Our Changing Climate

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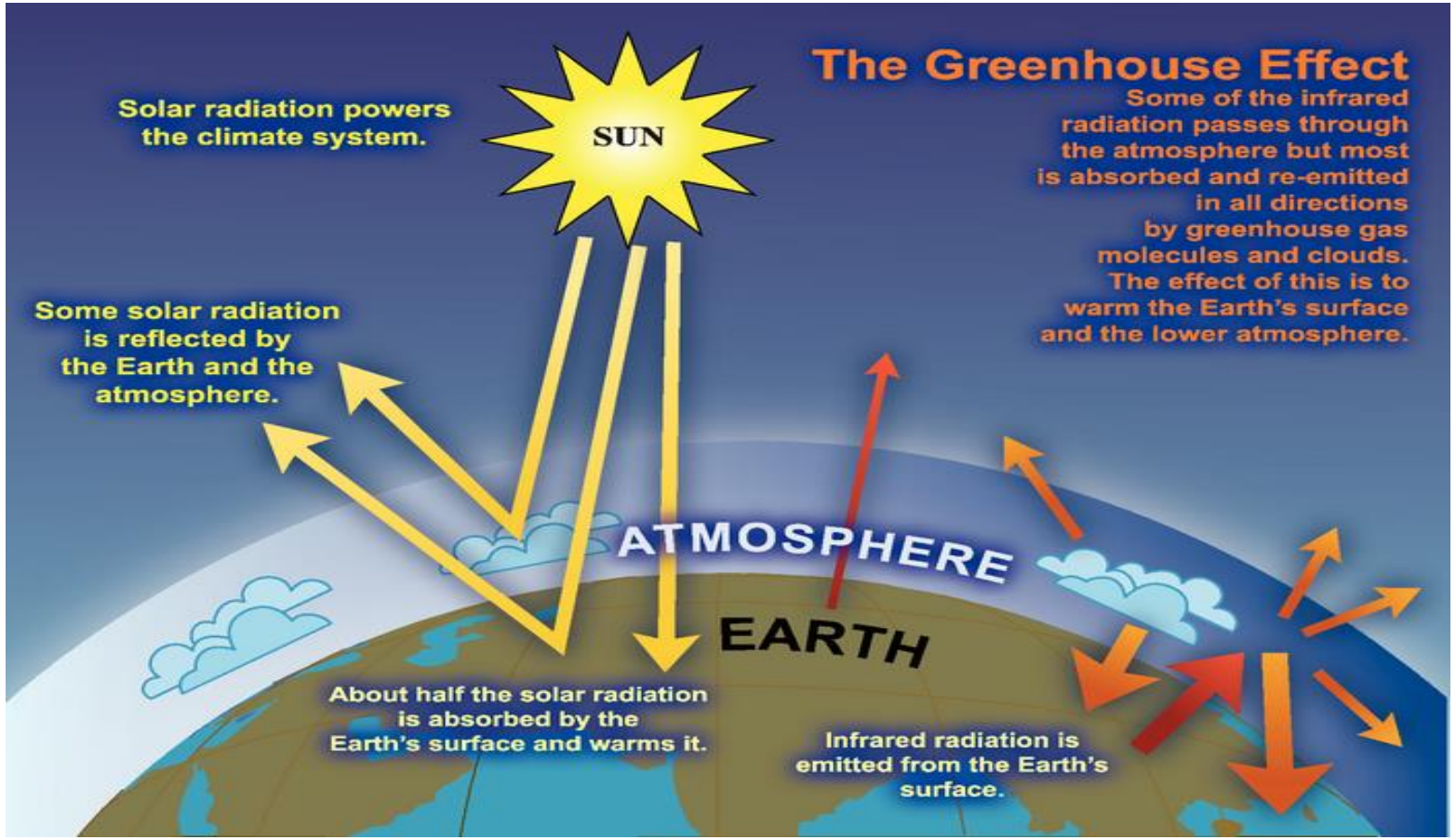
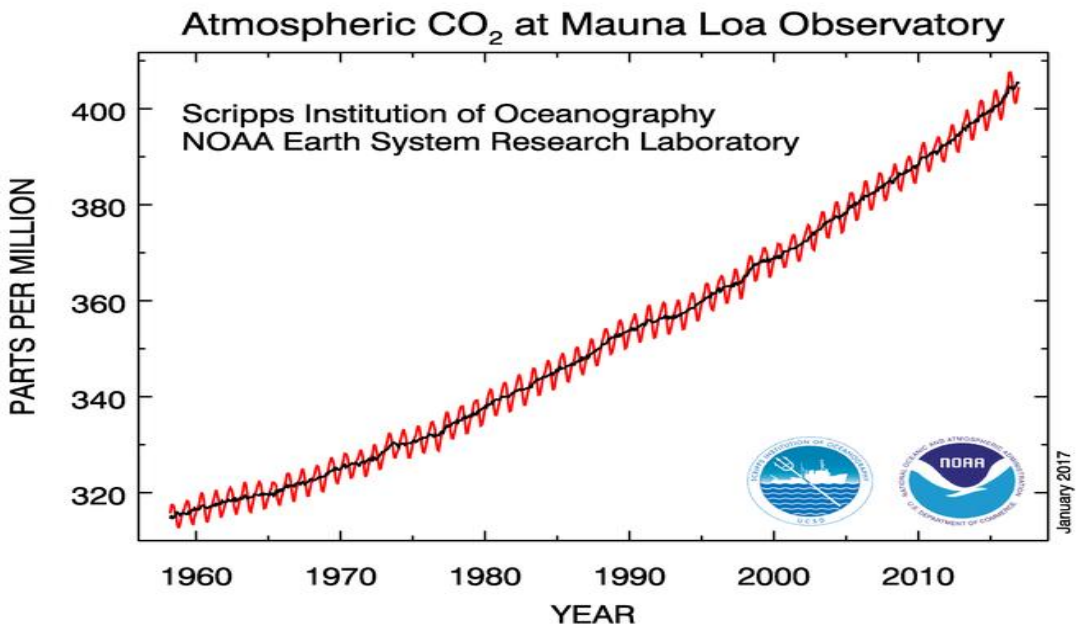
The natural greenhouse effect – a very different world without it!

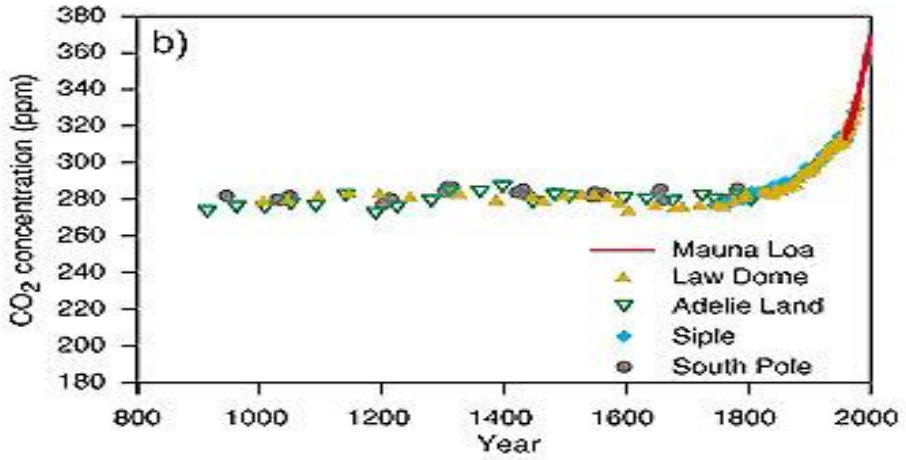


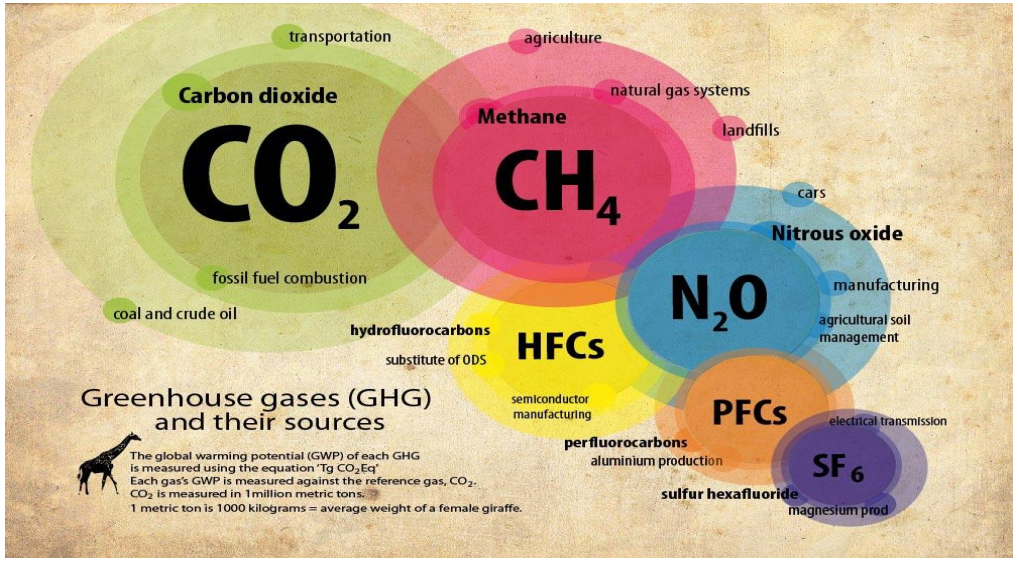
Without the greenhouse gases our planet would have an average temperature of approx. -19°C

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

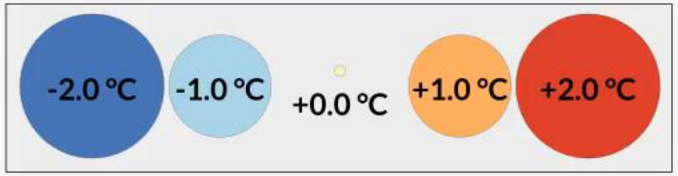

Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
YEAR
January 2017


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
natural gas systems
Methane
CH_4
landfills
cars
Nitrous oxide
N_2O
manufacturing
agricultural soil management
fossil fuel combustion
coal and crude oil
hydrofluorocarbons
substitute of ODS
HFCs
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.

