Isotope ratio in ice core

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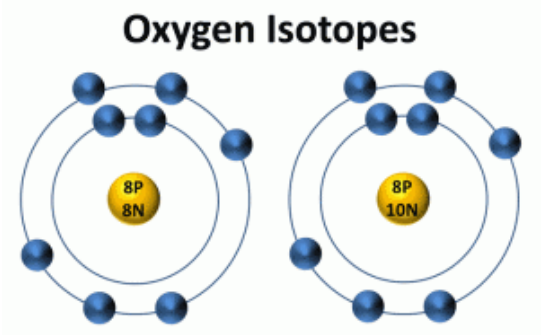
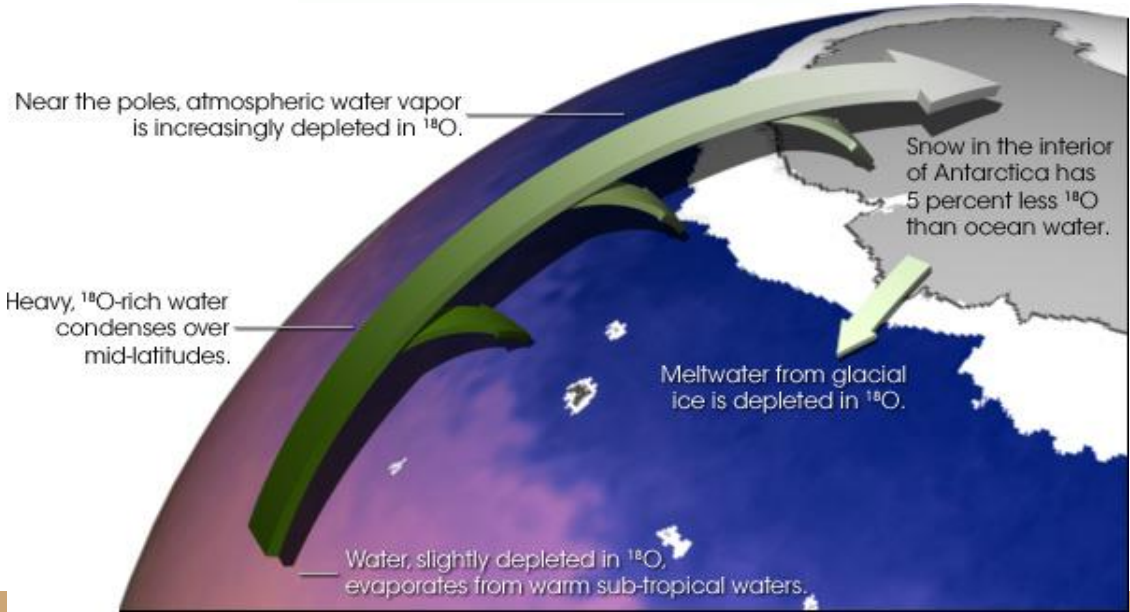
Oxygen isotopes in the water cycle

