# Observations for Climate: Sustained Ocean Observing System for Tropical Atlantic Variability

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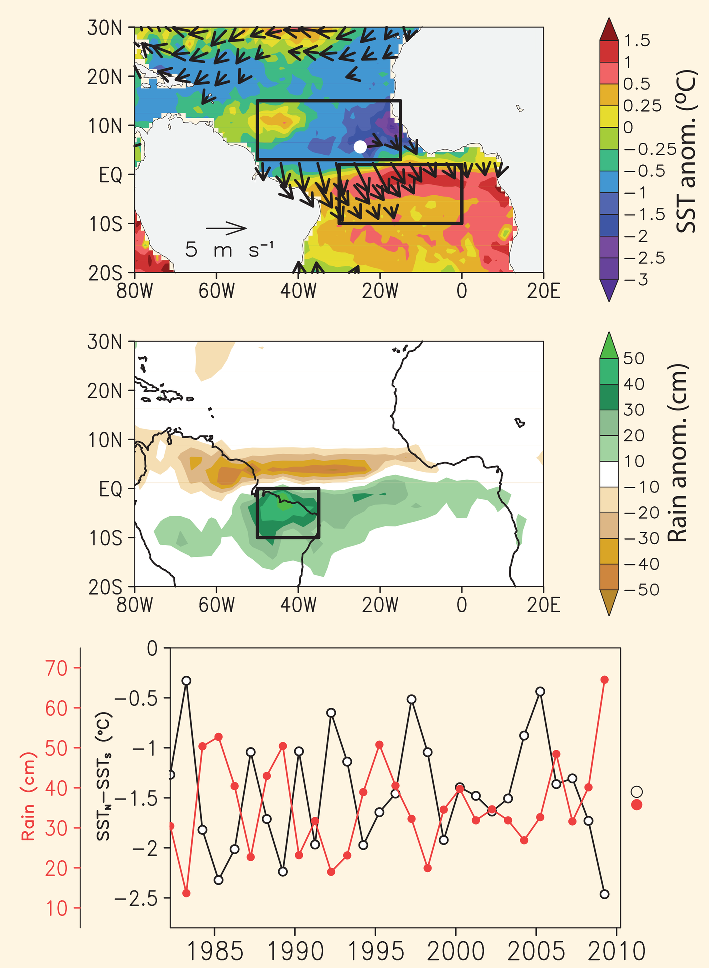
## ABSTRACT

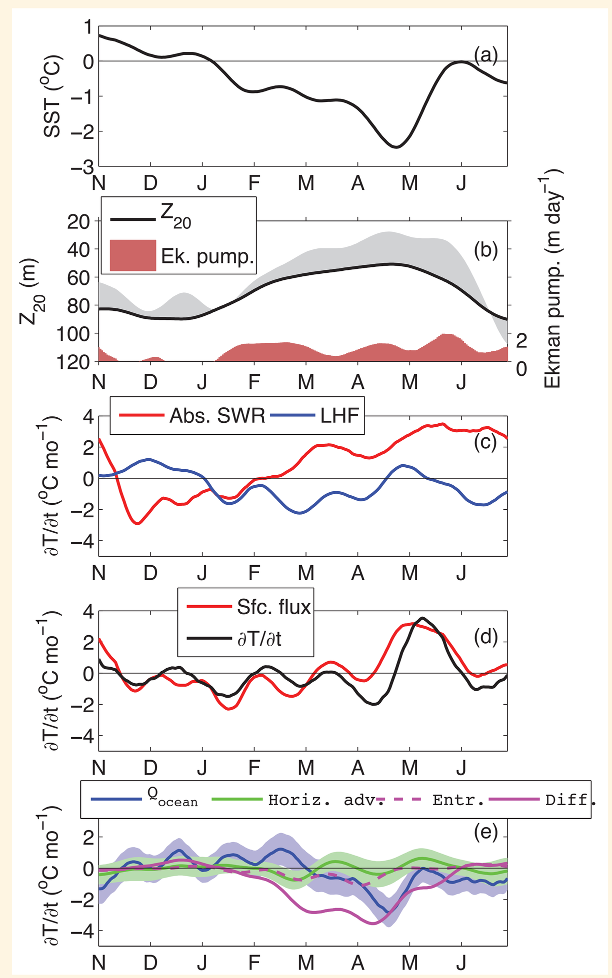
The tropical Atlantic is influenced by two main modes of variability on interannual to decadal timescales: The Meridional Mode and the Zonal Mode. The Meridional Mode is characterized by changes in the meridional gradient of sea surface temperature (SST) across the equator. Coupled ocean-atmosphere variability associated with the Meridional Mode contributes to rainfall variability over Brazil and Africa and affects tropical cyclone development in the North Atlantic. The Zonal Mode is distinguished by irregular warming and cooling of eastern equatorial Atlantic SST. This mode affects rainfall in equatorial Africa and atmospheric circulation in the eastern equatorial Pacific. Both modes are superimposed on a strong annual cycle in the tropical Atlantic

