14.6. The Impacts of Microphysics and Planetary Boundary Layer Physics on Model Simulations of U.S. Deep South Summer Convection

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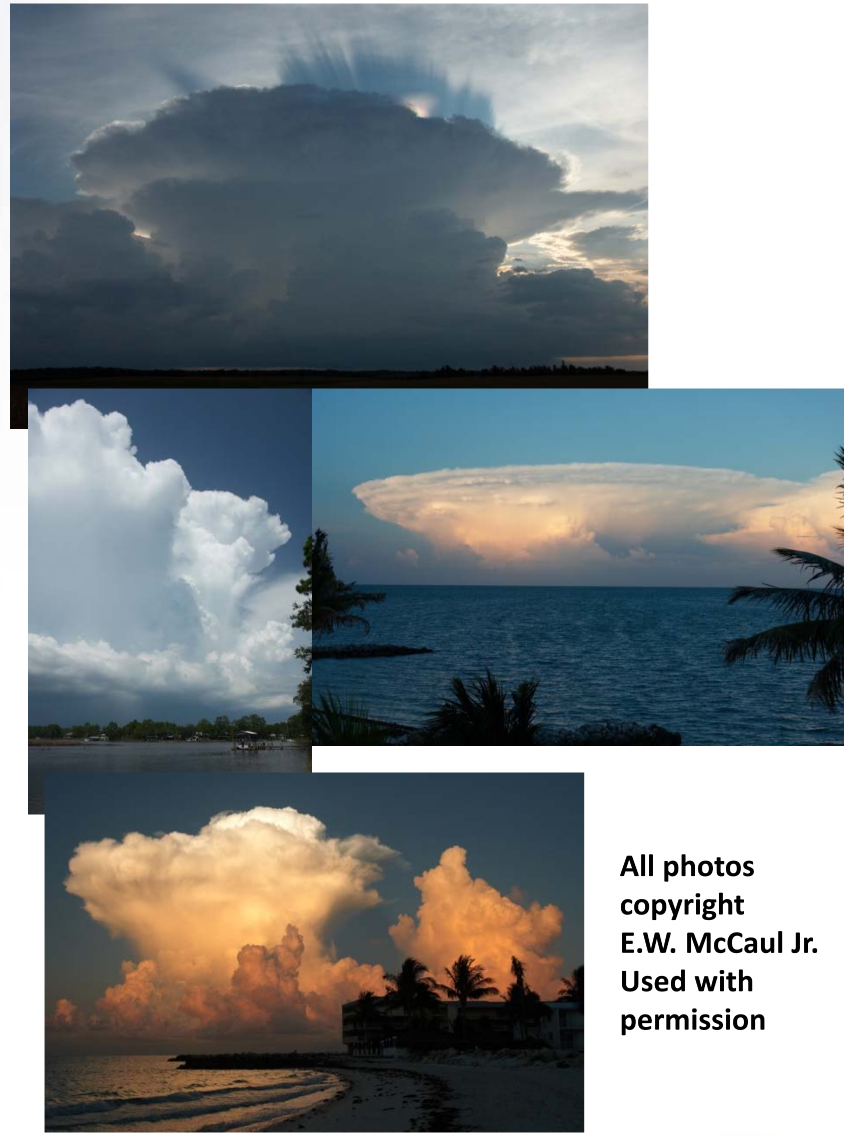
Introduction/Motivation

- **Accurate forecasting of convective initiation (CI) is a challenge for local-scale modeling**
  - **NWS WFOs: Use Weather Research and Forecasting (WRF) Environmental Modeling System (EMS)**
  - **SPoRT surface initialization data transitioned to EMS to help improve fields contributing to CI**

- **Results from Summer 2012 evaluation revealed that both Control and SPoRT-initialized forecasts exhibited a consistent under-prediction of precipitation coverage**

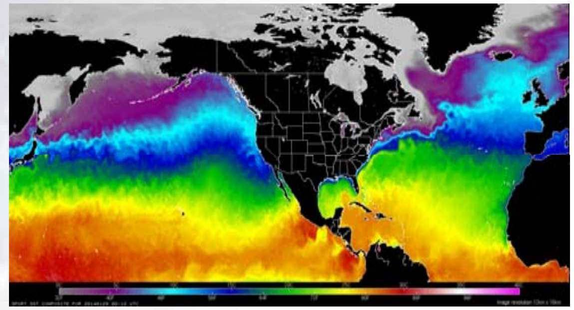
- **Motivation for this work:**
  1. **Determine impact of SPoRT initialization datasets in a variety of WRF model physics combinations**
  2. **Better understand model sensitivity to microphysics and PBL schemes to optimally configure WRF/EMS for forecasting CI with SPoRT datasets**



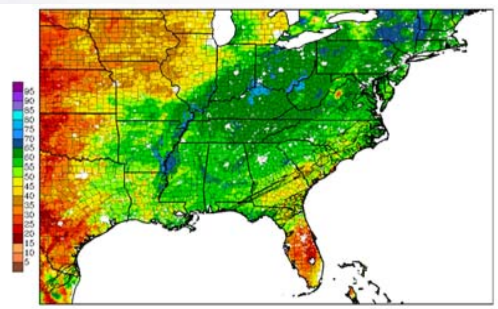
Model Configuration

- Advanced Research WRF v3.4.1
  - 9-km/3-km, 1-way nested grids
  - 40 vertical levels, 54-s timestep
  - Initialized at 0600 UTC; 24-h forecast
  - Initial and boundary conditions from GFS personal tile (0.5-deg data)
  - Convective parameterization: Kain-Fritsch (only on outer domain)
  - SW / LW radiation: Dudhia / RRTM
  - Noah land surface model (LSM)
  - Microphysics and PBL vary for an 8 x 3 matrix of runs

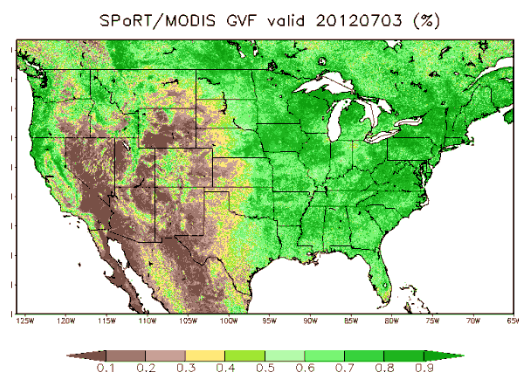
- Two sets of WRF forecasts:
  - Control (CNTL; GFS IC/BC)
  - SPoRT configurations (added 3 datasets at right)



SPoRT SST Composite
- 2-km resolution
- Generated twice daily
- Provides details that allow model to account for over-ocean fluxes and seabreeze forecasting



