HTAP/WRAP Workshop, 11-May-2015

Establishing process-oriented constraints on global models for ozone source attribution: Lessons from GFDL-AM3

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GFDL AM3 Global Simulations for HTAP2

- **Horizontal and vertical resolution:**
  - C90 cube sphere grid, ~1.0x 1.25 degrees
  - 48 vertical levels, from surface to 86 km altitude
- **Using HTAPv2 anthropogenic emissions**
  - HTAP2 emissions and RETRO VOC speciation
  - HTAP2 aircraft emissions distributed vertically based on ratios in ACCMIP
  - Daily FINN fire emissions emitted at the model surface level
  - MEGAN v2.1 biogenic isoprene emissions
- **Interactive stratospheric & tropospheric chemistry**
- **Nudged to NCEP GFS winds**
- **Citations for model documentation**
  - Donner L. J. *et al*. [**J. of climate**, 2011]
  - Lin M.Y. *et al* [**JGR**2012a; **JGR**2012b; **Nature Geosci**, 2014]

http://data1.gfdl.noaa.gov/nomads/forms/HTAP2/AM3_HTAP2_MODEL_DESCRIPTION.pdf

GFDL AM3 for HTAP2 regional boundary conditions

- **Available at NOAA GFDL data portal:**
  http://data1.gfdl.noaa.gov/nomads/forms/HTAP2/
- **Relatively long-lived chemical species (3-hourly & 3-D output)**
  Ozone, CO, PAN, sulfate, nitrate, BC, OC, dust, NO, NO2, SO2, NH3, ethane, propane, acetone

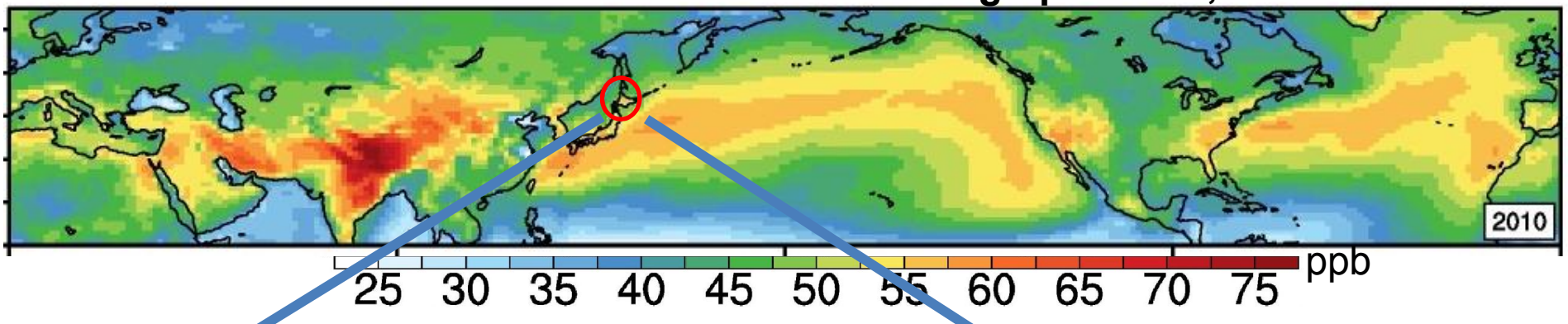
BASE	Base emissions, methane=1798 ppb (2008-2013)	get data
CH4INC	Base emissions, methane=2121 ppb (2008-2010)	get data
GLOALL	20% decrease of all anthropogenic emissions globally	get data
NAMALL	20% decrease of all anthropogenic emissions	get data
EASALL	20% decrease of all anthropogenic emissions	get data
EURALL	20% decrease of all anthropogenic emissions in HTAP2 Tier1 domain for Europe	get data

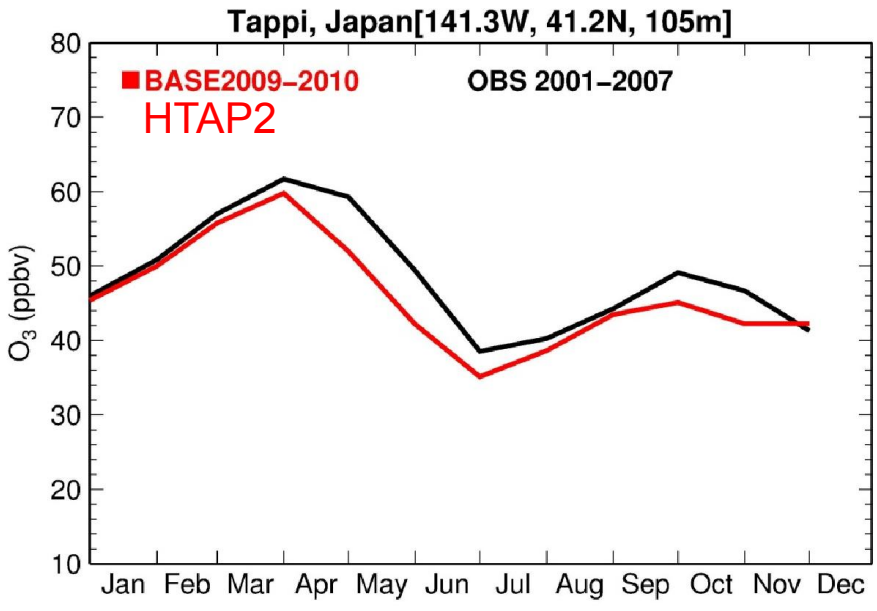
***Known issues:** The response is noisy and lack of a coherent spatial pattern

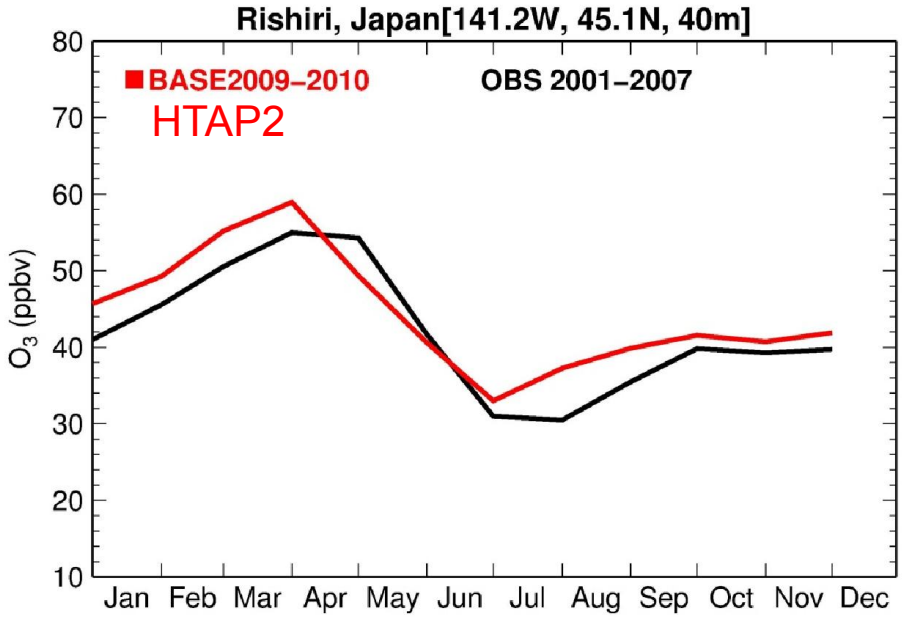
*Contact: Meiyun.Lin@noaa.gov for authorization

