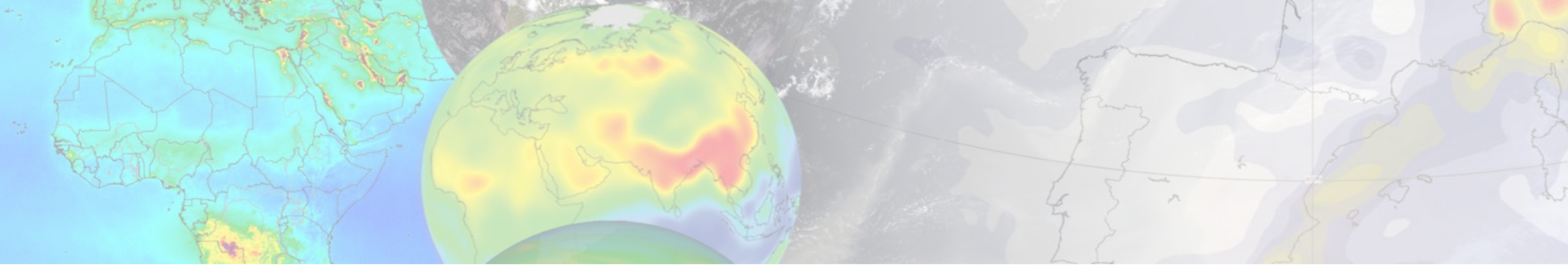


Analysis of ASIA-AQ observations with MUSICAv0

Louisa Emmons

Jun Zhang, Wenfu Tang, Ben Gaubert, Gabriele Pfister, … - *ACOM, NSF NCAR*

Hyerim Kim - *University of Iowa*

Yifan Cheng - *University of Illinois*

ASIA-AQ Science Team with collaborators in Thailand, Philippines, Taiwan and S. Korea

CESM Workshop – 10 June 2025

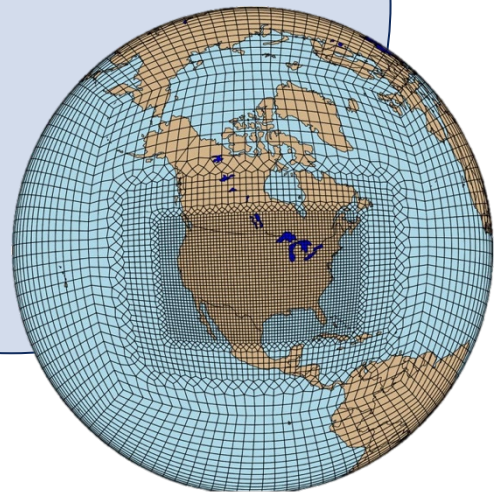
MUSICA
Multiscale Infrastructure for Chemistry and Aerosols

MUSICAv0 and MUSICAv1: Configurations of CESM CAM-chem

MUSICAv0

CESM/CAM

Hydrostatic Spectral Element DyCore

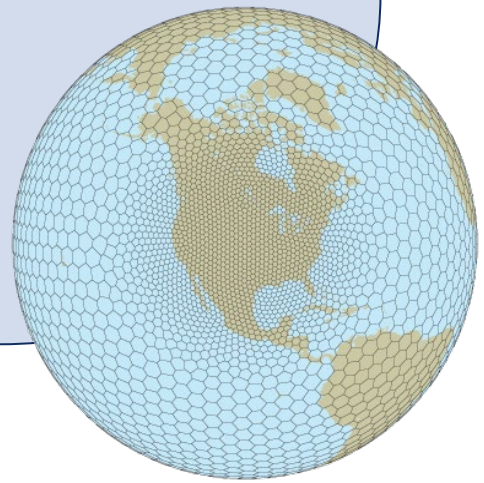


Available in CESM2.2 CAM-chem and WACCM

MUSICAv1

CESM/CAM

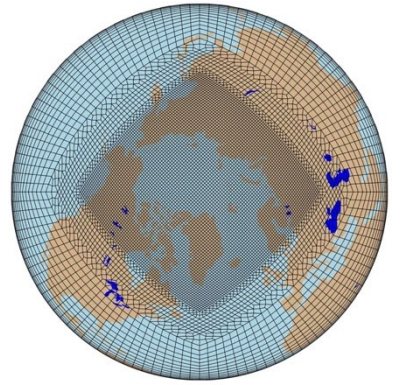
Non-Hydrostatic MPAS DyCore



CAM-MPAS-chem currently being tested

MUSICA
Multiscale Infrastructure for Chemistry and Aerosols

Using MUSICA



Documentation, Tutorials, etc:
https://wiki.ucar.edu/display/MUSICA/MUSICA+Home

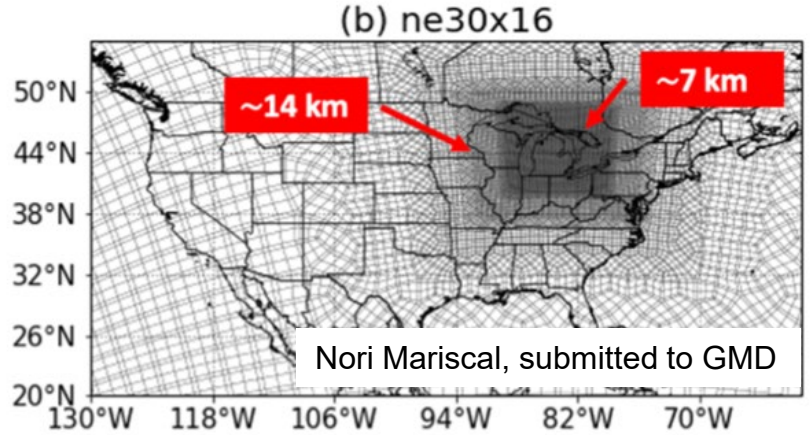
Grids available in CESM: CONUS, Arctic, Greenland Ice Sheet

Can create custom grids for MUSICAv0 (CAM-SE)
– instructions on wiki

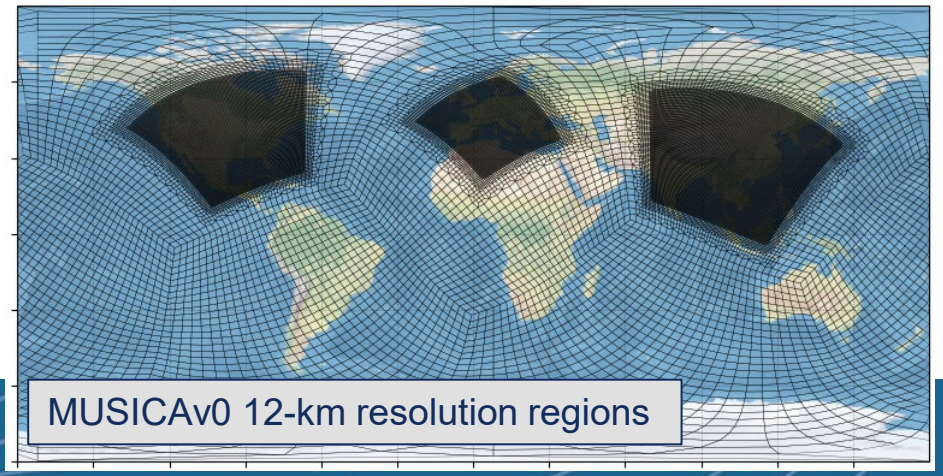
MUSICAv1 (CAM-MPAS-chem) is being tested and evaluated

- Existing variable resolution grids can be rotated to region of interest

Community Users and Projects:
https://wiki.ucar.edu/display/camchem/Users+and+Projects



