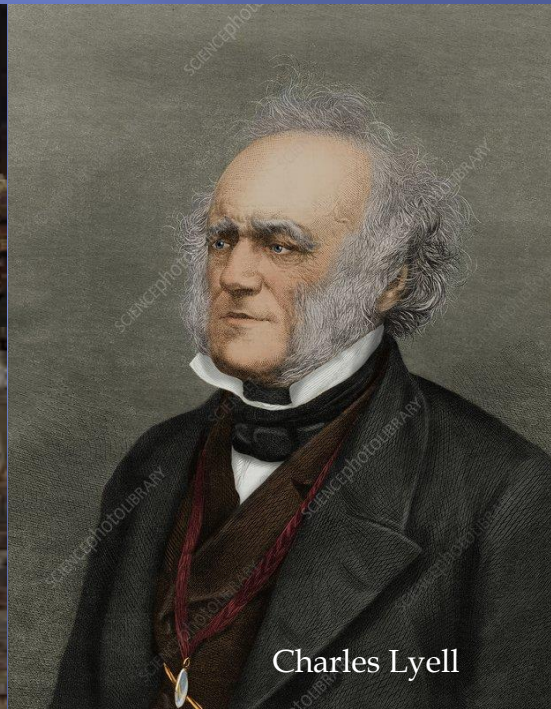
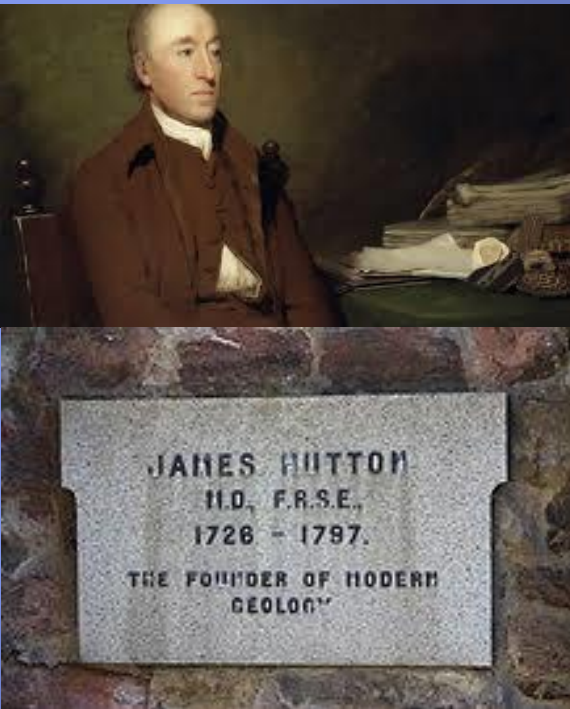


Climate Change and Geology : Is the Past the Key to the Future?



Uniformitarianism

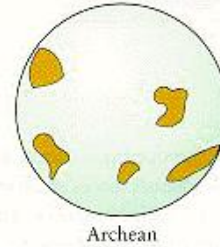
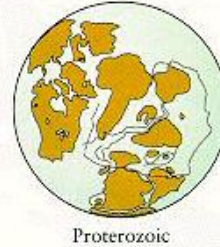
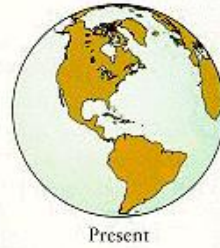
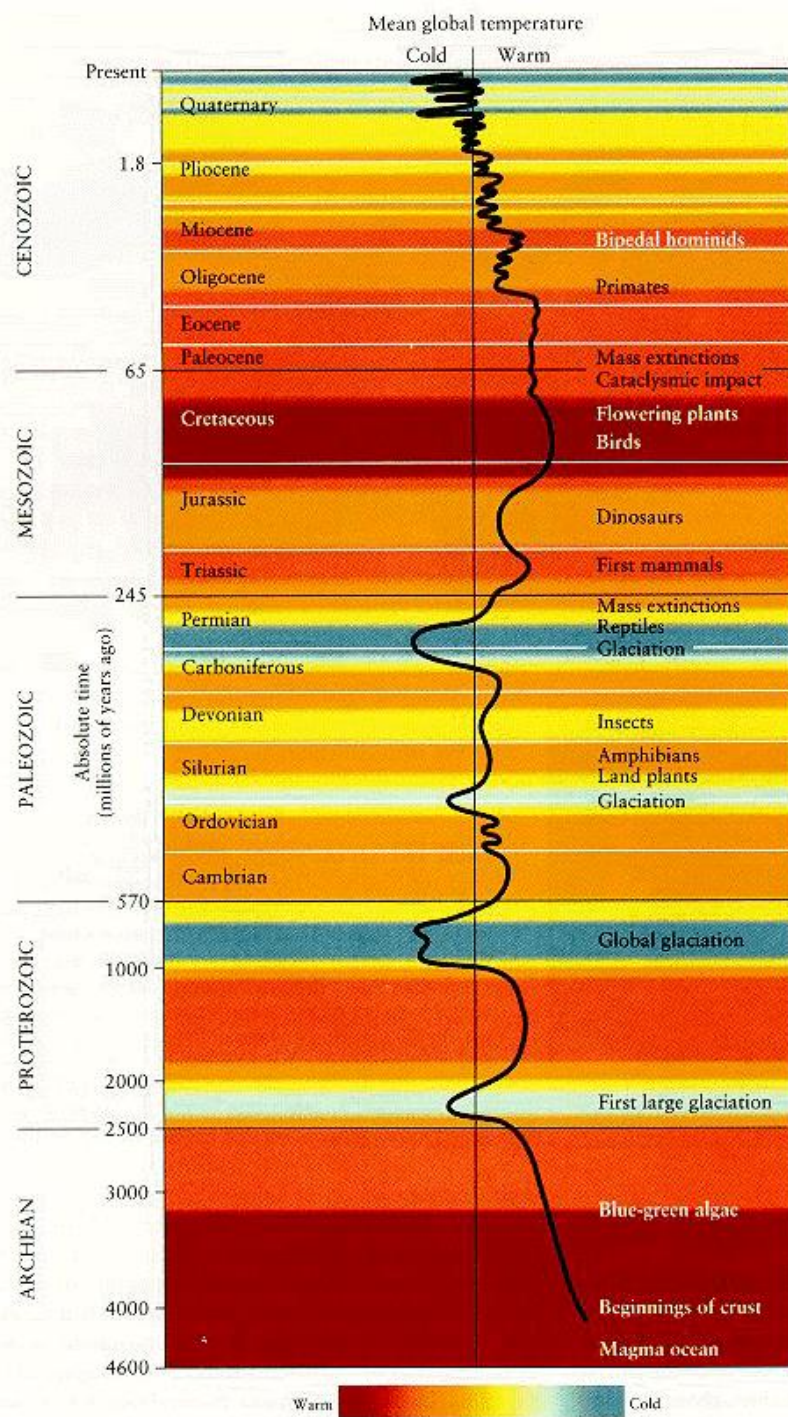
"The present is the key to the past."



ICARUS

Irish Climate Analysis and Research Units

John Sweeney, Emeritus Professor



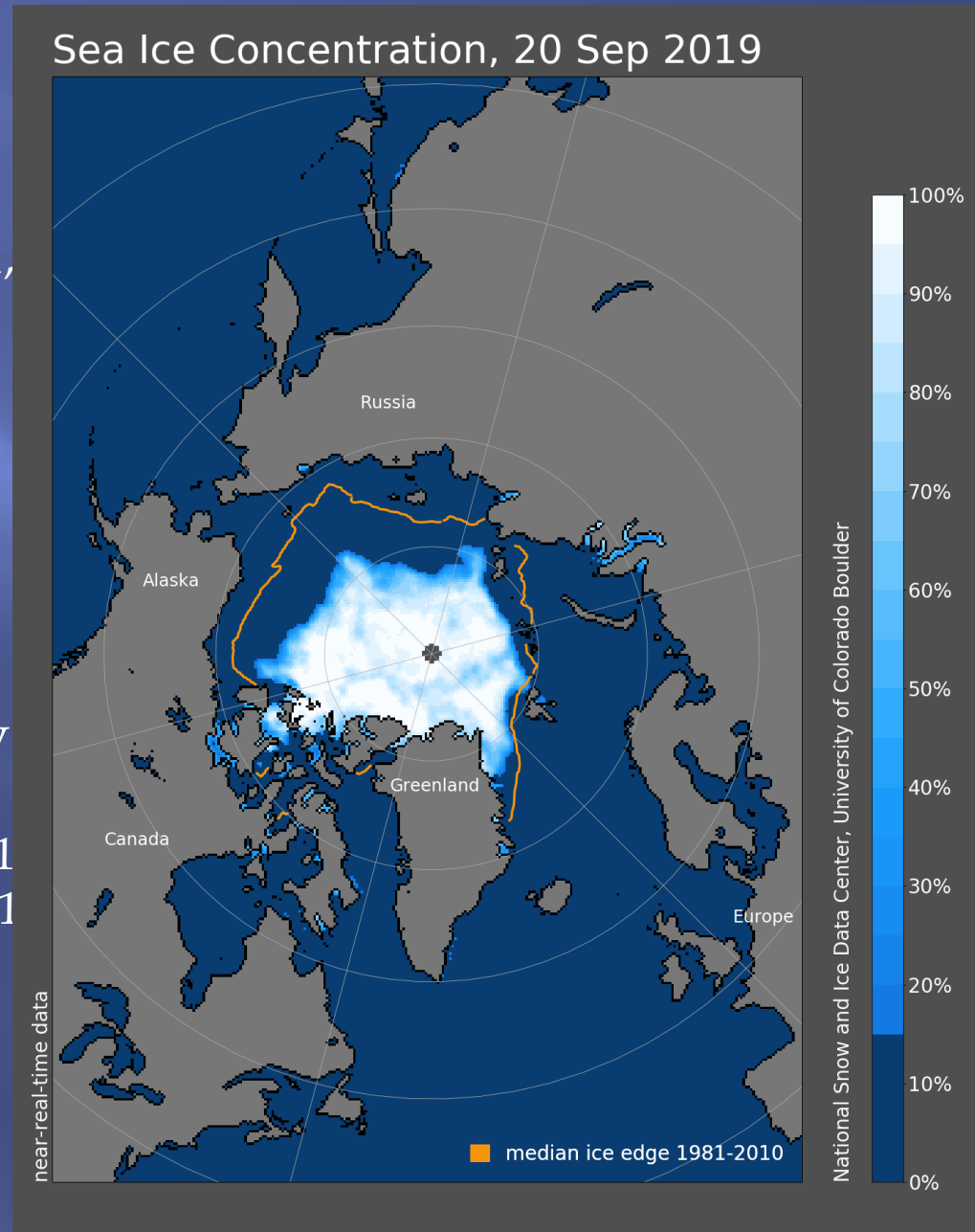
Climate has always been changing during the evolution of the Earth

During some geological periods higher than present atmospheric levels of CO₂ were likely to have occurred, though controls on climate were fundamentally different to more recent times.

The fossils of early humans who lived between 6 and 2 million years ago come entirely from Africa.

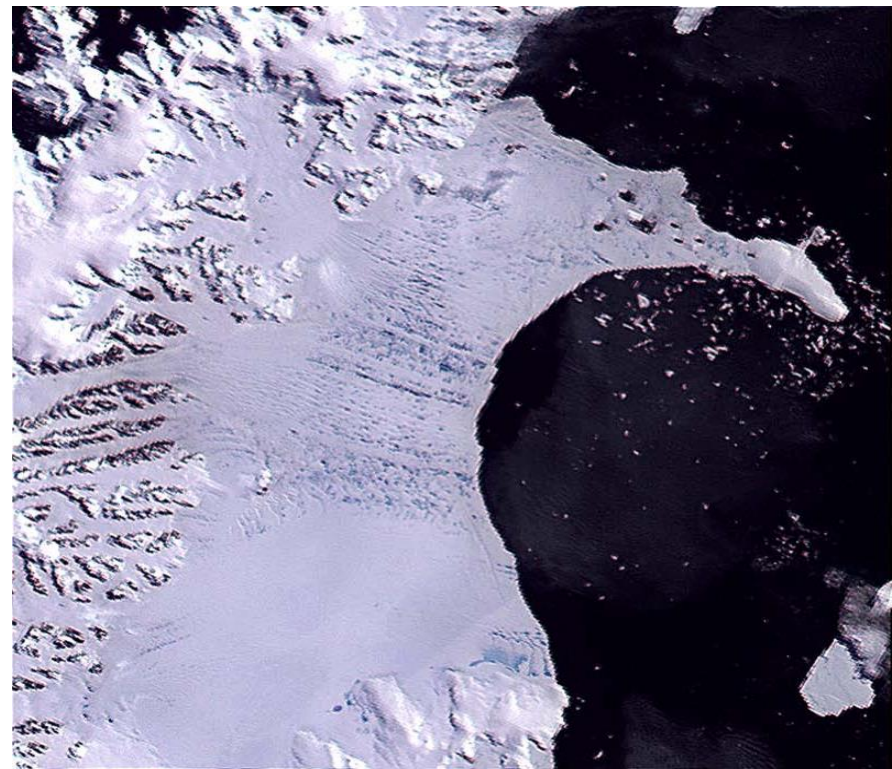
Glaciers and ice sheets are melting faster

- Greenland is melting much more quickly in recent years.
Average losses: 34 Gt/year 1992-2001,
215 Gt/year 1993-2009
- Arctic sea ice cover has decreased by 4% per decade since 1979. Mean winter sea ice thickness has halved.
- The Antarctic ice sheet is now indisputably losing mass.
Average losses: 30 Gt/year 1992-2001
147 Gt/year 2002-2011



