A real-time Coupled Wave/Atmospheric Regional Forecast and analysis System: CWARFS

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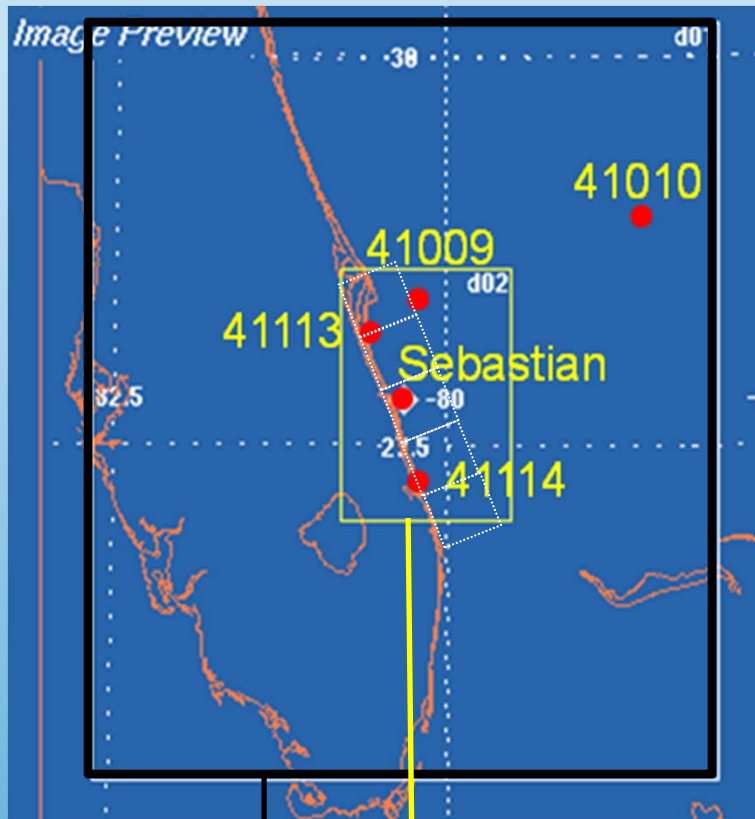
Florida Institute of Technology
21 July 2011

Talk Outline

1. Overview of model configuration and project

2. Assessment Highlights

3. Transition to NWS

5 wave subdomains embedded in nested WRF run

- National Weather Service's (NWS) Weather Research and Forecasting (WRF) Environmental Modeling System (EMS)
- 3 h NAM/GFS forecasts used for LBCs
- 0 h NAM/GFS used for ICs
- Full model dynamics and physics

1.5 km resolution
4.5 / 10 km resolution
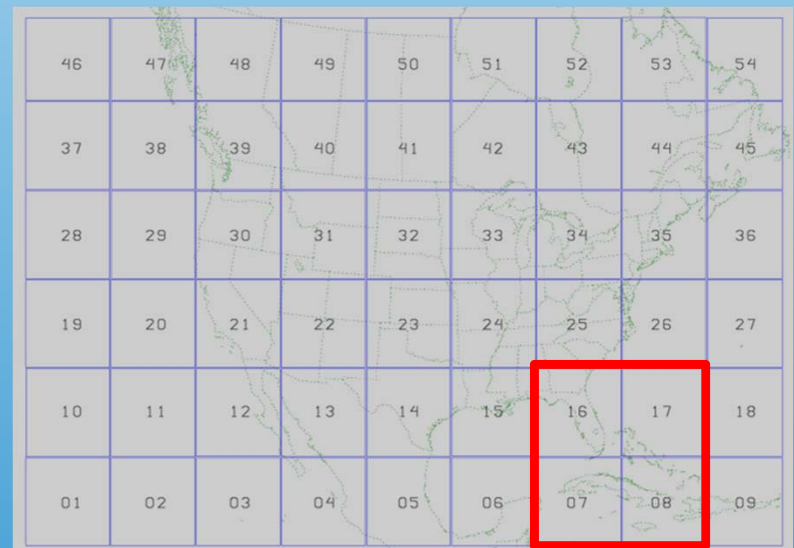
48 h WRF-EMS simulation

00 UTC   hourly output

Wave Model (100 m resolution)

Coastal Modeling System (CMS)-WAVE

Based on WABED *(**W**ave-**A**ction **B**alance **E**quation and **D**iffraction model, Mase et al. 2005)*

Employs a forward-marching, finite-difference method to solve the wave action conservation equation.

Capabilities
- wind input, shoaling, refraction
- diffraction
- dissipation
- wave-current interaction
- adjustable friction factor
- depth-limited breaking

CMS-Wave runs on all 8 nodes of a quad core 3.2 GHz Linux box

Wave Model Forcing (100 m resolution)

5 high-resolution (100 m) grids

~50 x 50 km

Coast parallel: North of Cape Canaveral south to Jupiter, FL
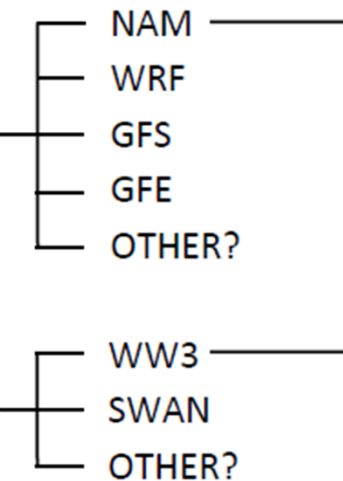
wave grids within the WRF 1.5 km nest

CMS-Wave is forced by time series inputs: BC's from WAVEWATCH III (WW3) and wind forcing.
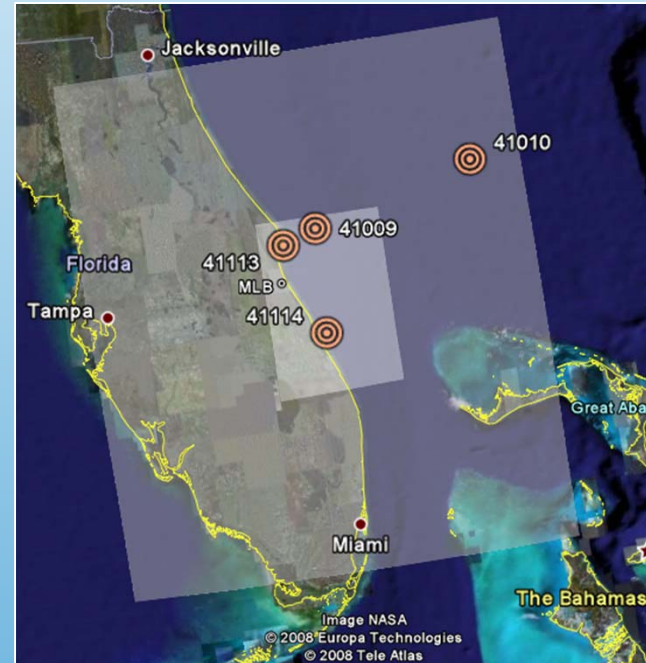
WW3

WINDS

Wind input   Wave input

| CMS WAVE INPUT VARIBABLE	VARIABLE SOURCE
	NAM
	WRF
	GFS
	GFE
	OTHER?
	WW3
	SWAN
	OTHER?

Assessment

- Forecast wind variability within wave forecast domains (model model)

- Wind forecast quality (WRF)

- Wave forcing quality (WW3)

- Wave model performance: onshore versus offshore winds

- Wave model performance for high wind events (wind speed > ~ 10 ms^{-1})

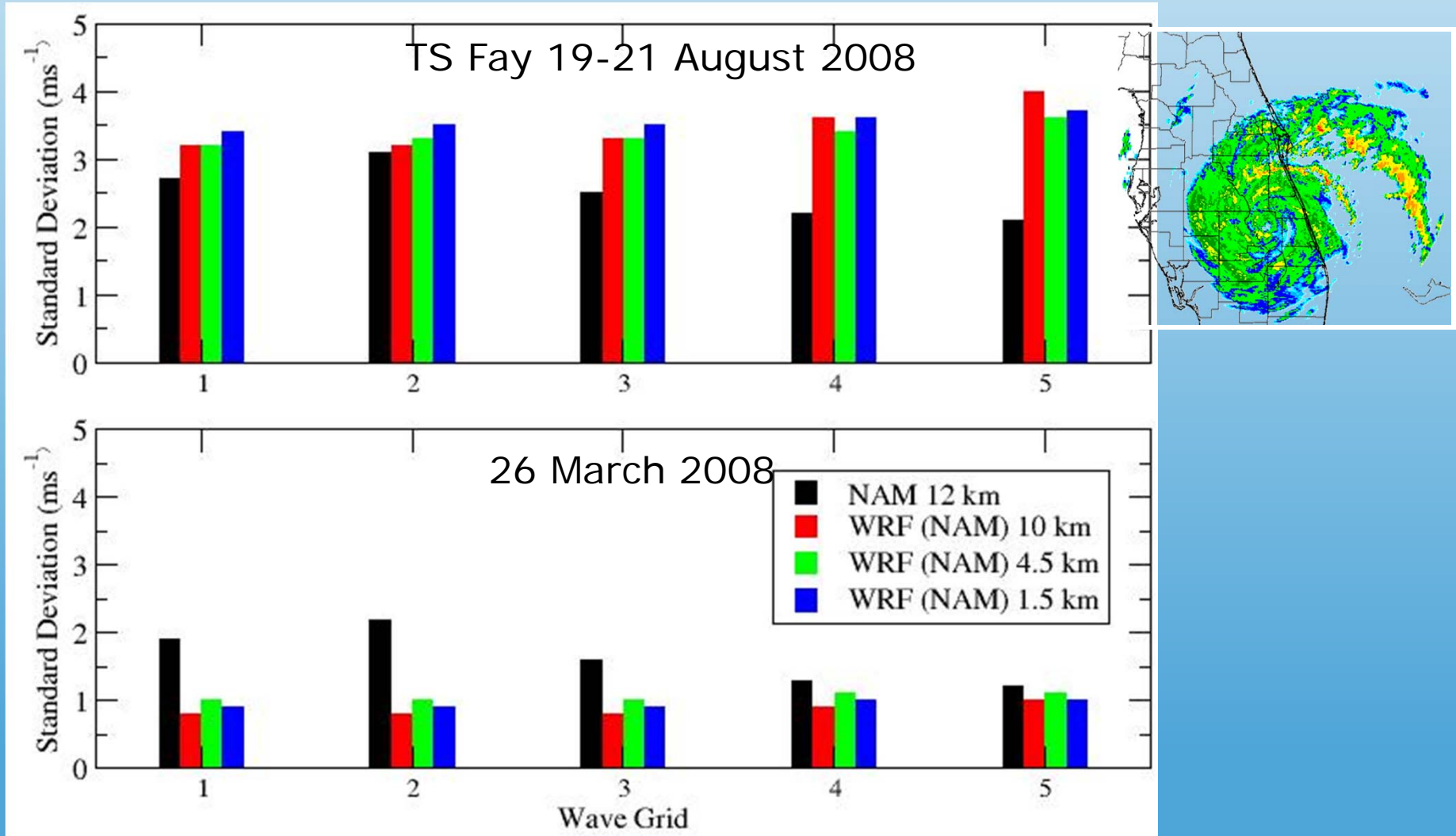| Tier	Wind Speed Thresholds
4	All
3	Wind events (12 consecutive hours > 9 m/s)
2	Same as Tier 3 + total 48 hour forecast period wind speed average > 9 m/s
1	Tropical Cyclone events *

