Improving High-Impact Tropical Weather Prediction Using Ocean Vector Winds and a Coupled Atmosphere-Wave-Ocean Model

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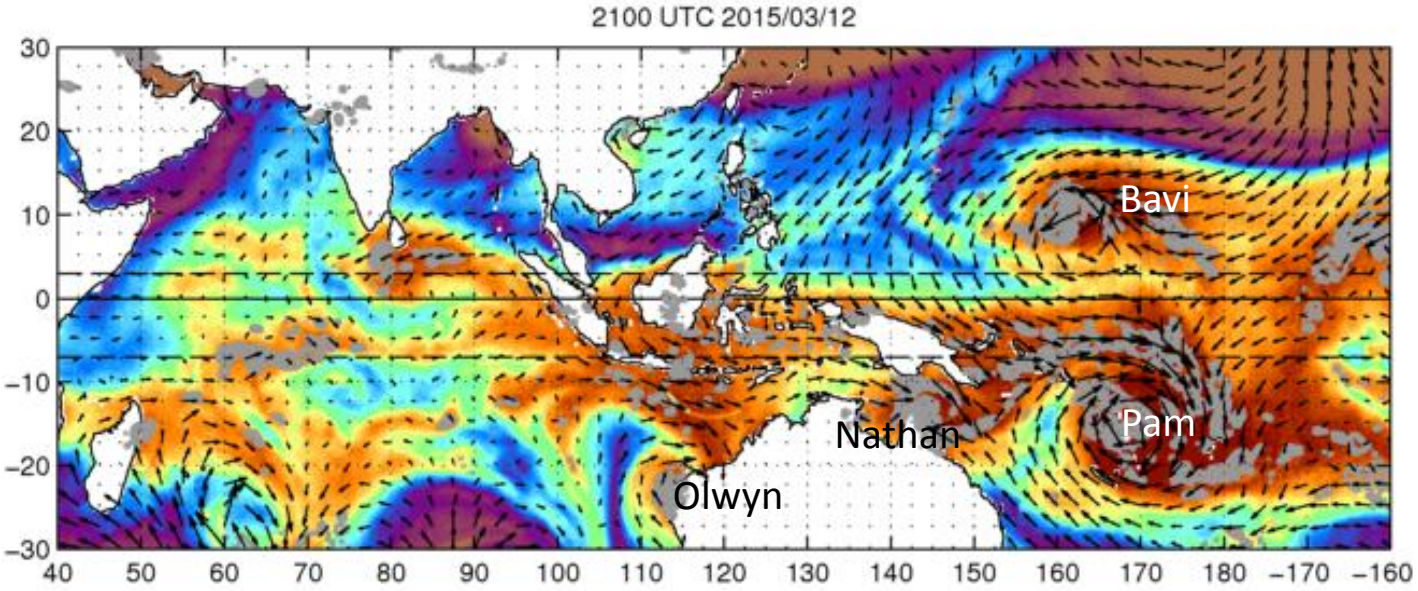
RSMAS/University of Miami



Acknowledgment.
C. Fairall, J. Edson, and NCAR/EOL

(IOVWST, Portland, OR, 20 May 2015)

Goal:

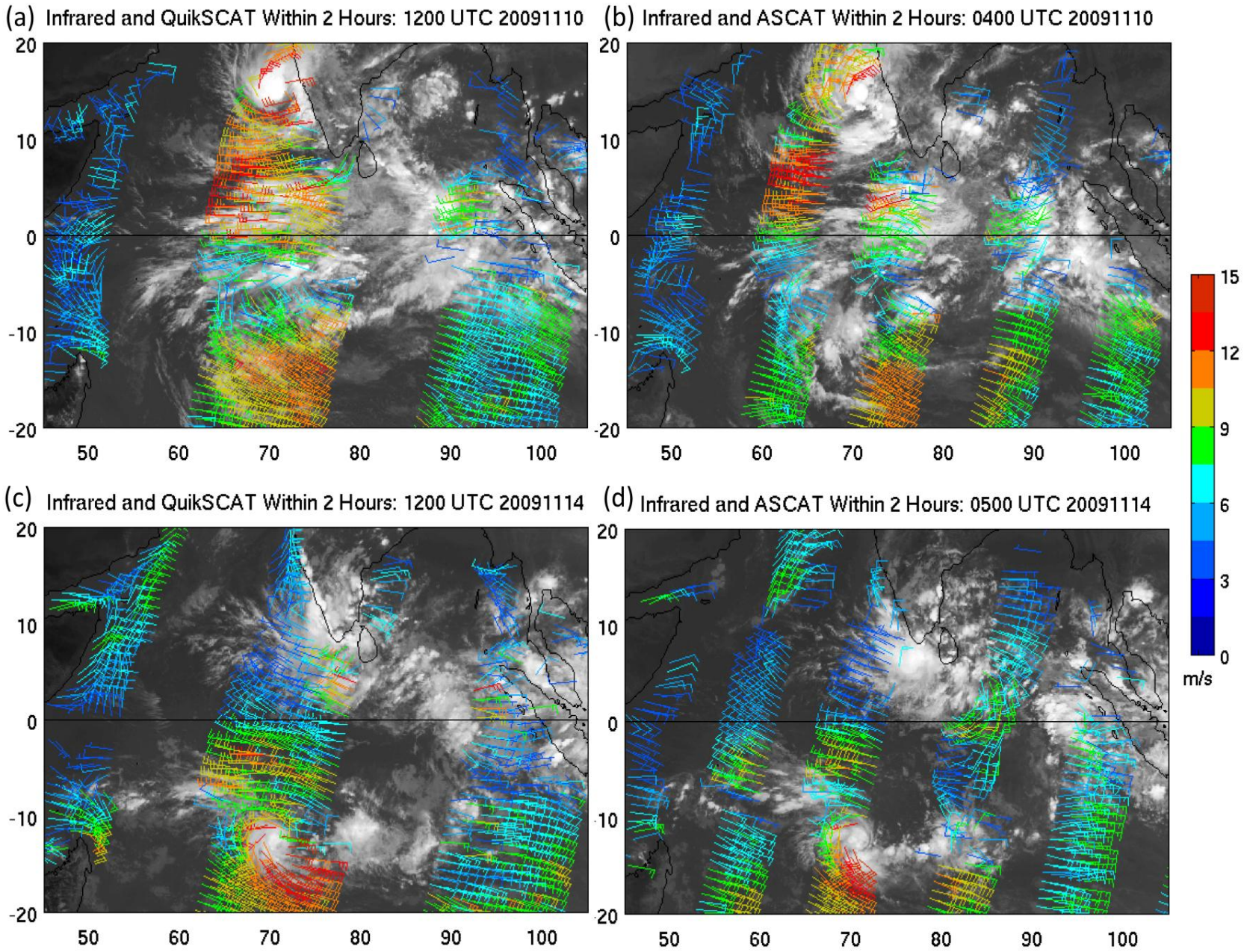
- Better OBSERVE and PREDICT high-impact tropical weather systems

Methods:

- Observations from satellites and in situ (airborne and ground-based) observations from recent field campaigns DYNAMO, ITOP with a focus on near surface properties and air-sea fluxes
- Coupled atmosphere-wave-ocean modeling of MJO, ITCZ, TCs

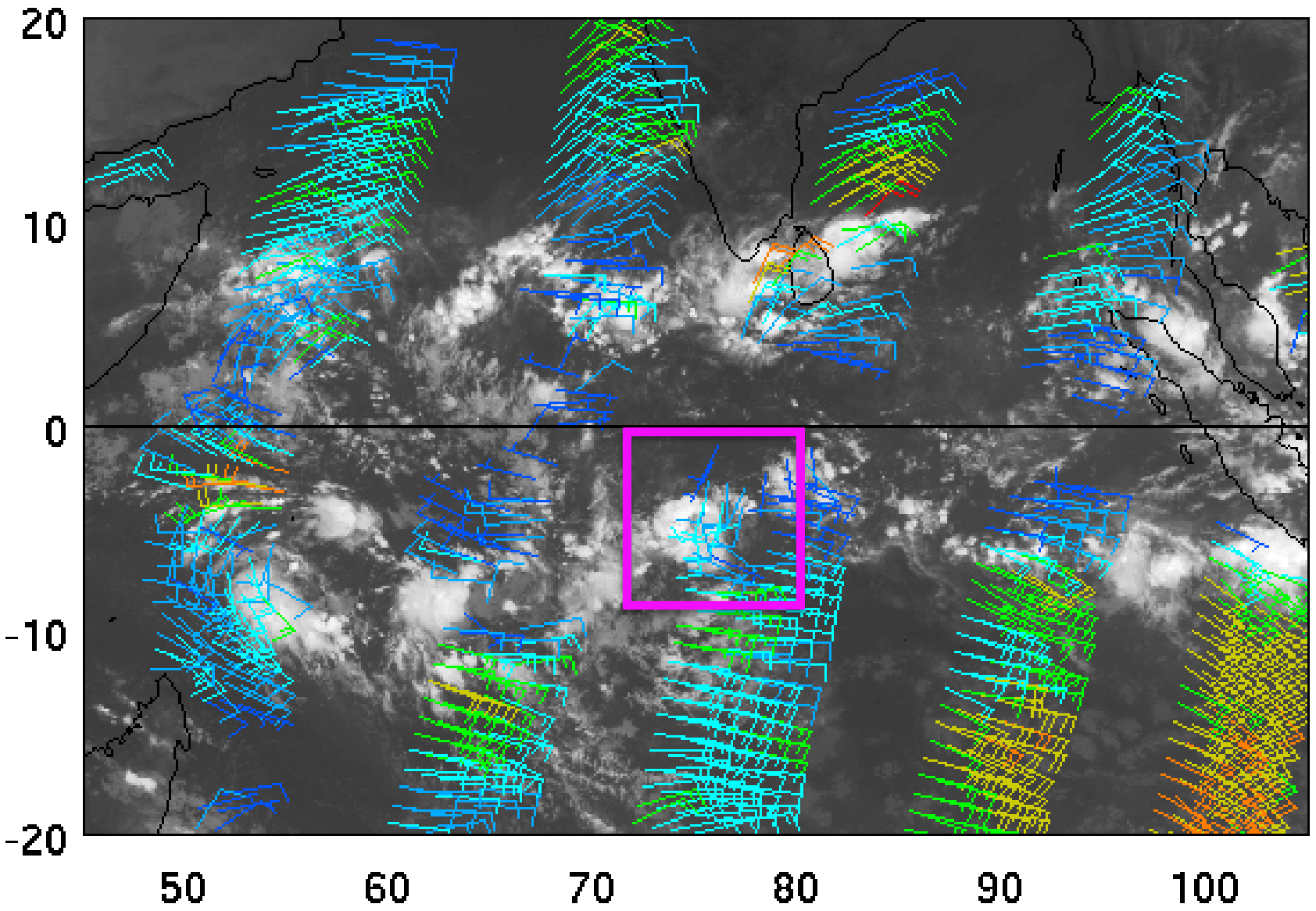
In this talk:

1. DYNAMO and scatterometer observations, and coupled modeling of the **MJO and ITCZ,** which are relevant to both climate and weather
2. OSCAT & SFMR observation of surface winds and coupled modeling of wind-wave-current in Superstorm Sandy (2012)

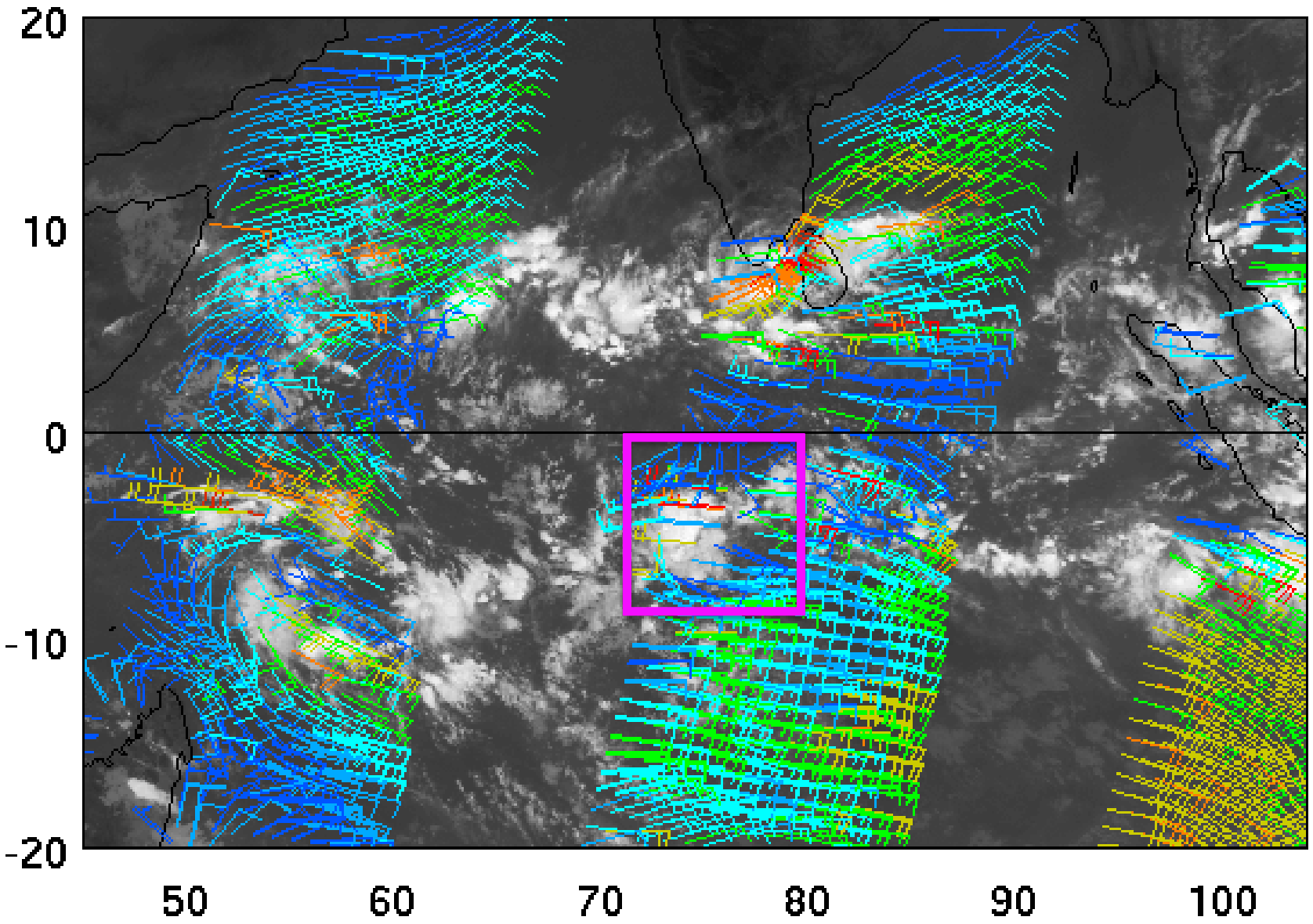


METEOSAT-7 IR image & QuikSCAT winds at 1200 UTC 10 Nov and 14 Nov 2009 (a, c) and ASCAT winds at 0400 UTC 10 Nov and 14 Nov 2009 (b, d).

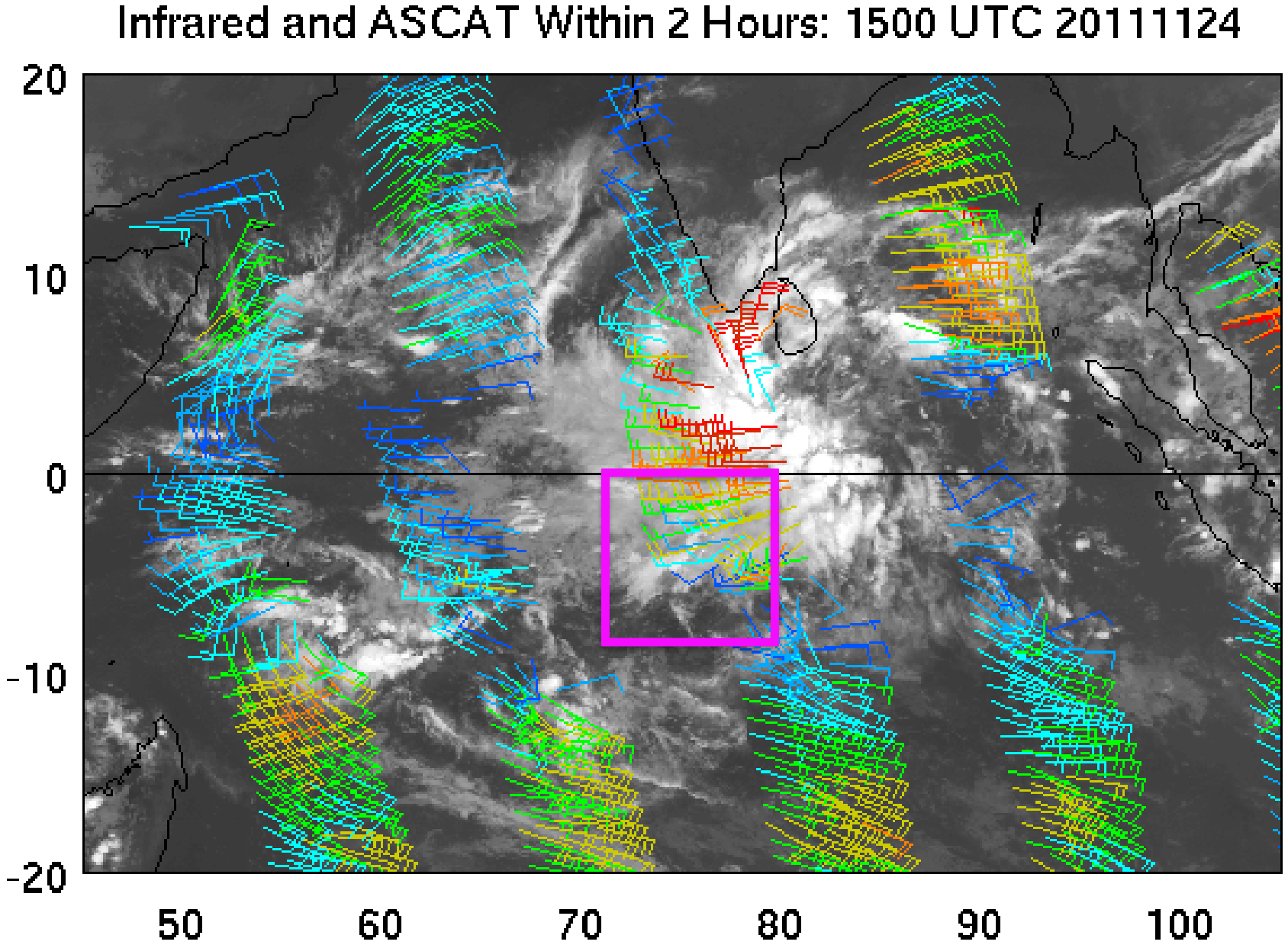
ITCZ


Infrared and ASCAT Within 2 Hours: 0400 UTC 20111120
20
10
0
-10
-20
50
60
70
80
90
100

ITCZ

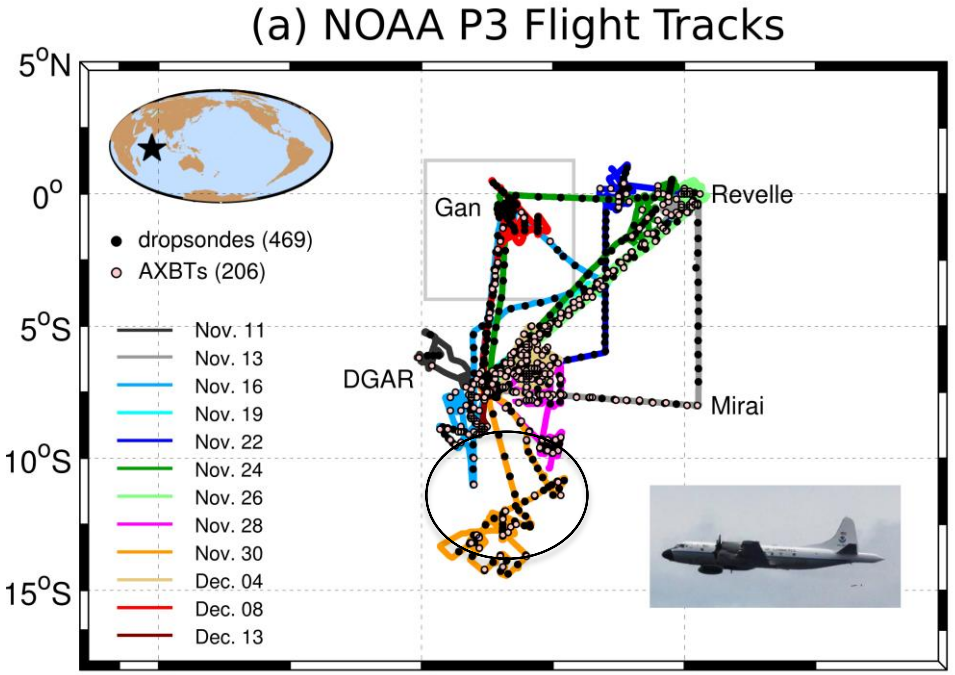

Infrared and OSCAT Within 2 Hours: 0600 UTC 20111120
20
10
0
-10
-20
50
60
70
80
90
100

