Comparison of DWFE Results with Limited Area Models as part of the Coastal Storms Initiative

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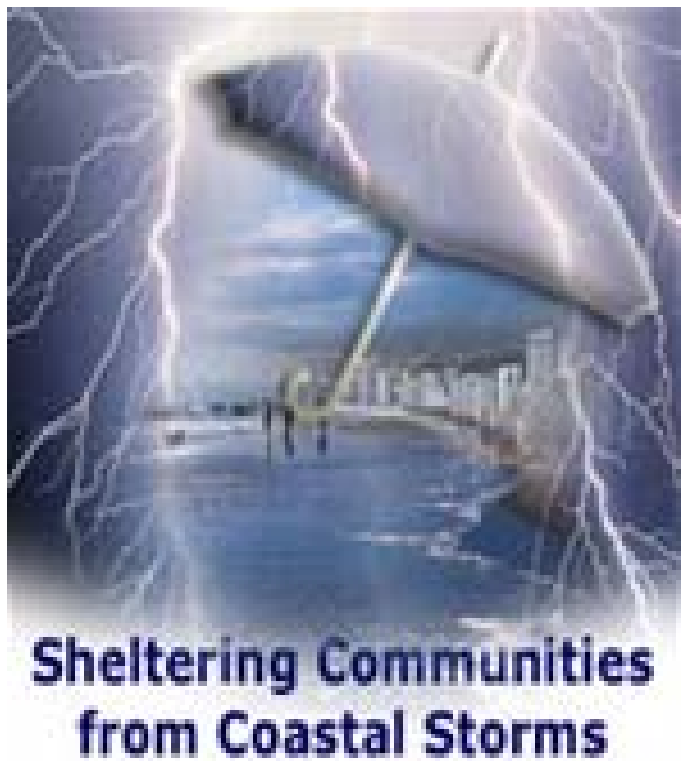
Outline

- Experiment Setup
- Verification Methods
- Results
- Conclusions



WRF Experiments

- Pilot CSI Project (2003 & 2004)
  - WRF-ARW (5 km) vs Eta (12 km)
- **2005 Summer Experiments (April 1st – July 30th)**
  - **Big / Small Domain ('WRF-CONUS' vs 'WRF-CSI')**
  - **Hot / Cold Start ('WRF-LAPS' vs 'WRF-Eta')**
- **Planned / in progress ?**
  - **Comparison of LAPS initialized ARW vs NMM**

Big / Small Domain Experiment

WRF-CONUS

WRF-CSI

- 5 km horizontal resolution in both set ups
- Dynamical core: Non-hydrostatic Mesoscale Model (NMM)
- Both configurations initialized at 00 UTC from Eta 212 analysis
- Run out to 48 hours with 3 h temporal resolution
- Big domain extension of DWFE runs

Big / Small Domain Experiment (cont)

- Lacis-Hansen shortwave radiation
- Feels-Schwartzkopf longwave radiation
- Mellor-Yamada-Janic 2.5 Planetary Boundary Layer scheme
- Ferrier Microphysics
- NOAH unified 5-layer land surface model
- No cumulus parameterization

Verification Techniques

- Real Time Verification System
- Ebert & McBride Technique
- Sea Breeze Verification

- Period One: 1st - 24th forecast hour
- Period Two: 25th - 48th forecast hour

Real Time Verification System

- Big / Small Domain Experiment
  - WRF verification system developed at NCEP and FSL
  - Uses metar observations for surface and radiosonde observations for upper air
- Hot / Cold Start Experiment
  - Uses madis observations
  - Surface verification only
- RTVS mostly used to verify temperature and wind speed. Neither verifies precipitation.

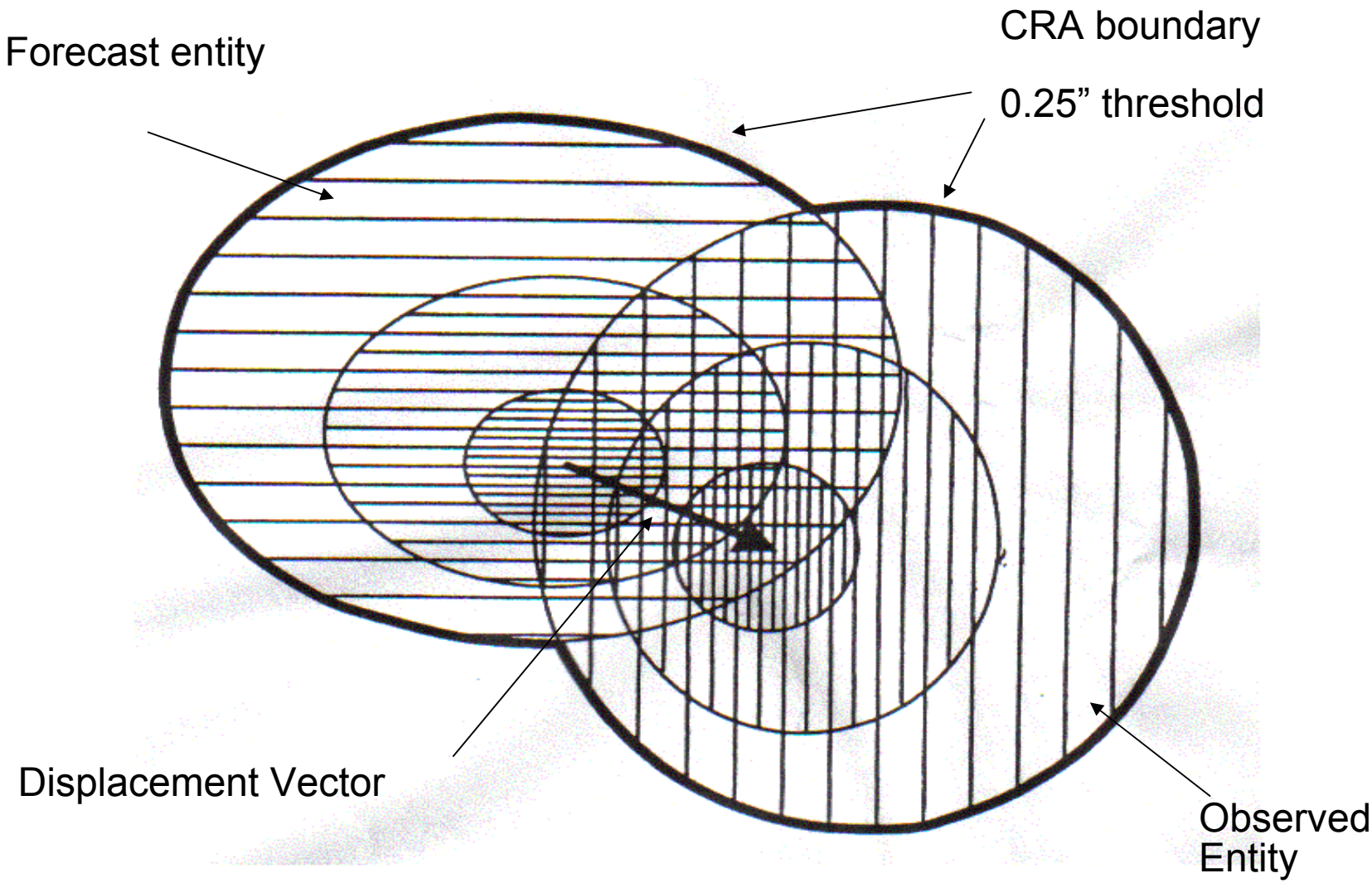
Statistical Limitations

- Does not tell you what is wrong with the model and provides no information for specific events
- Traditional statistics severely penalize an incorrect located precipitation system that may only suffer from a minor mislocation or shape error (especially in Florida!)
- Double penalty problem
- Solution:
  - Precipitation: Ebert & McBride
  - Sea Breeze: Contour Error Mapping (CEM) method

