Climate trends and extremes in Scotland

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RESAS SRP Project D5-2 Climate Change Impacts on Natural Capital

RESAS Seminar Series 4th October 2023

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Assessing Climate Change Impacts on Natural capital

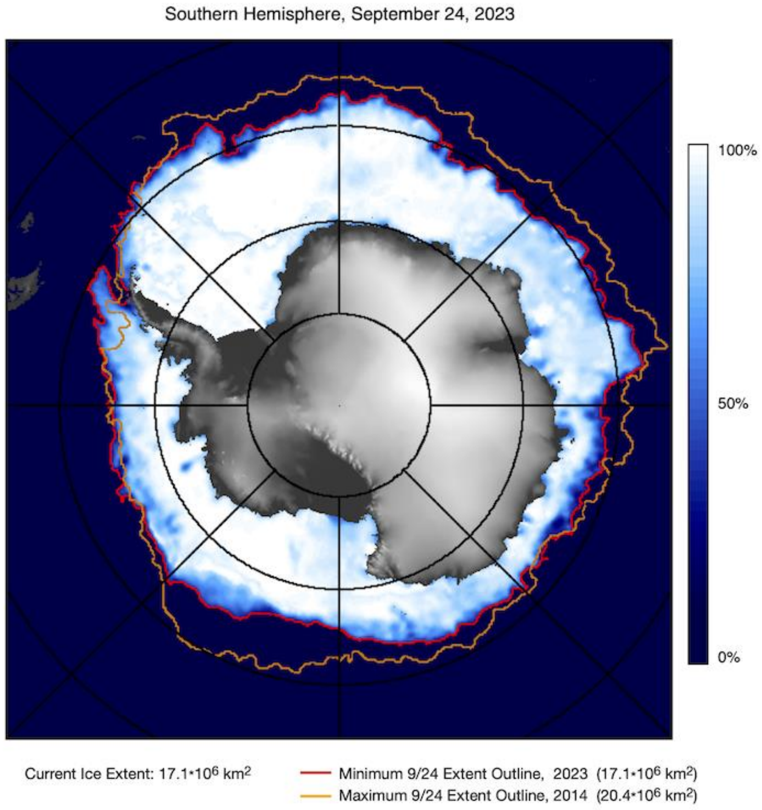
Research context:

- We need to know how changes in Scotland’s climate will impact Natural Capital and its ability to provide ecosystem services.
  - Land Capability for Agriculture and food production
  - Habitats e.g. Soils, Peatlands, Wetlands and Woodlands and role in GHG emissions and sequestration
  - Biodiversity and changes in competition, nutrient and energy flows.
  - Availability of water – for Nature and Human use
- Need to understand the spatial and temporal variation in climate trends and projections
- Climate proofing policies
- Outputs of value for Public Health Scotland, Transport, Green Investment, land value etc.

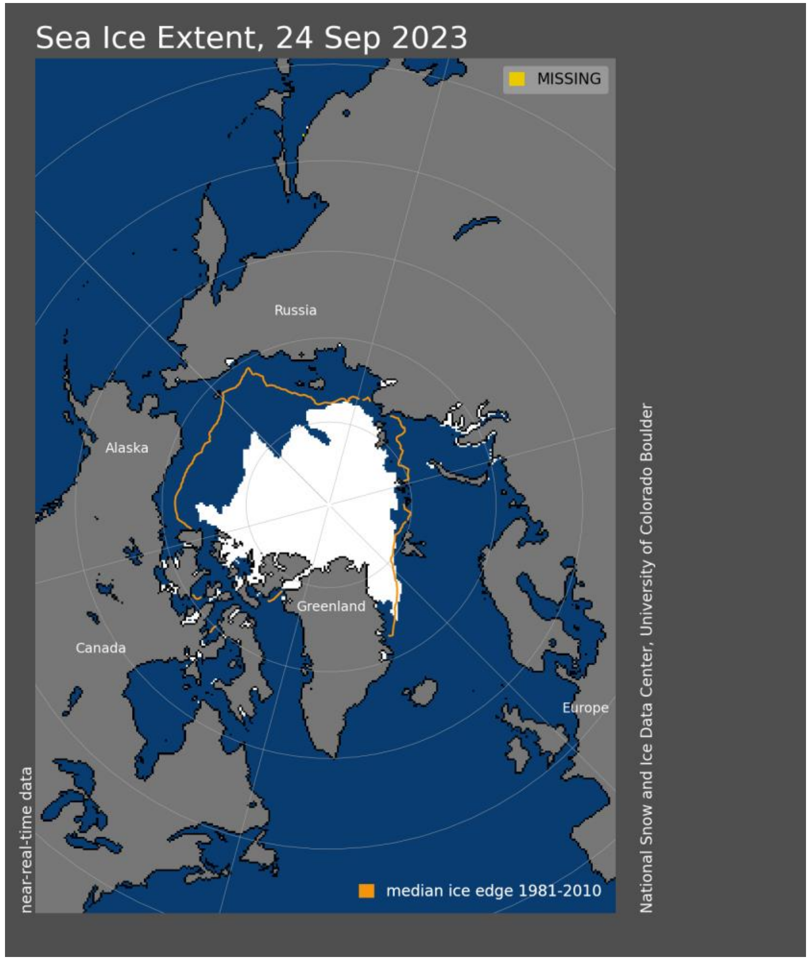
Before presenting the research findings it is useful to take a global perspective

Global Context

- Cryosphere decline
- Record ocean temperatures
- Record global temperatures
- 6 of 9 Planetary Boundaries transgressed
- Increasing emissions
- Declining ecosystem services, esp. climate regulation



https://earth.gsfc.nasa.gov/cryo/data/current-state-sea-ice-cover



Source: https://nsidc.org/arcticseaicenews/

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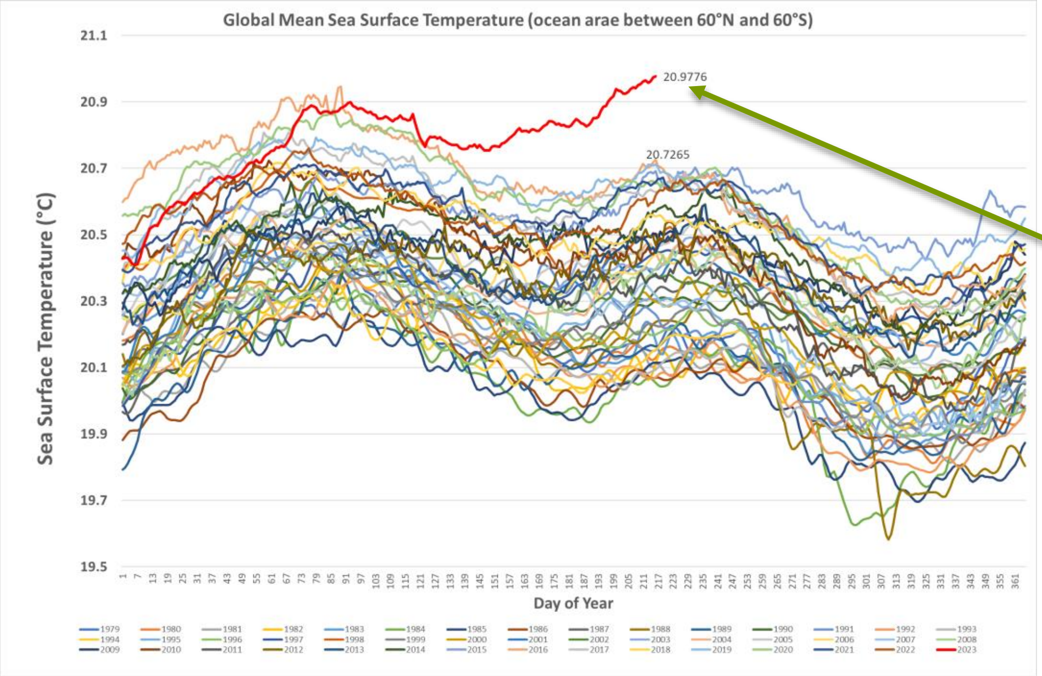
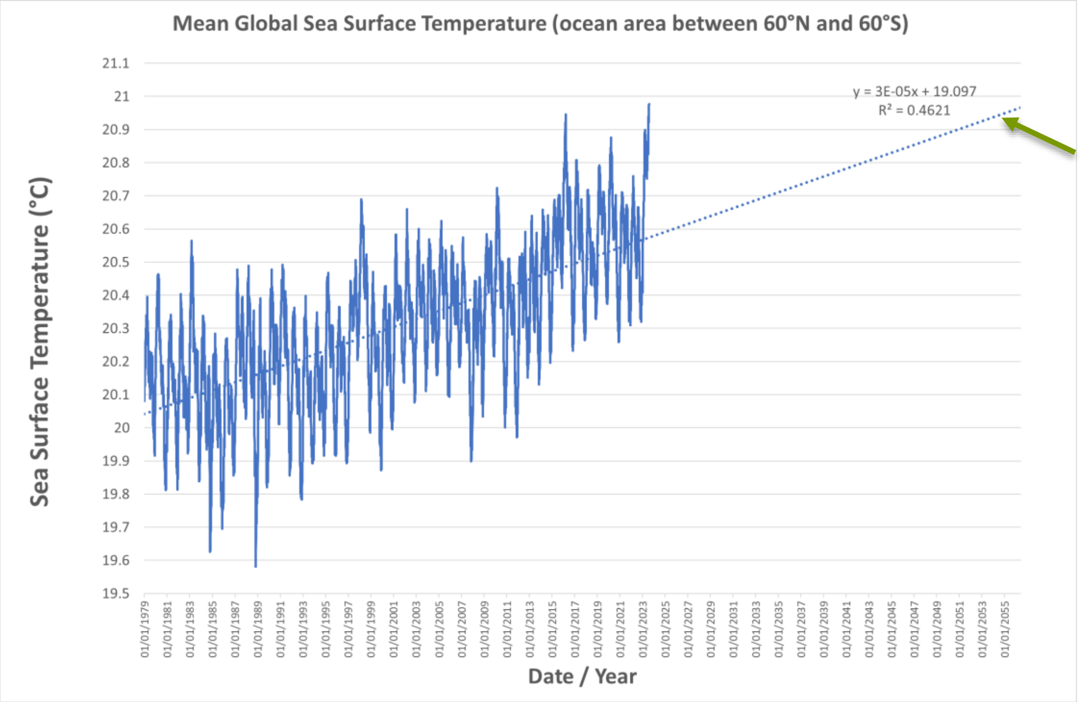


1st August 2023, 0.25°C warmer than previous high in August



2050: SST mean same as current record

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Global Context

- Cryosphere decline
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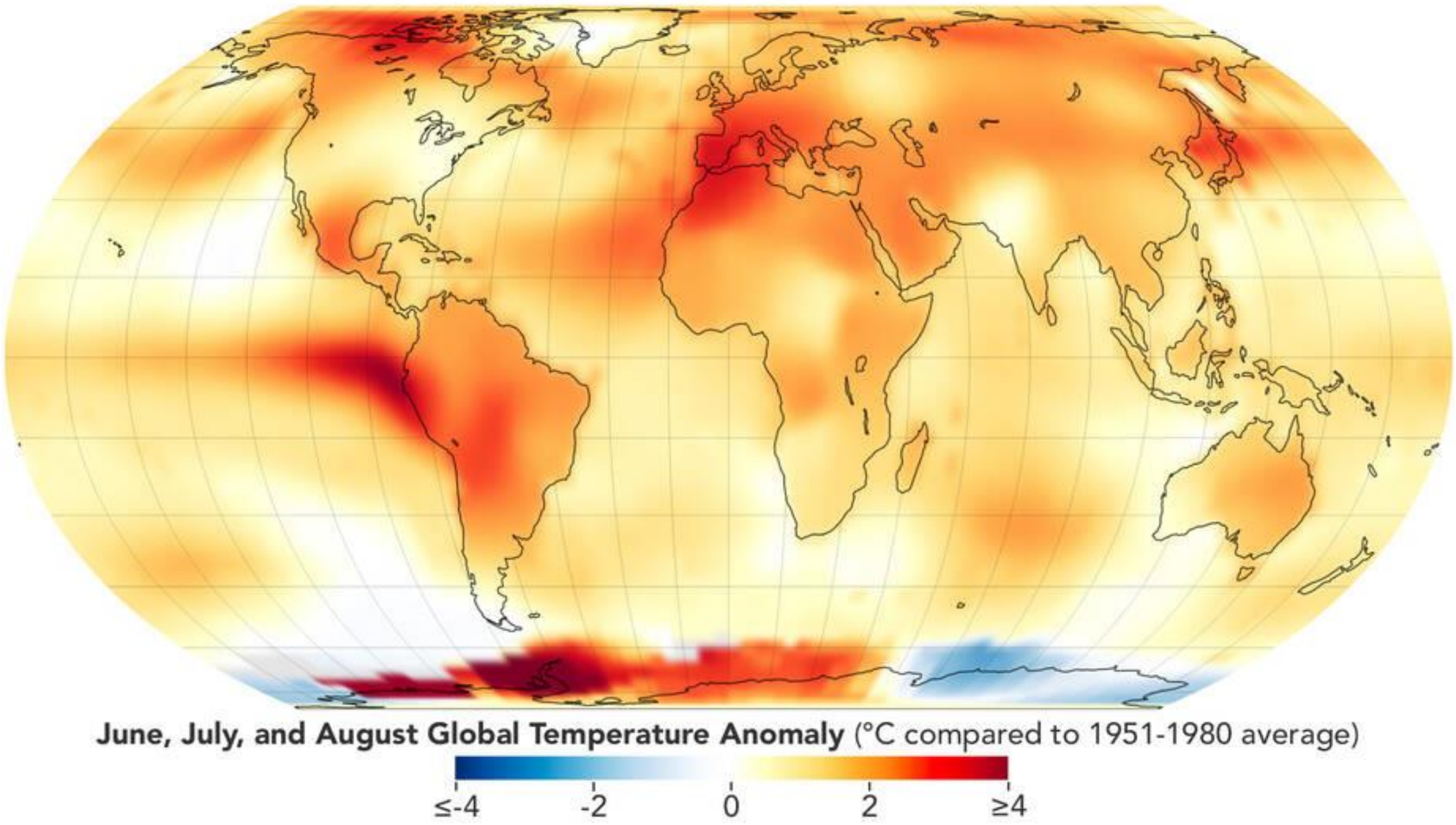
- Declining ecosystem services, esp. climate regulation
- Lack of risk perception and pollical will

Sep 14, 2023

RELEASE 23-105

NASA Announces Summer 2023 Hottest on Record



June, July, and August Global Temperature Anomaly (°C compared to 1951-1980 average)

Source: https://www.nasa.gov/press-release/nasa-announces-summer-2023-hottest-on-record

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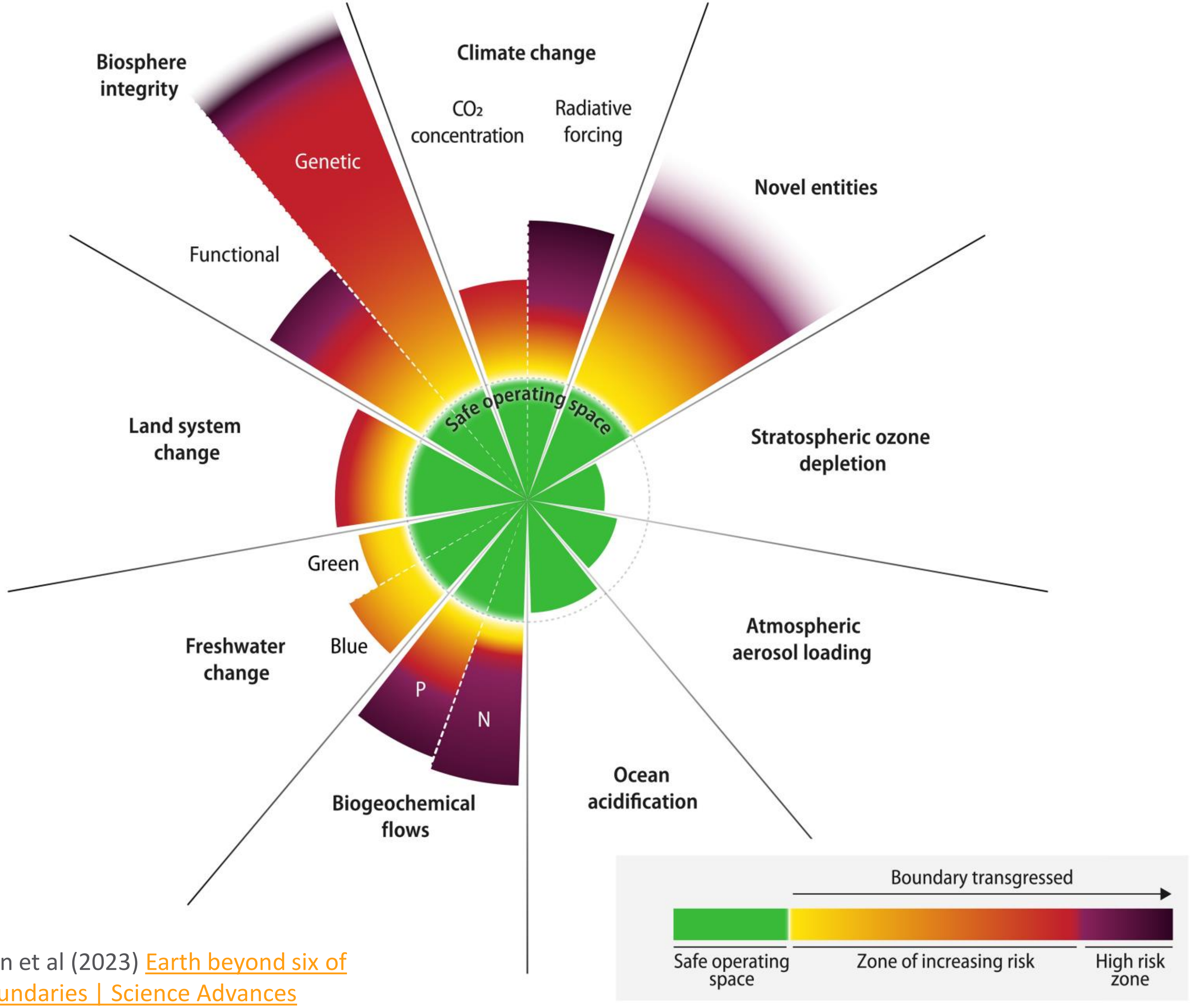

Source: Richardson et al (2023) [Earth beyond six of nine planetary boundaries | Science Advances]