Evaluation of GFDL AM3 with **EANET** observations

Mean surface ozone concentrations during April-June, 2010







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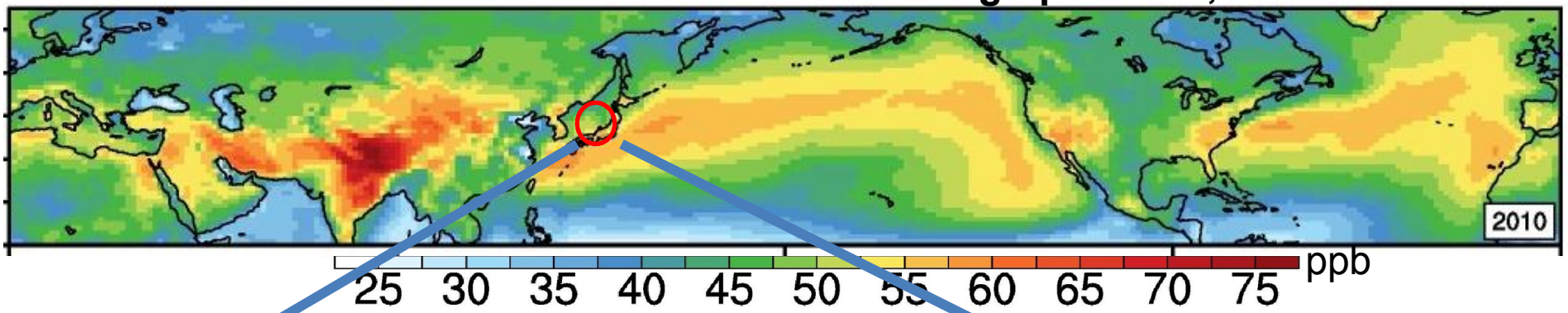
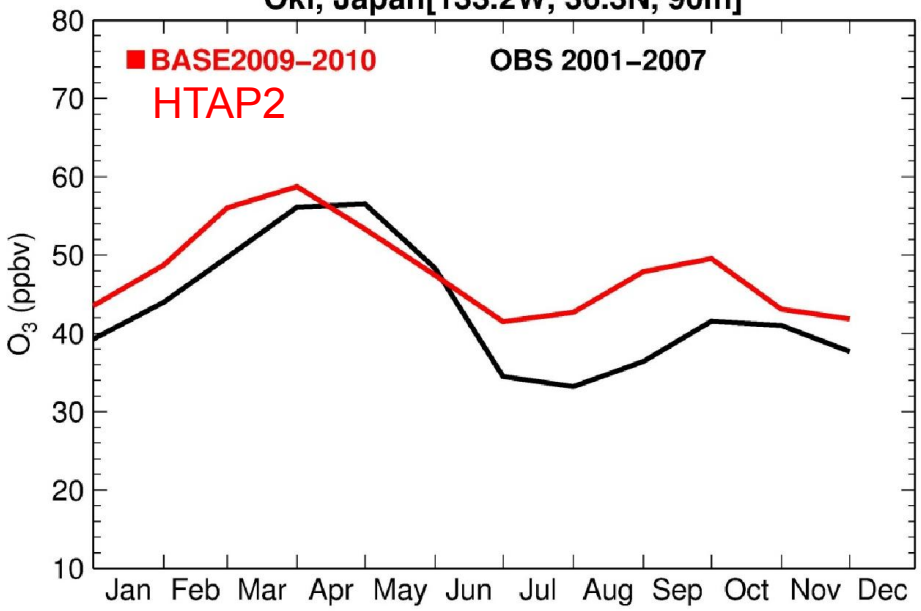
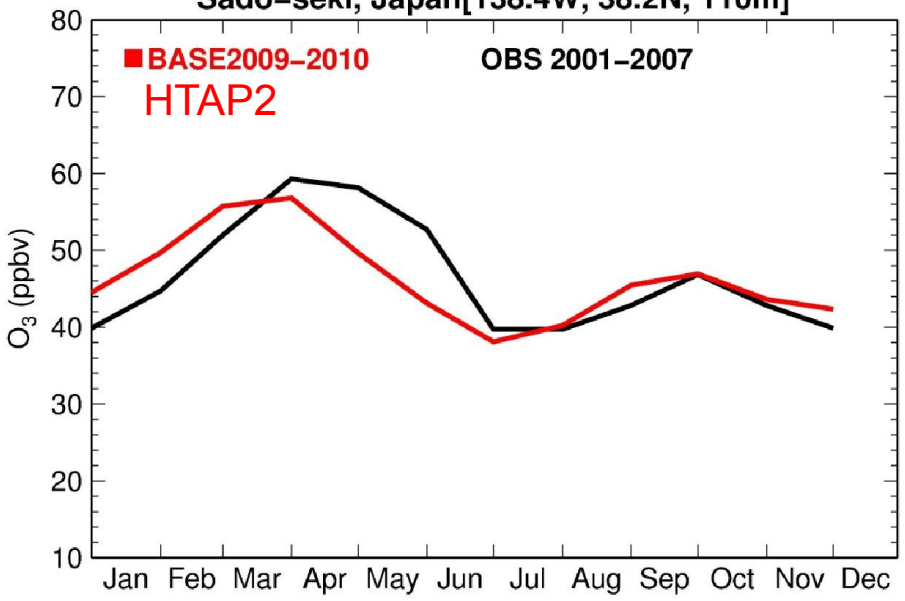


Oki, Japan[133.2W, 36.3N, 90m]

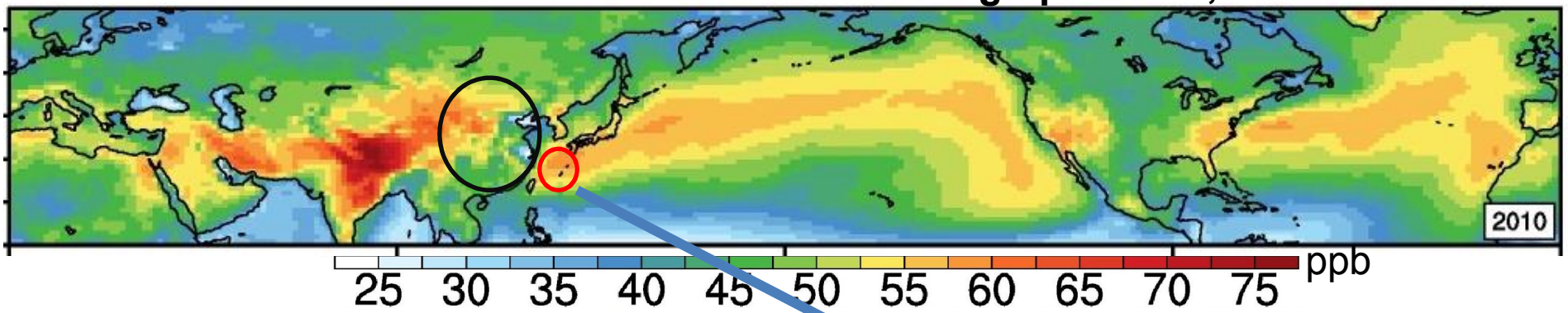


Sado–seki, Japan[138.4W, 38.2N, 110m]

