Qualifying Exam

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Abstract

In order to satisfy qualifying exam requirements adhered to by the School of Informatics and Computing, I will provide an explanation of near surface layers and global climate change with its implications to sea level rise.

Introduction

Glaciers are a source of climate history and information on subsurface features. While glaciers provide historical information, they also hold a vast amount of water. Complete melting of the world's ice sheets would result in a sea level rise of approximately 70 meters [3]. Although it is highly unlikely the glaciers will melt completely, sea level has been rising about 1.8mm per year, with global temperature rises as the primary reason [4]. One of the most important indicators of a glacier is its mass balance [2]. Scientists need to better understand the physics of global climate in order to understand how human actions affect the global environment. To make predictions, scientists have formulated models, which predict past and future climate conditions. The polar ice sheets are a major source of variability for climate models [1]. However, existing models cannot explain the recent satellite observations showing rapid thinning of ice sheet margins, the speedup of several outlet glaciers in Greenland, and the disintegration of ice shelves in West Antarctica. Current models for determining mass balance are prone to errors due to the sparse sampling of the ice sheets. Errors in calculating the mass balance are caused by uncertainties in calculating accumulation rates over the ice sheet [1]. Sparse sampling of the ice sheet, using ice cores to determine the accumulation over a broad area, does not provide a good indicator of the total accumulation over an area [9].

The Center for Remote Sensing of Ice Sheets, a Science and Technology Center established by the National Science Foundation, has developed and deployed nonintrusive instruments capable of increasing better estimates of the accumulation (as shown in Figure 1) for ice sheets to create more accurate mass balance assessments. Near-surface layers are of interest to climatologists and the scientific community because they contain information on accumulation rates of recent years. The ability to investigate the internal content of the ice sheets, and the ability to track accumulation rates and ice sheet movements will greatly aid in improving the accuracy of current mass balance estimate. Investigating deep layers in the ice sheet reveals information about accumulation and ice flow history, while the near-surface layers show recent accumulation.

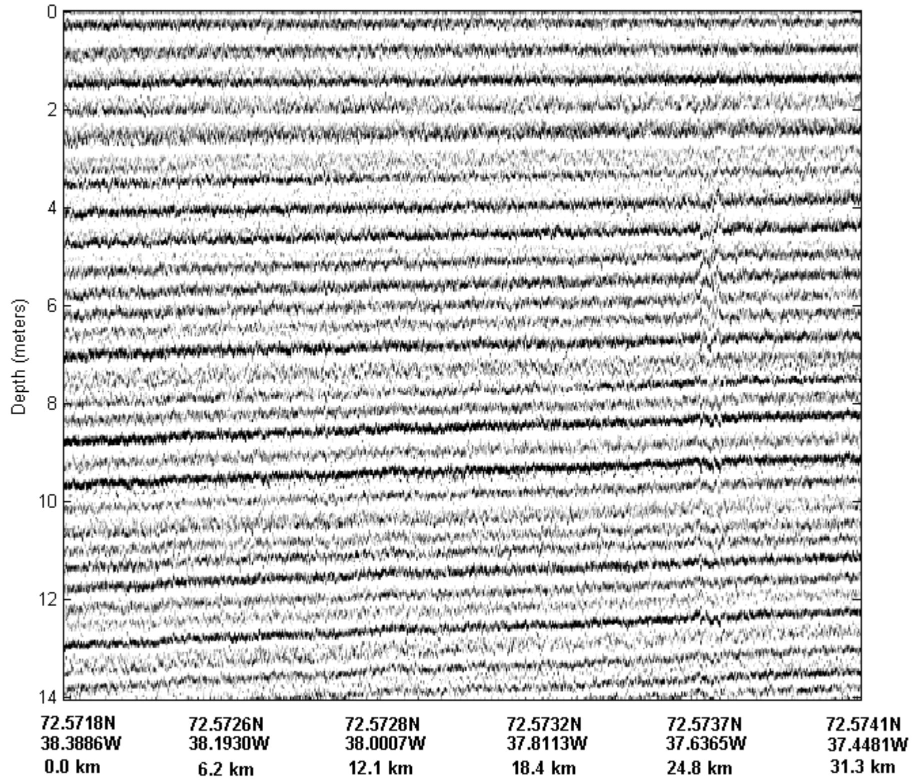

Figure 1: Example of Near Surface Internal Layers from Radar Sounding

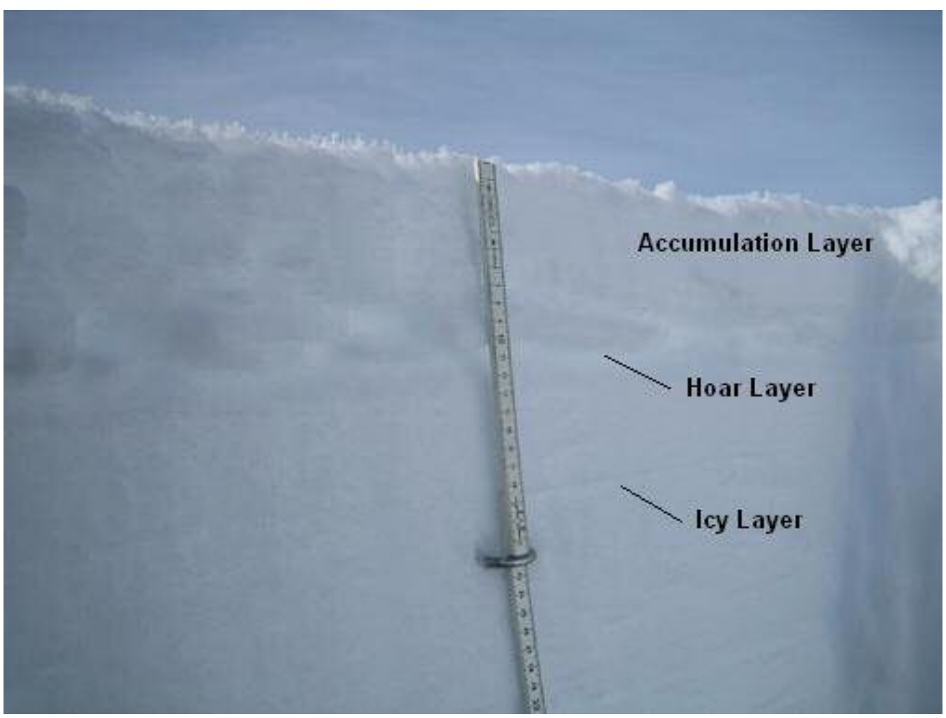

Figure 2: Description of

Physical Properties of Near Surface Layers

The characteristics of the near-surface layers are highly complex. The near-surface internal firn layers differ from year to year. Specific weather patterns, which vary from season to season, provide unique layer characteristics. The most salient types of layers can be categorized into three classes: accumulation and icy layers and depth hoars.

The greatest amount of firn near the surface of the ice sheet falls into the recent accumulation category. Accumulation layers form directly from precipitation accumulating on the surface of the ice sheet. As more accumulation events occur, previous accumulations are buried and compacted deeper into the ice sheet, generally becoming denser with greater depth. The weight of the accumulation layers is not the only action, which layers increase in density. Accumulation density can widely vary from layer to layer. Heat flux can cause layers to change density and structure forming depth hoars, while high winds may cause icy crusts to form. In addition to effects from heat flux and wind, firn density is dependent on initial particle size, while over time, the firn attempts to maintain the lowest structure. Despite either the initial size or shape of snow crystals, particles combine to form larger particles – reducing the overall surface area, and energy of the structure.

Hoar layers are among the most visual in near-surface layers. Hoar layer formation is caused by sublimation of ice crystals when temperature gradients are large. Strong temperatures gradients form when surface air temperature is warmer then the near-surface layers[6]. Water vapor is exchanged from grain to grain, redistributing the density of the layers [5]. Hoar layers are much less dense than the surrounding layers and caused substantial reflections of electromagnetic energy in near-surface layers because of the large contrast in density compared to adjacent layers.

Icy layers account for only a small volume of the near-surface layers, but cover vast areas. Icy layers, or crusts, form under many conditions including precipitation, temperature and wind conditions. Although rain and melting does not occur in the dry snow region, mechanisms, which form crusts in the dry snow are kinetic heating and compaction. During periods of strong wind, kinetic energy is absorbed in the form of heat when ice and snow crystals blow across the surface of the ice sheet. This heating can cause a slight melting, which freezes to form a thin ice crust[7]. Crusts formed in this manner are often referred to as wind crusts or wind glaze. Ice crusts can also form barriers to sublimation, forming hoar layers just beneath the ice crusts[8].

Conclusions

Global climate change can provide devastating consequences for coastal regions. Glaciers, which provide significant historical information, can provide an indication of the state of the mass balance. But, this understanding relies on developing accurate climate models for forecasting ice sheet behavior. The Center for Remote Sensing of Ice Sheets has used remote sensing technologies by sounding near surface layers, which are entails information about accumulation rate and ice sheet thickness.

References

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