Lecture 17

GLY102

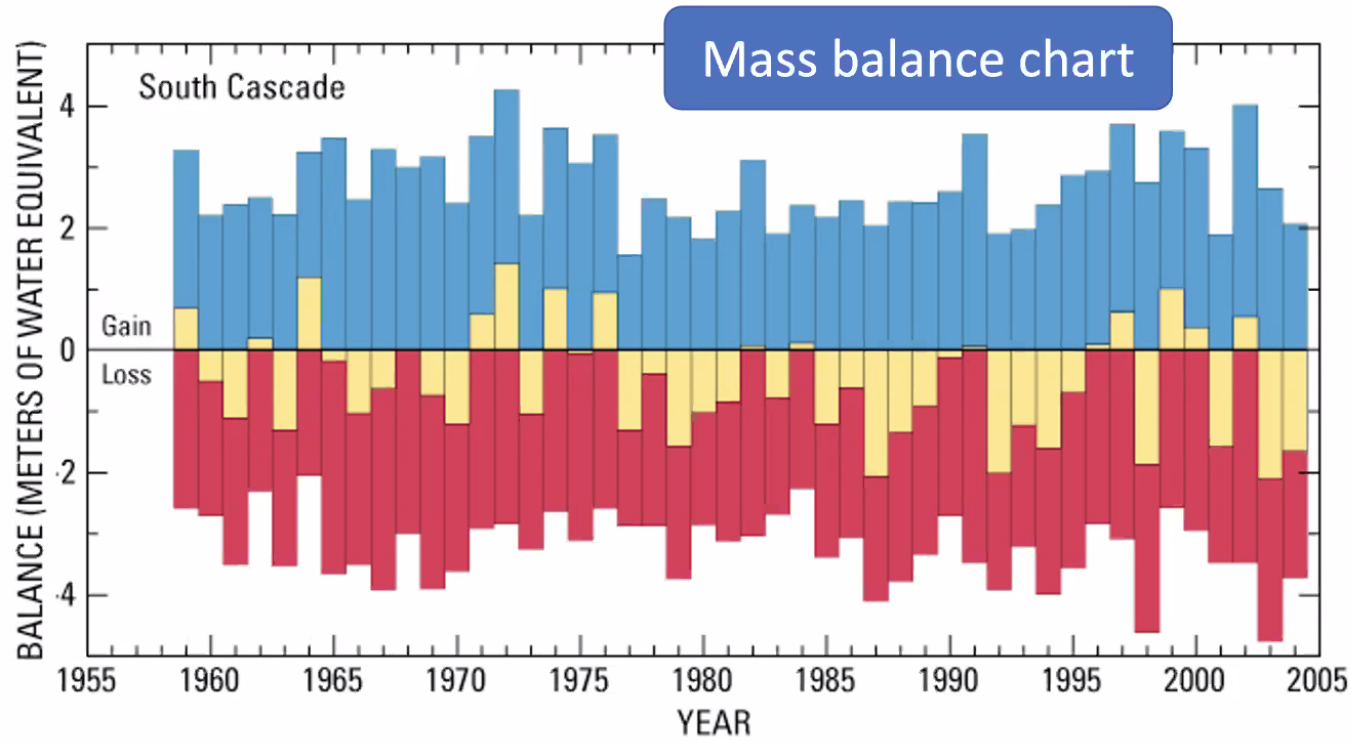
3/30/2021

Ice Sheets

Review

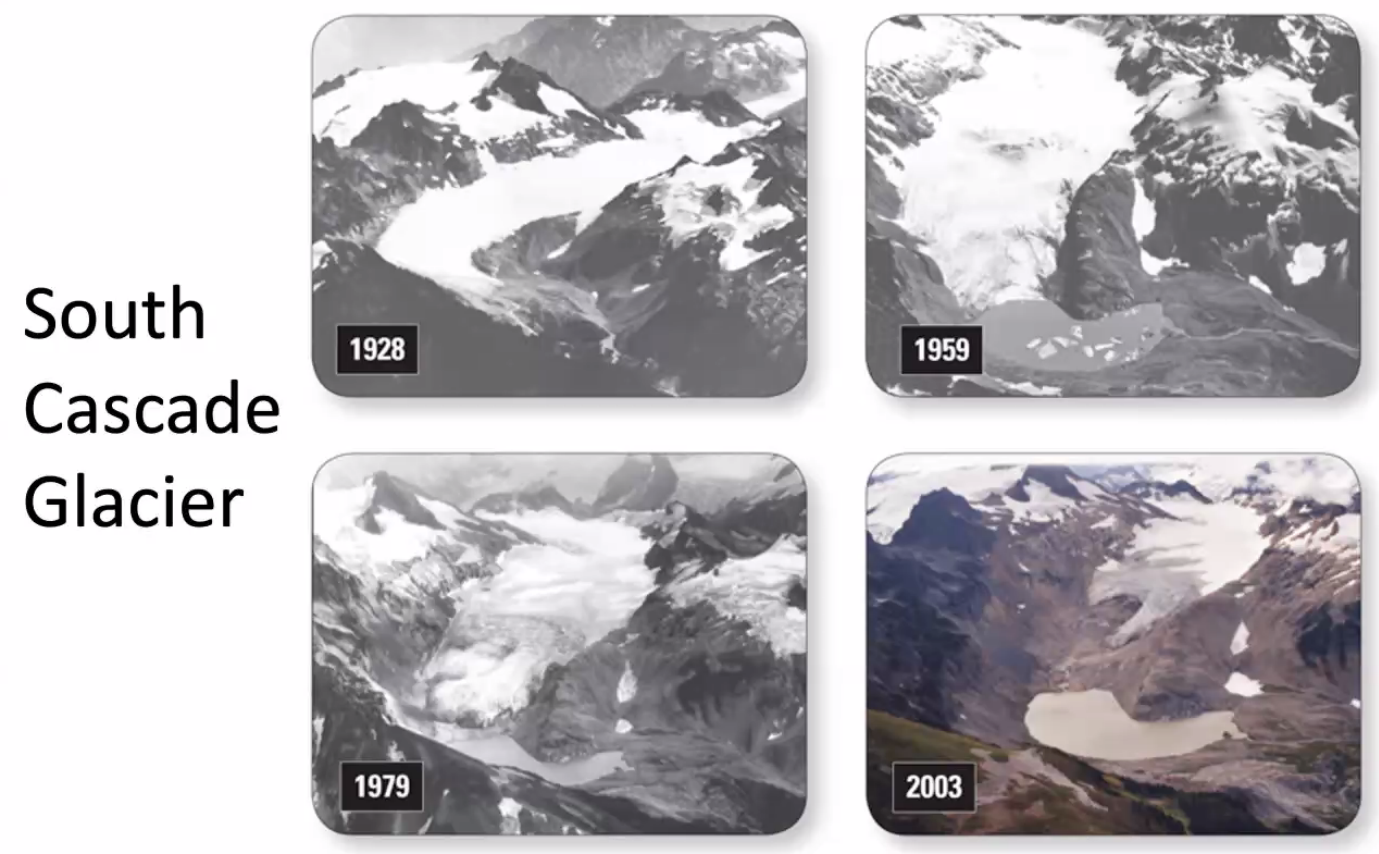
Glaciers


1936
2014



Note that the above chart is focused on the weather, rather than the climate. Year-to-year variability is normal.If we focus on the yellow, we see more signs of glacier retreat than growth, however.

