INTERNATIONAL POLAR YEAR

Ice Sheets

Ice sheets, the large, thick and 'permanent' frozen masses that cover most of Antarctica and Greenland, represent a distinctive feature of our planet. Antarctic and Greenland ice sheets contain almost all of the world's ice and most of the world's fresh water. Ice sheets accumulate new layers of snow at the surface. They slowly flow toward coastlines, often in large ice streams, and can extend over adjacent oceans as ice shelves. During cold climates (ice ages), the mass and area of ice sheets grow, and global sea level decreases. During warm climates, the mass and area of ice sheets decrease and sea level rises.

Antarctica

The large East Antarctic ice sheet, with average thickness of over 2 kilometres, probably started 25 million years ago. It flows over bedrock above sea level. The younger West Antarctic ice sheet currently fills basins that lie below sea level in many areas. Complete melting of the East Antarctic ice sheet would raise global sea level by more than 50 metres. Disintegration of the relatively unstable West Antarctic ice sheet would raise sea level by five meters.

Greenland

The Greenland ice sheet covers 85% of Greenland, with an average thickness greater than 2 kilometres. Most areas of the Greenland ice sheet receive more snowfall than the central areas of Antarctic ice sheets; Greenland also has relatively fast-moving ice streams and glaciers at its periphery. If glacier outflow and melting completely erode the the Greenland ice sheet, global sea level will increase by more than seven meters.

Ice Cores

As snow compresses at the surfaces of an ice sheet, it traps the current atmosphere as bubbles in the ice. These bubbles provide a stable and accurate record of atmospheric composition. By drilling cores through these ice layers, scientists reconstruct detailed records of past climate. The longest of these records, now reaching 800 000 years into the past, comes from a core drilled at Dome C in Antarctica. This core records nine cycles of warm (interglacial) and cold (glacial) climate. The longest ice core records from Greenland go back slightly more than 120 000 years. Due to higher precipitation rates and faster accumulation processes, the Greenland cores provide detailed records of past events that happened on time scales as short as decades.

Under the Ice

During cold climates, ice sheets eventually cover land features and form a gradual dome-like structure. As ice mass increases, the ice starts to deform and flow outwards.

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Processes beneath these flows, between the ice and underlying land or between ice shelves and underlying ocean, have important impacts on overall ice sheet flows. A network of sub-glacial lakes and channels exists beneath portions of the Antarctic ice sheets. Liquid water moves between the sub-glacial lakes, apparently relatively rapidly on occasion. In Greenland, melt water appears to penetrate quickly through hundreds of meters of ice to the base of ice streams. Research during IPY will focus on erosion of floating ice shelves and submarine ice sheets by warm ocean water, and on how loss of floating ice shelves appears to accelerate flows in adjacent land glaciers.

Historical Exploration

Adventurers with now-familiar names (Shackleton, Mawson, Amundsen, Scott) explored Antarctic ice sheets in the first decades of the 20th century. Systematic surveys of the structure, thickness and dynamics of ice sheets started during the International Geophysical Year (IGY) of 1957-58 when researchers from several nations conducted traverses across unexplored areas of Antarctica. These traverses produced excellent first approximations of snow surface elevation, ice thickness, snow accumulation and bed topography of East and West Antarctic ice sheets. Similar scientific traverses occurred in Greenland in the late 1950's and early 1960's.

Modern Exploration and Monitoring

Urgent questions of how fast ice sheets can change require advanced tools and models, but also on-ice measurements related to those of 50 years ago. Sensors on satellites monitor changes in ice sheet volume and rates and patterns of ice flows. Precise satellite observations of ice surfaces provide information about sub-glacial lakes. Other satellites detect changes of the large ice masses through sensitive measurements of the gravitational field.

Detailed on-ice measurements of glacial flows, especially in Greenland, provide new information about discharge rates at the Greenland margin. During IPY, international teams will conduct several traverses across Antarctic ice sheets, gaining essential information about accumulation, flows and sub-ice geology. IPY researchers will undertake new ice drilling operations, in high accumulation regions of Antarctica to match existing Greenland cores, through shelf ice into ocean sediments, and into sub-glacial lakes. Researchers will assess whether drilling in thick Antarctic ice near Dome A might provide a longer ice core record, of 1 000 000 years or more.

Ice Sheets

Ice Sheet Activity: Make an 'Ice' Sheet

Materials per pair of students:

- Clay for land. (To make your own clay, mix 1 cup of salt, 1 ½ cups of flour, and ½ cup of vegetable oil with water to make a thick clay-like mixture.)
- Small plate, bowl, or pan.
- Cornstarch (½ cup) mixed with a little water for ice. This mixture should drip from your fingers, but should feel 'solid' when tapped.

Directions:

1. Use clay to build a land mass with features like mountains and valleys.
2. Place 5-6 tablespoons of cornstarch mixture in the location that the ice sheet will first form. Watch where the ice sheet moves.
3. Add more cornstarch mixture at the ice center.
4. Observe where the "ice sheet" moves.

Concepts:

- The cornstarch behaves somewhat like a real ice sheet: it flows around mountains, it will flow over an ocean, it can cover the whole landscape.
- The cornstarch does not show all aspects of a real ice sheet. Large ice sheets can have continuous flows from high point to low point and from surface to bottom. Often, ice at the bottom of an ice sheet, under the most pressure, moves fastest.
- What would happen if your ice sheet flowed over a thin layer of liquid water?

For more information, try any of these links:

- https://www.cresis.ku.edu/education
- http://www.ldeo.columbia.edu/edu/polareducation
- http://www.discoveringantarctica.org.uk/index.php
- http://www.andrill.org/education

Find these and other educational materials in: Kaiser, 2010, Polar Science and Global Climate, An International Resource for Education and Outreach, ISBN 978 1 84959 593 3, www.pearson.co.uk.

www.ipy.org

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