Lecture 13

GLY102

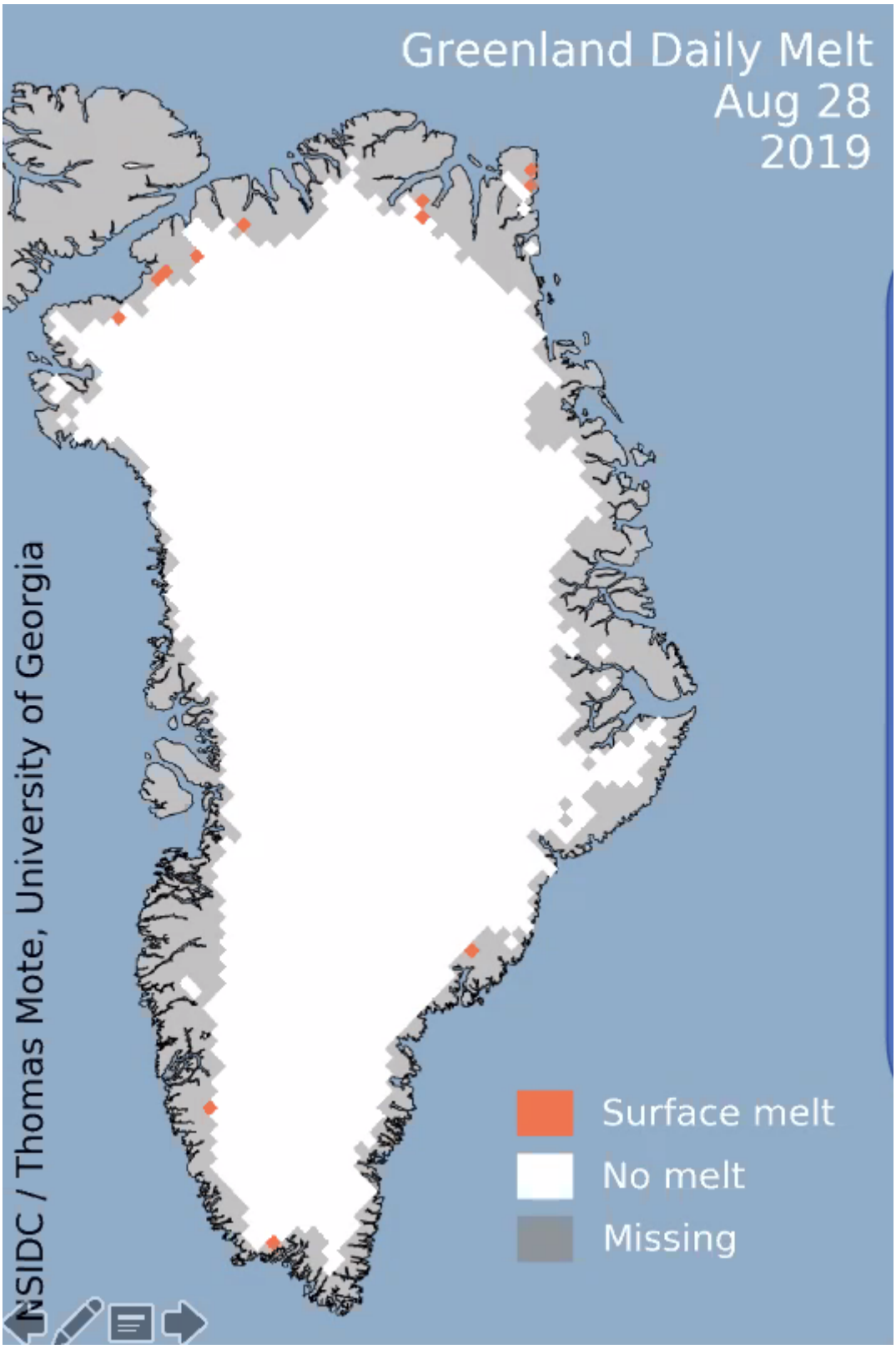
3/16/2021

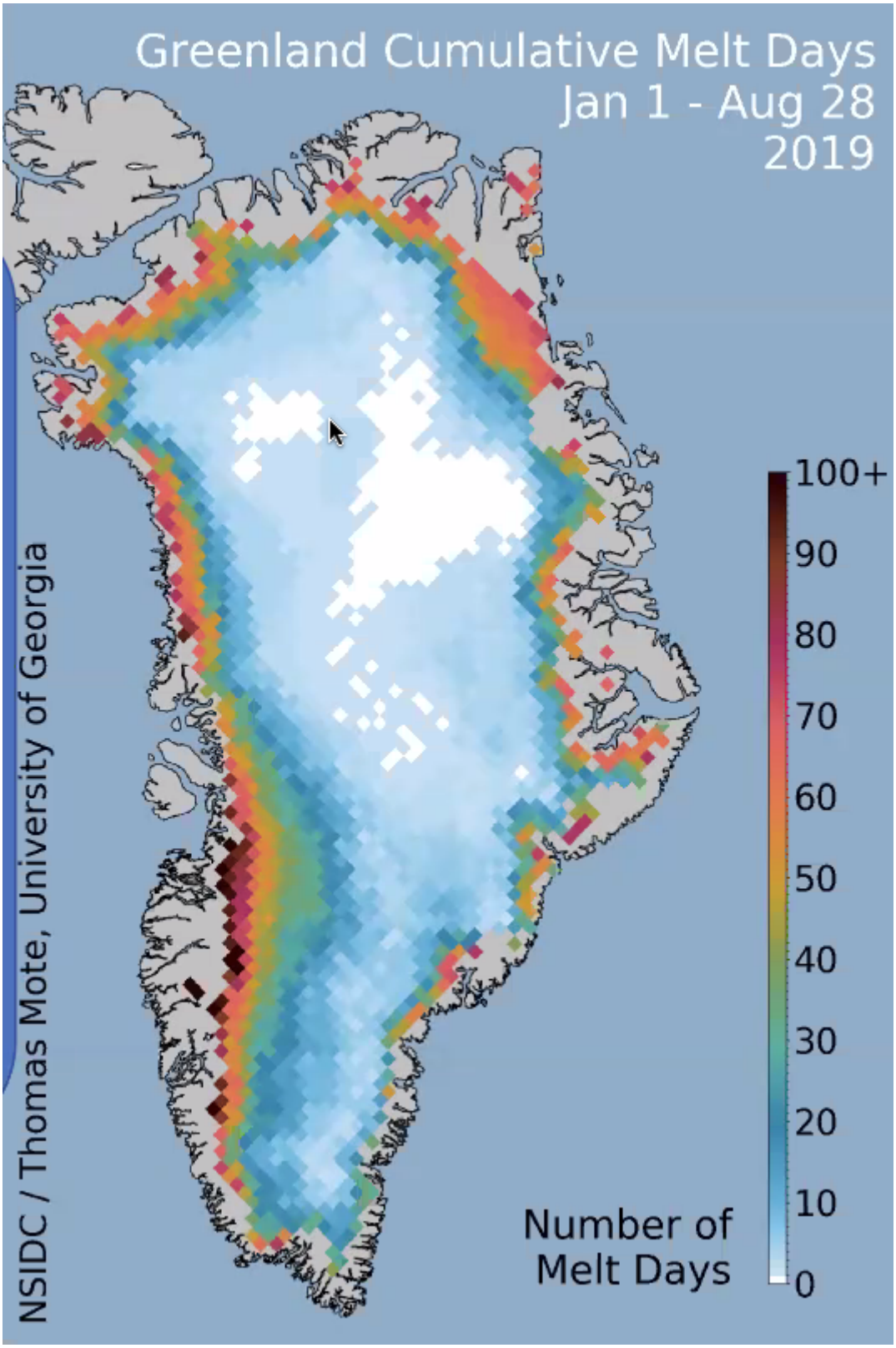
From Mud to Climate

Review

> ### What do ice cores record?
>
> 1. Past levels of greenhouse gasses in the atmosphere
> 2. Water isotopes (H and O) record changes in temperature and water source area
> 3. Ice layer thickness is a function of past precipitation amounts
> 4. Ice layers contain dust and volcanic ash