Pictures of the glacier on which the above chart is based:



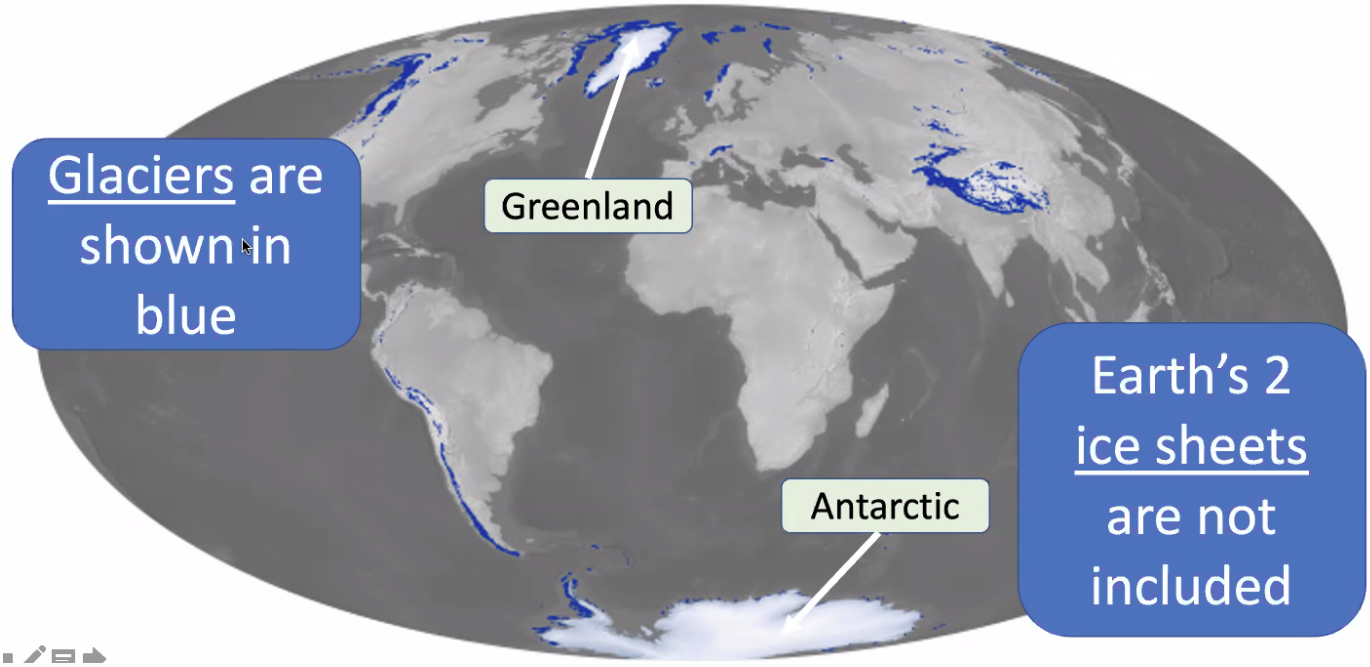
Thus, glaciers move via two mechanisms:

1. Internal deformation, like silly putty
2. Sliding at their base (water needed at the base for this)

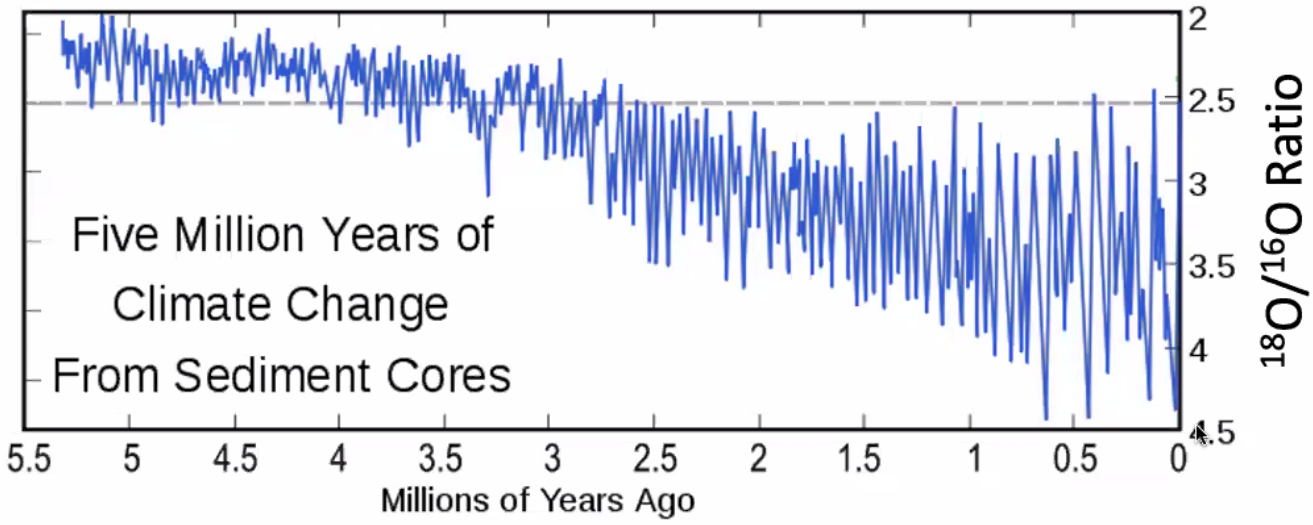
- The water being there implies the temperature is around 0°C, allowing both ice and water to exist at the bed of the glacier.
- If you put a lot of pressure on an environment, you can have water at below freezing (not by much, -1°C likely) so it's possible that temperature varies a bit.

> **Given global temperature increase, how might glacier flow change?**
>
> Melting on top of glaciers --> water pouring into the moulins of glaciers --> water going to the bottom of the glaciers --> water lubricates the bed --> causes more ice being put into the ocean faster --> faster sea level rise

