FSU FLUXES

Center for Ocean-Atmospheric Prediction Studies

The Atlantic and Indian Oceans

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Abstract

A new 1˚ by 1˚ monthly turbulent flux product for the Atlantic and Indian oceans is now available. The new Florida State University fluxes (the FSU3) are derived from in-situ marine observations from ships, drifters, and moorings with the sea surface temperatures being extracted from the Reynolds SST fields. An objective analysis technique produces fields of surface turbulent fluxes (momentum, latent heat, and sensible heat fluxes) and the fields used to create the fluxes (vector wind, scalar wind, near-surface air temperature and humidity, and regridded Reynolds SST). The FSU3 product moves beyond our past production of wind-only fields. The objective approach treats the various types of observations (voluntary observing ships, moored buoys, drifting buoys) as independent, and objectively determines weights for each type of observation. Spatially the FSU3 are limited to oceans north of 30˚S, due to the low observational density south of 30˚S, and are available for the period 1978-2004.

The FSU fluxes provide a new set of ocean surface forcing fields which will improve our understanding of the global climate system. Our long-term monthly in-situ fields are well suited for seasonal to decadal studies. Initial results for the Atlantic Ocean reveal a reversal in heat flux anomalies that appears to be associated with the phase shift of the Atlantic Multi-decadal Oscillation (Schlesinger and Ramankutty 1994, Kerr 2000). The Indian Ocean is dominated by the monsoon cycle and the Indian Ocean Dipole.

Data and Methods

FSU3 produced using ICOADS (1978-1997, 2004; Worley et al. 2005) and NCDC TD-1129 (1998-2003; NCDC 1998) surface marine observations.

Reynolds blended SST (Reynolds 1988) used in variational method.

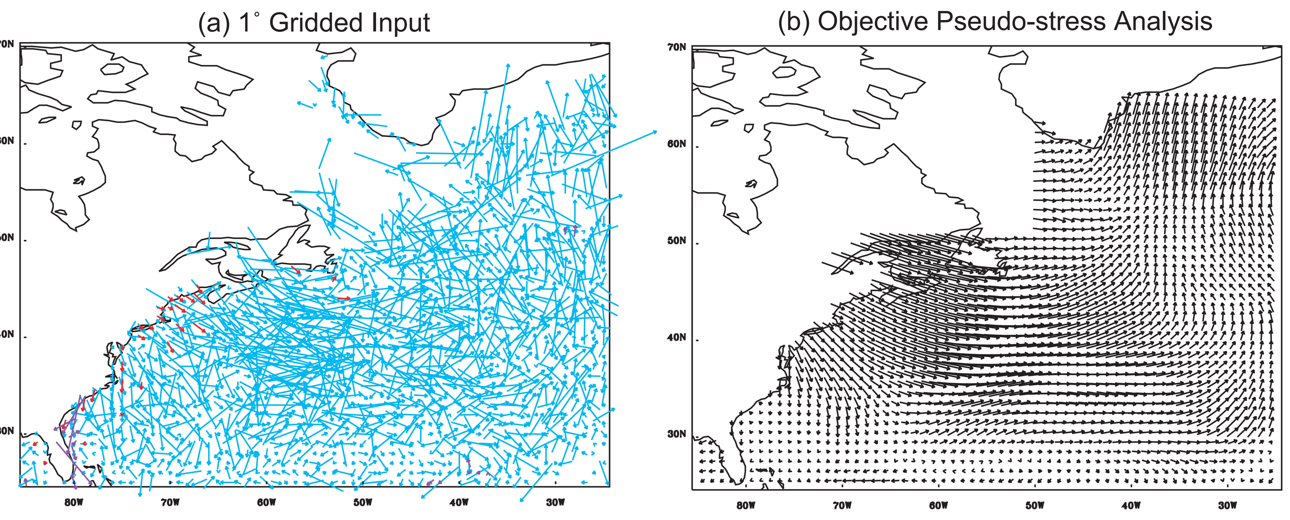
Three quality controls applied:
1. Climatology tests on individual observations
2. Nearest neighbor check on 1˚ means
3. Visual inspection of input data and final fields

A cost function based on weighted constraints (Pegion et al. 2005, Bourassa et al. 2005) is minimized via conjugate-gradient scheme (Shanno and Phua 1980).