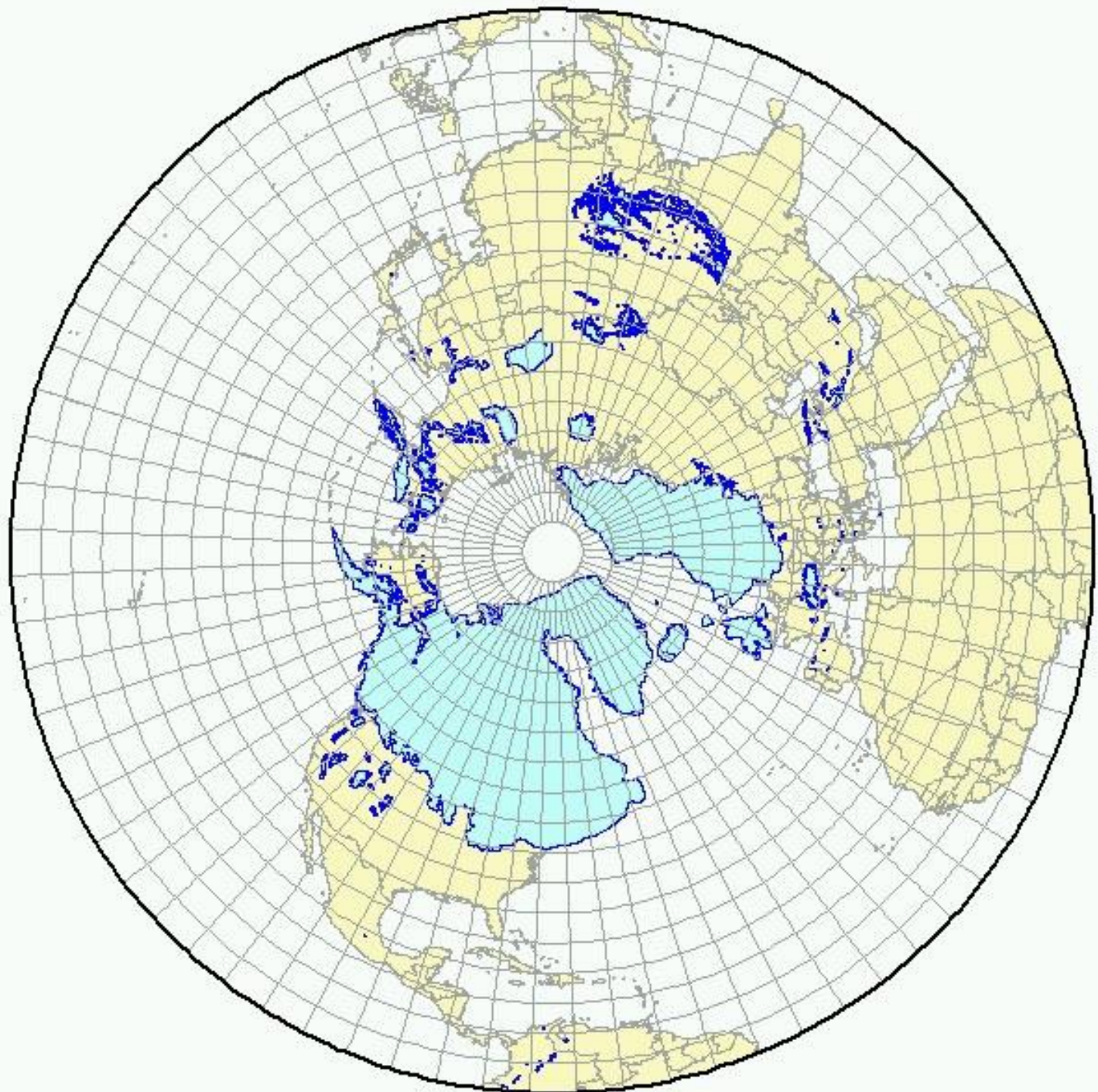


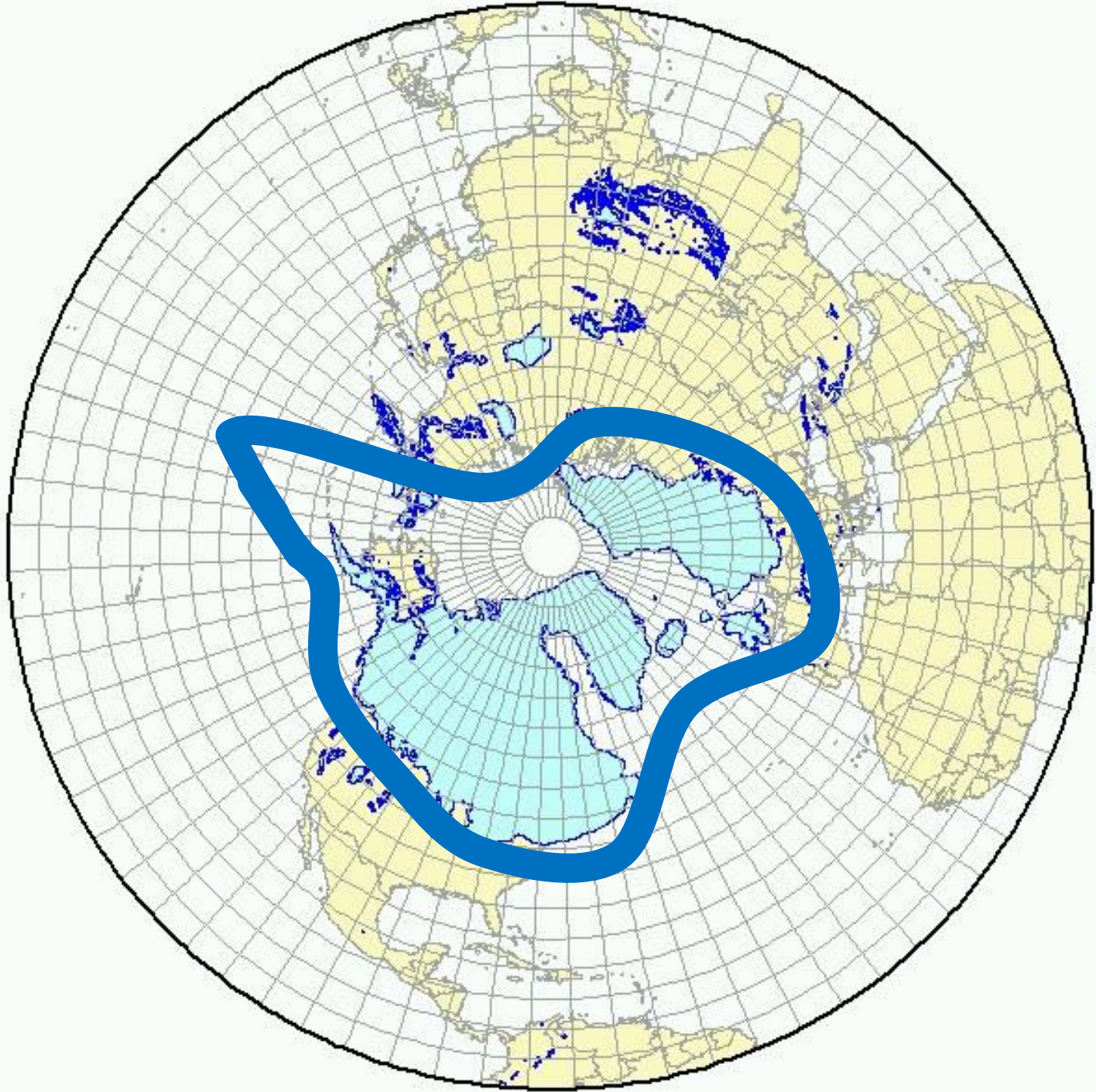
Collapse of Larsen Ice Shelf

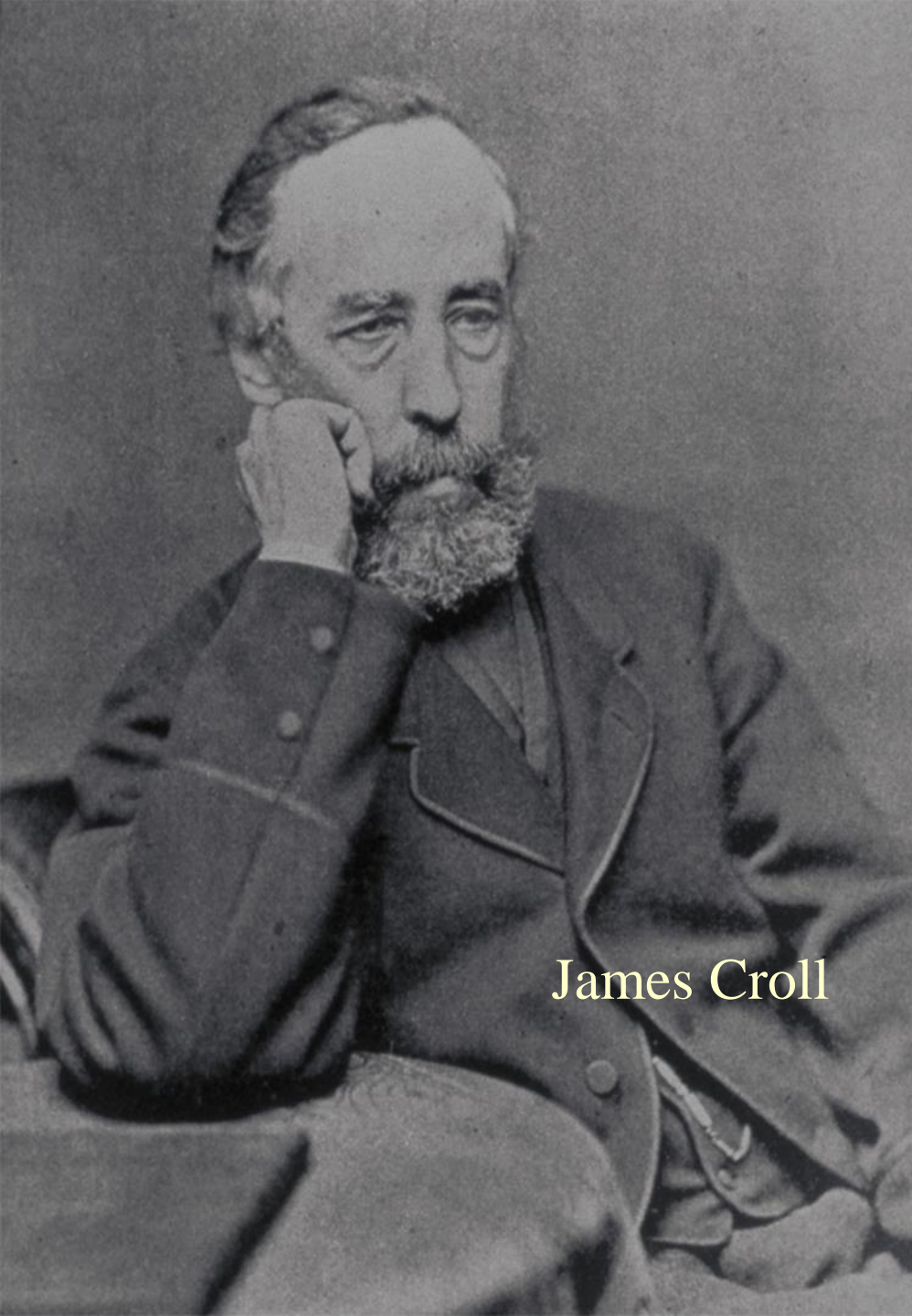


2,600Km² loss in 5 weeks in 2002

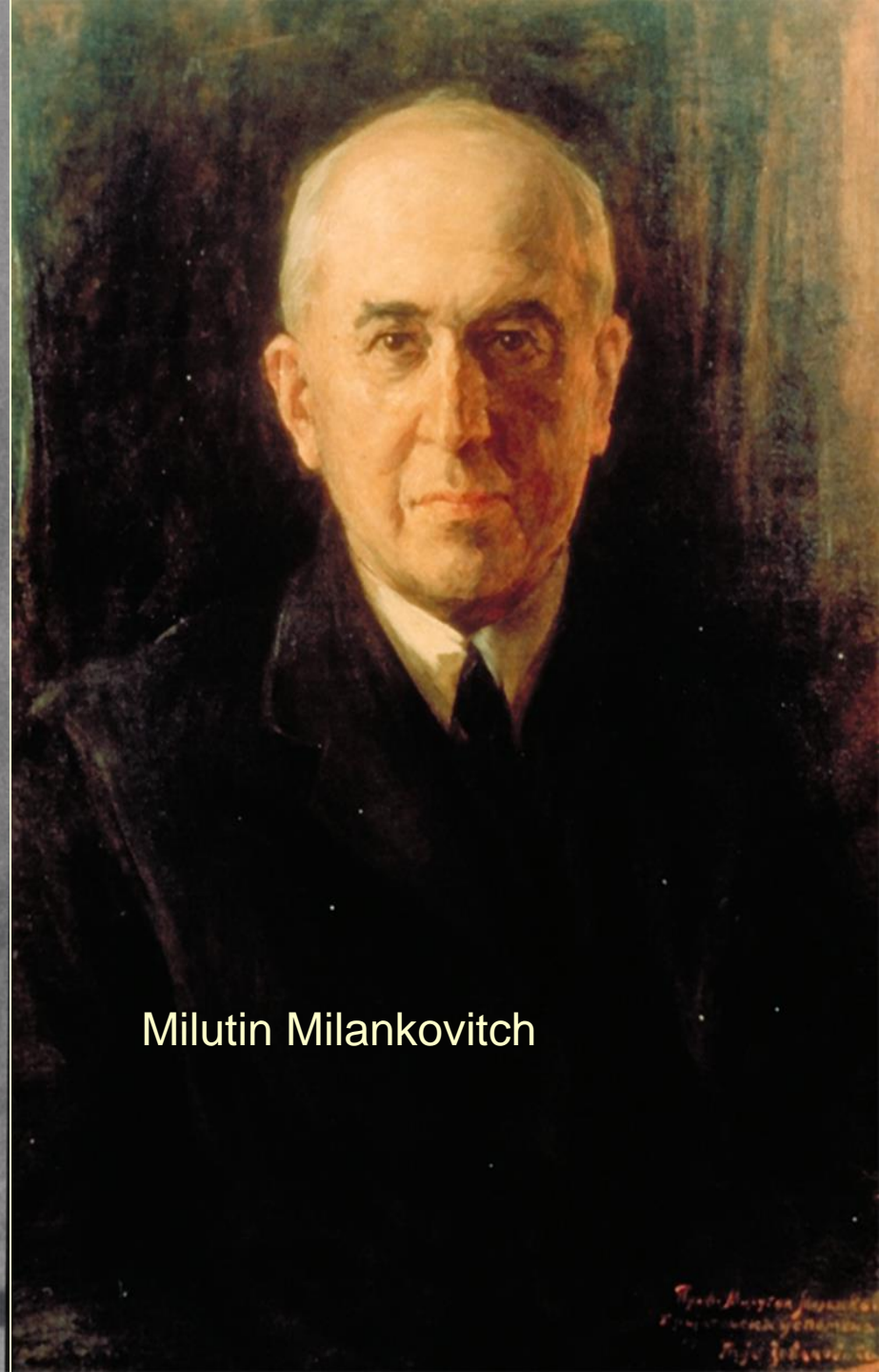
(= combined area of Counties Dublin+Kildare)



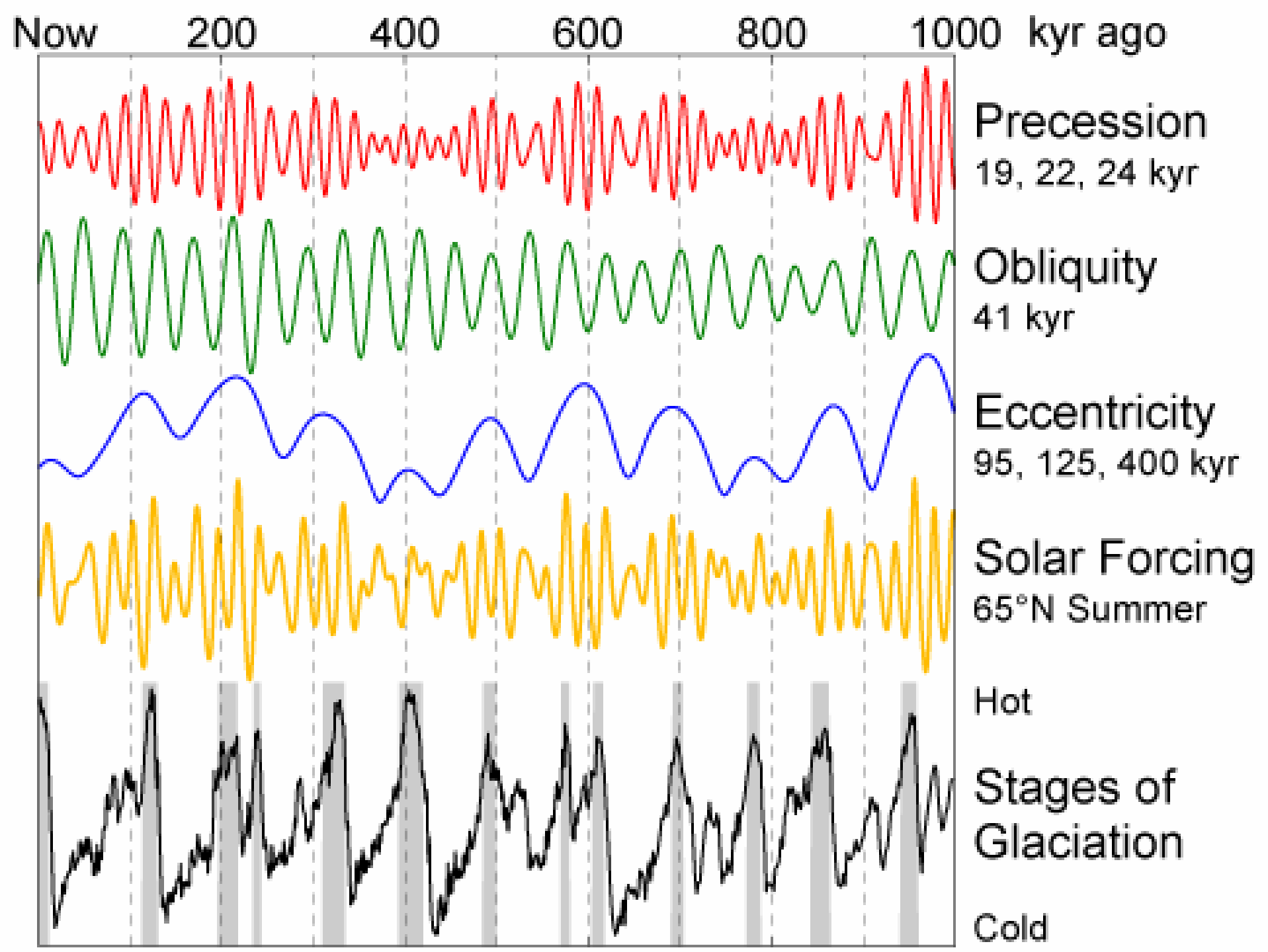


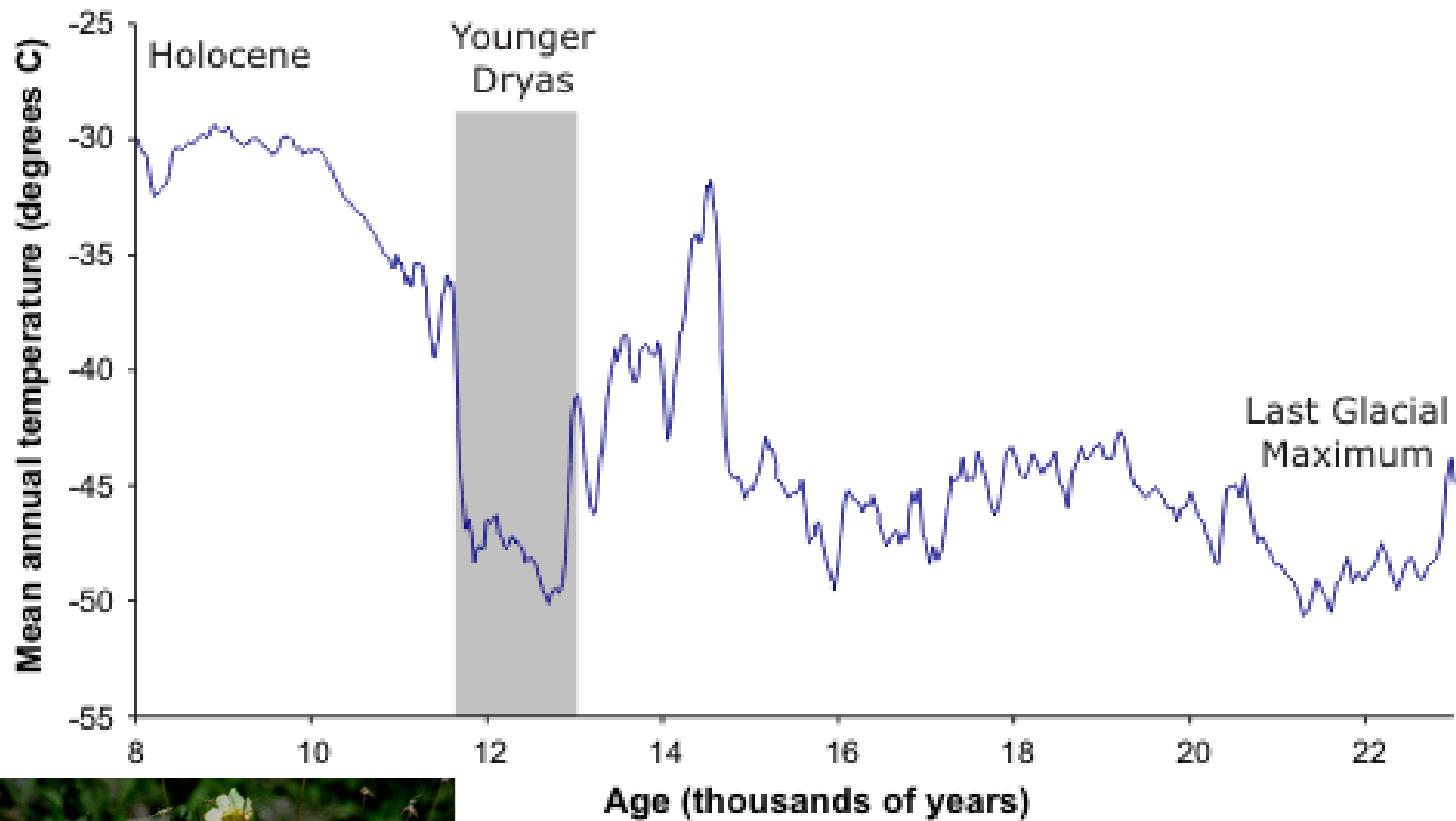


James Croll

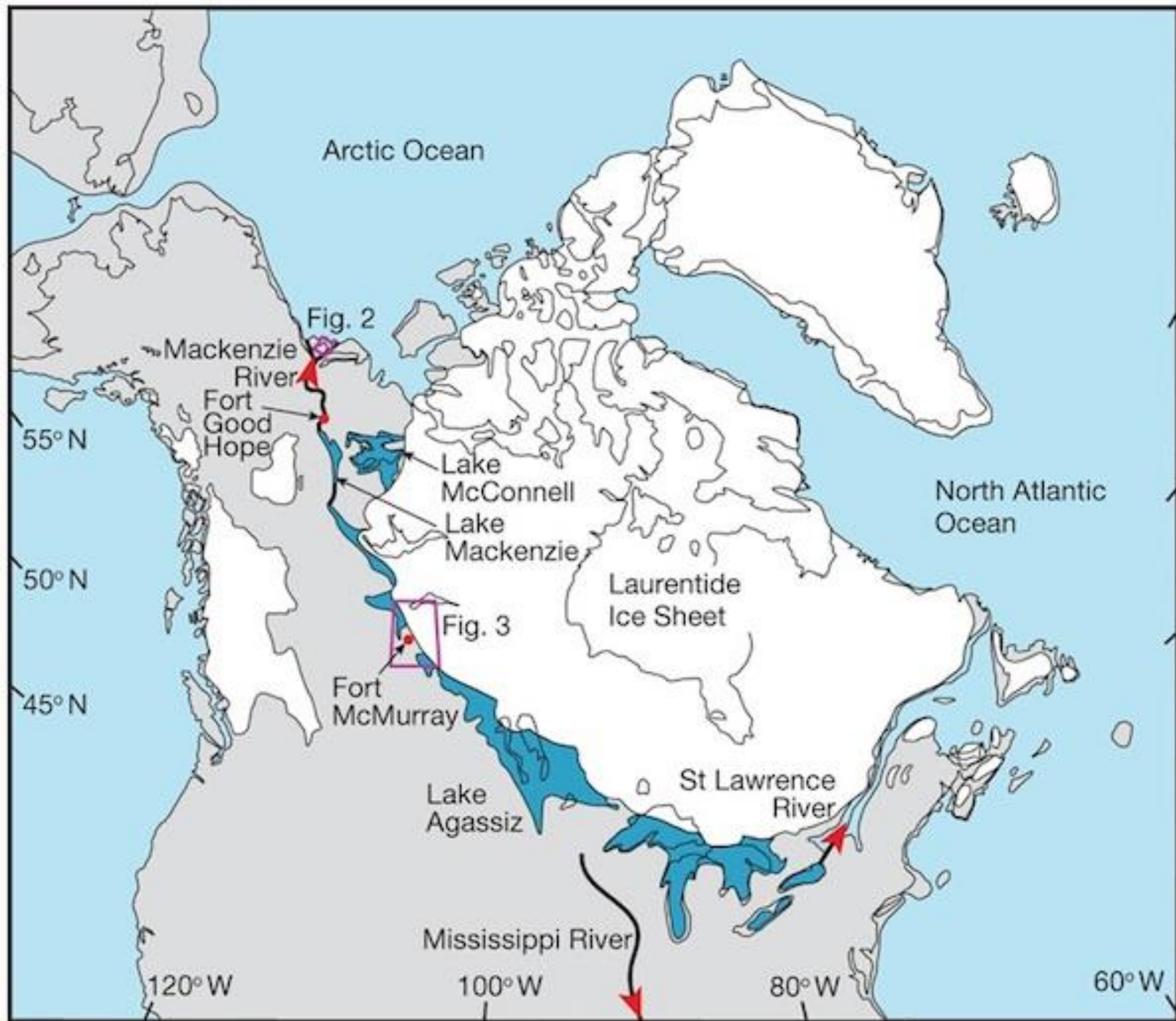


Milutin Milankovitch





Dryas (Mountain Aven)



