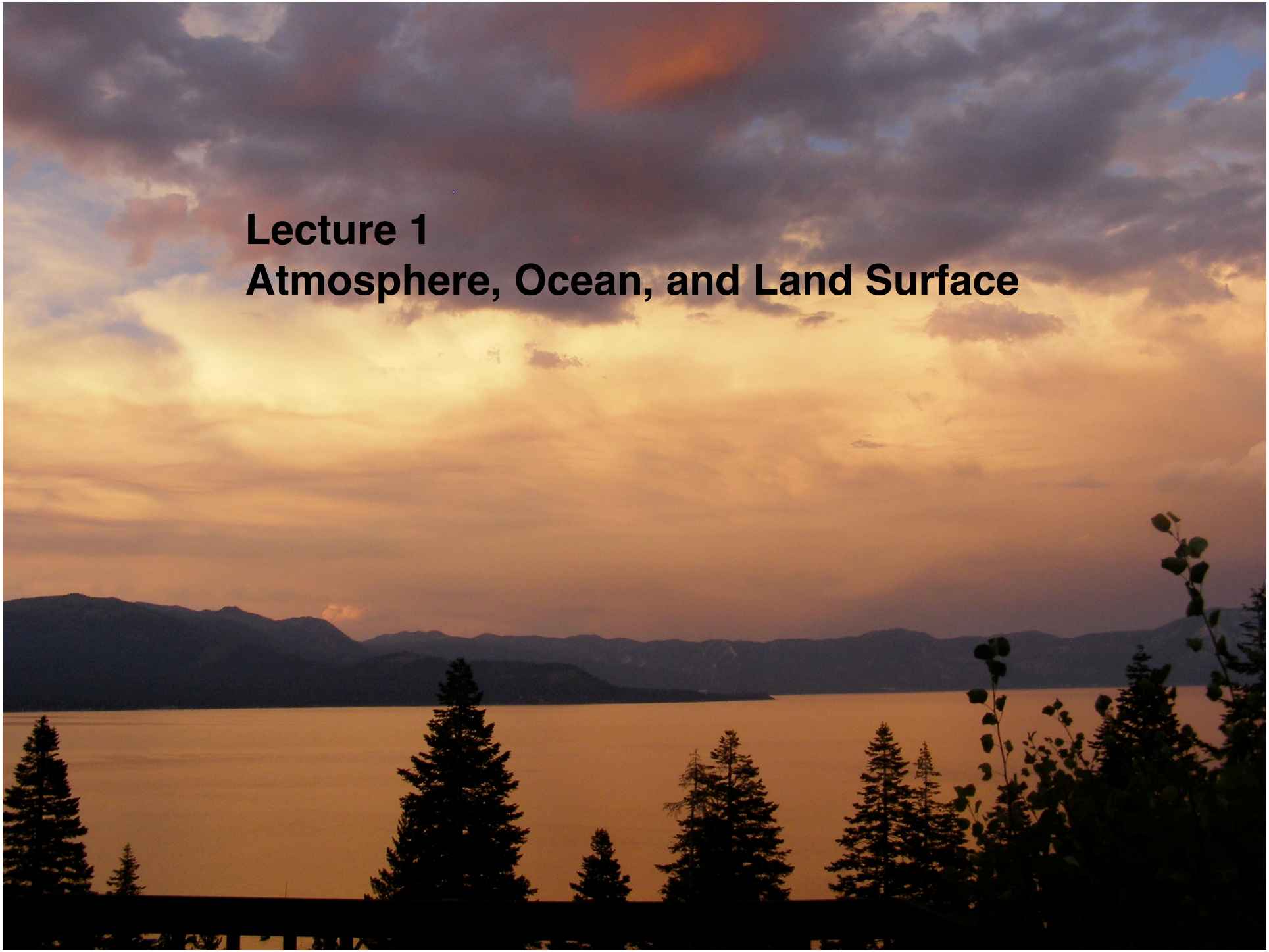
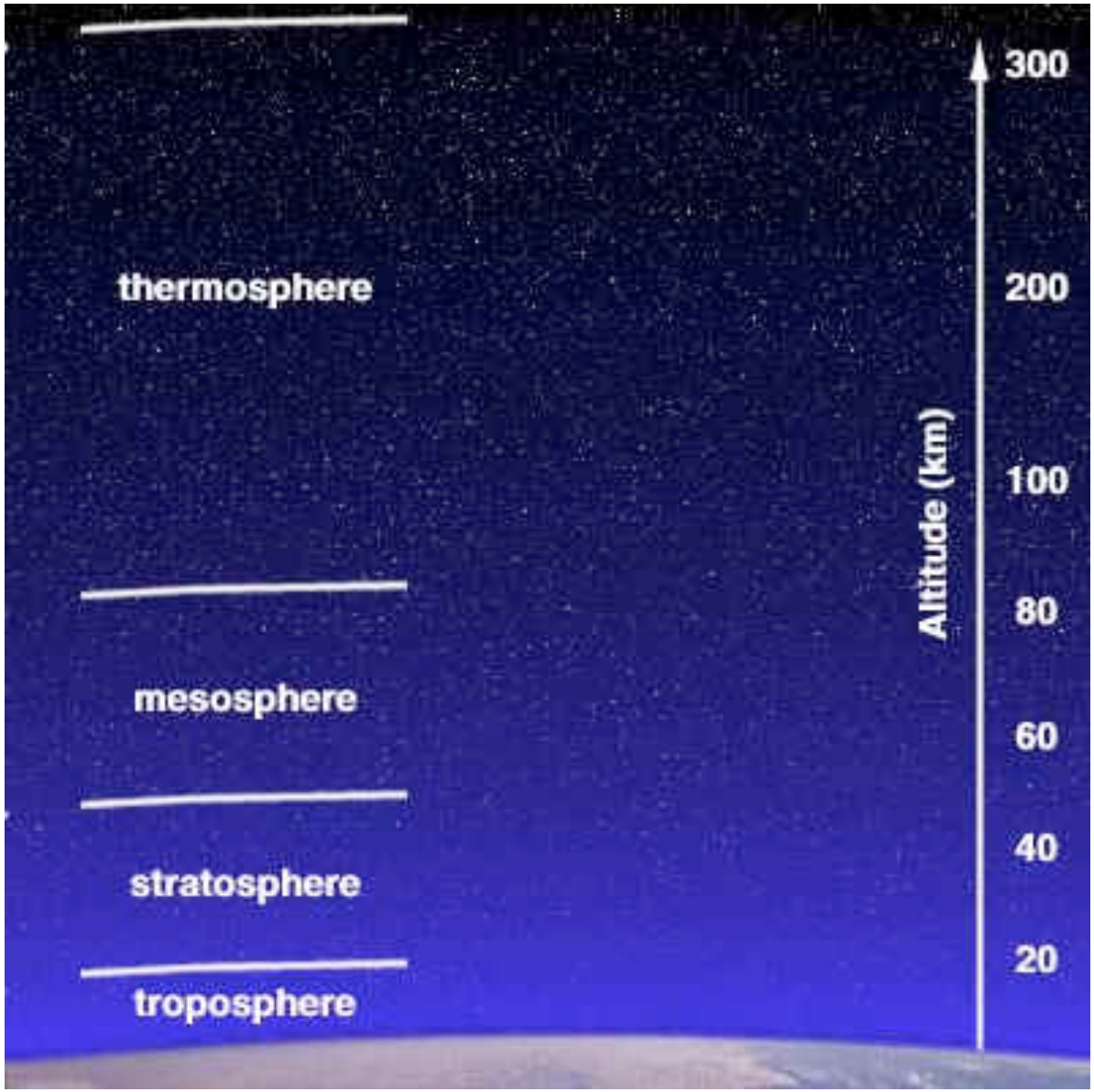


Lecture 1
Atmosphere, Ocean, and Land Surface

Nomenclature:

The west-to-east direction is referred to as the *zonal* direction and the south-to-north direction is referred to as the *meridional* direction.

