Modelling KORUS-AQ with CAM-Chem

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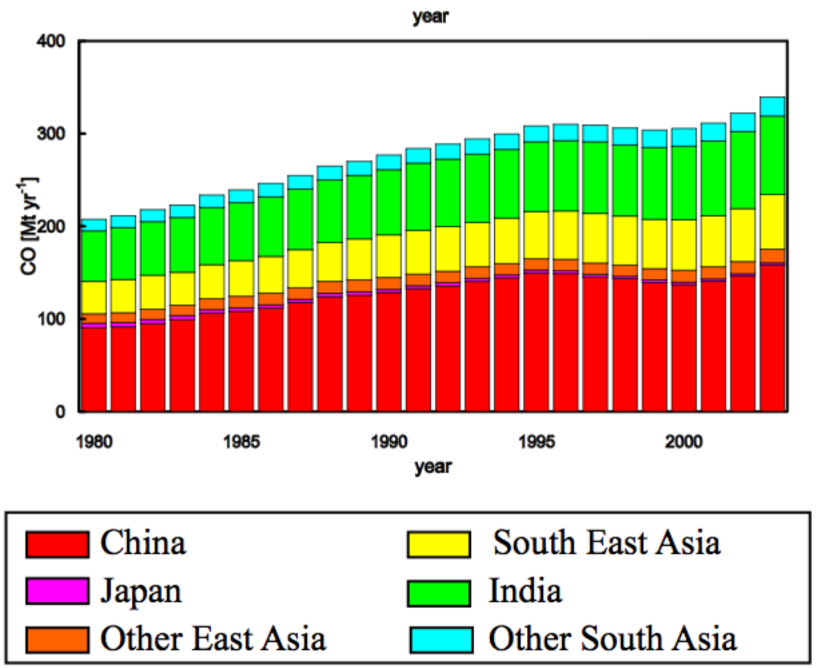
KORUS-AQ

Why Korea?

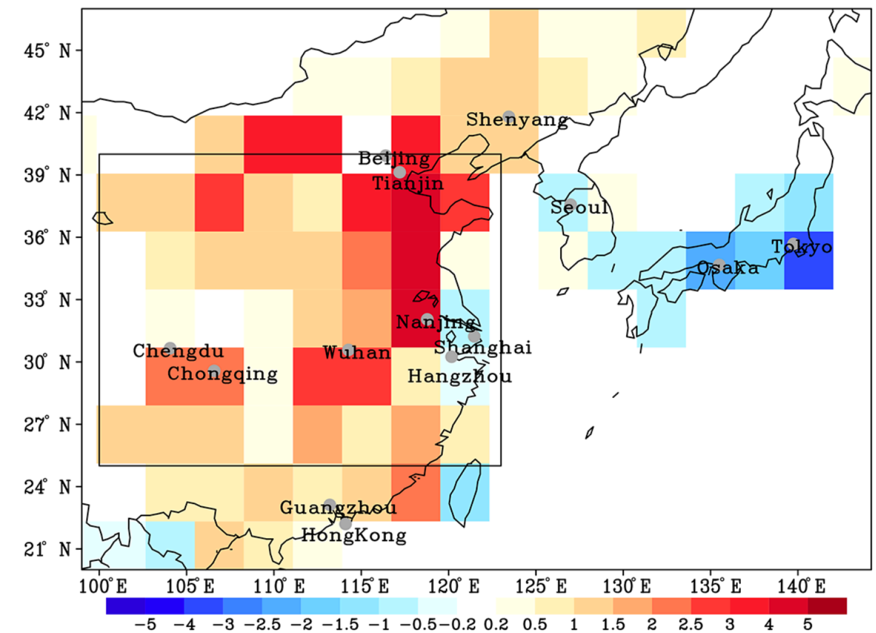
- strong air quality gradients both in time and space
- Rapid change in emissions
- A local contrast between forests, cities and Industries

1980 to 2003



Total annual CO emissions Ohara et al. (2007)

2005 to 2014



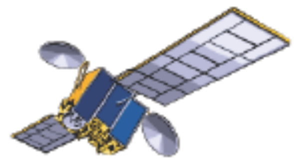
linear trend in surface NOx emissions (in 10^{-11}kg.m^{-2}.s^{-1} per decade) during 2005–2014 from the a posteriori emissions

K. Miyazaki et al.: Surface NO_x emissions 2005–2014

KORUS-AQ combined assets from the Korean and U.S. atmospheric science communities and their supporting organizations (NIER, NASA, Universities, etc.) to implement an integrated observing system for improving our understanding of Air Quality

Airborne sampling

- provides critical view for evaluation strategies in connecting ground-based and satellite observations
- Short term



Satellites

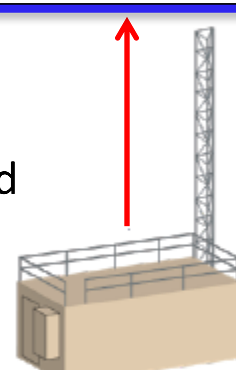
- provide broad coverage, continuity
- but it needs reliable information on near-surface exposure.

KORUS-AQ Goals

- **Improve capability for satellite remote sensing of air quality**
- **Better understanding of the factors controlling air quality**
- **Test and improve model simulation of air quality**

Ground monitoring

- It will continue to be the primary method for monitoring exposure.
- Coverage is limited.



Modeling

- provide Air quality forecasting and warning service
- but it needs reliable information on emission inventory and so on.

Question 1: How significant is the impact of the large point sources (power plants and petrochemical plants) along the west coast to the air quality of SMA temporally and spatially?

Question 2: Can we identify 1) the portion of aerosol derived from secondary production in SMA and across Korea, and 2) the major sources and factors controlling its variation?

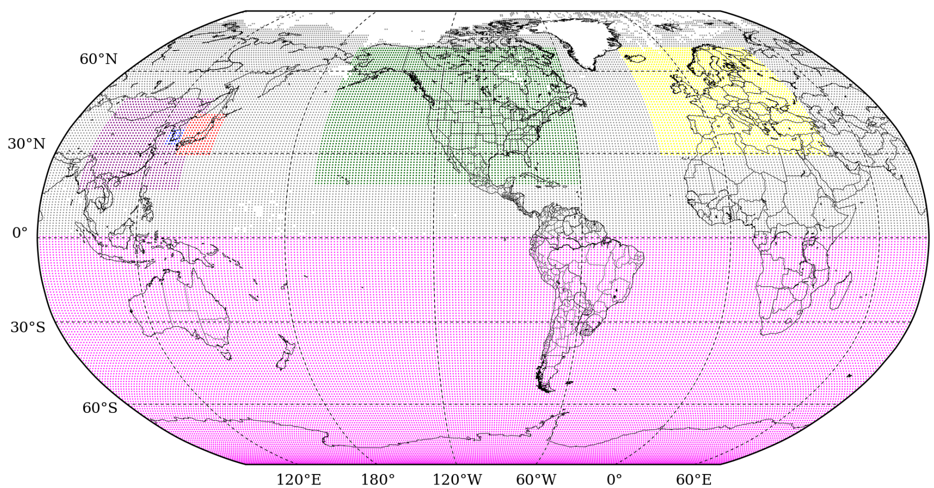
Question 3: Is ozone formation in SMA NOx limited or VOC limited? Can we determine the biogenic or natural contributions to ozone production?

Question 4: How is SMA affected by transport of air pollution from sources from regional to continental to hemispheric scales?

Question 5: How well do KORUS-AQ observations support current emissions estimates (e.g., NOx, VOCs, SOx, NH_3) by magnitude and sector?

