South Atlantic Meridional Overturning Circulation: Real-time Monitoring

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Introduction

The Meridional Overturning Circulation (MOC) plays a critical role in global and regional heat and freshwater budgets. Recent studies have suggested the possibility of a southern origin of the anomalous MOC and meridional heat transport (MHT) in the Atlantic, through changes in the transport of warm/salty waters from the Indian Ocean into the South Atlantic basin. This possibility clearly manifests the importance of understanding the South Atlantic MOC (SAMOC). Observations in the South Atlantic have been historically sparse both in space and time compared to the North Atlantic. To enhance our understanding of the MOC and MHT variability in the South Atlantic, a new methodology was recently published to estimate the MOC/MHT by combining sea surface height (SSH) measurements from satellite altimetry and in situ measurements (Dong et al., 2015).

The significant correlation between SSH and the depth of given isotherms (**Fig.1**) allowed to derive synthetic temperature profiles from altimetry measurements. The same method used to compute MOC and MHT at 34.5°S from expendable bathythermograph (XBT) measurements (Baringer and Garzoli 2007) was applied to the altimetry-derived temperature and salinity (T/S) profiles. For this work, salinity profiles were obtained using historical T-S relationship to estimate the MOC/MHT between 20°S and 35°S. The results obtained from this new methodology were assessed against estimates obtained from XBT measurements (**Fig.2**).

1. Methodology

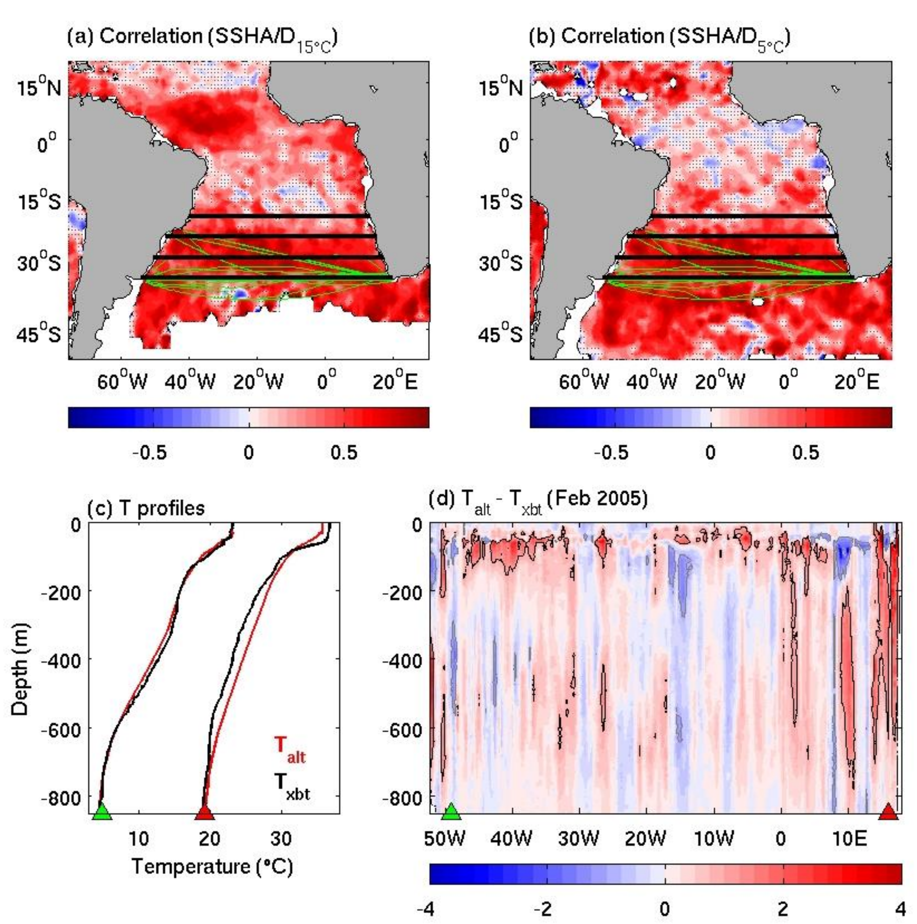
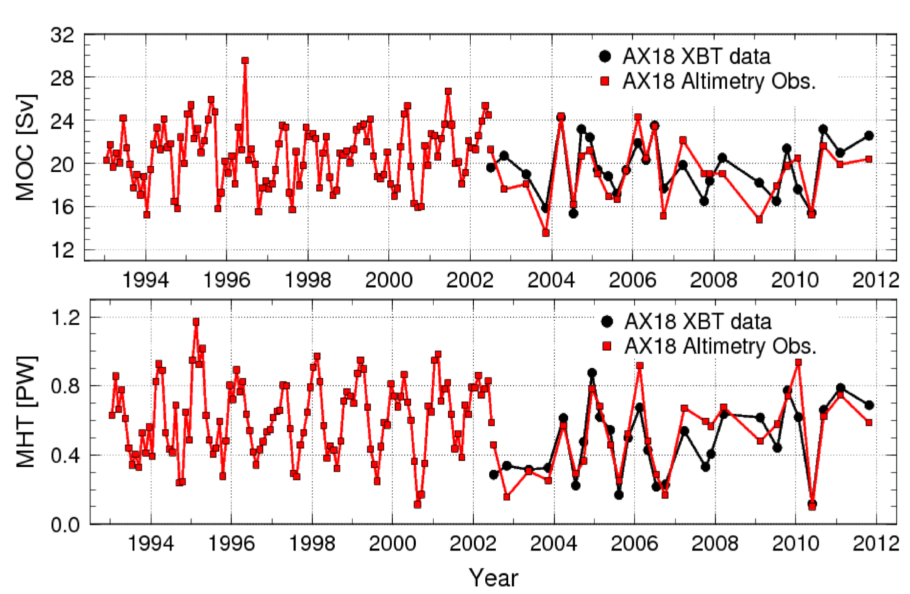


