The Great Salt Lake Summer Ozone Study

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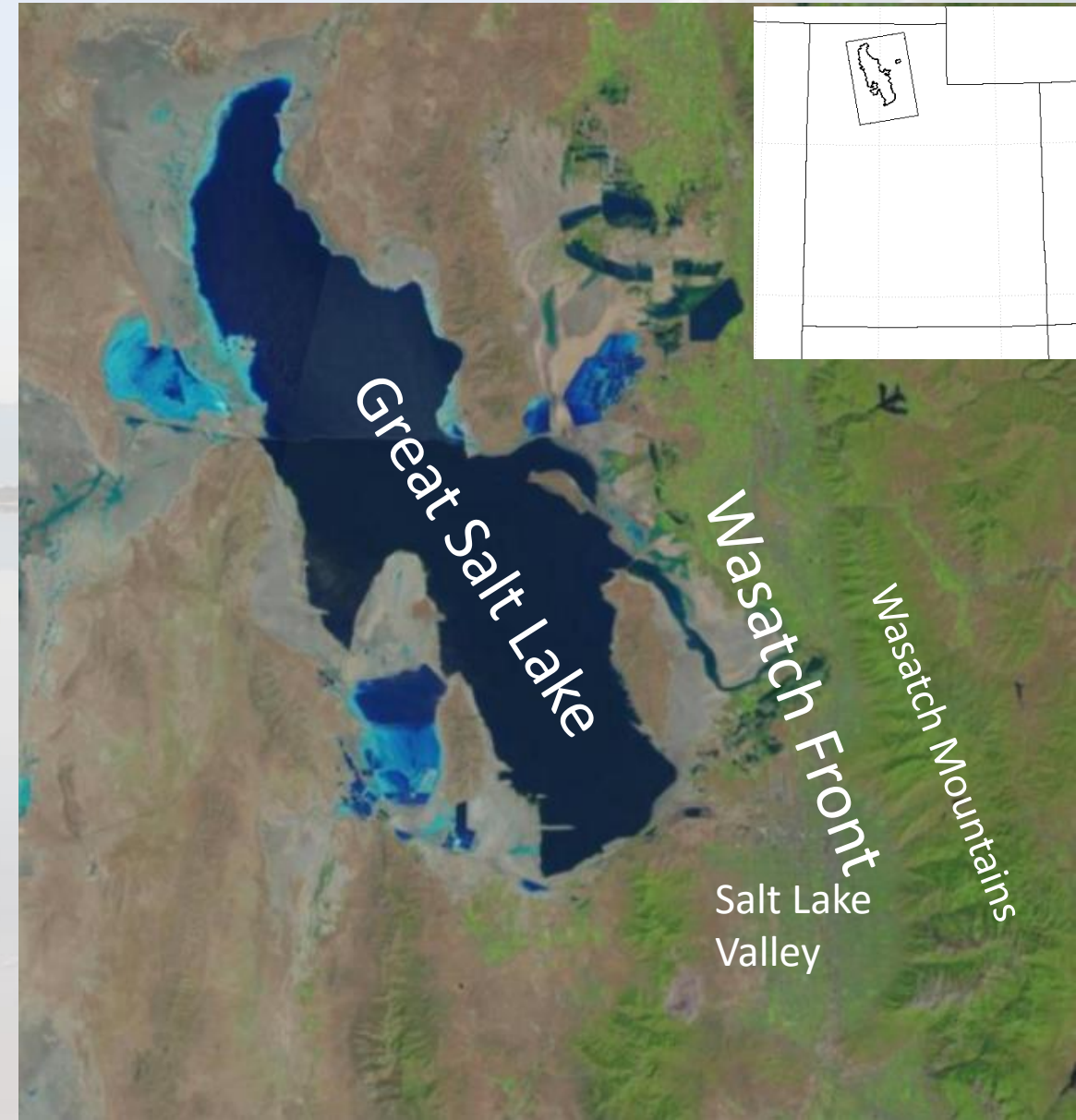
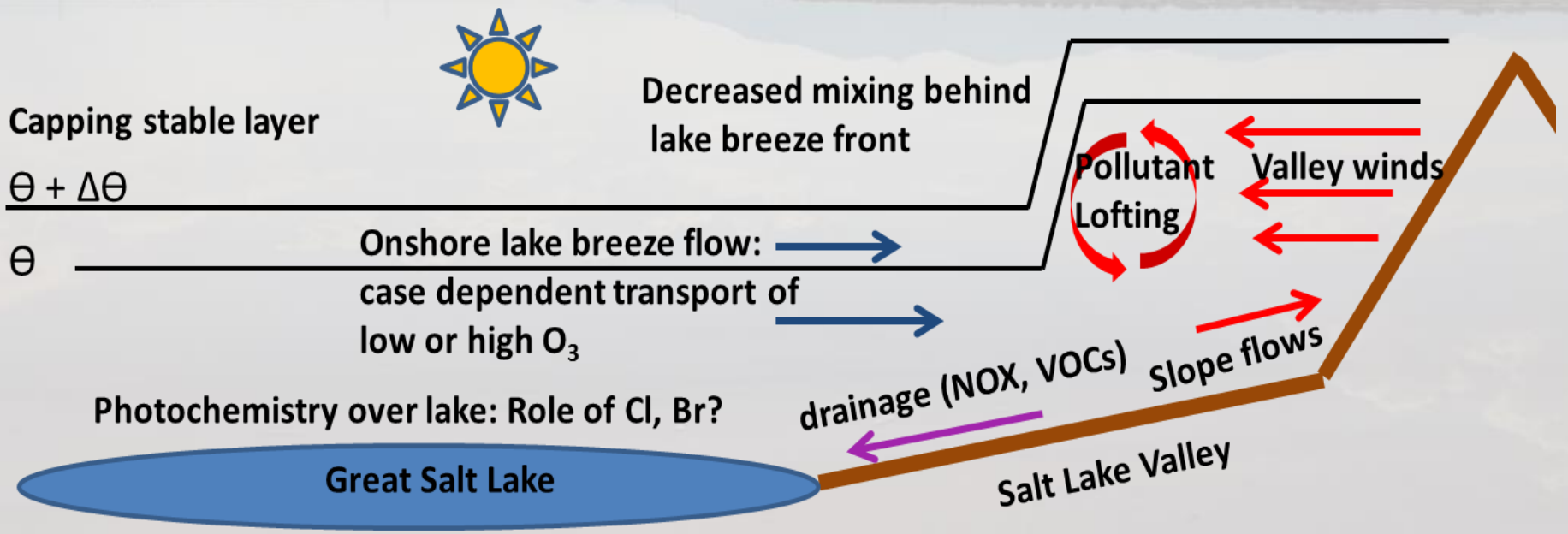
Why is ozone a concern along Wasatch Front?

- Background ozone levels in the west are high and likely to increase
  - Distant, regional, local emissions and transport
  - Increased wildfires
- Prior field & modeling studies by Utah Division of Air Quality (DAQ) indicated high ozone concentrations over & near the Great Salt Lake



Objectives of this pilot study…

1. Determine the distribution of ozone near the Great Salt Lake during summer
2. Improve understanding of the meteorological processes that control ozone concentrations over and surrounding the Lake during summer
3. Contribute to improved ozone forecasts by Utah DAQ



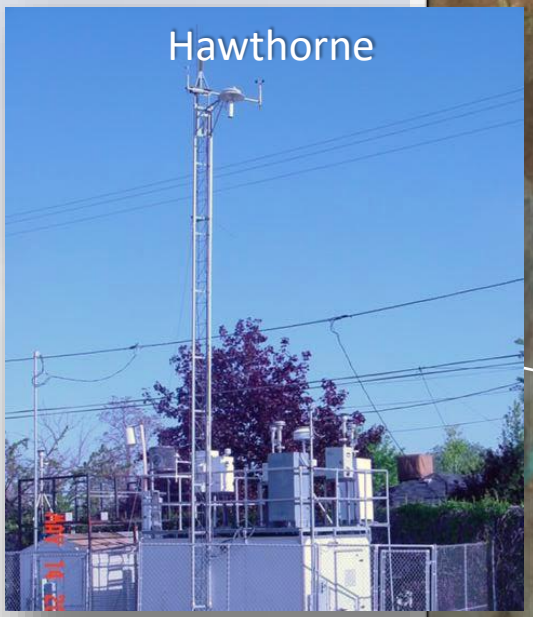
Cost-effective pilot field study

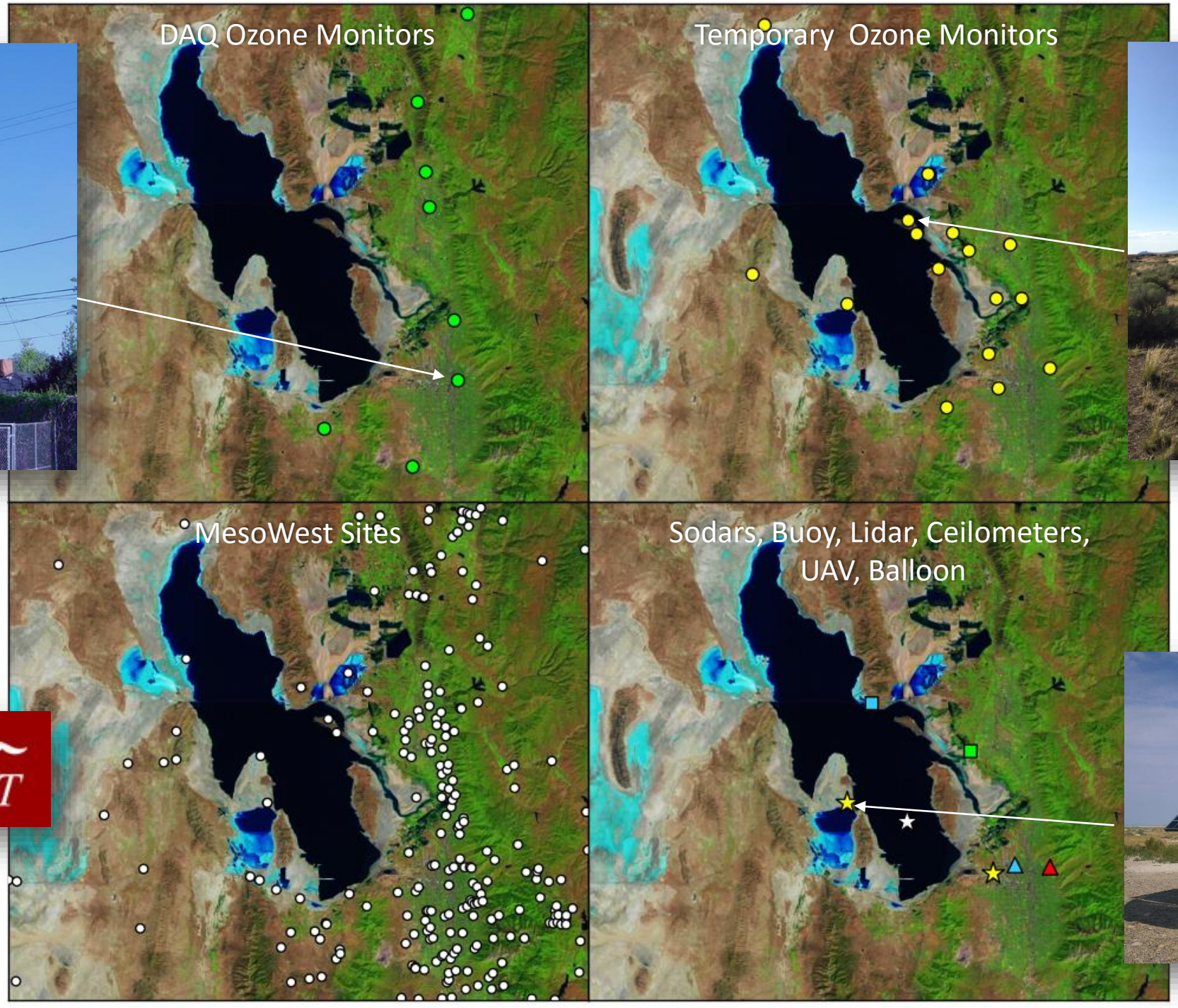
- **Small budget** from Utah DAQ leveraged by other funds
- **Used existing infrastructure in our own backyard** to reduce costs
- Real-time data collection and analysis**: 1 June - 31 August 2015**
- Summer study allowed for more graduate & undergraduate student participation

Leveraging Existing Resources

Real-time Ozone Measurements During the 2015 Great Salt Lake Summer Ozone Study
Jacques et al., Paper 7.2 18th Symposium on Meteorological Observation and Instrumentation