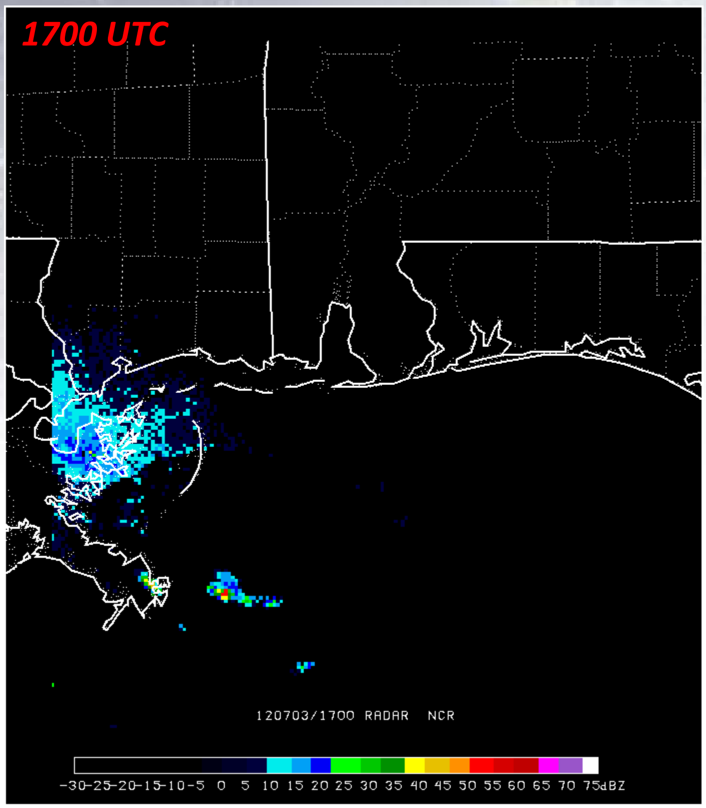
Land Information System (LIS)
- 3-km grid spacing
- Uncoupled Noah LSM
- Atmospheric analyses and specified soil/vegetation parameters to predict soil characteristics that shape energy fluxes for weakly-forced convection

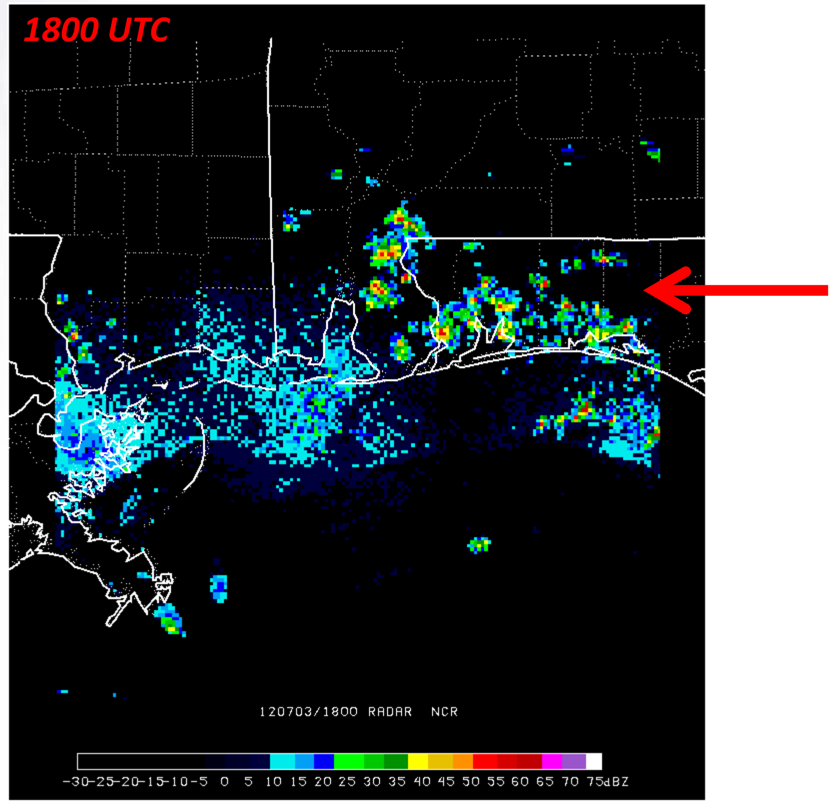


SPoRT MODIS GVFs
- 1-km resolution
- Generated once daily
- Replaces coarse monthly climatology with satellite-measured vegetation health in real-time

Mobile Case Study: 3 July 2012

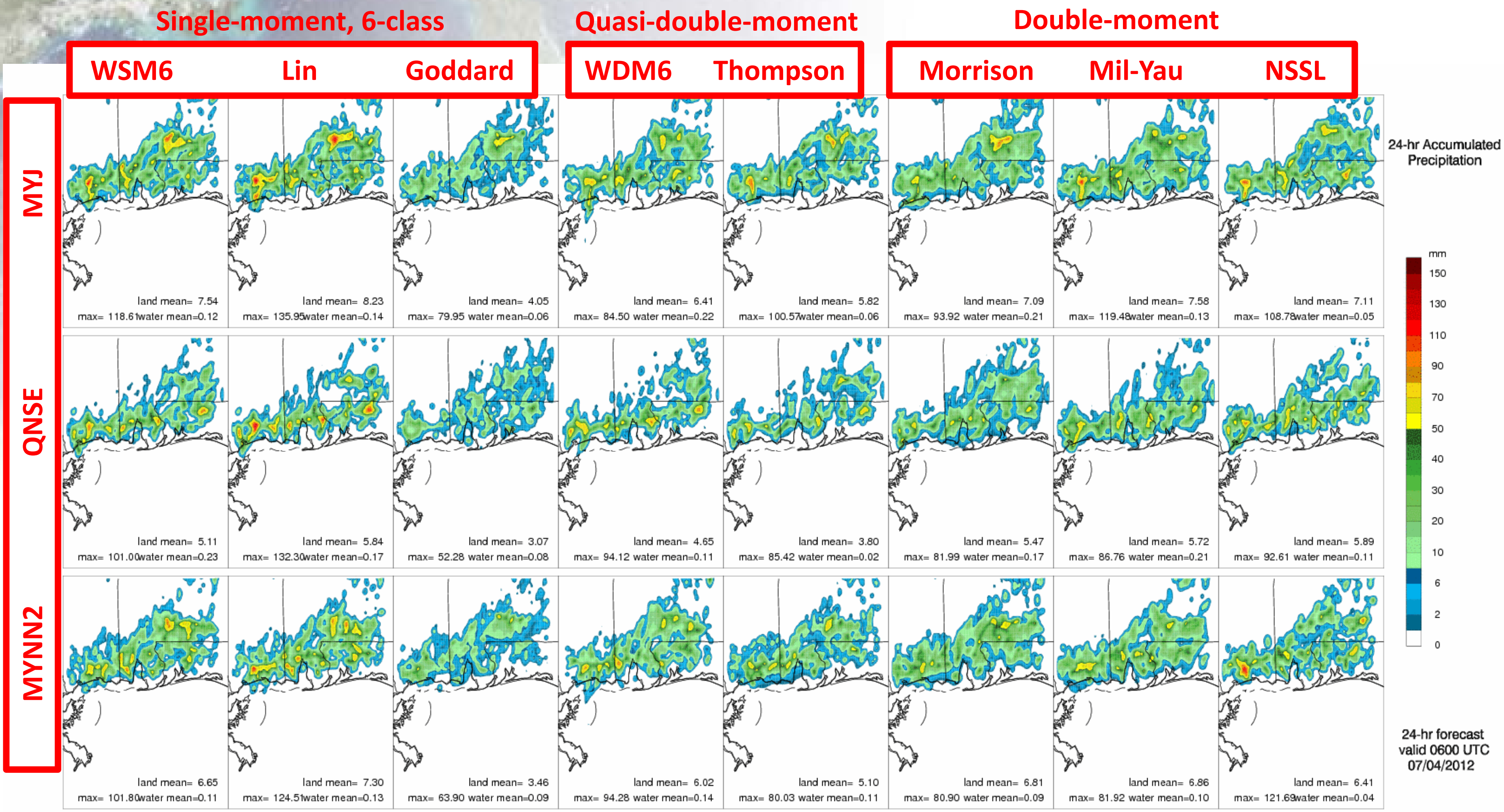
KMOB Level III Composite Reflectivity product





