

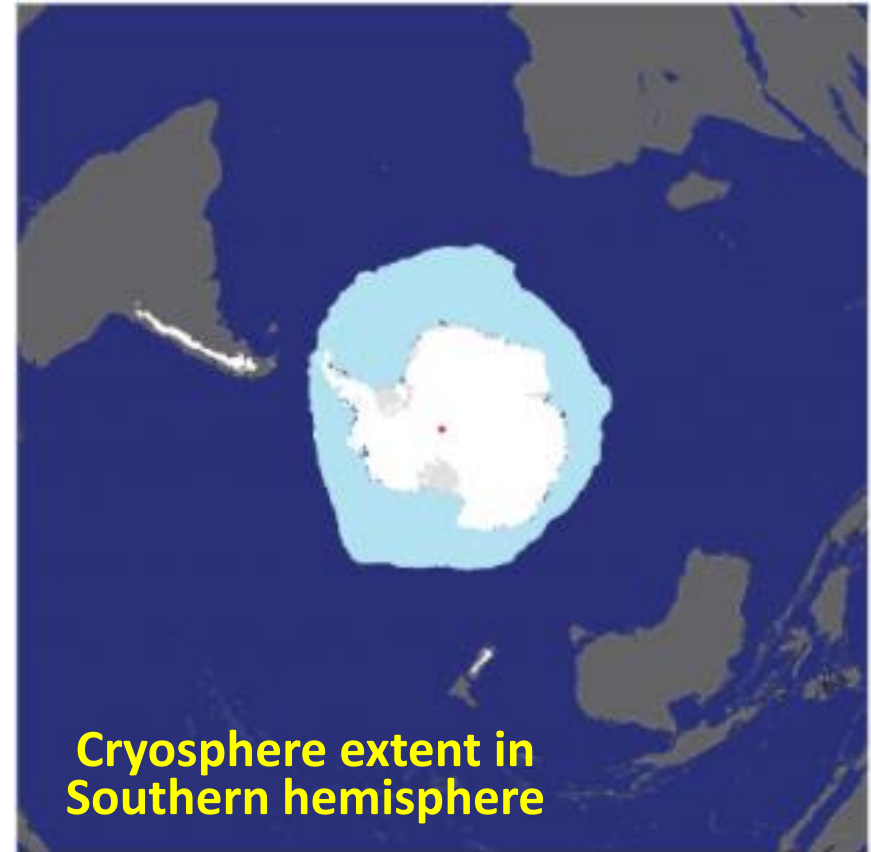
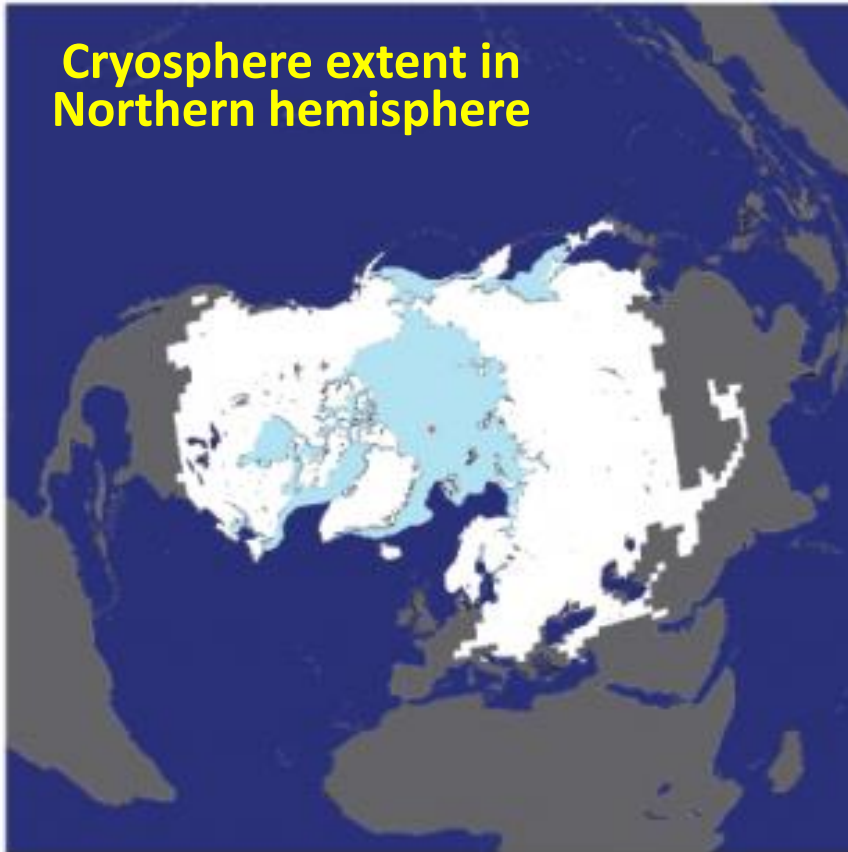


# CRYOSPHERE

## THE FROZEN EARTH

About **2/3** of the world's freshwater is **frozen** in ice sheets, glaciers, permafrost and sea ice.