Global Context

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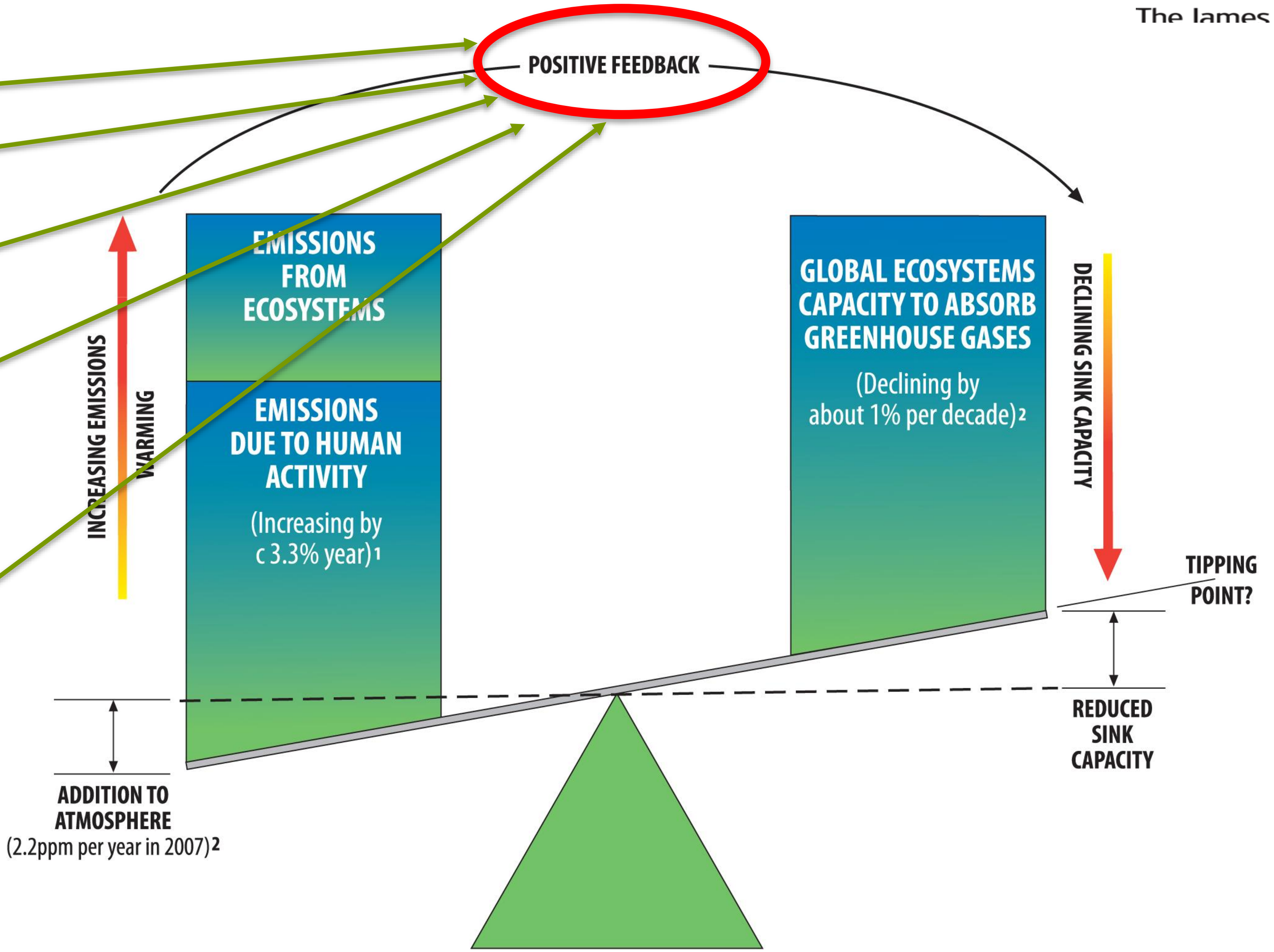


POSITIVE FEEDBACK

INCREASING EMISSIONS

WARMING

EMISSIONS FROM ECOSYSTEMS

EMISSIONS DUE TO HUMAN ACTIVITY

(Increasing by c 3.3% year)[1]

GLOBAL ECOSYSTEMS CAPACITY TO ABSORB GREENHOUSE GASES

(Declining by about 1% per decade)[2]

DECLINING SINK CAPACITY

TIPPING POINT?

REDUCED SINK CAPACITY

ADDITION TO ATMOSPHERE

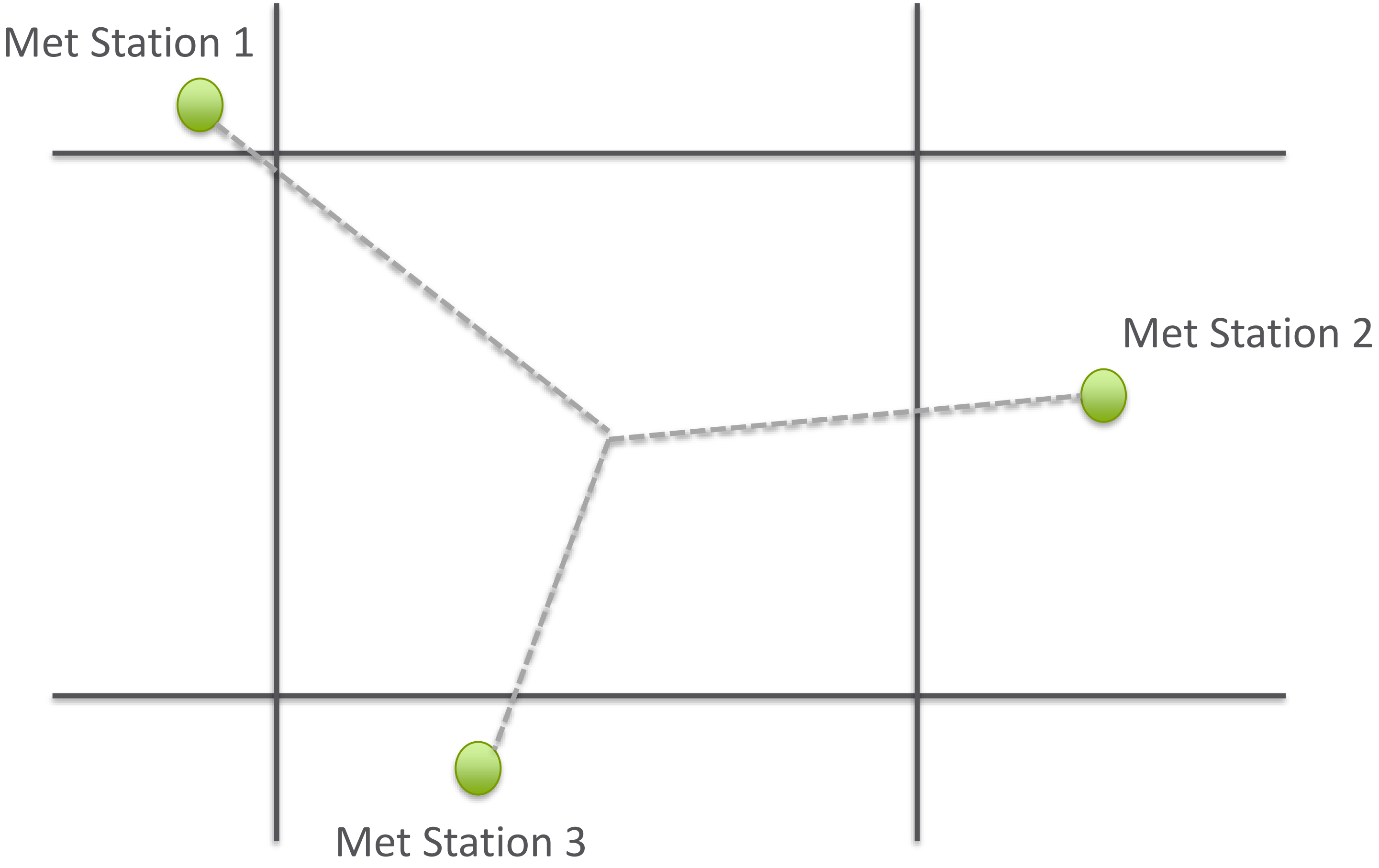
(2.2ppm per year in 2007)[2]

Assessing climate trends and projections in Scotland: Data and methods overview

- Presentation based on two reports:
  - Climate Trends and Future Projections in Scotland
  - Climate Extremes in Scotland
  - Summarised in: Summary of climate trends, future projections and extremes in Scotland and 2-page Summary for policy makers: Climate trends, projections and extremes and their implications for Natural Capital and Policy
- Observed weather baseline
  - UK Met Office 1km gridded daily data of precipitation and temperature
  - 1960 – 2019
  - Partially known uncertainties and caveats (see next slide)
  - We compared 1960-1989 with 1990-2019 to detect trends
- Climate projections
  - UKCP18 – 'high' emissions trajectory (RCP8.5) x12 Regional Climate Model projections
  - Spread of plausible future climates that cover possible lower emissions
  - Daily data spatially bias corrected to 1km resolution
  - Assessed model skill by comparing against the observed baseline
- We compared the future projections with the 1960-1989 baseline
  - Generated a broad series of maps and graphics of trends, projections and extremes

UKMO gridded observed baseline data - caveats

- 1km gridded observed climate variables
- Uses a spatial interpolation method to ‘fill gaps’ between Met Stations
- OK for temperature
- Works fairly well for precipitation in lowland areas with a high density of Met Stations
- Increasing uncertainty (reduction in utility) for areas with large topographical variation, few Met Stations and strong sea influence, i.e. the Highlands and Islands.
- **Errors in the baseline may be compensating but overall will have consequences for assessing observed trends and comparison with the future projections**



Observed changes in Scotland's climate

Precipitation:

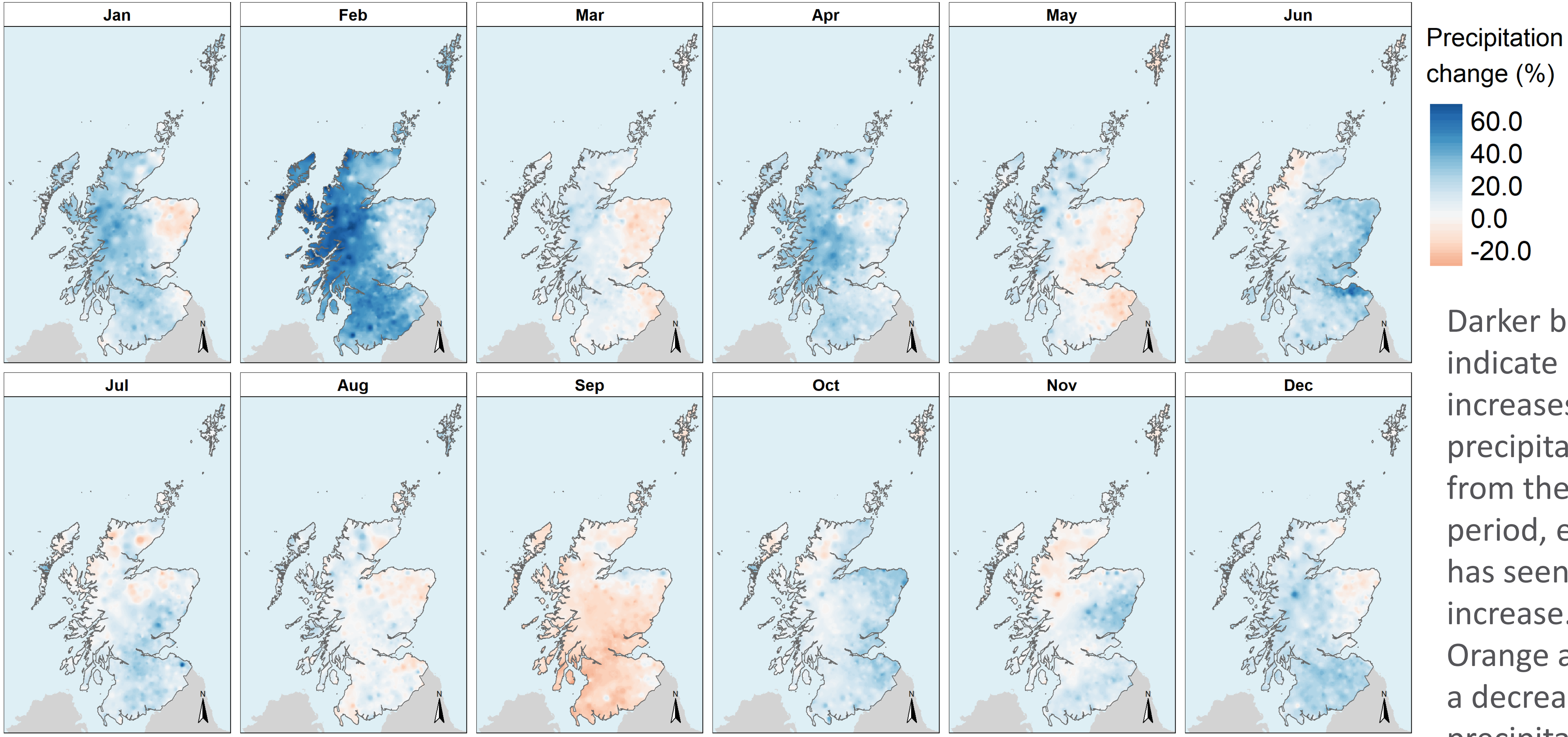
- Overall increase in annual total precipitation: area of Scotland experiencing higher precipitation being larger than that of decreases.
- Wide variation in spatial and temporal change.
    - In the west total precipitation increased between December to May, but either remained similar or decreased in July, August and October.
    - Eastern Scotland became drier in January, March, May, August, September and December, but wetter in February, June, July, October and November.
- The largest increases in precipitation occurred in February.
- There has been mixed response in terms of variability in temporal and spatial patterns of change in precipitation.
    - January, April, July and November (and to a lesser extent August) have seen a decrease in variability in the west.

Temperature:

- For all months there has been an overall increase in temperature.
- February and March show the largest amount of warming, up to 2°C, other months average increase of 1°C.
- Temperature rises relatively uniform across the country, and does not reflect the topographical influence, though for some locations there has been little or no change from the 1960 – 1989 baseline period.
- Mixed response in terms of variability of how much change and where.

Observed changes

Mean monthly precipitation change over the historical period 1990-2019 as compared to the baseline period 1960-1989

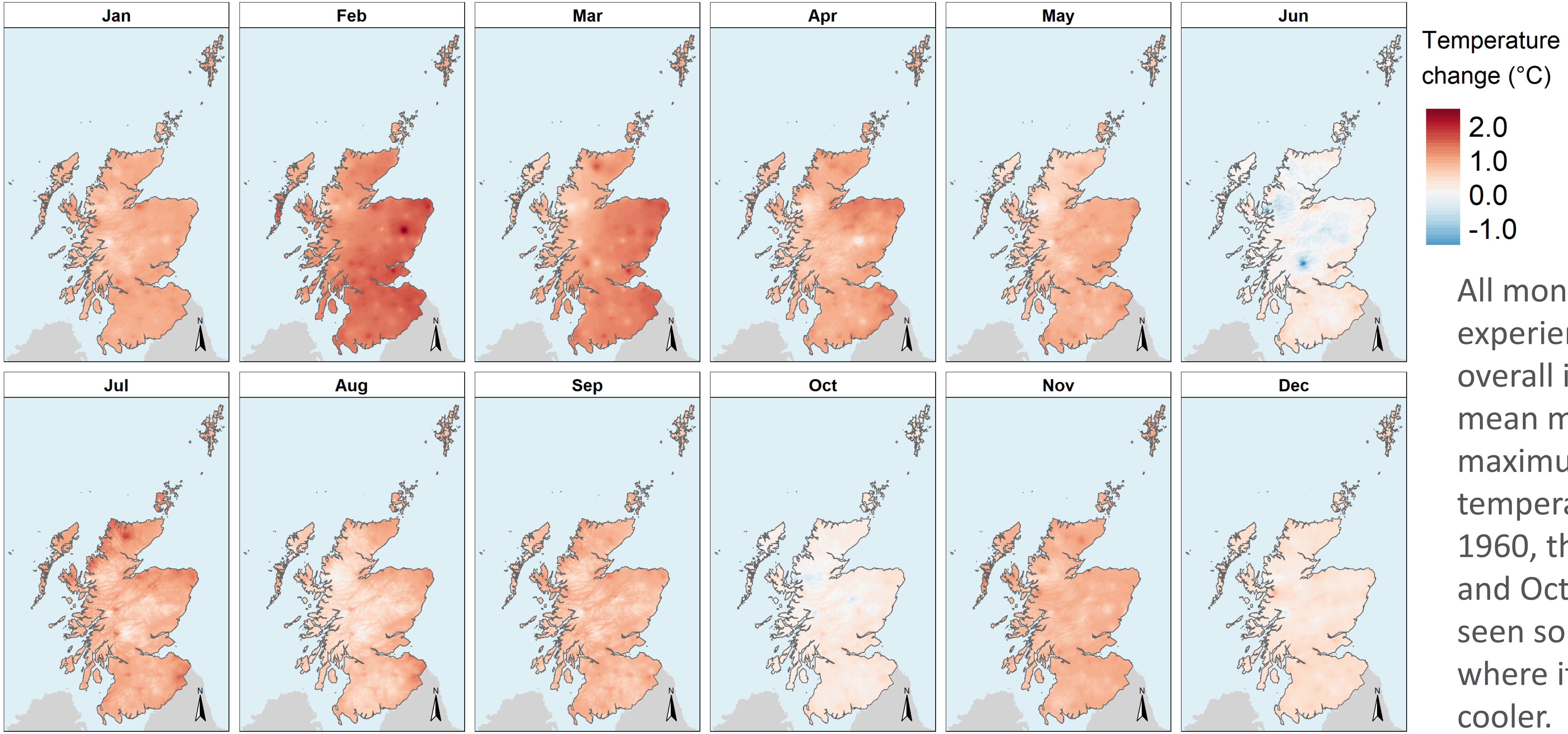


Darker blue areas indicate larger increases in precipitation change from the 1960-1989 period, e.g. February has seen up to 60% increase.

Orange areas indicate a decrease in precipitation.

