Multi-Model Inter-Comparison of Surface Ozone and Related Species Over East Asia

Tatsuya Nagashima[1], Li Jie[2], Hajime Akimoto[1], and MICS Asia III participants[3]

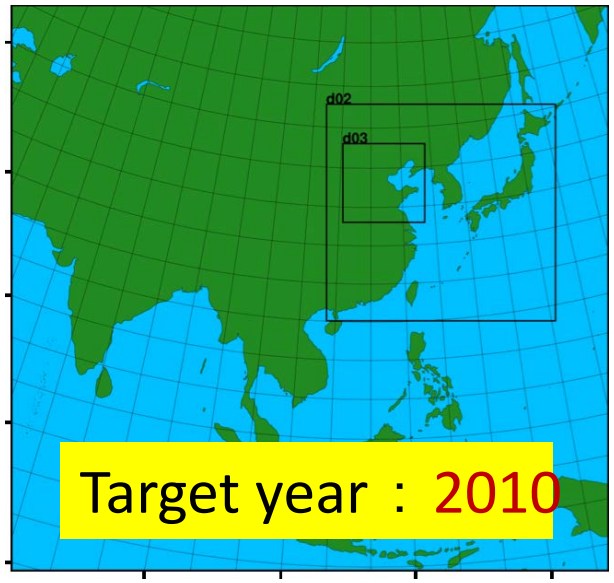
1) National Institute for Environmental Studies, Japan
2) Institute for Atmospheric Physics (IAP), China
3) Various affiliations

Model Inter-Comparison Study for Asia (MICS Asia)

Aim: To obtain common understanding of the performance and uncertainties of air quality models in the estimation of long-range transport and deposition of pollutants in Asia.

- Phase1 (1998-2000) : Sulfur deposition
- Phase2 (2004-2009) : S + N compounds, O_3, and Aerosols
- Phase3 (2012-) : Model / Emission / AQ & Climate

MICS-Asia III: **Unified** simulation settings



Model Domain

- Domain1 （Δx=45 km）
  Whole Asia ← So far, only D1 has been completed
- Domain2 （Δx=15km）
  East Asia (JPN, KOR, CHN)
- Domain3 （Δx=5km）
  Around Beijing

Meteorology

Meteorological fields (**T, V, Prep.**, etc.) to drive the models were calculated with **WRF** by IAP (China) and distributed to every modeling group.

Emission

Emission data sets developed in various projects were mixed to form an unified emission data, called **"MIX for MICS"** （Li et al., 2017）

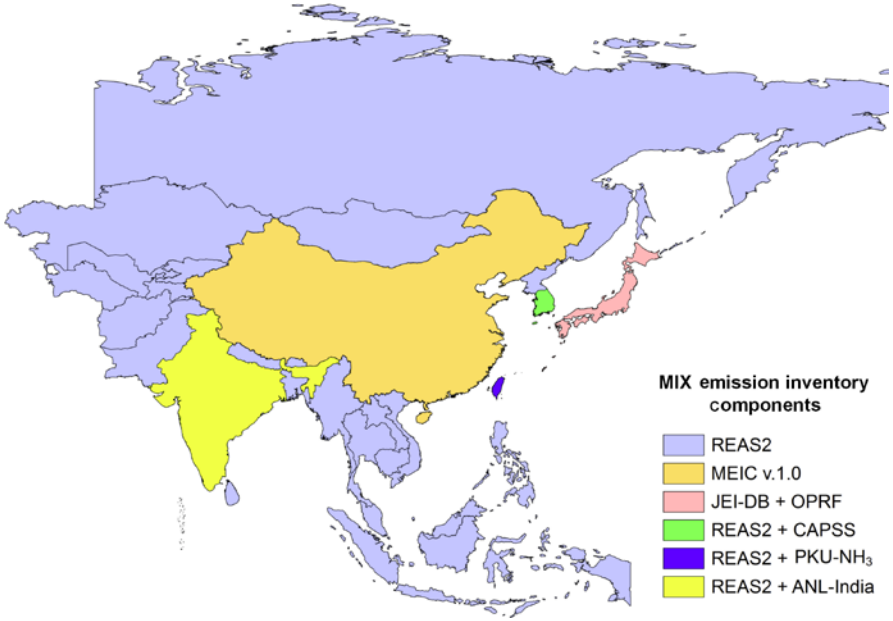
“MIX” emission inventory

MIX: a mosaic Asian anthropogenic emission inventory under the international collaboration framework of the MICS-Asia and HTAP

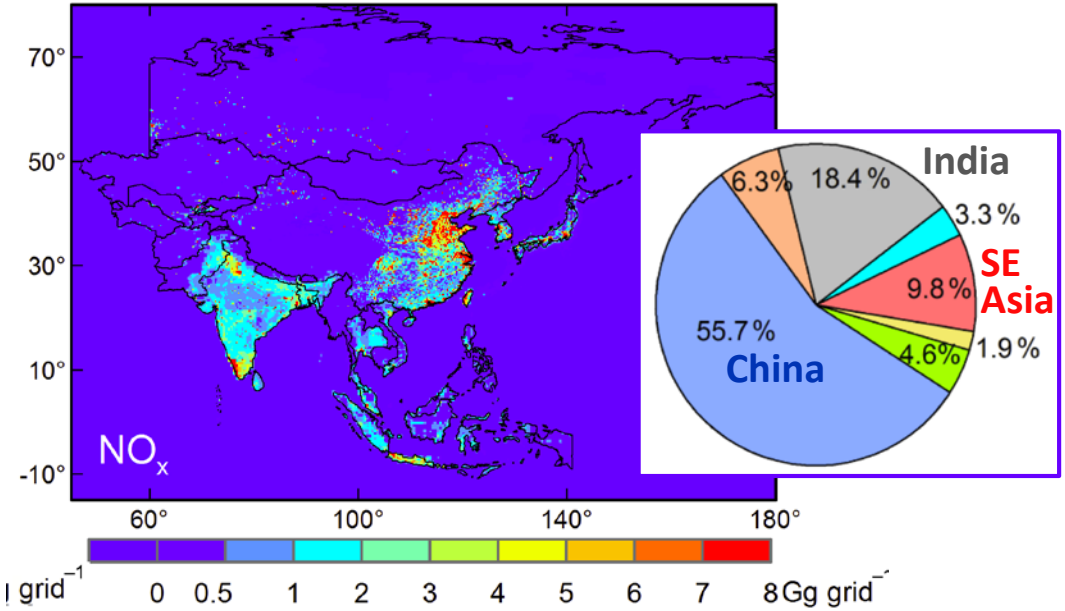
Meng Li[1,2], Qiang Zhang[1,12], Jun-ichi Kurokawa[3], Jung-Hun Woo[4], Kebin He[2,11,12], Zifeng Lu[5], Toshimasa Ohara[6], Yu Song[7], David G. Streets[5], Gregory R. Carmichael[8], Yafang Cheng[9], Chaopeng Hong[1,2], Hong Huo[10], Xujia Jiang[1,2], Sicong Kang[2], Fei Liu[2], Hang Su[9], and Bo Zheng[2]