Ebert & McBride Technique

- Developed in Australia in 2000 to add more value to Quantitative Precipitation Scores on the synoptic scale
- Introduces concept of Contiguous Rain Area (CRA), defined the union between the forecast and observed rain entity with a boundary defined by a predetermined threshold value
- A best fit between the forecast and observed rain entities is found
- Errors contributed from pattern, volume, and displacement can then be calculated

Contiguous Rain Area



Ebert & McBride Method (cont)

- Best fit found by correlation maximization technique
- Restrains: Correlation (95 % confidence) & size threshold
- Specific size thresholds can be applied to segregate synoptic & mesoscale CRAs

	Underforecast	**Approx Correct**	**Overforecast**
Close Placement	**Underestimate**	**Hit**	**Overestimate**
Far Placement	**Missed Event**	**Missed Location**	**False Alarms**

Contour Error Map Technique

- An automated technique to identify and verify sea breeze transition and propagation developed at Applied Meteorological Unit (AMU) in Cape Canaveral in 2000
- Identifies sea-breeze transition times in grids of observed and forecast wind, verifies the transition times, and computes statistics to determine timing bias of the onset and transition of the sea breeze
- Development study verified the RAMS 1 km against a network of wind towers at a five minute time step

Sea Breeze Verification

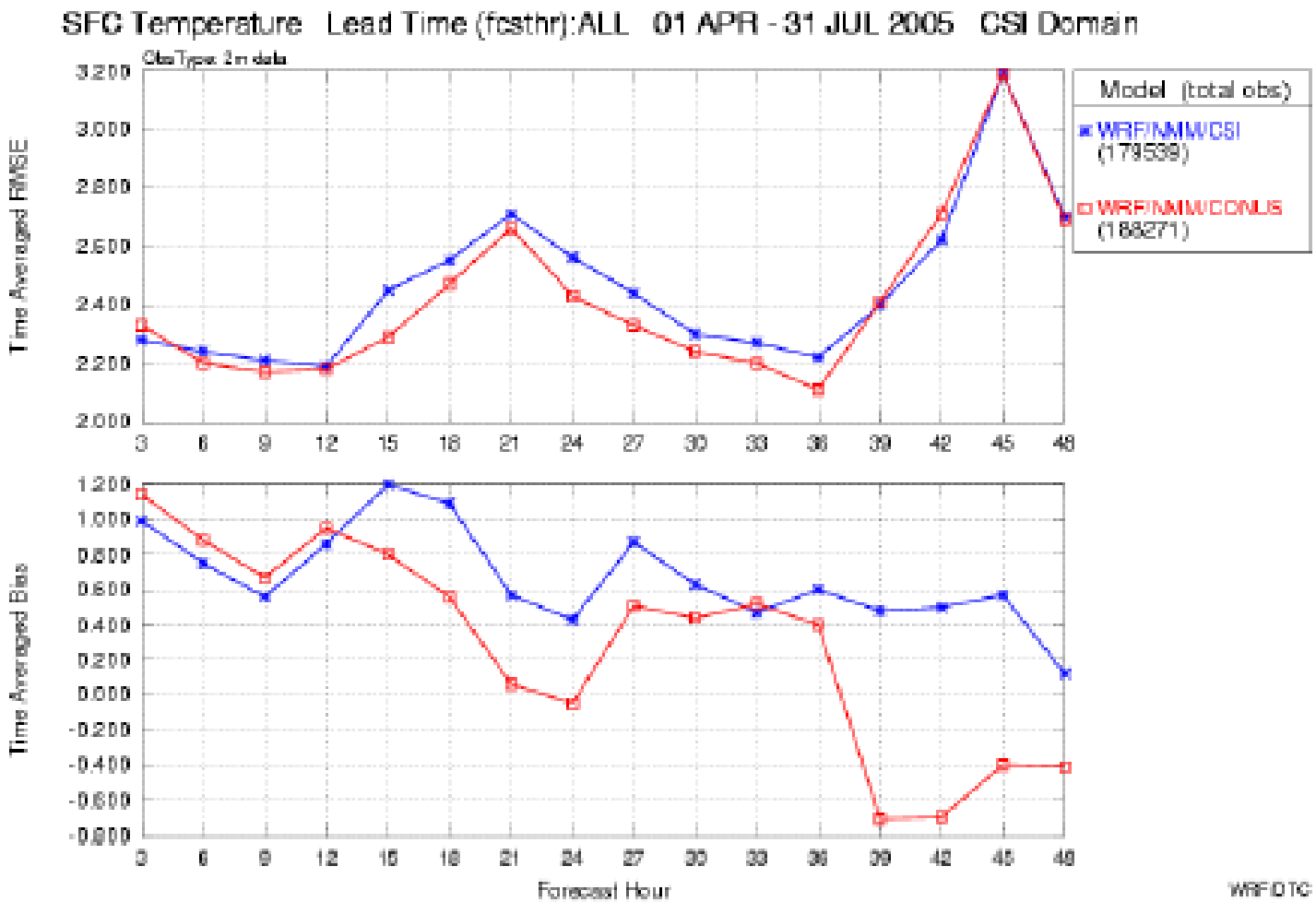
- CEM verification of the pilot CSI project utilized LAPS analysis grids as observational data set
- Big / Small Domain & Hot / Cold start experiments of 2006 LAPS analysis files not available and temporal resolution of 3 hours
- Method based off of CEM used to verify only sea breeze transition, not propagation.
- Mesonet and Metar obs used for verification along the coastlines of JAX, Tampa, and Cape Canaveral.

