



# 4 degrees warmer

Alasdair Skelton

Bolin Centre for Climate Research



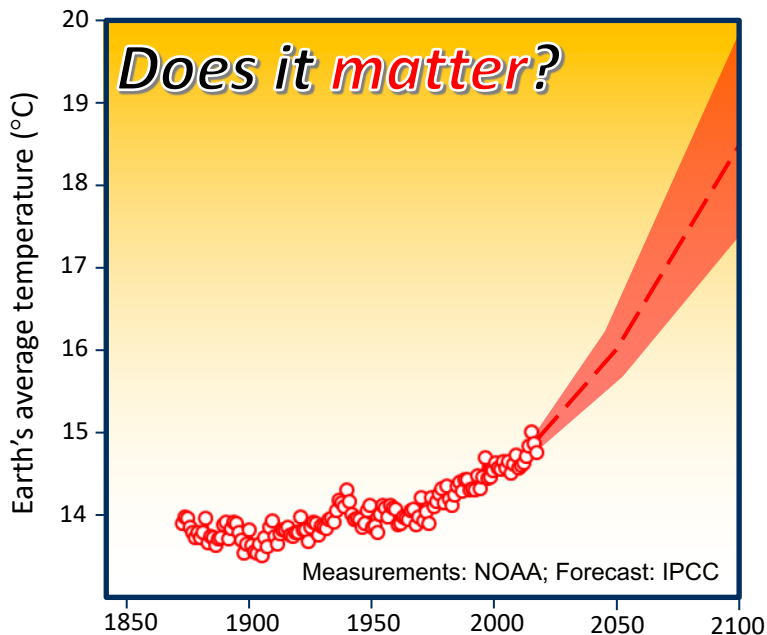
**SMHI**

Bolin Centre for Climate Research



Stockholm  
University

4 degrees warmer



Earth's climate

*What **controls**  
Earth's climate?*

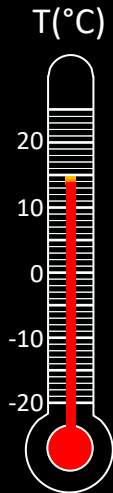
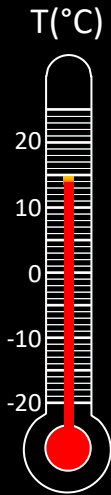


Image: NASA

# What controls Earth's climate?

- *Solar energy*
- *Albedo*
- *Greenhouse effect*
- *Weathering of rocks*





Which planet is warmest? Why?



