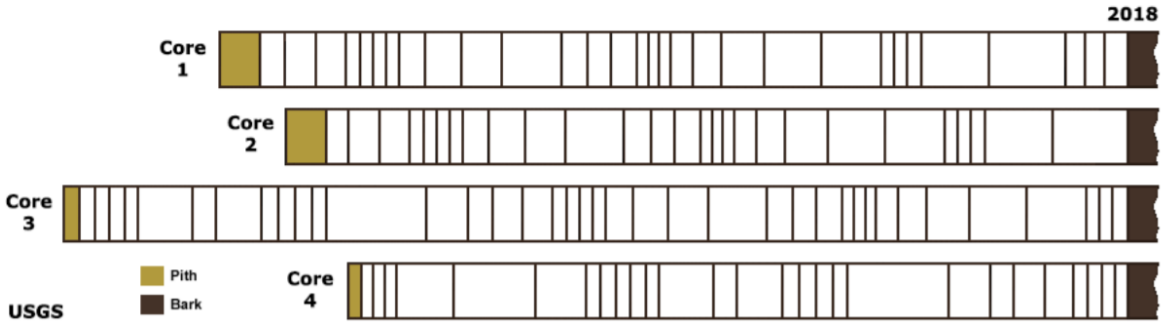
INTER ⇄ ACT

WORKSHEET – ANSWERS
TEACHERS' VERSION

ARCTIC ISSUES:
PAST ENVIRONMENTS

TASK 1. Dendrochronology: tree detectives

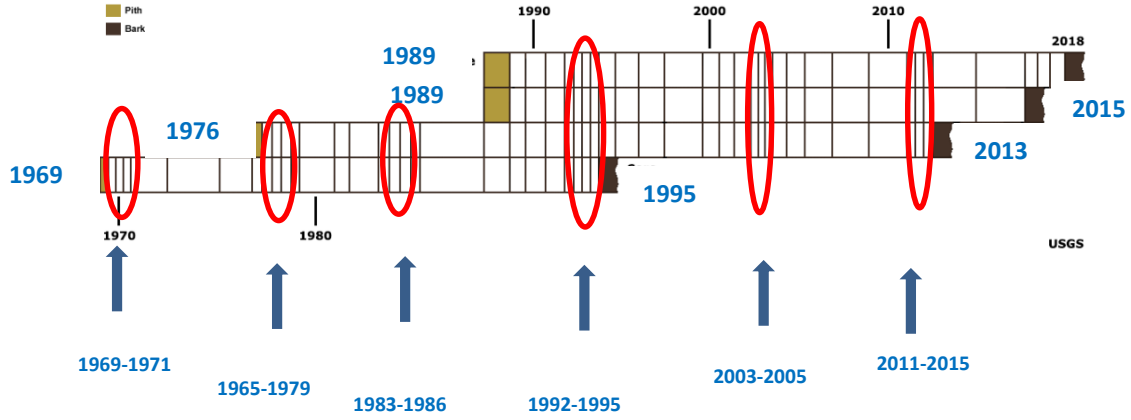


Source of sequences images: UCAR CENTER FOR SCIENCE EDUCATION

You have 4 samples of trees. Each horizontal bar represents the tree-ring pattern for one tree. The first one was sampled in 2018. Measure the rings with a ruler. By looking for matches in the patterns, build an overlapping sequence that stretches back in time. Try to determine: how old was each tree when it was cut down or sampled, what year where trees 2,3,4 cut down or sampled. Determine what year did the growth begin. Mark drought periods, when did they happen?

ANSWERS:

CORRECT SAMPLES ALIGNMENT:



CORE 1-> 30 years old; the tree was cut down/sample was taken in 2018, the growth started in 1989
CORE 2-> 27 years old; the tree was cut down/sample was taken in 2015, the growth started in 1989
CORE 3 -> 38 years old; the tree was cut down/sample was taken in 2013, the growth started in 1976
CORE 4 -> 27 years old; the tree was cut down/sample was taken in 1995, the growth started in 1969

TASK 2 Paleoclimatology – definitions

Combine the word with the corresponding definition/features Be careful, 2 definitions do not match to any of indicated terms

Proxy	
Foramnifera	
Cosmogenic isotopes	
Dendrochronology	
Peatland	

1) Magnetic field limits their amount
2) Scientific discipline concerned with dating and interpreting past events, particularly paleoclimates and climatic trends.
3) Ince igneous or sedimentary, they have been changed as a result of intense heat and/or pressure within the Earth's crust.

