Evaluation of the NCODA Assimilation as Initial/Boundary Conditions for Hurricane Ivan and West Florida Shelf Simulations

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Overview

- **Evaluate initial and boundary conditions provided by the NCODA ocean nowcast for two projects:**
  - **Simulation of the ocean response to hurricanes in the Gulf of Mexico**
    - **Long-term goal: Improve ocean model performance in coupled hurricane prediction models**
    - **Collaborators: Nick Shay (UM/RSMAS), S. Daniel Jacob (UMBC), Ole-Martin Smedstad (PSI), Carlos Lozano (NOAA/NCEP), Eric Uhlhorn (NOAA/HRD)**
  - **Coastal ocean simulations along the West Florida Shelf**
    - **Collaborators: Robert Weisberg and Alexander Barth (USF)**

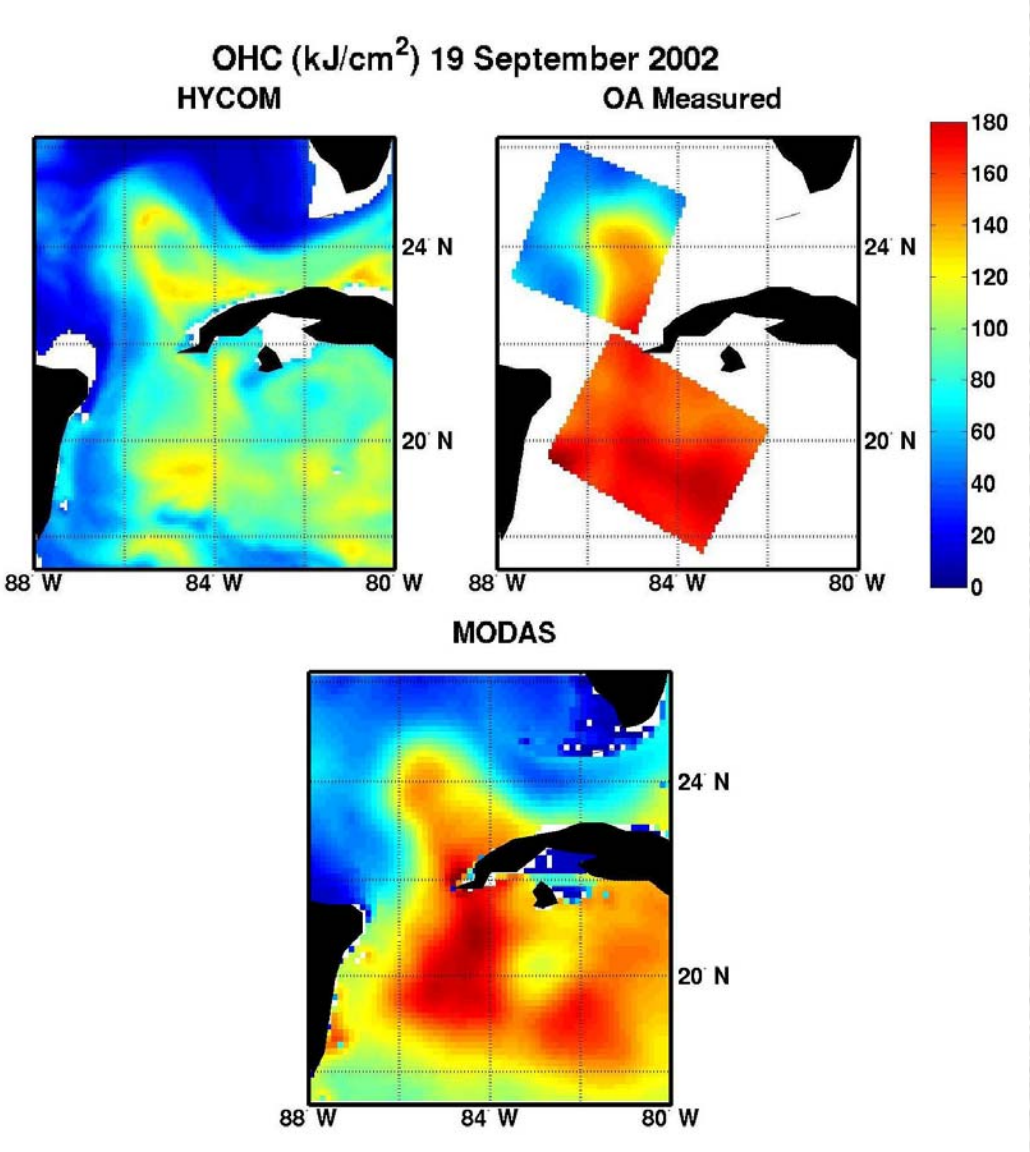
Hurricane Response Simulations

- **Motivation**
  - **Improve ocean model performance in coupled hurricane forecast models**
  - **HYCOM slated to be ocean component of HWRF**
- **High-quality ocean nowcasts are required for initialization**
  - **Currents and eddies must be in the correct locations**
  - **Local T - S profiles, including ocean heat content (OHC), must be accurate**

$$\mathrm{OHC} = c_p \int_0^{D_{26}} \rho \left(T - 26 \right) dz$$

  - **Large OHC differences occur due to the Loop Current and associated warm- and cold-core rings**

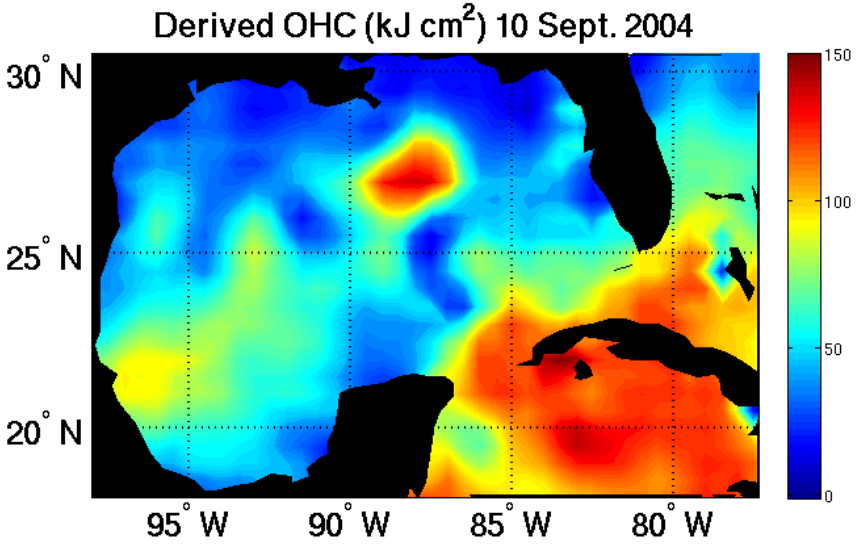
Hurricane Isidore Initial conditions from 1/12° Atlantic OI Nowcast

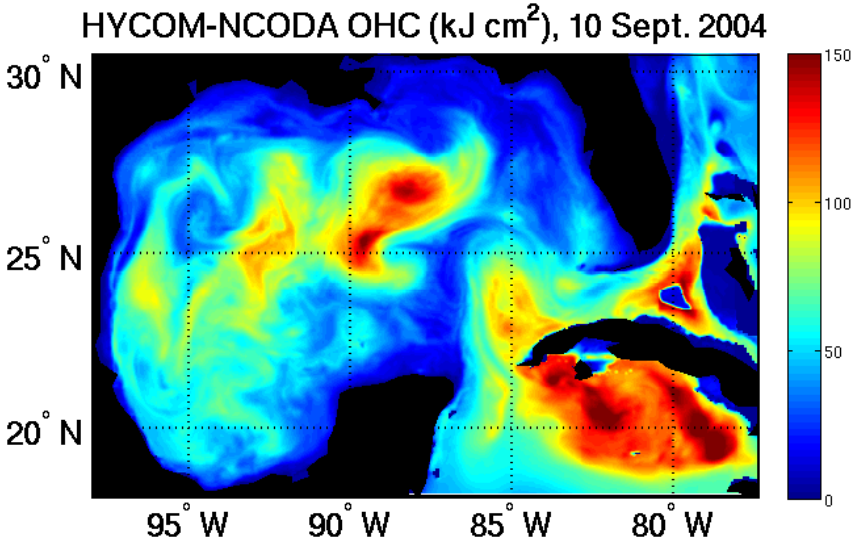


- HYCOM 1/12° Atlantic nowcast fields locate features correctly, but underestimate OHC by ~50%
- The nowcast also displays a large salinity bias (too fresh)
- The upper ocean cools too much when initialized by this nowcast product

