FSU FLUXES

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Introduction

The Florida State University (FSU) has been producing monthly wind, and more recently turbulent flux, products derived from in-situ shipboard observations since the 1970s (Smith et al. 2004). The early products were subjective (hand-drawn) analyses of the winds over the tropical Pacific that were used to develop early ENSO forecast models. These "FSU winds" evolved through the years and were the basis for early objective analyses of the Indian Ocean (Legler et al. 1989). Additional in-situ measurements from moorings and drifters were included as these technologies were deployed. In the late 1990s, we developed a new objective method to derive both wind and turbulent fluxes from the in-situ marine observations and sea surface temperatures extracted from the Reynolds product (Bourassa et al. 2005). The 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 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 present FSU winds and fluxes (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. An extended series for the Atlantic has been produced (w/o visual QC) for 1956-1977.

The monthly in-situ FSU fluxes are well suited for seasonal to decadal studies. The results for the tropical north Atlantic show that the turbulent fluxes exhibit a roughly 11-year oscillation with a transition to larger values following 1995. The transition to larger fluxes coincides with a shift of the Atlantic Multi-decadal Oscillation (AMO) back to a warm phase. The Indian Ocean is dominated by the monsoon cycle and the Indian Ocean Dipole. In addition, a comparison of the FSU fluxes to other available flux products is underway.

Product History

Early subjective Pacific FSU winds:
- Hand analyzed wind components on 2˚ latitude by 10˚ longitude grid (Figure 1) - could take up to a week to complete
- Digitized by hand (a 3 hour process per field)
- Final analysis produced and manually edited on 2˚ by 2˚ grid.

Legler et al. (1989) created first objective wind fields at FSU for the tropical Indian Ocean.
- Produced on 1˚ grid to resolve wind gradients around Somali Jet
- Jones et al. (1995) used similar technique for Indian Ocean fluxes
- Wind product still operationally produced (Figure 2)

Expanding on the work of Legler et al. (1989) and Pegion et al. (2005), an objective method for both winds and fluxes was developed (Bourassa et al. 2005)
- First used for 2˚ monthly tropical Pacific winds (the FSU2, Figure 4b)
- Current product (FSU3)
  - Uses ICOADS 2.2 (Worley et al. 2005) surface marine observations and Reynolds blended SST (Reynolds 1988)
  - 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 (Figure 3)
  - Background fields based on data alone (no NWP input)

Similar objective method is used to produce satellite-based wind and flux products (e.g., Figure 9).

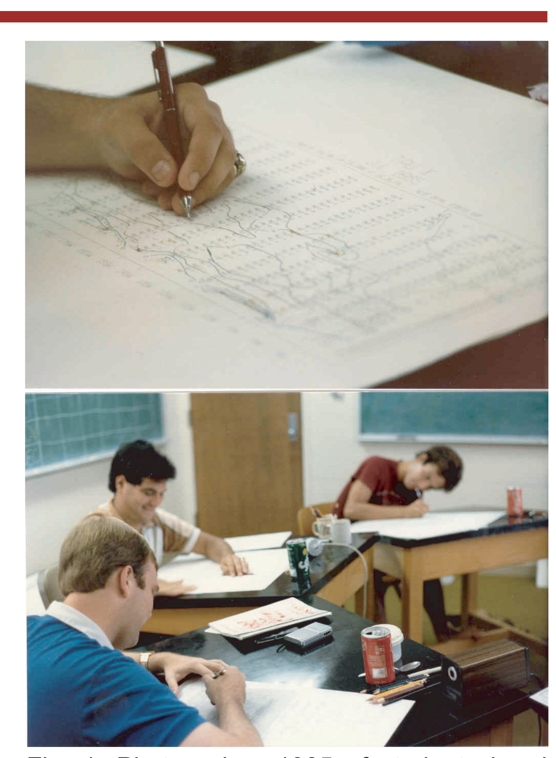

Fig. 1: Photos circa 1985 of students hand analyzing the 1965-1980 Pacific FSU winds.

