Argonne NATIONAL LABORATORY

MPAS Atmospheric Boundary Layer Simulation under Selected Stability Conditions: Evaluation using the SWIFT dataset

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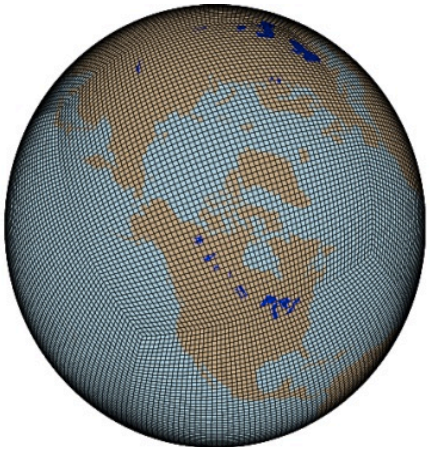
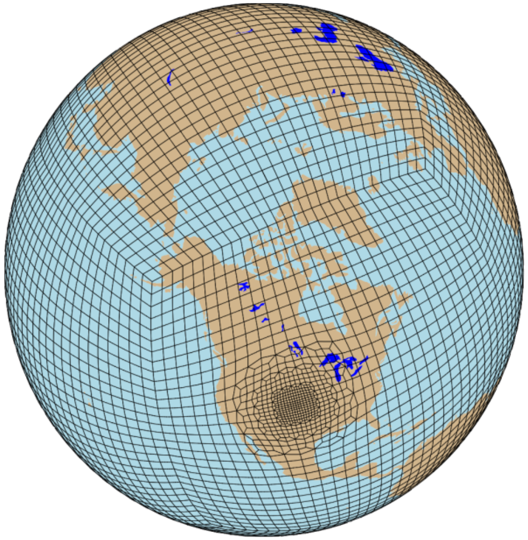
U.S. DEPARTMENT OF ENERGY

Motivation: Bridging the scales from Mesoscale to LES



The global grids show (left) a uniform 1/8th(~12km) degree global grid with refinement to 1/8th degree



New observations & modeling techniques needed (~10-3km)

Parameterized Physics (>10 km resolution)

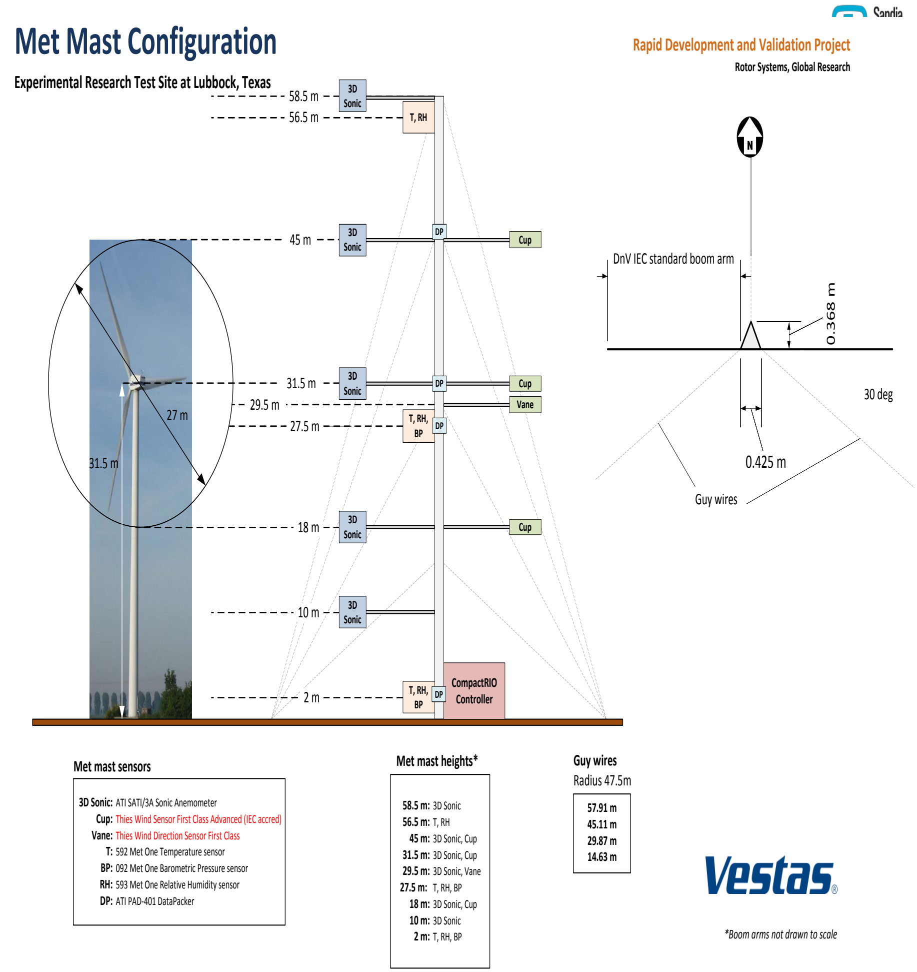
Gray Zone (no clear path for dealing with the transition zone)

Resolved Physics (< 3km resolution)

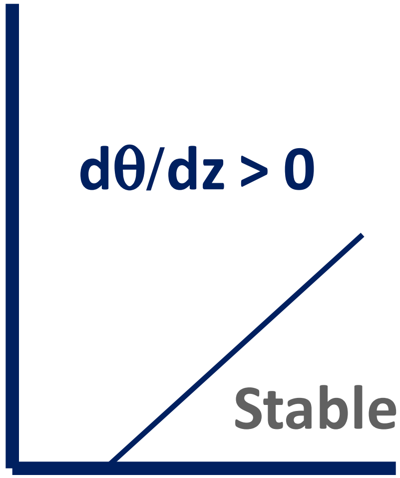
Objectives

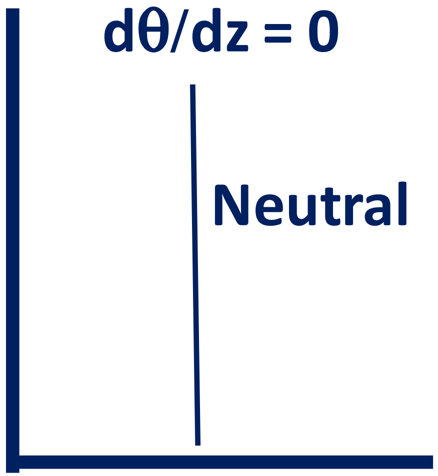
- **Interest in MPAS: Nesting vs Refinable Mesh**:
  - The scale-down ratio of 1:3 — recommended widely used for WRF — achieves a large refinement in resolution by using a number of nested domains but introduces numerical stability and convergence problems at each of the nesting boundaries.
  - A newer dynamical core with unstructured mesh (MPAS: Model for Prediction Across Scales) has been tested over the last few years, and a version of the MPAS model implemented with WRF physics is now available .
  - The nest down options provided by MPAS could likely be superior to that currently available with WRF
  - We initiated this work to evaluate the suitability of using MPAS for reaching higher spatial resolutions (< 3 km) for mesoscale phenomena.
- **TEST CASE**: Investigate the capability of WRF and Model for Prediction Across Scales (MPAS) models under various configurations to simulate an observed neutral boundary layer case

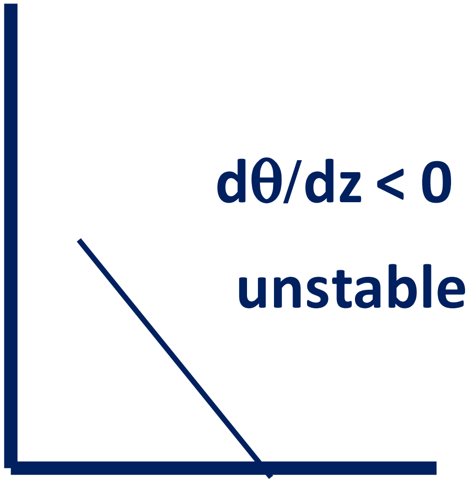
SWIFT Site (Lubbock, TX)