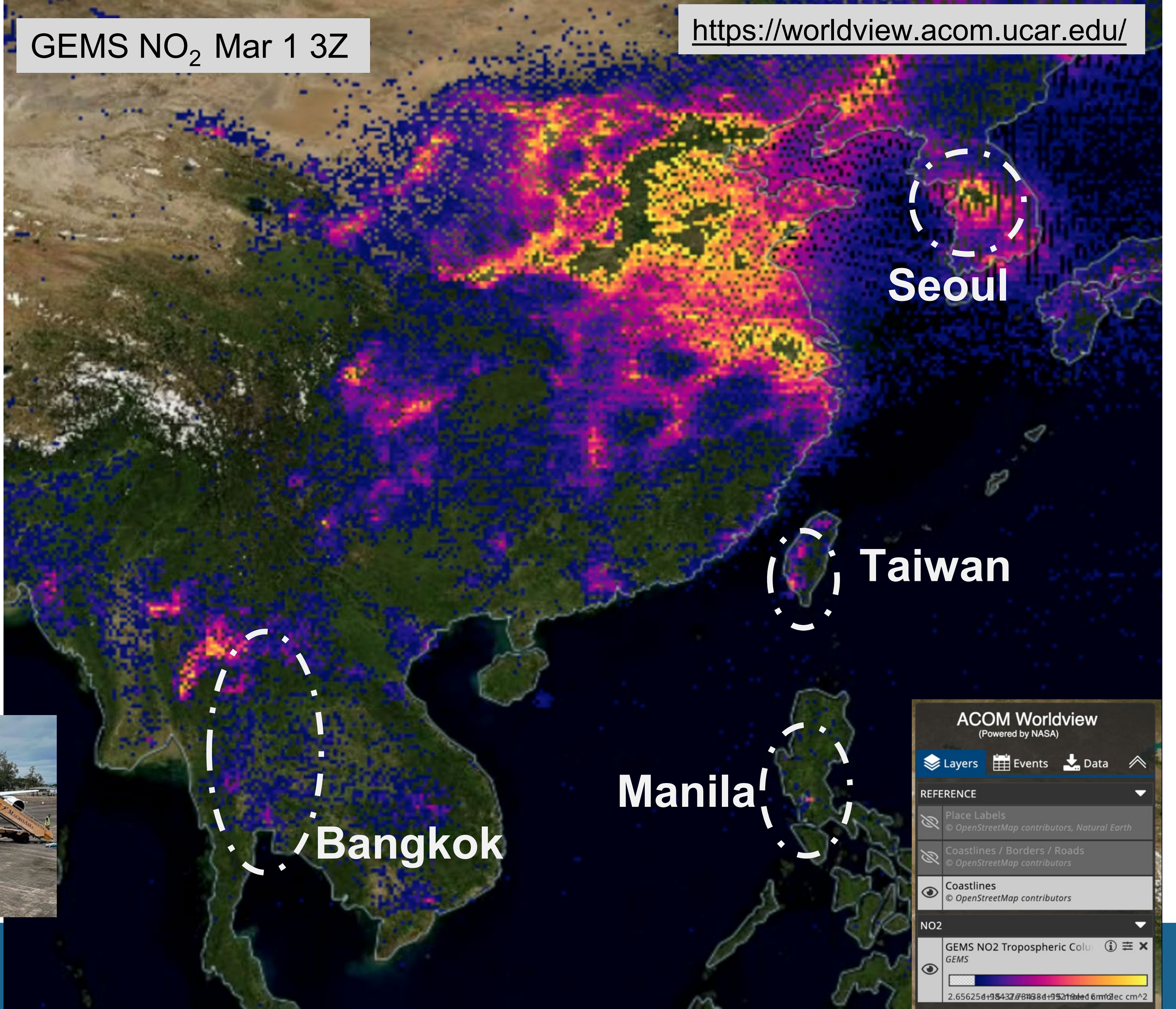
Nori Mariscal, submitted to GMD


MUSICAv0 12-km resolution regions

ASIA-AQ
Feb-Mar 2024

- Aircraft measurements on same track multiple days
- Pandora column NO_2, CH_2O
- Aeronet, etc.
- AQ monitors

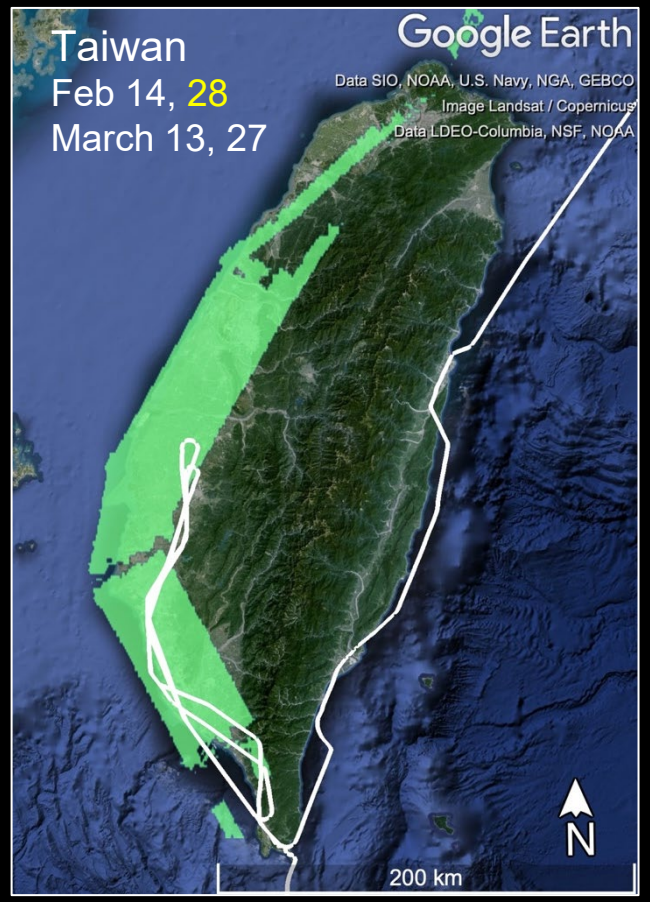
Goal: understand AQ influence from local and transported pollution

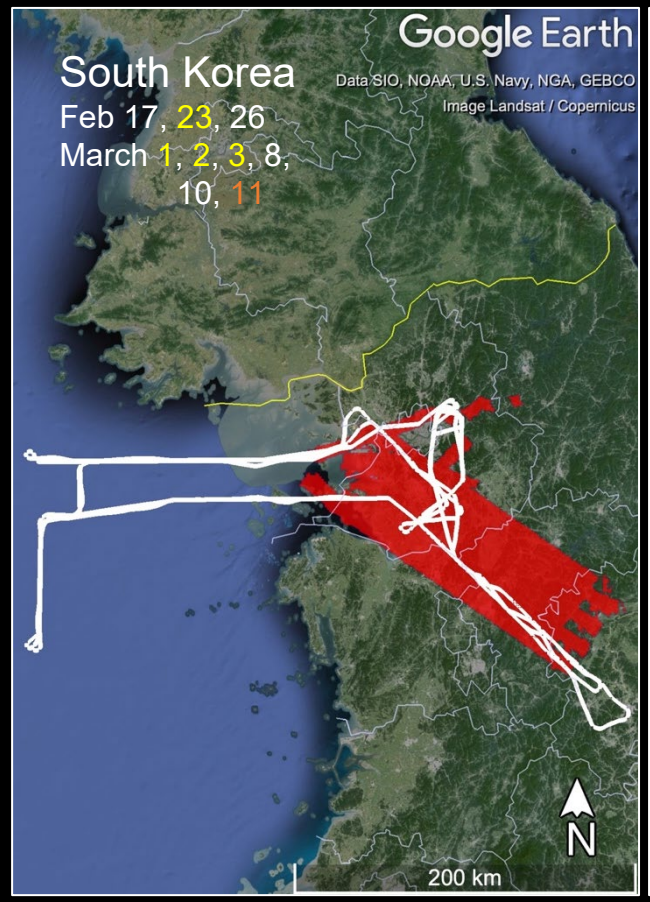


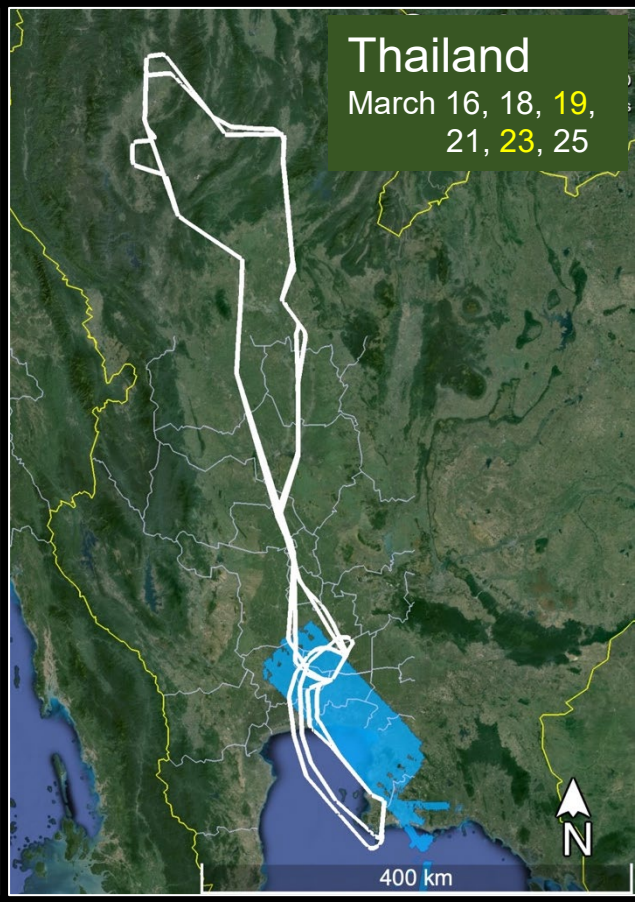
Platforms and instruments:

- NASA DC-8 (161 hours): 26 instruments measuring in situ parameters relevant to gas phase and aerosol composition
- LaRC GIII (209 hours): GCAS + HSRL2 measuring column densities of NO_2 and HCHO and profiles of aerosol characteristics and ozone.

