Use of Argo observations in Met Office forecast systems and climate research

Matt Palmer

Euro-Argo Workshop, Trieste, June 2009

Contents

This presentation covers the following areas

- Short-range ocean forecasting
- Seasonal forecasting
- Decadal climate forecasts
- Climate research

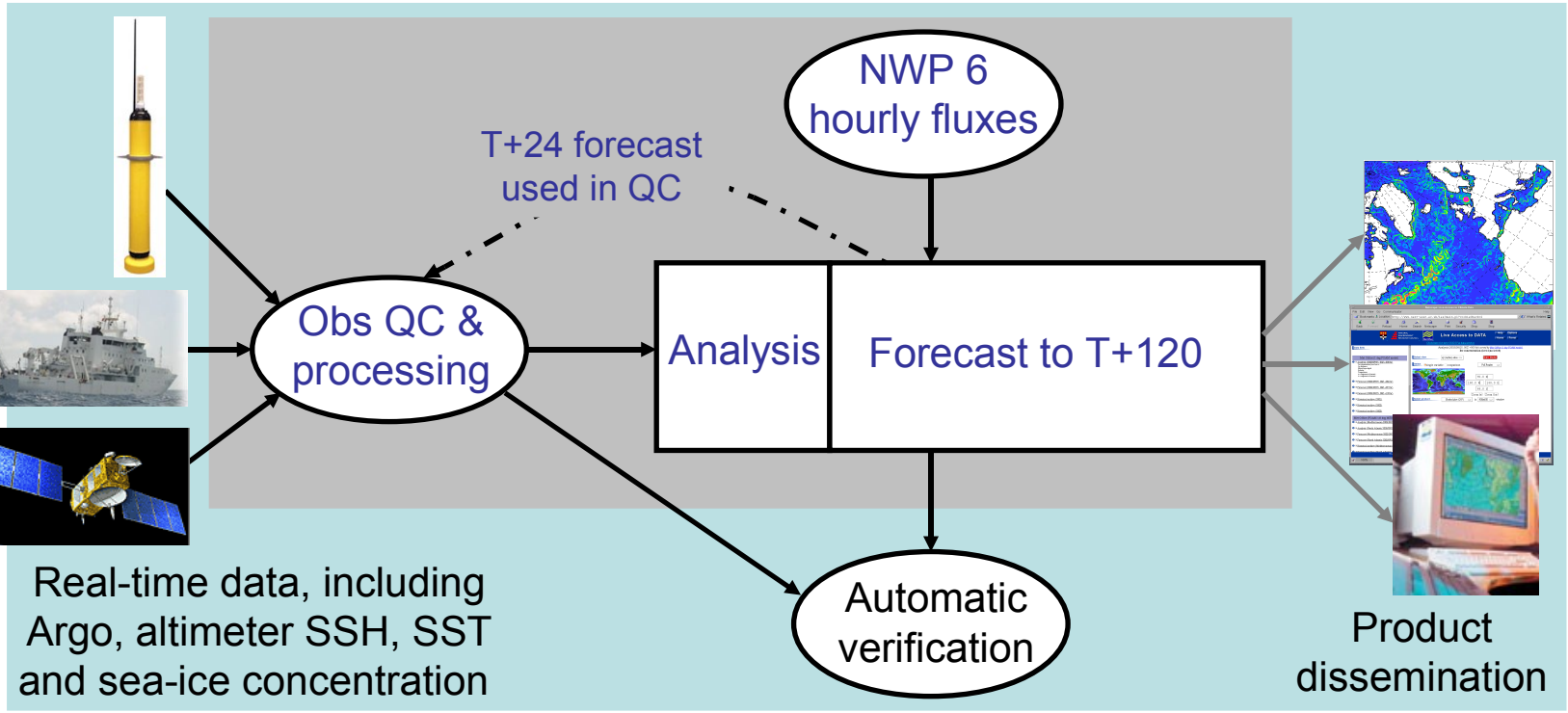
Forecasting Ocean Assimilation Model (FOAM)

Short range operational ocean forecasting

Matt Martin, Rosa Barciela, Ed Blockley, Catherine Guiavar'ch, Adrian Hines, Rachel Furner, Dan Lea, Ray Mahdon, Dave Storkey

Overview of the FOAM system:

System overview

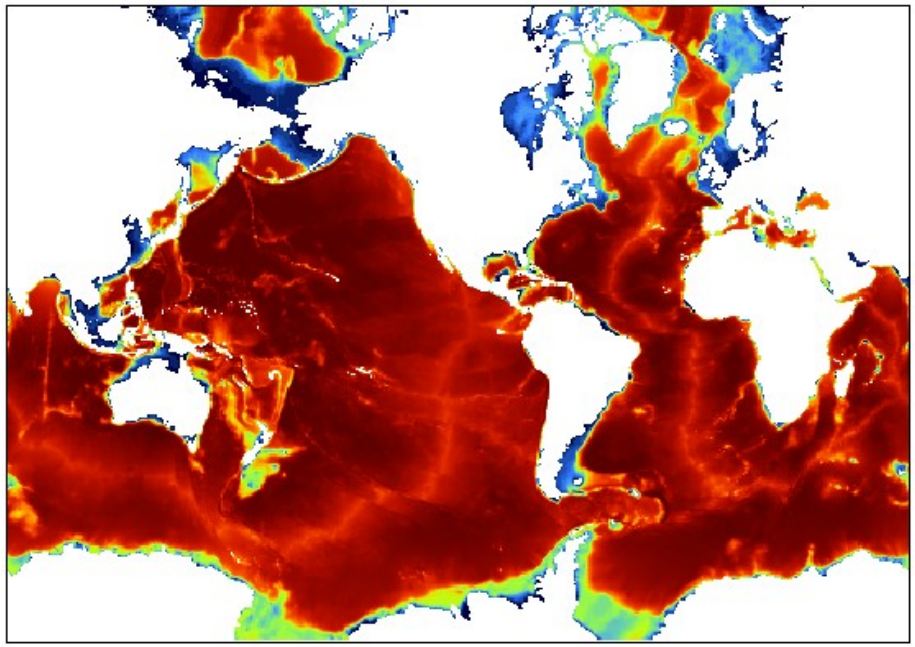


- Forecasting Ocean Assimilation Model
- Daily analyses and forecasts out to 5 days.
- Hindcast capability (back to 1997)

