HARVARD-CHINA PROJECT
on Energy, Economy and Environment

WRF-Chem Modeling of Interactions between Aerosol Concentration, Solar Radiation and Boundary Layer Growth

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Yale-NUIST Center Video Conference

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About Me

June, 2012 — B.S., Atmospheric Physics

May, 2015 — M.S., Chemical Engineering

Dec., 2015 — Ph.D., Chemical Engineering

Advisor: Greg Carmichael

2016- — PDF, Env. Sci. & Eng.

Advisor: Michael McElroy

About the HARVARD-CHINA PROJECT on Energy, Economy and Environment

Founded, 1993

RESEARCH AREAS:
China's economy, energy, atmospheric environment and environmental health.

Collaborations

HARVARD SCHOOLS : SEAS, SPH, KSG, FAS (EPS, ECON)
COLLABORATIONS WITH:
- Tsinghua University (ENV, ESS, ECON, EE)
- Nanjing University, School of the Environment;
- Peking University, School of Government, AOS)
- Huazhong University of Science and Technology
- Chinese Meteorological Administration
- State Grid Research Institute;
- Chinese Academy of Sciences

Alumni



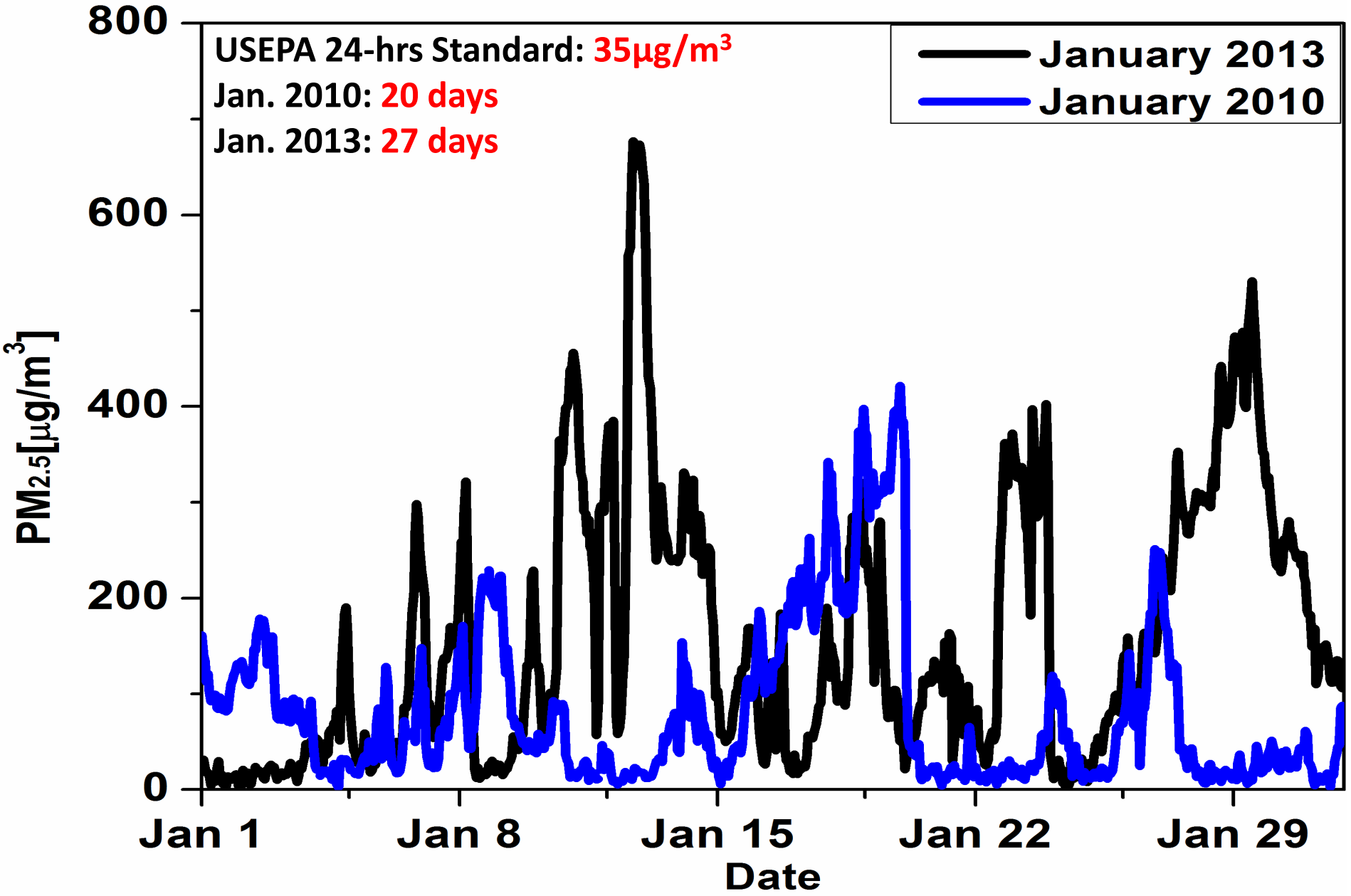



Background

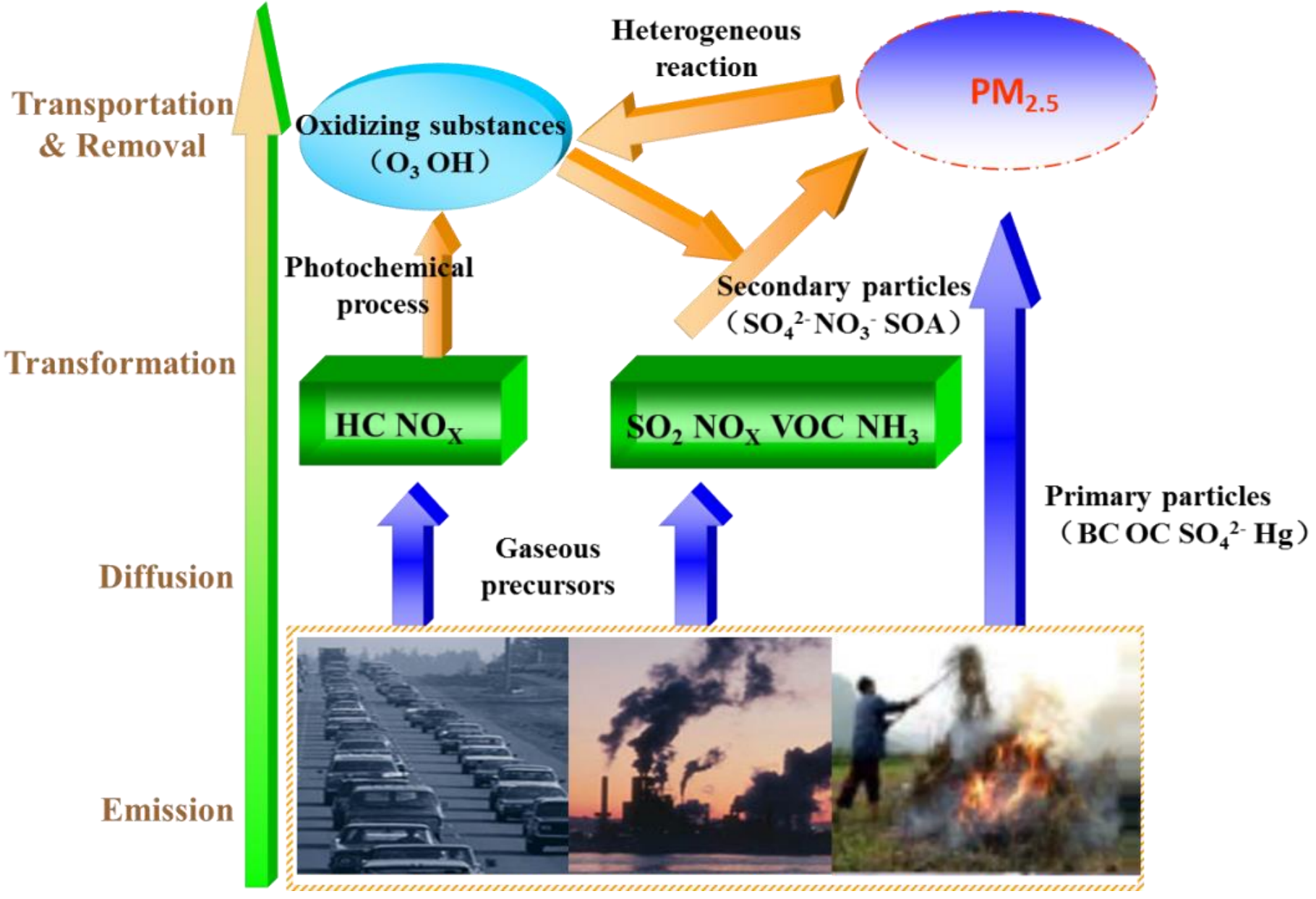
I durst not laugh for fear of opening my lips and receiving the bad air.