CI associated with a sea-breeze front occurred between 1700 and 1800 UTC across southern AL and western FL, east of Mobile Bay

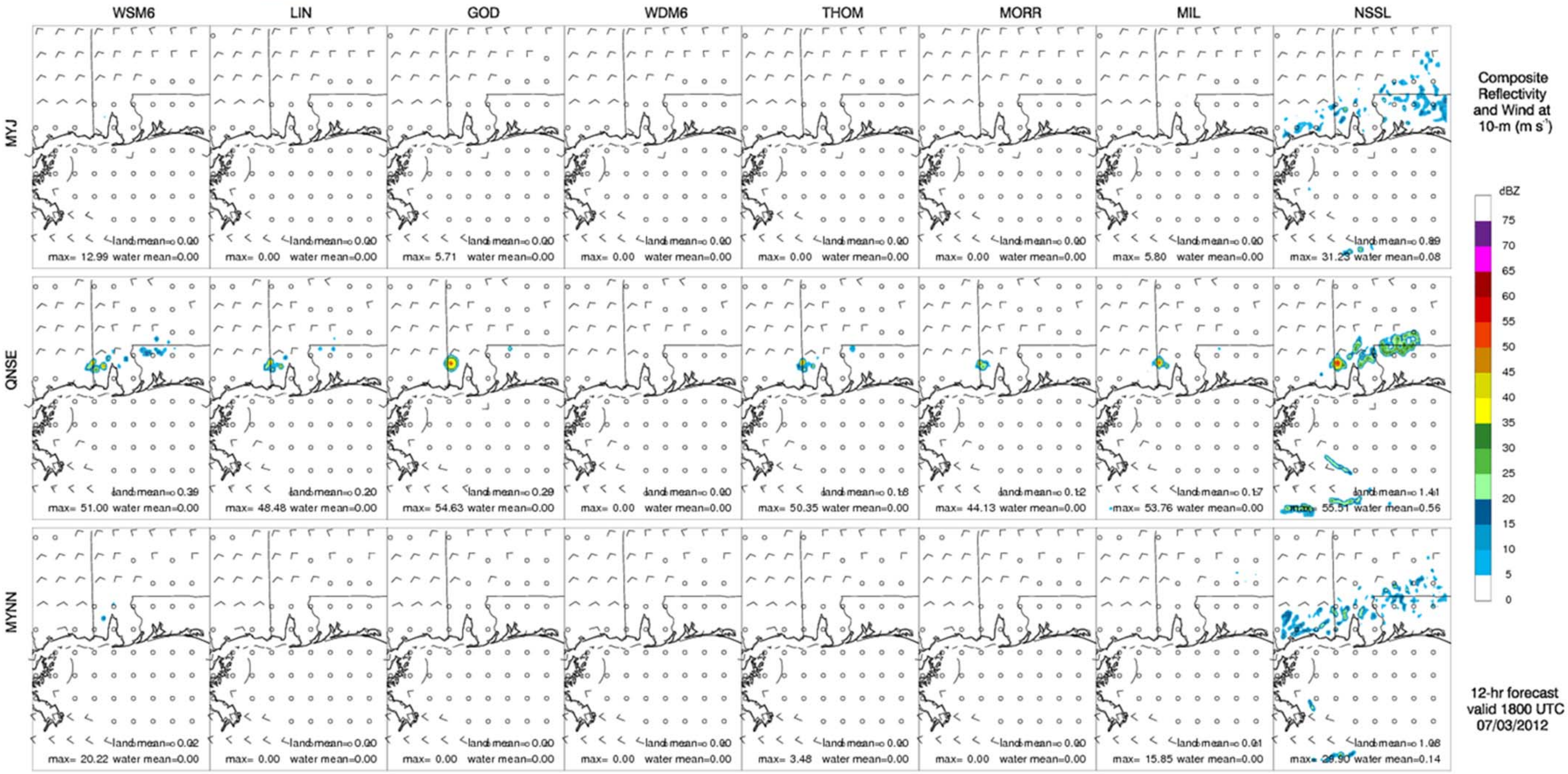
(8 MP)x(3 PBL) Matrix: 24-h precip (SPoRT runs)

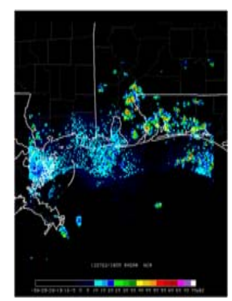


In general, microphysics schemes grow in complexity to the right

CNTL Composite Reflectivity Matrix

(12 h forecast valid 1800 UTC 3 July)





- Most physics combinations do not capture the CI location, coverage, or magnitude
- QNSE PBL and NSSL MP are most aggressive schemes for CI
- For this case, selection of PBL and microphysics schemes is important