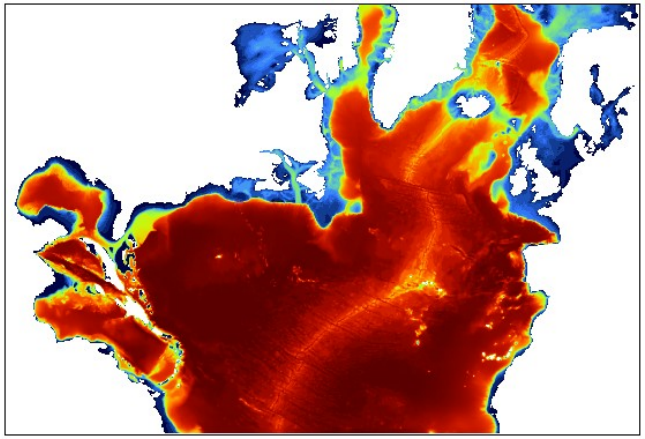
The new FOAM-NEMO system:

Model configurations

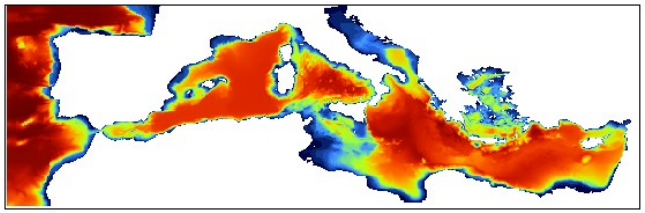
- The system has recently been changed to use the NEMO model, with various upgrades to the data assimilation.



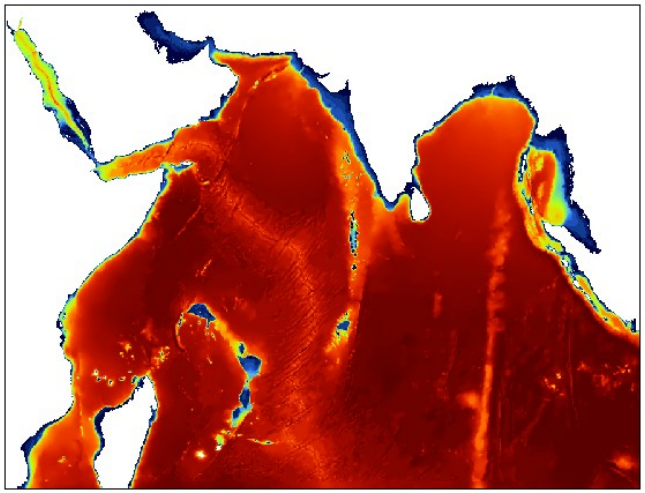
Global ¼˚ (ORCA025), developed in conjunction with Mercator



North Atlantic 1/12˚



Med. 1/12˚

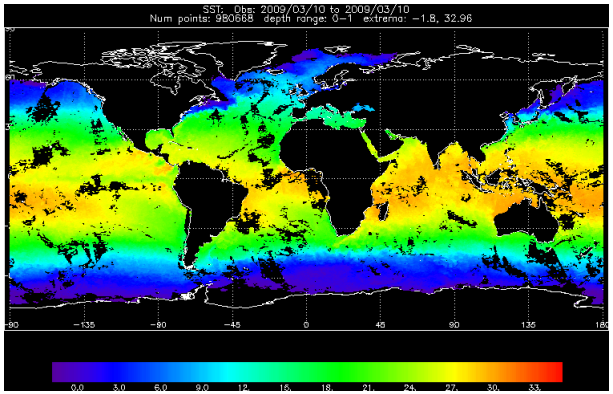


Indian Ocean 1/12˚

Overview of the *FOAM system*

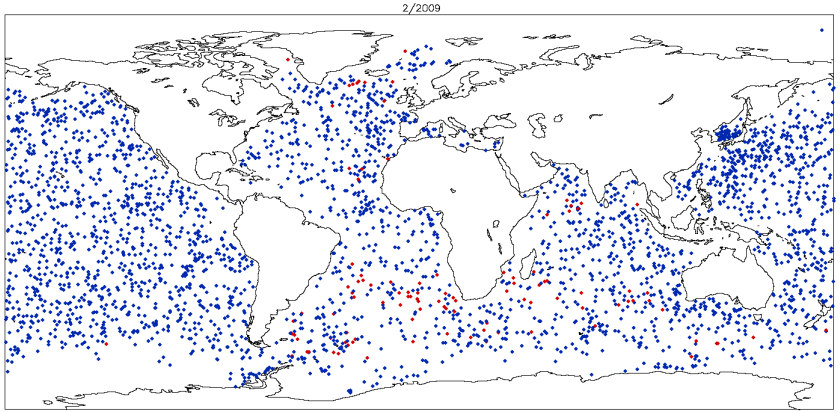
Data types assimilated

- All FOAM configurations assimilate a range of data using an Optimal Interpolation type method.

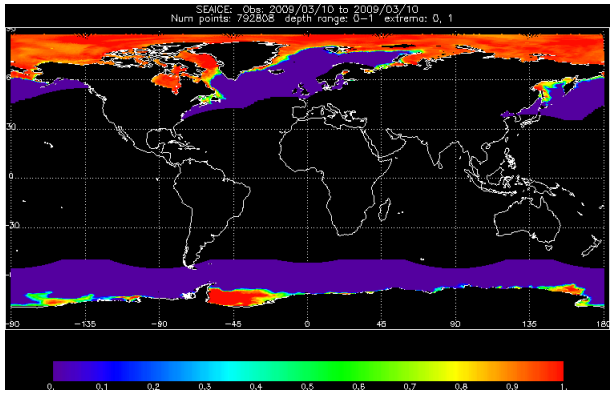


In situ and satellite SST (GHRSST)

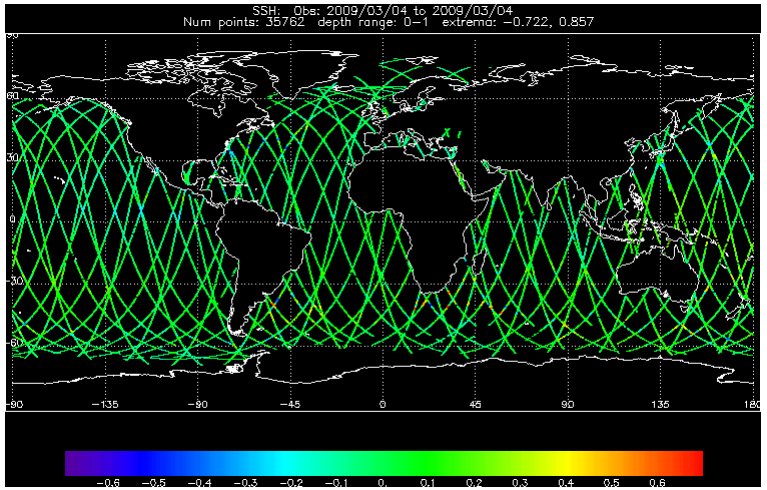
Temperature and salinity profiles including Argo floats (also XBTs, CTDs, buoys,…).