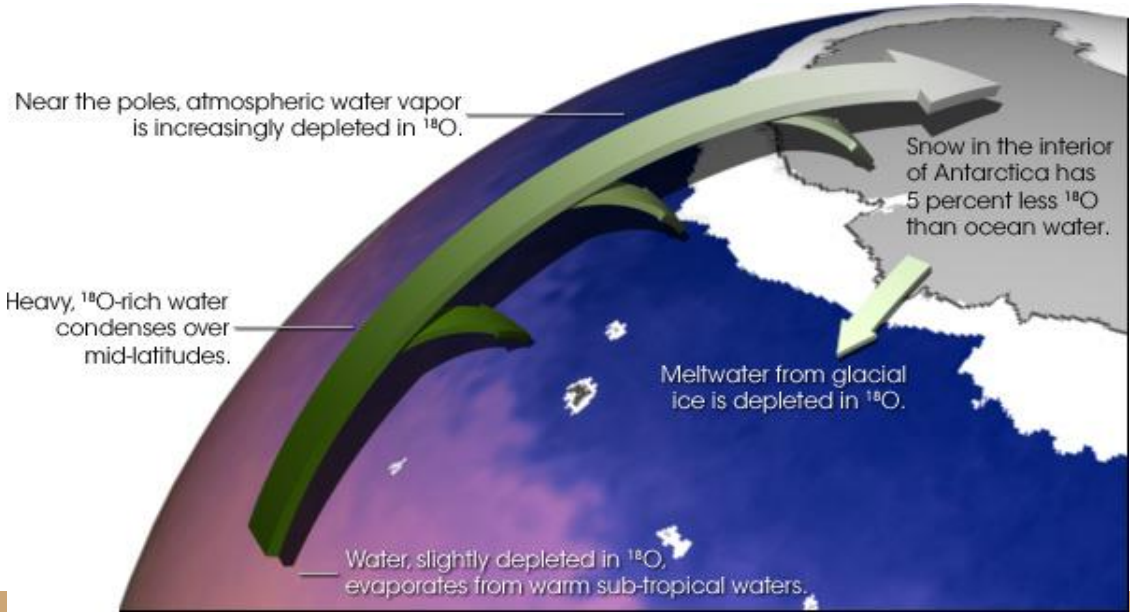
- the most common isotopes are ^{16}O and ^{18}O
  - ^{16}O is a product of stellar evolution, created during the triple-alpha process
  - ^{18}O is a heavier and much rarer isotope, has a natural abundance of only 0.2%
- the ratio of these two isotopes in the water changes with the climate
  - this ratio is influenced mainly by the water cycle
  - water containing ^{16}O evaporates more quickly, than water containing ^{18}O
  - however water vapour containing ^{18}O will form rain more quickly
  - the snow falls to the ground, creating a new layer on the surface, preserving the isotope ratio





Isotope ratio

- differences in the amount of these isotopes are measured by comparing the ratio of $^{18}O/^{16}O$ to the average ocean water
  - this comparison is called $\delta^{18}O$
  - average ocean water has a value of 0‰ $\delta^{18}O$
  - the water vapour is a few permil negative *(around -3‰)*, since it has less ^{18}O than average ocean water
  - on the way to the polar regions, ^{18}O will form rain in a greater extent than light isotopes due to its mass, making the rain have a more positive $\delta^{18}O$, than the clouds it fell from