Figure 1. Correlations between SSH and isothermal depths for (a) 15°C and (b) 5°C. Green lines show the AX18 XBT transect locations. Dotted areas indicate where the correlations are insignificant. (c) Examples of the temperature profiles close to the boundaries and (d) temperature differences between altimeter derived and observed from XBTs for the Feb. 2005 AX18 transect along 34.5°S. The corresponding locations for the profiles in Figure 1c are indicated by triangles in Figure 1d. Note that the profiles close to the eastern boundary (red triangles) in Figure 1c are shifted by 15°C in order to separate the two examples.



	MOC (Sv)	MHT (PW)
XBT AX18	19.6±2.6	0.48±0.20
Altimetry	19.2±2.8	0.51±0.22

Figure 2. Comparison of the (a) MOC and (b) MHT along XBT transect AX18 estimated from the XBT measurements (black line) and from altimetry-derived synthetic T/S profiles (red line).

The comparison indicates that the variabilities in the MOC and MHT observed from XBT measurements are well captured by altimetry-derived values. This suggests that the altimeter SSH can be used to estimated the MOC and MHT in the South Atlantic since 1993, near real-time MOC and MHT estimates.

2. Time series of MOC

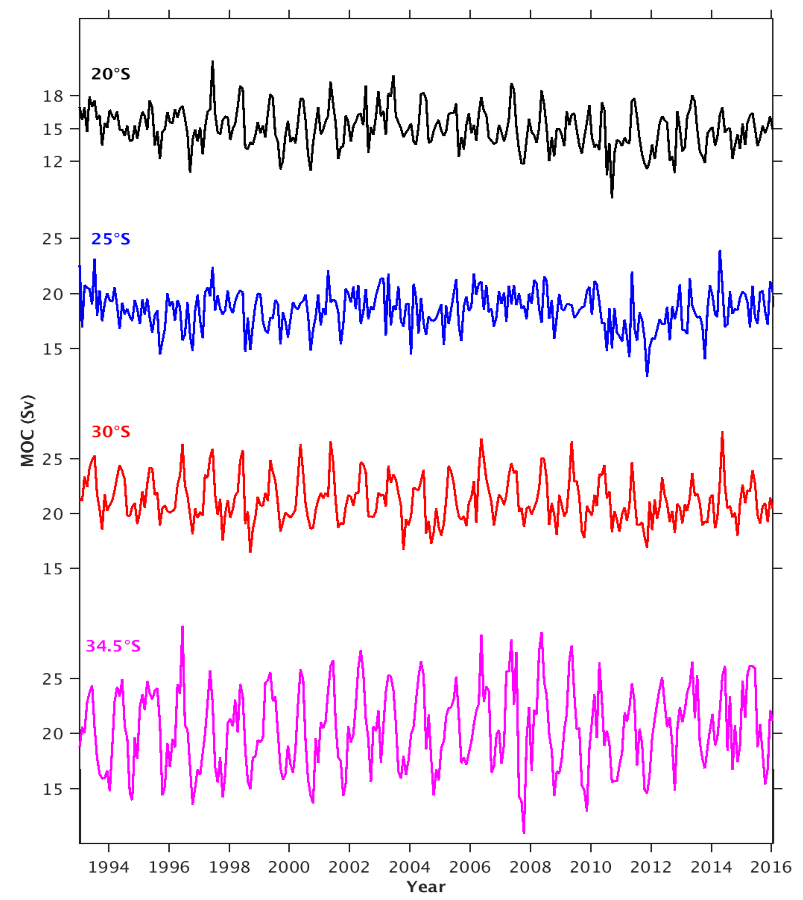


Figure 3. Time series of the MOC obtained from the altimetry-derived synthetic T/S at 20°S, 25°S, 30°S, and 34.5°S, respectively.

The high correlation between SSH and the depths of isotherm between 20°S and 35°S allowed us to calculate the MOC and MHT in this region. MOC and MHT were estimated at four latitudes with 5 degrees of latitude spacing in the region.

The geostrophic velocities were computed from the synthetic T/S profiles with the reference level at 1000 m depth, where constant absolute reference velocities were derived from Argo drift data. The zonal wind stress from NCEP/DOE Reanalysis 2 was used to compute the Ekman volume transport.

