Aura Science Team Meeting, Pasadena, Oct 1-3, 2012

Identifying and forecasting deep stratospheric ozone intrusions over the western United States from space

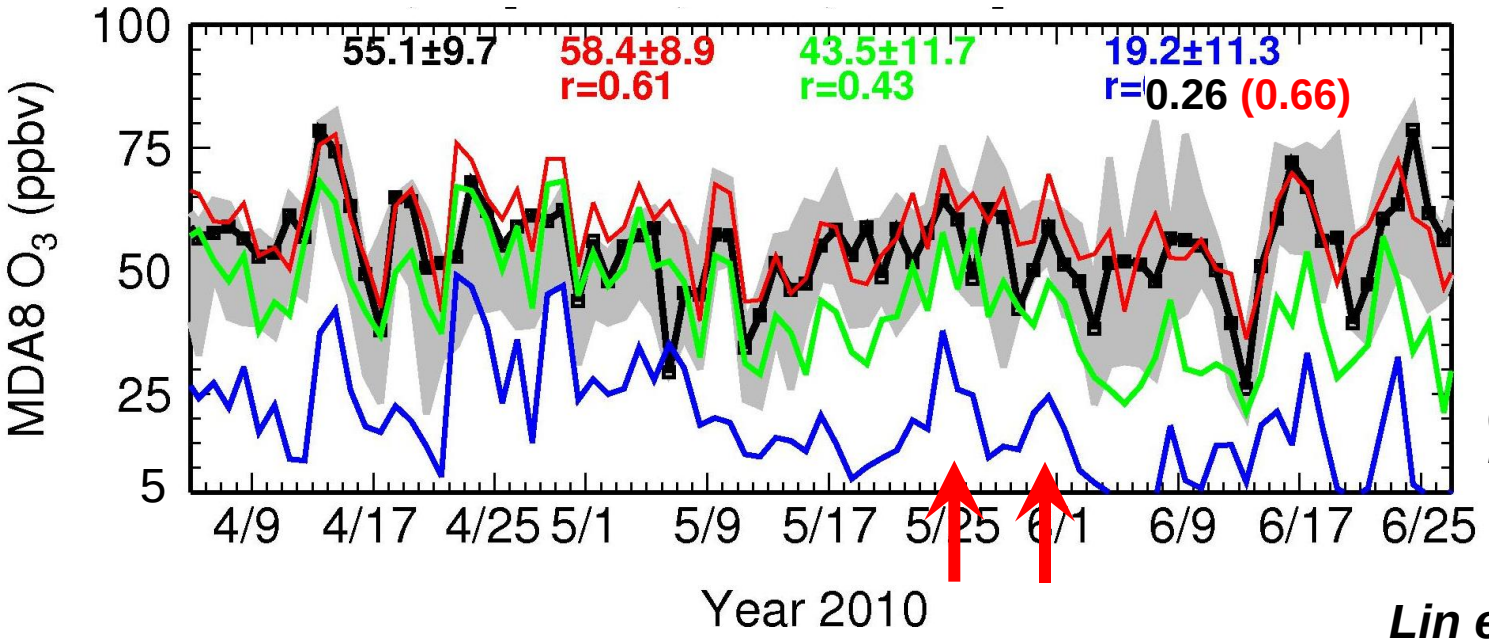
Meiyun Lin

Princeton University & NOAA GFDL

Collaborators: A. M. Fiore, L. W. Horowitz, X. Liu, L. L. Pan, O. R. Cooper, A. O. Langford, P. J. Reddy

Stratospheric intrusions drive a substantial portion of springtime high surface O_3 events in U.S. West

Daily max 8-hr average surface O_3 at Boulder (~2 km a.s.l.), Colorado



OBS (Range ~100km)

GFDL AM3

NA background

O_3-Strat
(w/ e90 tropopause, Prather et al., 2011)

Lin et al., 2012, JGR

Insights from a global Hi-Res model and multi-platform obs [*Lin et al., 2012; Langford et al., 2012*]

- Stratospheric intrusions can episodically increase surface MDA8 O_3 by 20-40 ppb, including on days when observed O_3 exceeds the standard (75 ppbv)

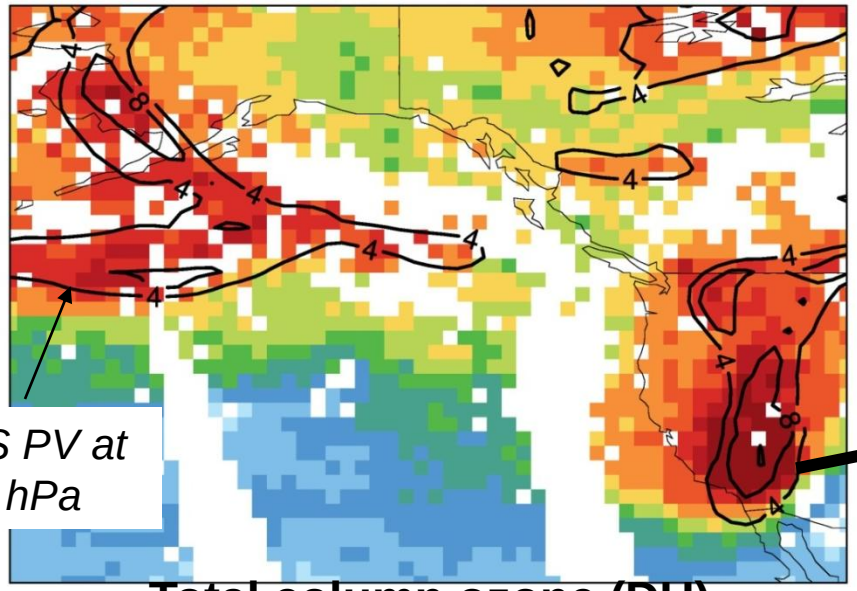
The policy challenge: 1) Screening of "exceptional events"
2) Advanced warning of incoming intrusions