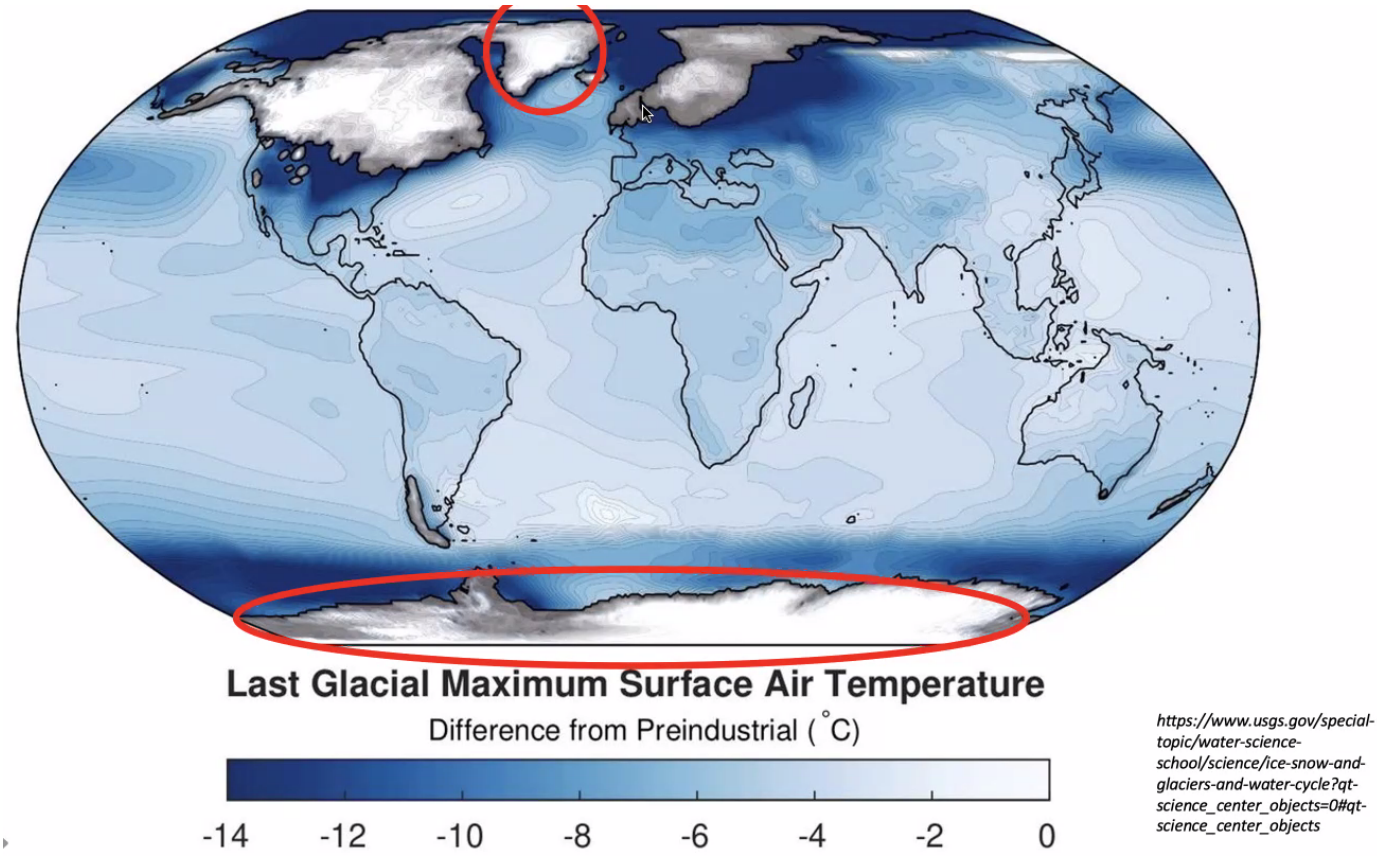
Glaciers and Ice Sheets



But remember, today's ice sheets are smaller (and there are fewer of them) than the typical conditions of recent Earth history...

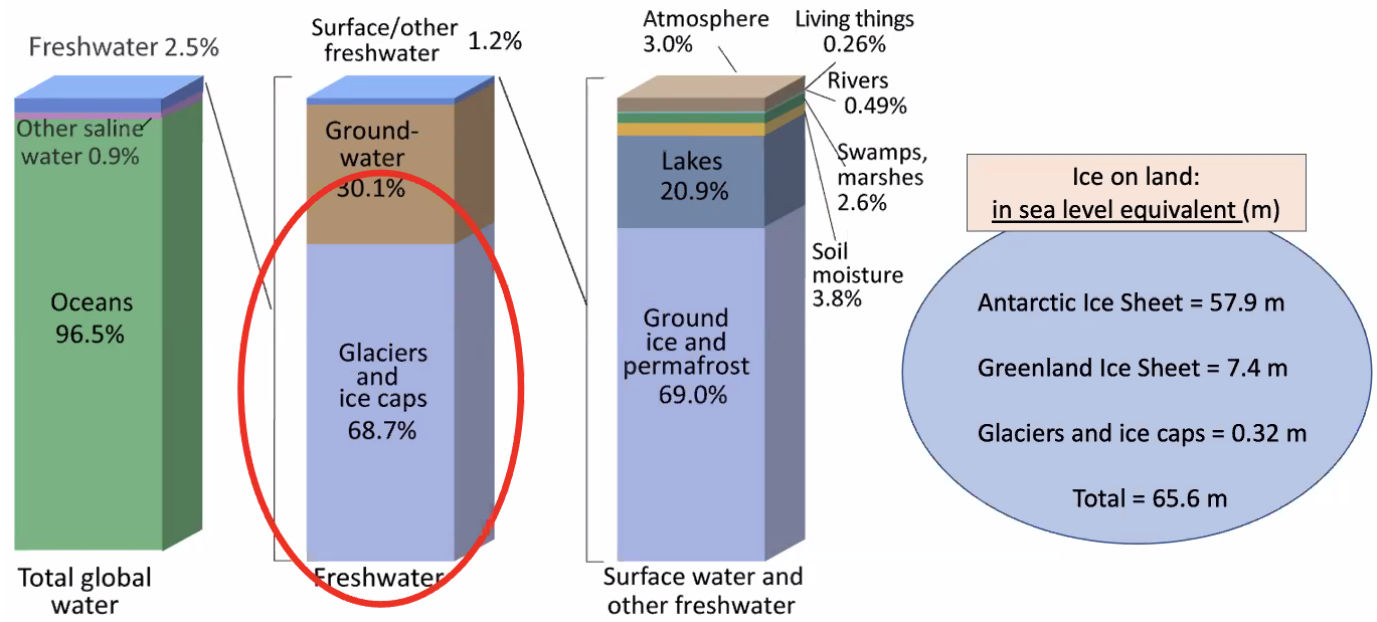


Map of the Ice Sheets of the past (I think):

