Comments on Argo real time data use by operational centres

Prepared by John Gould

The table Document 7.1 summarises information received in answer to a questionnaire sent to centres known to be using (and particularly assimilating) Argo data.

The questions were

a) Which operational centres are now routinely using Argo data
(Recipients were asked to pass the questions to other relevant contacts not on the list)
b) What products are being produced using Argo data?
c) Are both temperature and salinity data are being used?
d) What impact does Argo data have?
Is the main benefit from more data being available?
From more uniform distribution in space and time?
From greater depth penetration than XBTs?
From availability of salinity data?
From something else?
e) Is Argo data quality and timeliness of delivery adequate?
f) Are the Argo data centres sufficiently responsive to issues of data quality?

They were sent to
David Anderson, ECMWF,
Mike Bell, UKMO,
Pierre Bahurel, Mercator
Nadia Pinardi, MFSTEP
Geir Evensen Diadem/Topax
Johnny Johannesen Diadem Topax
Kensuke Takeuchi for JMA and Japan
Dave Behringer NCEP/CPC
Jim Cummings NRL/FNMOC
Harley Hurlburt NRL
Susan Wijffels/Neville Smith CSIRO/BoM

Replies were received from all but David Anderson, Dave Behringer and Jim Cummings.

A questionnaire was also sent to FUGRO-GEOS, a commercial company who do ocean forecasts and who are rumoured to use Argo data. No reply has been received.

Here are the answers to questions b) to f) and other comments.
UKMO (Mike Bell)
b)   All our operational forecasts assimilate Argo data
c) Both are assimilated
d) Tokyo workshop talk and technical note gave some details. Salinity data definitely has large impact on salinities. Greater depth penetration also means there is a large

impact on our fields below 1000 metres. Good distribution in space and time is also important.

e) At the moment yes.

f)   We asked for a reject-list of floats with salinity problems from Coriolis a while ago. I don't think we've got it yet.

NRL (Harley Hurlburt)

So far we are using ARGO data mainly as independent data to evaluate the temperature and salinity in data-assimilative eddy-resolving global, basin-scale and regional ocean models. These mainly assimilate satellite altimeter data and AVHRR so far. The ARGO data is outstanding for this purpose.

Real-time and near real-time results from 3 of these ocean prediction systems can be seen at

http://www.ocean.nrlssc.navy.mil/global_nlom
http://hycom.rsmas.miami.edu/ocean_prediction.html

Later this year we plan to start assimilating ARGO data directly into these systems. Some have argued that ARGO data will produce false eddies in eddy-resolving models, but in combination with the existing SSH and SST assimilation, I don't believe this will be a signficant problem. The NLOM system assimilates the altimeter track data using the model as a first guess (rather than assimilating model independent SSH analyses) and animations of steric SSH from the model do not show trackiness from the altimeter data assimilation in most regions. Also, the model steric SSH generally does not show large error in comparison to hydrographic data. Therefore, I believe the ARGO data will simply improve the accuracy of the data assimilative model where it is available.

For several purposes we use SSH, SST and the statistics of the historical hydrographic data base to project the surface data downward. We are eager to update these statistic using ARGO data as ARGO is greatly increasing the number of salinity profiles available and the depth of temperature profiles over most existing profiles.

INGV Nadia Pinardi

For the time being we are using the Argo data to validate the results of our predictions and present analysis scheme but we still do not assimilate them. We are preparing the assimilation of Argo data for this summer to be operational. Our MedARGO program (20-22 floats) will start only in September 2004. We are now operationally assimilating SLA, SST and XBT from VOS.

(Note added in second message - We do assimilate temperature profiles ONLY. This is why I told you that we still do not use ARGO because I consider the usage only of the temperature not enough to be called ARGO assimilation.)