Atmospheric Chemistry and Physics Open Access EGU

Domain and component of the MIX emission inventory



Grid map of NOx emission in MIX and regional contribution



Meng et al. (2017) ACP

Participant Models

The number of participating models is 14 (as of Sep. 2017)

WRF/CMAQ	6	v5.0.2 (×2), v5.0.1 (×1) v4.7.1 (×3)
WRF-Chem	4	v3.7.1 (×1), v3.6.1 (×1) v3.6 (×1)
Others	4	WRF-NAQPMS, RAMS-CMAQ, NHM-Chem, GEOS-Chem

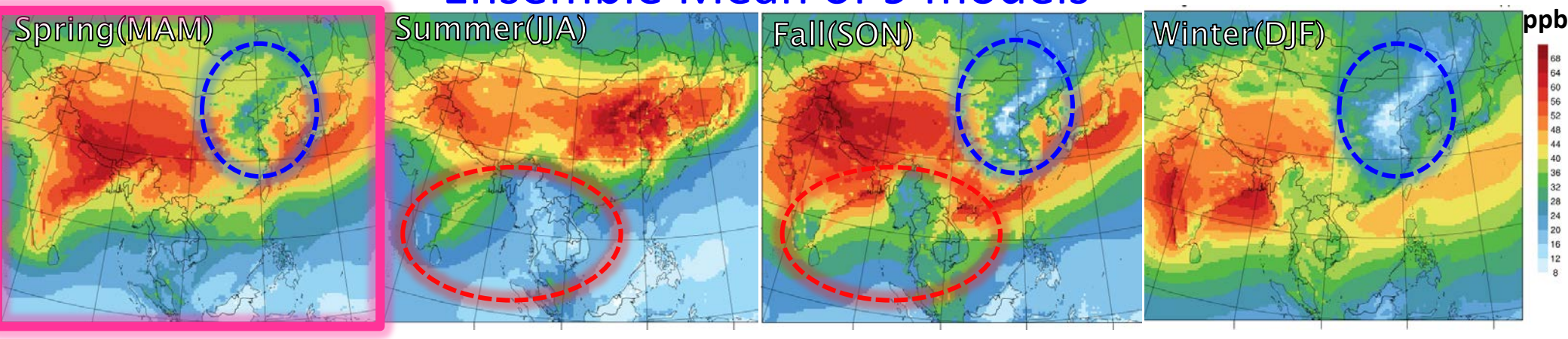
- Japan (4)
- China (7)
- Korea (1)
- US (2)

- 6 modeling groups used the CMAQ of 3 different versions.

Simulated surface ozone

Ensemble Mean of 9 models

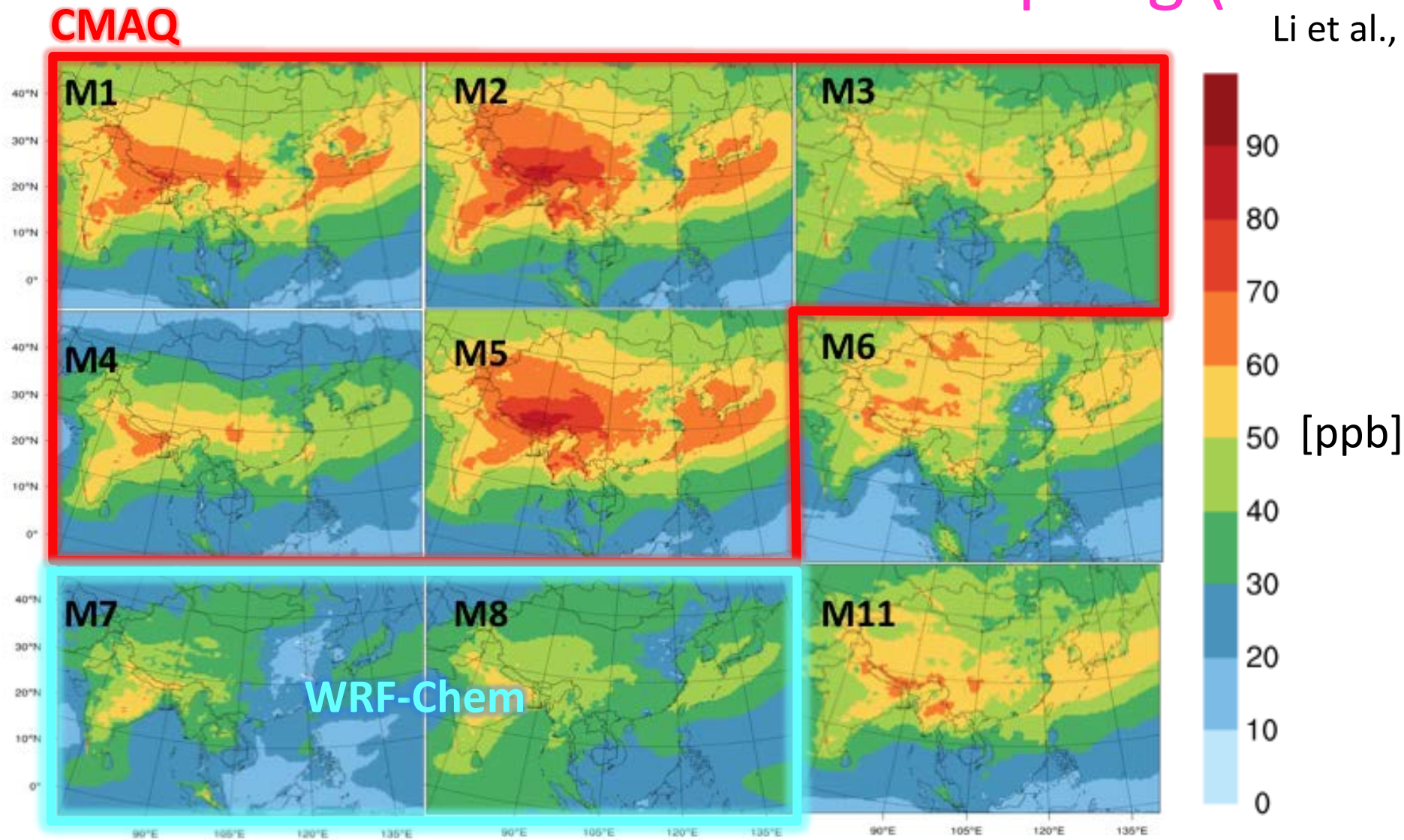
Li et al., in prep.