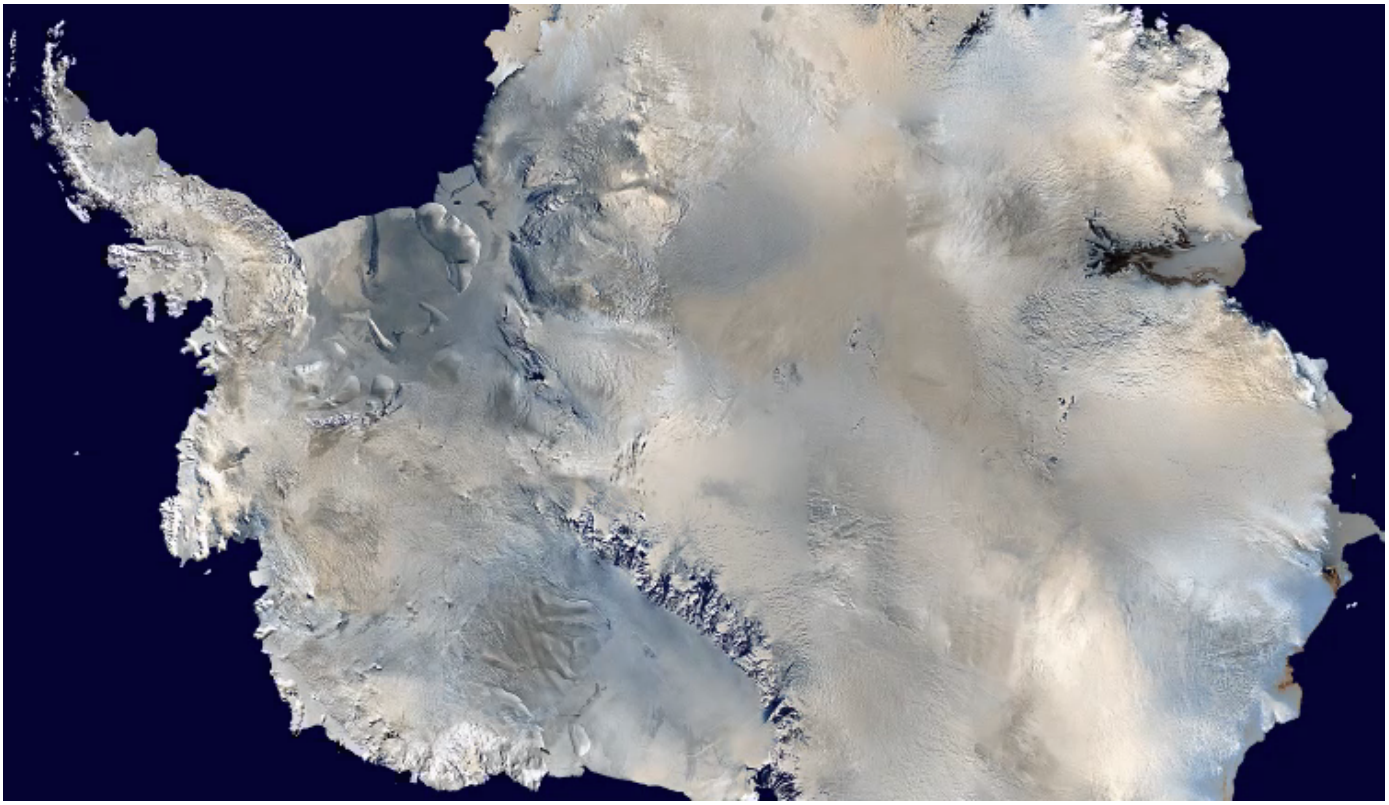


https://www.usgs.gov/special-topic/water-science-school/science/ice-snow-and-glaciers-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects

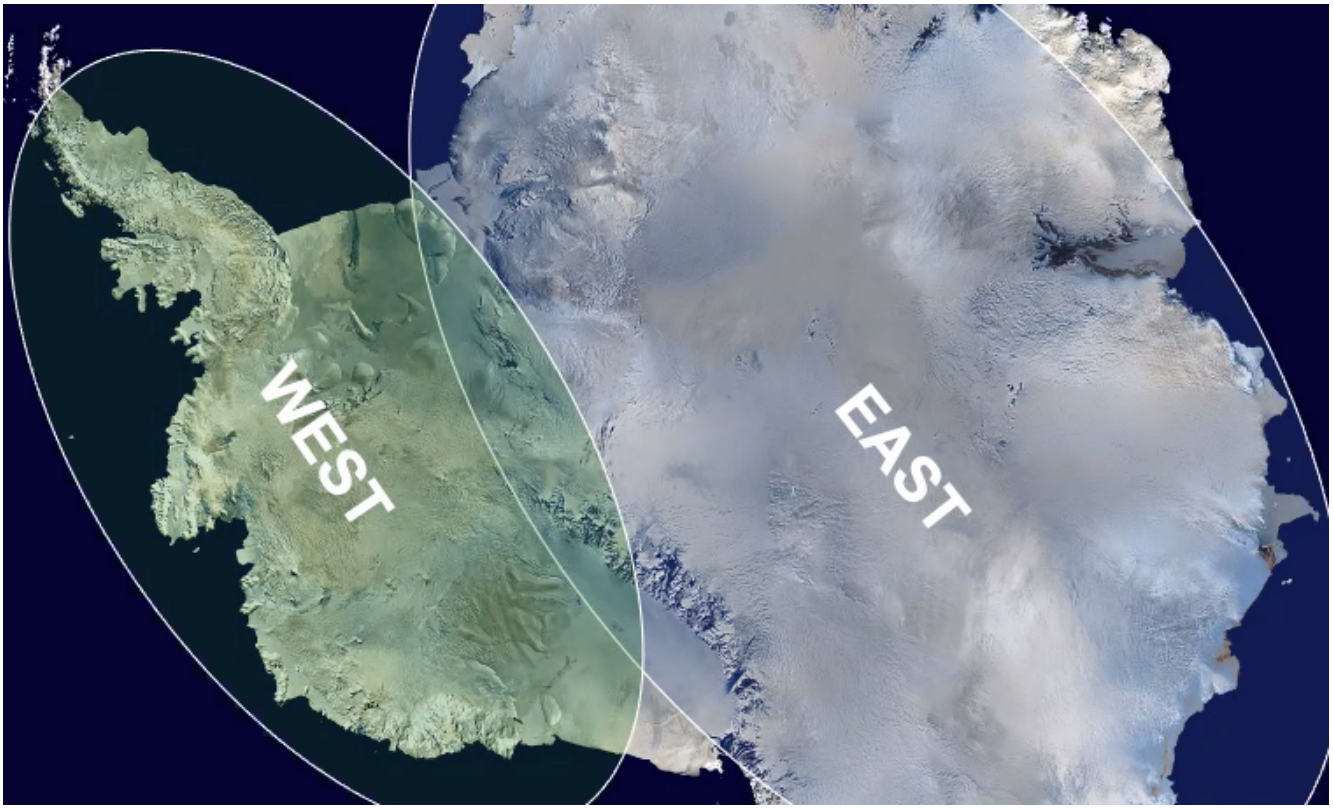
Where is Earth's Water?



