Hemispheric-CMAQ Application and Evaluation for 2016

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Outline

Overview

- Global model versions and options
- Emissions
  - Natural
  - Anthropogenic

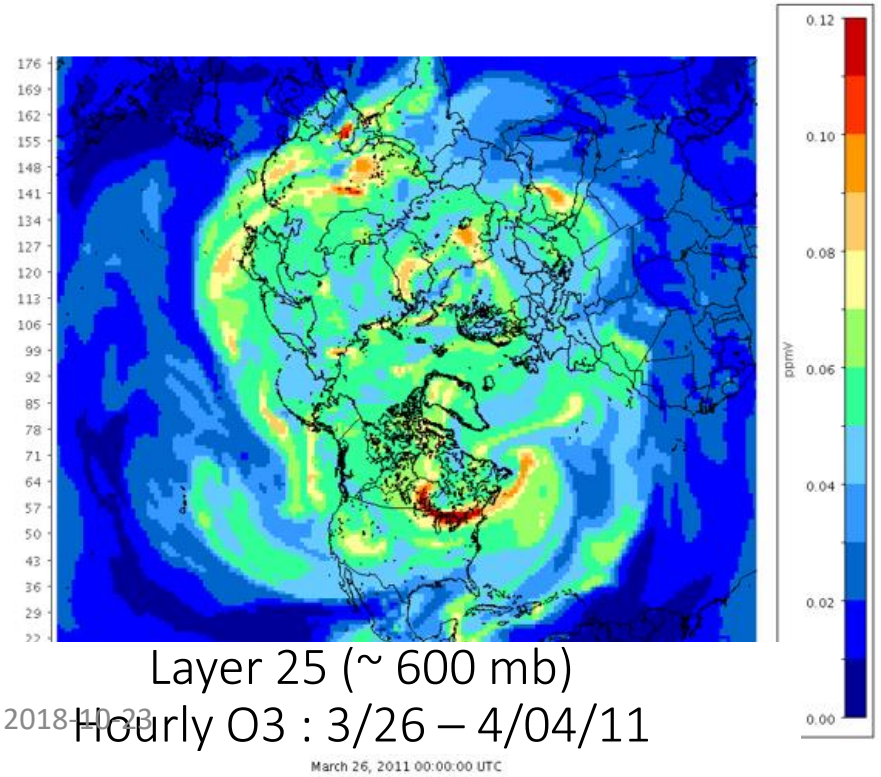
CMAQ Results and Evaluation

- Seasonal Average Ozone
- Sonde Evaluation
- CASTNet Evaluation
- Tropospheric Ozone Assessment Report Databases
- Satellite Qualitative

I won't show results from GEOS-Chem results, but I will occasionally reference the performance from GEOS-Chem in the 2011 EPA modeling platform and preliminary 2016 GEOS-Chem.

Hemispheric CMAQ

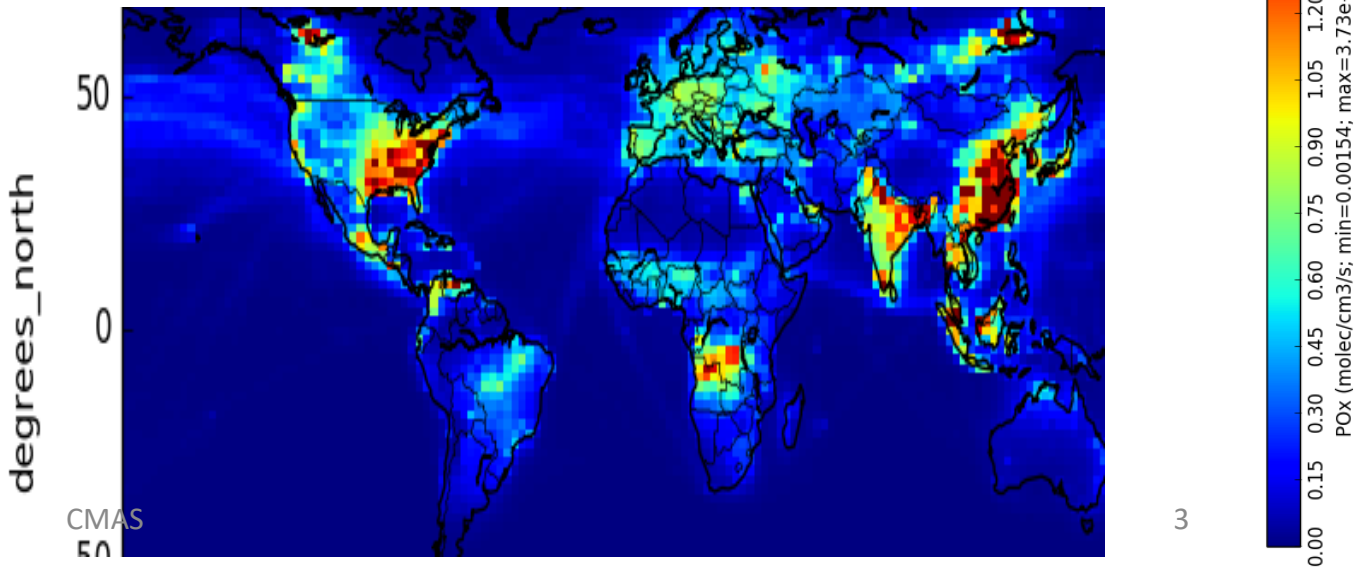
- v5.2.1 (IPV, dust, halogens)
- 8 month spinup period
- Polar stereographic (~1x1 deg)
- 44 Layers up to 50mb
- Weather Research and Forecasting



Layer 25 (~ 600 mb)
Hourly O3 : 3/26 – 4/04/11

GEOS-Chem

- Version 12.0.1
- 1-year spinup period
- 2x2.5 degree w/ half polar cells
- 72 vertical layers up to 0.01mb
  - ~38 up to 50mb
- Goddard Earth Observing System (v5) “forward product”



Natural Emissions

- Biogenics (plants and soils):
  - **BOTH:** Model of Emissions of Gases and Aerosols from Nature (MEGAN) v2.1
  - **H-CMAQ** North America Biogenic Emission Inventory System (BEIS)
- Wild and Prescribed Fires:
  - **GEOS-Chem**: 2011: GFED or 2-16: FINN v1.6
  - **H-CMAQ**: FINN v1.5 and over US 2016 platform
- Lightning:
  - **GEOS-Chem** with Lee Murray updates
  - **H-CMAQ** GEIA climatological averages by latitude & season
- Inline Dust:
  - **GEOS-Chem**: DEAD w/ current parameters
  - **HCMAQ**: Inline CMAQ algorithm
- Sea Salt: similar in-line schemes
- Dimethyl Sulfide
  - **GEOS-Chem** in-line
  - **H-CMAQ** not in present run
  - Relevant for aerosols and haze

More in Vukovich et al. Wednesday at 3:30pm in Grumman

Anthropogenic Emissions

Global

- EDGAR-HTAP base year 2010
  - ***BOTH interpolated to 2014 by CEDS sector/country scalars***
  - GEOS-Chem uses RETRO VOC
  - HCMAQ uses Pouliot sector-based speciation
- ***Shipping***:
  - HCMAQ: EDGAR-HTAP and 2016fe platform within Continental US modeling domain
  - GEOS-Chem: ARCTAS SO2, ICOADS CO, and over Europe from EMEP
- Aircraft:
  - HCMAQ: EDGAR-HTAP
  - GEOS-Chem: AEIC

Regional

- US: 2016fe Platform
- Canada: EC 2013 interpolated
- Mexico
  - Mobile 2016 MOVES
  - Other scaled from 2008
- Asia (non-China): MIXv1
- ***China: Tsinghua University (THU)***
  - Lower sulfate than CEDS
  - Lower NOx than CEDS
  - Similar trends in power sector
  - Differences in metals where THU applies government required controls