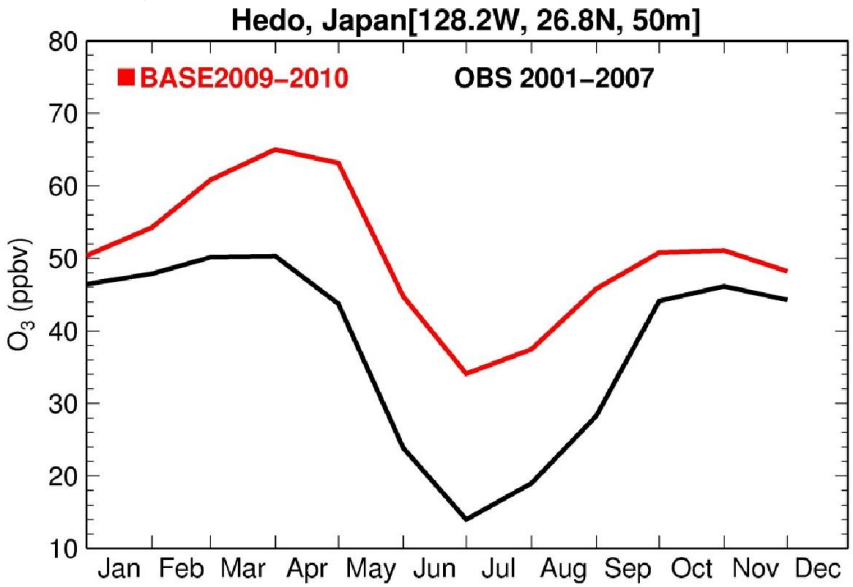


Evaluation of GFDL AM3 with **EANET** observations

Mean surface ozone concentrations during April-June, 2010

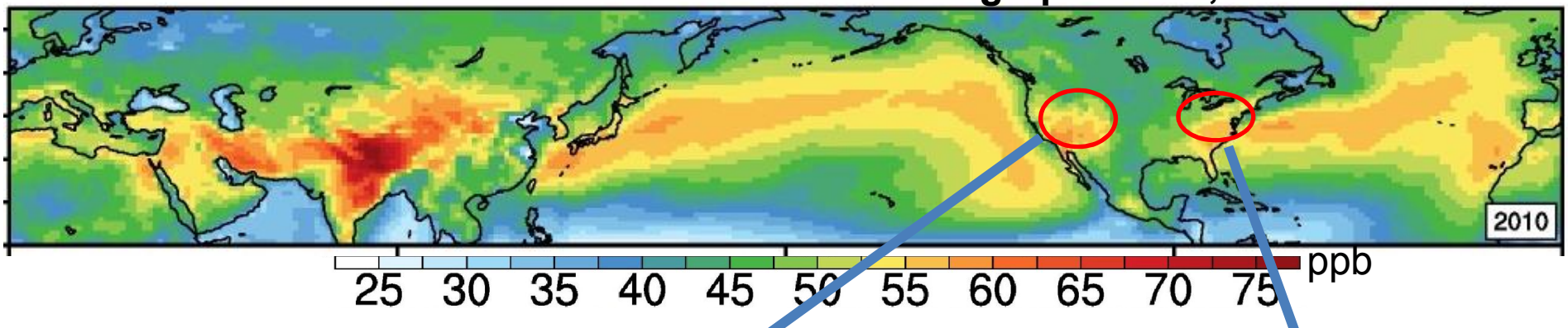


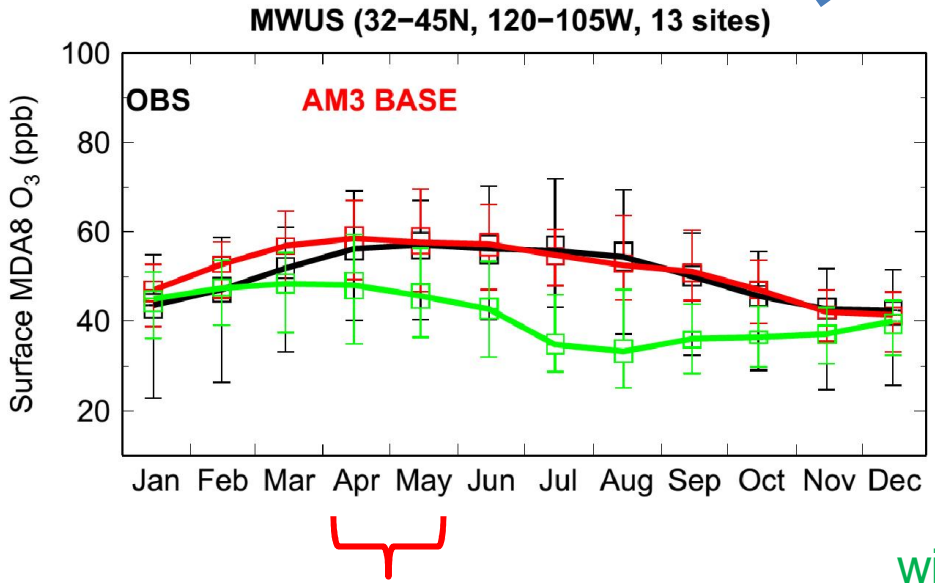
Need measurement data in China for additional model evaluation!!