Temperature Anomalies by Country
Years 1880 - 2017

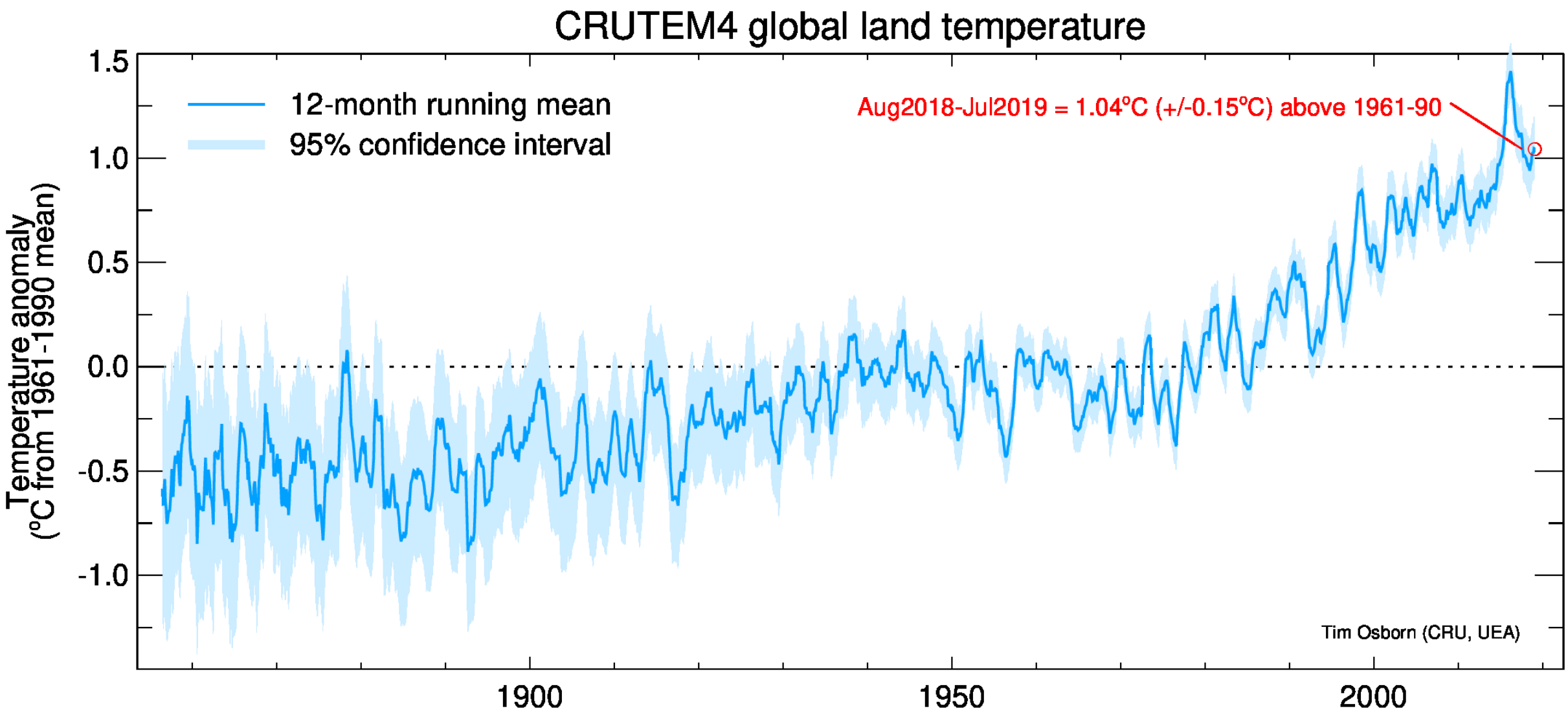
1880

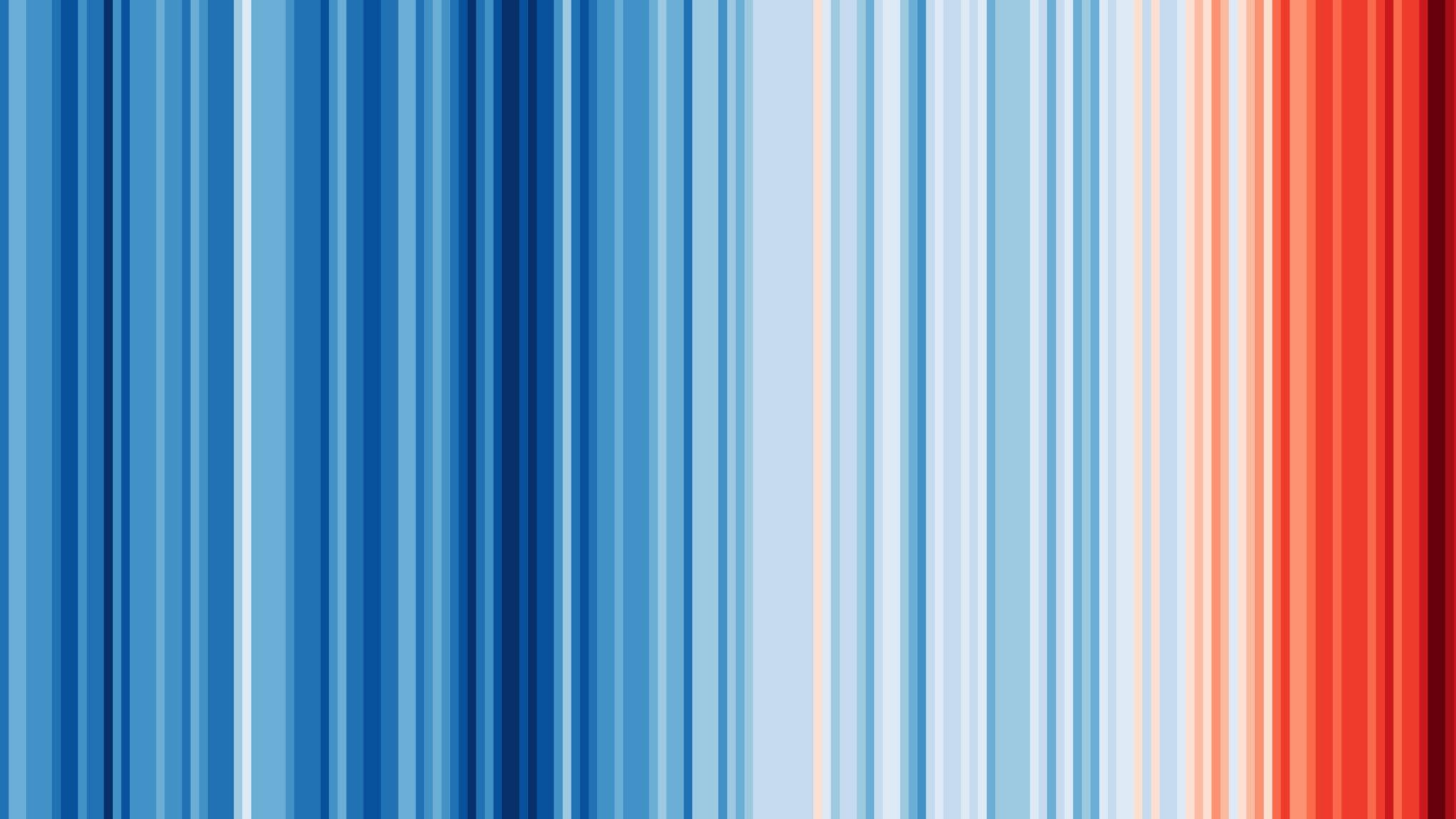


Afghanistan Albania Algeria Andorra Angola Antarctica Argentina Armenia Australia Austria Azerbaijan Bahamas, The Bahrain Bangladesh Barbados Belarus
Belgium Belize Benin Bhutan Bolivia Bosnia and H. Botswana Brazil Brunei Bulgaria Burkina Faso Burundi Cabo Verde Cambodia Cameroon Canada
Central African 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, Arab Rep. El Salvador Equatorial Guinea Eritrea Estonia eSwatini Ethiopia Fiji Finland France Gabon Gambia, The Georgia
Germany Ghana Greece Grenada Guatemala Guinea Guinea-Bissau Guyana Haiti Honduras Hungary Iceland India Indonesia Iran, Islamic Rep. Iraq
Ireland Israel Italy Jamaica Japan Jordan Kazakhstan Kenya Kiribati Korea, DPR Korea Kosovo Kuwait Kyrgyz Republic Lao PDR Latvia
Lebanon Lesotho Liberia Libya Liechtenstein Lithuania Luxembourg Macedonia, FYR 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 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 Seychelles Sierra Leone Singapore Slovak Republic Slovenia Solomon Islands Somalia South Africa South Sudan Spain
Sri Lanka St. Kitts and Nevis St. Lucia St. V. and the G. Sudan Suriname Sweden Switzerland Syria Taiwan Tajikistan Thailand Timor-Leste Togo Tonga Trinidad and Tobago
Tunisia Turkey Turkmenistan Tuvalu Uganda Ukraine United Arab Emirates UK Uruguay USA Uzbekistan Vanuatu Venezuela, RB Vietnam Yemen, Rep. Zambia
Zimbabwe

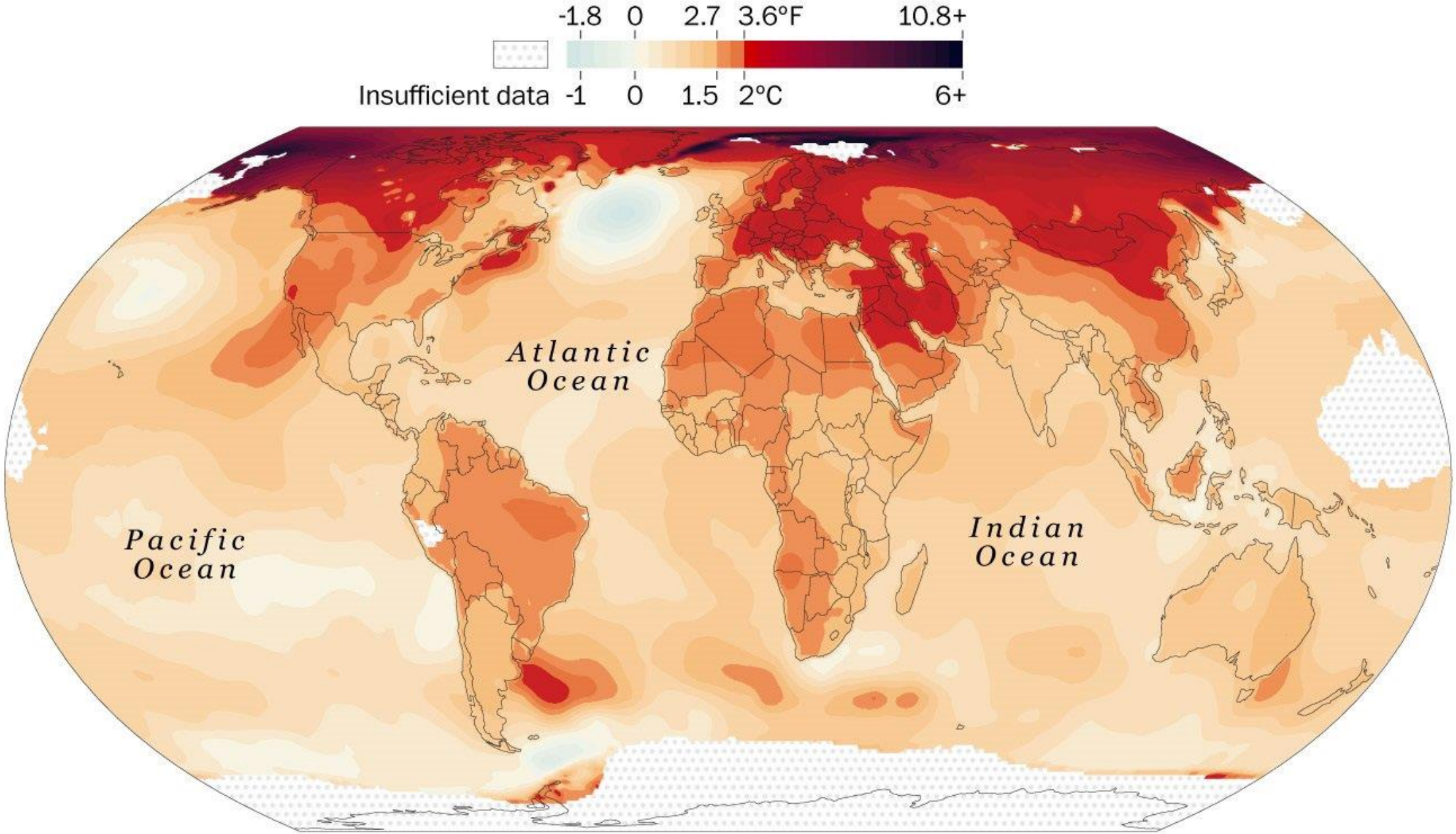
Data Source:
NASA GISS, GISTEMP Land-Ocean Temperature Index (LOTI), ERSSTv5, 1200km smoothing
https://data.giss.nasa.gov/gistemp/
Average of monthly temperature anomalies. GISTEMP base period 1951–1980.

Antti Lipponen (@anttilip)


CRUTEM4 global land temperature
12-month running mean
95% confidence interval
Aug2018-Jul2019 = 1.04°C (+/-0.15°C) above 1961-90
Temperature anomaly
(°C from 1961-1990 mean)
1.5
1.0
0.5
0.0
-0.5
-1.0
1900
1950
2000
Tim Osborn (CRU, UEA)

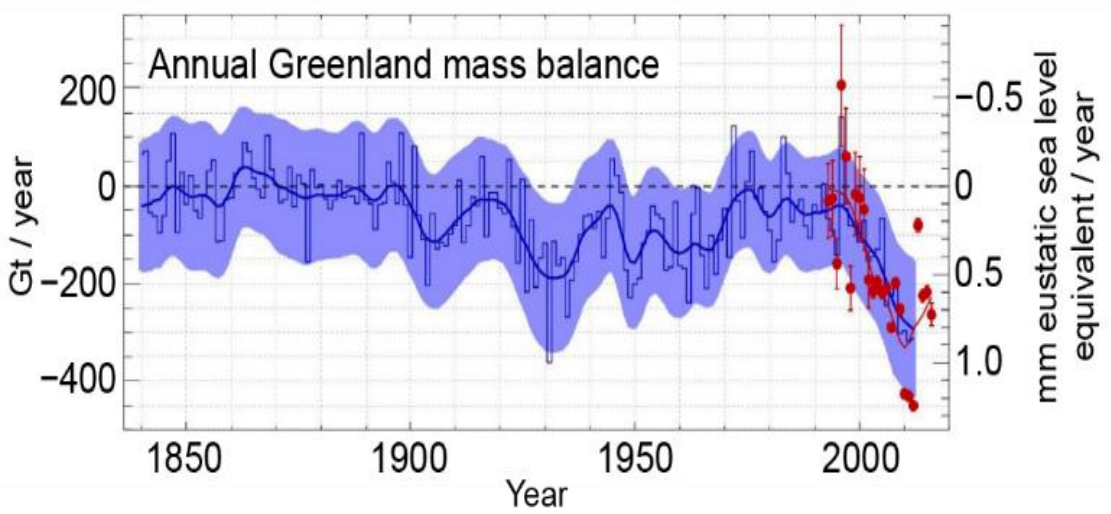


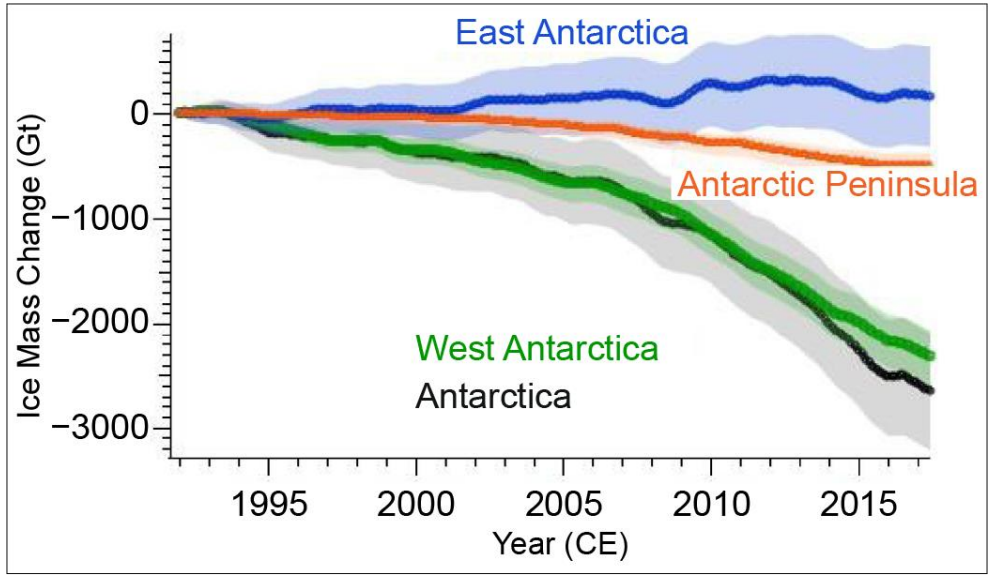
Temperature change, 2014-2018 compared with 1880-1899