William Shakespeare

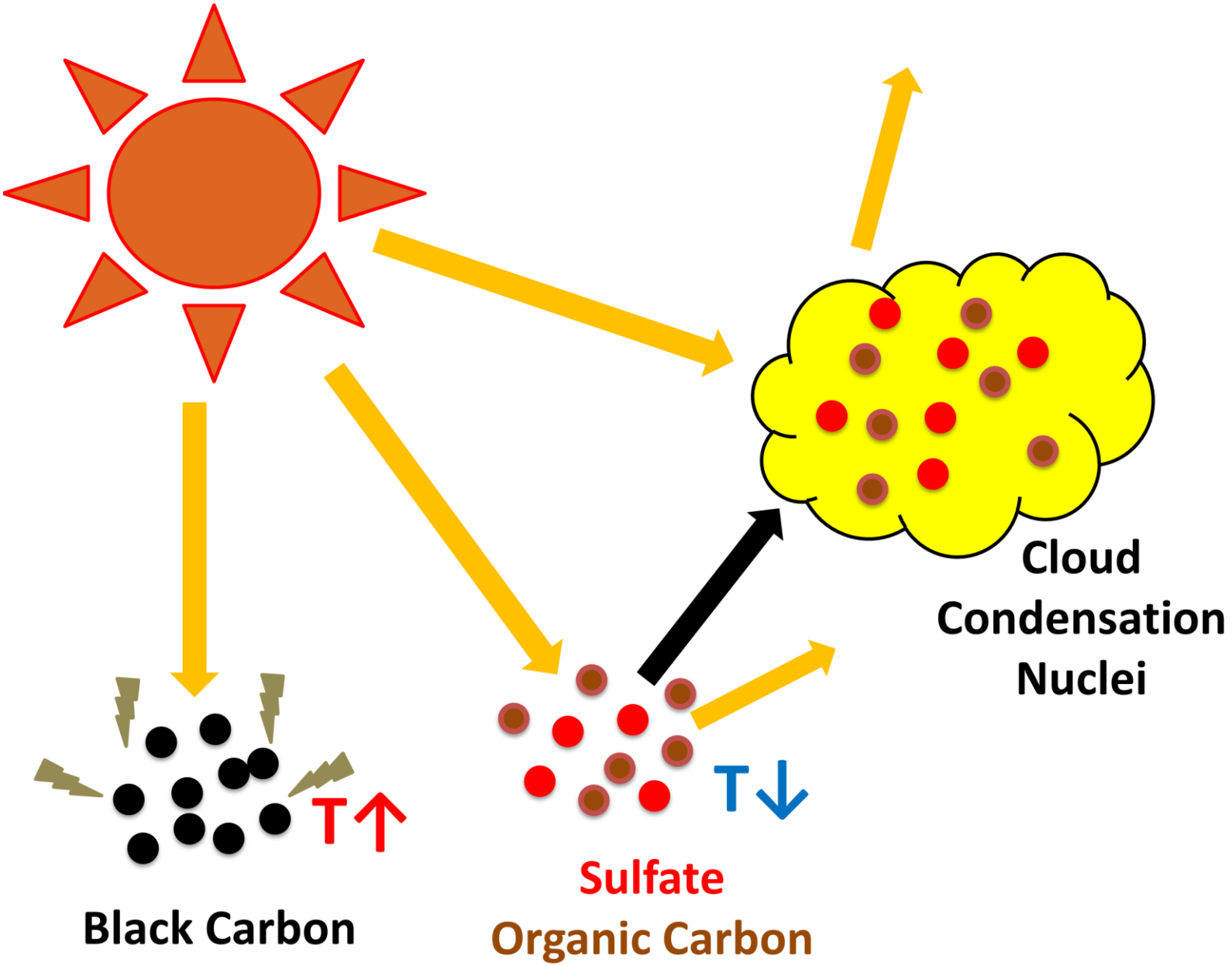
Extreme Winter Haze Events are Happening



