Global Warming: Beyond the Hockey Stick Controversy

SPRING 2020
Studium Generale

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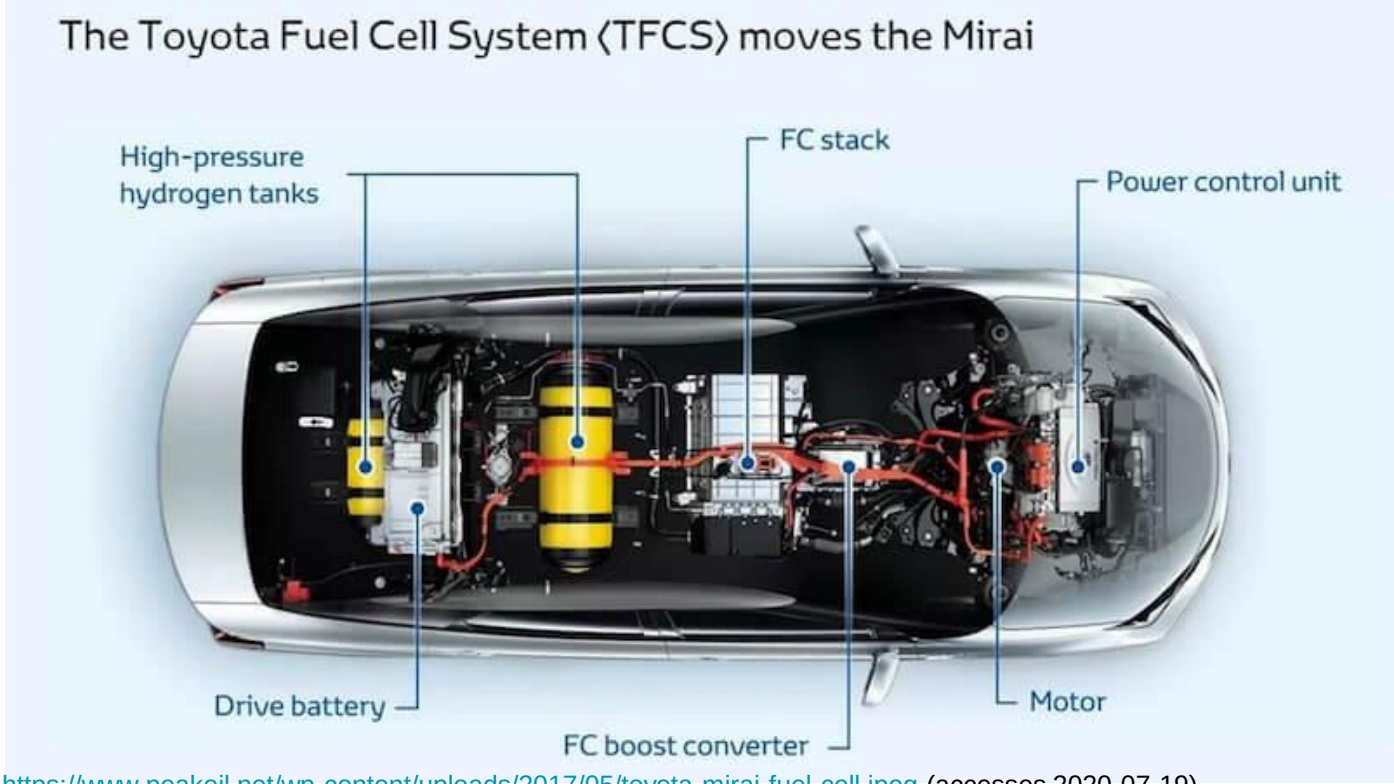
Background: Fuel Cells/Catalysts

From fossile fuels to renewable energies: Reducing the Carbon dioxide emission



https://www.peakoil.net/wp-content/uploads/2017/05/toyota-mirai-fuel-cell.jpeg (accesses 2020-07-19)

Content

1. Vocabulary
2. Introduction/History
3. Anthropogenic climate change & the controversy it sparked
4. Changes to Environment that already happened
5. What to expect in the future?
6. Summary

Vocabulary

Climate

Weather

Temperature

Glacier

Perpetual ice

Carbon dioxide

Atmosphere

Greenhouse effect

Ice age

Methane

Infrared radiation

Renewable energy

Anthropogenic climate change

Take a minute to check the meaning!

Introduction/History

Introduction/History

Global warming: Do think it is real: Yes or No?

Think about it for a minute, write down your opinion. After this lecture, reconsider and briefly state if your opinion changed or not!?

Introduction/History

How things started ….

Svante August Arrhenius (19/2/1859 – 2/10/1927) was a Swedish scientist.

- Nobel Prize in Chemistry 1903 (electrolytic theory of dissociation)
- Many research interests … “the origin of ice ages” ….

https://en.m.wikipedia.org/wiki/Svante_Arrhenius (accessed 2020-07-19)

Introduction/History

… the origin of **ice ages**: How can the repeated occurrence of long cold periods of the Earth's surface and atmosphere theory be explained?

Question: Are we now in the period of an **ice age?**

Answer: We are in a period of an **ice age** because North- and South-pole are both covered by extensive **ice sheets**. ("glacial period")

If earth is free from extensive ice sheets (warm period): "interglacial"

Introduction/History

The question about the origin of “erratic boulders”:

Jean-Pierre Perraudin (1767–1858) explained the erratic boulders in Val de Bagnes (Valais, Swiss) caused by **glaciers** in the past had extended further

→ Ice pushed the stones in today’s position, melted, and left the stones back.

Erratic boulder. Norber Erratics by Rob Glover / CC BY.

Introduction/History

Jens Esmark (1762–1839, a Danish-Norwegian geologist)

- Sequence of **ice ages**
- 1824: Changes in **climate** are the cause of the **ice ages** (glaciations)
  → Possibly changes in earth's orbit
- 1837: Karl Friedrich Schimper (1803–1867, German botanist): "Eiszeit" (German for **ice age**)

General understanding at that time:

Earth had cooled down steadily ↔ **periodical occurring** *ice ages*

Introduction/History

James Croll (1875): “*Climate and Time, in Their Geological Relations*”

- Changes in earth’s orbit cause derivations of the Gulf Stream
  → *Less heat* for the arctic
  → More ice → More reflection of sunlight → positive feedback

Changes in earth orbit ↔ Ice ages: How to prove?

What are the changes in earth orbit and which effect could they have?

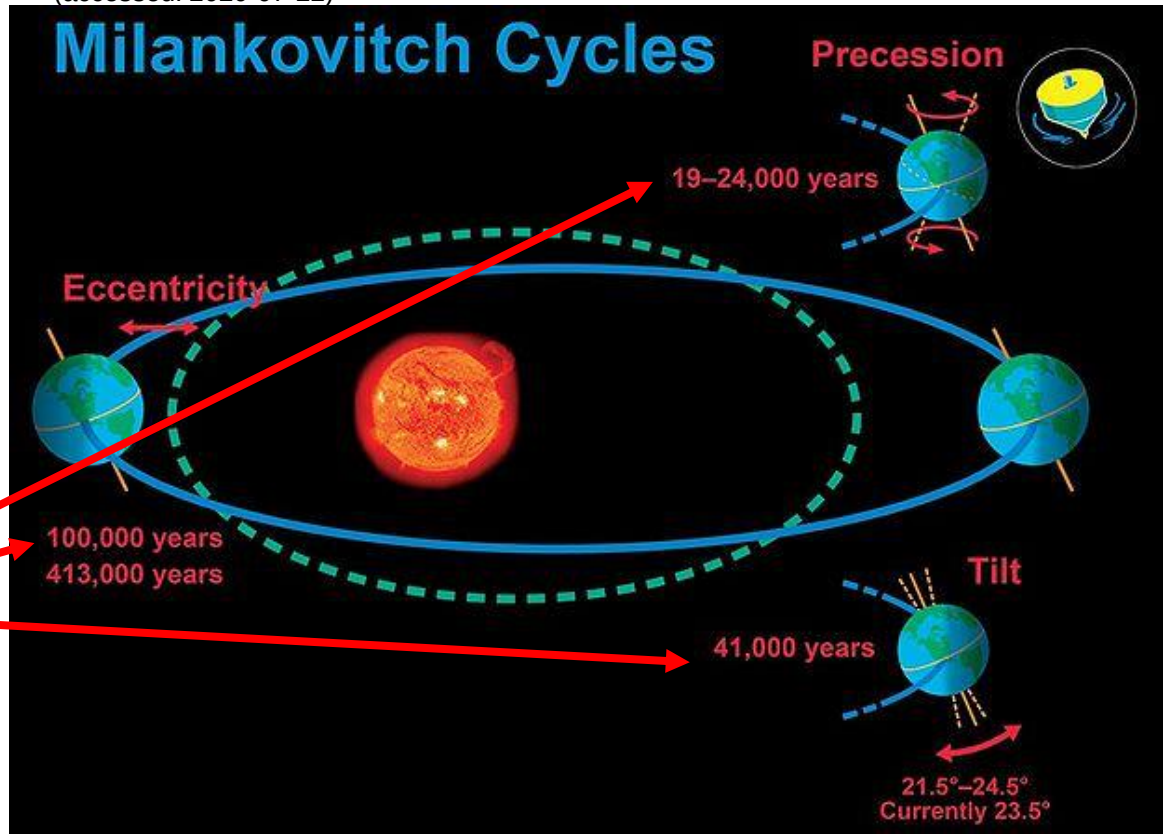
Introduction/History

https://www.universetoday.com/wp-content/uploads/2009/09/620px-milankovitchcycles.jpg
(accessed: 2020-07-22)

Change in earth orbit:

- Eccentricity
- Precession
- Tilt (obliquity)

The time scales!