Objective weights determined using cross validation (Pegion et al. 2005).

Background fields based on data alone (no NWP input; Bourassa et al. 2005).

Fig. 1: Stages of pseudo wind stress analysis for the northwest Atlantic during February 2004. (a) monthly average ship (blue), mooring (red), and drifter (purple) pseudo-stress derived from individual marine observations in 1˚ bins. (b) final objective analysis.



Products

NEW: Monthly pseudo-stress, wind stress, latent and sensible heat flux, and the quantities used to derive these fluxes (SST, Tair, Qair, wind speed) for Atlantic and Indian Oceans
- Period: 1978-2004 (research), 2005 (quicklook)
- Grid: 1˚ latitude by 1˚ longitude
- Coverage: North of 30˚S (Indian), 34˚S (Atlantic)

http://www.coaps.fsu.edu/RVSMDC/FSUFluxes/

NEW: Uncertainty fields (see related poster by Bourassa and Smith)

NEW: Distrubuting ISCCP-FO (MPF) radiation product by Zhang et al. (2004) regridded to match 1˚ product.

Continue to produce and distribute tropical Pacific pseudo-stress fields on a 2˚ grid for 1978-2004 (research) and 2005 - April 2006 (quick-looks).

http://www.coaps.fsu.edu/RVSMDC/html/winds.shtml

Production of FSU3 for Pacific planned for summer 2006. In future will extend time series back to ~1950.

