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Impact of urban heat island on inorganic aerosol in the lower free troposphere: a case study in Hangzhou, China

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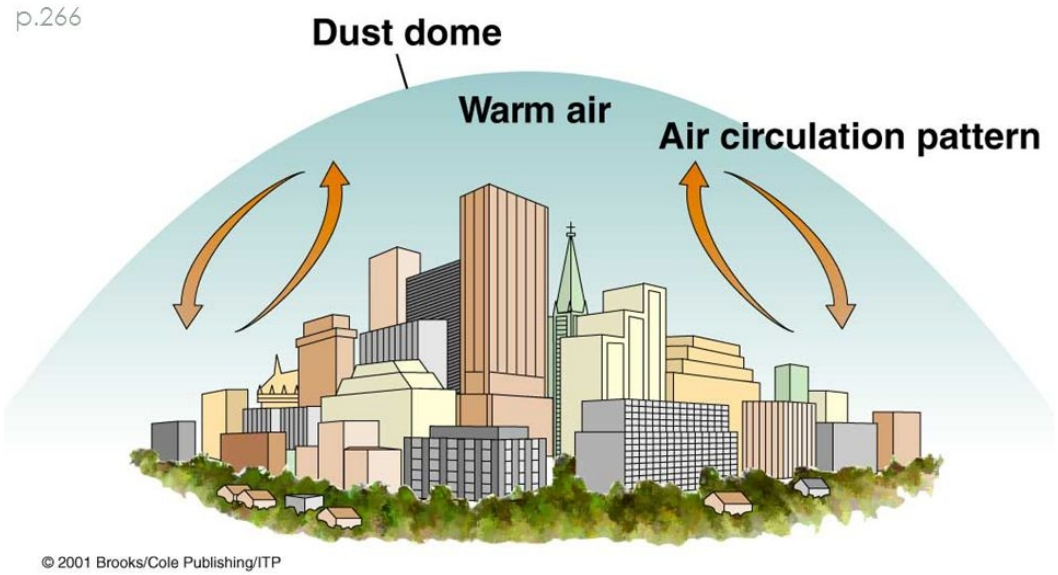
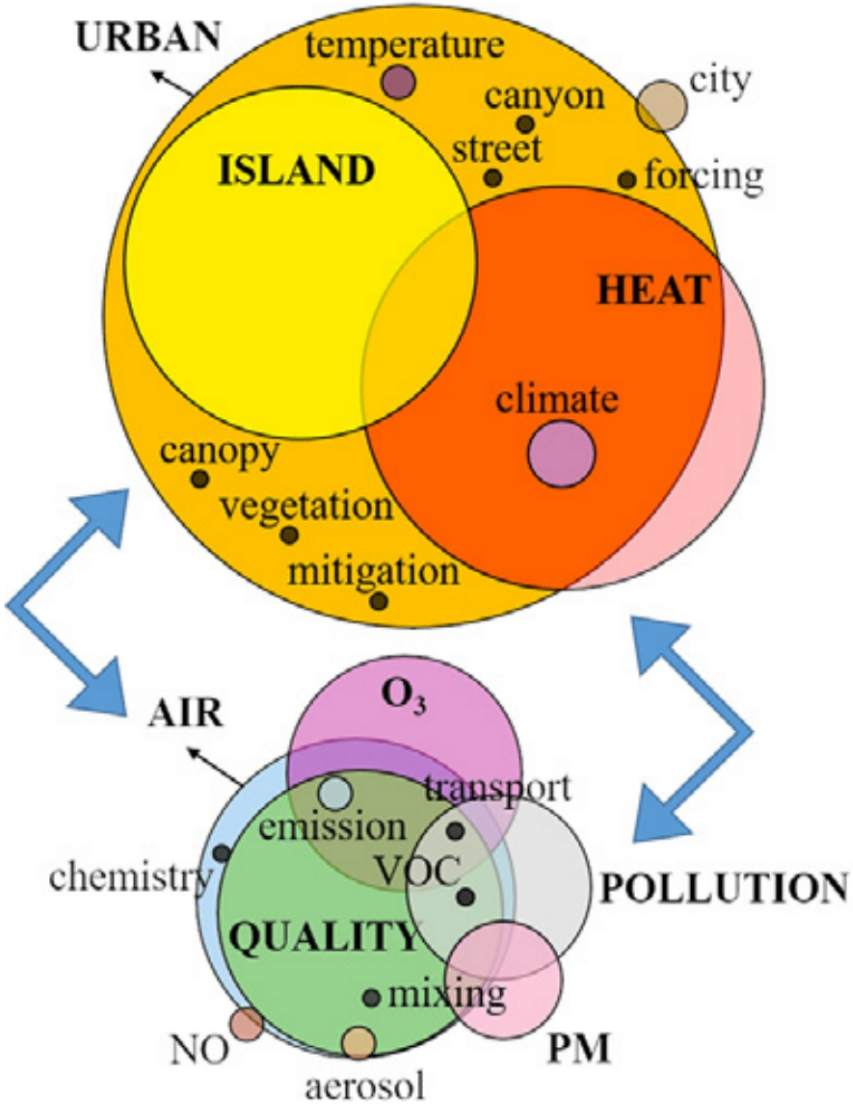
Interactions between urban heat island (UHI) and urban air pollution



