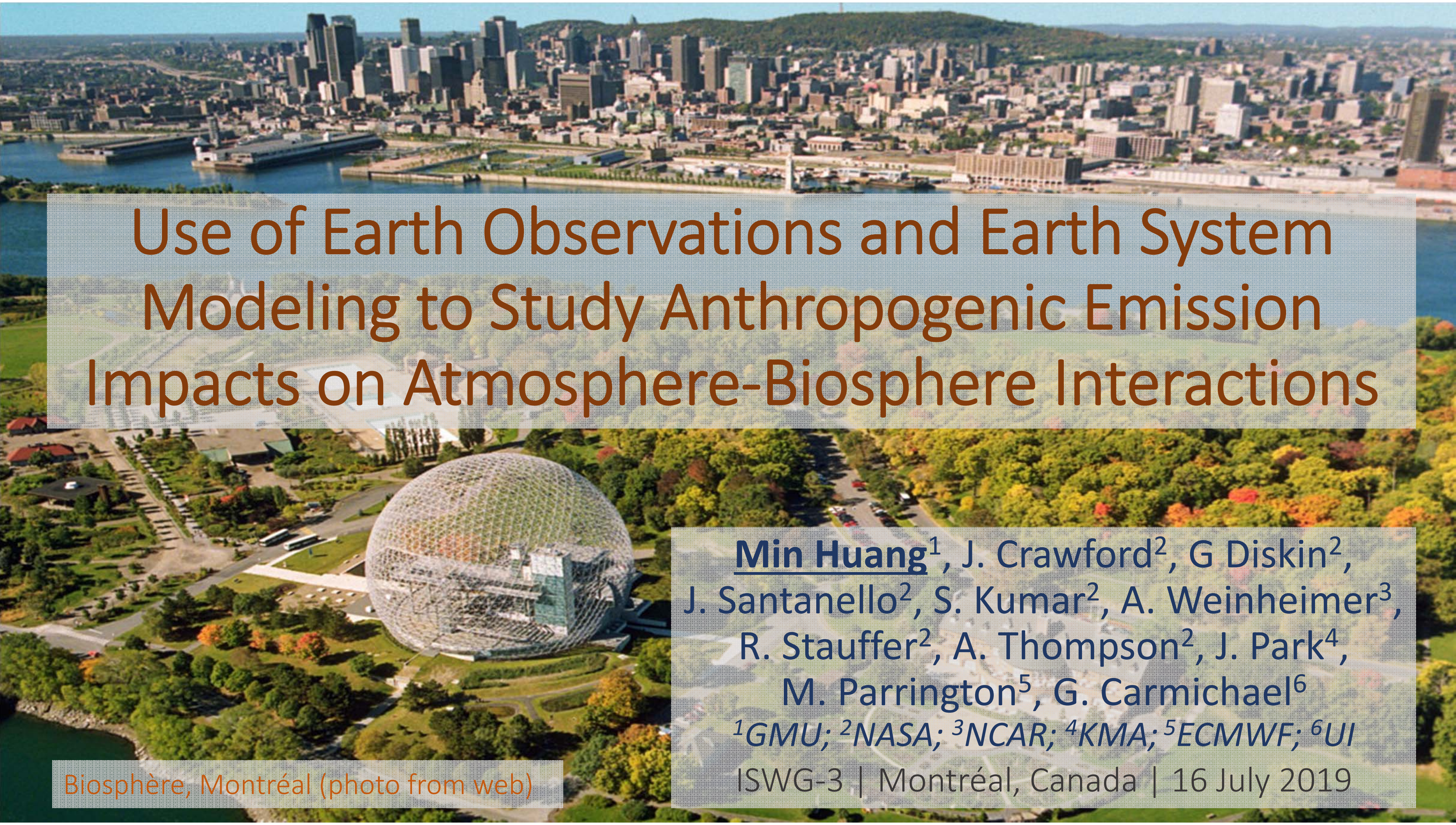


Use of Earth Observations and Earth System Modeling to Study Anthropogenic Emission Impacts on Atmosphere-Biosphere Interactions

Min Huang[1], J. Crawford[2], G Diskin[2], J. Santanello[2], S. Kumar[2], A. Weinheimer[3], R. Stauffer[2], A. Thompson[2], J. Park[4], M. Parrington[5], G. Carmichael[6]

[1]GMU; [2]NASA; [3]NCAR; [4]KMA; [5]ECMWF; [6]UI

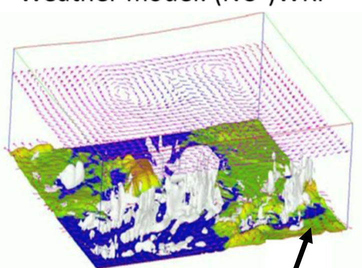
ISWG-3 | Montréal, Canada | 16 July 2019

Biosphère, Montréal (photo from web)

Review of materials presented at ISWG-2

We work on integrating various satellite land products into regional-scale weather & air quality modeling, including for the polluted East Asia

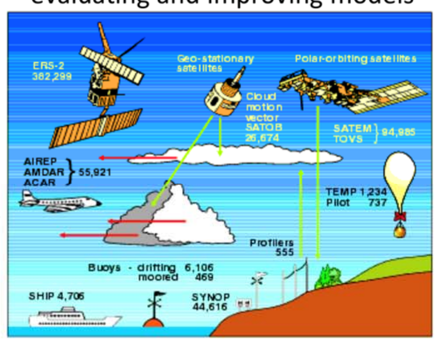
Weather model: (NU-)WRF



SQ1: Impact of (NU)WRF settings (e.g., land surface models and their initialization) on the simulated weather fields?

SQ2: (NU)WRF impacts on CTMs processes?

Observations (met and chemistry): evaluating and improving models



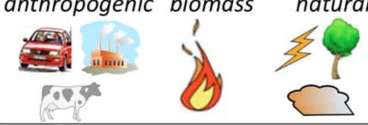
Chemical transport models (CTMs)

