中国科学技术大学
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Modeling diurnal variation of surface PM2.5 concentration over East China with WRF-Chem: Impacts from boundary mixing and emission

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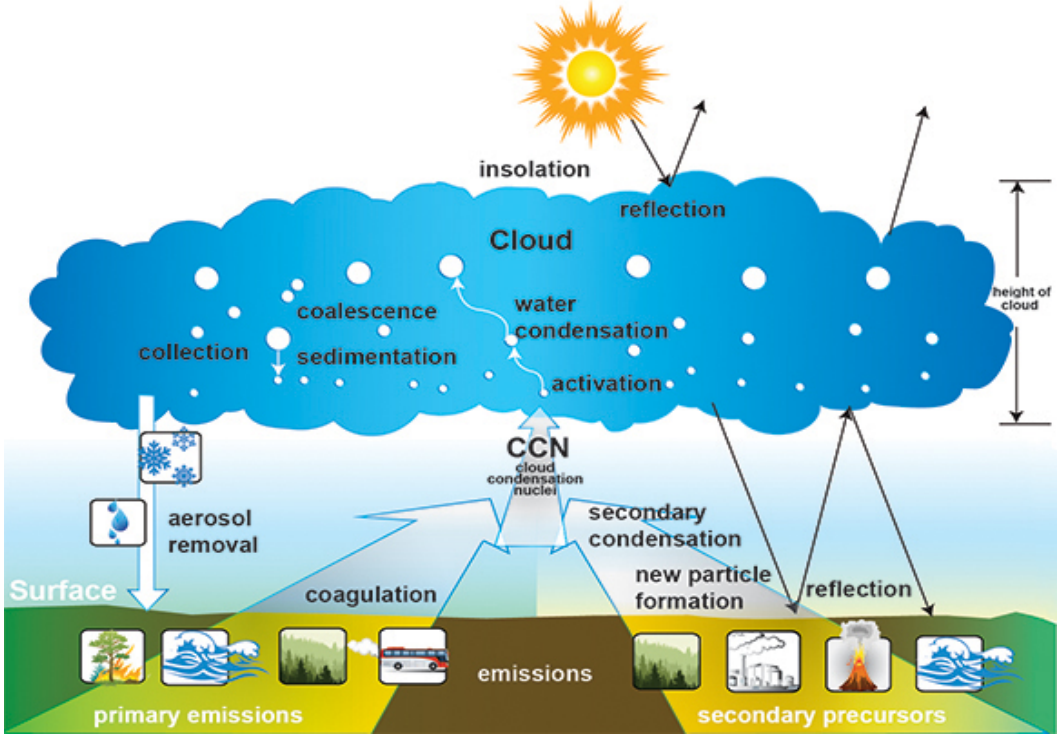
Importance of $PM_{2.5}$

- **Health effect**

  The fourth risk factors of deaths in China

- **Climate effect**

  Interacting with radiation, serving as cloud condensation nuclei (CCN) and affecting climate indirectly



Previous studies

➢ $PM_{2.5}$

- Formation, Spatial and temporal variations
- Daily, monthly, seasonal scales

➢ **Diurnal variation of $PM_{2.5}$**

- Lack of modeling studies, mechanisms still unclear
- Evident diurnal variations has been observed in East China
- Critical for revealing mechanisms of PM2.5 formation and evolution, affect simulating mean concentrations

Impact Factors

- **Emissions**

Strength, Diurnal profile, Injection height

- **Meteorology**

Advection, Wet and dry deposition, Planetary boundary mixing

- **Chemical reactions**

Secondary aerosol formation

Mechanisms of diurnal variation of $PM_{2.5}$ still unclear and no evaluation research of modeling with WRF-chem

Model and Data

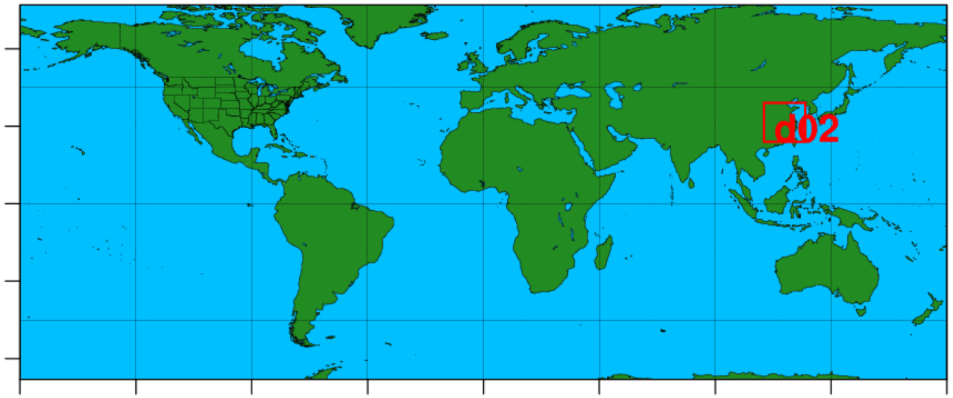
➢WRF-Chem

CBMZ gas chemistry, MOSAIC aerosol module,

KF convection，Morrison microphysics,

YSU/MYNN PBL scheme

Nest 1deg/15km domain



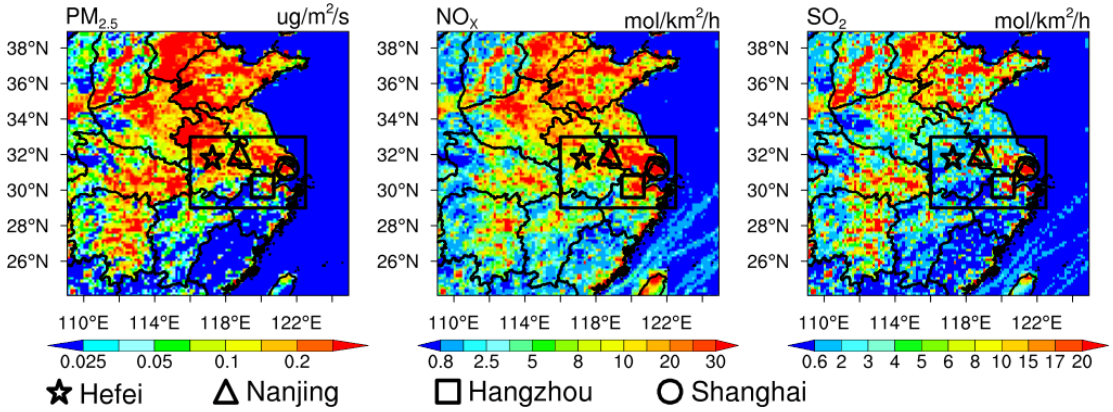
➢Domain & Period:

D01,Quasi-global domain(1deg,360x145)

D02,Nested domain(15km,112x105)

January, April, July, October of 2018

MEIC v1.2 2015



➢Anthropogenic Emission:

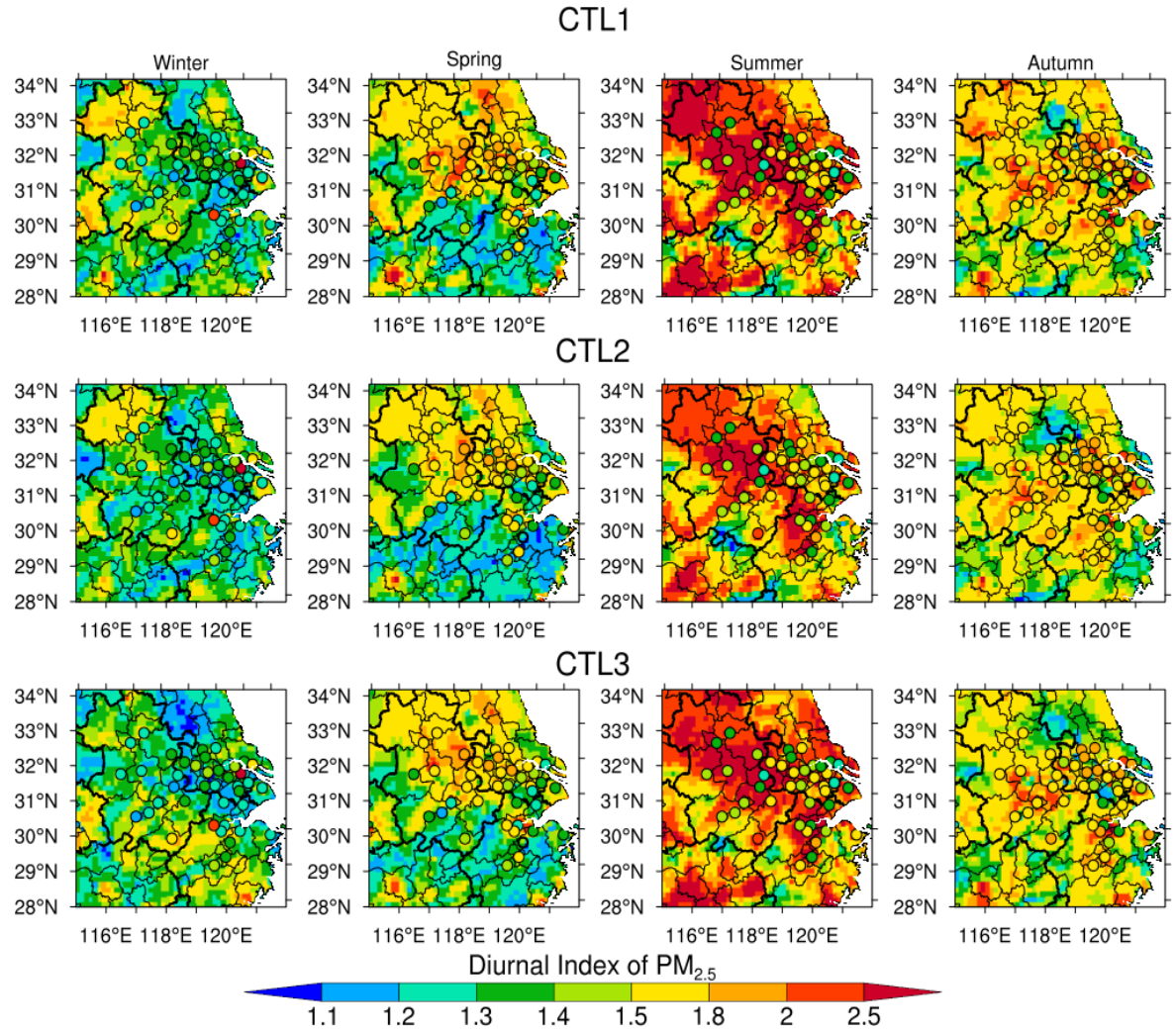
2010 HTAP-EDGAR for D01

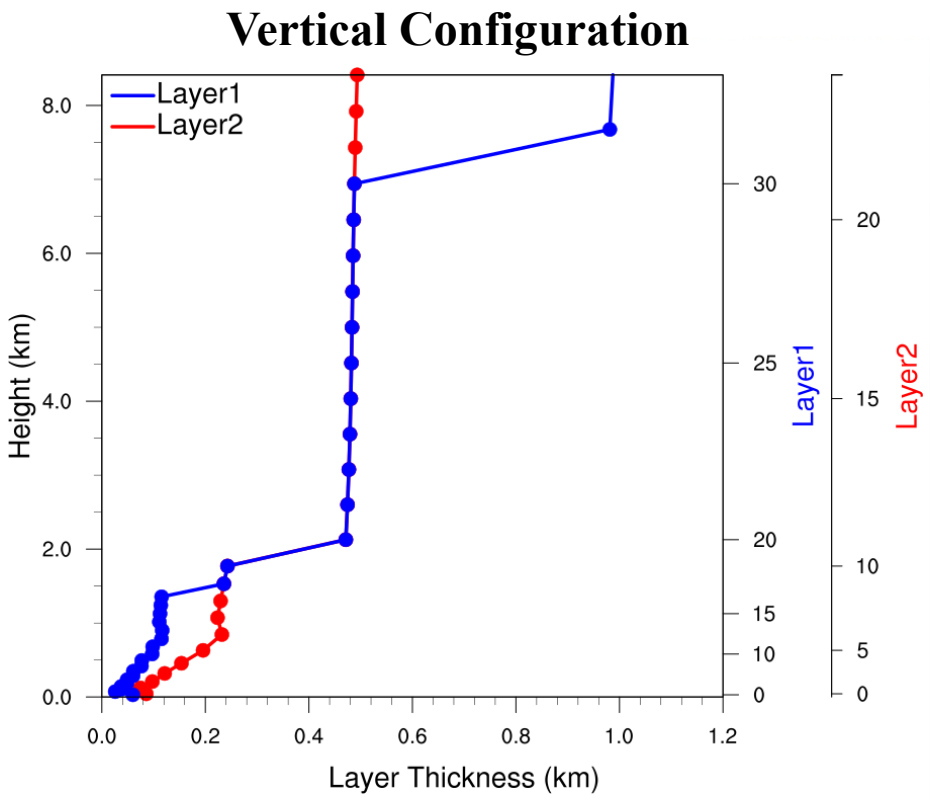
2015 MEIC for D02

➢Observation data:

Ground observations from the MEP of China,190 stations, East China, 2018

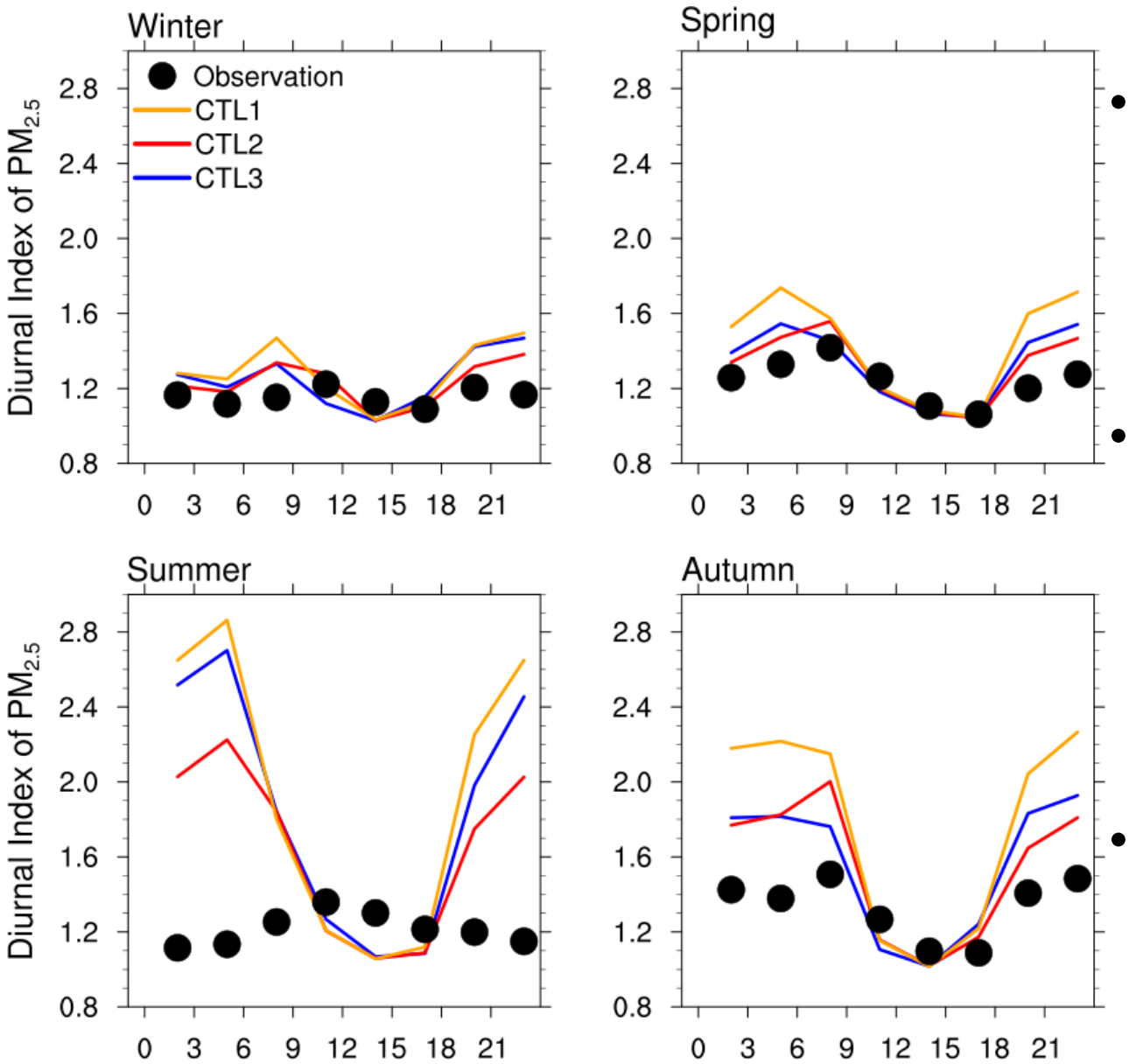
Sensitivity to the PBL mixing





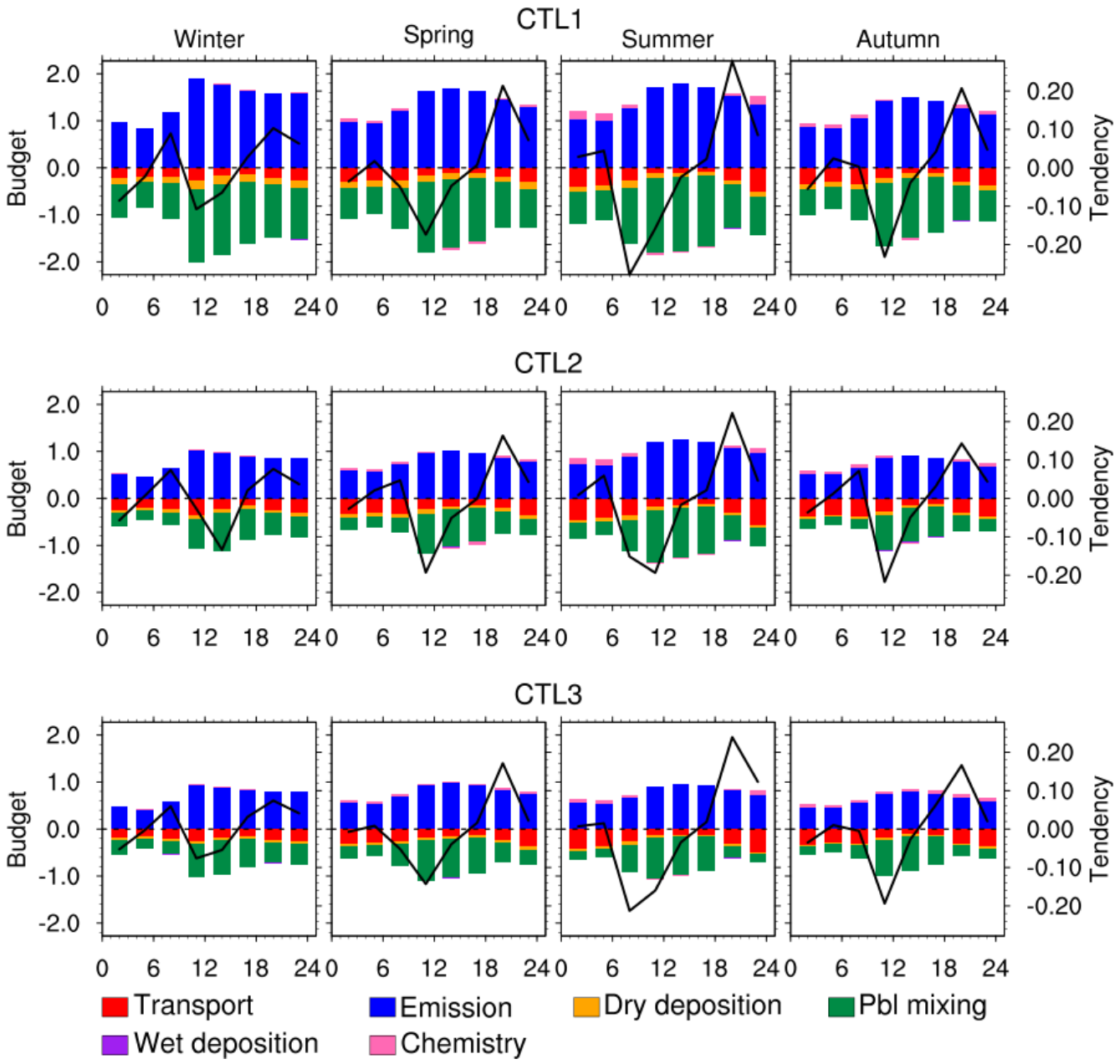
- **Diurnal Index(DI) = (Monthly average 24h) /Min_24h**
- Observed evident seasonal variations
- WRF-Chem significant overestimate DI in summer and autumn

Sensitivity to the PBL mixing