4) Physical, chemical and biological materials preserved within the geologic record that can be analyzed and correlated with climate or environmental parameters in the modern world
5) They lack cell nuclei and are therefore prokaryote.
6) Terrestrial ecosystem in which the production of organic matter exceeds its decomposition
7) They are among the most abundant shelled organisms in many marine environments

ANSWERS:

Proxy	**4**
Foramnifera	**7**
Cosmogenic isotopes	**1**
Dendrochronology	**2**
Peatland	**6**

TASK 3 Explain what methods of studying past climates are presented on photos:

ANSWERS:

1 – dendrochronology; sampling a tree

2 – pollen under compound microscope (protective outer walls visible)

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3 – sampling peatland – core of peat representing different climate conditions

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TASK 4 Match the beginning of the sentence on the left with a proper end on the right:

If we find Black Spruce pollen in old rocks or ocean sediments at lower latitudes (closer to the equator) …	… of changes in vegetation going back hundreds of thousands, and even millions of years.
The light-colored rings represent wood that grew …	… by making calcium carbonate from the ocean waters.
Since coral are only prevalent in low-latitude oceans, the climate record they provide complementary …	… where more frequent fires are observed.
Scientists study the record preserved in the sediment …	… farms were destroyed by advancing ice of glaciers and by melt water streams.
Current Arctic drying is clearly visible e.g. in Siberia or the Canadian Arctic …	… layers by drilling into the ocean bottom using a variety of coring devices.
Tax records form Little Ice Age in Scandinavia show many ...	… data to those from tree rings and ice cores, which comes from intermediate and high latitude regions.
As corals grow, they form skeletons …	… in the spring and early summer.
By analyzing pollen from well-dated sediment cores, scientists can obtain records …	… we can interpret that the Earth may have been colder in the geologic past.

ANSWERS

- If we find Black Spruce pollen in old rocks or ocean sediments at lower latitudes (closer to the equator), we can interpret that the Earth may have been colder in the geologic past.
- The light-colored rings represent wood that grew in the spring and early summer.
- Since coral are only prevalent in low-latitude oceans, the climate record they provide complementary data to those from tree rings and ice cores, which comes from intermediate and high latitude regions.
- Scientists study the record preserved in the sediment layers by drilling into the ocean bottom using a variety of coring devices.
- Current Arctic drying is clearly visible e.g. in Siberia or the Canadian Arctic where more frequent fires are observed.

- Tax records form Little Ice Age in Scandinavia show many farms were destroyed by advancing ice of glaciers and by melt water streams.
- As corals grow, they form skeletons by making calcium carbonate from the ocean waters.
- By analyzing pollen from well-dated sediment cores, scientists can obtain records of changes in vegetation going back hundreds of thousands, and even millions of years.

TASK 5 Are these sentences TRUE or FALSE? (underline the correct answer)

Coral reefs, pollen records and tree rings offer year-to-year changes-the highest resolution in paleoclimatology.

ANSWER: ~~TRUE~~**/FALSE**

Coral reefs and tree rings provide information on annual variations in past climates, however pollen records do not have such high resolution.

Microscopic foraminifera Neogloboquadrina pachyderma (N. pachyderma) serves as a particularly useful indicator of ocean temperature and is found in two forms

ANSWER: TRUE/FALSE

When the ocean water is relatively warm, this organism tends to grow into a right-coiling form. When the water is relatively cold, N. pachyderma grows into a left-coiling form.

Just like in tree ring records, the thickness of the annual layers of coral that serves as the primary climate indicator.

ANSWER: ~~TRUE~~**/FALSE**

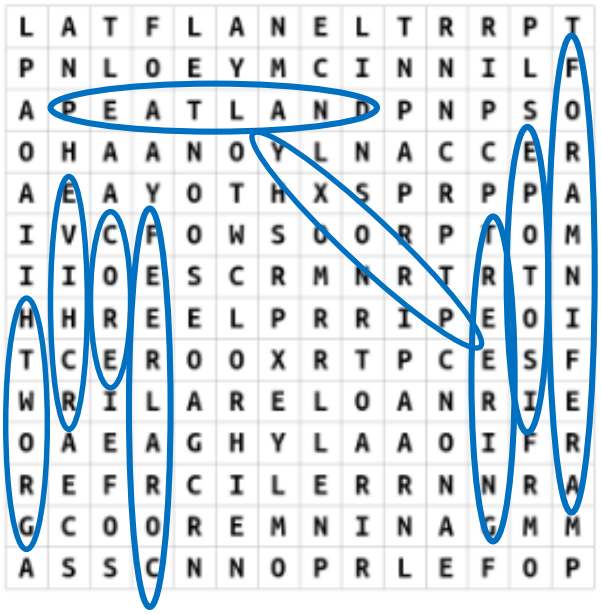
TASK 6

WORDSEARCH

Find 10 words related to paleoclimatology: remember they can go top-down, down-top, lef-right, right-left, and across in all directions.