Chemical transformation: Ozone and aerosol production

Transport

Emissions

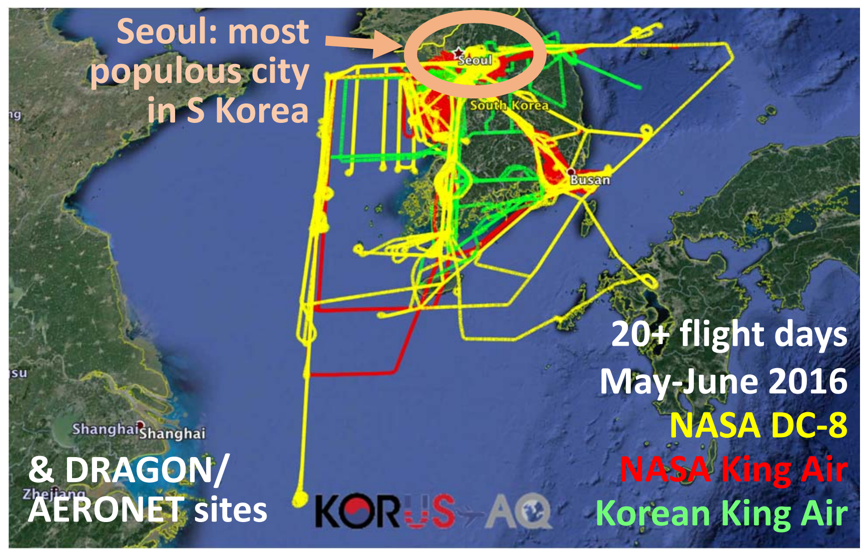
anthropogenic *biomass* *natural*



Deposition

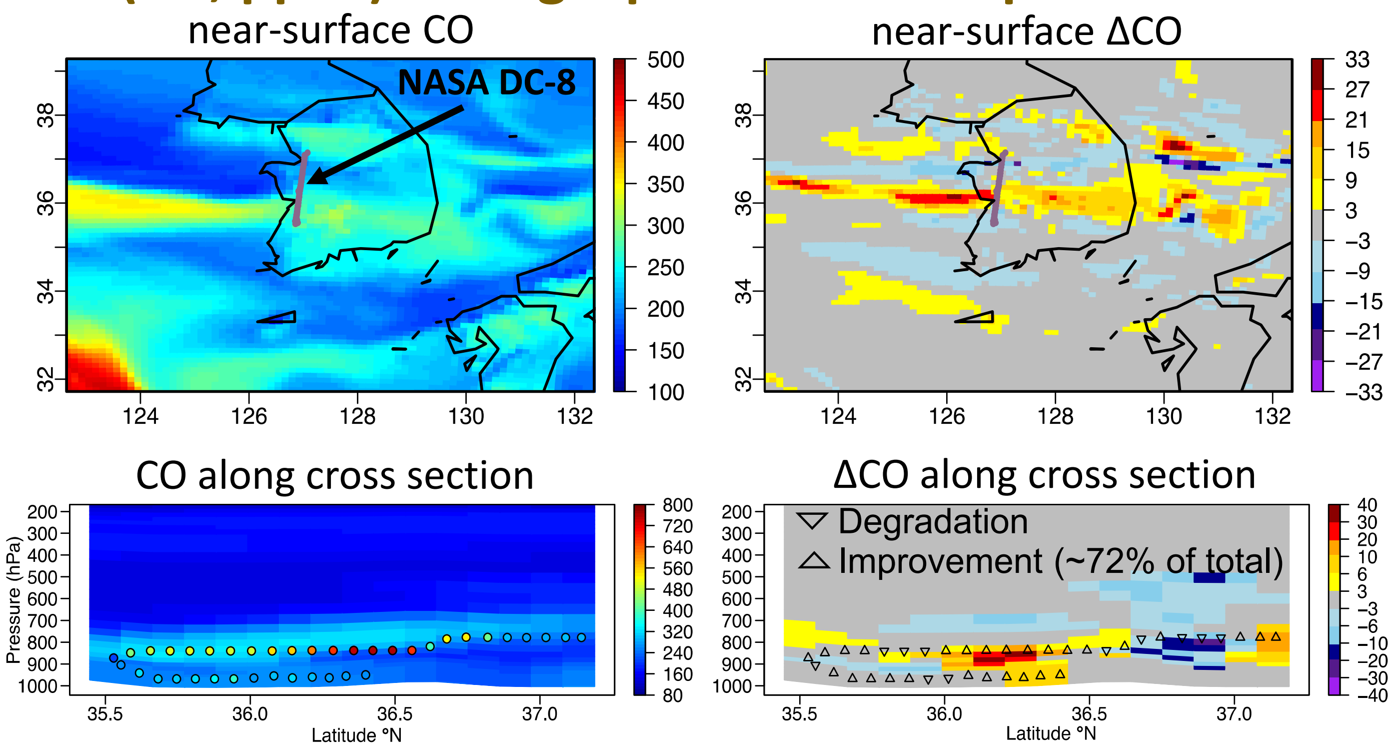
SQ3: How are pollution distributions related to weather and weather-dependent processes in CTMs?

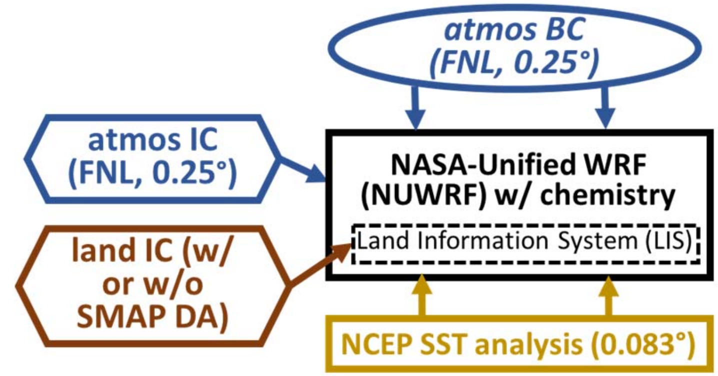
Health and policy-relevant analysis

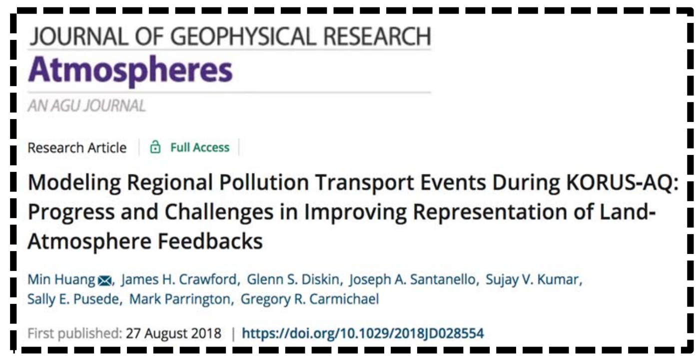


Review of materials presented at ISWG-2

SMAP DA impacts on NUWRF carbon monoxide (CO, ppbv) during a pollution transport event



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Atmospheres
AN AGU JOURNAL

Research Article Full Access

Modeling Regional Pollution Transport Events During KORUS-AQ: Progress and Challenges in Improving Representation of Land-Atmosphere Feedbacks

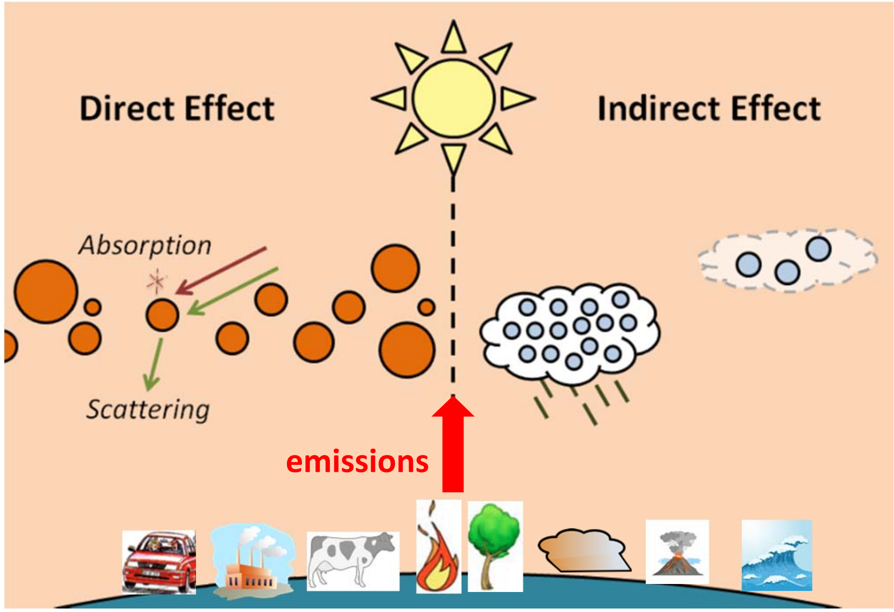
Min Huang, James H. Crawford, Glenn S. Diskin, Joseph A. Santanello, Sujay V. Kumar, Sally E. Pusede, Mark Parrington, Gregory R. Carmichael