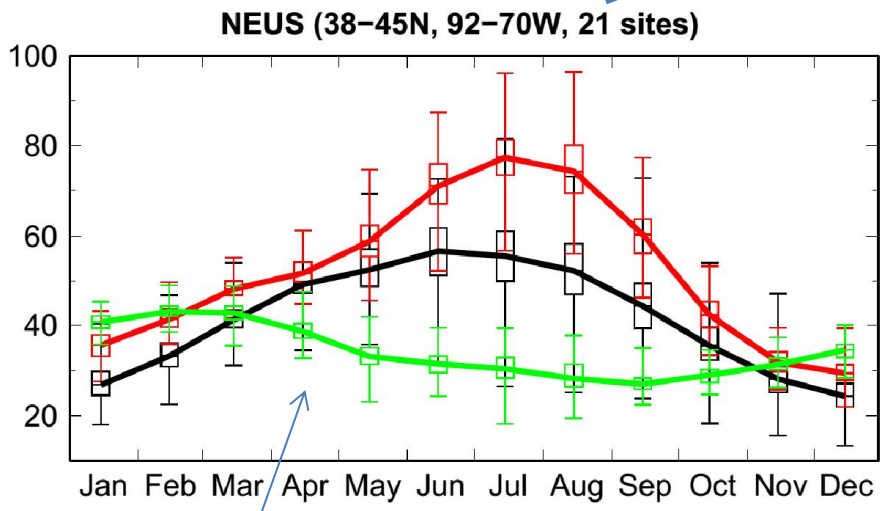


Evaluation of GFDL AM3 with **CASTNET** observations

Mean surface ozone concentrations during April-June, 2010

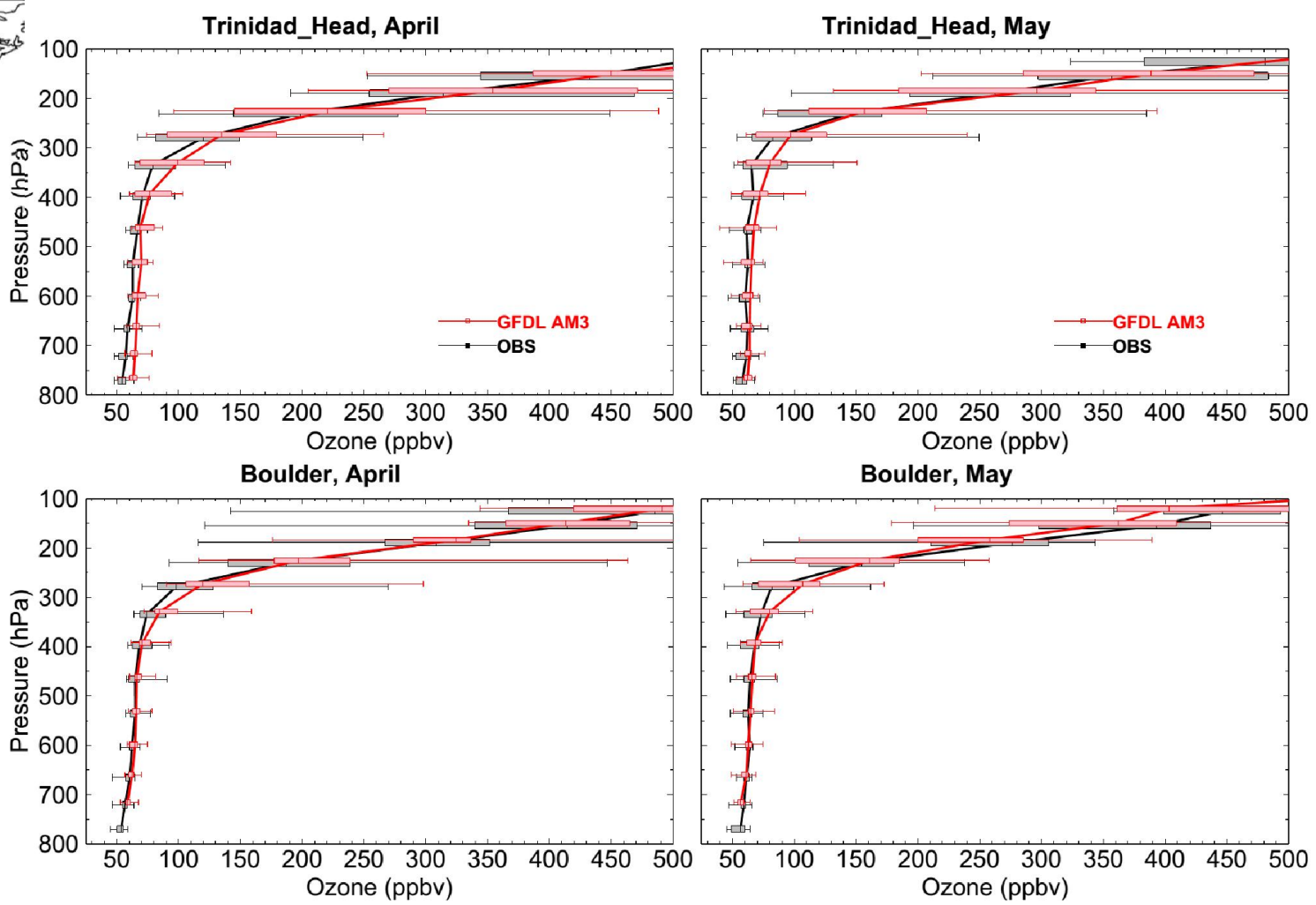






with NA anthropogenic emissions set to zero

Comparison of mean O_3 profiles with ozonesondes for April and May

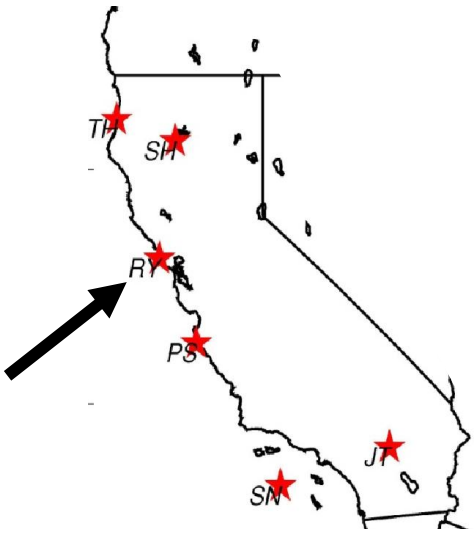


- Hindcast simulations (1979-2012) with anthrop & wildfire emissions set to climatology

See Supplemental Info in Meiyun Lin et al (Nature Communications, 2015)

The GFDL AM3 model explains 50-90% of observed daily O_3 variability in Point Reyes sonde

CalNex sondes



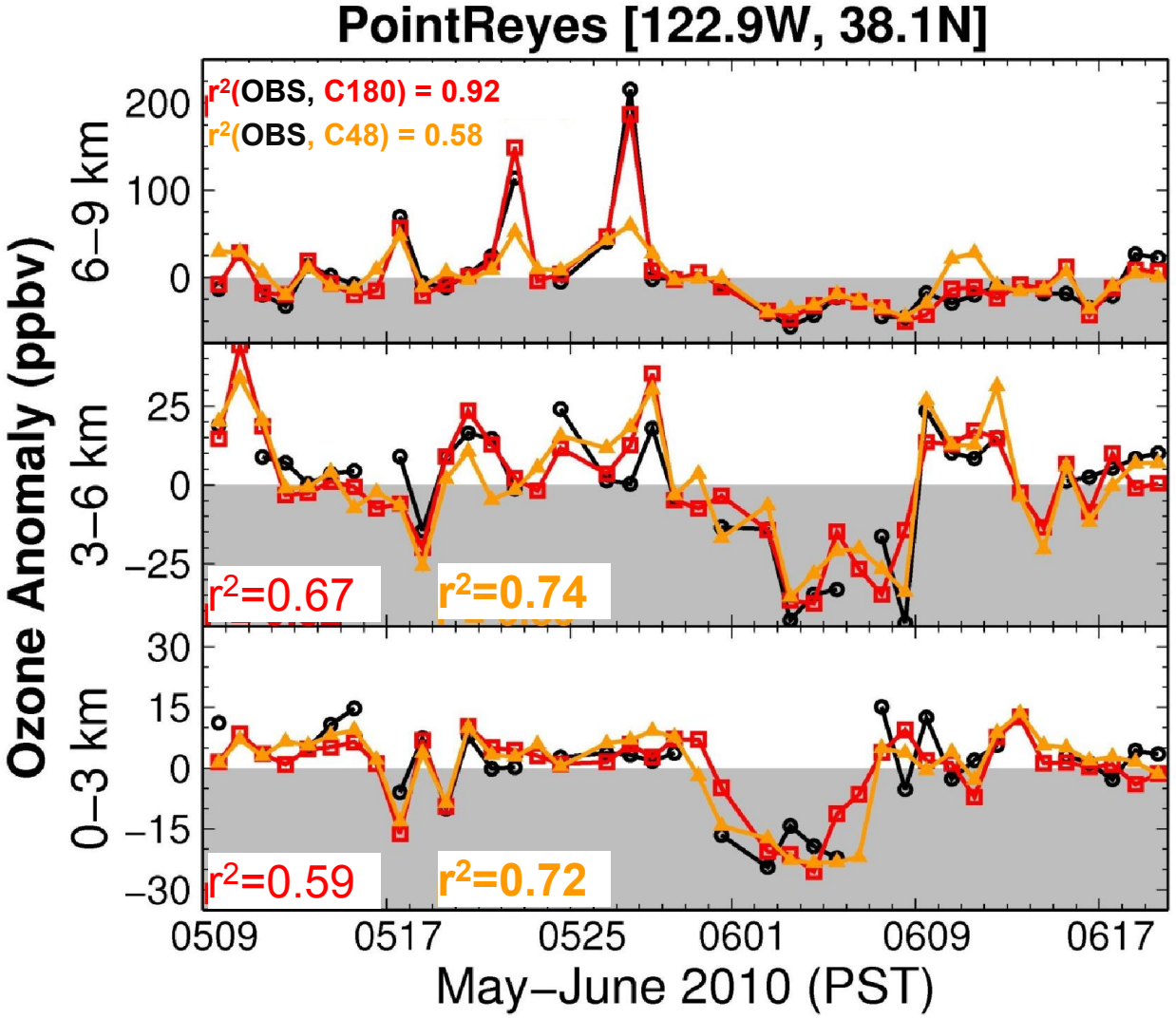
Cooper et al., 2011

Sonde

AM3/C180 (~50 km)

AM3/C48 (~200 km)

All sites: 40-90%

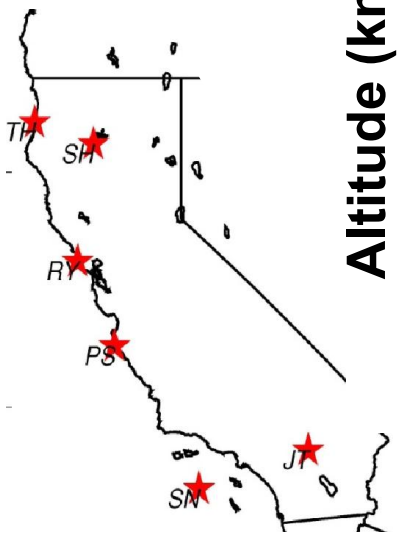


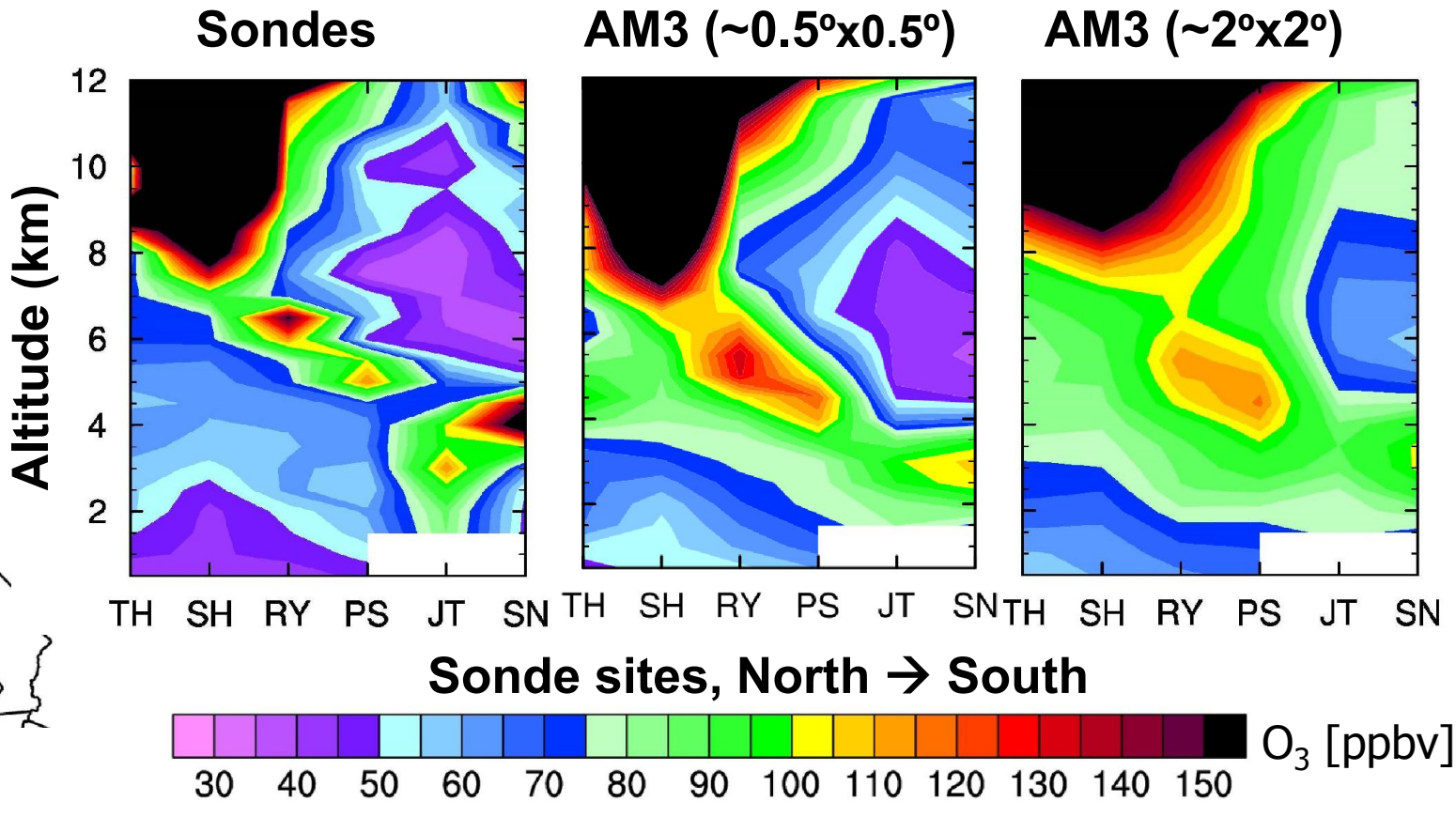
See Supplemental Info in Meiyun Lin et al (Nature Communications, 2015)

Evaluation of Source Attribution

- Deep STT
- Regional anthropogenic pollution
- Wildfires

Simulating deep stratospheric intrusions: role of model resolution (May 28, 2010 example)

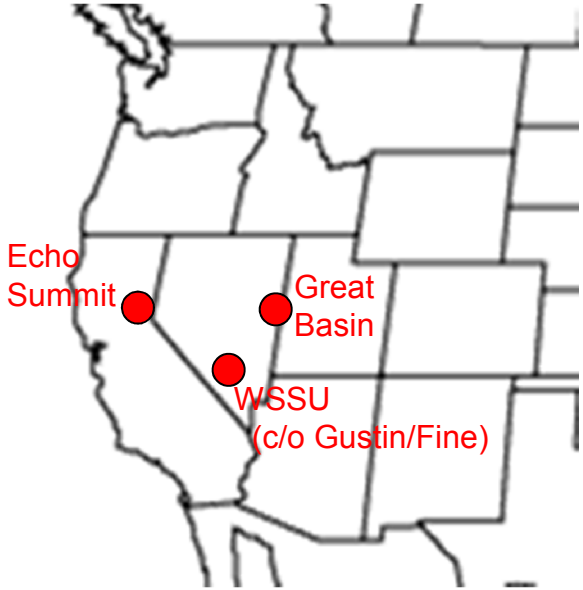




- 0.5° model better captures vertical structure
- 2° model reproduces the large-scale view (suitable for exploring IAV)

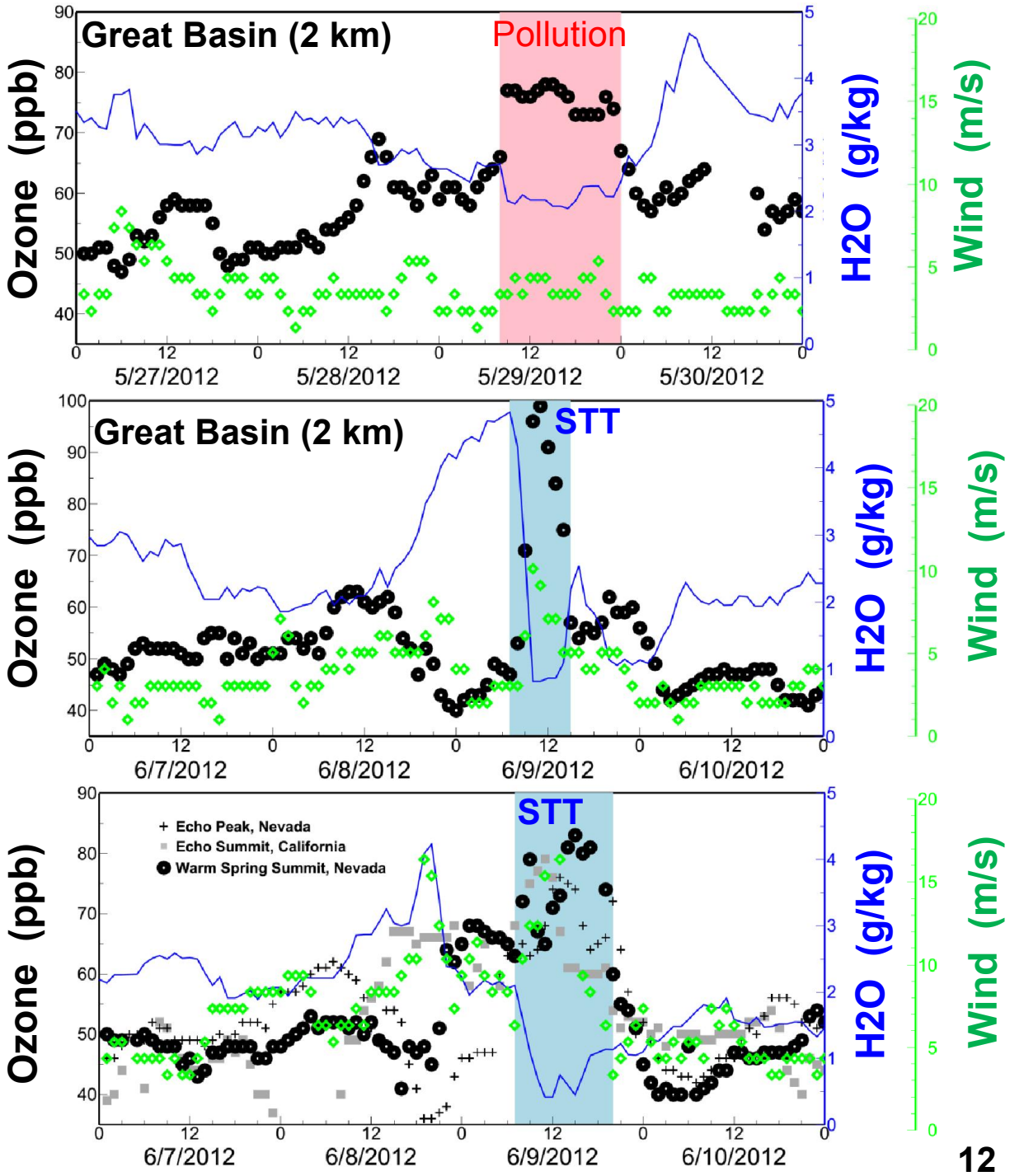
Lin MY et al (JGR, 2012b): *Springtime high surface ozone events over the western US: Quantifying the role of stratospheric intrusions*

Attribution of WUS high-O_3 events: **Observations**



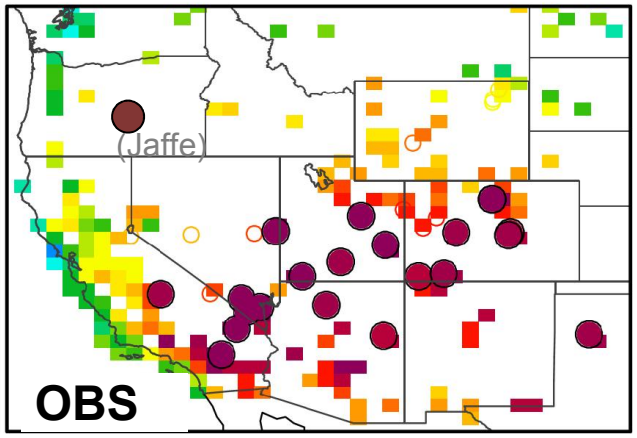
Anomalously frequent high-O_3 events were measured in Apr-May 2012 (Lin *et al.*, Nature Commun. 2015)

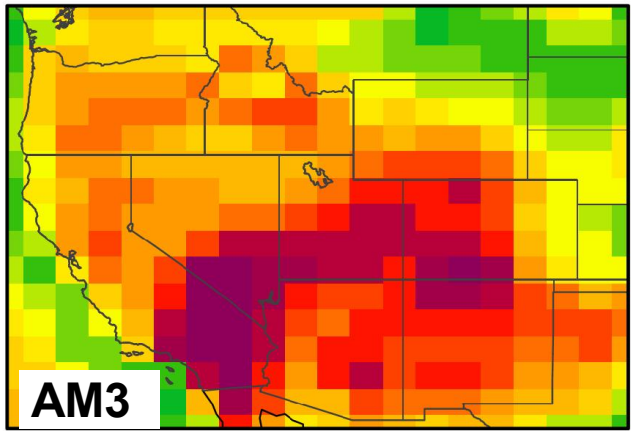
MY Lin et al (in prep, 2015)

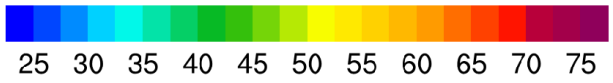


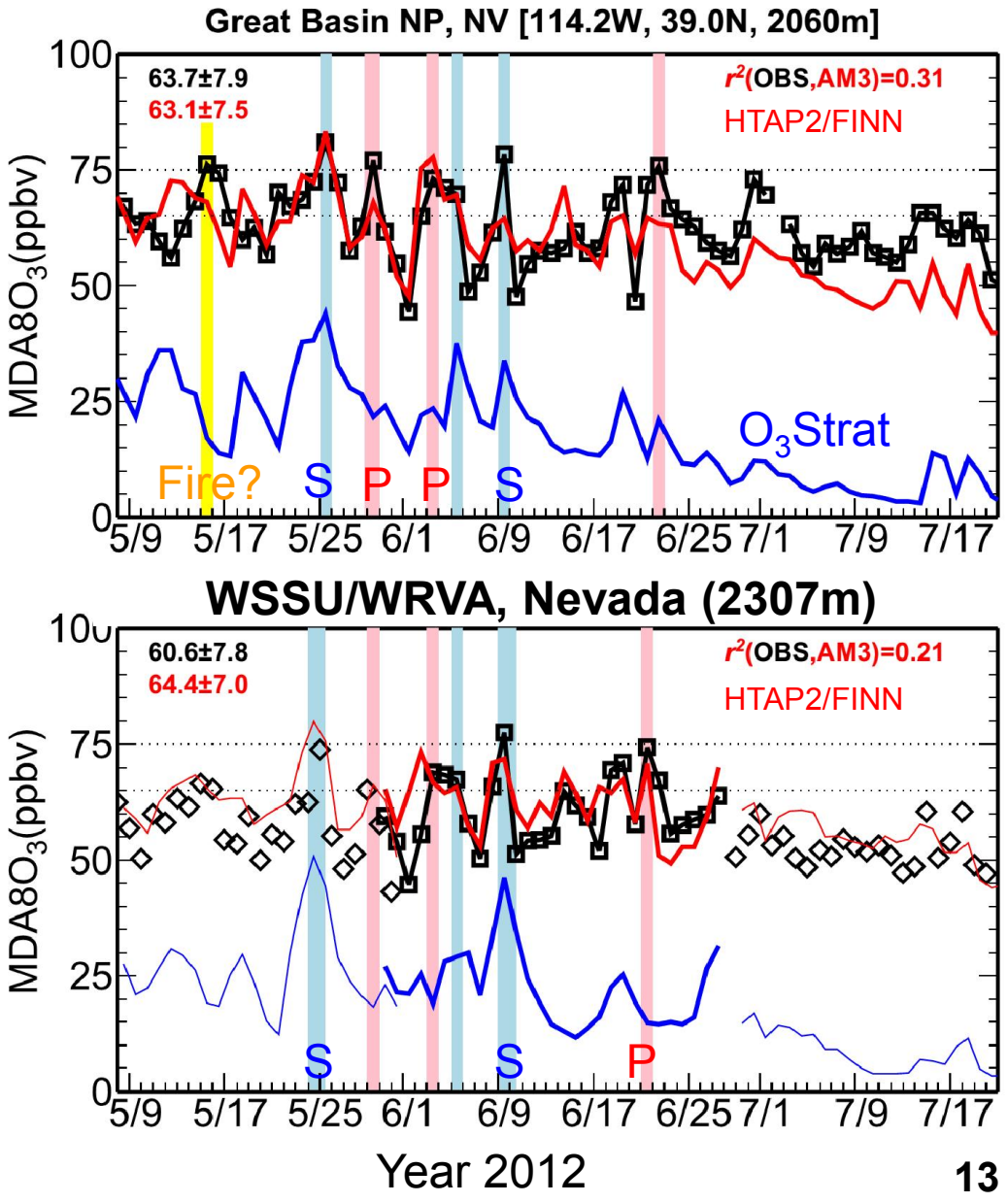
Attribution of WUS high-O_3 events: **GFDL AM3**

May 29, 2012 (Pollution)