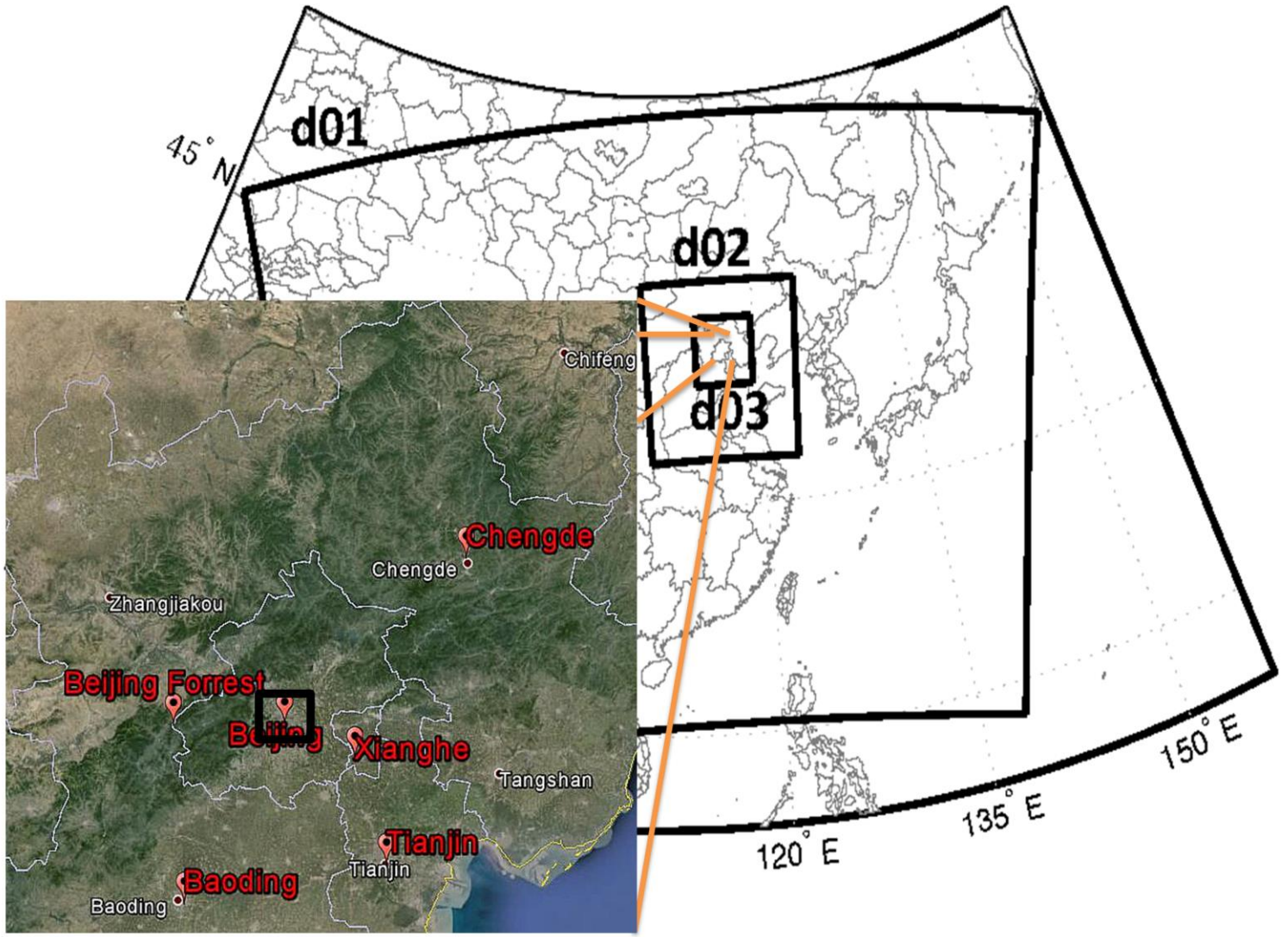
Sources of PM in the Atmosphere



Aerosol Effects



Modeling Study of the 2010 Winter Haze Event

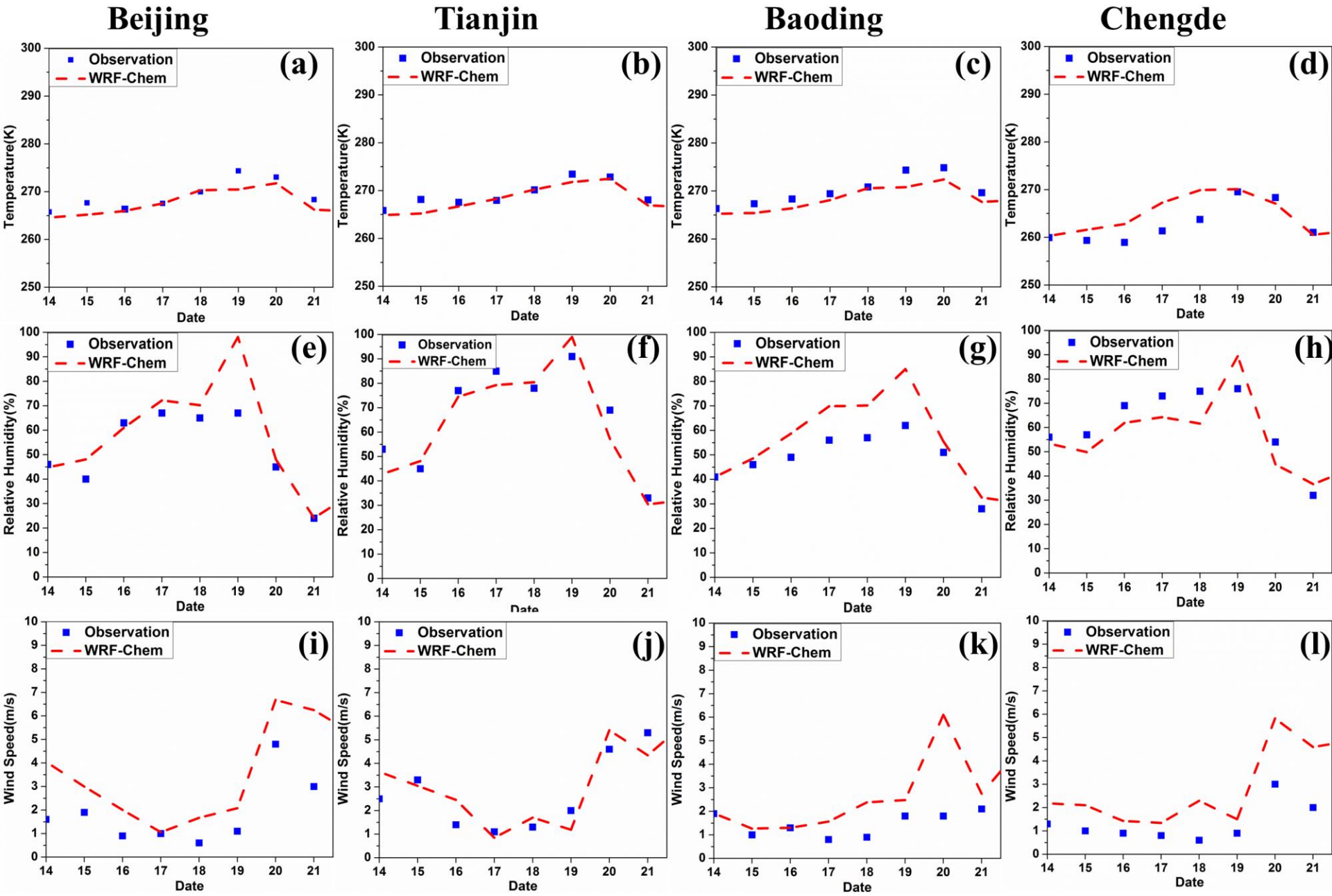


Three Nested Domains (9km, 27km, 81km)

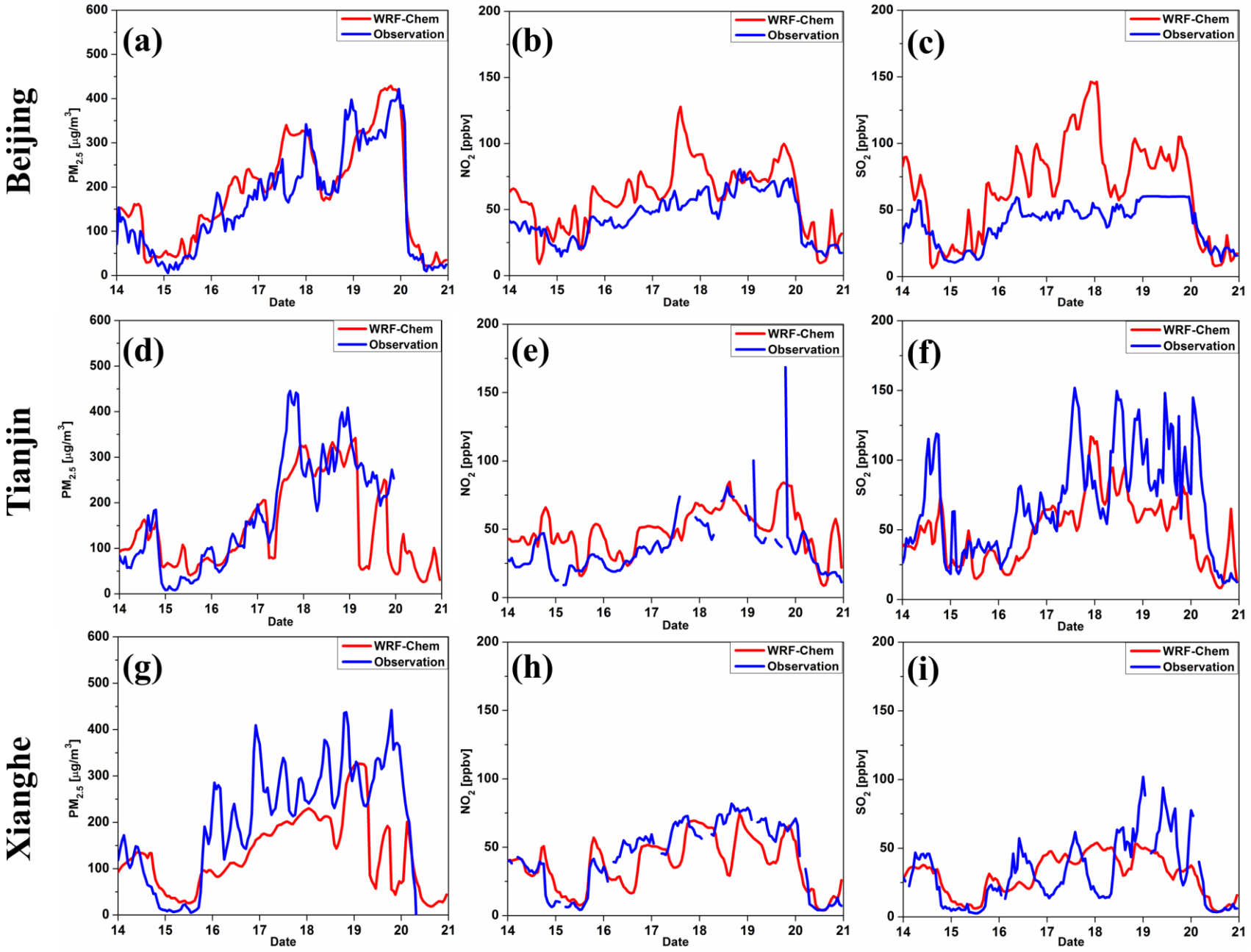
Jan. 16-19, 2010 Regional Haze in the NCP

Gao et al., Springer Book, 2017

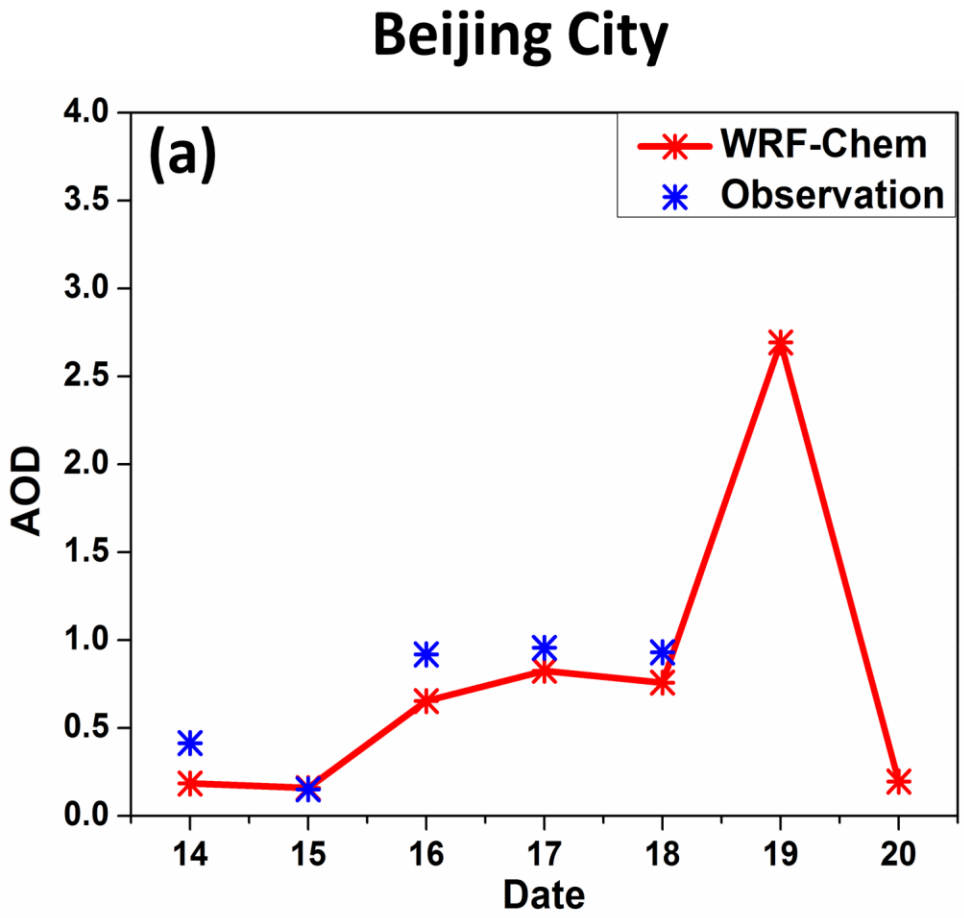
Temporal Variations of Meteorological Variables