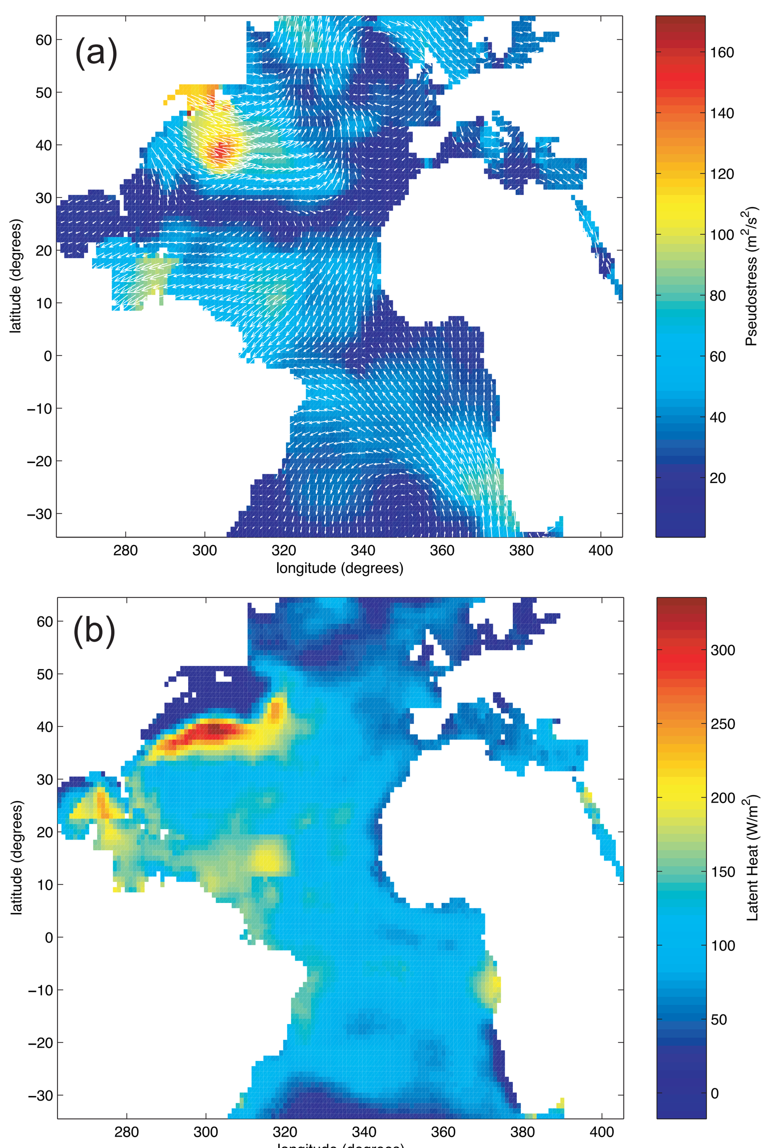


Fig. 2: Atlantic (a) pseudo-wind stress and (b) latent heat flux analyses for February 2004. Note that the strong offshore flow east of U. S. results in large latent heat fluxes over the Gulf Stream.

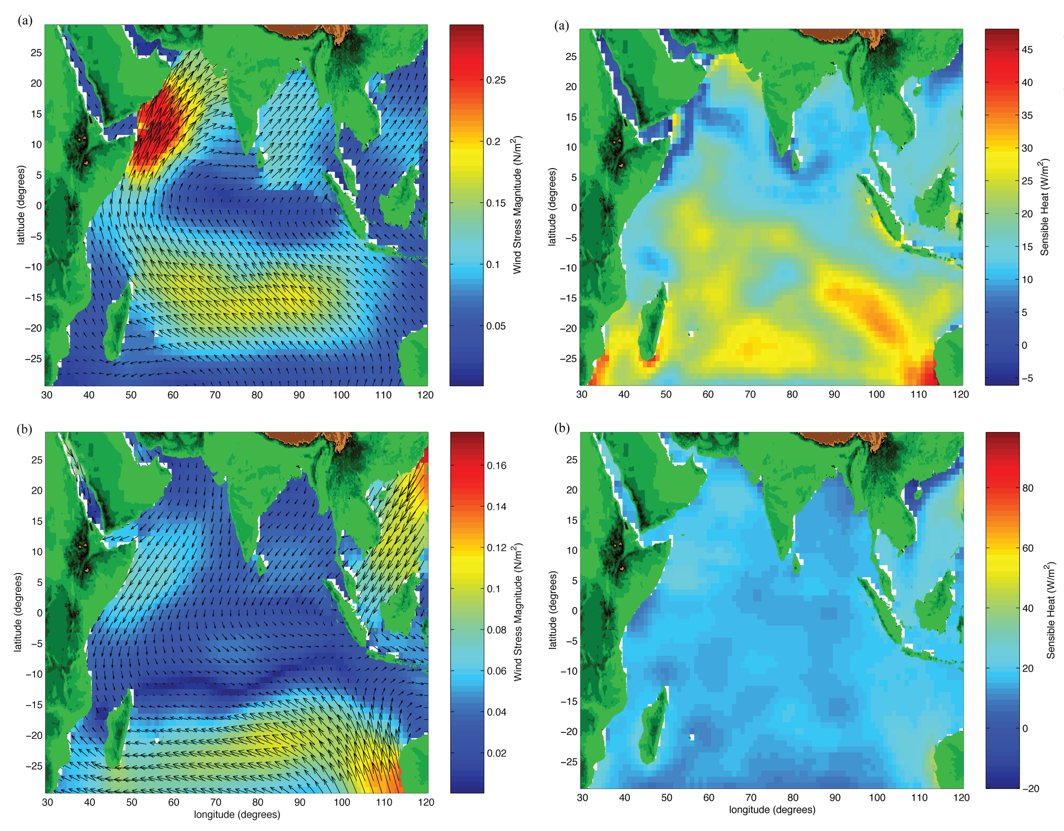


Fig. 3: Wind stress (left) and sensible heat flux (right) created from 22 years (1982-2003) of FSU3 analyses. (a) August and (b) February are representative months for the peak of the summer and winter monsoons, respectively. Latent heat flux (not shown) exhibits similar spatial patterns as the sensible heat flux.