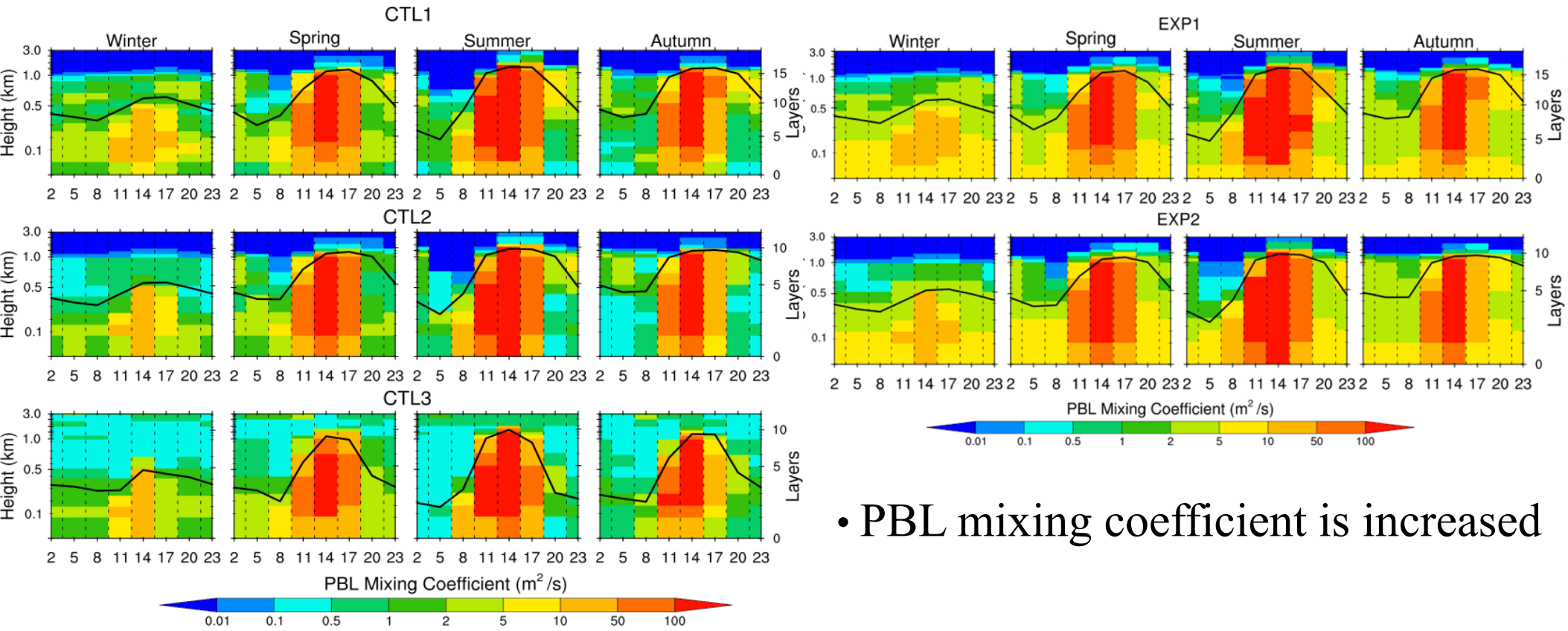
- In spring and autumn, observed DI are higher in the night and lower in the day, but shows noon peak in summer
- WRF-Chem catch the variation of observed DI with overestimate in the night, but fail to simulate the variation in summer
- Sensitivity to vertical layer configurations are lager than PBL schemes