Subgrid Wind Variability: Tier 3
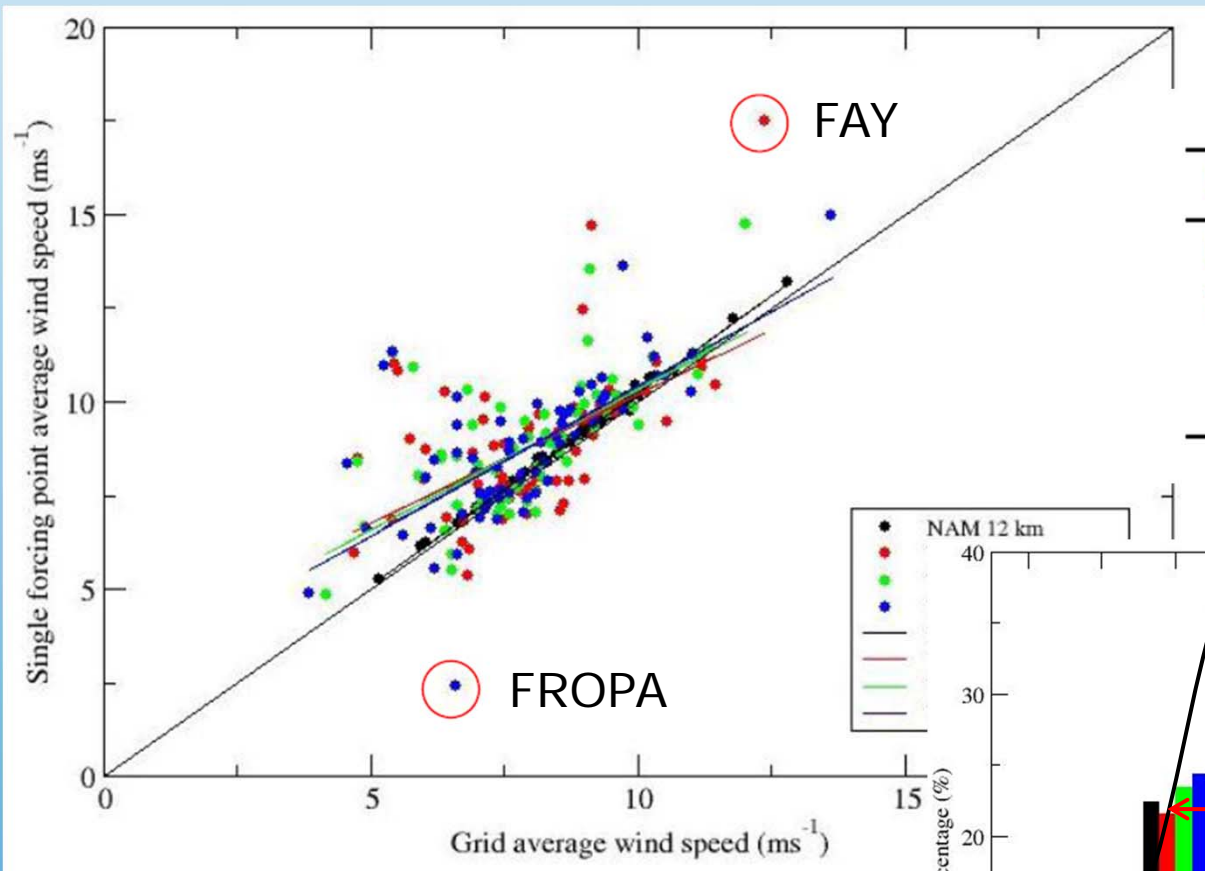
Model and resolution		R² value
NAM 218	12 km	0.9953
WRF-NAM	10 km	0.3113
	4.5 km	0.4293
	1.5 km	0.4592

Wind speed bins (ms⁻¹)
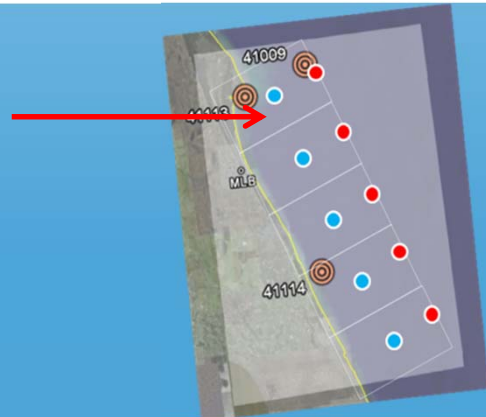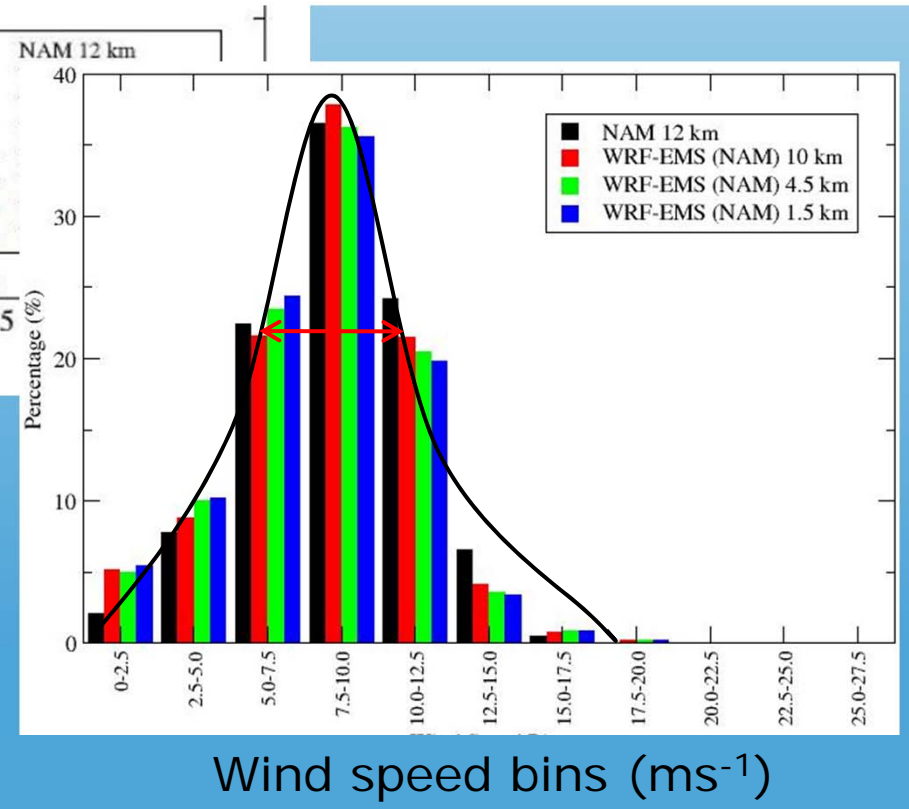
