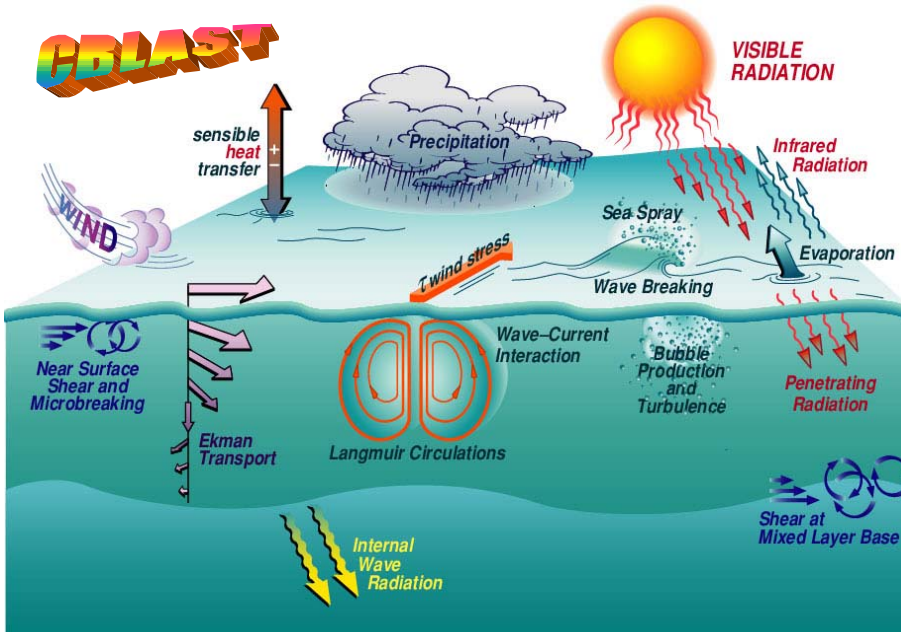
ONR Tropical Meteorology Research

- Fleet priority since WWII
- Establishment of JTWC in 1959
- ONR program thrust since 1980
- 1984: goal set by CINCPACFLT
  (reduce 72h track error to 150nm)
- Mid 1990's-AF cut recon in W. Pacific, emphasis on quant. satellite observations, mitigated impact due to loss of in-situ data
- Previous emphasis on track
  - Increase TC understanding and knowledge base. Q: could it be systematized to improve track forecasts and overcome lack of experience
    - Organized the knowledge base, developed Systematic Approach
    - SAFA operational at JTWC for 1999 TC season,
    - **Met 1984 goal in 2002 (~50% reduction in track error)**
- Recent program focus
  – coupling between ocean & atmosphere
  - WESTPAC unique processes (limited S&T relative to Atlantic basin)

CBLAST

Coupled Boundary Layers and Air-Sea Transfer



Motivation: Very few observation and little understanding of air-sea transfer processes in very low (<7 m/s) and very high (>30 m/s) wind regimes

Major Performers:

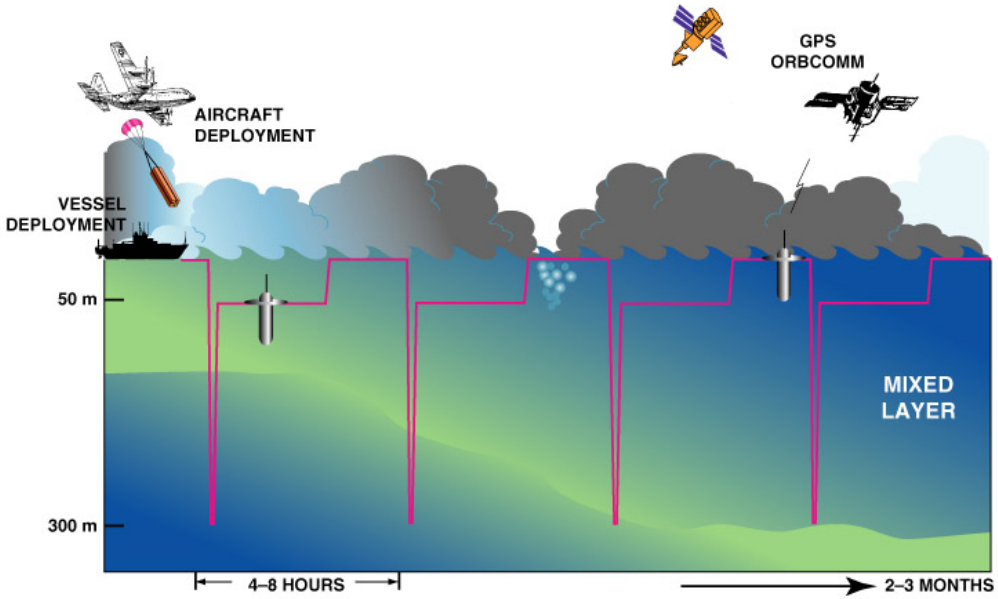
Academia (WHOI, SIO, UWash, OSU, UH, UMiami, URI, UWisc, MIT, etc.)