SPoRT Composite Reflectivity Matrix

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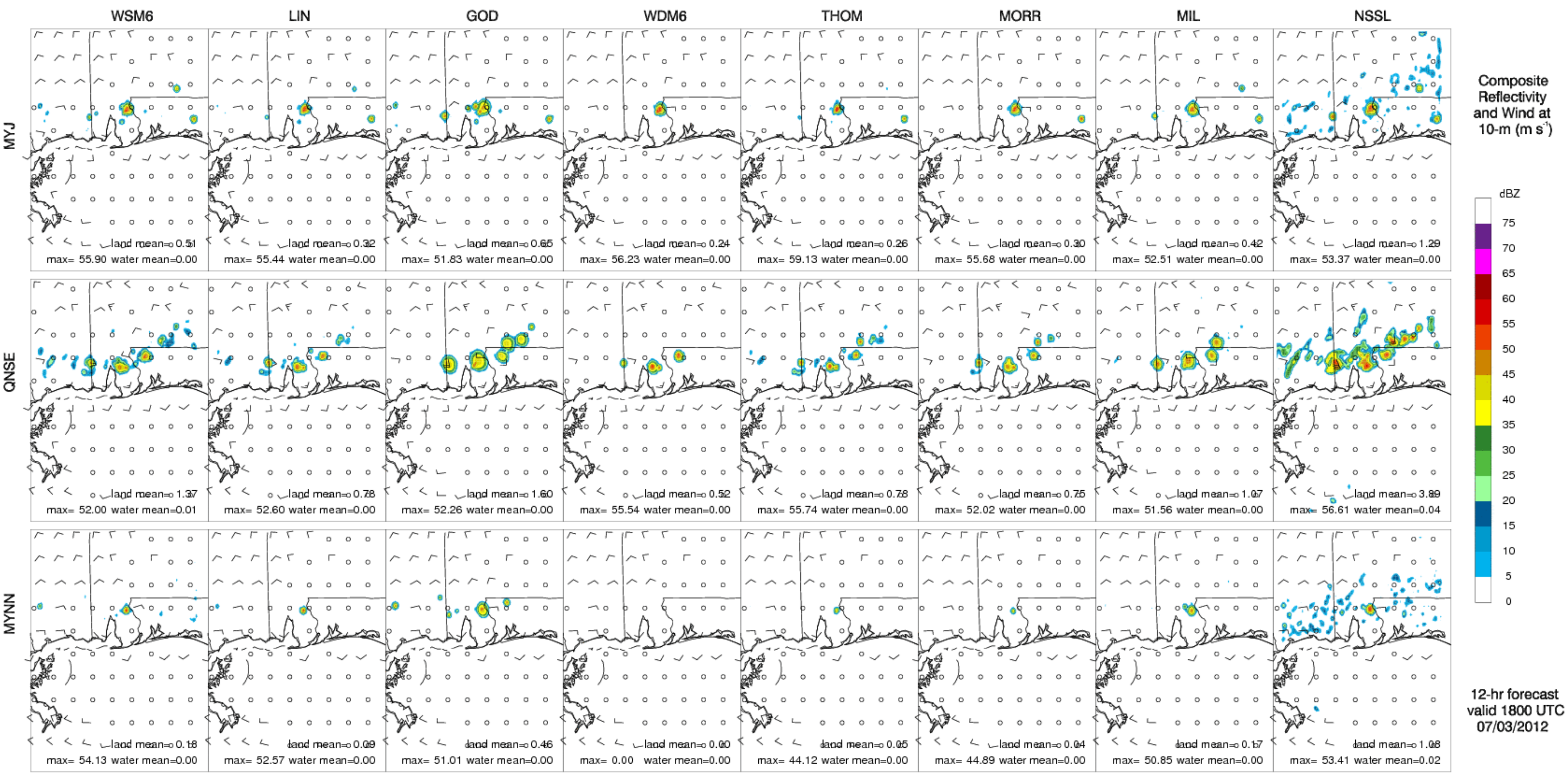
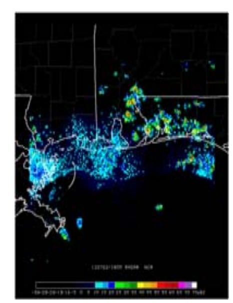
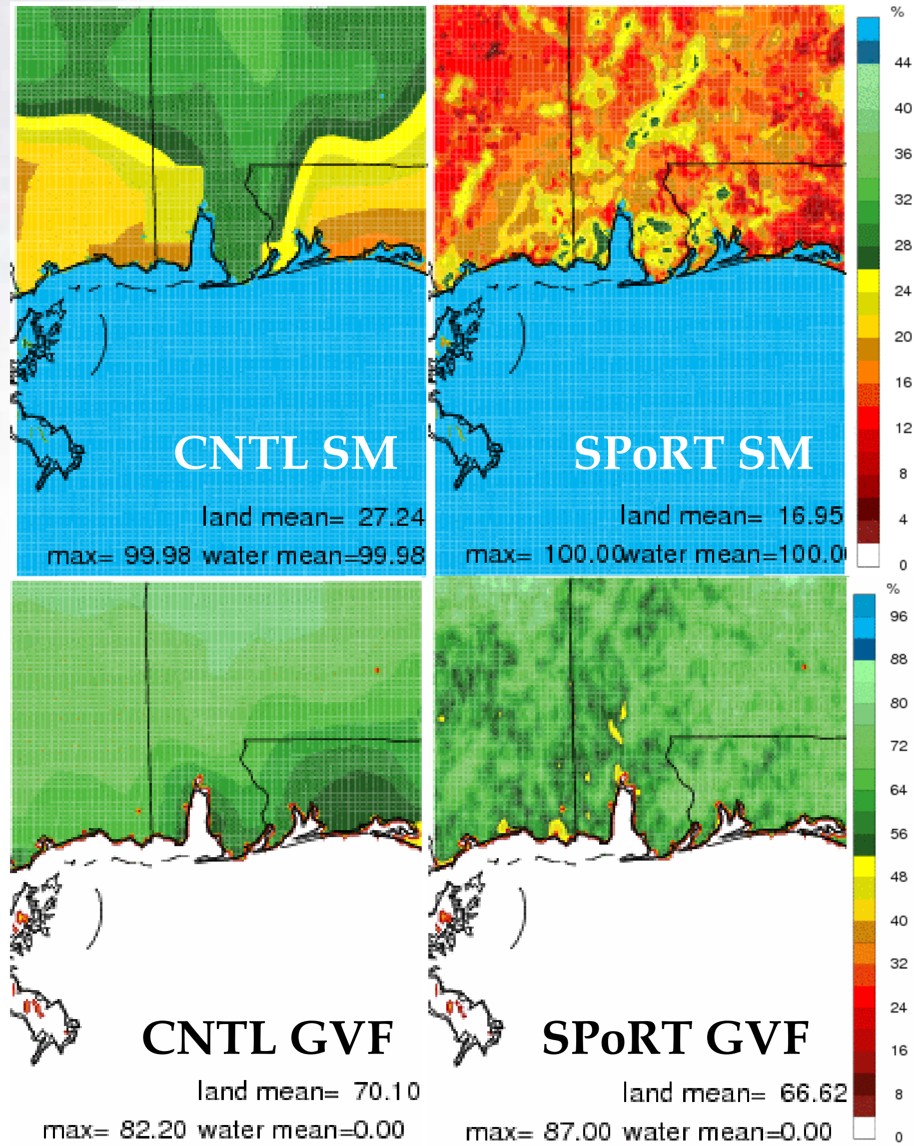




- SPoRT data improve location & magnitude of CI for most simulations
- Convection associated with sea-/bay-breezes more in-line with radar when SPoRT data are used for initialization compared to CNTL
- CI by 1800 UTC in all 24 SPoRT members, an improvement over CNTL

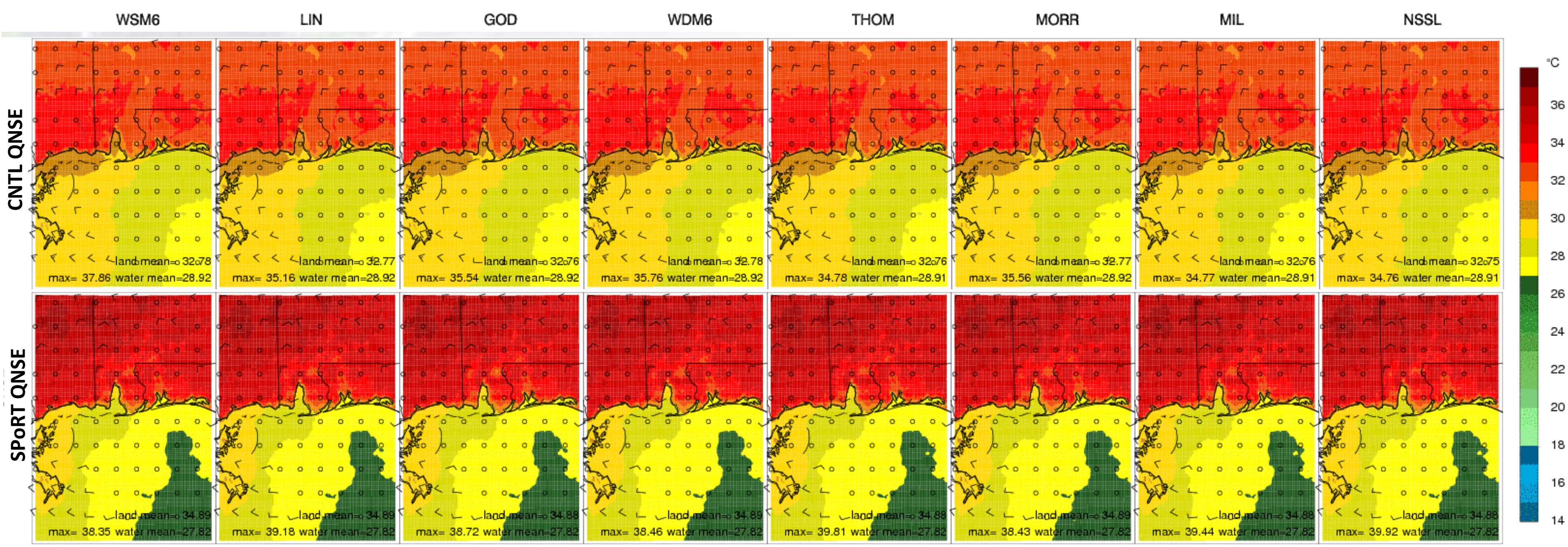
Evaluation of Land Surface

- **Differences in land surface initialization appear to have played a major role in the simulations**
- **Land surface features are very smooth with the 0.5-deg GFS initialization data**
- **Soil moisture (SM) from LIS & SPoRT-MODIS GVF provide greater detail of local features that affect may CI**
- **GFS SM considerably more moist than LIS data, which dried out the soils by an average of 10%**
- **SPoRT-MODIS GVF is slightly lower than CNTL, esp. in SW AL and SE MS**



