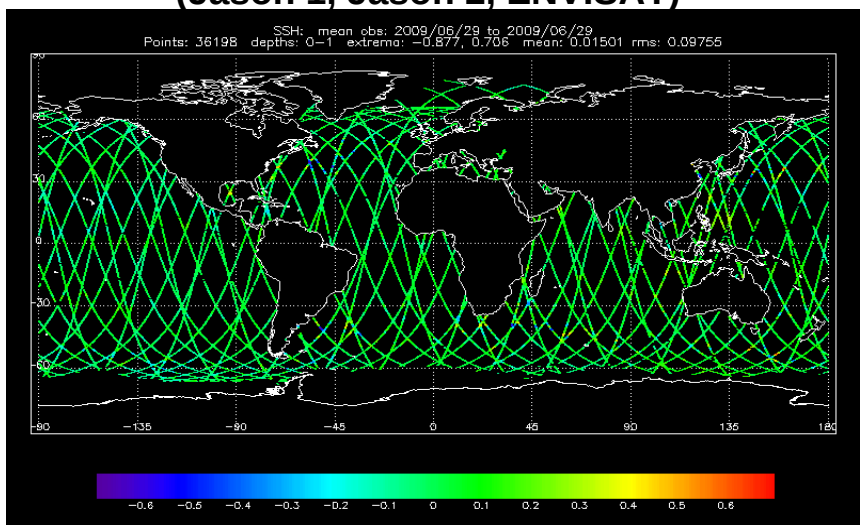
Satellite and in-situ SST
(AATSR, AVHRR, AMSRE, METOP)



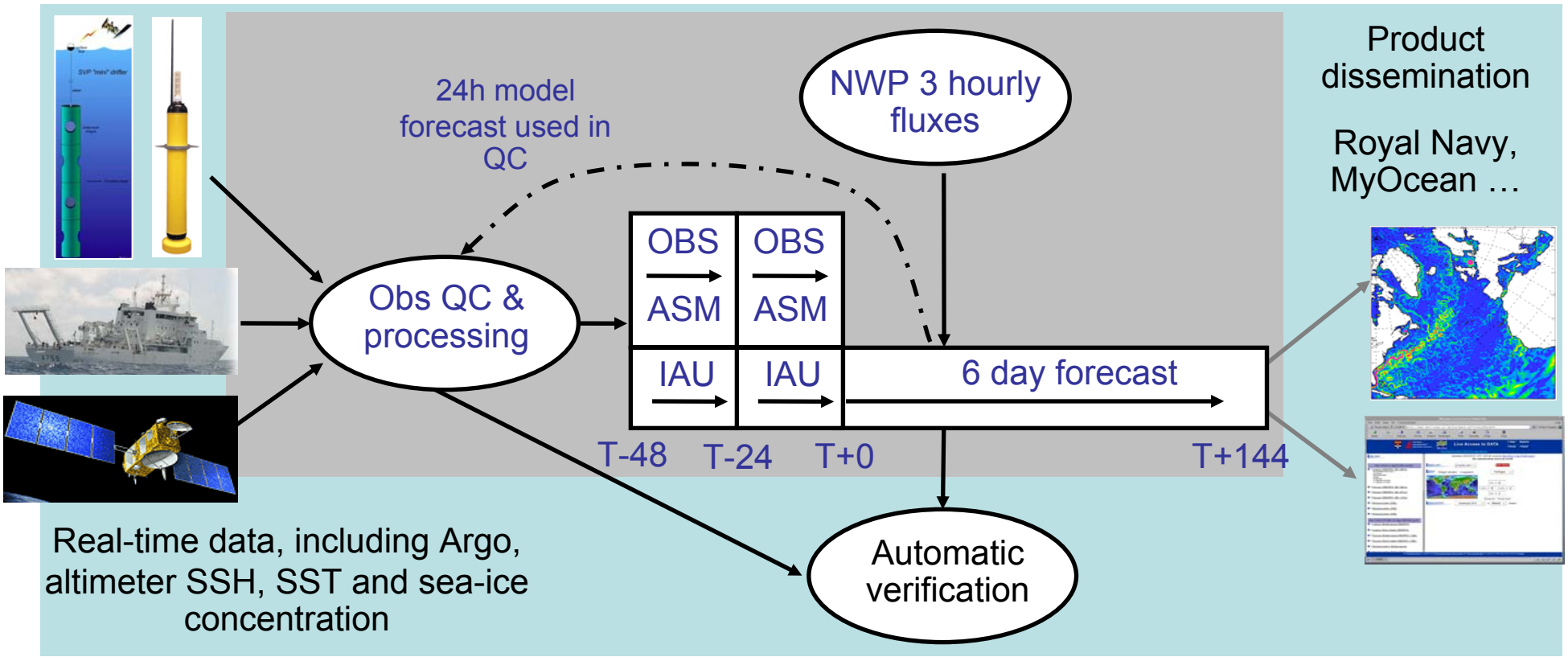
Seaice concentration
(OSI-SAF)