Primary collaborators include:
→ DENR, PhilSA, and Manila Observatory in the Philippines,
→ NIER and KMA in South Korea,
→ GISTDA and PCD in Thailand,
→ Ministry of Environment, NCU and Academia Sinica in Taiwan with numerous other agencies and research institutions
https://espo.nasa.gov/asia-aq/content/ASIA-AQ_Participants







Maps of the geographical regions sampled in February-March 2024 during ASIA-AQ. Colored areas are those mapped by the GIII and the white lines represent one flight from the DC8.

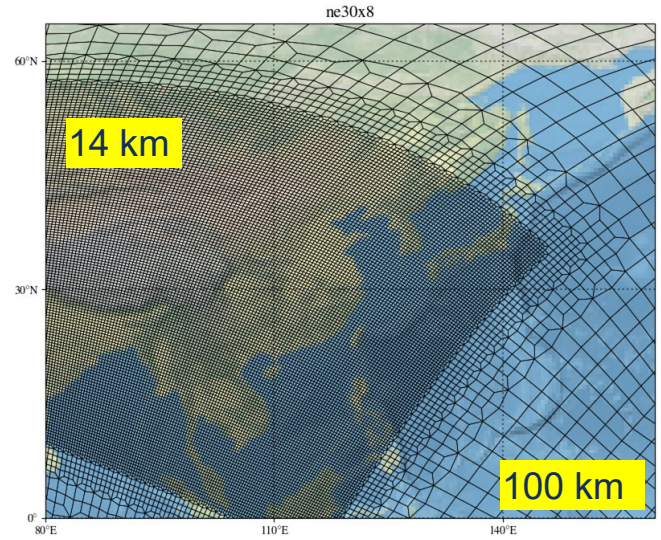
Data will be released before Oct 2024

MUSICA simulations for ASIA-AQ

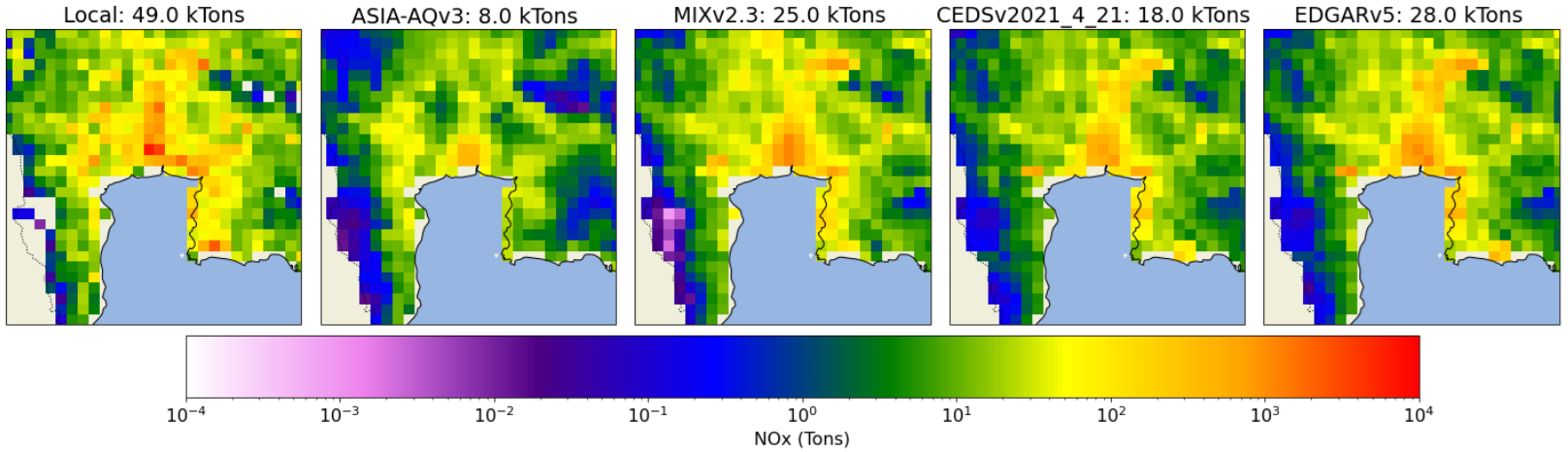
We provided forecasts with MUSICAv0 (CAM with Tagged CO tracers), as well as WRF with tracers (G. Pfister, R. Kumar) and several other NASA-funded and international teams

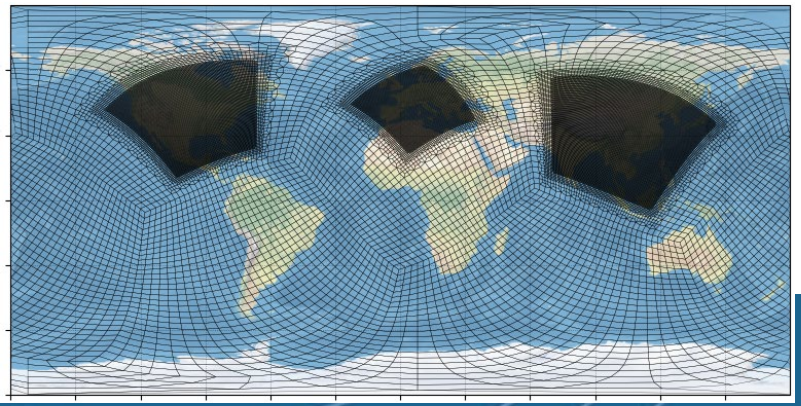
Model evaluation ongoing using surface, aircraft and satellite observations

Multiple anthropogenic and fire emissions inventories are available showing significant differences



Local inventory for Thailand 2-5 times greater than other inventories over Bangkok