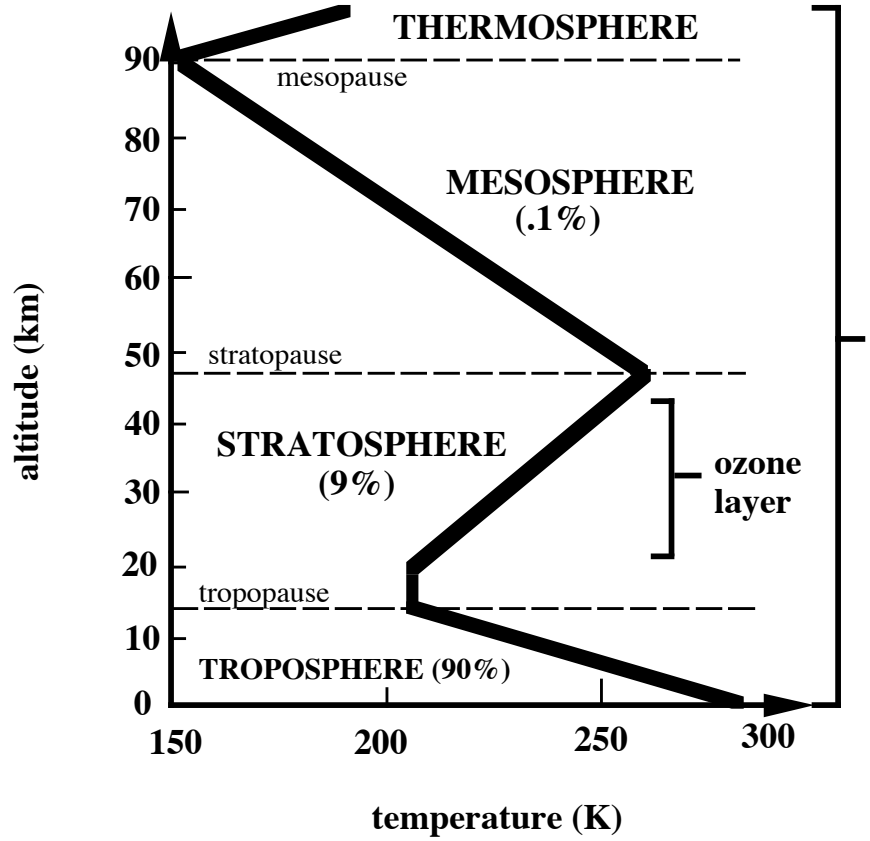


Earth's atmosphere

NASA GSFC Graphic

The vertical temperature profile - Standard Atmosphere

The average surface temperature of Earth is ~ 288K.



In the stratosphere air warms up as ozone (O_3) absorbs ultra-violet (UV) radiation.

In the troposphere the temperature decreases about 7K per kilometer.

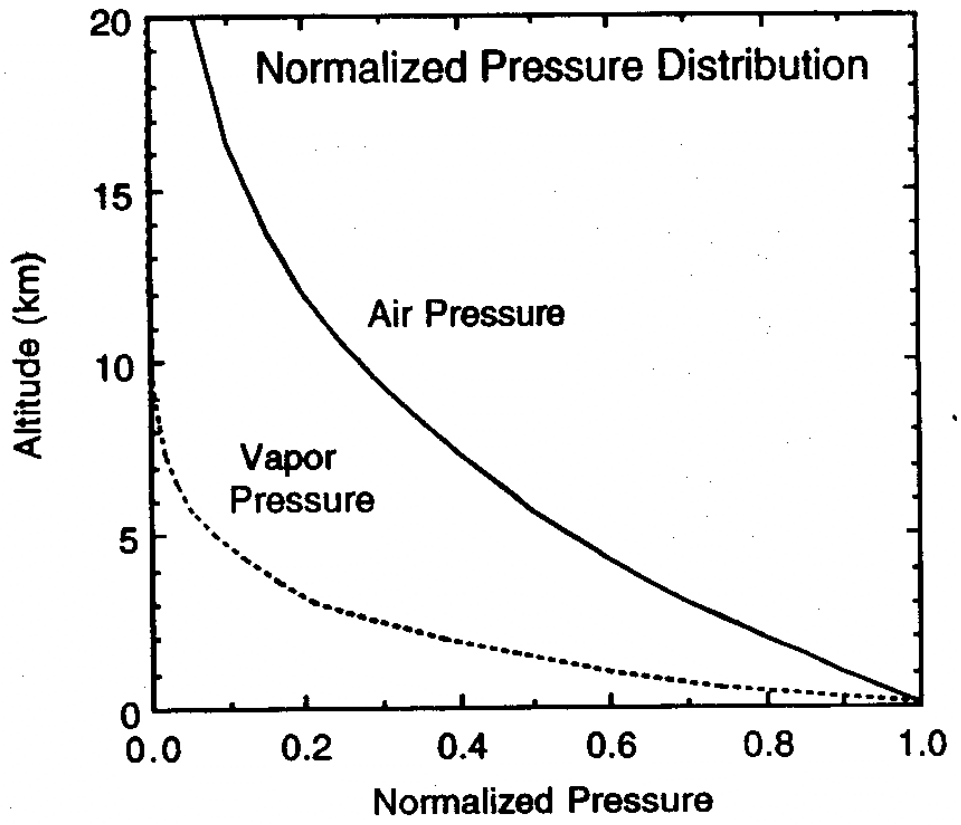


Fig. 1.8 Vertical distributions of air pressure and partial pressure of water vapor as functions of altitude for globally and annually averaged conditions. Values have been normalized by dividing by the surface values of 1013.25 and 17.5 mb (millibars), respectively. (Hartmann's)

Atmospheric Temperature

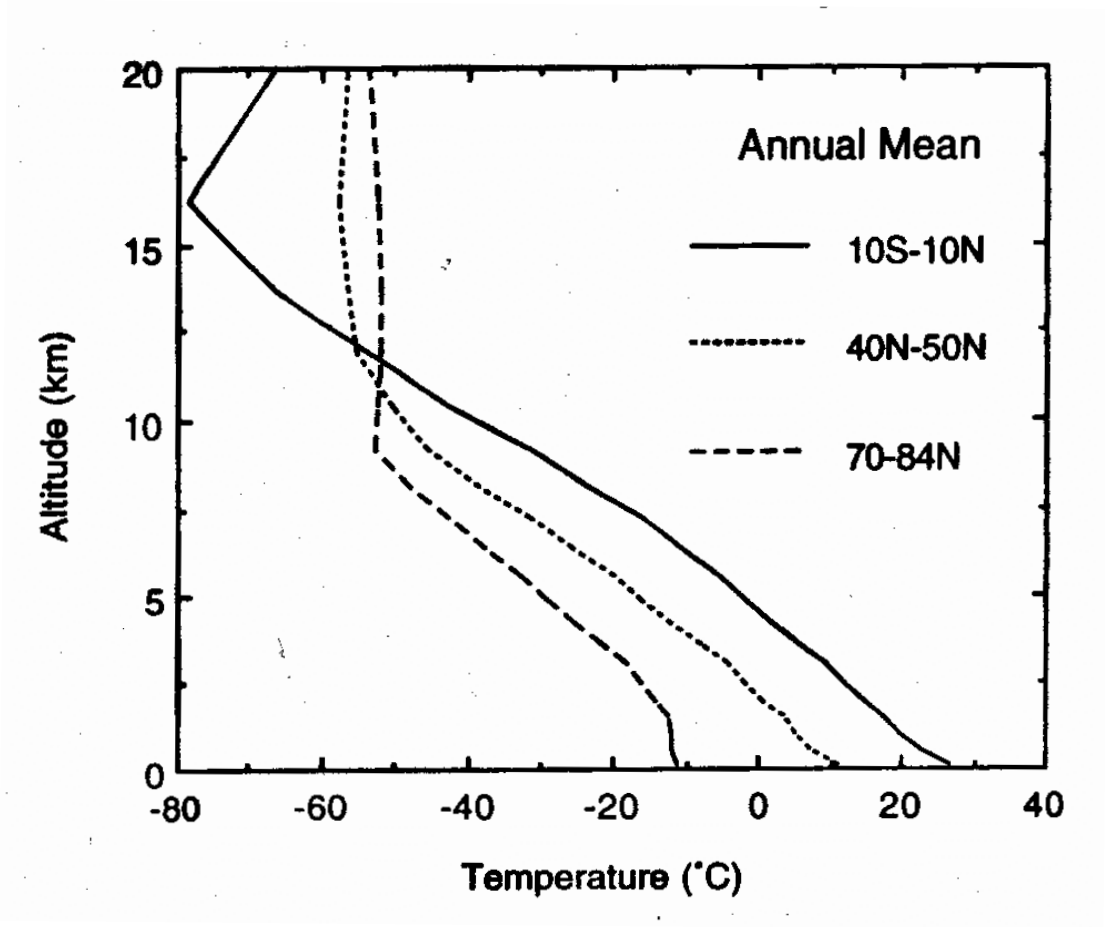


Fig. 1.3 Annual-mean temperature profiles for the lowest 20 km of the atmosphere in three latitude bands. (Hartmann's)