Observed changes

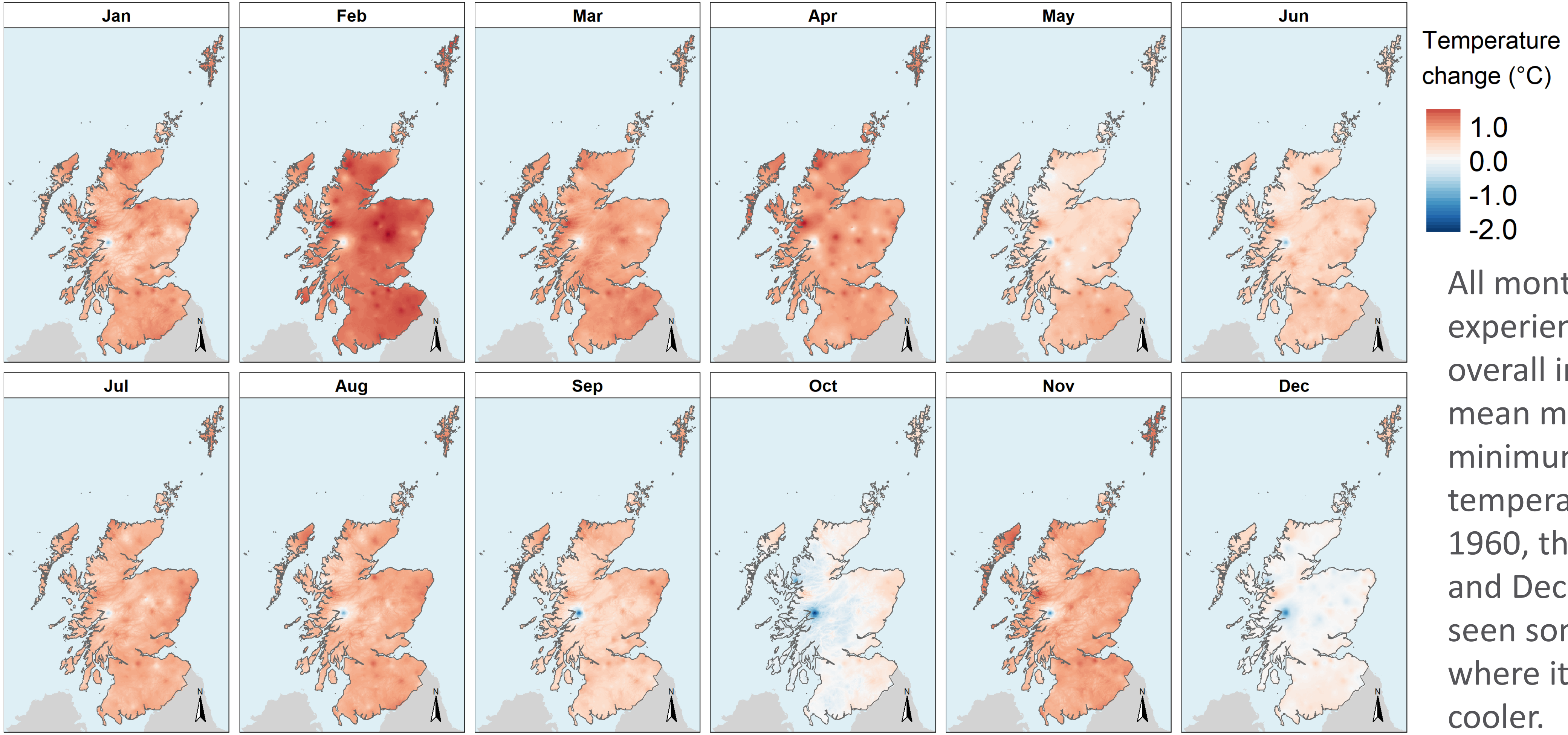
Mean monthly maximum temperature change over the historical period 1990-2019 as compared to the baseline period 1960-1989



All months have experienced an overall increase in mean monthly maximum temperature since 1960, though June and October have seen some areas where it has become cooler.

Observed changes

Mean monthly minimum temperature change over the historical period 1990-2019 as compared to the baseline period 1960-1989



All months have experienced an overall increase in mean monthly minimum temperature since 1960, though October and December have seen some areas where it has become cooler.

Observed changes at Cairngorm Chairlift 1960-2018 and future projections to 2079

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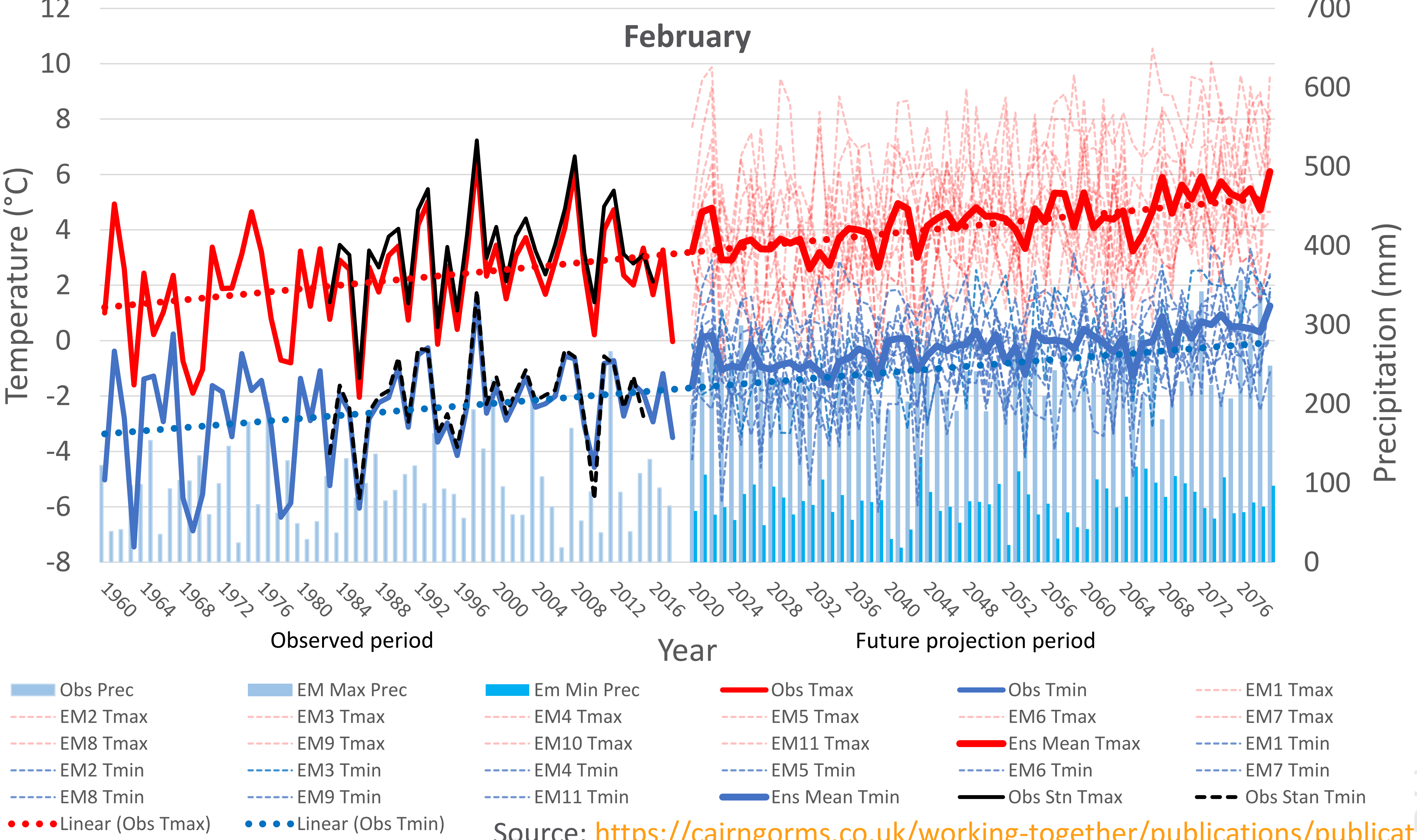
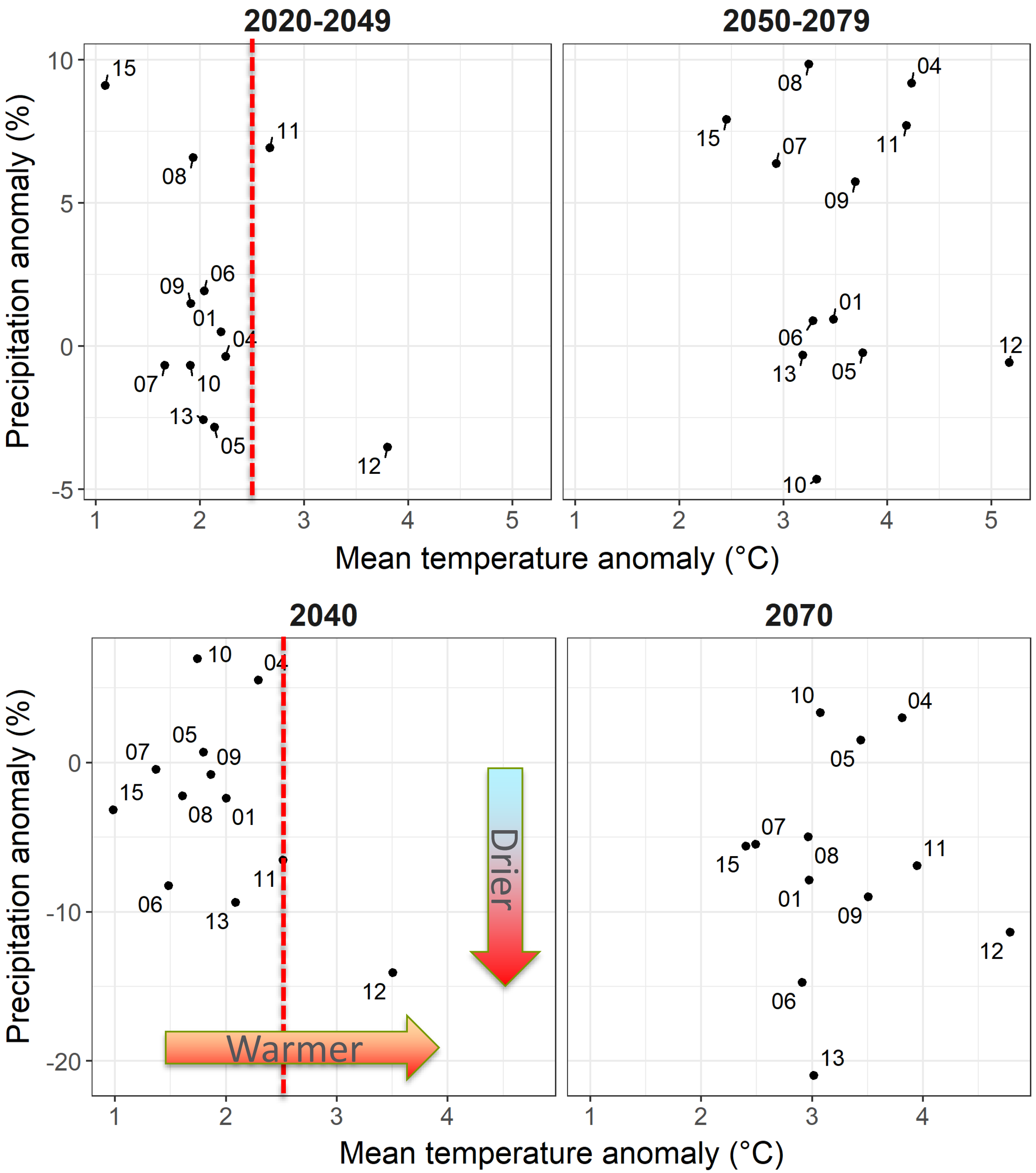


Source: https://cairngorms.co.uk/working-together/publications/publication/490/



Future Projections

Climate change signal for the 12 projections used to generate the future maps (UKCP18 RCP 8.5).

Top: Annual precipitation and temperature anomaly under RCP8.5 for 2030-2049 (‘2040’) and 2060-2079 (‘2070’) with respect to a 1994-2015 baseline. Bottom: Comparison of the Scotland arable area-wide mean climate change signal in the growing season only (March to September).

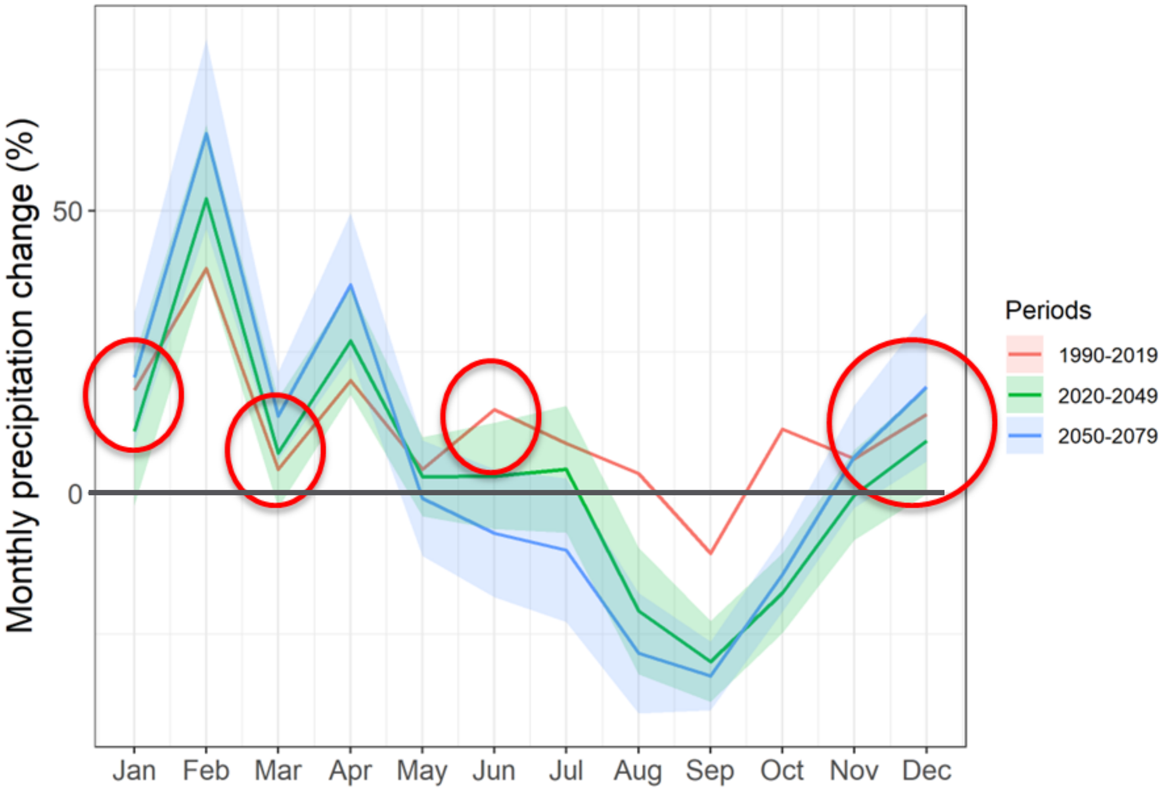
So… although emissions scenario is ‘High end’ RCP8.5, the 12 projections contain precipitation and temperature changes that also represent lower emissions as well (e.g. 15, 07, 06).

- - - - approx. temperature increase based on current global mitigation commitments to 2050