The Antarctic Ice Sheet



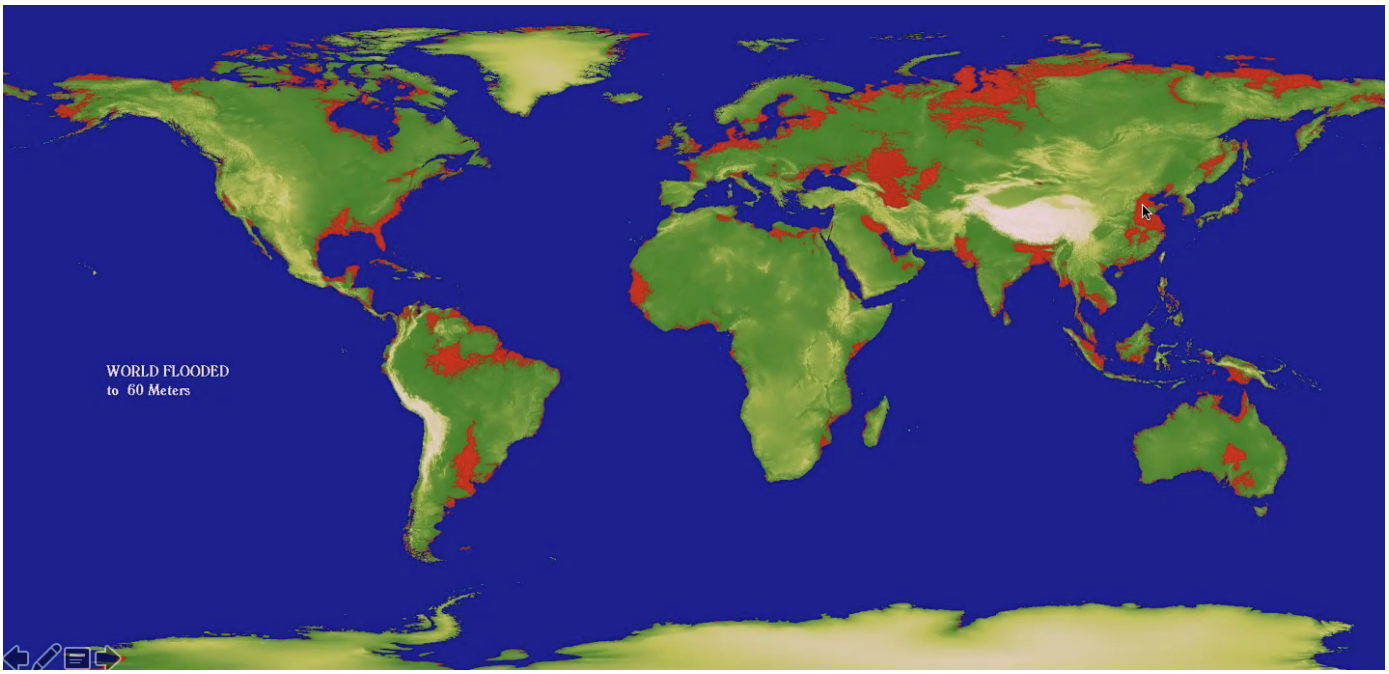
- 60% of all fresh water on Earth
- 68 meters of sea level equiv.
- 15650 ft. thick
- Composed of EAST and WEST Antarctic ice sheets:



The Greenland Ice Sheet

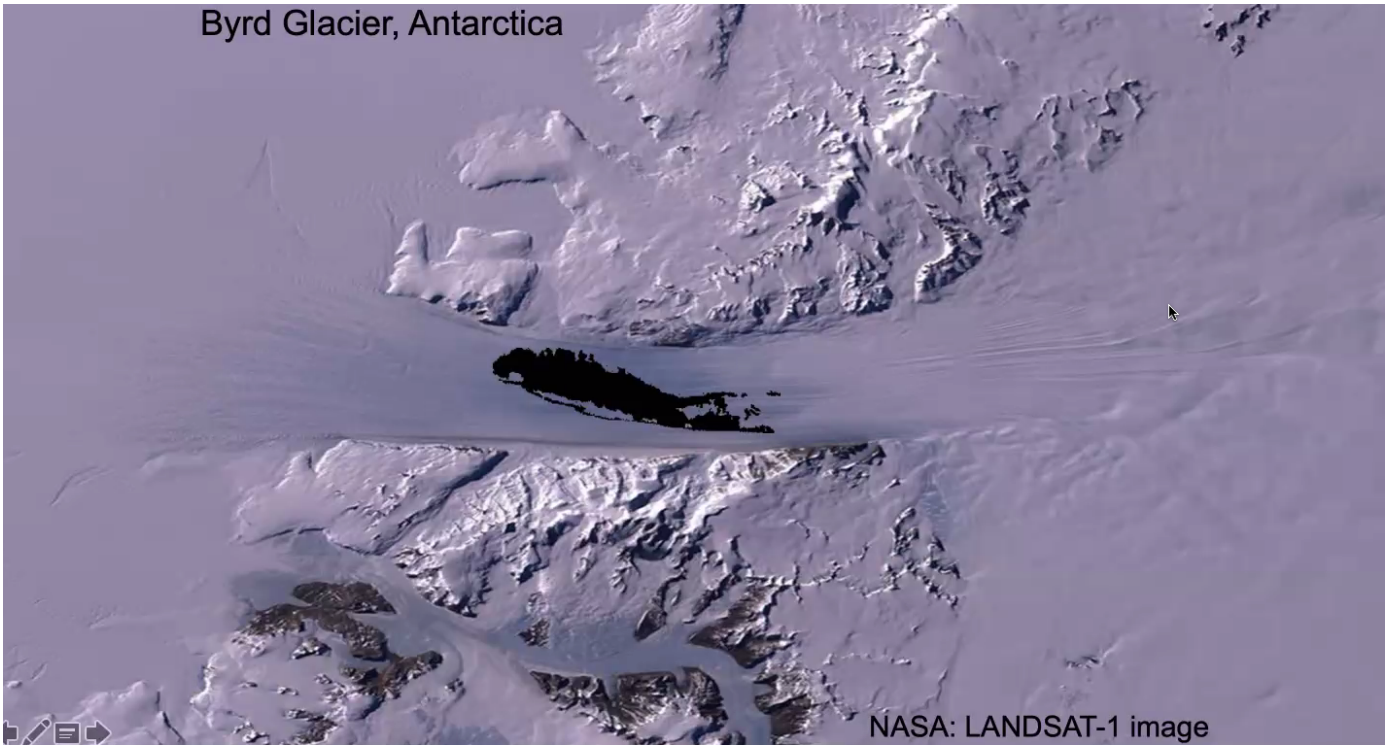
--~7 meters of sea level equiv. -Summit 10,794 ft asl -1.9 miles thick of ice	

The World Without Ice Sheets

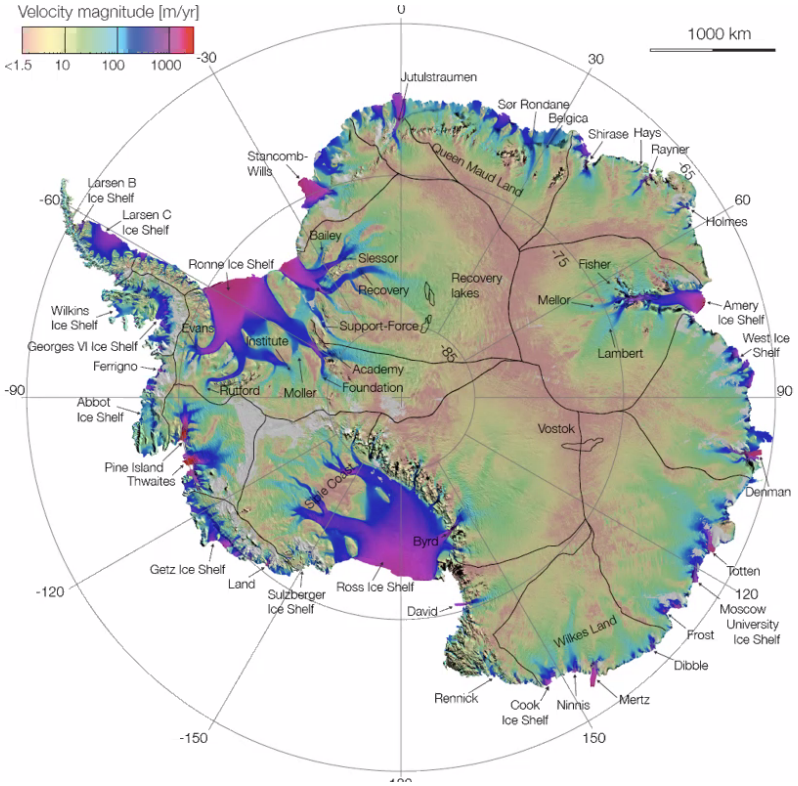


Satellite and Airplane Data

We know a lot more about the ice sheets because of our use of satellites.

