Mixed-Layer Depths along Line-P
The annual cycle and recent variability.

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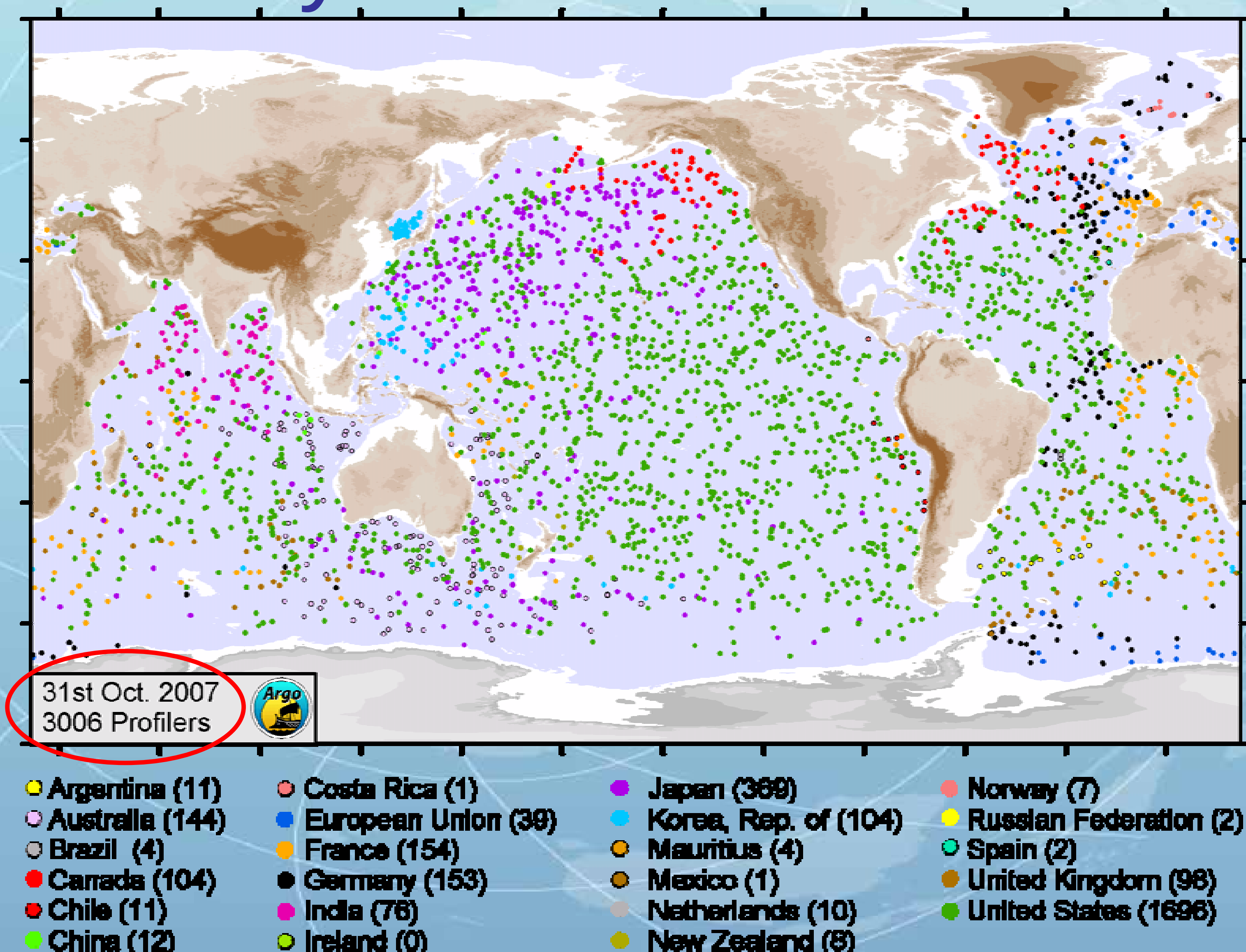
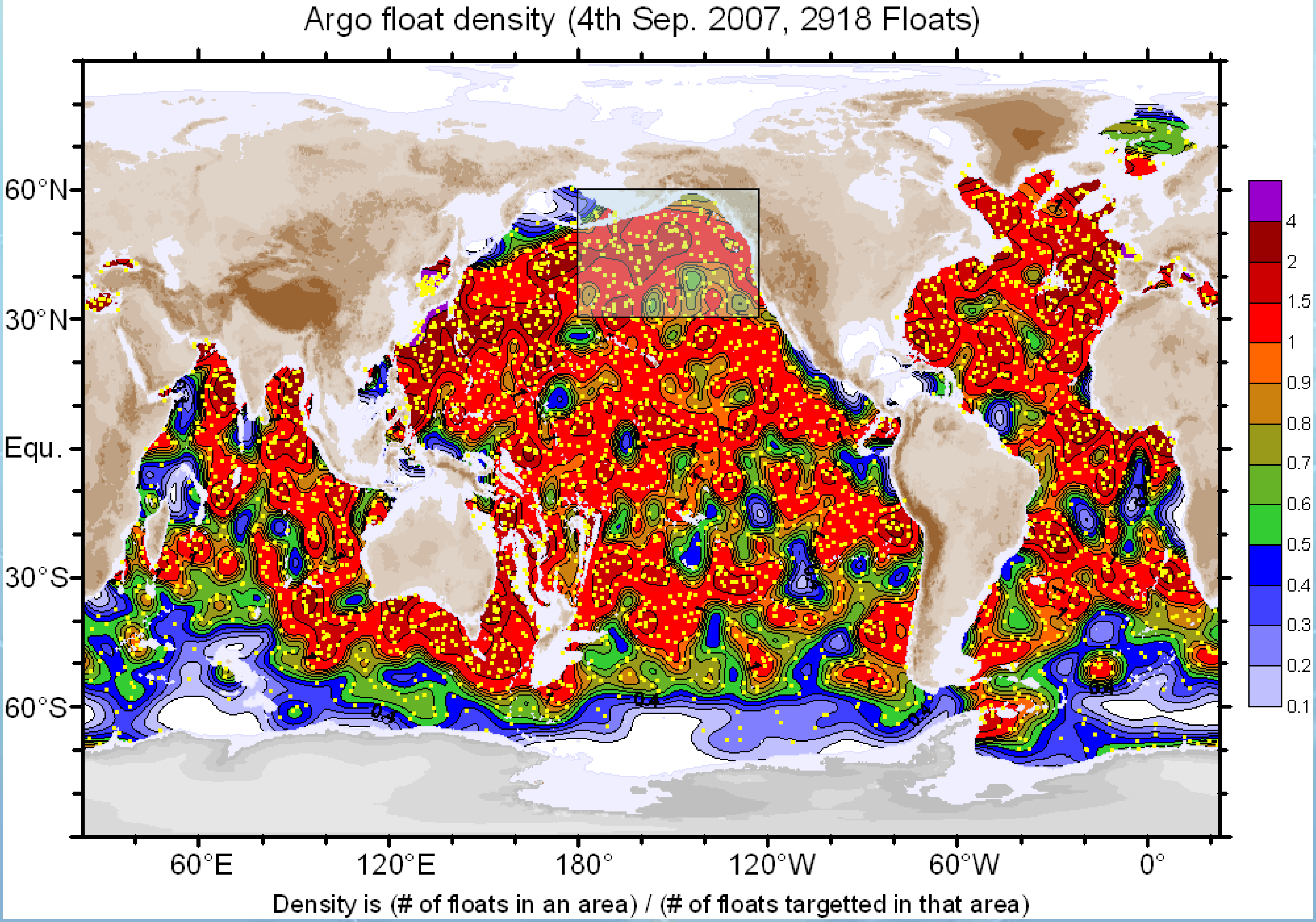
Also, acknowledgments to Patrick Cummins and Germaine Gatien for help with the conclusions, which caused me great stress.