Atmospheric Temperature

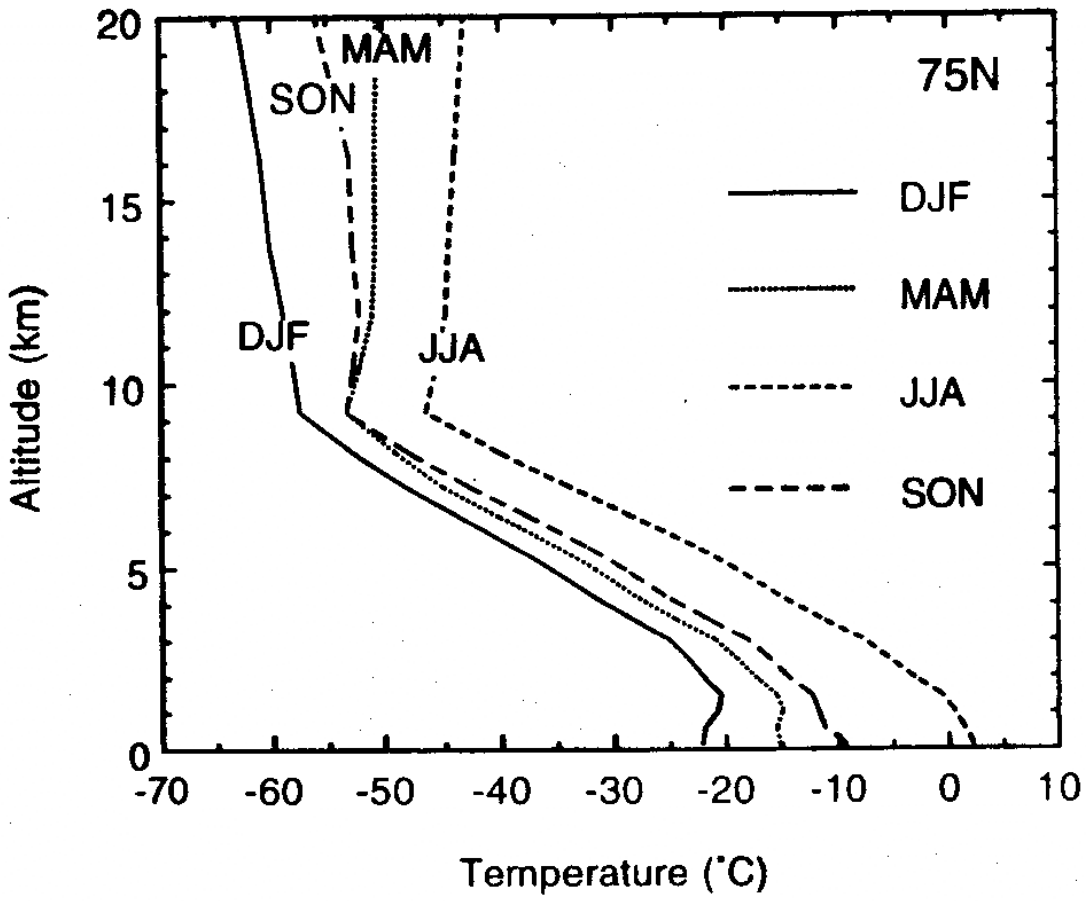
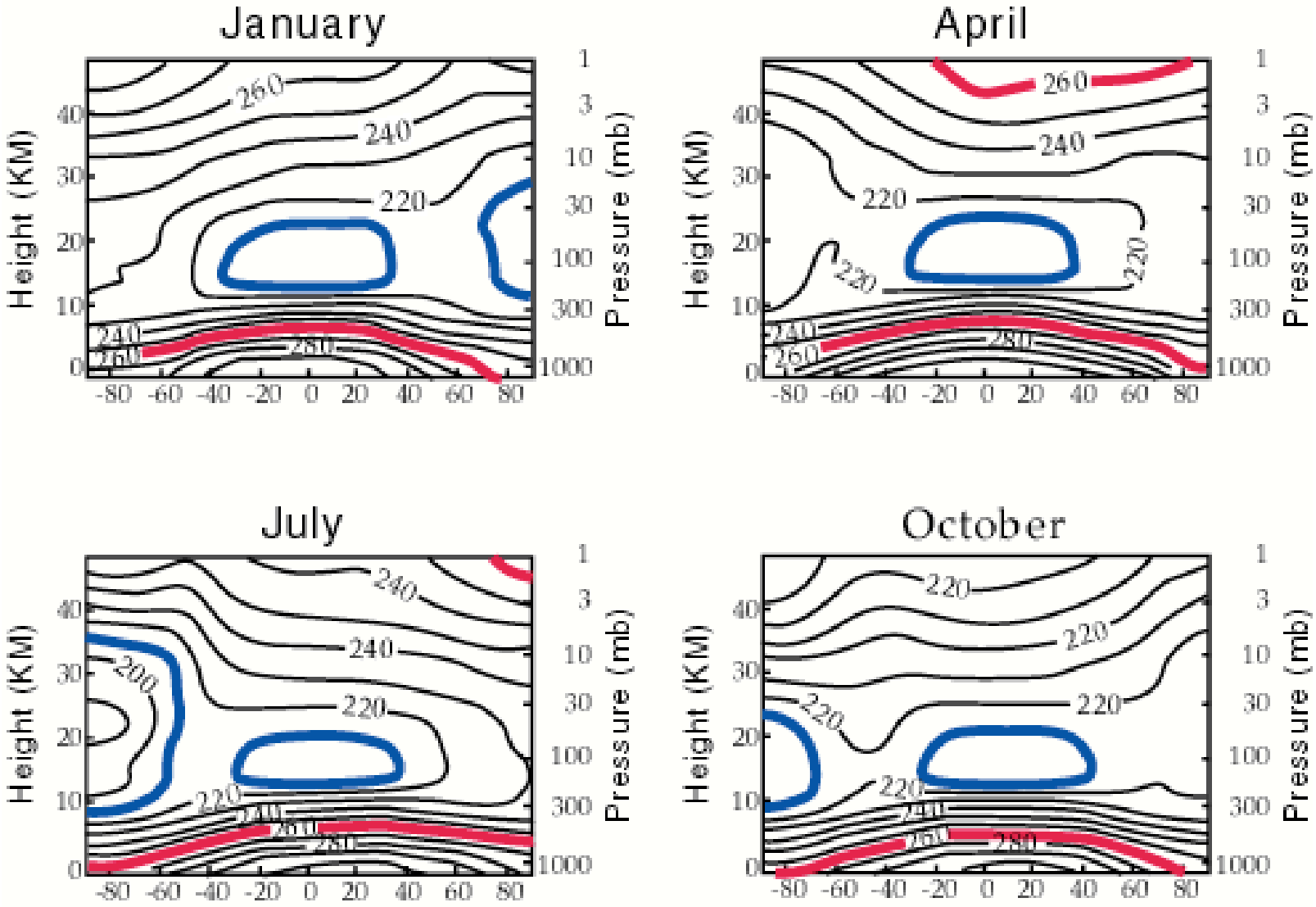
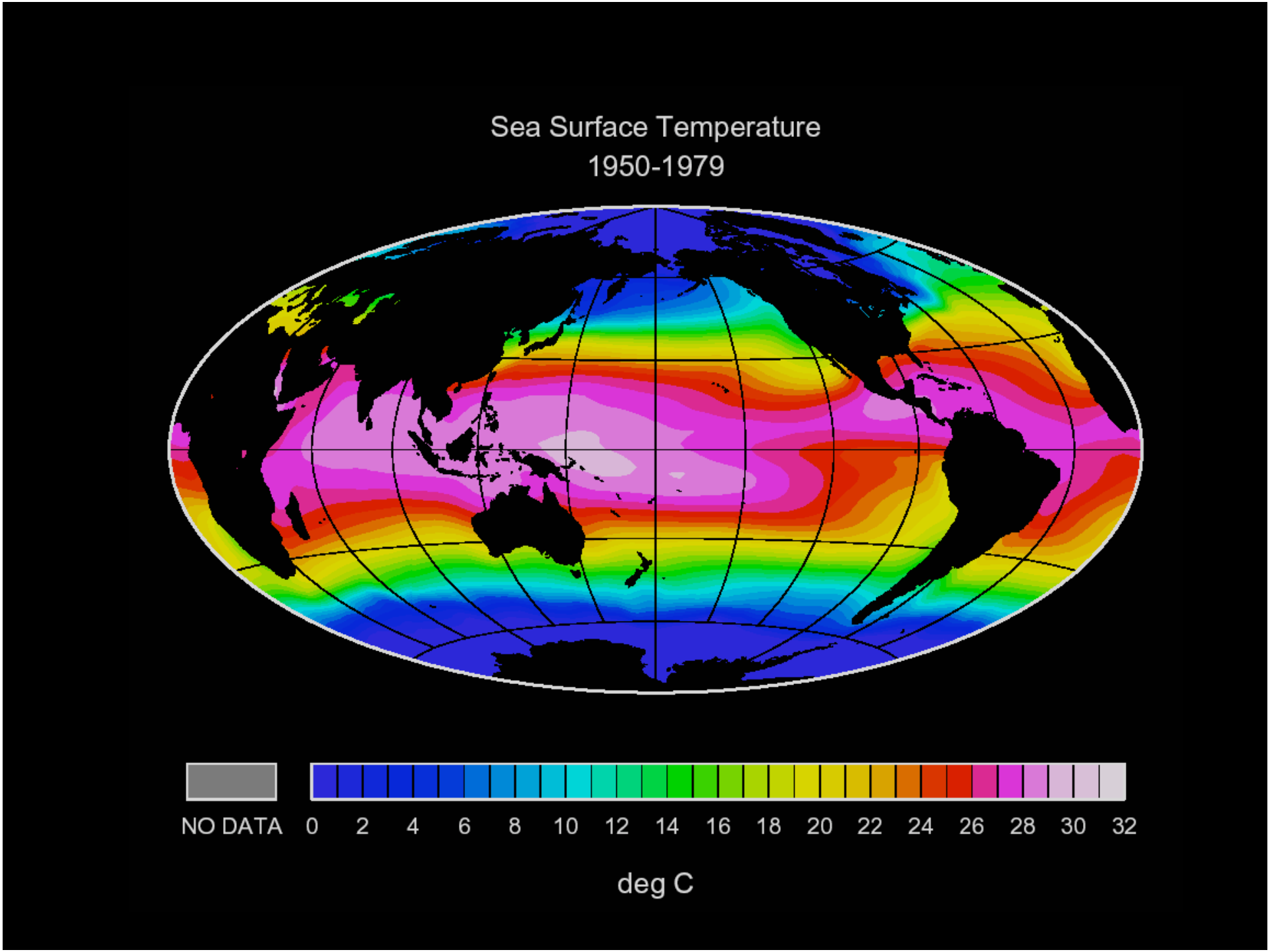