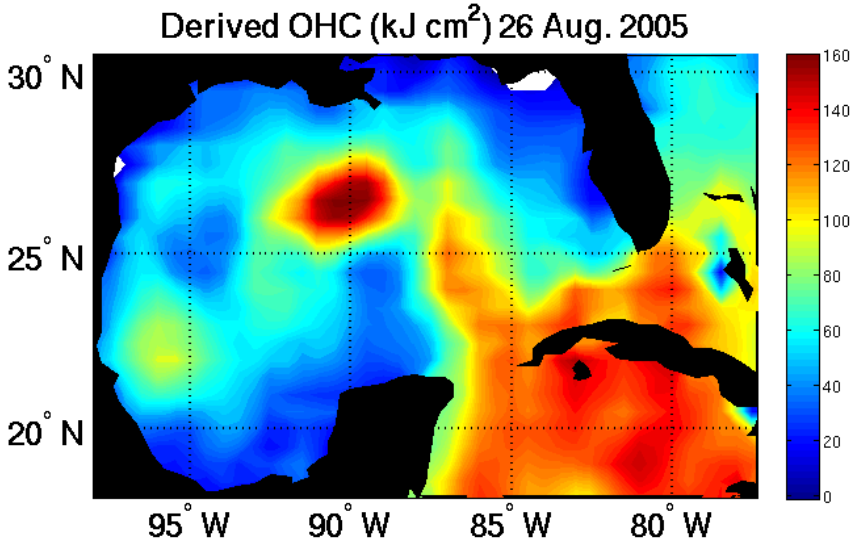
Initial OHC Maps from the NCODA GOM Nowcast

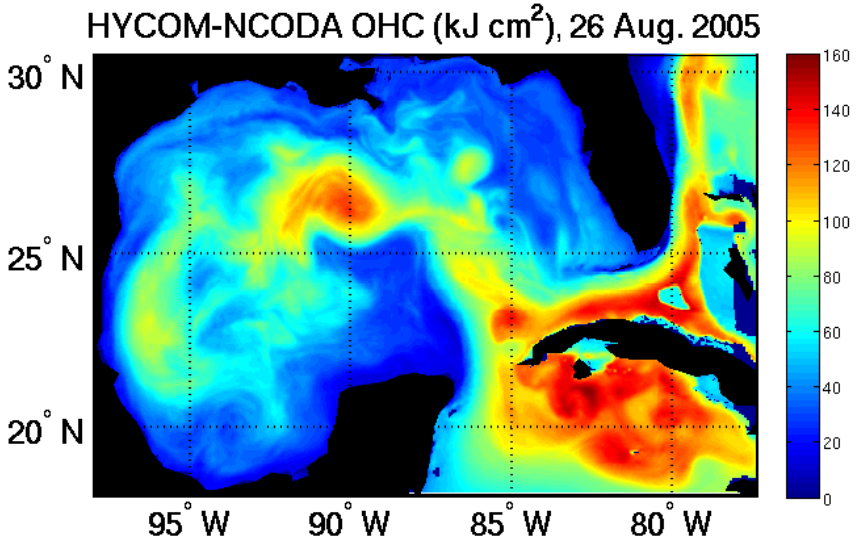
Pre-Ivan





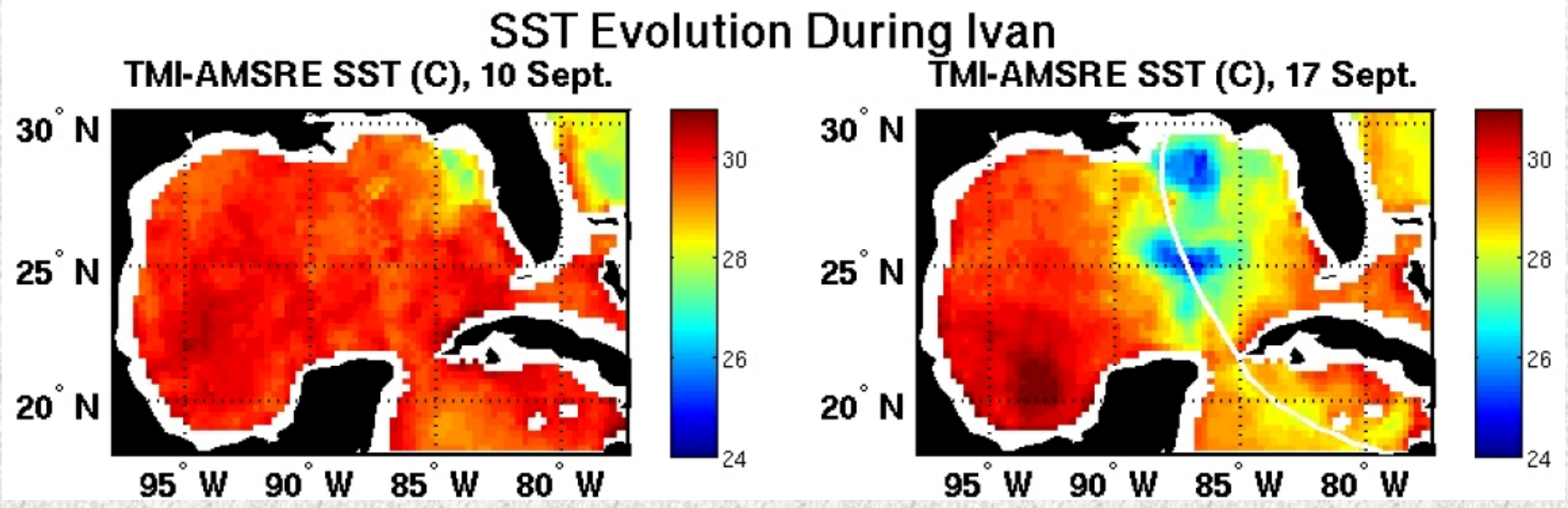
Pre-Katrina



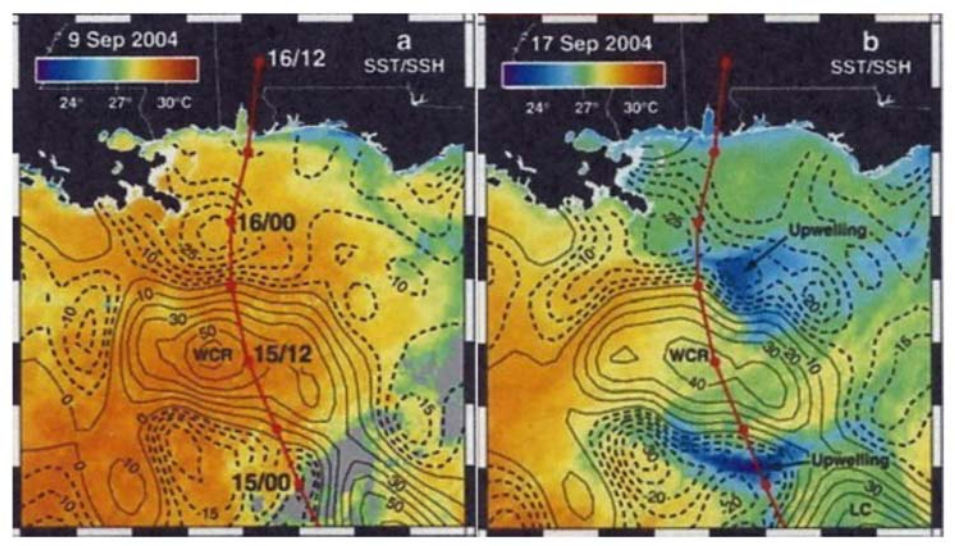


Observed Ocean Response to Hurricane Ivan

From microwave satellite measurements:



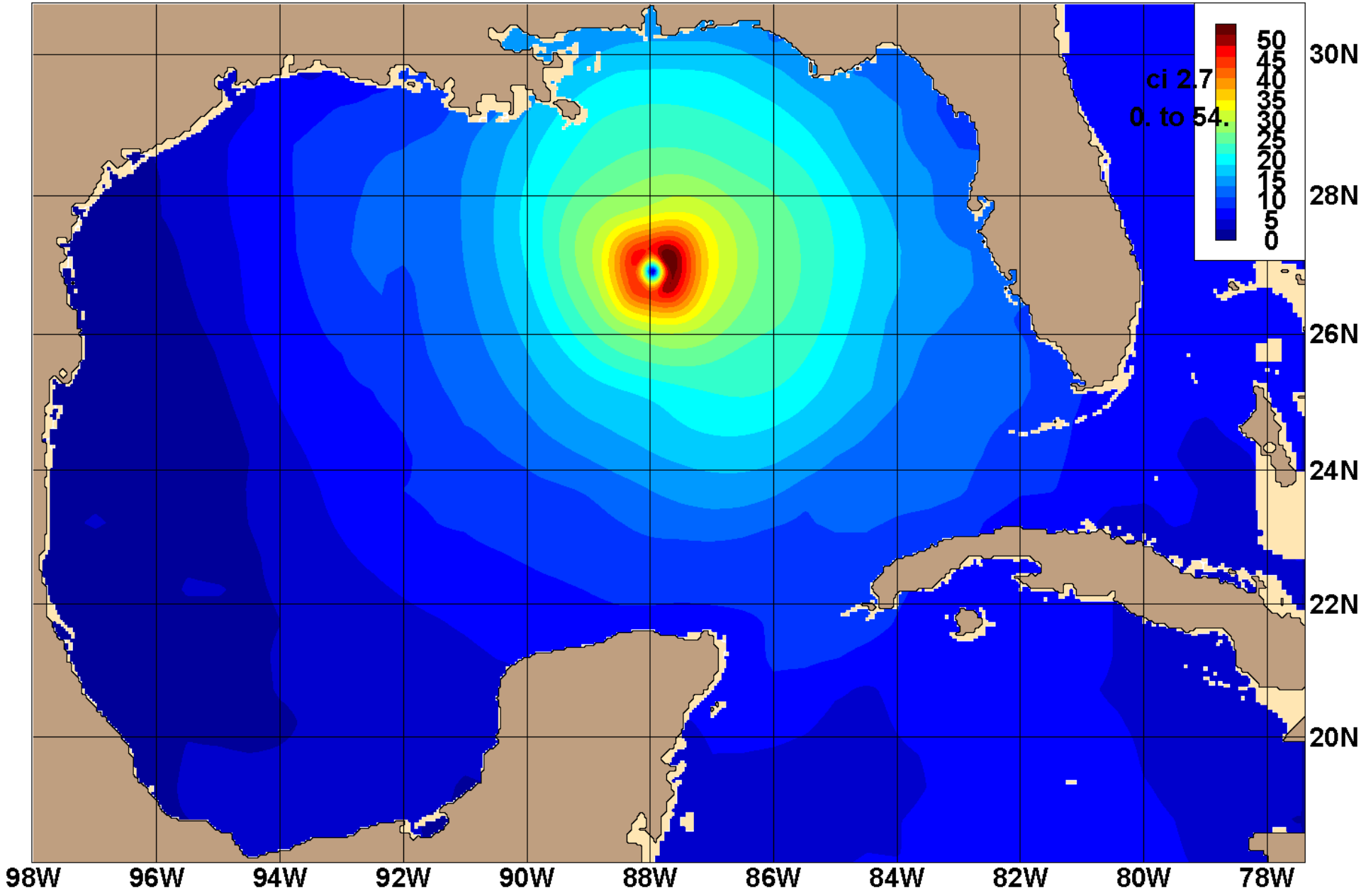
From AVHRR measurements (Walker et al, 2005):



Ivan Simulation

- Run within the 0.04° GOM Domain
- Initial and Boundary Conditions from NCODA
- GISS Vertical Mixing
- Atmospheric Forcing
  - Very important - must resolve the inner core of the storm
  - Start with the 0.5-degree NOGAPS forcing
    - Problems:
      - Eye and eyewall poorly resolved
      - Maximum winds underestimated by 30-40%
  - Blend NOGAPS wind field with HWIND gridded vector wind fields from NOAA/HRD
    - Produce wind speed and wind stress forcing fields that resolve the inner core structure

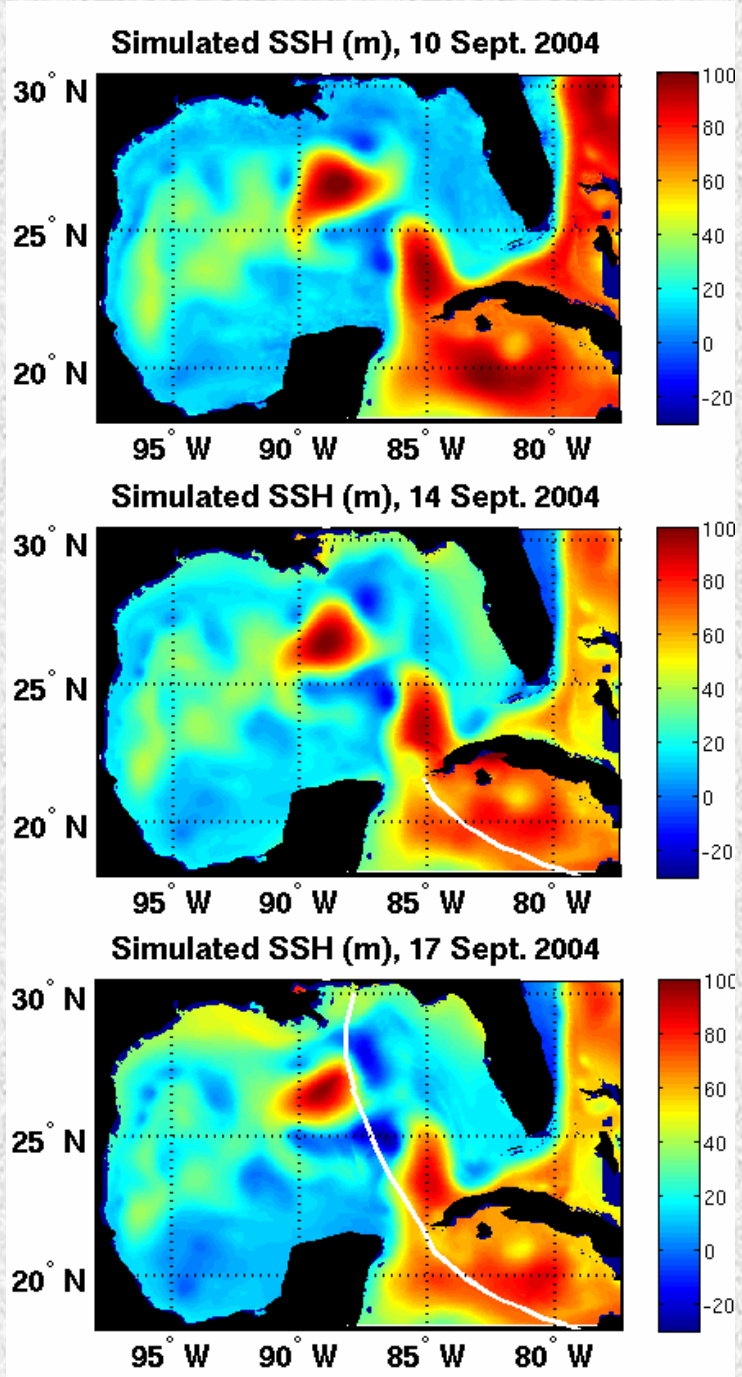
NOGAPS+HWIND Wind Speed (m/s), 1330 UTC, 15 Sept. 2004