First published: 27 August 2018 | https://doi.org/10.1029/2018JD028554

- SMAP SM DA (into Noah LSM) impacts on short-term NUWRF modeling during a pollution transport event: impacts on H_2O and CO correlated; improvements found in places
- chemical IC/BC: high-res ECMWF CAMS w/ chemical DA; emissions highly uncertain

What's new since ISWG-2: Noah→Noah-MP LSM

Primary & secondary aerosols from anthropogenic & natural emission sources alter weather patterns



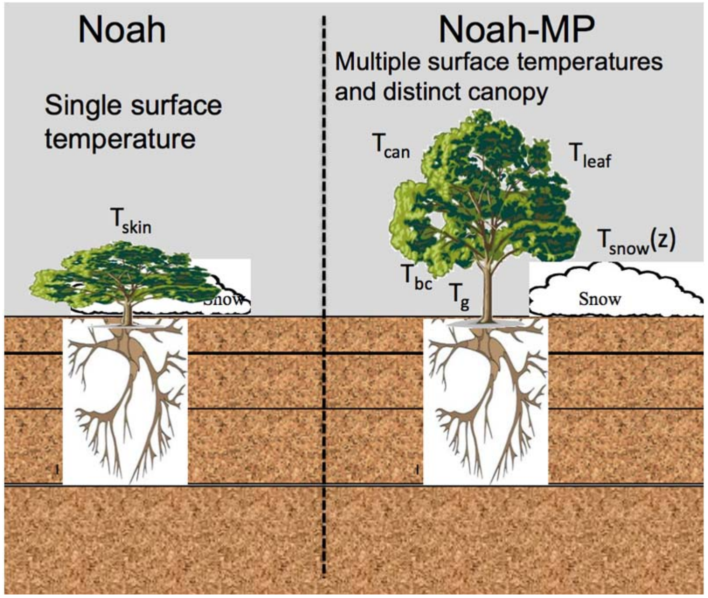


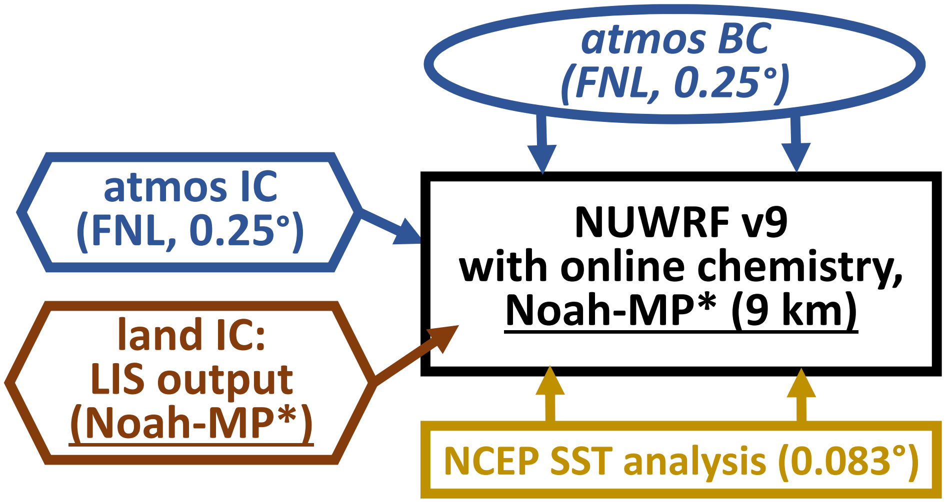
Figure source: English et al. (2011); Noah-MP tutorial (Barlage 2017)

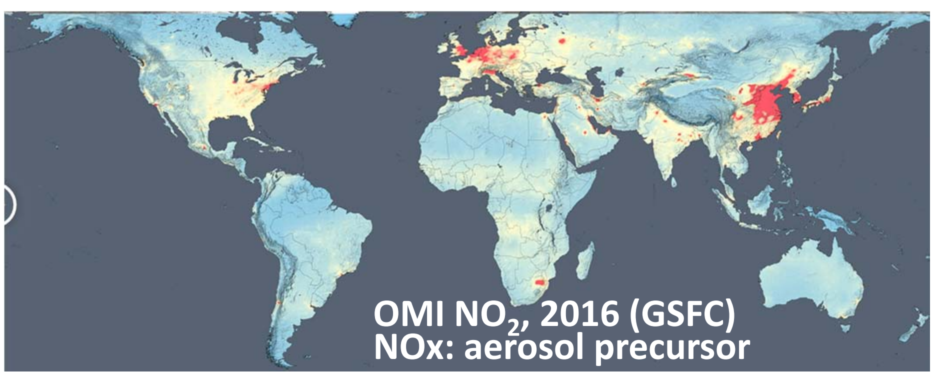
Noah-MP LSM:

- **Separate vegetation canopy**
- **Dynamic vegetation w/ Ball-Berry stomatal resistance**
- Multi-layer snowpack + other improvements from Noah

Ongoing work with Noah-MP in LIS/NUWRF

Evaluating immediate impacts of urban and shipping anthropogenic emissions on GPP and ET