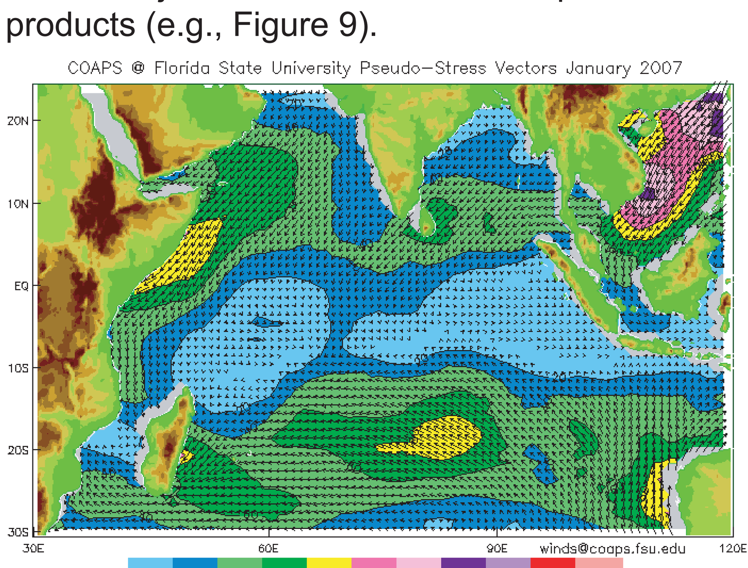

Fig. 2: January 2007 quick-look pseudo-stress analysis for Indian Ocean. Based on GTS observations from NCEP and produced using Legler et al. (1988) method.

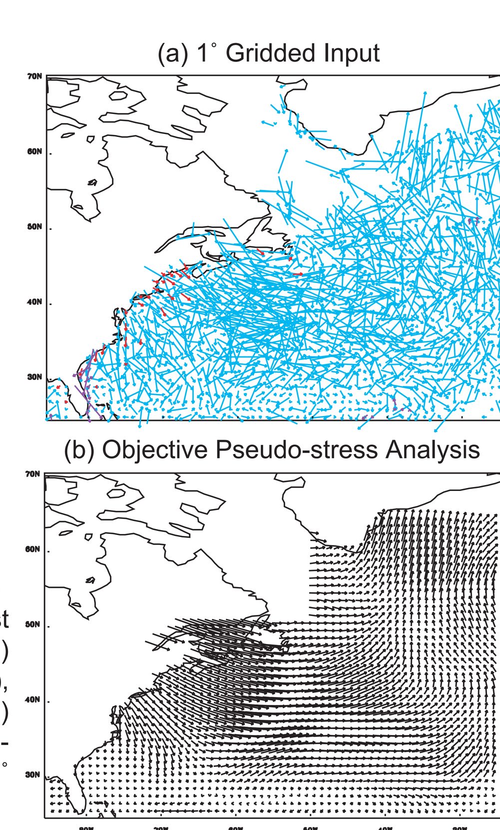

Fig. 3: Stages of FSU3 pseudo-stress analysis for the northwest Atlantic during February 2004. (a) monthly average ship (blue), mooring (red), and drifter (purple) pseudo-stress derived from individual marine observations in 1˚ bins. (b) final objective analysis.