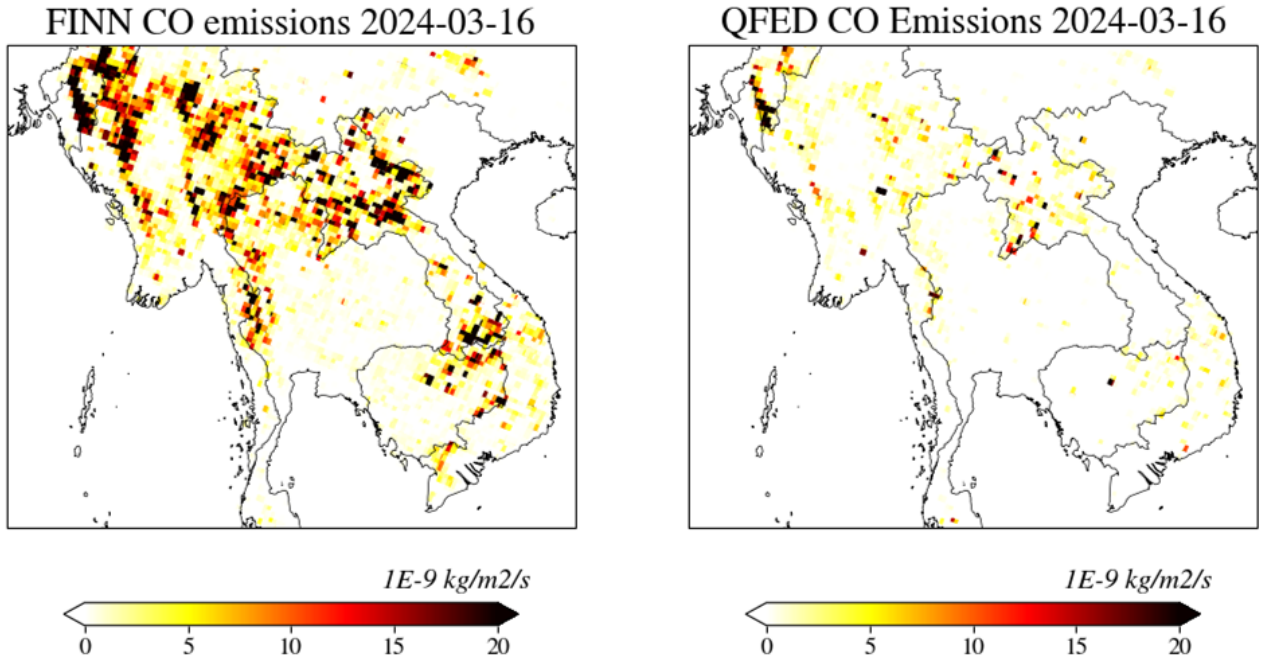


Fire emissions differ greatly - e.g., FINN and QFED

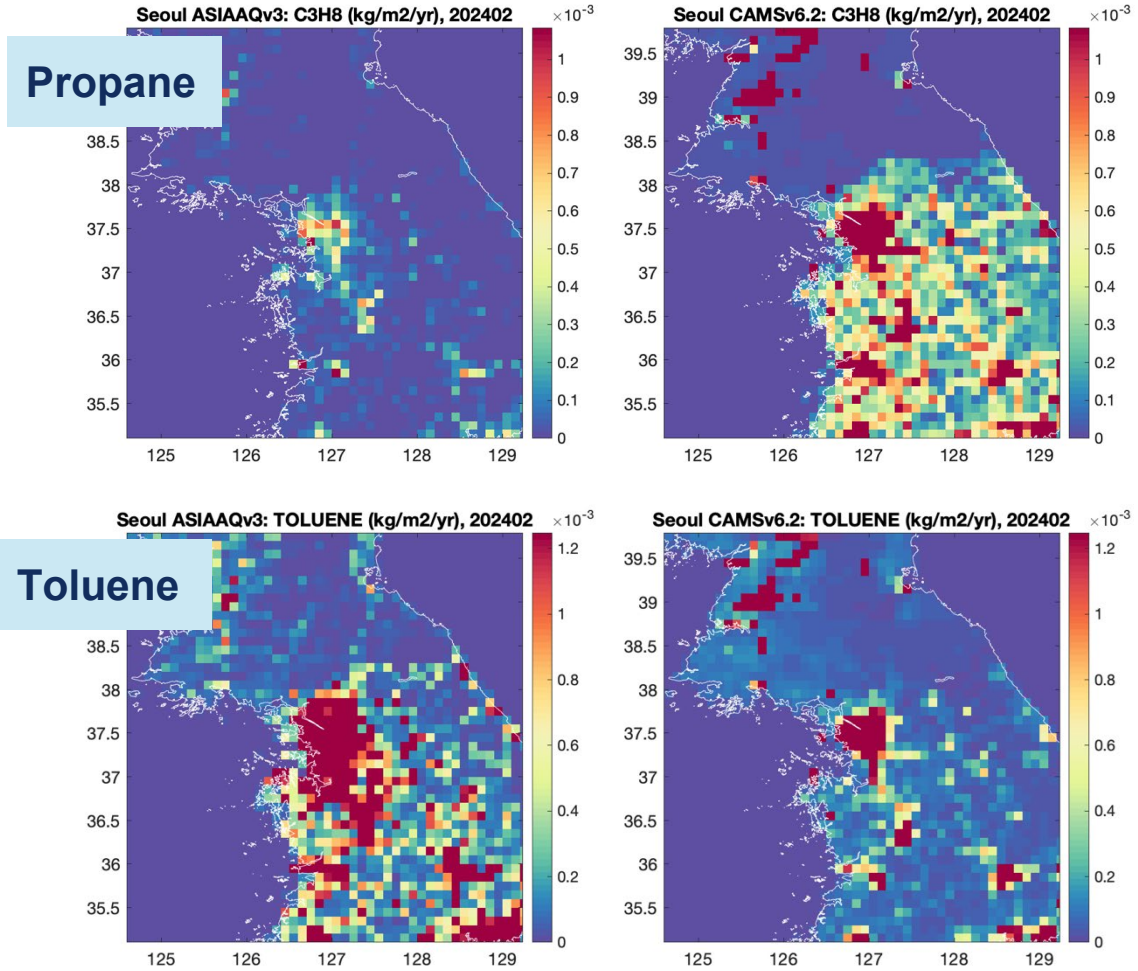
Will be challenging to evaluate

- Most fires distant from aircraft sampling
- Sampled air mixed with Anthro from China, etc.

Evaluating VOC speciation with detailed aircraft observations



VOC speciation varies greatly in anthro. inventories
Always challenging to get accurate local speciation

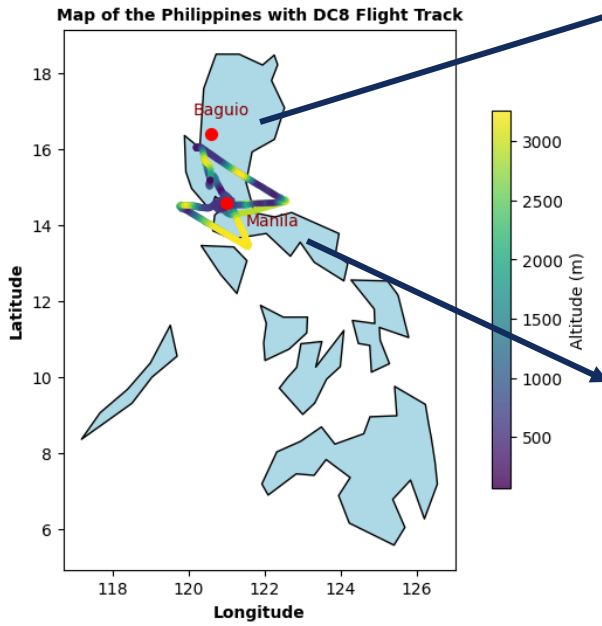


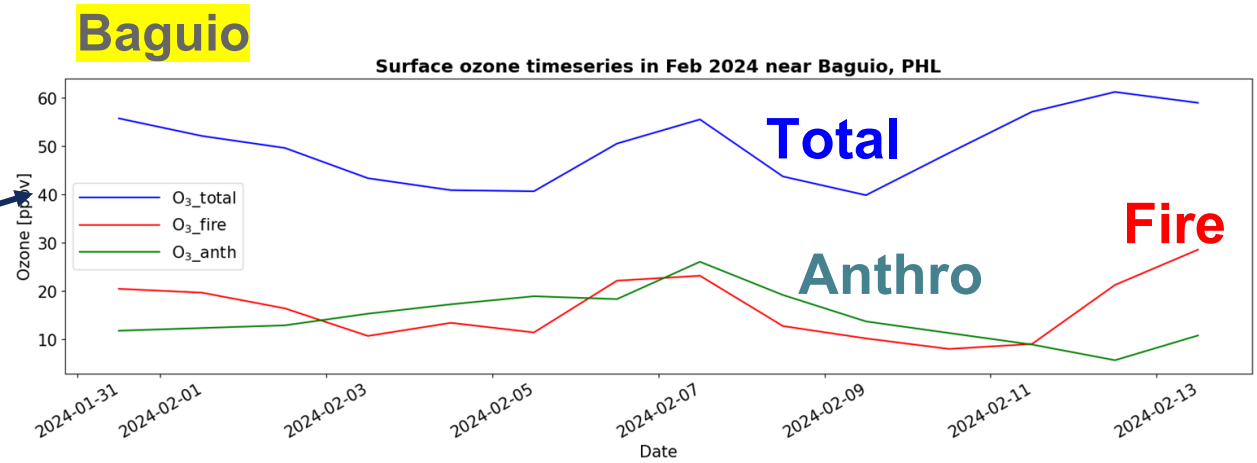
Surface Ozone Attribution using NOx tagging

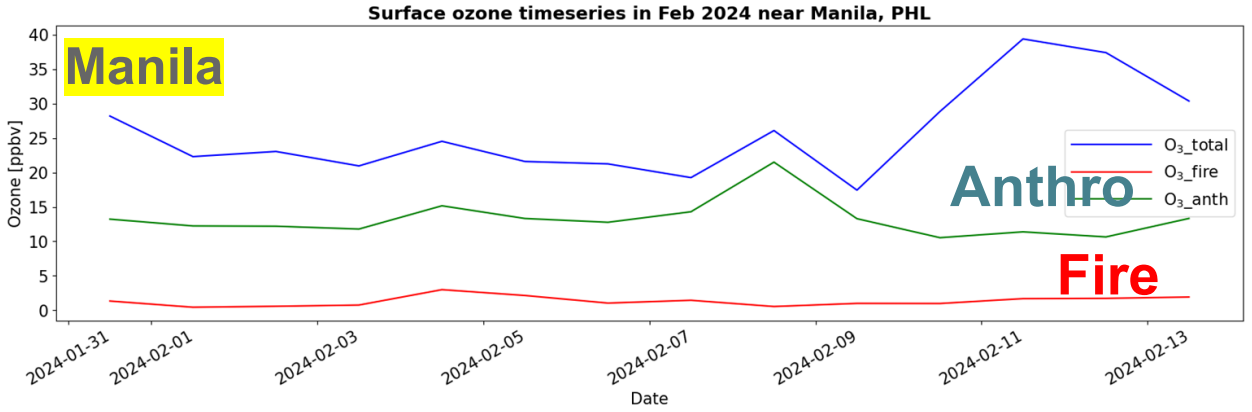
Tagging NOx from different sources and regions
XNO -> XNO2 -> XNOy(i) -> XO3

e.g., tag NOx source from anthropogenic and fire separately in the Philippines

Goal: to inform local air quality managers in each region what are the contributions of local and transported pollutants







Both anthropogenic and fire emissions play significant role in influencing surface ozone levels in Baguio, Philippines, whereas anthropogenic emissions are the primary contributors to surface ozone in Manila.