# Freshwater: Frozen Water



The cryosphere consists mainly of the permanent ice caps of Antarctica and Greenland, with much smaller amounts in Arctic and mountain glaciers.

# Cryosphere Components

ICE SHEETS

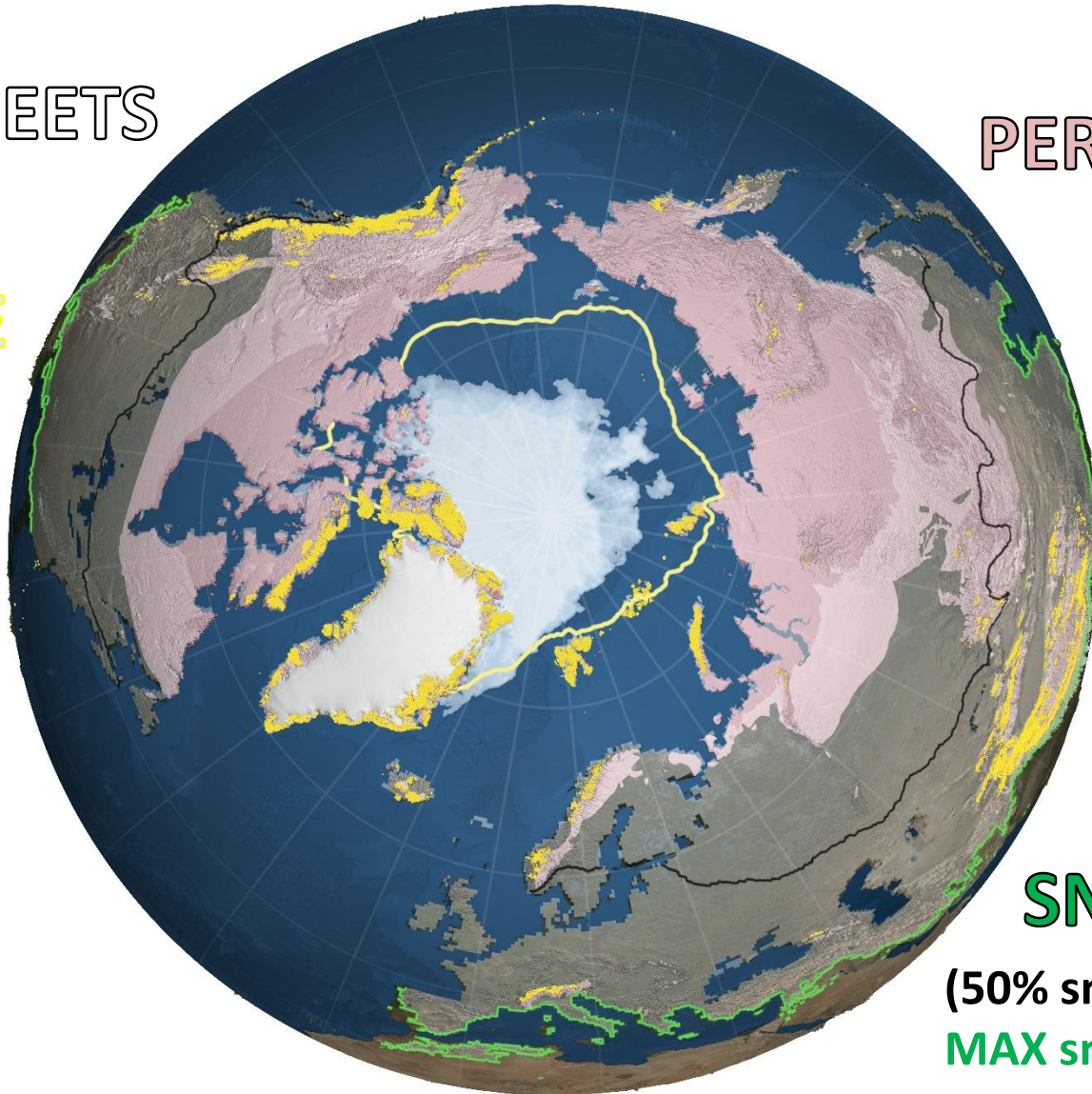
PERMAFROST  
(frozen ground)

SEA ICE

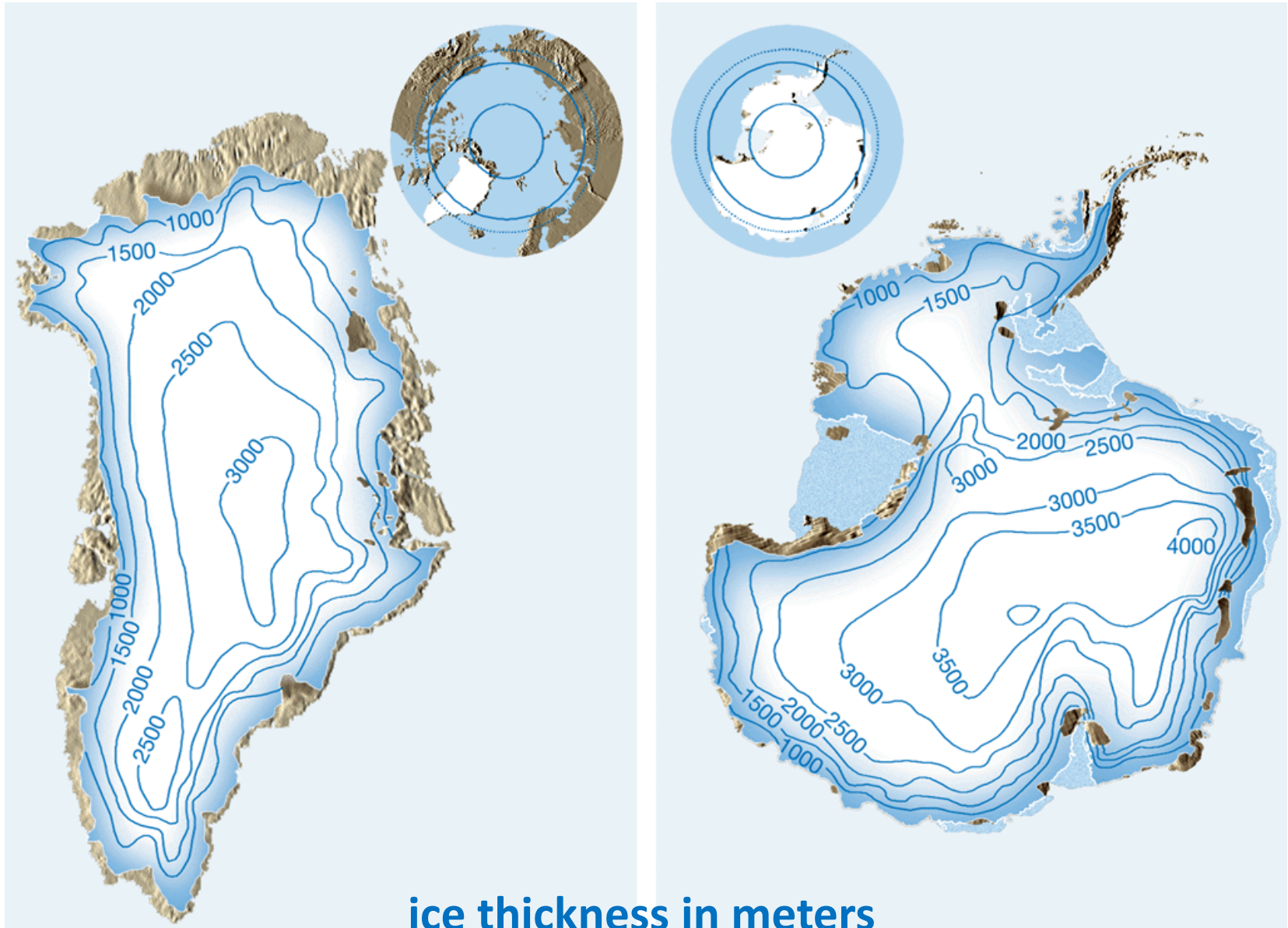
GLACIERS

SNOW

(50% snow extent line  
MAX snow extent line)



# Ice Cover of Greenland and Antarctica

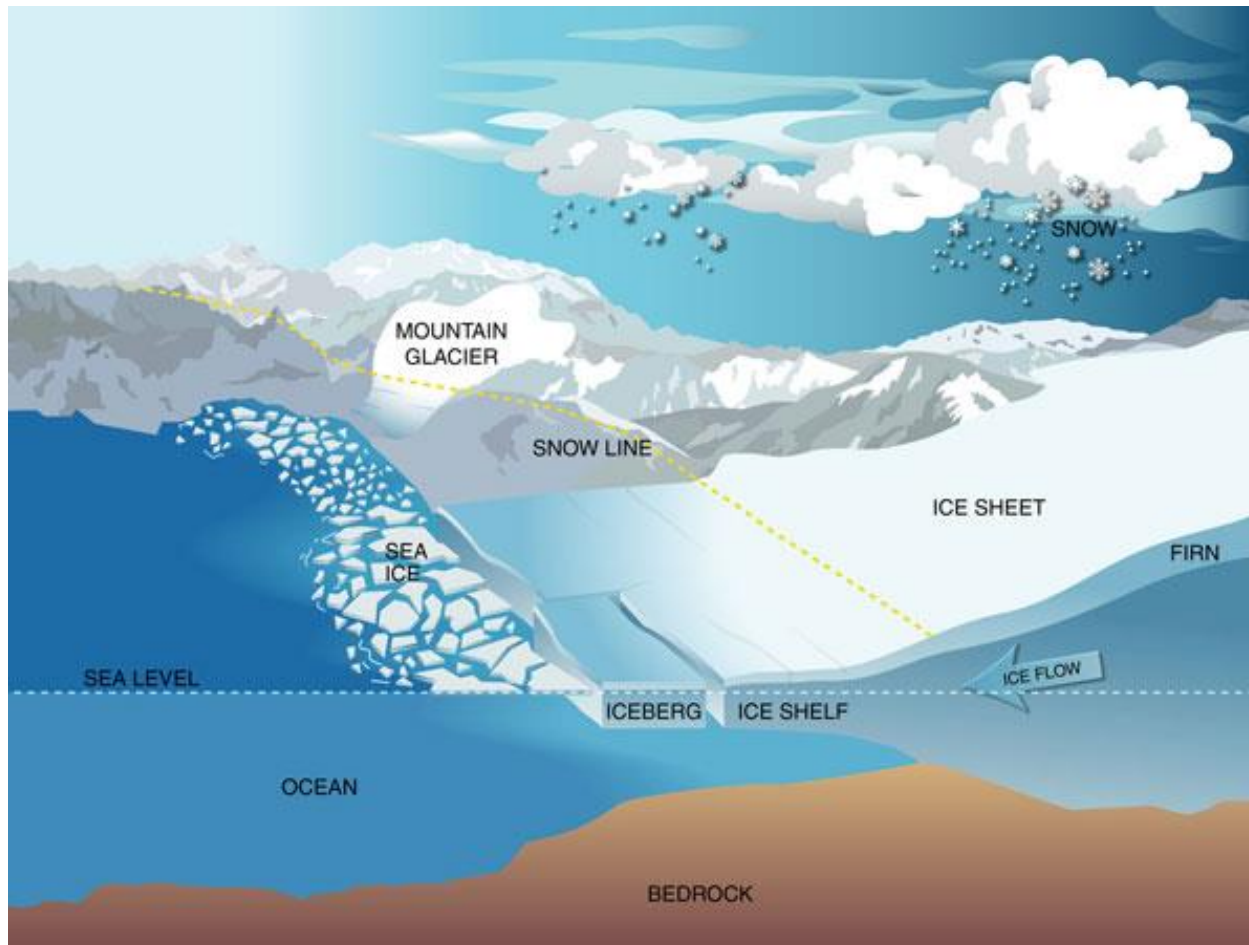


# What is Ice Age?

- During **ice ages**, ice sheets cover major parts of Earth's land area year-round for hundreds or thousands of years:
  - There have been at least **five major ice ages** in the Earth's past.
  - Within the ice ages, more temperate and more severe periods occur; the **colder periods** are called **glacials**, the **warmer periods** are called **interglacials**.
  - The advance and retreat of glaciers during these periods can produce major erosion and re-configuration of the landscape.
  - The most recent glacial period ended about 12,000 years ago, before the advent of civilized human history.
  - It is still not clear what causes the advent of ice ages.
- Scientifically speaking, **we are currently living in an Ice Age** (we have ice sheets over Greenland and Antarctica), during an *interglacial period*!

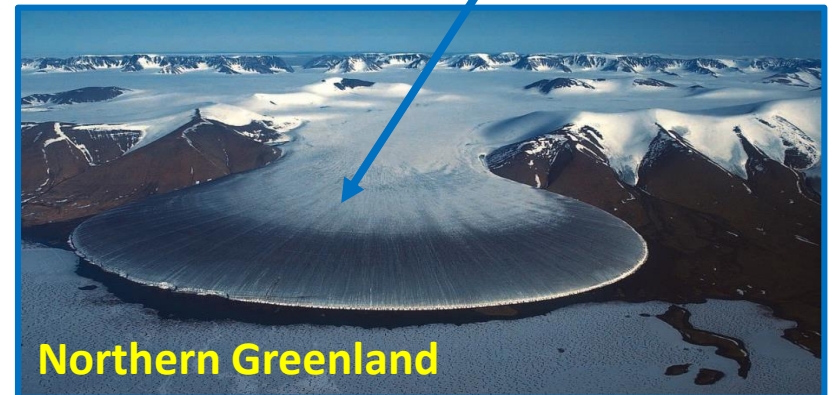
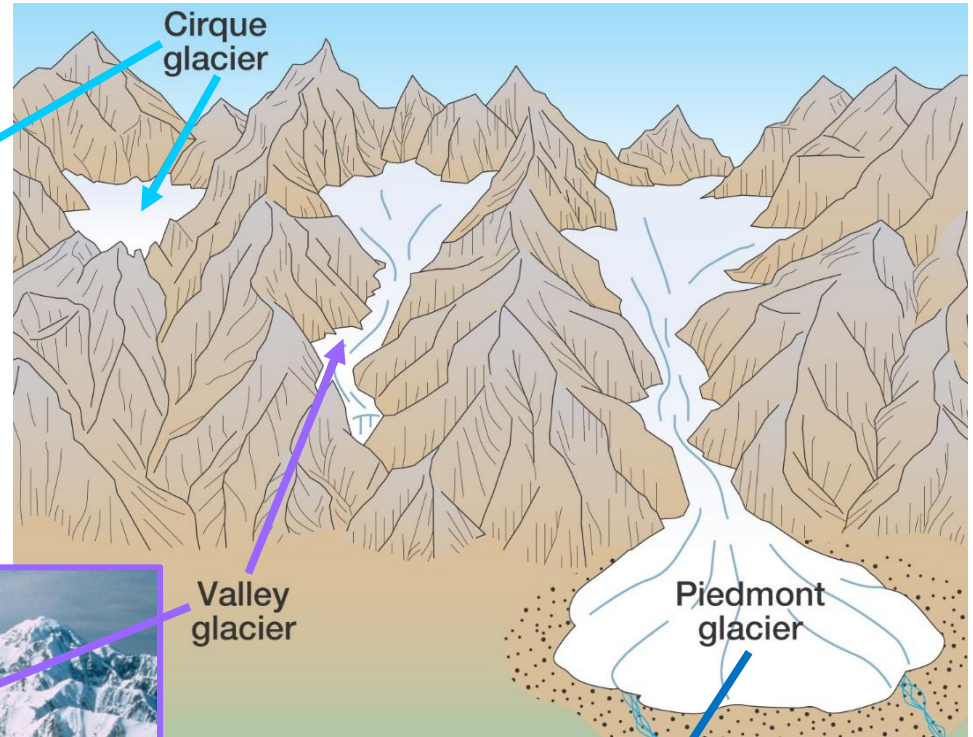
# Frozen Water Locations: Glaciers

A glacier is any large mass of ice that forms on land and moves (flows) slowly due to gravity and the internal deformation of ice.



On Earth,  
~99% of glaciers  
are **ice sheets**  
**in the polar**  
**regions**  
(Antarctica  
and Greenland)  
and  
~1% is found  
in **mountain**  
**ranges** on  
every continent  
except  
Australia.