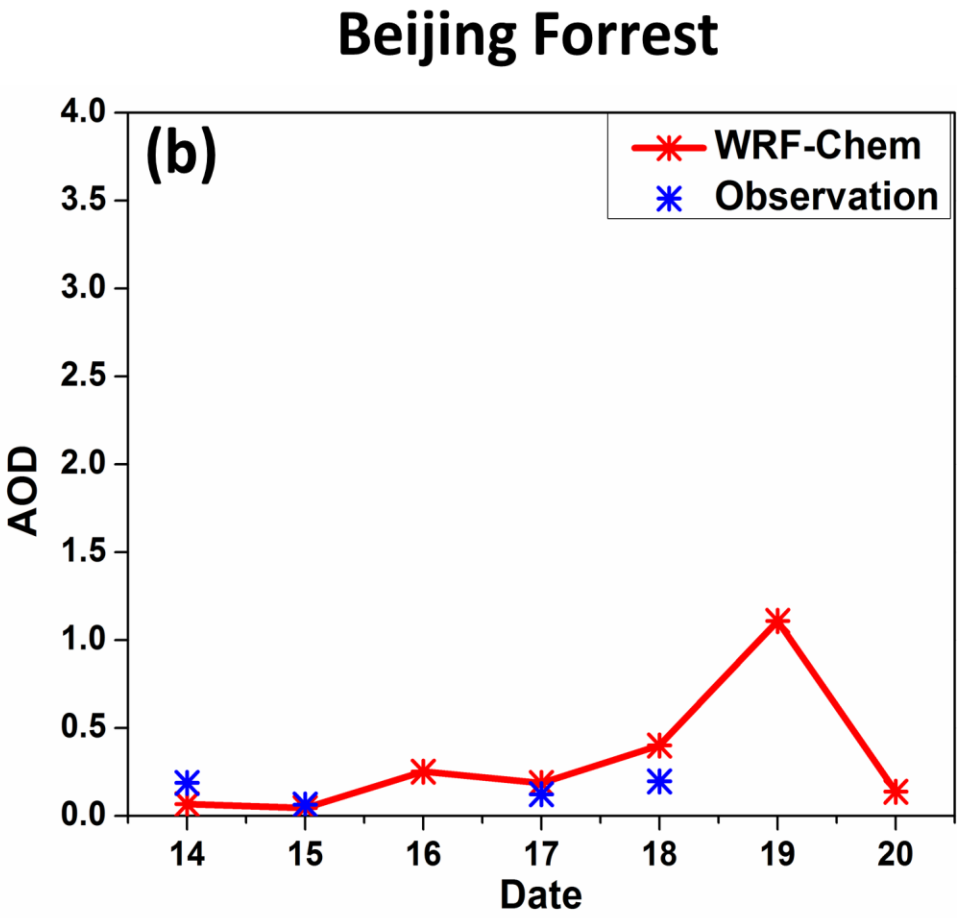


Temporal Variations of Air Pollutants



Simulated and Observed AOD





CALIPSO Lidar Measurements

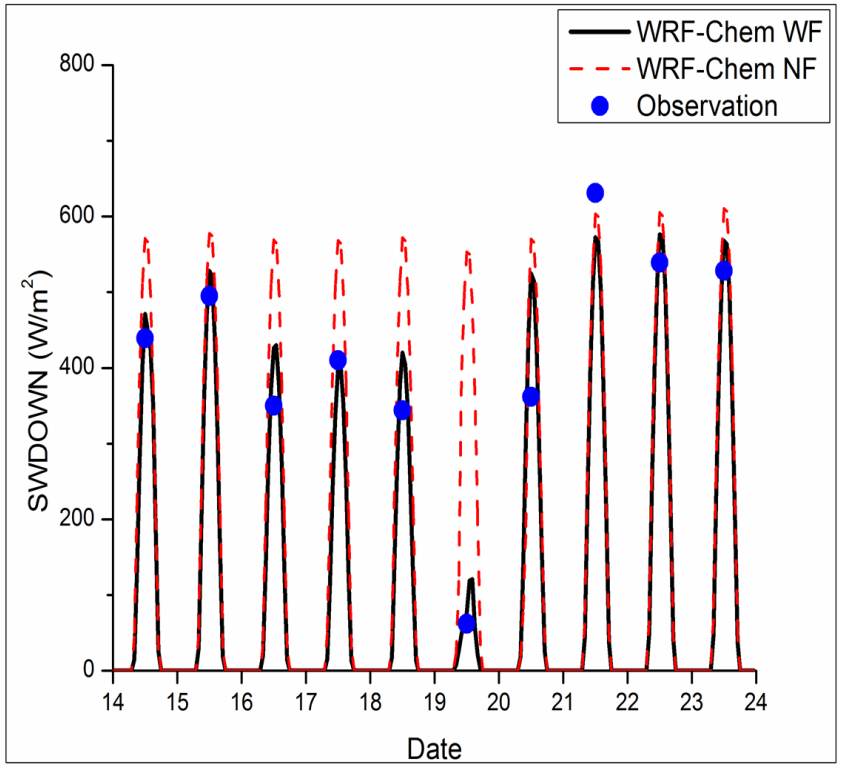
MODIS AOD

Simulations

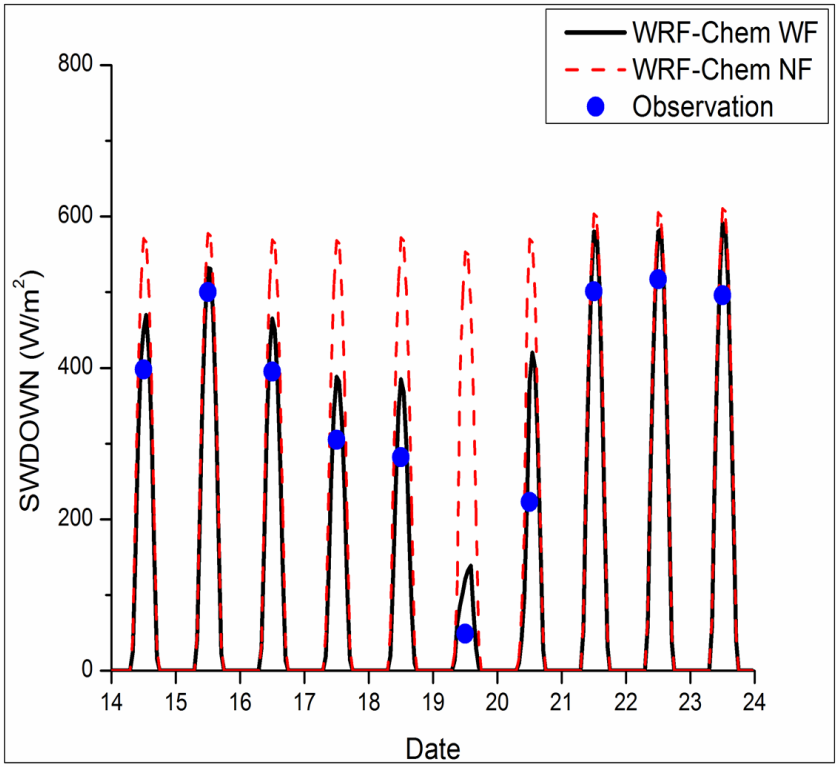
1. WF simulation includes full interactions between aerosols and meteorology (i.e., solar radiation is affected by aerosol concentrations and aerosols interact with clouds).
2. NF simulation eliminates aerosols' effects on radiation.

The difference between WF and NF cases is used to represent the influences of aerosol radiative effects.