CESM | COMMUNITY EARTH SYSTEM MODEL

- **CESM2**
- **Grid spacing: 0.9x1.25°**
- **CAM 6** physics / Specified dynamics from GEOS
- **Chemistry** MOZART Troposphere Stratosphere (TS1), mam4 aerosol scheme, SOA-VBS
- **CLM5** with prognostic MEGAN biogenic emissions
- **Emissions :**
  - ✓ **Anthropogenic:** KORUS-CREATE in East-Asia, HTAP2 and CCMI otherwise
  - ✓ **Biomass Burning: Fire INventory from NCAR (FINN 1.5)** (Wiedinmyer et al. 2011)
  - ✓ Prescribed Methane derived from surface observations, updated file from CMIP6 (Meinshausen et al. 2017)

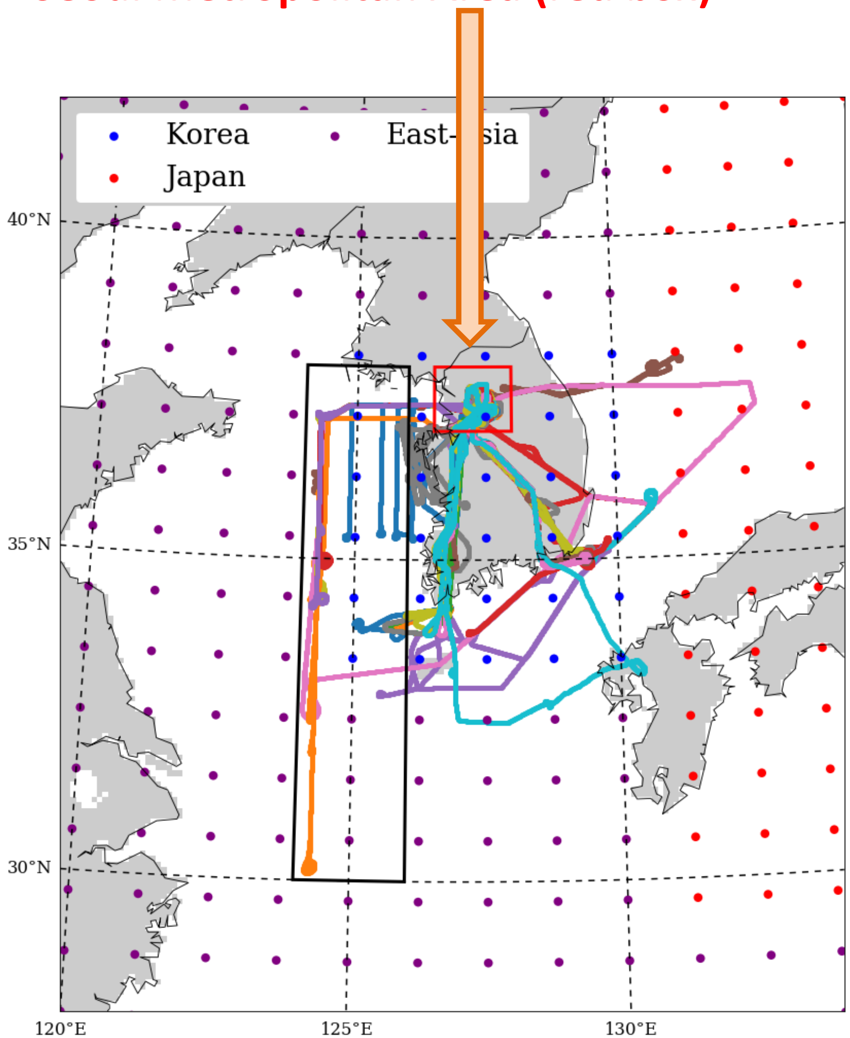


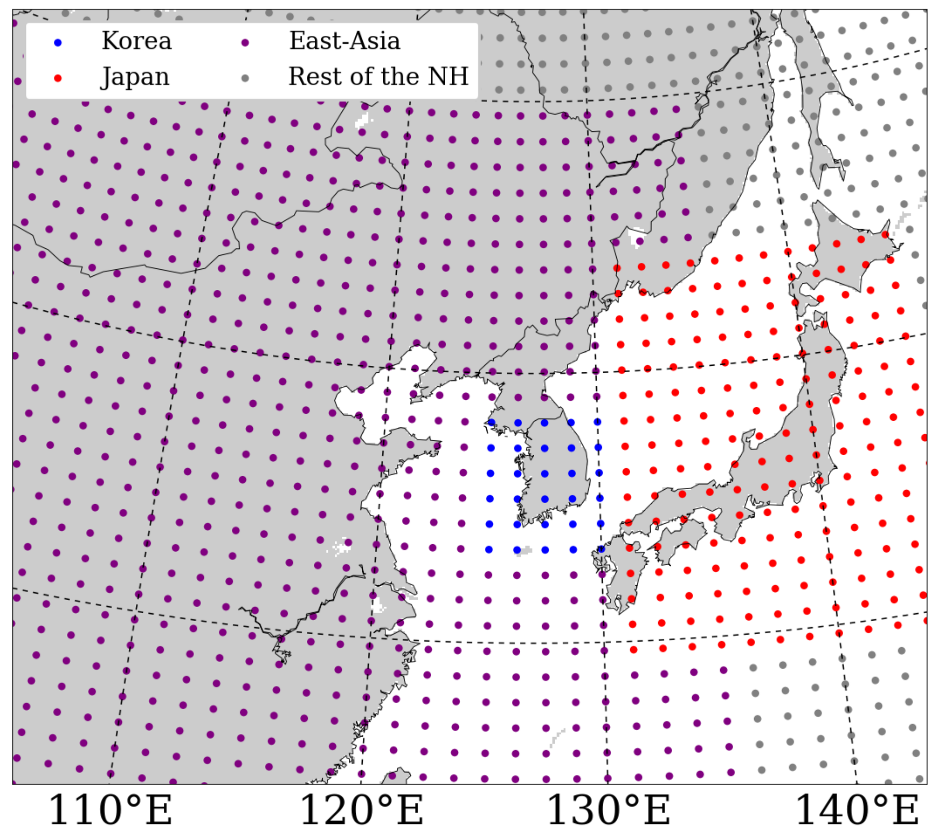
Map of CO tags from anthropogenic sources only (CO05 to CO11)

Tags Name	Tags Region	Tags sector
CO01	Global	Anthro
CO02	Global	BB
CO03	Global	Ocean
CO04	Global	Biogenic
CO05	Korea	Anthro
CO06	Japan	Anthro
CO07	East-Asia	Anthro
CO08	Europe	Anthro
CO09	NAM	Anthro
CO10	Rest of NH	Anthro
CO11	SH	Anthro

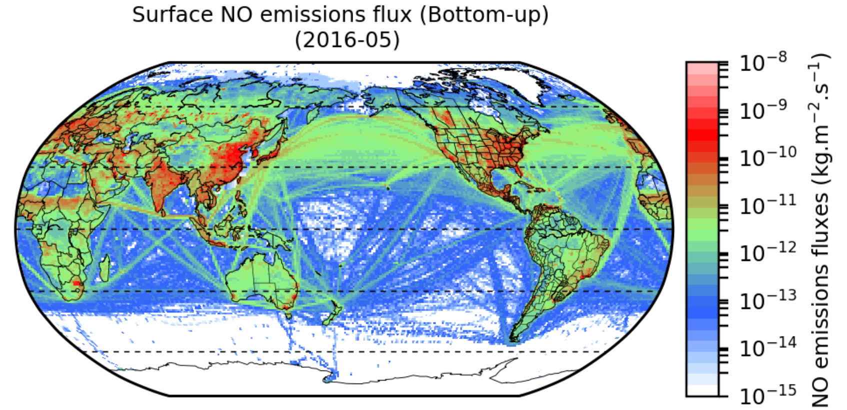
DC8 Observations

- **Simple evaluation of the CAM-Chem simulation and sensitivity experiments**
  - **Yellow sea: pollution transport capability (including recirculation) and inflow quantifications (black box)**
  - **Seoul Metropolitan Area (red box)**





