Processes influencing global tropospheric ozone: insights from OMI ozone observations

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With

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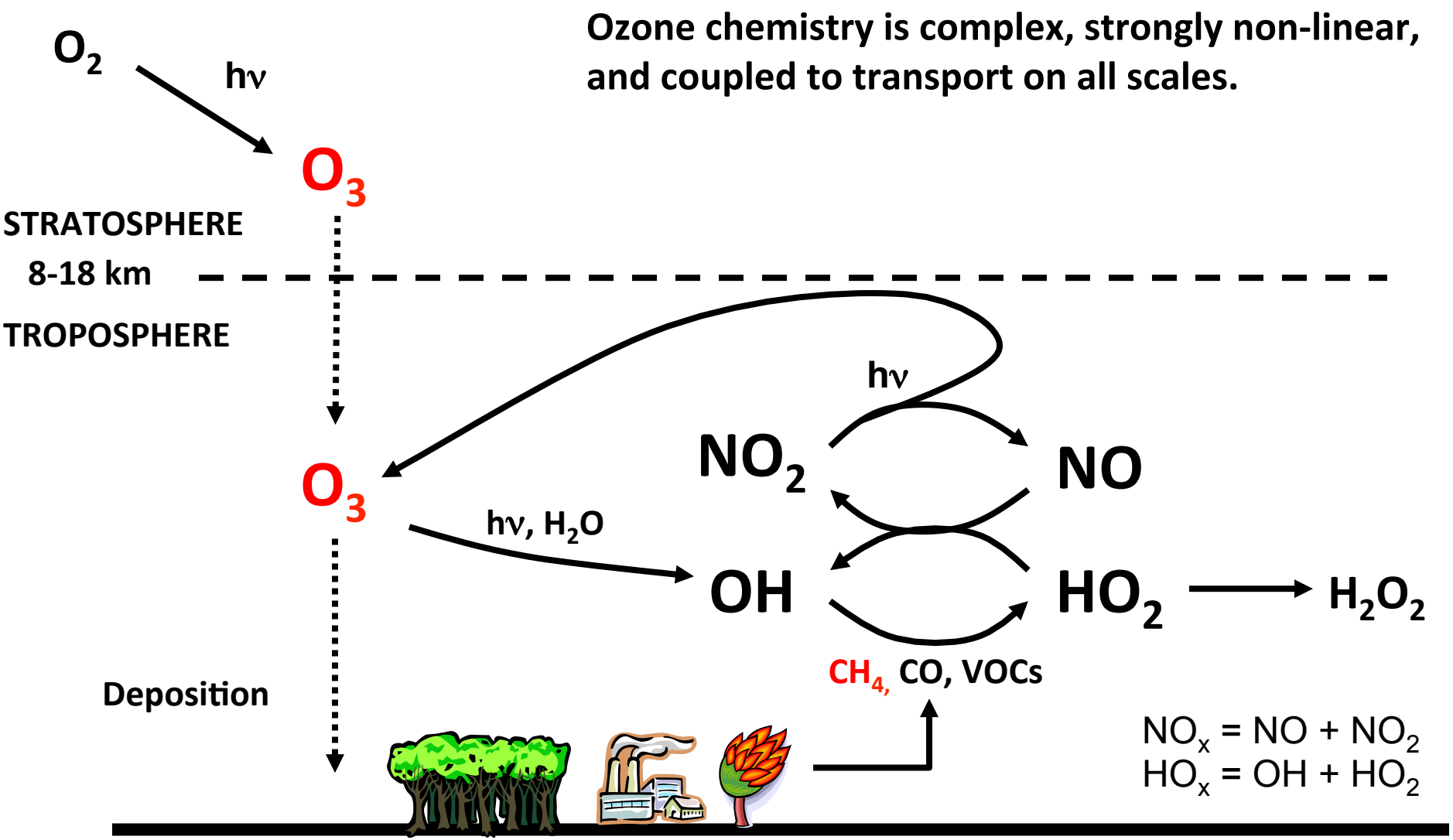
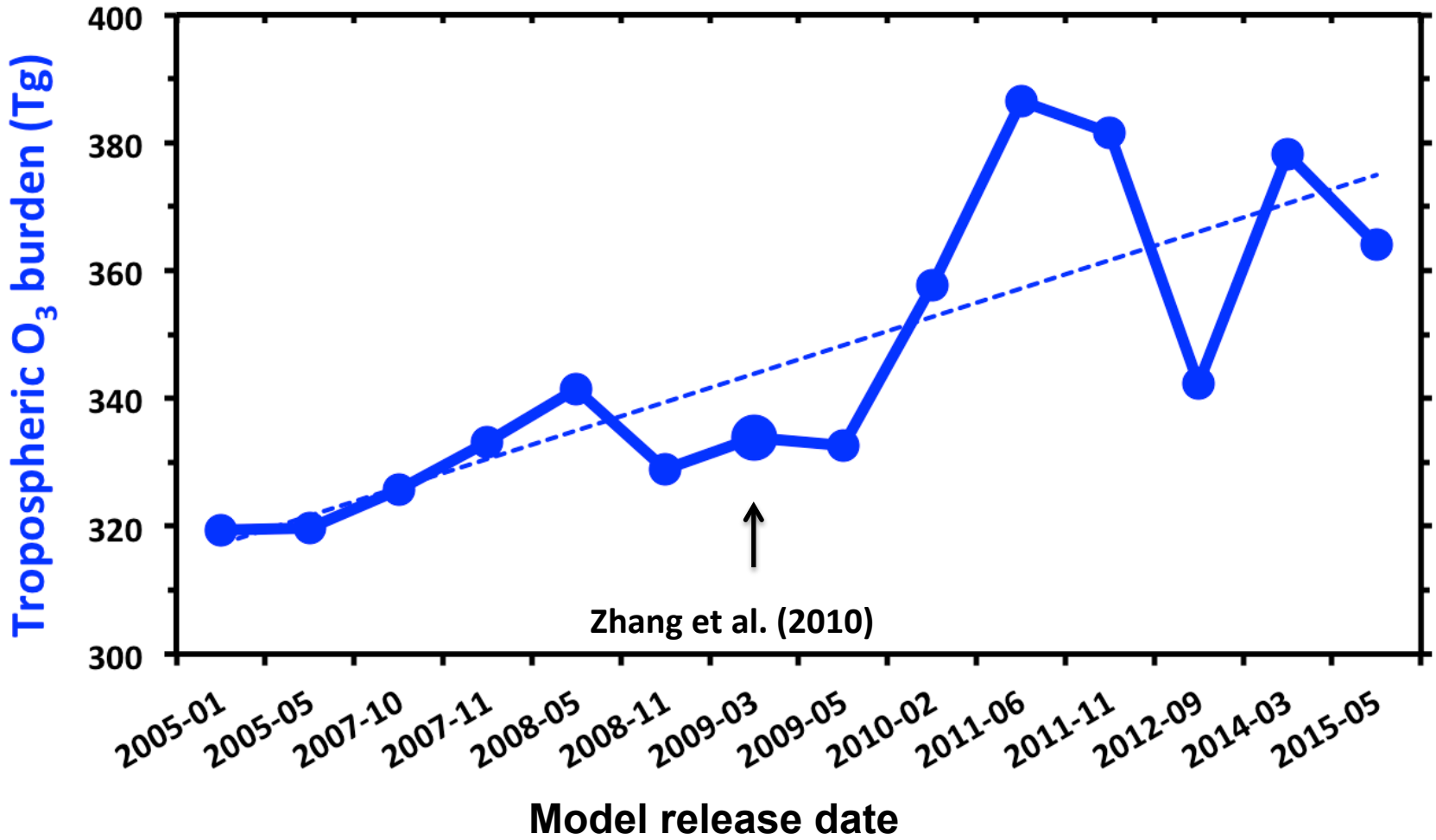
Tropospheric ozone plays a central role in tropospheric chemistry