Verification of SWDOWN



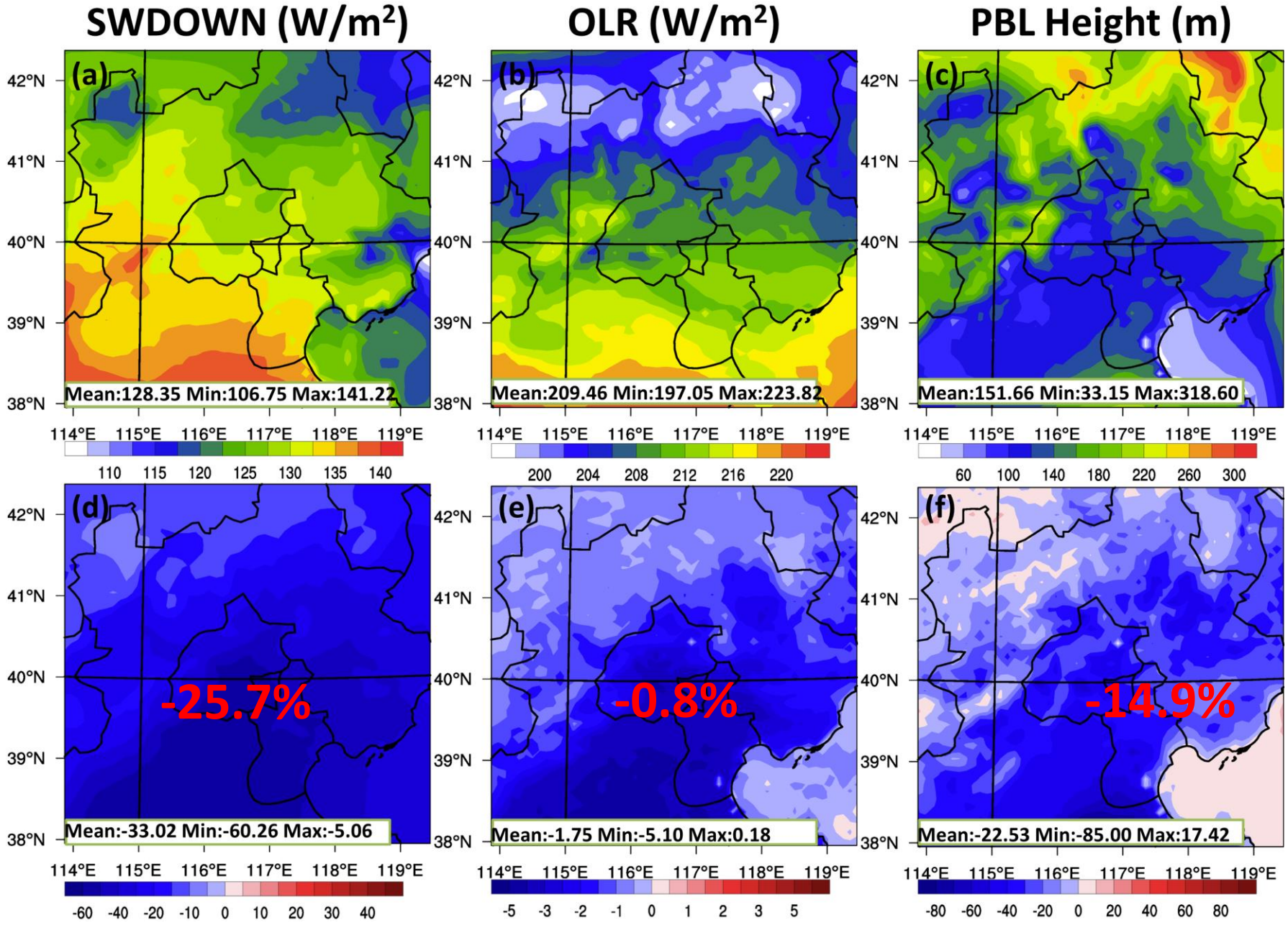
(a)



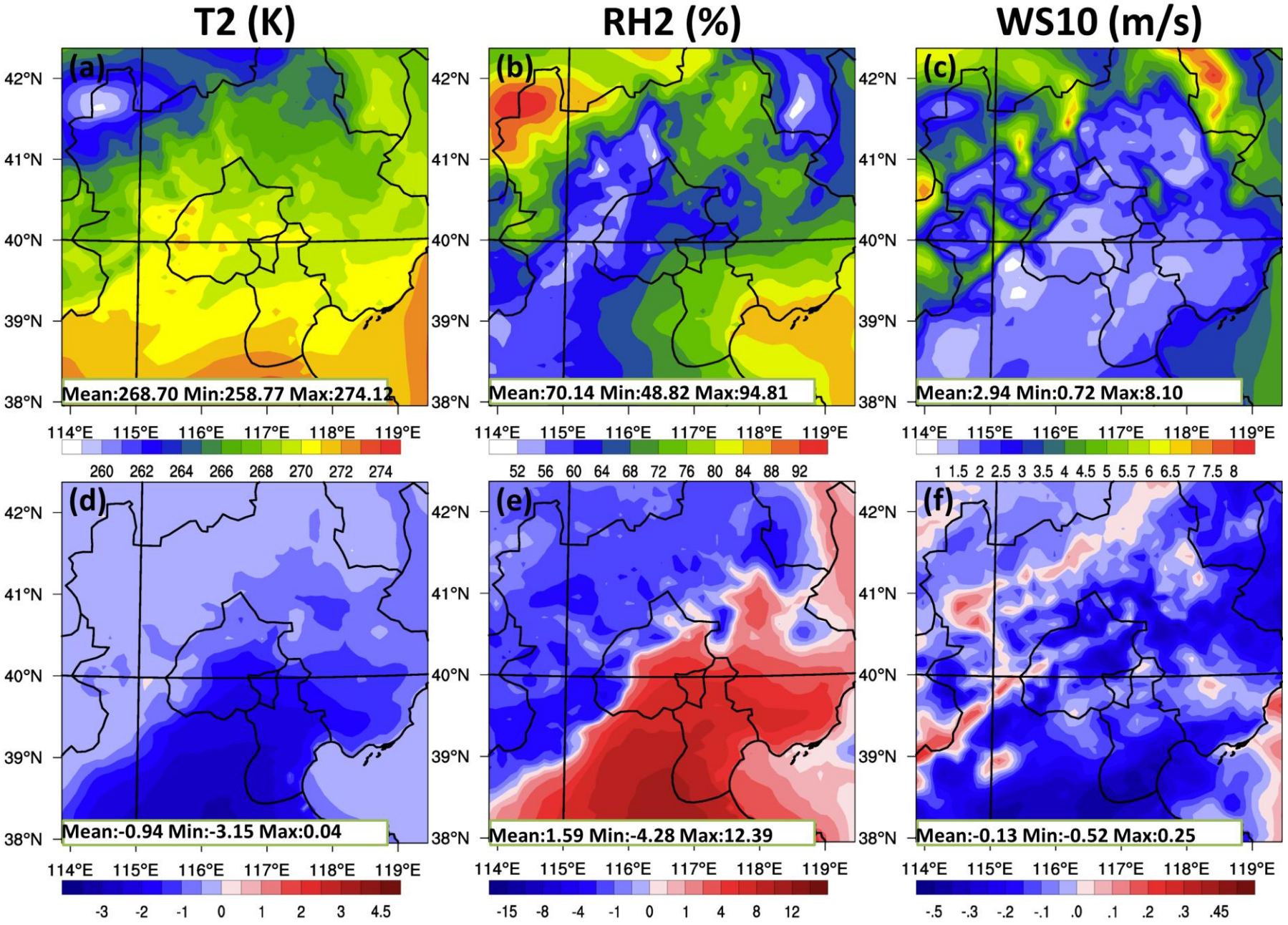
(b)

