Sensitivity of Simulated Drylines to Boundary Layer Parameterization and Grid-Spacing

Brice Coffer[1] and Adam Clark[2]

[1]North Carolina State, [2]NOAA National Severe Storms Lab/CIMMS

NC STATE UNIVERSITY

Introduction

One of the biggest challenges facing high-resolution numerical weather prediction is accurately depicting the boundary layer, which has direct impacts on low-level temperature, moisture, and winds, as well as instability and convection initiation. The dryline, an inherently boundary layer phenomenon, is often a significant factor in convection initiation. Previous studies (e.g. Coffer et al. 2013) have shown that 24-h forecasts of dryline position in a 4-km grid-spacing WRF model were associated with large eastward biases. **One possible hypothesis is that high-resolution simulations tend to over-mix the boundary layer, causing the dryline to propagate too far east. With that in mind, we will attempt to address the following research questions:**

1) Will more advanced boundary layer parameterization schemes yield better predicted drylines in high-resolution models?
2) Does decreasing the grid-spacing have an adverse effect on simulated drylines?

Methods

Using WRF version 3.5, sensitivity tests varying the boundary layer parameterization scheme and grid-spacing were performed using three dryline case studies (10 May 2010, 24 May 2011, 14 April 2012). All three cases were associated a "high-risk" for severe weather according to the Storm Prediction Center. **These dryline cases represent the biggest outbreak of tornadoes in the central Great Plains in their respective year and were specifically selected for their relevancy to convective forecasting.**
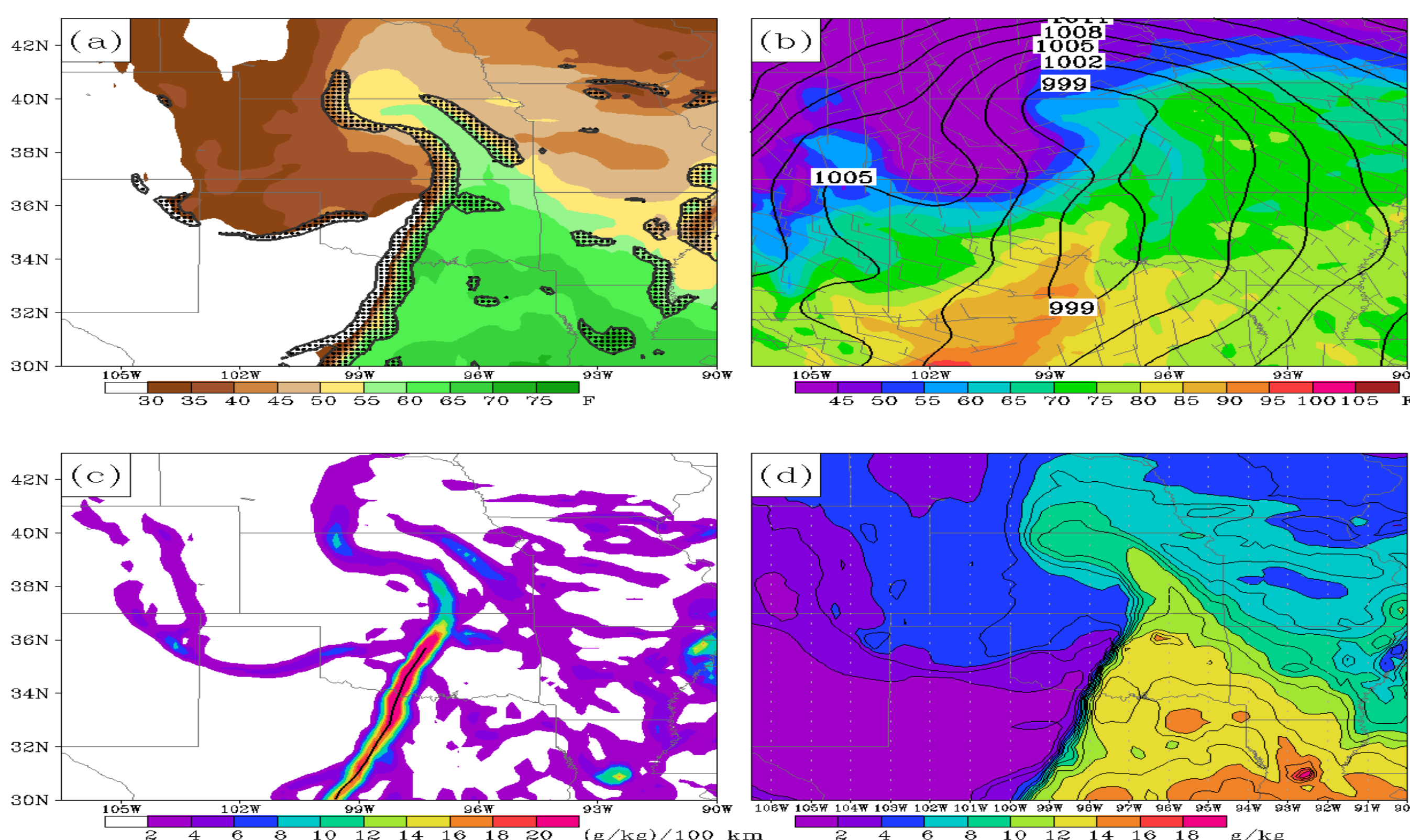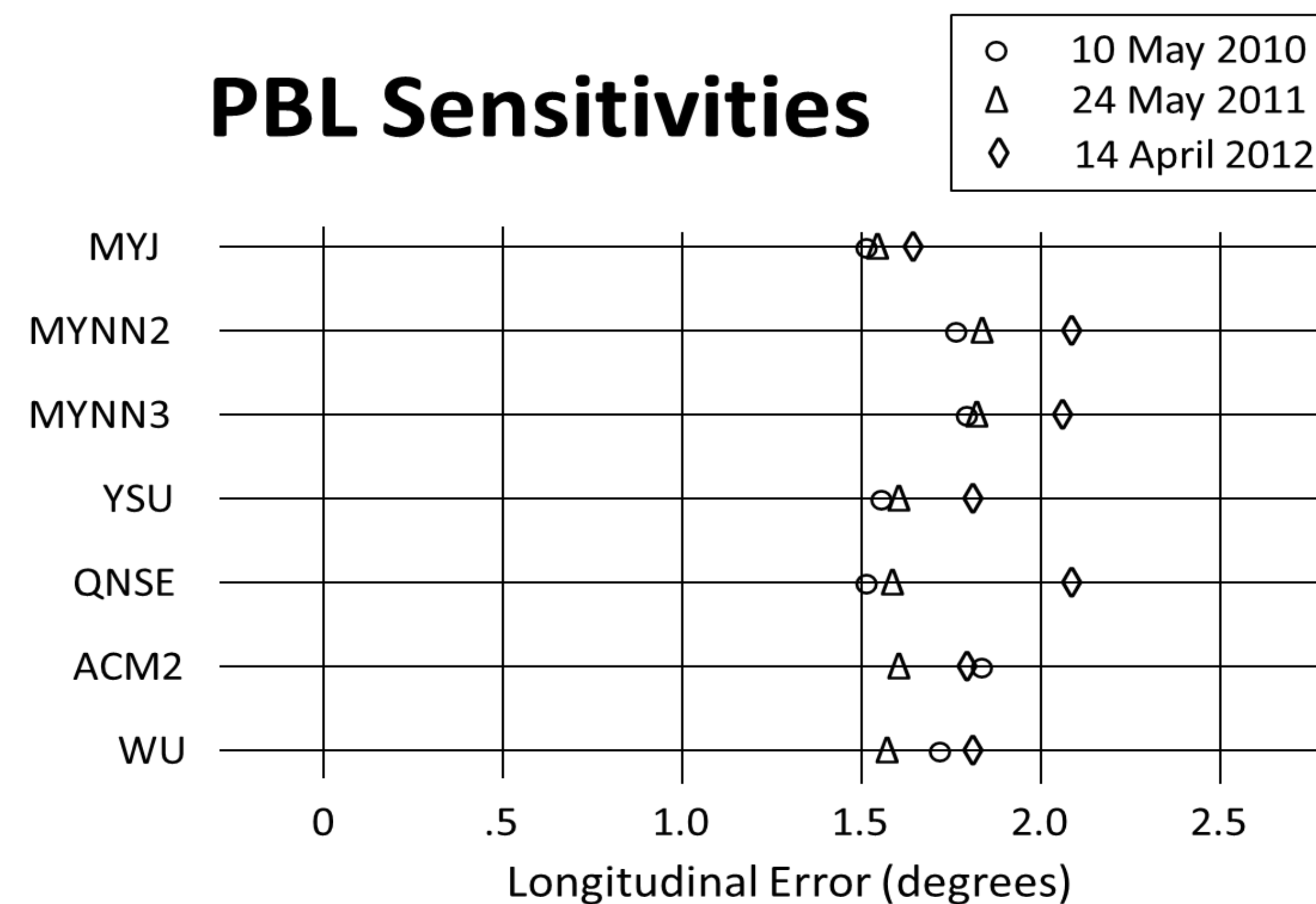

Dryline coordinates were recorded along the axis of maximum specific humidity gradient in each model simulation (see above figure), and 24hr forecast errors were calculated by comparing the average longitude in the RUC reanalysis to each WRF simulation.