More in Vukovich et al. Wednesday at 3:30pm in Grumman

Results and Evaluation

CMAQ-Only

Seasonal Averages for Ozone

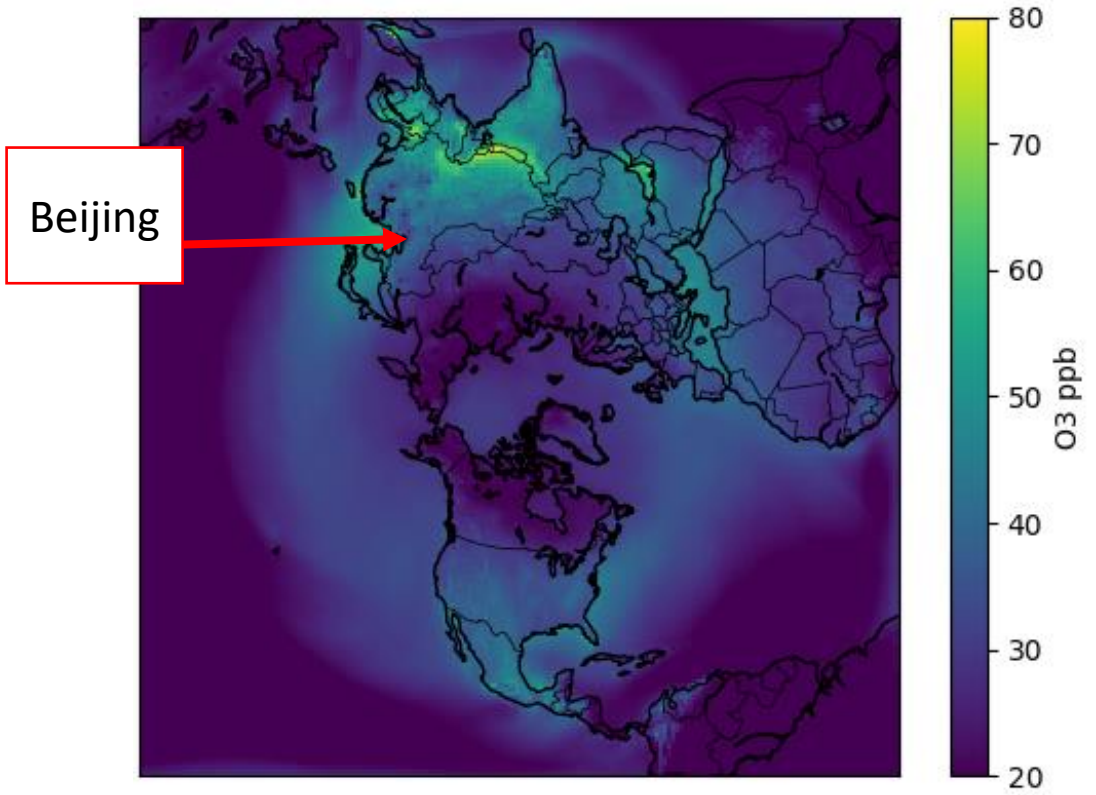
Sonde and CASTNet Evaluation

TOAR Qualitative Evaluation

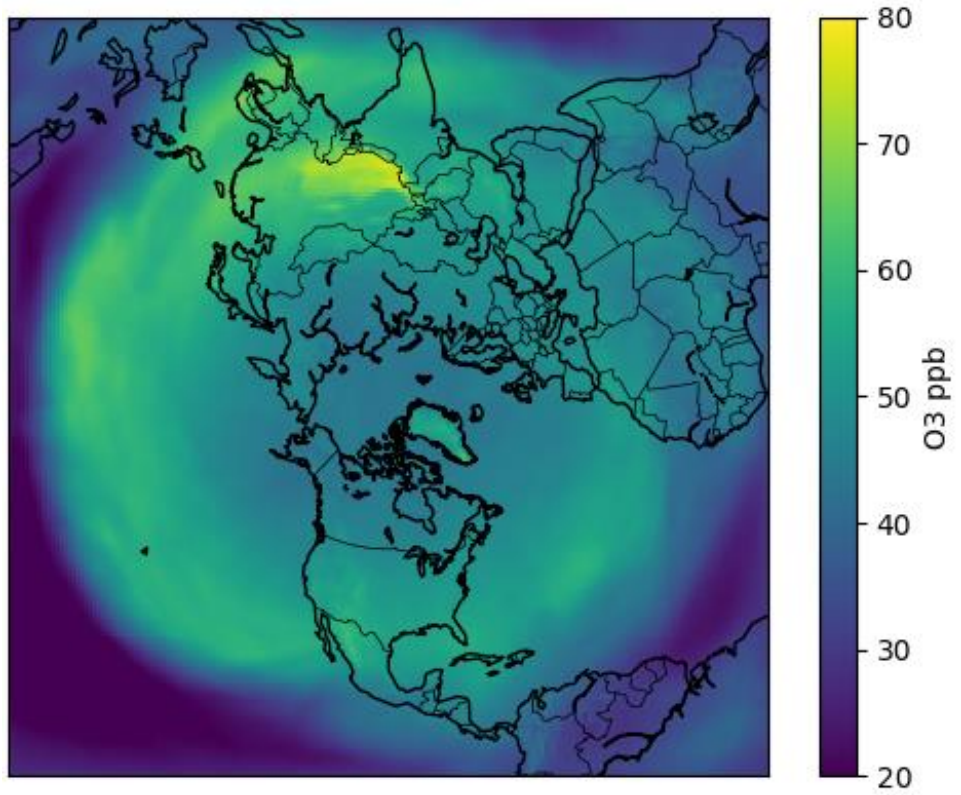
Ozone Surface and about 5km Spring

Northern Hemisphere Spring (March April May, MAM) concentrations are relatively low with clear transport in the mid-troposphere seen most strongly in the southern latitudes

Surface



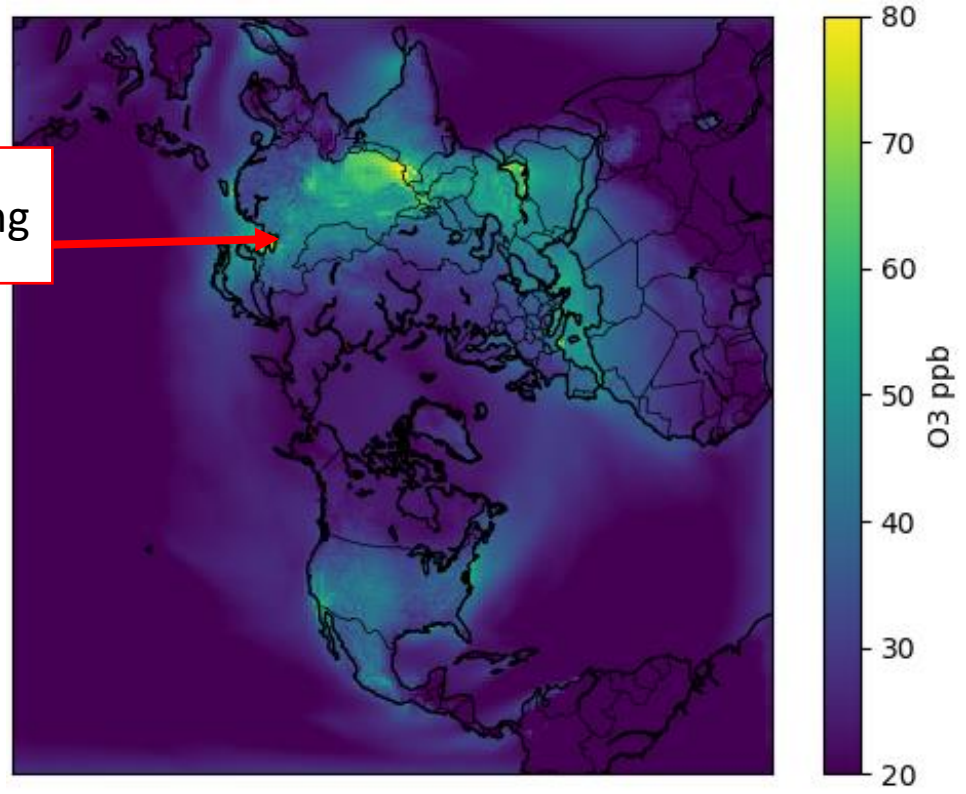
0.5 sigma or ~500hPa or 5km



Ozone Surface and about 5km Summer

Northern Hemisphere Summer (June-July-August, JJA) concentrations are higher both at the surface and aloft., but the transport patterns are less clearly defined than spring.