Gao et al., ACP, 2016

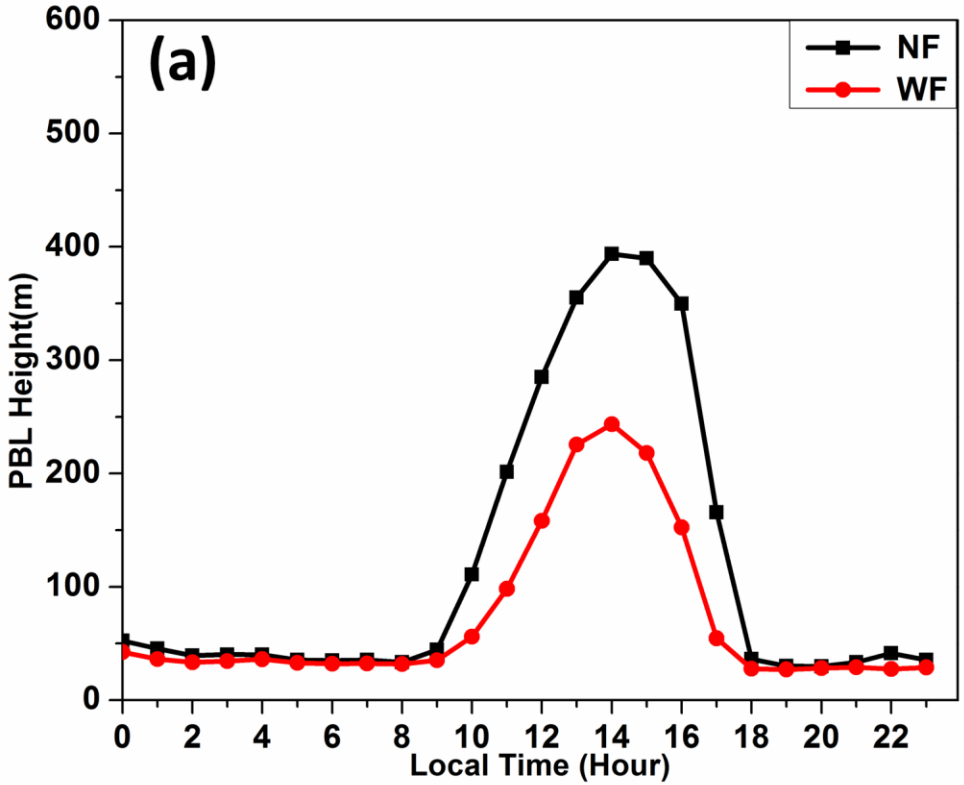
Meteorological Changes

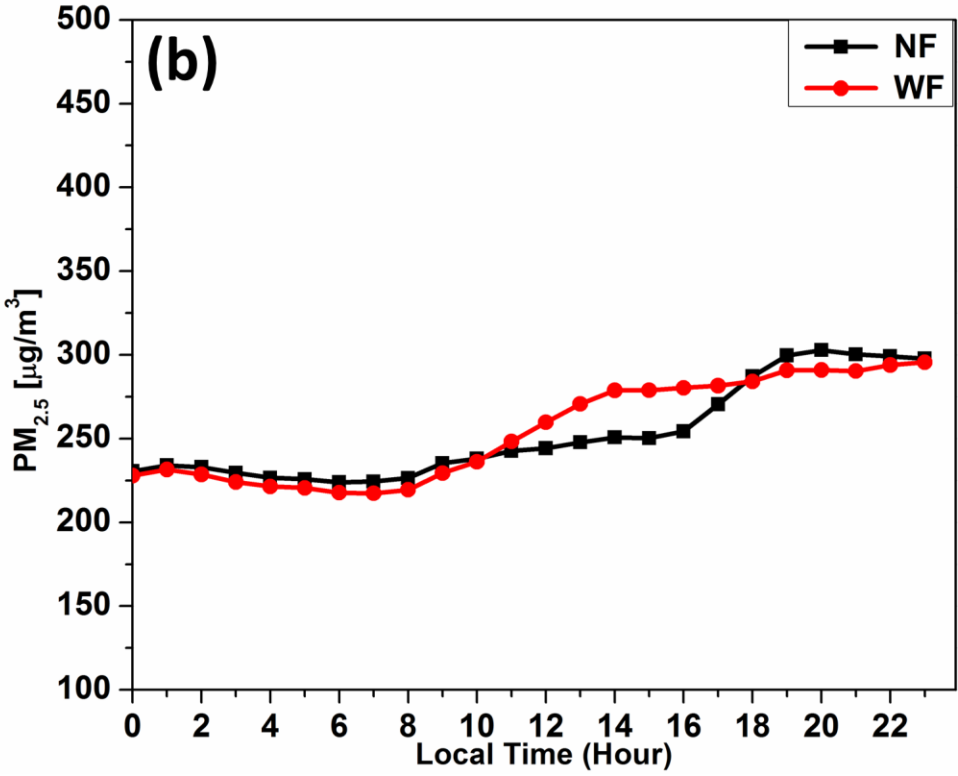


Meteorological Changes

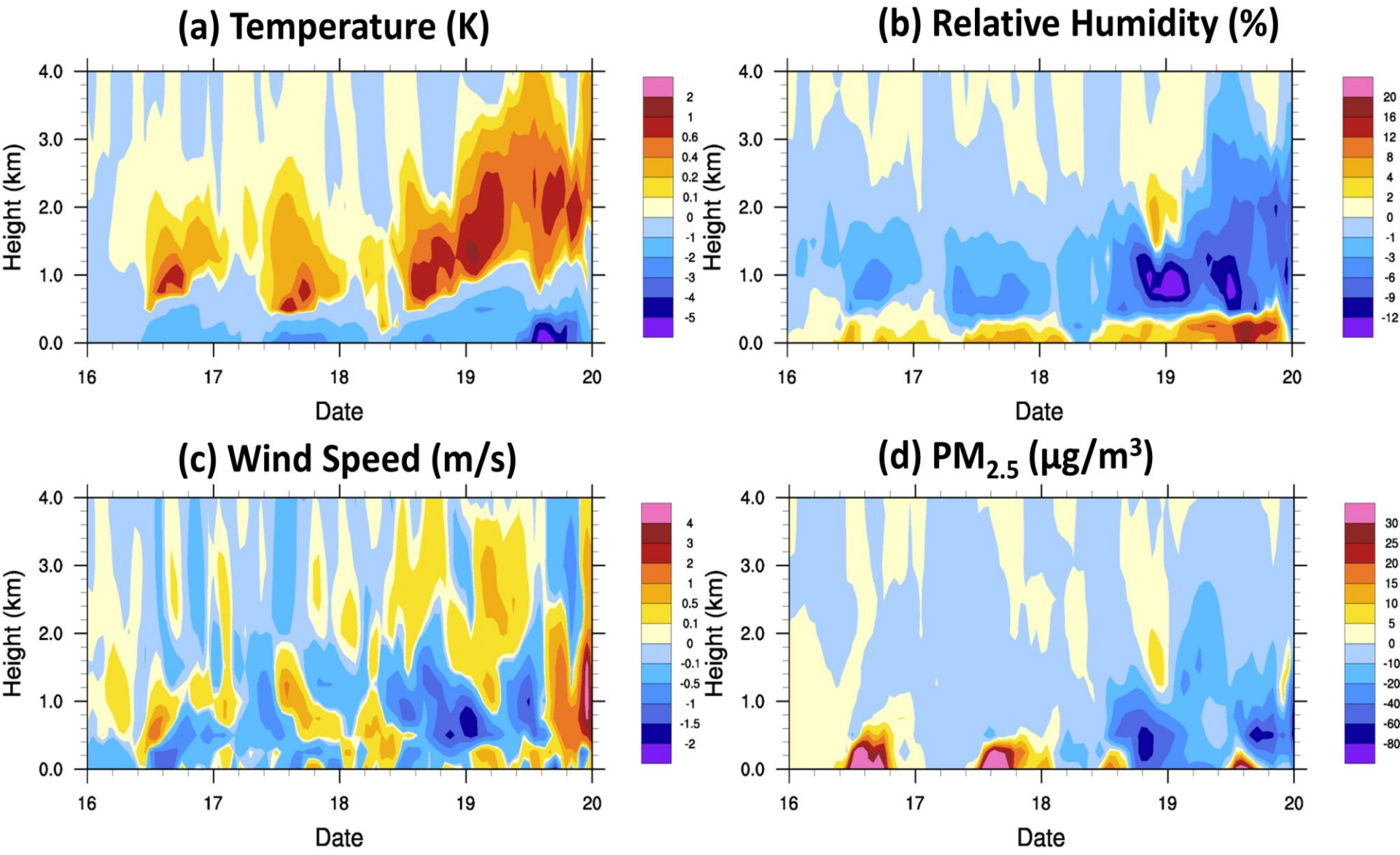


Meteorological Changes

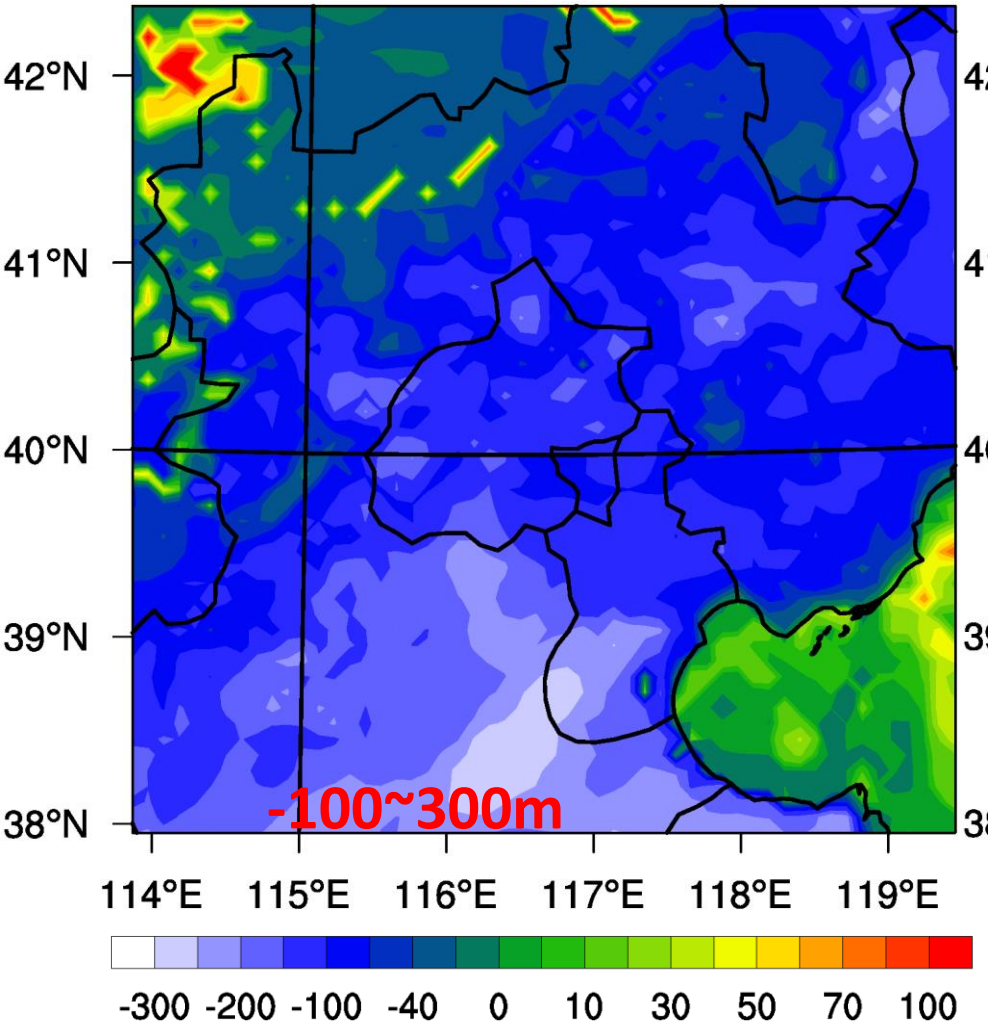




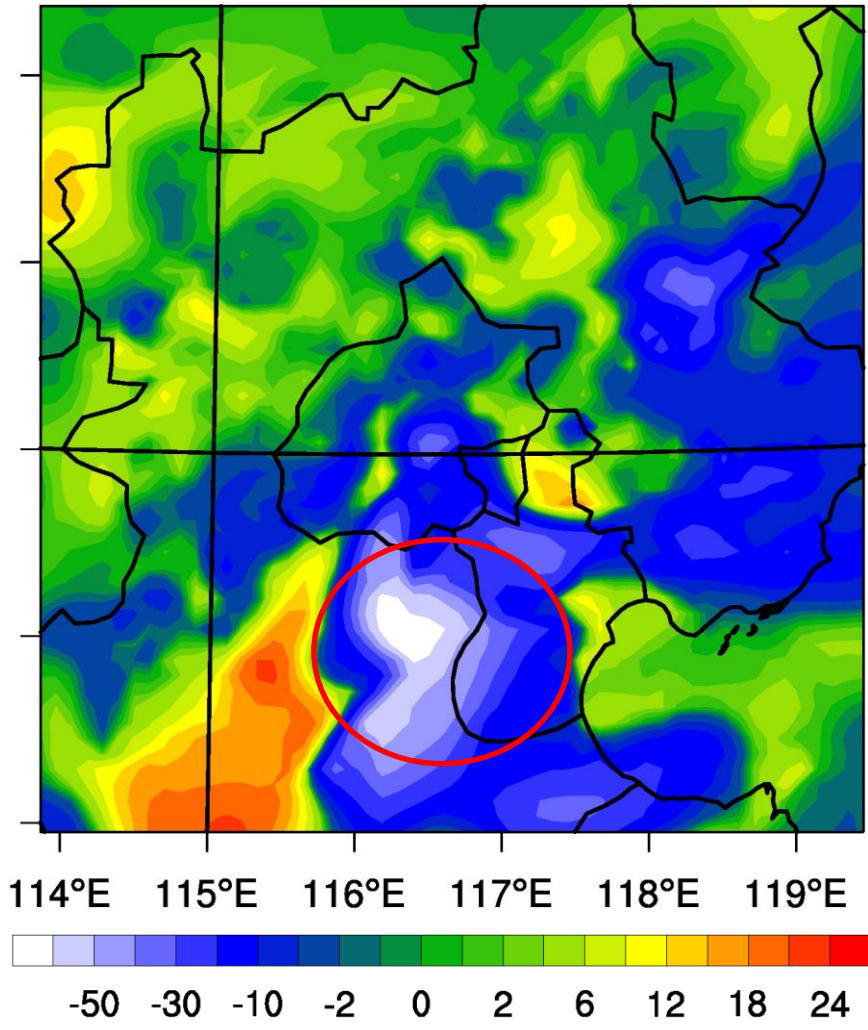
Vertical Profiles of Changes



Impacts of Aerosol Scattering and Absorption

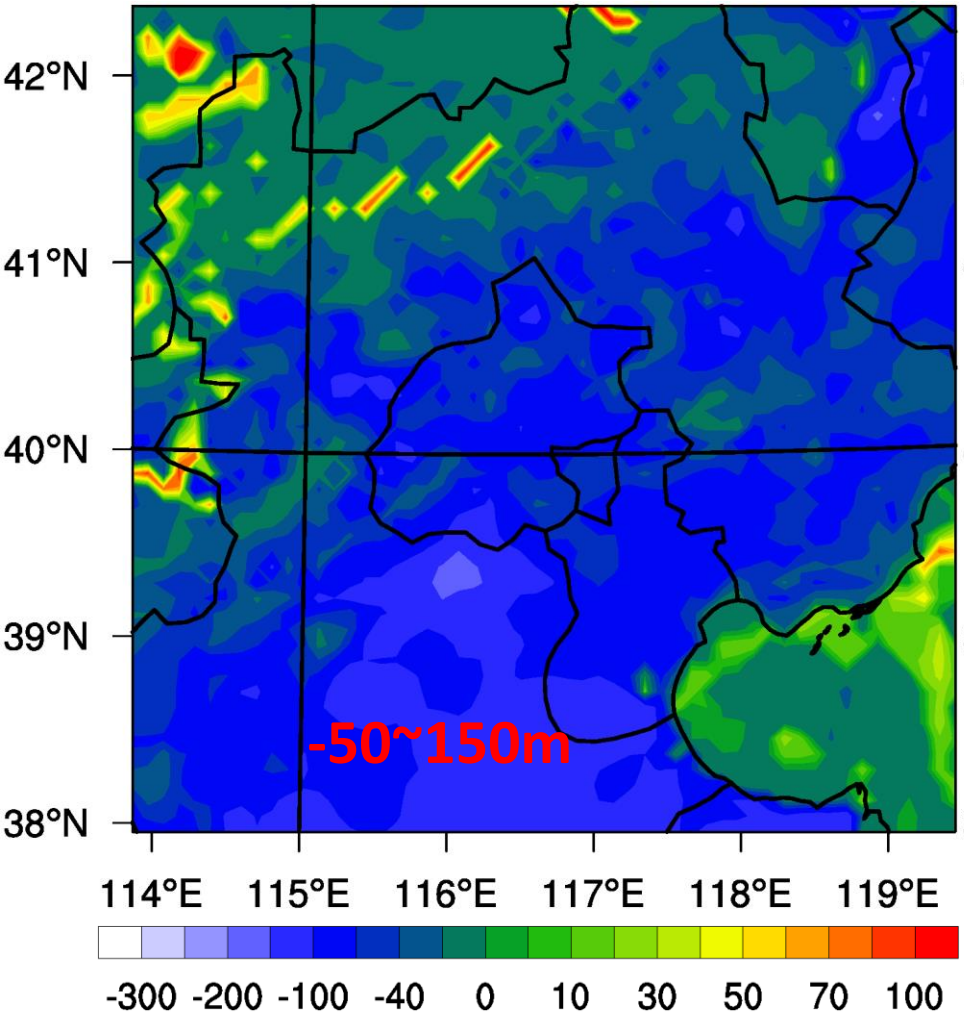


Daytime PBLH difference (WF-NF) m

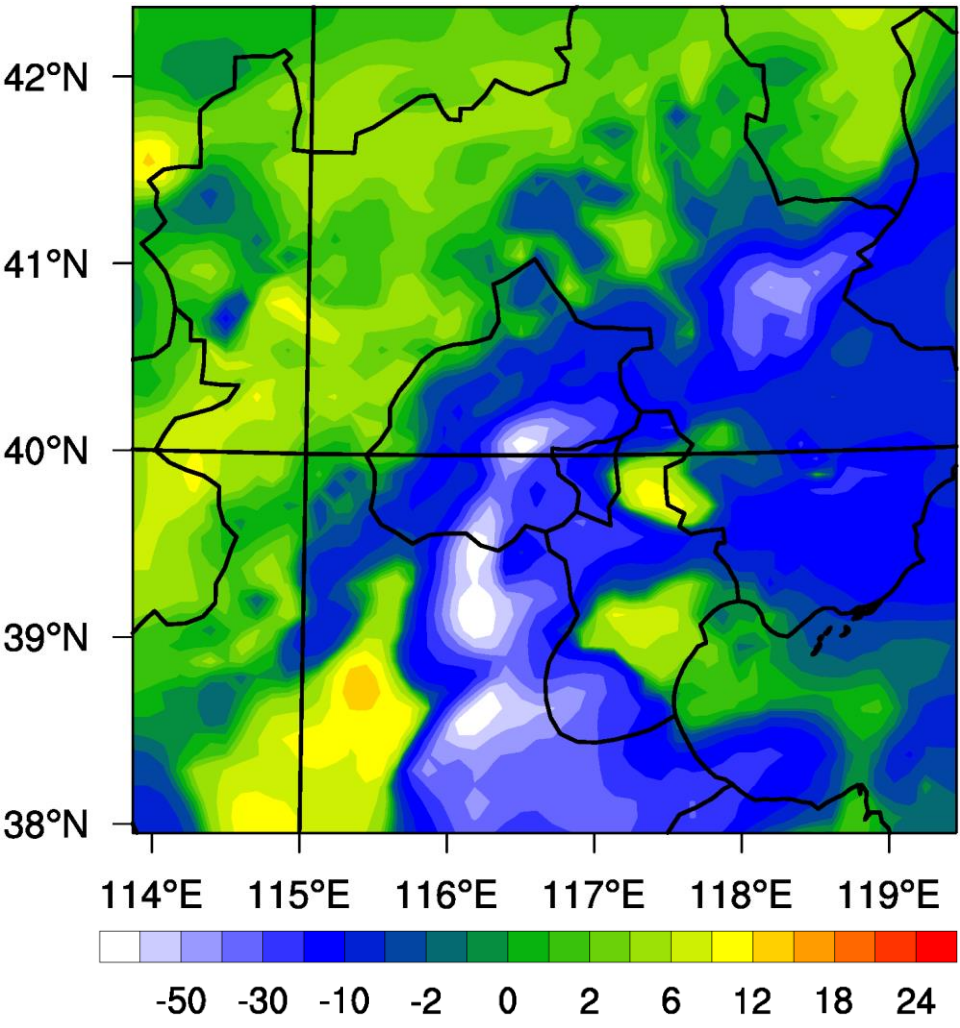


$PM_{2.5}$ difference (WF-NF) $\mu g/m^3$

Impacts of BC Absorption



