Salinity and Water Cycle: The Canary Current, its role in the North Atlantic Subtropical salinity maximum freshwater budget

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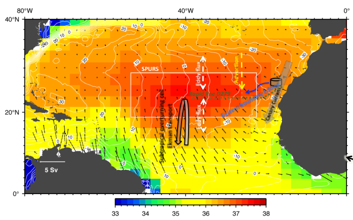
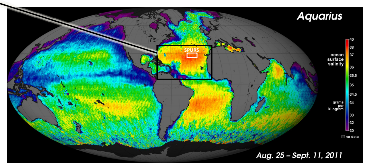
AQUARIUS
Sea Surface Salinity from Space



Ekman transport vectors in Sverdrups (1 Sv = 10^6 m^3s^{-1}) and contours (every 5 cm) of mean dynamic ocean topography (MDOT) of the sea surface. The long-term mean SSS is in color. Ekman transports were computed across 2.5x2.5 latitude-longitude cells using long-term mean wind stresses based on ECMWF-ERA-40 monthly data. SSS (average salinity of the upper 20m) was computed from the World Ocean Atlas 2009 (WOA09). The green dots show the Discovery RAPID cruise D279 station positions analyzed in this study.

Schematic of the processes within the SPURS area that may be associated with balancing on a yearly time scale the sea-air net evaporation-precipitation. The cool/fresh features may be eddies or filaments stirred into the SSS-max region by the energetic mesoscale eddy field of the region. Eddies that are projected out of the Eastern Boundary Current are observed by satellite altimeter to move WSW. That water once blended into the regional stratification may be carried by the northward Ekman transport into the SSS-max region.



The first global map of sea surface salinity produced by NASA's Aquarius instrument. Image credit: NASA/GSFC/JPL-Caltech. Boxes show locations of the present study and the SPURS site.

The role of the mesoscale features on the overall hydrological budget of the evaporative subtropical regime will be addressed as part of the 2012/13 Salinity Processes in the Upper-Ocean Regional Study (SPURS) program, and by the Aquarius satellite data.

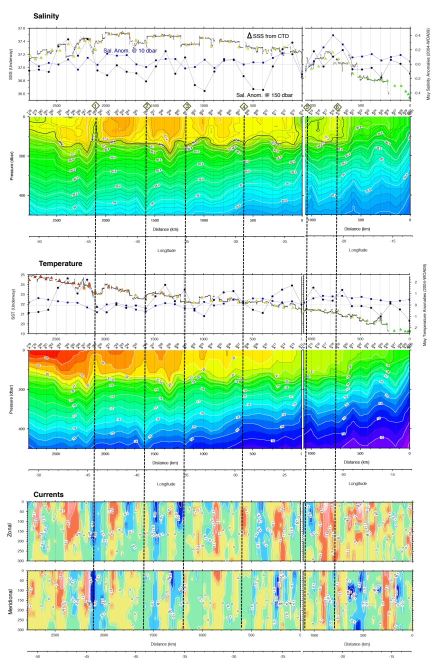
The SPURS field program along with the Aquarius global SSS data will bring a new appreciation of the complexity of the processes within the salty subtropical evaporative regimes.

Abstract: **The North Atlantic subtropical regime is marked by a mélange of eddies, with a general drift towards the west, displaying varied sea surface salinity (SSS). The eddies fluxes may be effective in injecting cool, low salinity surface water into the evaporative, subtropical SSS-max regime, perhaps as important to the overall hydrological cycle as the Ekman convergence and mean circulation. The eddies may enter into the subtropical regime from the cool/fresher northern and warmer/fresher southern boundaries of the SSS-max as well as from the eastern boundary. Here we consider the importance of eddies derived from the cool/fresher upwelling eastern boundary regime of the Canary Current.**

Research ship underway data, with CTD stations, and hull mounted ADCP, cutting across the central region of the North Atlantic SSS-max frequently reveal the presence of eddies and/or filaments relatively cool (~0.2°C), low salinity (~0.15) features, with horizontal scale along the ship track of up to 200 km. The T/S characteristics of these features are consistent with a Canary Current source, as well as contributions from the northern boundary of the SSS-max.

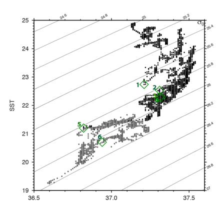
Satellite altimeter data reveal that the eddies drift westward at 3 to 4 km/day. These features may stir filaments of northern cool/fresher surface water into the SSS-max. CTD stations show that the most prevalent of these cool/low salinity surface features extend to at least 50 m. A water column with pure "Canary Current" characteristic (a SSS depression of 1.0 relative to the ambient SSS-max water column to the west) for the upper ~50 m transformed into the low salinity features observed within the SSS-max subtropics, would offset about 1 meter of E-P forcing, which is almost equivalent to a full year of E-P forcing in the North Atlantic subtropics.

The full impact of the subtropical eastern boundary features on the subtropical SSS-max depends on their 'population' and on the rate to which they blend into the resident fluid. We propose that the low salinity eddy field in the SSS-max plays a significant role in the overall salinity [freshwater] budgets of the subtropical SSS-max; its relative importance of the eastern boundary eddies needs to be quantified. This issue will be addressed as part of the 2012/13 Salinity Processes in the Upper-Ocean Regional Study (SPURS) program, and by the Aquarius satellite program.

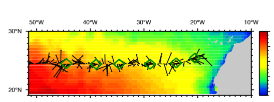


Salinity and temperature sections along ~24°N from the Discovery RAPID Cruise D279, April-May 2004. The upper panel in each parameter is from the underway system (solid black line) taken during the transect, left axis. Triangles represent an average of the upper 10 dbar from CTD data. Also plotted, the salinity anomalies, calculated from CTD relative to the climatological WOA09 May data at 10 dbar (squares) and 150 dbars (circles). On the lower panels, vertical sections from CTD. The sections are broken into a zonal section, on the left panels, from ~51°W to ~23°W and the one from ~23°W to the Canary Islands, on the right panels The green diamonds mark selected cool/fresh 'eddies/filaments'.

Underway hull mounted ADCP (SADCP) data collected during the Discovery 279 cruise. Blue are southward directed currents; red are northward directed currents. Upper panel zonal component and lower panel meridional component.

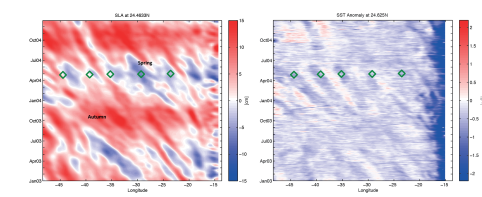


SST/SSS diagram for the D279 underway data. Selected labeled data correspond to the labeled stations on the vertical sections. The black dots correspond to the zonal section and in grey to the "meridional" section up to the coast.

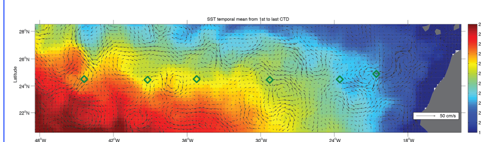


Map of the D279 SADCP current vectors averaged at 20-30 dbar superimposed on the mean SST (AVHRR-AMSR) for 24 April-07 May 2004.

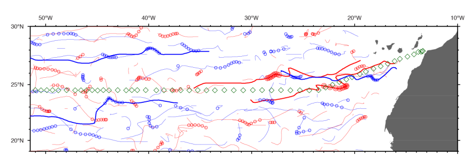
We are investigating a wide range of underway surface ocean data from VOS and research ships. Our objective is to gain a preview, of what the Aquarius data will reveal as well as to provide guidance to the SPURS field program planning.



Hovmoeller diagrams at ~24.5°N : left, Sea Level Anomalies from daily AVISO data; right: daily SST NOAA AMSR-AVHRR-1d anomalies from ~3day low-pass filter in longitude.



Mean geostrophic velocity field from AVISO (global merged daily) satellite altimeter data, averaged for the time of D279, 27 April-2 May 2004. The color pattern denotes SST (NOAA AMSR-AVHRR-1d) averaged for the same period.



Eddy trajectories from AVISO SSH fields (Chelton, et al. 2011) for 2004. Cyclonic (anticyclonic) in blue (red). The green diamonds represent selected stations from the D279 hydrographic section. The red/blue circles mark the trajectories at the time of the cruise. The thick lines denote eddies tracked for a period of time longer than 300 days.

Satellite altimeter data within the North Atlantic SSS-max region reveal an abundance of 'eddies' drifting westward at 3 to 4 km/day. These eddies propagating westward across the SPURS SSS-max area may be effective in injecting cool, low salinity surface water into the evaporative, salty subtropical ocean regime. The low salinity (cool) surface layer features are usually linked to southward currents.

How? Two ways: 1. direct injection of eddies from the eastern boundary current upwelling regime and 2. by eddy induced stirring filaments of cool/fresh water into the SSS-max area from the cooler/fresher northern limb of the subtropical gyre.

The cool/fresh features with a SSS depression of 1.0 relative to the ambient SSS-max, could offset about 1 meter of E-P forcing, which is almost equivalent to a full year of E-P forcing in eh North Atlantic subtropics. Their full impact on the SSS-max depends on their 'population' and on the rate to which they blend into the resident fluid.

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