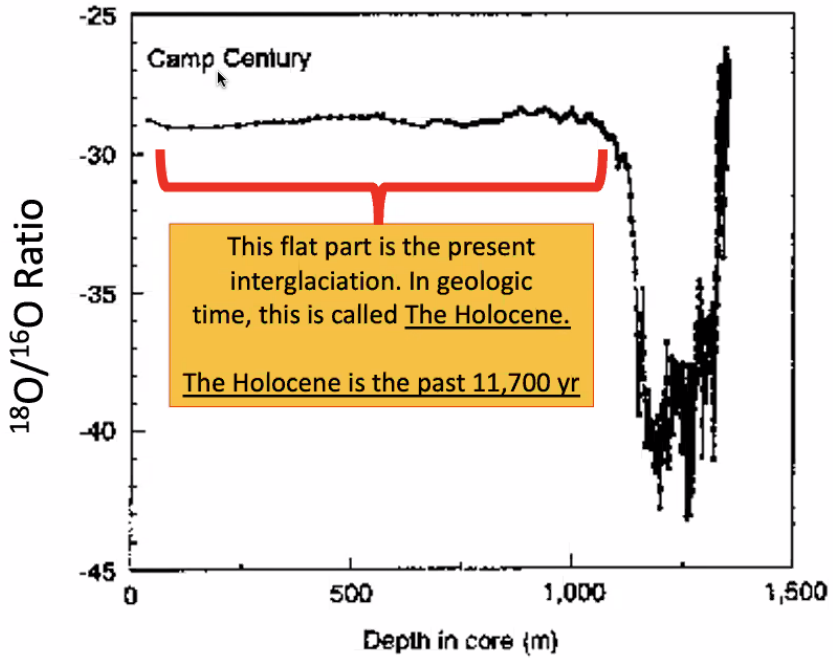


(Long Island in the middle for scale)



The first map showing Velocity of ALL of Antarctica didn't exist until 2011

Remember this Greenland Ice Core?



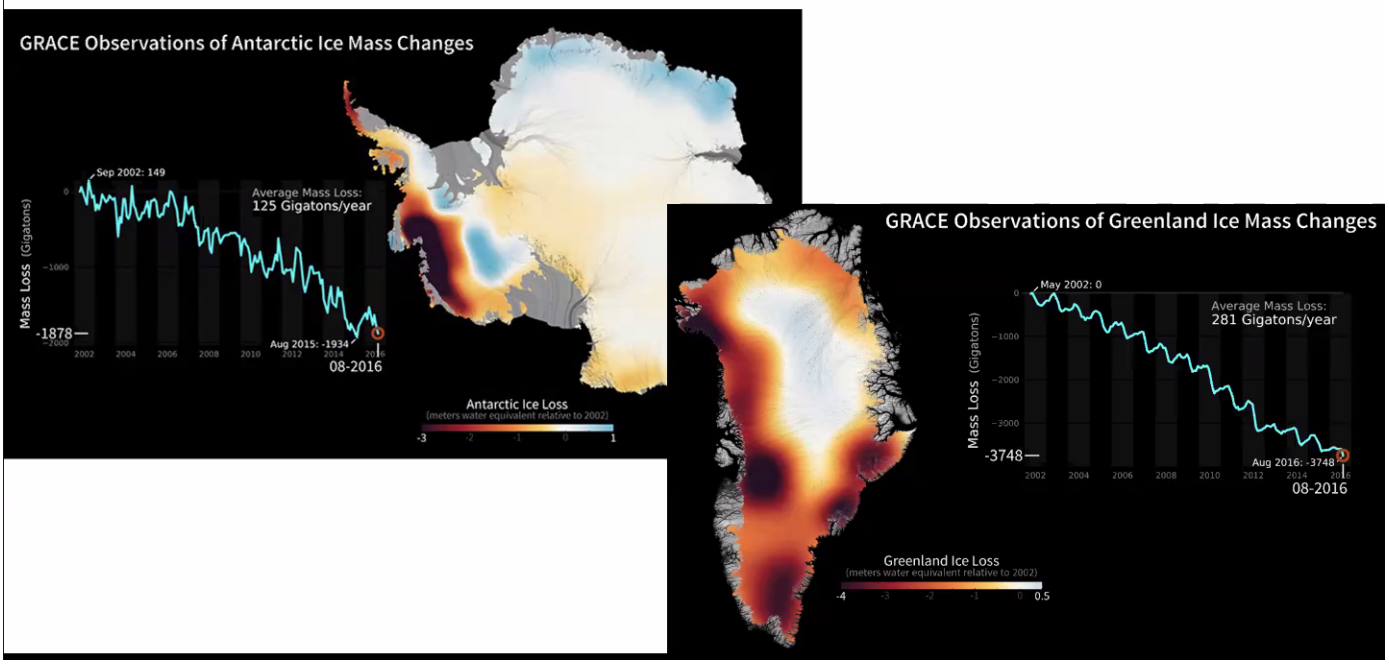
The big drop towards the right is the "last ice age" (really the last "glaciation") The high point to the far right is the last interglaciation, known as the *Eemian period*

One satellite (RADARSAT) uses RADAR to measure velocity.

ICESat uses laser altimetry to produce a map of surface elevation change.

The GRACE satellite measures the gravity anomalies (the study of gravimetry). It's used to determine changes in the Earth's mass through time.