Surface



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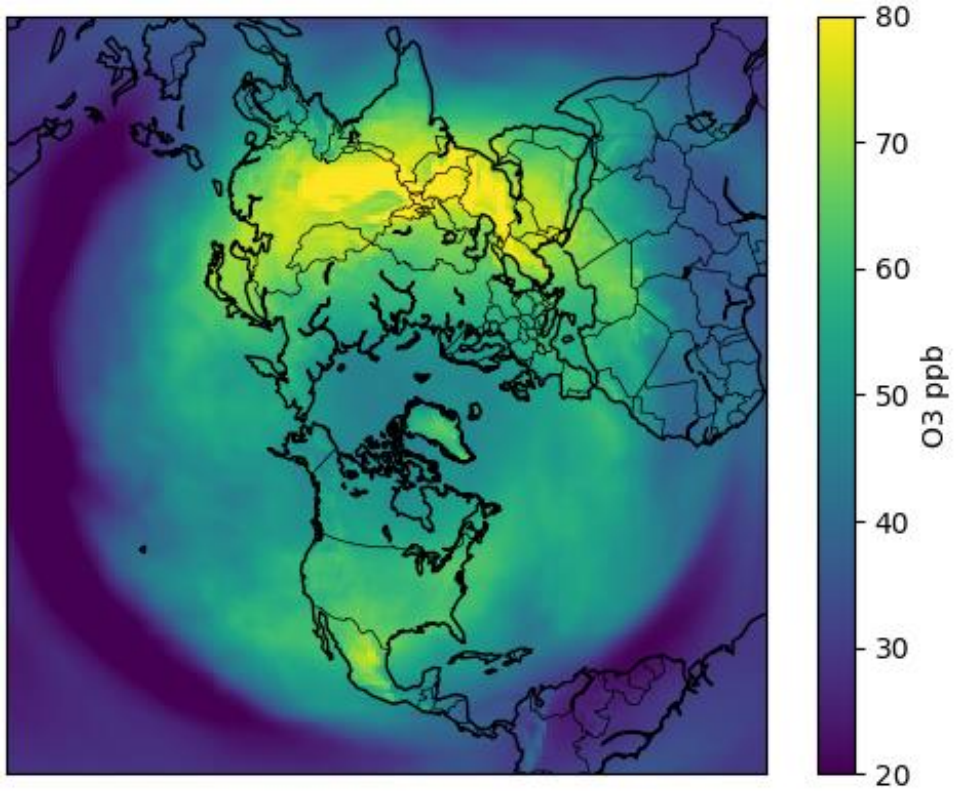
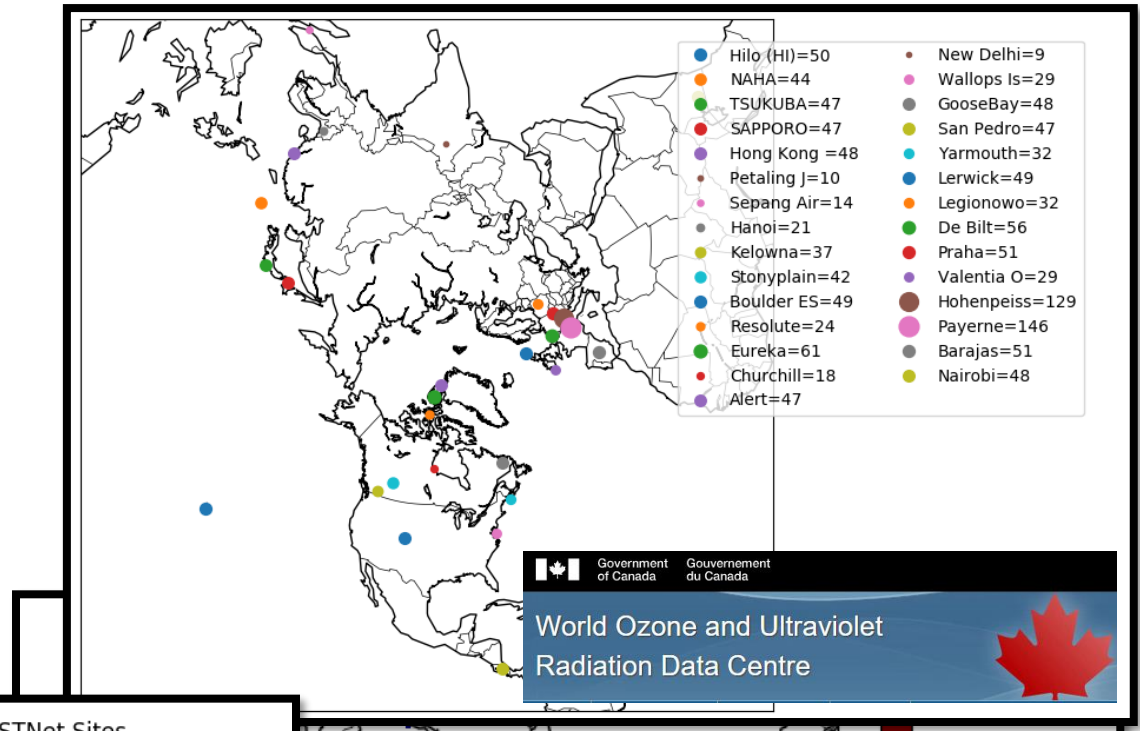
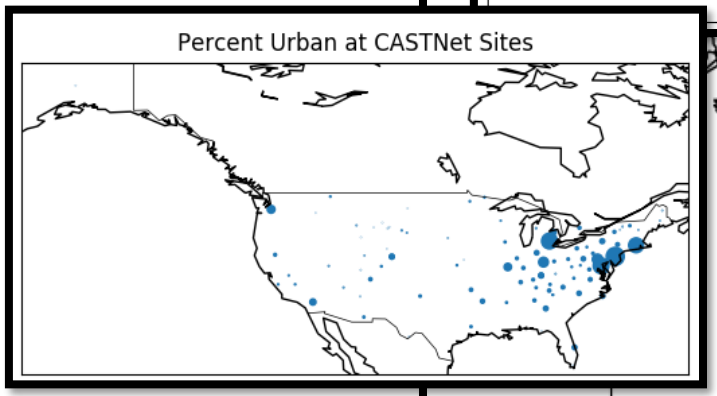
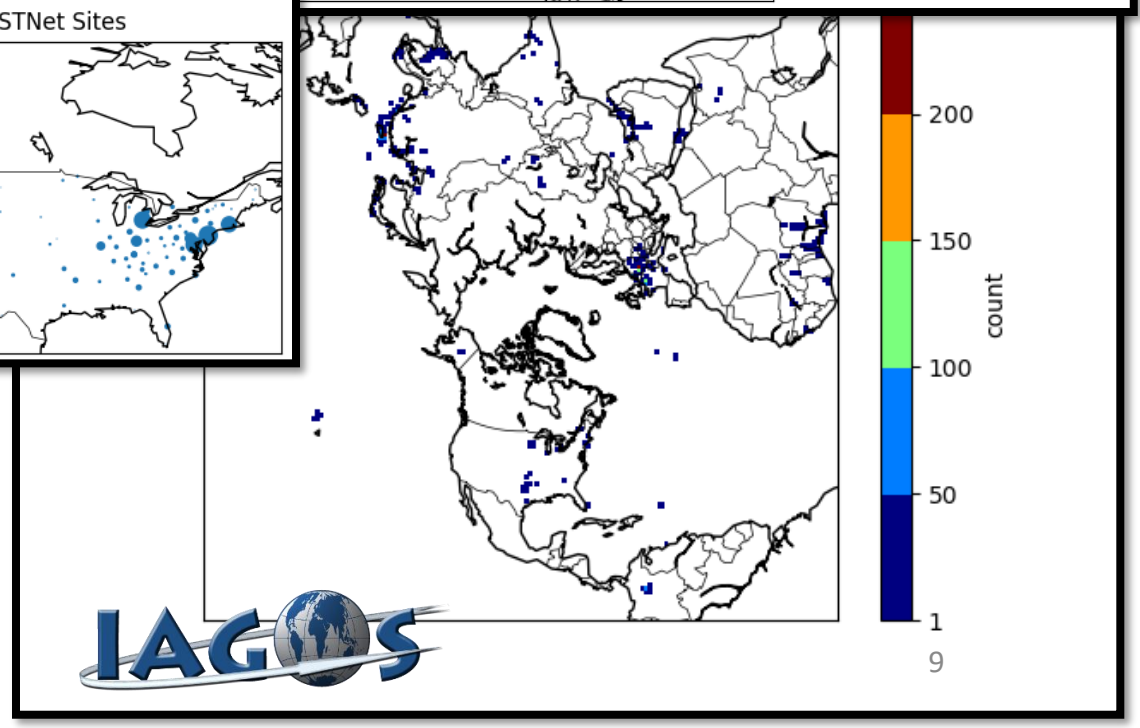