Sensitivity to the PBL mixing



- $PM_{2.5}$ tendency has largest variation in summer and smallest variation in winter
- PBL mixing determines the diurnal variation of $PM_{2.5}$
- CTL1 has the largest variations due to lager contributions from emissions and PBL mixing

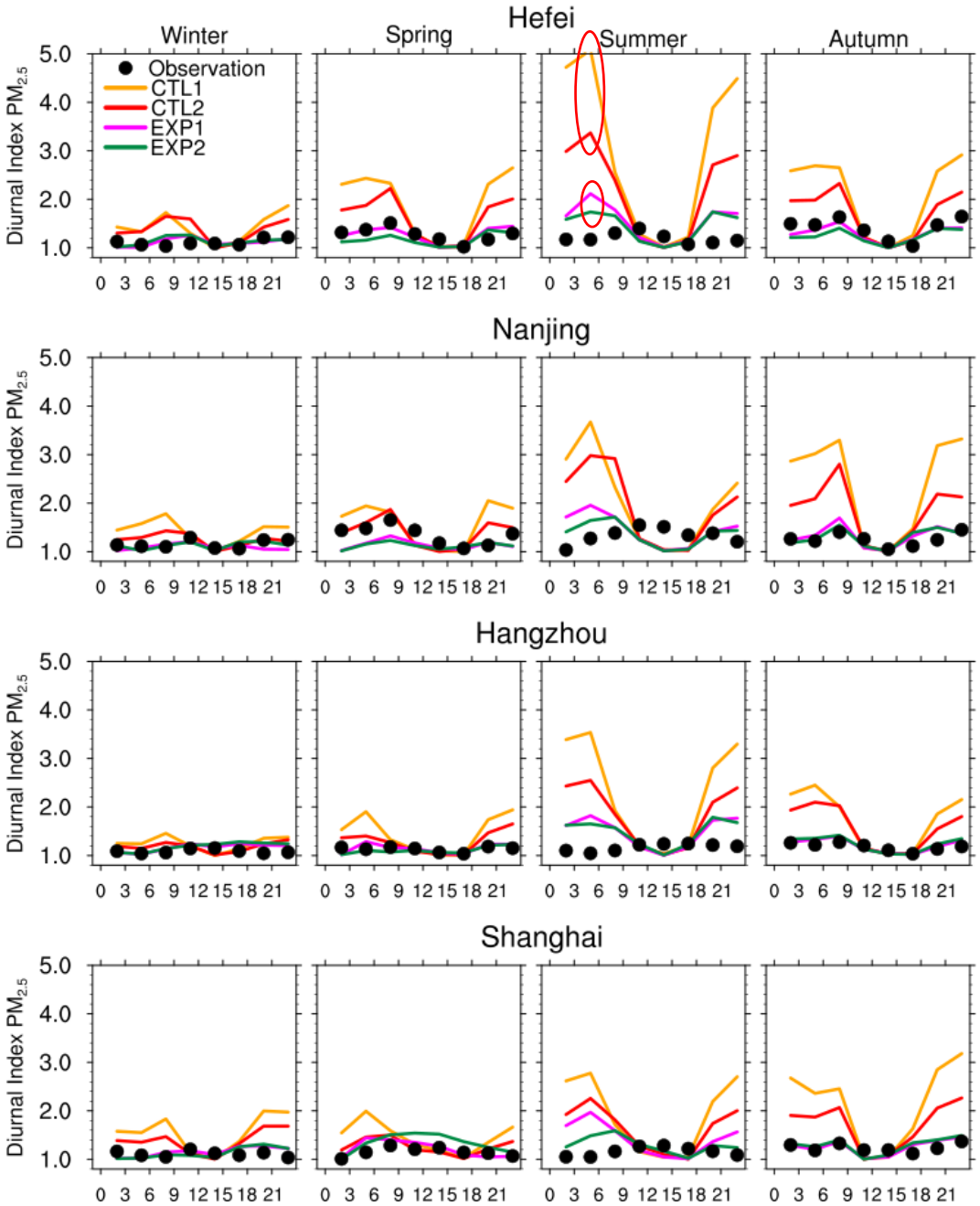
Sensitivity to the PBL mixing



- PBL mixing coefficient is increased

- PBL mixing is controlled by PBL mixing coefficient more directly in WRF-Chem
- PBL height show clear diurnal cycles and are similar between CTL1 and CTL2
- PBL mixing coefficient have larger variations, the largest diurnal variation of PBL mixing coefficients leads in summer to the largest PM2.5 variation