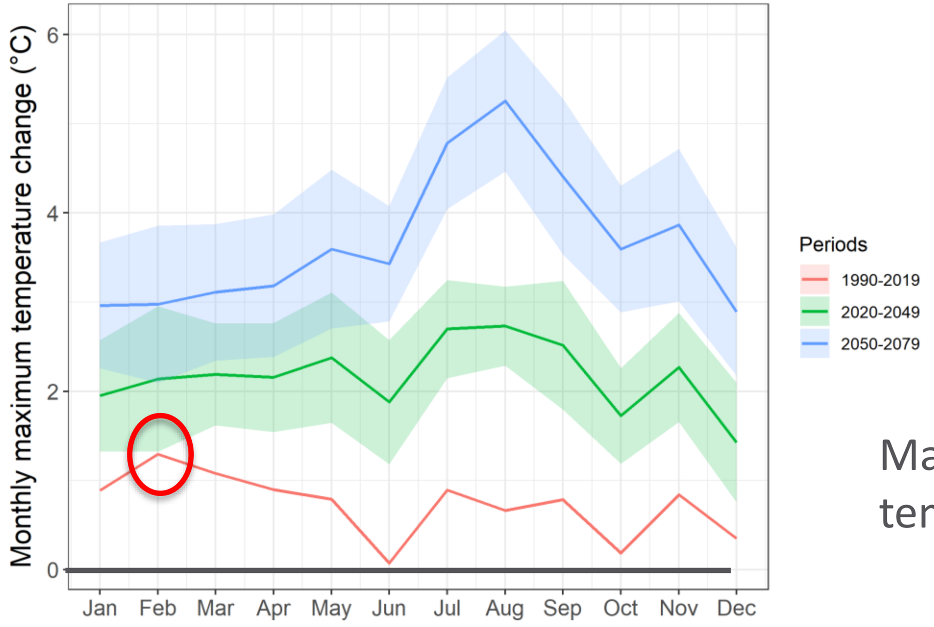
Future projections

National summary

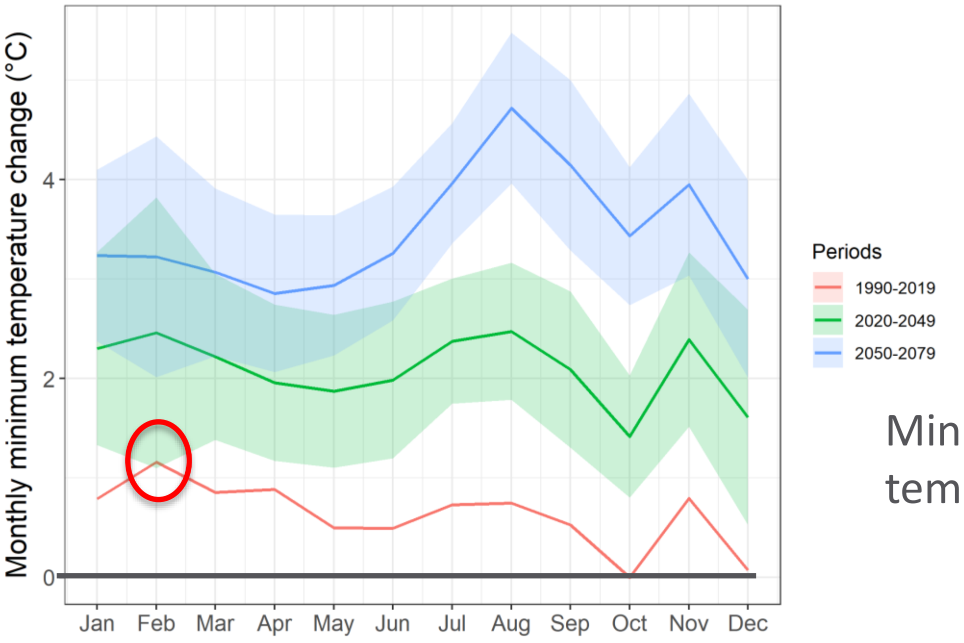
Precipitation



Black line represents the 1960 – 1989 baseline



Maximum temperature



Minimum temperature

Future projections

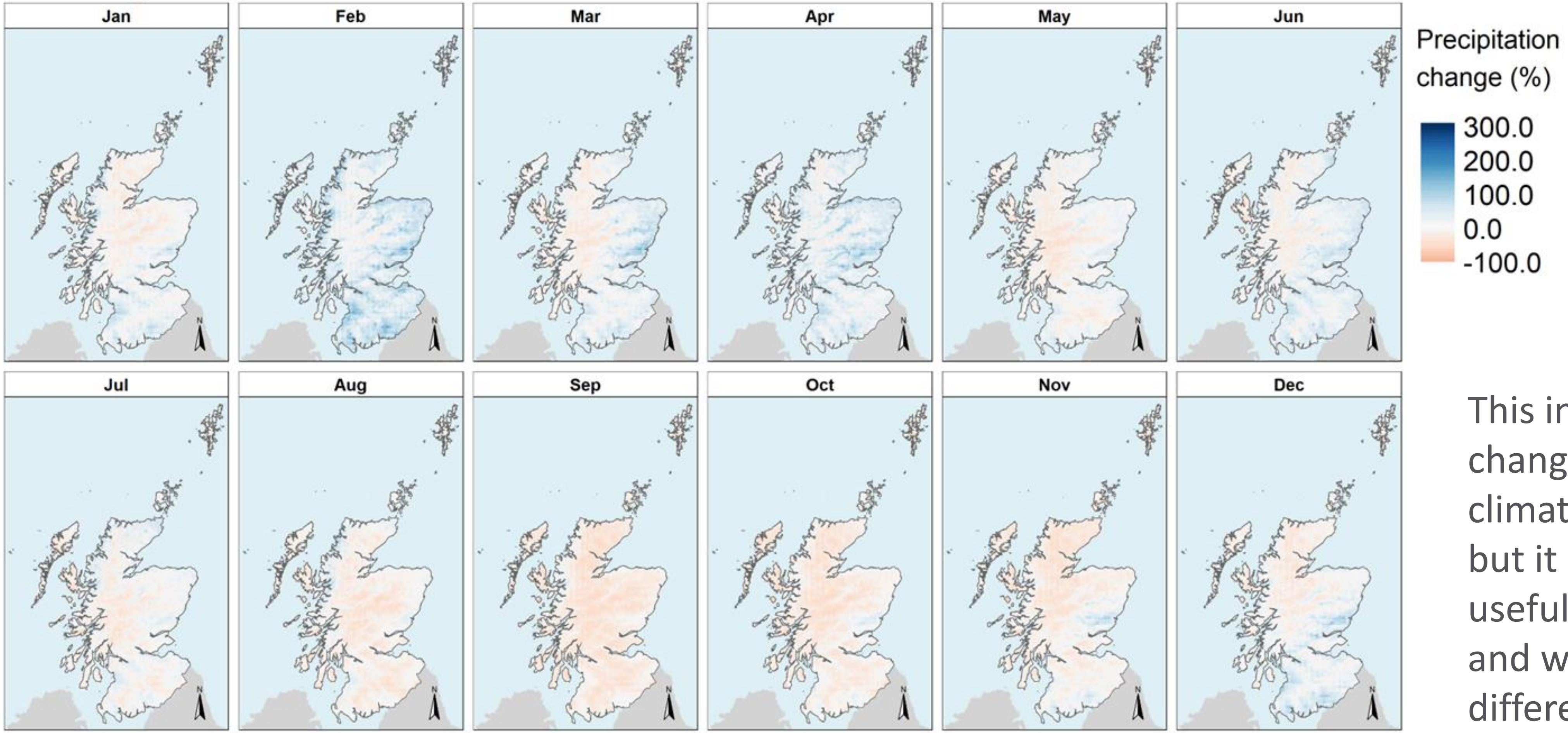
Precipitation:

- 2020 to 2049: Scotland’s climate to be wetter in December, January (both c.10%), February (45 – 55%) and April (25%) but less so in March (c. 5%). August, September and October are projected to become drier.
  - Projected changes align with the observed changes already seen.
- Patterns continue into 2050 – 2079 with increases in the magnitude of change.
- High level of agreement between projections that February and April precipitation will increase, whilst August, September and October will decrease.
- Large spatial variation in changes to the monthly mean precipitation between projections: eastern areas may become wetter in some months (February, April, May, November and December); upland areas are likely to decrease in May, August, September and October, and November in the north.

Temperature:

- Observed trends in maximum and minimum temperature projected to continue.
  - High agreement between all 12 projections on there being continued warming, with all exceeding 2°C by the 2070s.
- More warming between May and November (up to 4°C per month between 2020 – 2049), but also with substantial warming in the winter (variable by projection, approximately 2-3°C).
- The spatial distribution of change is relatively uniform across Scotland, e.g. does not reflect topographical differences.

Changes in mean monthly precipitation over the period 2020-2049 as compared to the historical baseline period 1960-1989 for the ensemble member 01



This informs us of changes for one climate projection, but it may be more useful to see how and where the different projections agree on the direction of change

Future projections

Agreement maps - precipitation

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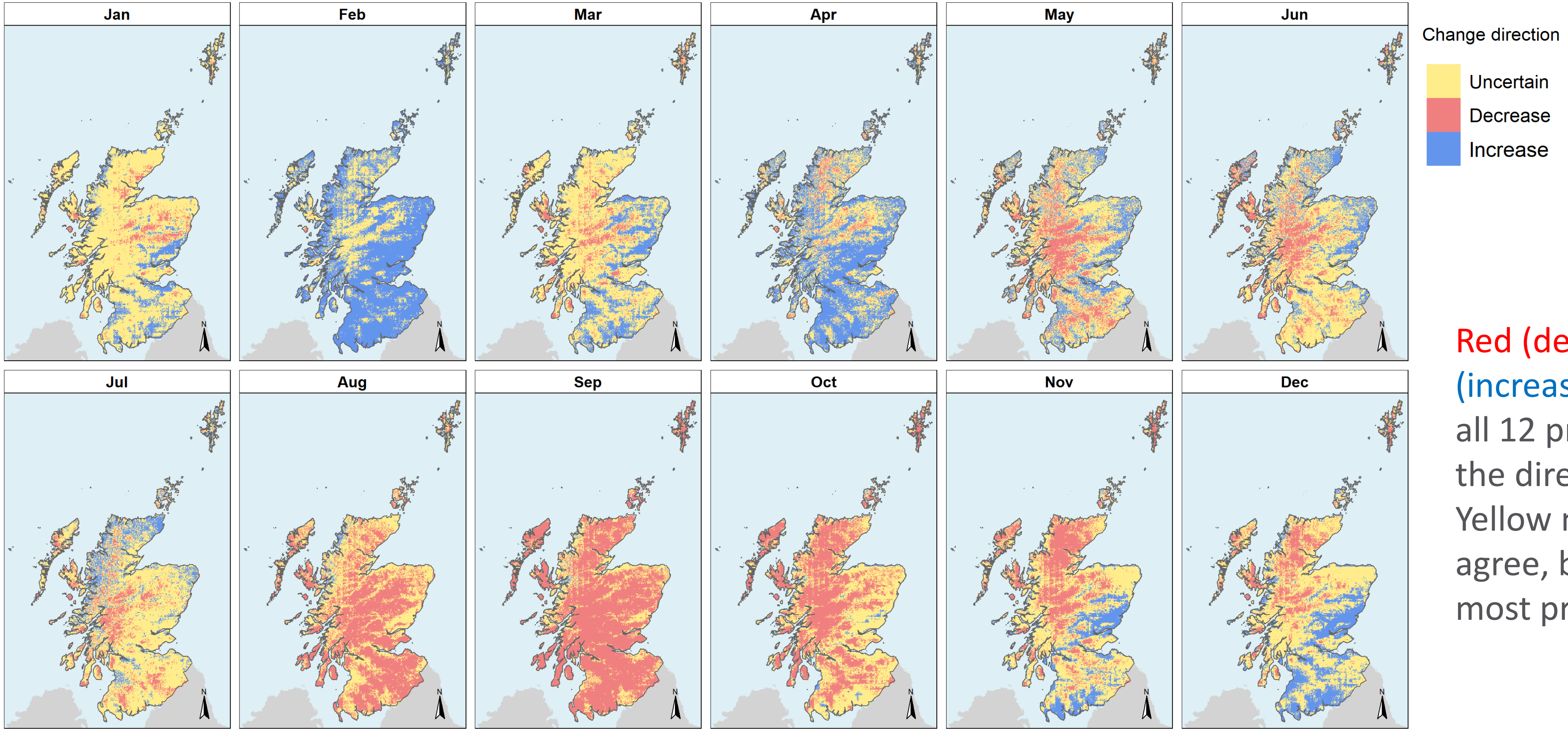
Change direction agreement for mean monthly precipitation over the period 2020-2049 for at least 12 ensemble members



Red (decrease) or Blue (increase) indicates where all 12 projections agree the direction of change. Yellow means not all 12 agree, but it may be that most projections do agree.

Climatic Water Balance (Precipitation – Evapotranspiration)

Observed trends:

- Observed change in Climatic Water Balance, which is variable both spatially and temporally.
    - West coast areas have become wetter (increased surplus water) between December to April.
    - March to May have experienced a decrease (reduced water) in the east.
    - June to August precipitation > evapotranspiration differences have increased.

Projected changes:

- Likely to be a shift in where and when parts of Scotland have a surplus or deficit of water.
- **A key finding is that some upland areas of central Scotland are projected to shift from water surplus to deficit.**
    - Most notably in May for the central Highlands and in August in the eastern and southern upland areas plus southern Argyll, Islay and Jura and parts of the Outer Hebrides.
    - By 2050 – 2079 for August there is a large increase in this upland area shifting from water surplus to a deficit.
        - Large parts of eastern Scotland in September are projected to see a shift to Climatic Water Balance deficit.
    - **Such changes may have substantial impacts on the ecological and hydrological functions of peatlands, as well as other Natural Capital asset types.**
- For both the 2020 – 2049 and 2050 – 2079 periods there is good agreement between the 12 projections that October through to March will remain in Climatic Water Balance surplus (precipitation is greater than evapotranspiration).
    - For both periods April shows large uncertainty in the direction of change.

Observed changes in Climatic Water Balance

(Precipitation – Evapotranspiration)

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Change in mean monthly climatic water balance over the historical period 1990-2019 as compared to the baseline period 1960-1989

Blue indicates areas where there has been more water available, orange shows where there has been less water.

Future Climatic Water Balance agreement map

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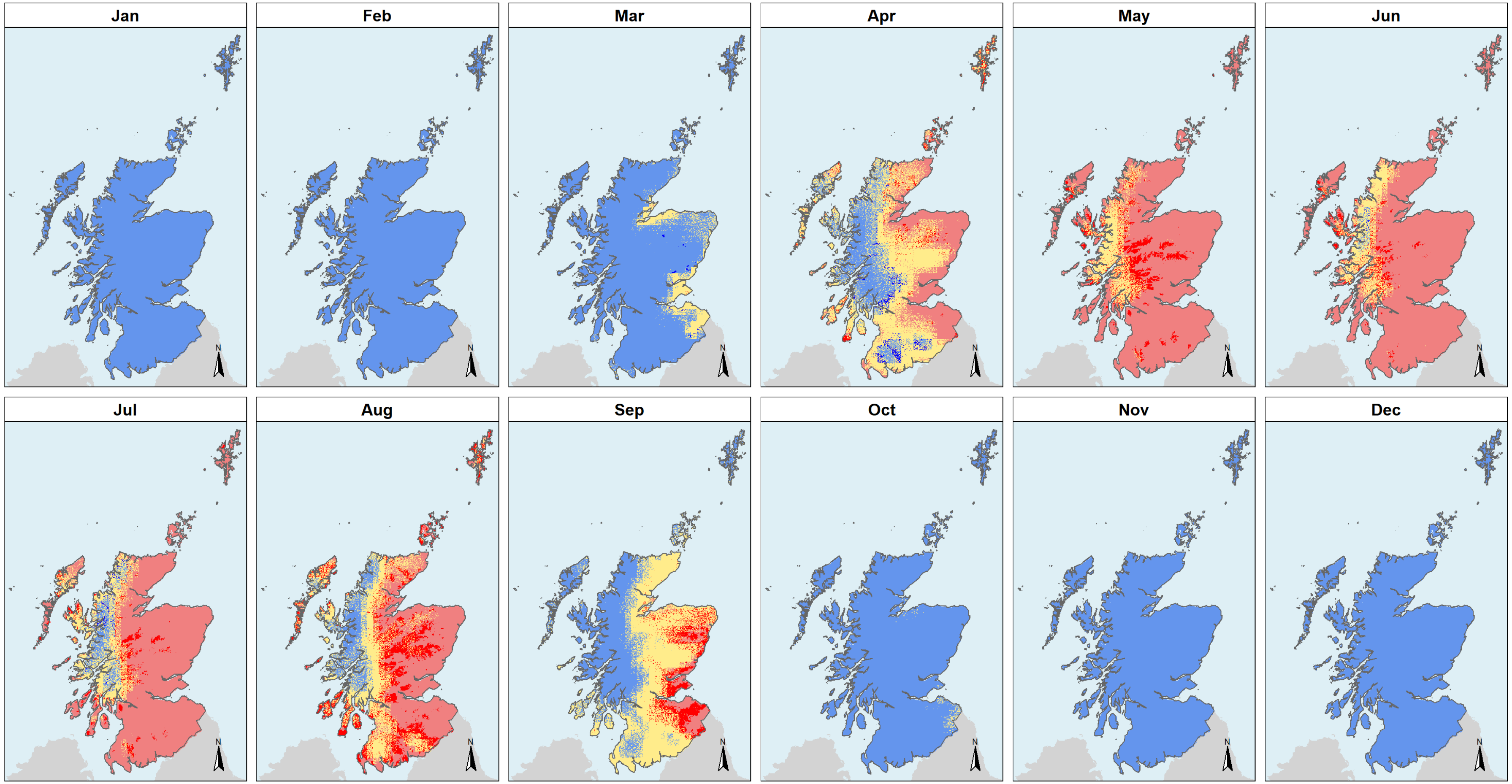
Change direction agreement for mean monthly climatic water balance over the period 2020-2049 for at least 12 ensemble members



Change direction

- 🟥 Surplus to deficit
- 🟦 Surplus to surplus
- 🟥 Deficit to deficit
- 🟦 Deficit to surplus
- 🟨 Uncertain

Habitats that exist in the areas that are projected to experience a shift from water surplus to deficit (dark red) are likely to experience higher levels of water stress.

Unknowns: role of occult precipitation (i.e. dew), ground water, hydrological flows

Extremes Indicators: Consecutive Dry Days (CDD) (maximum length of a dry spell in any one month, when precipitation is less than 1mm per day)

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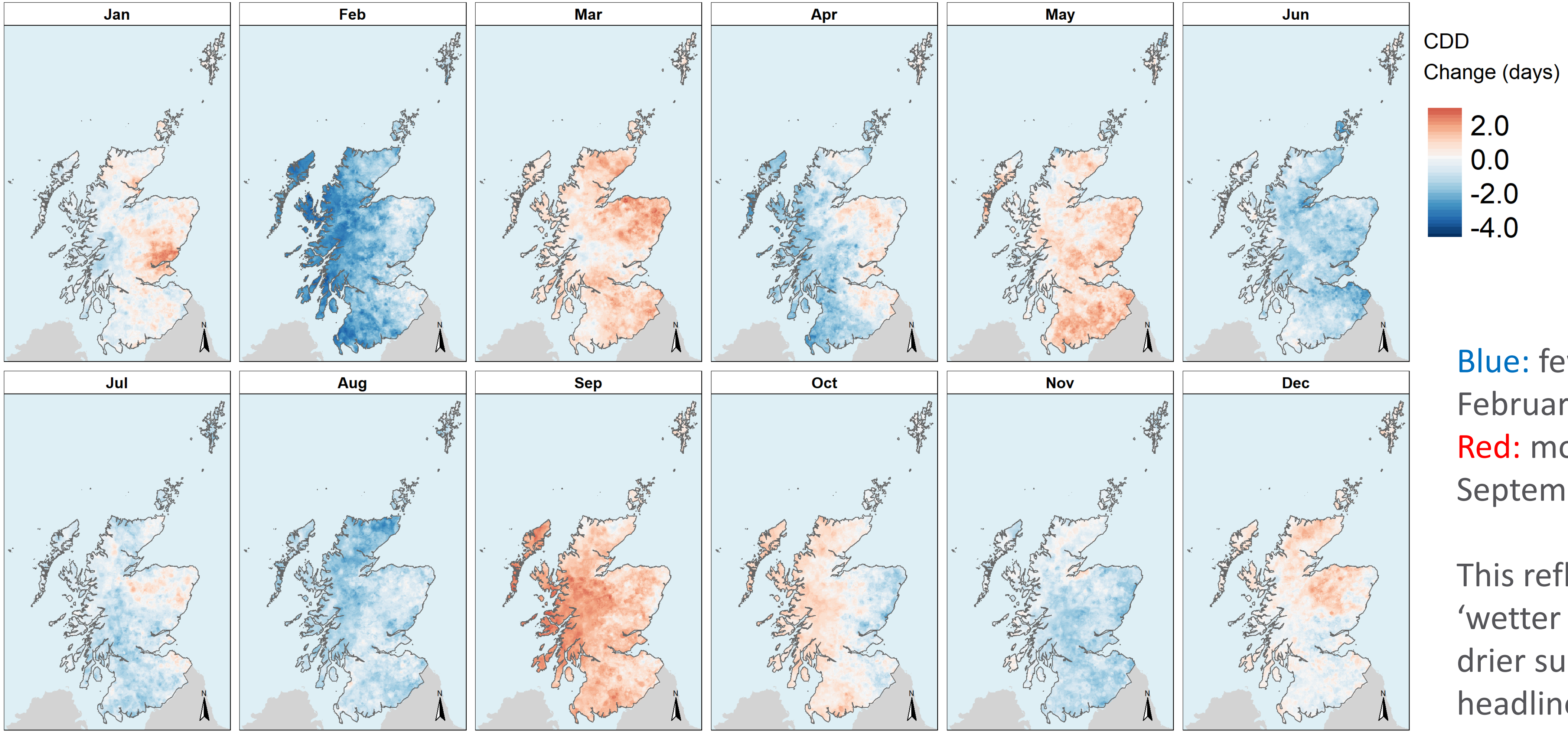
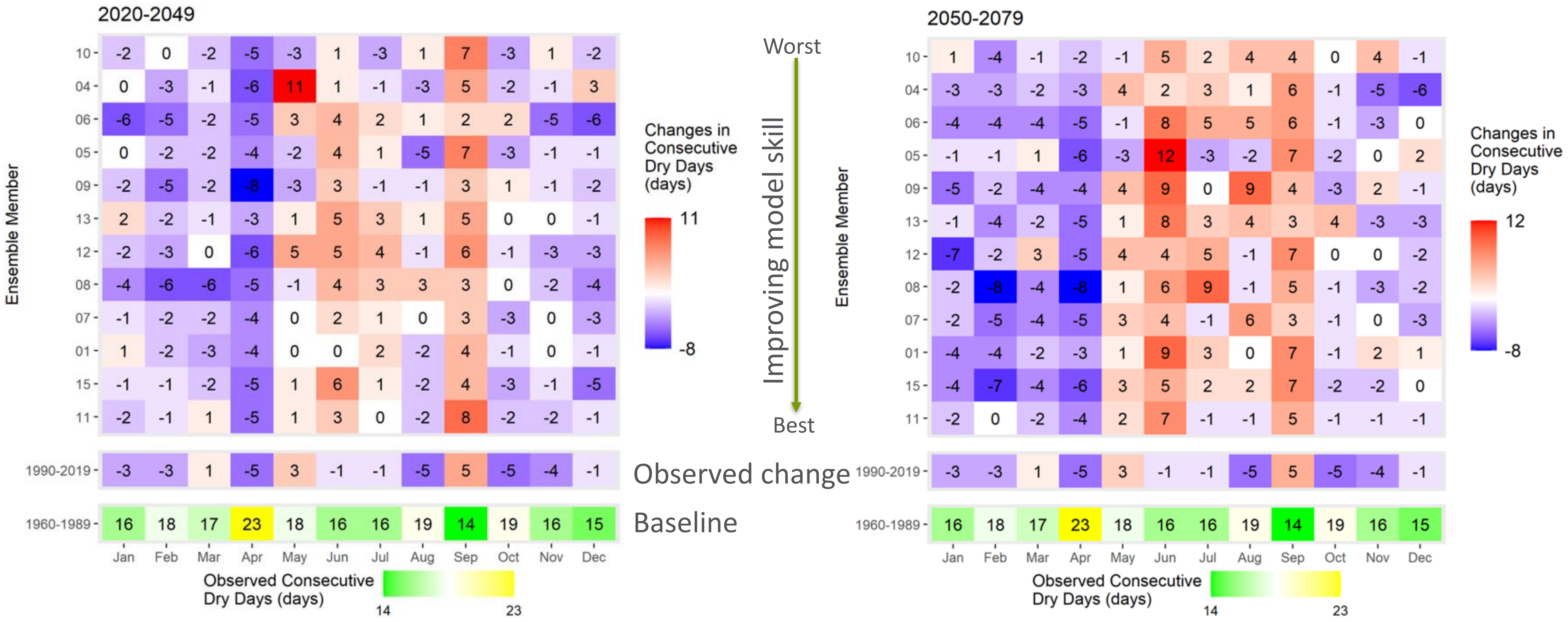
Changes in mean monthly consecutive dry days over the historical period 1990-2019 relative to the baseline period 1960-1989



