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WRF-GC: online two-way coupling of WRF and GEOS-Chem for regional atmospheric chemistry modeling

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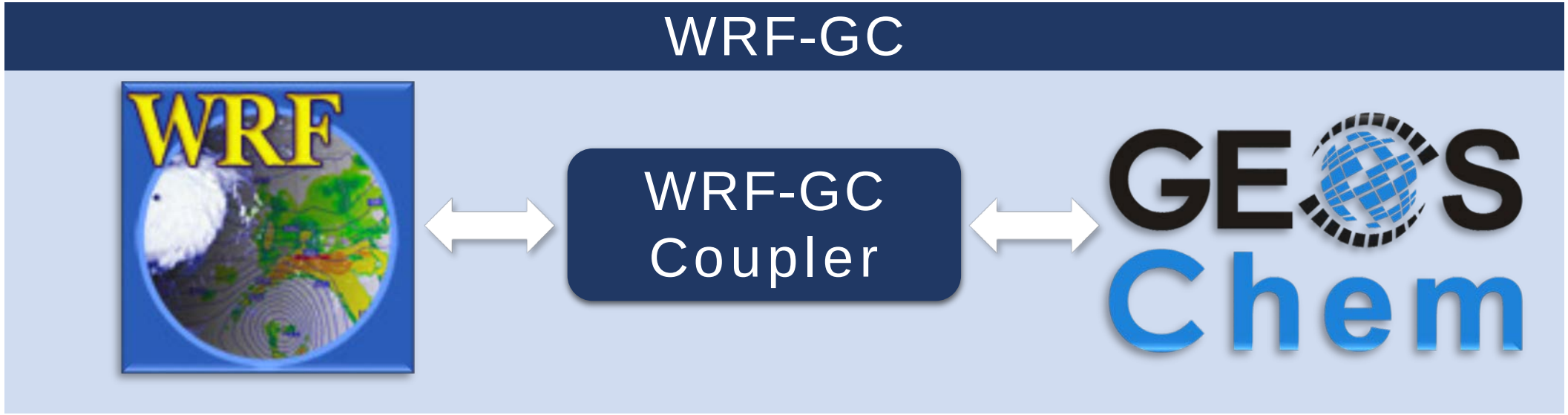
For more information see: http://wrf.geos-chem.org

Overview of a new online coupled air quality model: WRF-GC



WRF

- Powerful and flexible grid system at resolutions 1km to 100km
- Hindcast and forecast capabilities, driven by NCEP, EC, etc
- Massively parallel architectures

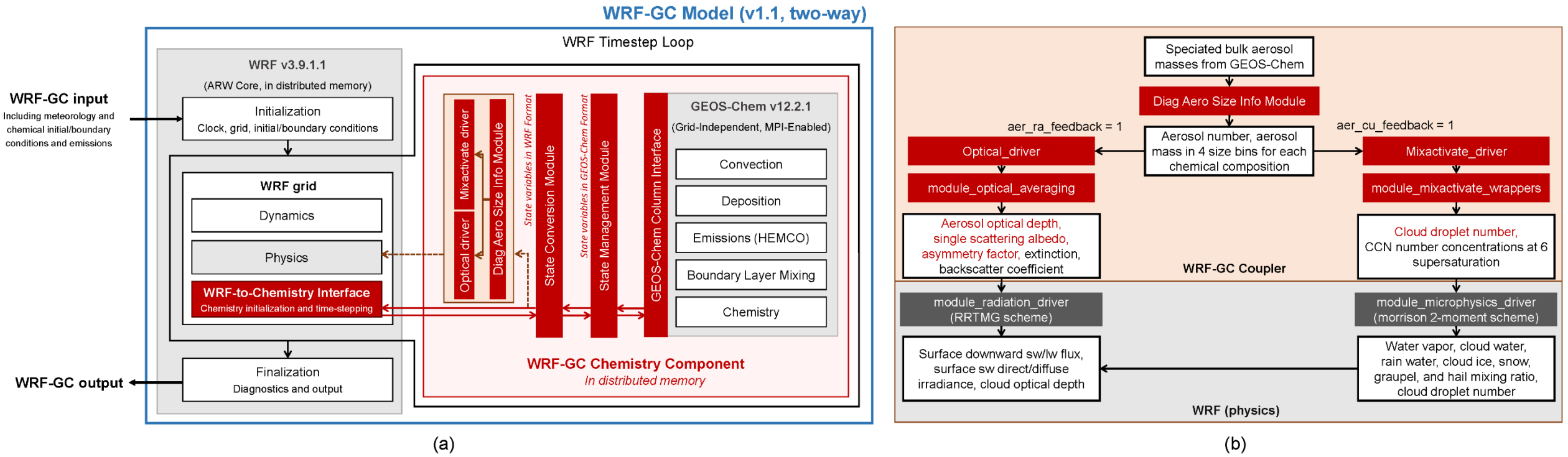
GEOS-Chem

- State-of-the-science, well-documented, traceable, benchmarked, GSCT-supported chemical module

WRF-GC

- WRF-GC uses unmodified copies of WRF and GEOS-Chem from their respective sources.
- The Coupler is separate from both parent models and allows future versions of either one of the parent models to be integrated into WRF-GC.