> 5. Melt layers record extreme summer warmth (to be revisited in this lecture)

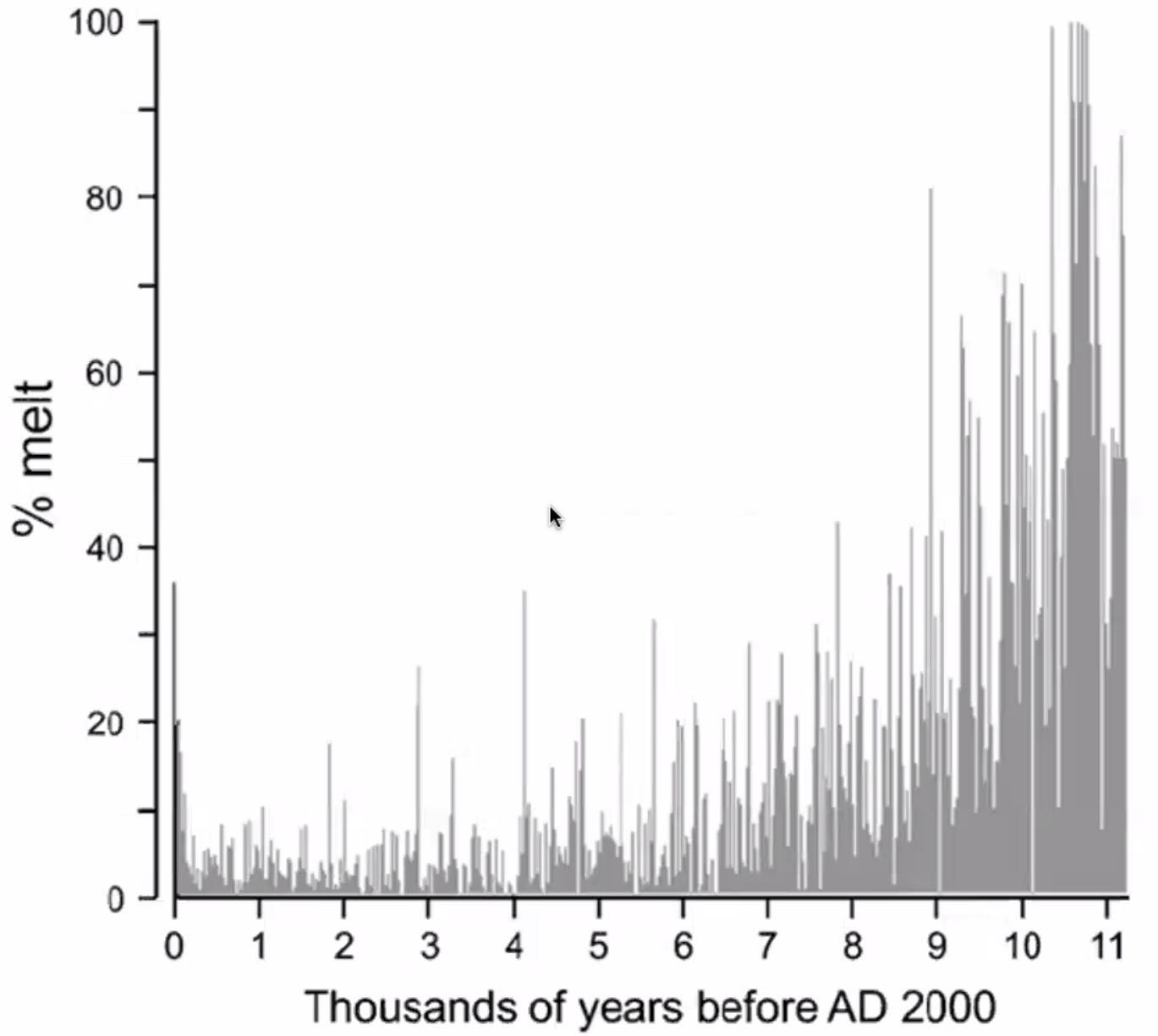
Recall from way back when we discussed the “anomaly”. We looked at these maps of Greenland:




Greenland Cumulative Melt Days
Jan 1 - Aug 28
2019
NSIDC / Thomas Mote, University of Georgia
100+
90
80
70
60
50
40
30
20
10
0
Number of
Melt Days

In this image, the ice portion in the middle of the snow is considered a “melt layer”.