Blue: fewer CDD e.g. February
Red: more CDD e.g. September

This reflects the ‘wetter winters and drier summers’ headline message

Most extreme Consecutive Dry Days (maximum length of a dry spell in any one month, when precipitation is less than 1mm per day)



2020-2049

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10	-2	0	-2	-5	-3	1	-3	1	7	-3	1	-2
04	0	-3	-1	-6	11	1	-1	-3	5	-2	-1	3
06	-6	-5	-2	-5	3	4	2	1	2	2	-5	-6
05	0	-2	-2	-4	-2	4	1	-5	7	-3	-1	-1
09	-2	-5	-2	-8	-3	3	-1	-1	3	1	-1	-2
13	2	-2	-1	-3	1	5	3	1	5	0	0	-1
12	-2	-3	0	-6	5	5	4	-1	6	-1	-3	-3
08	-4	-6	-6	-5	-1	4	3	3	3	0	-2	-4
07	-1	-2	-2	-4	0	2	1	0	3	-3	0	-3
01	1	-2	-3	-4	0	0	2	-2	4	-1	0	-1
15	-1	-1	-2	-5	1	6	1	-2	4	-3	-1	-5
11	-2	-1	1	-5	1	3	0	-2	8	-2	-2	-1
1990-2019	-3	-3	1	-5	3	-1	-1	-5	5	-5	-4	-1
1960-1989	16	18	17	23	18	16	16	19	14	19	16	15

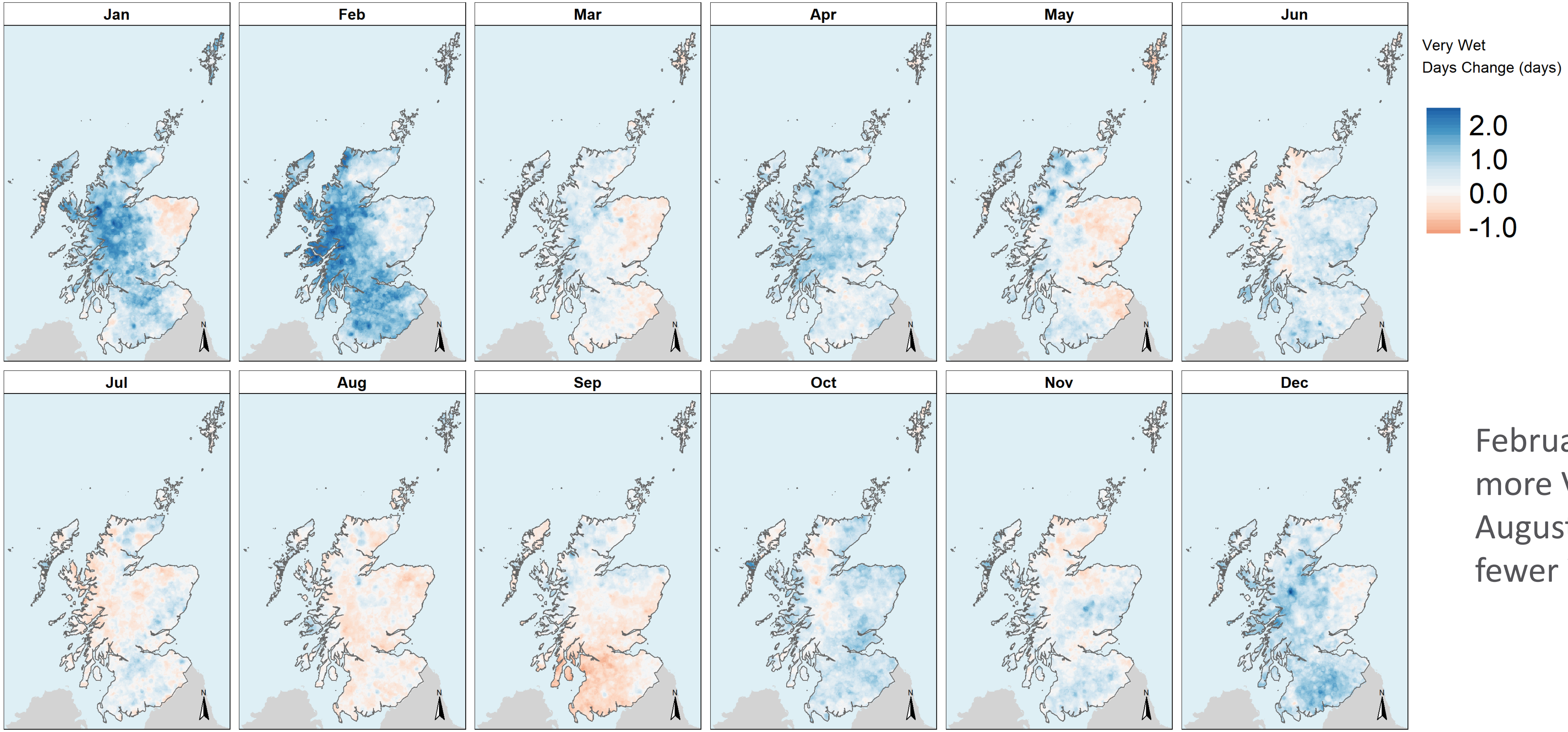
2050-2079

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10	1	-4	-1	-2	-1	5	2	4	4	0	4	-1
04	-3	-3	-2	-3	4	2	3	1	6	-1	-5	-6
06	-4	-4	-4	-5	-1	8	5	5	6	-1	-3	0
05	-1	-1	1	-6	-3	12	-3	-2	7	-2	0	2
09	-5	-2	-4	-4	4	9	0	9	4	-3	2	-1
13	-1	-4	-2	-5	1	8	3	4	3	4	-3	-3
12	-7	-2	3	-5	4	4	5	-1	7	0	0	-2
08	-2	-8	-4	-8	1	6	9	-1	5	-1	-3	-2
07	-2	-5	-4	-5	3	4	-1	6	3	-1	0	-3
01	-4	-4	-2	-3	1	9	3	0	7	-1	2	1
15	-4	-7	-4	-6	3	5	2	2	7	-2	-2	0
11	-2	0	-2	-4	2	7	-1	-1	5	-1	-1	-1
1990-2019	-3	-3	1	-5	3	-1	-1	-5	5	-5	-4	-1
1960-1989	16	18	17	23	18	16	16	19	14	19	16	15

National scale changes in the number of monthly Consecutive Dry Days **in the most extreme year** for the two observed periods (1960 – 1989, 1990 – 2019) and per climate projection for 2020 – 2049 (left) and 2050 – 2079 (right). Note: scales are slightly different between plots.

Very Wet Days (VWD) (precipitation amount that is greater or equal to the 95th Percentile of the observed baseline)

Changes in mean monthly number of very wet days over the historical period 1990-2019 relative to the baseline period 1960-1989



February:
more VWD
August:
fewer VWD

Very Wet Days (VWD) (precipitation amount that is greater or equal to the 95th Percentile of the observed baseline)

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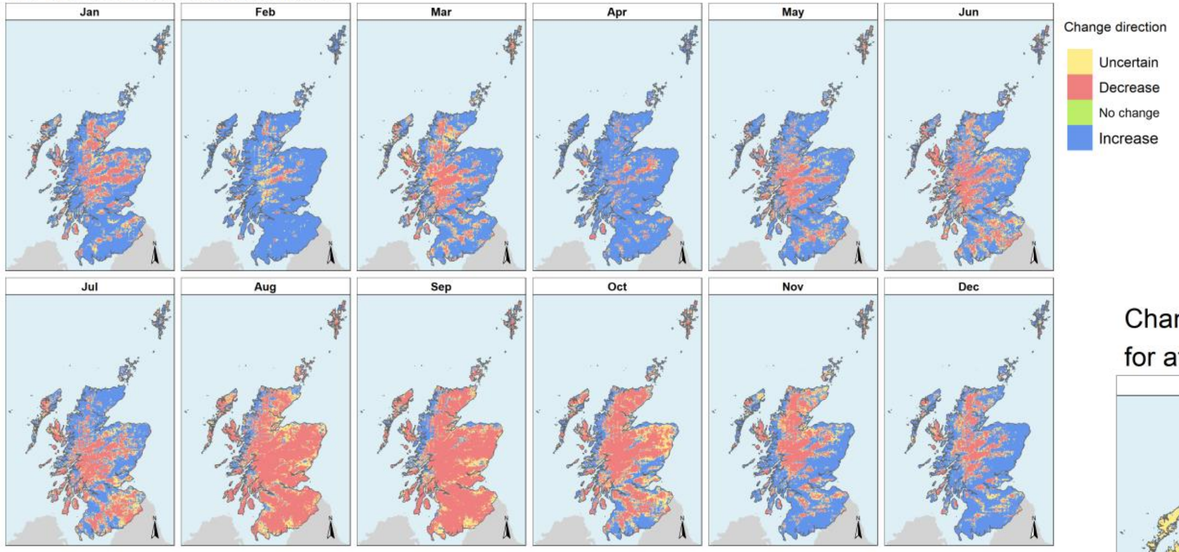
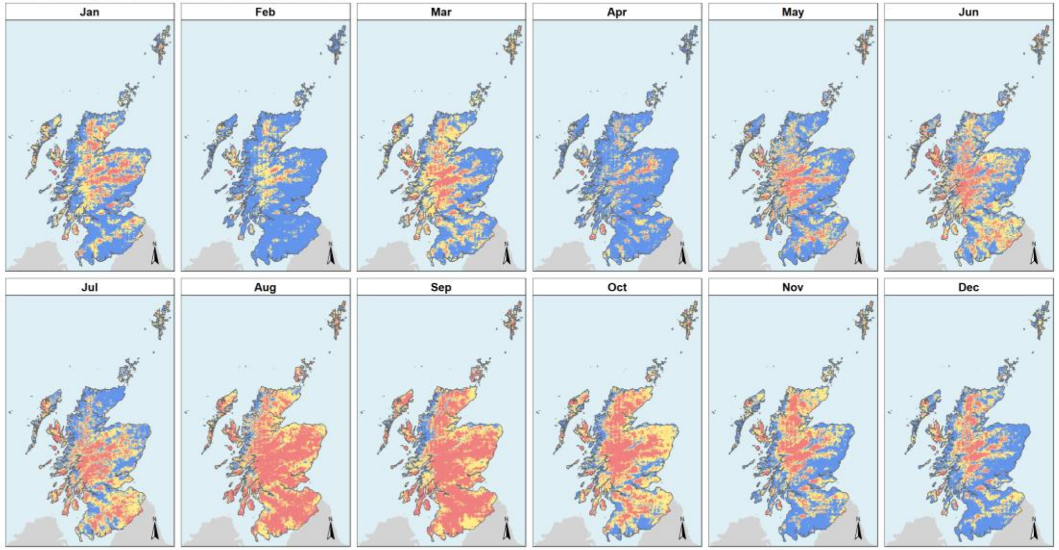
Very Wet Days: Agreement Maps (8, 10 and 12 projections)

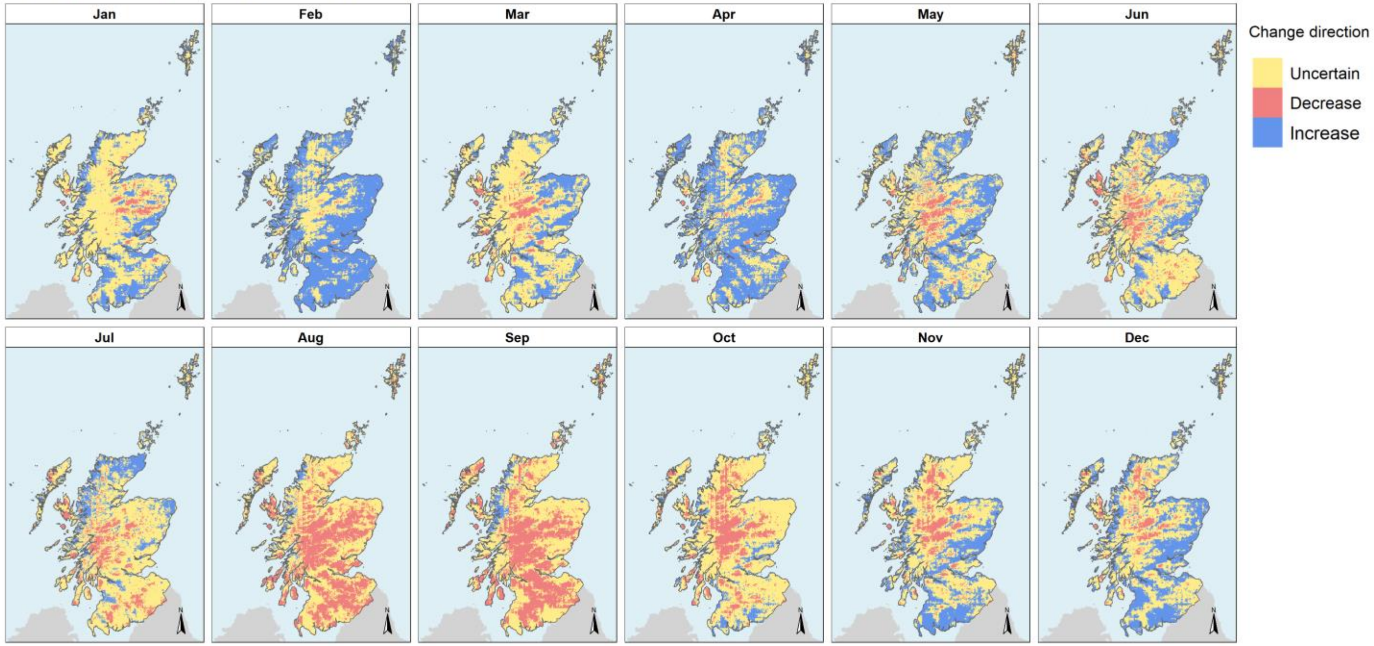
Change direction agreement for mean monthly number of very wet days over the period 2020-2049 for at least 8 ensemble members



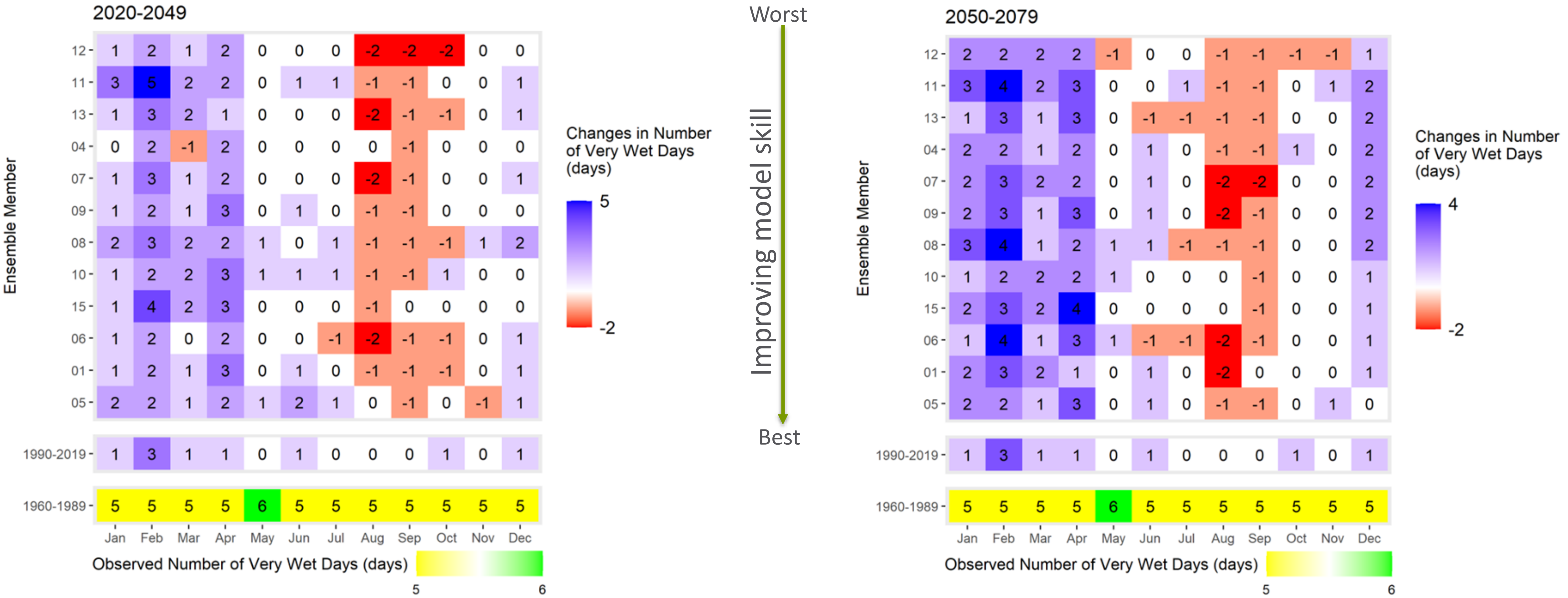
Change direction agreement for mean monthly number of very wet days over the period 2020-2049 for at least 10 ensemble members



Change direction agreement for mean monthly number of very wet days over the period 2020-2049 for at least 12 ensemble members



Very Wet Days (precipitation amount that is greater or equal to the 95th Percentile of the observed baseline)



2020-2049

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
12	1	2	1	2	0	0	0	-2	-2	-2	0	0
11	3	5	2	2	0	1	1	-1	-1	0	0	1
13	1	3	2	1	0	0	0	-2	-1	-1	0	1
04	0	2	-1	2	0	0	0	0	-1	0	0	0
07	1	3	1	2	0	0	0	-2	-1	0	0	1
09	1	2	1	3	0	1	0	-1	-1	0	0	0
08	2	3	2	2	1	0	1	-1	-1	-1	1	2
10	1	2	2	3	1	1	1	-1	-1	1	0	0
15	1	4	2	3	0	0	0	-1	0	0	0	0
06	1	2	0	2	0	0	-1	-2	-1	-1	0	1
01	1	2	1	3	0	1	0	-1	-1	-1	0	1
05	2	2	1	2	1	2	1	0	-1	0	-1	1
1990-2019	1	3	1	1	0	1	0	0	0	1	0	1
1960-1989	5	5	5	5	6	5	5	5	5	5	5	5

2050-2079

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
12	2	2	2	2	-1	0	0	-1	-1	-1	-1	1
11	3	4	2	3	0	0	1	-1	-1	0	1	2
13	1	3	1	3	0	-1	-1	-1	-1	0	0	2
04	2	2	1	2	0	1	0	-1	-1	1	0	2
07	2	3	2	2	0	1	0	-2	-2	0	0	2
09	2	3	1	3	0	1	0	-2	-1	0	0	2
08	3	4	1	2	1	1	-1	-1	-1	0	0	2
10	1	2	2	2	1	0	0	0	-1	0	0	1
15	2	3	2	4	0	0	0	0	-1	0	0	1
06	1	4	1	3	1	-1	-1	-2	-1	0	0	1
01	2	3	2	1	0	1	0	-2	0	0	0	1
05	2	2	1	3	0	1	0	-1	-1	0	1	0
1990-2019	1	3	1	1	0	1	0	0	0	1	0	1
1960-1989	5	5	5	5	6	5	5	5	5	5	5	5

National scale changes in the monthly number of Very Wet Days **for the most extreme year** from two observed periods (1960 – 1989, 1990 – 2019) and per climate projection for 2020 – 2049 (left) and 2050 – 2079 (right).