L	A	T	F	L	A	N	E	L	T	R	R	P	T
P	N	L	O	E	Y	M	C	I	N	N	I	L	F
A	P	E	A	T	L	A	N	D	P	N	P	S	O
O	H	A	A	N	O	Y	L	N	A	C	C	E	R
A	E	A	Y	O	T	H	X	S	P	R	P	P	A
I	V	C	F	O	W	S	O	O	R	P	T	O	M
I	I	O	E	S	C	R	M	N	R	T	R	T	N
H	H	R	E	E	L	P	R	R	I	P	E	O	I
T	C	E	R	O	O	X	R	T	P	C	E	S	F
W	R	I	L	A	R	E	L	O	A	N	R	I	E
O	A	E	A	G	H	Y	L	A	A	O	I	F	R
R	E	F	R	C	I	L	E	R	R	N	N	R	A
G	C	O	O	R	E	M	N	I	N	A	G	M	M
A	S	S	C	N	N	O	P	R	L	E	F	O	P

ANSWERS: pollen, archive, proxy, growth, isotopes, core, coral reef, tree ring, foramnifera, peatland



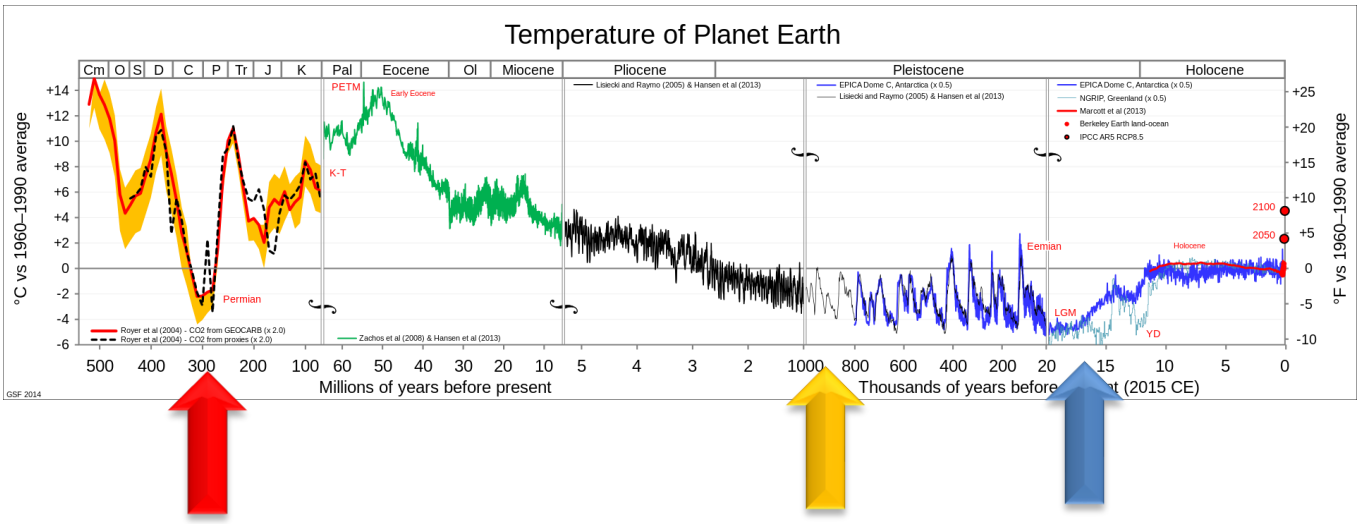
TASK 7

Look the graph below (author: Glen Fergus, CC-BY-SA 3.0)

1) **Which methods would you use to analyse past climate for moments in time indicated by red arrow, yellow arrow, blue arrow?**

Choose from: foramnifera records in sediments, tree rings, peatland cores.

Which of the three mentioned proxies/archives provides the shortest span (only the most recent data?). Is there any way to "push" it a little back and provide older data records?



ANSWERS:

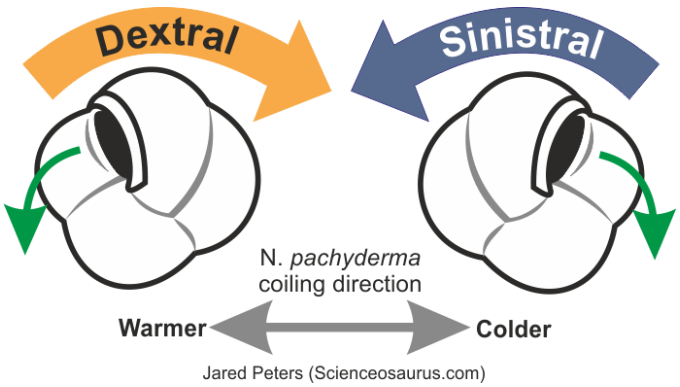
Foramnifera in sediment fossils allow us to look back at the climate conditions millions of years ago

Peatland records allow us to go back to 10 000 years

Tree rings give us the highest resolution of all three methods (annual variations) for relatively short periods of time. The time span can be extended if we use ancient wood from old buildings, not fresh-cut trees or samples from living trees.

TASK 8 Foramnifera as temperature proxies.