→ Can Aura (OMI) and Aqua (AIRS) sensors help to predict these events ?

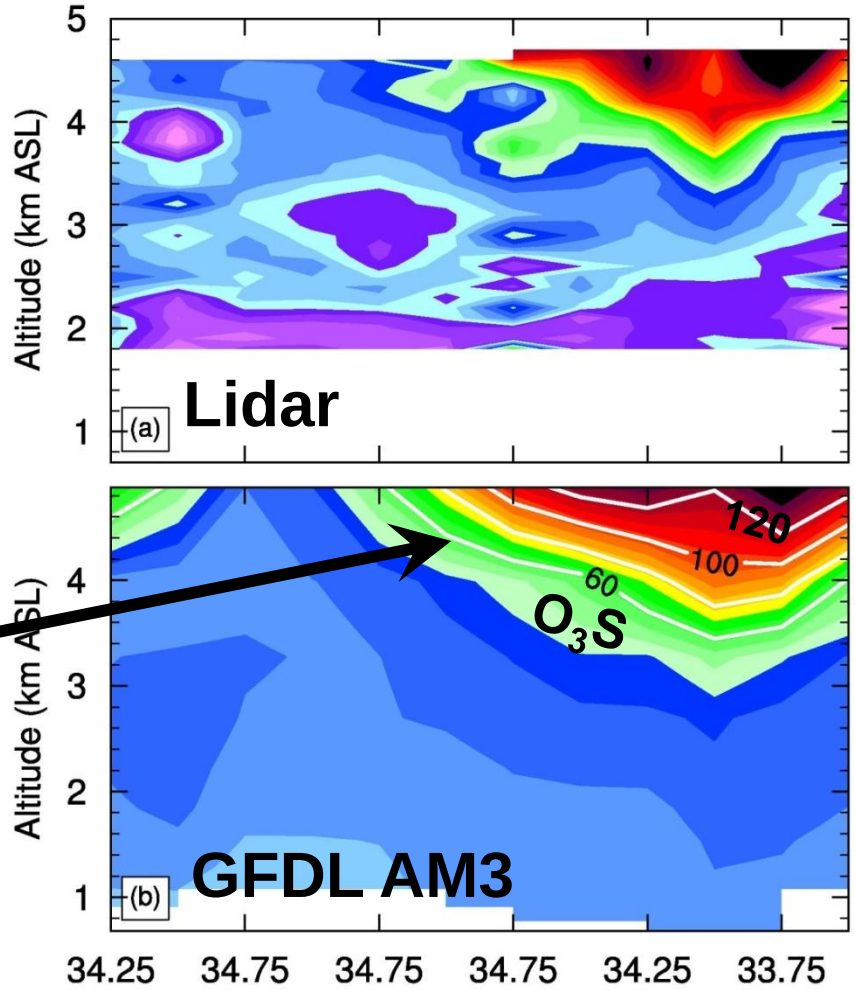
Total column O_3 retrievals capture the **dynamical variability** of O_3 due to a stratospheric intrusion (N→S)

Aqua AIRS Ascending, May 23, 2010

[V5.2; *Susskind et al., 2003*]



Southern California

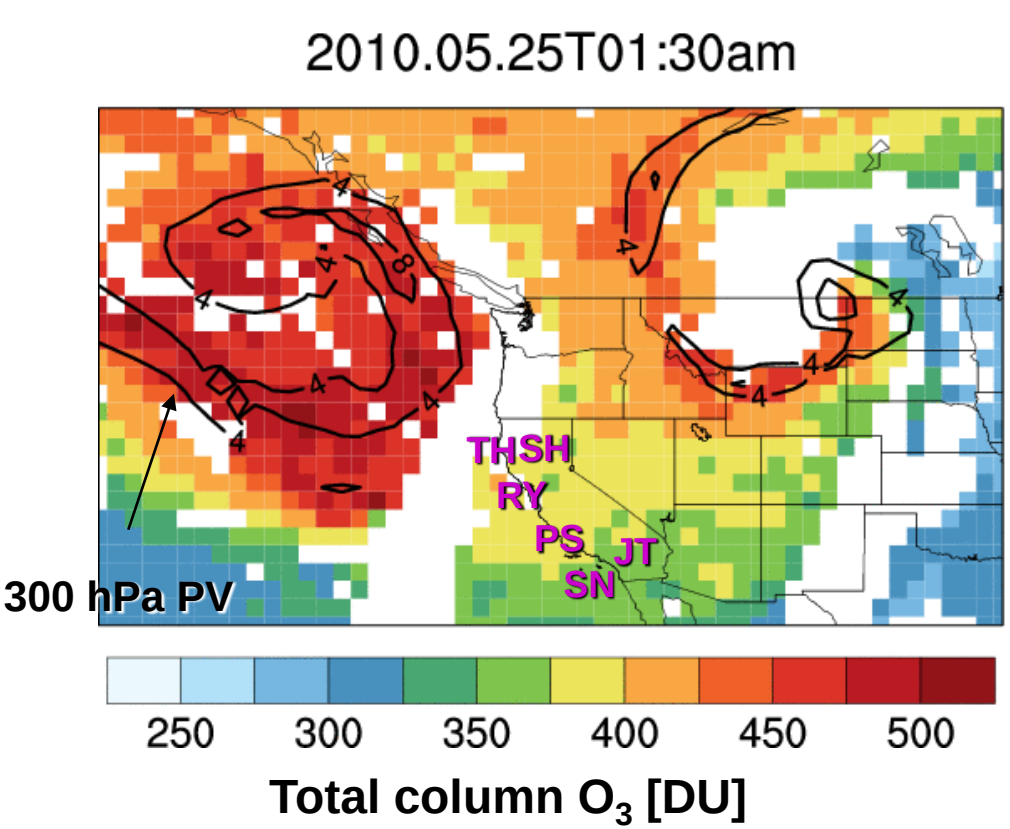


Consistent dynamic features in AIRS, PV, model and lidar measurements

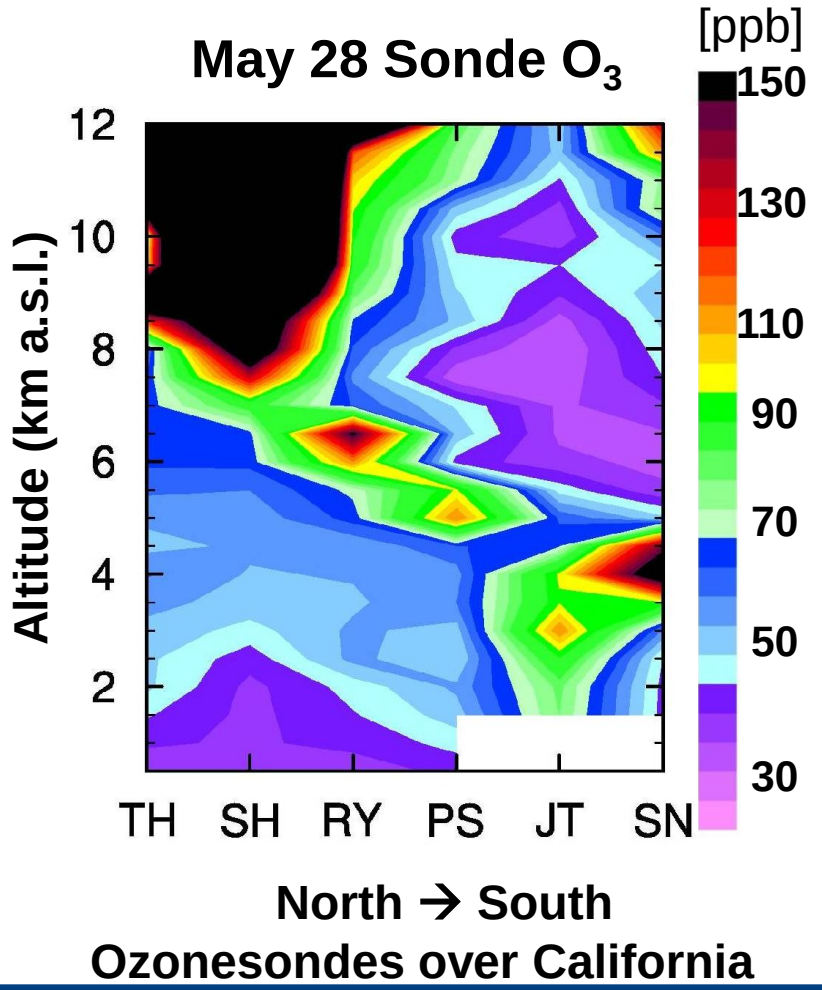
[see also *Pan et al., 2007; Pittman et al., 2009; Wei et al., 2010*]

AIRS captures **day-to-day progression** of upper dynamics conducive to deep stratospheric intrusions over the western U.S.

AIRS total column O_3 animated every 12 hours from May 25-29, 2010

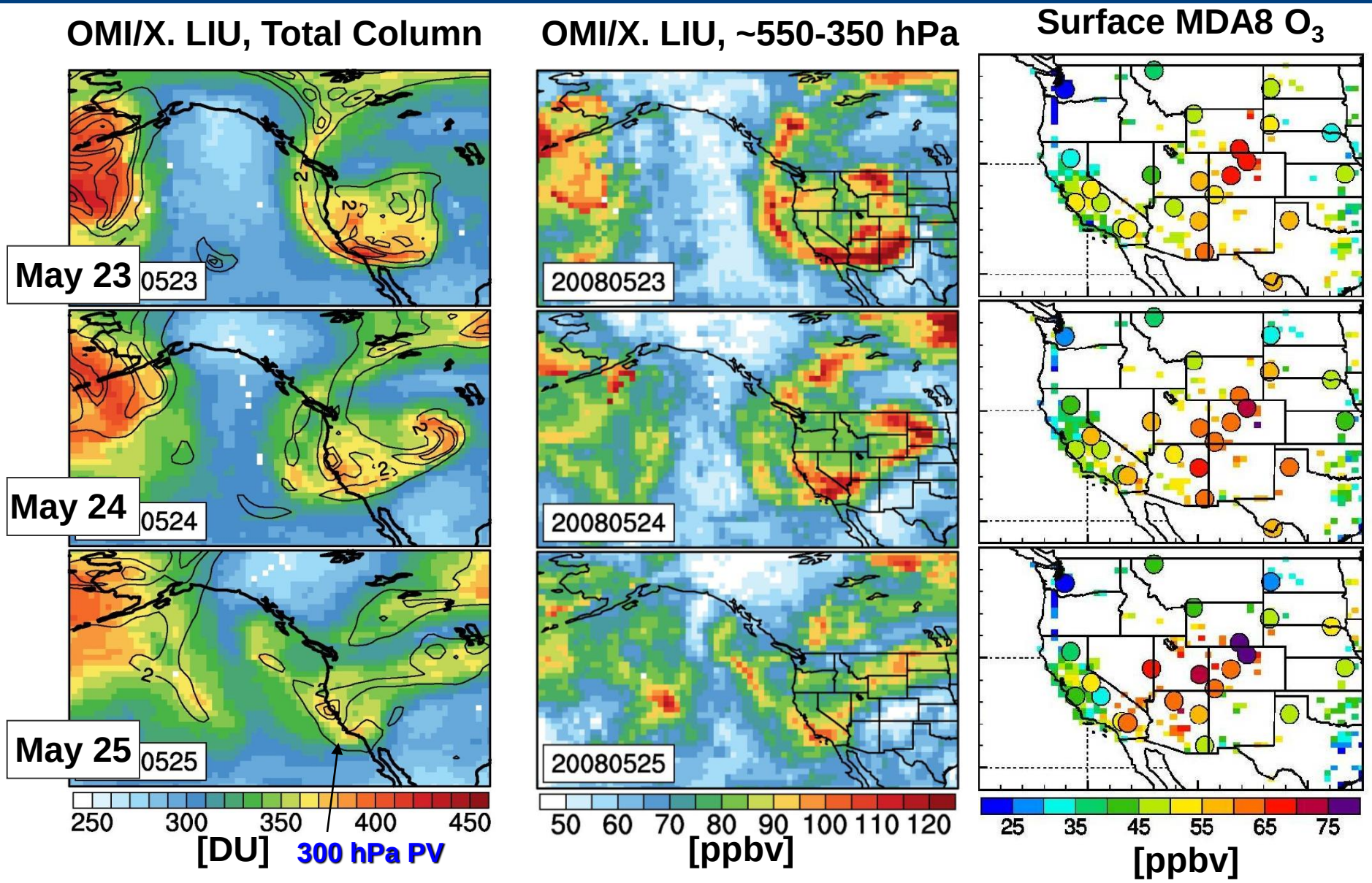


May 28 Sonde O_3



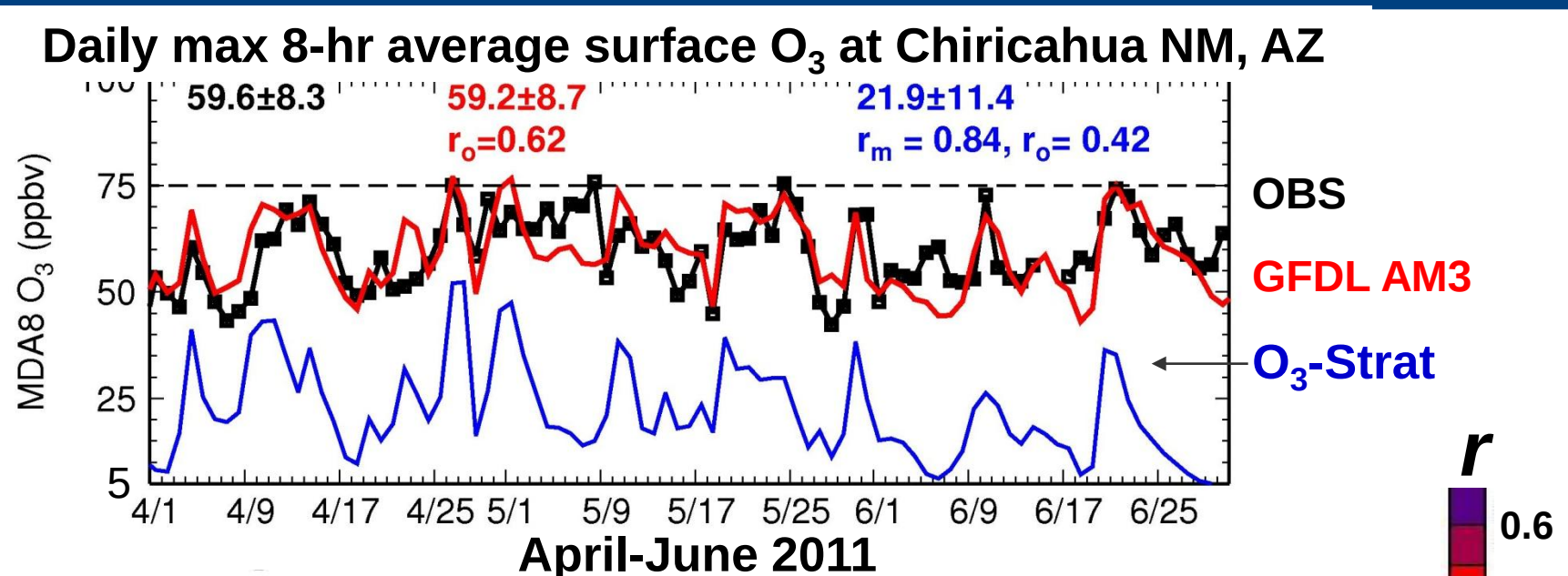
Western U.S. is prone to deep intrusions
→Co-varying O_3 enhancements in the UT/LS and in the lower trop

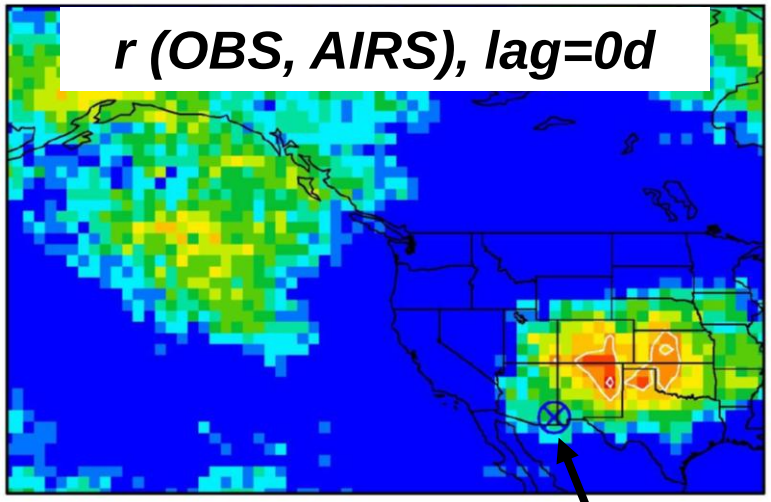
Spatial pattern: Surface O_3 is highest to the SE of where OMI column and mid-trop O_3 are enhanced (May 23-25, 2008 example)

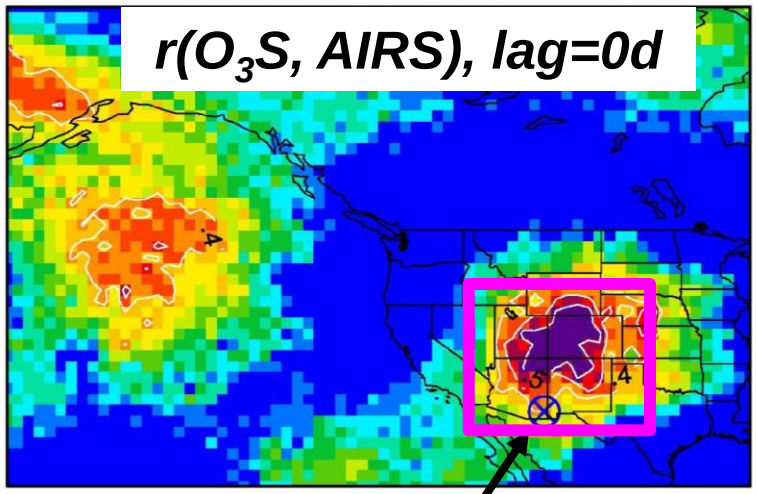


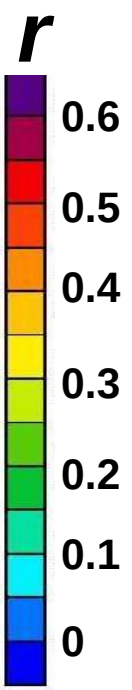
Towards a predictive relationship:

Correlations of daily AIRS UT/LS ozone and surface ozone





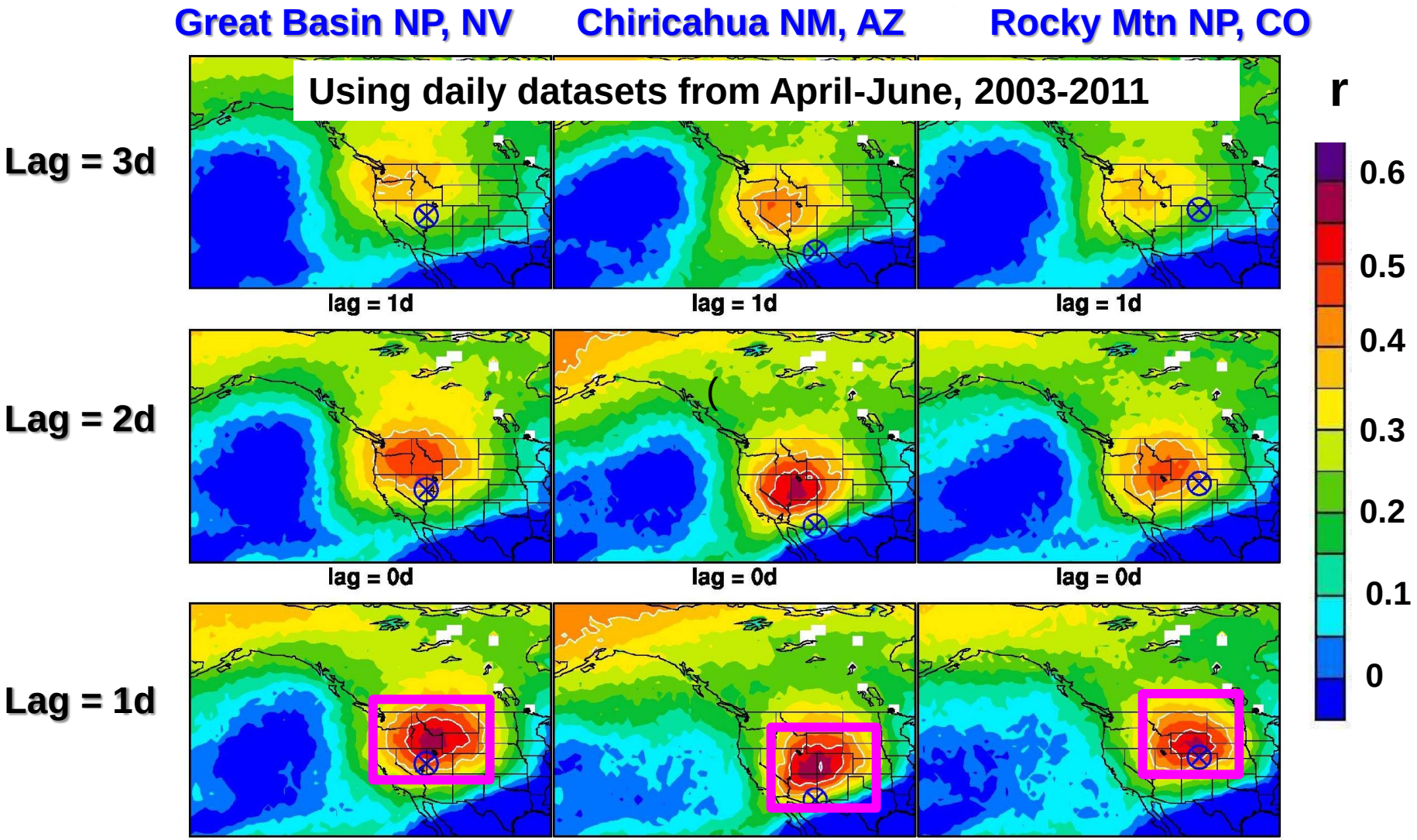




Correlation coefficient of observed O_3 and AM3 O_3S at **CHA** surface site, respectively, with AIRS 300 hPa O_3 at each 1ºx1º grid using daily datasets from **April-May in 2011**

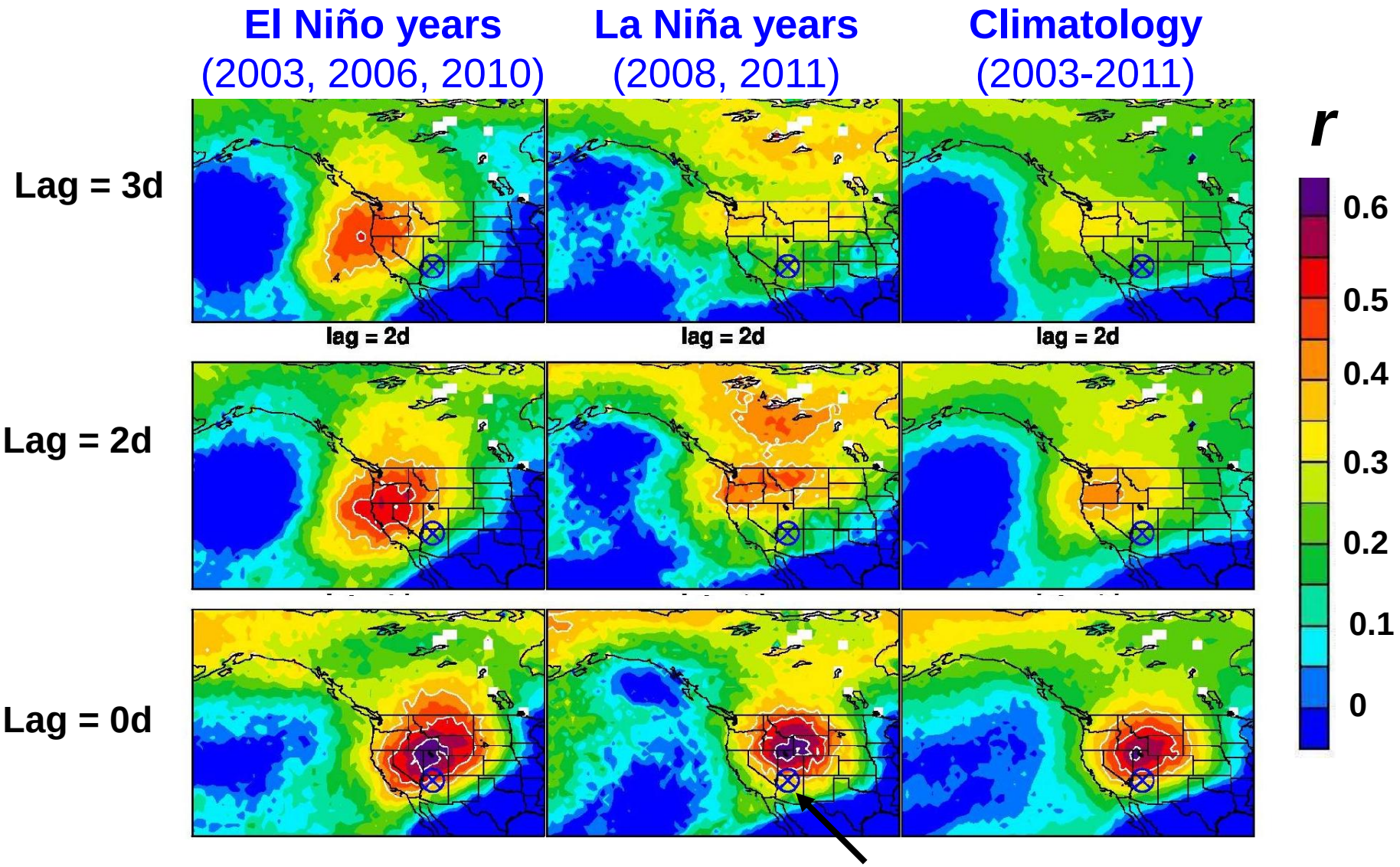
Forecasting surface destinations of transported O_3-strat:

AIRS variability ~5ºx5º NW of a receptor site indicates incoming intrusions



Stronger potential for accurate prediction in ~1 day as to where the intrusion will reach the surface

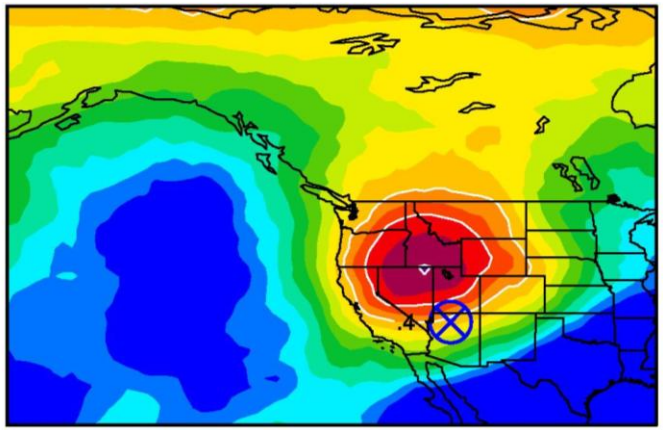
The spatial pattern of correlations varies interannually: Links to ENSO



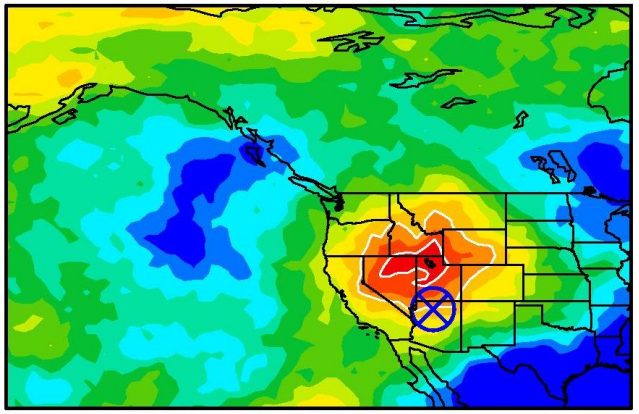
Correlation coefficient of **AM3 surface O_3S at Grand Canyon NP with AIRS total O_3 at each 1ºx1º grid**, **0-3 days prior** using datasets from April-June

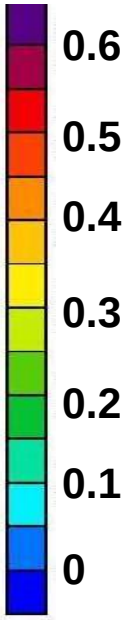
This first scoping study suggests potential for developing space-based indicators for day-to-day variability in stratospheric influence at WUS surface sites

r (surface O_3S, OMI total column O_3)



r(surface O_3S, OMI ~250-350hPa O_3)





Correlation coefficient of AM3 surface O_3S at Grand Canyon NP with **OMI data on the previous day** using daily datasets from April-June, 2005-2008

Potential AQ Applications:

- **Screening of "exceptional events"…**combined with suborbital observations
- **Advanced warning of regional high O_3-Strat events with a lead time of ~1-3 days** (more skill in 1 day)

→ **Qualitatively promising …ongoing work for a quantitative relationship ($\triangle O_3$)**

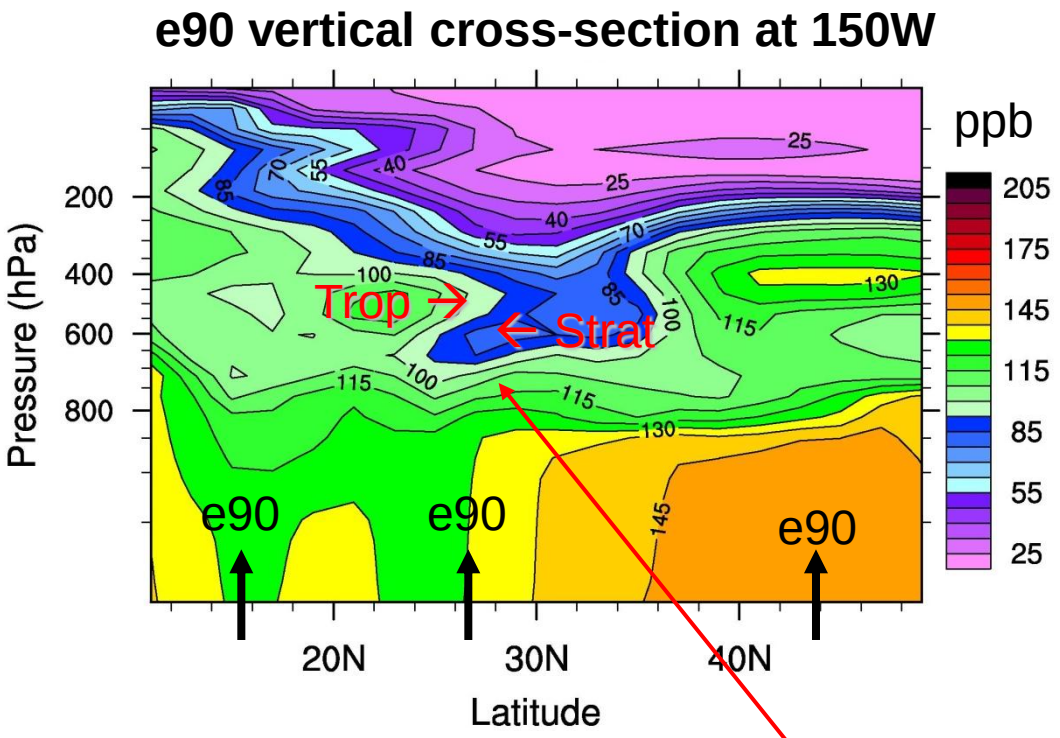
→ **Utility of other Aura ozone products, e.g. MLS and TES?**

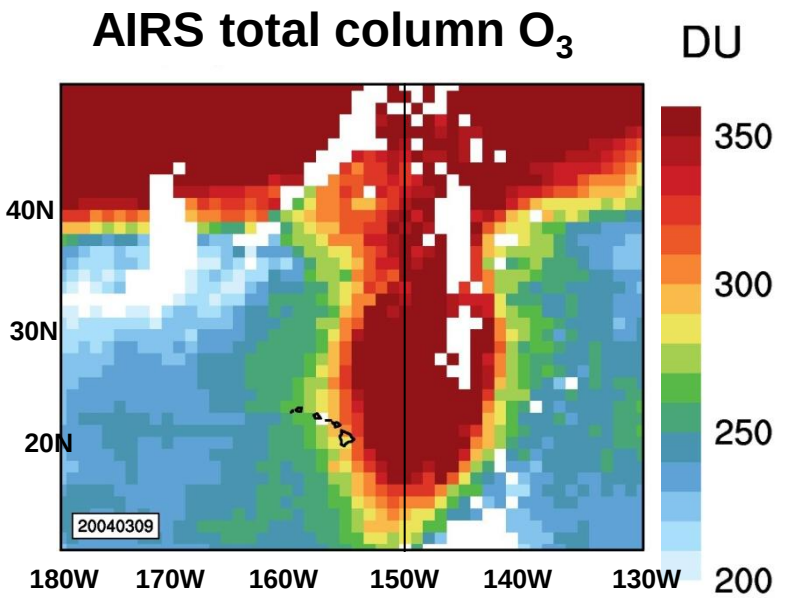
For discussion, please contact Meiyun.Lin@noaa.gov

Additional info for Q&A

Lin, M., A. M. Fiore, O. R. Cooper, L. W. Horowitz, A. O. Langford, H. Levy II, B. J. Johnson, V. Naik, S. J. Oltmans, and C. J. Senff (2012), ***Springtime high surface ozone events over the western United States: Quantifying the role of stratospheric intrusions***, *J. Geophys. Res.*, 117, D00V22, doi:10.1029/2012JD018151.

e90 tropopause tracer and O_3-Strat tagging in GFDL AM3: showing a deep intrusion over Hawaii on March 9, 2004





Dynamically varying e90 tropopause tracer *[Prather et al., 2011]:*

1) Emitting at the surface uniformly and statically; 90-day e-folding lifetime

2) Differentiate **stratospheric** (< 85 ppb) vs. **tropospheric** (>= 85 ppbv) air

Stratospheric O_3 tracer (O_3S) *[Lin et al., 2012b]:*

1) Set to simulated O_3 in stratospheric air; allowing multiple tropopauses

2) Subject to chemical and depositional loss in tropospheric air

…Transport of O_3, O_3S, and e90 fully driven by meteorology…