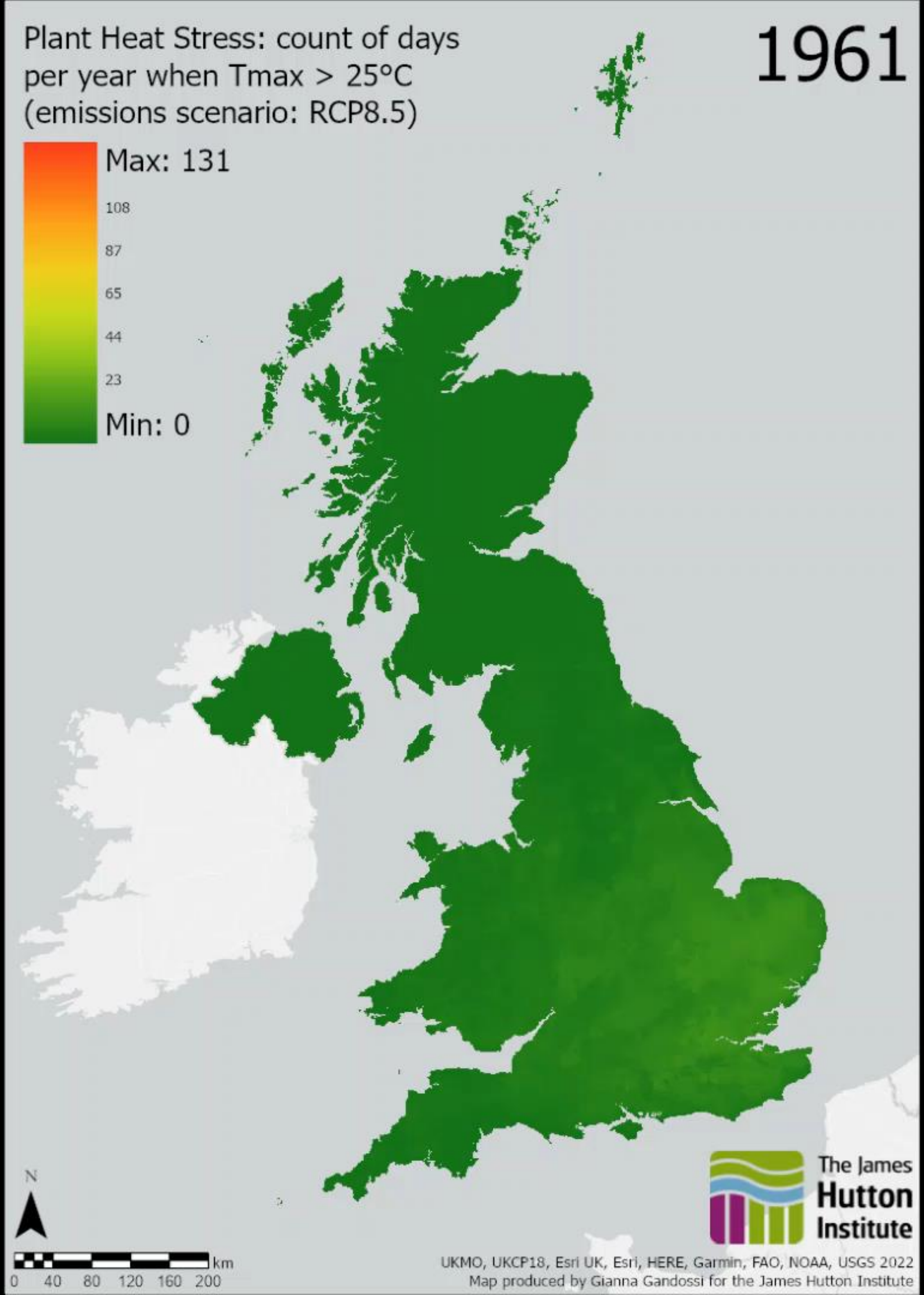
How do these indicators look like over time? Next example is for the count of days per year when Tmax > 25°C

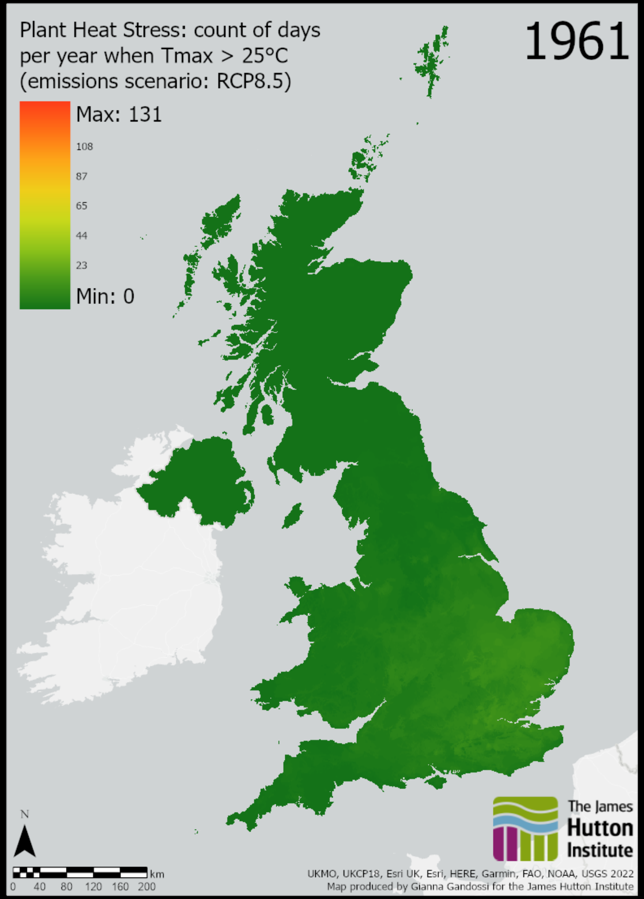
Visualisation of projections:

Observed data 1960 – 2020
Modelled data 2021 – 2098

Look out for 1976, 2003 and 2018 as a guide to the scale of future changes.

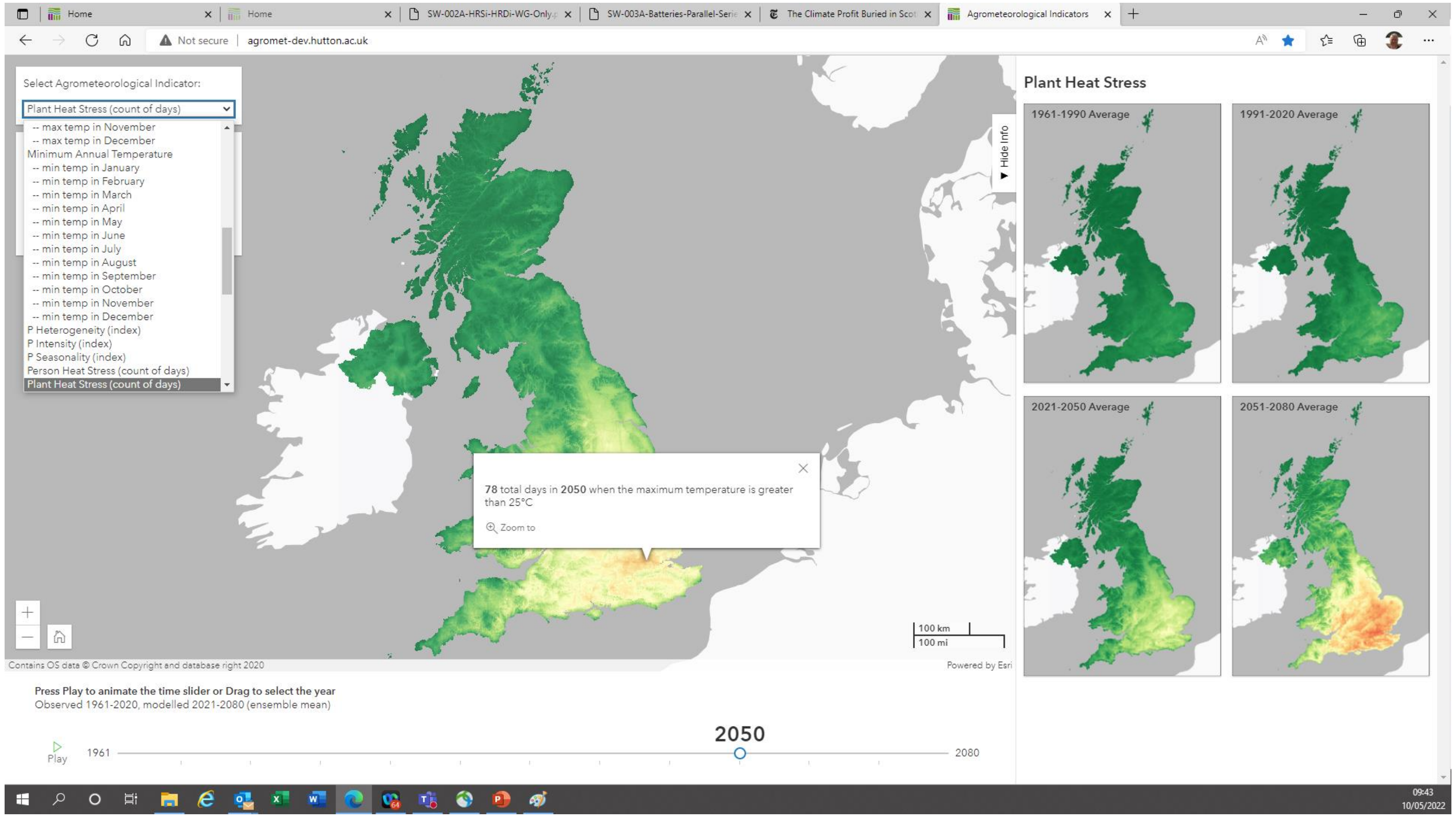
Note how Scotland is less impacted compared to the south-east (continental effect).





Tools for envisioning the future: Agrometeorological Indicators

- 30+ Indicators useful for land management purposes based on daily climate data
  - Longer growing season
  - Fewer frosts
  - More dry spells / heatwaves
  - Higher intensity rainfall events
  - Increased monthly precipitation and temperature variability
- 1km grid resolution
- 1960 – 2098
- Web platform – time series animations



78 total days in **2050** when the maximum temperature is greater than 25°C

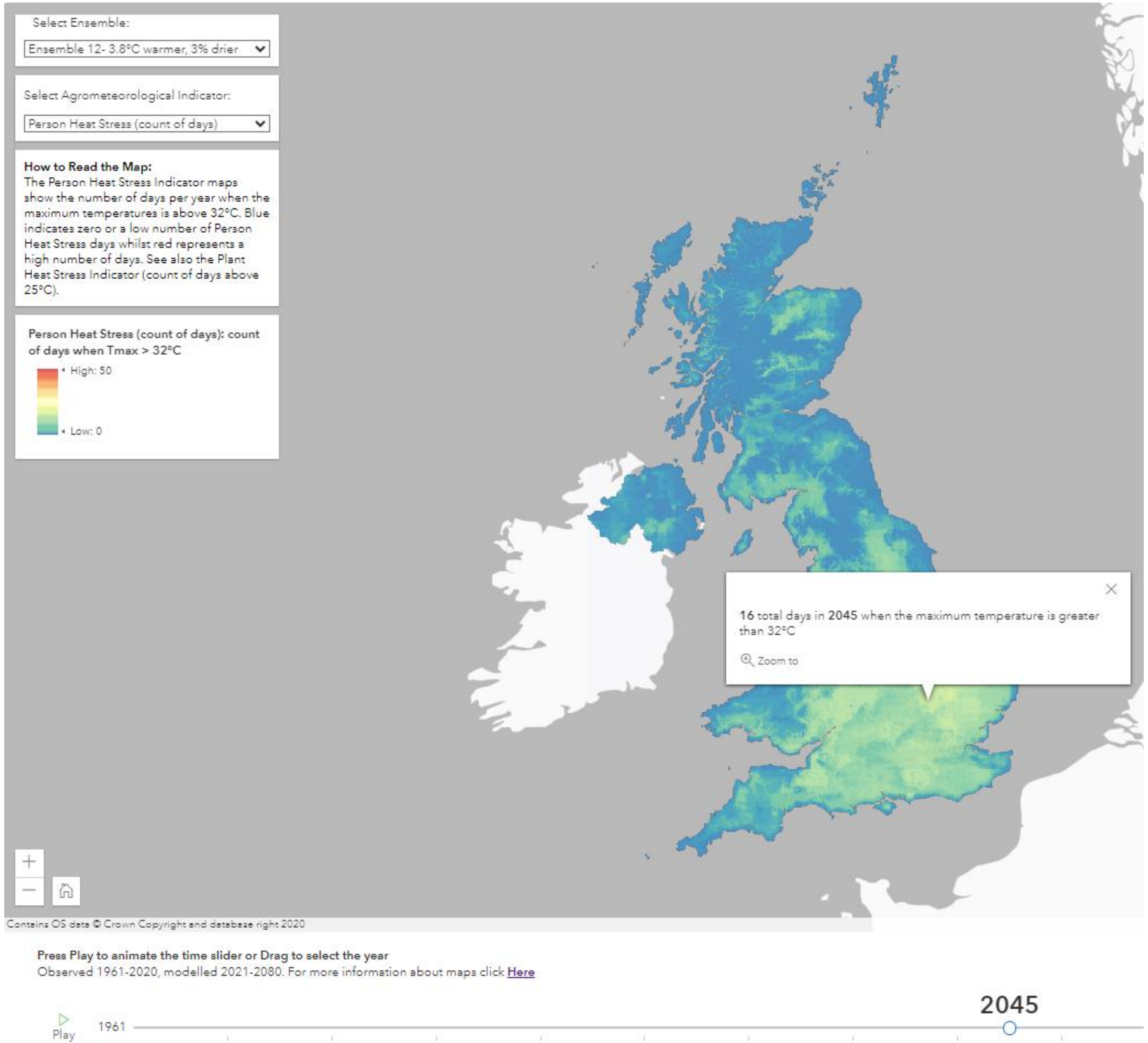
Contains OS data © Crown Copyright and database right 2020

Press Play to animate the time slider or Drag to select the year
Observed 1961-2020, modelled 2021-2080 (ensemble mean)

Product of C3 – Land Use Transformations and D5-2 Climate Change Impacts on Natural Capital projects

Person Heat Stress (count of the number of days per year above 32°C)

The James Hutton Institute



Select Ensemble:

Ensemble 12- 3.8°C warmer, 3% drier

Select Agrometeorological Indicator:

Person Heat Stress (count of days)

How to Read the Map:
The Person Heat Stress Indicator maps show the number of days per year when the maximum temperatures is above 32°C. Blue indicates zero or a low number of Person Heat Stress days whilst red represents a high number of days. See also the Plant Heat Stress Indicator (count of days above 25°C).