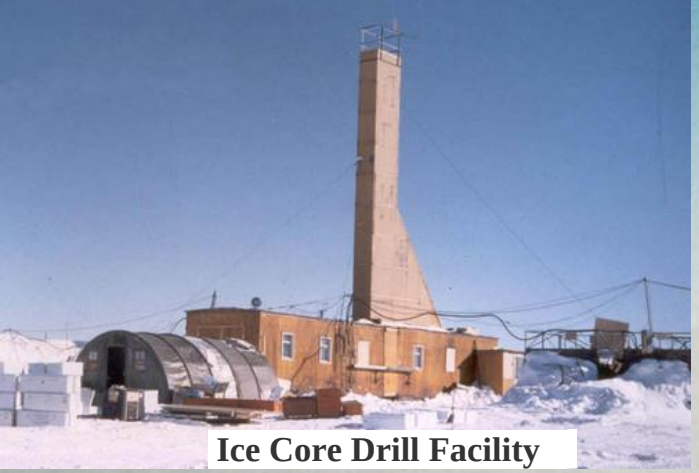


Ice core measurements

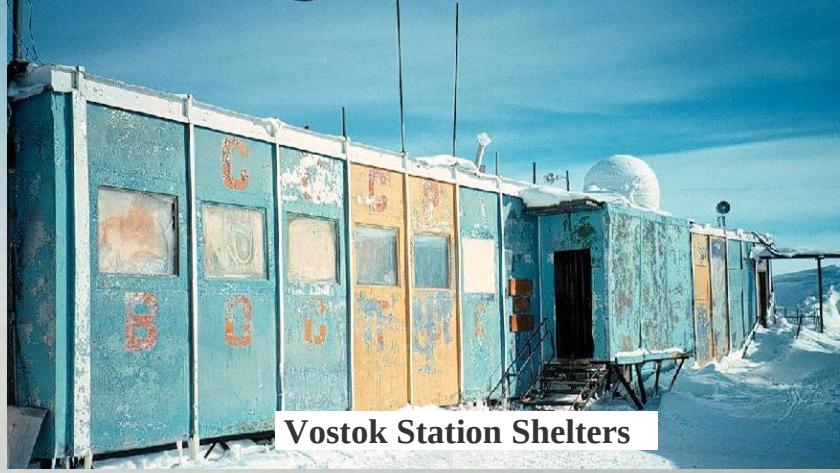
- glaciers form as layers of snow accumulate on top of eachother
  - each layer is different in chemistry and texture
  - as more and more layer falls to the ground, the snow compresses, forming ice
    - particles and air bubbles become a part of it. storing information about the climate conditions at the time of formation
      - for example: snow accumulation, local temperature, green gas concentration of the atmosphere, volcanic activity
- ice cores are extracted by drilling
  - most ice cores come from Antarctica or Greenland, where the longest ice cores extend to 3 kilometers
  - the oldest continuous ice core records extend to 130 thousand years in Greenland and 800 thousand years in Antarctica

Ice core measurements

- types of drills
  - mechanical: used where the ice is well below freezing
  - thermal: used where ice is above -10°C
- ice core sections are typically 1 meter to 6 meters long with a 50-132 millimeter in diameter
  - many repeated drill runs are required to collect a longer ice core
- hand augers: used when only the top 20-30 meters are targeted

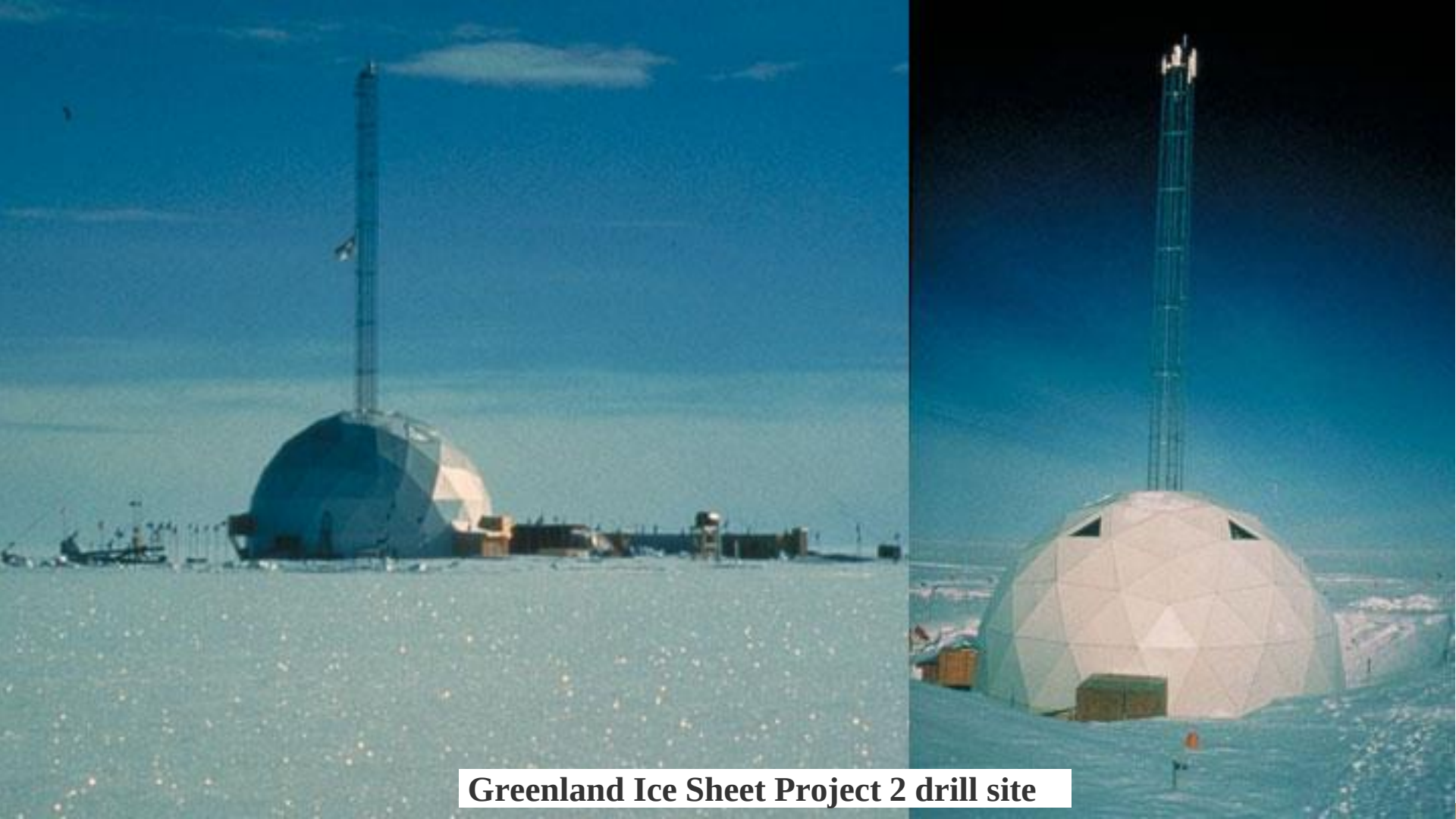


Ice Core Drill Facility

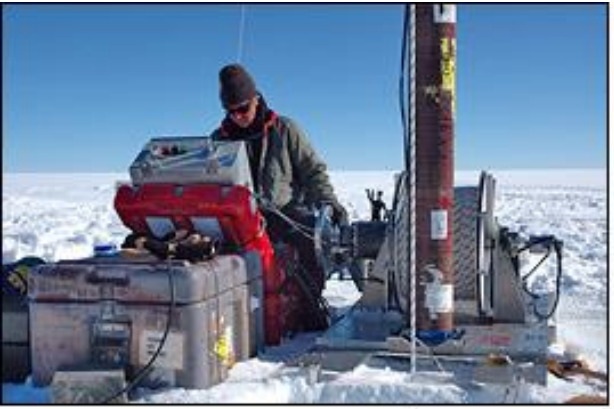


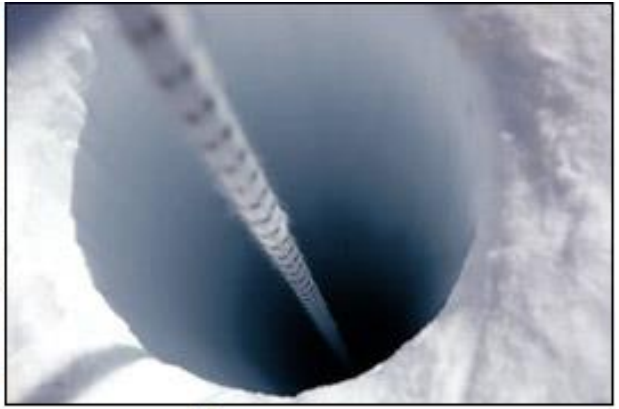
Vostok Station Shelters