Satellite Altimeter SSH
(Jason 1, Jason 2, ENVISAT)



FOAM System overview



- 48-hour observation window allows us to include much more data into the FOAM system

Met Office

OSTIA : Operational Sea surface Temperature and sea-Ice concentration Analysis

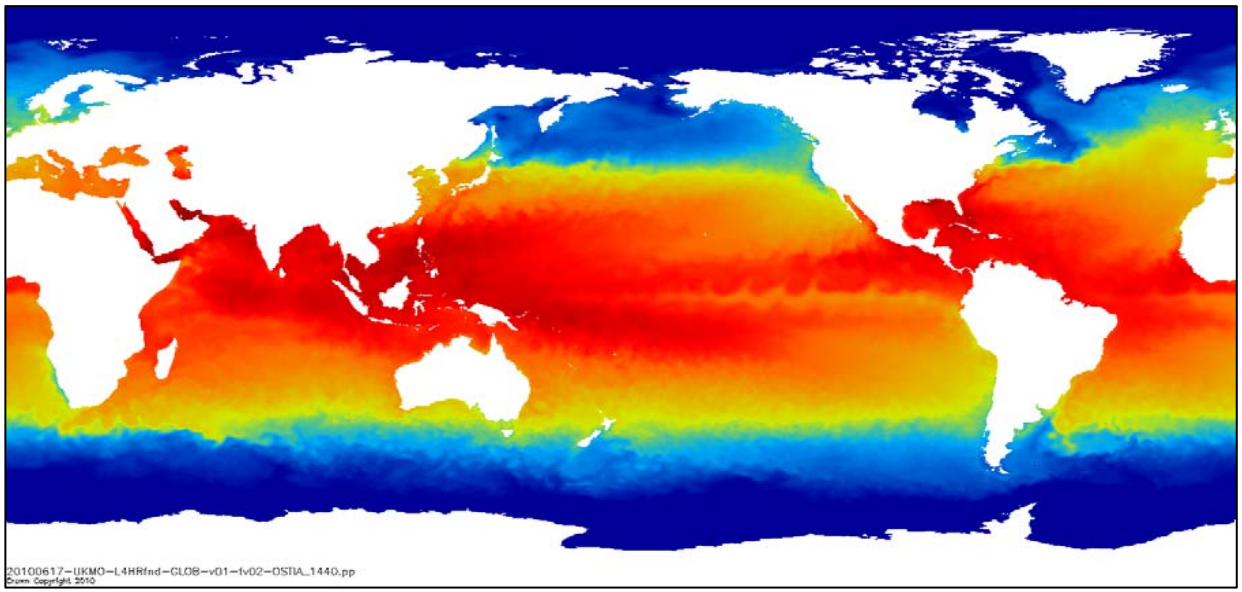
A brief introduction

Operational Sea surface Temperature and sea-Ice concentration Analysis

- OSTIA is run operationally on a daily basis at the UK Met Office
- Uses the same OI-type assimilation scheme and bias correction schemes used for SST assimilation in FOAM
- Produces daily, global SST and sea-ice concentration fields on a 1/20° grid
- The SST analysis produces an estimate of foundation SST (free of diurnal variability), using IR, MW satellite data (from GHRSST) and in-situ sources
- Used as a bottom boundary for Numerical Weather Prediction (NWP) models at the UK Met Office, ECMWF and other weather centres across the globe.