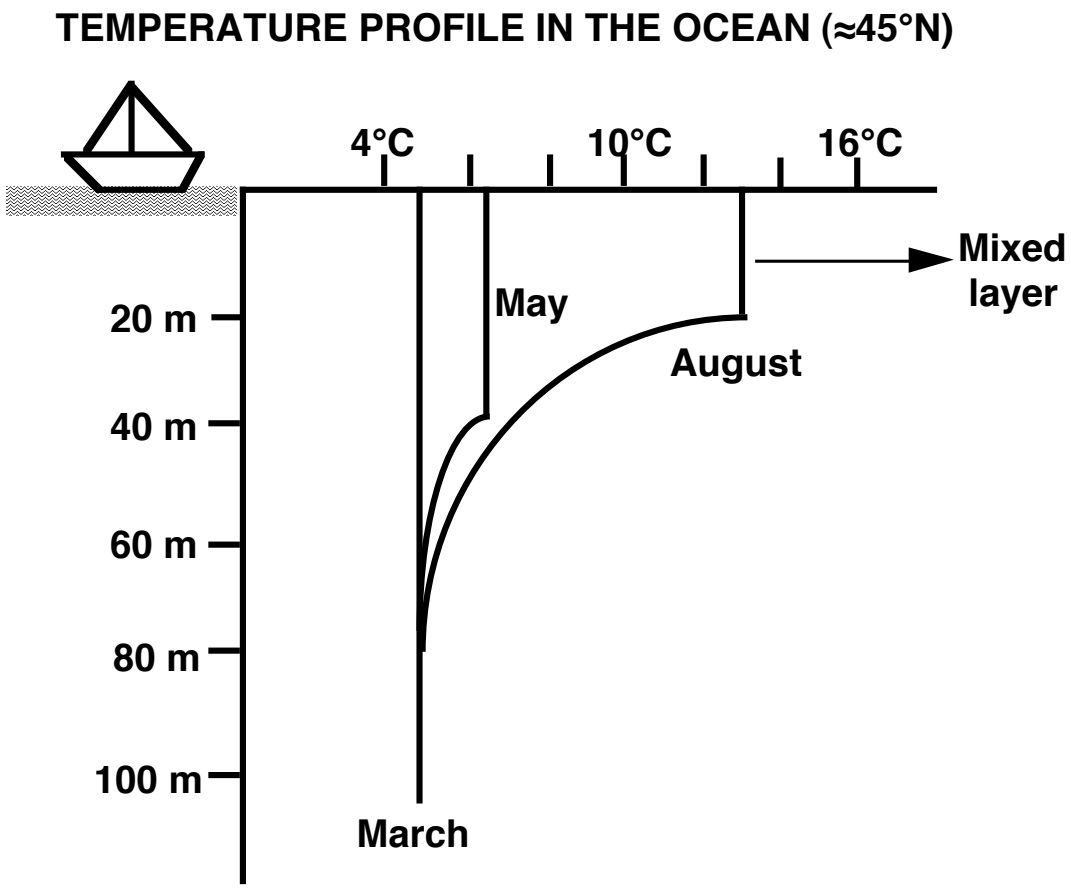
Fig. 1.4 Seasonal variation of temperature profiles at 75 degrees North (Hartmann's)

Zonal Mean Temperature ([T])
K




Sea Surface Temperature
1950-1979
NO DATA
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
deg C

The vertical temperature profile in the upper ocean



The surface layer of the ocean where temperatures are about constant in the vertical is known as the ***oceanic mixed layer***.

Further down, the temperature decreases with depth in the layer known as the ***thermocline.***

If a storm blows cold winds at the ocean surface this will cool down, and water parcels will become heavier and sink. This process is known as *thermal mixing.*

The wind also stirs the ocean water in a process known as *mechanical mixing.*

Mixing tends to homogenize the temperature of the ocean layers near the upper surface.

During summer, winds are weak, air is warm, and mixed layers tend to be shallow. During winter, winds are strong, air is cold, and mixed layers tend to be deep.

The World Ocean

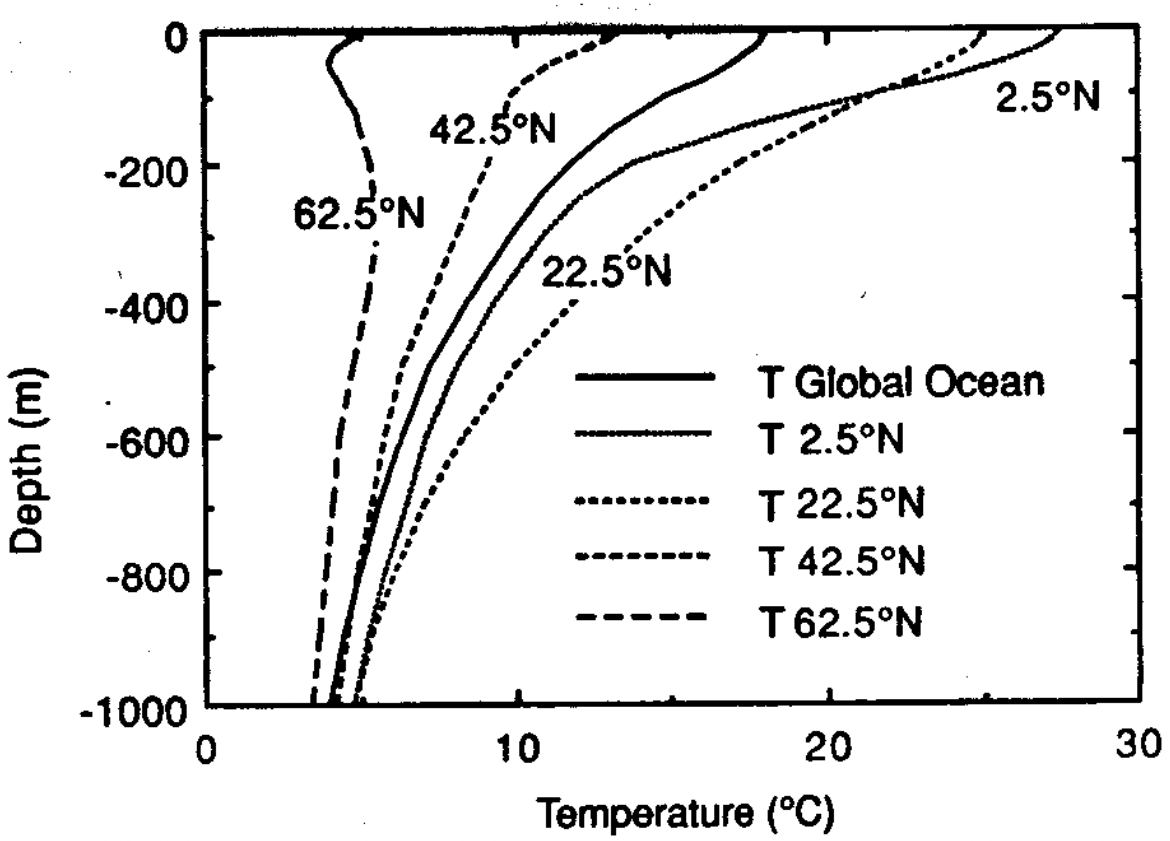
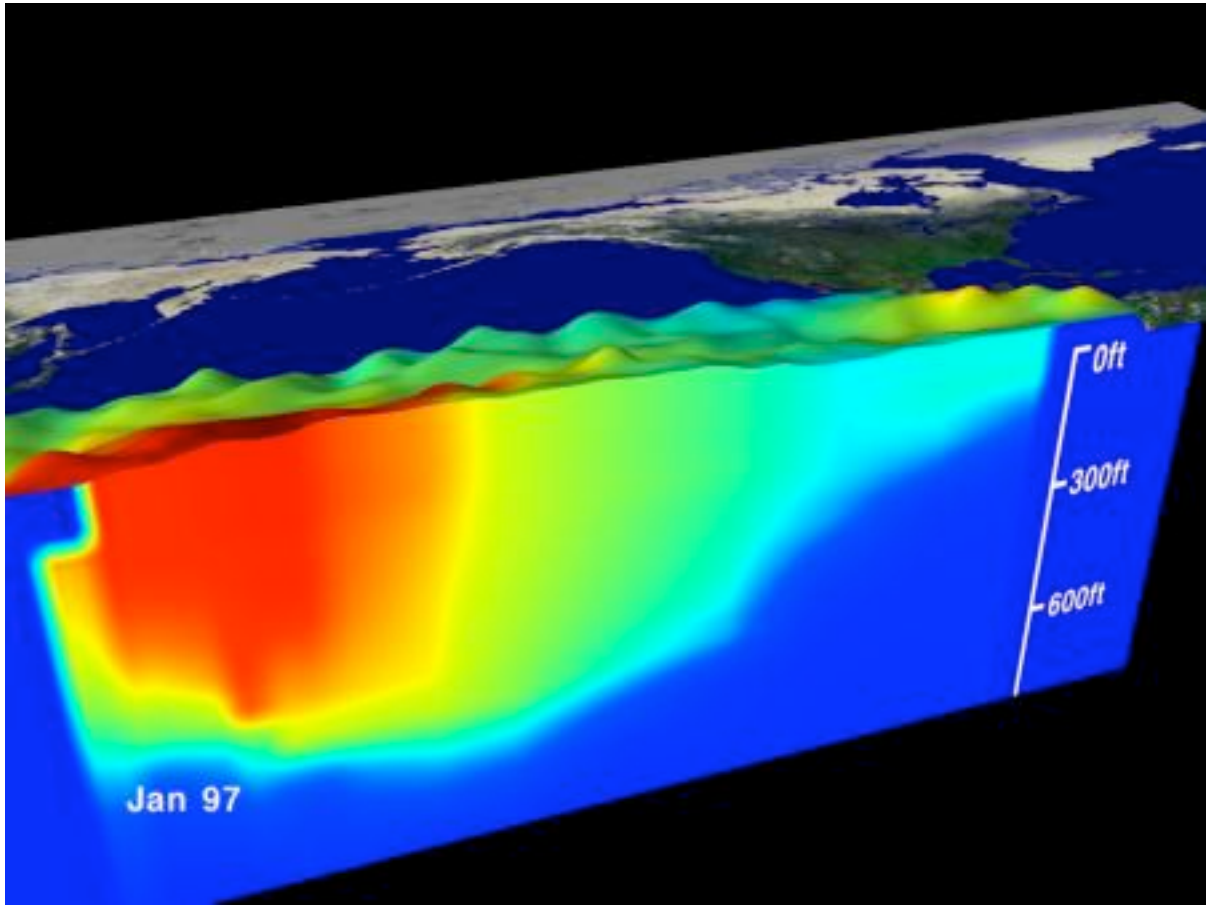