Here is the percentage of melt “anomalies” through the past 11,000 years:

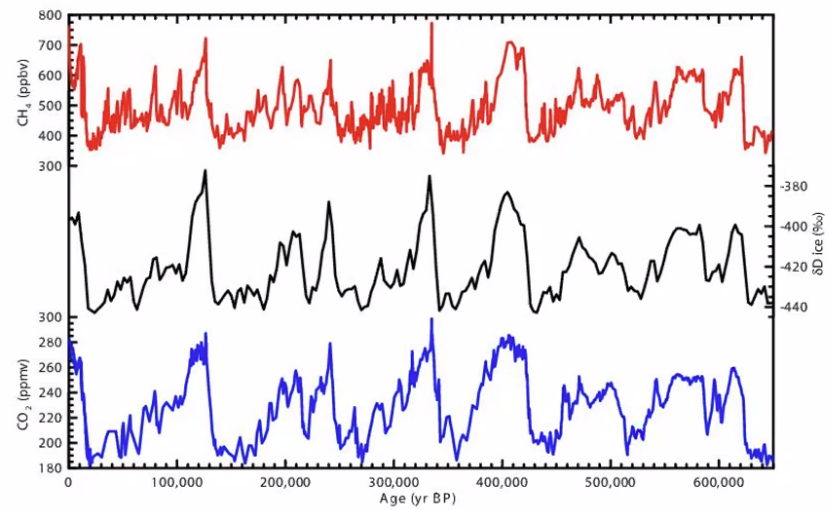


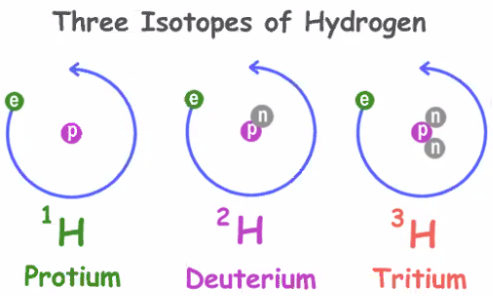
Over the course of these thousands of years, there have been less melt layers which means a cooler temperature. This is caused by the Milankovich cycles.

(Note: our time is on the left of the chart, not the right)

Note the spike right at x=0. This level of melt layers is greater than any record less than 4000 years!

Recall: (1) Greenhouse gasses in ice cores, and (2) the use of isotopes of water.

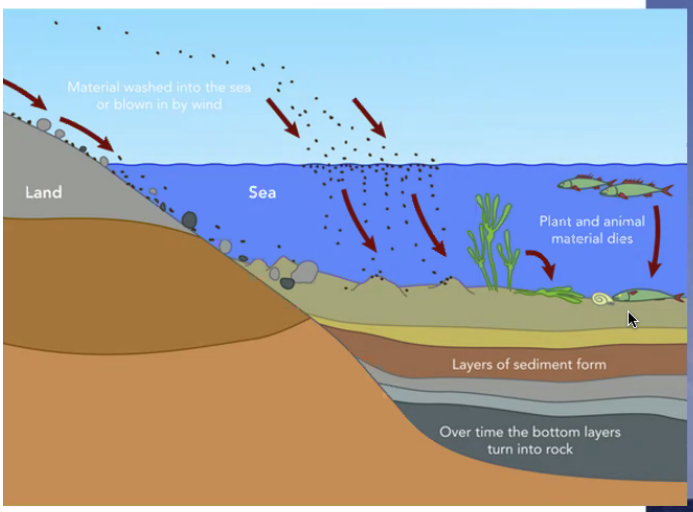


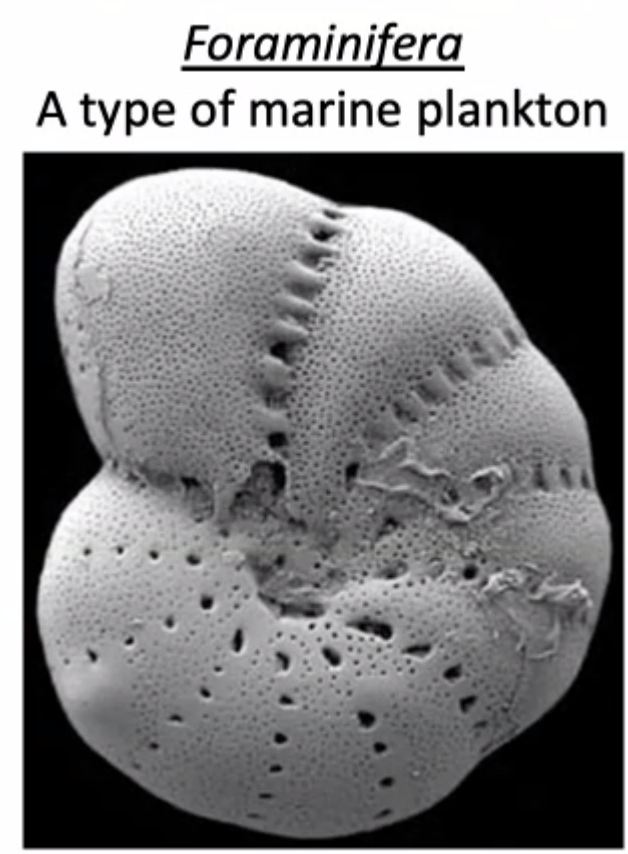


The ocean has a certain balance of 18s and 16s. People normalize the ystem to seawater (0) but by the time it evaporates, it will have less 16s (I think, this was hard to follow).