SSM/I sea-ice concentration

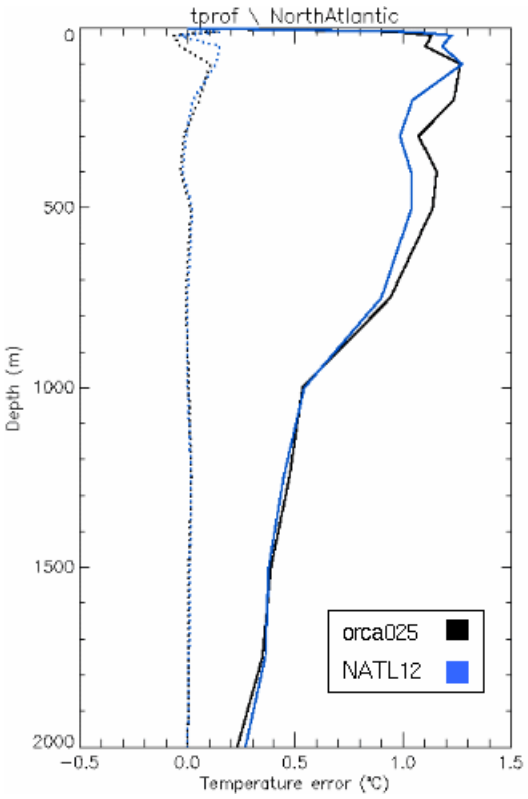


Satellite altimeter SLA

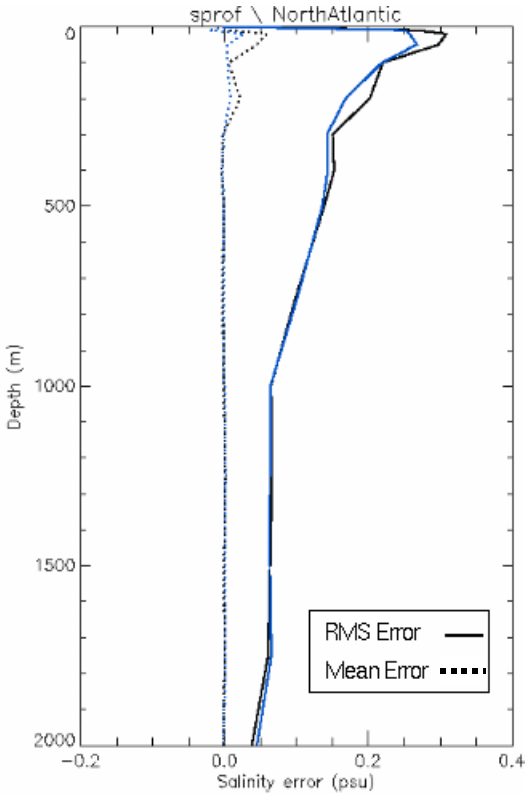


Using Argo data to assess the impact of model resolution

Temperature



Salinity

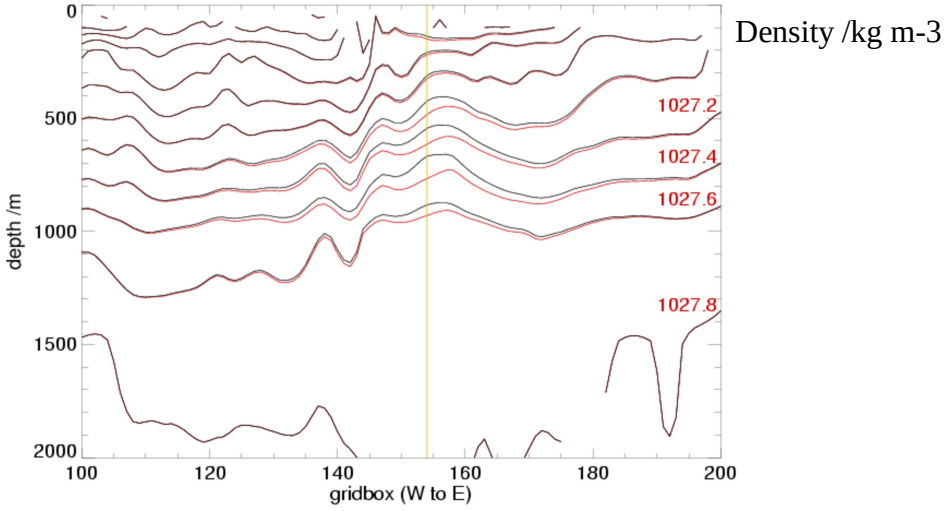


- Time period: 1st Apr 2005 – 31st Mar 2006
- Domain: North Atlantic Basin
- Impact of 1/4º vs. 1/12º resolution on the sub-surface temperature and salinity
- The higher resolution model has improved fit to the Argo data in both temperature and salinity.
- Significant impact can also be seen on surface fields.