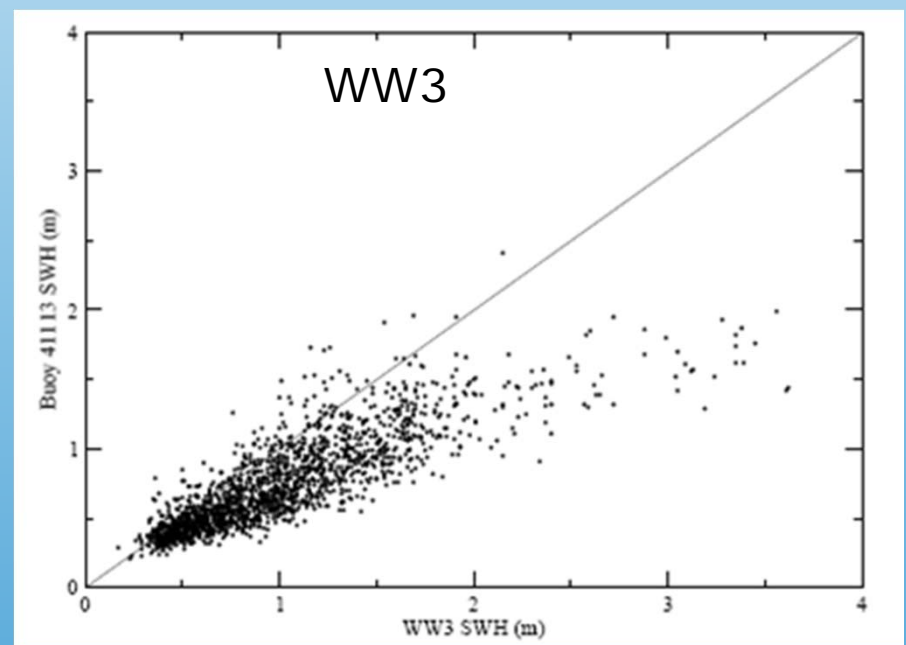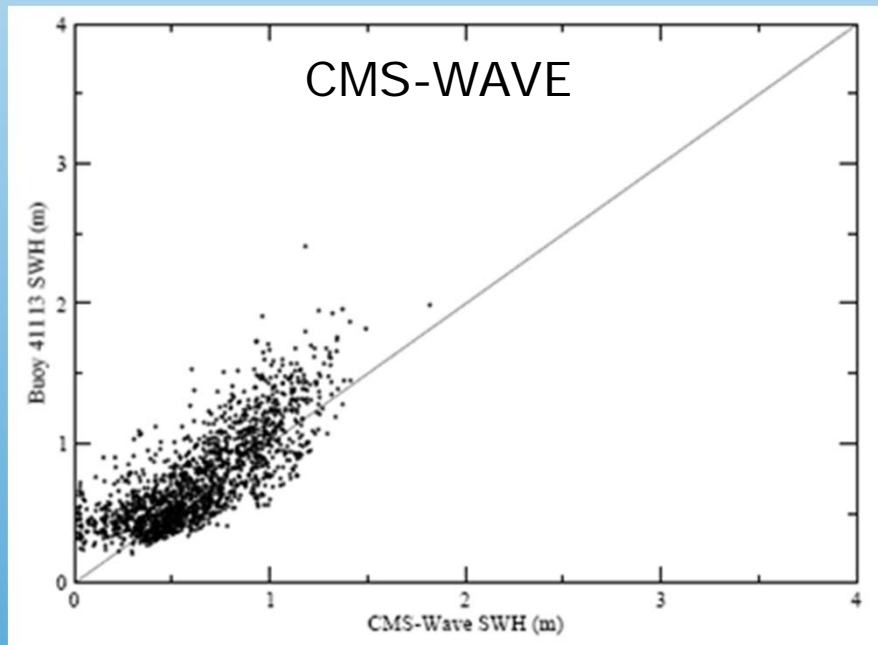# Subgrid Wind Variability: High Wind Events
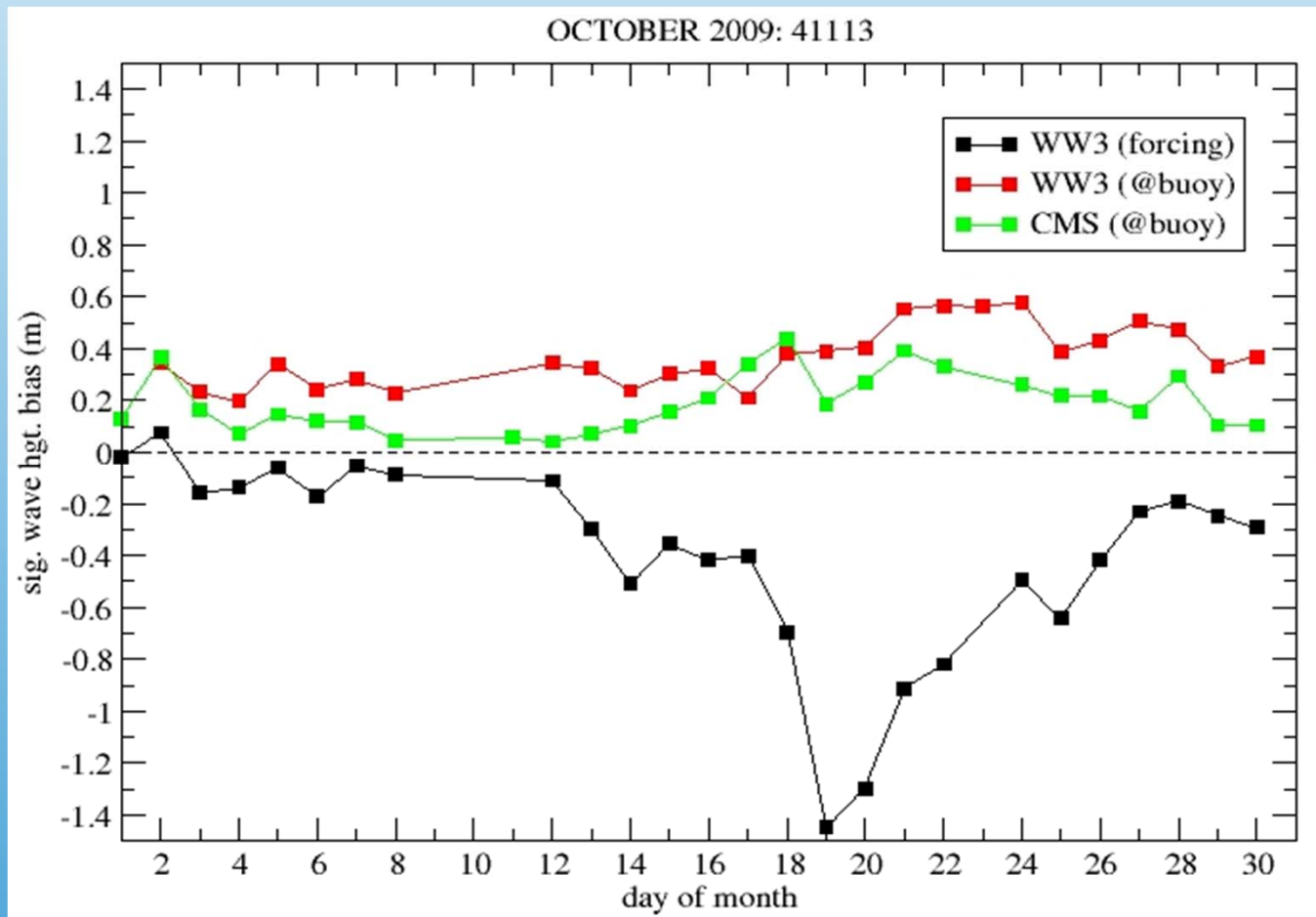
Wave Model Assessment: Tier 3
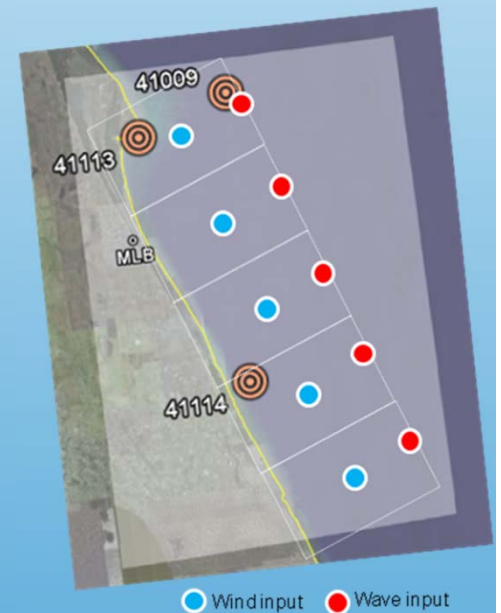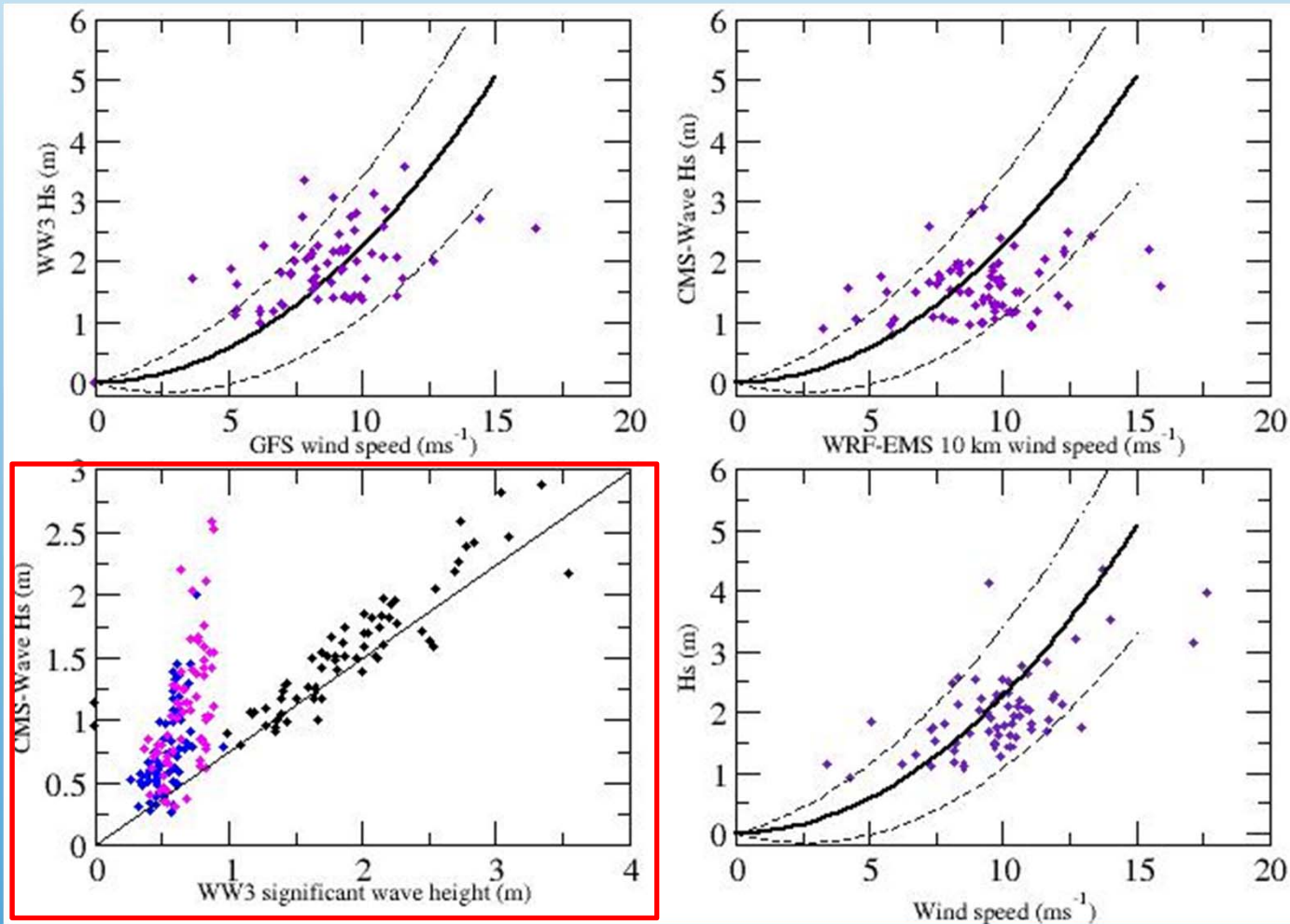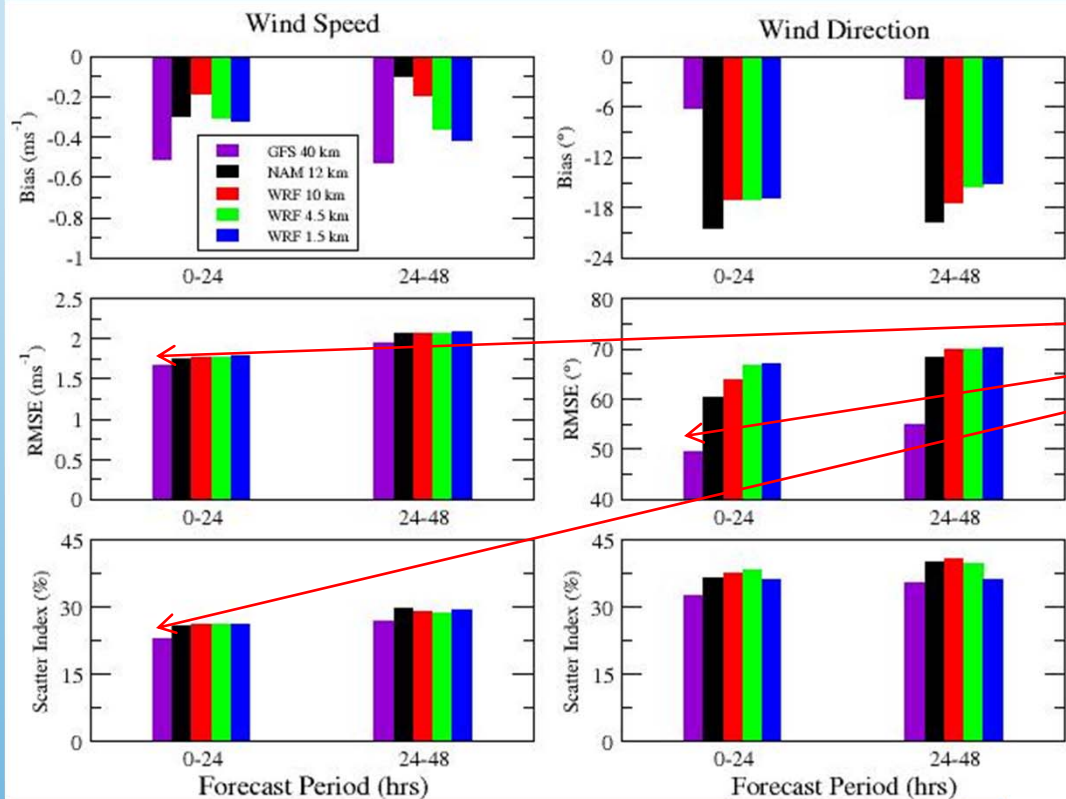