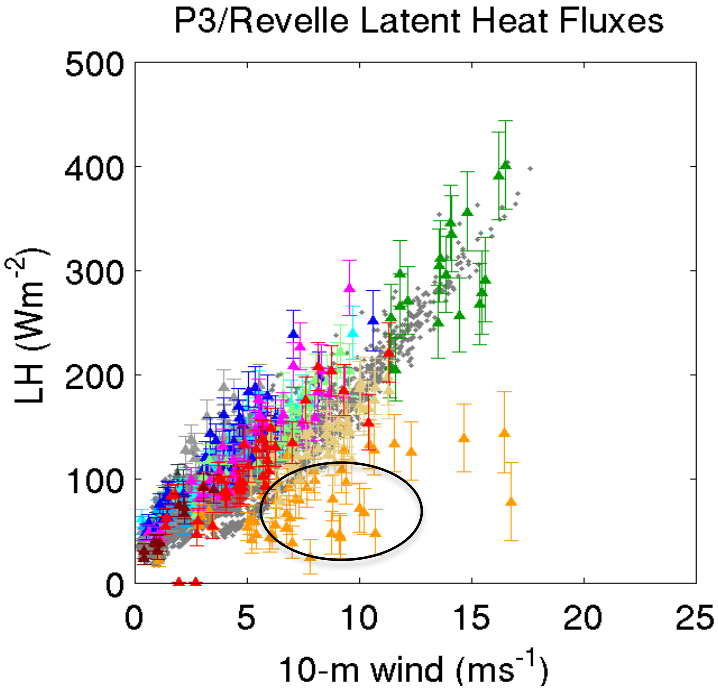
MJO

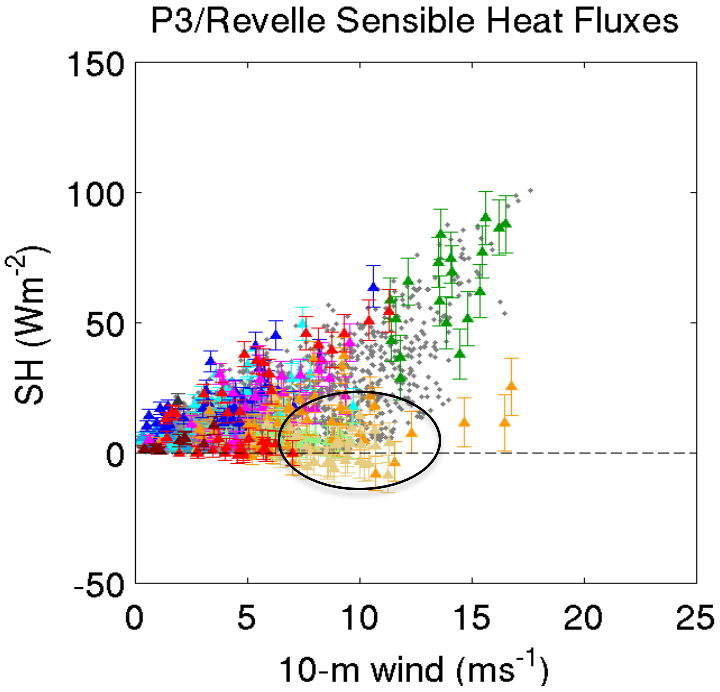

Infrared and ASCAT Within 2 Hours: 1500 UTC 20111124
20
10
0
-10
-20
50
60
70
80
90
100

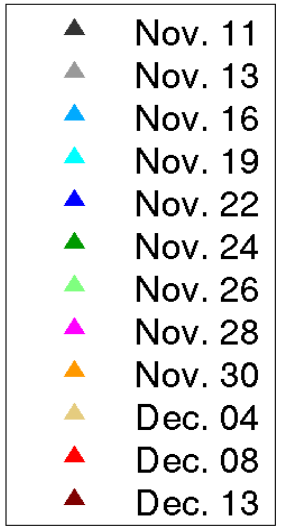
Air-Sea Fluxes

(Observed during DYNAMO by aircraft and ships)



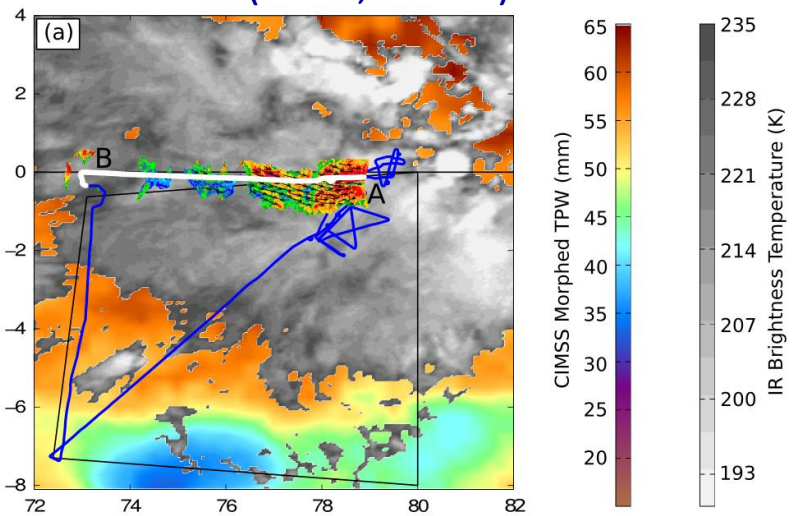


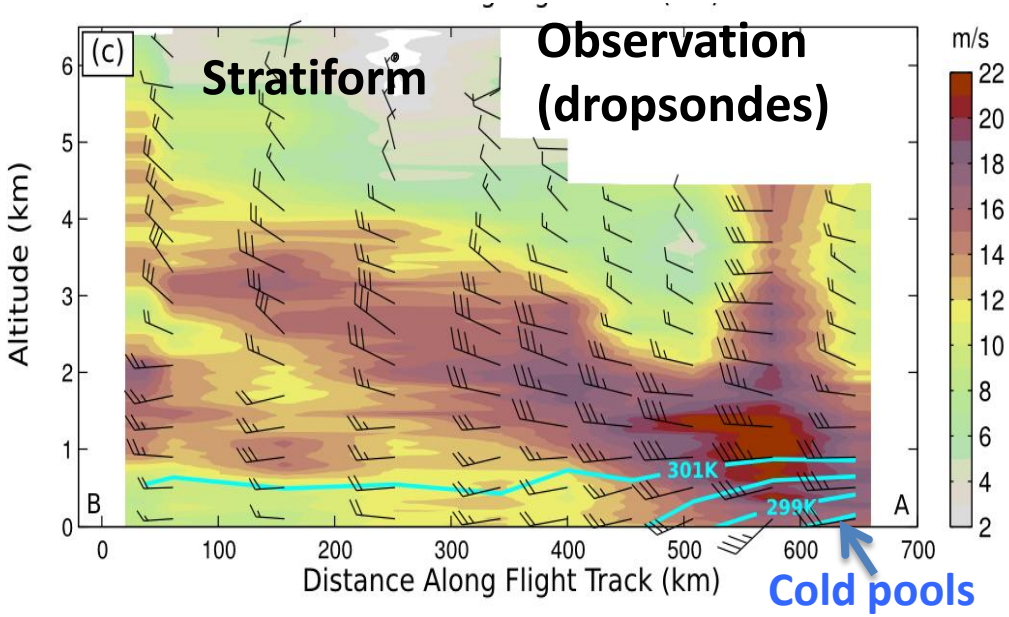




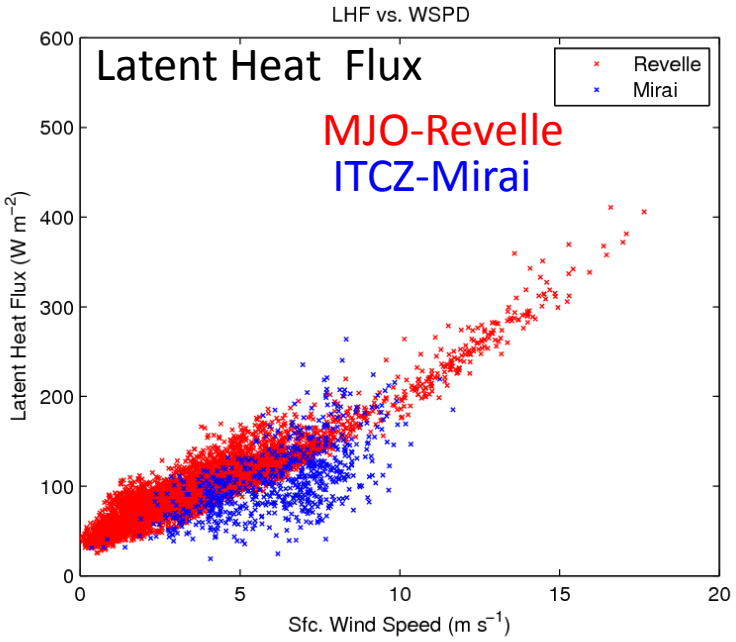
Effects of Model Resolution/Physics on Convection & Vertical Wind Structure

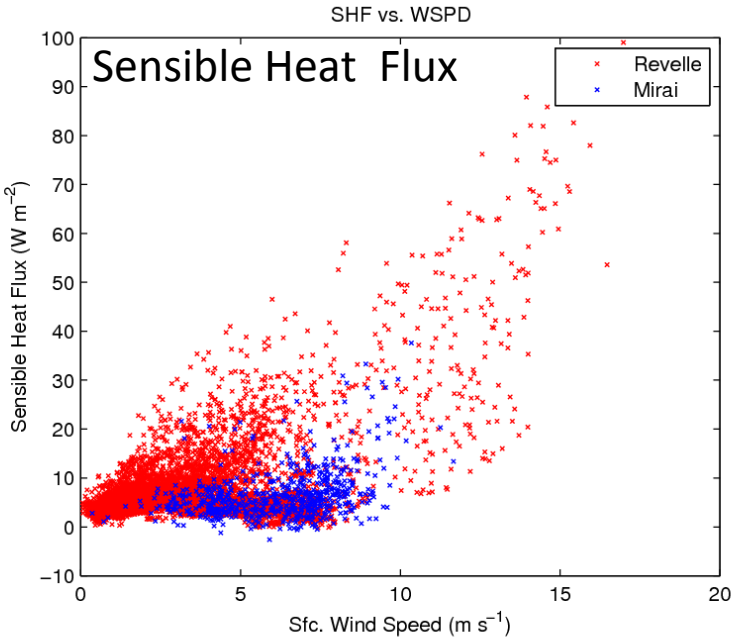
Chen et al. (2015, *BAMS*)