Introduction/History

Milutin Milanković, “Serbian **mathematician**, **astronomer**, **climatologist**, geophysicist, civil engineer and popularizer of science. Milanković gave two fundamental contributions to global science. The first contribution is the "Canon of the Earth's Insolation", which characterizes the climates of all the planets of the Solar system”

The second contribution is …

(Wikipedia, accessed 2020-07-20)

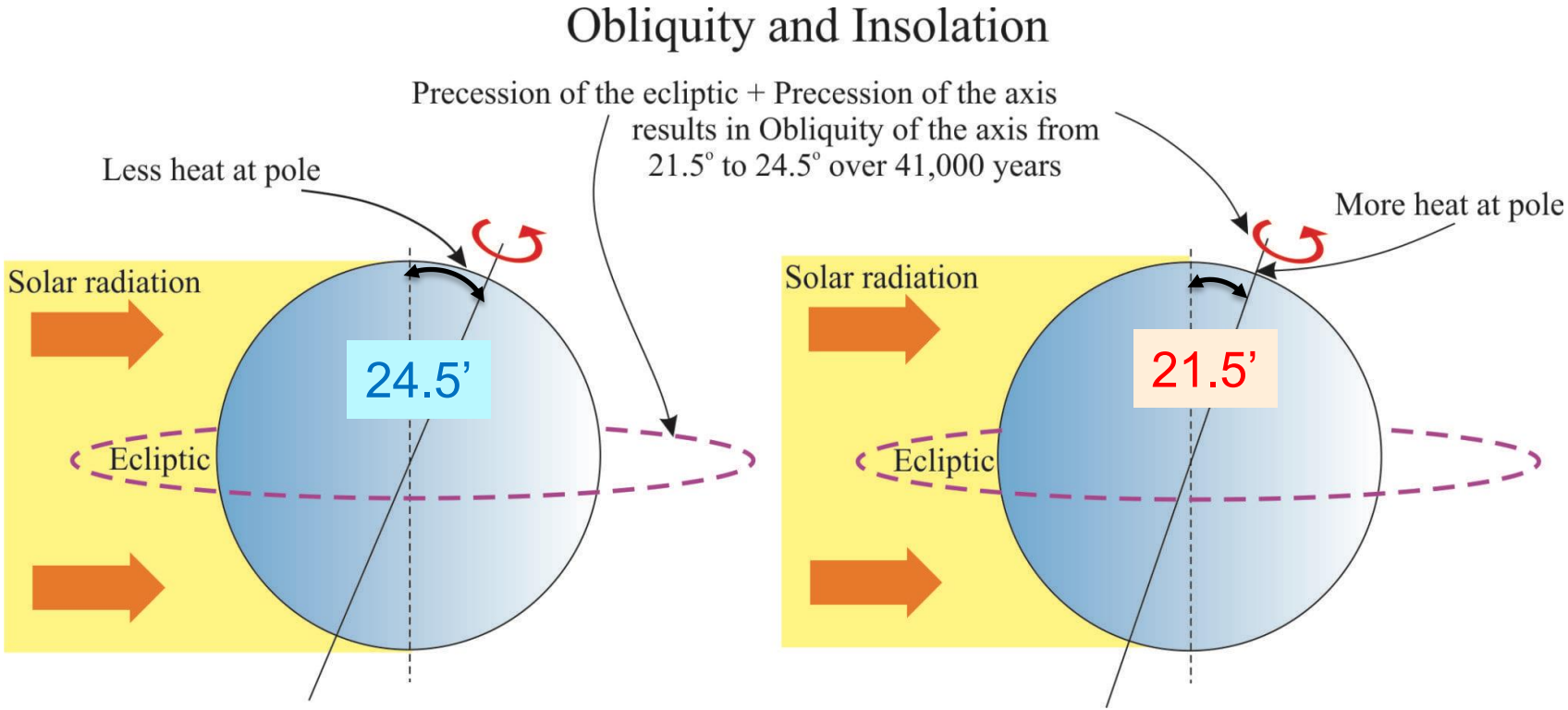
Introduction/History

“the explanation of Earth's **long-term climate changes** caused by changes in the position of the Earth in comparison to the Sun, now known as **Milankovitch cycles (Milankovitch Theory)**.” (Wikipedia, accessed 2020-07-20)

1930 “*Mathematical Climatology and the Astronomical Theory of Climate Change*” **Amount of sunlight each latitude received during all the earth’s orbital variations.**

(Sounds very scientific …)

Introduction/History

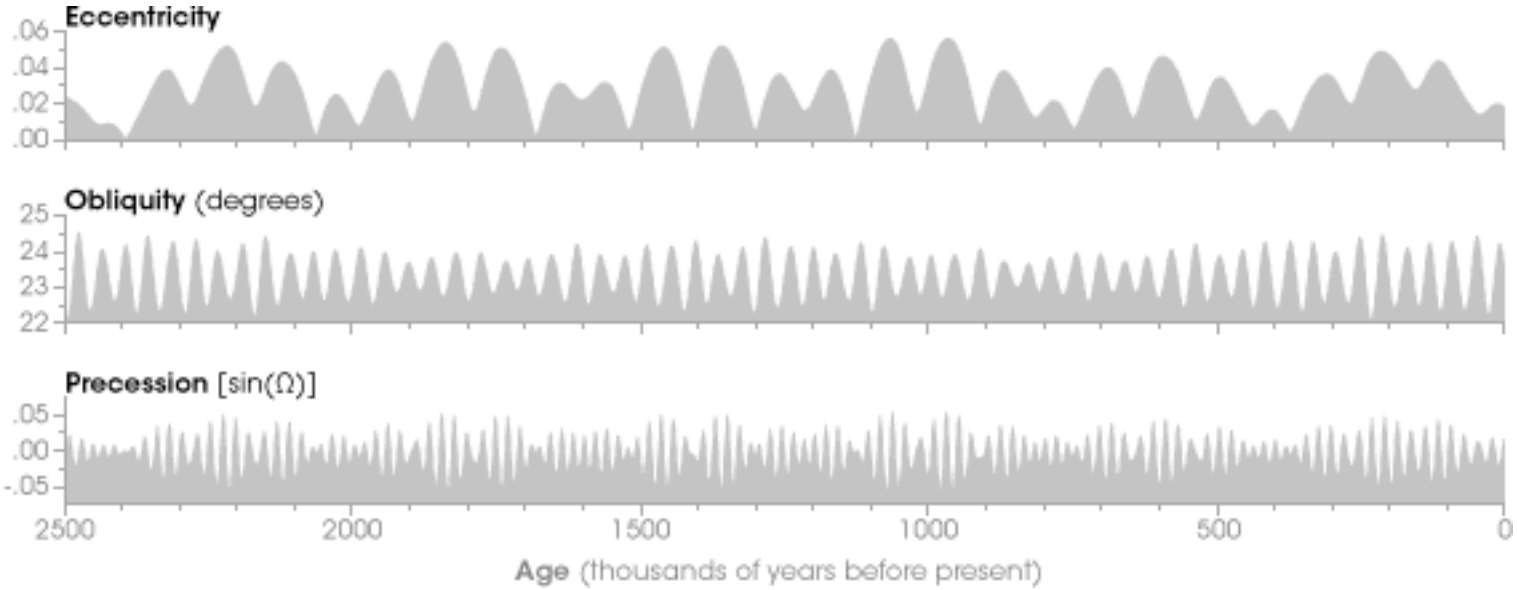


On a very extended time scale we get ….