Architecture of WRF-GC two-way coupled system

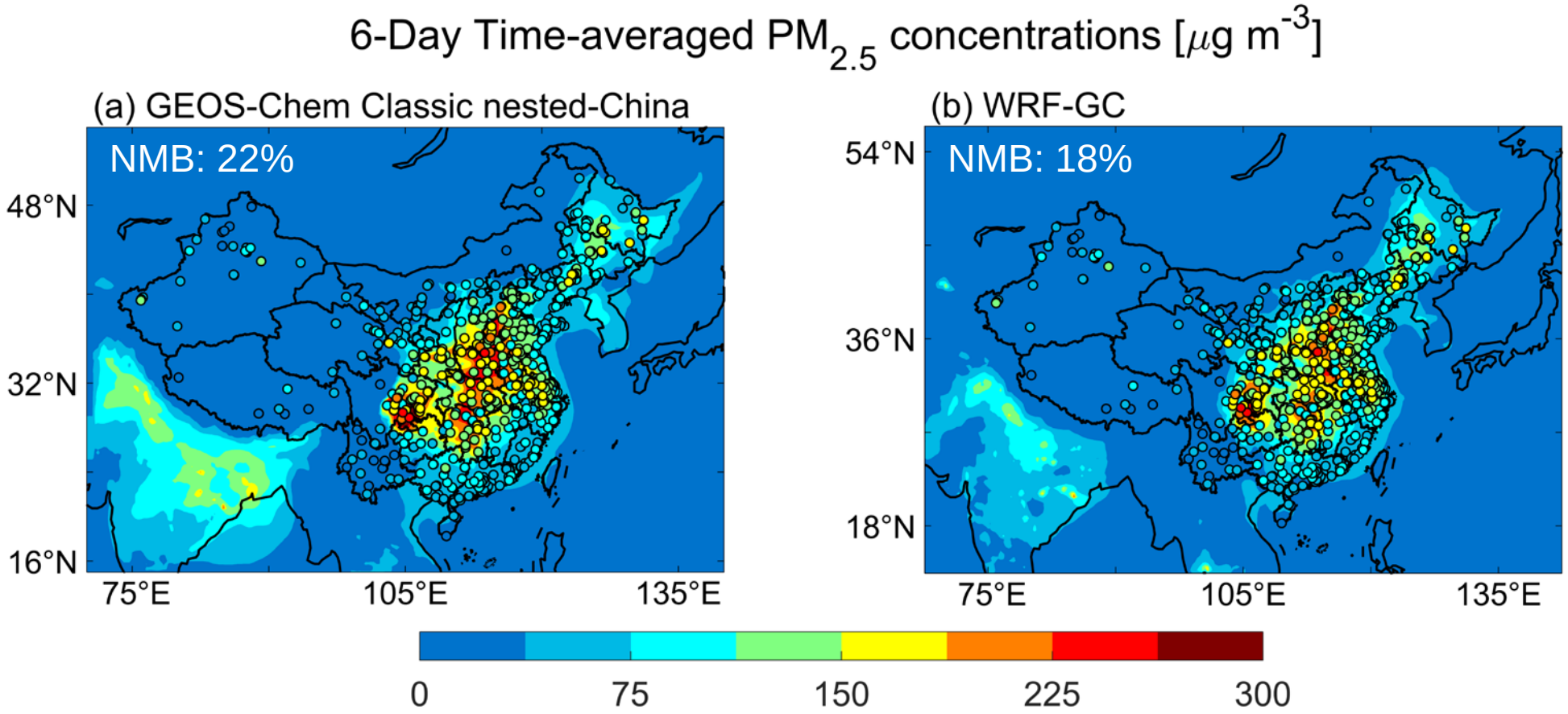


(a) Architectural overview of the WRF-GC model (v1.1, two-way). The WRF-GC Coupler (all parts shown in red) includes interfaces to the two parent models, state conversion module, state management modules, and the two-way coupling modules (shown in orange). The parent models (shown in grey) are standard codes without any modifications.

(b) Flow diagram of the aerosol-radiation and aerosol-cloud interactions in two-way coupled WRF-GC model.

(Feng et al., in preparation)