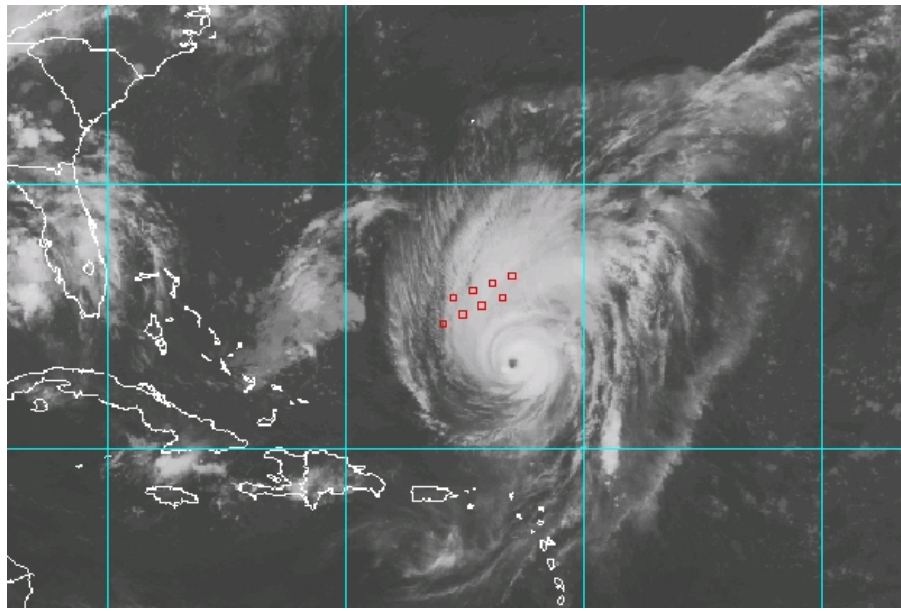
Govt. labs (NRL, NASA, NOAA)

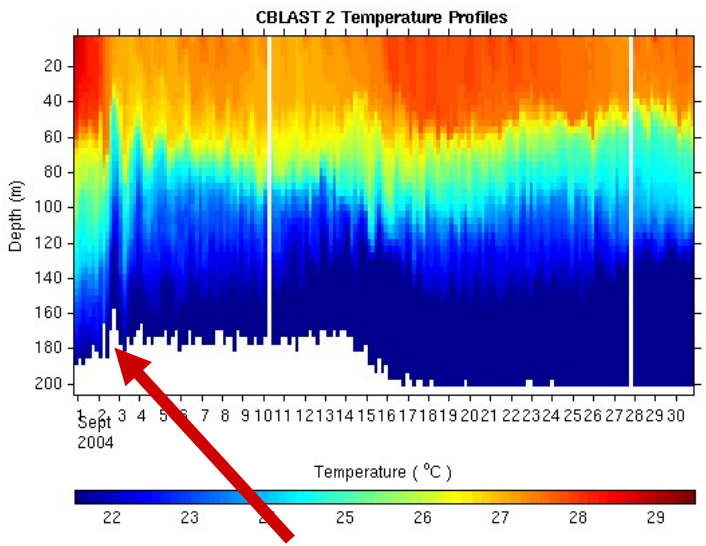
- **OBJECTIVES:**
  - **Understand the physical processes of air-sea interaction in the wave boundary layer at low and very high wind conditions**
  - **Quantify air-sea fluxes**
  - **Develop parameterizations of interfacial processes for predictive models**

- **Hurricane component of CBLAST**
  - **Initial 5-year program to measure, analyze and understand the critical air-sea coupling at hurricane winds**
  - **2-yr follow-on effort to extract and apply findings to increased understanding and development of advanced parameterizations**