Sensitivity to NOx emissions



- **Emissions (Bottom-up case 1):**
  - ✓ **Anthropogenic:** KORUS-CREATE in East-Asia, HTAP2 and CCMI otherwise
  - ✓ **Biomass Burning: Fire INventory from NCAR (FINN 1.5)** (Wiedinmyer et al. 2011)
  - ✓ **Prescribed surface methane (CMIP6)**

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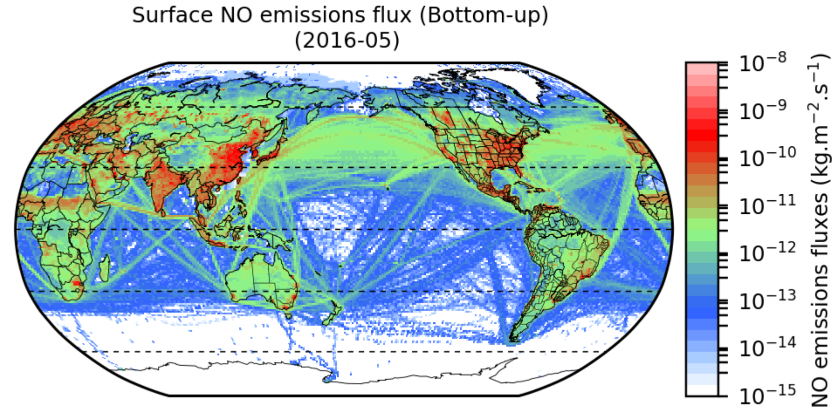
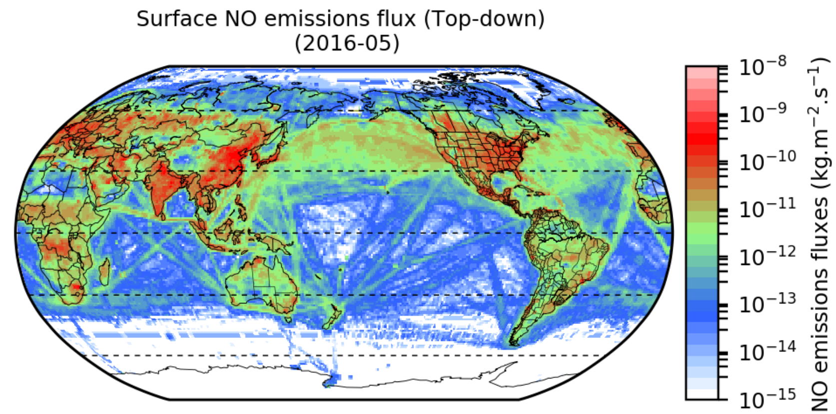
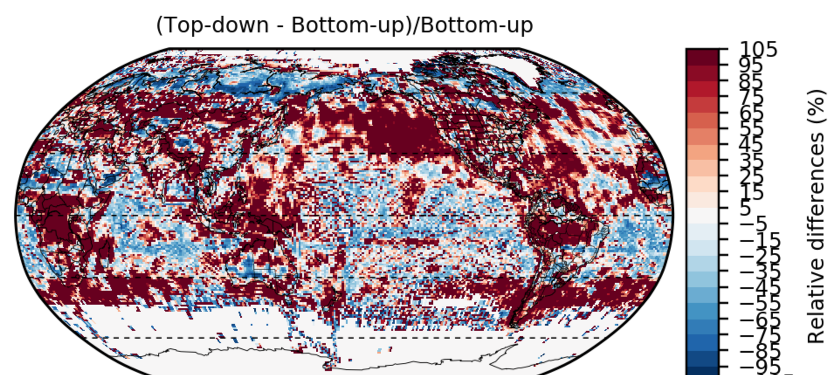
  - ✓ **Prescribed surface methane (CMIP6)**

- **<u>Emissions (Top-down case 2):</u>**
  - ✓ **All the same but with different surface NO emissions (soil, anthropogenic and BB)**
- **Emissions (Top-down case):**
  - ✓ **MIROC-Chem model with EDGAR and GFED**
  - ✓ **Direct constraints on NOx emissions from NO_2 assimilation (OMI, SCIAMACHY, and GOME-2)**
  - ✓ **Indirect constraints through MOPITT-CO, MLS O_3 and HNO_3 and TES-O_3**