Ocean mud coring

How we get marine sediment cores



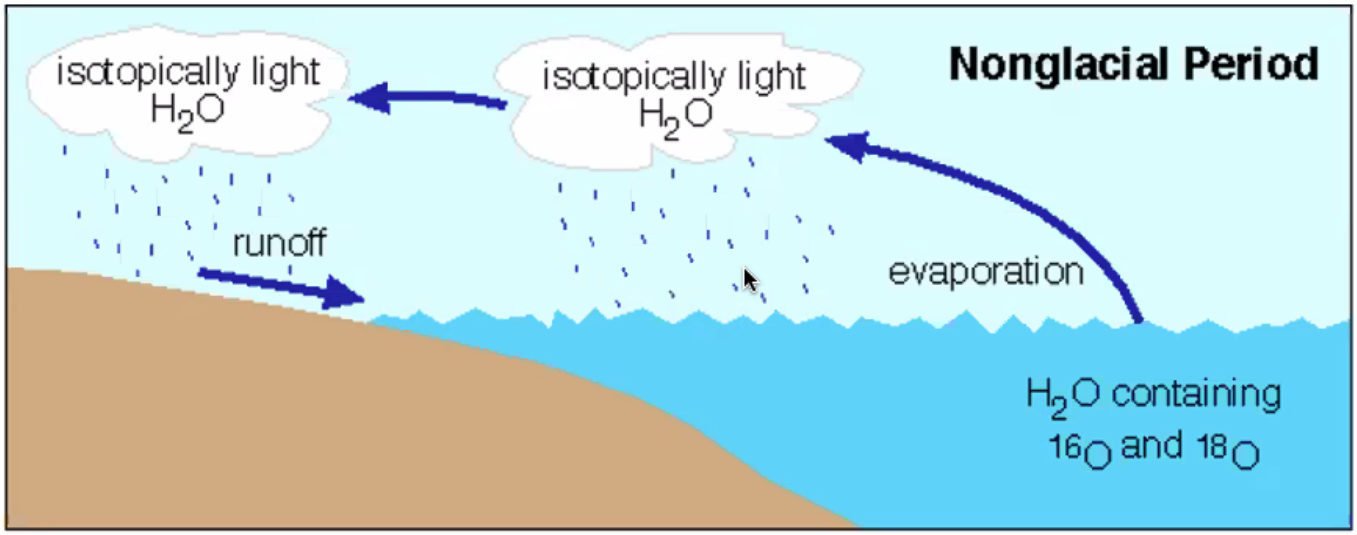


^ These get trapped in mud as fossils

Refer to the video provided in the slides for the rest of this section.

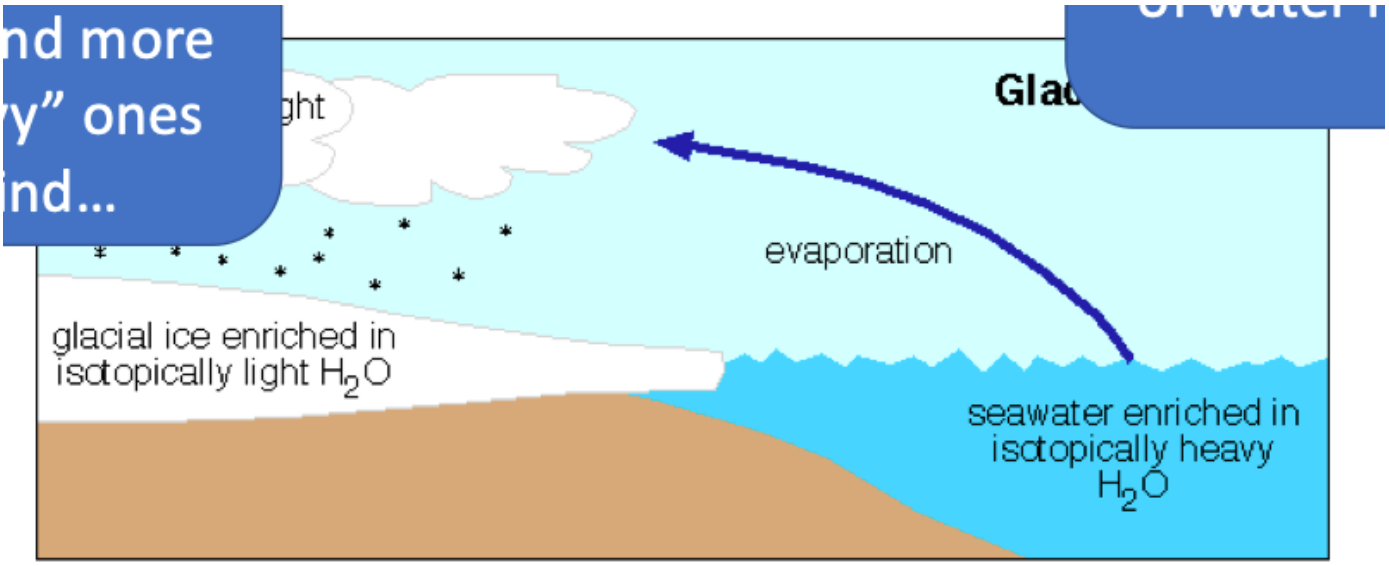
Ice volume

Ocean sediment cores record global ice volume through time! How?
These little *foraminifera* shells are made of $CaCO_3$.



More of the "light" water molecules leave the ocean, and more of the "heavy" ones stay behind...

If an ice sheet becomes present, the "light" molecules will not be put back into the ocean:

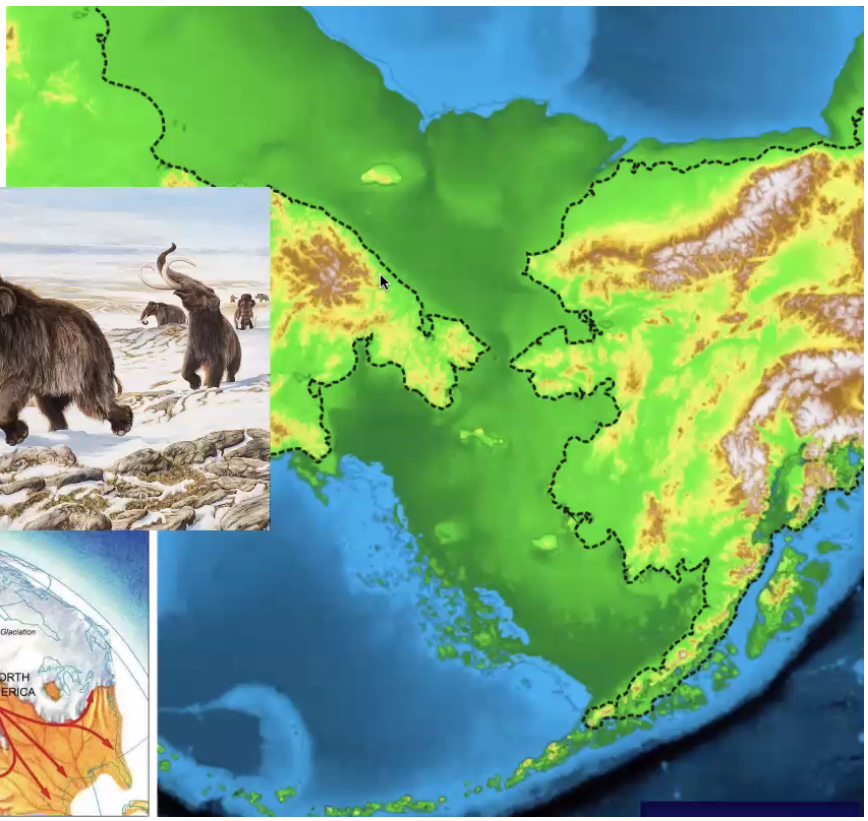


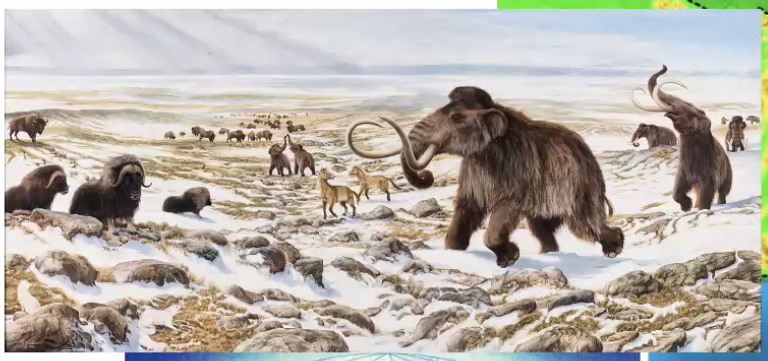
The seawater becomes enriched in the isotopically heavy water molecules.

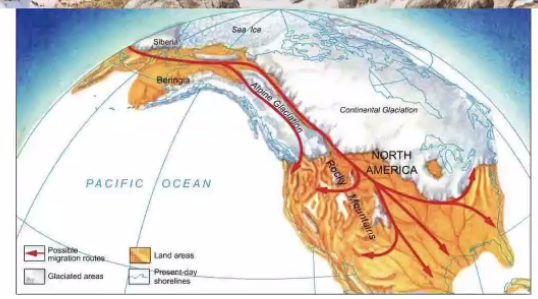
Evidence that some of the ocean's water got stuck on land:

^ This map shows global sea level lowering during the last glaciation.

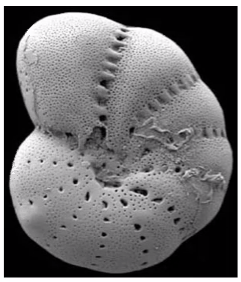
This is a zoom in of the
Bering Land Bridge







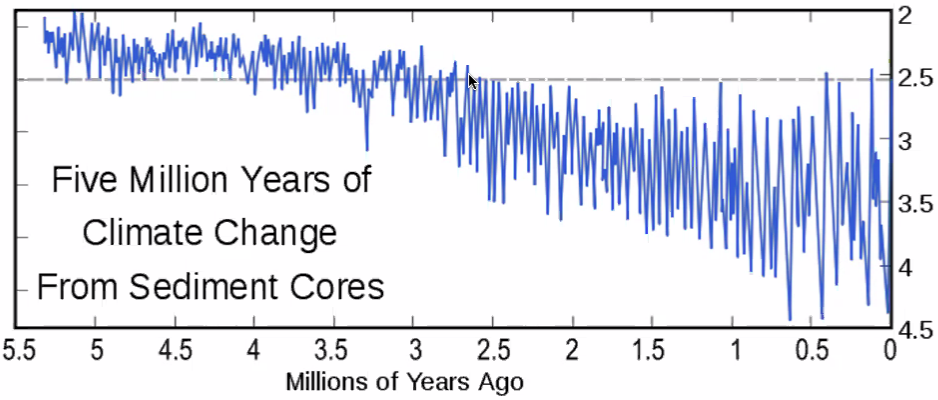
So, 1000s of measurements of these:



$CaCO_3$

From lots of these:

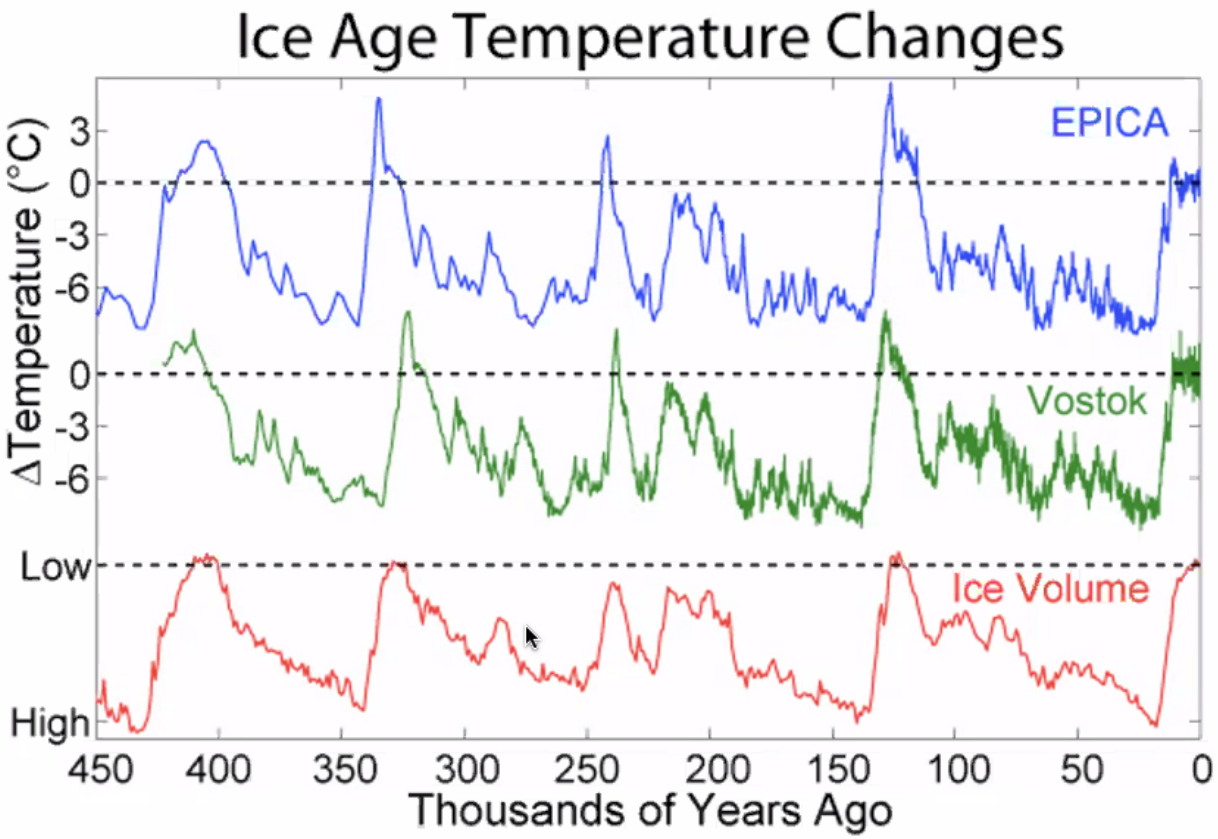
leads to this:



Note scale! opposite of ice cores

The oscillations here represent the glaciations/interglaciations.

Today, we have more 18O compared to 16O than we did 5 million years. This is what ocean sediment cores have been able to tell us about the history of our planet.



On the red curve, global ice volume is mapped. These are from the foraminifera measurements. What this tells us is that global temperature and ice volume are correlated.

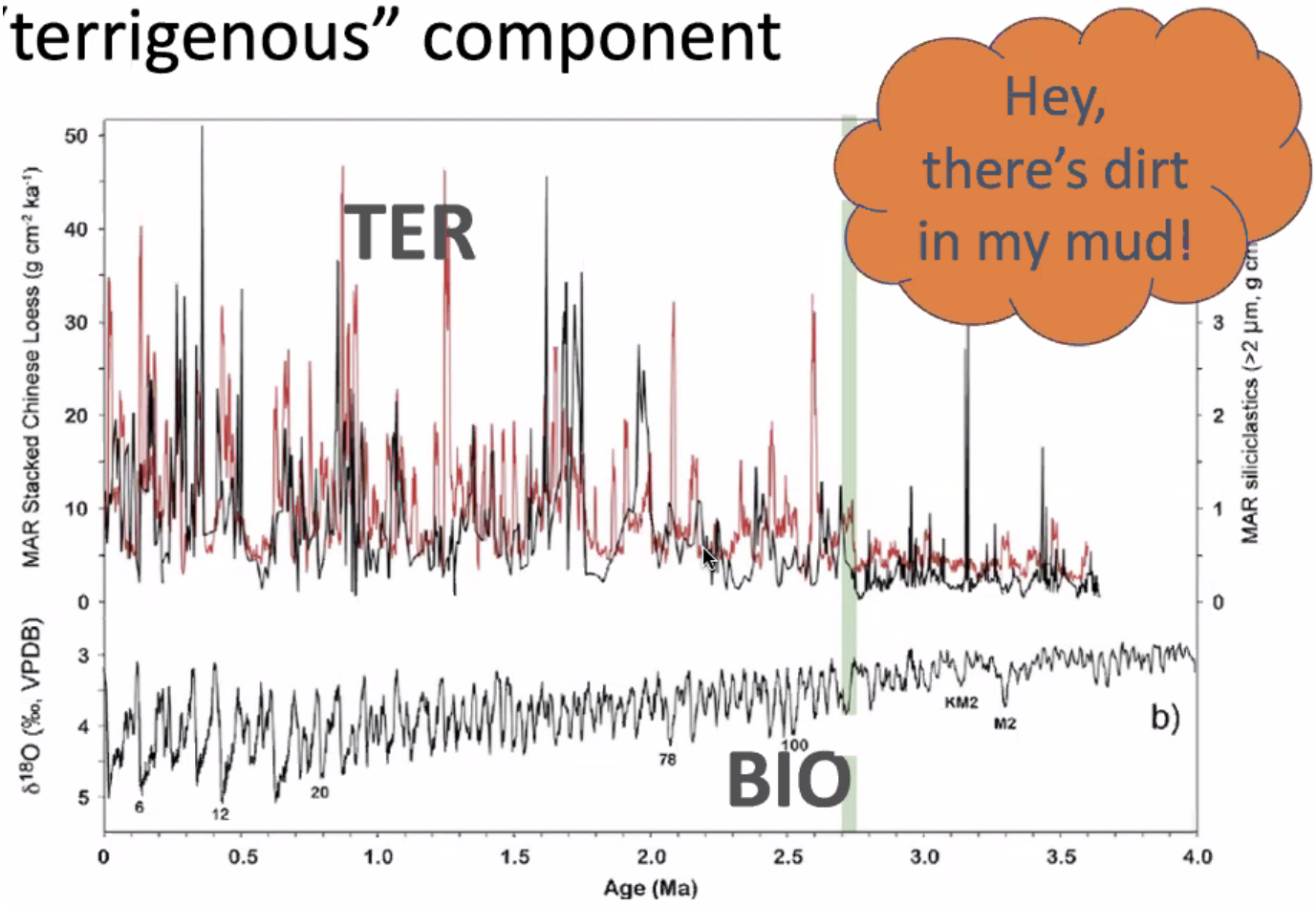
So, now we have greenhouse gasses, temperature, and ice volume all together.

