

The background of the slide is a photograph of a large number of salmon swimming in a net. The water is a deep green color, and the salmon are silvery with some darker spots. The net is visible as a grid pattern in the background.

Weather and Aquaculture

Course designed for industry education 2020

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Learning Outcomes

Aim of course: Provide students with a strong introduction to weather and climate and how they can affect salmonid aquaculture.

At the end of the course students will be to:

- Describe what weather is and what are the drivers of weather.
- How we forecast and interact with weather systems.
- Describe what is climate and what drives climate globally.
- Explain the difference between weather and climate.
- Explain what is climate change and anthropogenic climate change.
- Understand how aquaculture is impacted by different types of weather and climate (especially for salmon in Iceland).

Course Outline

- Total of 3 modules.
- Taught over two teaching days

Nov 30-Dec 1 2020

Module 1: Weather

Module 2: Climate

Module 3: Weather and Climate in Aquaculture

**Homework*

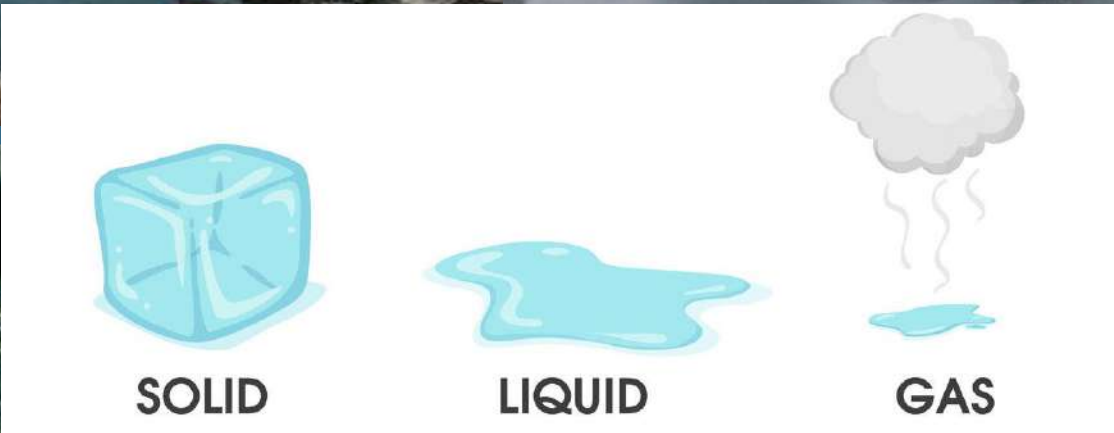
Online Session: Homework and question time.
(if requested)



Module 1: Weather: An introduction

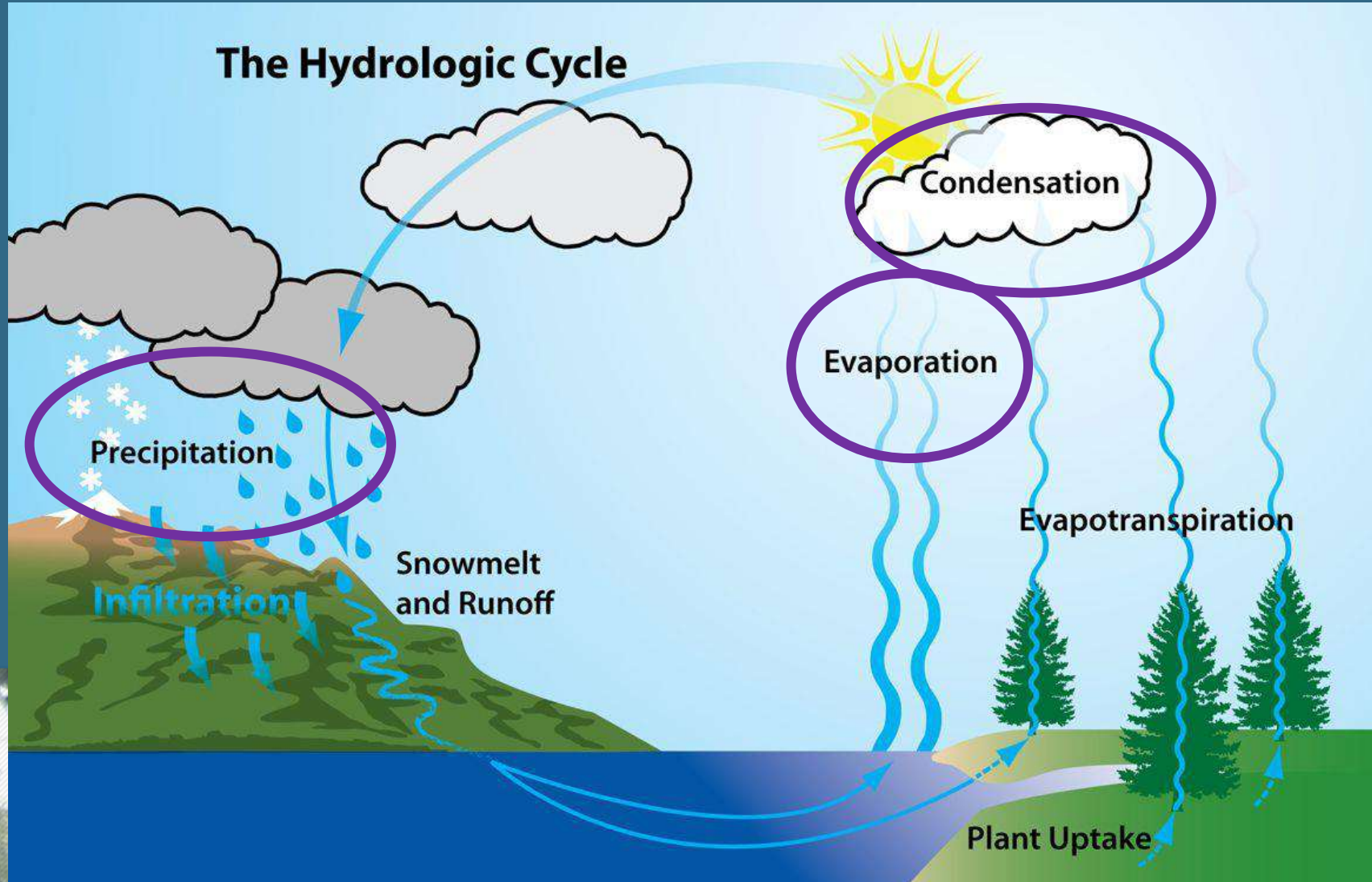


Background information



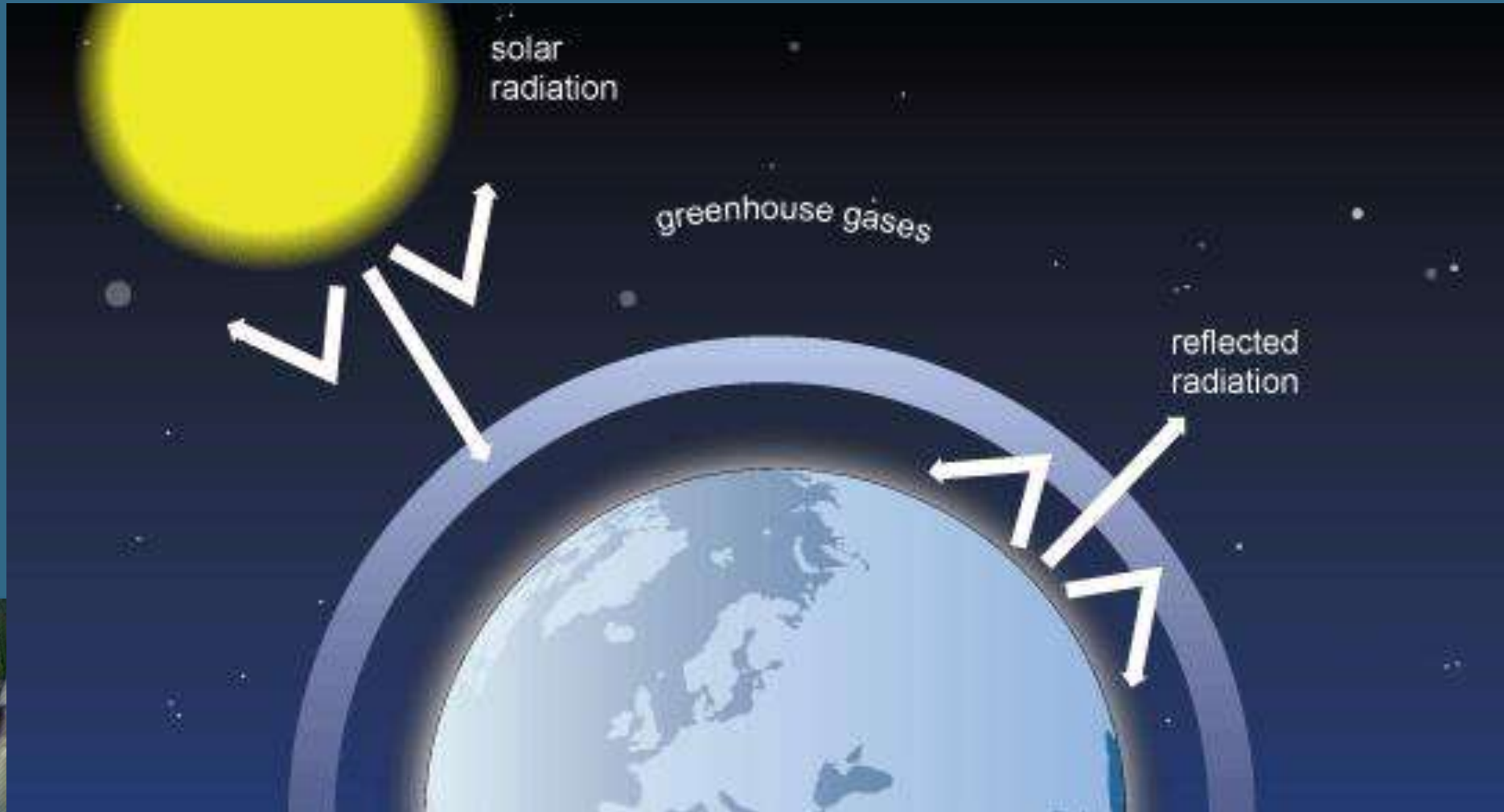
Background information

- The water cycle



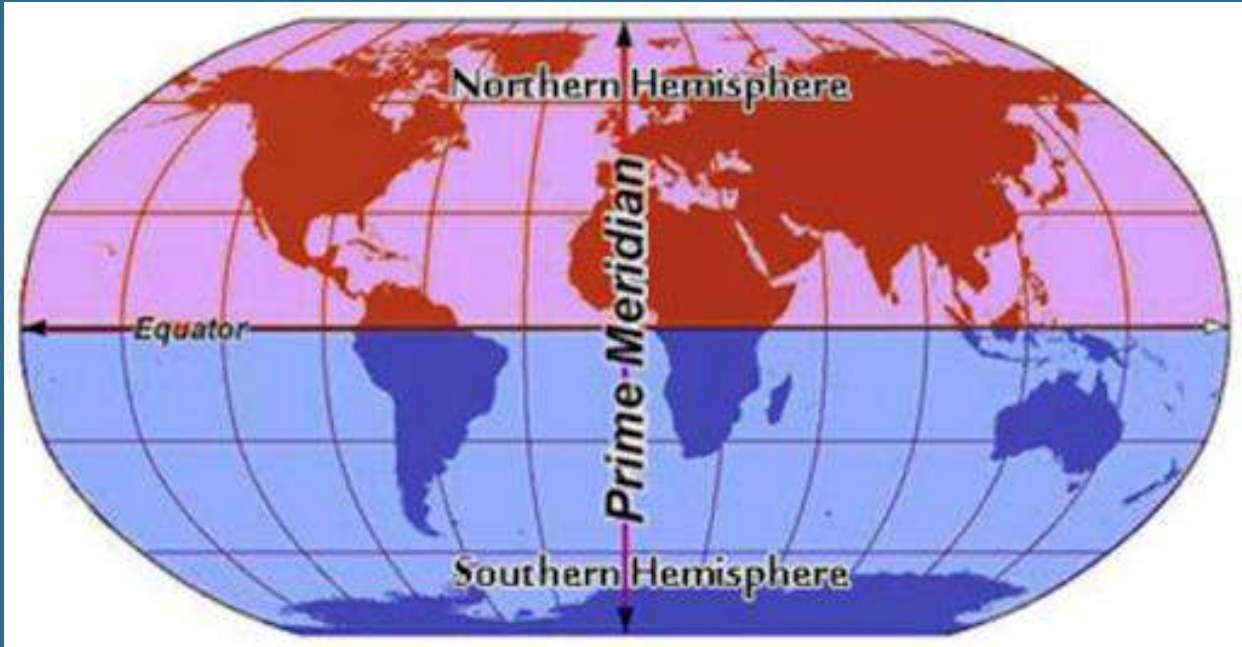
Background information

- The greenhouse effect

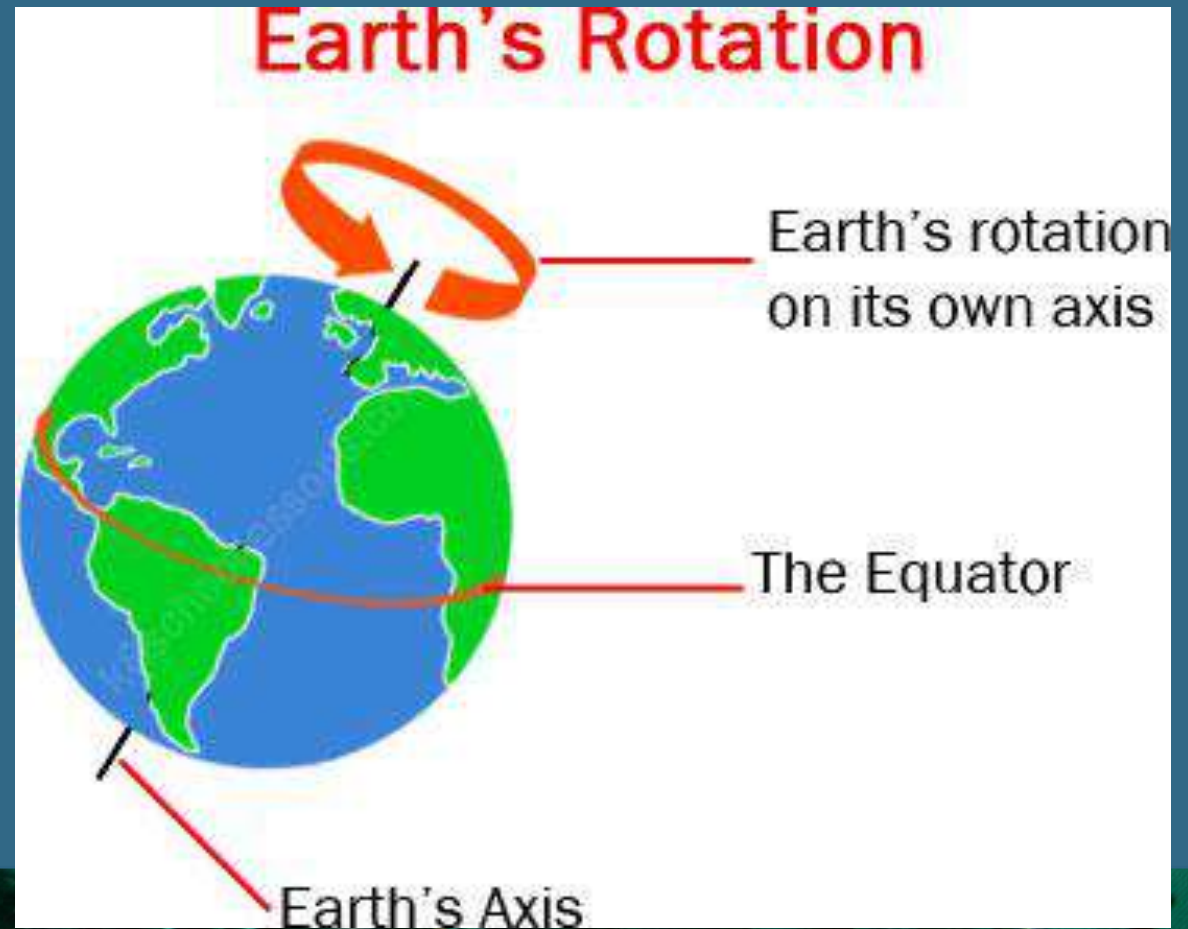


Background information

- North and Southern hemisphere

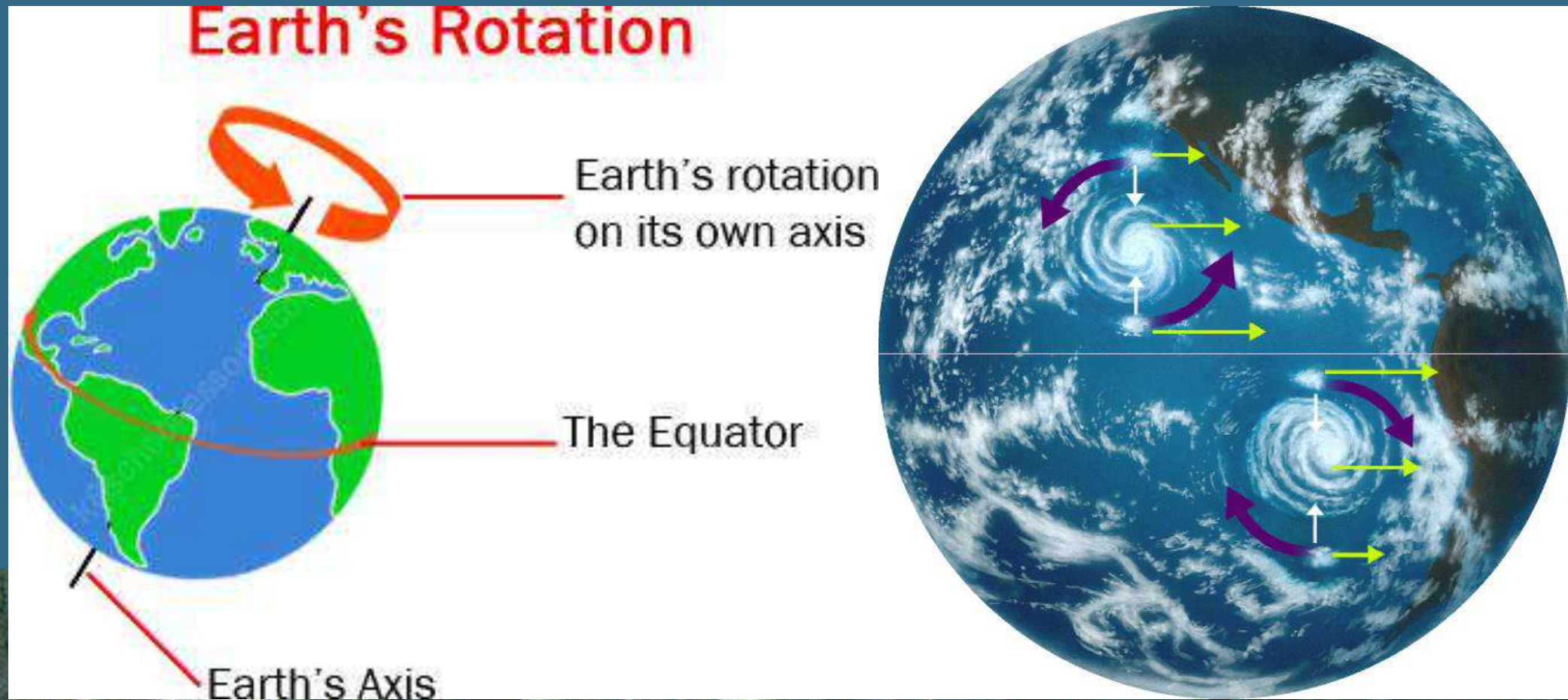


- Earth is rotating



Background information

- There is an apparent force caused by this rotation of earth:
The Coriolis Effect

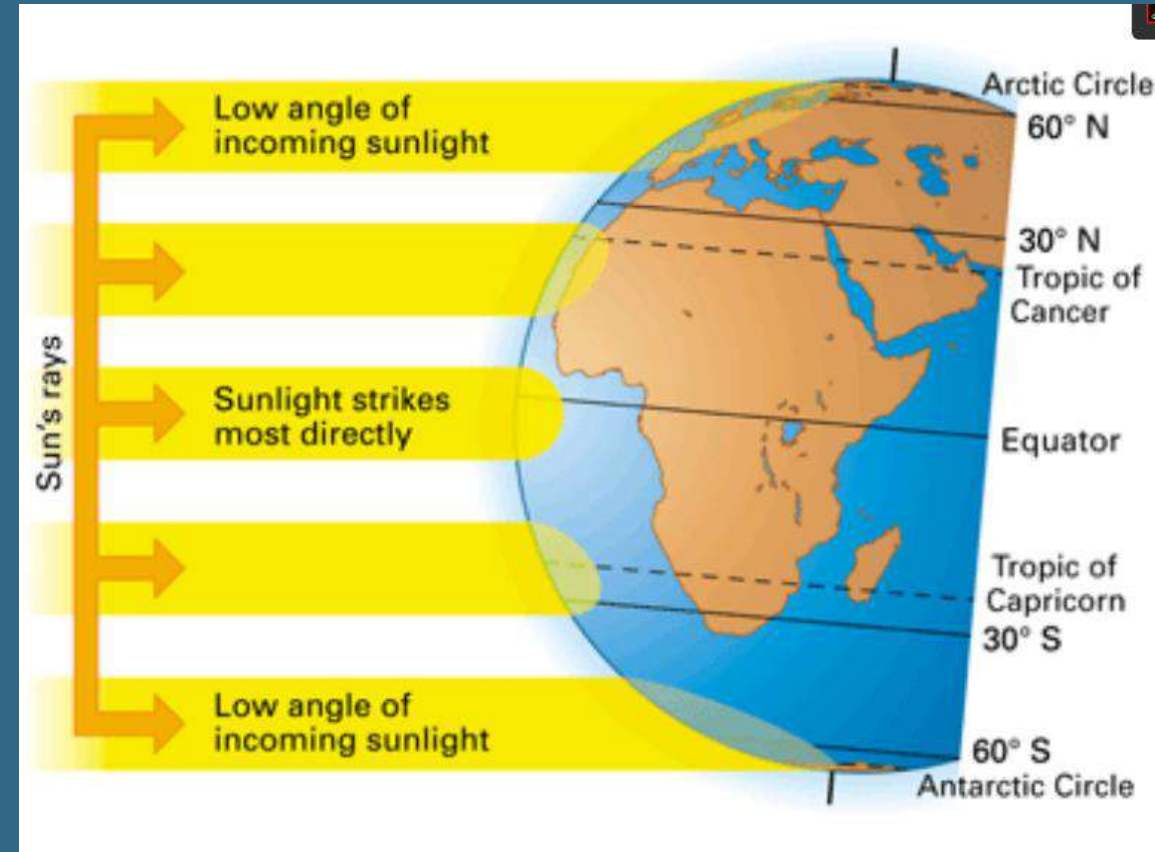


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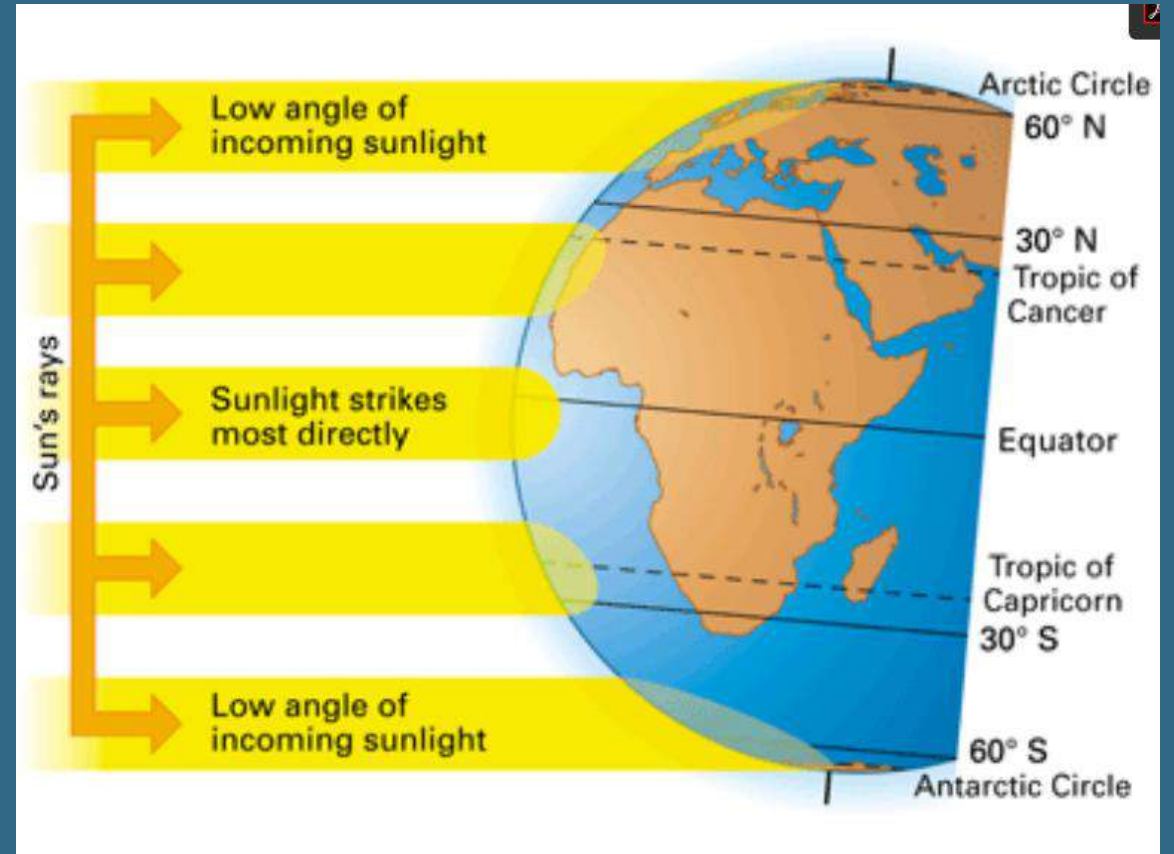
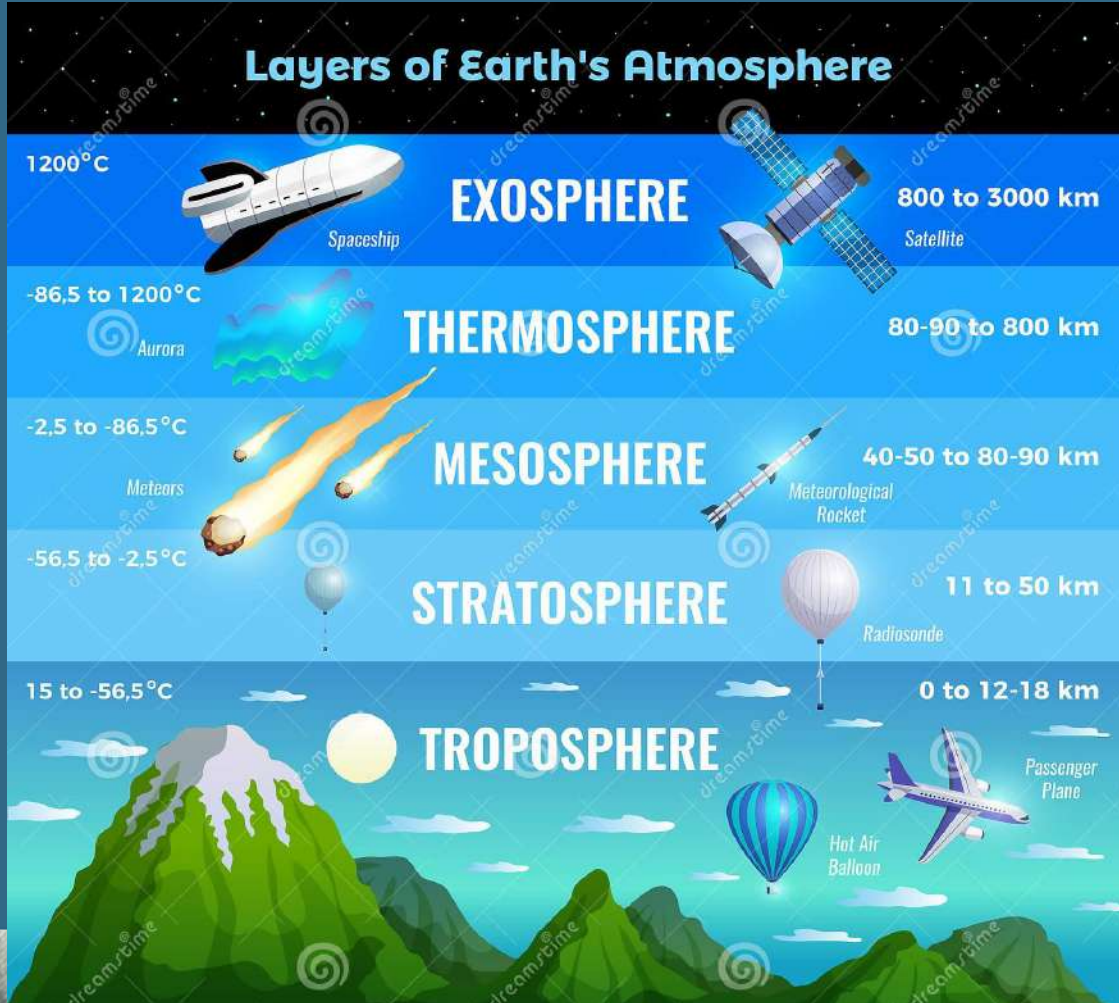
- The sun shines at different angles and onto different surfaces and different times all over the world.

(partly due to the curvature of the Earth)

- Not only does this make day and night in different locations at the same time
- It heats different surfaces in different ways.
- This effect is exacerbated by the fact that different surface heat in different ways.