Operational Sea surface Temperature and sea-Ice concentration Analysis

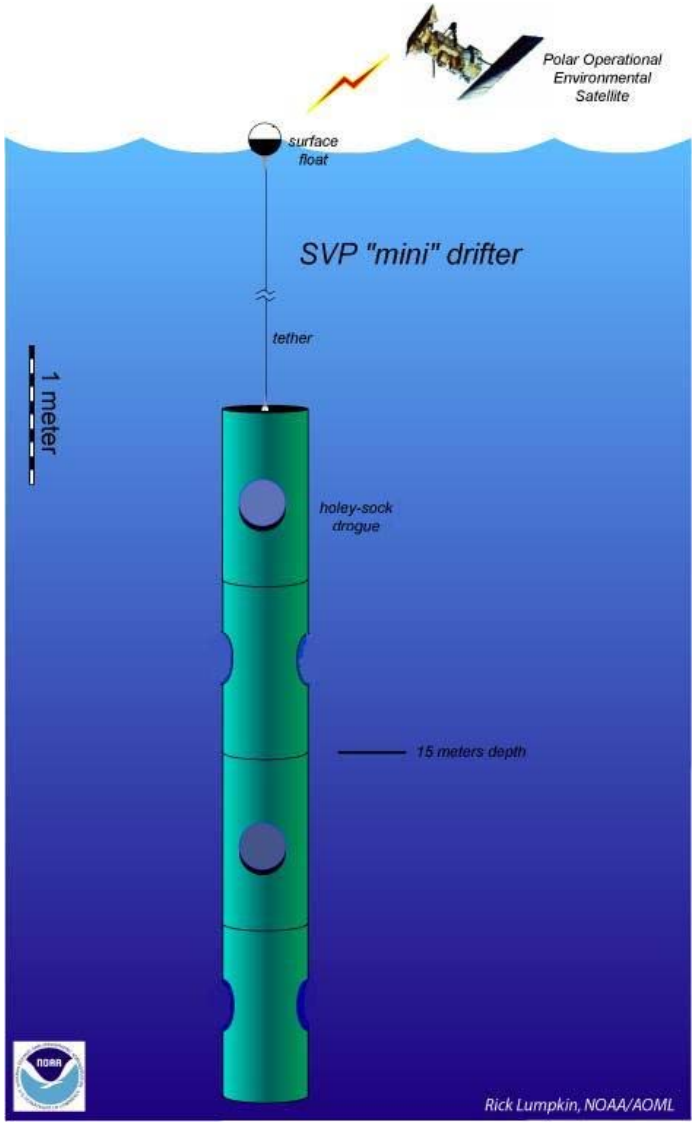
- OSTIA provides a quality control on the surface drifters – this information is sent to JCOMMOPS
- Contributes towards the Group for High Resolution SST (GHRSST)
- Data freely available through MyOcean project (www.myocean.eu.org).