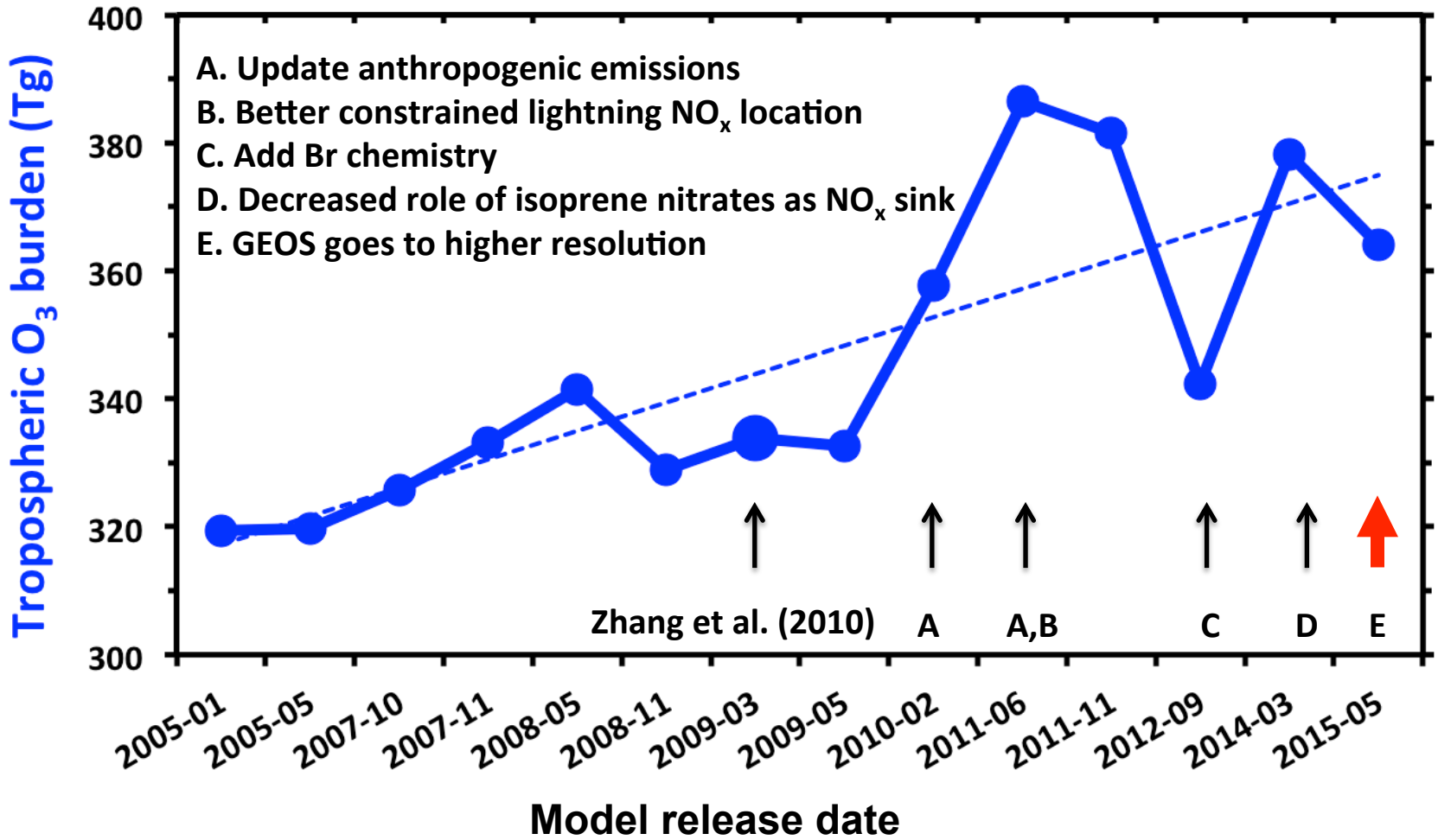


GEOS-Chem updates in past decade have led to more active tropospheric ozone chemistry



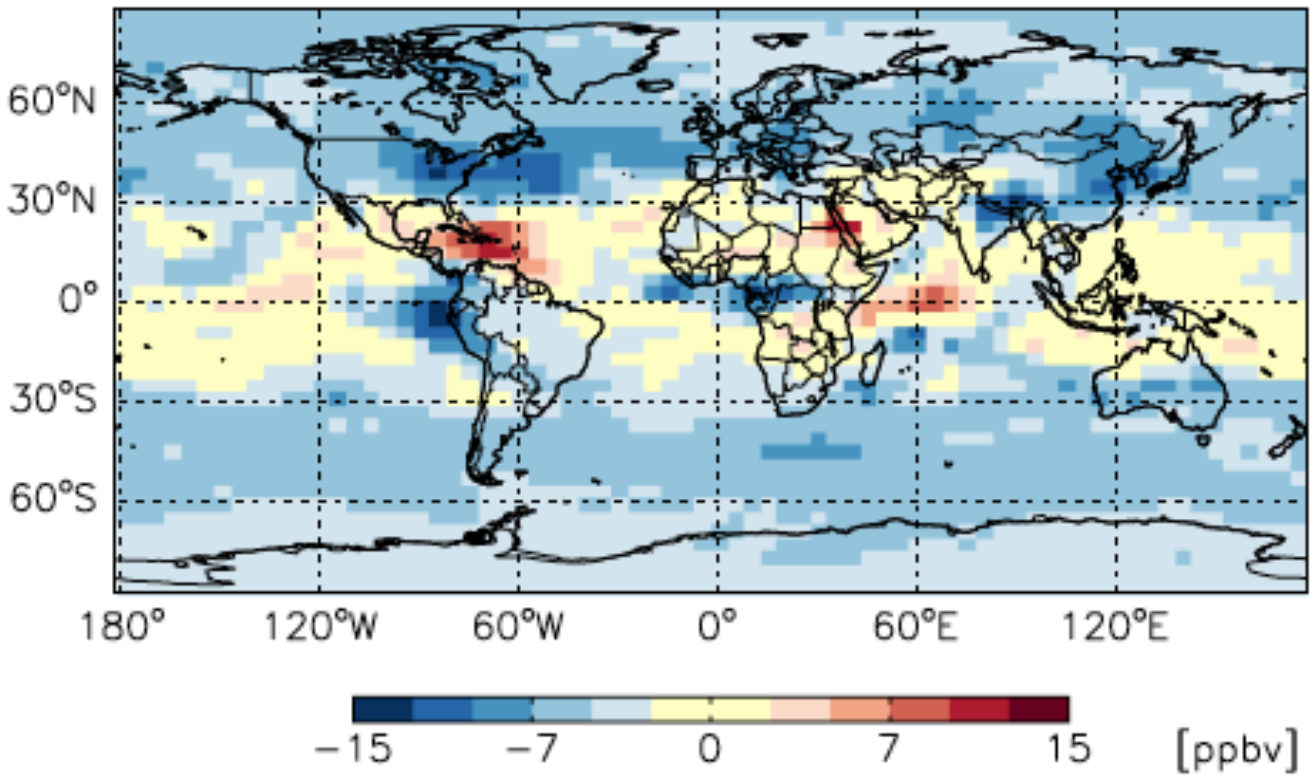
GEOS-Chem updates in past decade have led to more active tropospheric ozone chemistry

Global tropospheric ozone burden in GEOS-Chem benchmark outputs



Ozone is not just controlled by chemistry and precursors, but also by what meteorological fields we use to drive the model

