Modeling the Equilibrium Altitude of the Klinaklini and Tiedemann Glaciers

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Introduction

Modeling glacier mass can be a very intricate and complicated process. Although weather is a stochastic system, the long term climate is regarded as a deterministic system. The elements of climate are relatively well understood by the scientific community; however a full climate model is not required to accurately predict the equilibrium altitude.

In order to simplify the model several key assumptions need to me made. The primary assumption of the model is that elevation and surface temperature are the only variables affecting glacier mass balance. Glacier mass balance is a ratio of zones of ablation and accumulation. This can be best understood by the altitude of equilibrium. Glacier equilibrium altitude is the elevation at which a glacier is in equilibrium. This model uses a 0°C thermocline as the line of equilibrium. By using a 0°C thermocline the assumption is that surface temperature is an adequate representation of local climate.

Study Area

The Klinaklini and Tiedemann glaciers are located in the southern Coast Mountians of B.C near Mount Waddington. (51.463°N 126.082°W & 51.332°N 125.29°W). Both are mountain valley glaciers. Tiedemann flows east over an elevation range of 3400m and has an area of 62 km^2. The Klinaklini glacier flows south from the Ha-Iltzuk Icefield over an elevation range of 2800m and has an area of 480 km^2.

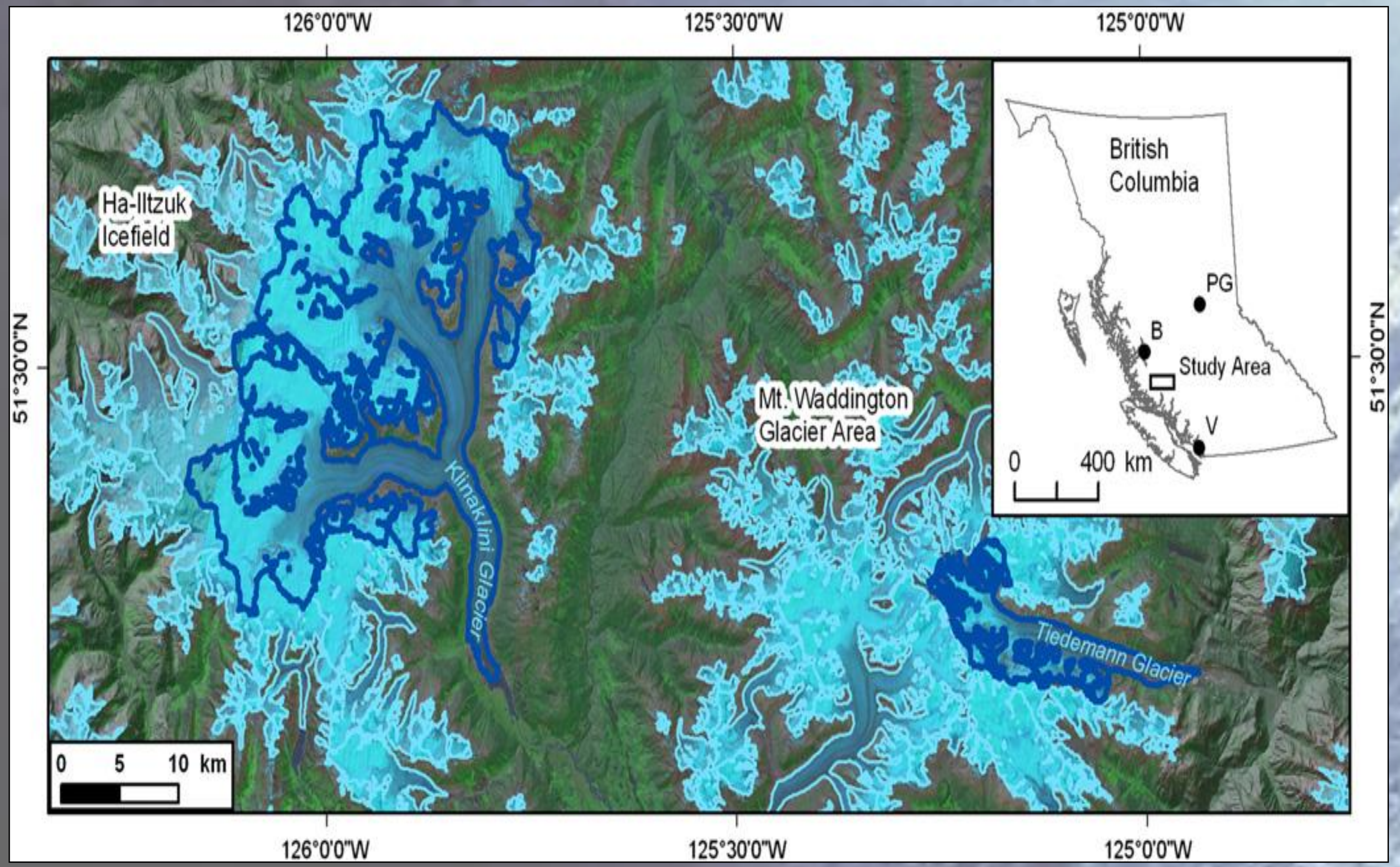

Figure 1: Locations of Klinaklini and Tiedemann Glaciers

Methods

The equilibrium model uses local temperature data from local weather observation stations. Since equilibrium altitude is highly dependent on the season, the climate normal for each meteorological station was used to get an average annual temperature. Temperature surfaces have been interpolated using a local standard lapse rate of 6.3°C/1000m. This lapse rate was determined by Tennant et AL in *Comparison of modeled and geodetically-derived glacier mass balance for Tiedemann and Klinaklini glaciers, southern Coast Mountains, British Columbia, Canada*.

Using ArcInfo, the locations of weather stations, climate normals, and the standard lapse rate were combined to interpolate a local temperature surface. The altitude of the 0°C thermocline was identified from the interpolated raster. The altitude of the equilibrium line of the initial model was validated by comparison to existing lines of equilibrium.

Once the model was validated, the impact of warming global temperatures was predicted. The modeled temperature surface was altered by increasing climate normals by 1°C and 2°C. The results of increasing temperature showed how the two glaciers equilibrium lines will change over time if annual temperatures increase.

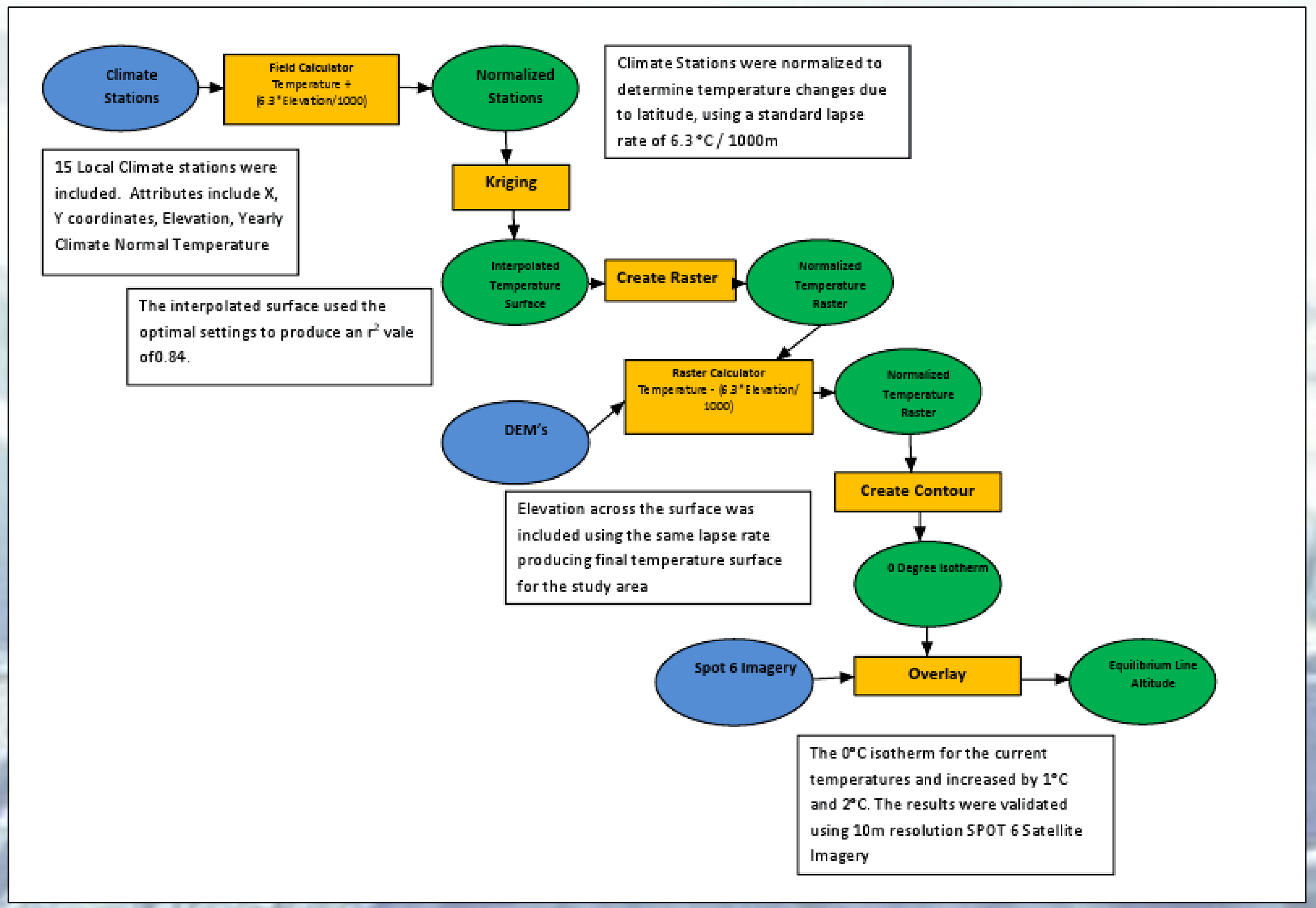

Figure 2: Flowchart of model analysis

Prior to the model analysis shown in Figure 2, the raw data was pre-processed. Since Point Files were not available for the climate stations, points were produced manually. 15 regional stations with climate data dating back 30 years were used. The Climate station points were produced manually using the latitude and longitude given by Environment Canada. The DEM's and the imagery mosaics were compiled into single raster's.

Results and Discussion

The current equilibrium elevation of the Klinaklini Glacier is 1400m and the equilibrium elevation of the Tiedemann Glacier is 1700m. As shown in Figure 3, the model was very accurate in predicting the equilibrium elevation of the Klinaklini Glacier. However the model under predicted the equilibrium elevation of the Tiedemann Glacier. This is because the Tiedemann Glacier is on a steep southwest-facing slope so it receives direct sunlight, speeding up its rate of ablation. Figure 3 also shows how drastic the effects of a 1°C and 2°C increase in climate normal will be on the equilibrium elevation. We cannot predict in what time period that temperature will increase but we can predict the effects of these changes.

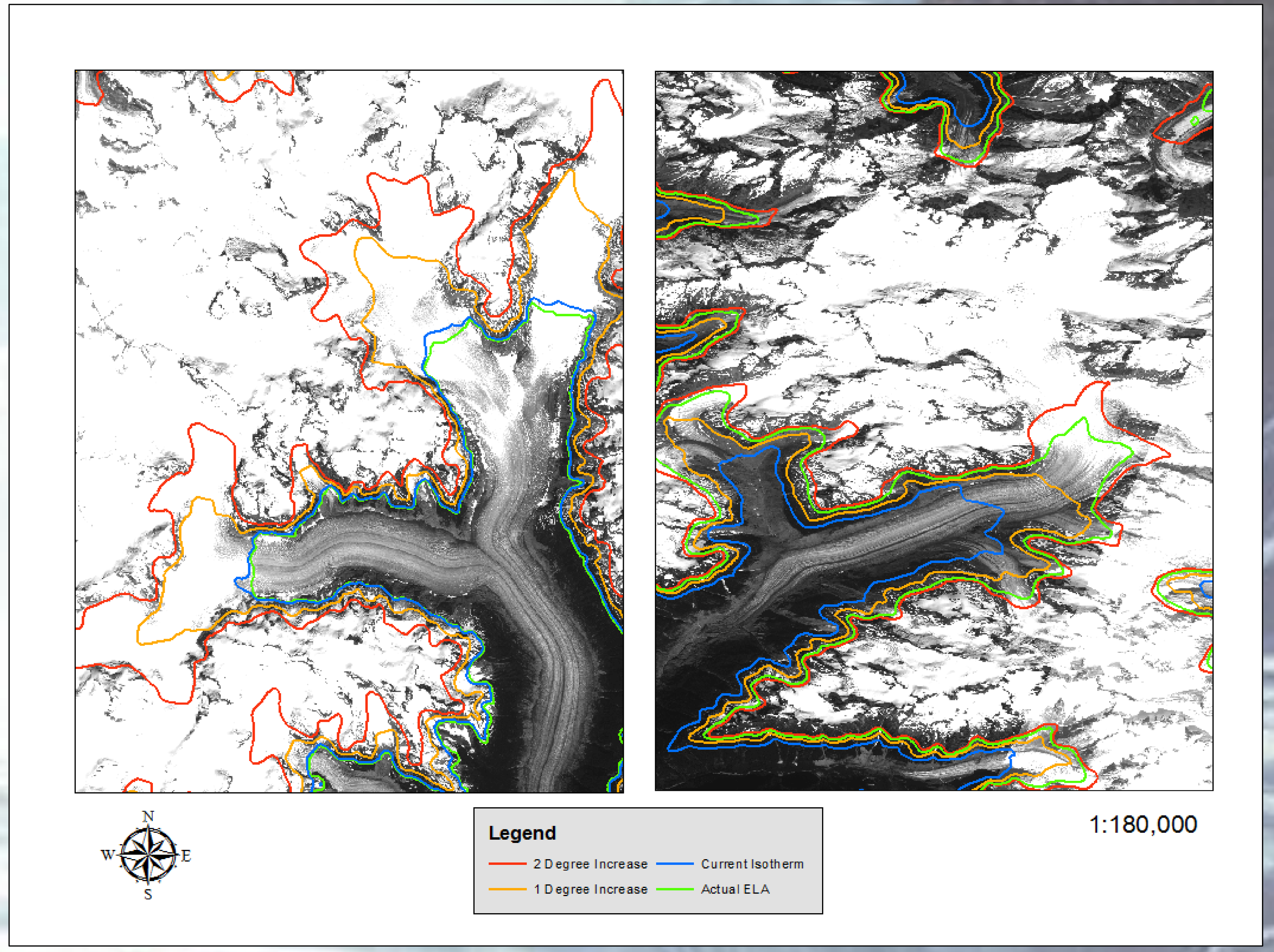

Figure 3: Predicted and actual equilibrium altitudes of Klinaklini and Tiedemann Glaciers

Conclusion

The model accurately predicted that the current equilibrium elevation of the Klinaklini Glacier is 1400m. It then predicted that is equilibrium elevation would move up to around 1570m for a 1°c increase and 1730m for a 2°c increase in climate normals. The model inaccurately predicted that the current equilibrium elevation of the Tiedemann Glacier to be 1450m when it is actually closer to 1700m. As a result the predicted 1°C and 2°C equilibrium elevations were also under predicted at 1600m and 1750m.

These results show that a minor temperature increase will have drastic effects on the health of the glacier. Receding glaciers will expose more slopes to erosion and reduce the amount of freshwater available in the region. Loss of glaciers in the region will increase the albedo providing a positive feedback on the system, increasing the ablation rates of other nearby glaciers. Positive effects of these changes are more useable area, increased vegetation in the region, and potential new areas for mineral extraction.