Met Office

Deriving currents from buoy positions

Float details

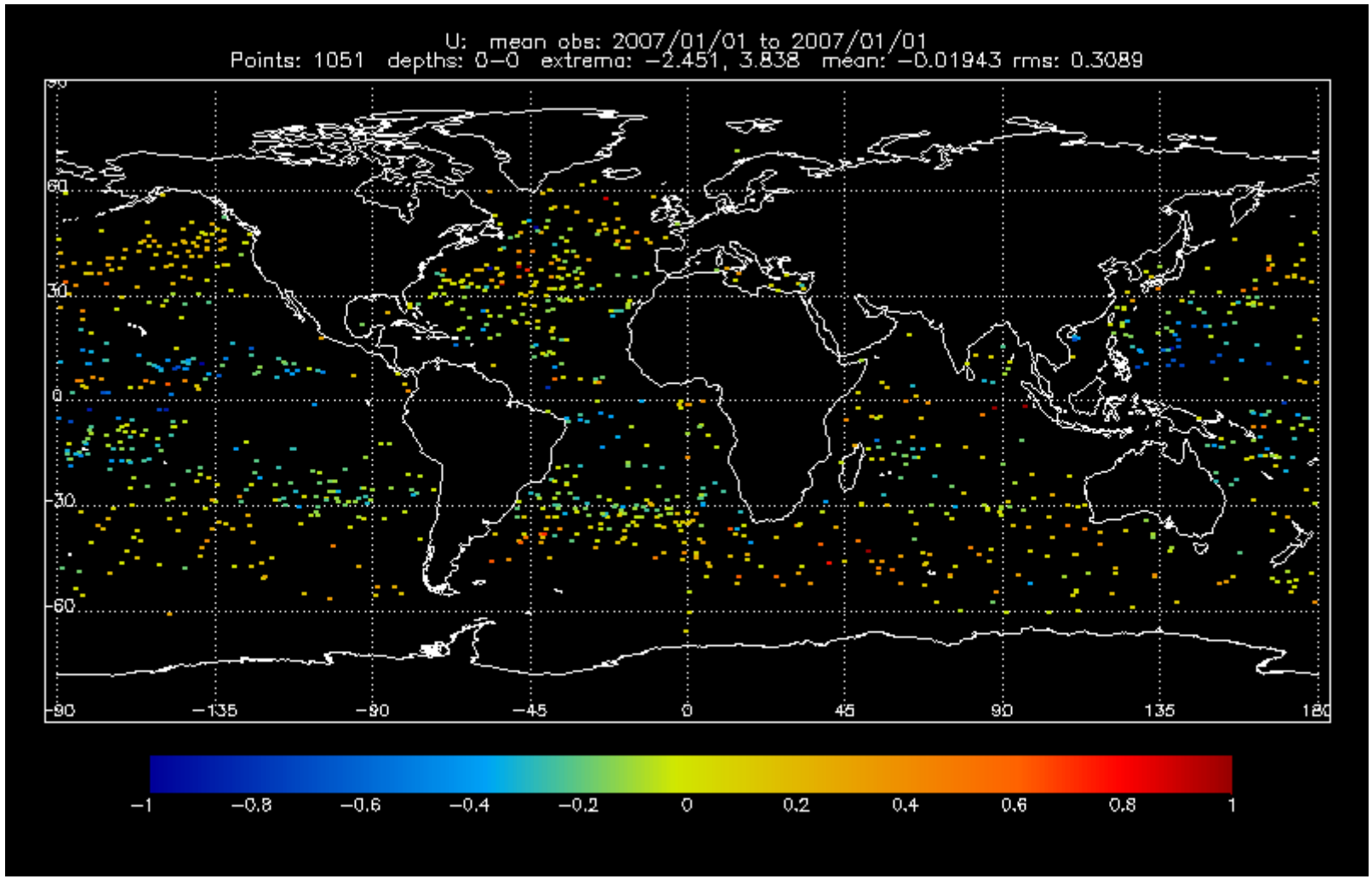


- Surface temperature sensor and transmission unit
- Hourly reports (generally) of surface temperature and position
- Heavy drogue at 15m depth to prevent wind ‘slip’ :
  - <1 cm/s in 10 m/s of wind with drogue attached.

Deriving velocity observations from drifting buoys

- Daily-mean float velocities are derived from the first and last reporting positions and times for each drifter each day
- These drifter derived currents can be compared with FOAM 15m current fields interpolated to the average latitude-longitude position of the float.
- Data is quality controlled with the following observations being removed:
  - derived velocities with magnitude greater than 3.5 m/s
  - velocities derived from 2 reports or fewer
  - reports from drifters known to have missing drogues
  - observations not passing the SST QC

Typical daily distribution of float-derived velocities



Results in equatorial regions

Comparisons with moored buoy arrays

Comparisons with equatorial mooring validation

- Before applying our drifter method to the global currents we consider the currents within 10 degrees of the equator
- We then compare this with some validation using current data from equatorial mooring arrays (TAO/TRITON, PIRATA and RAMA)
- We do this as a rough benchmarking exercise to hopefully give us some confidence in the drifter-derived current methodology
- This is done using FOAM 15m current fields from a 2-year hindcast of the 1/4º Global (orca025) FOAM for the period 2007-08

Comparison with equatorial mooring validation

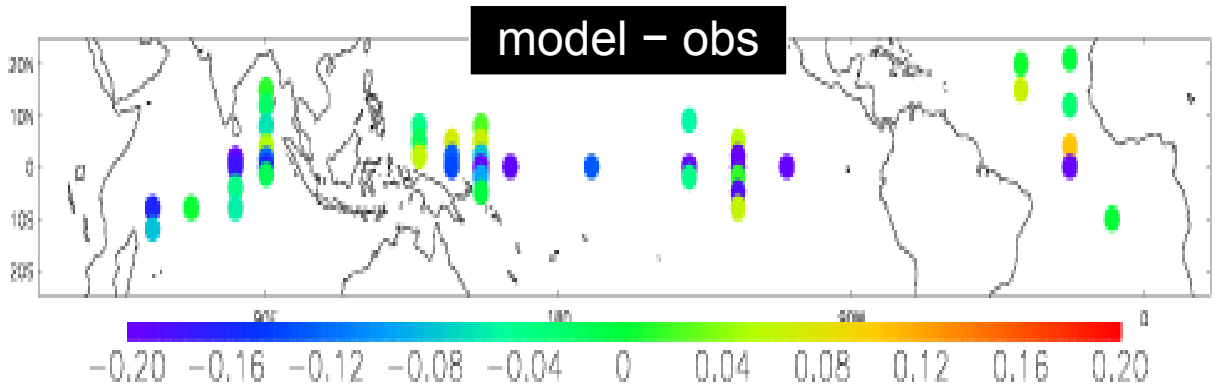
- RMS errors and correlations compare favourably between the two assessments