- 41009
- 41114
- 41113

Wave Model Assessment

Modeled (x-axis) vs. observed (y-axis) SWH for
Sept. 2006- Dec. 2007 at buoy 41113.

Significant Wave Height BIAS (41113)
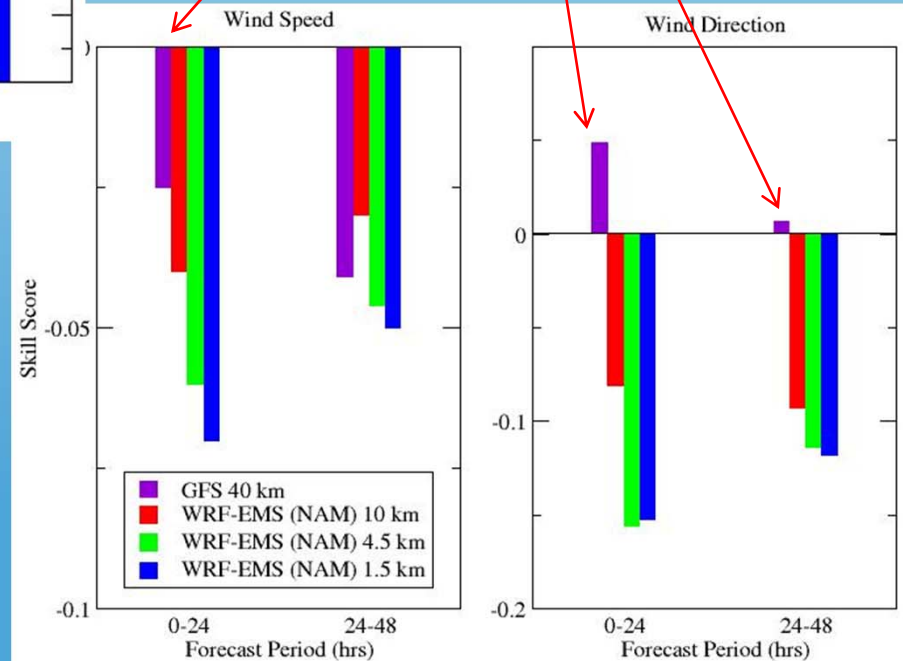

OCTOBER 2009: 41113

Wind Forecast / Forcing Validation @41009

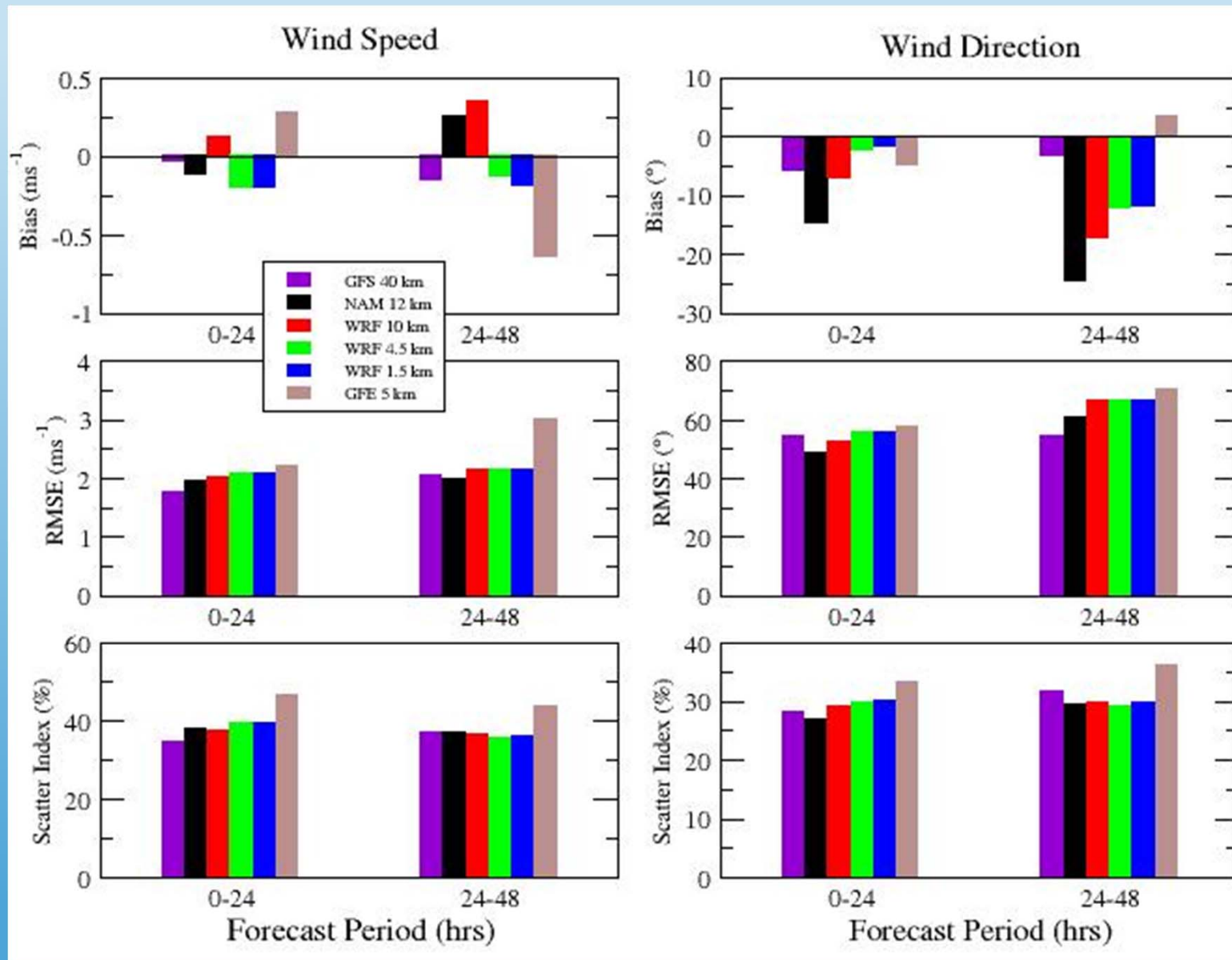213 48 h CMS Wave Simulations
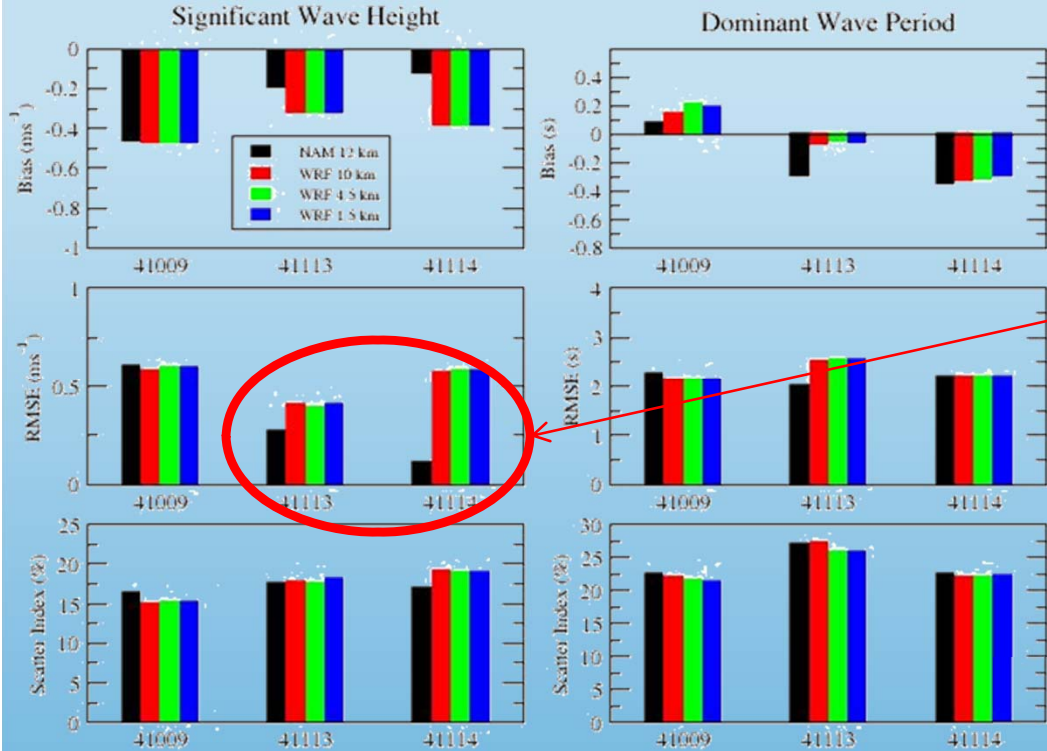
GFS beats NAM!

Skill Score **Versus NAM**

- NAM forced WRF-EMS not a significant improvement over NAM

- On average, only slight differences between wind forecast errors for the three WRF-EMS resolutions

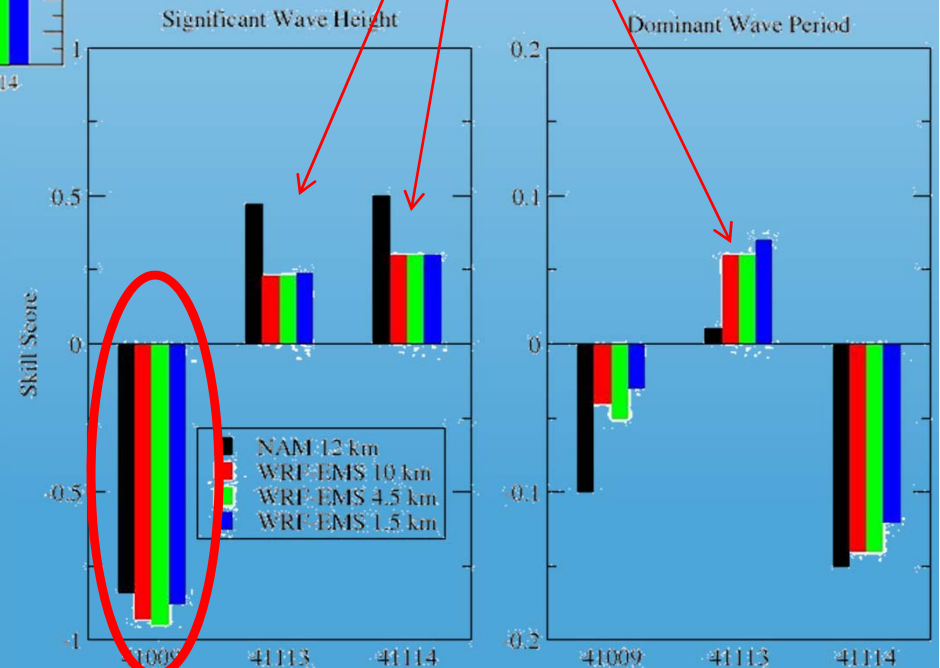# Wind Forecast/Forcing Validation GFE (May & June 2009)

CMS-Wave forecasts – Tier 3 analysis

NAM & WRF-EMS forced CMS-Wave beats WW3 in nearshore

Skill Score Versus WW3

- No significant differences in wave forecast errors between WRF-EMS resolutions
- Errors at 41009 not unexpected for model built for nearshore

Component	Tier 4/3 Daily basis	Tier 1 Tropical Cyclone / Highest wind events
Wind forecast (41009)	GFS 40 km	GFS 40 km NAM forced WRF-EMS 10 km
Notes:	Best for both variables, NAM close 2nd	1st 24 h – both GFS and NAM forced WRF-EMS 10 km 2nd 24 h – NAM forced WRF-EMS 10 km
Wave model wind forcing (41009, 41113, 41114)	NAM 12 km	NAM 12 km NAM forced WRF-EMS 10 km or 4.5 km
Notes:	Nearshore winner	Depends on buoy

- GFS forced WRF-EMS not an improvement for Tier 1 events, TC events?
- No difference in wind and wave forecast quality as resolution is increased in WRF-EMS

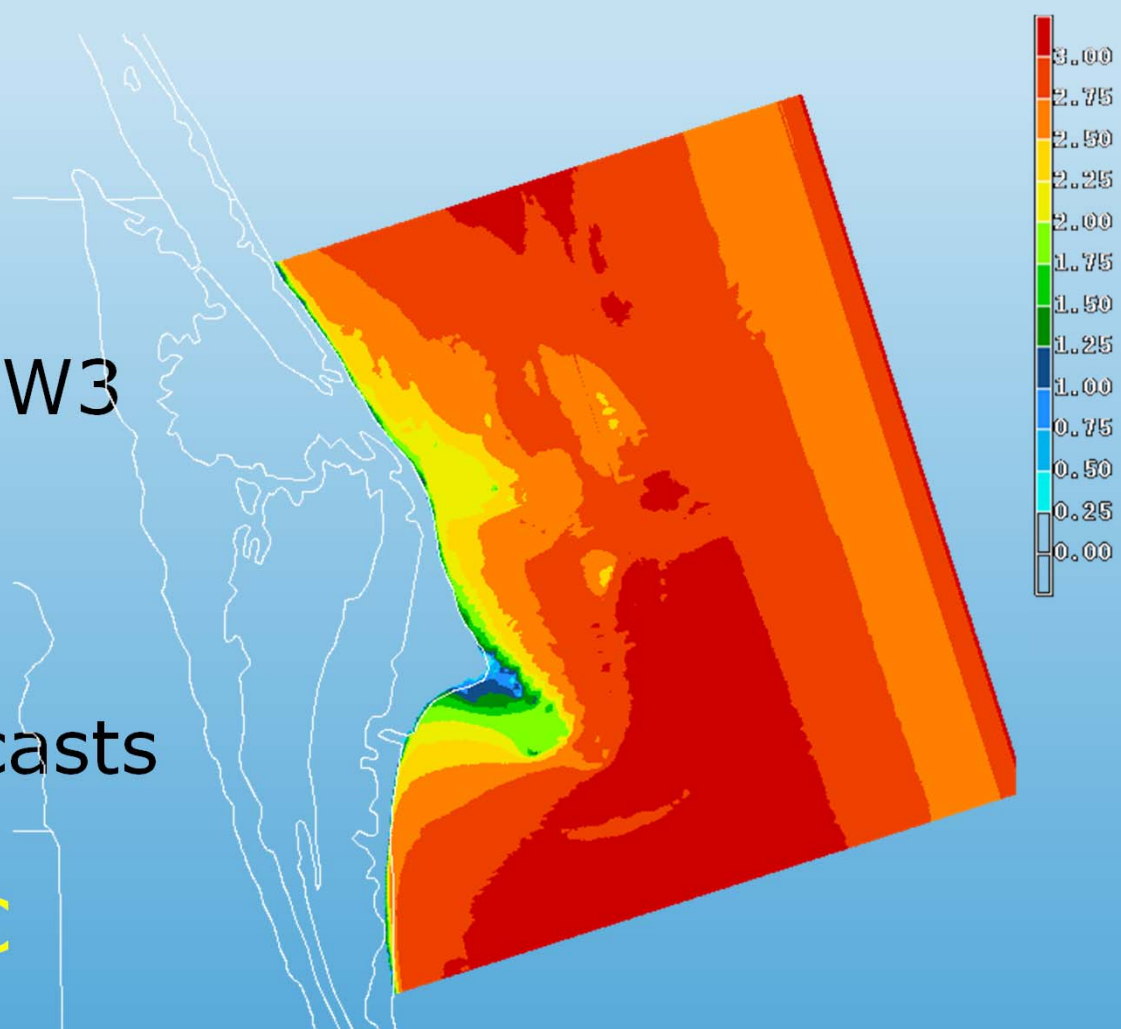| Atmospheric Model	00 UTC cycle NCEP availability	Run time *	
GFS 40 km	~ 0345 UTC daily	-	
NAM 12 km	~ 0215 UTC daily	-	**Add 2 hours to run current setup of CMS-Wave model**
WRF-EMS 10 km	-	5 minutes	
NWS GFE	???	-	
WRF-EMS 4.5 km	-	~ 1 hour	
WRF-EMS 1.5 km nest	-	~ 4 hours	

* FIT inhouse computer

FIT Configuration (no flow model)

GFS
&
CMS-Wave
with 18 UTC WW3

⬇

48 h wave forecasts
available
~ 0430 UTC

080820/0000V000   SFC   HTSGW

48 h WRF-EMS simulation

F06 WW3/GFS

00 UTC   hourly output

Transition to NWS

Transition Chronology:

The following is a chronology of the significant items in terms of transition the software to the NWS. The major players in this activity were:

1. Douglas Gaer – NWS Miami
2. Peter Blottman – NWS Melbourne
3. Michael Splitt – FIT

DATE	ACTIVITY	Comments
02-11-2010	Grid creation software	tarball/documentation posted
02-19-2010	NWS/FIT telecom	NWS IT/Project PI/Personnel
02-24-2010	Depth file creation testing complete	Process successfully expedited
02-25-2010	Grabbing NAM winds & WW3 forcing	Problems accessing latest NAM
03-30-2010	Alternative NCEP data grab	All timing problems resolved
04-07-2010	Wave model tests begin	tarball/documentation posted
04-30-2010	RTOFS flow software	tarball/documentation posted
05-13-2010	NCEP updates its WW3 output	File format and posting times change
05-19-2010	RTOFS updates	Latest documentation and scripts
05-21-2010	RTOFS testing	Current forcing file issues