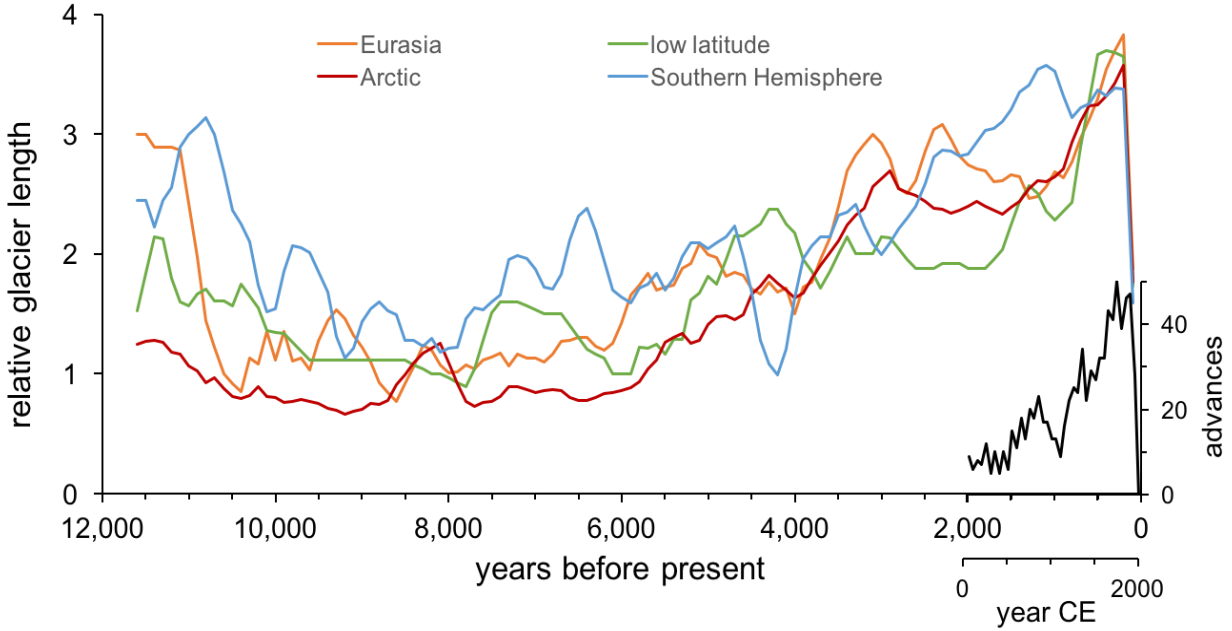


Source: Berkeley Earth

Ice is melting



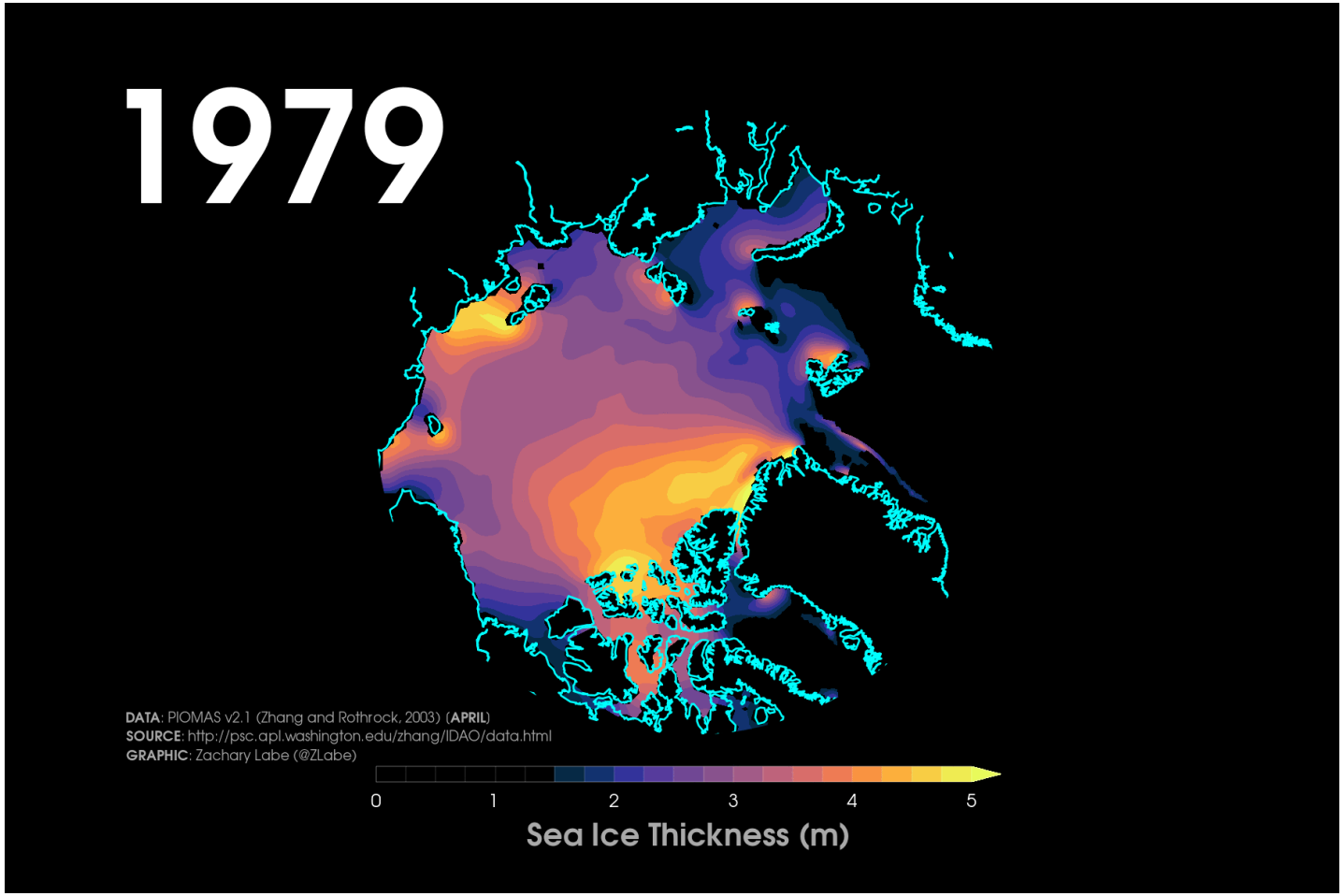




Glaciers and ice sheets are retreating (melting) and the rate of change is highly unusual

Figures courtesy Sebastian Gerland

And sea ice is decreasing

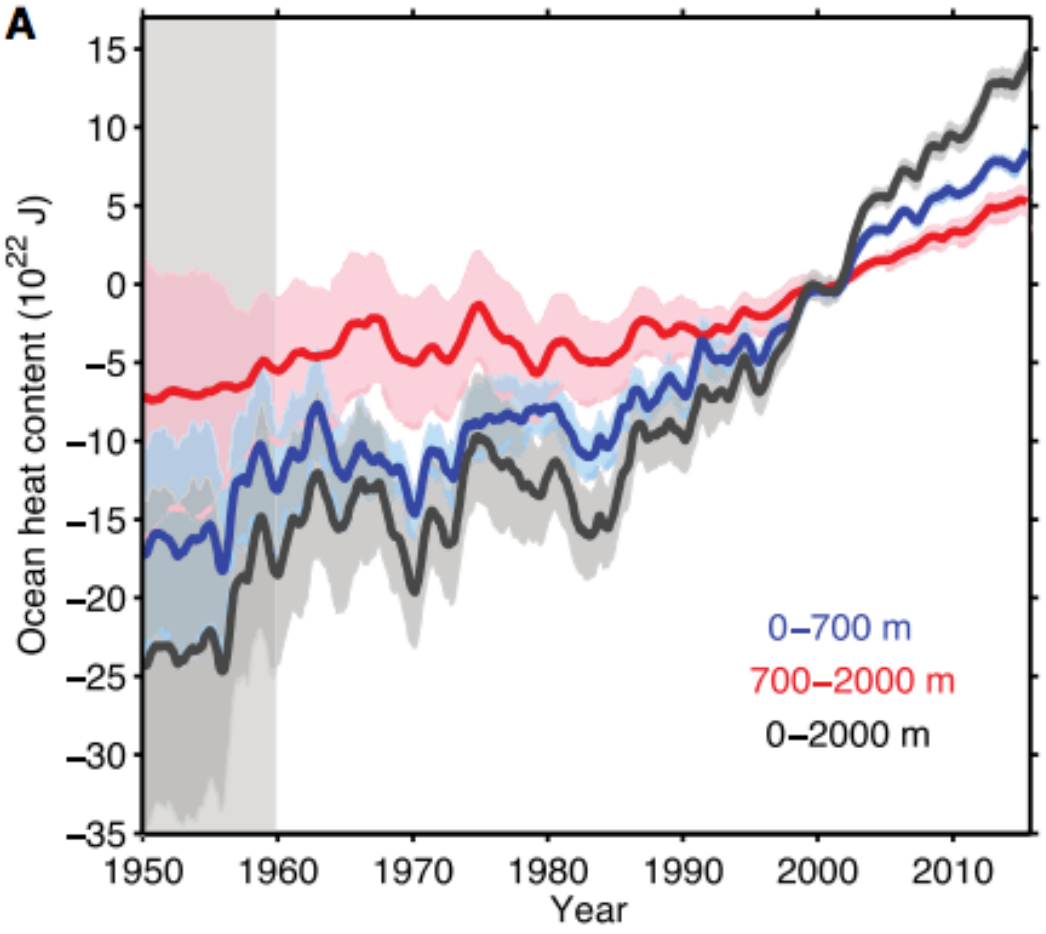


Sea ice:

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

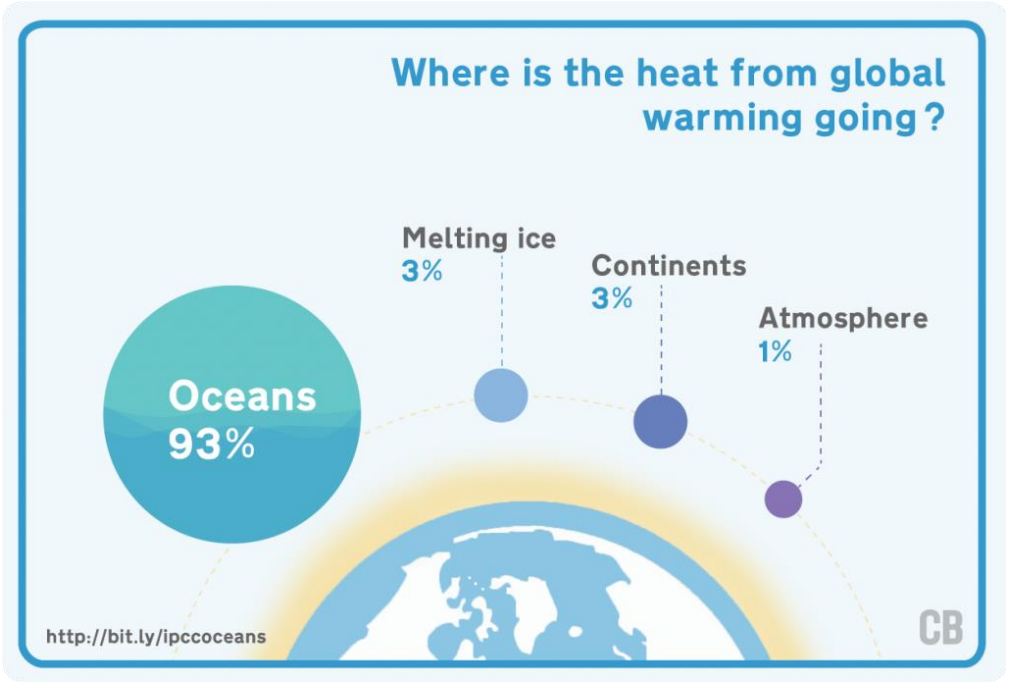
Figure courtesy Zachary Labe

Oceans are warming

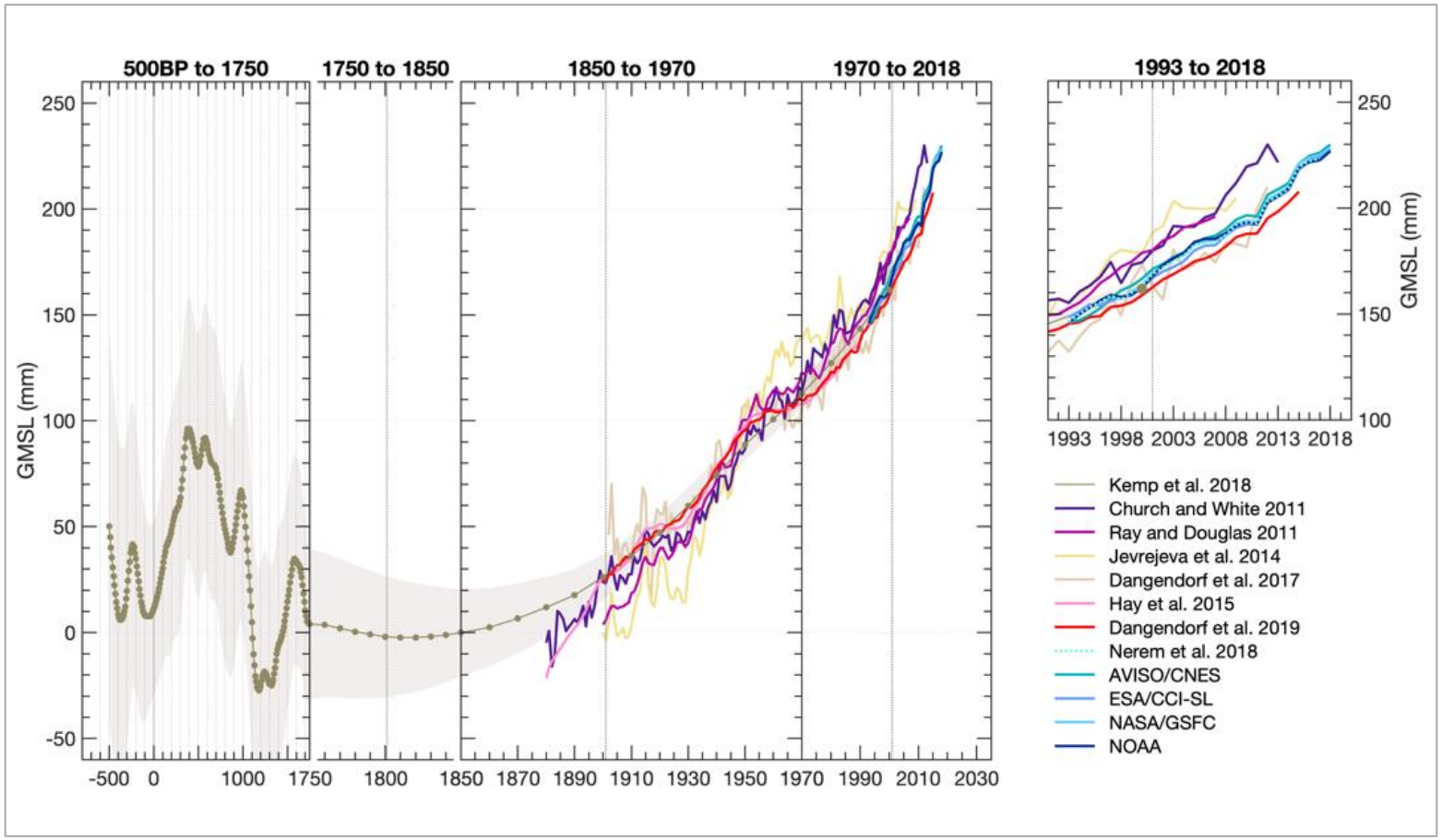


The oceans are warming at all depths.