Venus

**T = 460°C**



Earth

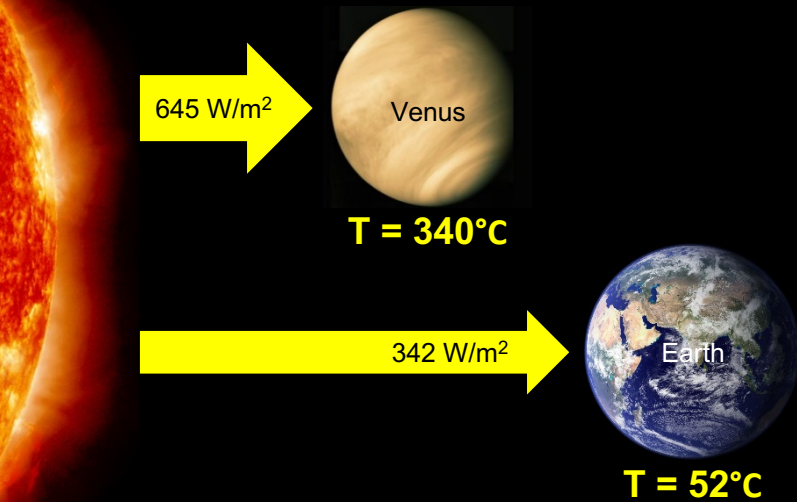
**T = 15°C**

# Solar energy



Image: Walmart

# Solar energy



Venus

Earth



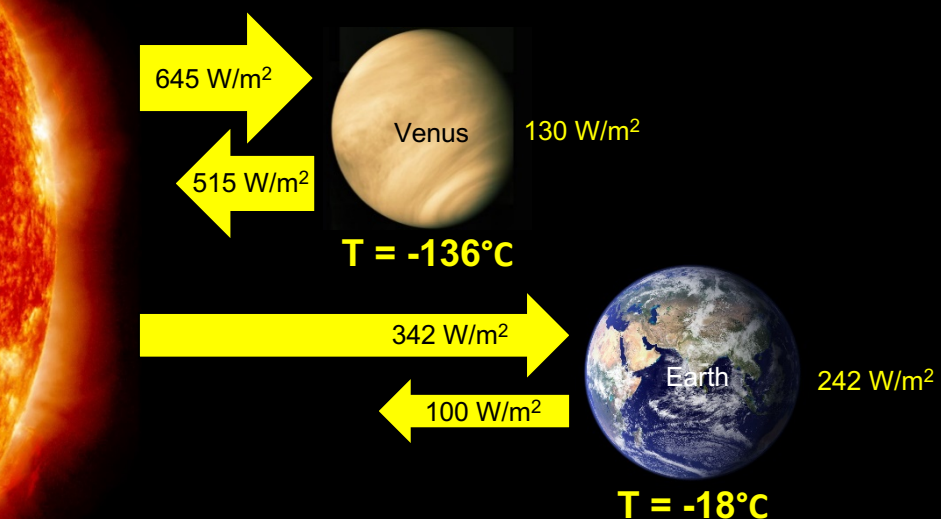
Albedo

Black  
seat

White cat



# Albedo



Venus

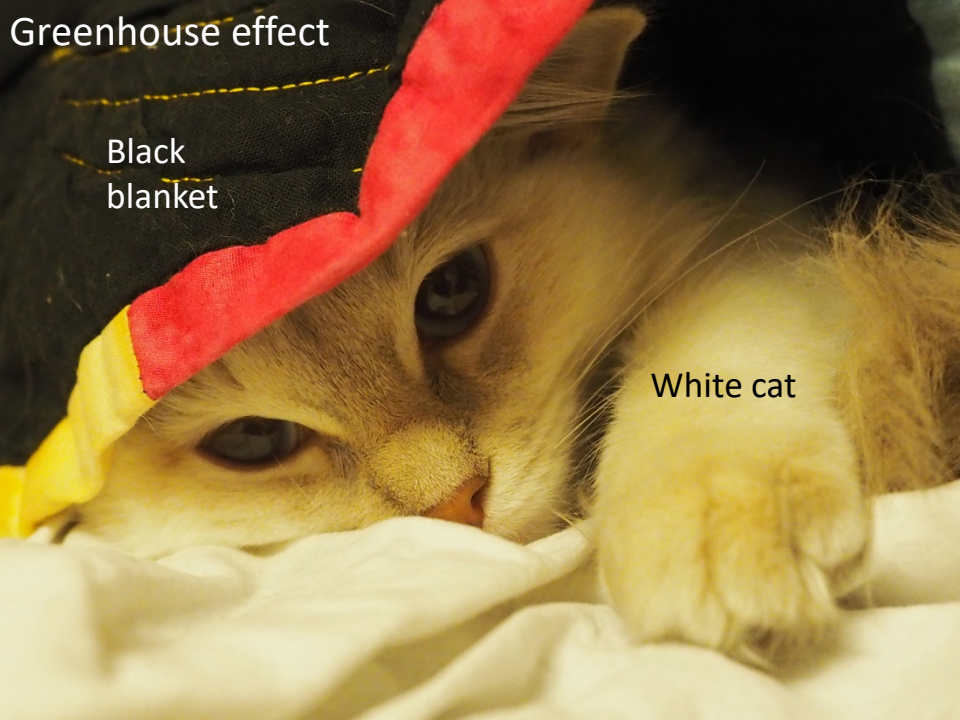
Earth



Greenhouse effect

Black  
blanket

White cat



# Greenhouse effect

$$T = -18^{\circ}\text{C} + 32^{\circ}\text{C} + 1^{\circ}\text{C} = 15^{\circ}\text{C}$$

0.04% CO<sub>2</sub>



Earth

Image: NASA

# Greenhouse effect

$$T = -136^{\circ}\text{C} + 596^{\circ}\text{C} = 460^{\circ}\text{C}$$

96.5% CO<sub>2</sub>

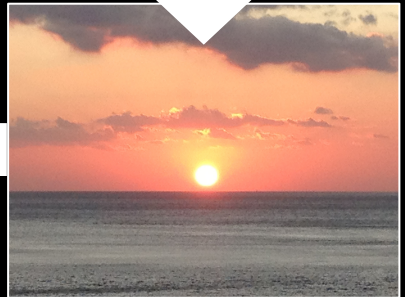
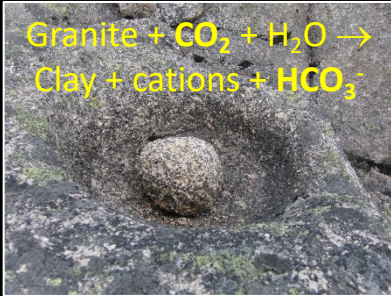