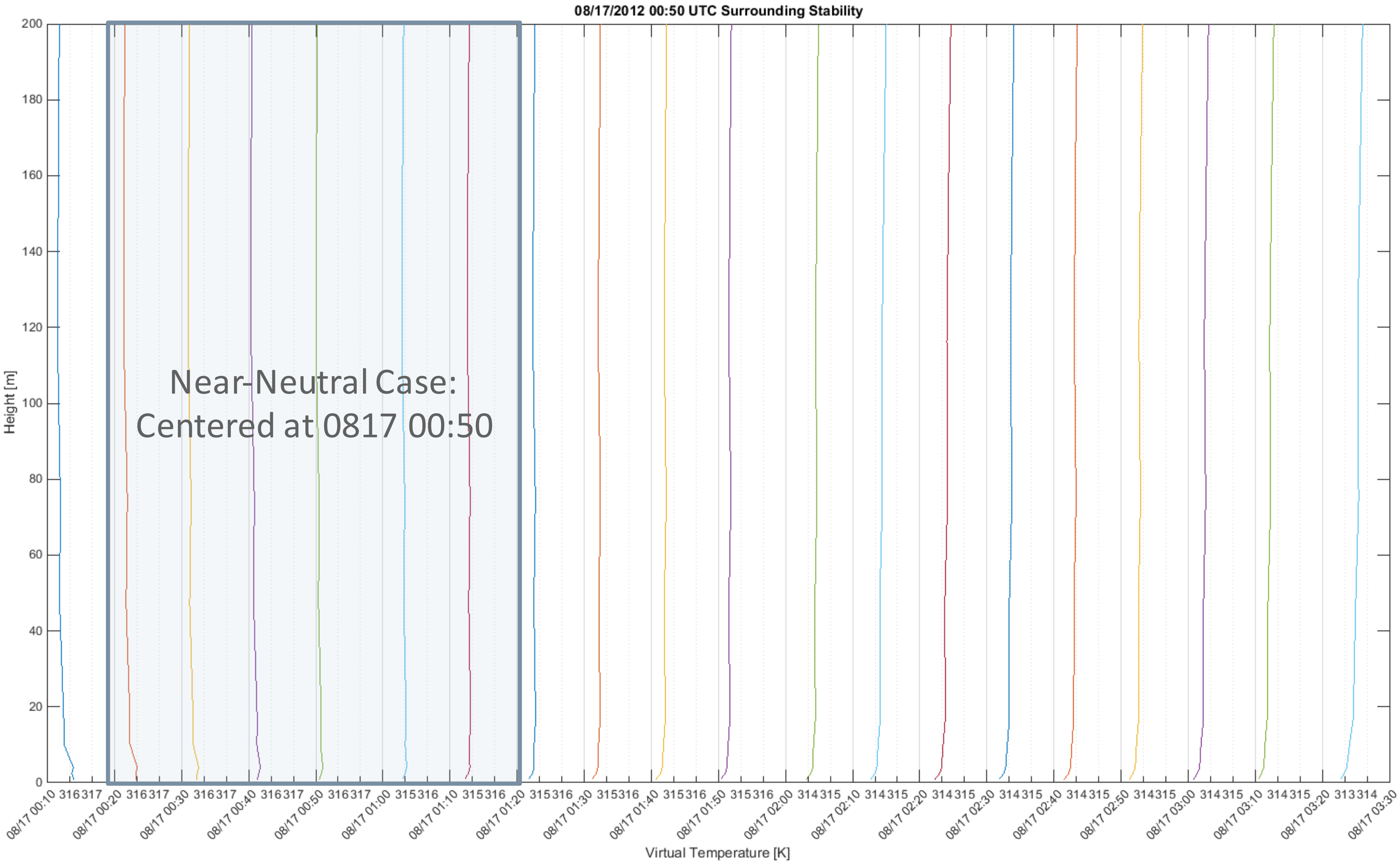
Atmospheric Stability (Case Studies)



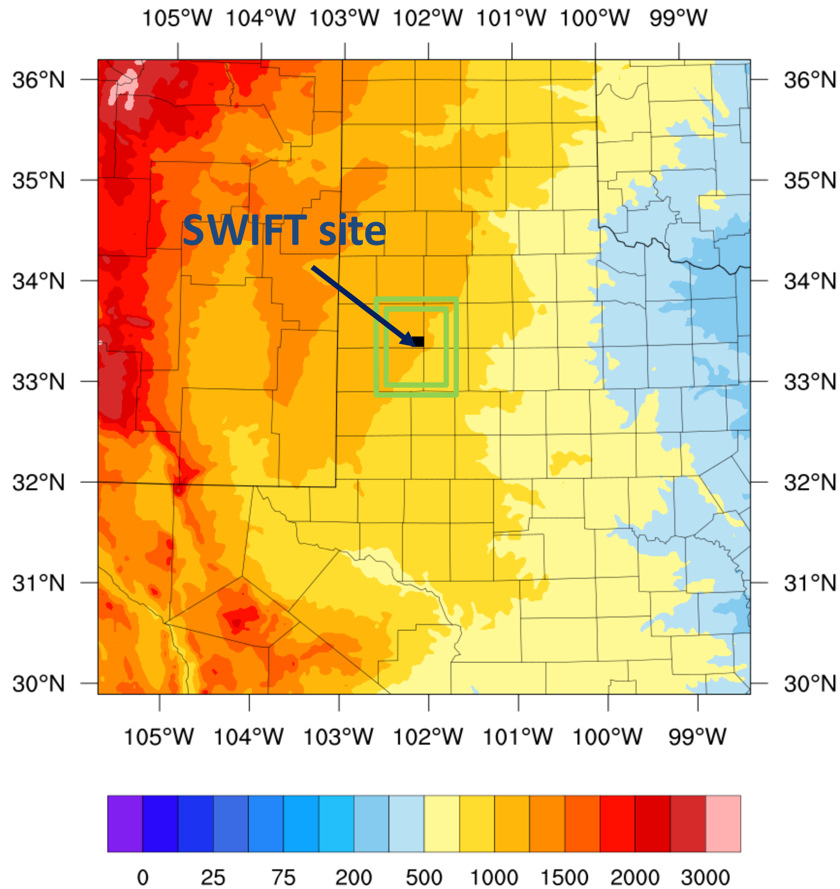




WRF Simulated Potential Temperature Profiles



WRF Setup



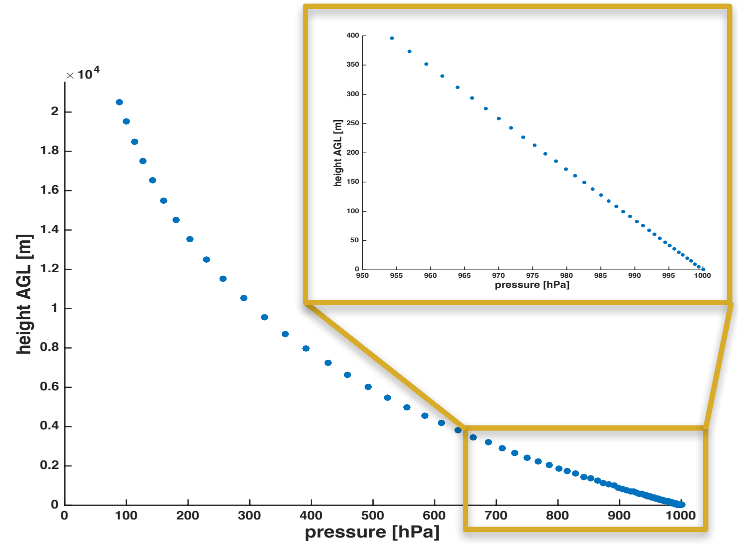
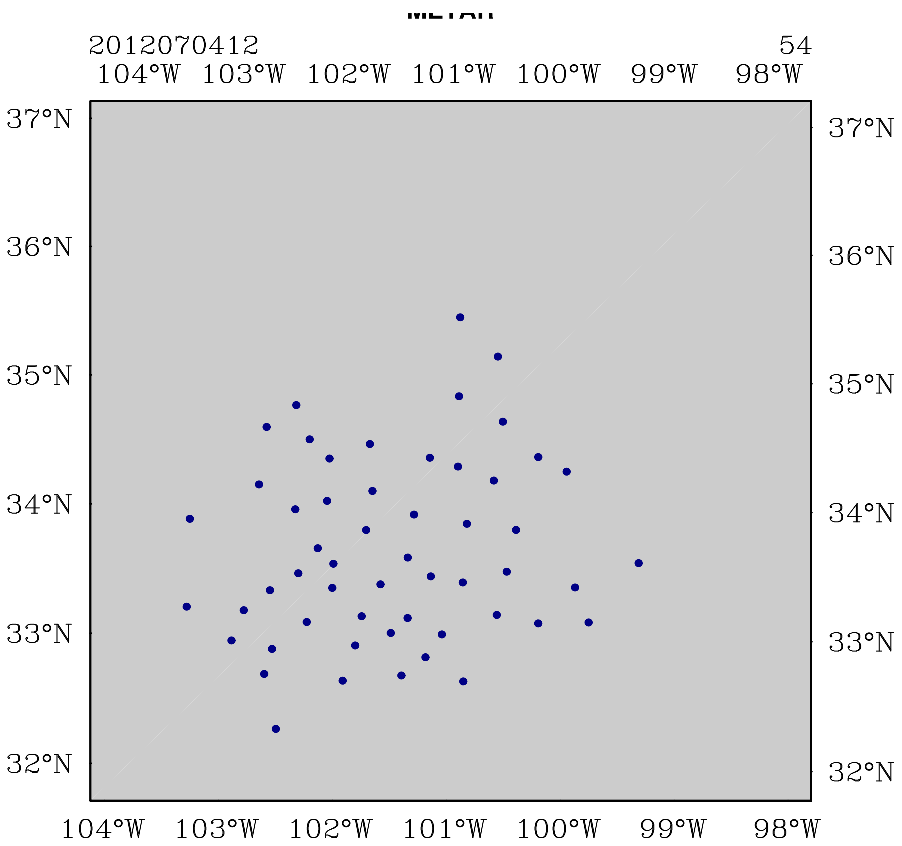