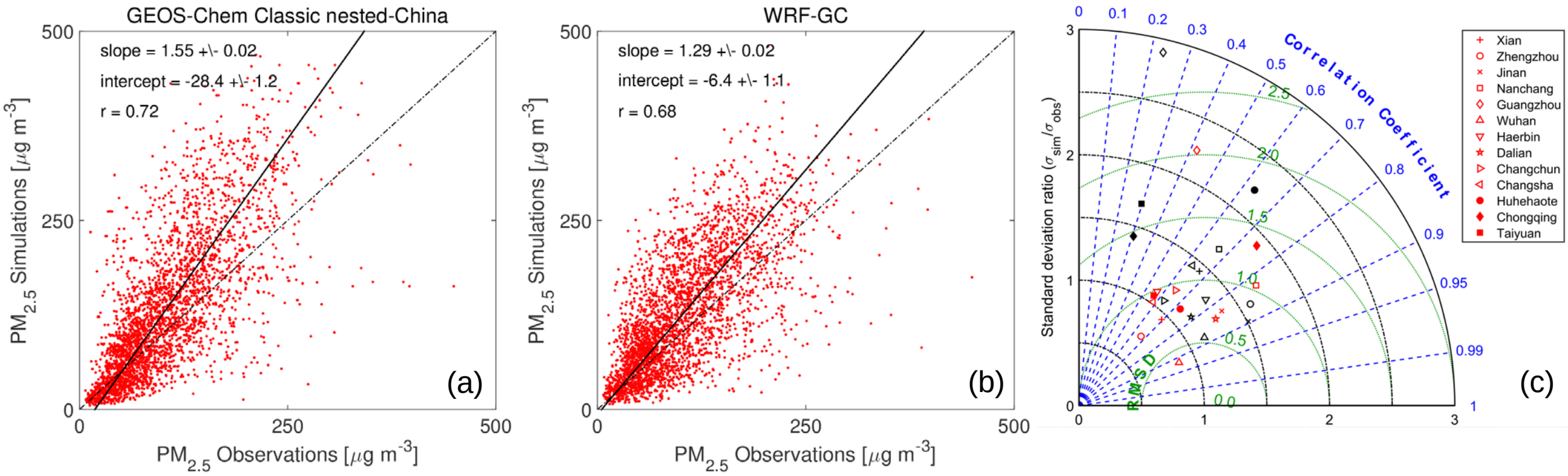
Evaluation of WRF-GC performance of $PM_{2.5}$ over China



- One-way coupled WRF-GC (WRF v3.9.1.1/GEOS-Chem v12.2.1)
- Simulation period: 2015-01-18 00:00 to 2015-01-28 00:00 (first 4 days initialized model)
- Spatial resolution: 27km (WRF-GC); GEOS-Chem Classic nested-China (0.25° × 0.3125°)
- Chemical initial and boundary conditions: GEOS-Chem 2° × 2.5° global simulation

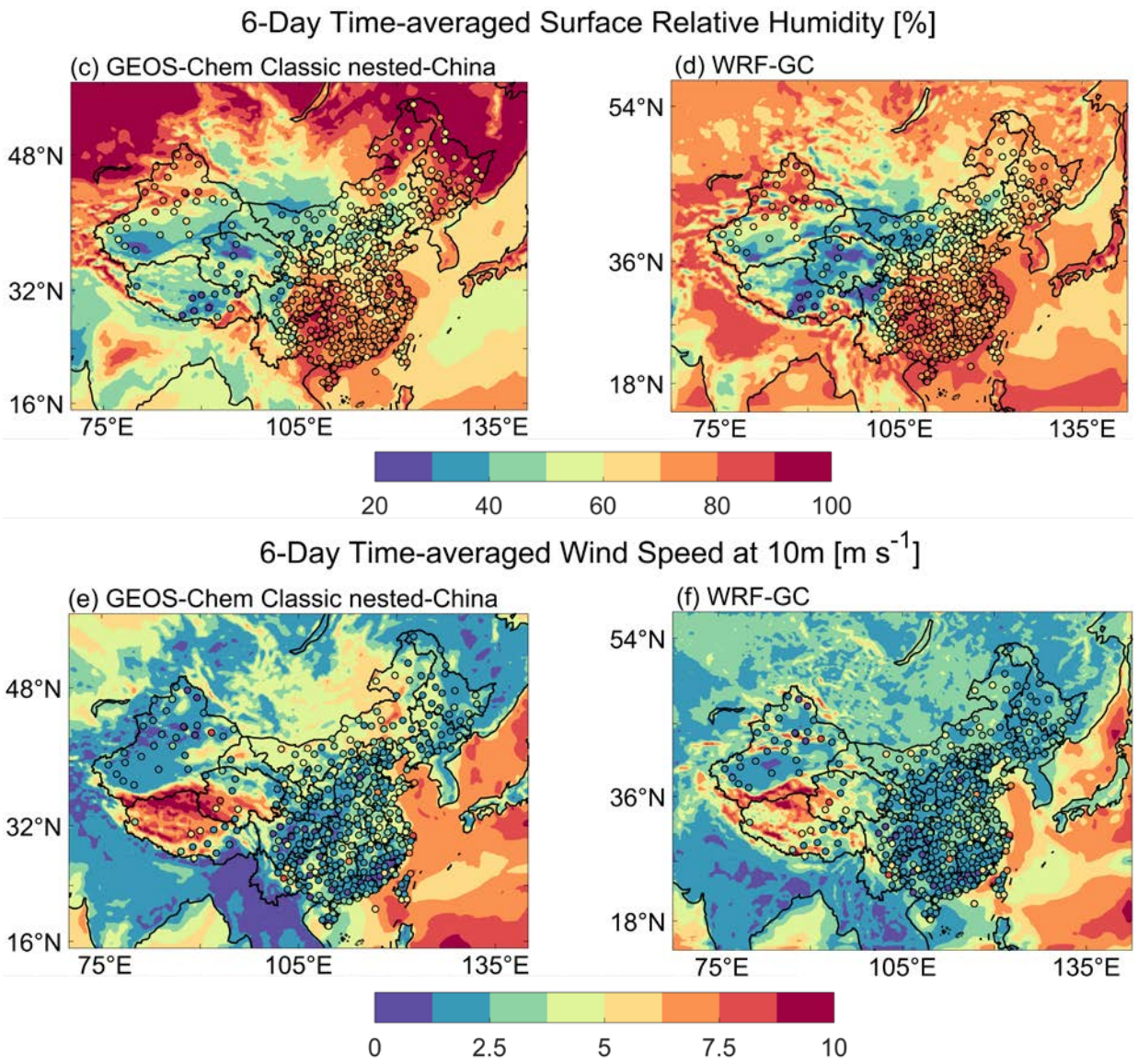
(Lin et al., 2019, GMDD)