Venus

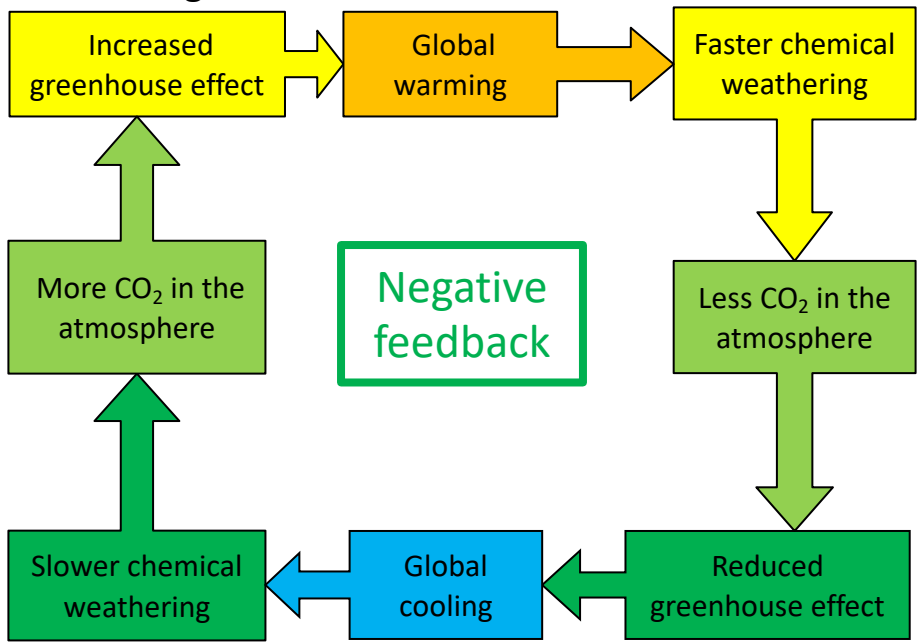
Image: phys.org



# Weathering of rocks



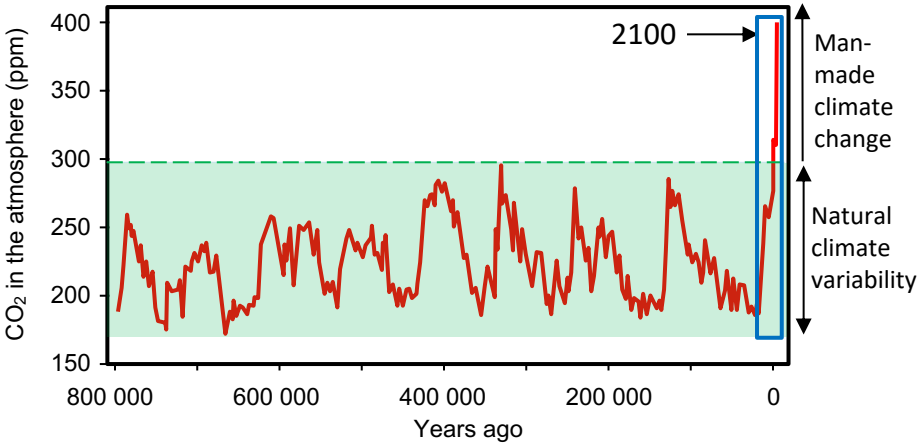
# Weathering of rocks



# Natural climate variability

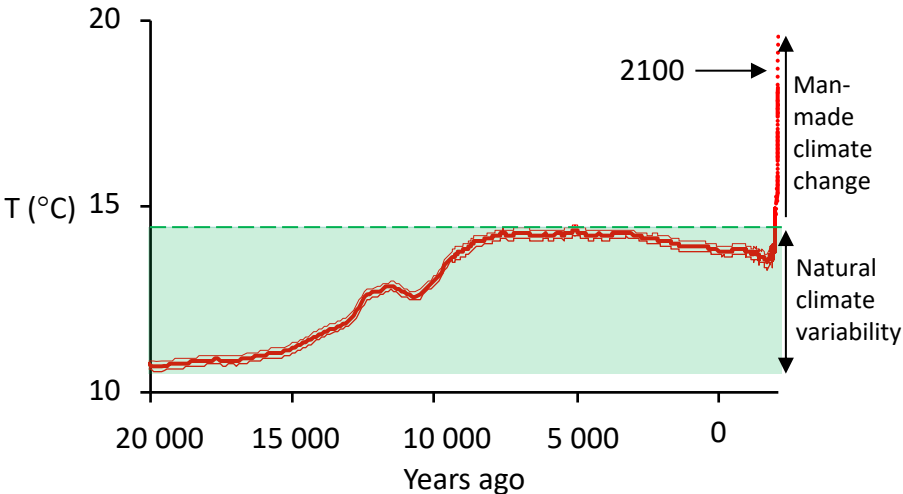


# Natural climate variability – CO<sub>2</sub>



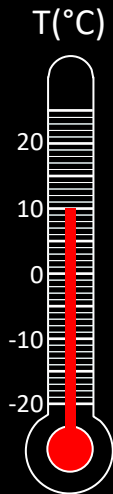
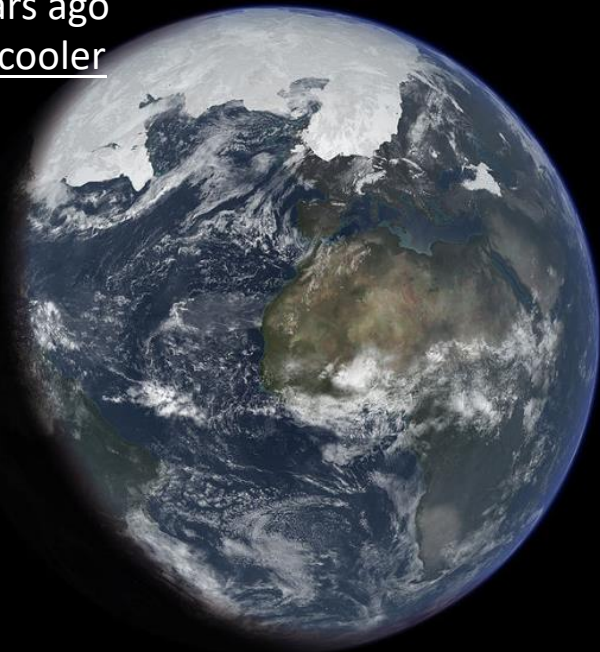
Data: EPICA 2004; Forecast: IPCC