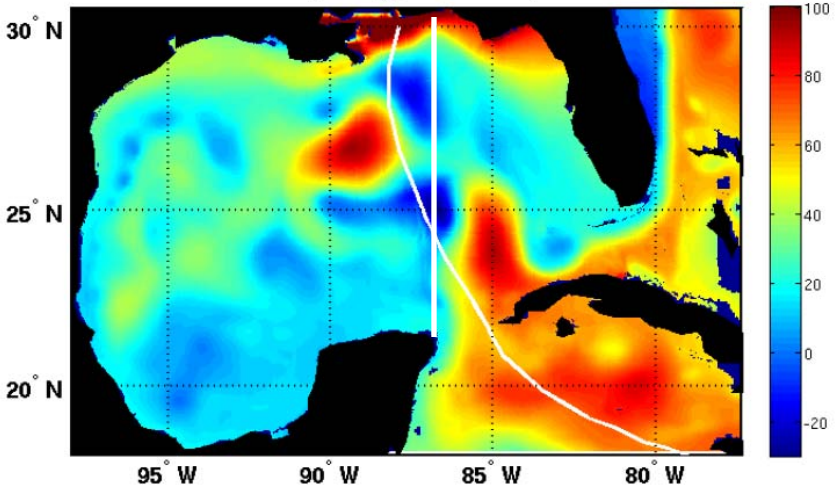


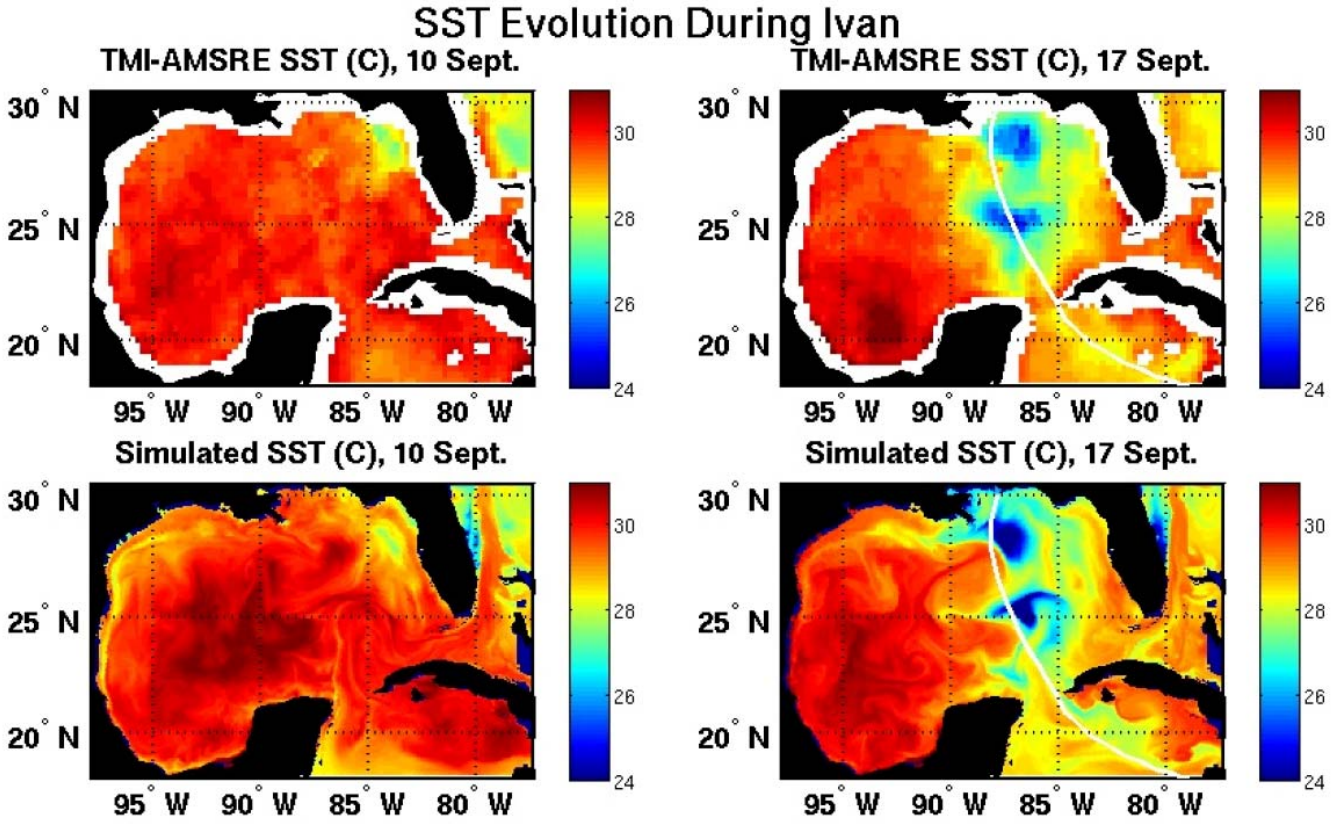
SSH Evolution During Ivan

Top panel is initial field From NCODA

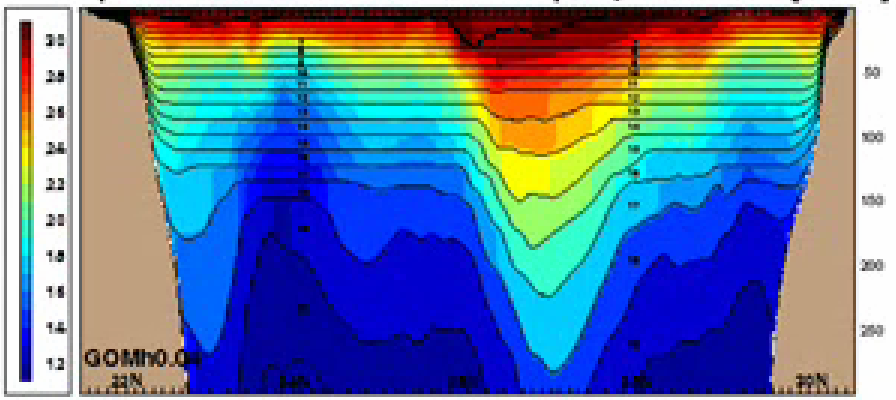
The Loop Current, warm-core ring, and two cold-core rings strongly influence the SST cooling pattern



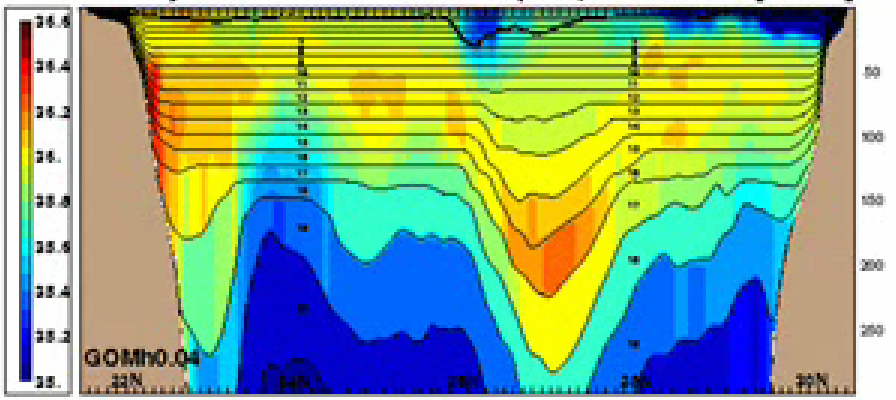

Simulated SSH (cm), 0300Z, 16 Sept. 2004
30° N
25° N
20° N
95° W
90° W
85° W
80° W
100
80
60
40
20
0
-20