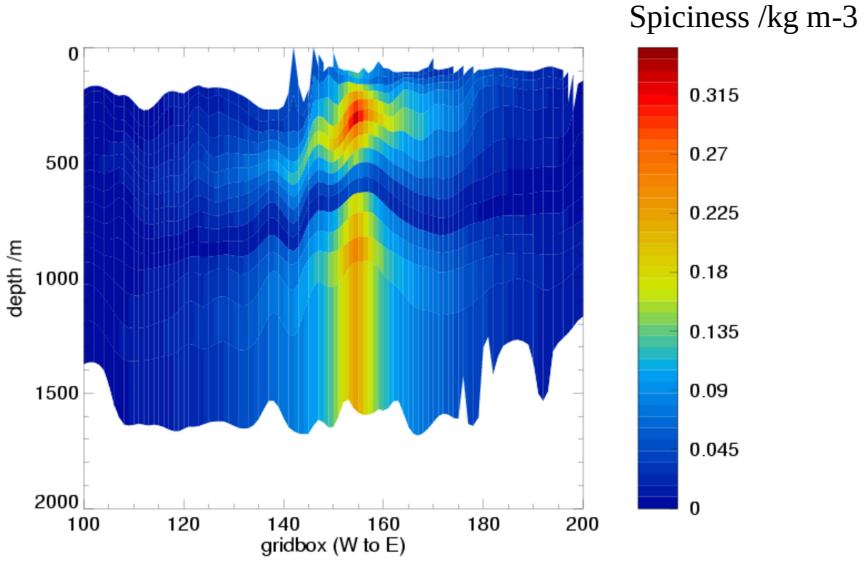
Future work with FOAM-NEMO

- Using the new system to run OSEs to show the impact of Argo data on forecasts
- Investigating impact of different changes of variable, e.g. density/spiciness assimilation, to make better use of the data.

Density level depth
z(ρ) before and after assimilation



Spiciness increment
π (ρ)



GloSea

Coupled ocean-atmosphere seasonal forecasting

Drew Peterson, Alberto Arribas, Margaret Gordon, Anna Maidens

GloSea4 – Met Office seasonal forecast system v4

- Coupled ocean-atmosphere model (HadGEM3)
- Ocean model is NEMO at 1º resolution.
- Initialisation of ocean is done using the same data assimilation scheme as FOAM, although doesn't currently assimilate the satellite altimeter data.
- New system still under development.
- Argo was shown to be useful in previous system and results from FOAM on its impact will be relevant to GloSea.

GloSea4: System design/infrastructure

FCST

Monday

- Grab NWP data
- Run ODA (1-day cycle)
- Weekly IC (atmos. recon.)
- N forecasts (6-month)
- Archiving/post-processing

Tue - Sun

- *Grab NWP data*
- Run ODA
- N forecasts (6-month)
- Archiving/post-processing

Every week

- Pull together last 4-weeks fcsts/ hcst
- Post-processing
- Products / web display

HCST

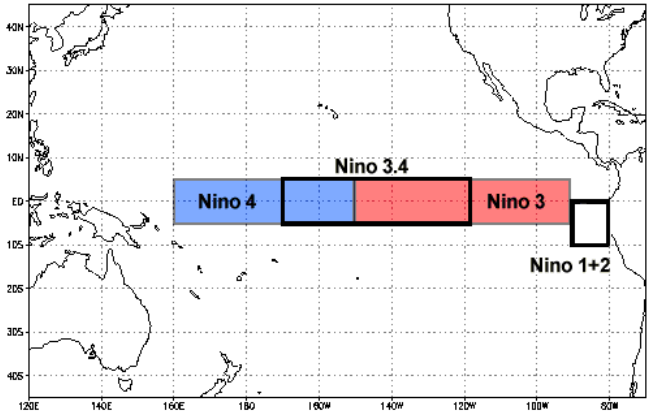
Every day

- Grab data. 'Weekly' ICs (1, 9, 17, 25)
- N forecasts (6-month) to accumulate minimum: Myears, X members
- Archiving/post-processing

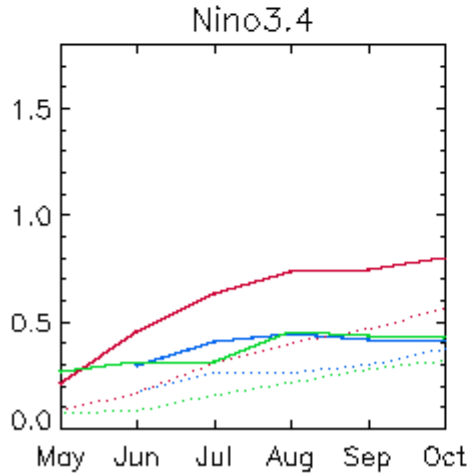
Off line

- Continuous ODA (e.g. 1989 – 1998)
- 'Weekly' Atmos + land.surf. Reanalysis data

Preliminary results for Nino 3.4 region



Hindcast Skill Assessment

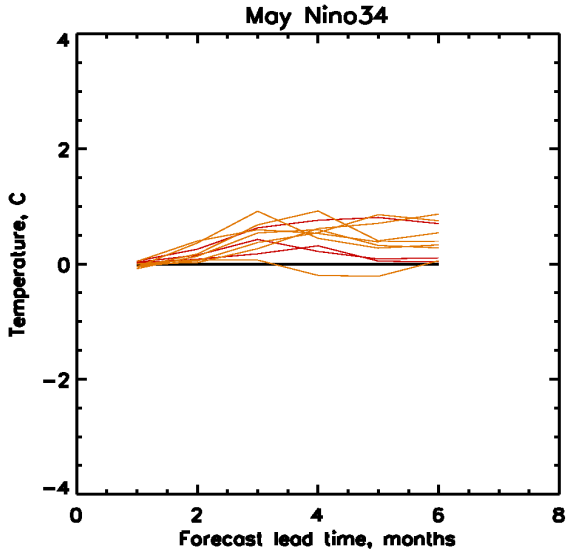


GloSea4 (May02 start, approx 6-members) RMSE ensemble mean (solid line)

GloSea3 (May1 start, 15-members) Mean ensemble spread (dotted line)