# Natural climate variability - Temperature



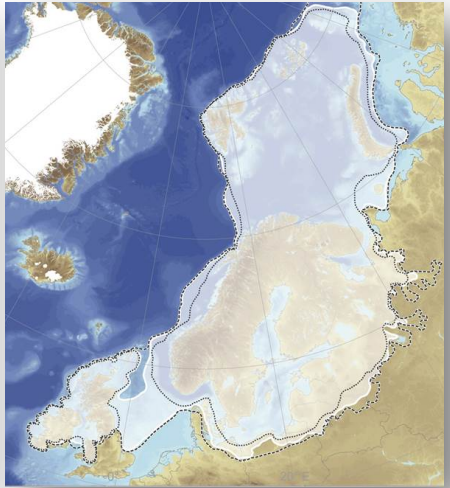
Data: Shakun et al., 2012; Marcott et al., 2013; NOAA; Forecast: IPCC

20 000 years ago  
4 degrees cooler



Images: Crowley (1995)

20 000 years ago  
4 degrees cooler



56 million years ago  
>4 degrees warmer

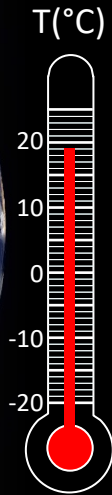
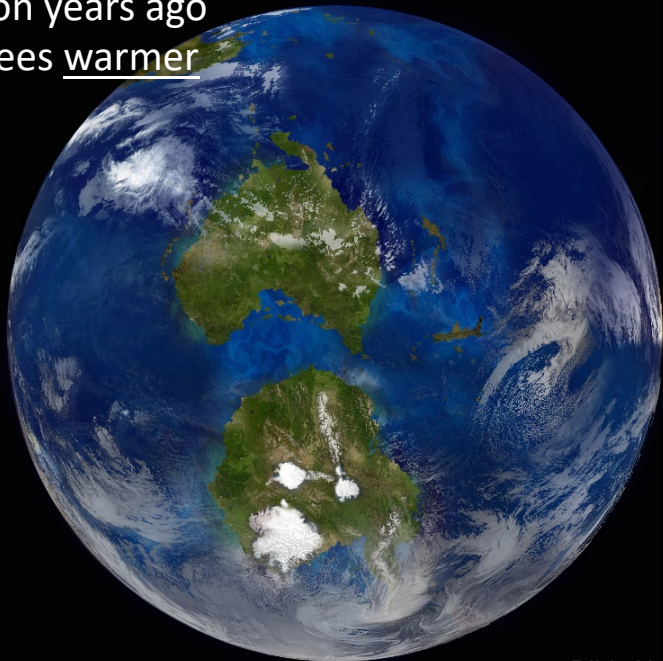


