Effects of the Great Salt Lake’s Temperature and Size on the Regional Precipitation in the WRF Model

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Introduction

- Great Salt Lake is largest endorheic lake in Western Hemisphere
- Size varied 71% (2,460-8,500 km²) during past 50 years
- Size, surface temperature and salinity typically not represented well in operational forecast models
- Our study
  - Varies lake size for case study sensitivity comparisons
  - Calculates MODIS lake surface temperatures similar to Knievel et al. (2010).
Great Salt Lake Area Topography & Bathymetry (m AMSL)

- 1272.5 meters above sea level
- 1275.0 meters above sea level
- 1277.5 meters (Historic Low 1964)
- 1279.5 meters (Current 2012)
- 1282.5 meters
- 1283.7 meters (Historic High 1985)

USGS Buoy

[Map of Great Salt Lake with bathymetric data]
WRF Simulations with Varying Lake Size

Model Setup

- 4 Domains
  - 1.1 km for d04
- Same Physics Options as Colorado Headwaters Project
  - Microphysicics: Thompson 7-Class
  - RRTM Longwave Radiation
  - Dudhia Shortwave Radiation
  - Monin-Obukhov Surface Layer
  - Noah Land-Surface
  - YSU PBL
- Two Simulations
  - **Big Lake**: 1986 Lake Size: **8500 km²**
  - **Small Lake**: 1964 Lake Size: **2460 km²**
Observed Salt Lake City Radar Analysis

Radar Data Missing During Early Portion of the Period

Before Cold Frontal Passage
Lake Enhanced Snow

Shortly After Cold Frontal Passage
Switching to Wind Parallel Bands

Later with Wind Shift to NWerly Shore Parallel Band
WRF Model Domain 4 Base-Level Reflectivity and 10-m AGL Streamlines

Lake Enhanced Snow

Wind Parallel Bands

Shore Parallel Band

WRF Simulation with Great Salt Lake at Historic Low Level: 1277.5 m

small lake

1300 UTC 27 November 2006

WRF Simulation with Great Salt Lake at Historic High Level: 1283.7 m

big lake

0500 UTC 28 November 2006

0600 UTC 29 November 2006

NCAR

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Previous “SST” Results from NASA NYC Project

- Operational Real-Time Global (RTG)
- Continuous Coverage from Satellite & In-Situ
- Coarse Effective Resolution (~100 km)

- MODIS 12-day Composite for NASA NYC
- Nearly-Continuous Coverage from MODIS Only (holes filled with RTG)
- Fine Resolution (~10 km)
- Showed greatest skill in shallow near-shore locations
• Most of Great Salt Lake is Shallow and Close to Shore 😊
• How Do MODIS “SSTs” Perform for GSL?
• Most operational models (e.g., NAM) use climatology for GSL temperature
• We want to perform a more in-depth analysis to see if we can make an improvement over climatology
NASA SST Product Availability for the Great Salt Lake

GSL MODIS LST Retrieval Frequency 2006-2010

Data void in summer and winter
Must Create Our Own Great Salt Lake Water Temperature Product

QCed Land Surface Temperature Plots over GSL for 12 Days

27 Jan  28 Jan  29 Jan  30 Jan
31 Jan  01 Feb  02 Feb  03 Feb
04 Feb  05 Feb  06 Feb  07 Feb

Temperature (°C)
Processing Steps

1. Quality Control from Concurrent Fields
   • Sky Cover
   • QC Parameter
   • 11 µm Emissivity
   • 12 µm Emissivity
   • Viewing Angle

2. Quality Control from Other Satellite Overpasses
   • Intraday Comparisons (Terra vs. Aqua)
   • Day-to-Day Temperature Comparisons

3. Bias Correct from Comparisons with Buoy

4. Determination of Optimal # of Days for Temporal Composite
   • Availability %
   • Minimize Errors vs. Buoy Observations

5. Fill in Remaining Spatial Gaps with Nearest Neighbor Technique
Fill in Spatial Gaps Using Nearest Valid Pixel

99.7% Availability for 2010-2011

Mean Absolute Difference vs. Buoy: **0.7 °C** (1.6 °C for climatology)
Conclusions

• Lake Size Can Have Large Effect on Nearby Mesoscale Processes
  • e.g., Produce Large Precipitation Differences during Lake Effect/Enhanced Events
• Temporal and Spatial QCing & Compositing of MODIS Data Produces
  • Nearly Continuous Water Surface Temperature Fields for Use in Operational Models
  • Spatial Heterogeneity, unlike using only single buoy reading for entire lake
• Accurate LST estimates (MAD = 0.7 °C)
  • Caveat: Verified against same data set used for calibration
  • Will test on 2012
Future Work

- Perform WRF Simulations Using Climatology vs. MODIS Composite
- Implement techniques operationally in WRF for Army Ranges
  - Real-time lake size
  - Real-time lake temperatures (currently use climatology)
- Vary salinity (and thus water surface heat and moisture exchange) for further sensitivity simulations
References