ECMWF (May1 start, 9-members) 1989-99 hindcasts

2009 Forecast



DePreSys

Coupled ocean-atmosphere decadal forecasting

Nick Dunstone, Doug Smith

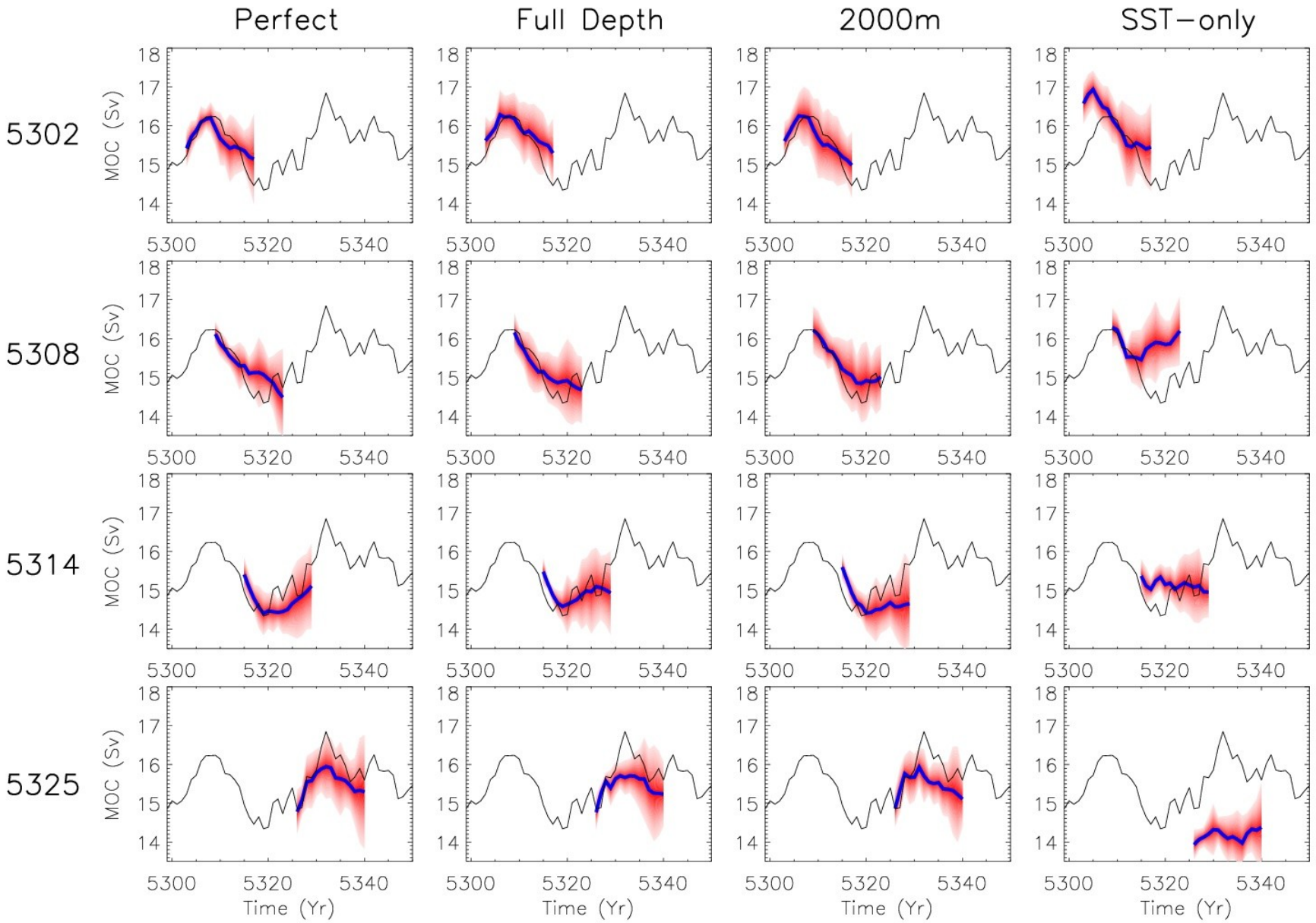
Using Argo-like “observations” to initialise decadal climate models

“Perfect Model” study to show potential of Argo.

Four initialisation experiments:

- ‘**Perfect Model**’ - uses conditions from original control run
- ‘**Full Depth**’ - assimilate full field, ocean **full depth Temperature & Salinity (T & S)**
- ‘**2000m**’ - assimilate full field, ocean **T & S to a depth of 2000m** (**like Argo data**)
- ‘**SST Only**’ - assimilate **SST only** following Keenlyside et al (2008).

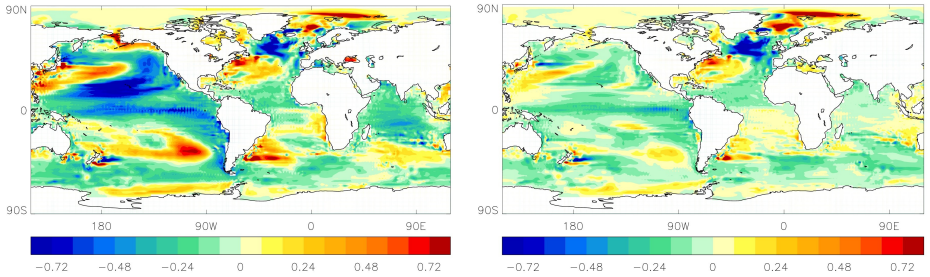
Forecasting the MOC



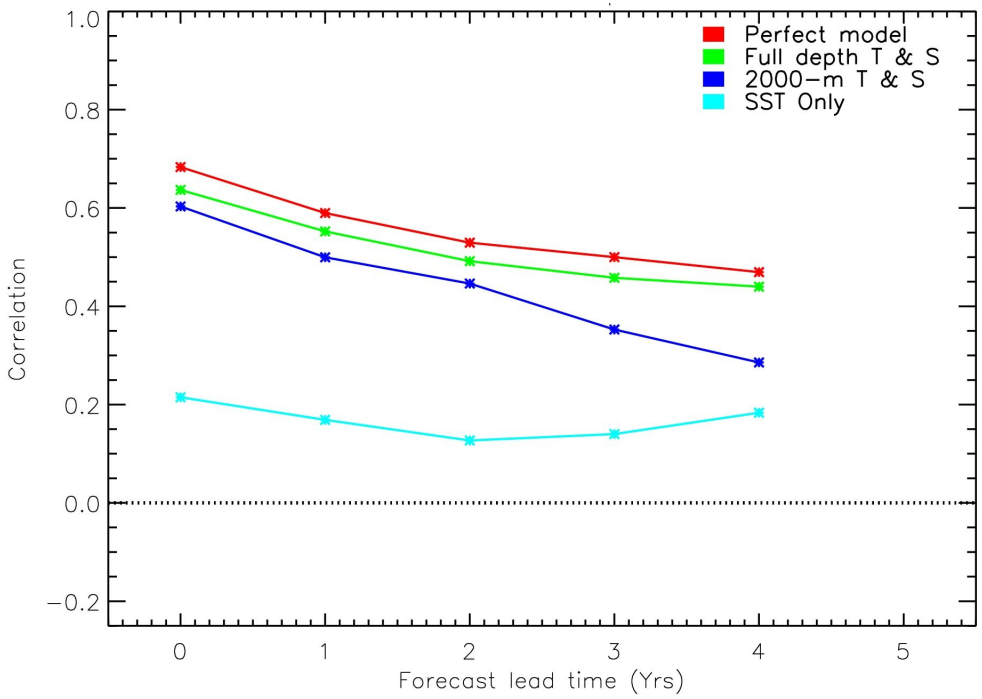
Comparing the global skill of the four experiments