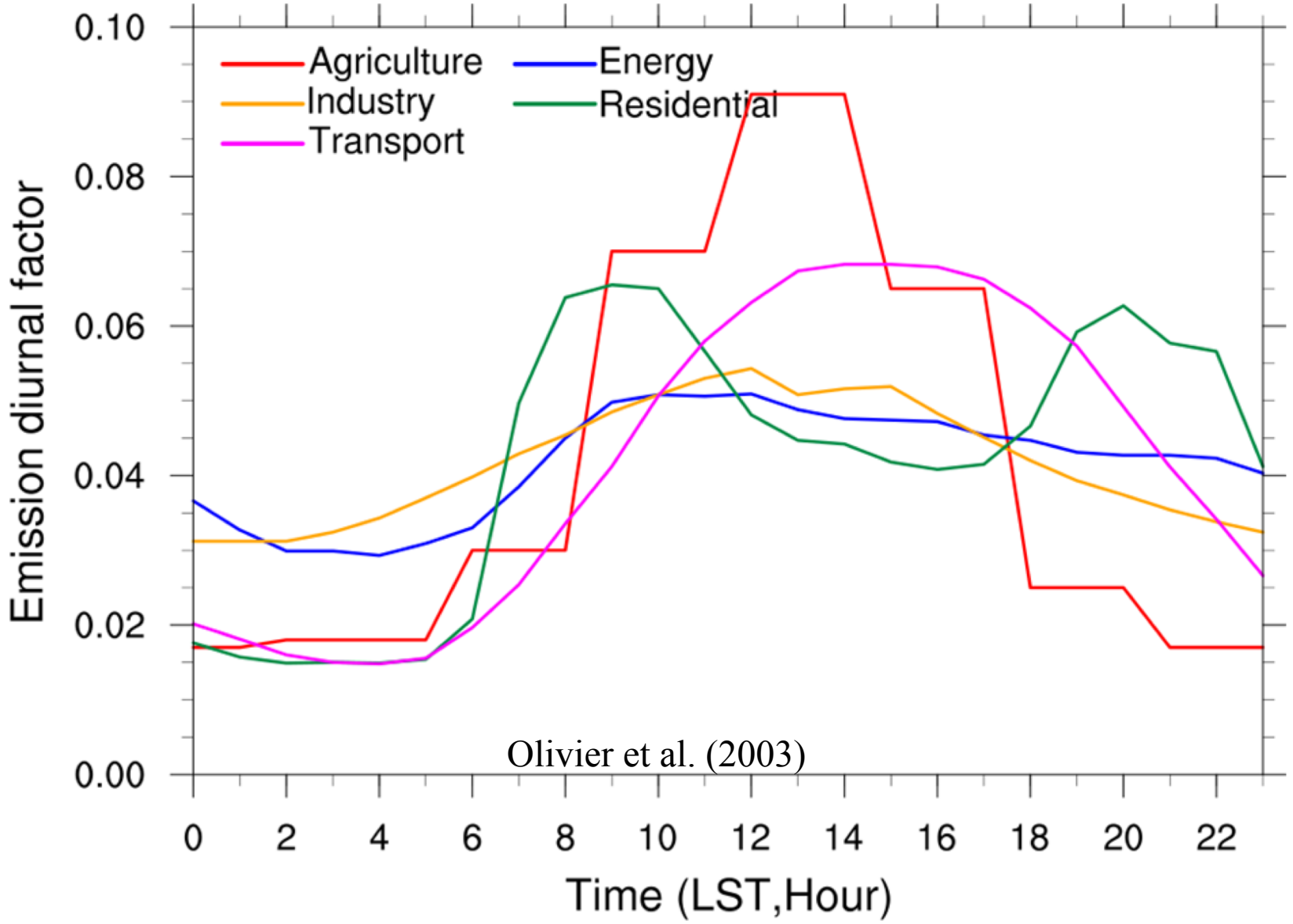
Sensitivity to the PBL mixing



- Diurnal index of $PM_{2.5}$ during night is significantly reduced and consistent with the observations better
- Enhanced PBL mixing coefficient reduces bias, but still get opposite diurnal pattern in summer due to a lack of SOA production
- Enhanced PBL mixing coefficient reduces the modeling sensitivity to the layer configuration