Bild: Alan Kennedy



# Melting permafrost



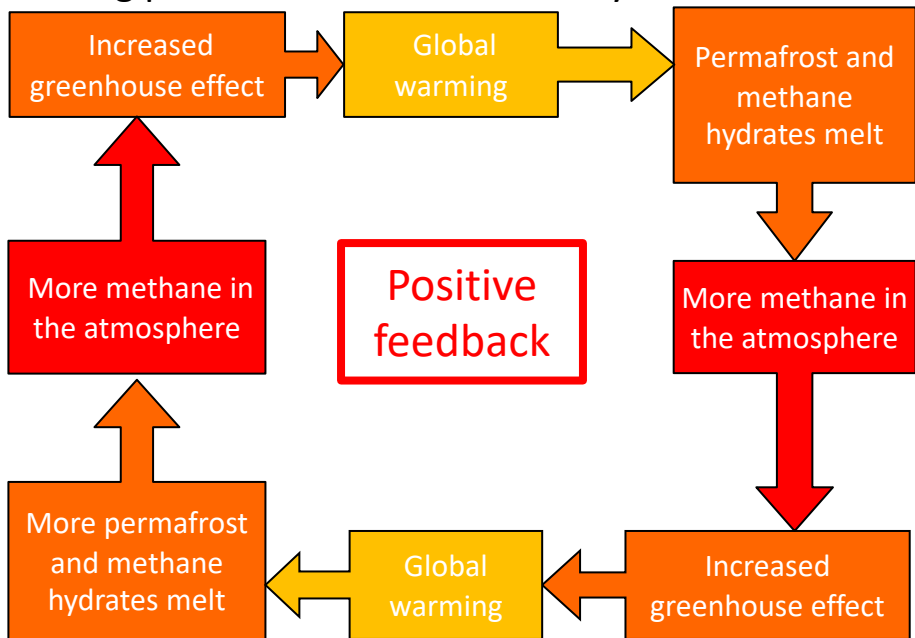
Image: NASA

# Melting methane hydrates



Image: SWERUS-C3

# Melting permafrost and methane hydrates



# Walvis Ridge

South Africa



Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
Image Landsat

1978 km



Google earth

# JOIDES Resolution



Image: Ocean Drilling Program

JOIDES Resolution



Image: Ocean Drilling Program



JOIDES Resolution



Image: Ocean Drilling Program

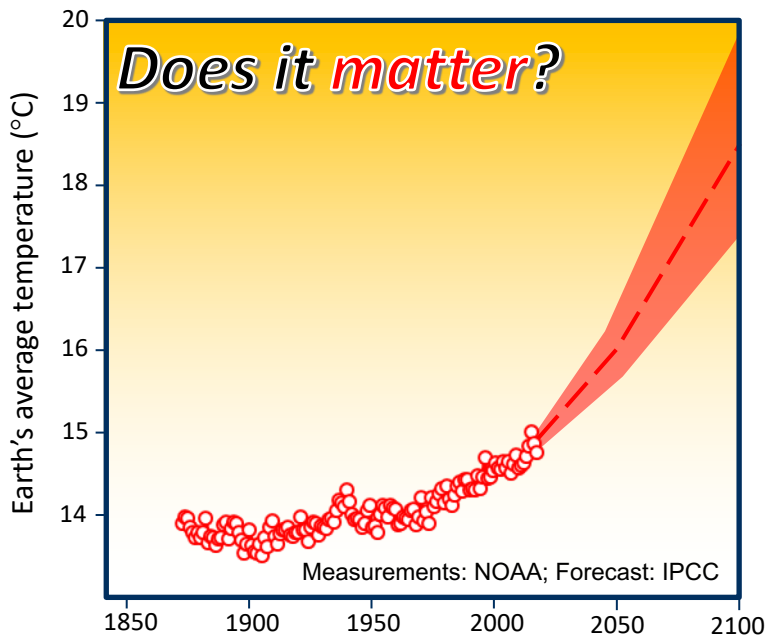
56 million years ago  
>4 degrees warmer