Dirt in mud

There are 2 major types of information in the ocean basins:

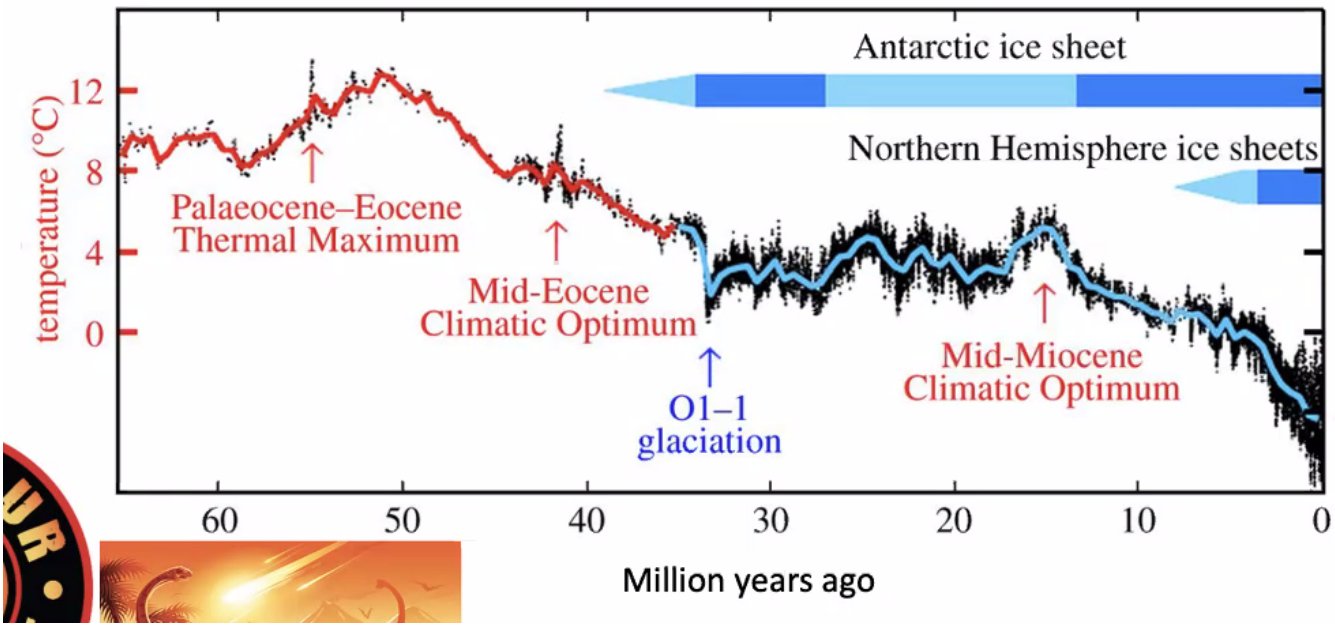
1. The *biology part* of sediment (fossils: micro and really micro)
    - Records ice volume (and other things: water tmeperature, salinity, circulation patterns)
2. *Terrigenous* material (the non-biology stuff)
    - Records aridity, intensity and direction of wind

Here are both the “biogenic” component and the “terrigenous” component:



Why does the terrigenous (sand and silt from continents) input to the oceans increase during the last Ice Age?
Ice sheets attached to land masses bring sediments from the continents out to sea as it grows and spreads.

Cooling since dinosaur times:



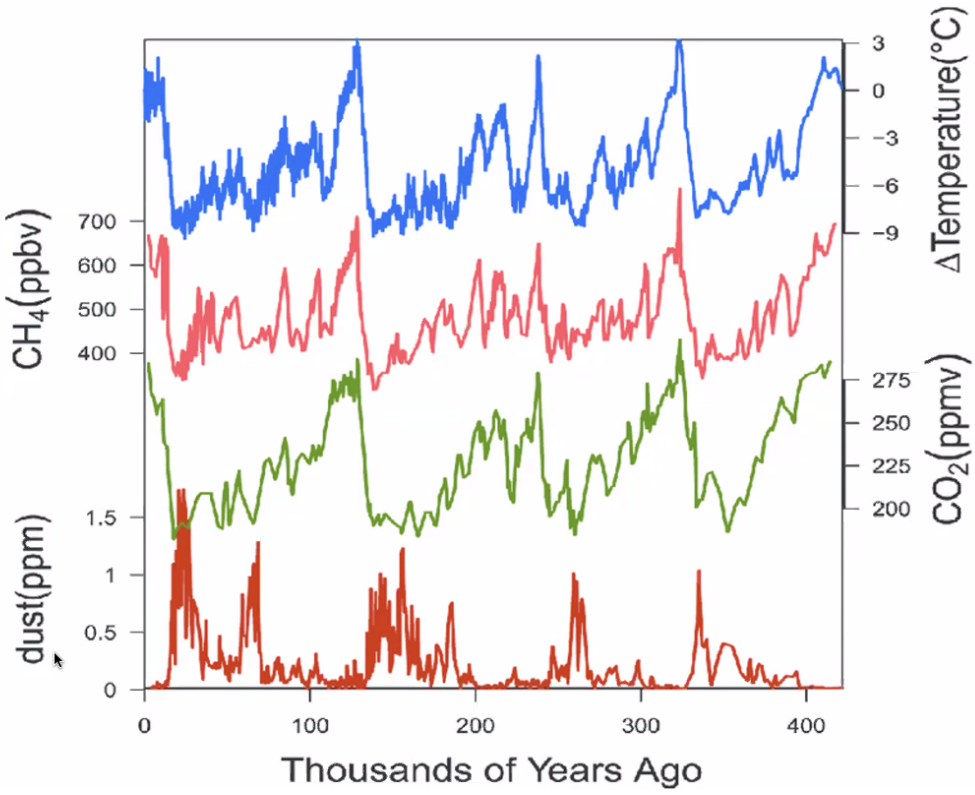
Notice, in this picture, the sediment that has been carried by this iceberg:

Sediment that gets dropped off an iceberg into the deep ocean is called **Ice-Rafted Debris**.