Verification Results

- Big / small domain results
  - RTVS
  - Ebert & McBride
  - Sea Breeze
  - Case Verification

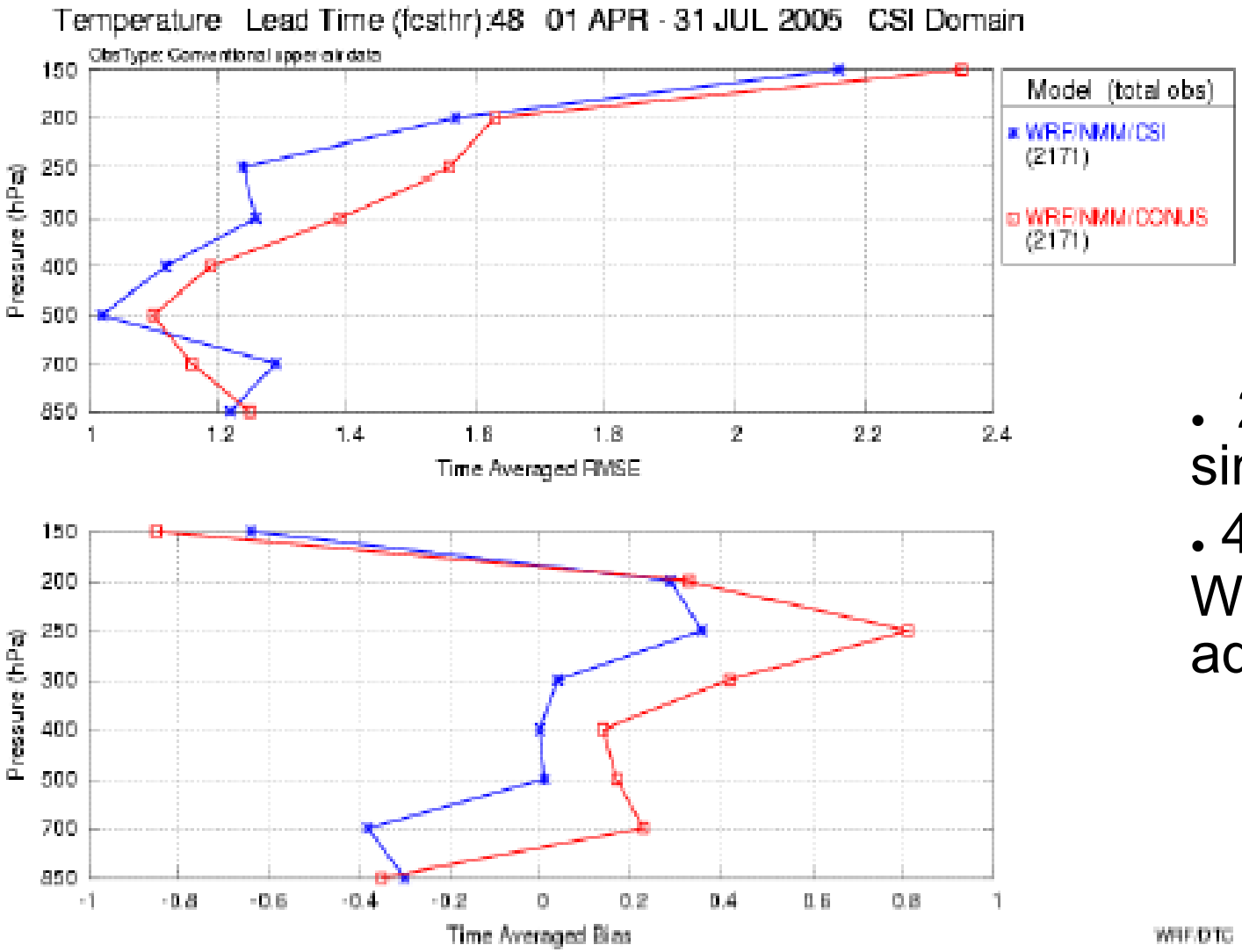
Big / Small Domain Results

Surface Temperature



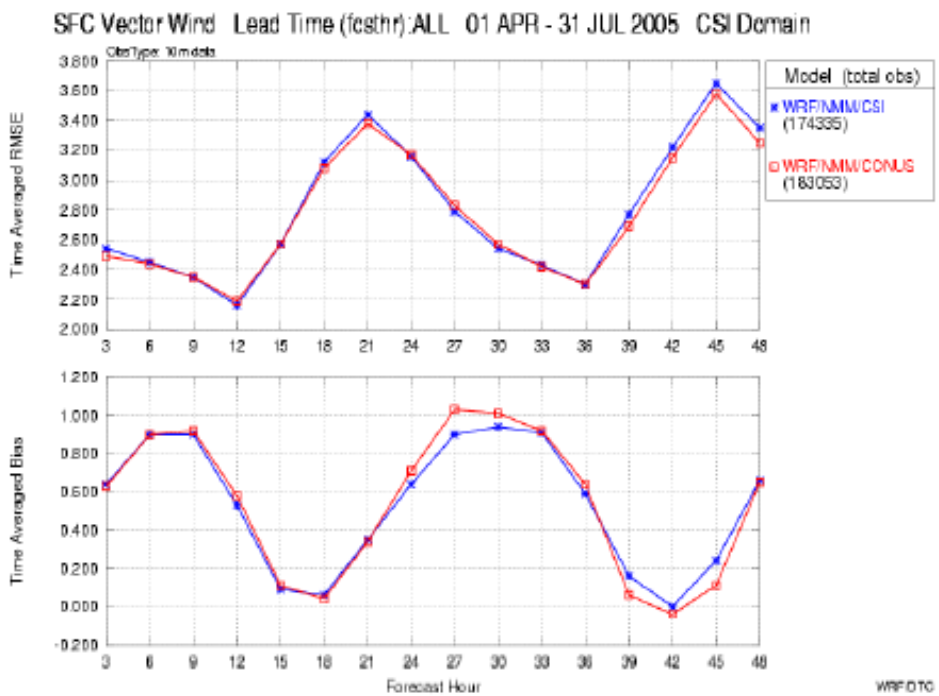
. WRF-CONUS, very slight advantage

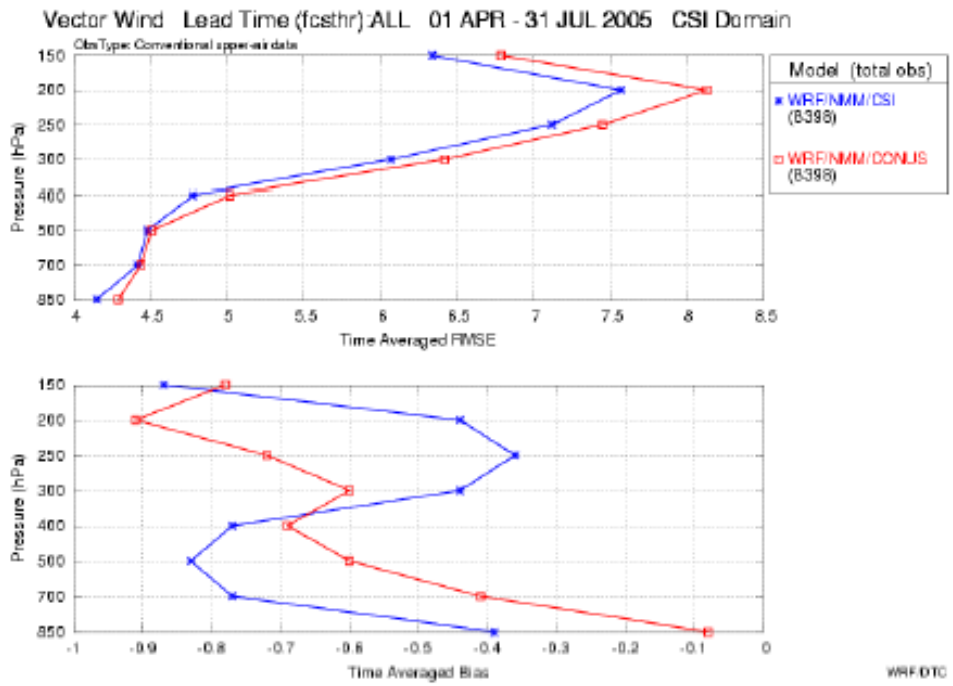
Upper Air Temperature