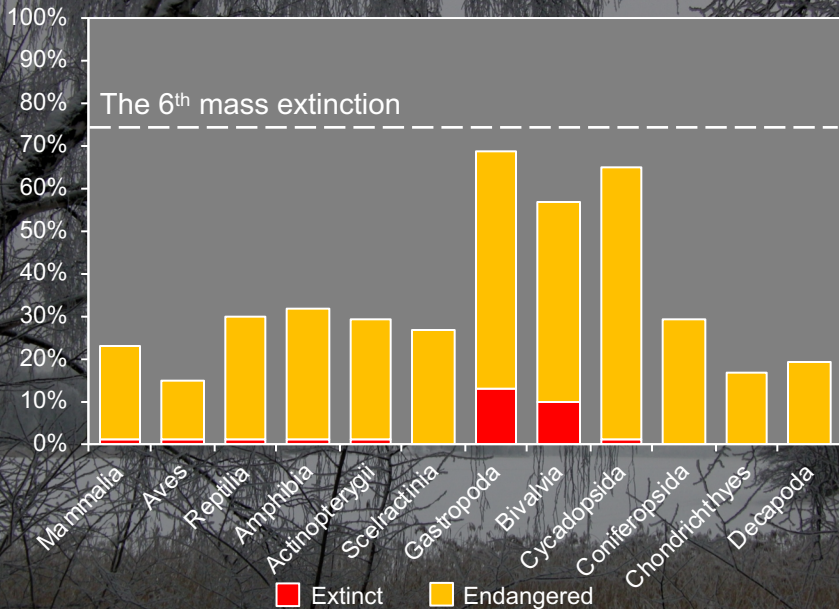
Image: Ocean Drilling Program



## 4 degrees warmer in one lifetime

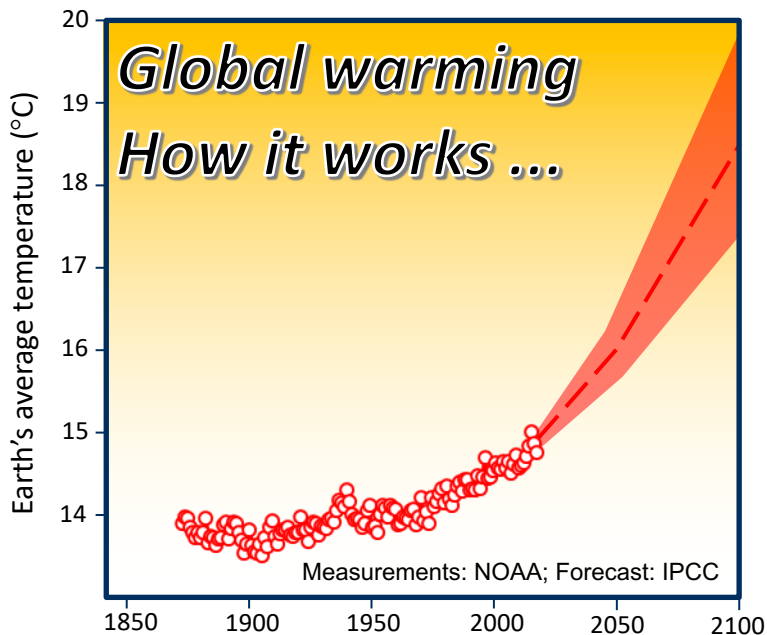


# Does it matter?



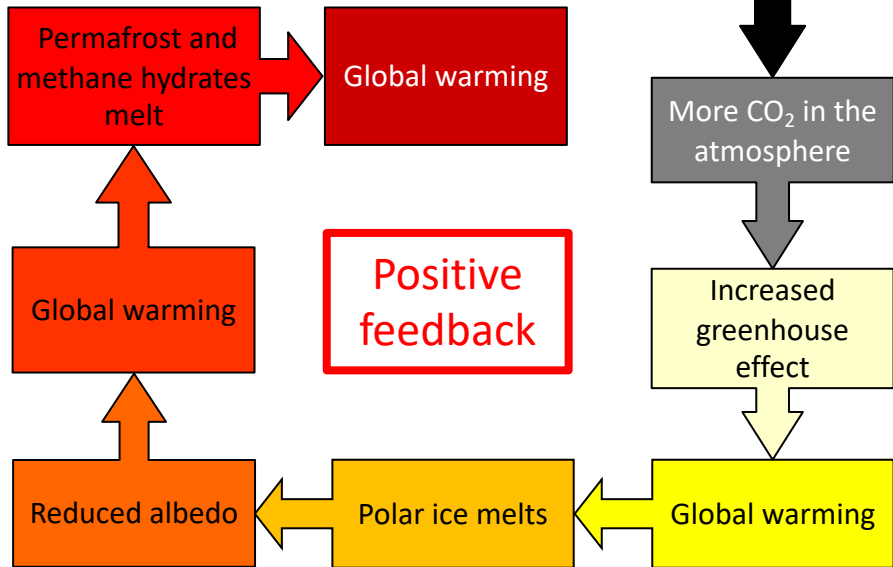
Data: Barnosky et al. (2011)

