DETERMINING OCEAN CORRELATION SCALES USING ARGO FLOAT DATA

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ABSTRACT

The scales over which ocean properties vary play an important part in the assimilation of ocean data. In this study Argo data have been used to develop a method of estimating the correlation scales of salinity on a potential temperature surface. The correlation scales of both salinity, and salinity anomalies relative to a reference field from WOA05 have been examined. For the development of the method, three test regions in the Pacific Ocean were chosen and scales are estimated on the 6° theta surface.

For pairs of data in a region, the difference in salinity is found. To determine scales in the mean field all pairs of data from one year are used. To determine scales in the anomaly field 7 years of Argo data are used but pairs are only included when the observations fall within a 10-day window. The salinity differences are then divided into 50 km bins according to the distance between the data points. The median difference in salinity is then calculated for each bin. A curve is fitted to the data varying exponentially from the near field to a far field limit based on a function devised by Bohme and Send (2005). By varying the scale parameter in the equation and finding the best fit to the data (the lowest rms error) a best estimate for the correlation scale is found.

This method will be used to estimate correlation scales across the global ocean so that the regional variation of these scales may be examined.

INTRODUCTION

An important aspect of ocean data assimilation is to understand the scales over which ocean properties vary, the correlation scales. This is also an important part of the Argo float delayed mode quality control process.

At present one set of scales is used by Argo for the global ocean with adjustments made for coastal regions and the poles.

The default scales used by the Argo group as of 2005 are 4° longitude and 2° latitude (Wong; King 2005). However, it is expected that these scales will vary with region and this has not yet been extensively researched.

Carton et al (2000) present a set of equations to estimate zonal and meridional scales for temperature anomaly data. The scales are dependant upon latitude and depth. Zonal scales vary from 450km at the equator to 375km at mid-latitudes, and the Meridional scales vary from 250km at the equator to 375km.

In this study a method to estimate correlation scales for salinity data interpolated onto potential temperature surfaces is developed to enable the investigation of scales with region.

Do ocean correlation scales vary with longitude and over theta surfaces? Are these scales longer than those on z levels?

MEAN FIELD SCALES

From one year of data from the ENACT (ENhAnced ocean data assimilation and ClimaTe prediction) data set a section of the Mid-Pacific was chosen.

Salinity data on the 6° C isotherm is used to estimate the correlation scales.

The area is divided into 3 sections, Northern, Mid and Southern to avoid fronts (expected to have shorter scales, need dealing with separately).

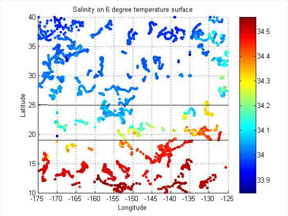

Figure 1: Plot of the salinity observations on the 6° potential temperature surface for the chosen Pacific region. Solid black lines show how the region is divided in to 3 section, Northern, Southern, and Mid-sections.

To determine the zonal scale:

Within each section, the salinity difference is determined for every pair of points that are separated by no more than 1.5° of latitude. These differences are sorted into 50 km longitude bins and the rms difference found in each bin.

Bohme and Send (2005) suggest that the rms difference should vary with separation and in this study the following equation is used to estimate the difference in salinity at various separations:

$$\Delta S = \left\{ 2\sigma^2 \left[1 - \exp\left(\frac{-D^2}{\lambda^2} \right) \right] + \gamma^2 \exp\left(\frac{-D^2}{\lambda^2} \right) \right\}^{\frac{1}{2}}$$

Equation 1: σ = standard deviation of the raw salinity field, λ = estimate of the correlation scale [km], D = separation of the observations [km], γ = y axis intercept (salinity difference at limit of zero separation).

The scale parameter and intercept are varied to achieve the best fit to the data (lowest rms error). This provides the best estimate for the correlation scale.

The meridional scales can be estimated for each section using an equivalent method.

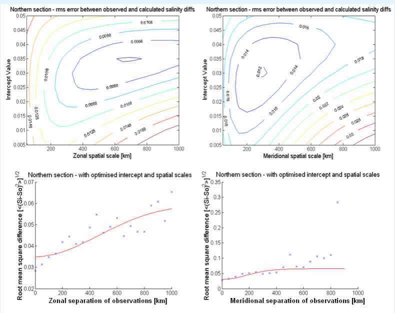

Figure 2: Top: Contour plots of the rms error between the observational data and the model ΔS (equation 1) for increasing spatial scale and intercept for the Northern section, in both the zonal and meridional directions. Bottom: Model fitted to the observations for the Northern section using the optimal values for the intercept and spatial scales obtained from the above plots.