Spatial correlations of Sea Surface Temperature (SST):

Truth: **Forecast:**



Spatial correlation = 0.64

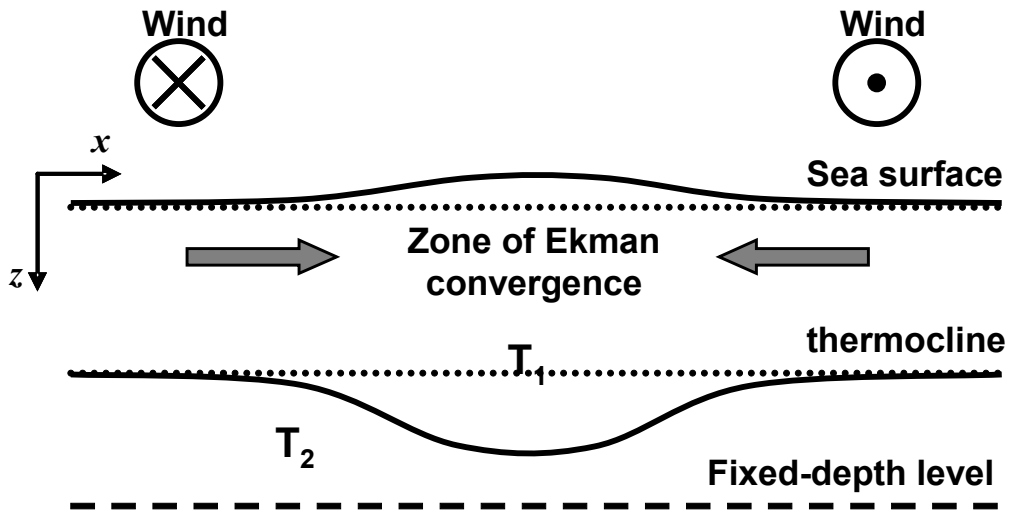


- Correlations are for five year means
- Skill is dependant upon the amount of information assimilated.
- Using 2000m T & S (like Argo data) potentially produces much more skilful forecasts than using SST data.

Understanding observed ocean climate change

Matt Palmer, Keith Haines, Simon Good, Nick Rayner and Peter Stott

A new approach to estimating ocean warming – using isotherms



Short time-scales: waves, eddies

Long time-scales: mean winds, ocean advection

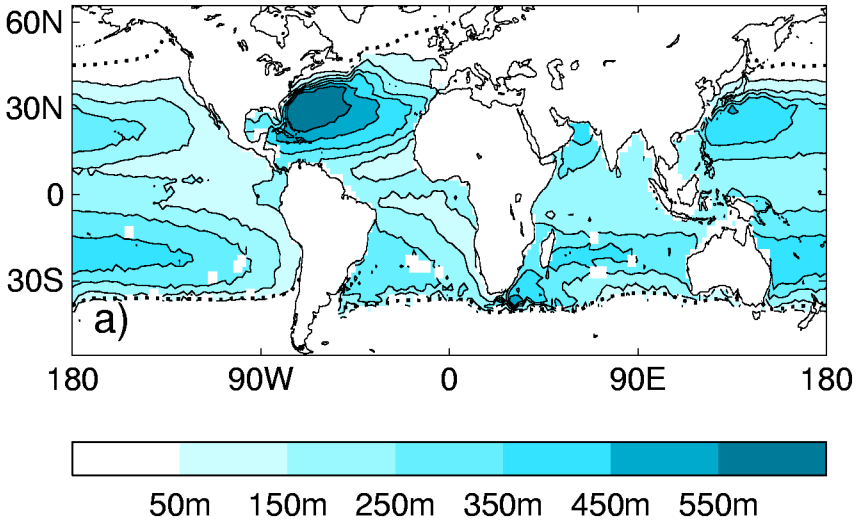
Walin [1982], Stevenson and Niiler [1983], Toole et al. [2004]

Three diagnostics of ocean warming

(i) Average temperature above 220m - $\mathbf{T_{220m}}$

(ii) Average temperature above 14°C - $\mathbf{T_{14C}}$

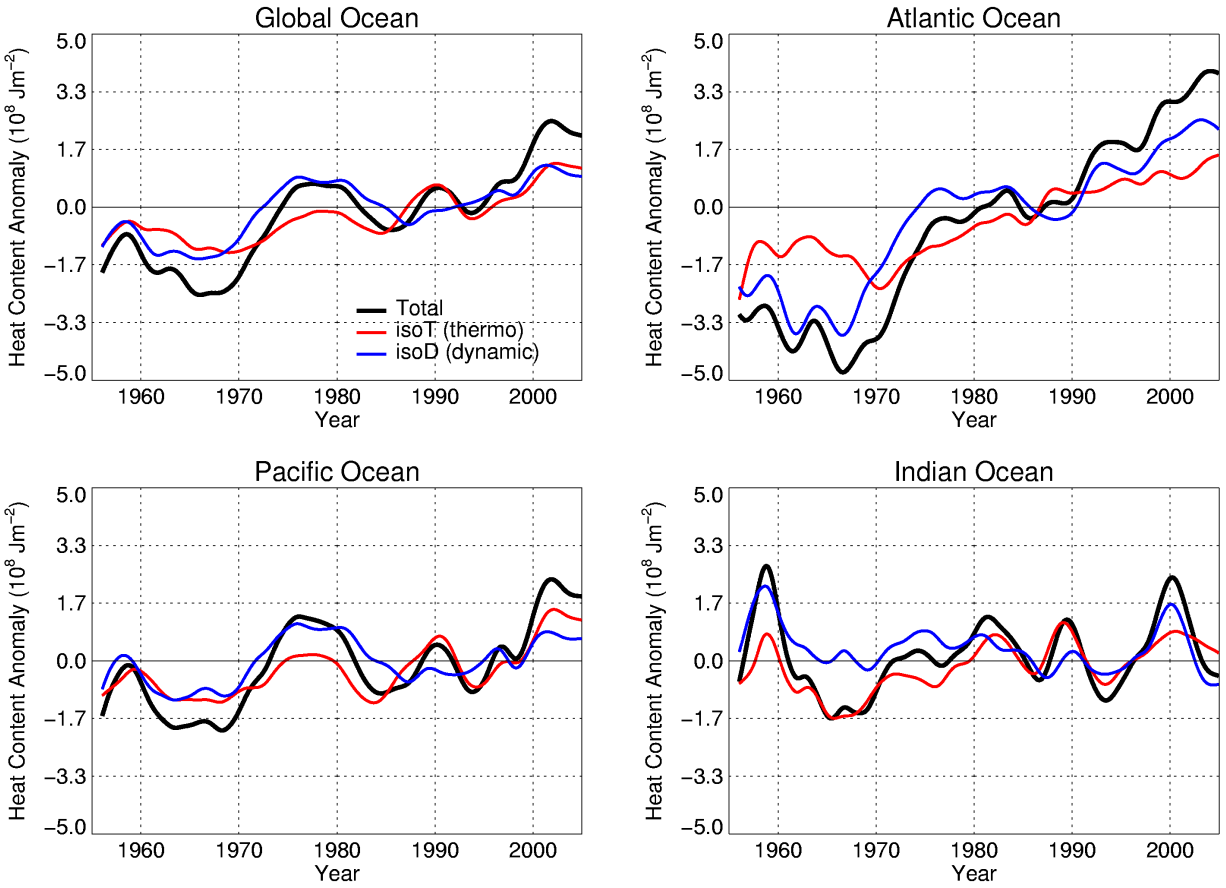
(iii) Average depth of 14°C - $\mathbf{D_{14C}}$