4 degrees warmer

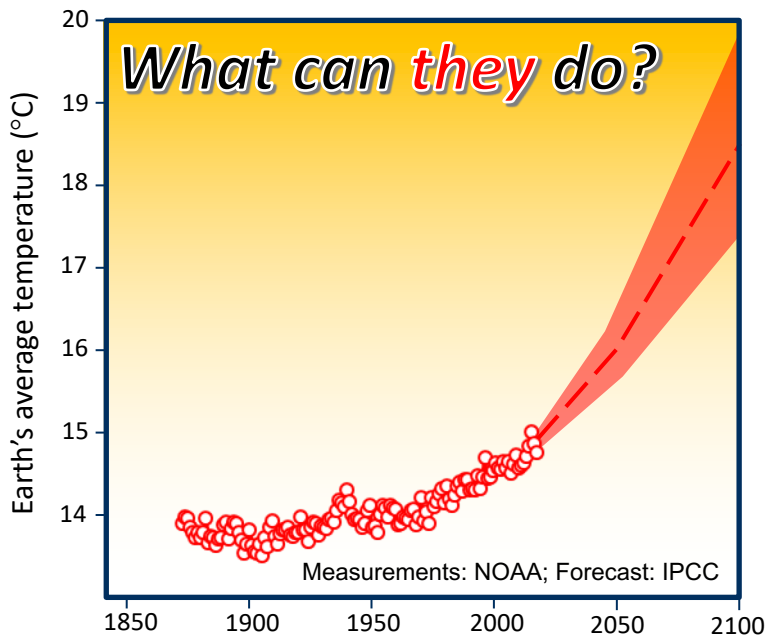


# Global warming

## How it works ...



4 degrees warmer

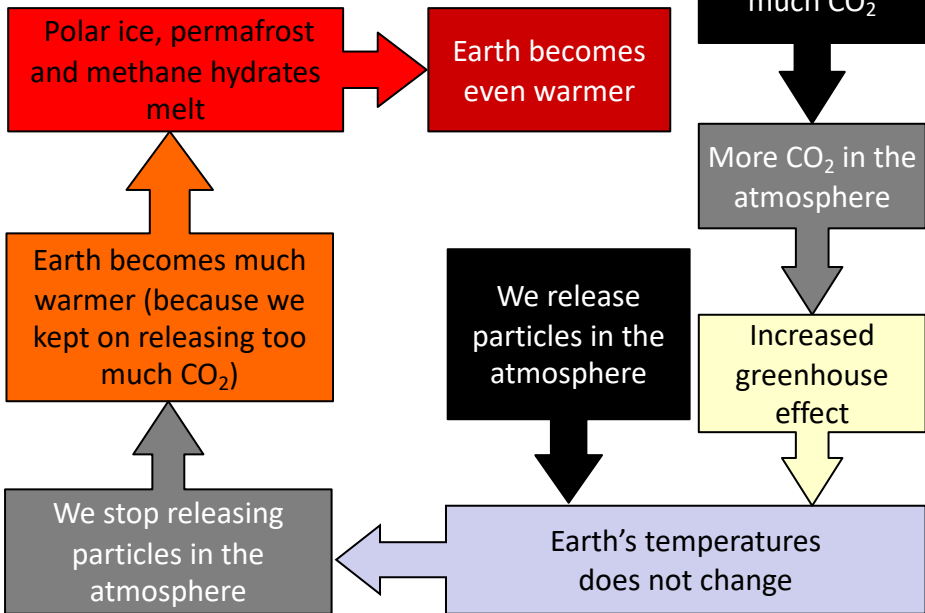


Climate manipulation

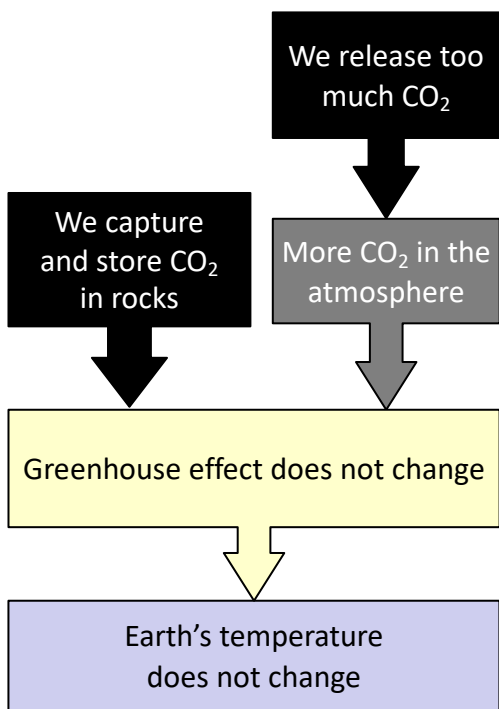


Bild: [www.geoengineeringwatch.org](http://www.geoengineeringwatch.org)

# Climate manipulation

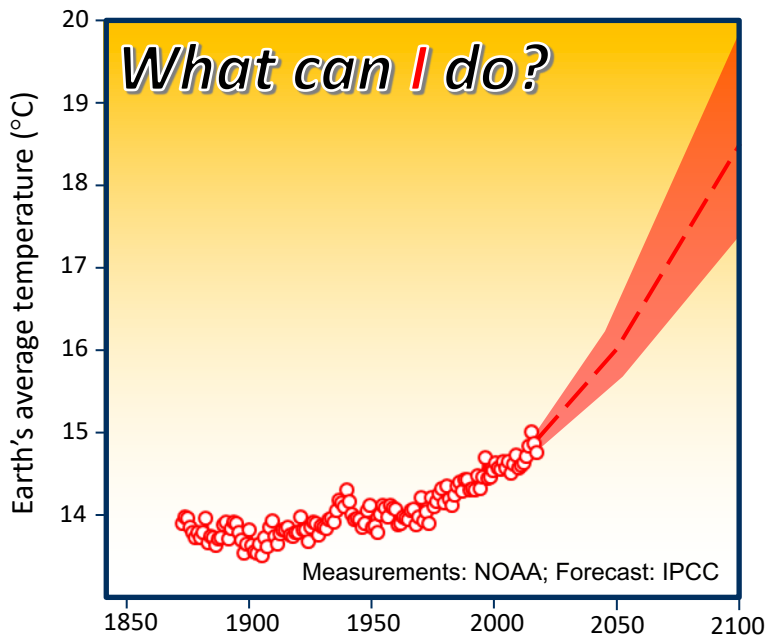


# Carbon capture storage





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What can I do?



“... serious, but  
not hopeless ...”

Bert Bolin, Svenska dagbladet, 2008

What can I do?



Image: Hanna Franzén/TT

# What can I do?

TELIA 17:42 klimatkalkylatorn.se

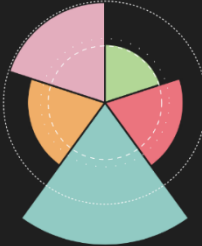
WWF SEI Stockholm Environment Institute Logga in

Senast 2050 ska vi alla leva inom gränserna för en planet. Men redan 2020 ska vi ha gjort stora förändringar i rätt riktning. Hur lever du? Och vad kan du ändra? Testa här!