- High O_3 in mid-latitude and Low O_3 in low-latitude
  - Large emission of O_3 precursors and stratospheric O_3 influence
- Large influence of monsoonal circulation in S/SE Asian regions
- Low O_3 concentration in North China Plain other than summer
  - Large emission of NOx --> Large NO titillation effect of O_3

Simulated surface ozone in spring (MAM)

Li et al., in prep.

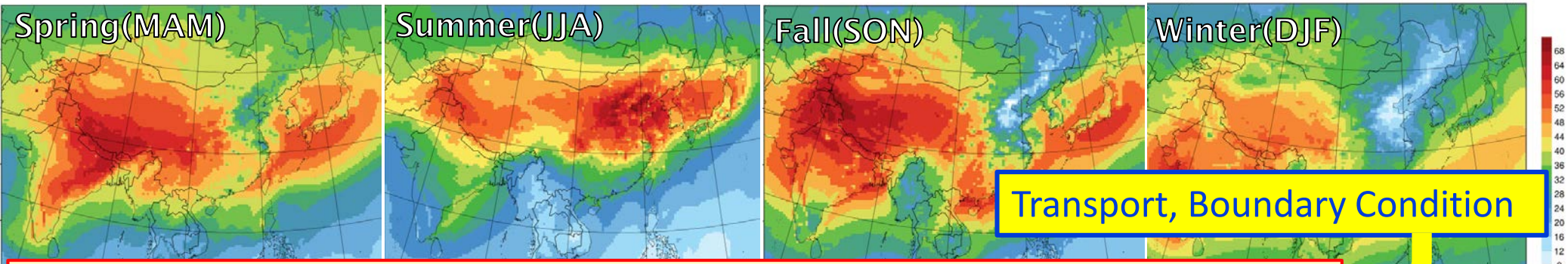


There are large variation among models, even among CMAQs

Simulated surface ozone

Ensemble Mean of 9 models

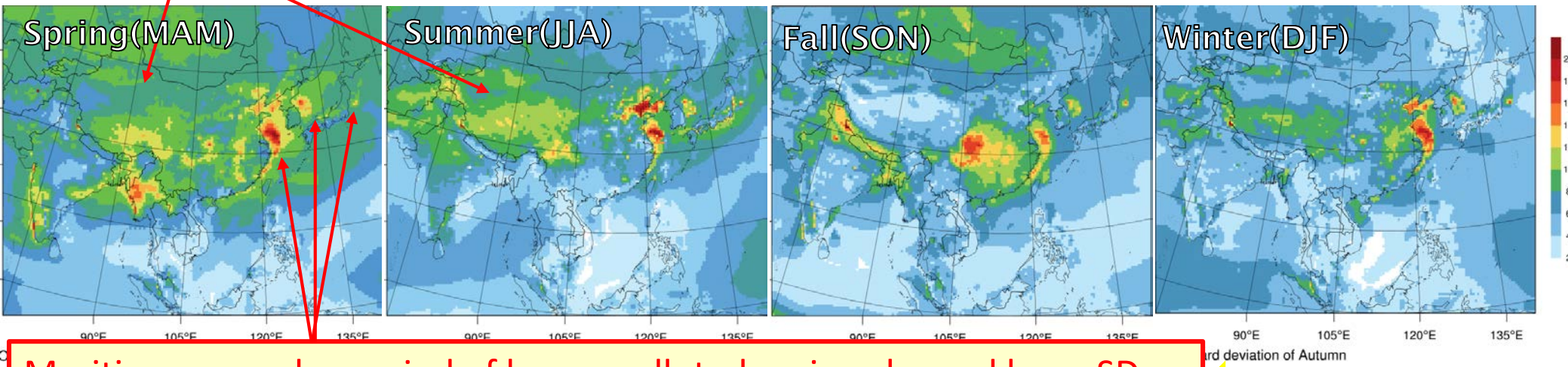
Li et al., in prep.