# Mountain (Alpine) Glaciers

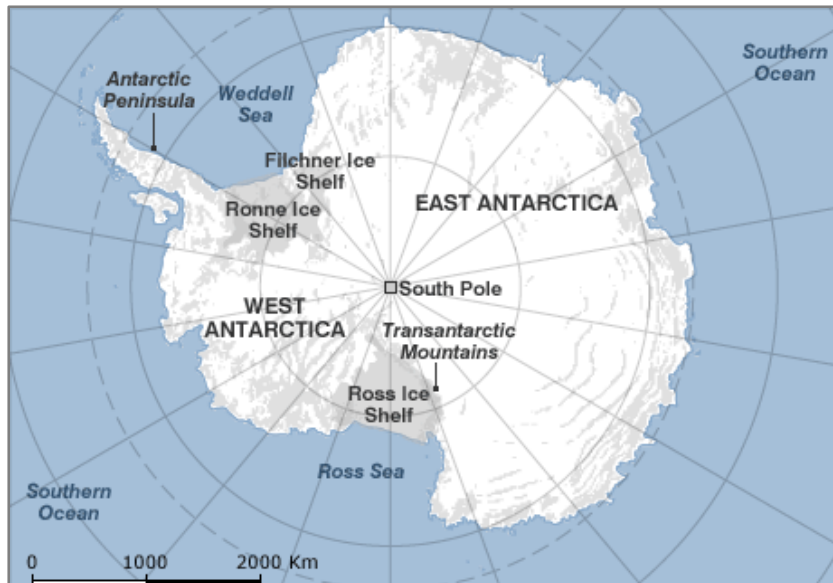


**Black Rapids  
Glacier, Alaska**

**Northern Greenland**

# Permafrost in Land Areas

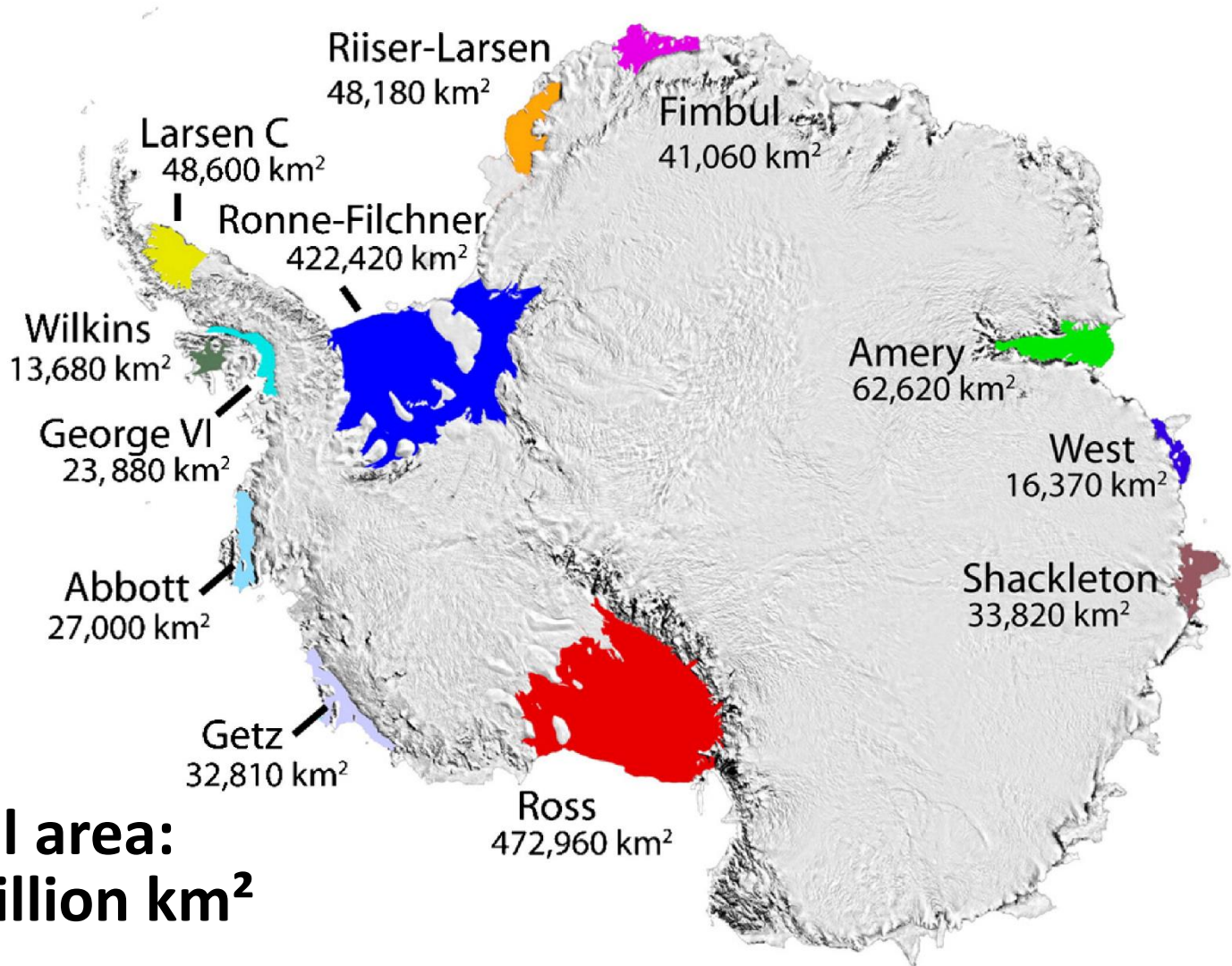
- Land areas in polar regions, such as Antarctica and Greenland, and the northern parts of Alaska and Siberia, have zones below their surfaces in which **ground water remains frozen year-round**.
- Those regions are known as **permafrost** areas.





# Antarctic Ice Shelves

Ice shelves are attached to ~44% of the Antarctic coastline.



**Total area:  
~1.5 million km<sup>2</sup>**

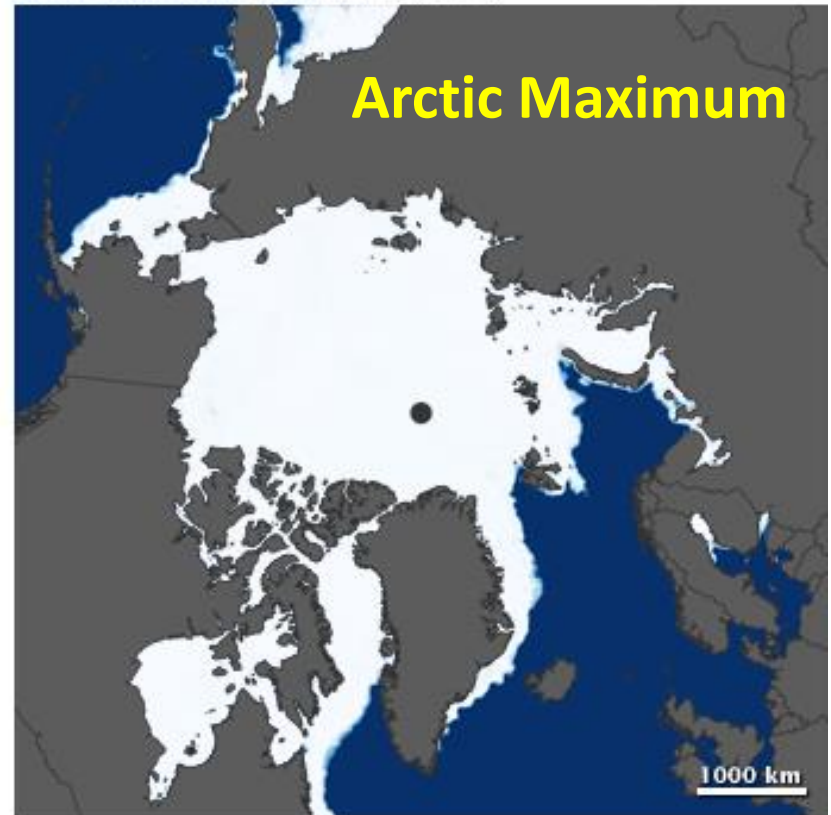
# Frozen Water Locations: Sea Ice

The amount of sea ice varies over the course of the year.

Arctic Minimum (September 14, 2008)



Arctic Maximum (February 28, 2009)



Arctic sea ice reaches its **maximum extent each March** (~16 million square kilometers or ~6 million square miles) and its **minimum extent each September** (~7 million square kilometers or ~2.7 million square miles).

# Sea Ice Animations

These video clips were created using real satellite observations.

## Arctic:

[www.youtube.com/watch?v=k3H7zfabJk8](http://www.youtube.com/watch?v=k3H7zfabJk8)

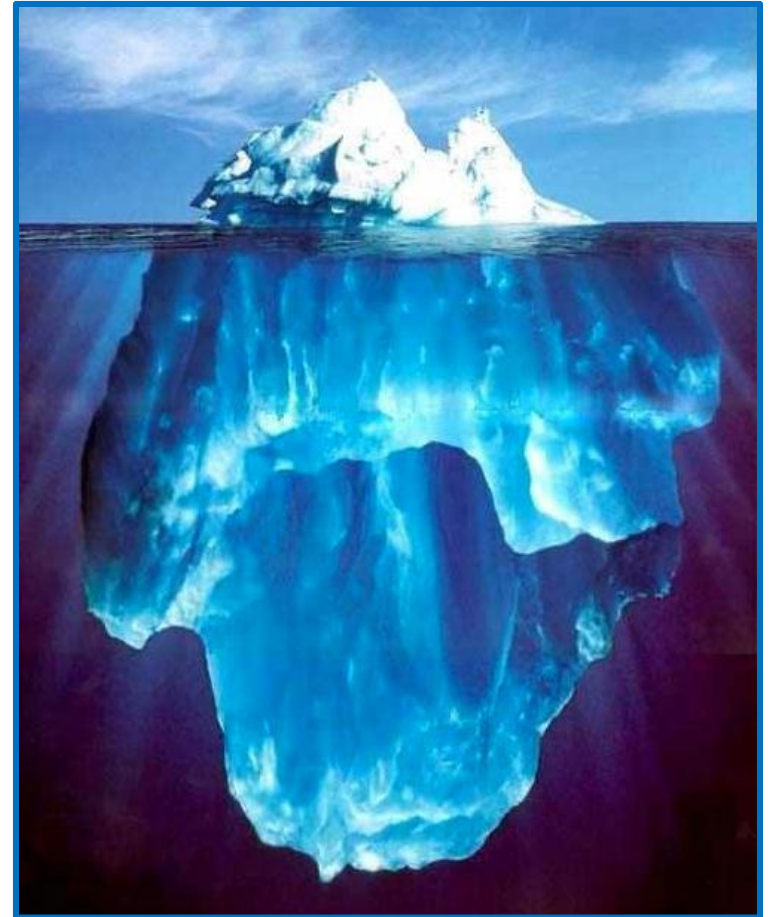
[www.youtube.com/watch?v=Fw7GfNR5PLA](http://www.youtube.com/watch?v=Fw7GfNR5PLA)

## Antarctic:

<https://www.youtube.com/watch?v=y5z-wXI4I90>

# Frozen Water Locations: Icebergs

An iceberg (Dutch “ice mountain”) is a large piece of freshwater ice that has broken off a glacier or an ice shelf and is floating freely in open water.