- 24th forecast hour, similar statistics
- 48th forecast hour, WRF-CSI slight advantage

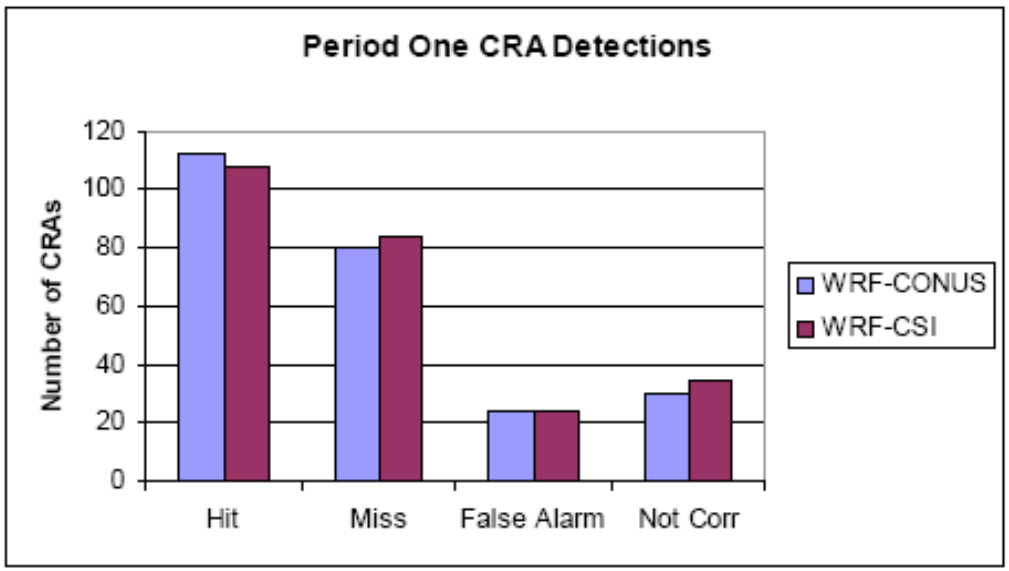
Vector Wind

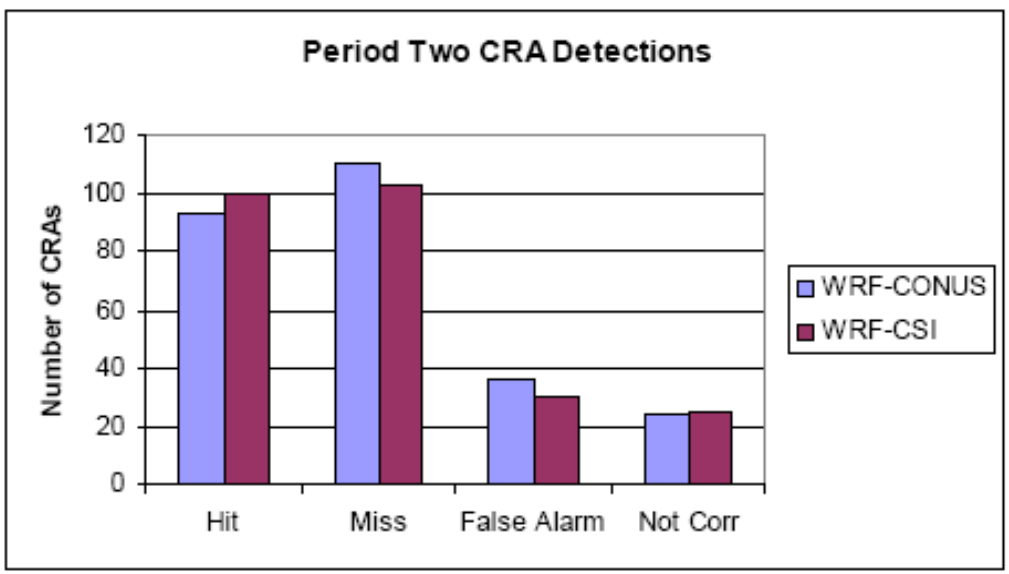




Near identical stats

Ebert & McBride Results
Detections

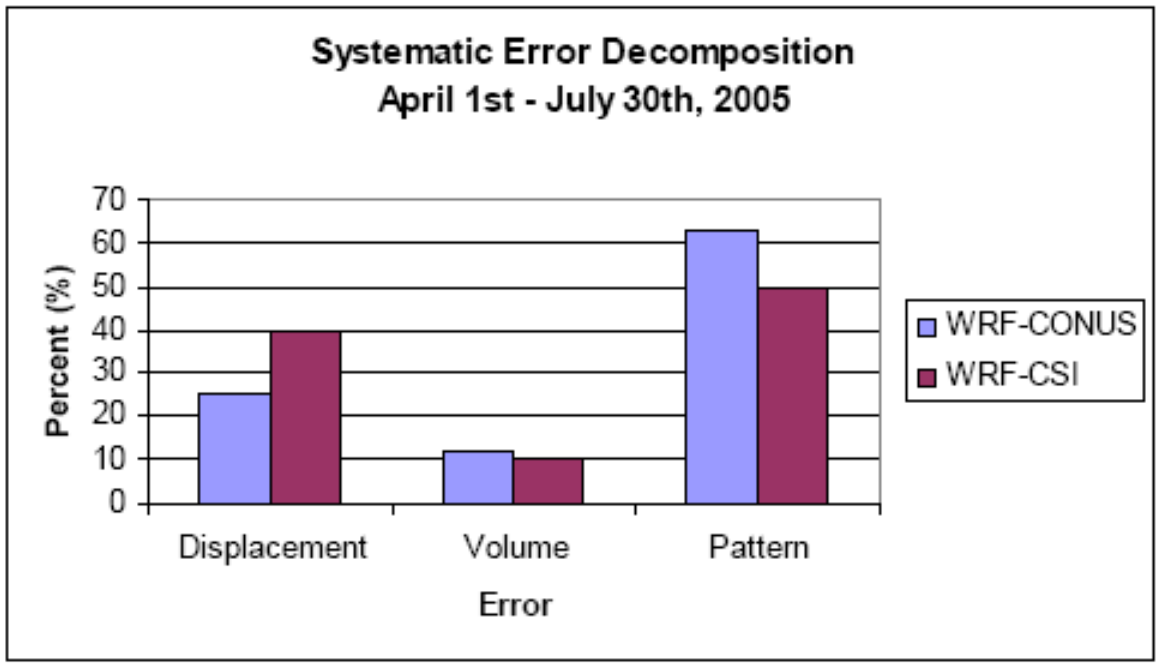




- 452 CRAs detected through observations.
  - WRF-CSI: 46.2 %
  - WRF-CONUS: 45.4 %