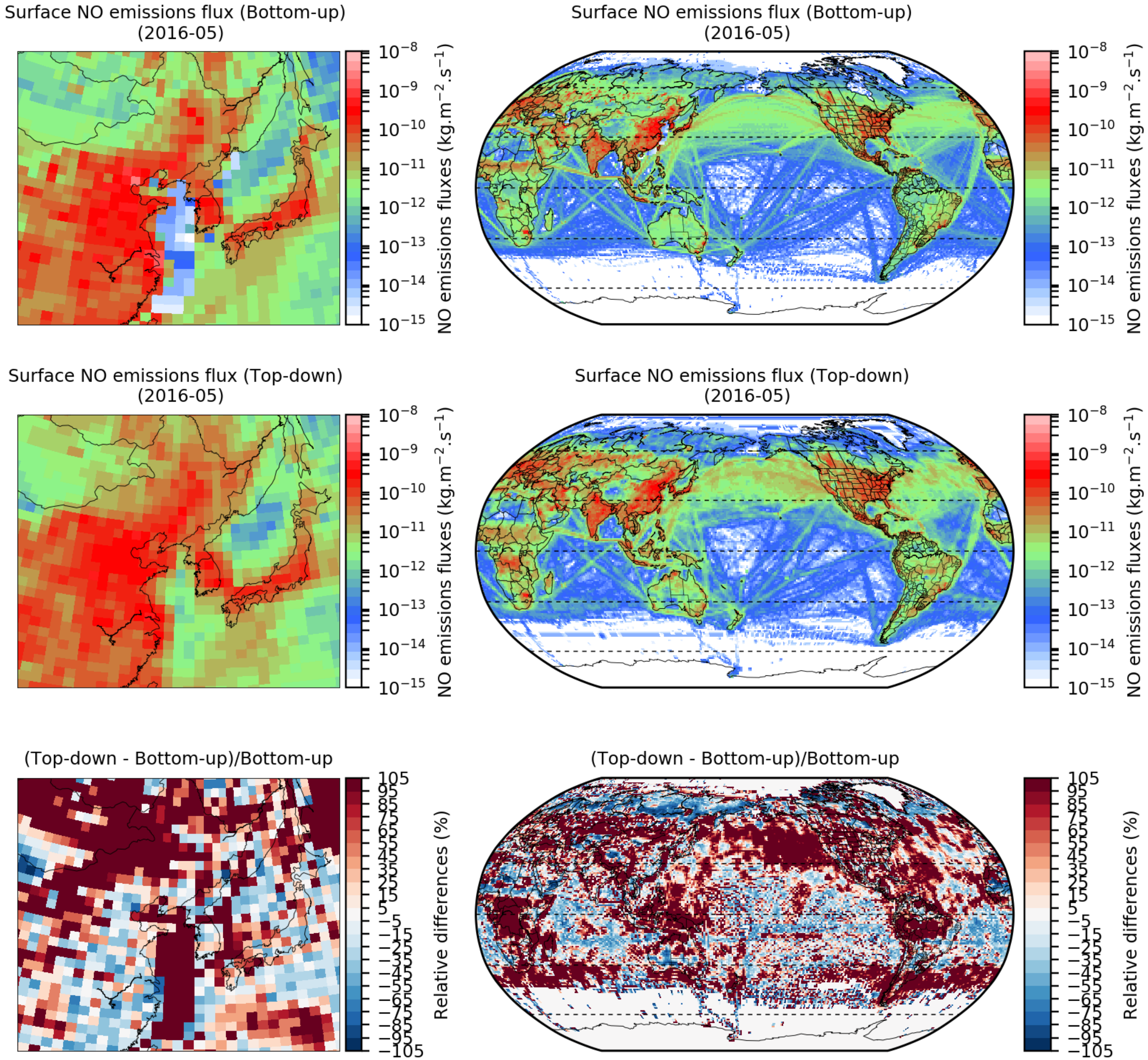




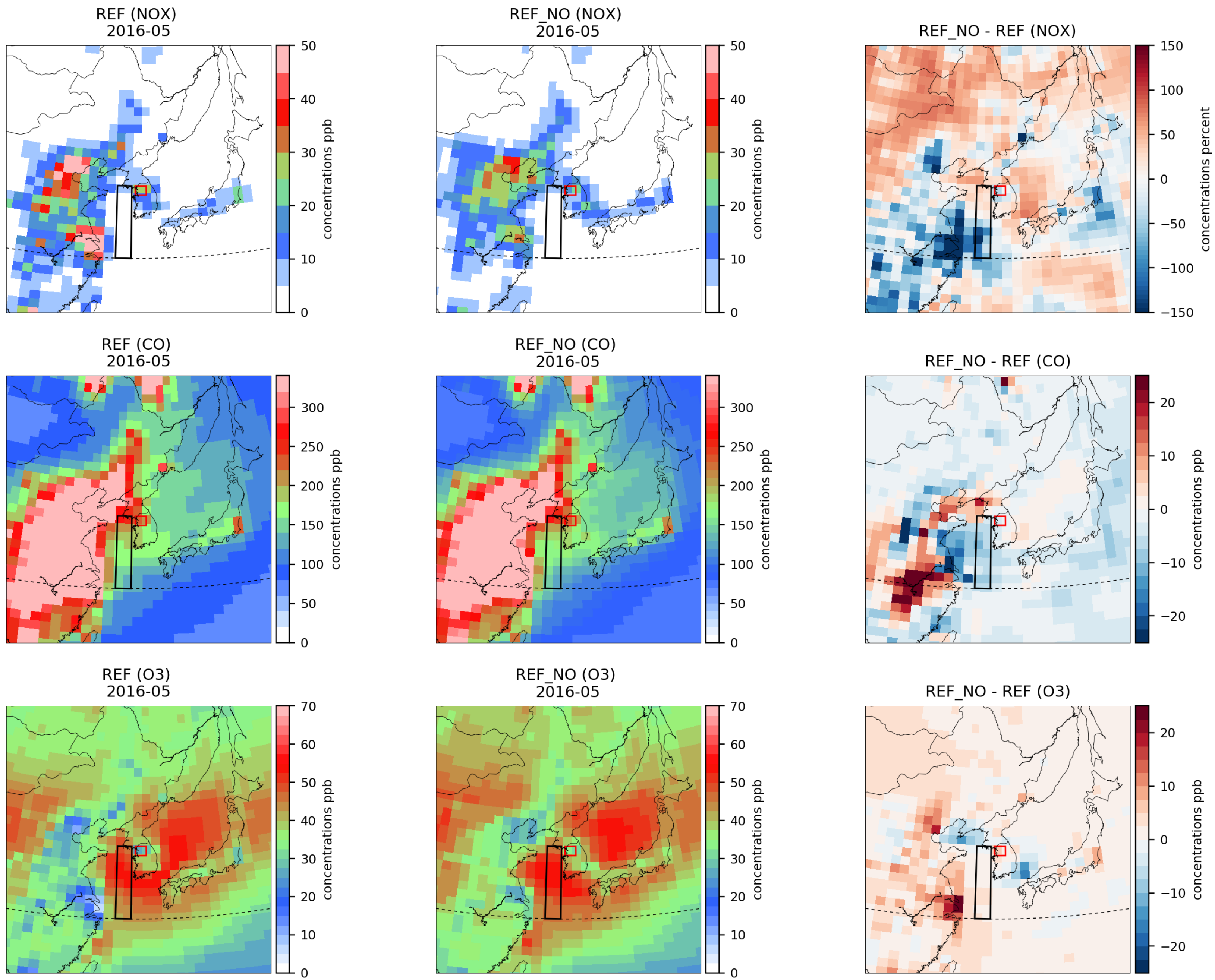


K. Miyazaki et al.: Surface NO_x emissions 2005–2014

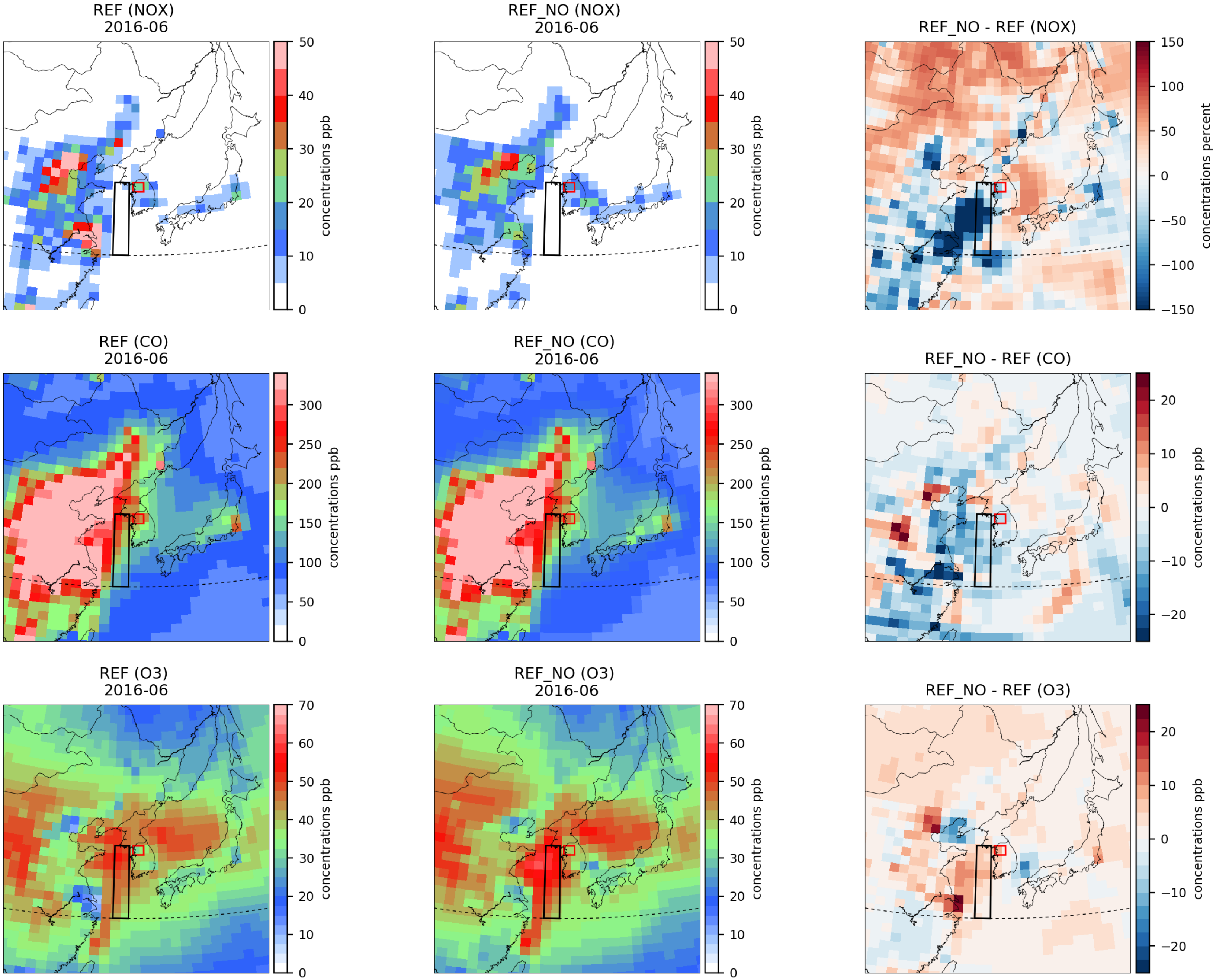
