The role of dynamics in determining tropospheric ozone variability and trends

Meiyun Lin

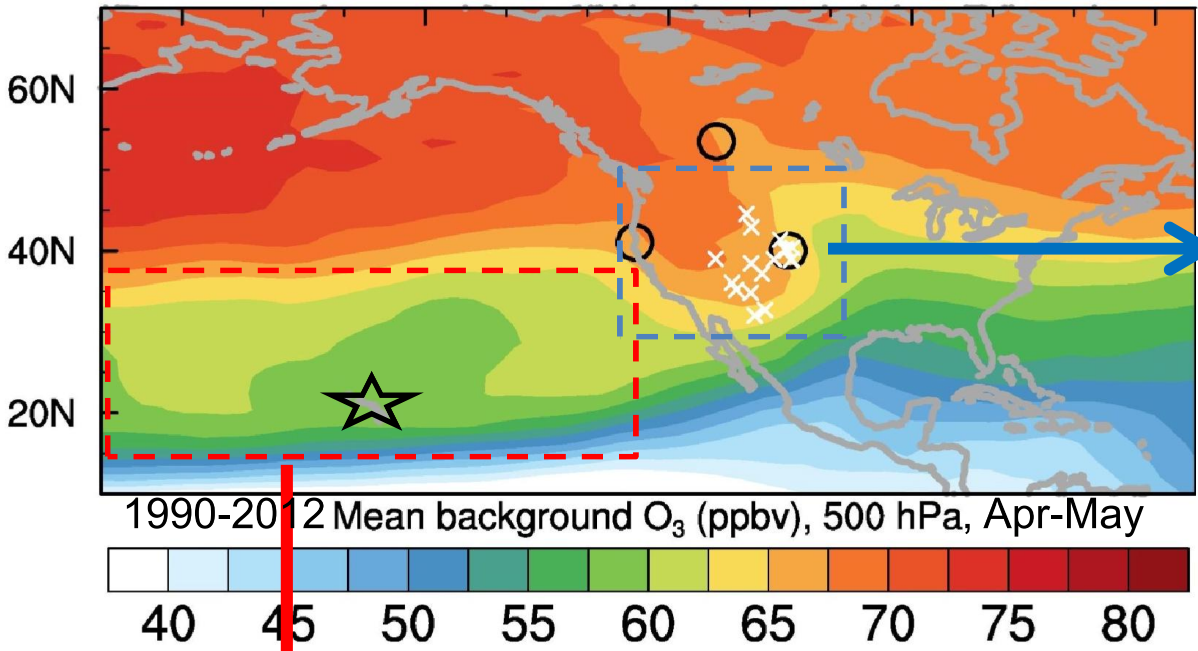
Lin M.Y., L.W. Horowitz, S. J. Oltmans, A.M. Fiore, SM Fan (2014a): ***Tropospheric ozone trends at Mauna Loa Observatory tied to decadal climate variability***, Nature Geoscience, 7, 136–143 (2014)

Lin M.Y., A.M. Fiore, L.W. Horowitz, A.O. Langford, S. J. Oltmans, D. Tarasick, H. Rieder (2014b): ***Climate variability modulates western U.S. surface ozone in spring through stratospheric influence***, in revision

Geophysical Fluid Dynamics Laboratory

Presented at CCMI 2014 Lancaster

Background O_3 over the Pacific and Western N. America varies in space and time



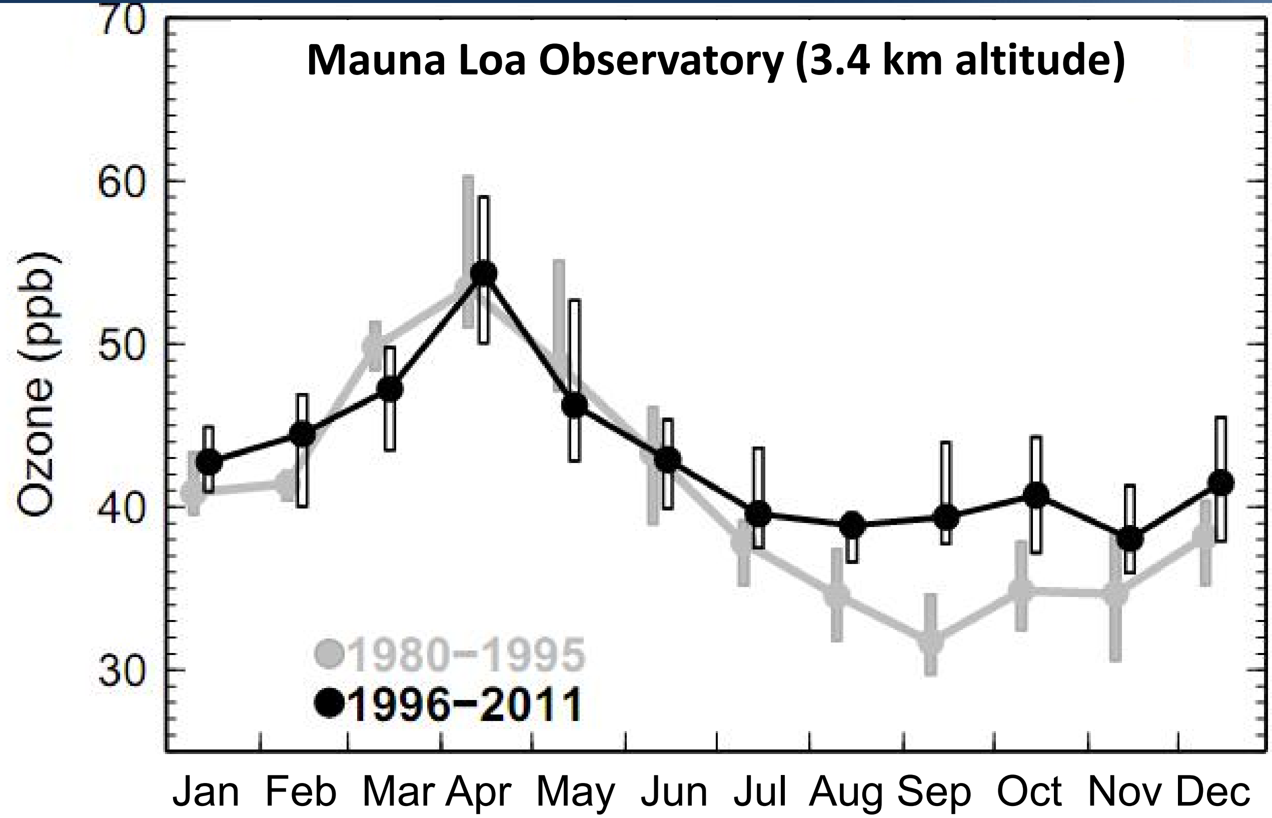
Western U.S.
- Sensitive to polar frontal jet
- Prone to deep strat. intrusions
- Highly variable on synoptic timescales