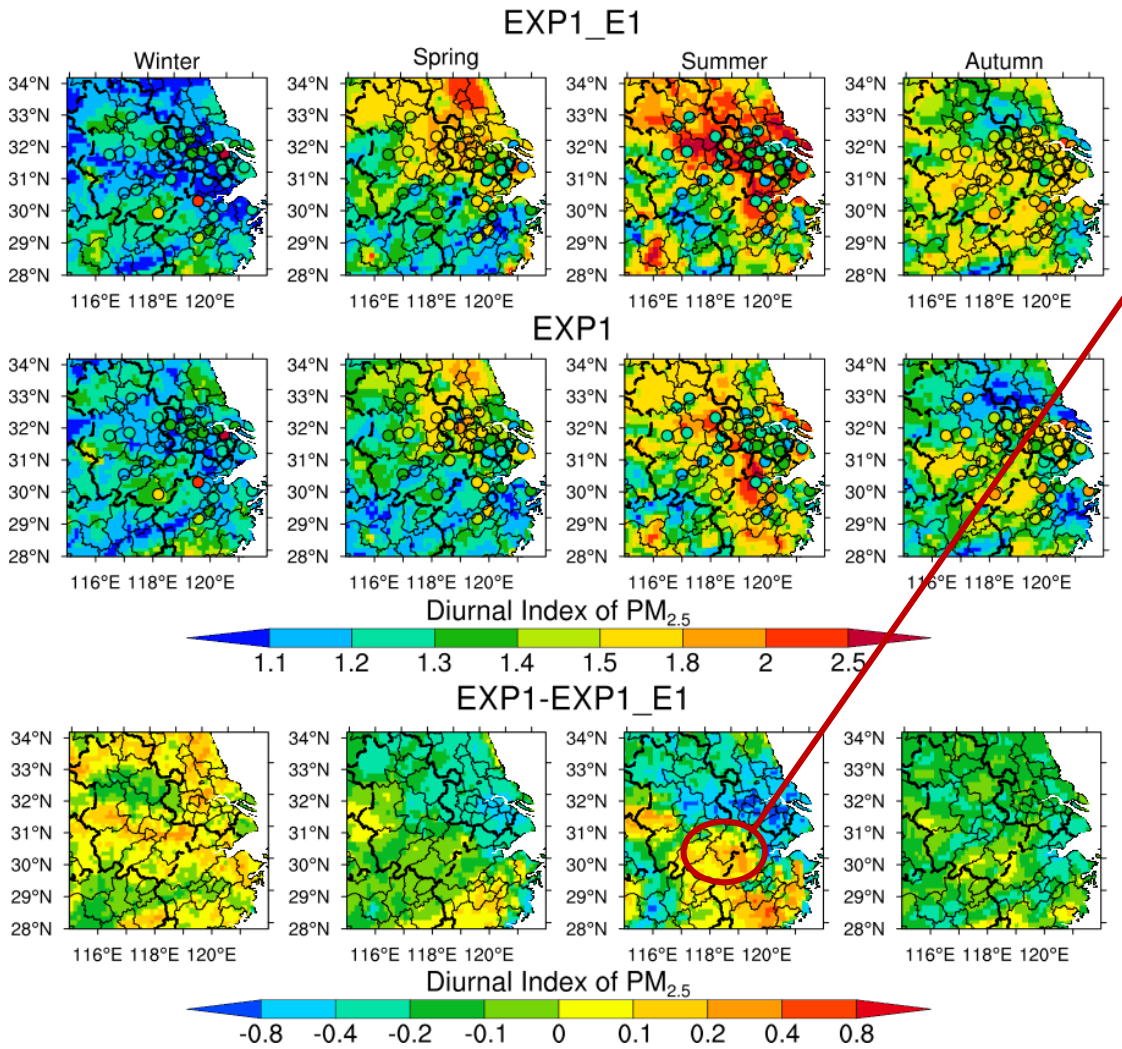
Sensitivity to Emissions

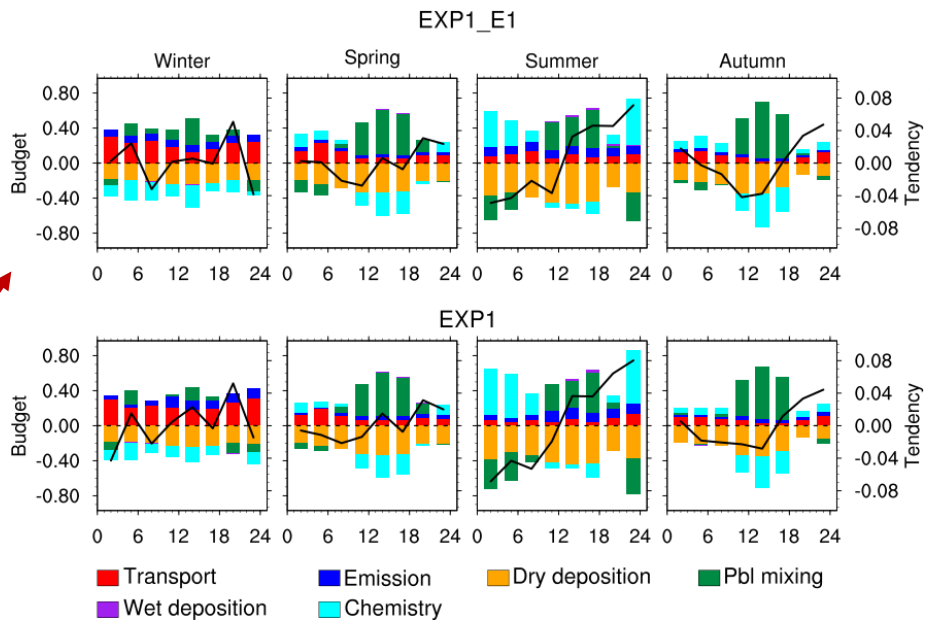
Diurnal cycle of emissions



Olivier et al. (2003)