Sensitivity to NOx emissions



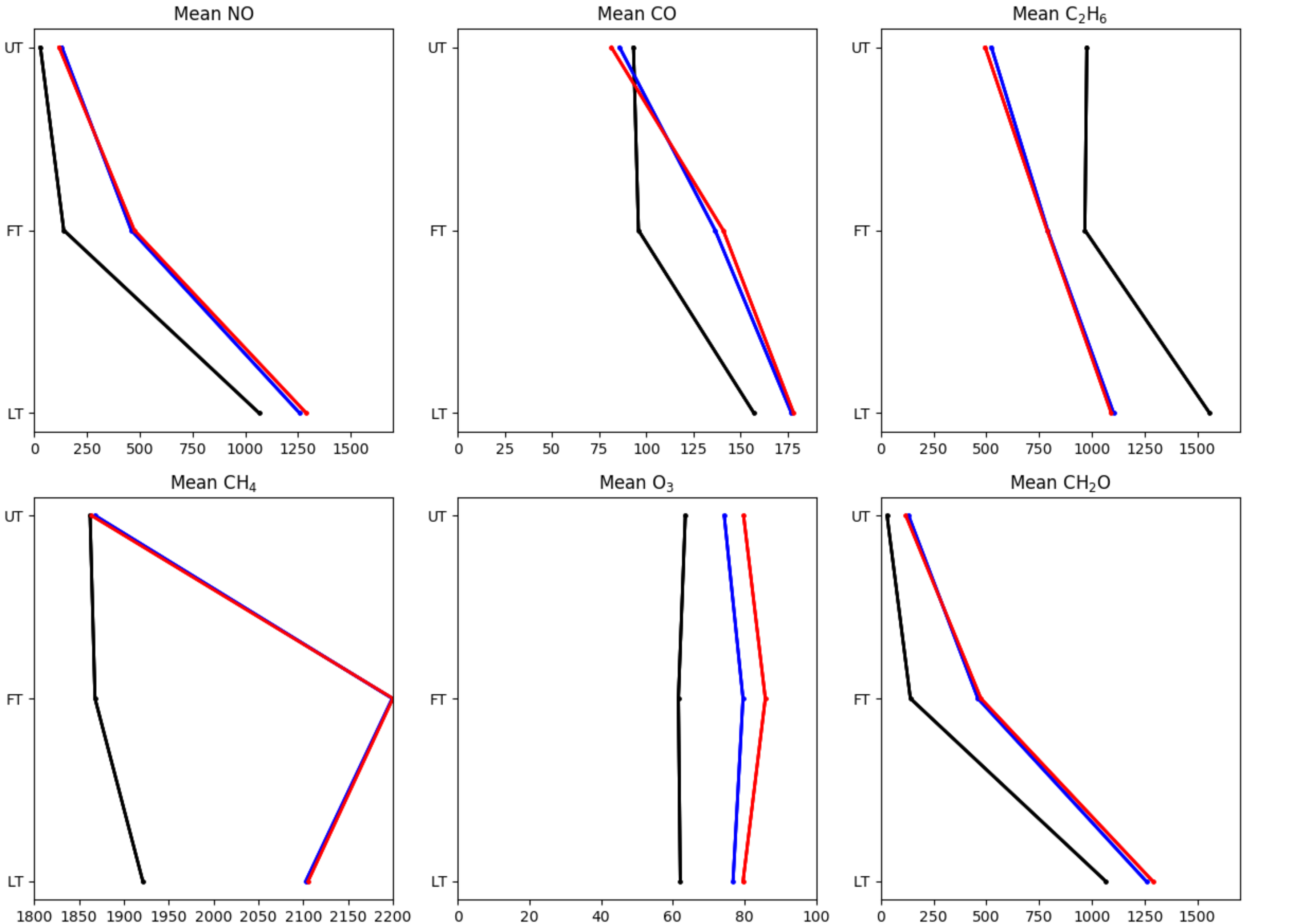
Sensitivity to NOx emissions (average May 2016)



Sensitivity to NOx emissions(average June 2016)

