A Southern Ocean variability study using the Argo-based Model for Investigation of the Global Ocean (AMIGO)

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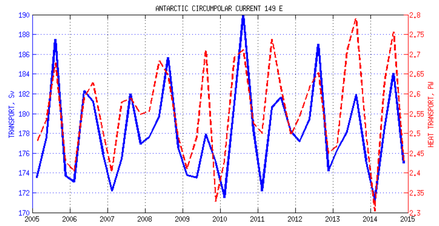
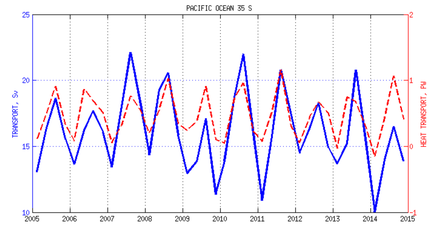
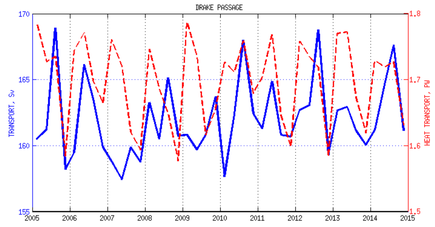
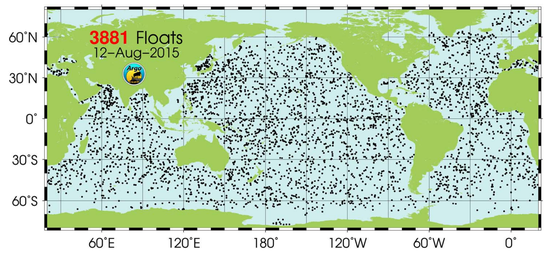
The AMIGO is a new P.P.Shirshov Institute of Oceanology numerical atlas, providing global maps of ocean variables to support the scientific community with near-real time, globally unified, user friendly, research quality dataset. The model uses Argo data to diagnose monthly one-degree global ocean temperature, salinity, and velocities best agreeing with Argo profiles and Aviso altimetry. Argo profiles variationally interpolated onto a vertical and horizontal grid are combined with the WOA09 climatology for layers below 2000 m and ECMWF winds into an ocean general circulation model (OGCM) to produce three-dimensional temperature, salinity, and velocities fields in the global ocean. The principle of the variational interpolation technique is to minimize the misfit between the interpolated fields defined on a regular grid and the irregularly distributed data, so the optimal solution passes as close to the data as possible. OGCM's data analysis is performed in two steps. At the first step the model velocity field is adjusted to the Argo-based T/S fields via forcing model equations of motion by the corresponding steady state winds and integrating them forward in time until all the fast transient processes are dumped. After that the full model is allowed to evolve freely under the stationary forcing fields at the surface. The integration is terminated after 10-30 days. This time is sufficient to remove fast trends from the solution. On the other hand the solution does not deviate too far from data.







Over the past decade, Argo floats have provided an unprecedented number of temperature and salinity profiles of the global ocean and revolutionized the distribution of ocean data within the scientific community. The original design of the Argo mission specified nominal 3 x 3 degree spacing, providing the most extensive and uniformly distributed dataset of oceanographic measurements ever. The array was 100% complete by November 2007. Today there is a global array of more than 3,800 free-drifting floats measuring the temperature and salinity of the upper 2000 m of the ocean with a 10-day sampling interval.



Argo is an international collaboration that collects high-quality temperature and salinity profiles from the upper 2000m of the ice-free global ocean and currents from intermediate depths. The data come from battery-powered autonomous floats that spend most of their life drifting at depth where they are stabilized by being neutrally buoyant at the "parking depth" pressure by having a density equal to the ambient pressure and a compressibility that is less than that of sea water. At present there are three models of profiling float used extensively in Argo. All work in a similar fashion but differ somewhat in their design characteristics. At typically 10-day intervals, the floats pump fluid into an external bladder and rise to the surface over about 6 hours while measuring temperature and salinity. Satellites determine the position of the floats when they surface, and receive the data transmitted by the floats. The bladder then deflates and the float returns to its original density and sinks to drift until the cycle is repeated. Floats are designed to make about 150 such cycles.

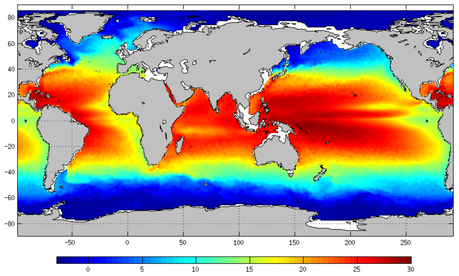
(1) The Variational Interpolation (VI) technique is used to spatially interpolate Argo data. The principle of the VI technique is to minimize the misfit between the interpolated fields defined on a regular grid and the irregularly distributed data, so the optimal solution passes as close to the data as possible.