Nobody has seen this before



The Argo array is near its global target density



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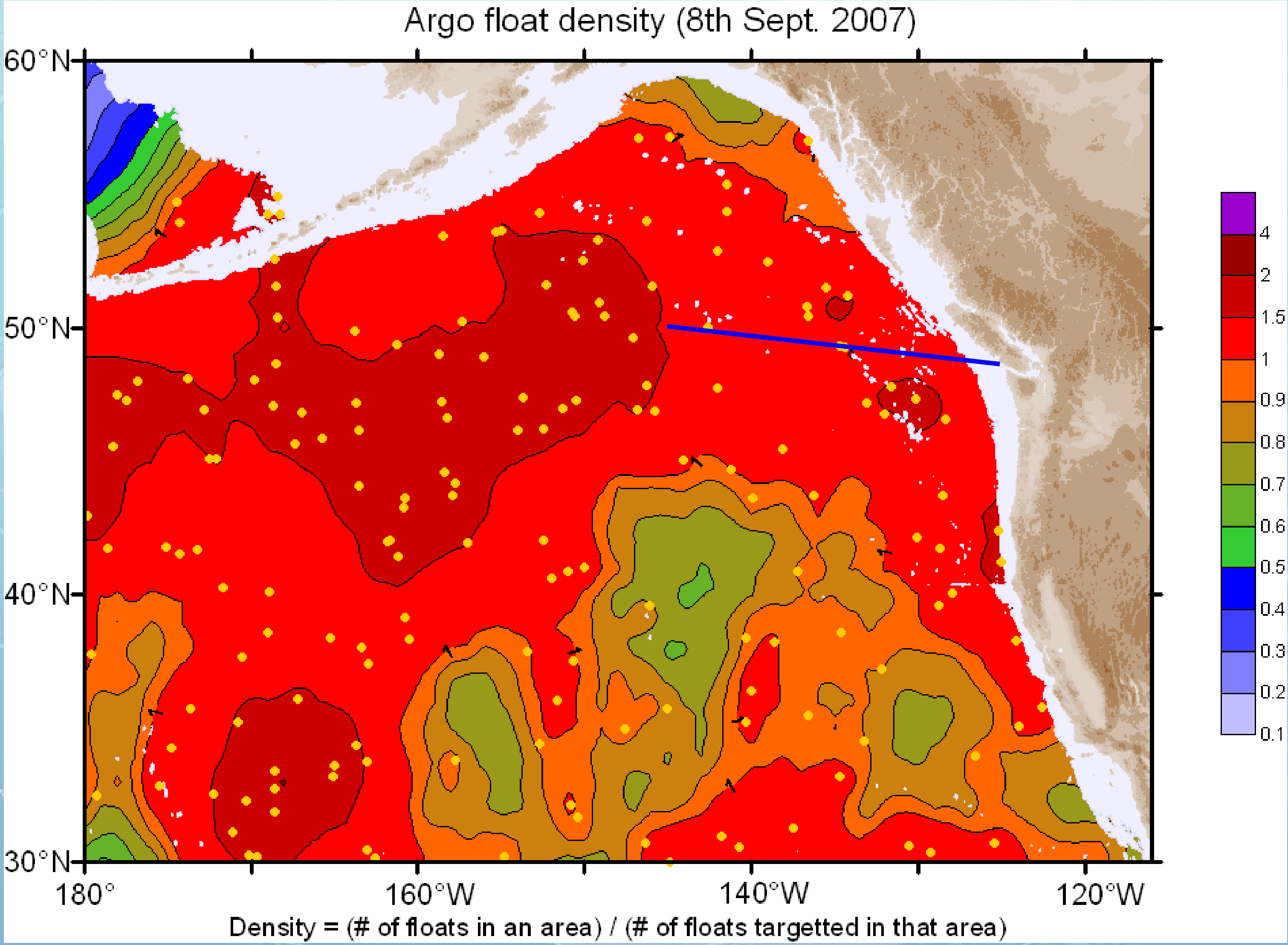