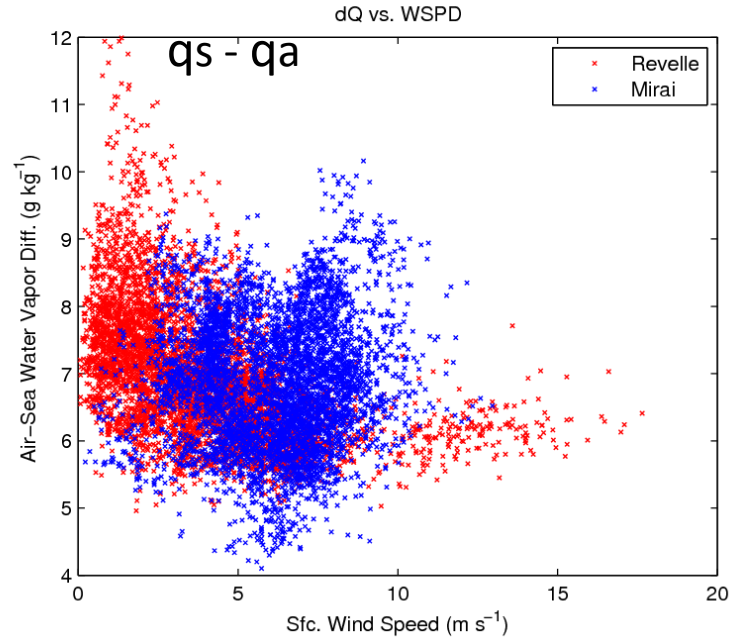


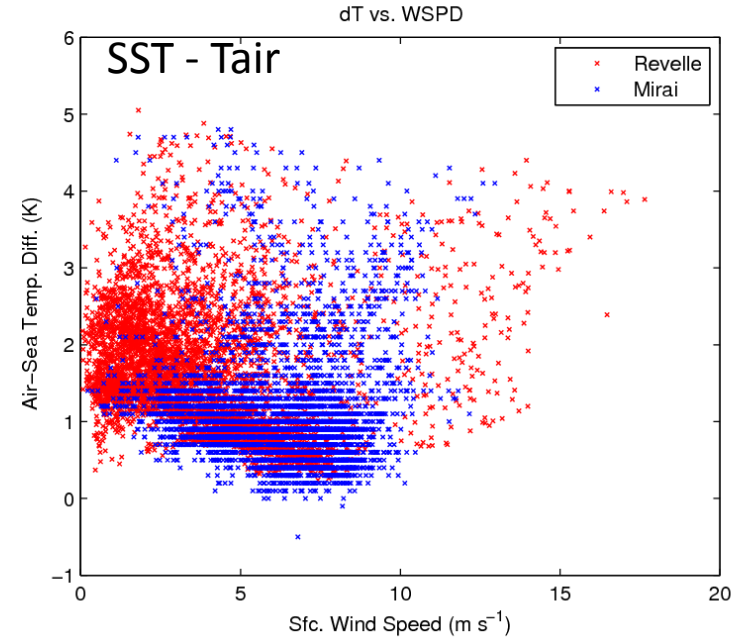


Ship Air-Sea Fluxes in MJO and ITCZ

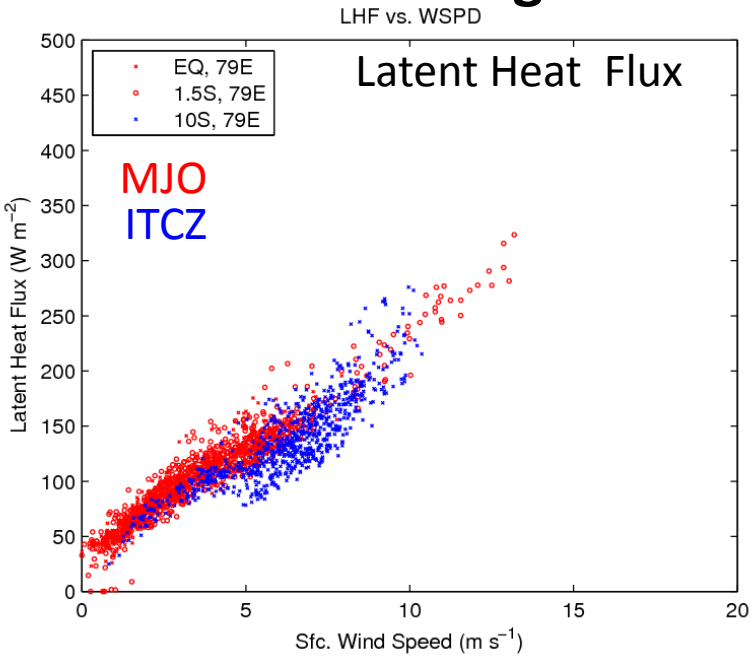


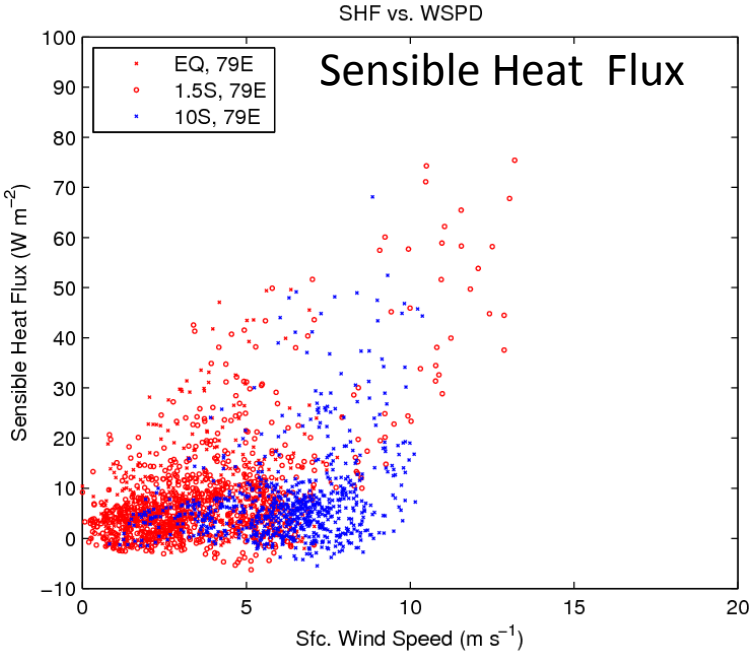


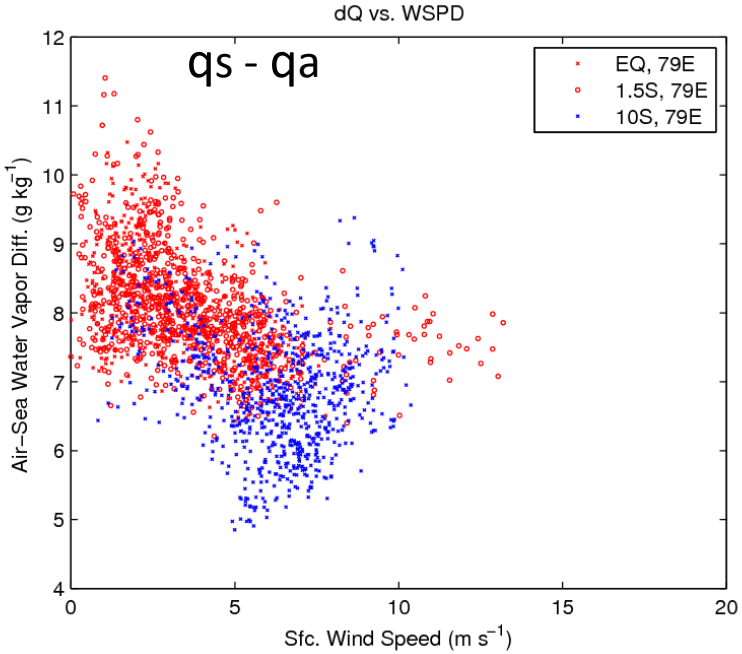


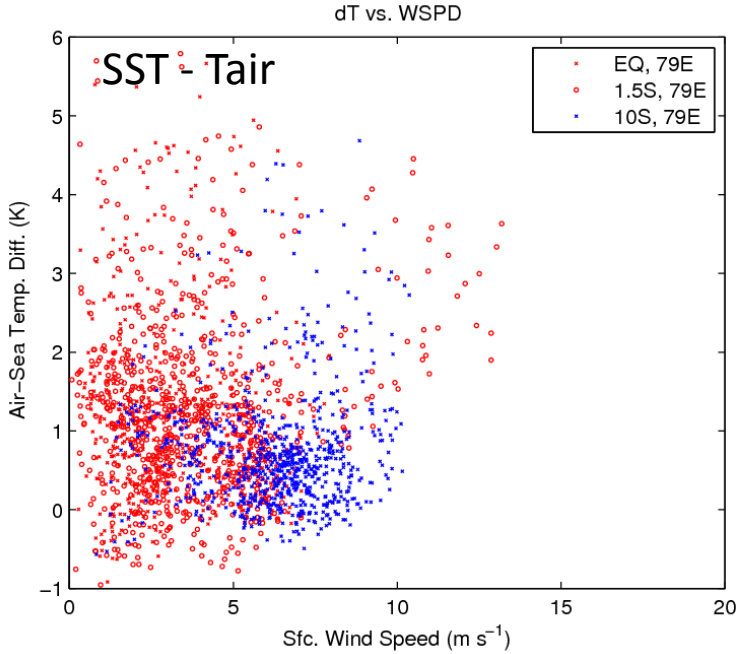


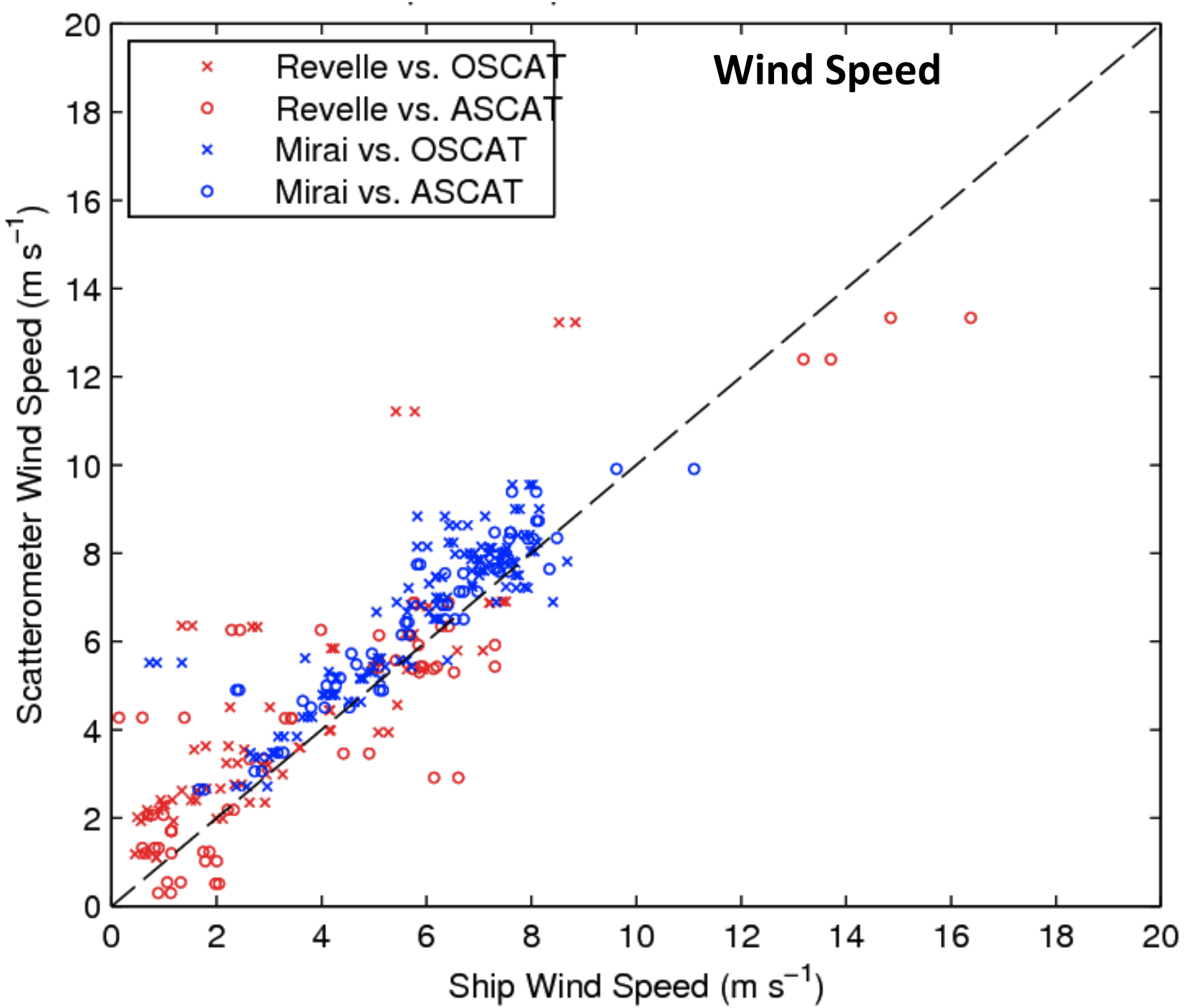
Mooring Air-Sea Fluxes in MJO and ITCZ