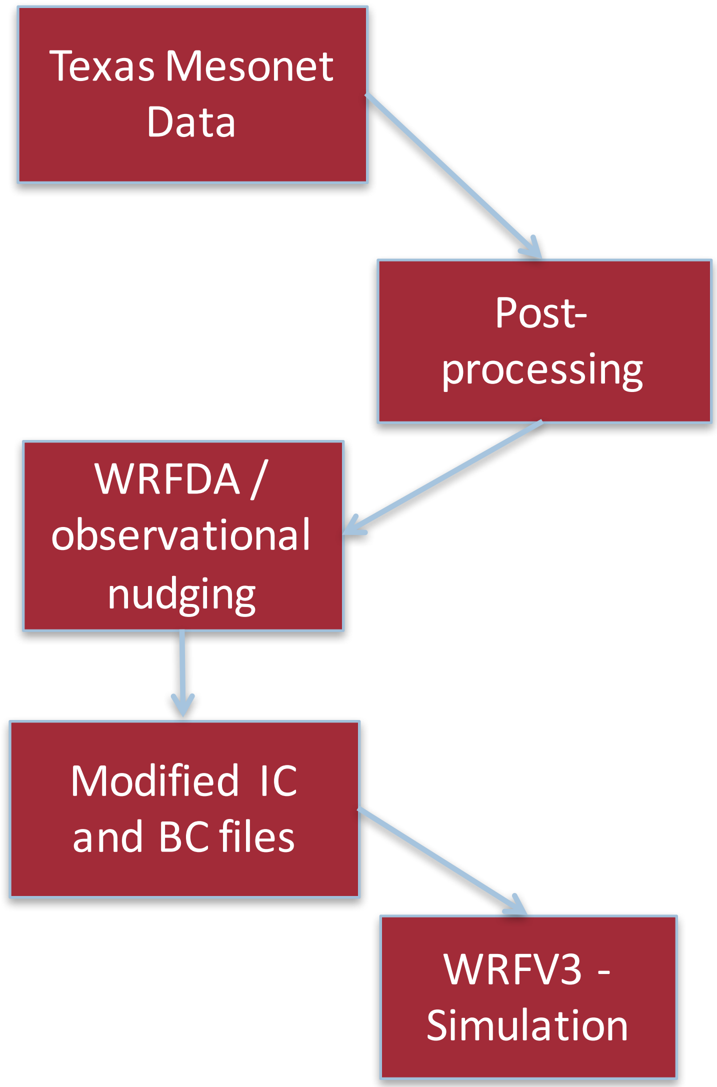
Figure from Carolyn Draxl, NREL

Model Setup

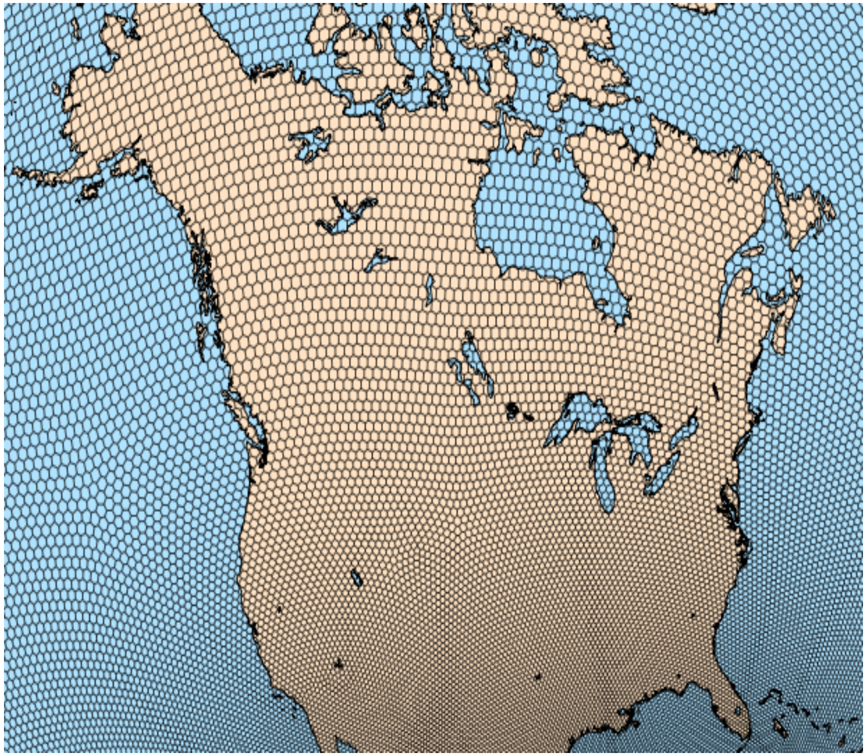
- YSU PBL scheme
- NCEP Boundary and Initial condition
- 80 vertical layers
- RRTM radiations physics

WRF- nudging, 3DVAR

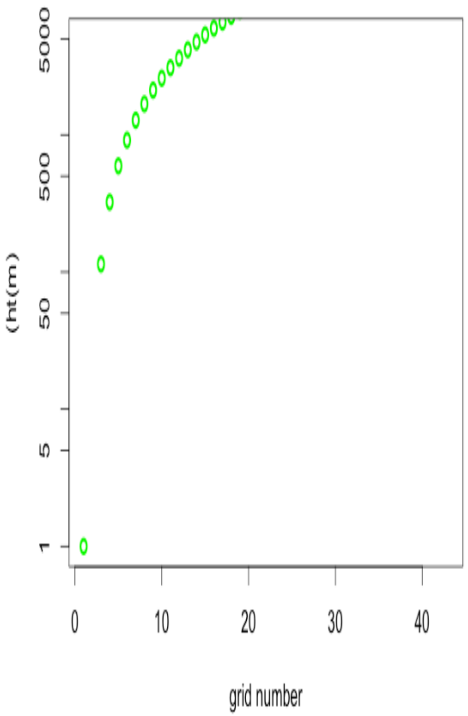




Model Prediction Across Scales (MPAS)



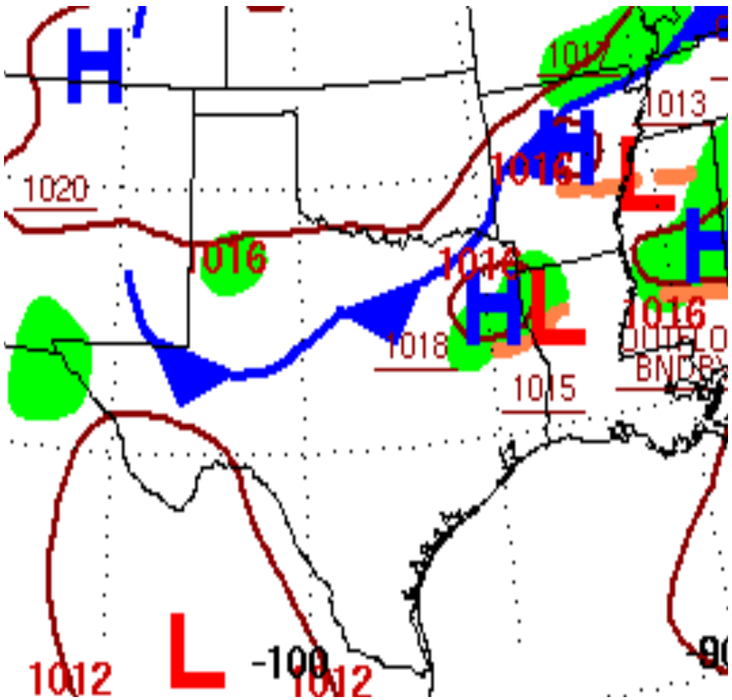
PBL Scheme: YSU
Initial conditions: NCEP
Surface conditions:
(updated every 6 hours)
Number of vertical levels:
41 (top 30km)
Soil levels: 4
Land use: USGS
Land Model: NOAH
Convection: Kain_Fritsch
Radiation: RRTMg
Surface Layer physics:
Monin Obukhov

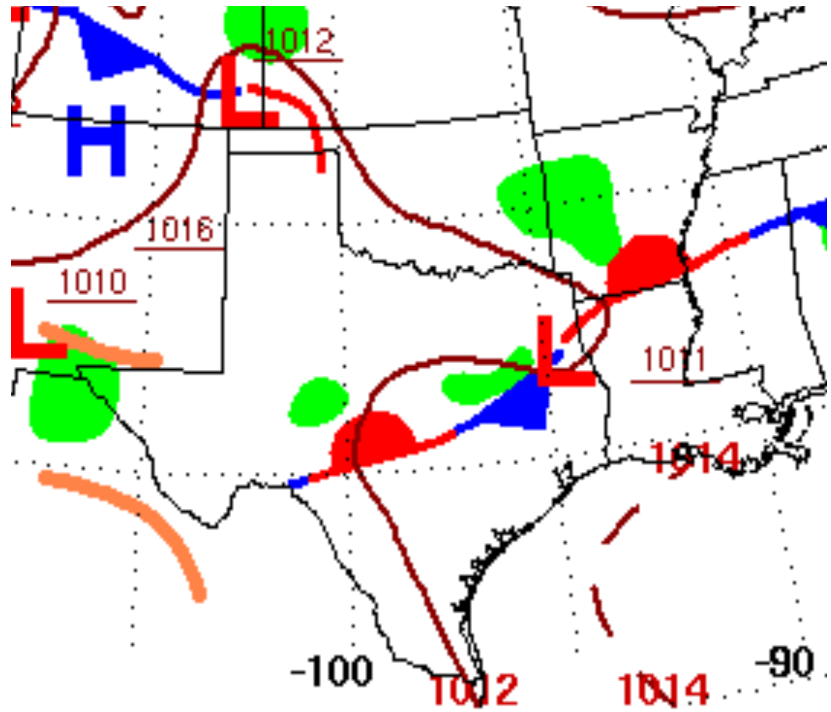


15 km global grid (atmospheric model)