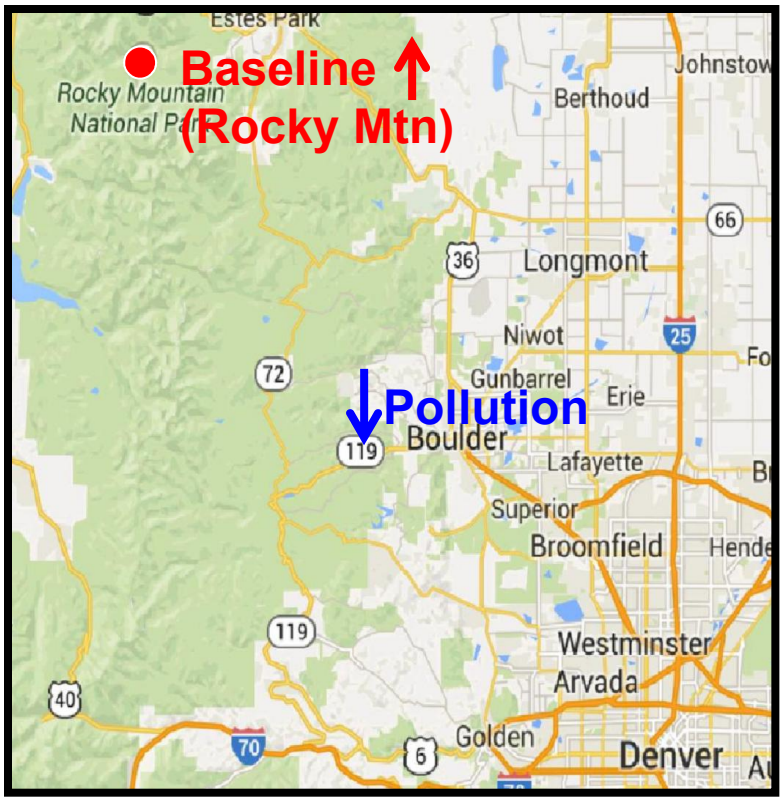


Meiyun Lin et al (in prep, 2015)

Long-term trends in US surface ozone

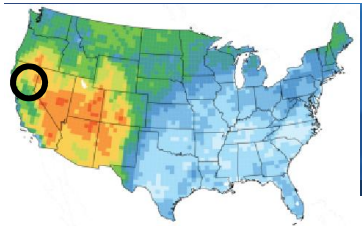
Selection of model baseline to be more representative of observed conditions at WUS mountain sites

Within a ~2ºx2º global model grid



Problem: -Model limitations in resolving observed baseline conditions
-Local pollution influence in the model grid perturbs the small baseline signal

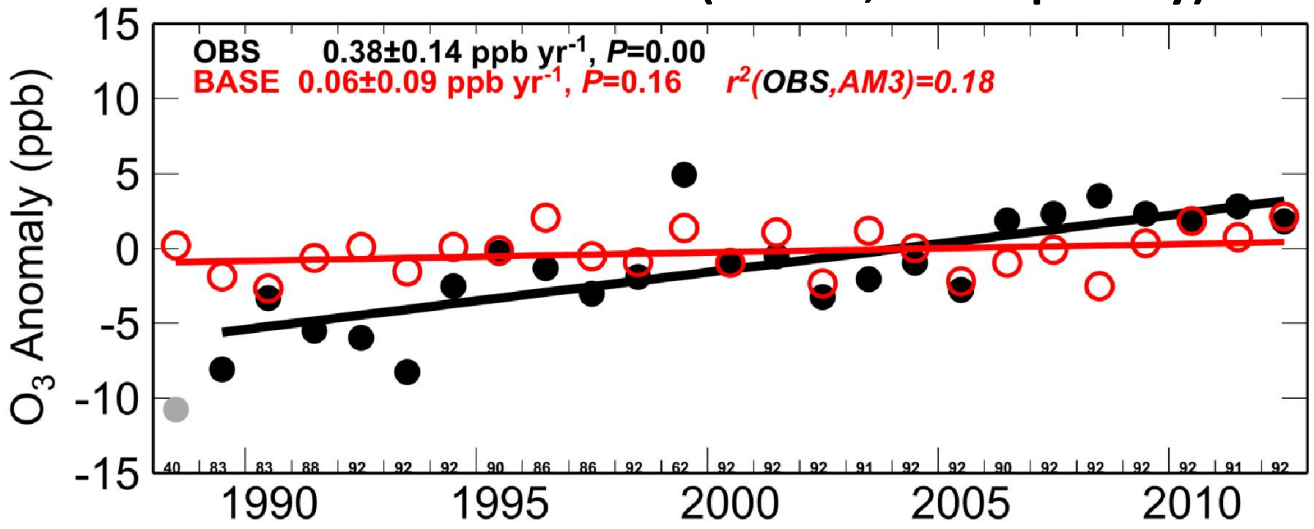
Approach: **-Sample the model at site elevation**
-Filter the model to remove the influence from fresh local pollution
(i.e. removing data on days when N. American COt ≥ 33th percentile)



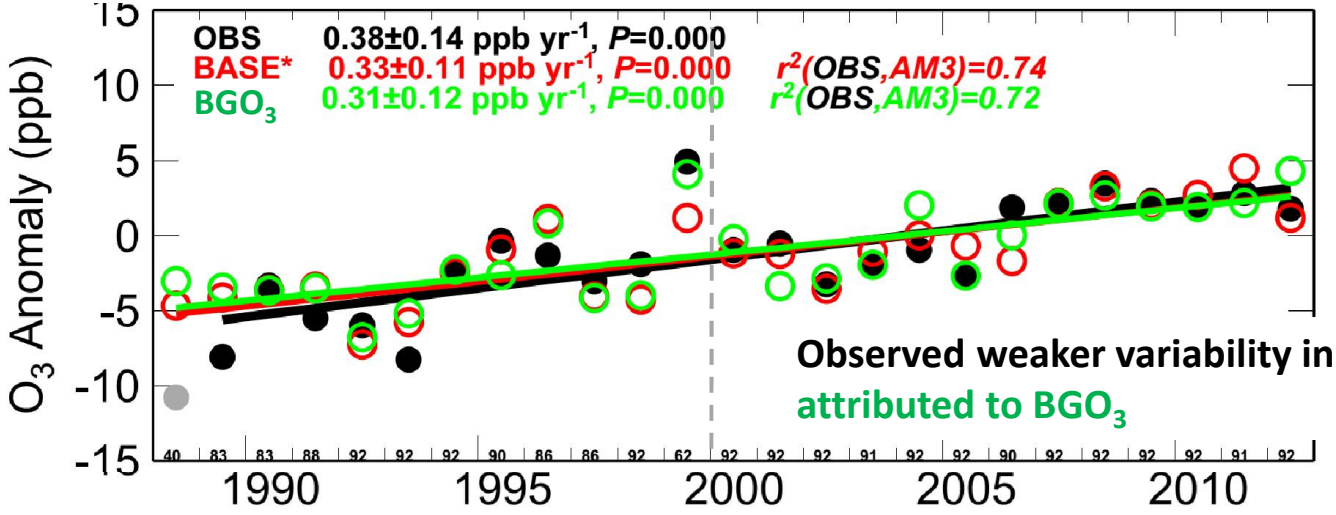
Simulated ozone trends with/without selection of baseline conditions in the model

Lassen Volcanic NP (1.7 km, Mar-Apr-May)