Continue to develop satellite wind and flux products with additional support from NASA.

http://coaps.fsu.edu/scatterometry/

Atlantic Ocean

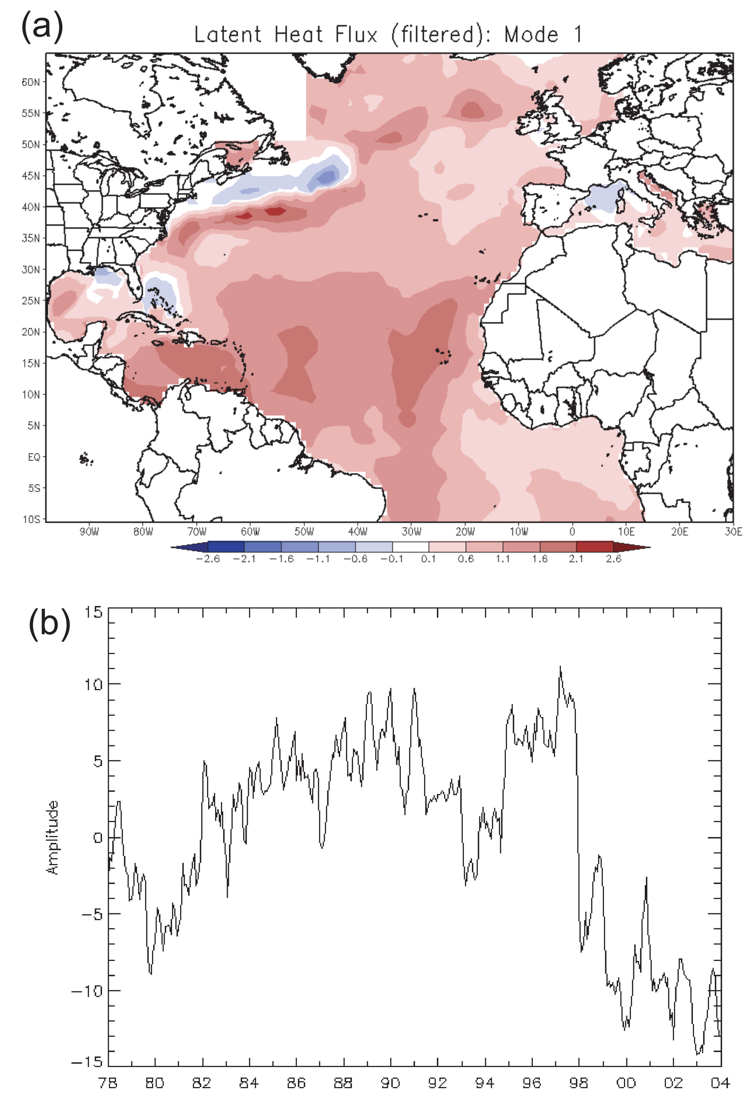


Fig. 4: Empirical orthogonal function (EOF) analysis performed on monthly latent heat flux anomalies for the time period 1978-2003. Anomalies filtered (temporally) prior to the EOF analysis. (a) Spatial pattern associated with the leading mode of variability. (b) Principle component time series for the leading mode. The year labels mark January for each year.

Analysis of the FSU3 for the Atlantic reveal signals of the North Atlantic Oscillation (NAO) and variability associated with the Atlantic Multi-decadal Oscillation (AMO).

Leading mode of latent heat flux (~25% of total variance) exhibits positive loadings across the basin (with the exception of the Gulf Stream extension; Fig. 4a).

PC time series transitions from positive values to predominantly negative values around 1998 (Fig. 4b).

Timing of transition similar to the phase shift of the AMO (Kerr 2000).

Examning differences between 1982-1997 and 1998-2003 period reveal:
- Wind speed differences are largest around the periphery of the north Atlantic subtropical high (Fig. 5)
- Higher zonal average wind speeds during 1982-1997 (Fig. 6)

Originally suspected this transition to be due to change in input data; however, additonal analysis (using SSM/I) show similar transition.

Wind speed changes along periphery of high translate to similar variations in latent and sensible heat fluxes.