Introduction/History

Milankovitch Theory

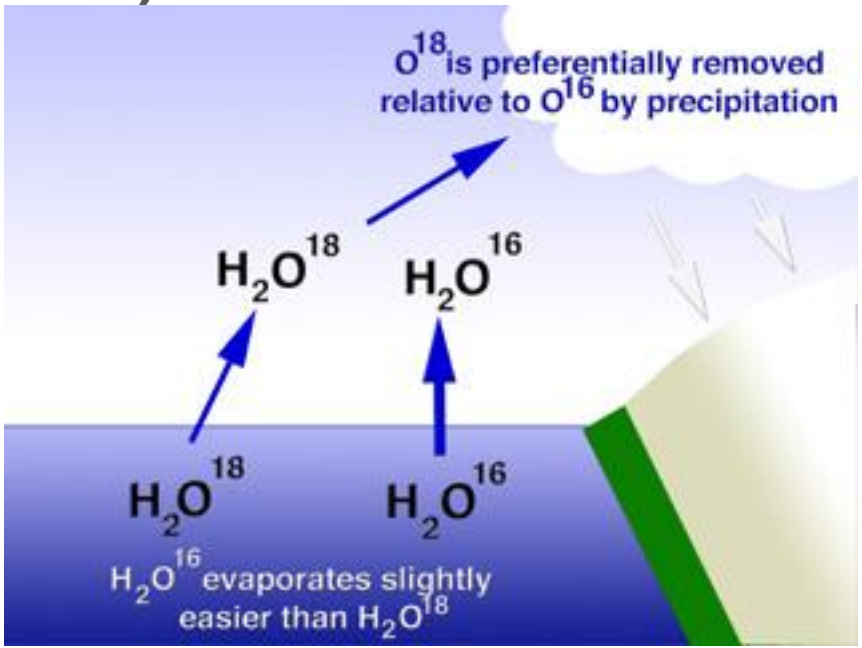
https://earthobservatory.nasa.gov/features/Paleoclimatology_Evidence (accessed 2020-07-20)



“Based on the orbital variations, Milankovitch predicted that the ice ages would peak every 100,000 and 41,000 years, with additional “blips” every 19,000 to 23,000 years.”

Introduction/History

A way to prove glaciation cycles: Isotope dating method: H_2O (water molecules)



https://globalchange.umich.edu/globalchange1/current/lectures/kling/paleoclimate/ (accessed 2020-07-20)

Water molecules containing light oxygen (H_2O^{16}) evaporate more readily than water with heavy oxygen (H_2O^{18}).

➳ Oceans will be relatively rich in O^{18} when glaciers grow and hold the precipitated O^{16}

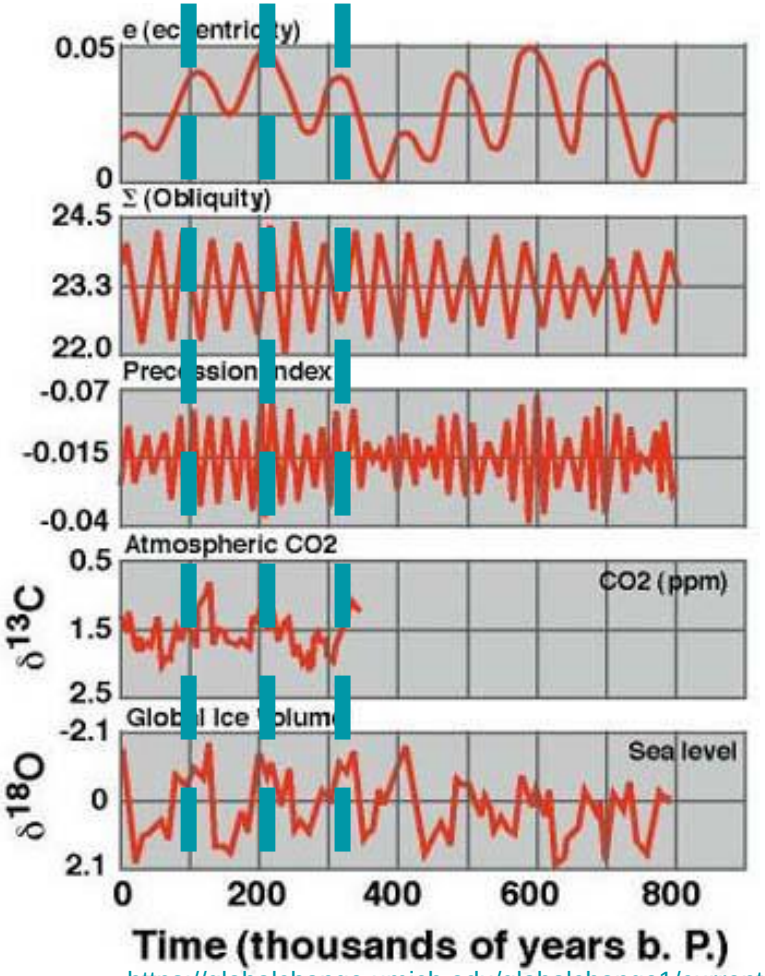
Introduction/History

Milankovitch Theory

A very good fit of calculated periodical changes in earth orbit and **isotope** change pattern in ^{18}O (a heavier version of the usual oxygen ^{16}O, found in air as O_2 molecule)

➳ All settled!

Really?



https://globalchange.umich.edu/globalchange1/current/lectures/kling/paleoclimate/ (accessed 2020-07-20)

Anthropogenic climate change & the controversy it sparked

Anthropogenic Climate Change

What does this term mean?

Anthropogenic: *of, relating to, or resulting from the influence of human beings on nature (Merriam-Webster)*

- How can human possibly influence nature so that the earth climate changes?
- Would this even be detectable?

Anthropogenic Climate Change

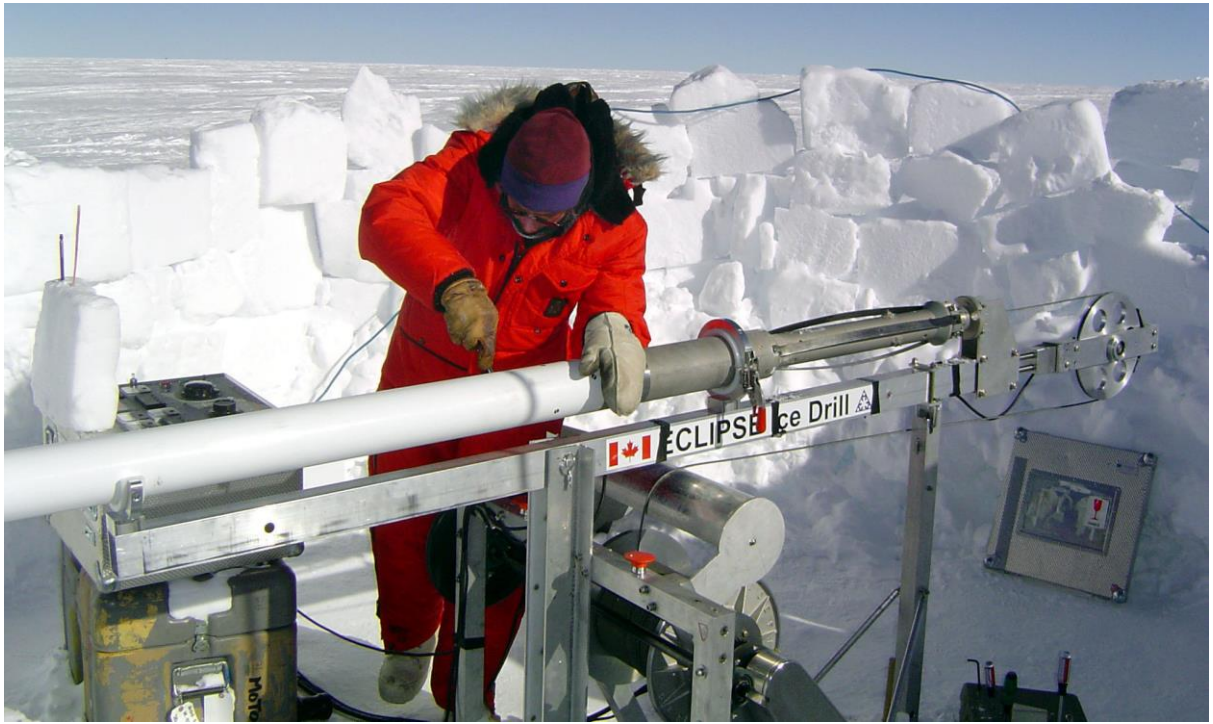
The Milankovitch Theory can not explain long term climate changes, the “Great Ice Ages”

But … another problem…

Scientists started to analyze Greenland’s and Antarctica's glacier using the H_2O^{18} method to analyze paleoclimate changes from changing O^{18} concentrations in ice cores…

Anthropogenic Climate Change

Scientists take ice core samples in cold, windy, and forbidding environments. After drilling through solid ice to retrieve a core, initial measurements are taken before it is sent away for more in-depth analysis and storage. Photo credit: NSIDC courtesy Ted Scambos and Rob Bauer



https://nsidc.org/cryosphere/icelights/2013/08/core-climate-history 2020/9/14

Anthropogenic Climate Change

… and found that:

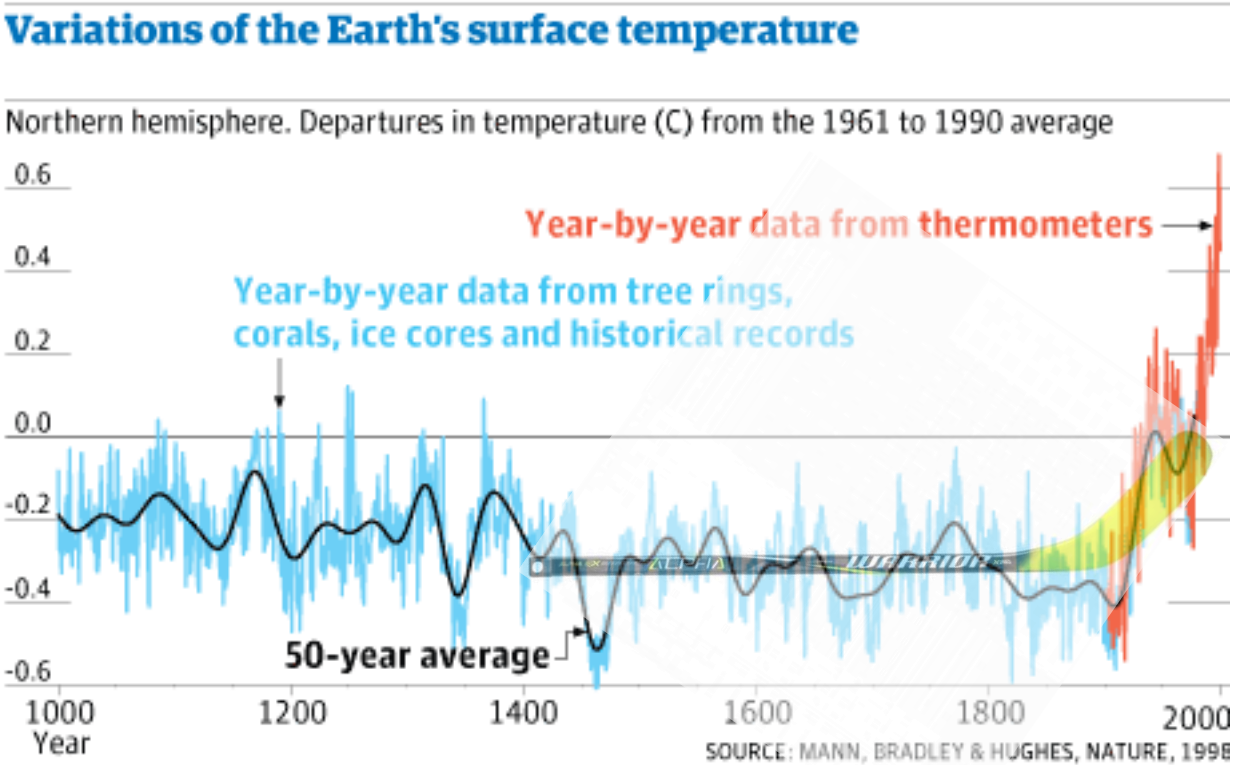
- changes in the ice cores supported the Milankovitch Theory
- the last ice age ended about 10,000 yrs. ago
- but since then temperatures changed very differentially from the expected way:

    ➳ **a steep temperature increase over a short time**

    ➳ **starting with the beginning of the industrialization …**

Anthropogenic Climate Change

“hockey stick”



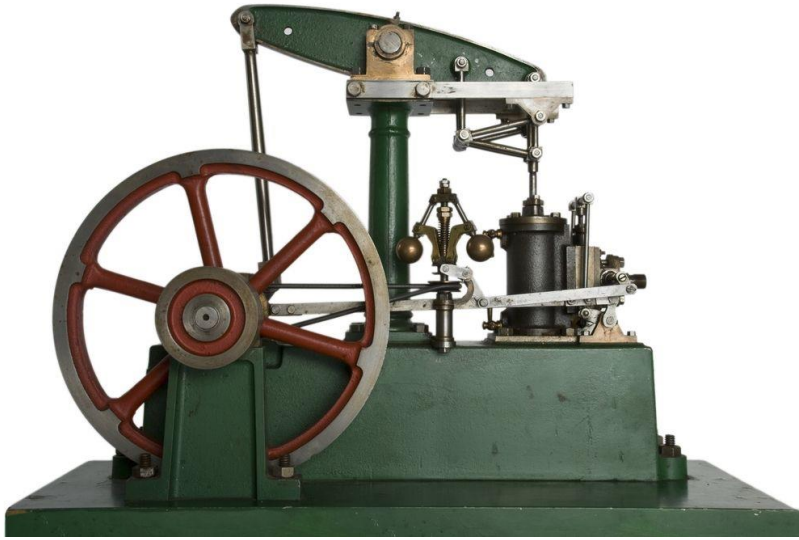
https://www.amazon.co.jp/WARRIOR-Warrior%E3%82%A2%E3%83%AB%E3%83%95%E3%82%A1QX-Mini-Stick/dp/B073DJKFZN 2020/9/14

http://thebritishgeographer.weebly.com/global-climate-change.html 2020/9/14

Anthropogenic Climate Change

Industrialization: What do you think were the key components of the industrialization process?

https://www.livescience.com/44186-who-invented-the-steam-engine.html (accessed: 2020-07-20)



- change form an agricultural society to a manufacturing society
- large scale manufacturing of steel: **burning coal**
- **burning coal:**
  carbon + oxygen (air) → carbon dioxide,
  a green house gas

Anthropogenic Climate Change

Carbon dioxide, a green house gas: Svante Arrhenius!

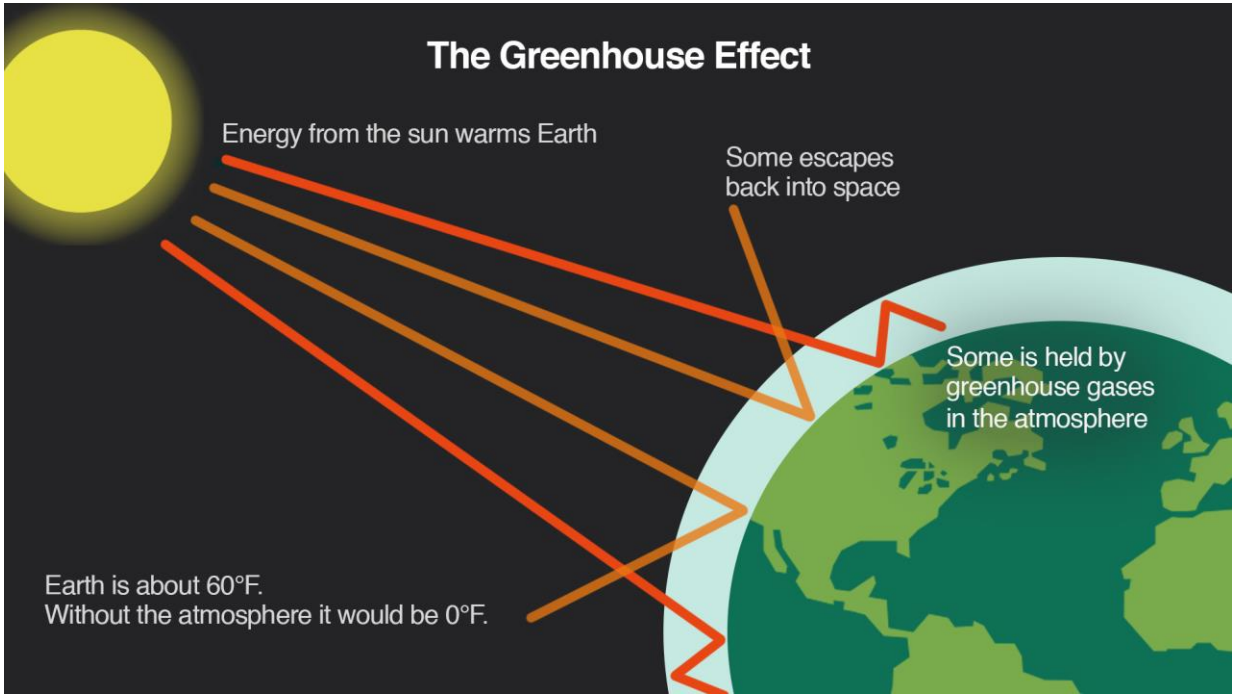
In 1896, using basic principles of **physical chemistry**: Calculating to which extend the concentration of **greenhouse gases** in the atmosphere is related to an increase of the surface temperature of the earth by the **green house effect….**

In 1824, Joseph Fourier: The atmosphere must be responsible for containing the heat absorbed from the sun: A box with a glass lid, light shines through the glass, the insides get warmer as the lid traps the heat

Anthropogenic Climate Change

Energy from sun (light) is partially “stored” in the atmosphere of the earth by certain molecules as water (H_2O) and carbon dioxide (CO_2)
→ Earth’s surface warms up

(Methane, CH_4, is another very import contributor to the greenhouse effect)



https://www.uml.edu/sustainability/practices/air-climate/greenhouse-gas-information.aspx 2020/9/14

Anthropogenic Climate Change

A small anecdote about Svante Arrhenius:

Being born in Sweden, a country with a rather cold climate and long winters in Northern Europe he had the following idea:

“Let’s burn all the coal beds to generate enough CO_2 that will warm up earth’s atmosphere” …

("We would then have some right to indulge in the pleasant belief that our descendants, albeit after many generations, might live under a milder sky and in less barren surroundings than is our lot at present.”) (

https://www.theguardian.com/environment/2005/jun/30/climatechange.climatechangeenvironment2, accessed: 2020-07-22)

Anthropogenic Climate Change

When trying to explain climate change of the past times, no model will explain the changes if not including greenhouse gases, especially carbon dioxide…

… the levels of carbon dioxide in the atmosphere are much higher than in the past 750,000 yrs. as revealed by the ice cores!

