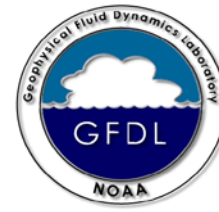


# Ozone pollution (events) in the GFDL AM3 chemistry-climate model



**Arlene M. Fiore**



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Larry W. Horowitz, Hiram Levy II, Vaishali Naik

**NCAR CESM Chemistry-Climate  
Working Group Meeting  
March 17, 2010**



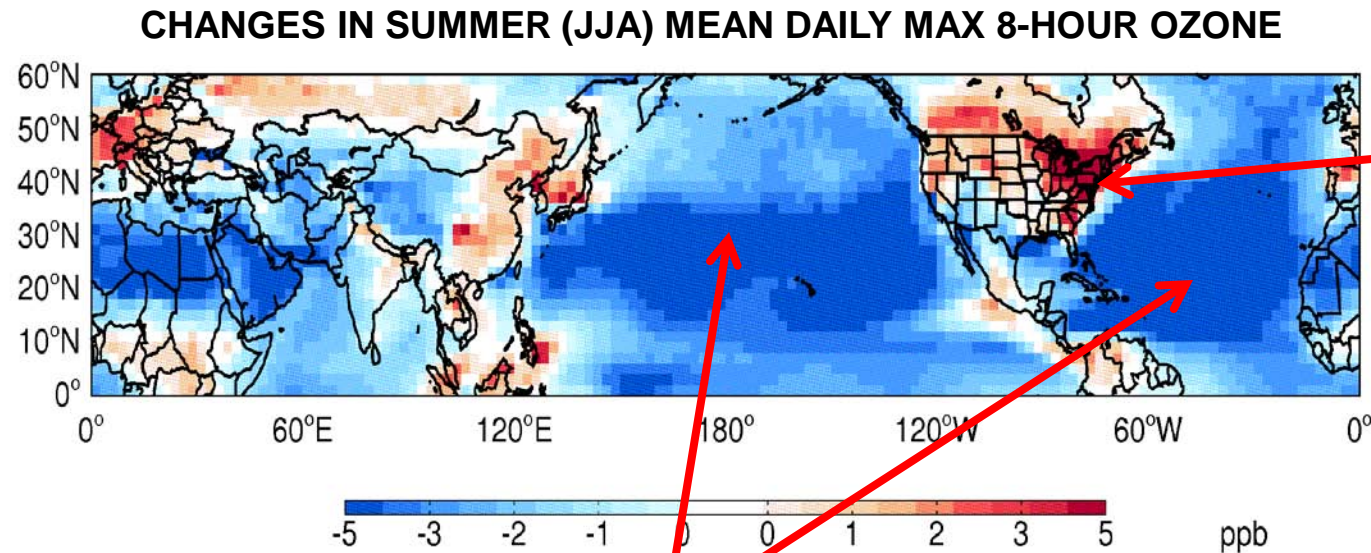
# Summertime surface O<sub>3</sub> changes in a warmer climate in the new GFDL chemistry-climate model (AM3) [Donner et al., 2011]

Prototype version of AM3: full strat and trop (gas+aerosol) chem plus idealized tracers.

20-year simulations with annually-invariant present-day emissions of ozone and aerosol precursors [Fang et al., submitted to JGR]

**Present Day Simulation** (“1990s”): observed SSTs + sea ice (1981-2000 mean)

**Future Simulation** (“A1B 2090s”): observed SSTs + sea ice + average 2081-2100 changes from 19 IPCC AR-4 models



Previously noted degradation of summertime EUS O<sub>3</sub> air quality e.g., reviews of Jacob and Winner, *Atmos. Environ.* 2009 and Weaver et al., *BAMS*, 2009

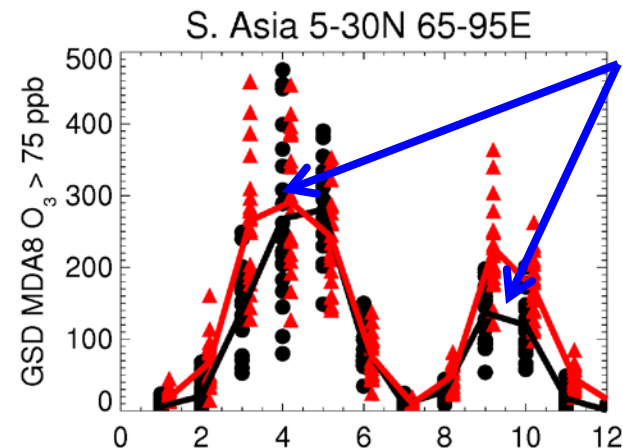
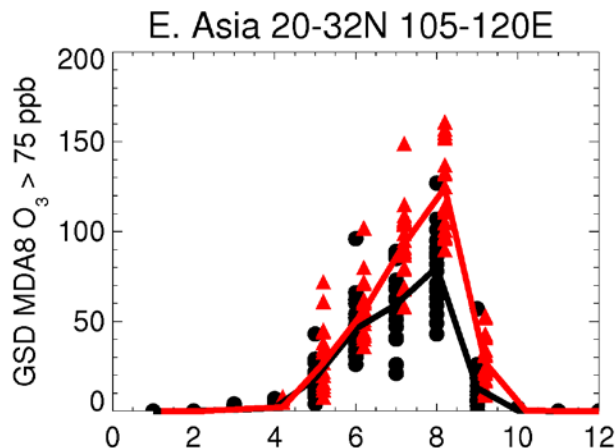
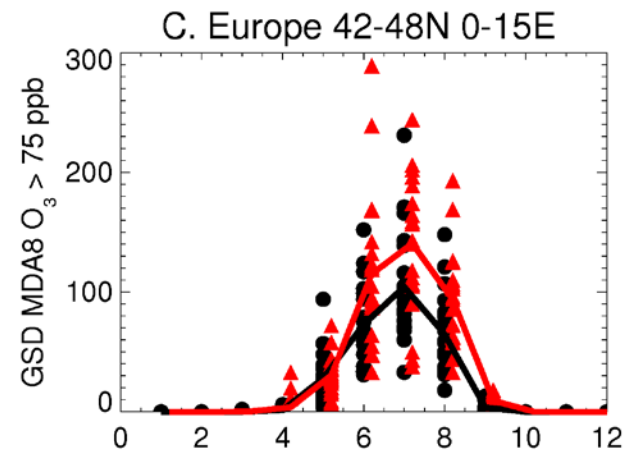
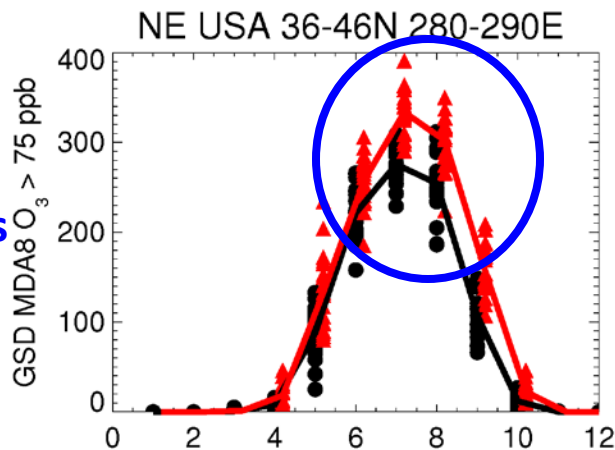
Previously noted decrease of lower troposphere background O<sub>3</sub> e.g., Johnson et al., *GRL*, 2001; Stevenson et al., *JGR*, 2006