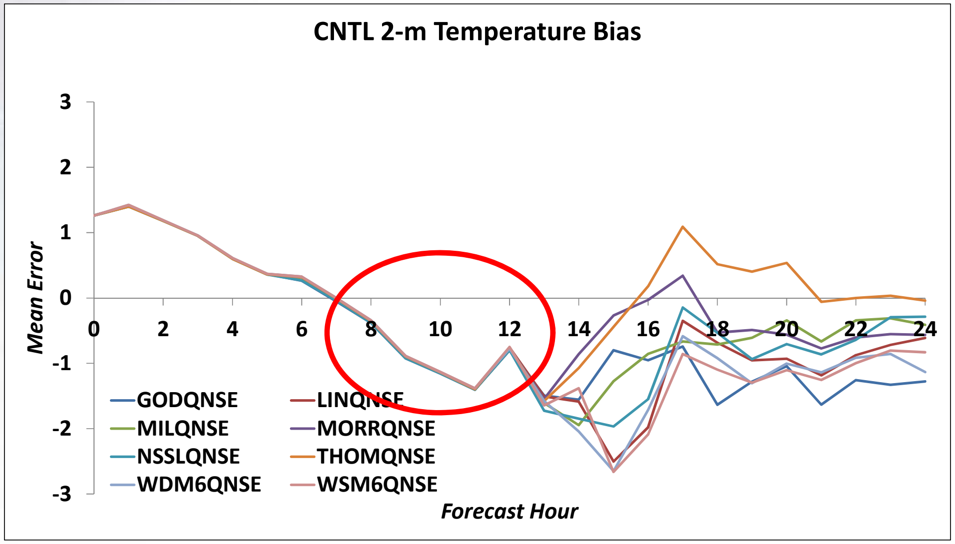
Evaluation of 2-m Temperature

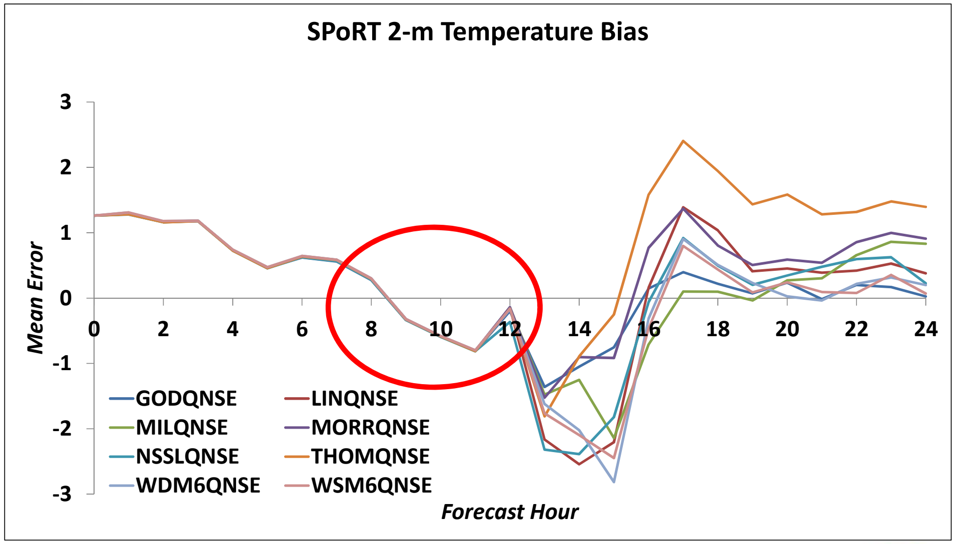
- Drier, less vegetated surface in SPoRT runs results in faster heating of land surface
- SSTs over Gulf of Mexico appear to be cooler in SPoRT runs
  (2-m temperature over water is on average about 1 deg C cooler than in CNTL)
- Combination of warmer land temperatures (SPoRT: 34.9 deg C; CNTL: 32.8 deg C) and cooler mean over-water temperatures (SPoRT: 27.8 deg C; CNTL: 28.9 deg C) produced stronger sea breeze and accelerated CI



Verification: 2-m Temperature

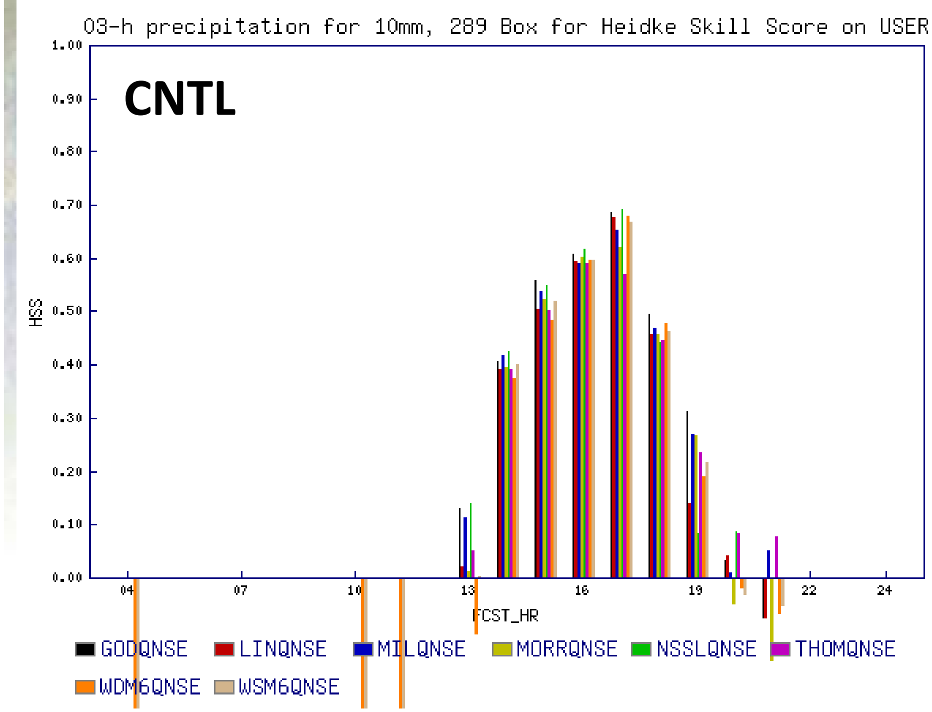
- Sample size ~46 points
- Smaller 2-m Temperature bias in SPoRT-QNSE runs before CI
- MYJ and MYNN PBL schemes have similar biases prior to CI, with the SPoRT biases smaller than CNTL (not shown)