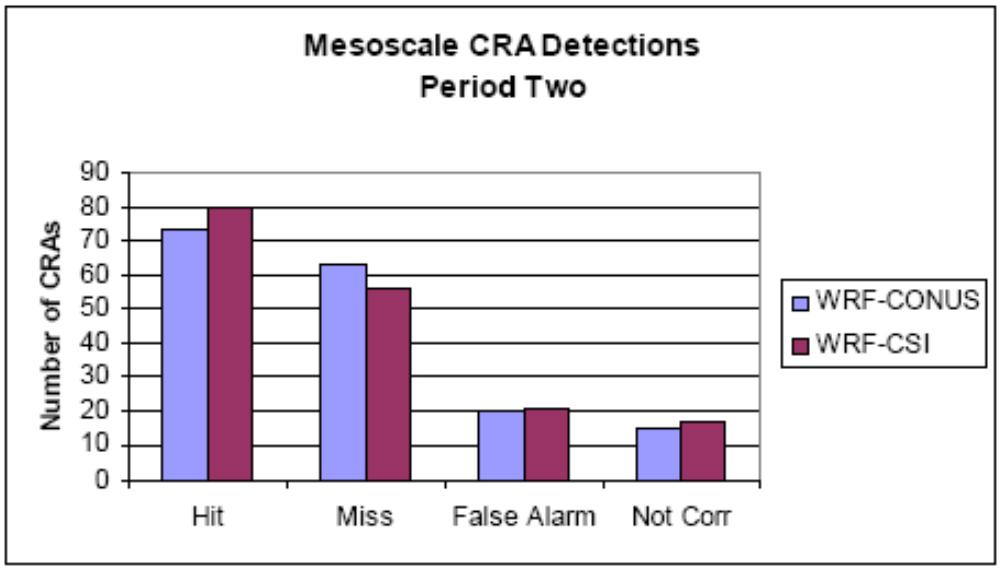
- Small domain more detections during period two?

Error Decomposition

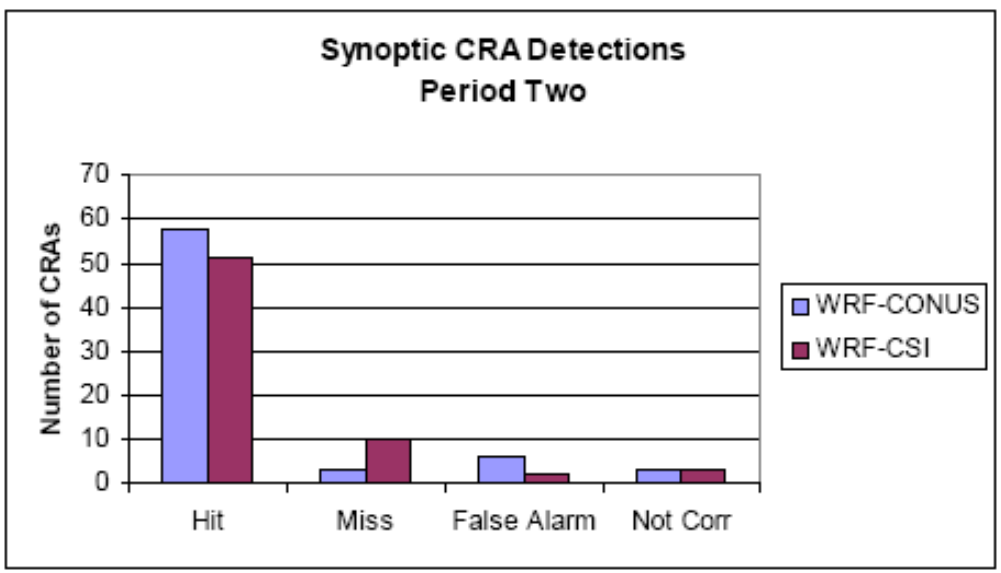


WRF-CSI higher displacement errors (mostly from synoptic size CRAs)

Ebert & McBride Results
Period Two Detections



- WRF-CSI higher hit rate



- WRF-CONUS higher hit & false alarm rate

Ebert & McBride Comparison

CRA Stats	WRF-CONUS	WRF-CSI
Unshift Correlation	0.198	0.187
Shift Correlation	0.406	0.398
RMSE	0.45	0.50
Bias	1.18	1.26
ETS	0.42	0.37
Displacement	0.46°	0.50°
Avg Rain Rates (0.34" /6 hr observed)	0.70	0.77

- Bottom Line: WRF-CSI higher detect rate, WRF-CONUS detects more accurately.

← Both configurations grossly overforecast

Sea Breeze Results

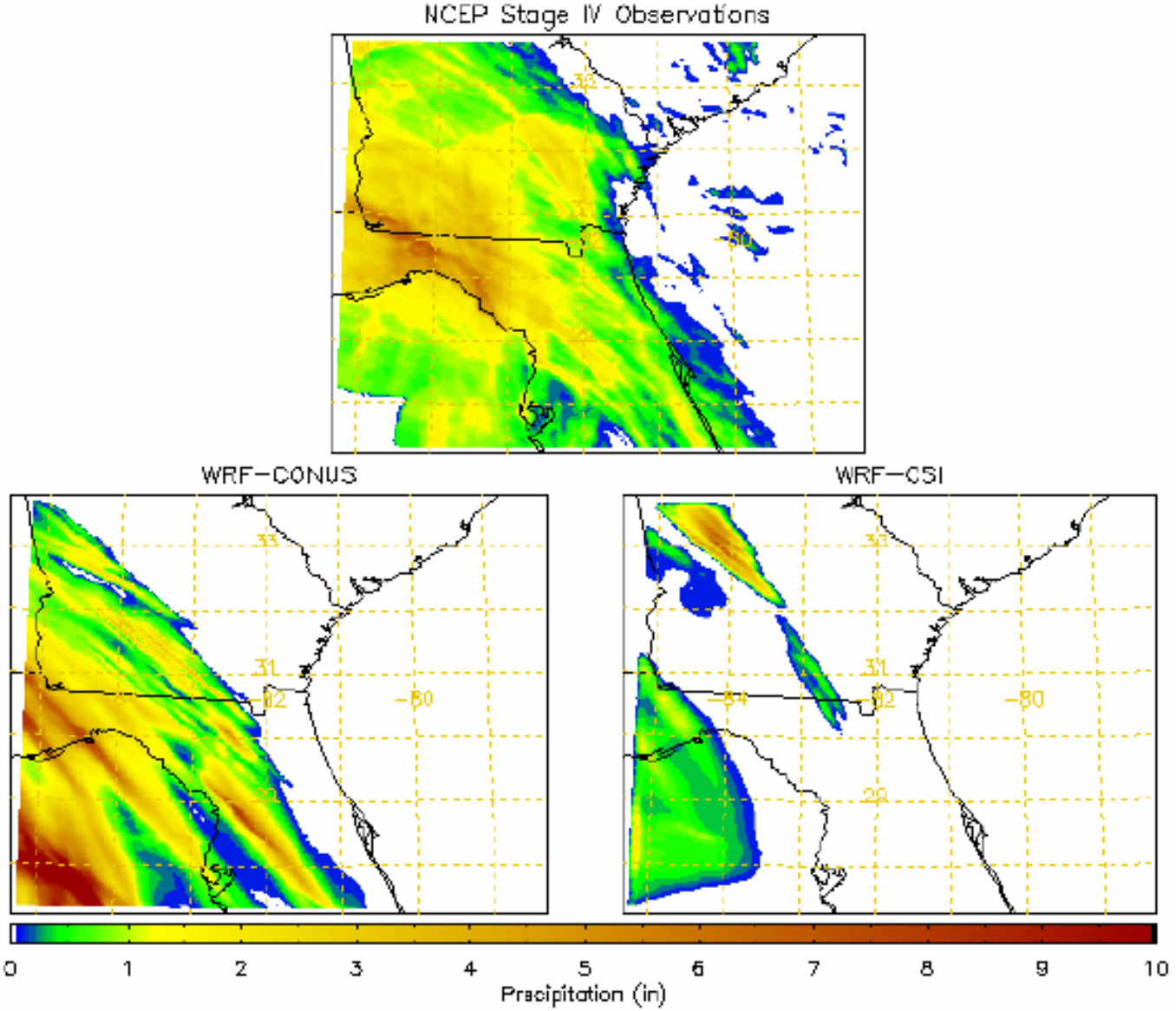
	WRF-CONUS	WRF-CSI
Wind Speed Bias (m/s)	1.15	1.18
Wind Speed RMSE (m/s)	1.25	1.30
Wind Direction RMSE (°)	19	25
Temp Bias (K)	-0.52	-0.60
Temp RMSE (K)	1.02	1.12

- 91 Days of Complete Data in the three sub-domains
  - 87 sea breezes detected through obs
  - WRF-CONUS: 92 %
  - WRF-CSI : 93 %
- WRF-CSI higher detection, WRF-CONUS detects more accurately.
- Exact same detection rate for period one, differences in period two

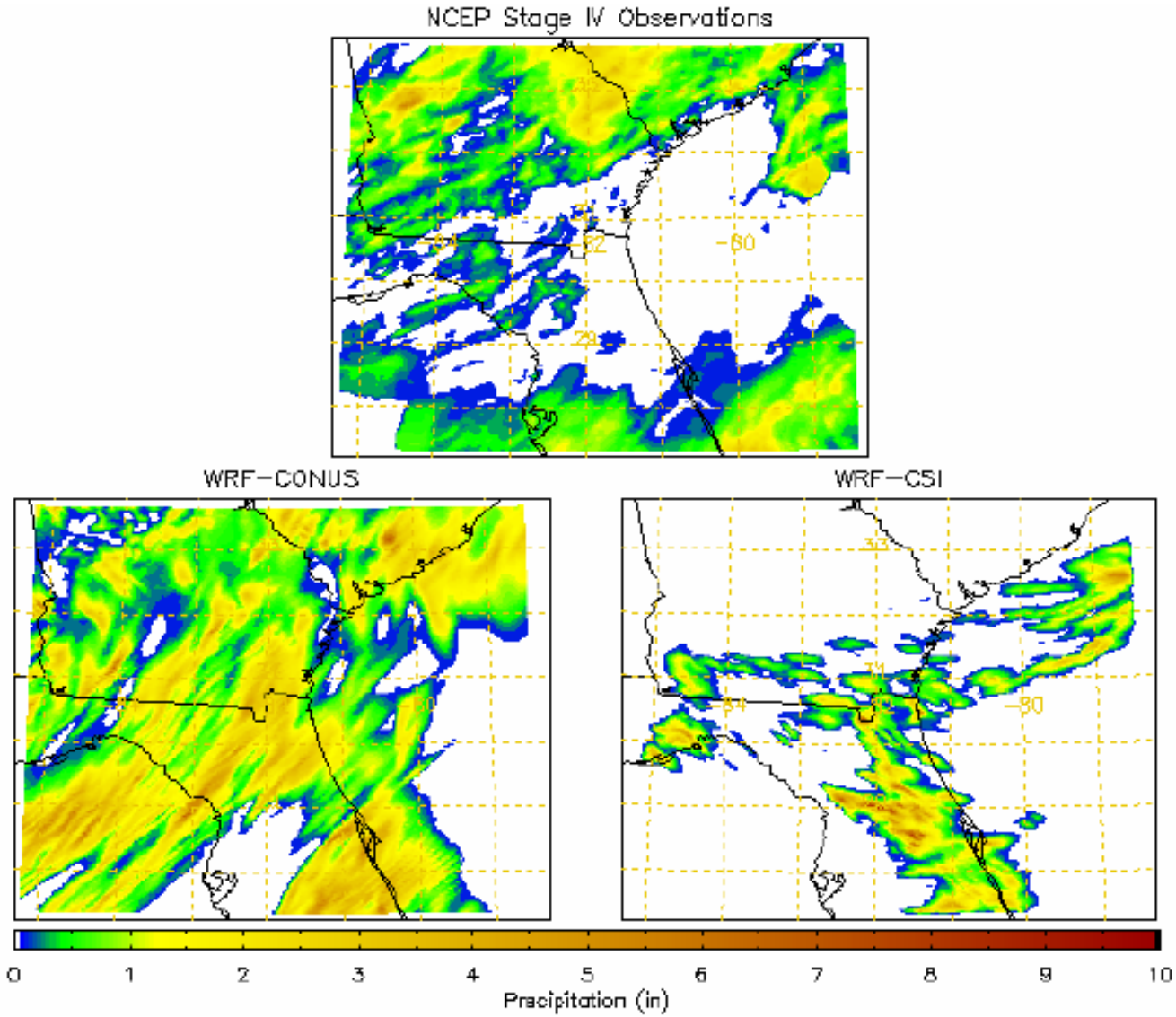
Case Verification

- Eye-ball verification: Period one yields no substantial differences in forecast ability between WRF-CONUS & WRF-CSI
- All differences exist in period two when synoptic influences 18-36 hours away from JAX domain during initialization.
- Examples:
  - Hurricane Dennis
  - Sea Breeze
  - Frontal

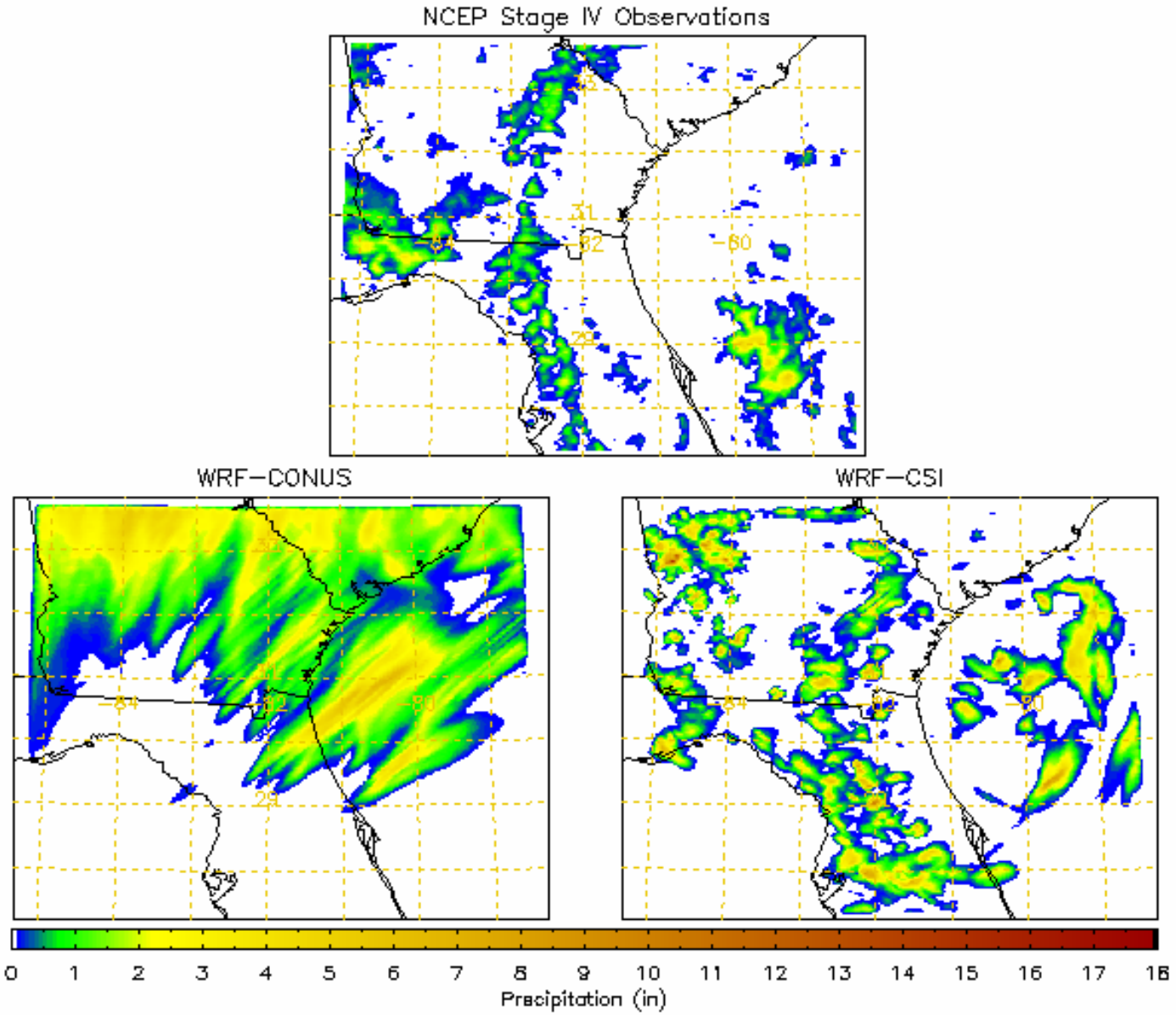
Hurricane Dennis
June 9th, 2005



Case Example
June 2, 2005



Case Example
June 6, 2005



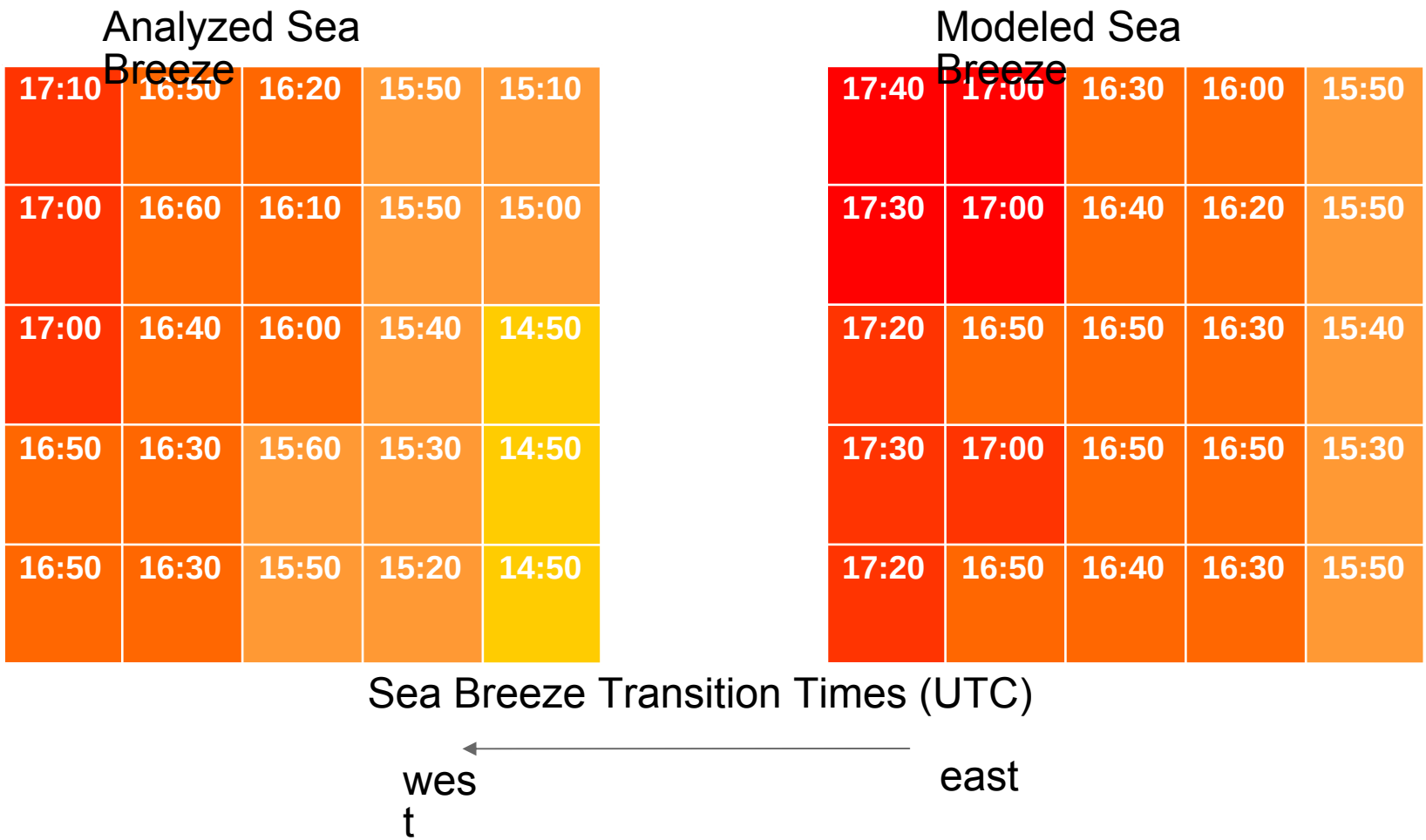
Conclusions

- WRF-CONUS shows no overall advantage over WRF-CSI for SE USA.
- In general, WRF-CSI has more detections (CRAs, sea breeze) but WRF-CONUS has better stats.
- Most likely a result of the mesoscale driven patterns of SE USA.

WRF Code Suite Implementation

- Possible development of object oriented verification code made available in the WRF suite
  - Precipitation (Ebert & McBride)
  - Sea Breeze (Contour Error Method)
  - Others...

CEM Simplified Sea Breeze Example



Transition timing bias: 0.32 hrs

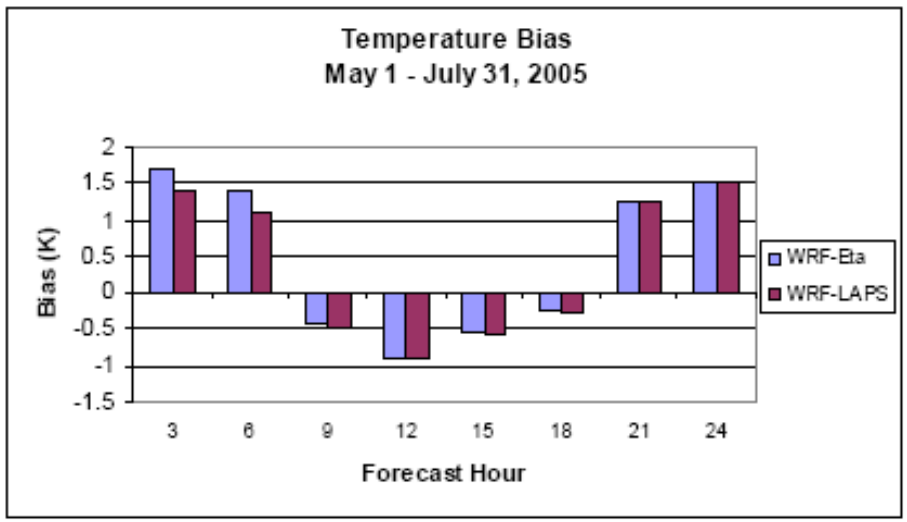
Standard deviation of timing bias: 0.12 hrs

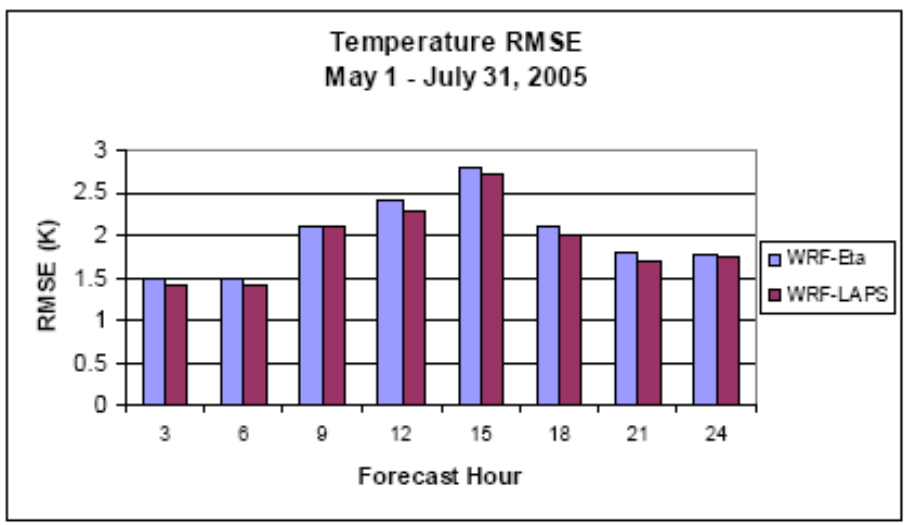
Best Fit Method

- Each forecast CRA is shifted incrementally, grid point by grid point, in 32 directions covering 360^{o}
- Either a maximization of the correlation coefficient or a minimization of the MSE technique can be used to determine the best fit
- 20% of forecast entity allowed to be removed from grid
- A test nine random CRAs suggests that the correlation maximization technique helps to a achieve a best fit that makes the most logical

Hot / Cold Start Results

Temperature





Ebert & McBride Results

	WRF-LAPS	WRF-Eta
Unshift Correlation	0.201	0.19
Shift Correlation	0.392	0.387
RMSE	0.39	0.42
Bias	0.92	0.89
ETS	0.40	0.39
Displacement	0.43°	0.49°
Avg Rain Rates (0.31" /6 hr observed)	0.52	0.57

Sea Breeze Results

	WRF-LAPS	WRF-Eta
Wind Speed Bias (m/s)	1.18	1.20
Wind Speed RMSE (m/s)	1.20	1.32
Wind Direction RMSE (°)	24	27
Temp Bias (K)	-0.43	-0.50
Temp RMSE (K)	0.97	1.05

Hot / Cold Start Experiment

- Both configurations exactly the same except for initialization
- Operational WRF simulations provided by JAX WFO
- “hot-start” (WRF-LAPS) initialized using FSL's Local Analysis and Prediction System (LAPS)
- “cold-start” (WRF-Eta) initialized using forecasts from 00 UTC Eta 218 grids
- ARW core, Dudhia shortwave, Rapid Radiative Transfer model for longwave, YonSei University PBL, Grell-Devenyi cumulus, and NOAH land surface model.

CSI Pilot Project

- **CSI JAX WRF:**
  - 5 km resolution
  - 145 X 145 grid points
  - 42 vertical levels from surface to 100 mb
  - 24 hour forecasts, temporal resolution of one hour
  - Version 1.3 initially installed, ARW core
  - Comparison with Eta 12 km