SST Evolution During Ivan
TMI-AMSRE SST (C), 10 Sept.
TMI-AMSRE SST (C), 17 Sept.
Simulated SST (C), 10 Sept.
Simulated SST (C), 17 Sept.
30° N
25° N
20° N
95° W
90° W
85° W
80° W
30
28
26
24

temperature merid.sec. 86.84w Sep 10, 2004 03Z [21.0H]



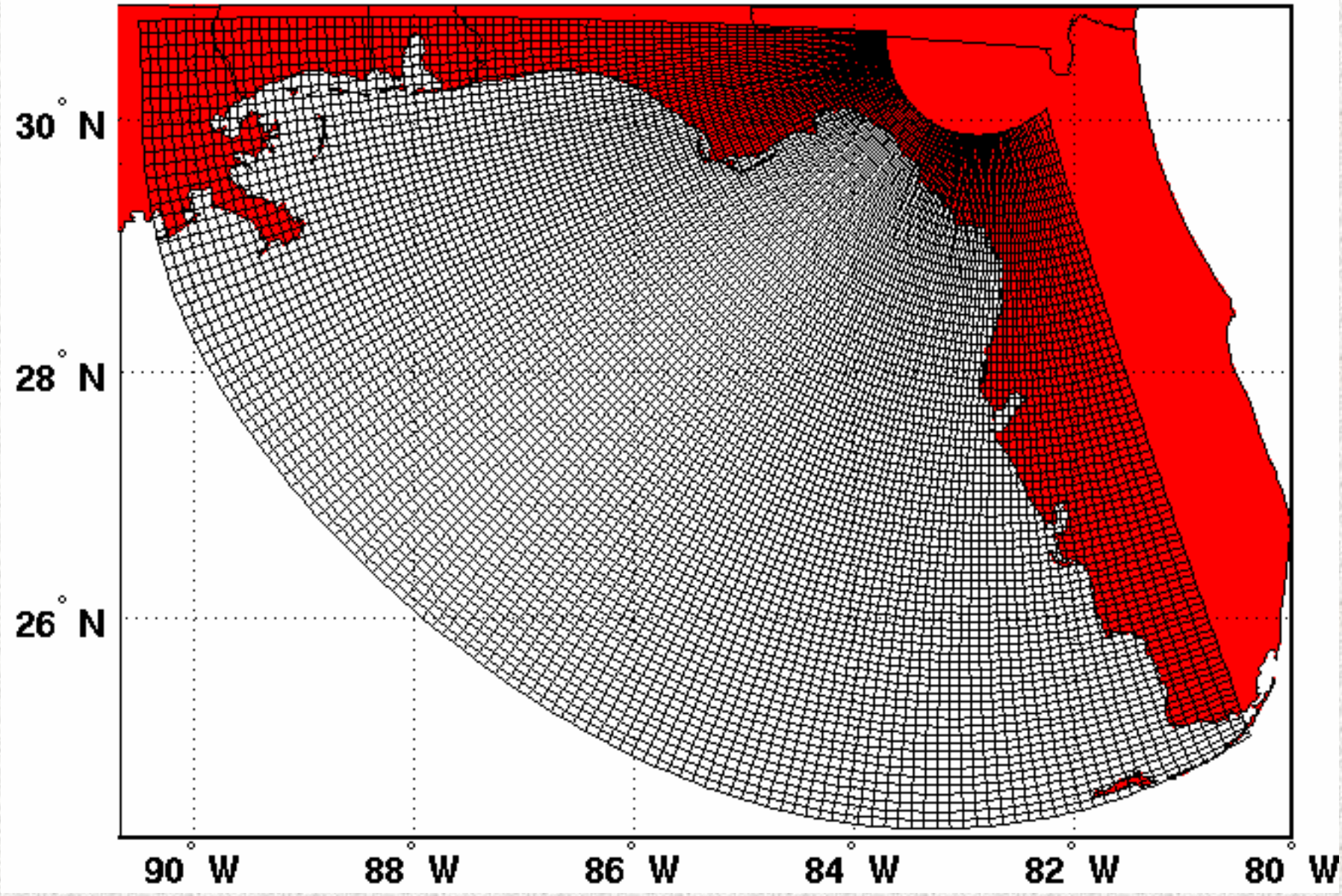
salinity merid.sec. 86.84w Sep 10, 2004 03Z [21.0H]