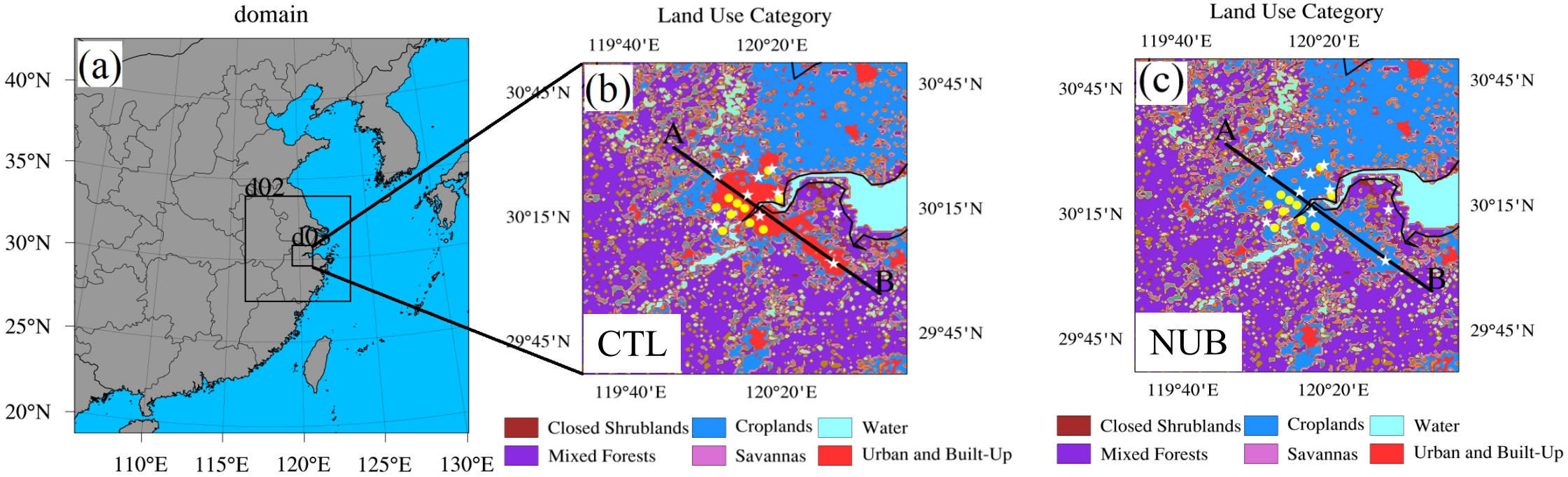
- The enormous amount of heat generated creates an urban heat island
- Additional heat changes climate of surrounding area
- Keep polluted air from being diluted and cleansed



Ulpiani, 2021 (STE)

