Tropospheric chemistry and air quality

Advances in understanding air pollution trends and extremes with GFDL models

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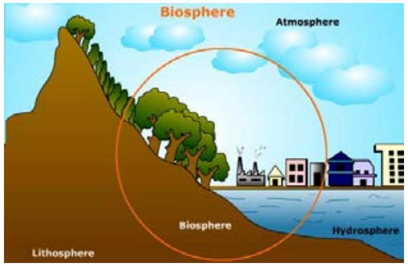
Model challenges in simulating pollutant trends and extremes

Air quality at given locations responds to varying global-to-regional precursor **emissions+chemistry, biosphere-atmosphere couplings, climate+extreme weather.**



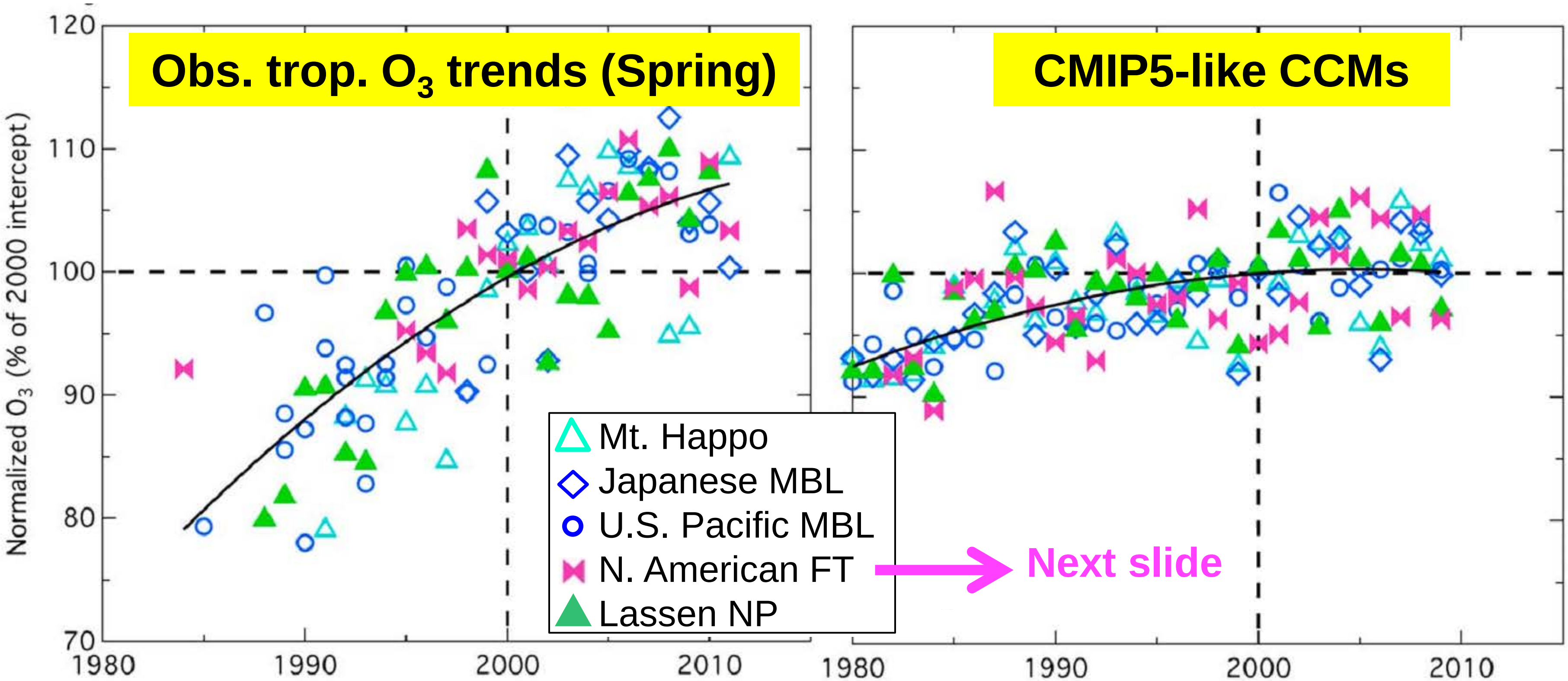
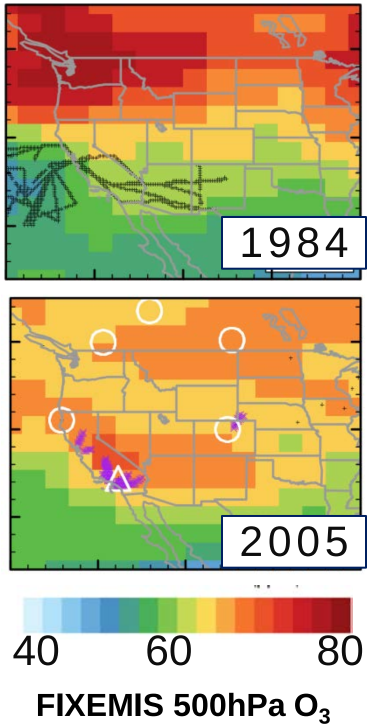


Figure c/o Parrish et al., 2014; see also Lamarque 2010; Koumoutsaris2012; Wild2012; Strode et al., 2015

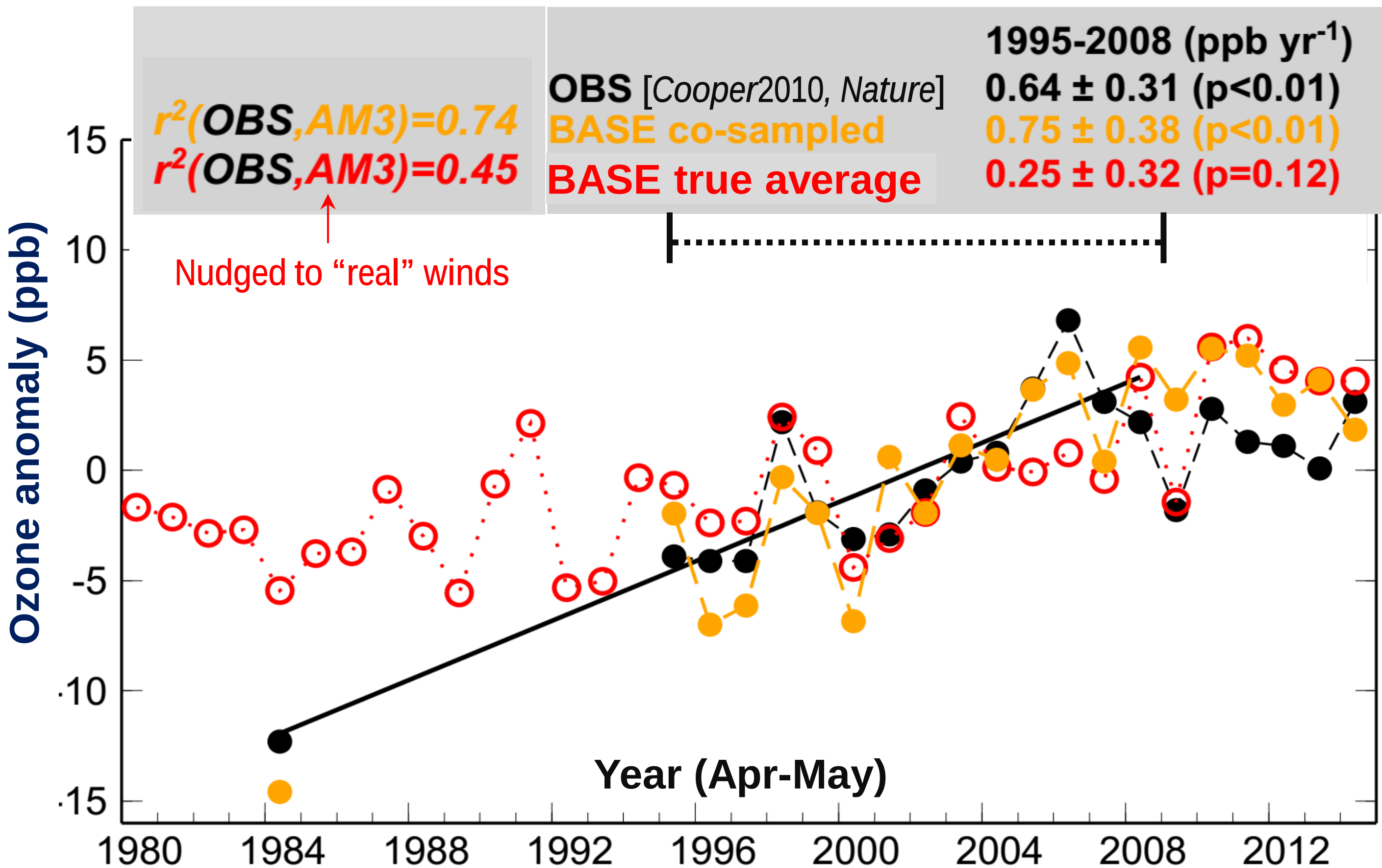
How robust are inferred trends in tropospheric ozone?

- **Interannual to decadal climate variability modulates trop. O_3 distribution**
  (*Lin M. et al., Nature Geosci., 2014; Lin M. et al., Nature Commun., 2015*)

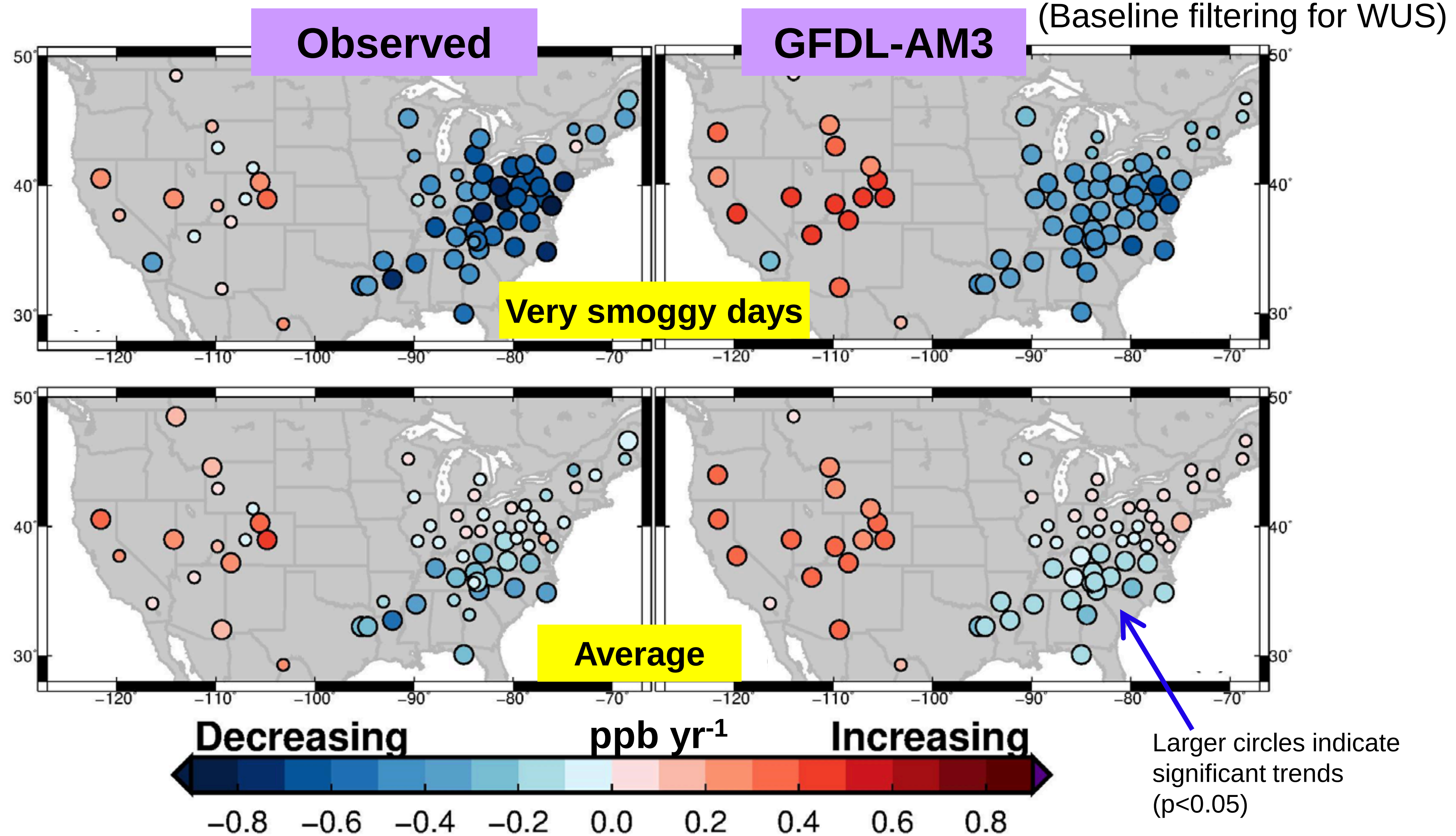
Sparse *in situ* sampling



Western N. American FT (3-8 km altitude)



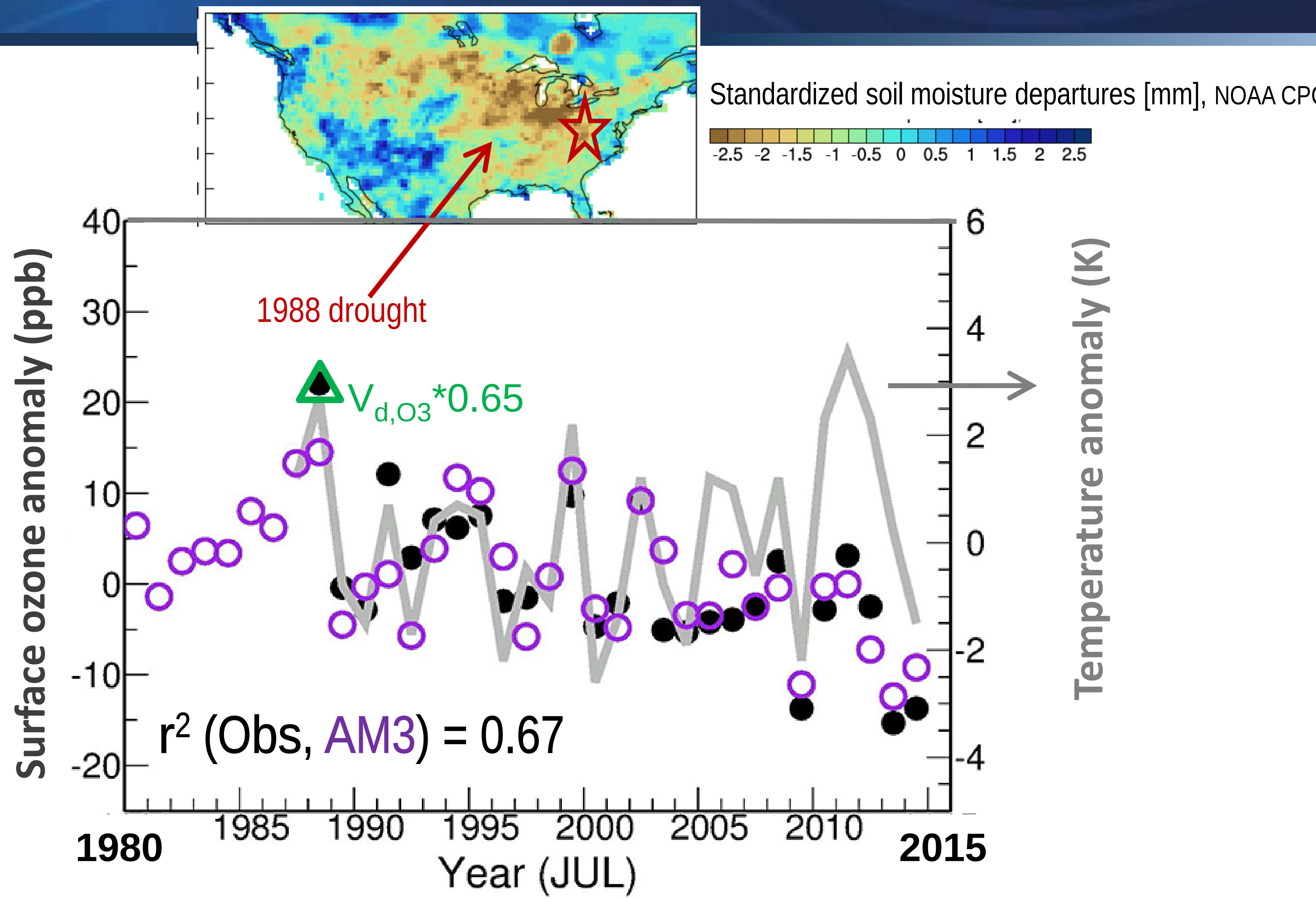
Competing effects of domestic emission controls versus rising Asian emissions



The 1988-2014 trends in springtime surface ozone levels

Lin M., Horowitz LW, Payton R., et al. [Atmos. Chem. Phys., 2017]

Heat waves and droughts worsen regional ozone pollution



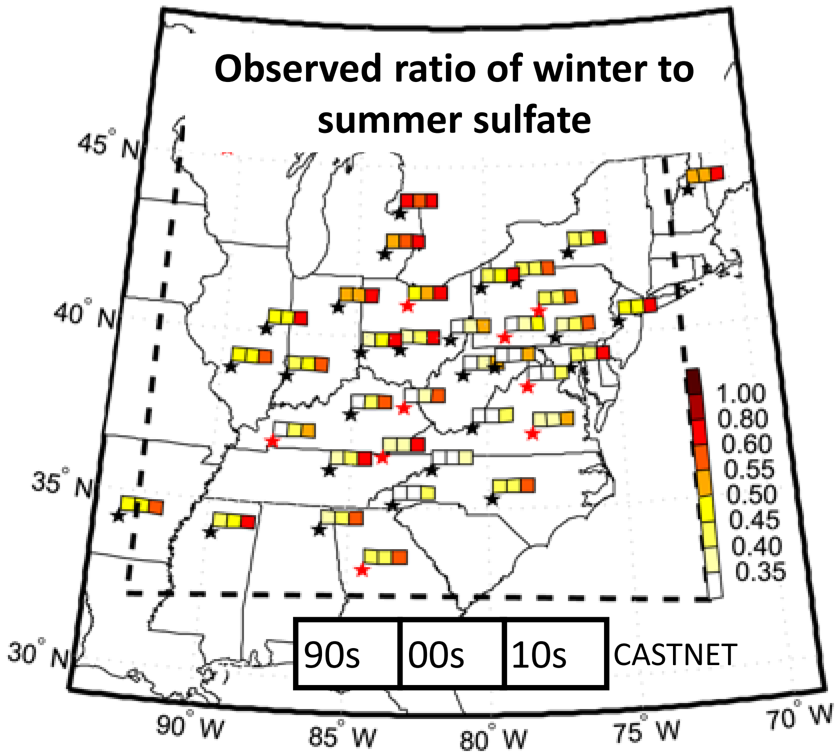
→ **Drought reduced stomatal uptake of O_3**

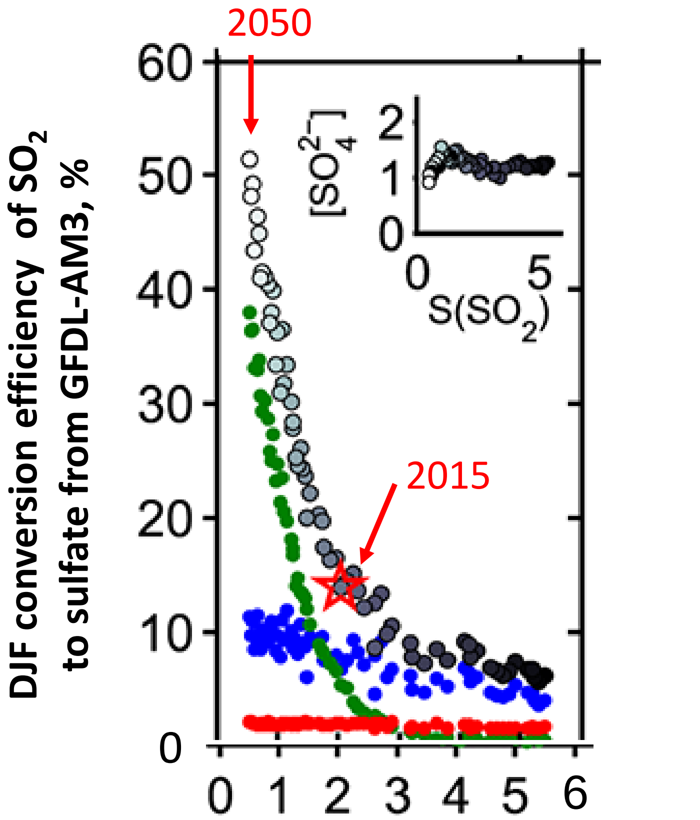
→ **GFDL is building tools to address such couplings**

Lin M. et al. [Atmos. Chem. Phys., 2017]

Chemistry is delaying improvements in U.S. wintertime PM air quality

Sulfate aerosols are decreasing more slowly in winter than in summer in response to SO_2 controls





- Decrease in SO_2 emissions cancelled by ↑ in the conversion efficiency of SO_2 to SO_4
- ↑ from **ozone + SO_2 pathway** favored by ↓ fossil fuel (NO,SO_2) and ↑ agriculture emissions (NH_3) ➡ chemistry not represented in many GCMs.

Paulot, Fan, Horowitz [GRL, 2017]

Improved simulation of PM and ozone in GFDL-AM4

95th percentile $PM_{2.5}$, 2015-16 winter

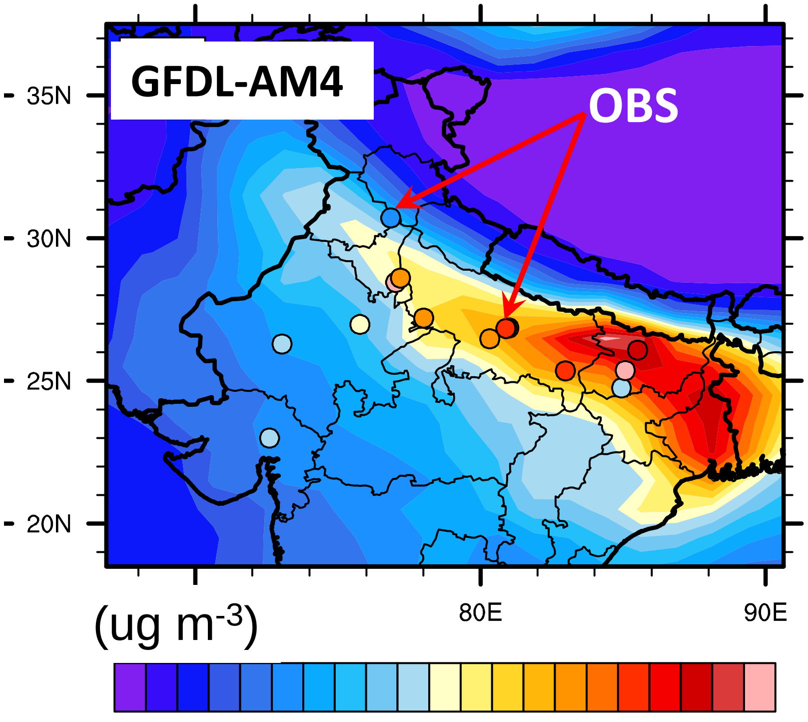


Figure by J. Schnell

March mean O_3 vertical profile above Colorado, 1995-2014

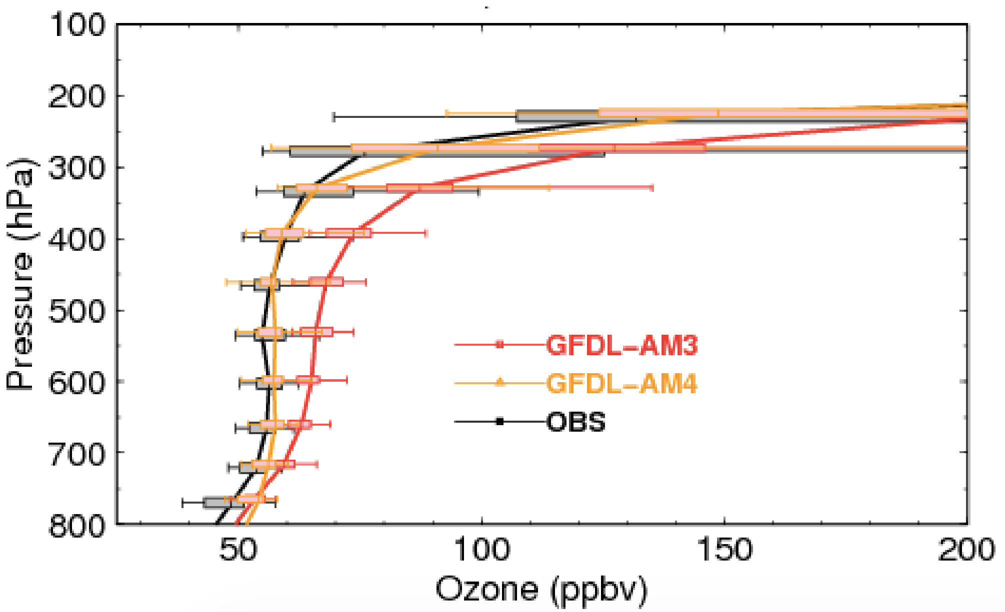


Figure by Alex Zhang and M. Lin

Take-Home Message

Unified earth system modelling with interactive chemistry enables us to integrate information across scientific disciplines to understand air quality and climate.