Webex Agenda, 6 March 2014

1. Access to Science Team Meeting Presentations
2. Update on Colorado logistics and schedule
3. Science Presentations: Chris Senff, Gail Tonnesen, and Patrick Reddy

Presentations have been posted. Posters will be added soon. Please send your poster to Mary Kleb if you haven't already.

Presentations can be accessed from links on the main site and the data archive or directly at the following url:

https://www-air.larc.nasa.gov/cgi-bin/DocView/DAQScienceMtgLaRC

The User ID is:

discoveraq

The password will be emailed separately.

FRAPPÉ Science Team Meeting

The FRAPPÉ Science Team will be held in Boulder on 3-4 April.

We will not be travelling DISCOVER-AQ personnel to this meeting, but locals may wish to attend. Jim Crawford and Ken Pickering will also attend.

Remote access through webex will be provided for those who are interested. Instructions will be emailed to the DISCOVER-AQ mailing list.

FRAPPÉ /DISCOVER-AQ Media Day

The media day has been scheduled for 14 July. This is the day after the transit of the NASA aircraft and the day before the first science flight.

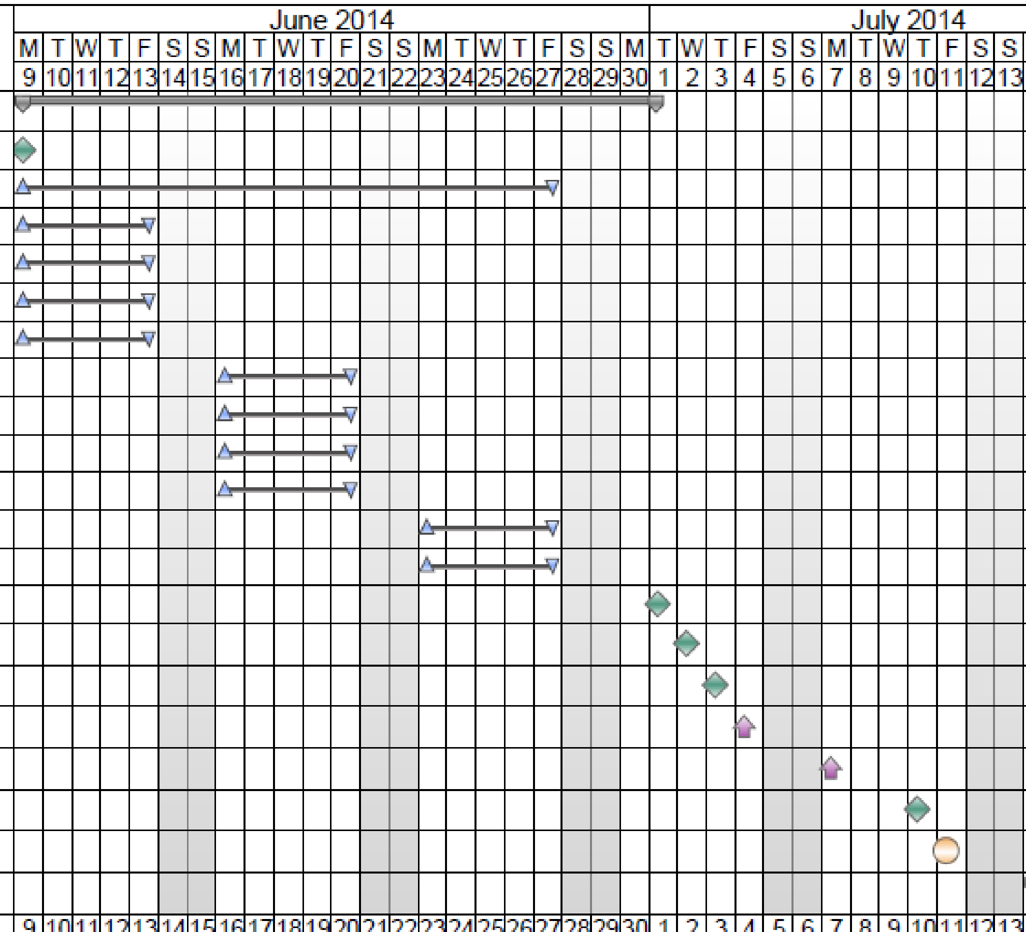
This worked well in Houston and will give the public a heads up before science flights begin.

DISCOVER-AQ

Integration and Download

Martin Nowicki has produced a draft integration schedule. Don't make hard plans yet, since it might undergo one last tweak. I would like to consider the possibility of completed the check flight and packing by 3 July and release everyone until the transit. This would be possible with a slightly earlier start.

	Activity Name	Duration (Days)	Start Date	Finish Date
1	DISCOVER-AQ Upload (Denver)	16.00	6/9/14	7/1/14
2	Upload Begins	0.00	6/9/14	6/9/14
3	Aerodyne (Herndon)	15.00	6/9/14	6/27/14
4	LARGE (Anderson)	5.00	6/9/14	6/13/14
5	CAPS (Anderson)	5.00	6/9/14	6/13/14
6	Data System/AIMMS-20 (NSERC)	5.00	6/9/14	6/13/14
7	TD-LIF (Cohen)	5.00	6/9/14	6/13/14
8	PTR-MS (Wisthaler)	5.00	6/16/14	6/20/14
9	DFGAS (Fried)	5.00	6/16/14	6/20/14
10	AVOCET/PAMCO2 (Yang)	5.00	6/16/14	6/20/14
11	j(NO2) (Barrick)	5.00	6/16/14	6/20/14
12	NOXY (Weinheimer)	5.00	6/23/14	6/27/14
13	DACOM/DLH (Diskin)	5.00	6/23/14	6/27/14
14	FIIR	0.00	7/1/14	7/1/14
15	FRR	0.00	7/2/14	7/2/14
16	ATP	0.00	7/3/14	7/3/14
17	ECF	0.00	7/4/14	7/4/14
18	PCF	0.00	7/7/14	7/7/14
19	MRR	0.00	7/10/14	7/10/14
20	Pack Day	0.00	7/11/14	7/11/14
21	Mission Deployment	23.00	7/14/14	8/13/14



Integration and Download (cont.)

Additional instructions for integration

The schedule reflects when racks will be uploaded (i.e. aircrew support). You are more than welcome to come early and work on your rack in the lab or stay and work on your rack once it is uploaded.

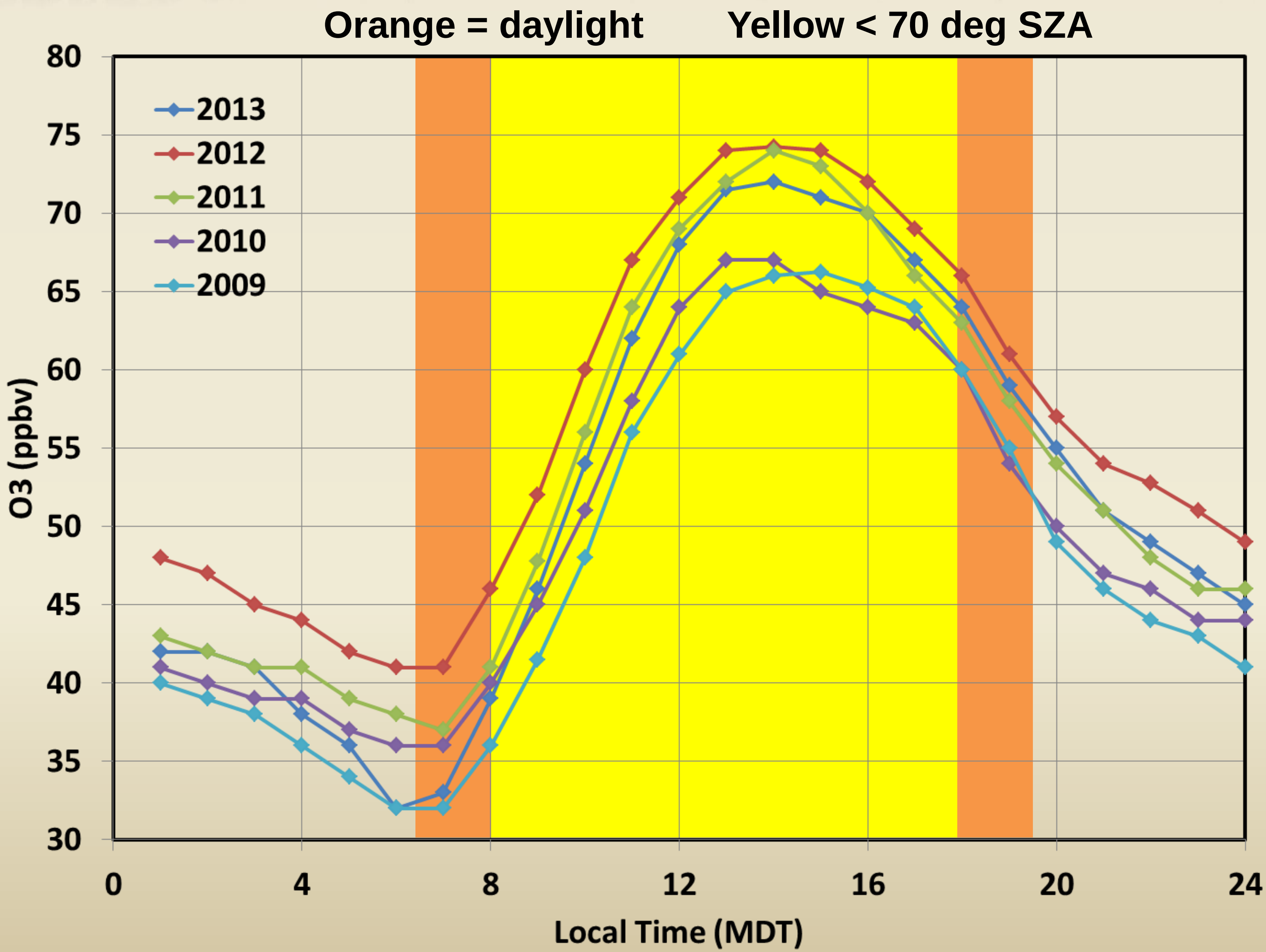
All windows will be installed in the first few days (before the racks block the windows). All windows should be at WFF 1 week prior to the start of integration.

If we get ahead of schedule, racks may be uploaded earlier than scheduled. If you want to be present for the upload of your rack, plan to arrive a few days early or make special arrangements with Martin (i.e. rack brought on plane but not bolted down).

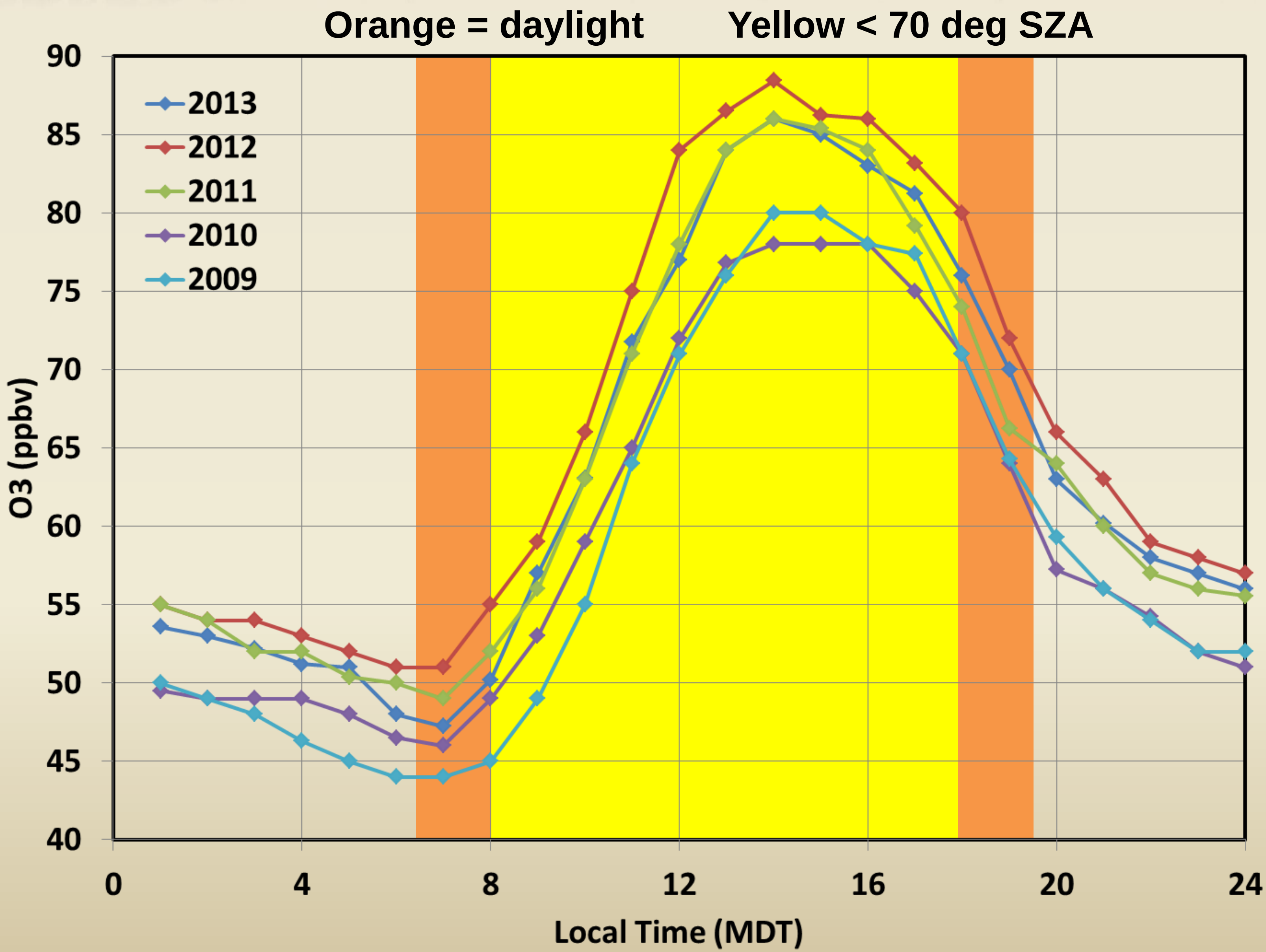
Current status of download

Download of some instruments in Colorado (specifically, Weinheimer, Fried, and Cohen) will likely be feasible. Martin Nowicki is working out the details. Weinheimer will be easy, but Cohen and Fried will have to squeeze through some tight spots.

75^{th} Percentile Ozone Values (Jul-Aug)



95th Percentile Ozone Values (Jul-Aug)



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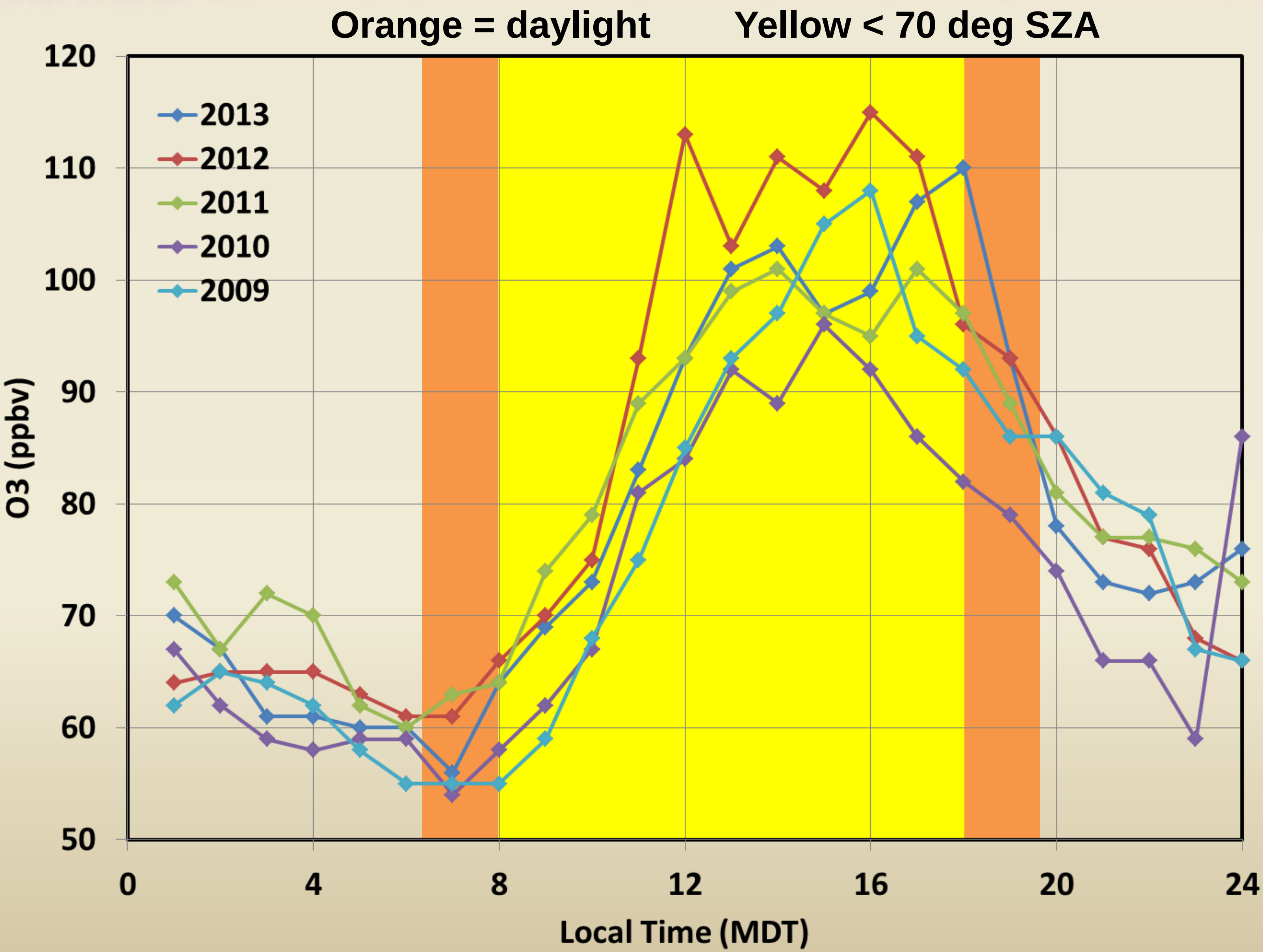
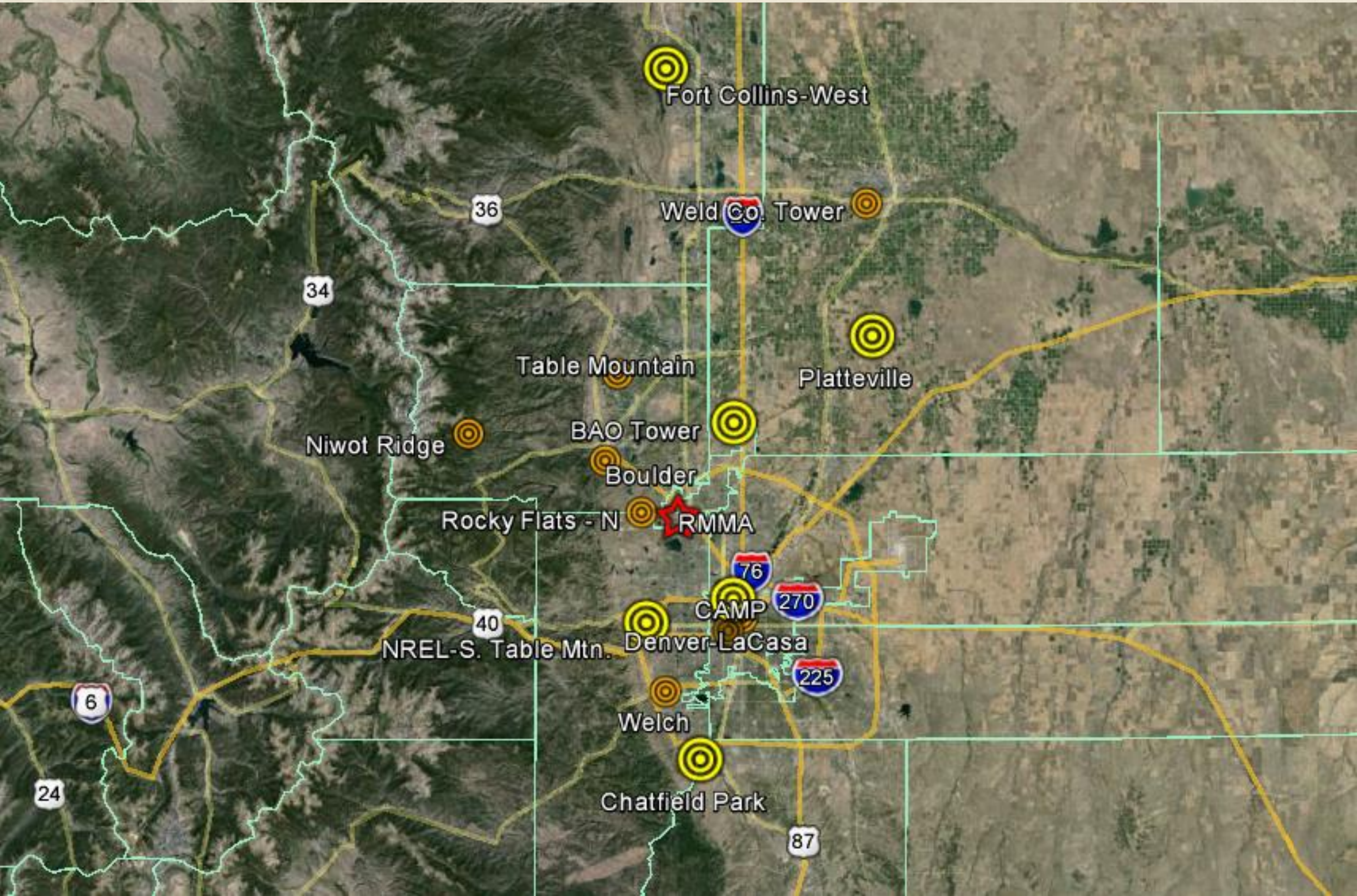
Maximum Ozone Values (Jul-Aug)



Ground Sites for Colorado

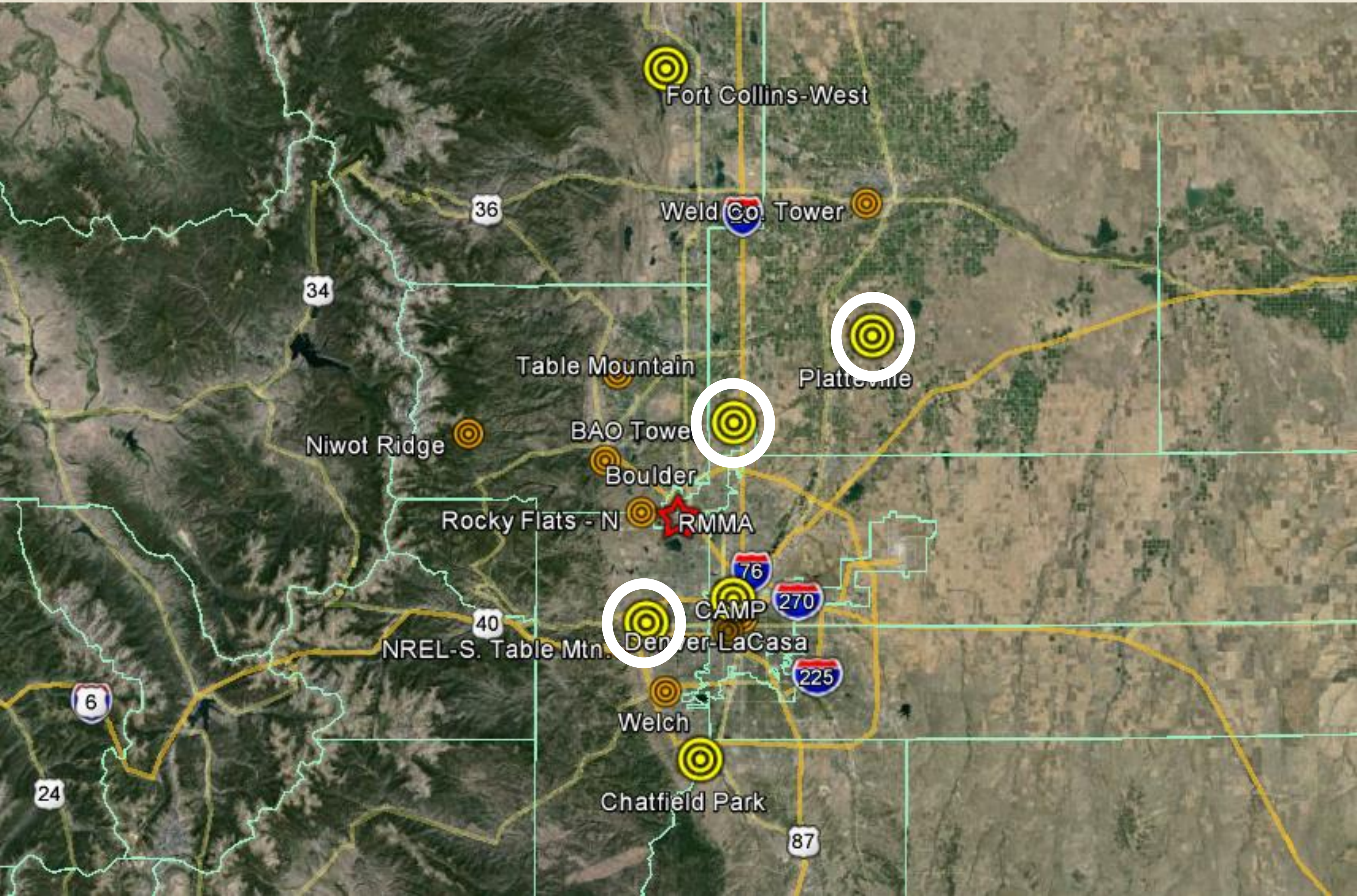


Ground Sites for Colorado

Name	Spiral	Overflight	Pandora	EPA NO2	Missed Approach	Lidars	Balloons	Comment
BAO Tower	X		2			NOAA TOPAZ and HRDL, UW HSRL		CSU, 3 mobile hookups (NEMA 14-50), small sensors on tower
Chatfield Park	X		1	X				
Denver-LaCasa Ncore	X		2	X				
Fort Collins-West	X		1	X	500 feet	TOLNet O3		
NREL-S. Table Mtn.	X		2	X		MPL, TOLNet O3, Leosphere Windcube	Tethersonde	Millersville also brings sodar, flux tower, nephelometer; Pandoras by EPA here, UMBC trailer, EPA ceilometer, port-a-pot
Platteville	X		1	X			Ozonesondes	NATIVE, NOAA Radiation, 3 mobile hookups (NEMA 14-50), Pandora by NATIVE here; Extra trailer, shed (sondes), port-a-pot
Boulder		X	1					Pandora already at this location
CAMP		X						small sensors either along street canyon or on building?
I-25 Denver			1	X				near-road NO2 monitor; EPA for sure here; AQMesh
Niwot Ridge			1					exact location TBD - prefer tundra location
Rocky Flats - N		X	1	?				
Table Mountain		X	1					possible ozone monitor
Welch		X	1					
Weld Co. Tower		X	1	?				remote sensors on county building
Greeley-Weld Co. Airport					X			Missed approach along BL run
Parkland Airport					500 feet			Missed approach with BAO spiral

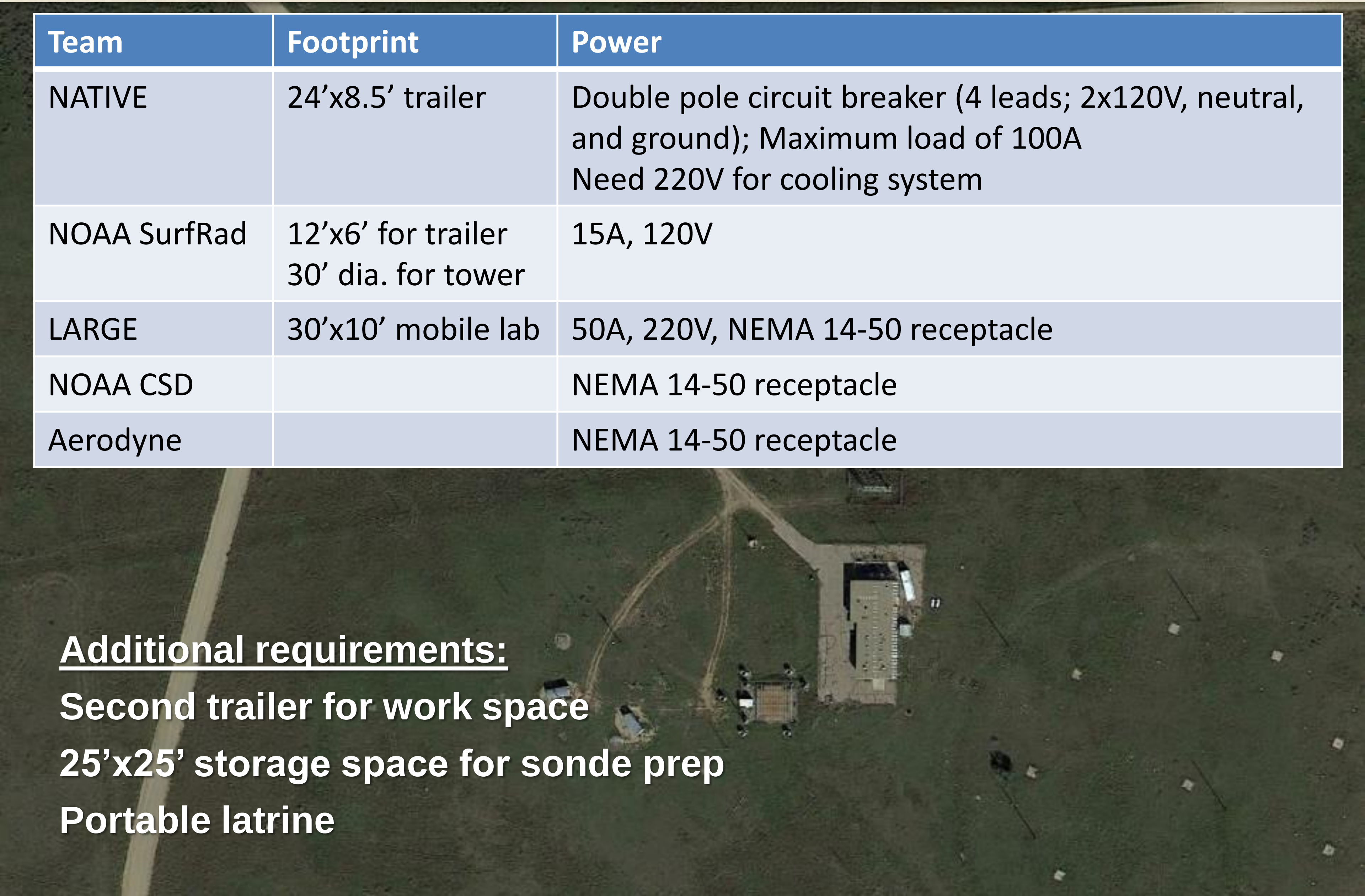
Early installation desired for Pandora and Aeronet (as early as April). Can CDPHE accommodate this?

Major Ground Sites for Colorado



Platteville Site Considerations

Platteville Site Considerations



Team	Footprint	Power
NATIVE	24'x8.5' trailer	Double pole circuit breaker (4 leads; 2x120V, neutral, and ground); Maximum load of 100A Need 220V for cooling system
NOAA SurfRad	12'x6' for trailer 30' dia. for tower	15A, 120V
LARGE	30'x10' mobile lab	50A, 220V, NEMA 14-50 receptacle
NOAA CSD		NEMA 14-50 receptacle
Aerodyne		NEMA 14-50 receptacle

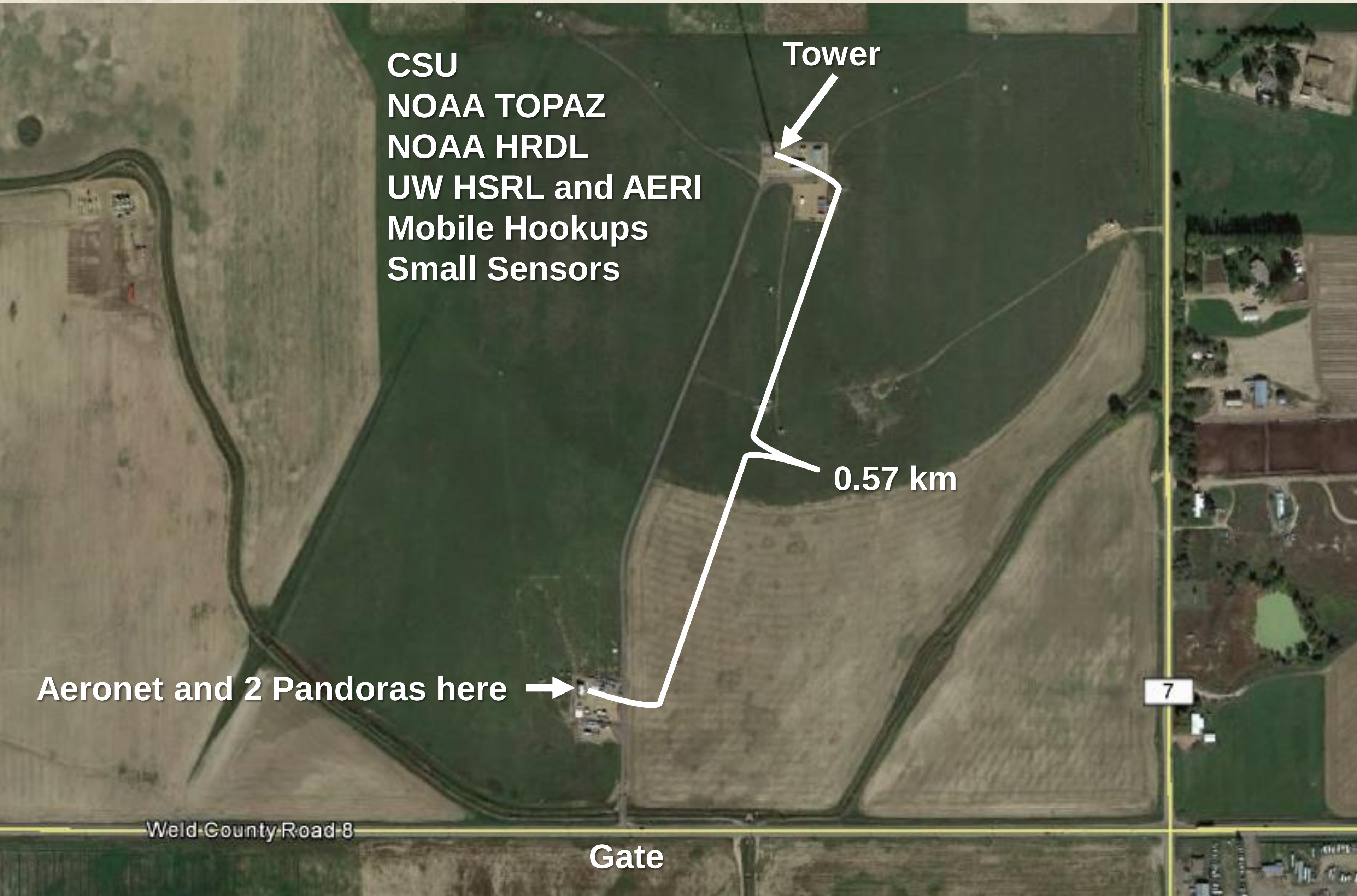
Additional requirements:

Second trailer for work space

25'x25' storage space for sonde prep

Portable latrine

BAO Tower Site Considerations



BAO Tower Site Considerations

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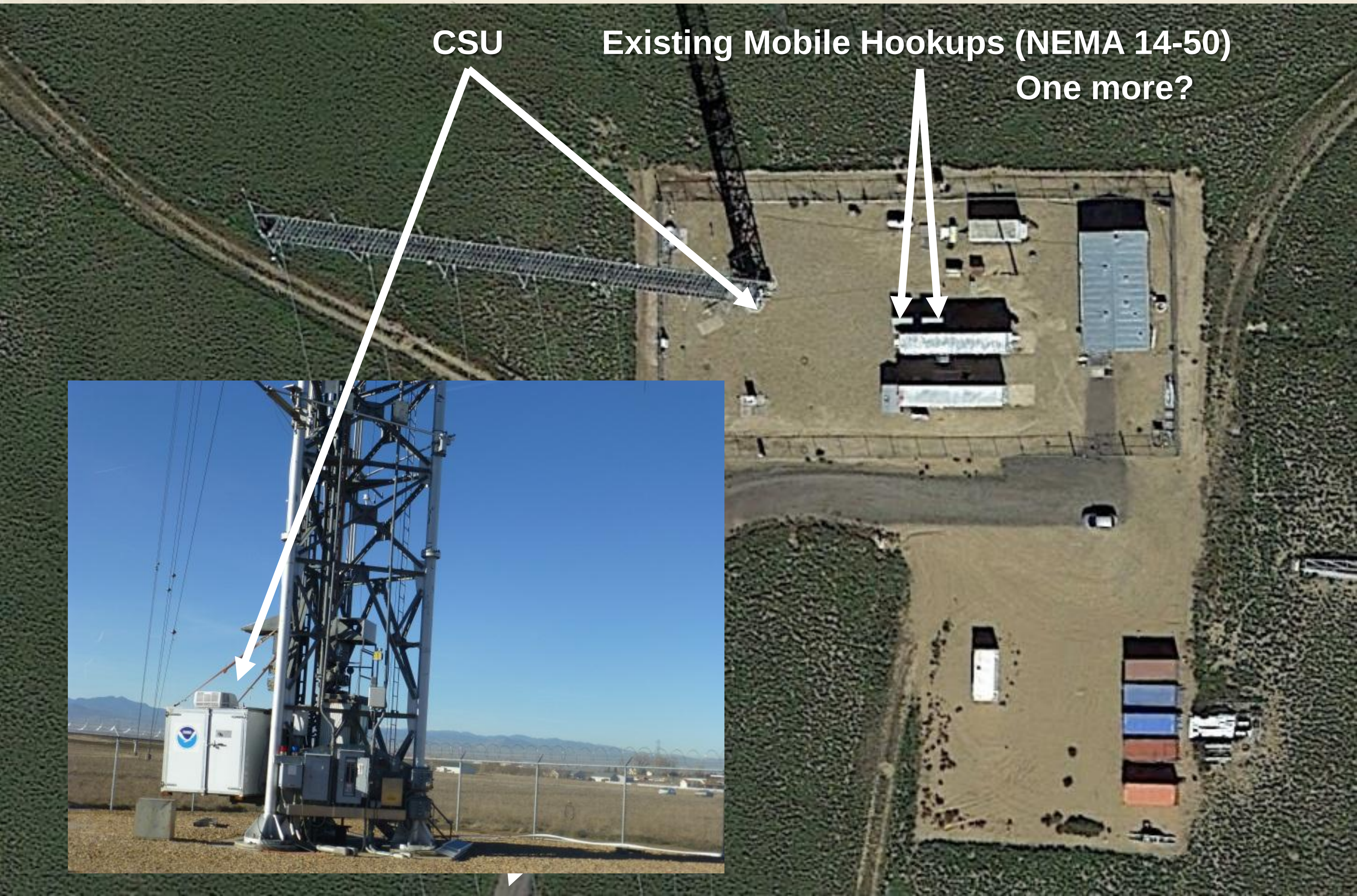

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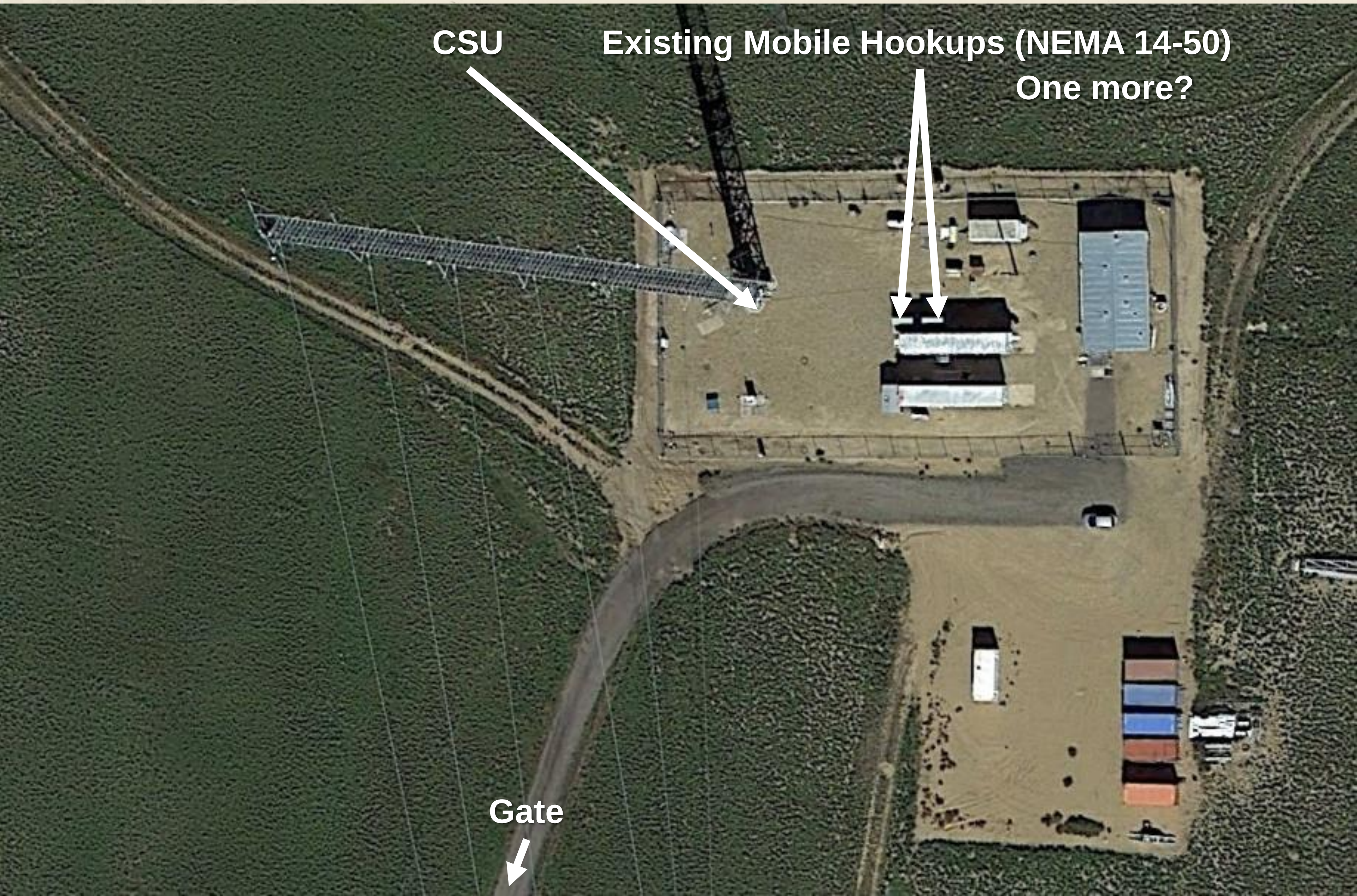
BAO Tower Site Considerations



BAO Tower Site Considerations

Group	Power	Space	Comment
NOAA-TOPAZ	120/240 VAC; 50 Amps 10 kW	27' x 15'	The plug that we currently use to power the lidar is a Hubble brand 60 A, 125/250 VAC, 3 pole, 4 wire, watertight pin and sleeve connector part number HBL460P12W. We suggest to install the matching receptacle for this plug which is Hubble part number HBL460R12W.
NOAA-HRDL			
UW-HSRL and AERI	120/240 VAC; 60 amps	35' x 13'	We use the same HBL460P12W connector that the NOAA-TOPAZ group. For maximum safety we typically deliver for installation ahead of SPARC arrival a fused circuit interlock box to provide power, but we are certainly able to plug into a Hubble HBL460R12W if that is already available. Power requirement is listed as 60 amps, but 50 amps would be fine as well. The power inlet is at the front of our trailer and we carry a 100' #4 AWG power cord with the Hubbell connectors. Unit is 50' when including both truck and trailer.
CSU			Installation on the tower carriage; working with Steve Brown
Pandora (2)	Standard 120V receptacle 300W each	3' x 3' each	Prefer to mount telescope on a rooftop railing (can also be tripod mounted) and place instrument inside the trailer/structure.
Aeronet	Standard 120V receptacle	3' x 3'	Prefer to mount telescope on a rooftop railing (can also be tripod mounted) and place instrument on roof of trailer/structure.
CairTub units	Self powered/battery		A number of units would be mounted on the tower at various heights
AQMesh units	Self powered/battery	N/A	A number of units would be mounted on the tower at various heights
Mobile hookups (3)			NEMA 14-50 receptacles. Mobile labs would come and go, but need space for up to three during comparison periods
LARGE Mobile Lab	220V; 50 Amps		
Aerodyne Mobile Lab			
NOAA Mobile Lab			

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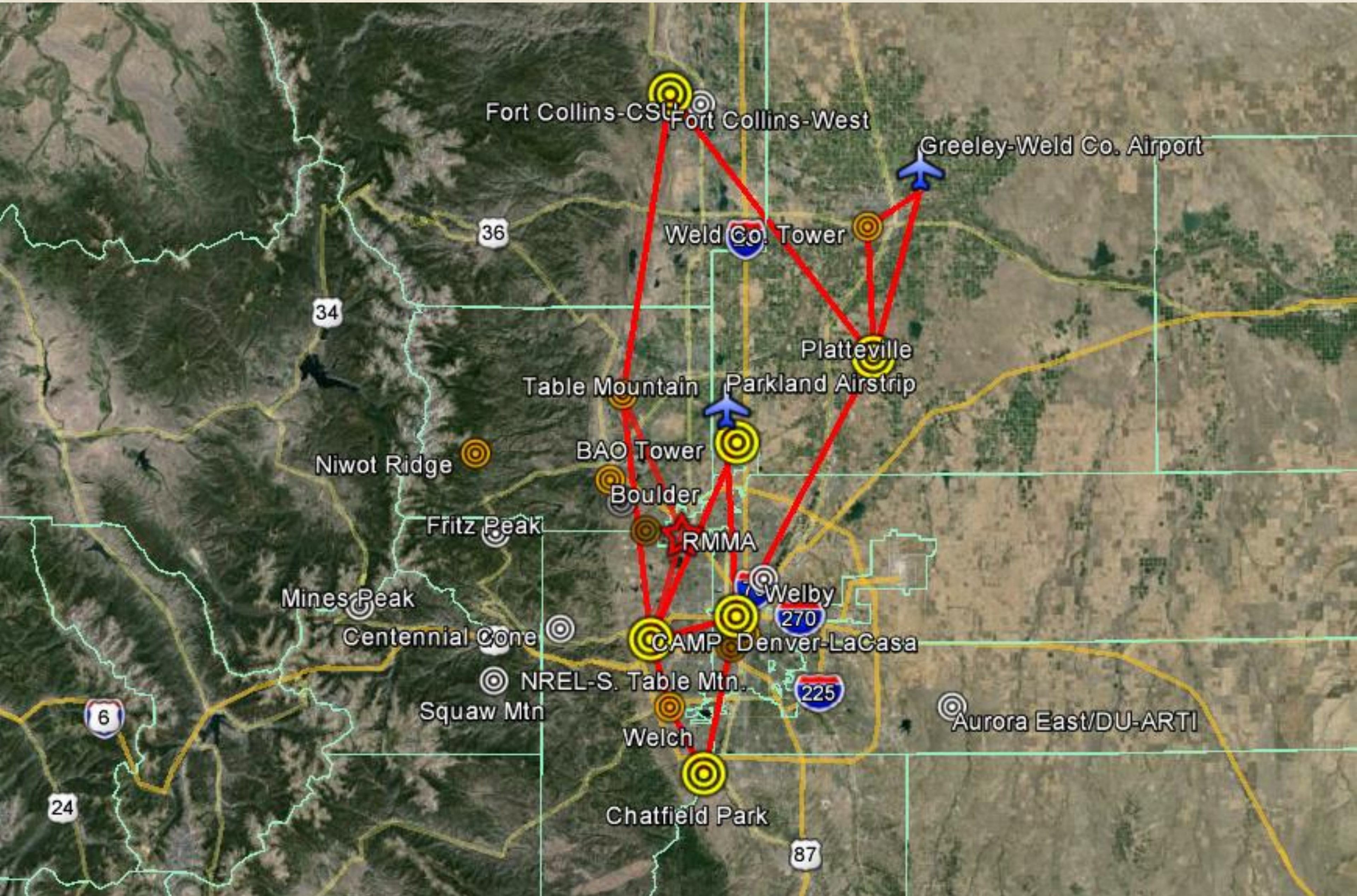
NREL-Golden Site Considerations

Others expected at this site:
TOLNet O3
UMBC trailer and Leosphere Windcube
EPA (in CDPHE shelter)

Possible Ancillary Ground Sites



Future Telecons

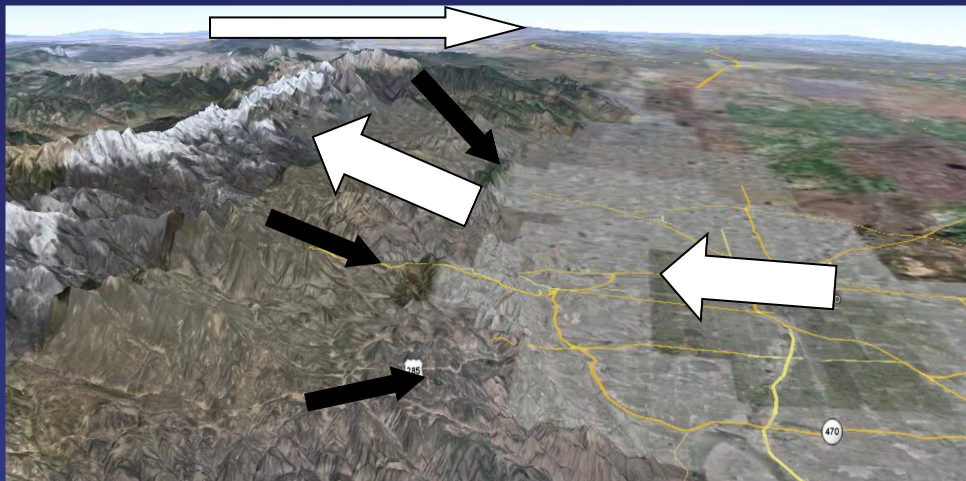
1. The normal schedule will not work for the next two months due to FRAPPE meeting April and Korea meeting in May

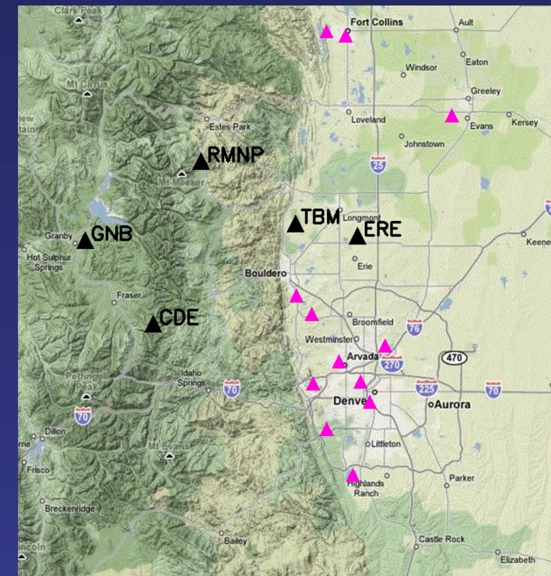
2. With integration starting in June, opportunities are few

3. Suggest more frequent telecons (still on Thursdays at 3pm) to provide updates and track progress

Suggested dates: 27 March, 17 April, 8 May, and 29 May

Front Range Air Quality Study: July 2008





Objectives

- Investigate role of mountainous terrain west of Denver on pollutant transport and distribution
- Evaluate WRF/FLEXPART model performance in/near complex terrain
- Pilot study for 2010 CALNEX air quality study

Instrumentation

- NOAA O_3 lidar flown on Twin Otter aircraft
- 3 boundary layer wind profilers and a meteorological surface station

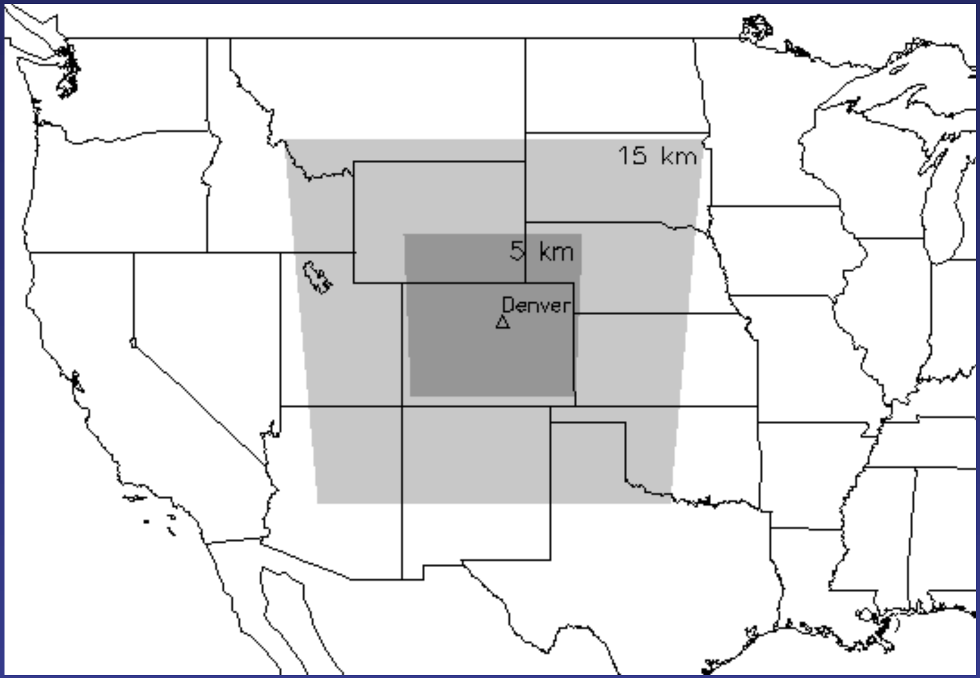
TOPAZ: NOAA's Ozone/Aerosol Lidar

(TOPAZ = Tunable Optical Profiler for Aerosols and oZone)

- Ozone and aerosol backscatter profiles from near the surface to ~3 km AGL
- Resolution: 90 m vertical, 600 m horizontal
- Precision (O_3): 3-15 ppb

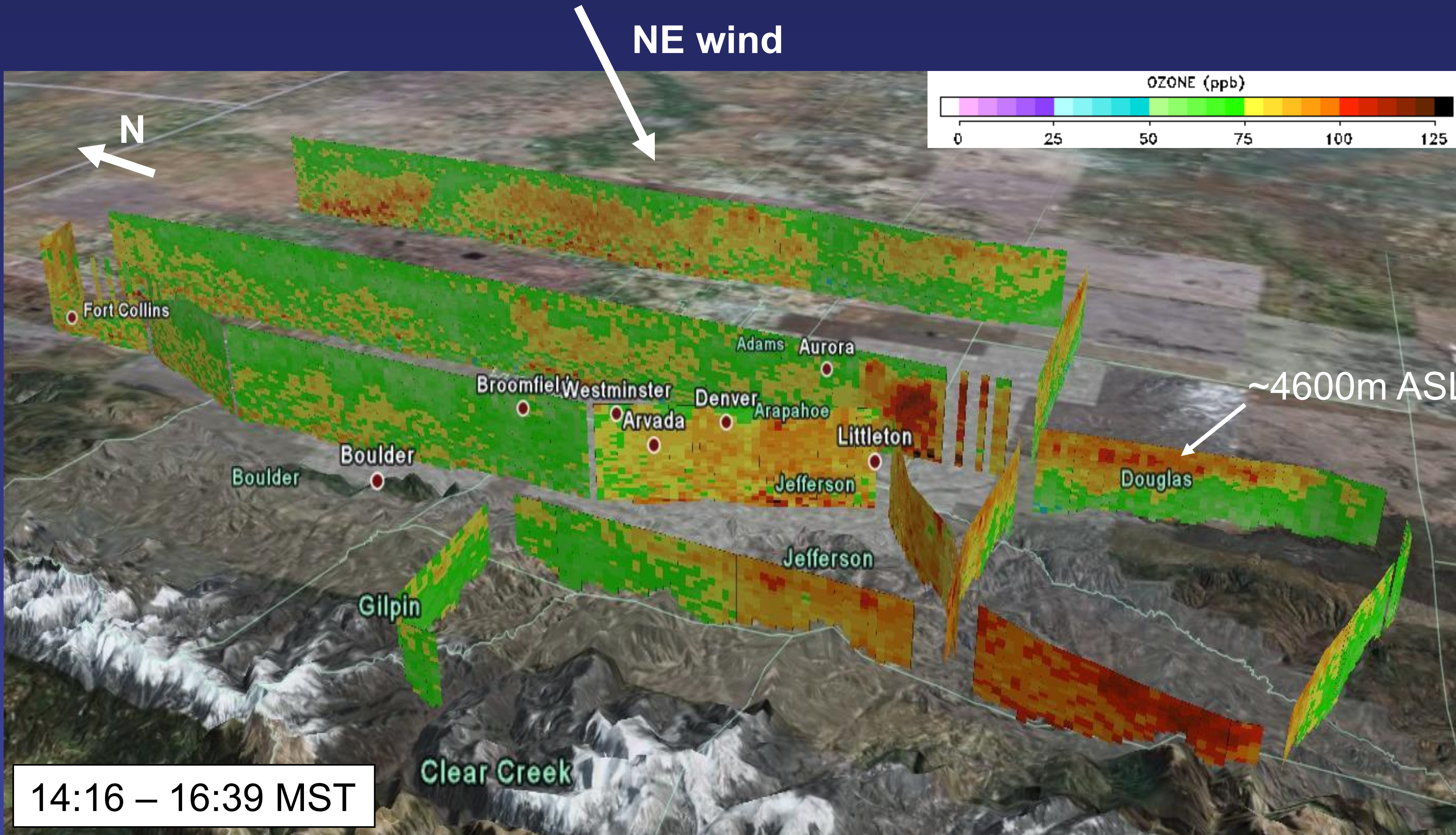
TOPAZ on NOAA Twin Otter

Coupled WRF/FLEXPART model



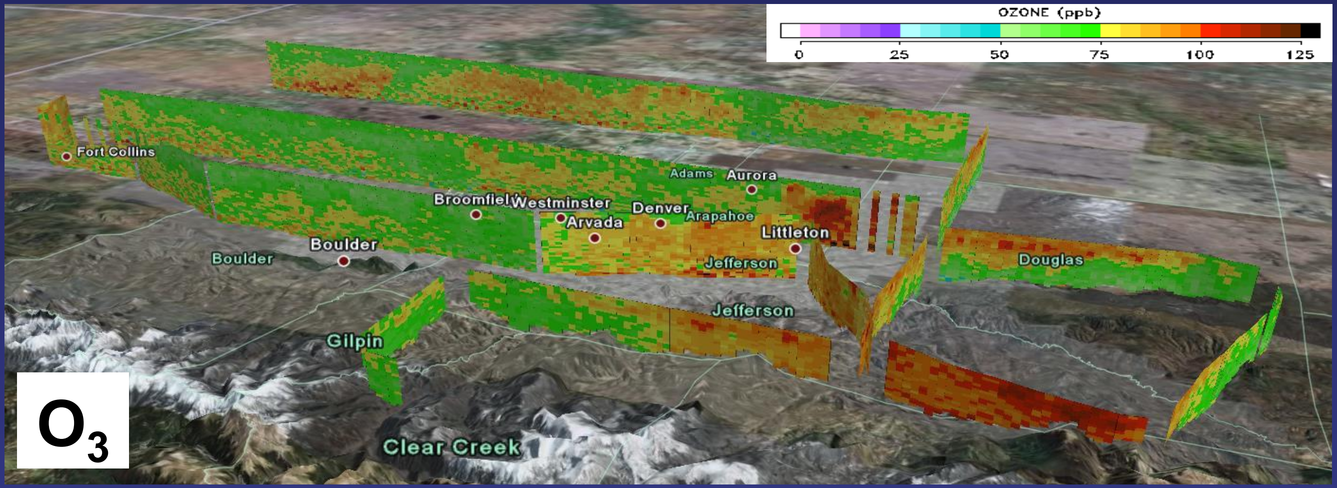
- FLEXPART (Lagrangian particle dispersion model) uses U.S. EPA emission inventory data and is driven by WRF meteorological fields
- WRF is run on a nested grid and initialized at the boundary every 3 hours with the NCEP GFS global model
- WRF/FLEXPART provides CO and NO_x fields at 1.7 km resolution

27 July 2008

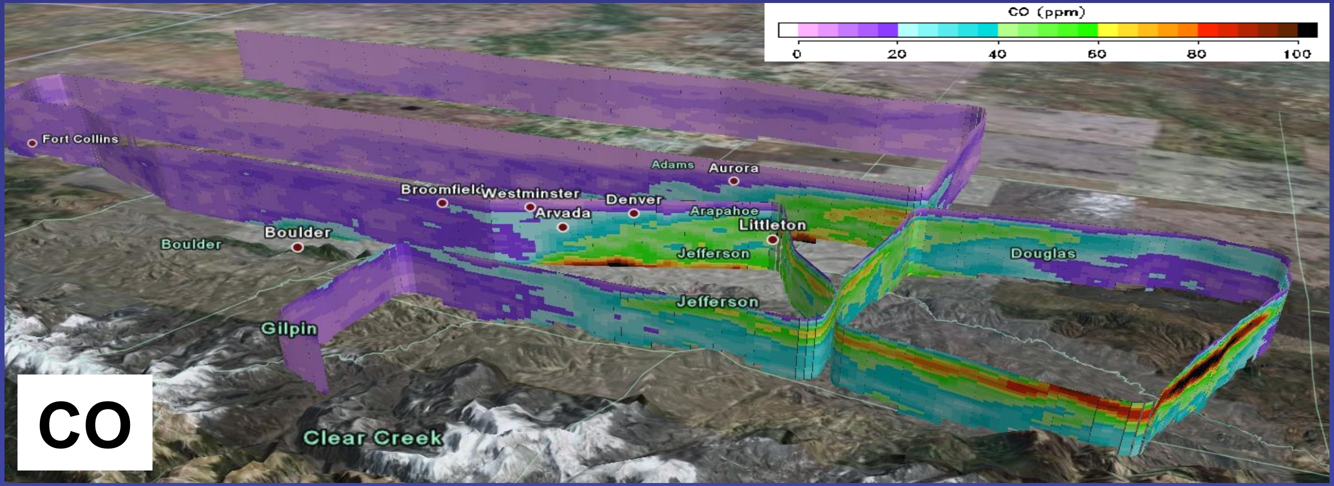


3-d distribution of O_3 from TOPAZ lidar

27 July 2008

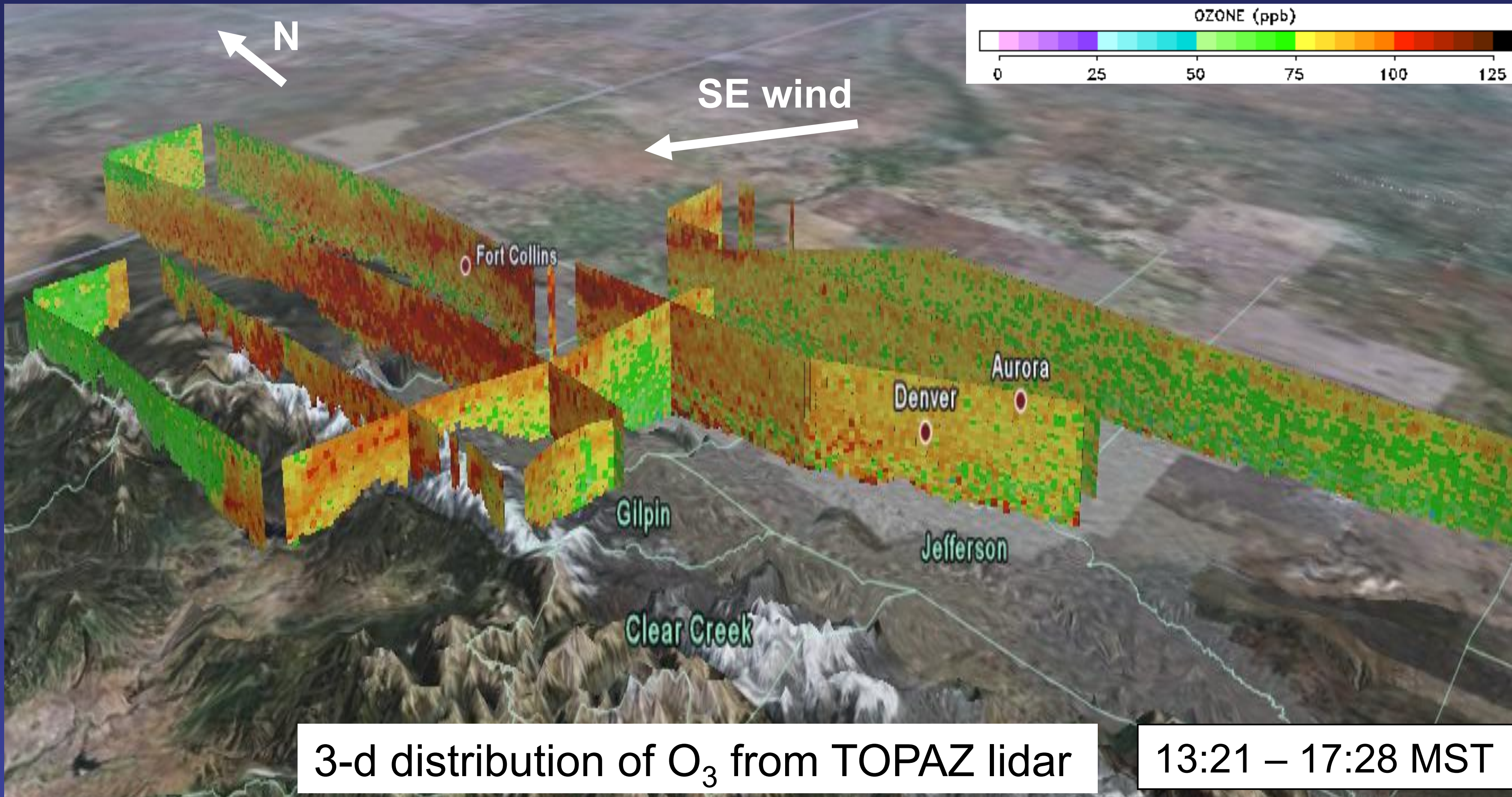


TOPAZ lidar measurement



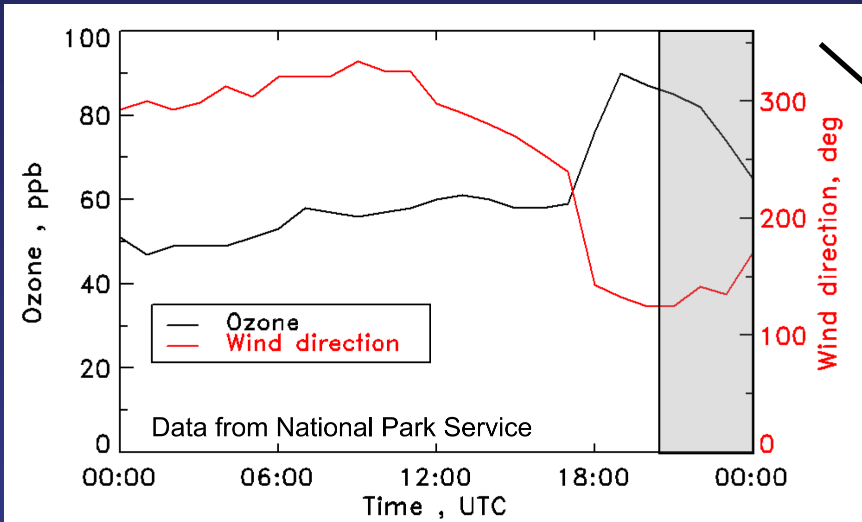
WRF-FLEXPART model results

31 July 2008

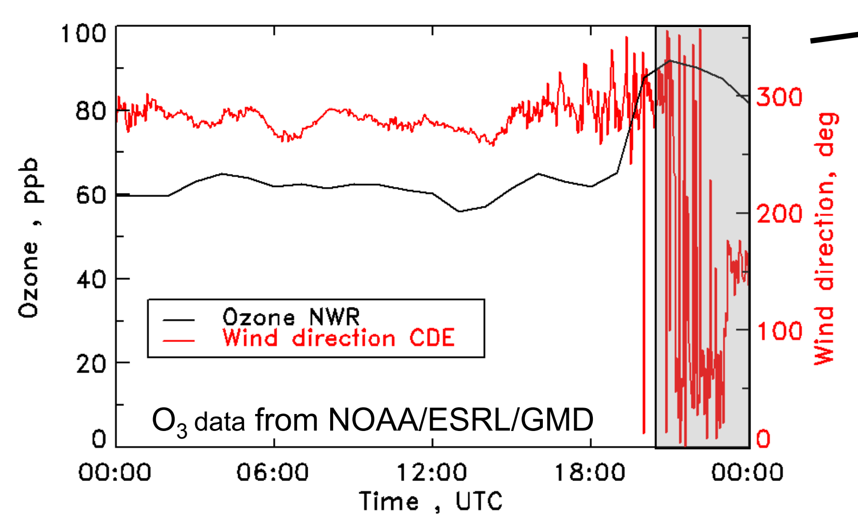


- O_3 from the greater Denver area is transported up the eastern slope of the Front Range Mountains and across the Divide into Jackson and Grand Counties.
- High levels of O_3 were observed over Rocky Mountain National Park.

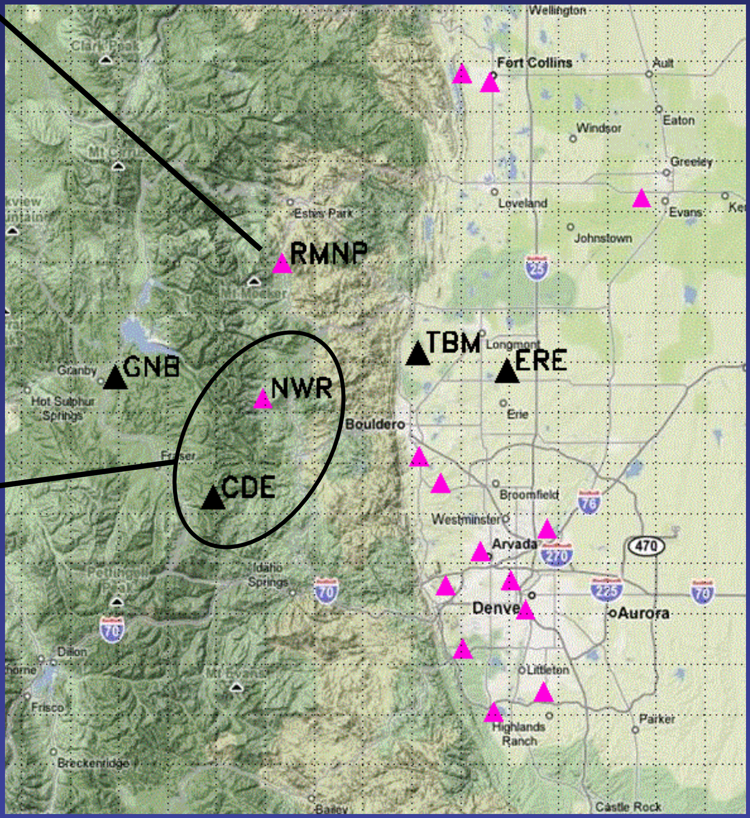
31 July 2008



RMNP Longs Peak site – 2743 m ASL



CDE – 3700 m ASL / NWR – 3538 m ASL



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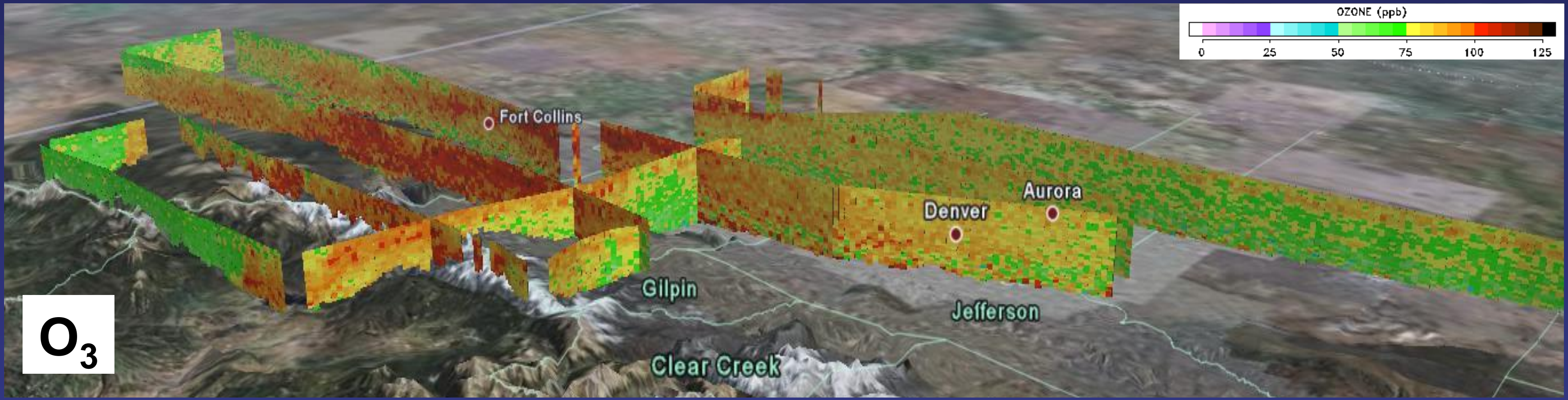
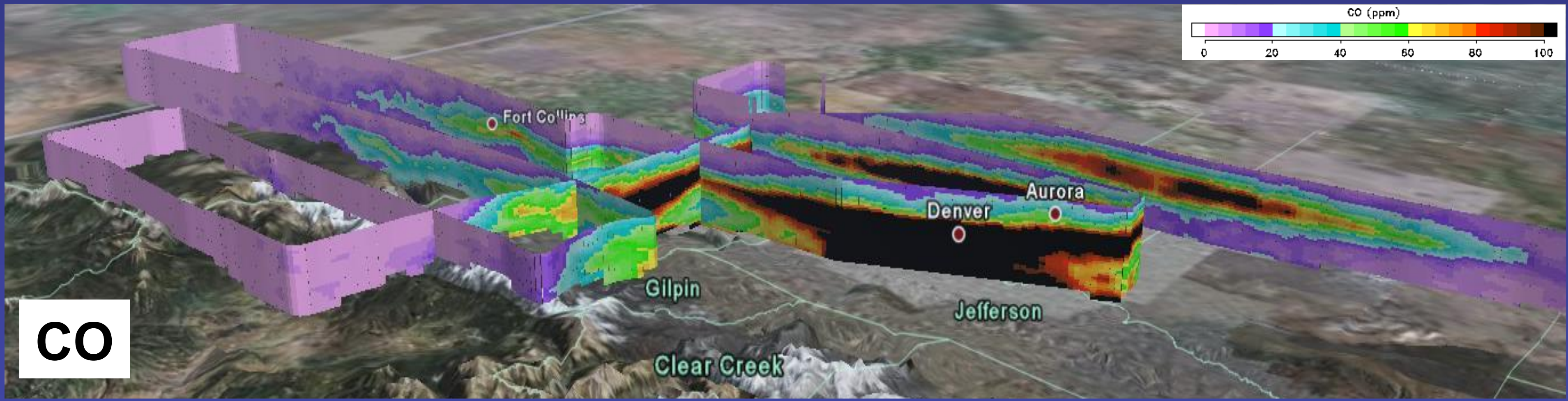
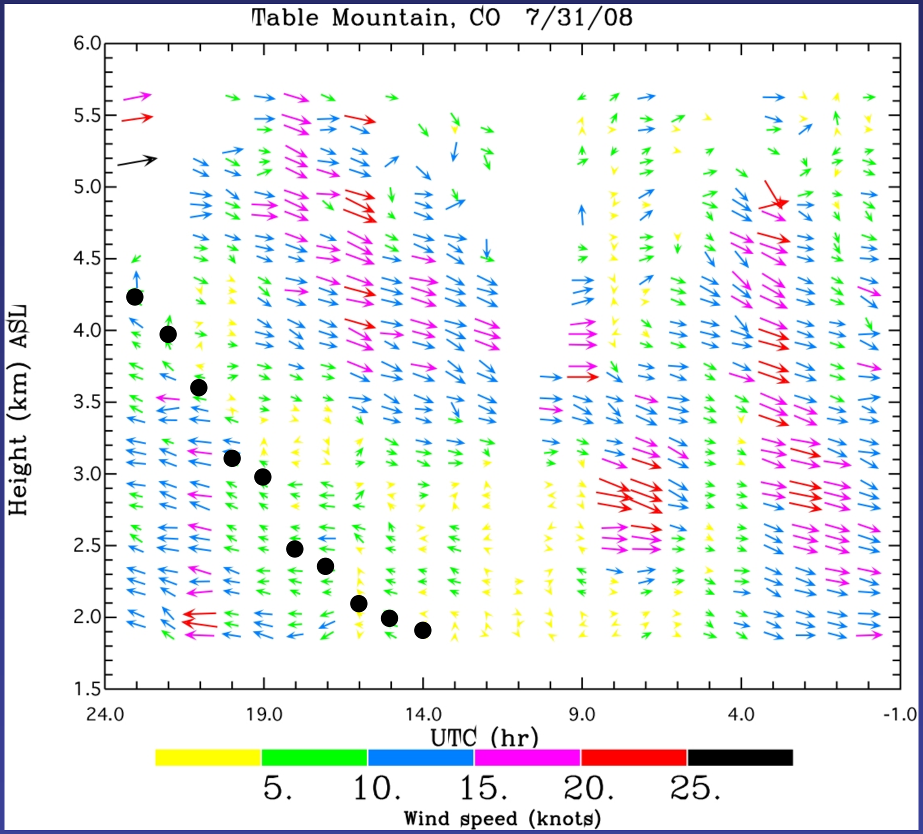


TOPAZ lidar measurement

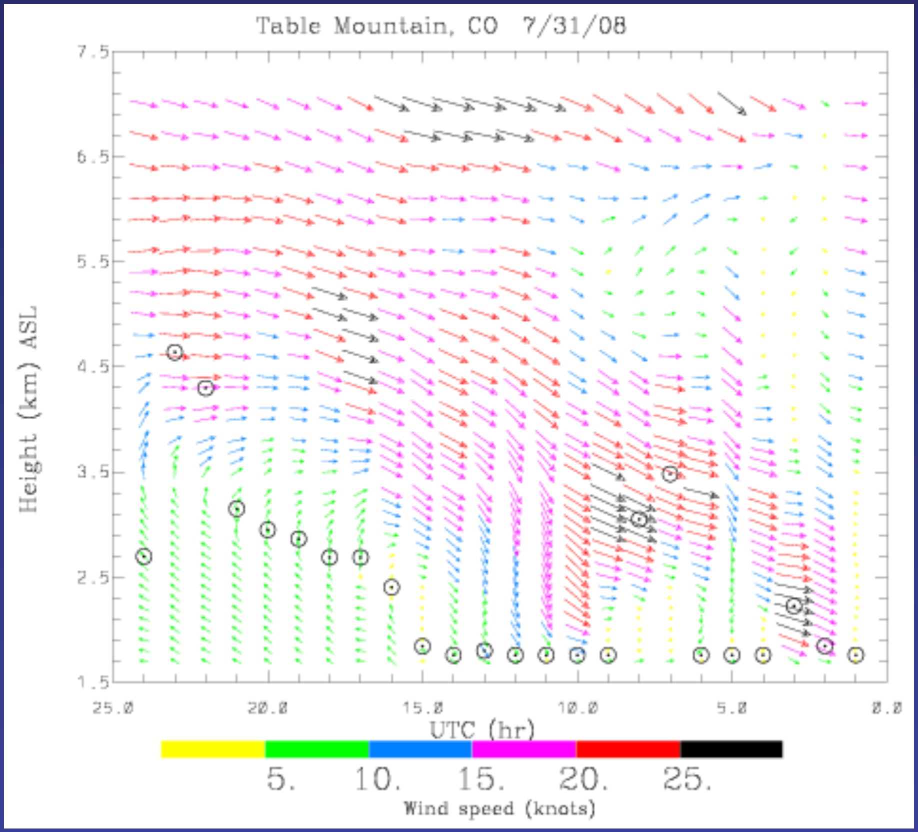


WRF-FLEXPART model results

31 July 2008

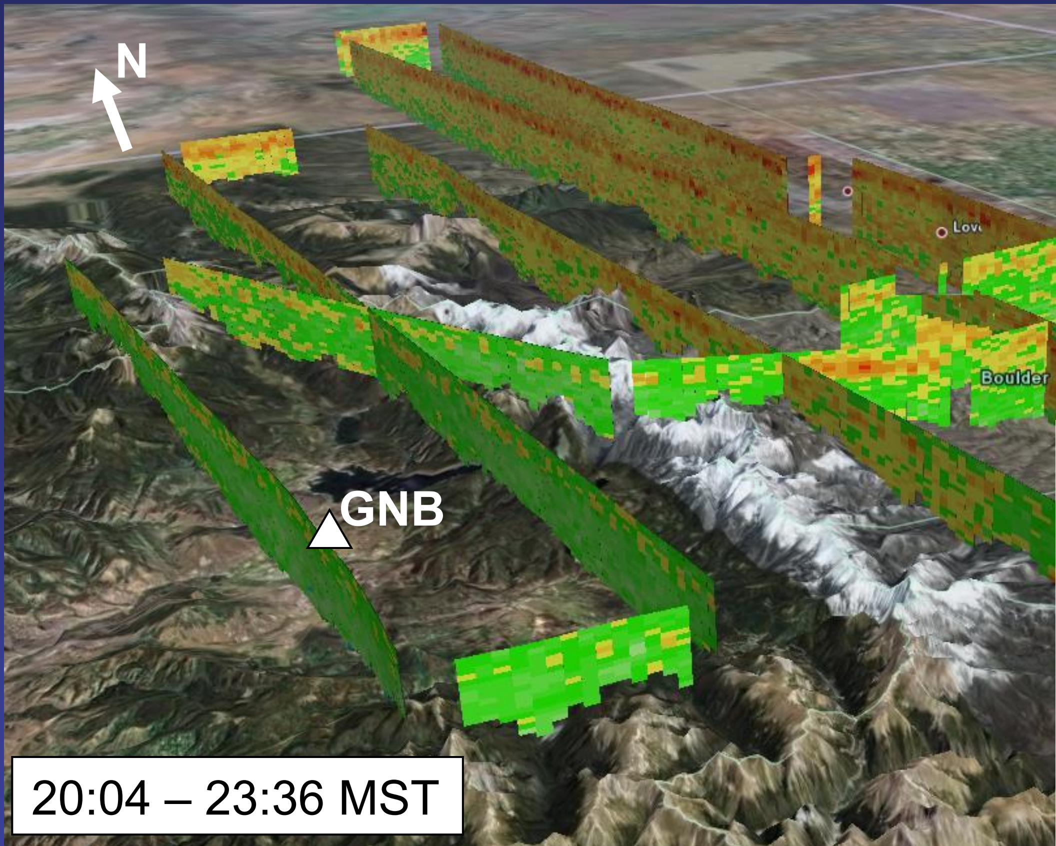


TBM radar wind profiler data

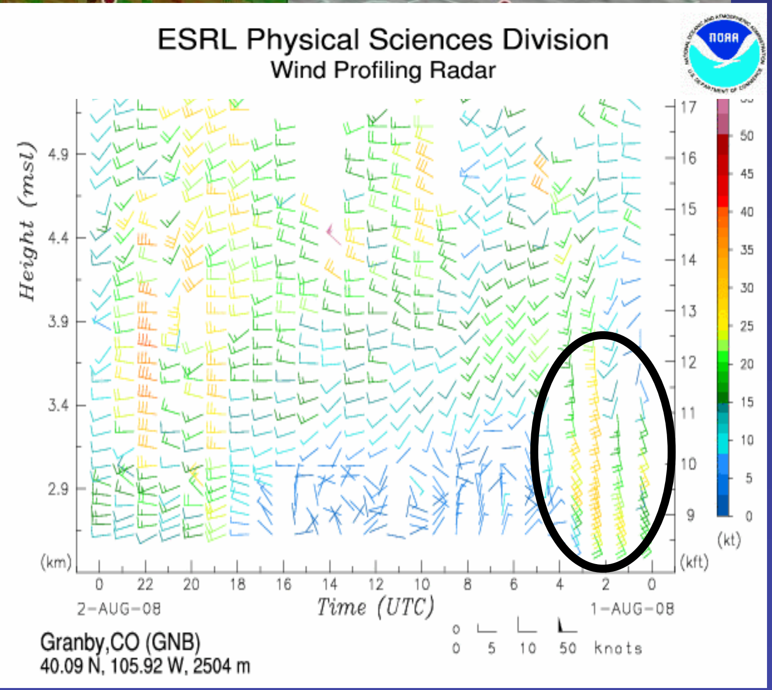


WRF/FLEXPART wind profiles at TBM site

31 July 2008 (TOPAZ evening flight)



3-d distribution of O_3 from TOPAZ lidar



GNB radar wind profiler data

Summary

- Prevailing easterly boundary layer winds transported pollutants from the Denver area towards and into the mountains.
- Highest ozone values were typically found along the eastern slope of the mountains.
- One case of transport of the Denver ozone plume across the Divide.
- WRF/FLEXPART model reproduced pollutant distribution quite well, but did not capture transport across the Divide due to an underestimation of boundary layer wind speeds and mixing heights.

Acknowledgements

Coauthors: R. J. Alvarez II, J. Brioude, S. A. McKeen, A. M. Weickmann, W. A. Brewer, S. P. Sandberg, A. B. White, W. M. Angevine

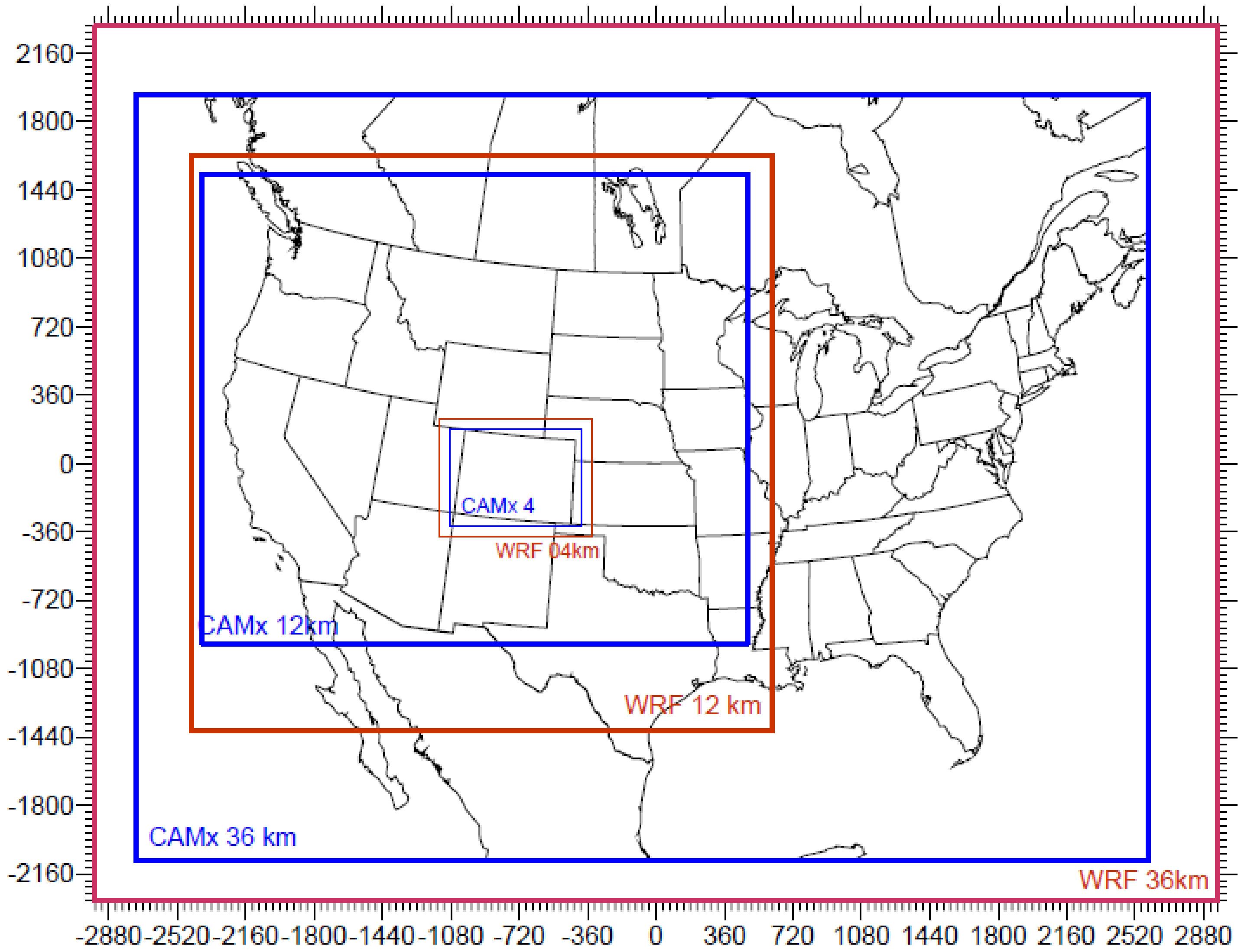
National Park Service Air Resources Division

Background Ozone Sources in the Denver/Northern Front Range

Gail Tonnesen, EPA Region 8

Nested 36/12/4-km WRF/CAMx Domains

Lateral BC from NCAR MOZART



37-layer WRF, with layer collapsing to 25 layer CAMx

L25: 15-19 km

L21: 5.8-7.4 km

L15: 2.1-2.5 km

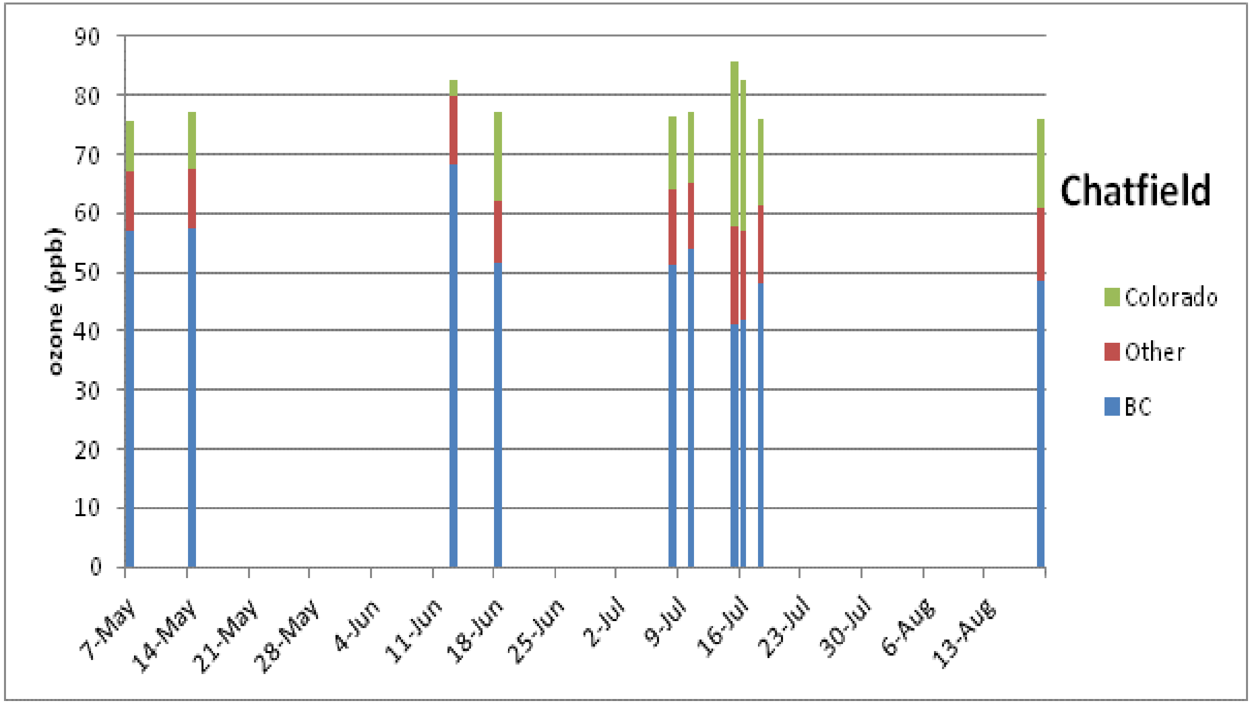
L1: 24 meters

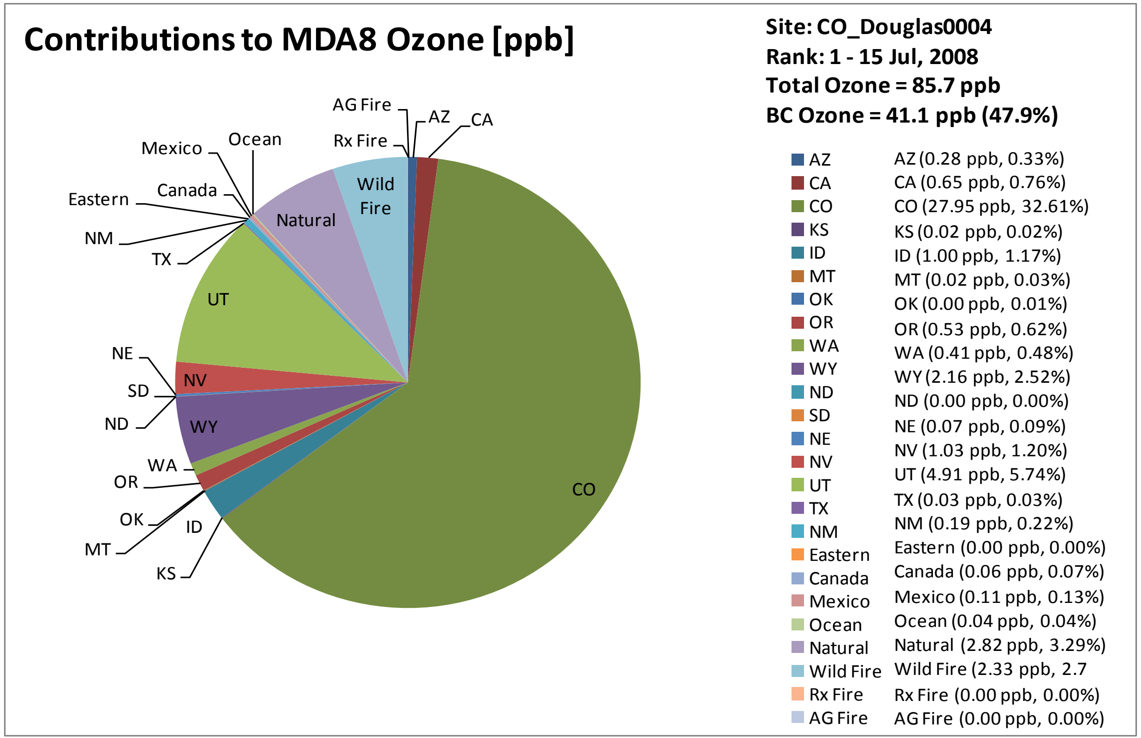
Table 4-3. Vertical layer definition for WRF simulations (left most columns), and appr reducing CAMx layers by collapsing multiple WRF layers (right columns).

WRF Meteorological Model					CAMx Air Quality Model		
WRF Layer	Sigma	Pressure (mb)	Height (m)	Thickness (m)	CAMx Layer	Height (m)	Thickness (m)
37	0.0000	50.00	19260	2055	25	19260.0	3904.9
36	0.0270	75.65	17205	1850			
35	0.0600	107.00	15355	1725	24	15355.1	3425.4
34	0.1000	145.00	13630	1701			
33	0.1500	192.50	11930	1389	23	11929.7	2569.6
32	0.2000	240.00	10541	1181			
31	0.2500	287.50	9360	1032	22	9360.1	1952.2
30	0.3000	335.00	8328	920			
29	0.3500	382.50	7408	832	21	7407.9	1591.8
28	0.4000	430.00	6576	760			
27	0.4500	477.50	5816	701	20	5816.1	1352.9
26	0.5000	525.00	5115	652			
25	0.5500	572.50	4463	609	19	4463.3	609.2
24	0.6000	620.00	3854	461	18	3854.1	460.7
23	0.6400	658.00	3393	440	17	3393.4	439.6
22	0.6800	696.00	2954	421	16	2953.7	420.6
21	0.7200	734.00	2533	403	15	2533.1	403.3
20	0.7600	772.00	2130	388	14	2129.7	387.6
19	0.8000	810.00	1742	373	13	1742.2	373.1
18	0.8400	848.00	1369	271	12	1369.1	271.1
17	0.8700	876.50	1098	177	11	1098.0	176.8
16	0.8900	895.50	921	174	10	921.2	173.8
15	0.9100	914.50	747	171	9	747.5	170.9
14	0.9300	933.50	577	84	8	576.6	168.1
13	0.9400	943.00	492	84			
12	0.9500	952.50	409	83	7	408.6	83.0
11	0.9600	962.00	326	82	6	325.6	82.4
10	0.9700	971.50	243	82	5	243.2	81.7
9	0.9800	981.00	162	41	4	161.5	64.9
8	0.9850	985.75	121	24			
7	0.9880	988.60	97	24	3	96.6	40.4
6	0.9910	991.45	72	16			
5	0.9930	993.35	56	16	2	56.2	32.2
4	0.9950	995.25	40	16			
3	0.9970	997.15	24	12	1	24.1	24.1
2	0.9985	998.58	12	12			

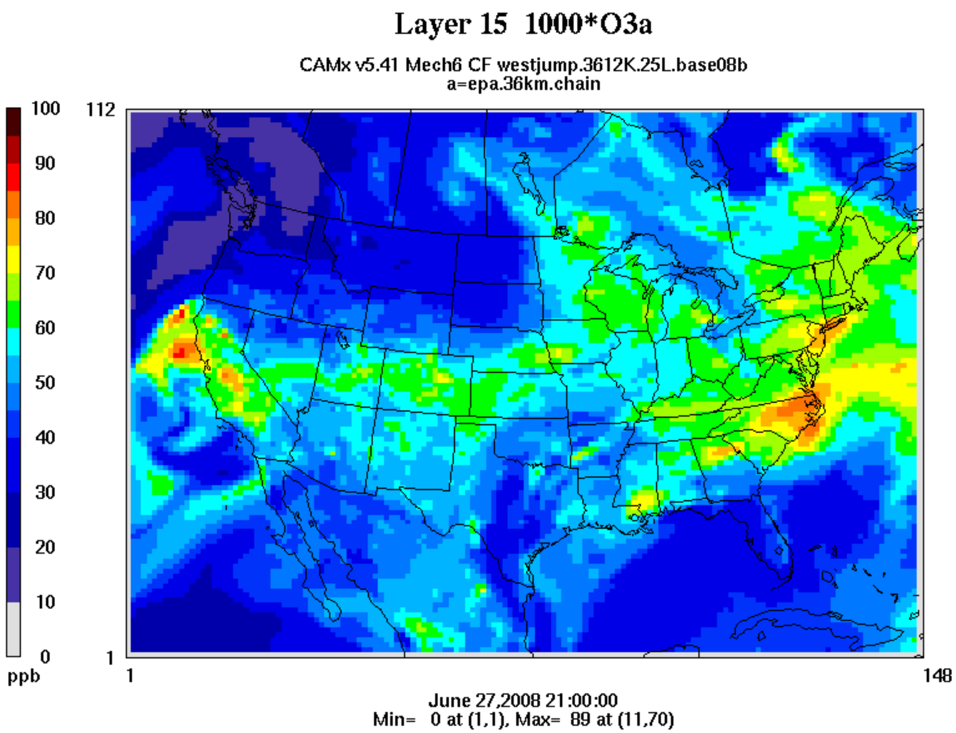
CAMx O3 Source Apportionment

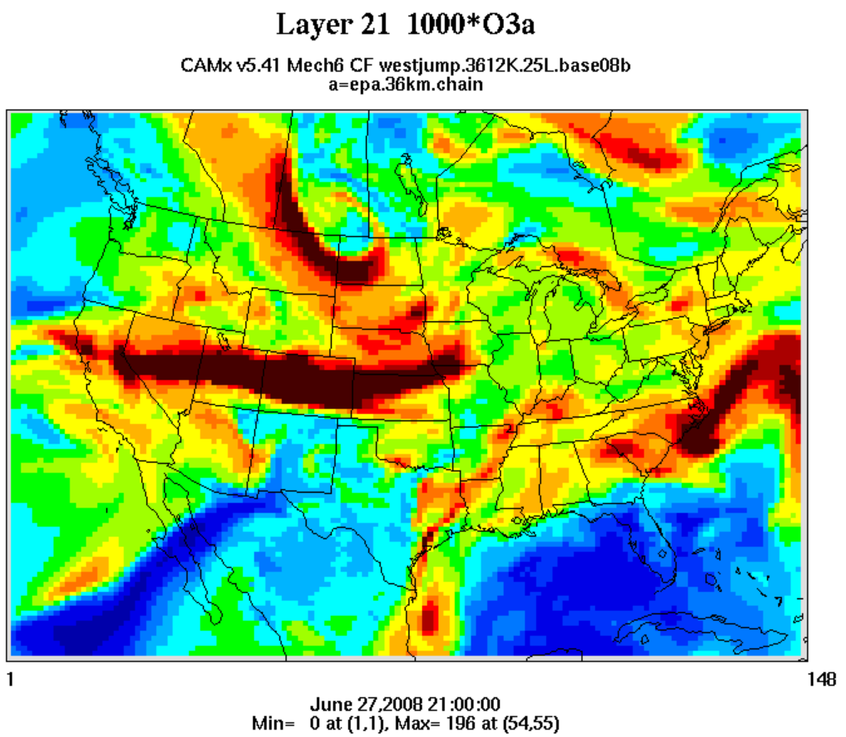
Ten highest 2008 modeled ozone days, 12-km grid





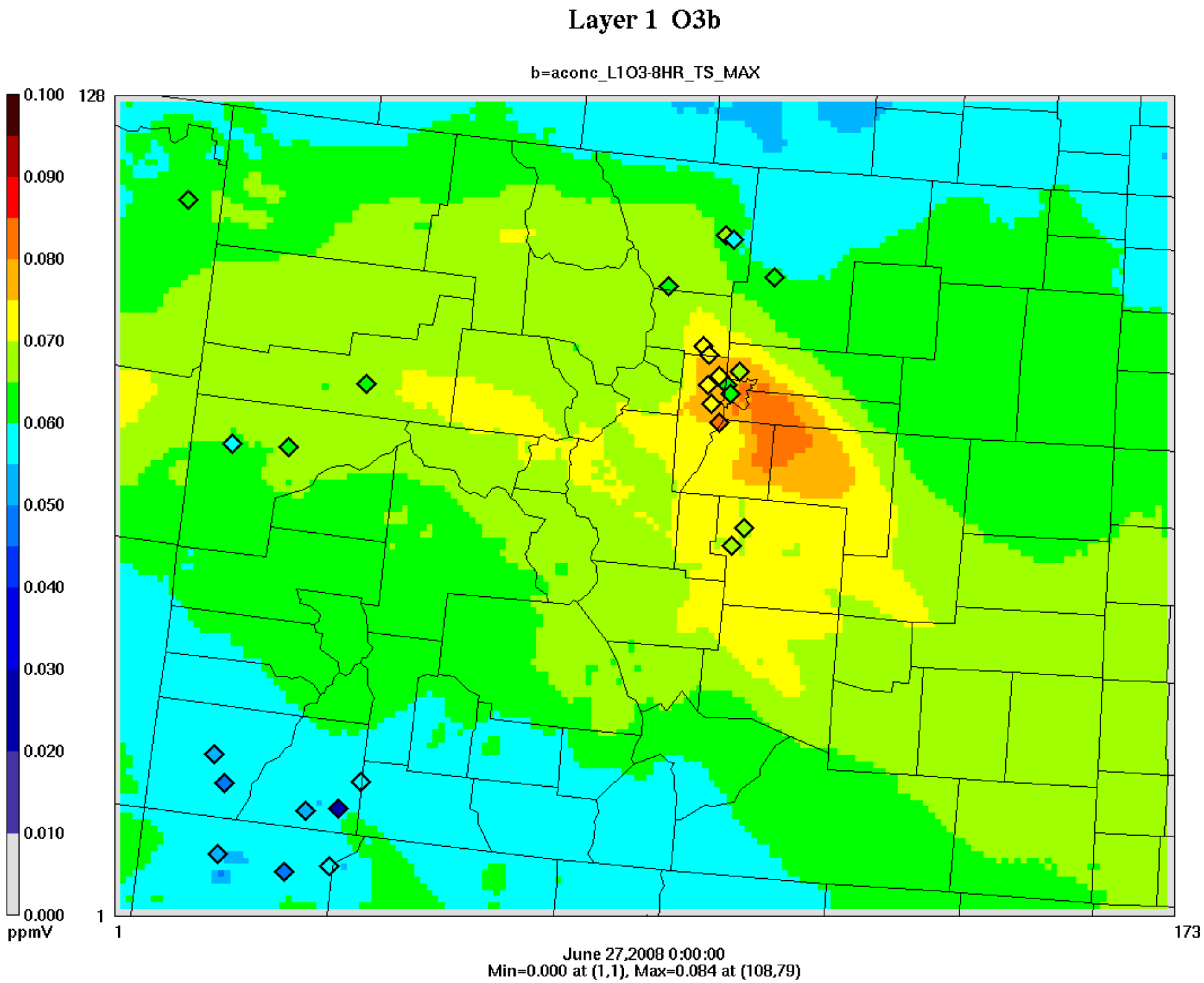
June 27: A band of high ozone in the free troposphere extends into the PBL fro CA to KS, and also extends into the PBL in NC





June 27 Surface Layer O3

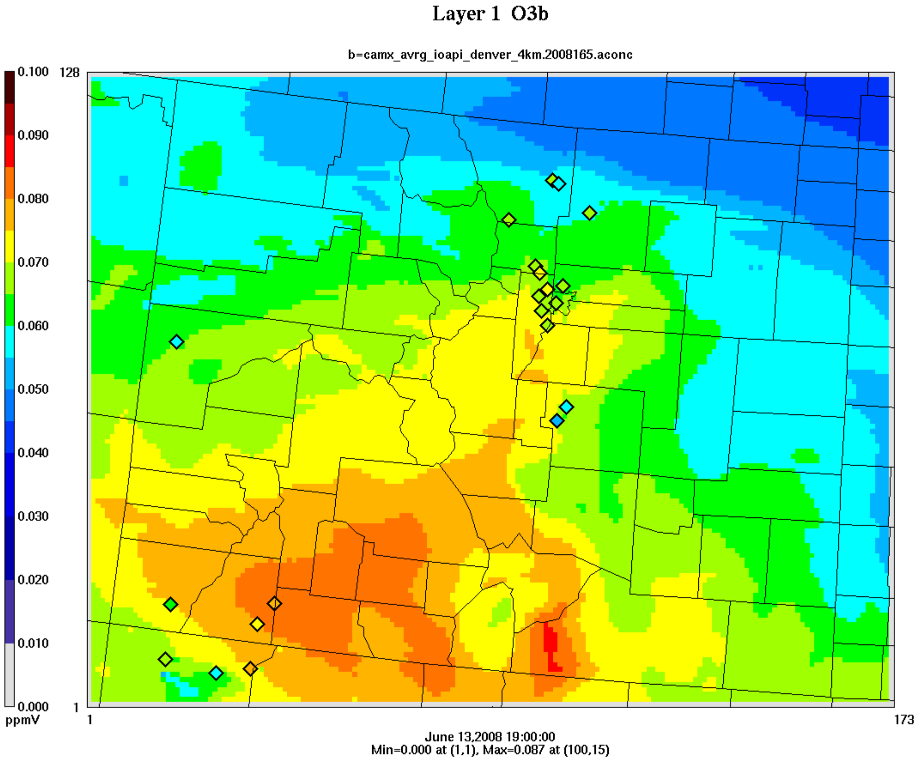
MD8

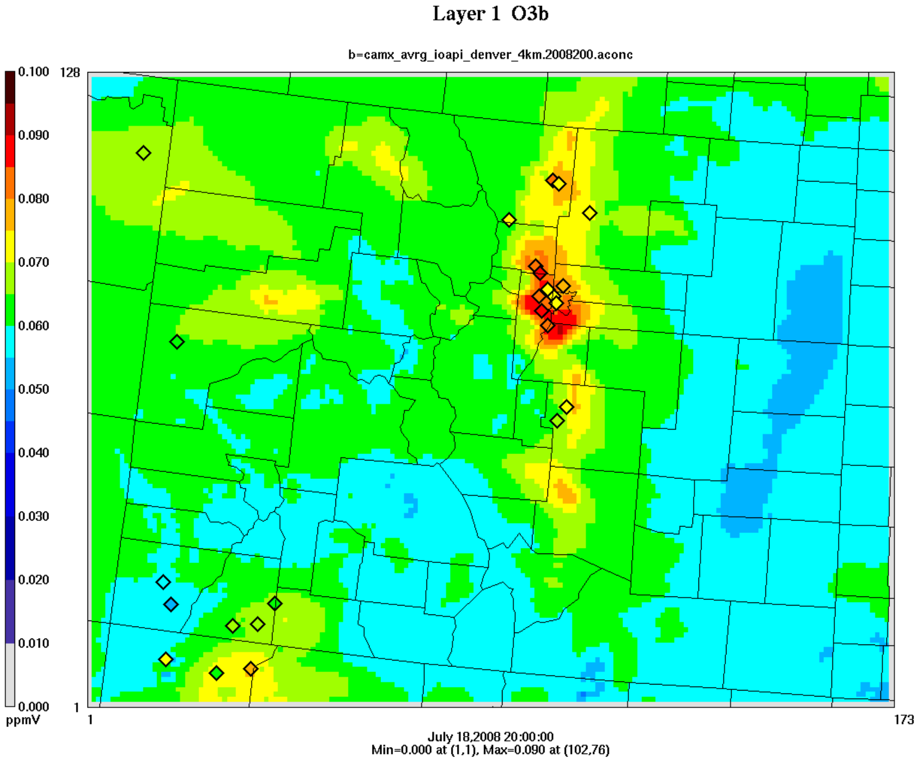


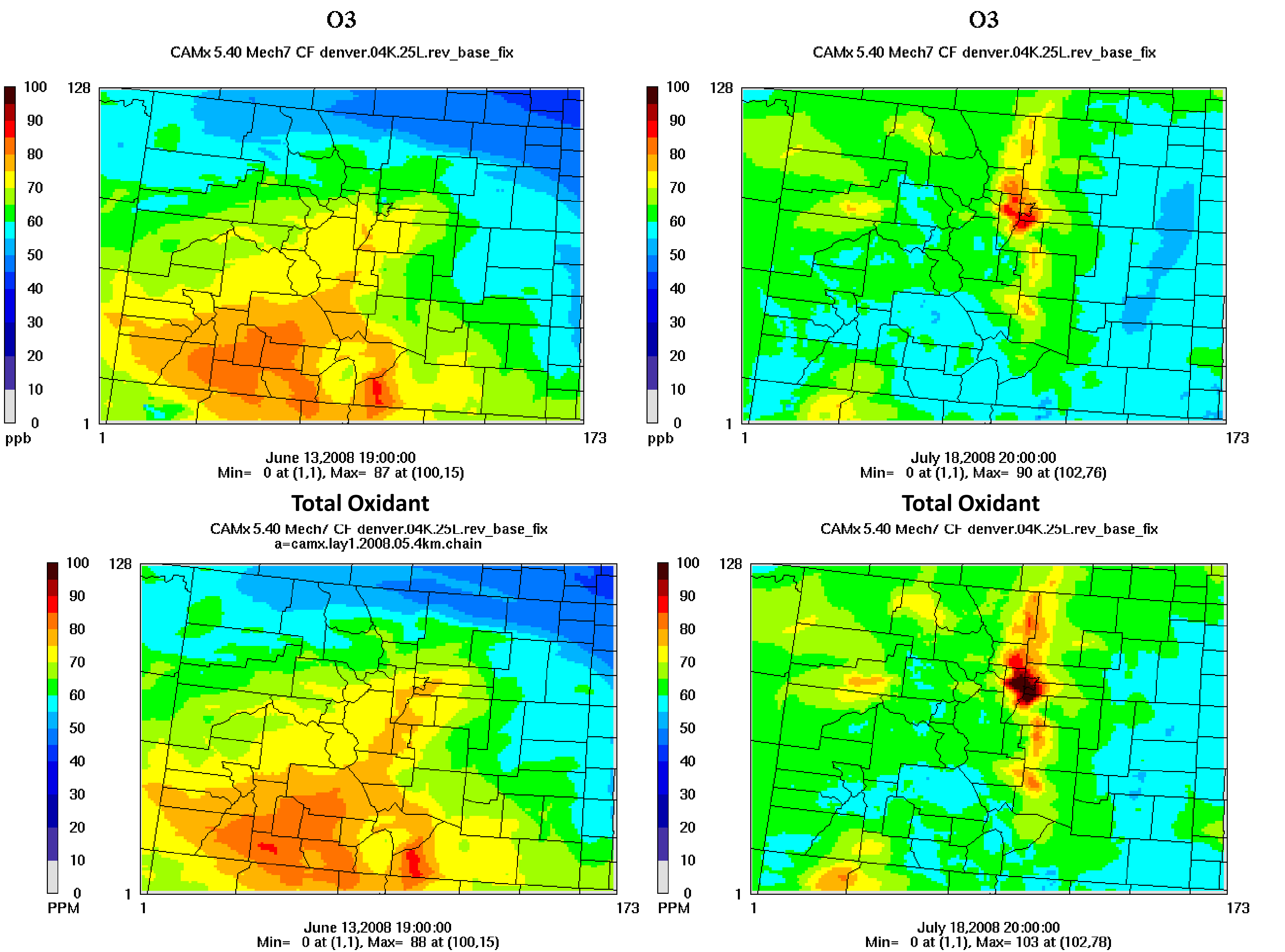
Ozone during SI and smog events

June 13: high ozone across large region including rural areas

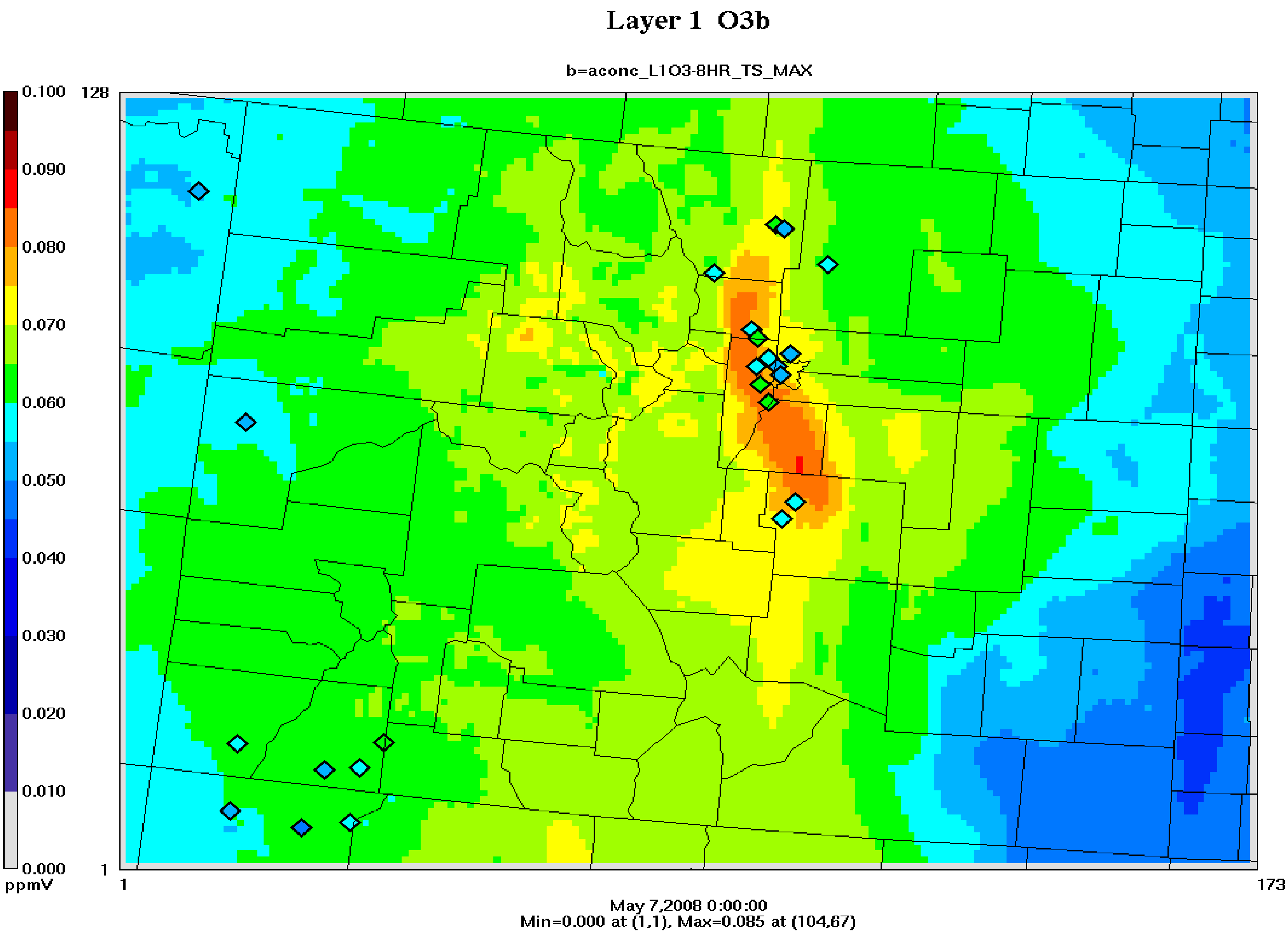
July 18: high ozone in urban areas and areas with precursor emissions



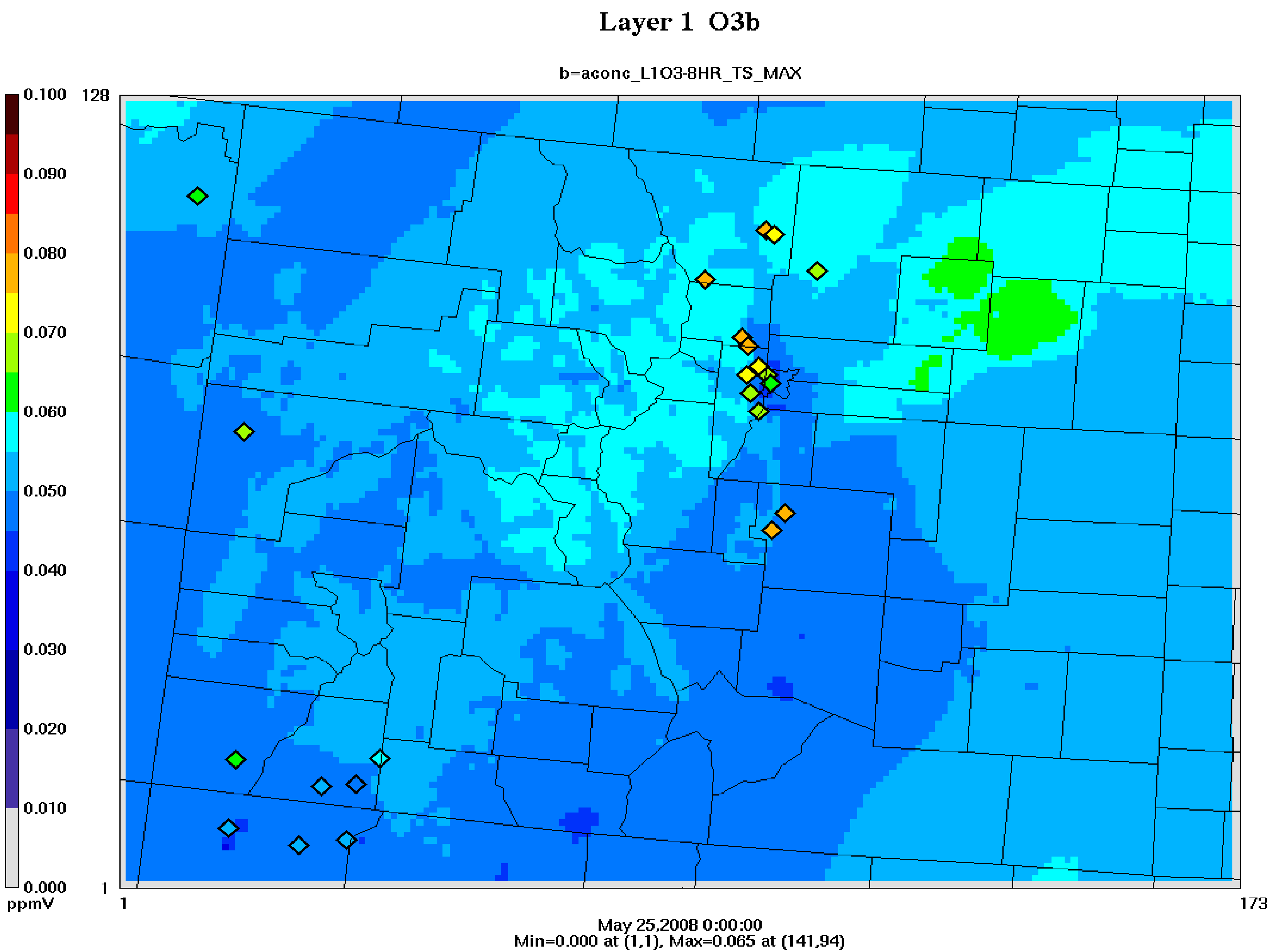



O3
CAMx 5.40 Mech7 CF denver.04K.25L.rev_base_fix
100
90
80
70
60
50
40
30
20
10
0
ppb
128
1
1
173
June 13,2008 19:00:00
Min= 0 at (1,1), Max= 87 at (100,15)
O3
CAMx 5.40 Mech7 CF denver.04K.25L.rev_base_fix
ppb
July 18,2008 20:00:00
Min= 0 at (1,1), Max= 90 at (102,76)
Total Oxidant
CAMx 5.40 Mech7 CF denver.04K.25L.rev_base_fix
a=camx.lay1.2008.05.4km.chain
PPM
June 13,2008 19:00:00
Min= 0 at (1,1), Max= 88 at (100,15)
Total Oxidant
CAMx 5.40 Mech7 CF denver.04K.25L.rev_base_fix
PPM
July 18,2008 20:00:00
Min= 0 at (1,1), Max= 103 at (102,78)

May 7: Model biased high for background O3



May 25: Model Biased low for background O3



SI and Background O3 Research Needs

- Background and transported ozone is highly variable in both space and time.
- Important to accurately model background O3:
  - transported O3 can cause exceedances of the NAAQS.
  - background O3 level also affects the reactivity of the VOC-NOx mixture.
- What type of monitoring network is needed to characterize background ozone?
  - surface monitors; lidar profiles; ozonesondes; satellite data; research grade CO, RH, met data; urban, rural and high elevation sites.

Relationships between July Mean Daily Maximum Surface Ozone and Satellite NO2 and Meteorological Variables For Sites in Colorado and the Western United States

Patrick J. Reddy

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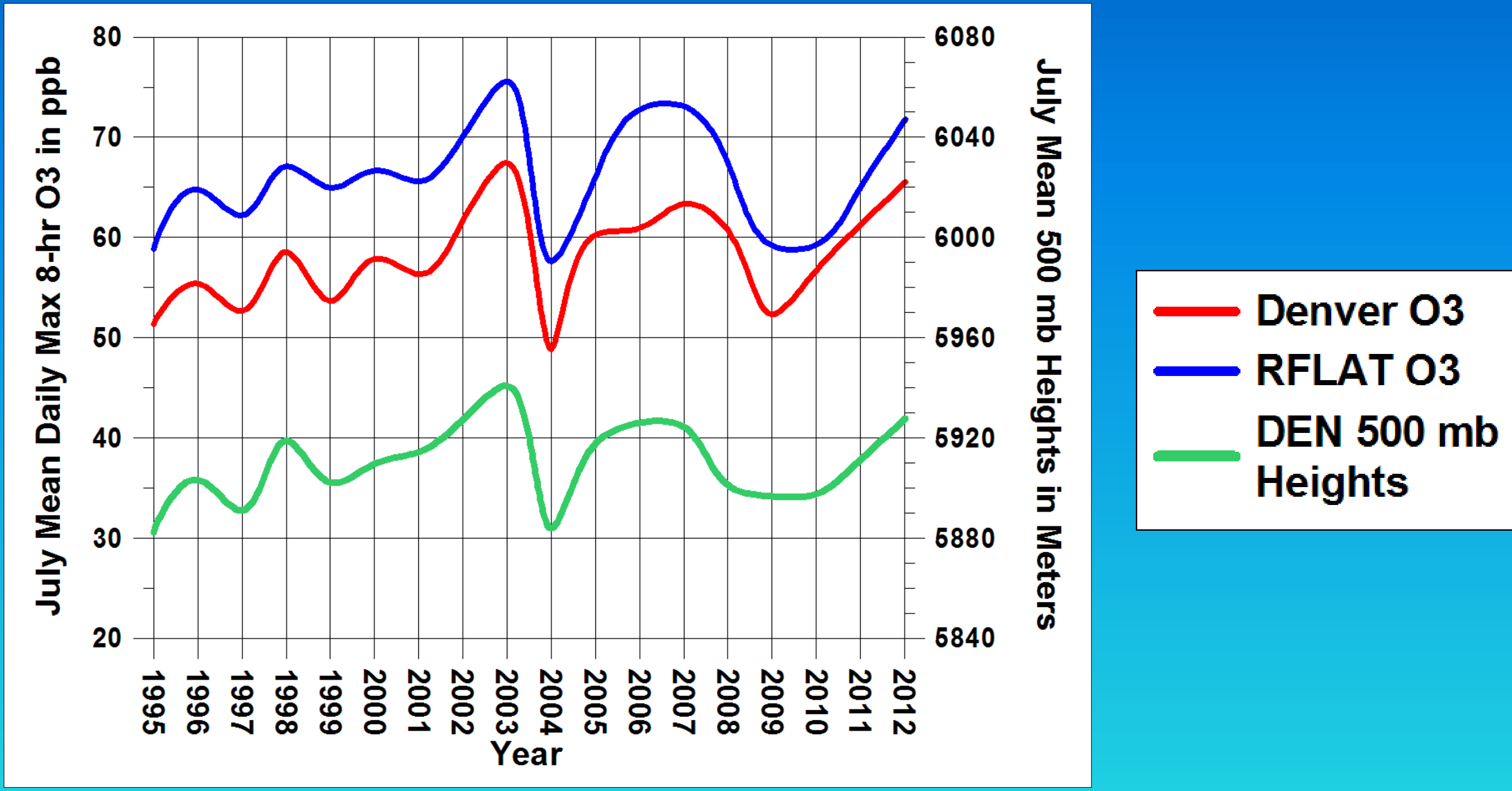
patrick.reddy@state.co.us

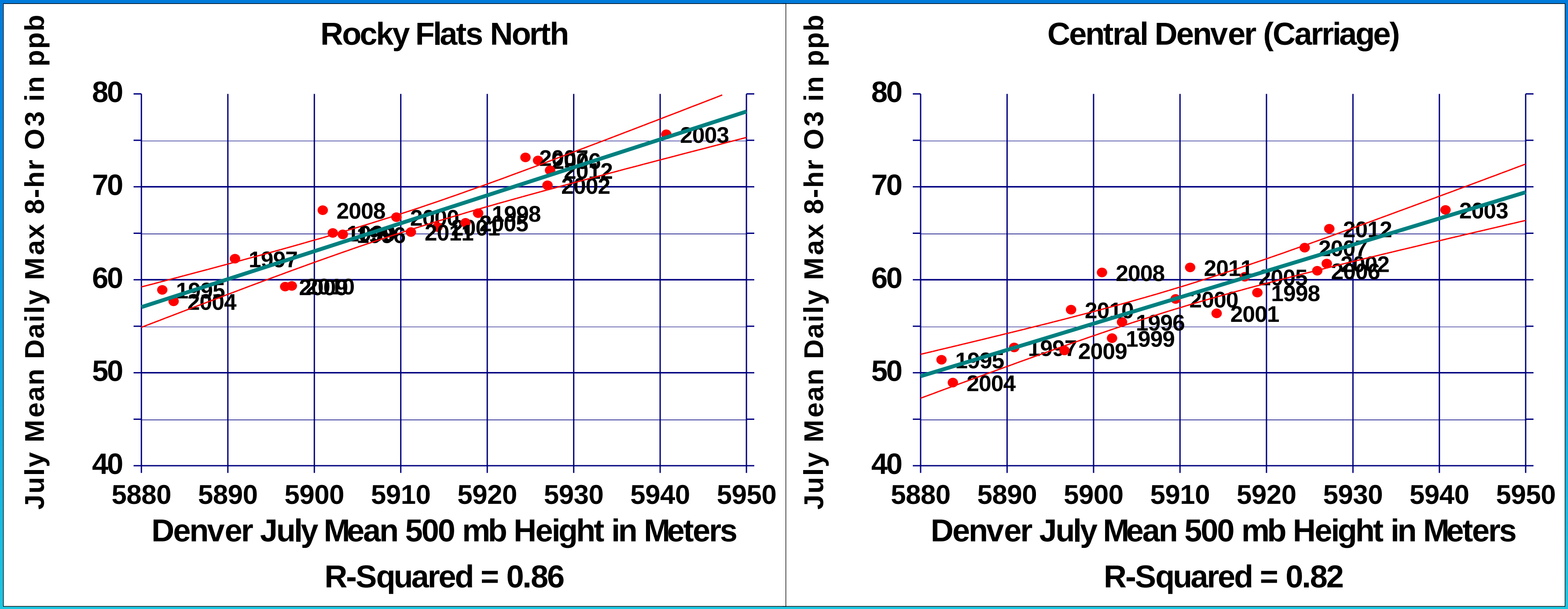
- There is a very strong relationship between July mean 500 mb heights and July DMAX 8-hr O3 in Colorado and other western sates.
- Under the influence of an upper high, skies are often clear, temperatures are elevated, and westerlies are reduced in strength.
- These conditions promote the formation of mountain-plains solenoid circulations and westward propagating density currents along the Colorado Front Range and in the mountainous terrain of central Colorado.
- Mid-day PBL typically extends to 6 to 8 km levels over Front Range and mountains to the West.
- These circulations appear to enhance O3 and NO2 and lead to the highest concentration events.

Mean July Daily Max O3 Tracks with Mean July 500 mb Heights



Large decline in surface O3 in 2004 after worst O3 in decades in 2003. Exploration of ~ 100 variables (time scales 1 day to 1 month) showed that mean July 500 mb heights had the greatest predictive power, followed by July 700 mb temperatures and July surface temperatures.

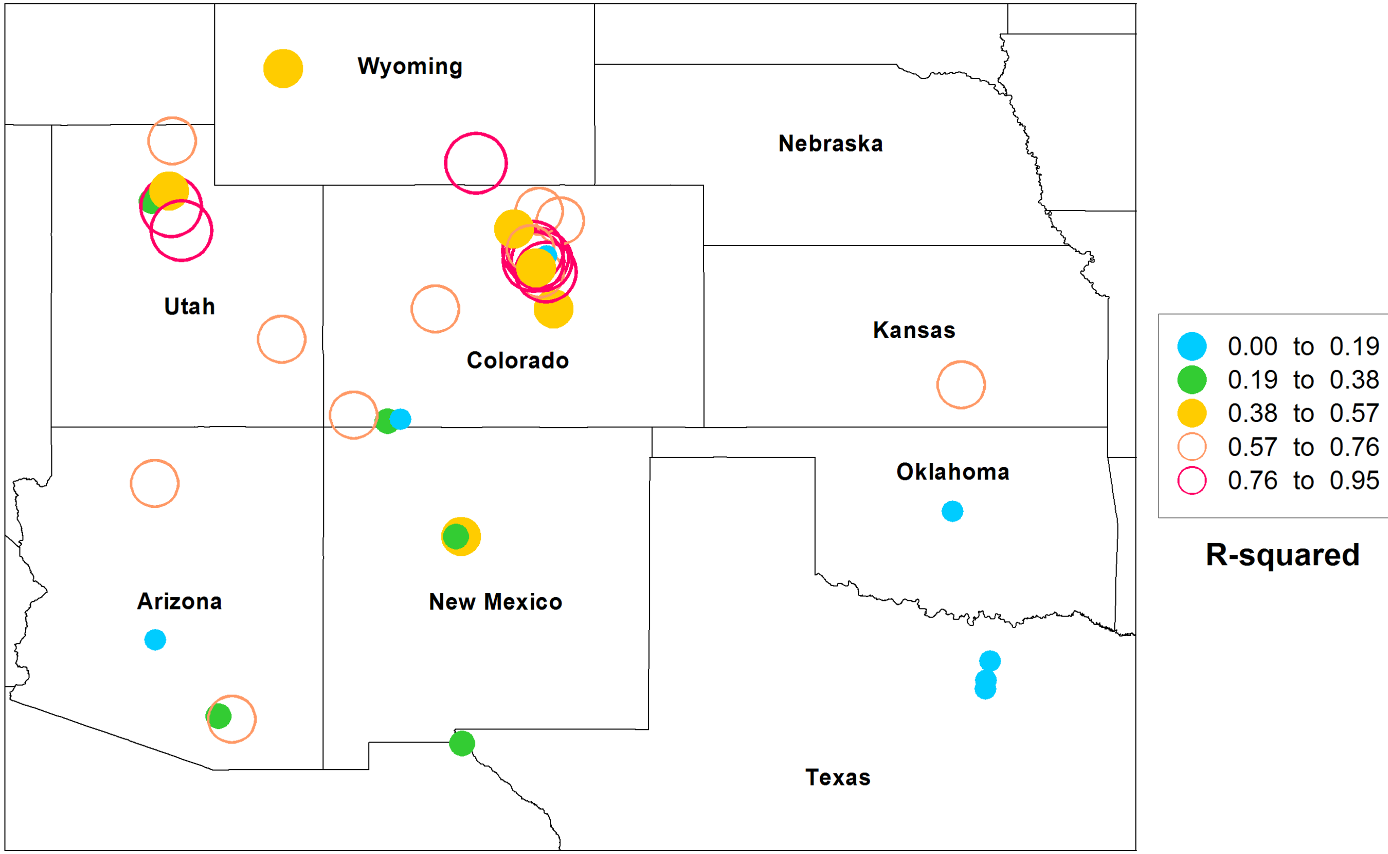
Very High Correlations Between July Means for Daily Max O3 and 500 mb Heights



Linear regressions: Rocky Flats and Carriage July mean daily max 8-hour O3 and July mean 500-mb heights. **Rocky Flats is a high-concentration site; Carriage is a low-concentration site west of downtown Denver**.

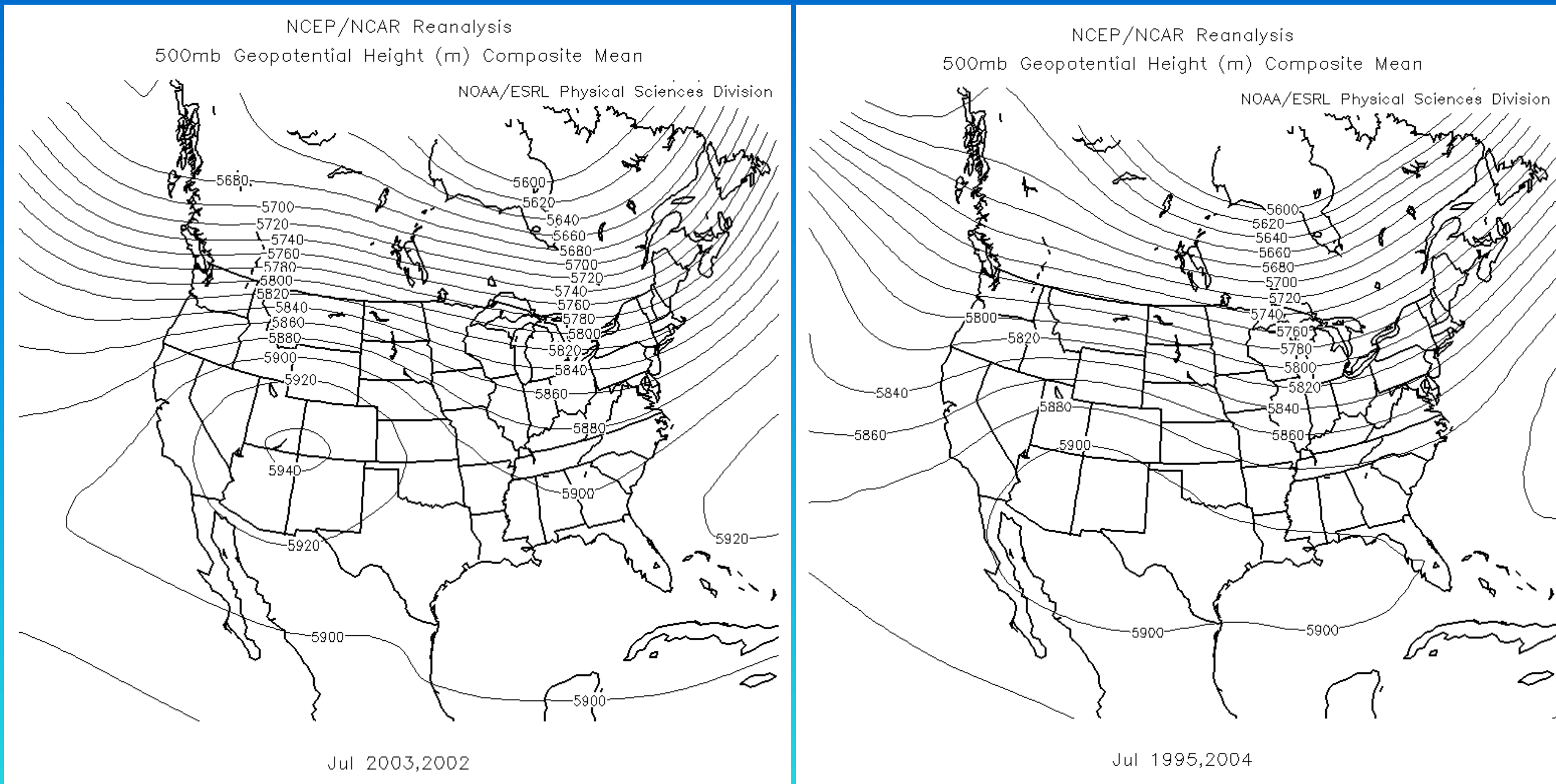
500-mb heights from the NCAR/NCEP Reanalysis data set (Kalnay et al. 1996)

Analyses for Many Sites in CO, UT, AZ, WY, & NM Show Similar Correlation.

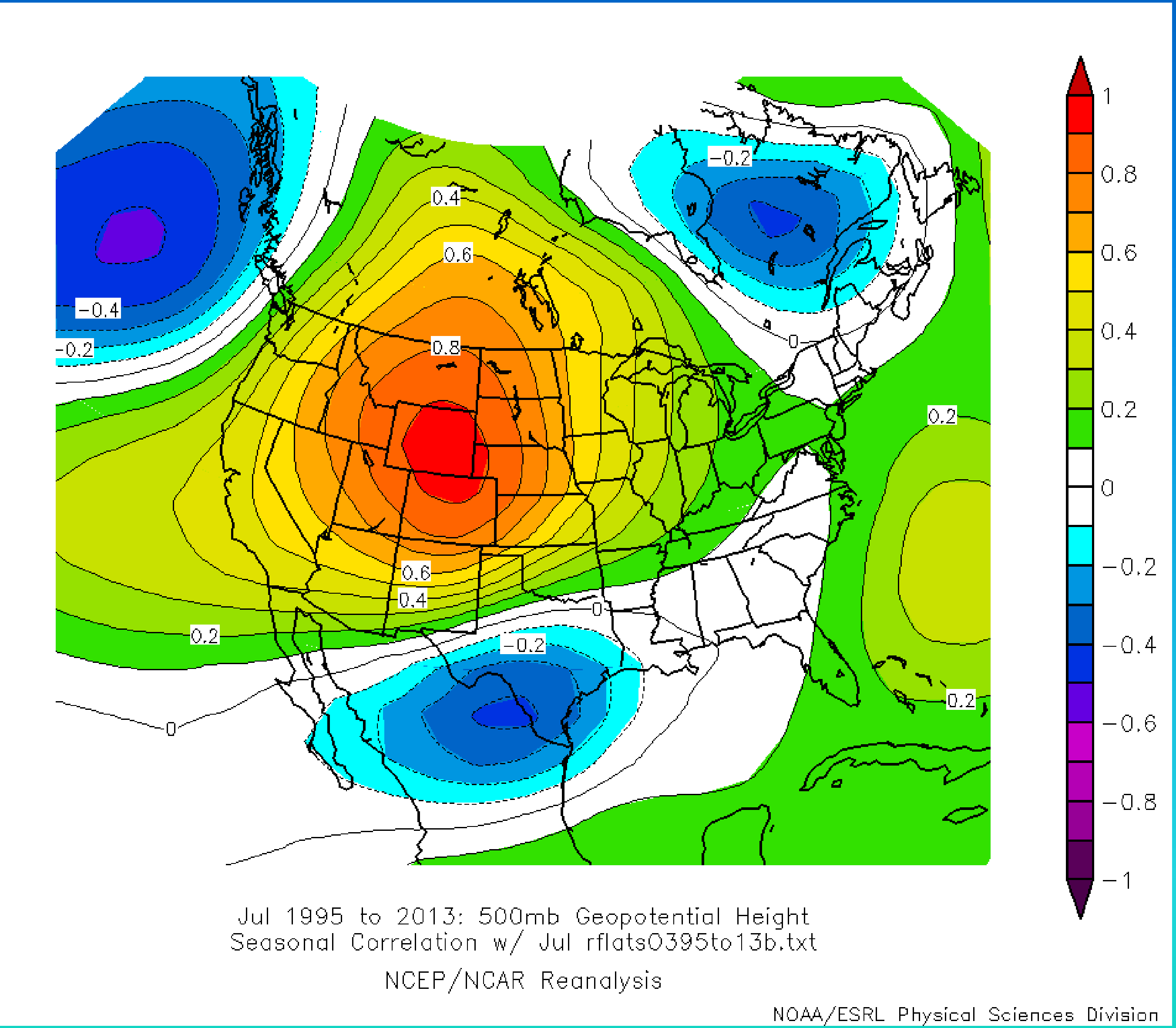


Correlation, R-squared, between July Mean Daily Max 8-hour Ozone and Local July Mean 500 mb Heights 1995-2004

Relationship between July mean daily max O3 and 500-mb heights is strongest in Utah and Front Range of Colorado, and in NM, AZ, and WY. 500 mb heights have much weaker influence in LA and Houston.

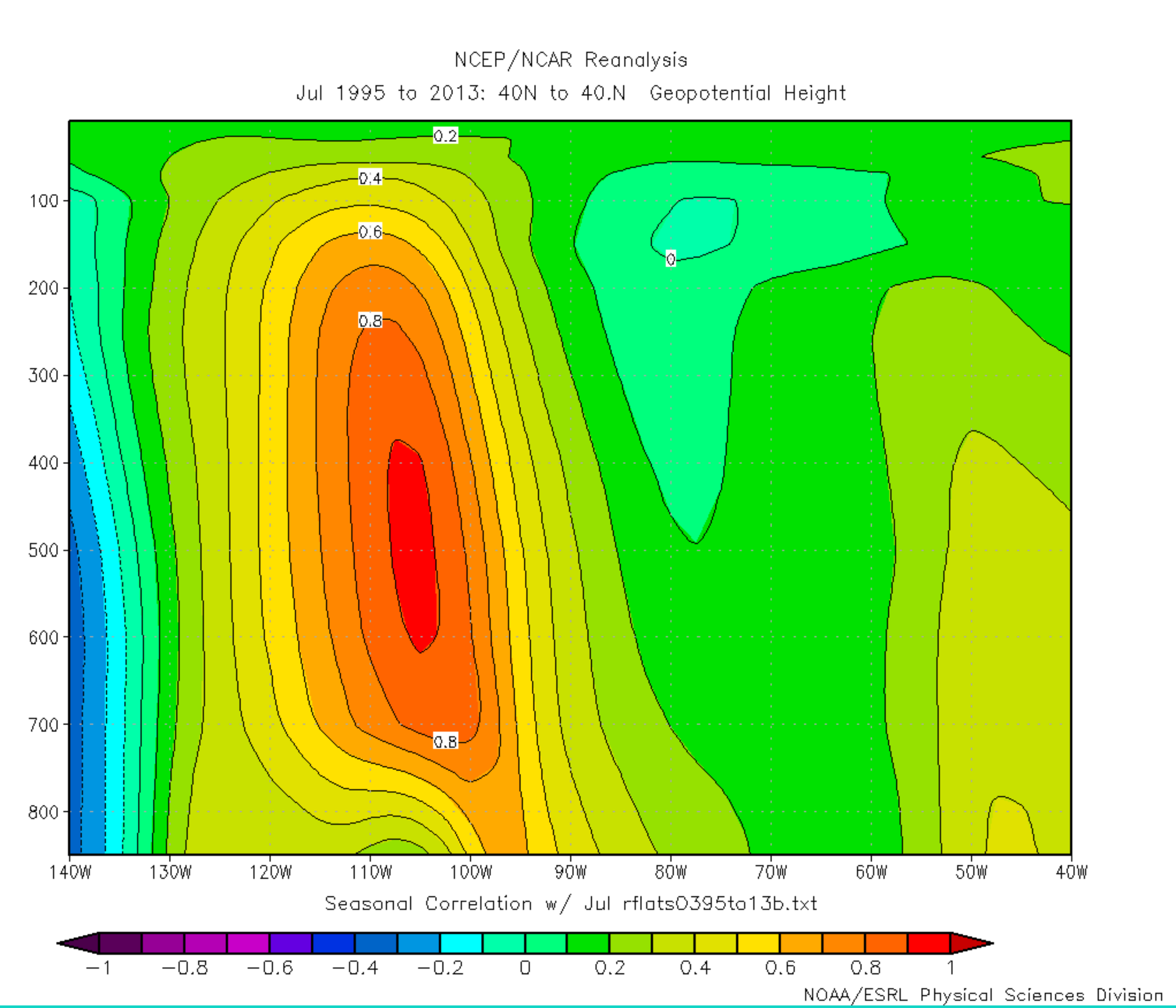


July mean NCEP/NCAR Reanalysis 500 mb heights in 2002 &2003, high O3 years **left**, and 1995 & 2004, low O3 years **right**, showing a northward intensification in 2002 & 2003 and the establishment of Four Corners high in 2002 & 2003.



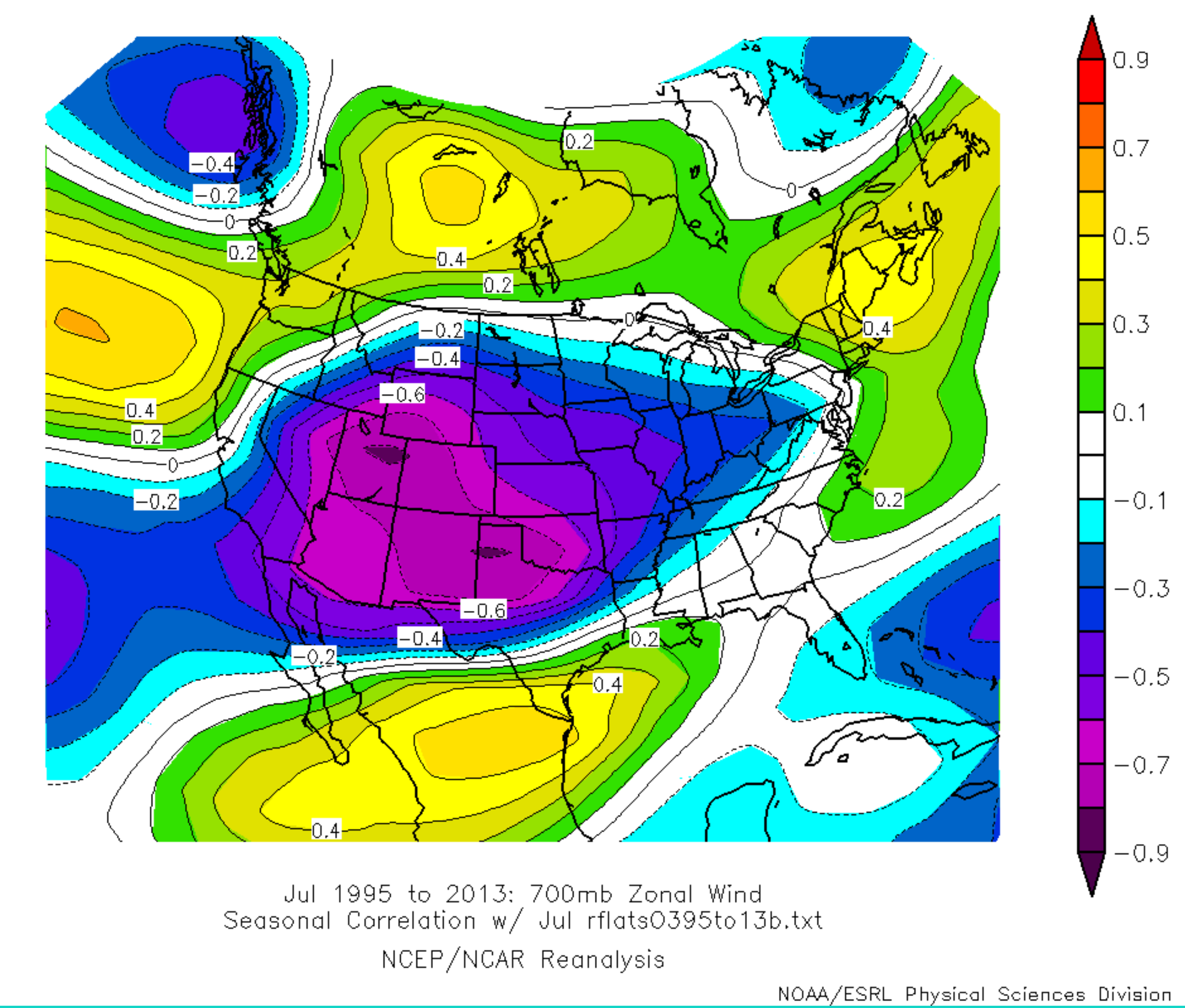
Based on 1995-2013 July mean NCEP/NCAR reanalysis data: Rocky Flats July mean DMAX 8-hr O3 is sensitive to an increase in heights in WY and northern CO.

This is consistent with a northward expansion of ridge and a build-up of high pressure at 500 mb in the 4 Corners states.



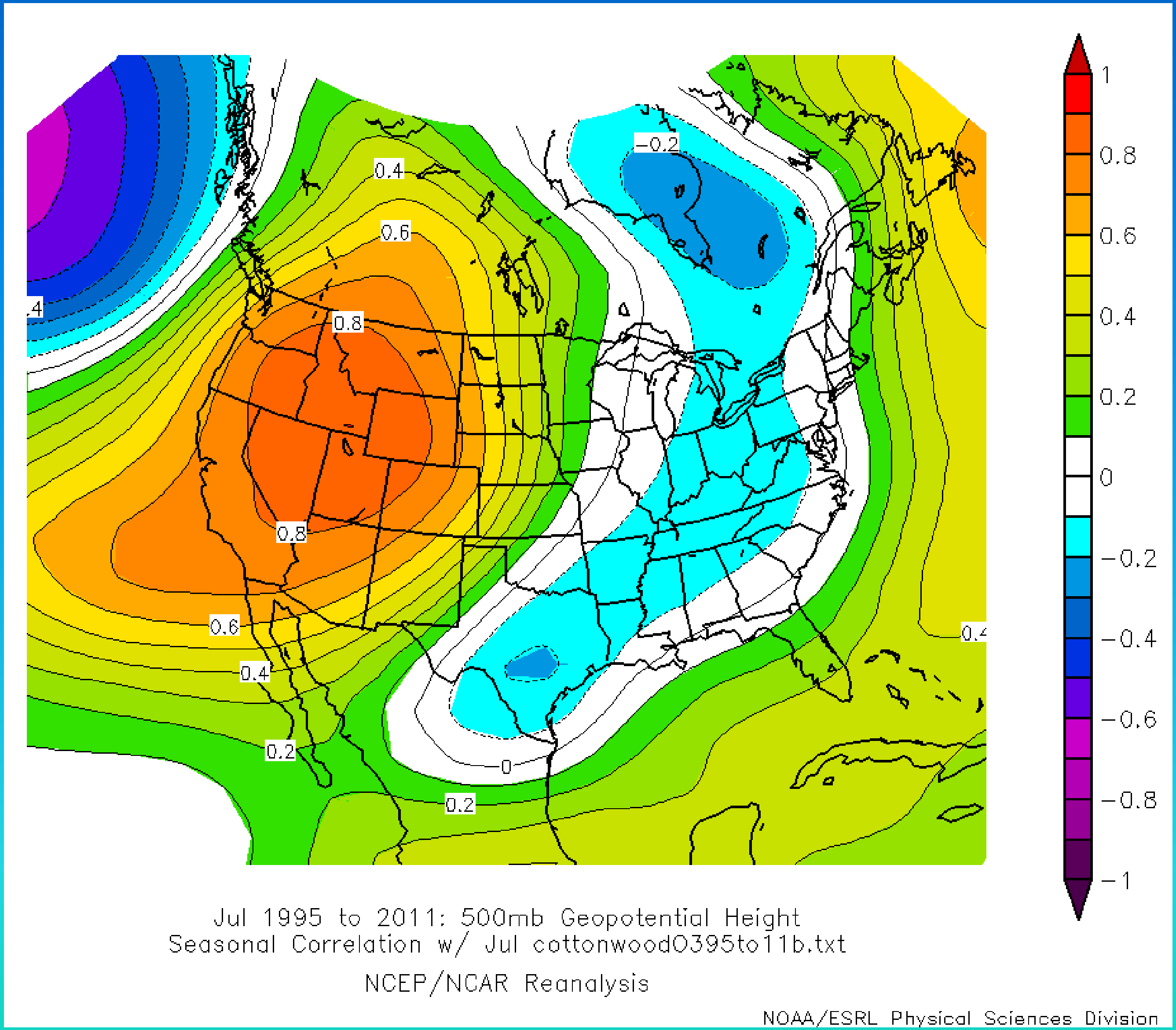
A west-east cross section of correlations from 140W to 40W shows the response of RFLAT O3 to geopotential heights based on 1995-2013 July mean data.

RFLATS O3 is most Sensitive to increases In heights between 600 and 400 mb.

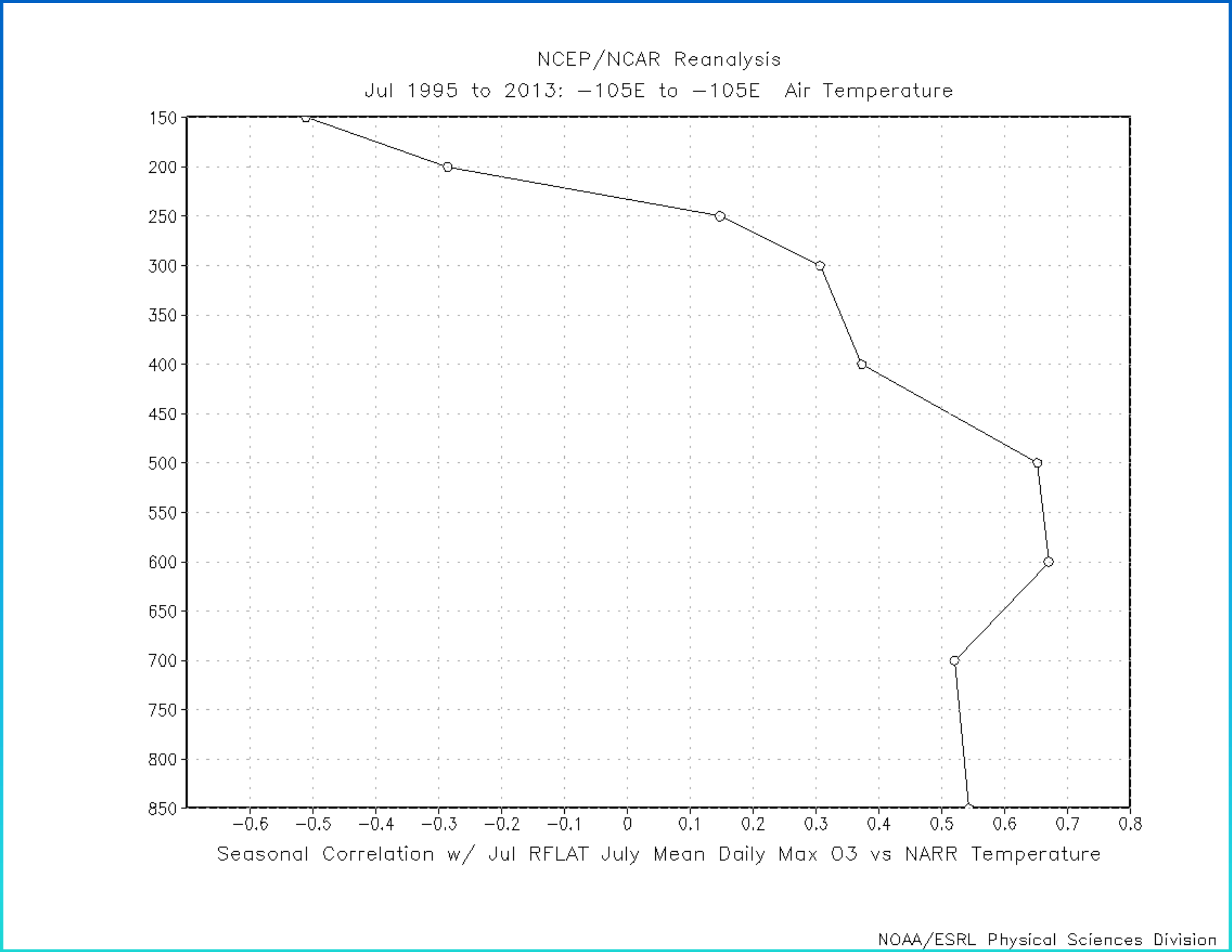


Based on 1995-2013 July mean NCEP/NCAR reanalysis data: Rocky Flats July mean DMAX 8-hr O3 is anti-correlated with 700 mb zonal flow in 4 corners states.

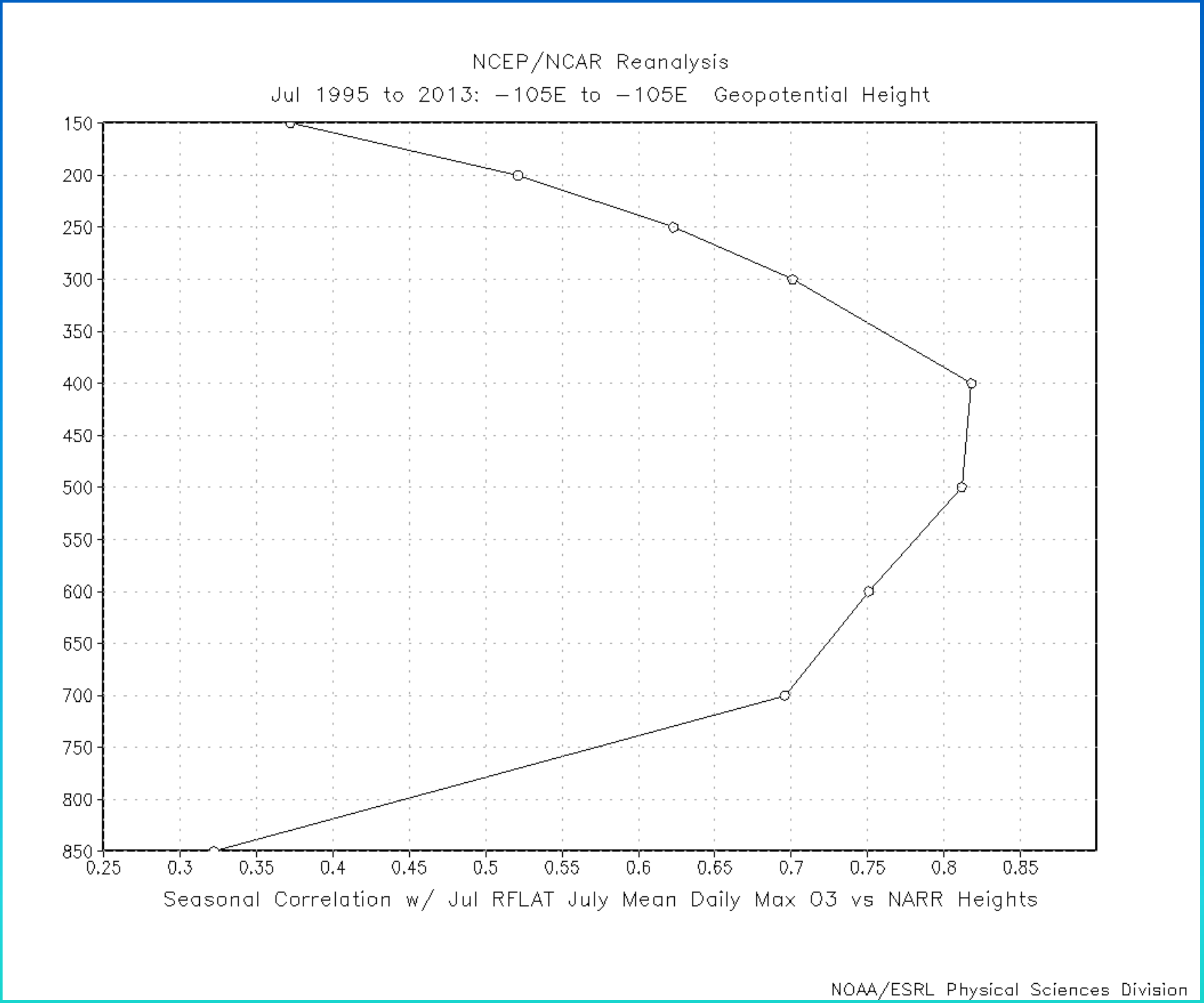
This is consistent with a northward expansion of ridge and a build-up of high pressure at 500 mb in the 4 Corners states.



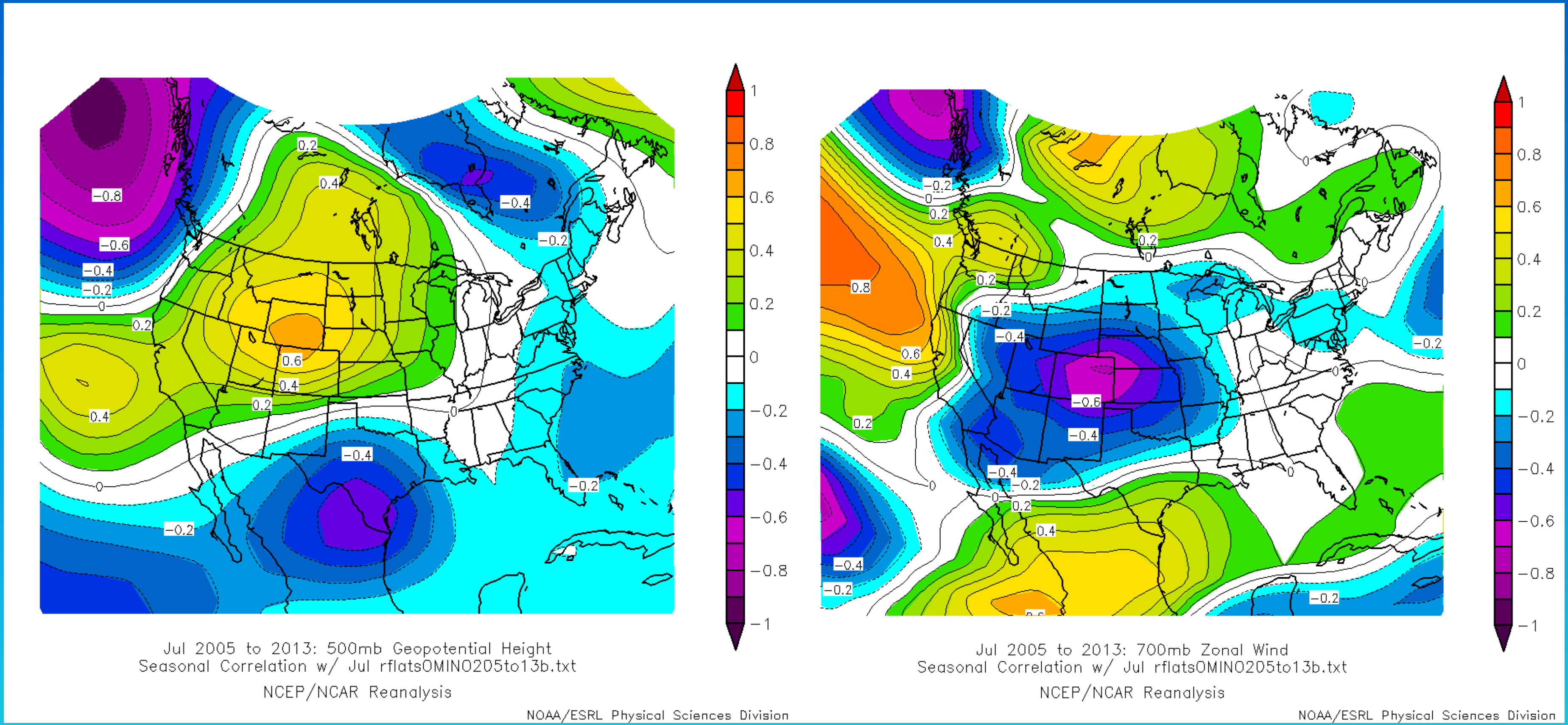
A similar relationship between 500 mb heights and O3 can be seen at the Cottonwood site in SLC in Utah for 1995-2011.



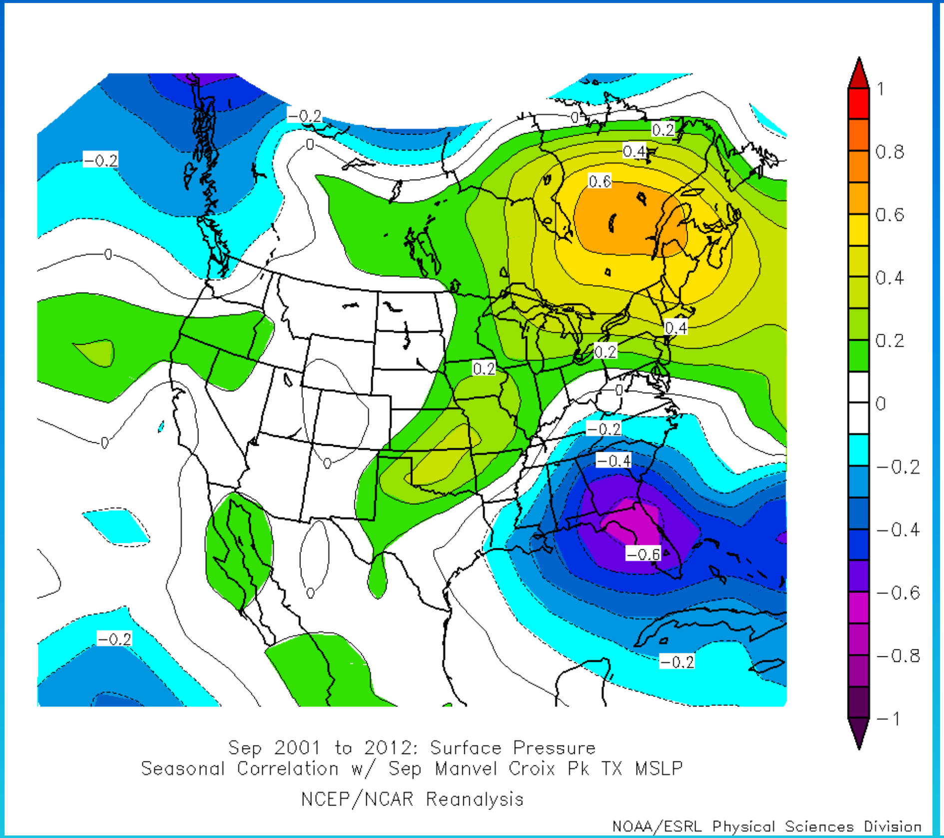
Correlation: 1995-2013 RFLAT July mean DMAX 8-hr O3 versus temperature in the vertical (850 to 150 mb levels).

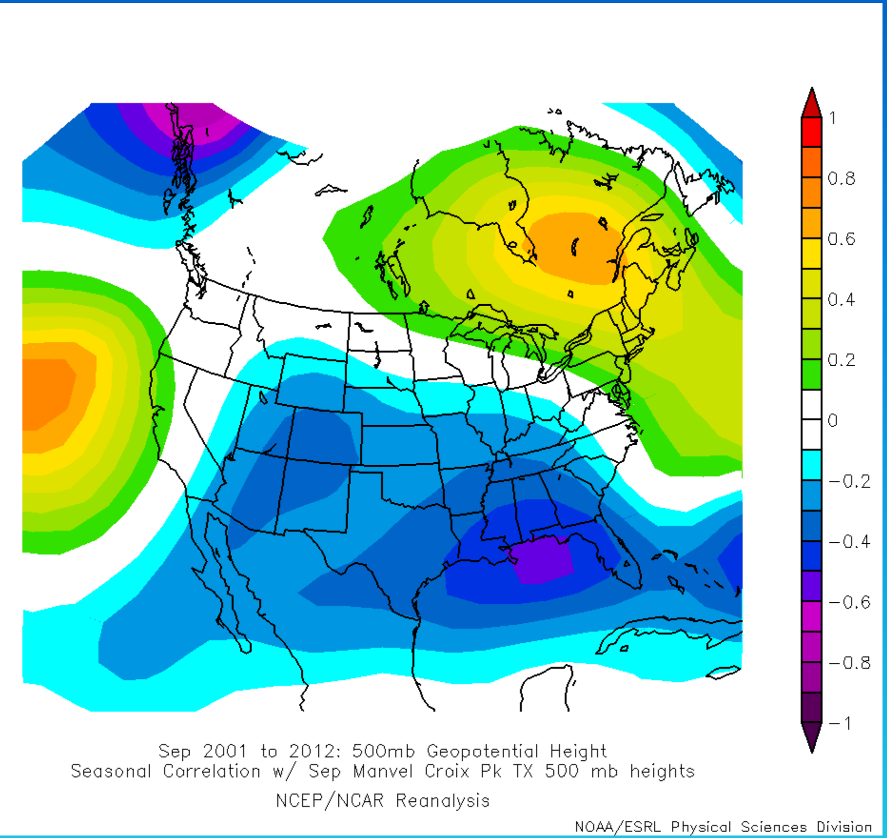


Correlation: 1995-2013 RFLAT July mean DMAX 8-hr O3 versus heights in the vertical (850 to 150 mb levels).

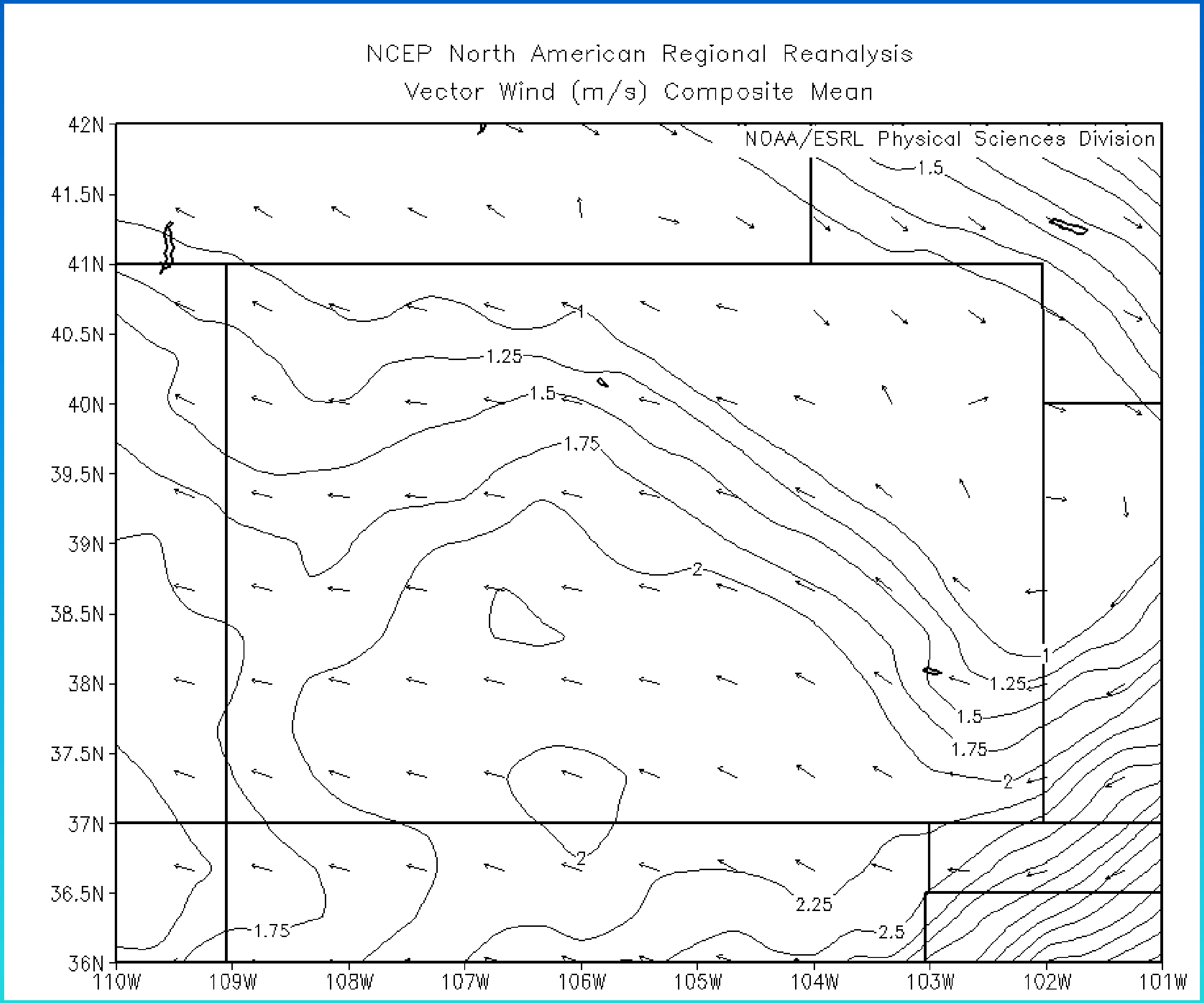


July mean RFLATs OMI level 3 tropospheric NO2, like O3, is strongly sensitive to increase in 500 mb heights in Colorado and Wyoming and strongly anti-correlated with zonal flow at 700 mb over Colorado.



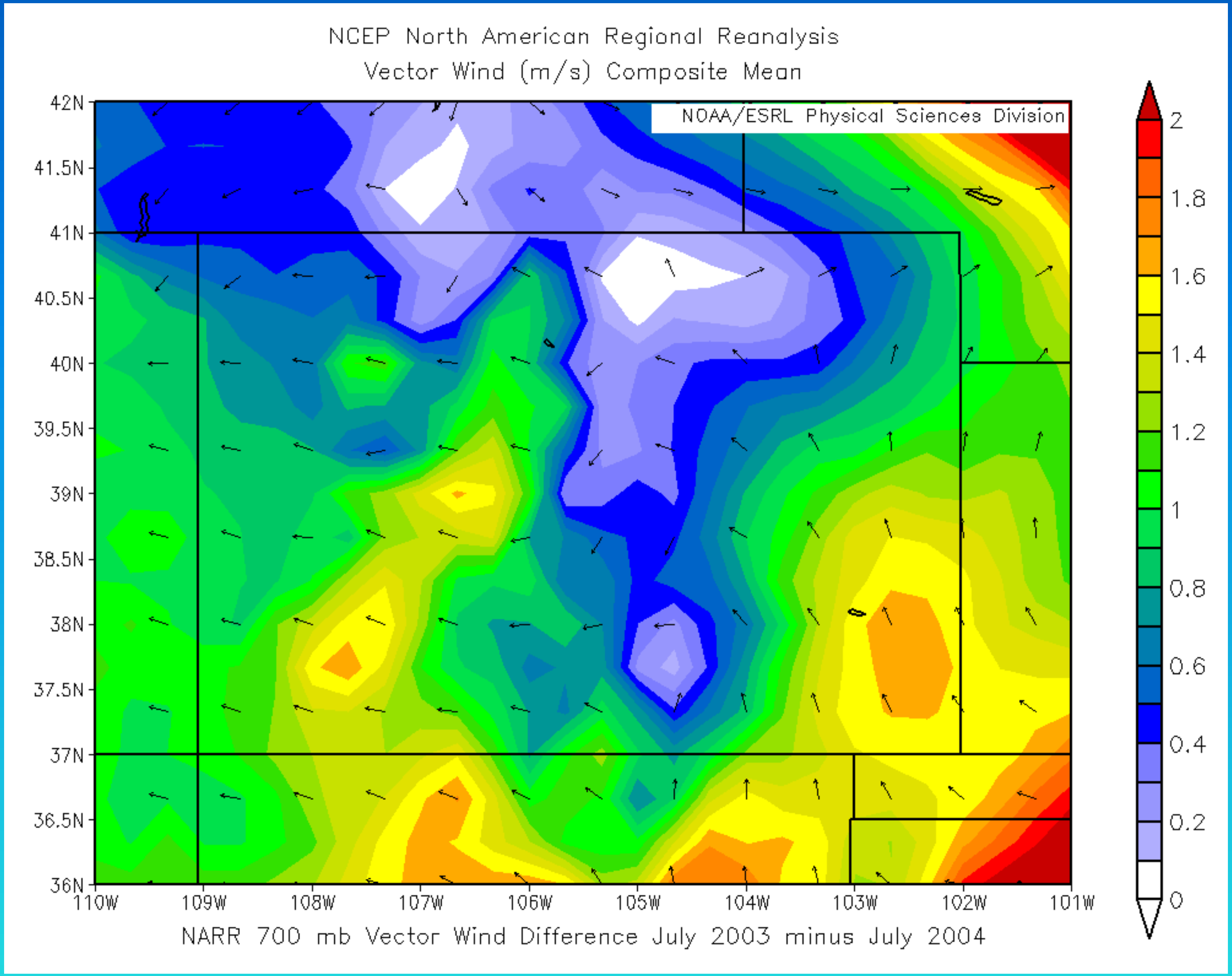


In places like Houston and LA, things are quite different. Few strong correlations are found with mid and upper level variables. September mean Manville Croix Park (near Houston) DMAX 8-hour O3 is anti-correlated with the strength of the Bermuda High (at the surface [left plot] and 500 mb [right plot]) for 2001-2012. Reduced synoptic scale on-shore flow leads to enhanced sea breeze, lighter winds, and increased O3?

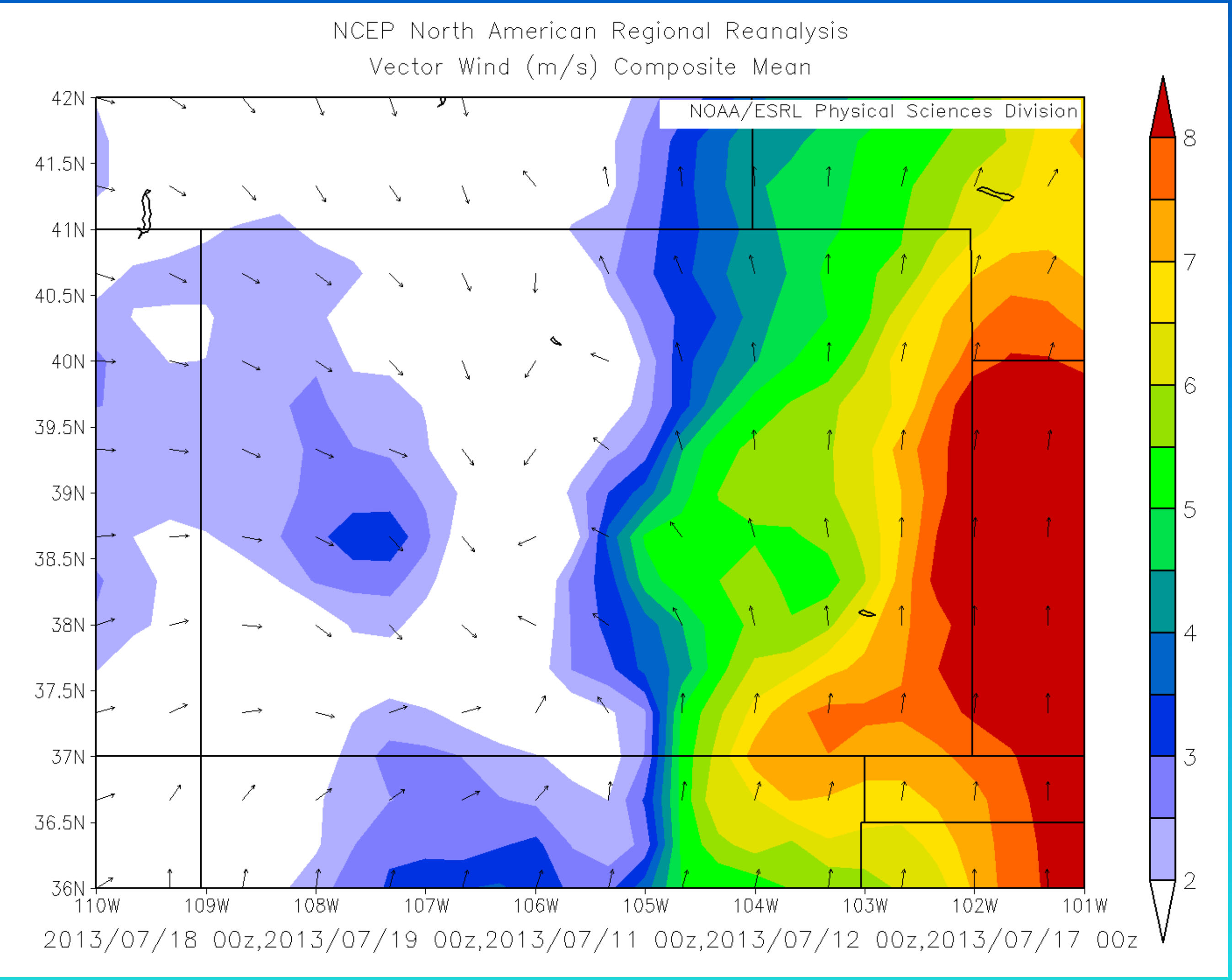


What does a 4 Corners high have to do with winds in Colorado?

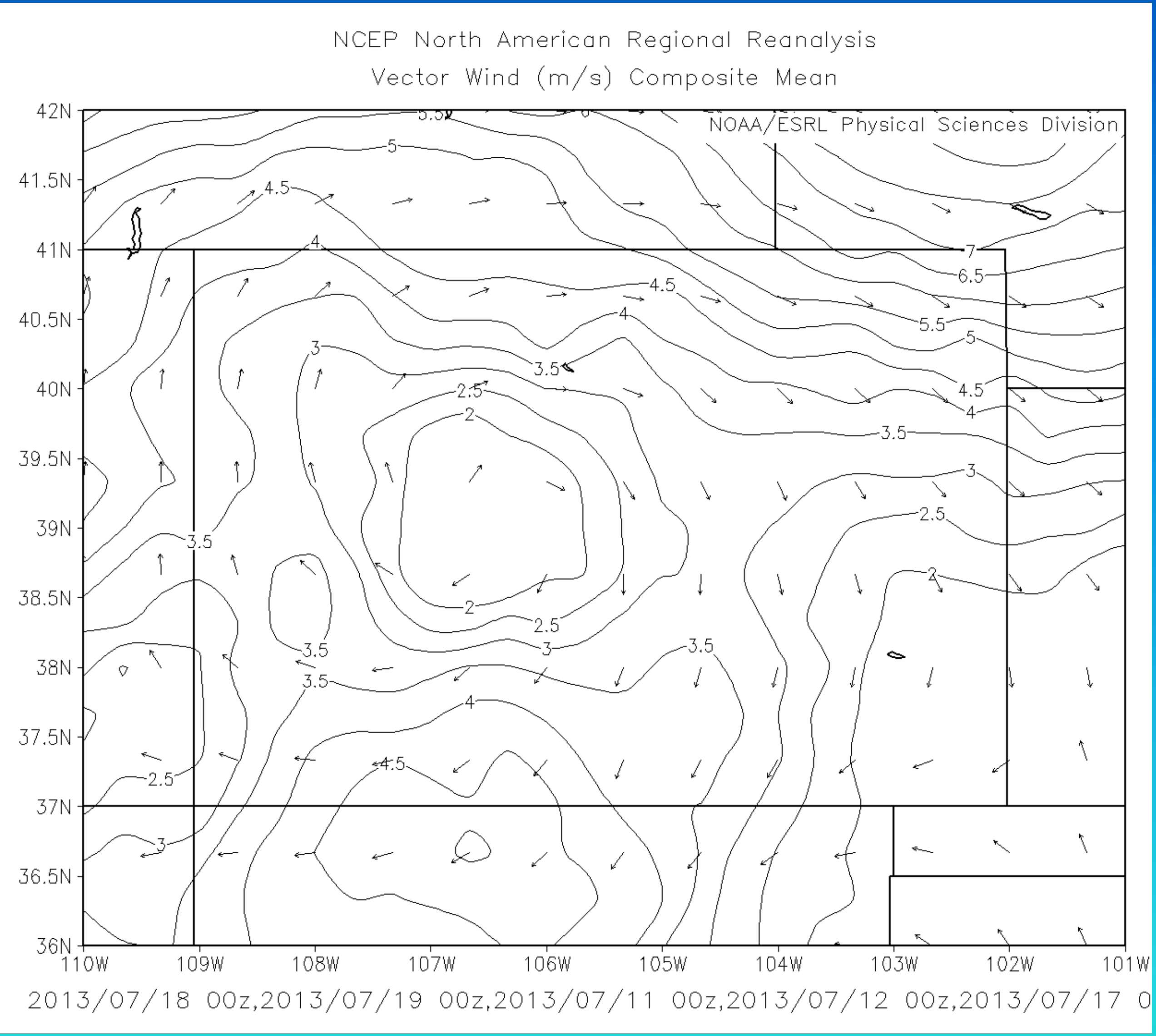
In Colorado, 2003 was a high O3 and high heights year. 2004 was a low O3 and low heights year. The 2003 minus 2004 vector difference in 600 mb winds shows a peak reduction in westerlies of 2 m/s over central CO.



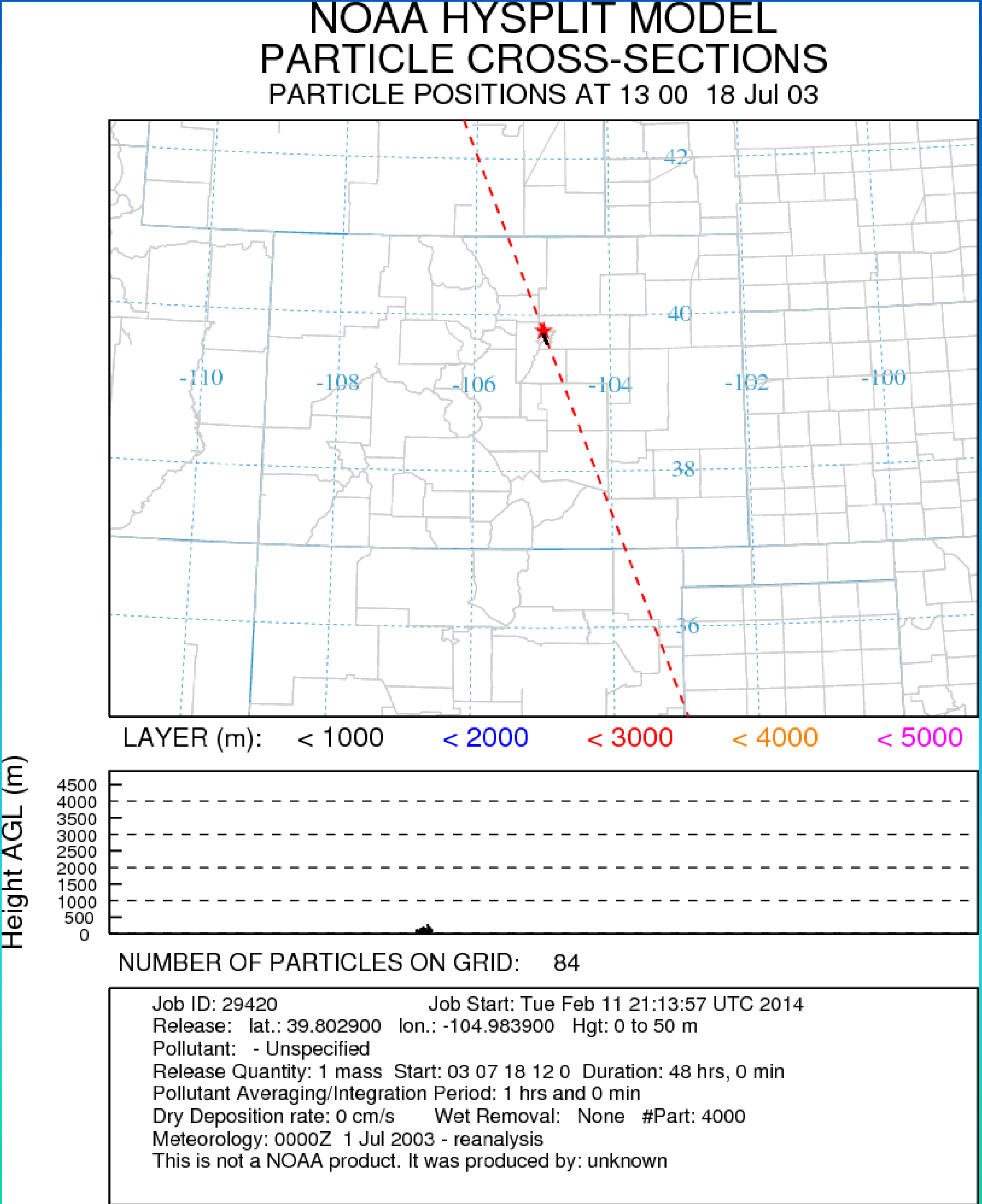
The 2003 minus 2004 vector difference in 700 mb winds shows a peak reduction in westerlies or increase in easterlies of ~2 m/s over mountains. The pattern suggests that the solenoid circulation is present in both years, with further westward extent during high-height, high-ozone 2003.



A composite of reanalysis data for 6 PM MST on 5 high O3 days in 2013 shows easterly flow at 700 mb as far west as Leadville CO, data for later times show easterly flow as far west as Aspen and Gothic CO.



A composite of reanalysis data for 6 PM MST on 5 high O3 days in 2013 shows clockwise circulation at 500 mb over west-central Colorado.

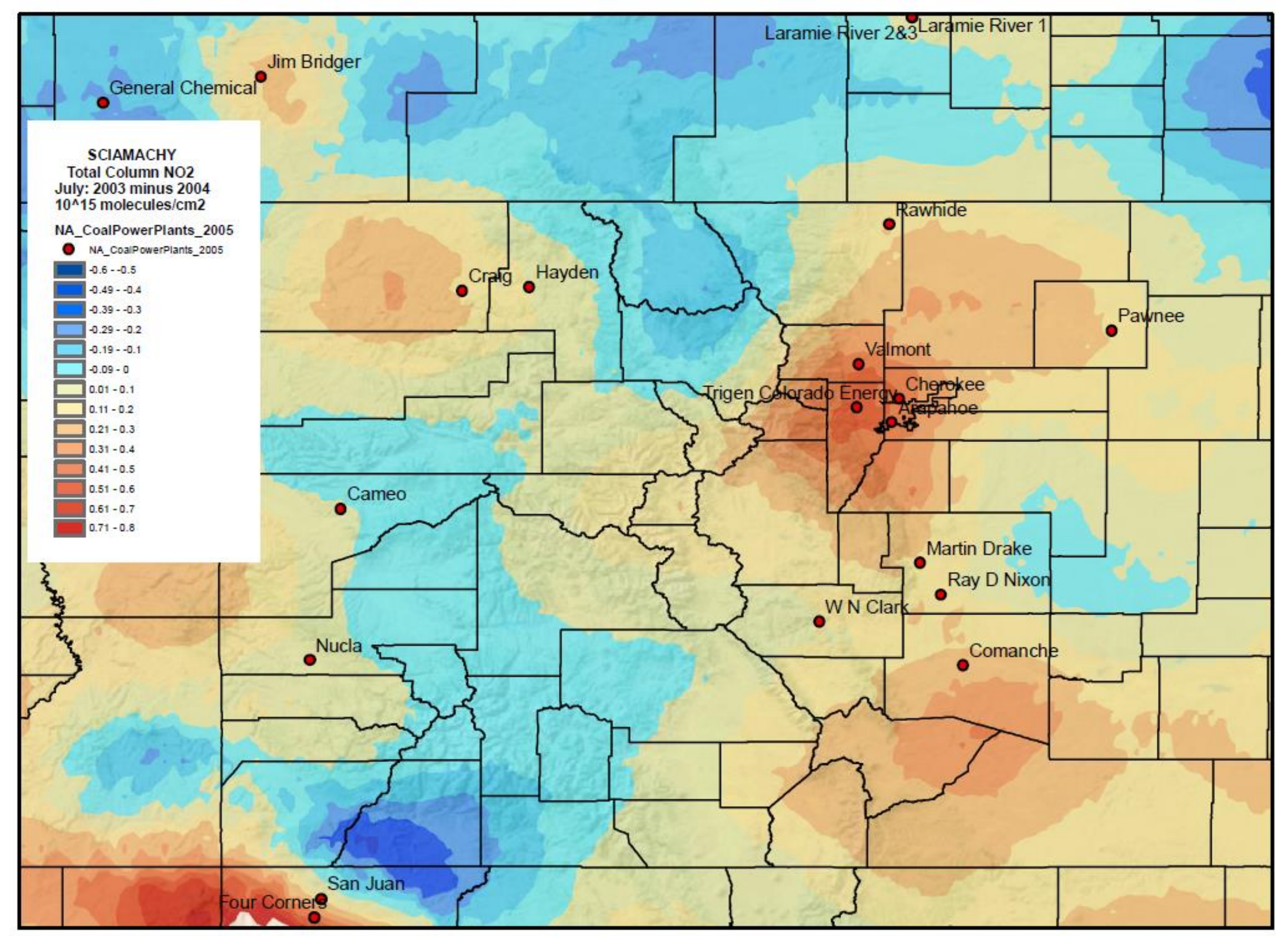


This HYSPLIT dispersion model animation for the O3 episode of July 18 through 20, 2013, shows transport deep into the mountains, easterly flow at low levels, weak westerlies aloft, mixing to 3.5 km above ground and a mountain plains solenoid keeping particles “trapped” in looping flow along the Front Range.

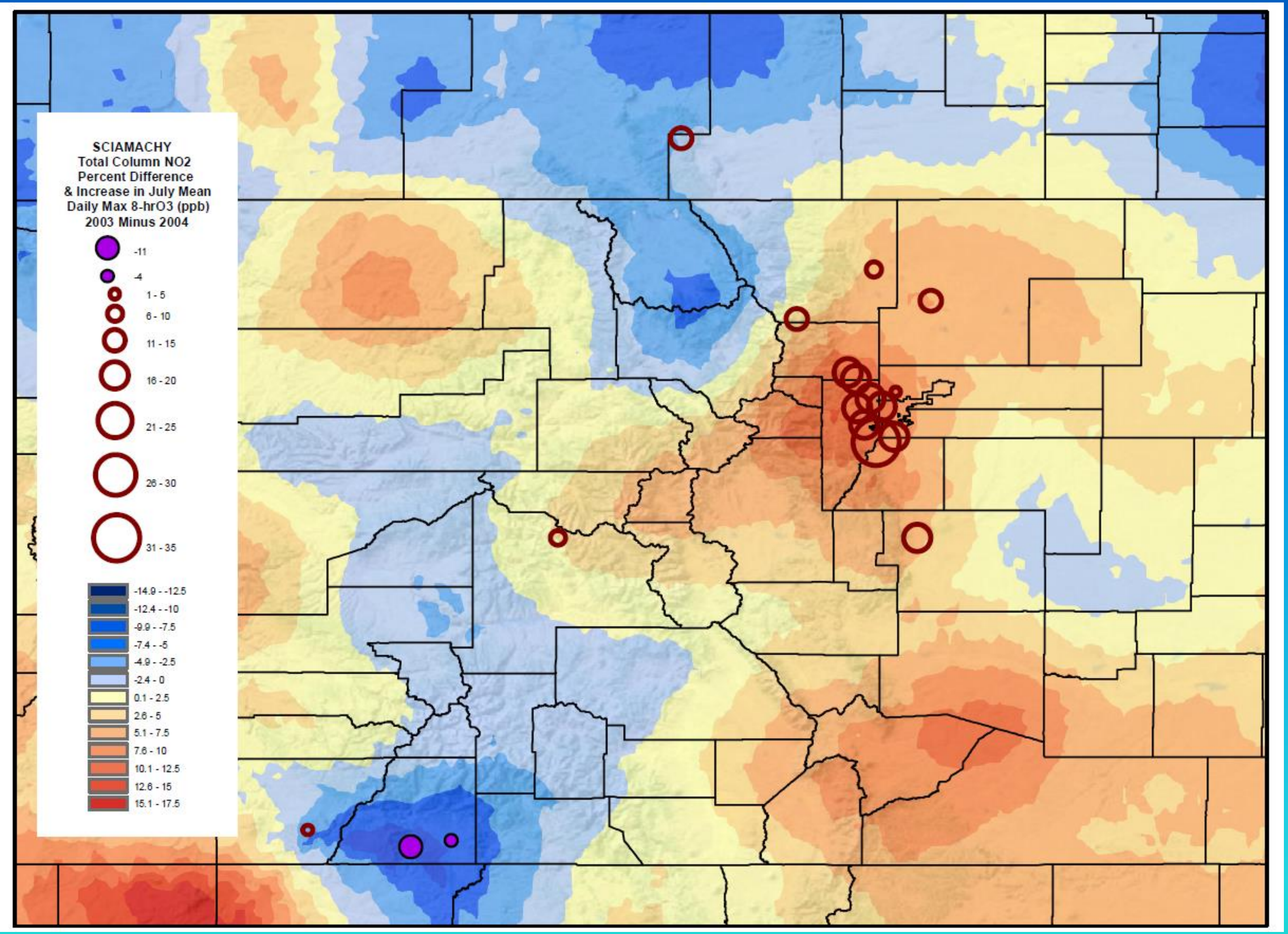
Upper level high pressure favors the development of this kind of recirculation. 5950m high over UT on July 18

Does satellite NO2 tell us anything about the spatial extent of this pattern?

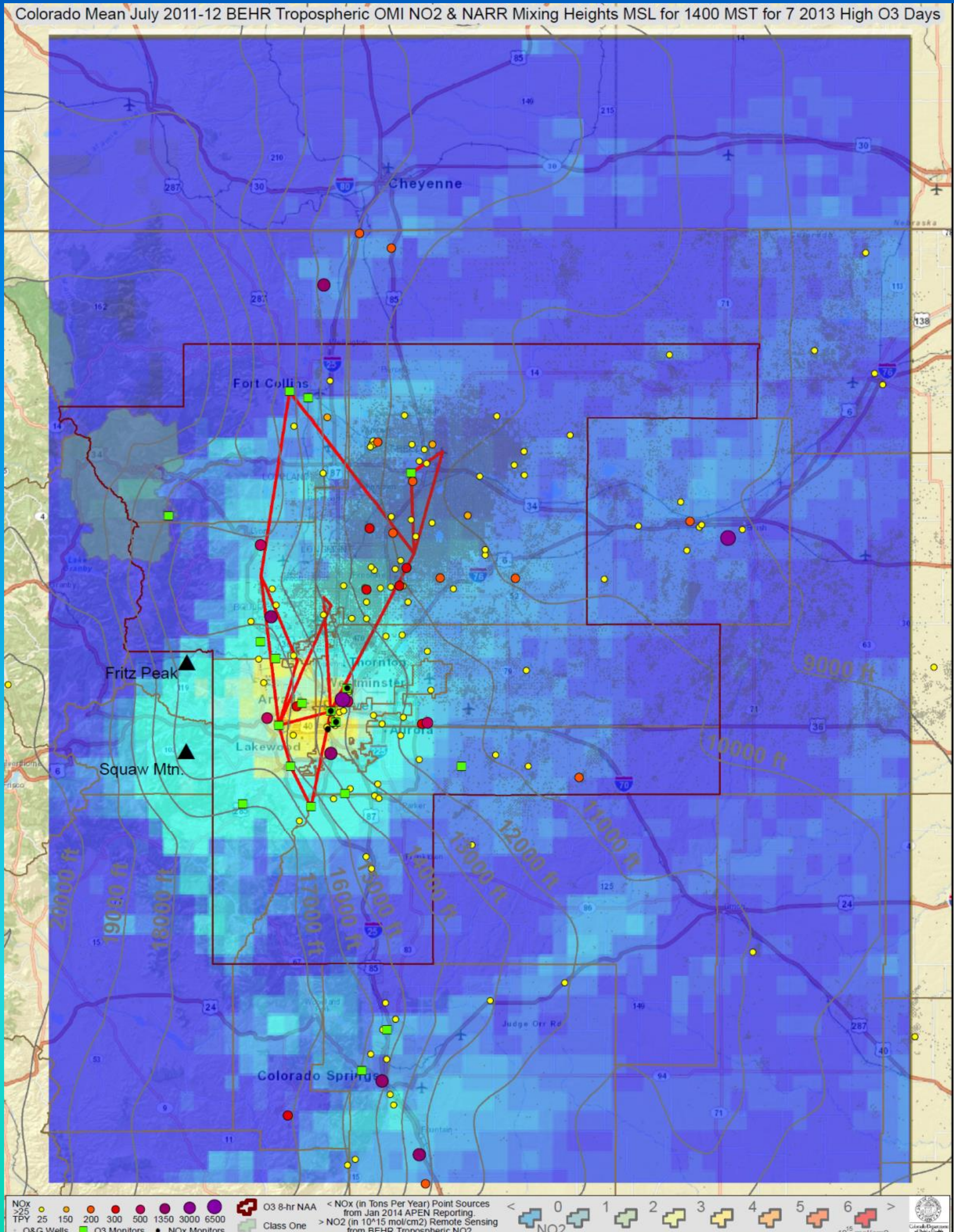
7/18: 84 ppb CHAT, 83 ppb AFA
7/19: 75 ppb CHAT
7/20: 75 ppb NREL & RFLAT



The difference between SCIAMACHY July mean total column NO2 (2003 minus 2004) gives us an idea of where NO2 increases and decreases when mean upper level high pressure is strong. NO2 penetration deep to the southwest, enhancements along the Platte River to the northeast of Denver. At 10 MST thermally-driven upslope has typically not crossed the Divide.



Circles show increases or decreases in July DMAX 8-hr O3 (2003 minus 2004) along with SCIAMACHY NO2 (2003 minus 2004). Increases in NO2 in central Colorado likely represent NO2 emissions from previous day(s).

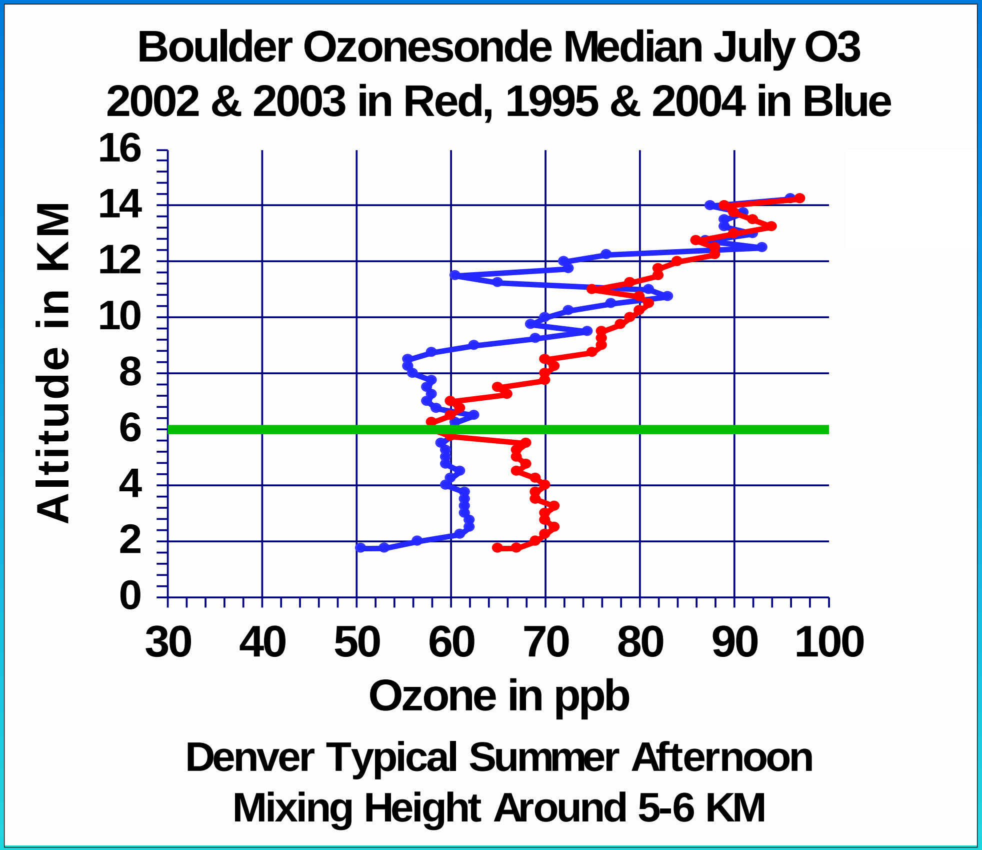


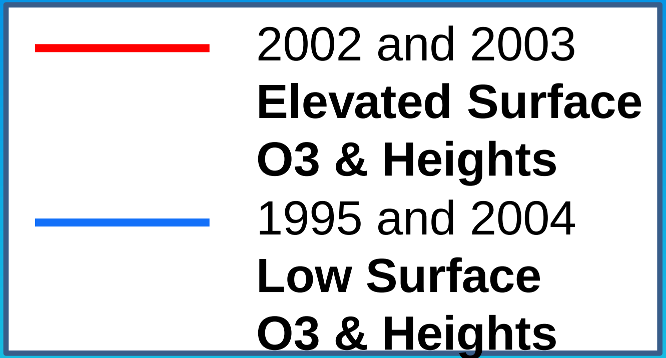
BEHR mean July tropospheric NO2
For 2011-2012 shows early afternoon
Plume moving west and southwest
Of Denver.

Data courtesy of the Berkeley
Satellite group:
http://behr.cchem.berkeley.edu/Home.aspx

Is flight path still current?

Comparison of Median Boulder Ozonesonde Profiles for 2002/2003 and 1995/2004 (high O3/height, low O3/height years) show decoupling of Upper Troposphere and PBL. Potential Influence of Lightning NOx?

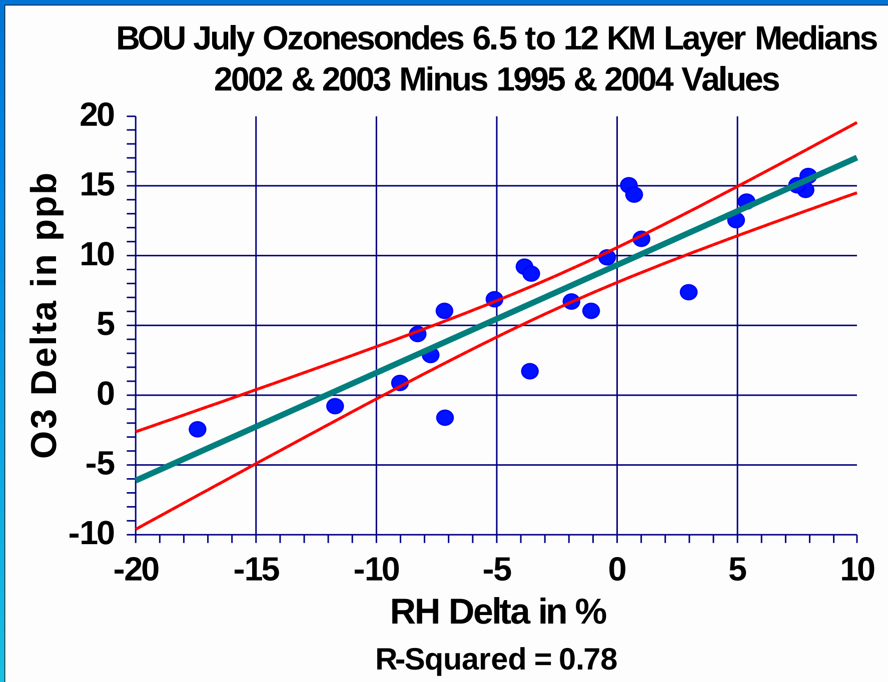


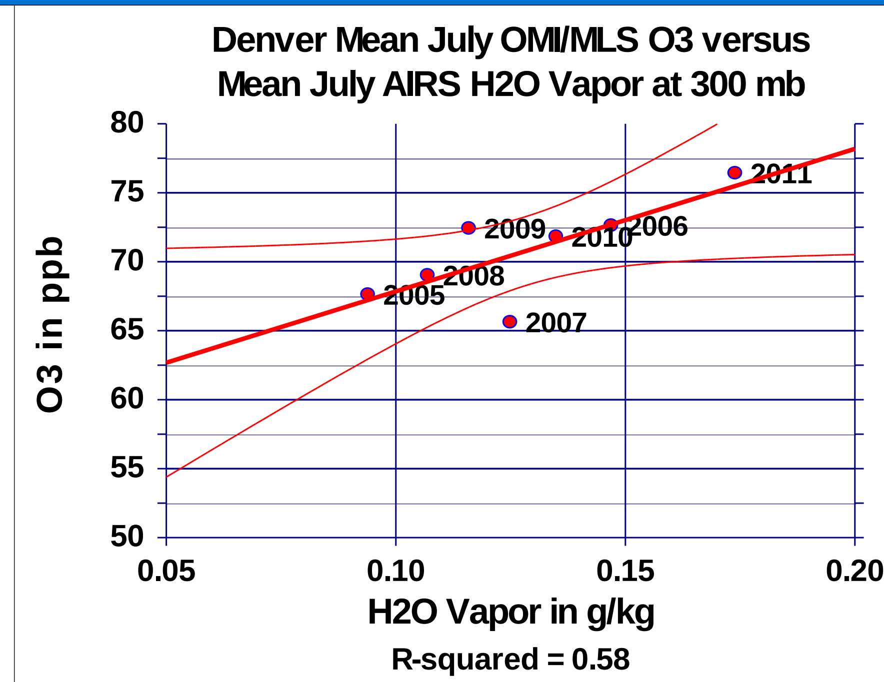


Ozonesonde data courtesy of NOAA ESRL GMD: http://www.esrl.noaa.gov/gmd/dv/ftpdata.html

Typical afternoon mixing height ~ 5 - 6 km MSL. 2002 & 2003 show variable O3 increases in 6.5 to 12 km layer in free troposphere. Does residual lightning NOx account for differences in free troposphere?

Higher Upper Tropospheric O3 in 2002/2003 Strongly Correlated With Higher RH.
DEN OMI/MLS Mean July Trop. O3 Correlated with Aqua AIRS 300 mb H2O Vapor.





Ozonesonde differences in free troposphere O3 strongly correlated with increases in RH.

DEN Mean July OMI/MLS Trop. O3 increases With AIRS H2O Vapor for Upper Troposphere.

Does relationship between H2O vapor and O3 in the upper troposphere support a residual lightning NOx hypothesis, injection of PBL air, thunderstorm impacts, or point to other processes or retrieval issues?

Data courtesy of NASA GSFC, Ziemke et al 2011, and KNMI: http://www.temis.nl/airpollution/no2.html

Conclusions

- There is a very strong relationship between July mean 500 mb heights and July DMAX 8-hr O3 in Colorado and other western sates.
- Under the influence of an upper high, skies are often clear, temperatures are elevated, and westerlies are reduced in strength.
- These conditions promote the formation of mountain-plains solenoid circulations and westward propagating density currents along the Colorado Front Range and in the mountainous terrain of central Colorado.
- These circulations appear to enhance O3 and NO2 and lead to the highest concentration events.
- Deep mixing and terrain-driven circulations set this region apart from low-altitude and coastal areas. (A fraction of high O3 events do have shallow PBL heights below the 3 km level with brisk westerlies aloft).
- Satellite NO2 and HYSPLIT runs provide evidence for extensive and persistent re-circulations of Front Range emissions under strong ridging aloft.