Office of Marine Prediction, Japan Meteorological Agency (JMA)

b) The JMA is producing and distributing followings:

    - Ocean current chart in the Western North Pacific

    - Sub-surface temperature chart in the Western North Pacific

c)   - Yes our system is using both of them.

d) Is the main benefit from

More data being available? - Yes

More uniform distribution in space and time? - Yes, but coverage in the western boundary area is not sufficient in both space and time.
Greater depth penetration than XBTs? - Not so much contribution.
Availability of salinity data? - Probably yes. It has not been evaluated.
e) Is Argo data quality and timeliness of delivery adequate?   - Yes
f) Are the Argo data centres sufficiently responsive to issues of data quality?   - Yes

Climate Prediction Division, Japan Meteorological Agency (JMA)
b)   - Analysis of sub-surface temperatures in the equatorial Pacific
        - El Nino Outlook based on a coupled forecast model
c)   - Yes. Both are used.
d) Is the main benefit from
More data being available? - Yes
More uniform distribution in space and time? - Yes, particularly enforced coverage in the Indian Ocean and outside the equatorial wave guide in the Pacific is desirable.
Greater depth penetration than XBTs? - Not so valuable for ENSO monitoring and forecast
Availability of salinity data? - Potentially yes, but the data (number and period) is not sufficient yet for evaluation.
e) Is Argo data quality and timeliness of delivery adequate?   - Yes
f) Are the Argo data centres sufficiently responsive to issues of data quality?   - Yes

Mercator Ocean (Bahurel)
"MERCATOR OCEAN" is using ARGO data for validation, and assimilation.
b) What products are being produced using Argo data
- **Mercator/PSY1 : North Atlantic (70°N-20S) real time analysis and 2-week forecasts** (assimilation of Argo T&S assimilation + all insitu T&S vertical profiles provided by Coriolis, + SST + ALTIMETRY (Jason, Envisat, GFO)) ; a **15-year reanalysis** is undergone.
- **Mercator/ARMOR : Global Ocean near-real-time analysis** (combination altimetry, SST, in situ Argo and other T&S vertical profiles)
- **Mercator/PSY2 : high resolution N.Atlantic and Med Sea analysis and forecast**s (assimilation of altimetry) are validated with Argo information ; assimilation of ARGO T&S in these configurations is foreseen in 2004 (Med Sea).

c) Whether both temperature and salinity data are being used
Yes
d) What impact Argo data has
    Is the main benefit from more data being available?
   more uniform distribution in space and time?
   greater depth penetration than XBTs?
   availability of salinity data?
   something else?
Poster at Argo Workshop shows some preliminary results.
Extended studies will be conducted in 2004, for the reanalysis case. Impact of salinity is really important.
e) Is Argo data quality and timeliness of delivery adequate?
f)   Are the Argo data centres sufficiently responsive to issues of data quality?
Argo data provided through CORIOLIS data center ; and International Argo Information Centre Manager.
Timeliness is OK.

Access to Med Sea Argo information is to be looked at.
Close collaboration between MERCATOR and CORIOLIS for the quality of in Situ
information : Mercator feedback is positive, with a "black list" of bad data.

TOPAZ (Laurent Bertino)
a) the assimilation of ARGO data (from IFREMER through CLS) in the TOPAZ system
operated at NERSC has been evaluated and will be included in March 2004.

The assimilation has been evaluated in previous studies on simplified cases (an article
by Birol et al. has been submitted to J. Mar. Geodesy, plus a section in the TOPAZ final
report, available from the link below) and in the configuration used in real-time. These
studies indicate that low frequency sampling in the deep waters is sufficient, while more
frequent sampling is needed in the sub-surface layers. They also stress the need for
consistency with the Mean Dynamic Topography used when assimilating altimetry data
as a first order limitation of their use.

b) What products: Analyses and 10-days forecasts for physical parameters of the
Atlantic Ocean, plus boundary conditions for nested high-resolution models (North Sea,
Gulf of Mexico) each with specific users: oil industry and coastal environment.

c) Both temperature and salinity can be assimilated consistently in the EnKF assimilation
scheme.

d) impact: Still a little early to answer these questions, yet the availability of salinity is a
significant advantage since temperature alone does not give an accurate information
about the water density profile.
The spatial distribution and depth penetration are other clear advantages. Quantification
will come after operational use.

e) quality and timeliness Quality: evaluation is ongoing between NERSC and CLS.
TOPAZ operates a weekly cycle centered on the Wednesday 00UTC
ARGO data obtained between 10 and 3 days (included) delay will be assimilated so
timeliness is not yet critical. TOPAZ has no need for more recent data as long as
altimetry products need 6 days of delay for orbit correction.

f) responsivity: Too early to tell.