Boundary Layer Parameterization

- All seven different schemes tested produced eastward errors greater than 1.5 degrees of longitude, or approximately 150 km.
- Each dryline case was associated with a highly progressive upper-level pattern, which has previously been found to be related to larger than normal eastward biases.
- On average, no scheme improved upon the control MYJ simulation, in fact, more advanced schemes, like the MYNN, performed worse.

Grid-Spacing

- The 2-km simulation produces the largest eastward error, giving credence to the original hypothesis that decreasing the grid spacing could have a negative effect on accurately simulating drylines.
- Increasing the grid-spacing to 12-km improves dryline position, however the difference is small and likely not statistically significant.
- No consistent signal was found in the vertical grid spacing tests.

NOAA Hazardous Weather Testbed

- Each spring, the NOAA HWT in cooperation with the Center for Analysis and Prediction of Storms has been producing an ensemble of convection-allowing forecasts. We are currently using this dataset to establish a long-term climatology of boundary layer parameterization sensitivity in dryline forecasts.
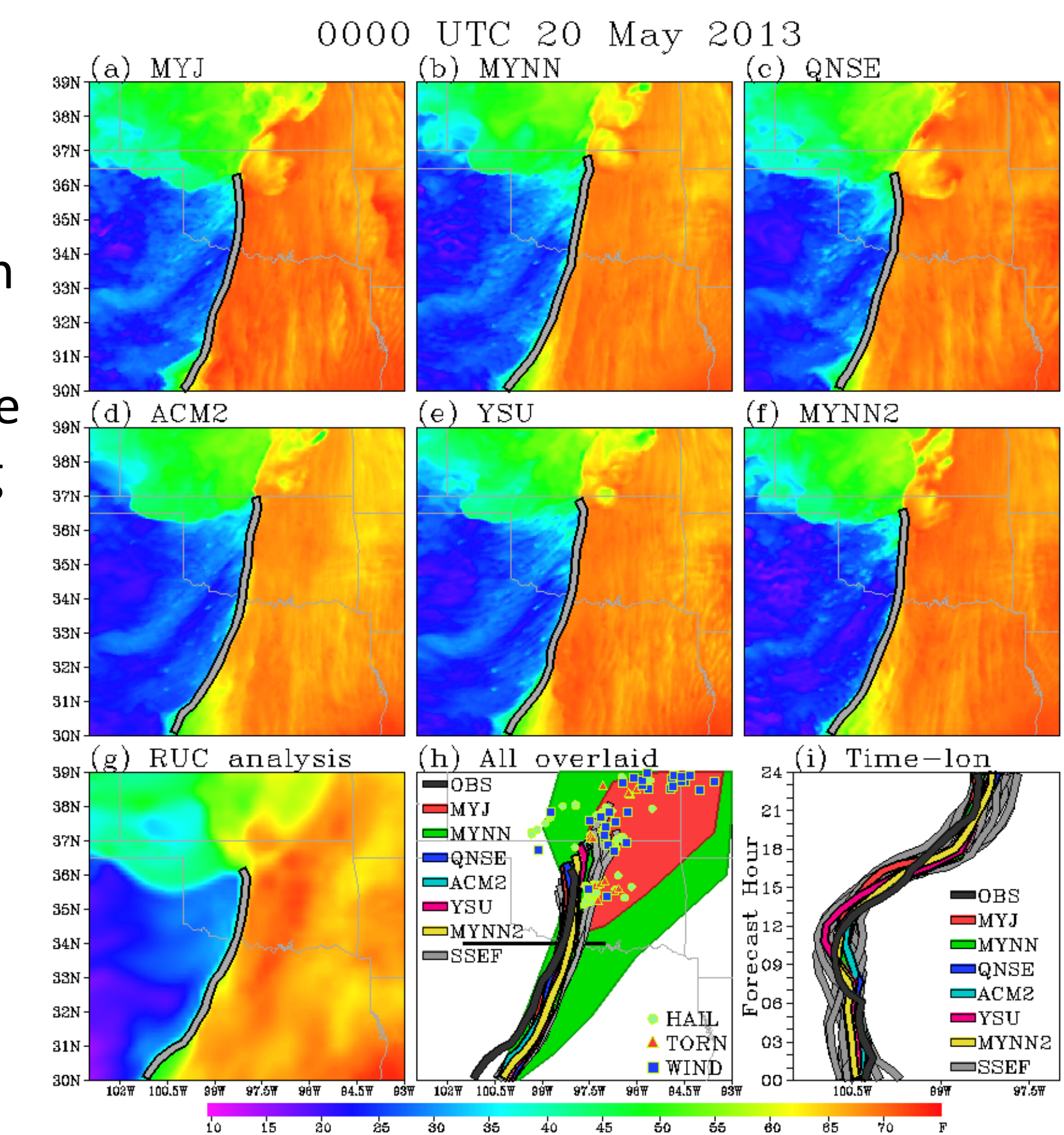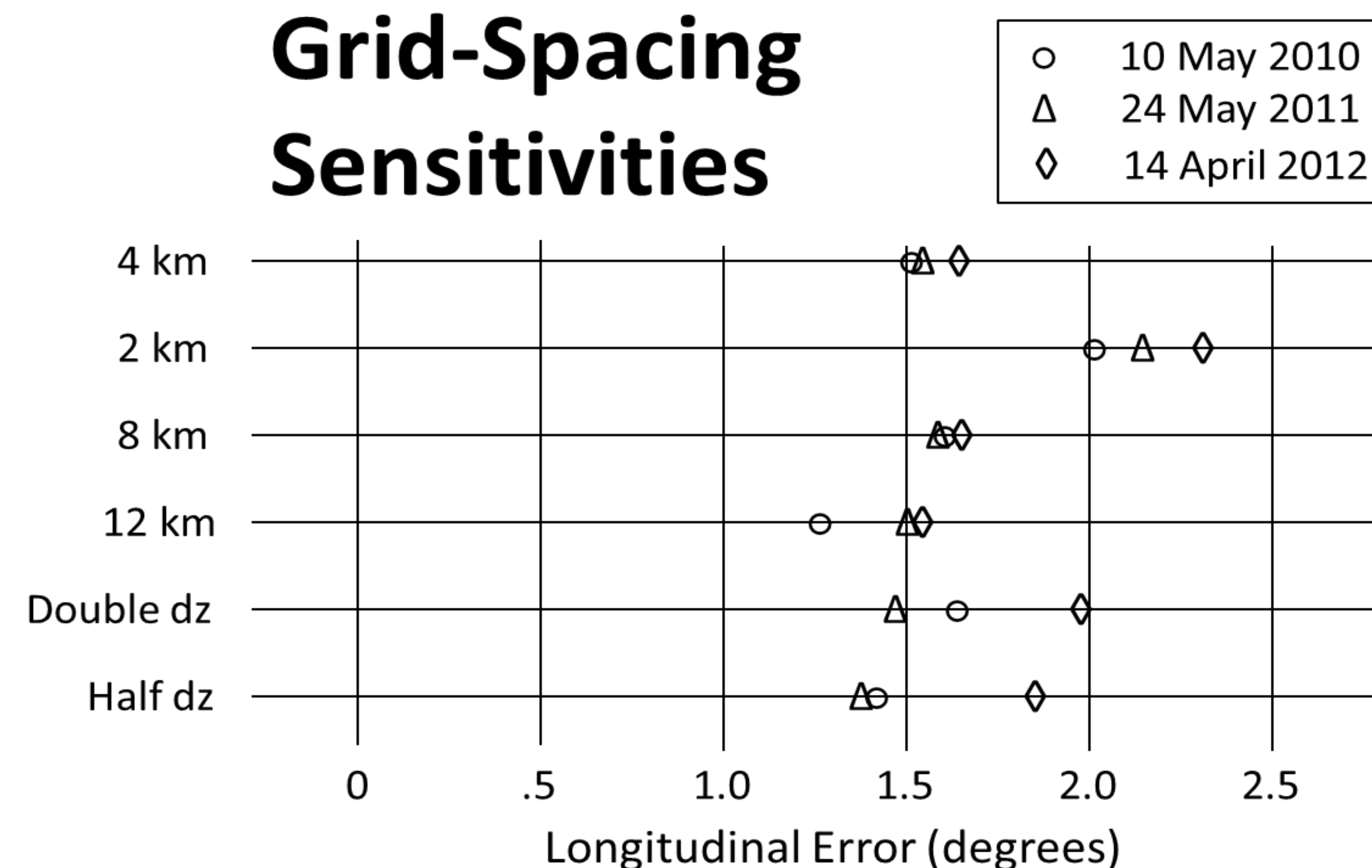

- See talks 4.4 (Tue 4:15pm) & 12.3 (Thu 9:00am) by Andrew MacKenzie and Adam Clark for further analysis and improvements in dryline forecasting using high-resolution NWP models.

Synthesis

In order to answer some of the questions raised by Coffer et al. 2013, several simulations were performed varying the boundary layer parameterization and grid-spacing.

- Higher resolution, convection-allowing simulations seem to over-mix the boundary layer. This is possibly due to partially resolving boundary layer eddies, while the PBL scheme is accounting for the same eddies.
- Increasing the complexity of the PBL scheme did *not* improve dryline forecasts.

Future Work

- Although little differences existed in the PBL schemes, preliminary work shows a much greater sensitivity to the initial and boundary conditions used.
- Simulations with semi-LES grid spacing (250m) are in the works. This grid-spacing will somewhat preclude the need to use a boundary layer parameterization.
- Establishing a long-term climatology with an ensemble of PBL schemes is currently ongoing.