CBLAST: Float Array
Air-Deployed Ahead of Hurricane



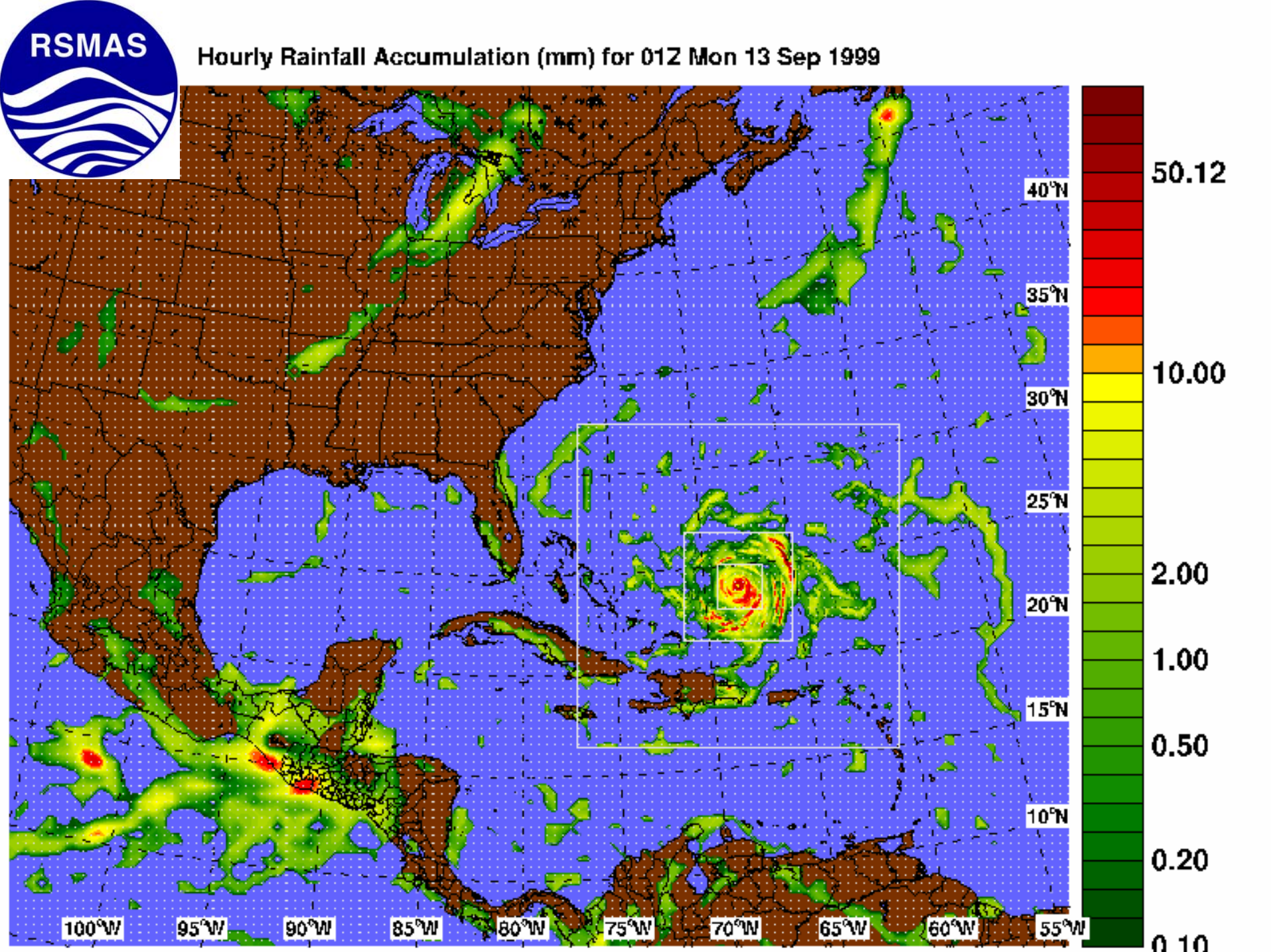


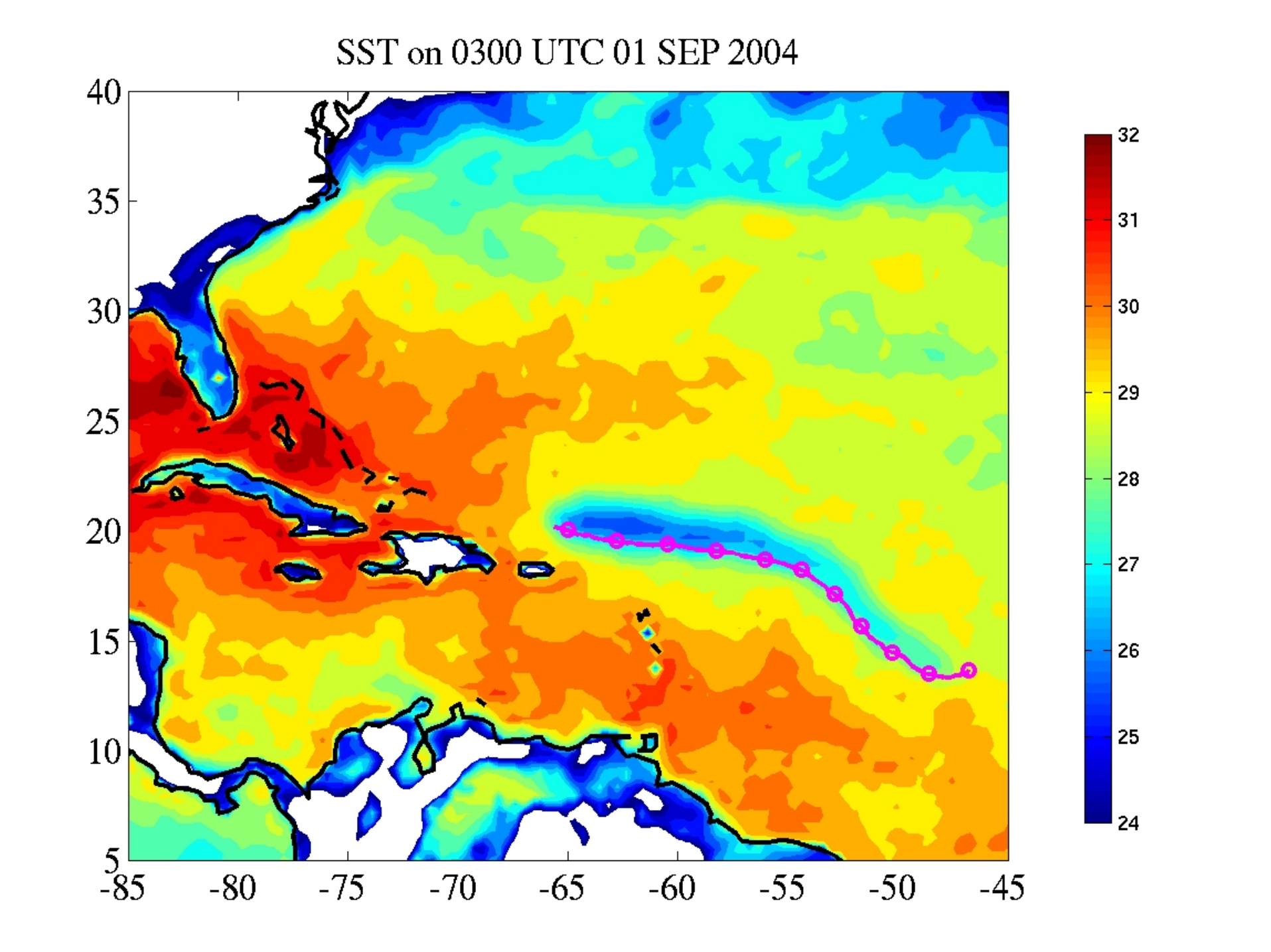


Rapid uplift when eyes passes overhead

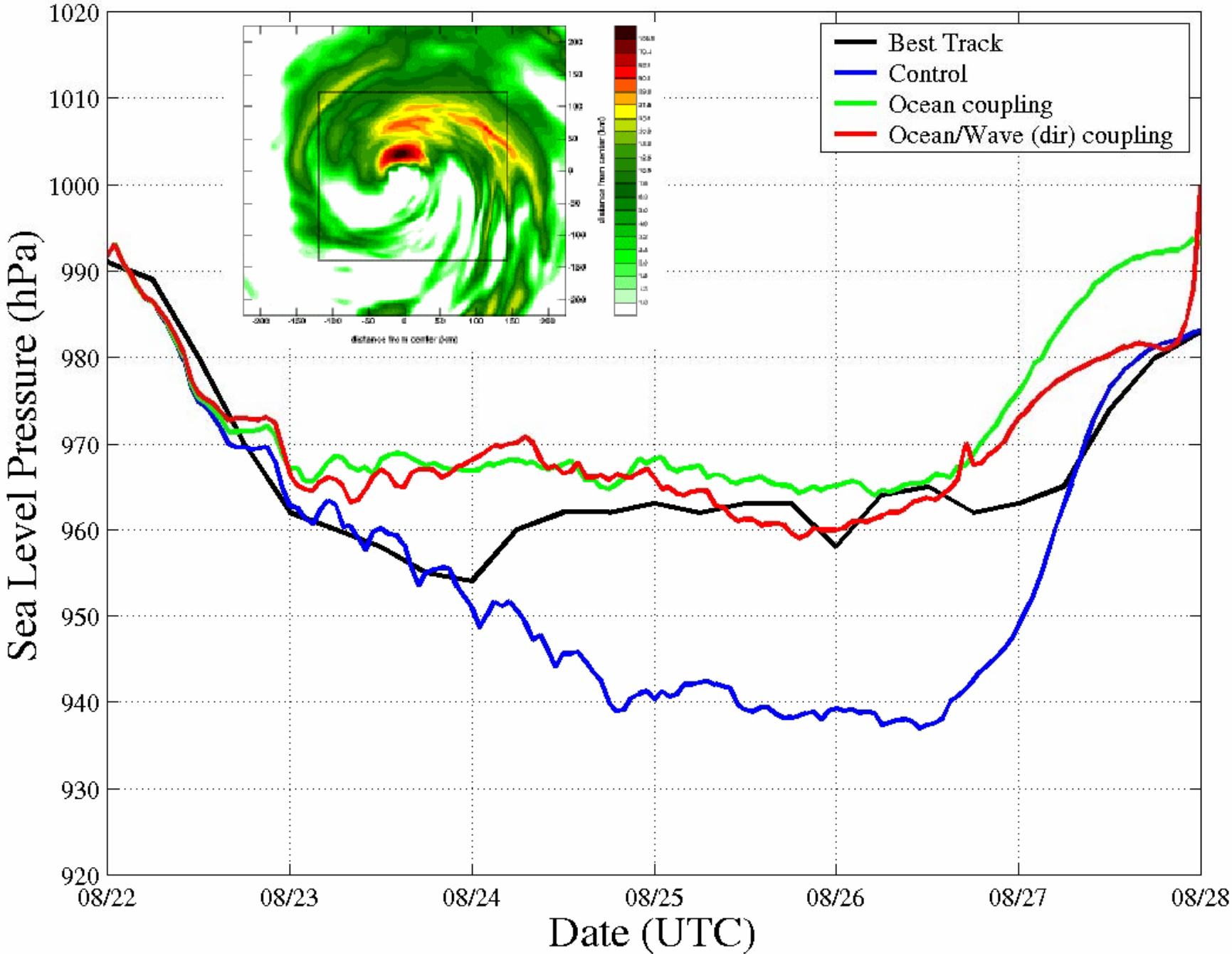
Ocean Thermal Energy Structure Underneath a Hurricane Revealed by Instrumented Float.

Hurricane Francis


RSMAS
Hourly Rainfall Accumulation (mm) for 01Z Mon 13 Sep 1999
40°N
35°N
30°N
25°N
20°N
15°N
10°N
100°W
95°W
90°W
85°W
80°W
75°W
70°W
65°W
60°W
55°W
50.12
10.00
2.00
1.00
0.50
0.20
0.10


SST on 0300 UTC 01 SEP 2004
40
35
30
25
20
15
10
5
-85
-80
-75
-70
-65
-60
-55
-50
-45
32
31
30
29
28
27
26
25
24

Minimum SLP for Bonnie (1998)



CBLAST-Hurricane Findings

Coupled Atmosphere-Wave-Ocean Modeling

✓The *in situ* atmosphere and ocean data set acquired during the CBLAST 2004 field program offer an unprecedented view of ocean dynamics in severe forcing.