3. Seasonal and interannual variations in the MOC

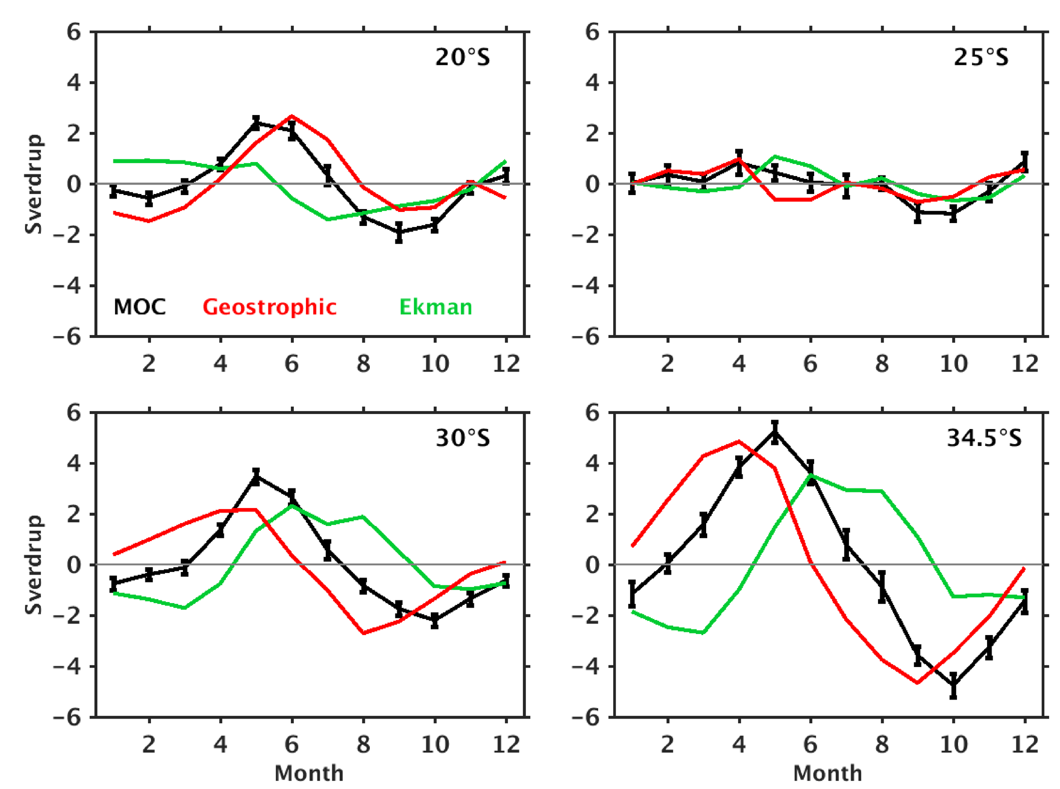


Figure 4. Seasonal variations of the MOC (black) and contributions from the geostrophic (red) and Ekman (green) components estimated from the synthetic T/S profiles at 20°S, 25°S, 30°S, and 34.5°S, respectively. The time-mean values for the total MOC and each component have been removed. Error bars indicate two standard errors.

Both MOC and its contributions from the geostrophic and Ekman transports exhibit statistically significant seasonal cycles at 20°S, 30°S, and 34.5°S, but not at 25°S.