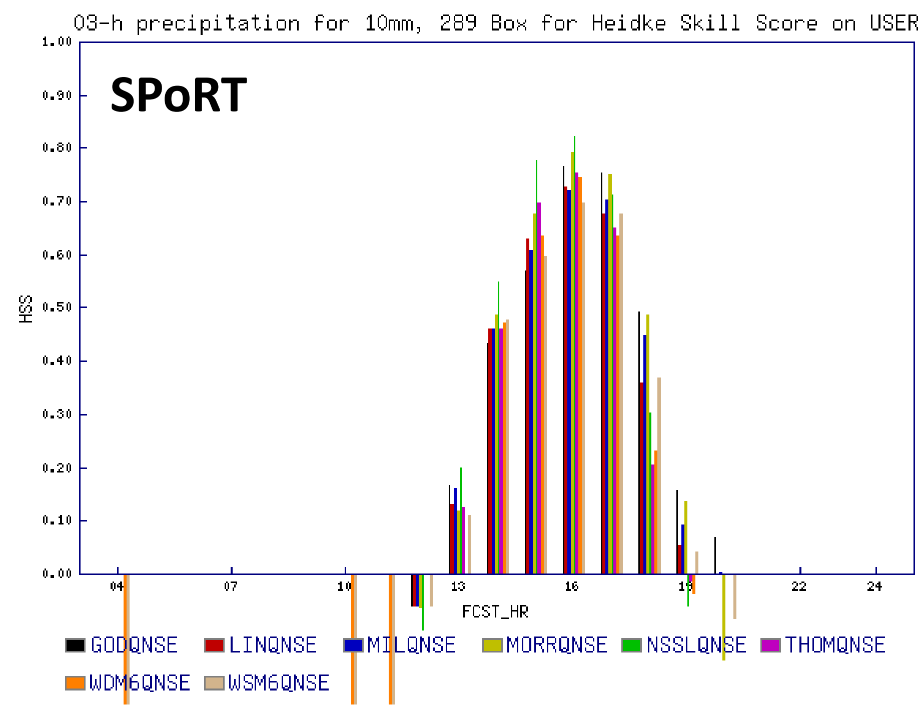




transitioning research data to the operational weather community

Verification: 3-h Precipitation





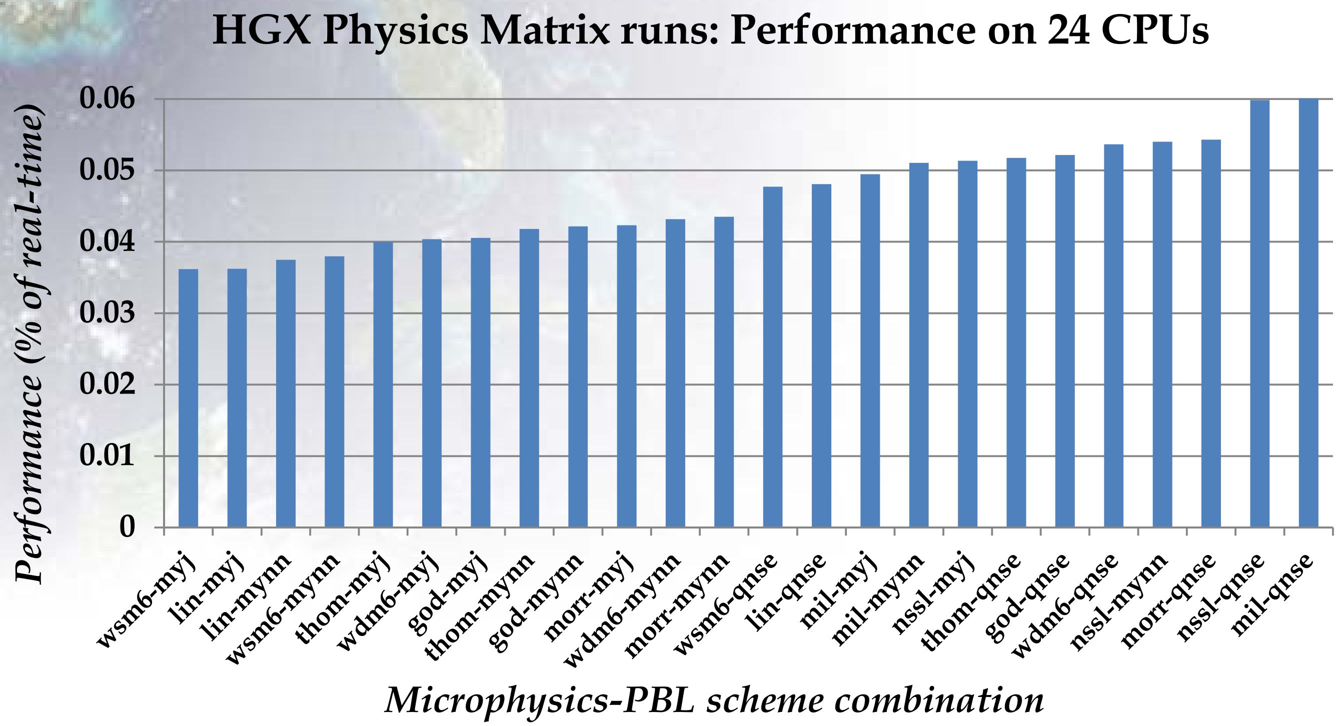
- **Results from QNSE PBL scheme shown**
- **Improved Heidke Skill Score (HSS) during forecast hours of active convection**
- **Similar results seen for this case with other PBL/microphysics combinations**

Summary/Future Work

- Overall, SPoRT runs compare more favorably in timing, position, and intensity of CI compared to CNTL for Mobile, AL case presented
- Sea breeze likely more accurately in SPoRT-initialized run due to improved land-sea contrasts in 2-m temperature
- For case presented, use of SPoRT initialization datasets had largest impact on simulations than sensitivity to PBL and/or microphysics schemes
- Further evaluation of this case needed to determine if winds are improved with SPoRT datasets (further indication of sea-breeze improvement)
- Efforts ongoing to evaluate matrix results for 9 other cases to understand performance of different land surface initialization, microphysics, and PBL to generate cumulative statistics for more robust conclusions
- Results will be analyzed and compared to computational constraints to determine optimal configuration for NWS WFOs in CI applications