In **May last year David Anderson (ECMWF) wrote**

We are in fact in the middle of doing OSEs for TAO, XBT, altimeter and to a more limited
extent ARGO.

The base experiment is to assimilate everything for the period 1992- 2002. Then we
selectively withdraw one observing system. This is a much more demanding test than
starting with no observing system and adding one: This latter can give much more
impact but doesn't correspond to an ideal operational analysis system in which you
would assimilate everything. Our approach would show up redundancy between
observing systems. So if two systems overlapped strongly, withdrawing one would show
little effect. Of course some redundancy is actually desirable since it allows you to
callibrate/ validate the observing system. Too much redundancy is not a good use of
money.

The other thing to remember is that you can get a bigger impact if you start with a lousy model.

So given all these caveats, we have done a variety of impact studies not just on the analyses but then have run an extensive set of seasonal forecasts from the analyses - that's the expensive part. OSEs which don't do this step are of reduced value. Since ARGO is really only available for the last few years, it isn't possible to do a comprehensive set of forecasts. All we can do is show the impact on the analyses. The array is evolving so the impact will vary as a result.

In July 2003 I received this from Jim Cummings
Naval Research Laboratory, Monterey CA; also Fleet Numerical Meteorology and Oceanography Center (FNMOC), Monterey, CA (where the data assimilative model runs are performed).

Three major uses at present.
1) Argo data are used in daily global and regional ocean data assimilation runs - global runs are with LANL POP model running on 55 km at equator Mercator grid (soon to go to 37 km at equator Mercator grid, ~25 km at mid-latitudes). The global system can be run fully two-way coupled with the Navy NWP model (NOGAPS). Regional model runs are primarily in marginal seas of Navy interest (not officially supported by Argo as I understand it).

2) Argo is also used in experiments to validate a direct method ofassimilating altimeter SSH observations. Argo float time series are predicted by assimilation of SSH differences between float cycles (as a proxy for altimeter SSH). The subsequent float cycle provides a validation profile. The large geographic and seasonal coverage of Argo floats provides a rigorous test of the method on a global scale.

3) Argo float data are QC'd through automated QC procedures. The Argo float data are critical for the success of the cross validation of other profile data types (which otherwise are too sparse in space and time).

Global Argo data available off GTS are used in the analysis and QC systems. I would like to build in a feedback of the delayed mode data off the Argo GDAC into the system. Just haven't found the time to do this yet.

Both temperature and salinity profiles are used.

Complete vertical profiles at all observed levels are used.

Unfortunately the current GTS decoders at FNMOC are dropping the new high vertical resolution profiles (>255 levels). This problem should be fixed in the next few weeks. In the meantime the GTS data are being lost (need to retrieve profiles from the GDAC).

All data are used immediately upon receipt at FNMOC in the real-time QC and model runs. Timeliness in receipt is thus a critical issue.

All data are considered useful no matter what the delay in receipt.

Data below the seasonal thermocline are always considered synoptic.

Observation errors are increased at shallower depths in late receipt data. Ideally I should not have to do this if all Argo data are received within 24 hrs of observation.

The data assimilation system uses all data sources – satellite SSTs (AVHRR, GOES, soon microwave sources), in situ SSTs (ships, fixed and drifting buoys), TESAC, XBT, float profiles, altimeter SSH, SSM/I sea ice, etc. The analysis system is multivariate with temperature, salinity, geopotential, and velocity as the 3D analysis variables (sea ice, SST and SSH are analyzed as 2D variables).

Argo is important because of its sampling characteristics -
- vertically (high resolution, deep) and horizontally (samples new areas routinely).
- of critical importance are the Argo salinity observations. Argo salinity helps prevent salinity drift in the POP model.

Currently the ocean DA and models are being done in R&D mode for eventual transition to operations at FNMOC. The customer base for operational FNMOC ocean products is quite large (all of DOD, NOAA, CIA, etc.). The QC'd Argo profiles are available on the Monterey GODAE server in real-time. The profile files include all of the GTS data plus data about the GTS data: climatology and model background profiles (global and regional); climate variability and model errors; observation error estimates; QC flags from a wide range of QC tests; Argo SSHA from long term SSH mean, derived salinity from observed temperature using Navy TS models, analyzed SST valid at Argo location and sampling time, etc.