LA-UR-17-20321



The Effect of Boundary-Layer Scheme on WRF model simulations of the Joint Urban 2003 Field Campaign

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1/25/2017

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Importing WRF into QUIC

- Imports meteorological fields important to atmospheric transport and dispersion:
 - U, V, T, P, RH, PBLH, 1/L, TKE, u_*
 - Precipitation Rate
 - UV intensity in discrete bandwidths.
- Turbulence can either be parameterized using the Monin-Obukhov Similarity parameters or imported directly from WRF's TKE output.





Test Case: Joint Urban 2003

- The Joint Urban 2003 (JU2003) dataset is ideal for verification and validation of WRF's ability to reproduce the flow and turbulence in the ASL as well as the effects of the two turbulence models on the transport and dispersion of contaminants.
- JU2003 included both daytime and nighttime intensive observation periods (IOPs). IOPs 2 (daytime) and 8 (nighttime) were used here to test out using WRF in both thermally unstable and stable conditions.

Clawson KL, Carter RG, Lacroix DJ, Biltoft CA, Hukari NF, Johnson RC, Rich JD, Beard SA, Strong T (2005) Joint urban 2003 (ju03) sf6 atmospheric tracer field tests. Tech. Rep. NOAA Technical Memorandum OAR ARL-254, NOAA, Field Research Laboratory, Idaho Falls, Idaho, U.S.A.







WRF B-L Scheme Evaluation

Three simulations were performed for the entire month of July 2003:

- MYJ BL scheme
- YSU BL scheme
- MYNN BL scheme



- Nelson et al. 2016a: A Case Study of the Weather Research and Forecasting Model Applied to the Joint Urban 2003 Tracer Field Experiment. Part 1: Wind and Turbulence, *B-Layer Meteor.*, **158**, Issue 2, pp 285–309
- Nelson et al. 2016b: A Case Study of the Weather Research and Forecasting Model Applied to the Joint Urban 2003 Tracer Field Experiment. Part 2: Gas Tracer Dispersion, *B-Layer Meteor.*, doi:10.1007/s10546-016-0188-z.



JU2003 Observations





Central Business District

120-m level of the PNNL Sodar is used to evaluate wind speed and direction.

55-m level of the IU tower instrumented with 3D sonic anemometers is used to evaluate the turbulence parameters.



WRF B-L Scheme Evaluation: Wind Direction





Note the large differences between the observed and predicted wind direction when using the MYJ and YSU B-L schemes.

The MYNN simulation performs much better and does not exhibit the strange deviations from the prevailing patterns.



WRF B-L Scheme Evaluation: Wind Speed





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Note the large underprediction of wind speed in the instances when the MYJ and YSU schemes erroneously predicted deviations from prevailing patterns.



WRF B-L Scheme Evaluation: Turbulent Kinetic Energy



MYJ scheme tends to under-predict turbulence levels



WRF B-L Scheme Evaluation: Friction Velocity





WRF simulations occasionally over-predict the friction velocity.

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WRF B-L Scheme Evaluation: Obukhov Length





WRF simulations usually under-predict observed night time thermal stability.

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WRF B-L Scheme Evaluation: MYJ vs MYNN TKE Comparison











Mesoscale vs Microscale







1700





Mesoscale vs Microscale





Conclusions



- WRF can be used to drive QUIC with realistic spatially and temporally varying meteorological conditions.
- The MYNN B-L scheme performs better than the MYJ and YSU B-L schemes.
 - MYNN is better able to reproduce the observed wind direction and does not exhibit the strange deviations from the observations that are found in both the MYJ and YSU simulations.
 - MYNN is also better able to reproduce the observed turbulence levels, while MYJ was consistently found to underpredict the observed turbulence levels.





Conclusions (Cont.)

- WRF's ability to simulate intermediate-scale motions (i.e., small mesoscale to large microscale) is limited. These motions can have a significant effect on the flow through urban terrain and therefore near-source transport and dispersion in urban areas.
- See Poster 1382 in Poster Session 9 for an example of the effects of these intermediate-scale motions on urban transport and dispersion.
- Further investigation is required to determine the reasons why the MYNN B-L scheme has better performance than the MYJ and YSU schemes.