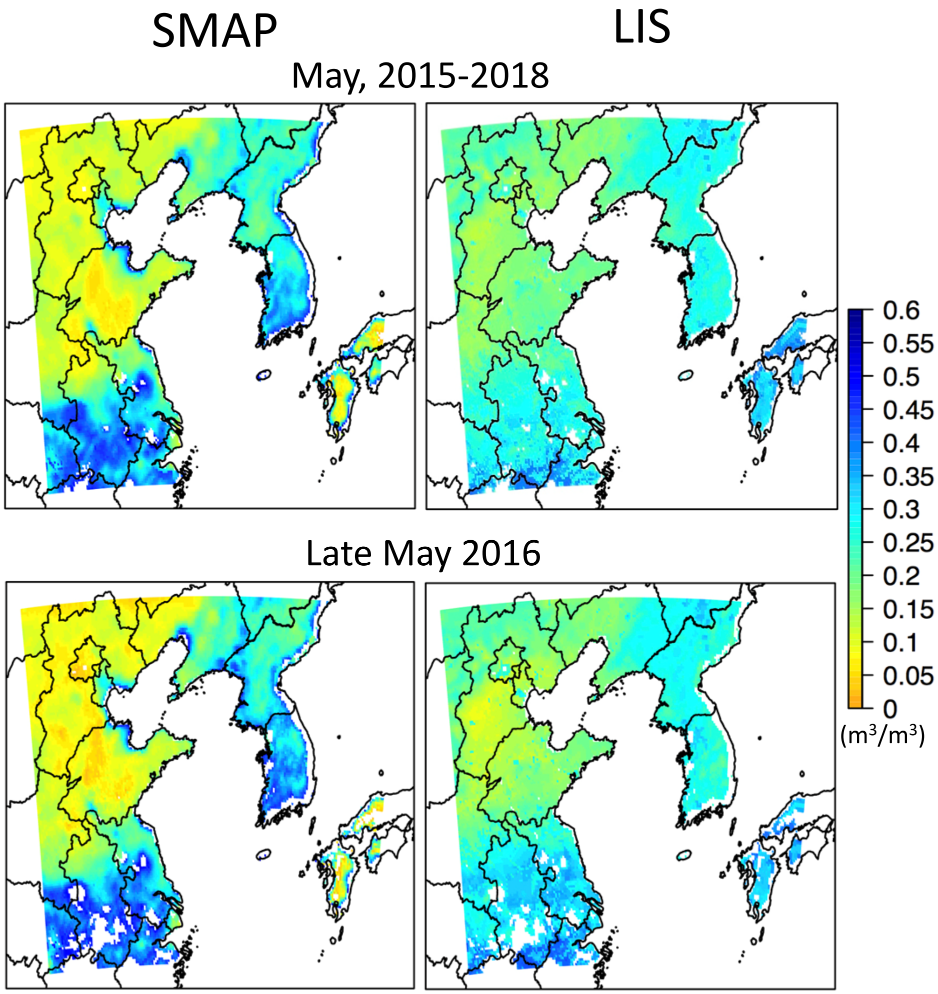


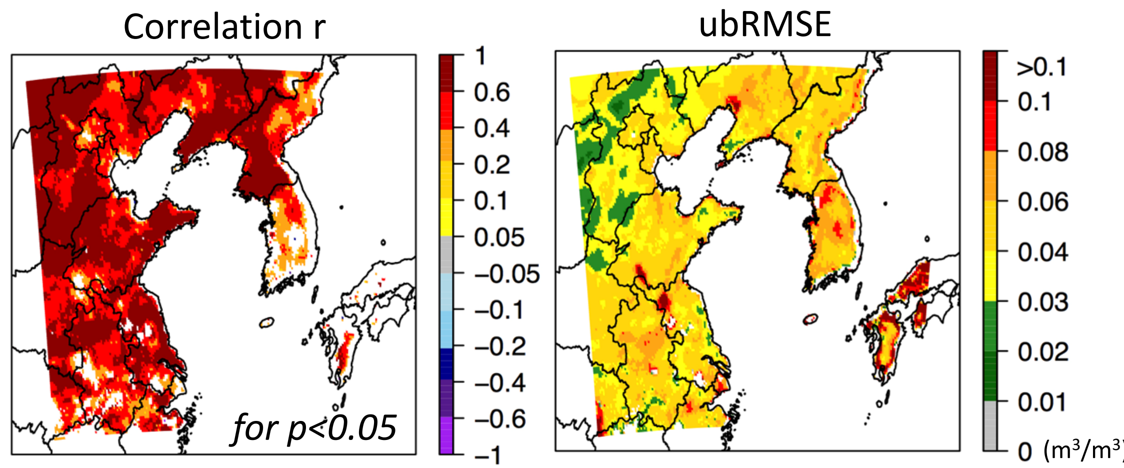


Offline LIS (Spring 2015-Spring 2018):
- physics settings accounting for Yang et al. (2011) recommendations
- SM/LAI evaluated with SMAP/MODIS

NUWRF runs (31 May 2016, cloudy):
- *Base:* largely based on HTAP2 (bottom-up) emissions
- *Sensitivity:* replacing NOx emissions with DECSO-OMI (satellite-constrained) in urban & non-terrestrial areas
- *Both:* Aerosol direct & indirect effects on
- GPP/ET compared with SMAP L4/COMS
- AOD/nitrogen species evaluated

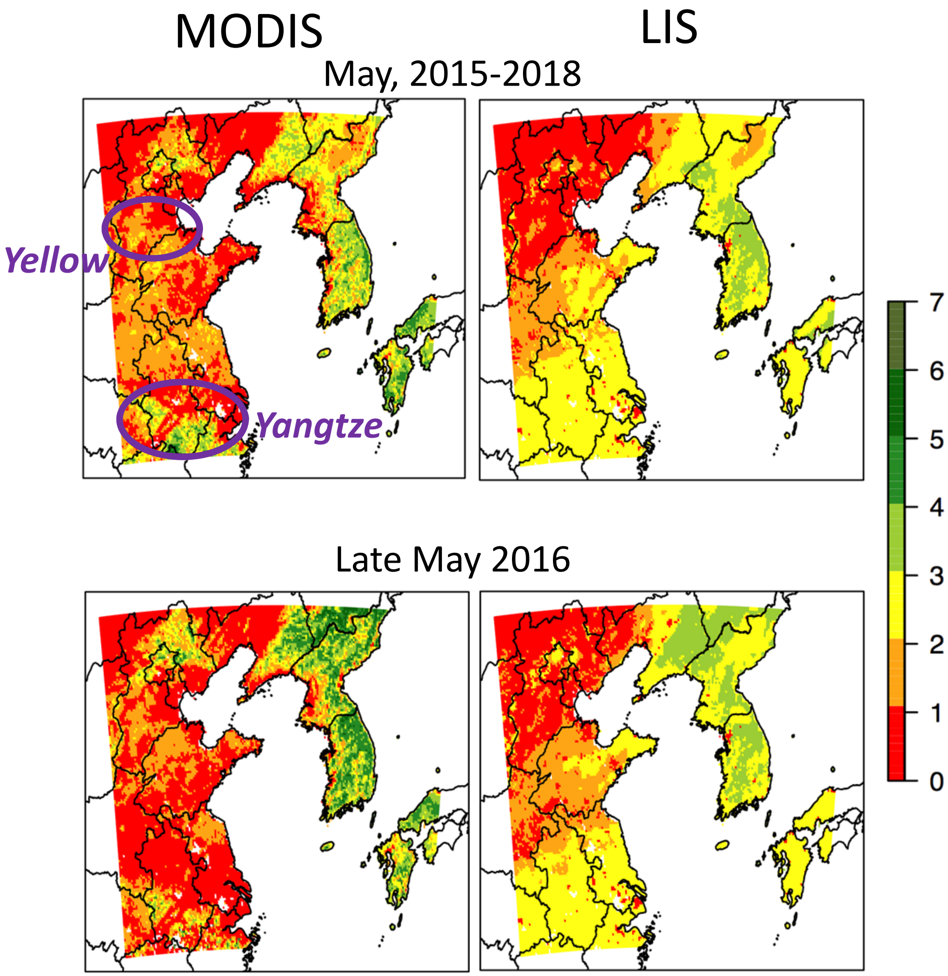
Surface SM from SMAP and offline LIS/Noah-MP





- **Model SM dynamic ranges smaller than SMAP**
- **Late May 2016 relative to climatology: drier in N China Plain (NCP), wetter in S Korea**
- **Higher r & lower ubRMSE in NCP than in S Korea**
- **However, more investigations needed on SMAP quality over S Korea (SMAPVEX19 NE US helpful)**