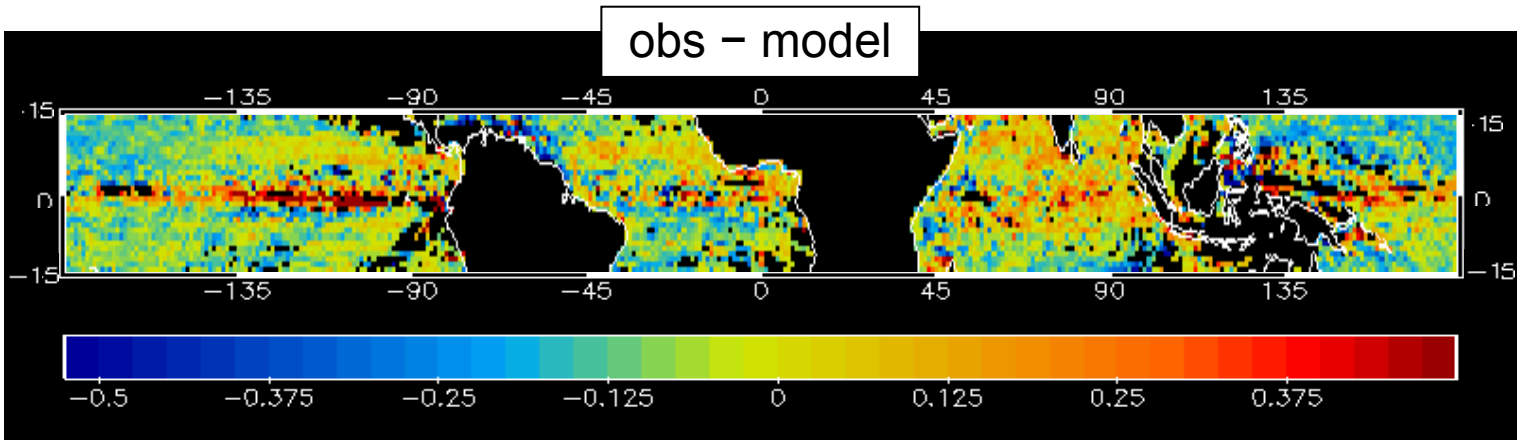
ZONAL	RMS Error	Correlation	No. Obs
Equatorial Buoys	0.248	0.768	16,627
Drifters	0.242	0.734	92,796

- Additionally both assessments show a westerly (i.e. too strong) bias, particularly in the Tropical Pacific (see next slide)….

Comparison with equatorial mooring validation

- Currents too strong at the equator





Met Office

Global drifter-derived current analysis

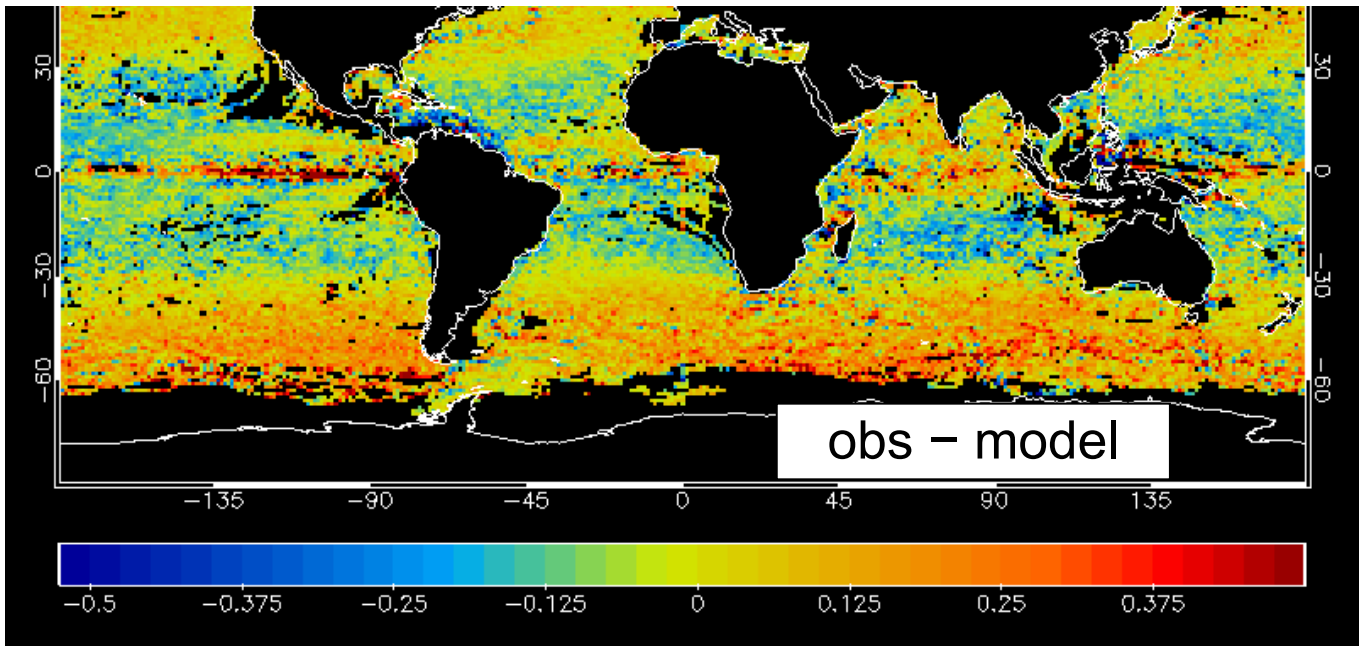
Global drifter-derived current analysis: 1/4º Global FOAM statistics

- Currents were derived from drifter locations for the whole global model for all of 2007 and 2008 giving over 774,000 current observations
- Correlations are significantly worse than for the equatorial analysis
- In particular the Southern Ocean seems to be worse than other areas.