Historical spatial average value of D14C ≈ 220m

Palmer et al. [2007]

Estimating global ocean heat uptake using isotherms: HadGOA



Dominated by ocean advection

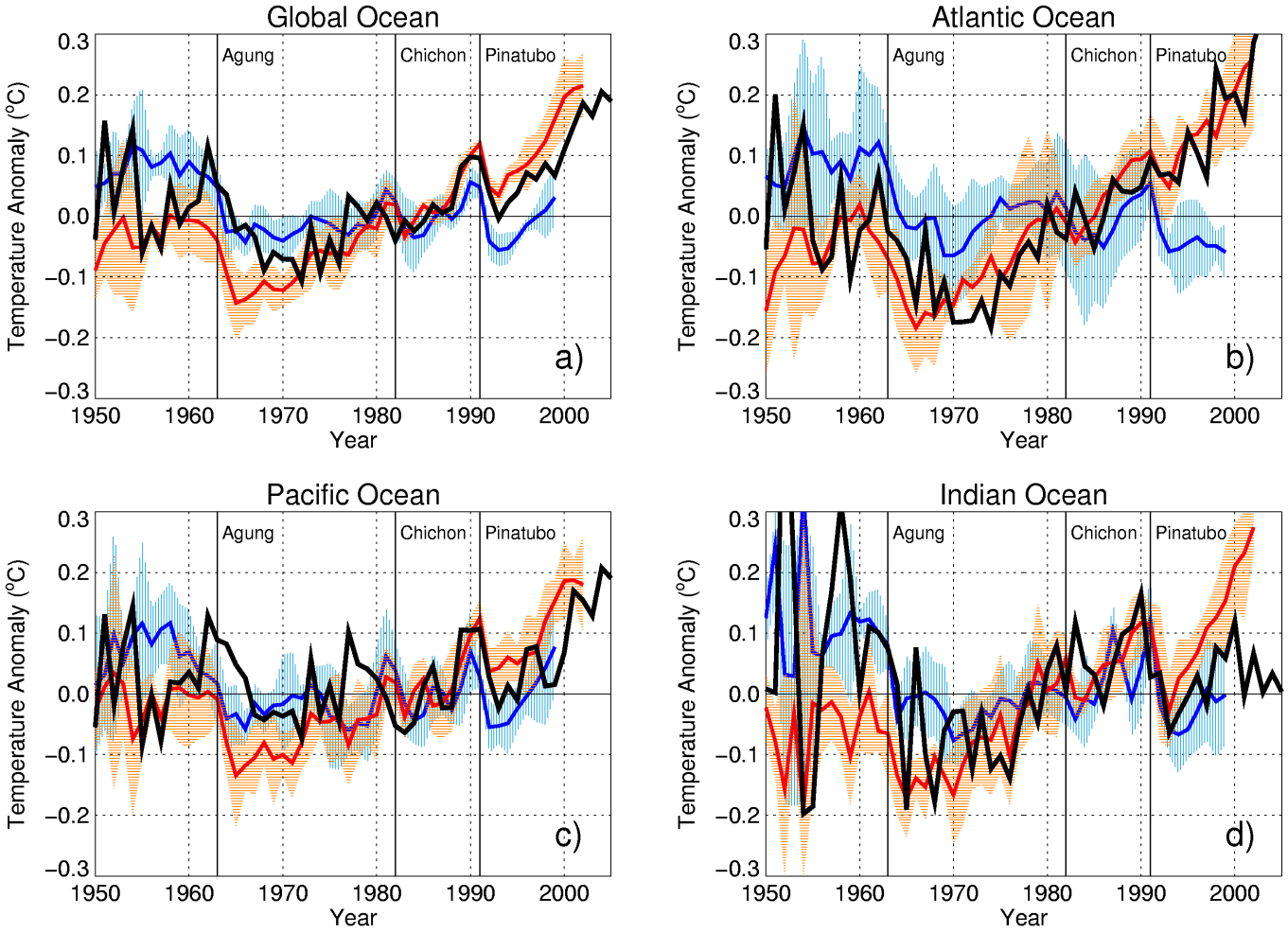
Dominated by air-sea heatflux

(N.B. no XBT corrections)

Same ideas could be used even more effectively using Argo temperature density measurements

Palmer and Haines – J. Clim (accepted)
See also Palmer et al. (2007)

Natural and Anthropogenic drivers of observed ocean climate



Palmer et al. submitted to GRL

Argo for estimating global ocean heat uptake

How can Argo help <u>now</u>?

