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Ocean Salinity Stratification during the 2002-2016 period as derived from the ISAS13 Argo atlas

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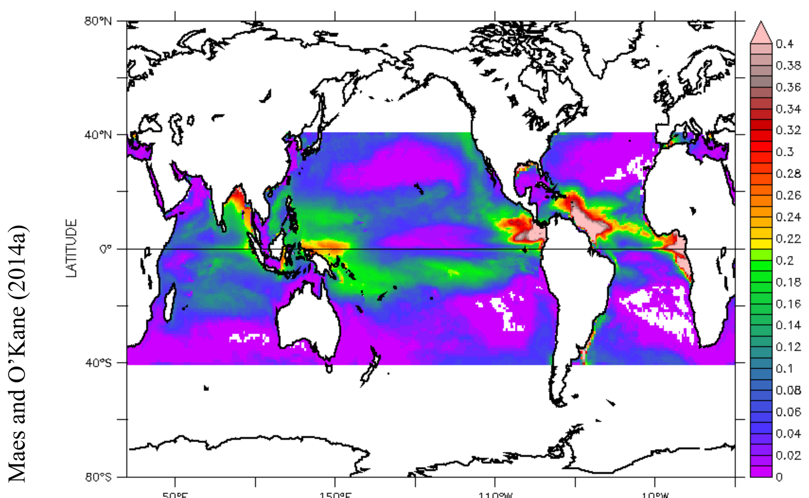
⦿ MOTIVATIONS

From the salinity stratification in the Tropics…

From the studies by Maes (2008) and Maes and O'Kane (2014a, b), we propose to follow the perspective and methodology for describing the impact of the salinity on the static stratification of the oceanic upper layers. This perspective recognizes that the stabilizing effect of the salinity operates near the bottom of the mixed layer but that its effect could be expanded down to the main pycnocline, and to regions where both the salinity and temperature are mixed over the same depths. Hence, we consider a methodology that treats the salinity stratification in a simple partitioning of the thermal and haline effects in the vertical profiles of $N^2(T, S)$, the Brunt Väisälä frequency (see on the right). Note that, in contrast to the classical approach of the salinity barrier layer, the Ocean Salinity Stratification (OSS) retains the idea of a single definition for the OSS as the part of the stabilizing effect due to salinity, whatever the counterpart of the temperature effect could be.



OSS (cph)

In the following, the ocean salinity stratification (OSS) is defined in terms of the difference between $N^2(T, S)$ and $N^2(T)$ thereby allowing the identification of the layer where the salinity stratification has its greatest impact on buoyancy in terms of stabilizing the water masses [*Maes*, 2008]. Specifically, we define OSS as the vertical mean average of positive $N^2(S)$ over the upper 300 m depth range, i.e.,

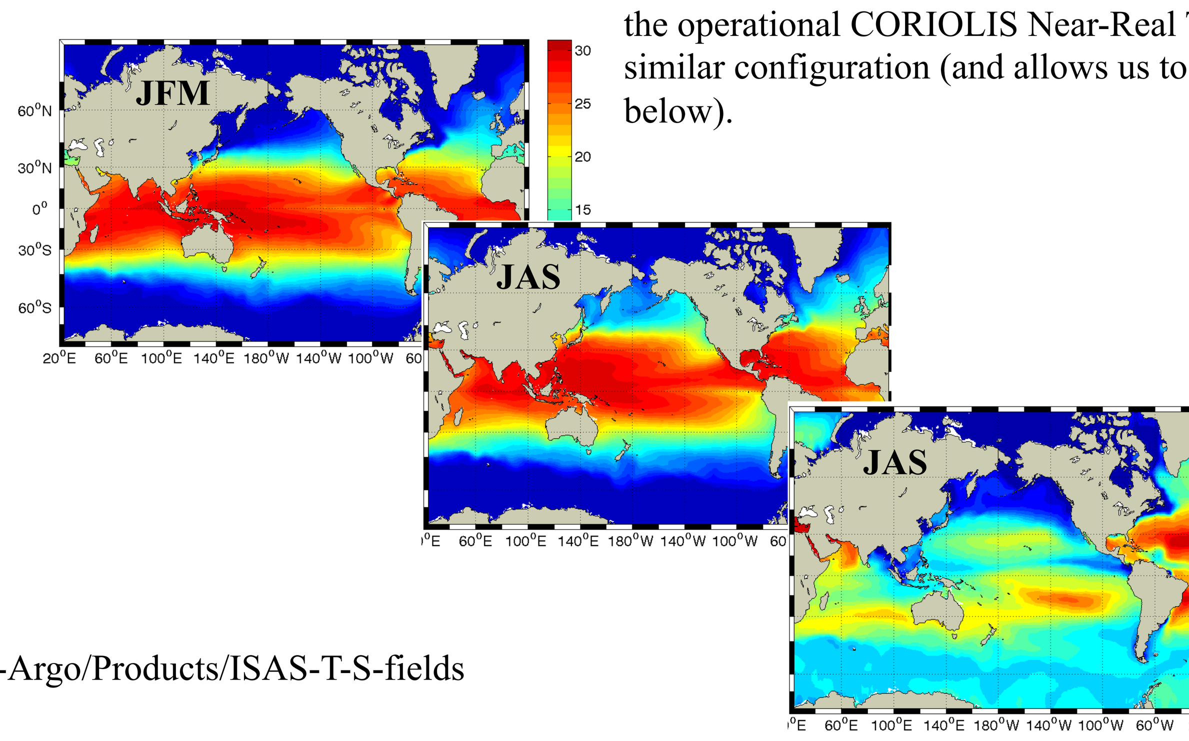
$$OSS = \langle N^2(T,S) - N^2(T) \rangle_{0-300m}$$

