**Reconstructing the paleo Lake Bonneville in Utah/Idaho**

**Background**

Approximately 15,000 years ago, lakes in the Great Basin of the western United States achieved their maximum late Pleistocene extents. Three of those lake systems stand out in terms of surface area: Lake Lahontan with a surface area of 22,300 km2, Lake Bonneville with a surface area of 51,300 km2, and Lake Missoula with 7,770 km2. These gigantic freshwater bodies, which had surface areas approximately 10 times their reconstructed mean-historical values, have been the subject of intensive scientific research since Russell’s seminal study of Lake Lahontan (Russell, 1885) and Gilbert’s seminal study of Lake Bonneville (Gilbert, 1890).

Three main questions have occupied the minds of present-day paleoclimatologists working in these basins: (1) what caused the lakes to grow so large, (2) what was the record of lake-level change in each basin during the last glacial period, and (3) were lake-size changes linked to abrupt changes in the climate of the North Atlantic signaled by Dansgaard-Oeschgerand Heinrich events (see, e.g., Bond et al., 1993; Dansgaard et al.,1993). It is assumed that the ice shield covering North America during that period placed dams on the lakes, which led them to grow in area and depth. It is assumed that melting of the ice sheets “pulled the plug” and rapidly lowered water levels. Bonneville reached its highstand level at 18.6 ka; it fluctuated near that level until 17.5 ka, at which time it incised its threshold at Red Rock Pass, Idaho, reaching the spillover level named “Red Rock Pass level” at 17.4 ka.

Multiple research groups dated paleo-shorelines of Lake Bonneville and corroborated dates of lake levels using sediment cores (e.g., Benson et al. 2011). This project proposes to explore the potential to use publicly Digital Elevation Models (DEMs) to calculate the water volumes in the Lake Bonneville system at different times during the last glacial. Specifically, this project seeks to answer whether spillover points and outflow locations can be detected using satellite imagery.

**Objectives**

1. What was the volume and area of glacial paleo-Lake Bonneville during different time intervals and how does it compare to the modern Great Salt Lake?
2. How much of a difference in volume is represent by different shoreline levels?
3. Where were the spillover points/ice dams for ancestral Lake Bonneville for shoreline levels at various heights?

Digital Elevation Models will be readily available from U.S. agencies. However, I expect that no paleo-DEMs will be available, since paleo-cartography includes a lot of uncertainty. It has to be assumed that the geomorphology did not change dramatically since the last glacial maximum, which will be an error factoring into the model. Further, locations of dams will need to be extracted from the literature and modeled. Exact placement and size of dams will be a matter of interpretation.

**Data Sources**

I will use shapefiles for the maximum extent of Lake Bonneville provided by the The Utah Automated Geographic Reference Center (AGRC) <https://gis.utah.gov/data/water/historic-lake-bonneville/> and 30 m DEMs provided by the USGS The National Map via the Utah ARGC <https://raster.utah.gov/>. Optionally, the USGS also provides 10 m DEMs but at a much larger size of the dataset, which would make processing unwieldy.

**Planned Methods**

The different times and water depths will have to be gathered from the literature. Only the highest lake level is typically referenced in most publications – multiple lower levels were recognized from the sediment record. The lowest location and elevation above sea level of the lake will have to be determined via the shapefile sourced from ARGC. The DEM can be re-calculated to have a value of zero at the lowest location of the lake. It then has to be decided if multiple versions of zero at the lake levels can be created. Comparing with AGRC shape file, the dam and spillover locations can be inferred for each lake level. The DEM values will have to be modified to model dam structures in these locations. Once the paleo lakes are “plugged up”, bathymetric contour lines can be drawn. Using ArcScene’s capabilities, 3D mesh surfaces will be created from each DEM representing the lake bottom. The tool “3D Analyst - Surface Volume” will be used to set a hypothetical plane representing lake level and calculate the volume enclosed between DEM and plane.

These methods will be repeated for each lake level reported in the literature and the modern Great Salt Lake for comparison. Once complete, differential volumes and fluxes into the lake per year can be calculated.

**Expected Results**

First, I expect that finding paleo DEM’s will not be possible largely because it would involve speculation that is difficult to put in numbers without an uncertainty measure. Second, neither shapefiles of Lake Bonneville other than the most publicized highest water level. Instead it is necessary for this project to iterate and model the paleo conditions as GIS features that were present during the last glacial. However, it is to be expected that much of the geomorphology present today will be reasonably similar and spillover points reliably determined by empirical modeling in GIS. After for all time-slices the drain and spillover points are closed, which requires a degree if interpretation, volumes and fluxes can be calculated. These modeled values then can be compared with data from the literature. The 30 m DEM will be a starting point for analysis and if not proven sufficiently accurate, a 10 m DEM mosaic can be procured and the process repeated.

**References**

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