1. Provide an improved climatology (current underestimate of global ocean warming?)

1. Provide error covariances for in-filling of historical data (Doug Smith's work)

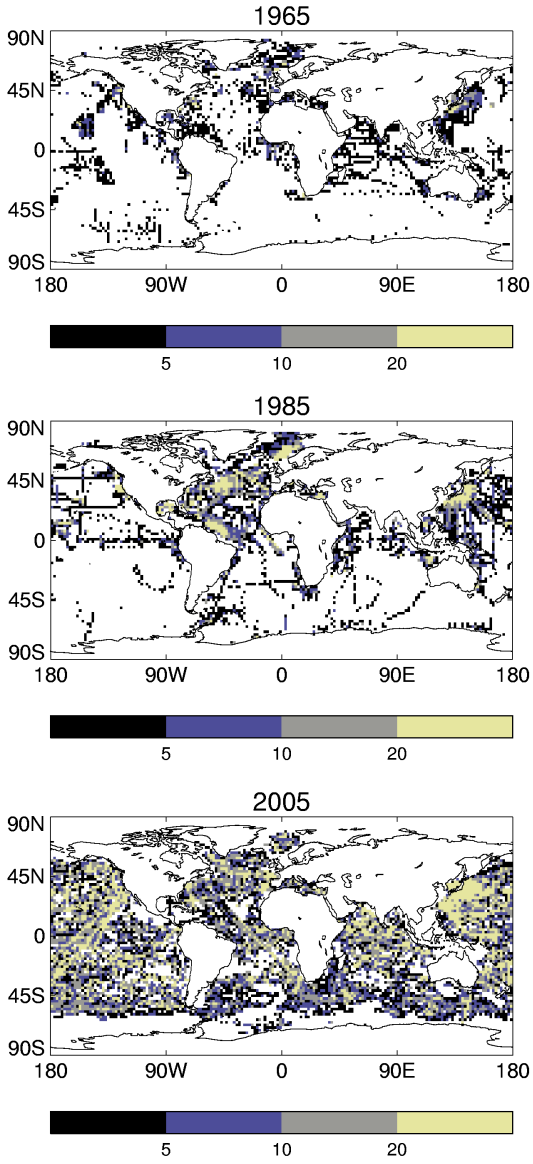
How can Argo help <u>in future</u>?

1. Provide routine, quasi-global observations to 2000m

1. Warming relative to *isopycnals* => better understanding of dynamic and thermodynamic influences

1. Provide baseline array for development of *full-depth* monitoring

Number of observations in upper 700m on 2°×2° lat-lon grid



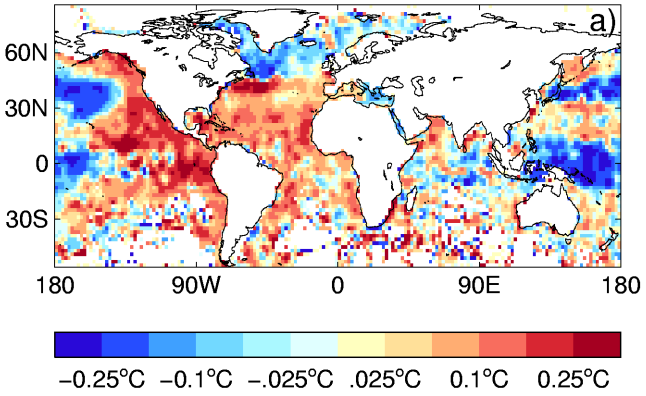
Questions and answers

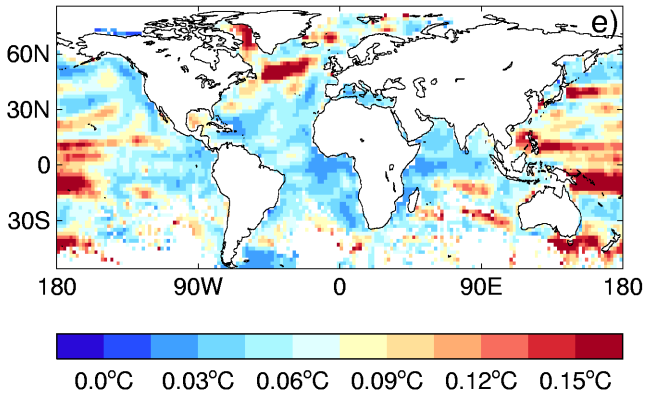
Argo observations essential for:

- future development and validation of forecast systems on all timescales
- understanding/monitoring the regional patterns of ocean heat uptake and sea-level change
- monitoring future changes in the hydrological cycle (salinity and water mass changes)
- providing observational constraints on projections of future climate change
- possibility of quantifying ocean uptake of CO_2.

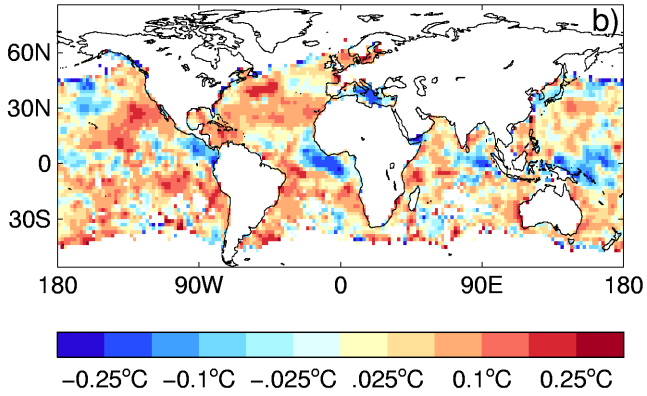
Natural and Anthropogenic drivers of observed ocean climate

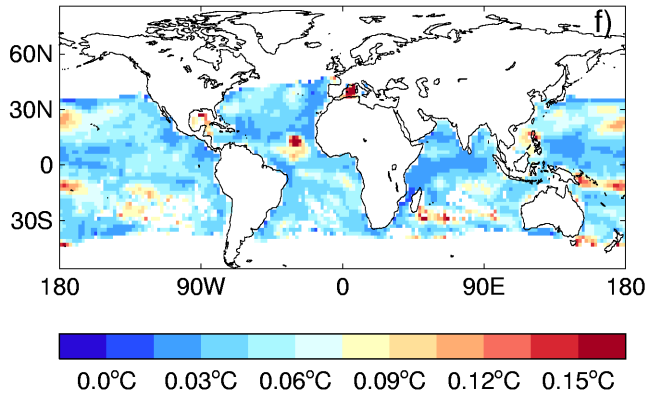
220m fixed depth analysis





14C fixed isotherm analysis





Palmer et al. submitted to GRL