

# **Earth 436B Thesis**

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# 1 Introduction

- Movement of Earth's crust atop the mantle is driven by many factors including buoyancy
- Addition and removal of weight, in this case the Laurentide Ice Sheet, from the crust will cause vertical adjustments known as GIA
- As inclination of ground surface changes, water levels (ie Lakes) and the paths taken by the flow of water (rivers, lake outlets, groundwater) change
- This has implications for engineering and environmental assessments
- projection of future changes due to GIA relies on having a reliable estimate of past rates of GIA

## 2 Previous Work

- OSL dating used to determine age for sequences of Quaternary beach deposits (strandplain sequences) at each site vs current day elevation.
- This is then used to create a graph of elevation vs time for each site
- Paleohydrographs were created in Johnston et al. 2012

### **3 Locations**

- Grand Traverse Bay, Michigan (GTB)
- Au Train Bay, Michigan (ATB)
- Batchawana Bay, Ontario (BATB)
- Tahquamenon Bay, Michigan (TAHB)

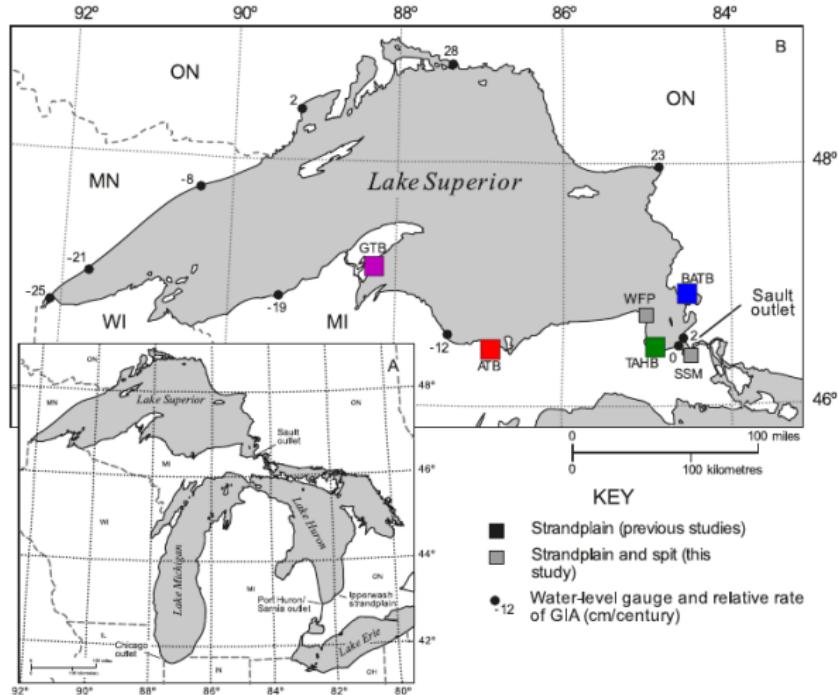
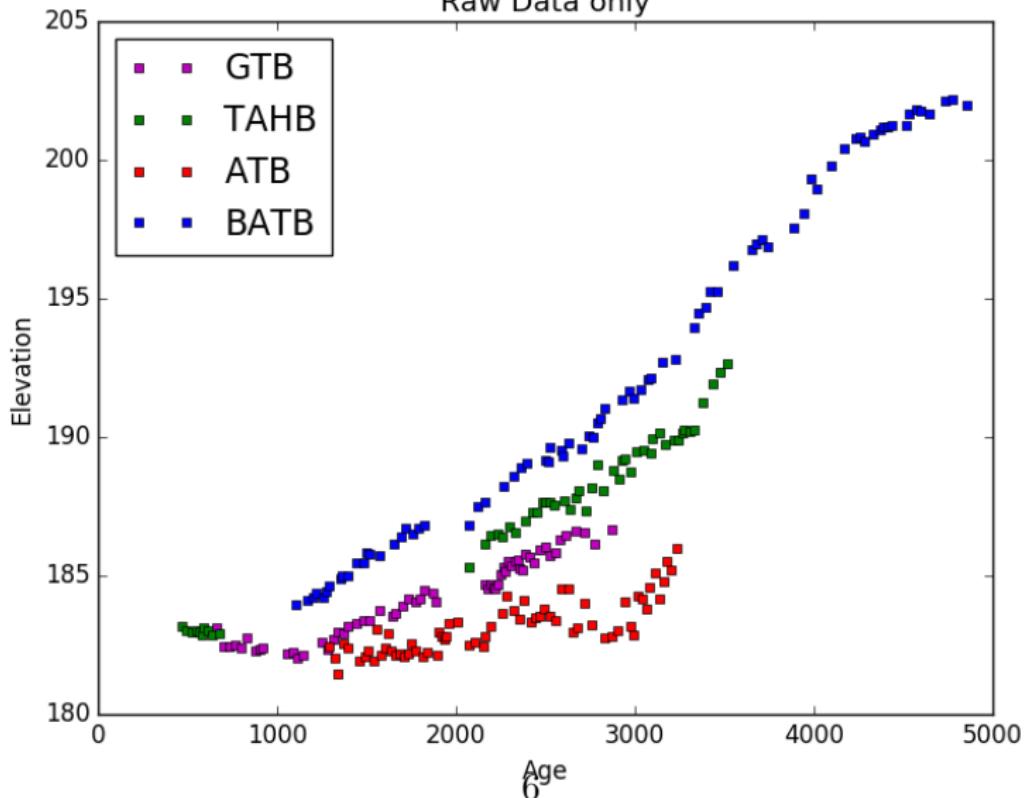


Figure 1: Map of the study sites used. Reproduced with permission from Johnston et al. 2012

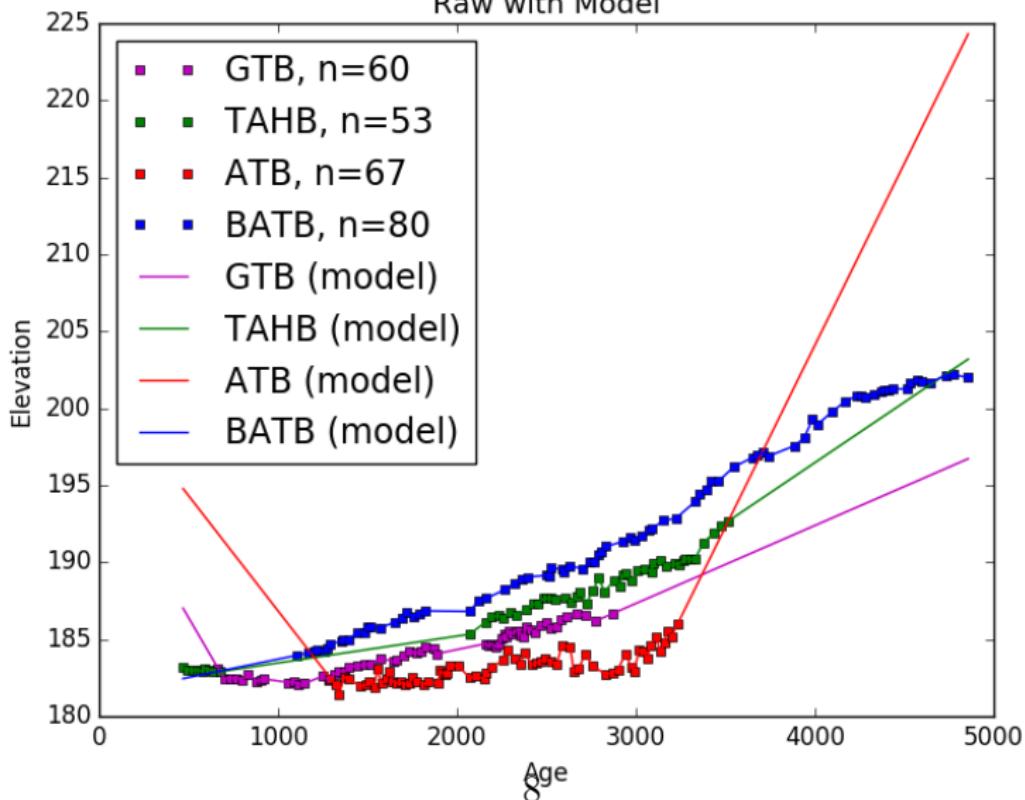
Plot of Elevation by Age  
Raw Data only



## 4 Method

- Johnston et al. 2012 used a linear regression method for each site to get relative GIA rates between sites
- Model is likely too simplistic and doesn't take account of local variations
- Data not available continuously for each site, or at the same time for each site to compare gia, so values must be inferred using linear interpolation between known data points.

Plot of Elevation by Age  
Raw with Model



## 5 Method

-GIA is now plotted by subtracting between the measured values of one dataset and the modelled value of another.

-6 combinations of pairs of sites are created, each of which has a forward (A to B) and backward (B to A) comparison.

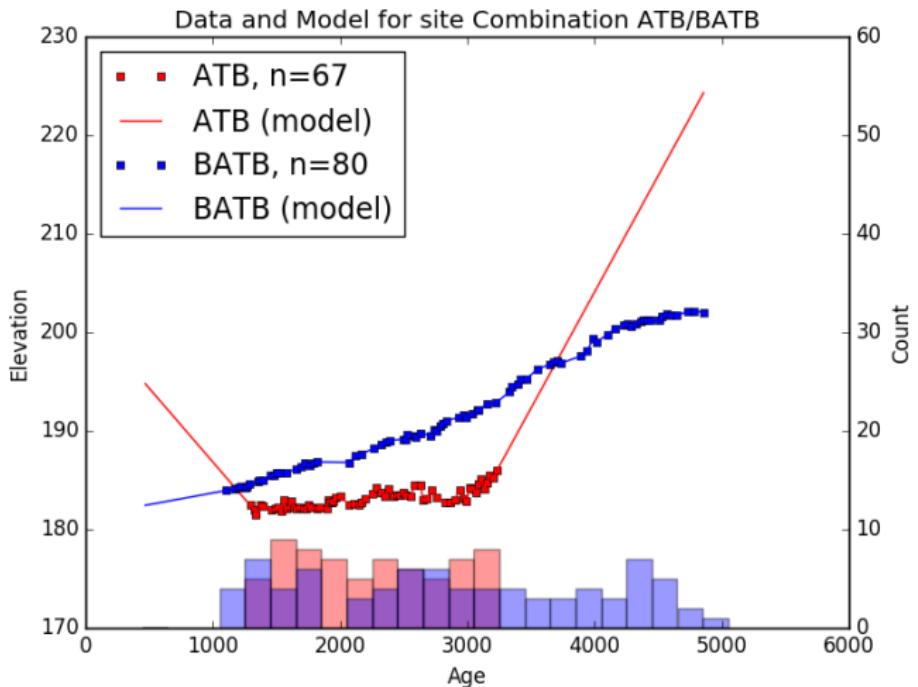


Figure 4: ATB-BATB raw data with linear interpolation model

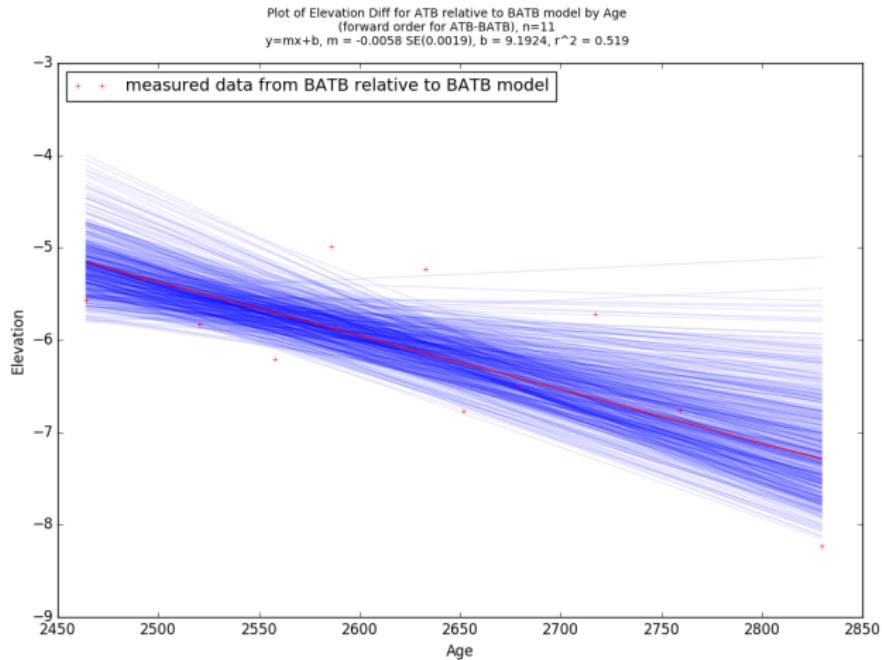


Figure 5: Differences in elevation measured from the ATB data to the ATB model

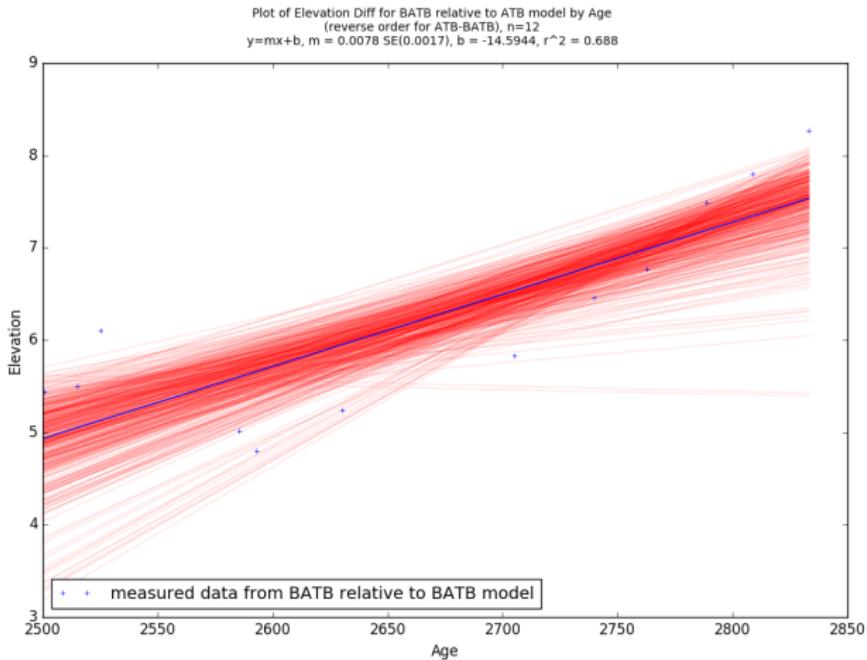


Figure 6: Differences in elevation measured from the BATB data to the ATB model

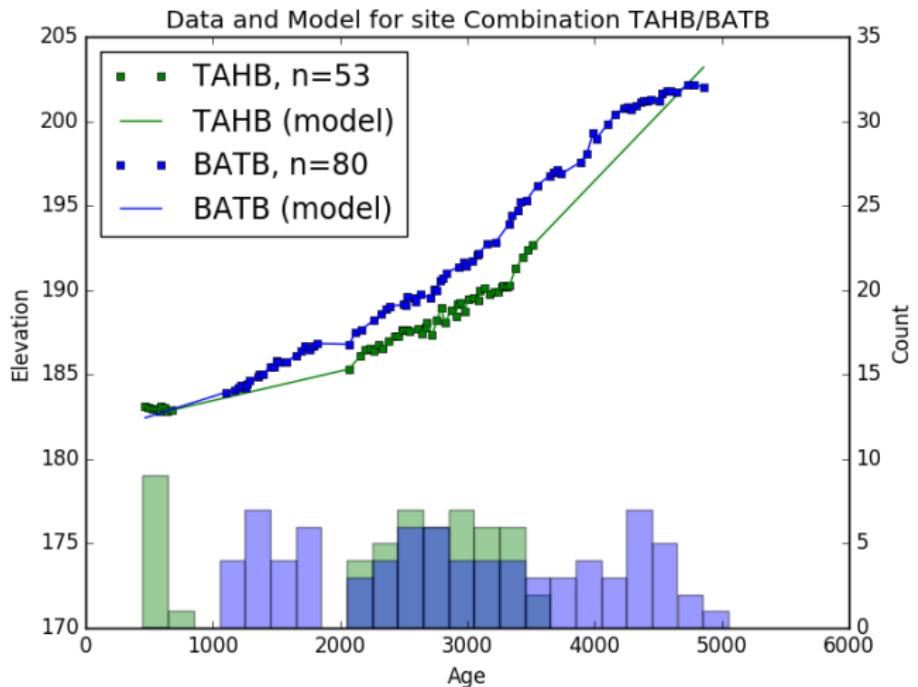


Figure 7: TAHB-BATB raw data with linear interpolation model

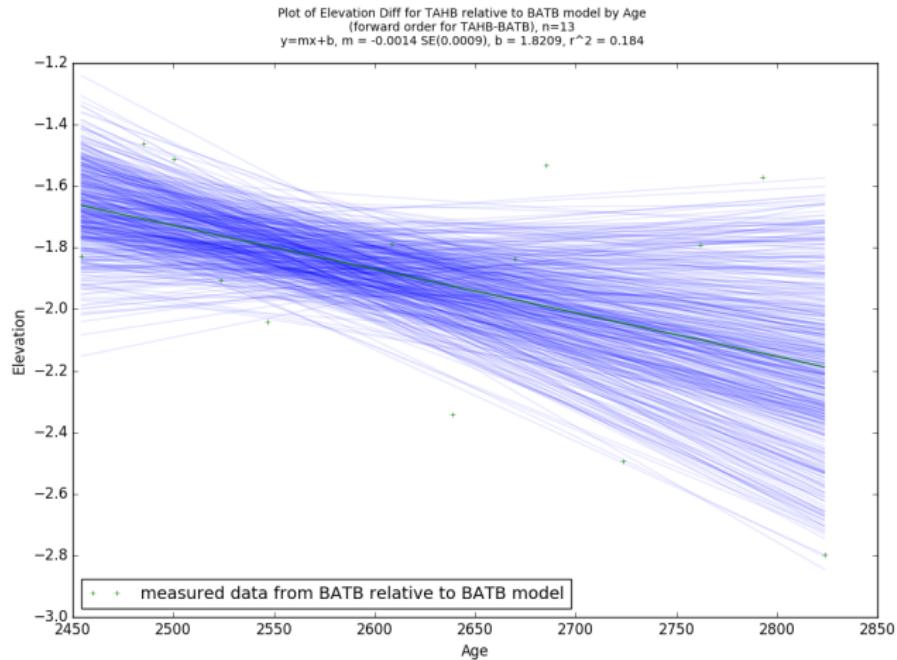


Figure 8: Differences in elevation measured from the TAHB data to the BATB model

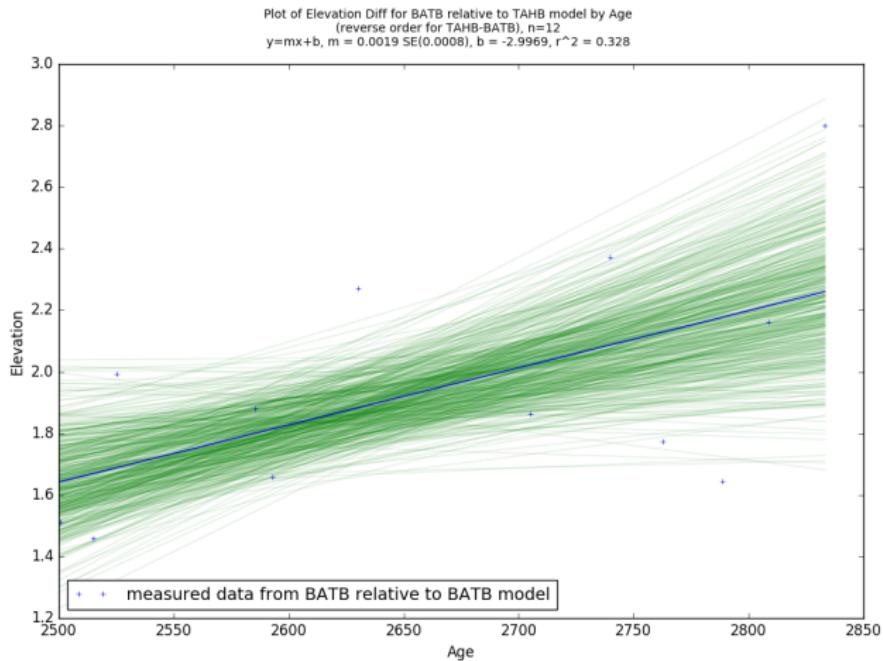


Figure 9: Differences in elevation measured from the BATB data to the TAHB model

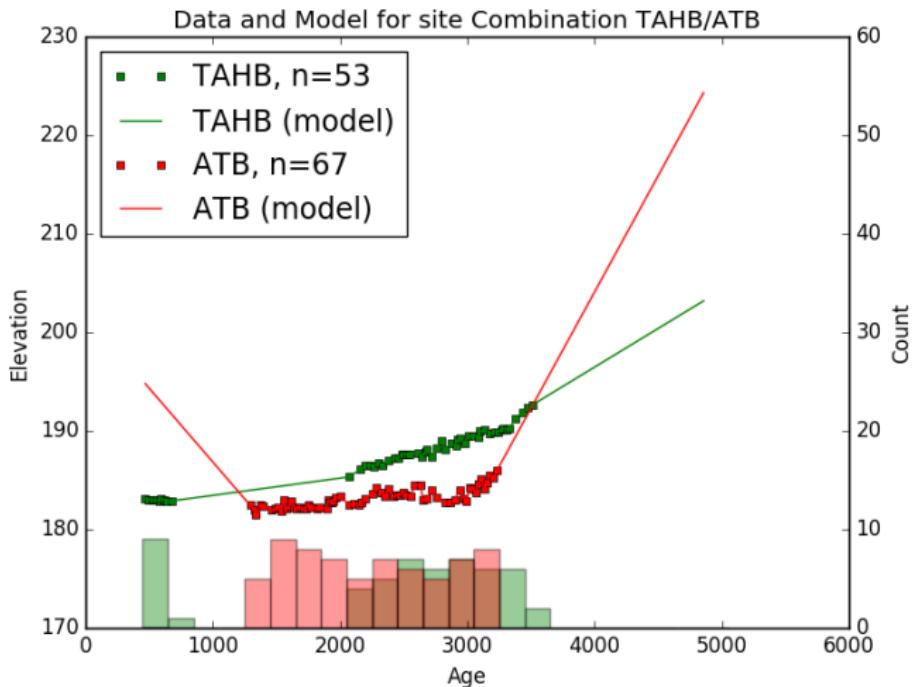


Figure 10: TAHB-ATB raw data with linear interpolation model

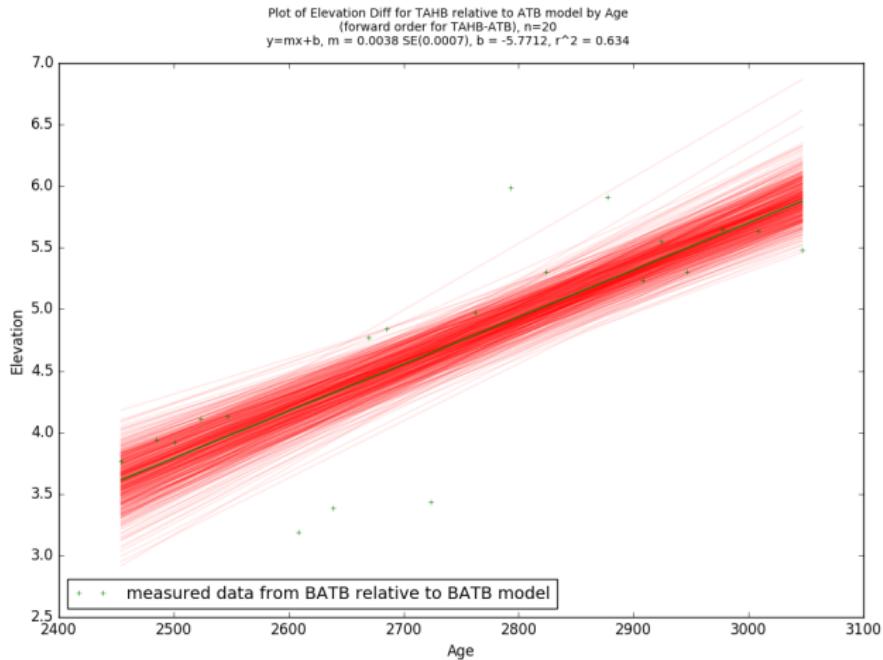


Figure 11: Differences in elevation measured from the TAHB data to the ATB model

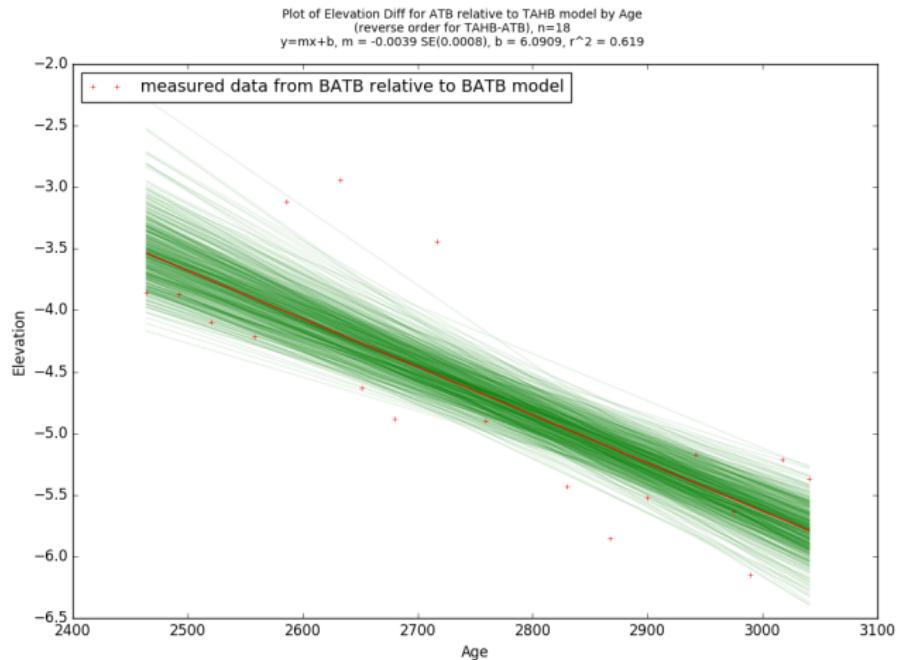


Figure 12: Differences in elevation measured from the ATB data to the TAHB model

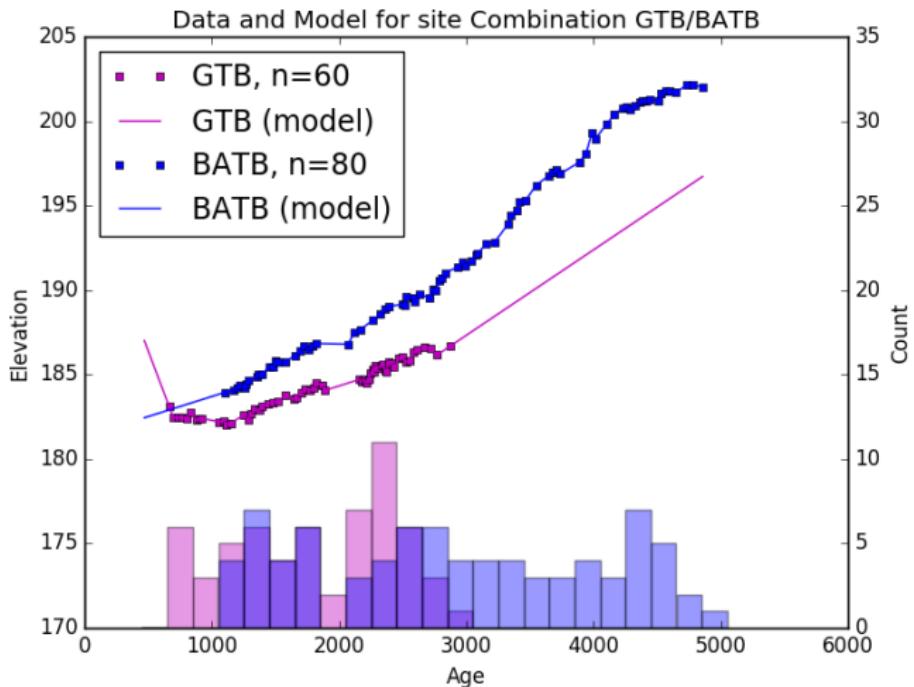


Figure 13: GTB-BATB raw data with linear interpolation model

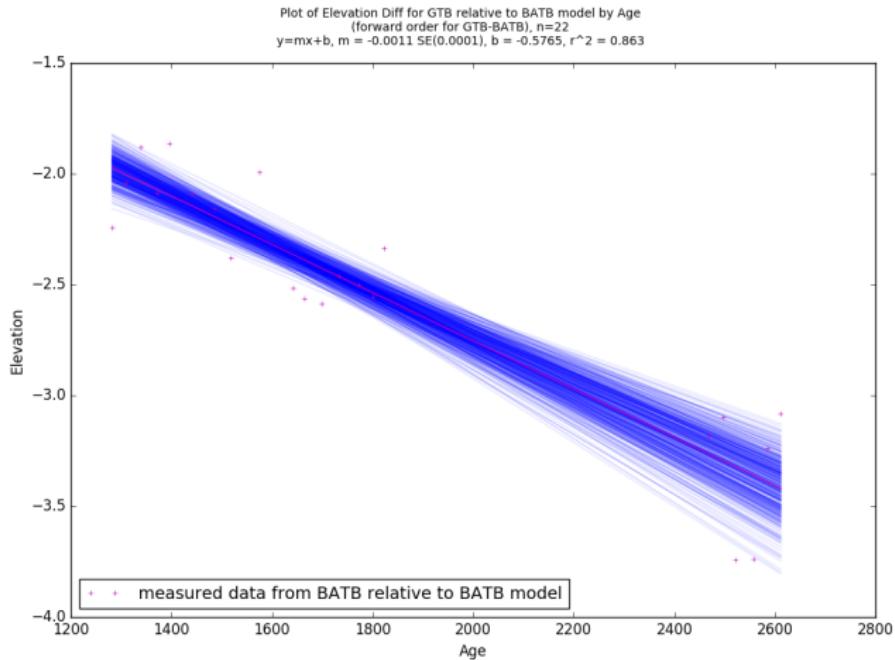


Figure 14: Differences in elevation measured from the GTB data to the BATB model

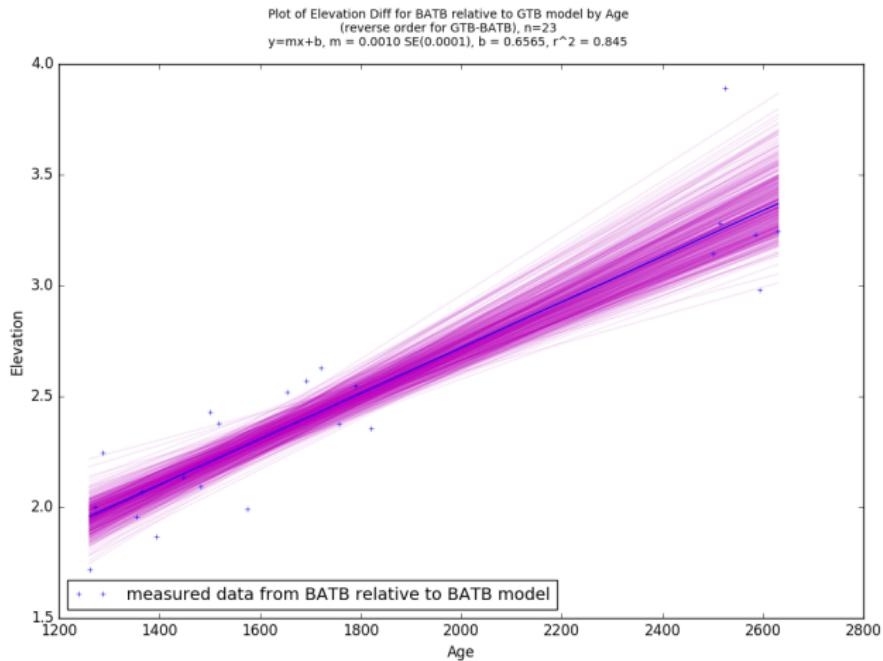


Figure 15: Differences in elevation measured from the BATB data to the GTB model

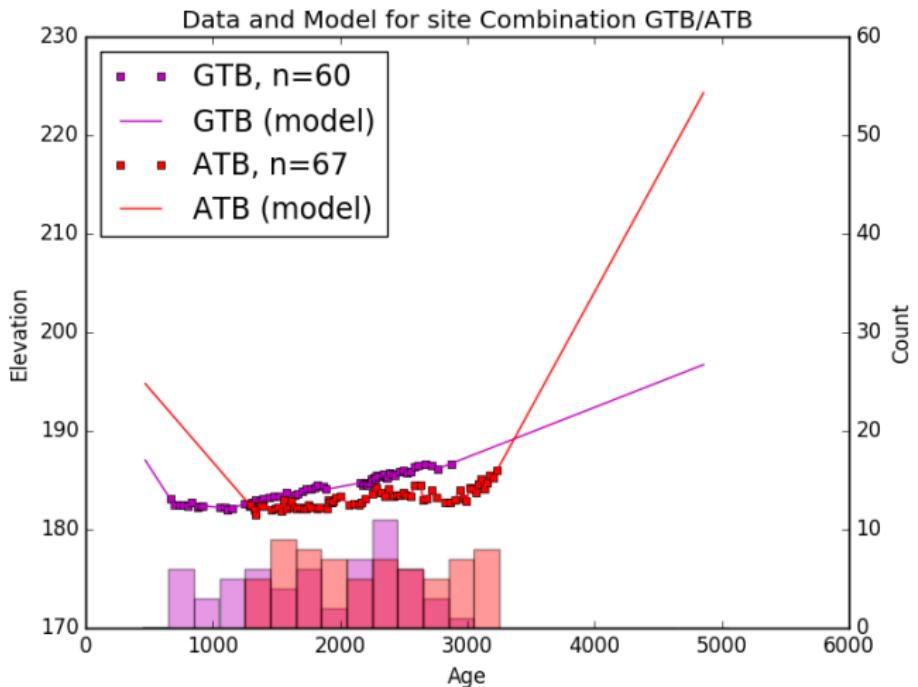


Figure 16: GTB-ATB raw data with linear interpolation model

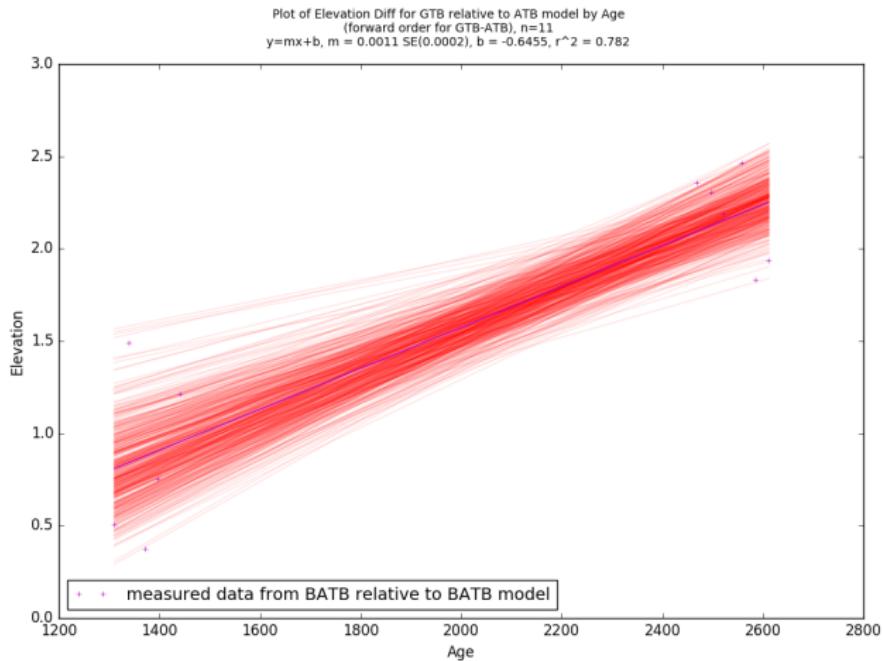


Figure 17: Differences in elevation measured from the GTB data to the ATB model

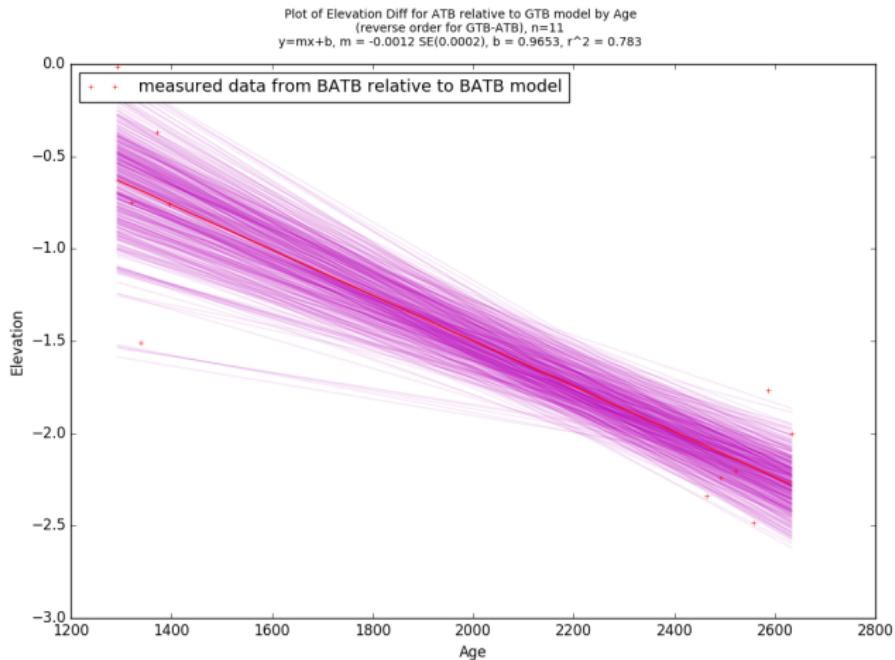


Figure 18: Differences in elevation measured from the ATB data to the GTB model

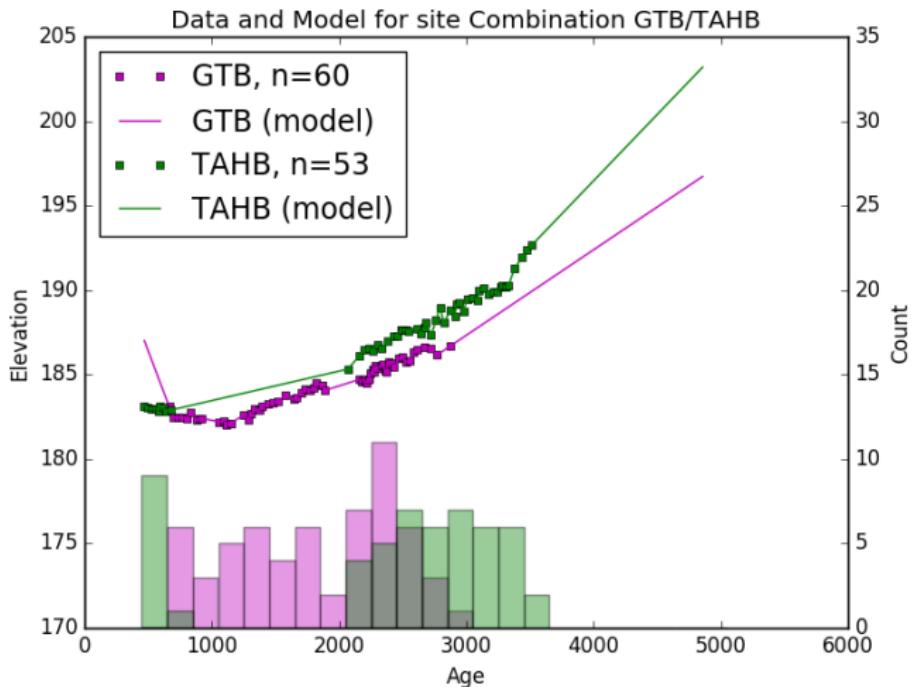


Figure 19: GTB-TAHB raw data with linear interpolation model

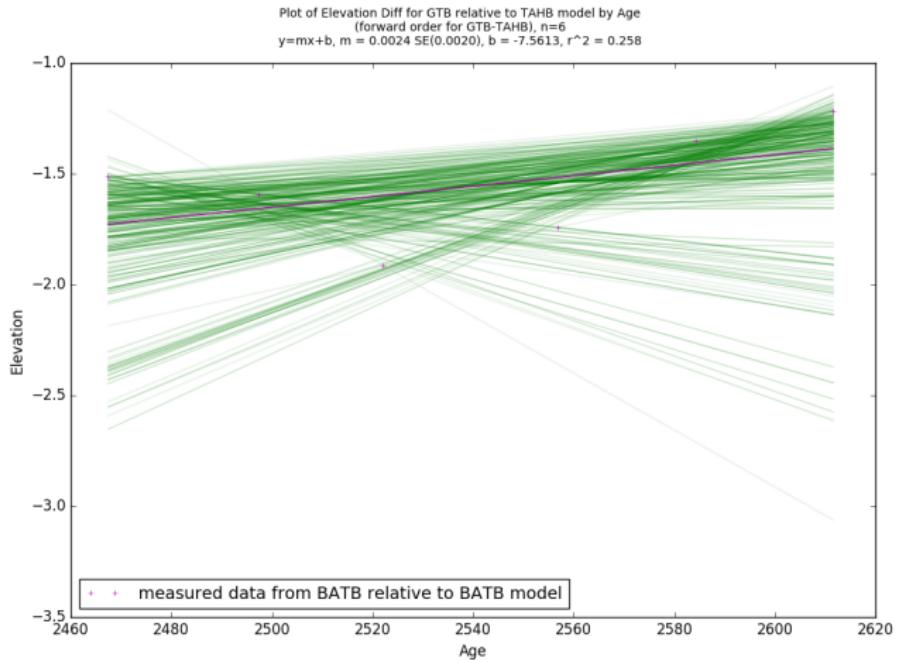


Figure 20: Differences in elevation measured from the GTB data to the TAHB model

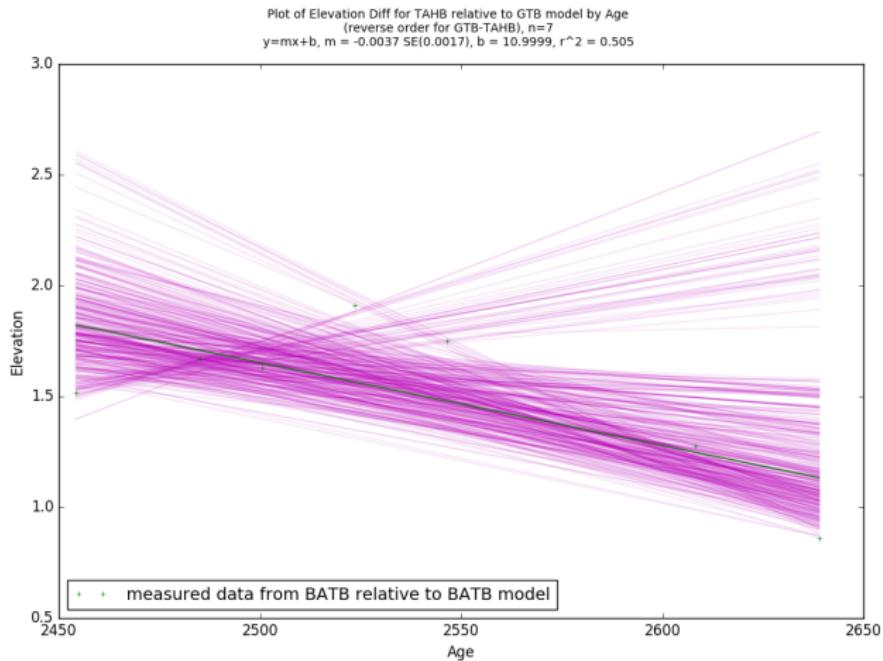


Figure 21: Differences in elevation measured from the TAHB data to the GTB model

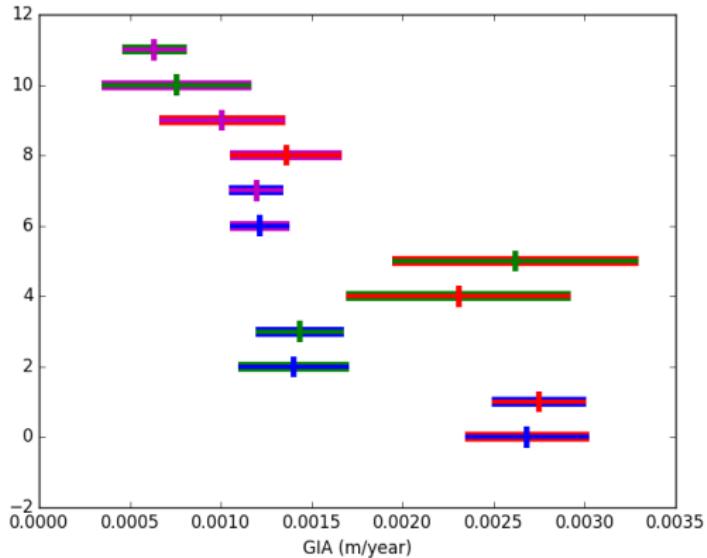


Figure 22: 95p Confidence intervals on GIA rates obtained from site comparisons

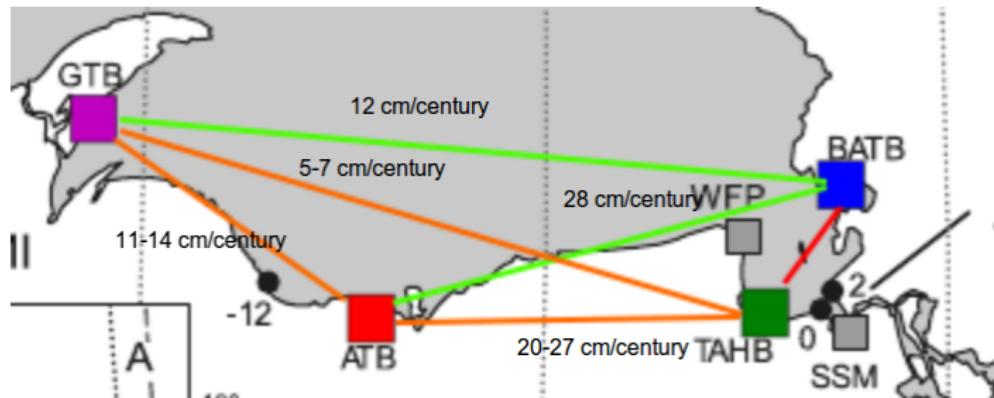


Figure 23: Relative GIA Rates produced by this paper's method

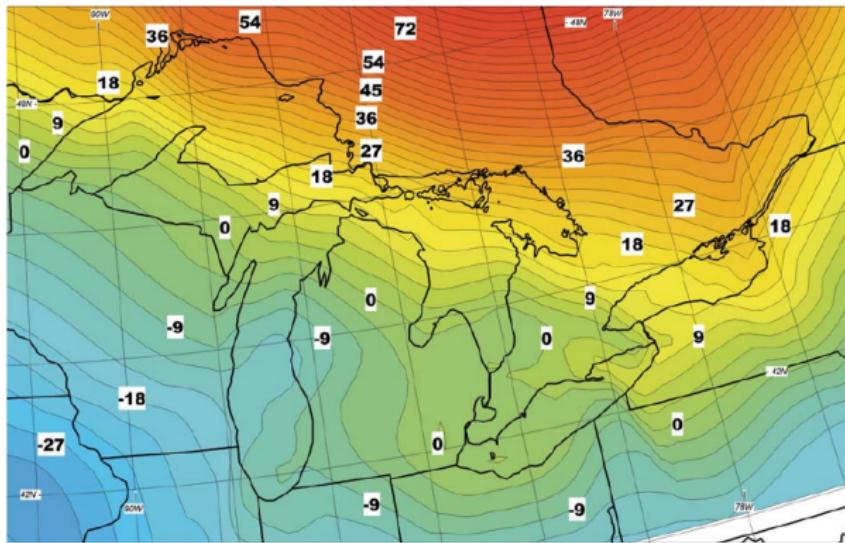


Figure 7. Contour map of vertical velocities derived from water level gauges over the Great Lakes surrounded with ICE-3G-derived velocities. Contour interval—3 cm/century.

Figure 24: Relative GIA Rates produced by Mainville & Craymer (reproduced from Mainville & Craymer, 2005)

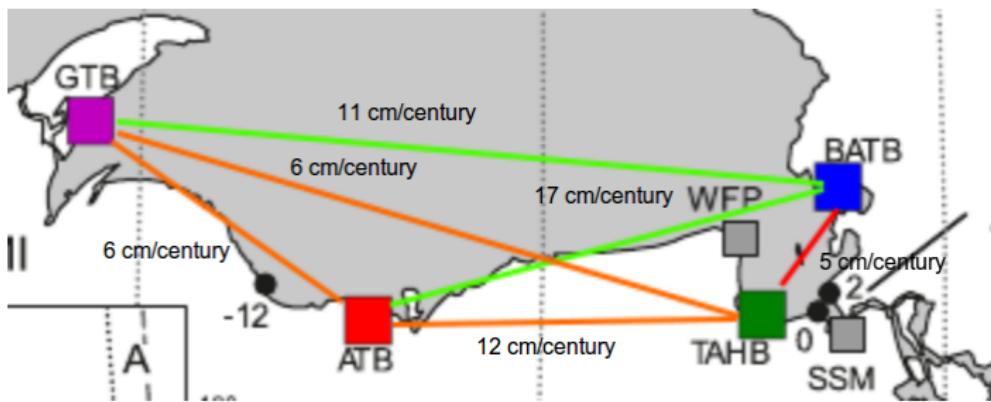


Figure 25: Relative GIA Rates produced by Mainville & Craymer