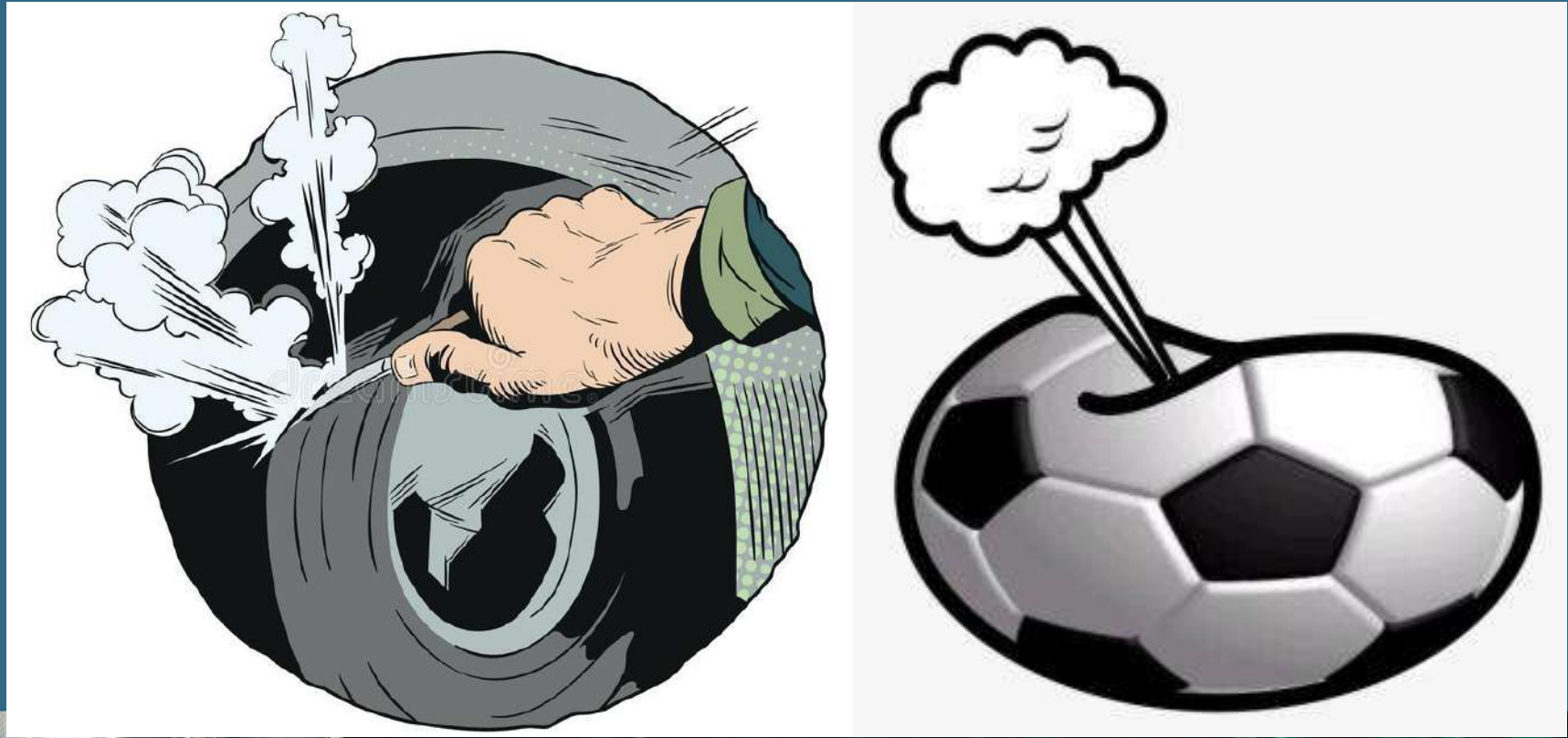


Why is this important?

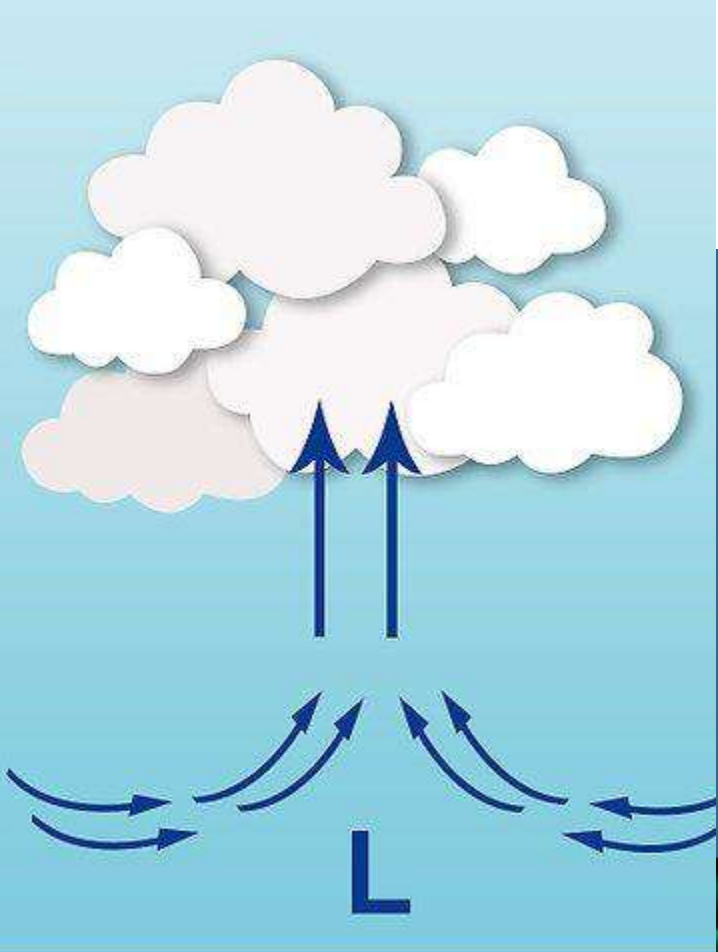
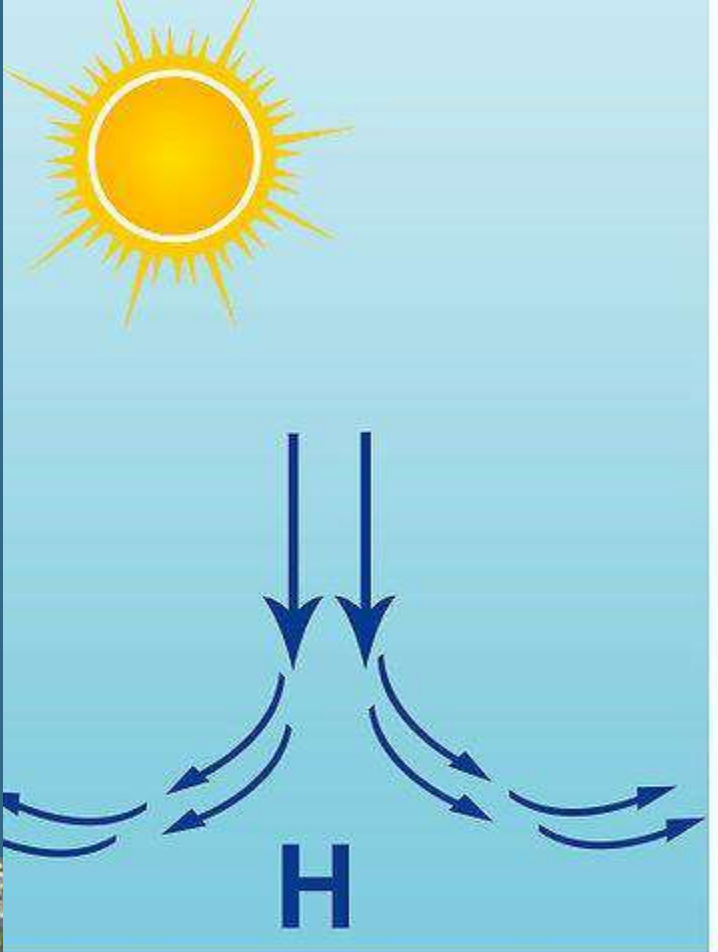


Air pressure

- What happens when you puncture a tire or a football?



Air pressure

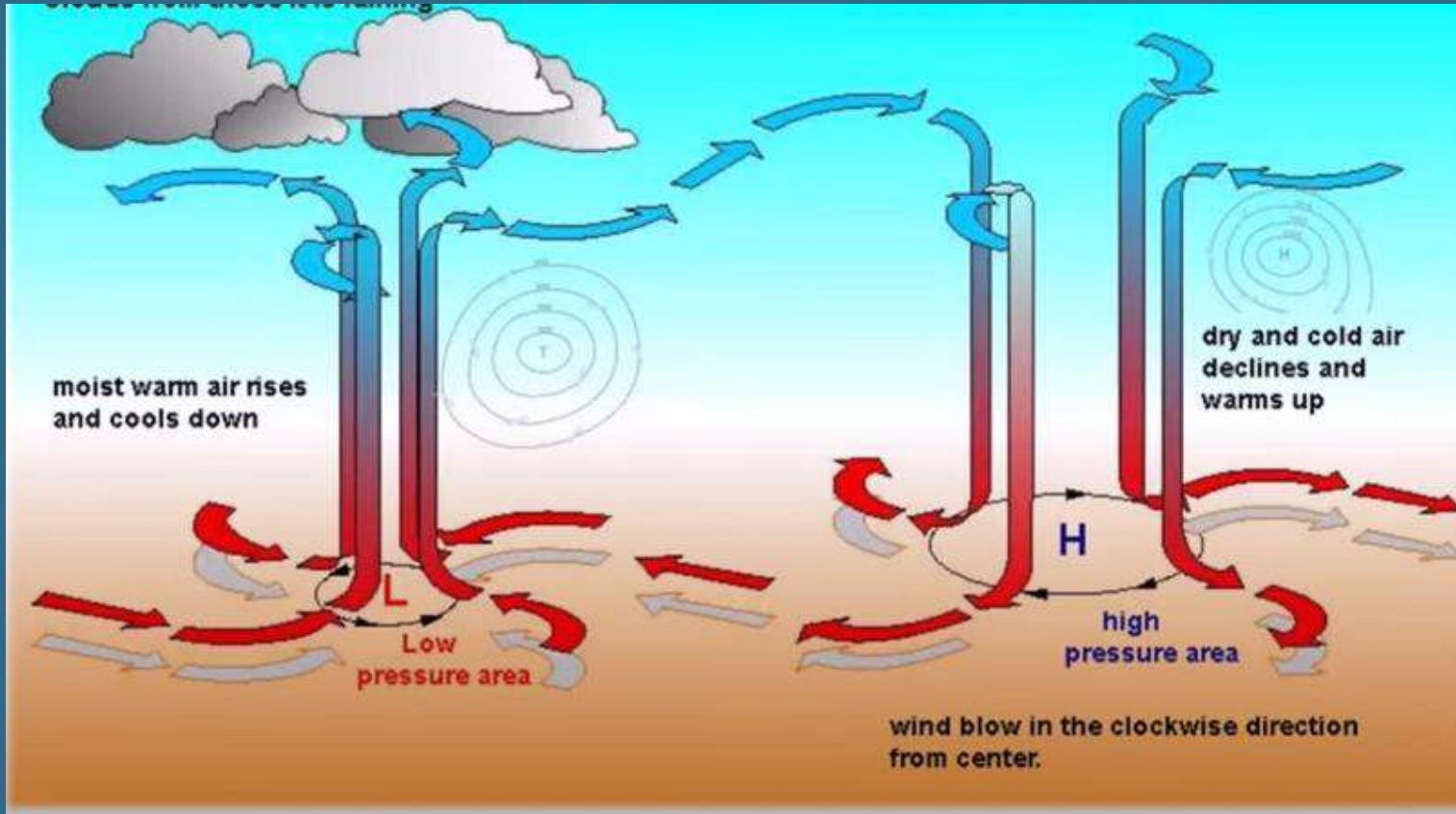


L - Low Pressure
H - High Pressure

wikiHow to Read a Weather Map



Air pressure

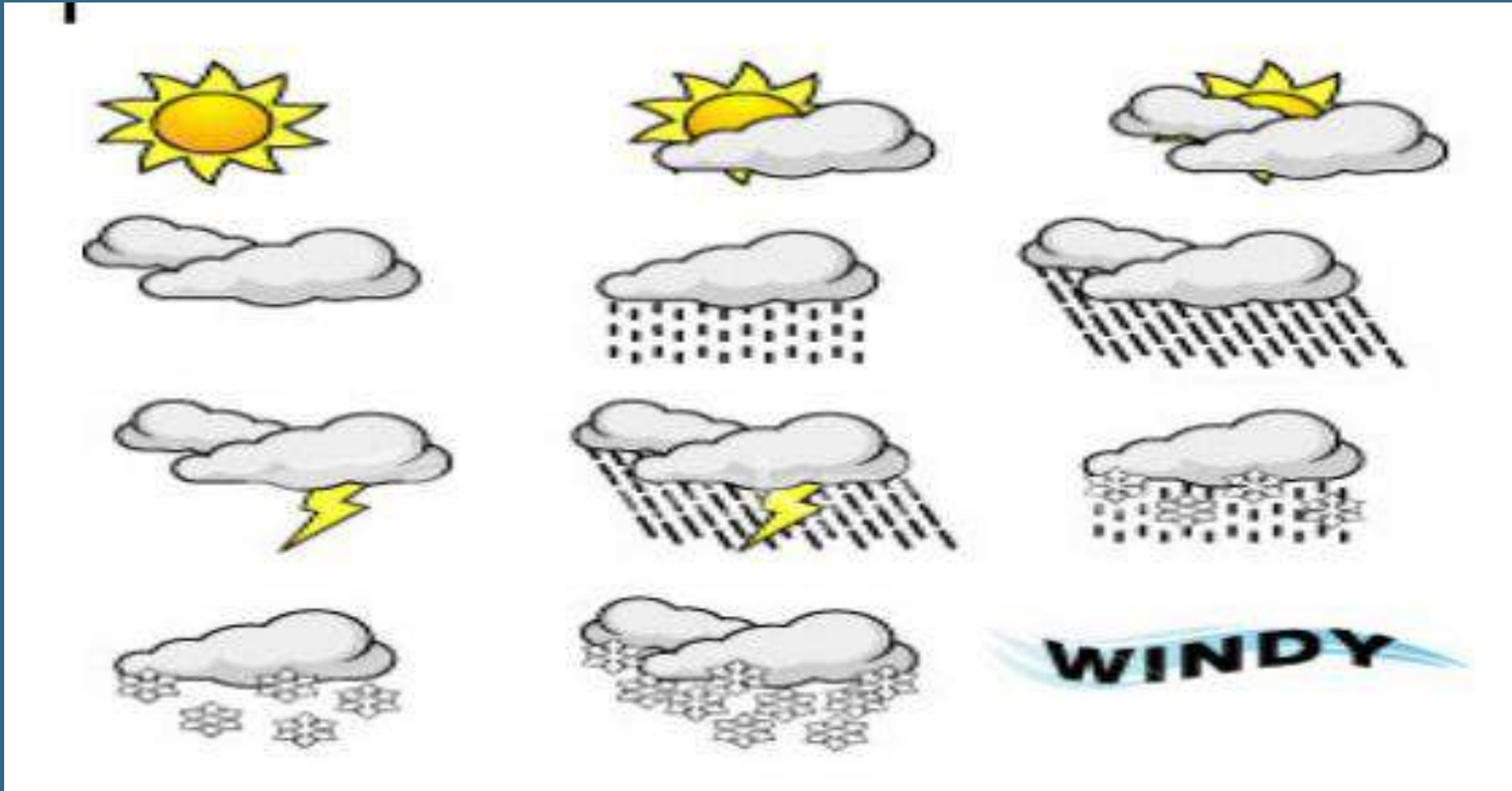


Low pressure=up & anti-clockwise

High pressure=down & clockwise



Definition to Weather

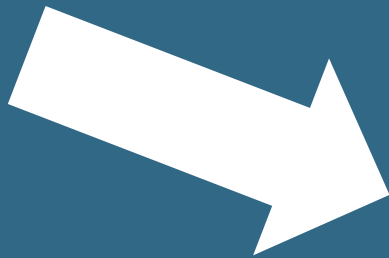


Weather is the minute-by-minute changes that happen in the atmosphere. It is local to certain time and place.

Where does weather happen?



Where weather happens



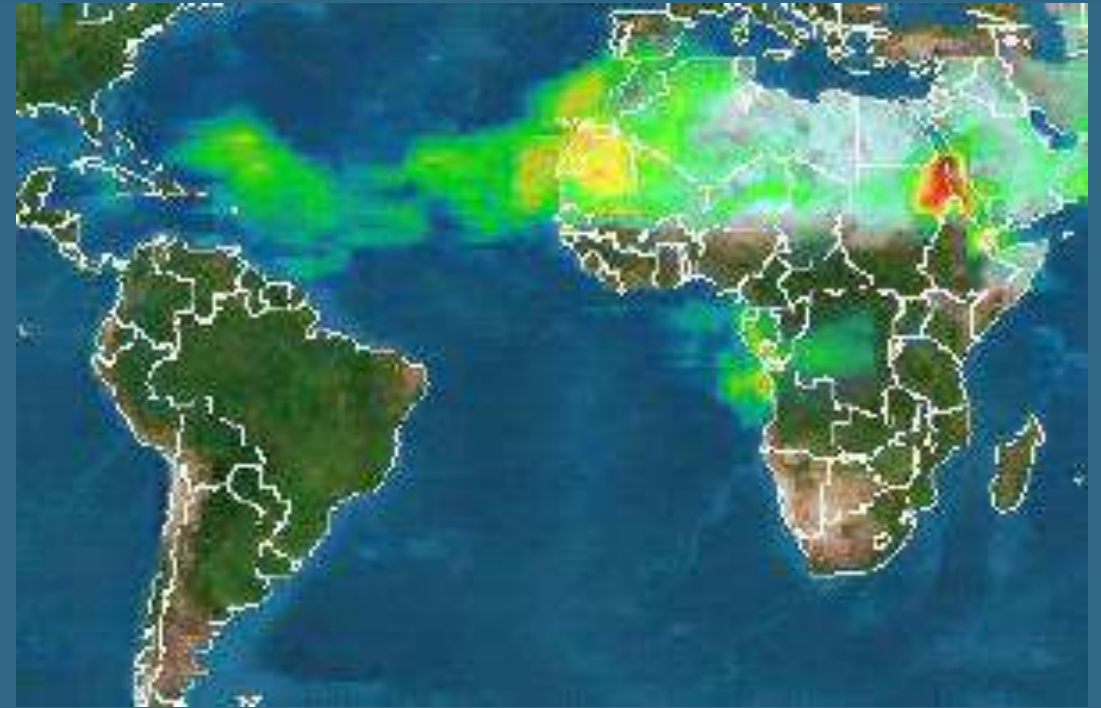
Wind

Causes:

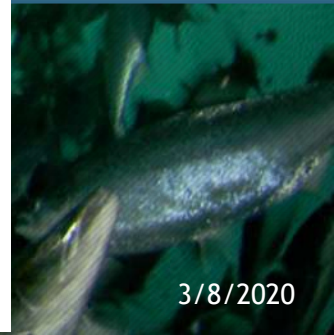
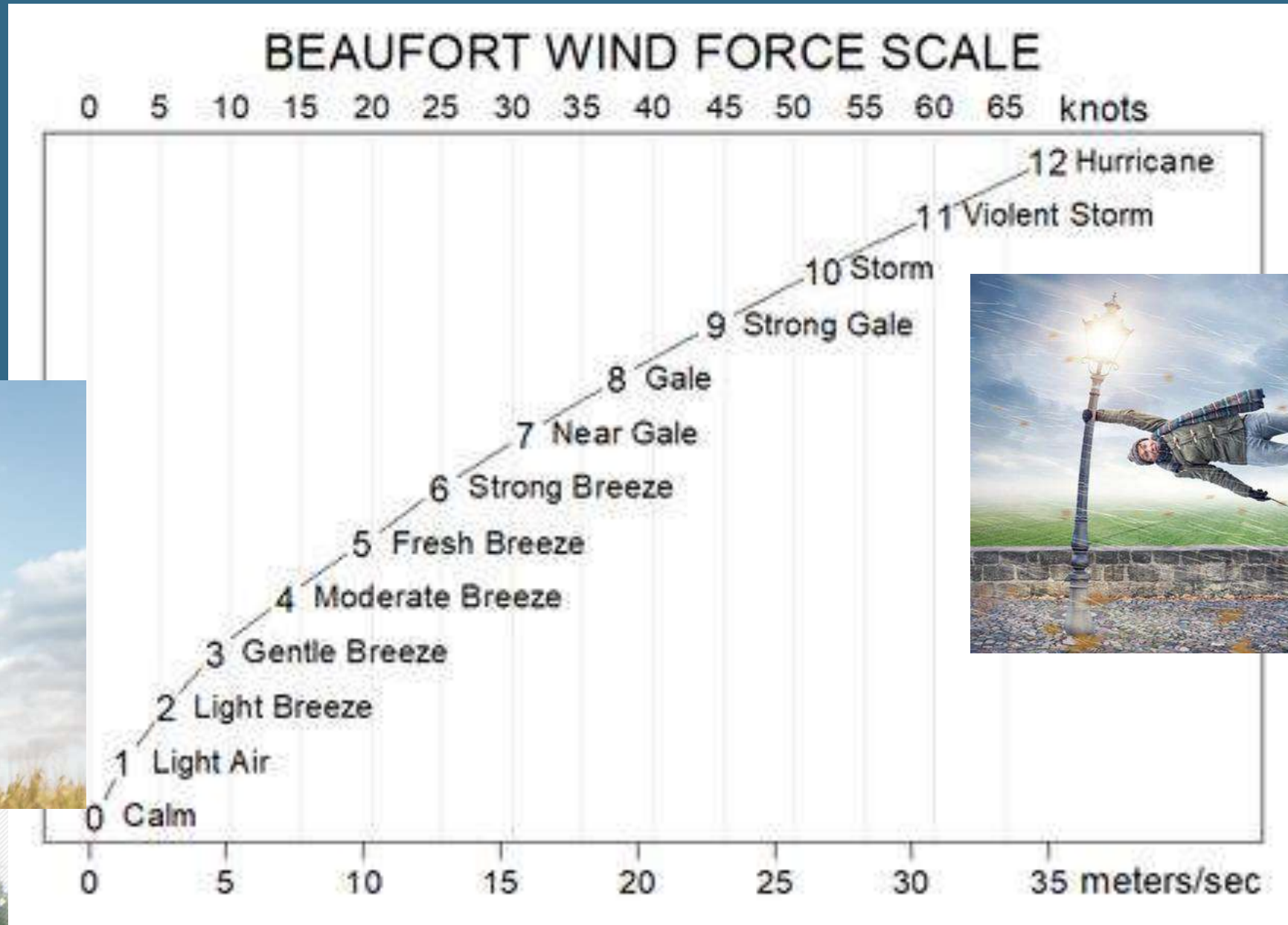
- Air moving from low pressure zone to a high-pressure zone.
- Uneven heating of the Earth.

Importance:

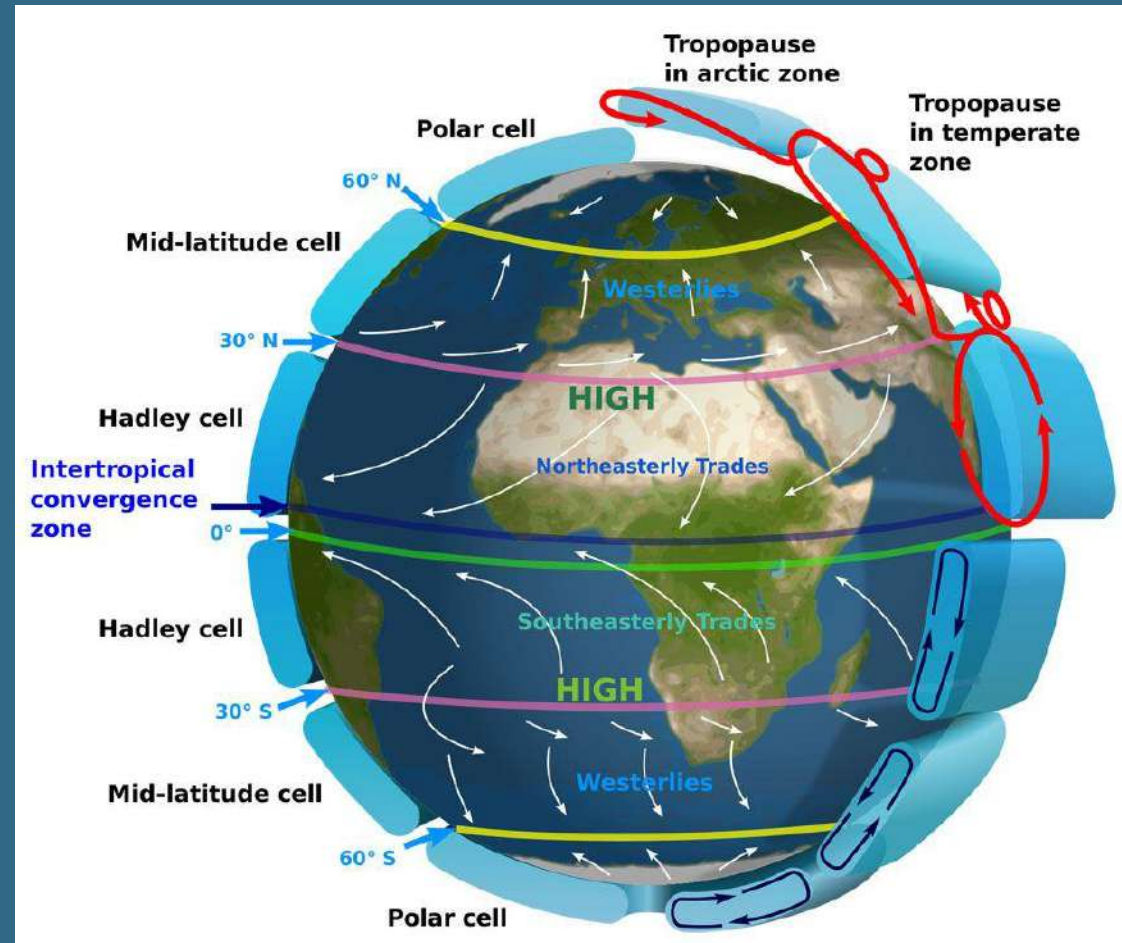
- Transporter.
- Shapes many of our planets formations.