NWS office validation

48 h forecast significant wave height (m) for SW Florida. Initialized 12 UTC 8 April 2010 @ Miami NWS.
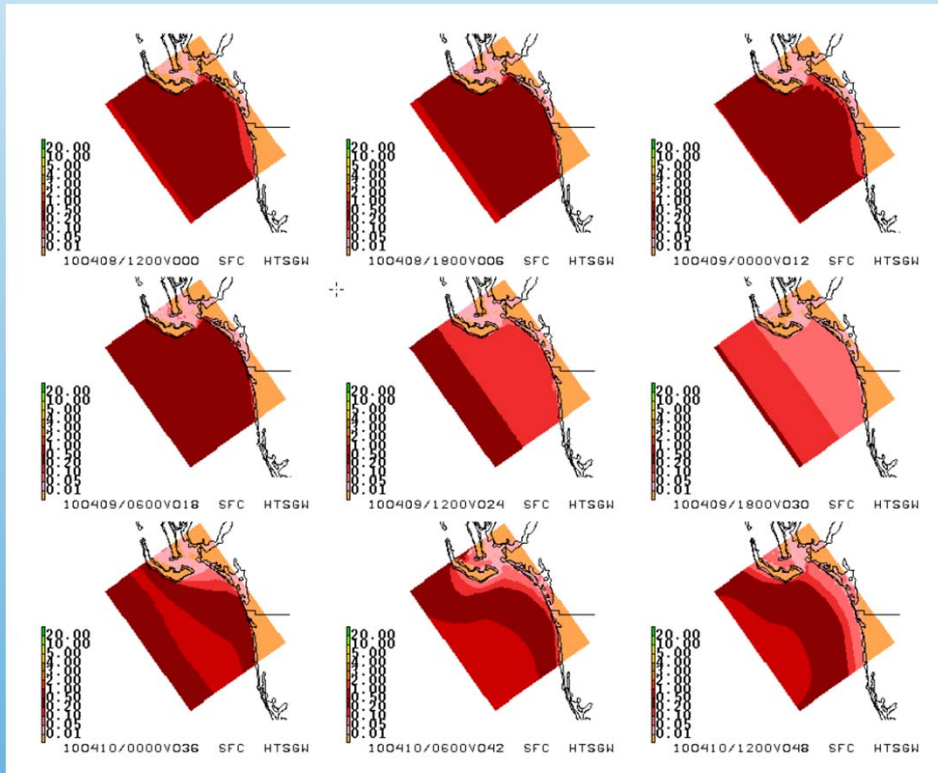
48 h forecast significant wave height (m) for east central Florida. Initialized 06 UTC 12 April 2010 @ Melbourne NWS.
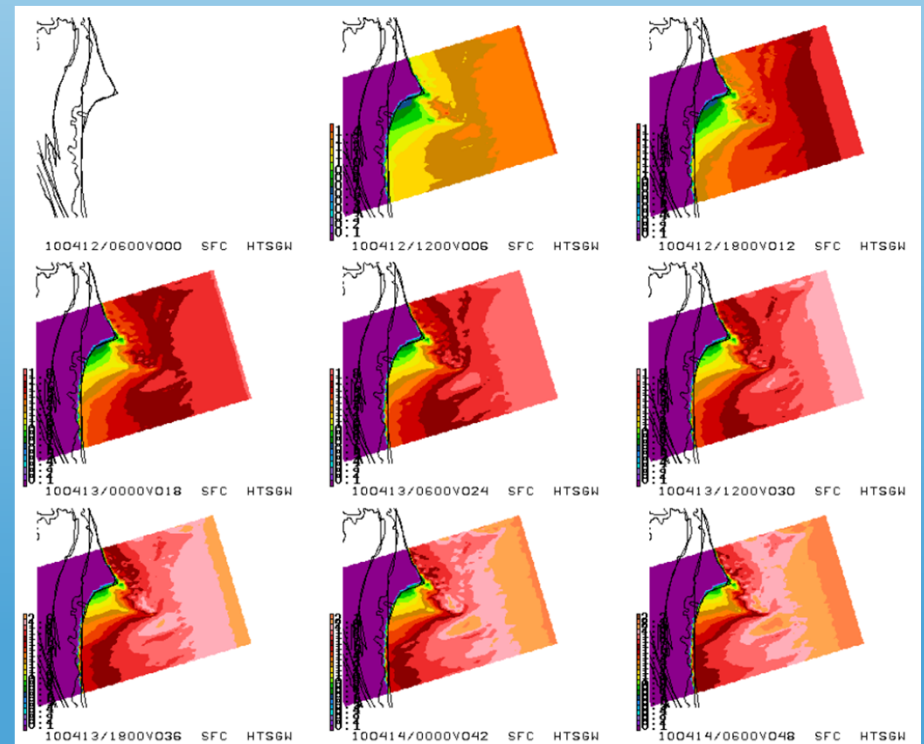
Build your own grids

"Build your own grids" software completed and tested at NWS offices

Forcing data download software completed and tested at NWS offices

Wave model and output software tested at NWS offices
- Newer version of CMS-Wave is now being used
- Expanded set off output variables

- Scripts include ability to "flip grid" in scenarios with strong offshore flow.

- Software has been modified to account for problems identified in runs ant NWS Miami
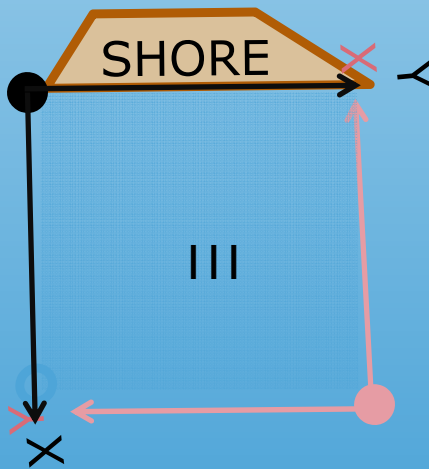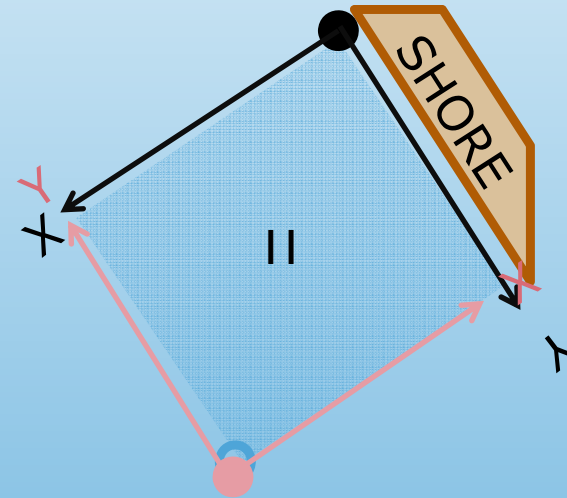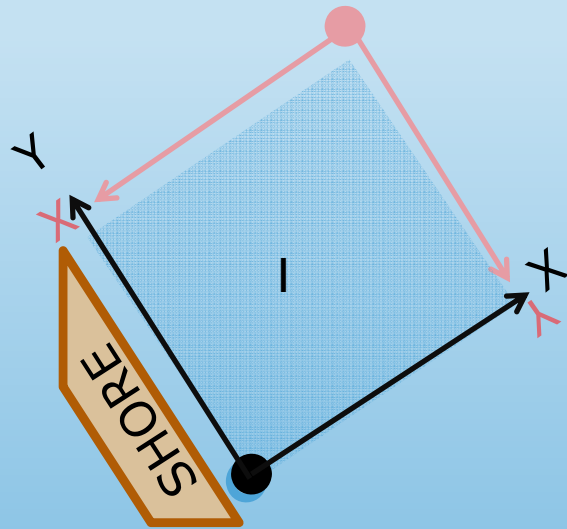
Flow model component *nearly* complete
- NCEP RTOFS used for currents
- Documentation and software delivered

Automated Wave Model Set-Up
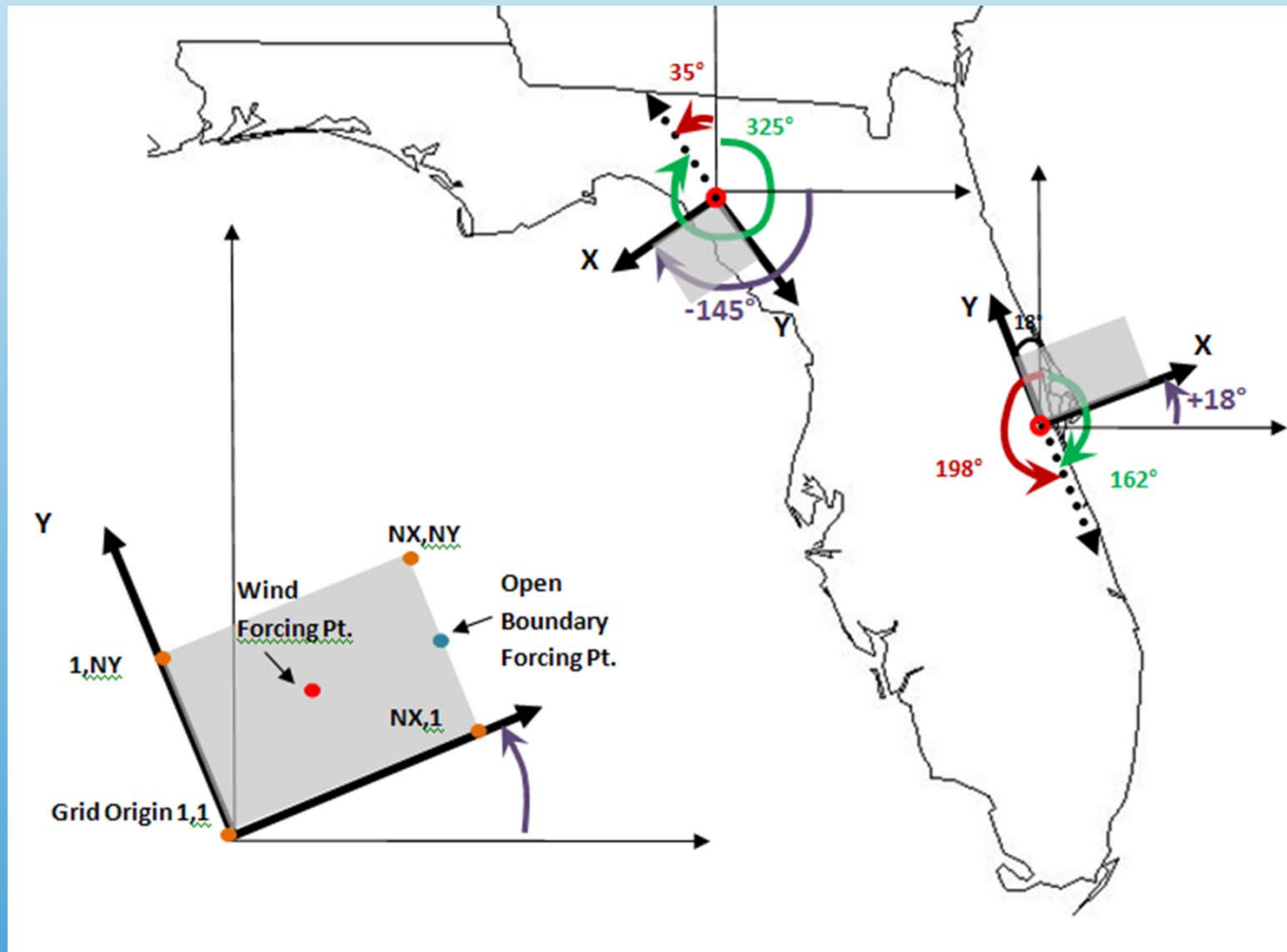
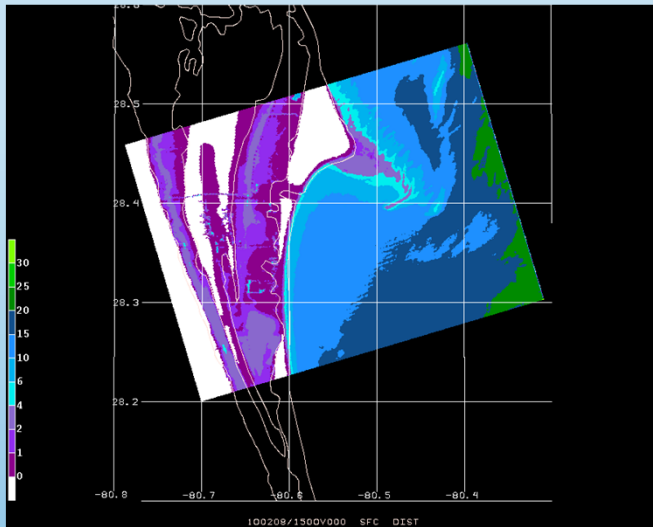"Shore-relative" reference frame