Current Products

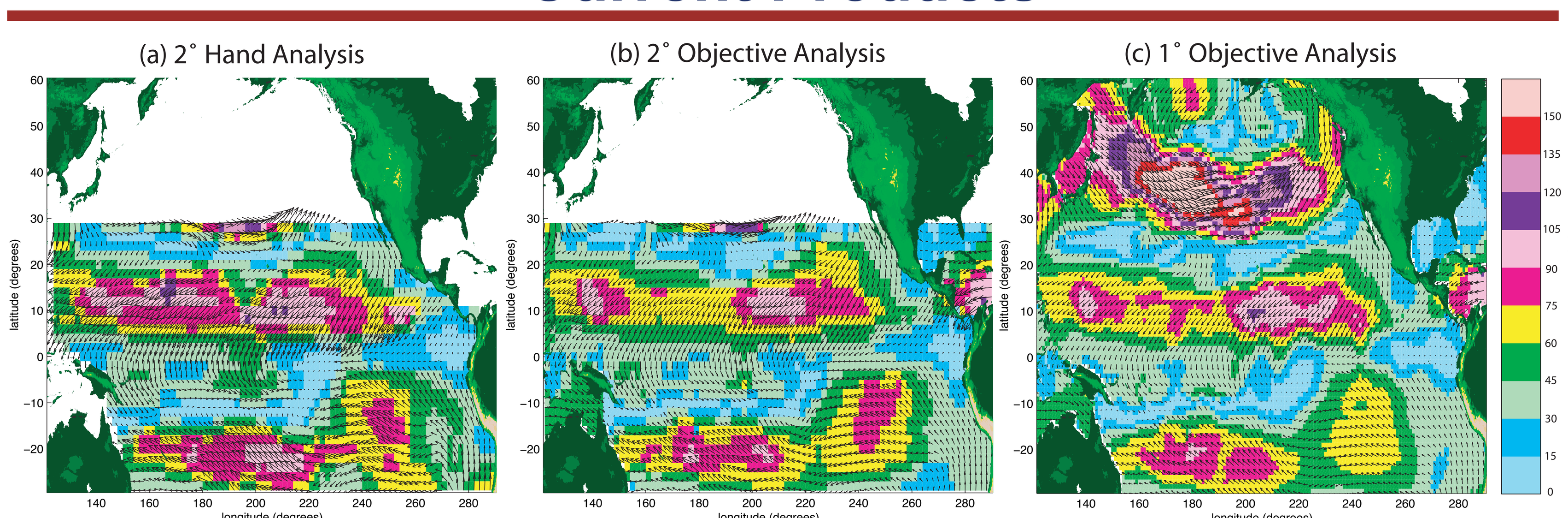

Fig. 4: Comparison of (a) 2˚ subjective, (b) 2˚ FSU2 objective, and (c) 1˚ FSU3 objective pseudo-stress analysis for January 1998. Changes between FSU2 and 3 include Smith (1988) vs. Bourassa (2006) flux algorithm, independent weights for moored and drifting buoys, and NCDC vs. ICOADS data.

FSU3: Monthly one-degree pseudo-stress for entire Pacific Ocean north of 30˚S for 1990-2004. Fluxes coming Fall 2007.

Monthly pseudo-stress, wind stress, LHF, SHF, SST, Tair, Qair, and wind speed for Atlantic and Indian Oceans. Also distributing ISCCP-FO (MPF) radiation product by Zhang et al. (2004) regridded to match FSU3 product
- Period: 1978-2004
- Grid: 1˚ latitude by 1˚ longitude
- Coverage: North of 30˚S (Indian), 34˚S (Atlantic)

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

Continue to produce and distribute:
- Tropical Pacific pseudo-stress on 2˚ grid (Bourassa method): 1978-2004 (research), 2005 - June 2007 (quick-look)
- Tropical Indian pseudo-stress on 1˚ grid (Legler method): 1970-2003 (research), 2004 - June 2007 (quick-look)

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

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

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

FSU3 Flux Variability

Clear interannual variability is shown in both fluxes and parameters used to derive fluxes in the tropical N. Atlantic (Figs 5 and 6).
- Upward trend in wind speed in part due to increase in wind measuring heights
- The latent heat fluxes largely dominated by the air/sea moisture and temperature differences
- A 11-year cycle exists in heat fluxes and humidity (e.g., Fig. 5).