Backup Slides

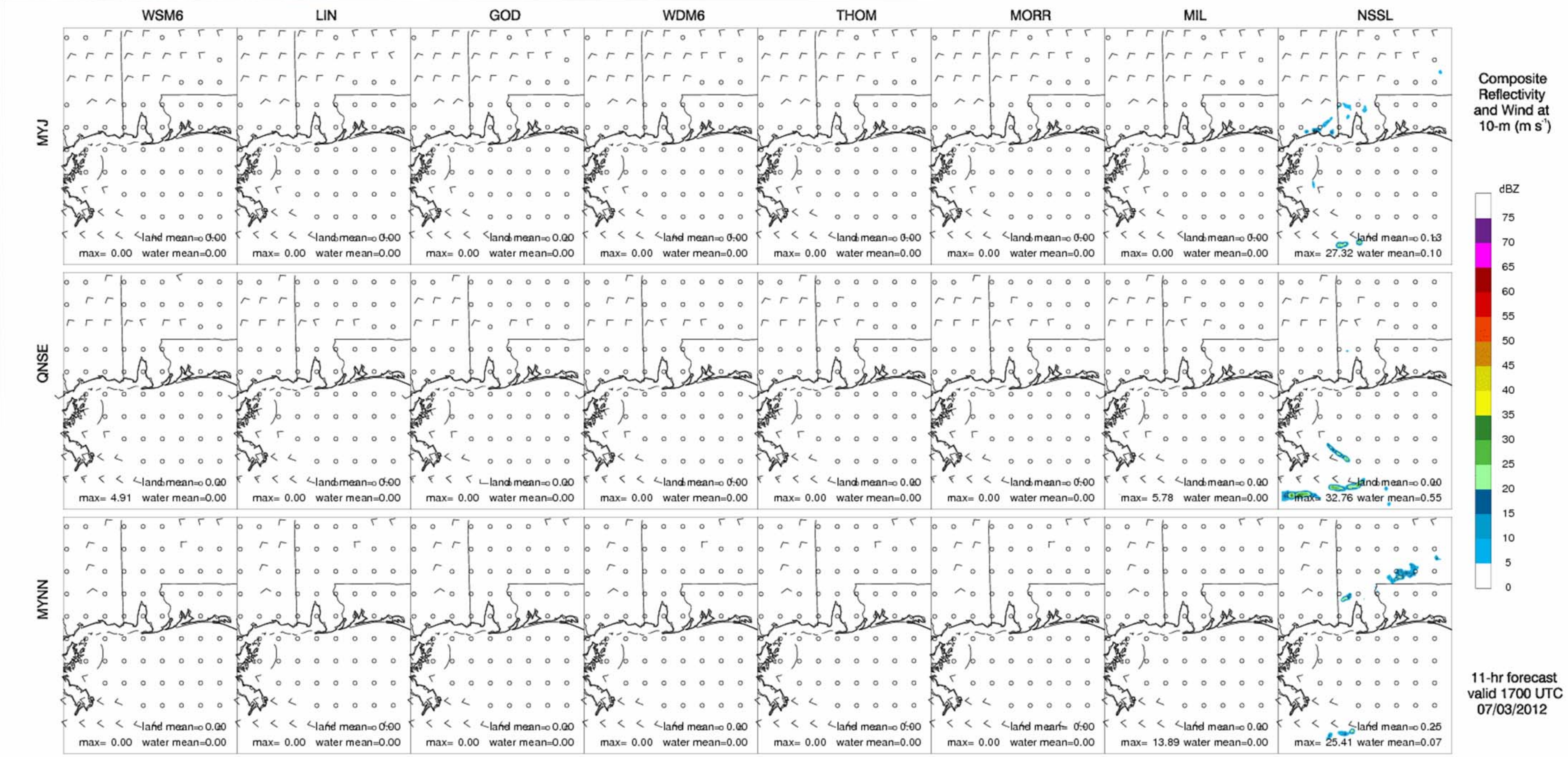
Time Constraints



- **One consideration that must be taken when dealing with operational forecasts is the time constraints involved with forecast delivery**
- **Both HGX and MOB currently use WSM6/MYJ, which is computationally cheapest**
- **QNSE appears to be best PBL scheme, but is also most computationally expensive**
- **Each forecast office will need to determine based on their resources and time of forecast delivery which option is feasible**

CNTL Composite Reflectivity Matrix Loop

(11-14 h forecast valid 1700-2000 UTC 3 July)



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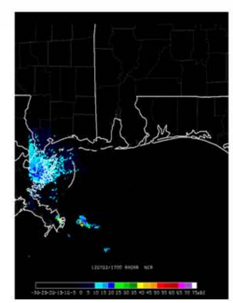

SPoRT Composite Reflectivity Matrix Loop

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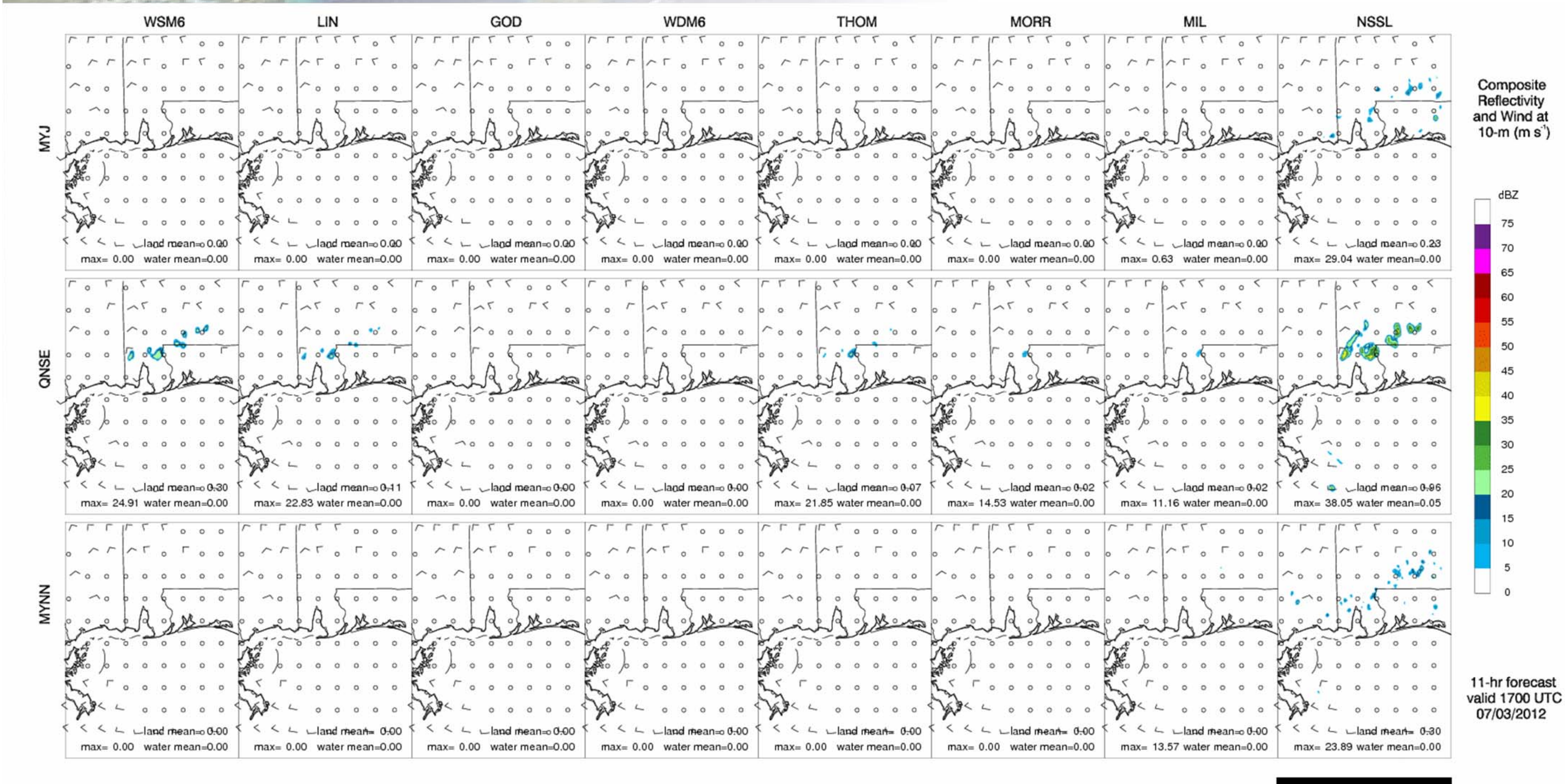