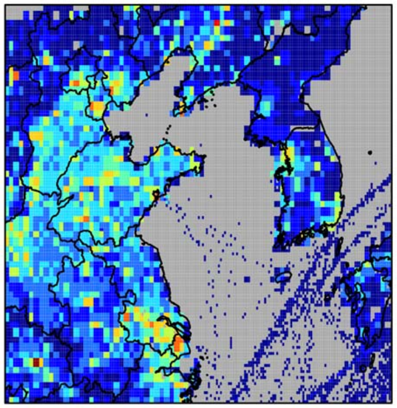
LAI from MODIS and offline LIS/Noah-MP



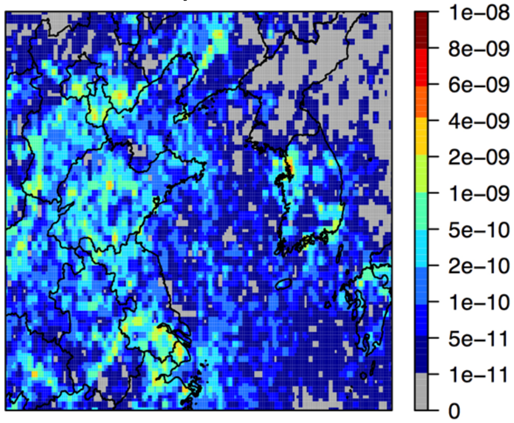
- **Model under/overpredicted regions China's Yellow/Yangtze river basins, similar to Yang et al. (2011) results**
- **Underprediction over the colder regions reflects a delayed spring outburst of leaves controlled by leaf dying process in model**
- **Late May 2016 relative to climatology: lower LAI in NCP, higher in Korea, model did not quite capture this anomaly in Korea (energy-limited?)**

HTAP2 (bottom-up) and DECSO-OMI NOx emissions

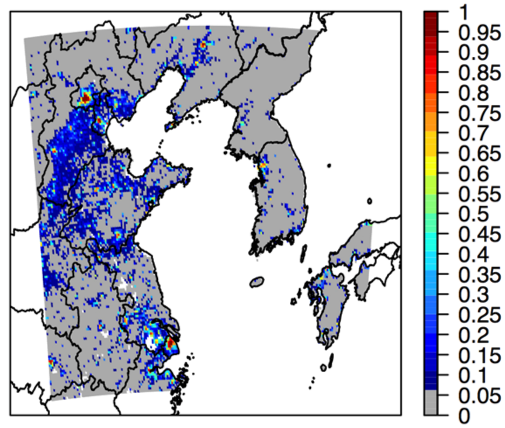
HTAP2 anthropogenic,
May 2010



DECSO all surface emis,
May 2016

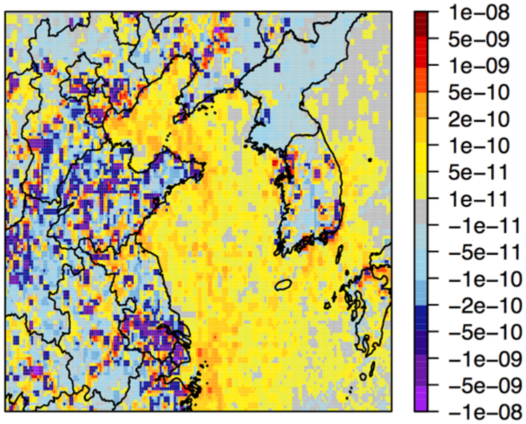


CCI land cover, urban fraction



VIIRS city lights 2016

DECSO-HTAP2

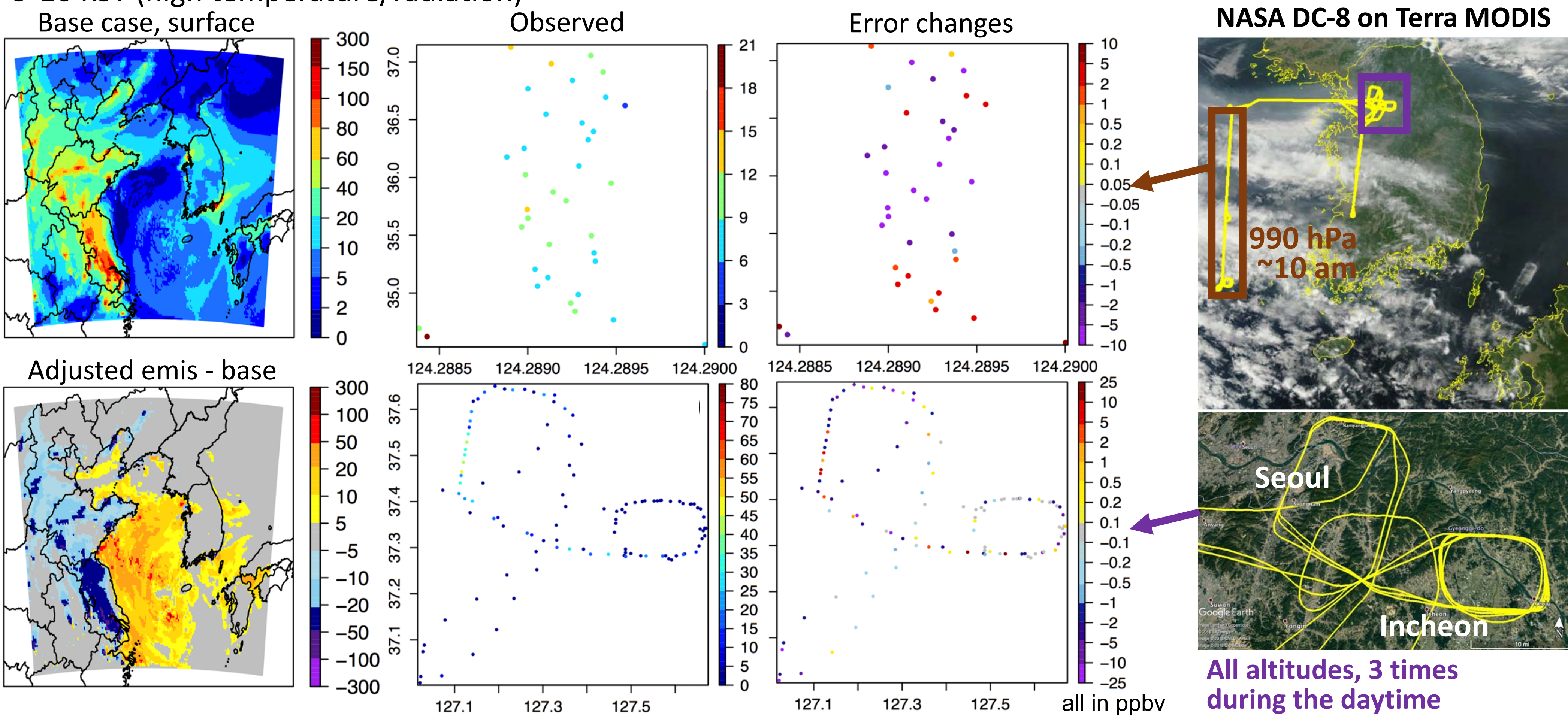


emissions: in $kg/m^2/s$

- **DECSO-OMI higher over broad oceanic areas (due to shipping) and multiple S Korea cities, lower in many Chinese cities**
- **CCI land cover used to separate urban & shipping emissions for use in the NUWRF emission sensitivity run**
- **After merging HTAP2 and DECSO, total anthropogenic emissions reduced by ~10%, urban+shipping >60 % of the total**