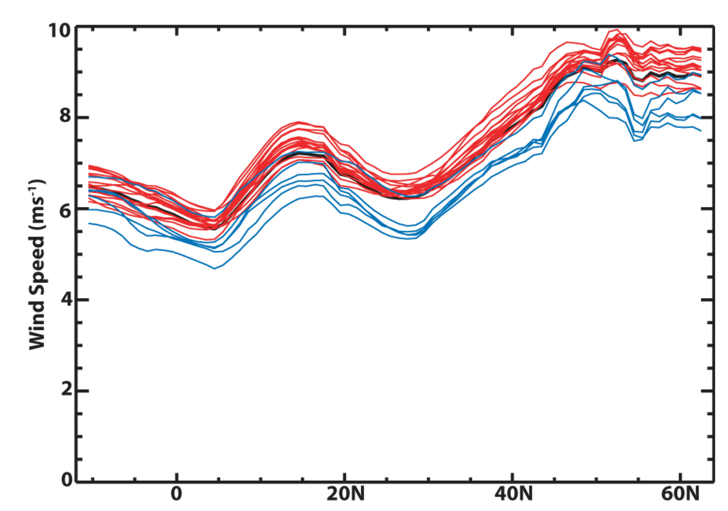


Fig. 6: Zonal average (10.5°S-62.5°N) wind speed (ms-1) for 1978-2003. Black line signifies the overall mean (1978-2003). Red lines represent yearly averages for the 1982-1997 time period. Blue lines represent yearly averages for 1982-2003.

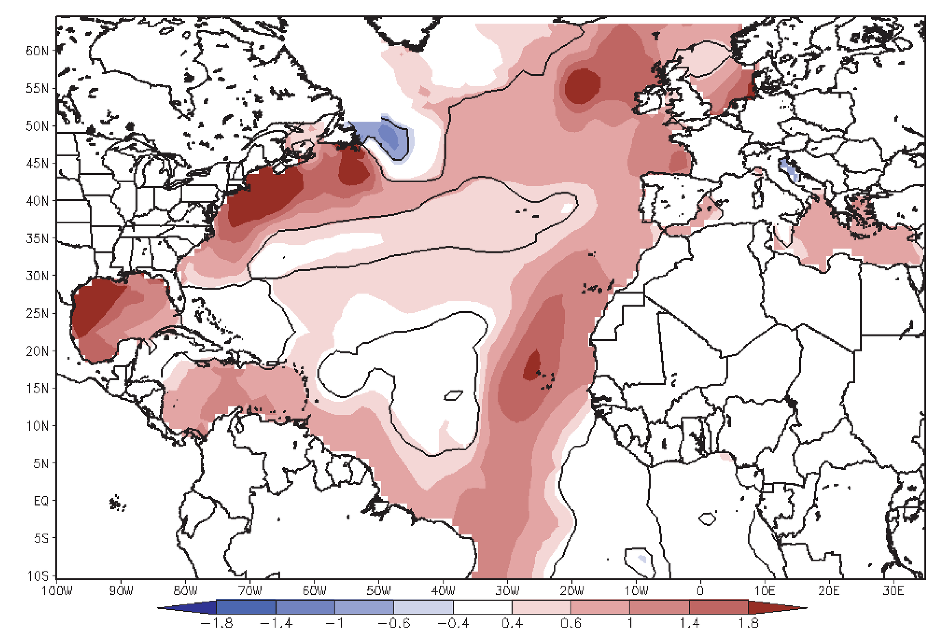


Fig. 5: 1982-1997 overall mean minus 1998-2003 mean wind speed (ms-1). Solid black line represents where the difference exceeds the 95% confidence limit via a two-tailed t test.

Indian Ocean

The FSU3 show the primary modes of Indian Ocean flux variability to be associated with the monsoons and the Indian Ocean Dipole (IOD; Banks 2005).

Monsoons

Boreal summer and winter climatological fields dominated by monsoon flow (Fig. 3).

FSU3 adequately resolves strong Somali Jet in summer and northeast winter flow in South China Sea

Heat fluxes are strongest during boreal summer, with maximum values south of the Equator

Indian Ocean Dipole

The peak amplitude of the IOD occurs in the boreal fall.

