Some notes on glaciers

Density of water

- Liquid water is 1 gram per cubic centimeter (g/cm^3)
- Glacial ice is ~0.9 g/cm^3 -- less dense than liquid water, so ice floats
- Firn (granular recrystallized snow) is ~0.4-0.5 g/cm^3
- Snow varies from ~0.03-0.07 g/cm^3 (dry snow) to ~0.1-0.2 g/cm^3 (wet snow)

Archimedes Principle of buoyancy applied to an iceberg: the volume of submerged ice displaces a mass of liquid water equal to the total mass of an iceberg. Hence, only 10% of the iceberg sticks up above the water line.

Continental glaciers and ice caps occur on continental crust. Current examples are on Greenland and Antarctica.

Alpine glaciers currently exist in highland areas and generally flow down pre-existing stream drainages.

Sea ice is seldom more than a few meters thick and is not properly considered a glacier.

An **ice shelf** is the seaward extension of a continental ice sheet, so there is sea water below the ice shelf.

Glaciers can reach a thickness of no more than ~4 km (~2.5 miles). Beyond that thickness, the pressure at the base of the glacier compresses the ice into a denser form: liquid water.

Glaciers have a **brittle upper layer** that is ~40 m (~130 ft) thick, and cracks in that layer are called **crevasses**.

Below the brittle upper layer, there is a **lower creeping layer** because the glacial ice is under sufficient pressure to flow (like silly putty) rather than fracture.

If ice is less than ~40 meters thick, it cannot flow and is not a glacier. It is a persistent **ice patch**.

Glacial ice flows from its thickest point in the zone of accumulation to the thinnest points at the (downflow) edge of the glacier. Continental glaciers are so heavy that they can depress the continental crust by as much as ~1 km below pre-glacial levels. Consequently, continental glaciers typically occupy a dish-like basin, and flow (along their base) ***uphill*** given that they flow from thick to thin.

Over the past ~3 million years, continental ice sheets have formed repeatedly on North America, centered on Hudson's Bay, Canada. From that center, they have flowed in all directions, including south to as far as around St. Louis, Missouri. The most recent glacial maximum was around 18,000 years ago, and the continental glacier retreated from the continental United States by around 10,000 years ago.

Glaciers have a **zone of accumulation** (the area in which more snow accumulates each winter than is melted during the subsequent summer) and a **zone of ablation or wastage** (where less snow accumulates each winter than melts during the summertime). The **firn limit** s the approximate dividing line/zone between the two.

All ice particles in a glacier move from the zone of accumulation toward the zone of ablation, from thick ice to thin ice. **Glaciers do not have a reverse gear**. In an **advancing** glacier the end of the glacier (*i.e.,* the terminus) moves down-flow. In a **receding** or **retreating** glacier, the terminus moves up-flow as the glacier melts faster than it moves forward.

Glaciers shrink by **melting**, **evaporation**, **sublimation**, **calving** to form icebergs (if they flow into a body of water), or **segmentation** by abandoning stagnant ice blocks.

Glaciers erode the material they pass by through **plucking** of blocks, **grinding** and **abrasion** of bedrock (creating grooves, striae and polished bedrock), **landslides** along the sides of alpine glaciers, and by erosion and deformation of older glacial deposits.

Glacially sculpted valleys have a characteristic U-shaped profile. (In contrast, valleys incised into bedrock by streams tend to have V-shaped profiles.)

Ridges of debris deposited by glaciers are called moraines. There are **medial**, **lateral**, **end/terminal**, and **recessional** moraines.

Varves are layered sediments deposited in glacial lakes, in which one layer is deposited per year.