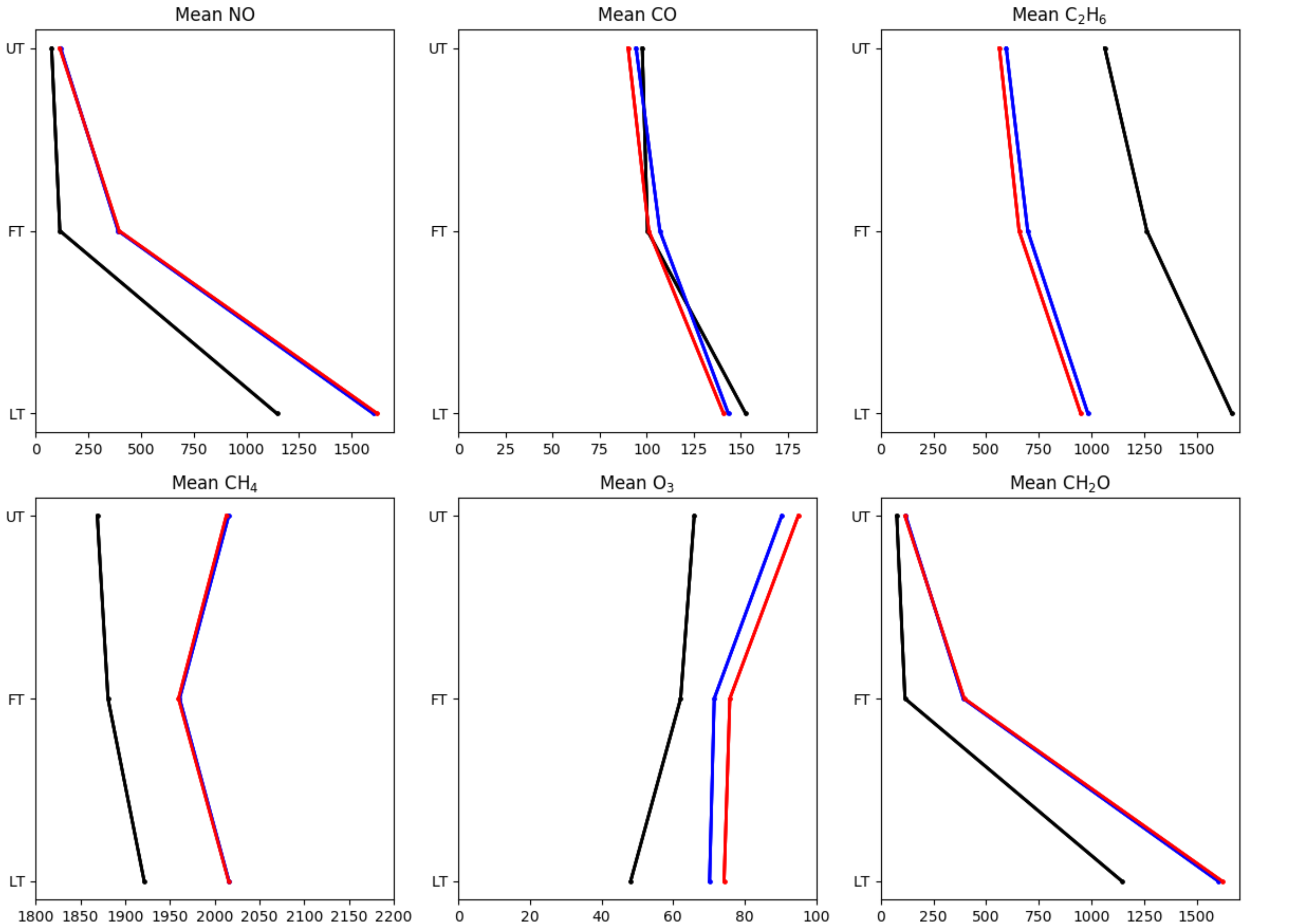


Evaluation against DC8 Observations: Yellow sea



All values are in ppb CH2O and C2H6 in ppt

Evaluation against DC8 Observations: Seoul Metropolitan Area



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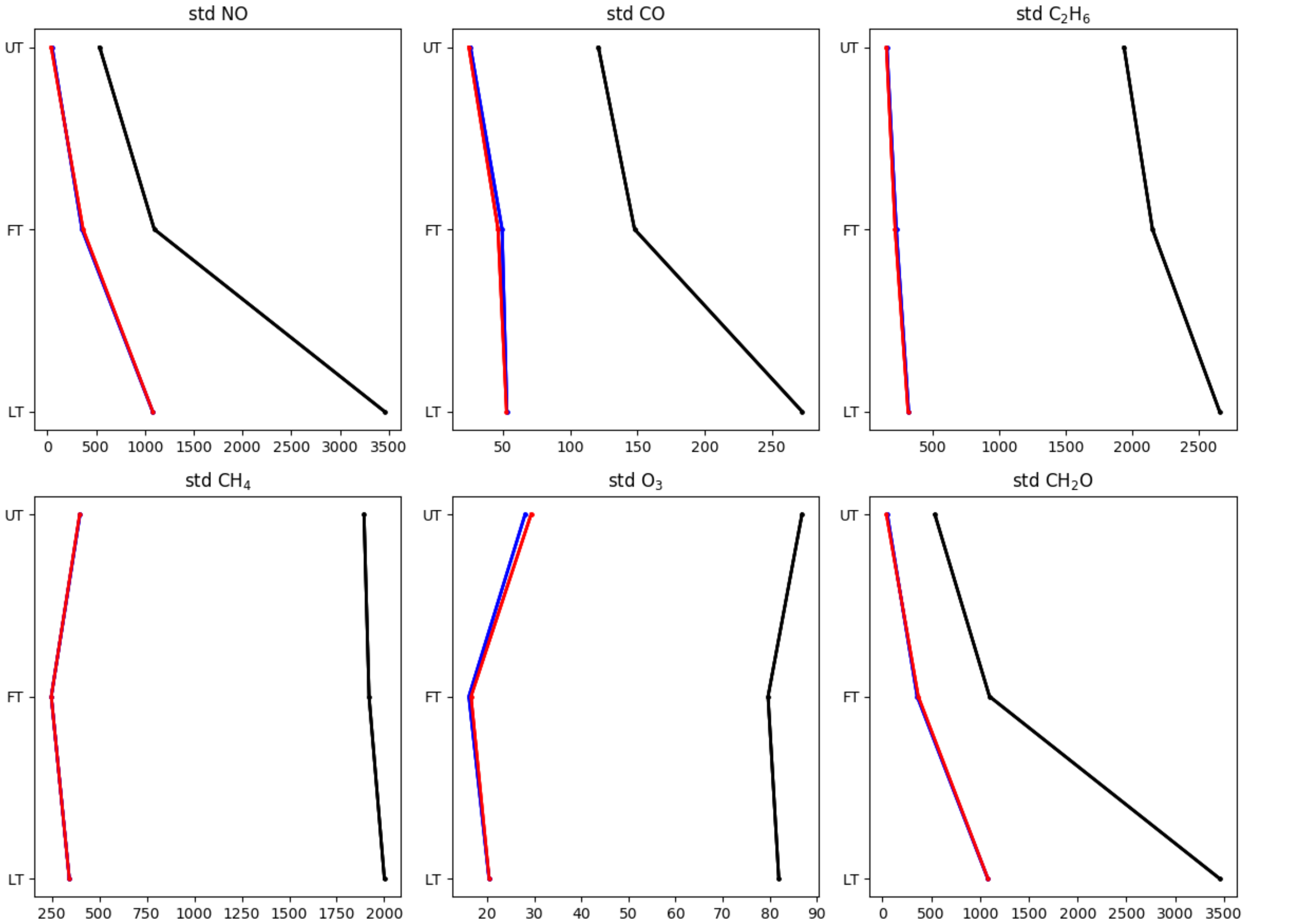
Evaluation against DC8 Observations: Seoul Metropolitan Area