Fig. 1.10 Annual-mean ocean temperature profiles for various latitudes. (Hartmann's)



Ocean temperature in the Pacific along the equator in January 1997 (TAO data)

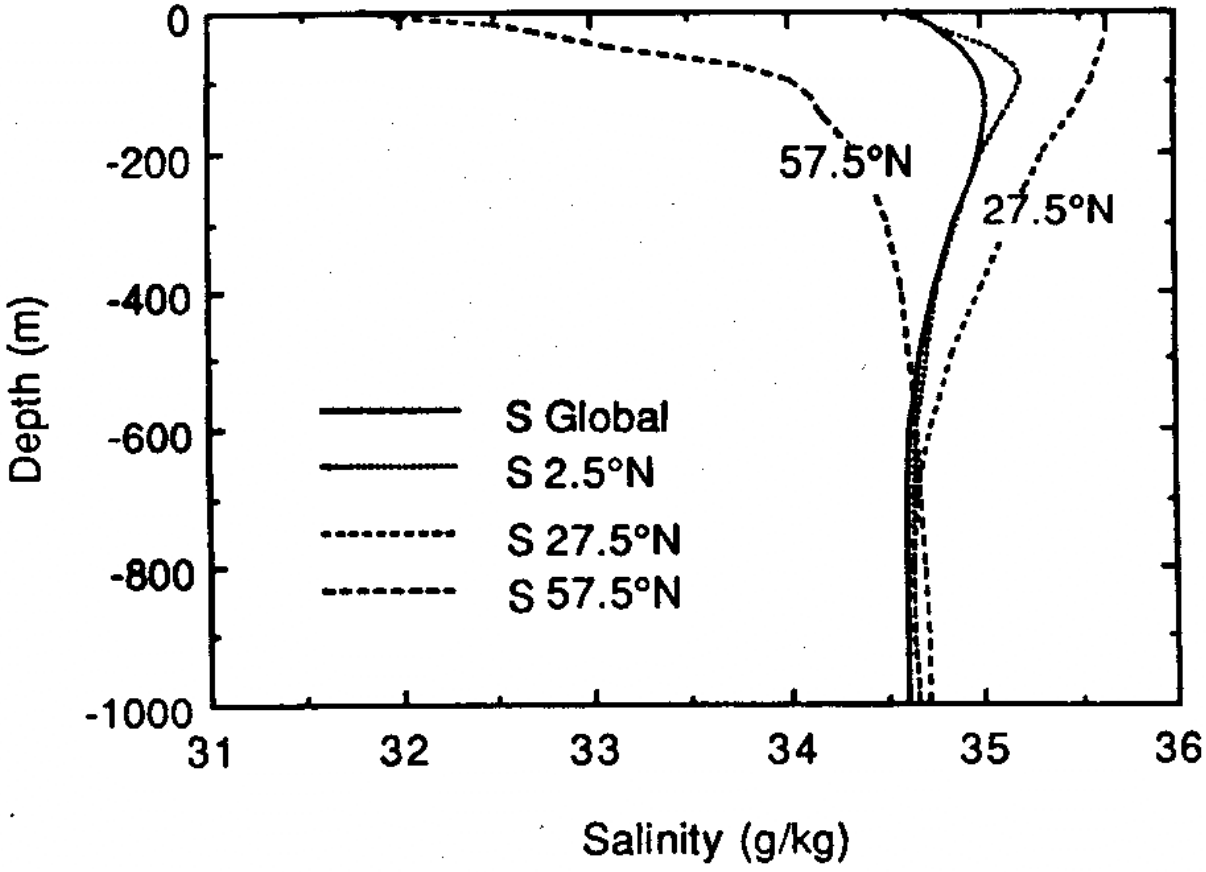


Fig. 1.11 Profiles of annual-mean salinity for the global mean and for various latitudes. (Hartmann's)

