Atmospheric Chemistry

Presented by

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Geophysical Fluid Dynamics Laboratory Review

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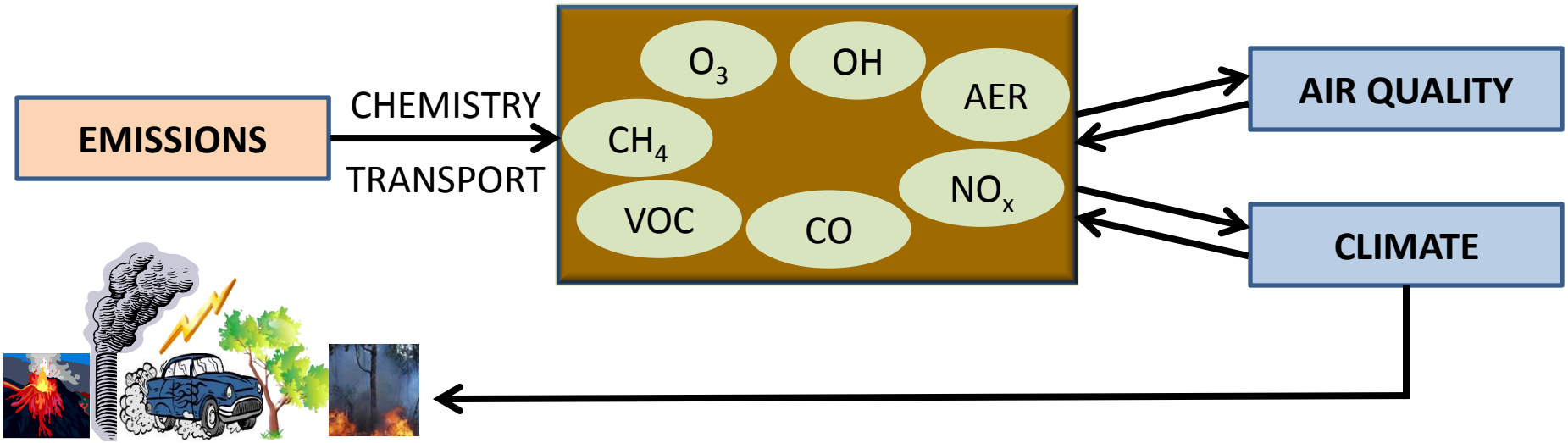
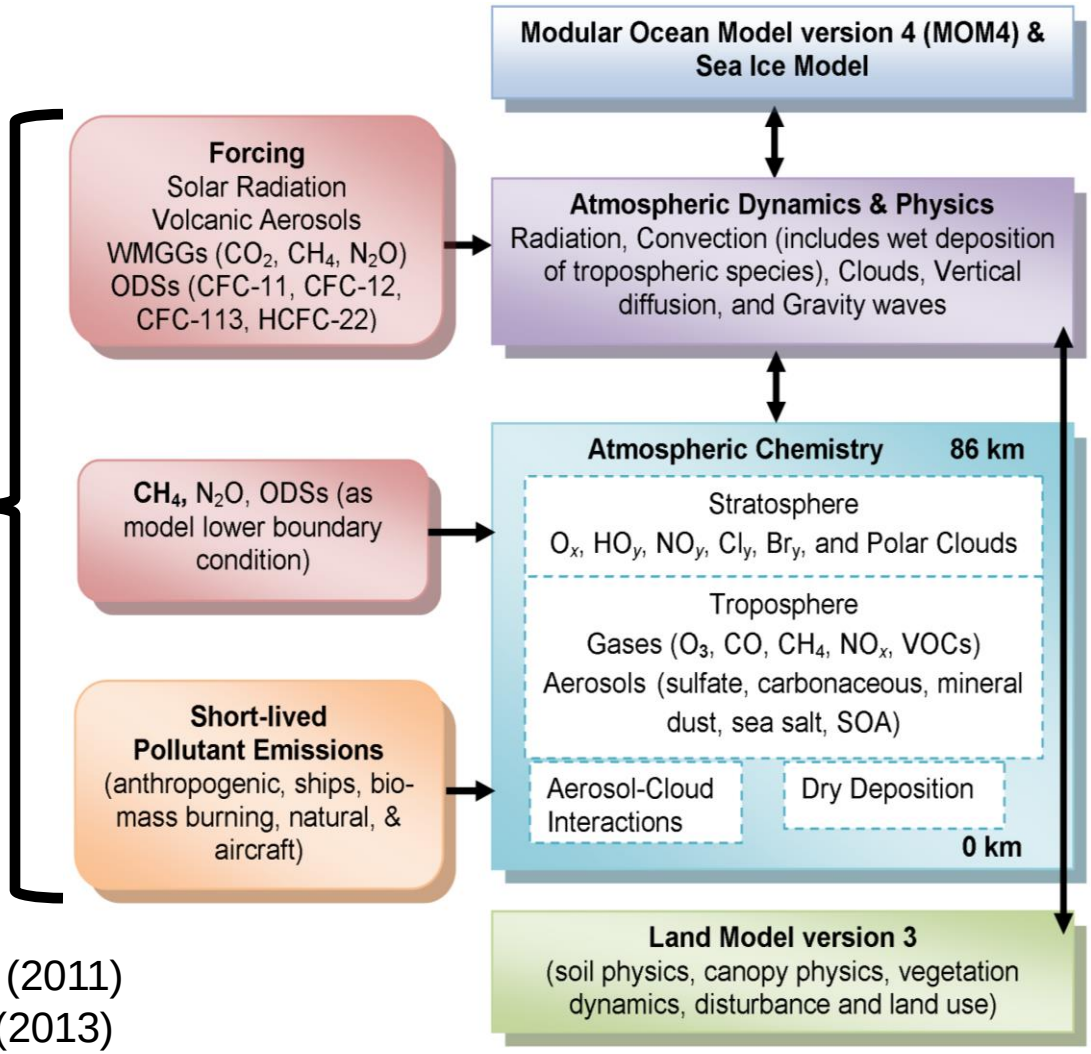
Atmospheric Chemistry Links Issues of Air Quality and Climate



Emissions of short-lived chemical compounds control abundance of surface air pollutants and radiatively active gases and aerosols

CM3 Coupled Climate Model

AM3
Atmospheric Model

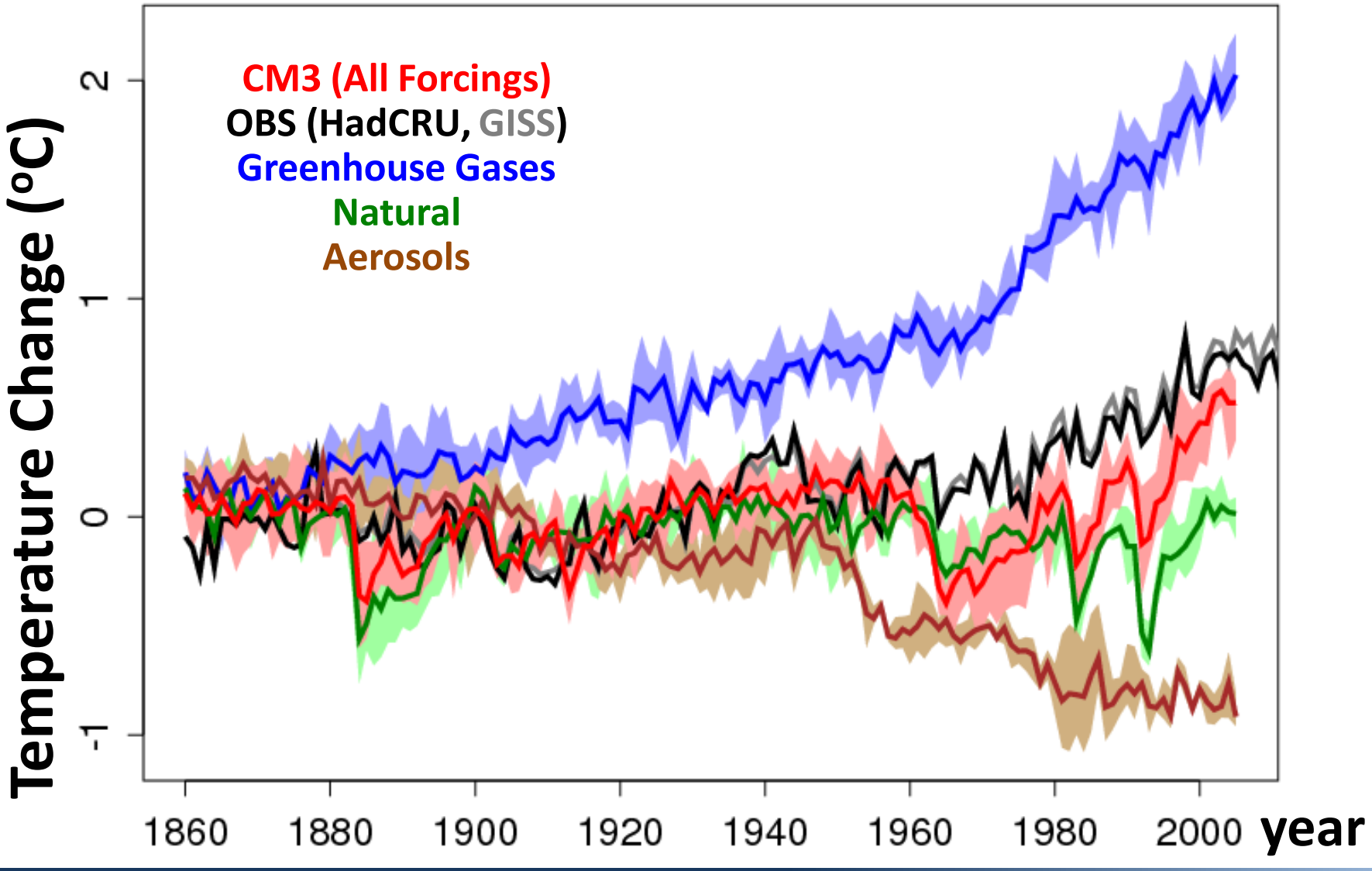


Donner et al. (2011)
Austin et al. (2013)
Naik et al. (2013)

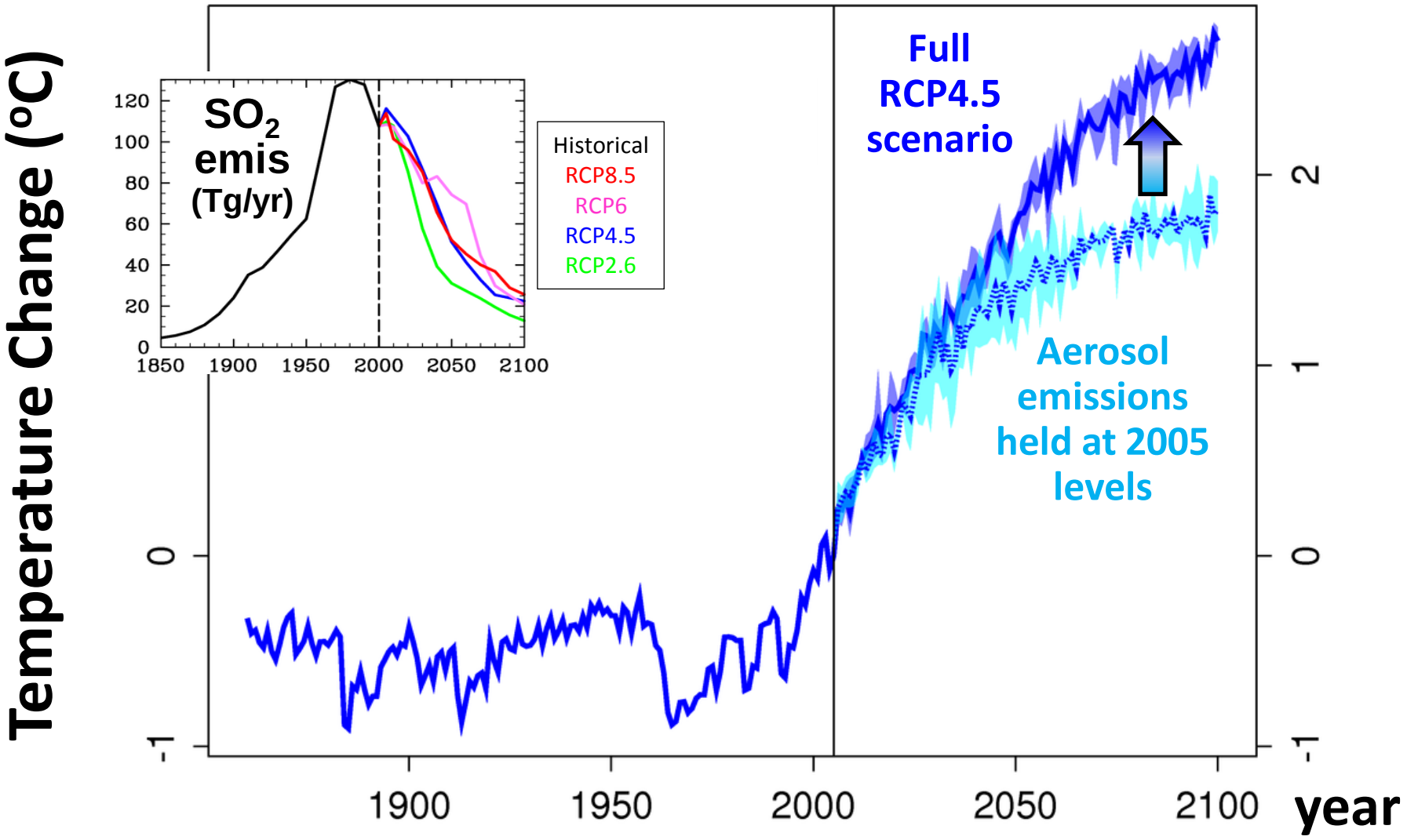
Designed to address:

- Aerosol-cloud interactions
- Chemistry-climate feedbacks
- Stratosphere-troposphere coupling (high model top)

Late 20th century cooling from aerosols and volcanoes in CM3



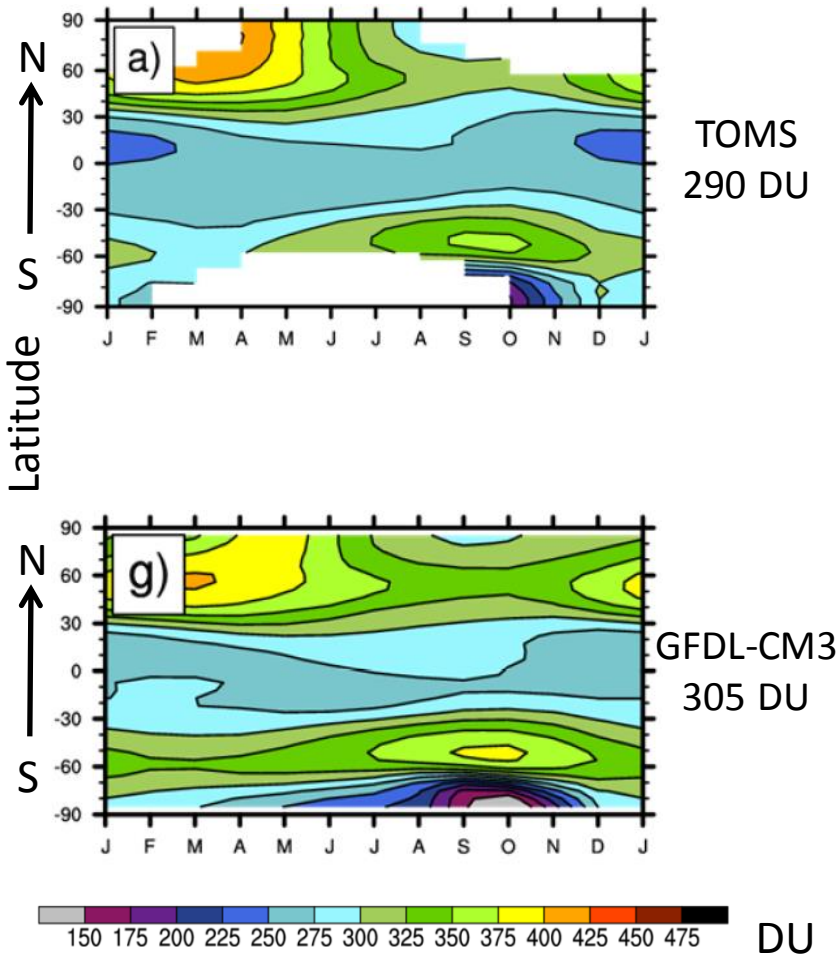
Aerosol reductions warm climate over 21st century



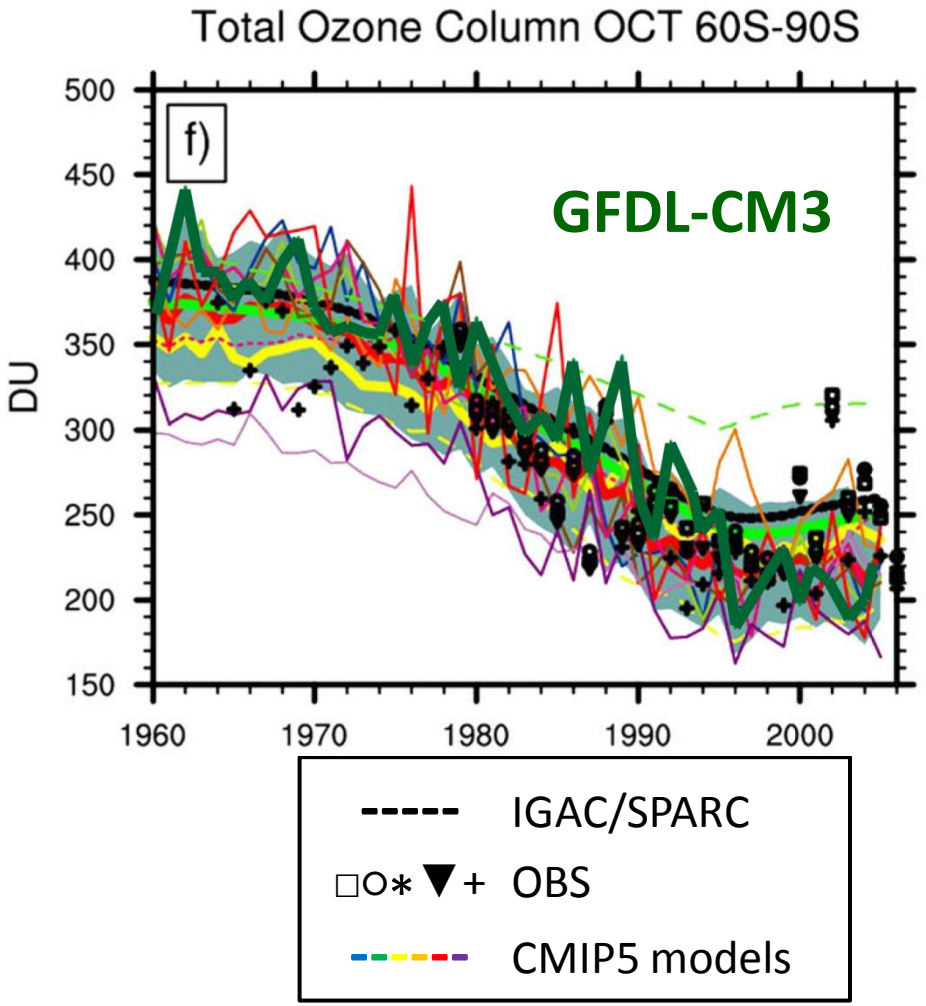
H. Levy et al., *JGR (2013)*

Stratospheric ozone distributions and trends are well simulated

Ozone Column



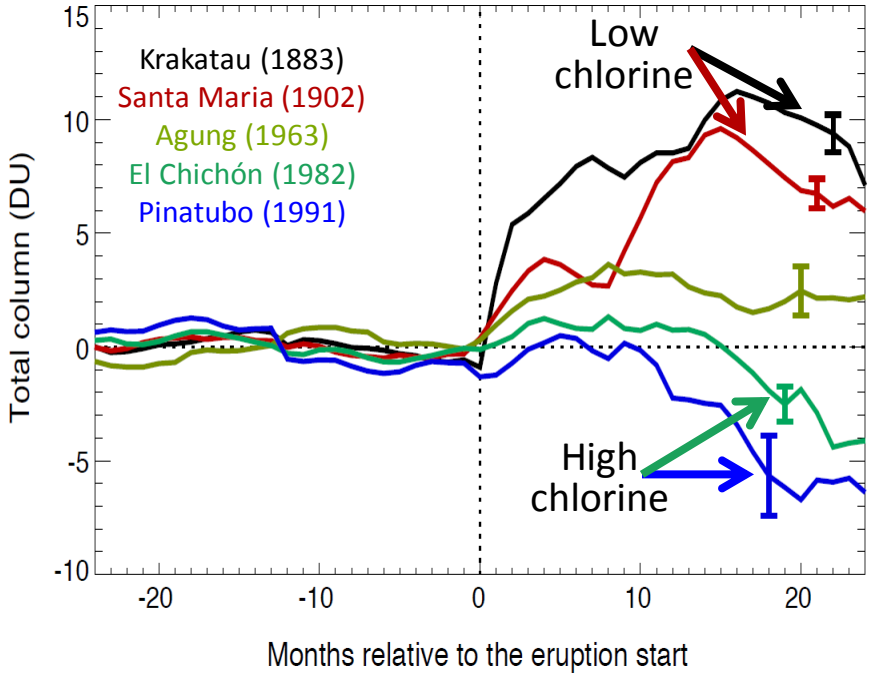
Development of Antarctic Ozone Hole



Eyring et al., *JGR (2013)*

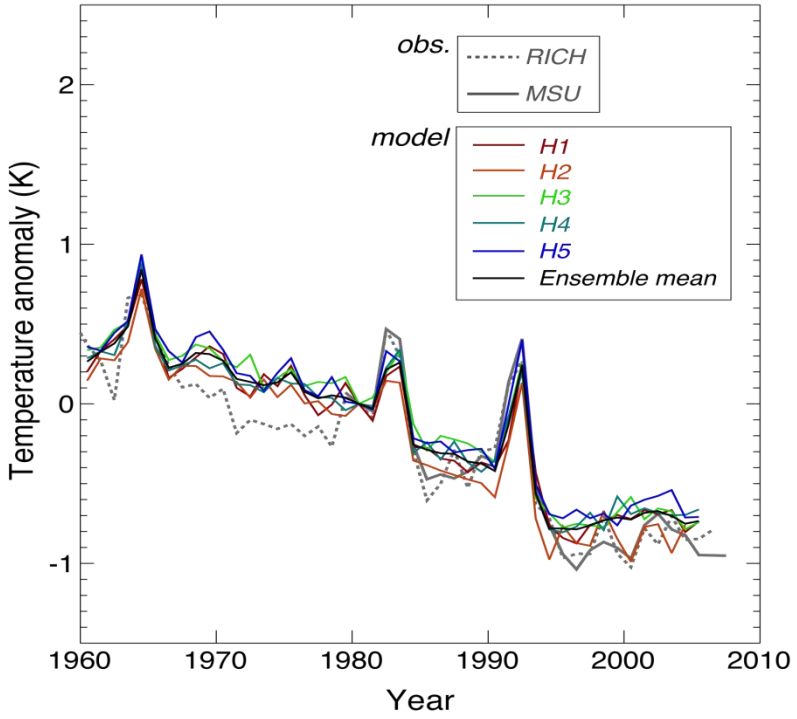
Stratospheric ozone and temperature respond strongly to volcanic eruptions

Ozone Column



Sign of ozone response to volcanic aerosols depends on atmospheric chlorine loading

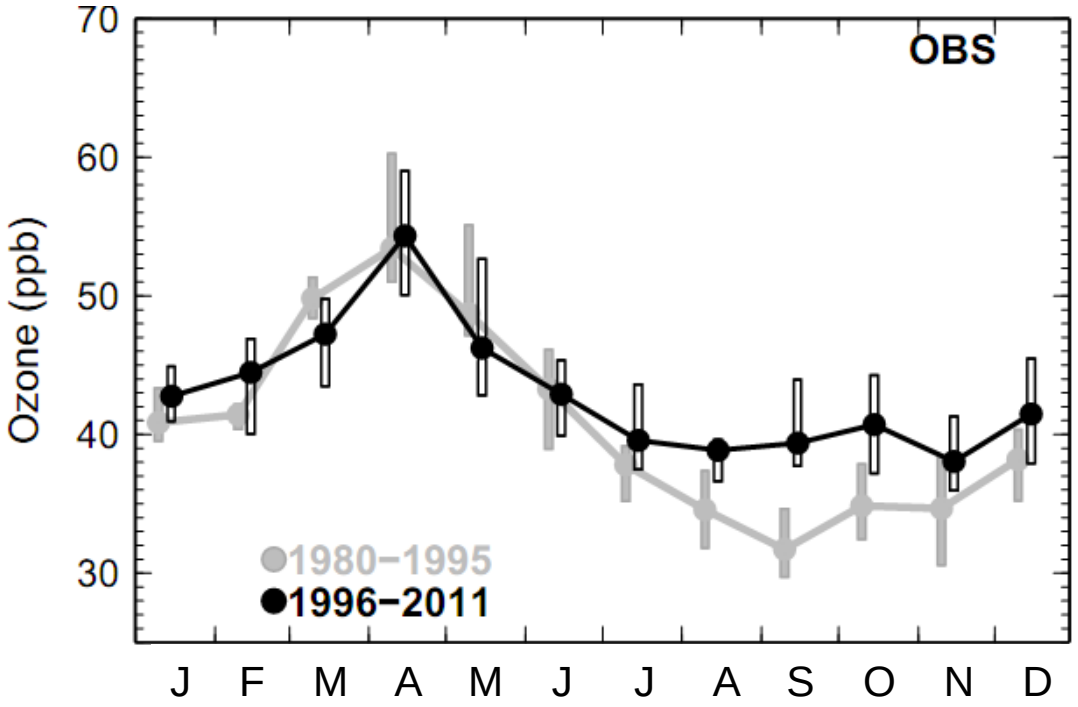
Temperature



Post-volcanic warming and long-term cooling in stratosphere are well simulated by CM3

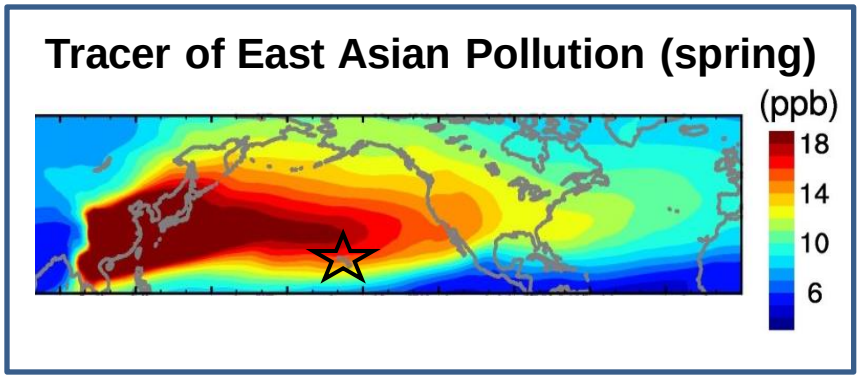
Austin et al., *J.Clim. (2013)*

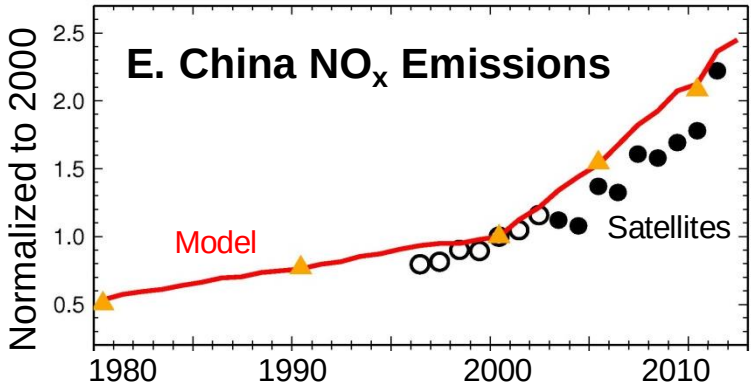
Tropospheric ozone trends at Mauna Loa Observatory tied to decadal climate variability



The puzzle:

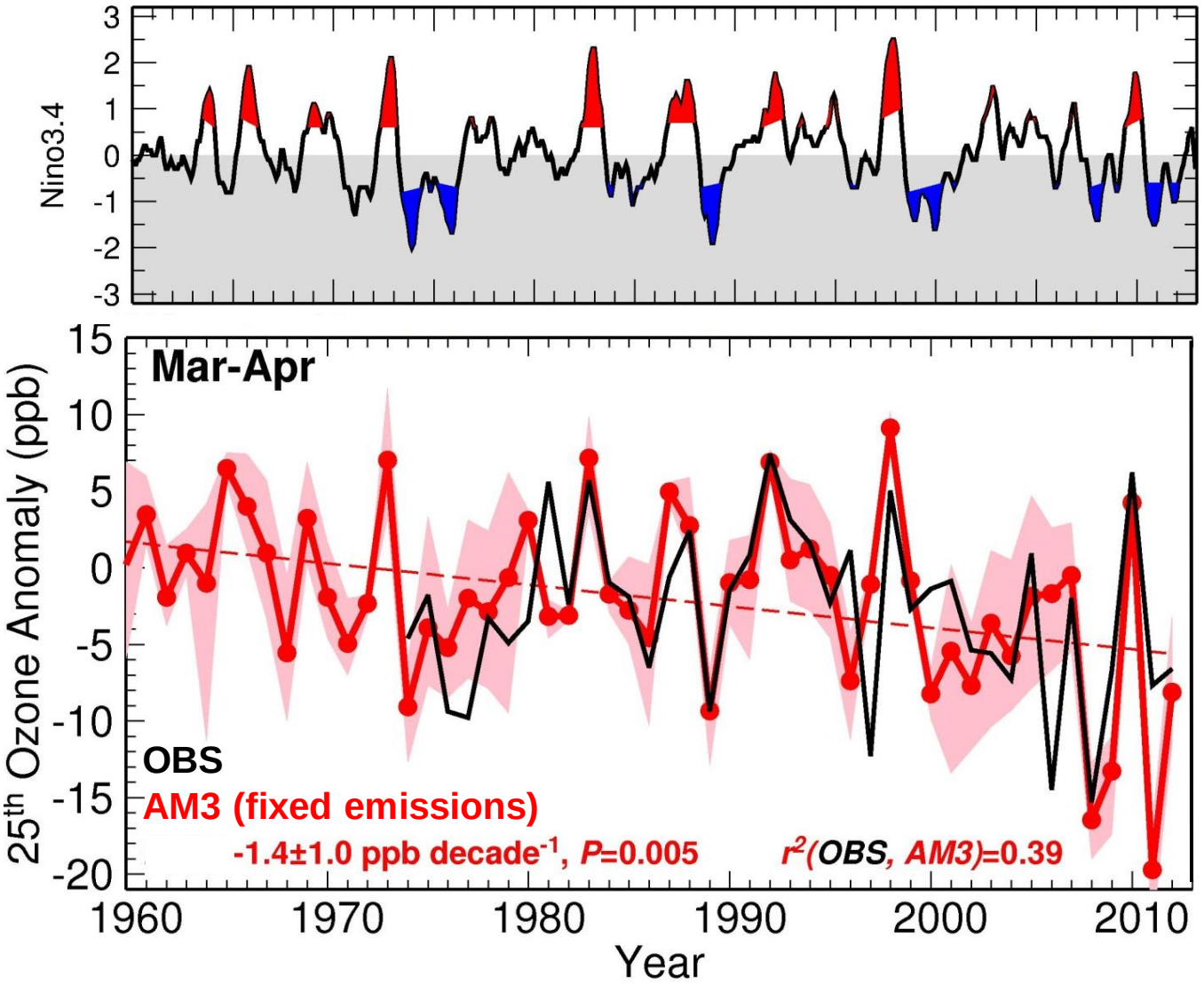
- Asian emissions increasing rapidly
- Strong transport from East Asia to MLO in spring
- Little ozone trend in spring (unlike fall)





M. Lin et al., *Nature GeoSci.* (2014)

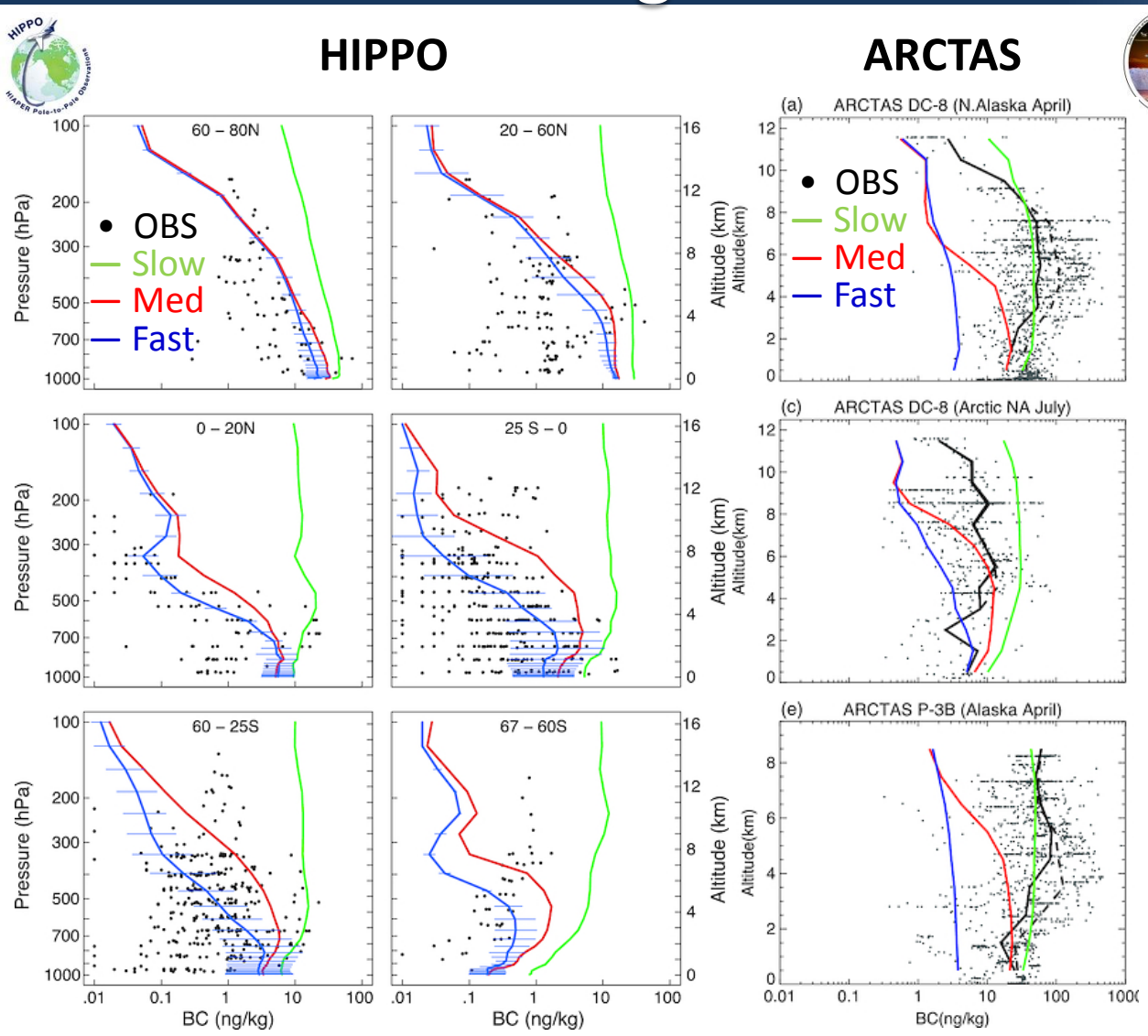
Weakening airflow from Asia in spring tied to recent La-Niña-like decadal cooling in the eastern equatorial Pacific



Decadal circulation changes offset rising Asian emissions

M. Lin et al., *Nature GeoSci.* (2014)

Inferring ice formation processes from global-scale black carbon profiles



Removal by snow

Slow

Intermediate

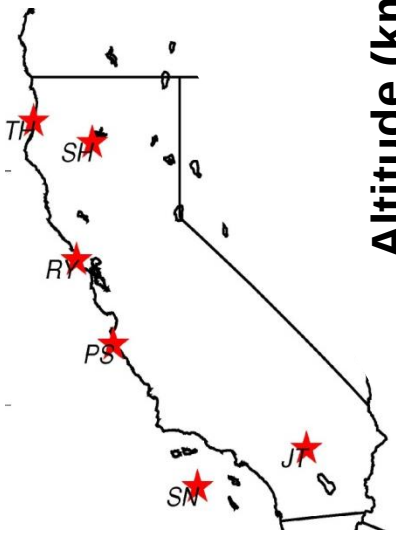
Fast

Simulated black carbon vertical profiles are highly sensitive to assumed scavenging by snow

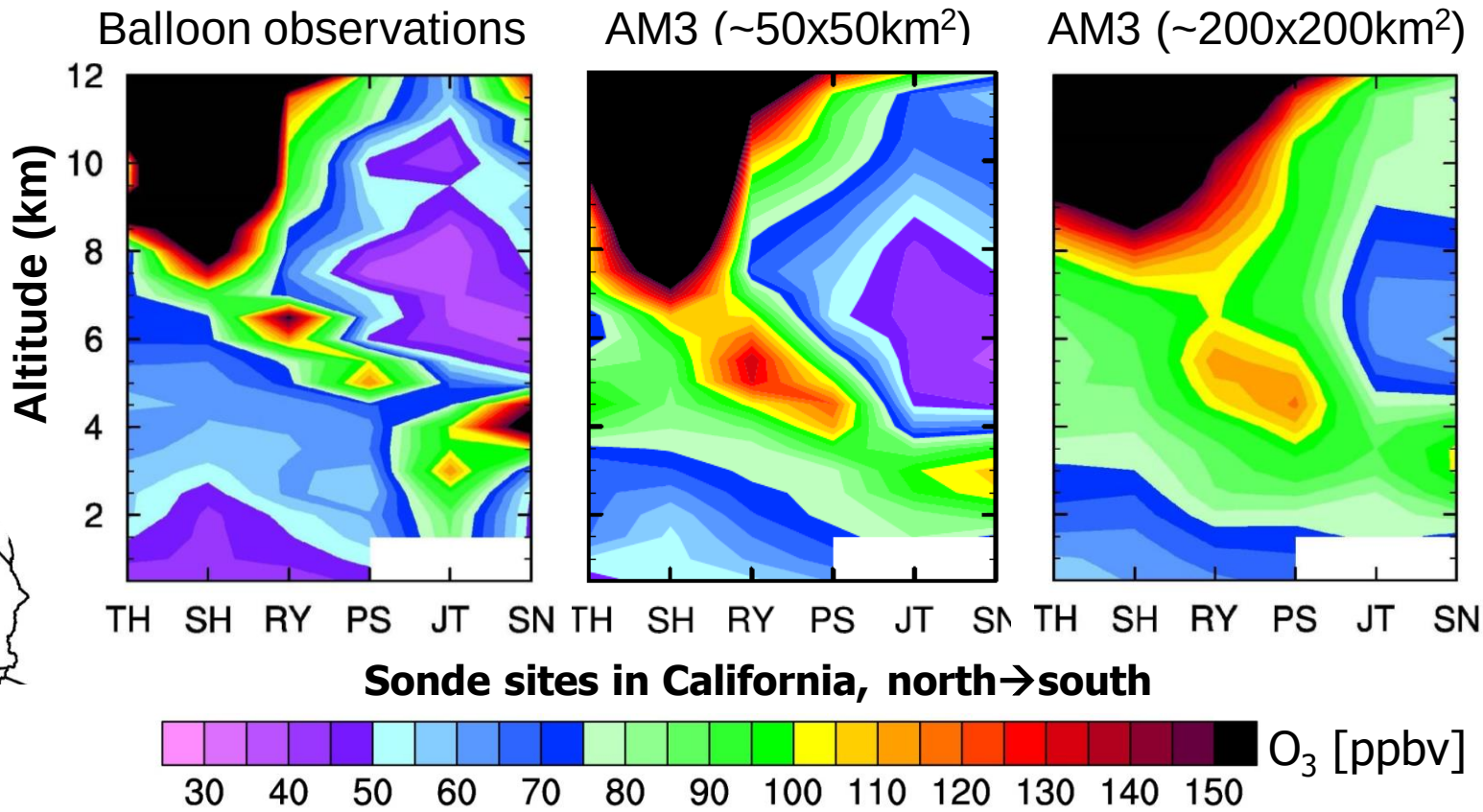
⇒OBS suggest slow removal by snow in mixed-phase clouds

Deep stratospheric ozone intrusions captured by AM3

NOAA CalNex 2010 field campaign:
AM3 (nudged to GFS winds) compared with ozonesonde observations

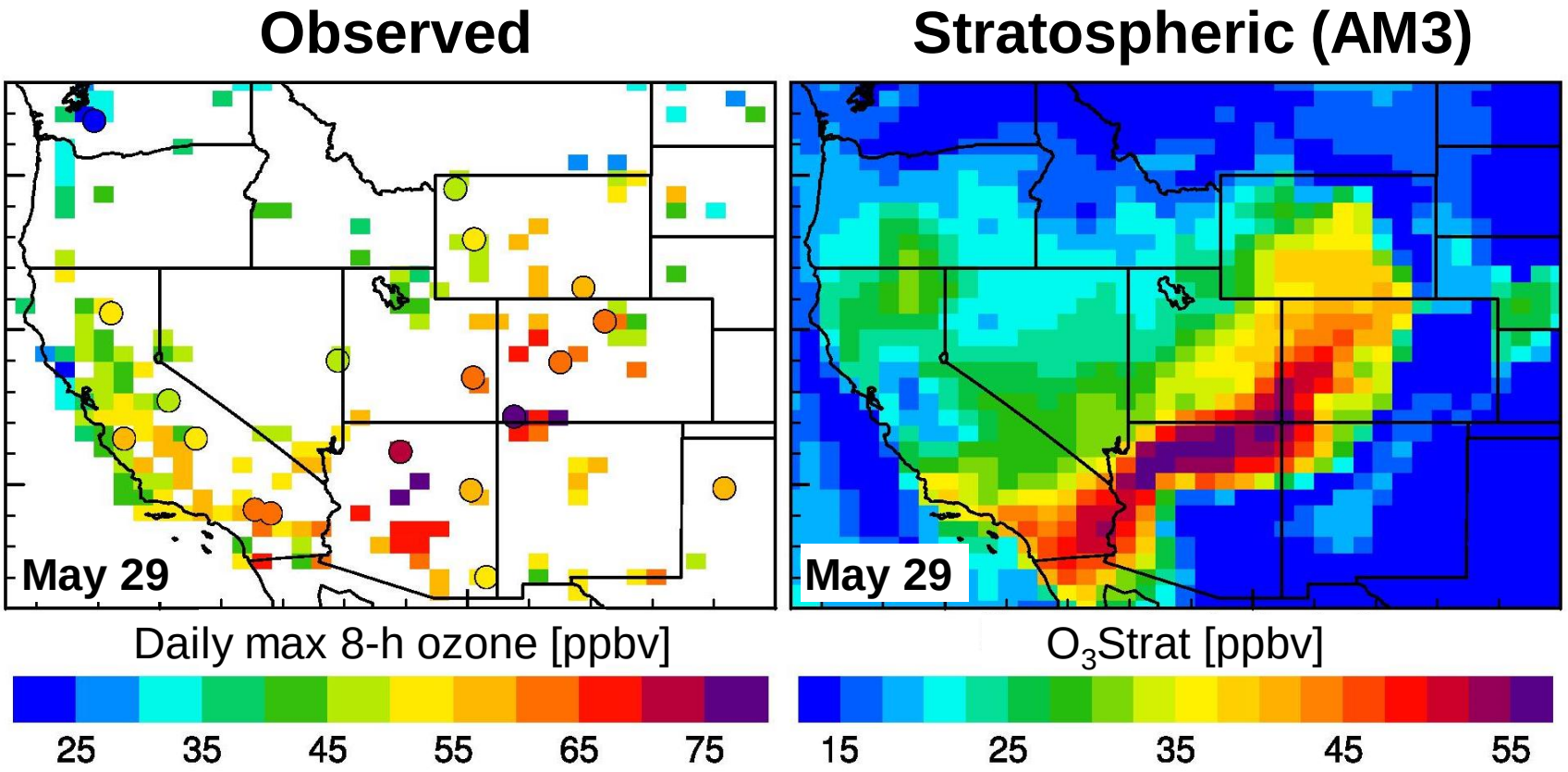


Case Study: May 28, 2010



Stratospheric ozone penetrates to lower troposphere over southern California

Stratospheric O_3 impacts surface air quality



Stratospheric sources contribute *episodically* to high-ozone events above the health-based threshold

M. Lin et al., *JGR* (2012)

Conclusions

AM3/CM3 chemistry-climate model successfully applied to:

- Chemistry-climate-air quality research
  (aerosol forcing, ozone depletion, long-range transport, strat-trop exchange)
- Contributions to CMIP5, CFMIP, ACCMIP, CCMI
- Public health and economic impacts (with collaborators)

Future plans: Chemistry-Climate Model → Earth System Model

- Interactive and self-consistent biogeochemical fluxes among atmosphere, land, and ocean (e.g., reactive nitrogen)
- Emissions-based methane, stratospheric volcanic aerosols
- Higher spatial resolution (relevant for air quality)

Additional Presentations on Atmospheric Chemistry

by Jasmin John, Meiyun Lin, Vaishali Naik, and Jingqiu Mao