**Probable sources of detrital carbonate from
North America and Greenland found in North
Atlantic Heinrich events**

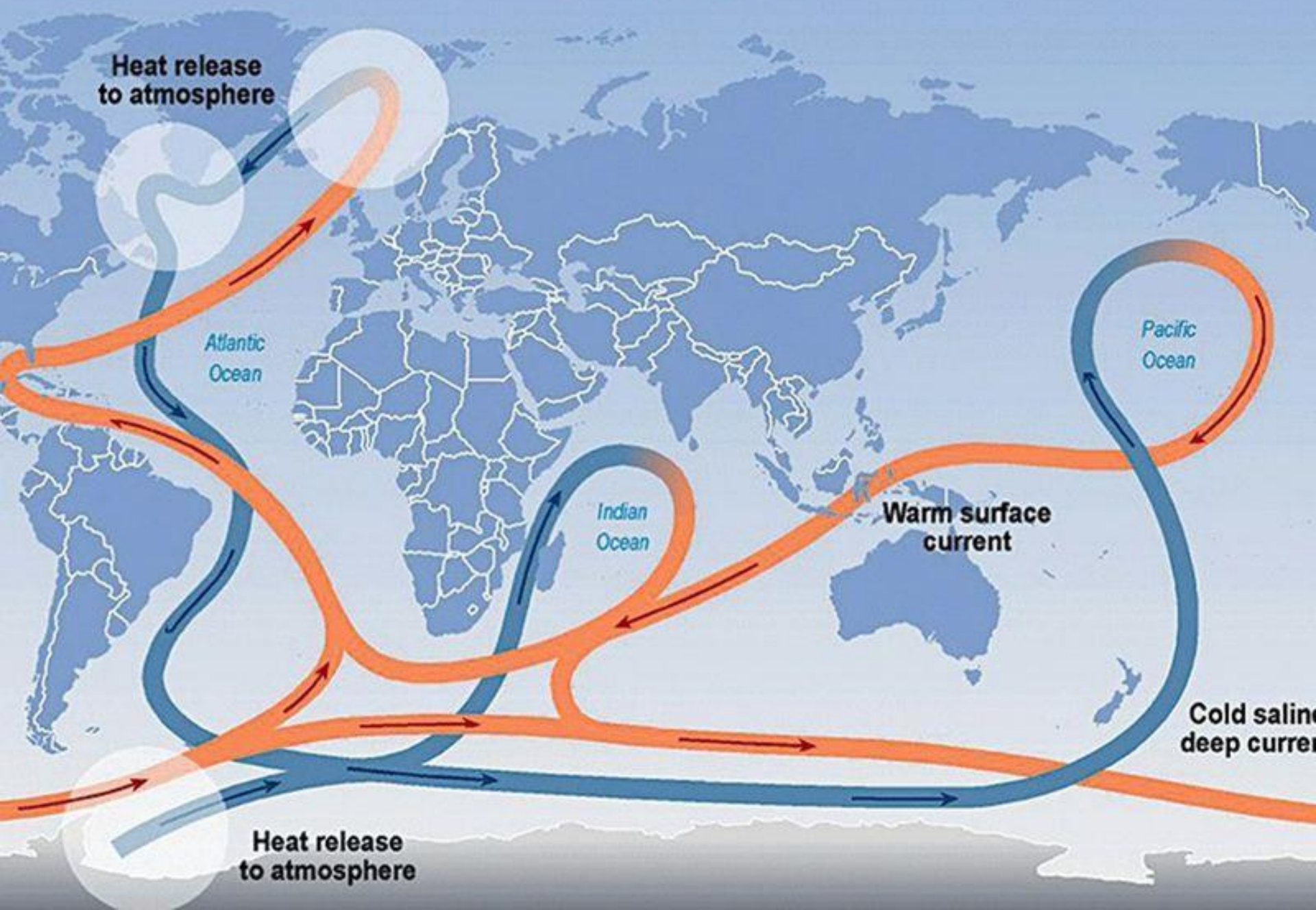


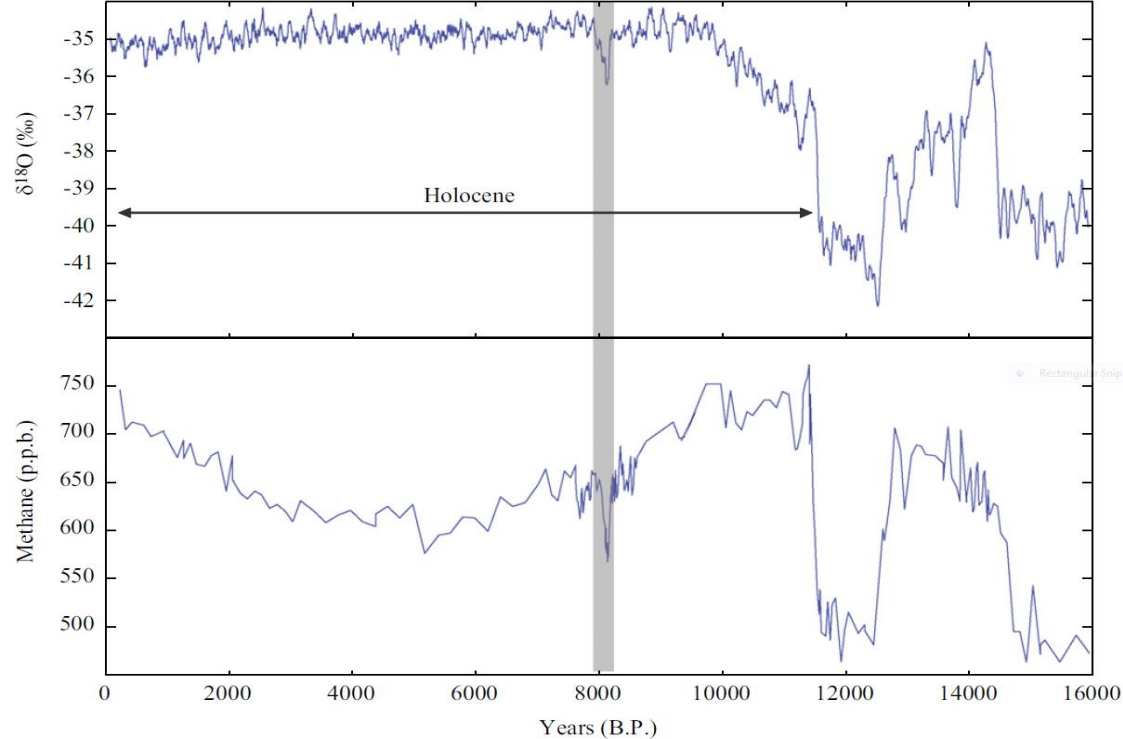
■ carbonate sources
➡ transport paths for carbonates

Younger Dryas

- Triggered by opening up of Gulf of St. Lawrence
- Identified by angular sediments on ocean floor – iceberg debris
- Debris could be traced to Canada

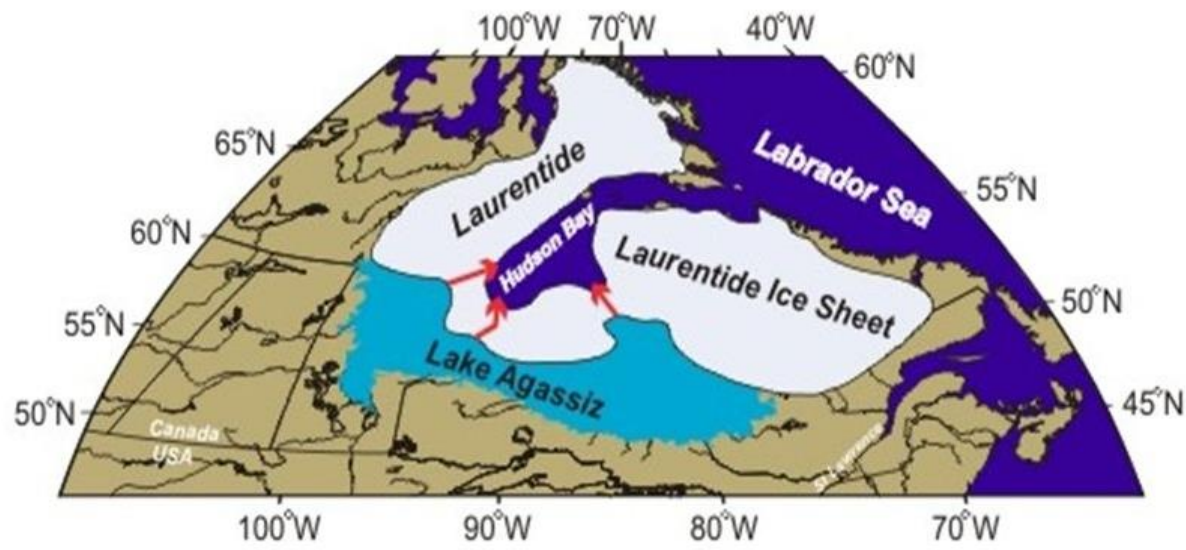
Great ocean conveyor belt





Cause of the 8.2Ka event

Sudden freshwater release caused a marked reduction in the strength of the Atlantic Overturning Circulation. A rapid recovery followed within 200 years of the event





Main Lessons of the Past

- Climate changes of the Quaternary in the Northern Hemisphere reflect an interaction between the topography/geography and forcing factors.
- The flushing of freshwater from melting ice sheets into the Atlantic has an impact on the oceanic conveyor belt.
- Maximum sea level rise during the last interglacial was at least 5m above present day. During warm periods in the Pliocene (3.3-3M BP) sea level was up to 20m above present day
- Orbital forcing will be unable to trigger widespread glaciation during the next 1000 years. Climate models simulate no glacial inception during the next 50,000 years if CO₂ concentrations remain above 300 ppm.
- The climate system has a tendency to change abruptly in a step-wise fashion
- Tipping points exist from which recovery may not be possible on decadal or even century scales



What's
different
about
today?



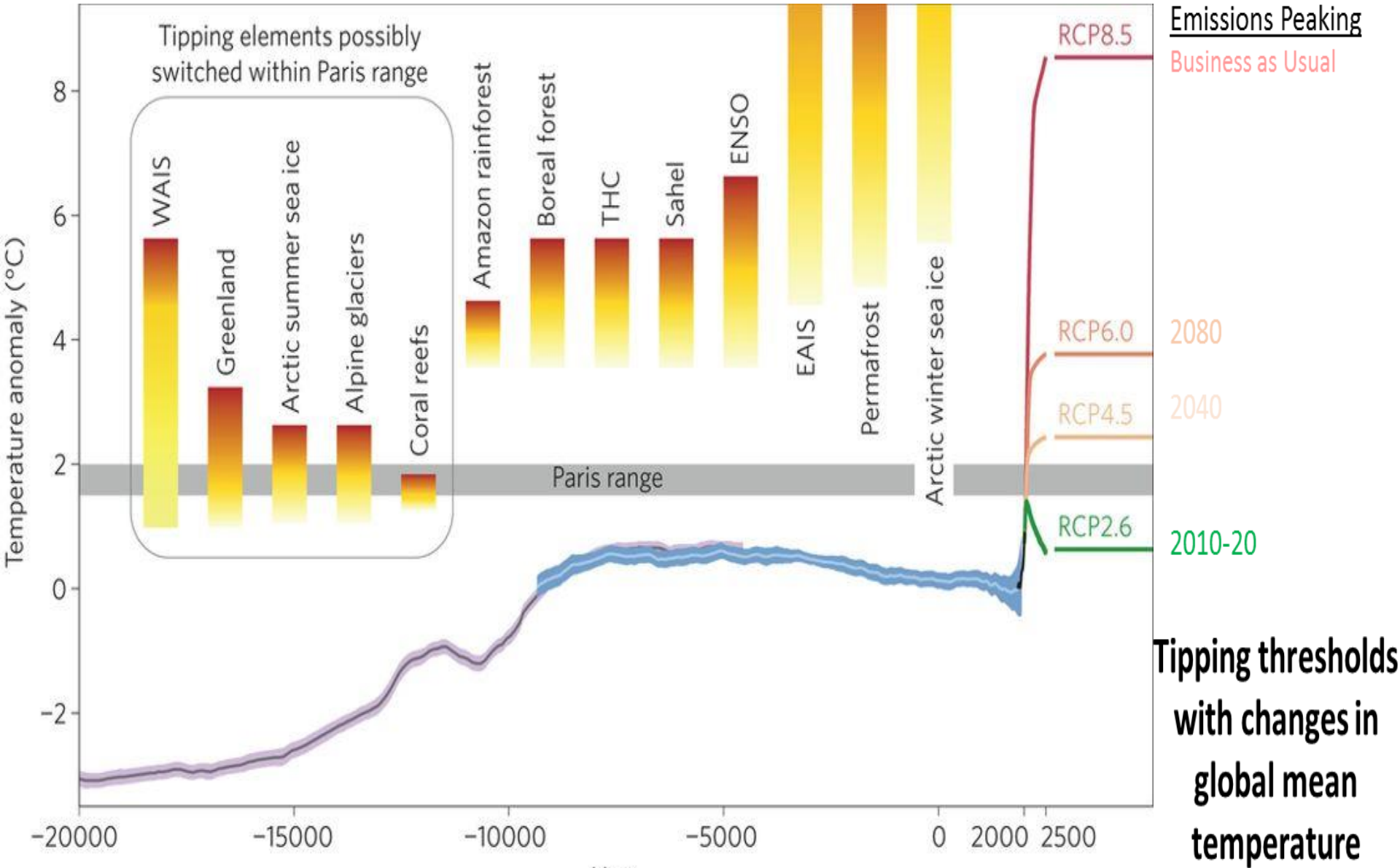
Last Year
Ireland emitted
the equivalent
of
61M tonnes

Each of us on
average was
responsible for
12.8 tonnes

On an individual basis,
we are the third worst
in the EU.

Our emissions are 50%
higher than the EU
average

So Where are today's
Tipping Points



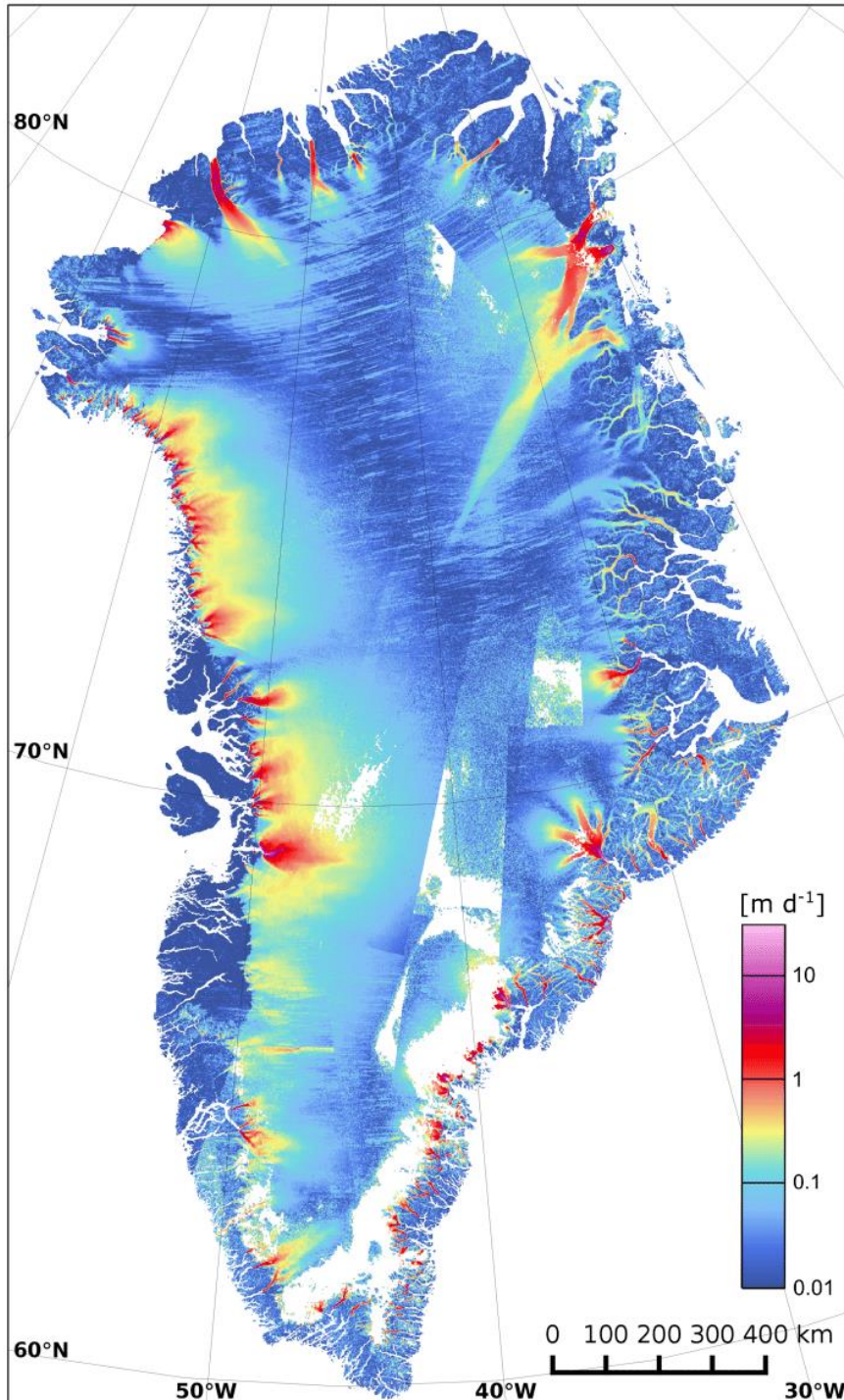
WAIS: West Antarctic Ice Sheet THC: Thermo-Haline Circulation ENSO: El Niño Southern Oscillation EAIS: East Antarctic Ice

Source: Schellnhuber, Rahmstorf and Winkelmann (2016)

Greenland: Ice Velocity

“The melting of the Greenland ice sheet is greater than at any point in the last three to four centuries, and probably much longer than that,”

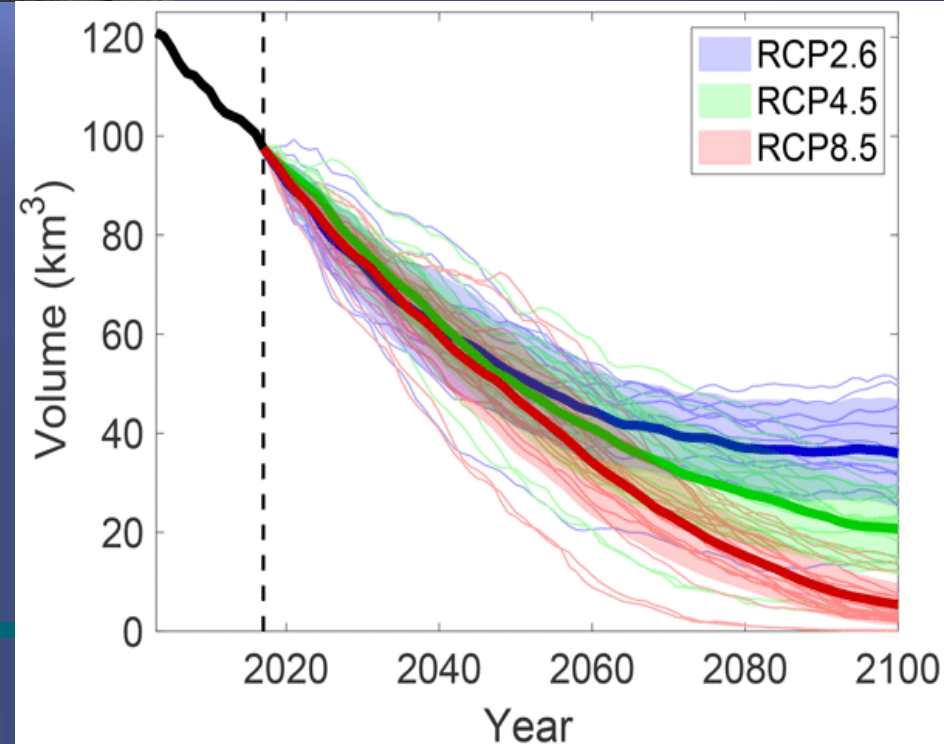
Average losses: 34 Gt/year 1992-2001,
215 Gt/year 1993-2009