Levels of wind



Wind

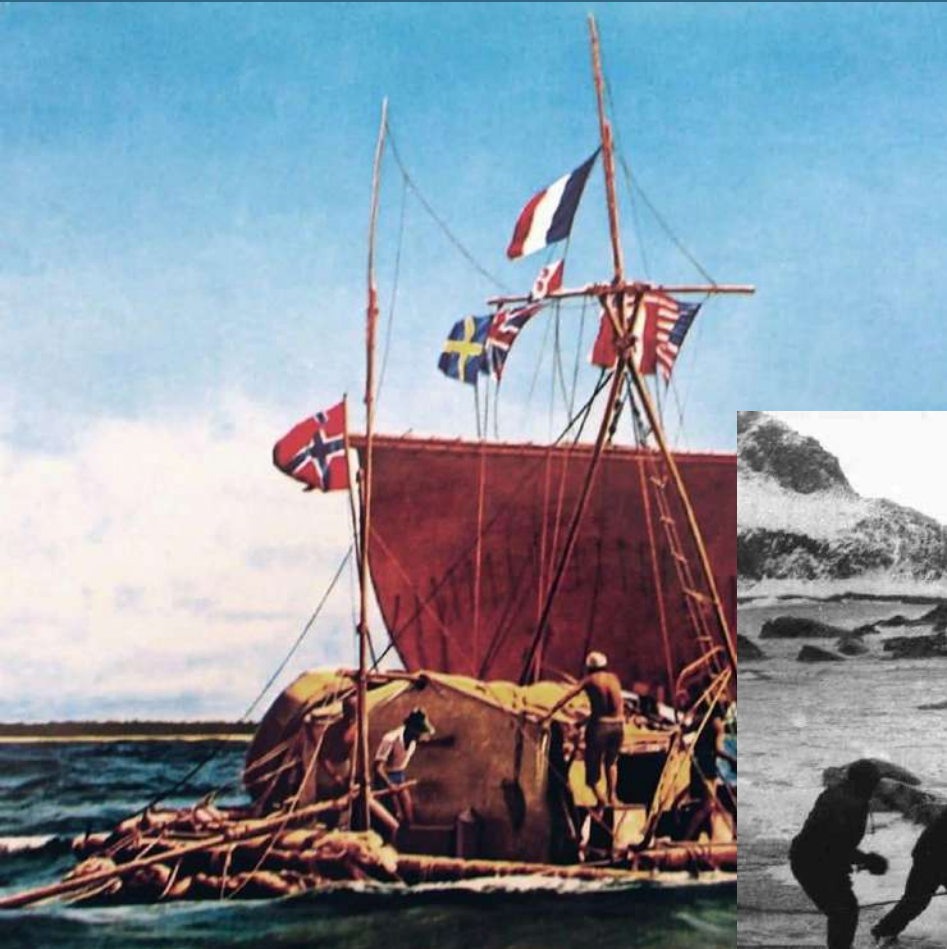


Winds follow some long-term patterns and so are easy to predict



Wind is a huge driver in maritime history

The Kon-tiki



Vikings arriving in Iceland

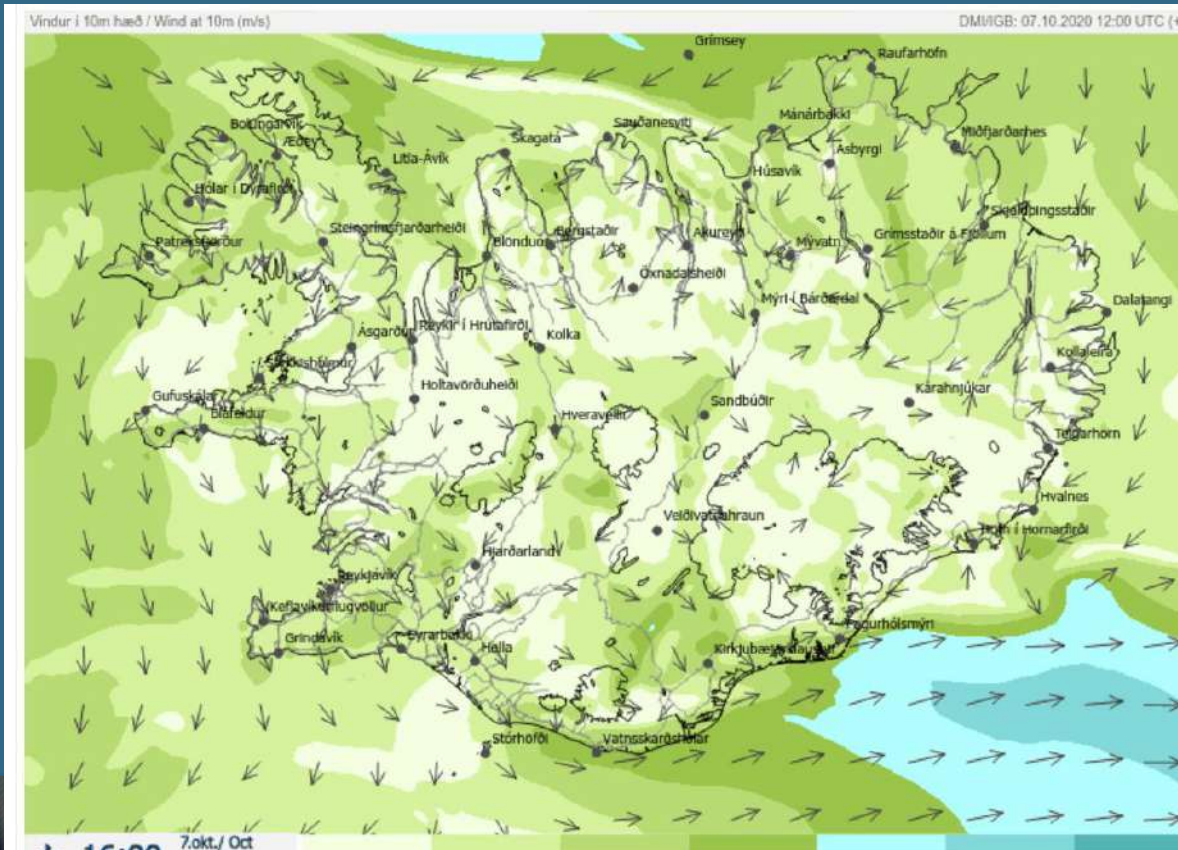


The James Caird

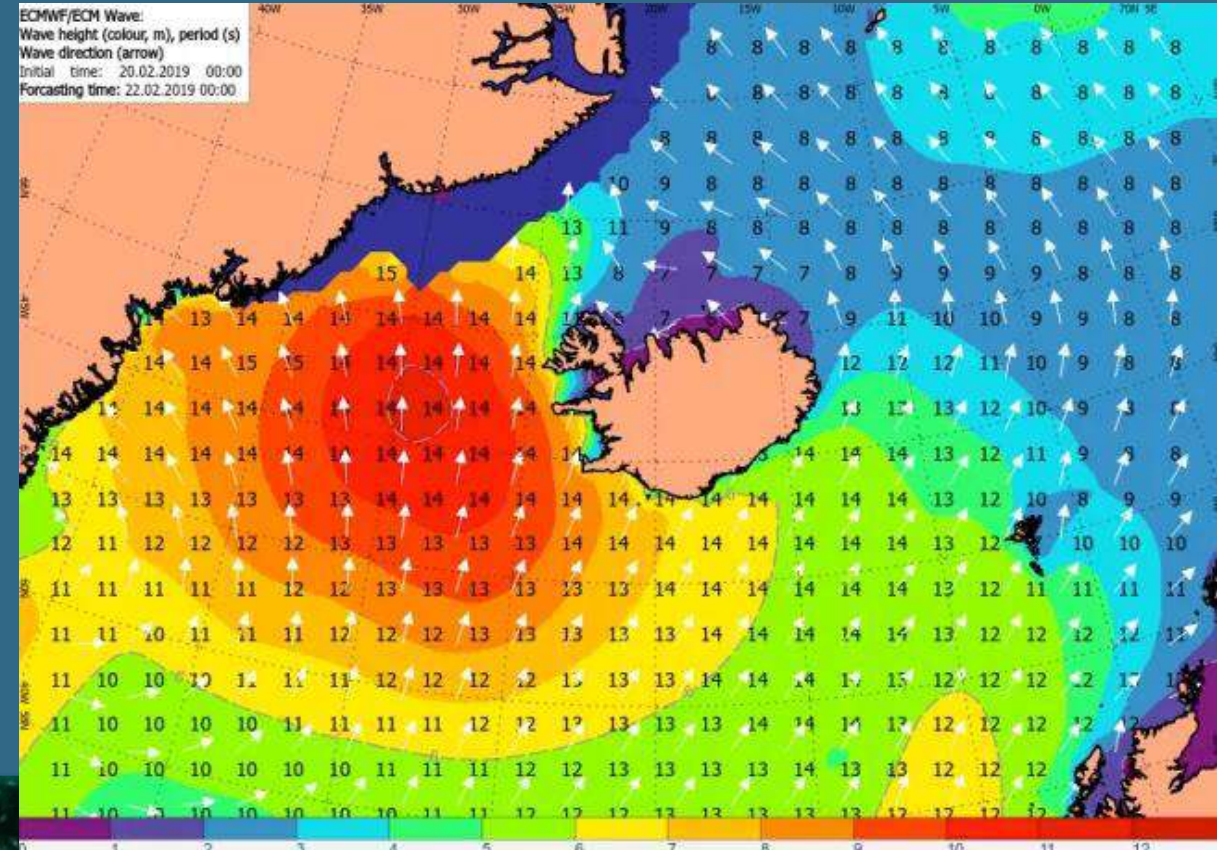


The physics of the sea

Localized wind



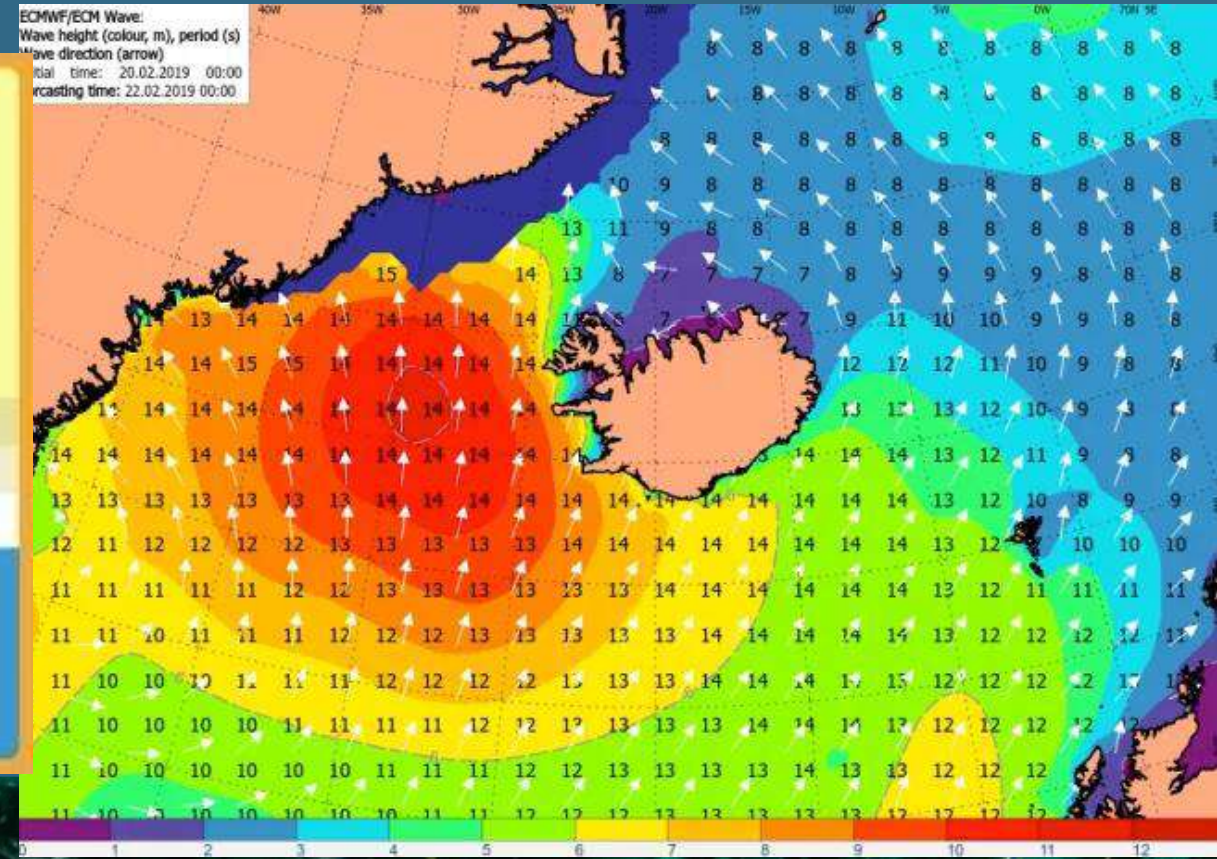
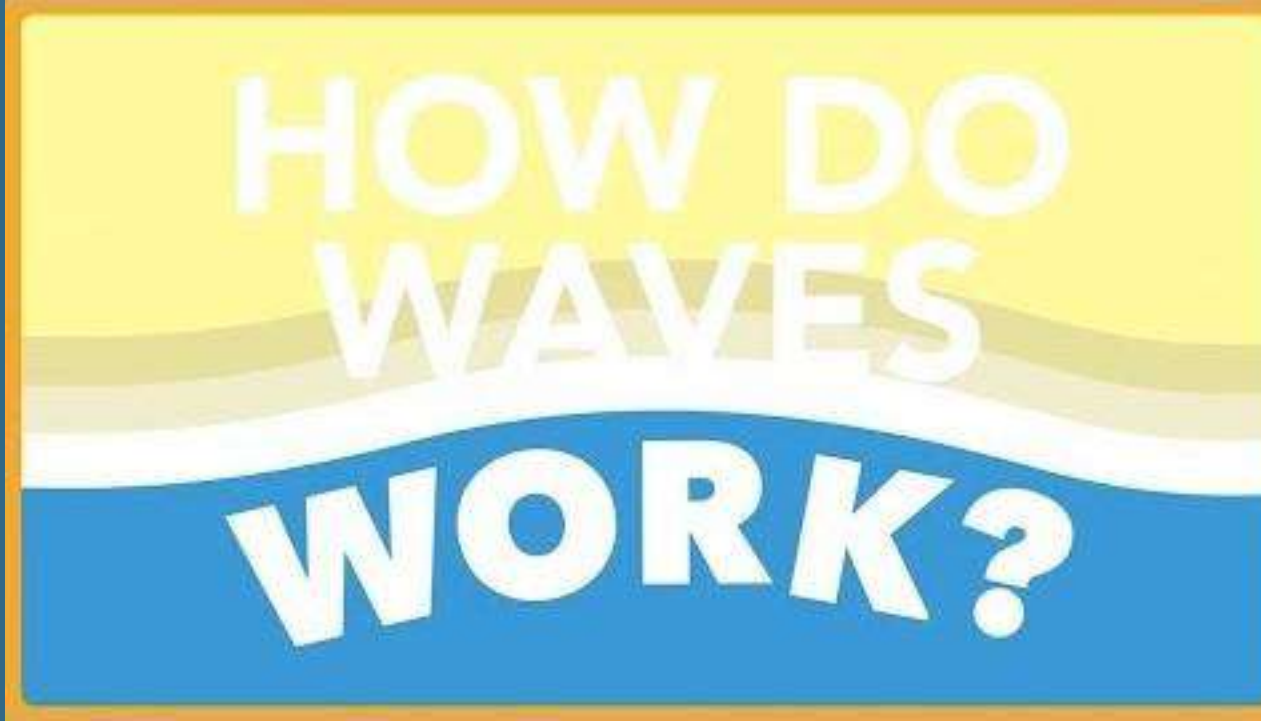
Localized wave height



The physics of the sea

Waves

Localized wave height

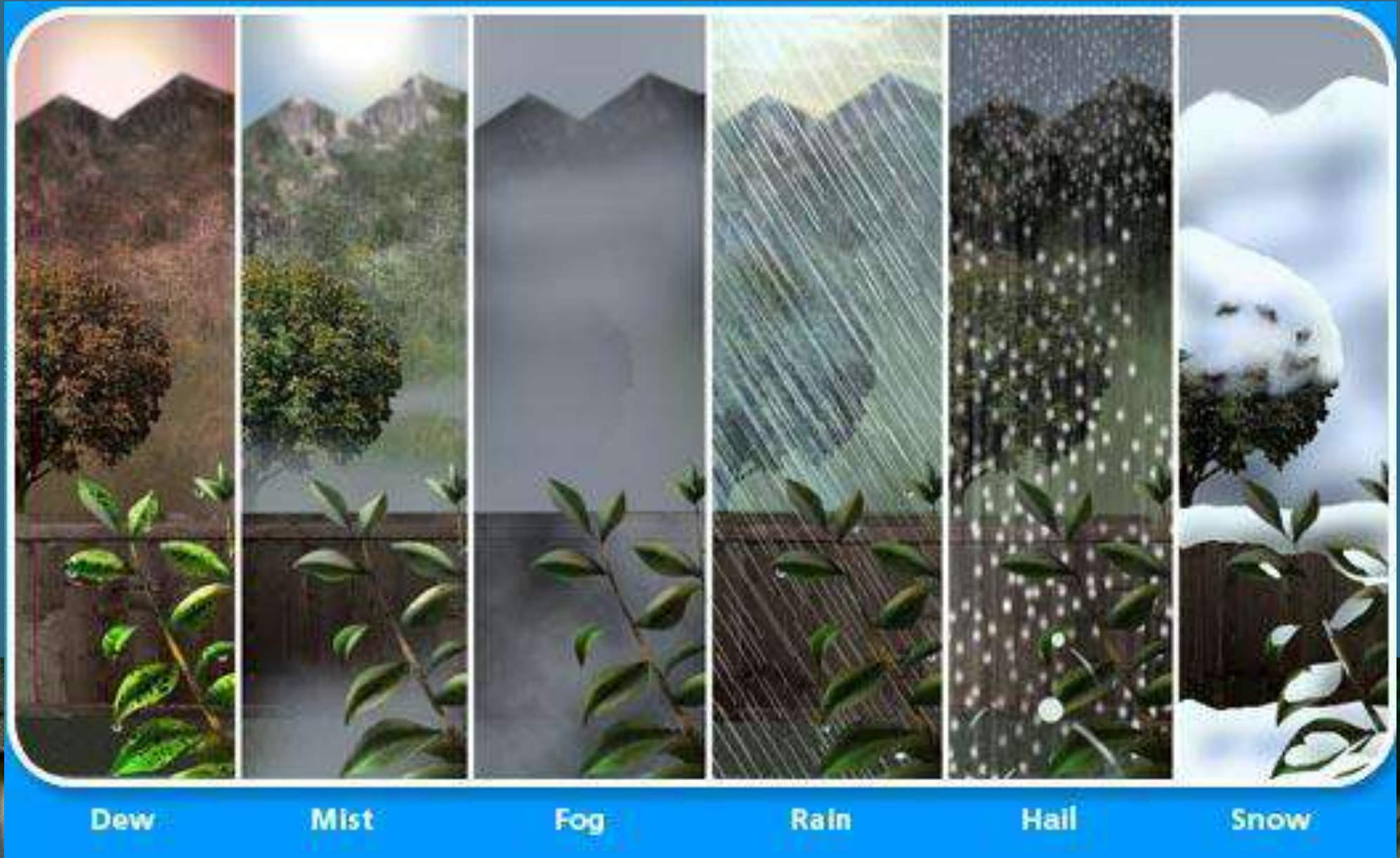


More on waves

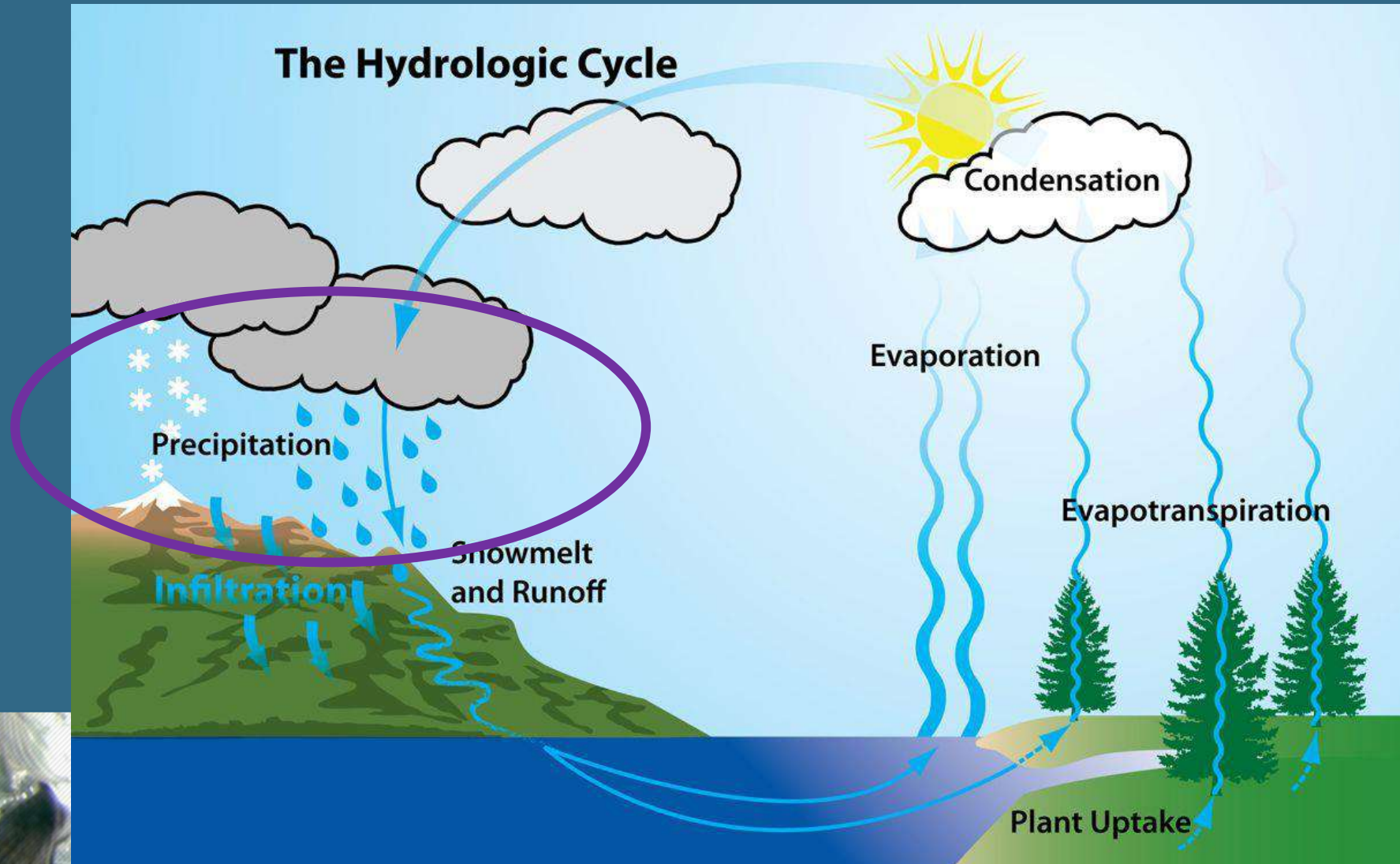
- Waves transport energy.
- They shape our coastal landscapes (constructively and destructively).
- Driven by friction
- Size of waves dependent on location, season and sometimes seismic activity



Precipitation



Precipitation



Precipitation

- When clouds become saturated or filled with water droplets.....one of the things that are released is rain.
- Rainfall happens in different volumes around the world.
- Too much rain...can lead to flooding.
- Too little rain can lead to drought.
- Delicate balance on the planet for the ideal living and food production systems.



Rain



Precipitation

ALBEDO



Snow



Precipitation

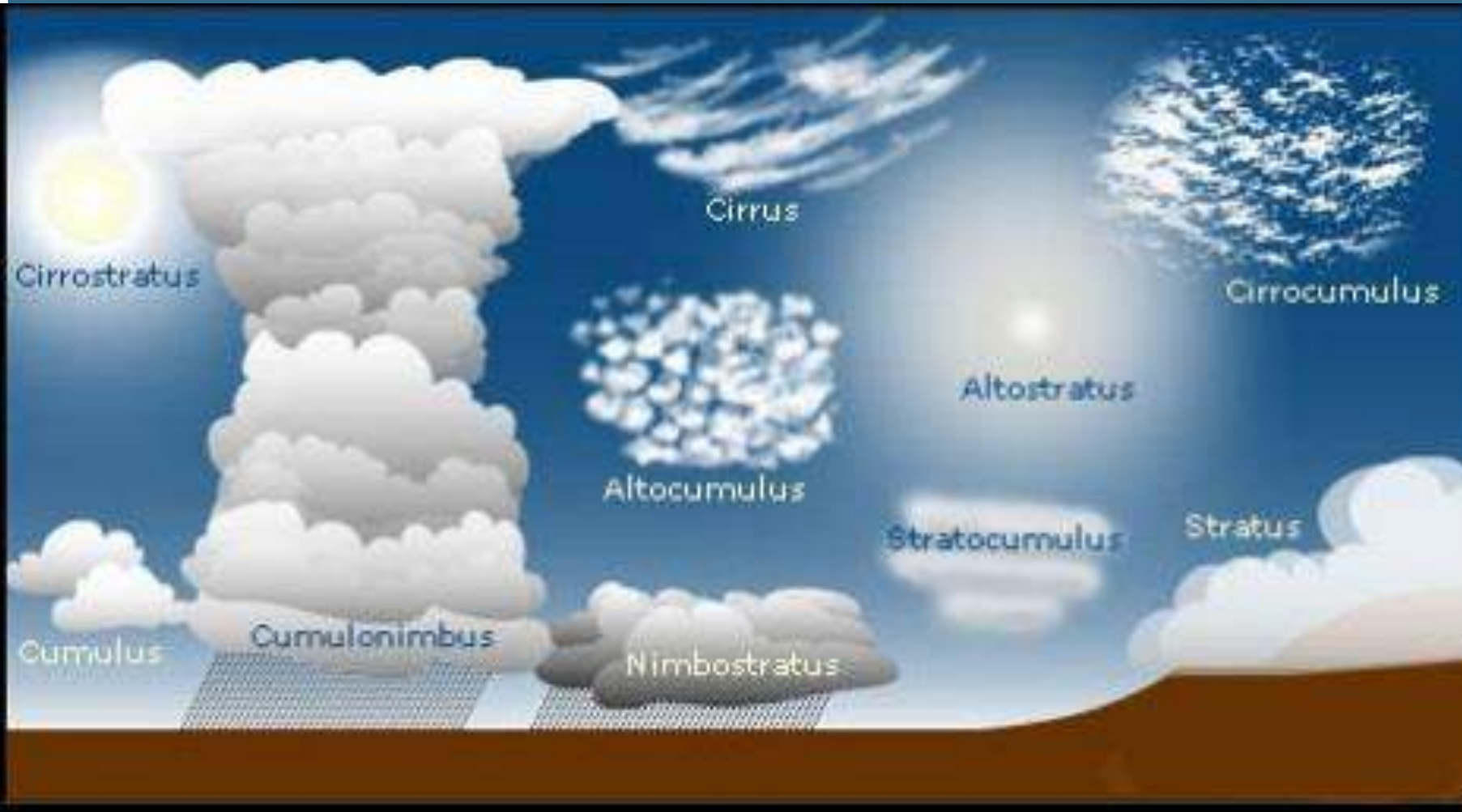
- Cloud that touches the Earth.
- Happens in humid conditions when the air is really full of water vapor.
- In hot humid places but also freezing fog can happen.



Fog



Clouds



How a cloud looks is determined by how high up in the atmosphere it was formed.

Sunshine

- Source of light and heat on planet earth.
- It heats different parts of the earth differently
- Most life on earth dependent on energy from the sun

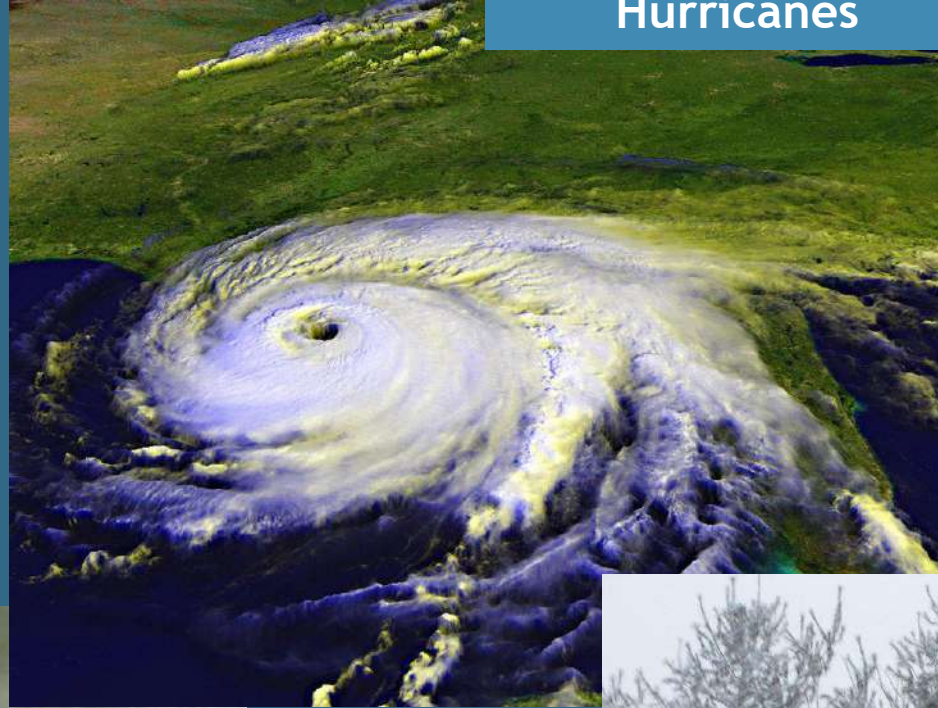


Extreme weather

Lighting



Hurricanes



Tornados

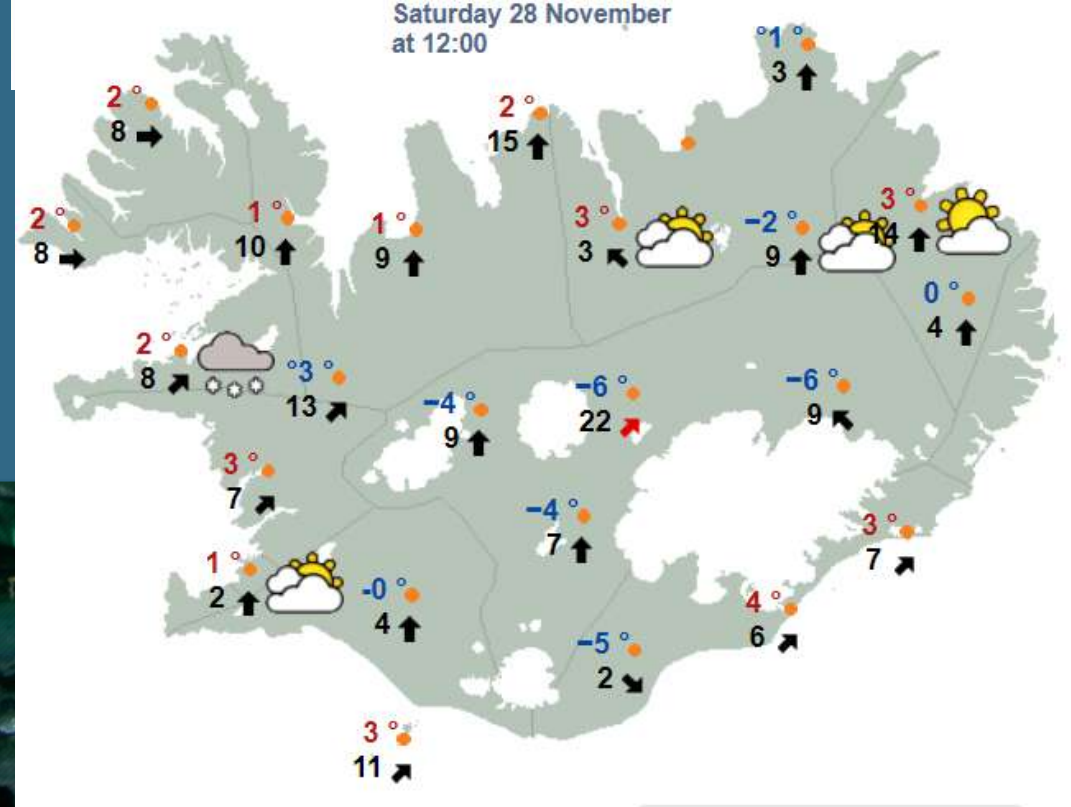
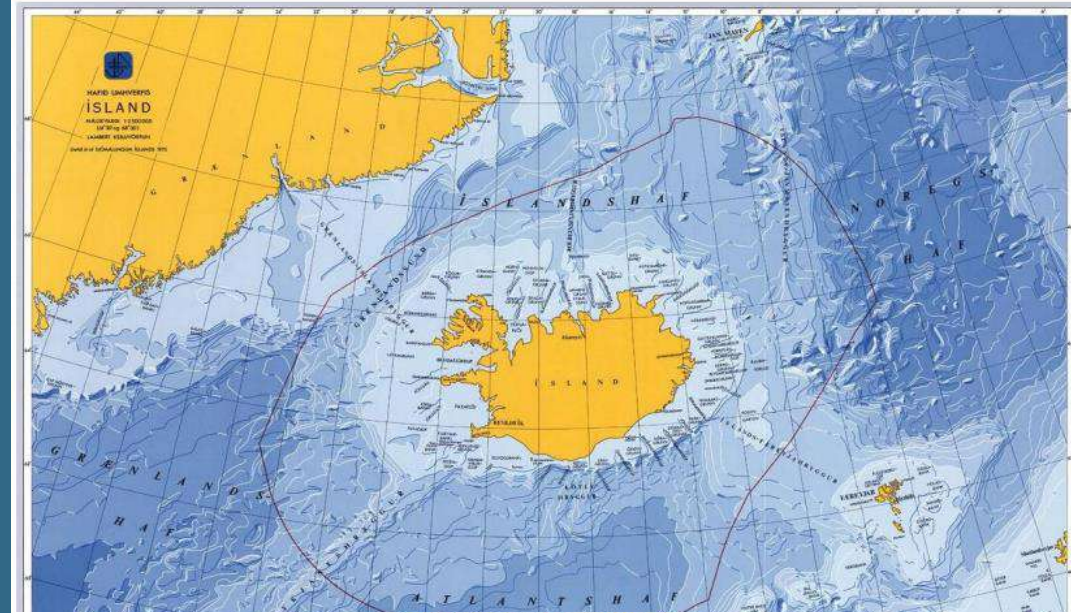


Blizzards

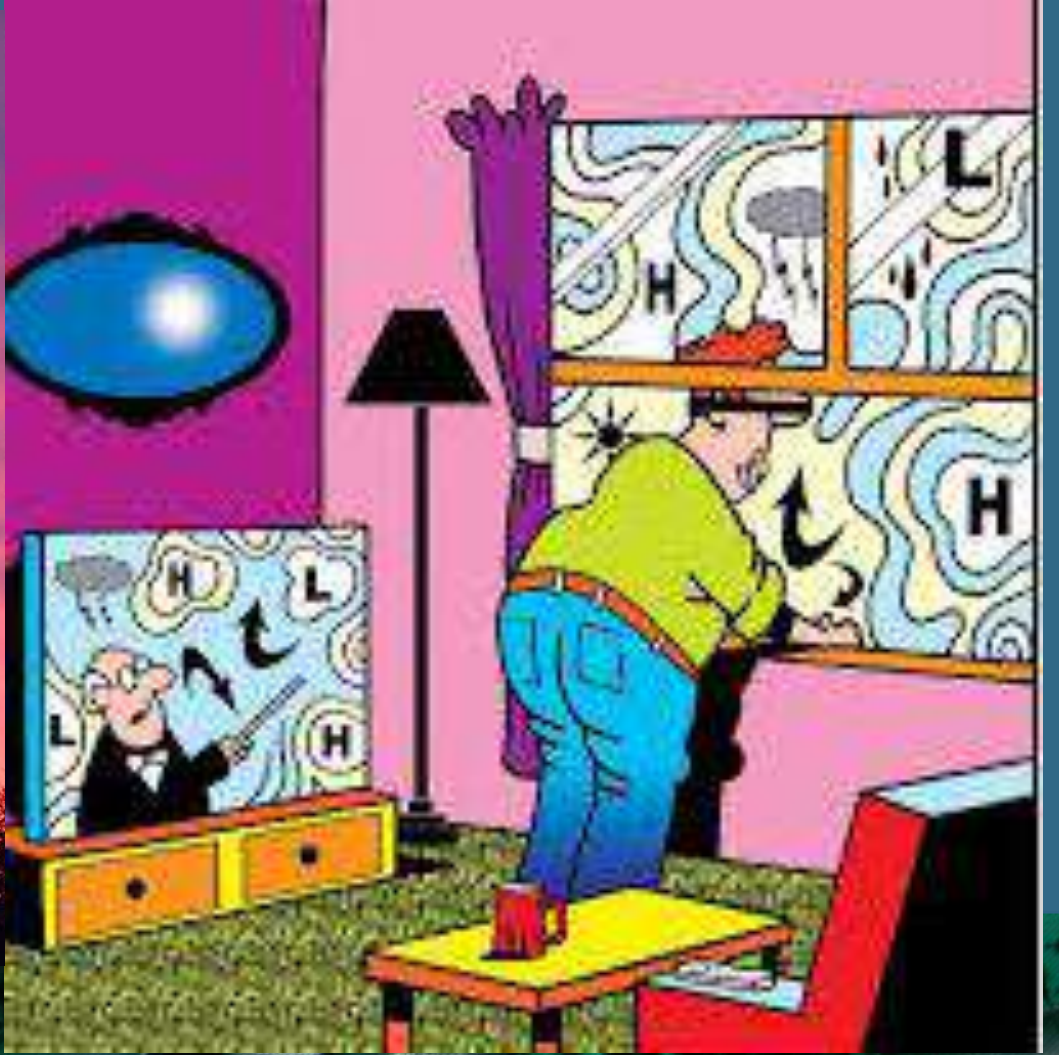


Weather in Iceland

- Strong winds
- Frequent precipitation
- Cool summers (avg. 10°C)
- Iceland has much more mild winters than the Eastern American coast...why? (Avg. 0°C)