WRF-CMAQ modeling domains and settings

CTL-NUB: Urban heat island effects



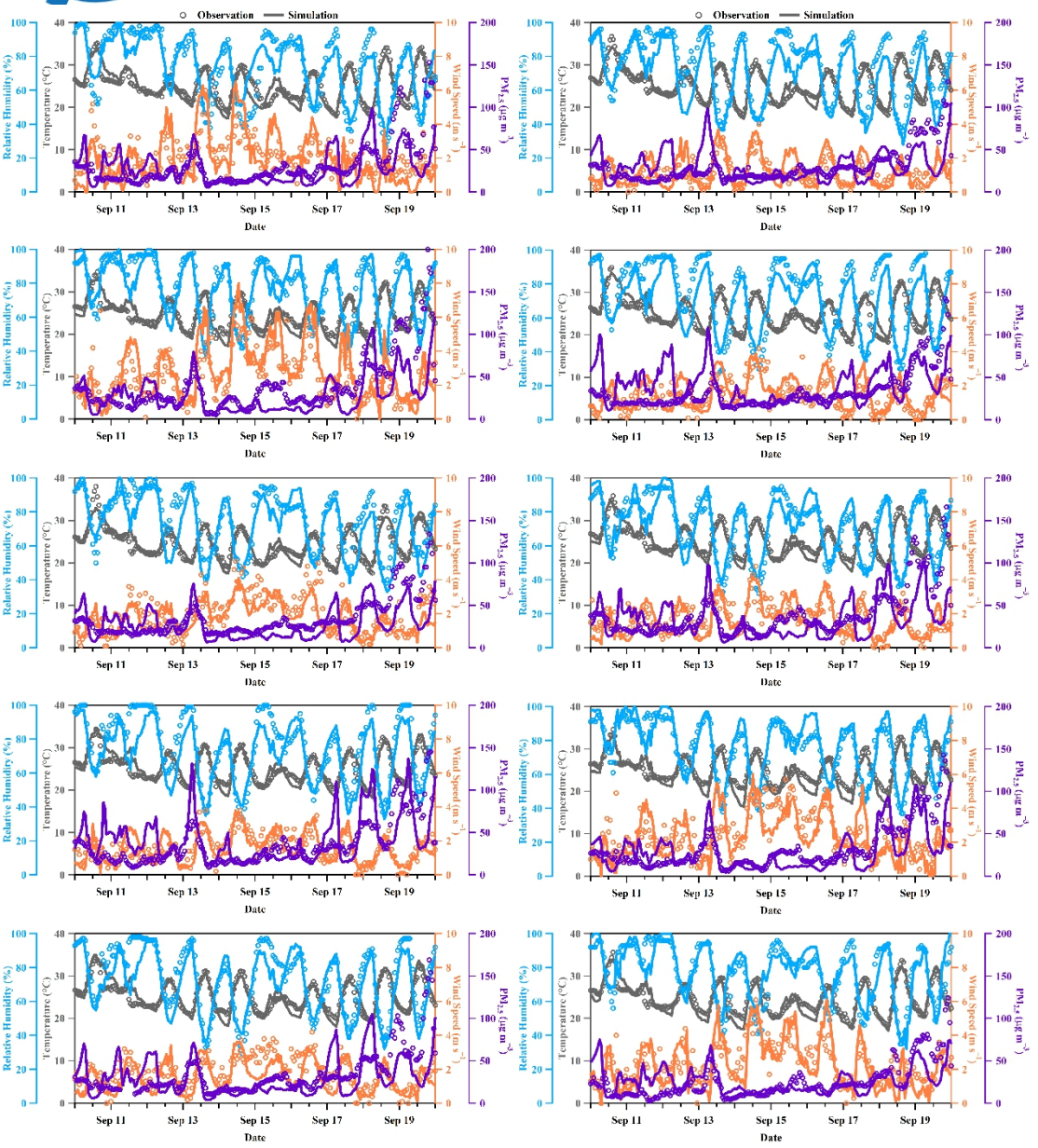
WRF settings

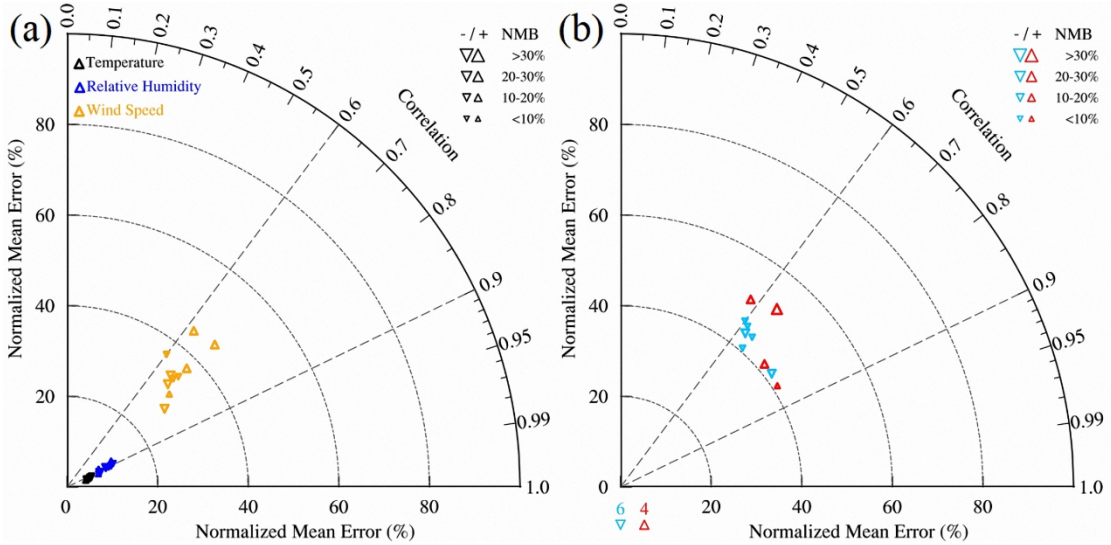
Grid numbers: 300×300, 240×240, 140×140
Grid space: 9 km, 3 km, 1 km