This poster highlights progress made toward understanding the role of the ocean in tropical Atlantic variability, focusing on analyses of measurements from NOAA's sustained ocean observing system. Results show the importance of mixed layer dynamics for the Meridional Mode and emphasize the connection between interannual variability of the wind-driven currents and the Meridional and Zonal Modes. Measurements of ocean circulation in the equatorial Atlantic reveal pronounced interannual variations of tropical instability waves and strong seasonal variability of deep (800-1100 dbar) zonal currents, both of which have implications for understanding SST variability associated with the Zonal Mode.

## 1 Role of mixed layer dynamics in the Meridional Mode

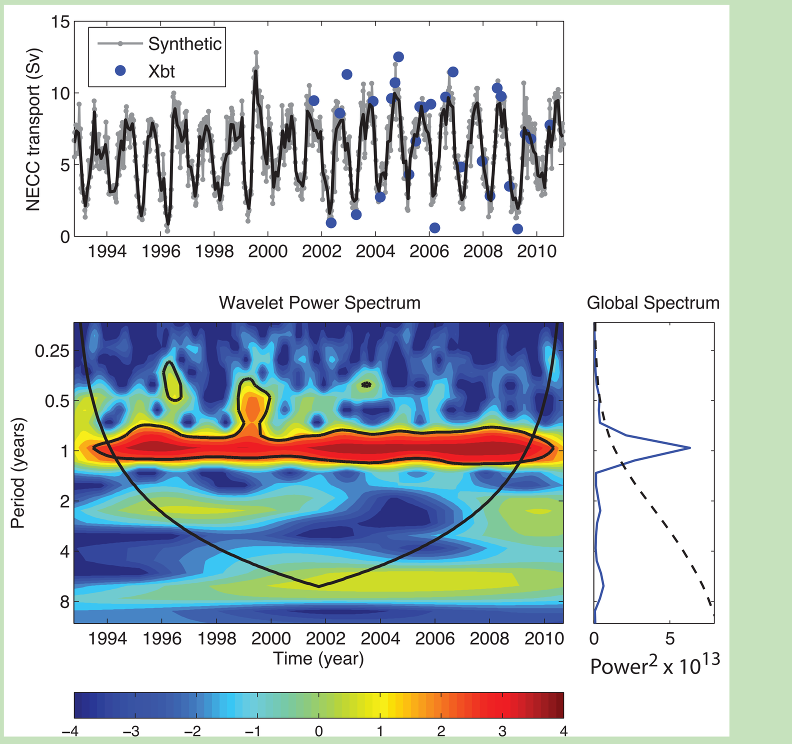



**A strong Meridional Mode event developed in the tropical Atlantic during 2009.** Top two panels show anomalous conditions during the peak of the event in April-May. Bottom shows difference in SST across the equator (average in northern box minus southern box shown in top panel) and rainfall in Northeast Brazil (boxed region in middle panel) since 1982.