But why did levels of carbon dioxide change? All made up?? Most importantly, when did scientists sounded their rather alerting findings to the public?

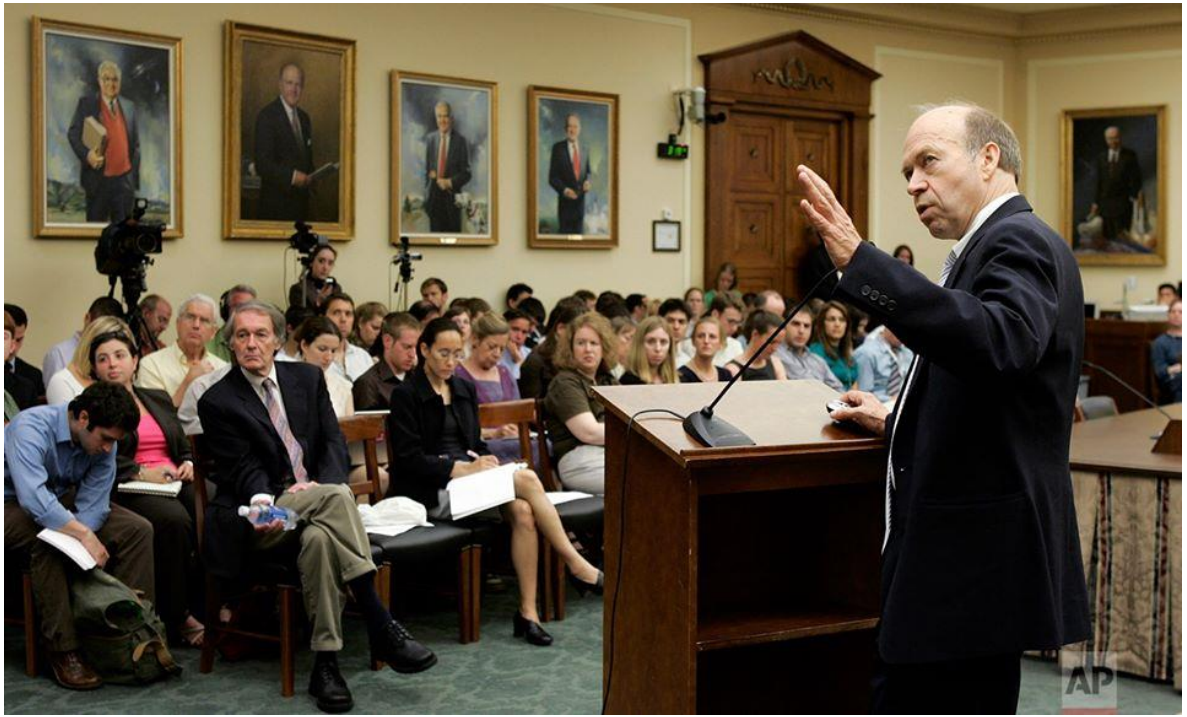
Anthropogenic Climate Change: The Discovery

The first mentioning to the public: (https://www.nasa.gov/topics/earth/features/climate_by_any_other_name.html)

- “Its first use was in a 1975 Science article by geochemist Wallace Broecker of Columbia University's Lamont-Doherty Geological Observatory: "Climatic Change: Are We on the Brink of a Pronounced Global Warming?"[1]
- “Broecker's term was a break with tradition. Earlier studies of human impact on climate had called it "inadvertent climate modification."[2]
- “The Charney Report for its chairman, Jule Charney of the Massachusetts Institute of Technology in Cambridge, declared: "if carbon dioxide continues to increase, [we find] no reason to doubt that climate changes will result and no reason to believe that these changes will be negligible."[3]

[1] Wallace Broecker, "Climatic Change: Are We on the Brink of a Pronounced Global Warming?" Science, vol. 189 (8 August 1975), 460-463.
[2] For example, see: MIT, Inadvertent Climate Modification: Report of the Study of Man's Impact on Climate (Cambridge, Mass.: MIT Press, 1971).
3National Academy of Science, Carbon Dioxide and Climate, Washington, D.C., 1979, p. vii.

Anthropogenic Climate Change: The Announcement



https://www.staugustine.com/nationworld/20180618/james-hansen-wishes-he-wasnt-so-right-about-global-warming 2020/9/14

AP Images
Page Liked · June 23 ·

On this day in 1988, James E. Hansen, a climatologist at the Goddard Institute for Space Studies, told a Senate panel that global warming of the earth caused by the "greenhouse effect" was a reality.

Photo Caption: James Hansen, a leading researcher on global warming, gives a briefing on global warming on Capitol Hill in Washington, June 23, 2008. NASA's top climate scientist in 1988, Hansen warned the world on a record hot June day that global warming was here and worsening. In a scientific study that came out a couple months later, he even forecast how warm it would get, depending on emissions of heat-trapping gases. (AP Photo/Susan Walsh)

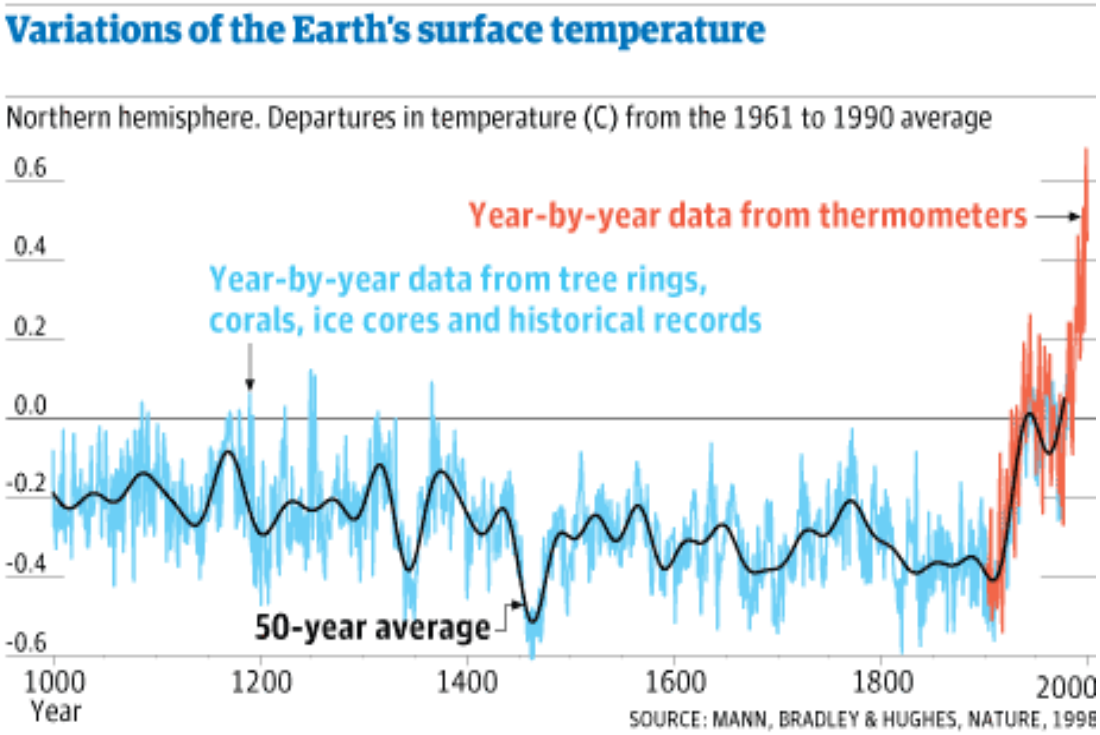
http://www.apimages.com/ 2020/9/14

Anthropogenic Climate Change: The Controversy

Thermometer for **direct** measurements of temperature only since 1848 (Lord Kelvin)