Some calcareous, planktonic species of foraminifera have different morphotypes (different types of individuals within one species). Often these morphotypes involve the test's coiling direction. In case of Neogloboquadrina pachyderma, when ocean water temperatures are cooler than 8° to 10° C, forams add these new chambers in a counterclockwise spiral ("left-coiling"). When temperatures are warmer than 8° to 10° C, they add their new chambers in a clockwise spiral ("right-coiling"). The coiling direction of fossil forams can therefore serve as an indication of ancient temperatures. We call this sort of evidence a "proxy" of paleotemperature.

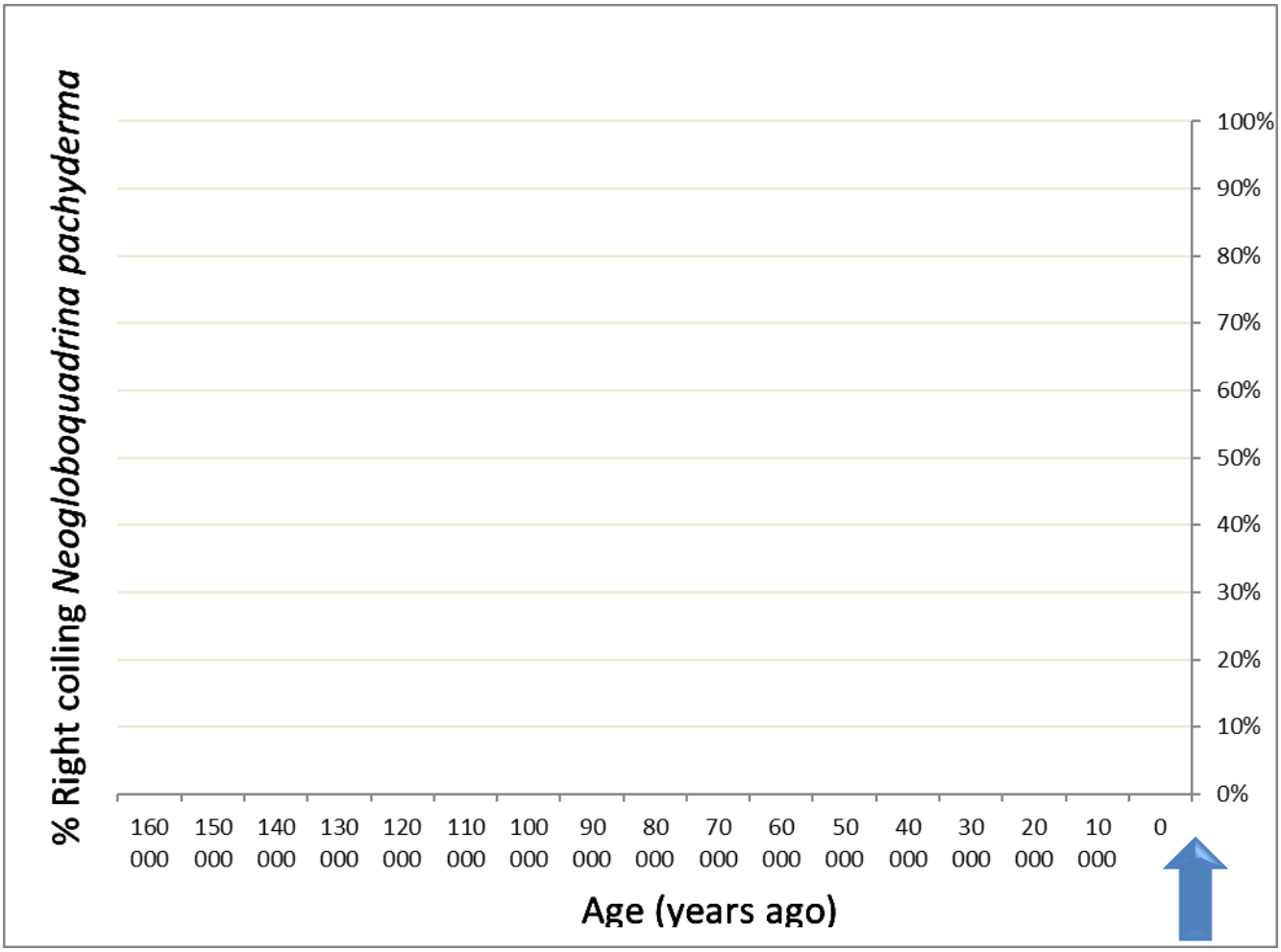


Source: https://scienceosaurus.com/

Fill in the table below – calculate percentages of right-coiling and left-coiling N. pachyderma