More than 90% of
glacier volume in the
Alps could be lost by
2100

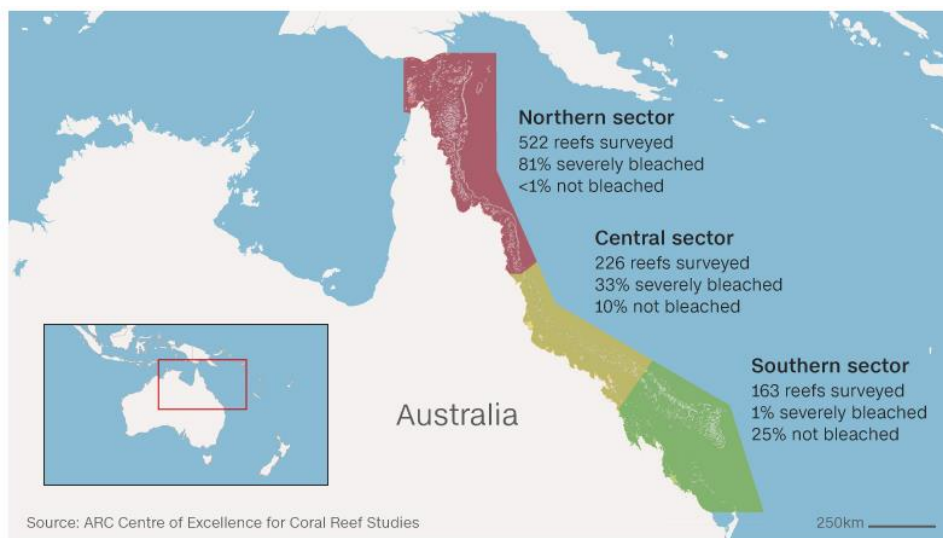
April 9, 2019
Source: European Geosciences Union



Zekollari, H., Huss, M., and Farinotti, D.: Modelling the future evolution of glaciers in the European Alps under the EURO-CORDEX RCM ensemble, *The Cryosphere* (2019). DOI: [10.5194/tc-13-1125-2019](https://doi.org/10.5194/tc-13-1125-2019)



Loss of Coral Reefs

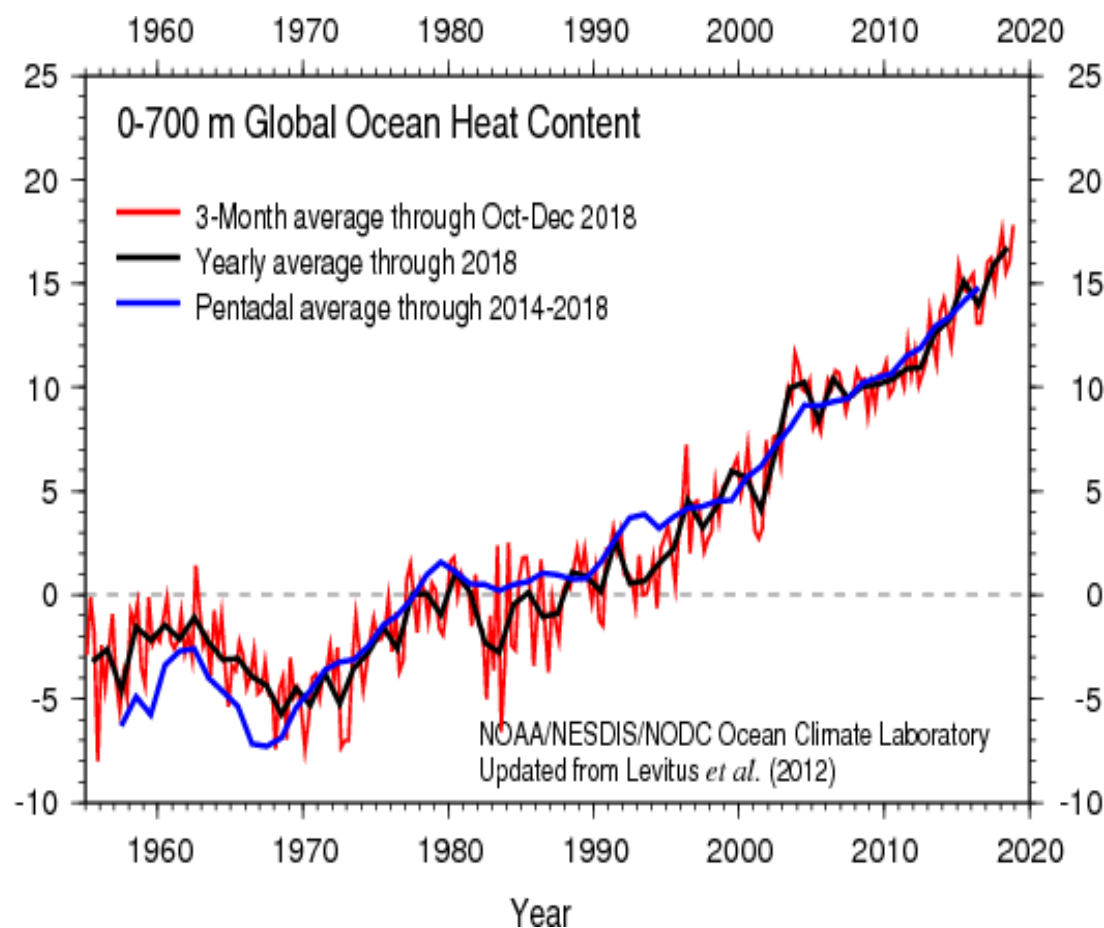
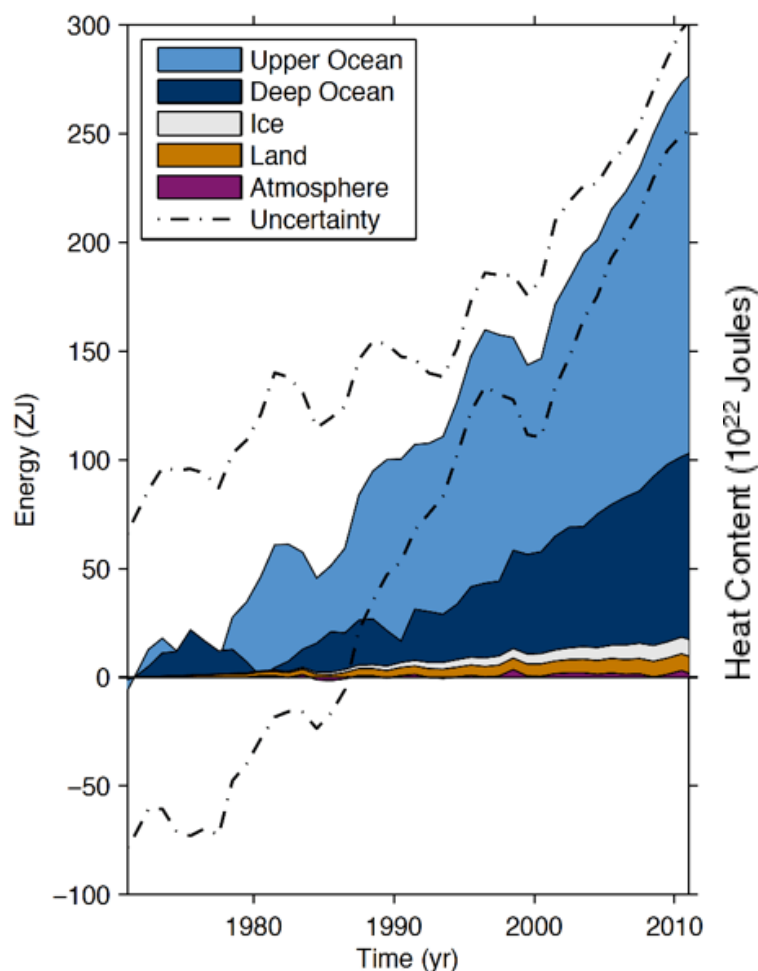


What has the science been saying since AR5?

- Improved Modelling
- Climate Change Attribution Advances
- Increased awareness of probably higher climate sensitivity estimates
- Indications of greater variability in the polar jetstream

Continued Uptake of Anthropogenic Heat by the Ocean

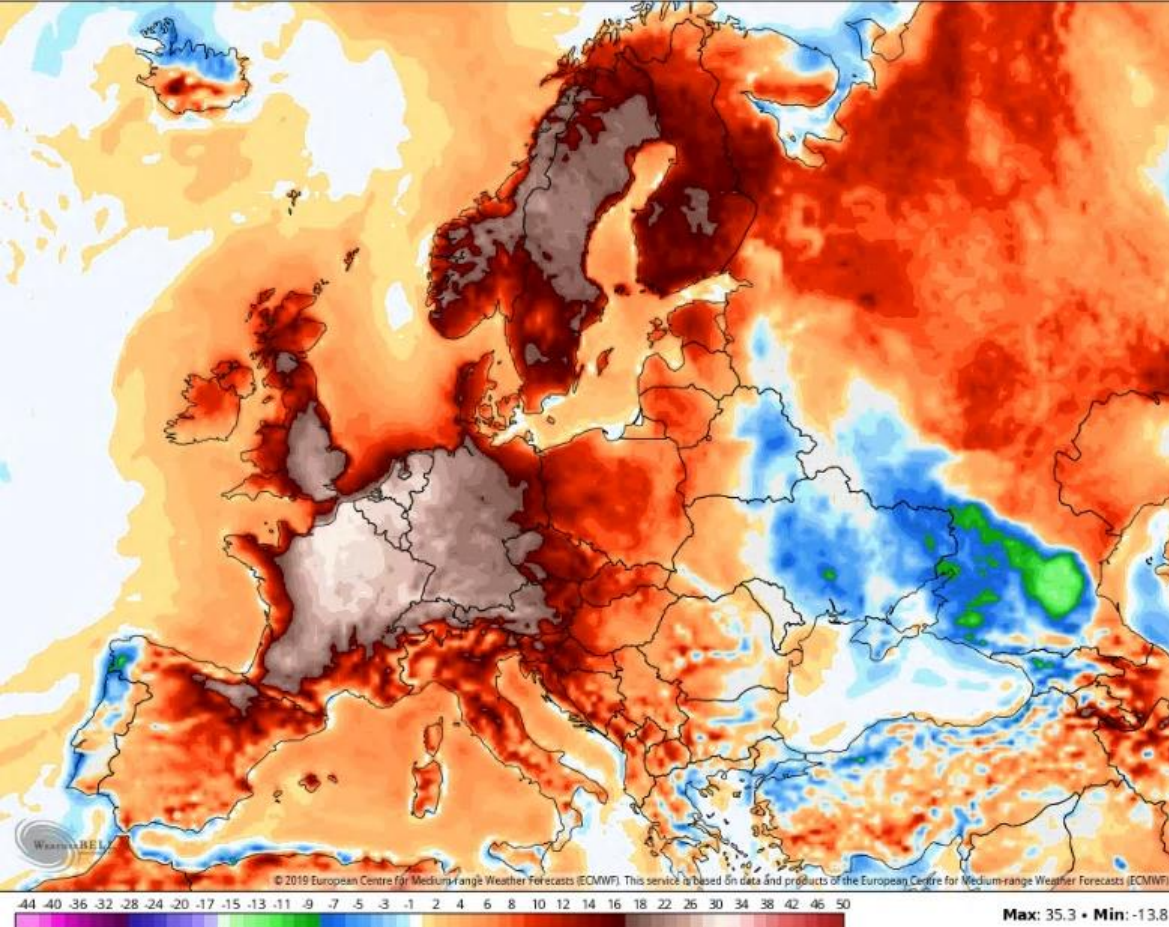
Warming of the ocean accounts for about 93% of the increase in the Earth's energy inventory between 1971 and 2010 (high confidence), with warming of the upper (0 to 700 m) ocean accounting for about 64% of the total. (IPCC, AR5)



Attribution of Extreme Events to Climate Change

- 43 research papers looking at links between climate change and extreme weather events, of which 32 found that climate change made the events more likely or more intense.
- 75% of all papers over the past 3 years and 100% of those that looked at heatwaves found positive links with climate change
- Pace of investigation and rate of positive link discoveries is accelerating

The old argument that you can't link climate change to a particular extreme event is no longer tenable



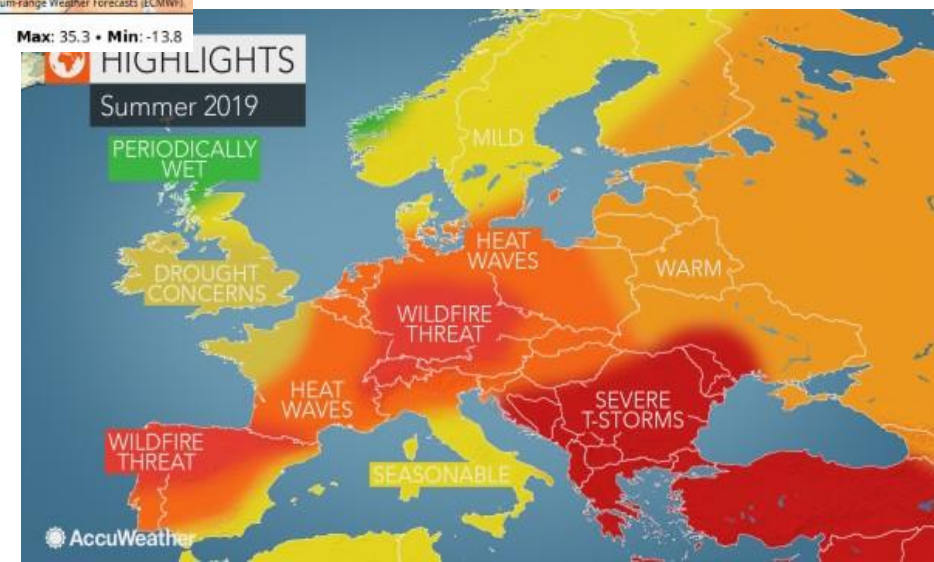
Combining information from models and observations, we find that such heatwaves in France and the Netherlands would have had return periods that are about a hundred times higher (at least 10 times) without climate change.

Over France and the Netherlands, such temperatures would have had extremely little chance to occur without human influence on climate (return periods higher than ~1000 years).

In July 2019, France experienced its second heat wave in less than a month, beating several regional and national temperature records. A national record temperature of 46.1 °C was measured in the southern commune of Gallargues-le-Montueux in the June event..

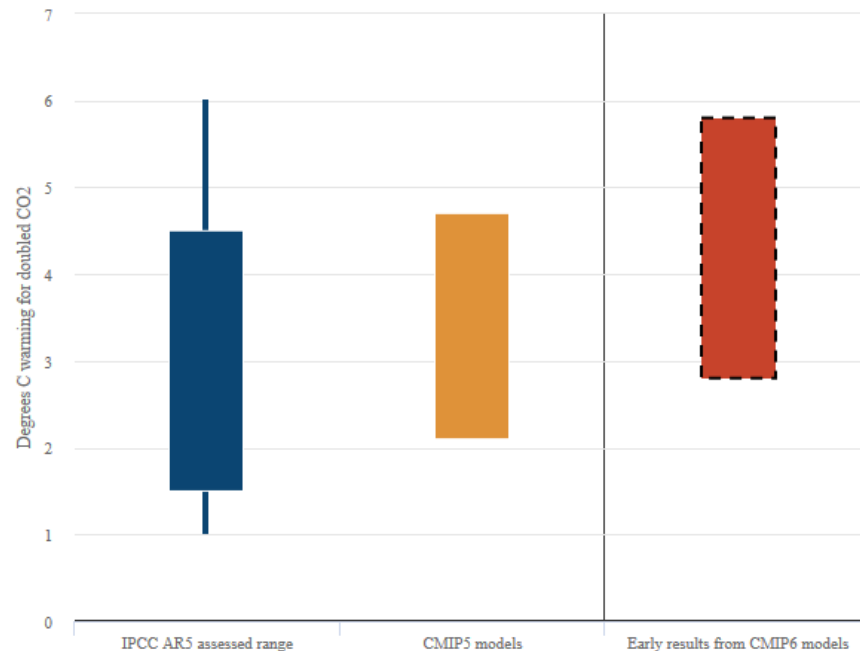
World Weather Attribution is a partnership of:

- Environmental Change Institute, University of Oxford (ECI)
- Royal Netherlands Meteorological Institute (KNMI)
- Laboratoire des Sciences du Climat et de l'Environnement (LSCE)
- University of Princeton
- National Center for Atmospheric Research (NCAR)
- Red Cross Red Crescent Climate Centre (The Climate Centre).



It is likely that AR6 will increase the probable values of Equilibrium Climate Sensitivity

Equilibrium climate sensitivity estimates

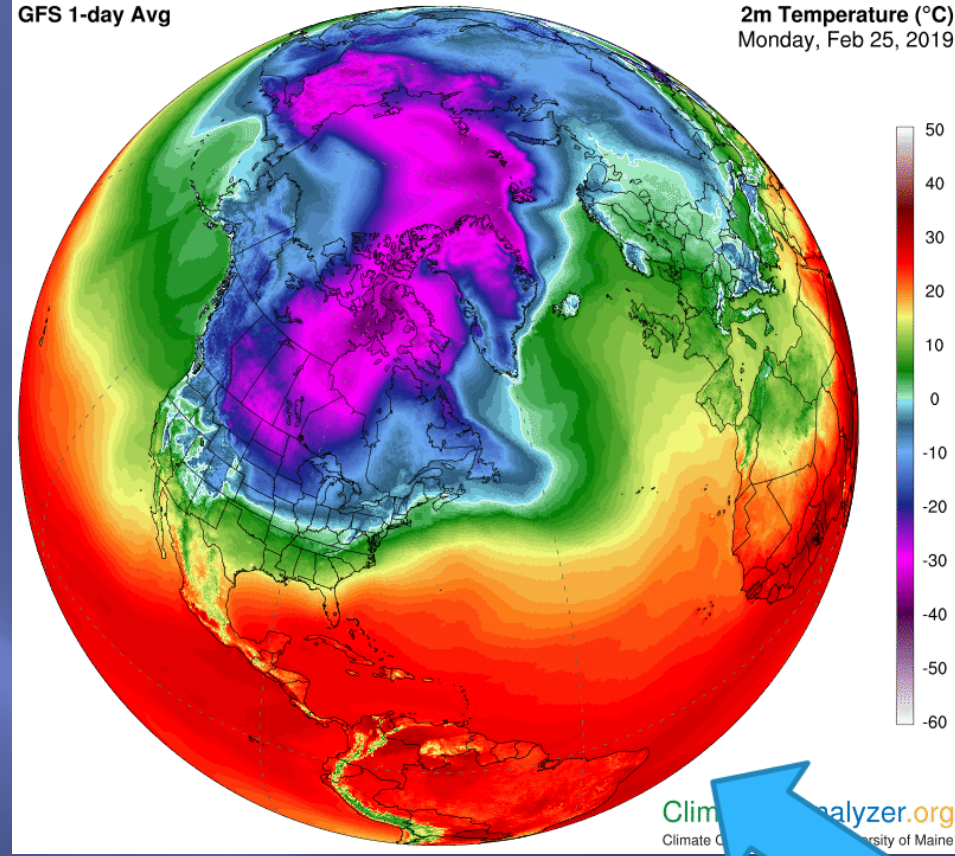
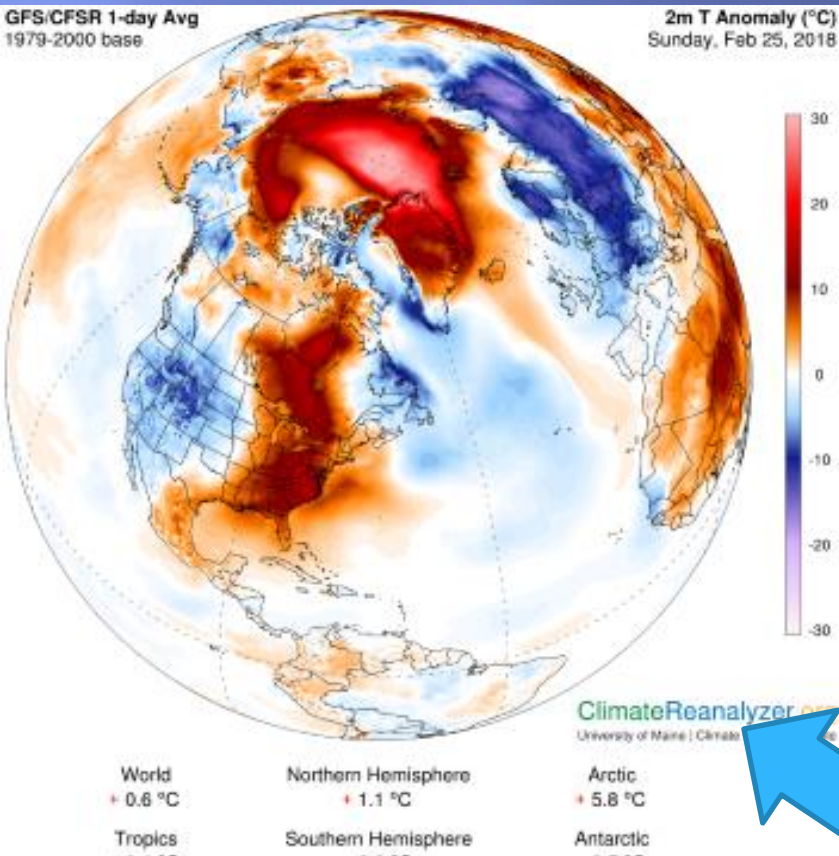


CB

Assessment range for ECS from IPCC AR5 (blue bar; thick bar denotes likely range, thin bar extending from it shows values below which ECS is “extremely unlikely” and above which ECS is “very unlikely”), range from CMIP5 (orange bar) and preliminary estimates of ECS values from new global climate models (red bar).