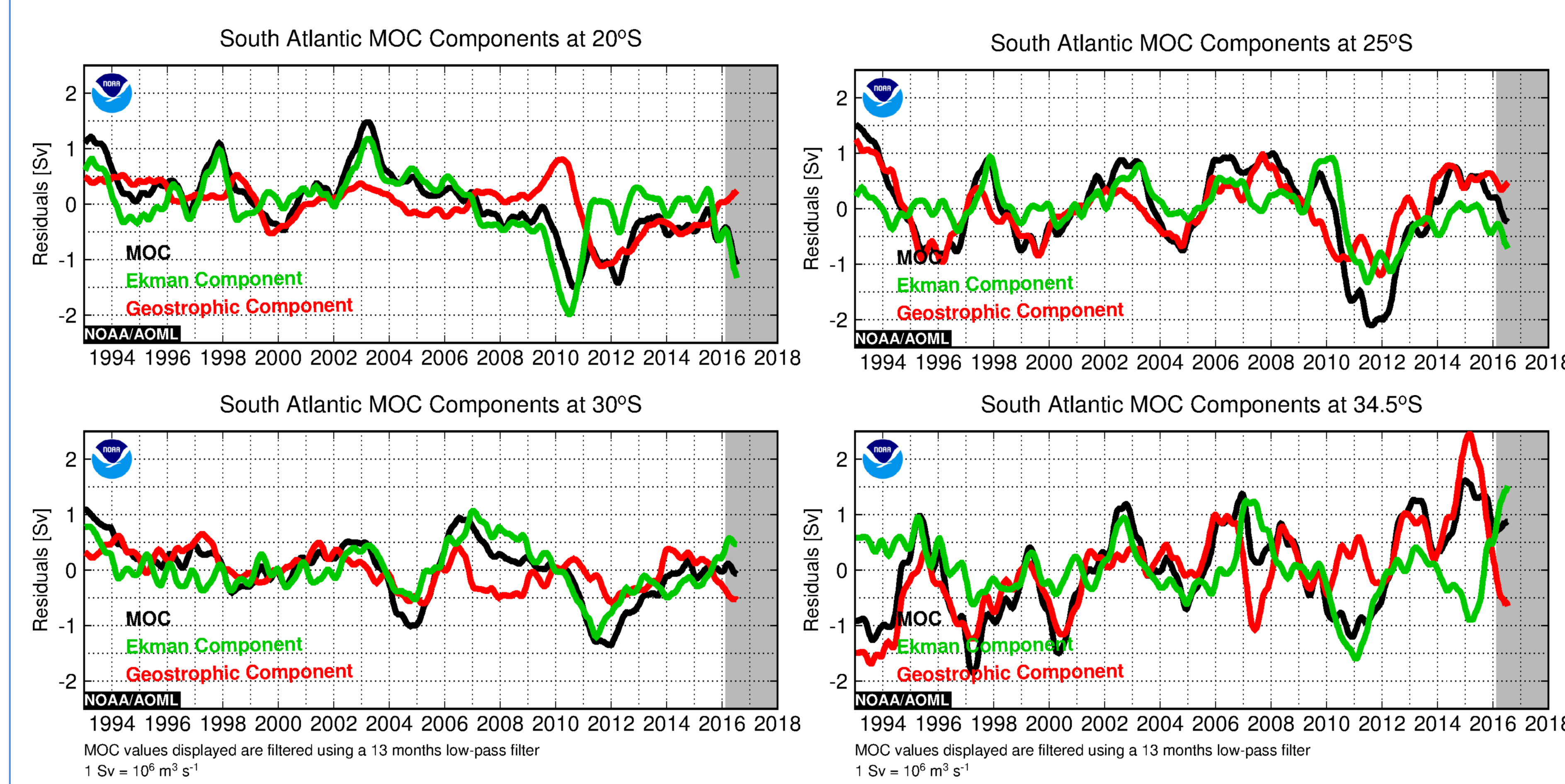


Figure 5. Interannual variations of the MOC (black) and contributions from the geostrophic (red) and Ekman (green) components at 20°S, 25°S, 30°S, and 34.5°S, respectively. A 13-month running average was applied to derive the interannual variations.

4. MHT indicators

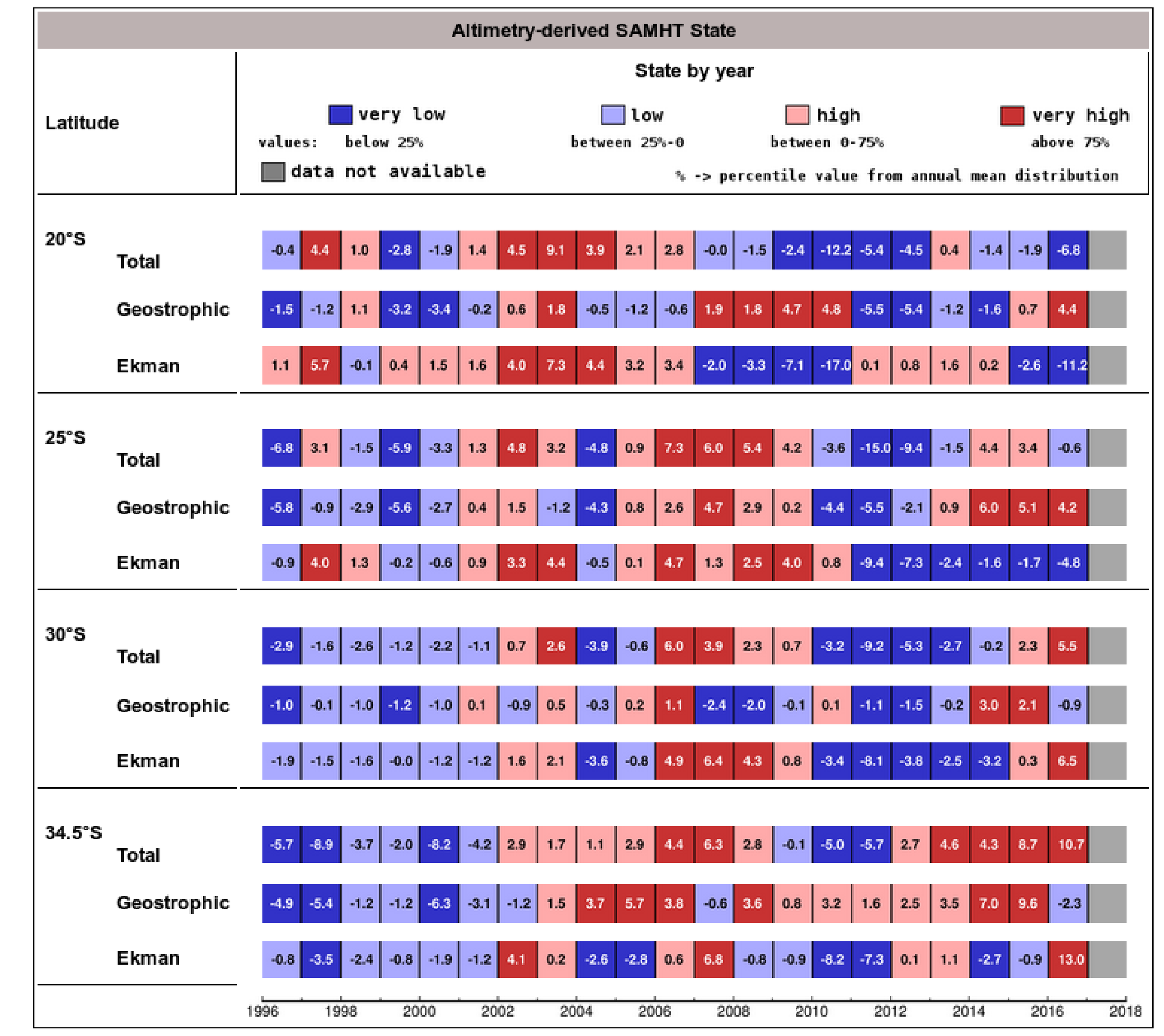


Figure 6. Indicators of the state of the MHT at 20°S, 25°S, 30°S, and 34.5°S, respectively (Yearly averaged anomalies, unit is PW×100).

Available at; http://www.aoml.noaa.gov/phod/indexes/samoc_alt.php

- **Current state of the SAMHT based on these estimates: the anomalies in 2016 are positive at 34.5°S and 30°S, but negative at 25°S and 20°S, this may be an indication of heat convergence in the subtropical South Atlantic during 2016.**

Summary

- This is the only effort to monitor MOC/MHT in the South Atlantic in near real-time at different latitudes.
- For the first time the contributions of the geostrophic and Ekman components to the MOC/MHT in the South Atlantic are assessed at different latitudes on interannual time scales. For example, at 34.5°S, the geostrophic transport dominates during 1993-2001 and 2012-2016, whereas the Ekman transport plays a larger role during 2002-2011.
- Values of MOC/MHT are posted online in the indicators webpage.
- This work highlights the importance of continuous in situ observations in order to validate this new methodology to determine MOC and MHT using satellite measurements.

Reference: *Dong, S. G. Goni, and F. Bringas, 2015: Temporal variability of the Meridional Overturning Circulation in the South Atlantic between 20S and 35S. Geophys. Res. Lett., 42, 7655-7662.*

These altimetry-based MOC estimates have motivated further studies of the mechanism of the South Atlantic MOC variability (Lopez et al. 2016) and a century-long reconstruction of the MOC time series (Lopez et al. 2017). ***Please see the poster led by Hosmay Lopez for detail.***

Lopez, H., S. Dong, S.-K. Lee, and E. Campos, 2016: Remote influence of interdecadal Pacific Oscillation on the South Atlantic Meridional Overturning Circulation variability. GRL., 43(15):8250–8258.

Lopez, H., G. Goni, and S. Dong, 2017: A reconstructed South Atlantic Meridional Overturning Circulation time series since 1870. GRL,, 44, in press.

Acknowledgment: This research was supported by NASA (OSTST program) and NOAA OOMD, CPO, and also by the NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML).