What is the truth about climate change?

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Lecture 2

Why should we be concerned - wouldn't it be good to be warmer? What impacts are expected and roughly when?

Bealings Village Hall

30 January 2008

So what of the future?

How does one model future climate?

Who coordinates world wide scientific activity?

What may we expect?

Climate prediction

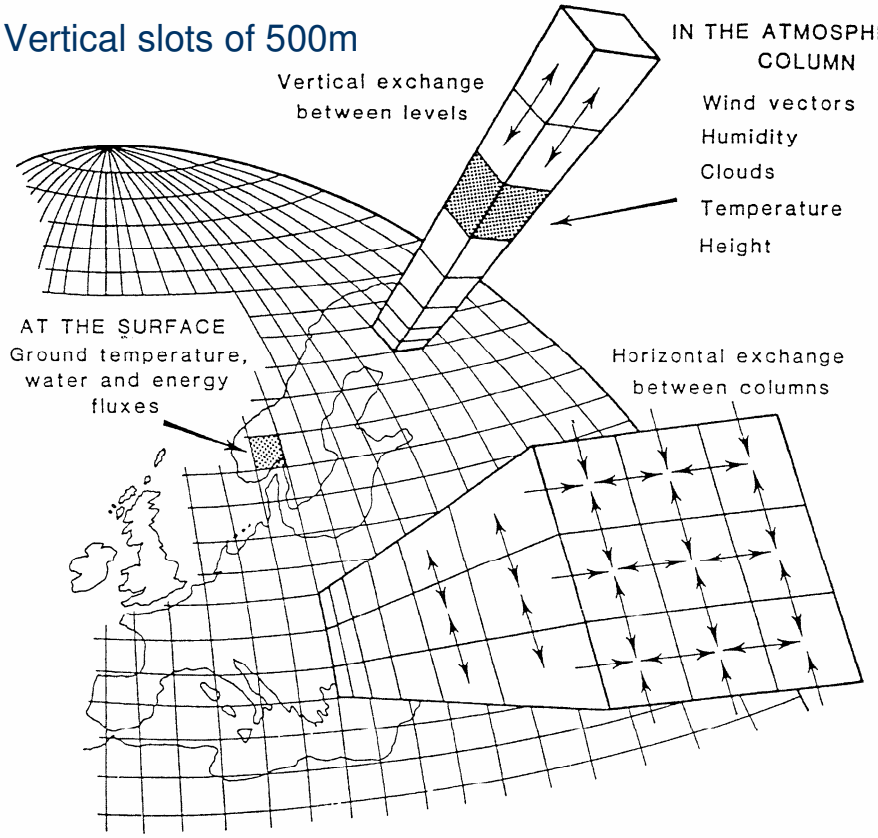
- Done using very powerful computers
- Climate is linked throughout the planet
- So the whole planet's weather must be included.
- And at the detail level, must include :-
  - Heating, cooling, evaporation, precipitation
  - Winds, currents, mountains, valleys, snow, ice, oceans
  - Forests, crops, deserts, volcanoes, rivers, lakes
  - Human activity
  - Sun position & strength
  - etc

Global Climate Model - GCM

(or General Circulation Model)

At the position of the UK, a 3° square is about 224 x 123 miles.

This can only model large scale climate features.



Time steps 30 min.

Grid Spacing 3^0 x 3^0

Source - "Sustainable Energy" by Tester et-al

Note GCM statistics :-

- 120 x 60 = 7200 surface squares
- 8 to 10 altitude slots
- 0.5 hour sample time = 17,000 per annum.
- 1.2 Billion slot evaluations/annum of climate
- Each with multiple variables.
- And each interacts with nearest neighbours
- Takes supercomputer 10 hours to simulate one year of global climate.

How can we know the system works?

- By modelling past climate and comparing computer prediction with known climate result.
- Tests show the system works well.
- But to model the future, one must make assumptions about the future
  - E.g. what will human activity be?

Intergovernmental Panel on Climate Change

Coordinating world wide studies of climate change.

www.ipcc.ch

IPCC role

- To critically review all published scientific work on climate-change in the world.
- To distill from it the most likely interpretations
- To fully explore their implications
- To report these conclusions to
  - the public at large
  - Governments
  - and the scientific community.

About IPCC reports

- Must be approved by Scientists AND Governments
- Hence they only report what is very well established
- And tend to play down potentially more serious but less certain issues.
- As well as politically embarrassing ones

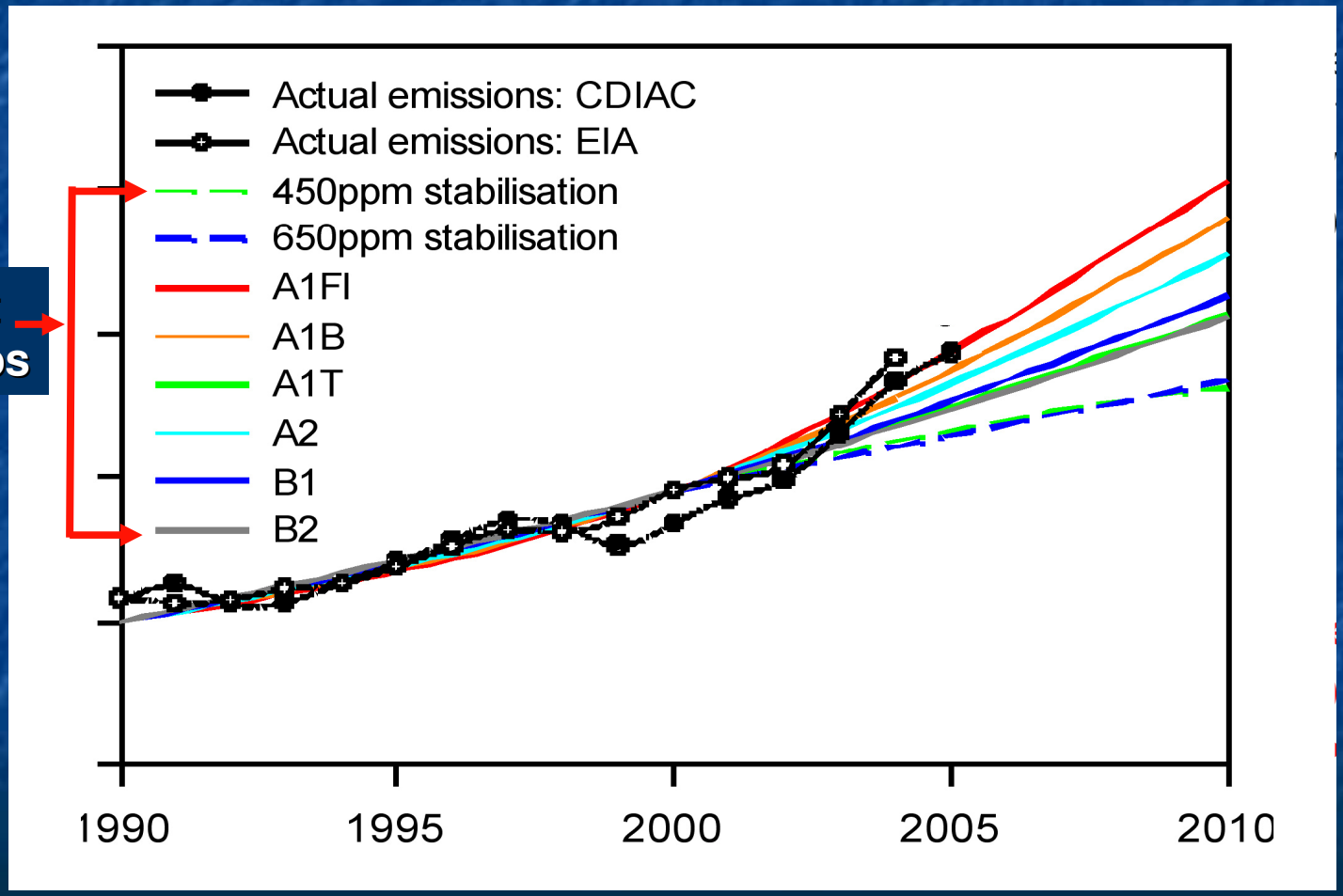
IPCC scenarios

- IPCC established a series of scenarios for modeling purposes by all participating groups.
- They range from :-
  - The Human Race continues “business as usual”
  - To it pulls out all the stops to reduce CO_2 and CH_4 emissions ASAP.
  - And a number in between
- They appear in most simulations

IPCC reports

- In 2001 & 2007, they published major reports
  - Each has three parts
    - Science
    - Mitigation
    - Impacts, adaptation & vulnerability
- They form the basis for most Govt.plans
- You can download them for free from :-
  - www.ipcc.ch

Predicted CO_2 emission rates

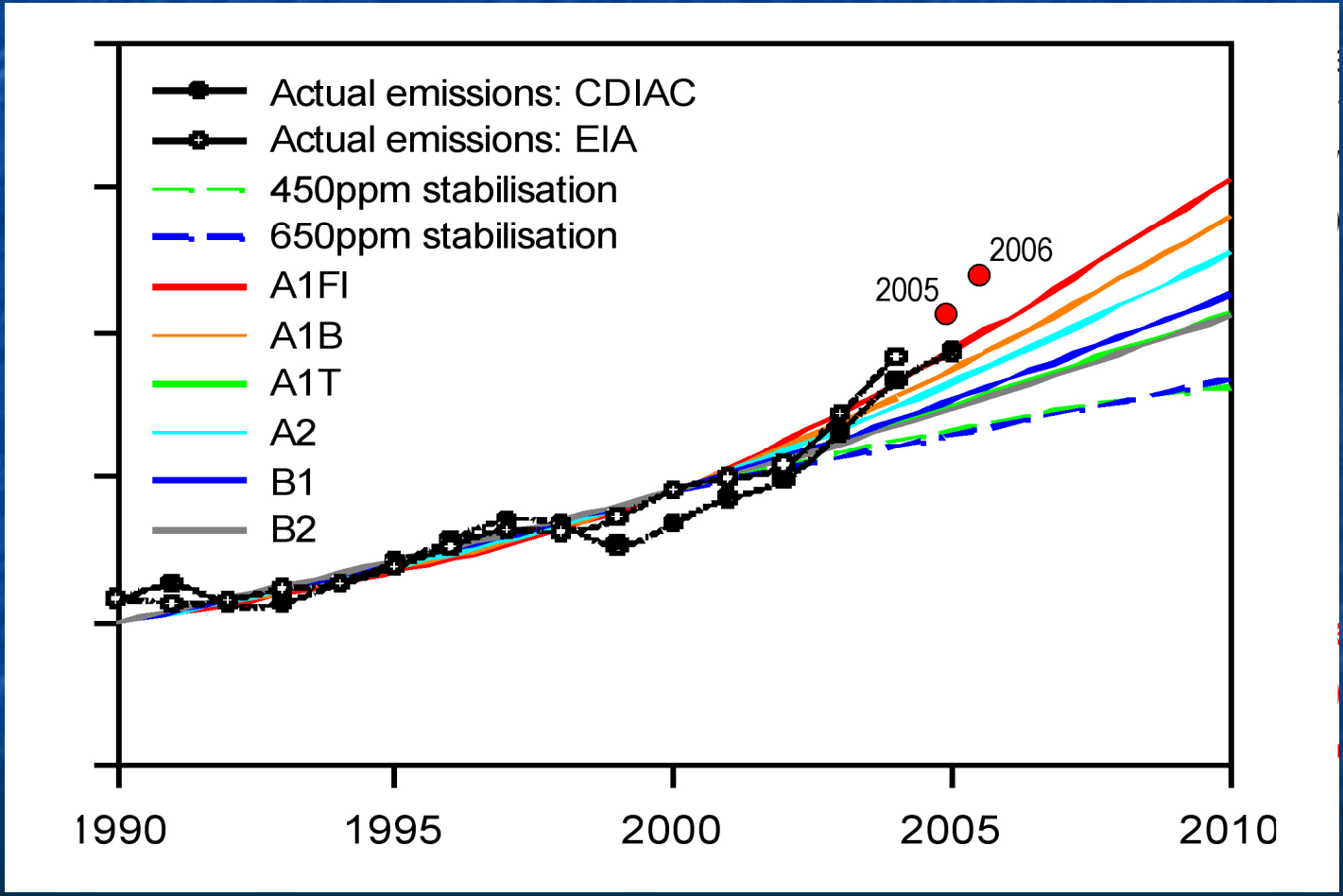


Different Scenarios

Source - IPCC

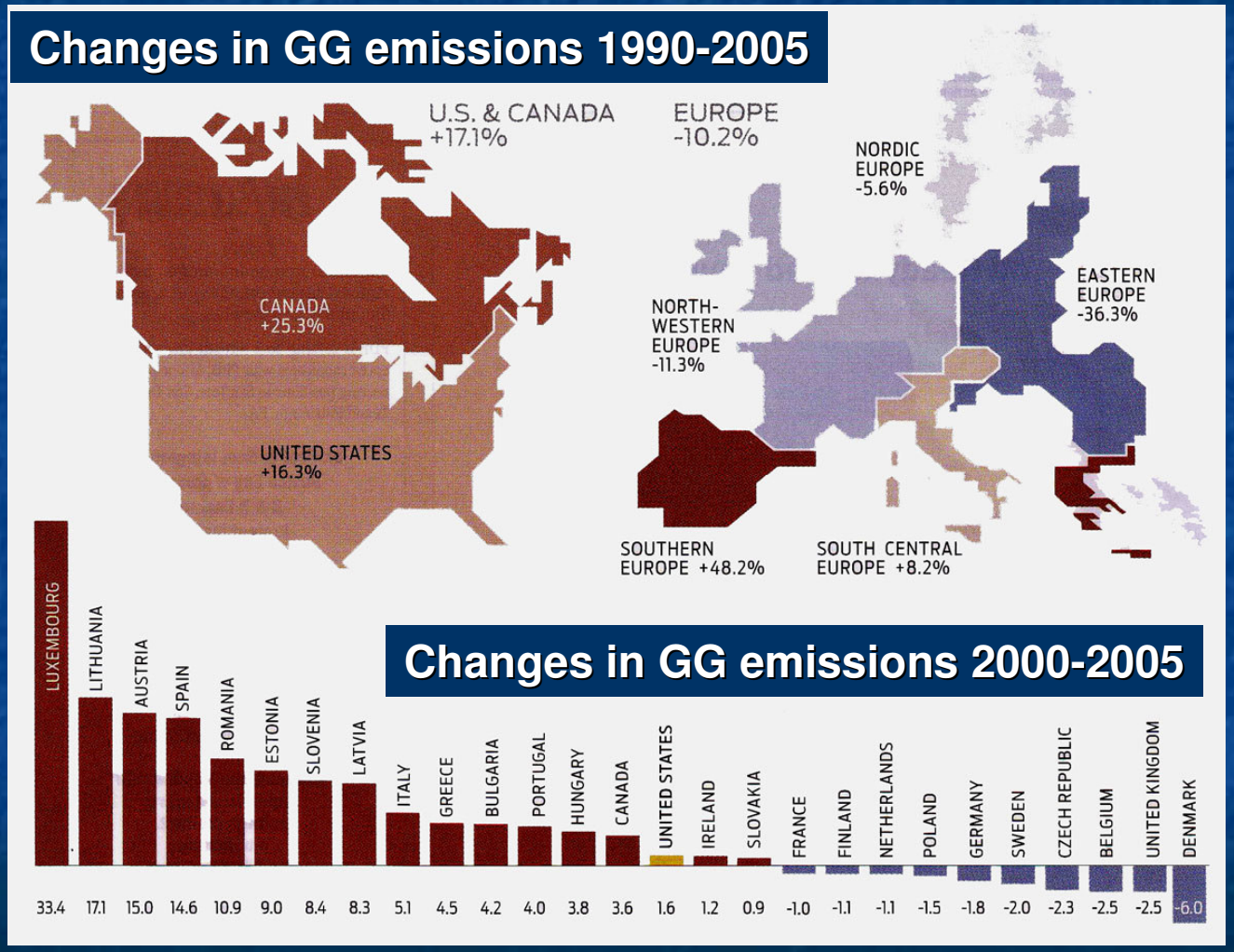
Recently observed CO_2 emission rates

- reality is already much worse than the worst case scenario.



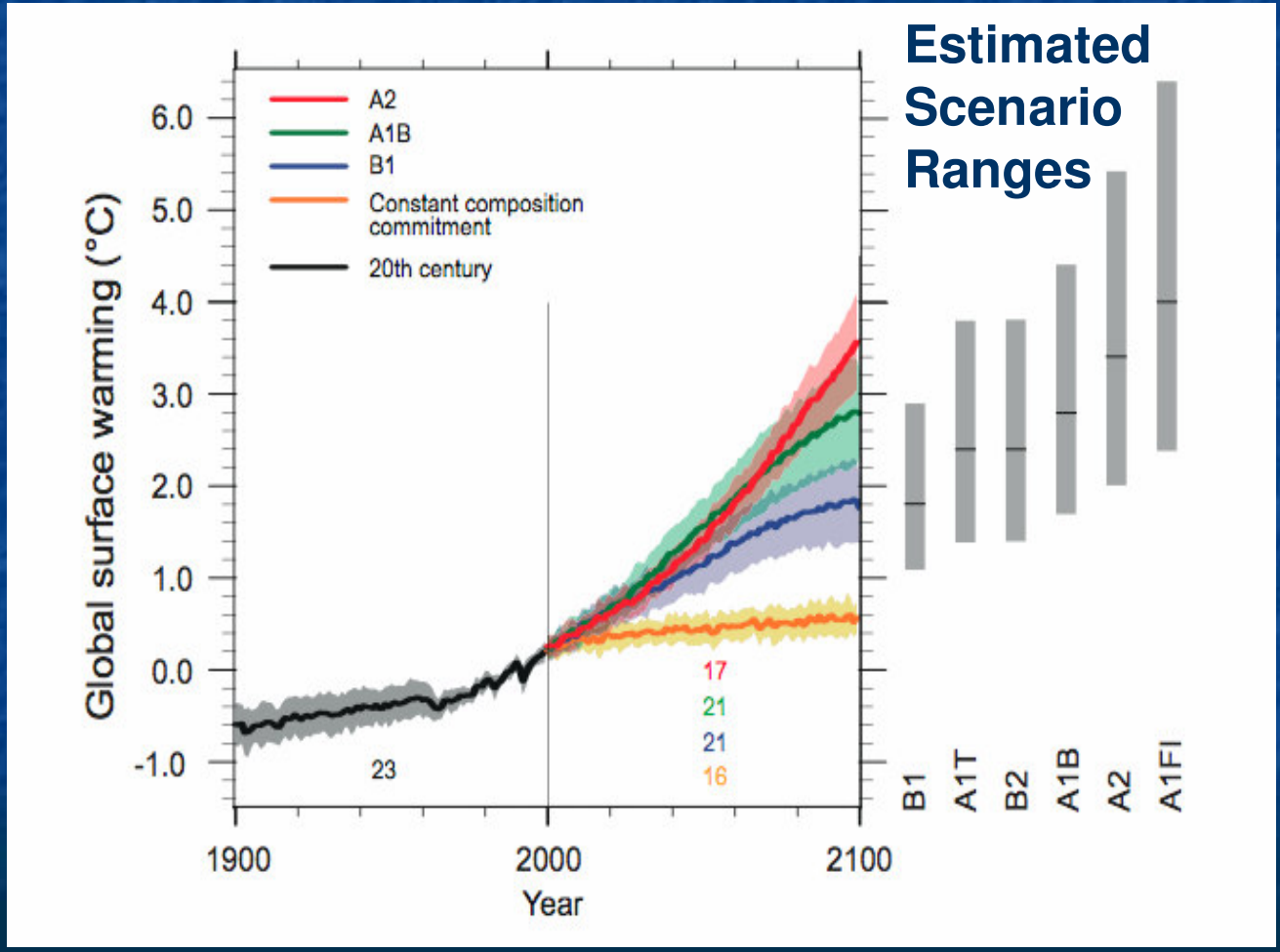
Source - IPCC

Recently observed CO_2 emission rates



Source - IEEE Spectrum - Jan.2008

Average Global Temperature change
(conservative linear model).



Source IPCC

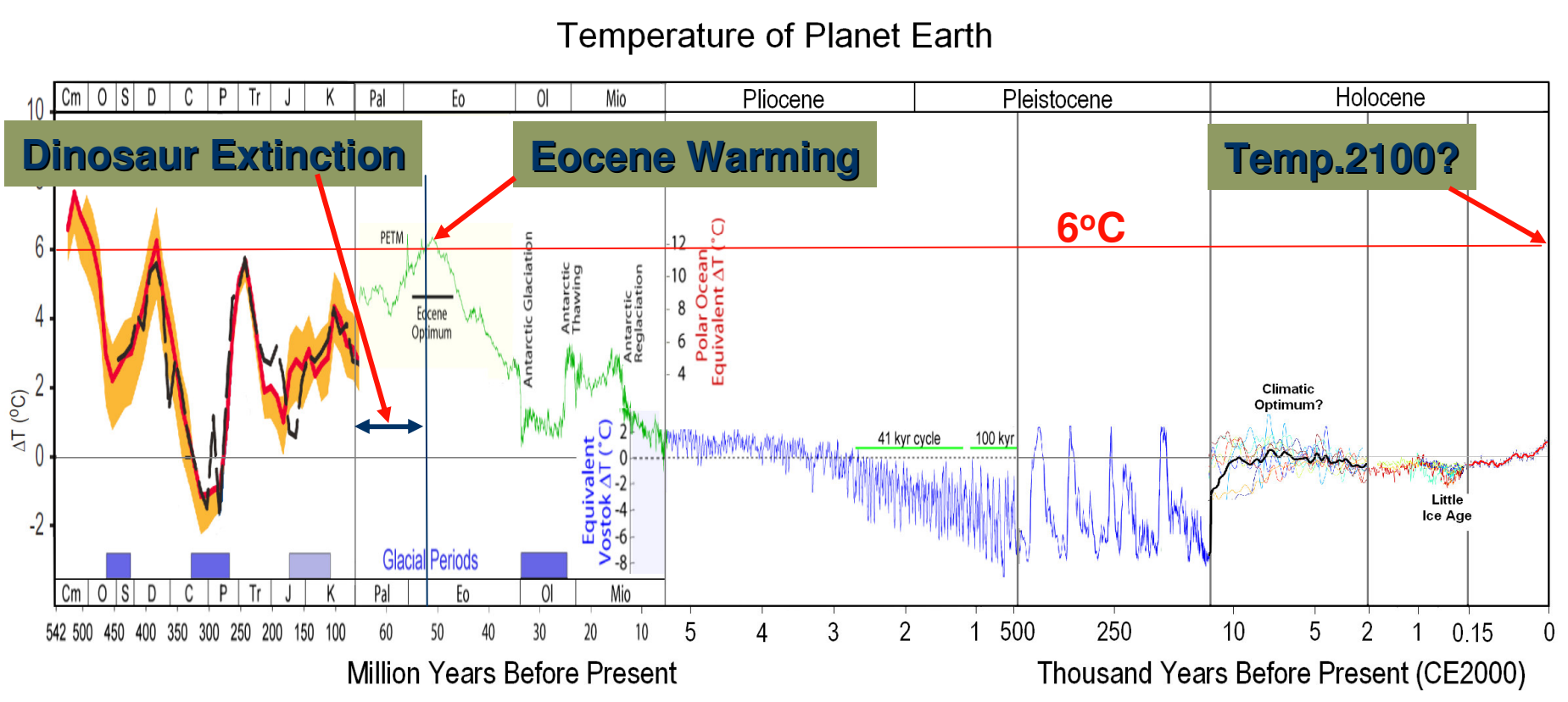
Just 6 degrees!

Equals a nominal 750 mile climate-zone shift!

Poland gets a Greek climate!

Temperature of Planet Earth over 542 Million Years

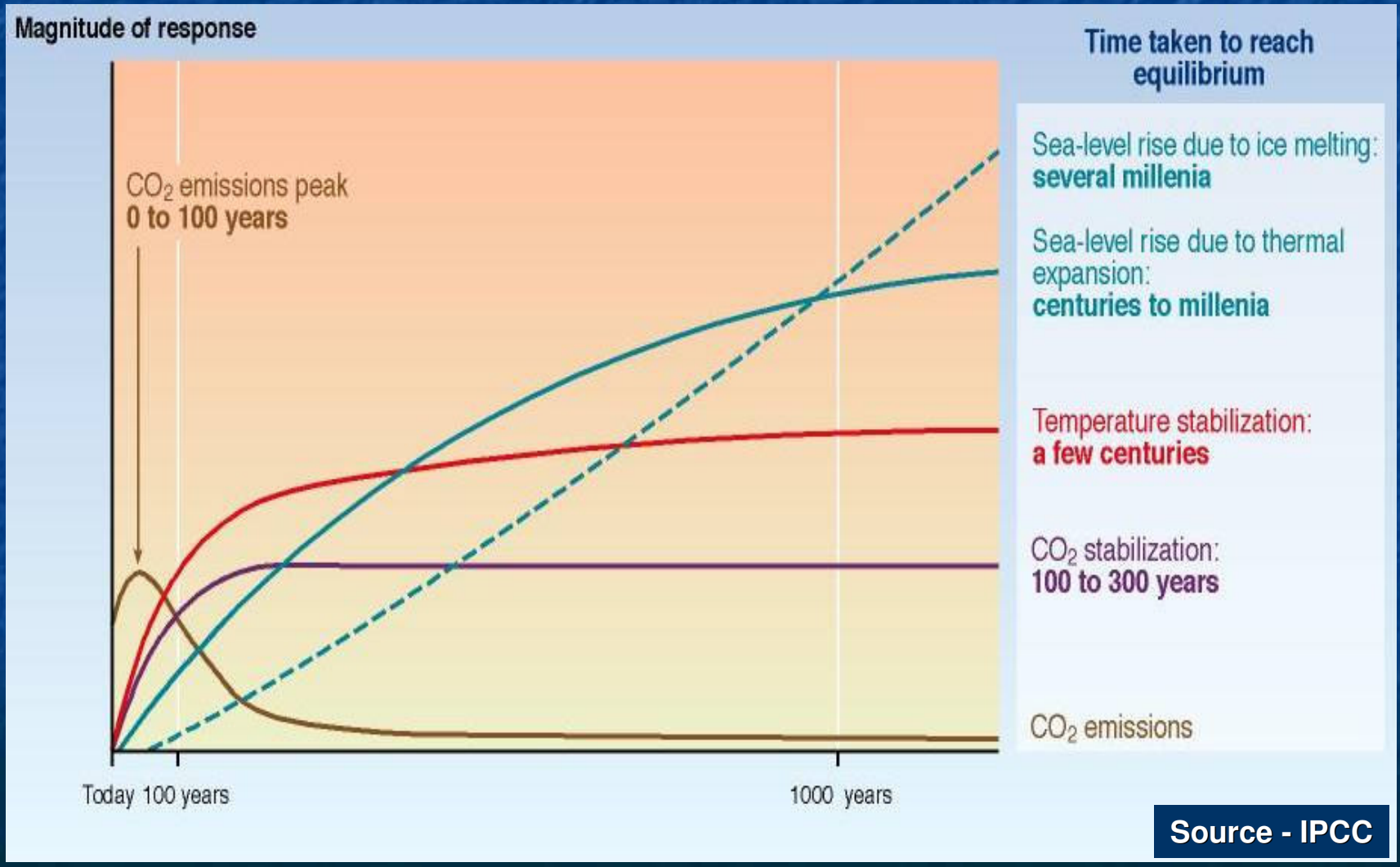
The last 6 degree hotter period was 55 million years ago!



Source - Wikipedia

Predicted Temperature Equilibrium -

Note temp. doesn't stabilise until long after emissions start to decline.



Source - IPCC

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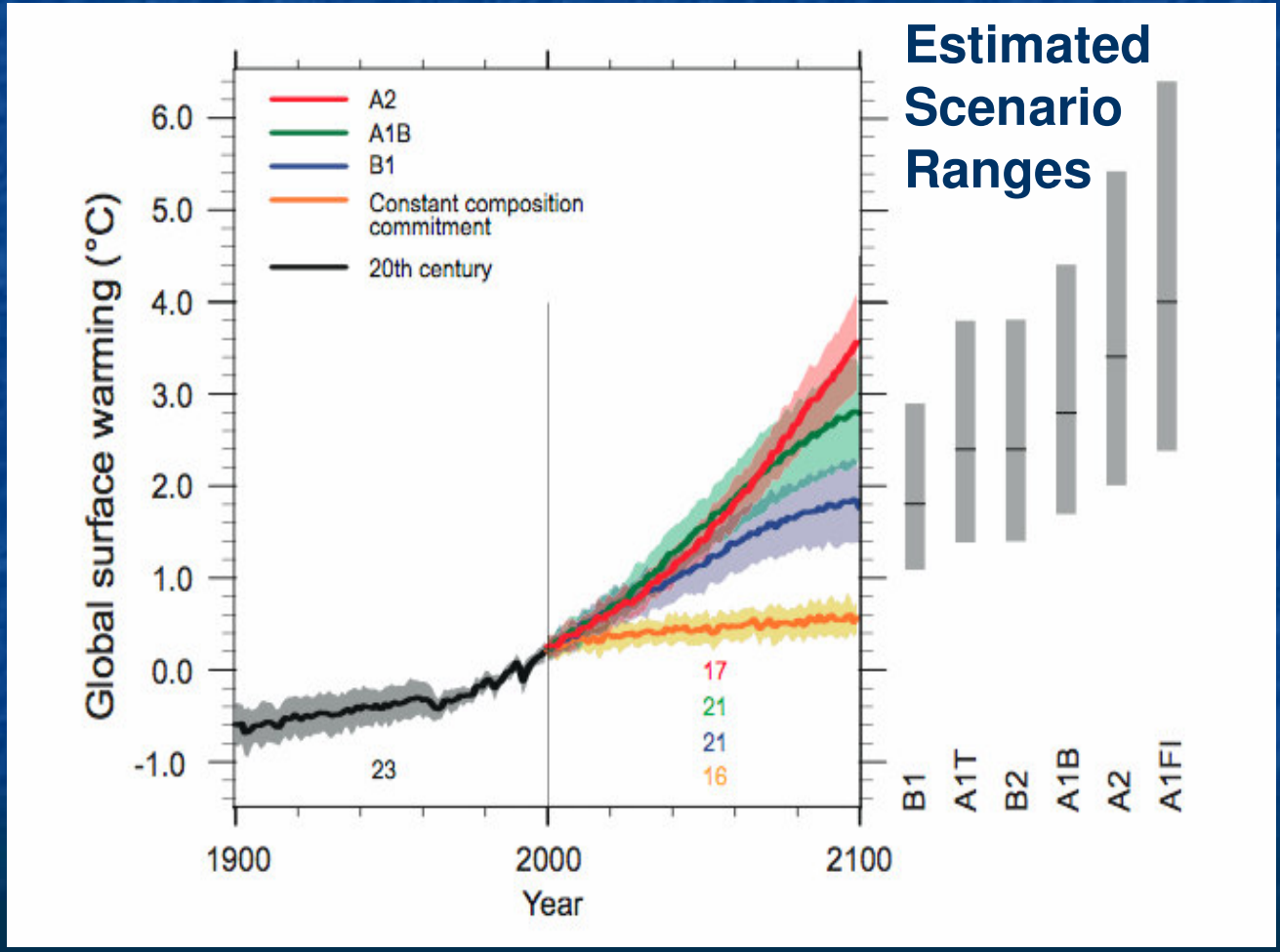
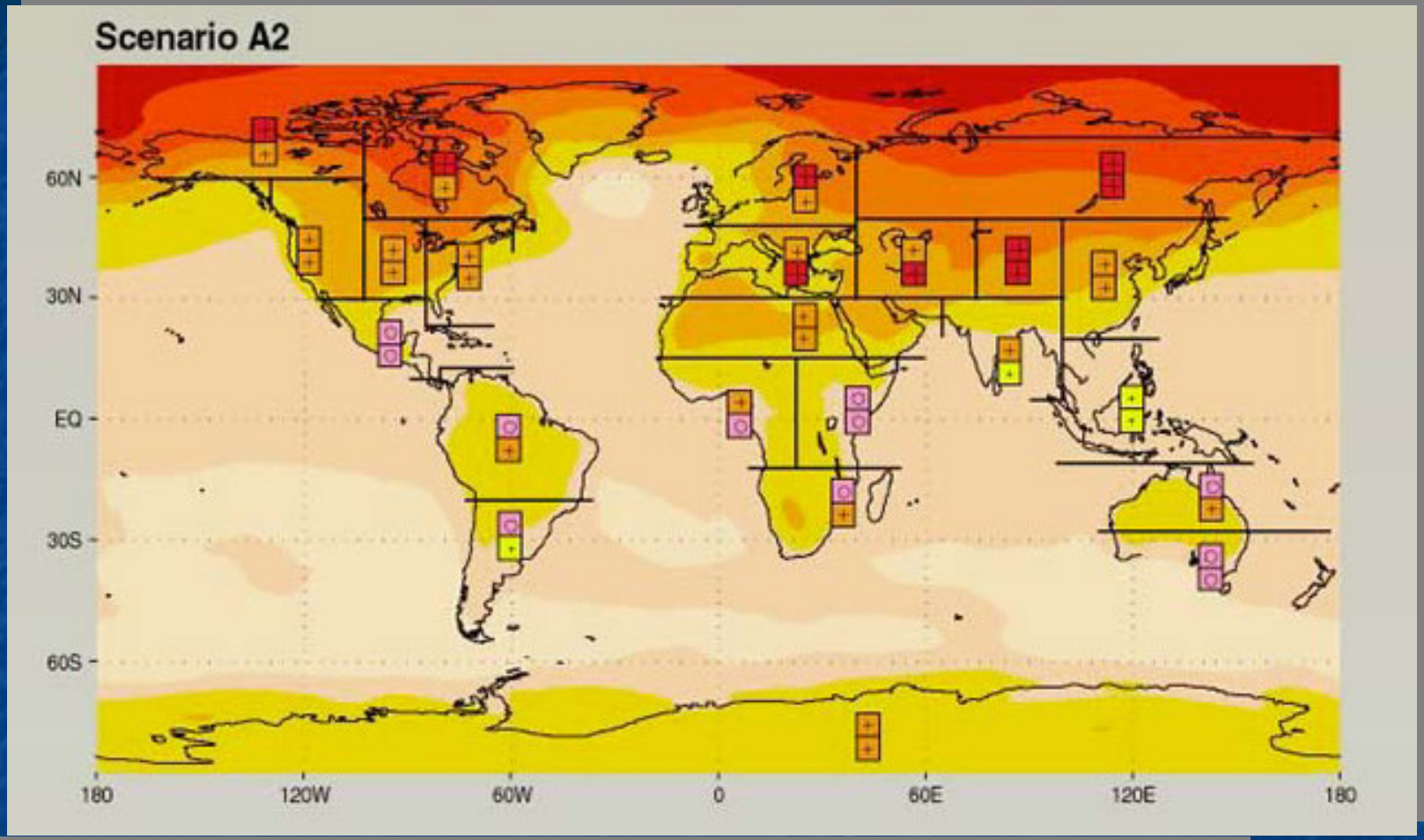


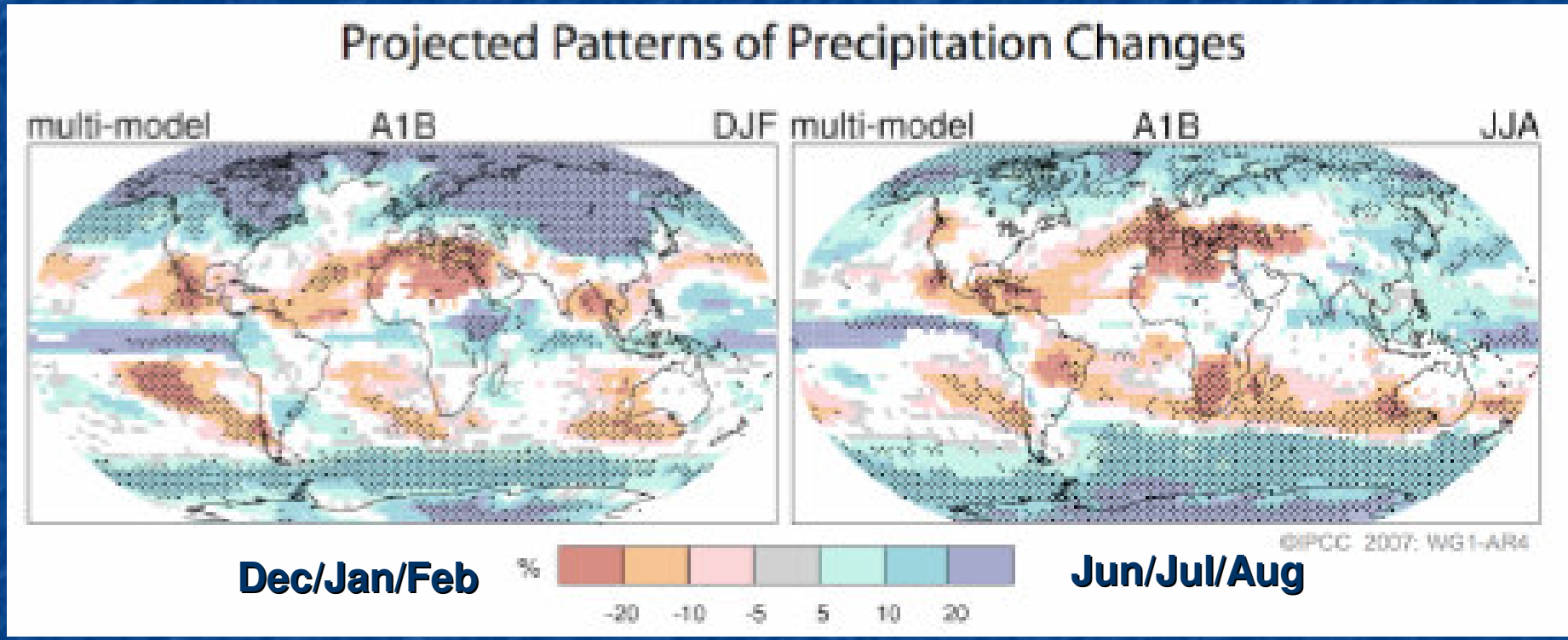
Source IPCC

Global Temperature changes -2100.



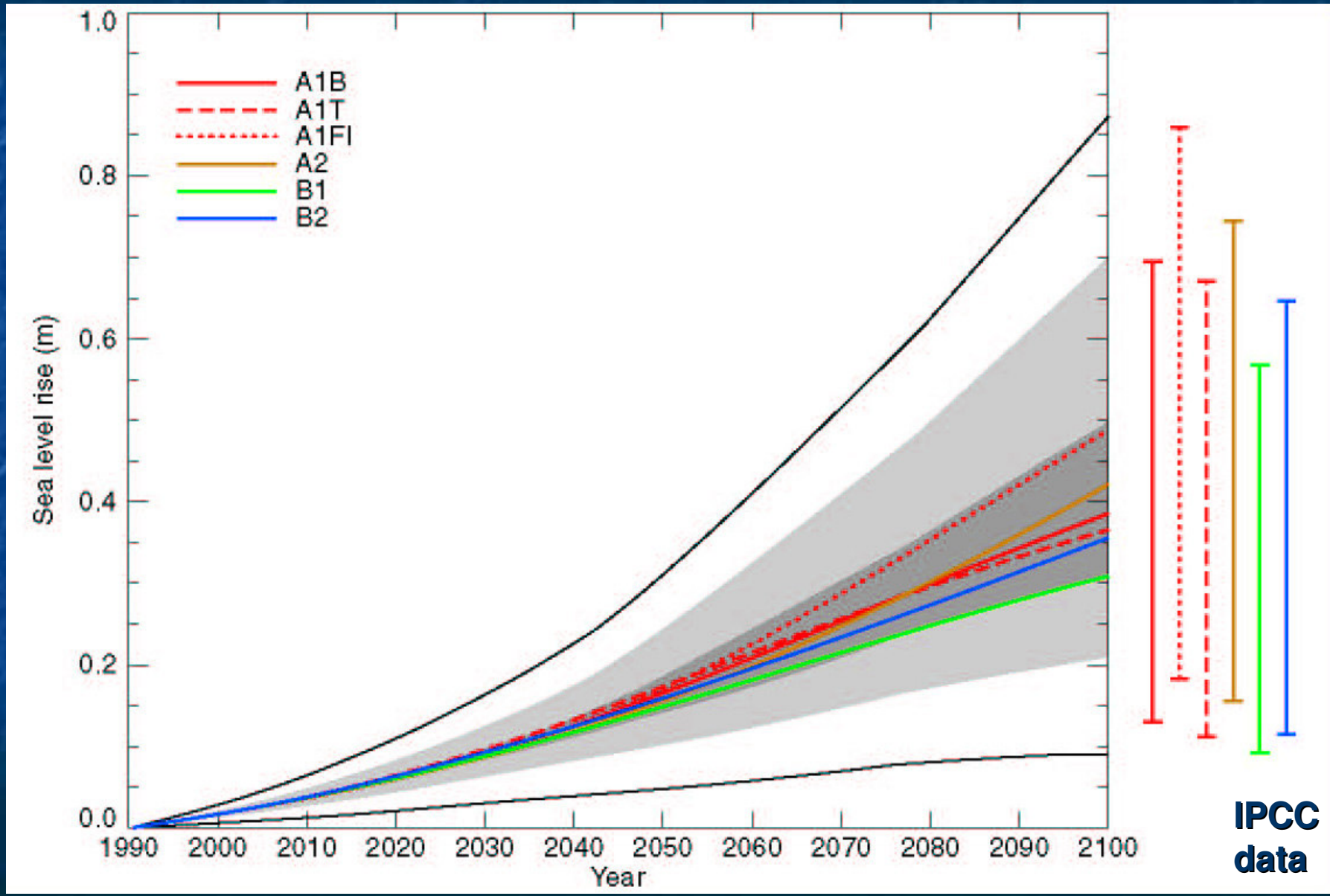
IPCC

Global Precipitation changes - 2100. IPCC-2007



IPCC

Predicted sea level changes



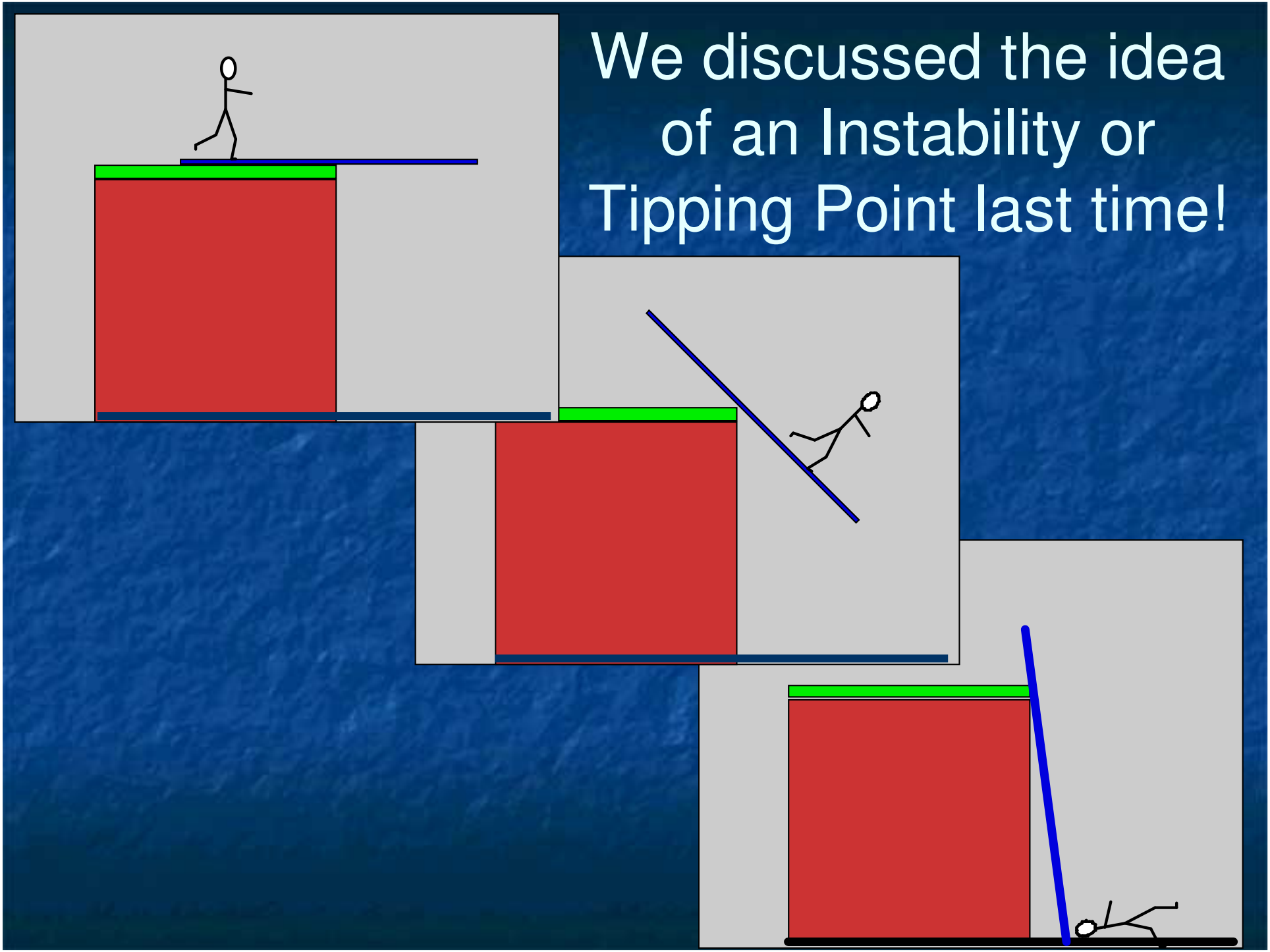
Effects already visible
(and all ahead of predictions).

Generally warming climate
Disruption of rainfall patterns (Australian drought)
Melting of glaciers and ice-caps.
Increased frequency of major storms
Melting of the North-Polar ice & reduction of sea ice generally.
Melting of Permafrost
Break-up of Antarctic ice-shelves.
Steadily rising sea levels.
Changes in the Gulf Stream flow rates.
Ecological disruption for plants, insects, birds etc

These changes are already :-

- Bad news for much of the human race
- And are already devastating for some
- Could lead to several hundred million refugees by 2100
- But the real worry is worse than this
  - Albeit still a subject of intense scientific debate and uncertaintity.

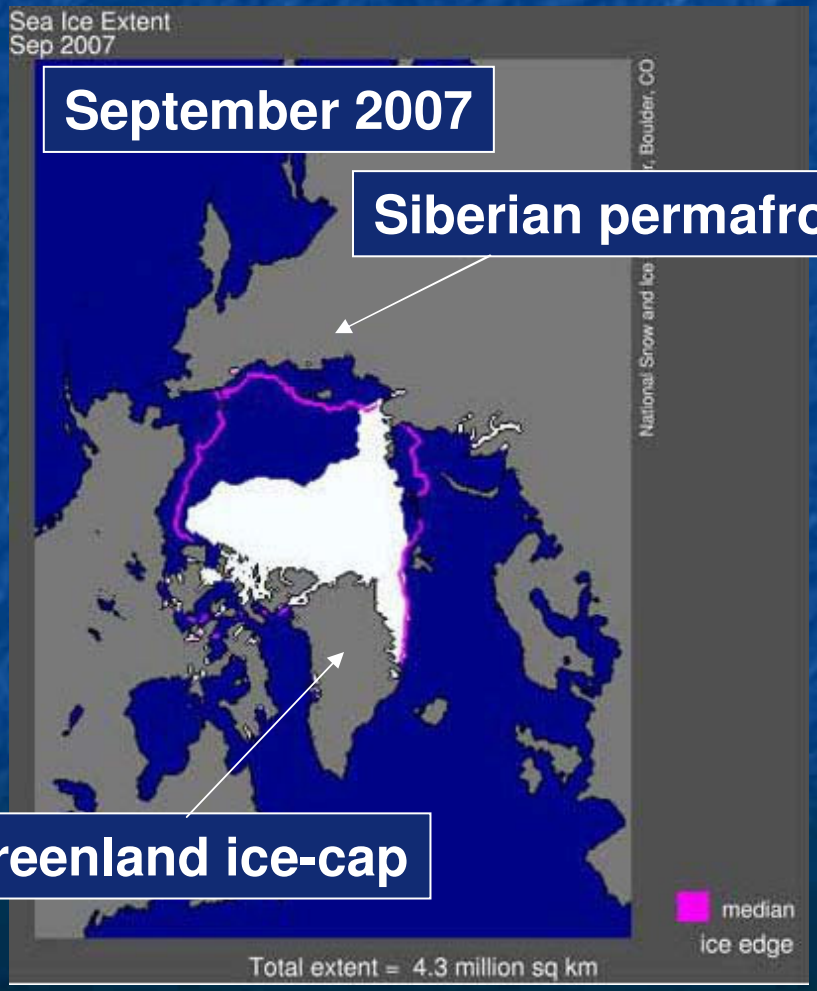
We discussed the idea of an Instability or Tipping Point last time!



Here are some more examples of known Climate Instabilities.

The North Polar Sea-Ice

Seems to be an instability already triggered that is closely linked to two worse ones.?



National Snow & Ice Data Centre, USA

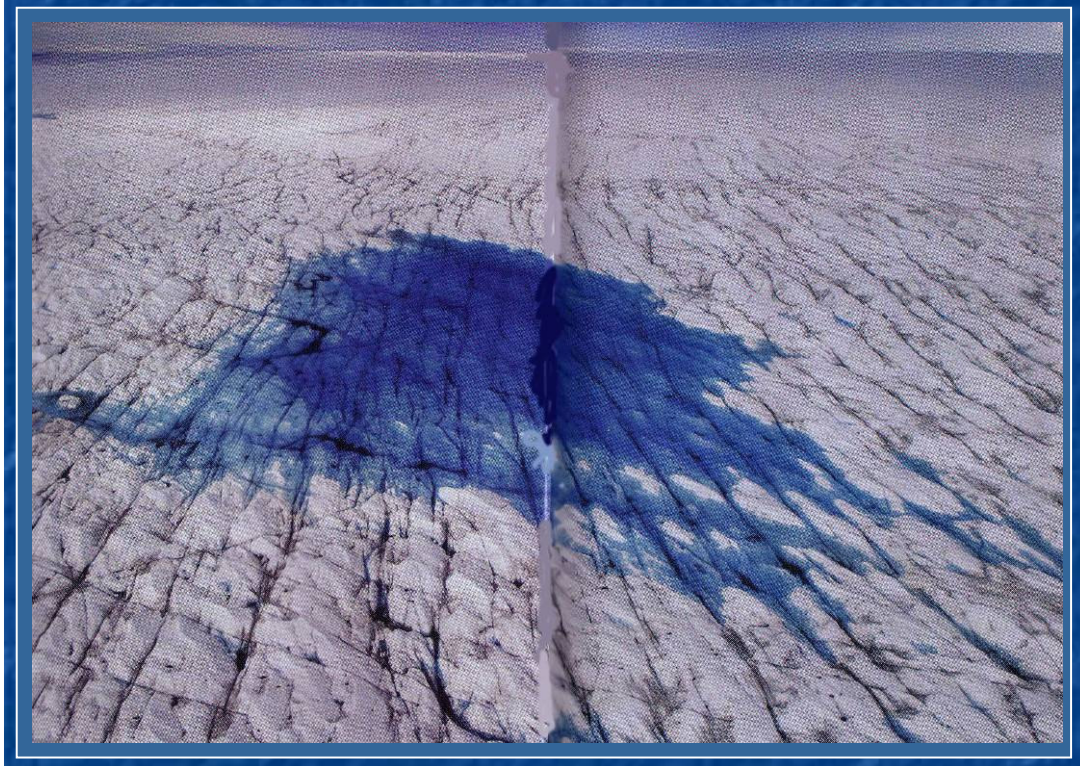
Greenland Ice Cap

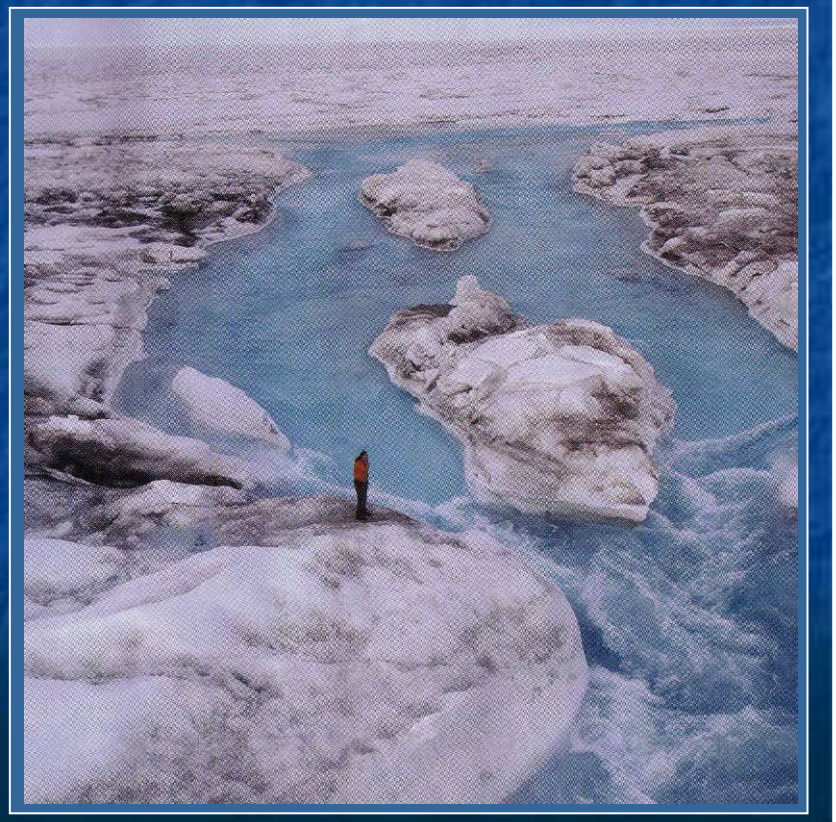
- Another major snow & ice field subject to unstable melting
- Already shown to be melting far faster than expected
- Losing 200 cubic kilometres of ice/annum
- Gives a 7m or 23 foot sea level rise if it all melts.

Ice Cap Melting

- What seems to be happening is that :-
  - The surface ice is melting
  - The melt-water tunnels down through crevasses to the ground level
  - This then causes large blocks to slide down into the sea (e.g. Glaciers flow much faster)
  - Where they break off and melt in the ocean
- This means the Greenland & West Antarctic Ice Caps are melting far faster than predicted.

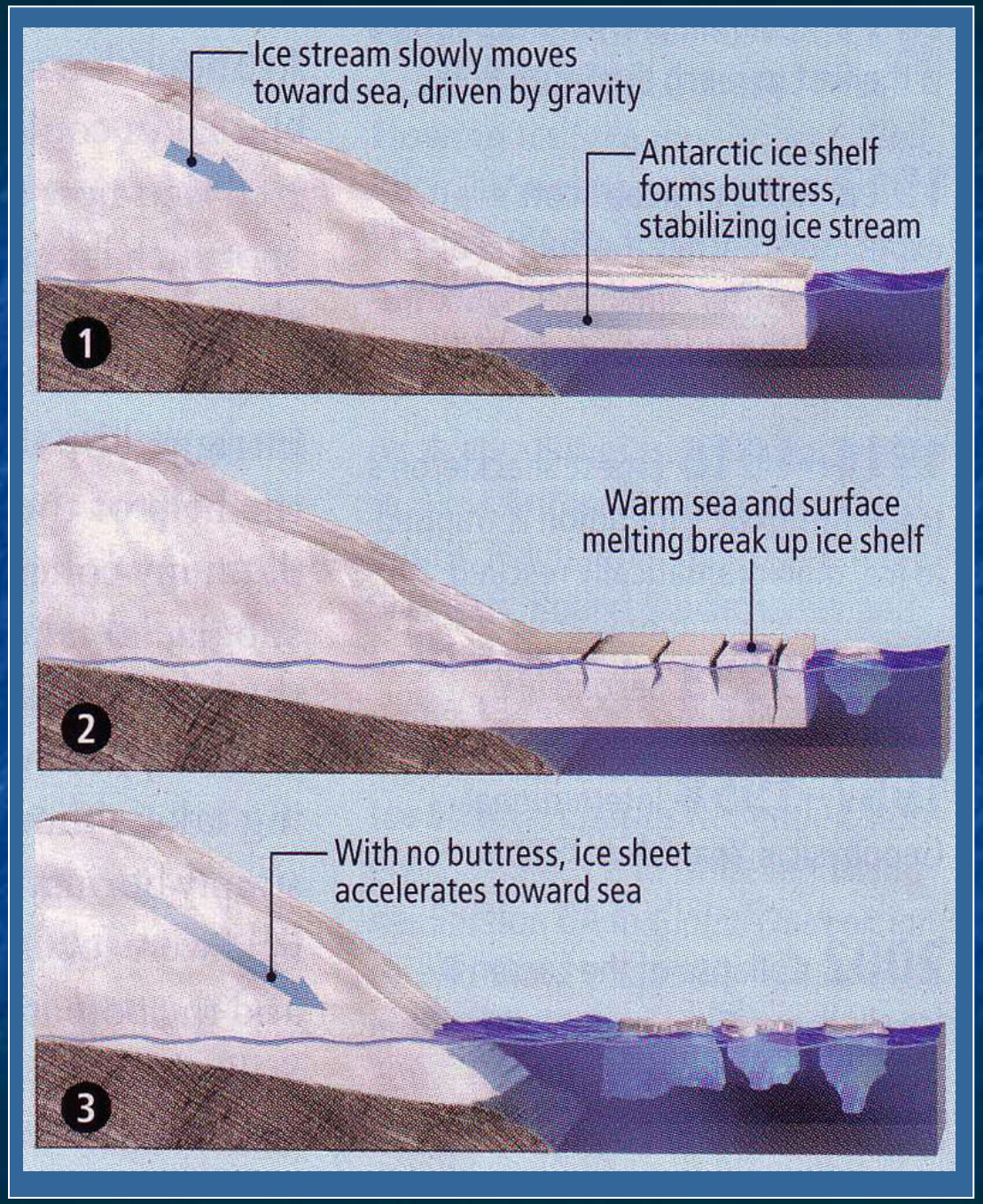
Meltwater lake & sink-hole on the Greenland Ice-cap





Source - Scientific American

Effect of ice-shelf loss, another effect speeding melting.



Source - Scientific American

The Planet's stores of Ice.

Location	Volume Cubic kms	Potential sea level rise (m)
East Antarctic ice sheet	26,039,200	64.80
West Antarctic ice sheet	3,262,000	8.06
Antarctic Peninsula	227,100	0.46
Greenland	2,620,000	6.55
All other ice	180,000	0.45
Total	32,328,300	80.32

Note - at 200 cub.km./annum, Greenland takes 13000 years to melt.

Source - USGS

Permafrost in Canada & Siberia?

Another tipping point?

- Rotting vegetable matter produces methane.
- In permafrost, this is trapped under the frozen layer.
  - But once this layer melts, methane can bubble out
  - and methane is a powerful greenhouse gas
  - which now produces more warming.
  - which melts more Permafrost
  - which frees up more methane
- And the Siberian permafrost is showing signs of melting
- Another tipping-point balanced on the edge or over it?

Permafrost in Siberia?

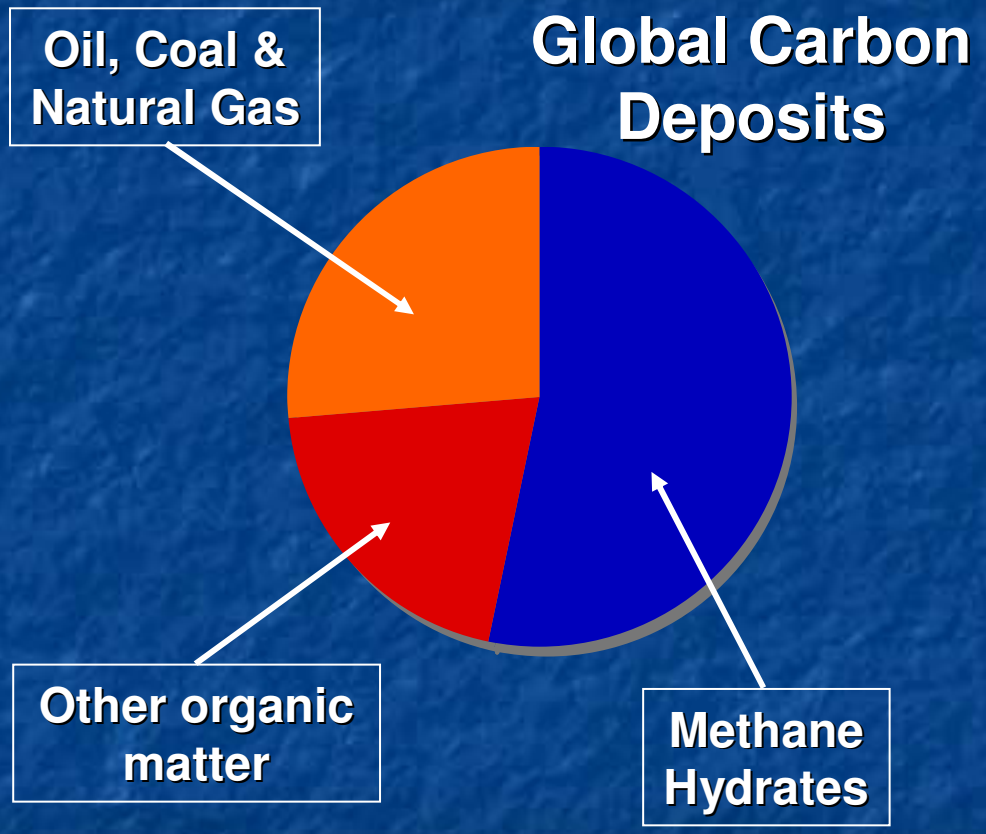
Melting permafrost peatlands at Noyabrsk, Western Siberia

Methane hydrates in ocean sediments

- Rotting vegetable matter also produces methane in ocean sediments or silt.
- And it can be trapped as Methane Hydrate if :-
  - The pressure is high enough
  - The temperature is low enough
- It is known that ocean warming can lead to its release

Note - Methane Hydrate = $(CH_4)_8.(H_20)_{46}$

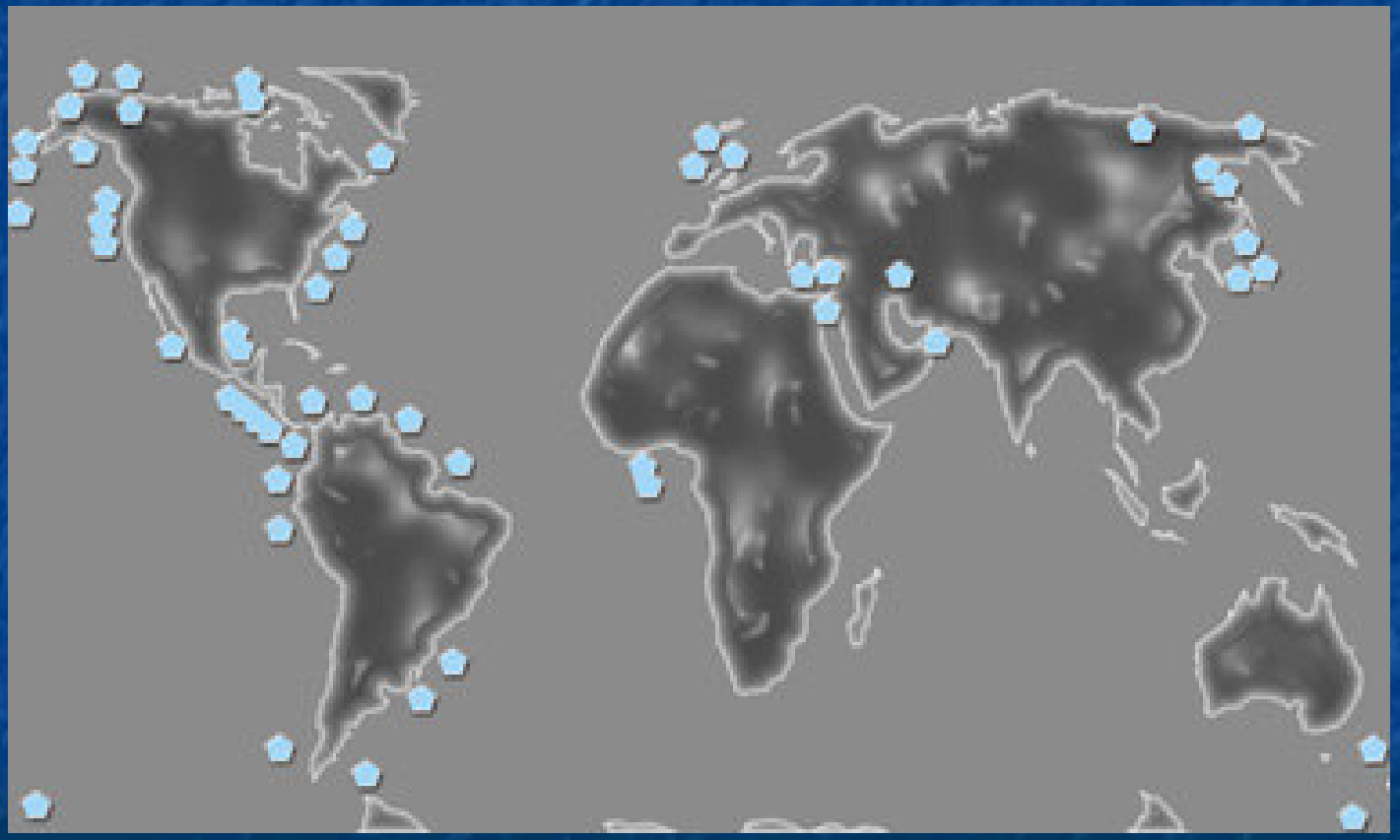
Methane hydrates.



Methane Hydrate looks like ice!

Source - Prof E Thomas, Weslyan U, USA

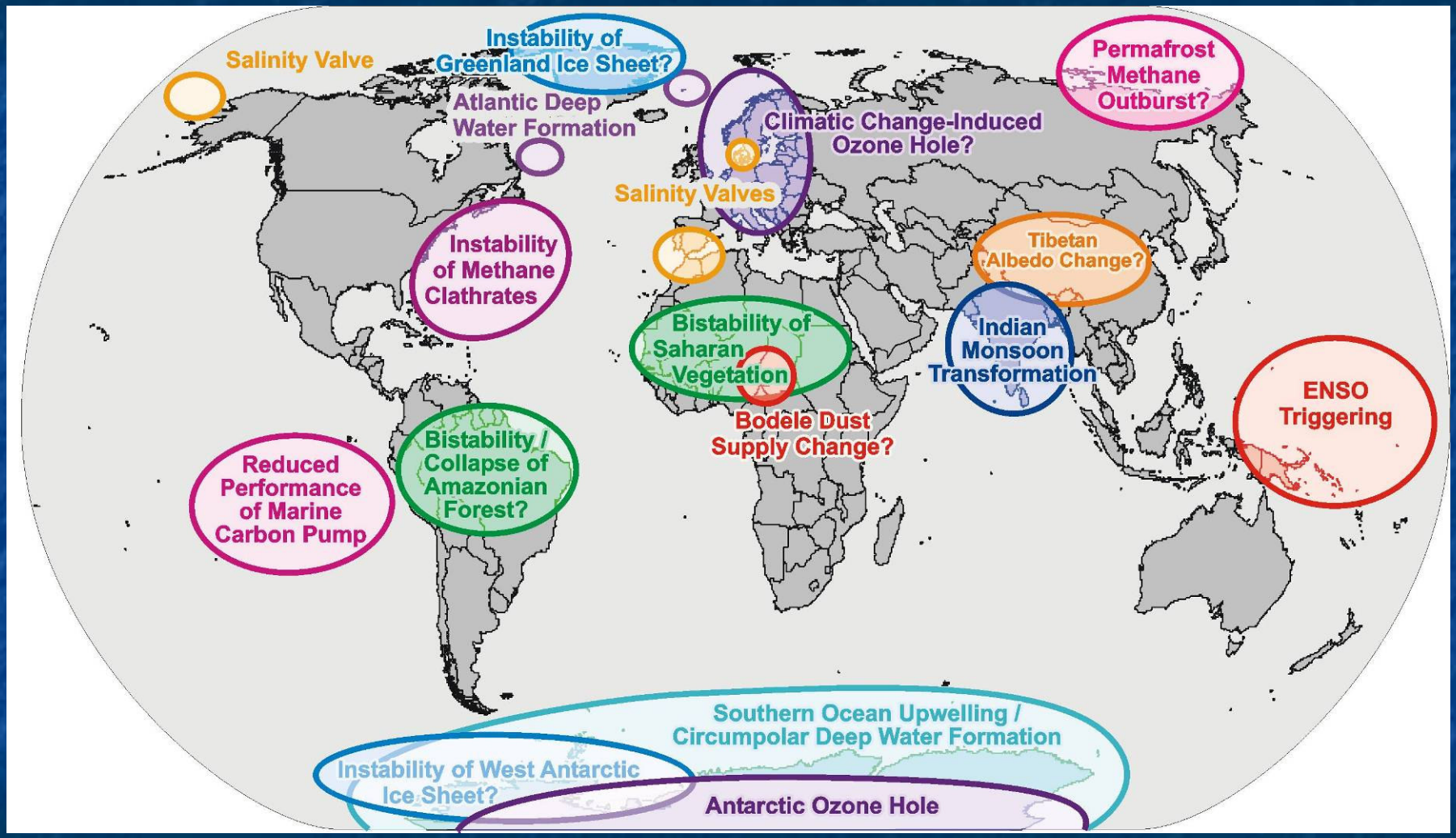
Methane hydrates in ocean sediments - known locations.



Note - Methane Hydrate = $(CH_4)_8.(H_20)_{46}$

Source - USGS

Tipping Points in the Earth System



Slide produced by J Schellnhuber, Potsdam Institute

ENSO - El Nino Southern Oscillation
Bodele depression supplies dust to fertilise the Amazon delta (40Mt/a)!

Instabilities

- So far as I know none has triggered as yet
- Nor is any definitely predicted to do so shortly
- But if we wished to trigger one or several we could hardly be trying harder!

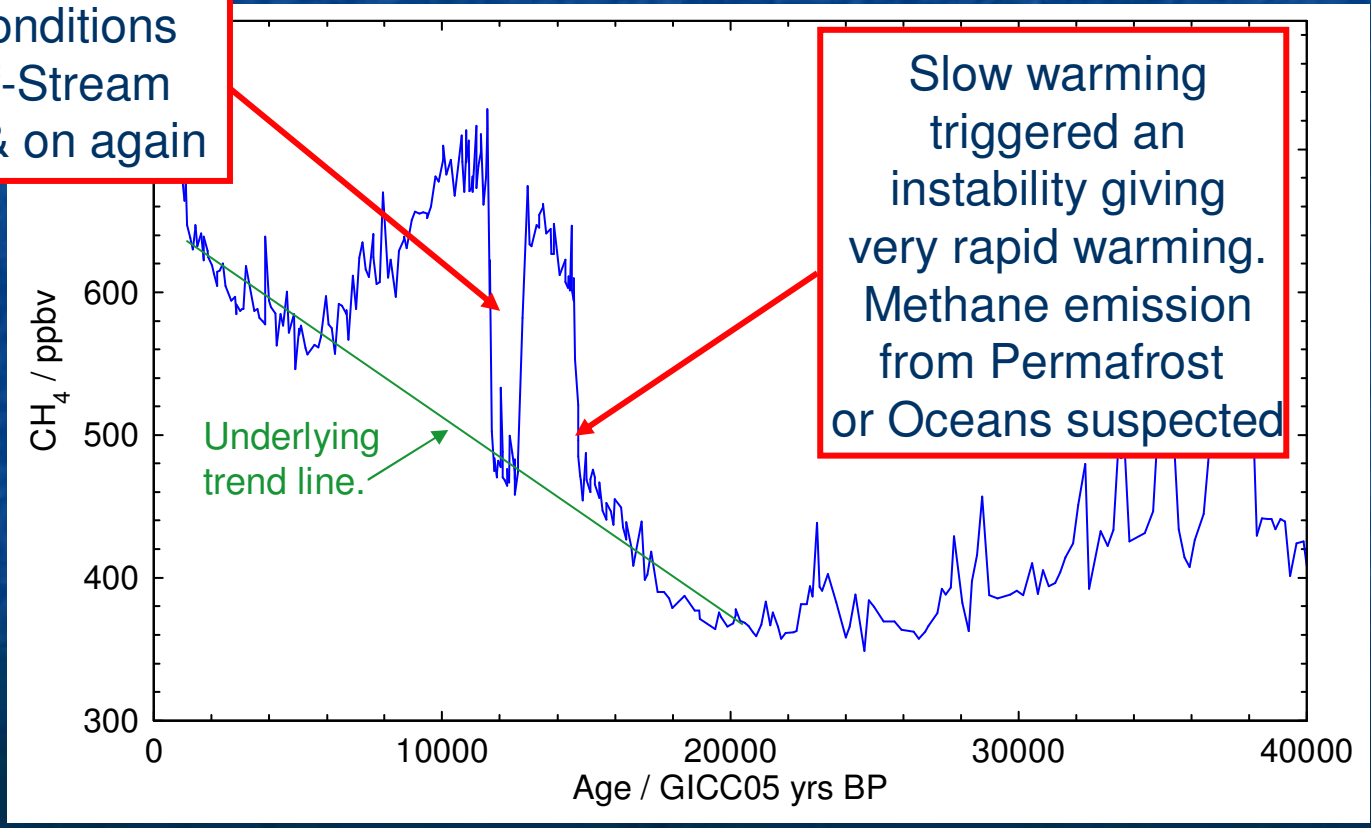
Note

- this is not pure fiction
- we have been here before!

The Planet was warming gently but Northern Europe's temperature bounced around brutally!

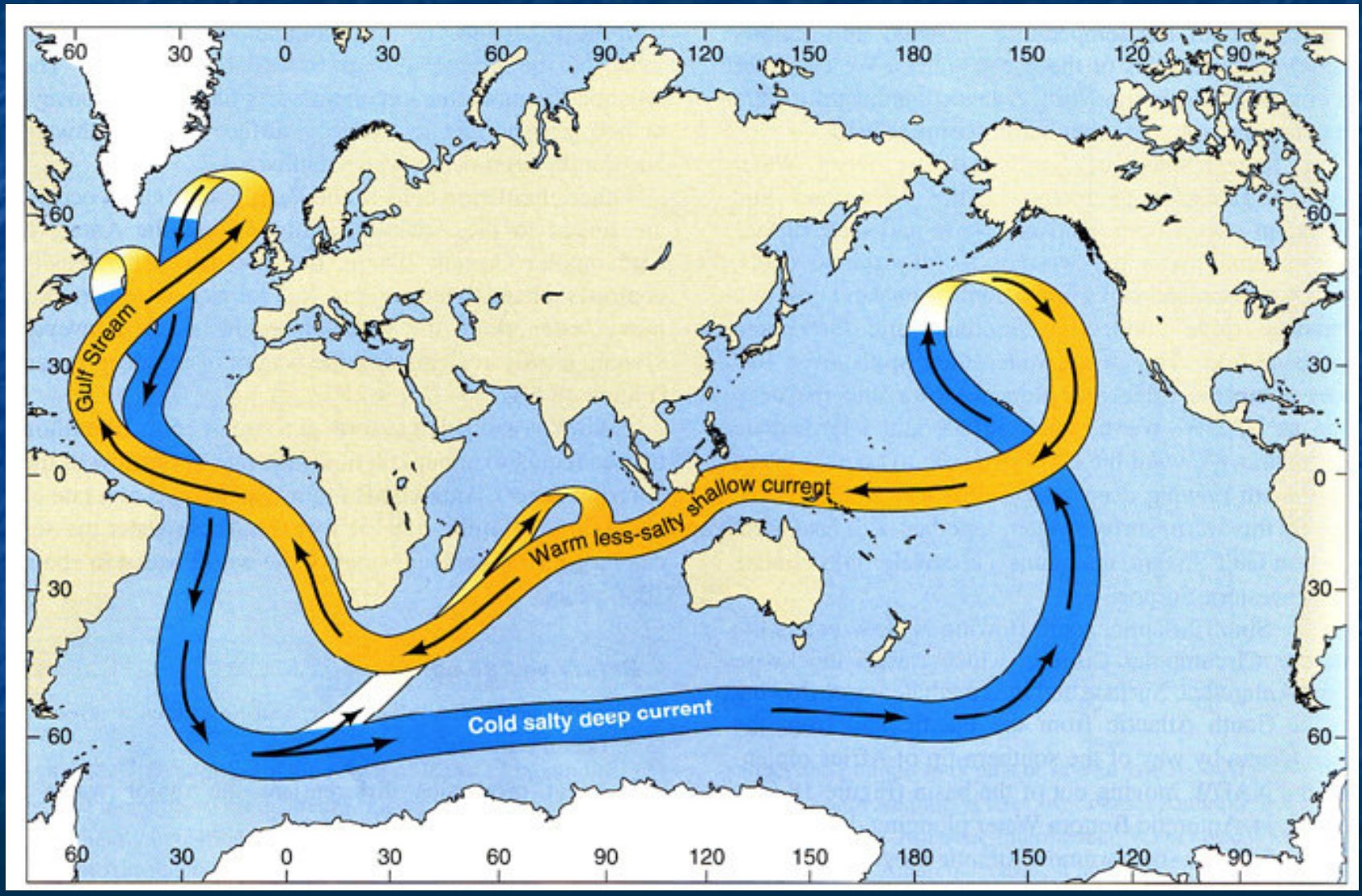
Small temperature triggers set off much bigger instabilities.

Rapid return to ice-age conditions when Gulf-Stream turned off & on again



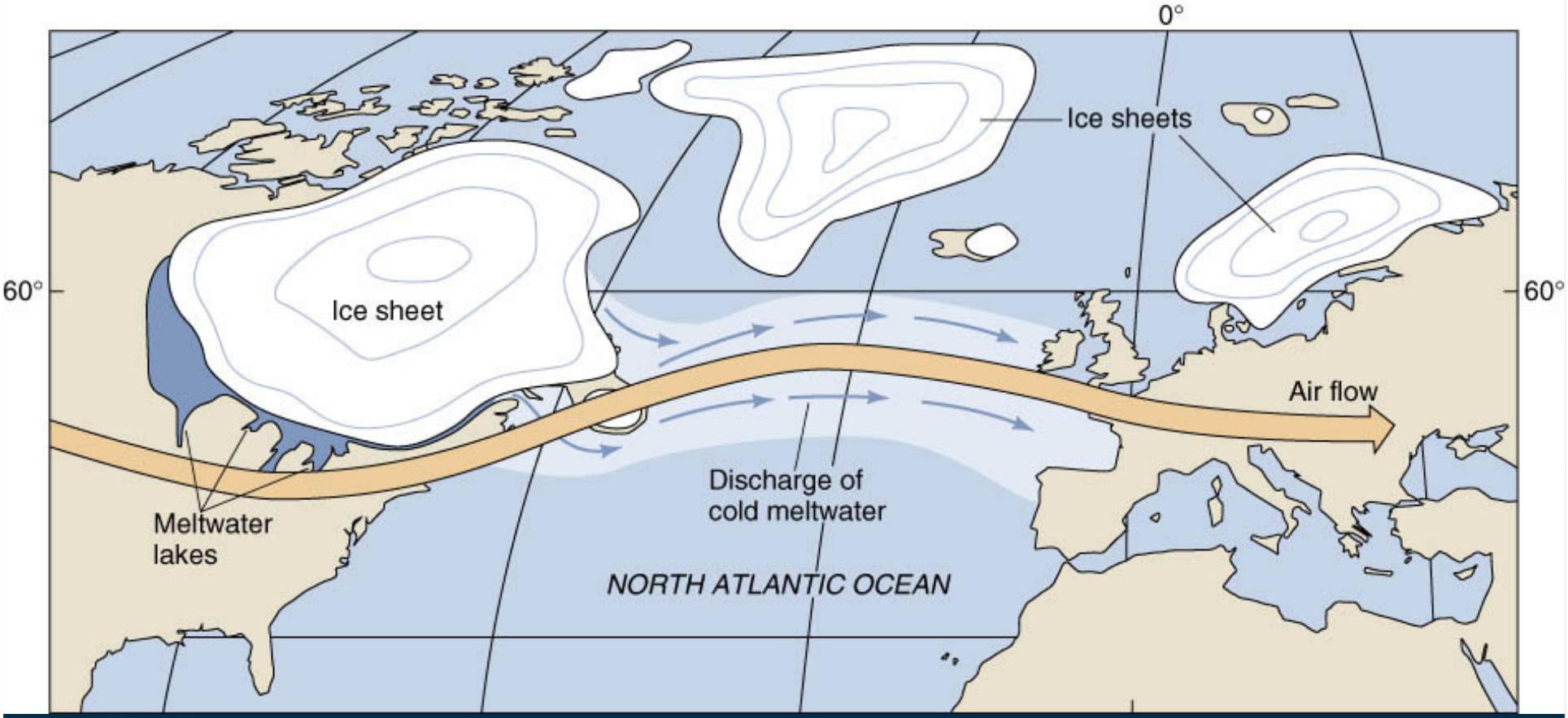
Slow warming triggered an instability giving very rapid warming. Methane emission from Permafrost or Oceans suspected

Today's "ocean energy conveyor"



Source - "Dynamic Earth, an Introduction to Physical Geology", Pub Wiley.

The “Younger-Dryas” event
~ 12000 -11000 y.b.present
Gulf-Stream turn-off!



Source - “Dynamic Earth, an Introduction to Physical Geology”, Pub Wiley.

Why should we be concerned?

We know :-

- we have triggered very rapid warming.
- the N.Polar ice sheet is melting rapidly
- the Greenland ice cap is melting
- the West Antarctic ice cap is melting
- Methane is starting to leak from Siberian permafrost.
- massive Methane Hydrate deposits exist
- the Gulf Stream flow is changing.
- The potential for disaster is scary!

Some predictions follow based on worst case assumptions

Taken from “6 degrees” by Mark Lynas

1 degree rise

- Ice free sea absorbs more heat & accelerates global warming
- Fresh water lost from 1/3rd planet surface
  - More severe droughts
- Low lying coastlines flooded
  - Small sea level rises

From “SIX DEGREES” by Mark Lynas

2 degree rise

- Europeans dying of heatstroke
- Forests ravaged by fire
- Stressed plants start to emit CO_2 rather than absorb it
- A third of all species face extinction

From “SIX DEGREES” by Mark Lynas

3 degree rise

- Carbon release from plants and soils speeds global warming
- Death of Amazon rainforest
- Super hurricanes hit coastal cities
- Starvation in Africa

From “SIX DEGREES” by Mark Lynas

4 degree rise

- Runaway thaw of Permafrost makes global warming unstoppable
- Much of Britain suffers severe flooding
- Mediterranean region abandoned

From “SIX DEGREES” by Mark Lynas

5 degree rise

- Methane from ocean floor accelerates global warming
- Ice gone from both poles
  - (50-80m sea level rise)
- Humans migrate in search of food and try to live like animals off the land.

From “SIX DEGREES” by Mark Lynas

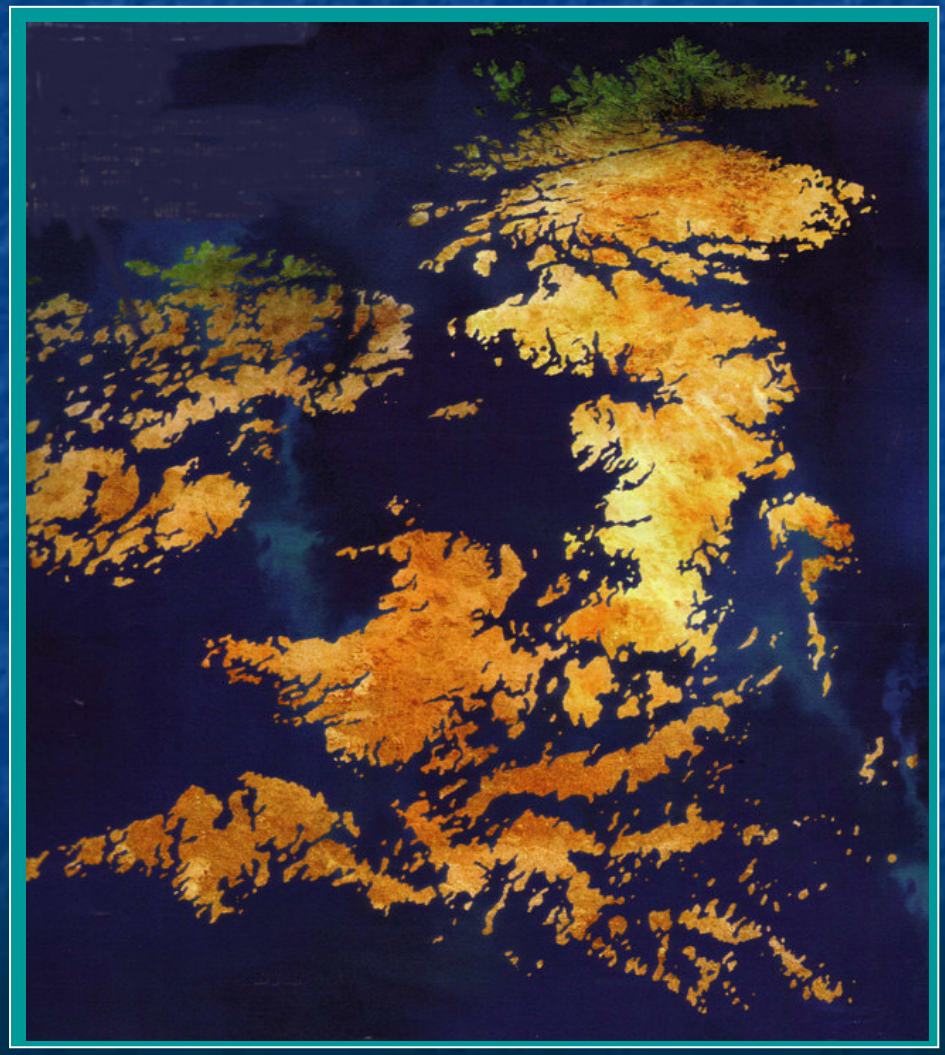
6 degree rise

- Life on earth ends with apocalyptic storms, flash floods and H_2S and CH_4 fireballs racing across the globe with the power of atomic bombs
- Only fungi survive.

From “SIX DEGREES” by Mark Lynas

The UK with 80m sea level rise

(long term impact of passing a major tipping point)



Europe, Africa & Asia after 80m sea-level rise.

The Americas after 80m sea-level rise.

Major Conclusions (by IPCC - not me!).

The Earth's climate is warming -

- human activities are primarily responsible

- further climate change is inevitable without actions to reduce GHG emissions

Major Conclusions (by IPCC - not me!).

Most socio-economic sectors, ecological systems and human health will be adversely affected by climate change, with developing countries being the most vulnerable

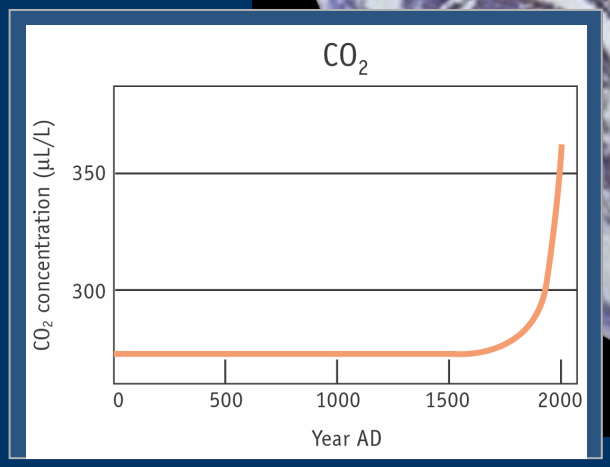
Major Conclusions (by IPCC - not me!).

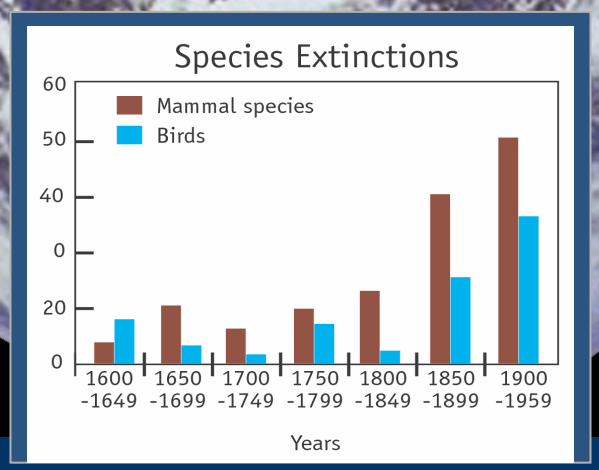
Technologies are available to reduce greenhouse gas emissions

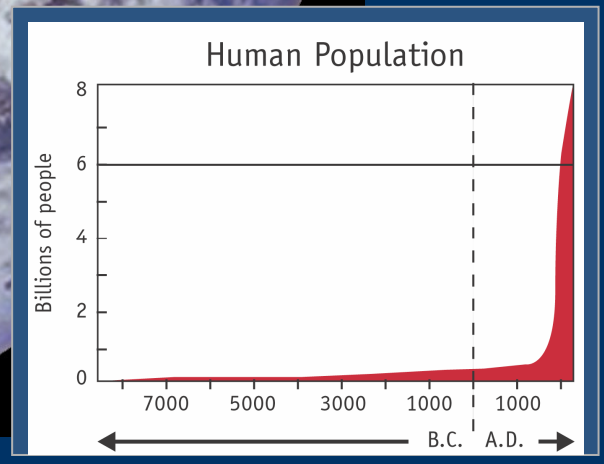
- but policies and measures are needed to realize the technological potential

The Huge Challenge: Sustainable Management of an Ever-Changing & Overpopulated Planet

Source - IPCC





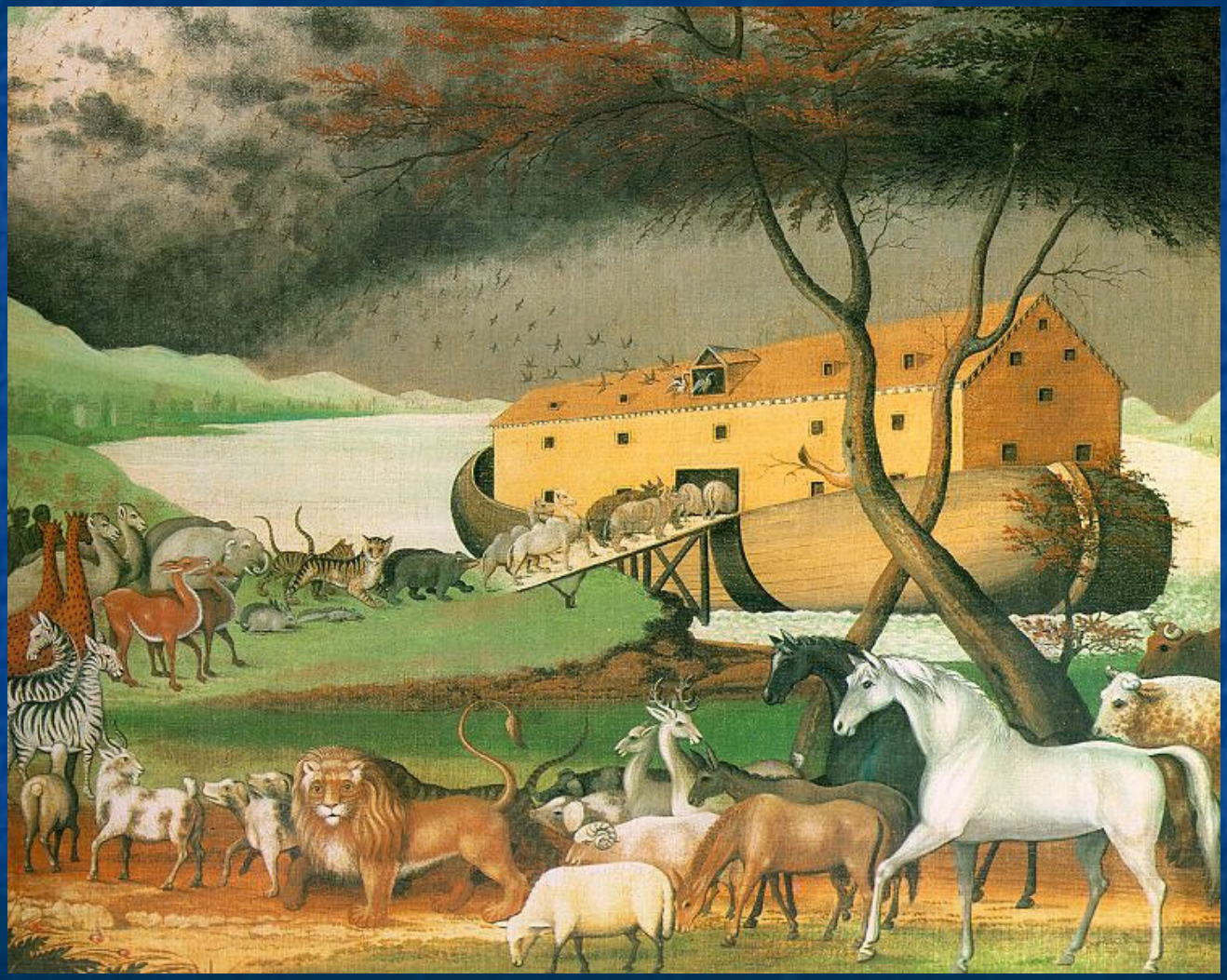


Closing words!

We don't need to worry about saving the Planet - it will be just fine. It is the human race we need to worry about!

"The Power of the Planet" by Iain Stewart BBC Television. His closing words, not mine!

The ideal present for your loved ones!

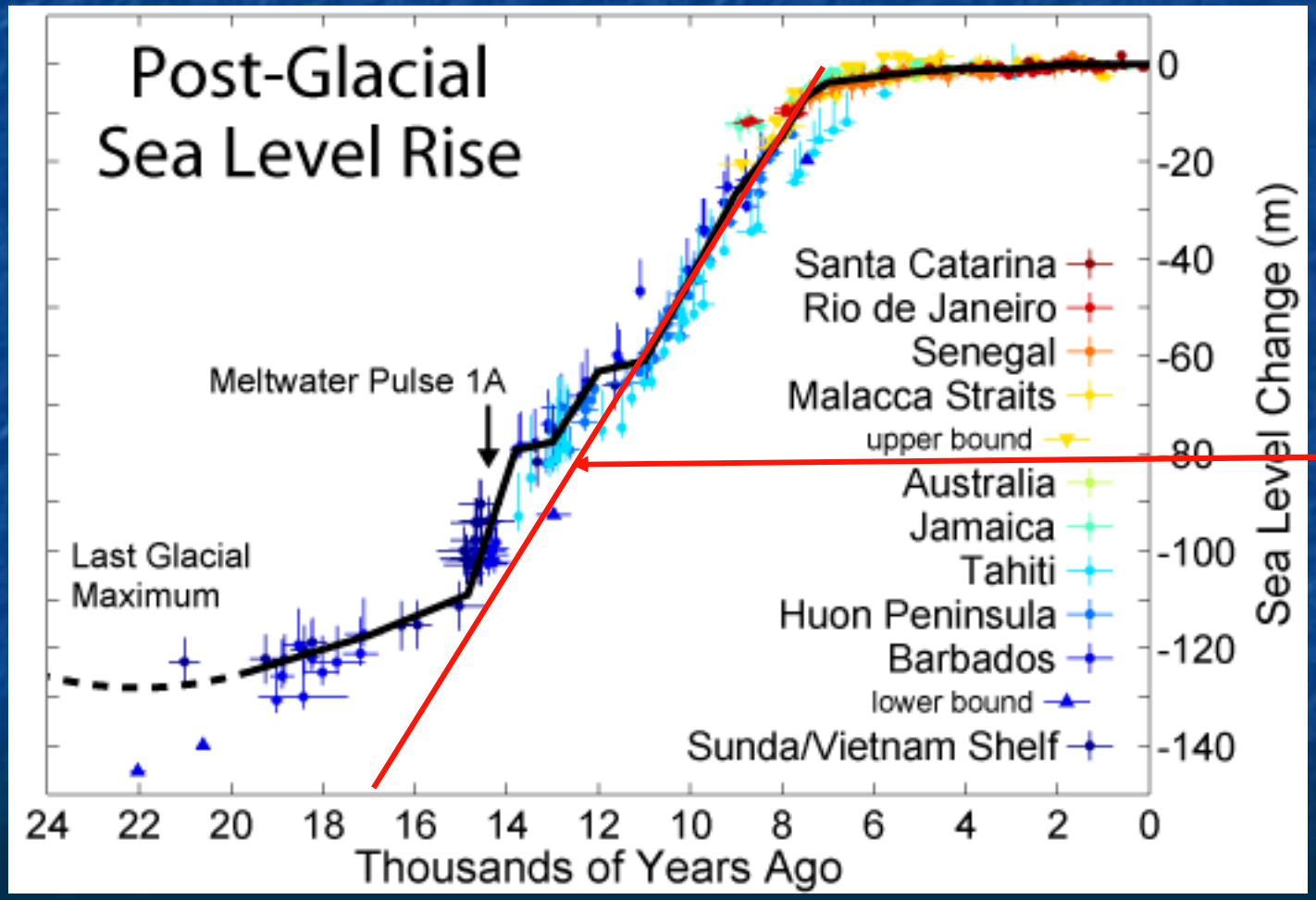


FINIS Part 2.

Acknowledgements

- Figures are acknowledged as they occur.
- Linking text and overall presentation by J E Midwinter.

Sea Level change post the last ice-age.



Slope is about 1.7m per century