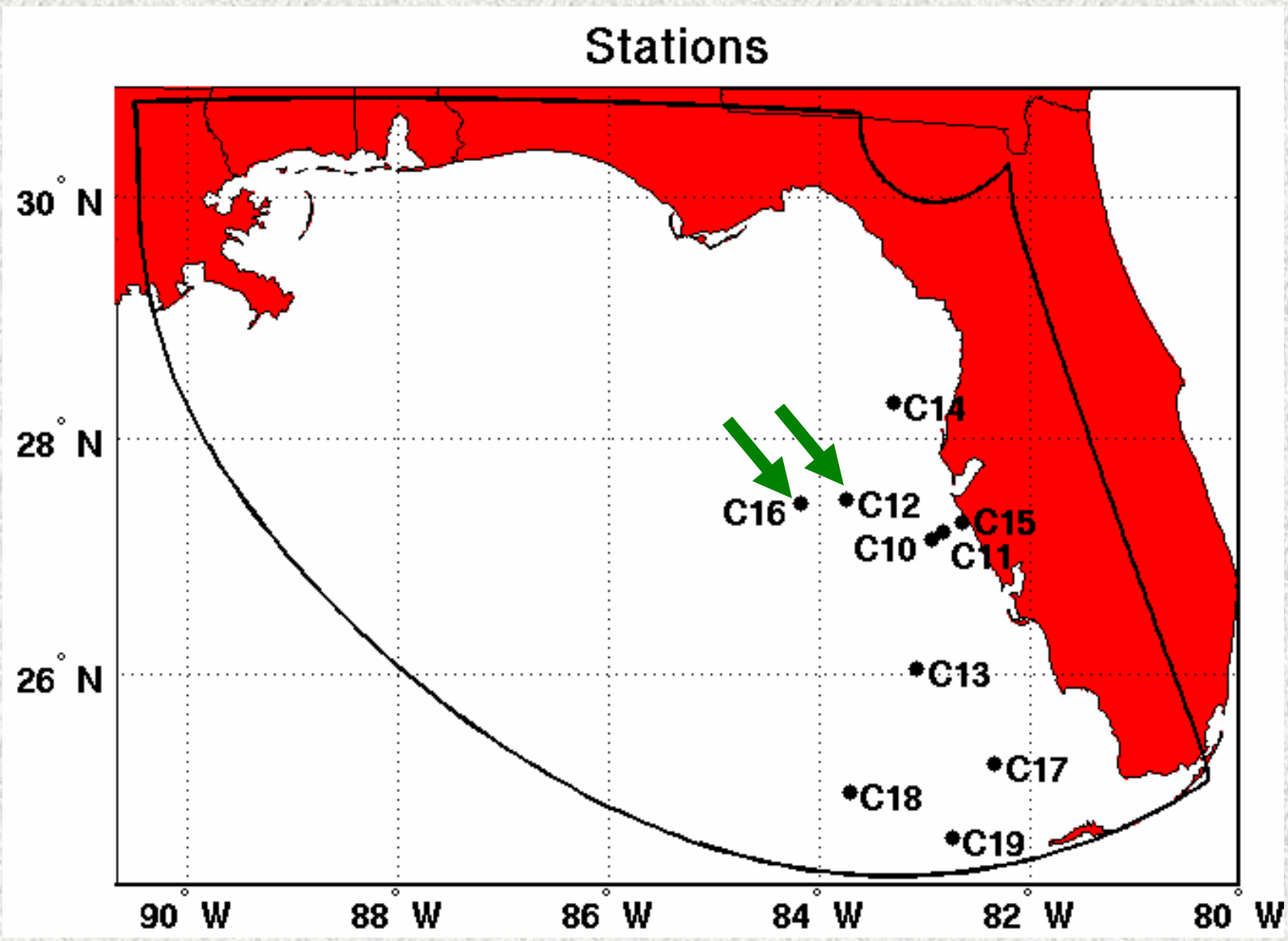


West Florida Shelf Simulations

- **Plans**
  - **Run HYCOM in the same curvilinear coordinate domain used for POM and ROMS at USF.**
  - **Evaluate HYCOM performance as a coastal ocean model**
  - **Quantify model sensitivity to initial and boundary conditions provided by ocean nowcast-forecast systems**
  - **Directly compare HYCOM to ROMS in twin experiments**
  - **Perform scientific studies in collaboration with USF researchers**