One measure of the long-term response of the climate over hundreds of years is known as the “equilibrium climate sensitivity” (ECS), which is defined as the temperature increase when CO₂ has doubled and the climate system has come into equilibrium. The higher the ECS is, the smaller the remaining carbon budget has to be to meet a particular climate target.

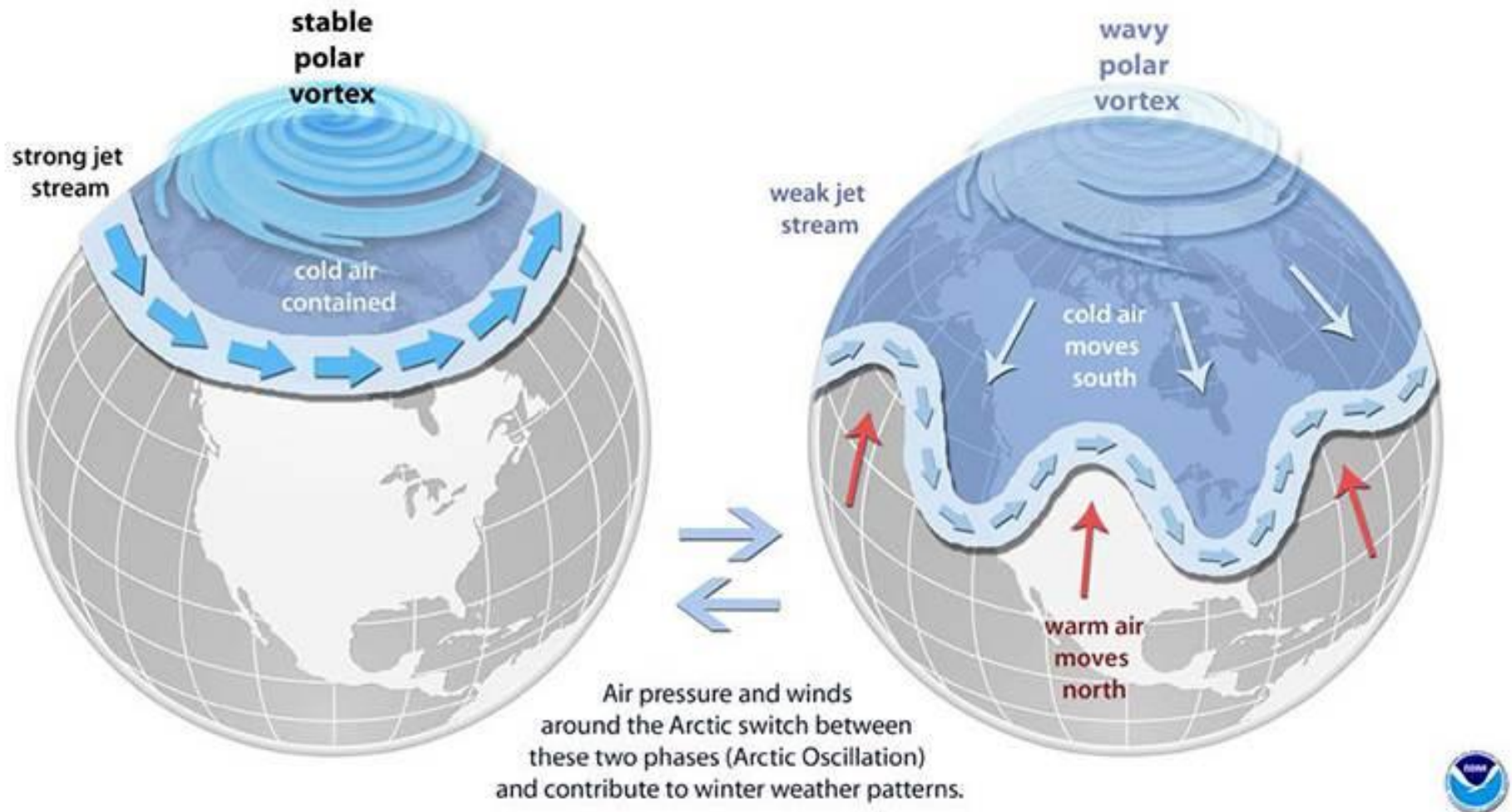
Early results suggest ECS values from some of the new CMIP6 climate models are higher than previous estimates, with early numbers being reported between 2.8C and 5.8C. This compares with the previous coupled model intercomparison project (CMIP5), which reported values between 2.1C to 4.7C. The IPCC’s Fifth Assessment Report (AR5) assessed ECS to be “likely” in the range 1.5C to 4.5C and “very unlikely” greater than 6C.



North Pole above
freezing and
abnormal warmth
in the Arctic in
February/March
2018

Snow in the Sahara
Desert in January
2018

Abnormal cold
in North
America and
abnormal
warmth in
western Europe
February 2019



The Jetstream has weakened since the 1960s and meanders more, giving anomalous weather events.

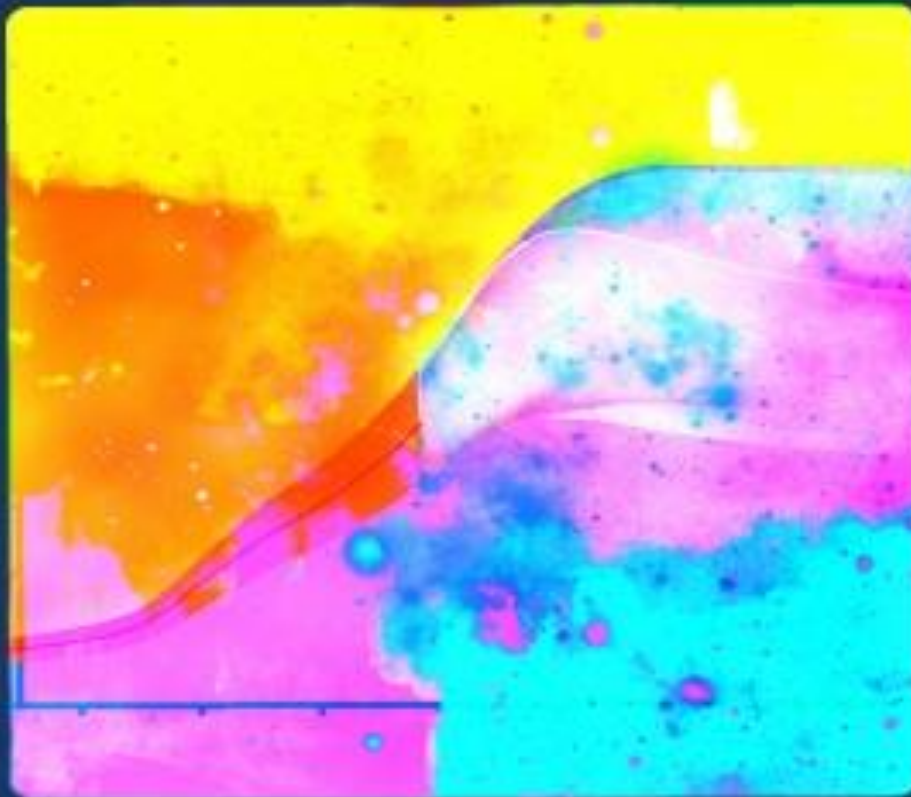
Is the warming of the Arctic (due to changes in sea ice) reducing the temperature gradient that drives the Jetstream.

ipcc

INTERGOVERNMENTAL PANEL ON climate change

Global Warming of 1.5°C

An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty



WG I × WG II × WG III

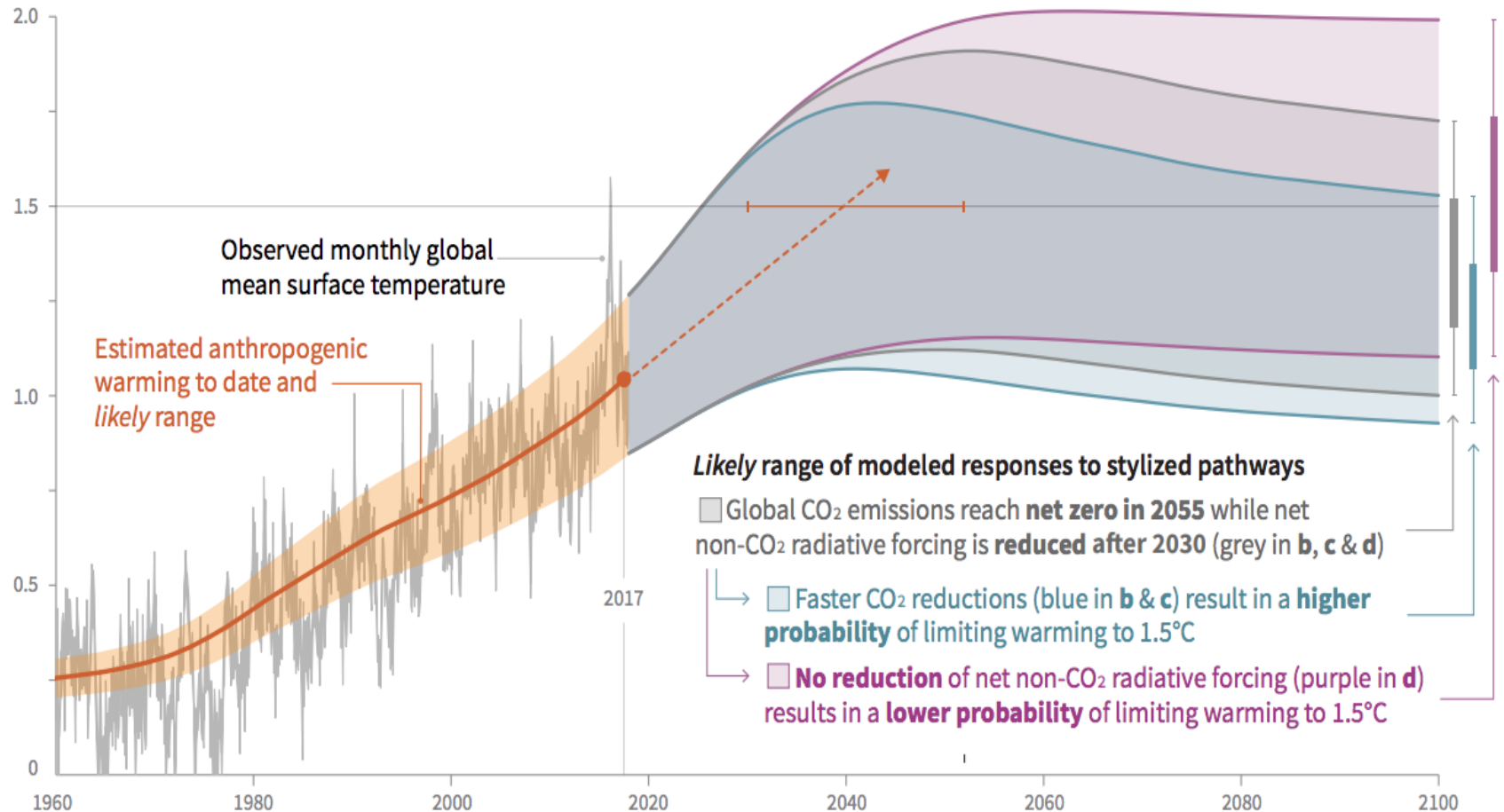


Report requested at COP21 Paris by the UNFCCC despite opposition from Saudi Arabia.

Adoption of the IPCC Summary for Policymakers blocked at IPCC Plenary by Saudi Arabia until the last minute

Report not welcomed at COP24 Katowice due to opposition from USA, Saudi Arabia, Bahrain and Russia

Global warming relative to 1850-1900 (°C)

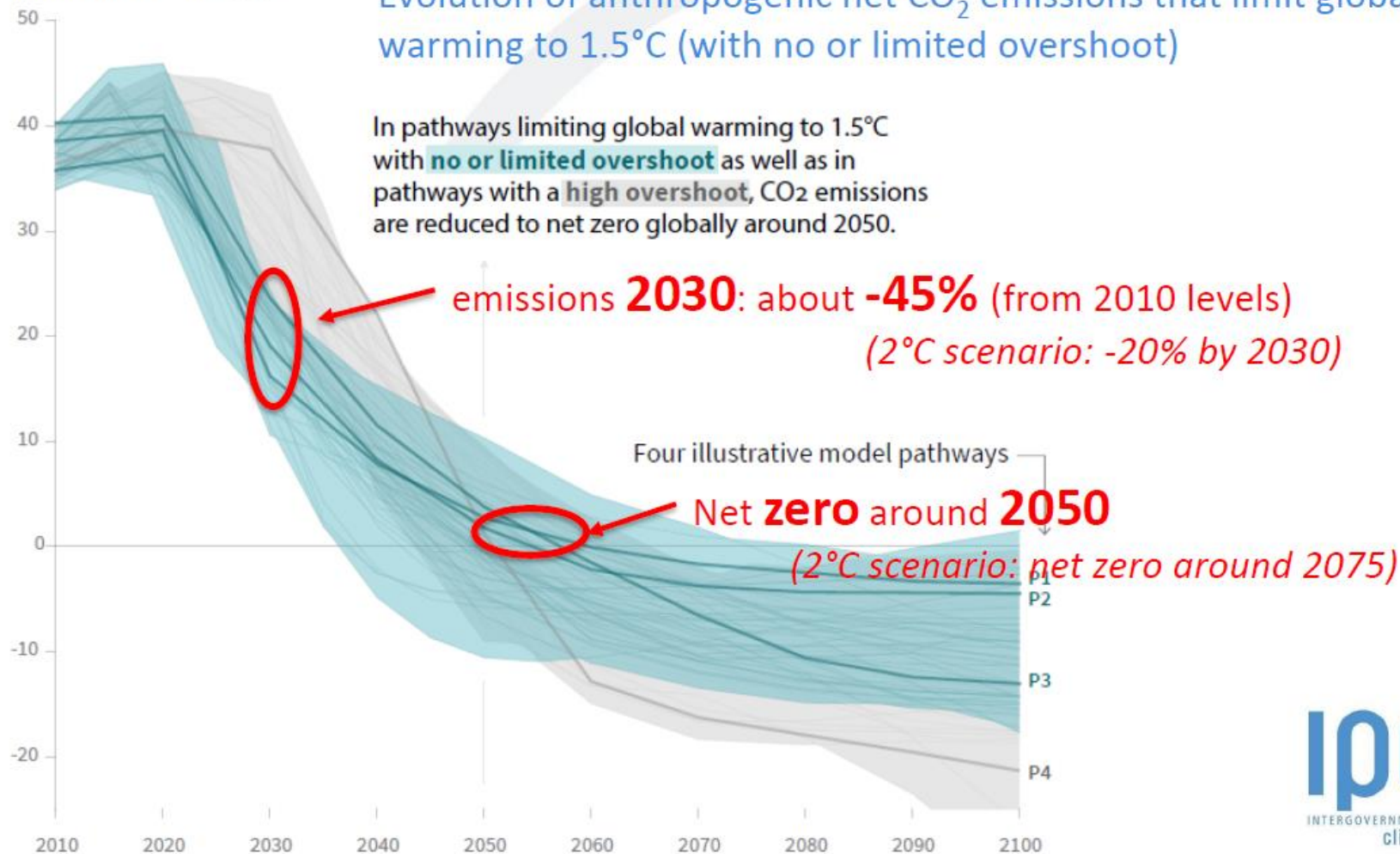


Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate (IPCC, October, 2018)

Billion tonnes of CO₂/yr

Evolution of anthropogenic net CO₂ emissions that limit global warming to 1.5°C (with no or limited overshoot)

In pathways limiting global warming to 1.5°C with **no or limited overshoot** as well as in pathways with a **high overshoot**, CO₂ emissions are reduced to net zero globally around 2050.