Grid Coordinate System

I

II

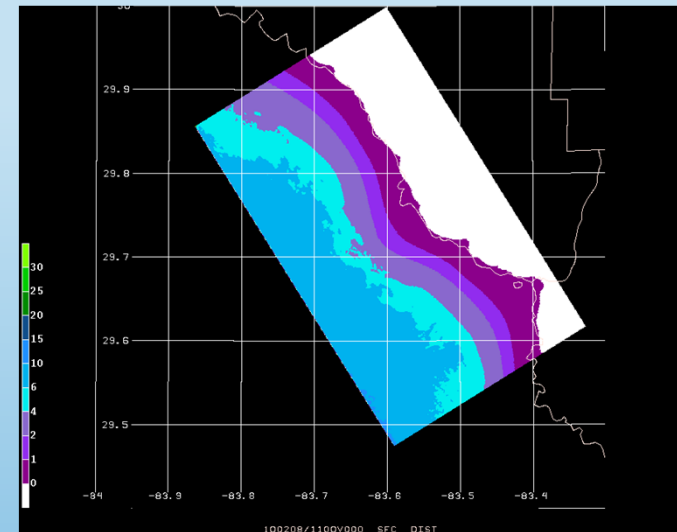III

IV

SHORE
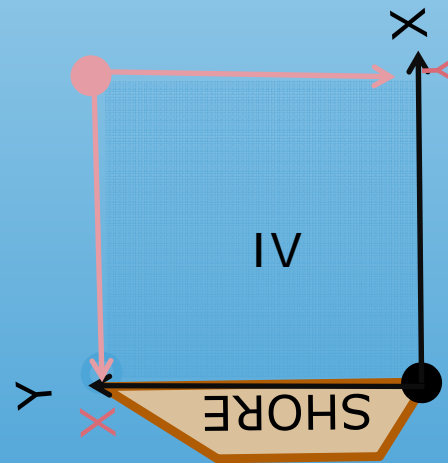
Designed

CMS

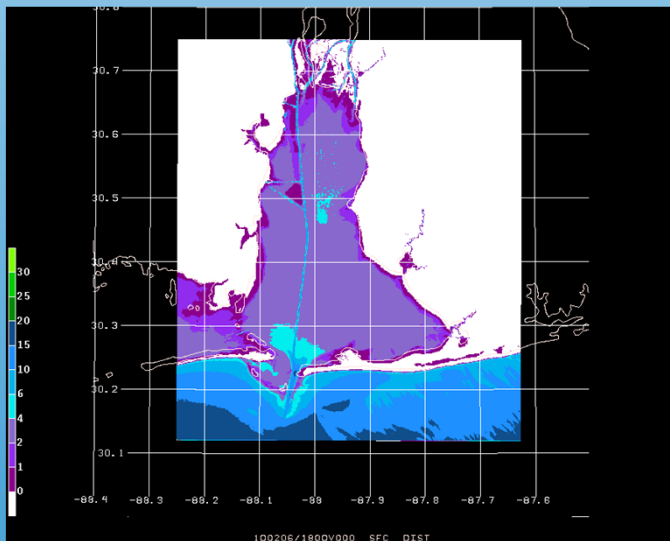LCC

LCC origin is
Always "SW"
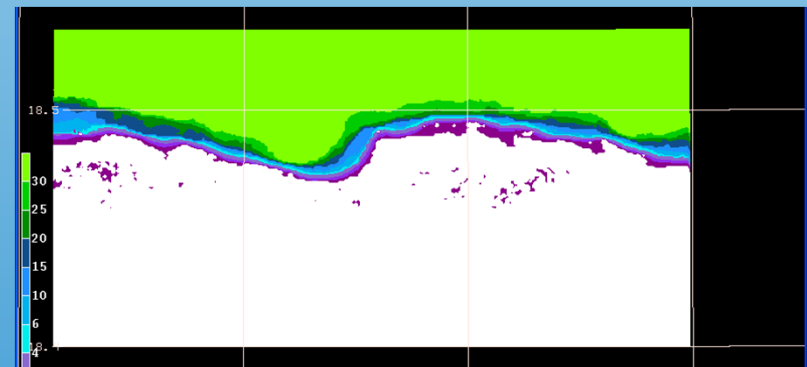Grid Corner

Grid Rotation

CASE 1/Grid1 (land west/water east – EC Florida Coast)

CASE 2/Grid 2 (land east/water west – NW Florida Coast)

CASE 3/Grid 3 (land north/water south – Mobile Bay)

CASE 4 (land south, water north – Puerto Rico)

CWARFS grid set-up overview

Maxim...

Uses G...

http://ww...

Suppo... ...cing,
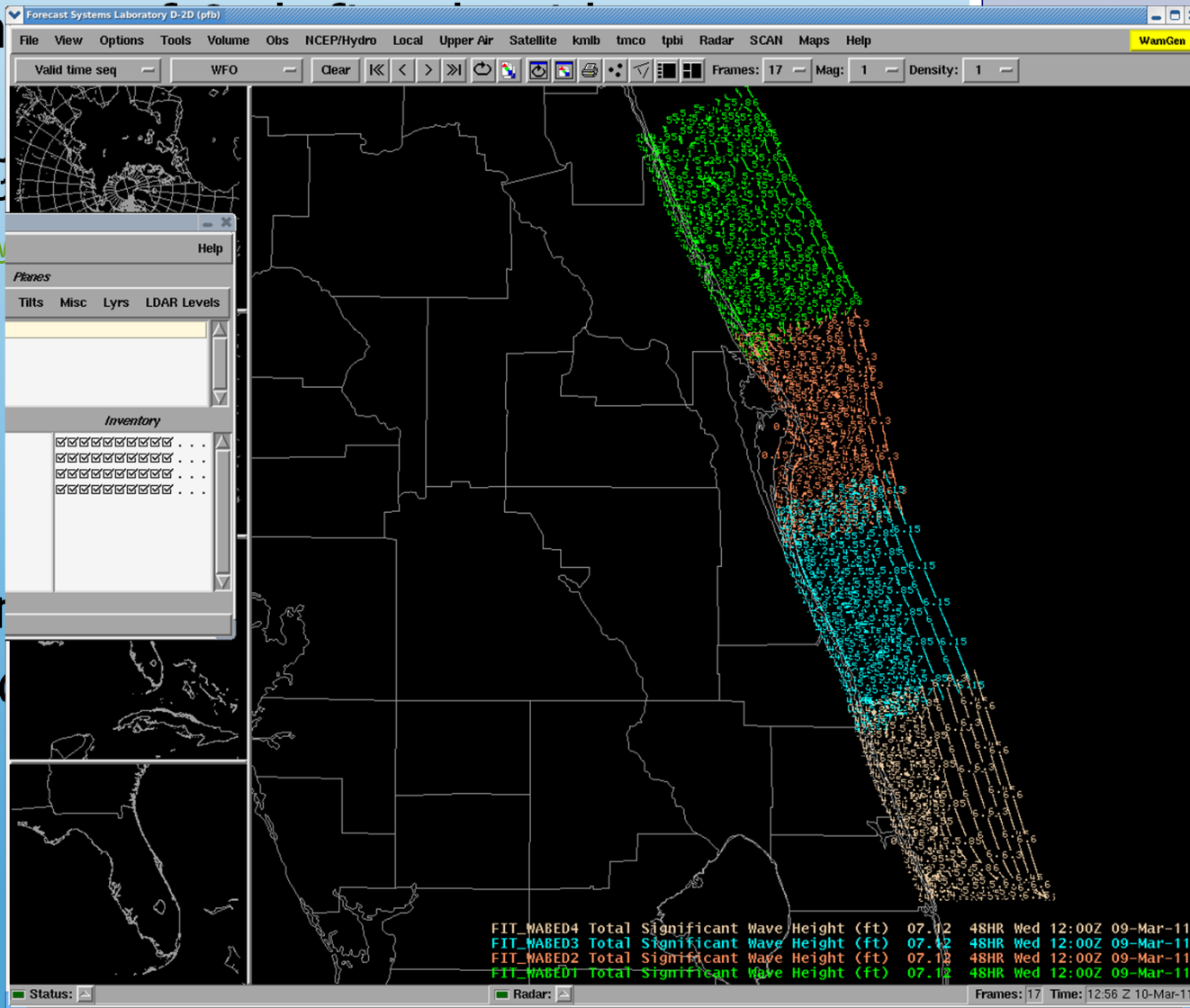model ...

Resour...
(perl, ... zlib)
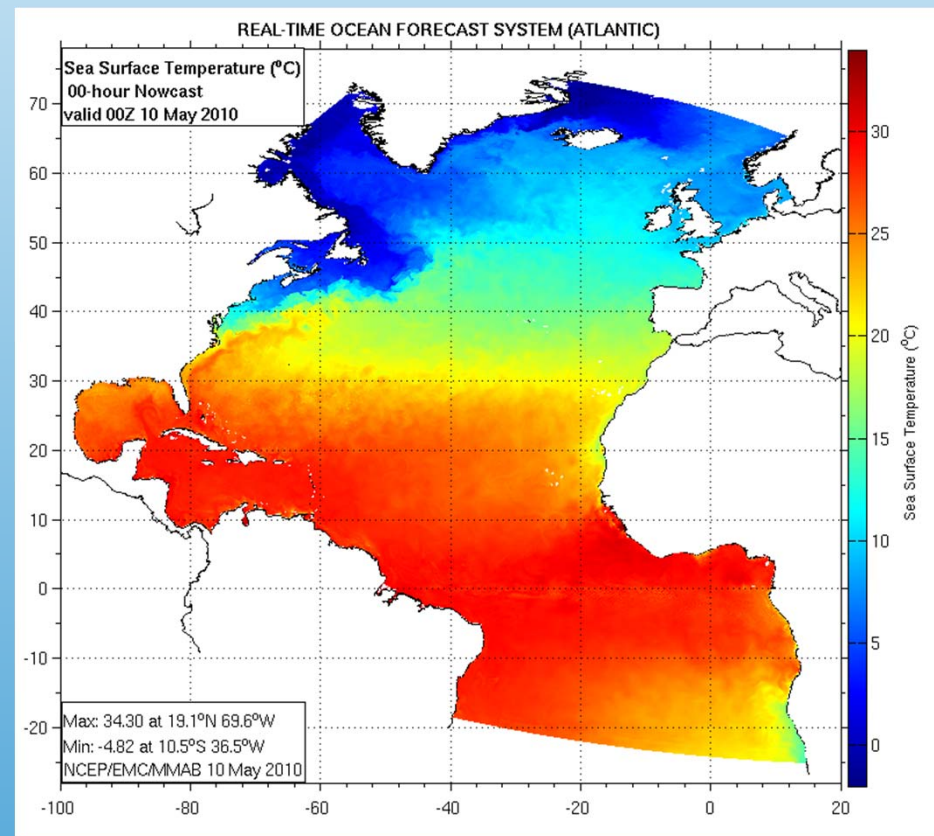
RTOFS (currents for flow model)

Real Time Ocean
Forecast System
(RTOFS):