Will compare to other source attribution studies in other models (e.g., Hyerim Kim, U.Iowa, with WRF-chem)

Jun Zhang (NCAR/ACOM)

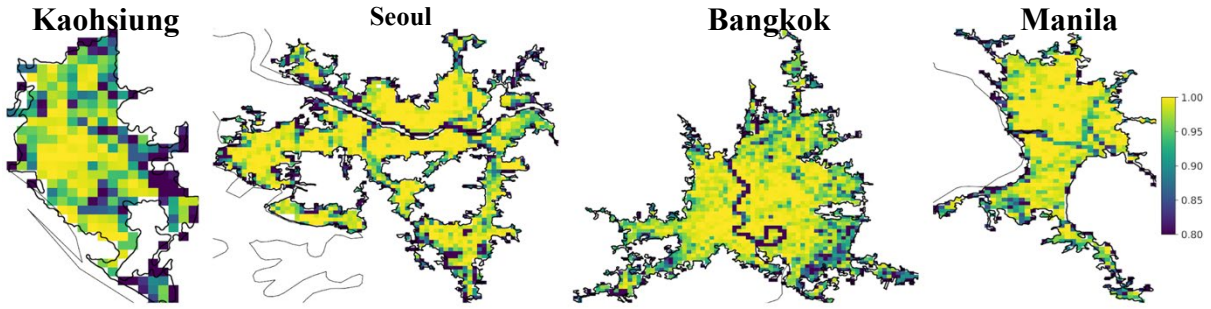
Urban-resolving air quality modeling via high-res urban representation

Coarse scale urban canopy parameters based on look-up table → Spatially continuous urban canopy parameters from remote sensing

	Facet-level urban canopy parameter change	Roof	Impervious canyon floor	Pervious canyon floor	Wall
Radiative	Emissivity	■	■	■	■
	Albedo	■	■	■	■
Morphological	Fraction	■	■	■	
	Height, width	■	■	■	
Thermal	Conductivity	■	■		■
	Heat capacity	■	■		■
	Thickness	■			■

**grey shaded areas indicate changes*

1km urban percentage distribution within cities

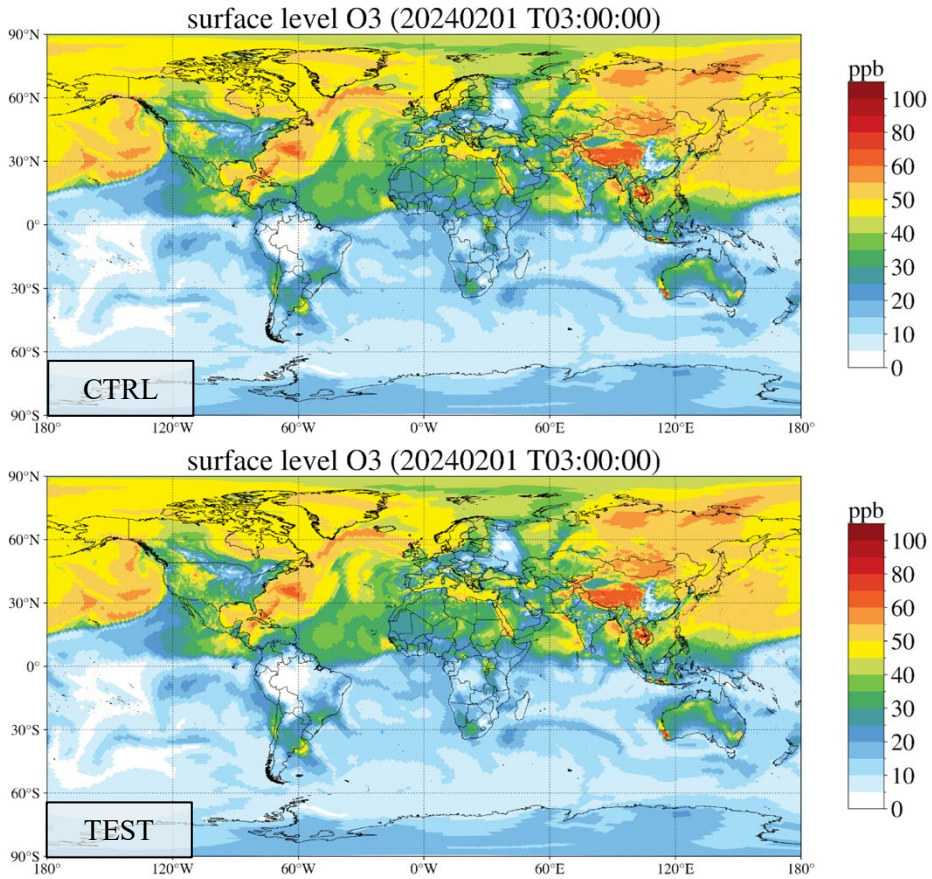


Data source: the U-Surf dataset
Cheng et al. (2025), ESSD

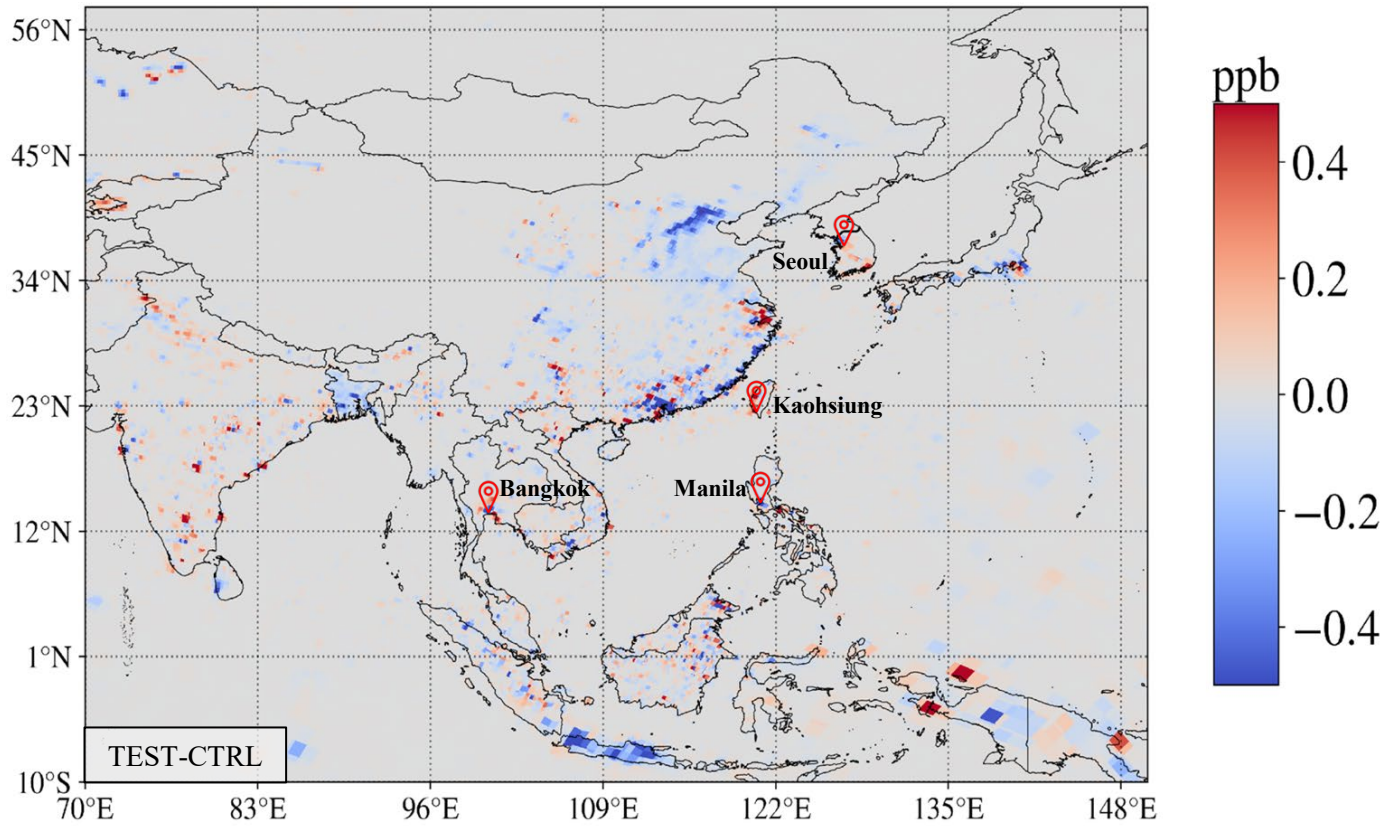
Simulating ASIA-AQ period and evaluating with observations

Urban-resolving air quality modeling via high-res urban representation (cont.)

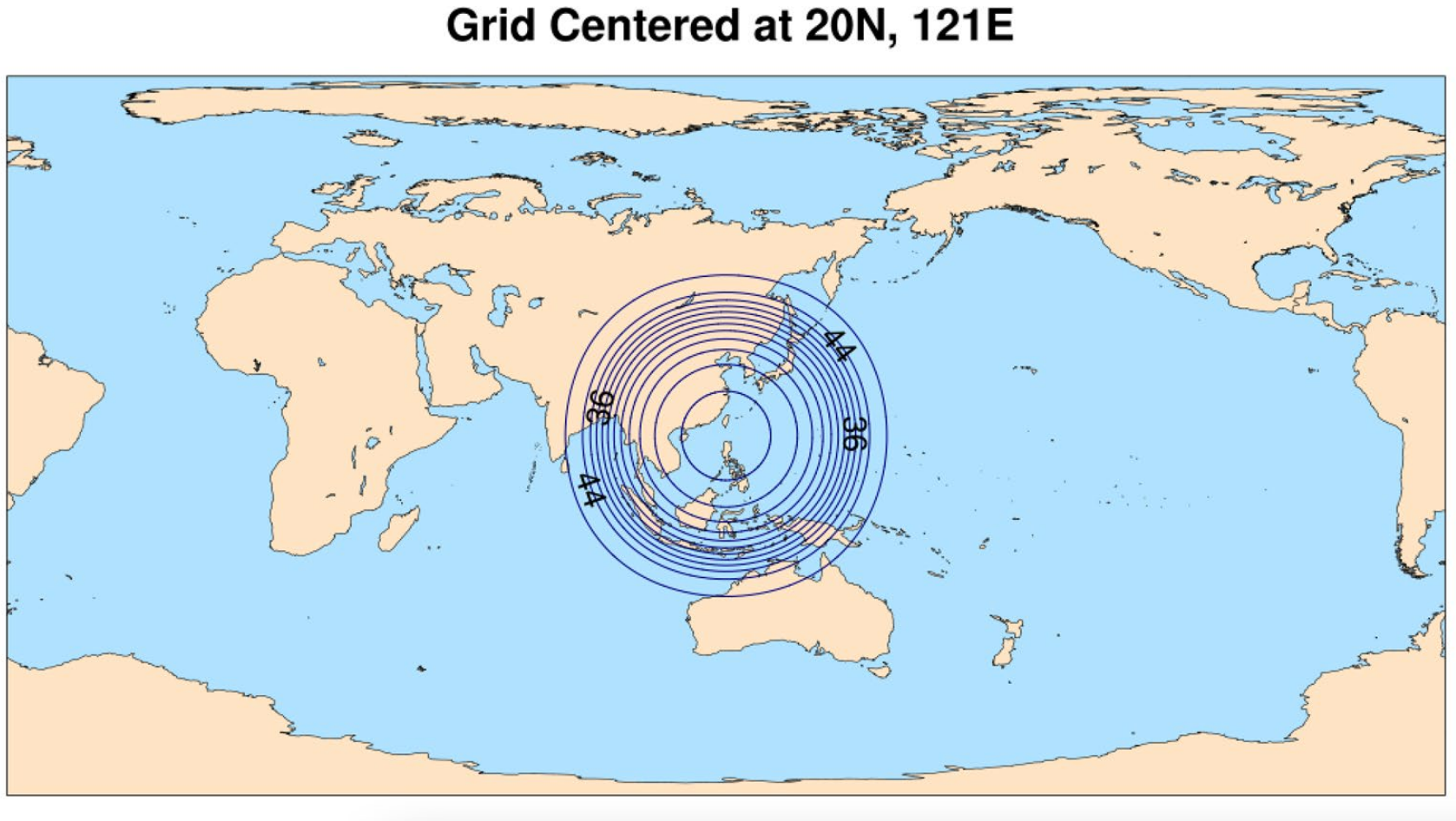
MUSICAv0 with NAEUASne30x8 grid
(land surface fully spun-up)



Difference introduced by high-resolution urban representation



MUSICAv1 (MUSICA-MPAS) for ASIA-AQ



We are testing MUSICA-MPAS for ASIA-AQ

60km-3km mesh is used

The configuration has been successfully running with nudging and regridded emissions

Results need to be evaluated

Wenfu Tang, Behrooz Roozitalab, Louisa Emmons, Ben Gaubert (NCAR/ACOM)

A modular framework to compare model results and observations of atmospheric chemistry

MELODIES: Model EvaLuation using Observations, DIagnostics and Experiments Software

MONET: Model and ObservatioN Evaluation Toolkit

https://github.com/NCAR/MELODIES-MONET

Version 1 almost released

Matches model results to time and location of observations

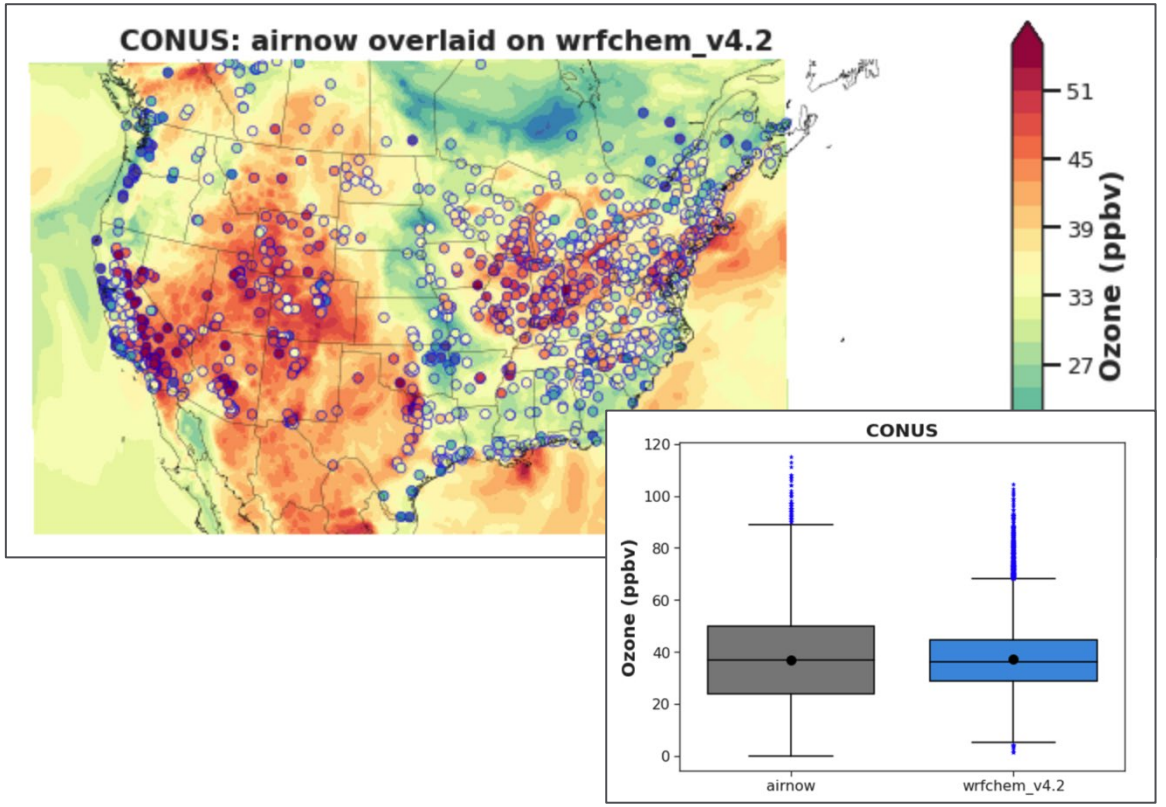
ADF provides climatological evaluation

Current observations:

- EPA AirNow
- Aeronet
- Aircraft (ICARTT files)
- Satellites: MODIS AOD, MOPITT CO, TROPOMI NO2, OMPS

