The Great Salt Lake Summer Ozone Study

Ansley Long and Brian Blaylock

UofU: John Horel, Erik Crosman, Alex Jacques, Luke Leclair-Marzolf, Will Howard, Jeff Jenkins, Allyson Dugan, Sebastian Hoch, Susan Bush, Xia Dong, Nola Lucke, Taylor McCorkle, Dillon Ulrich, Tom Gowan, Chris Galli, Fahad Alotaibi

DAQ: Seth Arnes, Munkh Baassandorj **Weber State:** John Sohl and group **USU:** Randy Martin and group

Department of Atmospheric Sciences Seminar, University of Utah, 7 October 2015

U. researchers launch pollution monitoring project

By Jed Boal | Posted Sep 3rd, 2014 @ 11:11pm

Ozone study to show Great Salt Lake's impact on Utahns' health

POSTED 8:20 AM, JUNE 16, 2015, BY BRYON MUIR, *UPDATED AT 12:12PM, JUNE 16, 2015*

SALT LAKE CITY – Scientists with the Utah Department of Environmental Quality have teamed up with researchers at several Utah

Researchers working to determine why ozone is increasing around Great Salt Lake

POSTED 3:38 PM, JUNE 18, 2015, BY ASHTON EDWARDS AND TAMARA VAIFANUA, *UPDATED AT 03:42PM, JUNE 18, 2015*

Summer ozone blast threatening Utahns' health, thanks to sunshine and car exhaust

By BRIAN MAFFLY | The Salt Lake Tribune CONNECT

First Published Jun 29 2015 04:27PM • Last Updated Jul 07 2015 11:47 pm

On bad day, Great Salt Lake air has 3 times more ozone than Wasatch Front

By EMMA PENROD | The Salt Lake Tribune CONNECT

First Published Aug 02 2015 07:15AM • Last Updated Aug 02 2015 10:04 am

The Salt Lake Tribune

Ozone in the Troposphere

Low vs. High elevation

- Ozone increases with height
- Stronger insolation at high elevation >= photochemical reactions

Morning vs. Afternoon

- Higher ozone in afternoon from photochemical processes

Impact on Health

- *"When ground-level ozone is at unhealthy levels, your chances of being affected increase the longer you are active outdoors and the more strenuous your activity."*

-United States EPA

- Air Quality improvement over last 20 years
  - Health effects of ozone are more understood

+

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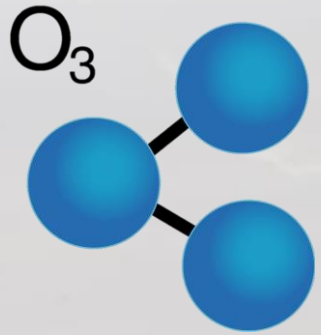


EPA Ozone Standard Revision

EPA Strengthens Ozone Standards to Protect Public Health/Science-based standards to reduce sick days, asthma attacks, emergency room visits, greatly outweigh costs

Release Date: 10/1/2015

Officials say Utah can attain EPA's new lower ozone standard

By EMMA PENROD | The Salt Lake Tribune CONNECT

First Published Oct 01 2015 05:36PM • Updated 6 hours ago

The Salt Lake Tribune

Previous Studies in Intermountain West

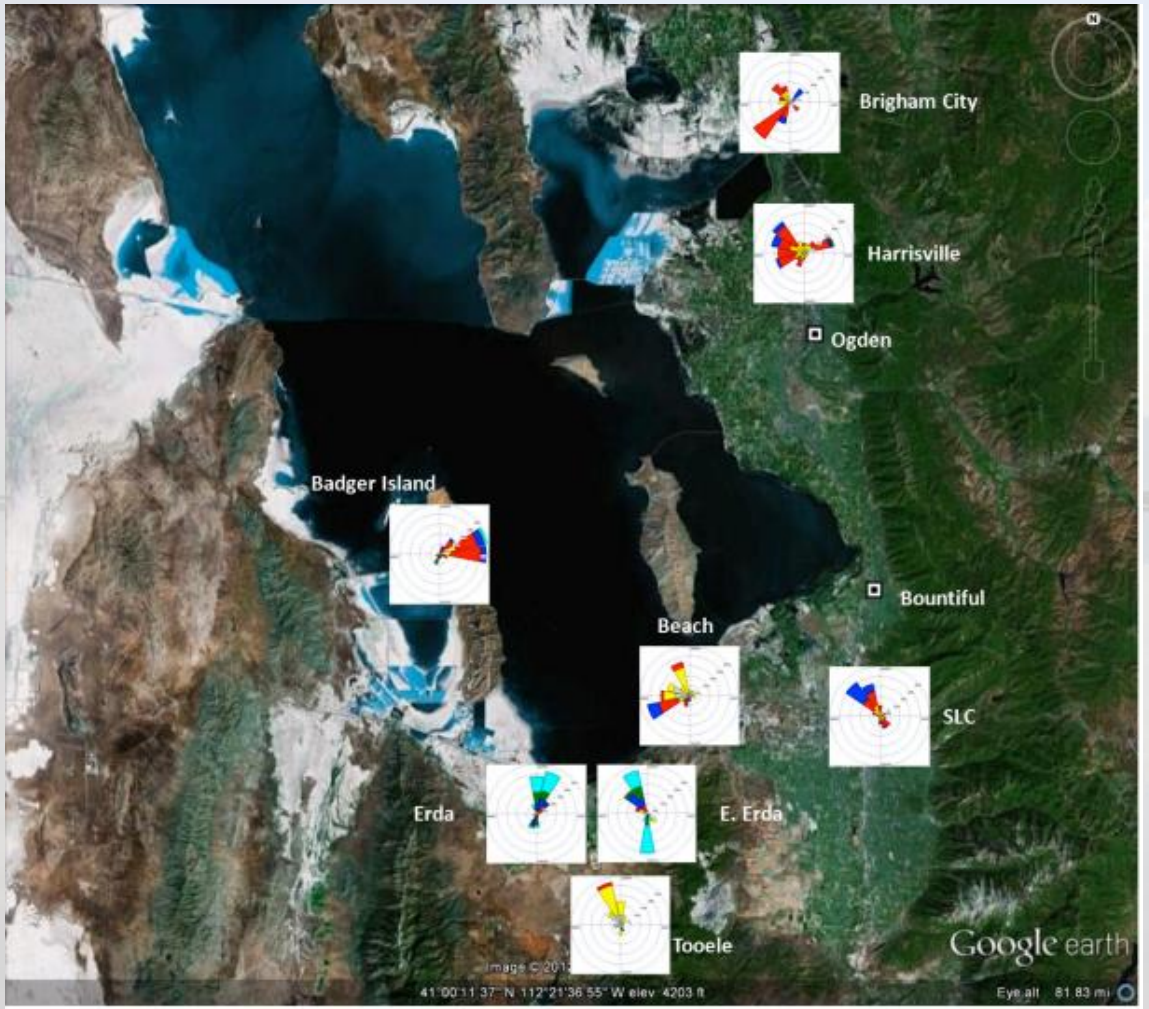


Figure 21. Daytime wind patterns on high ozone concentration days (>75 ppb) in 2012 at sites surrounding Great Salt Lake. Wedges on the wind rose point to the direction a wind blew from; larger wedges indicate a longer duration of wind from that direction. Different colors represent different wind speed classes.

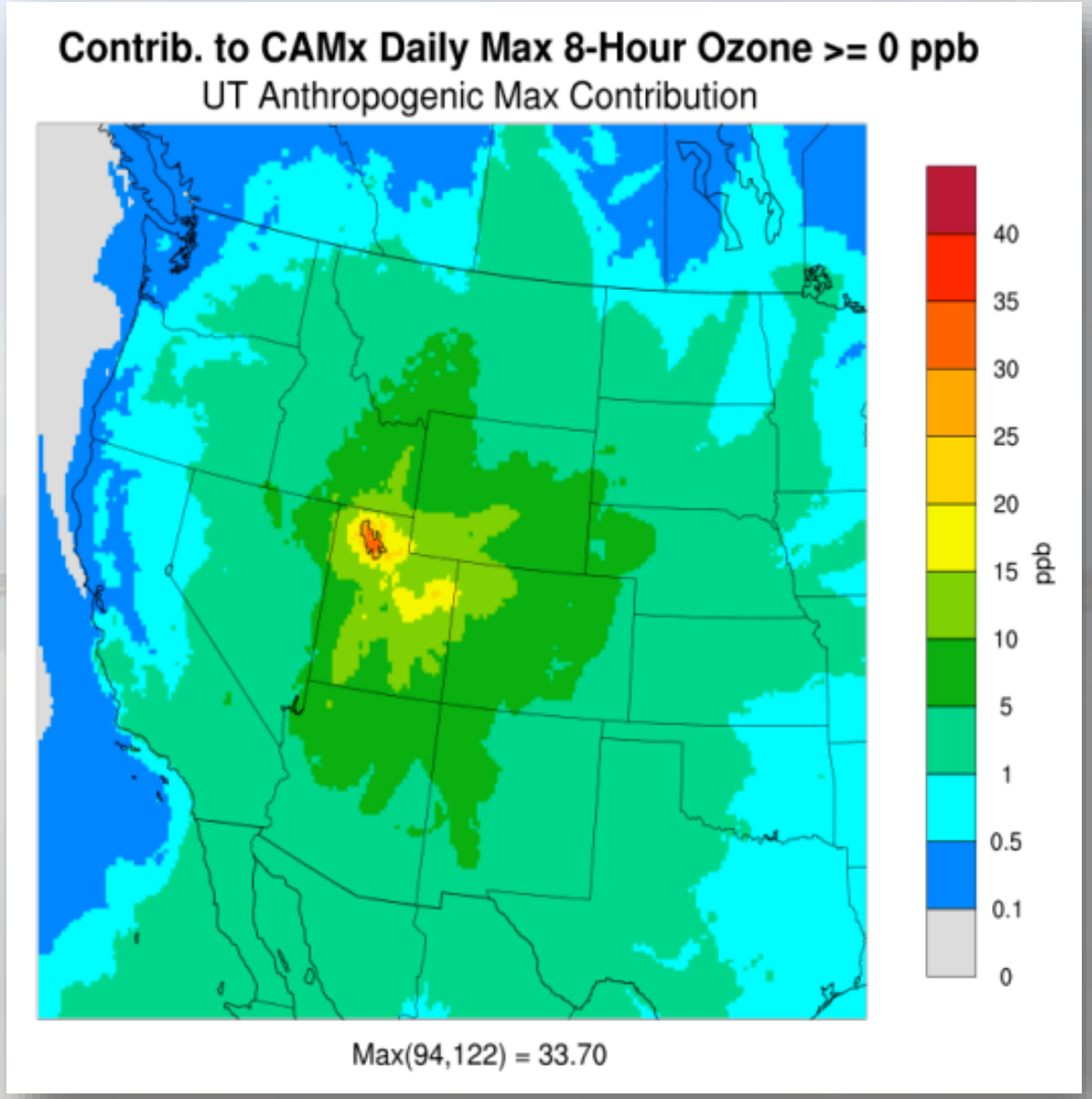
- Arens and Harper (2012)
  - Found greater ozone concentrations over GSL and mountains

(Arens and Harper, 2012)

Western Regional Air Partnership Modeling

Contribution of Utah's anthropogenic emissions on ozone in the West.

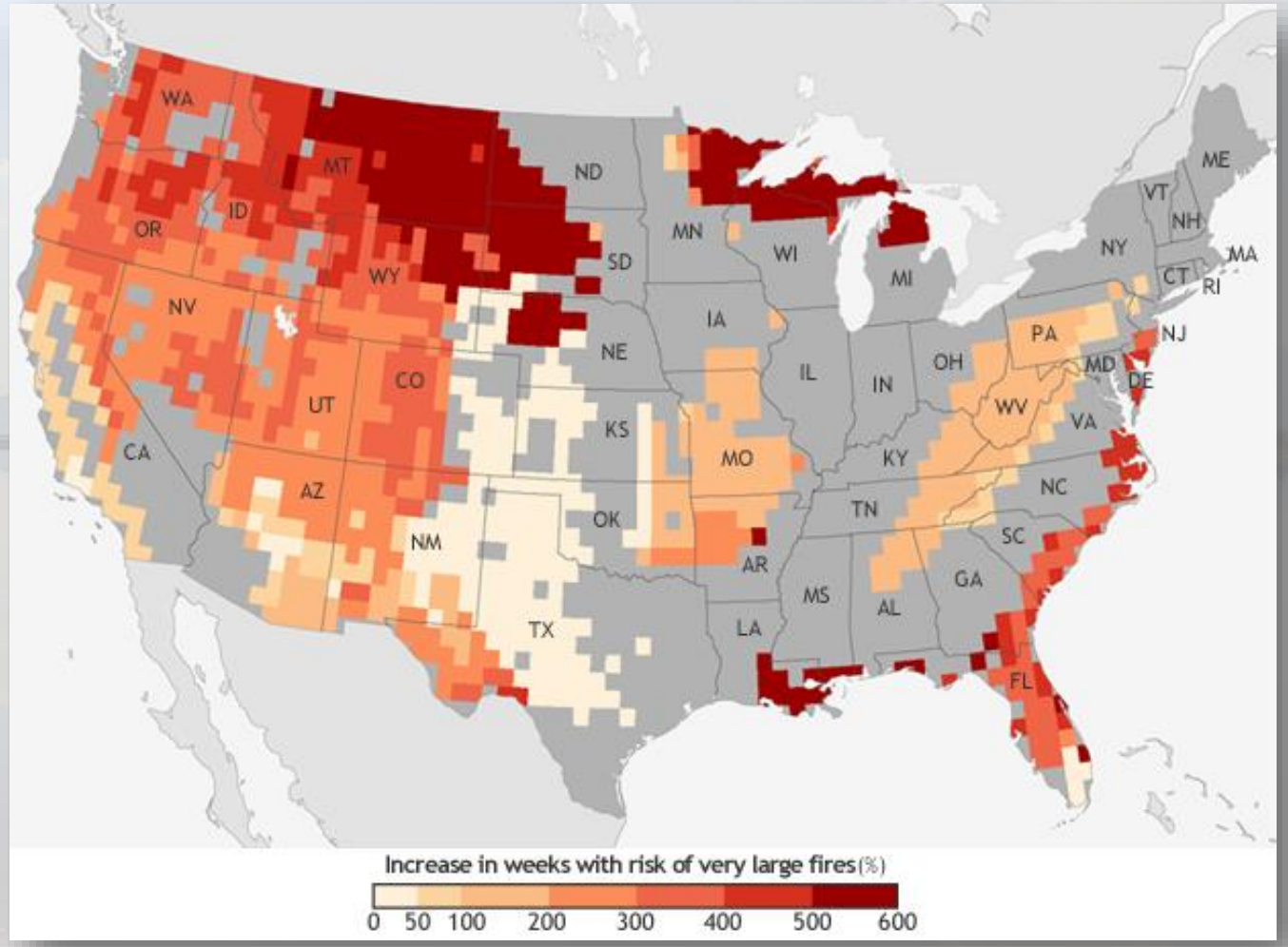
"Bull-eye" over the lake and downwind of metropolitan areas.



(T. Moore 2014)

Why is ozone a challenge/concern?

- Background ozone levels in the west are high
  - Downwind transport from Asia
  - Regional/Local
    - Wildfires
    - Emissions
- Background ozone is expected to increase
- Wildfires expected to increase



Projected percentage increase in the number of weeks with very large fires during 2041-2070 compared to 1971- 2000. From Barbero et al. (2015)

Purposes of this study…

1. Determine the distribution of ozone over and surrounding the GSL in the summer.
2. Understand meteorological processes that control ozone concentrations over and surrounding GSL in summer
3. Improvement of DAQ ozone forecasts

Which day has unhealthy air?

Two Pollution Seasons

Winter PM 2.5	Summer Ozone
Shallow boundary layer	Deep boundary layer
Emission in a quasi-closed system	Local + transported emissions
Photochemical secondary reactions	Photochemistry dominate
Multi-day events	Diurnal max and mins
Weaker thermally driven winds	Stronger thermally driven winds
People generally inside	People recreate outside

Investigators

UofU

-Horel Group

-Sebastian Hoch

-Susan Bush

Weber St.

-John Sohl and group

USU

-Randy Martin and group

DAQ

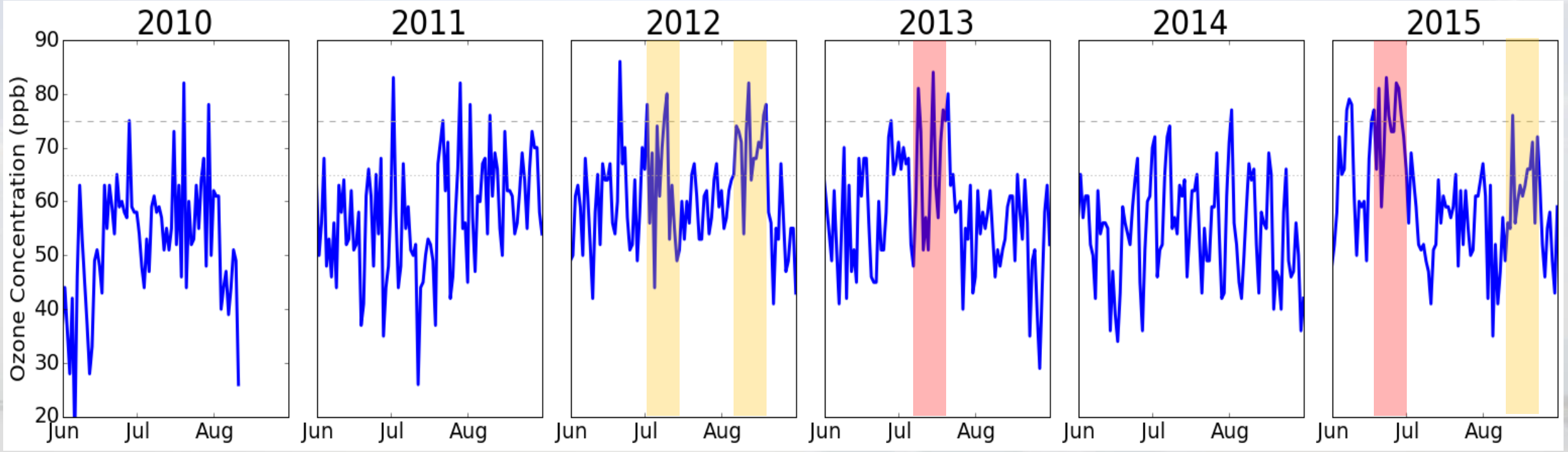
-Seth Arnes

-Munkh Baassandorj

Not a Major Field Study

- **Small budget** from DAQ. Leveraged other funds.
- **Used existing infrastructure** to reduce costs.
- **Studied our own backyard** reduced travel costs
- **Real-time data collection**
- Summer study allowed for more undergraduate participation

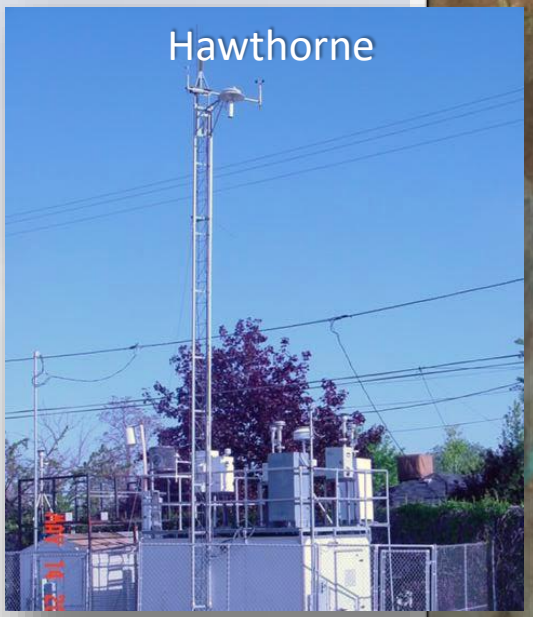
Daily Max 8-hr Ozone at Hawthorne for summer months: June, July, and August

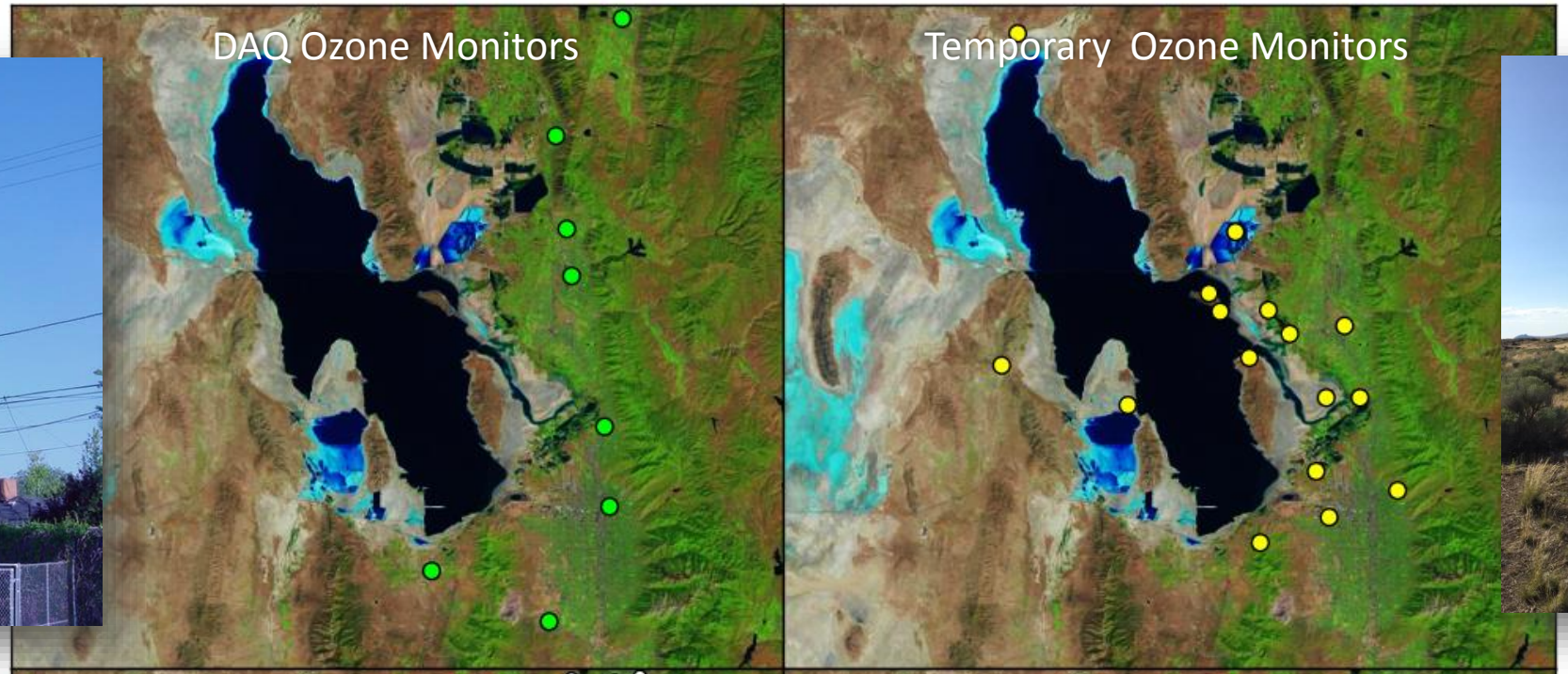


Year	# Days > 65 ppb	# Days > 75 ppb
2010	5	2
2011	23	4
2012	28	7
2013	20	4
2014	12	1
2015	27	11

Synoptic Ridge

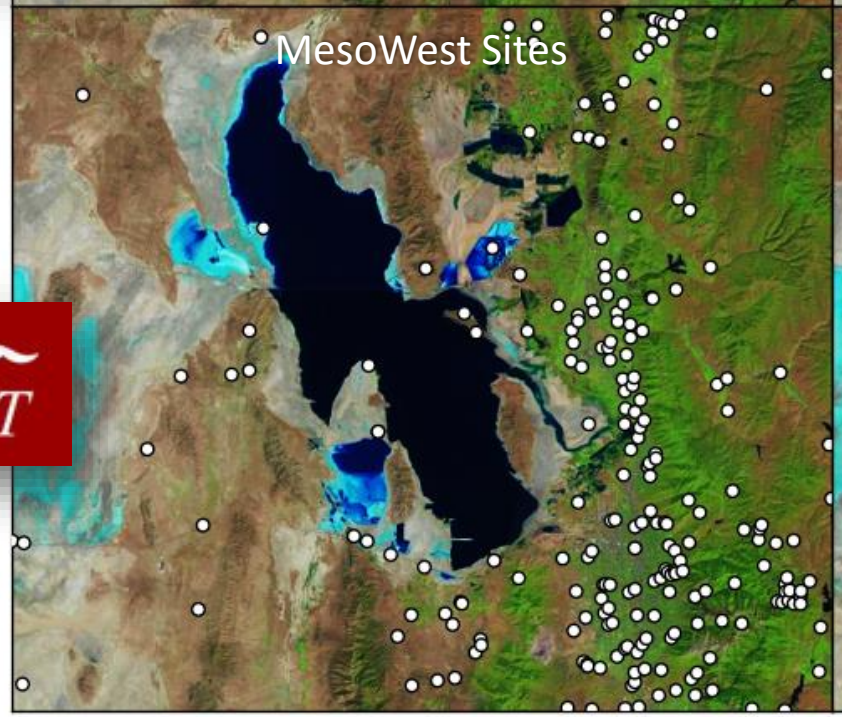
Wildfire Smoke

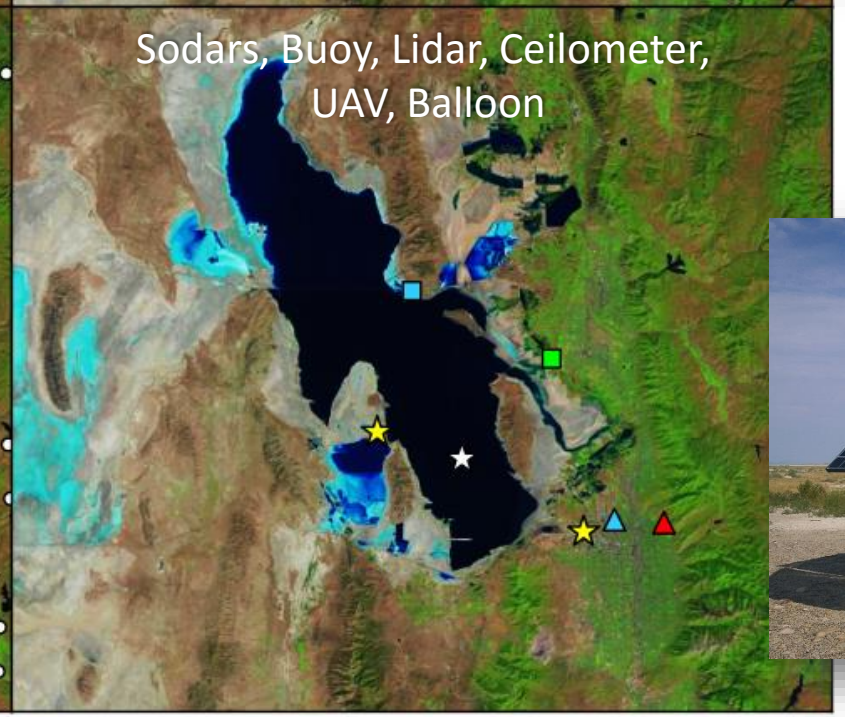

Hawthorne


DAQ Ozone Monitors

Temporary Ozone Monitors


Fremont Island

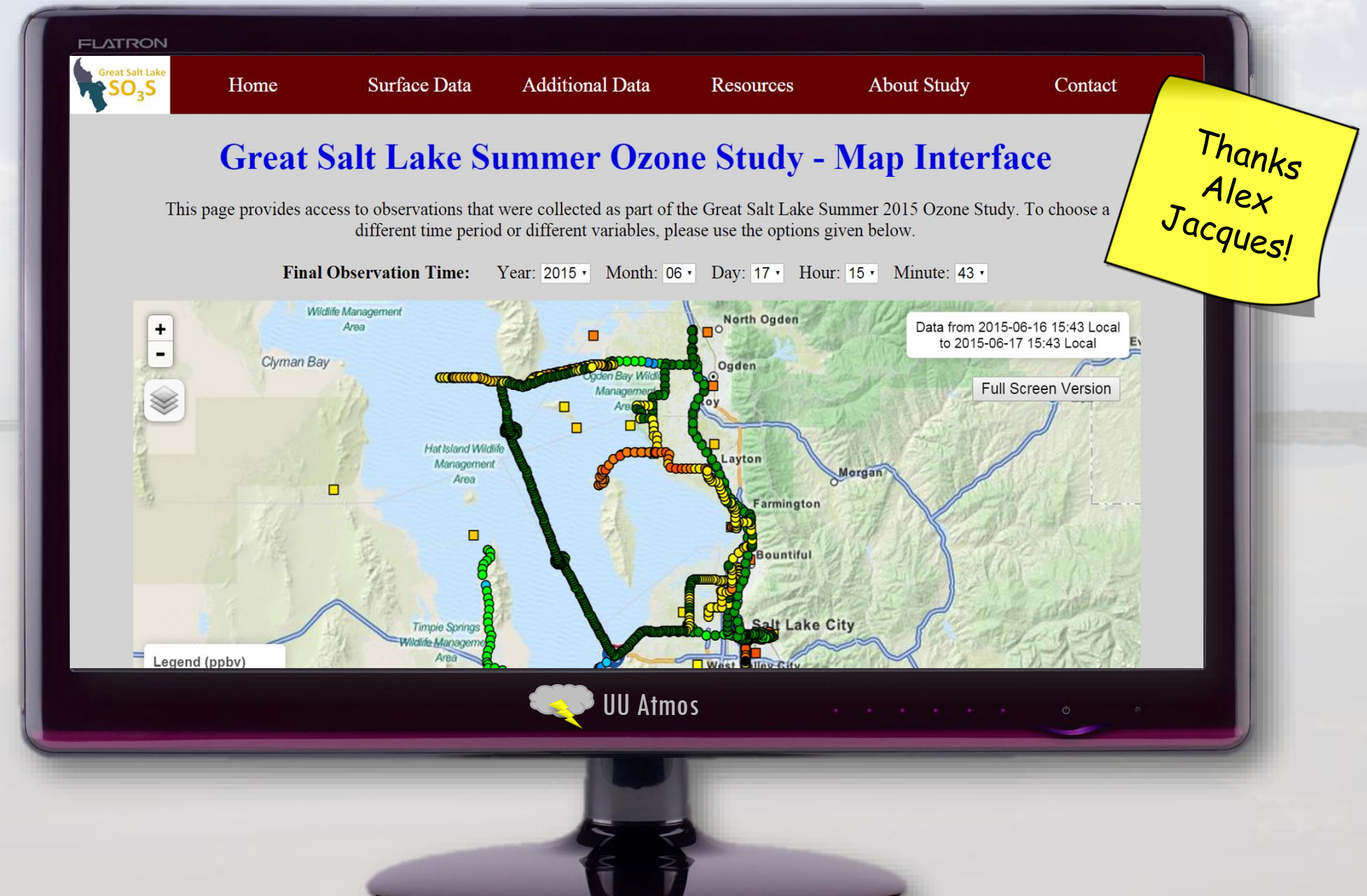

MesoWest Sites


Sodars, Buoy, Lidar, Ceilometer,
UAV, Balloon


Badger Island

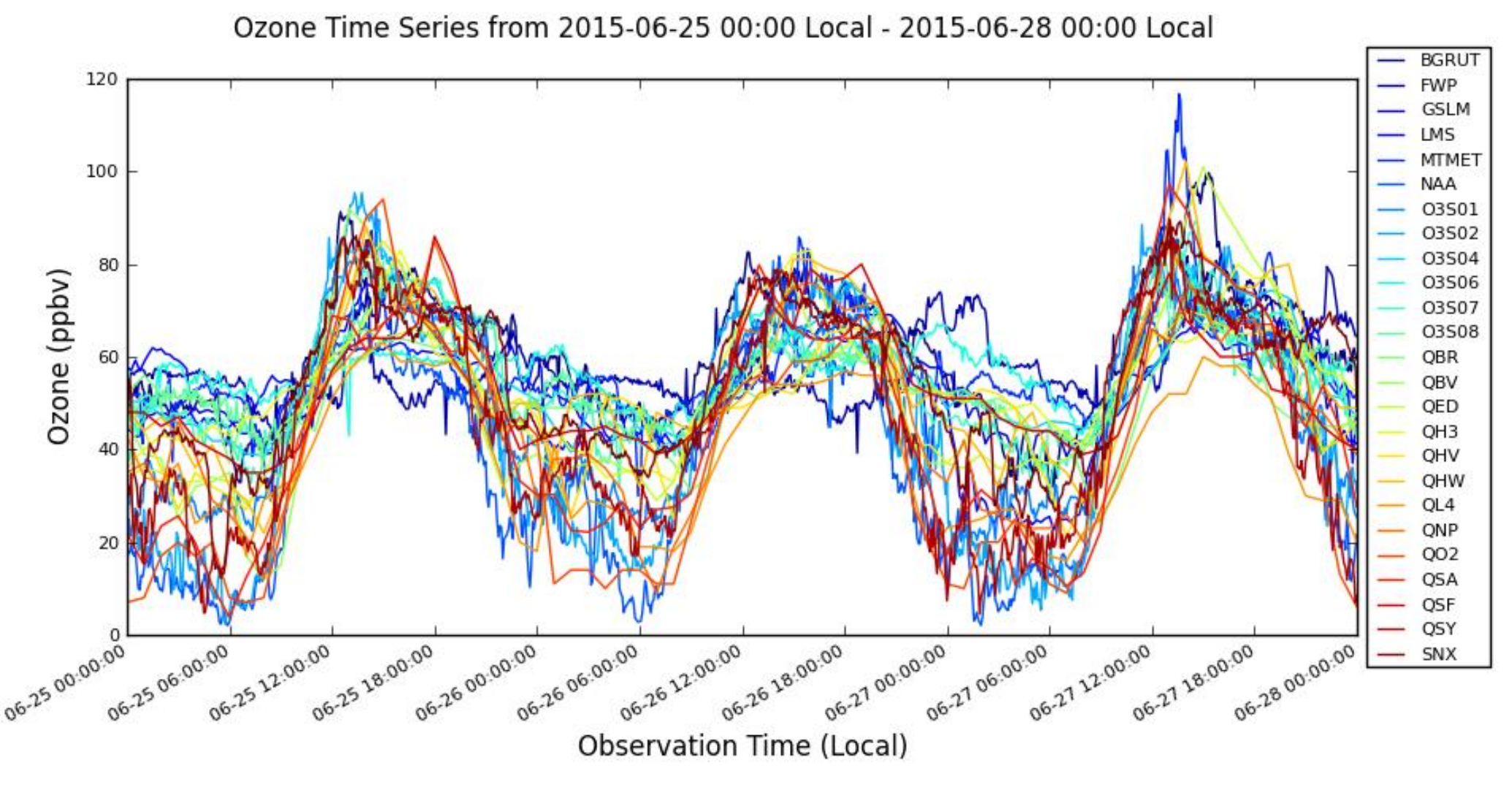
MESOWEST

http://meso2.chpc.utah.edu/gslso3s/



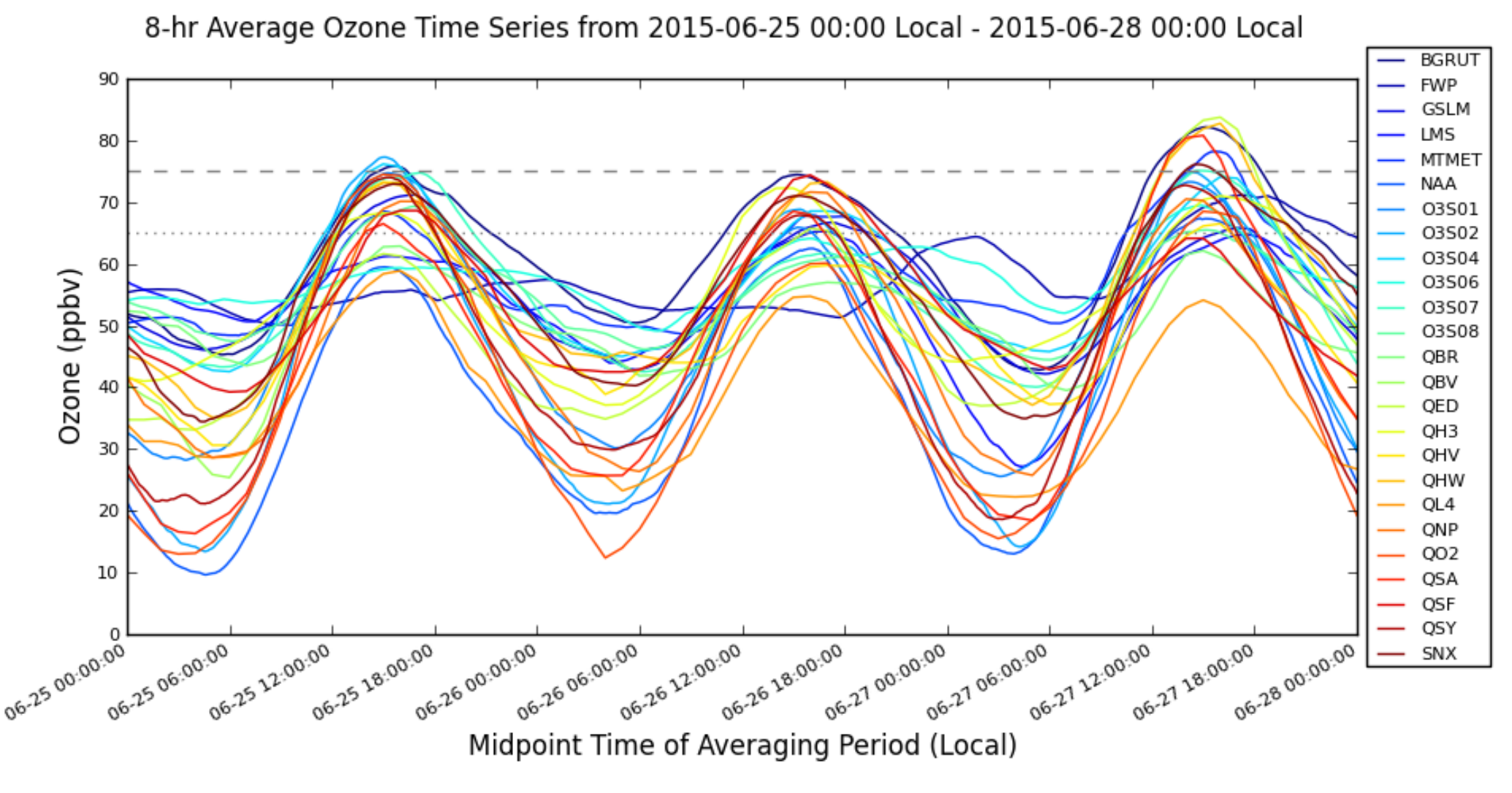
In Situ Sites

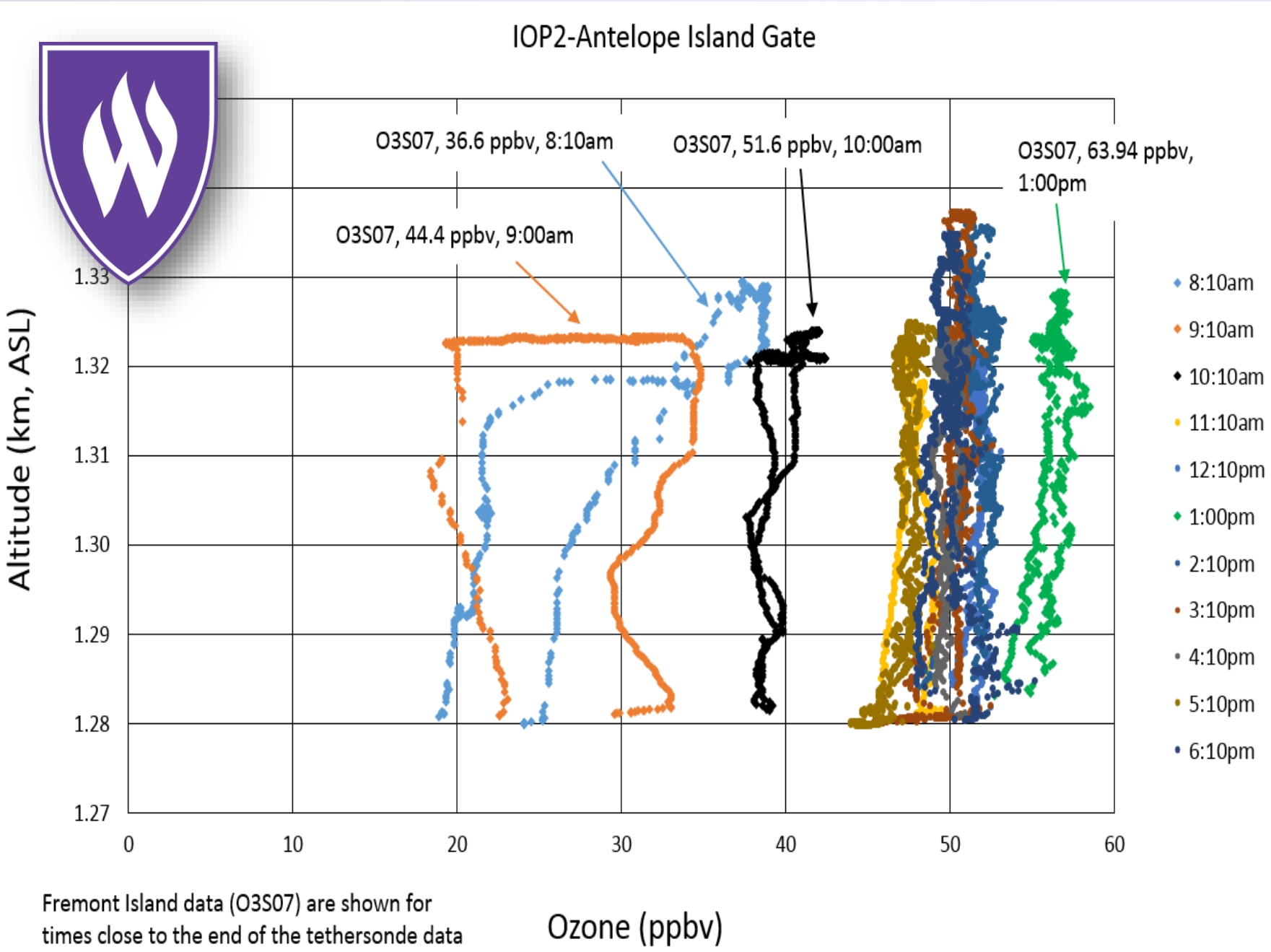
- Continuous observations
- 5-min or 1-hr averages.



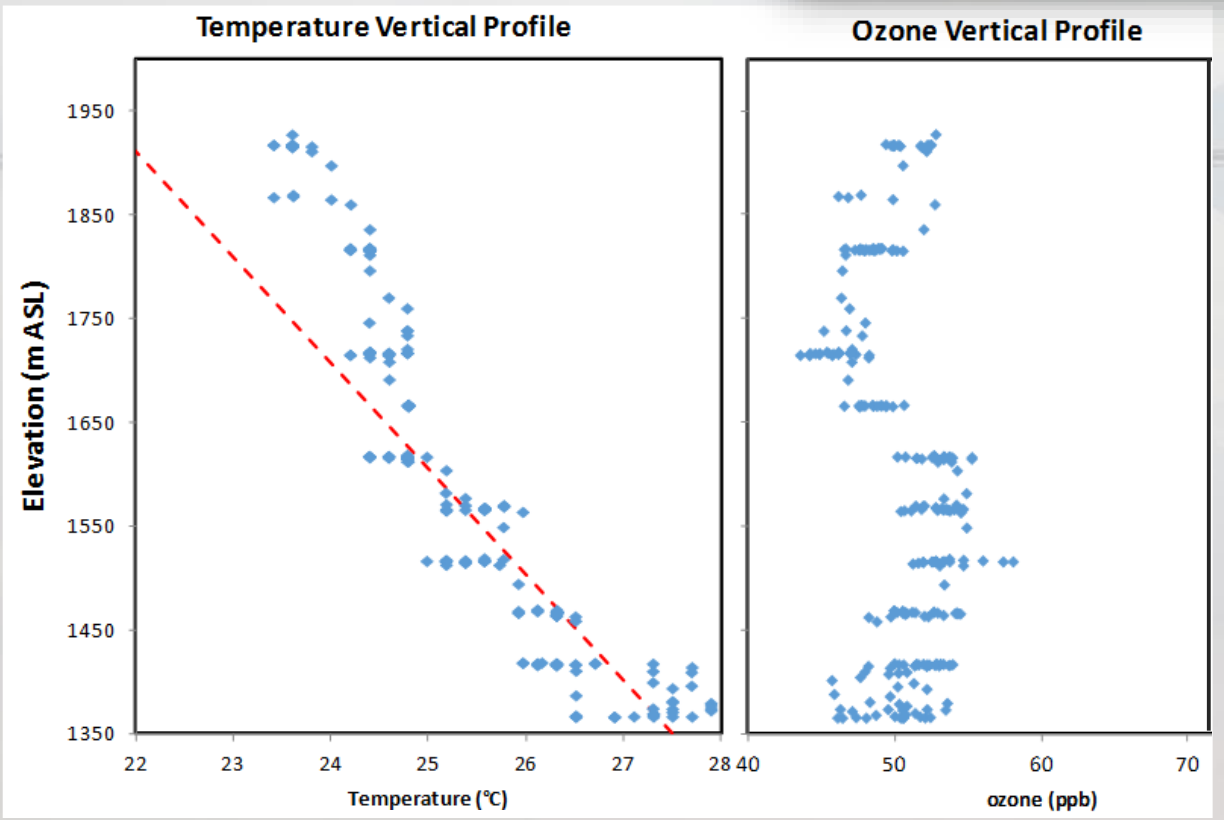
In Situ Sites

- 8 hour averages
- Calculated using the web interface





Fremont Island data (O3S07) are shown for times close to the end of the tethersonde data runs for select times. Note the general agreement in the trends.



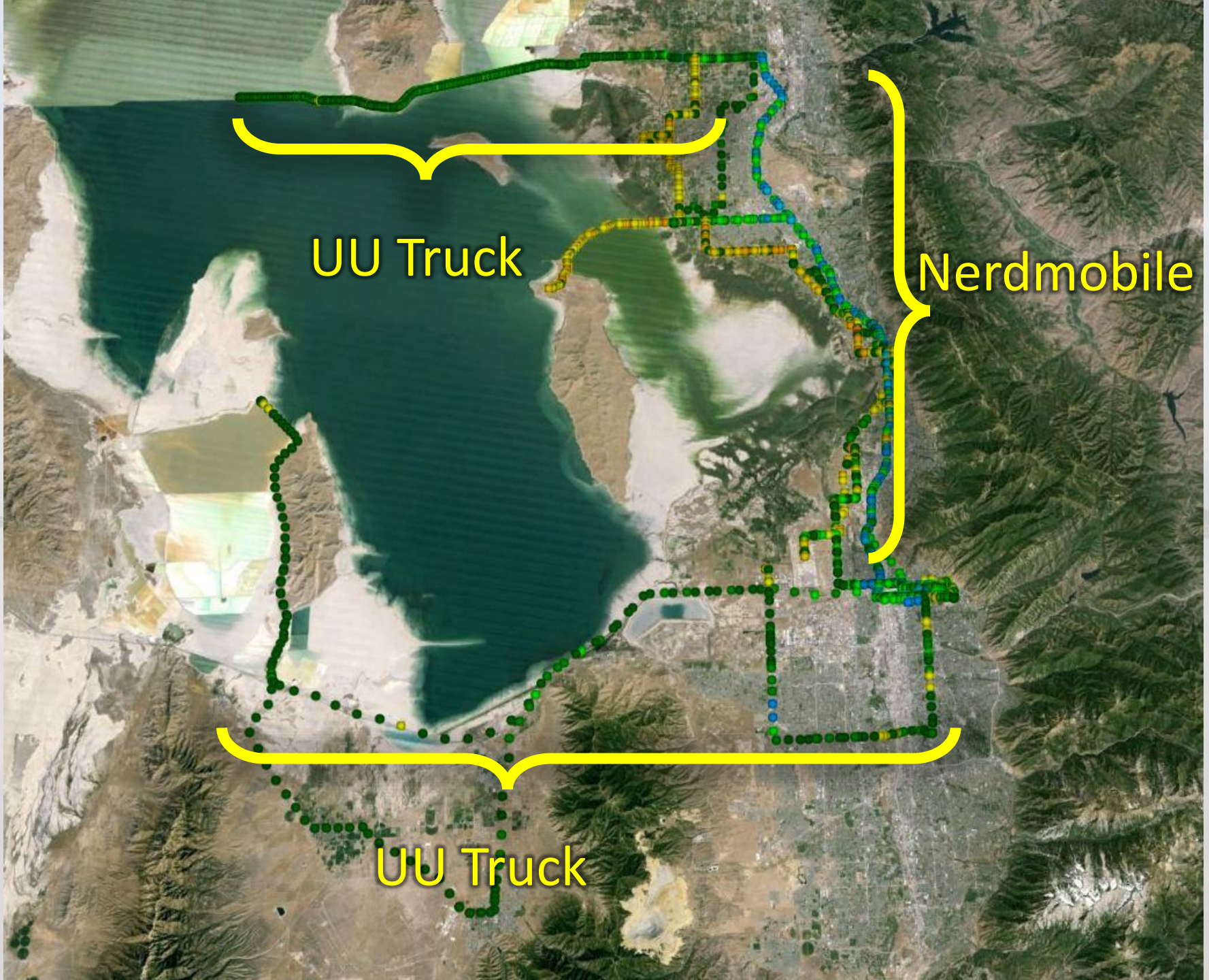

UAV Flying at Promontory Point

Mobile Observations


U of U Truck at Badger Island


Nerdmobile at Farmington Bay

Susan Bush


UU Truck
Nerdmobile
UU Truck

UTA

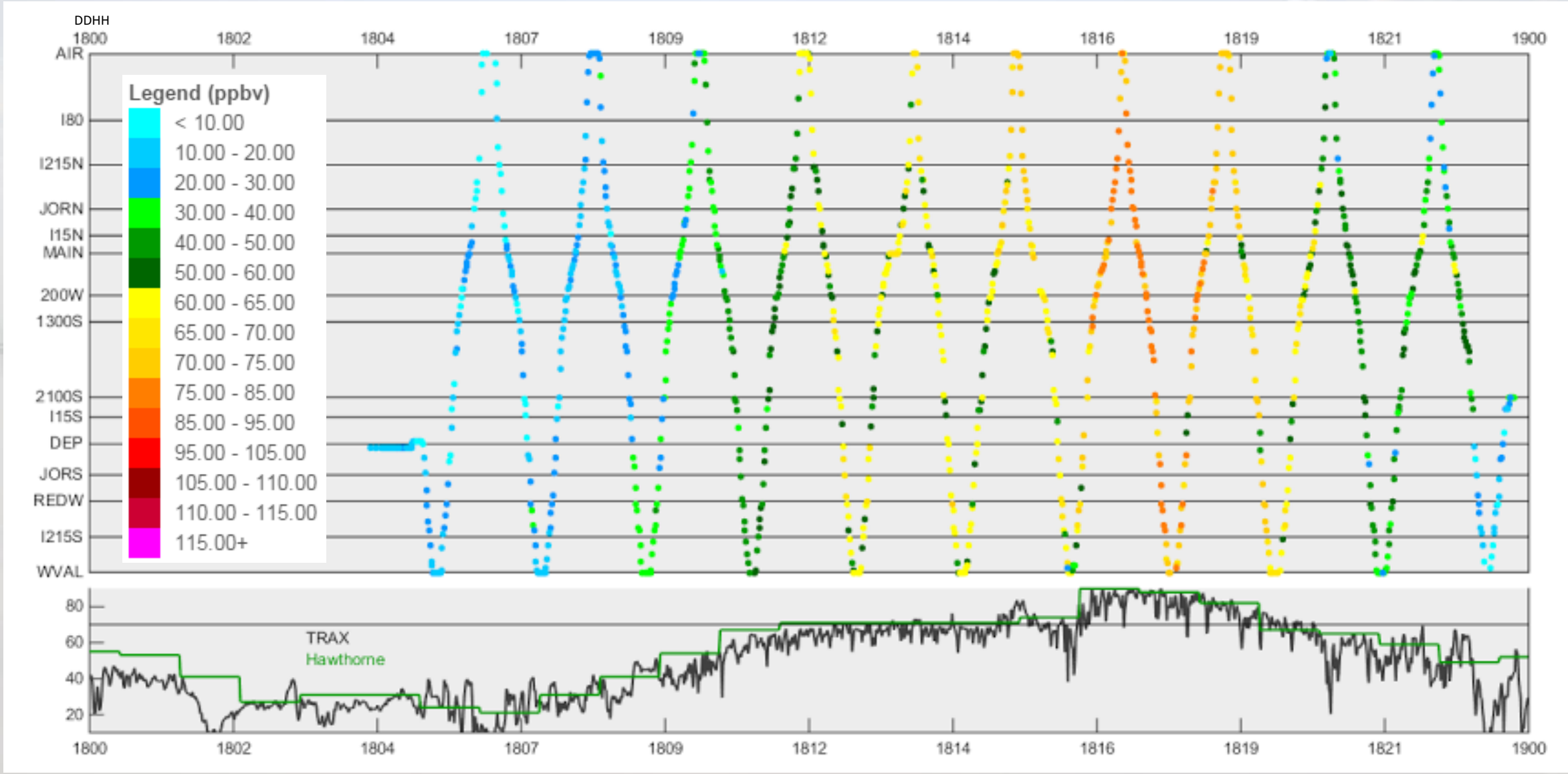
Red Line

Green Line

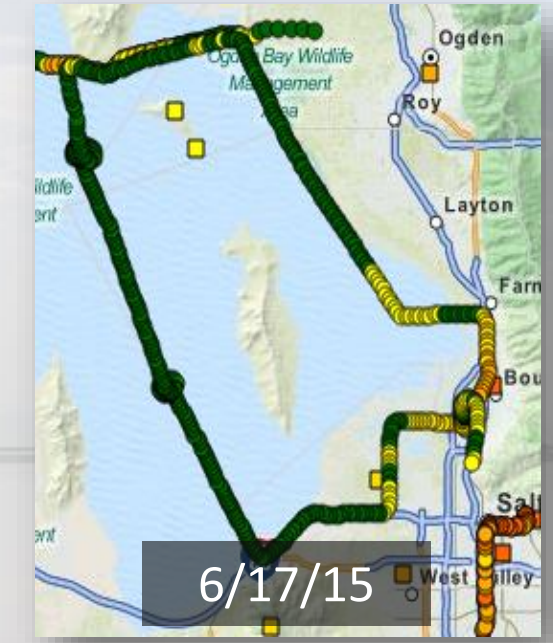
June 18, 2015

UTA

Green Line



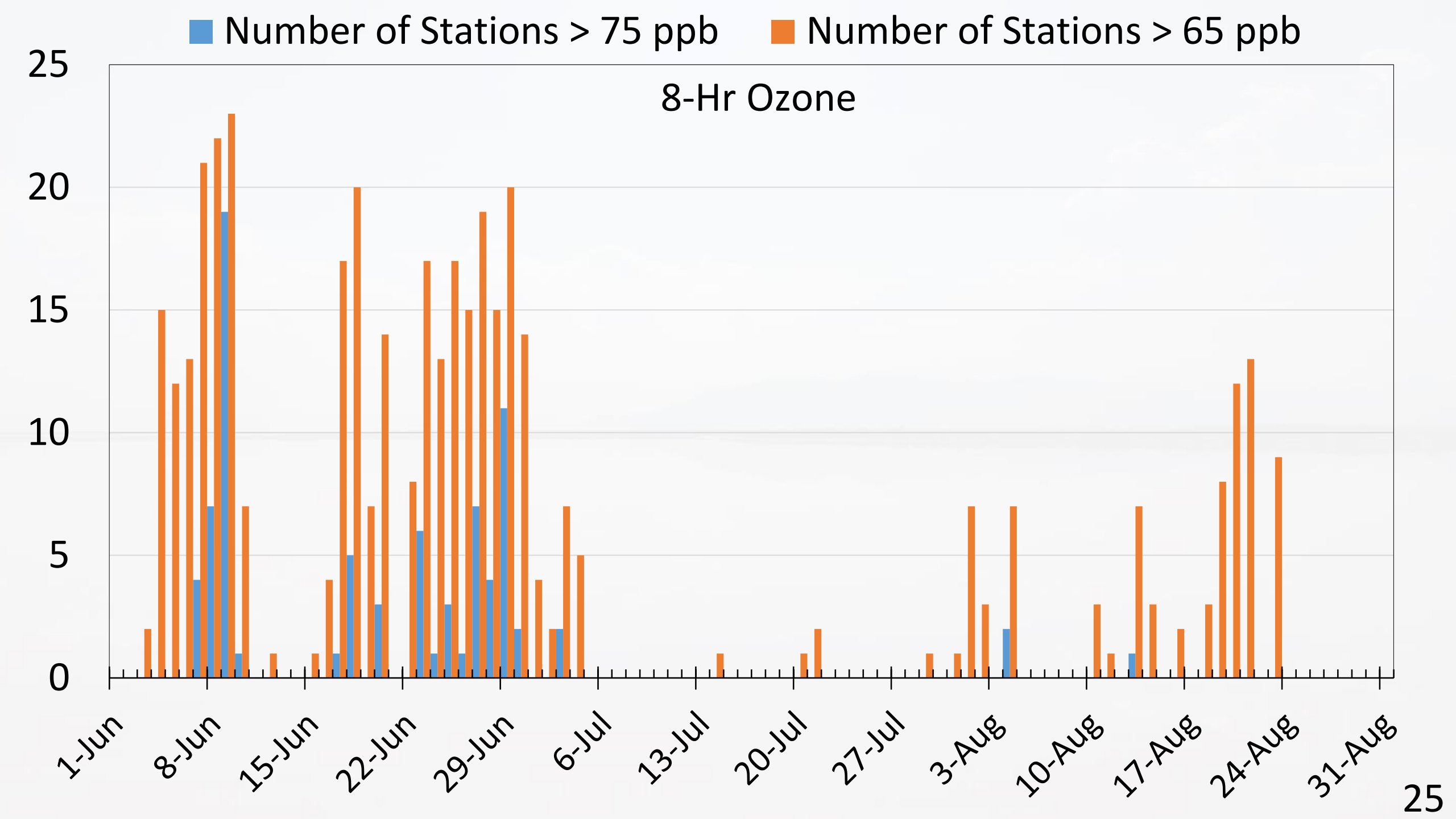
Chopper 5

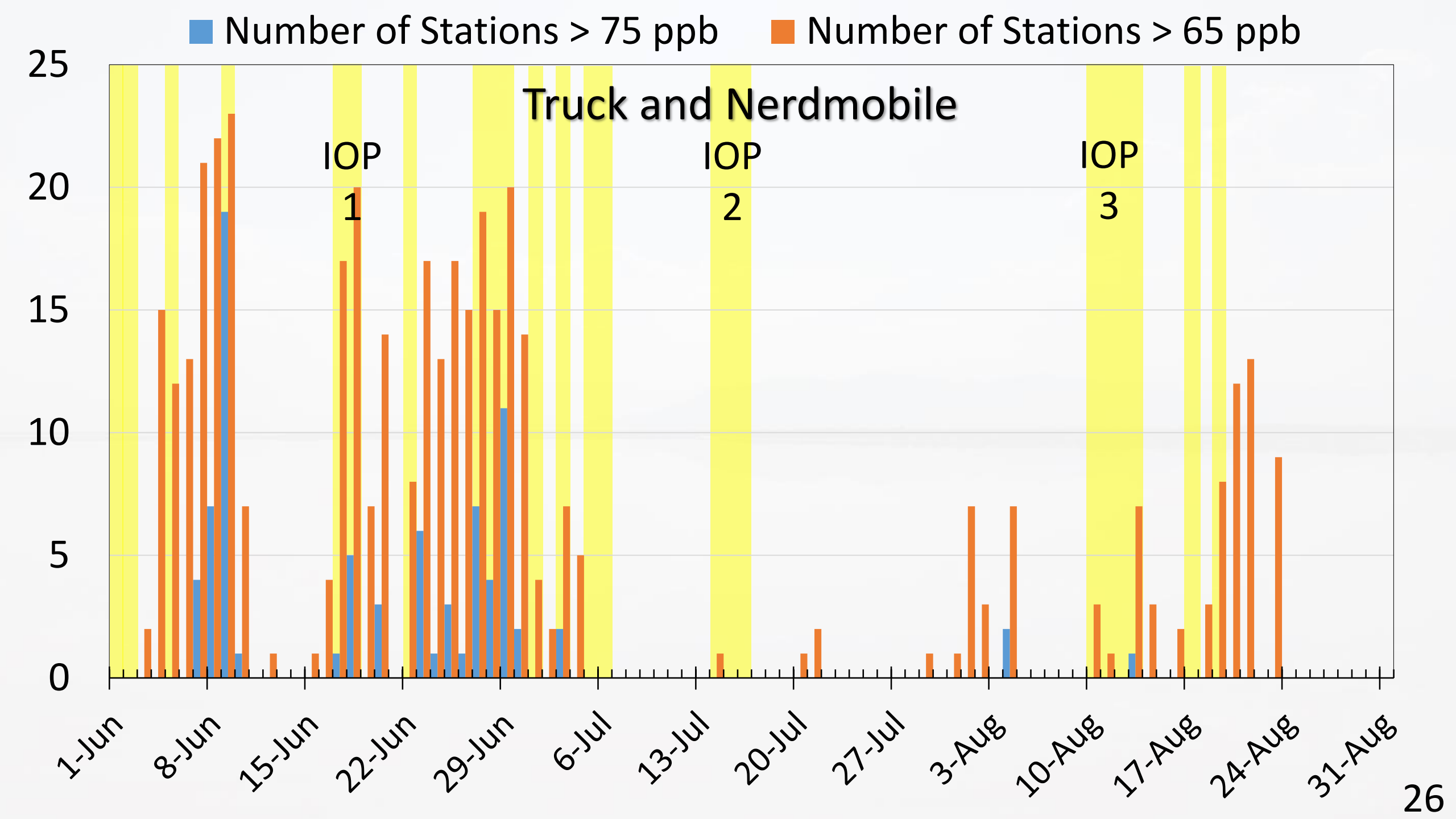

Ogden
Roy
Layton
6/17/15

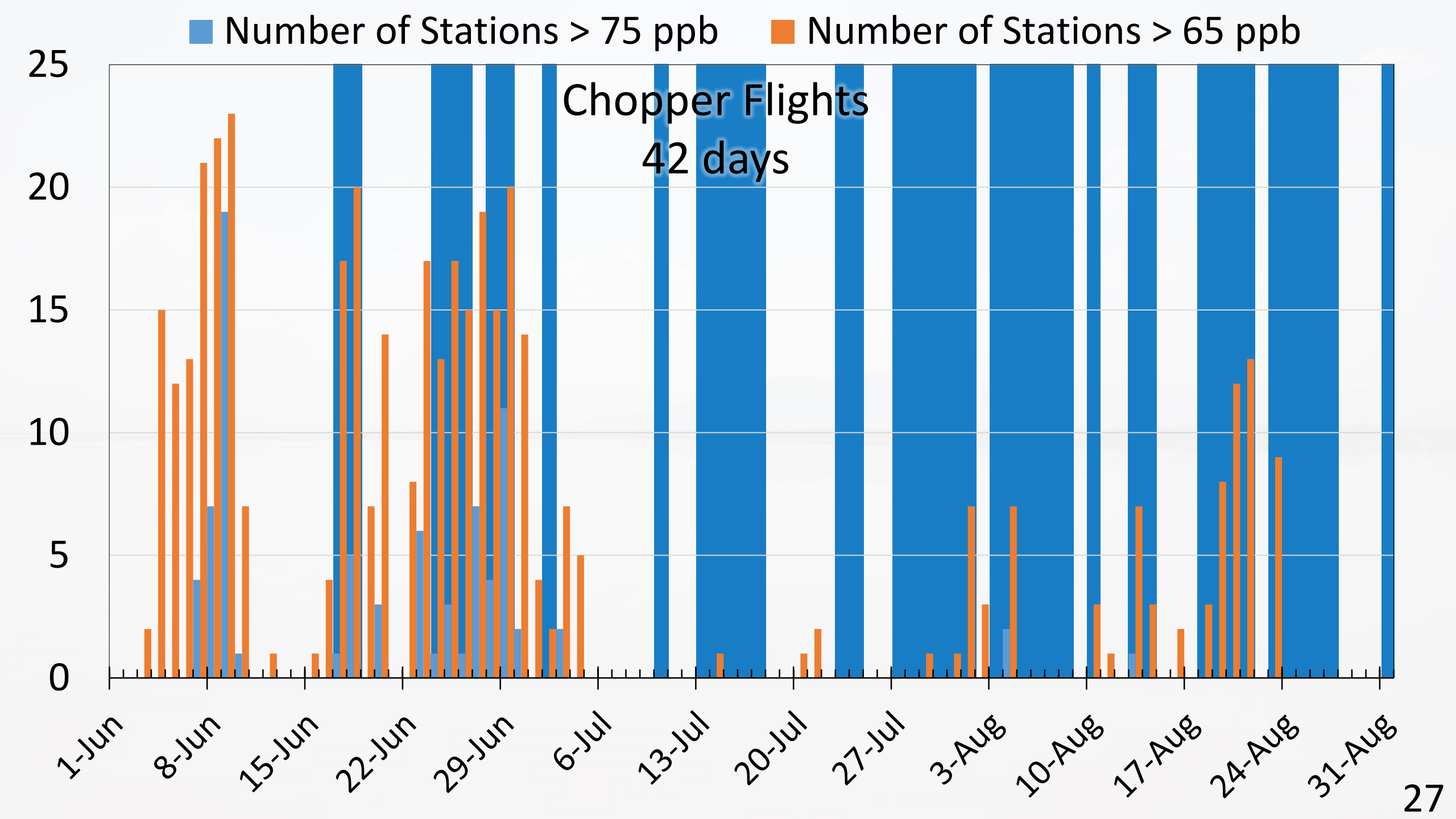

Farmington
Bountiful
Salt Lake City
West Jordan
Highland
Pleasant
6/18/15

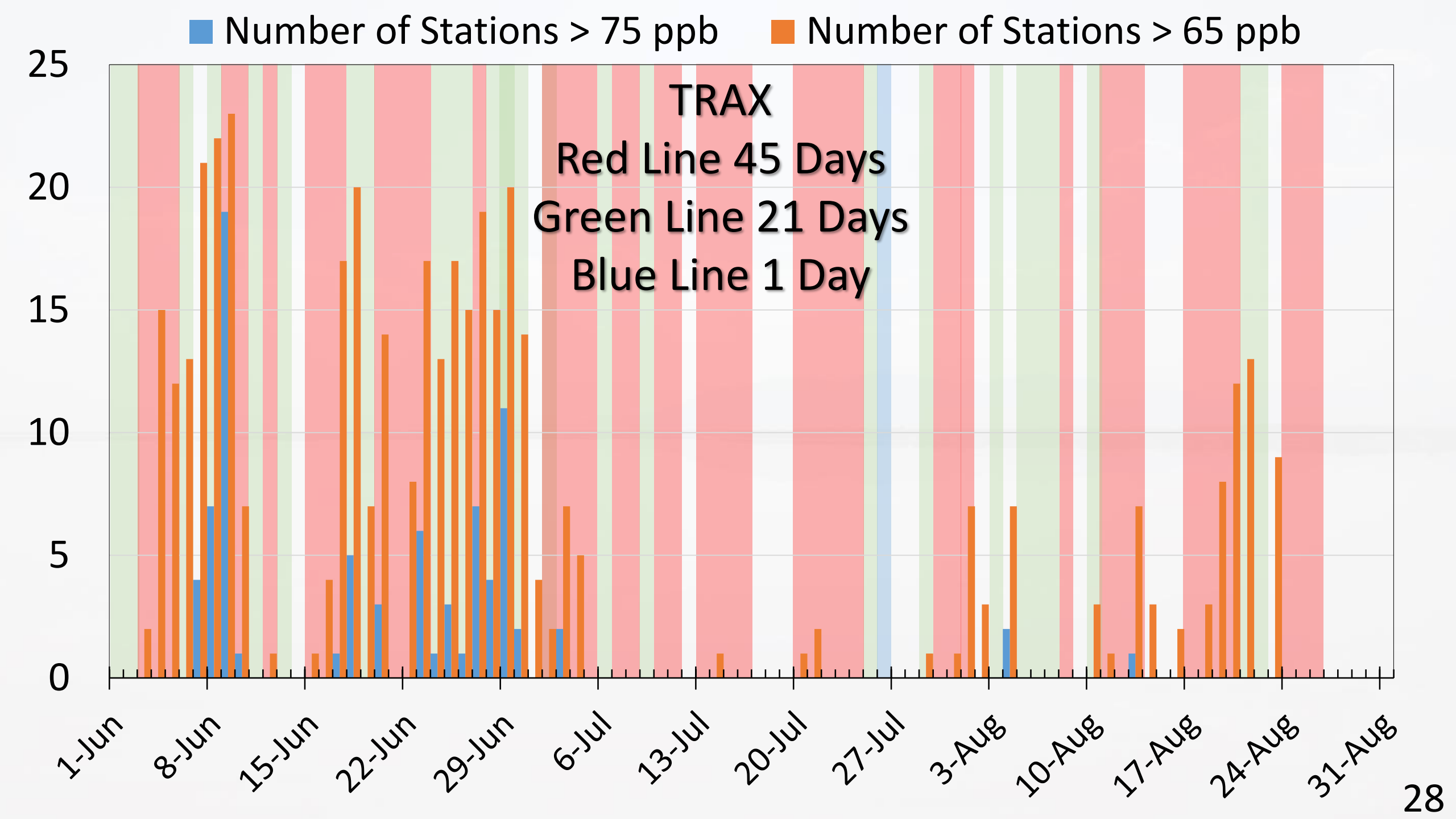

Ozone Monitor

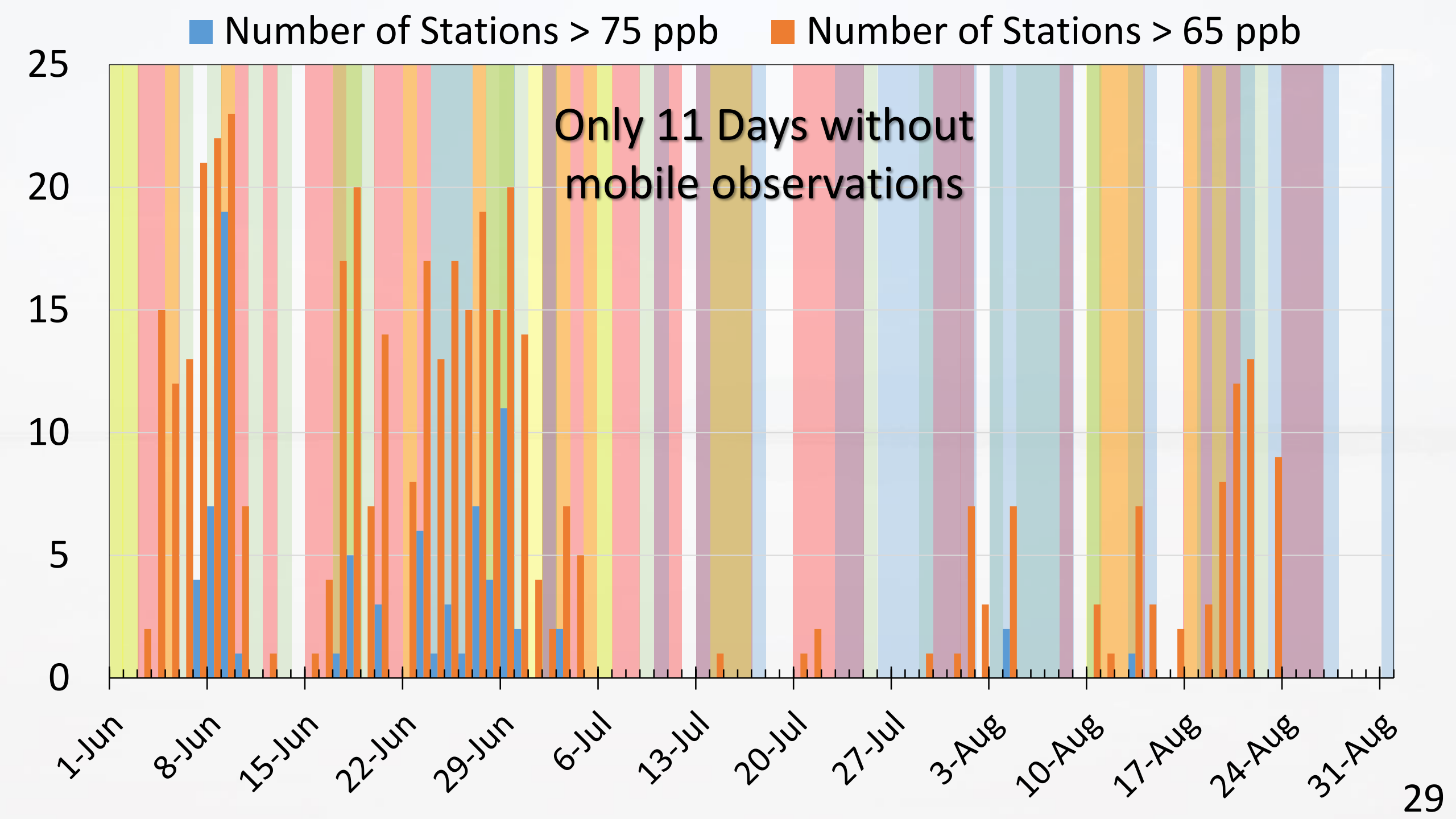

FSI

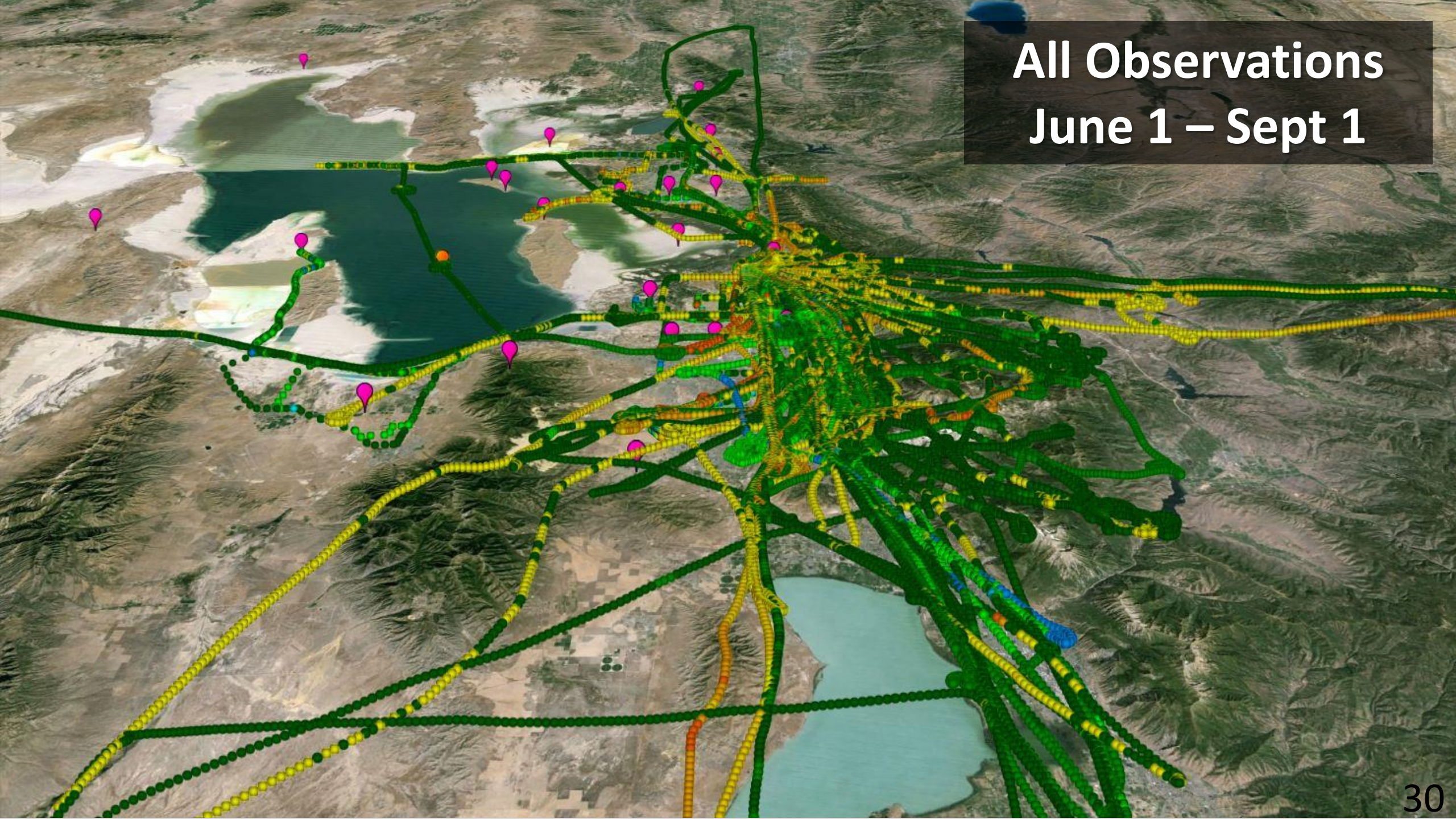

Number of Stations > 75 ppb
Number of Stations > 65 ppb
8-Hr Ozone
25
20
15
10
5
0
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug


Number of Stations > 75 ppb
Number of Stations > 65 ppb
Truck and Nerdmobile
IOP 1
IOP 2
IOP 3
25
20
15
10
5
0
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug

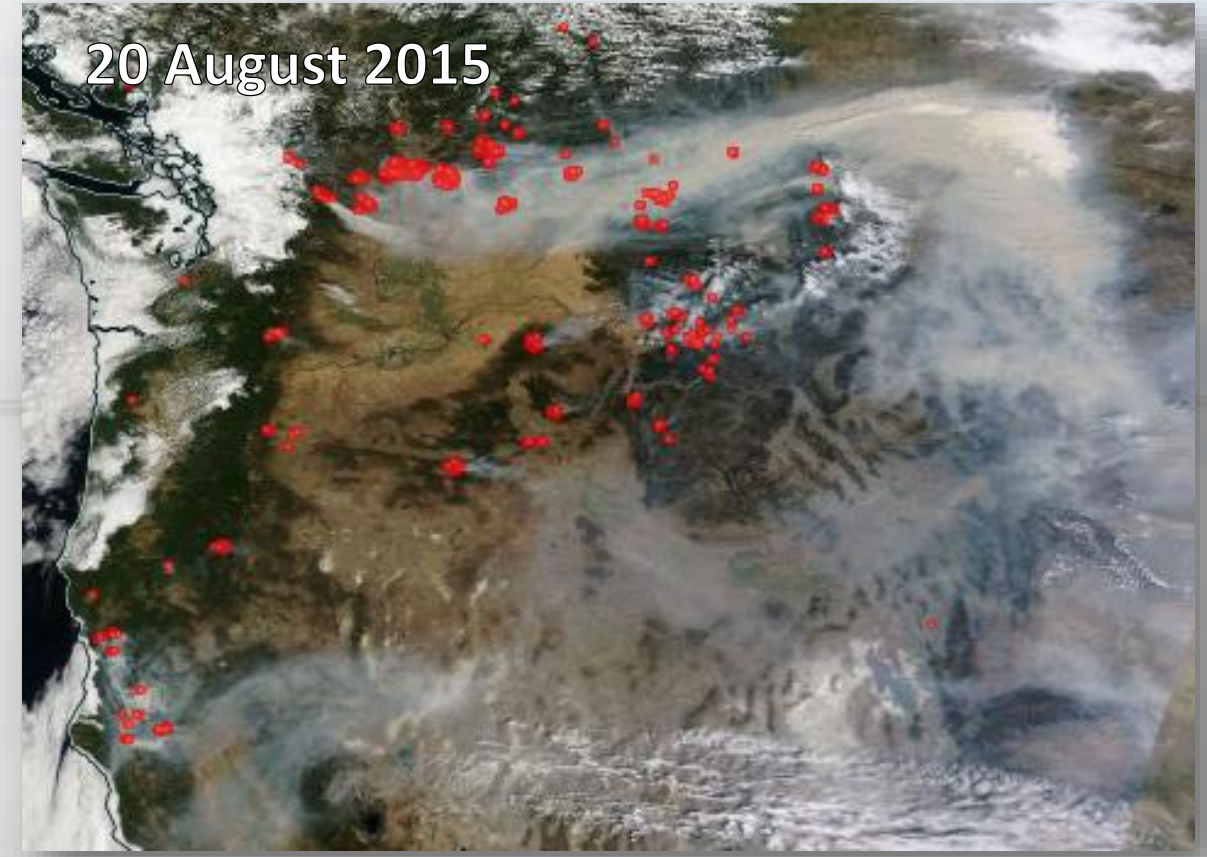

Number of Stations > 75 ppb
Number of Stations > 65 ppb
Chopper Flights
42 days
25
20
15
10
5
0
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug


Number of Stations > 75 ppb
Number of Stations > 65 ppb
TRAX
Red Line 45 Days
Green Line 21 Days
Blue Line 1 Day
25
20
15
10
5
0
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug

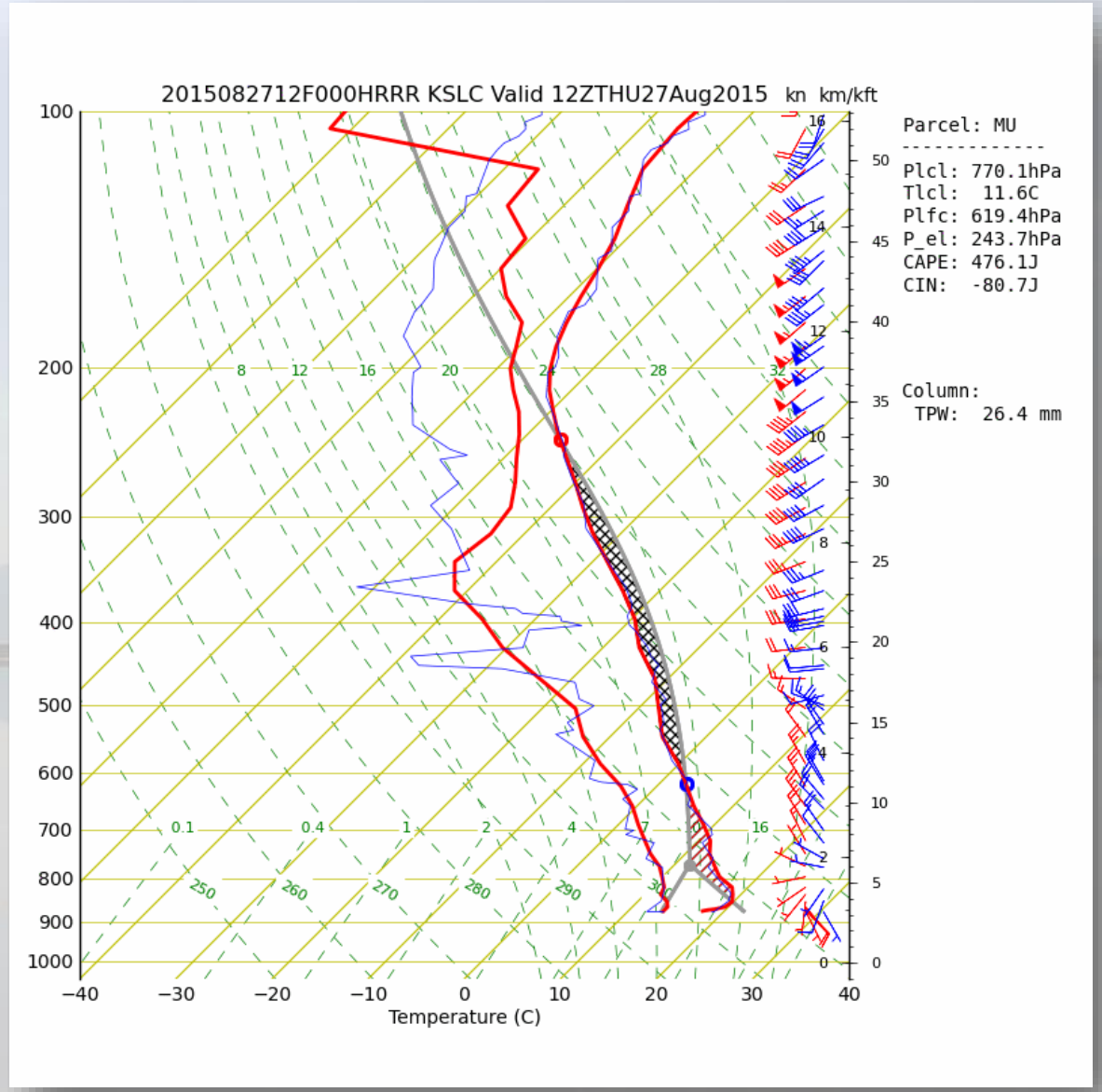

Number of Stations > 75 ppb
Number of Stations > 65 ppb
Only 11 Days without mobile observations
25
20
15
10
5
0
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug


All Observations
June 1 – Sept 1

Additional Data

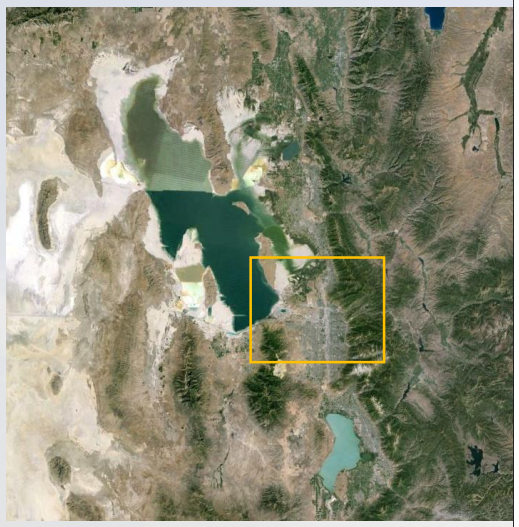


MODIS Satellite Images

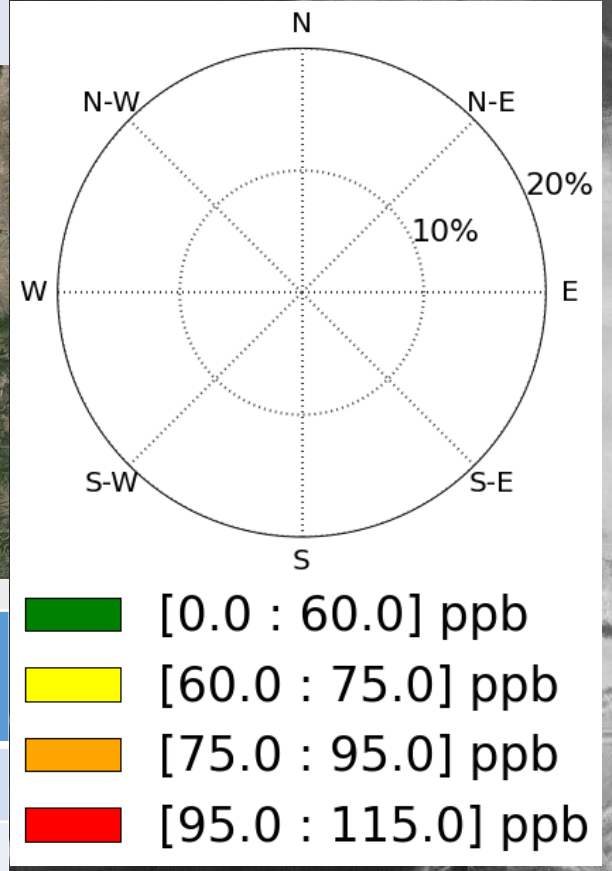


HRRR model sounding (red)
NWS Soundings (Blue)

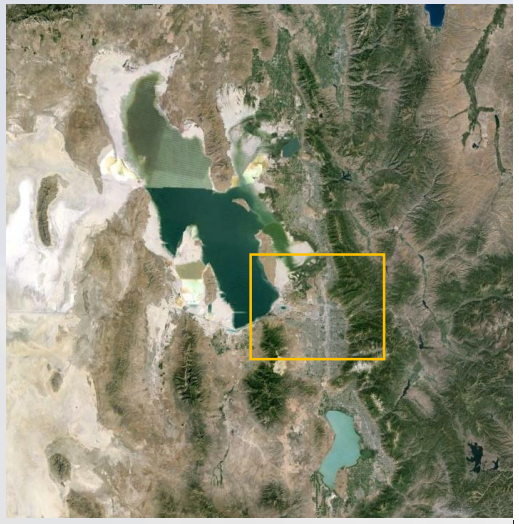
Ozone Rose

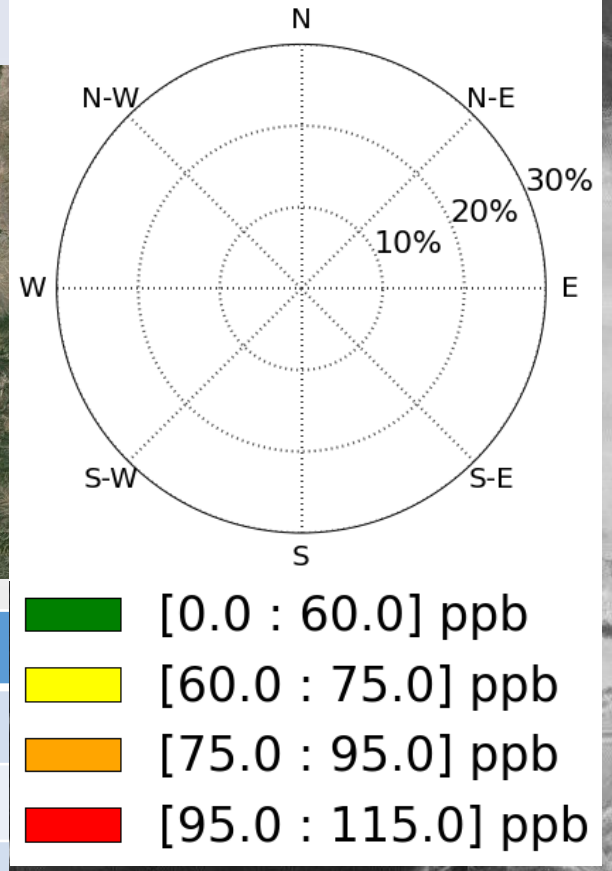


Station	Observation Frequency
MTMET	5 min
QHW	1 hr
QBV	1 hr
QSA	1 hr
NAA	5 min
FWP	5 min



Ozone Rose



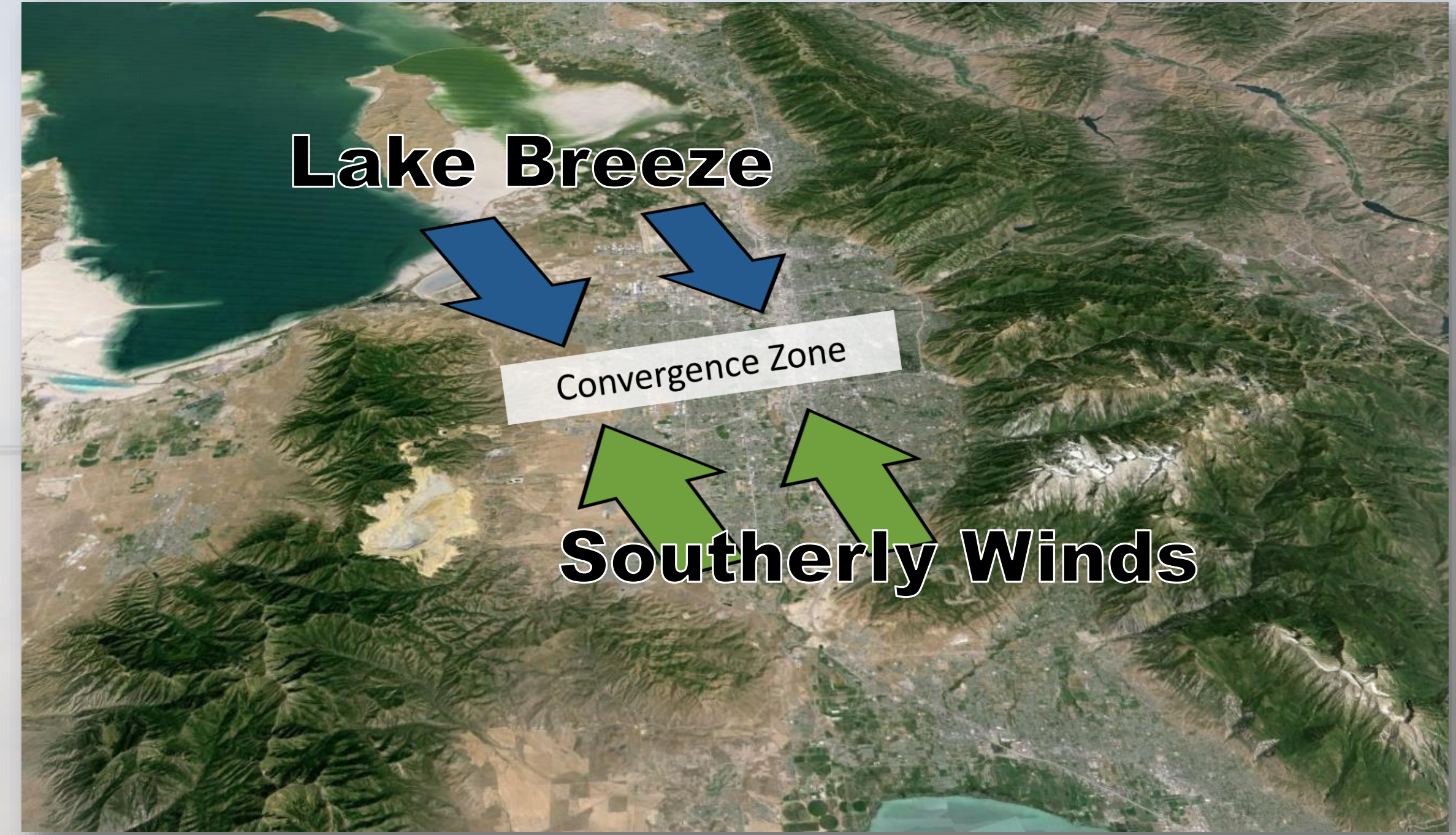


Station	% observations
MTMET	15.92%
QHW	17.69%
QBV	16.48%
QSA	16.58%
NAA	7.49%
FWP	12.34%

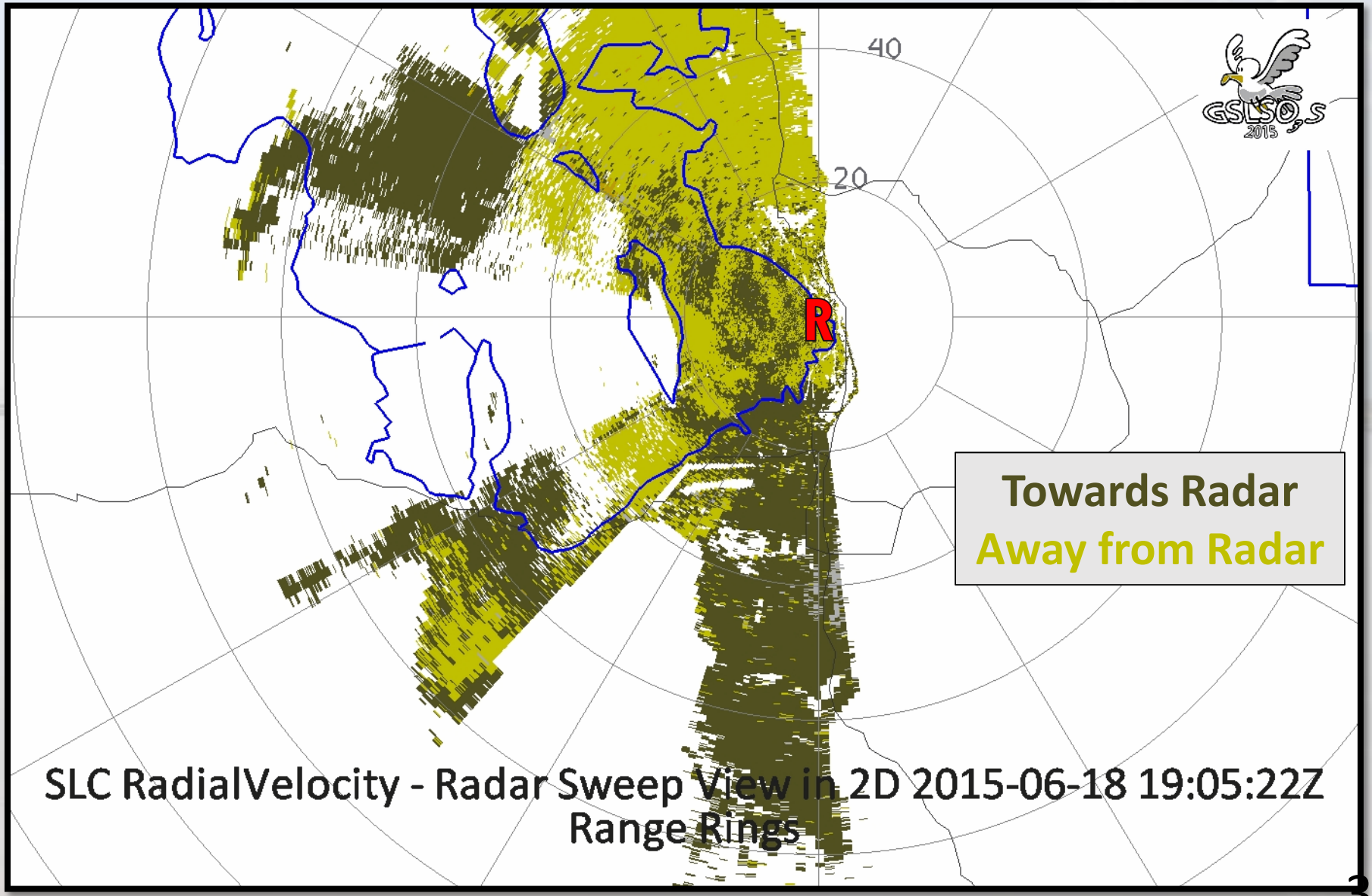
Interesting Case:

Lake Breeze

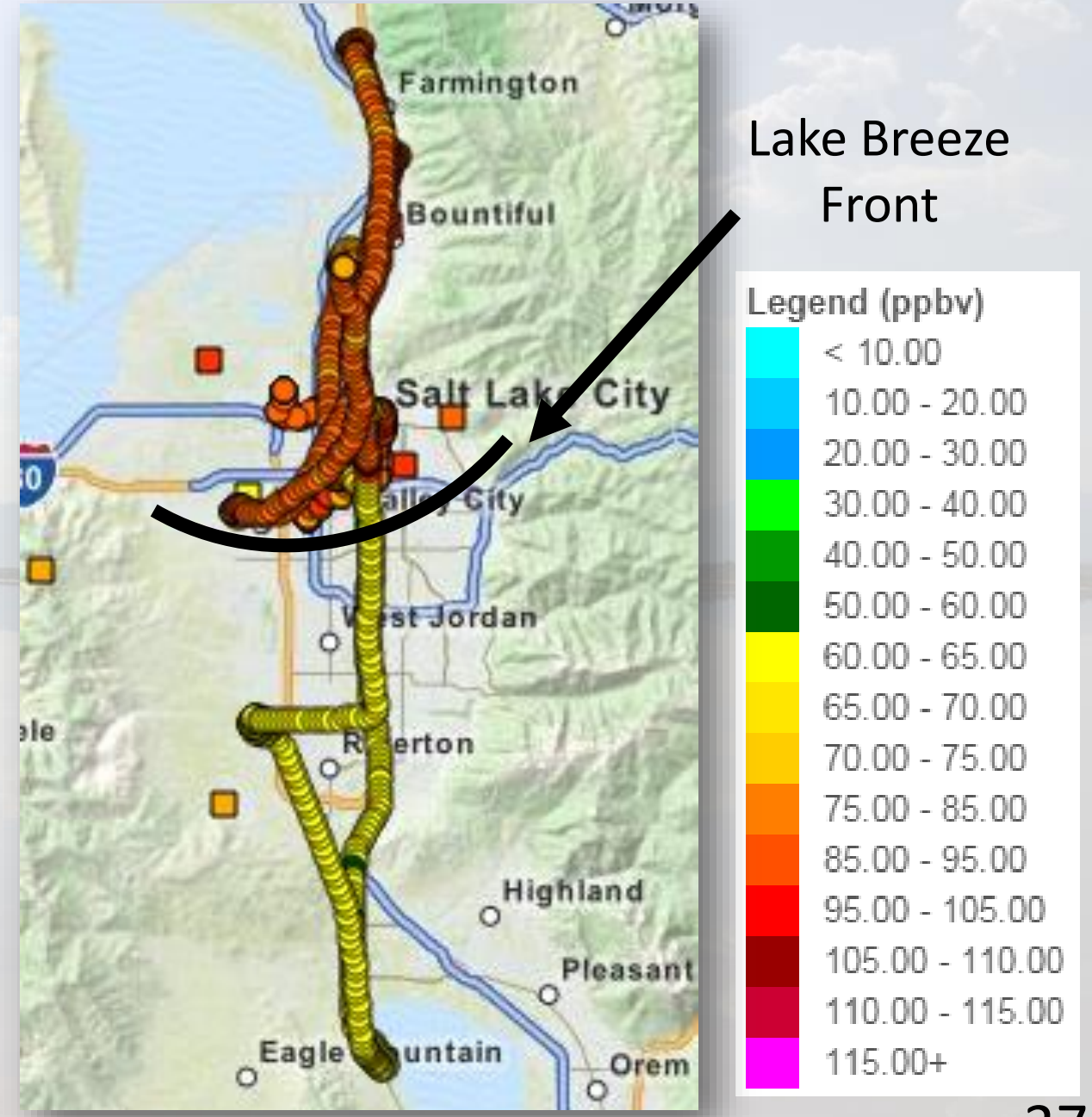
18 June 2015

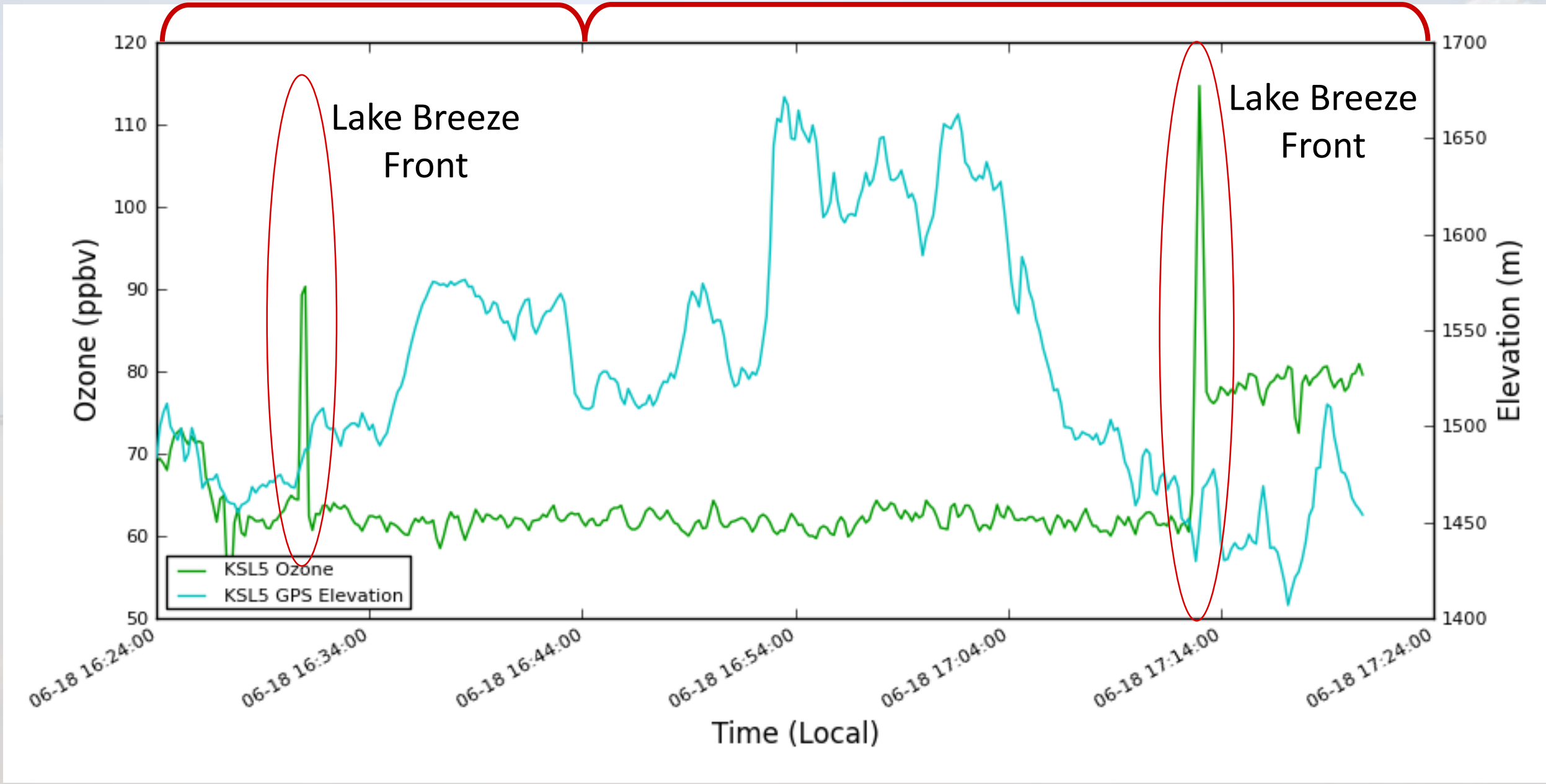

Lake Breeze
Convergence Zone
Southerly Winds

TDWR – Radial Velocity



Lake Breeze
June 18

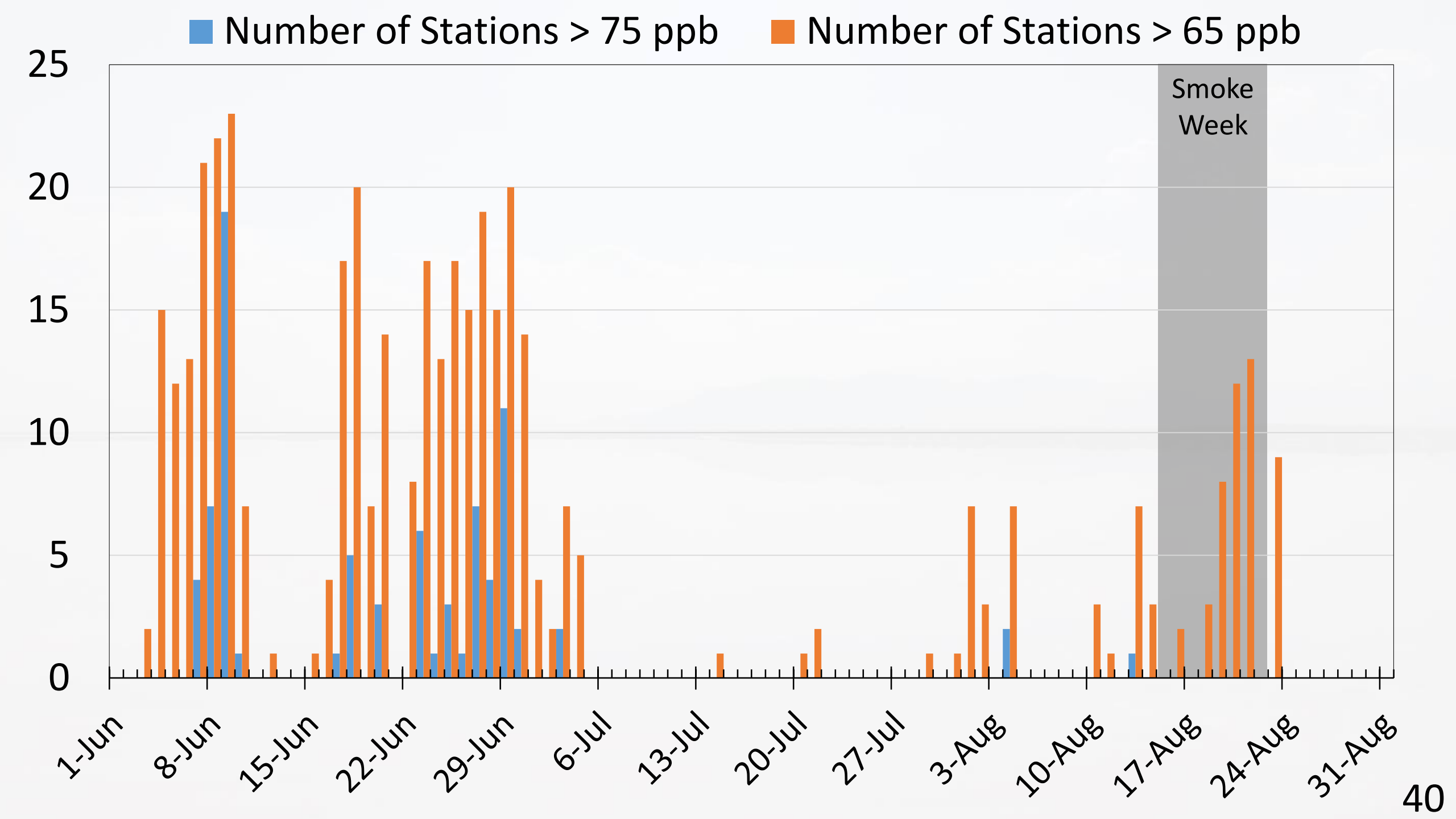


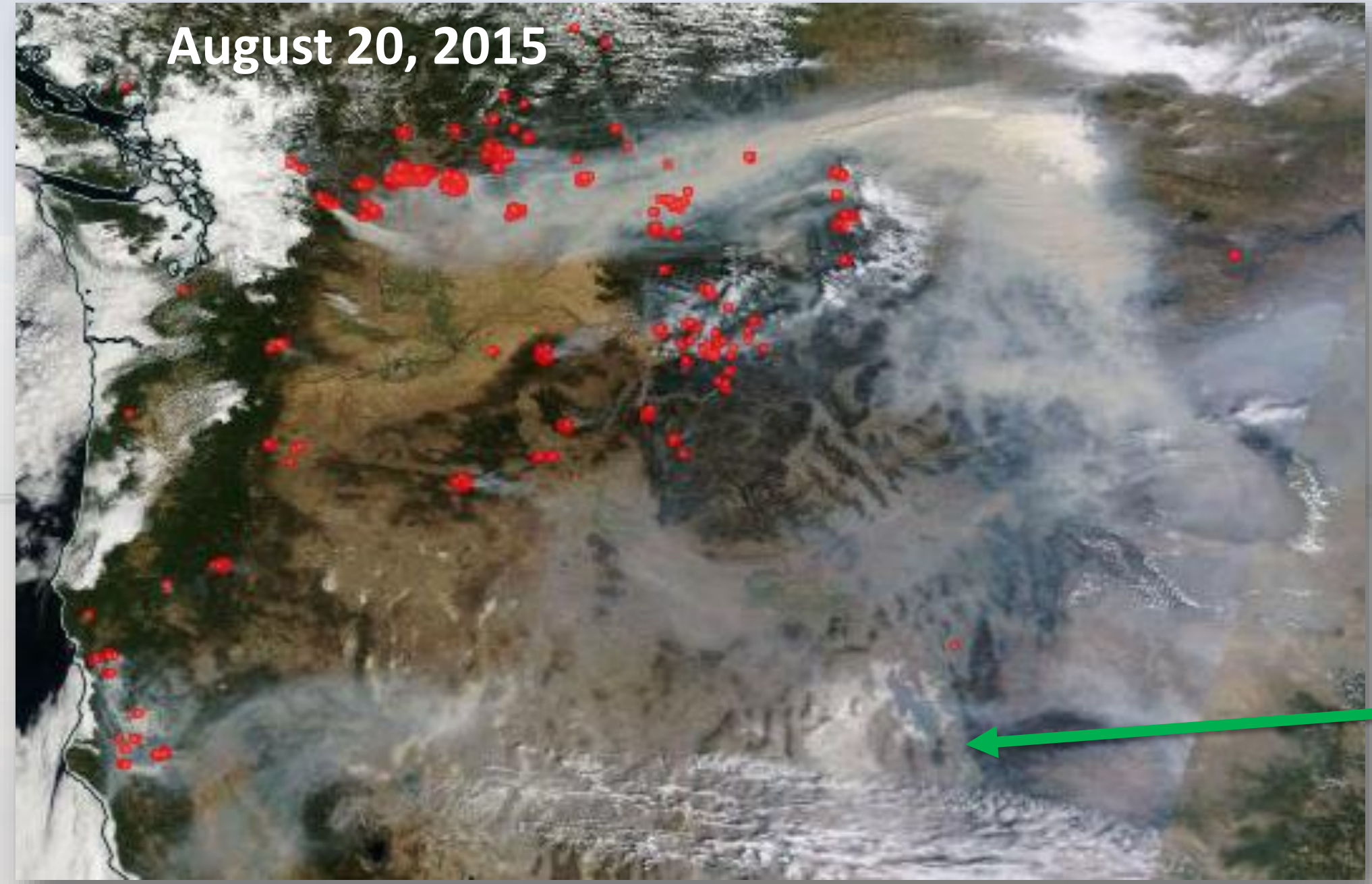

Flying South
Flying North
Lake Breeze Front
Lake Breeze Front
Ozone (ppbv)
Elevation (m)
Time (Local)
KSL5 Ozone
KSL5 GPS Elevation
120
110
100
90
80
70
60
50
1700
1650
1600
1550
1500
1450
1400
06-18 16:24:00
06-18 16:34:00
06-18 16:44:00
06-18 16:54:00
06-18 17:04:00
06-18 17:14:00
06-18 17:24:00

Interesting Case:

Smoke Week

15-23 August 2015


Number of Stations > 75 ppb
Number of Stations > 65 ppb
25
20
15
10
5
0
Smoke Week
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug



(NASA Worldview)

Smoke Week

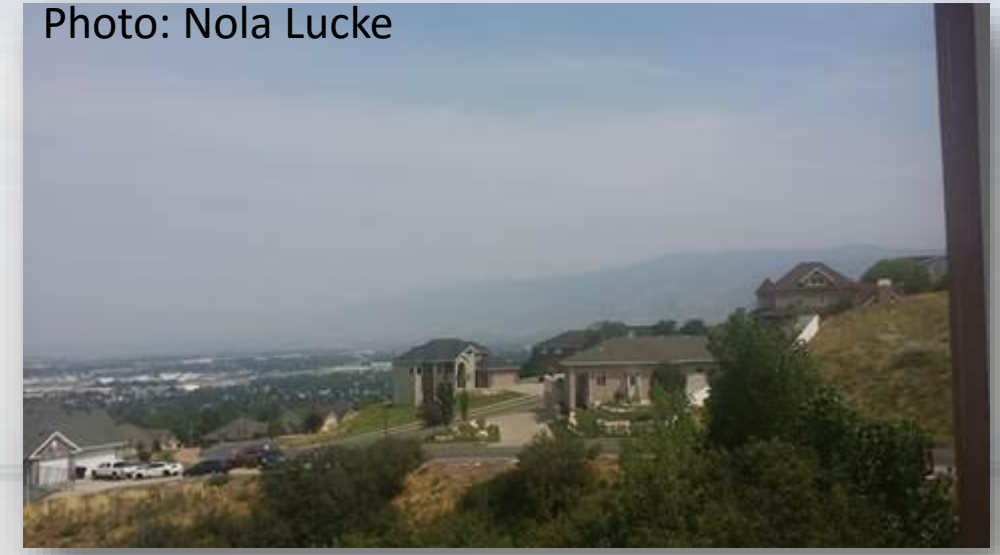
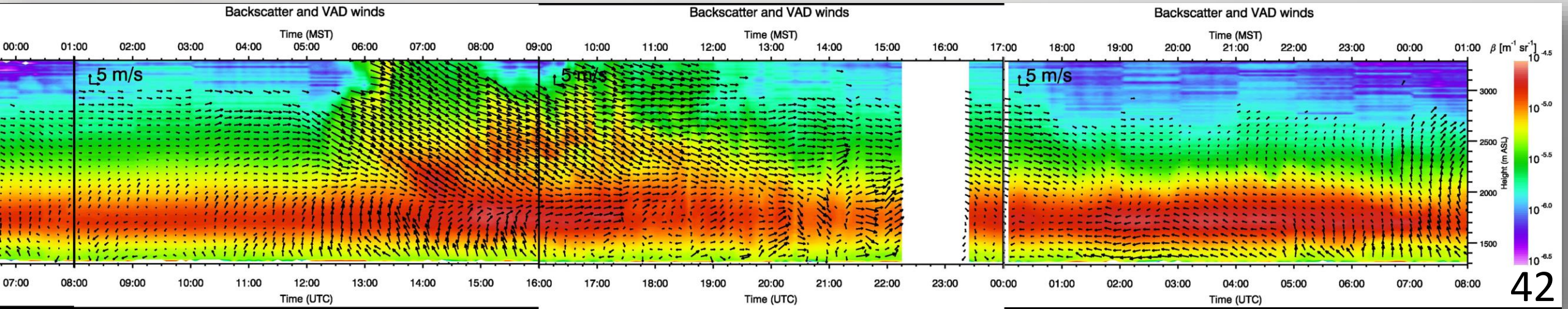


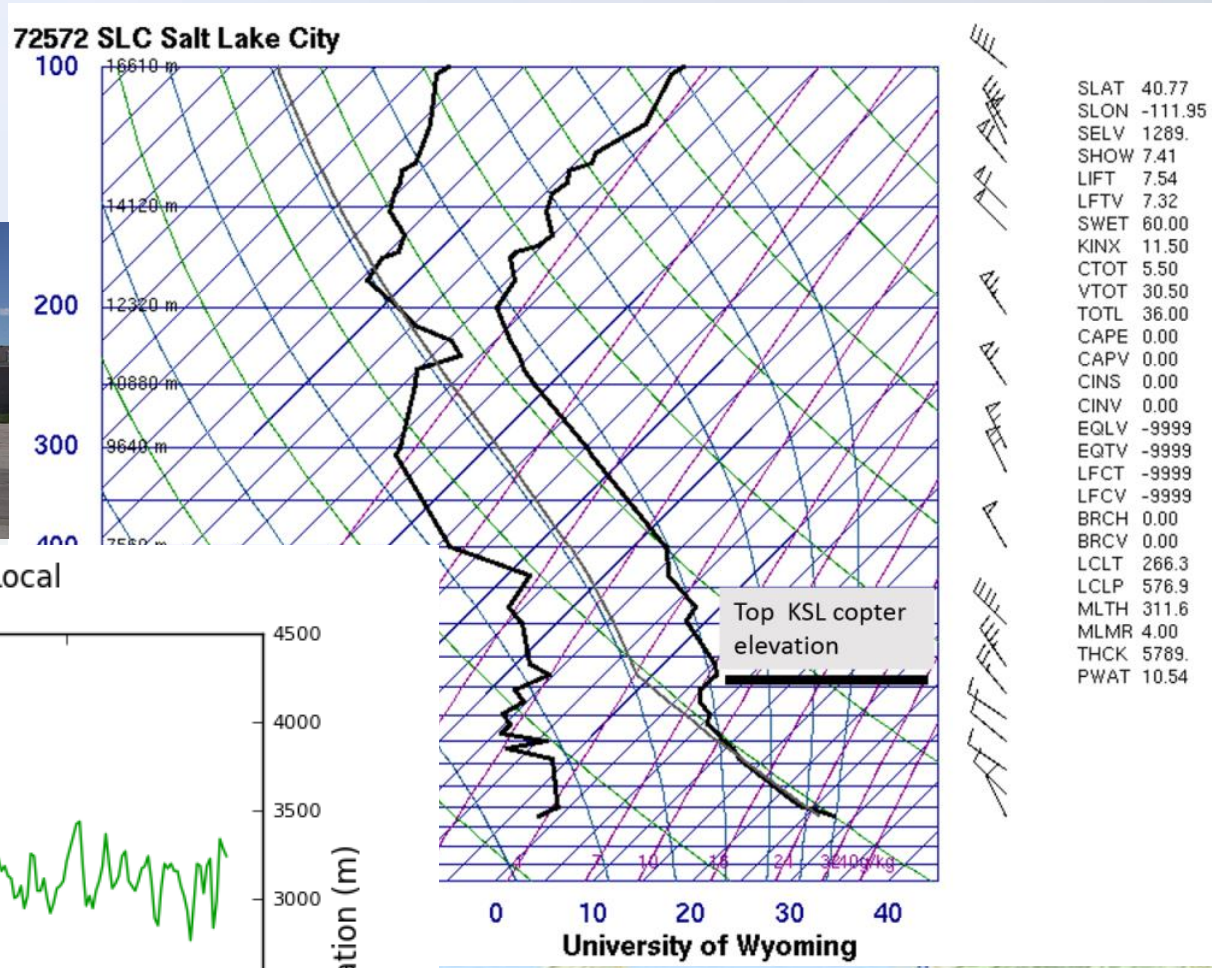
Photo: Nola Lucke

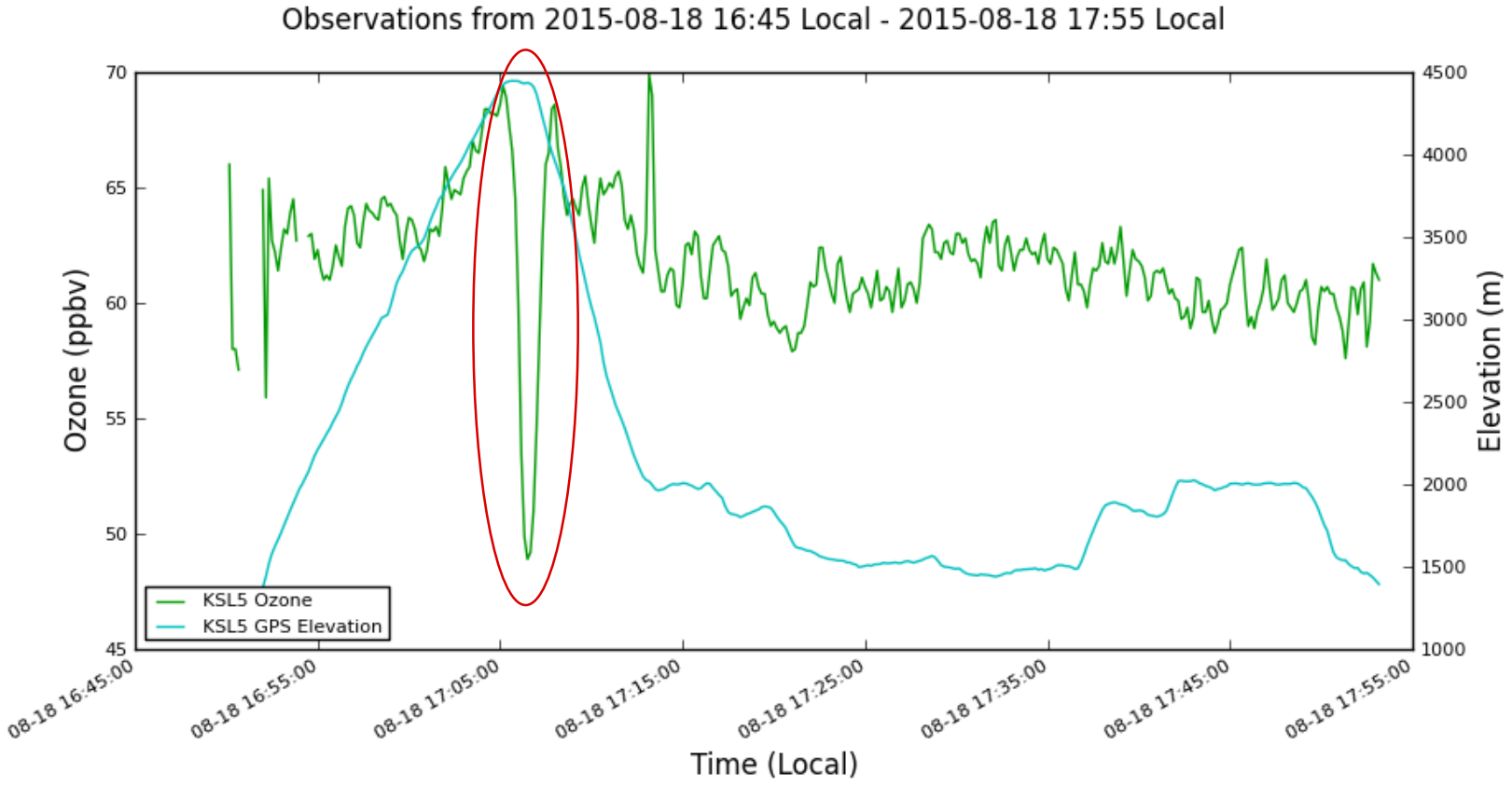
Lidar: Sebastian Hoch




KSL WEATHER
83°
6:17
KSL
#KSLLive

Smoke Week
August 18th





Take home points…

- Wasatch Front residents are occasionally exposed to unhealthy ozone levels in the summer.
- Ozone distribution is influenced by meteorology.
- We utilized existing infrastructure to collect unprecedented ozone measurements in the Salt Lake Valley.
- Real-time observations helped us target ozone measurements

We have a lot of data…Now what?

Ansley: UU2DVAR analysis of spatial and temporal distributions of ozone concentrations over the GSL and areas nearby.

Brian: Use WRF simulations initialized by the HRRR to study thermally driven transport of ozone.

- Why did June have such high ozone? Was the boundary layer more shallow? Lake temperature play a role?
- What role does biogenics play on ozone?
- How are ozone patterns different at rural and urban locations?

Website: http://meso2.chpc.utah.edu/gslso3s/

Blog: https://gslso3s.wordpress.com/