Model surface



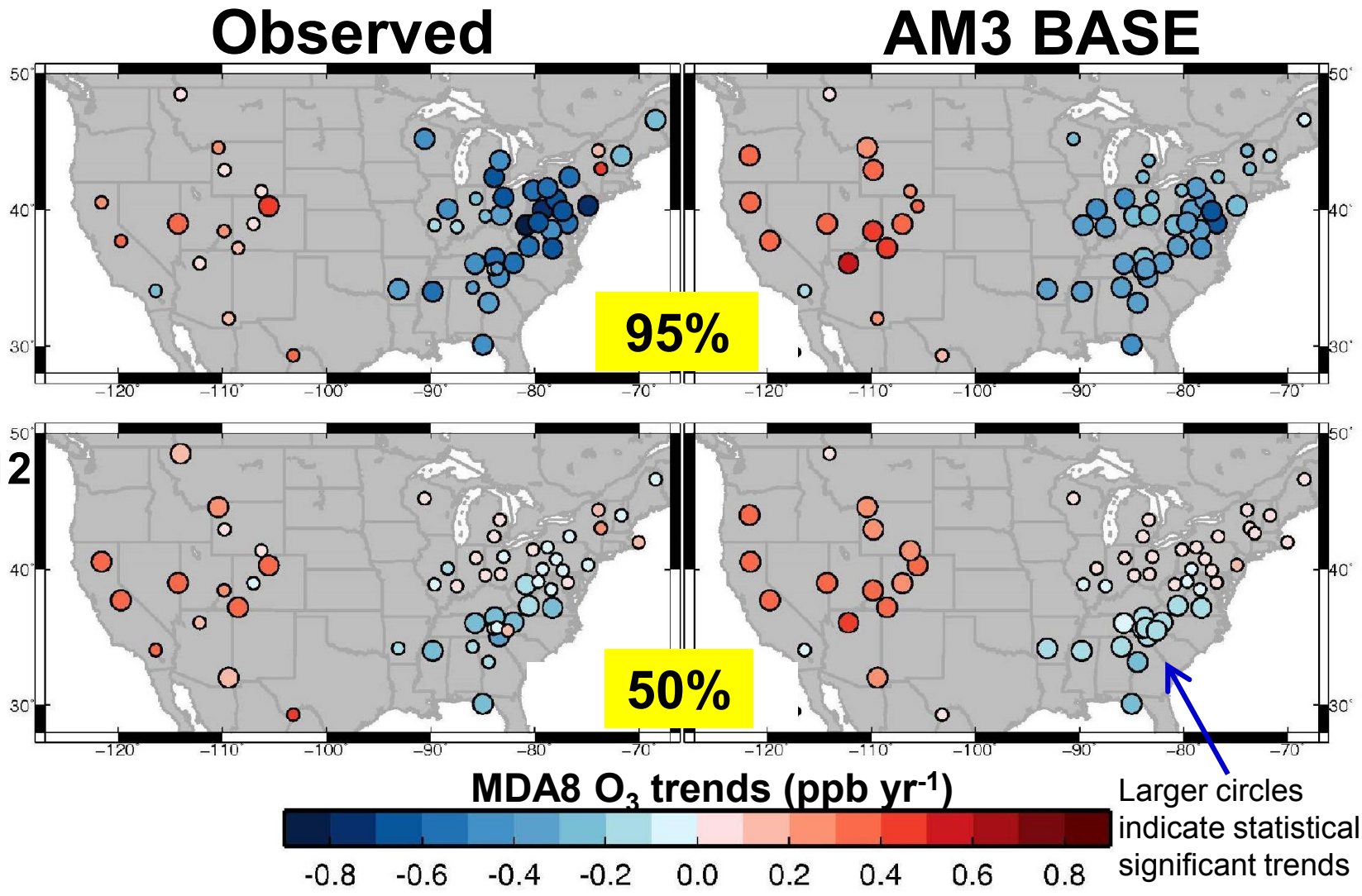
Model Baseline



Observed weaker variability in the 2000s attributed to BGO_3

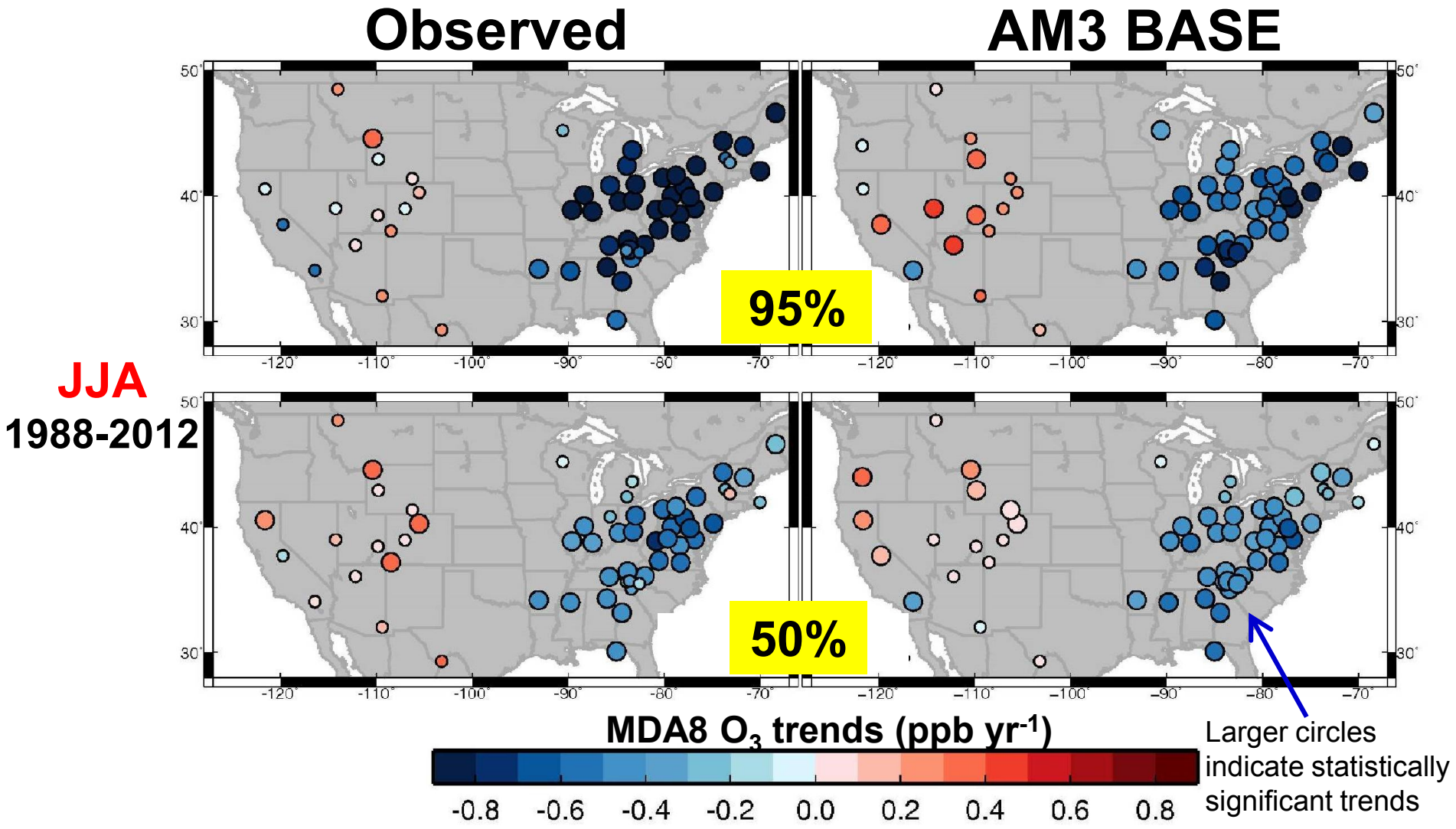
MY Lin, LW Horowitz, OR Cooper *et al* (in prep, 2015)

SPRING U.S. surface O_3 trends: Do domestic NO_x reductions work?



WUS { **Model filtered to be more representative of observed conditions**
High background, thus little response to local NO_x reductions

SUMMER U.S. surface O_3 trends: Do domestic NO_x reductions work?



MY Lin, LW Horowitz, OR Cooper *et al* (in prep, 2015)

Some final thoughts on process-oriented model evaluation

- Leveraging **high-quality** observational constrains (e.g. daily ozonesondes, hourly meteorological parameters)
- Evaluating ability to quantitatively relate pollutant concentrations to their **sources** and transport on synoptic time scales
- Investigating ability to capture variability on **daily to decadal** time scales and from the **regional** to **local** scales
- Examining the **full range** of pollutant distribution (e.g. 95^{th}, 75^{th}, 50^{th}, 25^{th}, 5^{th})

→ Ensure an apple-to-apple comparison btw OBS and Models

Thank you!! (Meiyun.Lin@noaa.gov)