TRACKING LONG-TERM LAKE DYNAMICS

Water resource management is of critical importance due to its intimate relationship with nearly every industry, field, and lifeform on this planet. The success of future water management will rely upon having detailed records of current and historic water dynamics. Unfortunately, current monitoring techniques are often limited in some capacity. This research leverages Google Earth Engine to estimate long-term lake dynamics using the Landsat 5 image archive, the Shuttle Radar Topography Mission digital elevation model, and bathymetry data. The proposed method was comprehensively tested using numerous water index, water boundary, segmentation thresholds, and statistic types. The method will expand lake dynamic studies to water bodies not compatible with conventional methods.

David Weekley & Xingong Li GIS Day @ KU 2018

What are lake dynamics?

Lake dynamics describe where, when, and how much water is present for a given water body. In other words, lake dynamics are the spatiotemporal representation of water on the landscape.

Lake dynamics include the following measurements:

Surface Elevation
Surface Area
Volume
Volume Change

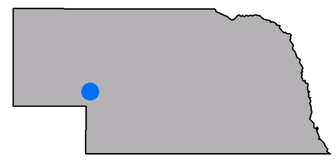
Current Monitoring Methods and Limitations

The most common current lake dynamic monitoring methods and their limitations.

- **In-situ Hydrological Stations**: Limited coverage, especially at global scale.
- **Satellite Altimetry:** Poor spatial resolution and large ground-track spacings limit observations to large water bodies.
- **Elevation/Area/Volume Relationships**: Acquisition date mismatches between optical imagery and altimeters, lack of in-situ elevation measurements, reliance upon accurate surface area estimates.

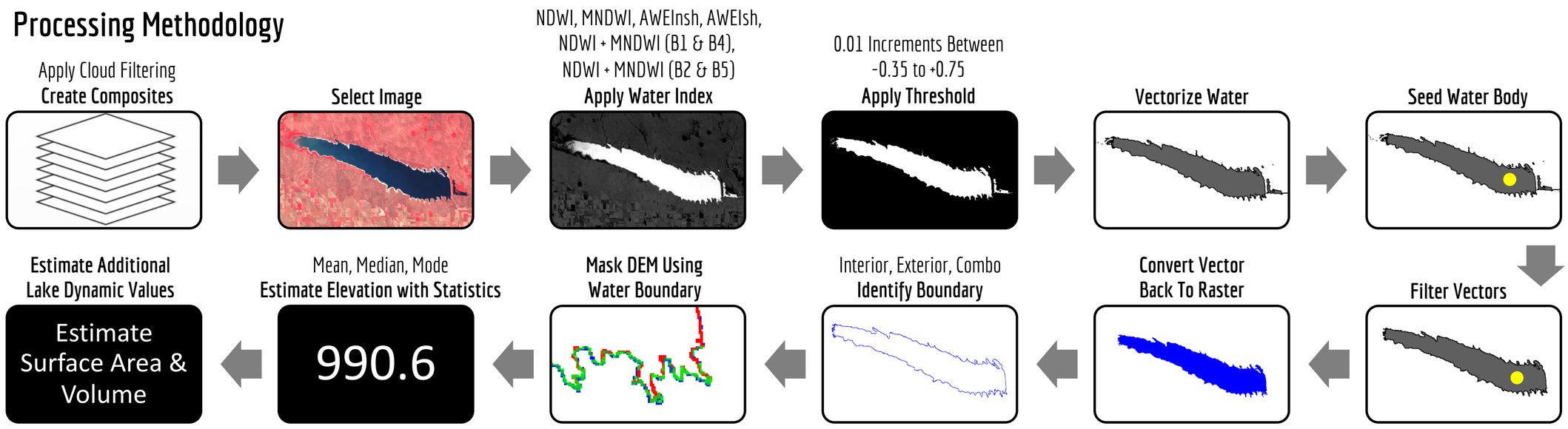
Study Area & Data

Lake McConaughy: Largest reservoir in Nebraska



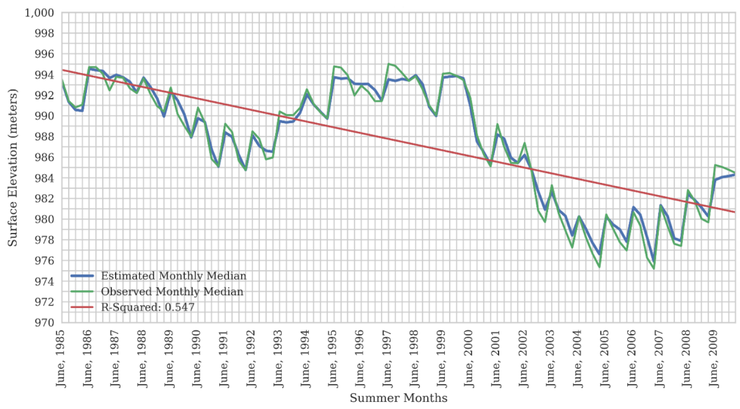
Landsat 5 Imagery (Monthly Composites 1985 – 2009)
Shuttle Radar Topography Mission Digital Elevation Model
Lake McConaughy Bathymetry (USGS, 2003)
Lake McConaughy Daily Surface Elevation Measurements (Validation)

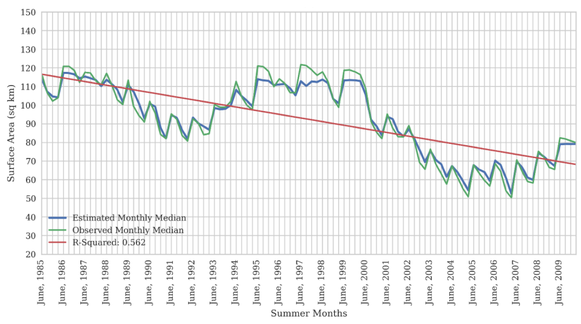
Processing Methodology

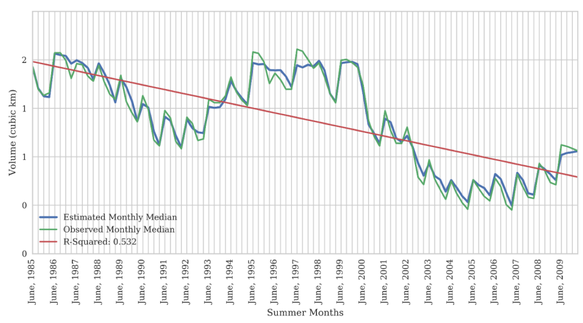


Results

- 5,994 Parameter Combinations Tested
- 863 Combinations Performed Better Than 1.0 Meters RMSE
- Overall Best Performing Combination
  - NDWI + MNDWI (B1 & B4)
  - Combination Boundary
  - Mean Statistic
  - 0.05 Segmentation Threshold
  - Accuracy: 0.745 RMSE







Conclusions

- The proposed method outperforms current techniques
  - Proposed Method: 0.745 m RMSE
  - Elevation / Area Relationship: 0.81 m RMSE
  - Altimetry: Typically well in excess of 1 meter for water bodies of this size and shape
- Technique capable of expanding lake dynamic studies to unmonitored water bodies given bathymetry availability.
- Technique is able to identify both seasonal and long-term trends in water dynamics.

Future Work

- Increased accuracy expected if high-resolution imagery and/or topographic datasets are employed.
- Techniques are being studied to use imperfect imagery including cloud cover, snow/ice, sensor failure, etc.