NUWRF NOy changes due to NOx emission adjustments

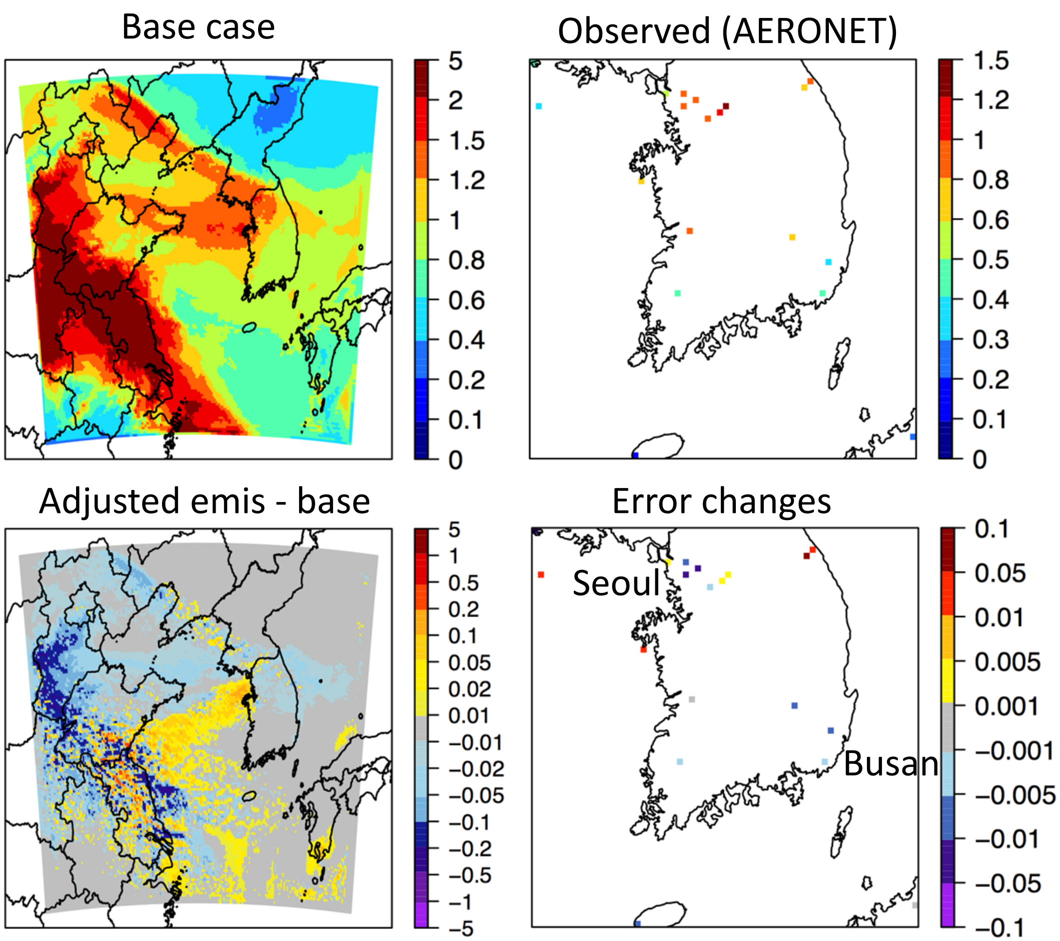
9-16 KST (high temperature/radiation)

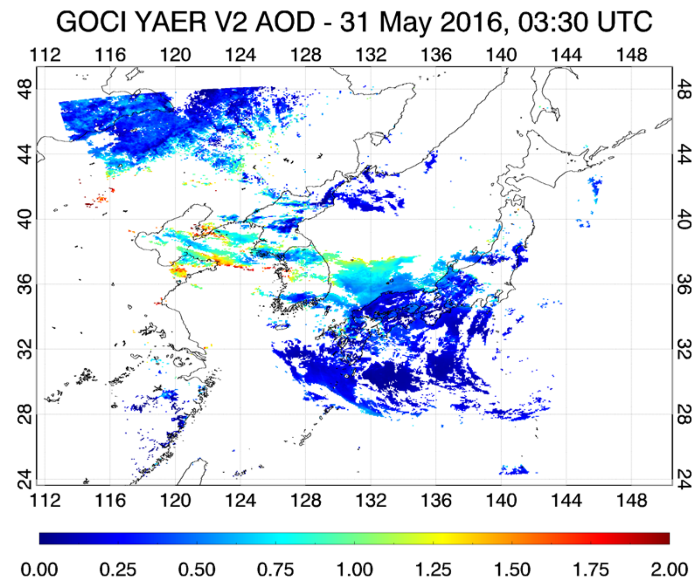


For entire flight, offshore, or Seoul, RMSEs reduced by 1-3 ppbv

NUWRF AOD changes due to NOx emission adjustments

9-16 KST (high temperature/radiation)



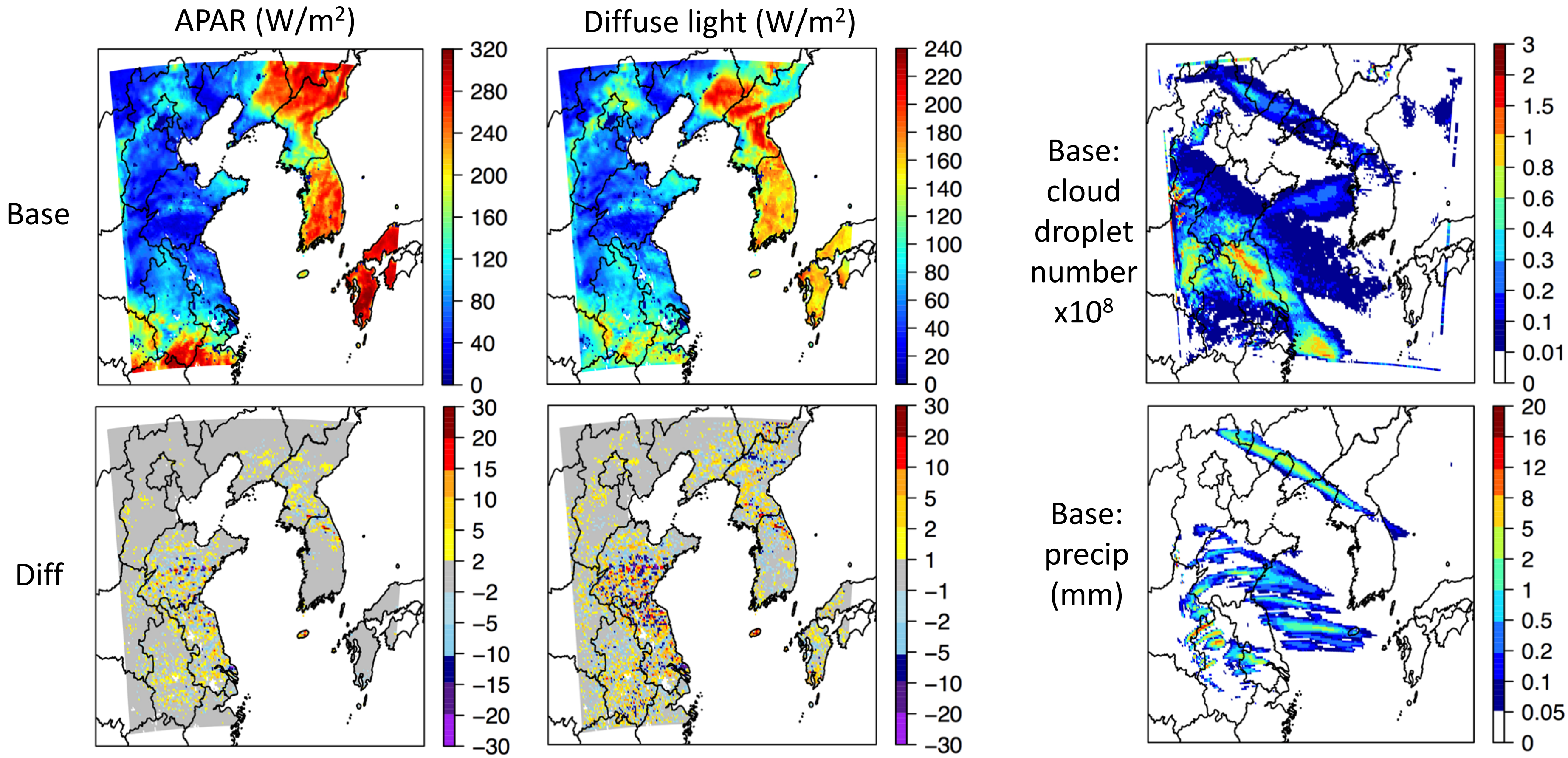


- **Cloudy, polluted situation in China**

With emission adjustments:

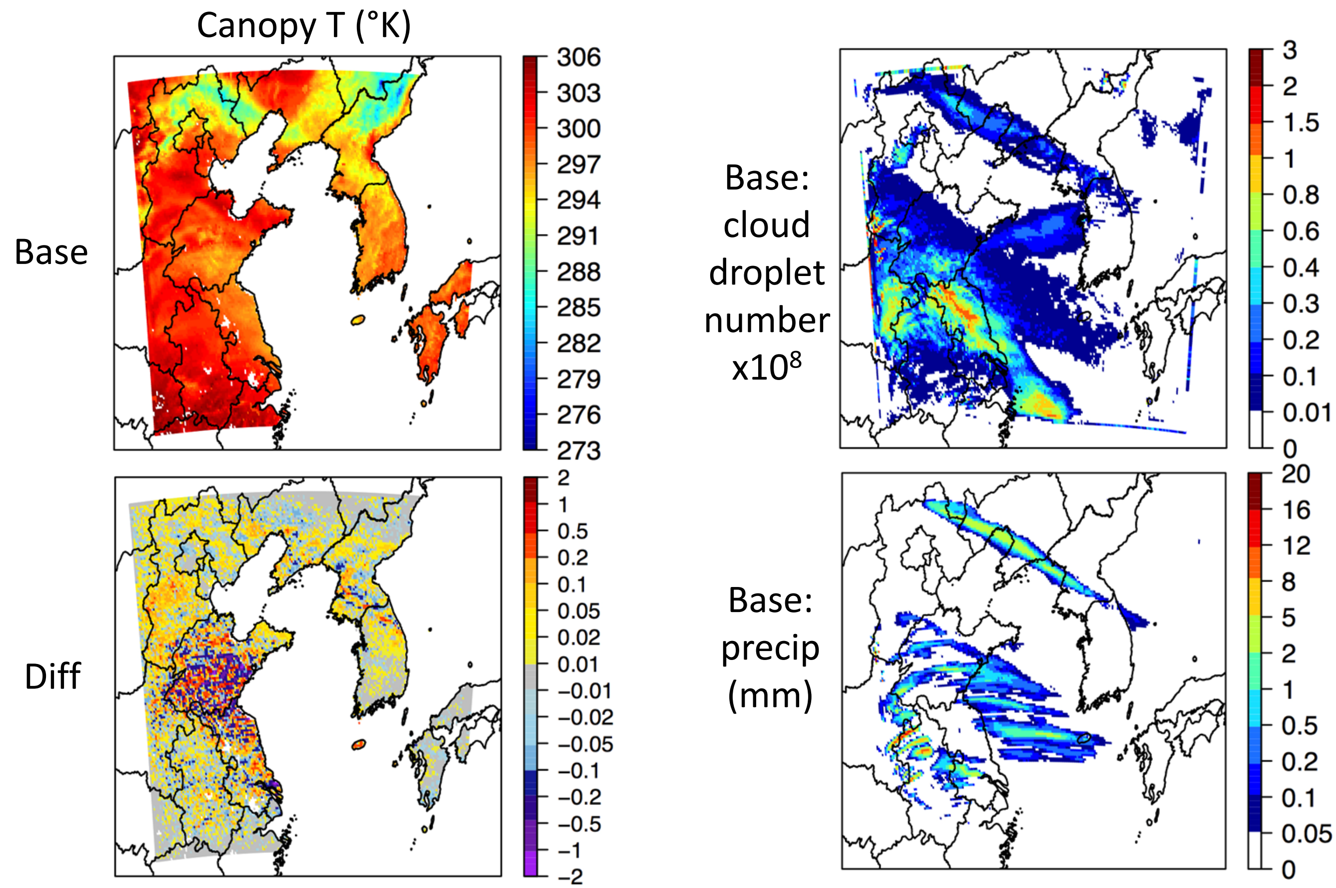
- **AOD slightly decreased over land overall and over S Korea domain**
- **AOD improvements around Seoul and Busan in S Korea**

NUWRF radiation changes (9-16 KST)



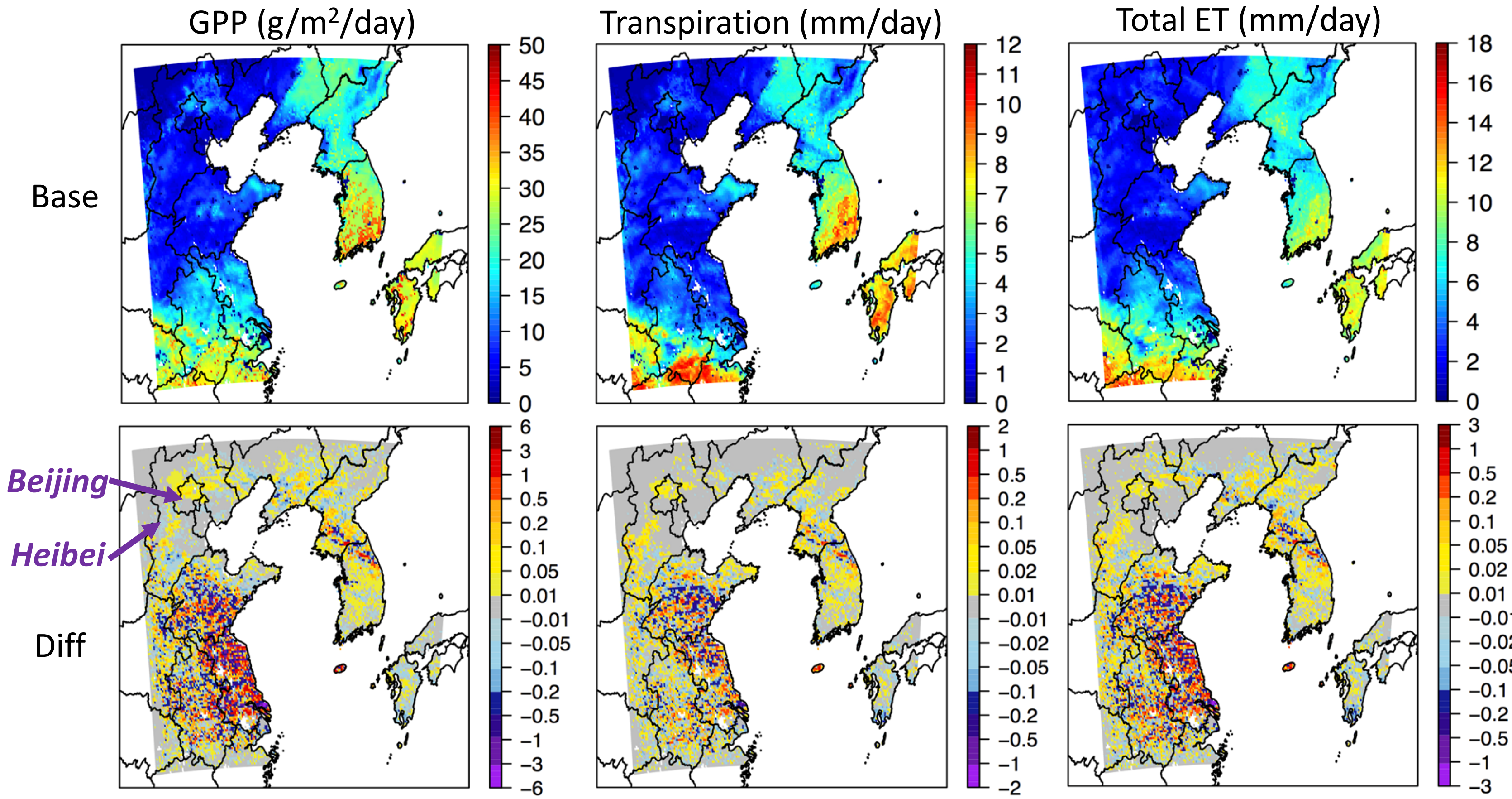
- **APAR and diffuse light changes stronger changes over cloudy and precipitating regions**
- **More cloudy regions: diffuse fraction high, reducing AOD increased diffuse light**
- **Less cloudy regions: diffuse fraction low, reducing AOD decreased diffuse light**