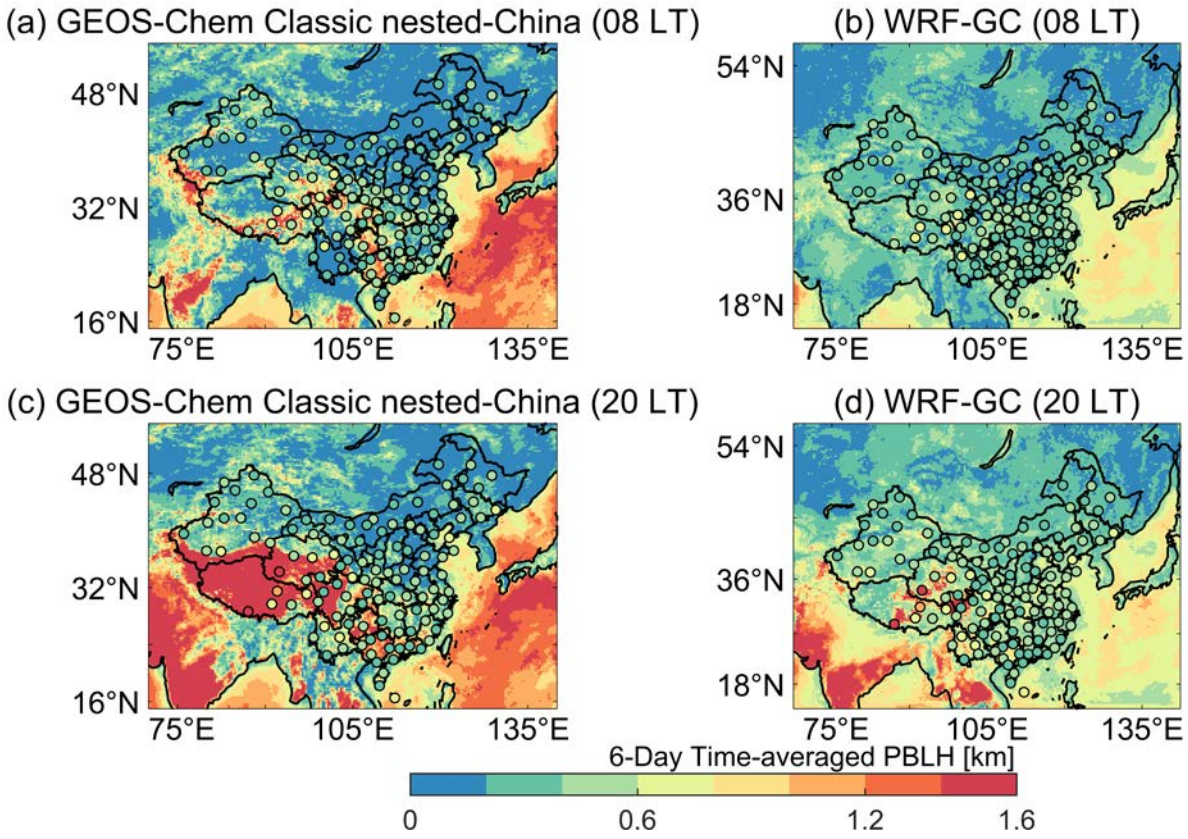
WRF-GC well reproduced the spatiotemporal distribution of $PM_{2.5}$



- Scatter plots of observed and simulated daily mean $PM_{2.5}$ concentrations during Jan 22 to 27, 2015 at 507 surface sites over Eastern China for (a) the GEOS-Chem Classic nested-China simulation and (b) the WRF-GC nudged simulation.
- Taylor diagrams of hourly $PM_{2.5}$ concentrations during Jan 22 to 27, 2015 from the GEOS-Chem Classic nested-China simulation (black symbols) and the WRF-GC simulation (red symbols) for (c) 13 major Chinese cities.