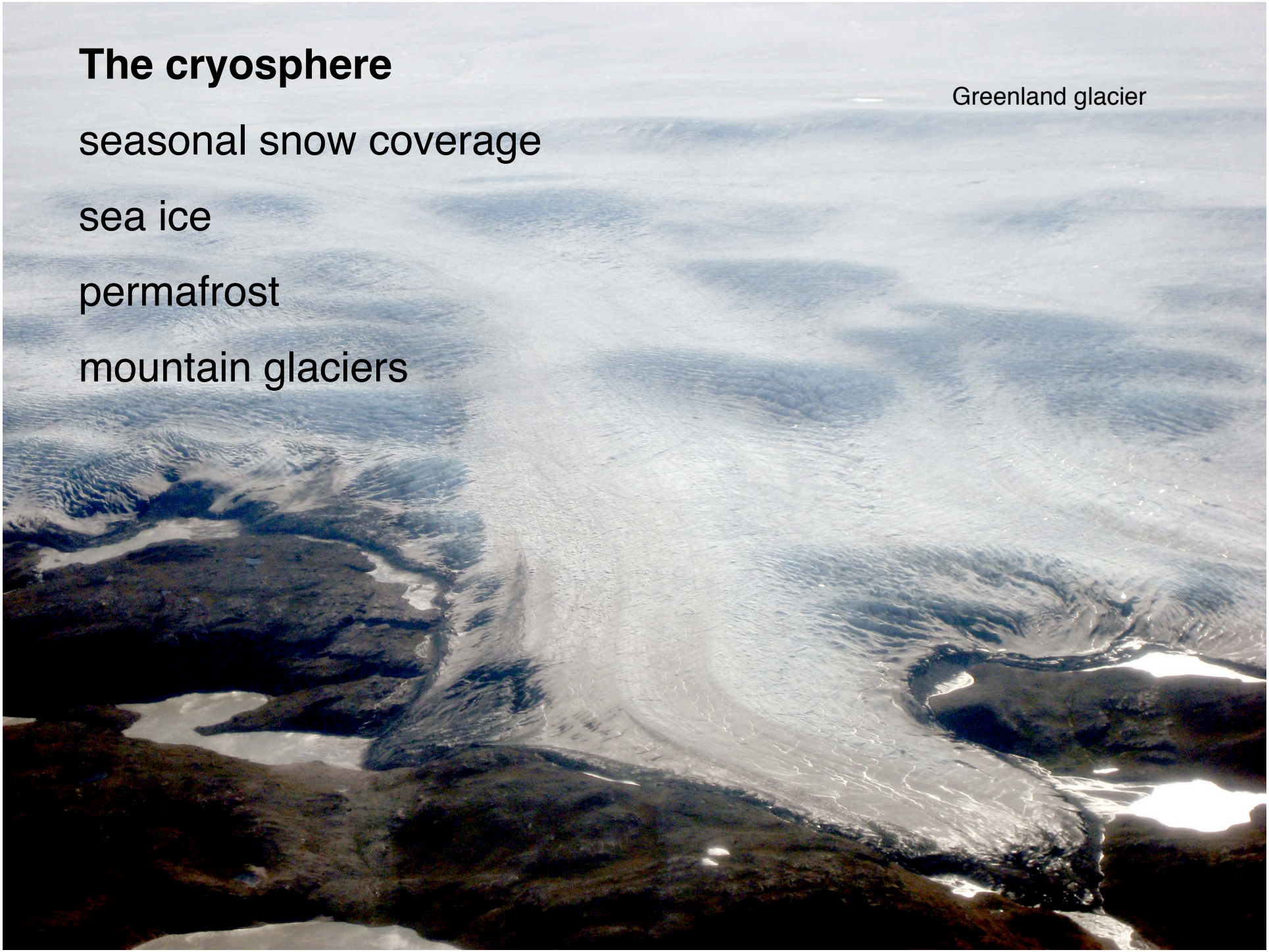
The cryosphere

seasonal snow coverage

sea ice

permafrost

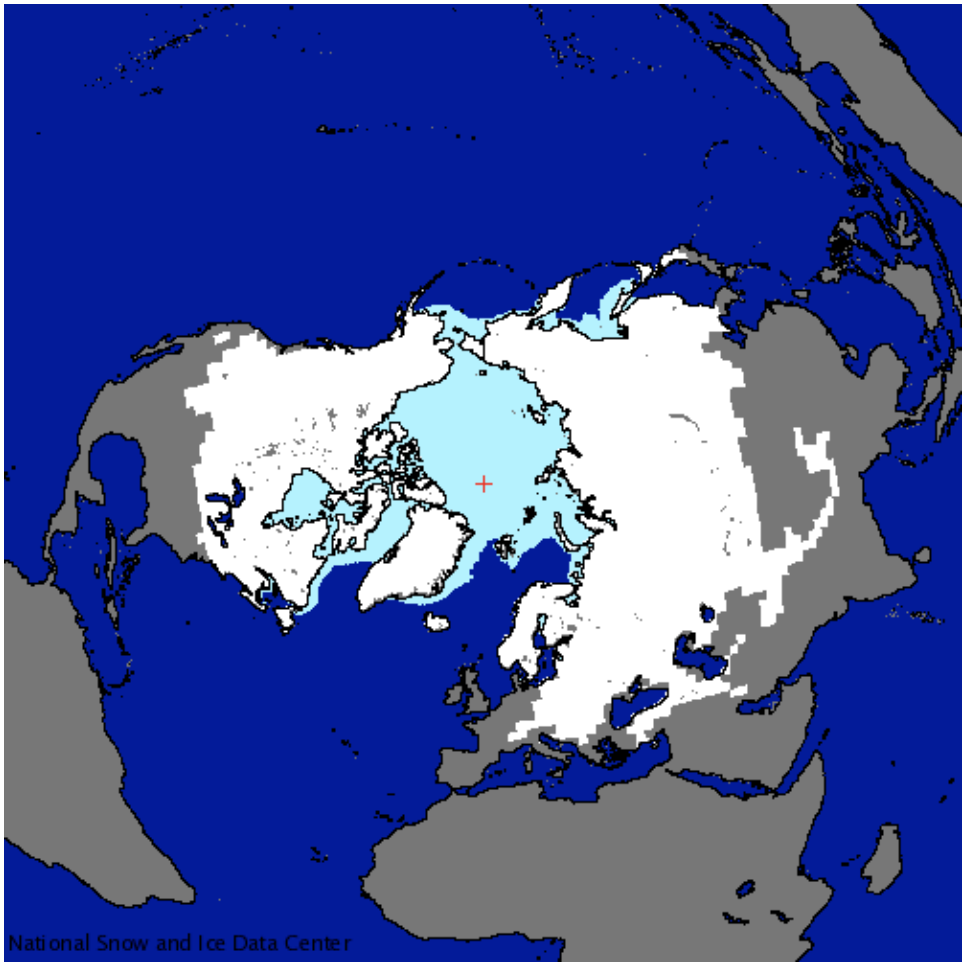
mountain glaciers



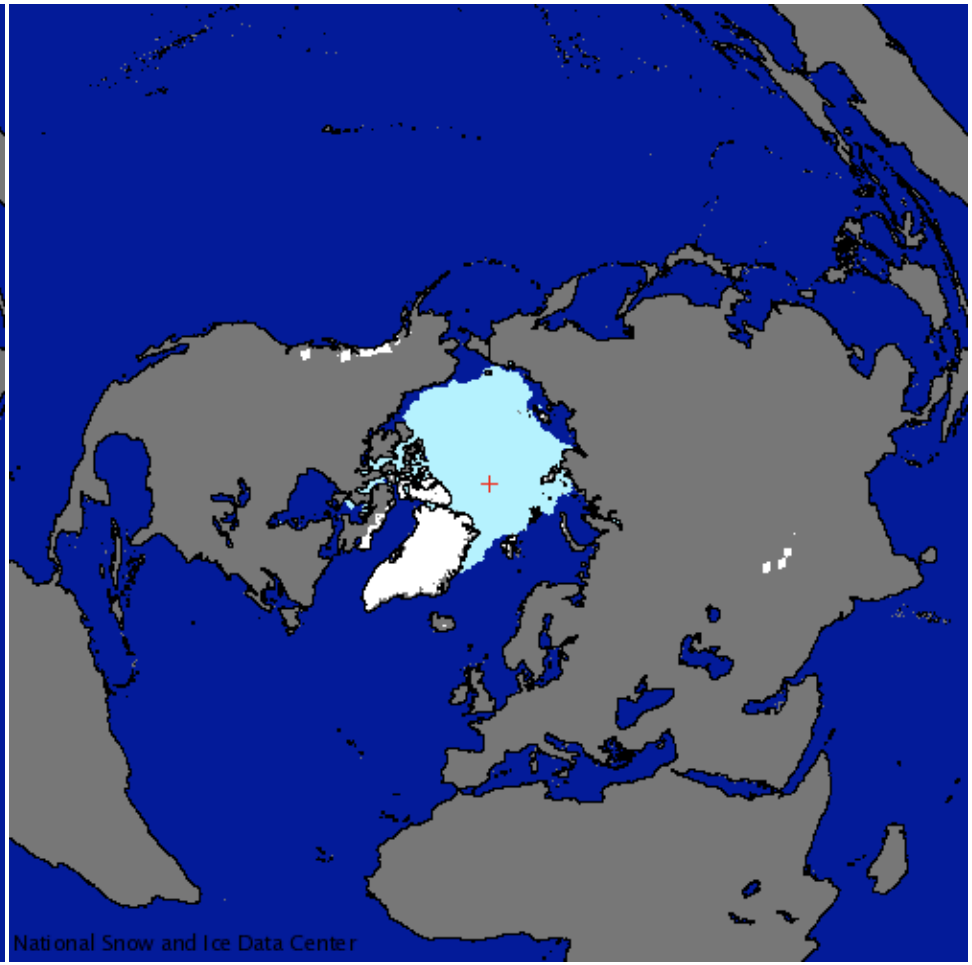
Greenland glacier

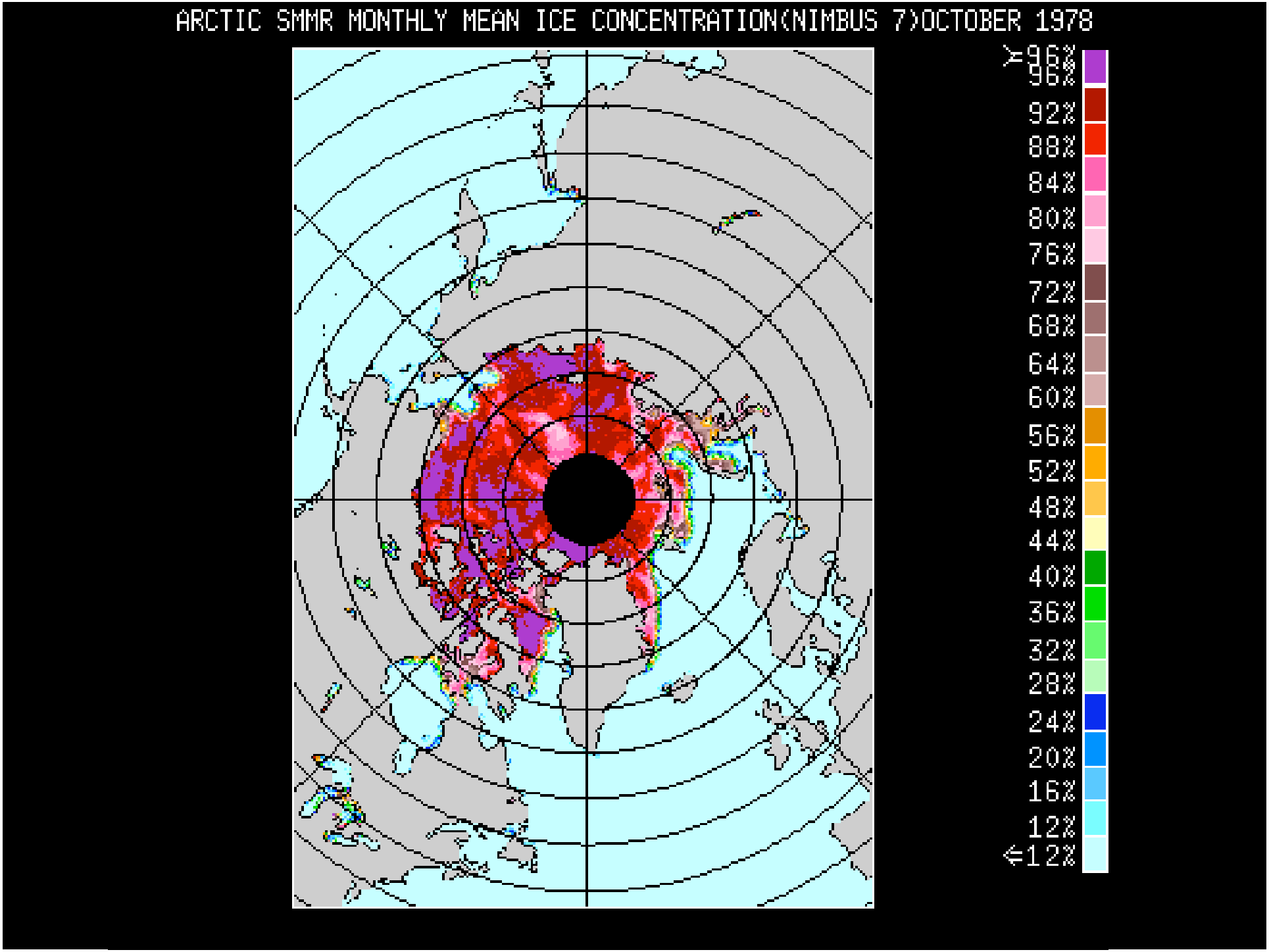
Northern Hemisphere Climatological Snow and Ice Extent, from the National Snow and Ice Data Center