Gravity anomalies of ice sheets

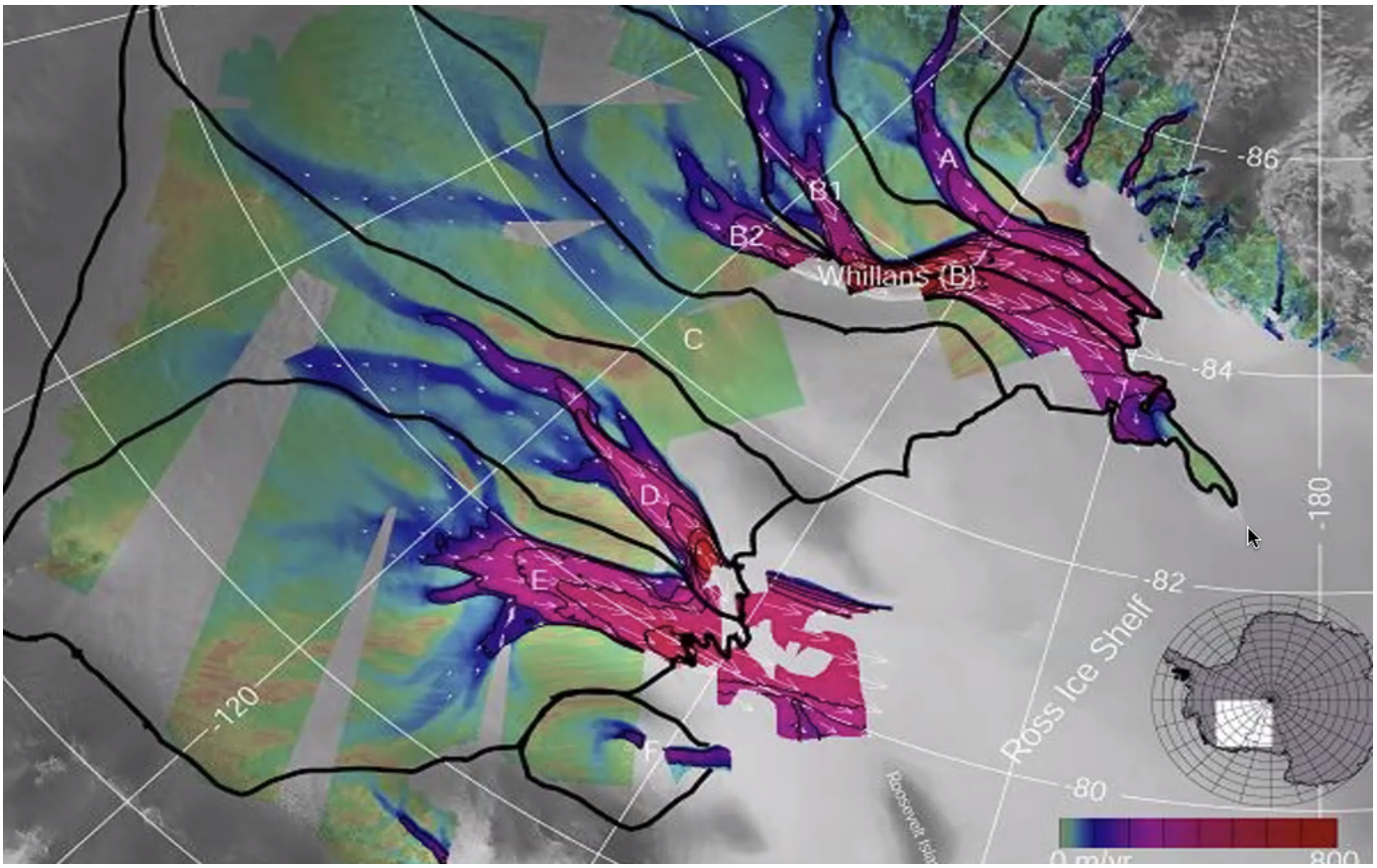


Satellites: Summary

1. Satellites (and airplanes) that use RADAR (like RADARSAT) measure ice sheet velocity and ice sheet thickness
2. Satellites that use laser altimetry (ICESat) measure changes in ice sheet surface elevation
3. Satellites that use gravimetry (GRACE) measure mass changes of ice sheets through time.

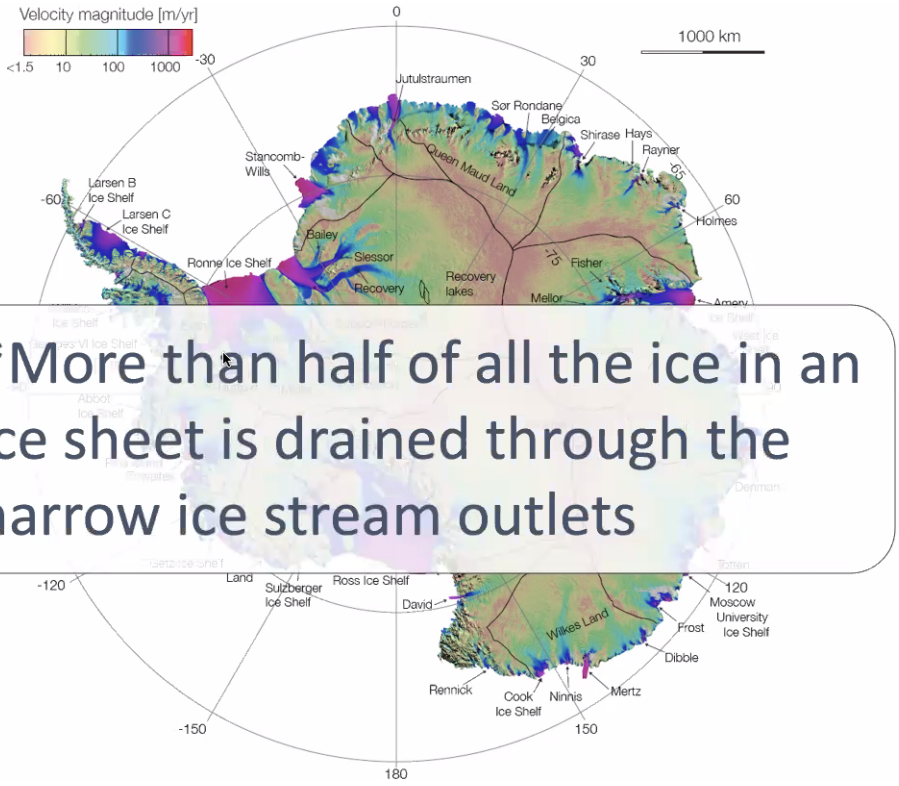
Ice Streams and Ice Shelves

Ice Streams



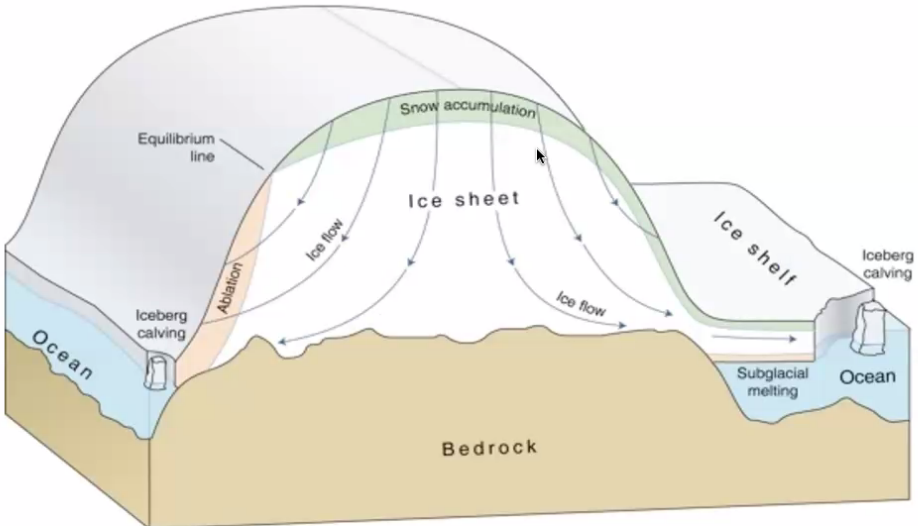
> **An Ice Stream is a zone of fast flowing ice within an ice sheet.**