		Y axis intercept	Spatial Scale (km)
Northern Section	**Zonal (x)**	0.035	700
	Meridional (y)	0.03	300
Mid Section	**Zonal (x)**	0.06	450
	Meridional (y)	0.05	100
Southern Section	**Zonal (x)**	0.02	450
	Meridional (y)	0.02	150
Atlantic Section	**Zonal (x)**	0.10	400
	Meridional (y)	0.08	100

Table 1: Intercept values and correlation scales estimated for all 3 sections of the chosen pacific region and also for a section of the North Atlantic.

ANOMALY FIELD SCALES

Salinity anomalies relative to the WOA05 climatology are calculated (Fig. 3) and the scales calculated in an equivalent manner as for the mean field. This time however, observation pairs are only included if they are separated by no more than 10 days. The same regions and theta surface are used.

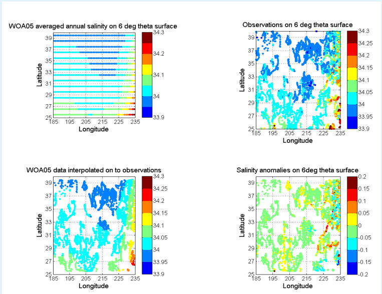

Figure 3: Scatter plots of salinity in the Northern region. Top: Climatology data and observations. Bottom: Climatology interpolated onto the observations and the corresponding anomalies.

The distributions of each bin were examined and the median was found to be more representative of the bin average than the mean. Also to remove bias caused by noise in the data all salinity differences greater than the 90th percentile were excluded from the scale calculations (see Fig. 4).

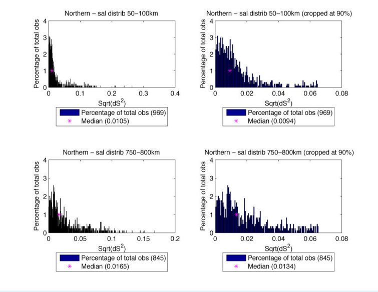

Figure 4: Distributions of the salinity differences in two bins within the Northern region. Left column shows the full distributions and right column shows distributions after cropping at the 90th percentile.

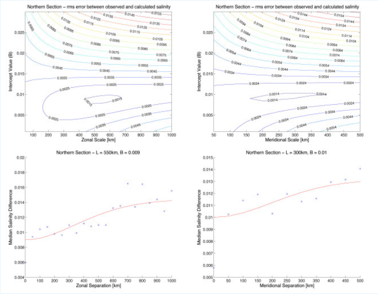

Figure 5: Top: Contour plots of the rms error between the observational data and the model ΔS (equation 1) for increasing spatial scale and intercept for the Northern section, in both the zonal and meridional directions. Bottom: Model fitted to the observations for the Northern section using the optimal values for the intercept and spatial scales obtained from the above plots.

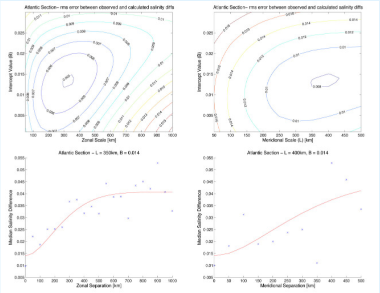

Figure 6: As Figure 5 but a region in the North Atlantic.

		Y axis intercept	Spatial Scale (km)
Northern Section	**Zonal (x)**	0.009	550
	Meridional (y)	0.01	300
Mid Section	**Zonal (x)**	0.0290	550
	Meridional (y)	0.0220	150
Southern Section	**Zonal (x)**	0.005	50
	Meridional (y)	0.005	100
Atlantic Section	**Zonal (x)**	0.014	350
	Meridional (y)	0.014	400
S. Pacific Section	**Zonal (x)**	0.004	500
	Meridional (y)	0.003	250

Table 2: Intercept values and correlation scales estimated for all 3 sections of the chosen pacific region, Atlantic region and also an extra region in the South Pacific.

CONCLUSIONS AND FUTURE WORK

- The correlation scale estimates are reasonably consistent with those proposed by Carton et al (2000). But there does appear to be variation with longitude as well as latitude (the Northern region and Atlantic region are at approximately the same latitude range).
- In most cases the anomaly scales are found to be shorter than the mean field scales.
- Scales now need to be explored on a number of different theta surfaces to examine the variability.
- A method of recognising and dealing with frontal regions need to be developed as these will affect the scale estimates.

REFERENCES

- Bohme, L. and U. Send, 2005 Deep Sea Research II, **52**, 651-664
- Carton, J. A., G. Chepurin, and X. Cao, 2000, Journal of Physical Oceanography, **30**, 294-309.
- Wong, A. and B. King, 2005: Report on First Delayed-Mode QC Workshop, 27 pp.