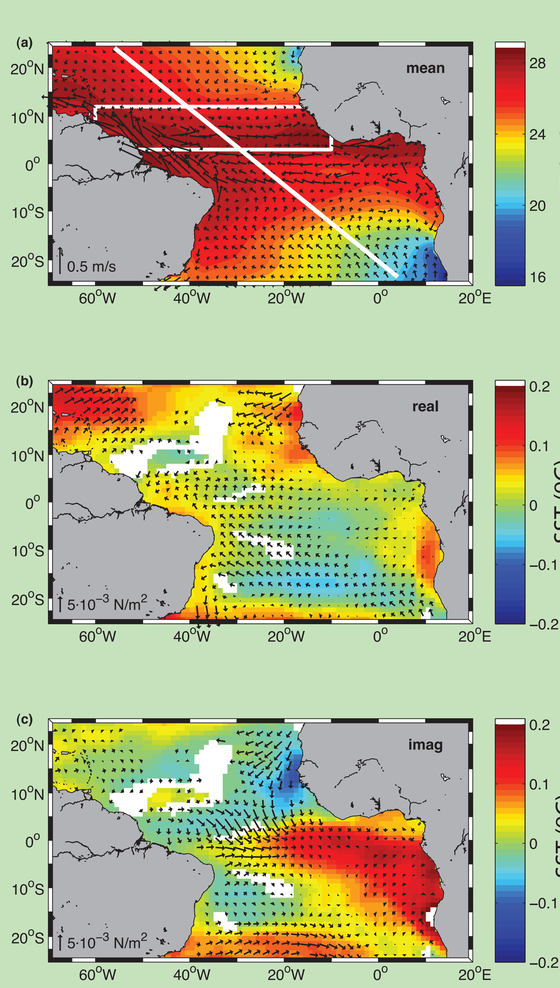



**Measurements from a PIRATA Northeast Extension mooring (white dot in upper left panel) aided in diagnosing the causes of the 2009 event.** The strong anomalous cooling of SST during Jan-Apr (a) was driven by anomalous Ekman pumping and associated shoaling of the thermocline (b) and enhanced wind-induced evaporative cooling (c). The mixed layer temperature budget shows the dominance of surface fluxes during Jan and the vertical heat flux at the base of the mixed layer (purple curves) during Mar-Apr (d, e).