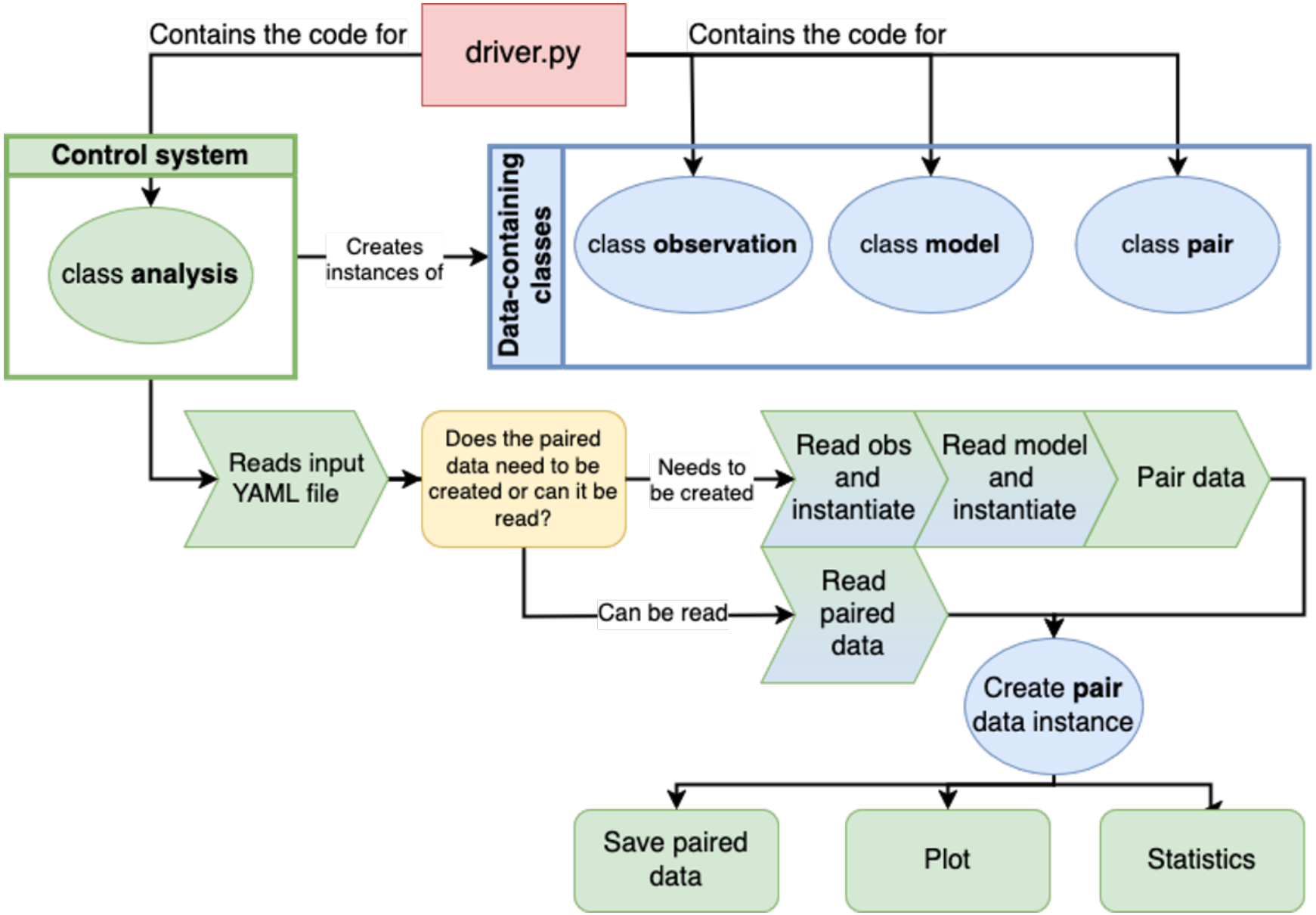
In progress:

- Pandora
- GEMS

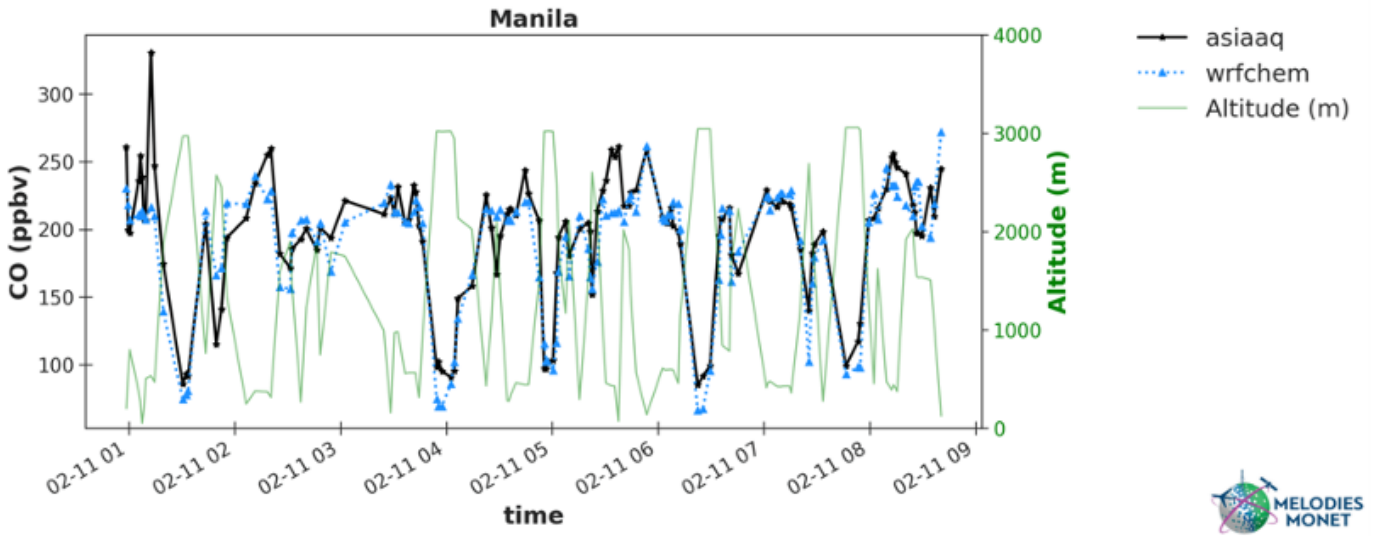


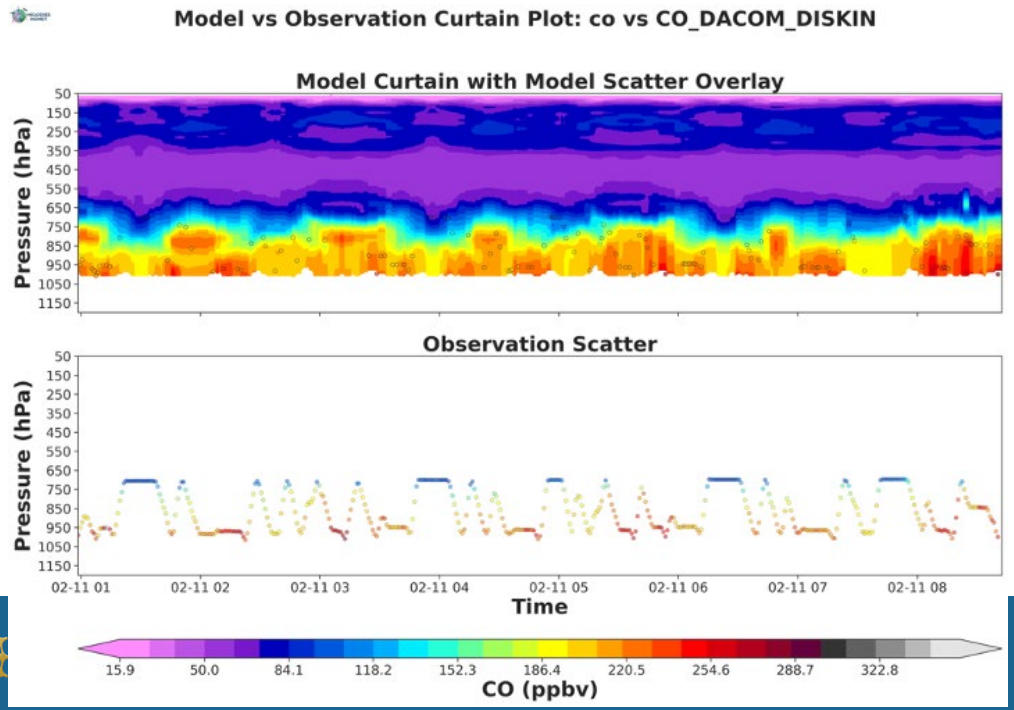
https://www2.acom.ucar.edu/events/melodies-tutorial-2024

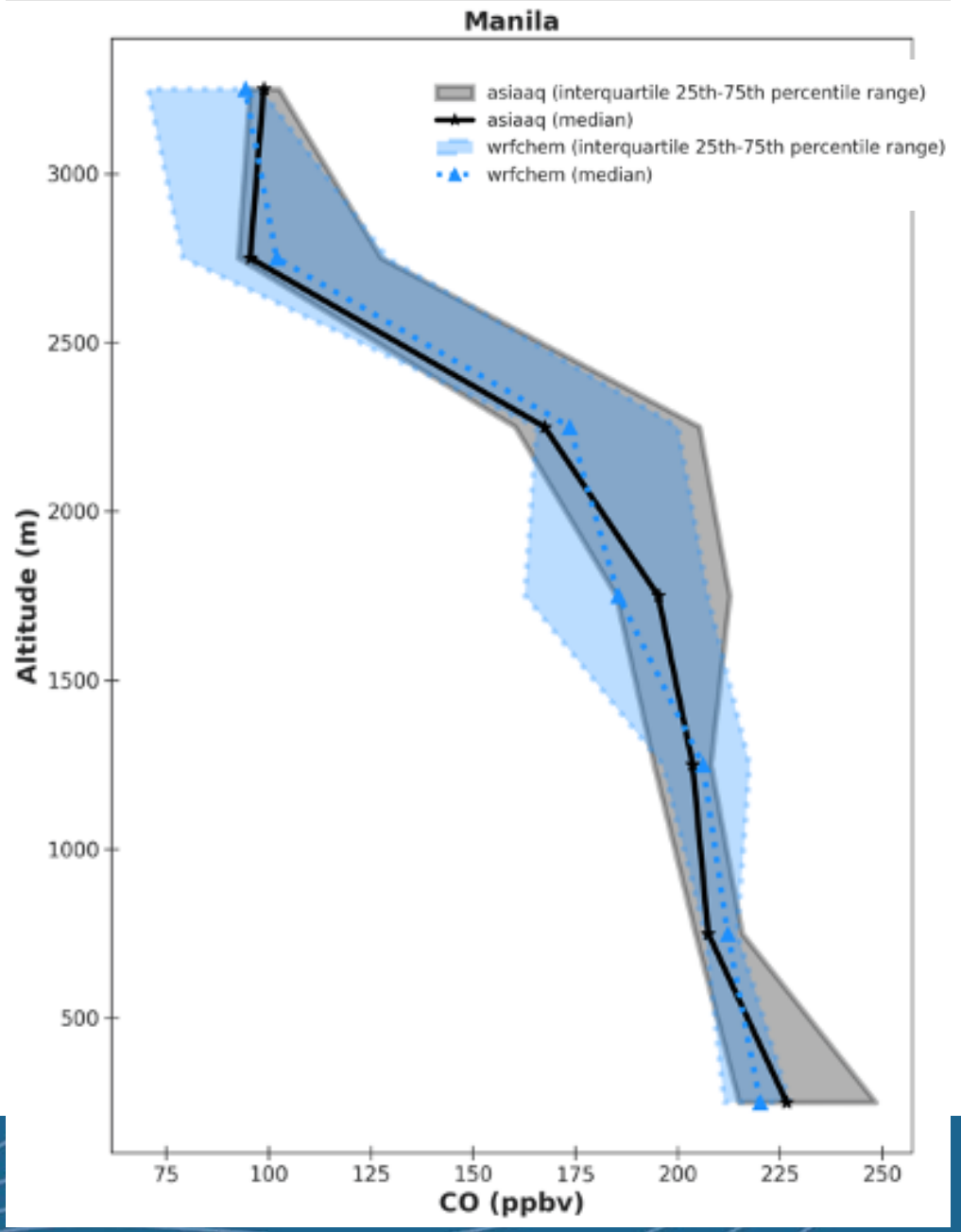
MELODIES MONET
Code Structure



MELODIES MONET for ASIA-AQ

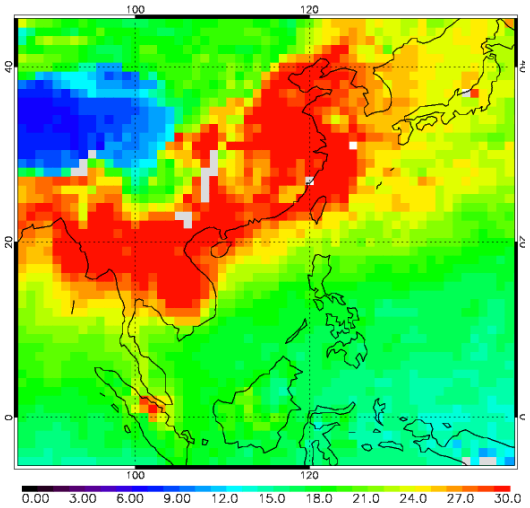




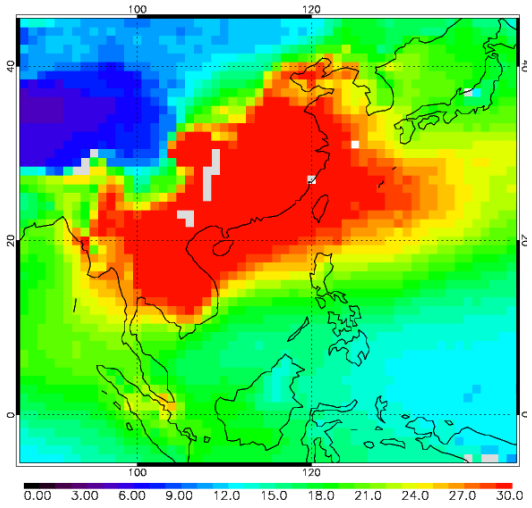


Model evaluation with MELODIES MONET

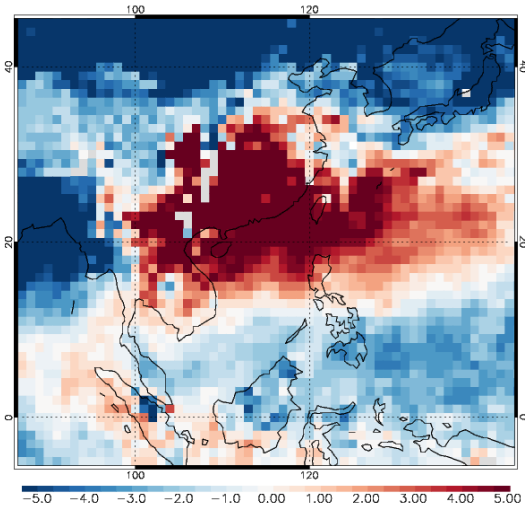
MOPITT CO



WRF-Chem



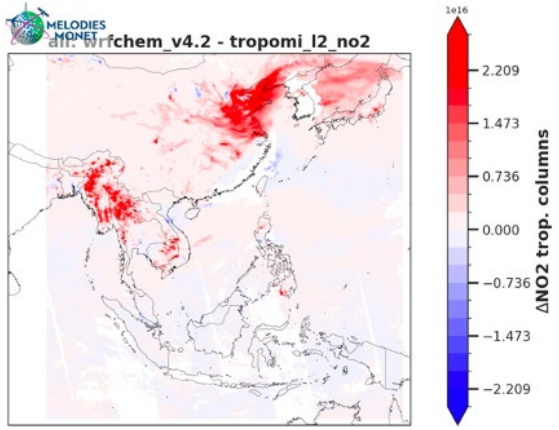
WRF-Chem - MOPITT



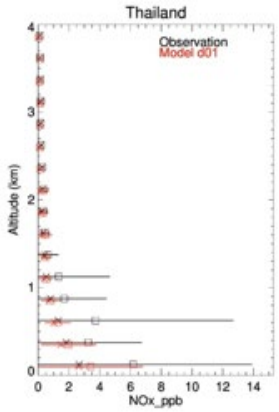
MELODIES MONET pairs model and obs, produces plots

- March monthly avg
- Model too high over China, but too low over India, Siberia, Tropical Pacific

model minus TROPOMI NO2



Model & aircraft obs



Model evaluation with satellite, aircraft and surface observations provides complementary information on emissions accuracy and model chemistry, etc.

Future Work

ASIA-AQ Multi-model Comparison

- A combined emissions inventory being developed, including local inventories from Korea, Thailand, Taiwan with MEIC for China, MIX for rest of SE Asia

MELODIES MONET

- Users and developers welcome!

MUSICA

- Users and developers welcome!