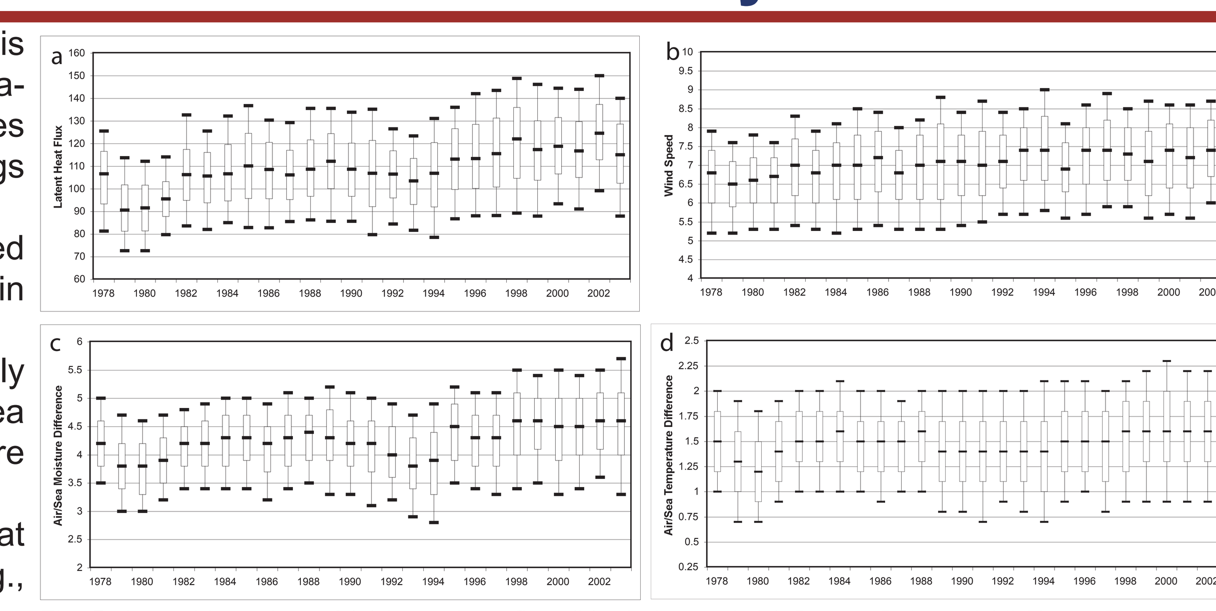

Fig. 5: Annual box plots of (a) latent heat flux, (b) wind speed, (c) Qsea - Qair, and (d) Tsea - Tair over the tropical North Atlantic (0˚-20˚N, 277˚-342˚E). Median, interquartile range, and 10th/90th percentiles shown.