Cost function

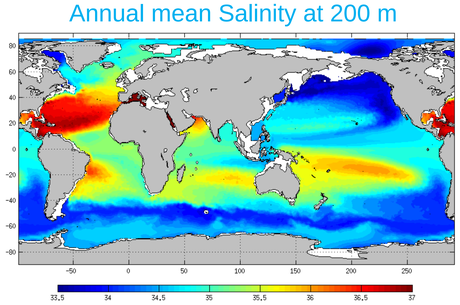
$$F = \sum_{n \in L} \left(A_{g-d}{}^{n} - A_{d}{}^{n}\right)^2 + C_1 \sum_{i,j} \left(A_{g}{}^{i,j} - A_{c}{}^{i,j}\right)^2 + C_2 \sum_{i,j} \left(\left(dX^{j}\right)^2 \Delta A_{g}{}^{i,j}\right)^2,$$

"A" is an Argo variable to be gridded (T or S)

Annual mean Temperature at 75 m



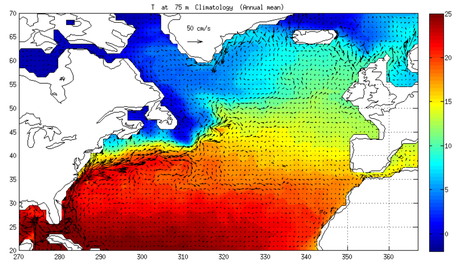
Annual mean Salinity at 200 m



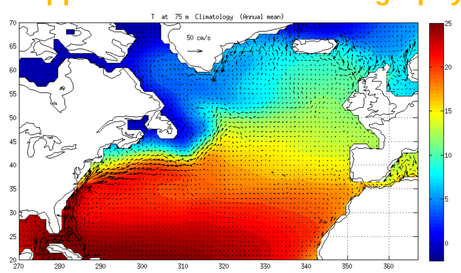
(2) The OGCM's data analysis is performed in two steps. At the first step the model velocity field is adjusted to the Argo-based "frozen" T/S fields. After that the full model is allowed to evolve freely under the stationary forcing fields at the surface. The integration is terminated after 10-30 days. This time is sufficient to remove fast trends from the solution.

Variational Interpolation technique (**AMIGO** data) versus Optimal Interpolation (**Scripps** Institution of Oceanography data) and objectively analyzed fields (NOAA **World Ocean Atlases** 2013 and 2009)

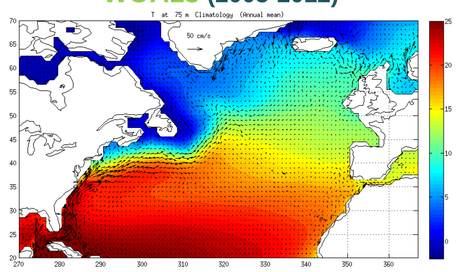
AMIGO



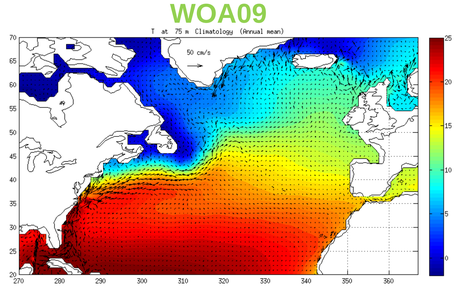
Scripps Institution of Oceanography



WOA13 (2005-2012)



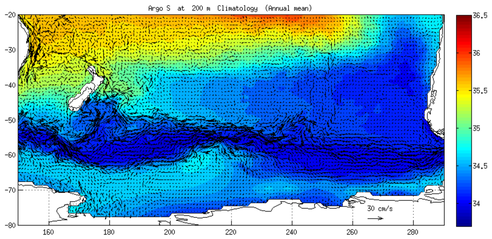
WOA09



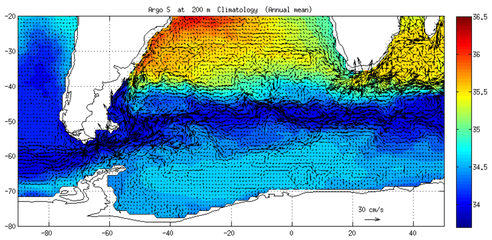
North Atlantic annual mean temperature and currents at 75 m

Southern Ocean mean salinity and currents at 200 m

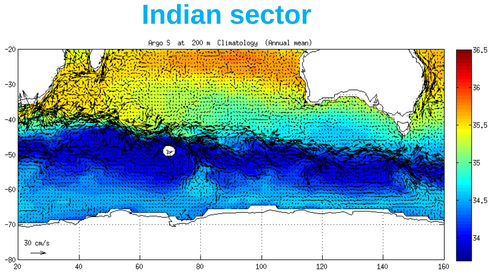
Pacific sector



Atlantic sector



Indian sector



REFERENCES:

K.V. Lebedev (2016): An Argo-Based Model for Investigation of the Global Ocean (AMIGO) Oceanology , 2016, Vol. 56, No. 2, pp. 172-181.

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