Sensitivity to Emissions



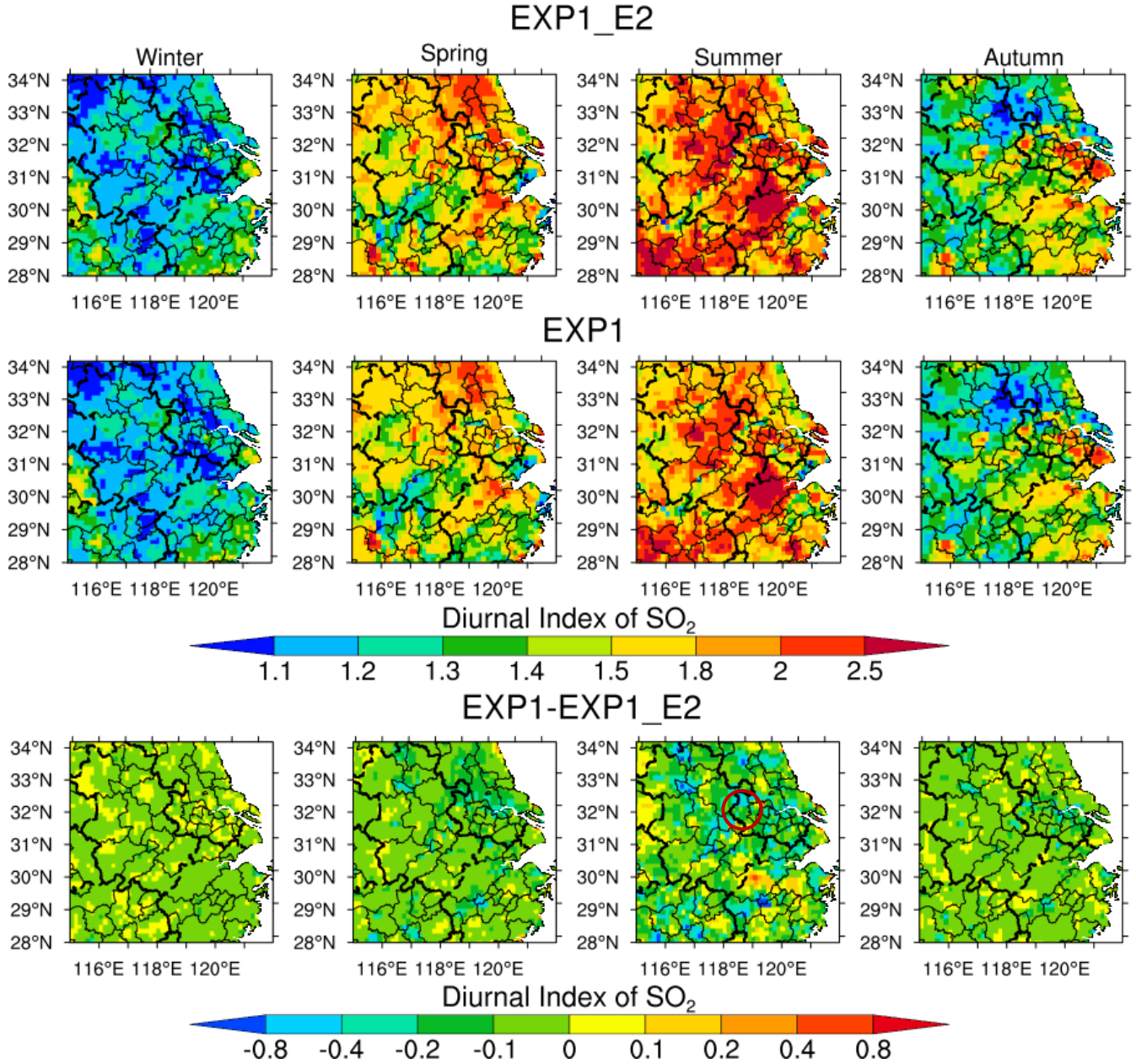


- Impact of diurnal cycle of emission is smaller than that from PBL mixing

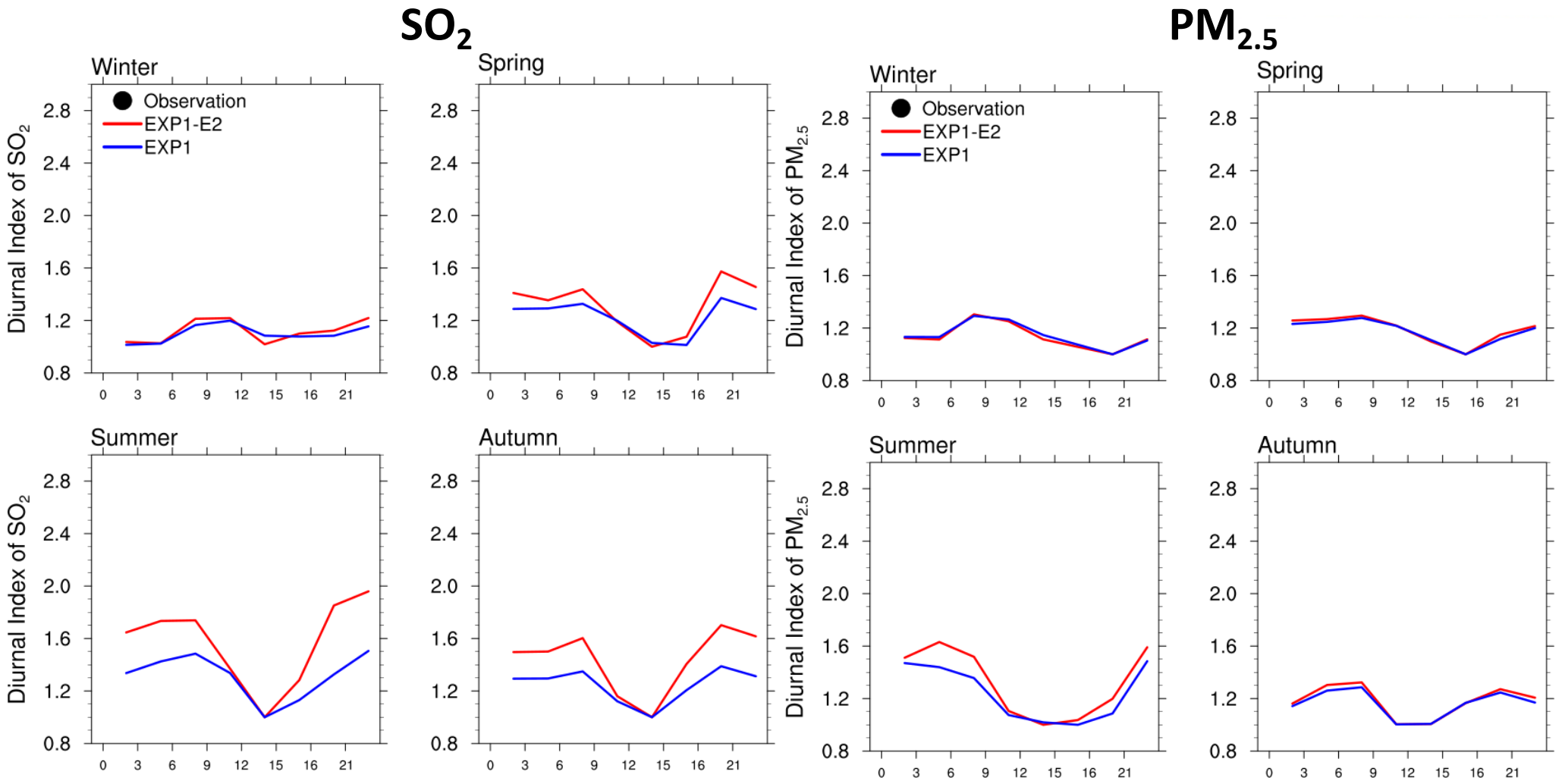
- Diurnal index is reduced in spring and autumn but increase in winter and the south area in summer
- Decrease was shown in center cities, Increase happens in low emissions area due to the increase of transport and PBL mxing processes

Sensitivity to Emissions

Injection height of emission



Sensitivity to Emissions



- SO_2 concentration is significantly reduced in the night, this impact can reach up to 30%
- Impacts on $PM_{2.5}$ is quite smaller, the difference between two experiments < 10% in all seasons

Summary and Conclusion

- PBL mixing is the determinant factor in modeling the diurnal cycle of surface $PM_{2.5}$ concentration over East China
- The PBL mixing coefficient instead of PBL height is the key factor controlling the diurnal cycle of surface PM2.5 concentration in WRF-Chem
- The increase of PBL mixing coefficient within boundary layer during the night can significantly reduce the modeling biases in simulating surface $PM_{2.5}$ concentration and also the modeling sensitivity to the vertical layer configuration
- The diurnal cycle and injection height of emission play roles on simulating diurnal cycle of surface $PM_{2.5}$ concentration but smaller than the impact from boundary mixing

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Thank you!