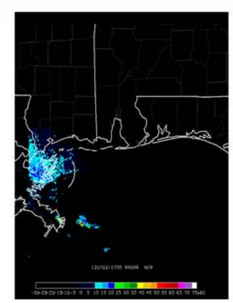

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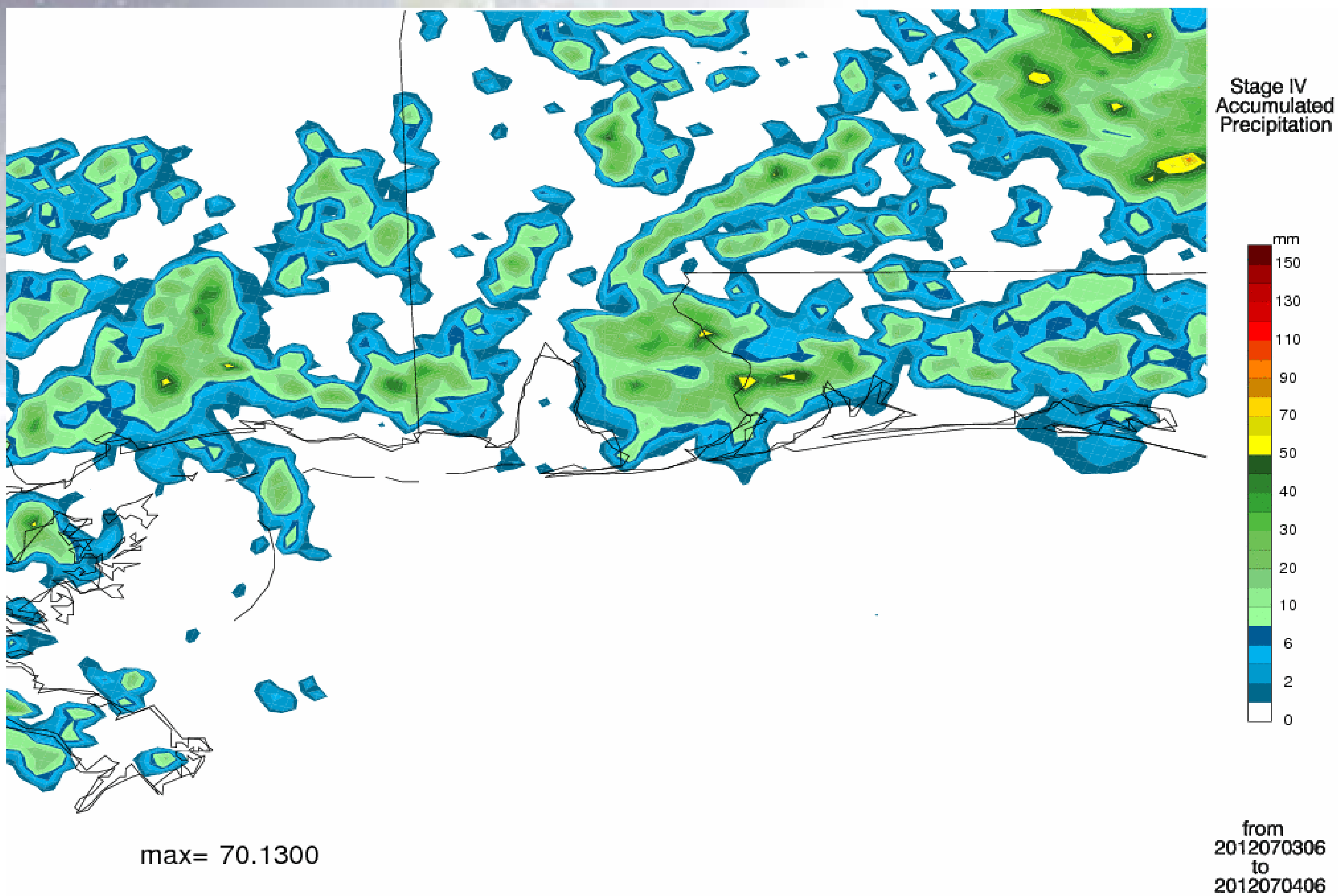
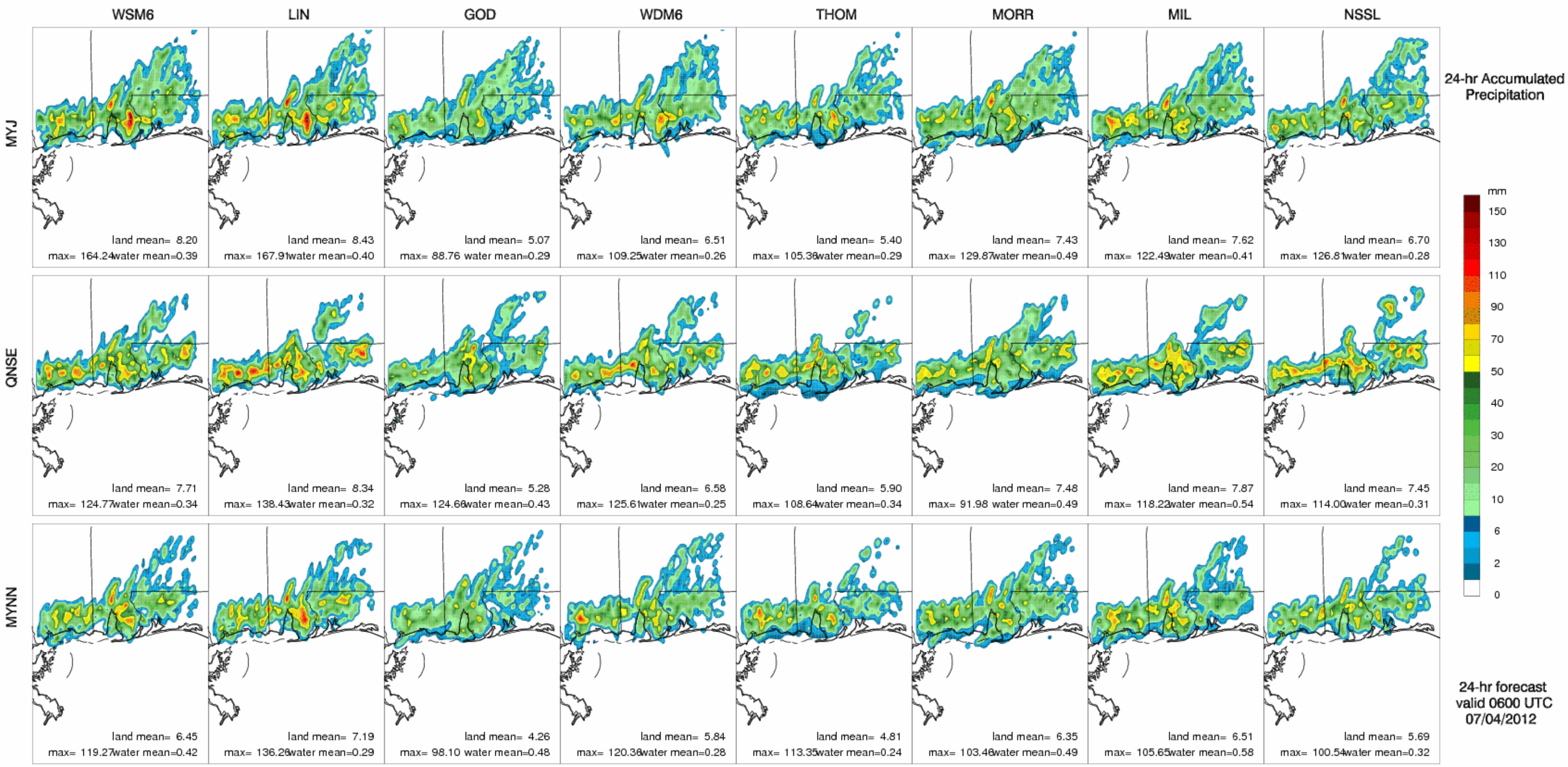
MOB Case Stage IV 24-h precip



MOB Case CNTL 24-h precip



MOB Case SPoRT 24-h precip