Interdecadal Variability of Surface Heat Fluxes Over the Atlantic Ocean

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Introduction

The spatial and temporal variability of the surface heat fluxes over the North Atlantic is examined using the new objectively produced FSU3 monthly mean 1°x1° gridded wind and surface flux product (Pegion et al. 2000, Bourassa et al. 2005). The FSU3 product is derived from in situ ship and buoy observations thus can be used as a comparison for longer time scale modeling studies. The analysis shows that the latent and sensible heat fluxes exhibit a low frequency (basin wide) mode of variability over the North Atlantic Ocean. It is hypothesized that the longer time scale variability is linked to changes in the large scale circulation patterns (meridional pressure gradients) possibly associated with the Atlantic Multidecadal Oscillation (AMO; Schlesinger and Ramankutty 1994, Kerr 2000). The anomalous heat fluxes appear to be forced by fluctuations in mean wind speed.

Results

The leading mode of the latent heat flux depicts a basin-wide spatial pattern where much of the North Atlantic is dominated by positive loadings (Figure 1a). The main (positive) action centers are located over the tropical North Atlantic, Caribbean Sea, Gulf Stream, and regions north of 50°N. The PC time series (Figure 1b) depicts longer time scale variability, suggesting a transition from predominantly positive latent heat flux anomalies to negative values around 1998. Similar spatial (north of 40°N) and temporal patterns are also shown in the leading mode of the sensible heat flux (Figures 1c and 1d).

Time series plots of the monthly anomalies (not shown) reveal the low frequency variability. The surface heat fluxes are shown to transition from primarily positive (negative) to negative (positive) anomalies over the tropical North Atlantic (New England coast) around 1998. The transition is not as evident over the central and higher latitude regions.

The two periods (1982-1997 and 1998-2003) are compared by computing the difference between the overall means. The greatest differences for the latent heat fluxes (Figure 2a) occur over the tropics and higher latitude regions of the North Atlantic with values ranging from 20 Wm^{-2} to greater than 30 Wm^{-2}. The greatest sensible heat flux differences (Figure 2b) are located along the New England coast and high latitude regions (exceeding 16 Wm^{-2}). Differences across the tropics, although much smaller, are still statistically significant. The largest wind speed differences ($\geq$ 1 ms^{-1}) appear to be located around the periphery of the subtropical high, thus suggesting a response to changes in the meridional pressure gradient (Figure 2c). Figure 3b indicates a slight enhancement of the northeasterly trade winds and midlatitude westerlies during 1982-1997. Conversely, Figure 3c shows a weakening of the large scale circulation patterns during 1998-2003 compared to climatology (Figure 3a).

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References

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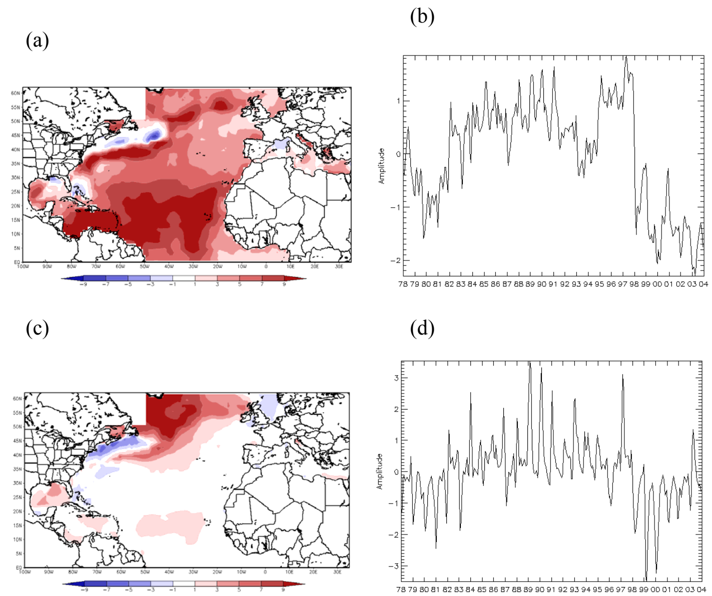

Figure 1. Empirical orthogonal function (EOF) analysis performed on monthly latent and sensible heat flux anomalies (1978-2003). Anomalies filtered (temporally) prior to the EOF analysis. (a) Spatial pattern associated with the leading mode of latent heat flux (~25% variance explained). Loadings are scaled (multiplied by) the standard deviation of the time series. (b) PC time series for mode 1 of latent heat flux. The amplitude values are scaled by dividing through by the standard deviation of the time series. (c) Same as (a) except for sensible heat flux (~21% variance explained). (d) Same as (b) except for sensible heat flux.

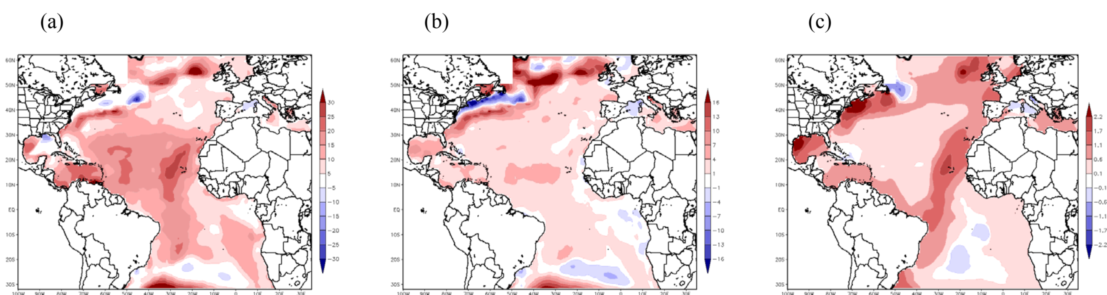

Figure 2. 1982-1997 overall mean minus 1998-2003. (a) Latent heat flux (Wm^{-2}). (b) Sensible heat flux (Wm^{-2}). (c) Wind speed (ms^{-2}). Regions of largest differences were found to be statistically significant at the 95% confidence limit via a two-tailed t test.

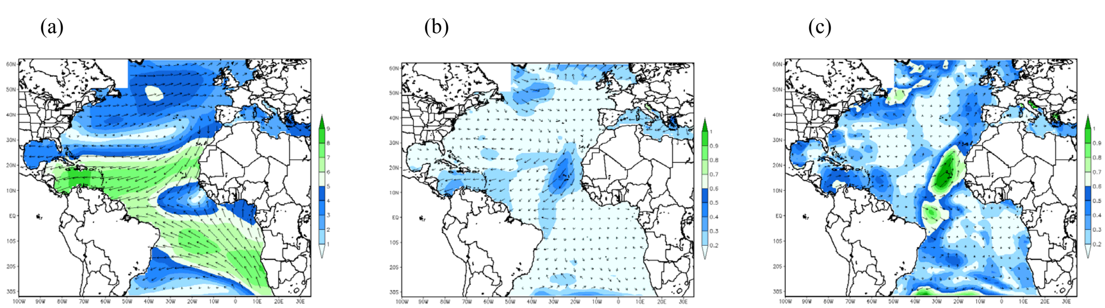

Figure 3. (a) 1978-2003 climatology of vector wind speed (ms^{-1}). (b) Vector wind anomalies for 1982-1997 (ms^{-1}). (c) Vector wind anomalies for 1998-2003 (ms^{-1}).