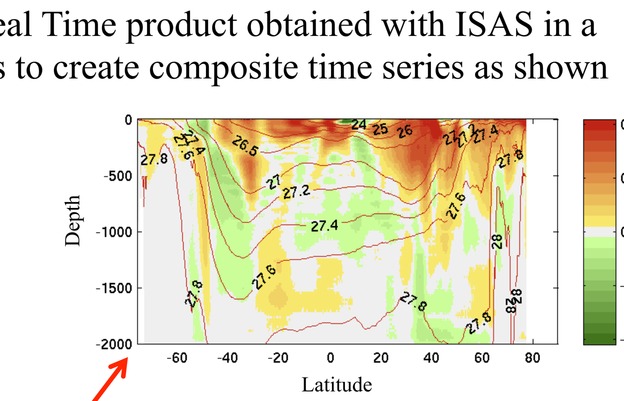
where

$$N^2(T,S) - N^2(T) > 0$$

… to global perspectives

The In Situ Analysis System (ISAS) was developed to produce gridded fields of temperature and salinity that preserve as much as possible the time and space sampling capabilities of the Argo network of profiling floats. ISAS produces global monthly fields from Argo data merged with observations from other networks, on a 0.5° grid and with a vertical resolution of 152 levels from 0 to 2000m. ISAS is based on an optimal estimation method (OI), it is developed and used in research at LPO in close collaboration with Coriolis data centre, one of the Argo Global Data Assembly Center (GDAC). ISAS13 is a re-analysis of the 2002-2012 period made at LPO. NRTOA is the operational CORIOLIS Near-Real Time product obtained with ISAS in a similar configuration (and allows us to create composite time series as shown below).

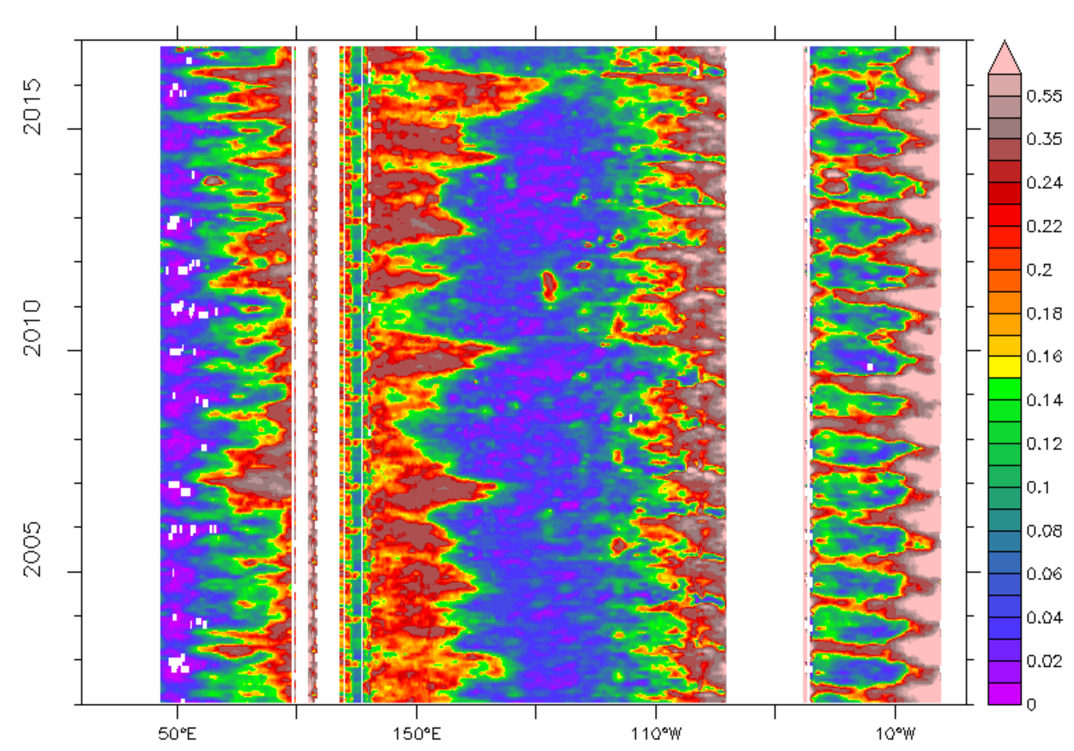




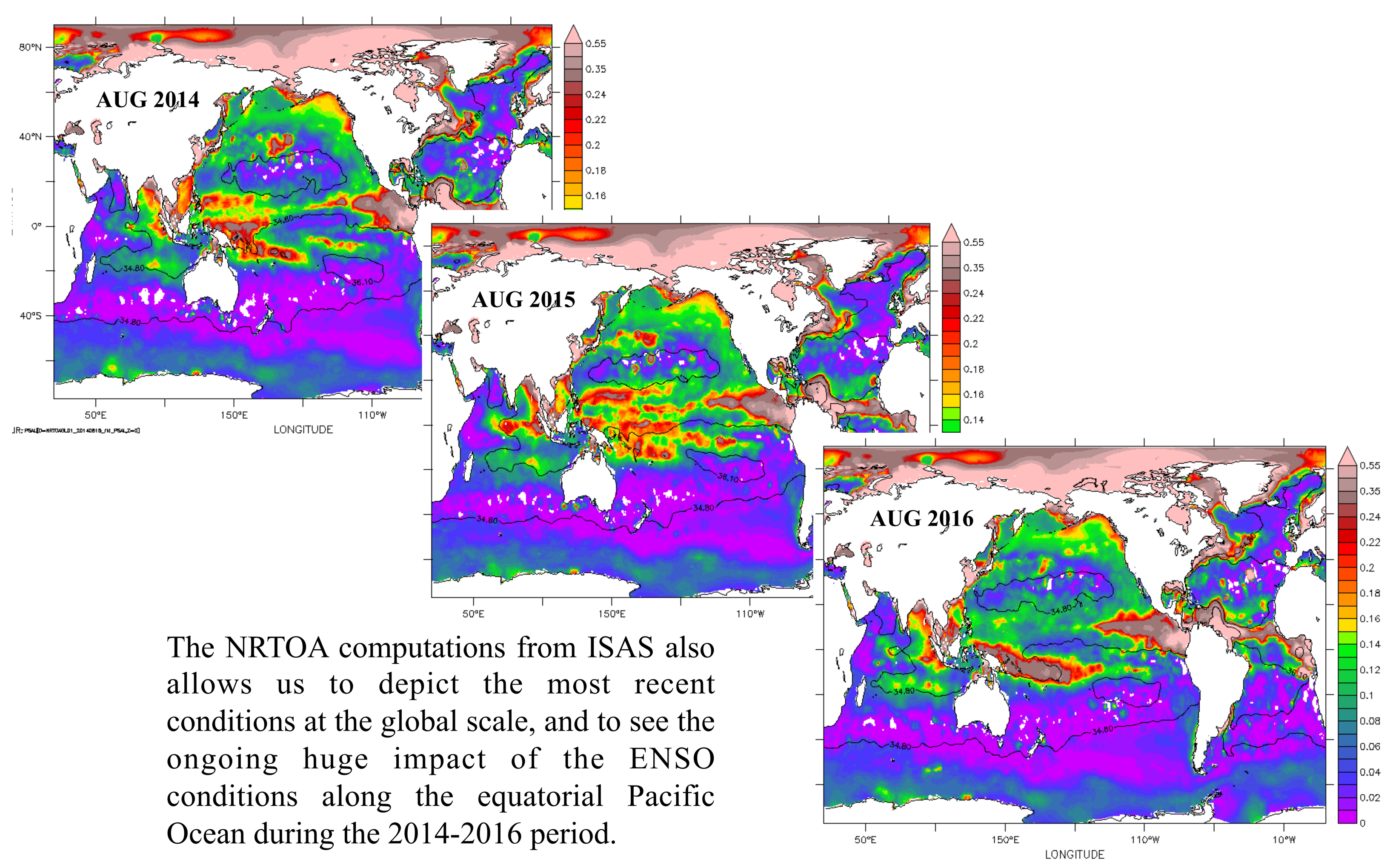
Vertical section of salinity anomaly across the Atlantic Ocean