ZONAL	RMS Error	Mean Error	Correlation	Obs. / day
Global	0.215	-0.003	0.537	1059
Tropical Pacific	0.210	-0.065	0.708	159
Southern Ocean	0.242	0.078	0.297	240

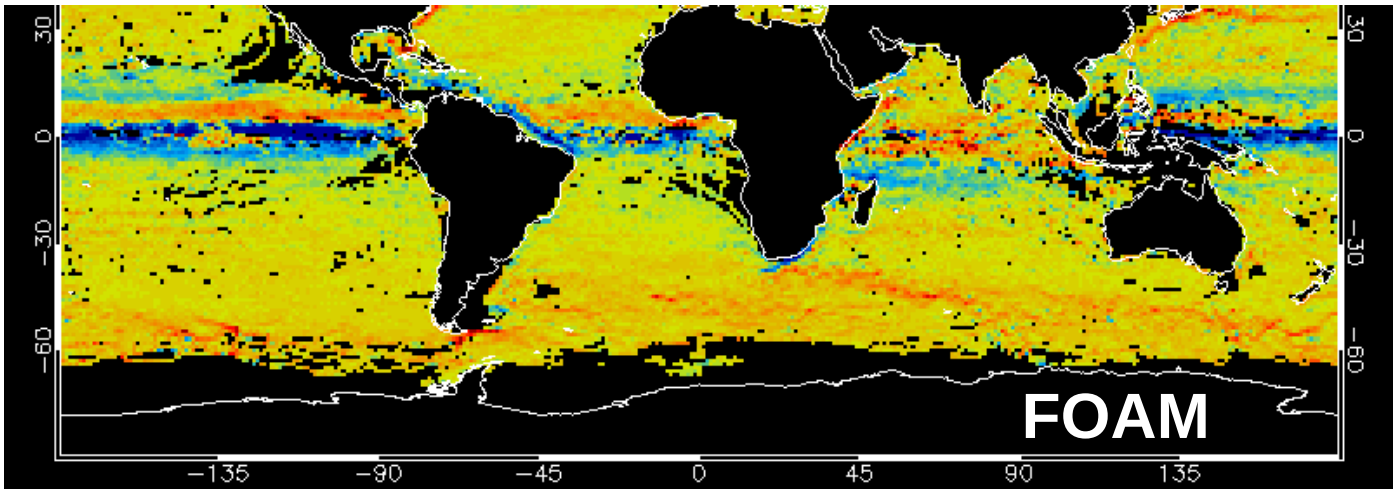
Southern Ocean currents

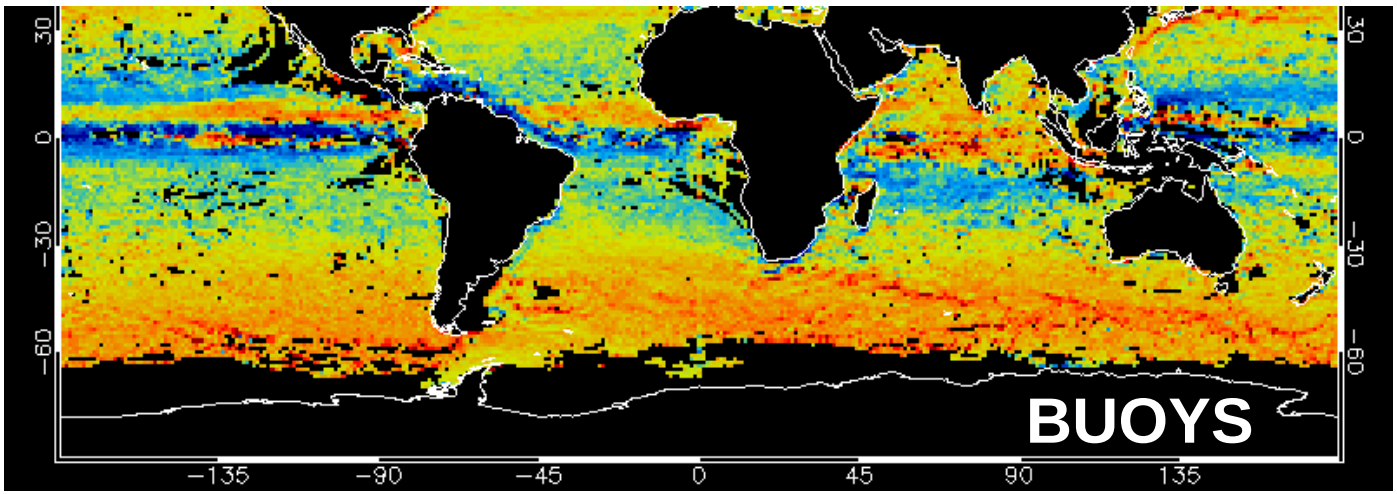
- Strong positive mean error suggests FOAM currents in the Southern Ocean are too westerly (i.e. the ACC is too weak)



- However this is contrast to our analysis of the volume transport through the Drake Passage (which at 173 Sv. is well above the estimated ACC value of 130 Sv.)