Daytime difference (WF-NBCA) m

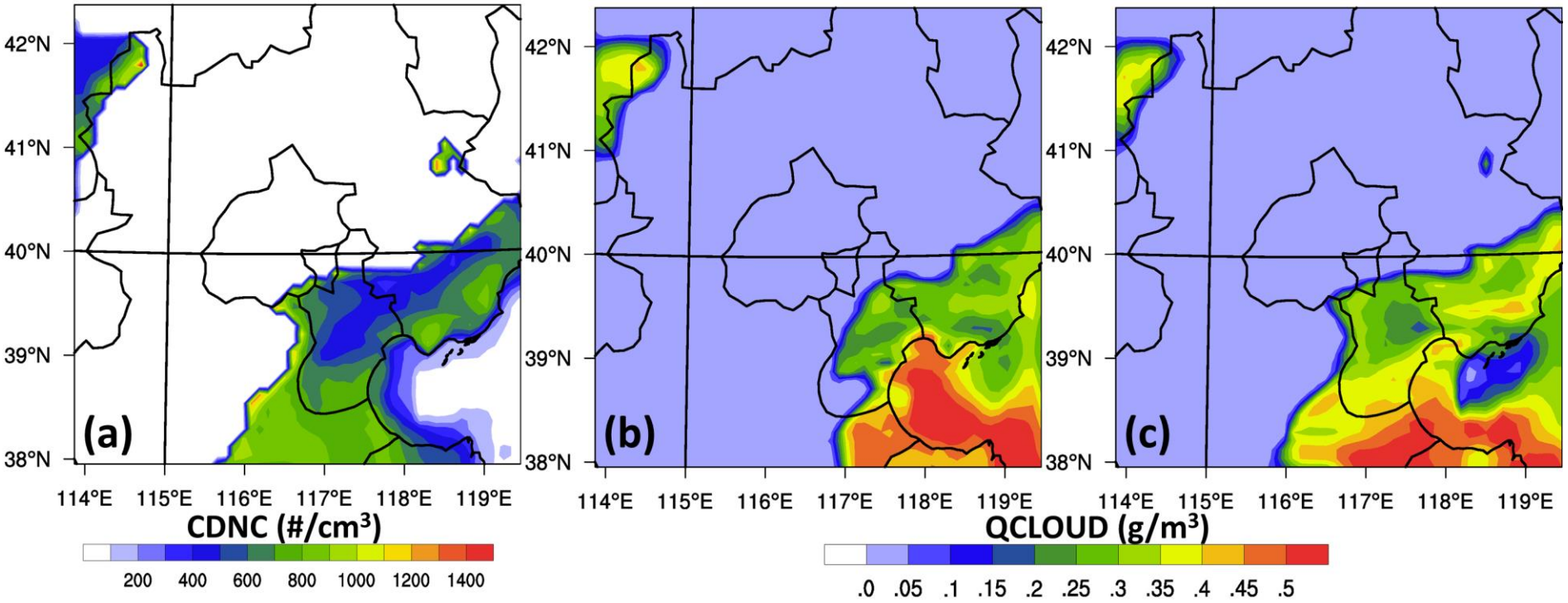


$PM_{2.5}$ difference (WF-NBCA) $\mu g/m^3$

Aerosol Indirect Effects

MET: CDNC is prescribed 250 (#/cm3)

WF: CDNC is calculated based on aerosol concentrations



Near surface cloud droplet number concentration (CDNC) from the WF simulation (a) and near surface cloud water concentration from the MET simulation (b) and the WF simulation (c) at January 19 08:00 AM

MICS-Asia T3: Aerosol-Radiation-Weather Interactions

M1: PNU WRF-Chem

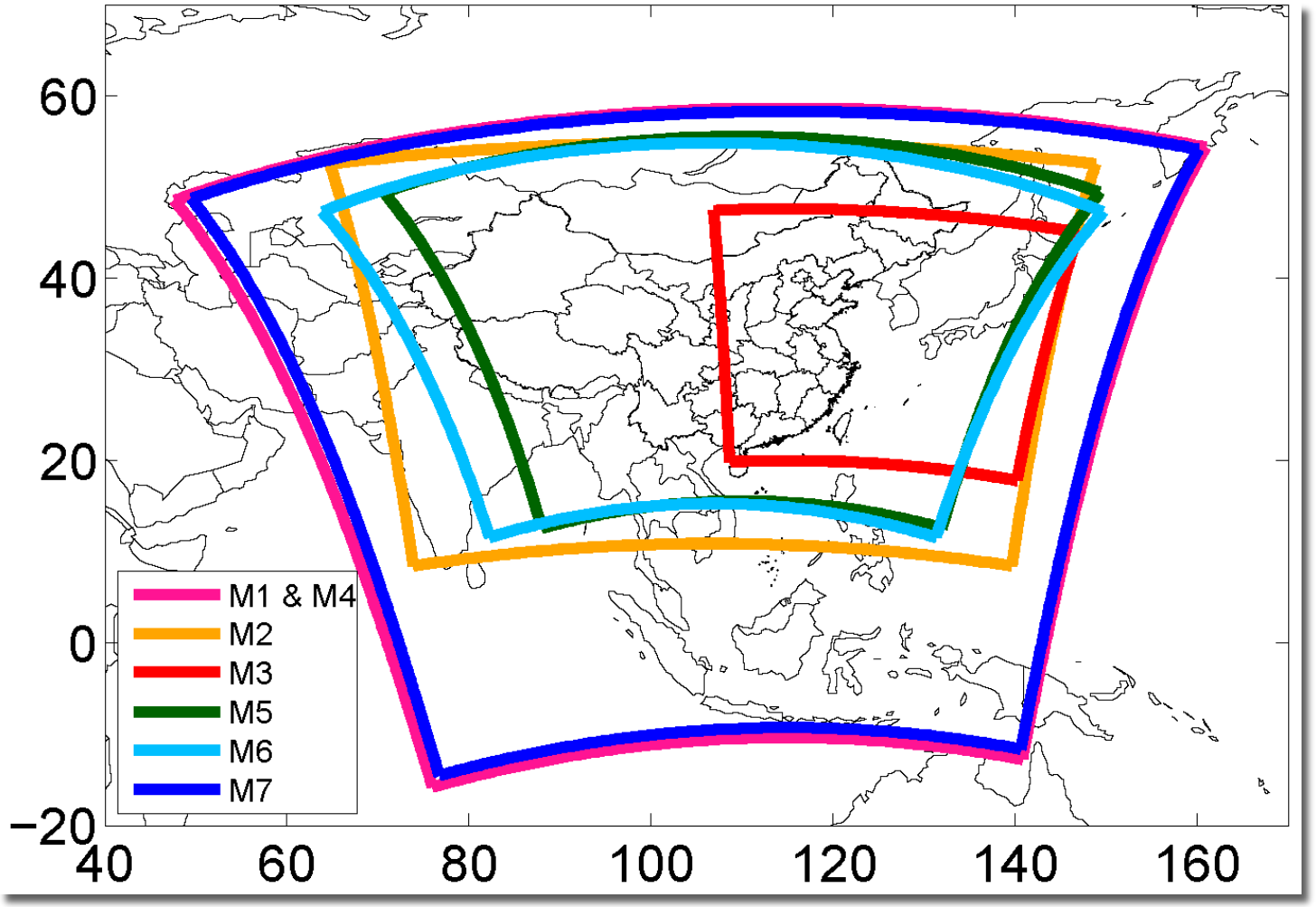
M2: UIOWA WRF-Chem

M3 M4: NU-WRF

M5: IAP RIEMS-Chem

M6: RegCCMS

M7:WRF-CMAQ



Summary

1. Due to aerosol radiative feedbacks, SWDOWN decrease by 25.7% and PBL heights reduce by 14.9% on domain average;
2. Aerosol radiative effects also affect T2, RH2 and WS10;
3. In urban Beijing, the averaged increase in surface PM2.5 concentrations can reach 28.0μg/m3 (+11.2%) at 14:00;
4. BC absorption account for a large fraction in aerosol feedbacks;
5. High aerosol loadings during haze can promote cloud formation, which might favors aerosol formations from cloud chemistry.

Questions?