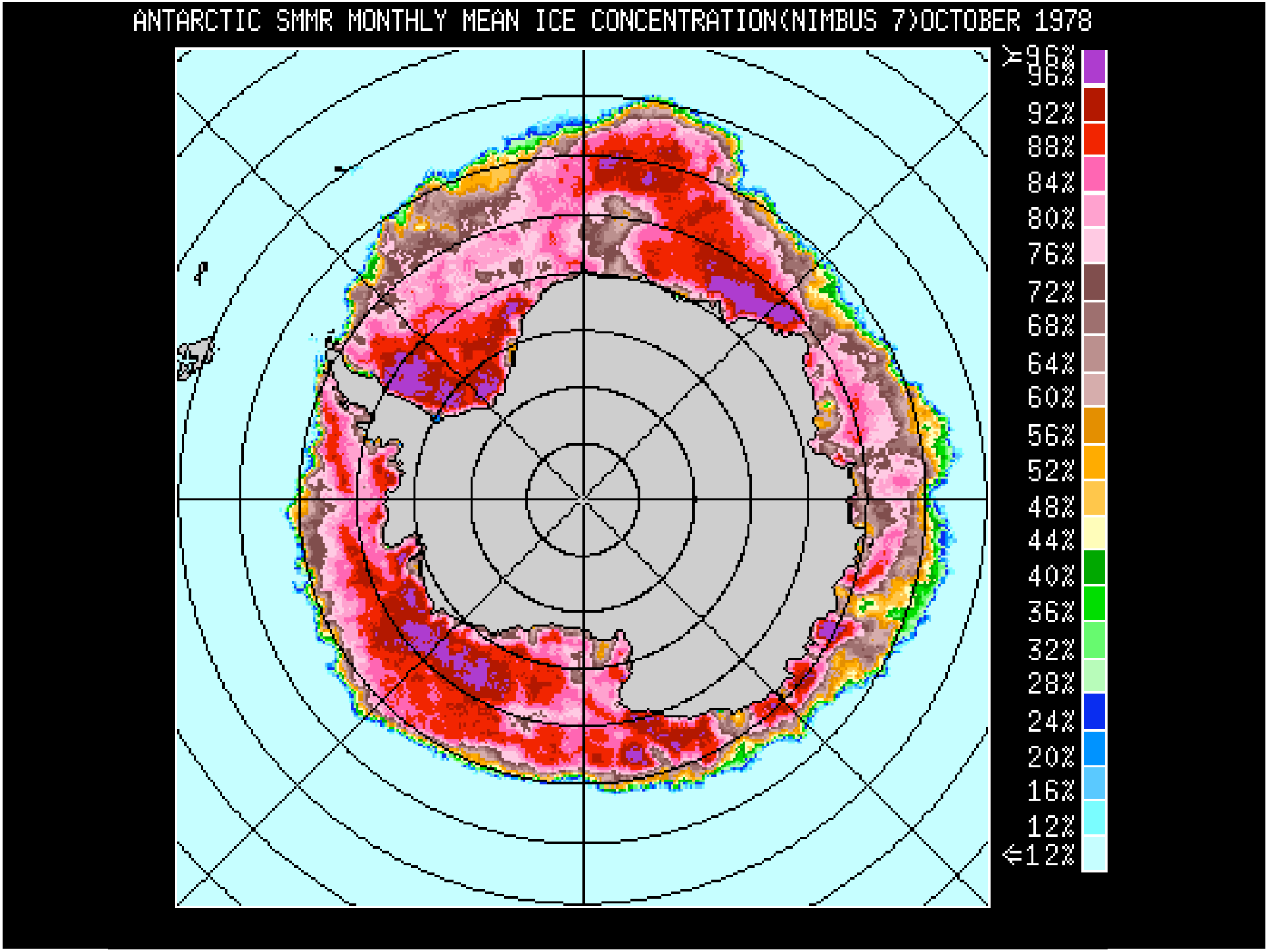
January



August




ARCTIC SMMR MONTHLY MEAN ICE CONCENTRATION(NIMBUS 7)OCTOBER 1978
≥96%
96%
92%
88%
84%
80%
76%
72%
68%
64%
60%
56%
52%
48%
44%
40%
36%
32%
28%
24%
20%
16%
12%
≤12%

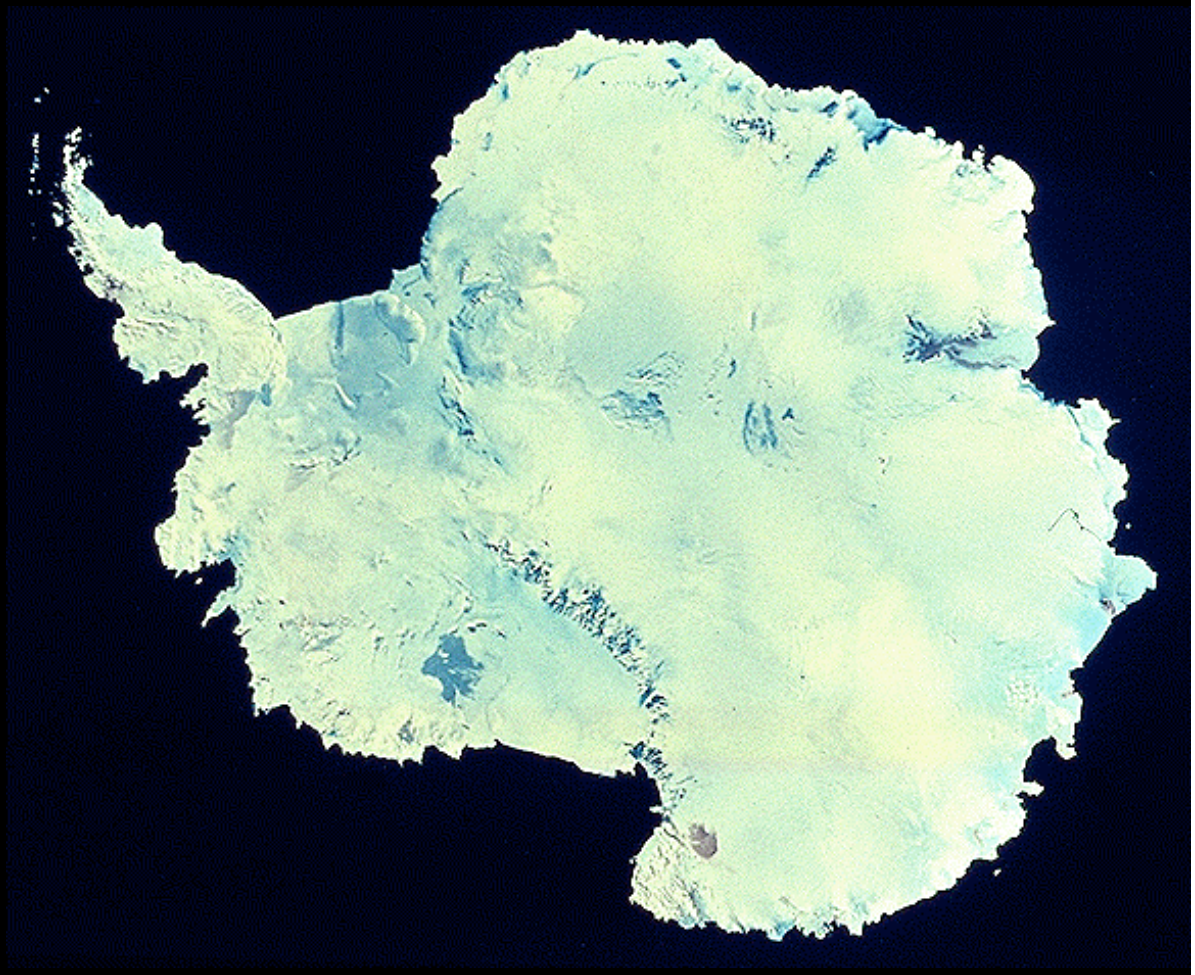

ANTARCTIC SMMR MONTHLY MEAN ICE CONCENTRATION(NIMBUS 7)OCTOBER 1978
≥96%
96%
92%
88%
84%
80%
76%
72%
68%
64%
60%
56%
52%
48%
44%
40%
36%
32%
28%
24%
20%
16%
12%
≤12%

Where are the ice sheets in the present-day climate?