[Cooper et al. 2004; Langford et al. 2009; Lin et al. 2012ab; Skerlak et al. 2014]

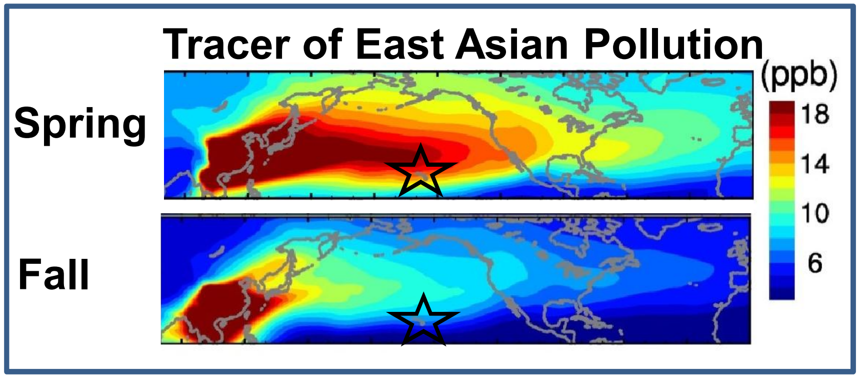
Pacific subtropical region:
- Sensitive to the subtropical jet location *[Zeng & Pyle 2005; Koumoutsaris et al 2008; Neu et al 2014]*
- Greater Asian than stratospheric influence on variability *[Lin et al., 2014a]*

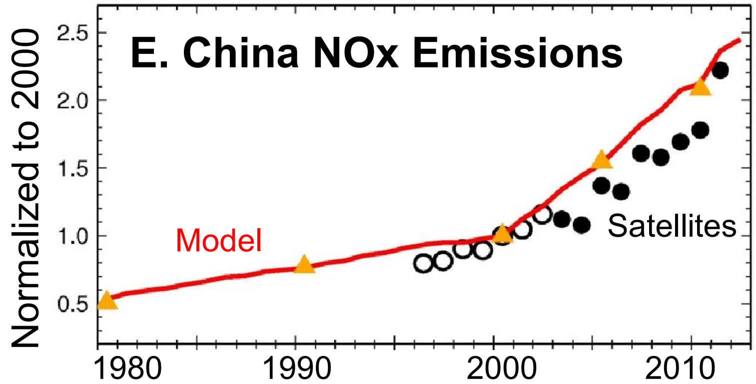
→ Need process-level understanding on daily to multi-decadal timescales
→ Must consider climate variability for attribution of observed trends

The puzzle: Mauna Loa ozone increases in autumn but shows little change in spring



Lin M.Y. et al (Nature Geo, 2014)





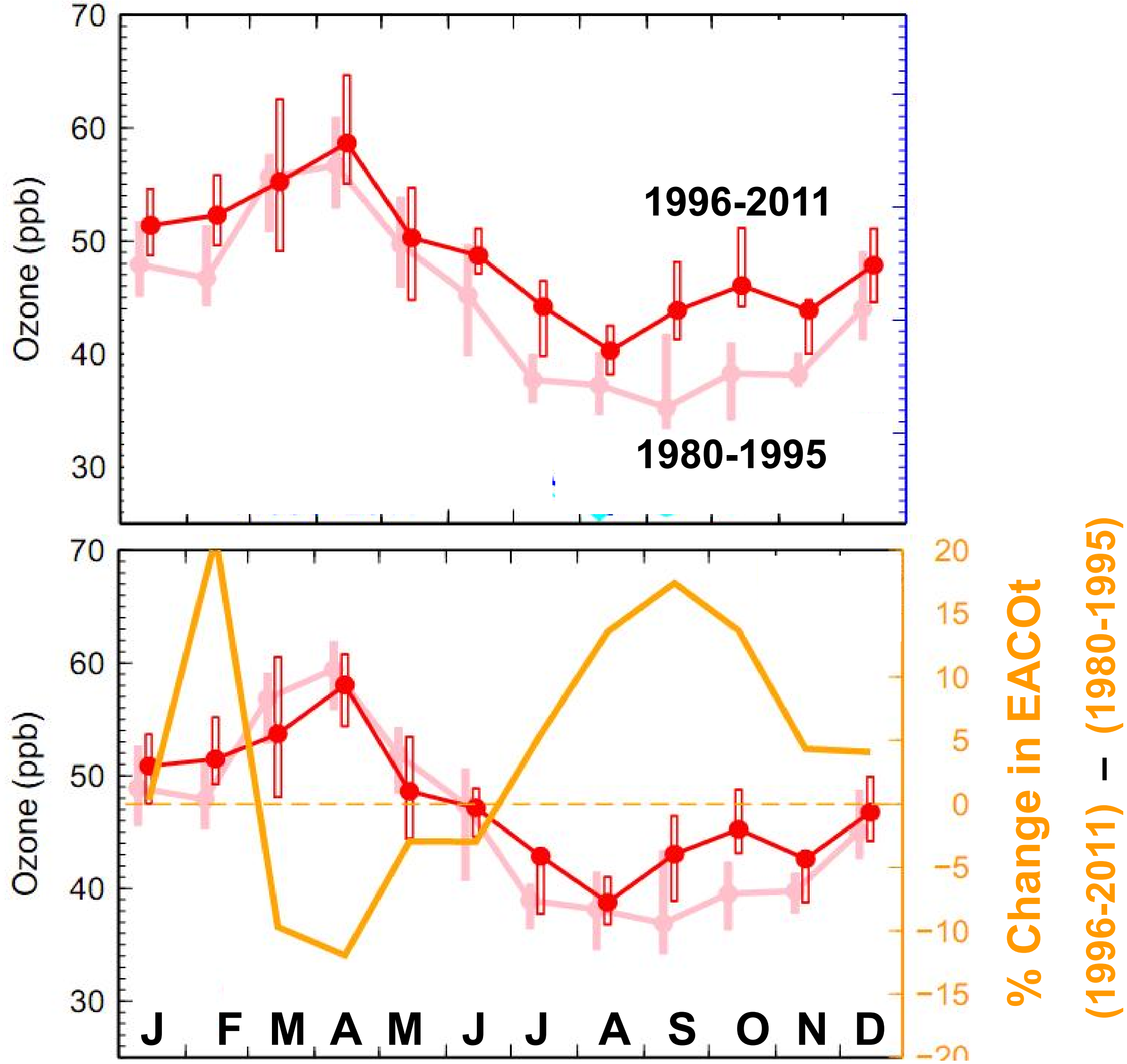
GFDL model indicates influence from circulation shifts that modulate Asian pollution reaching Hawaii

BASE

- Varying emissions
- Nudged to “real winds”

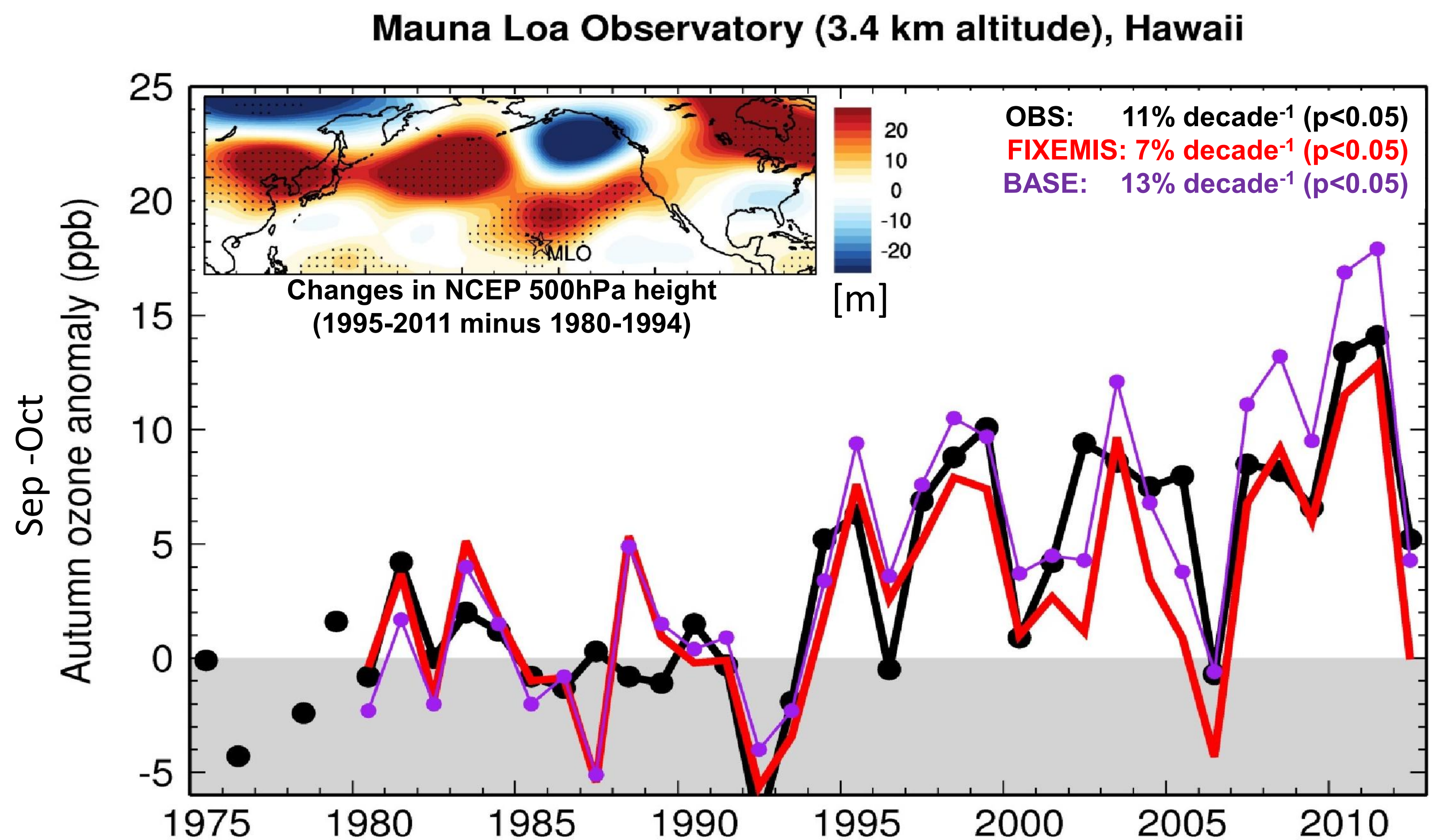
FIXEMIS

- Constant emissions
- Nudged to “real winds”



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

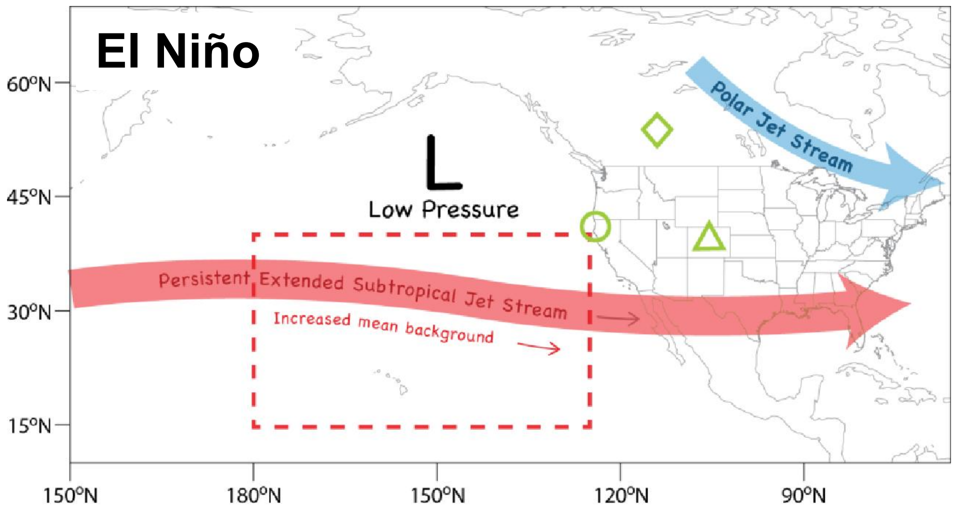
Increasing ozone at Mauna Loa in FALL tied to a shift in circulation patterns since the mid-1990s

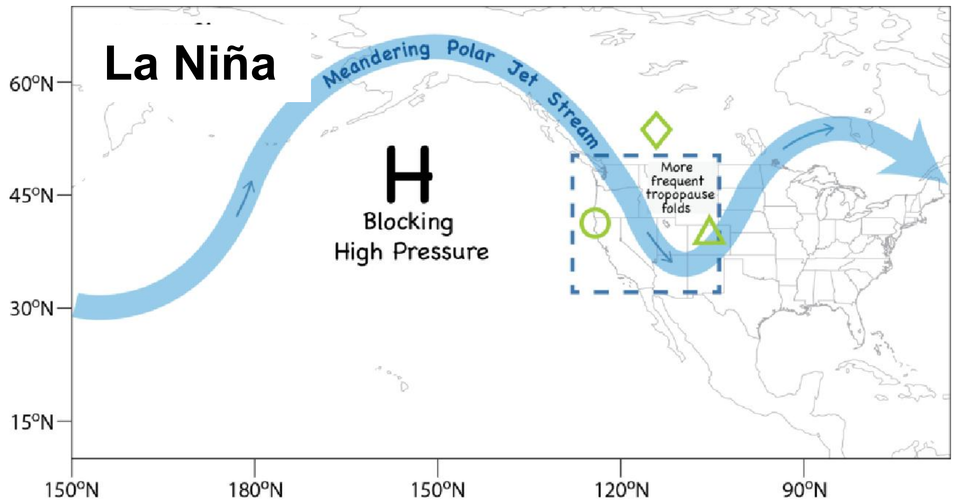


Must consider decadal climate variability as well as emission changes for attribution of pollutant trends

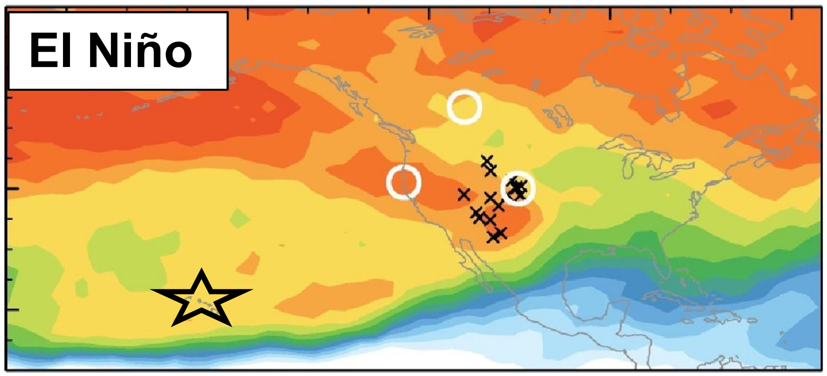
Lin M.Y. et al (Nature GeoSci., 2014)

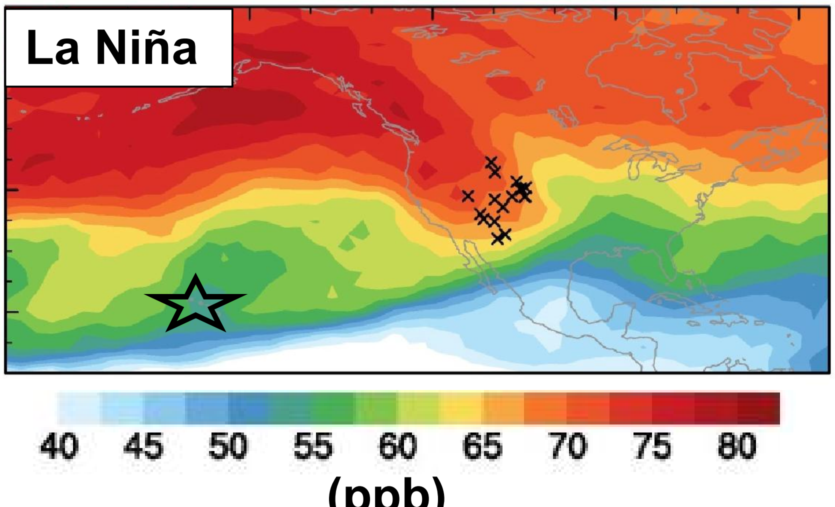
ENSO and mid-tropospheric O_3 over Pacific N.A. in SPRING





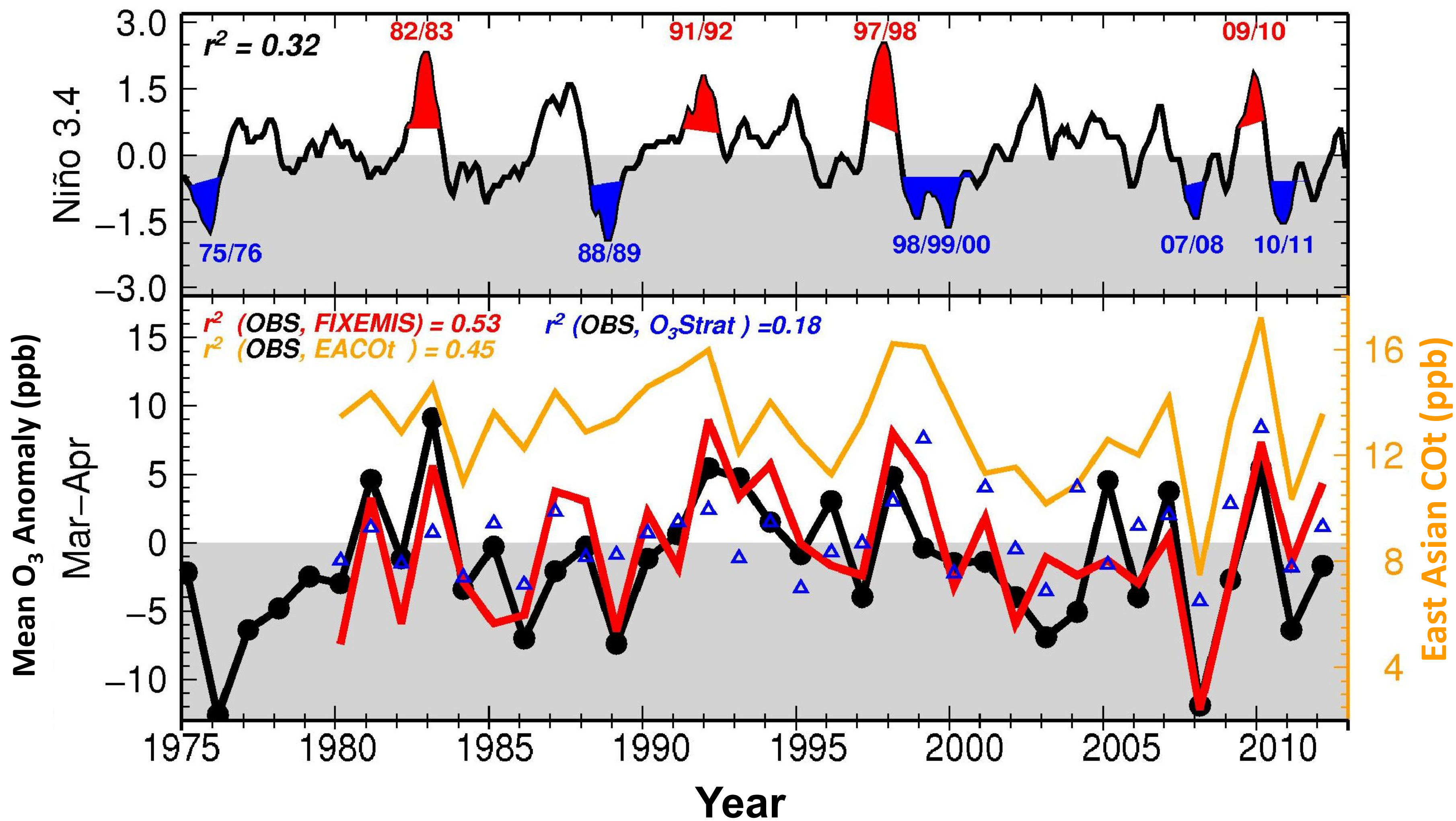
Median background O_3 at 500hPa





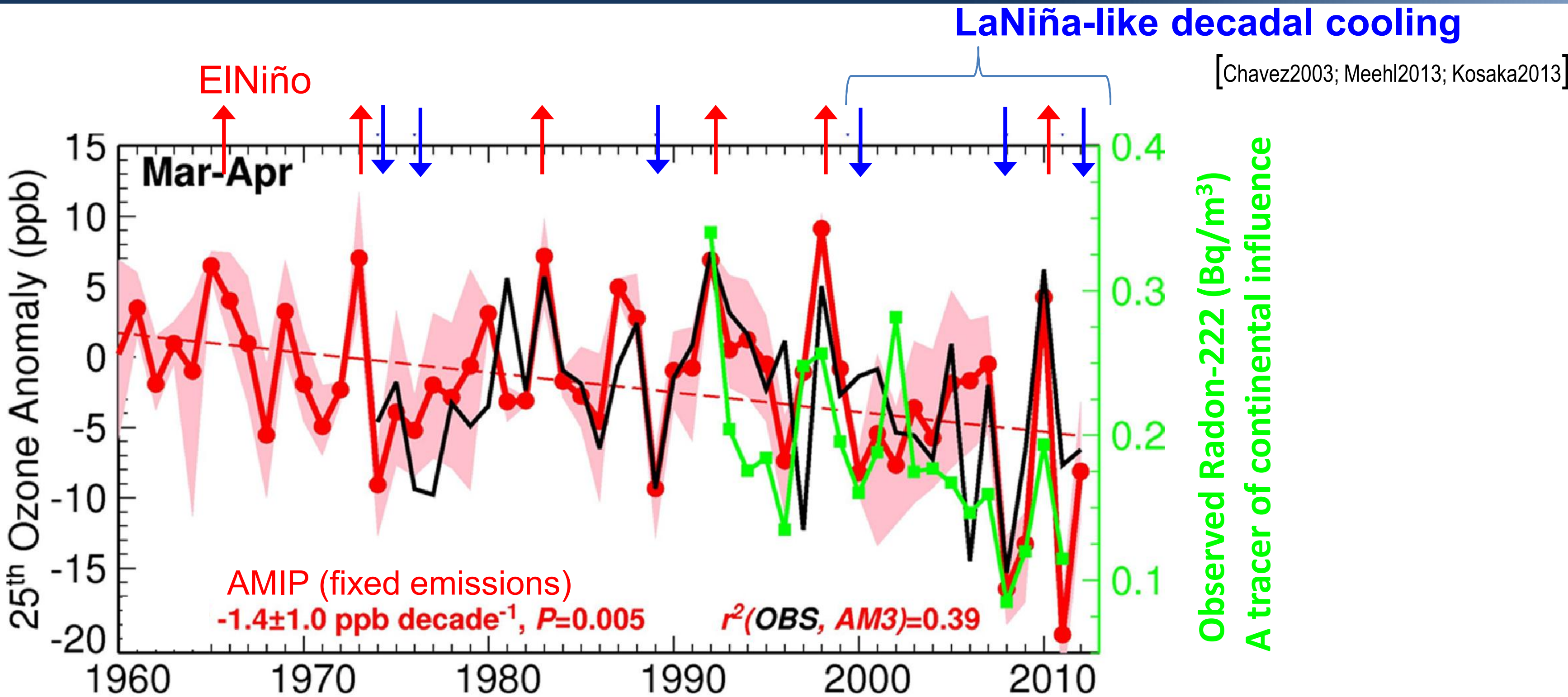
Lin M.Y. et al (2014b, in revision)

Following El Niño conditions, stronger airflow from Asia towards Hawaii in SPRING

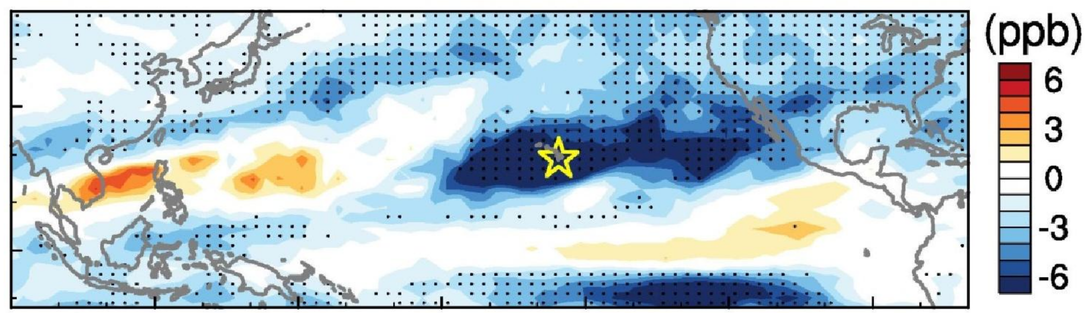


Lin M.Y. et al (Nature GeoSci., 2014)

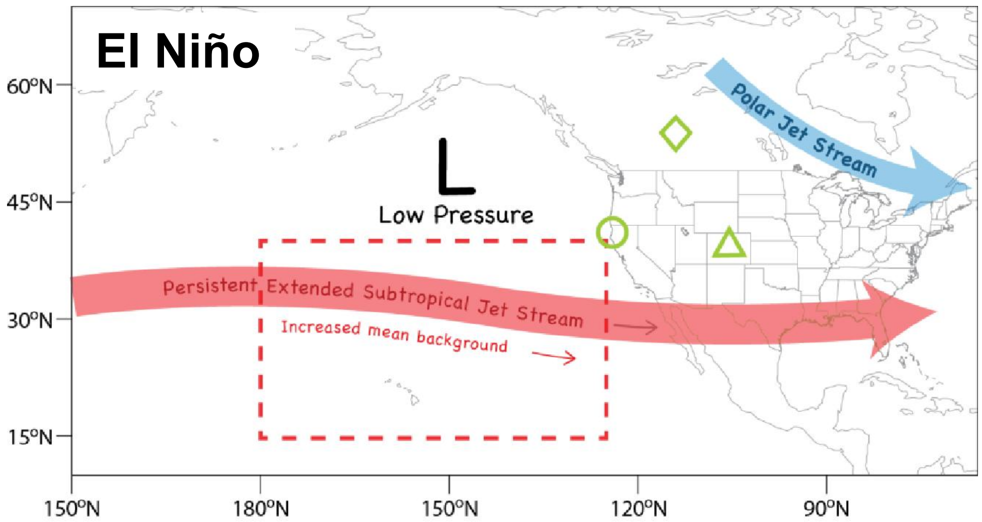
Decreasing ozone at Mauna Loa in SPRING tied to recent La-Niña-like decadal cooling + tropical expansion



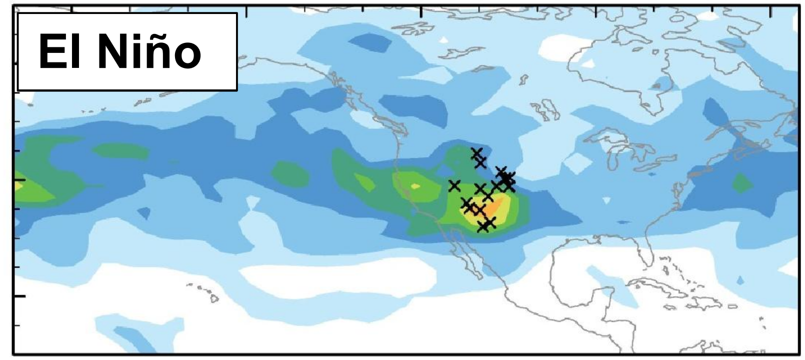
675hPa 25th percentile O_3 changes for ENSO Neutral conditions
(2000-2012 minus 1960-1975)

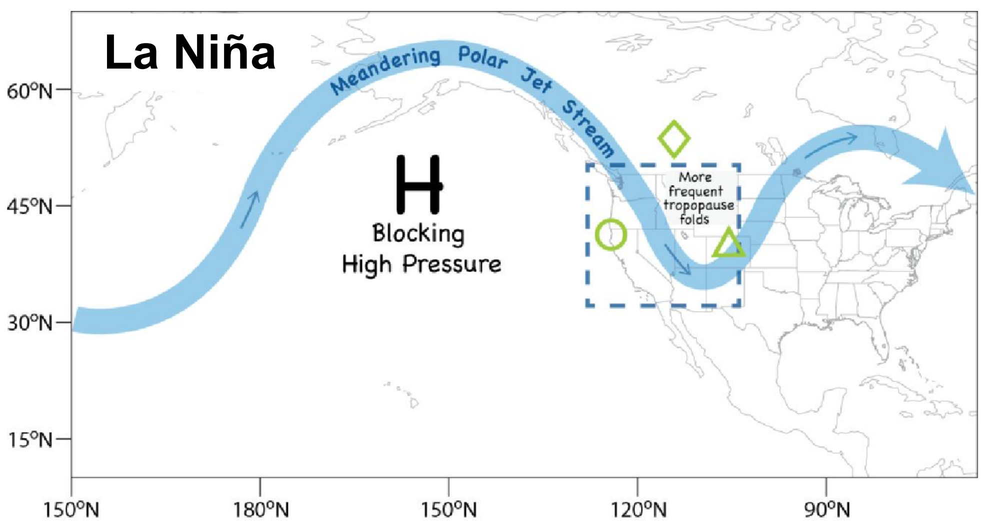


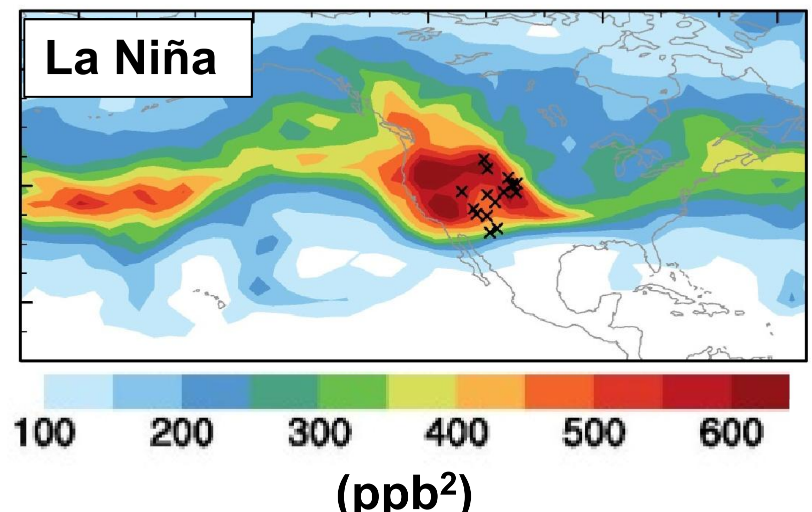
Following La Niña conditions, more frequent tropopause folds over Western N.A. in spring



Variance in daily O_3Strat at 500hPa



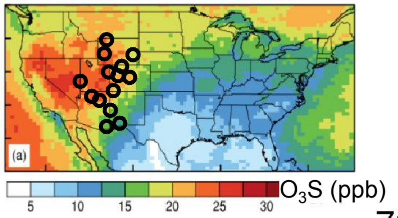


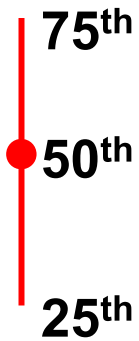


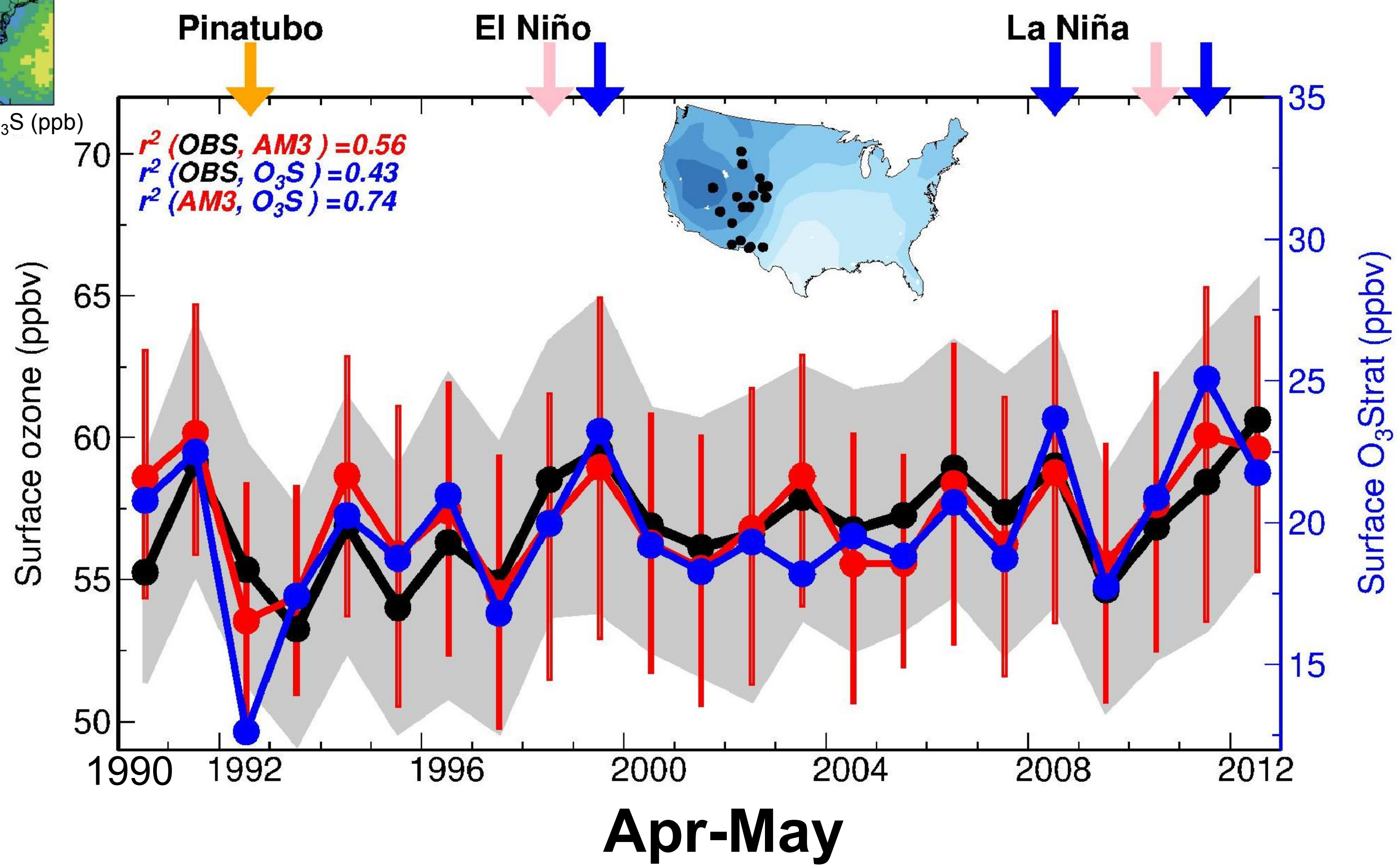
Lin M.Y. et al (2014b, in revision)

Strong stratospheric influence on year-to-year variability of Western U.S. surface O_3 during spring

High-altitude sites



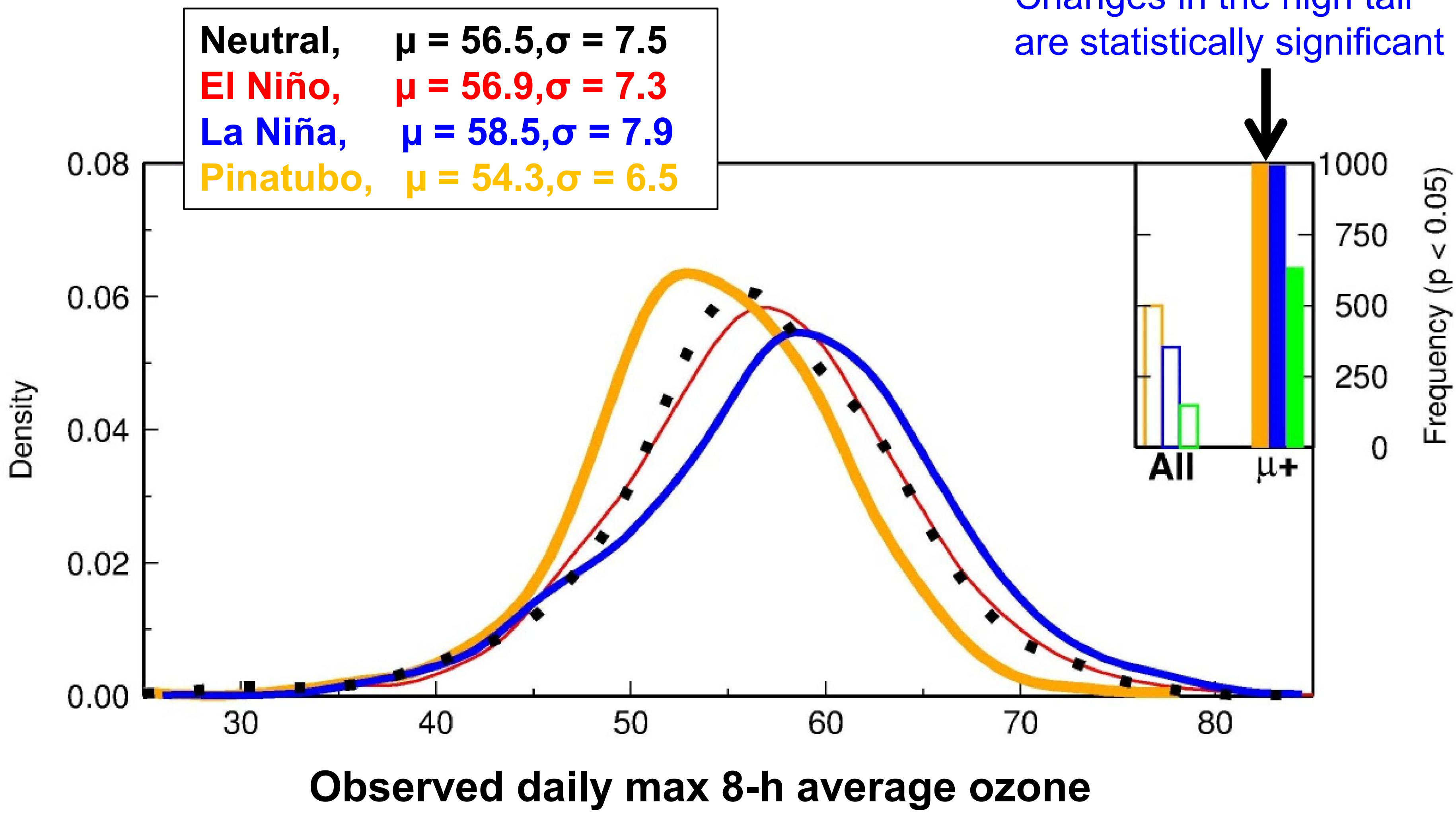




Lin M.Y. et al (2014b, in revision)

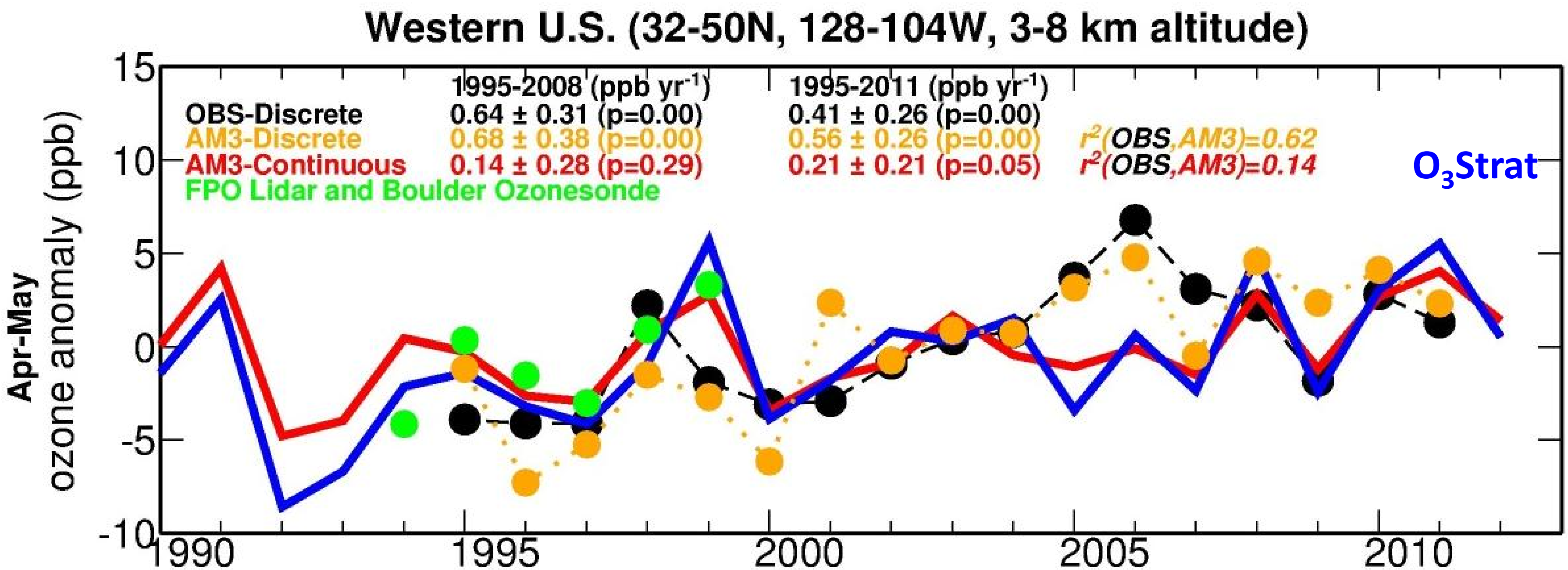
The high tail of the observed daily surface O_3 distribution over Western U.S. increases during La Niña springs

Changes in the high tail are statistically significant



Lin M.Y. et al (2014b, in revision)

Role of dynamical variability on free tropospheric ozone over Western U.S. during spring



- **Observations as in Cooper et al. [2010; 2012].**
- **Sparse sampling and short records may complicate the unambiguous attribution of observed trends**

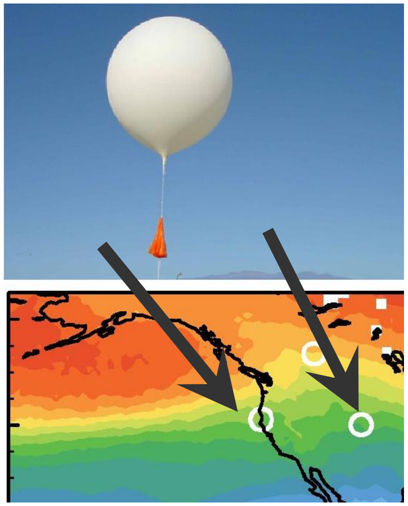
So what?

- Long-term ozone measurements contain signatures of interannual to decadal climate variability.
- Shifts in atmospheric circulation patterns should be considered when interpreting observed trends in tropospheric ozone levels.
- Sparse sampling and short records may complicate the unambiguous attribution of observed trends.
- An apple-to-apple comparison must be ensured when interpreting bias between models and observations.

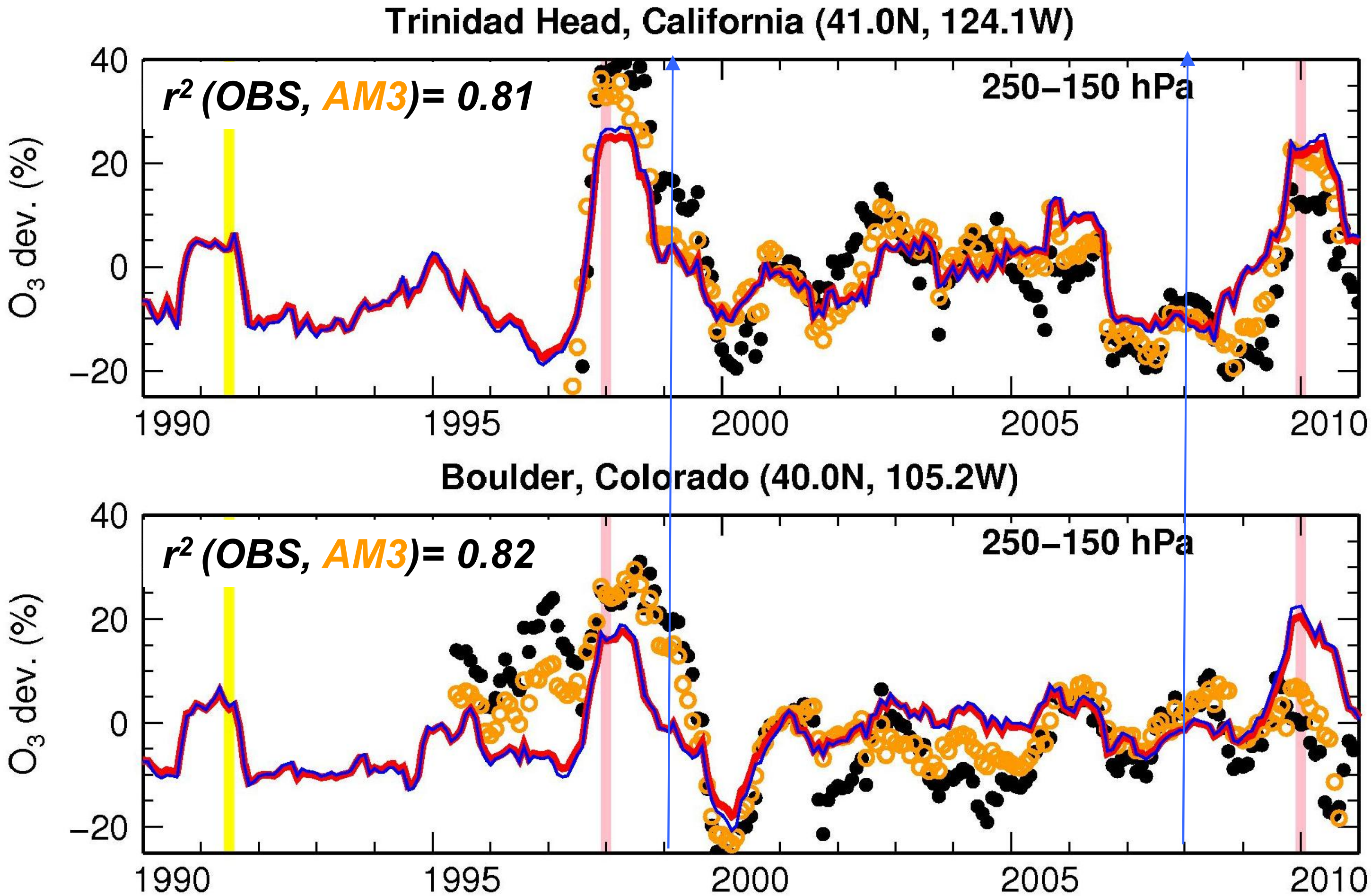
Contact: Meiyun.Lin@noaa.gov

Additional slides for Q & A

Changes in lower stratospheric ozone



12-month running mean



- ***UT/LS O_3 is observed to increase following El Niño conditions***
  (see also Langford et al.,1998; Bronnimann et al., 2004; Manzini, 2009; Randel et al., 2009)
- ***Little change in UT/LS O_3 during La Niña despite increased O_3S in surface air***