Methods……

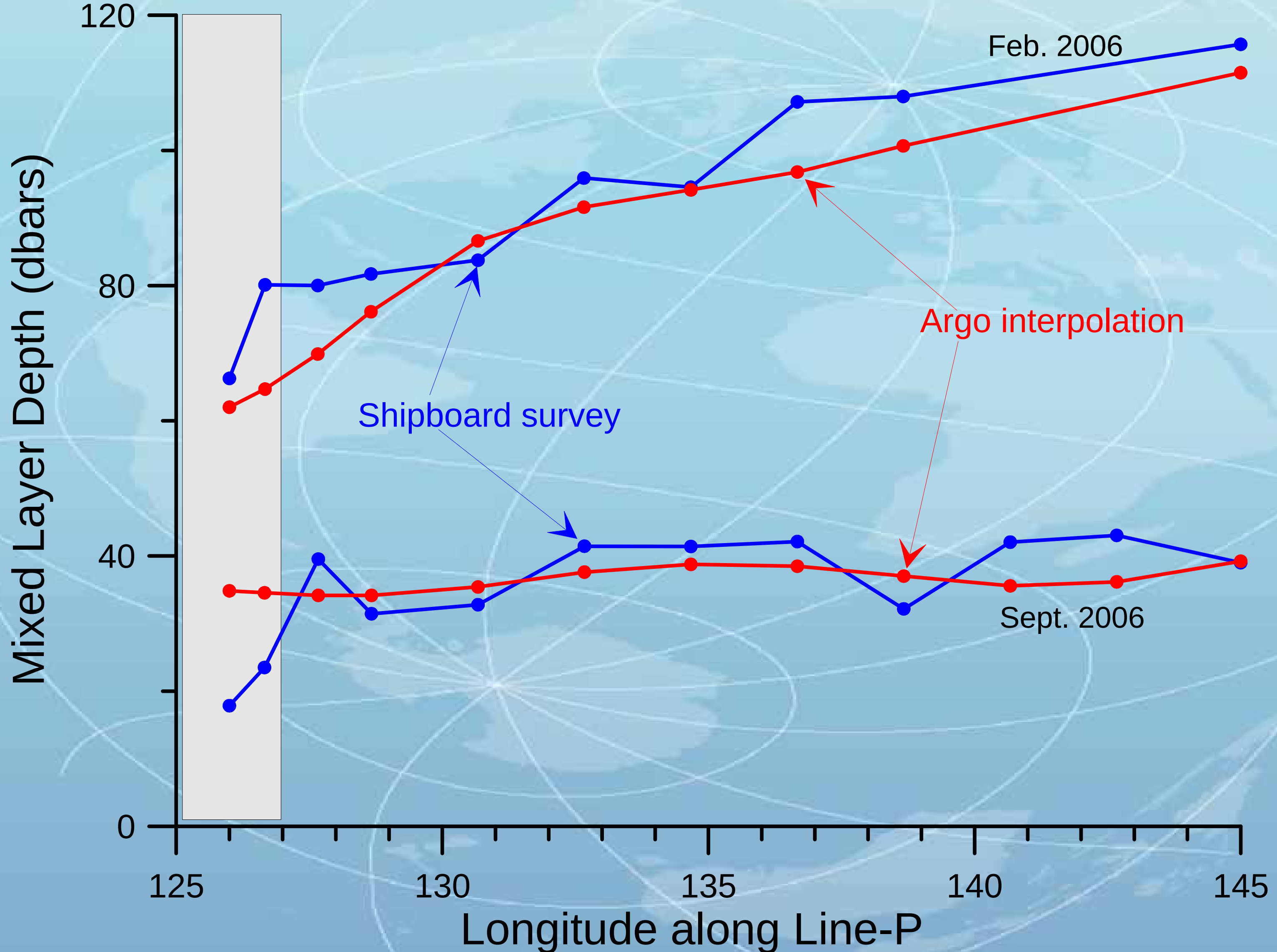
1) Floats are examined by month, thus each float might report up to 3 times during the mapping period.