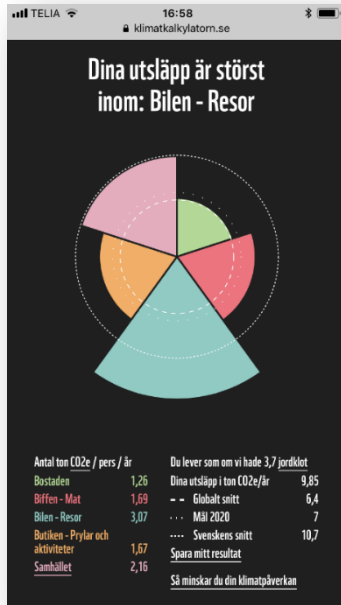
TELIA 16:58 klimatkalkylatorn.se

## Dina utsläpp är störst inom: Bilen - Resor



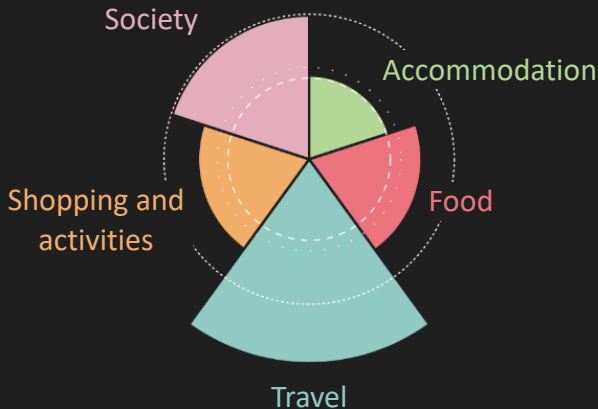
Antal ton CO <sub>2</sub> e / pers / år	Du lever som om vi hade 3,7 jordklot
Bostaden 1,26	Dina utsläpp i ton CO <sub>2</sub> e/år 9,85
Biffen - Mat 1,69	- - Globalt snitt 6,4
Bilen - Resor 3,07	... Mål 2020 7
Butiken - Prylar och aktiviteter 1,67	.... Svensns snitt 10,7
Samhället 2,16	Spara mitt resultat

Så minskar du din klimatpåverkan



# What can I do?

My footprint  
**9.85 tons CO<sub>2</sub>/yr**



## My holiday flights

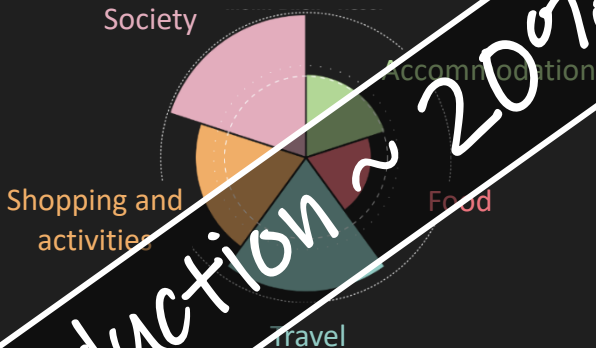
Skåne (1)  
Scotland (2)  
Greece (1)

## How much food do I throw away?

- None – I throw nothing away
- Some – I throw some food away
- Lots – I throw a lot of food away

# What can I do?

My footprint  
8.11 tons CO<sub>2</sub>/yr



## My holiday flights

Skåne (0)  
Scotland (1)  
Greece (1)

## How much food do I throw away?

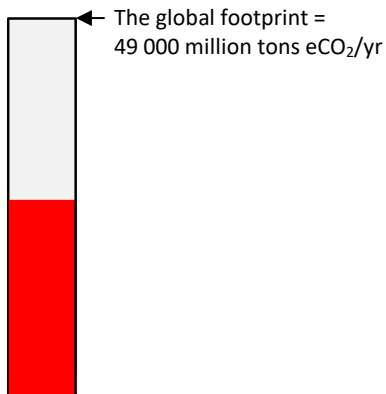
- None – I throw nothing away
- Some – I throw some food away
- Lots – I throw a lot of food away

# What can I do?

- Reduction = 20%
- Average Swede's footprint = 10.7 tons  $CO_2$
- Reduction = 2 tons  $CO_2$
- 10 million Swedes
- Sweden's reduction = 20 million tons  $CO_2$

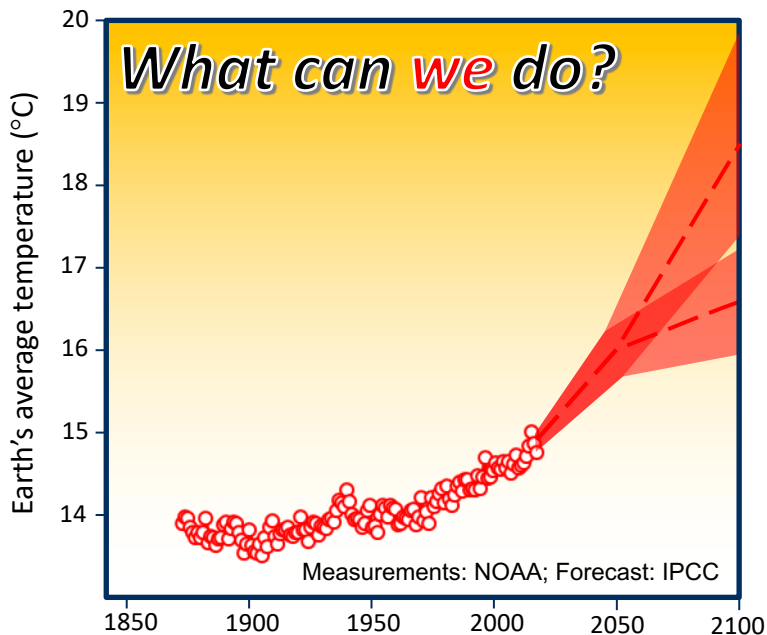
# What can I do?

- 20% reduction in Sweden  
20 million tons CO<sub>2</sub>
- 20% reduction in EU  
850 million tons CO<sub>2</sub>
- 20% reduction in USA  
1400 million tons CO<sub>2</sub>
- If we double our efforts ...
- ... and if the rest of the world helps too ...





Together we can bend the curve





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[www.bolin.su.se](http://www.bolin.su.se)



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University