Evaluation Networks

- WOUDC
  - In domain sites: 29; launches: 1315
  - Many in NA and W EU
  - Averaging samples w/in CMAQ sigma levels
- CASTNet
  - Large scale simulations will not capture small-scale gradients
  - Not all CASTNet sites are rural
- In-service Aircraft for Global Observing System (IAGOS)
  - 333 grid cells covered
  - 3156 ascents or descents

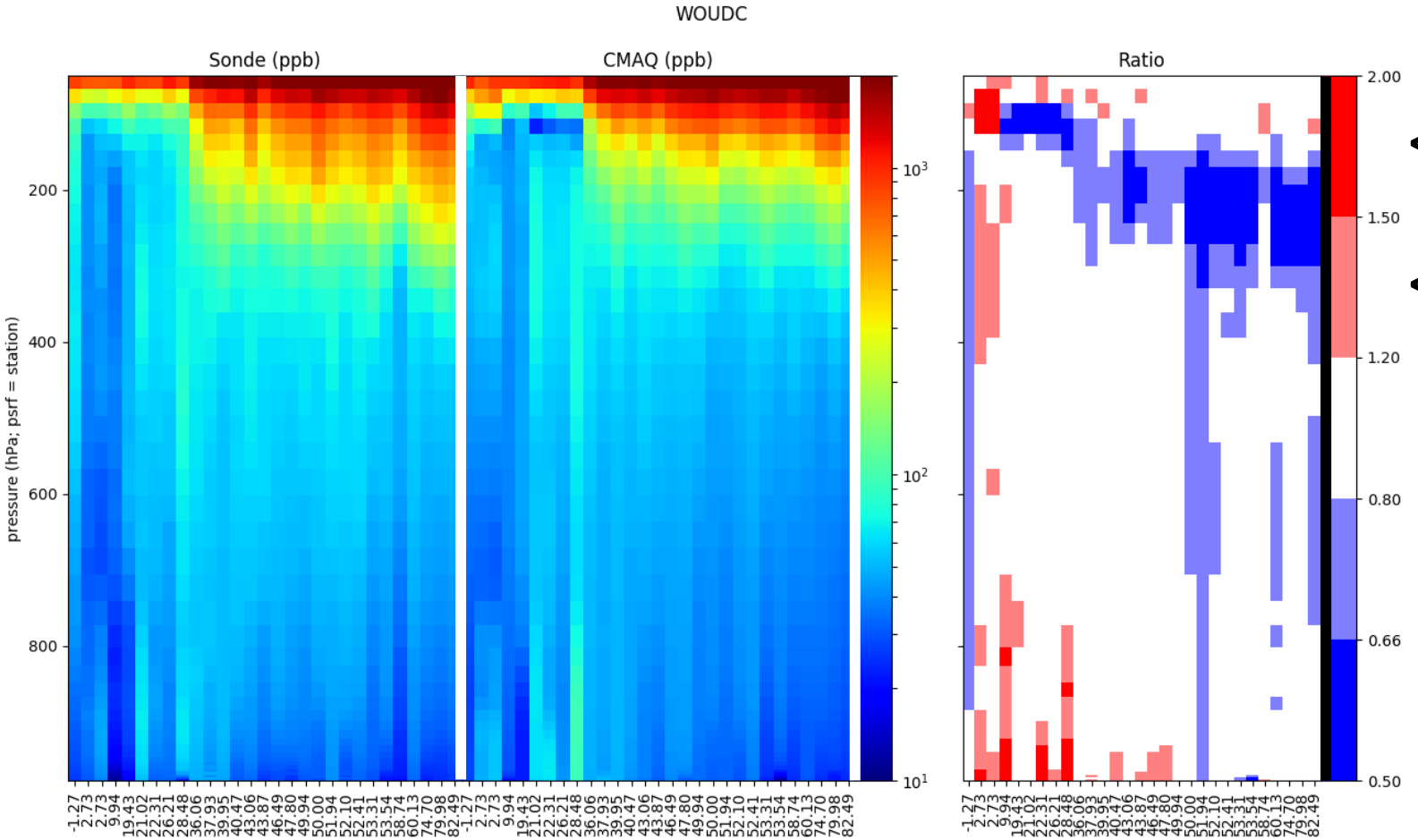






WOUDC Sondes: by Site (all Times)

- Sorted by latitude and averaged across launches
- Near tropopause bias that is strongest in the northern latitudes



<2x

<3/2 x

(80, 120) percent

>2/3 x

>1/2 x

-1 degrees

Observations

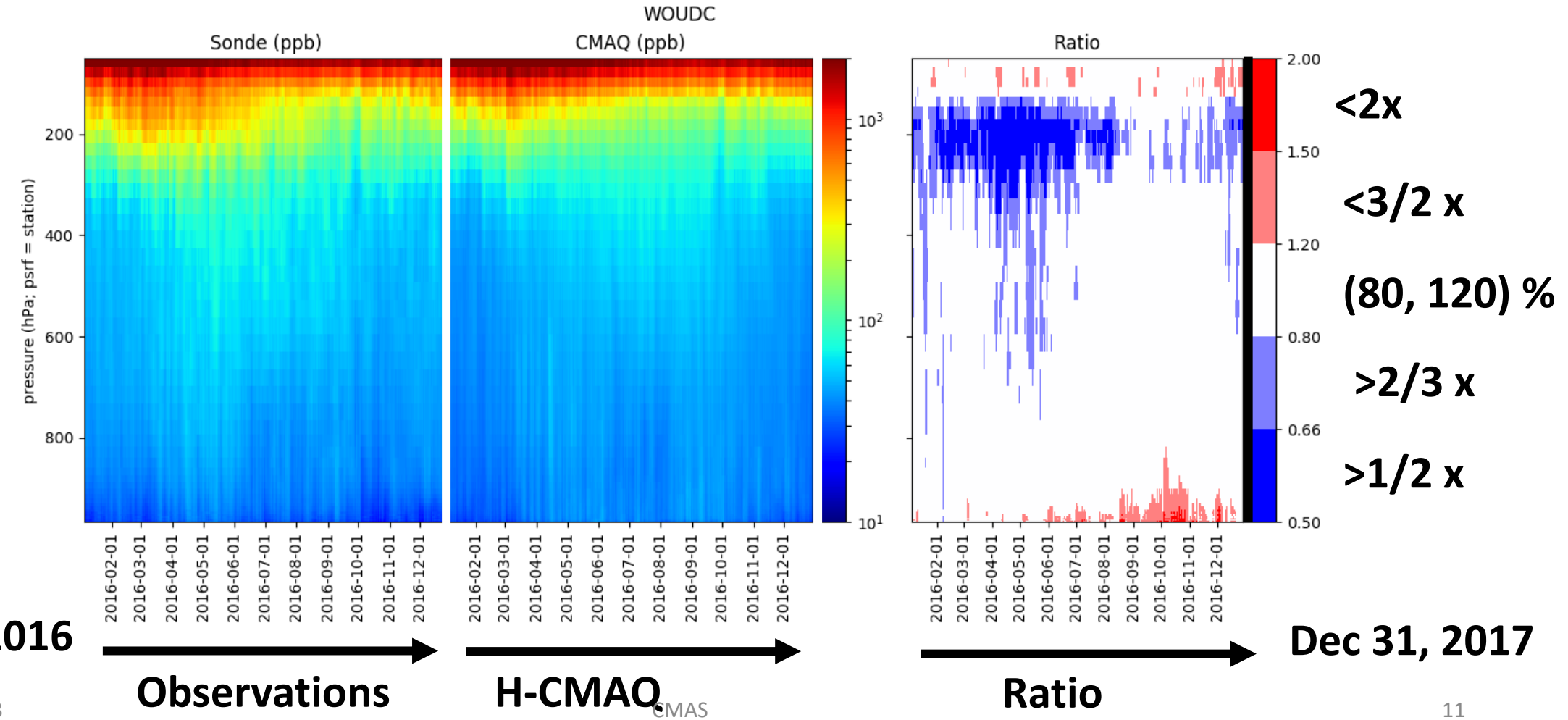
H-CMAQ

Ratio

82 degrees

WOUDC Sondes: by Time (all Sites)

- Near tropopause bias is strongest in the spring.
- WRF-CMAQ demonstrates increased downward mixing in March/April, but it appears muted compared to the sondes.
- The mid troposphere (600-400 hPa) sondes have a maximum in that is not present in CMAQ.