Simulations: **Month of August, 2012**
Output size**: 500 Gb /day**

Case selection based on the weather conditions (NOAA daily weather maps)

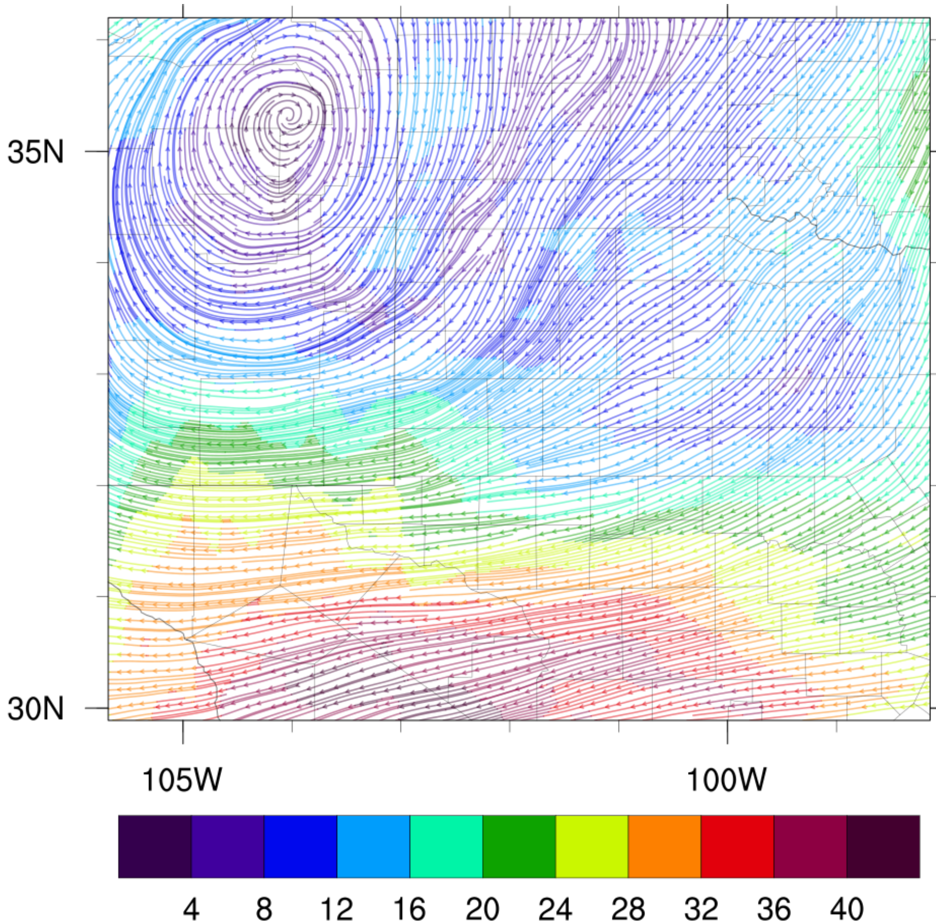




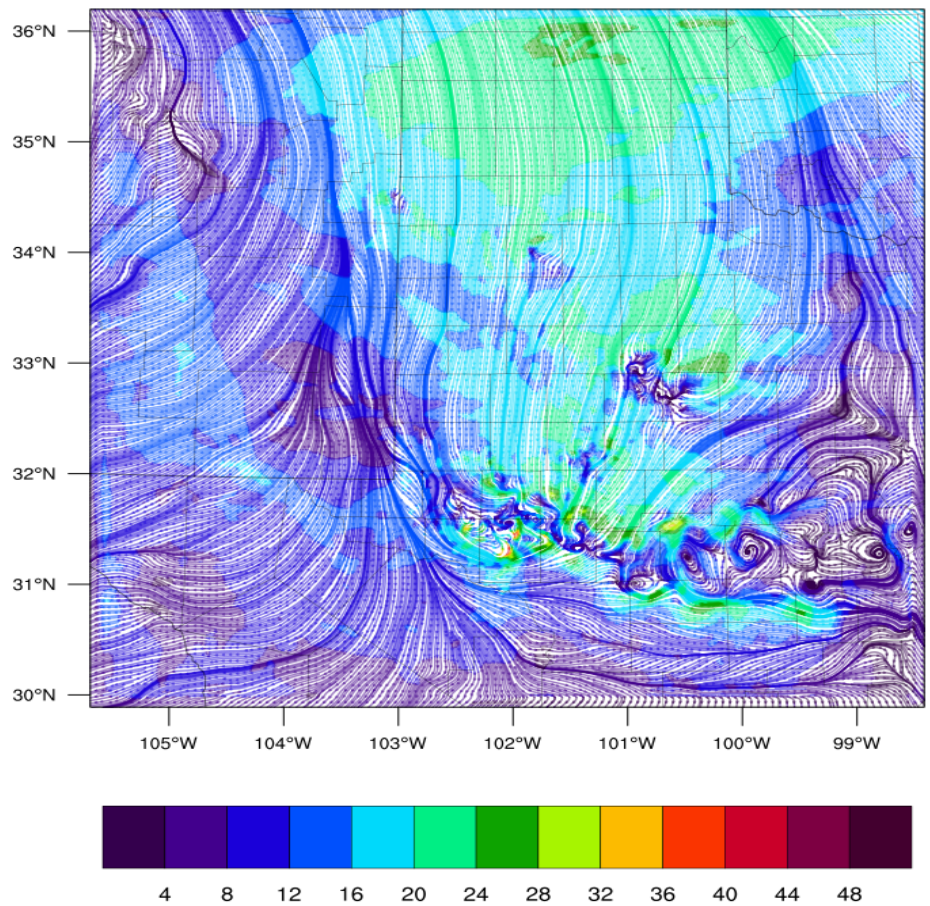
August 17th, 2012 (7 AM)

August 18th, 2012 (7 AM)