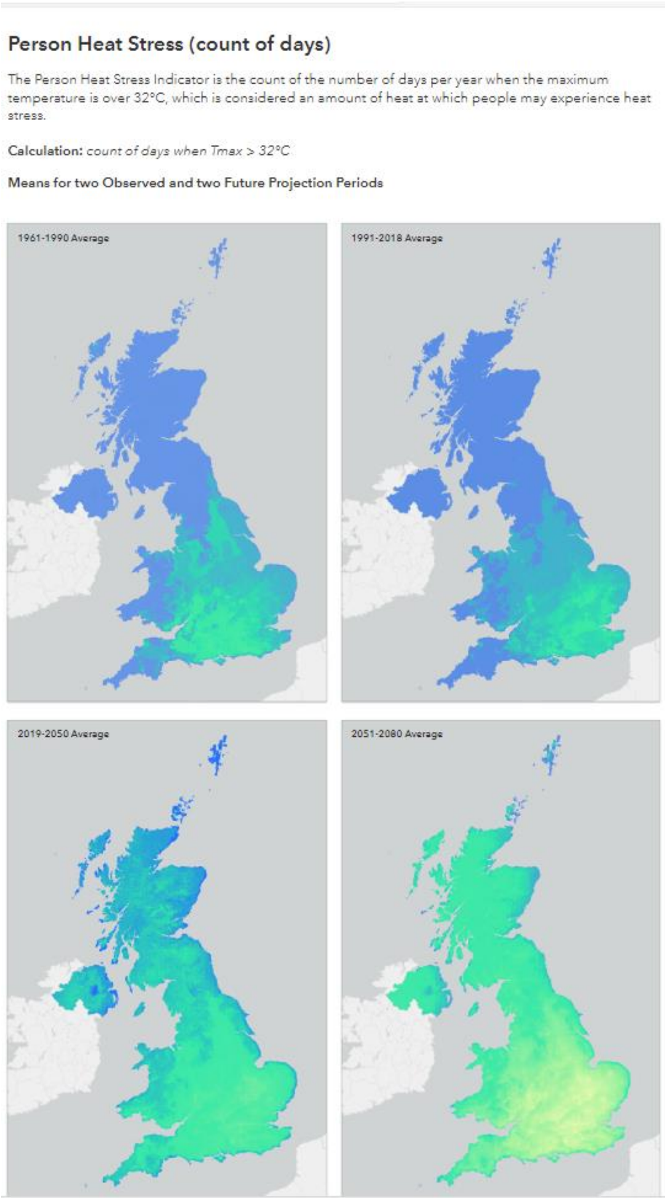
Person Heat Stress (count of days): count of days when Tmax > 32°C

- High: 50
- Low: 0

16 total days in **2045** when the maximum temperature is greater than 32°C

Contains OS data © Crown Copyright and database right 2020

Press Play to animate the time slider or Drag to select the year
Observed 1961-2020, modelled 2021-2080. For more information about maps click Here



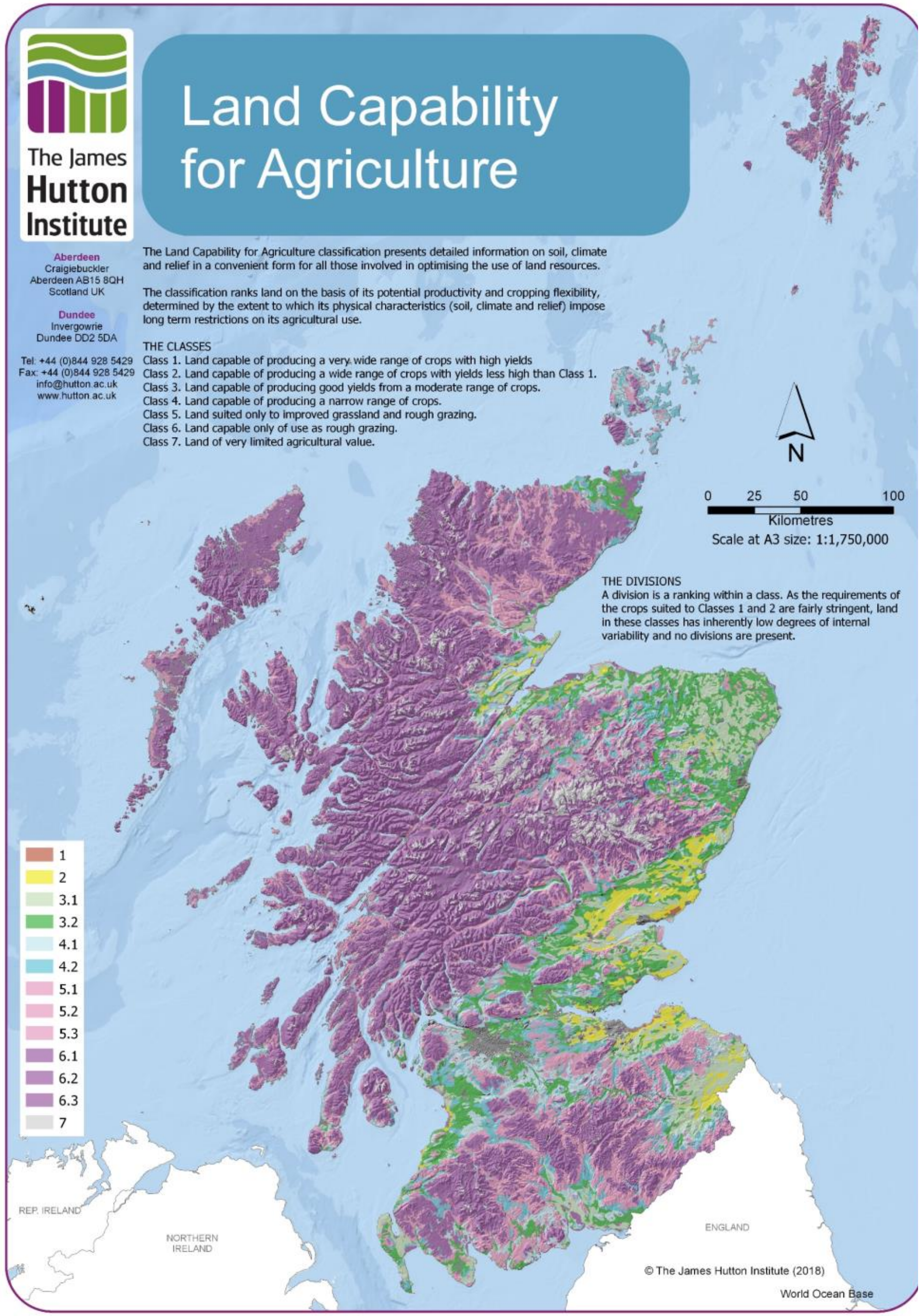
Person Heat Stress (count of days)

The Person Heat Stress Indicator is the count of the number of days per year when the maximum temperature is over 32°C, which is considered an amount of heat at which people may experience heat stress.

Calculation: *count of days when Tmax > 32°C*

Means for two Observed and two Future Projection Periods

The James Hutton Institute



Land Capability for Agriculture

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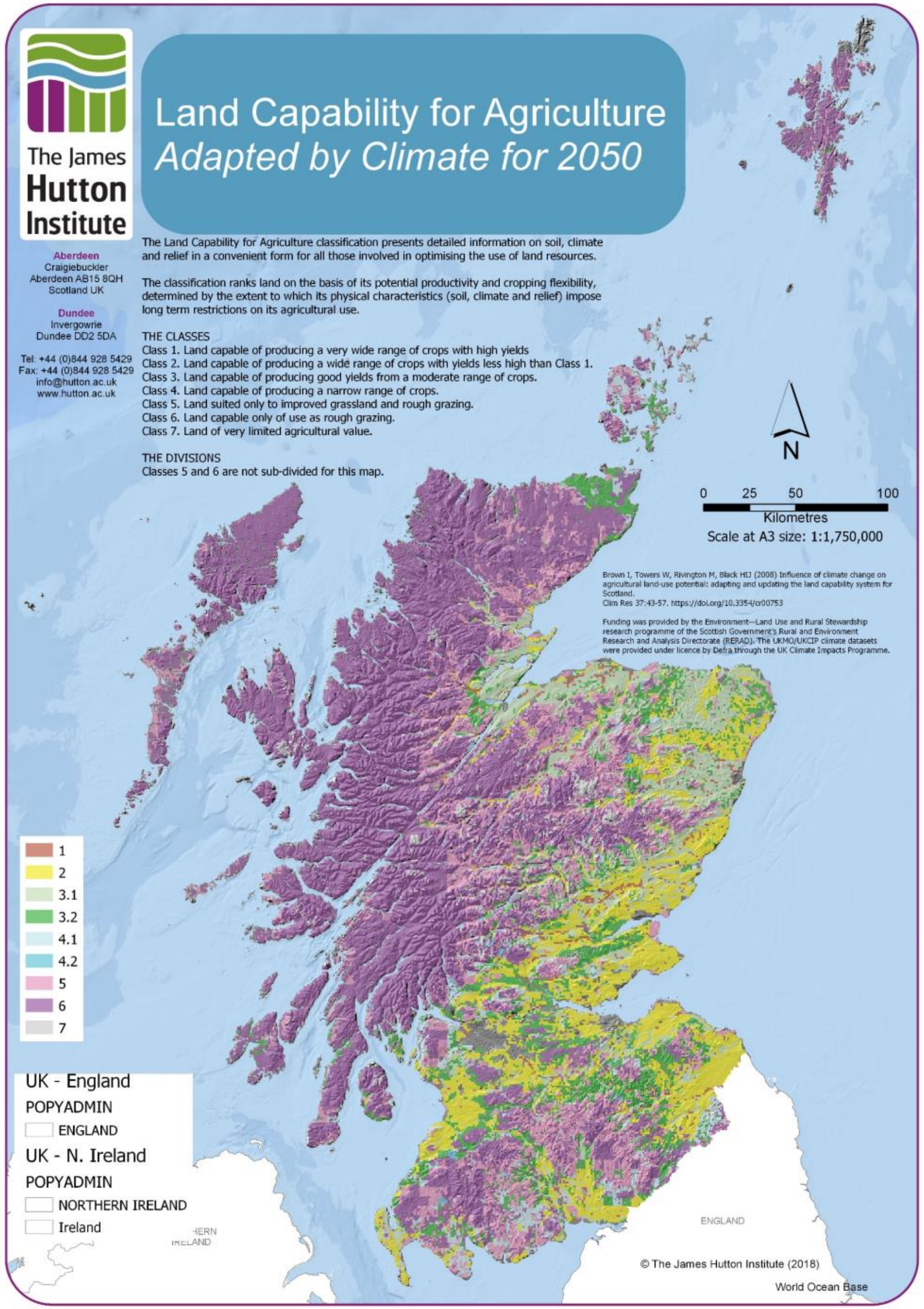
The Land Capability for Agriculture classification presents detailed information on soil, climate and relief in a convenient form for all those involved in optimising the use of land resources.

The classification ranks land on the basis of its potential productivity and cropping flexibility, determined by the extent to which its physical characteristics (soil, climate and relief) impose long term restrictions on its agricultural use.

THE CLASSES
Class 1. Land capable of producing a very wide range of crops with high yields
Class 2. Land capable of producing a wide range of crops with yields less high than Class 1.
Class 3. Land capable of producing good yields from a moderate range of crops.
Class 4. Land capable of producing a narrow range of crops.
Class 5. Land suited only to improved grassland and rough grazing.
Class 6. Land capable only of use as rough grazing.
Class 7. Land of very limited agricultural value.

THE DIVISIONS
A division is a ranking within a class. As the requirements of the crops suited to Classes 1 and 2 are fairly stringent, land in these classes has inherently low degrees of internal variability and no divisions are present.



Land Capability for Agriculture *Adapted by Climate for 2050*

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THE DIVISIONS
Classes 5 and 6 are not sub-divided for this map.

Brown I, Towers W, Rivington M, Black HIJ (2008) Influence of climate change on agricultural land-use potential: adapting and updating the land capability system for Scotland.
Clim Res 37:43-57. https://doi.org/10.3354/cr00753

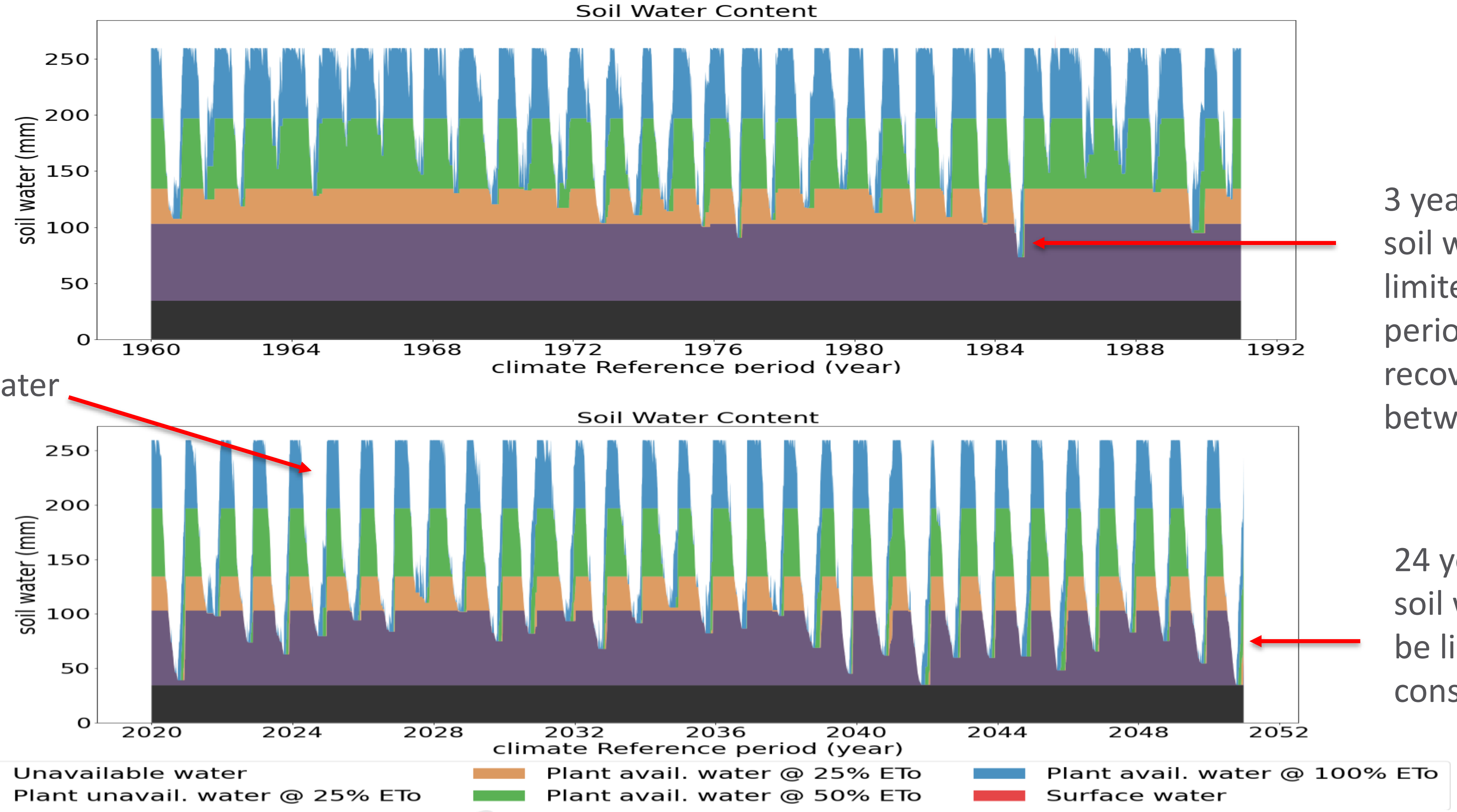
Funding was provided by the Environment—Land Use and Rural Stewardship research programme of the Scottish Government's Rural and Environment Research and Analysis Directorate (RERAD). The UKMO/UKCIP climate datasets were provided under licence by Defra through the UK Climate Impacts Programme.

- Prime land (low carbon) may become more vulnerable to droughts.
- Marginal land (currently grassland, higher carbon) may become more productive,
  - Increasing land prices and competition with afforestation.
- Changes from spring to winter cereals (emissions consequences)
- Opportunities for new crops

Tools for assessment: Soil Water Content - past and future

(477,256 unique soil-climate combinations)

Brown earth soil near Biggar, (ensemble member 12*).



Past

3 years when soil water was limited, with periods of recovery in between

More ‘white space’ = less water available

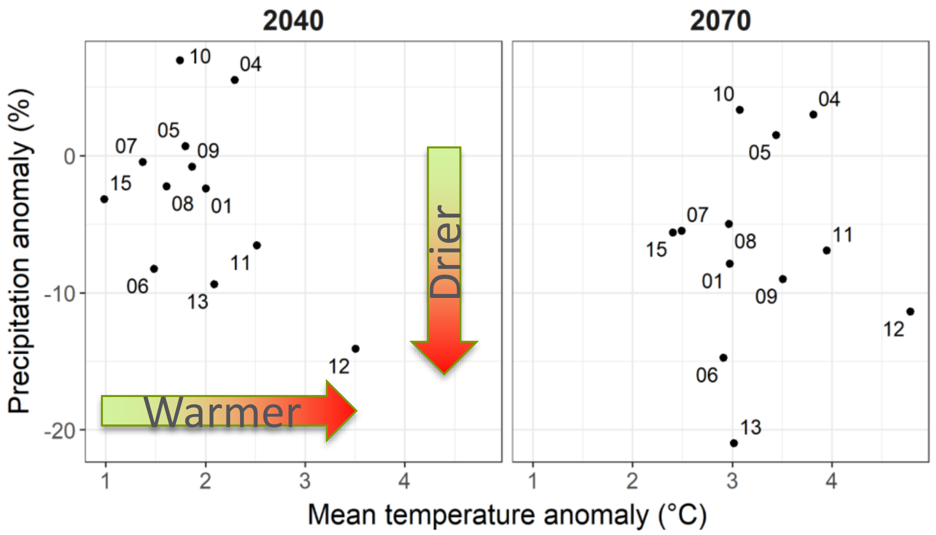
Future

24 years when soil water may be limited, many consecutive

* 3.5°C warmer, 14% drier therefore a more ‘extreme’ plausible future

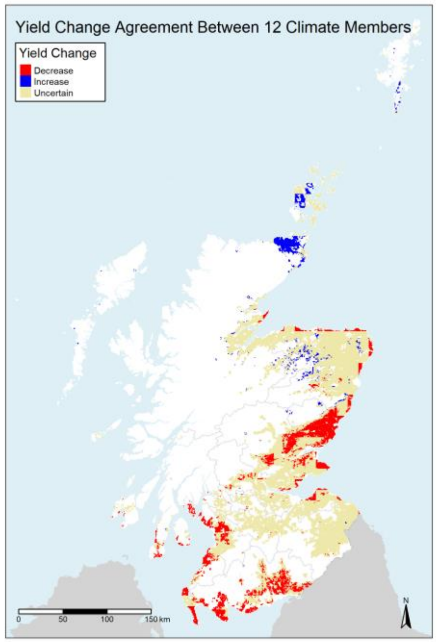
Barley yield change direction in Scotland in the 2040s

- Agreement maps of where barley yield is estimated to increase (blue) or decrease (red)

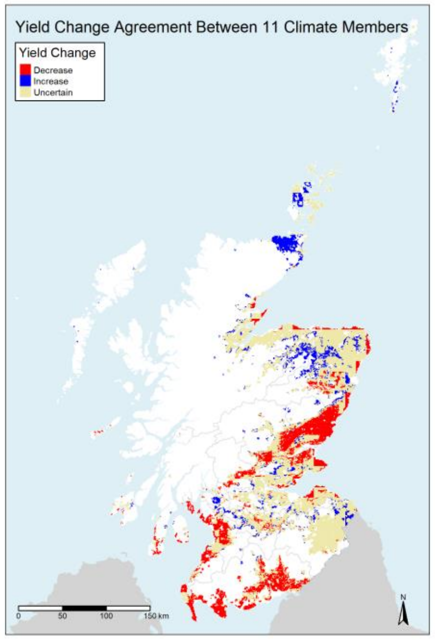


Growing season precipitation and temperature anomaly from observed baseline (1994-2015) from UKCP18 RCP8.5