The positive mode of the IOD (represented by 1997) is characterized by an easterly stress anomaly along the equator that is stronger than the negative phase (represented by 1993; Fig 7).

Wind stress during the negative phase (Fig. 7d) is stroger in the Bay of Bengal and Arabian Sea as compared to the positive phase (Fig. 7a).

Stronger winds in the Bay of Bengal and Arabian Sea during the negative phase result in increased latent heat flux (Fig. 7f) as compared to the positive phase (Fig. 7c).

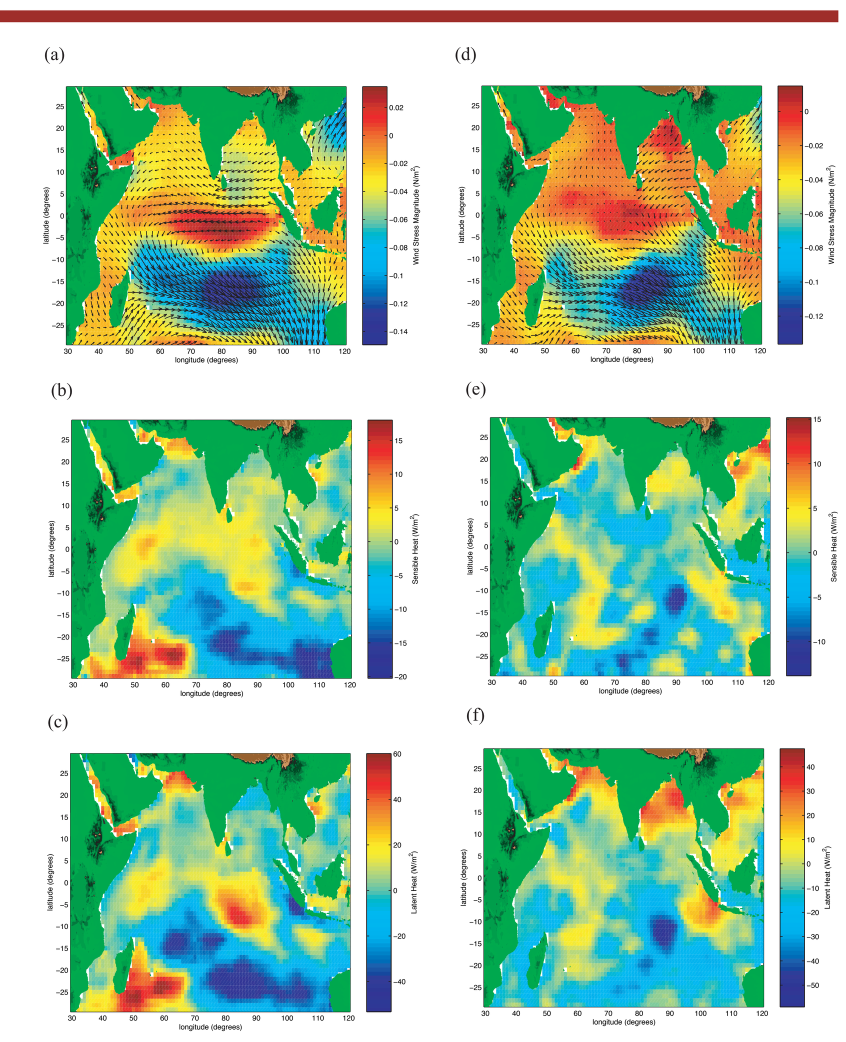


Fig. 7: Observed September-October-November (SON) composite anomalies for the 1997 positive mode (a thru c) and the 1993 negative mode (d thru f) of the Indian Ocean Dipole (IOD). Composites are shown for wind stress (a) and (d), sensible heat flux (b) and (e), and latent heat flux (c) and (f).

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Acknowledgements

The FSU Fluxes are funded by the NOAA Office of Climate Observation and the Ocean Sciences branch of the National Science Foundation.