Wind Flow at 5 km

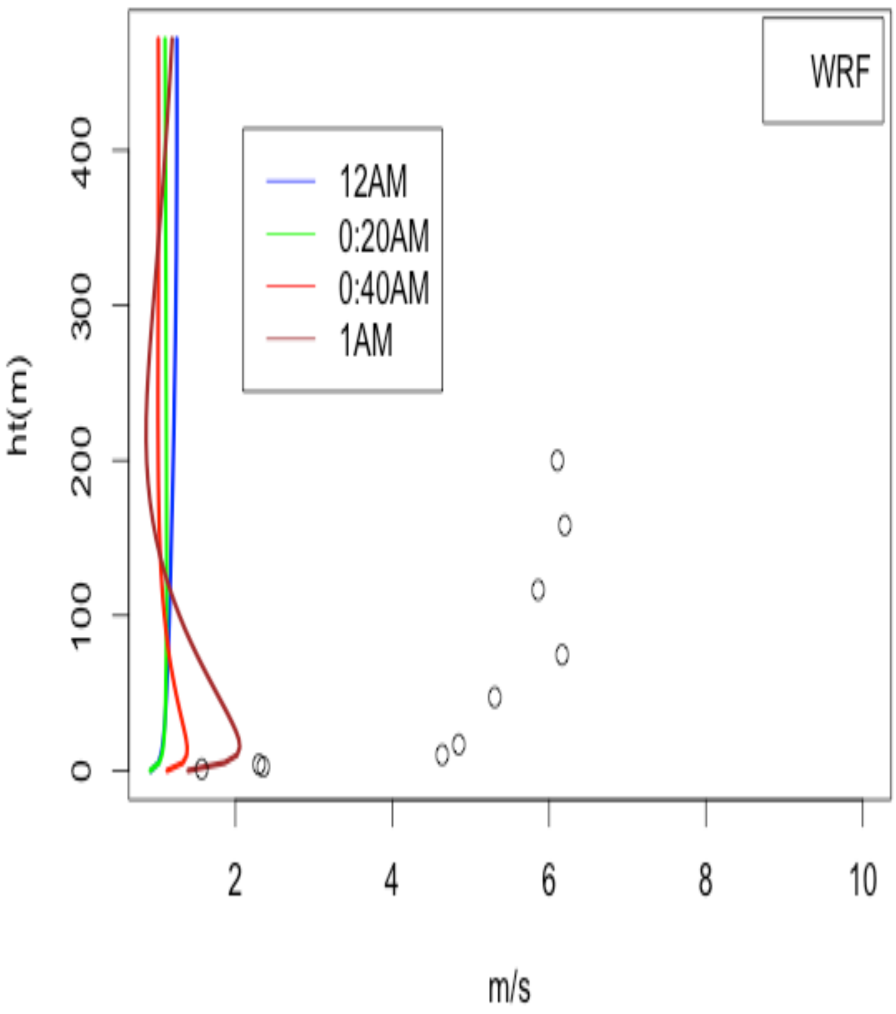


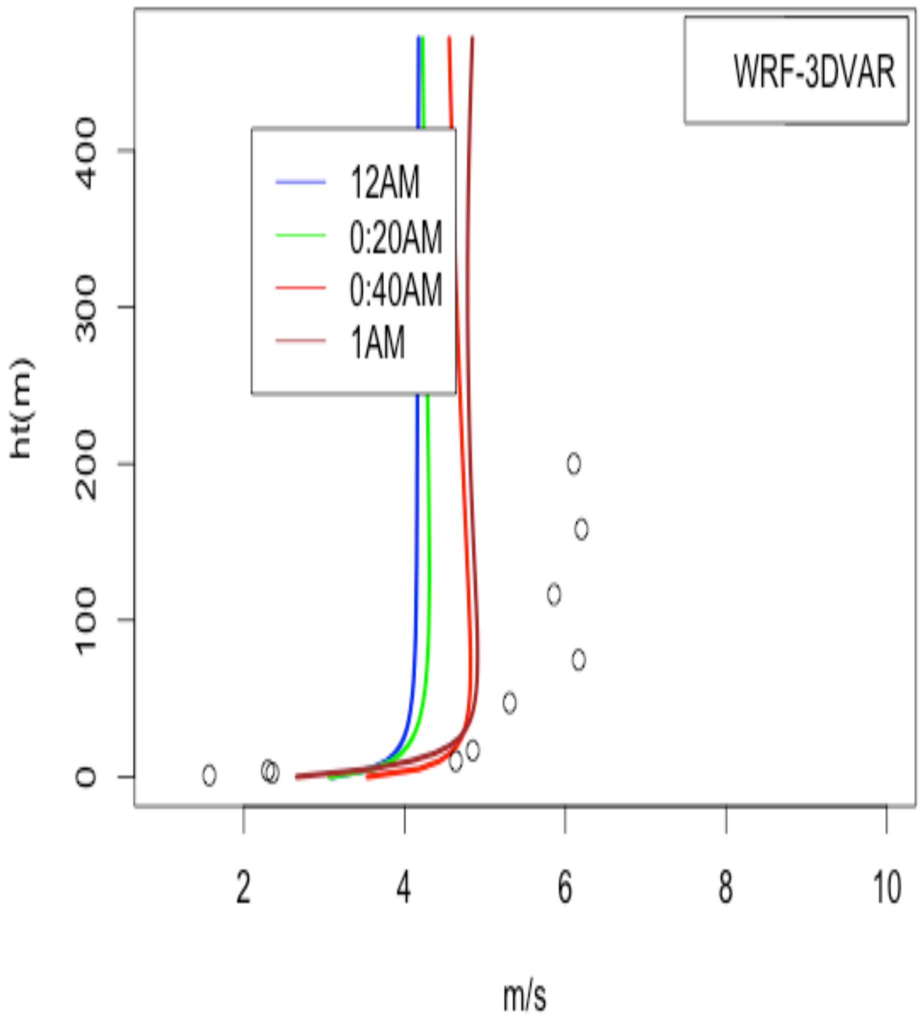
MPAS



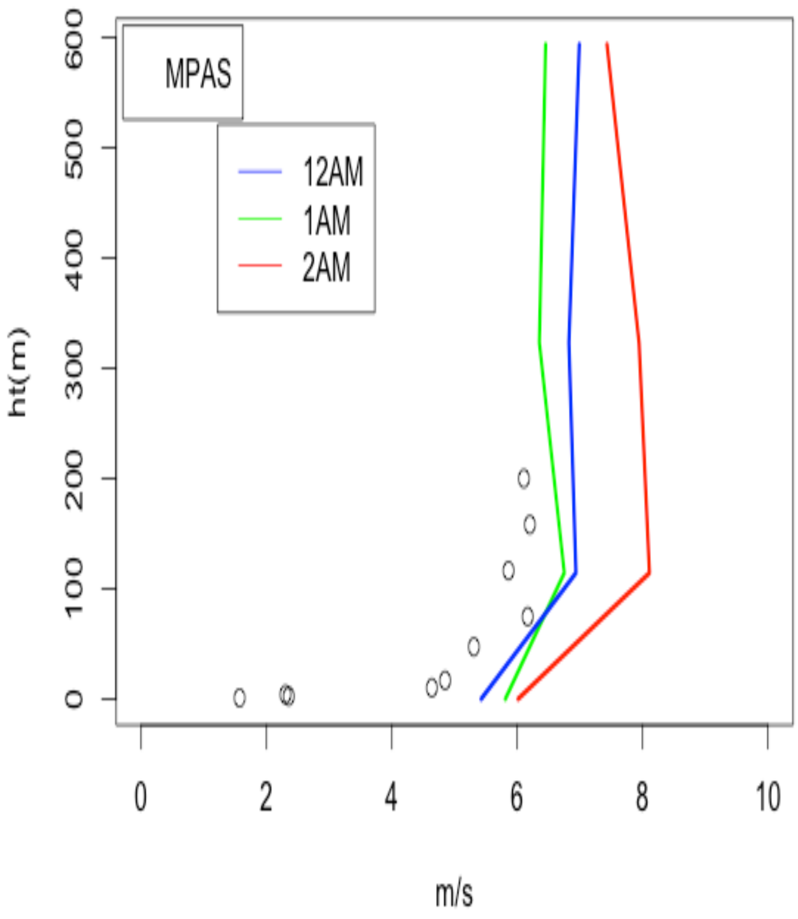
WRF

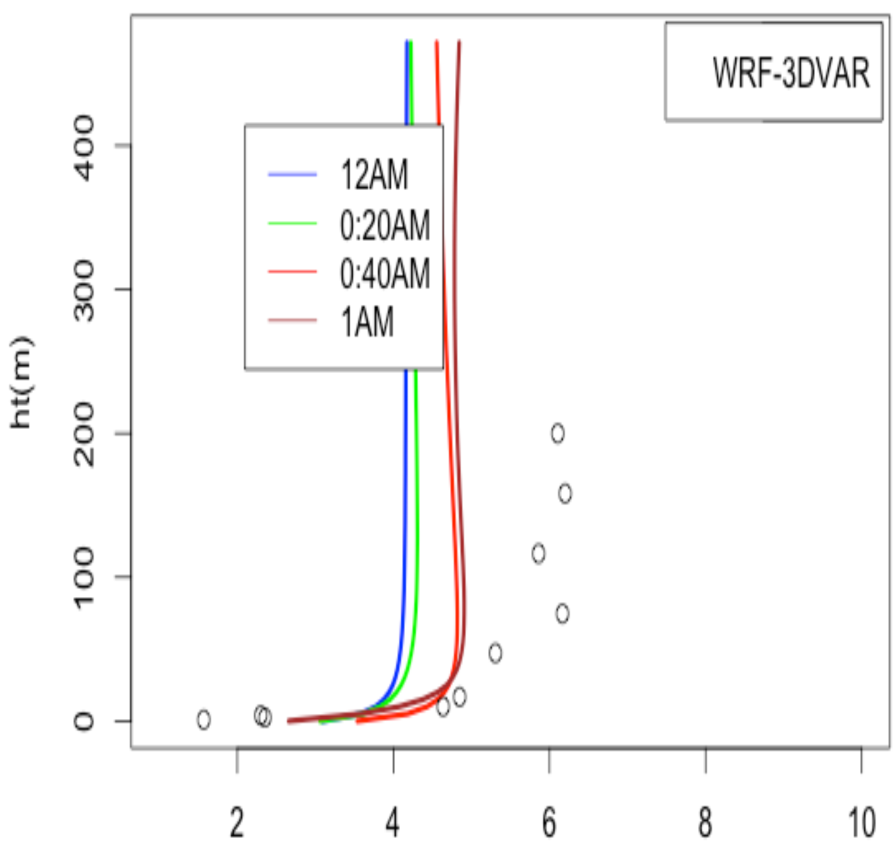
Neutral Case: Wind Profiles from two WRF configurations: WRF vs WRF-3DVAR