# Changes in pollution events: Incidences of daily max 8-hr $O_3 > 75$ ppb (land only)

**FUTURE:** ▲ individual years — 20-yr mean (climate change only)

**PRESENT:** ● individual years — 20-yr mean

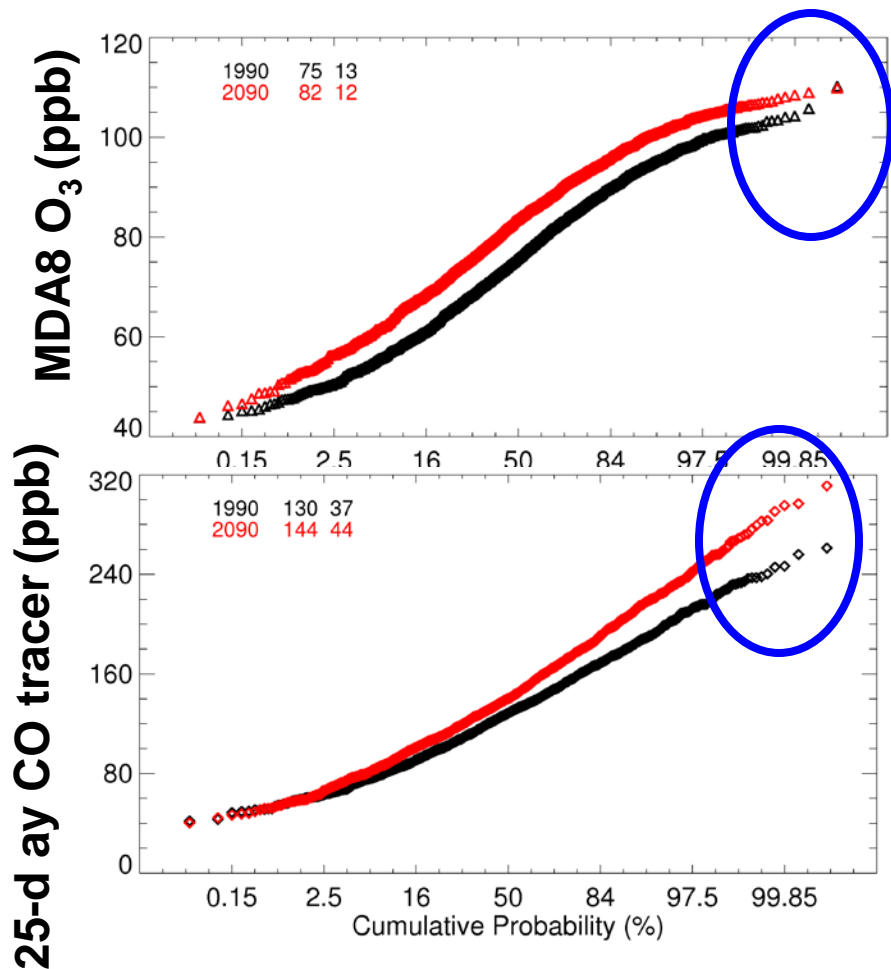
Air quality  
degradation  
(prior studies  
suggest  
cyclones)



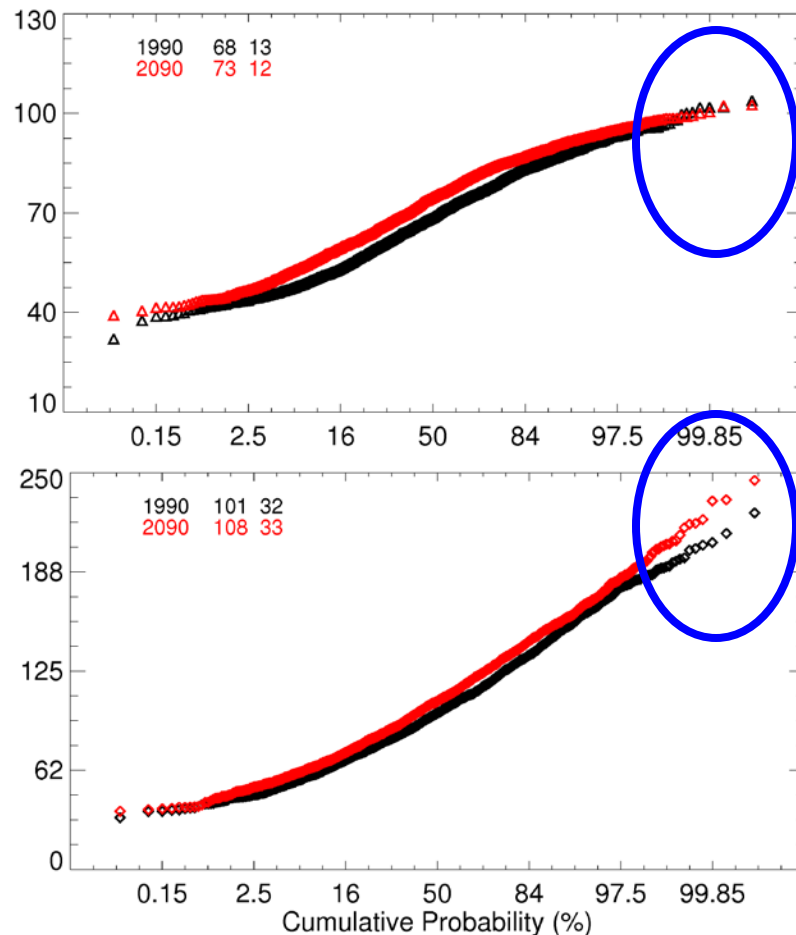
Two  $O_3$   
pollution  
seasons in  
S. Asia; climate  
change impact  
largest in fall:  
robust?

# Pollution events, Present and **Future (Climate change only)**: Ozone vs. idealized tracers

## Northeast USA

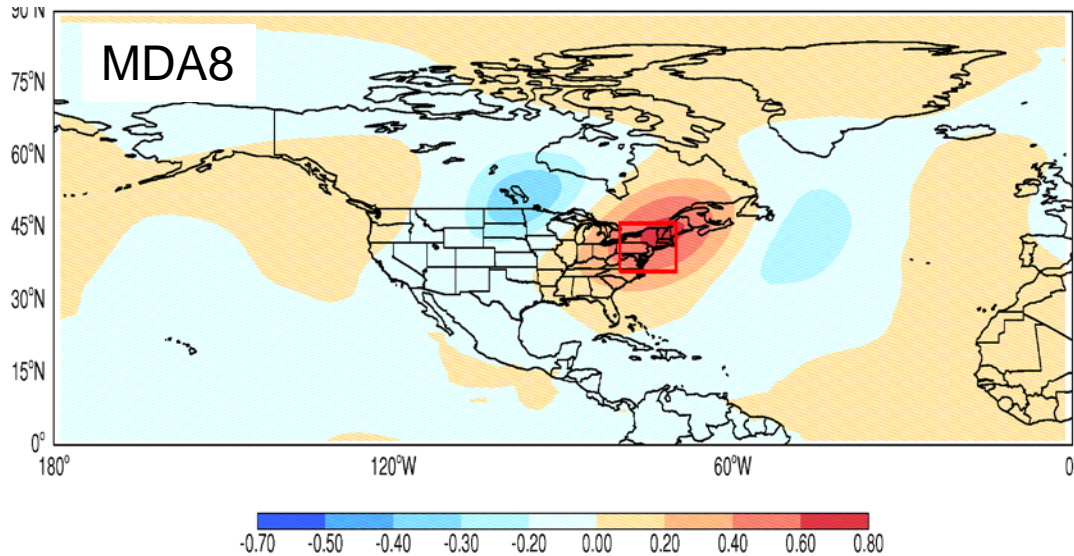


## Great Lakes USA



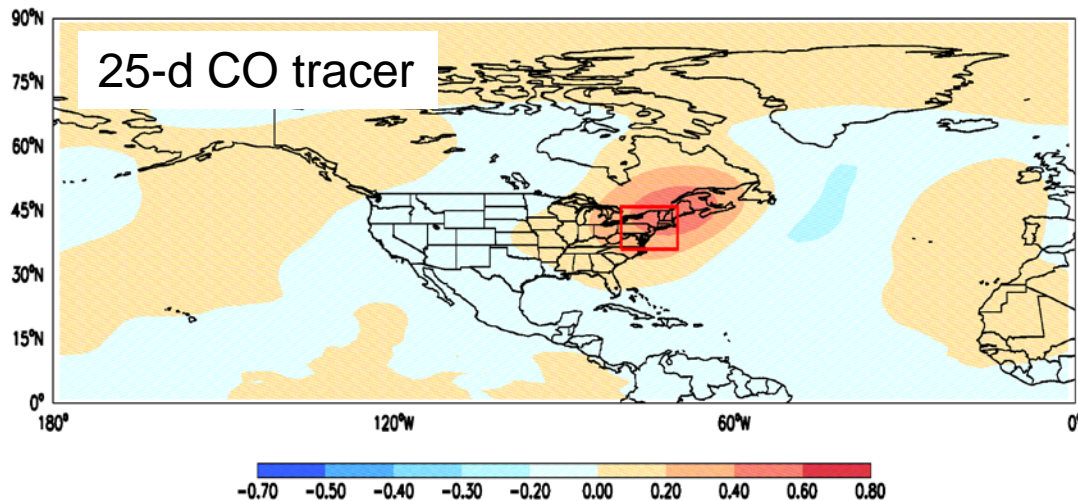
- Shapes of present-day distributions vary by tracer and region
- Changes in distributions (especially high extremes) differ

# Idealized tracers (cheaper than full chemistry!) may offer insights into how pollution responds to shifts in climate



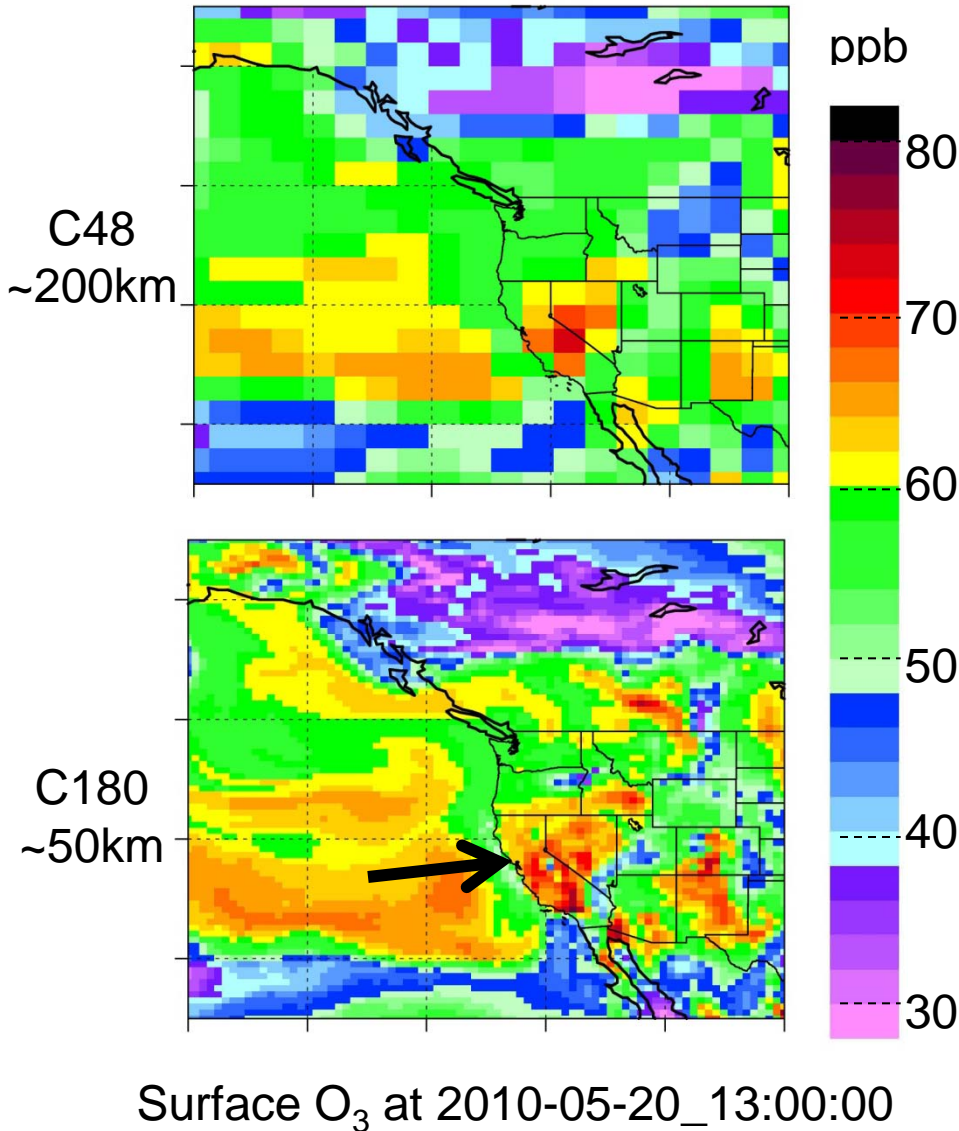
Correlation (r) of regional Average daily values with 500 hPa geopotential heights in present-day simulations

Similar patterns emerge.



→ Correlation analysis between idealized tracers and meteorological fields useful for identifying meteorological factors controlling build-up of pollution (and how those change in the future)

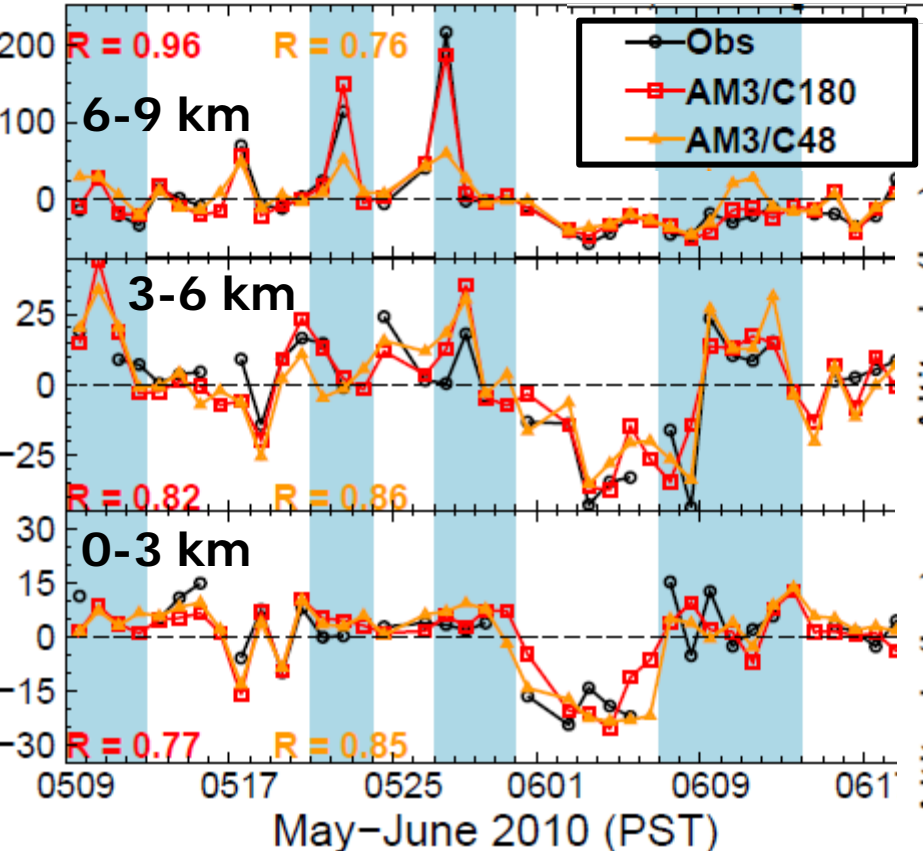
# High-resolution version of GFDL AM3 global climate-chemistry model



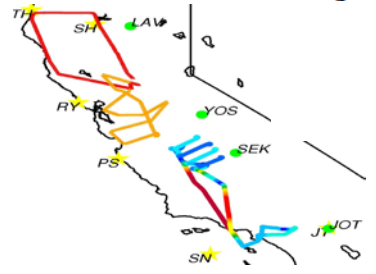
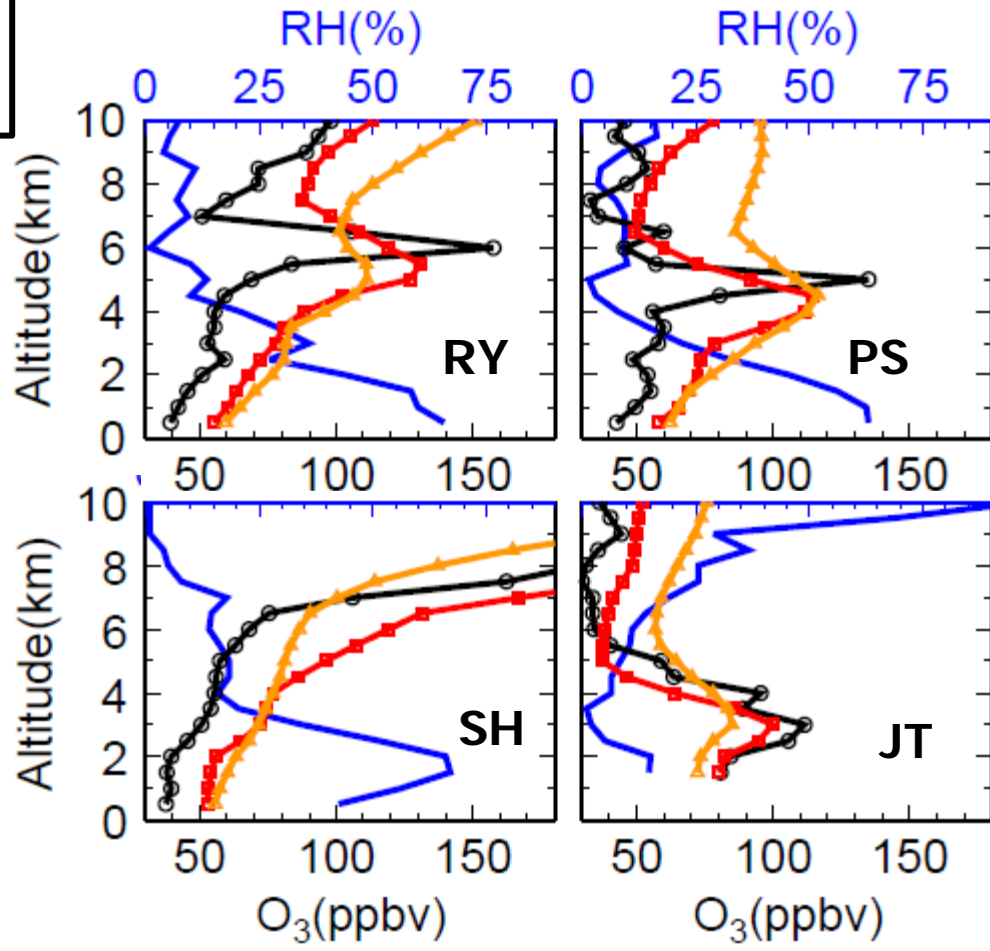
- Nudged to Global Forecasting System U and V
- Up-to-date emissions
  - US NEI 2005
  - Asia INTEX-B scaled to 2010
  - Daily resolved fire emissions
- 1-year coarse-res spin up with and without Asian (15-50N, 95-160E) anthropogenic emissions
- High-res run for Jan-Jul 2010 (NOAA CalNex field campaign)

# AM3 captures daily variability at sonde locations & structure of stratospheric intrusions along U.S. west coast

Point Reyes [122.9W, 38.1N]



May 28 2010, 1:30-2:00 pm PST



**Influence of this intrusion on surface ozone?**

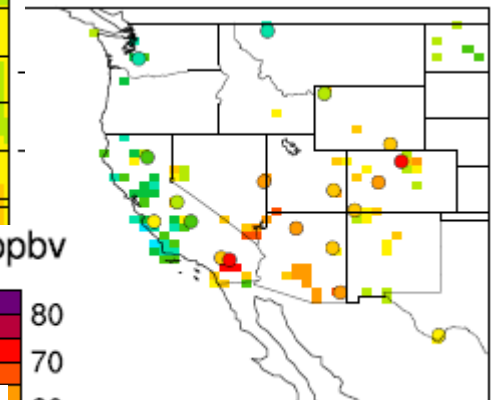
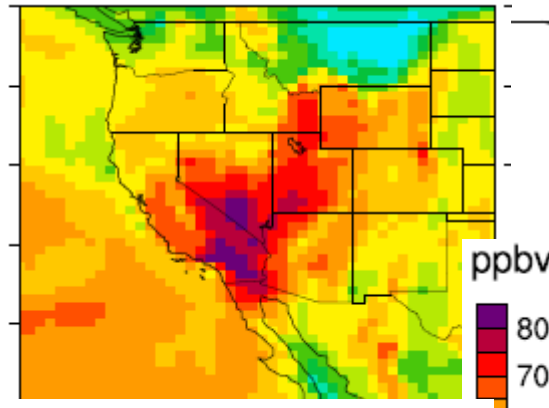
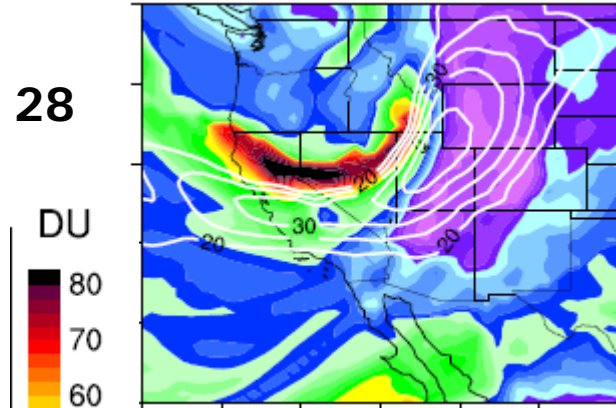
# STE event associated with simulated and observed surface O<sub>3</sub> enhancements, May 28-29 2010

Trop. column O<sub>3</sub> (DU)  
500 hPa wind speed (contour)

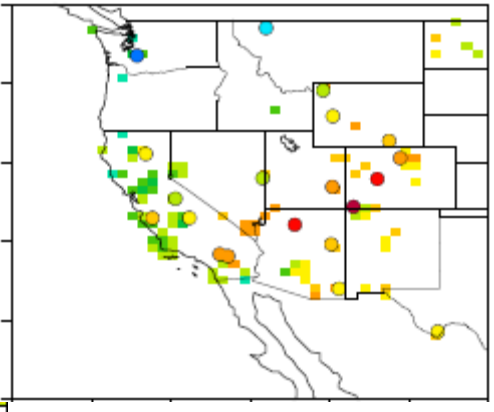
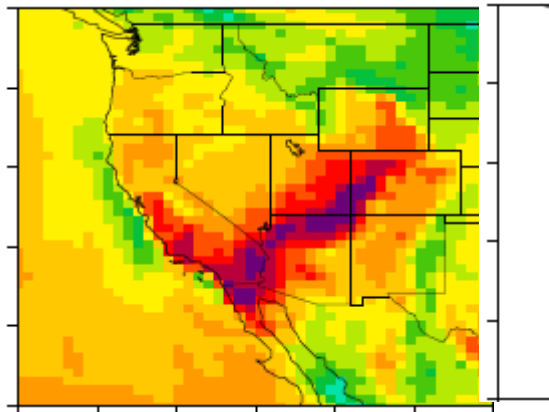
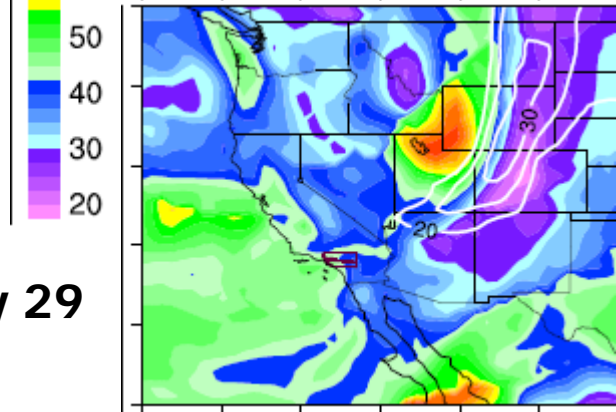
AM3 surface O<sub>3</sub> (ppbv)

Observed O<sub>3</sub> (ppb)  
AQS + CASTNet

May 28



May 29

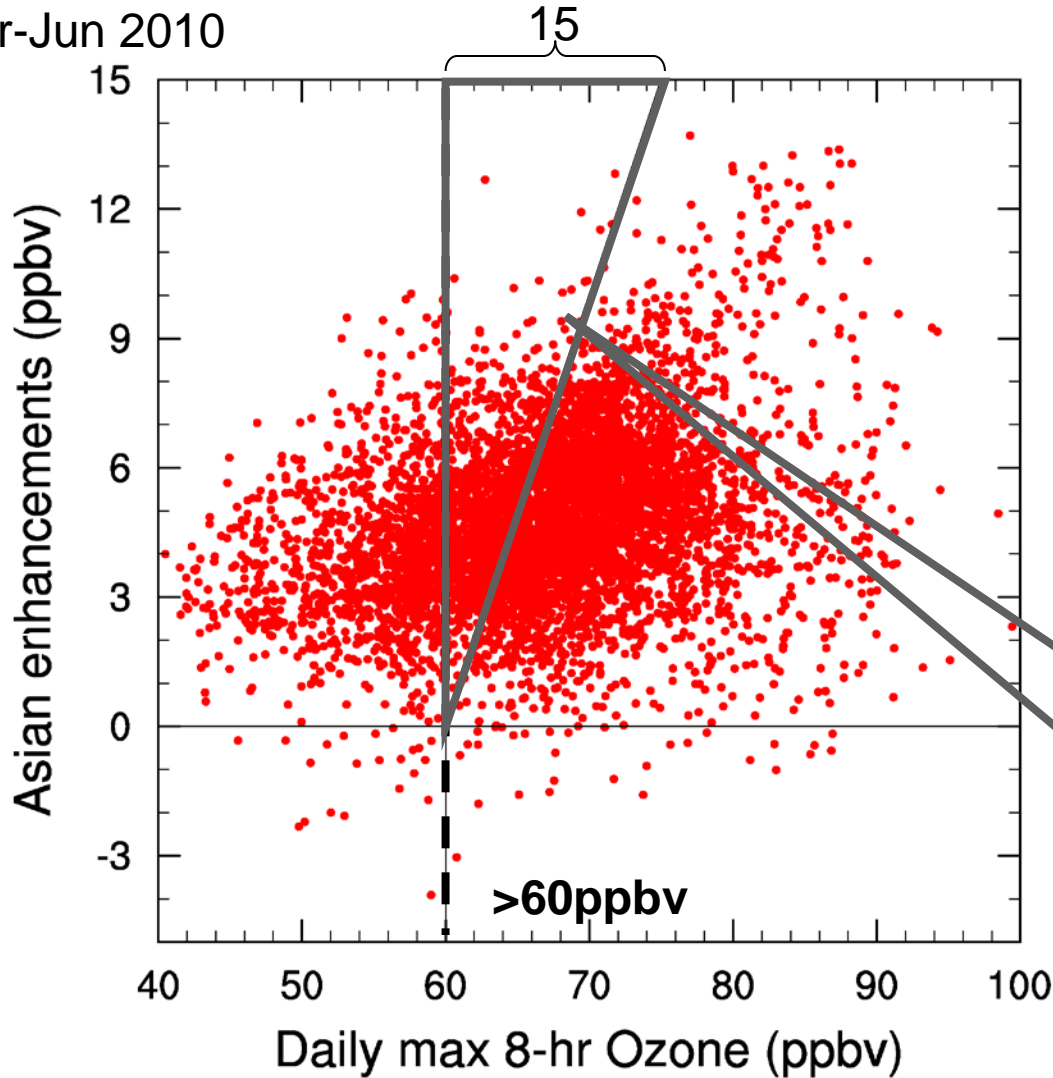


Suggestive of STE influence at surface; needs further examination  
with strat O<sub>3</sub> tracer and "background" simulations

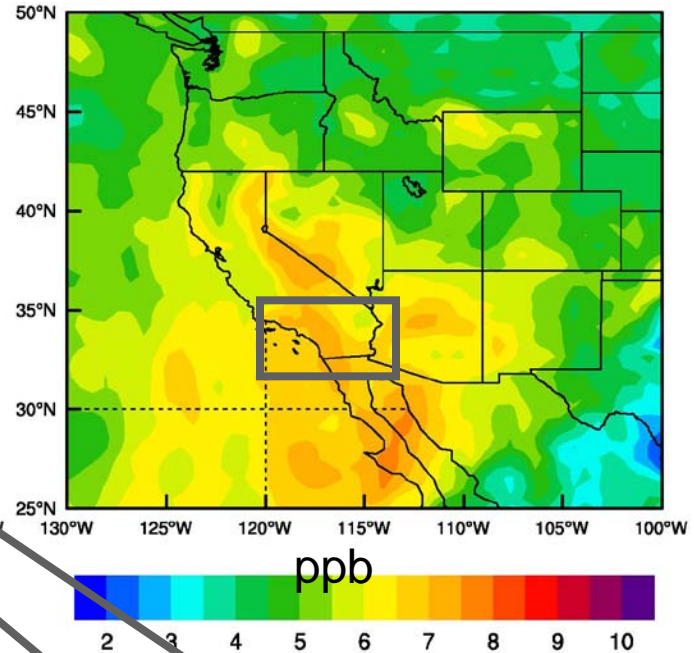
*M. Lin et al., in prep*



# The role of Asian Emissions on Ozone Exceedances in Southern California



Mean Asian Ozone at ~800hPa in May 2010



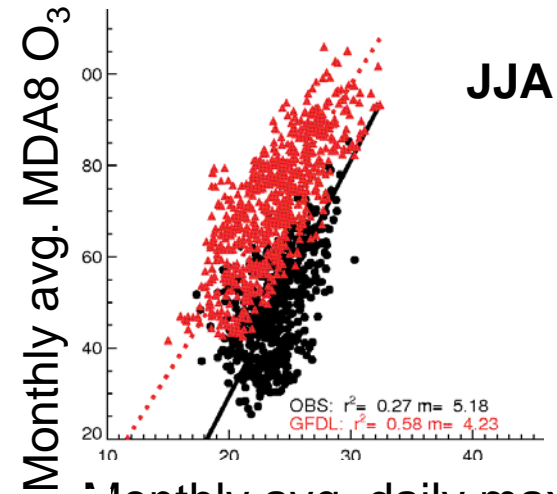
22% of model MDA8 > 60 ppbv would not occur in the absence of Asian emissions

# How well does a global chemistry-climate model simulate regional O<sub>3</sub>-temperature relationships?

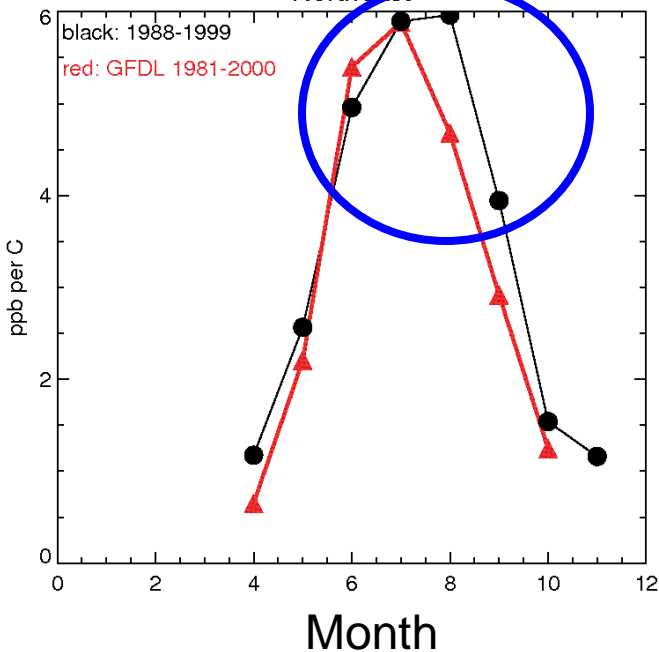
**NORTHEAST USA:**  
 monthly average daily max 8-hr avg (MDA8 O<sub>3</sub>)  
 vs. monthly avg. daily max. T

**AM3 model: 1981-2000**

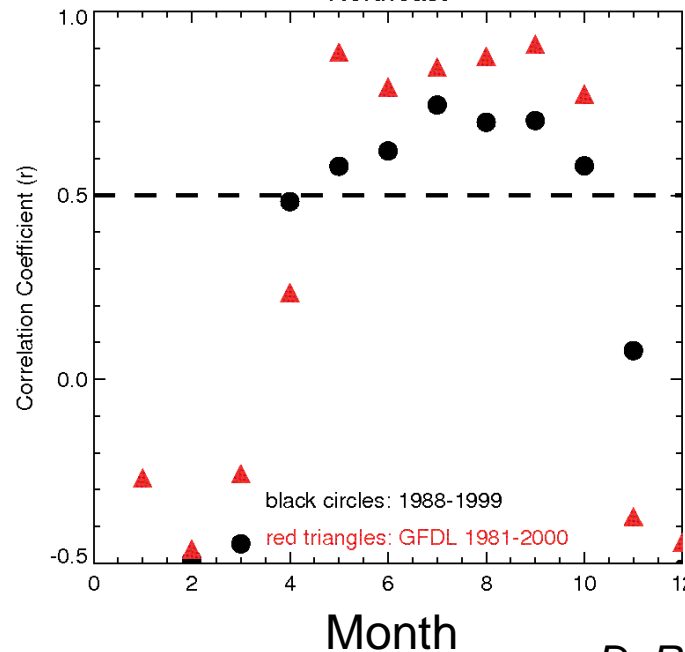
**Observed: 1988-1999**



**Slopes (ppb O<sub>3</sub> per C)**



**Correlations (r)**

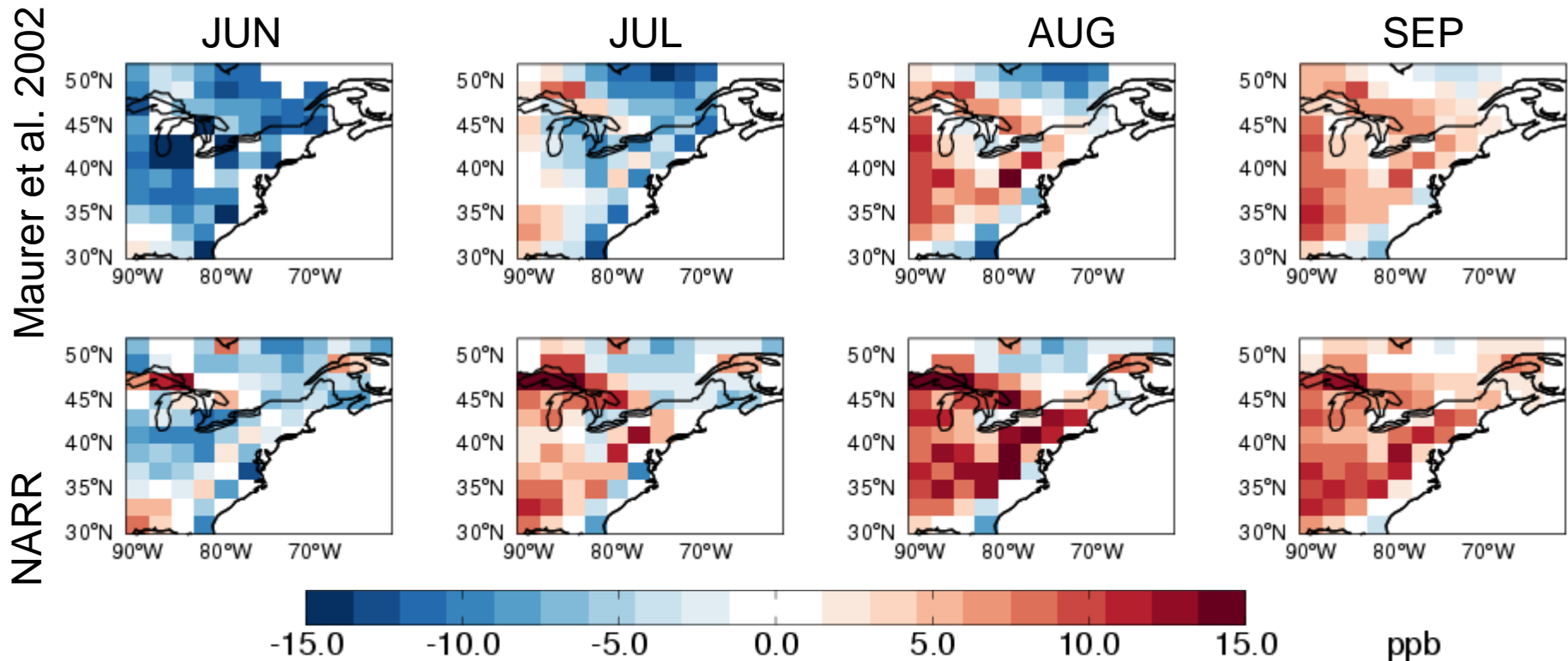


Monthly avg. daily max T

**Model generally captures observed O<sub>3</sub>-T relationships & their seasonal transitions (despite mean T and O<sub>3</sub> biases)**

# How large a contribution are temperature biases in chemistry-climate models to surface O<sub>3</sub> biases?

- A) Use 2 independent datasets to assess bias in daily max temperature
- B) Assume 4 ppb per C in Jun-Aug & 3 ppb per C in Sep applies throughout EUS



- May be a significant contribution in Aug/Sep, possibly Jul, not Jun
- Additional factors still at play in model bias, but illustrates critical need for accurate representation of daily T max (diurnal cycle)