ipcc
INTERGOVERNMENTAL PANEL ON
climate change

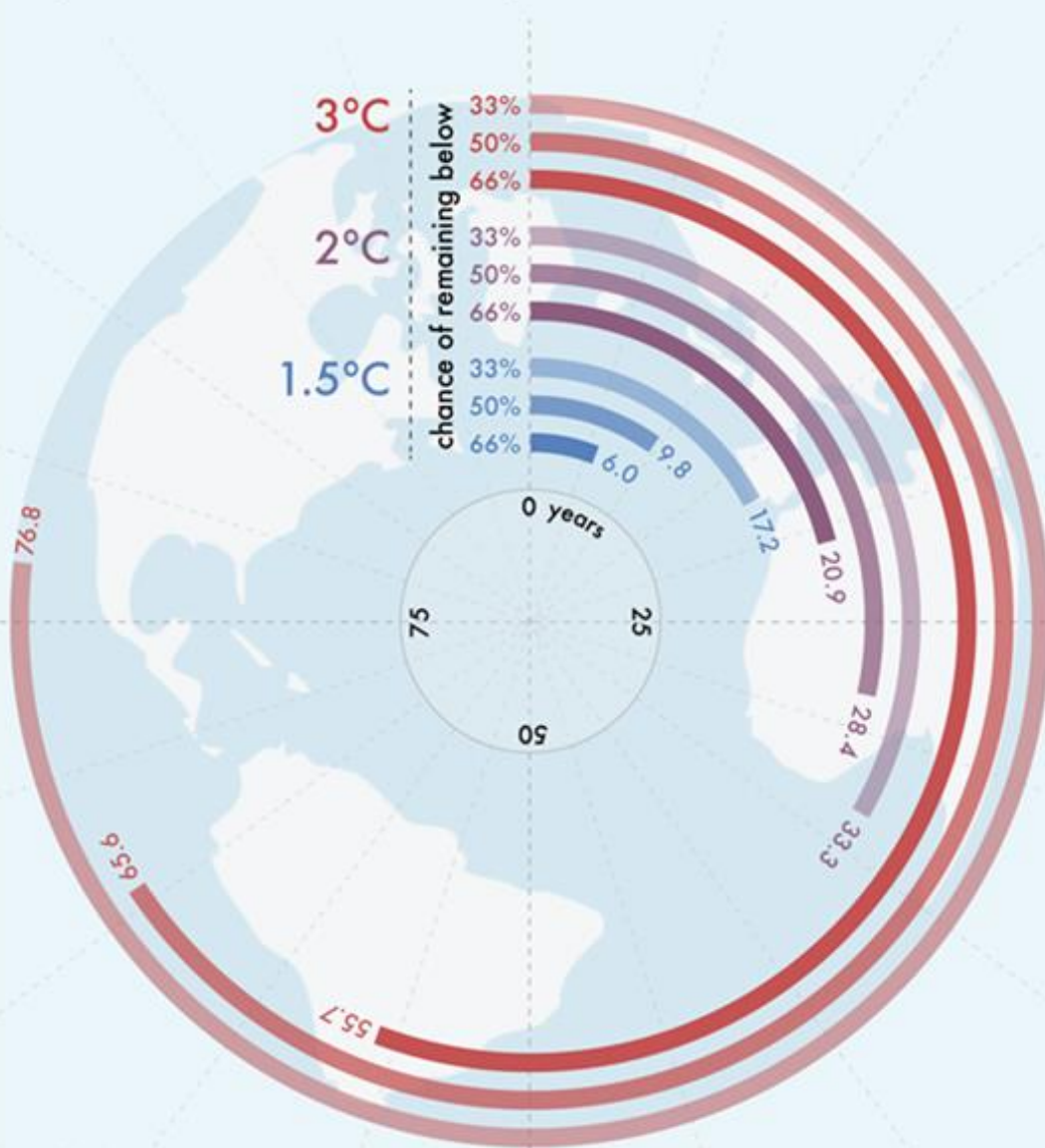
Timing of net zero CO₂

Line widths depict the 5-95th percentile and the 25-75th percentile of scenarios



Carbon Countdown

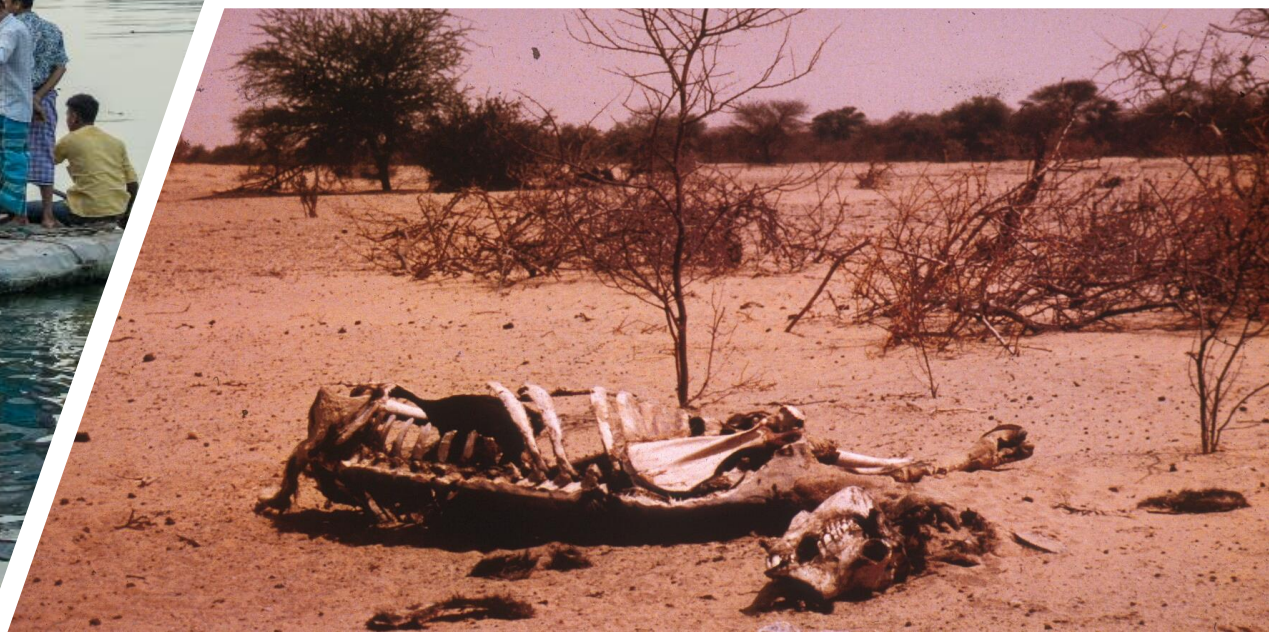
How many years of current emissions would use up the IPCC's carbon budgets for different levels of warming?



<http://bit.ly/carboncountdown>

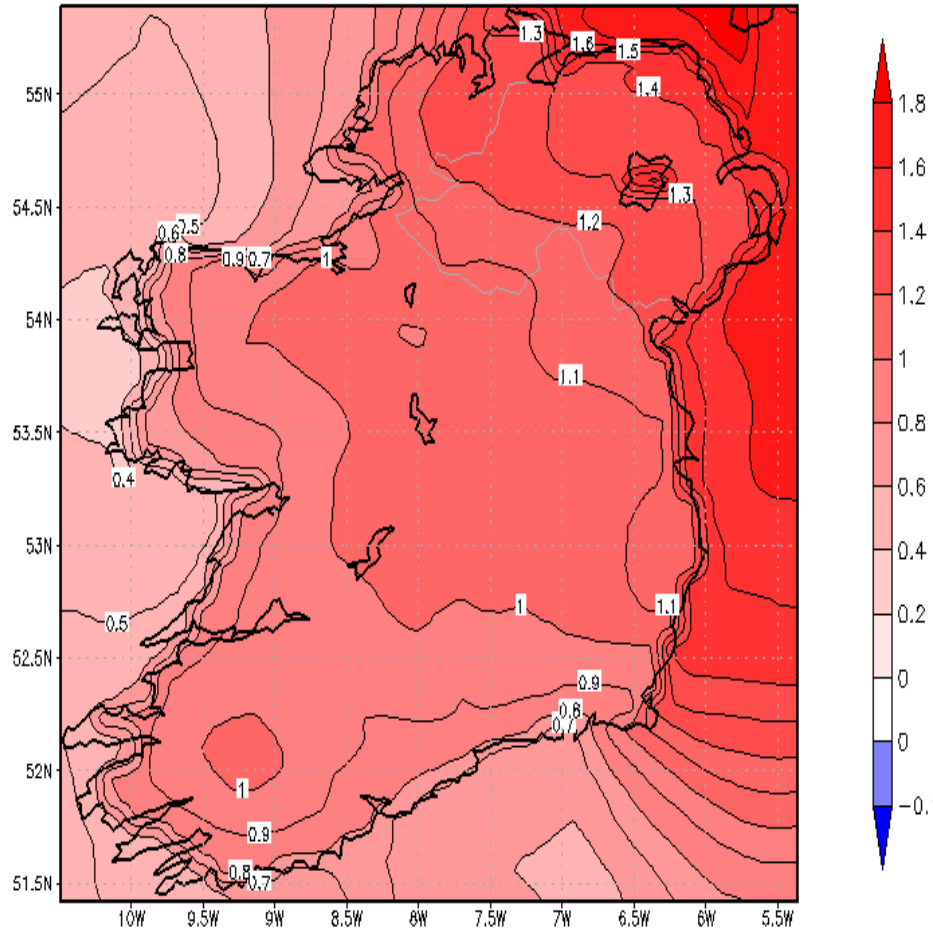
At current levels of emissions, to have a 50:50 chance of avoiding 1.5°C warming, the carbon budget for the entire 21st Century would be exhausted within the next decade.

At current levels of emissions, to have a 50:50 chance of avoiding 2°C warming, the carbon budget for the entire 21st Century would be exhausted within the next 3 decades.

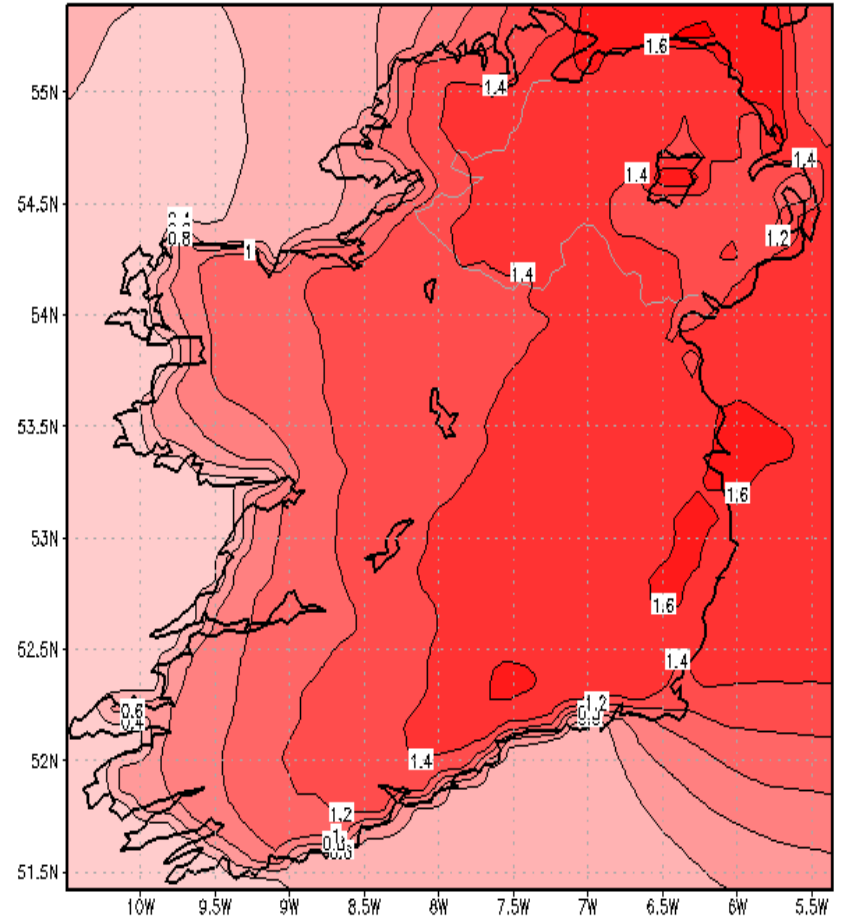


Regional Climate Model Projected Temperature Changes from 1961-90 to 2021-50

DJF 21-50 WRFmax-temp anomaly in ($^{\circ}\text{C}$) from 61-90



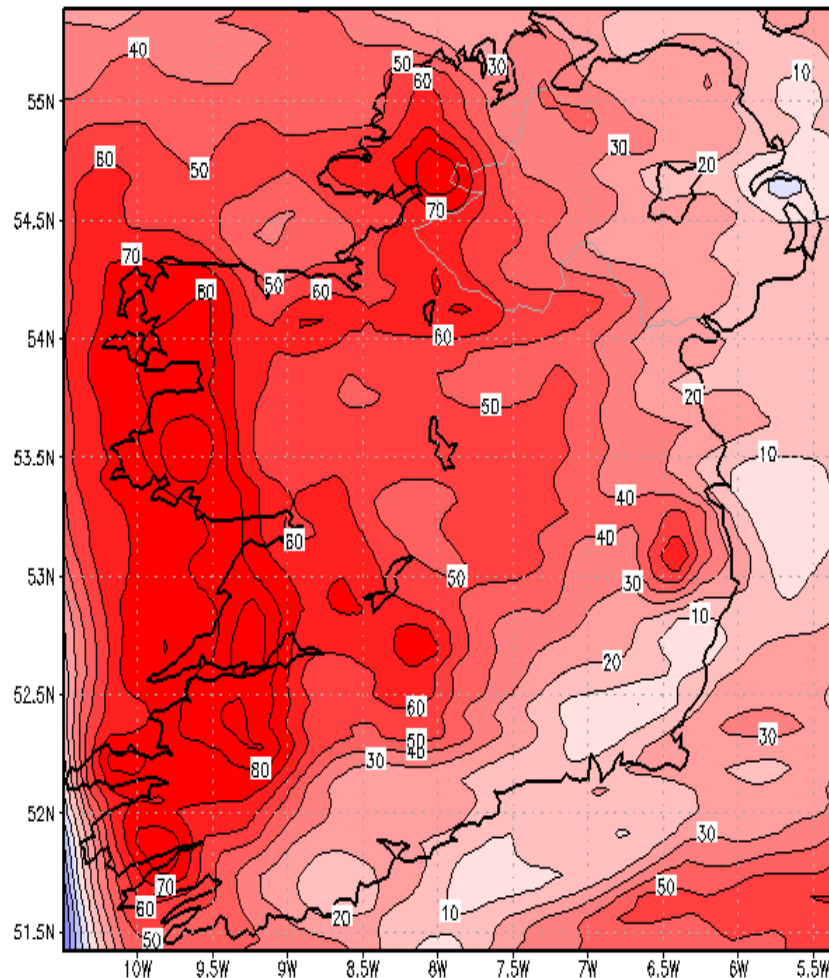
JJA 21-50 WRFmax-temp anomaly in ($^{\circ}\text{C}$) from 61-90



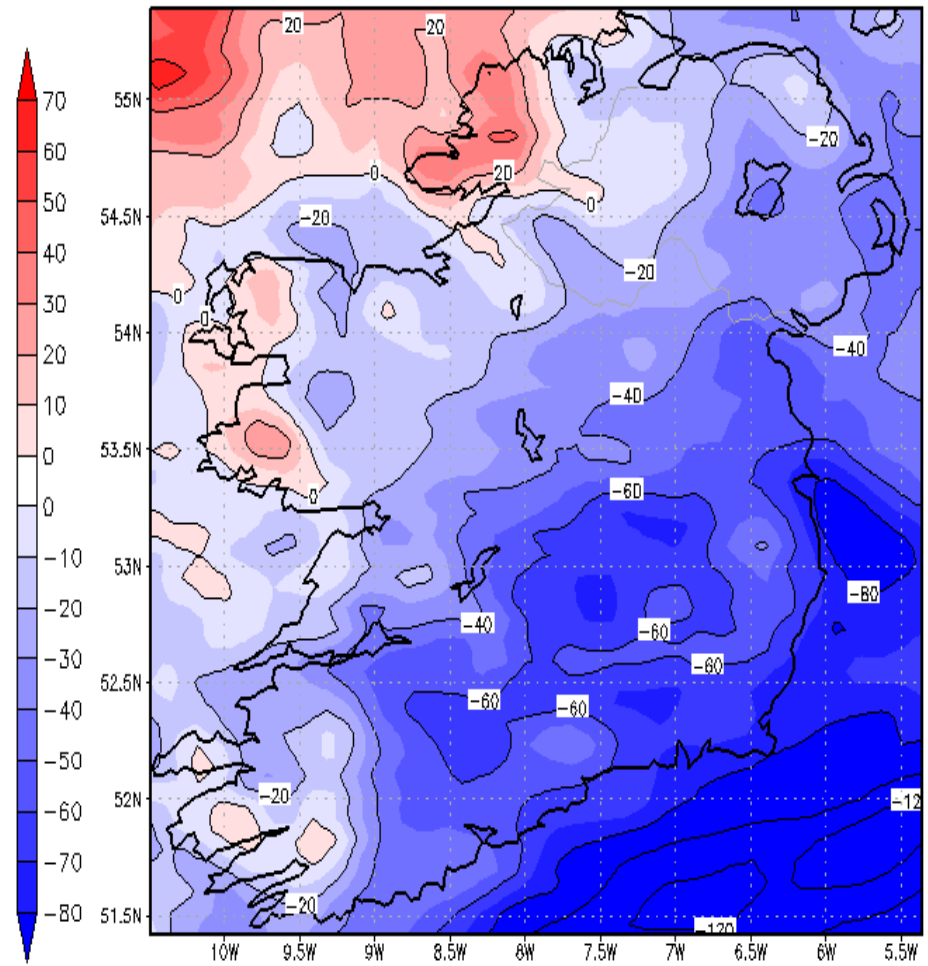
GCM: EC-Earth RCP8.5 RCM: WRF (ICARUS, Maynooth University)

Regional Climate Model: Projected Rainfall Changes from 1961-90 to 2021-50

DJF 21-50 WRFprecip anomaly (mm) from 61-90



JJA 21-50 WRFprecip anomaly (mm) from 61-90



GCM: EC-Earth

RCP8.5

RCM: WRF

(ICARUS, Maynooth University)



Winter 2013/14



Stormiest Winter on Record and at least for 143 years

Winter 2015/16

Wettest Winter on Record over half of Ireland

Highest Daily Flow Recorded on the River Moy – December 2015

Donegal: 22nd August 2017

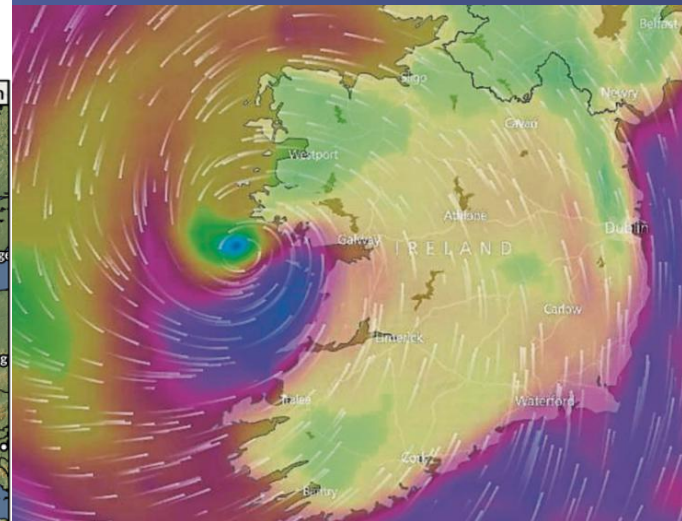
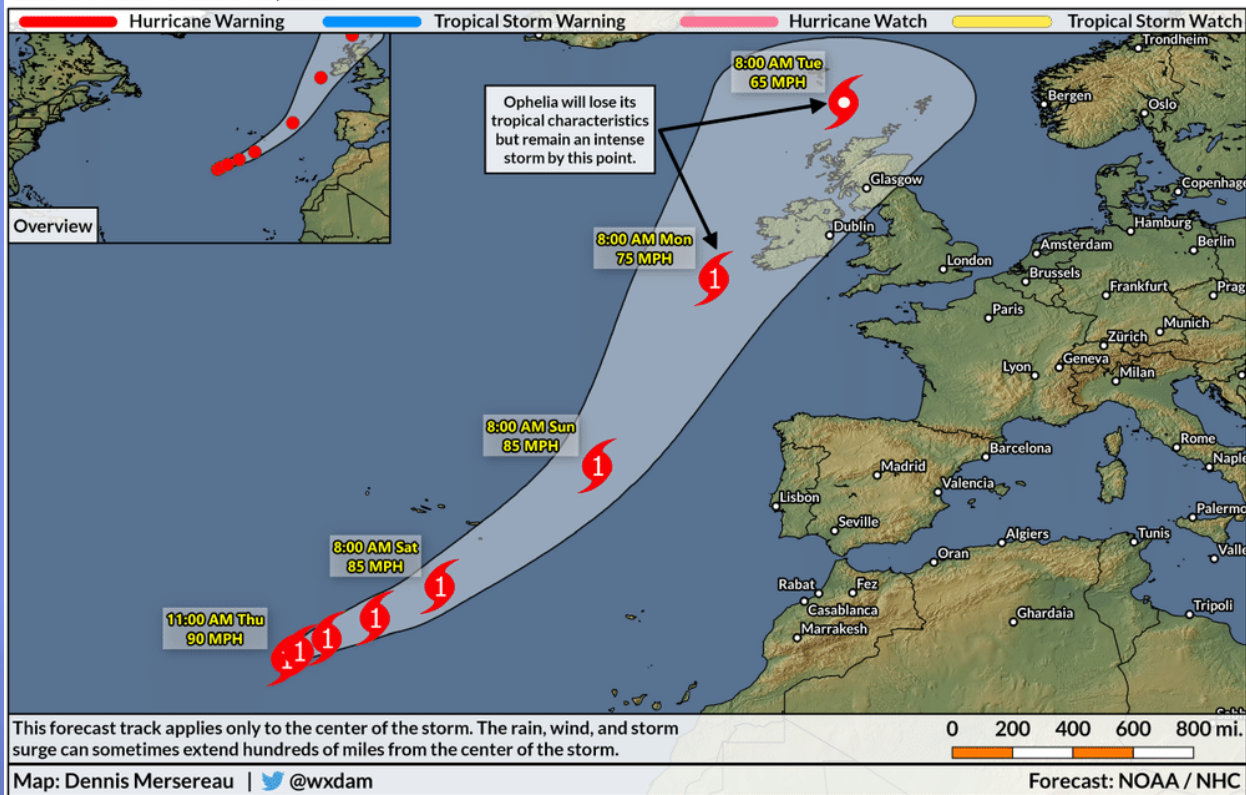
63mm of rain within a six-hour period