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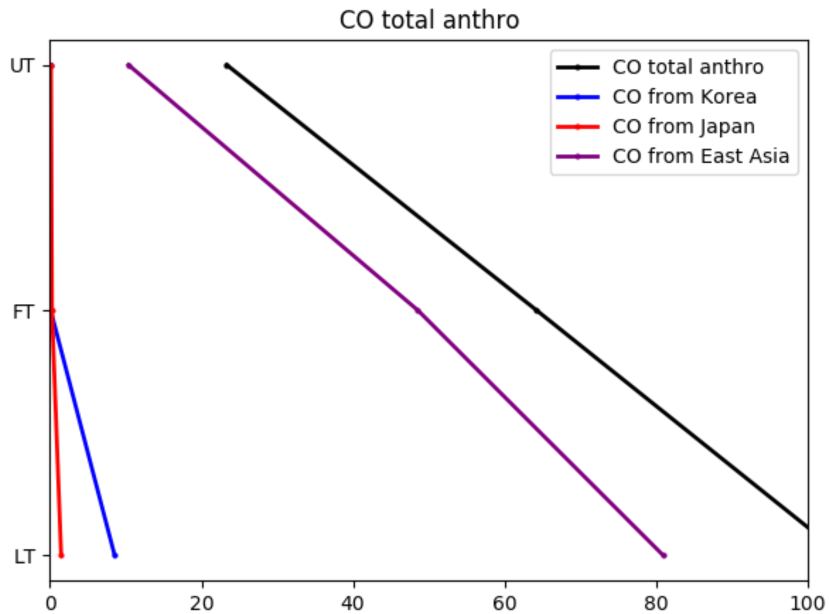
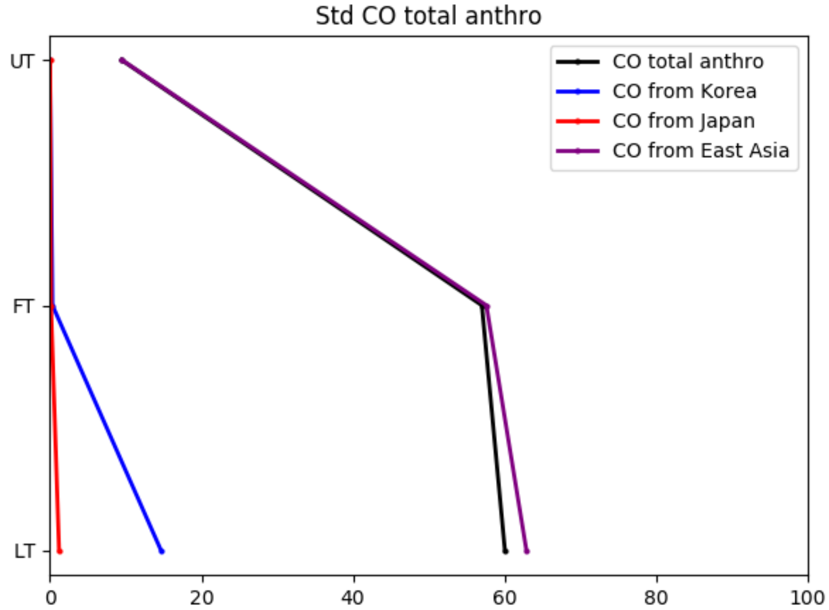
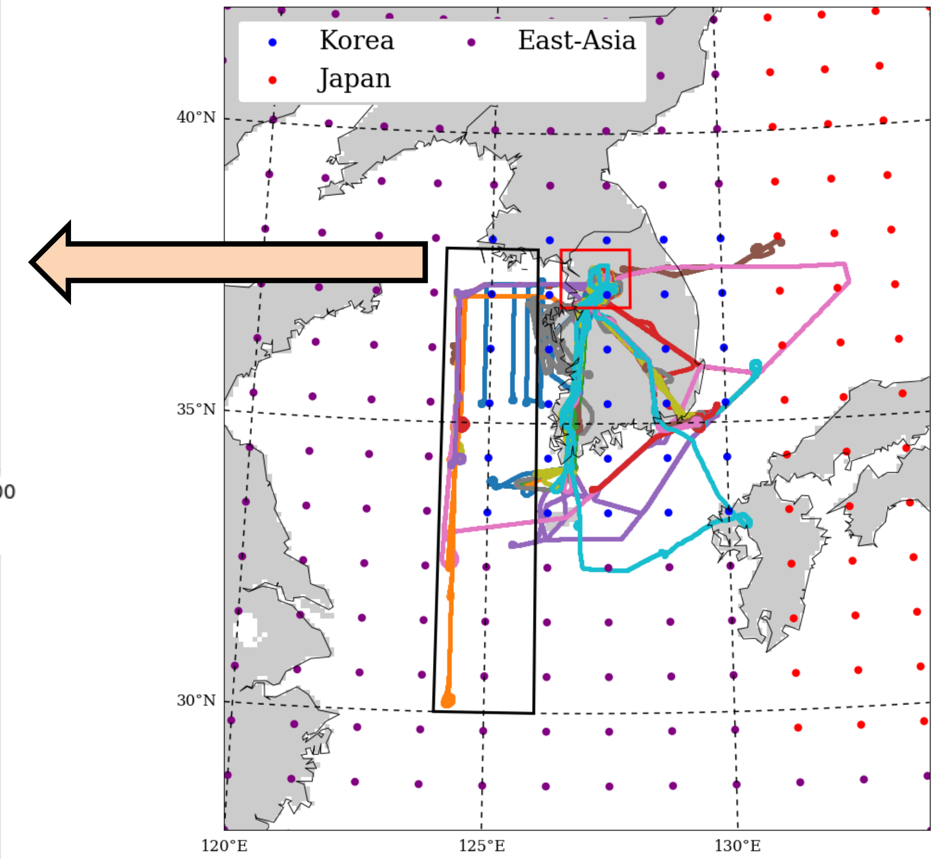
Evaluation against DC8 Observations (yellow sea)

