The Great Salt Lake Summer Ozone Study

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Seth Arens, Utah Division of Air Quality; Randy Martin, Utah State University and John Sohl, Weber State University
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

<table>
<thead>
<tr>
<th>Instruments</th>
<th>Resource</th>
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</thead>
<tbody>
<tr>
<td>DAQ Fixed Site Ozone Monitors</td>
<td>DAQ Ozone Monitors - part of regular monitoring network</td>
</tr>
<tr>
<td>Temporary Fixed Site Ozone Monitors</td>
<td>DAQ and UofU temporary deployments, some adjacent to existing UofU weather stations and available in real-time</td>
</tr>
<tr>
<td>Weather Observations</td>
<td>MesoWest <a href="http://mesowest.utah.edu">http://mesowest.utah.edu</a></td>
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<tr>
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<td>MesoWest API <a href="http://mesowest.org/api">http://mesowest.org/api</a></td>
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<tr>
<td>Mobile Ozone Observations</td>
<td>UTA TRAX Light Rail Car (continuous)</td>
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<td>KSL-TV “Chopper” 5 (often late afternoon)</td>
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<td></td>
<td>UofU Nerdmobile (IOPs)</td>
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<td></td>
<td>UofU Additional Vehicles (IOPs)</td>
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<tr>
<td>Boundary Layer Air Quality Observations</td>
<td>USU UAV</td>
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<td>WSU Tethersonde</td>
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<tr>
<td>Boundary Layer Remote Sensing</td>
<td>UofU Sodars, Lidar, and Ceilometers</td>
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</table>
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
Chopper: Opportunistic flights
June-August 2015
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](http://meso2.chpc.utah.edu/gslso3s)
Daily 8-h Maximum Ozone in Salt Lake Valley (Hawthorne) during summer

Synoptic Ridge

Wildfire Smoke

<table>
<thead>
<tr>
<th>Station</th>
<th># 2015 Summer Days &gt; 70 ppb</th>
</tr>
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<tbody>
<tr>
<td>Farmington Bay</td>
<td>19</td>
</tr>
<tr>
<td>Salt Lake Valley (Hawthorne)</td>
<td>18</td>
</tr>
<tr>
<td>Badger Island</td>
<td>17</td>
</tr>
<tr>
<td>Saltaire</td>
<td>16</td>
</tr>
</tbody>
</table>
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

Persistent cross-lake easterly flow

Dominated by nocturnal land breezes and Daytime lake breezes
(replace with daytime only one?)
## Intensive Observing Periods (IOPs) and Other Periods of Interest

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

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

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

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

Ozone: PM 2.5
18-19 August: Conditions on UU Campus on eastern side of Valley

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

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

Funding provided by the Utah Division of Air Quality

Field study participants:
• **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

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

- Case
Objective analyses of ozone and wind near the surface: 18 June.

Impact of lake breeze

• Case
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

• Case

5:00 PM MDT
18 June
Objective analyses of ozone and wind near the surface: 18 June. Impact of lake breeze

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• Case