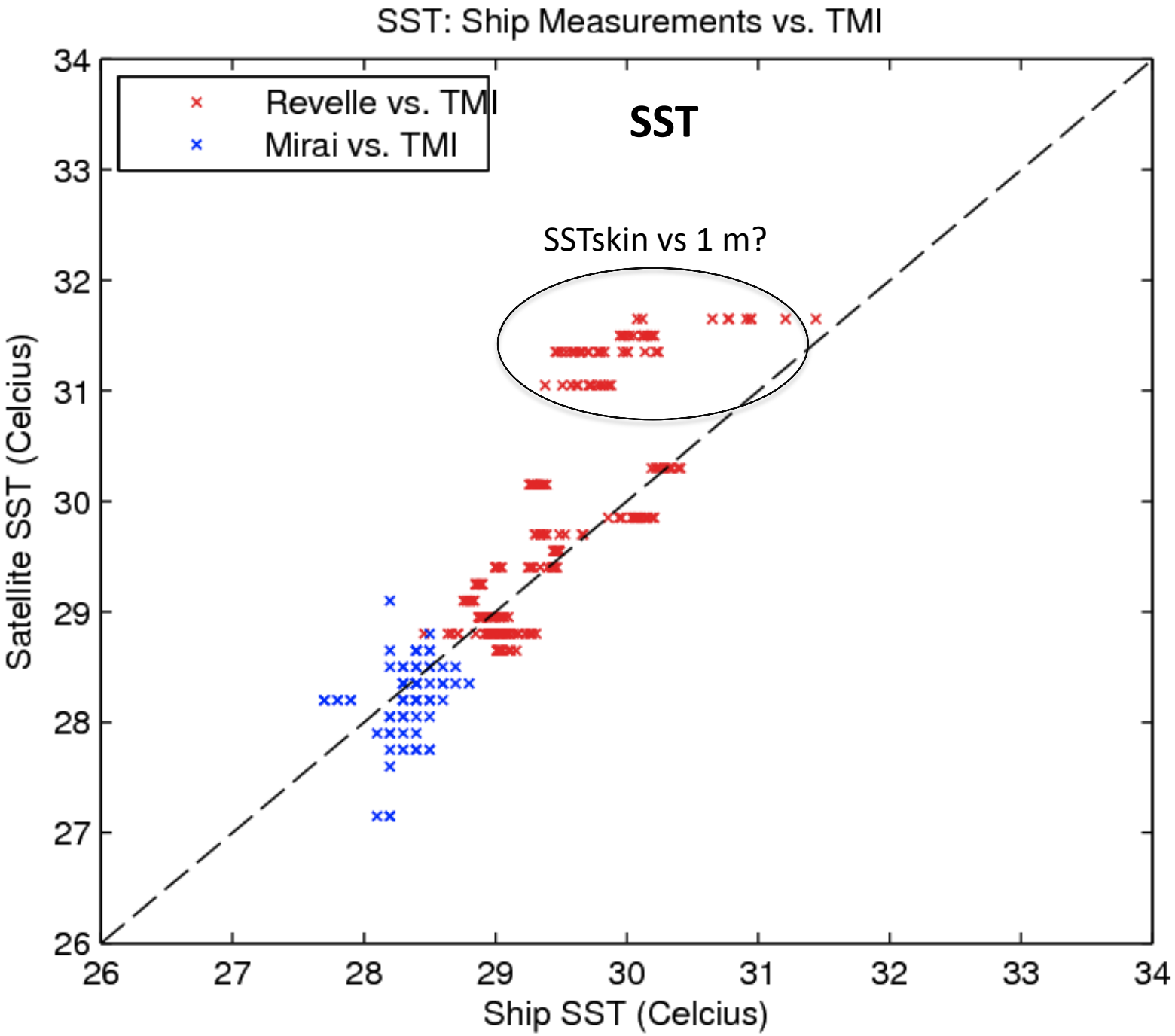




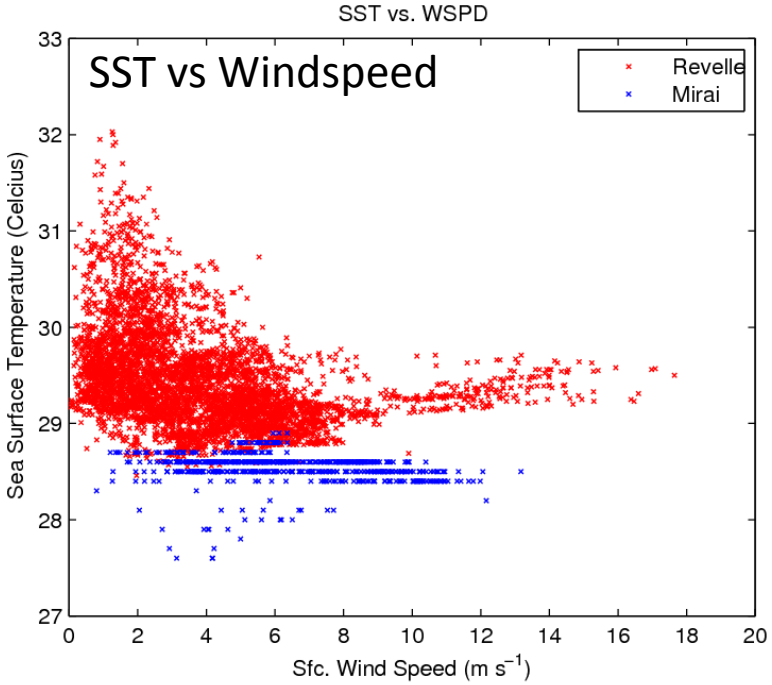


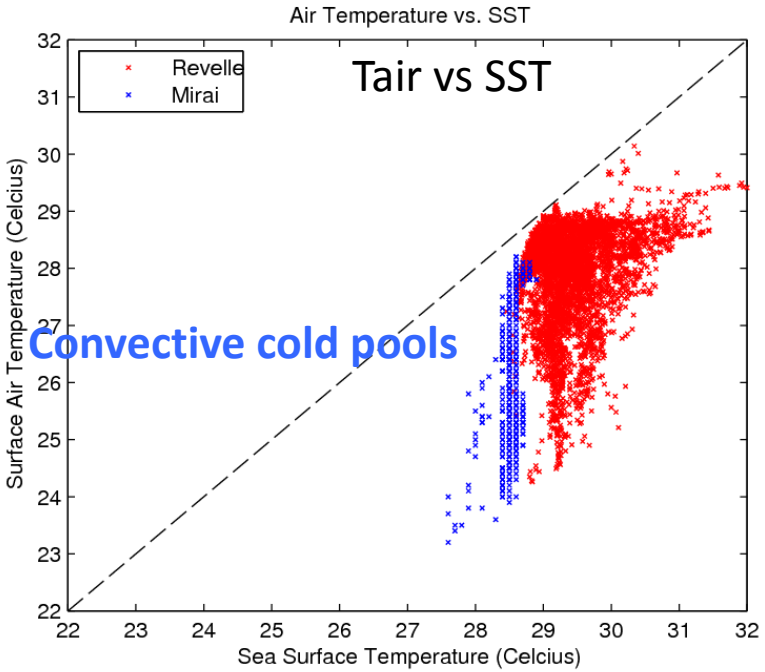


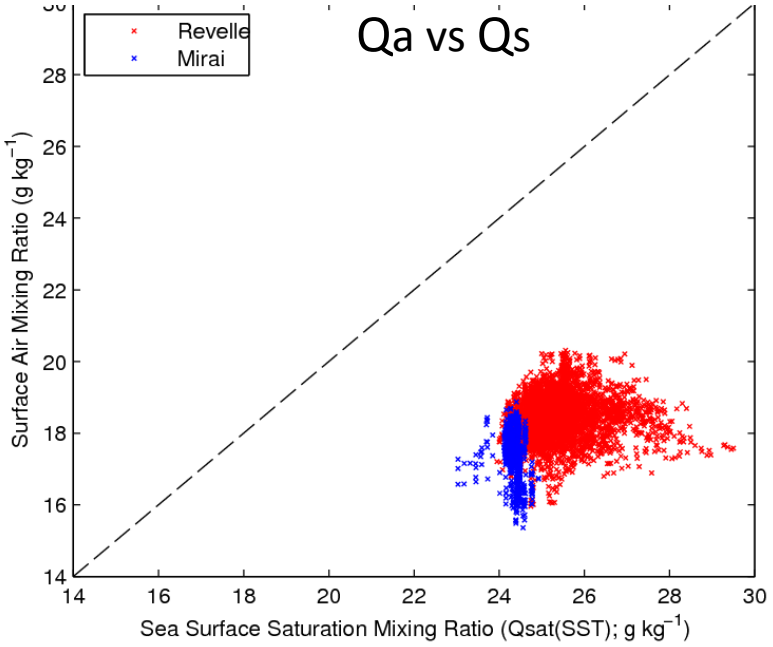

Wind Speed
Revelle vs. OSCAT
Revelle vs. ASCAT
Mirai vs. OSCAT
Mirai vs. ASCAT
Scatterometer Wind Speed (m s^{-1})
Ship Wind Speed (m s^{-1})
0
2
4
6
8
10
12
14
16
18
20

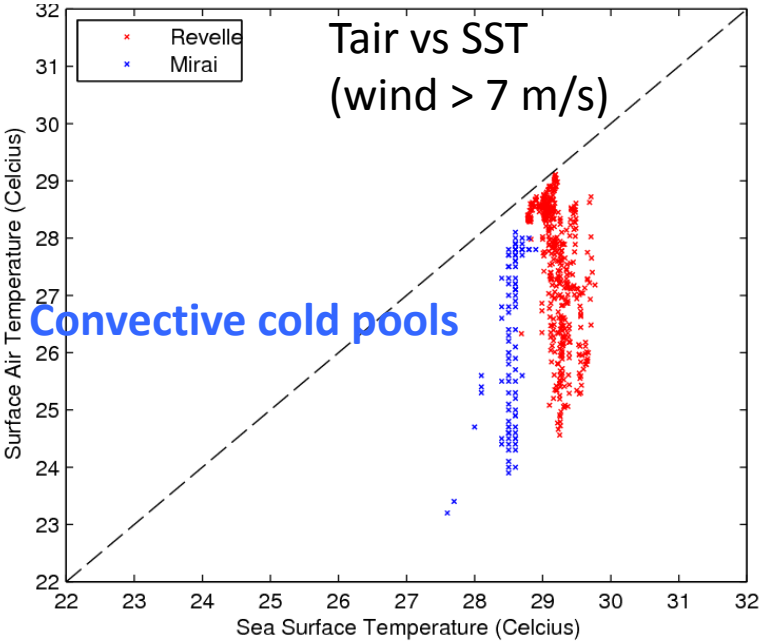

SST: Ship Measurements vs. TMI
Revelle vs. TMI
Mirai vs. TMI
SST
SSTskin vs 1 m?
Satellite SST (Celcius)
Ship SST (Celcius)
34
33
32
31
30
29
28
27
26
26
27
28
29
30
31
32
33
34

Air vs Sea Processes Air-Sea Fluxes



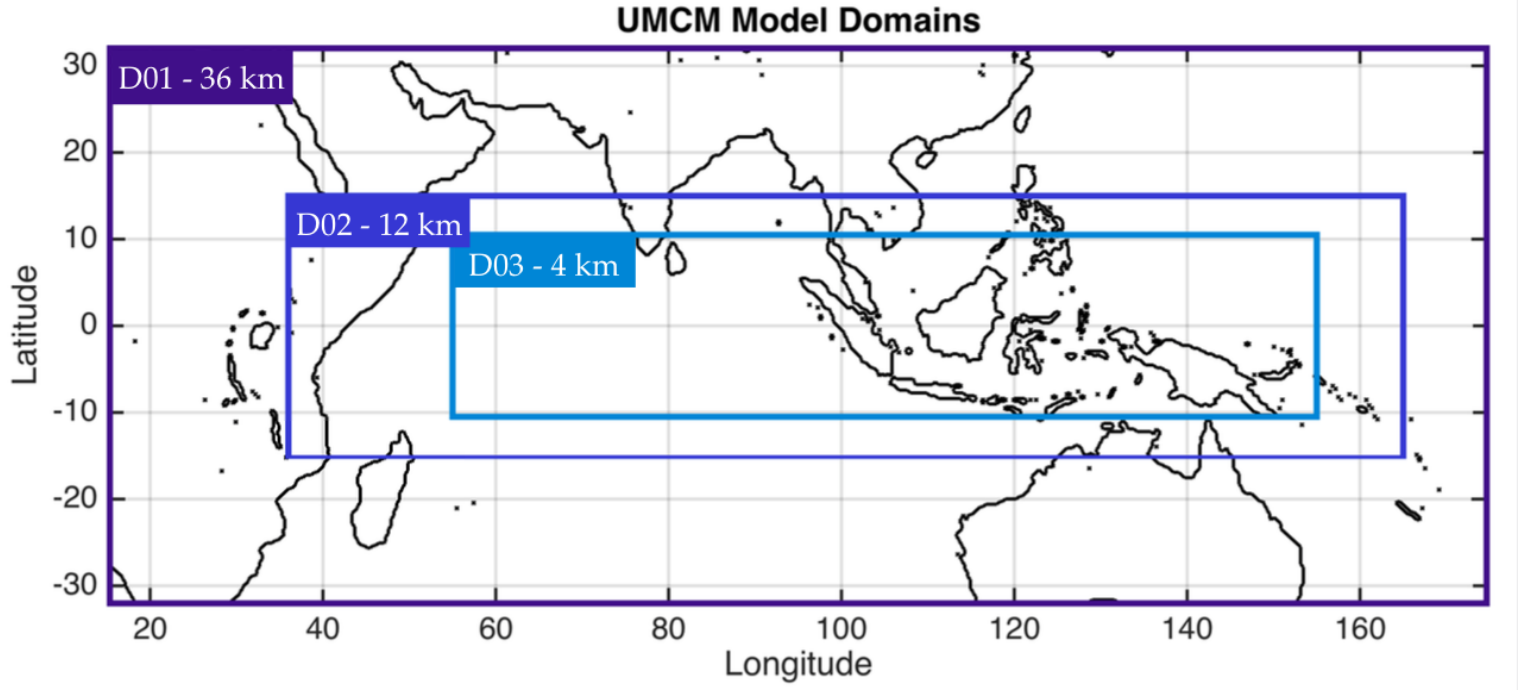




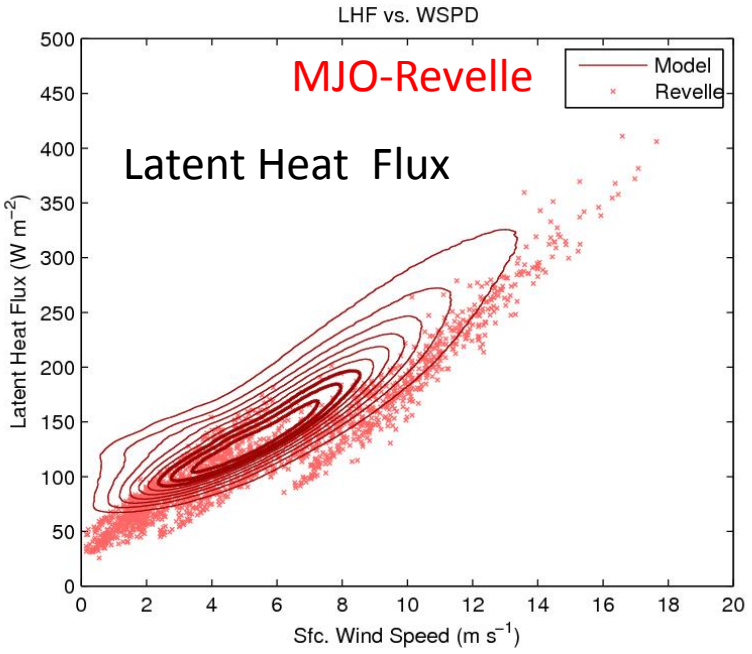


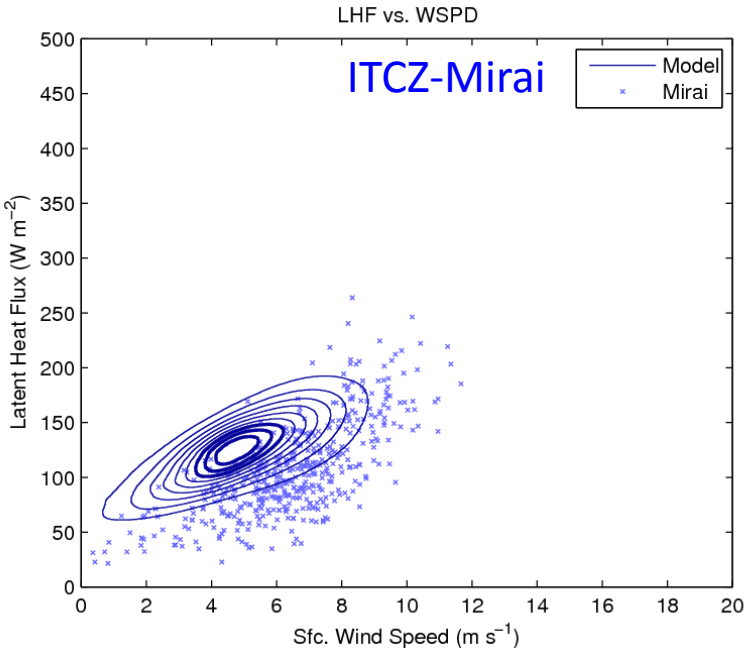
Coupled Atmosphere-Wave-Ocean Model:

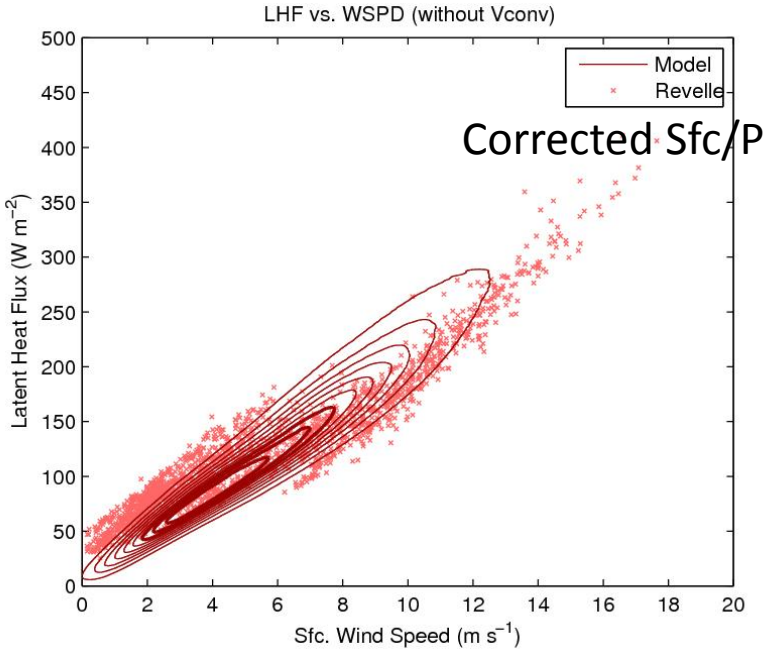
- Weather Research and Forecasting (WRF-ARW) v3.5:
  12-4-1.3 km nested grids, 36 vertical levels
  physics: YSU PBL, Donelan+Garrat sfc., WSM6 microphy
  Initial and boundary conditions from ECMWF analysis fields
- University of Miami Wave Model (UMWM) v1.2:
  4 km, 0.01 Hz
- HYbrid Coordinate Ocean Model (HYCOM) v2.2.34:
  1/25 degree (~4 km) horizontal resolution, 32 vertical levels;
  Initial and boundary conditions from global 1/12 deg. HYCOM



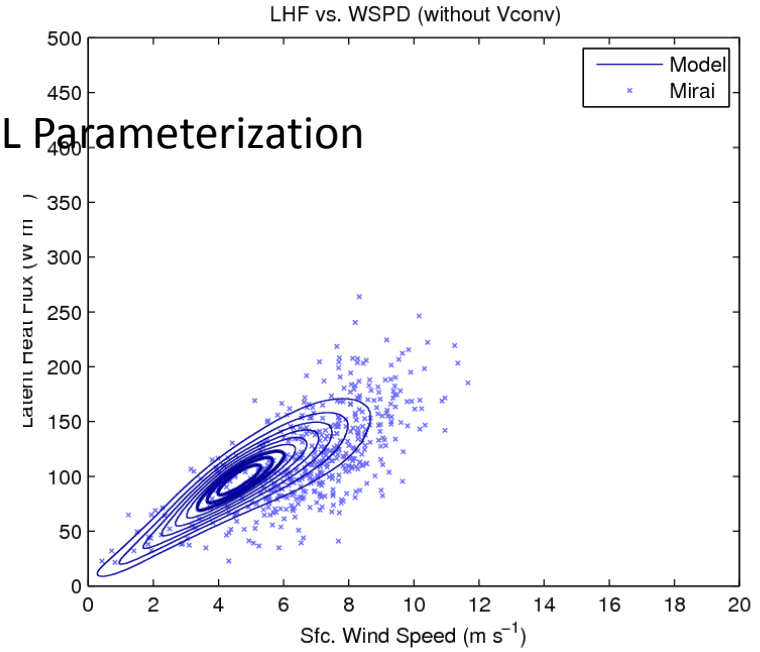
Correction of Model Bias due to Parameterized Convective Velocity in Sfc/PBL







Corrected Sfc/PBL Parameterization

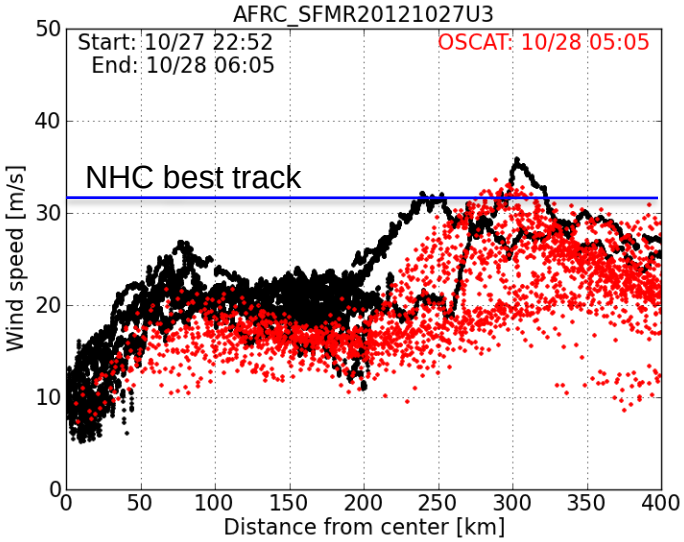


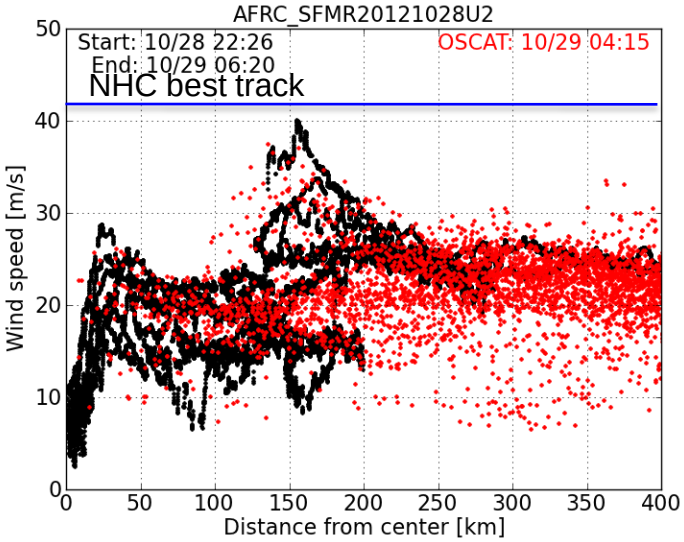
SUMMARY and IMPLICATION

- **Distinct air-sea fluxes in ITCZ and MJO equatorial convection**
- **DYNAMO observations help correct model biases**
- **MJO and ITCZ bridge the weather and climate time scales, which will be critical for both weather and climate models to get them right – a major challenge!**
- **What can we expect in satellite-derived air-sea enthalpy fluxes if the air temperature and humidity (most difficulty to observe from satellites) are dominate the variability?**

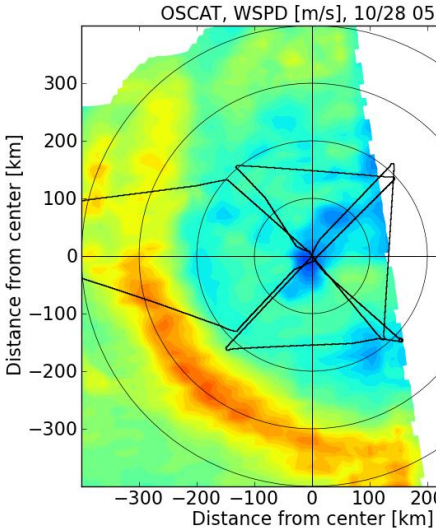
Wind Observations from SFMR and OSCAT

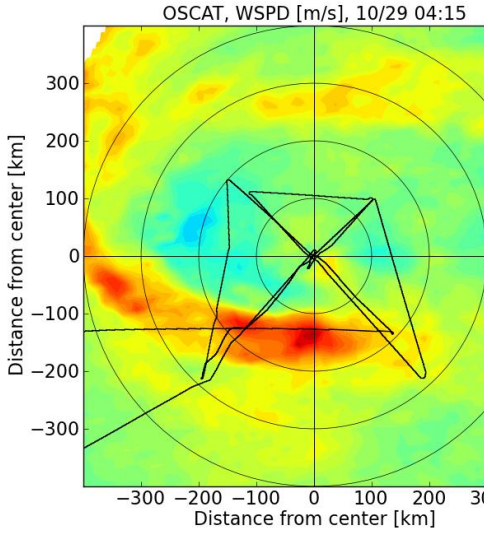
SFMR

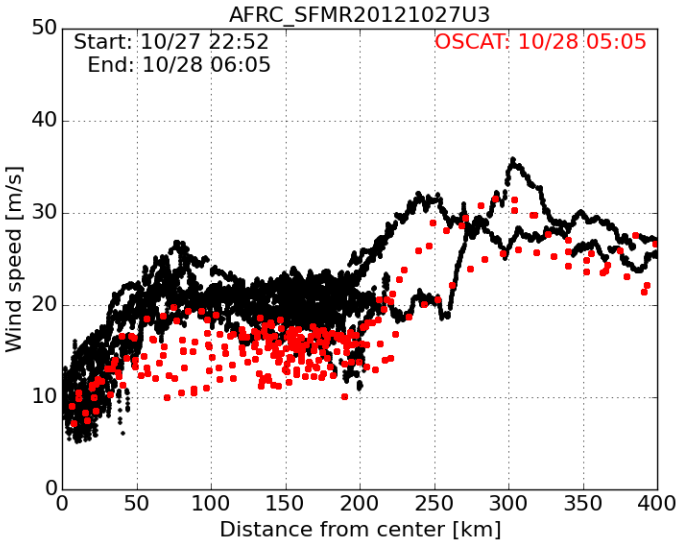


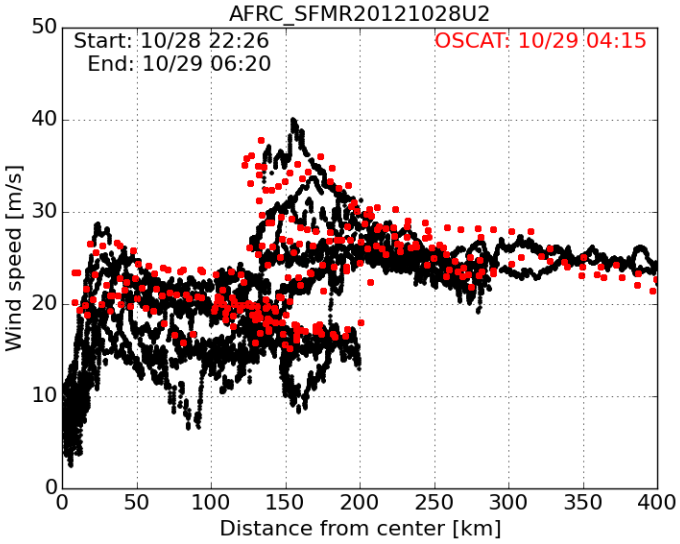


OSCAT

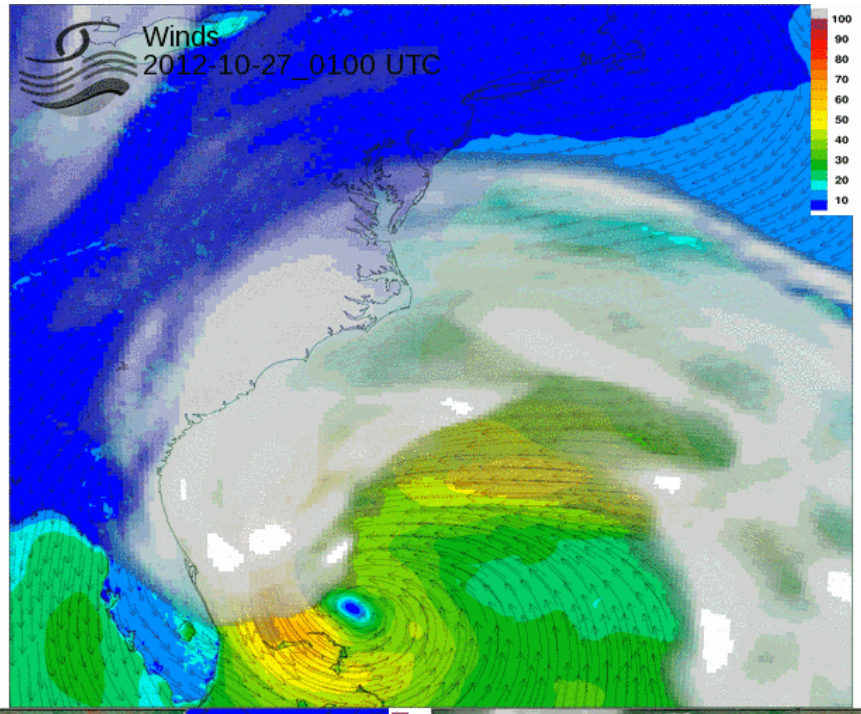






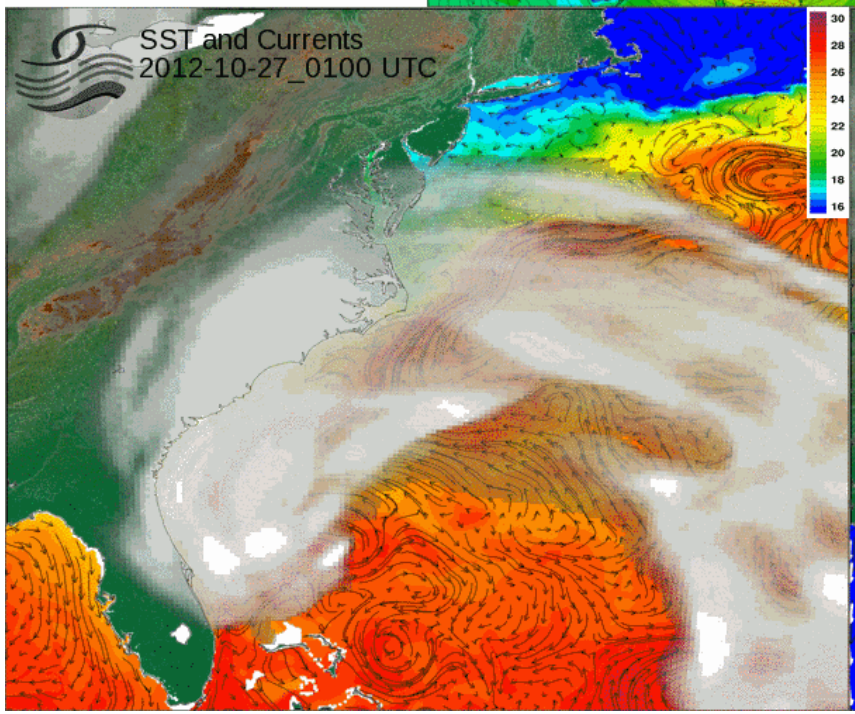


Coupled wind, wave, and current in Super-storm Sandy (2012)

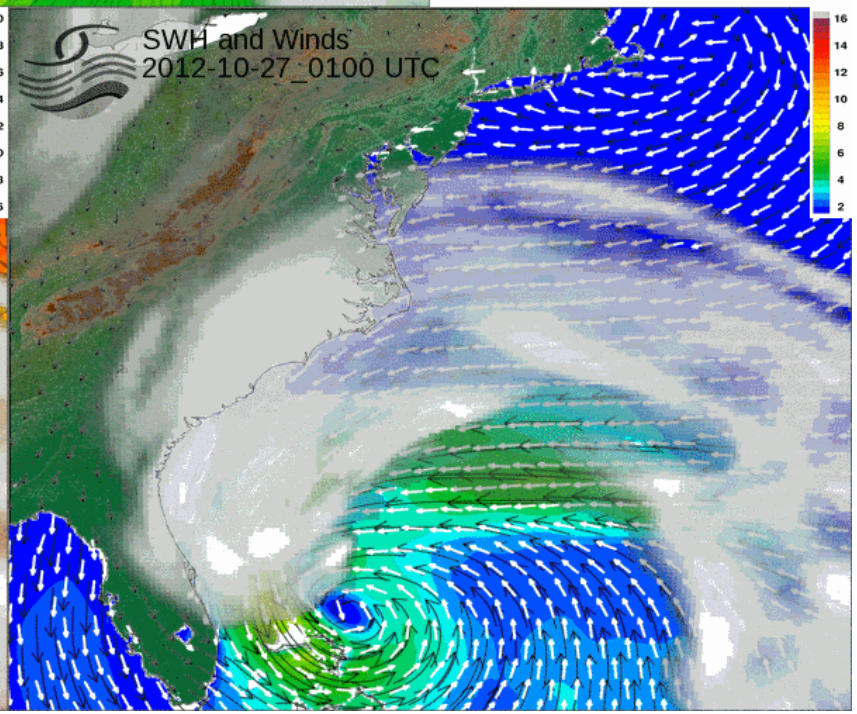


Wind + Rain

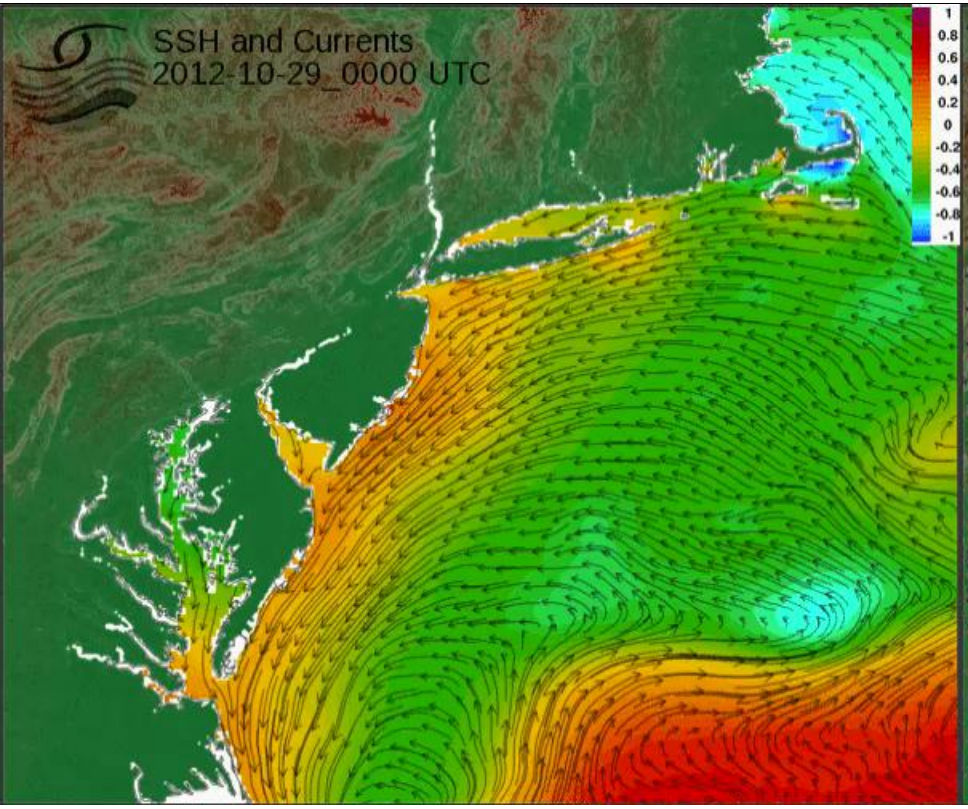
Current + SST



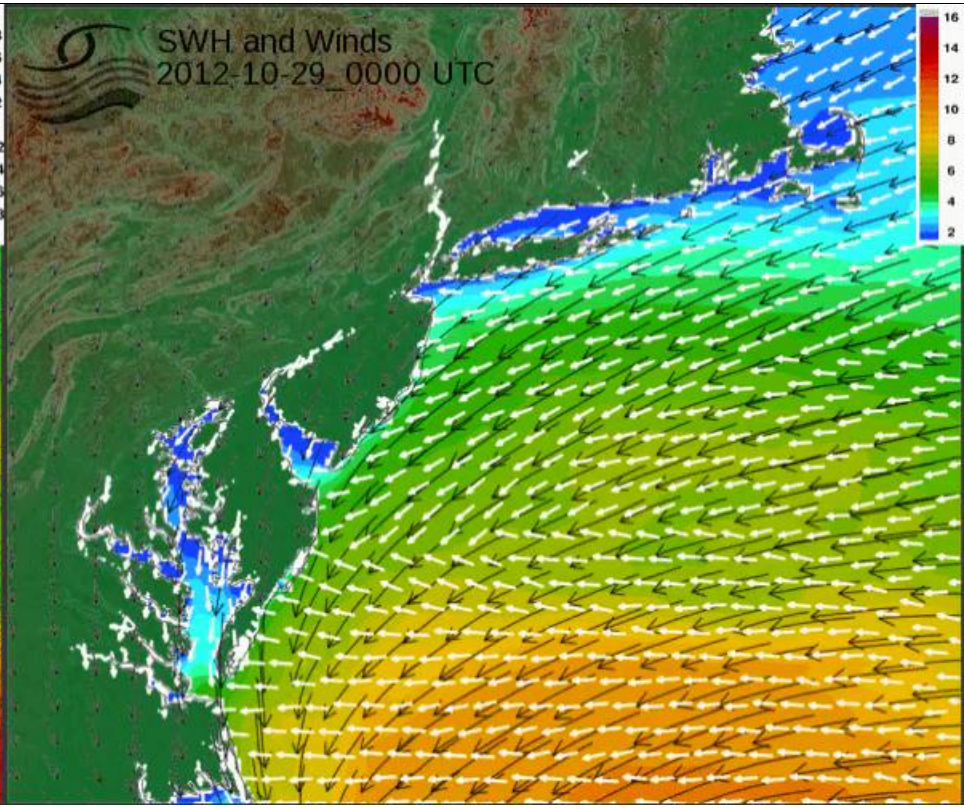
S. Wave Height



Superstorm Sandy Impacts - University of Miami Coupled Model Forecasts



Wave Height



Sea Surface Height