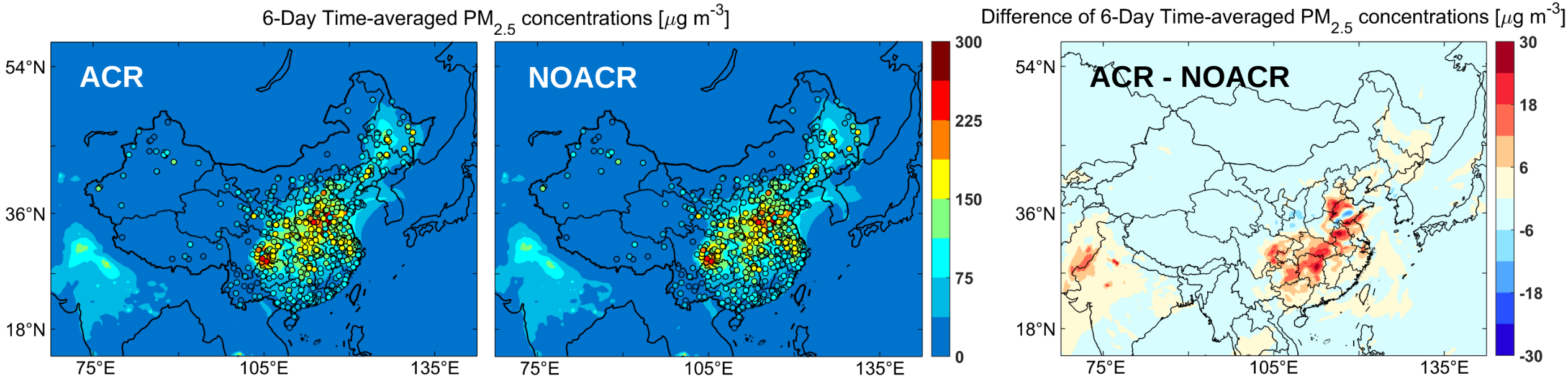
Representation of regional pollution meteorology





WRF-GC simulation nudged with meteorological observations was able to better represent the regional meteorology, such as the RH, WS10M, and PBLH in comparison with those from GEOS-FP dataset.

Impacts of aerosol-cloud-radiation interactions (ACR) on $PM_{2.5}$ over China



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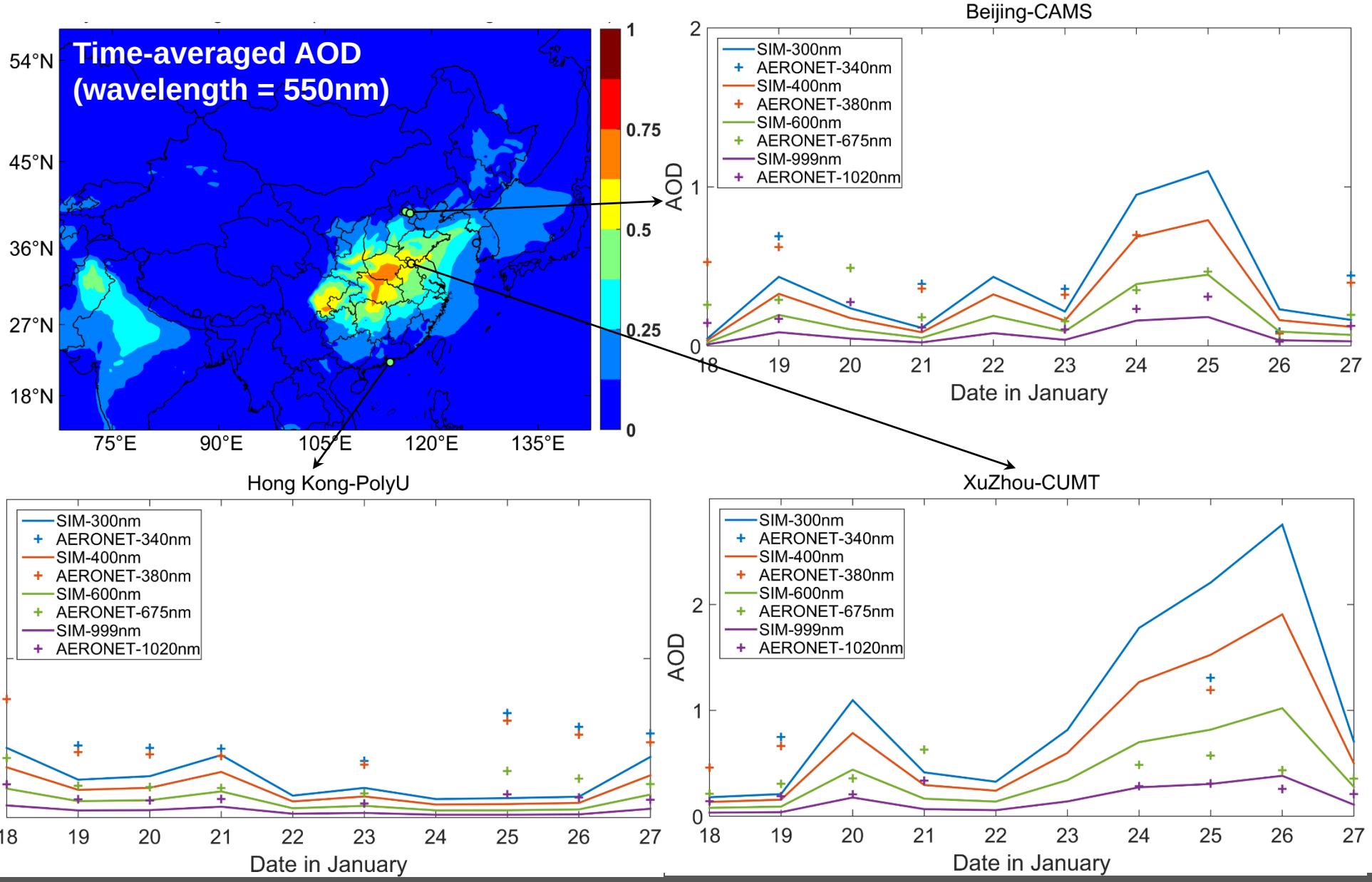
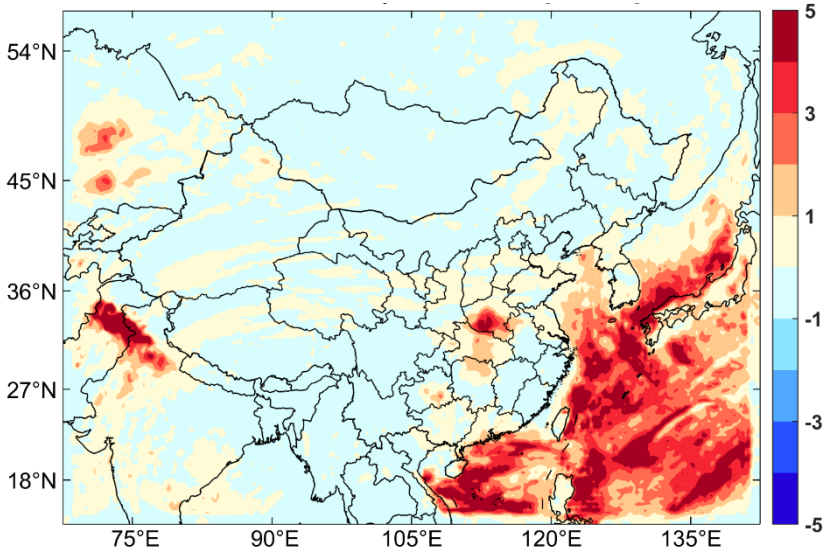
Simulated AOD by WRF-GC in comparison with AERONET dataset