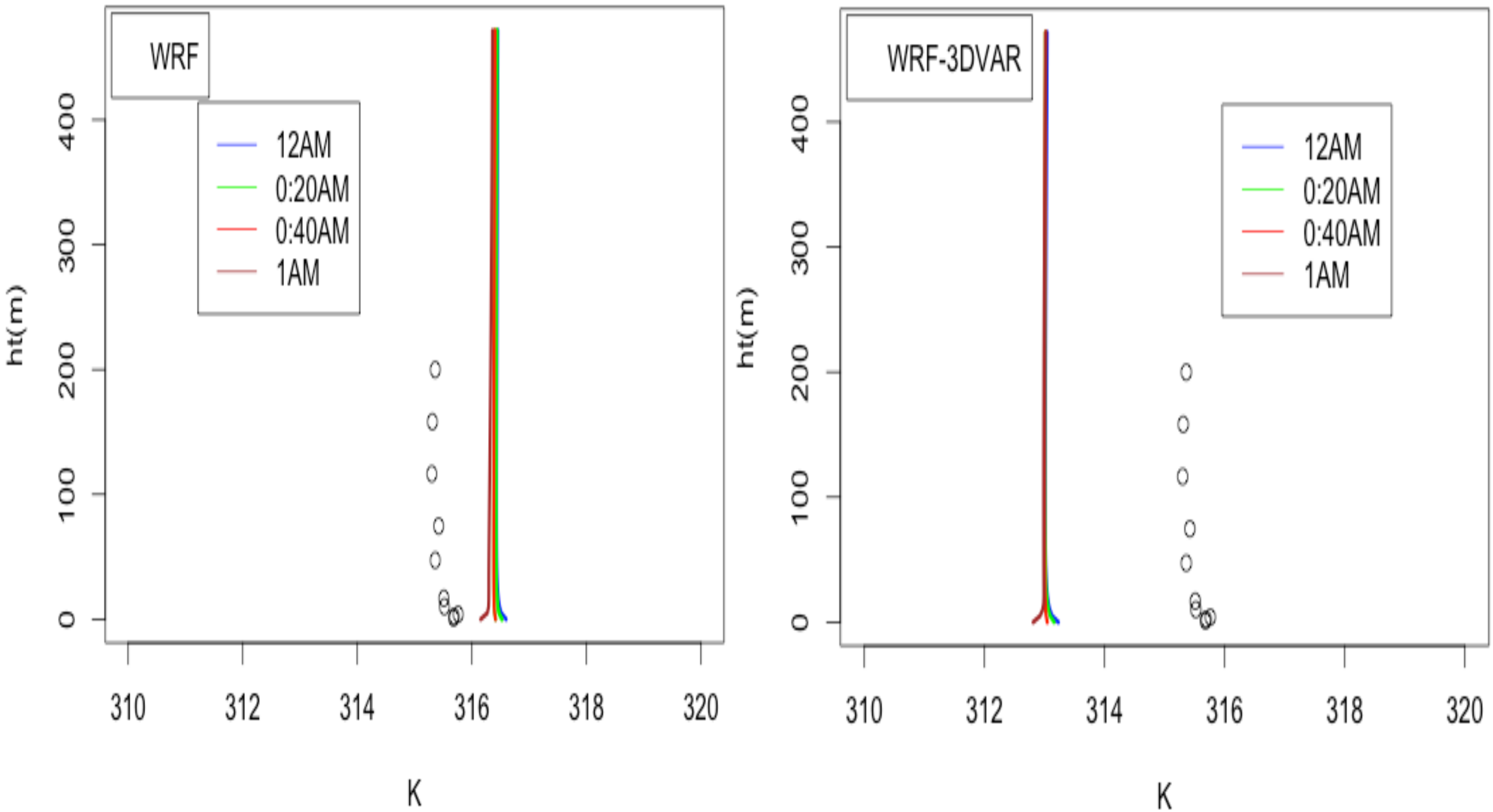


Comparison of Wind Profiles from MPAS vs WRF-3DVAR

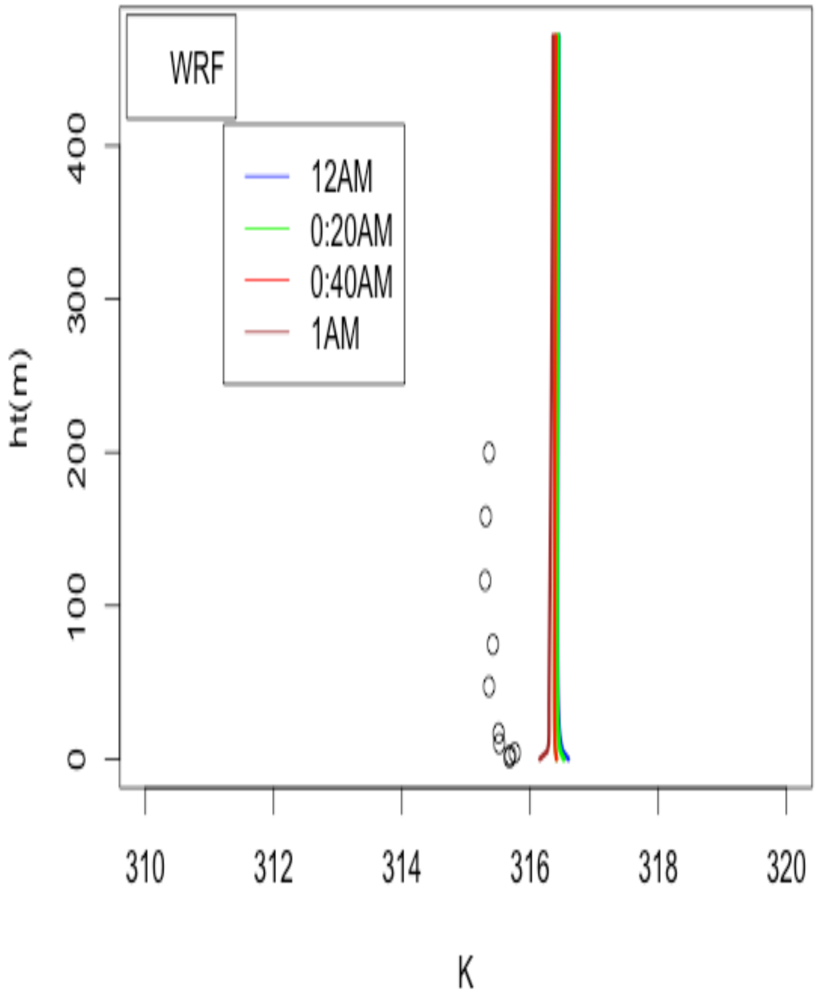


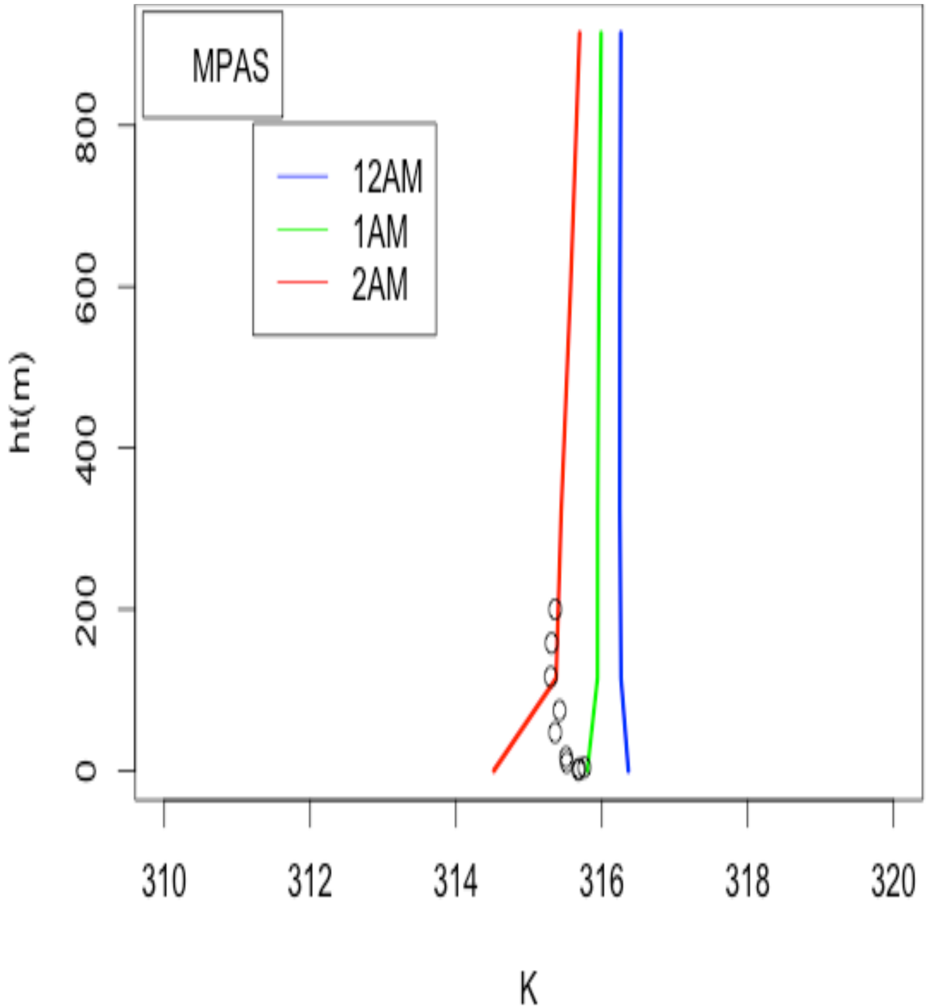


Neutral Case: Potential Temperature Profiles from two WRF configurations: WRF vs WRF-3DVAR



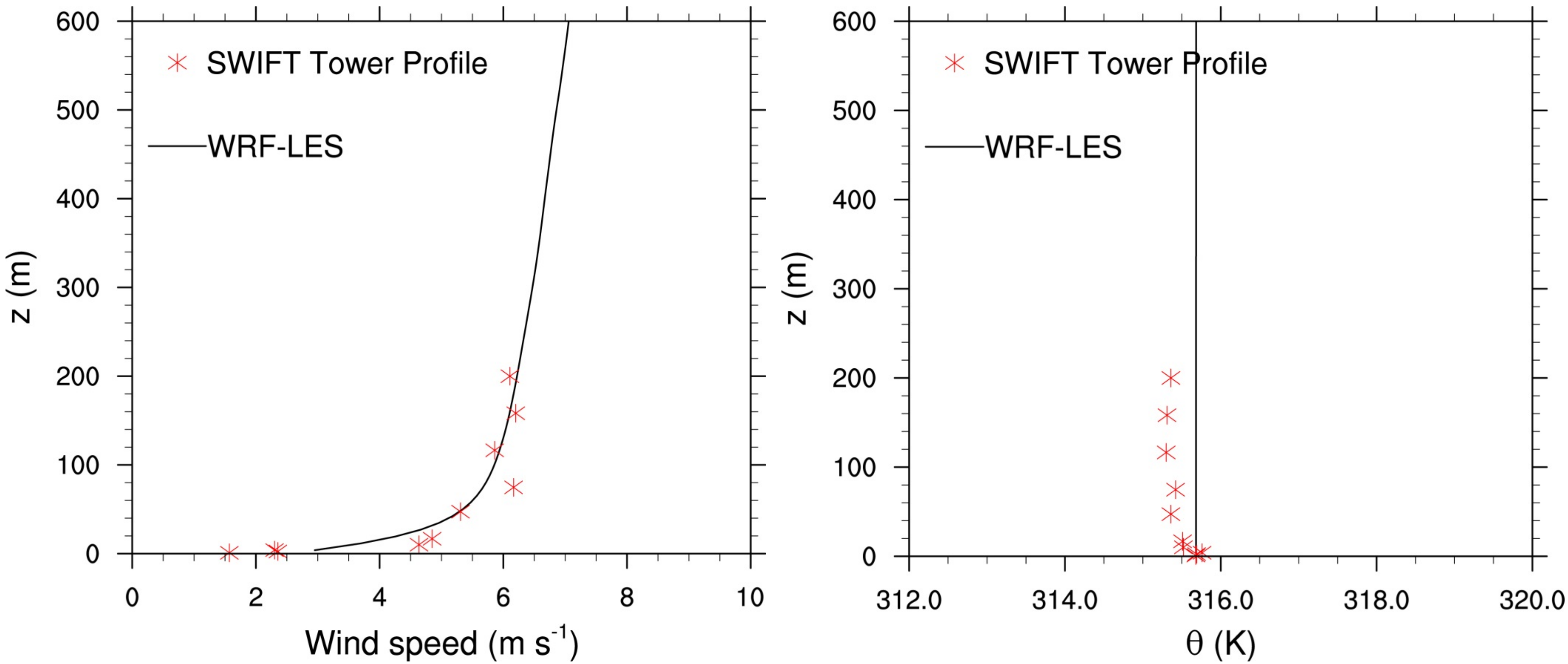
Comparison of Potential Temperature Profiles from MPAS vs WRF-3DVAR



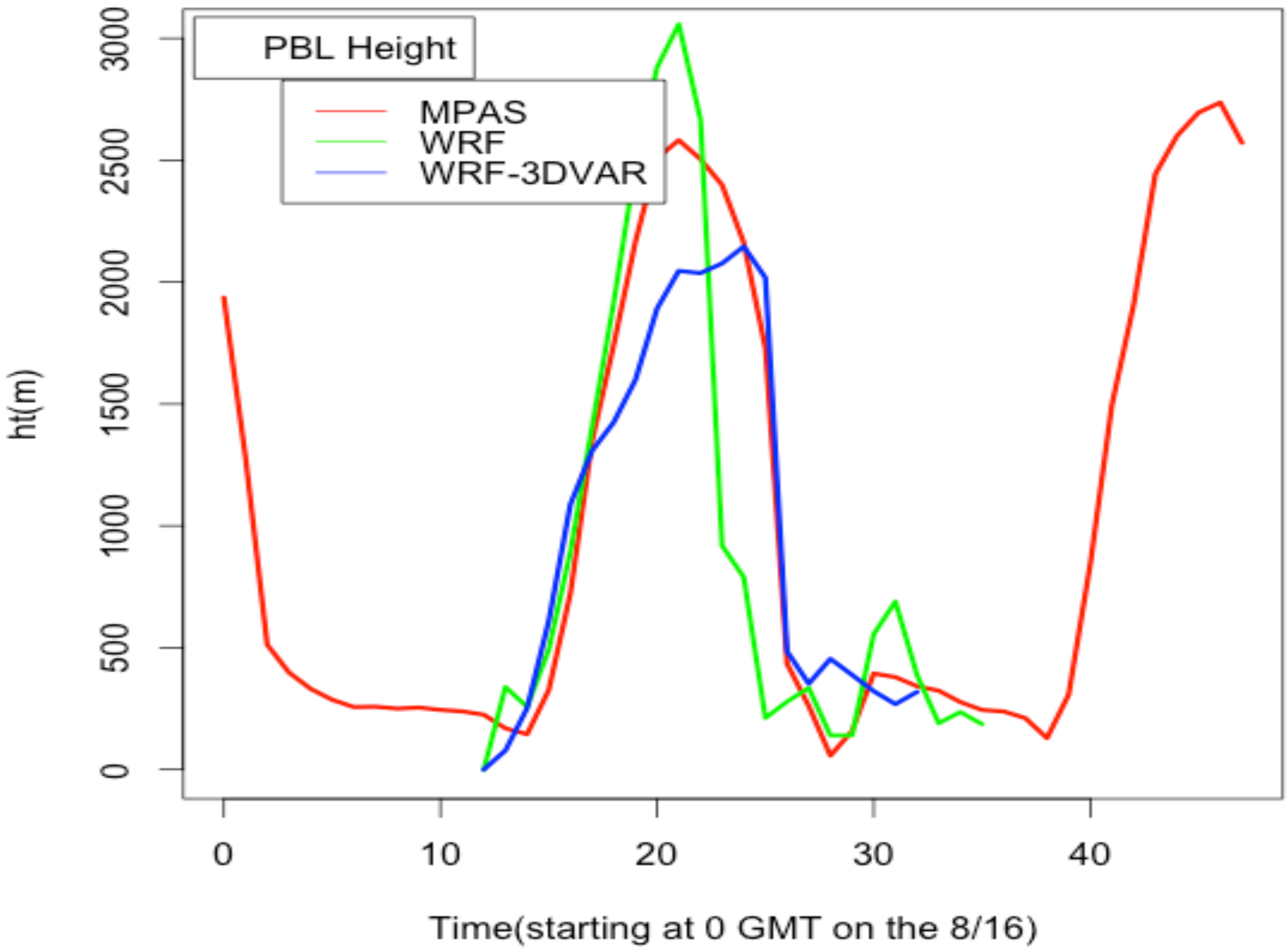


Wind and Potential Temperature Profiles from WRF-LES

Time: 00:00 hour on 08/17



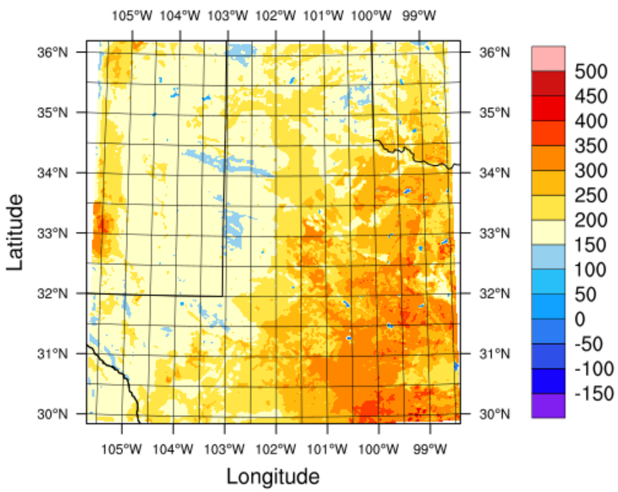
Neutral Case: Planetary Boundary Layer Height Comparison of WRF, WRF-3DVAR, and MPAS



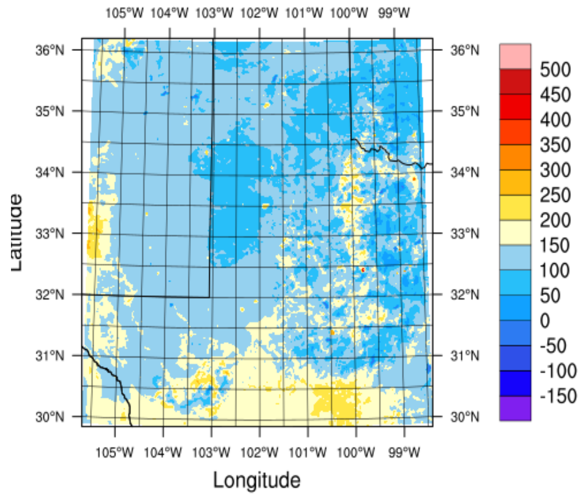
Comparison of Sensible Heat Flux (W m^{-2}) from WRF-3DVAR vs MPAS