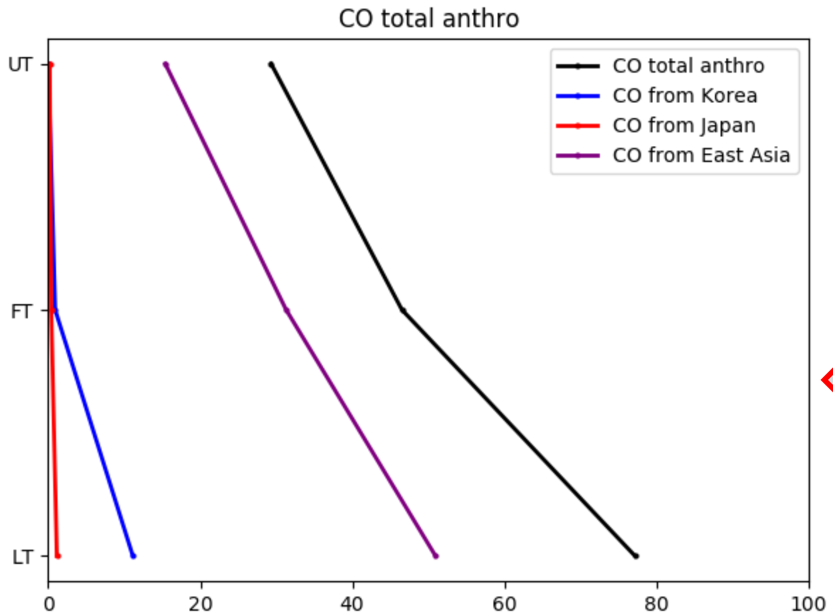
CO Tags

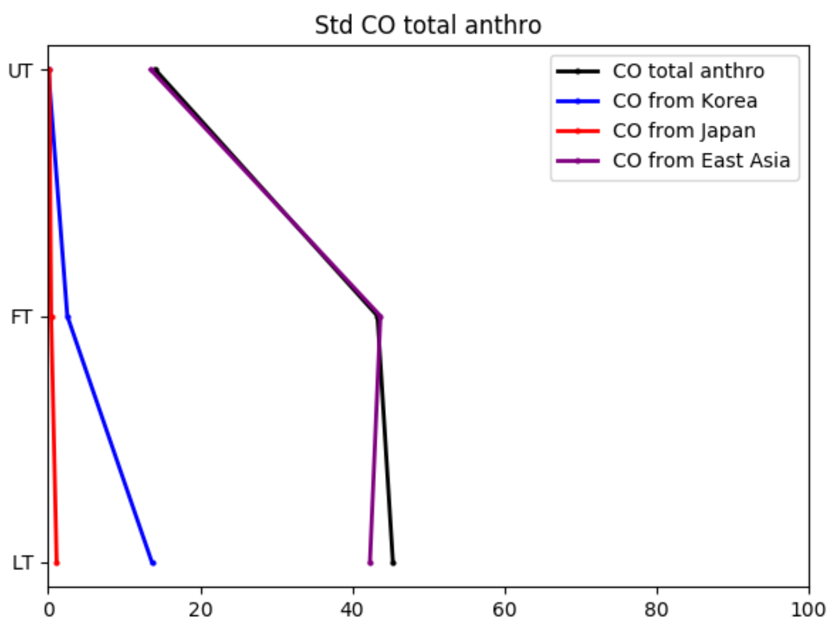


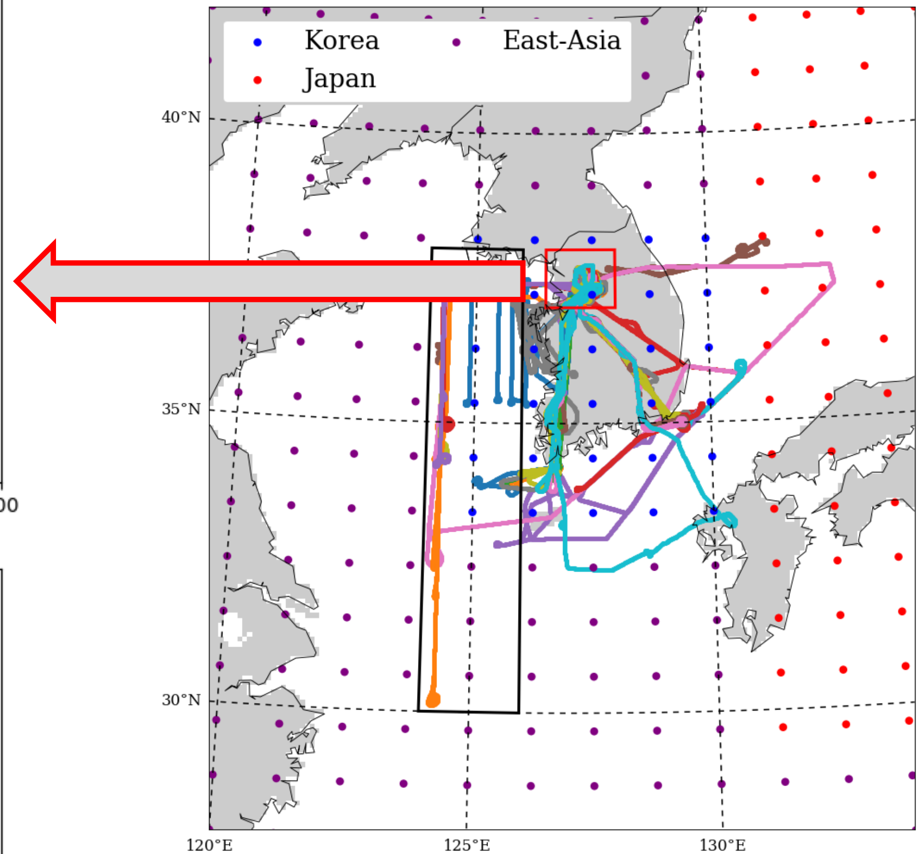




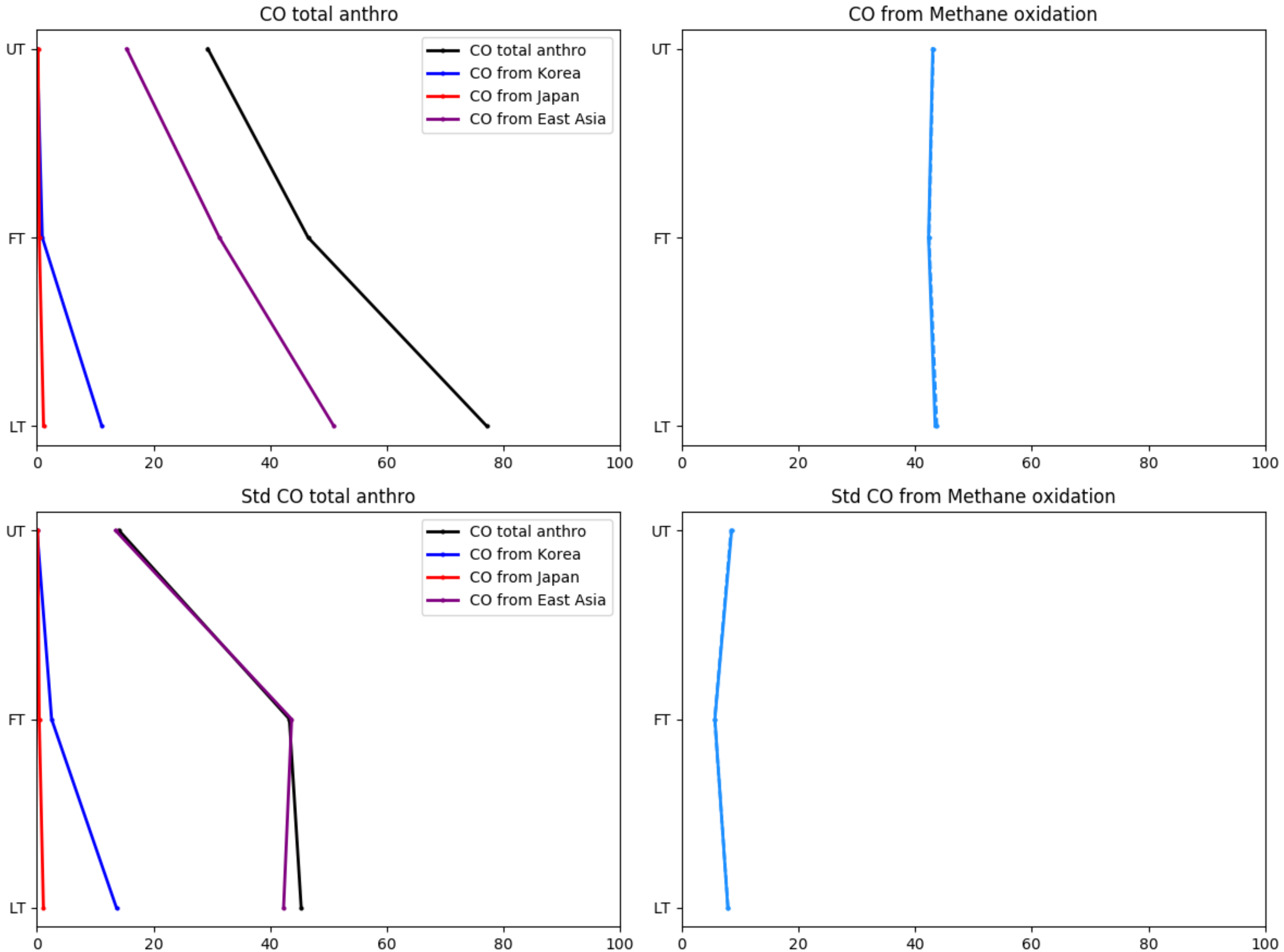
Evaluation against DC8 Observations Seoul Metropolitan Area CO Tags







Evaluation against DC8 Observations Seoul Metropolitan Area CO Tags



Conclusions

- **Yellow sea pollution levels are similar to Seoul**
  - **With significant levels of transported pollution**
  - **Average ozone of 60 ppb**
- **Secondary pollutants are overestimated (CH_2O, O3), which leads to a good average CO due to secondary production**
- **CH_4 variations and VOC's are largely underestimated**

- **Preliminary results of CESM2/CAM-Chem**
- **Grid spacing surely play a role**
  - **Need to identify large scale transport and background**
  - **Avoid comparison with local and unresolved plumes**
  - **Make sure the temporal sampling is coherent**
- **Identify contribution from stratospheric ozone**
- **Evaluate chemical regimes of ozone production**

Perspectives

- **Assimilation of MOPITT V7 with meteorological observations**

- **Improve ensemble design to estimate emissions and concentrations**
- **Uncertainty of emissions and (chemistry balance) using**
  - **an ensemble of emission inventories (anthropogenic and BB separately) from both top-down and bottom-up inventories**
- **Perturbing of chemical kinetics of key reactions (Ridley et al. 2017, GRL)**

Thanks for your attention

Evaluation against DC8 Observations (yellow sea)

CO Tags