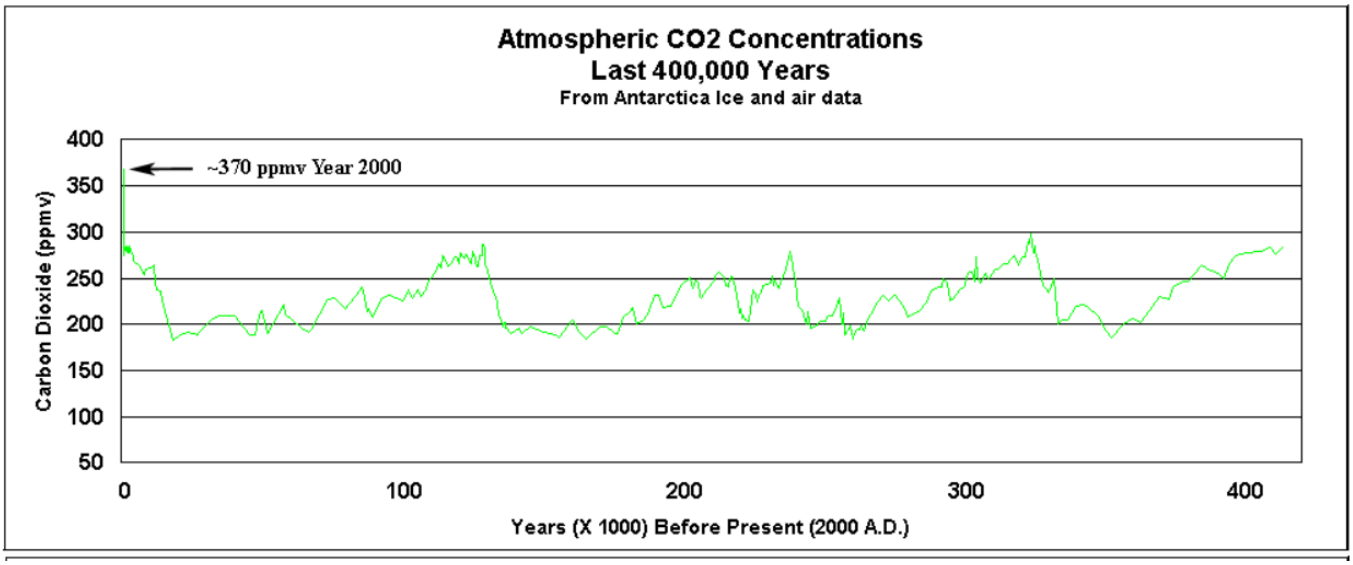
Age (years ago)	**Right coiling *Neogloboqua drina pachyderma***	**Left coiling *Neogloboqua drina pachyderma***	**Total number *Neogloboqua drina pachyderma***	**% Right coiling *Neogloboqua drina pachyderma***	**% Left coiling *Neogloboqua drina pachyderma***
0	210	44			
10 000	228	72			
20 000	65	232			
30 000	48	290			
40 000	54	308			
50 000	63	399			
60 000	21	141			
70 000	55	286			
80 000	62	264			
90 000	211	54			
100 000	125	25			
110 000	67	54			
120 000	203	66			
130 000	53	228			
140 000	41	335			
150 000	99	132			
160 000	100	143			

Draw a graph presenting percentage of right-coiling N. pachyderma. According to the coiling direction of the sampled forams, when was the temperature hotter? When was it colder?



PRESENT DAY

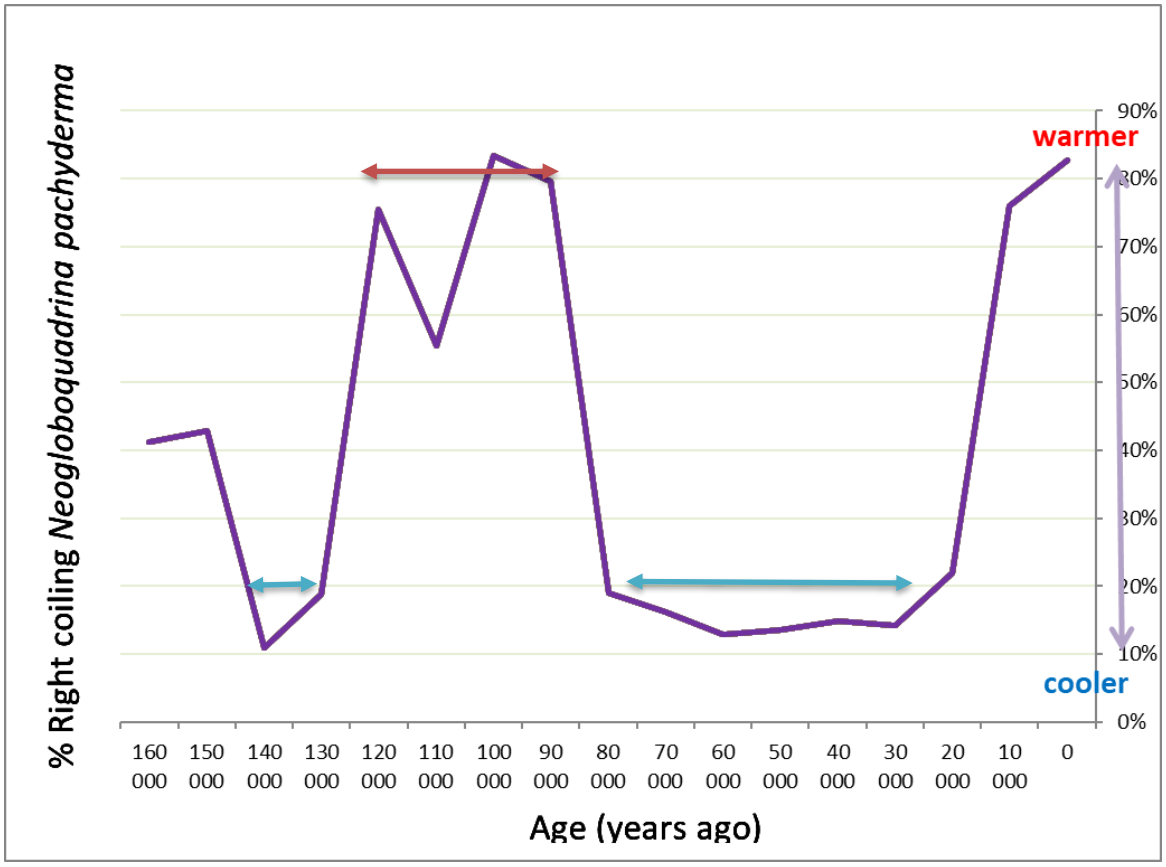
Now look at graph representing data gathered from ice core in Vostok station (Antarctica) from last 400,000 years and compare temperature maxima and minima with CO_2 in atmosphere.



SOURCE: https://www.geocraft.com/WVFossils/last_400k_yrs.html

ANSWERS:

Age (years ago)	Right coiling *Neogloboquadrina pachyderma*	Left coiling *Neogloboquadrina pachyderma*	Total number *Neogloboquadrina pachyderma*	% Right coiling *Neogloboquadrina pachyderma*	% Left coiling *Neogloboquadrina pachyderma*
0	210	44	**254**	**83%**	**17%**
10 000	228	72	**300**	**76%**	**24%**
20 000	65	232	**297**	**22%**	**78%**
30 000	48	290	**338**	**14%**	**86%**
40 000	54	308	**362**	**15%**	**85%**
50 000	63	399	**462**	**14%**	**86%**
60 000	21	141	**162**	**13%**	**87%**
70 000	55	286	**341**	**16%**	**84%**
80 000	62	264	**326**	**19%**	**81%**
90 000	211	54	**265**	**80%**	**20%**
100 000	125	25	**150**	**83%**	**17%**
110 000	67	54	**121**	**55%**	**45%**
120 000	203	66	**269**	**75%**	**25%**
130 000	53	228	**281**	**19%**	**81%**
140 000	41	335	**376**	**11%**	**89%**
150 000	99	132	**231**	**43%**	**57%**
160 000	100	143	**243**	**41%**	**59%**



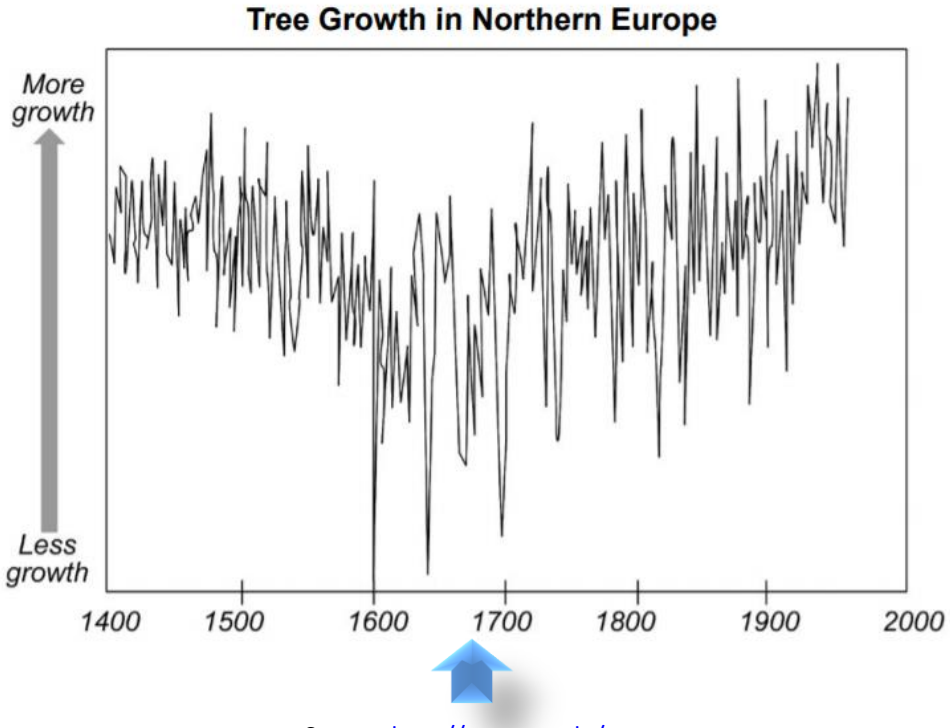
Temperature minima from foramnifera record (c.a. 130,000 – 140,000 years ago and 30,000-60,000 years ago) align with lower CO_2 in the atmosphere. Maxima from foramnifera records last 10,000 years, and 90,000-130,000 years ago, align with higher CO_2 concentration.

TASK 9 Historical climate change

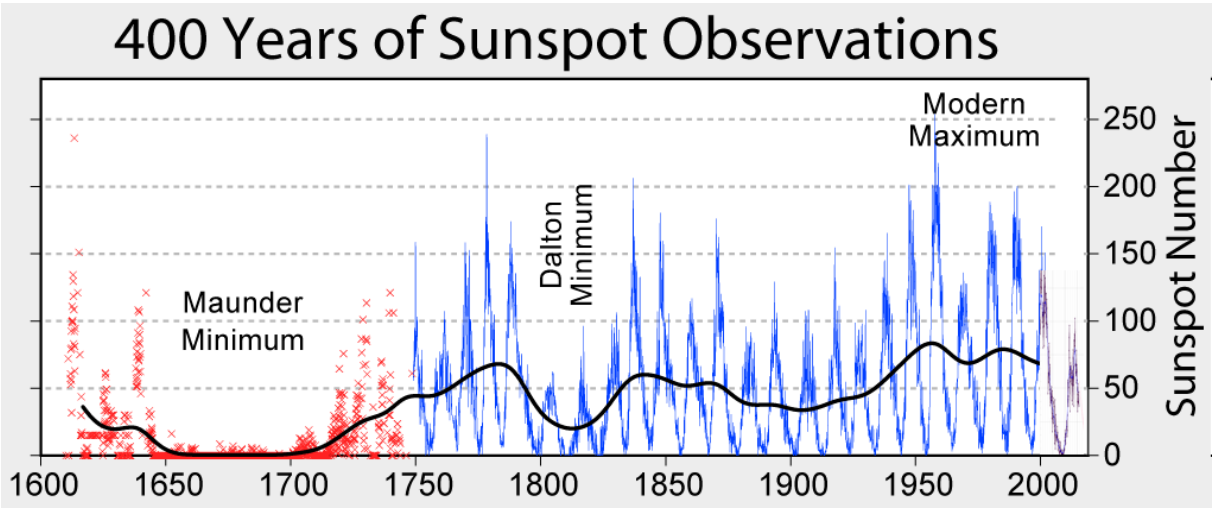
Observe 3 following graphs and

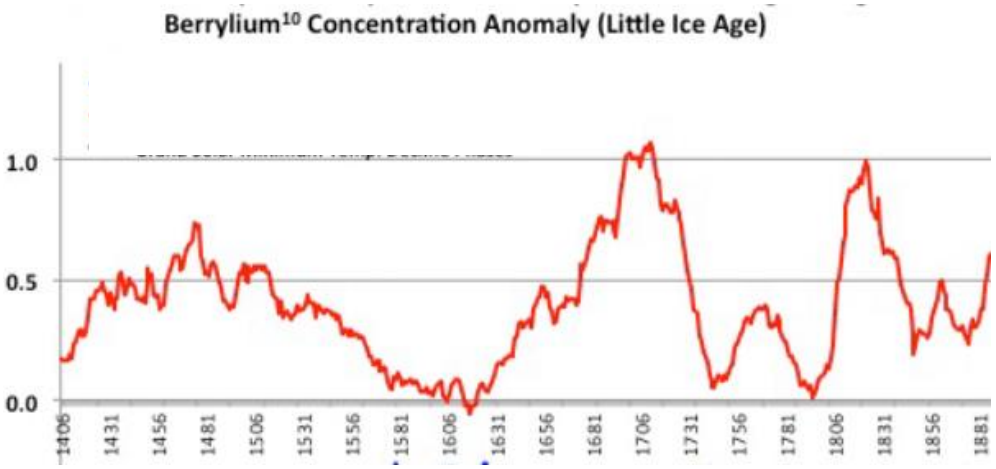
- ➔ **Records of tree growth in Northern Europe AD 1400 – AD 1950, based on dendrochronological records**
- ➔ **Sunspot observations AAD 1600- AD 2000**
- ➔ **10 Be concentration AD 1405- AD 1881**

+ one image showing North Atlantic Oscillation

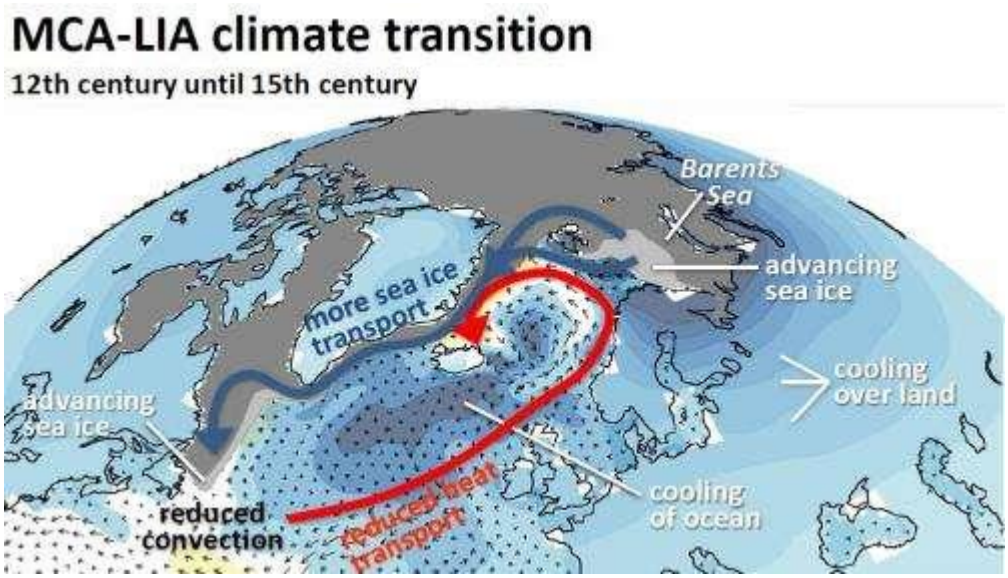


Source: http://eo.ucar.edu/





Source: grandsolarminimum.com



Source: https://phys.org/news/2013-09-sea-ice-formation-sustained-ice-age.html

Try to analyse overlapping periods, find similarities. Discuss possible relationships between these phenomena.
Now fill in the gaps in text below:

Solar magnetic activity, as historically measured by the occurrence of _____ and aurora, varies with the approximately 11 year _____.
Solar activity reconstructions based on radionuclide data – _____ _____, such as 14C, _____ and 44Ti, show that cycles are modulated by much longer-term variations, resulting in grand maxima and grand minima of activity. The _____ (MM), AD 1645–1715, is the most recent grand minimum and the only one covered by telescopic sunspot observations. The Sun's solar wind acts like a protective bubble, called the heliosphere, which fills the solar system deflecting _____ _____.
When the Sun's quiet, the _____ is weaker allowing more cosmic rays to get through and collide with oxygen atoms in the Earth's atmosphere, generating more beryllium isotopes.
However, many scientists maintain that _____ _____ _____in Europe resulted from a reversal of the North Atlantic Oscillation (NAO), a large-scale atmospheric-circulation pattern over the _____ _____ and adjacent areas. The NAO is believed to have a large influence over winter weather in Europe.
The Little Ice Age is best known for its effects in _____ and the North Atlantic region. Alpine glaciers advanced far below their previous (and present) limits, destroying farms, churches, and villages in Switzerland, France, and elsewhere. Frequent cold _____ and cool, wet _____ led to crop failures and famines over much of northern and central _____. In addition, the North Atlantic cod fisheries declined as ocean temperatures fell in the _____ century.

ANSWERS:

Solar magnetic activity, as historically measured by the occurrence of **sunspots** and aurora, varies with the approximately 11 year **cycle**s.
Solar activity reconstructions based on radionuclide data – **cosmogenic isotopes**, such as 14C, **10Be** and 44Ti, show that cycles are modulated by much longer-term variations, resulting in grand maxima and grand minima of activity. The **Maunder Minimum**(MM), AD 1645–1715, is the most recent grand minimum and the only one covered by telescopic sunspot observations. The Sun's solar wind acts like a protective bubble, called the heliosphere, which fills the solar system deflecting **cosmic radiation**.
When the Sun's quiet, the **heliosphere** is weaker allowing more cosmic rays to get through and collide with oxygen atoms in the Earth's atmosphere, generating more beryllium isotopes.
Many scientists maintain that the **Little Ice Age** in Europe resulted from a reversal of the North Atlantic Oscillation (NAO), a large-scale atmospheric-circulation pattern over the **North Atlantic** and adjacent areas. The NAO is believed to have a large influence over winter weather in Europe. The Little Ice Age is best known for its effects in **Europe** and the North Atlantic region. Alpine glaciers advanced far below their previous (and present) limits, obliterating farms, churches, and villages in Switzerland, France, and elsewhere. Frequent cold **winters** and cool, wet **summers** led to crop failures and famines over much of northern and central **Europe**. In addition, the North Atlantic cod fisheries declined as ocean temperatures fell in the **17th** century.