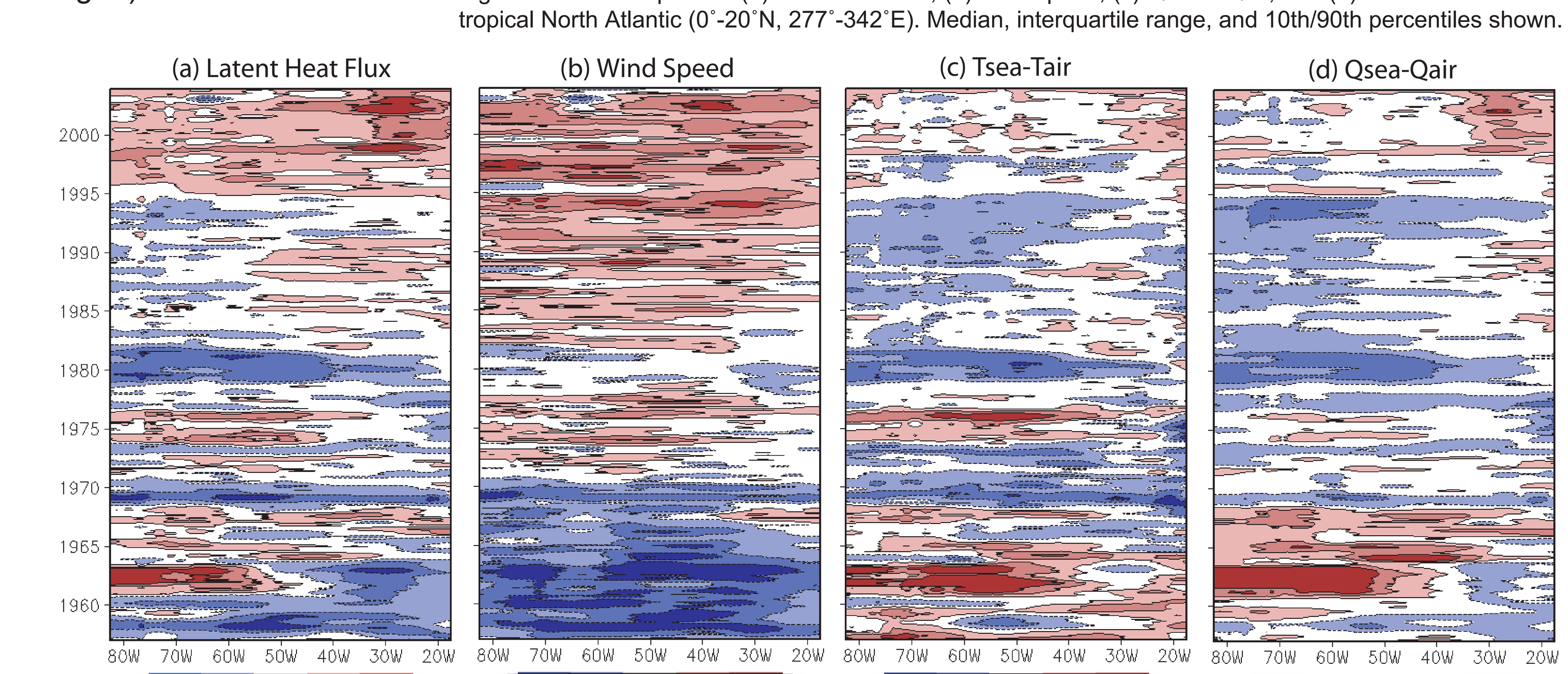

Fig. 6: Time-longitude plots of (a) latent heat flux, (b) wind speed, (c) Tsea -Tair, and (d) Qsea - Qair over the tropical North Atlantic (0˚-20˚N, 277˚-342˚E). Anomalies are based on the 1956-2004 climatology.

Product Comparison

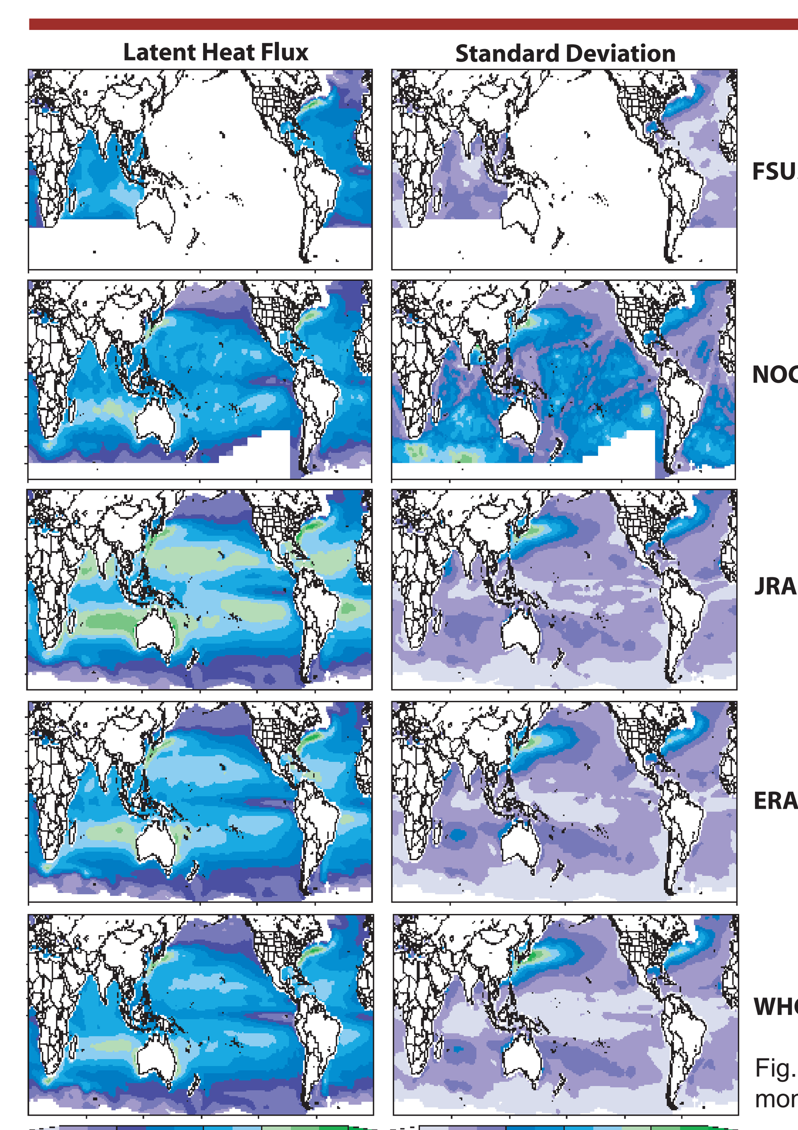

Fig. 8: Comparison of latent heat flux (Wm^{-2}) long term mean (03/1992-12/2000) and monthly standard deviations for five available air-sea flux products.

