AQAST3, UW-Madison, 6/13/2012

Strong stratospheric impacts on surface ozone episodes over the western U.S. in spring: Not-so-rare events?

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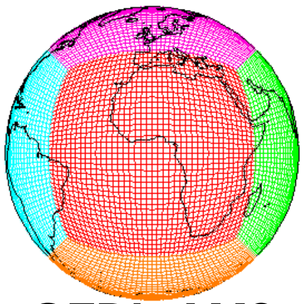
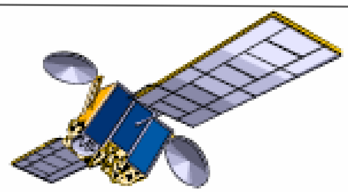
AQ Managers: **Joe Pinto** (EPA NCEA); **Pat Dolwick** (EPA OAR)
AQ Outcomes: **Contributions to the ozone ISA**

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



GFDL AM3



AIRS, GOES-West

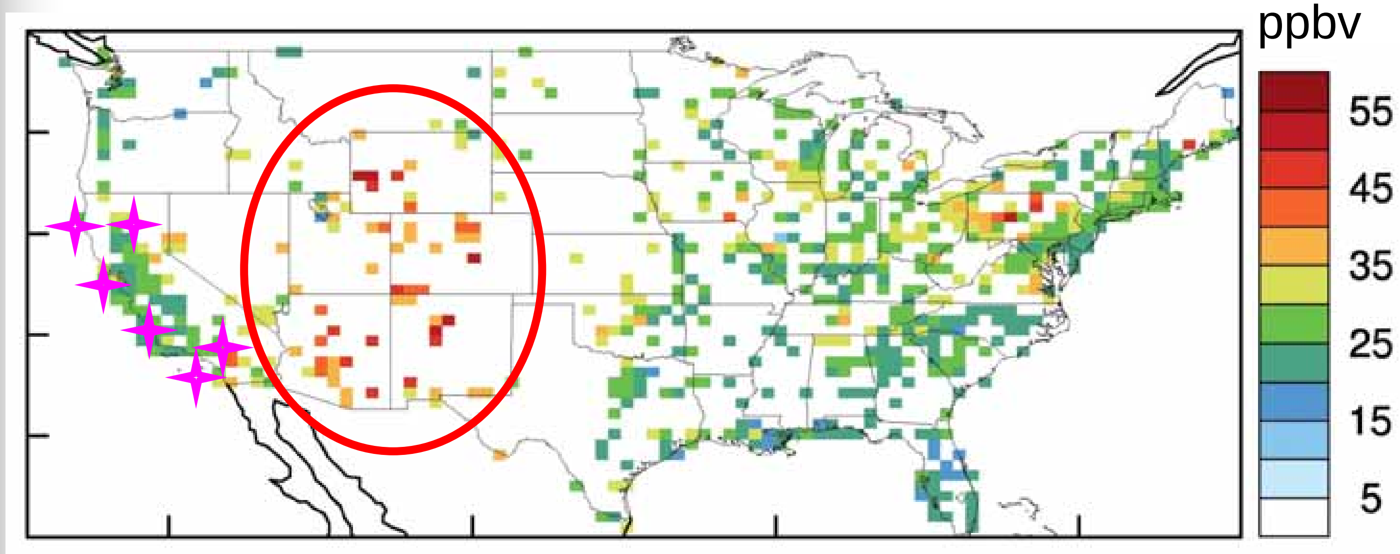
The NEW GFDL AM3 model:

1) Cubed-sphere grid at ~50x50 km^2 (CalNex 2010)
48 vertical levels (surface→ 86 km)

2) Nudged to NCEP GFS winds [*Lin et al., 2012a; JGR*]
(weakening the nudging strength with decreasing pressure)

3) Fully coupled strat & trop chem [*Donner et al., 2011*]
as opposed to using Linoz or Synoz tracers in prior CTMs

4) Stratospheric O_3 tracer (O_3S) defined relative to a dynamically-varying tropopause *[e90; Prather et al., 2011]*



Maximum strat. impacts on surface O_3 in Apr-Jun 2010
(8-hour average; bias-corrected)

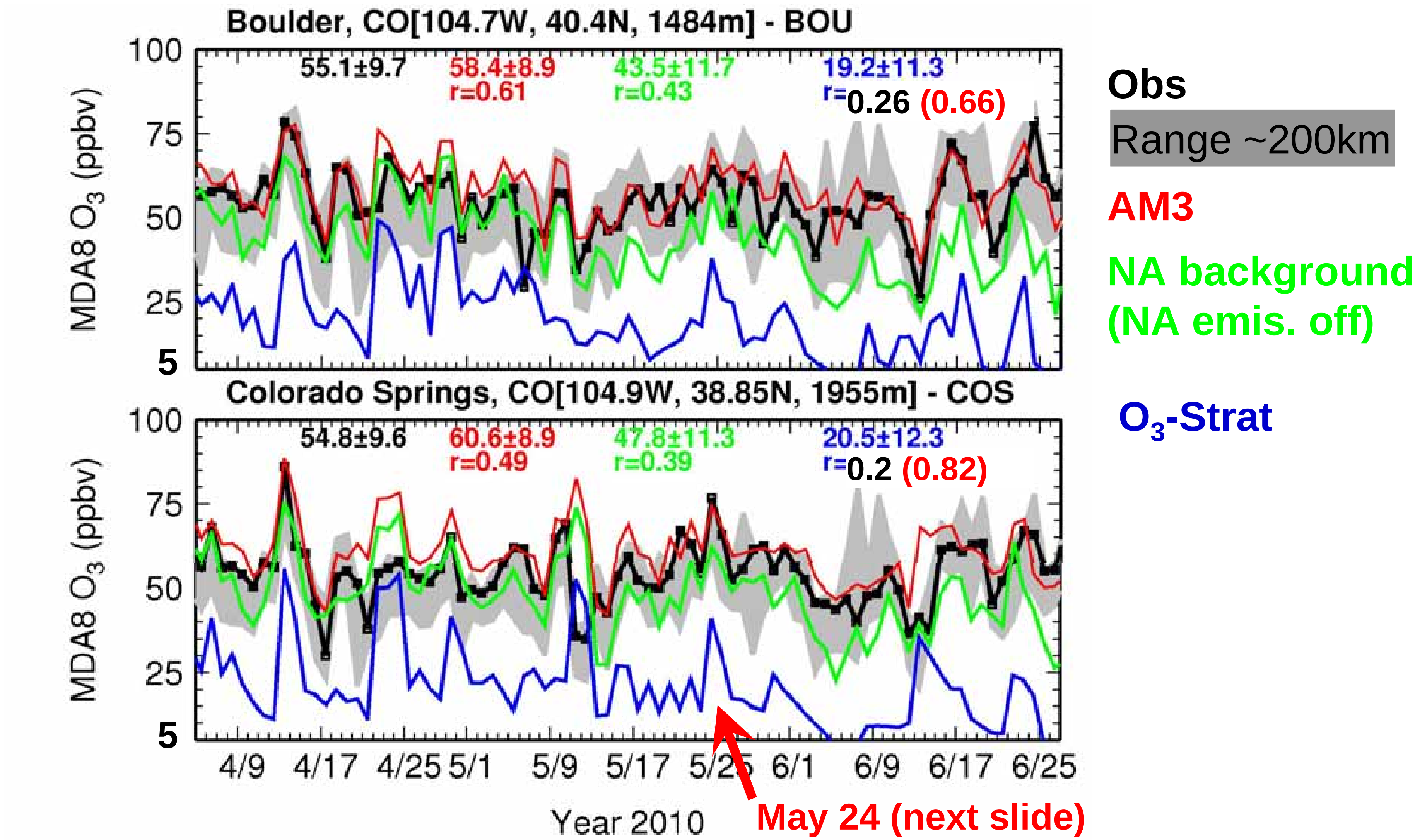
Thirteen intrusions in Apr-Jun 2010 enhanced daily max 8-hour ozone to 60-85 ppbv at WUS surface sites

Events	Synoptic conditions in satellite imagery	Descent captured in ozonesondes, lidar, aircraft	Major surface impact regions
Apr. 6-7	AIRS /GFS PV	Not measured	Colorado, New Mexico, Wyoming
Apr. 9-10	AIRS/GFS PV	Not measured	Wyoming
Apr. 12-15	AIRS/GFS PV	Not measured	Arizona, Colorado, Utah
Apr. 21-23	AIRS/GFS PV	Not measured	Colorado, Nevada
Apr. 28-29	AIRS/GFS PV	Not measured	Colorado, Wyoming
May 11-13	AIRS/GOES-West	Sonde, P-3 aircraft	Arizona, New Mexico, W. Texas
May 17-20	AIRS/GOES-West	Sonde	California, Wyoming
May 22-24	AIRS/GOES-West	Sonde and lidar	New Mexico and Colorado
May 27-29	AIRS/GOES-West	Sonde and lidar	Arizona, California, Nevada
Jun. 7-8	AIRS/GOES-West	Sonde	Idaho, Utah, Wyoming
Jun. 10-15	AIRS/GOES-West	Sonde	Spread in Southwest
Jun. 16-17	AIRS/GOES-West	Sonde	Colorado
Jun. 22-23	AIRS/GFS PV	Not measured	Colorado

→ **Five events directly led to exceedances of the NAAQS**

→ **In discussion with EPA R8 managers to flag events + quantify baseline**

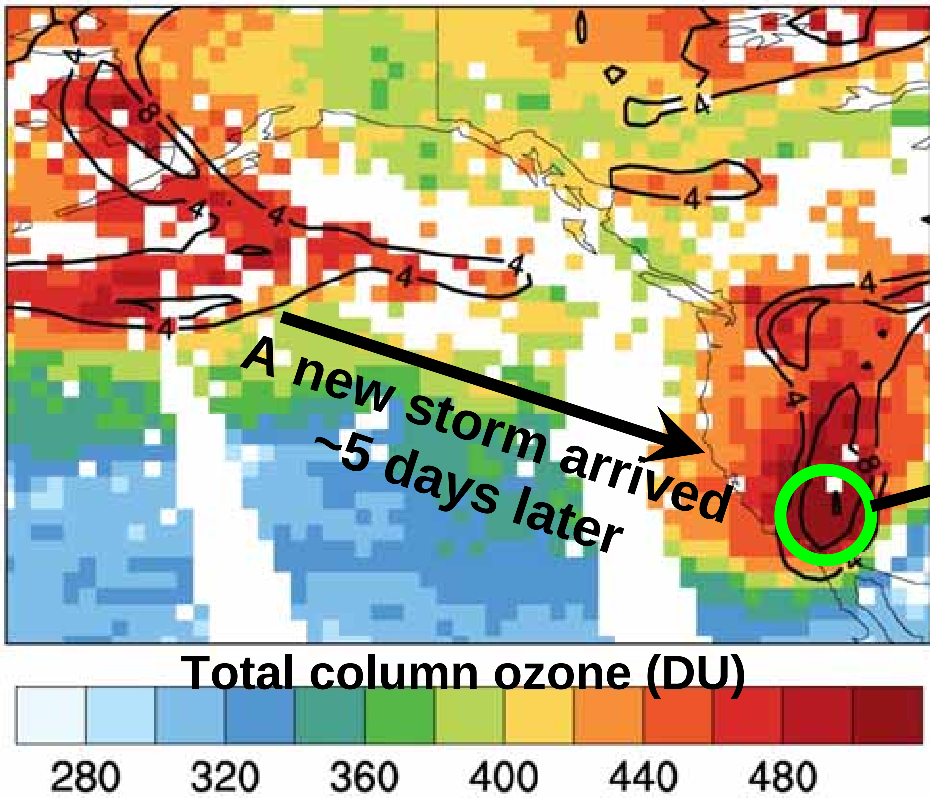
Stratospheric intrusions drive a substantial portion of the observed synoptic variability of surface ozone



- **AM3 captures some high-O_3 events due to stratospheric influence**
- **But limitations, due to resolution of meso-scale meteorology**

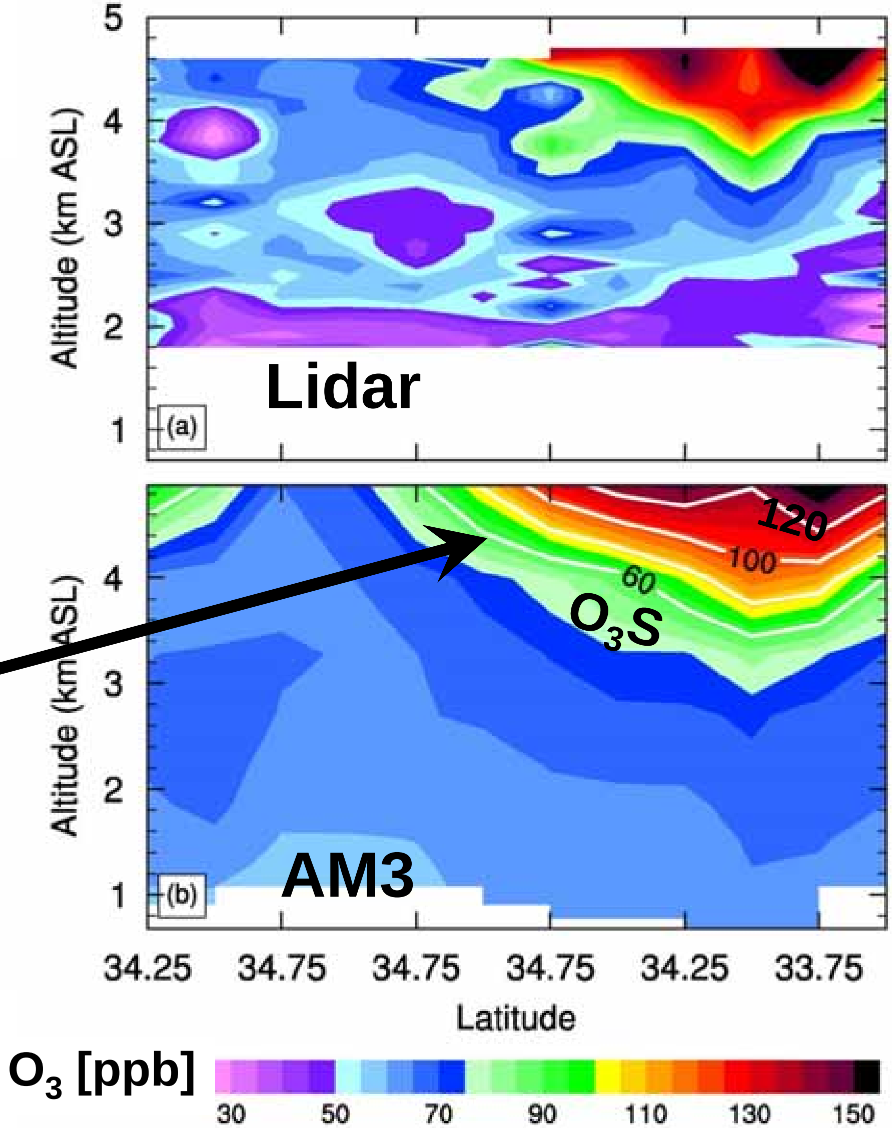
Observing stratospheric intrusions from space: Consistent with AM3 lidar and (May 23, 2010)

NASA/Aqua AIRS
Ascending orbit (~1:30 pm)

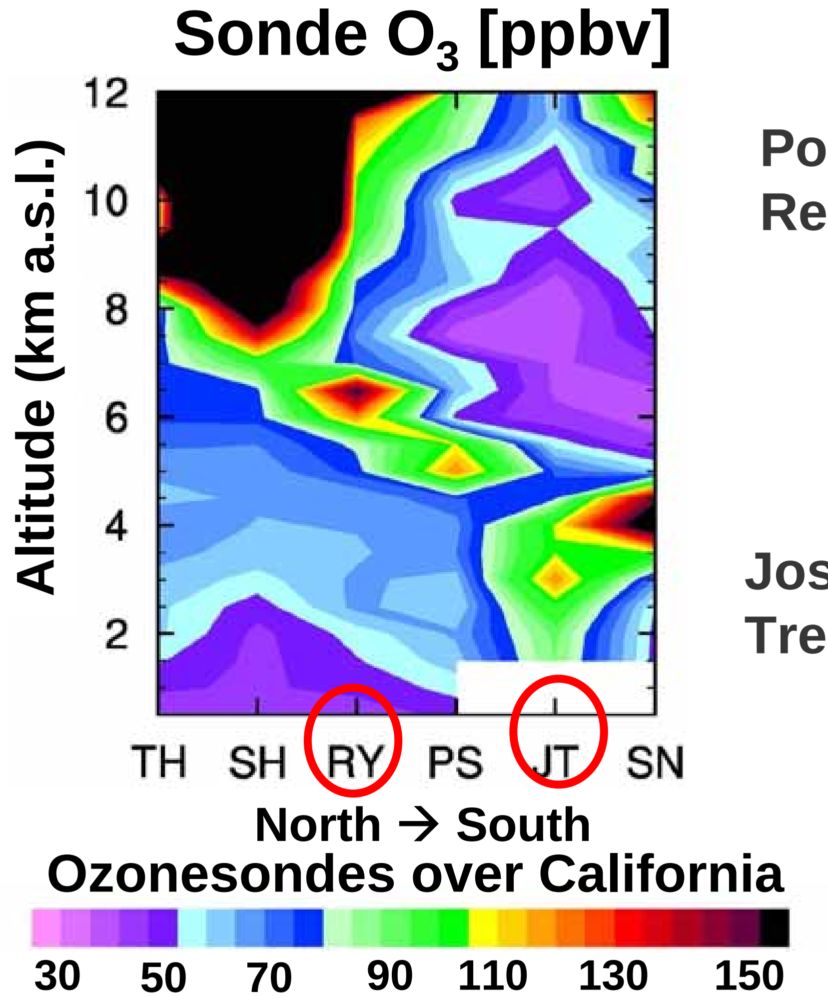


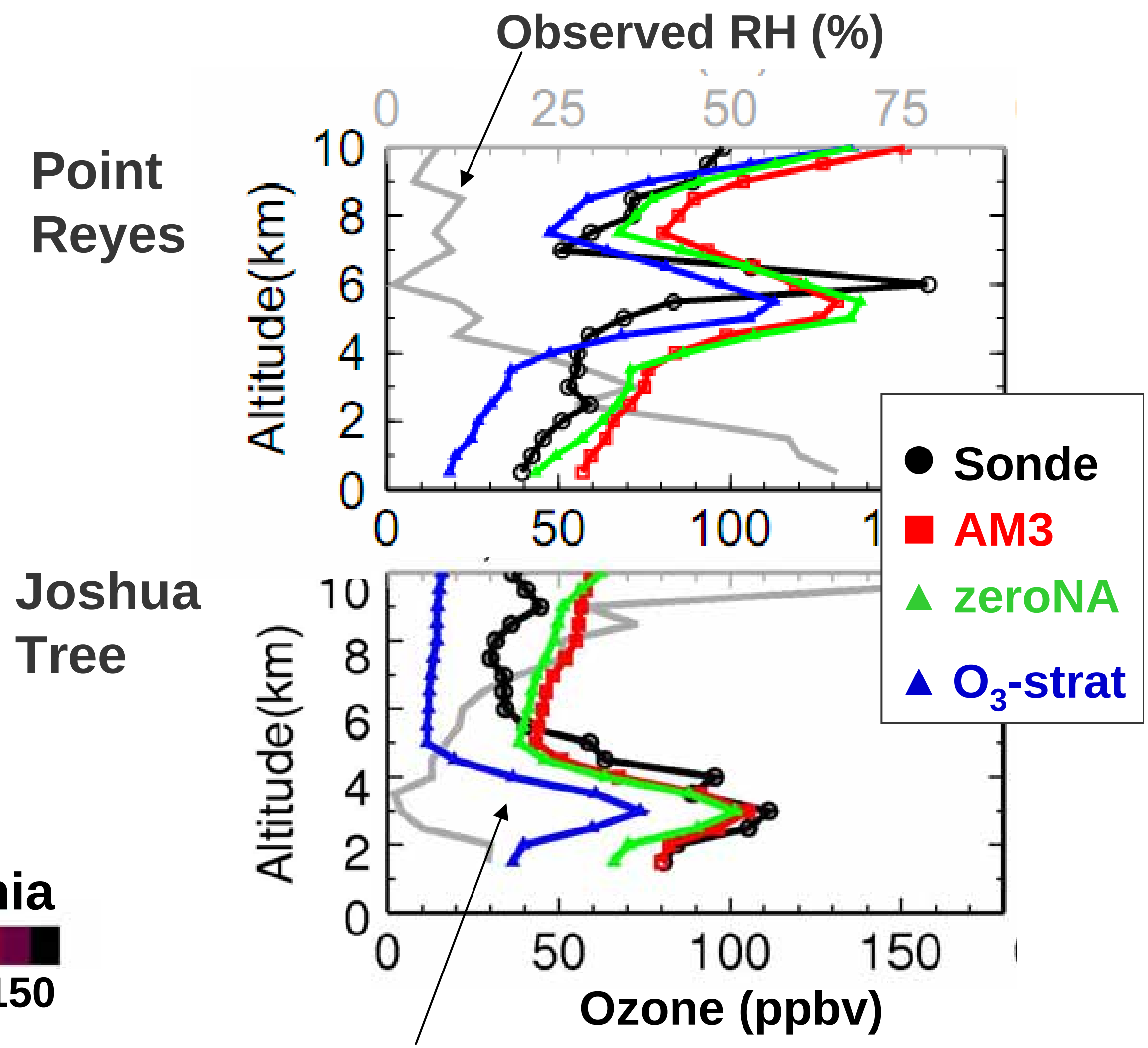
Contours (GFS PV at 300 hPa)

Southern California



Subsidence of stratospheric O_3 to the lower trop of S. California (May 28, 2010)

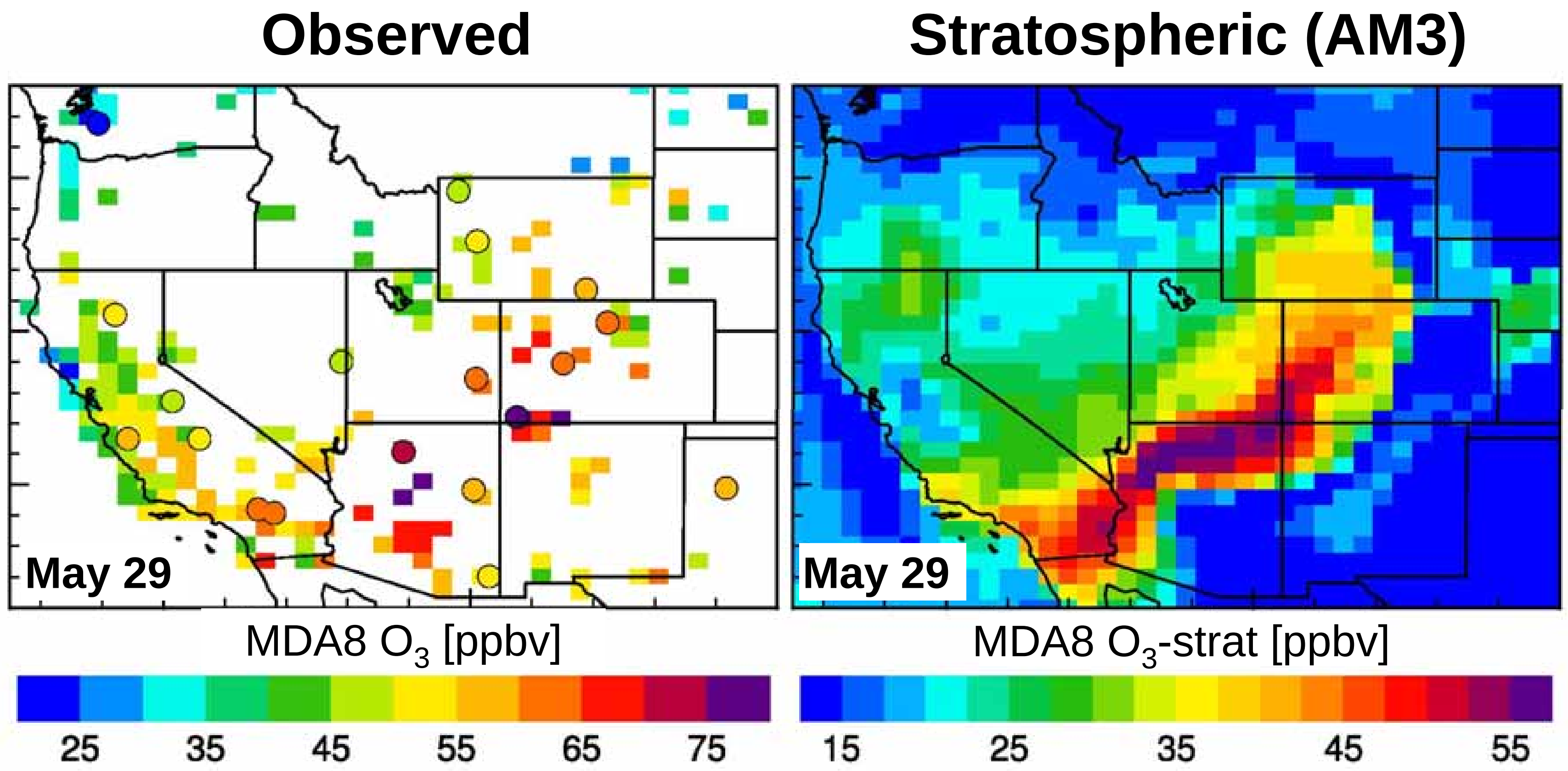




→ O_3-strat contributes ~75% to enhanced O_3 >100 ppbv at 2-5 km a.s.l.

→ Consistent with observed low humidity; NA emissions contribute little

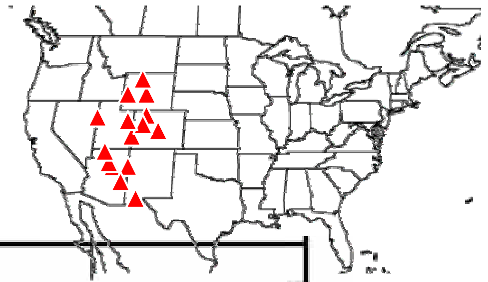
Transport of stratospheric O_3 to the surface (e.g. May 29, 2010)

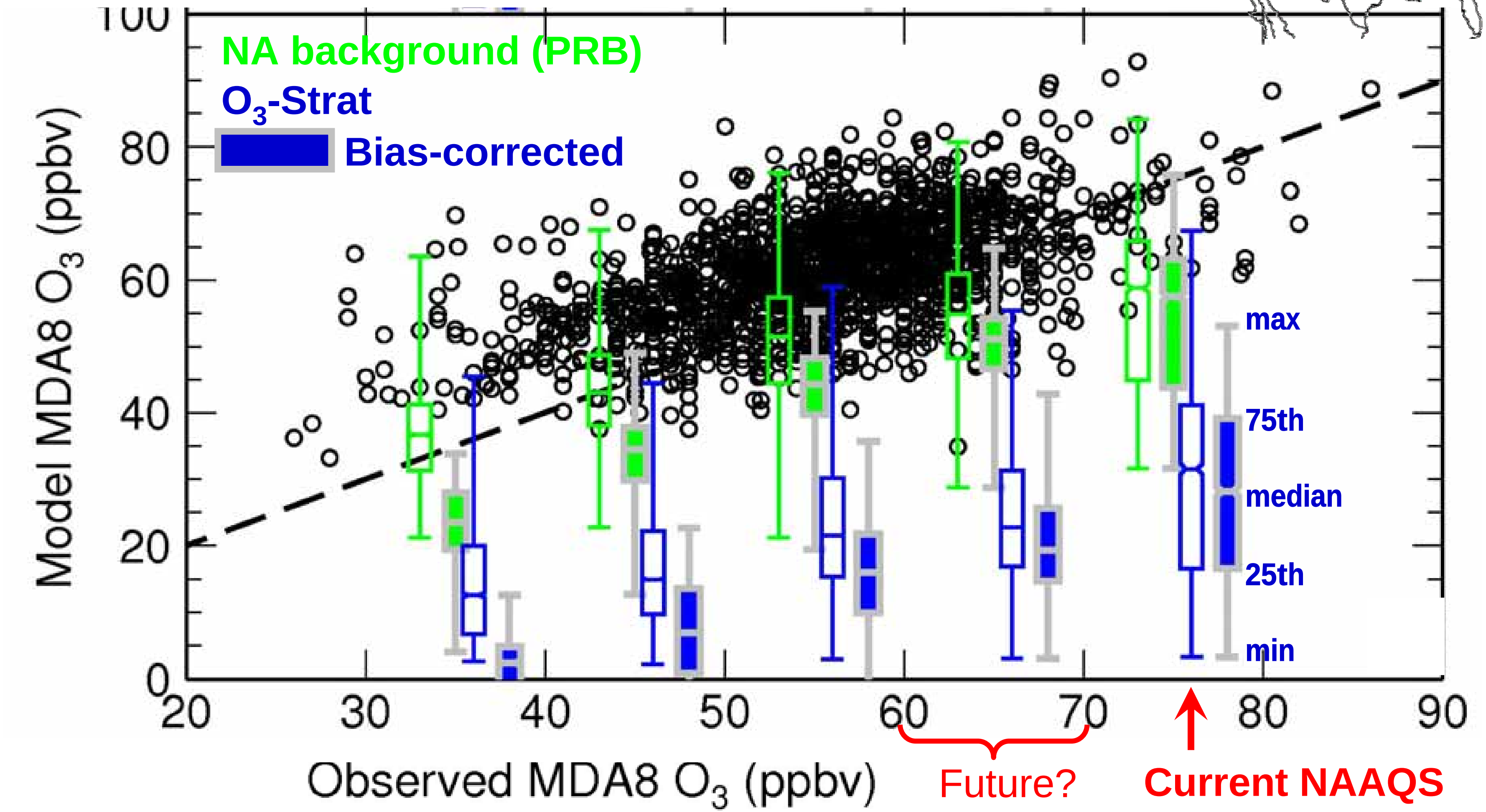


- **High O_3-strat coincides with regions experiencing peak surface O_3 levels** (+ sharp decreases in humidity and dew point temperature)
- **Stratospheric intrusions elevate baseline levels (~15 ppbv) and can contribute 35-55 ppbv to MDA8 O_3 during events, up to 2-3 times higher than previously reported!**

Summarizing results for Apr-Jun 2010

15 high-elevation (>1.4 km) western U.S. sites

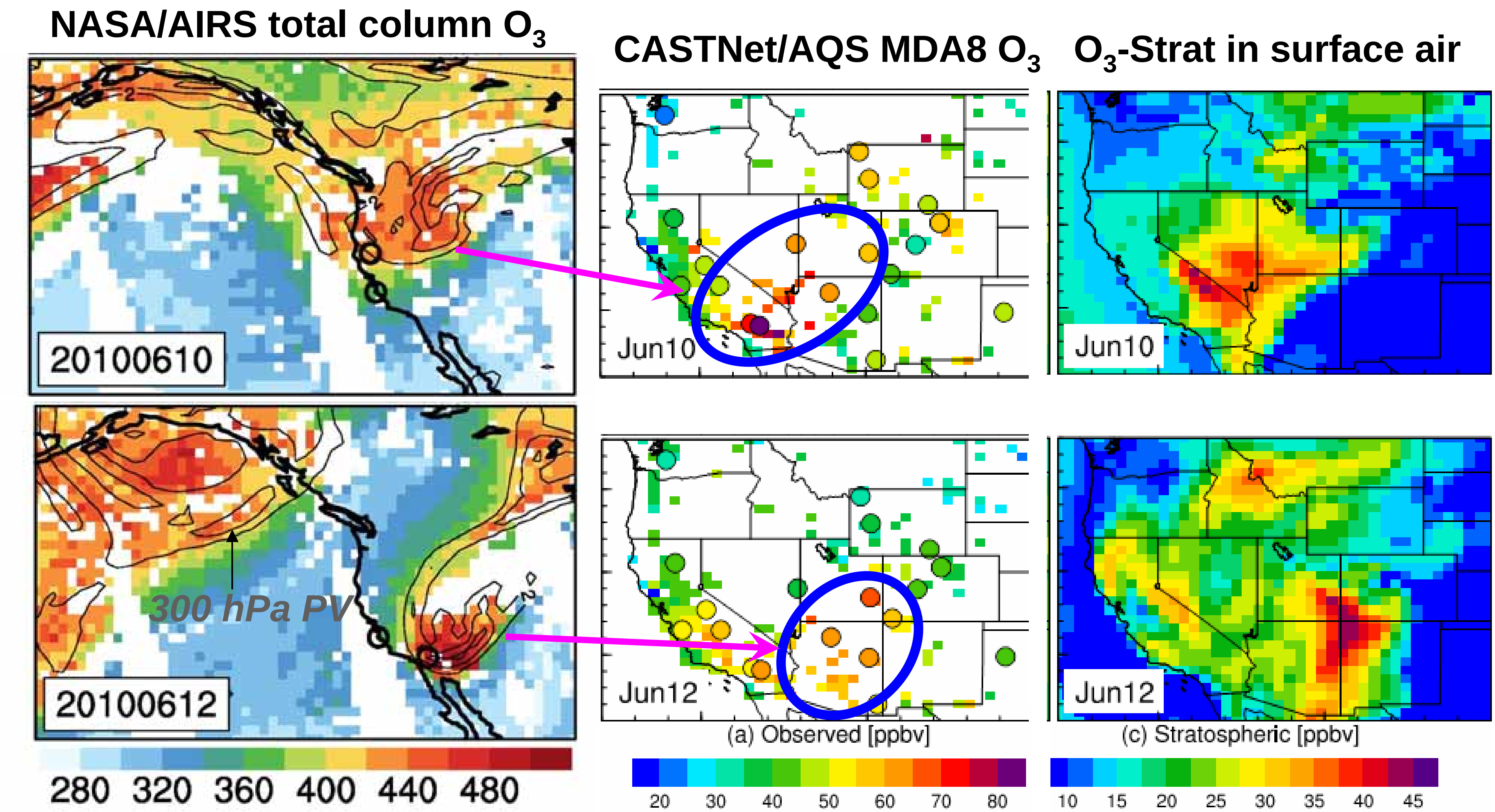




- Background O_3 can reach 60-75 ppbv for ~25% of observed high-O_3 >=70 ppbv
- A major role for strat. intrusions in driving high-O_3 events (spring; west)

→ Enhanced knowledge needed to forecast and identify events

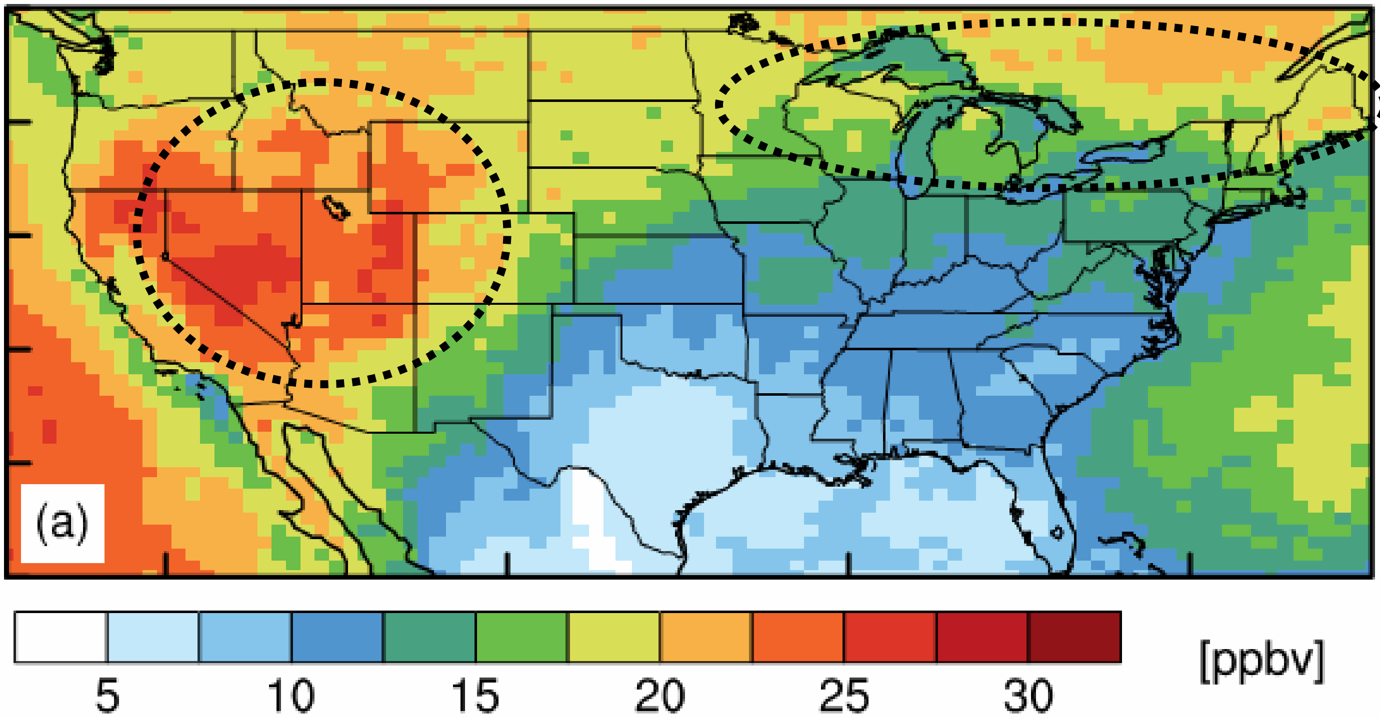
New IP: Can NASA satellite provide an advanced warning of potential O_3 action days due to a stratospheric intrusion?



→Enhanced observed O_3 and model O_3S in surface air southeast of the intrusion as seen by AIRS (consistent with ozonesondes)

Questions?

Median stratospheric impacts on surface O_3 in spring 2010



Likely NE US, but further evaluation needed; IONS 2004/2006/2008 and DISCOVER AQ data may help.

Key Points:

→ Stratospheric intrusions can episodically contribute 50-60% to surface O_3

→ Regularly influence the high-elevation WUS in late spring

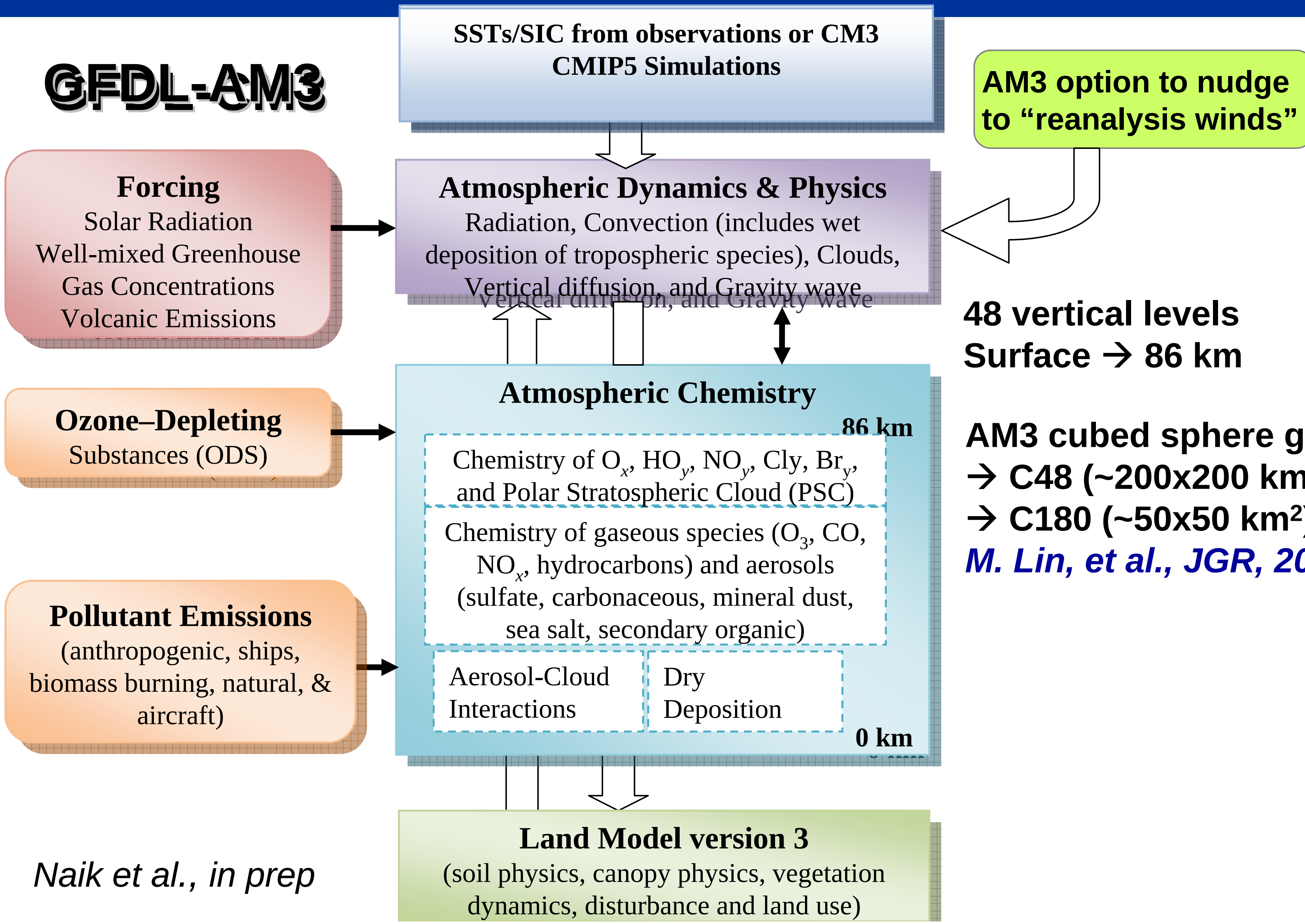
→ NASA near real-time ozone products may provide an advanced warning

For further discussions, please contact Meiyun.Lin@noaa.gov

Additional slides for Q&A

The new GFDL CM3/AM3 chemistry-climate model

Donner et al., Golaz et al., Griffies et al., J. Climate, 2011



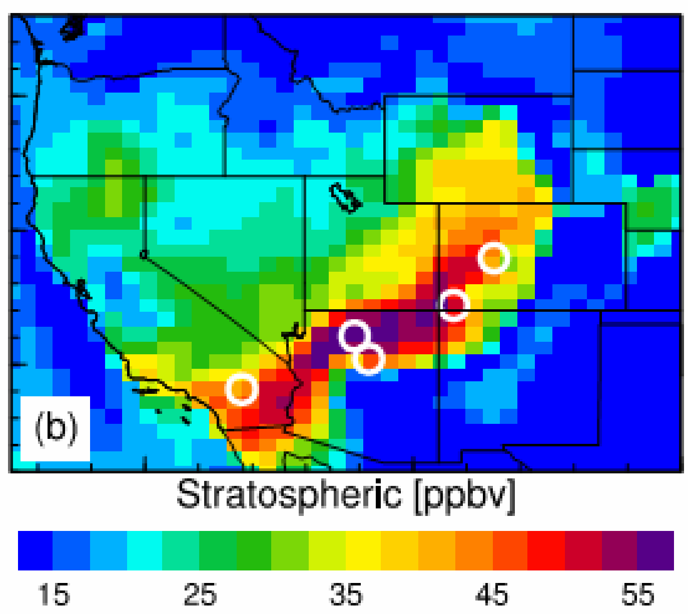
48 vertical levels
Surface → 86 km

AM3 cubed sphere grid
→ C48 (~200x200 km²)
→ C180 (~50x50 km²)
M. Lin, et al., JGR, 2012

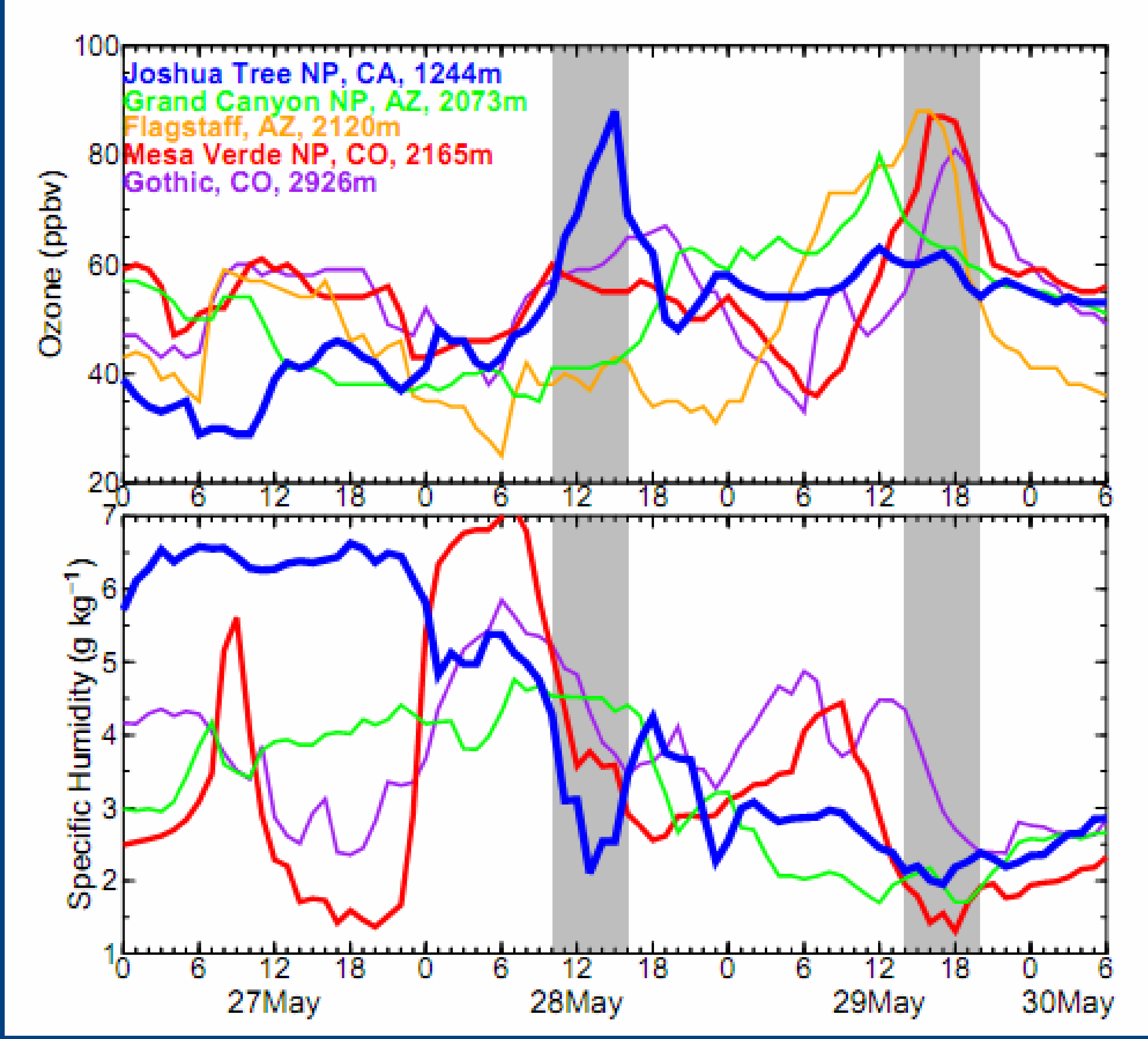
Naik et al., in prep

Observed

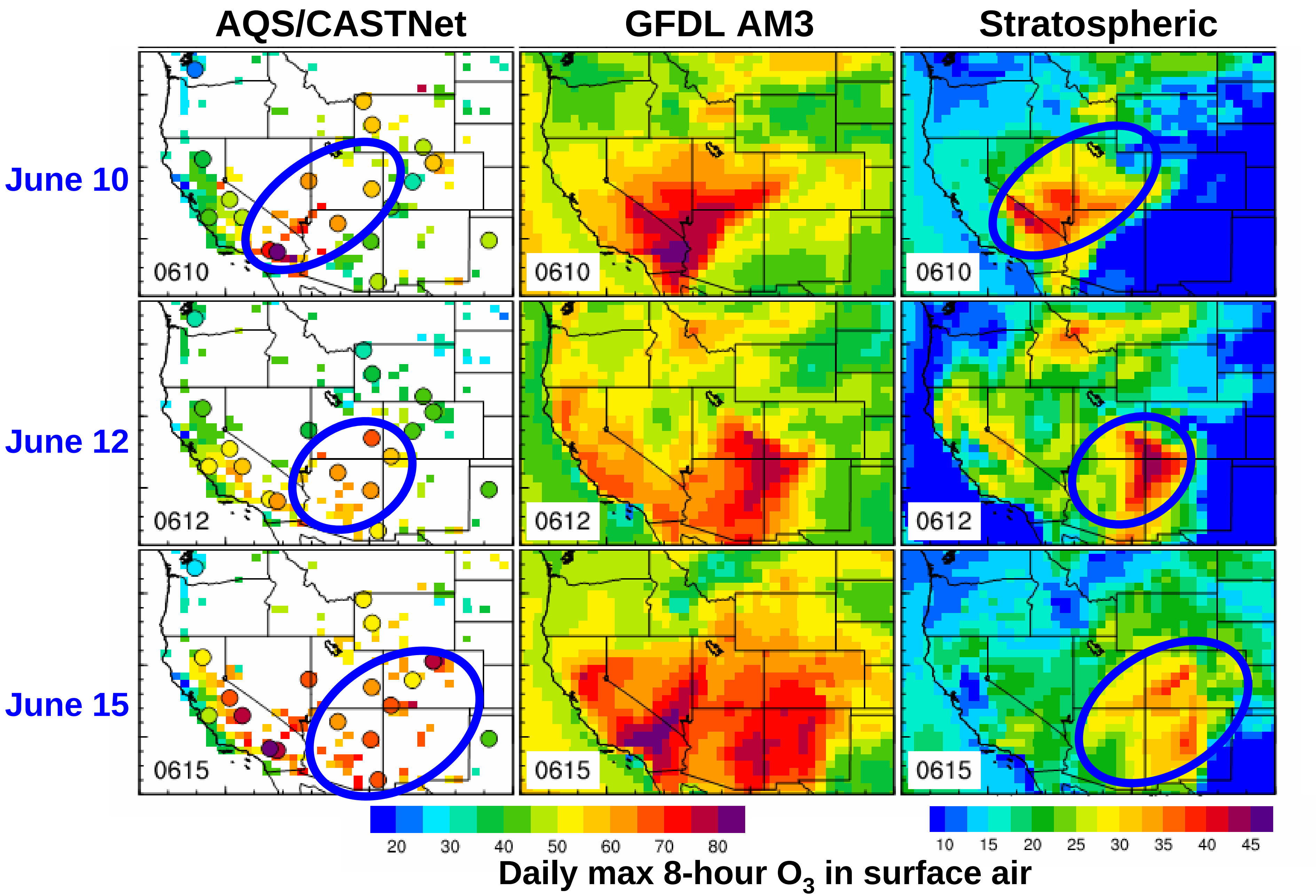
AM3 O_3S



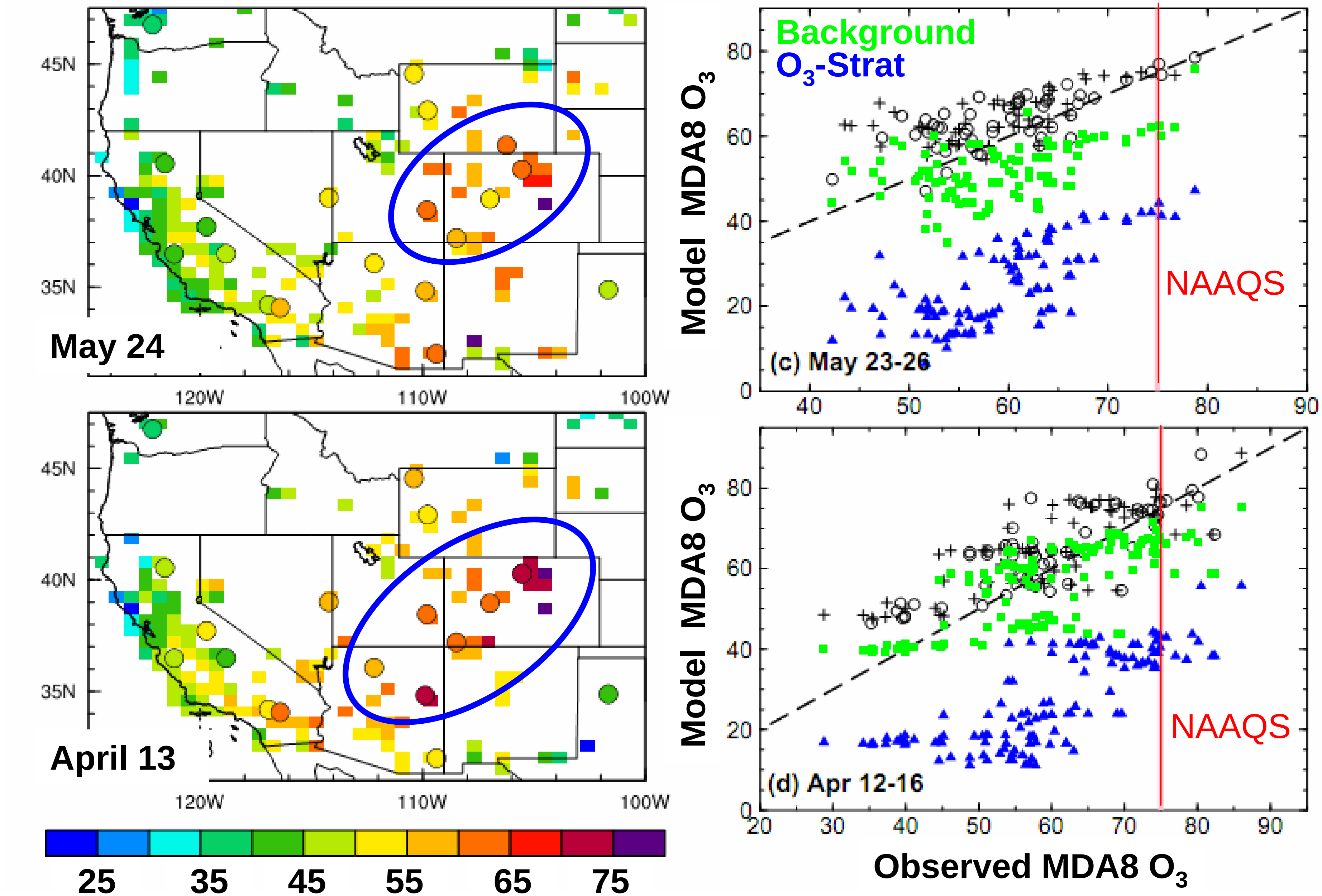
May 29, 2010



Case #3: Stratospheric intrusions drive a substantial portion of the observed synoptic variability of surface O_3



Stratospheric impacts on the Four Corners region



Stratospheric ozone tracer in AM3

→Distinguish **stratospheric** vs. **tropospheric** air using the e90 tropopause tracer proposed by *Prather et al. [2010]; allowing double tropopause*

→**Set O_3S equal to O_3 in stratospheric (e90<85 ppb) air masses**; **subject to chemical and depositional loss in tropospheric (e90>85 ppb) air masses**

→Transport of O_3S and e90 both driven by meteorology

Lin, et al., 2012, submitted to JGR