<2x

<3/2 x

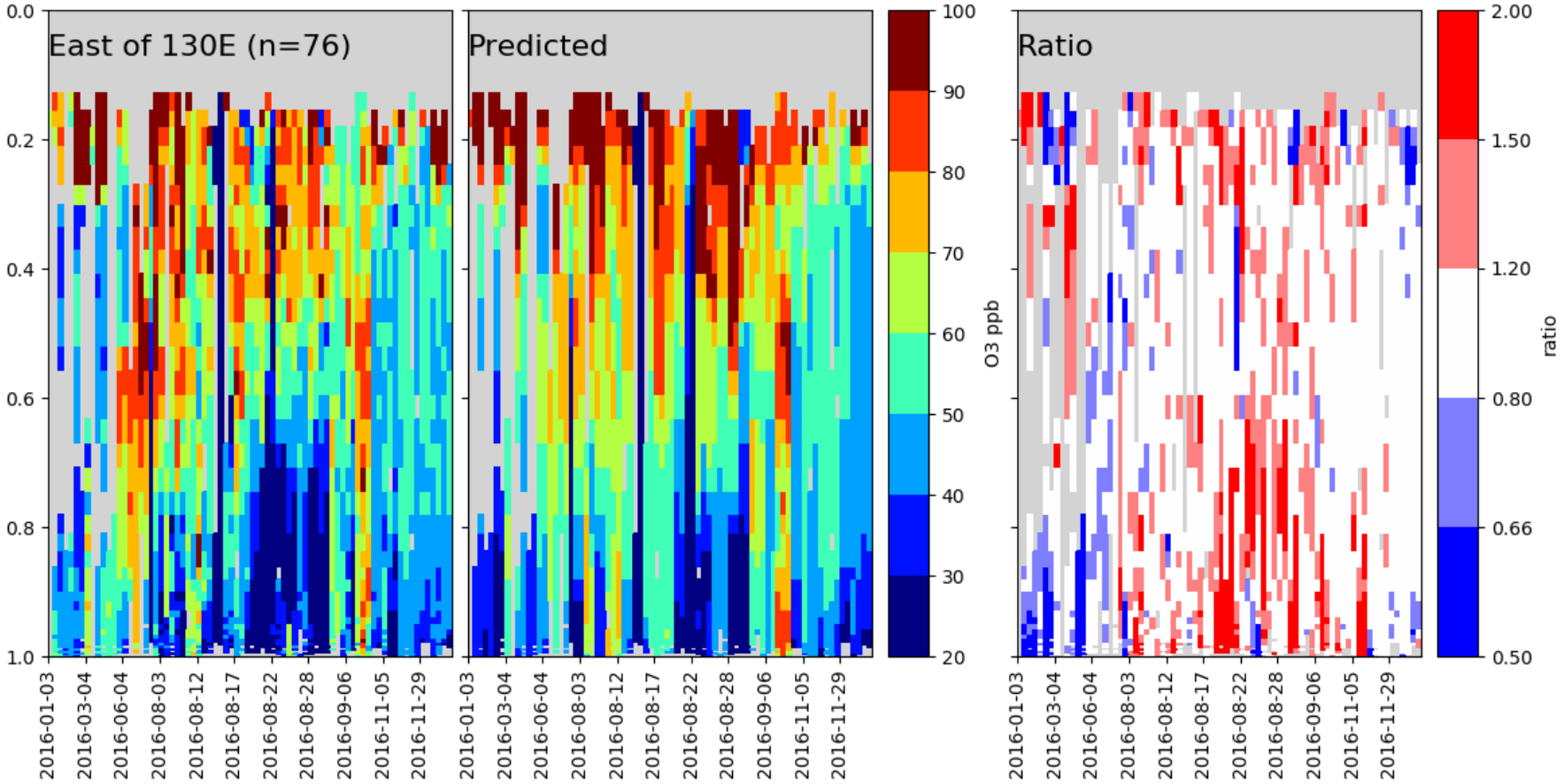
(80, 120) %

>2/3 x

>1/2 x

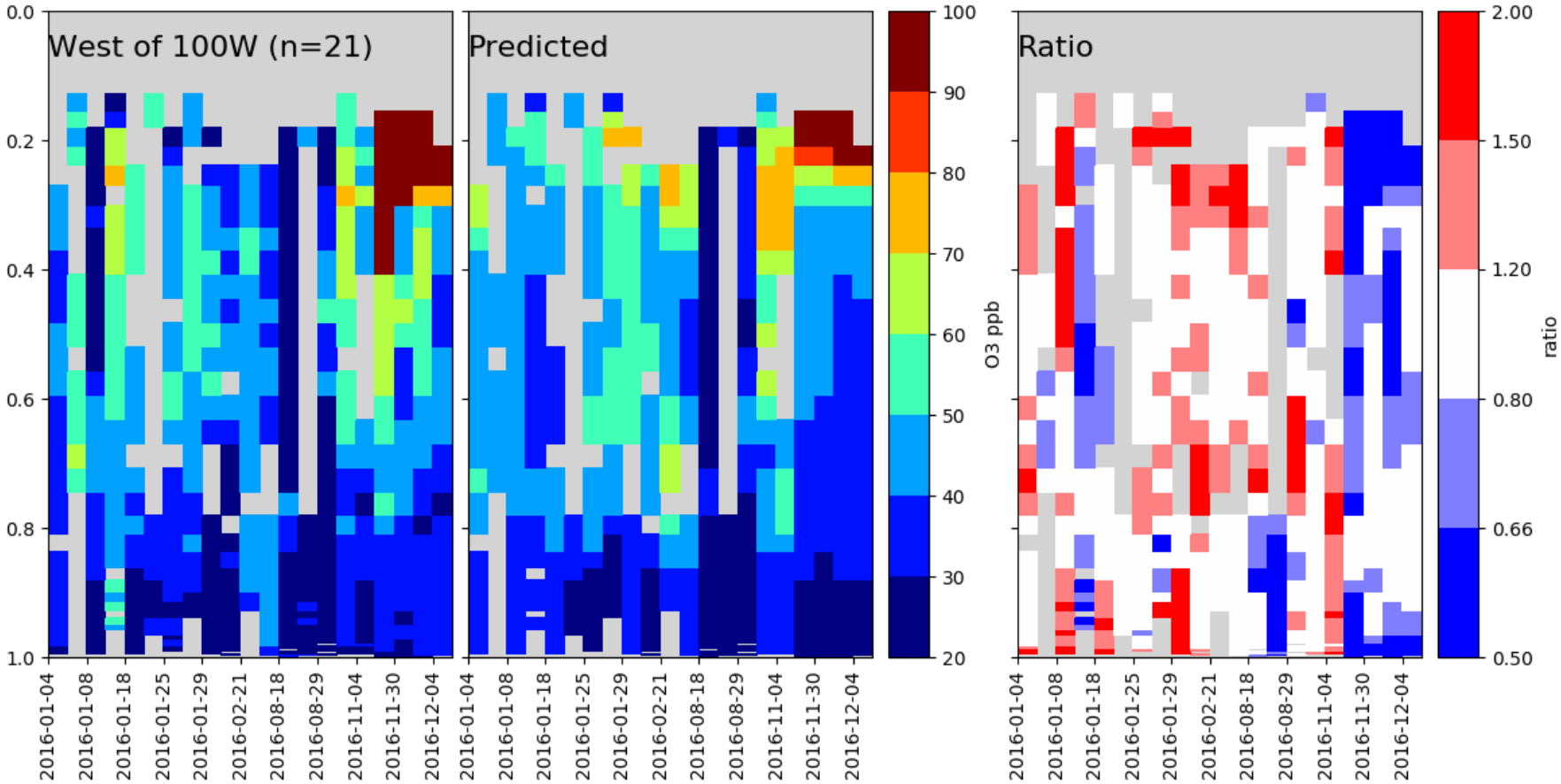
IAGOS Flights

- Focusing on east (Japan) for Asian outflow
- Missing Apr, Jul, and Oct flights
- Captures a few prominent upper air features
- Tends to be high biased
- Over the continent, tends to be higher biased