↔

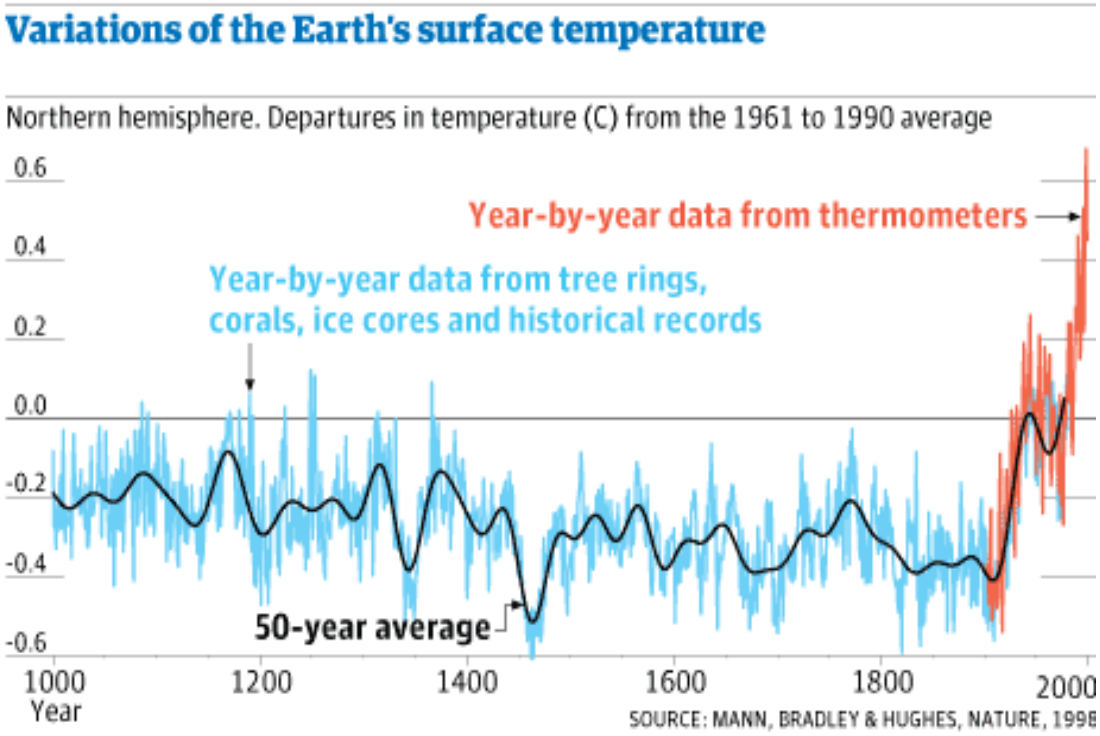
indirect data (tree rings etc.)



Anthropogenic Climate Change: The Controversy

"CO_2 theory of runaway warming was propounded by **Hansen** based on the discovery that the super-heated Venusian atmosphere is consists almost entirely of CO_2?"

(Presumption: Venus has a 90 times higher atmospheric pressure than earth, but **Arrhenius started all of it**)

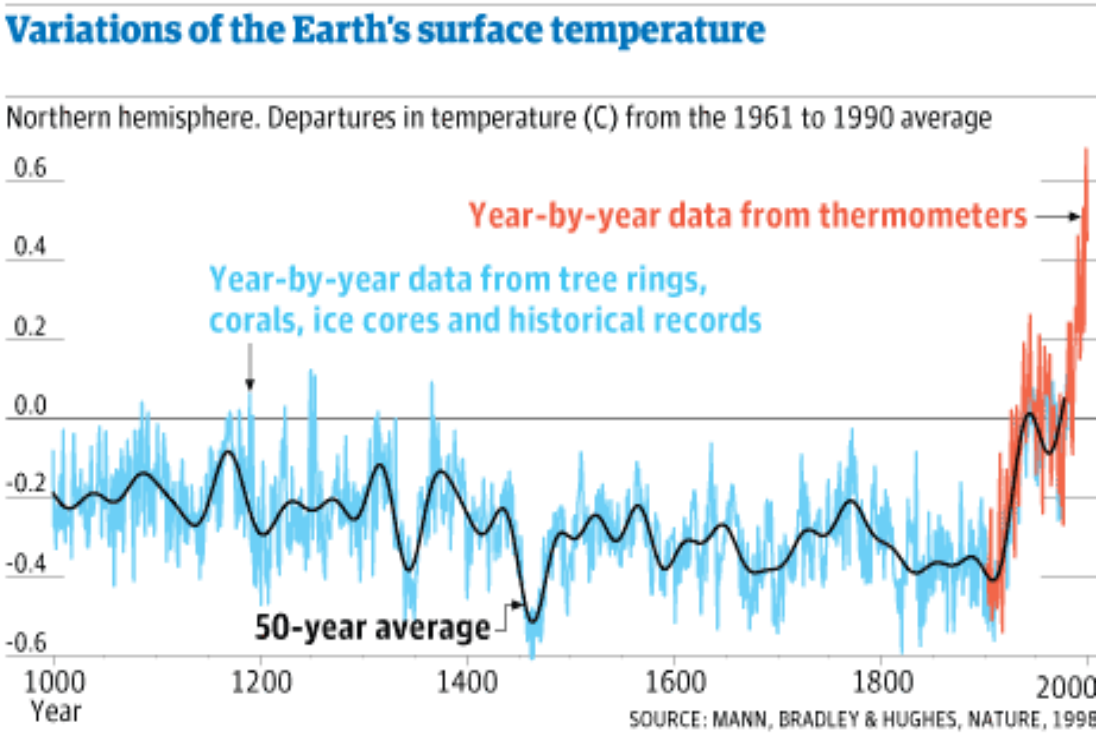


Anthropogenic Climate Change: The Controversy

”Climate change is natural”

↔ of course it is natural! … but that is missing the point!

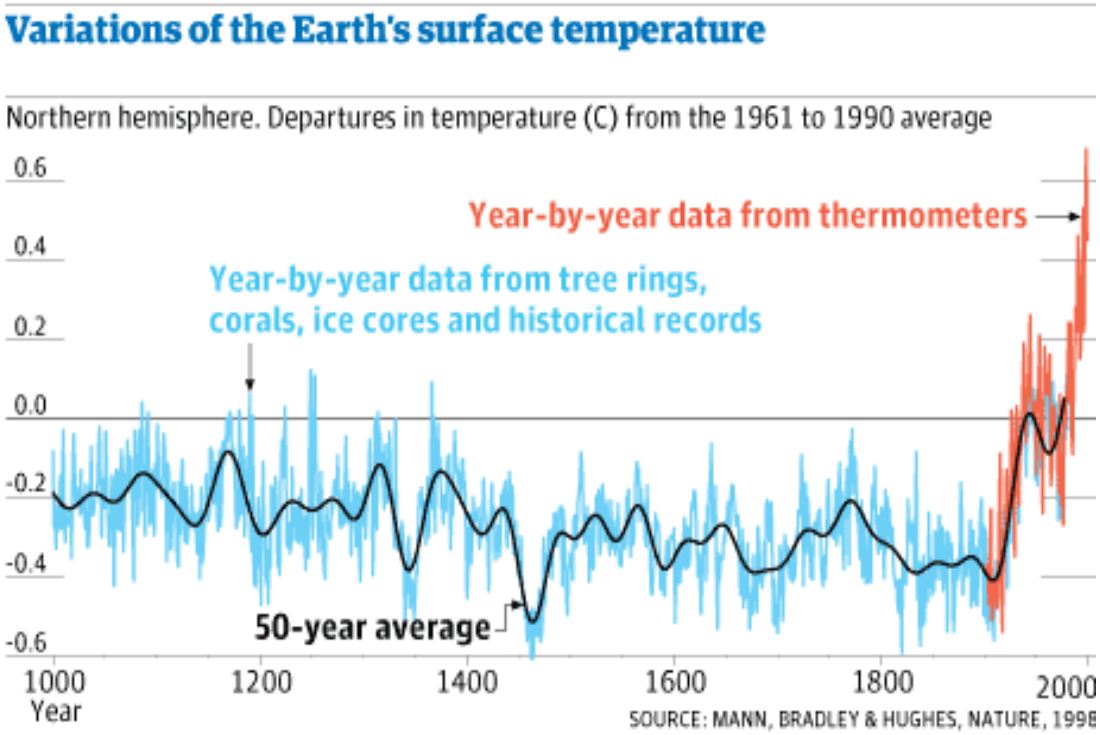
↣ the **rate** ⮥ of change is the crux of the matter!



Anthropogenic Climate Change: The Controversy

”There isn’t enough agreement in science on it and it is not credible”

↔ Things get difficult when people stop sticking to facts but start to **believe**



Anthropogenic Climate Change: The Controversy

”If carbon dioxide levels changed periodically **before** humankind entered the stage, how could we explain it?

- **Global Conveyor Belt**
- **Position of the continents**

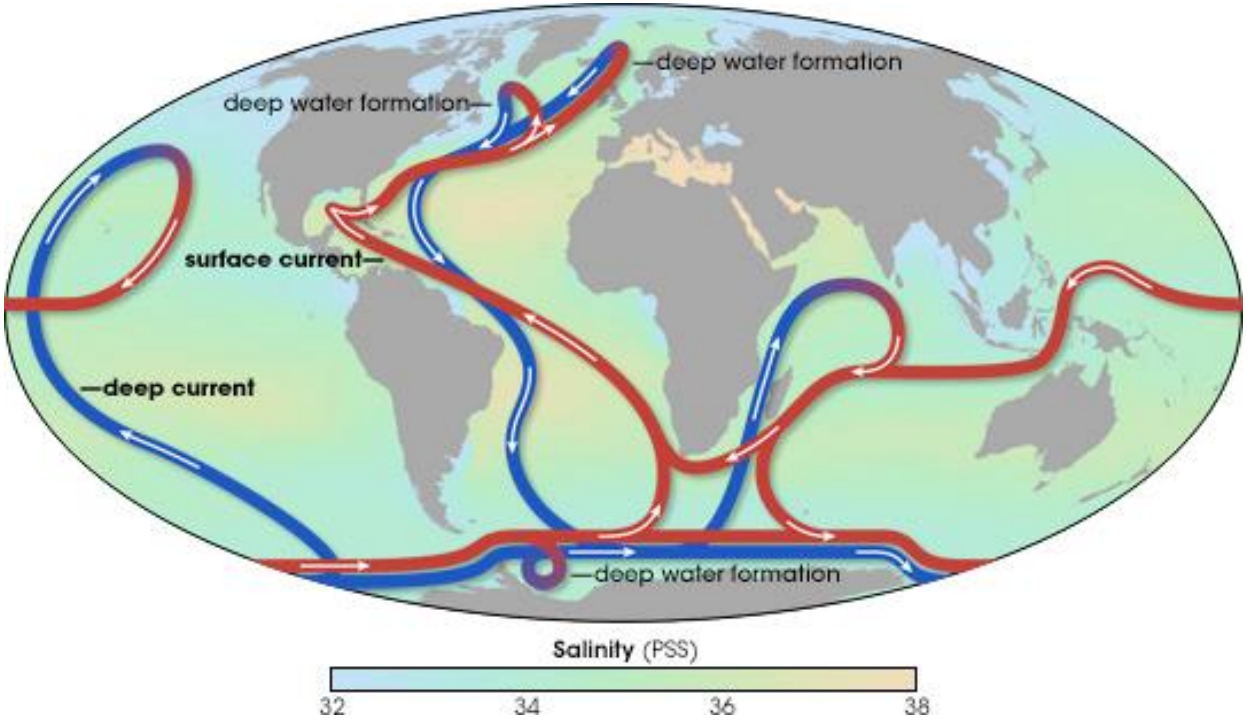
} Related to each other!

- **Volcanism** ↔ only if there is a period of super active volcanism

Anthropogenic Climate Change: Global Conveyor Belt

The position of the continents allows exchange of ocean warm and cold ocean waters

➳ Melting brings fresh water into the sea water and changes its freezing point



https://earthobservatory.nasa.gov/features/Paleoclimatology_Evidence/paleoclimatology_evidence_2.php (accessed: 2020-07-21)

Anthropogenic climate change & the controversy it sparked

Summary question: Do you think that carbon dioxide concentration in the atmosphere is the origin of the climate change or the result of climate change?

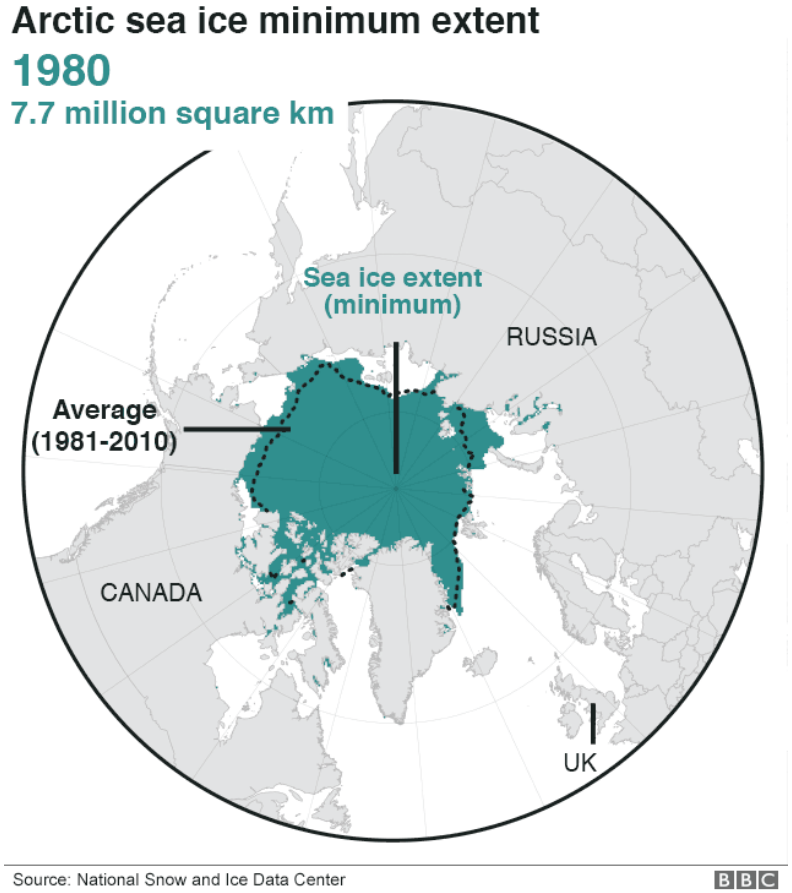
Think about it for a minute, write down your opinion

Changes to Environment that already happened

Changes to Environment that already happened

The change in minimum size of the frozen part of Artic sea ice, 1980 ~ 2019:

7.7 -> 4.2 million km^2
(- 45% in **just 39 yrs.**)



Changes to Environment that already happened

“The glacier “has been retreating for the last 100 years,” according to Ian Joughin, senior principal engineer at the Polar Science Center, part of the University of Washington's Applied Physics Laboratory.”

“Jakobshavn is now shedding ice nearly three times as quickly as it was 20 years ago, dumping enormous and growing quantities into the ocean. It's **contributed 0.1 millimeters per year** to **worldwide sea-level rise** — **more than 3 percent of the 3 mm produced globally — for the past decade.**”

A view from the village of Ilulissat, Greenland of icebergs that broke off from the Jakobshavn Glacier on July 24, 2013. As the sea levels around the globe rise, researchers affiliated with the National Science Foundation and other organizations are studying the melting glaciers and long-term ramifications.
Credit:Joe Raedle (https://www.pri.org/stories/2014-03-09/we-have-problem-science-behind-rising-seas?fbclid=IwAR1aw-TwI91w0ZFJV2PxE3UQ9fLOS7VWhgP3Y9xEm_hDhy7GBJLmpaMGIiQ) accessed: 2020-07-21

Changes to Environment that already happened

Rising sea levels in some parts of the world have let sunk islands already

300 yrs. old trees, drowning

https://www.9news.com.au/world/60-minutes-solomon-islands-climate-change-global-warming-rising-sea-environment/3712f288-6c55-4b5e-aeb6-96adefb1e2bc#close (accessed: 2020-07-21)

Changes to Environment that already happened

Summary question: What other examples can you find that are a consequence of rising temperatures?