WFS Grid

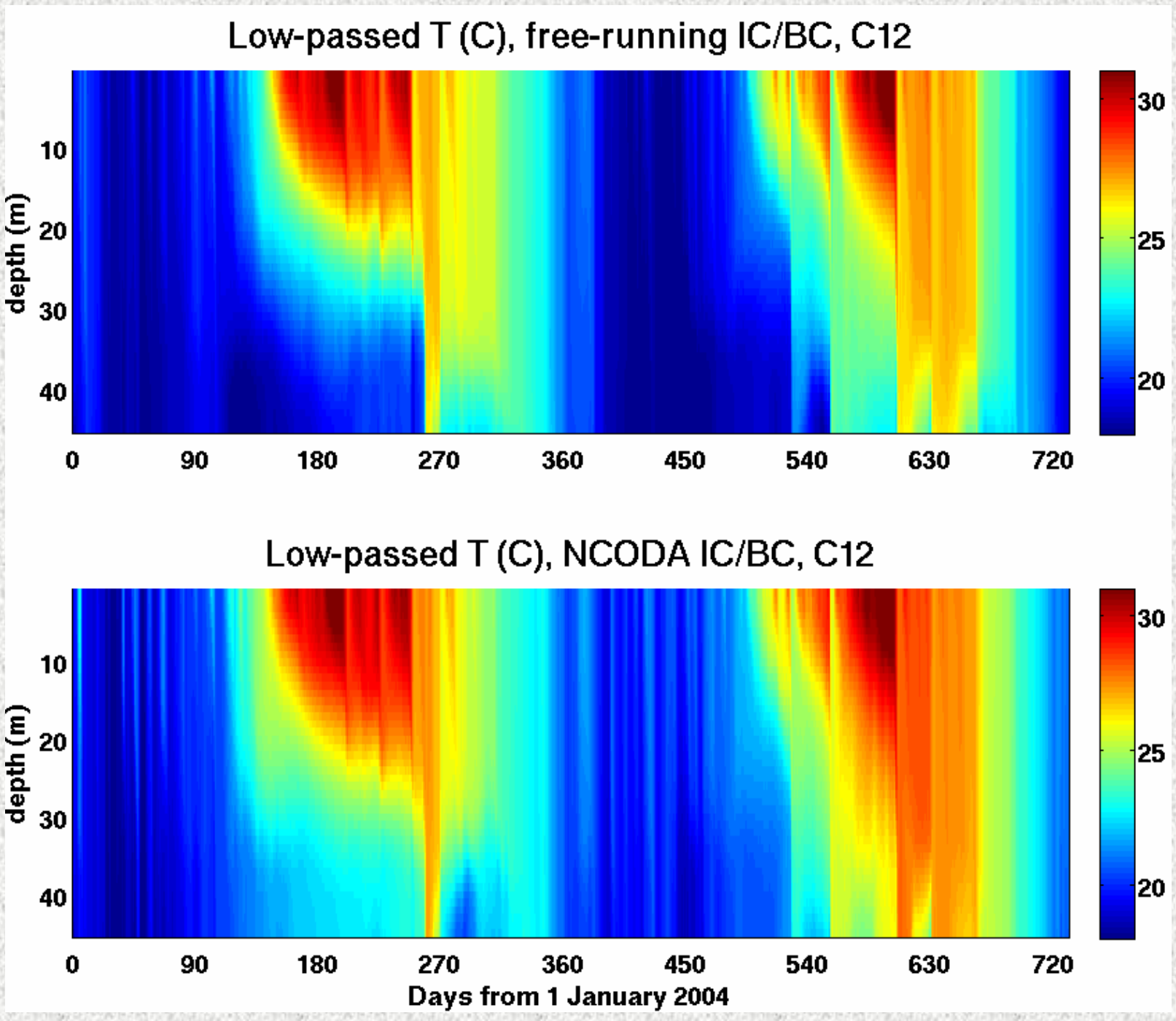


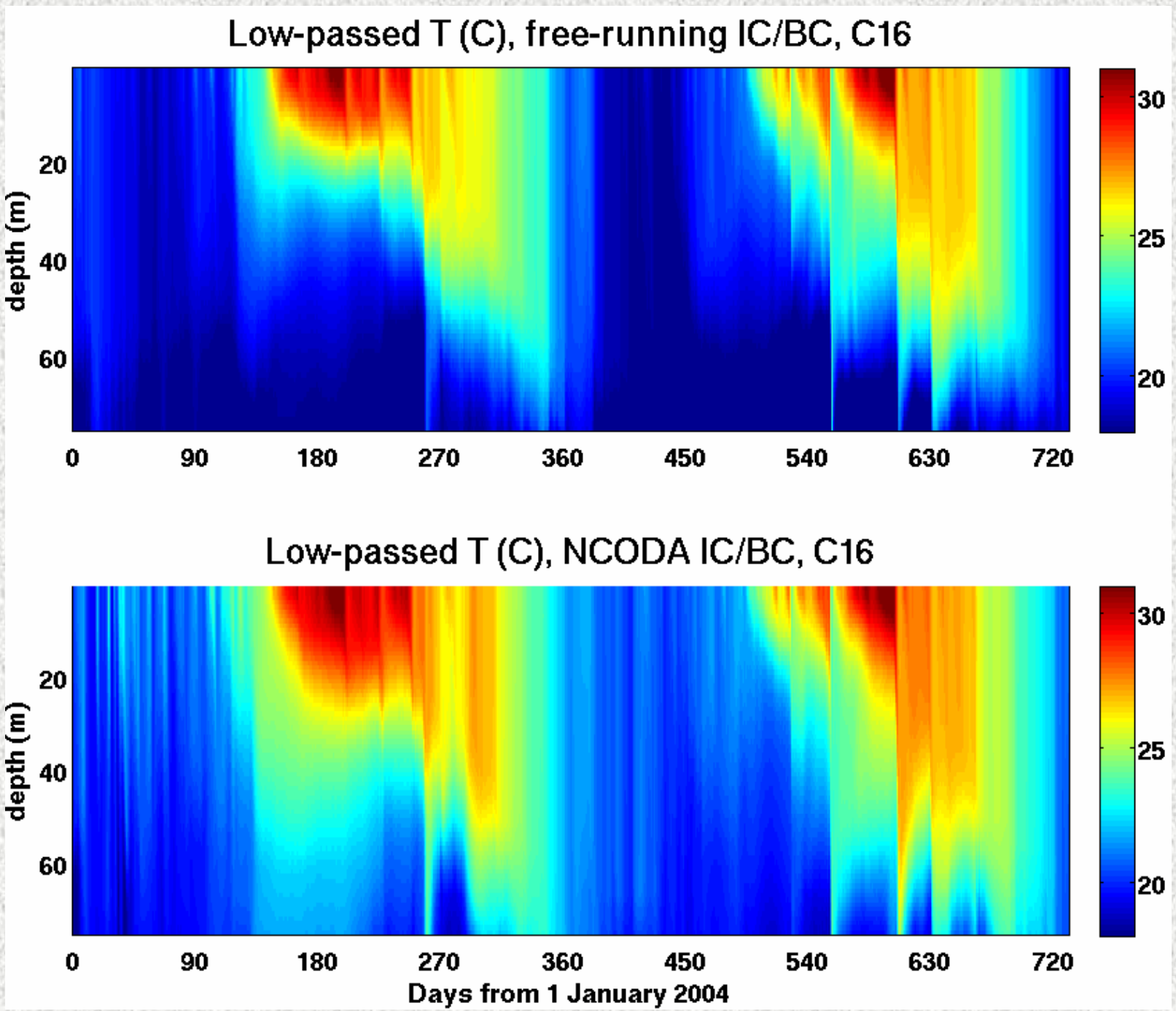


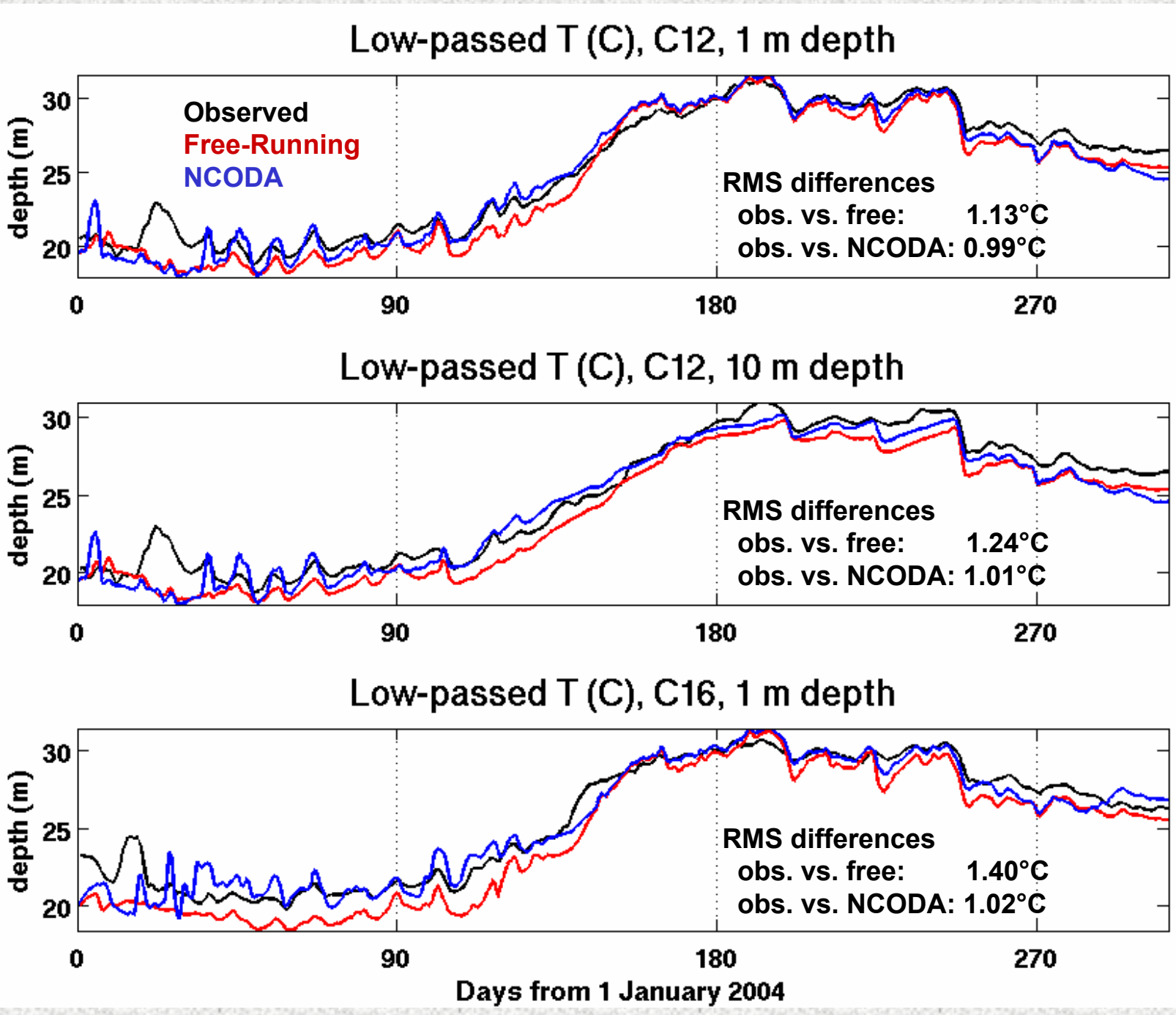
USF Moorings (ADCP, temperature)
HYCOM sampled by synthetic moorings at run time