2) At each float location MLD was computed using "Kara's Method". This involves applying a density threshold determined by a temperature threshold applied to surface T and S values. Hence the density threshold varies slightly with season.

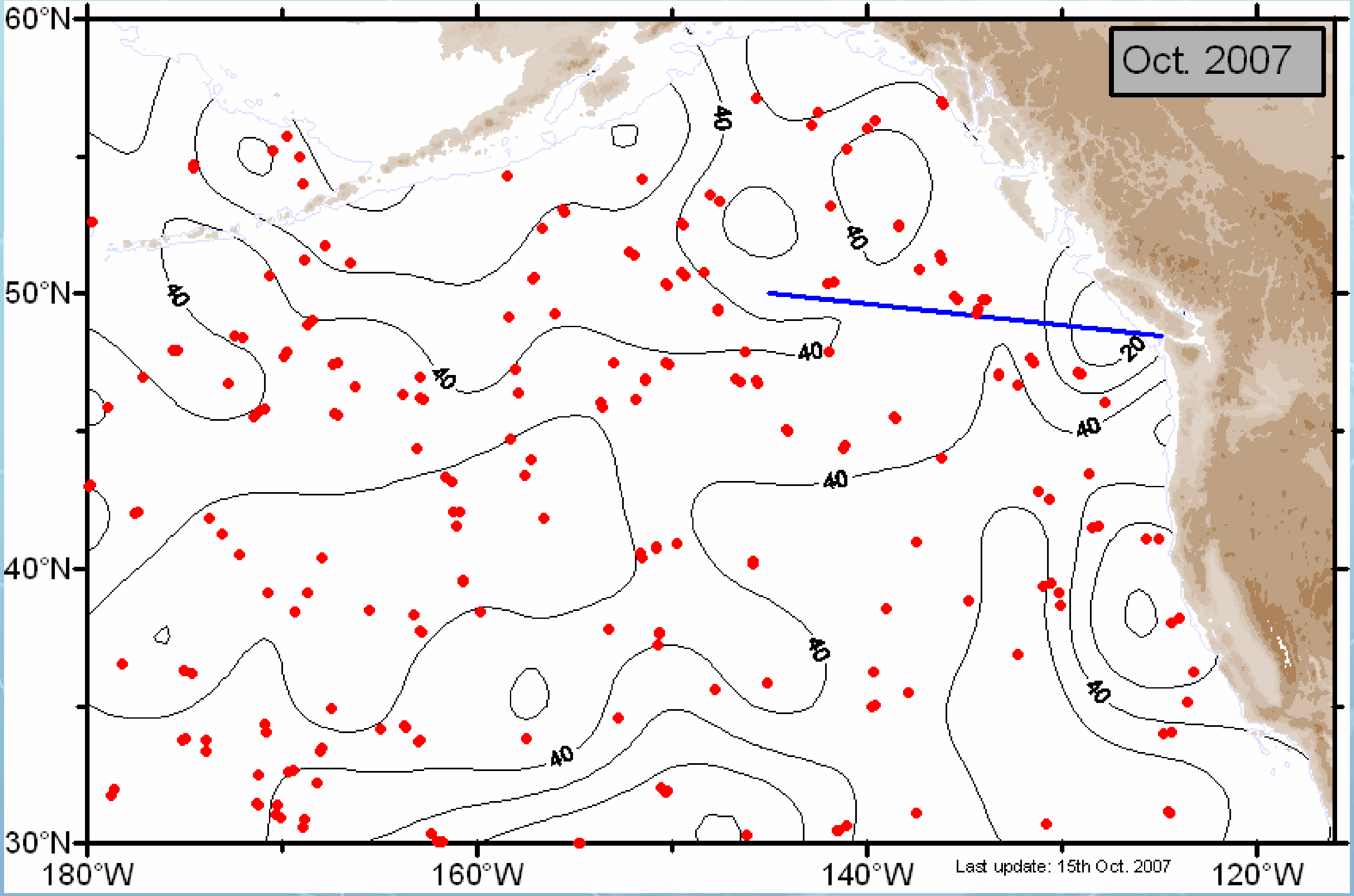
3) MLD is then gridded using optimal interpolation (a.k.a. Objective analysis, or Gauss-Markov Theorem). This has the nice property of yielding an expected-error field in a very natural way. The imposed correlation function is Gaussian $(1 + \varepsilon^2)\exp(-\rho^2/R_0^2)$ where R_0 = 400 km and $\varepsilon^2 = 0.1$, initially at least, it can go to 0.11 or 0.12 using a "ridge regression".

The MLD maps are for a 31-day window centred on the 15th of each month which is considerable averaging, but how well do these match Line-P observations?

The Argo maps are one month wide which is considerable averaging, but how well do these match Line-P observations?



Maps emerge of the MLD Distribution



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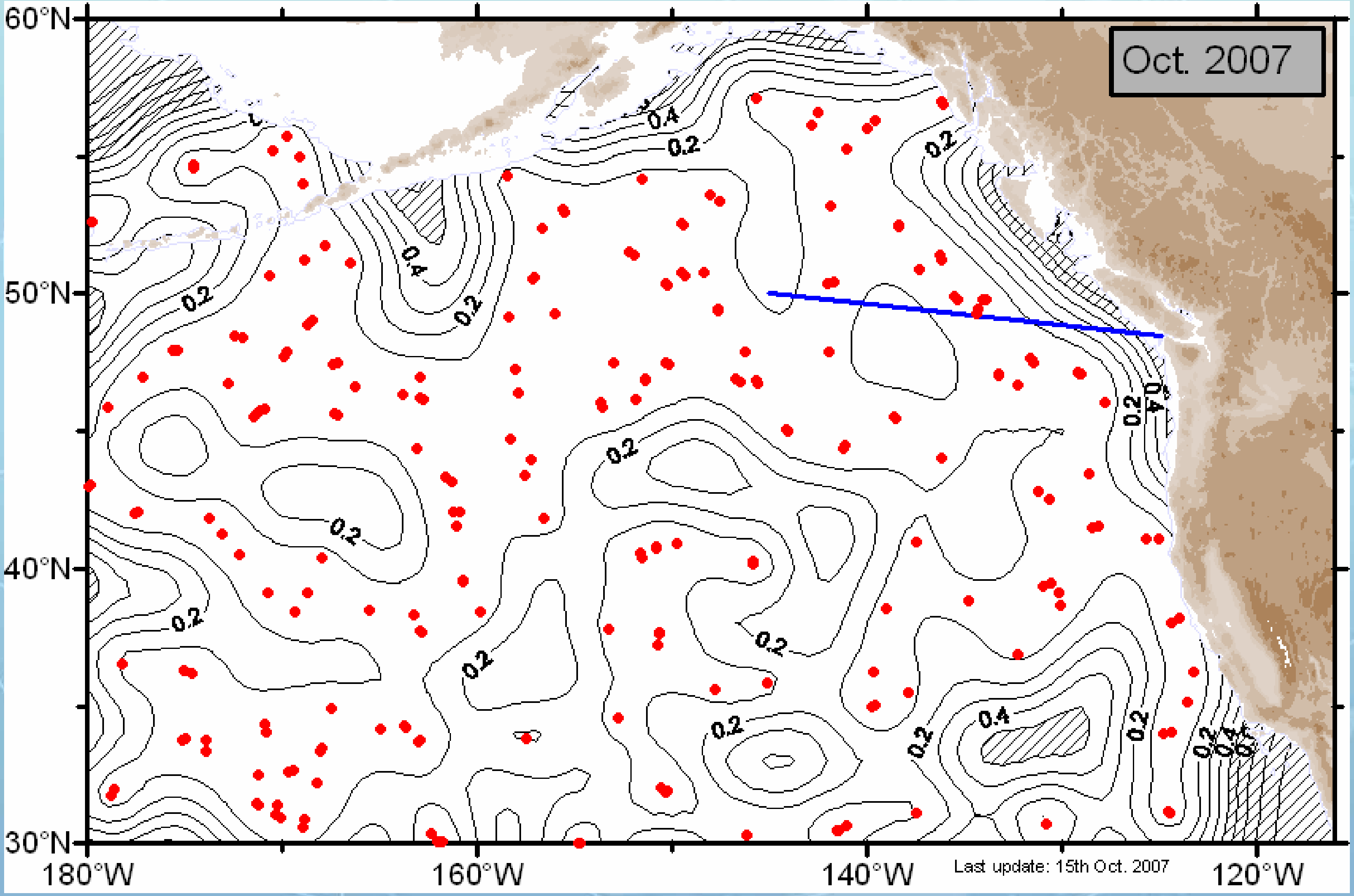
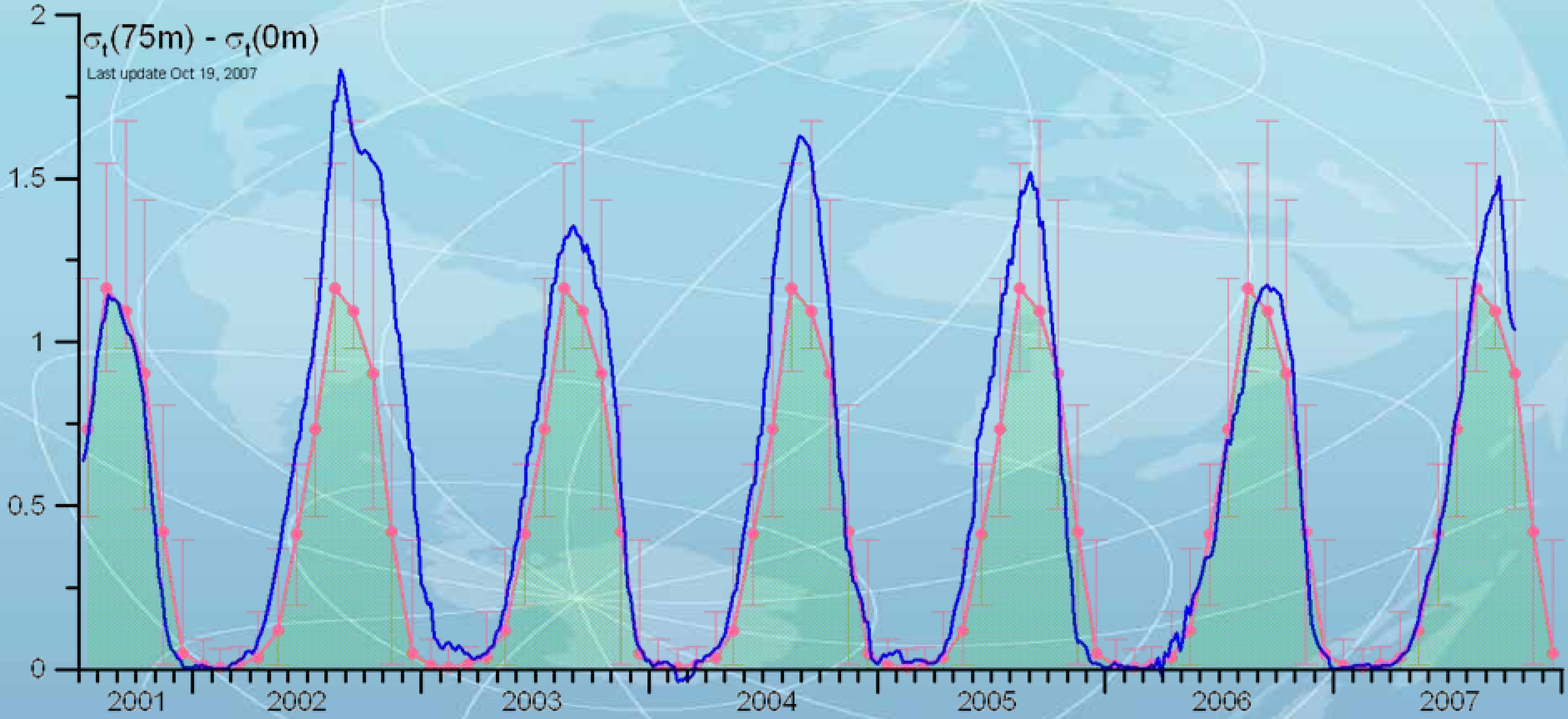
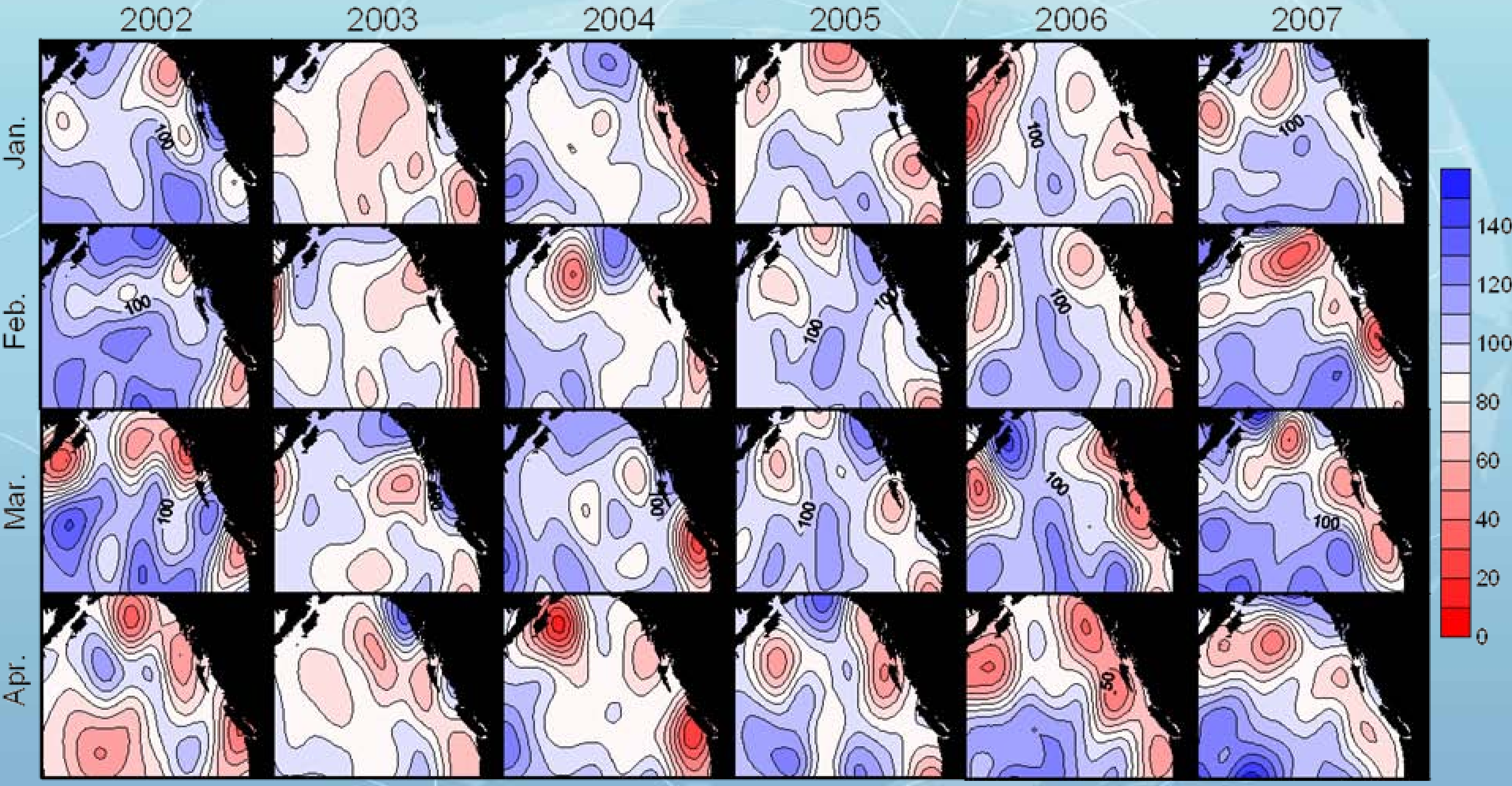
…and of the expected error field



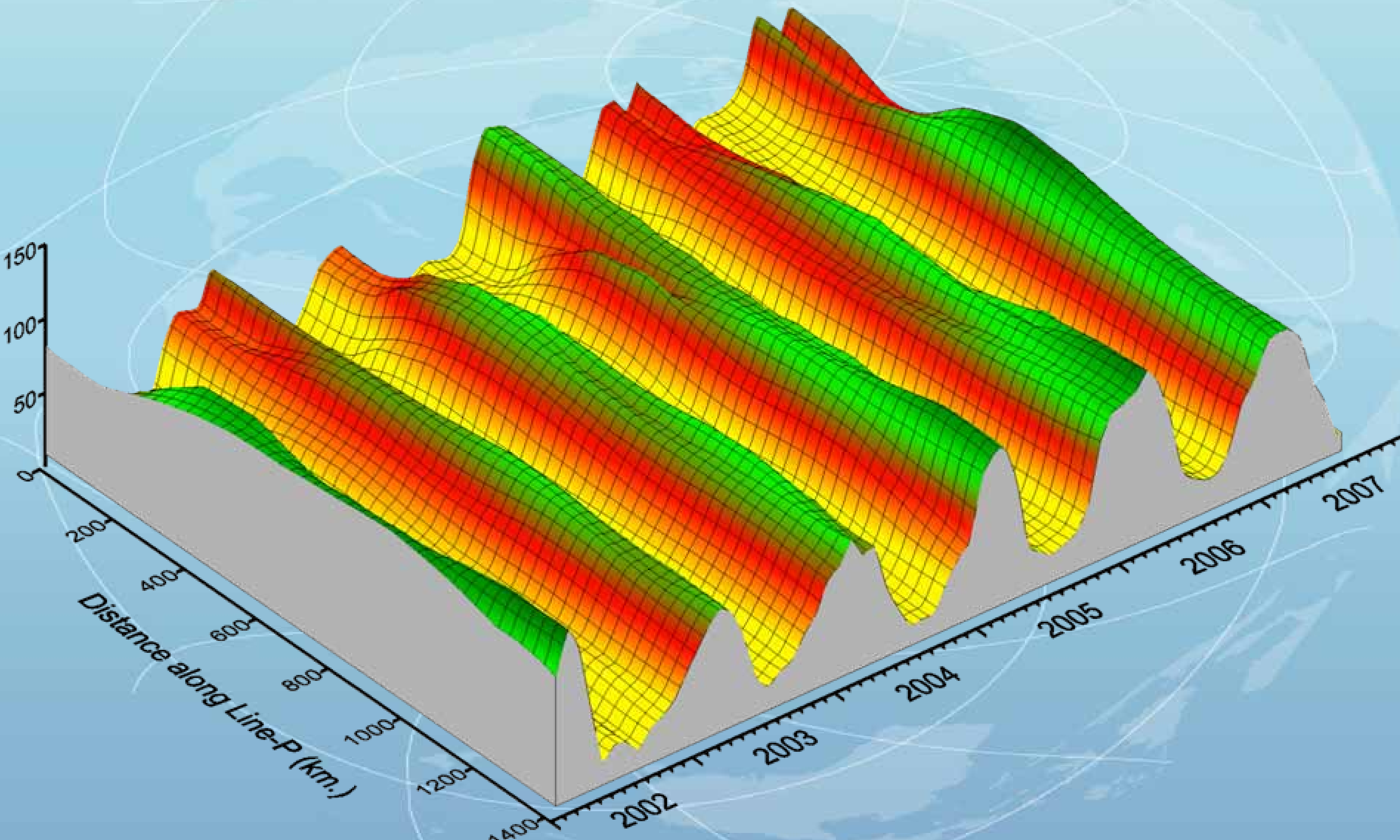
In some recent years the stratification of the upper ocean in the Gulf of Alaska has been unusually high



Mid-winter mixed layer depth in the GAk



Mid-winter mixed layer depths along Line-P



What drives MLD variability?

