Preliminary results of the WRF model over Midwest USA

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Introduction

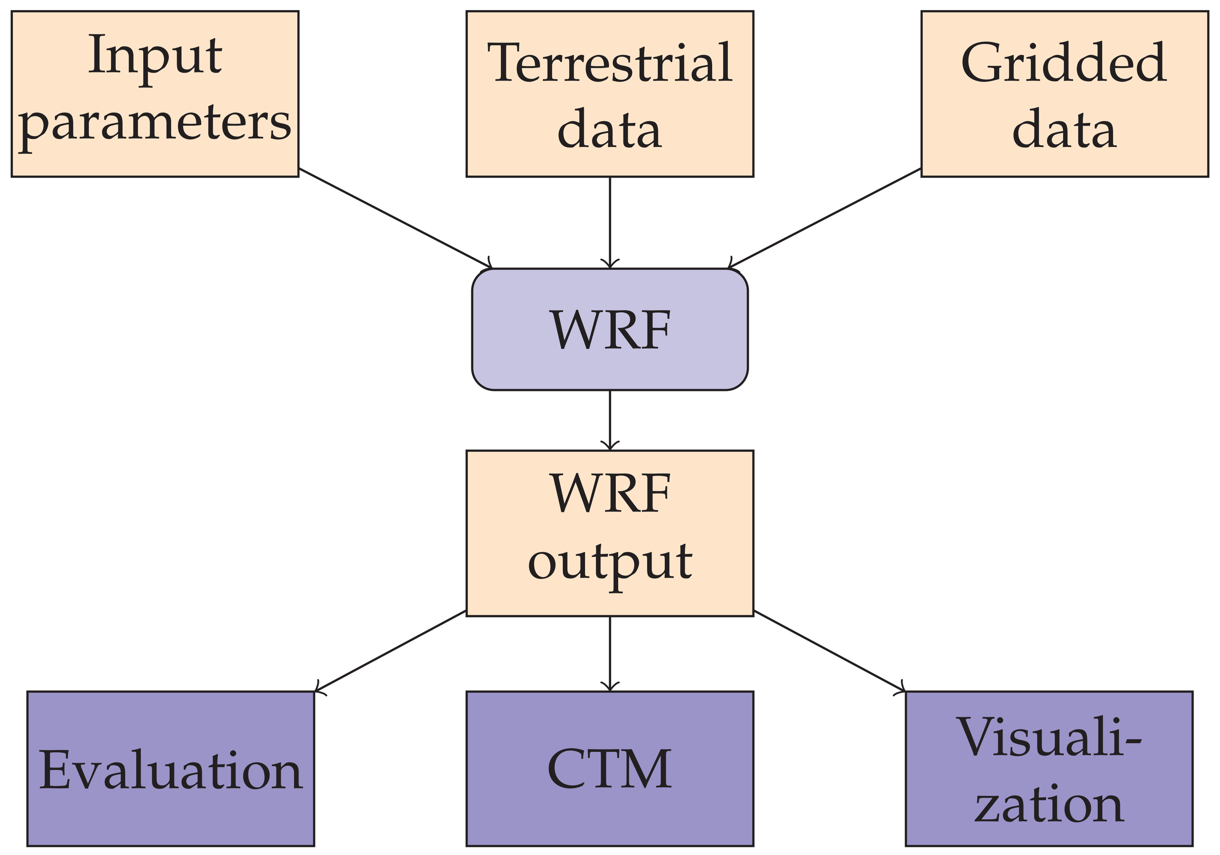
Reducing uncertainty of spatial and temporal variability of ammonia (NH_3) emissions from chemical agricultural fertilization and bi-directionality of NH_3 fluxes in the presence of canopies has been identified, as a factor for improving air quality modeling predictions of $PM_{2.5}$ concentrations.

Our research group works on improving spatial and temporal resolution of NH_3 emissions to be used as input to Chemical Transport Model (CTM) to predict regional air quality effects of chemical fertilizer use for crops. CTMs also require gridded meteorological data, as inputs.

Objective

The objective of the research presented here is to install, run and validate the Weather Research and Forecast (WRF) model for a domain over the U.S. Midwest corn belt.

WRF data flow chart



WRF model configuration

Code:

- WRF Preprocessing System (**WPS**) 3.5.1
- **WRF-ARW** 3.5.1
- Unified Post Processor (**UPP**) 2.2
- Model Evaluation Tools (**MET**) 4.1

Selected physics options:

Atmospheric process	scheme
Microphysics	WSM3
Longwave radiation	RRTM
Shortwave radiation	Dudhia
Land surface model	Thermal diffusion
Planetary boundary layer	ACM2