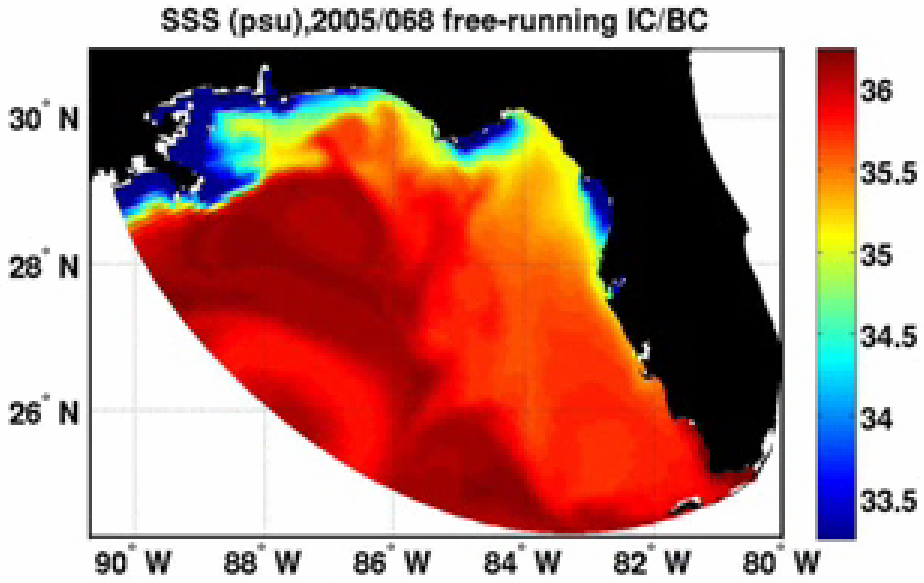
WFS HYCOM Simulations, 2004-2005

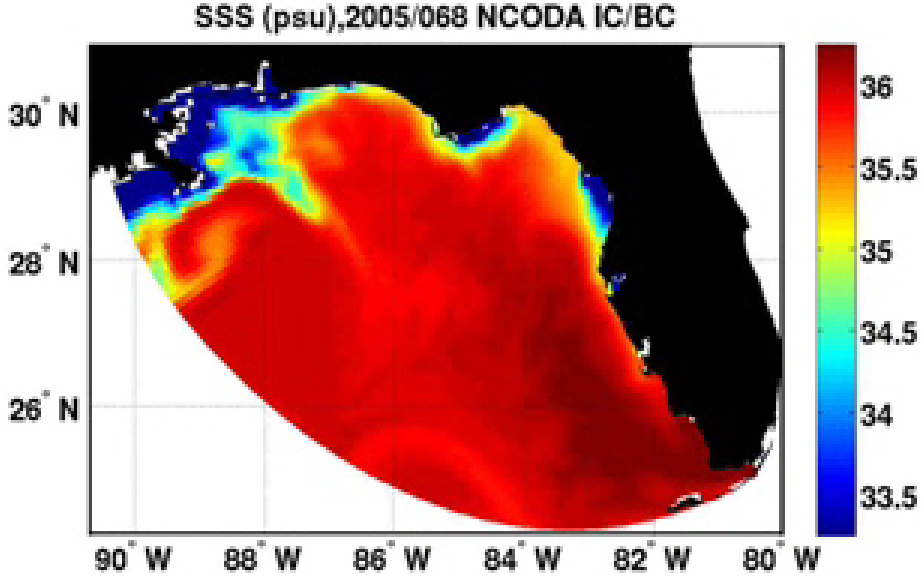
- Different initial and boundary conditions
  - Climatology
  - 0.08° Atlantic OI nowcast
  - 0.04° free-running GOM simulation
  - 0.04° NCODA GOM nowcast
- These cases are otherwise identical
  - KPP Vertical Mixing
  - 0.5-Degree NOGAPS Atmospheric Forcing
  - Climatological annual cycle forcing from several rivers
- Analyze temperature at stations C12 and C16
  - ADCP temperatures still being processed


Low-passed T (C), free-running IC/BC, C12
depth (m)
10
20
30
40
0
90
180
270
360
450
540
630
720
30
25
20
Low-passed T (C), NCODA IC/BC, C12
depth (m)
10
20
30
40
0
90
180
270
360
450
540
630
720
Days from 1 January 2004
30
25
20


Low-passed T (C), free-running IC/BC, C16
depth (m)
20
40
60
0
90
180
270
360
450
540
630
720
30
25
20
Low-passed T (C), NCODA IC/BC, C16
depth (m)
20
40
60
0
90
180
270
360
450
540
630
720
Days from 1 January 2004
30
25
20


Low-passed T (C), C12, 1 m depth
depth (m)
30
25
20
Observed
Free-Running
NCODA
RMS differences
obs. vs. free: 1.13°C
obs. vs. NCODA: 0.99°C
0
90
180
270
Low-passed T (C), C12, 10 m depth
depth (m)
30
25
20
RMS differences
obs. vs. free: 1.24°C
obs. vs. NCODA: 1.01°C
0
90
180
270
Low-passed T (C), C16, 1 m depth
depth (m)
30
25
20
RMS differences
obs. vs. free: 1.40°C
obs. vs. NCODA: 1.02°C
0
90
180
270
Days from 1 January 2004

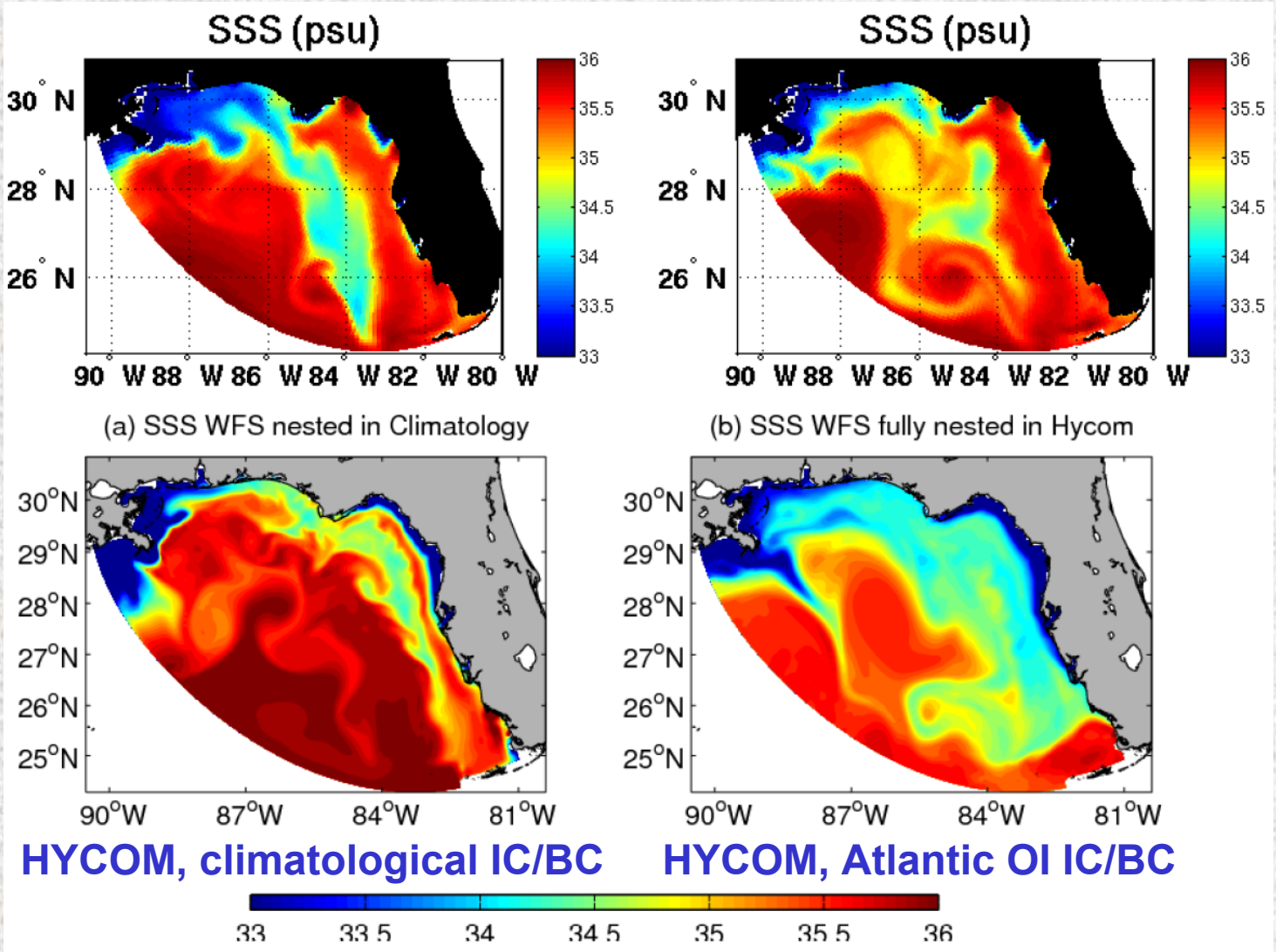

SSS (psu),2005/068 free-running IC/BC
30° N
28° N
26° N
90° W
88° W
86° W
84° W
82° W
80° W
36
35.5
35
34.5
34
33.5


SSS (psu),2005/068 NCODA IC/BC
30° N
28° N
26° N
90° W
88° W
86° W
84° W
82° W
80° W
36
35.5
35
34.5
34
33.5

Surface Salinity, HYCOM & ROMS, 08/17/2004

HYCOM, free IC/BC

HYCOM, NCODA IC/BC



HYCOM, climatological IC/BC

HYCOM, Atlantic OI IC/BC

Summary and Plans

- Initial evaluation of NCODA encouraging for nesting hurricane and coastal ocean (WFS) simulations
- Will continue effort to improve HYCOM performance when forced by hurricanes
- Will complete more extensive evaluations of HYCOM in the WFS domain in the near future in collaboration with Alex Barth and Bob Weisberg
- Collaborate with V. Kourafalou on South Florida coastal simulations and Northern GOM coastal simulations
- Collaborate with Z. Garraffo on Atlantic basin multi-decadal ocean climate simulations
- Study sensitivity of nested coastal ocean models to initial and boundary conditions provided by ocean nowcasts