-Based on HYCOM
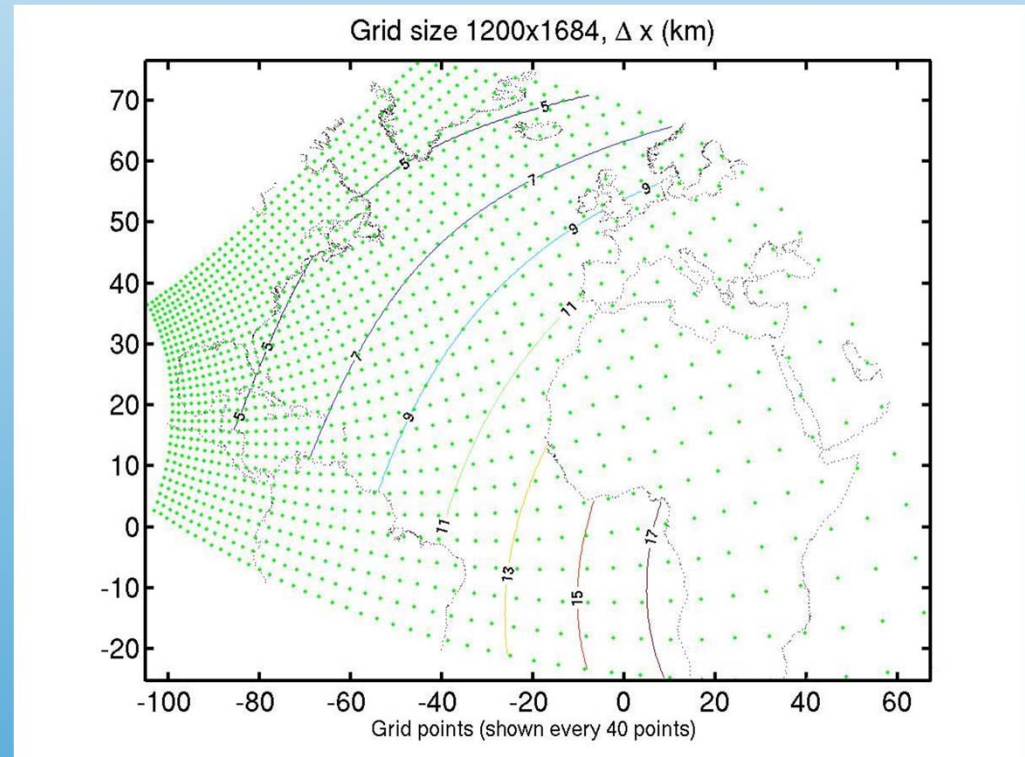
-Run once a day
(00Z)

-Forced by GFS,
tides, and rivers

REAL-TIME OCEAN FORECAST SYSTEM (ATLANTIC)

Sea Surface Temperature (°C)
00-hour Nowcast
valid 00Z 10 May 2010

Max: 34.30 at 19.1°N 69.6°W
Min: -4.82 at 10.5°S 36.5°W
NCEP/EMC/MMAB 10 May 2010

RTOFS (Flow Model)
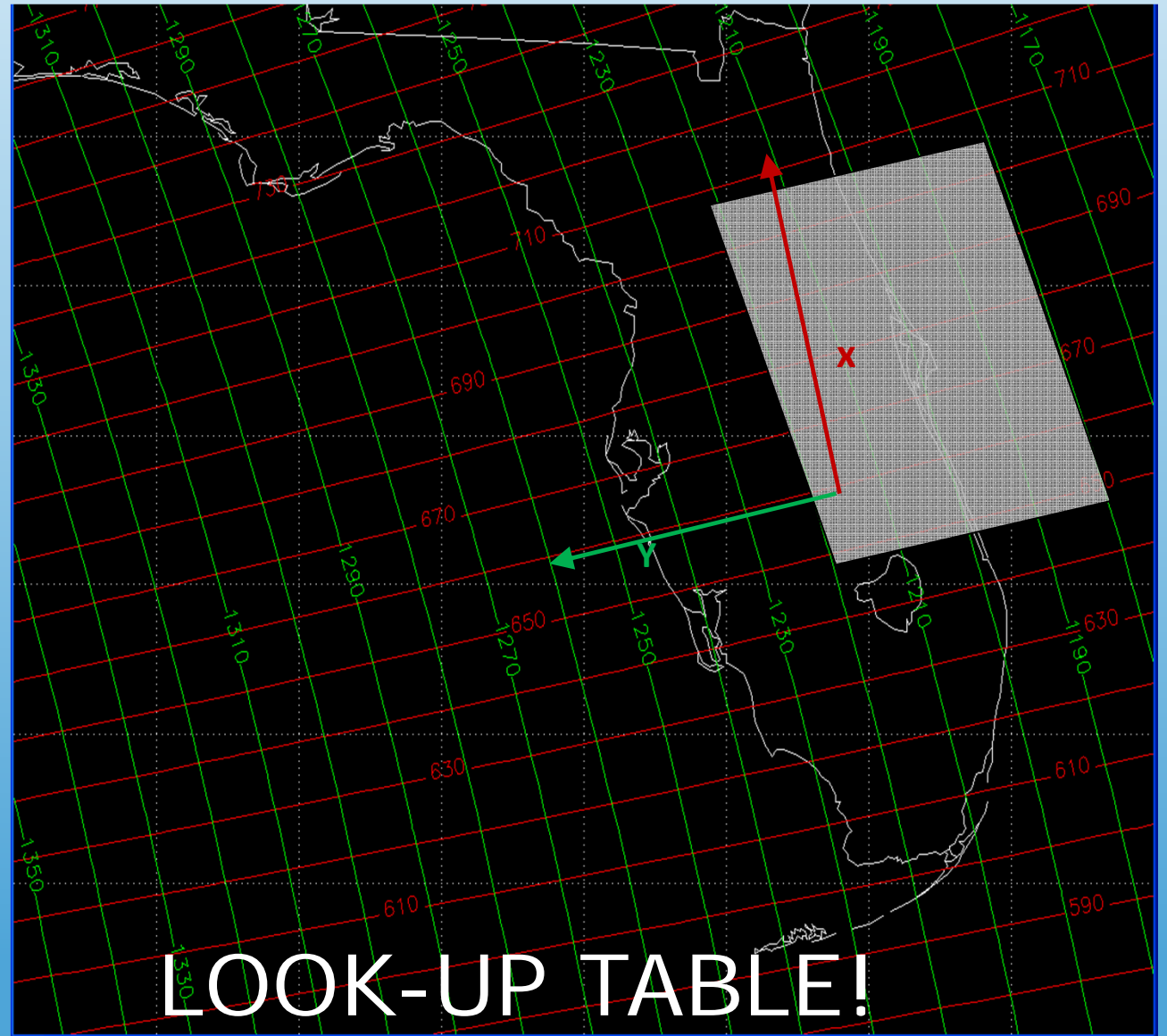
Not part of the initial evaluation!

Rectilinear grid
~5km resolution
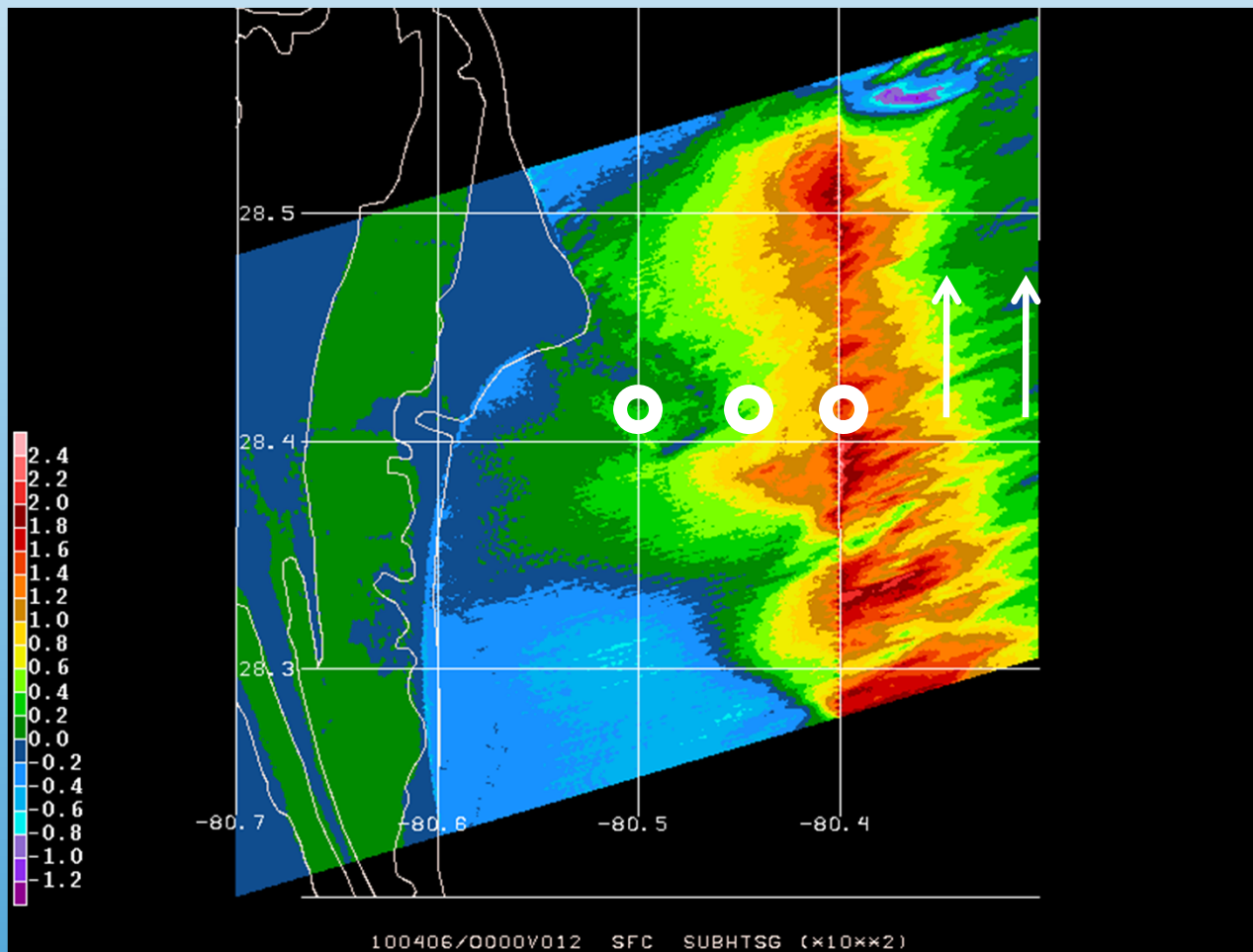East Coast U.S.

f000 output
available around
0800 UTC

RTOFS grid near Florida

RTOFS: x-axis oriented NNW along FL east coast. y-axis oriented to WSW

LOOK-UP TABLE!

Flow Model test with strong shear (analytic)

Wave Height Difference (x 10^2 m) from no current run.

CWARFS/FLOW overview

Create lat/lon file for each wave grid

Create RTOFS lookup table for each wave grid

RTOFS processing script
  Once per day data download
  Rotate RTOFS current u,v to wave model u,v

Run CWARF with RTOFS
  Run for only designated grids

Documentation and Script Updates

Where are we (5/30/11)?

ALL software installed at NWS Melbourne office (and most at Miami) and domains configured.

Successfully ported the wave domains into AWIPS using the grib2 decoder.

Using the GFS wind option

"The CMS/WABED has not been running *recently* as that server is being used for another project that will come to an end by the end of the summer. We should start the runs up again then (hopefully with some of the issues resolved)." IT Peter Blottman NWS Melbourne (7/18/2011).

"The model has been running well for several days now and hasn't missed a cycle running 4 times a day. This is great news." Peter Blottman.

Issues/Problems/Fixes:

Sometimes a fast ramp up of wave heights over a short forecast period (related to high resolution RTOFS currents?)

NWS added comments to the runtime script regarding the 'grid flipping' setting which will make the flip/no flip option clearer. The grid flip option changes the forcing boundary to the opposite side of the domain for offshore flow.
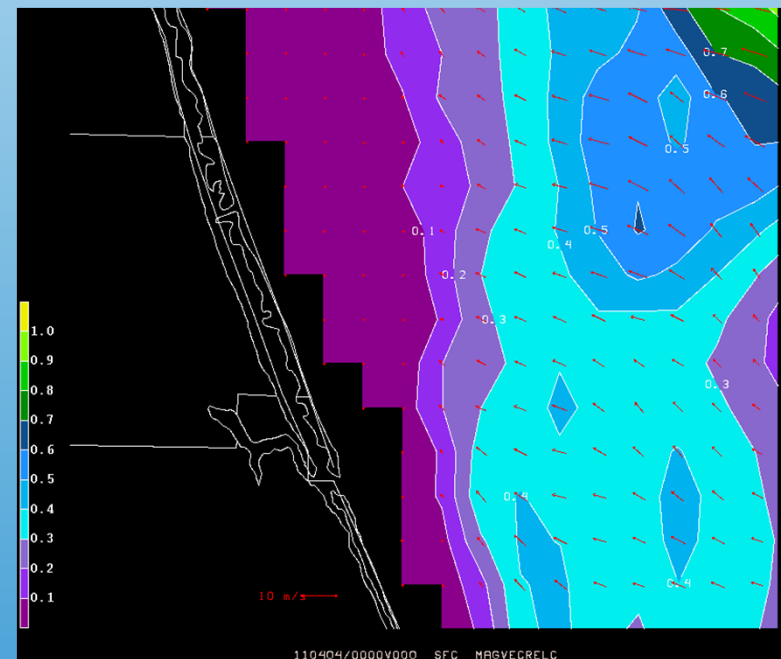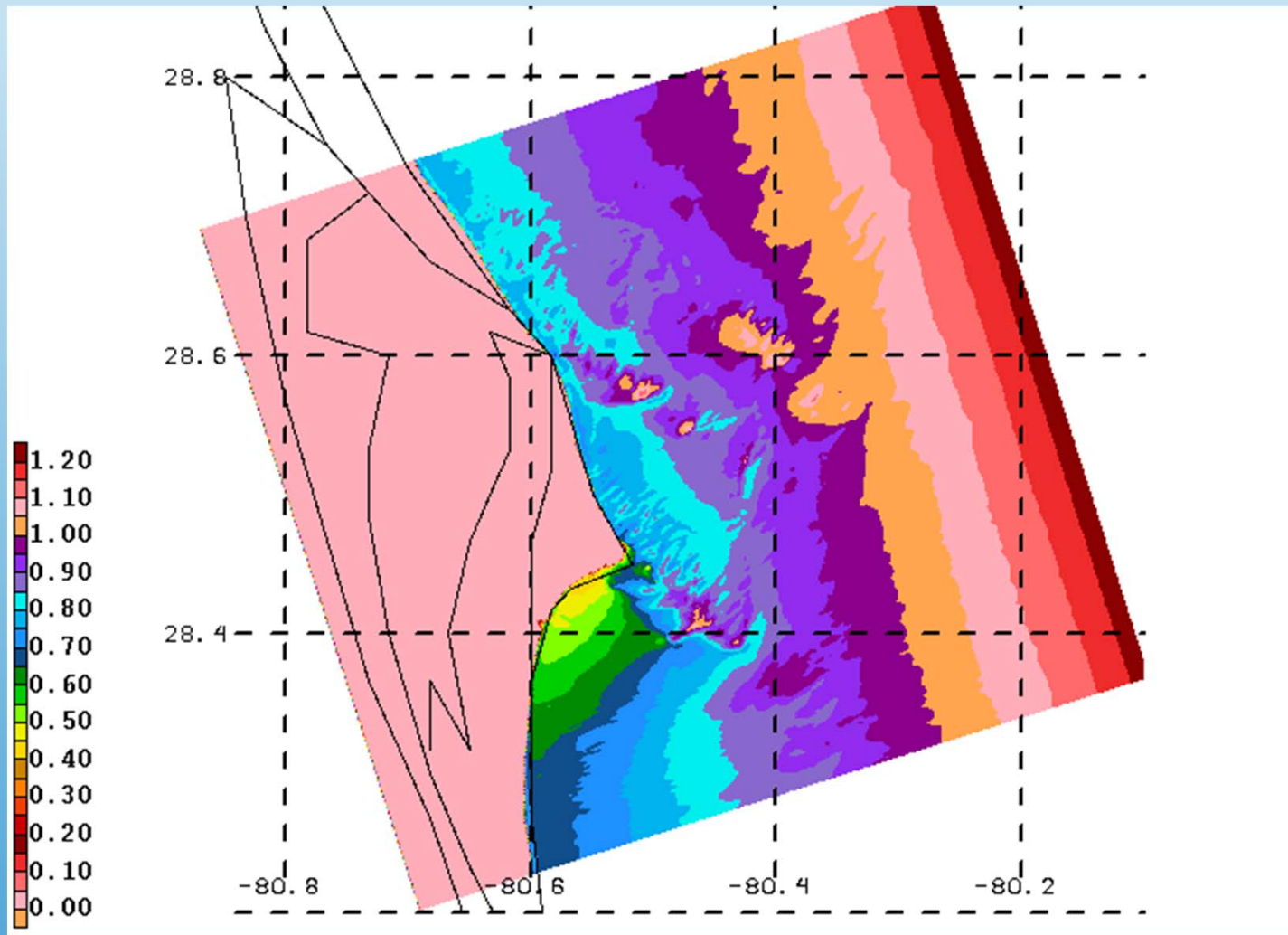

RTOFS 00 UTC surface analysis currents valid 4 April 2011.
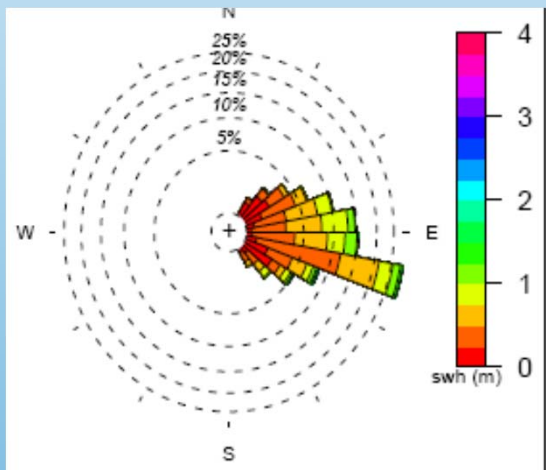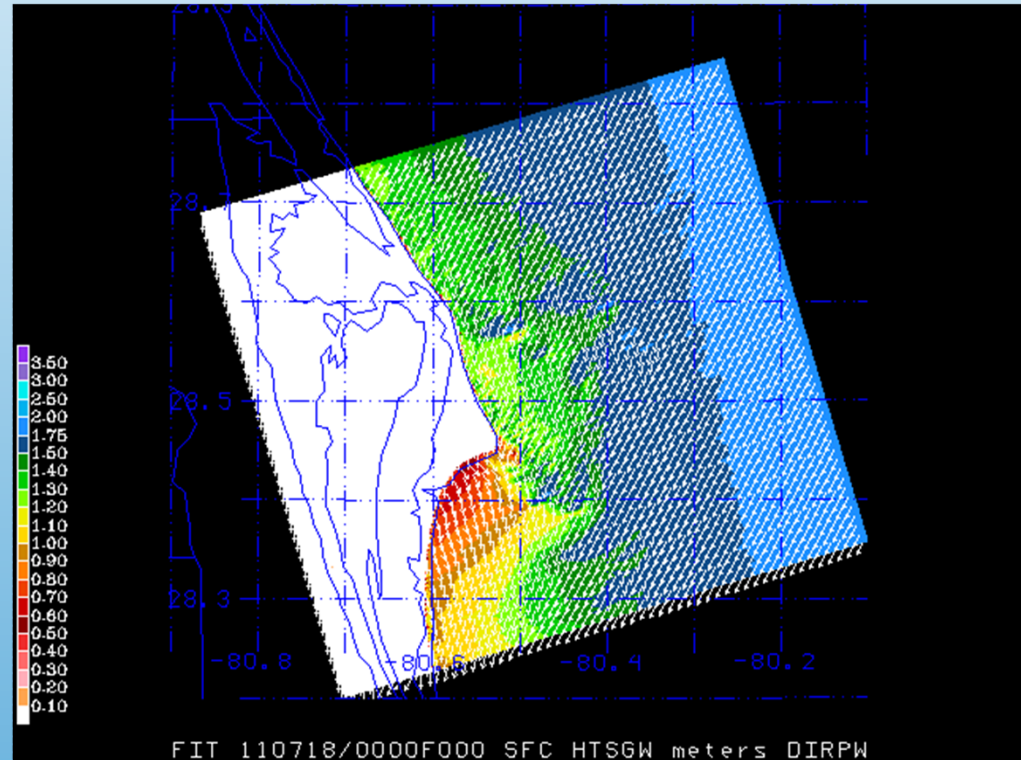
Wave Climate?
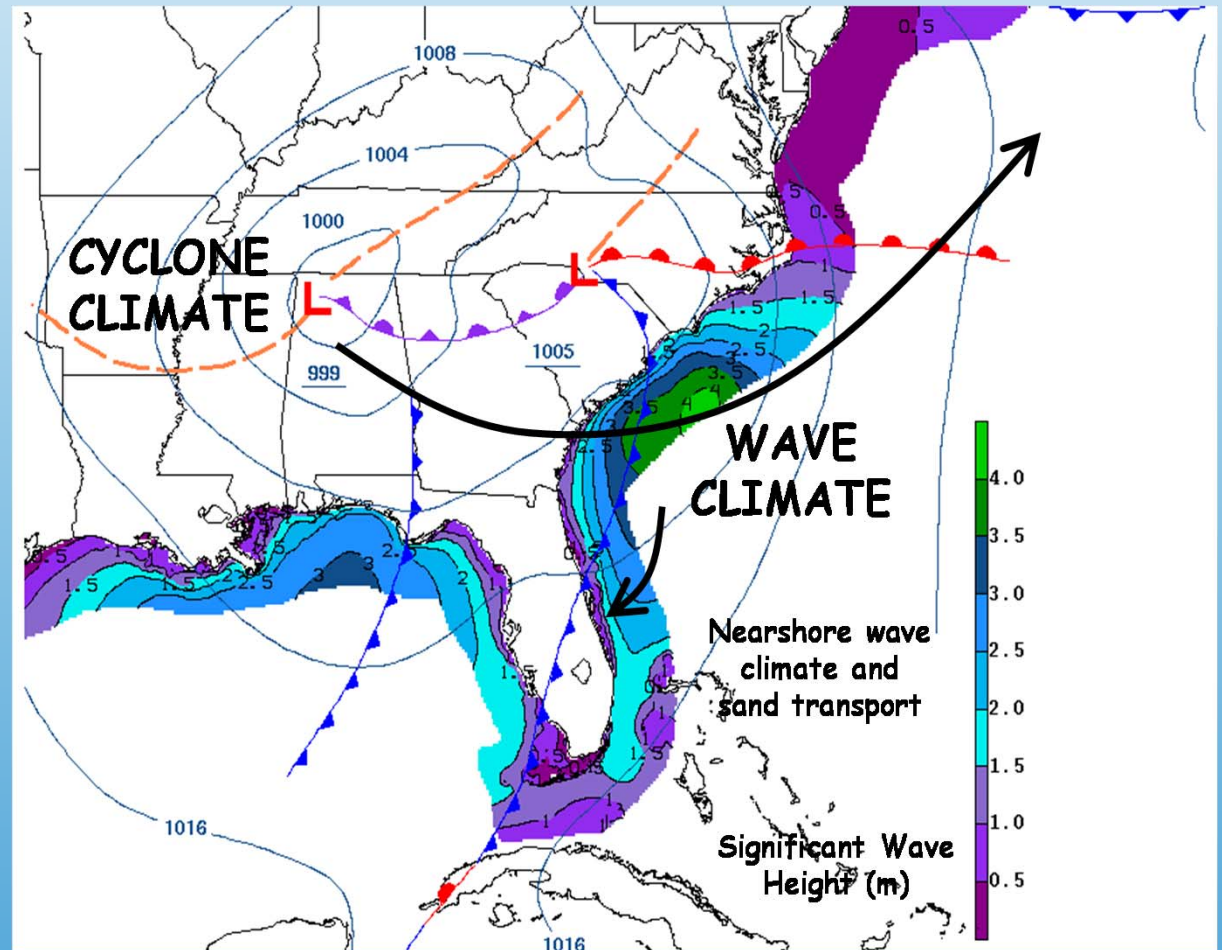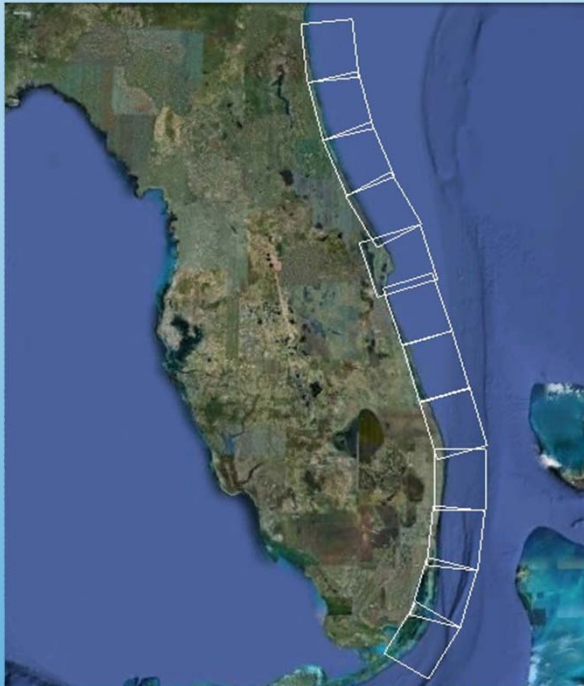
Wave Climate

9-year Wave climatology Summer/Spring

Questions?

Wave rose for hindcast CMS-Wave generated H_s at buoy 41113 for 2006-2007.

FIT 110718/0000F000 SFC HTSGW meters DIRPW

48 h CMS wave height (m) forecast initialized 00 UTC 18 July2011.

http://my.fit.edu/wx_fit/?q=obs/cmswave