Ice stream shear zone



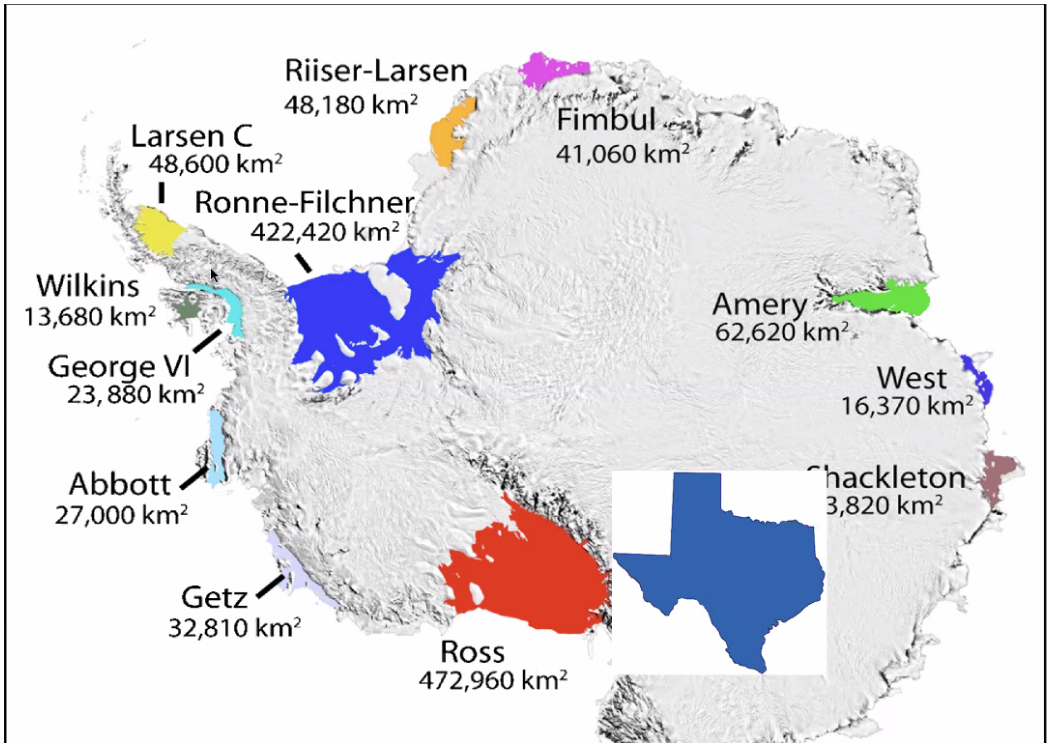
*More than half of all the ice in an ice sheet is drained through the narrow ice stream outlets

Ice Shelves



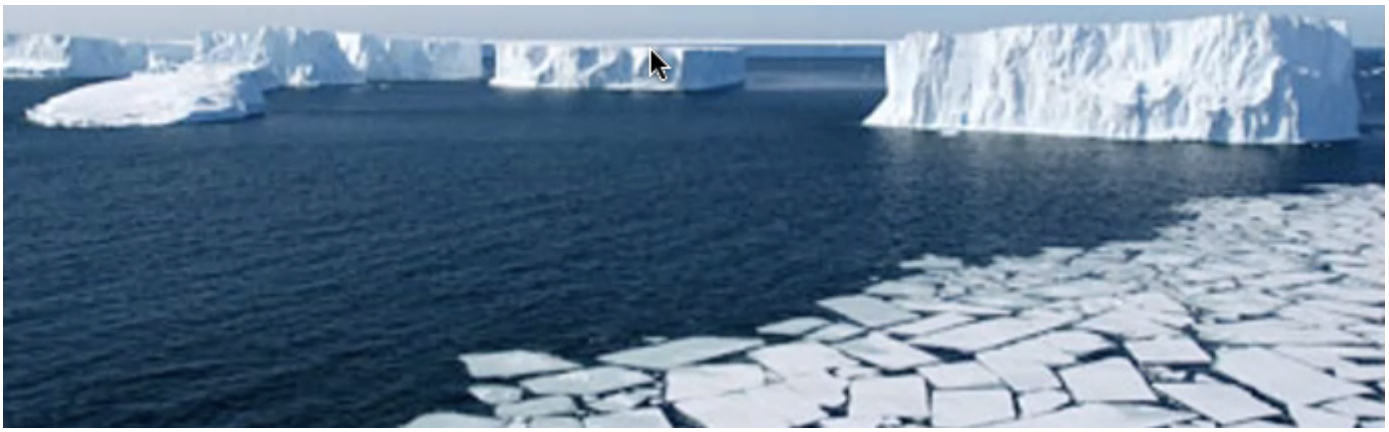
Ice shelves are the “front” of an ice sheet being pushed out into the ocean.

- Floating, flowing glacier ice
- Input by ice sheet flow
- Output by calving
- They experience basal melting



We can tell the thickness of Ice Shelves from satellites, similar to ice sheets.

Sea ice and ice shelves are NOT the same thing:



Sea ice is the seasonally freezing of the ocean surface.

Ice shelves are where glacier ice flows into the ocean.

Ice Sheet Mass Balance

All glaciers strike a *balance* between parts that accumulate snow (which turns into ice) and parts that experience net ice loss.

These zones are referred to as the "accumulation zone" and the "ablation zone".

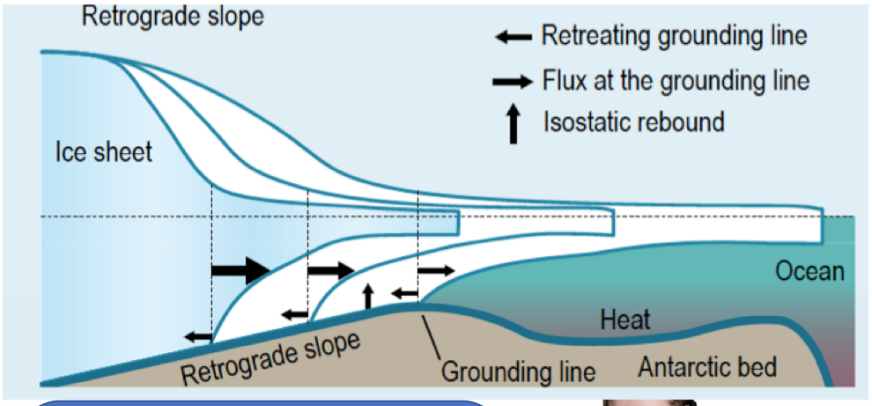
- Same as for a glacier, but the geometry is different. Summit (high elevation) is the accumulation zone.
- Some ice sheet sectors do not experience surface melt, hence all "ablation zone" ice loss is via calving of icebergs.

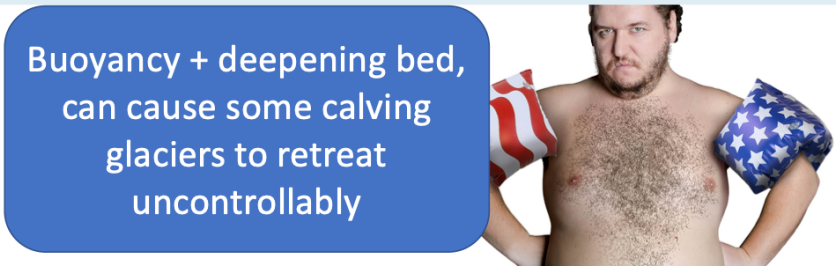
The Antarctic Ice Sheet has very little ablation zone. So what happens to all the snowfall? **It exits via calving.**

Calving Glaciers - any glacier that flows into a lake or ocean, and breaks off (calves) into icebergs

Glacier calving rates can increase in deeper water. When the glaciers approach deeper water, they become buoyant and float which is “an easy way to make icebergs” and break apart.

This is not good because it means once you begin to retreat into deeper water, you continue to retreat.





Next Lecture: Sea Level Rise