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



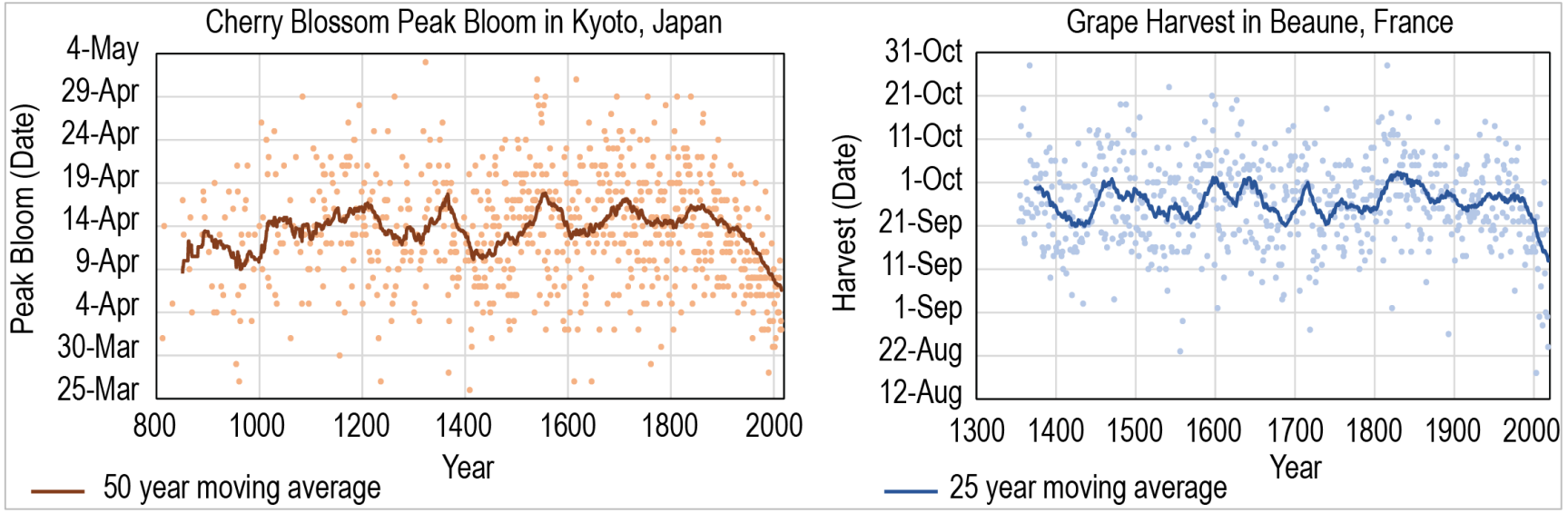
Sea level is increasing as a result



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.

How do we know humans are the cause?

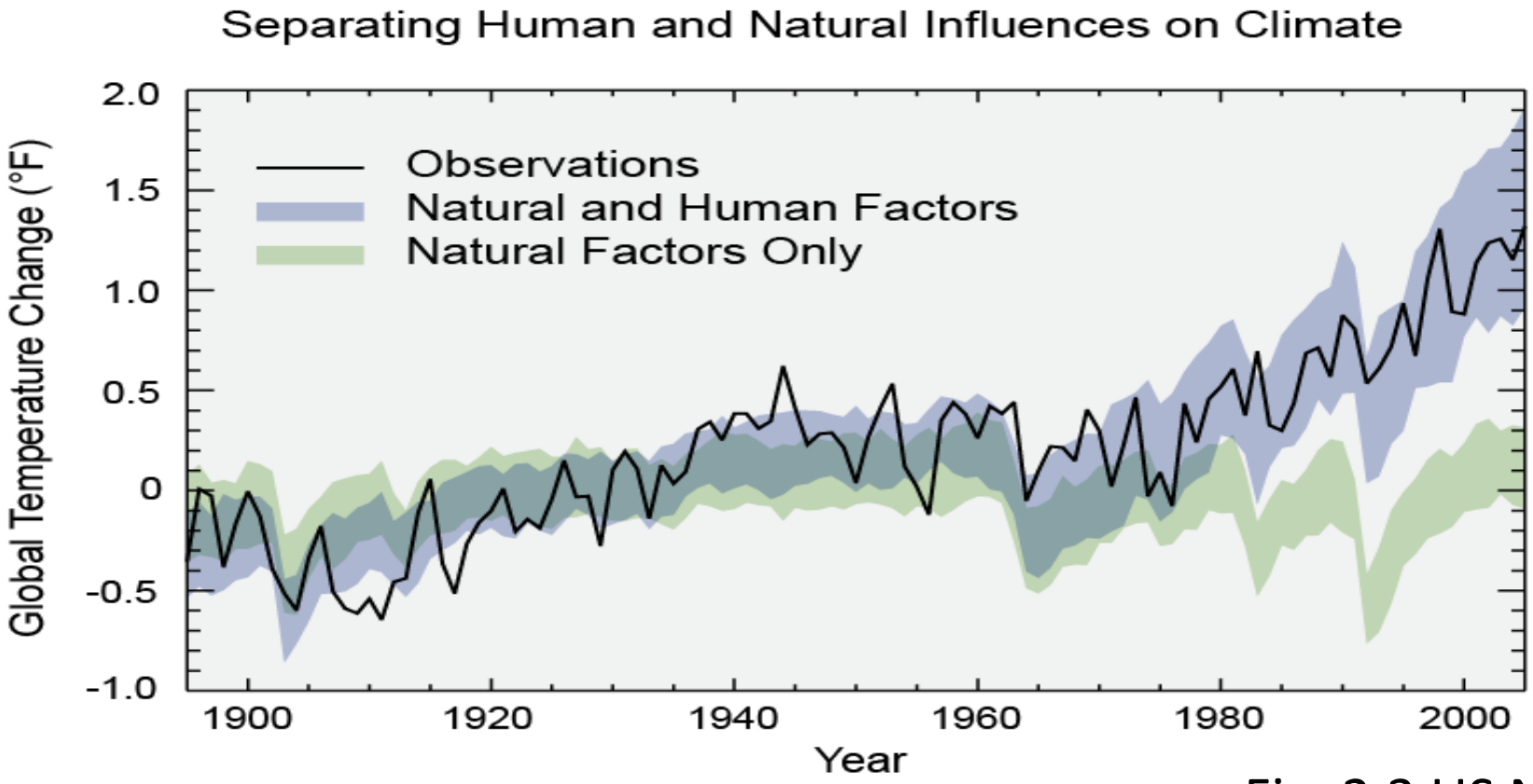
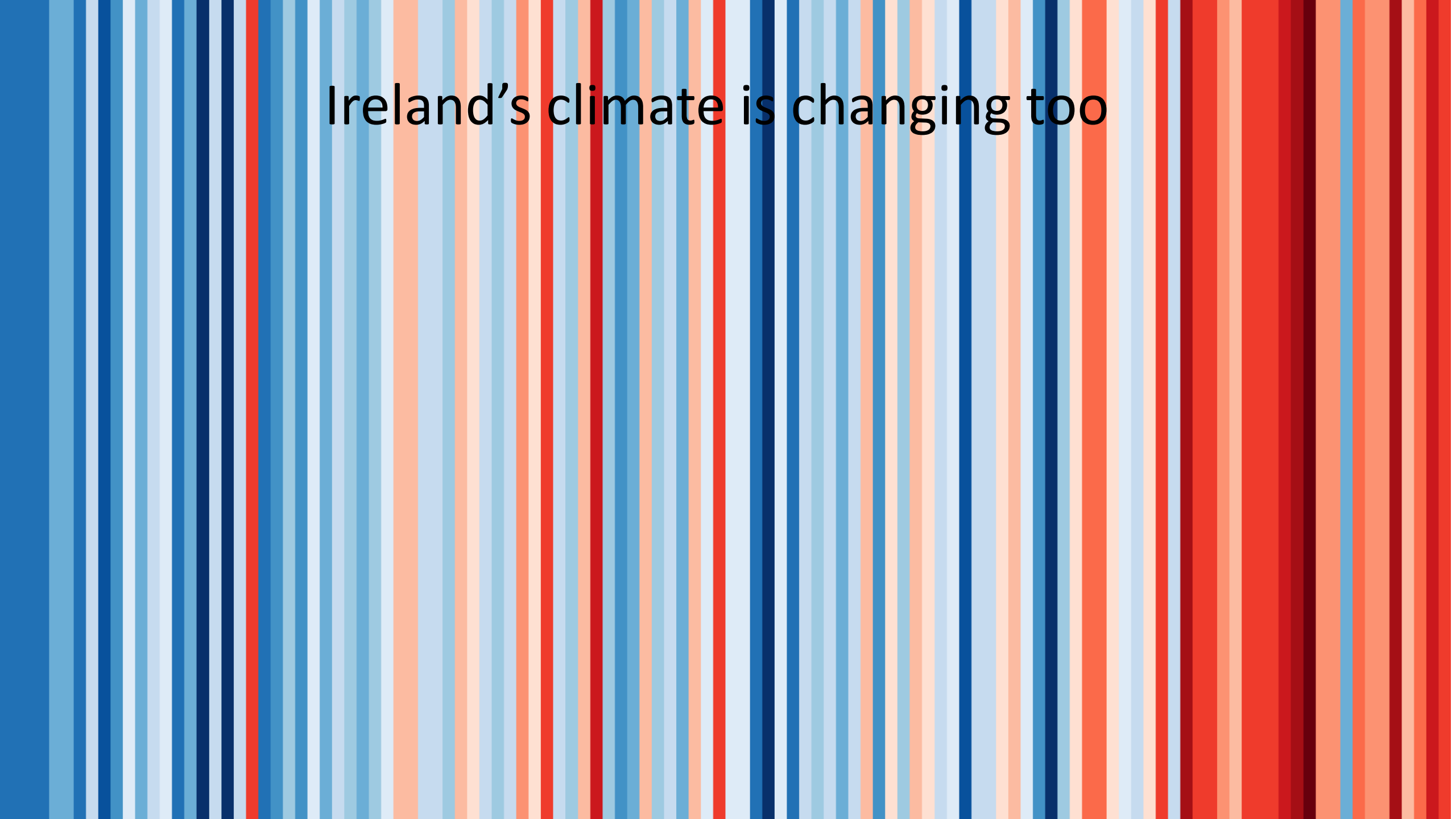


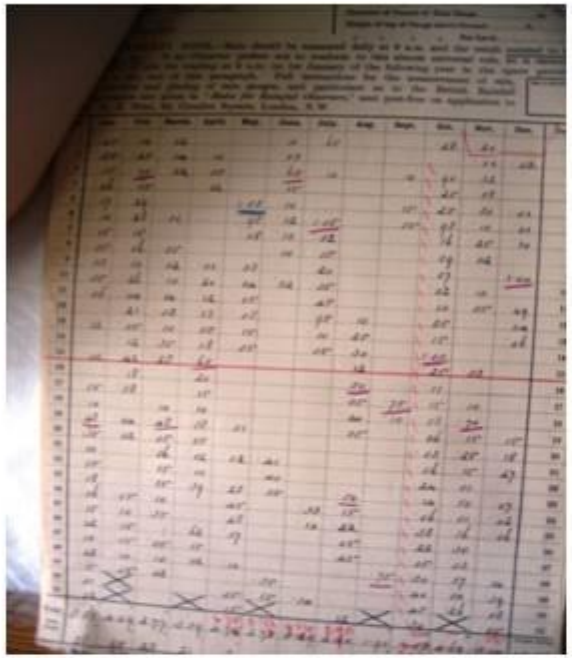
Fig. 2.3 US National Climate Assessment 2014

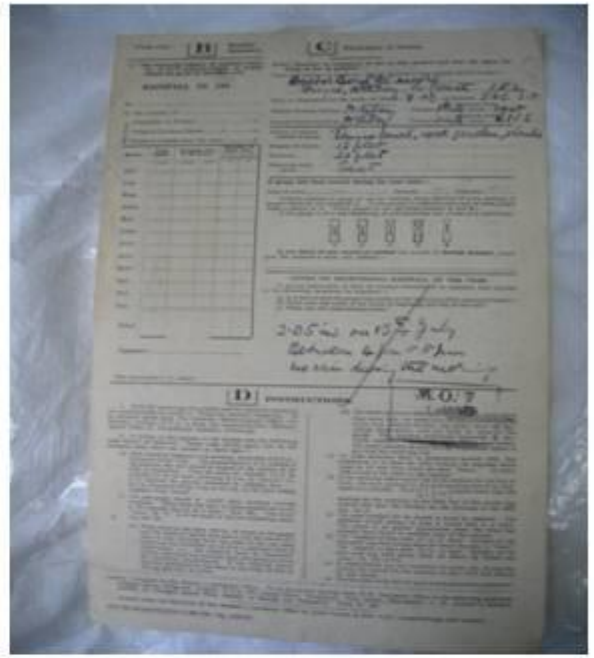
https://www.bloomberg.com/graphics/2015-whats-warming-the-world/

Ireland’s climate is changing too



Archived hand written precipitation records held at Met Eireann





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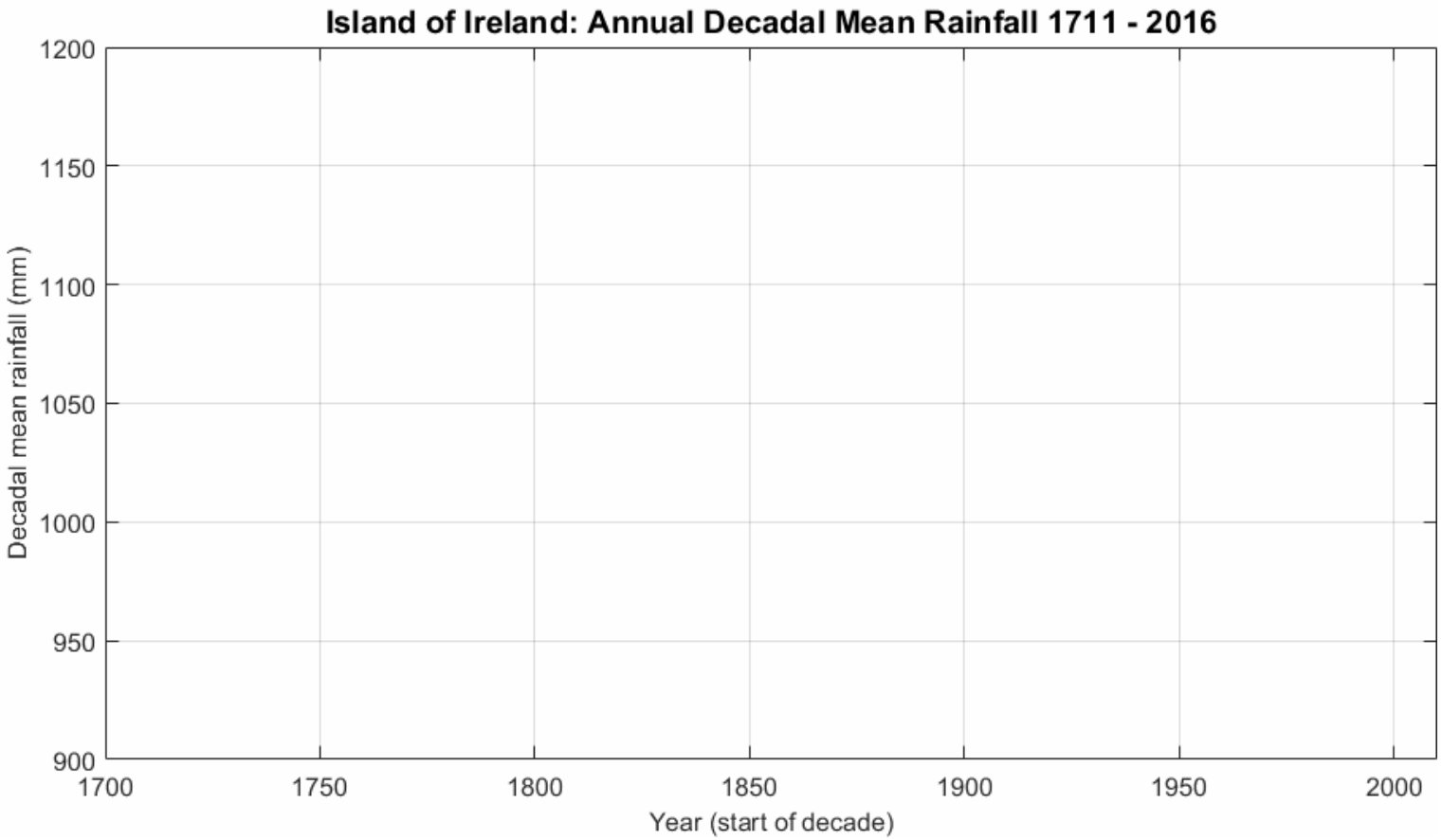

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Brainstorm | About Brainstorm Contribute to Brainstorm

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

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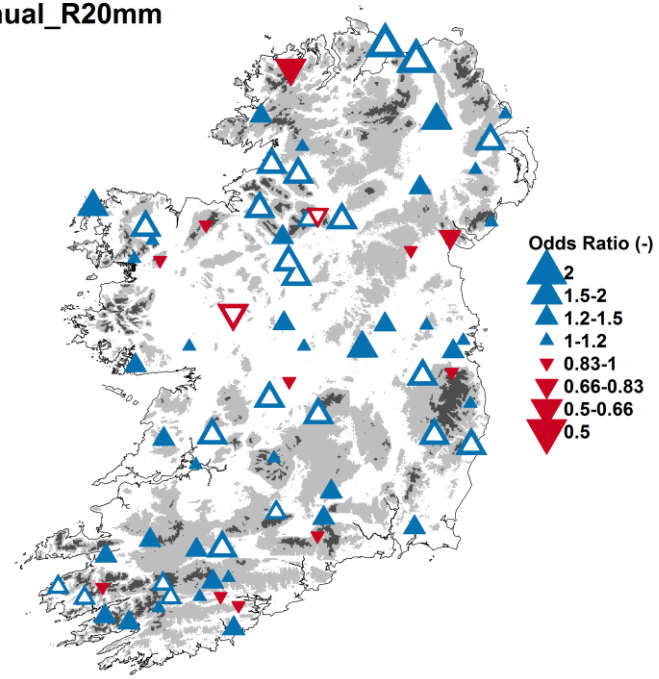
Heavy rainfall events more common in summer in SE

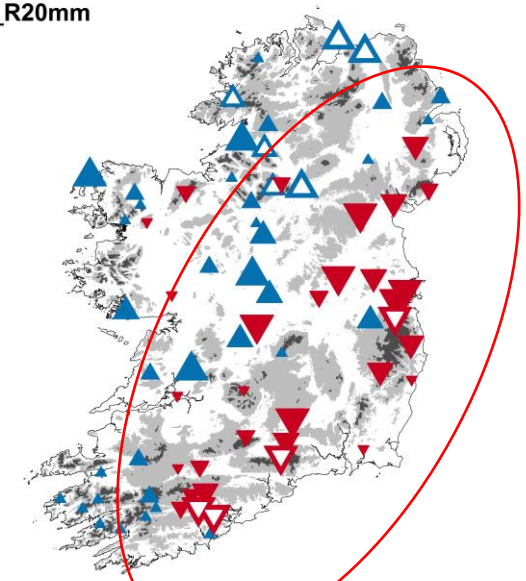
R20mm

Annual_R20mm



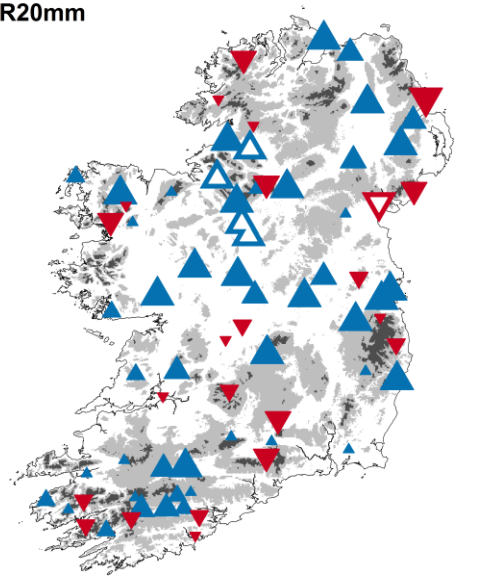
Mag.: 1.3% ; +ve(sig.): 82.2(31.5)% ; -ve(sig.): 17.8(2.7)%

W_R20mm



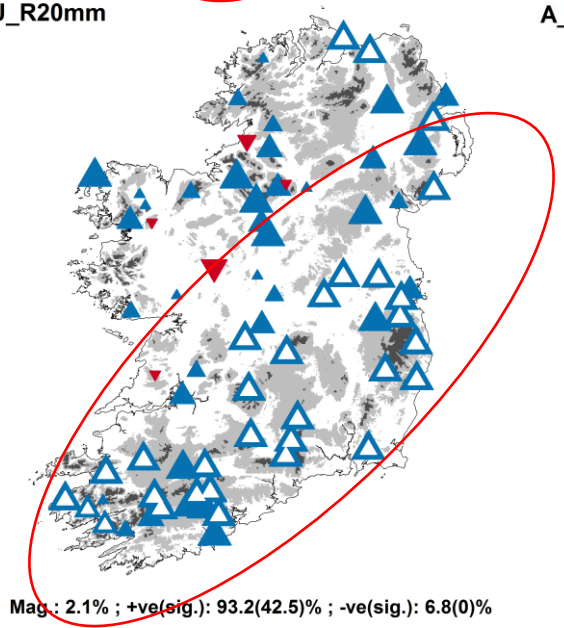
Mag.: 1.1% ; +ve(sig.): 56.2(8.2)% ; -ve(sig.): 43.8(5.5)%

SP_R20mm



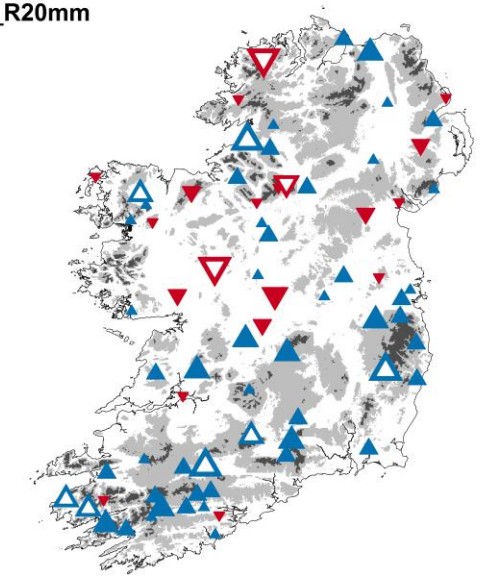
Mag.: 1.2% ; +ve(sig.): 68.5(5.5)% ; -ve(sig.): 31.5(1.4)%

SU_R20mm



Mag.: 2.1% ; +ve(sig.): 93.2(42.5)% ; -ve(sig.): 6.8(0)%

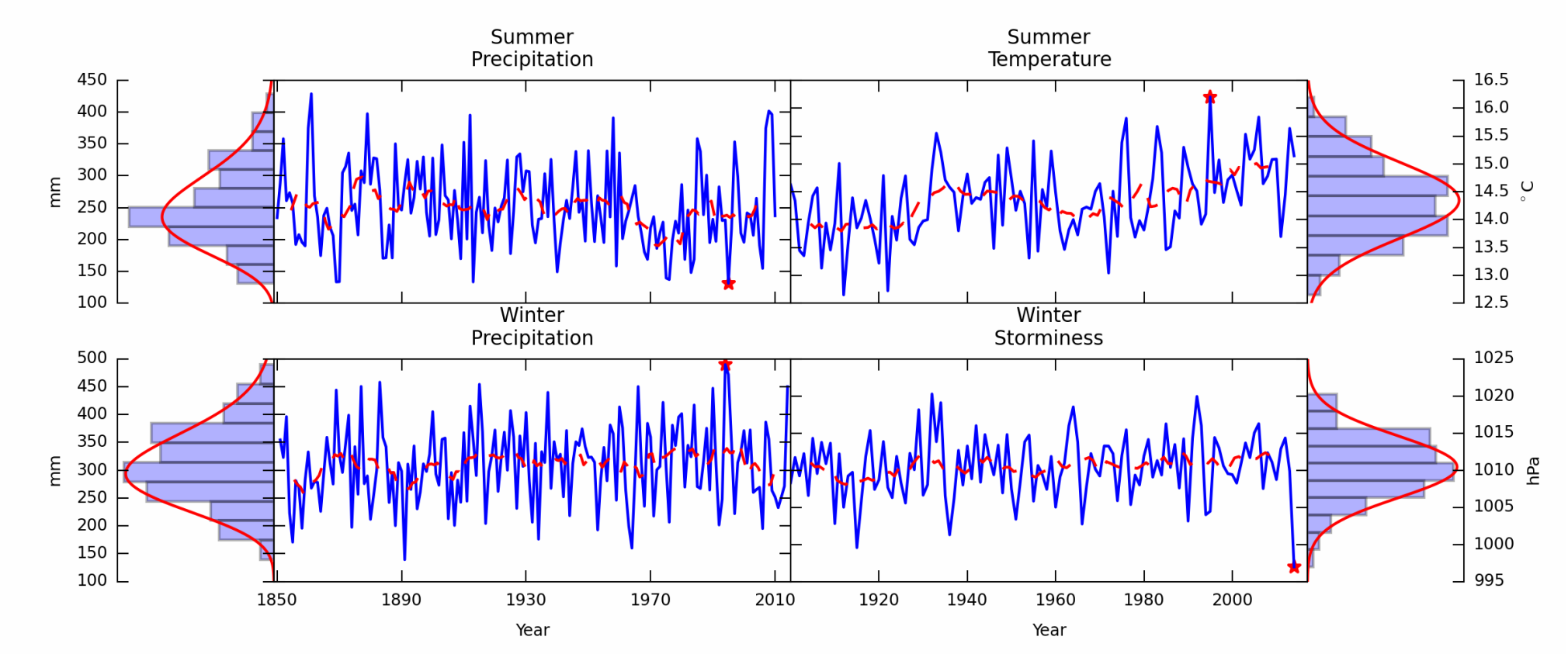
A_R20mm



Mag.: 1.2% ; +ve(sig.): 72.6(9.6)% ; -ve(sig.): 27.4(4.1)%

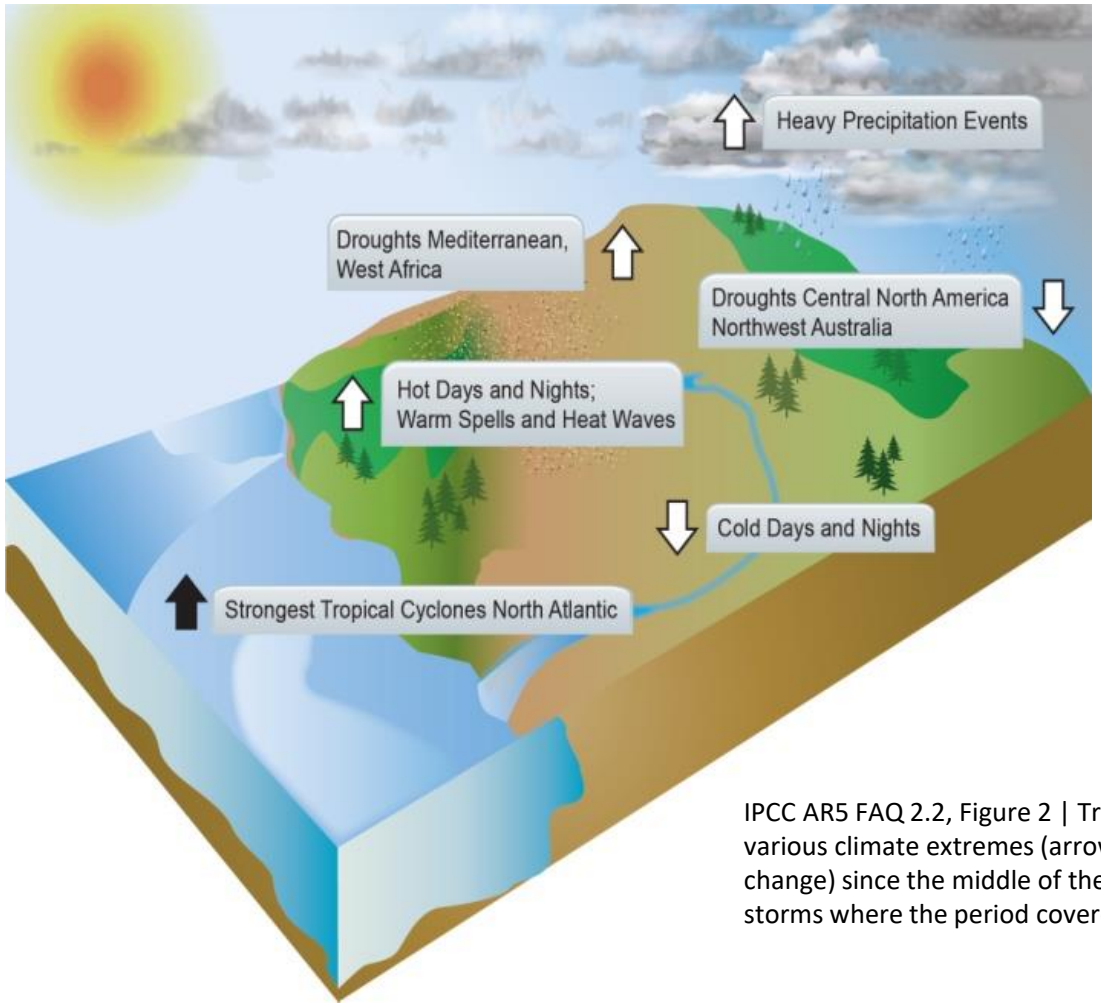
Source: Harrigan, 2016

Memorable Irish extremes – how has their likelihood changed?

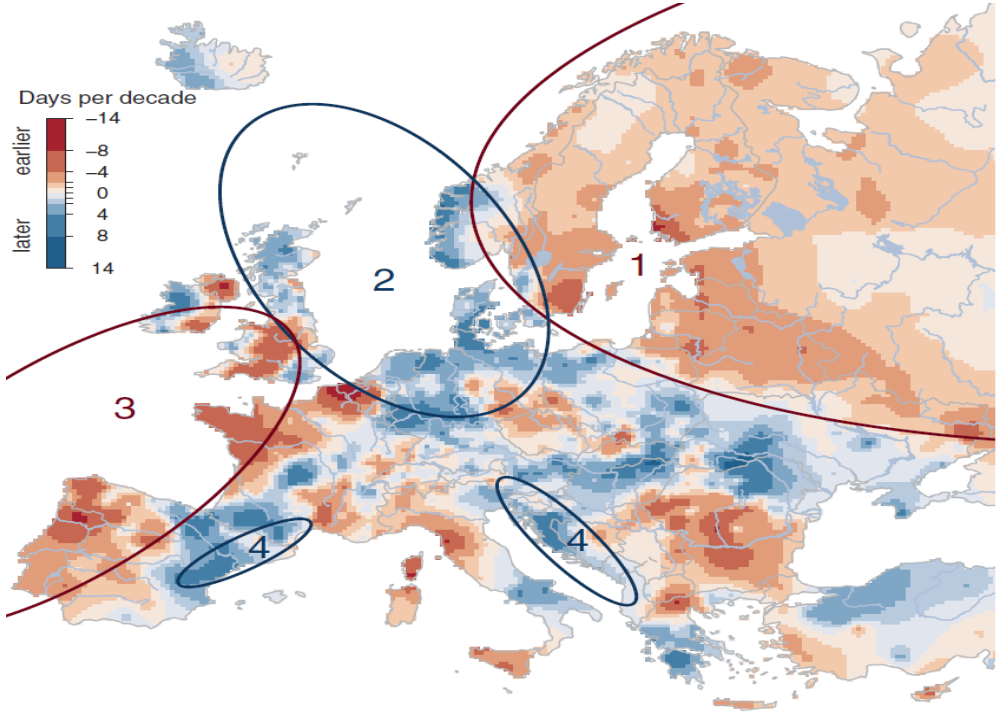


Over the period (1900–2014) records suggest a greater than 50-fold increase in the likelihood of the warmest recorded summer (1995), whilst the likelihood of the wettest winter (1994/95) and driest summer (1995) has respectively doubled since 1850.

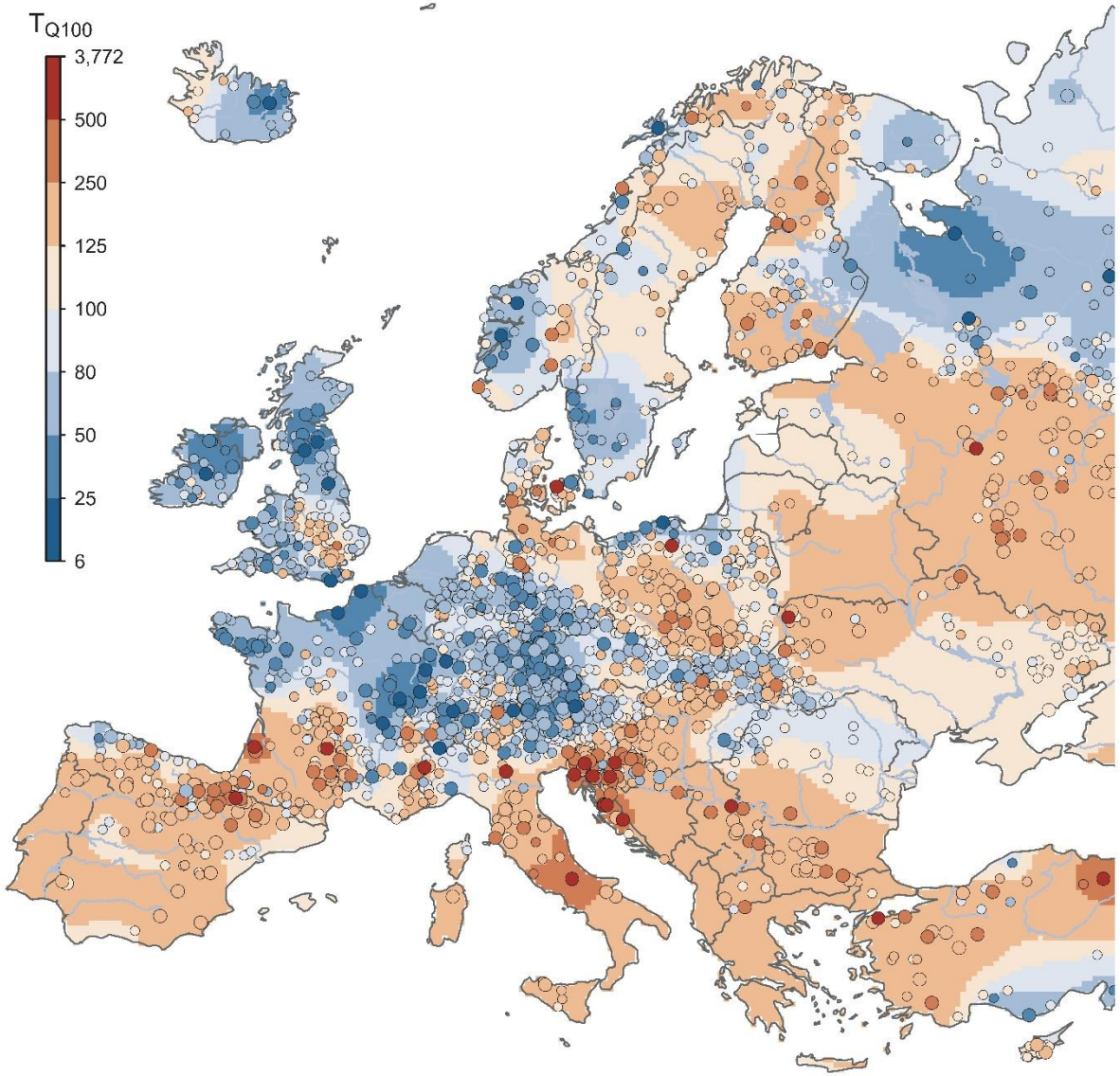
And extremes?



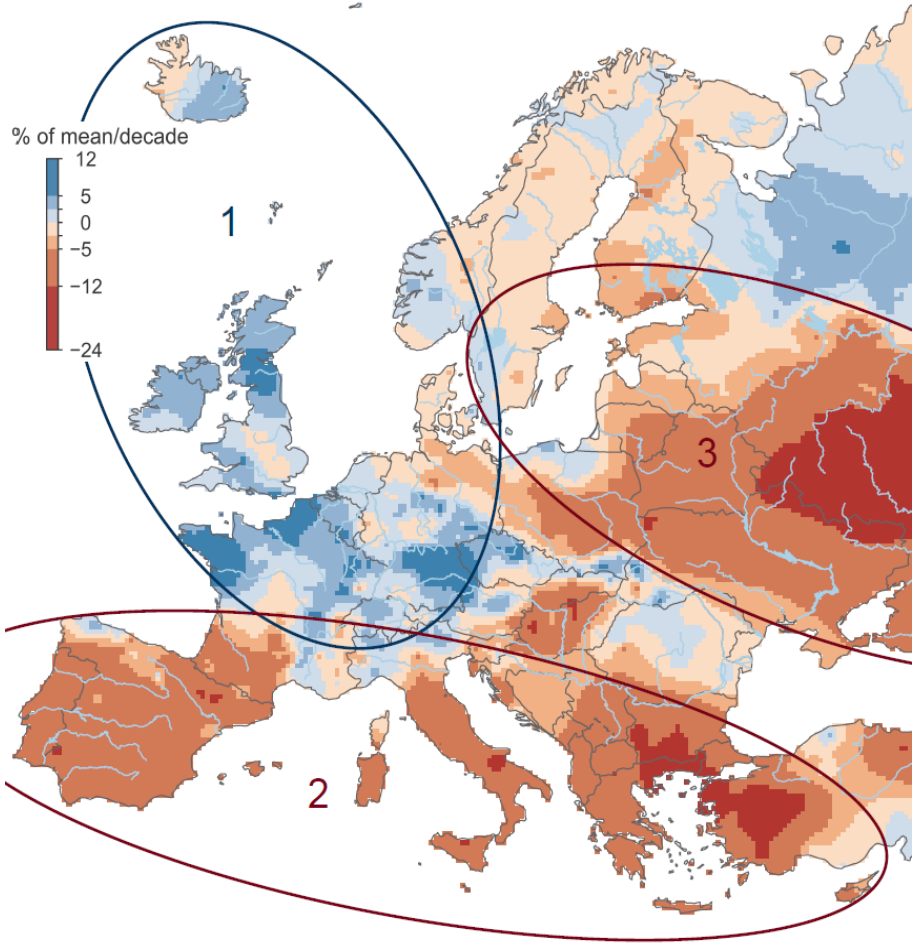
IPCC AR5 FAQ 2.2, Figure 2 | Trends in the frequency (or intensity) of various climate extremes (arrow direction denotes the sign of the change) since the middle of the 20th century (except for North Atlantic storms where the period covered is from the 1970s).



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



Floods getting bigger



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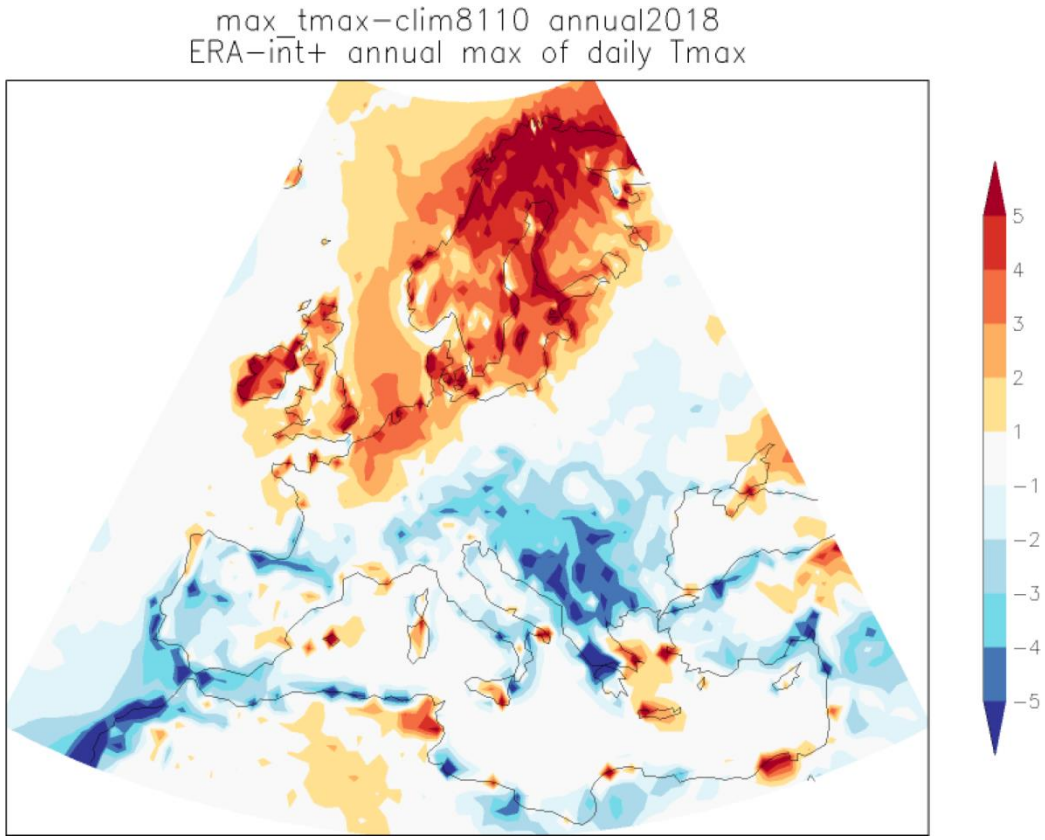
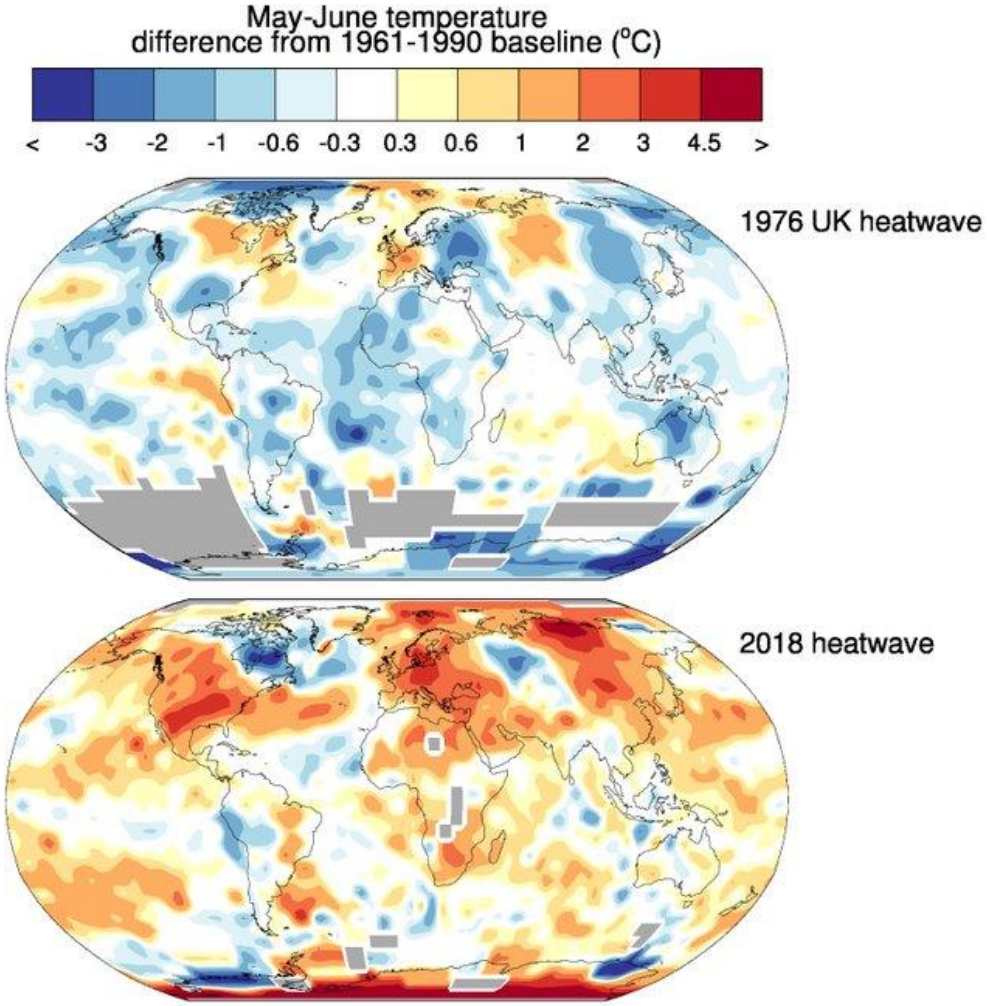
Summer 2018



The hottest 3-day average of Tmax in 2018 (ECMWF analyses up to 24 July, forecasts up to 31 July) compared to the highest 3-day maximum temperature in the period 1981-2010 that is currently the "normal" period (ERA-interim). Along coasts there are artefacts from comparing the high-resolution analyses with the lower-resolution ERA-interim reanalysis. Source: Worldweatherattribution.org



In Ireland, there are clear trends towards more heat waves in the observations. Attribution study on this summer's extreme temperatures using climate models give a very similar increase in probabilities to the observations — roughly a factor two more likely in Dublin

Environmental Research Letters

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]

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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
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E-mail: climatom86@gmail.com

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

Supplementary material for this article is available online

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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.

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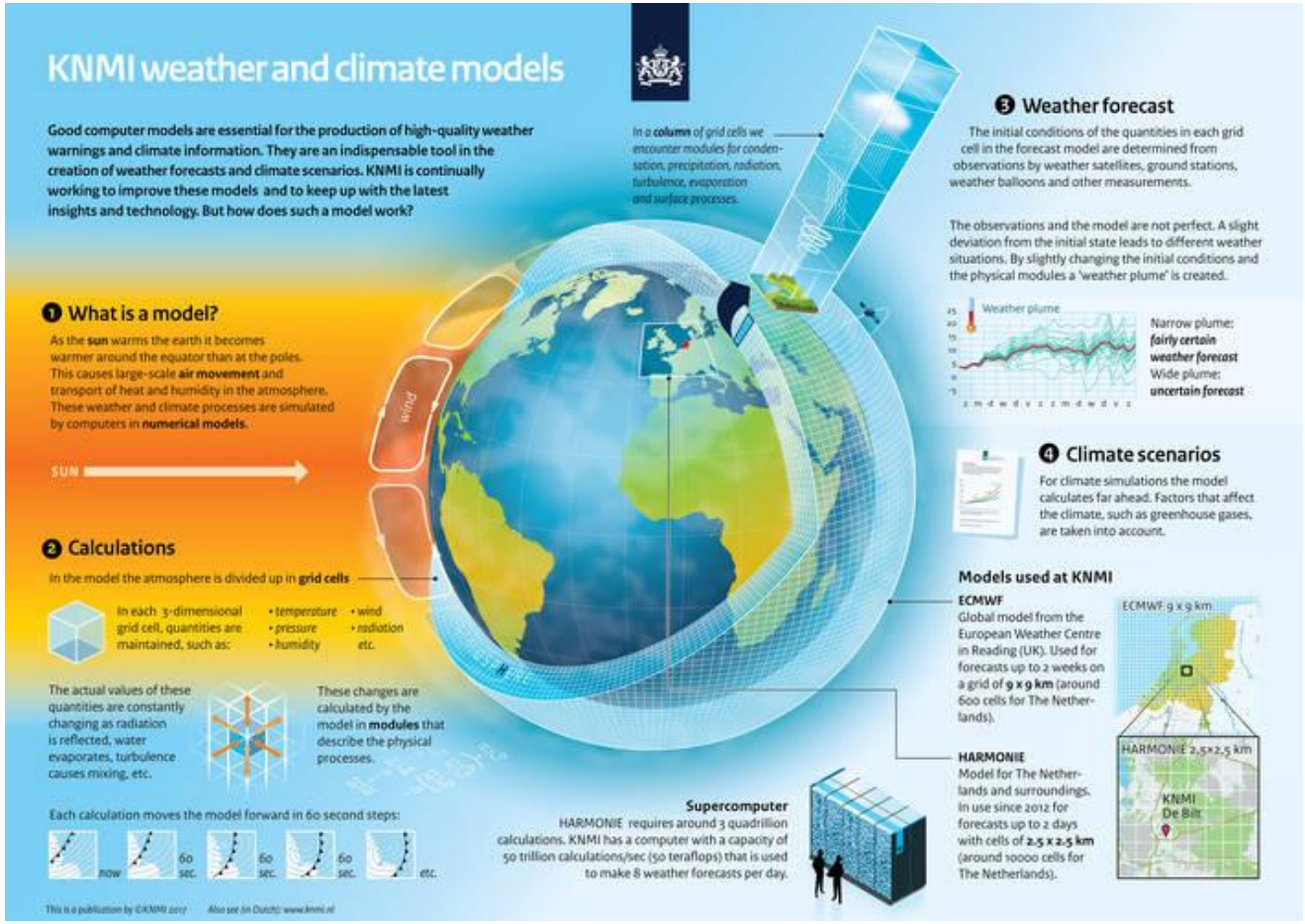
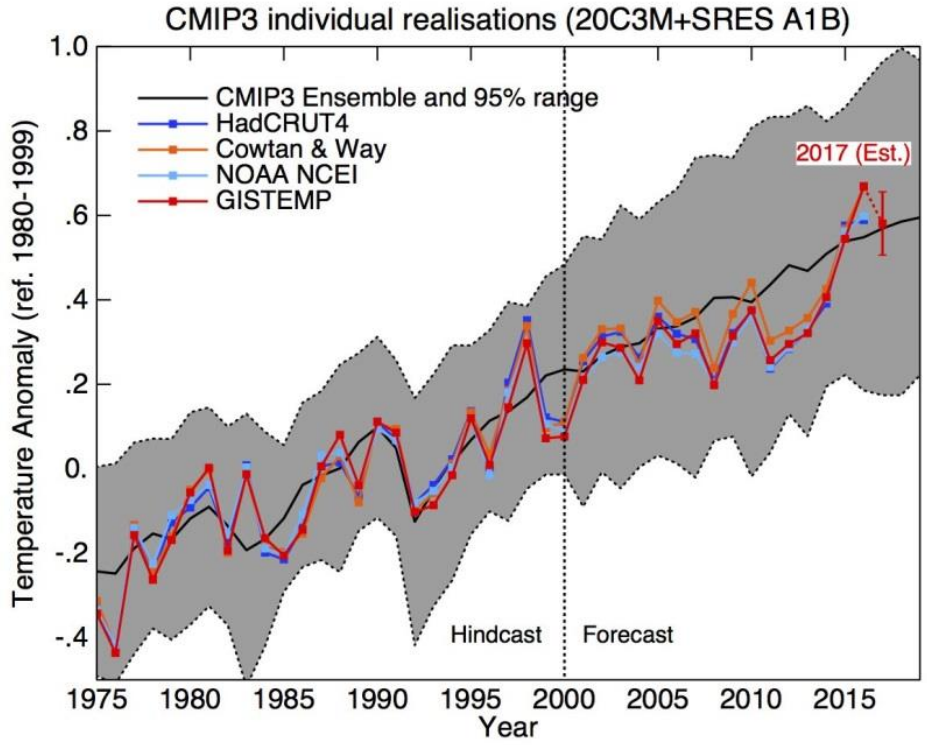
Understanding future climate





Source: Gavin Schmidt NASA

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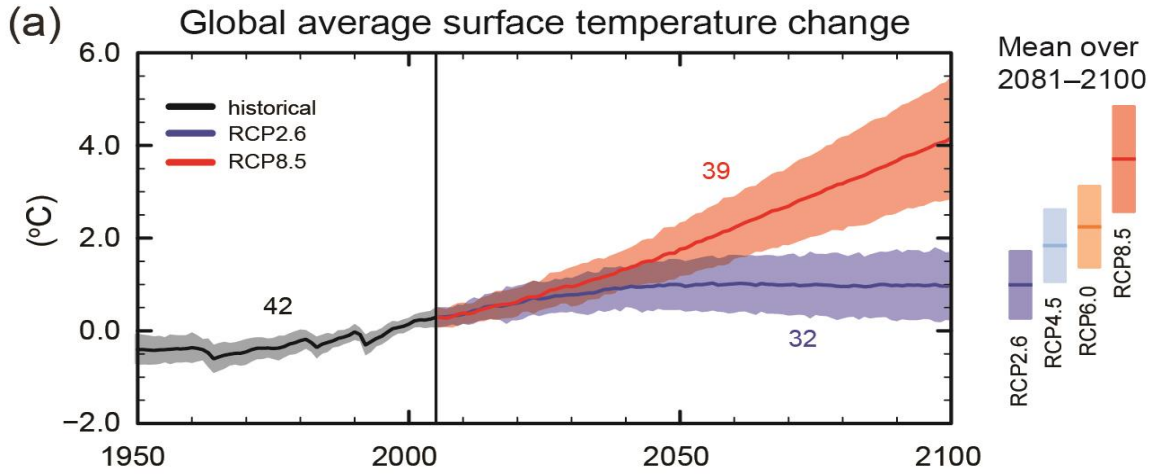
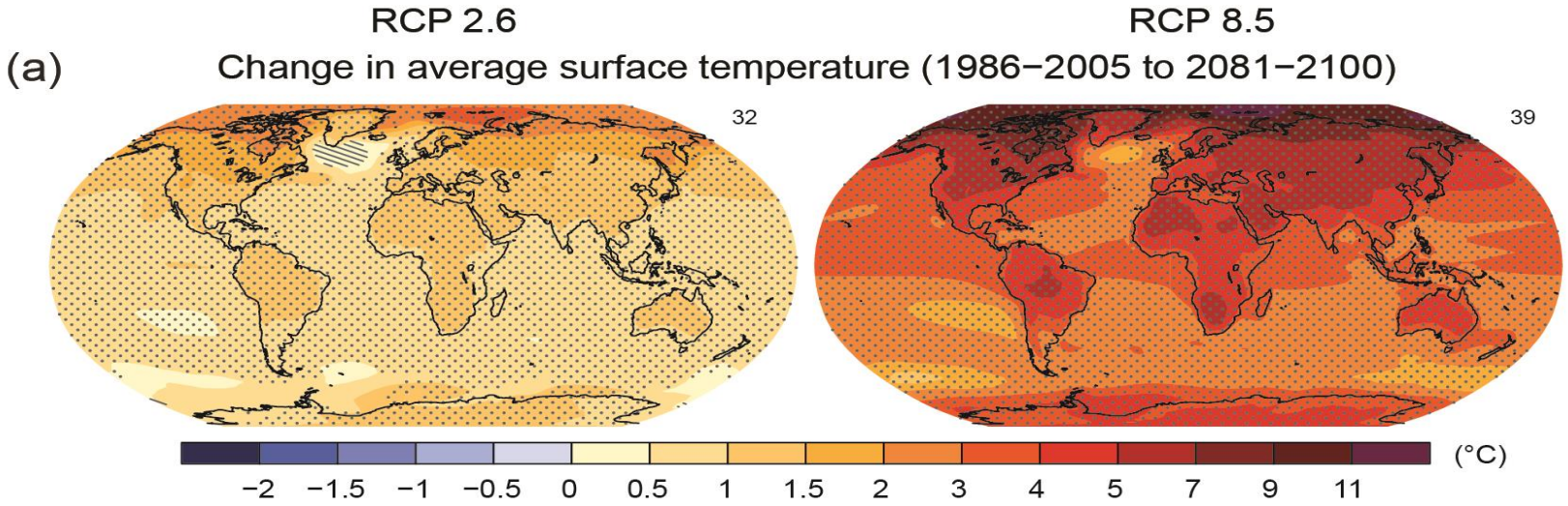
What future do we want?





Source: IPCC AR5

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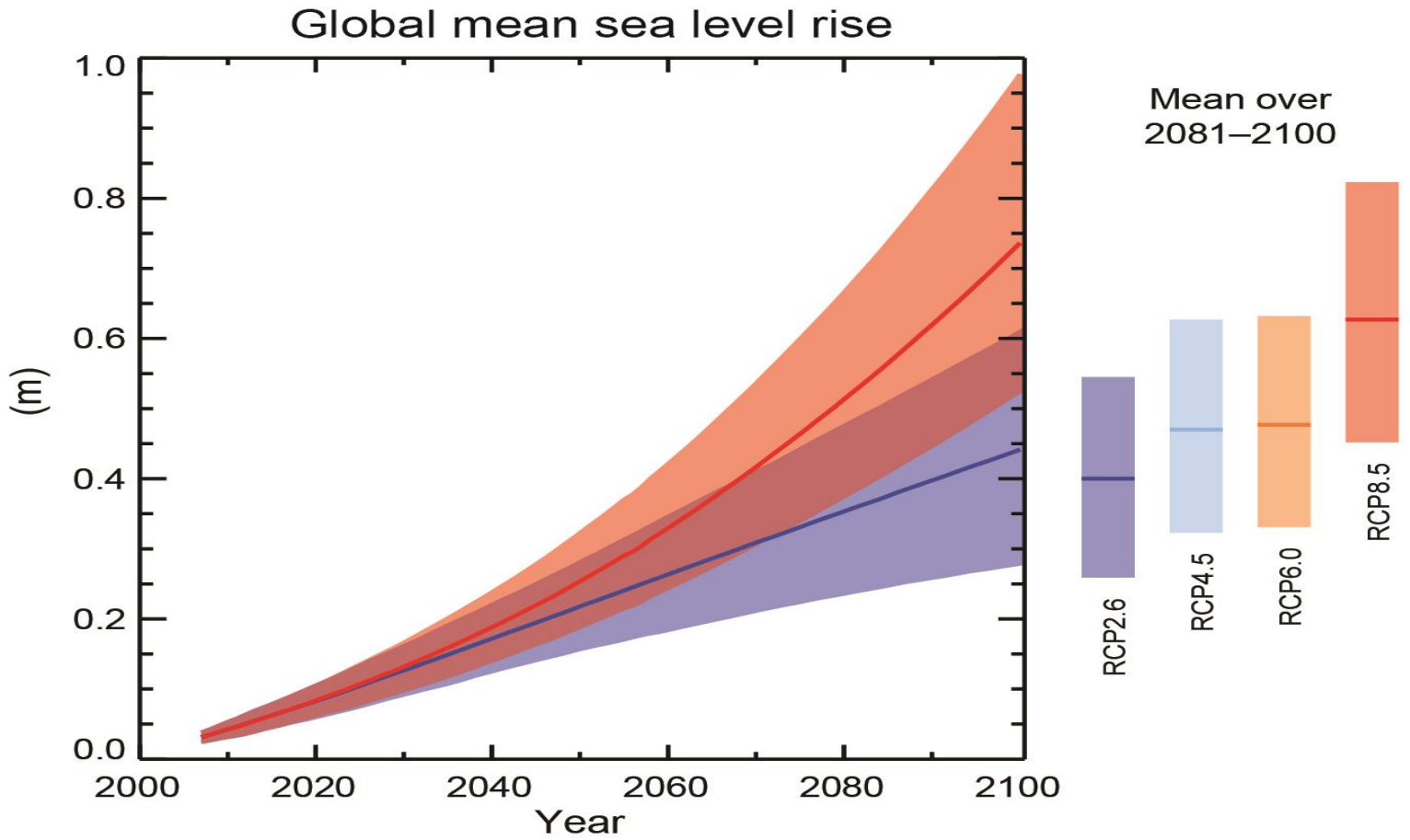
What future do we want?