✓ It seems fairly clear that Cd does not increase with wind speed at the very high speeds found in Frances.

✓SST cooling in the Frances region (~ 2.5 C) was due mainly to vertical mixing and wind-generation of upper ocean currents of approx 1.2 m/s.

✓Atmosphere-Ocean coupling improves tropical cyclone intensity forecasts, especially at very high resolution.

✓Wind-Wave coupling contributes to storm asymmetry that varies significantly from storm-to-storm. The SST cooling and the amplitude of wind-driven UO current transport was also asymmetric.

✓SST in the cooled wake relaxed back to pre-Frances values with an e-folding time of about 10 days.

✓A full ocean model, e.g. HYCOM, with ~10m vertical resolution is needed for coastal regions and over the Gulf Stream and warm eddies.

Future research directions

Track errors will continue to improve as global model skill increases

- Assimilation of new sources of remote sensing data should help, as will ocean observing system
- Profiling floats/drifters should be considered as part of routine TC recon.

BUT:

- 72h track error <150nm but less improvement in 96h track errors (WESTPAC disturbances can go to fully developed TC in <3 days)
- Improvement in forecasting intensity changes is not evident
- Need to treat as a coupled problem

A coupled atmos./wave/ocean mesoscale modeling system at ~1km resolution is feasible

- Improved understanding of heat, moisture and momentum fluxes bridge a significant knowledge gap
- Needed to address genesis, intensity changes, structure and asymmetries; improved wave/surge prediction