Transport, Boundary Condition

Large SD area was spread in wider region in spring/summer than in fall/winter

Standard deviation



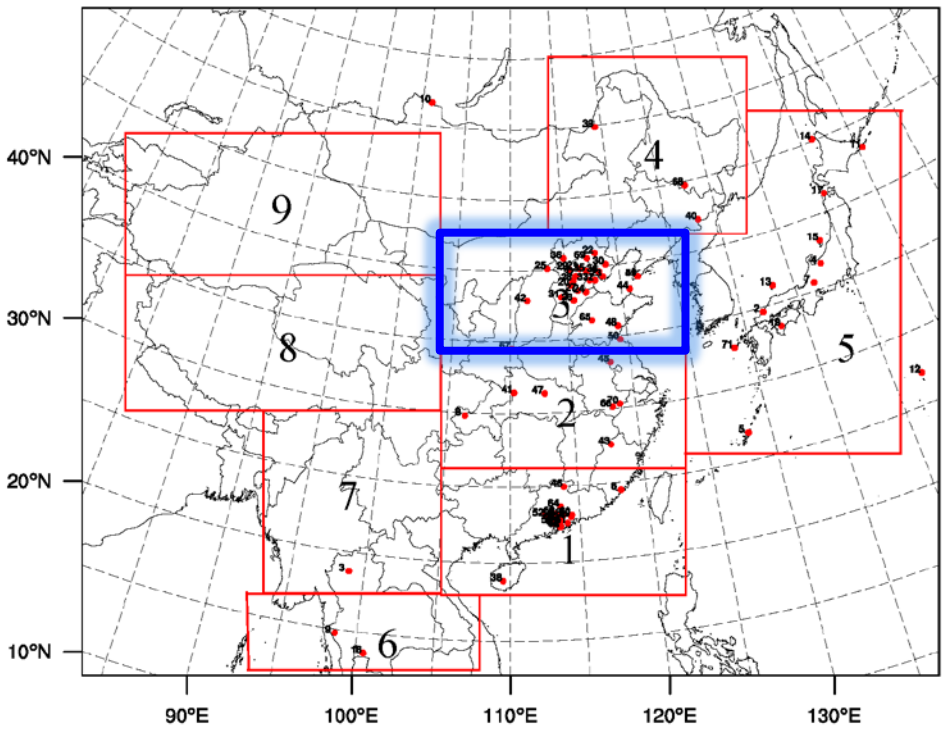
Maritime areas downwind of heavy polluted region showed large SD

Chemistry and Deposition of O_3 or its precursors over the ocean

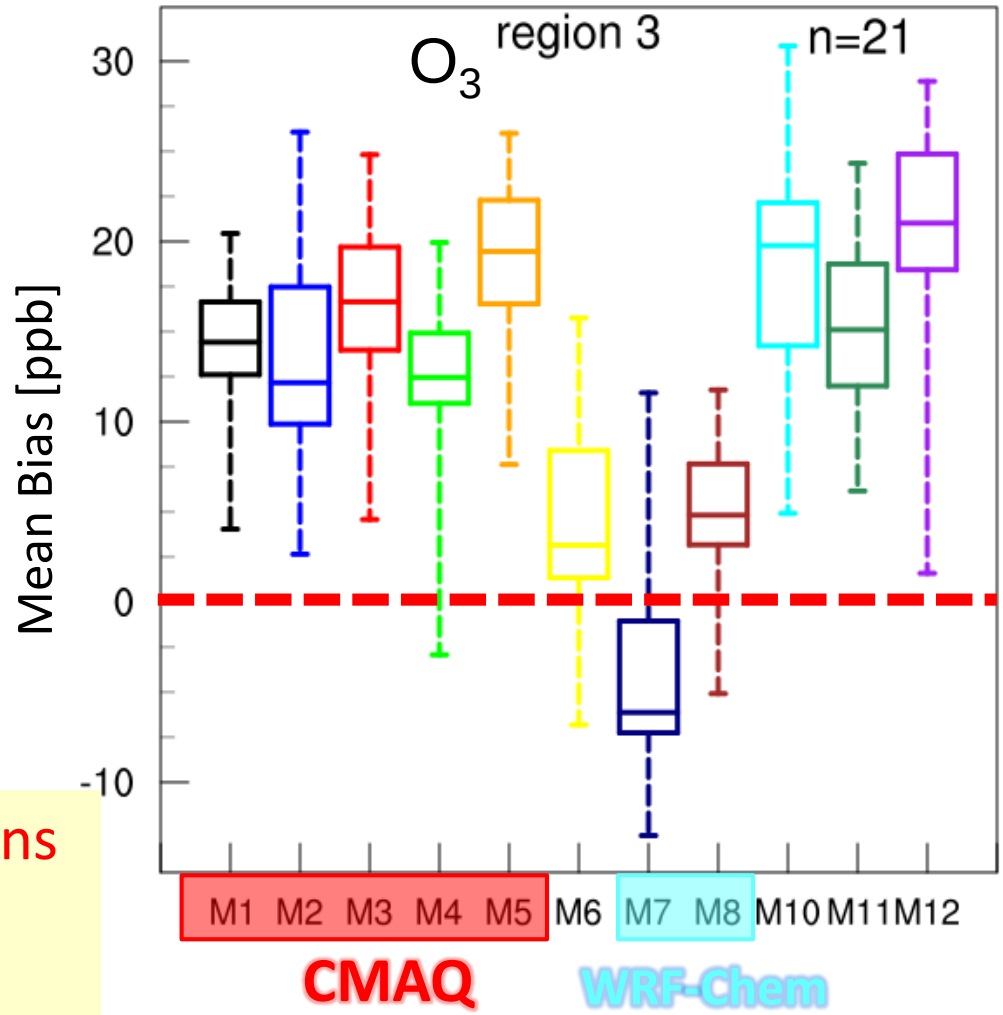
Comparison with observation : North China Plain

Li et al., in prep.

Annual mean



Mean Bias (= Model-Obs)

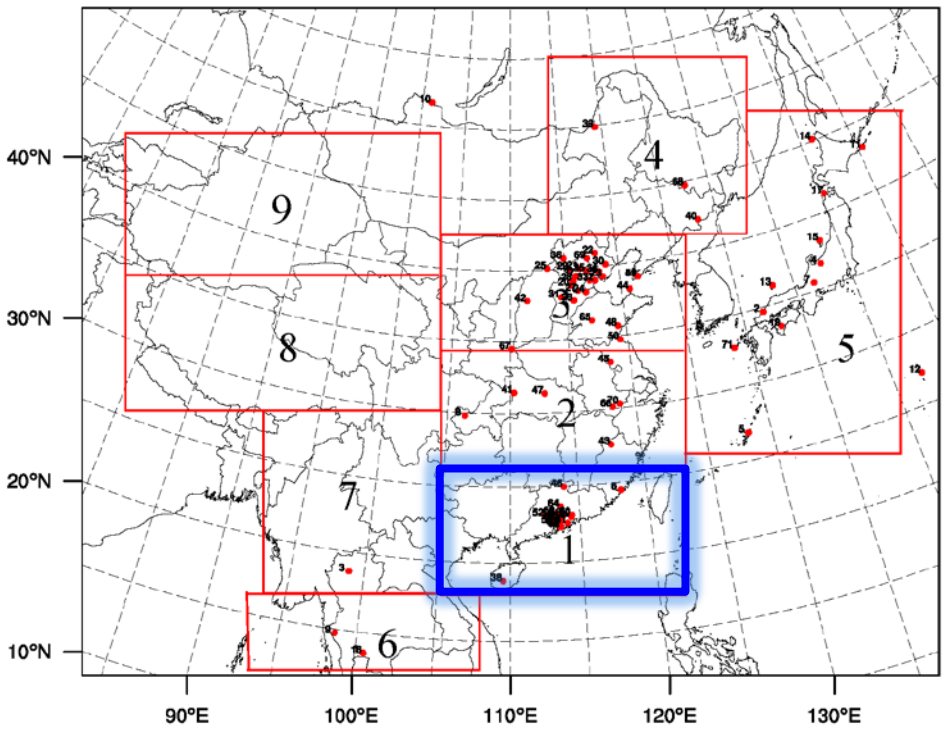


- CMAQs overpredicted at all locations
- M6 and WRF-Chem showed better representation

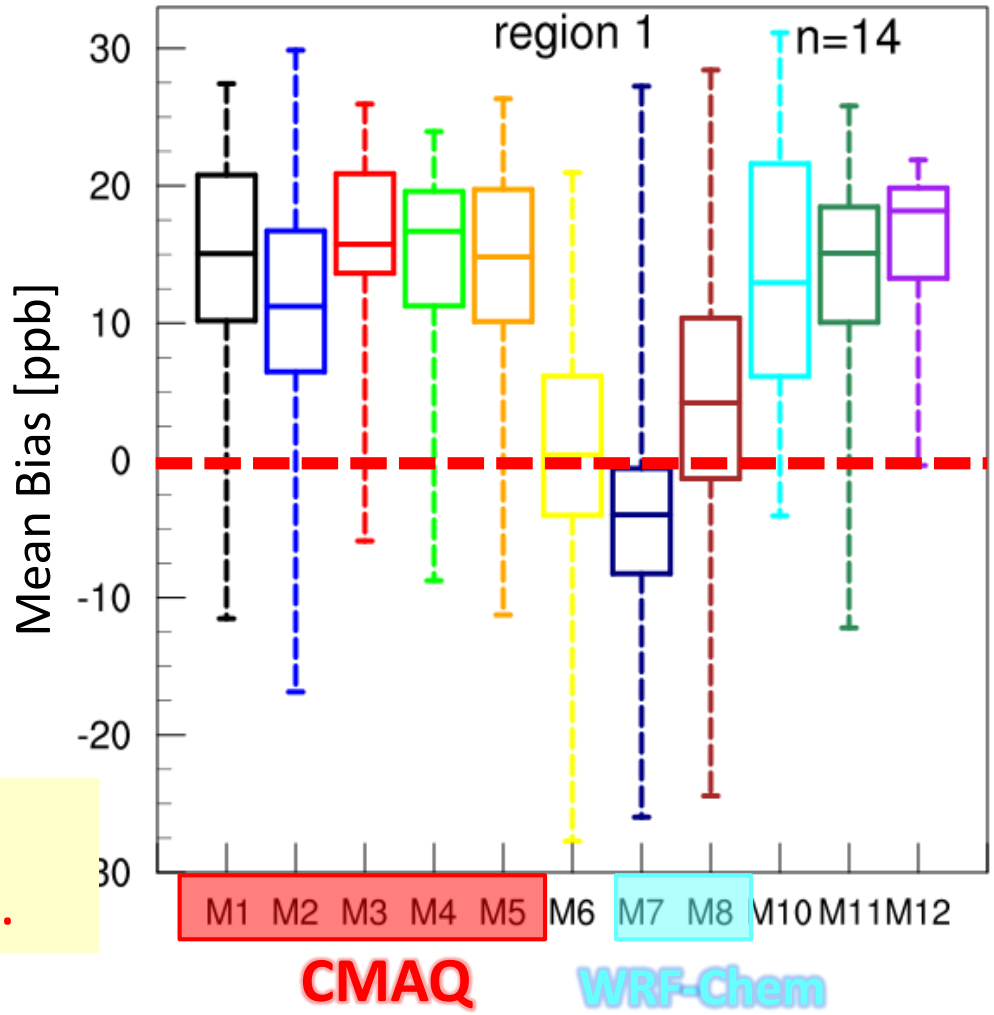
Comparison with observation : **Perl River Delta**

Li et al., in prep.

Annual mean



Mean Bias (= Model-Obs)

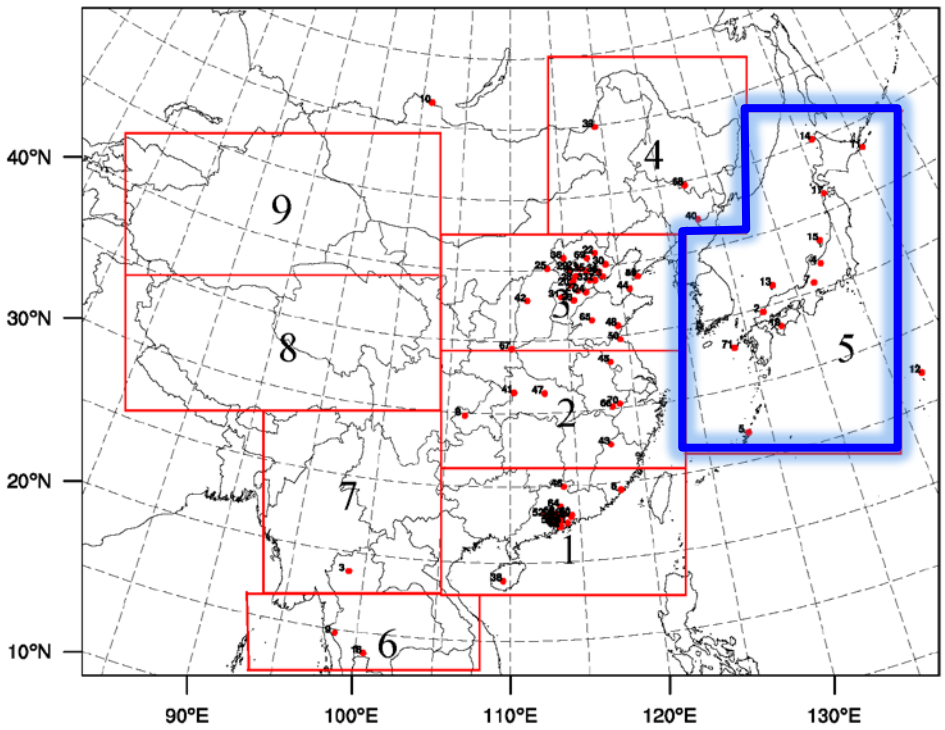


- CMAQs underpredicted at some locations but mainly overpredicted.

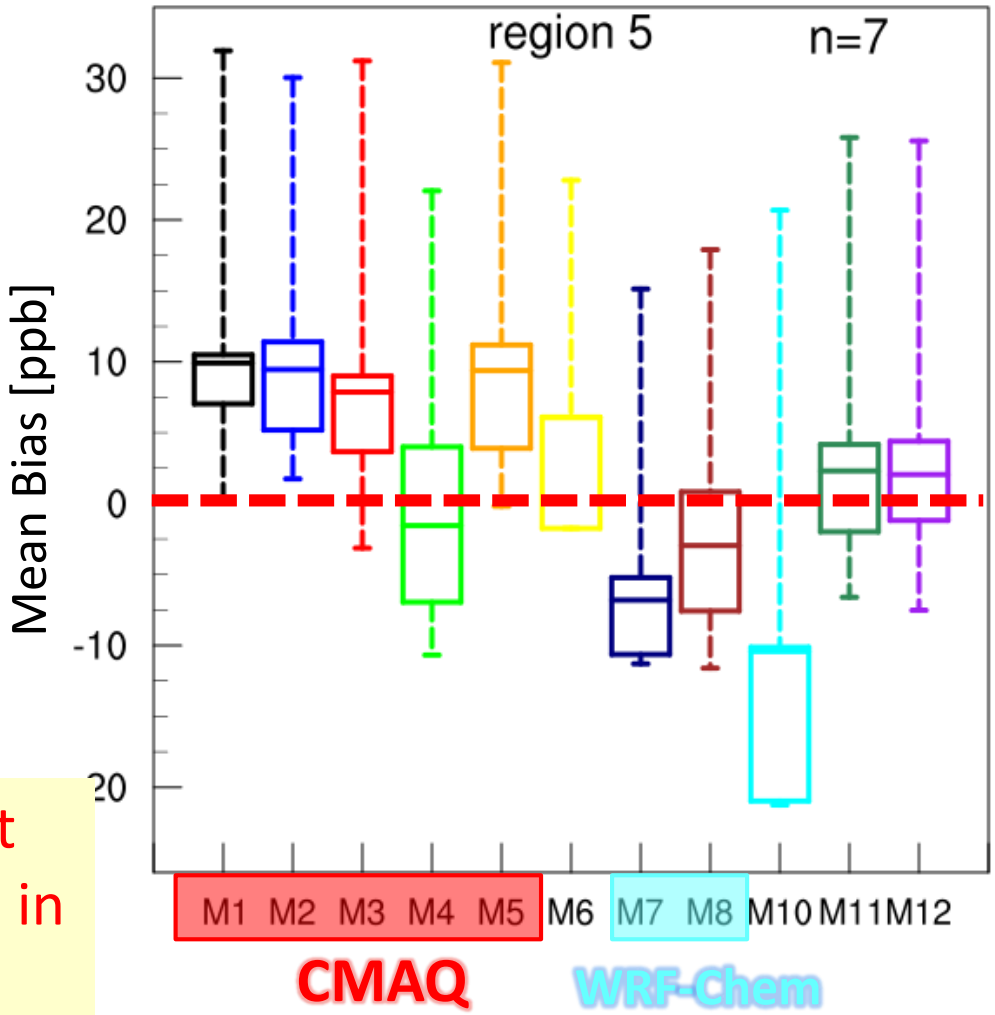
Comparison with observation : Japan

Li et al., in prep.

Annual mean

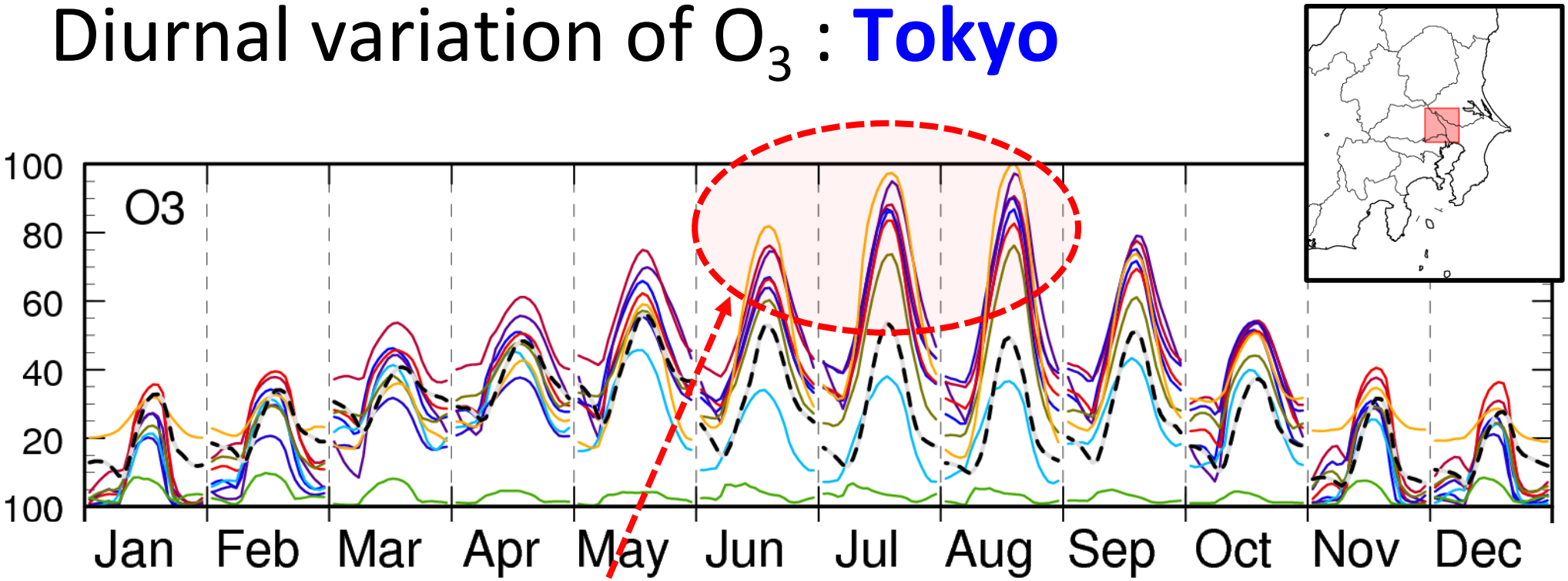


Mean Bias (= Model-Obs)



- CMAQs still overpredicted a bit, but showed better representation than in the other two regions in China.

Diurnal variation of O_3 : Tokyo



Most of the models largely overpredicted the surface O_3 concentration in summer, even the model which can properly simulate it in spring did so.

- - - - OBS

M1 M2 M3

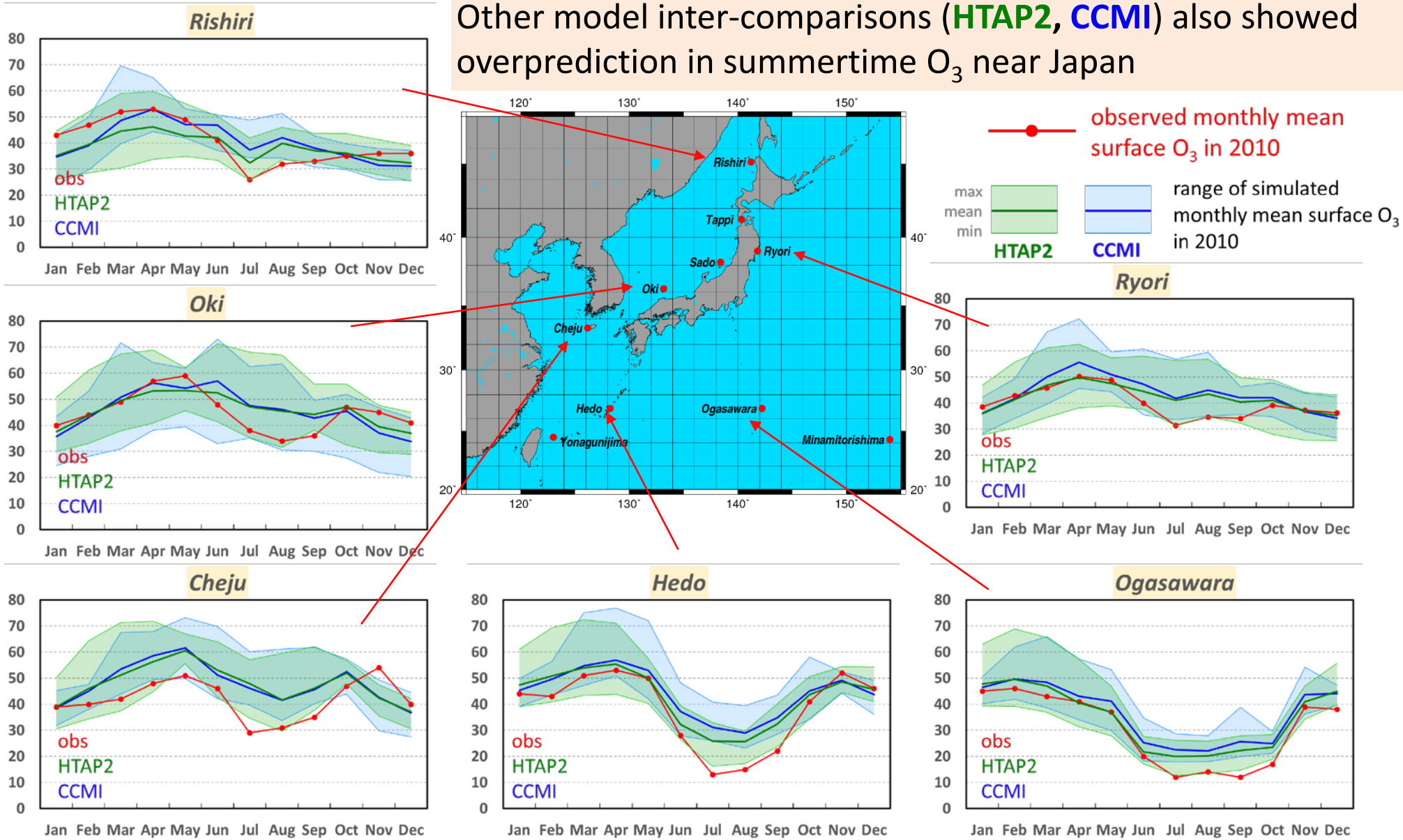
M4 M5 M6

M7 M8 M9

Nagashima et al., in prep.

Overprediction of summertime O_3 in Japan

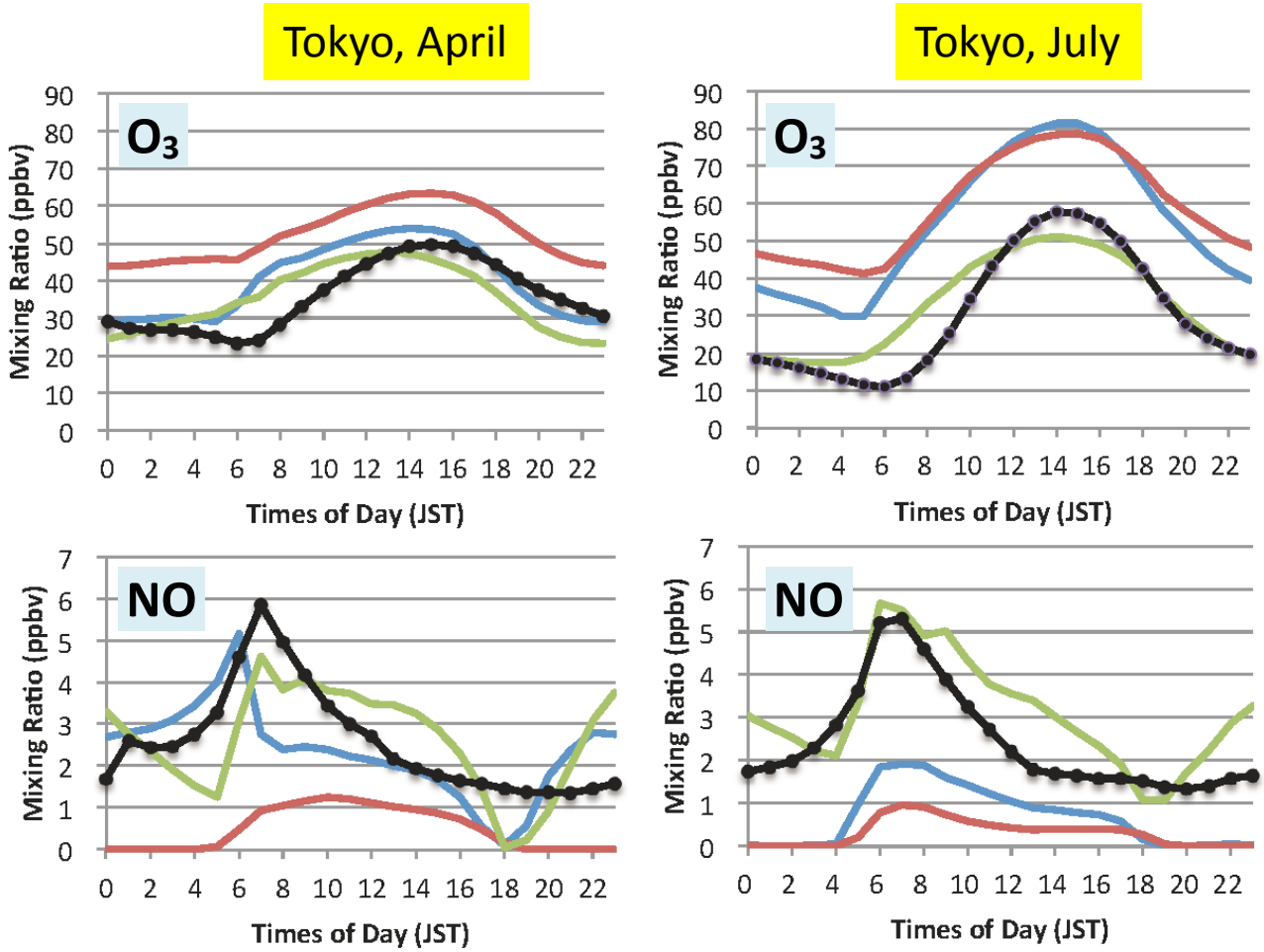
Other model inter-comparisons (**HTAP2**, **CCMI**) also showed overprediction in summertime O_3 near Japan



Diurnal variation of O_3 and NO: Tokyo

The model which can predict relatively high NO concentration tended to simulate O_3 in better agreement with the observation.

Keeping relatively high concentration of NO in nighttime is a key to more realistic simulation of O_3



Akimoto et al., in prep.

Summary

- The MICS-Asia III atmospheric chemical model inter-comparison showed large variation in simulated surface O_3 over E-Asia even with unified settings (domain, met., and emission).
- Even the state-of-the-art models still overpredict summertime surface O_3 around Japan.
- The model with relatively high NO concentration tended to simulate O3 in better agreement with the observation.