Think about it for a minute, write down your opinion

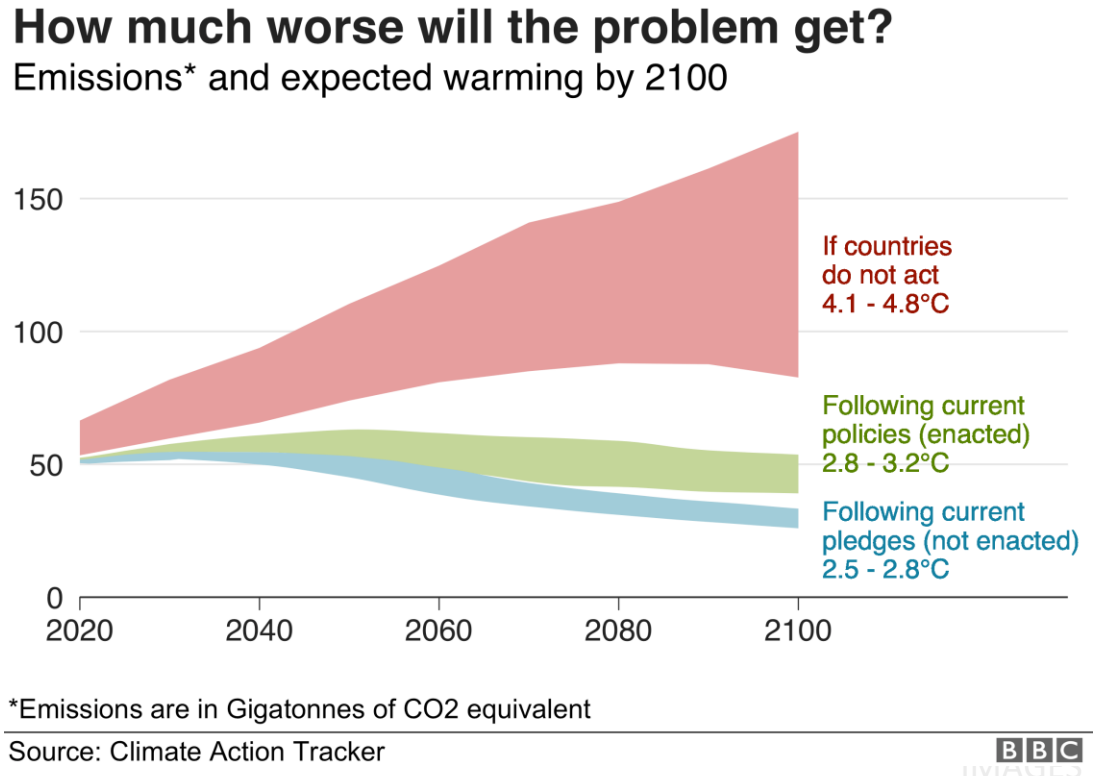
What to expect in the future?

What to expect in the future?

https://www.bbc.com/news/science-environment-46384067?SThisFB&fbclid=IwAR3YJ54vOE11JuNPxQLNuqnXy0gcBOGxP2_Nwxt99HlkJ-uzVE-1Ioui4MY (accessed: 2020-07-21)

What to expect in the future?

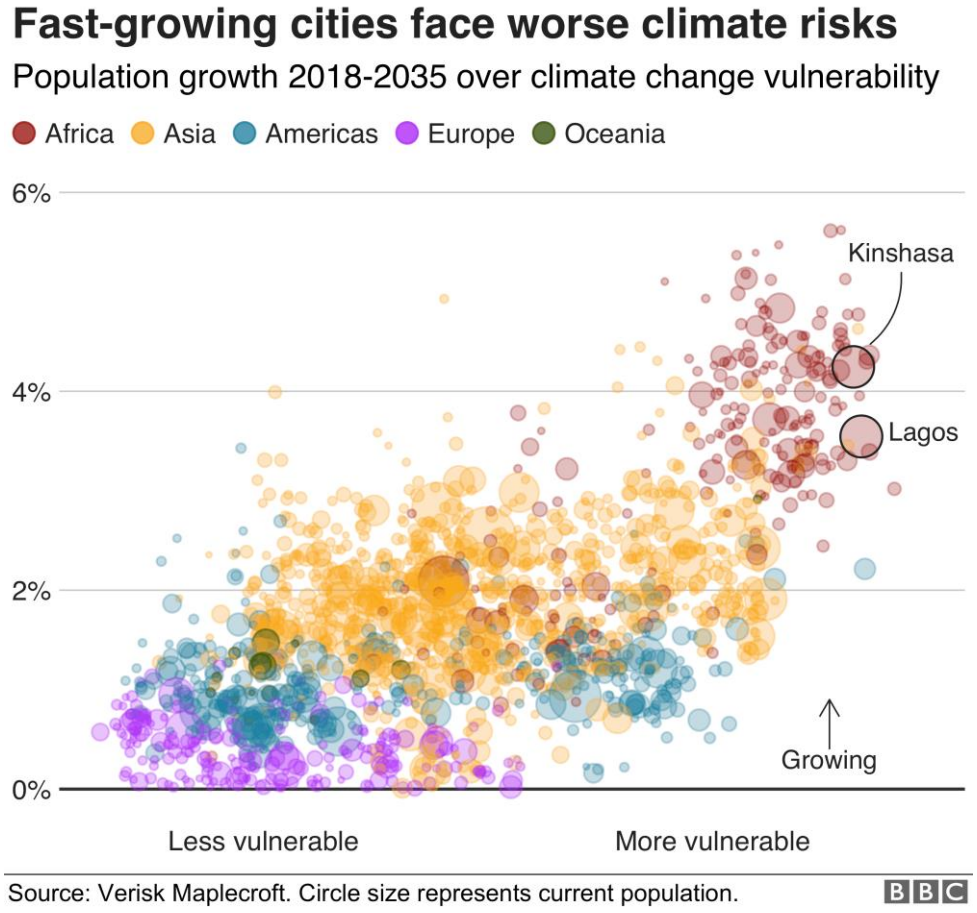
“Scientists now agree that we actually need to keep temperature rises to below 1.5C.”



What to expect in the future?

“It's the faster-growing cities that are most at risk, including megacities like Lagos in Nigeria and Kinshasa in the Democratic Republic of Congo.”

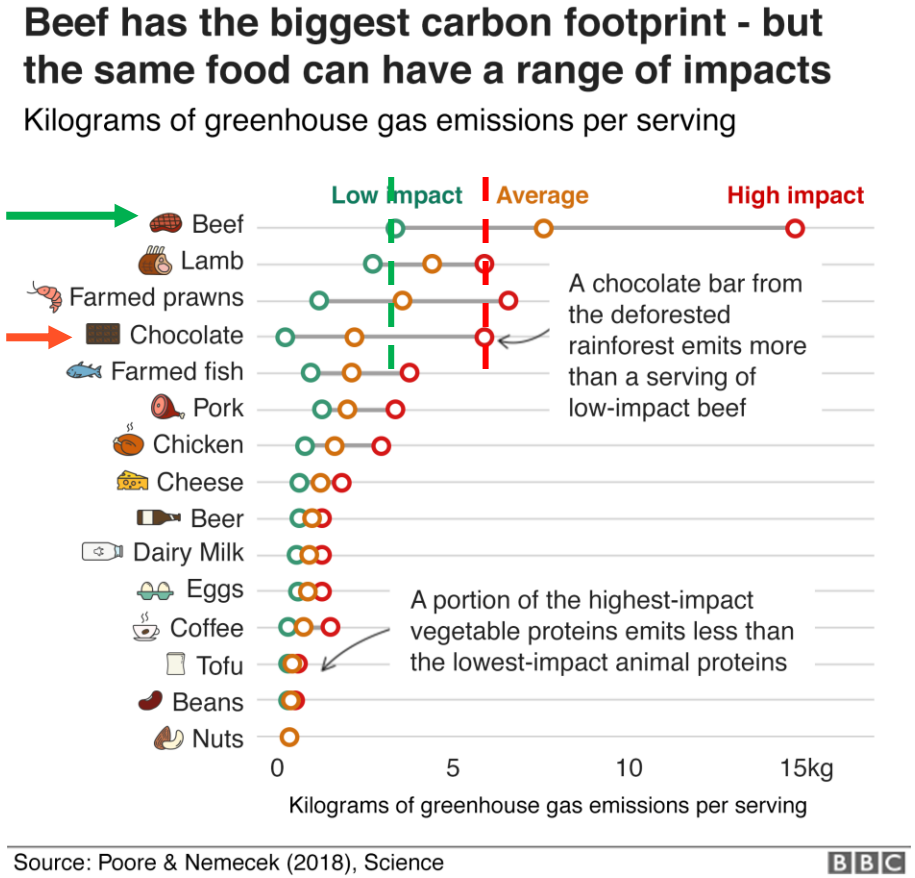
“Some 84 of the world's 100 fastest-growing cities face "extreme" risks from rising temperatures and extreme weather brought on by climate change.”



What to expect in the future?

“One of the biggest ways to reduce your environmental impact on the planet is to modify your diet to include less.”

“The IPCC[1] says we need to: buy less meat, milk, cheese and butter; eat more locally sourced seasonal food - and throw less of it away; drive electric cars but walk or cycle short distances; take trains and buses instead of planes; use videoconferencing instead of business travel; use a washing line instead of a tumble dryer; insulate homes; demand low carbon in every consumer product.” [1]Intergovernmental Panel on Climate Change, https://www.ipcc.ch/



Summary / Conclusion

- There is not one single explanation that completely explains climate change
- Carbon dioxide emission/atmospheric concentration is a key factor
- Climate change is real, too many indicators that can’t be denied
- There might be a chance to keep at least things as they are now
- Everybody can help by reflecting about his own life style …..

Summary / Conclusion

Summary question(s)

1) Coming back to the initial question: Did you change your opinion about global warming? Is a treat or just a hoax? Give reasons for your opinion

2) Do you know about any examples how climate change has effected you, your family or friends?

3) What do you think is the best that you could do to prevent things from getting worse?

Think about it for a minute, turn to your neighbours and share! (Alternatively, discuss with friends and/or family)

THANK YOU!!