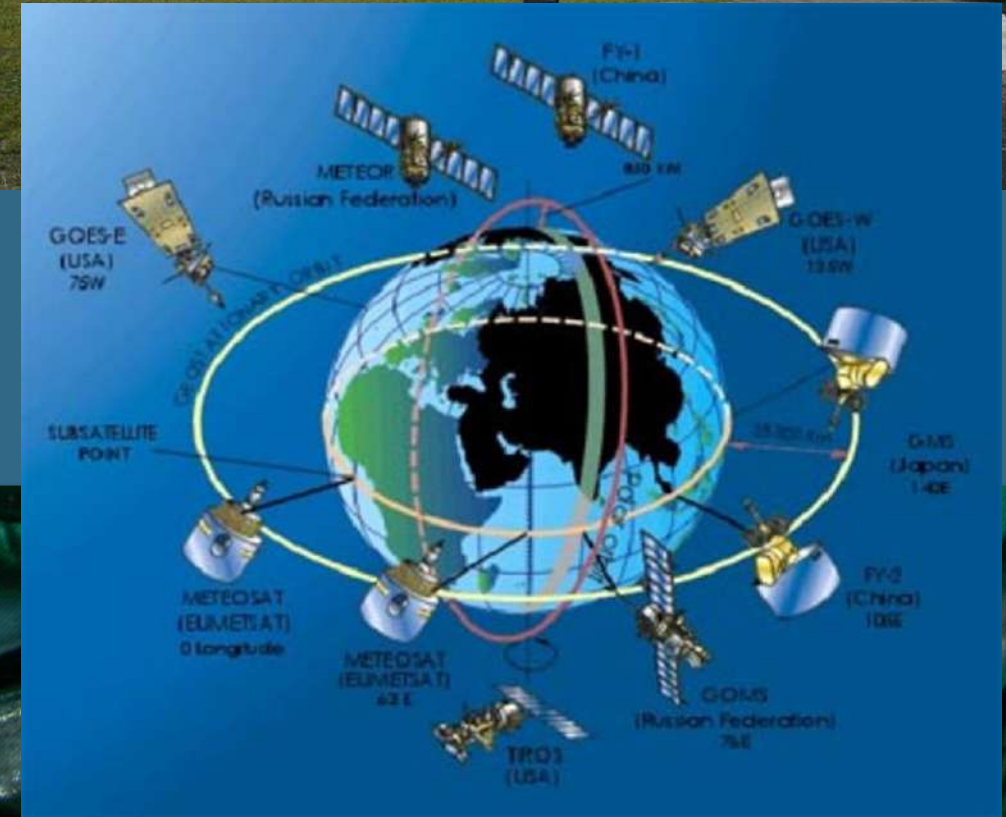
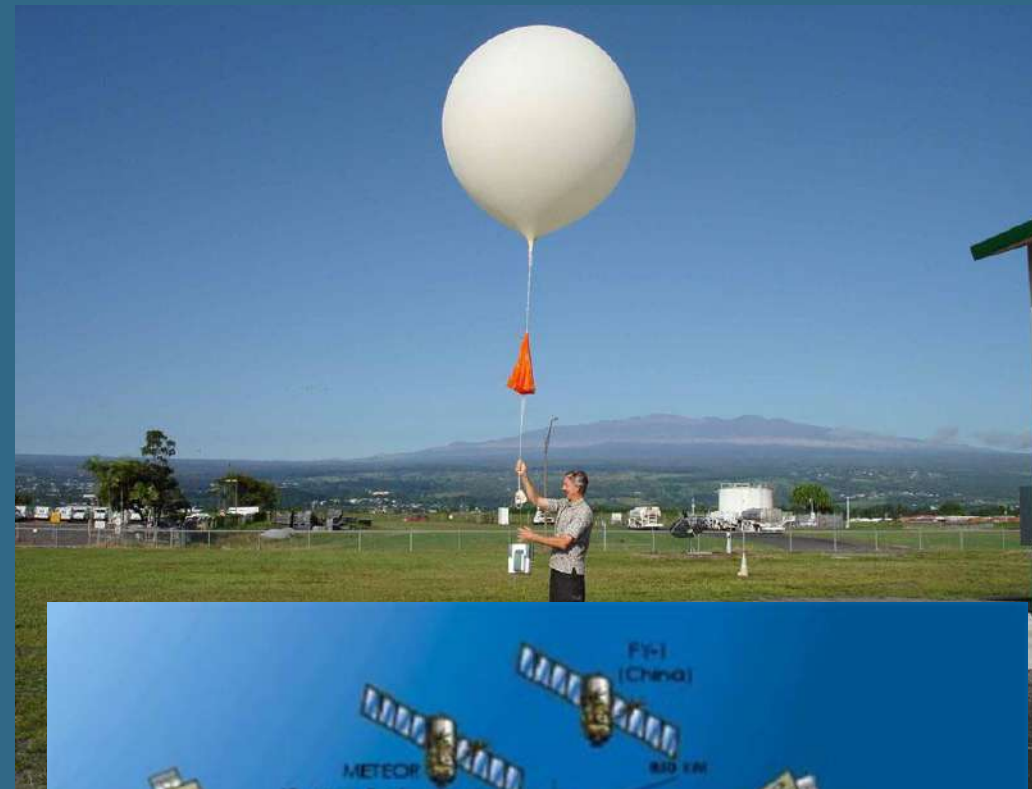


Forecasting the weather



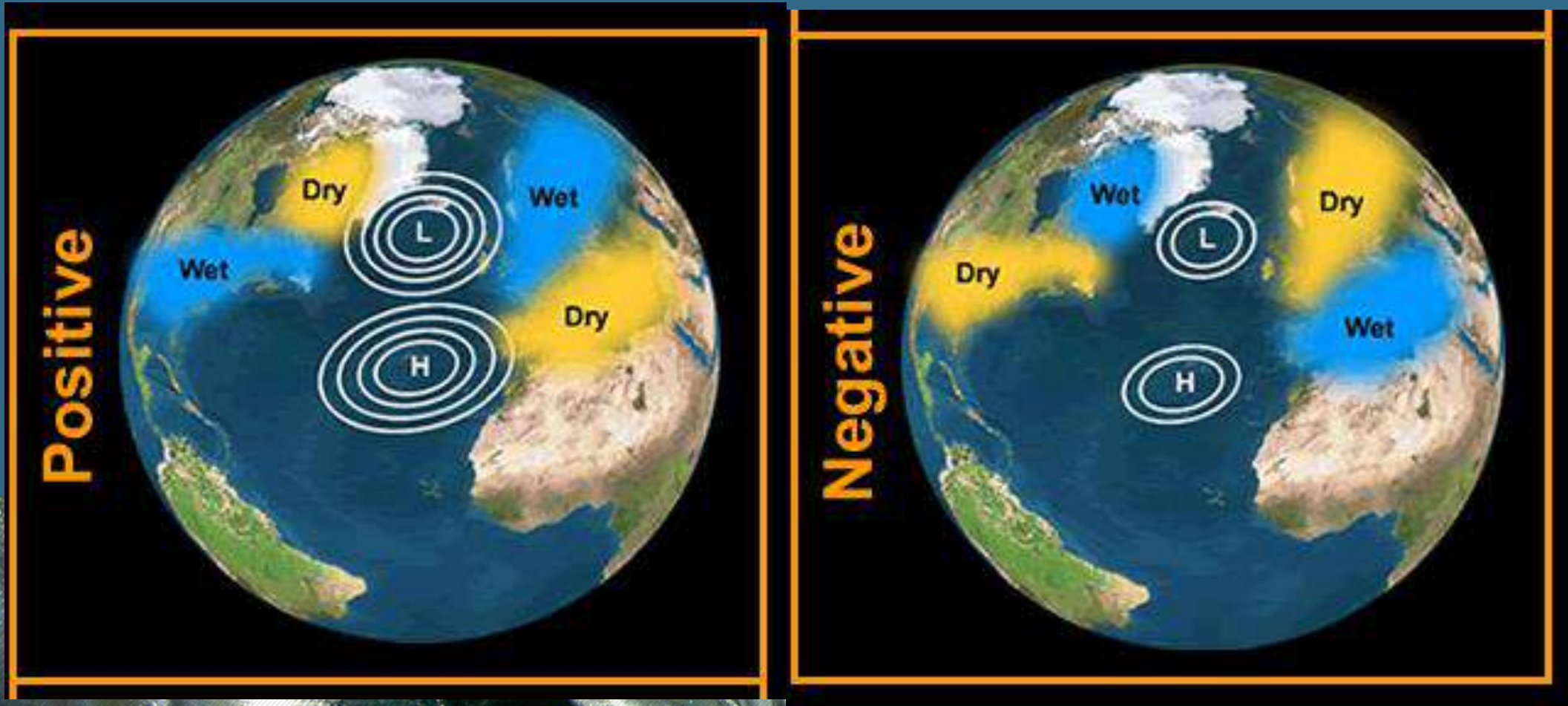
Forecasting the weather

- Many tools now exist to give us information on things like temperature, wind speed, humidity, rain fall which make predictions much better but still complicated.
- Predicting extreme weather events is much easier but even so we are still quite powerless against many of these events.



Cycles of Weather; Patterns overtime that affect climate

The North Atlantic Oscillation



Key points from Module 1

- Weather is the minute-by-minute changes of conditions in a localized area.
- Average weather conditions are determined by the climate of a given region.
- Despite how much data we can collect and how much we know, predicting weather is still a very complicated task.



Summary quiz for module 1



Module 2: Climate Introduction



Background Information

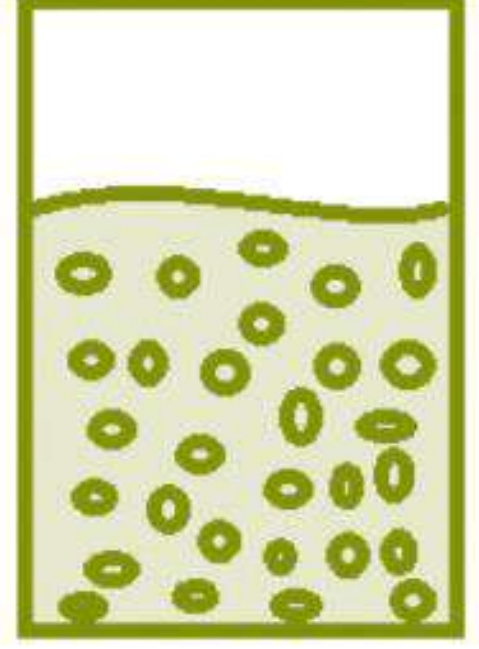
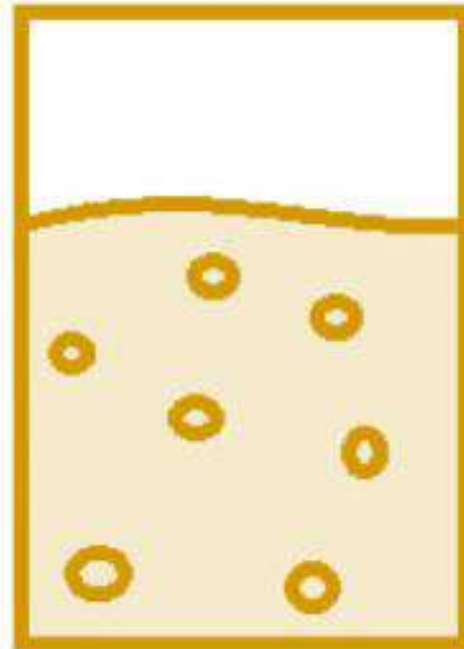
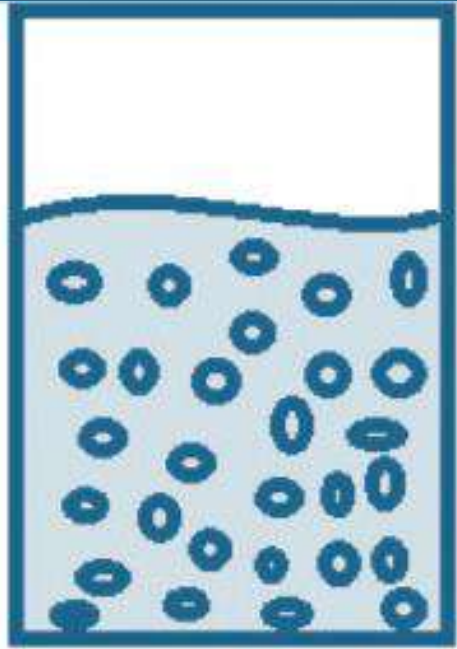
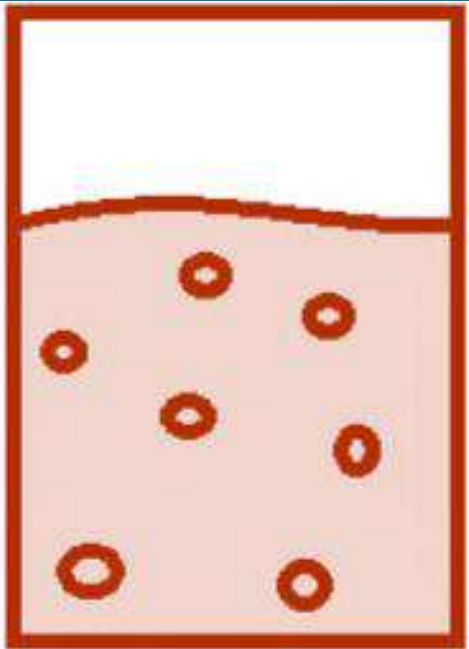
Density has a strong relationship with temperature and salinity

Hot water

Cold water

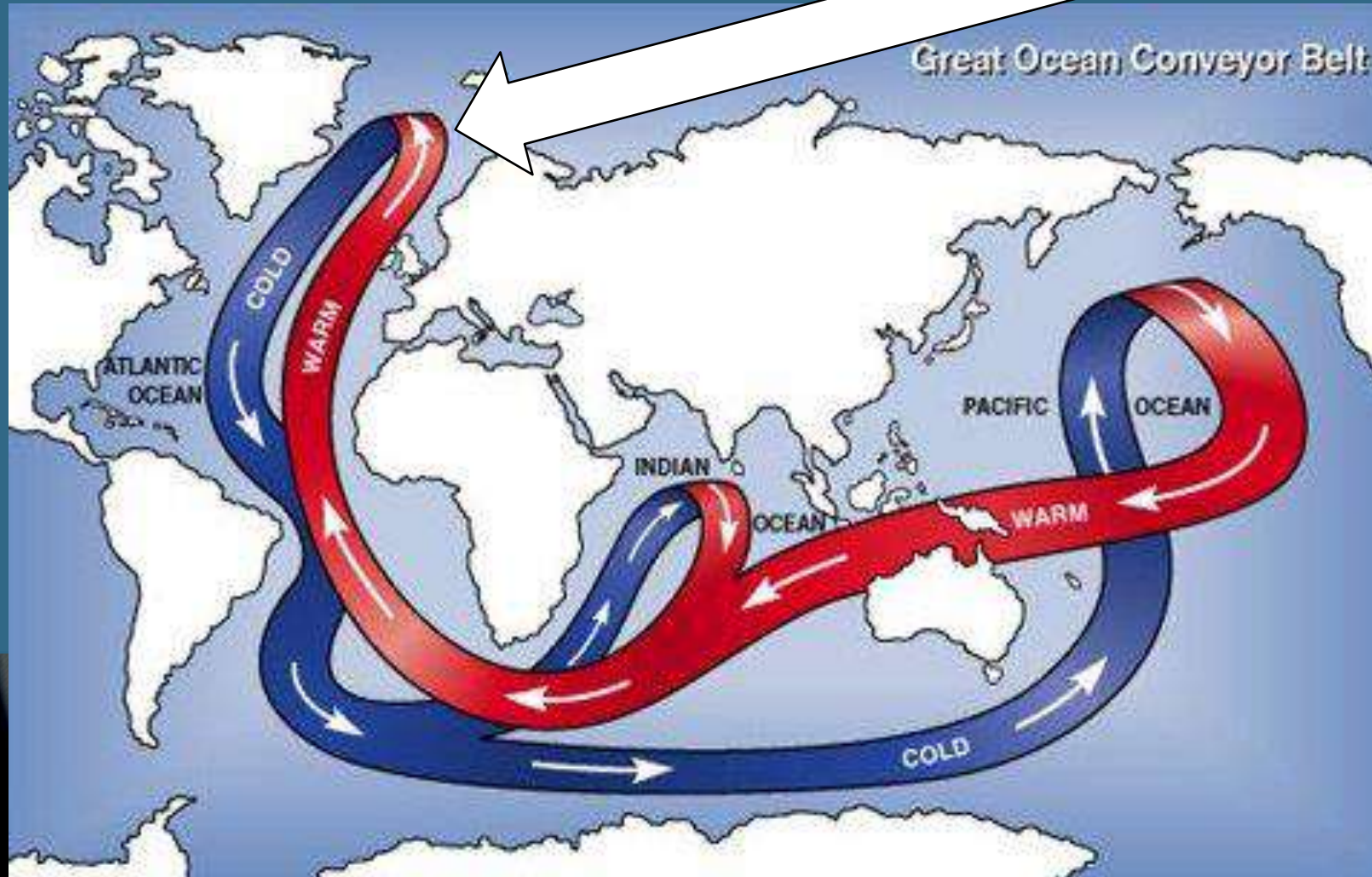
Fresh water

Salty water



Background Information

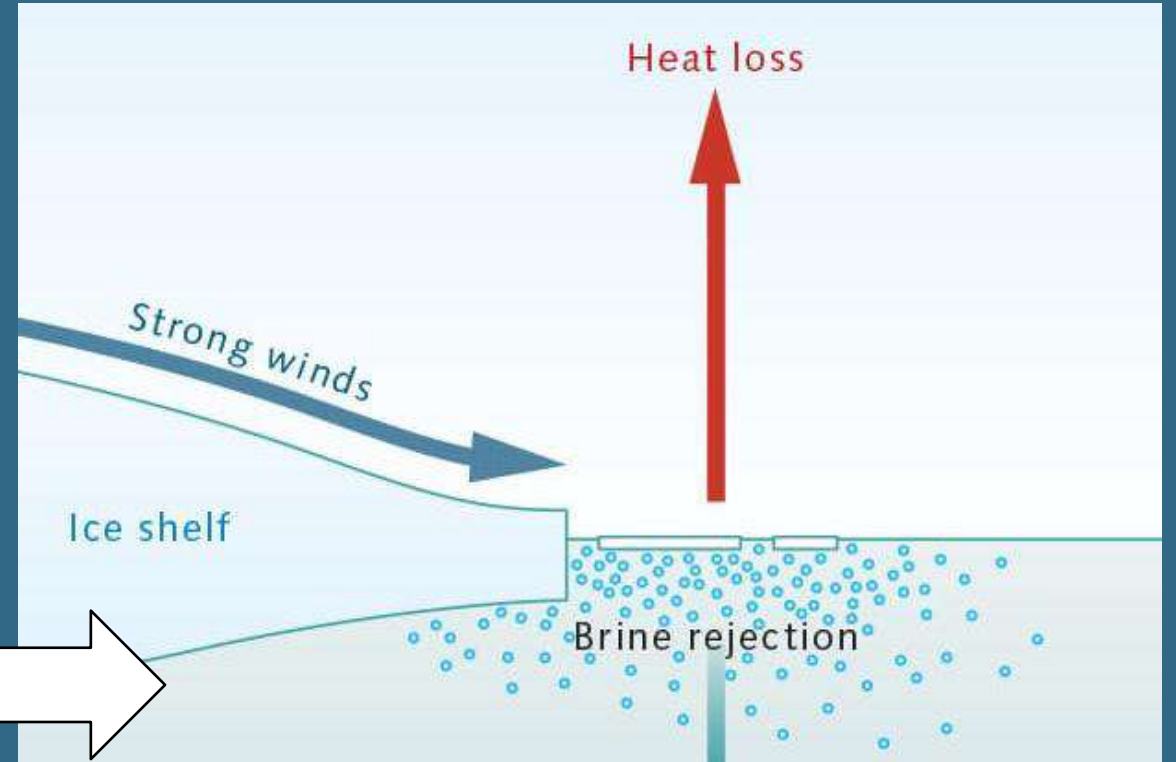
The global conveyor belt



Sea Ice



Background Information



Background Information



- Cold winds = very cold surface water



- Sea Ice = Very salty surface water



Background Information



- Cold winds = very cold surface water



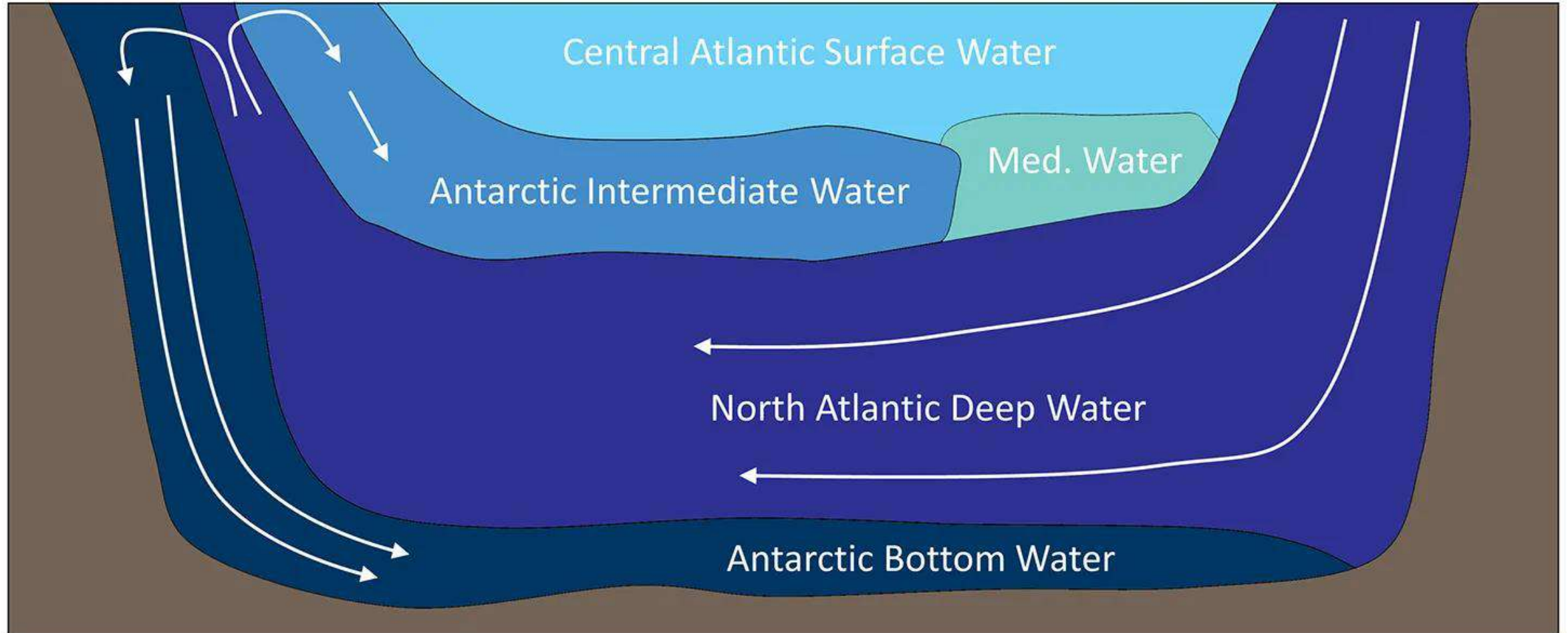
- Sea Ice = Very salty surface water



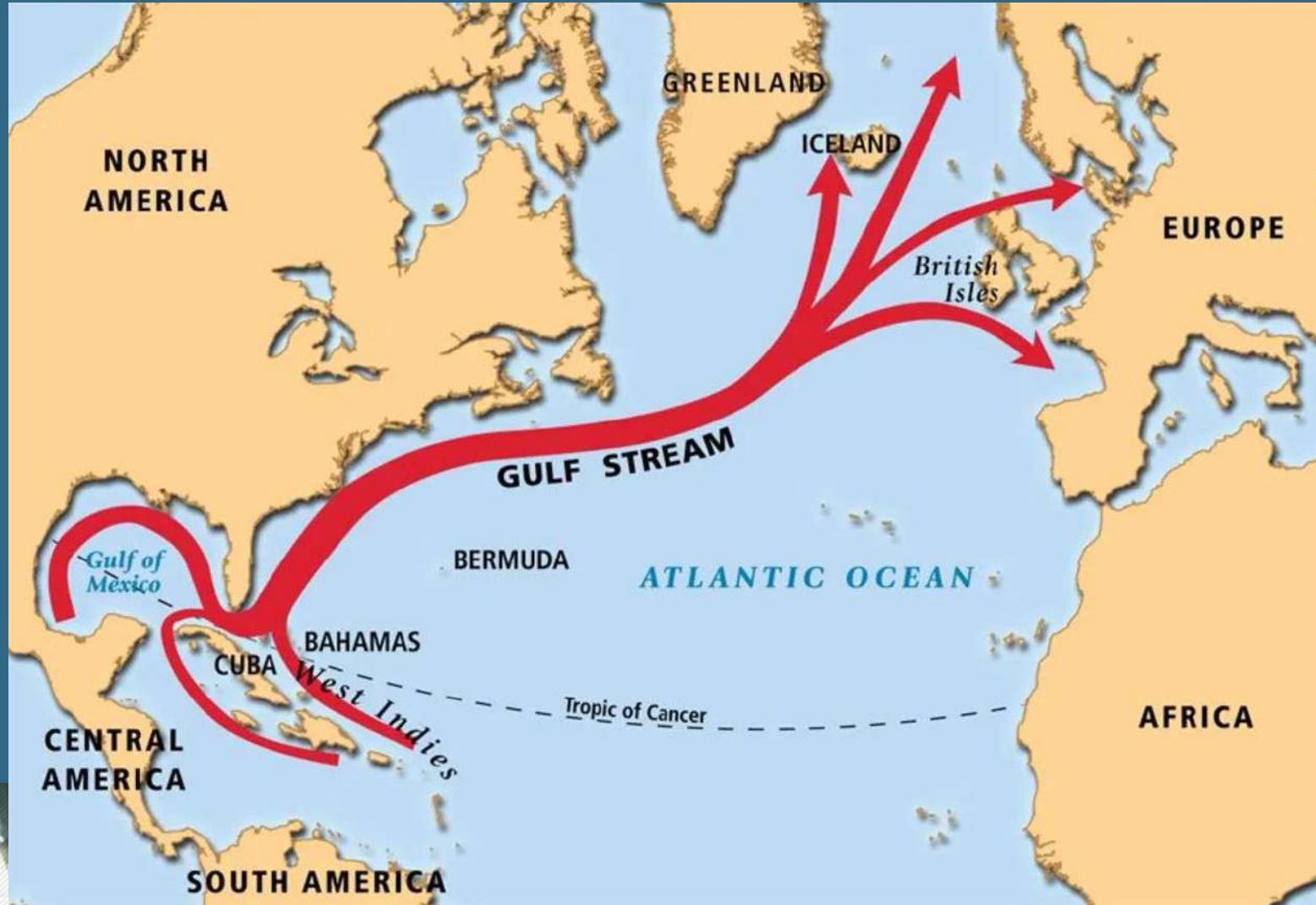
Background Information

South

North



Background Information



Gulf Stream benefits

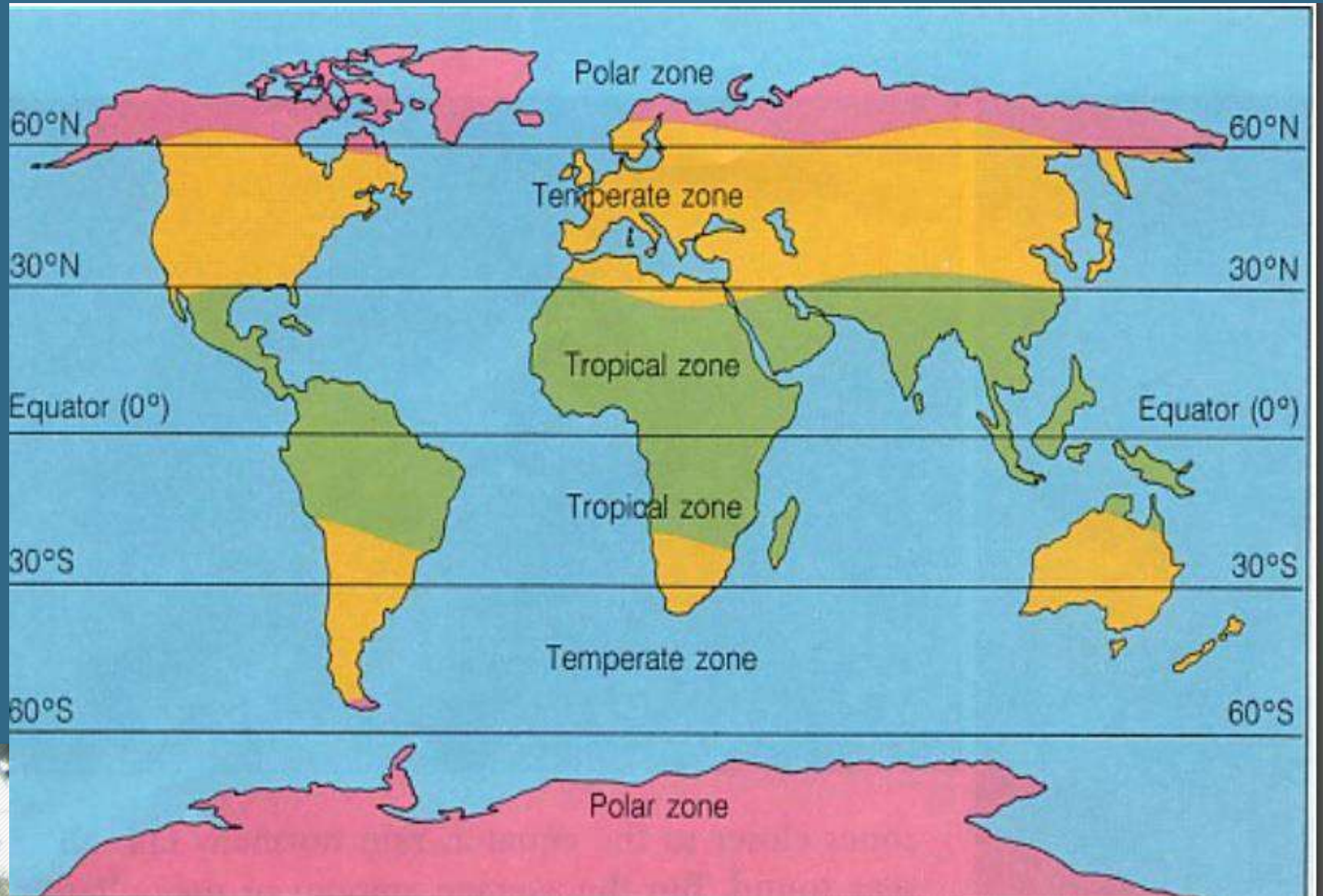


A definition of climate



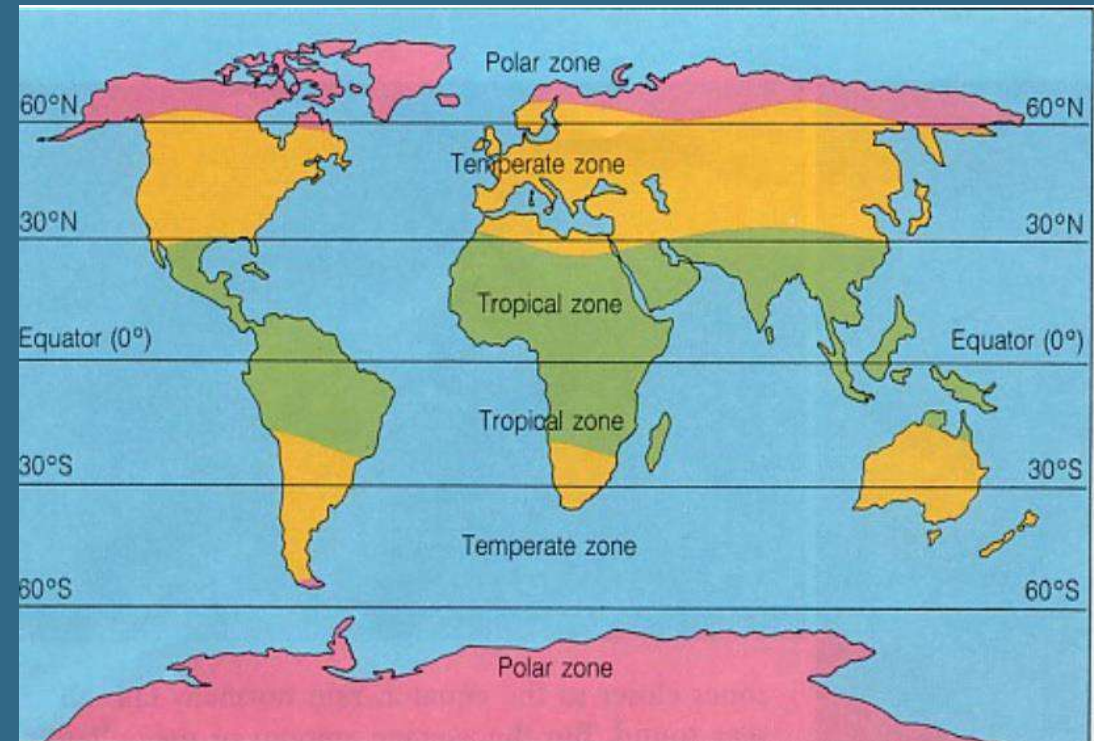
The usual condition of temperature, humidity, air pressure, rain fall etc. in an area of the Earth's surface over long time periods.

Climate Zones



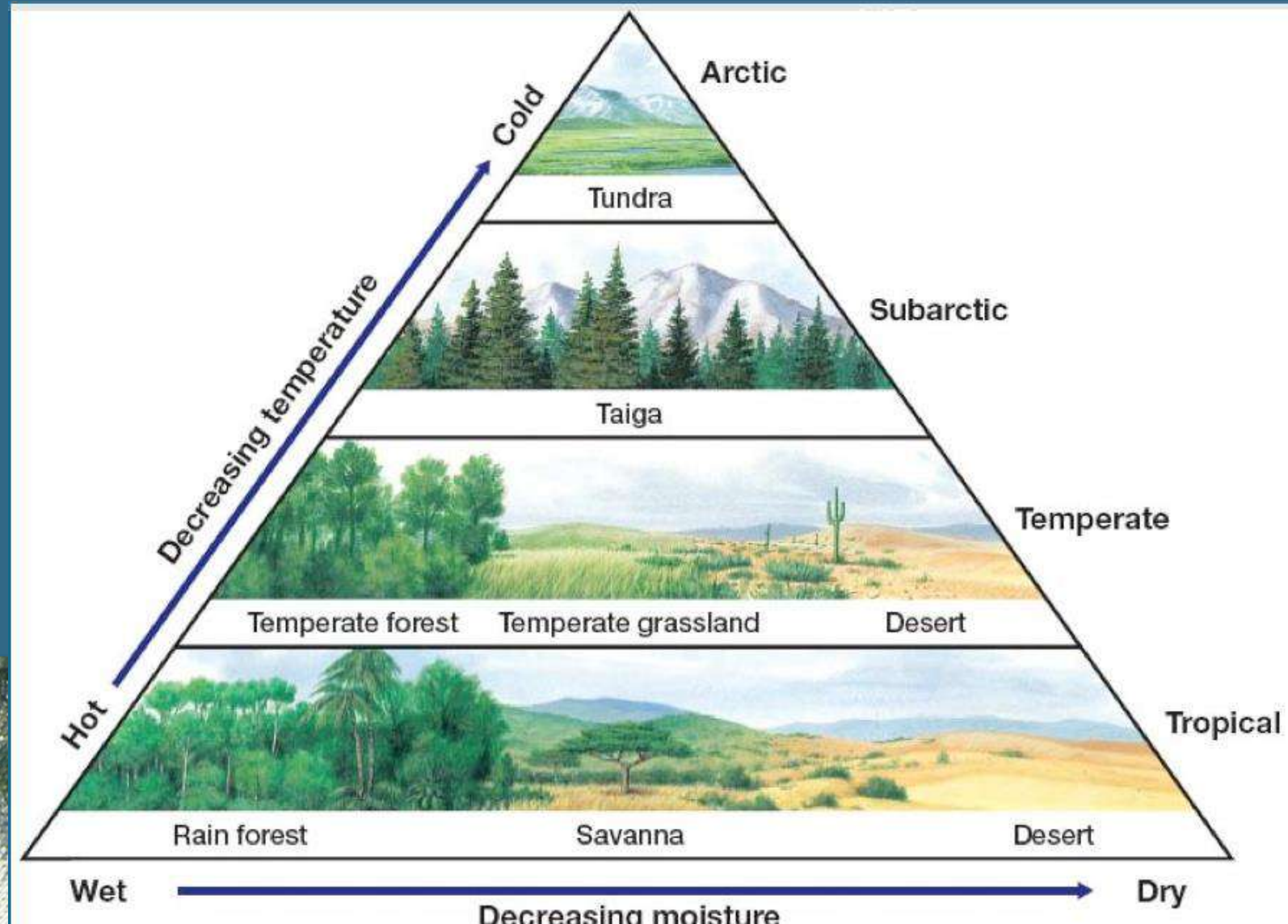
Climate Zones

- Distance from the equator.
- Height above sea level.
- How far from a large body of water.
- Flat or mountainous
- Ocean currents and circulation



Climate Zones

- Flora and fauna follows climate regions



Climate Zones

TERRESTRIAL ECOSYSTEM WORLD MAP

ISOMETRIC

TEMPERATE BROADLEAF AND MIXED FOREST

GEOGRAPHY BIOME VECTOR COLLECTION

MAMMALS



PLANTS



BIRDS

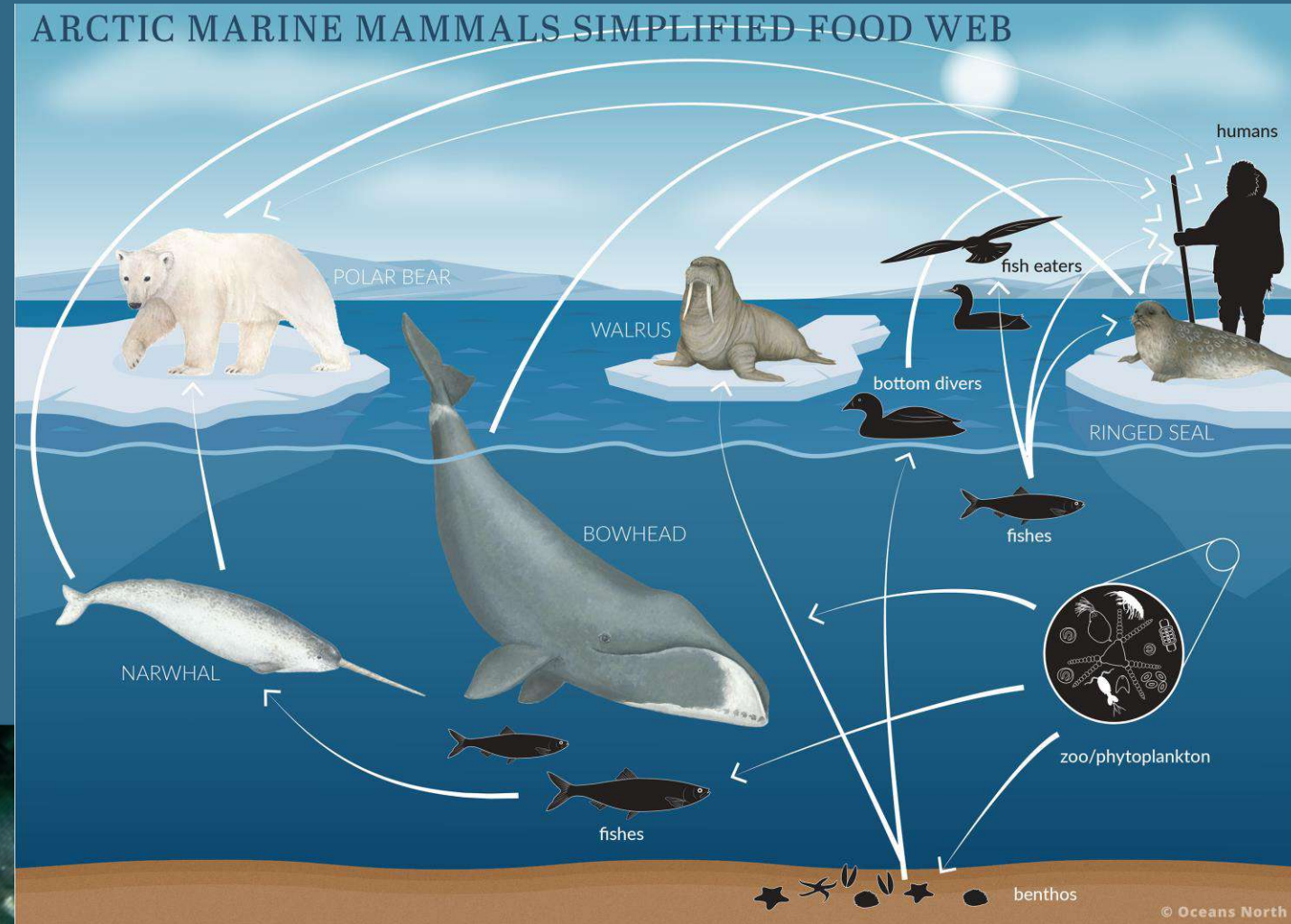


Climate Zones



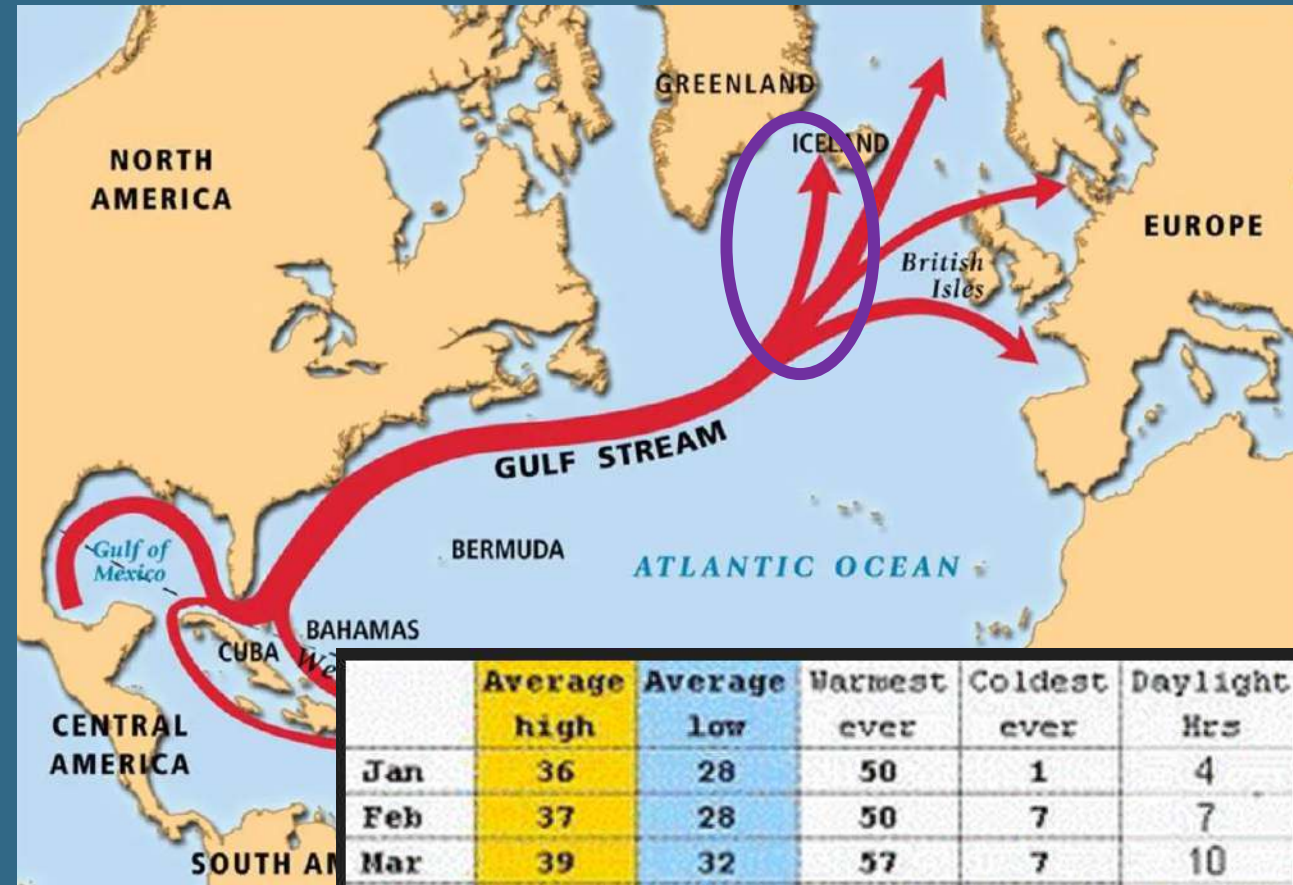
Climate Zones= BIOMES

- Flora and fauna follows climate regions
- Drives the food webs and there for animals we see in different places.
- Which has affected how societies have developed.
- Particularly extreme examples include Inuit populations



Climate Biome of Iceland

- Iceland = Tundra Biome
- Short growing season
- Large population oscillations



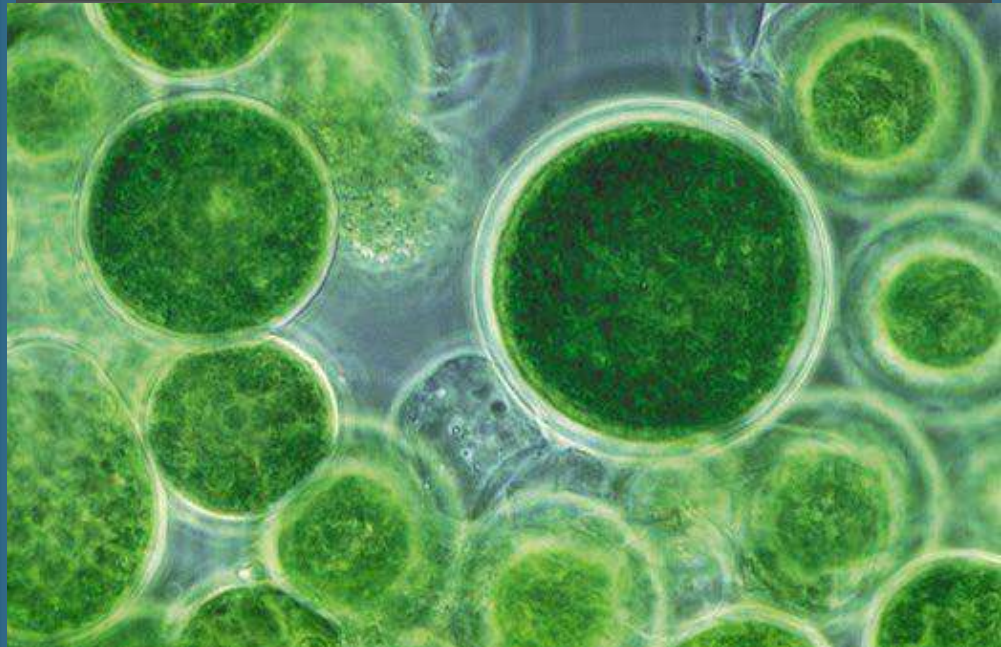
	Average high	Average low	Warmest ever	Coldest ever	Daylight Hrs
Jan	36	28	50	1	4
Feb	37	28	50	7	7
Mar	39	32	57	7	10
Apr	45	33	59	9	15
May	50	39	70	19	18
Jun	54	45	70	32	20-22
Jul	60	50	74	34	19
Aug	57	48	70	32	16
Sep	52	43	68	25	13
Oct	45	37	61	14	9
Nov	39	34	54	10	6
Dec	36	28	52	1	4



Volcanos and our atmosphere



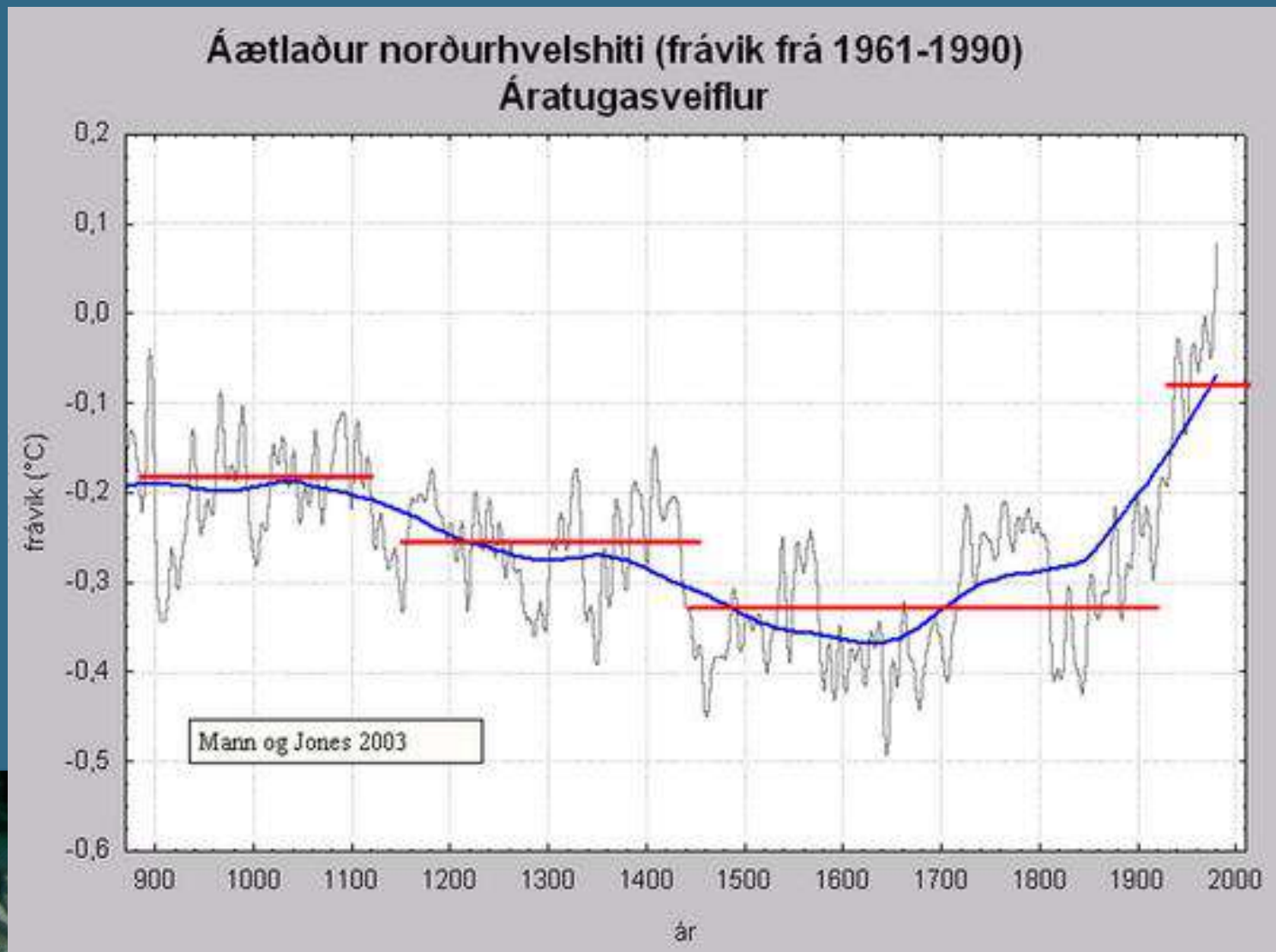
Early volcanic activity release many gases into the air but not oxygen.



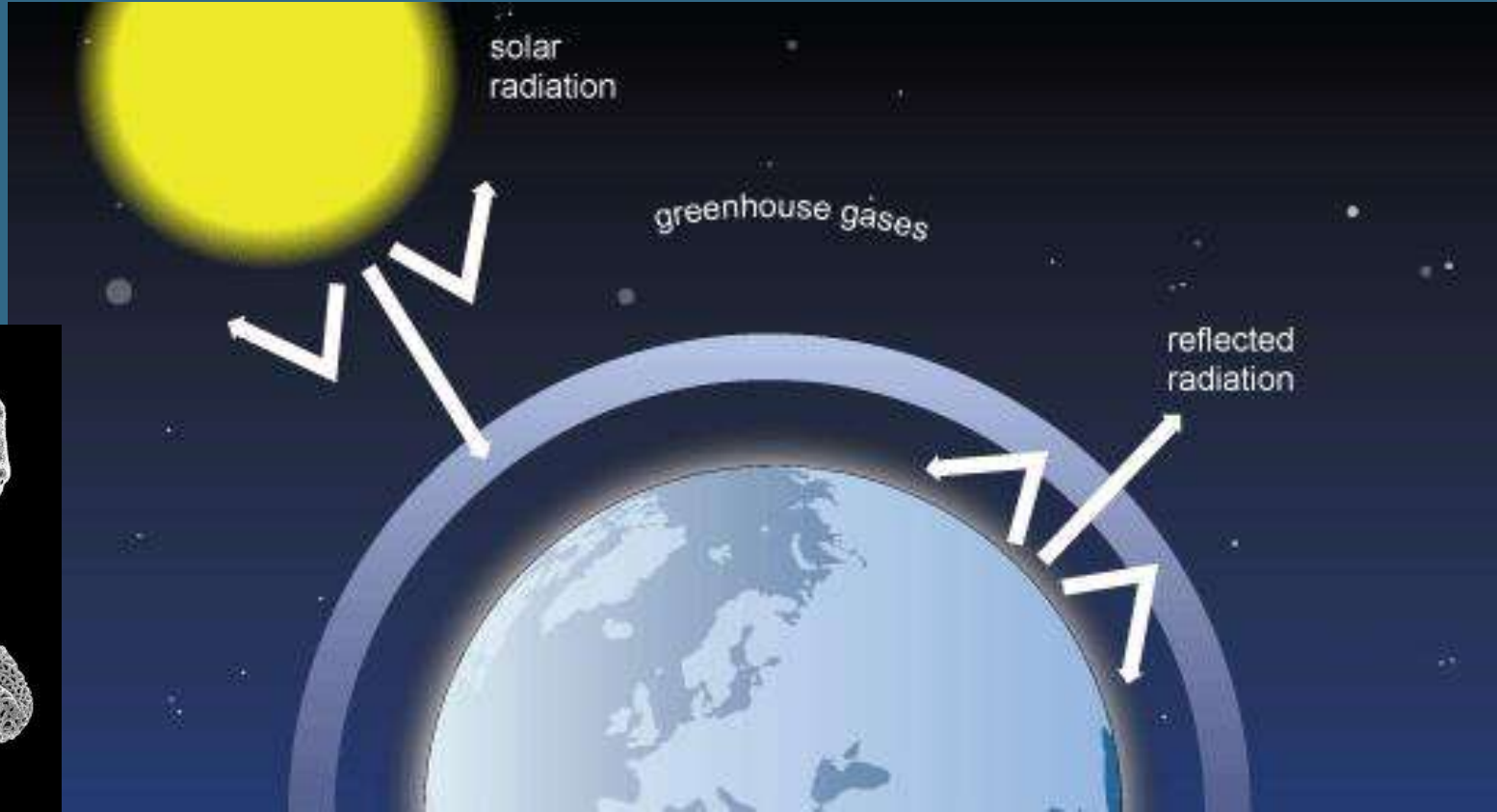
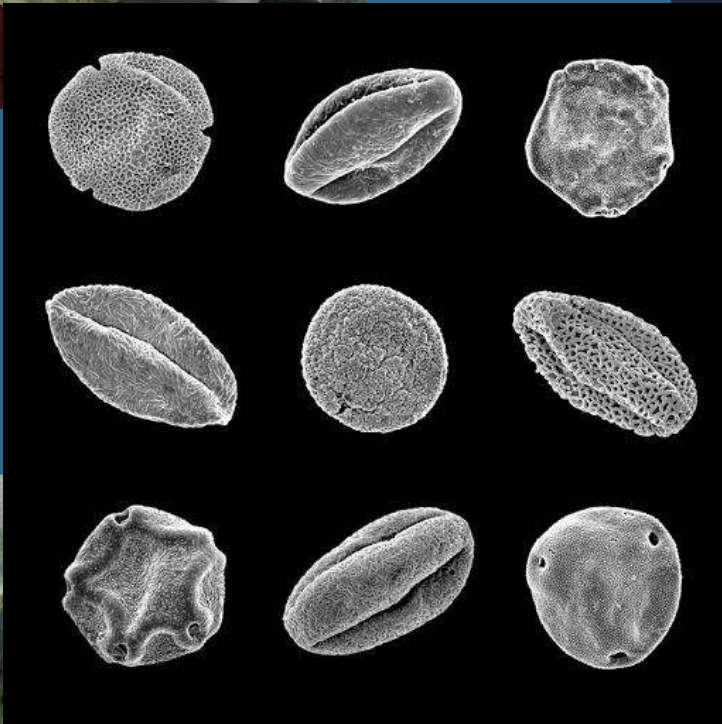
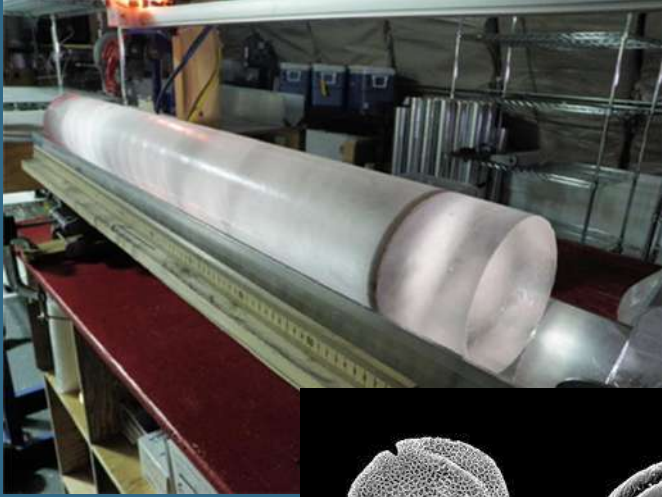
Then Cyanobacteria (a phytoplankton) evolved to use carbon dioxide and release oxygen.

Climate of Iceland

- Changing over time
- This is the change in temperature in the Northern hemisphere from the start of Icelandic settlement.



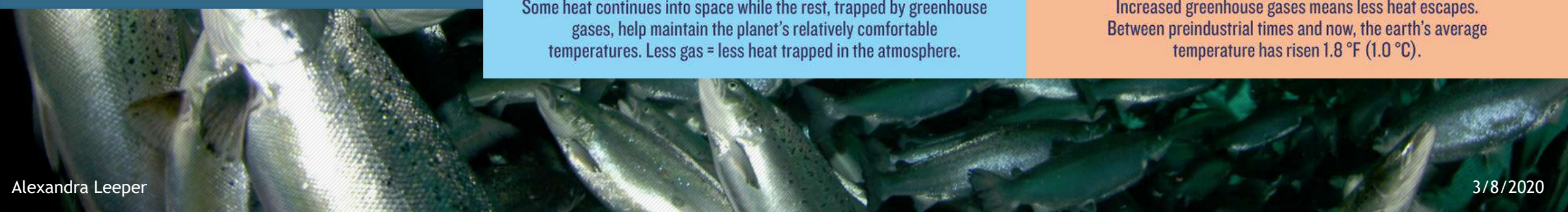
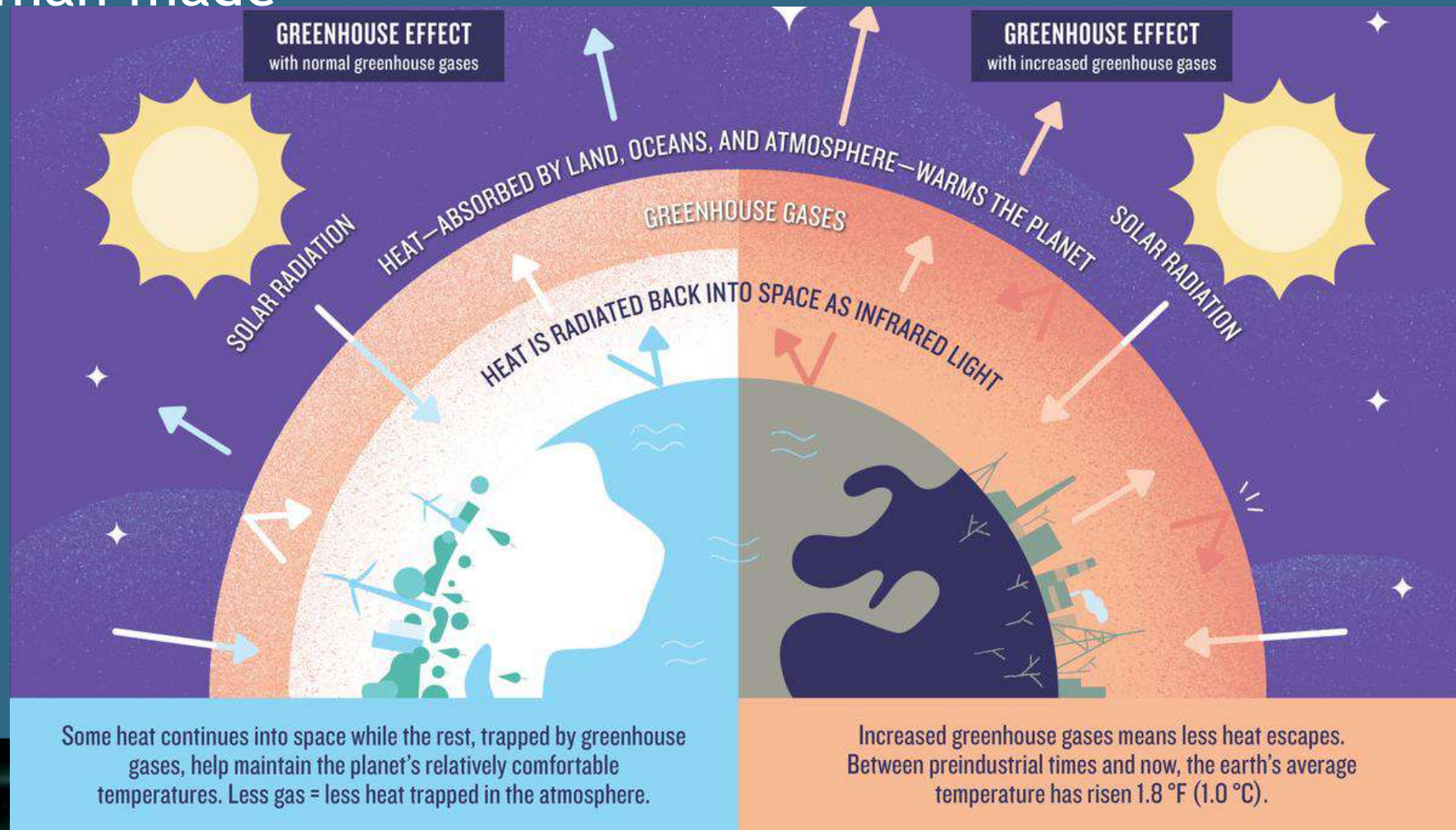
Climate Change



Antropogenic Climate Change

Anthropogenic = Human made

- Carbon Dioxide
- Methane
- Water vapor



Antropogenic Climate Change

Anthropogenic = Human made

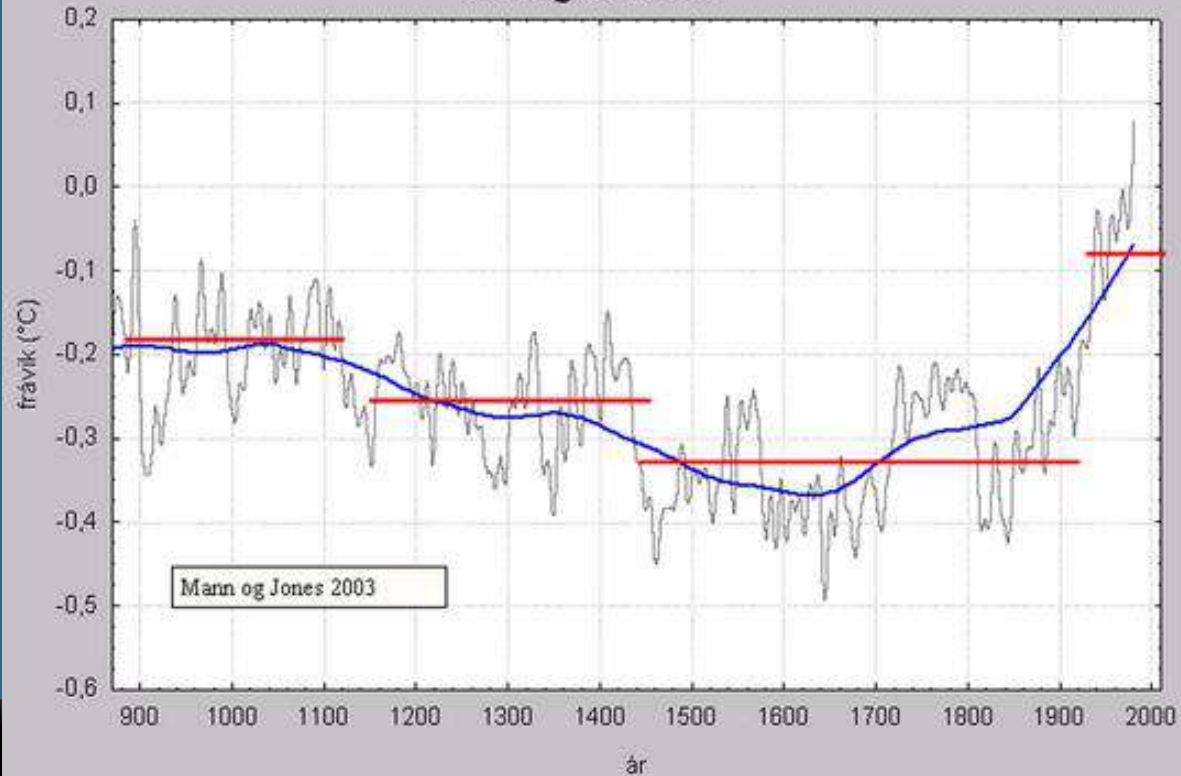
- Carbon Dioxide
- Methane
- Water vapor



Antropogenic Climate Change

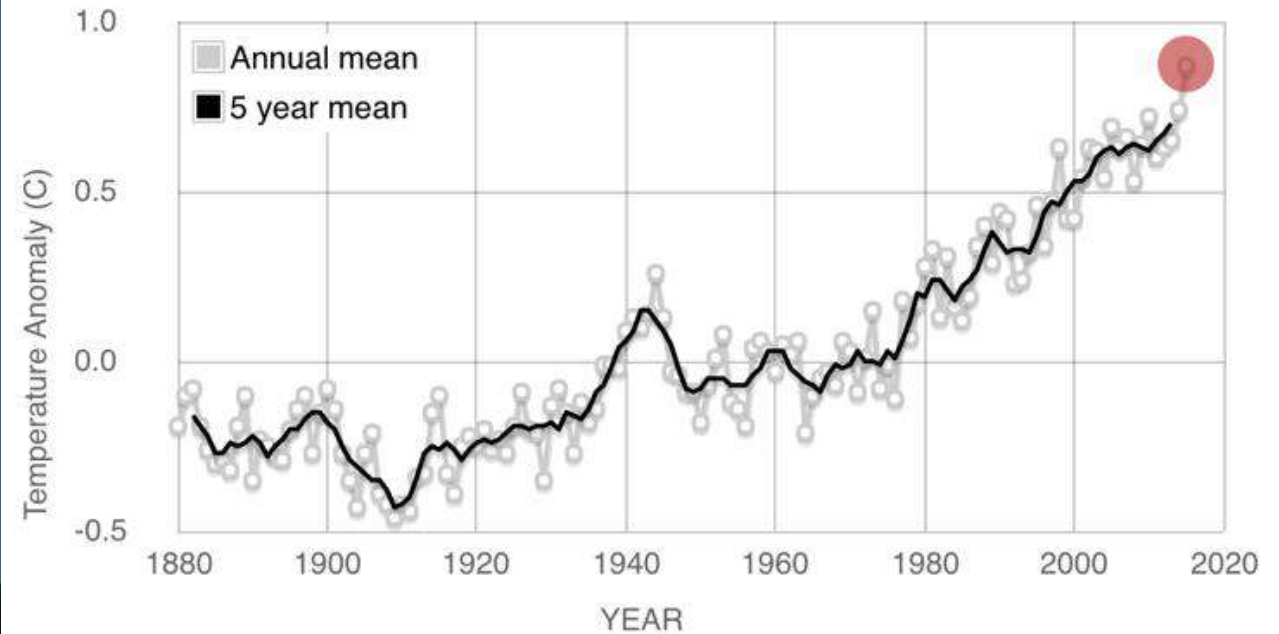
Anthropogenic = Human made

Áætlaður norðurhvelshiti (frávik frá 1961-1990)
Áratugasveifur



GLOBAL LAND-OCEAN TEMPERATURE INDEX

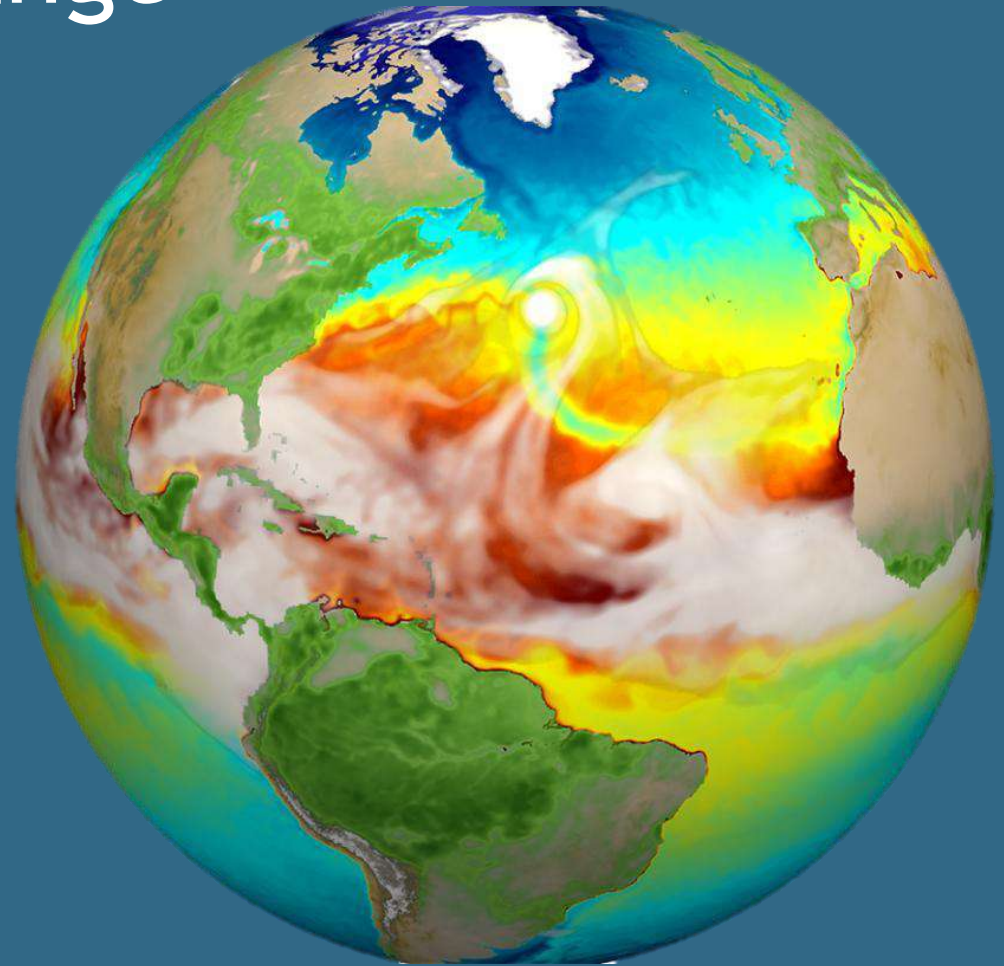
Data source: NASA's Goddard Institute for Space Studies (GISS). Credit: NASA/GISS



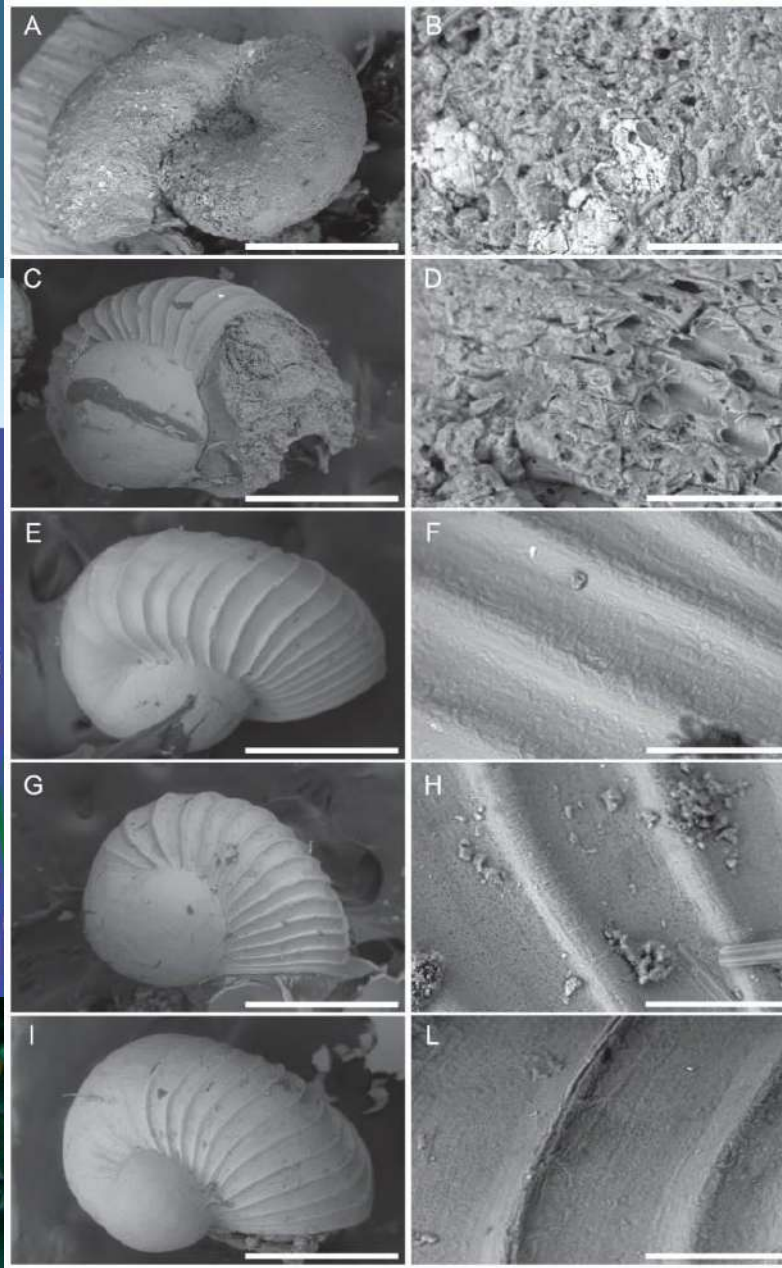
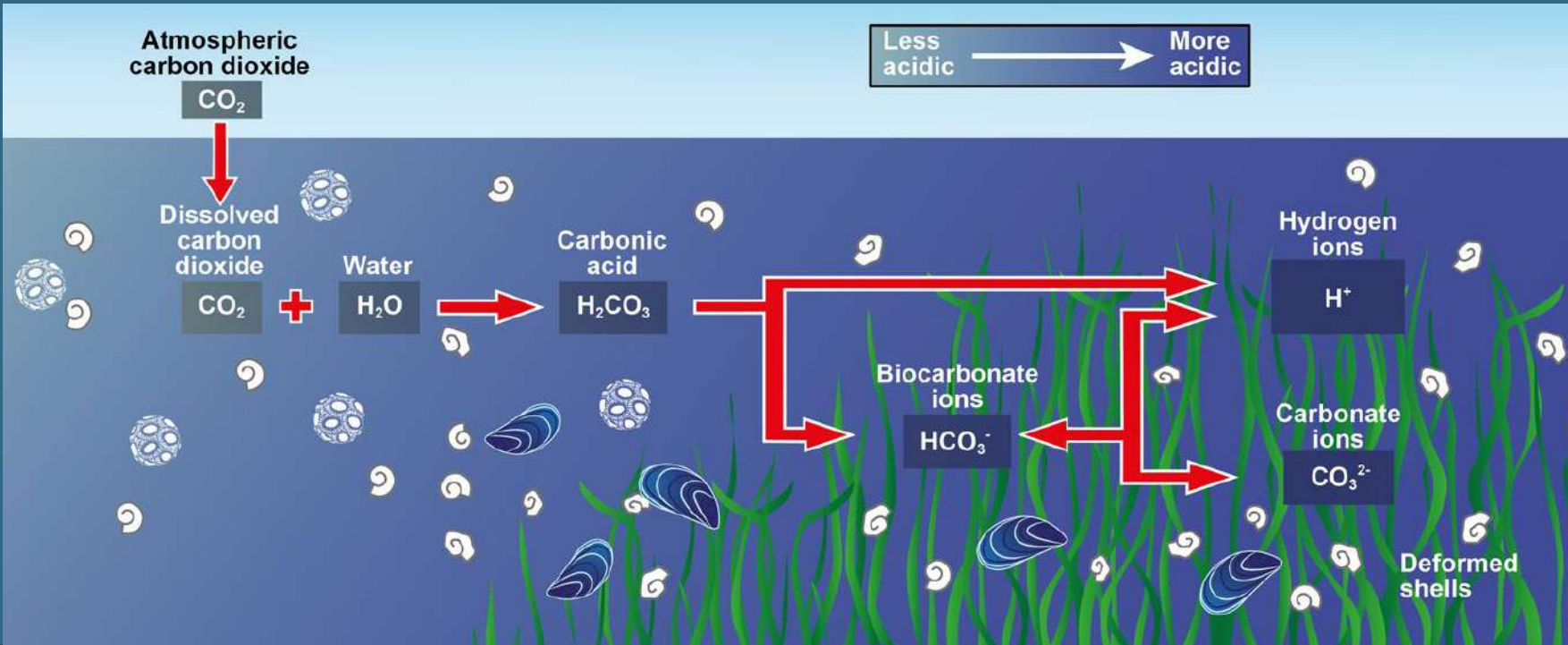
Anthropogenic Climate Change

Consequences

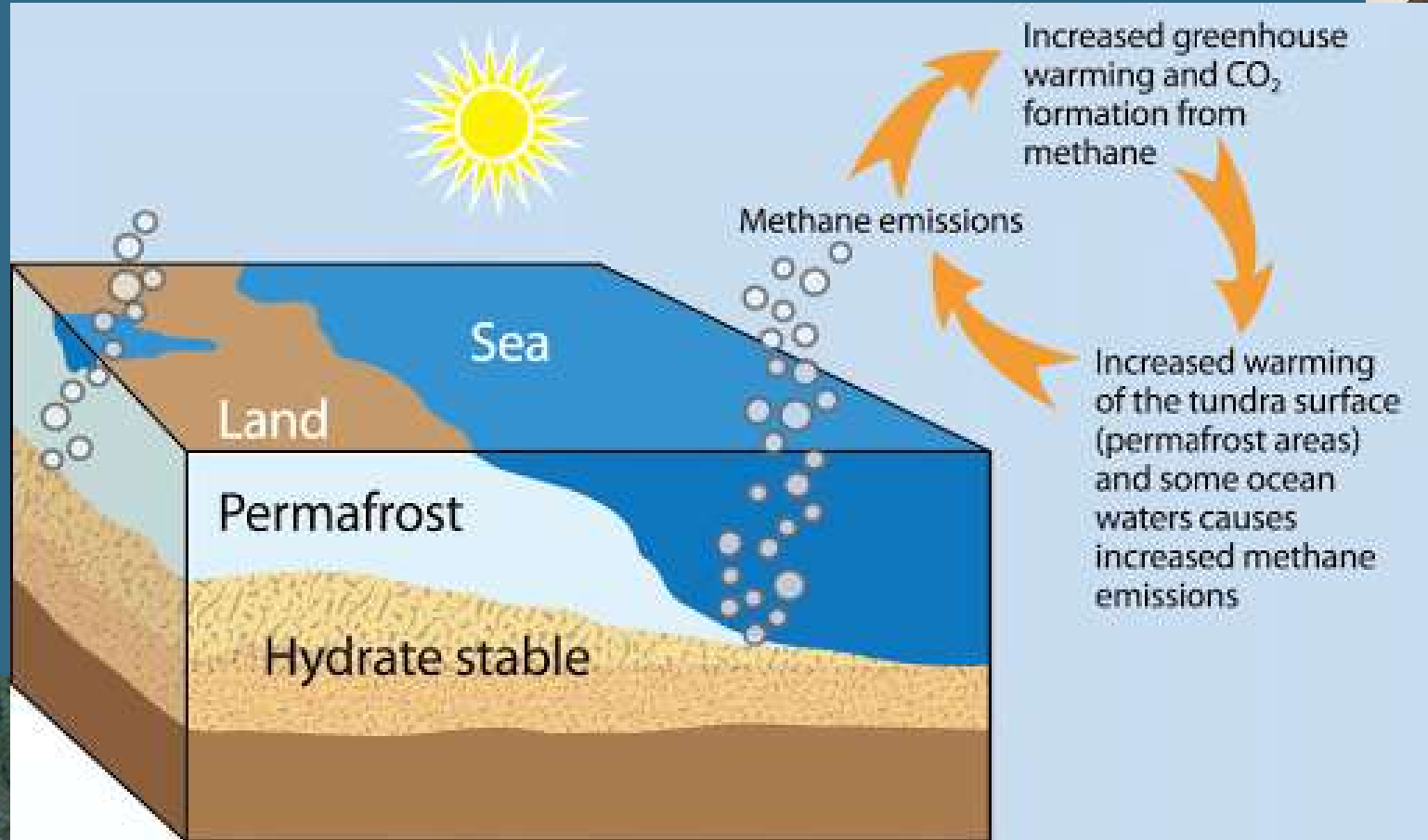
- Melting of ice
- Rising seas
- Thermal expansion
- Extreme weather events
- Change in weather patterns
- Ocean Acidification
- Melting of permafrost



Ocean Acidification



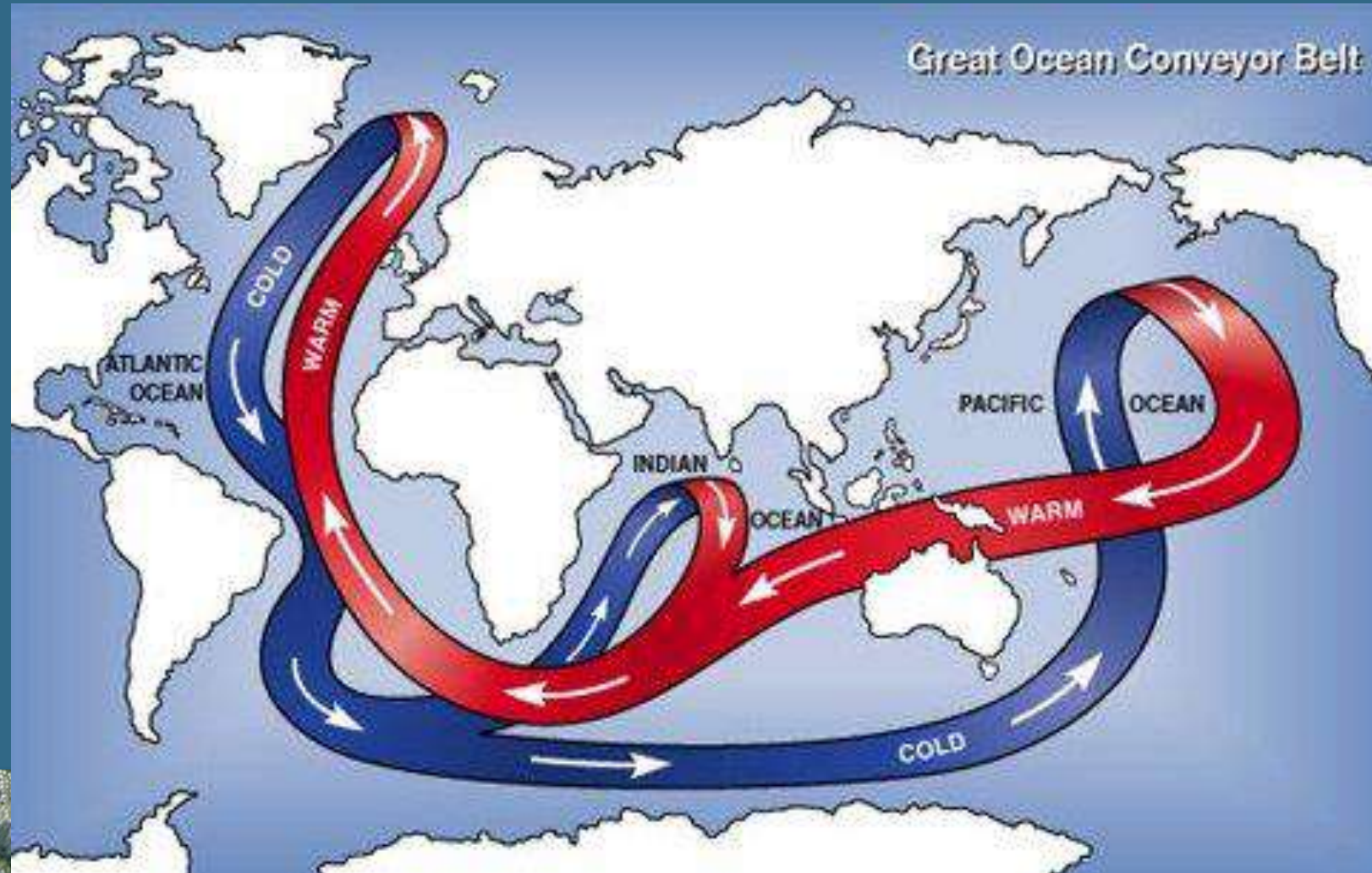
Melting of Permafrost



Climate change in Iceland



Climate change and global conveyor belt



Climate of Iceland

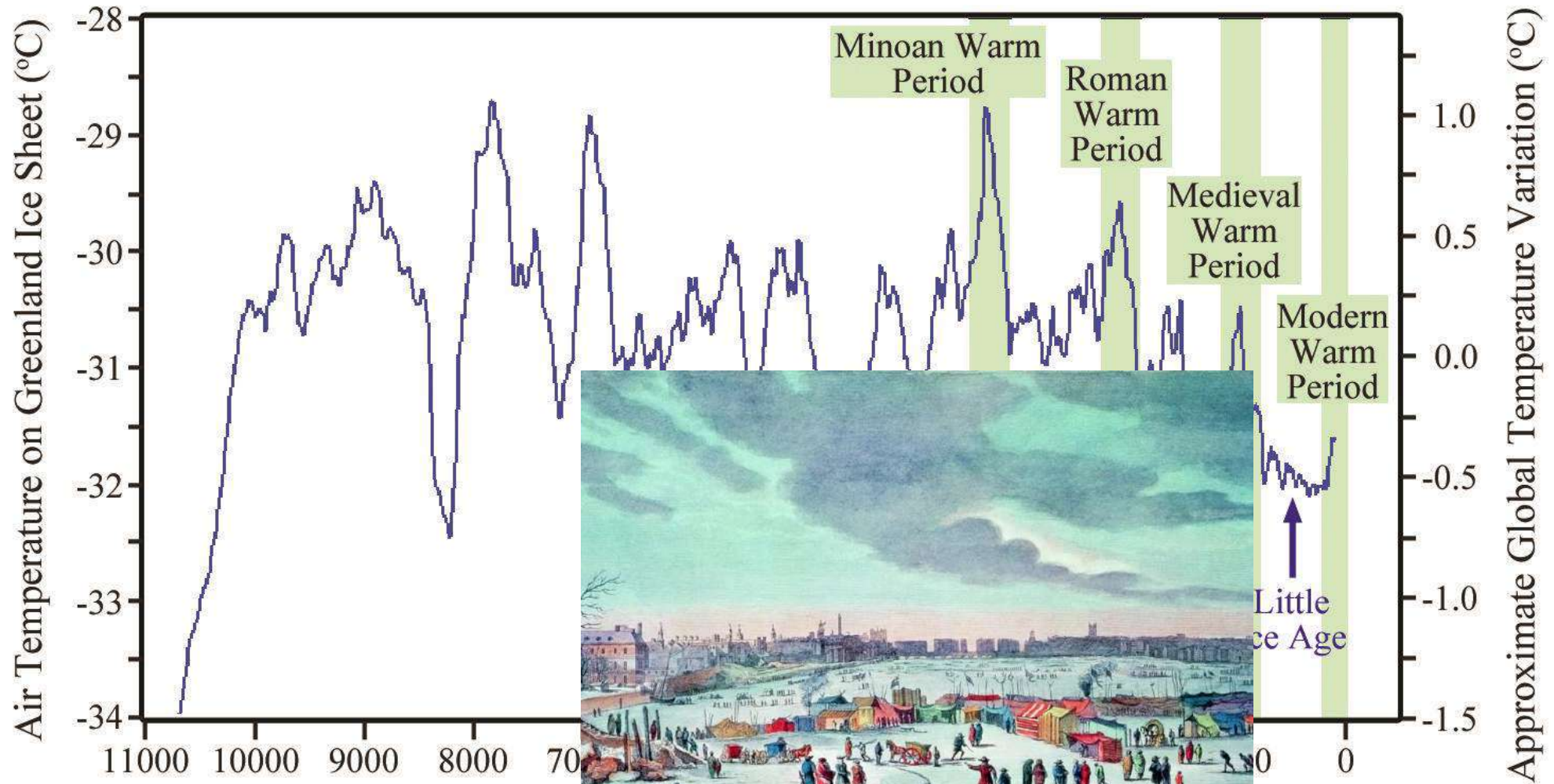


Climate of Iceland



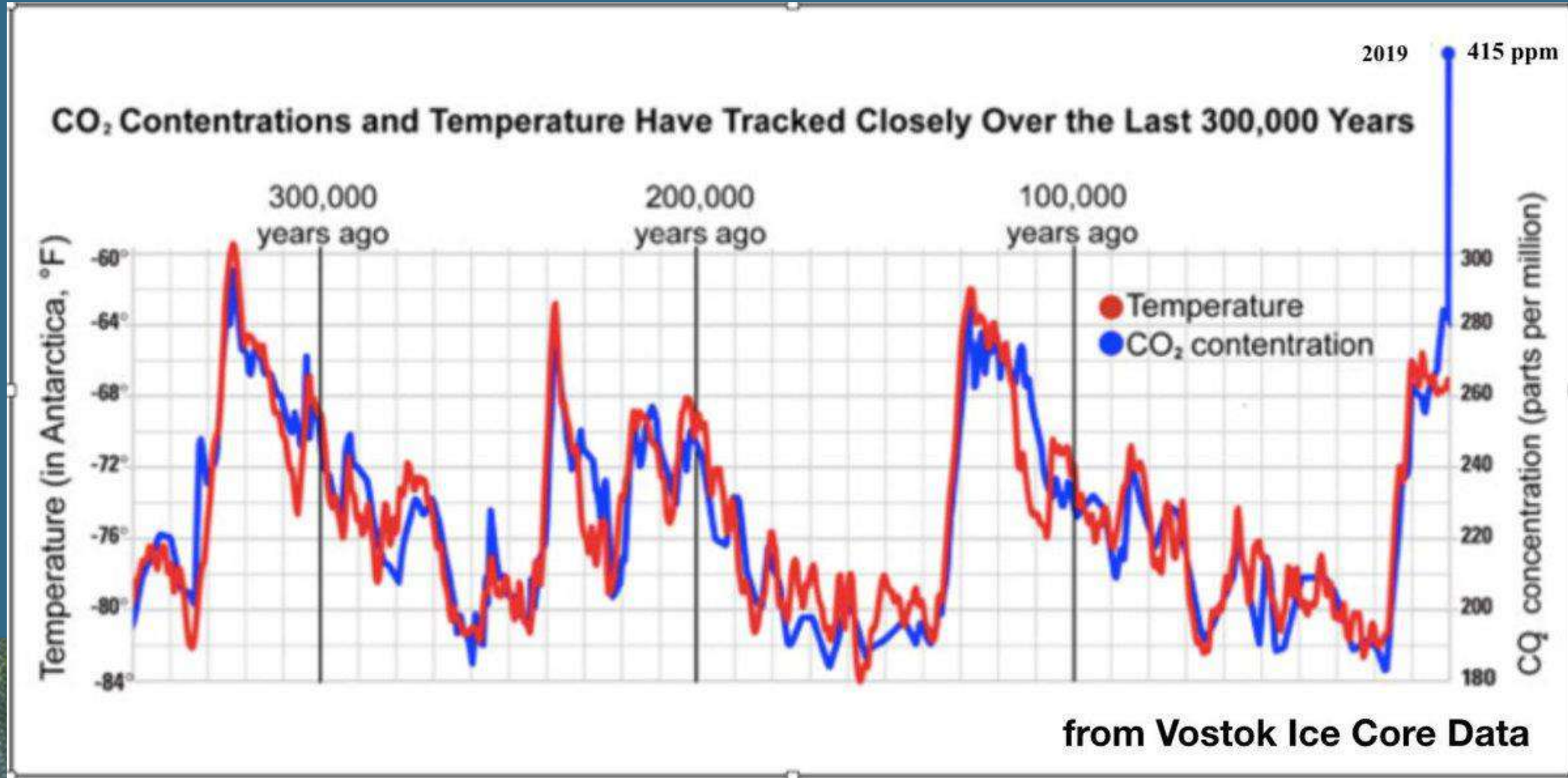
Climate change through history

Global Temperature Variation Over the Last 10,000 Years



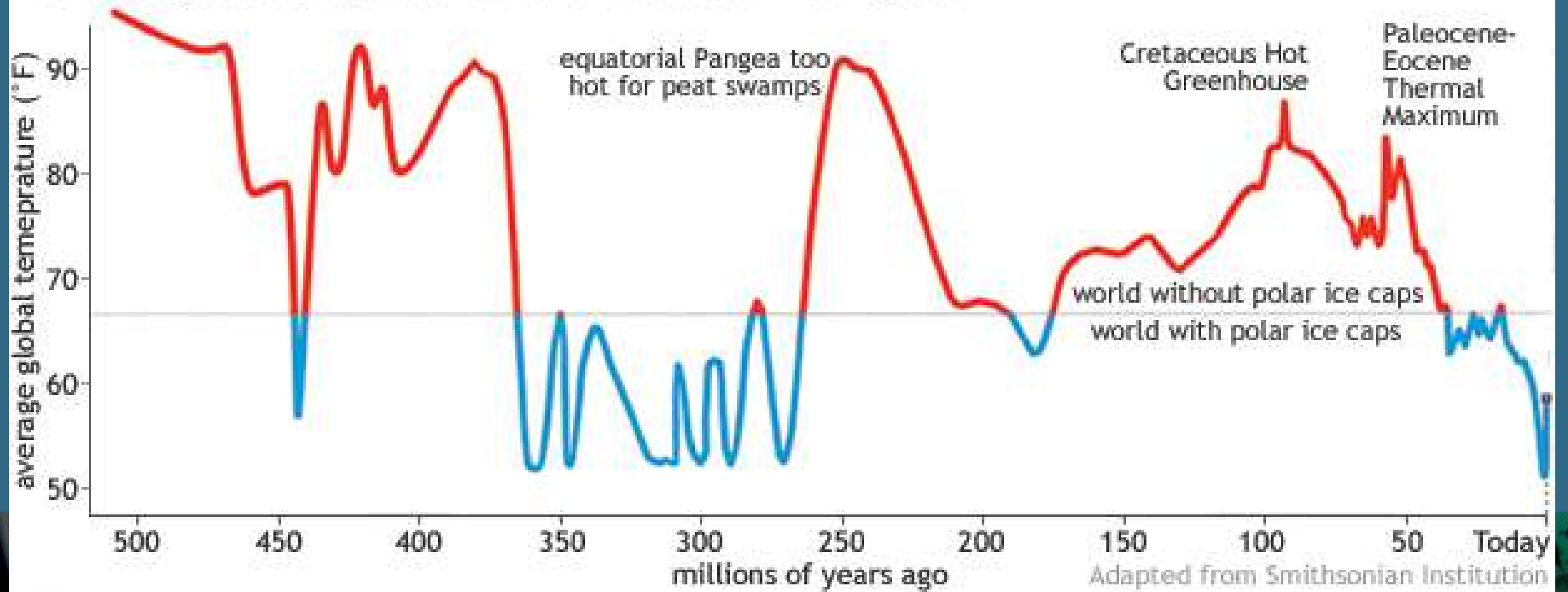
Climate4You, 2015

Climate change through history



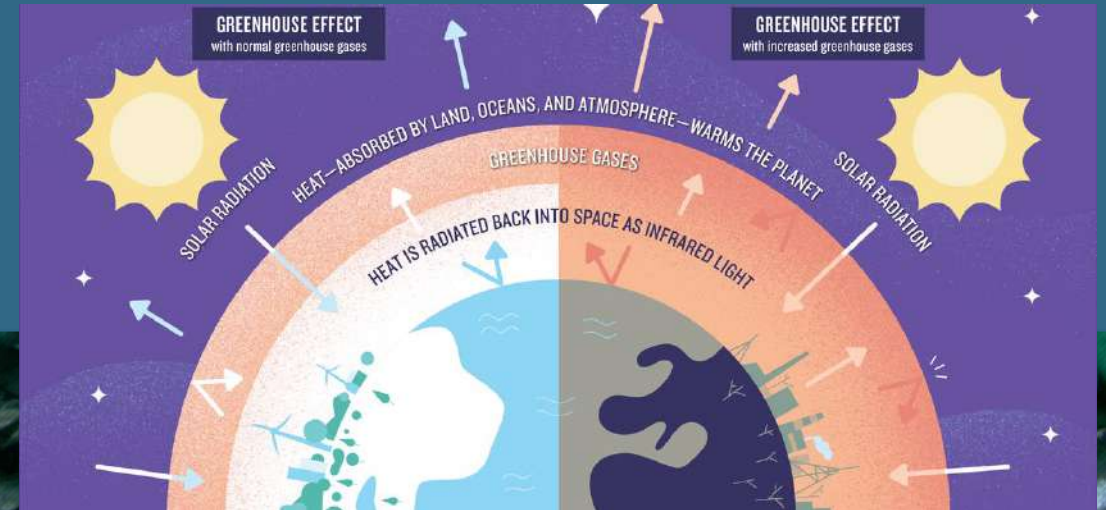
Climate change through history

Estimated global temperature over the last 500 million years



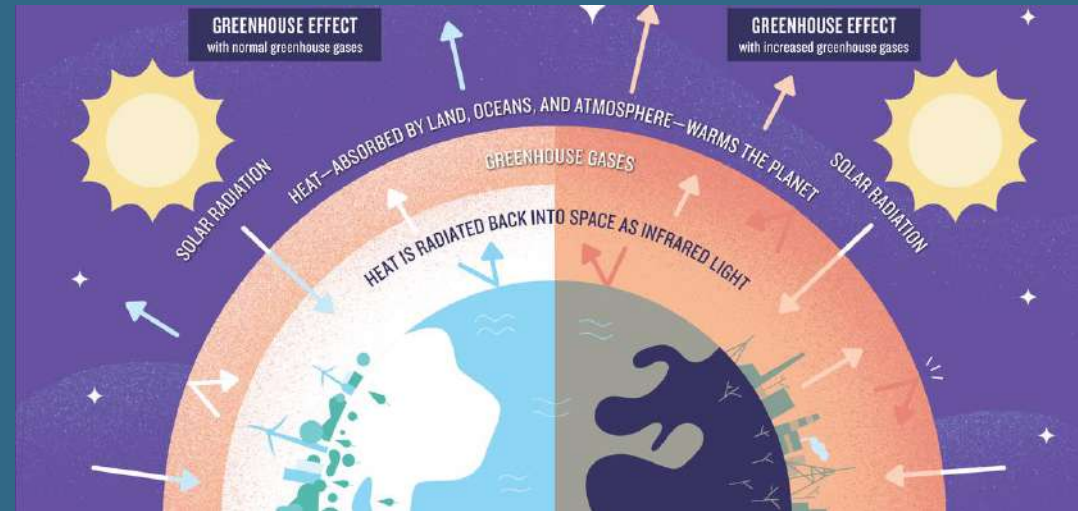
Why is this climate change different

- Modern climate change is happening much faster than in the past.
- Because it is so much faster plants and animals do not have time to adapt.
- Human activity has added to the natural cycle....pushing CO2 to all time highs



Key points from Module 2

- Climate is the long-term average conditions.
- It is driven by the long term patterns in winds, currents and heat and energy transport.
- It drives the plants and animals found in different parts of the globe.
- It is changing more dramatically than ever due to human activity



Summary quiz for module 2

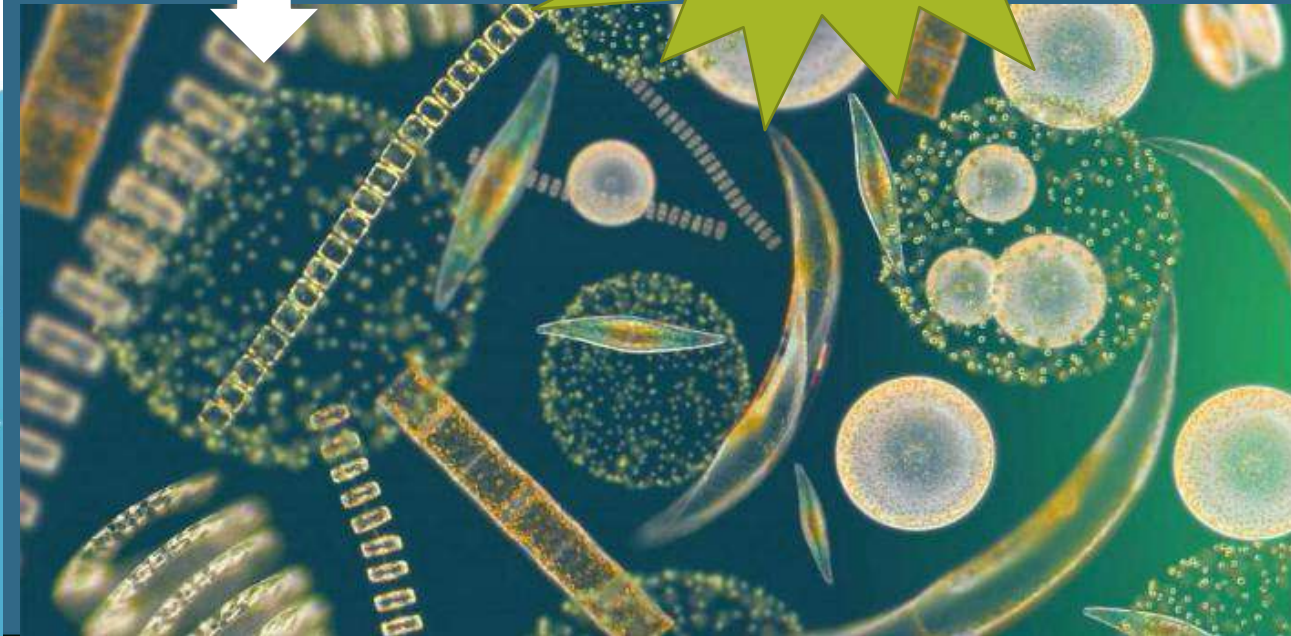
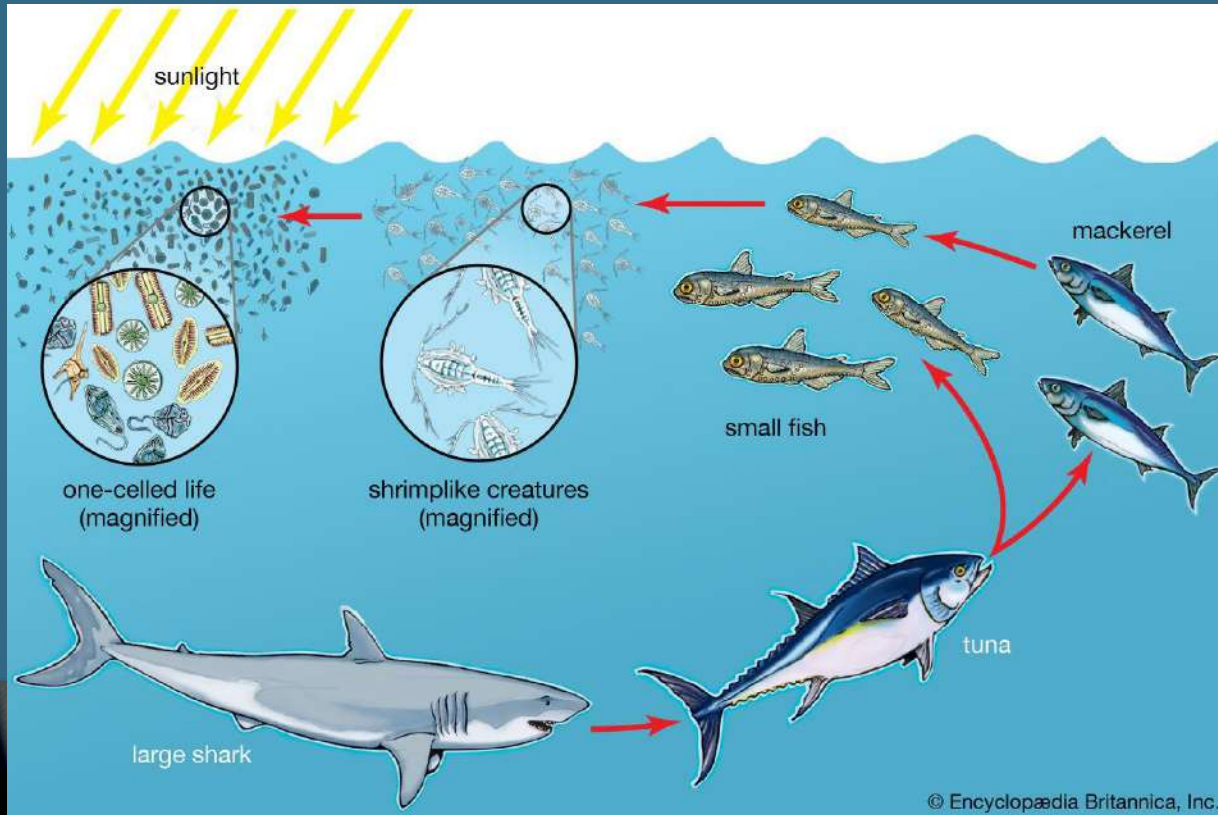


Module 3: Weather, Climate & Salmon farming



Background: Primary Productivity

- Primary production is the conversion of sunlight into energy by specialized organisms: grasses, trees, phytoplankton.



Contain chlorophyll



Re-cap

Weather



Minute-by-minute changes that happen in the atmosphere. It is local to certain time and place.

Climate



The usual condition of temperature, humidity, air pressure, rain fall etc. in an area of the Earth's surface over long time periods.



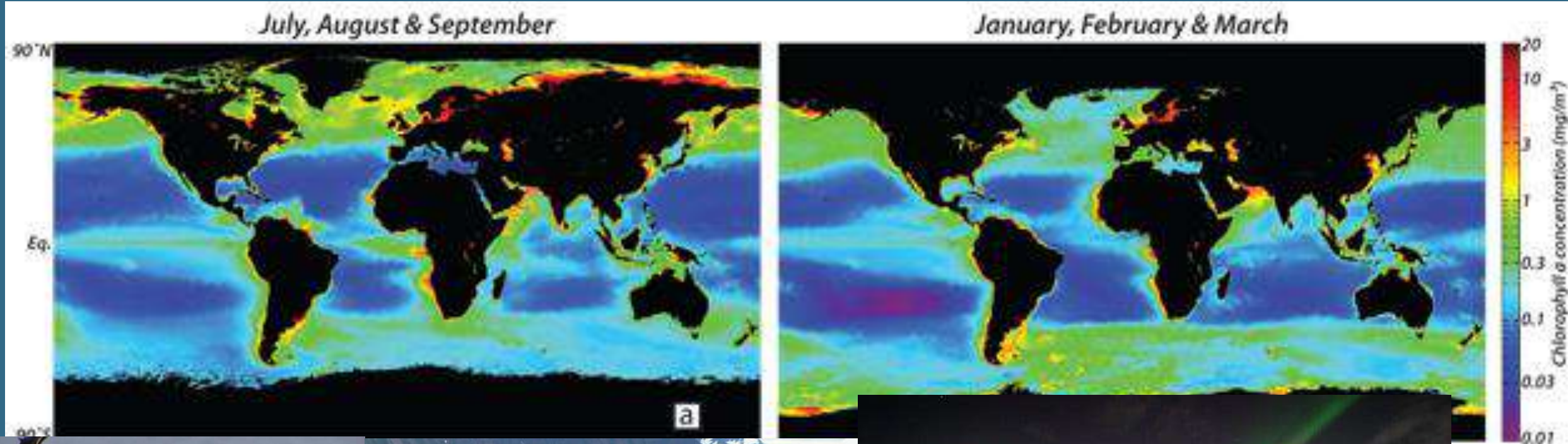
Climate and Aquaculture



The usual condition of temperature, humidity, air pressure, rain fall etc. in an area of the Earth's surface over long time periods.



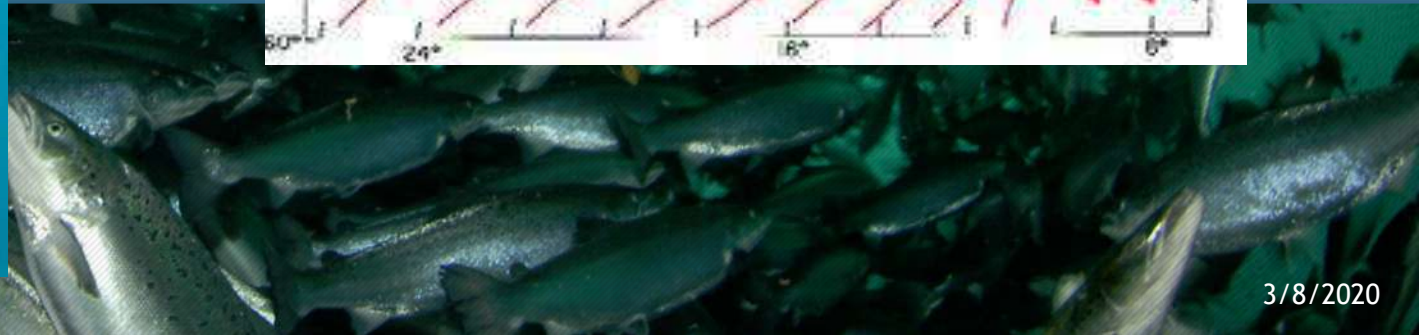
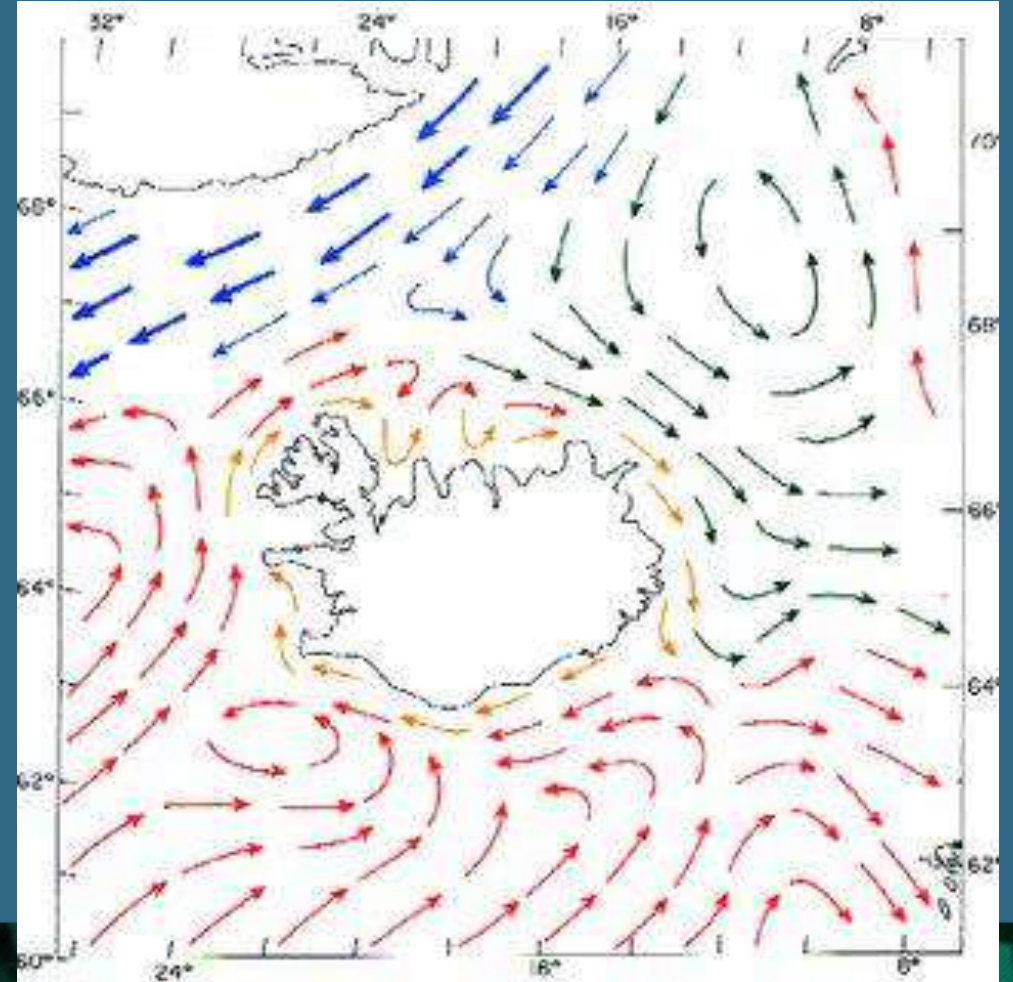
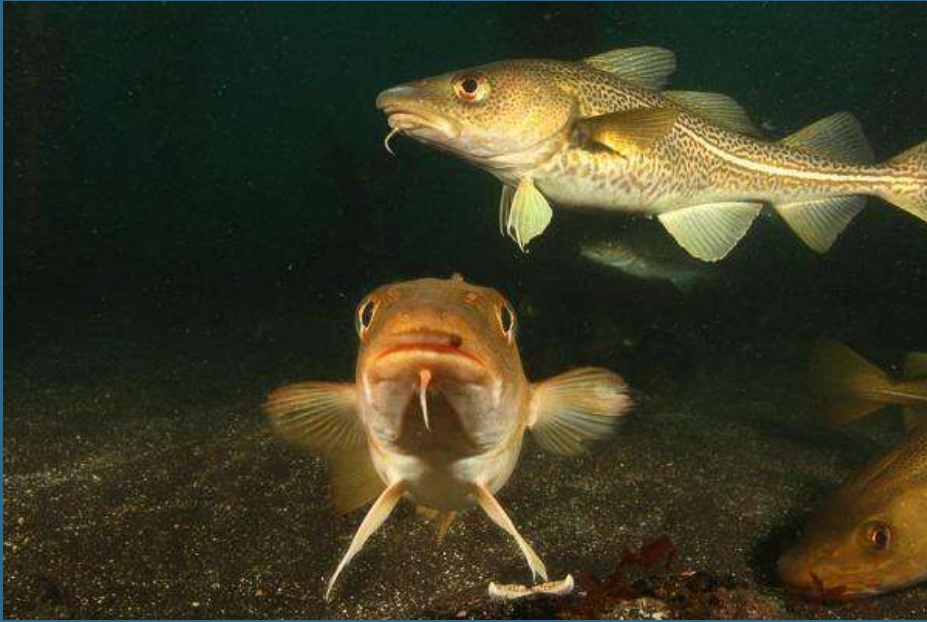
The biology of sea



The marine biome



The marine biome: Iceland



Climate determines the species found in Iceland

Atlantic Cod



Herring (Síld)



Capelin (Loðna)



Mackerel (Makrill)



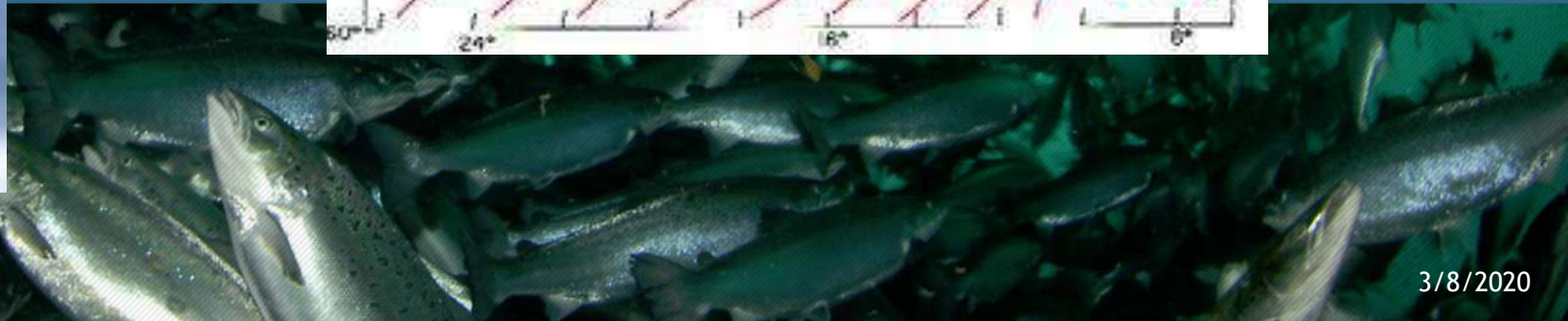
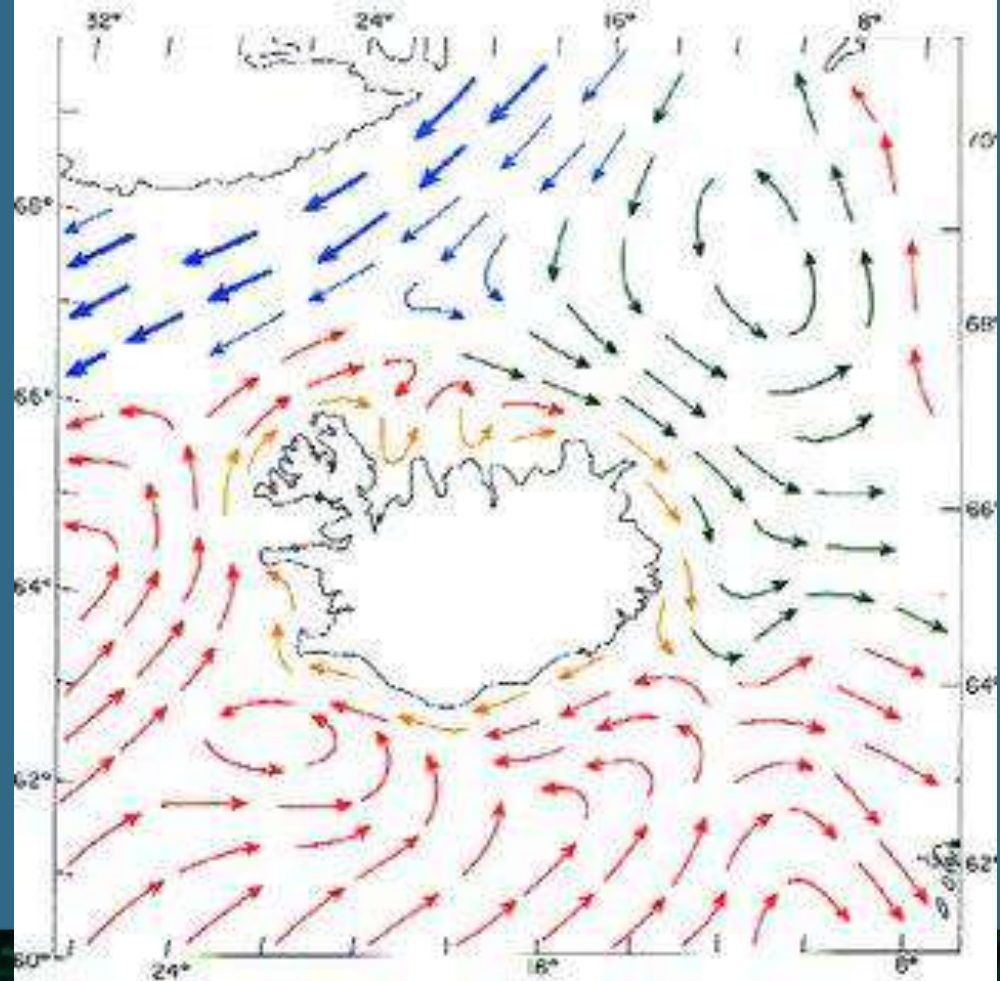
Arctic charr

Atlantic Salmon

Brown Trout (Urriði)



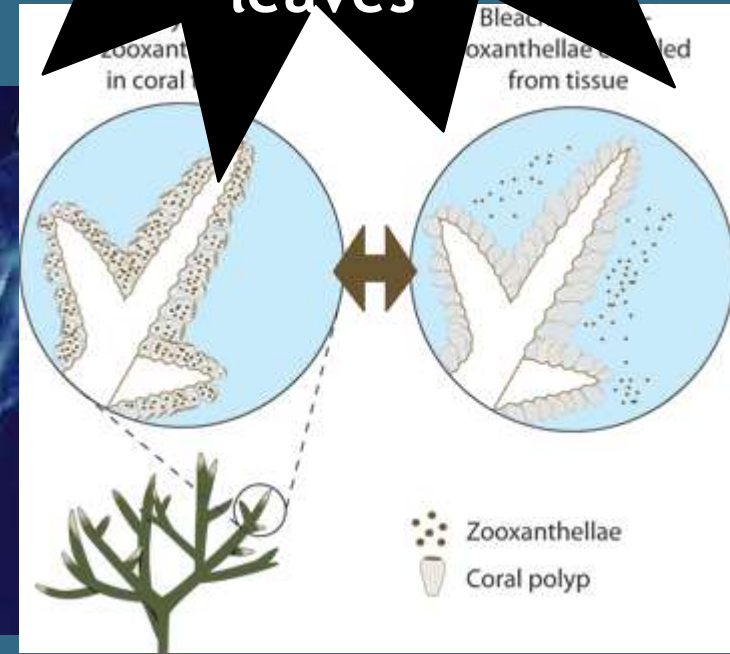
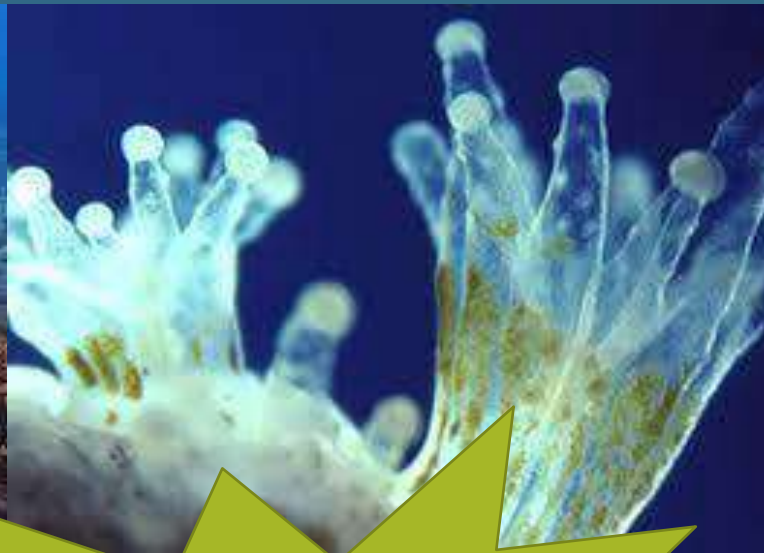
The marine biome



How might the ocean change with climate change?

Warming and acidity: Coral Bleaching

When it is too hot or too acidic the symbiont leaves

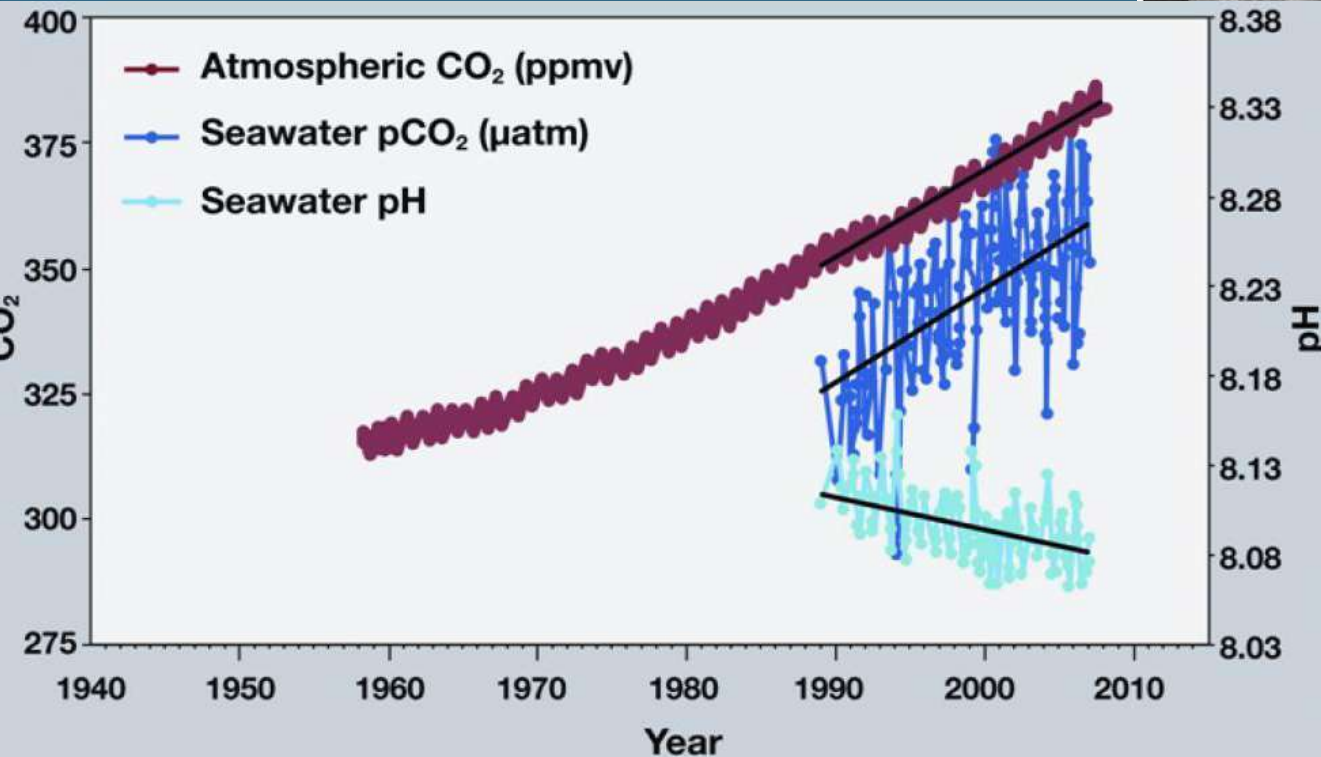
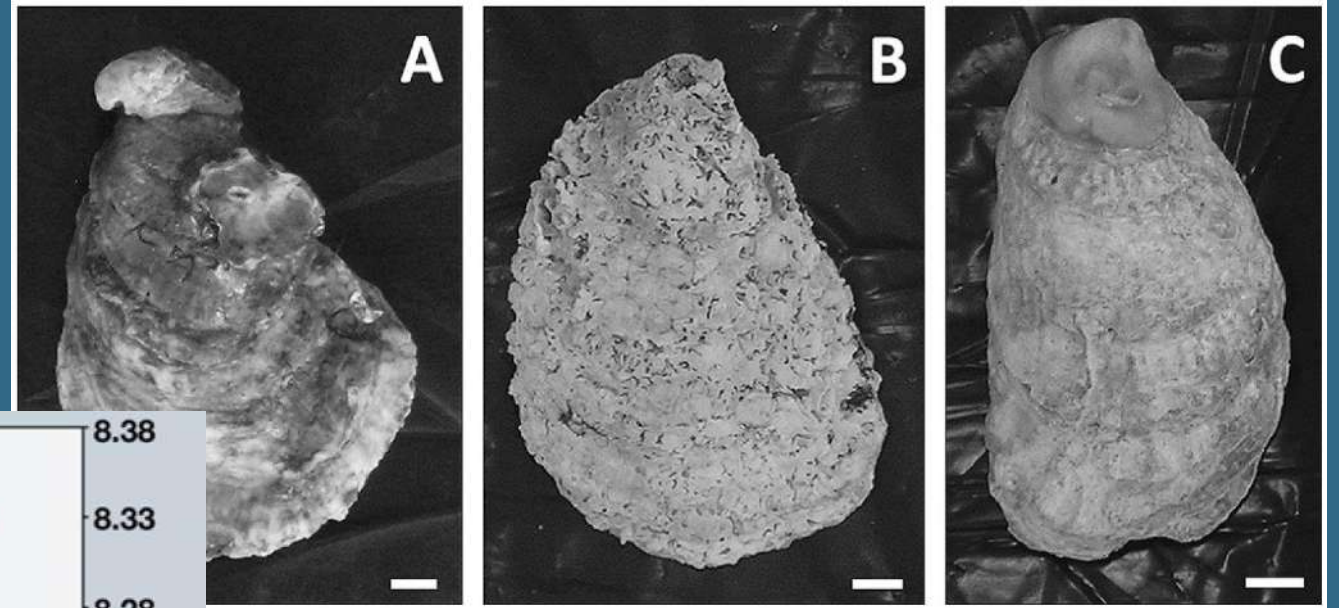


Coral is an animal

It lives in symbiosis with a primary producer

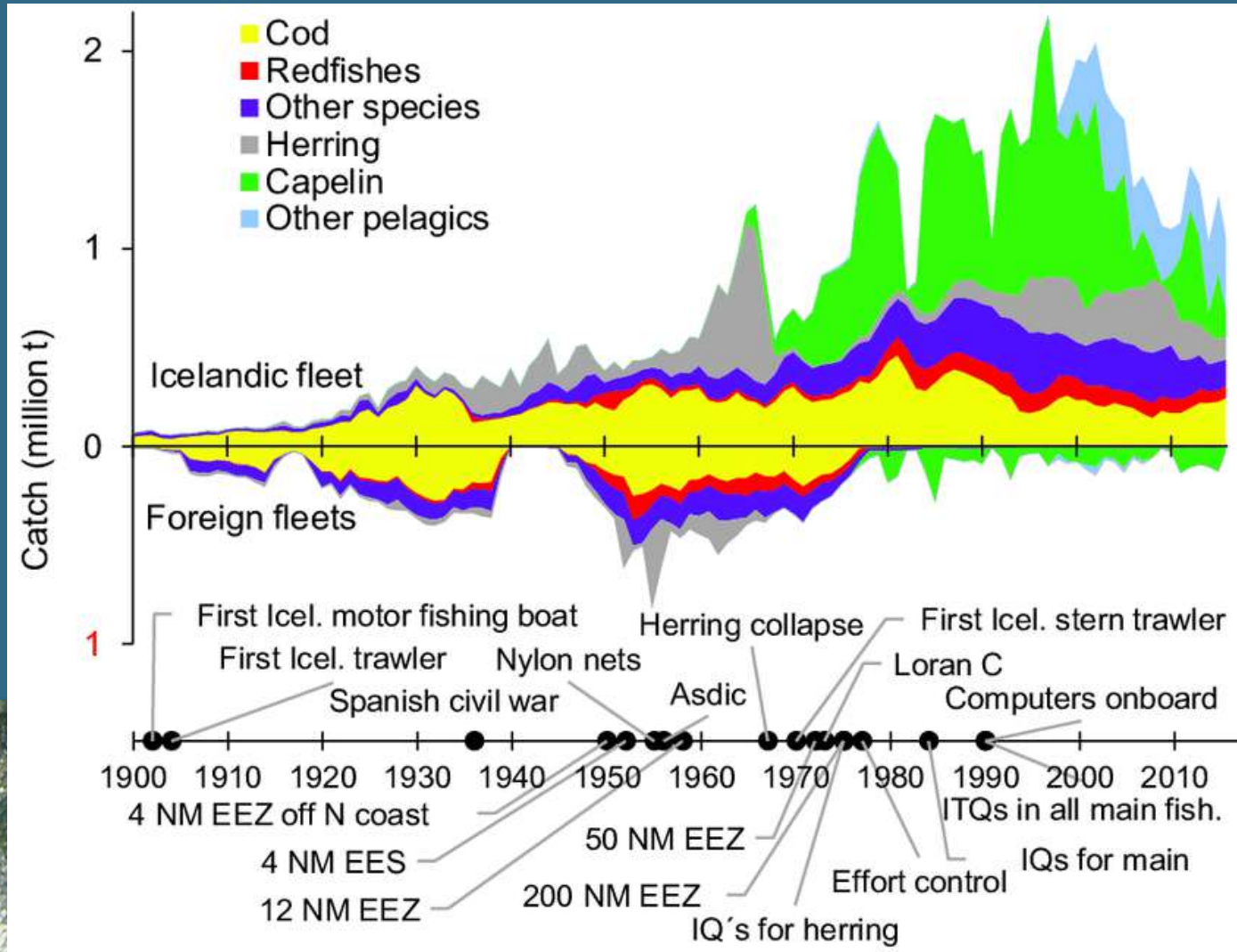
How might the ocean change with climate change?

Ocean acidity: Seafood aquaculture and fishery



How might the ocean change with climate change?

Fish migration

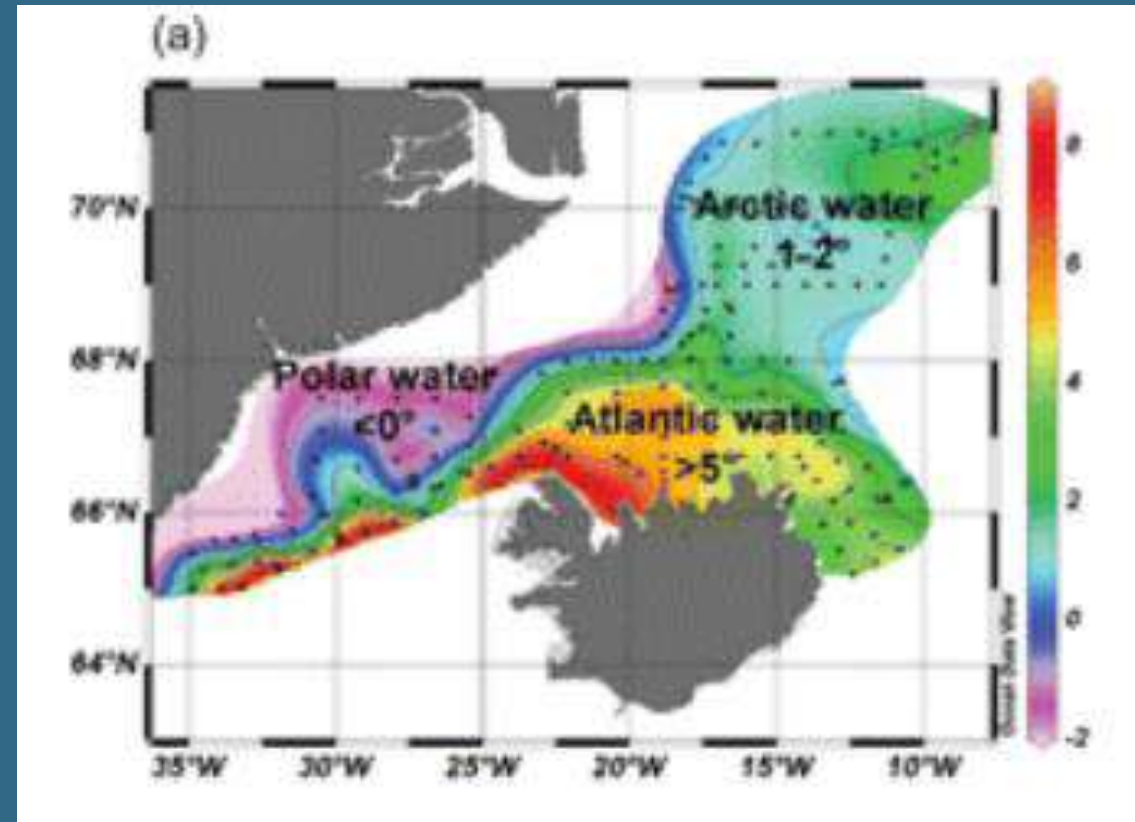
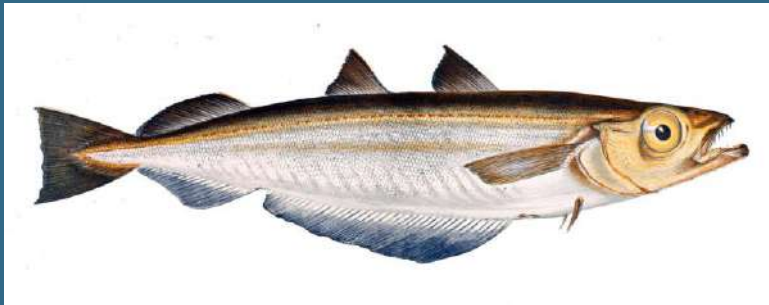


Climate determines the species found in Iceland

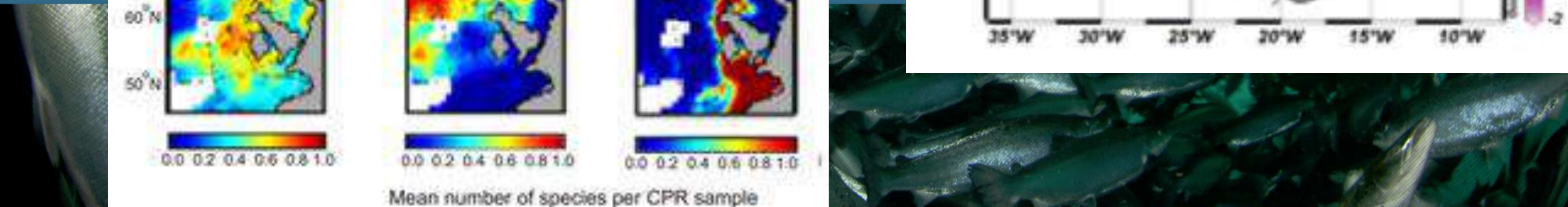
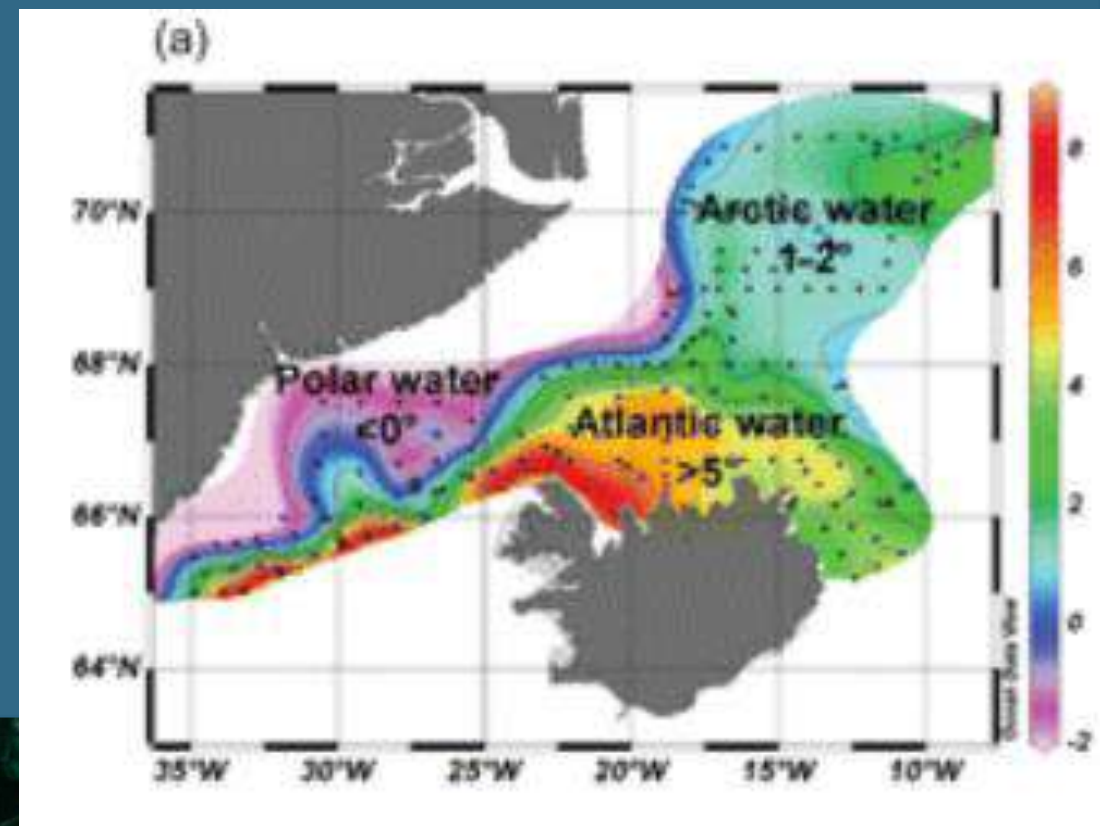
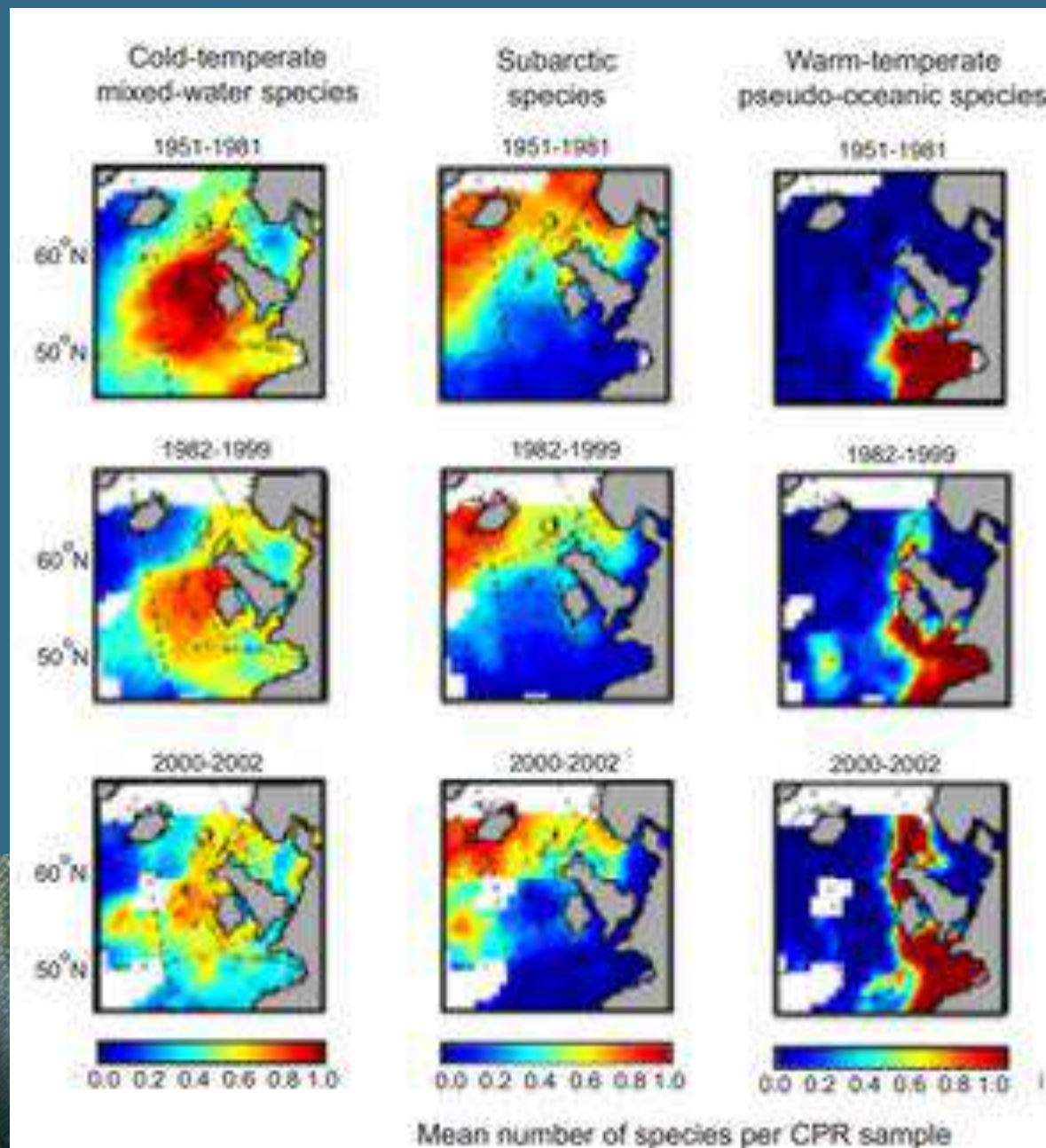
Capelin (Loðna)



Blue Whiting



Climate determines the species found in Iceland



How might the ocean change with climate change?

Other impact on fisheries:

- Alterations to the entire food web - (fish migration or even loss)
- Challenging conditions for calcifying (shell-making organisms)
- Reduce some species number but increase others as distributions change.
- Extinctions of vulnerable species.
- Countries may need to adapt to different species/processing/eating
- Socio-economic problems due to changes or loss of certain fisheries in countries legal waters
- Possible that this will lead to geo-political tensions and bad relationships between countries.



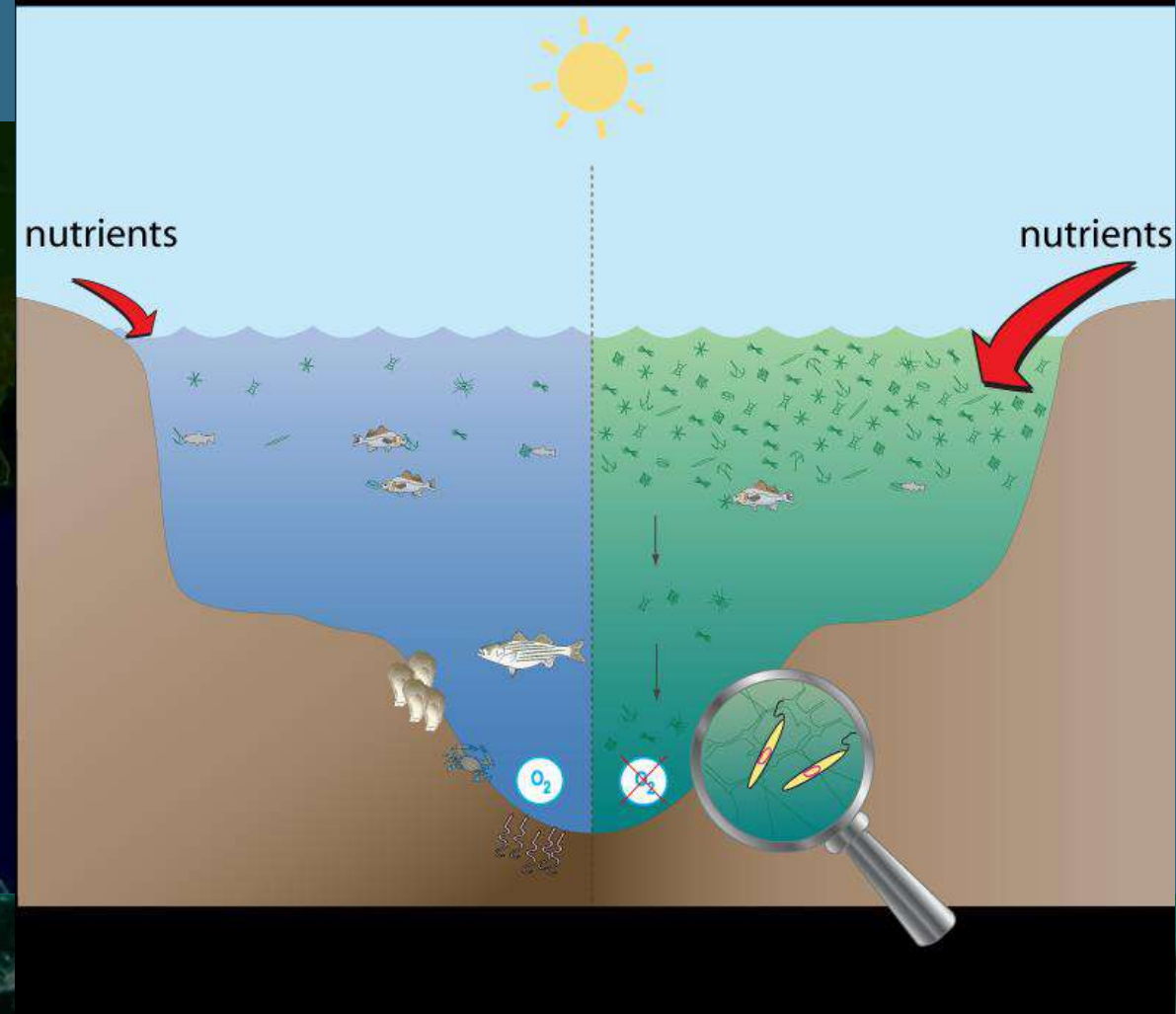
What about aquaculture?

In General

- Aquaculture species cannot migrate like wild fish!
- Availability of freshwater for on-land aquaculture in drought prone regions
- Changes in temperature and salinity of water bodies, especially shallow ones will change what can be grown where, and when.
- More algal blooms and coastal dead zones....damaging coastal aquaculture
- Increase in extreme weather events



Deadzones & Algal blooms



What about aquaculture?

Atlantic Salmon

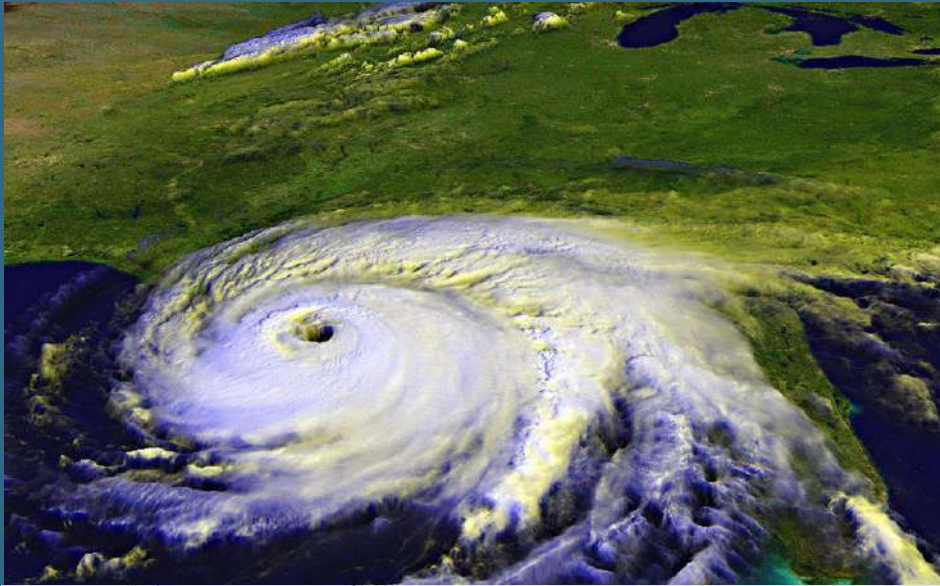
- Optimal growth range: 8-14°C
- Too warm = too rapid development = malformation-even lethal.
- Increased risk of infection and bacterial outbreak
- Increase in lice presence
- Change in raw materials available to feed salmon
- Jellyfish blooms (linked to warming and acidity)

Iceland:

- it will change harvest times, and time out at sea vs freshwater
- Increased growth rates
- lice
- problem species and blooms



Weather and Aquaculture



Minute-by-minute changes that happen in the atmosphere. It is local to certain time and place.



Weather dangers

- Bad weather (precipitation)
- Heavy winds
- Waves
- Strong currents



MOWI: Storm damages

73,600 fish escape from Mowi site after storm damages cage



Nearly 50,000 salmon escape from Scottish fish farm after storm damage

Damage from Storm Ellen has led to a major fish escape on a Mowi site near Campbeltown in Scotland, with almost 50,000 salmon escaping the torn nets.

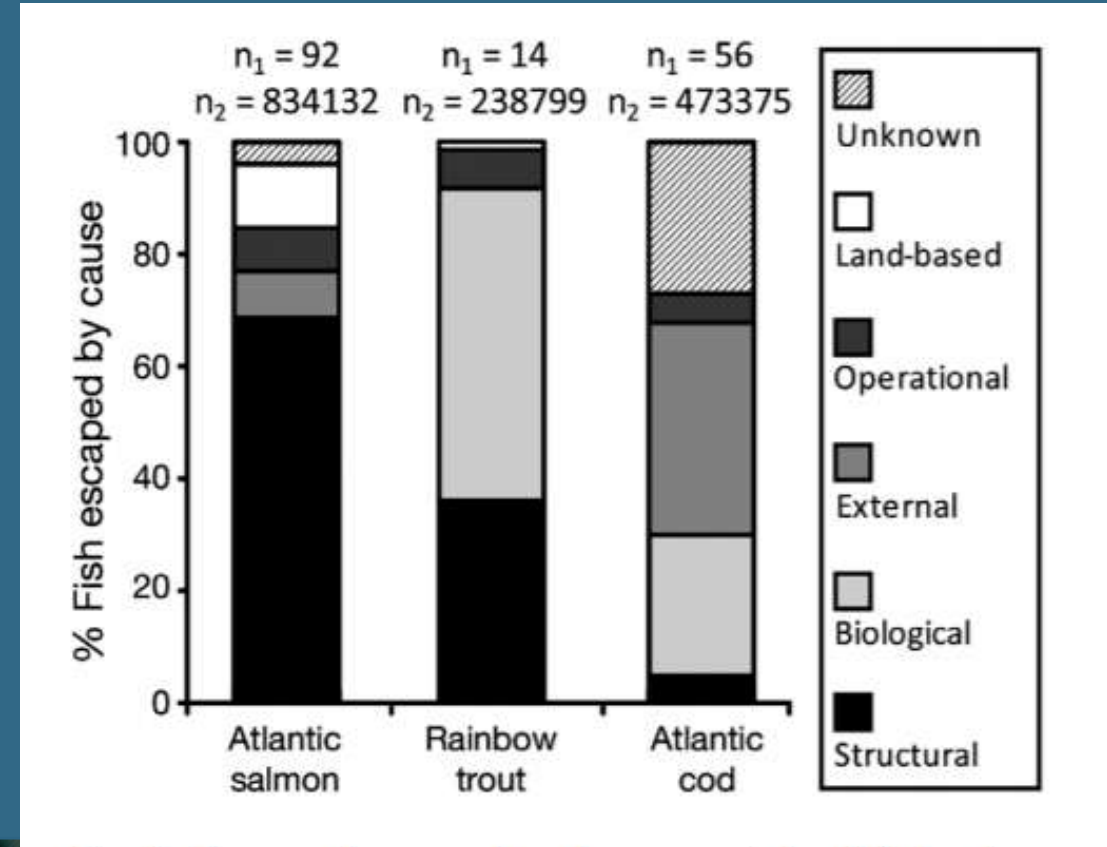
23,000 salmon escape from Cermaq Chile site

SalMar: offshore challenges



Escapees: How does it happen

- Through holes and tears in the nets.
- Structural failures in containment equipment.
- Escape through spawning (primarily farmed cod).



Weather and Aquaculture

- Much of the aquaculture in Iceland infrastructure and processing facilities = sea level areas
- Warmer and wetter weather. More coastal productivity.
- In the short term, it is likely that the Atlantic Salmon industry will benefit in terms of production but will face more general problems too.



Farming in exposed areas

- As aquaculture moves further offshore the risks of extreme weather, wave and current conditions.
- We will need very clever engineering ,risk analysis
And good prediction of danger
to keep the industry going.



Future of Aquaculture

- Will need to adapt:
 - Different species
 - new or increased problems
 - Improved technology to survive the elements
 - Weather and climate data: to observe and predict long term patterns
 - Change location
 - Improve treatments for problems like lice



Key points from Module 3

- Climate and the resulting weather determines where fish and shellfish are found.
- As the climate changes there will be a lot of consequences for aquaculture and especially salmon aquaculture.
- The industry will need to grow and adapt to survive.



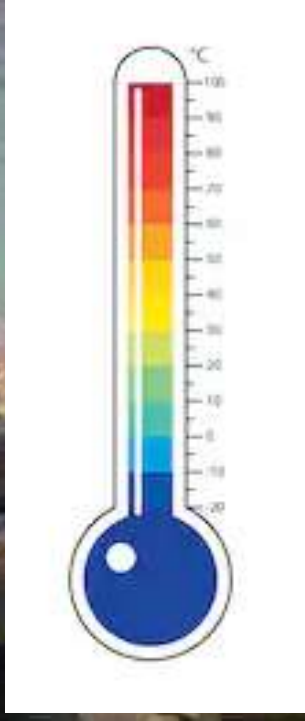
Summary quiz for module 3



Temperature, metabolism and feed

- The warmer it is, the more we need to feed, the more the fish will grow
- Metabolism is how fast the reactions in the body are happening.

Warmer = fast metabolism
= faster growth



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