

Testing a Planetary Boundary Layer Scheme in MM5 for the Phoenix Metropolitan Region

S. Grossman-Clarke¹, J.A. Zehnder^{2,3}, Y. Liu⁴ and J.D. Fast⁵

¹International Institute for Sustainability ASU, P.O. Box 873211, Tempe, AZ 85287-3211, ²Department of Geography, ASU; ³Department of Mathematics, ASU; ⁴National Center for Atmospheric Research/RAP, Boulder, CO; ⁵Pacific Northwest National Laboratory, Richland, WA

Introduction

Previous atmospheric modeling efforts related to the Central-Arizona Phoenix (CAP) Long-term Ecological Research (LTER) Project:

- Refining the urban land use/cover classification in the fifth-generation PSU/NCAR mesoscale meteorological model MM5 based on remotely sensed data by Stefanov *et al.* 2001.
- Enhancing the MM5 model by characteristics of the urban energy balance such as anthropogenic heat production, sky view factor and increased surface volumetric heat capacity and heat conductivity (Grossman-Clarke *et al.* 2005).
- Apply MM5 for studying urban heat island; nitrogen deposition; effects of historic and future land use changes on weather in the CAP LTER study region.

Current MM5 modeling efforts are:

- Testing a new planetary boundary layer (PBL) scheme that includes the refined urban surface energy budget and a modified version of the Medium Range Forecast (MRF) boundary layer scheme developed at the National Center for Atmospheric Research (Liu *et al.* 2004).
- Important for studying the influence of the urban area on thunderstorm propagation; interactions of the urban and rural thermal environment through mesoscale circulations; influence of land use changes on air quality and near-surface meteorological variables.

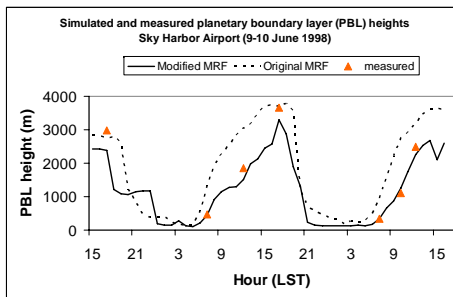


Figure 1: Simulated and measured planetary boundary layer heights at the National Weather Service Station Sky Harbor on Airport on 9-10 June 1998. Simulations were carried out by MM5 using the non-local closure Medium Range Forecast (MRF) boundary layer scheme in its original (Hong and Pan 1996) and modified version (Liu *et al.* 2004).

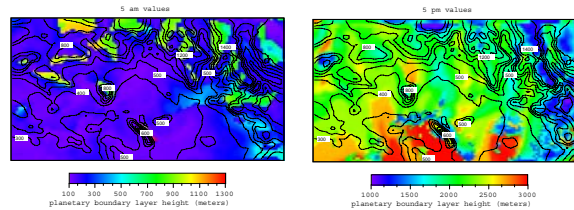


Figure 3: Simulated planetary boundary layer heights in the 2 km x 2 km modeling domain covering the Phoenix metropolitan region and surrounding mountainous and desert areas at 9 June 1998 5 am and 5 pm obtained with the modified version of the MRF scheme by (Liu *et al.* 2004).

Model Description and Numerical Experiments

- Tendency of original MRF scheme (Hong and Pan 1996) to underestimate near-surface wind speeds and to overestimate sensible heat fluxes and boundary layer heights under free-convection conditions because of empirical description of the convective velocity and use of non-local bulk Richardson number (Liu *et al.* 2004).
- In modified MRF scheme (Liu *et al.* 2004) PBL height is determined by local bulk Richardson number computed between two neighboring model levels.
- Modified MRF scheme was applied and tested in MM5 during a 72-hour simulation starting at 0000 Universal Time (UTC) 8 June 1998, i.e. 1700 Local Standard Time (LST) 7 June 1998.
- Nested simulations with four domains and resolutions of 54 km, 18 km, 6 km and 2 km (size east-west 212 km; north-south 132 km), respectively and 32 vertical layers were performed.
- Initial and boundary conditions provided by the NCEP ETA grid 212 (40 km resolution) analysis and include assimilation of upper air observations.
- Model results were compared with measurements from a field campaign conducted in May/June 1998. Vertical temperature profiles were measured at Sky Harbor Airport five times per day (0800, 1000, 1200, 1400, 1700 LST).

Results and Conclusions

- Figure 1 shows simulated PBL heights. Original MRF scheme yields up to 1500 m and 200 m higher PBL heights during daytime and nighttime respectively.
- Simulated PBL heights of the modified MRF scheme showed clearly better agreement with the measurements. However, the original MRF scheme captured the magnitude of the maximum PBL height better.
- Figure 2 shows the regional distribution of PBL heights at 5 am and 5 pm on 9 June 1998 as obtained with the modified MRF scheme.
- Figure 3 shows the course of simulated and measured wind speeds at a height of 10 m at Sky harbor Airport during the simulation period with significantly improved results for the modified MRF scheme (original MRF calculated near zero wind speeds during daytime).
- Application of the modified MRF scheme in MM5 led to significantly improved results for PBL heights and wind speeds.
- This has an influence on applications of MM5 for investigating the propagation of Thunderstorms in the region, real-time weather forecast and downscaling output of Global Climate models to the region.
- The modified MRF scheme will be tested further against experimental data from two field campaigns conducted in May/June 1998 and June/July 2001 in the Phoenix metropolitan area.

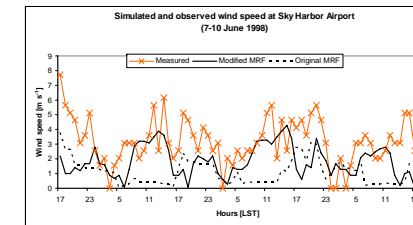


Figure 3: Simulated and observed wind speeds for June 7, 1998 17:00 LST to June 10, 1998 17:00 LST for the NWS station at Sky Harbor Airport. Simulations were carried out by MM5 using the non-local closure Medium Range Forecast (MRF) boundary layer scheme in its original (Hong and Pan 1996) and modified version (Liu *et al.* 2004).

References

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