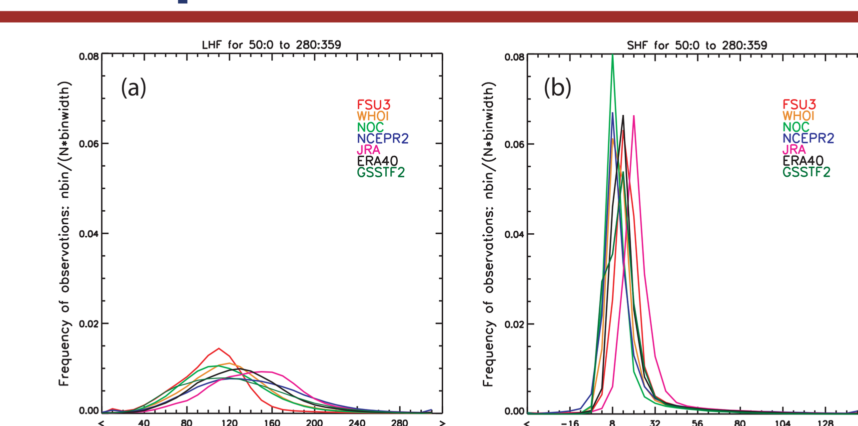

Fig. 7: Probability density functions for monthly (a) latent and (b) sensible heat flux for seven available air-sea flux products. Distributions derived from 1988-2000 for the North Atlantic (0˚-50˚N, 280˚-359˚E).

Overall, the JRA exhibits the largest latent and sensible heat fluxes compared to other products.

The NOC (version 1.1) shows spatial variability associated with ship tracks (Figure 8). This variability is not as apparent in the FSU3.

For LHF distributions, the FSU3 has the least spread over the North Atlantic, while the reanalysis products (JRA, ERA, and NCEPR2) have large spread.

Satellite Flux Example

Our satellite and NWP hybrid fluxes are used to examine the surface turbulent fluxes (Fig. 9) and their influences on the ocean. We found that preconditioning of the environment, such as the earlier passage of a cold front, has an enormous influence on heat fluxes. Our stresses are used to examine storm surge, such as the large surge that hurricane Dennis (2004) brought to the Big Bend portion of Florida. We have also examined the changes in the water column due to the separate influences of heat fluxes and stress.

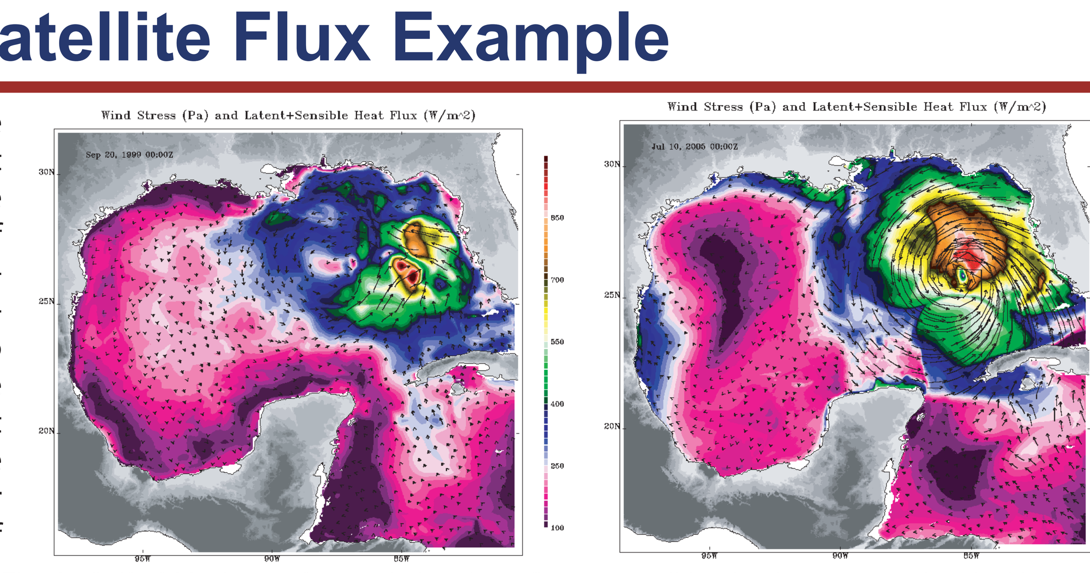

Fig. 9: Gulf of Mexico surface turbulent heat fluxes (sensible plus latent) associated with tropical storm Harvey (left) and hurricane Dennis (right). Vectors indicate trajectories based on 10m winds.

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Acknowledgements

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