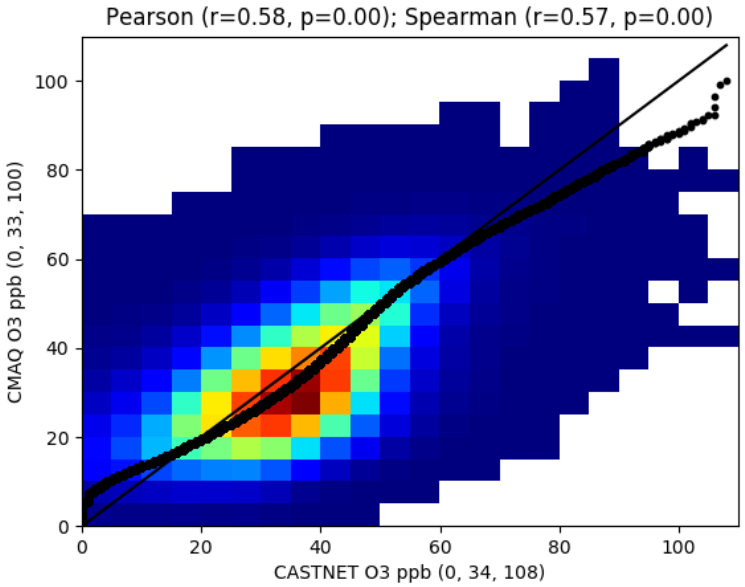


IAGOS Flights

- Focusing on west (Hawaii) for incoming air
- Missing Mar-Jul, and Oct flights…
- Captures several key features
- Mixed performance

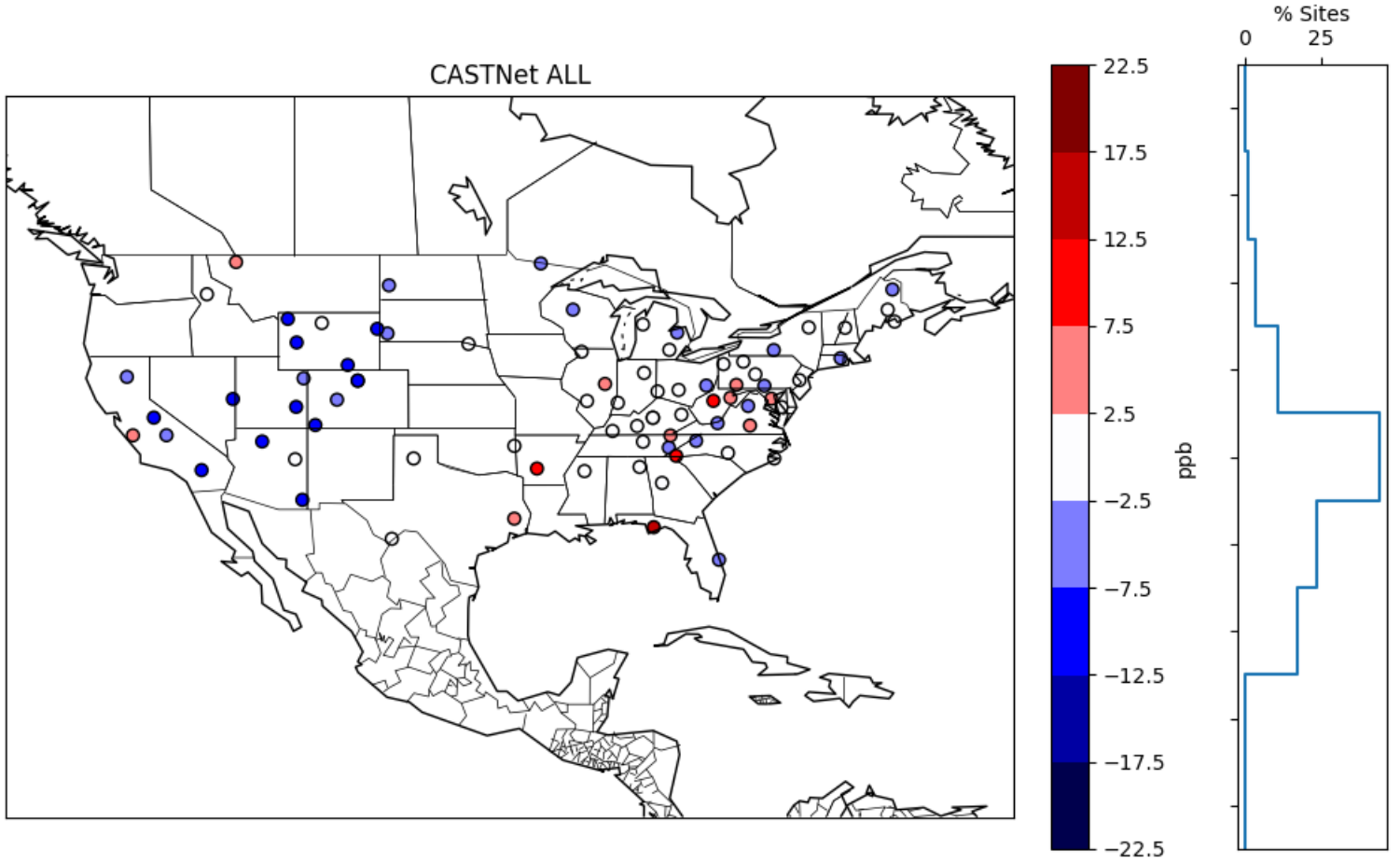


CASTNet Monitors: All Year

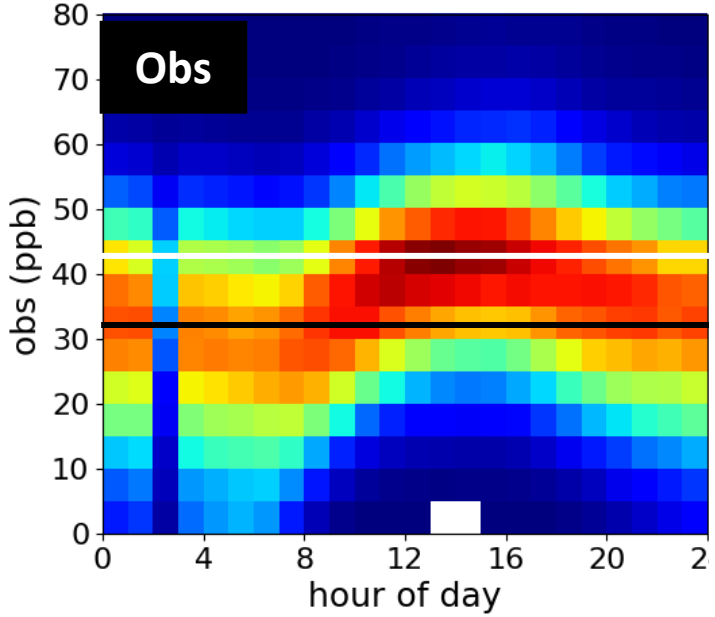


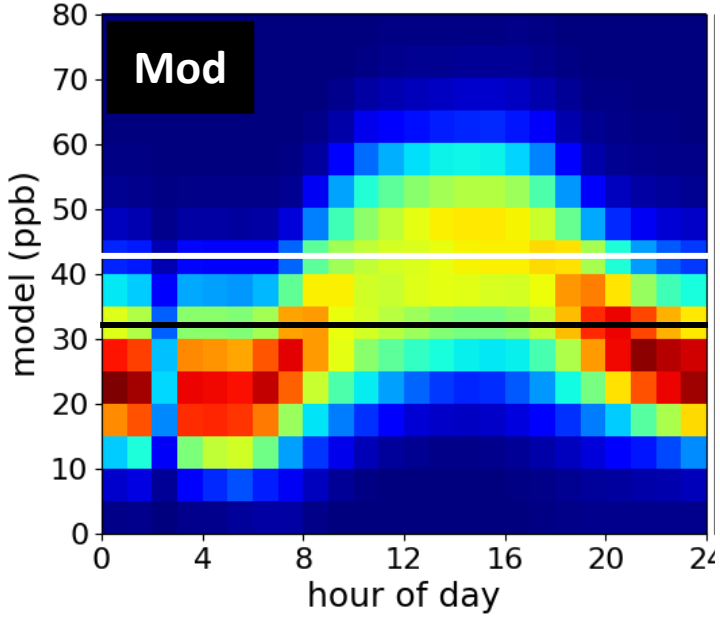
CASTNet monitors are not all rural, but they are frequently used as a proxy. Here we evaluate hourly ozone.

