Glaciers and Glaciation

The portion of the Earth system frozen all year is called the cryosphere.

How to get a glacier

- A glacier can only form in a place where the total accumulation of snow in the winter is greater than the total amount of ablation in the summer.
  - Ablation = melting and sublimating
- The snowline is the altitude/latitude at which winter snowfall equals summer ablation.
  - Higher altitude/latitude has net accumulation.

Six fundamental types of glaciers
1. Cirque glaciers
2. Valley glaciers
3. Fjord glaciers
4. Ice caps
5. Ice sheets
6. Ice shelves

Cirque Glacier

Valley glacier
Ice cap

Malaspina glacier in southeastern Alaska is a piedmont glacier

Thermal classification

- Warm glaciers (Temperate glaciers)
  - Glacier in which the ice is at or near its pressure-melting point throughout the ice mass

- Cold Glaciers (Polar glaciers)
  - Subpolar glaciers (cold glaciers)
    - Glacier in which the ice mass is generally below the pressure-melting point except for summer melting of the upper few meters
  - High-polar glaciers
    - Glacier characterized by an ice mass that is below the pressure-melting point at all times
Temperature at base of glacier
• Temperature of basal ice relative to melting temperature is perhaps the primary determinant of a glacier’s ability to do geomorphic work.
• Glaciers with basal ice at melting temperature tend to move faster, erode more, and carry greater loads than polar glaciers.

Mass Balance (Glacial Budget)
• Accumulation = water equivalent of ice and snow added to a glacier over a period of time in question.
  – Snowfall, rain, and other water that freezes on the surface, avalanches from the valley walls, and the “freeze-on” of meltwater at the base of the glacier.
• Ablation = removal of snow or ice by melting, evaporation, wind erosion, sublimation, and calving in the period of time in question.

Mass Balance for a glacier
• Any glacier may have
1. Positive mass balance = more accumulation than ablation
2. Negative mass balance = excess of ablation
3. Zero mass balance = accumulation and ablation are balanced

Zones of accumulation and ablation
• Upper part of the glacier usually has a positive mass balance, and lower part a negative mass balance.
• Zones of accumulation and ablation are separated by the equilibrium line.
  – Equilibrium line ≠ firn line (snowline) which is usually marked by snow above the line and dense blue ice below it.
How glaciers move

1. Internal flow
   - Ice deforms under gravity as ice crystals shear past each other.

2. Basal sliding
   - The glacier’s base slips along its contact with the soil/bedrock floor.
Erosional features

- Horn peaks
- Arêtes
- Cirques
- Glacial valley and hanging valley
- Glacial polish and scour
- Roche moutonnée
Abrasion

- Ice is 1.5 on the Moh's Scale of Hardness
  - Need fragments of other rock particles to abrade
Depositional features

- Erratics
- Moraines
- Kames
- Eskers
- Till
- Drift
Blue line is 2002
Left to right are modeled extents in 2030, 2060, and 2090

Recent N. Pole temperature
Sea ice formation and surface ocean salinity.

- As ocean water freezes, salt is excluded from the ice.
- Formation of sea ice leads to more saline surface water, which can become dense enough to sink.
- This is a major source of deep ocean water.
- As sea ice melts, surface water salinity drops.

Other effects of sea ice on the Earth system

- Ice is more reflective than water (higher albedo).
  - Reflection of solar radiation keeps the area cooler than it would be with water.
- Sea ice separates the ocean from the atmosphere and reduces evaporation.
  - Makes the air dryer than if water was exposed to atmosphere.
- Allow migration routes for some organisms
The Ice Age and glacial periods

• We are presently in an ice age that began about 2 Ma.
  – Pleistocene epoch of the Quaternary period of the Cenozoic era.
• The last glacial period began about 75,000 years ago.
• We are presently in an interglacial period which we call the Holocene epoch that began 10,000 years ago.

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<th>Name</th>
<th>Climate</th>
<th>Time Spanned (years ago)</th>
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<td>pre-Nebraskan</td>
<td>predominantly warm</td>
<td>1,600,000 - 800,000</td>
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Causes of Ice ages

1. Plate tectonics
   – Continents grouped over the poles
2. Reduce greenhouse gas in the atmosphere
   – Burry organic material or increase weathering of continental crust
3. Changes in the orbit of the Earth around the Sun
   – Milankovitch cycles
“This is the way a glacier dies.” – Mark Bowen, *Thin Ice*