Instruments	Resource
DAQ Fixed Site Ozone Monitors	DAQ Ozone Monitors - part of regular monitoring network
Temporary Fixed Site Ozone Monitors	DAQ and UofU temporary deployments, some adjacent to existing UofU weather stations and available in real-time
Weather Observations	MesoWest (http://mesowest.utah.edu) MesoWest API (http://mesowest.org/api)
Mobile Ozone Observations	UTA TRAX Light Rail Car (continuous) KSL-TV "Chopper" 5 (often late afternoon) UofU Nerdmobile (IOPs) UofU Additional Vehicles (IOPs)
Boundary Layer Air Quality Observations	USU UAV WSU Tethersonde
Boundary Layer Remote Sensing	UofU Sodars, Lidar, and Ceilometers


Hawthorne


DAQ Ozone Monitors
Temporary Ozone Monitors
MesoWest Sites
Sodars, Buoy, Lidar, Ceilometers,
UAV, Balloon

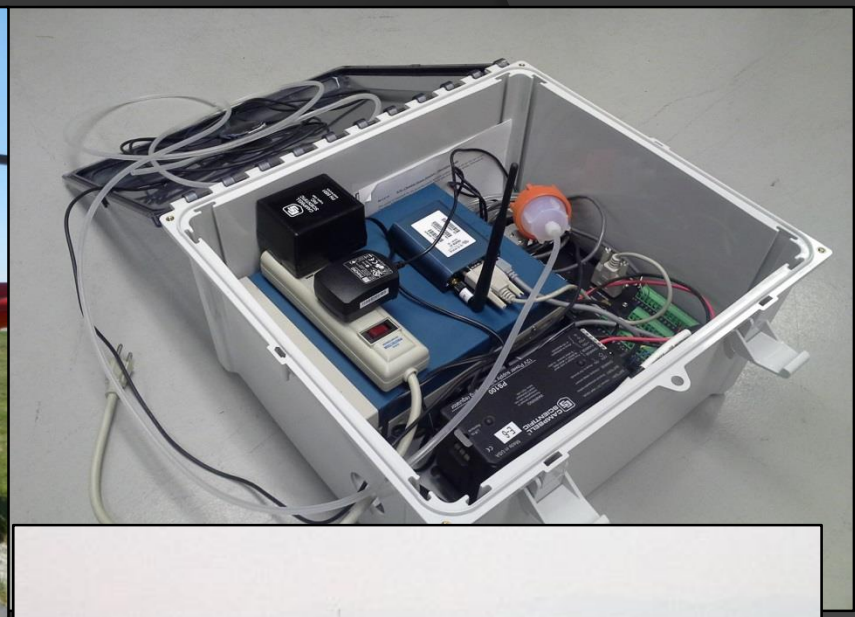

Fremont Island

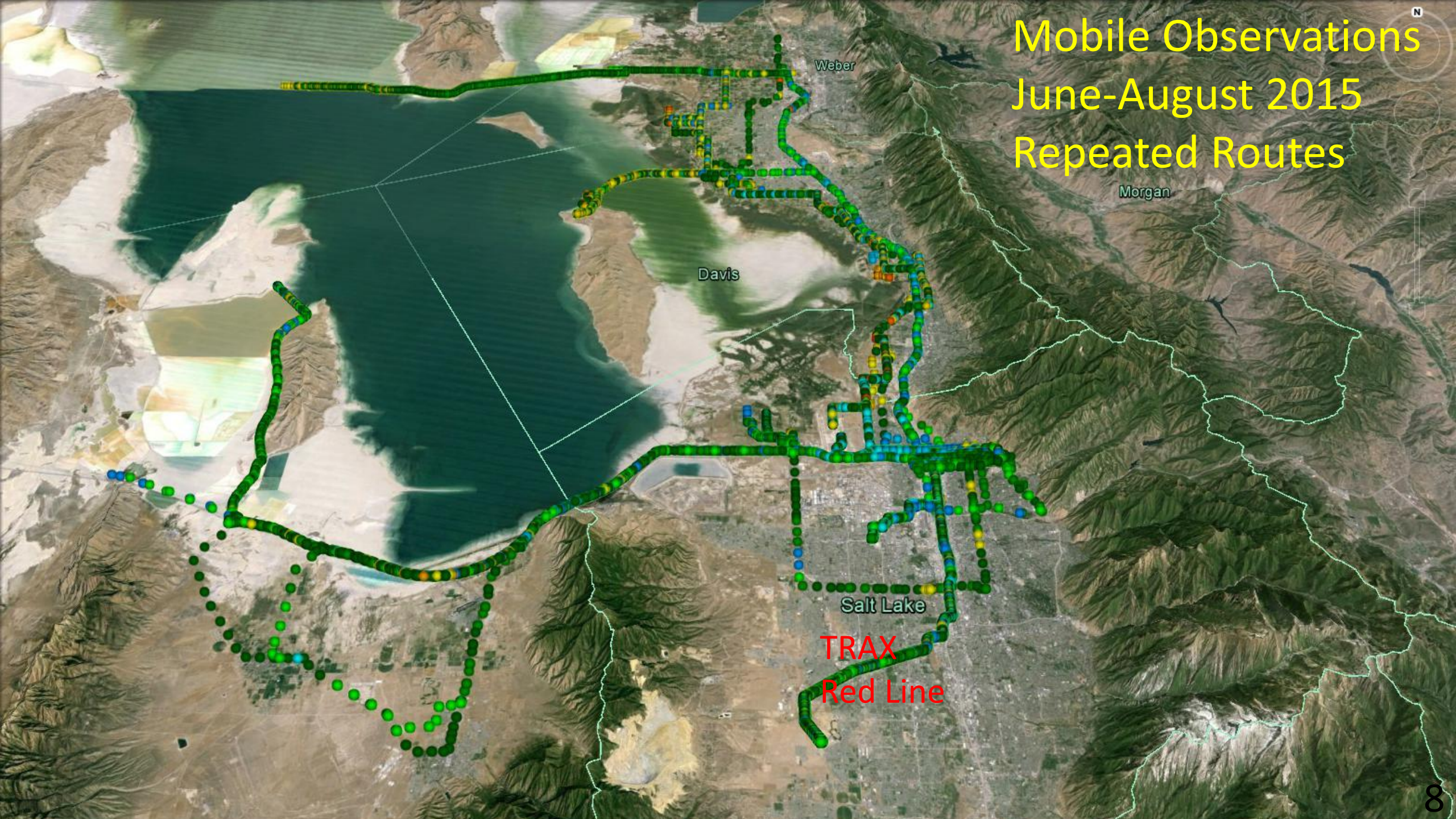

Badger Island

MESOWEST

Mobile Ozone Observations

- Continuous real-time monitoring via instrument deployed on Utah Transit Authority (UTA) TRAX Light Rail Car
- Intermittent deployment of mobile units with real-time cellular communications deployed in vehicles and on KSL-TV “Chopper 5” helicopter



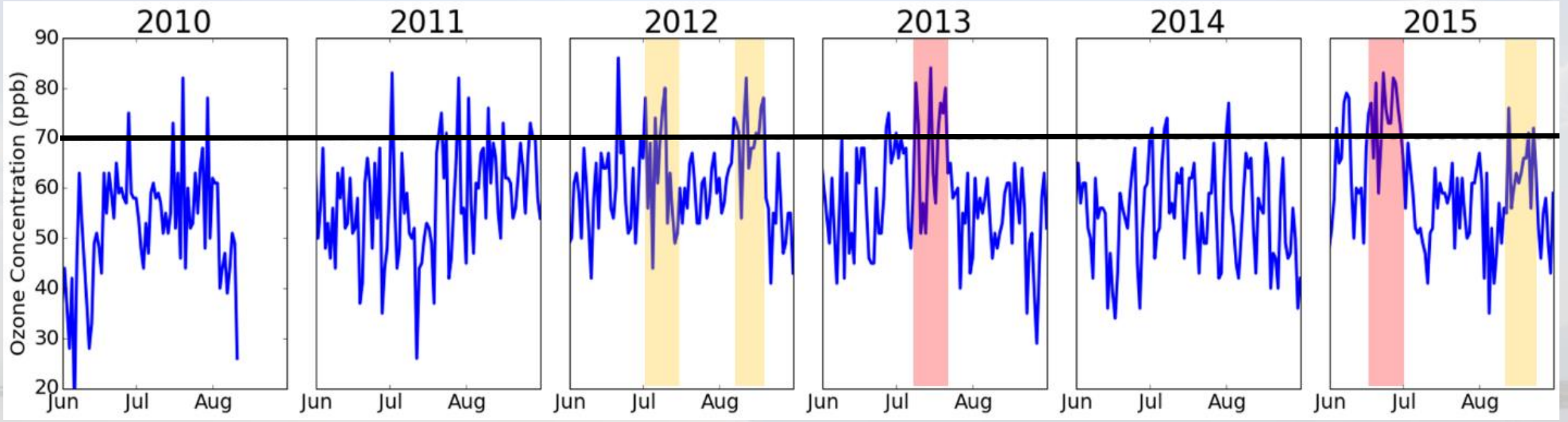

Mobile Observations
June-August 2015
Repeated Routes
Weber
Morgan
Davis
Salt Lake
TRAX
Red Line


Chopper:
Opportunistic
flights
June-August 2015
Davis
Morgan

Real-Time Ozone Processing and Display

- Data collected from logging devices in real-time
- Processed into MesoWest database (fixed sites) or HDF5 (mobile)
- Data synthesized on website: http://meso2.chpc.utah.edu/gslso3s

Daily 8-h Maximum Ozone in Salt Lake Valley (Hawthorne) during summer

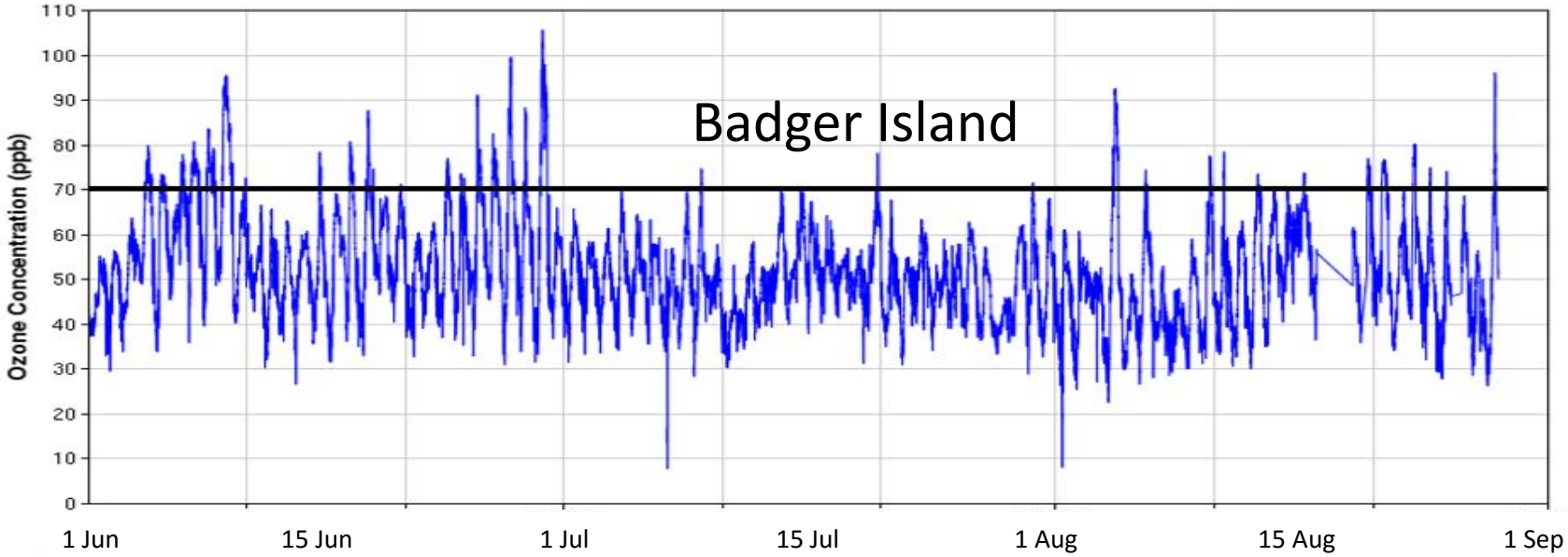


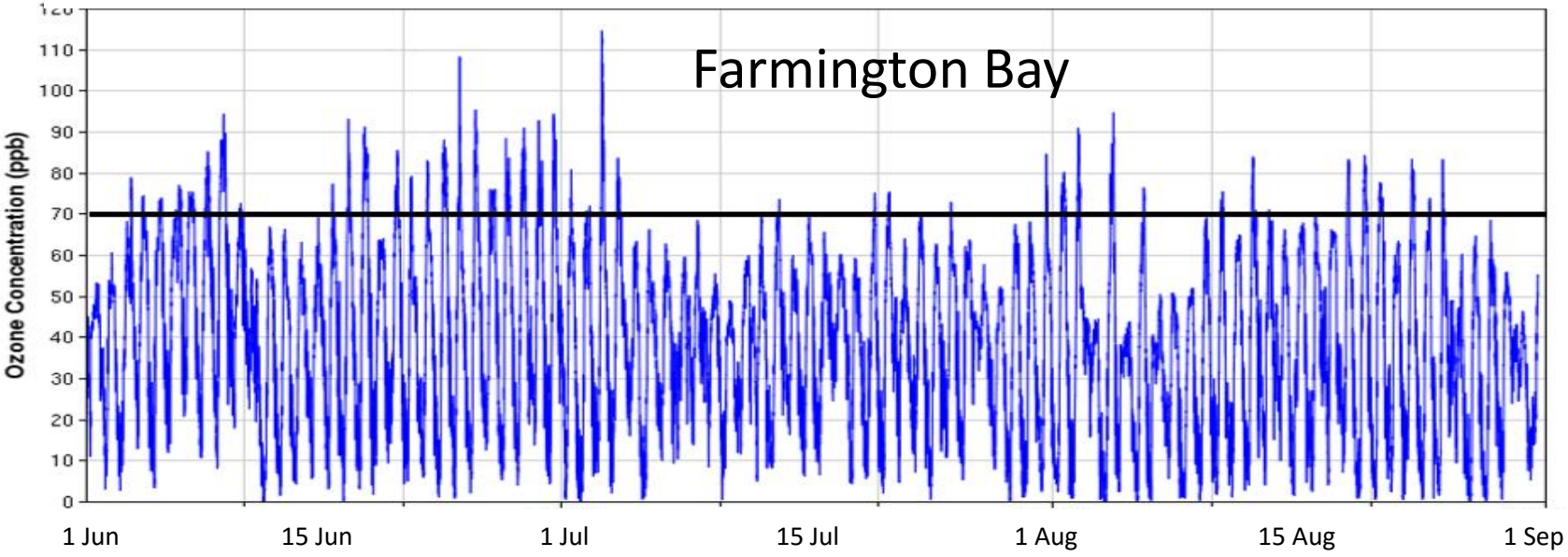
Synoptic Ridge

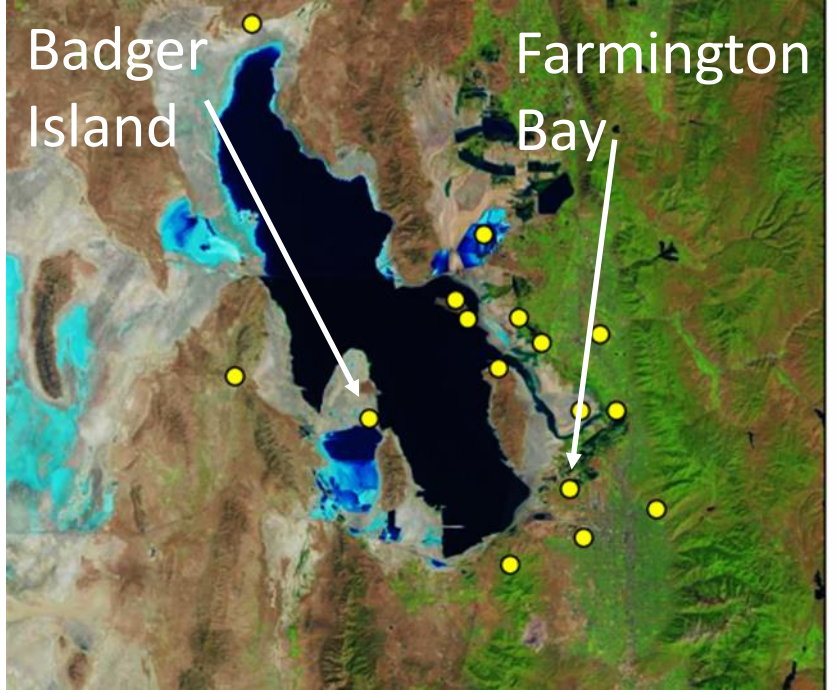
Wildfire Smoke

Station	# 2015 Summer Days > 70 ppb
Farmington Bay	19
Salt Lake Valley (Hawthorne)	18
Badger Island	17
Saltaire	16

In-Situ Observations at 5-min intervals

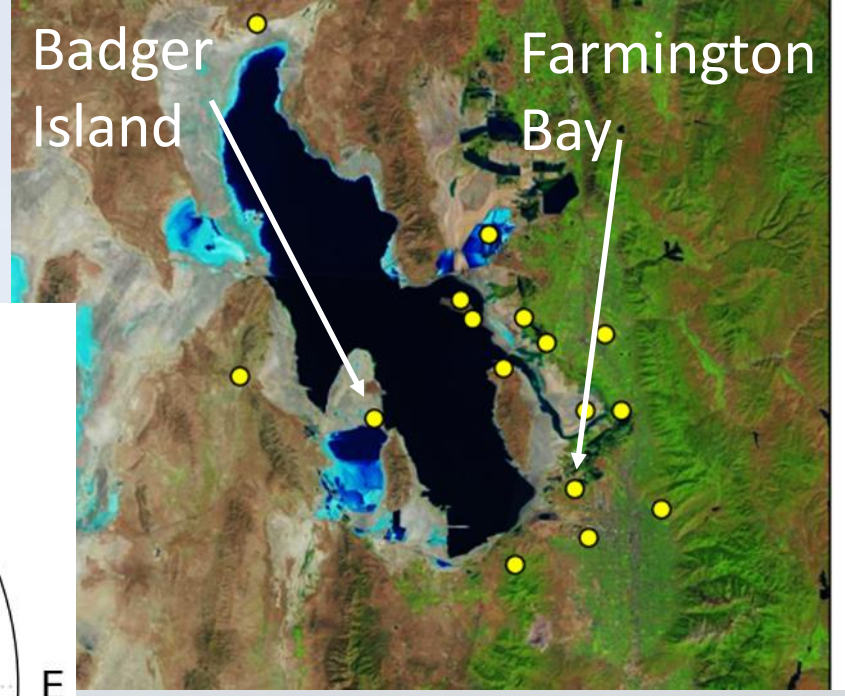




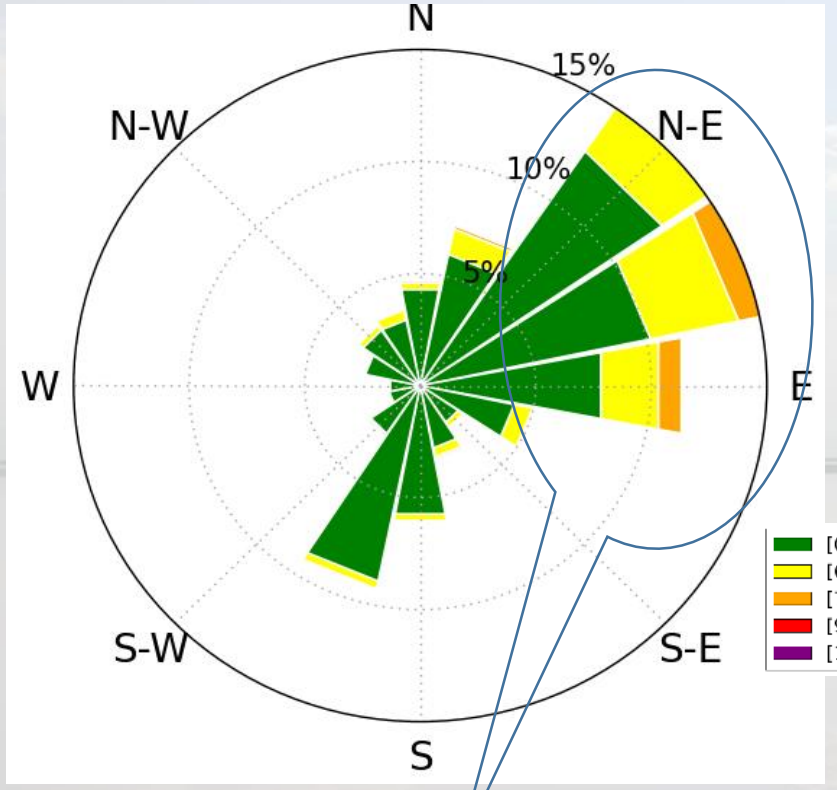


Nocturnal titration reduced at remote Badger Island relative to Farmington Bay located between Lake and urban areas

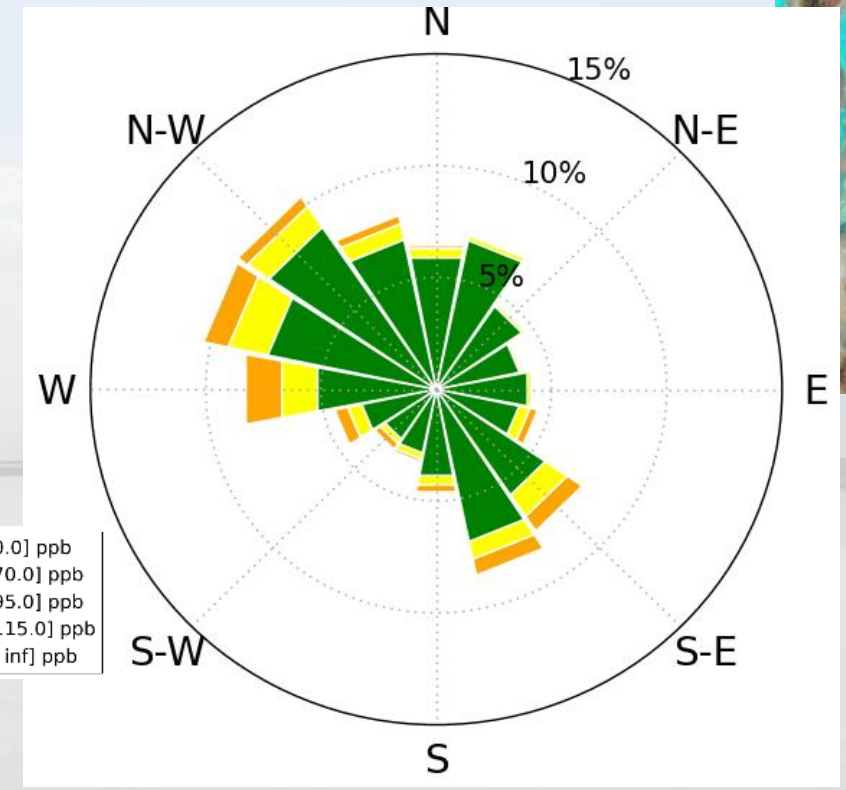
Ozone Roses: 1 June - 31 August

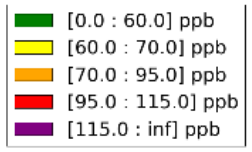


Badger Island



Farmington Bay

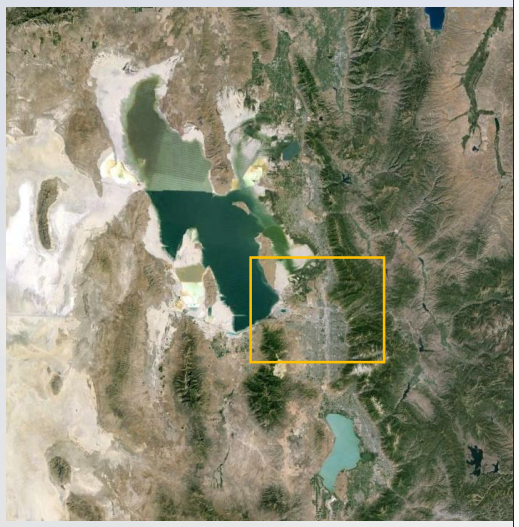


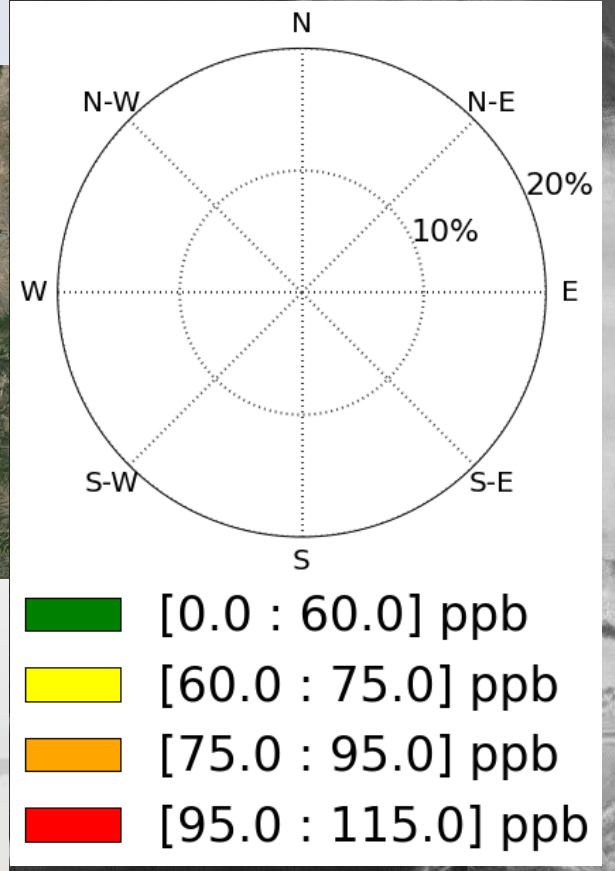


Persistent cross-lake easterly flow

Dominated by nocturnal land breezes and Daytime lake breezes
(replace with daytime only one?)

Ozone Rose




N
N-W
N-E
20%
10%
W
E
S-W
S-E
S
[0.0 : 60.0] ppb
[60.0 : 75.0] ppb
[75.0 : 95.0] ppb
[95.0 : 115.0] ppb

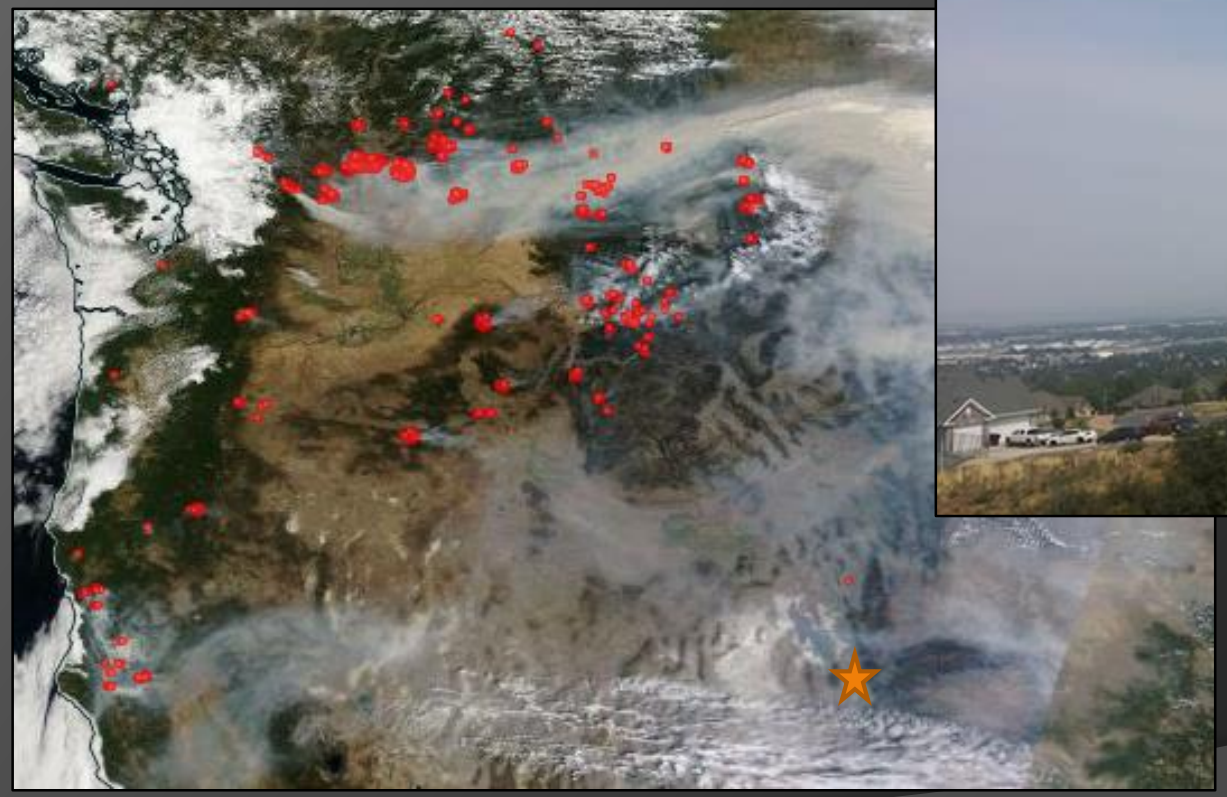
Intensive Observing Periods (IOPs) and Other Periods of Interest

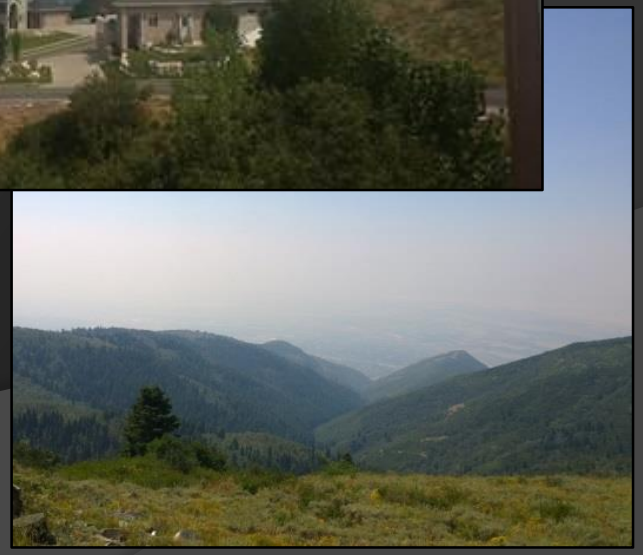
Period	Conditions	Ozone (ppb)	Field Notes
3 June	Evening Thunderstorm	Over 70 ppb at Salt Lake Valley stations	June 3
17 June - 3 July	Ridging & hotter than normal	Peak ozone over 70 ppb somewhere every day	Chopper 5
IOP 1: 17 - 18 June	Strong lake breeze front on 18th	Ozone concentrated along frontal boundary aloft	IOP 1
IOP 2: 15 - 16 July	Well mixed, deep boundary layer up to 550 mb with afternoon convection	Peak concentrations barely exceeding 70 ppb	IOP 2
IOP 3: 10 -12 August	Monsoonal conditions	8 h avg over 70 ppb in Salt Lake Valley	14 August Daily Summary
16 - 24 August	Regional smoke transport	Elevated ozone and PM2.5 concentrations	Smoke Week

Next talk: Brian Blaylock

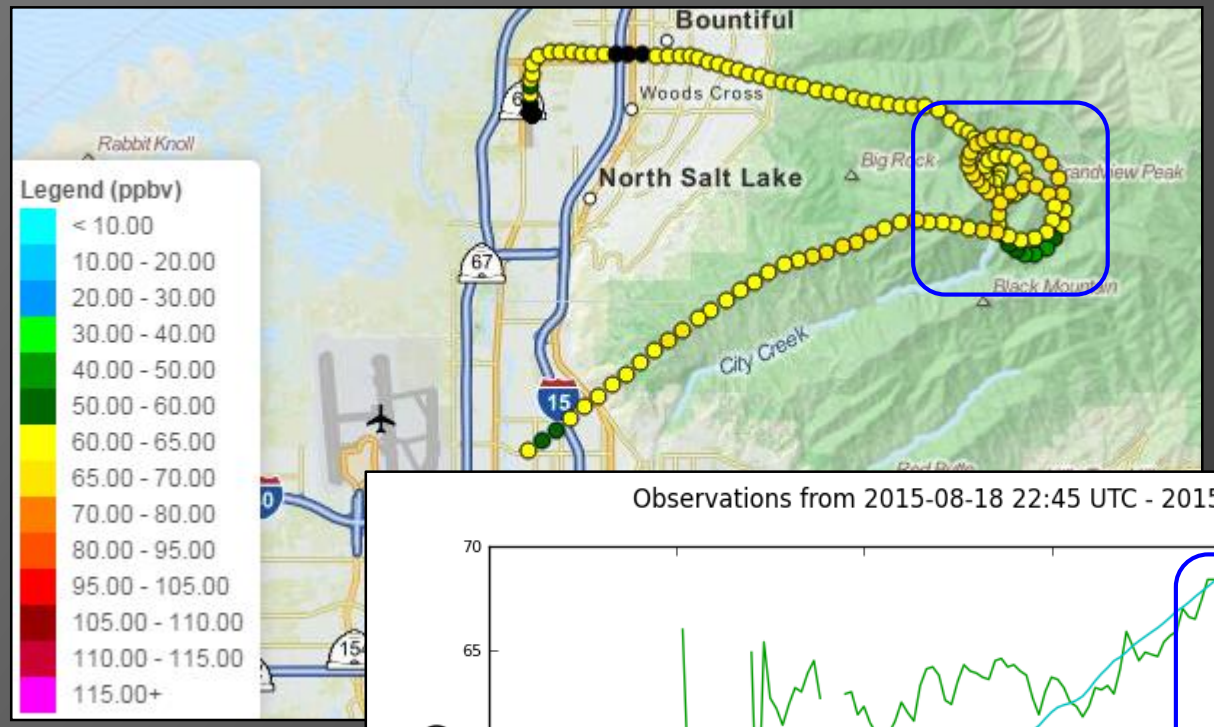
Wasatch Front: Crossroads of the Smoky West

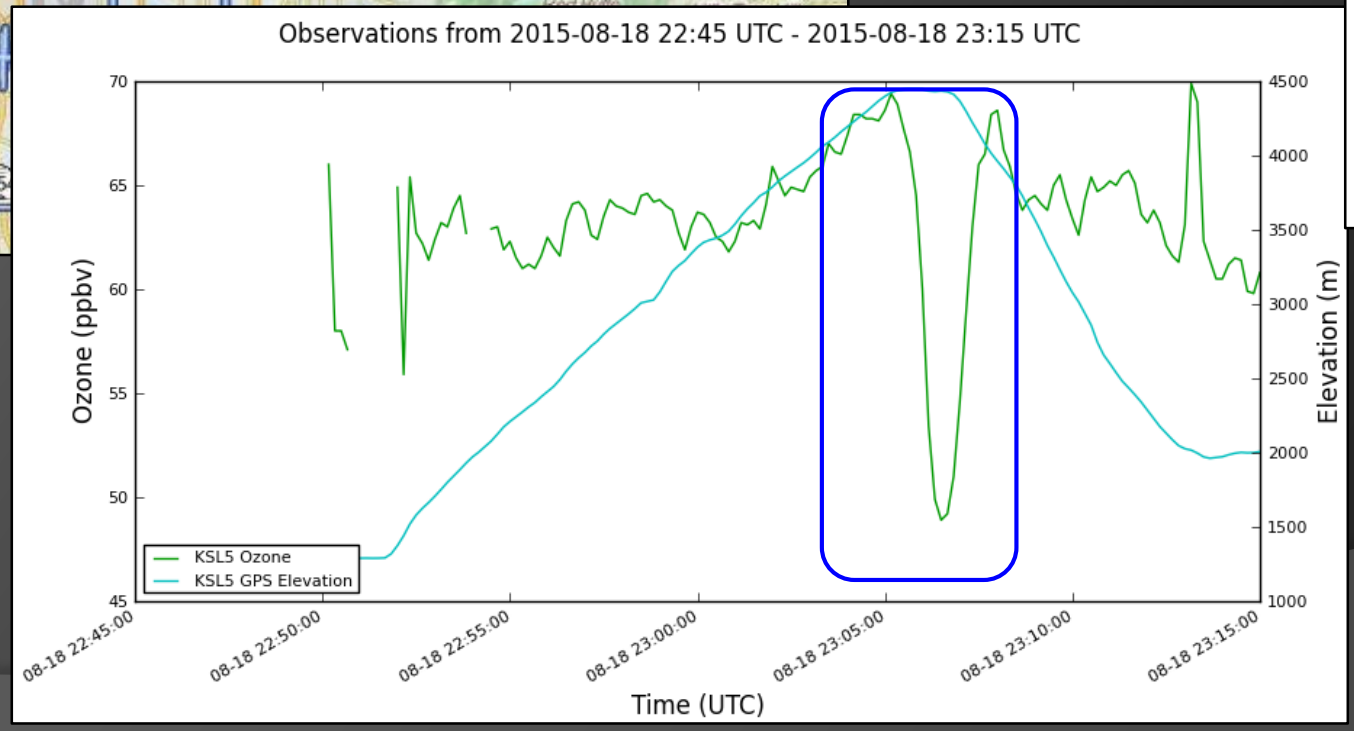
- 15-24 August 2015
- Cessation of summer monsoon; dry NW flow advected smoke from Pacific Northwest and California wildfires
- Elevated ozone and particulate levels obscured visibility

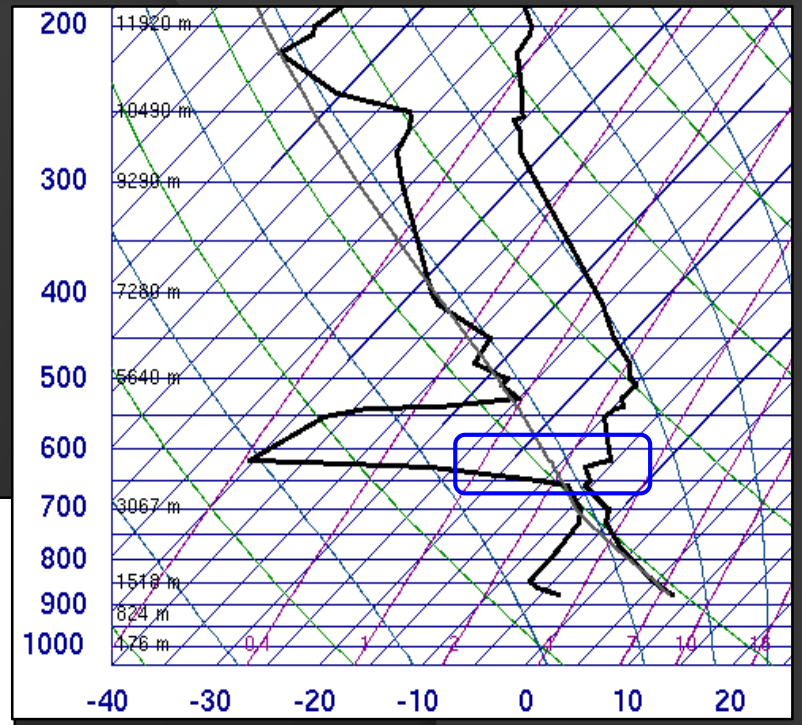




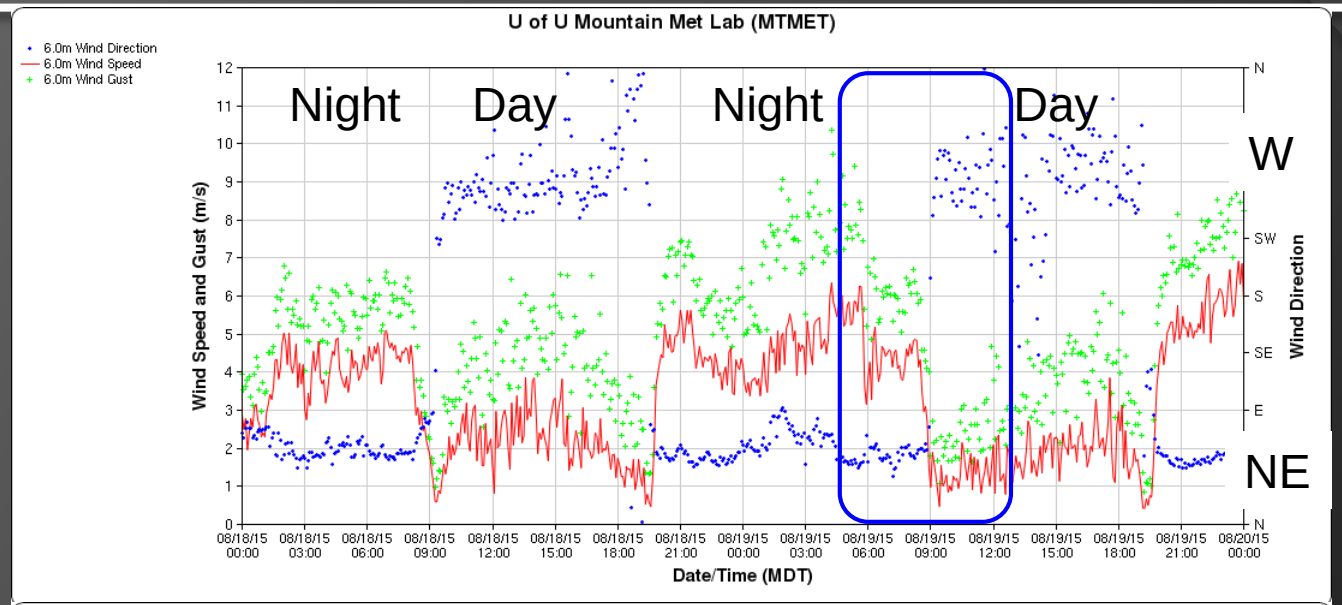
18 August: Chopper 5 asked to fly above smoke in boundary layer

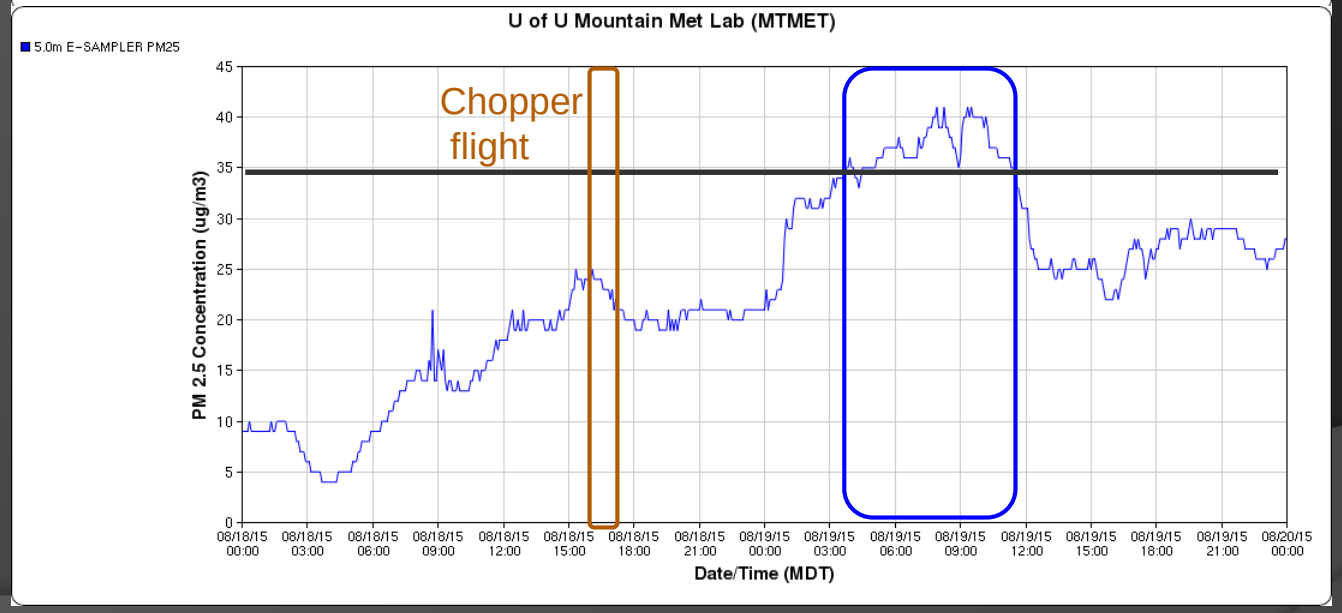






18- 19 August: Conditions on UU Campus on eastern side of Valley





Blue: wind direction
Red: wind speed
Green: peak wind

Blue: PM 2.5

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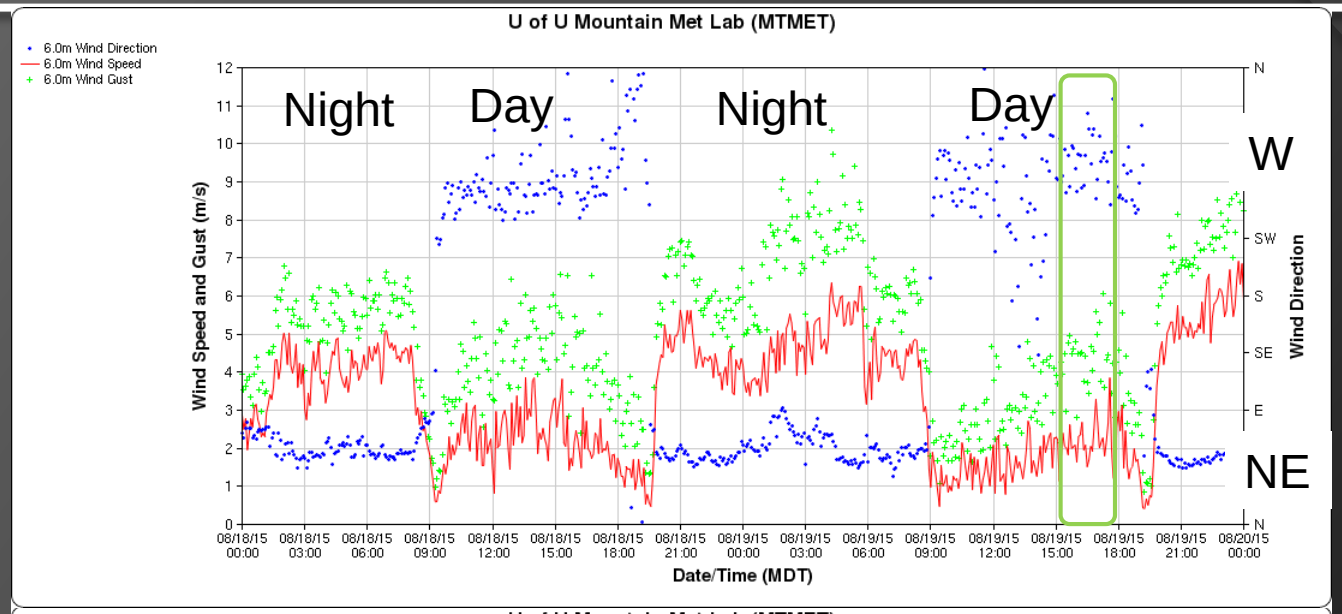

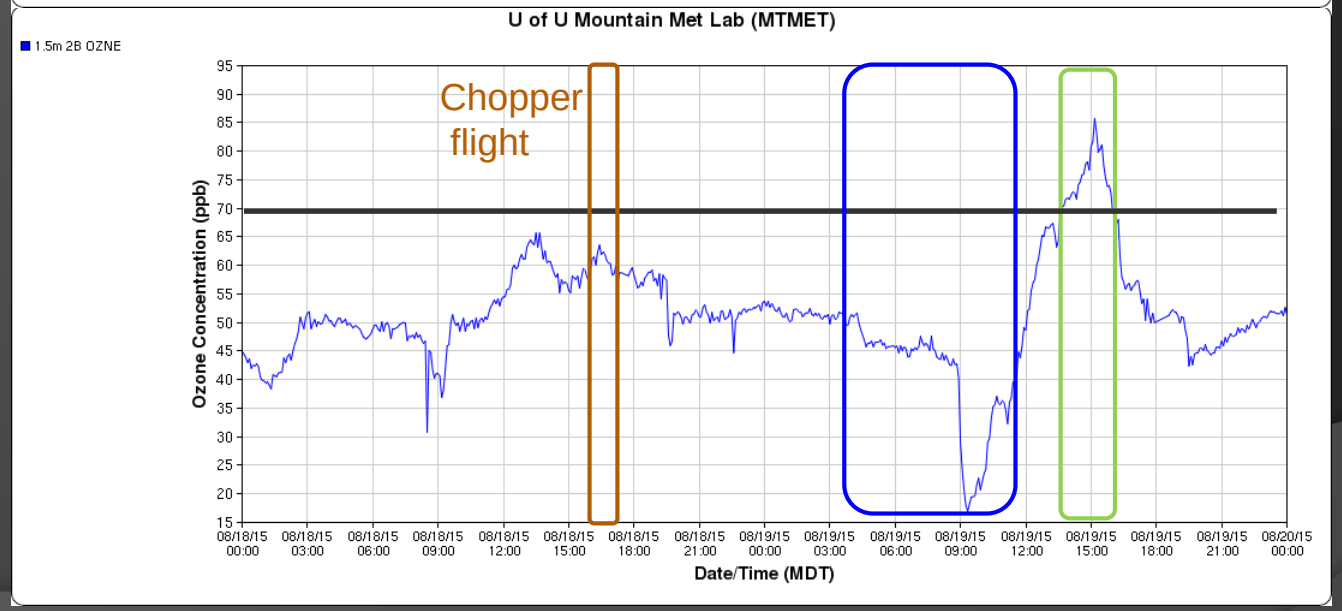

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Ozone: PM 2.5

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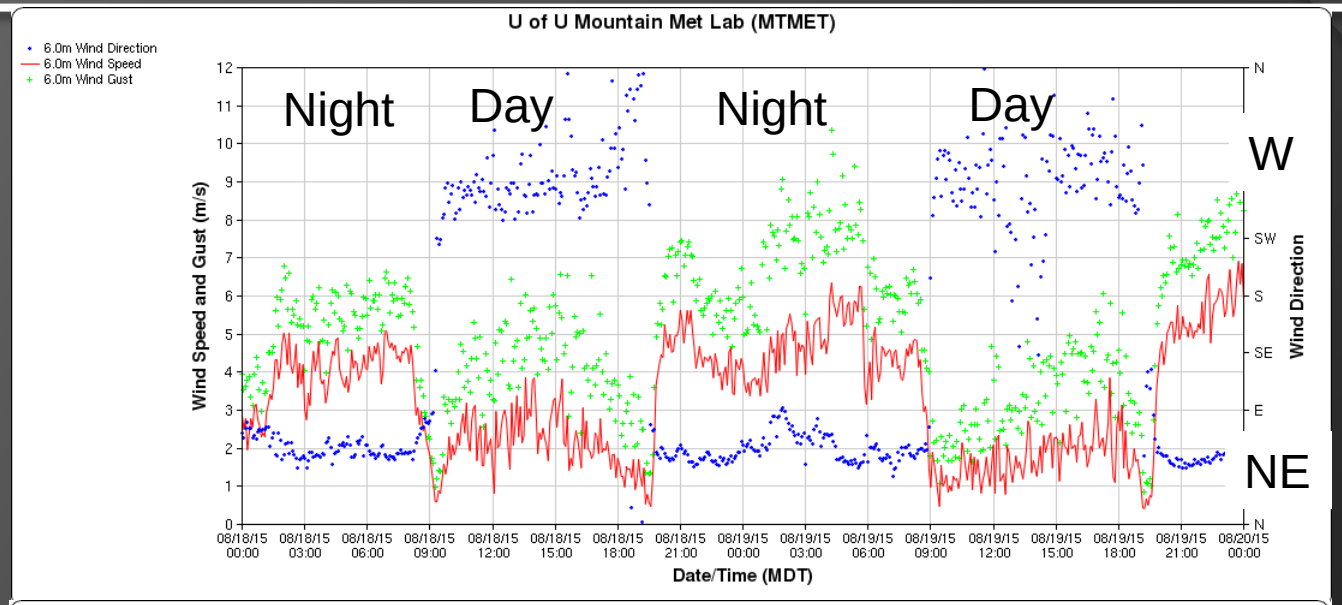

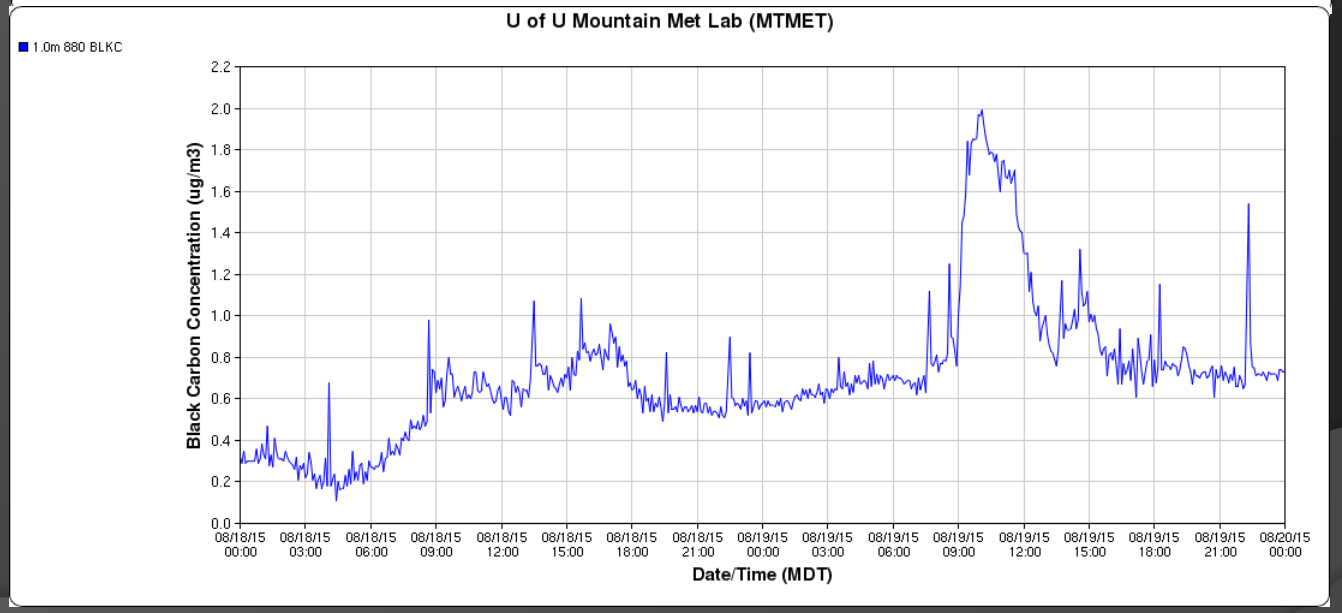

Blue: wind direction
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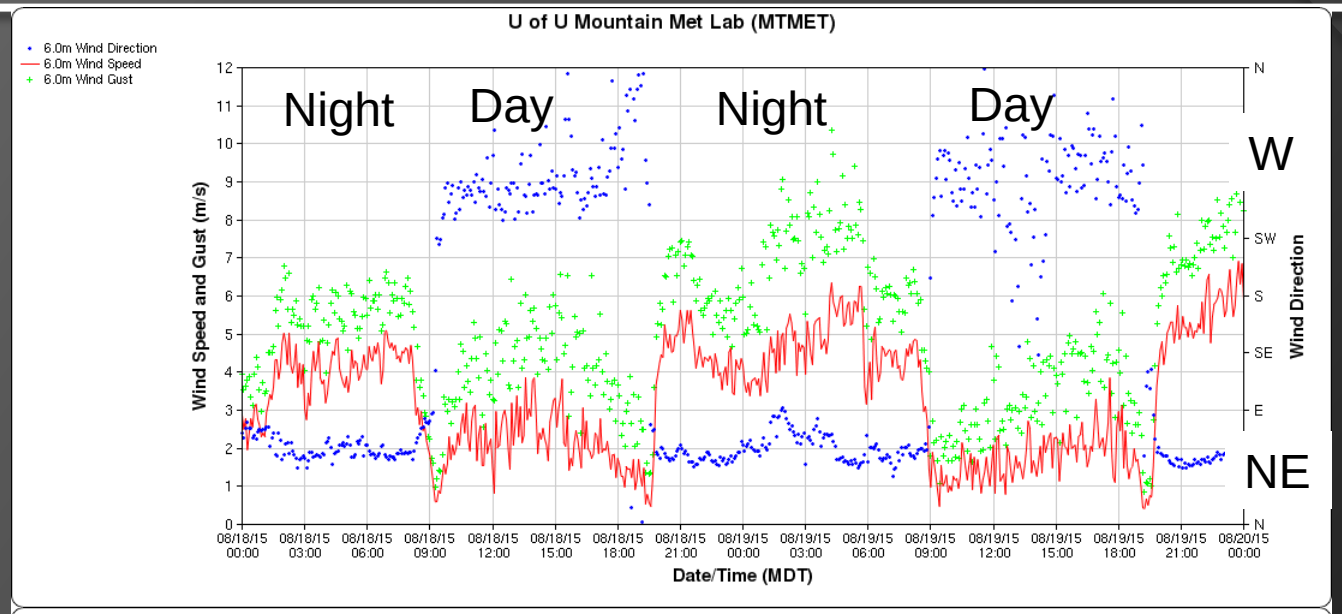
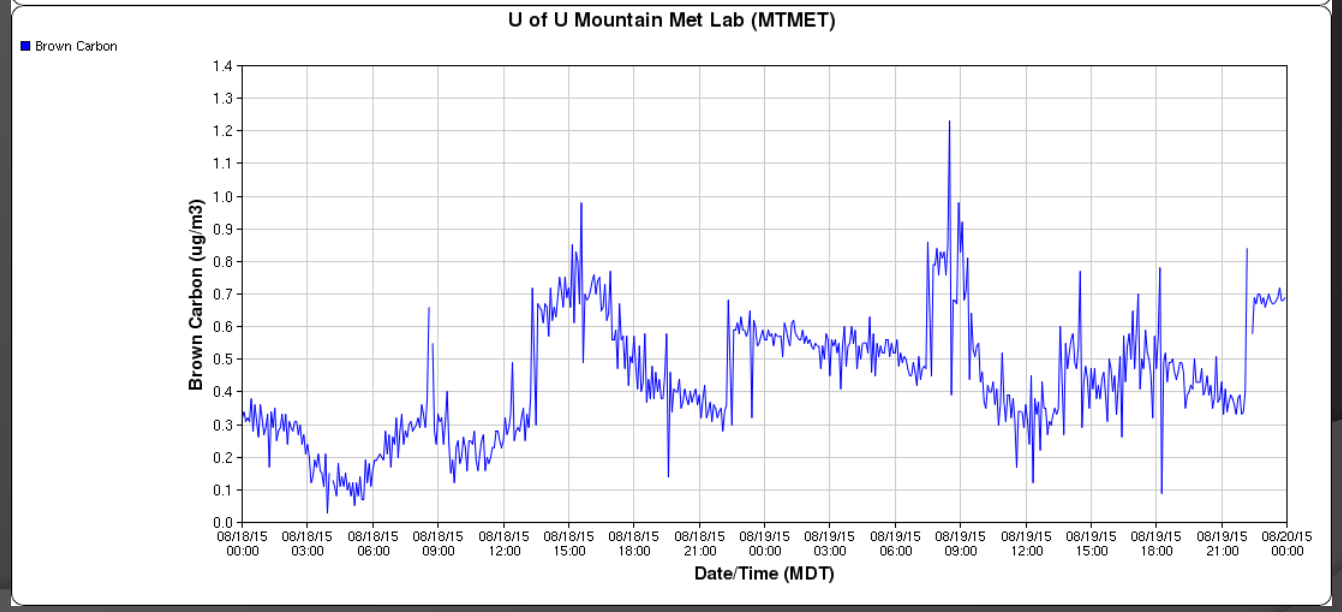
Black Carbon. Aethalometer provided by Sonoma Tech

18- 19 August: Conditions on UU Campus on eastern side of Valley





Blue: wind direction
Red: wind speed
Green: peak wind

Brown Carbon. Aethalometer provided by Sonoma Tech

Summary

- Even though a pilot study, the Great Salt Lake Summer Ozone Study was the most extensive field study ever undertaken related to summer air quality along the Wasatch Front
- We utilized existing infrastructure, temporary deployments, and sensors on diverse mobile platforms
- Real-time data collection and web displays helped us target how to collect the data as well as allow quick-look analyses
- Access the data and preliminary analyses from meso2.chpc.utah.edu/gslso3s/

Incompletely answered issues and questions

- Wet spring on low-lying and hillside vegetation possibly leading to generation of biogenic ozone precursors
- Early season shallow lake thermocline leading to shallow Lake boundary layer and higher ozone
- Why were the highest ozone concentrations near the margins of the Lake rather than further offshore?
- What was the influence of enhanced albedo from the exposed salt flats on ozone formation?
- What are the direct and secondary roles of the Great Salt Lake on ozone production including chlorine chemistry?
- How does the intensity and duration of nocturnal titration along the shores of the Great Salt Lake depend on other pollutants (NOX, etc.)?
- How are the ozone concentrations affected by the relative strength, intensity, and timing of land and lake breezes compared to those of concurrent mesoscale and synoptic-scale circulations?
- What are the impact of canyon flows and other terrain-circulations on ozone and precursor transport along the Wasatch Front?
- To what extent did the regional transport of wildfire smoke and its impacts on particulate concentrations affect ozone production?

Acknowledgements

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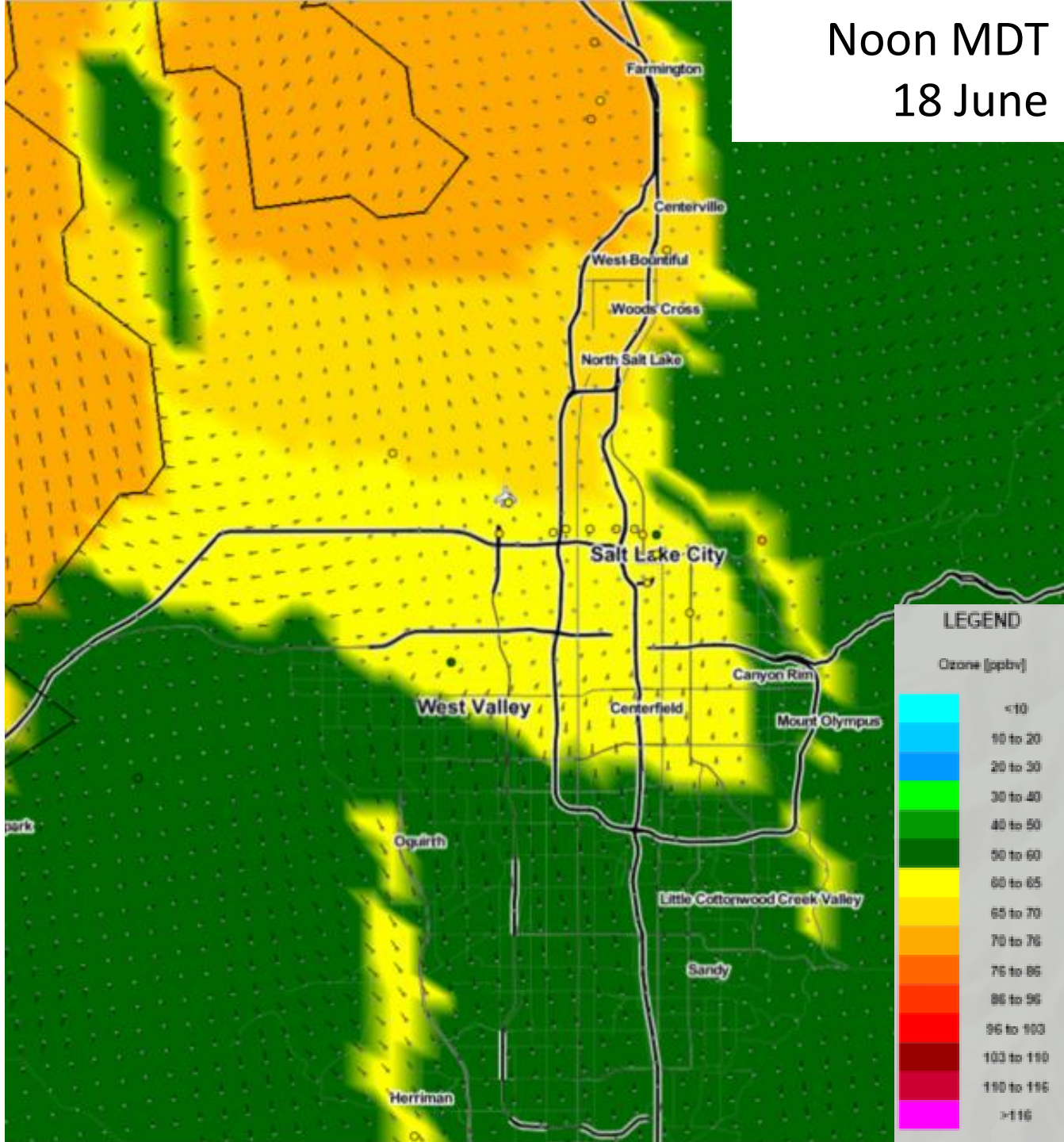
Field study participants:

- **UofU:** 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
- **USU:** Randy Martin and group
- **WSU:** John Sohl and group

Objective analyses of ozone and wind near the surface: 18 June. *Impact of lake breeze*

- Case discussed further in the next talk by Brian Blaylock
- Here: 1 km horizontal resolution surface analyses of ozone and vector wind



Objective analyses of ozone and wind near the surface: 18 June. Impact of lake breeze

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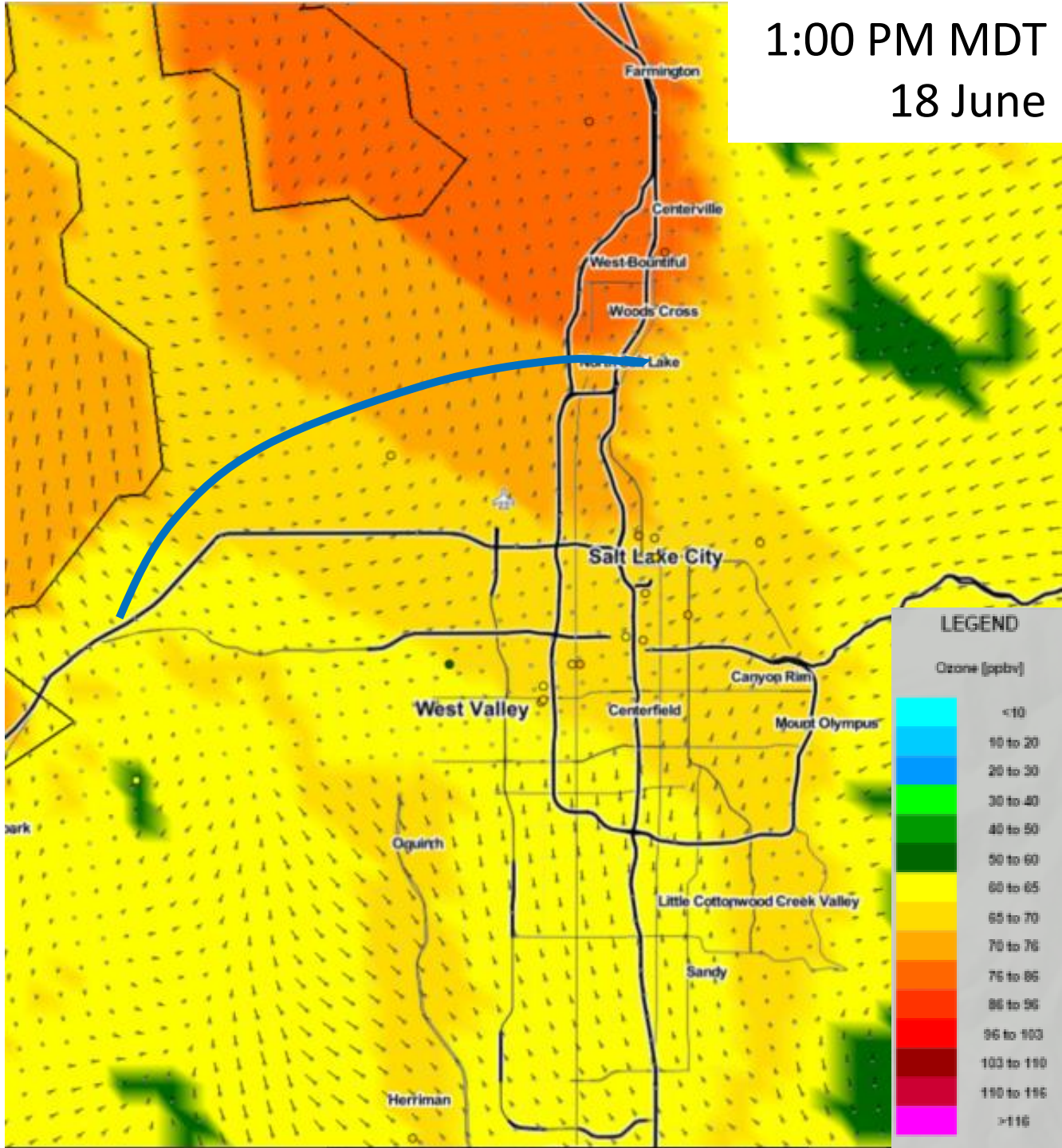

Objective analyses of ozone and wind near the surface: 18 June. Impact of lake breeze

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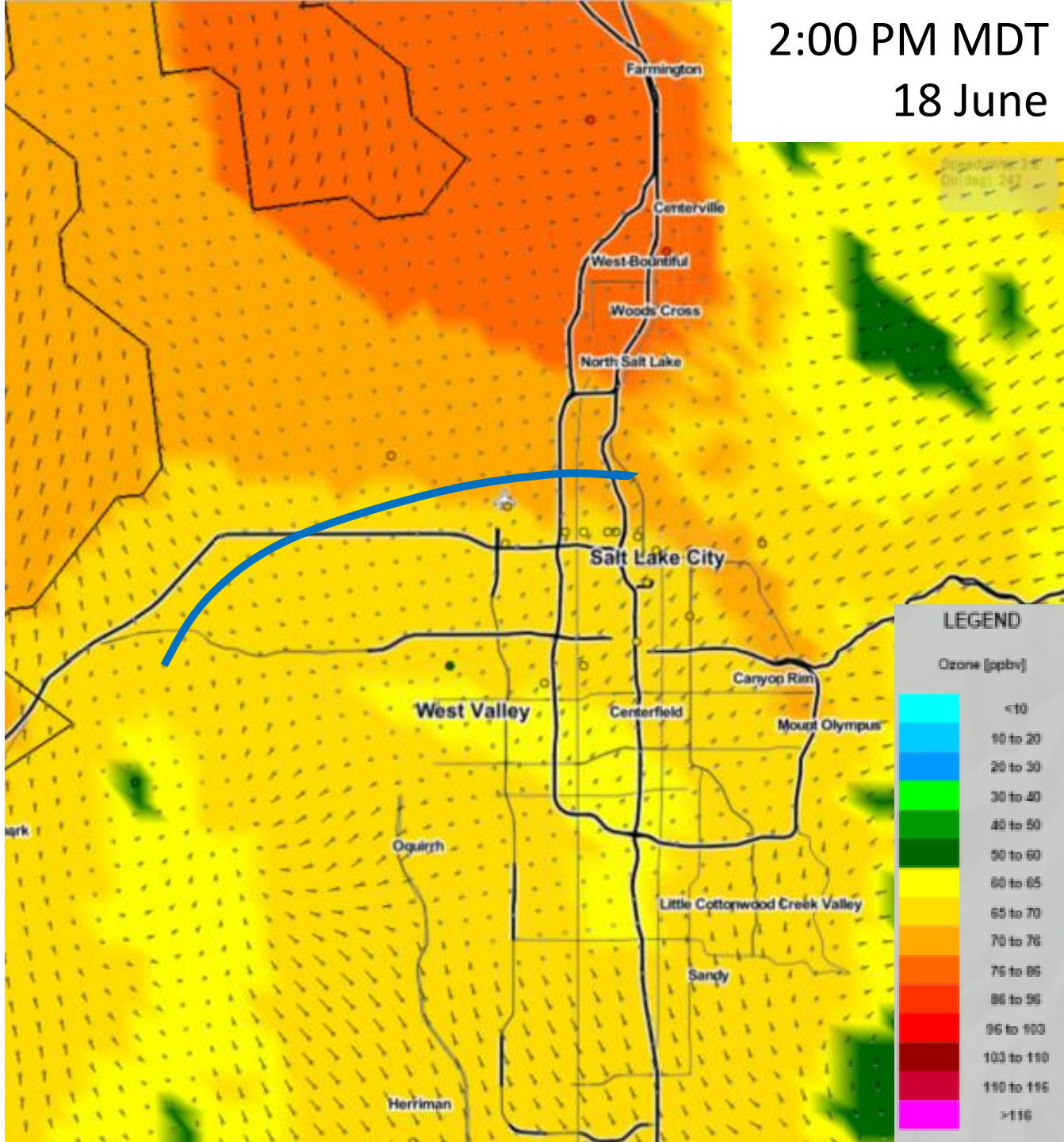

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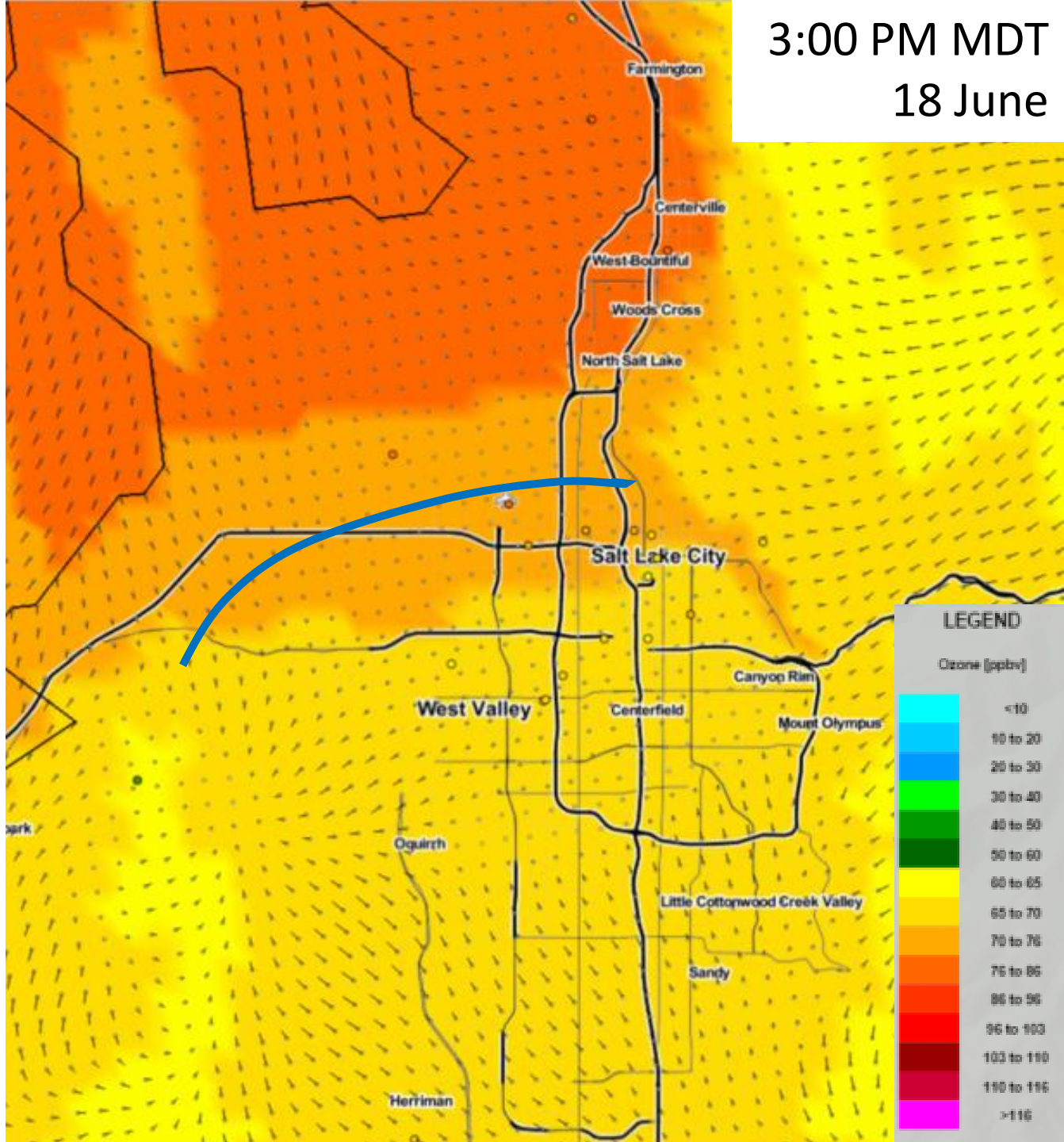

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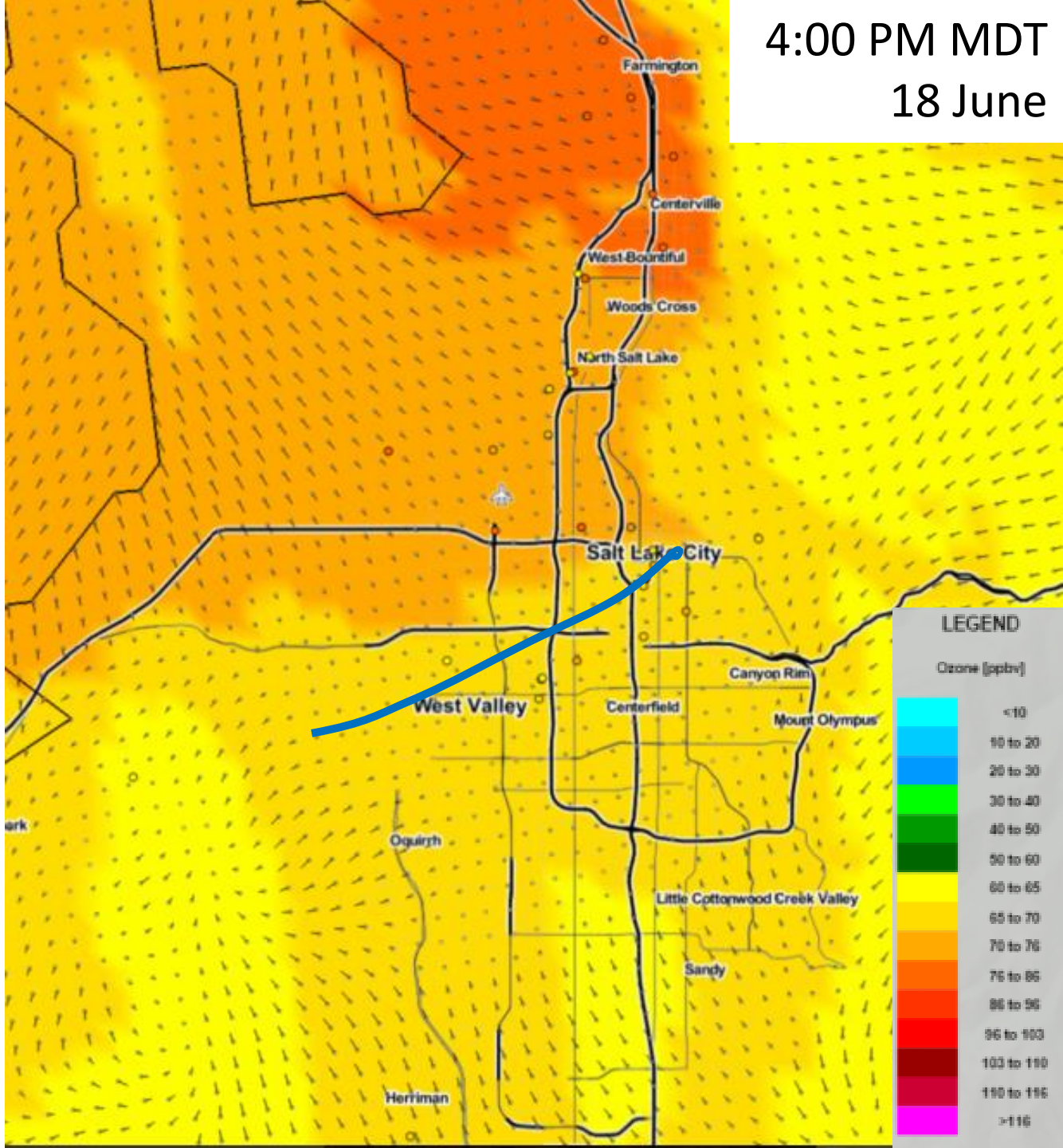

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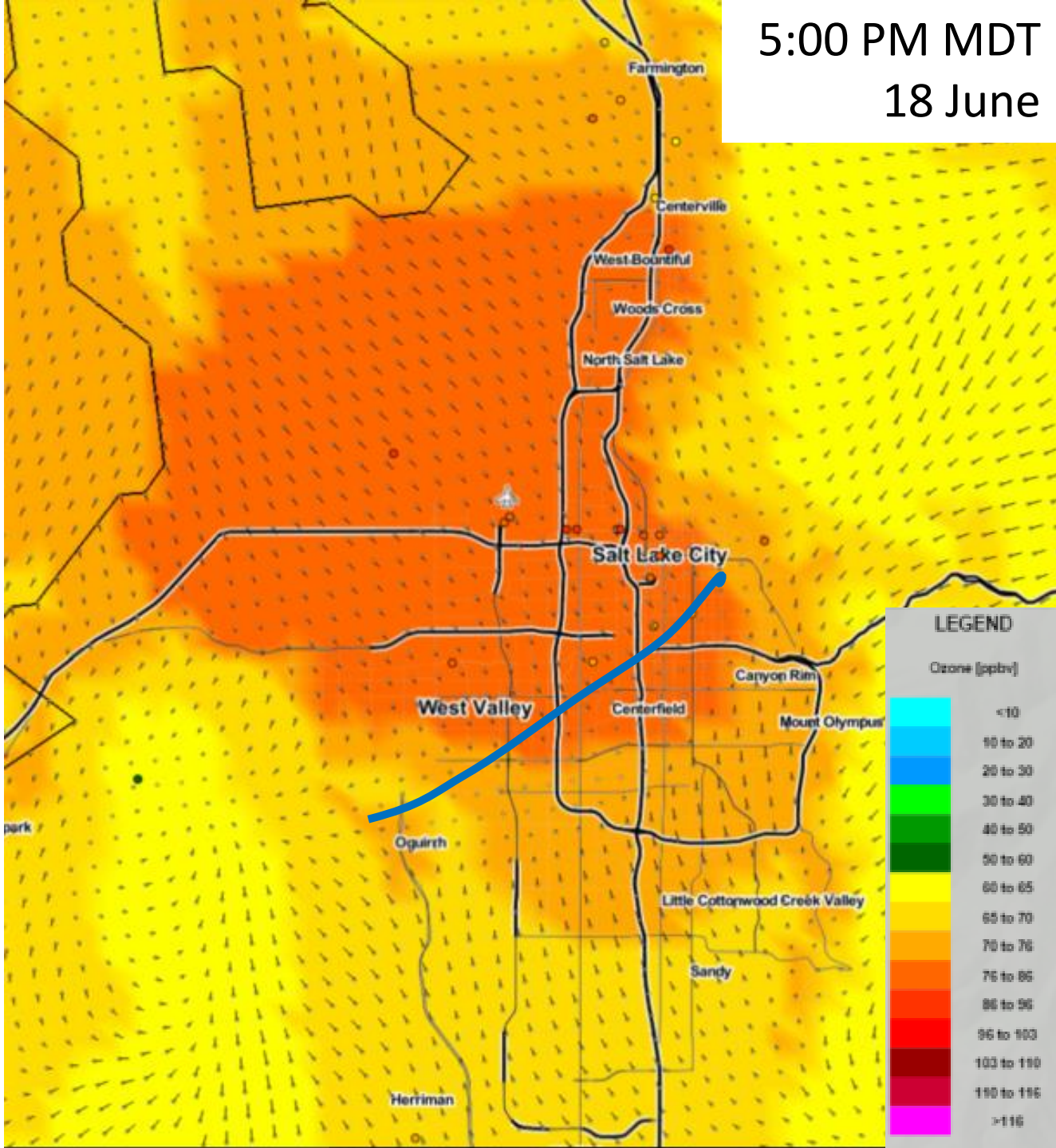

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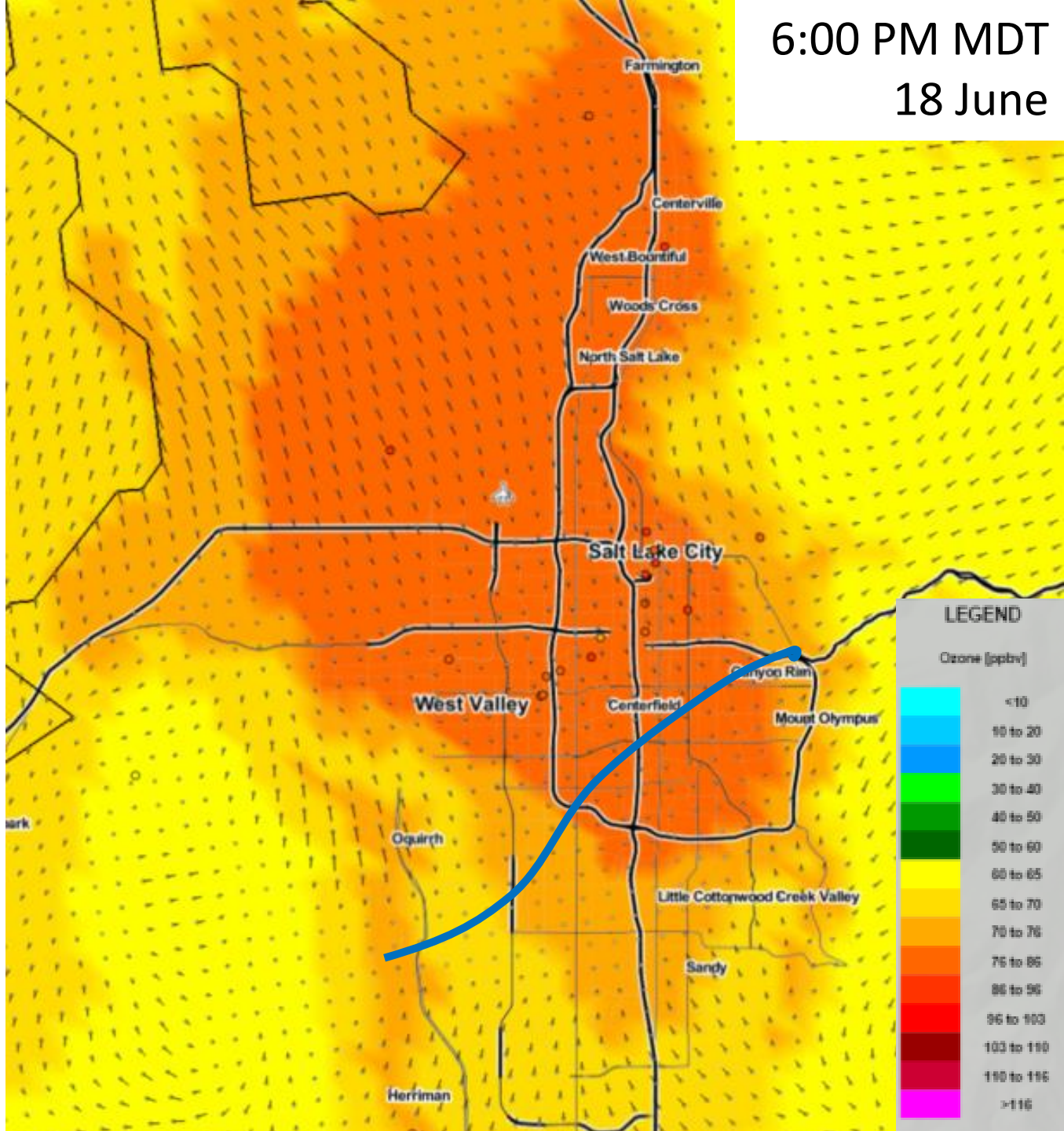

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