WRF 3D-VAR

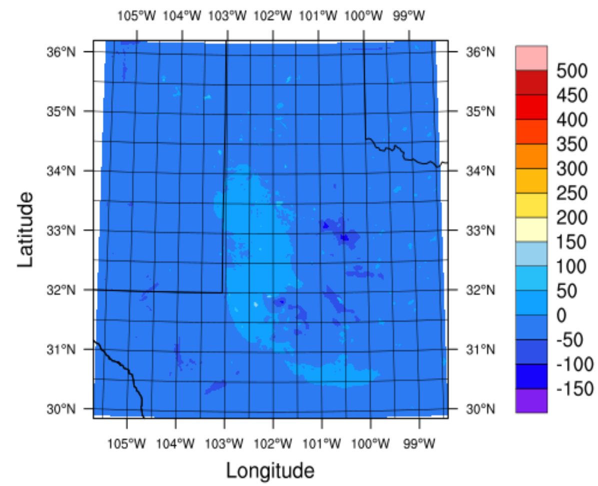
12 pm



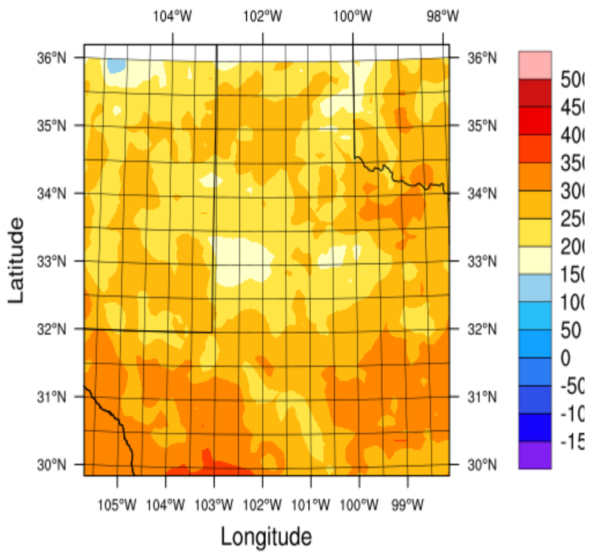
6 pm

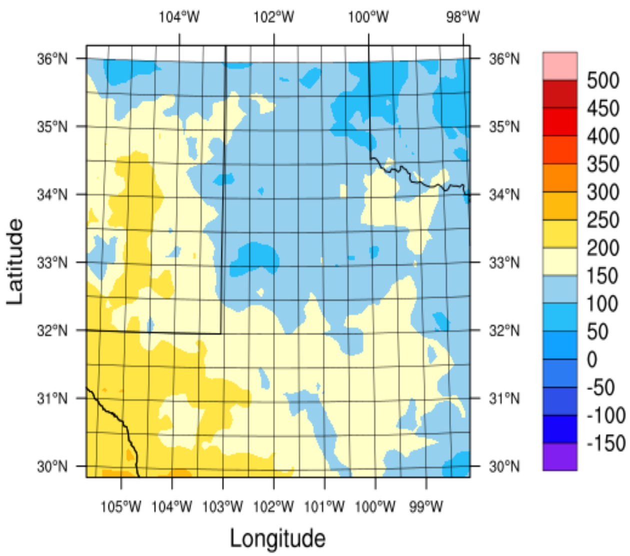


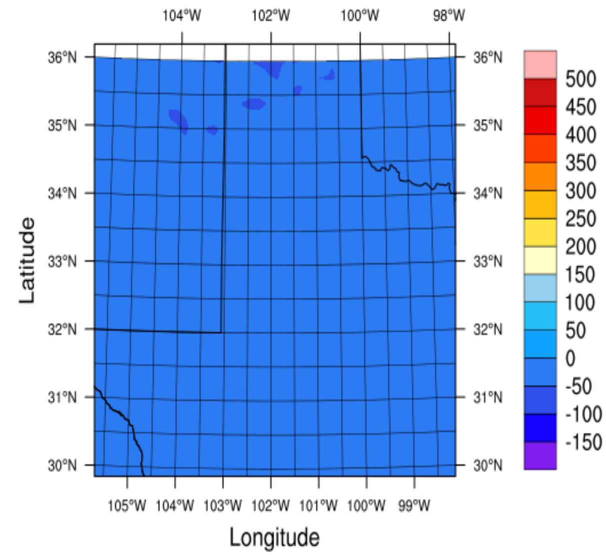
1 AM



MPAS



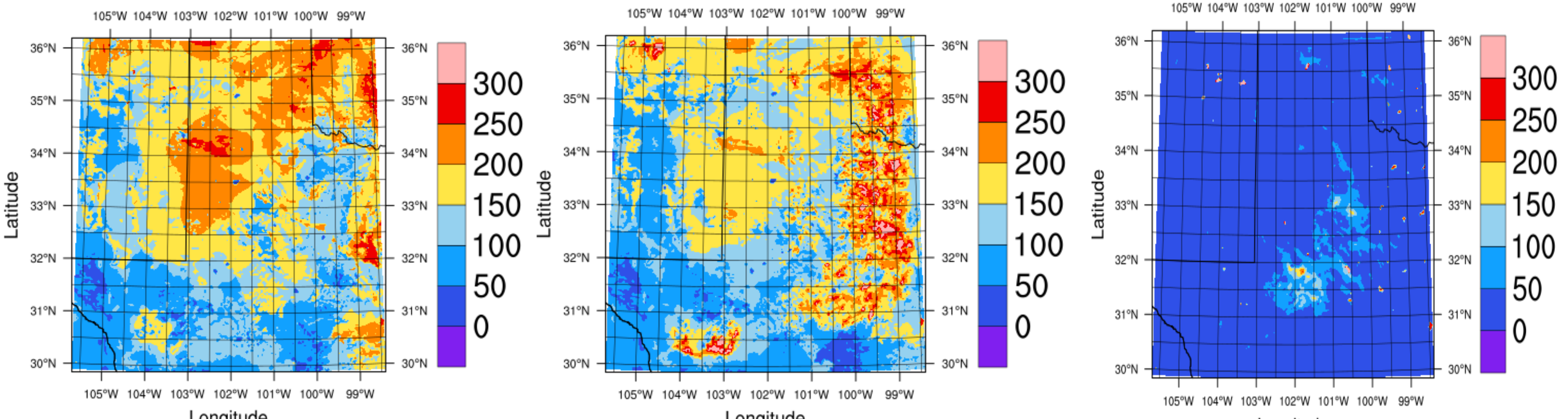




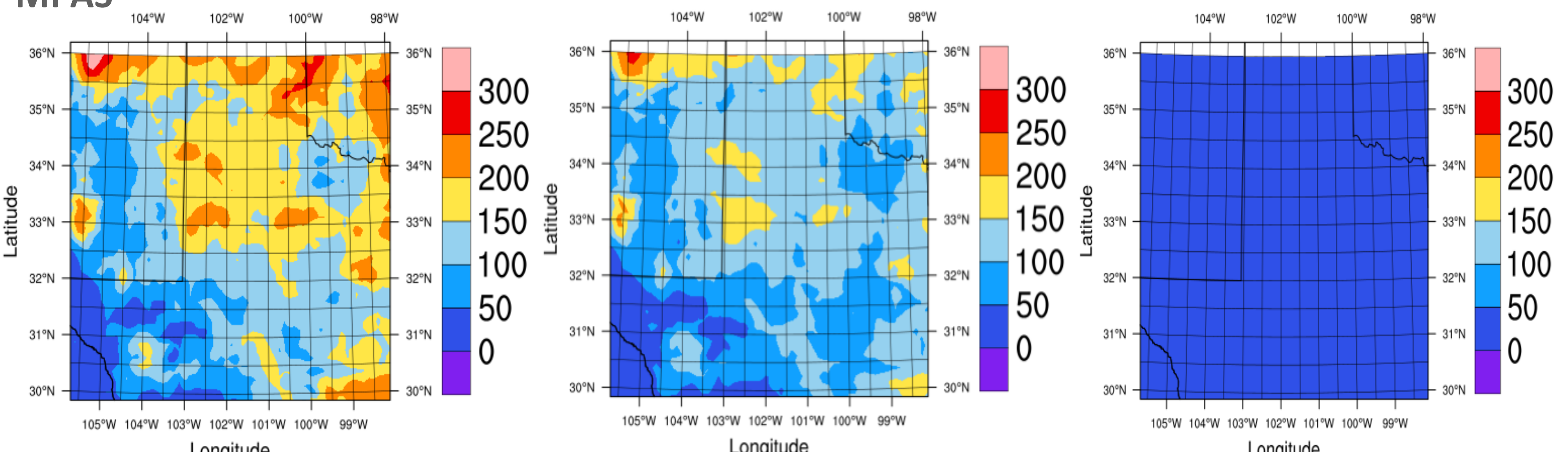
Comparison of Latent Heat Flux (W m^{-2}) from WRF-3DVAR vs MPAS

WRF 3DVAR

12 PM | 6 PM | 1 AM



MPAS



Conclusions and future work

- Surface heat fluxes calculated by WRF and MPAS are similar for the selected neutral case
- Boundary layer vertical profiles of wind speed calculated for the neutral case with MPAS were similar to the WRF meso-scale models
- WRF observationally nudged wind profiles with initialization the hour before produced the best comparison to the observed winds
- Potential temperature profiles for all three cases show a neutral profile at the time when the observations were made.
- WRF 3D-VAR and LES produced the closest reproduction of the observations
- The PBL heights calculated by the three models differ by several hundred meters during the daytime but show similar diurnal transition
- Higher vertical resolution for MPAS most likely will help.
- Data volumes from the MPAS model at spatial resolution of 15 km and higher will be a problem.
- Very few plotting and analysis tools are useful for handling this amount of output as we will need parallel processing tools (e.g. paraview).

Acknowledgements

- DOE NERSC Computing facility for providing the computing resource
- DOE EERE WWTPO Program for funding
- The entire MMC team lead by Susan Haupt (NCAR)