Climate Change: What is the problem and what can we do?

Professor Conor Murphy,

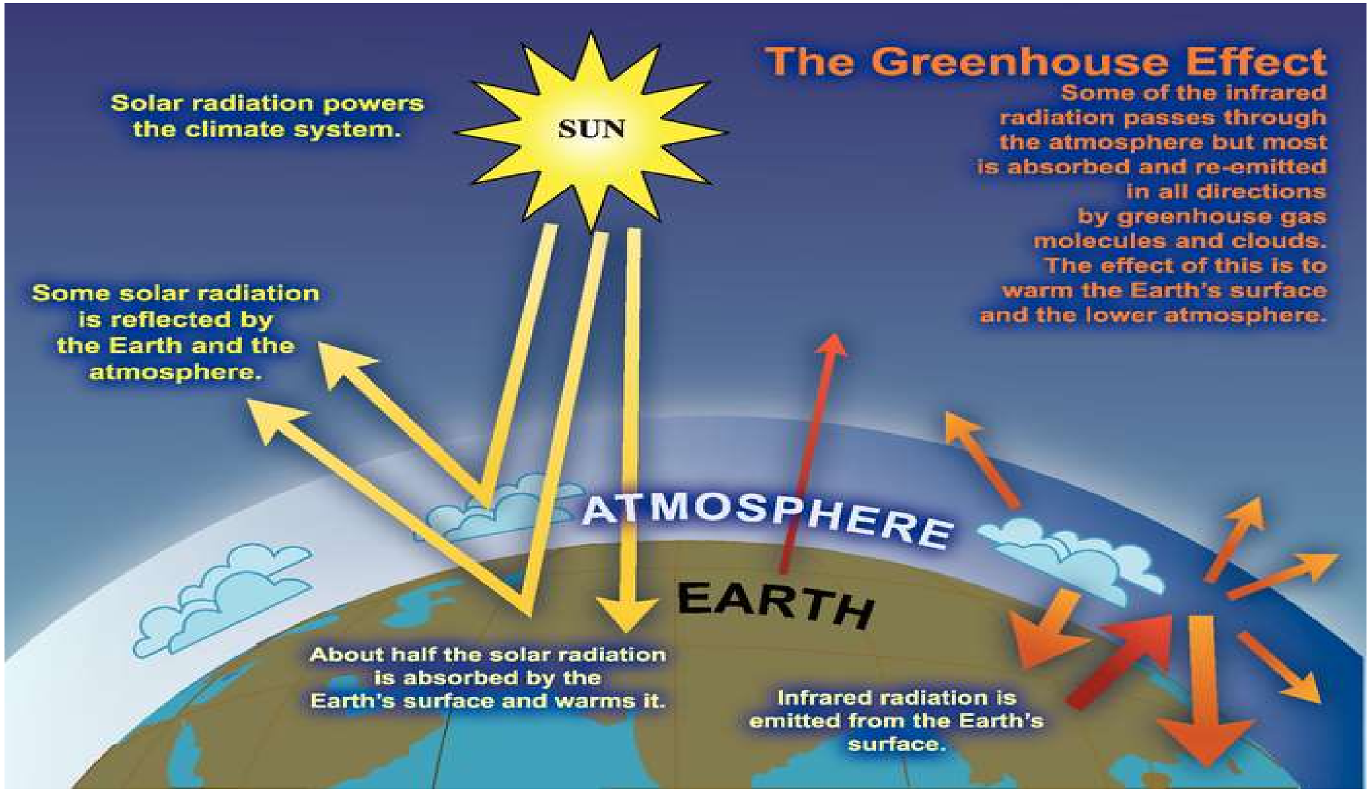
Irish Climate Analysis and Research UnitS (ICARUS),

Dept. of Geography

Maynooth University

Maynooth University
National University of Ireland Maynooth

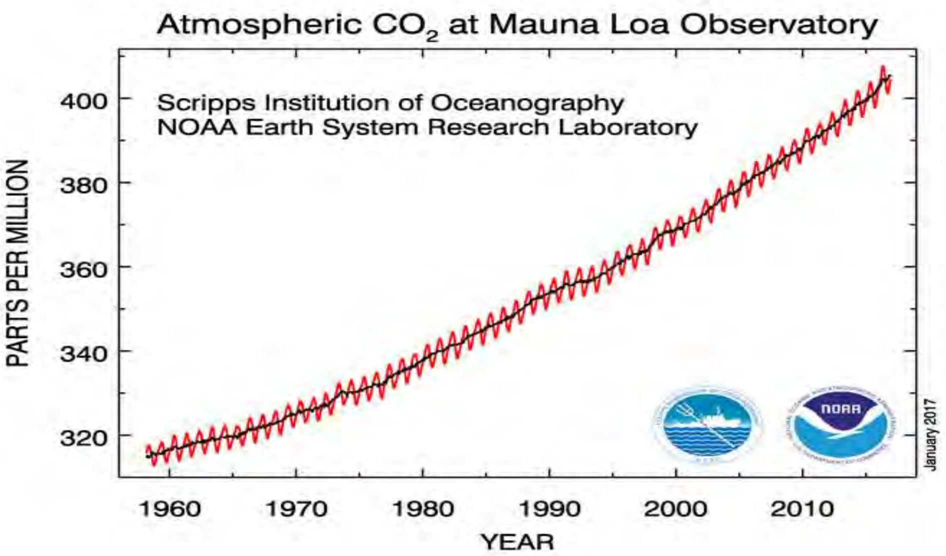
The natural greenhouse effect – a very different world without it!



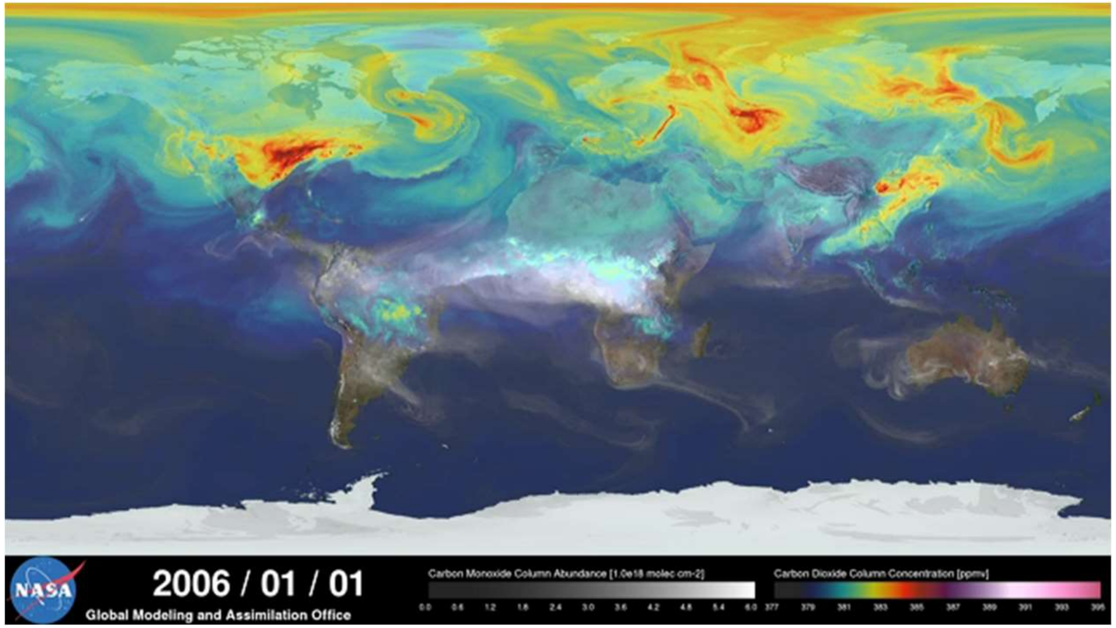
Without the greenhouse gases our planet would have an average temperature of approx. -19^{o}C

1827- A French scientist, Jean-Baptiste Fourier, first recognised the warming effect of greenhouse gases in the atmosphere. He used the analogy of the glass in a greenhouse, which led to the name 'greenhouse effect'.

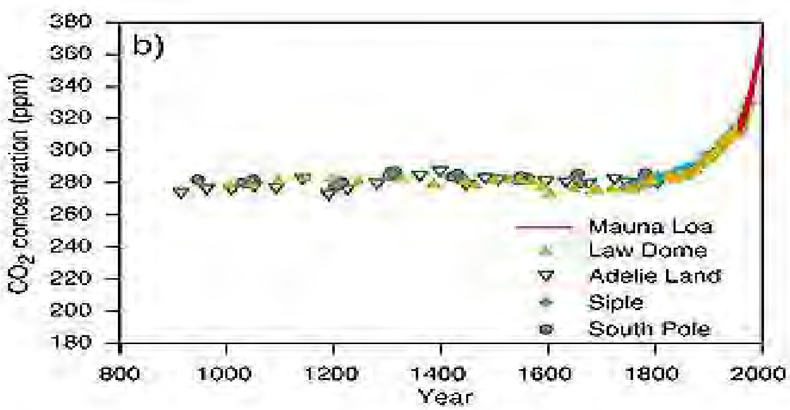
1860- Irish scientist, John Tyndall, measured the absorption of infrared radiation by GHGs



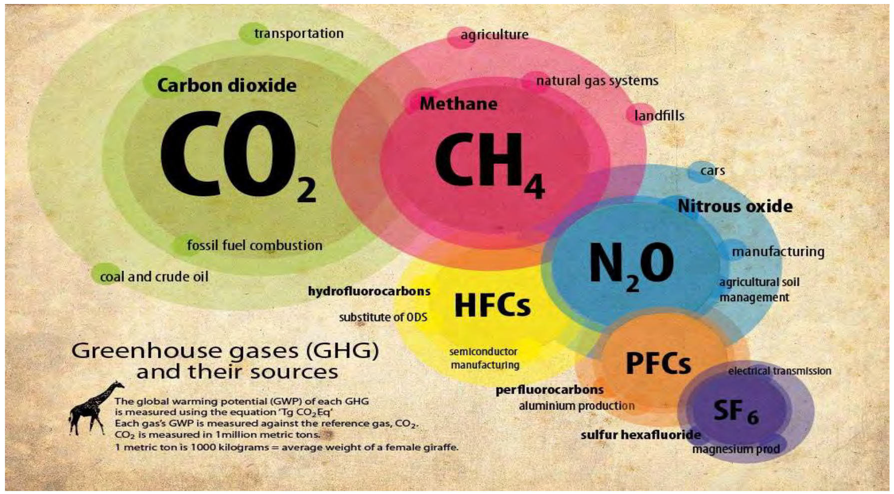
Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
YEAR
January 2017



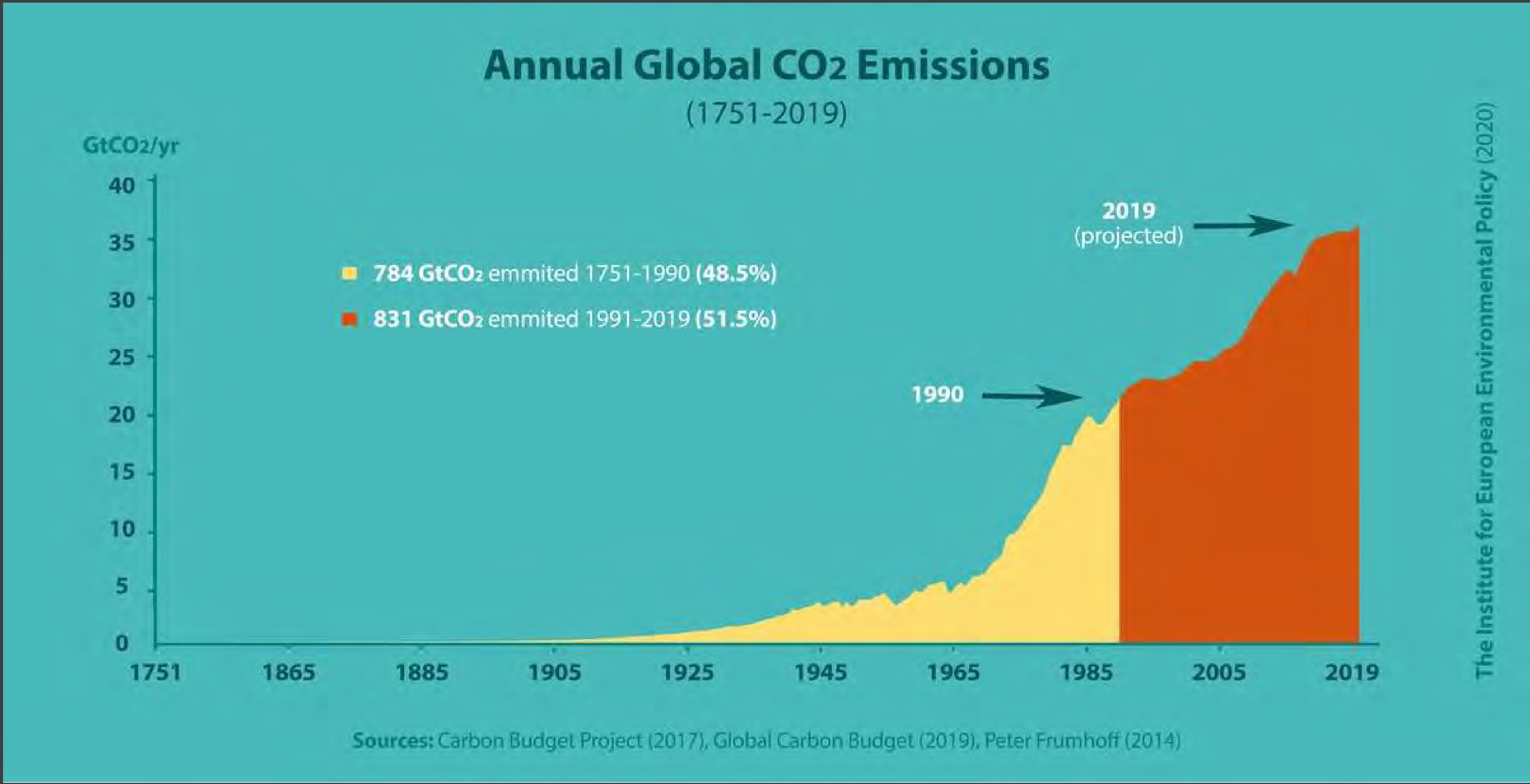
2006 / 01 / 01
Global Modeling and Assimilation Office
Carbon Monoxide Column Abundance [1.0e18 molec cm-2]
Carbon Dioxide Column Concentration [ppmv]



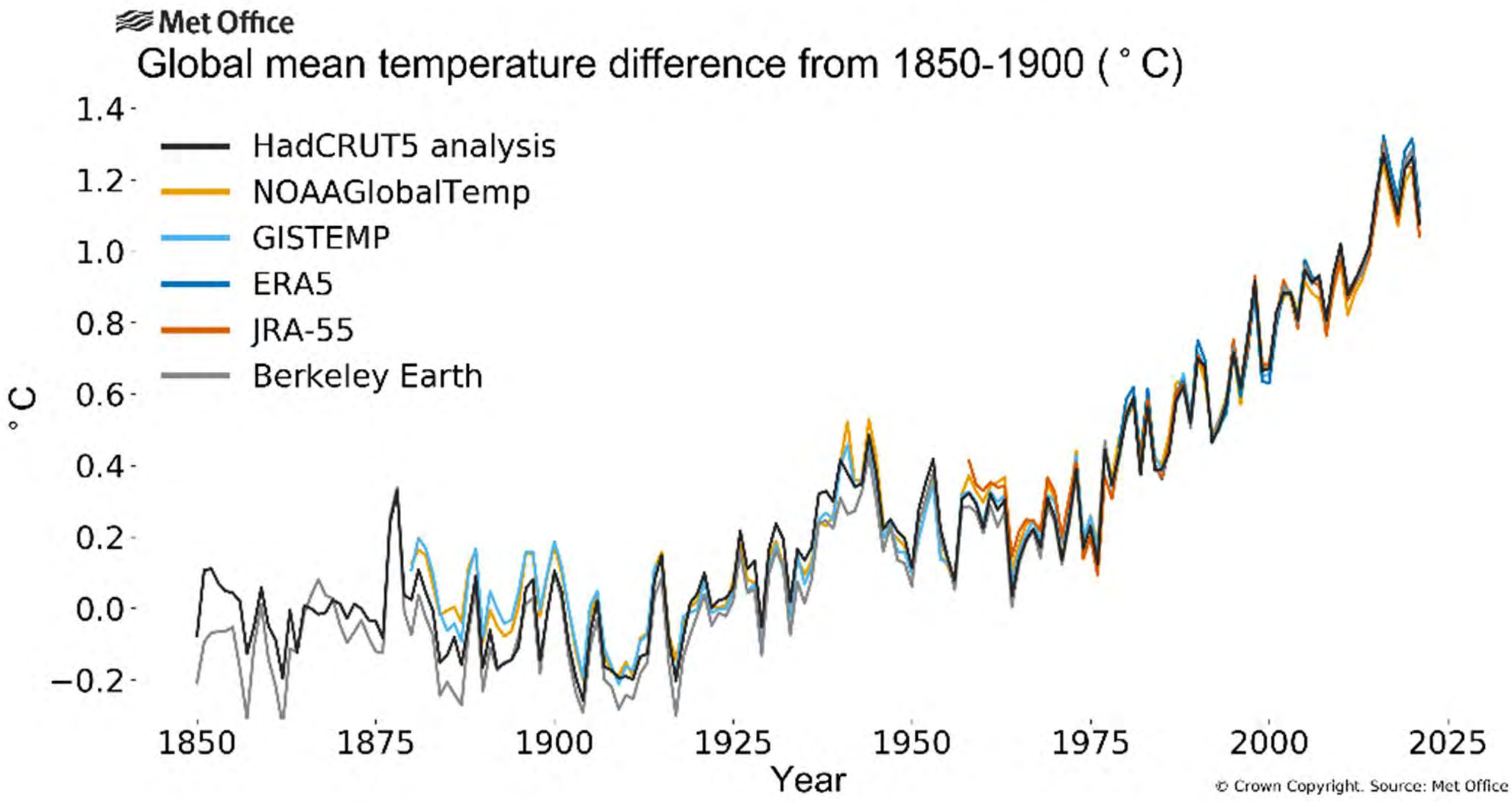
b)
CO_2 concentration (ppm)
380
360
340
320
300
280
260
240
220
200
180
800
1000
1200
1400
1600
1800
2000
Year
Mauna Loa
Law Dome
Adelie Land
Siple
South Pole



transportation
agriculture
Carbon dioxide
CO_2
Methane
CH_4
natural gas systems
landfills
cars
Nitrous oxide
N_2O
fossil fuel combustion
coal and crude oil
manufacturing
agricultural soil management
hydrofluorocarbons
HFCs
substitute of ODS
semiconductor manufacturing
PFCs
perfluorocarbons
aluminium production
electrical transmission
SF_6
sulfur hexafluoride
magnesium prod
Greenhouse gases (GHG) and their sources
The global warming potential (GWP) of each GHG is measured using the equation 'Tg CO_2Eq'
Each gas's GWP is measured against the reference gas, CO_2.
CO_2 is measured in 1million metric tons.
1 metric ton is 1000 kilograms = average weight of a female giraffe.

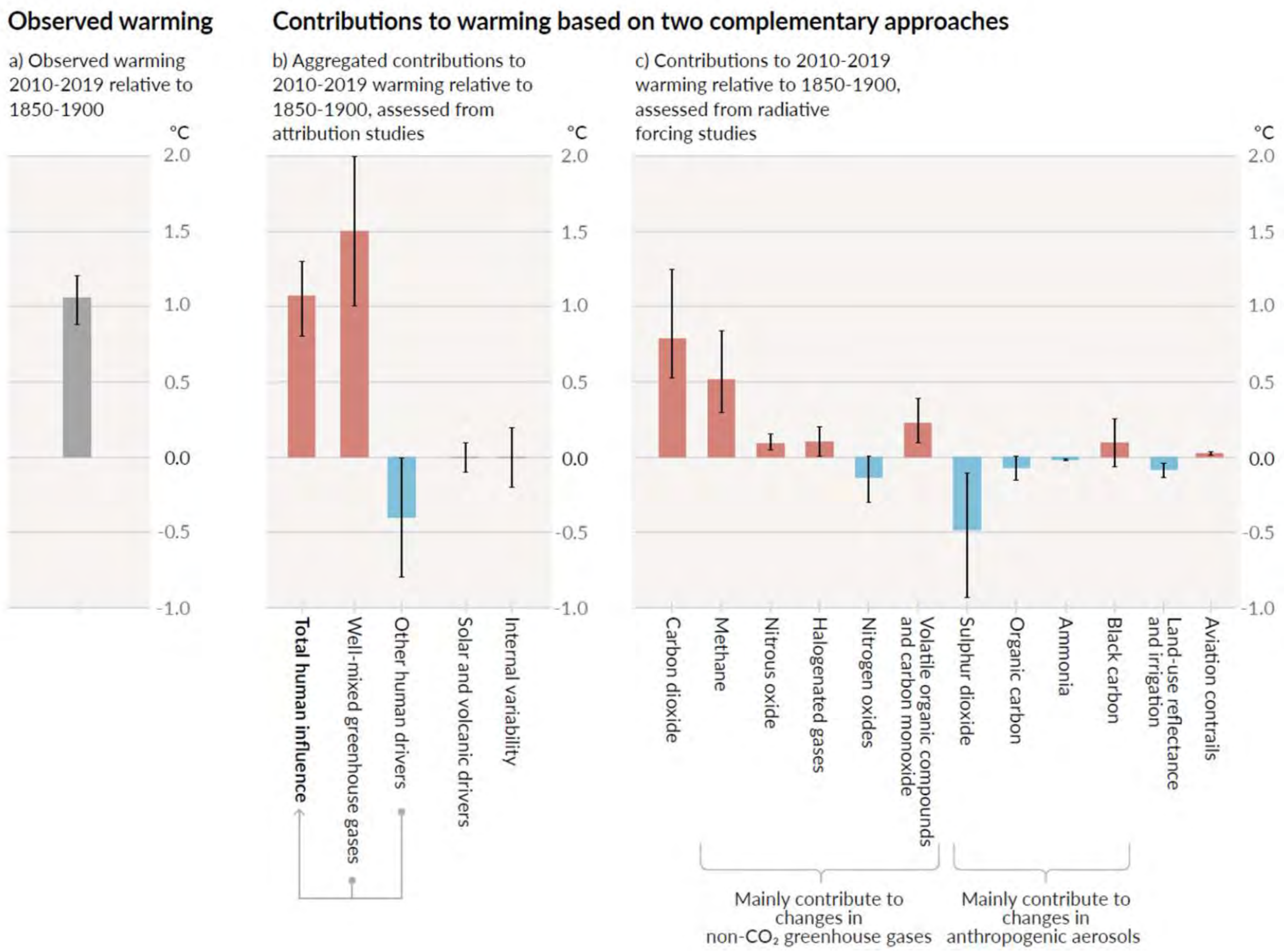


Annual Global CO2 Emissions
(1751-2019)
GtCO2/yr
40
35
30
25
20
15
10
5
0
784 GtCO2 emmited 1751-1990 (48.5%)
831 GtCO2 emmited 1991-2019 (51.5%)
2019
(projected)
1990
1751
1865
1885
1905
1925
1945
1965
1985
2005
2019
The Institute for European Environmental Policy (2020)
Sources: Carbon Budget Project (2017), Global Carbon Budget (2019), Peter Frumhoff (2014)

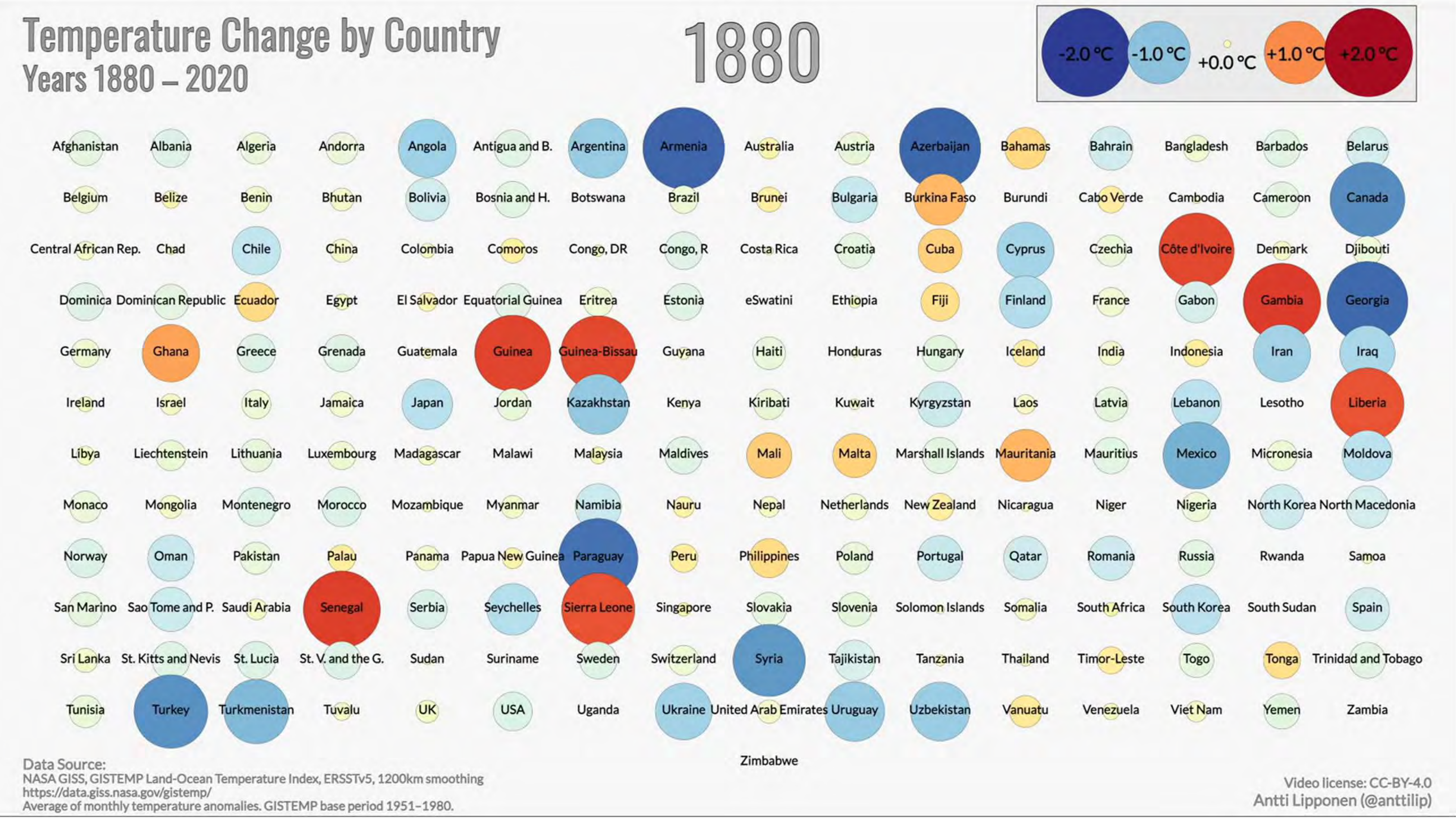


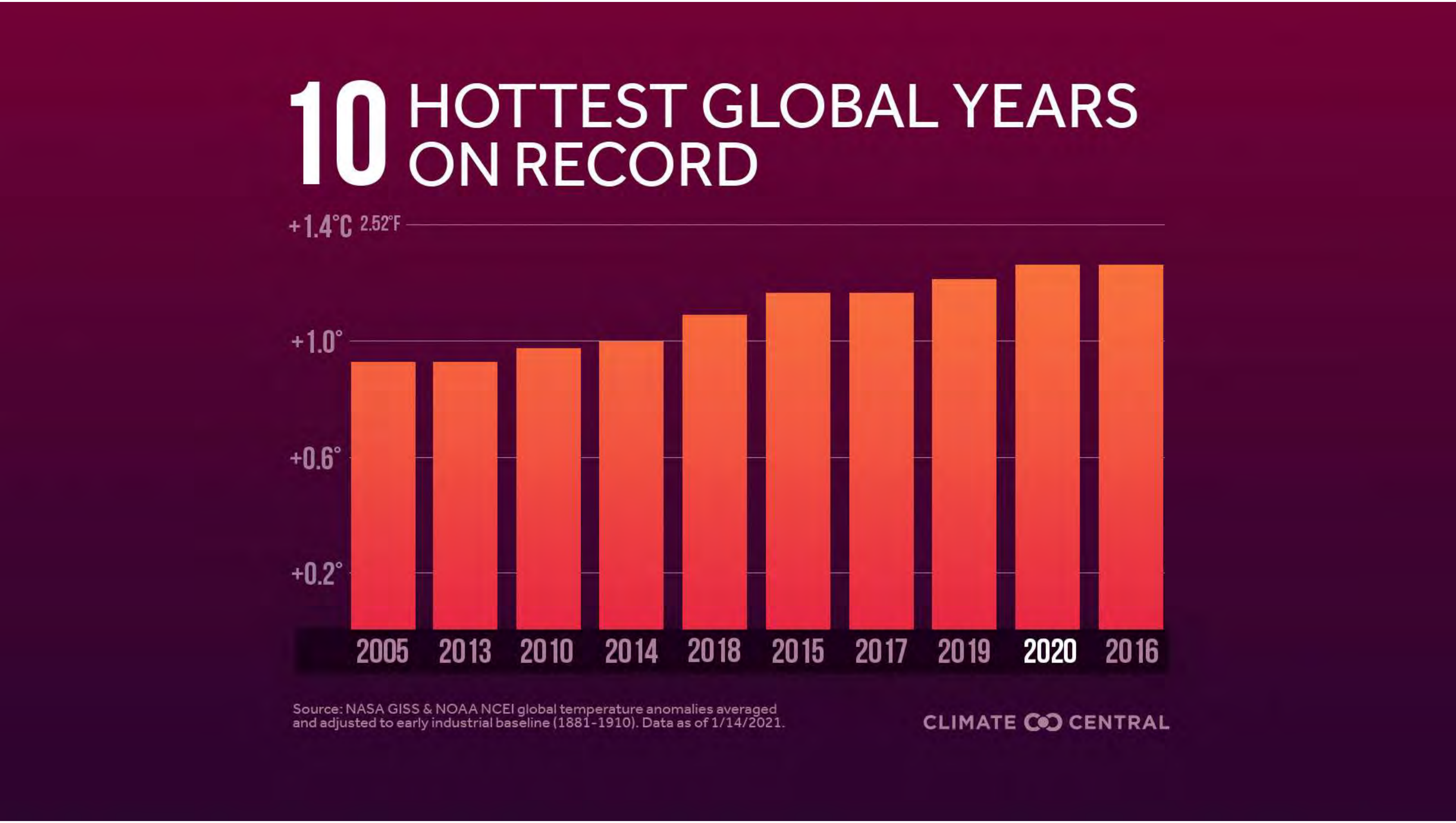
Met Office
Global mean temperature difference from 1850-1900 (°C)
HadCRUT5 analysis
NOAAGlobalTemp
GISTEMP
ERA5
JRA-55
Berkeley Earth
°C
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
1850
1875
1900
1925
1950
1975
2000
2025
Year
© Crown Copyright. Source: Met Office

Observed warming is driven by emissions from human activities, with greenhouse gas warming partly masked by aerosol cooling

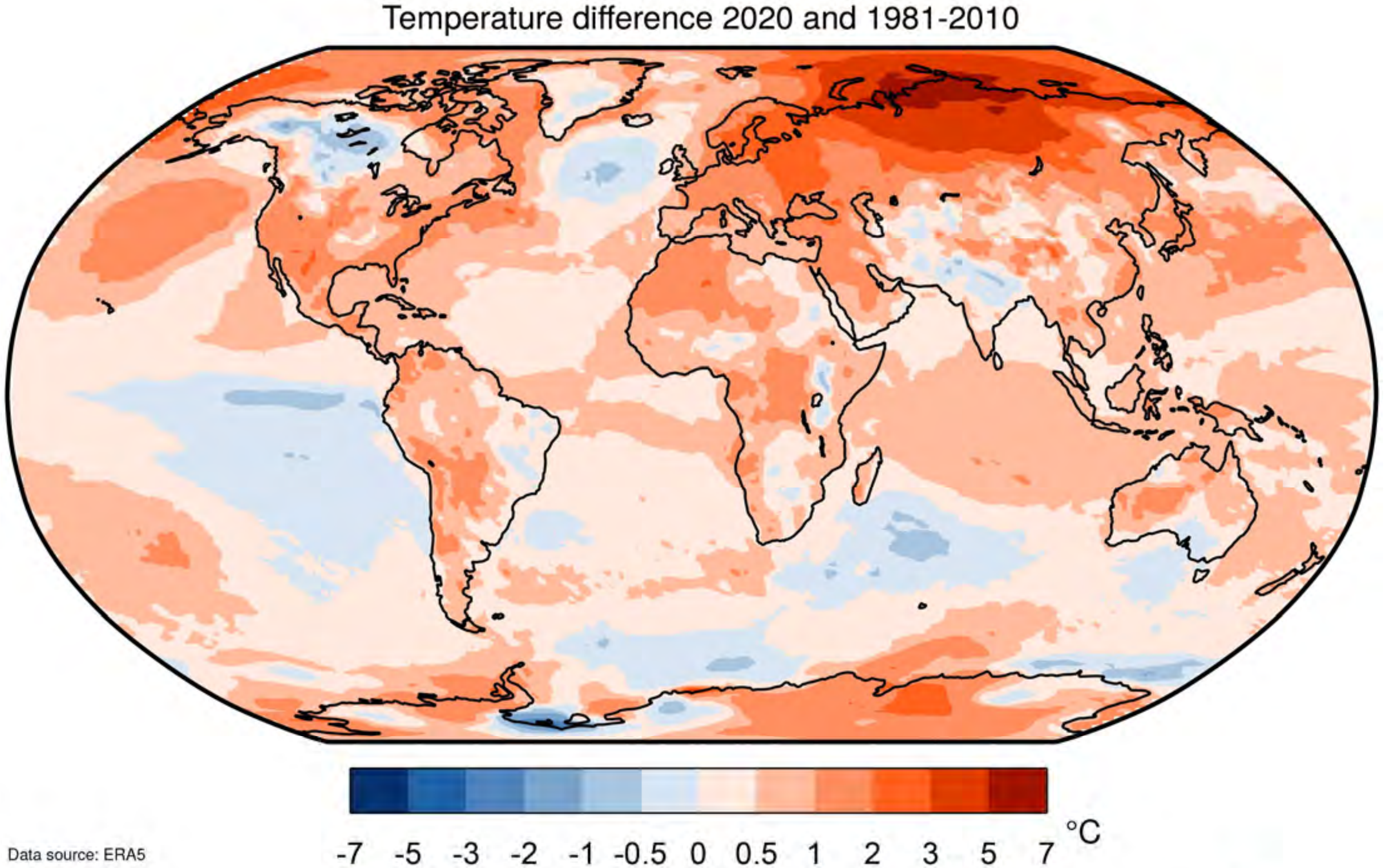


- The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C.
- It is *likely* that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to 0.1°C, and internal variability changed it by –0.2°C to 0.2°C.


Temperature Change by Country
Years 1880 – 2020
1880
-2.0 °C
-1.0 °C
+0.0 °C
+1.0 °C
+2.0 °C
Afghanistan Albania Algeria Andorra Angola Antigua and B. Argentina Armenia Australia Austria Azerbaijan Bahamas Bahrain Bangladesh Barbados Belarus
Belgium Belize Benin Bhutan Bolivia Bosnia and H. Botswana Brazil Brunei Bulgaria Burkina Faso Burundi Cabo Verde Cambodia Cameroon Canada
Central African Rep. Chad Chile China Colombia Comoros Congo, DR Congo, R Costa Rica Croatia Cuba Cyprus Czechia Côte d'Ivoire Denmark Djibouti
Dominica Dominican Republic Ecuador Egypt El Salvador Equatorial Guinea Eritrea Estonia eSwatini Ethiopia Fiji Finland France Gabon Gambia Georgia
Germany Ghana Greece Grenada Guatemala Guinea Guinea-Bissau Guyana Haiti Honduras Hungary Iceland India Indonesia Iran Iraq
Ireland Israel Italy Jamaica Japan Jordan Kazakhstan Kenya Kiribati Kuwait Kyrgyzstan Laos Latvia Lebanon Lesotho Liberia
Libya Liechtenstein Lithuania Luxembourg Madagascar Malawi Malaysia Maldives Mali Malta Marshall Islands Mauritania Mauritius Mexico Micronesia Moldova
Monaco Mongolia Montenegro Morocco Mozambique Myanmar Namibia Nauru Nepal Netherlands New Zealand Nicaragua Niger Nigeria North Korea North Macedonia
Norway Oman Pakistan Palau Panama Papua New Guinea Paraguay Peru Philippines Poland Portugal Qatar Romania Russia Rwanda Samoa
San Marino Sao Tome and P. Saudi Arabia Senegal Serbia Seychelles Sierra Leone Singapore Slovakia Slovenia Solomon Islands Somalia South Africa South Korea South Sudan Spain
Sri Lanka St. Kitts and Nevis St. Lucia St. V. and the G. Sudan Suriname Sweden Switzerland Syria Tajikistan Tanzania Thailand Timor-Leste Togo Tonga Trinidad and Tobago
Tunisia Turkey Turkmenistan Tuvalu UK USA Uganda Ukraine United Arab Emirates Uruguay Uzbekistan Vanuatu Venezuela Viet Nam Yemen Zambia
Zimbabwe
Data Source:
NASA GISS, GISTEMP Land-Ocean Temperature Index, ERSSTv5, 1200km smoothing
https://data.giss.nasa.gov/gistemp/
Average of monthly temperature anomalies. GISTEMP base period 1951–1980.
Video license: CC-BY-4.0
Antti Lipponen (@anttilip)


10 HOTTEST GLOBAL YEARS ON RECORD
+1.4°C 2.52°F
+1.0°
+0.6°
+0.2°
2005
2013
2010
2014
2018
2015
2017
2019
2020
2016
Source: NASA GISS & NOAA NCEI global temperature anomalies averaged and adjusted to early industrial baseline (1881-1910). Data as of 1/14/2021.
CLIMATE CENTRAL

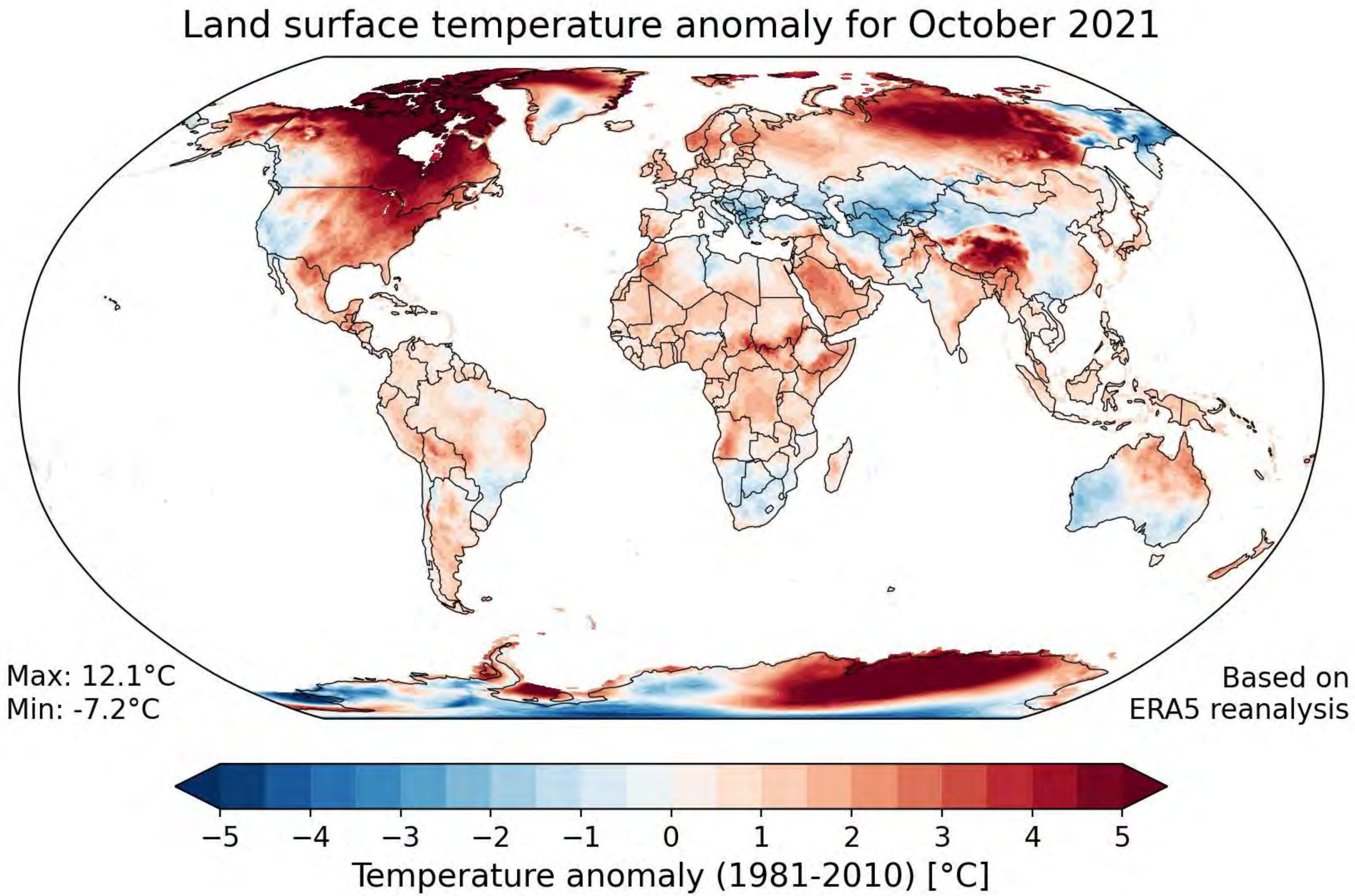
2020 temperature minus the long term mean



Copernicus
Europe's eyes on Earth

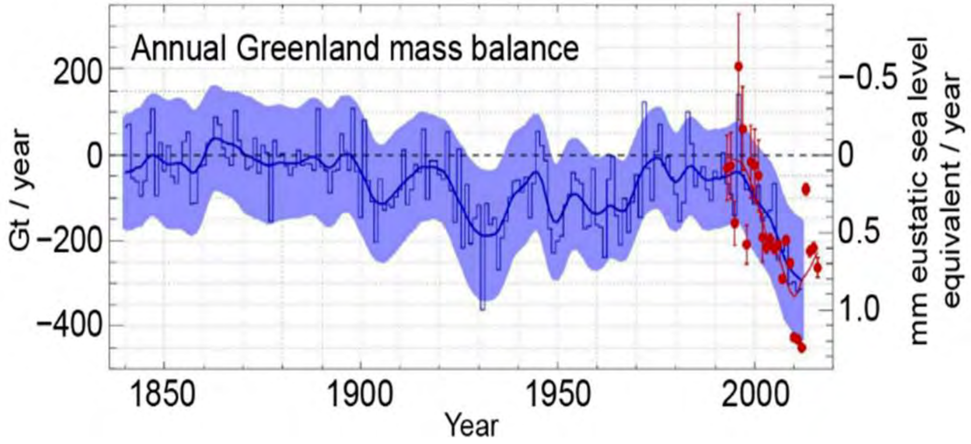
IMPLEMENTED BY ECMWF

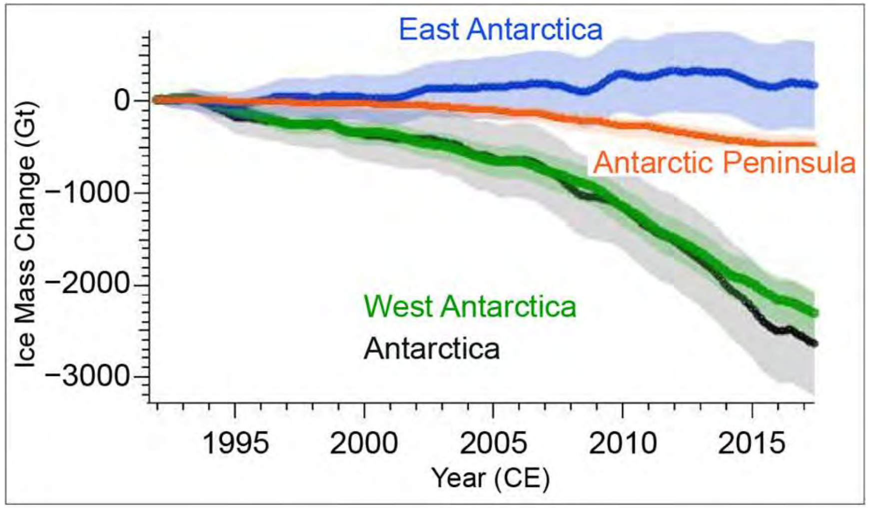
Climate Change Service

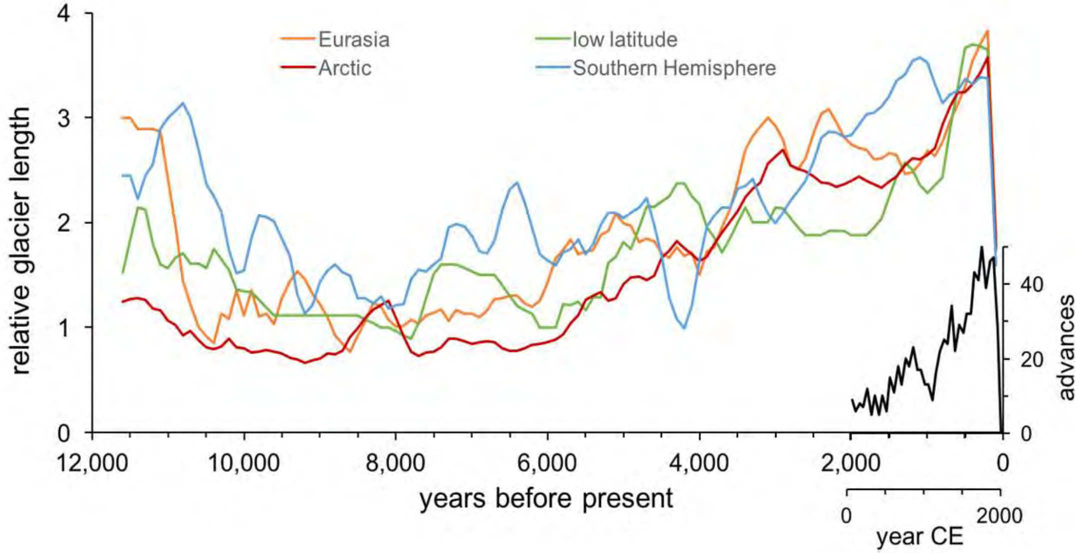


- October 2021 was globally the 3rd warmest (as per ERA5 data).
- But if considering only the land area (where we people actually live!), the month was the *1st warmest* on record.

Ice is melting



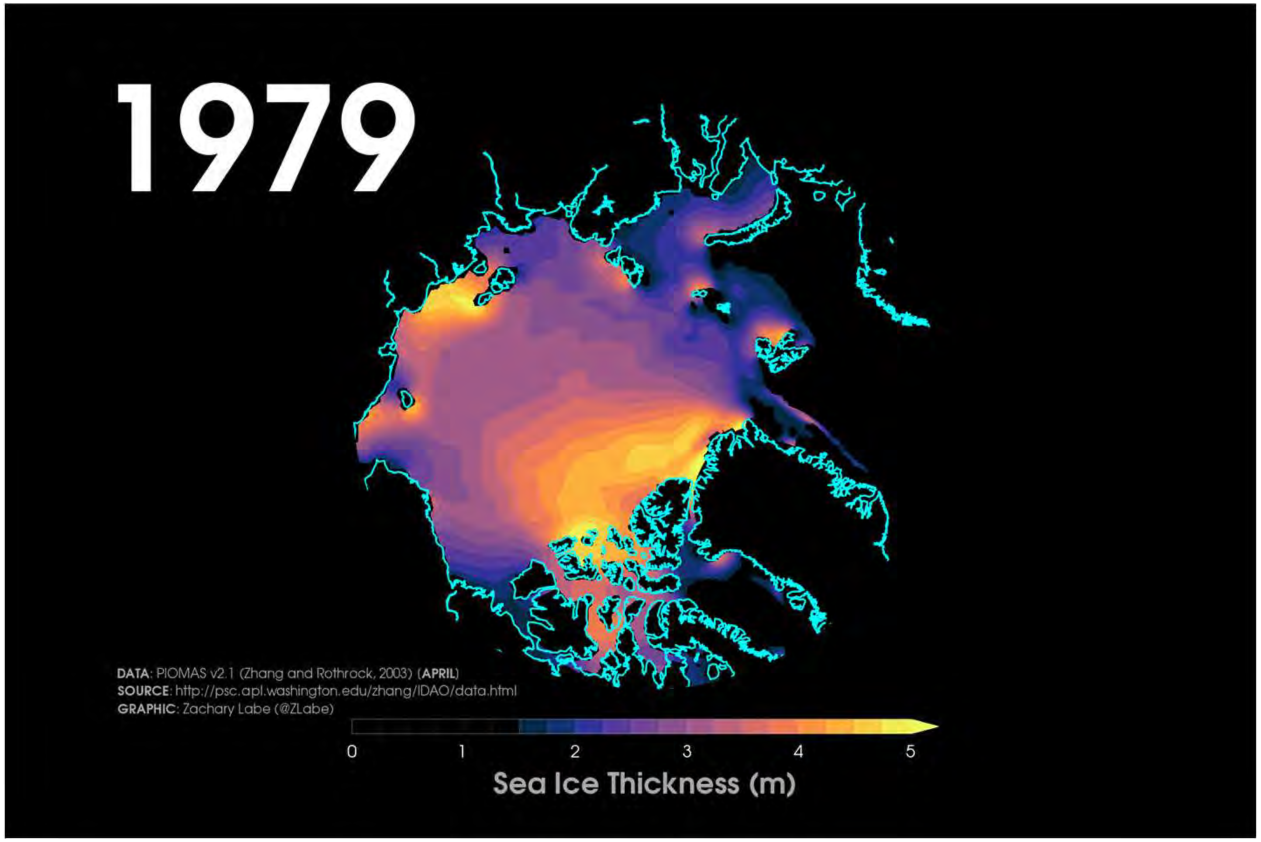




Glaciers and ice sheets are retreating (melting) and the rate of change is highly unusual

Figures courtesy Sebastian Gerland

And sea ice is decreasing

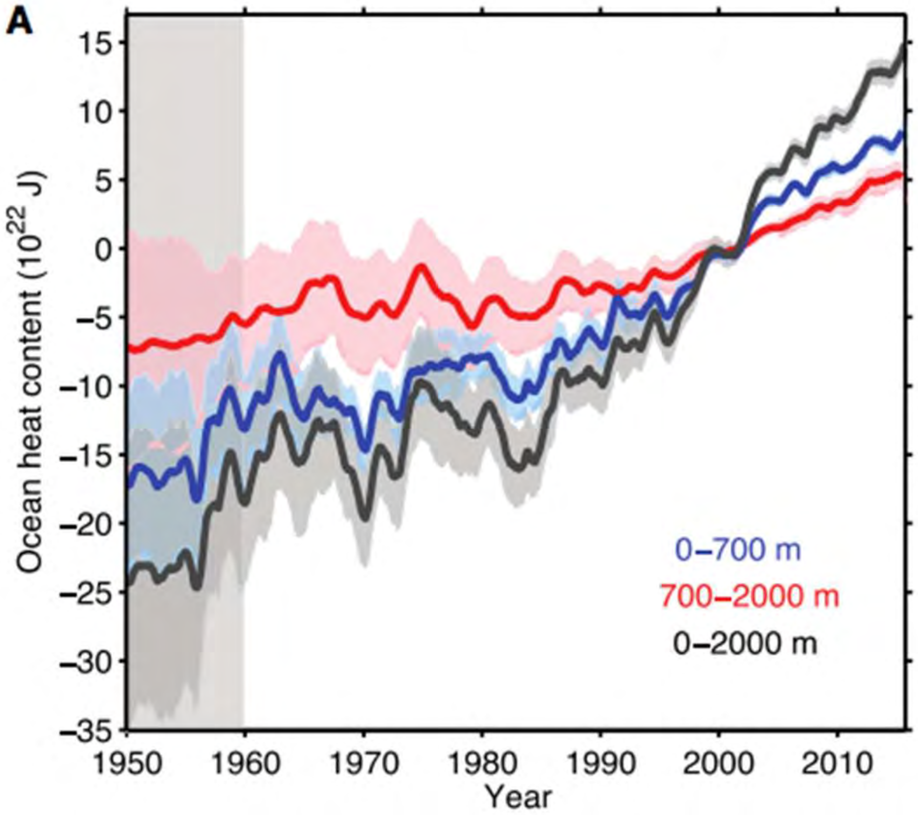


Sea ice:

- Extent / area decreased
- Younger
- Thinner
- Moving faster

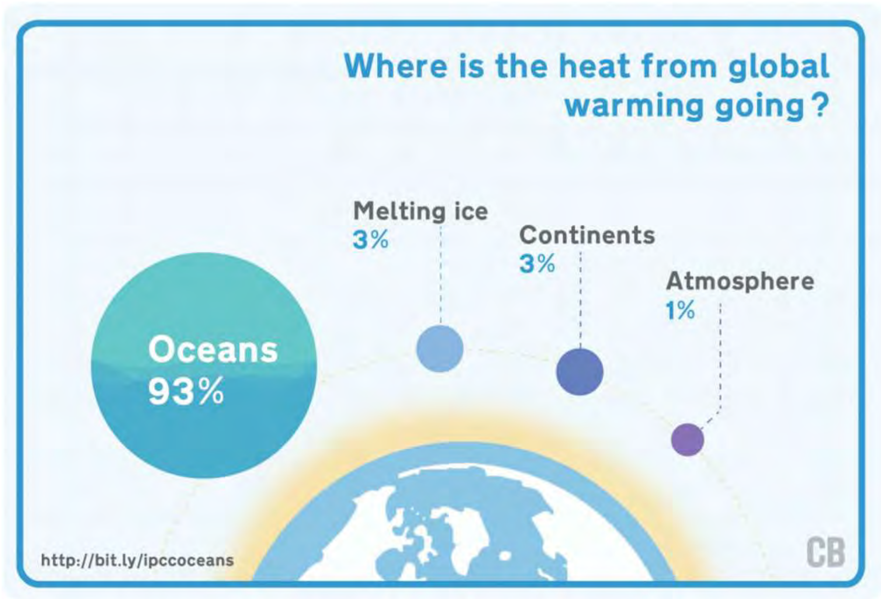
Figure courtesy Zachary Labe

Oceans are warming

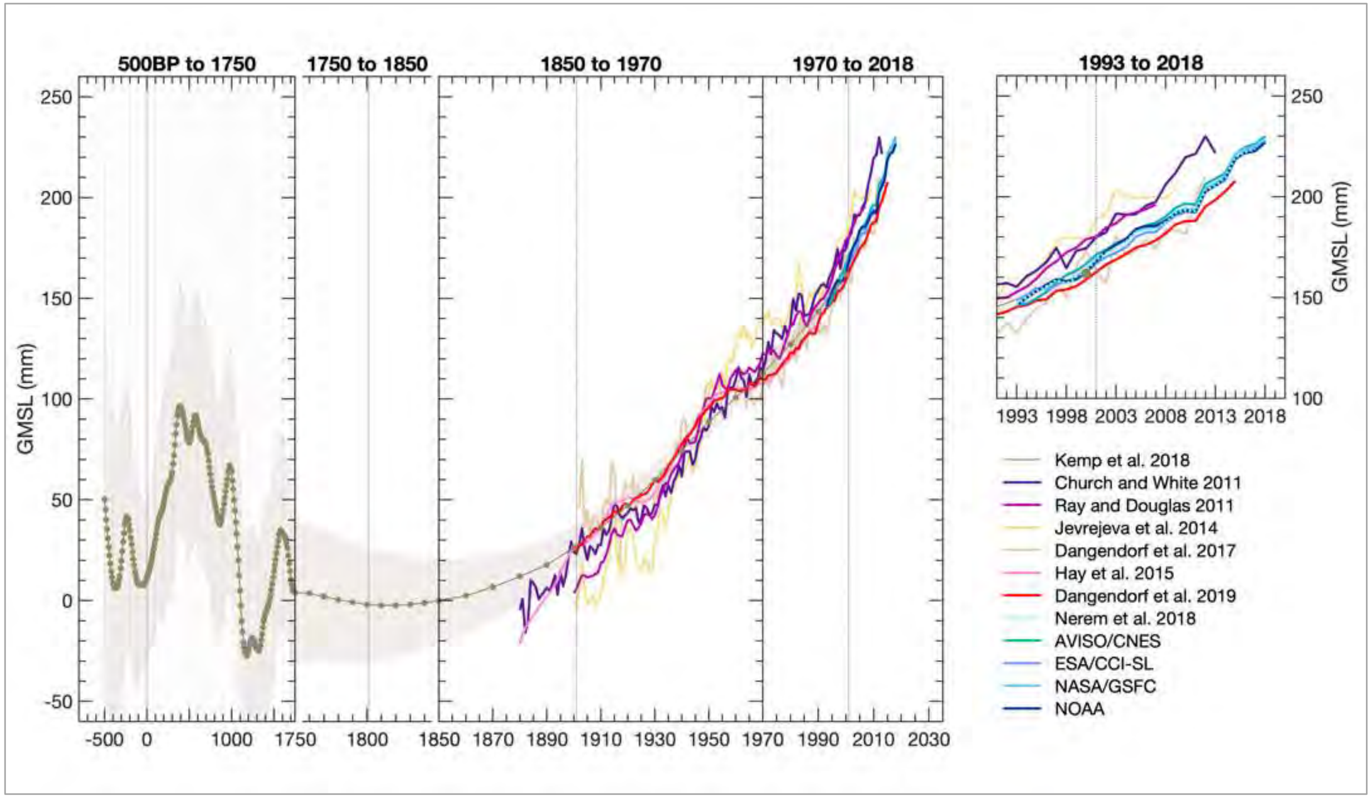


The oceans are warming at all depths.

Over 90% of the energy accumulated in the climate system is accumulating in the oceans.



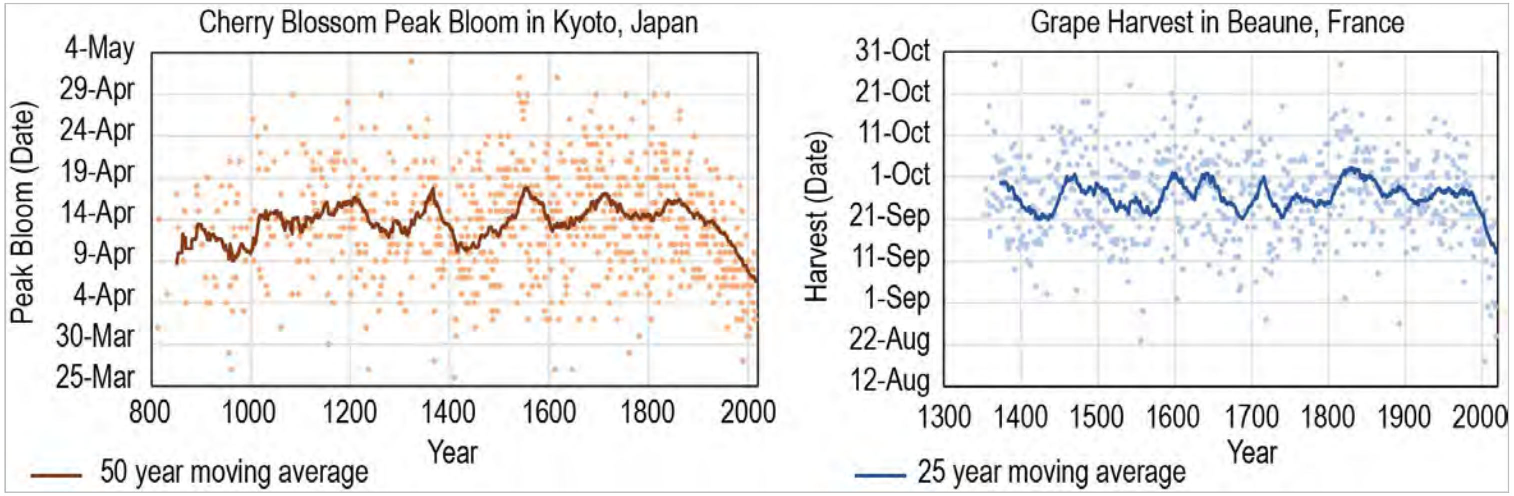
Sea level is increasing as a result



Sea level has increased and current sea levels are unusual in the context of at least the past 3 thousand years

Figure courtesy Catia Domingues

The plants are responding



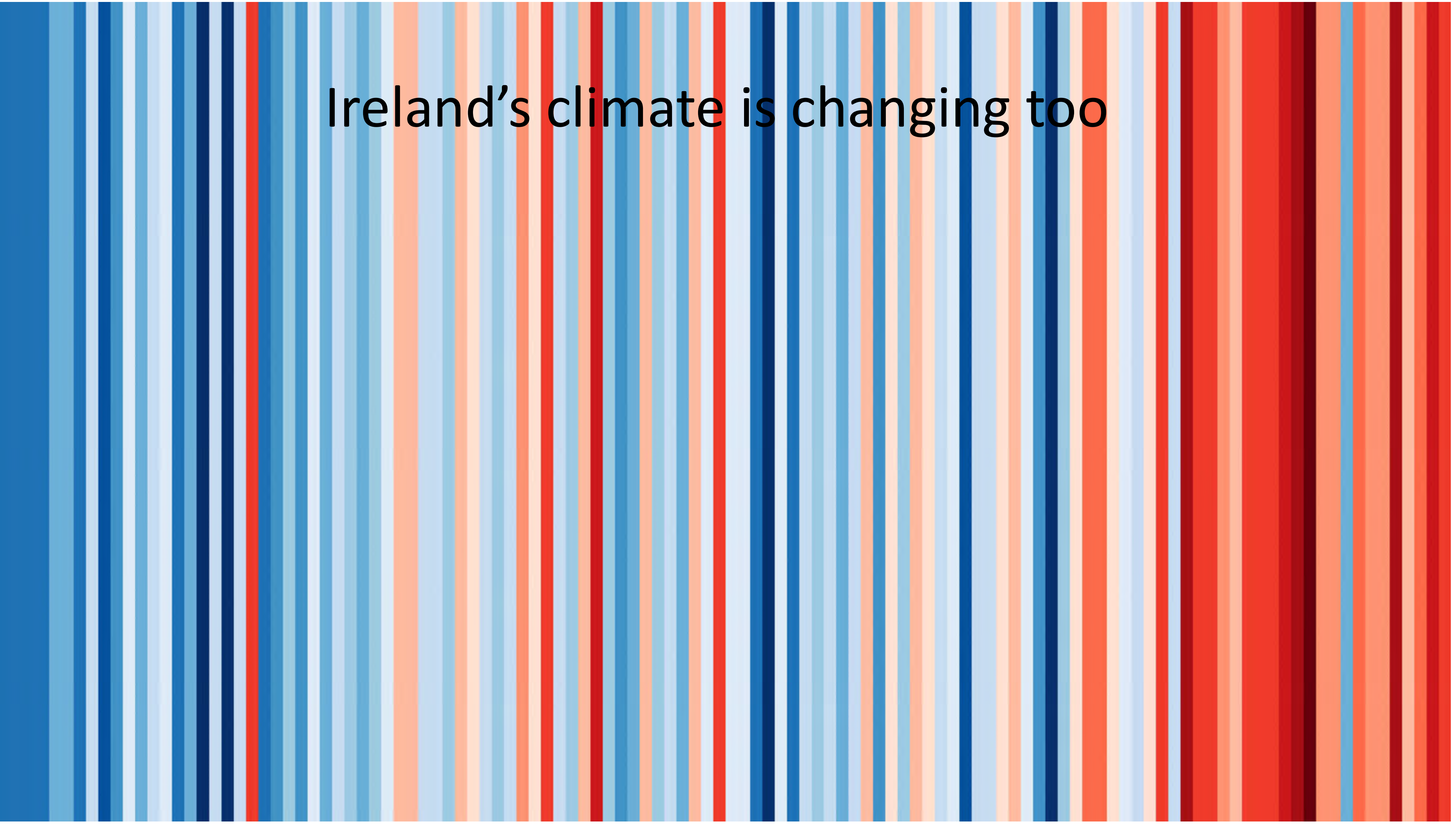
The terrestrial biosphere is responding in ways that are unusual

Figure courtesy Russ Vose

Global Climate is changing

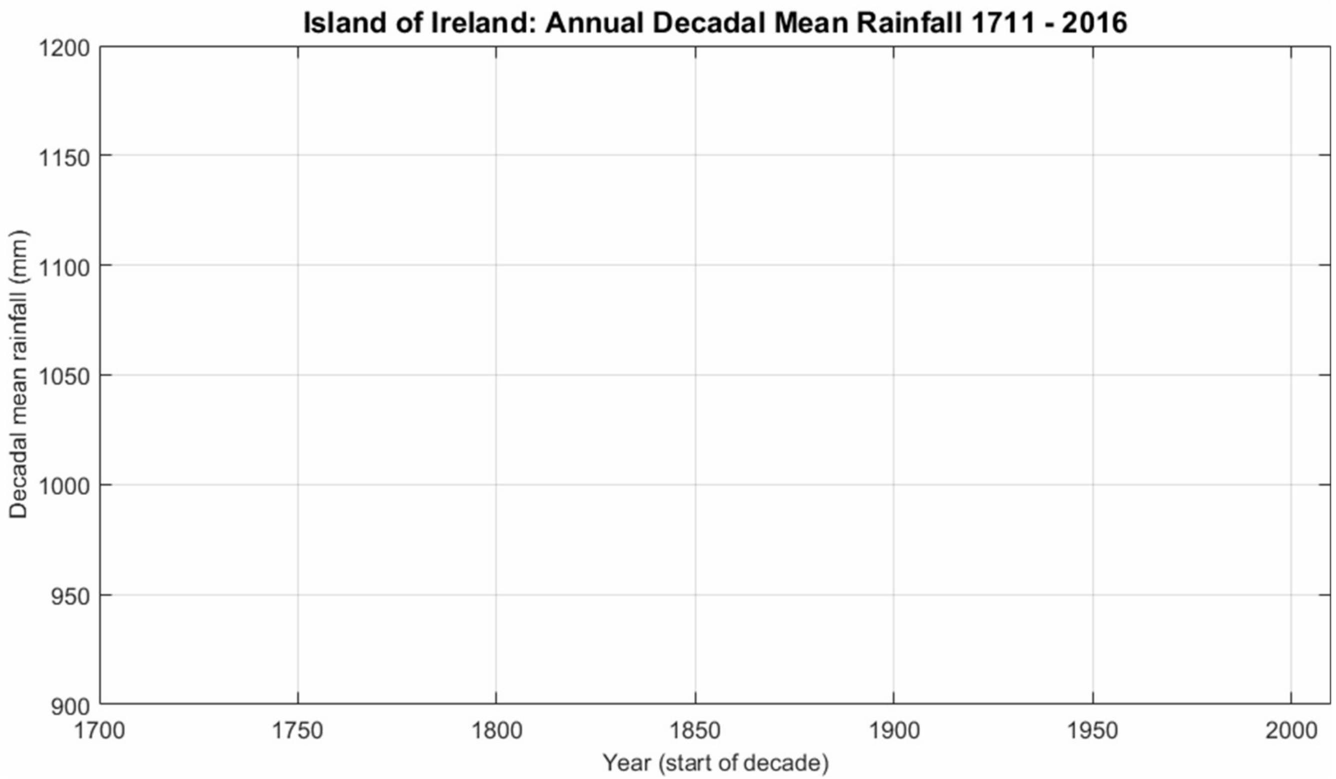
- Climate change is unequivocal
- Changes in key indicators across the atmosphere, oceans, cryosphere and biosphere are happening at a rate unprecedented since at least the last deglaciation.
- Most key indicators are now in states unseen for centuries through to many millennia.

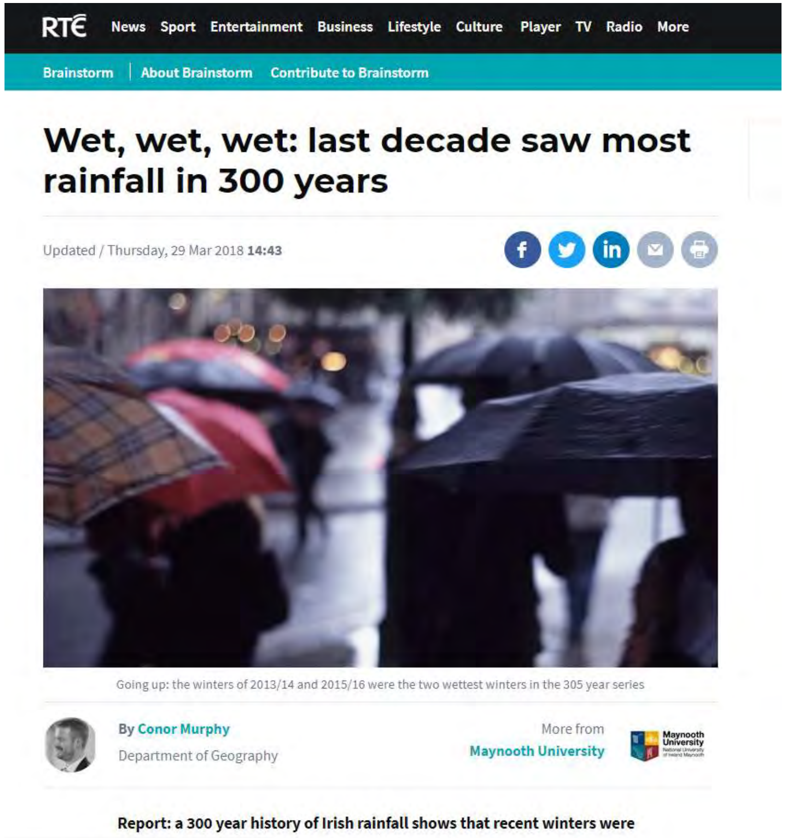
Ireland’s climate is changing too



Archived hand written precipitation records held at Met Eireann

Maynooth University
National University of Ireland Maynooth




RTÉ News Sport Entertainment Business Lifestyle Culture Player TV Radio More

Brainstorm | About Brainstorm Contribute to Brainstorm

Wet, wet, wet: last decade saw most rainfall in 300 years

Updated / Thursday, 29 Mar 2018 **14:43**

Going up: the winters of 2013/14 and 2015/16 were the two wettest winters in the 305 year series

By Conor Murphy
Department of Geography

More from
Maynooth University

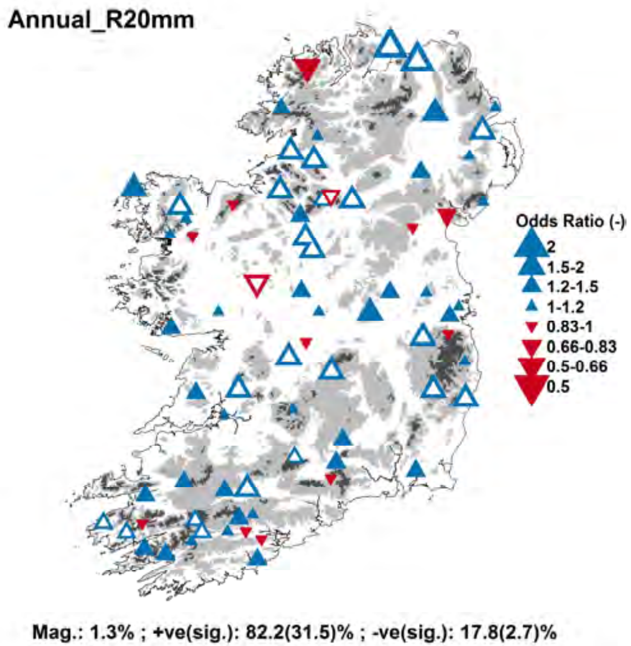
Report: a 300 year history of Irish rainfall shows that recent winters were

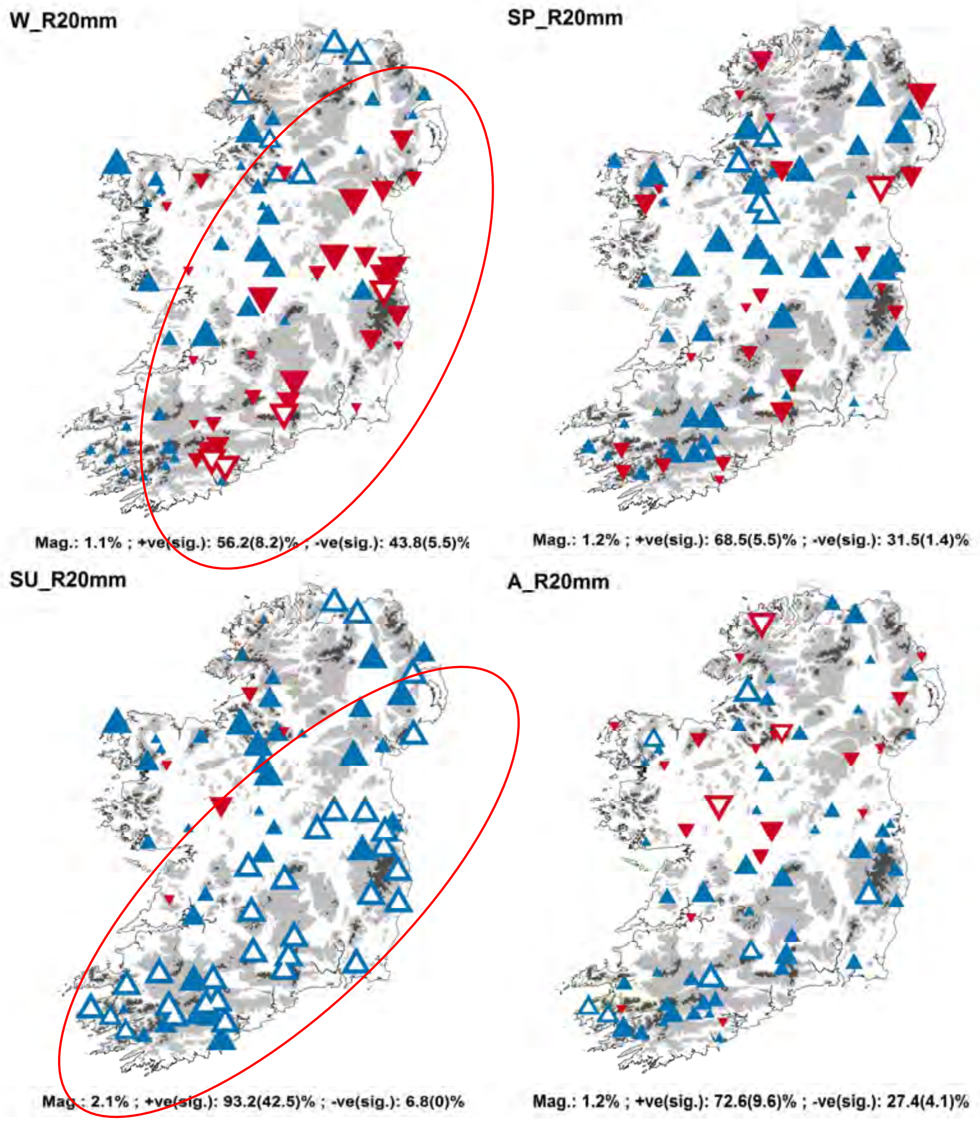
Maynooth University
National University of Ireland Maynooth

ICARUS
Irish Climate Analysis and Research Units

Heavy rainfall events more common in summer in SE

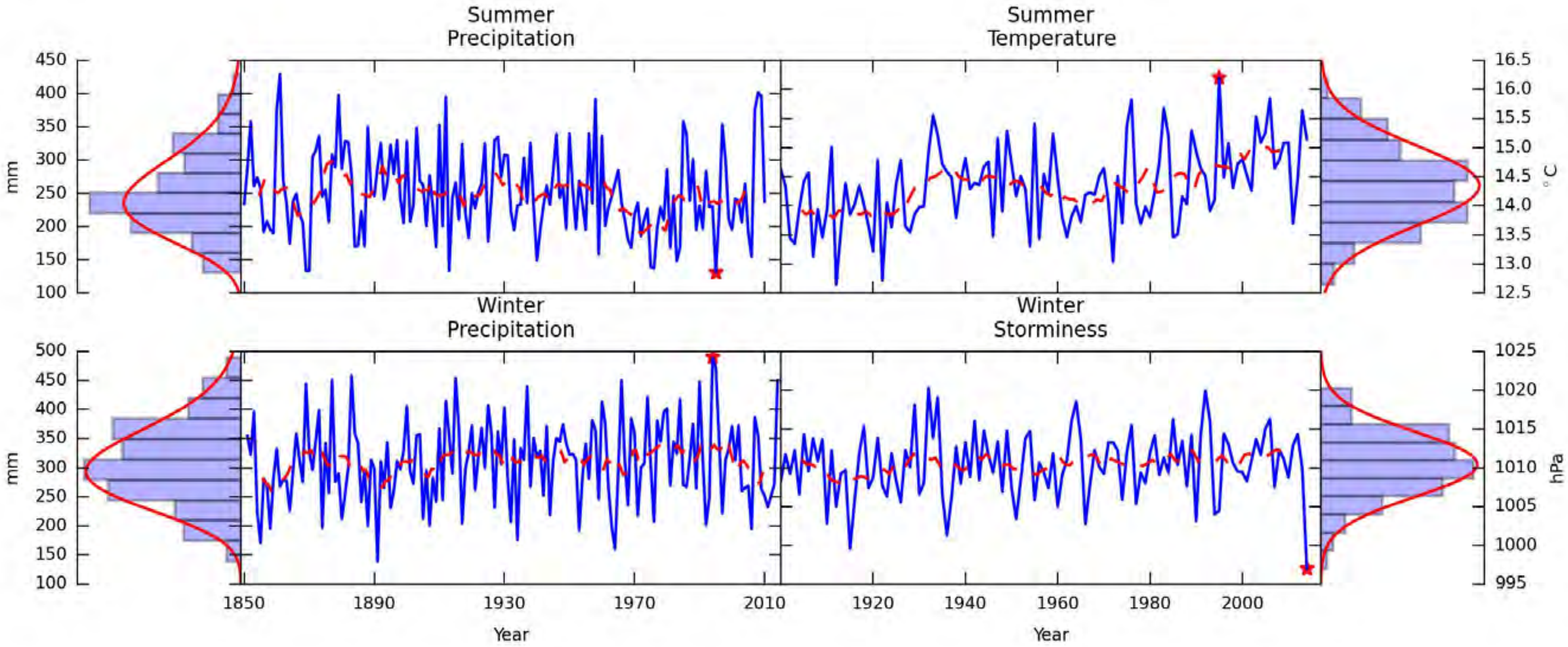
R20mm





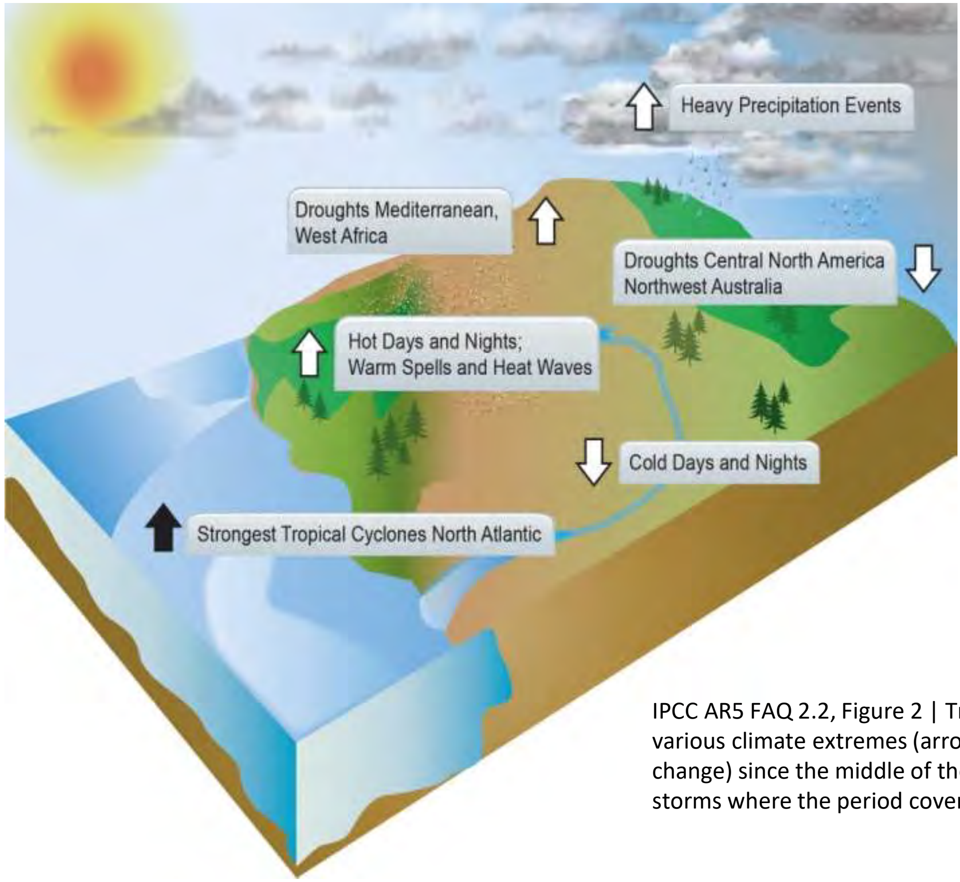
Source: Harrigan, 2016

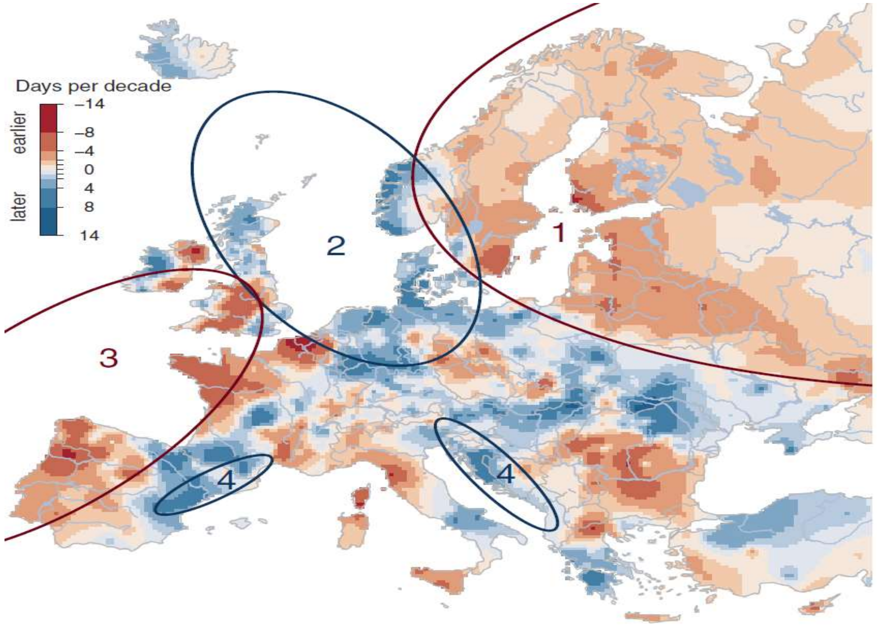
Memorable Irish extremes – how has their likelihood changed?



Over the period (1900–2014) records suggest a greater than 50-fold increase in the likelihood of the warmest recorded summer (1995), whilst the likelihood of the wettest winter (1994/95) and driest summer (1995) has respectively doubled since 1850.

And extremes?





Shift in the timing of European Floods (Bloschl et al., 2017; Science)

IPCC AR5 FAQ 2.2, Figure 2 | Trends in the frequency (or intensity) of various climate extremes (arrow direction denotes the sign of the change) since the middle of the 20th century (except for North Atlantic storms where the period covered is from the 1970s).

Maynooth University
National University of Ireland Maynooth

ICARUS
Irish Climate Analysis and Research Units

Environmental Research Letters

OPEN ACCESS

RECEIVED
28 June 2017

REVISED
28 October 2017

ACCEPTED FOR PUBLICATION
7 November 2017

PUBLISHED
18 January 2018

LETTER

Super Storm Desmond: a process-based assessment

T Matthews[1,5], C Murphy[2], G McCarthy[3], C Broderick[2] and R L Wilby[4]

1 School of Natural Sciences and Psychology, Liverpool John Moores University, Liverpool L3 3AF, United Kingdom
2 Irish Climate Analysis and Research Units, Department of Geography , Maynooth University, Kildare, Ireland
3 National Oceanography Centre, Southampton, SO14 3ZH, United Kingdom
4 Department of Geography, Loughborough University, Loughborough, LE11 3TU, United Kingdom
5 Author to whom any correspondence should be addressed.

E-mail: climatom86@gmail.com

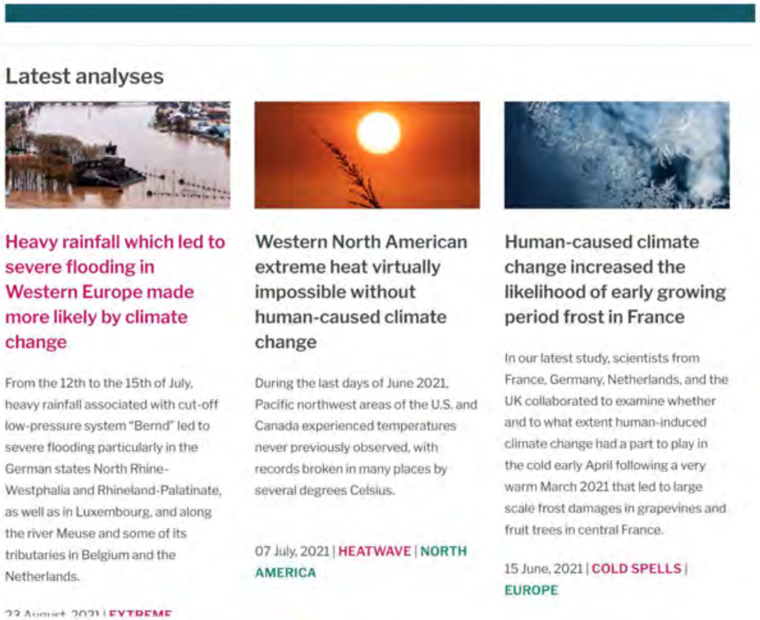
Keywords: atmospheric river, climate change attribution, extratropical cyclones, North Atlantic warming

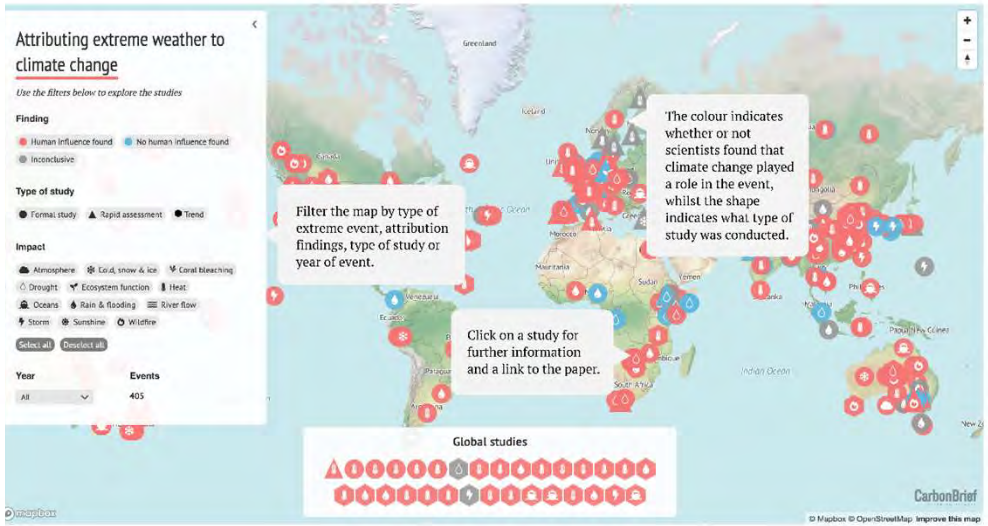
Supplementary material for this article is available online

Abstract

'Super' Storm Desmond broke meteorological and hydrological records during a record warm year in the British–Irish Isles (BI). The severity of the storm may be a harbinger of expected changes to regional hydroclimate as global temperatures continue to rise. Here, we adopt a process-based approach to investigate the potency of Desmond, and explore the extent to which climate change may have been a contributory factor. Through an Eulerian assessment of water vapour flux we determine that Desmond was accompanied by an atmospheric river (AR) of severity unprecedented since at least 1979, on account of both high atmospheric humidity and high wind speeds. Lagrangian air-parcel tracking and moisture attribution techniques show that long-term warming of North Atlantic sea surface temperatures has significantly increased the chance of such high humidity in ARs in the vicinity of the BI. We conclude that, given exactly the same dynamical conditions associated with Desmond, the likelihood of such an intense AR has already increased by 25% due to long-term climate change. However, our analysis represents a first-order assessment, and further research is needed into the controls influencing AR dynamics.

Can now see the fingerprint of climate change on many extreme events around the world



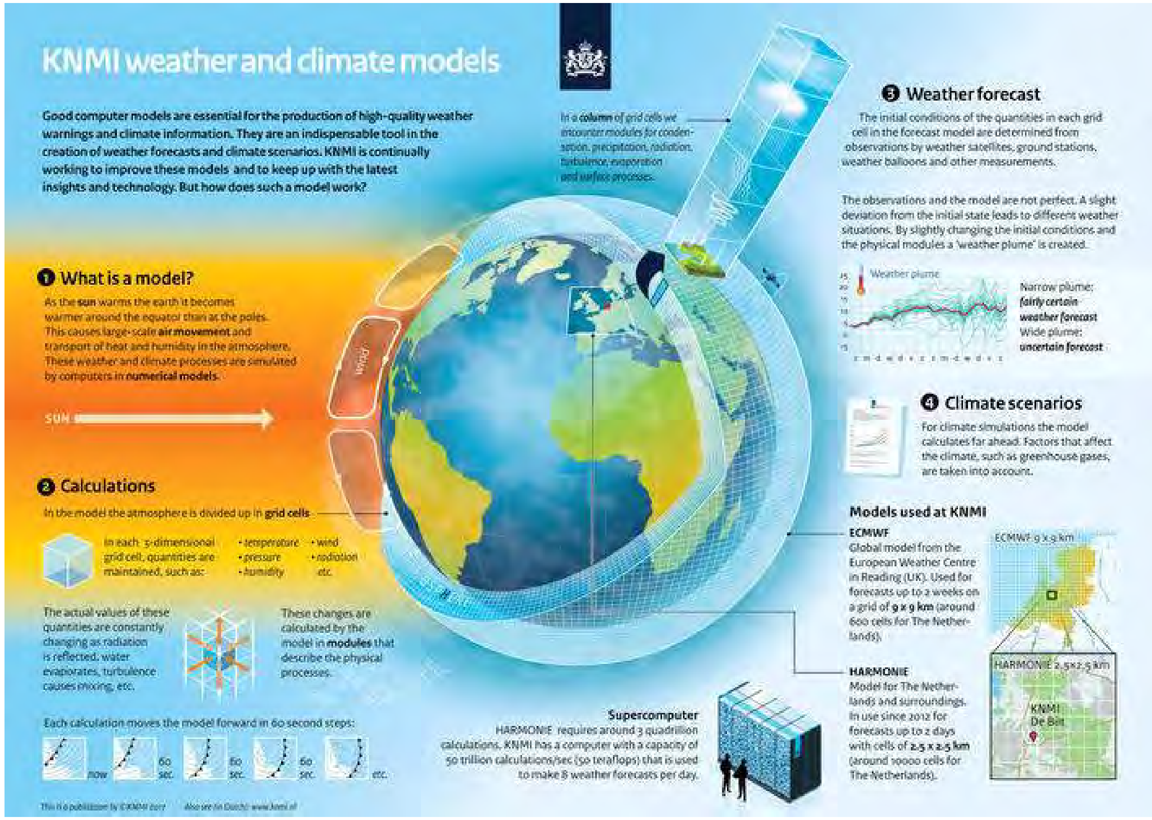


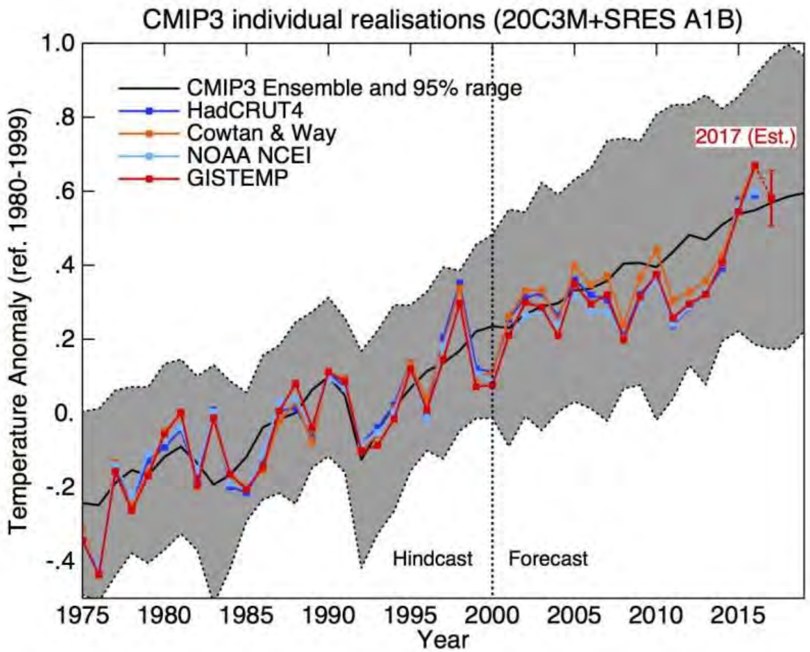
world weather attribution

Maynooth University
National University of Ireland Maynooth

maynoothuniversity.ie

Understanding future climate



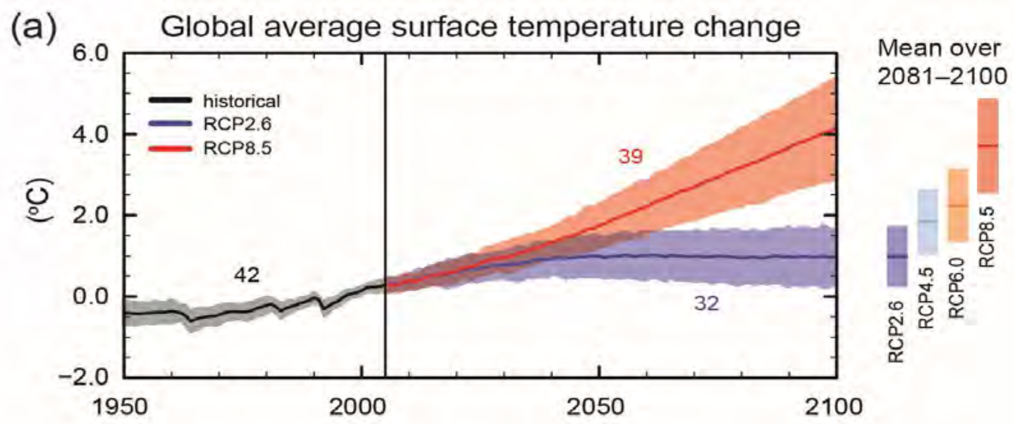


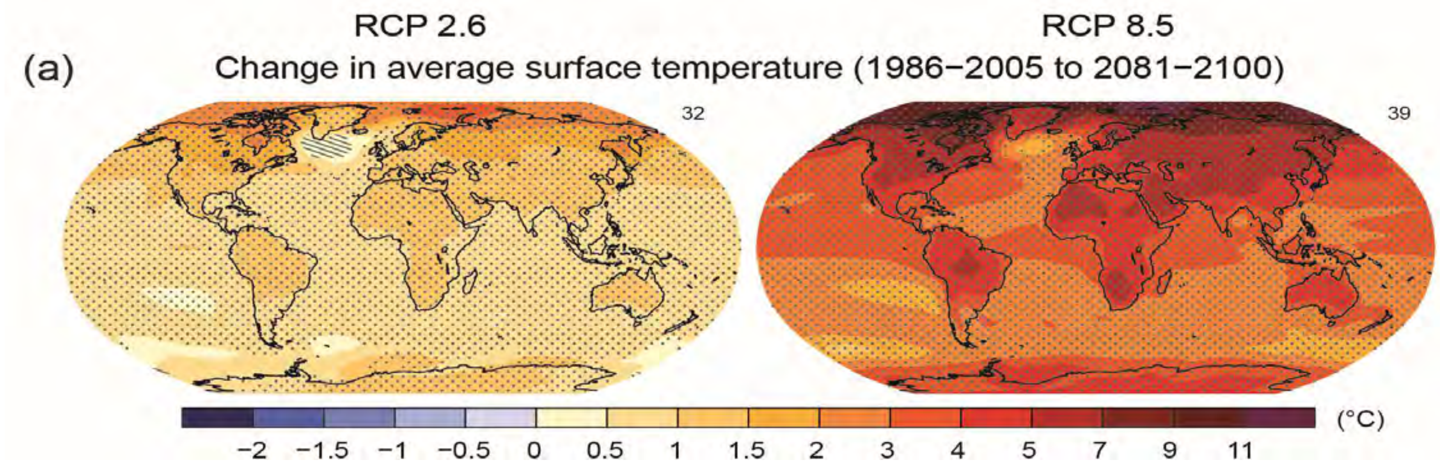
Source: Gavin Schmidt NASA

Maynooth University
National University of Ireland Maynooth

ICARUS
Irish Climate Analysis and Research Units

What future do we want?



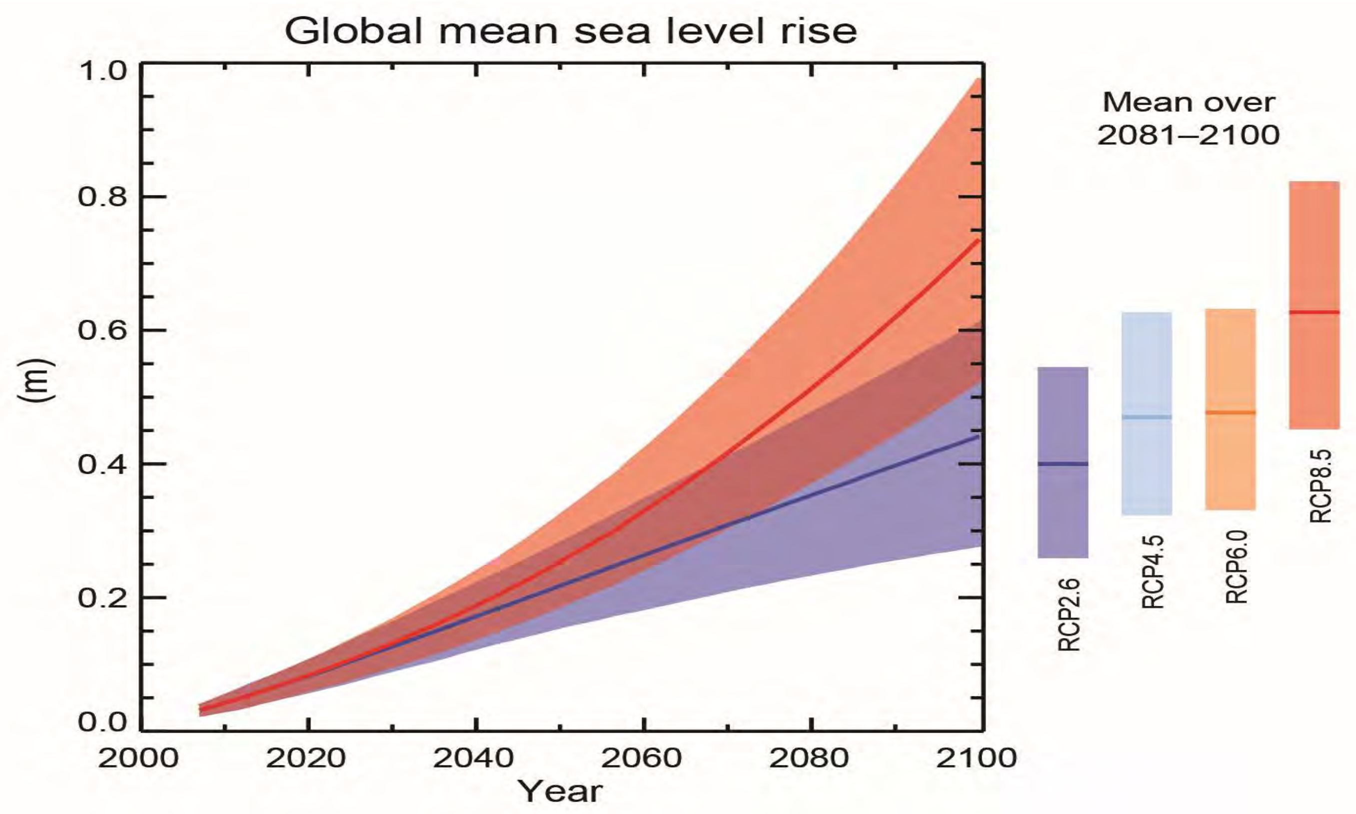


Maynooth University
National University of Ireland Maynooth

Source: IPCC AR5

ICARUS
Irish Climate Analysis and Research Units

What future do we want?



Source: IPCC AR5

How frequent may those Irish events become in future?

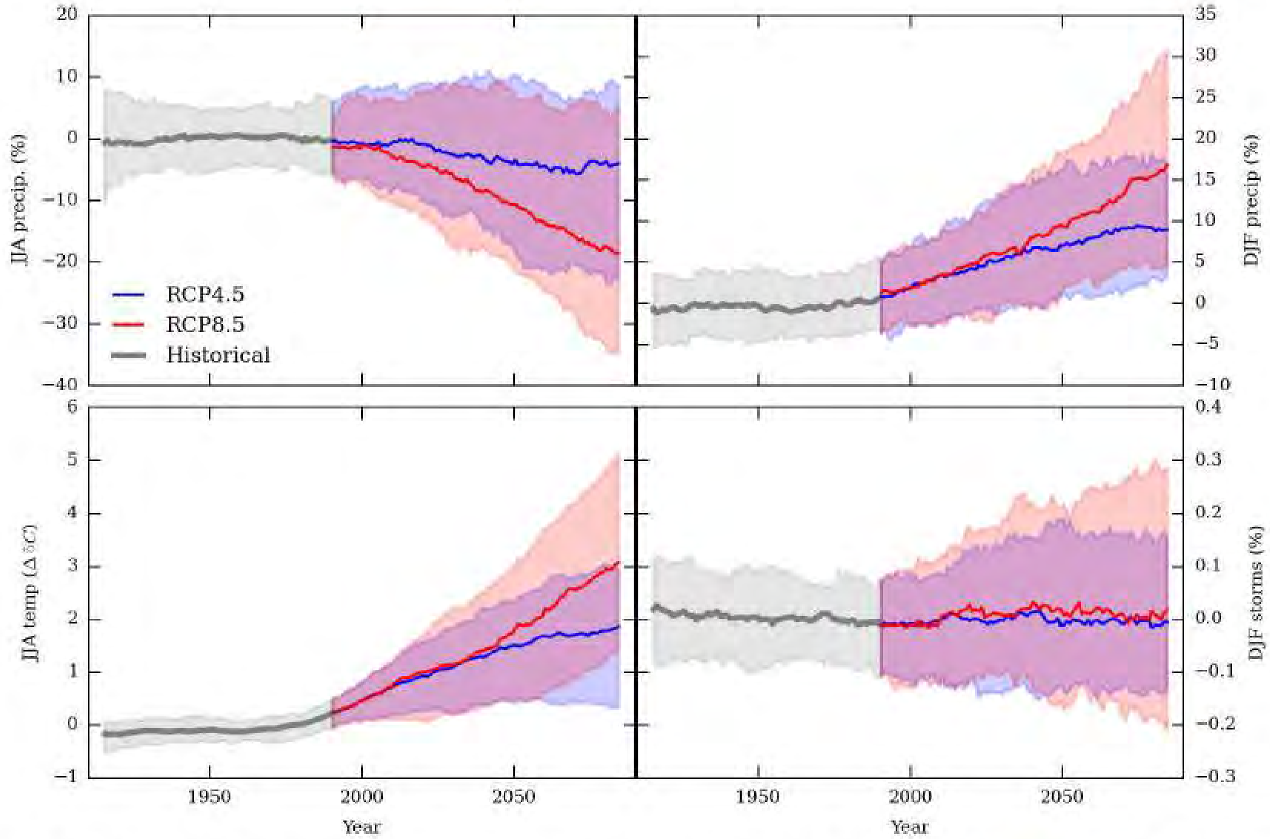
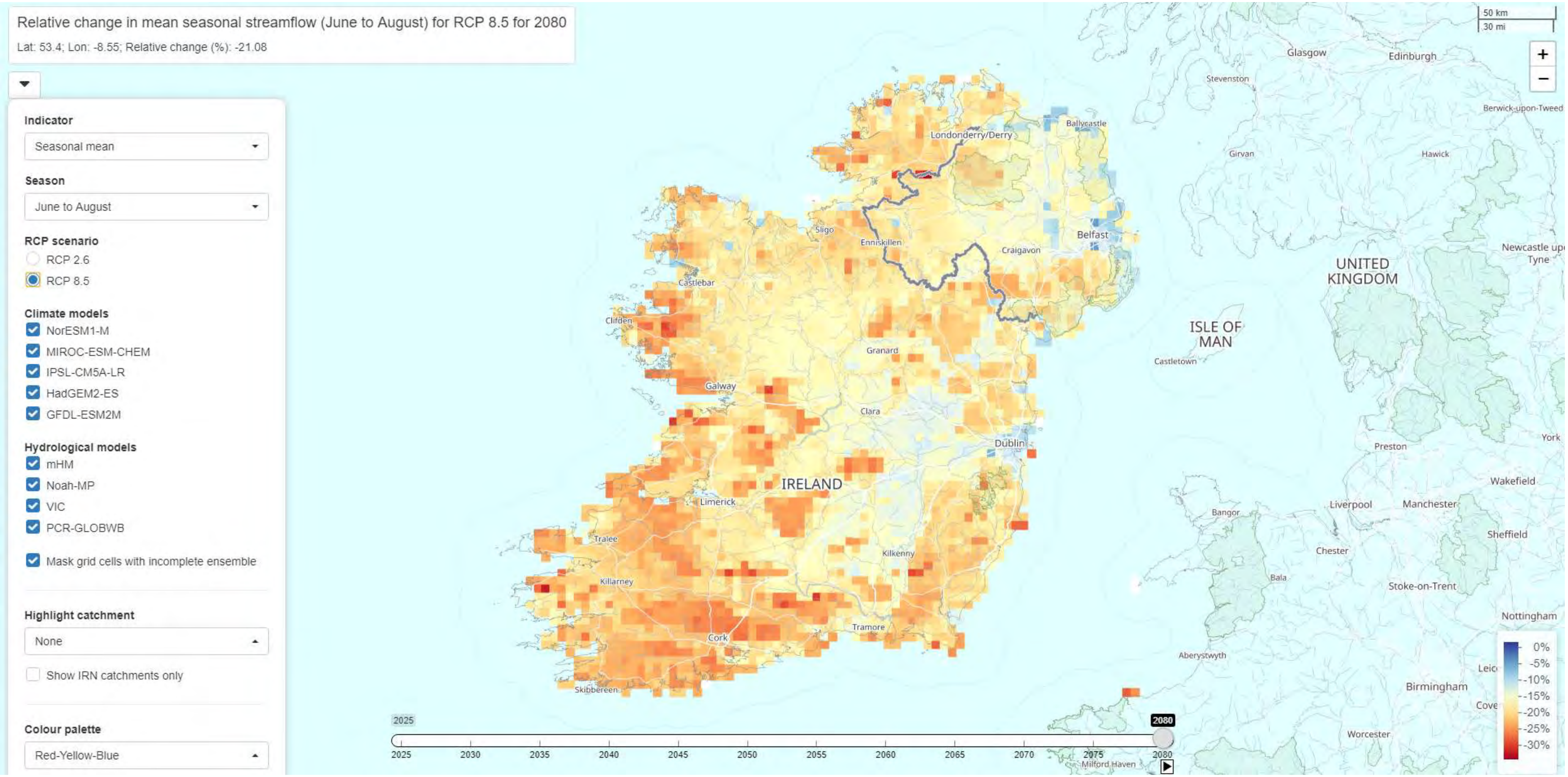
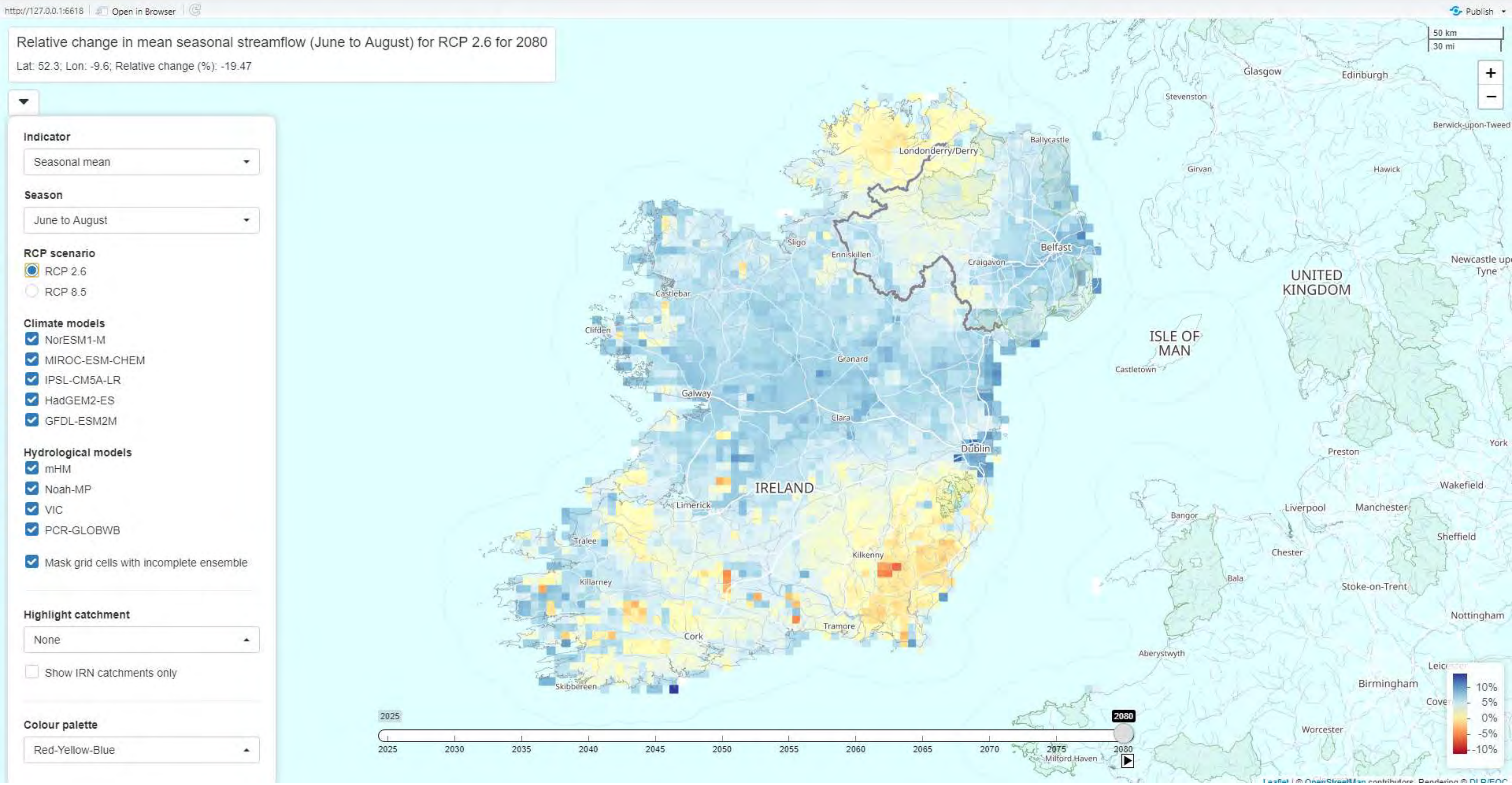


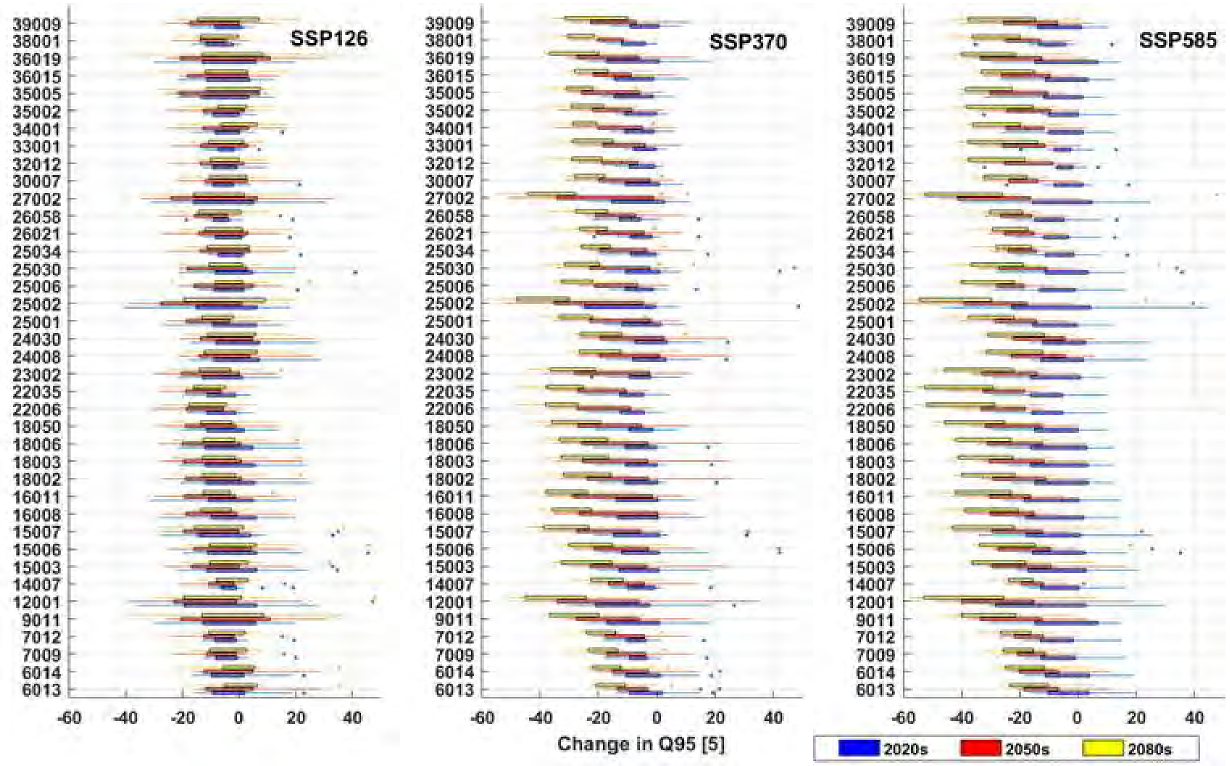
Fig. 10. Centred 30-year running means of the respective variables, expressed as anomalies from 1901–2005. See Fig. 8 caption for further details.

- In a business as usual world..
- 1 in 8 years as dry as 1995
- 1 in 8 years as wet as 1994
- 1 in 7 years ***as cool as*** 1995
- BUT these graphs also allow us to consider vulnerability to future change


Relative change in mean seasonal streamflow (June to August) for RCP 8.5 for 2080
Lat: 53.4; Lon: -8.55; Relative change (%): -21.08
Indicator
Seasonal mean
Season
June to August
RCP scenario
RCP 2.6
RCP 8.5
Climate models
NorESM1-M
MIROC-ESM-CHEM
IPSL-CM5A-LR
HadGEM2-ES
GFDL-ESM2M
Hydrological models
mHM
Noah-MP
VIC
PCR-GLOBWB
Mask grid cells with incomplete ensemble
Highlight catchment
None
Show IRN catchments only
Colour palette
Red-Yellow-Blue
50 km
30 mi
Glasgow
Edinburgh
Stevenston
Berwick-upon-Tweed
Ballycastle
Londonderry/Derry
Girvan
Hawick
Sligo
Enniskillen
Belfast
Craigavon
Castlebar
Clifden
UNITED KINGDOM
Newcastle upon Tyne
ISLE OF MAN
Castletown
Granard
Galway
Clara
Dublin
IRELAND
Preston
York
Wakefield
Limerick
Bangor
Liverpool
Manchester
Sheffield
Tralee
Chester
Kilkenny
Killarney
Bala
Stoke-on-Trent
Cork
Tramore
Nottingham
Aberystwyth
Skibbereen
Birmingham
Worcester
Milford Haven
0%
-5%
-10%
-15%
-20%
-25%
-30%
2025
2080
2025
2030
2035
2040
2045
2050
2055
2060
2065
2070
2075
2080


http://127.0.0.1:6618
Open in Browser
Publish
Relative change in mean seasonal streamflow (June to August) for RCP 2.6 for 2080
Lat: 52.3; Lon: -9.6; Relative change (%): -19.47
Indicator
Seasonal mean
Season
June to August
RCP scenario
RCP 2.6
RCP 8.5
Climate models
NorESM1-M
MIROC-ESM-CHEM
IPSL-CM5A-LR
HadGEM2-ES
GFDL-ESM2M
Hydrological models
mHM
Noah-MP
VIC
PCR-GLOBWB
Mask grid cells with incomplete ensemble
Highlight catchment
None
Show IRN catchments only
Colour palette
Red-Yellow-Blue
50 km
30 mi
Glasgow
Edinburgh
Stevenston
Berwick-upon-Tweed
Ballycastle
Londonderry/Derry
Girvan
Hawick
Belfast
Sligo
Enniskillen
Craigavon
Newcastle upon Tyne
UNITED KINGDOM
Castlebar
Clifden
ISLE OF MAN
Castletown
Granard
Galway
Clara
Dublin
Preston
York
IRELAND
Wakefield
Limerick
Liverpool
Manchester
Bangor
Sheffield
Tralee
Kilkenny
Chester
Killarney
Bala
Stoke-on-Trent
Cork
Tramore
Nottingham
Aberystwyth
Skibbereen
Birmingham
Worcester
Milford Haven
10%
5%
0%
-5%
-10%
2025
2080
2025
2030
2035
2040
2045
2050
2055
2060
2065
2070
2075
2080

Projected changes (%) in low flows



Maynooth University
National University of Ireland Maynooth

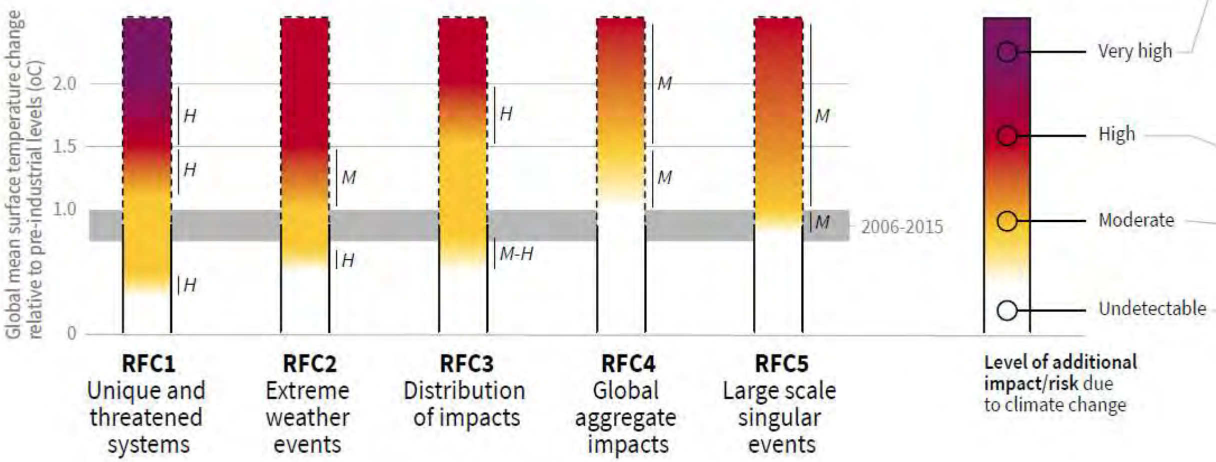
Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

What level of risk is acceptable globally?

How the level of global warming affects impacts and/or risks associated with the Reasons for Concern (RFCs) and selected natural, managed and human systems

Five Reasons For Concern (RFCs) illustrate the impacts and risks of different levels of global warming for people, economies and ecosystems across sectors and regions.

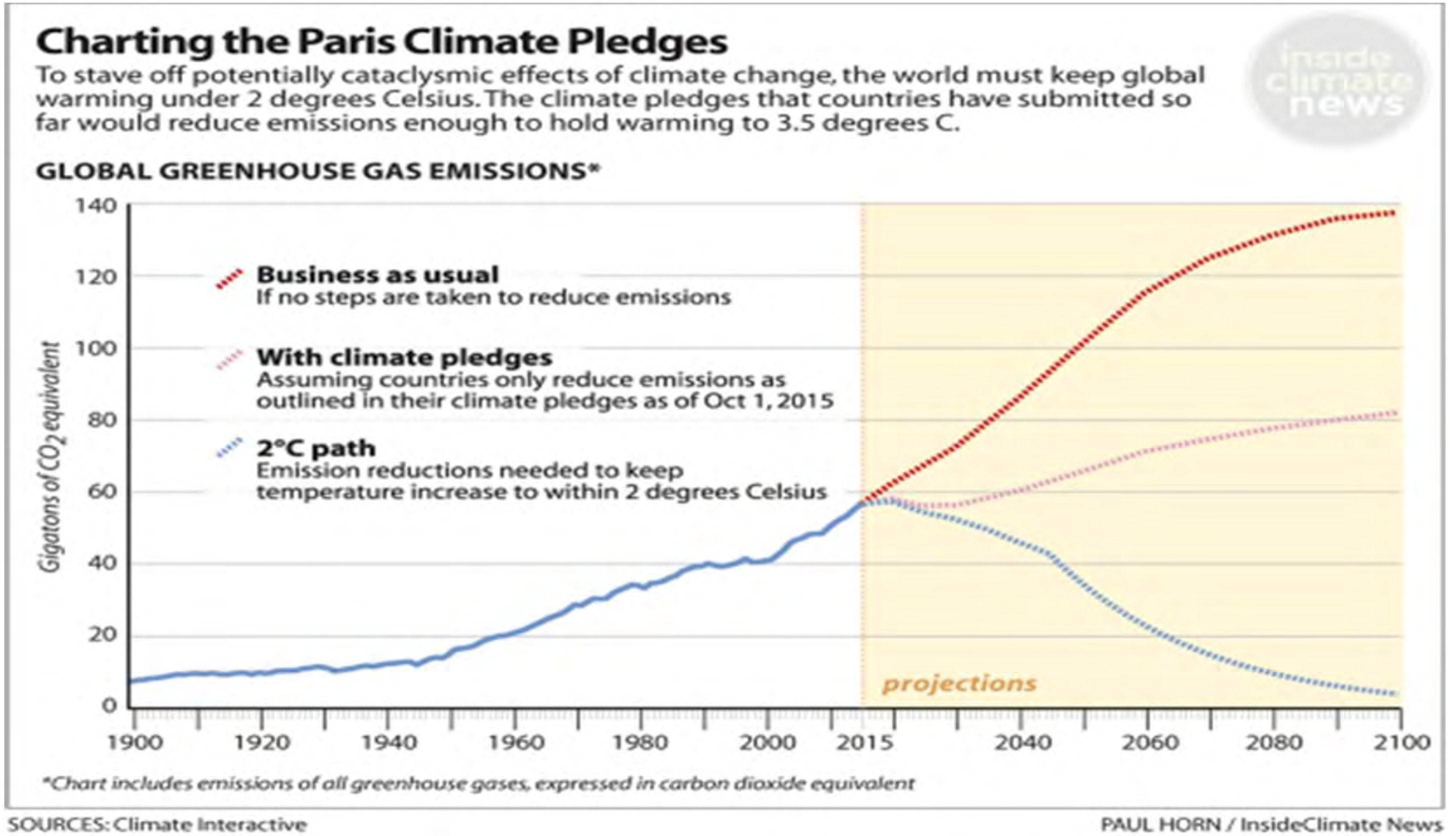
Impacts and risks associated with the Reasons for Concern (RFCs)



Purple indicates very high risks of severe impacts/risks and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impacts/risks.
Red indicates severe and widespread impacts/risks.
Yellow indicates that impacts/risks are detectable and attributable to climate change with at least medium confidence.
White indicates that no impacts are detectable and attributable to climate change.

IPCC SR1.5

How fast do we need to bend the curves?



Current stated ambitions under the Paris Agreement would not limit warming to 1.5C , or even 2.oC

Effectiveness of carbon removal technology can only be achieved if global emissions start to decline well before 2030 (IPCC SR1.5)

What can we do?

- Climate change is real, it is happening, and the future is in our hands
- We have a lot of work to do to bend the curves
- But climate action needs reduction in greenhouse gases AND adapting our systems to a changed future

RTÉ News Sport Entertainment Business Lifestyle Culture Player TV Radio More

Brainstorm | About Brainstorm Contribute to Brainstorm

We need to talk about how we adapt to climate change

Updated / Friday, 20 Sep 2019 **13:59**

Flooding in Galway after Storm Erik in February 2019. Photo: Pat McGrath

By Conor Murphy
Department of Geography

More from
Maynooth University

Opinion: while it is critical to reduce greenhouse gas emissions, we also need to think about adaptation to what climate change will bring our way

Maynooth University
National University of Ireland Maynooth

ICARUS
Irish Climate Analysis and Research Units

What does effective adaptation look like?

Regional Environmental Change (2021) 21:46
https://doi.org/10.1007/s10113-021-01778-y

ORIGINAL ARTICLE

Solastalgia, place attachment and disruption: insights from a coastal community on the front line

Christopher Phillips[1] · Conor Murphy[1]

Received: 27 April 2020 / Accepted: 12 April 2021 / Published online: 8 May 2021

Abstract
We explore how solastalgia, a concept that describes distress and inability to derive solace from one's environment caused by disruptive environmental change, is currently being experienced by a community in southeast Ireland as they struggle to cope with place disruption through loss of a beach by coastal erosion. We analyse relationships between empirical measurements of solastalgia, place attachment and place disruption as well as their association with community outlook for the future. Results indicate that solastalgia, resulting from loss of place, is experienced by almost half of residents, especially those who have lived in the area >20 years. Seasonal variation exists for residents who experience the highest levels of solastalgia, with expression strongest in summer. We find that solastalgia is positively correlated with place attachment; those having higher levels of place attachment express stronger feelings of solastalgia and impacts to their lives due to loss of place. Place attachment is most weakly expressed through place dependence, suggesting ongoing adaptation of relationships with place. We find that solastalgia is positively correlated with negative statements regarding future outlook. However, negative outlooks are moderated for those with high levels of place attachment, despite experiencing solastalgia. Given the vulnerability of coastal environments and communities to climate change, understanding and assessing solastalgia will be critical to helping communities navigate environmental disruption.

Keywords Solastalgia · Place attachment · Place disruption · Environmental change · Coastal erosion

Droughts in Europe if we stay within 2 degrees warming

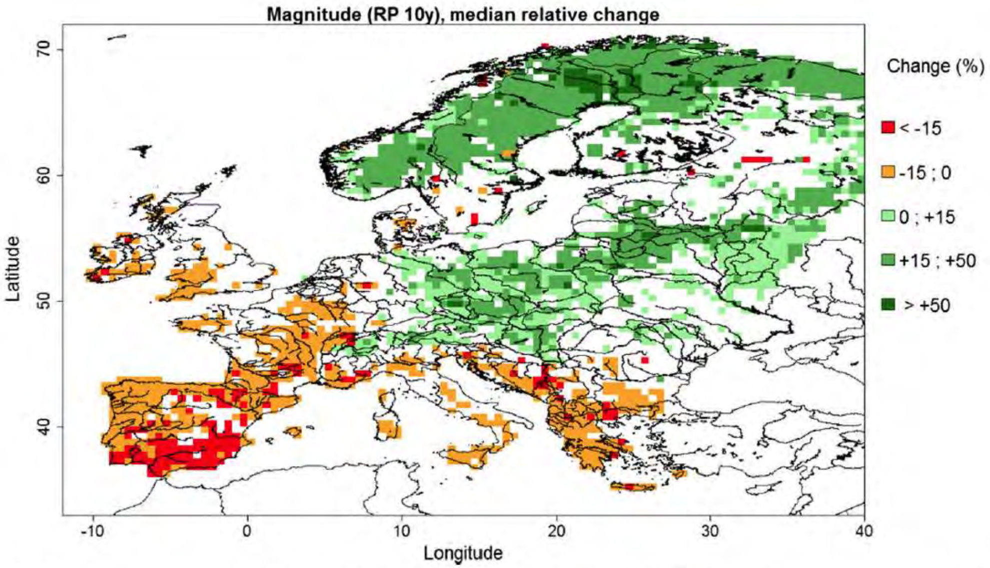
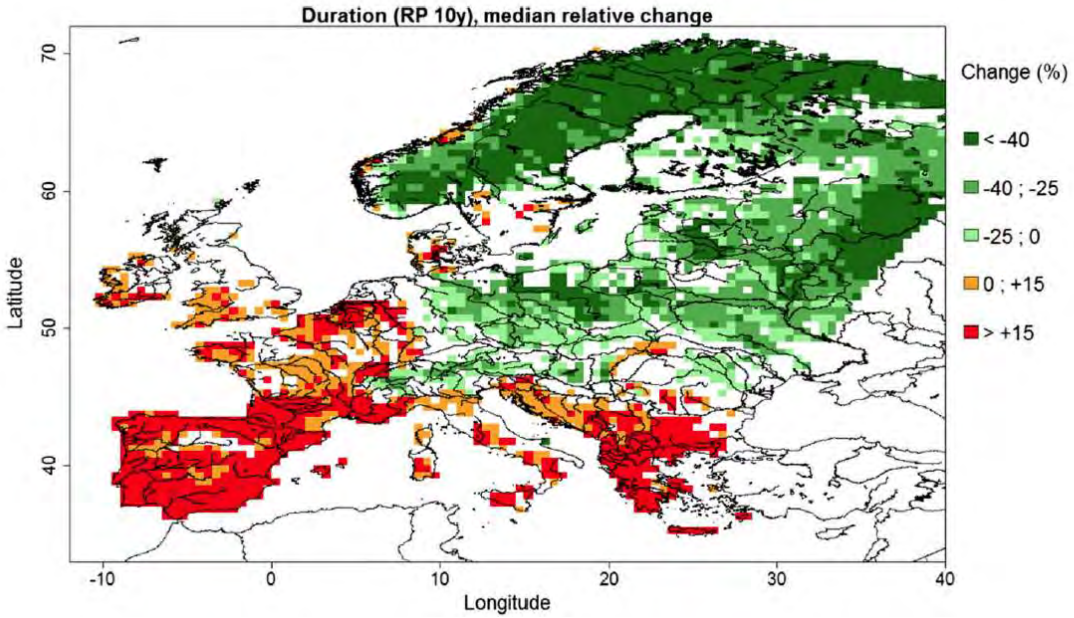


Fig. 3 Characteristics of low flows (RP10): duration (top) and magnitude (bottom). The median is computed over 22 ensemble members. Only significant changes (i.e. passing the Wilcox test at 5 %) are shown here. When QlowRP10 is zero for the baseline period, we set the relative change as missing value



Floods in Europe if we stay within 2 degrees warming

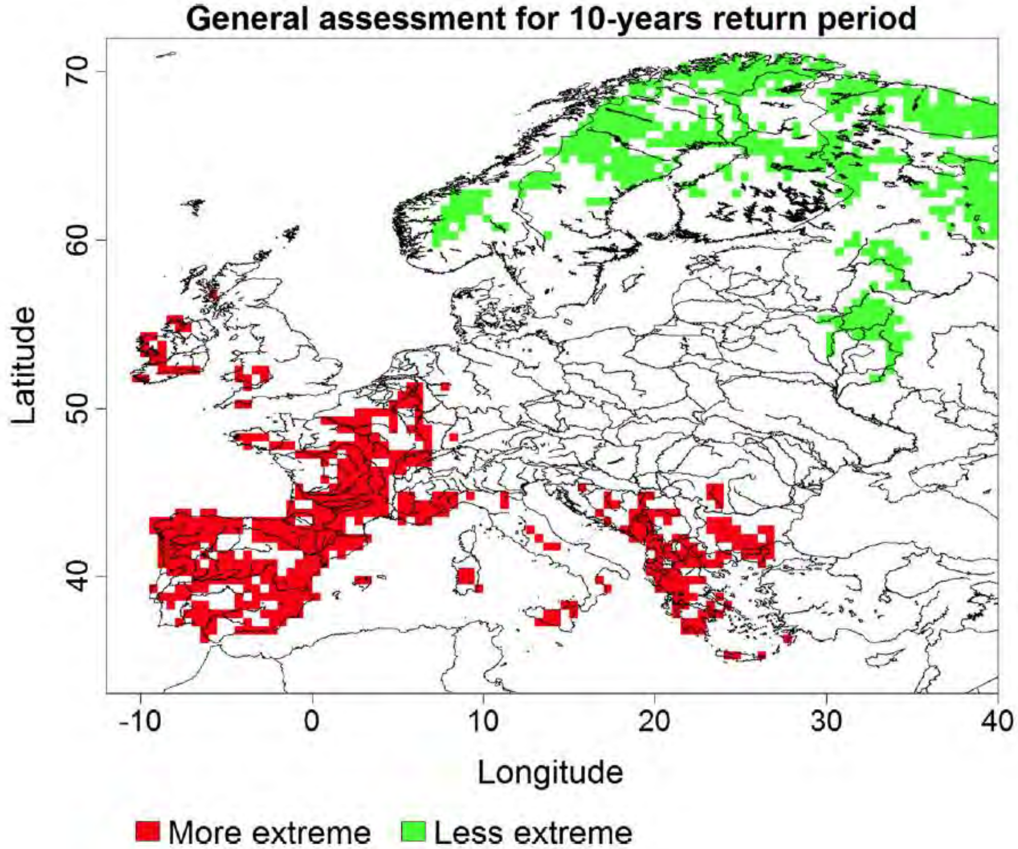
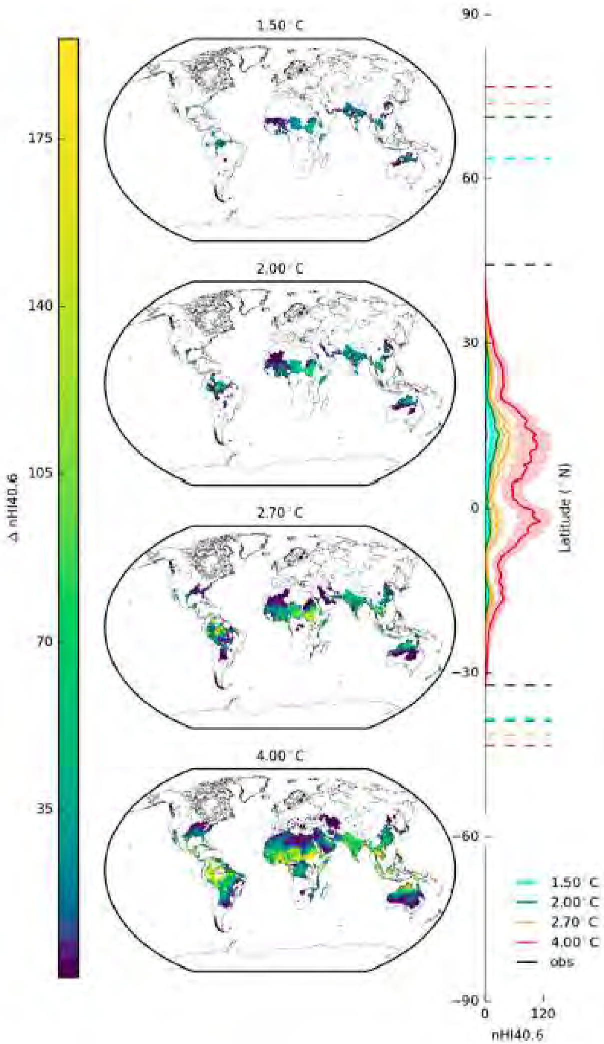


Fig. 5 Summary of the impacts of extreme discharge (return period is 10 years) under a + 2C warming. Green area means that (i) QRP10 change < −5 %, (ii) QRPlow10 change > +5 % and (iii) QRPlow10 duration change <−5 %. We show here only pixels where all three change are statistically significant

Sobering human impacts even at 'safe levels' of warming– Heat stress

- One of the most 'robust' changes of concern in a warmer climate, is an increasing frequency of 'dangerously hot' weather
  - Europe (2003): **70,000** fatalities
  - Russia (2010): **50,000** fatalities



By 2050 about 350m more people living in megacities could be exposed to deadly heat each year.

Progressively heavier impacts as Paris targets breached

1.5°Cwarming, the global heat stress burden x6

2.0°C warming, global heat stress burden x12

4.0°C warming, global heat stress burden x75

In a 2°C warmer world, Karachi could experience 2015 type deadly conditions at least once a year. If global warming reaches 4°C, the record heat of 2015 would be commonplace – more than 40 days a year (Lahore – similar exposure).

How is human vulnerability changing – ageing population?

Conclusion

- Climate change presents us with challenges of both mitigation and adaptation.
- Every action matters but the transformation ahead needs to be just and inclusive.
- We cannot 'solve' climate change by mitigation alone we also need to do adaptation?