Hurricane Ophelia

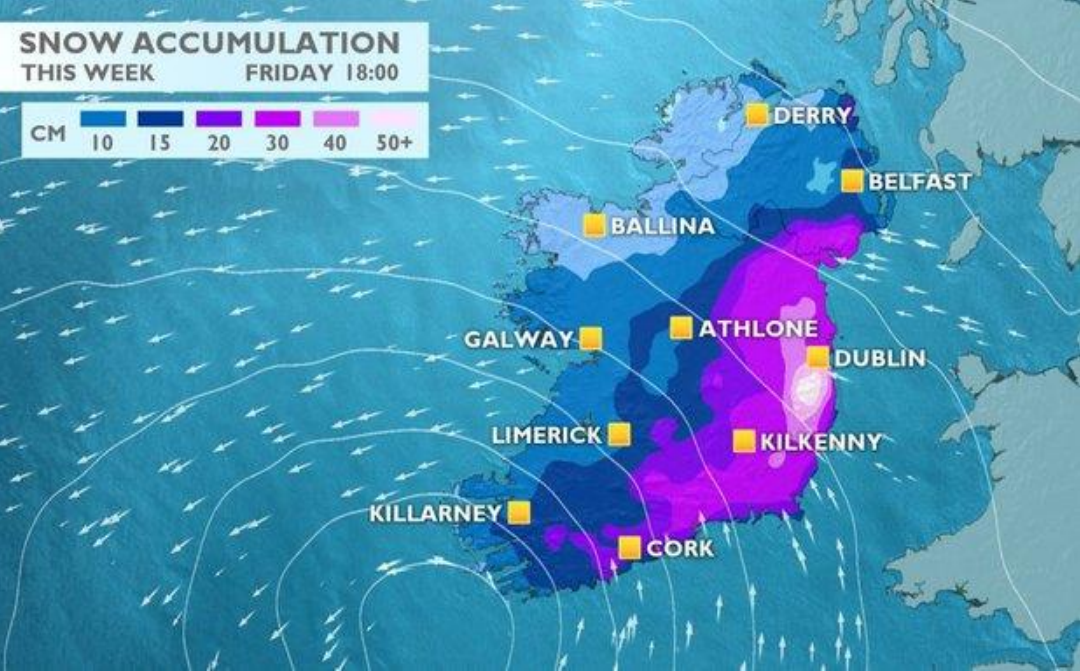
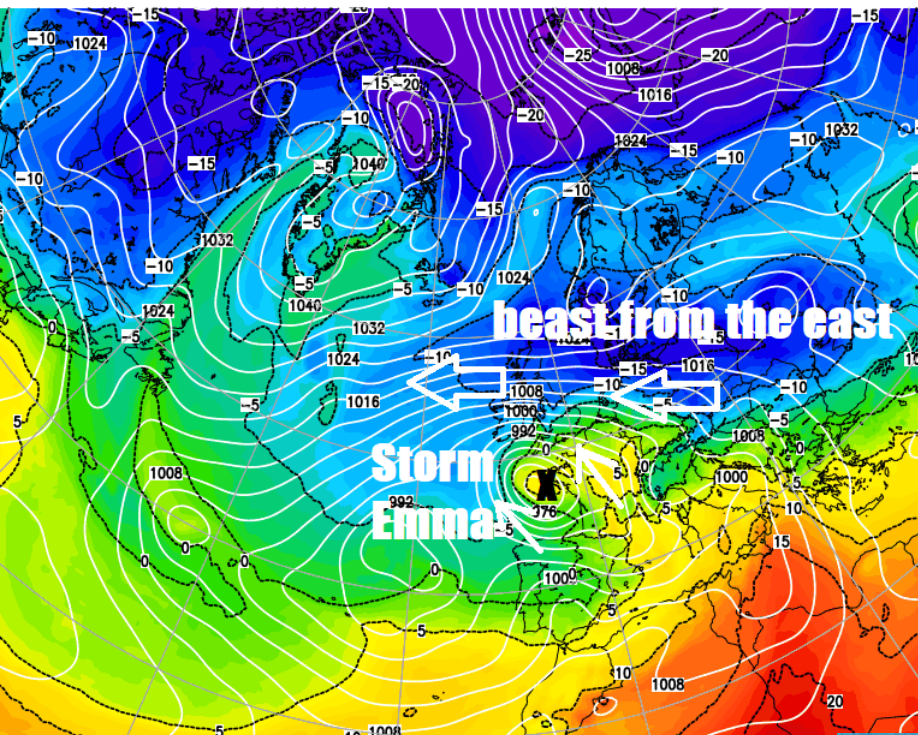
11:00 AM EDT October 12, 2017

WINDS: 90 MPH || MOVEMENT: NNE @ 2 MPH || MIN. PRESSURE: 978 mb



Ophelia





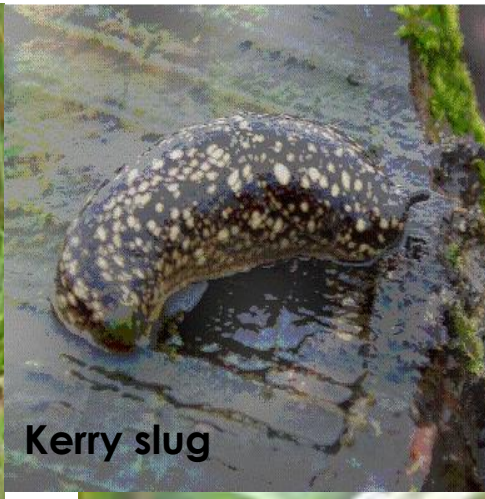
Threatened Landscapes of Ireland



Some vulnerable species in Ireland



Curlew



Kerry slug



Irish damselfly



Budapest slug



Salmon



Cowberry



Arctic Char



Water beetle



Buzzard

CLIMATE ACTION PLAN 2019

To Tackle Climate Breakdown

How credible is it?



Rialtas na hÉireann
Government of Ireland

Positive Aspects of Climate Action Plan

5 –year emissions budgeting supported by new legislation

Establishment of a Climate Action Delivery Board chaired by the Department of the Taoiseach tasked with quarterly progress reporting

Strengthened Climate Action Council and ‘standing’ Oireachtas Committee

Government investments subject to carbon impact assessment

Enshrining of 2050 targets into legislation

Negative Aspects of Climate Action Plan

Short term action limited to 2030 compliance and amounts to an emissions reduction rate of 2% per annum. Early and deeper emission cuts are required now to establish a Paris compliant pathway.

Over-reliance on marginal abatement cost curves to determine short term mitigation. No long-term vision in line with Paris Agreement requirements.

Cost of mitigation repeatedly emphasised. Damage costs of inadequate mitigation largely ignored.

The recommendations of the Joint Oireachtas Committee are not fully implemented and the mandate of the public, as evident in the Citizens' Assembly, is also diluted.



Is the public aware of
the transition
necessary to achieve
2030 compliance?

Is the commitment of
government
convincing?

- 1,000 more Wind turbines
- 840,000 EVs/PHEVs by 2030
(Currently 2.7M vehicles on Irish Roads)
- Ban on petrol/diesels vehicles in 2030
- 45,000 deep retrofits per year to 2030
- Installation of 600,000 heat pumps by 2030

[Afforestation 300,000Ha (2X area of Co. Kildare) to sequester 1Mt C.
(Agricultural emissions 20Mt)

Reduction in national herd (~1.5M)
/abandonment of Foodwise 2025
production targets]

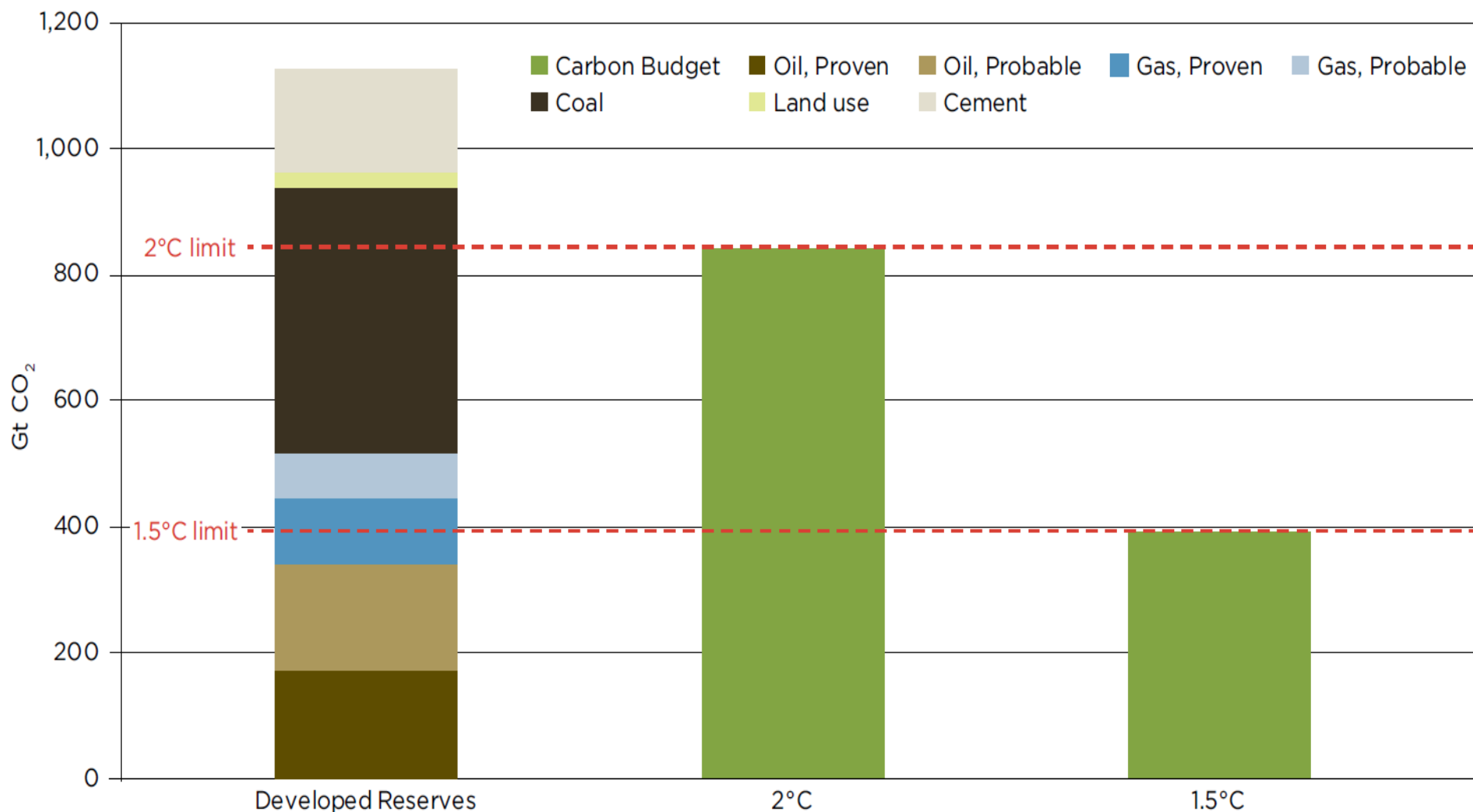


Whither Geology?

- There is no future for petroleum geology
- Geology needs to refocus on key sub fields such as hydrogeology and potentially carbon capture and storage

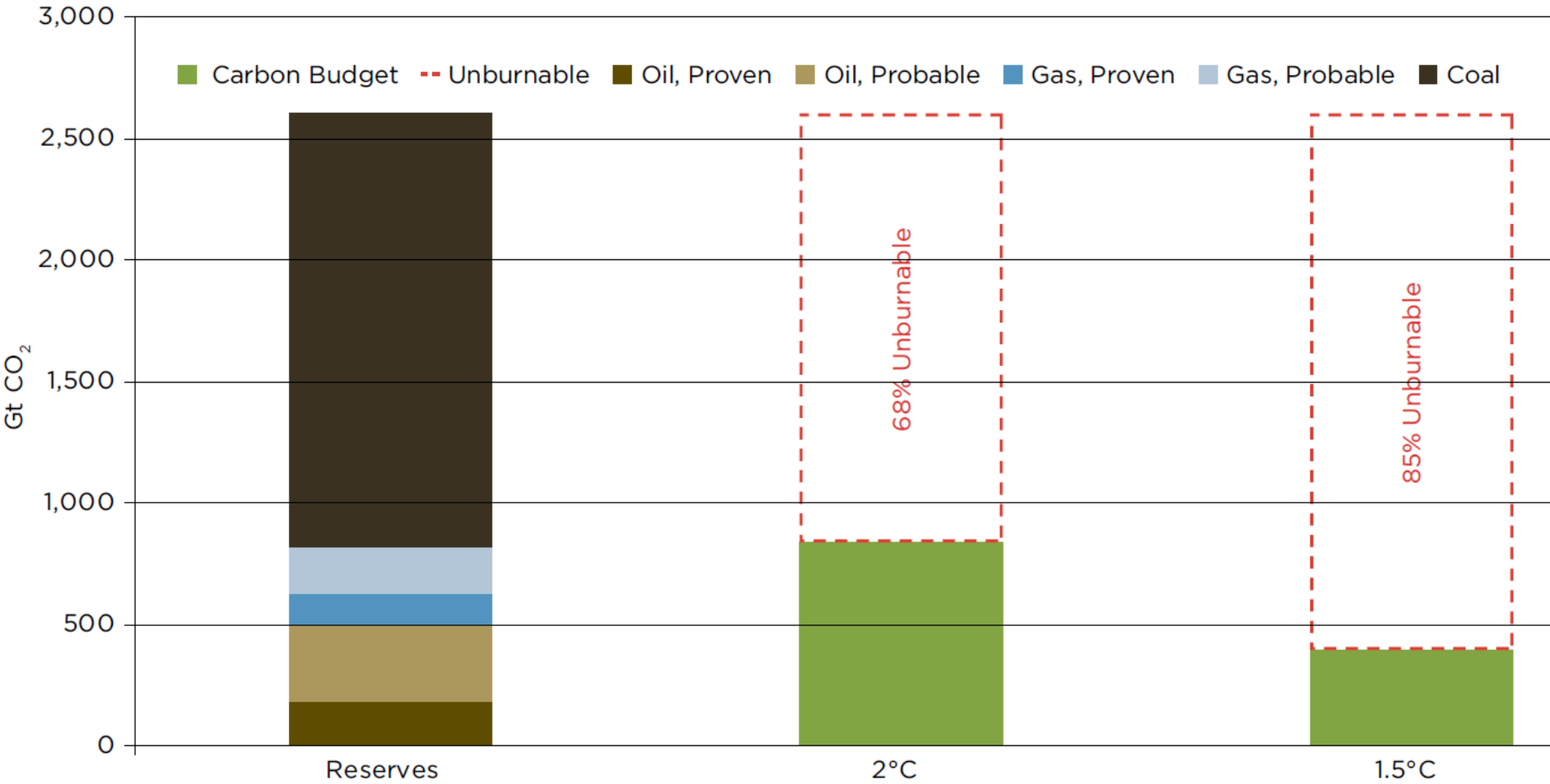
Further extraction of fossil fuels is irresponsible and accelerates dangerous climate change

Figure ES-1: Emissions from Developed Fossil Fuel Reserves, Plus Projected Land Use and Cement Manufacture



Sources: Rystad Energy, International Energy Agency (IEA), World Energy Council, Intergovernmental Panel on Climate Change (IPCC)

Figure 2: Global Fossil Fuel Reserves Compared to Carbon Budgets for Likely Chance of 2°C and Medium Chance of 1.5°C²⁸



Sources: Rystad Energy, World Energy Council, IPCC

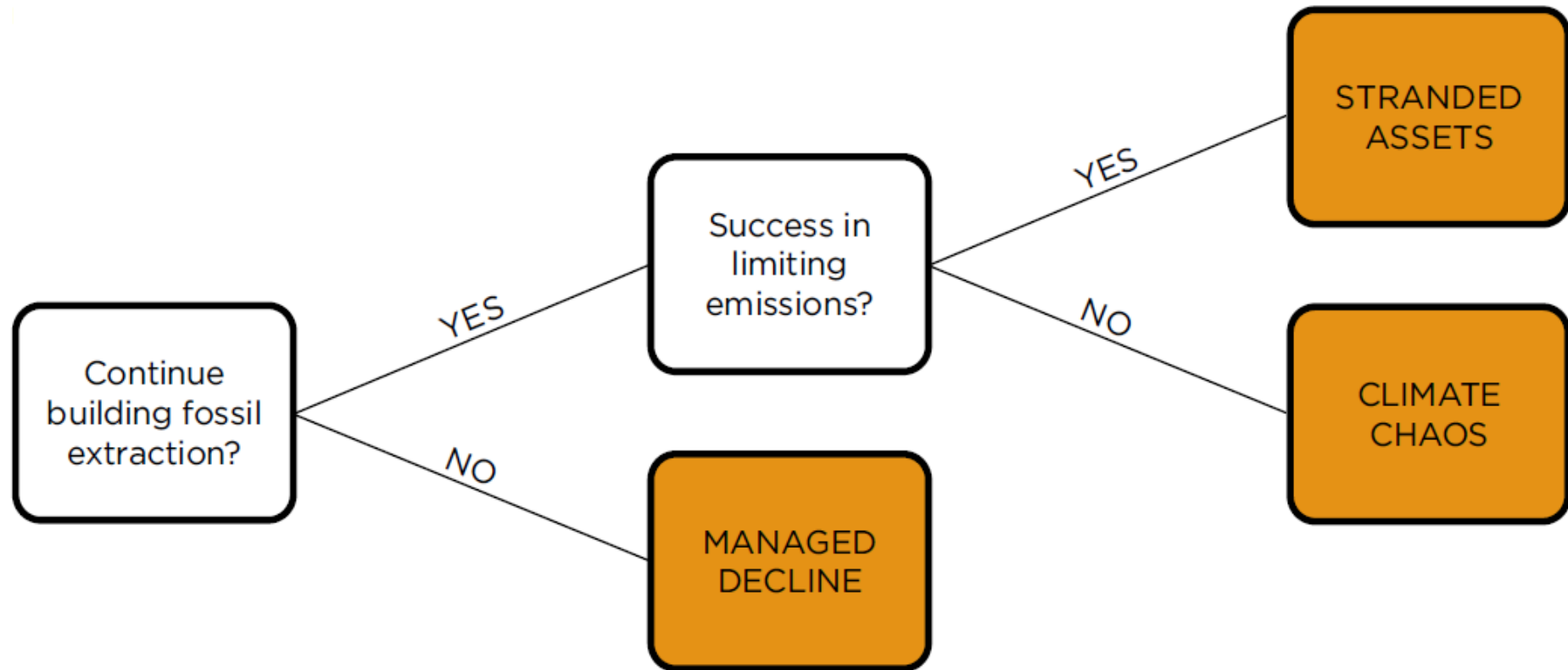
Key Findings:

- The potential carbon emissions from the oil, gas, and coal in the world's currently operating fields and mines would take us beyond 2°C of warming.
- The reserves in currently operating oil and gas fields alone, even with no coal, would take the world beyond 1.5°C.
- With the necessary decline in production over the coming decades to meet climate goals, clean energy can be scaled up at a corresponding pace, expanding the total number of energy jobs.

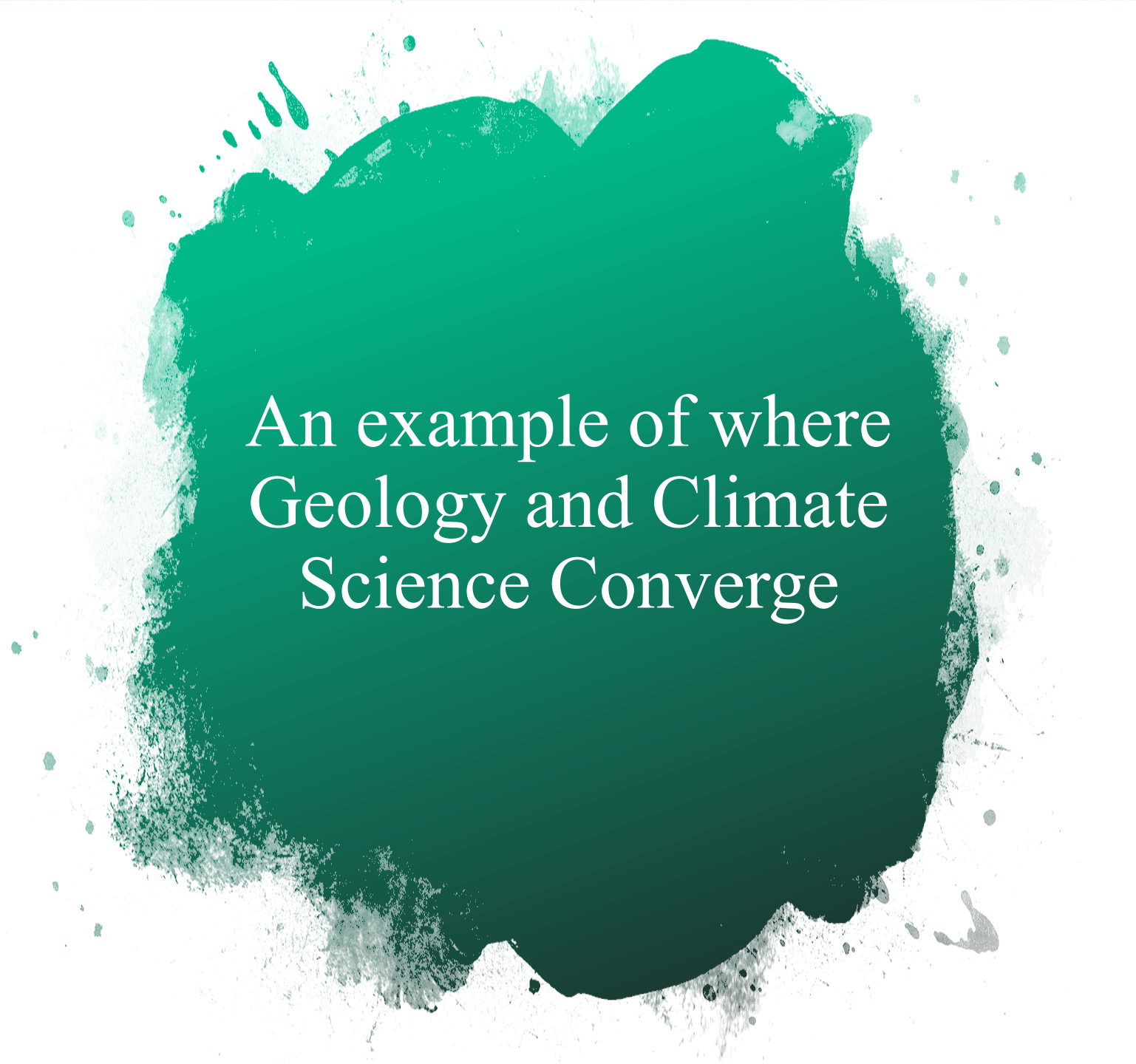
Key Recommendations:

- No new fossil fuel extraction or transportation infrastructure should be built, and governments should grant no new permits for them.
- Some fields and mines – primarily in rich countries – should be closed before fully exploiting their resources, and financial support should be provided for non-carbon development in poorer countries.
- This does not mean stopping using all fossil fuels overnight. Governments and companies should conduct a managed decline of the fossil fuel industry and ensure a just transition for the workers and communities that depend on it.

Logic Tree of Fossil Fuel Extraction versus Compliance with International Obligations for Emissions Reductions

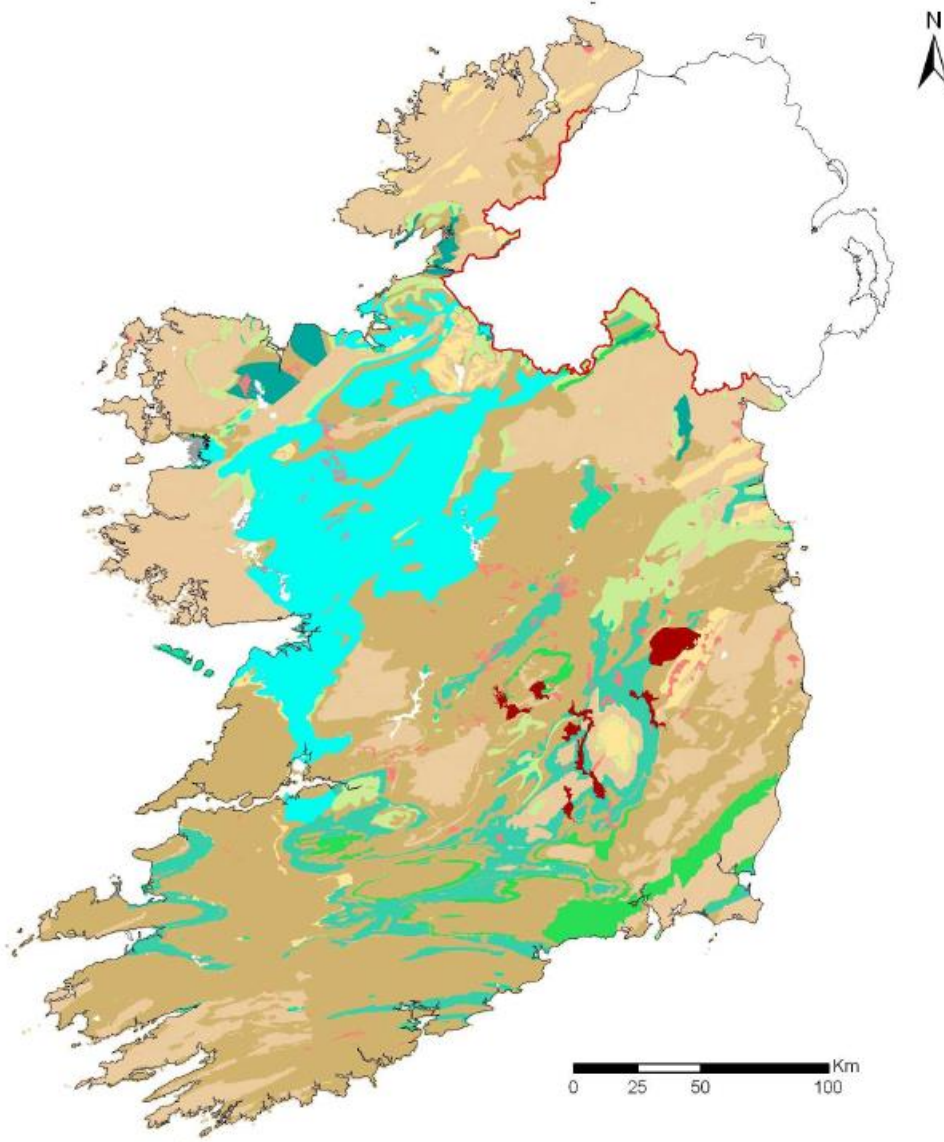


Source: Oil Change International



An example of where
Geology and Climate
Science Converge

National Aquifer Map



Bedrock aquifers

Regionally Important Locally Important

Rk Karstified

Lm Generally moderately productive

Rf Fissured bedrock

Li Moderately productive only in local zones

Lk Locally important karstified aquifer

Poor

Pi Generally unproductive except for local zones

Pu Generally unproductive

Gravel aquifers

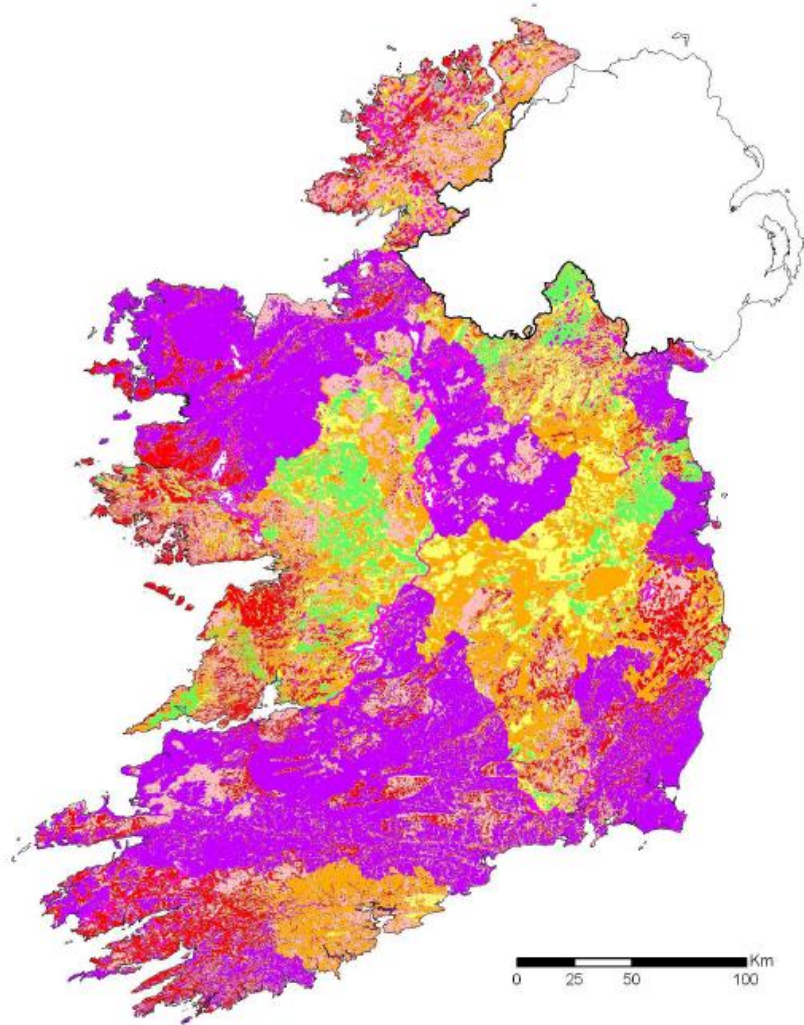
Regionally Important **Rg**

Locally Important **Lg**

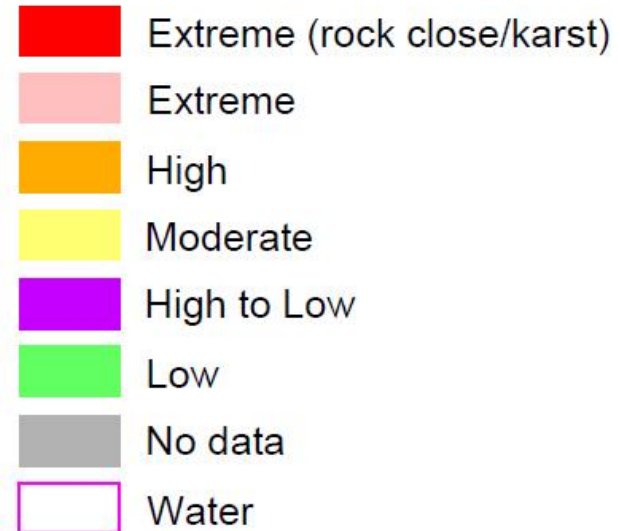
GSI hydrogeologists – past and present
– Donal Daly, Vincent Fitzsimons,
Geoff Wright,
Coran Kelly



National Interim Vulnerability Map



Groundwater Vulnerability

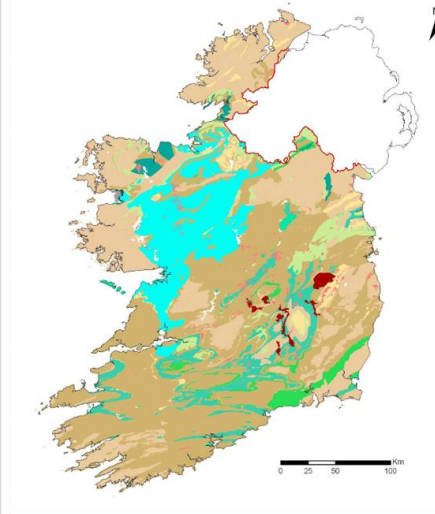
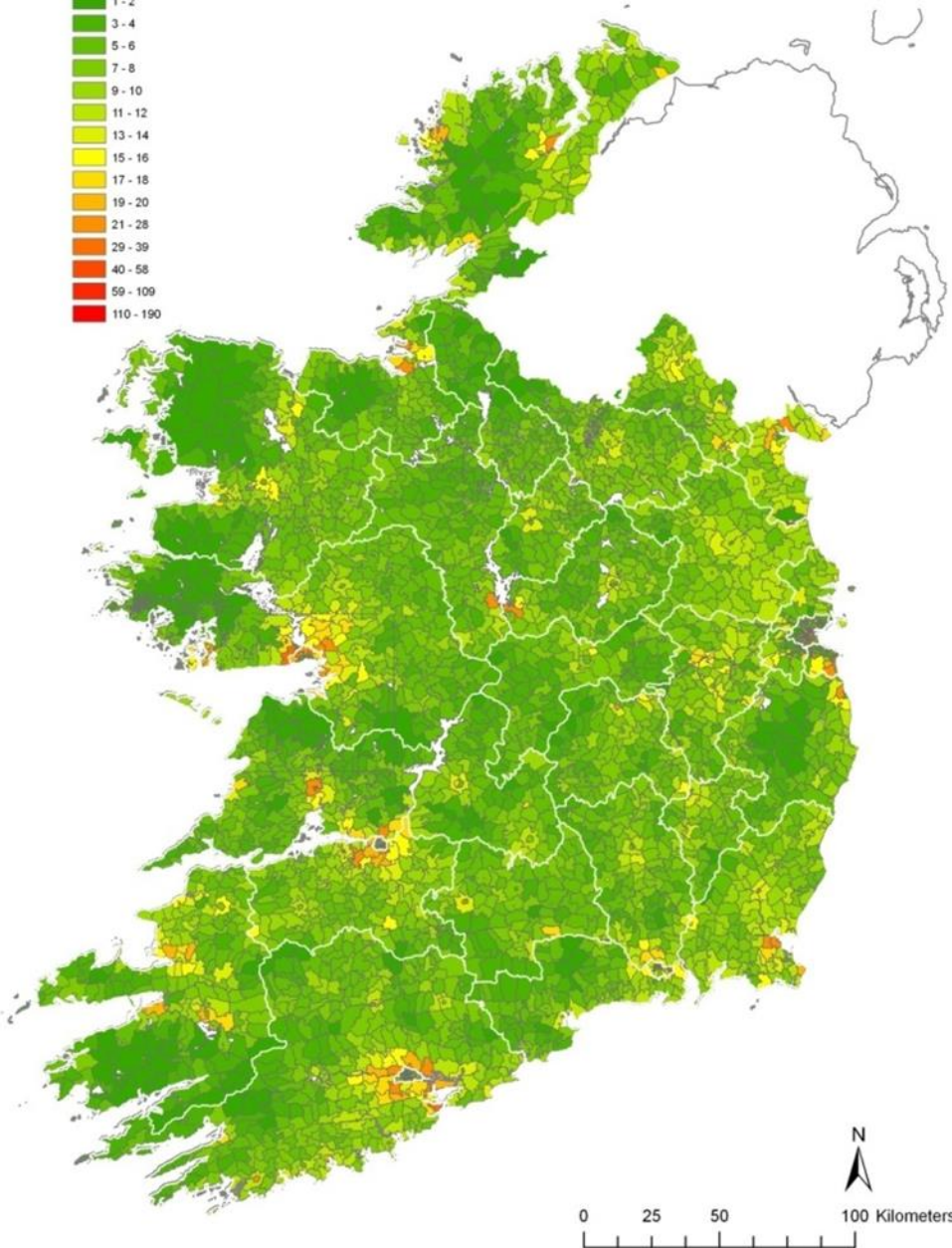


GSI hydrogeologists – past and present
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Geoff Wright,
Coran Kelly

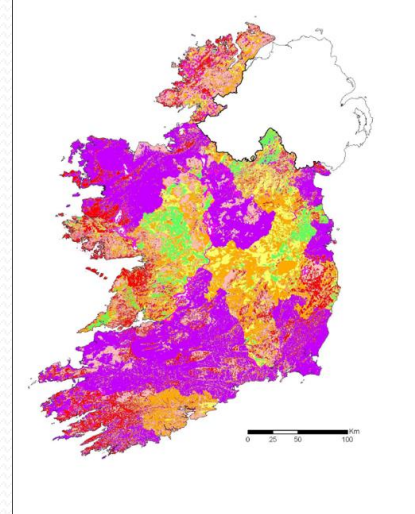
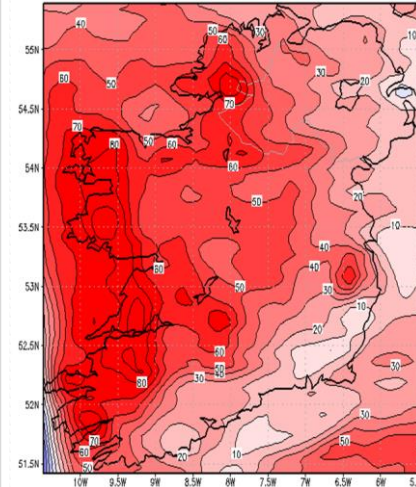


Septic tank density by electoral division

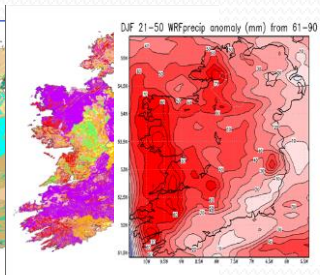
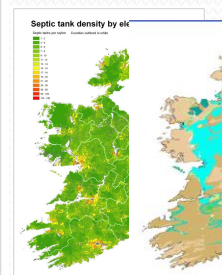
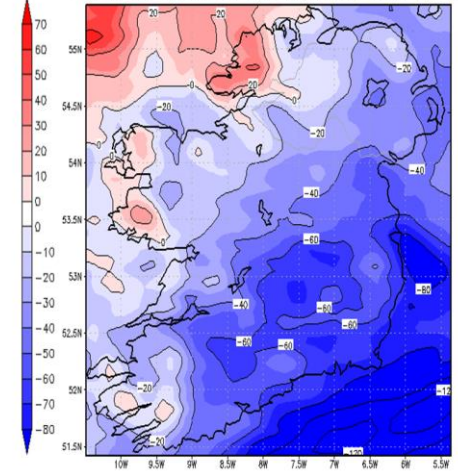
Septic tanks per sq/km Counties outlined in white



DJF 21-50 WRFprecip anomaly (mm) from 61-90



JJA 21-50 WRFprecip anomaly (mm) from 61-90



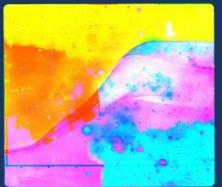
Geology can and must be relevant to community needs



COP21-CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

ipcc
Global Warming of 1.5°C

An IPCC special report on the impacts of global warming of 1.5°C, drawing on the latest science, to inform the global response to the threat of climate change, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty



WGL WGL WGL



**CLIMATE
ACTION
PLAN
2019**

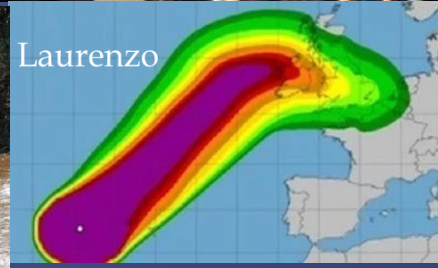
To Tackle Climate Breakdown



Riadas na Míneam
Government of Ireland



Dublin Friday 20th September 2019



**Maynooth
University**
National University
of Ireland Maynooth



ICARUS
Irish Climate Analysis and Research Units

John Sweeney, Emeritus Professor