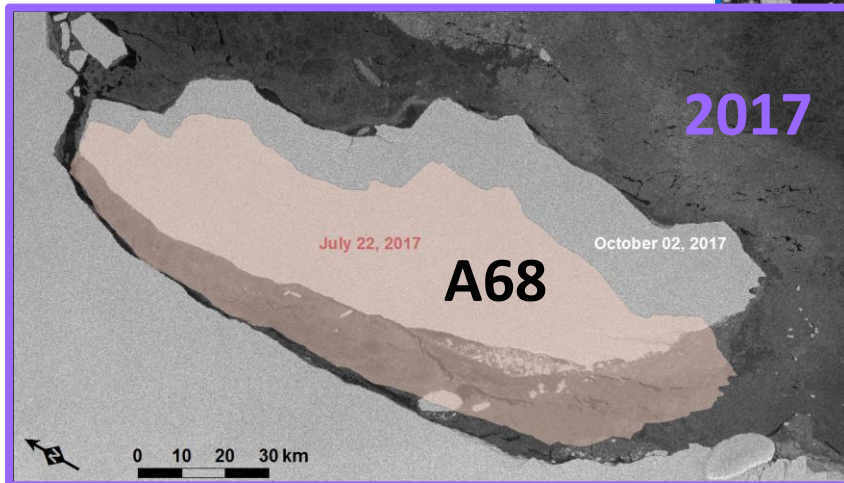
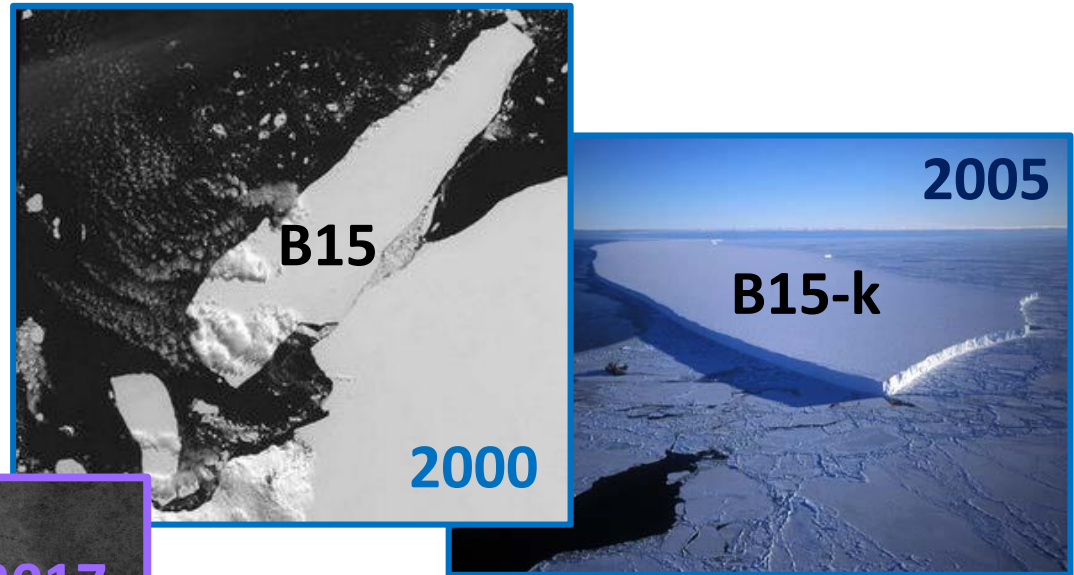


Typically only **one-tenth** of the volume of an iceberg is **above water**.

# How large can an iceberg be?

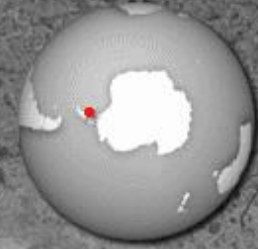
Formation of an iceberg, as it separates from an ice shelf or a glacier, is termed “calving”. The largest icebergs recorded have been calved from the Ross Ice Shelf of Antarctica.

- **B15**, calved in March 2000, holds an **absolute record ever** with an area of 11,000 sq km (4,200 sq mi, about **the size of the state of Connecticut**). B15 has since broken up, but parts of it still exist around the Antarctic today.



- The most recently formed major iceberg is **A68**, measuring about 2,400 square miles (about **the size of the state of Delaware**) and weighing over one trillion tons. It calved from the Larsen C Ice Shelf in **July 2017**.

**A68 is finally moving away from  
Larsen C and is due to be carried  
further north into warmer waters.**



***(took over  
1 year to  
turn!)***

**2017 - 03 - 12**

Contains modified Copernicus Sentinel data (2017–18), processed by Swansea University–A. Luckman



# Cryosphere and Climate Change

Major changes in sea level can occur during times of global climate change (*ice ages* and *global warming*), due to associated changes in the water content of the cryosphere.

## IF ALL ICE MELTS...

Global warming could potentially result in melting of the polar ice caps, which would raise the water level of the oceans by more than 200 feet and cause flooding of coastal areas of the continents.