Southern Ocean currents





- The FOAM currents look more realistic with an ACC around 0.25 m/s
- Meanwhile the drifter observations (below) are nearer to 0.5 m/s

Suggested reasons for a Southern Ocean bias in the drifter currents dataset

1. Wind slip
    - perhaps more than a linear dependence of wind speed past 10-15m/s wind (i.e. slip greater then 1 cm/s per 10 m/s wind)
    - surface winds in the Southern Ocean often gust to over 20-25 m/s
2. Stoke's Drift
    - nonlinearly proportional to the significant wave height and wave period
    - with such windy conditions around the ACC the surface waves are fairly large and plentiful
3. Representation issues (both horizontal & vertical)
    - horizontal representation problems arise from the way the observations are derived and the discretisation of the model
    - with a linear free surface model and no surface waves the drogue may not coincide with the model 15m depth level

General Conclusions

General Conclusions / Summary

- In equatorial regions comparisons between FOAM and the drifter-derived observations look similar to comparisons with equatorial moored buoys
- This gives us confidence in the drifter-derived currents
- In general the equatorial analysis looks good for FOAM zonal currents
- Although there appears to be westerly bias in FOAM - probably caused by the winds (in both the drifter and moored buoy analysis)
- Things are not so good in other areas however. In particular in the Southern Ocean where the drifter-derived currents seem to be far too strong.

Future work and ideas

Future Work : Current Validation

- Seeding numerical drifters in the NEMO model at exact float times/locations
  - These can then be compared with true float positions when next they report.
- Site-specific current validation and forecasts

Met Office

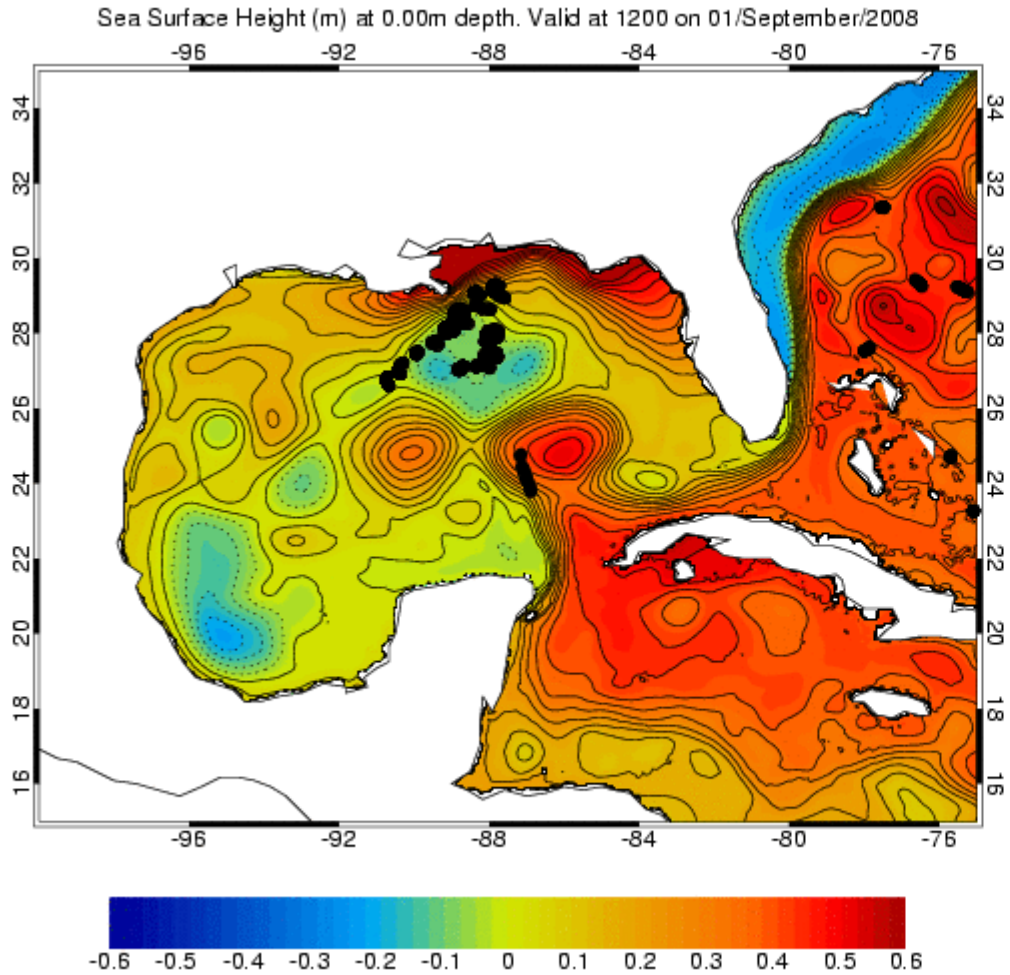
Questions and answers

Animations

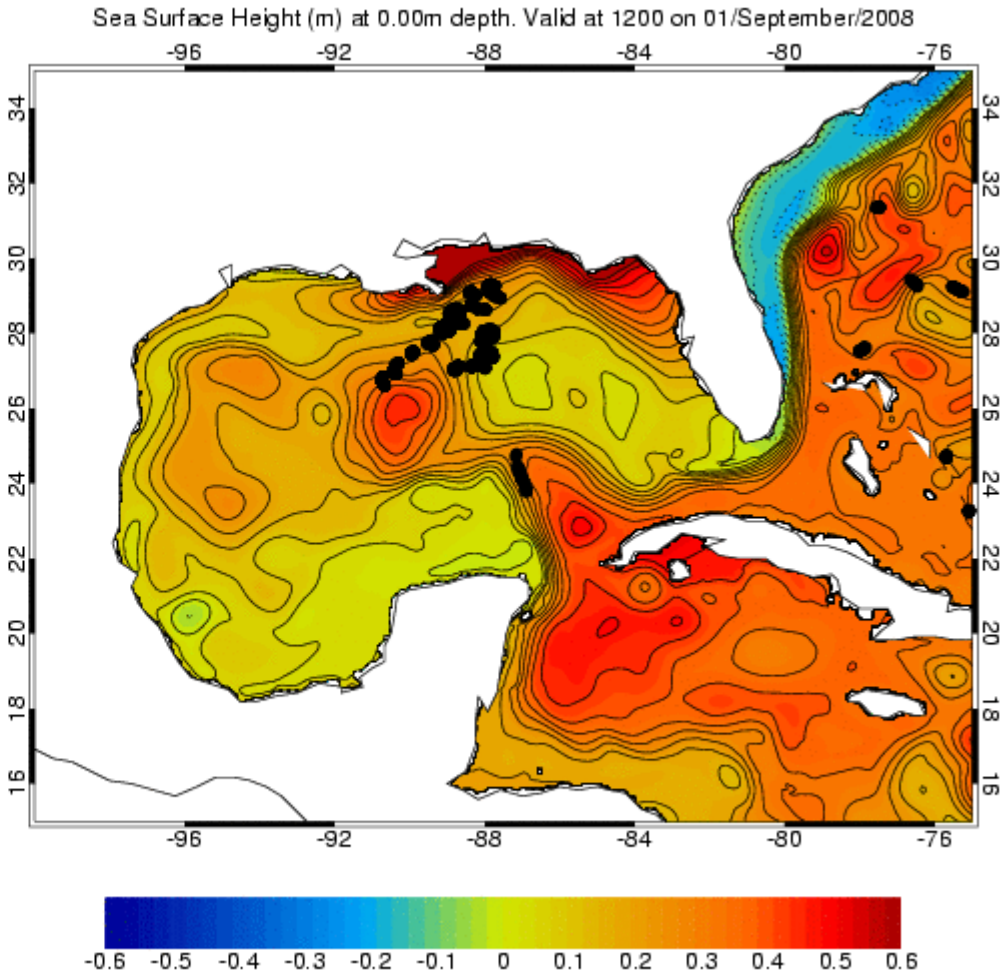
Impact of data assimilation

FOAM SSH contours with drifters overlaid

1/4º FOAM



1/4º NEMO



Extra slides

Global drifter-derived current analysis: 1/4º Global FOAM statistics

ZONAL	RMS Error	Mean Error	Correlation	Obs. / day
Global	0.215	-0.003	0.537	1059
Tropical Pacific	0.210	-0.065	0.708	159
Southern Ocean	0.242	0.078	0.297	240

MERIDIONAL	RMS Error	Mean Error	Correlation	Obs. / day
Global	0.195	0.002	0.375	1059
Tropical Pacific	0.169	-0.002	0.497	159
Southern Ocean	0.218	-0.002	0.235	240

- Currents were derived from drifter locations for the whole of 2007 and 2008 giving over 774,000 current observations.