## 2 Interannual variability of the North Equatorial Countercurrent

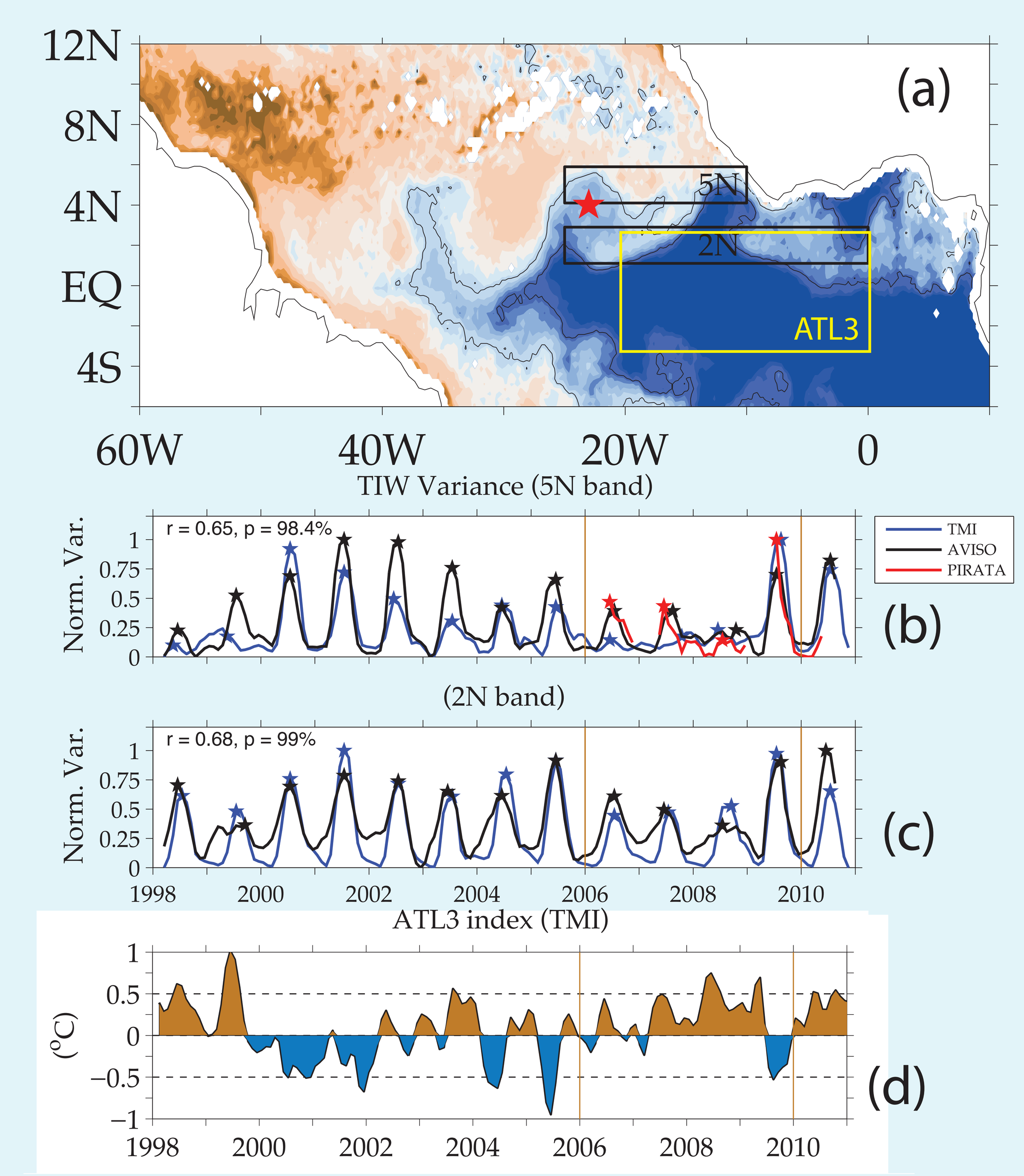



**North Equatorial Countercurrent variability.** Top: Absolute geostrophic transport of the NECC averaged between 3°N-10°N along the AX08 XBT line (shown in the upper right panel) from XBT data (blue dots) and from a satellite-XBT synthesis (black, with weekly values in grey). Bottom: Wavelet transform for the NECC, showing the dominance of the annual cycle as well as noticeable interannual variability.