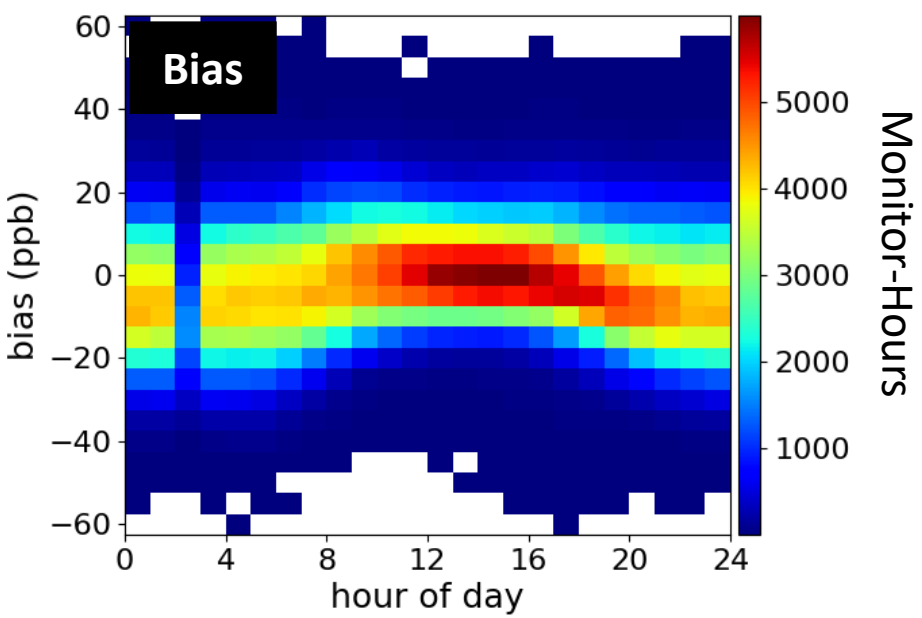
- 15LST has an r=0.67
- Performance at these monitors is within ±7.5 ppb at most monitors.
- There is a west-east bias divide

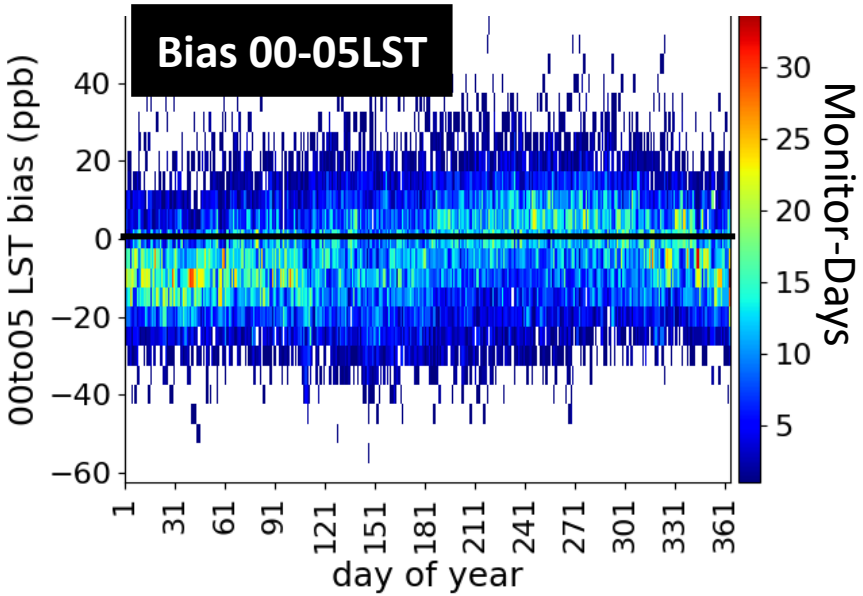


CASTNet Diurnal Performance



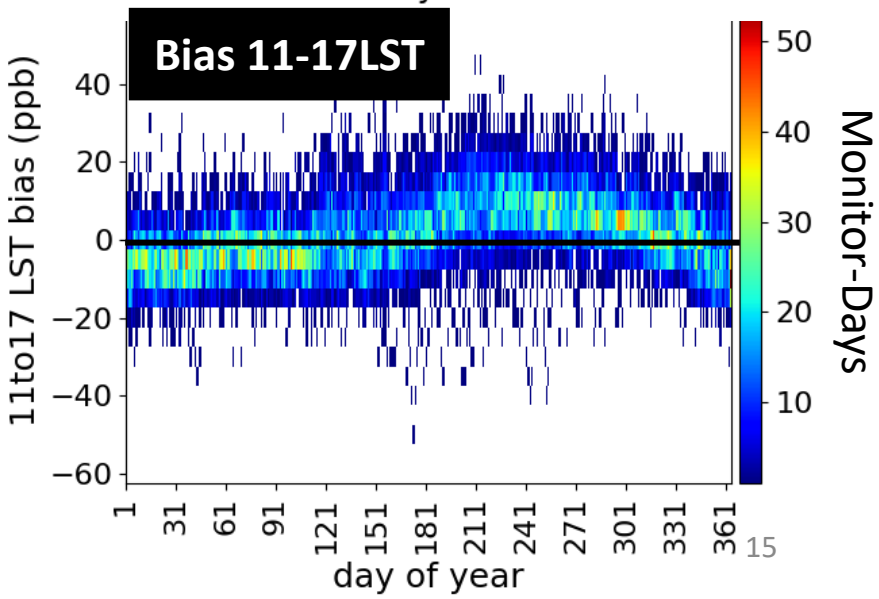






Plots show count of monitor-days with bias as a function of hour of day or day of year

- Hour of day all year
- 0-5LST over the year
- 11-17LST over the year



Summary

- Compares well to sondes in the mid troposphere
  - appears to have a near tropopause low-bias
  - low bias northward of 50 degrees Dec-May
  - performing similarly to GEOS-Chem used for the 2011 platform
- Routine aircraft measurements show mixed results.
- Performs best in JJA compared to CASTNet
  - Most data is within 10 ppb of observations
  - Clear West-East bias gradient
- TOAR evaluation suggests similar results with better performance at rural than urban monitors
- Compared to current test of GEOS-Chem v11-02* were less biased.
  - H-CMAQ was low-biased while GC was high-biased compared to sondes
  - Testing GC version (v12.0.1), considering meteorology