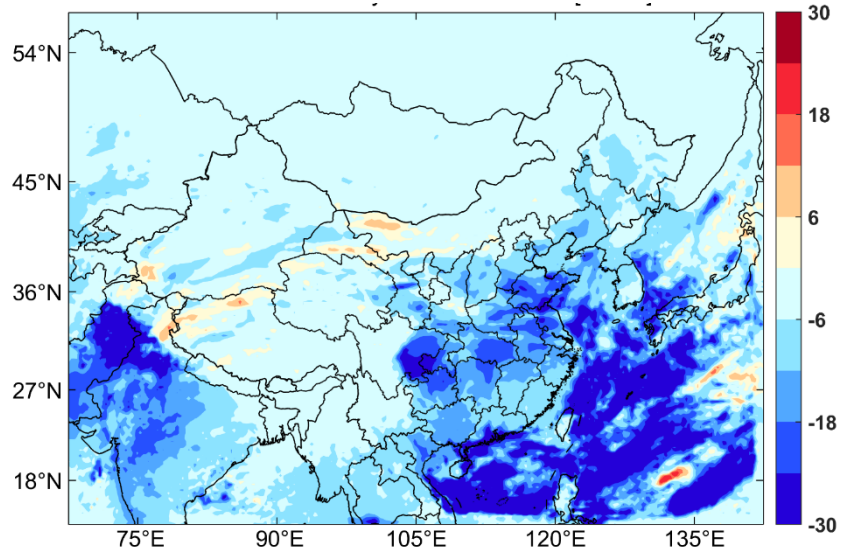


Impacts of aerosol-cloud-radiation interactions (ACR) on meteorology

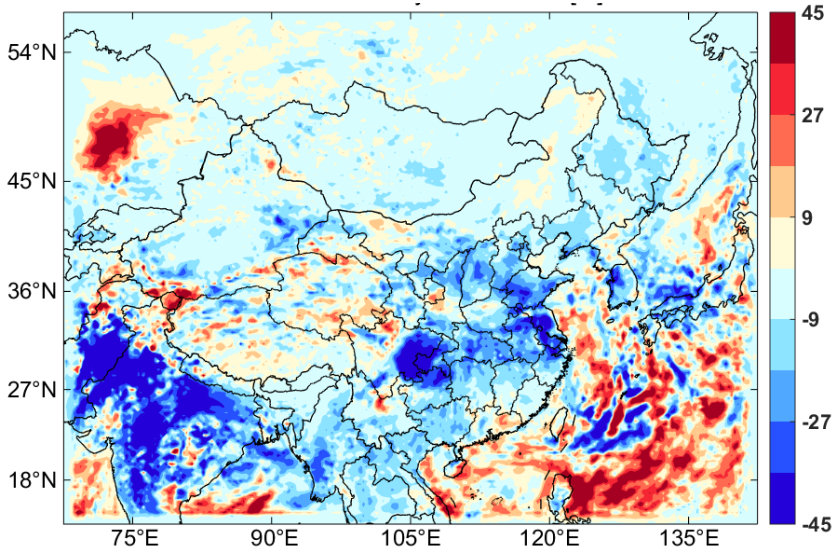
Cloud optical depth [unitless]
ACR - NOACR



Downward surface solar radiation [W m^{-2}]
ACR - NOACR



PBLH [m]
ACR - NOACR



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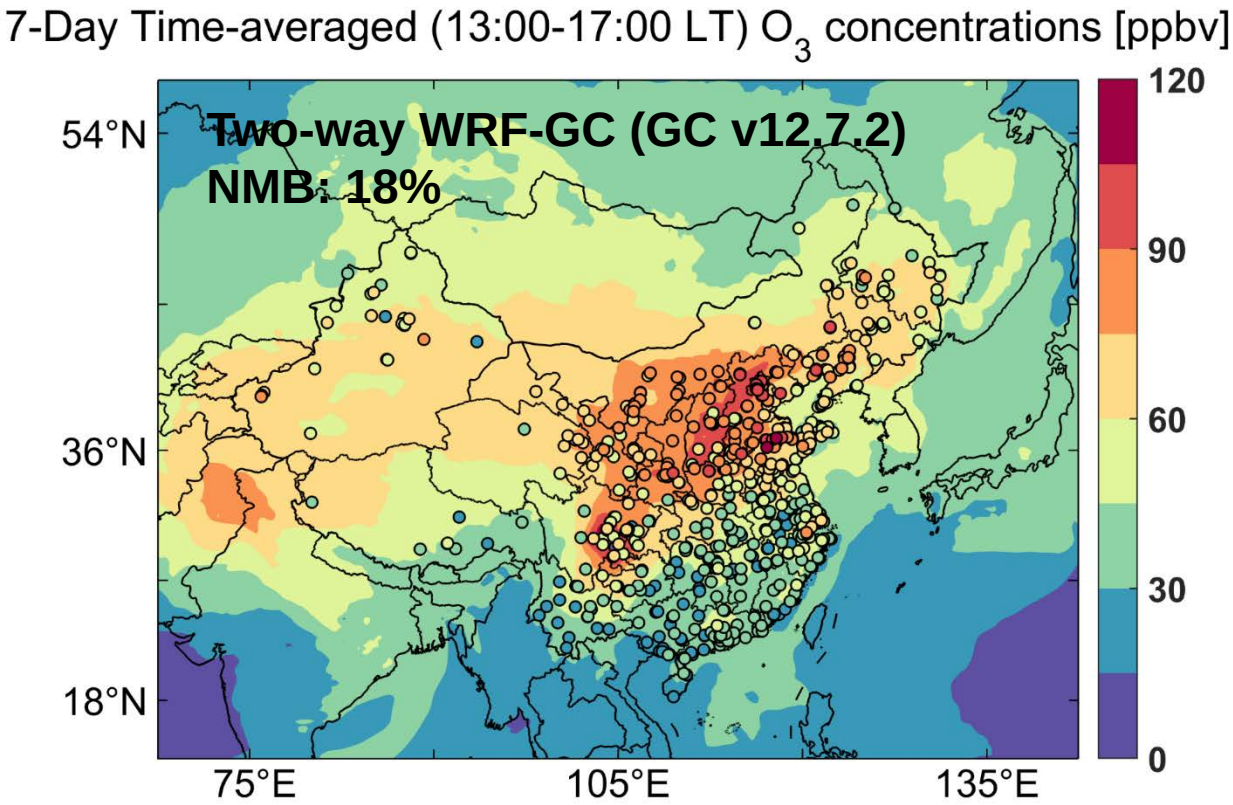
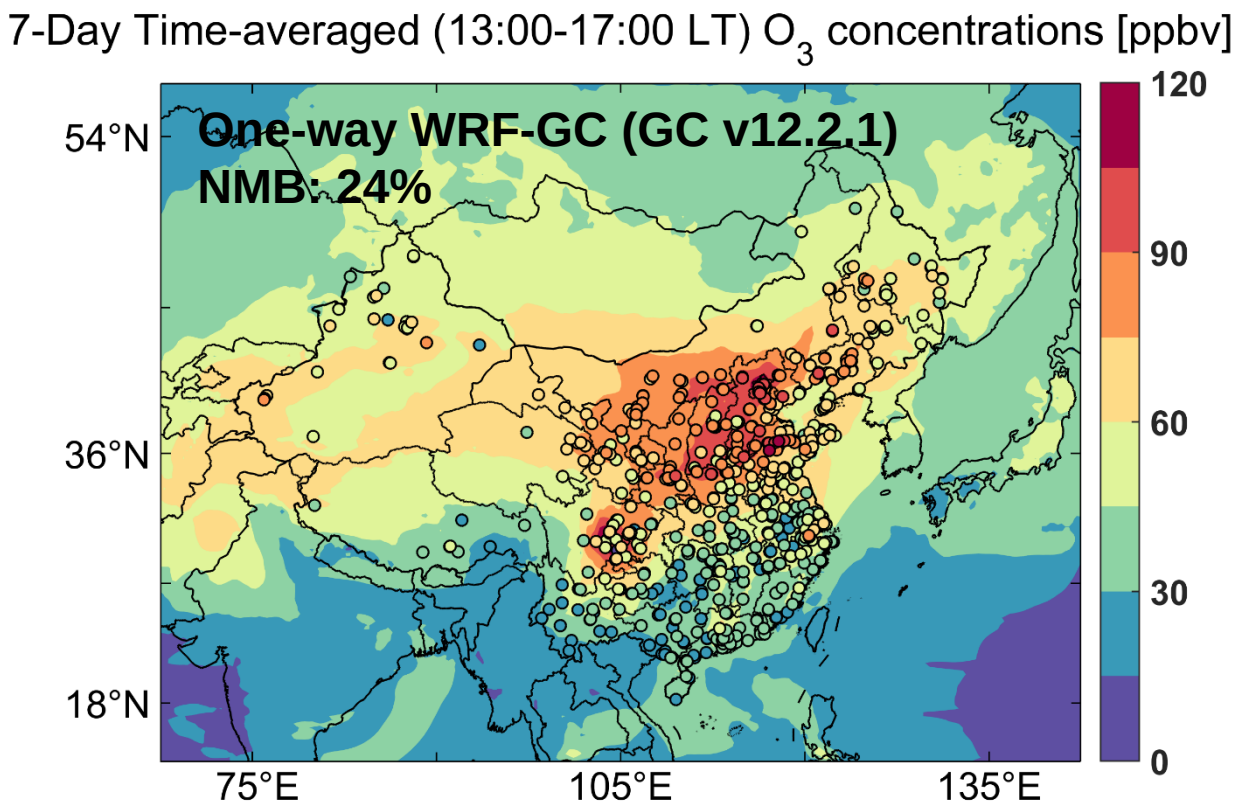
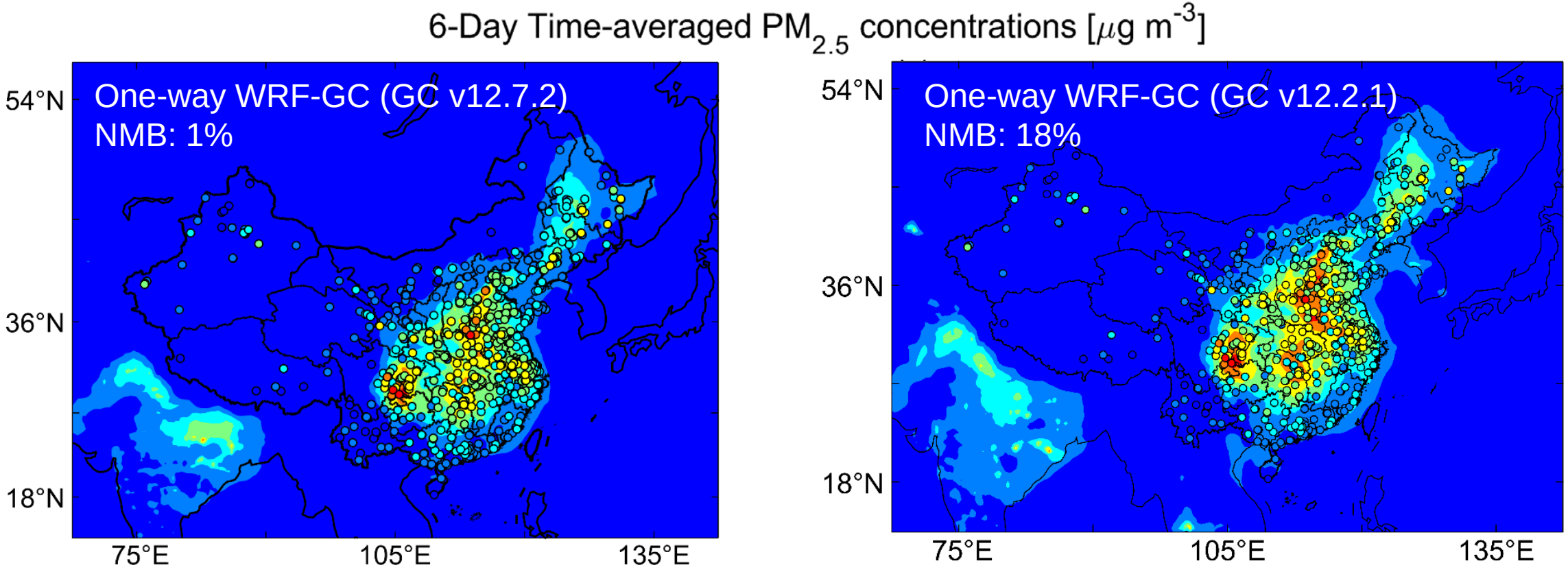
Evaluation of WRF-GC performance of summer ozone over China





- Simulation period: 2016-06-27 00:00 to 2016-07-08 00:00 (first 4 days initialized model)
- Spatial resolution: 27km
- Chemical initial and boundary conditions: GEOS-Chem 2° × 2.5° global simulation
- Meteorology nudging: off

Improvement of simulated $PM_{2.5}$ due to updates of the dry deposition (HNO3)



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- Meteorology nudging: on

WRF-GC is open-source and freely available

- WRF-GC Homepage: http://wrf.geos-chem.org

- *More information on one-way WRF-GC model: https://www.geosci-model-dev-discuss.net/gmd-2019-333/gmd-2019-333.pdf*

Contact us

If you are interested in downloading WRF-GC and giving it a spin, please send us an email (fuzm@sustech.edu.cn) and tell us your name, affiliation, and intended general application. We will add you to a mailing list and keep you updated on new version releases.