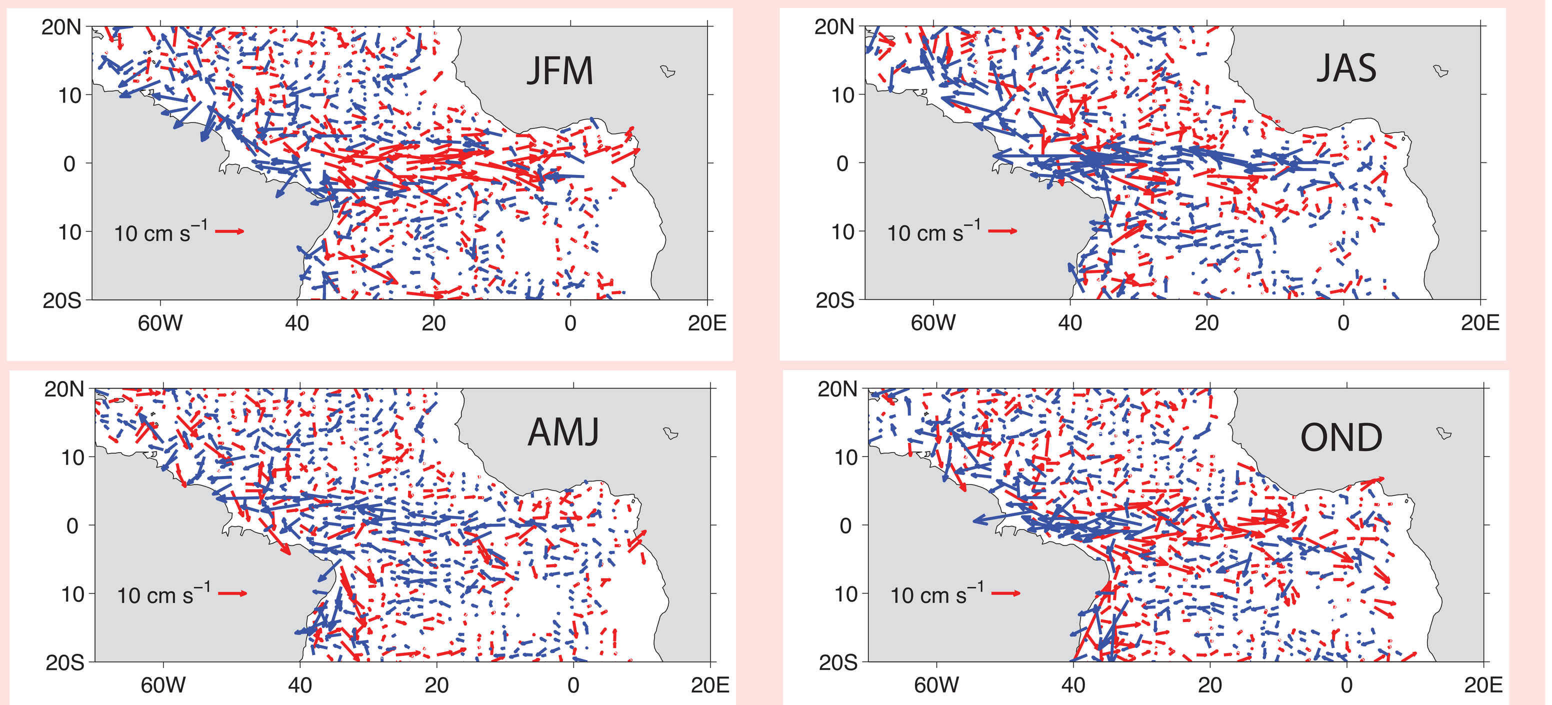

**Relationship between NECC variability and the Meridional and Zonal Modes.** Top panel: Mean surface geostrophic circulation during1992-2009 from a synthesis of surface drifter trajectories, winds, and satellite altimetry. Shading is mean SST and white box denotes the NECC region. Middle and Bottom: Regression of interannual SST anomalies (shading) and wind stress anomalies onto the first complex EOF mode of interannual NECC variability, illustrating the connection between the NECC and the Meridional (middle) and Zonal (bottom) Modes.

## 3 Interannual variations of tropical instability waves




TMI SST during 1-4 Aug 2009, showing strong TIW activity (a). TIW variances averaged in the 5°N box (shown in top panel), calculated from SST (blue) and altimetry (black), reveal pronounced interannual variability (b). Red line is TIW variance from direct velocity measurements at a PIRATA Northeast Extension mooring (red star in top panel), confirming that the strong interannual variability of SST and sea level in the TIW frequency band is caused by changes in the strength of the TIWs. TIW variance in the 2°N box shows similar interannual fluctuations of TIWs (c). TIW activity in each region varies out of phase with the ATL3 SST index (d). Further studies are needed to assess the impact of interannual TIW variability on the Atlantic Zonal Mode.

## 4 Seasonal cycle of equatorial deep currents




Velocity at 800-1100 dbar from Argo floats during each season, showing a strong seasonal cycle in zonal velocity within 1° of the equator, with maximum eastward flow (red) in boreal winter (JFM) and westward flow (blue) in summer (JAS). Quantifying variability of the deep equatorial currents may lead to improvements in understanding the Atlantic Zonal Mode (e.g., Brandt et al., *Nature*, 2011).