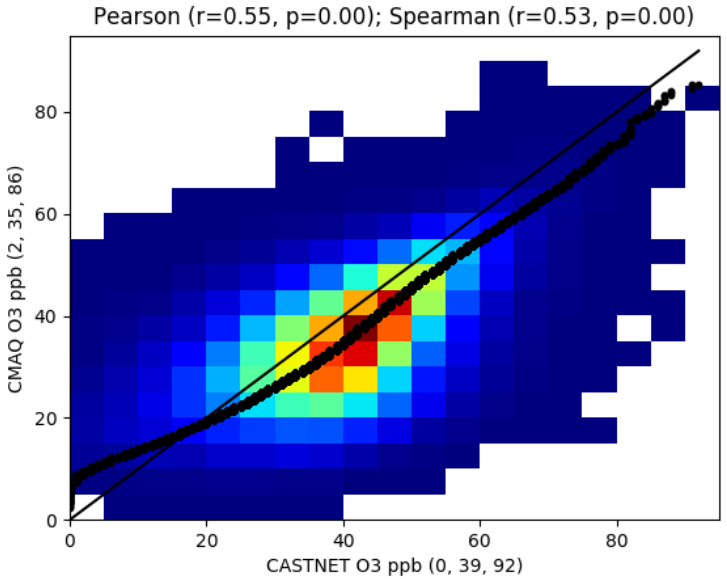
*w/FINN fires and 2016 lightning

Next Steps

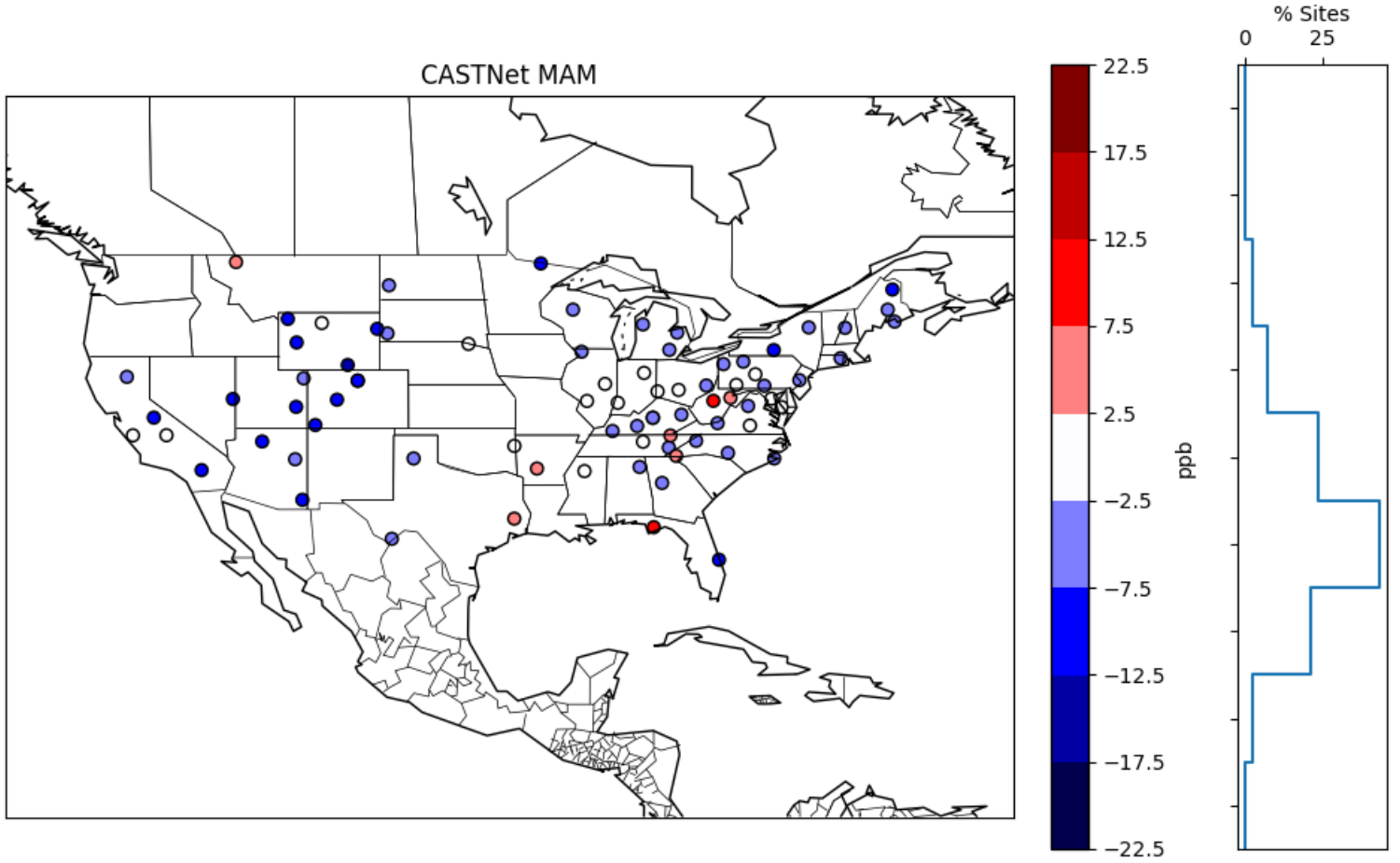
- Provide boundary conditions for regional scale modeling.
- Continue to evaluate, particularly for aerosols.
- Estimate Ozone contributions from
  - Natural (global) sources
  - Anthropogenic
    - International sources
    - Domestic sources

Appendix

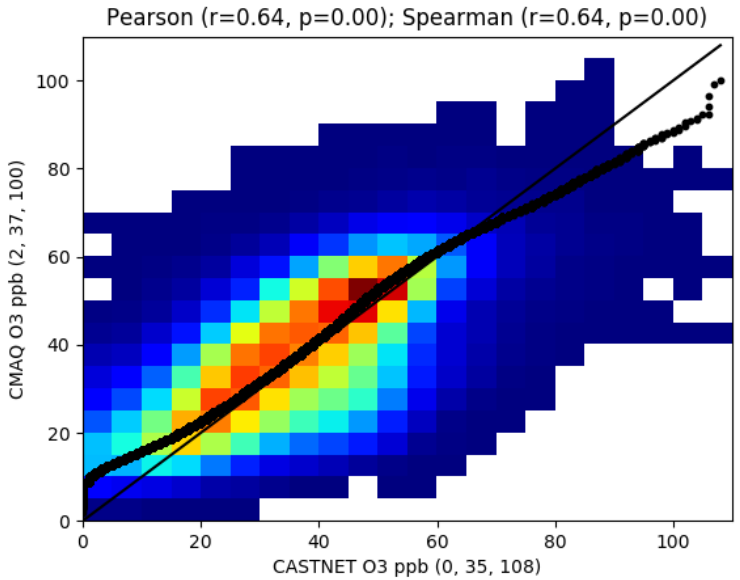
CASTNet Monitors: Spring

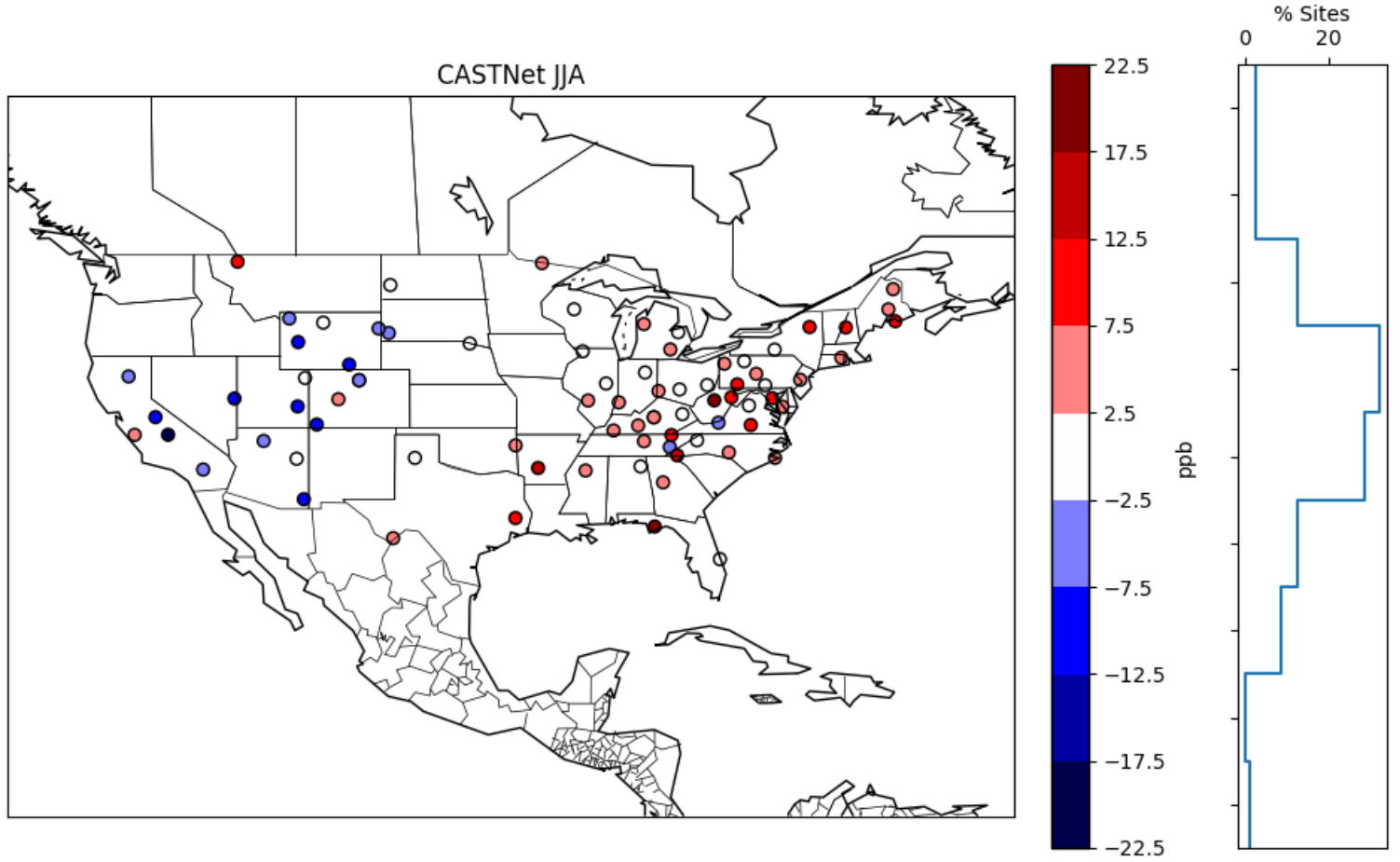


- Spring (MAM) has a low-bias
- 15LST r=0.63
- Majority of monitors within ±7.5 ppb
- The west-east gradient is less strong than for the whole year



CASTNet Monitors: Summer





- Summer (JJA)
- 15LST has an r=0.66
- Majority of monitors within ±7.5 ppb.
- The west-east bias gradient is most strongly present in the summer.