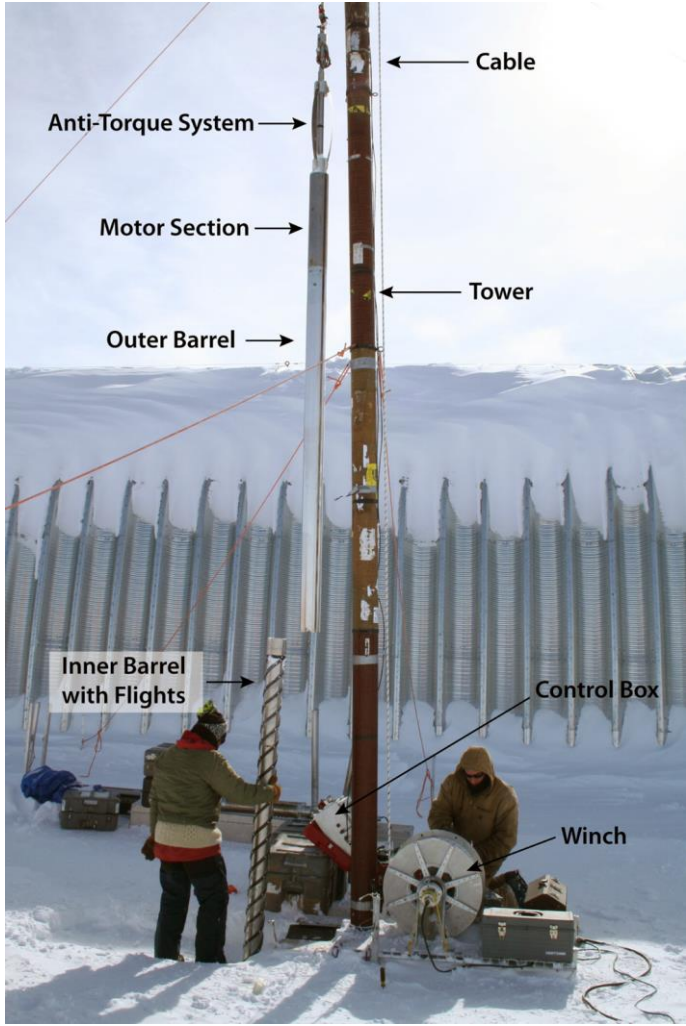
Vostok Station



Greenland Ice Sheet Project 2 drill site






Cable
Anti-Torque System
Motor Section
Tower
Outer Barrel
Inner Barrel with Flights
Control Box
Winch

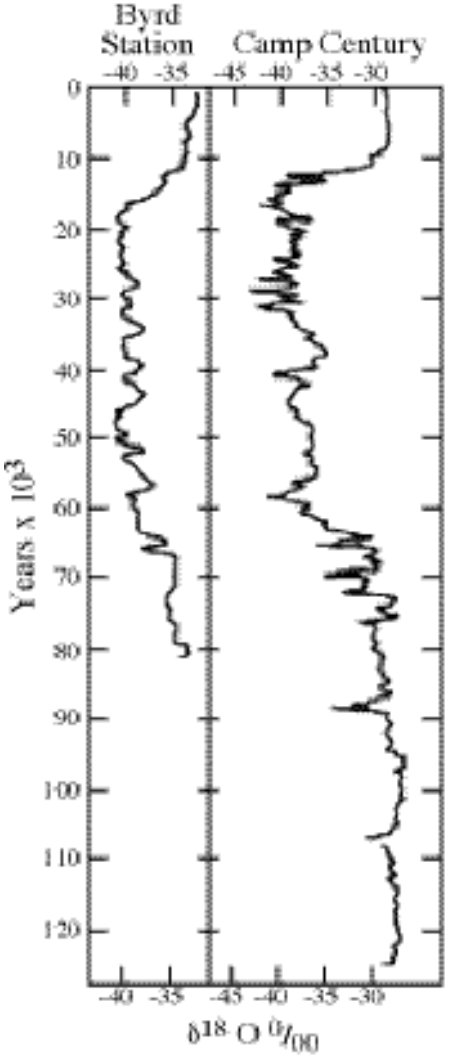
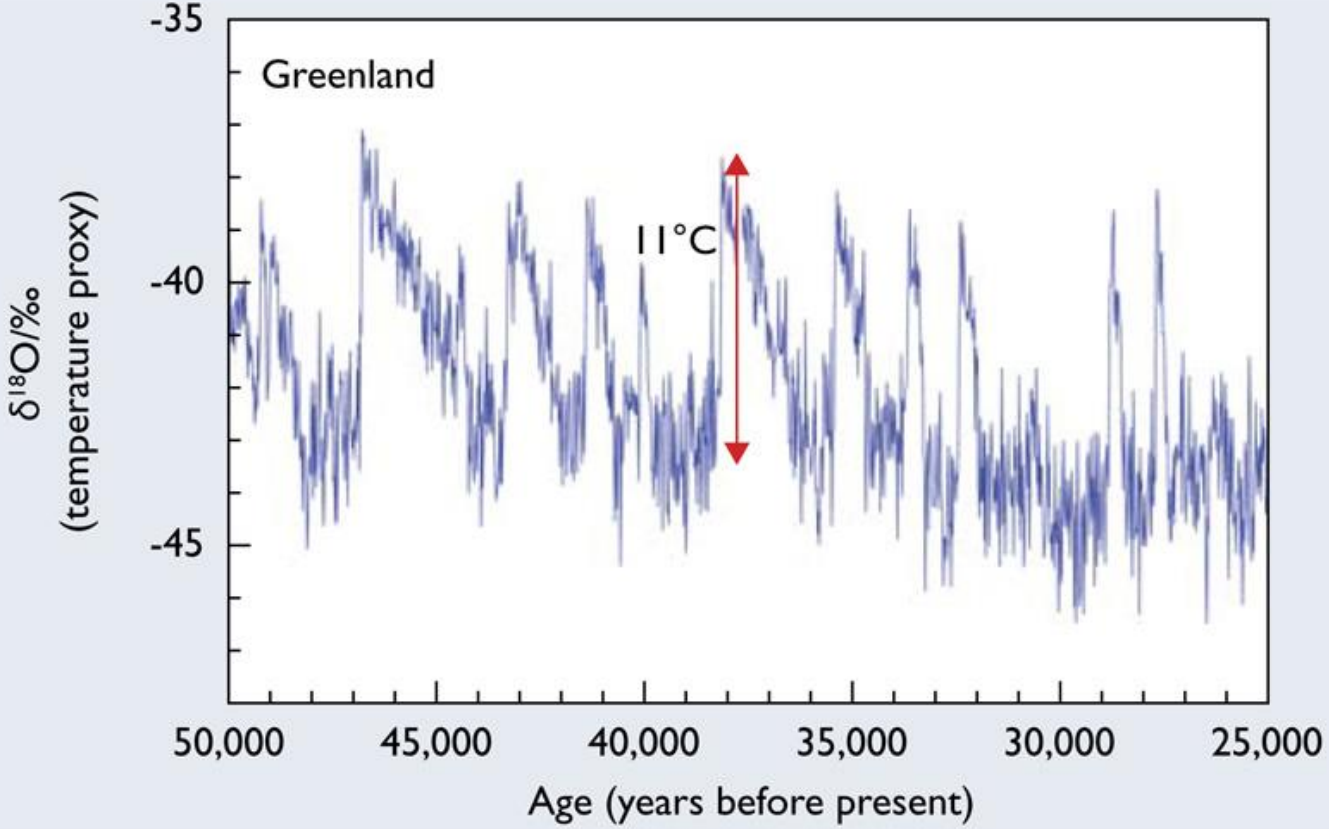

Byrd Station
Camp Century
-40 -35
-45 -40 -35 -30
0
10
20
30
40
50
60
70
80
90
100
110
120
Years x 10^3
$\delta^{18}O$ ‰

Fig. 5: *Oxygen isotope ratio (temperature proxy) from the NorthGRIP (Greenland) ice core showing a sequence of rapid temperature jumps*[8]



Sources

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- https://www.bas.ac.uk/data/our-data/publication/ice-cores-and-climate-change/