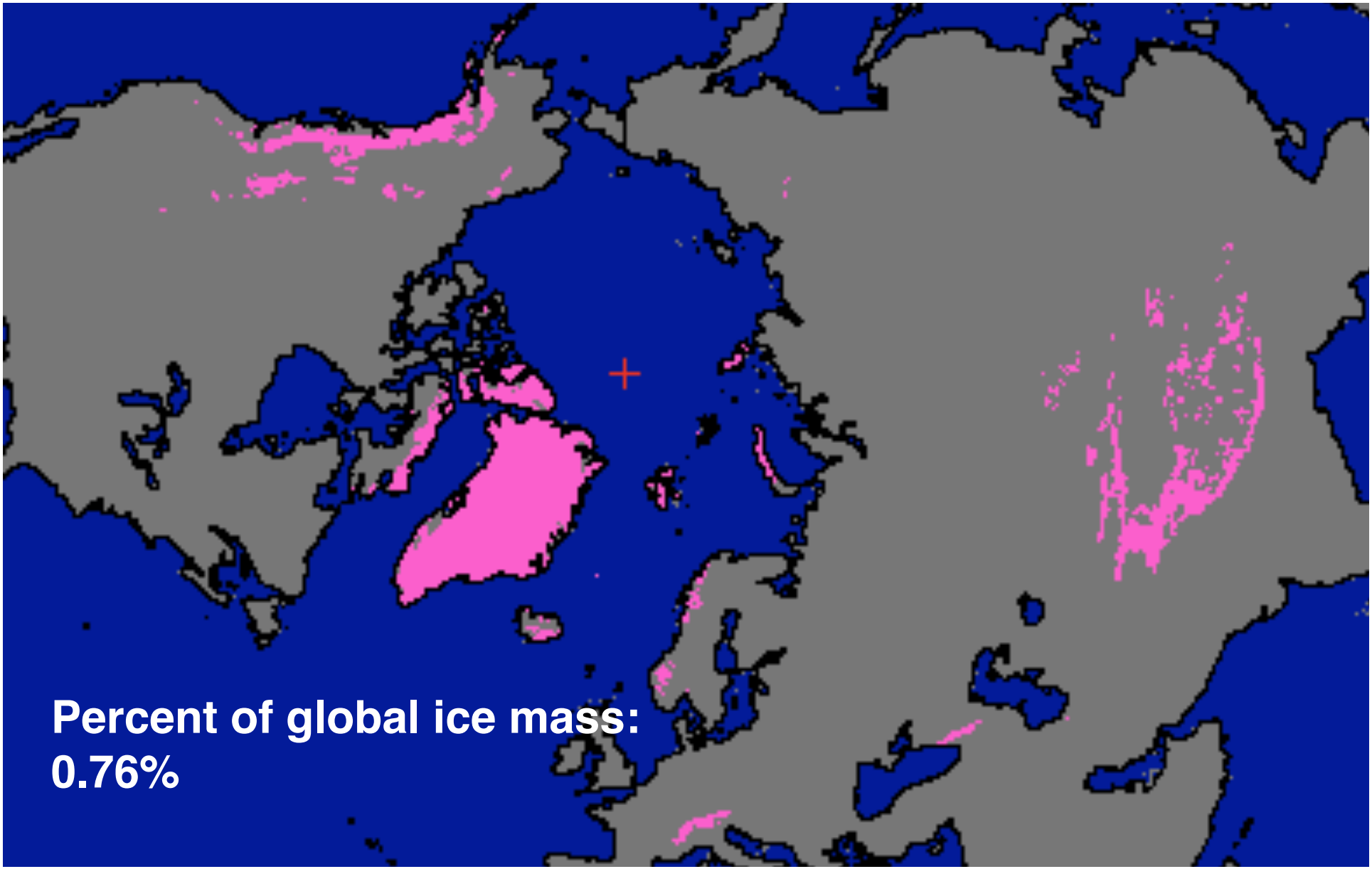
In the northern hemisphere, Greenland is covered by an enormous ice sheet which is a few kilometers thick and more than five times larger than the state of California in area. If this ice sheet were to melt, global sea level would rise by about 7 meters. (percent of total global ice mass: 8.6%)

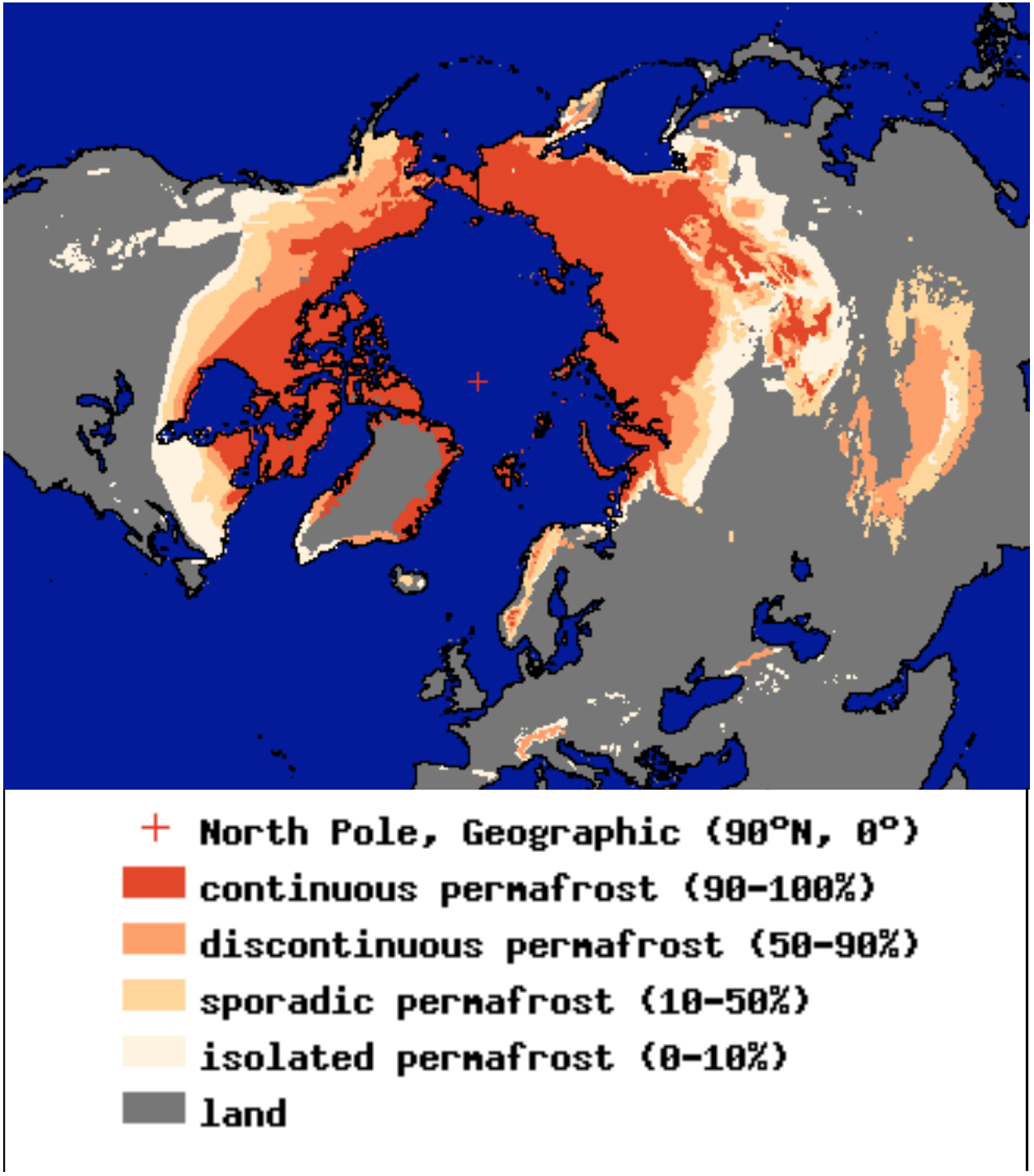
This is all that remains of the huge ice sheets that covered North America and Eurasia during the last glacial maximum, about 20,000 years ago.

In the southern hemisphere, the Antarctic continent is covered with an even larger ice sheet. The Antarctic continent is about 25% larger than the United States. If this ice 3 km high sheet were to melt entirely, global sea level would rise by about 70 meters. (percent of global ice mass: 89.3%)



Current distribution of mountain glaciers in the northern hemisphere





Northern Hemisphere Permafrost

Permafrost is a layer of soil or rock, at some depth beneath the surface, in which the temperature has been continuously below 0°C for at least several years.
(percent of global ice mass: 0.95%)