The Shrinking Great Salt Lake May Exacerbate Droughts by Reducing Local Precipitation: A Case Study

Wei Zhang\textsuperscript{1,2,3}, Hongping Gu\textsuperscript{3} and Robert Gillies\textsuperscript{1,3}

\textsuperscript{1}Department of Plants, Soils and Climate, Utah State University
\textsuperscript{2}Ecology Center, Utah State University
\textsuperscript{3}Utah Climate Center, Utah State University
There is a sharp decrease in the areal extent of the Great Salt Lake (1987 vs 2022).
The changing land use land cover within and surrounding the Great Salt Lake

From Ratterman etc.
Question: Weather, the extent to which and how the changing water body of the Great Salt Lake would affect local precipitation?
During 1998–2009, lake-effect precipitation in the Great Salt Lake accounts for up to 8.4% of the total cool-season precipitation in the Great Salt Lake basin, with the largest contribution to the south and east of the Great Salt Lake. Yeager et al., 2013

The GSL could increase precipitation averaged over its downwind area from October 2001 to April 2002 by 3.2%. Wen, 2015
Methodology

• Weather Research and Forecasting (WRF) Model coupled with the Lake Module (WRF-Lake; Gu et al. 2015)
• Initial and boundary forcing (North American Regional Reanalysis-NARR)
• Three nested domains (~1km for the inner domain)
• Ensemble runs (initial dates and parameterization schemes)
We selected an extreme precipitation event on 6 June 2007.
WRF-Lake outperforms WRF in reproducing observed temperature in the Great Salt Lake.
Five scenarios were designed:

100% (a; as of 2004 in USGS data)
75% (b)
50% (c)
25% (d)
0% (e; completely dry)
WRF_Lake can reasonably reproduce observed precipitation for the selected case.
The simulate results are consistent across different initial time.
Overall, the results are consistent across different parameterization schemes, such as microphysics, boundary layer physics, and radiation.
A reduced lake extent would dramatically reduce downwind precipitation.
The results strongly supported a linear decrease in precipitation associated with this precipitation event corresponding to a reduced lake water extent, with an average decrease of 4.7 mm for every 25% reduction in the lake extent.
This decrease in precipitation is principally attributed to a diminished water vapor flux and moist static energy (MSE) above the lake.
Conclusions

• We utilized the Weather Research and Forecasting model version 4.2 coupled with a lake model to simulate a series of high-resolution numerical experiments; these experiments aimed to assess the effect of varying lake areal extents on a storm event that occurred on June 6, 2007.

• The results revealed a systematic decline in the quantity of precipitation over the GSL and downwind regions with declining areal coverage. In the event of complete disappearance, the regional average precipitation would experience an approximate 50% reduction relative to its 2004 base lake extent.

• The research underscores the consequences of a shrinking GSL, not just for precipitation delivery downstream but that of a negative feedback loop within the hydroclimatic system of the GSL basin, i.e., water flow reductions into the basin.
Questions?
Hongping.gu@usu.edu
Thanks for your attention!

Table 1. Key lake physical parameters and their values used in the WRF-Lake experiments.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Units</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of liquid water</td>
<td>Kg m^{-3}</td>
<td>$1.0 \times 10^3$</td>
</tr>
<tr>
<td>Emissivity of the water surface</td>
<td>-</td>
<td>0.97</td>
</tr>
<tr>
<td>Specific heat of water</td>
<td>J kg^{-1} K^{-1}</td>
<td>$4.188 \times 10^3$</td>
</tr>
<tr>
<td>Latent heat of evaporation for water</td>
<td>J kg^{-1}</td>
<td>$2.501 \times 10^6$</td>
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<tr>
<td>Thermal conductivity of water</td>
<td>W m^{-1} K^{-1}</td>
<td>0.6</td>
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<tr>
<td>Molecular diffusion coefficient for water</td>
<td>m^2 s^{-1}</td>
<td>$4.188 \times 10^6$</td>
</tr>
<tr>
<td>Stefan-Boltzmann constant</td>
<td>W m^{-2} K^{-4}</td>
<td>$5.67 \times 10^{-8}$</td>
</tr>
<tr>
<td>Water layers</td>
<td></td>
<td>10</td>
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