Predicting Lake Depth from Topography to Map Global Lake Volume

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Background

- Lake depth and volume are important in biogeochemical and thermal processes.  
- Current climate models often ignore lake depth.  
- Depth is not known for most lakes; it must be measured on site by boat.  
- Prior research has predicted approximate lake depth from DEM data on regional scale.

Methods

- Get mean depth values for 330 lakes from ILEC database of lakes; match them in ArcGIS to polygons from the Global Lake and Wetland Database (GLWD).  
- Construct buffers around lakes; calculate ASTER GDEM elevation statistics (mean, min, max, several percentiles) within each buffer in Google Earth Engine.  
- Use multiple linear regression in R to model depth from elevation statistics and location; choose best model with two predictors.  
- Check choice of predictors with cross-validation and by applying model to SRTM DEM.  
- Apply model to 242,197 GLWD lakes to create 1-degree gridded maps of predicted volume and average depth, adding in large lakes with known depth.  
- Use Monte Carlo error propagation for gridded predictions.

Example: Lácar Lake, Argentina

Results: Model

\[
\log_{10}(\text{depth}) = b_0 + b_1 \cdot \log_{10}(\text{p50} - \text{p10} + 1) + b_2 \cdot \text{glacial}
\]

p50 and p10 are the 50th and 10th percentiles of elevation in the buffer; glacial = 1 if lake is in LGM ice sheet area, 0 otherwise.

Future Directions

- Improve resolution of gridded product by using lake databases beyond GLWD, which may become available in the near future.  
- Combined with SWOT water surface elevations, depth estimates could help constrain total lake volume.  
- Get more lakes with known depth, to study regional differences in topography-depth relationship.  
- Include additional predictor variables.

Conclusions

- Lake depth mirrors topographic relief on global scale, and is roughly predictable from 100m DEM.  
- Glacial lakes are deeper.  
- Our gridded product can be used in models of climate and biogeochemical cycling.  
- Our predictive model can be used for regional studies of water resources.

References

- https://www.osti.gov/servlets/purl/1260365