http://wwz.ifremer.fr/lpo/SO-Argo/Products/ISAS-T-S-fields

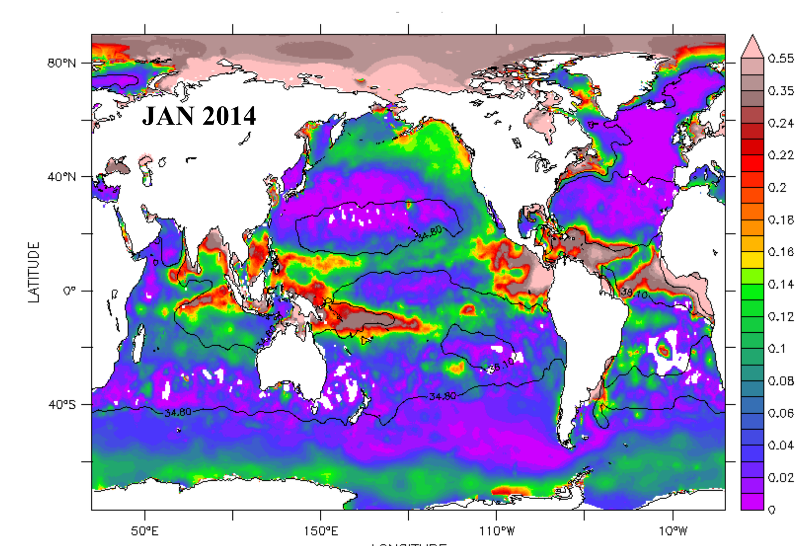
⦿⦿ VARIABILITY OF THE OCEAN SALINITY STRATIFICATION FROM ISAS-13



The OSS field has been designed to understand the behavior of the western Pacific Warm Pool (WPWP) edge, and in particular the imprint of the ENSO variability. As expected, the variability in such a region is large and zonal displacements could be associated with the interannual variability (see the Niño3.4 index). Note also that both other basins exhibit some important variability at interannual time scales.



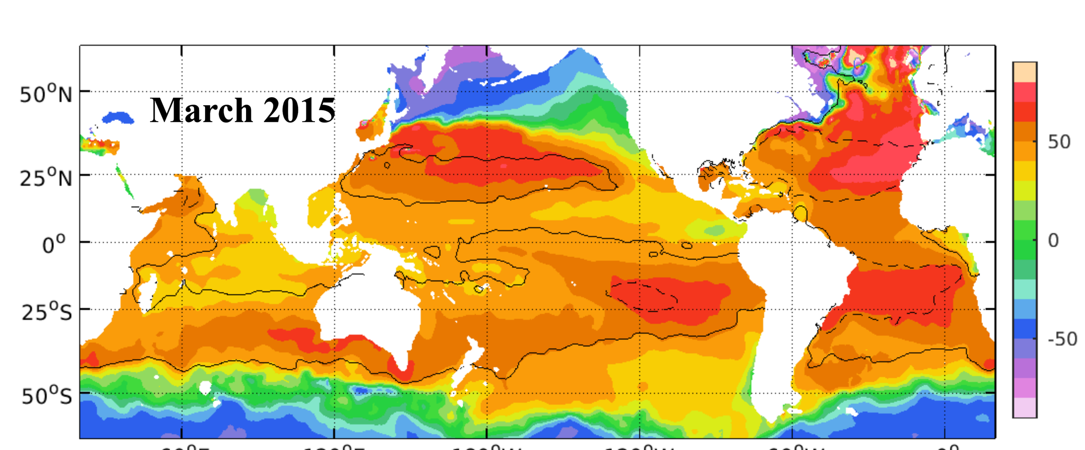
The NRTOA computations from ISAS also allows us to depict the most recent conditions at the global scale, and to see the ongoing huge impact of the ENSO conditions along the equatorial Pacific Ocean during the 2014-2016 period.