Question: What ultimately drives the vigor of atmospheric circulation?
Answer: The equator-to-pole temperature gradient

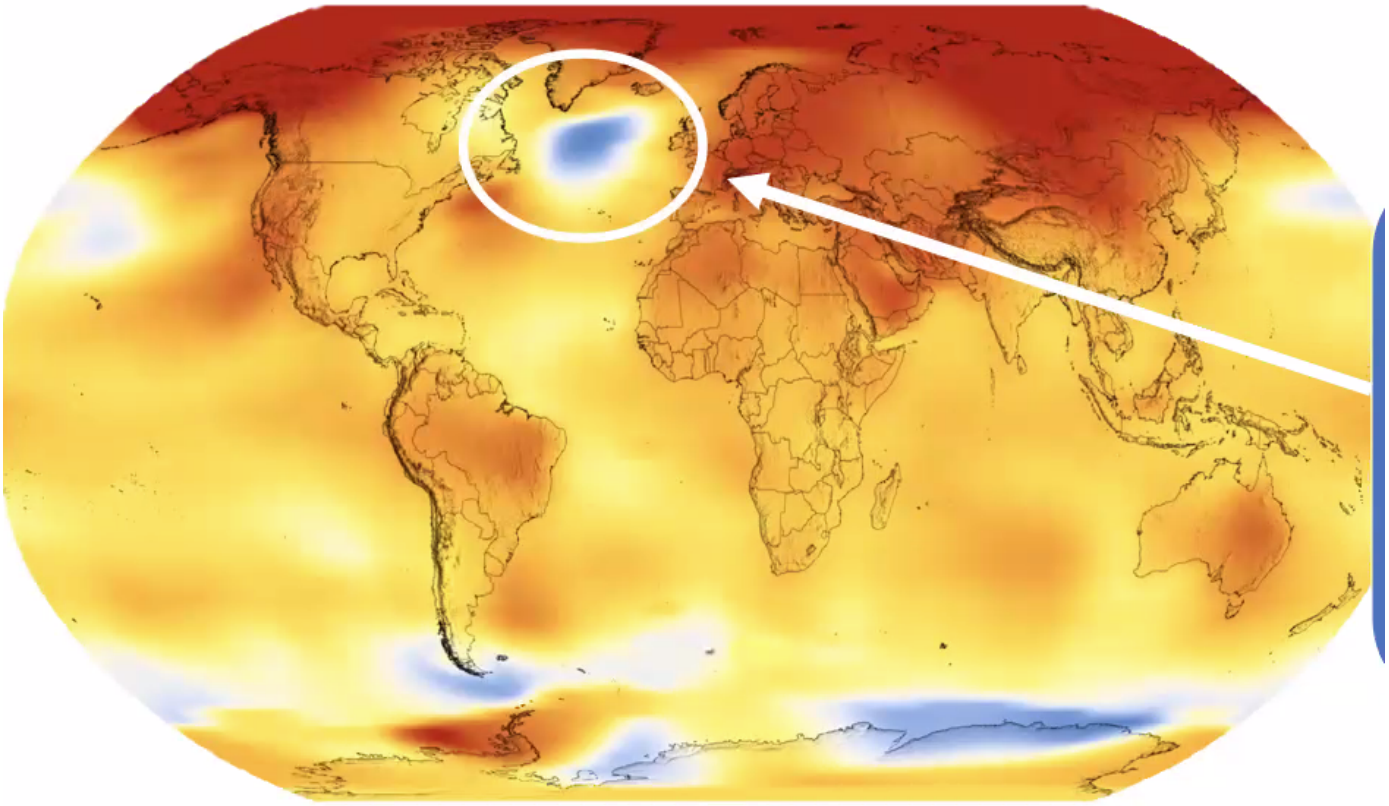
NEW: bottom plot!

It shows dust (found in both ice cores and in ocean sediments)



Cold blob

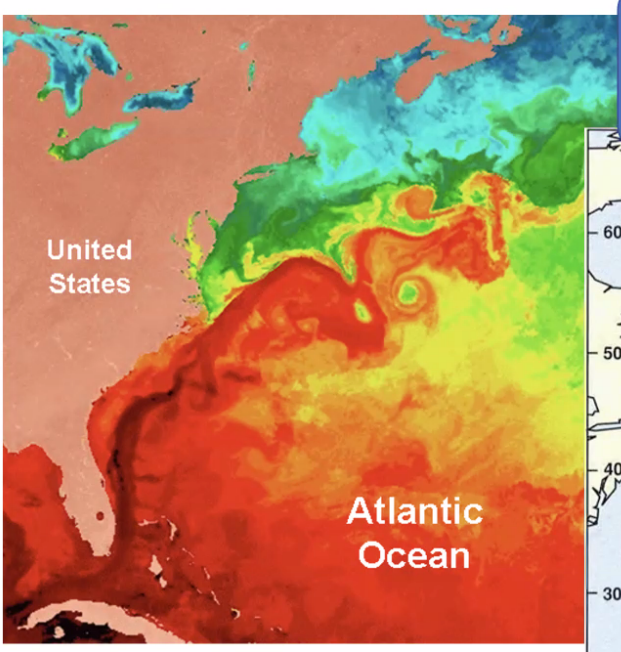
Temperature Change in the Last 50 Years



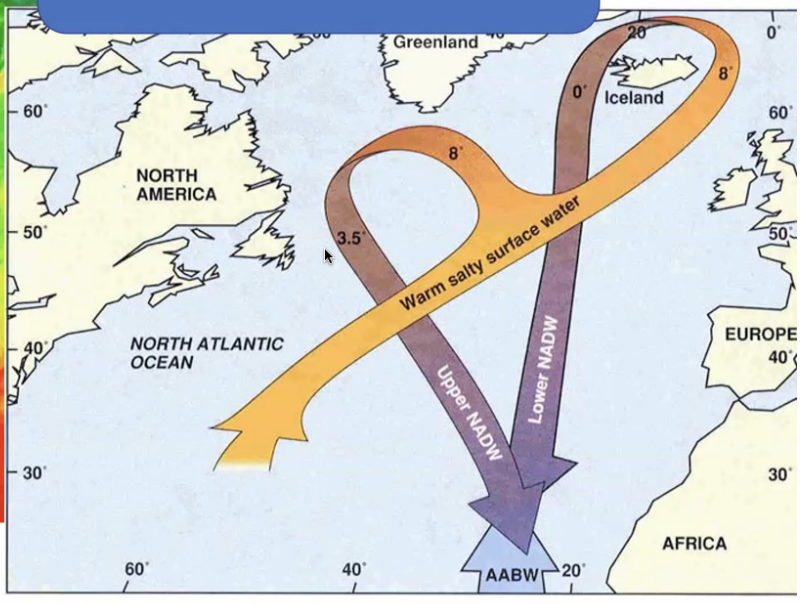
2014-2018 average vs 1951-1980 baseline

-2°C -1°C 0°C +1°C +2°C

The cold blob lives at the top of the Gulf stream area:



AMOC



Scientists measured chemical data in the mud layers below the cold blob. the chemicals they measured are “tracers” for AMOC. Their data show a slow-down of AMOC: