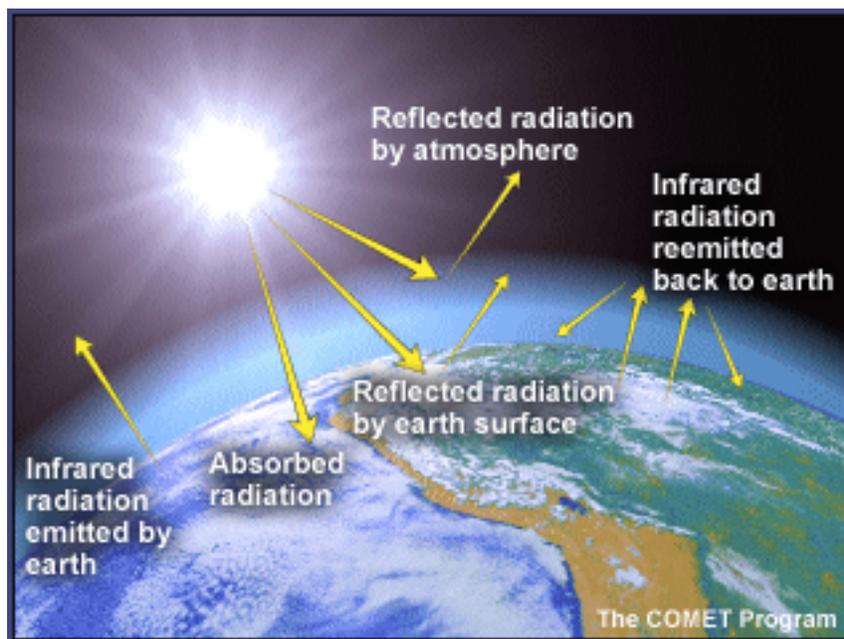


# Qualifying Exam

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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.



**Figure 1: Processes Describing the Greenhouse Effect [8]**

## Introduction

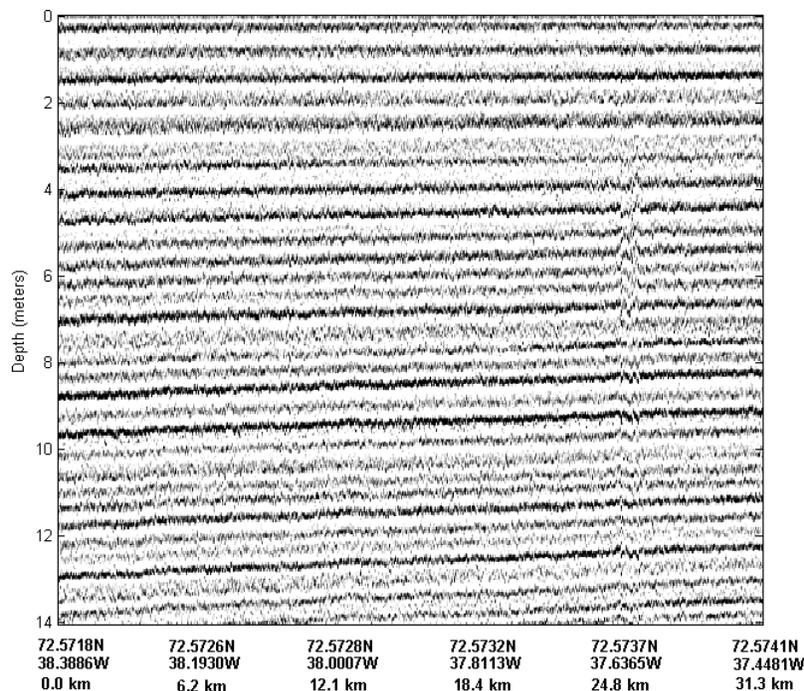
Global climate change, which is caused by greenhouse gases are trapped in Earth's atmosphere are influenced by the following greenhouse gases:

1. Water Vapor - an most abundant gas increases as the Earth's atmosphere warms, and it provides important feedback into the greenhouse effect.

2. Carbon Dioxide – a minor but very important gas, it is released by natural processes and human activities, which have increased atmospheric concentration is thought to be a major forced causing of climate change.
3. Methane – an active, but less abundant gas is produced both through natural sources and human activities.
4. Nitrous Oxide – a greenhouse gas produced by organic processes.
5. Chlorofluorocarbons - a gas composed entirely of industrial origin materials

The greenhouse effect could warm oceans and melt glaciers (process shown in Figure 1), which would increase sea level and cause devastating outcomes for those living in coastal areas. In fact, sea level has been rising approximately 1.8mm per year [4], and although the glaciers are unlikely to melt in its entirety, the amount of water contained in glaciers could raise sea level to 70 meters [3]. Understanding ice sheet contribution is determined by mass balance, which is either the net gain or loss of ice. There are a number of approaches for estimating the mass balance -- three include: the integrated, ice flux, and Earth gravity field approaches. In the integrated approach, an ice sheet is estimated by measuring the elevation to ice volume change. The ice flux technique compares the snow accumulation and ice flow masses along with the water drained at ice sheet margins. Lastly, the Earth's gravity field approach correlates changes from satellites observations to ice volume change. Mass balance estimates are used as input into climate models for forecasting global climate change [2]. Traditionally, scientists have used sparse sampling [1] for determining the mass balance, but this technique is susceptible to errors and do not cover a broad enough area.

The Center for Remote Sensing of Ice Sheets (CREGIS), 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 2) for ice sheets to create more accurate mass balance assessments. Information acquired from subsurface features imaged using radar technology include accumulation and ice thickness. Ice thickness result from accurate selection of surface and bedrock topographies while the accumulation rates are determined from near-surface internal layers. For the purpose of discussion, I will discuss ice features, namely near surface internal layers since tracking accumulation rates will greatly improve accuracy for climate models by analyzing the internal content of the polar ice sheets. There are two main internal layers: deep layers and near surface internal layers.



**Figure 2: Example of Near Surface Internal Layers from Radar Sounding [10]**



**Figure 2: Description of Various Near Surface Ice Layers [7]**

### **Physical Properties of Near Surface Internal Layers**

Near surface internal layers are complex and vary from year to year and can be characterized into three classes: accumulation, icy layers, and depth hoars. An explanation of the three specific layers can be explained below:

Accumulation layers are the greatest amount of granulated, compacted snow, which has passed through a particular melt season, near the surface. Snow, during an accumulation event, gets buried deeper into the ice sheet. Accumulation densities are influenced by heat flux and weight, which vary and cause depth hoards. Also,

Hoar layers, most visual in near surface layers are formed when ice crystals are sublimed because of large temperature gradients. Near surface internal layers cause temperature gradients to form when surface air temperature is warmer [6]. Modulating layer density allows water vapor to exchange among layers [5]. The density among surrounding layers

are caused by substantial reflection because of the huge contrasts compared to adjacent layers.

Icy layers represent a small fraction of near surface internal layers, but they cover very broad areas. Precipitation, temperature and wind conditions form icy layers, and although the dry snow zone does not have events of either rain or melt, mechanisms allow for kinetic heating and compaction.

## **Conclusion**

Global climate change can provide devastating consequences for coastal regions due to a rise in sea level. The state of the mass balance is depended on glaciers since they provide significant historical information. Understanding glacier behavior relies on developing accurate climate models for forecasting global climate change. 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.

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