Levels: 37
Urban Canopy Model: BEP

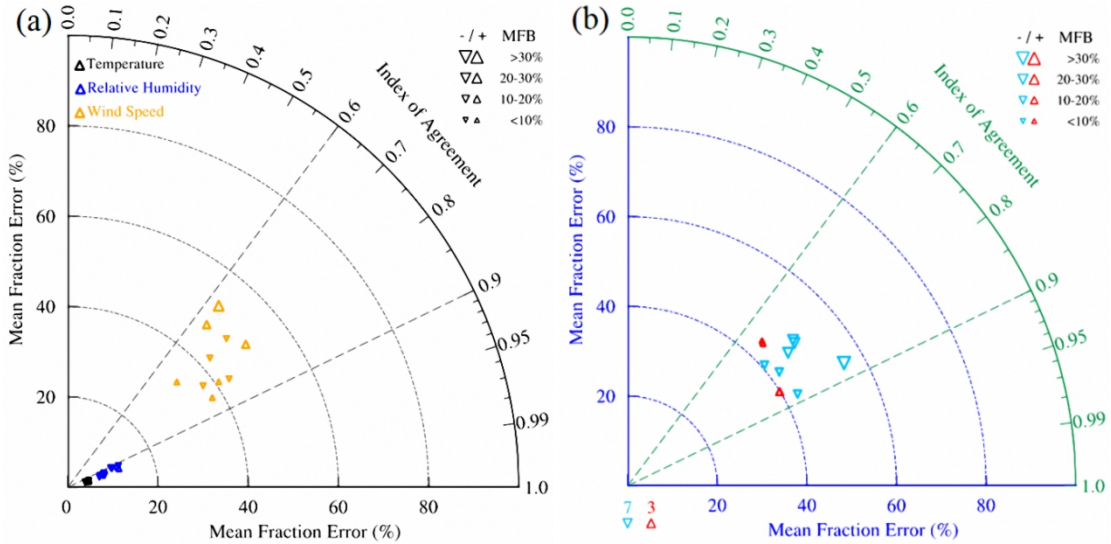
CMAQ settings

Gas chemistry: CB05
Aerosol: AERO6
Anthropogenic emission: MEIC 2017, HMEEB 2016
Biogenic emission: MEGANv2.1
ICON & BCON: MOZART-4