Source: IPCC AR5

How frequent may those Irish events become in future?

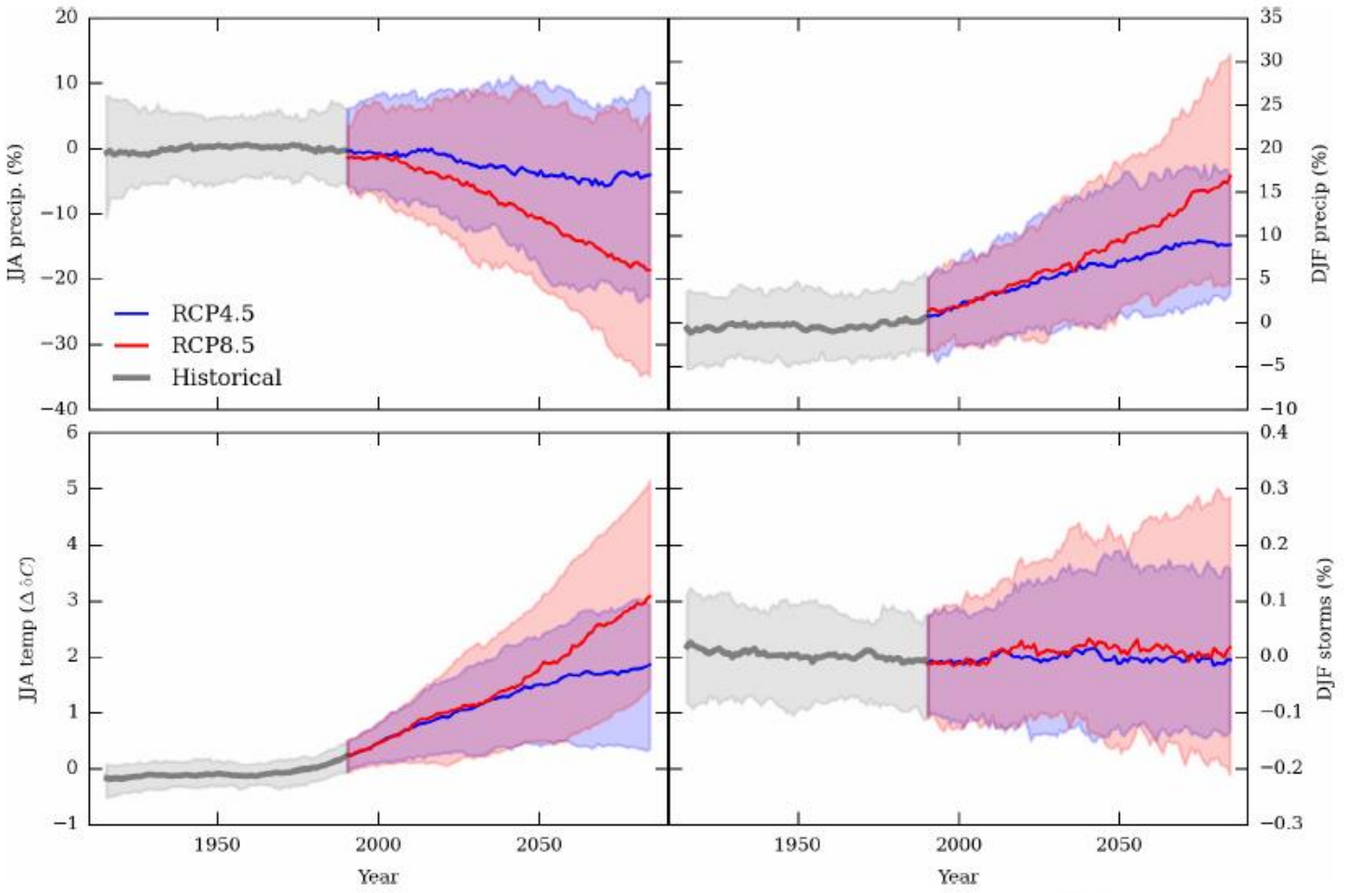


Fig. 10. Centred 30-year running means of the respective variables, expressed as anomalies from 1901–2005. See Fig. 8 caption for further details.

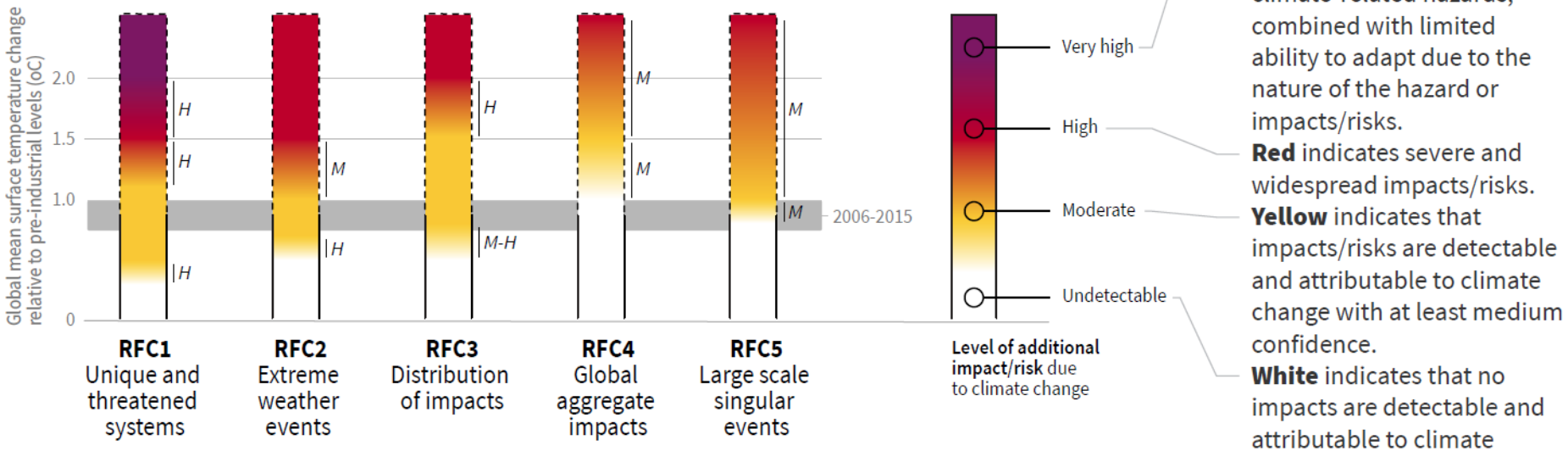
- In a business as usual world..
- 1 in 8 years as dry as 1995
- 1 in 8 years as wet as 1994
- 1 in 7 years ***as cool as*** 1995
- BUT these graphs also allow us to consider vulnerability to future change

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.

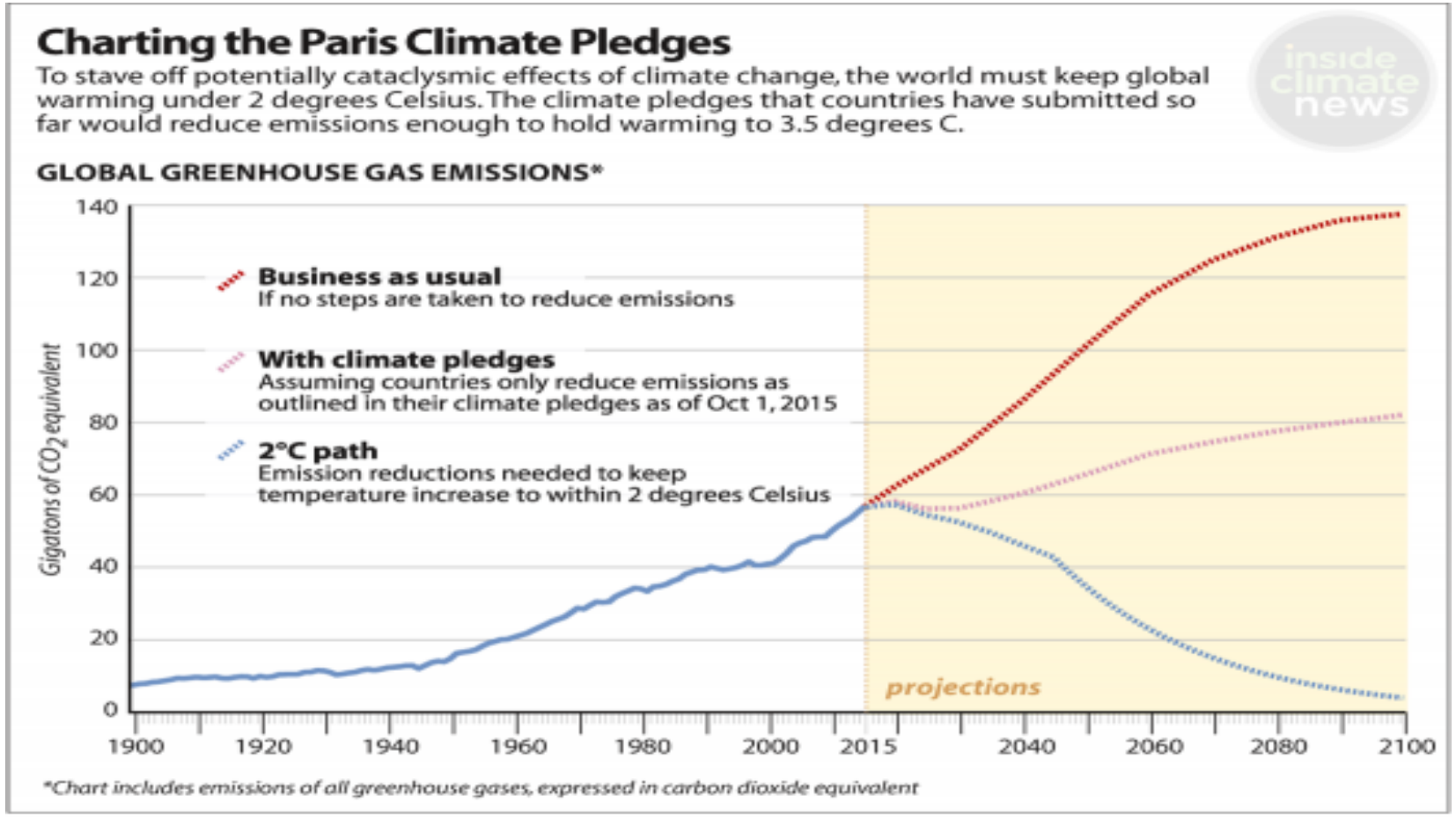
Red indicates severe and widespread impacts/risks.

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)

Adaptation

- 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

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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

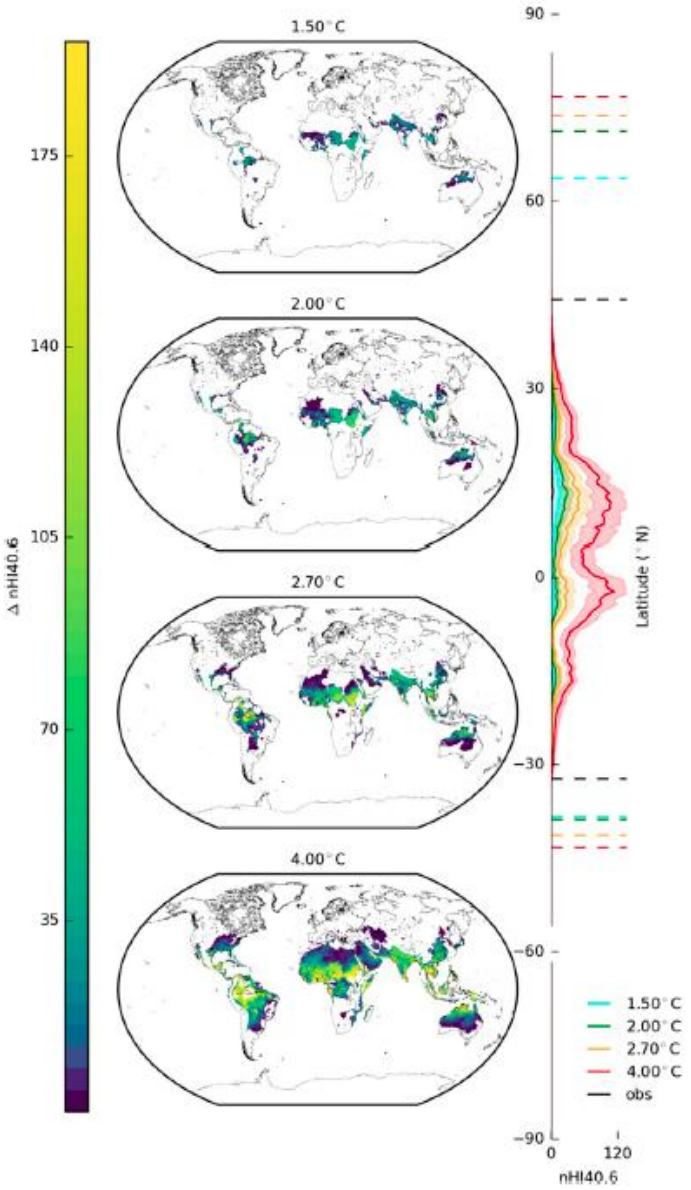
Opinion: while it is critical to reduce greenhouse gas emissions, we also need to think about adaptation to what climate change will bring our way

Maynooth University
National University of Ireland Maynooth

ICARUS
Irish Climate Analysis and Research Units

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

1.5ºCwarming, the global heat stress burden x6

2.0ºC warming, global heat stress burden x12

4.0ºC warming, global heat stress burden x75

In a 2℃ warmer world, Karachi could experience 2015 type deadly conditions at least once a year. If global warming reaches 4℃, 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.

Why does social justice matter?

- **Distributional justice**
- **Procedural justice**
- **Inter and intra-generational justice**

Climate Justice