NUWRF temperature changes (9-16 KST)



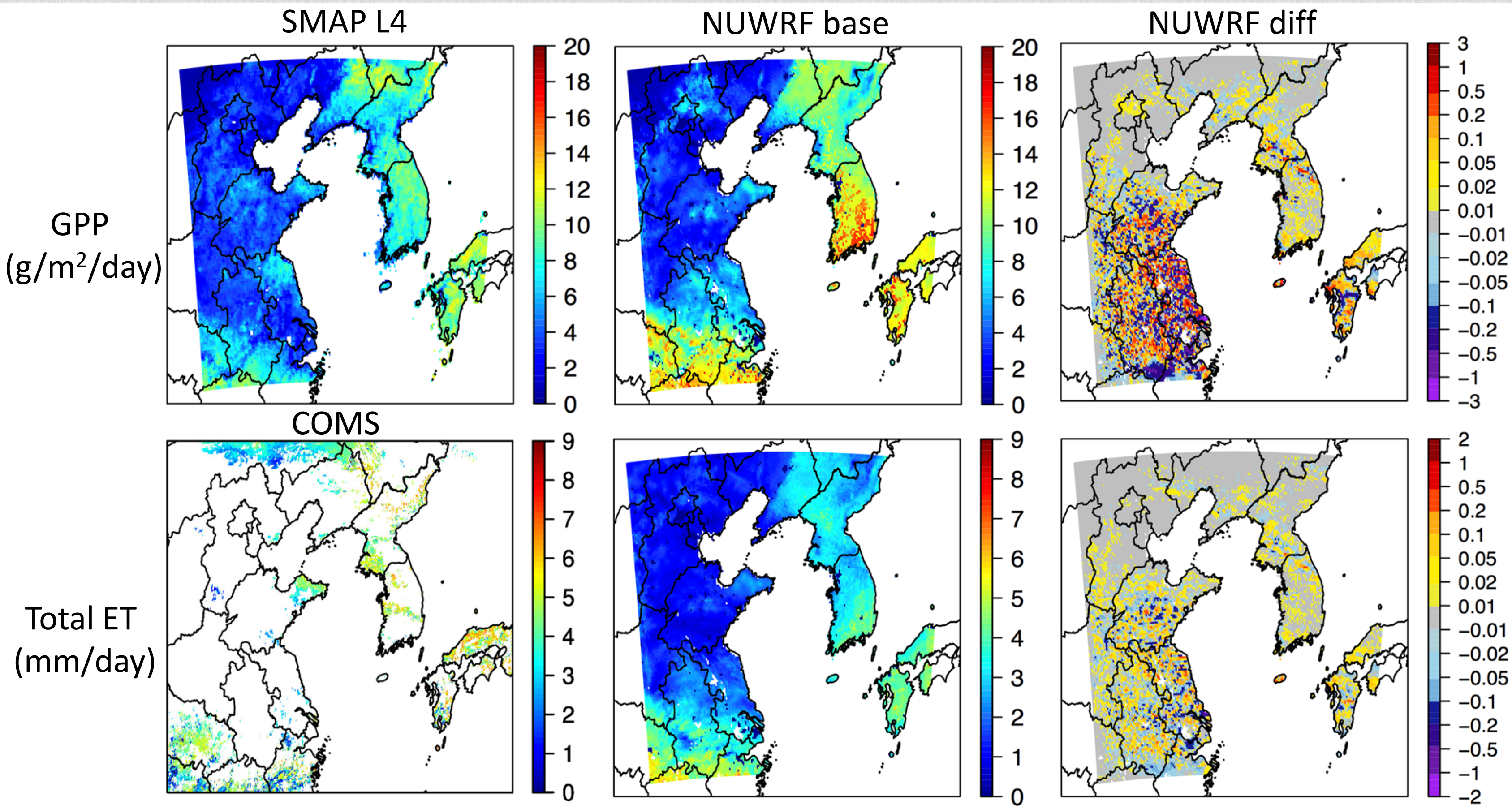
- Canopy T above and below 298 °K (optimal photosynthesis) in China and S Korea, respectively
- T increased, with stronger changes over cloudy and precipitating regions
- T2, which is ~2 °K different from canopy T, slightly better modeled in the sensitivity run

NUWRF GPP and ET changes (9-16 KST)



- **low T (S Korea, N Beijing): positive ΔGPP and promoted photosynthesis**
- **high T (S Heibei Province): positive and negative ΔGPP (combined light and T effects)**
- **consistent spatial patterns ΔGPP and ΔET (strongly linked with stomatal resistance)**

NUWRF GPP and ET (daily), comparing with other products



- **Smaller than in daytime: observational or observation-constrained subdaily GPP/ET needed**
- **Further evaluation needed (FLUXNET data not available for this period)**

Summary & Next steps

Based on LIS/NUWRF w/ Noah-MP dynamic vegetation:

•Regional emissions important to assessing atmosphere-biosphere interactions

•GPP-AOD relationship on a cloudy day -2% per unit AOD

(Huang et al., 2019, in revision)

Next steps:

- Urban/shipping anthropogenic emissions → individual anthropogenic and natural emission source sectors
- Adjusting NOx → other chemical species: multi-species chemical DA; utilization of newer sensors (TROPOMI and later TEMPO/GEMS)
- Constraining emissions jointly w/ land DA (SM, vegetation, snow, etc)
- Expanded regions (including North America), extended periods (including recent/planned field campaigns), under variable weather conditions

Acknowledgements to various science teams & your attention