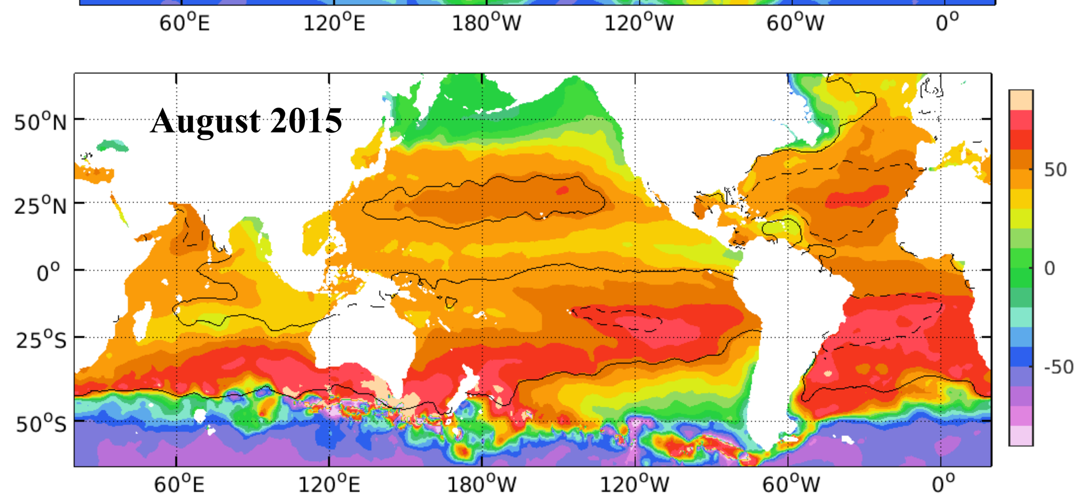


The ISAS products exhibit a variability at the seasonal time scales that is comparable to the previous results reported by Maes and O'Kane (2014a). The extension at global scales show that there are also some interesting signals outside of the tropical band, especially in the north-eastern Pacific region as well as in the Arctic Ocean.

Note : all the OSS fields are plotted in cycle per hour (cph), and the black lines show the contours at 34.8 and 36.1 for the Sea Surface Salinity.

⦿⦿⦿ THE COMPENSATED STRATIFICATION PART





←Bulk Turner Angle in the upper 300m depth as computed with ISAS during March 2015 (boreal winter, upper panel) and August 2015 (austral winter, lower panel); black lines are identical to the above figures.

The Turner angle, **Tu,** is closely related to the density ratio $\mathbf{R_\rho}$. The Turner angle represents a measure of the relative contribution of salinity and temperature related stratification to the density stratification. Here is shown a computation of the bulk Turner angle within the 300m depth following Kolodziejczyk and Gaillard (2012):

$$Tu_b = atan\left(\frac{\alpha\,\Delta_{300}T + \beta\,\Delta_{300}S}{\alpha\,\Delta_{300}T - \beta\,\Delta_{300}S}\right)$$

where $\Delta_{300}T$ and $\Delta_{300}S$ are the differences between surface (10m depth) and 300m depth temperature and salinity, respectively; α and β are the upper 300m averaged thermal expansion and haline contraction coefficients.

Tu (-90°<Tu<90°) range/ related stratification:	$\partial_z T$	$\partial_z S$
Tu<-45°	Destabilizing	Stabilizing
-45°<Tu<45°	Stabilizing	Stabilizing
45°<Tu	Stabilizing	destabilizing
Tu → 90°	**~Compensated**	**~Compensated**

The bulk Turner angle indicates the different regimes of thermohaline vertical gradients within the upper ocean. Within the mid-to-low latitudes, Tuner angles are generally higher than 20°, indicating that the upper ocean stratification is mainly maintained by the temperature gradient. In the subtropical regions, in particular during winter of both hemispheres, Turner angles larger than 60-70° indicate large compensation by the destabilising salinity gradient. This regime is associated with low stratification favouring convection and subduction of water masses (Kolodziejczyk et al., 2012, 2013, 2014, 2015). In high latitudes, vertical salinity gradient acts to stabilize while vertical temperature gradient destabilizes.

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⦿⦿⦿⦿ PERSPECTIVES

Perspectives of this work include:

-Study the variability of the OSS in relation with the climatic variations at the global scales

-Replace the variations of the OSS in a dynamical framework

-Determine the importance of the unstable part of the stratification due to temperature or salinity, and regions potentially impacted by convection and subduction of the water masses.