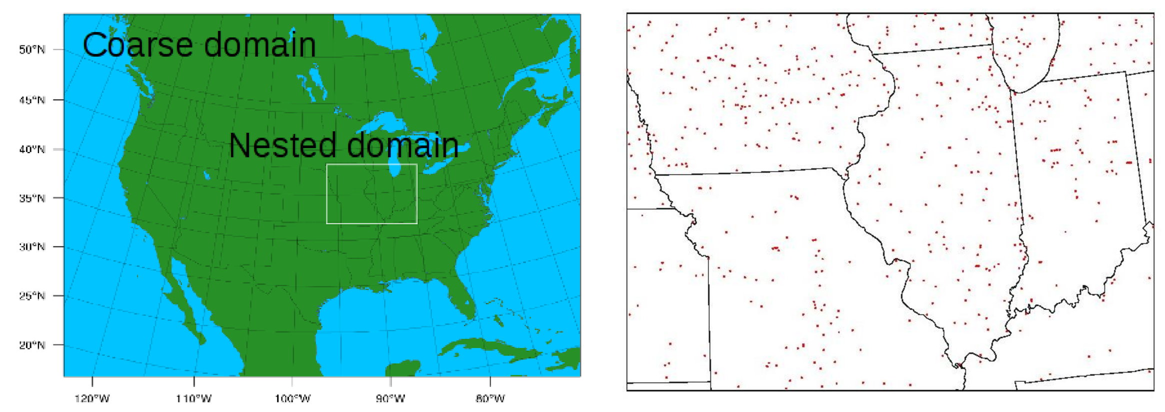
Data source:

Input North American Mesoscale (NAM) 218 from National Operational Model Archive and Distribution System

Observations Global Upper Air and Surface Observations (DS 337.0) and Earth System Research Laboratory SURFRAD Network.

Geographical domain

Model domain:



Coarse domain (12×12 km, left) covers North America and nested domain (4×4 km, right) covers Midwest USA.

Evaluation results over nested domain

Simulation period from 16 April 2011 to 20 April 2011, with an additional 24 hour spin-up time from 15 April to 16 April. Downward shortwave and longwave radiative flux at surface (DSW and DLW, W/m^2), Temperature at 2m (T2, °C), Zonal mean wind speed at 10m (U10, m/s) and Meridional mean wind speed at 10m (V10, m/s) are compared with observational data.

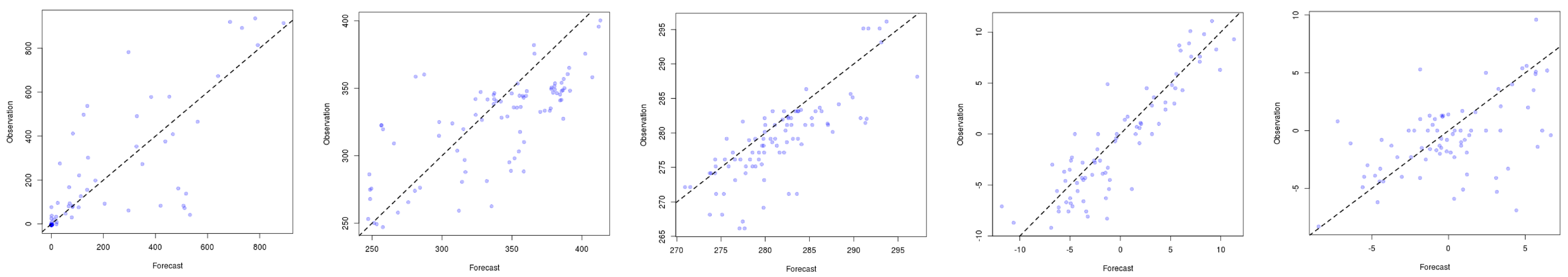


Figure 1 Aggregated scatter plots of estimated vs observed values of DSW, DLW, T2, U10 and V10, from left to right

Table 1 Statistics performance of WRF output[a]

	DSW, W/m^2	DLW, W/m^2	T2, °C	U10, m/s	V10, m/s
Mean Observation	155.78	325.13	5.90	-0.65	-0.59
MB	-4.03 (16.62)	12.75 (-16.6)	2.54 (-0.02)	0.56 (-0.05)	0.69 (-0.04)
RMSE	151.64 (32.40)	34.32 (23.54)	4.54 (1.83)	2.48 (0.97)	3.37 (0.85)
NMB, %	-2.59 (8.91)	3.92 (-5.63)	42.01 (-0.38)	-85.8 (-452)	-117.1 (26.2)
NME, %	51.07 (12.91)	8.62 (6.75)	55.43 (21.34)	-299.9 (6471.8)	-405.6 (423)

Values in parentheses are obtained from a WRF evaluation paper[b] to provide a reference value. Results suggested that overall performance is not so good as that in the reference paper, especially in terms of RMSE. T2 is generally overestimated. Large NME and NMB in wind speed may due to the near zero mean value of the observations.

[a]MB: Mean Bias, RMSE: Root Mean Square Error, NMB: Normalized Mean Bias, NME: Normalized Mean Error

[b]Zhang, Y. (2012). The Global Weather Research and Forecasting (GWRF) Model: Model Evaluation, Sensitivity Study, and Future Year Simulation. Atmospheric and Climate Sciences, 02(03), 231-253

Summary

In this case study, WRF model was run over Midwest U.S.A.. Evaluation results suggest that the WRF output over the considered domain still needs improvement, possibly by modifying physics options to make WRF better interpret the atmospheric process.

Future research

- Evaluate different combination of physics options to improve the WRF output.
- Validate WRF output with a coarse (12×12 km) resolution and compare CTM performance between fine (4×4 km) and coarse resolution.

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