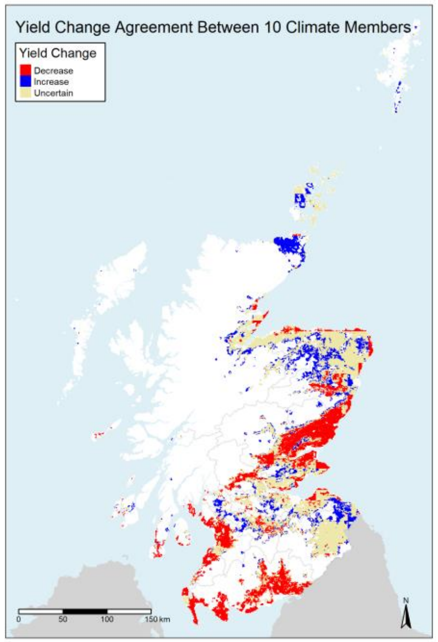
12 Climate Members



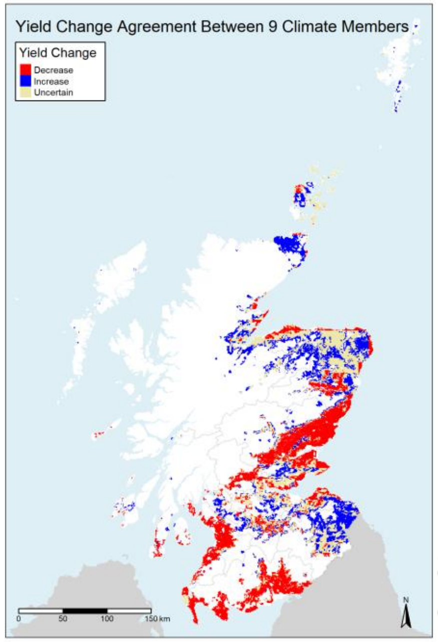
11 Climate Members



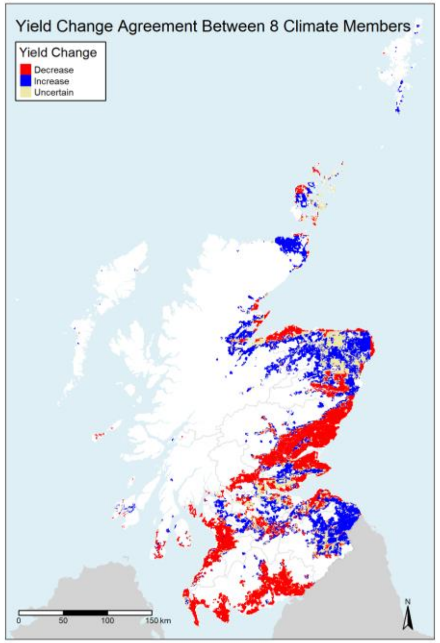
10 Climate Members



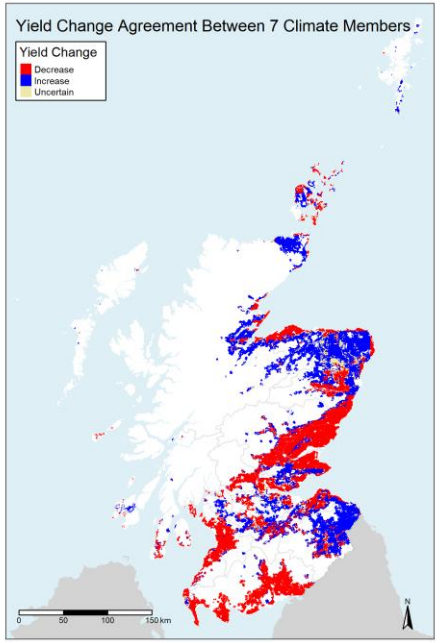
9 Climate Members



8 Climate Members



7 Climate Members



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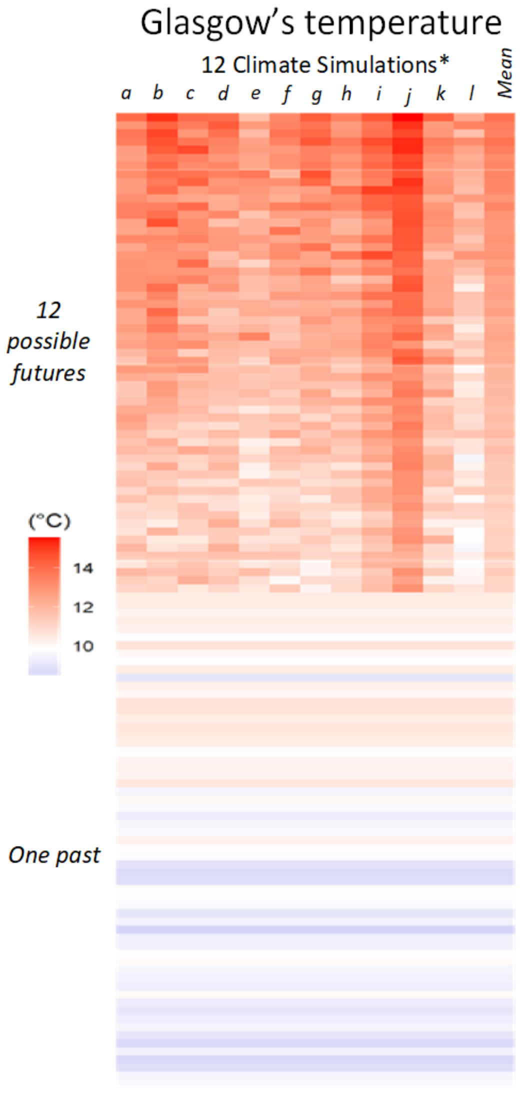
Putting projected changes in a global perspective

- Scotland may be ‘relatively’ less impacted directly by climate change and ecosystem degradation (initially) than other countries.
- BUT – we need to take a global perspective to understand local and Scotland-scale impacts and adaptation needs.

CoP26: Putting Glasgow’s changing climate in a global context



* UKCP18 Climate Projections, RCP8.5

Mid-point for scale: average temperature 1980-2010

Plausible Global Impacts

2080 4.4°C (3.3 – 5.7°C)† Unprecedented droughts, heatwaves, floods. Severely reduced agricultural production.

2070 Loss of climate regulation ecosystem services: only 38% of emissions captured by Nature. Ocean acidification increases. Mass species extinction.

2060 Amazon rainforest collapse. Sea level rise of 0.5m means many Island States disappear.

2050 2.4°C (1.9 – 3.0°C)† Paris Agreement 2°C limit exceeded. 300m people displaced by sea level rise. Arctic Sea practically ice-free (September).

2040 1.6°C (1.3 – 1.9°C)† global average temperature rise exceeds 1.5°C. More frequent droughts, intense storms and flooding, increased rate of species extinction, loss of coral reefs. Arctic releasing more carbon. Food Security threats.

2030 50 million climate refugees.

2021 Atmospheric CO_2 is 412 ppm. Emissions from energy increasing by 4.8%. Nature increasingly a source of carbon, not a sink. 25 million climate refugees.

2003 European heatwave with 20,000 heat related deaths.

1960 Atmospheric CO_2 is 318 parts per million.

† Increase above pre-industrial levels, IPCC AR6 WG1 2021

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Policy implications (a few examples)

- **Net Zero:** ecosystem capabilities to store and sequester carbon
- **Environment Strategy and Biodiversity:** Restoring Nature accounting for climate impacts
- **Peatlands:** need to identify areas currently in good condition that may need pre-emptive intervention to protect against future drying.
- **Water:** abstraction limitations, quality (pollution flushes), risks to Private Water Supplies, stream temperature, reduced snow cover, changes to wetland functions,
- **Agriculture Bill** - Enhanced Conditionality (C3 Land Use Transformations Project):
  - Climate proofing long-term measures,
  - Efficacy of measures due to climate variability.
  - Landscape planning – collaboration at the catchment scale
- **Woodland expansion:** identifying most appropriate locations
- **Offsetting, Green Investments:** sequestration efficacy of investments over time
- **Public Health:** increases in heat stress, reduction in productivity
- **Food Security:** Climate shocks leading to shortages and price spikes
- **NPF4:** Local Authority planning for multiple objectives, Resilience and Adaptation planning
- **Emergency services planning:** increase wildfire risk
- **Immigration:** increases due to climate stress globally
- **Tourism and rural infrastructure:** increase in visitor numbers seeking ‘cool’ holidays.

For further details please contact:
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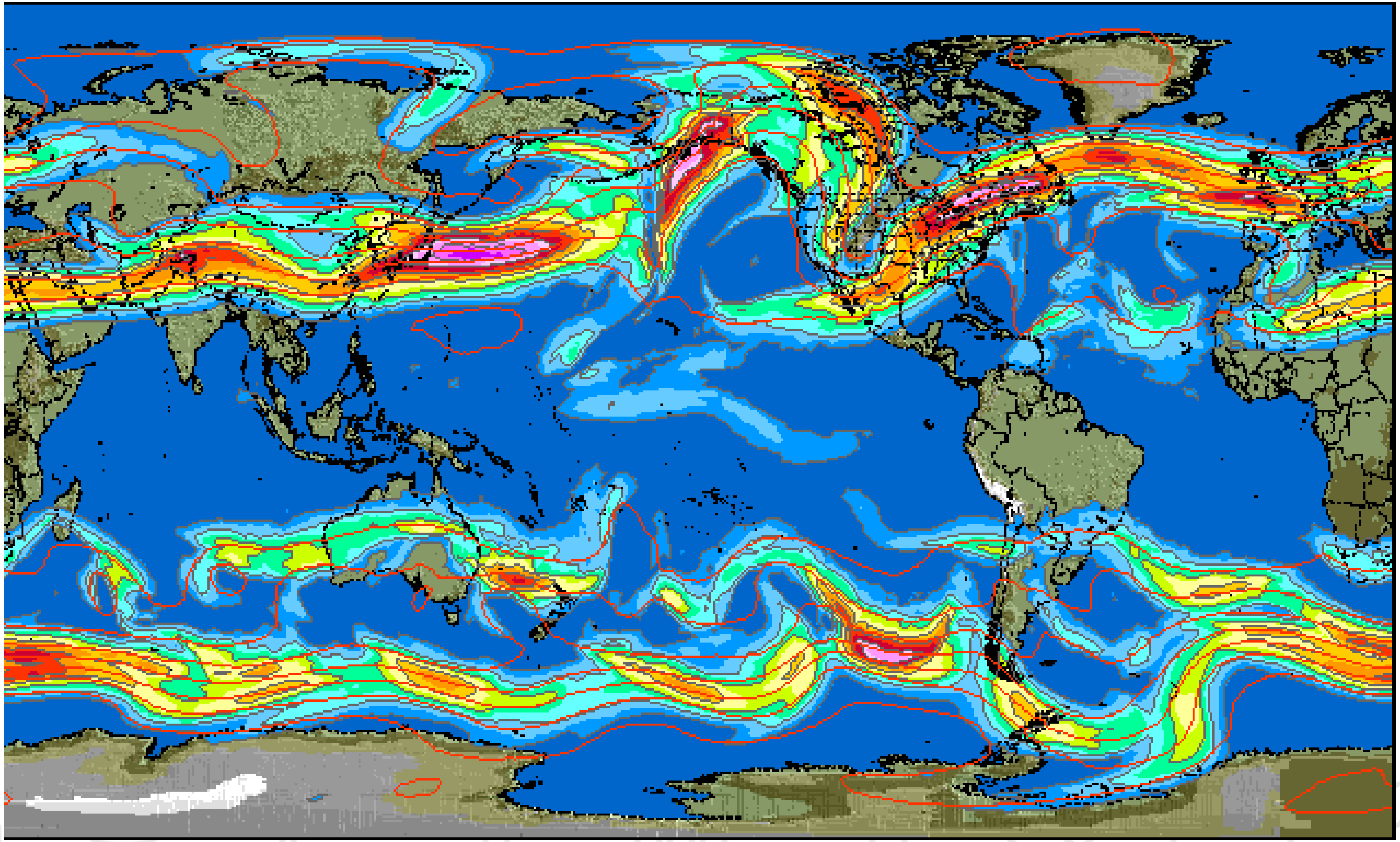
Reports available here:
Trends and future projections:
https://www.hutton.ac.uk/sites/default/files/files/D2_1a%20Climate%20trends%20summary%20report%20FINAL%206-12-22.pdf
Extremes:
https://www.hutton.ac.uk/sites/default/files/files/D2_1b%20Climate%20extremes%20report%205-3-23%20FINAL%20submitted.pdf

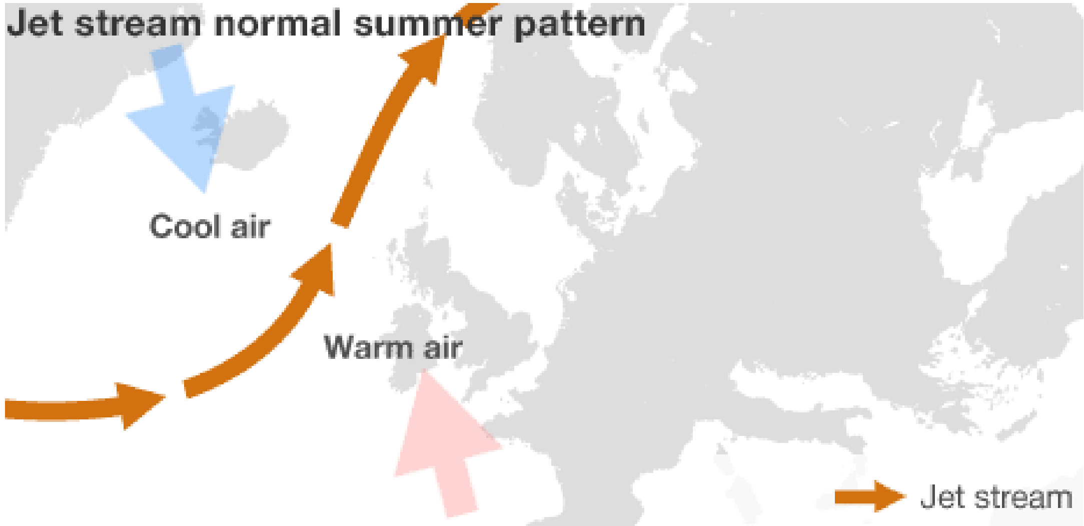
The speed and position of the jet stream is determined by the temperature deferential between the tropics and high latitudes:

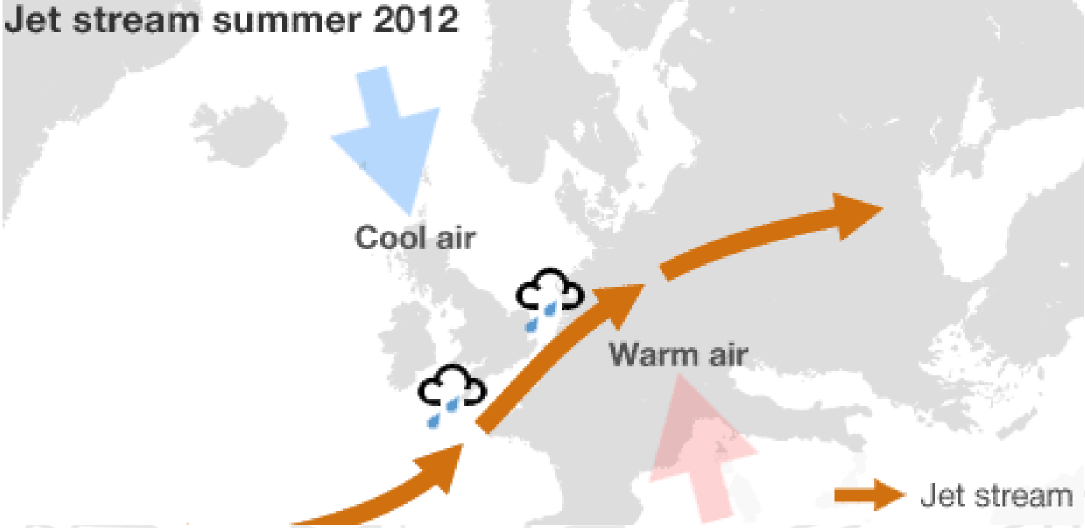
High differential = jet stream is fast and straight

Low differential = jet stream is slow and meandering



Uncertainty in the Jet Stream





Still large uncertainties as to why the jet stream follows a particular pathway.

Since 1970 there has been a 4% increase in atmospheric moisture over the sea, leading to higher probability of heavier rainfall events.

Extremes Indicators

Indices	Summary of implications
Consecutive Dry Days	Prolonged periods of drought will have implications for water resources and water quality. Coupled with reduced precipitation, the increased number of dry days in March and April may have negative impacts during a key time of plant growth. Longer dry periods increase the wildfire danger and soil erosion by wind and heavy precipitation.
Number of Dry Days	The impacts of changes in the number of Dry Days in respect of crops, semi- and natural vegetation is likely to vary depending on soil hydrology, with potentially both positive and negative effects, also variable depending on the timing of when dry periods occur. Drier spring and summers on well drained soils are at risk of reduced crop yields and vegetation biomass production (variable depending on species). There is an increased risk of fire danger.
Heavy Rain Days	Increases in Heavy Rain Days in winter are associated with a higher risk of flooding, while fewer HRD in summer may lead to a reduced water availability and higher water stress. In summer, it is expected for many Natural Capital assets: soil, vegetation, waters to face a reduced level of ecological functionality and a potential loss of biodiversity because of the increase in drought and threats from fewer but heavier precipitation events. Floodplains can reduce the assimilative capacity of containing floods and high soil erosion of arable land and uplands can reduce the carbon stock. Summertime water stress can reduce tree and peatland carbon sequestration.
Very Wet Days	The increase in the number of largest precipitation events per month in the winter implies an increased risk of flooding and soil erosion, but the reduced number of Very Wet Days in the summer implies an increased risk of dry soil and habitat conditions and increased fire danger. Large precipitation events occurring when soils are dry will likely result in soil erosion and nutrients lost to surface waters. Potential benefit from wetter conditions in the winter and more Very Wet Days by increasing the potential for recharge of ground water to maintain water table levels.
Highest Temperature	Increases in the extremes of maximum temperature will likely increase heat and water stresses on plants, animals and habitats, potentially damaging ecological function and delivery of ecosystem services. Higher temperatures in spring will drive earlier plant and insect phenological development. Higher maximum temperatures pose threats to people and infrastructure due to heat stress.
Very Warm Days	Increases in the duration of the warmest temperatures per spring, summer and autumn month will likely increase heat stresses on plants and animals, and alongside high maximum temperatures test the thermal range tolerance of species and habitats, whilst altering inter-species competition, driving more rapid phenological development, damaging ecological function and delivery of ecosystem services. Longer warm periods in the winter are likely to increase snow melt and loss of snow cover
Coldest Temperature	The increase (warming) in the Coldest Temperature reflects a higher probability of fewer days of less intense frosts and amount of freezing of open water and in soils. Less intense cold may help improve the over-winter survivorship of some species. There is likely to be less snow consolidation into ice and more snow melt leading to changes in surface albedo resulting in more heat absorption.