Difference of simulated ozone between
NEW and OLD meteorological fields

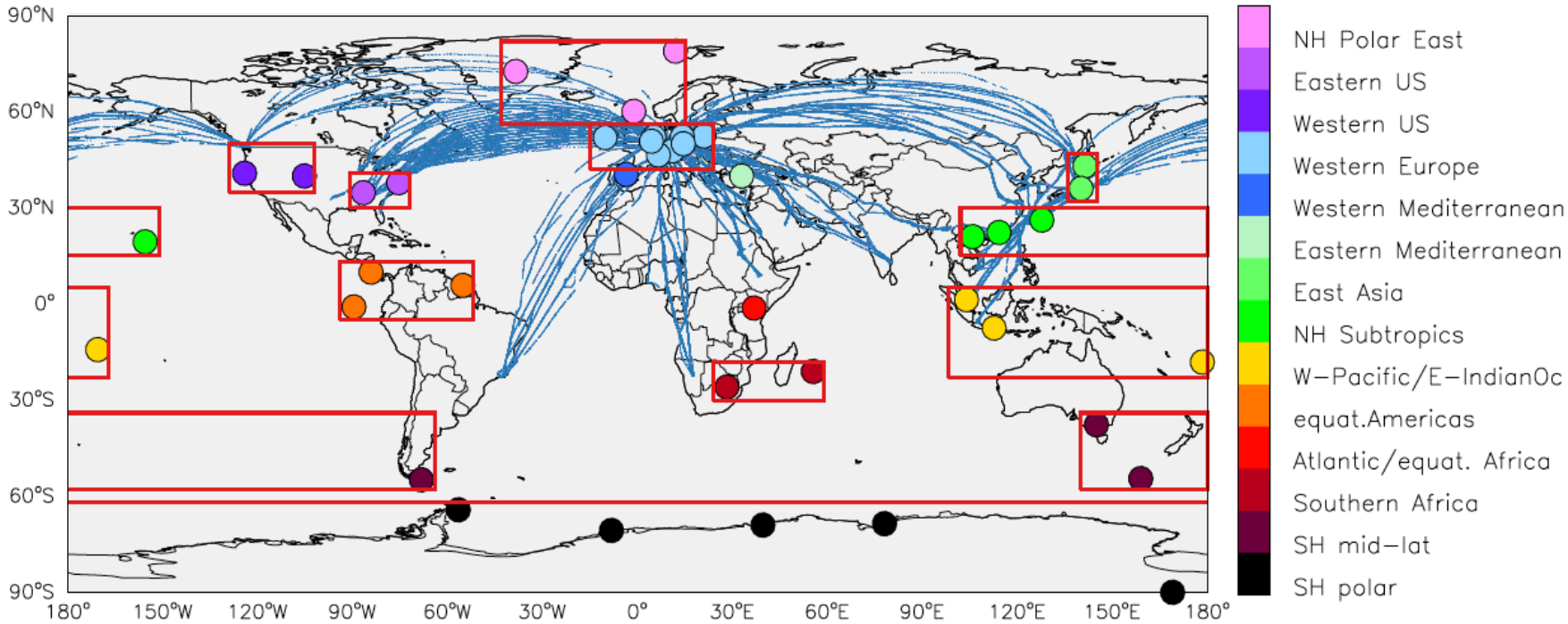


July mean O_3 at 500 hPa

New meteorological field (since June 2012):

- **Higher temporal and horizontal resolution: 0.25° × 0.3125°**
- **Start to resolve convection (much weaker convective mass flux)**
- **Lower temperature → lower global isoprene emission (by 30%)**

Do recent updates improve our ability to simulate tropospheric ozone?

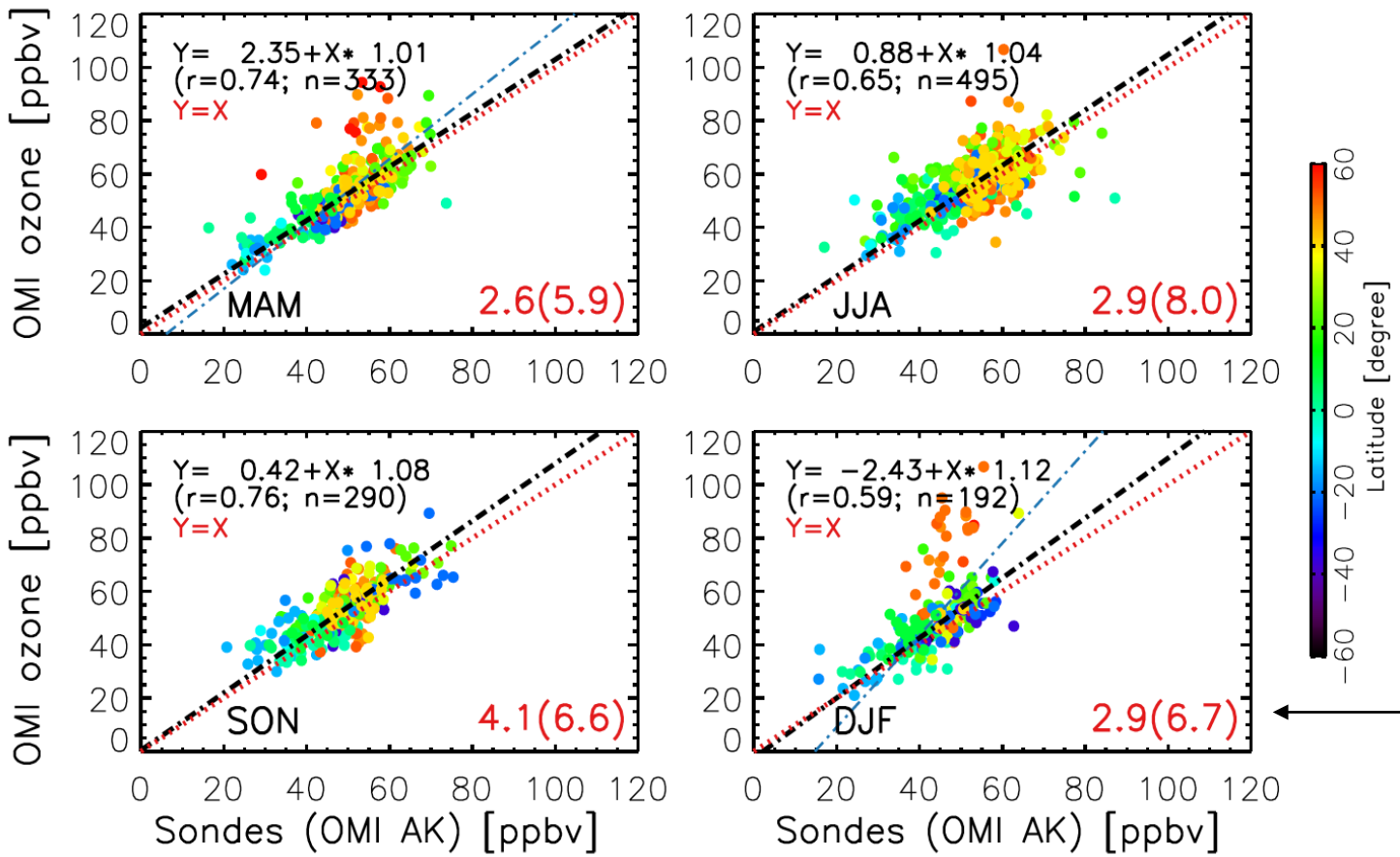


Today:

- **Validation of OMI tropospheric ozone retrieval with ozonesondes (2008 *vs.* 2013)**
- Global evaluation of current GEOS-Chem ozone simulation with OMI data for 2013

Level 2 product of OMI PROFOZ ozone profile retrievals developed by Xiong Liu et al. at Harvard-Smithsonian Center for Astrophysics

OMI mid-tropospheric ozone data reproduces spatial/seasonal patterns of ozonesonde observations

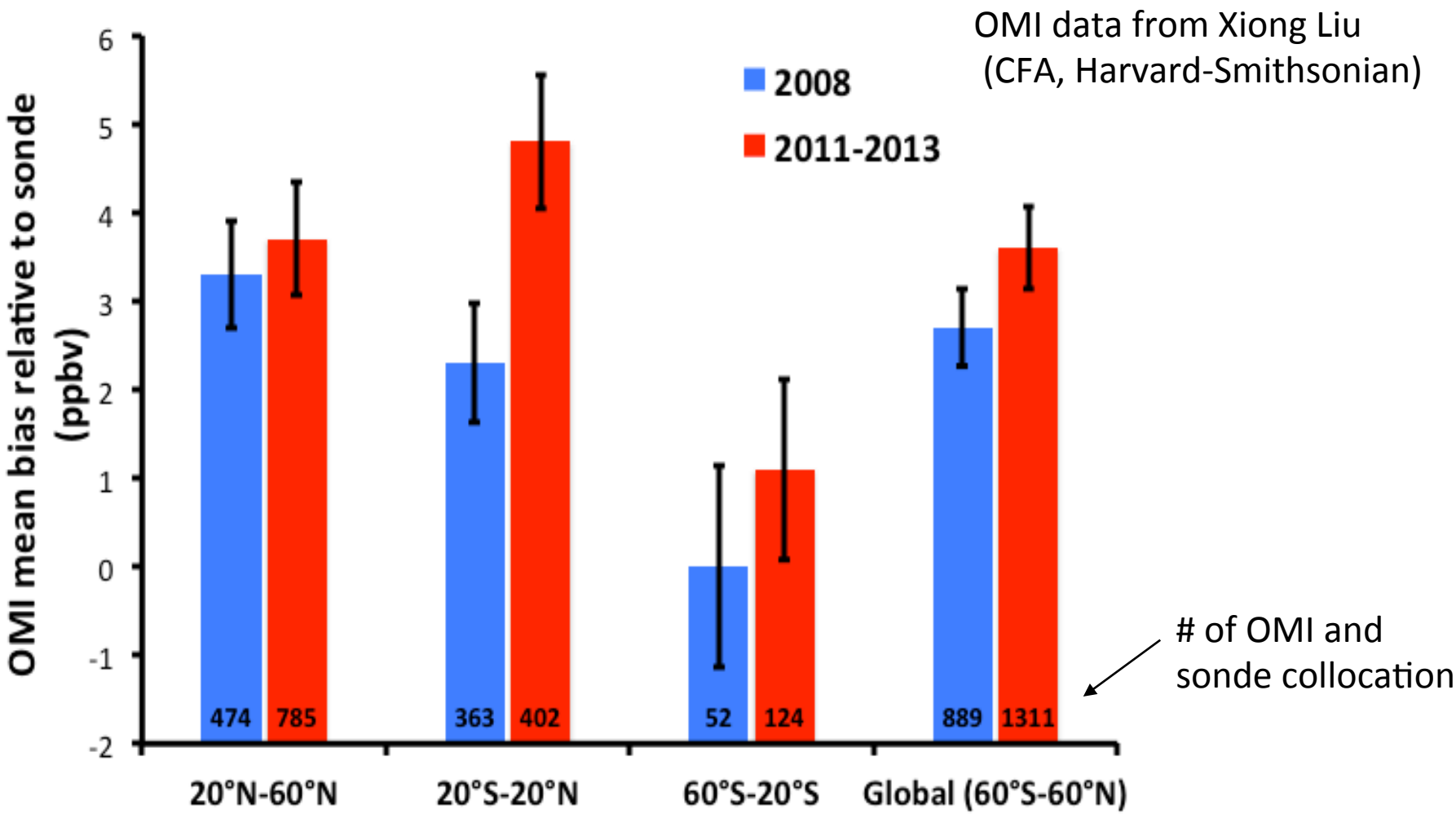


- OMI data have been adjusted to a single fixed a priori
- Ozonesonde data are smoothed by OMI averaging kernels

mean bias (StdDev)

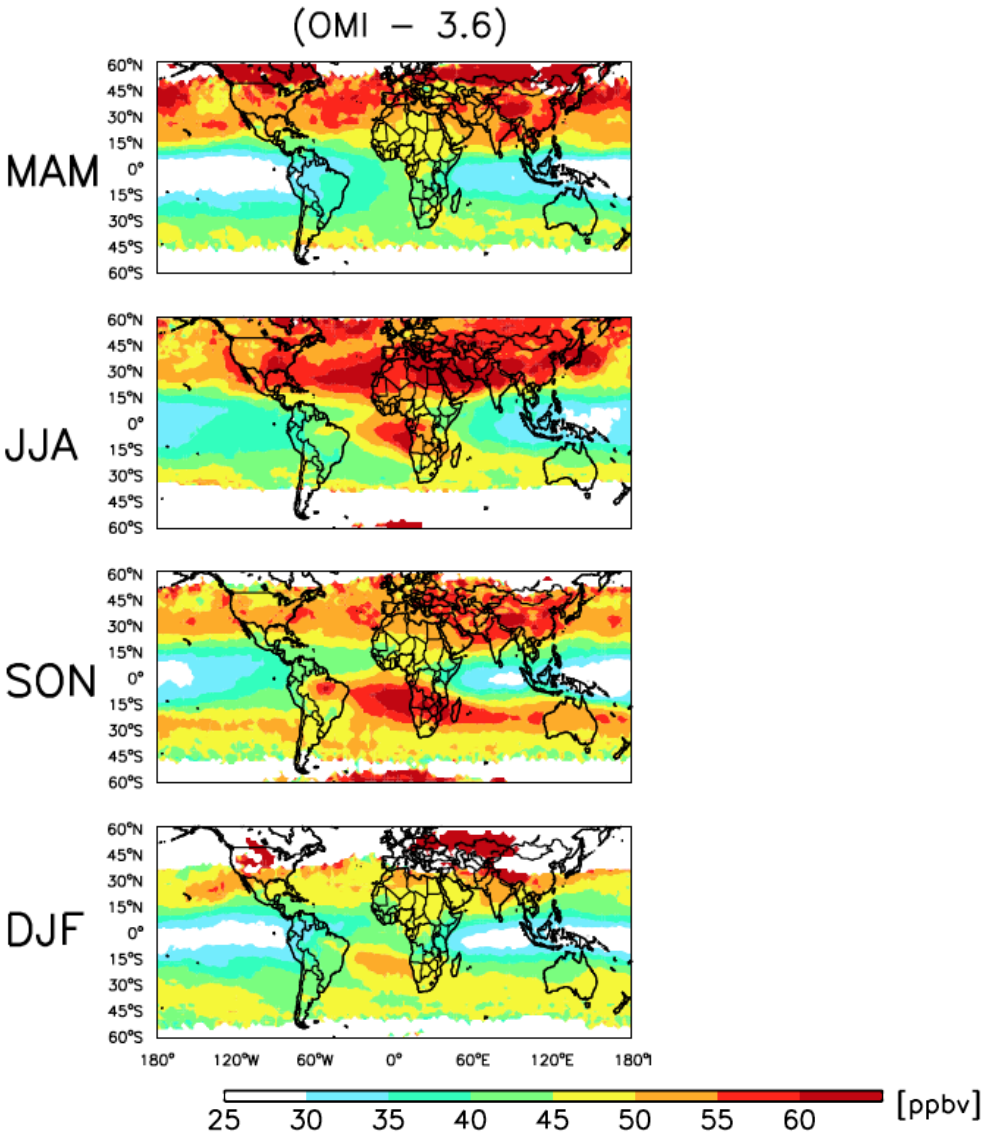
OMI data are of high quality except at high latitudes in winter-spring

Small global OMI bias corrections relative to ozonesondes



The PROFOZ OMI retrieval for tropospheric ozone shows no significant data degradation through 2013

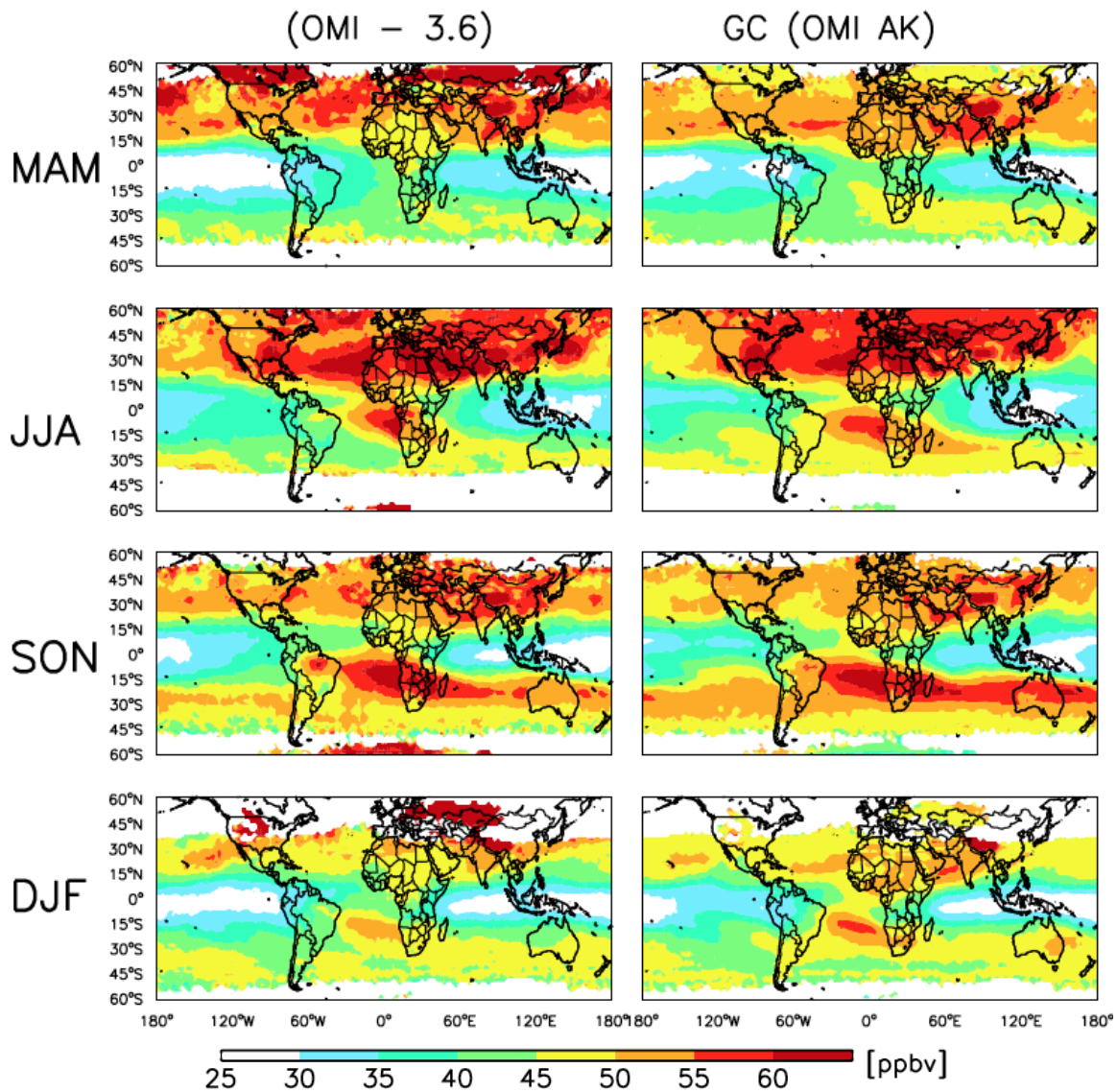
Global comparison to OMI ozone data at 700-400 hPa for 2013



- OMI data have been
  a) adjusted to a single fixed a priori
  b) corrected for a global bias relative to ozonesondes

OMI ozone data from Xiong Liu (CFA, Harvard-Smithsonian)

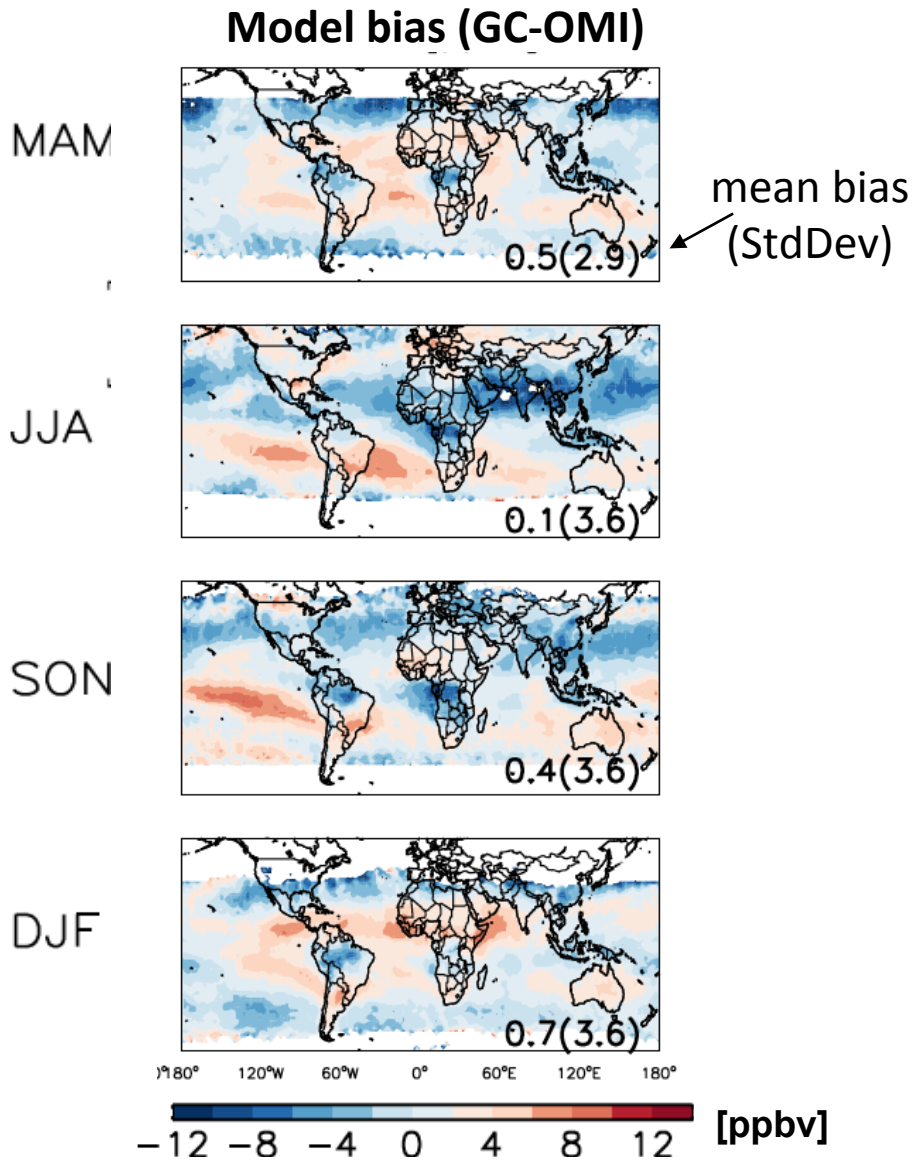
Global comparison to OMI ozone data at 700-400 hPa for 2013



- OMI data have been
  a) adjusted to a single fixed a priori
  b) corrected for a global bias relative to ozonesondes
- Model data have been
  a) sampled along the OMI tracks
  b) smoothed by OMI averaging kernels

OMI ozone data from Xiong Liu (CFA, Harvard-Smithsonian)

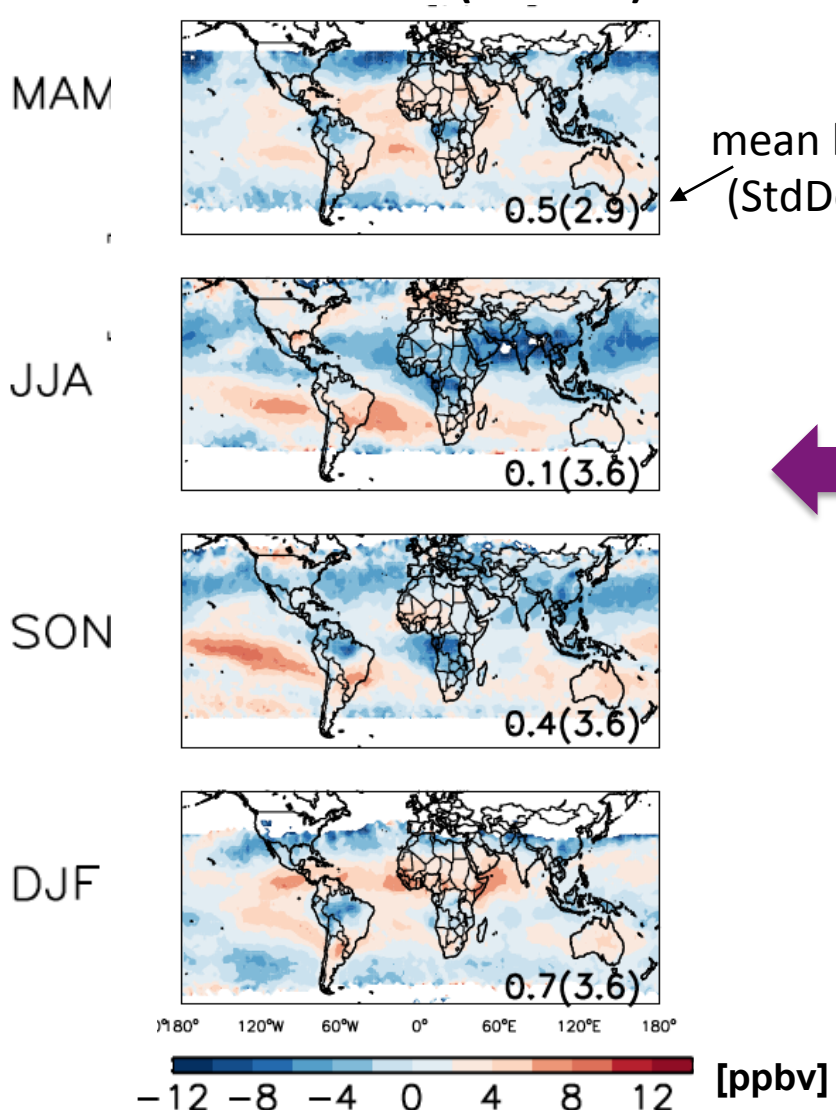
GEOS-Chem shows no significant bias relative to OMI at low latitudes



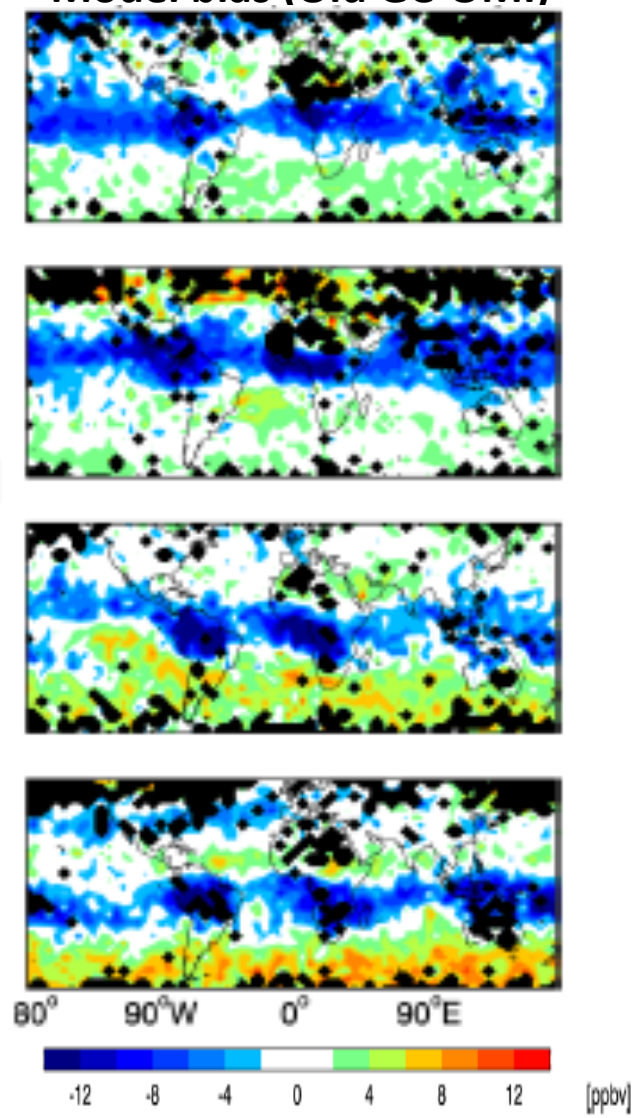
Hu et al., [2016]: v10-01, 2°×2.5°, GEOS-FP, 2013, updated isoprene chemistry, with Br, 'Linoz'

Improved simulation of global tropospheric ozone compared to previous versions

Model bias (GC-OMI)



Model bias (Old GC-OMI)



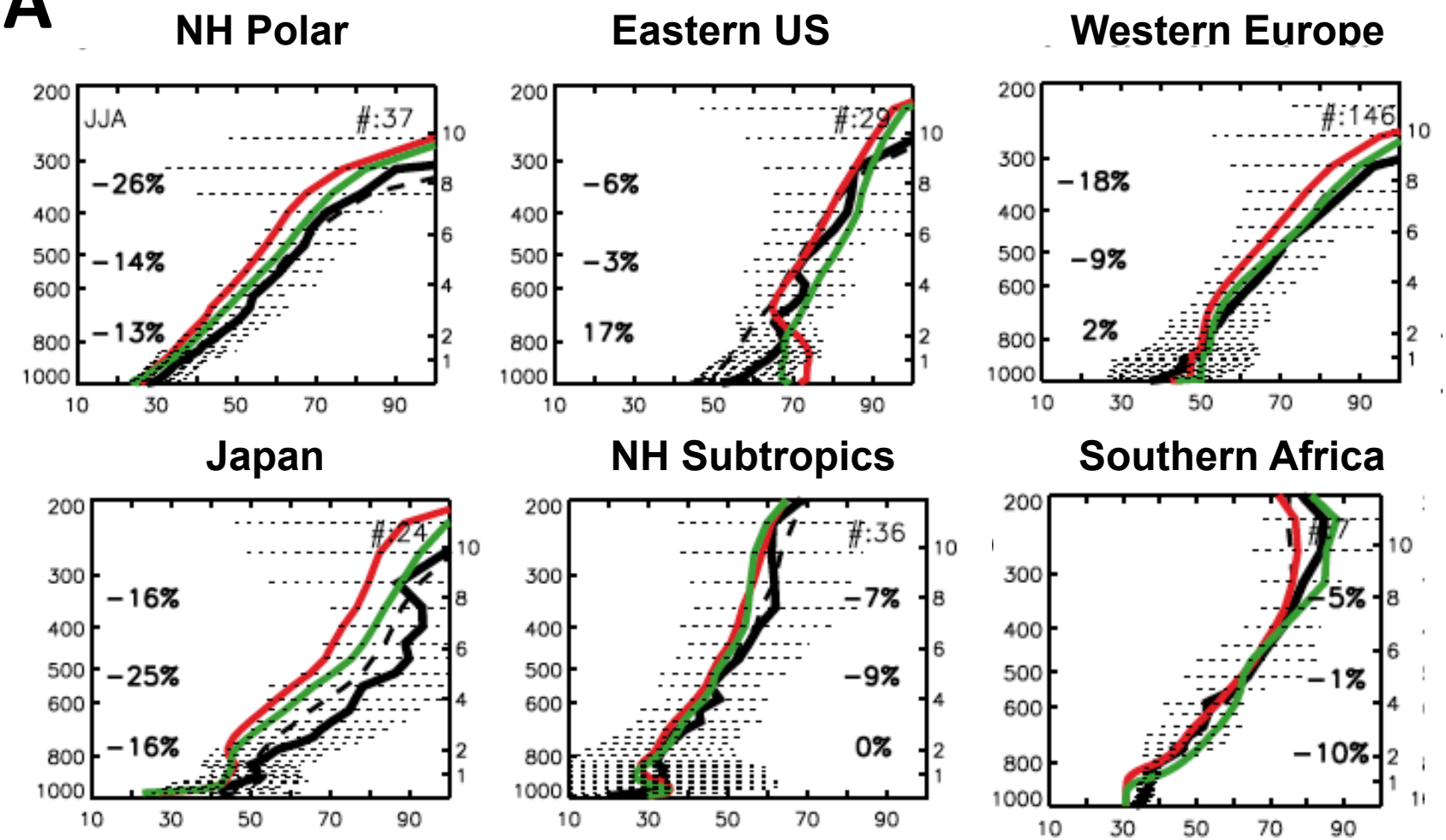
Hu et al., [2016]: v10-01, 2°×2.5°, GEOS-FP, 2013, updated isoprene chemistry, with Br, 'Linoz'

Zhang et al., [2010]: v8-01-04, 4°×5°, GEOS-4, 2006, 'old ' isoprene chemistry, no Br, 'Synoz'

GEOS-Chem shows a negative bias relative to ozonesondes at high northern latitudes, also a large sensitivity to meteorological fields

Ozonesonde | Base (GEOS-5 0.25°) | GEOS-5 at 0.5°

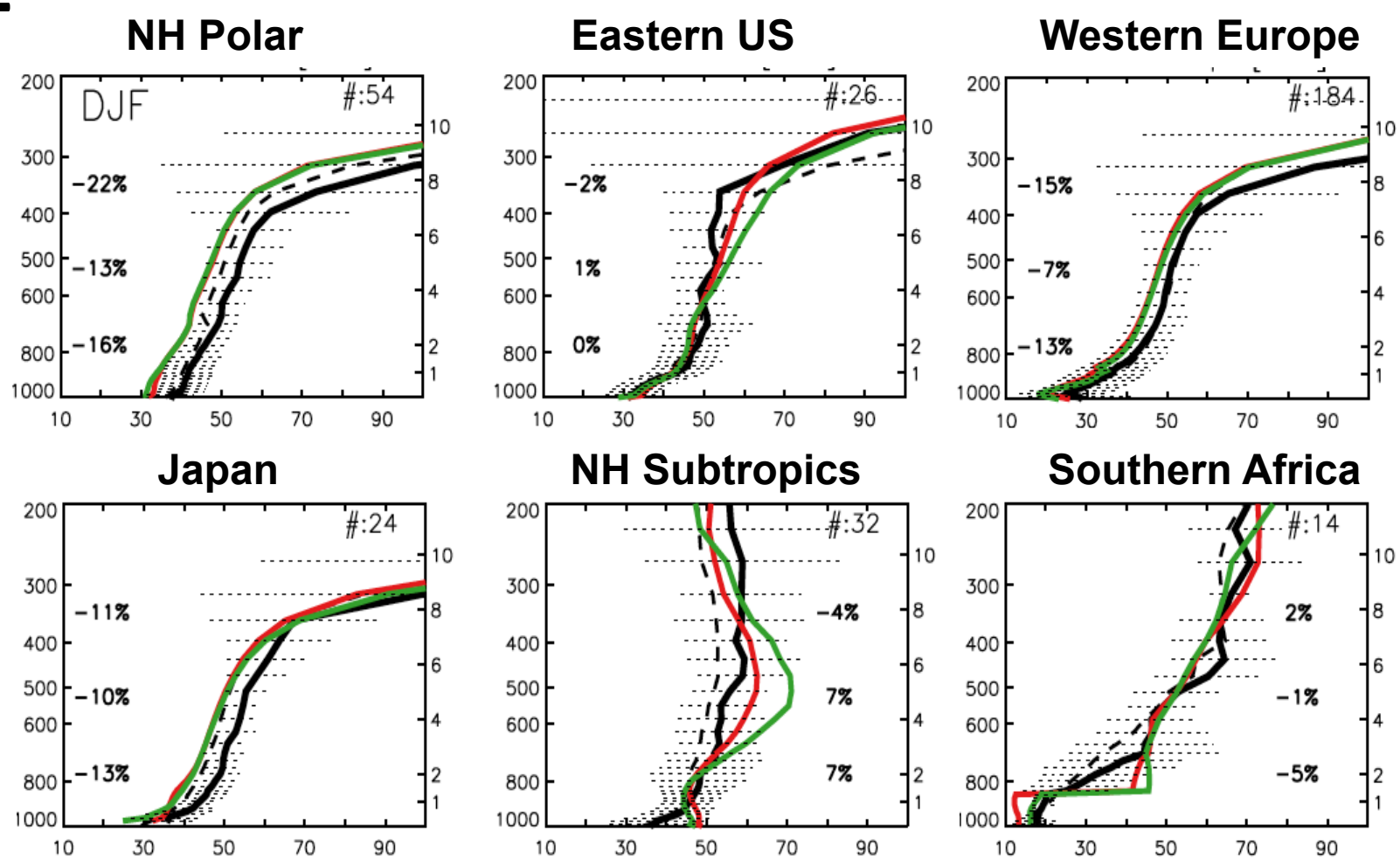
JJA



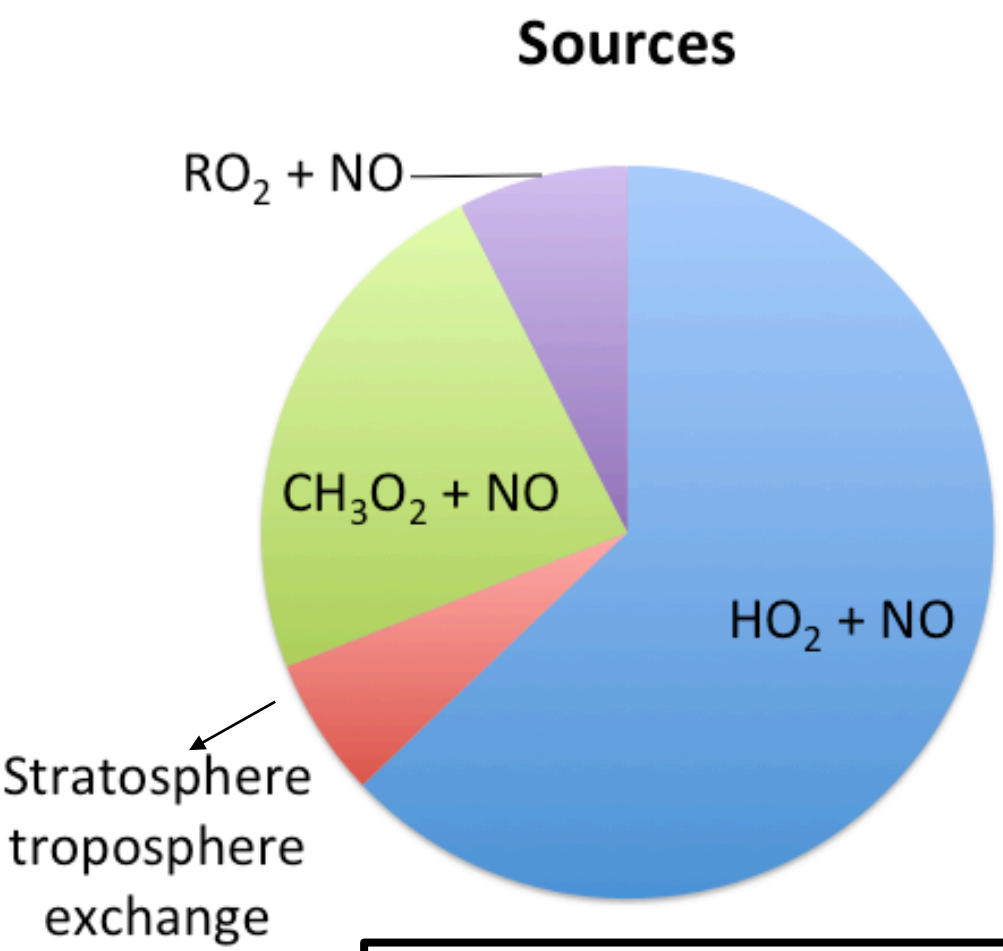
GEOS-Chem shows a negative bias relative to ozonesondes at high northern latitudes, also a large sensitivity to meteorological fields

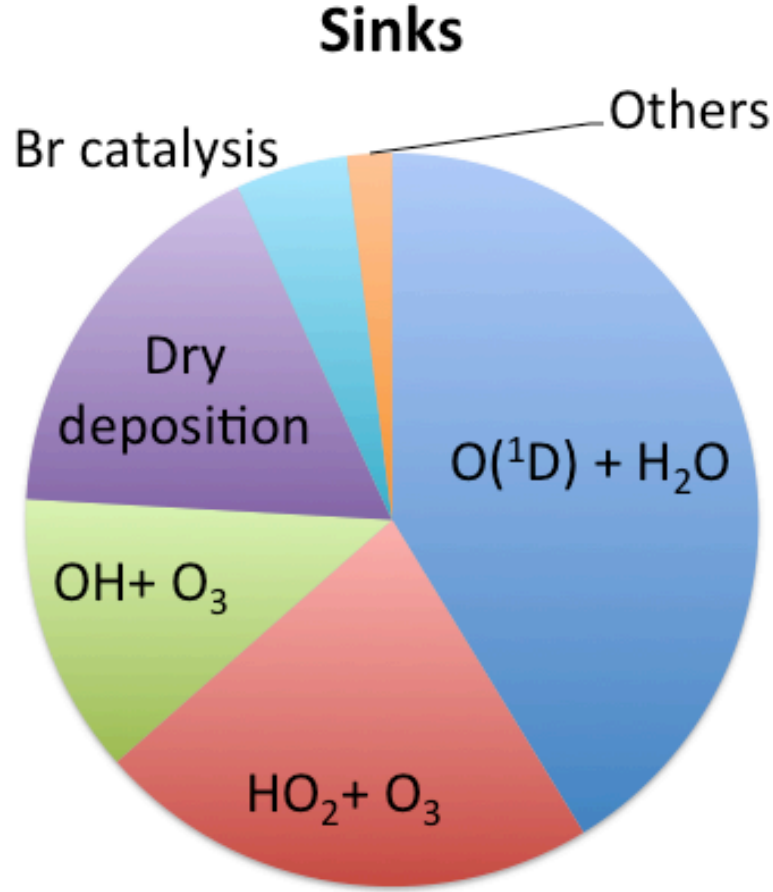
Ozonesonde **Base (GEOS-5 0.25°)** **GEOS-5 at 0.5°**

DJF



Tropospheric ozone budget in current GEOS-Chem model





325 Tg a^{-1} *vs.* 500±140 Tg a^{-1} from Olsen et al. (2001)

	GEOS-Chem	ACCMIP (Young et al. 2013)
Chemical production:	4962 Tg a^{-1}	3877-5989 Tg a^{-1}
Burden:	351 Tg	314-360 Tg
Lifetime:	24.2 days	19.9-25.5 days

Conclusions

- **The PROFOZ OMI retrieval for tropospheric ozone shows no significant data degradation through 2013; data are of high quality except at high latitudes in winter-spring.**

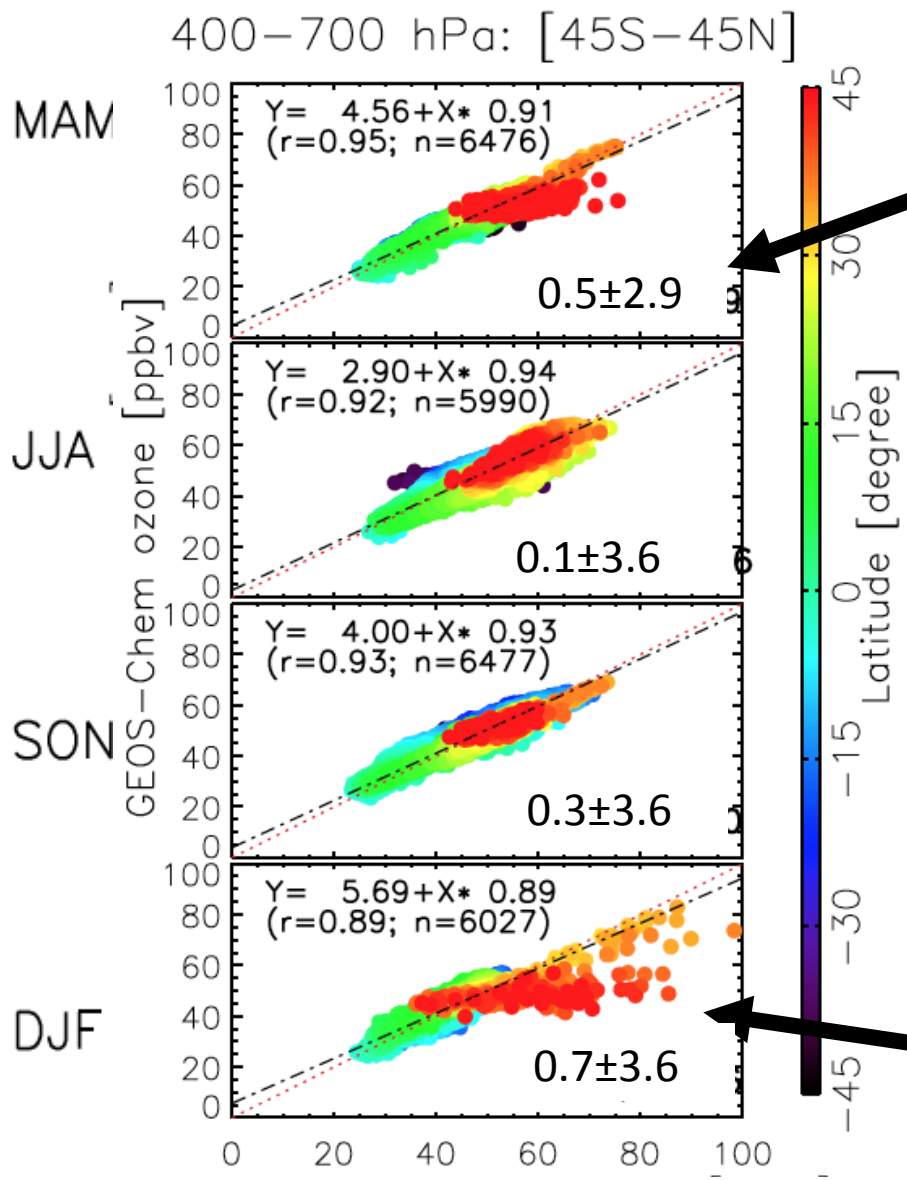
- **The current GEOS-Chem simulation of global tropospheric ozone shows no significant bias relative to OMI at low and middle latitudes, but a negative bias relative to ozonesondes and aircraft at high northern latitudes.**

- **Global model simulations of tropospheric ozone are highly sensitive to the driving meteorological fields including the effects of deep convection, clouds, and temperature.**

- **Recent improvements in global tropospheric ozone models such as GEOS-Chem indicate more active ozone chemistry (production and loss), with implications for simulating long-term ozone trends.**

Thanks!

Global comparison to OMI satellite data



Global mean bias ± StdDev

Each point represents seasonal mean O_3 at 700-00hPa for a model grid (2x2.5)

Bias at northern mid-high-latitude partly due to satellite error