Capotondi, Alexander, Deser and Miller. 2005 – Low frequency pycnocline variability in the Northeast Pacific.

They point out that the winter MLD in the NE Pacific is close to the pycnocline depth and look at a simple model of variability and compare results with a numerical model. How does this work with real observations?

What drives MLD variability?

Capotondi et al suggest a simple Markov model:-

$$\frac{dh}{dt} = -W_e - \lambda h$$

This implies that MLDs (h) lead the Ekman upwelling velocity by an amount that varies with frequency and a frictional time-scale $T_f = \lambda^{-1}$, specifically, phase lag is:-

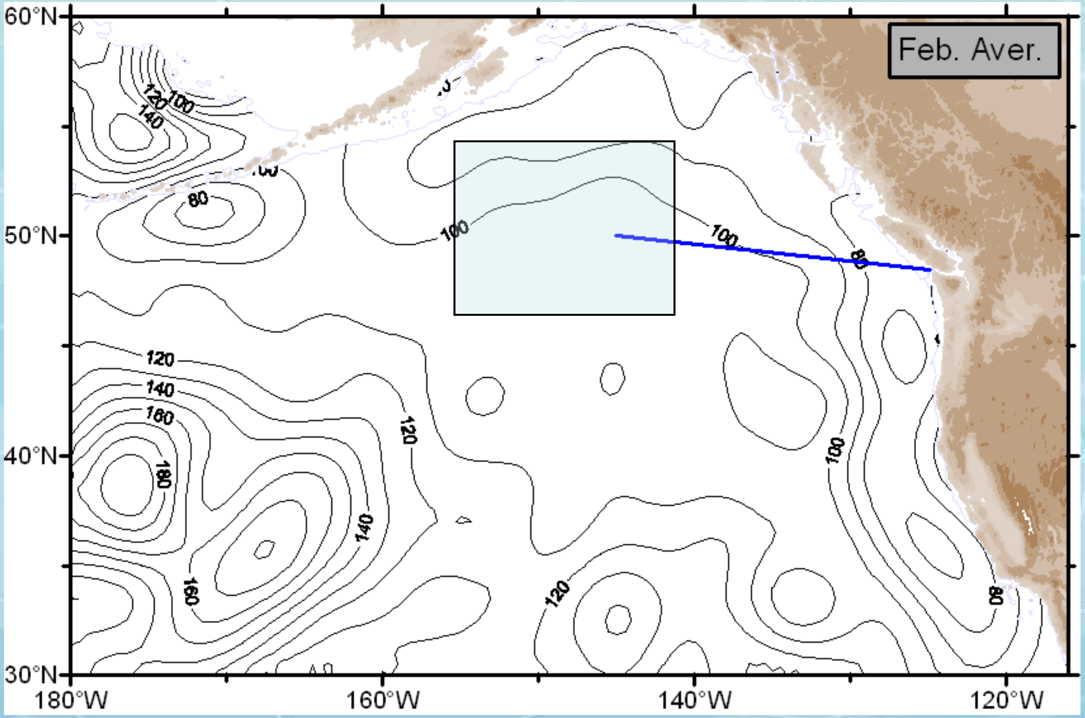
$$\Phi = \arctan(\omega\lambda^{-1}) = \arctan(2\pi T_f / T_s)$$

Estimates of T_f vary between 12 months and 16 months.

Case 1 (HF): $2\pi T_f/T_s$ is large, phase lag = π/2 = quadrature
we expect zero corrln at zero lag and large corrln at 90° phase lag.

Case 2 (LF): $2\pi T_f/T_s$ is small, phase lag = 0
we expect large negative correlation at zero lag.

What drives MLD variability?



Compute JFM averages of W_e and MLD at the above locations for the winters of 2001, 2, 3, 4, 5, 6 7 and correlate them.

Lag (years)	Correlation	Deg. of freedom	Conclusion
+1	+0.04	6	no relationship, as expected
0	-0.09	5	either random or in quadrature
-1	+0.59	6	physically implausible

What drives MLD variability?

Conclusion?

The standard Capotondi et al model does not explain the variability of MLD in the Gulf of Alaska over the last 6 years.

Hypothesis: I know the time series is short and the statistics are dominated by the unusual advective event of the winter of 2002/03, perhaps the lack of any plausible relationship is due to the influence of that one event.

Perhaps the advective events are typical, in which case the Capotondi et al model is not a good model of the variability in the Gulf of Alaska.