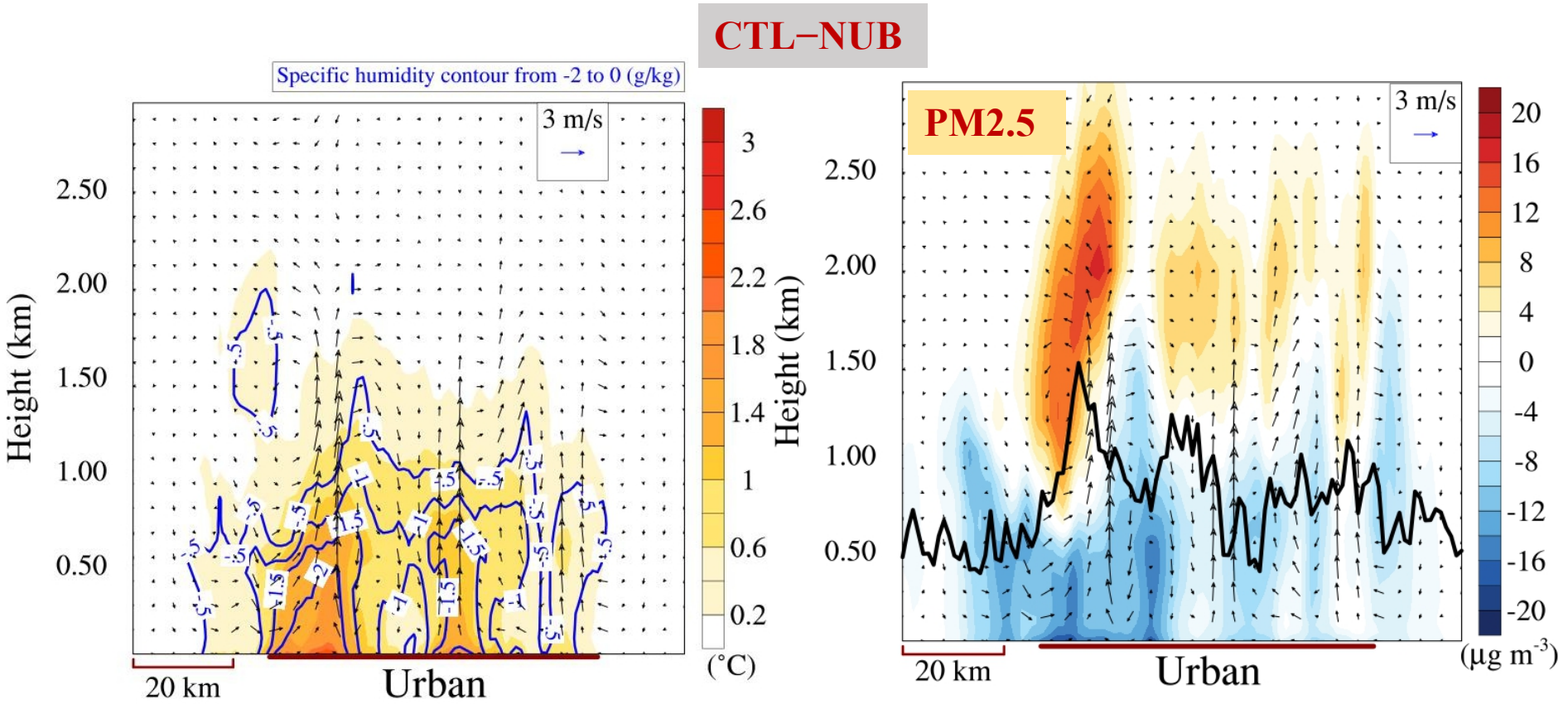
Model evaluation







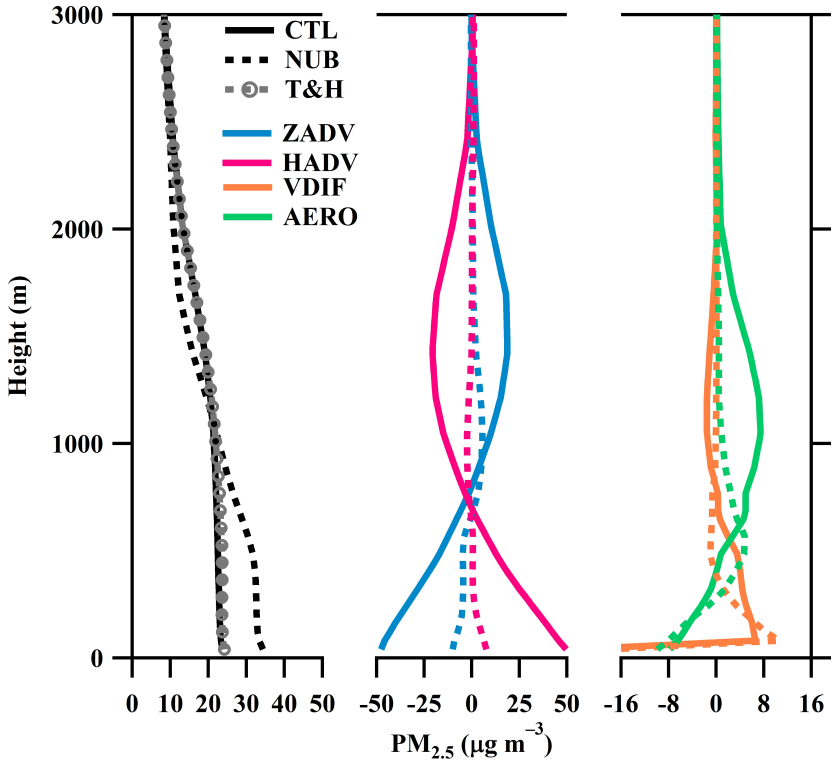
UHI effect and its impact on PM2.5



UHI decreased boundary layer (BL) PM2.5 by ~26% and increased lower free troposphere (LFT) PM2.5 by ~21%

A strong UHI case occurred on Sep 18, 2017

Process analysis on PM2.5

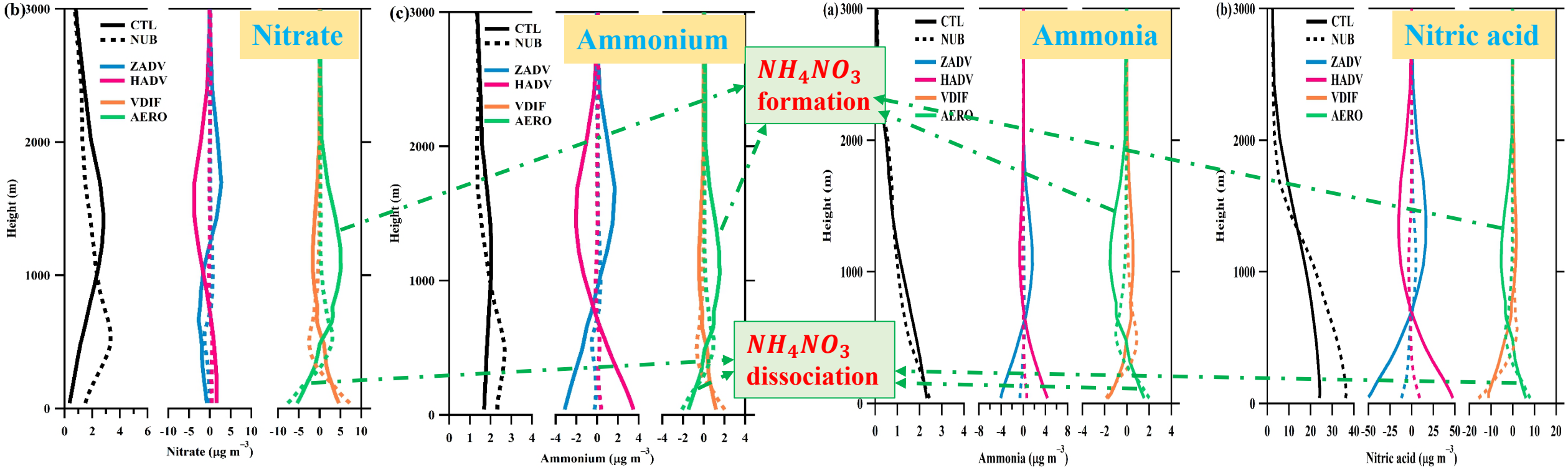


UHI increases LFT PM2.5 through vertical advection (ZADV) and aerosol (AERO) processes;

UHI decreases BL PM2.5 through ZADV and AERO processes.

Process analysis on Ammonium Nitrate and its precursor gases

$$NH_4NO_3(s) \rightleftharpoons HNO_3(g) + NH_3(g) \qquad K = exp\left[118.87 - \frac{24084}{T} - 6.025ln(T)\right]$$



Nitrate and ammonium aerosols formed in the upper BL and LFT, while they dissociated into ammonia and nitric acid gases in the lower BL;

UHI increases vertical transport of ammonium nitrate and its precursor gases from the BL to the LFT.

UHI increases secondary formation of ammonium nitrate in the LFT;

Conclusions

- **UHI decreases BL PM2.5 and increases LFT PM2.5 by enhancing vertical transport and aerosol formation/dissociation processes;**

- **UHI circulation transport HNO3 and NH3 from the BL to the LFT and form NH4NO3 in the cold environment.**