Extreme Convective Weather in Future Decades

Alan Gadian, James Warner, Ralph Burton, James Groves, Alan Blyth and Stephen Mobbs*
NCAS, University of Leeds, UK

Greg Holland, Cindy Bruyere, James Done, Mari Tye
MMM , NCAR, USA

Jutta Thielen
Climate Risk Management Unit, JRC

UNIVERSITY OF LEEDS

National Centre for Atmospheric Science
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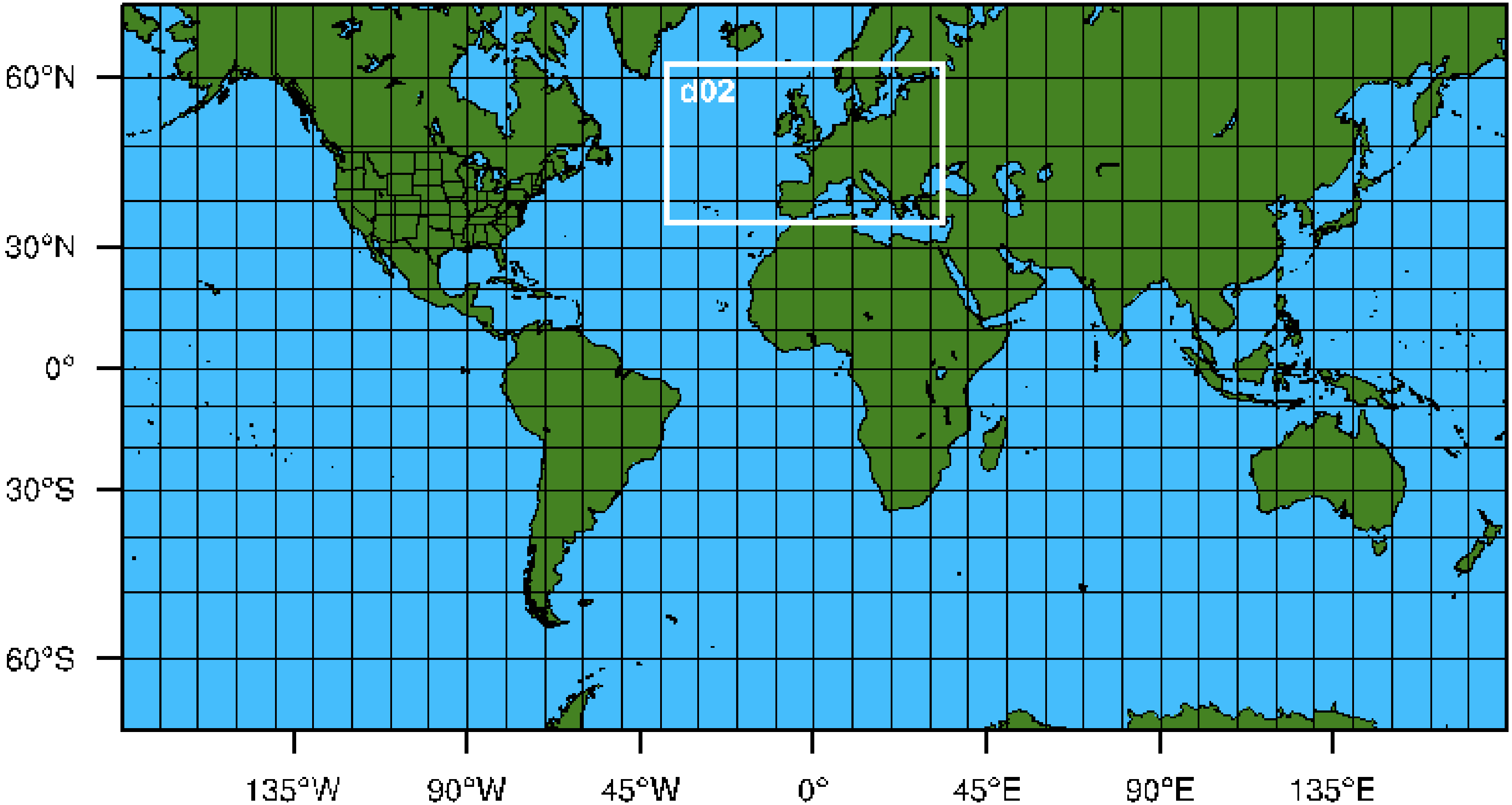
Domain construction

The model is driven by ERA-Interim and CCSM surface and North / South lateral boundaries.



Domain structure for the WISER simulation. The outer domain resolution is 20km at +/- 30° and 8km at 68° N/S. The inner domain is nested at a ratio of 5:1

Progress … summer 2016 *(40 million core hours on a Cray XC30)*

Years 1989 – 1995

- **Control simulation driven at the boundaries by ERA-Interim data.**
- **“Climate” simulation driven at the boundaries by CCSM data.**

Objective: To compare the “climate” and the “analysis” driven data. Data from 1989 are ignored as spin-up and only the 6 years 1990 – 1995 used for comparison purposes.

Years 2020 – 2025 and 2030 – 2036

“Climate” simulation driven at the boundaries by CCSM data

- ***2021 – 2025***
- ***2031 – 2036***

Objective: To compare the differences in weather scale data for five years of weather data, 2021 – 2025 and 2031 – 2036. Data from 2020 and 2030 are ignored as spin up.

Summary.

The WISER project is designed to look at changes in weather patterns (a) over recent decades, and (b) the future weather in a regional framework. It uses WRF 3.5.1 in a convecting permitting formulation for the inner domain.

The resolution (~3km) is required to resolve weather patterns needs high resolution, reducing the errors / upscaling limitations.

The project involves collaboration with the US National Centre for Atmospheric Research (NCAR) and the European Flood Awareness System which is based at the EU Joint Research Centre (JRC), ISPRA, Italy.

The 900 Tbyte netcdf data set will be available for open access.

The project has used more than ~ 40 million equivalent Cray XC30 core hours (500 Megawatt hours of electricity).

Objectives and specific outcomes

- ***Predicted changes in quantity and frequency of severe and hazardous convective rainfall events. The frequency of flash flooding due to heavy convective precipitation. Links to be examined with JRC for flooding.***

- Predicted changes in general precipitation over Western Europe and the UK over decadal timescales.

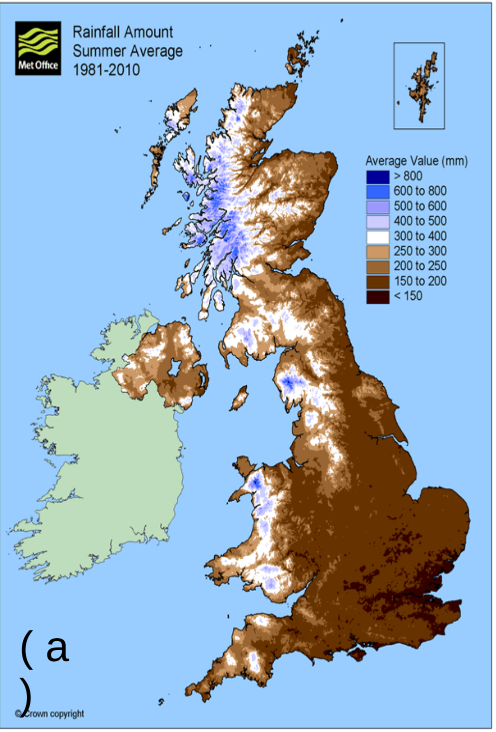
- Predicted changes in patterns of frontal tracks on decadal time scales and to examine the strength, the frequency and the location of Western Atlantic storm tracks for historical and future simulations.

- Past and predicted occurrence of blocking in the North Atlantic

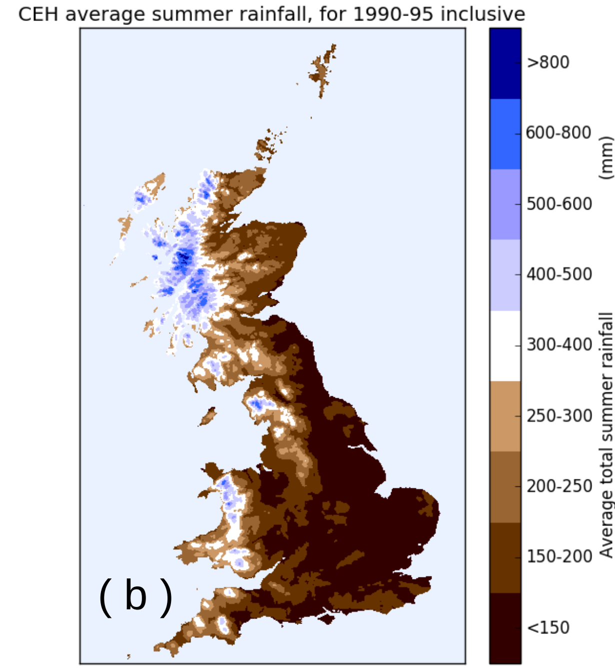
- Changes in meso-scale cloud structure patterns

Comparison of current and future precipitation patterns for the UK.

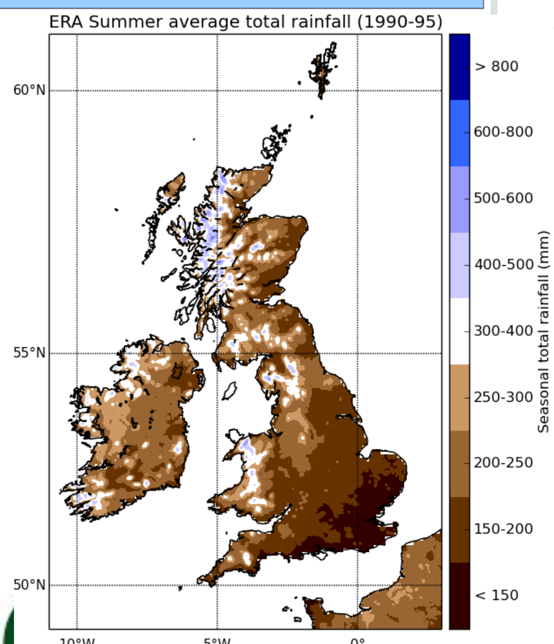
***Panel (a)** indicates the UK rainfall amounts for summer (JJA) 1981-2000. **Panel (b)** indicates the UK rainfall amounts for summer (JJA) 1990-1995. **Panel (c)** indicates the values with the outer domain D01 driven by the ERA Interim data and **Panel (d)** driven by CCSM DATA for 1990-1995. **Panel (e)** shows the model data for years 2031-2035 driven by CCSM data.*



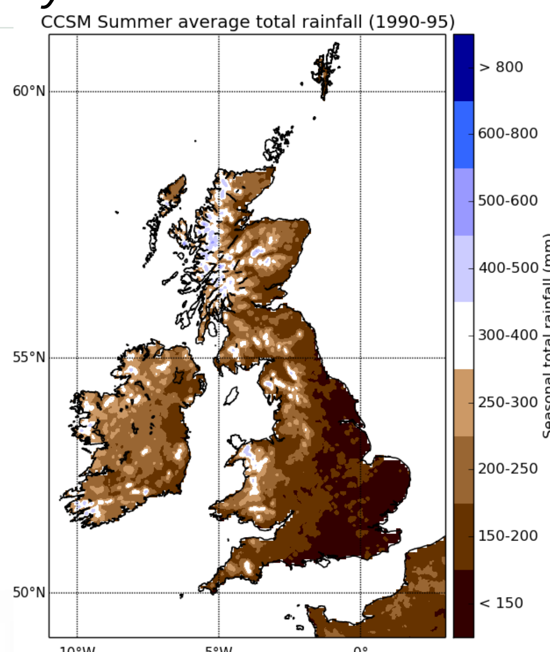
(a)



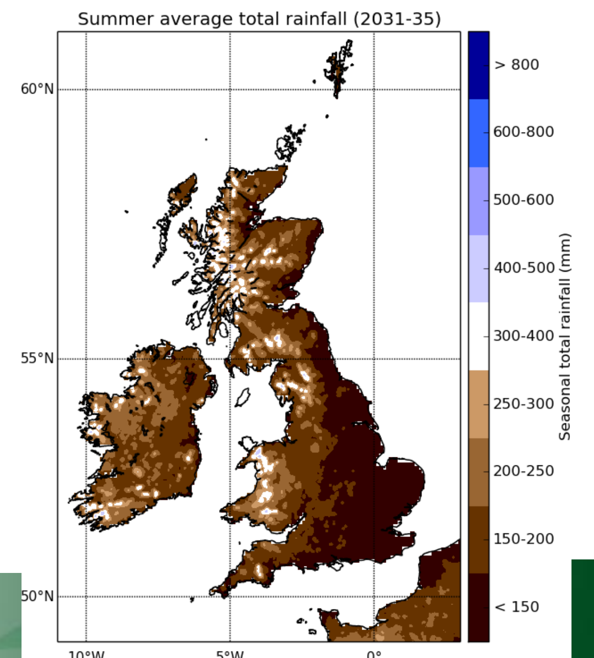
(b)



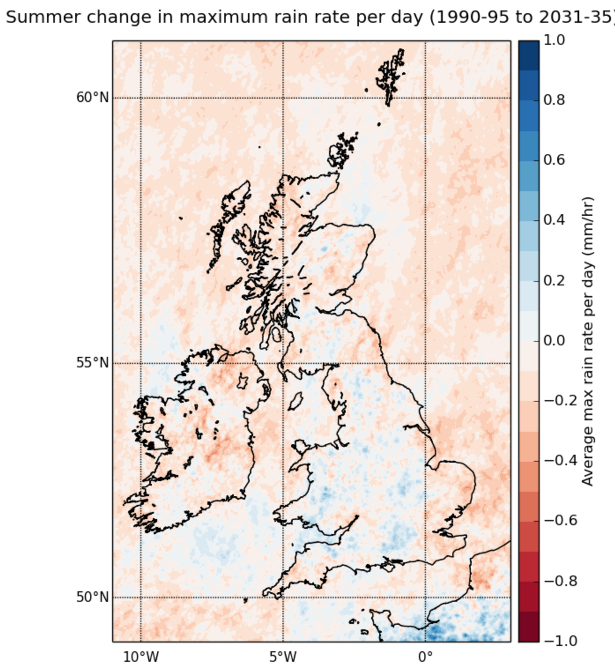
(c)

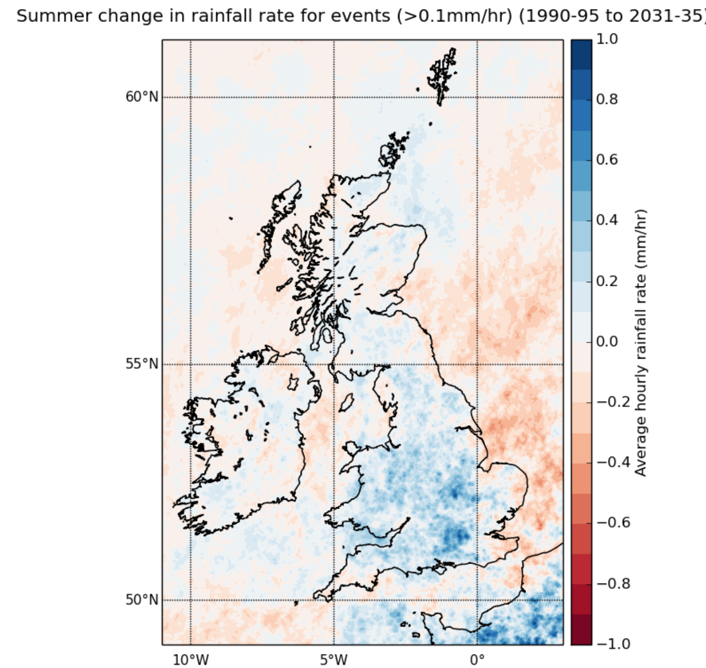


(d)



(e)

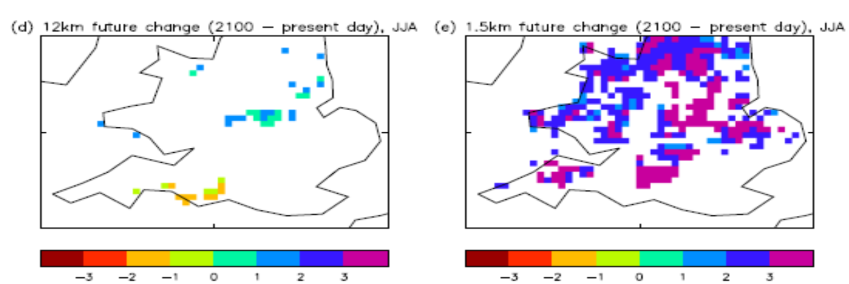


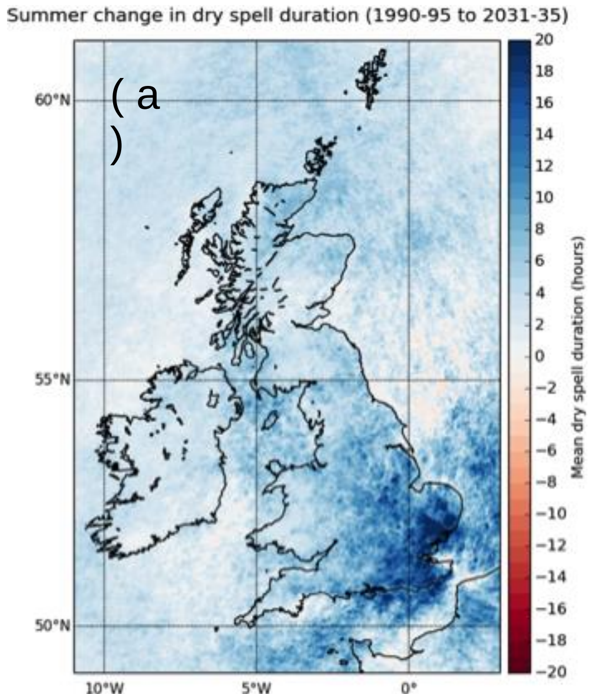


Upper left plot: Changes in maximum hourly precipitation rate per day, for UK in the inner domain (d02) ~ 2km. Note differences are values (mm/hr) 2031-35 minus 1990-95. (JJA)

Upper right plot: Changes in mean hourly precipitation rates for rainfall events for the UK in the inner domain (d02) ~ 2km. Note differences are values (mm/hr) 2031-35 minus 1990-95. (JJA)

Lower plot: Change in precipitation in 12km and 1.5 km model simulation. Differences for JJA in precipitation, (mm/hr) between 2100 and current values. The displayed area represents the whole inner domain. Kendon et al. NCC, (2014)





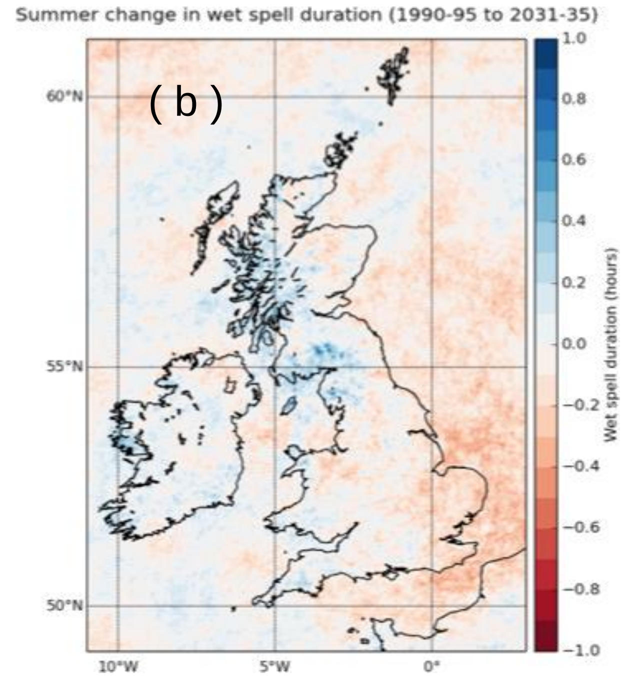
*Summer, JJA, (UK) changes in dry spell, **Panel (a)** and wet spell duration, **Panel (b).***

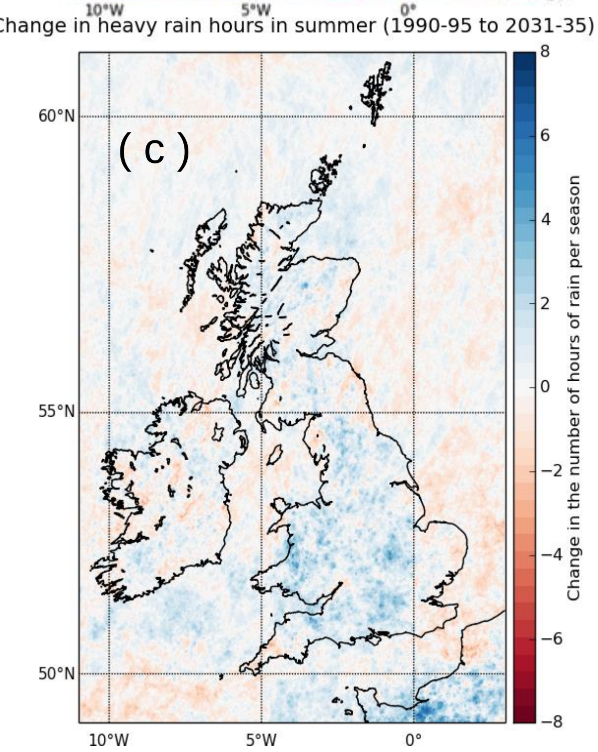
__Panel (c):__ change in heavy rain (> 7.6mm/hour__).__

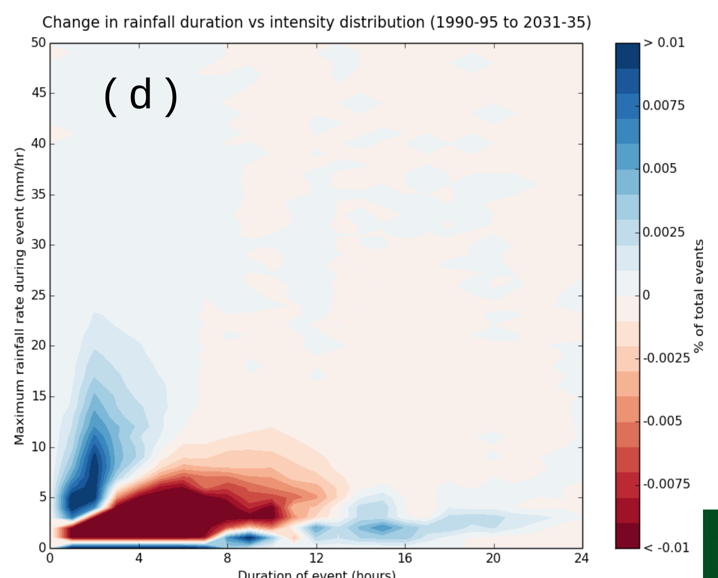
All changes are produced by subtracting the 1991-1995 from the 2031-2035 average values at each pixel__.__

In __Panel (c)__ the number of hours of heavy precipitation per event increases by ~ 2 hours, indicating when it rains, it rains harder__.__

__Panel (d)__ summarises these results by plotting the maximum precipitation against the duration of the each event. A critical result. In the future scenarios, there are shorter bursts of heavier rain. A significant increase in precipitation in relatively short ~2 hours rain events is at the expense of longer (~ 4 hours) lower rainfall rate events.





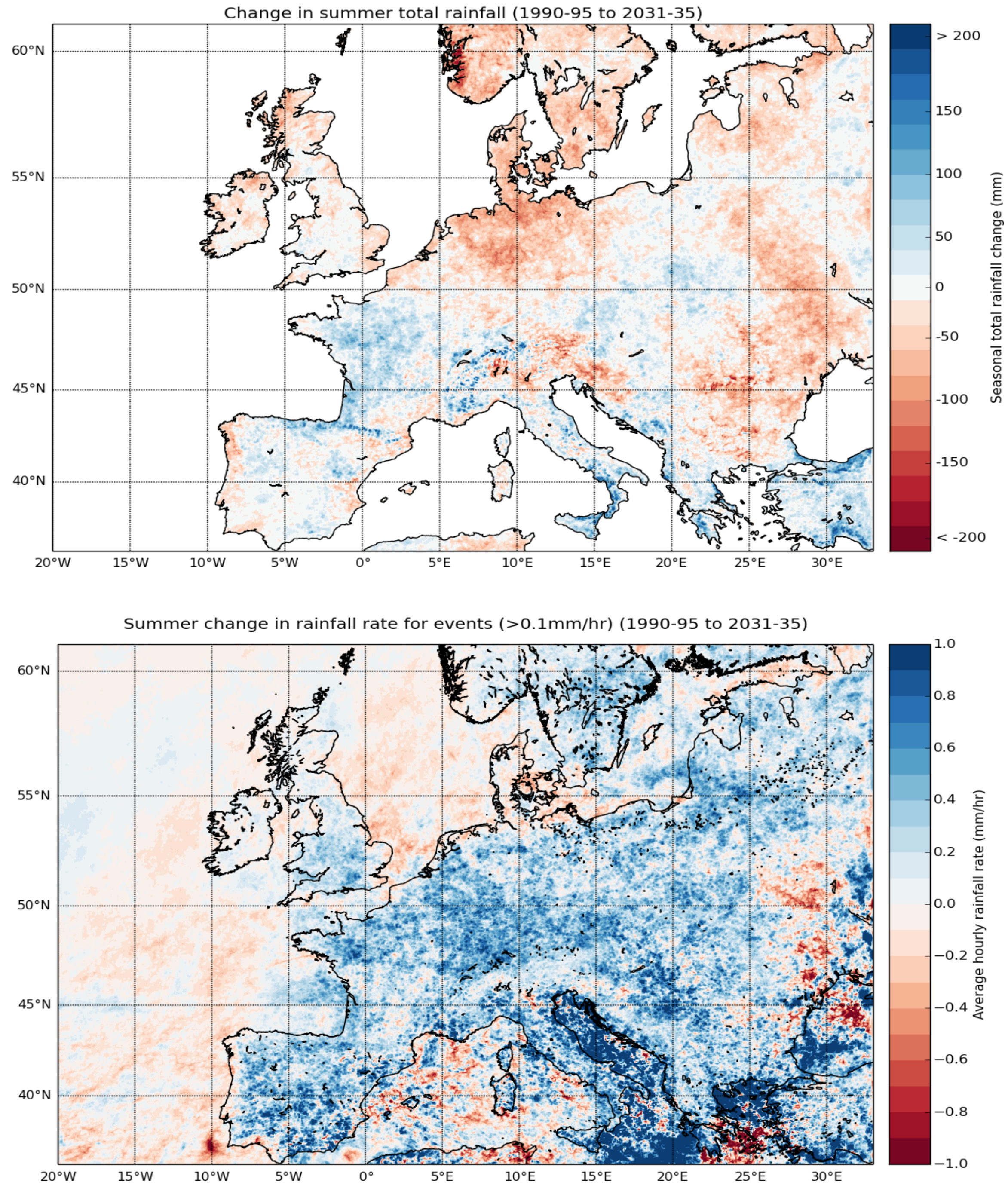


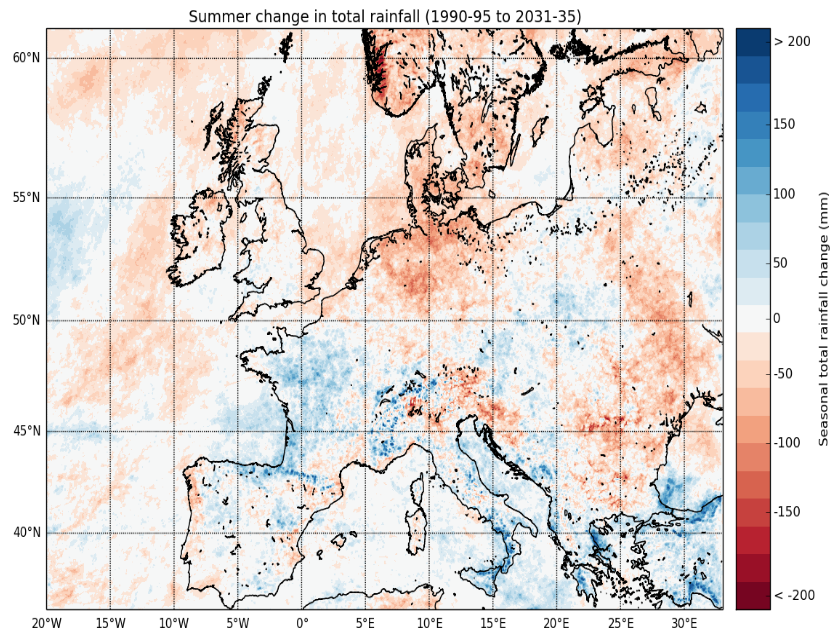
Summer, JJA, (for domain D02 ~ Europe) changes in total rainfall (upper panel)

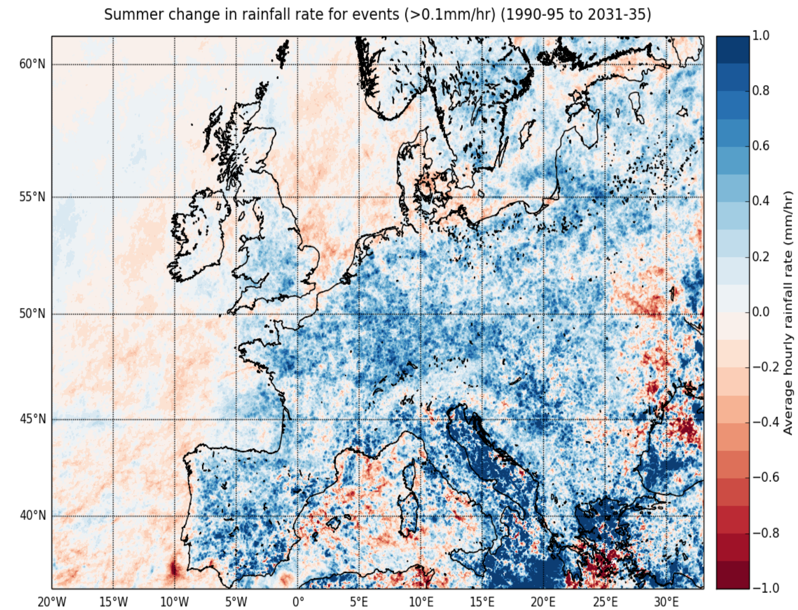
and

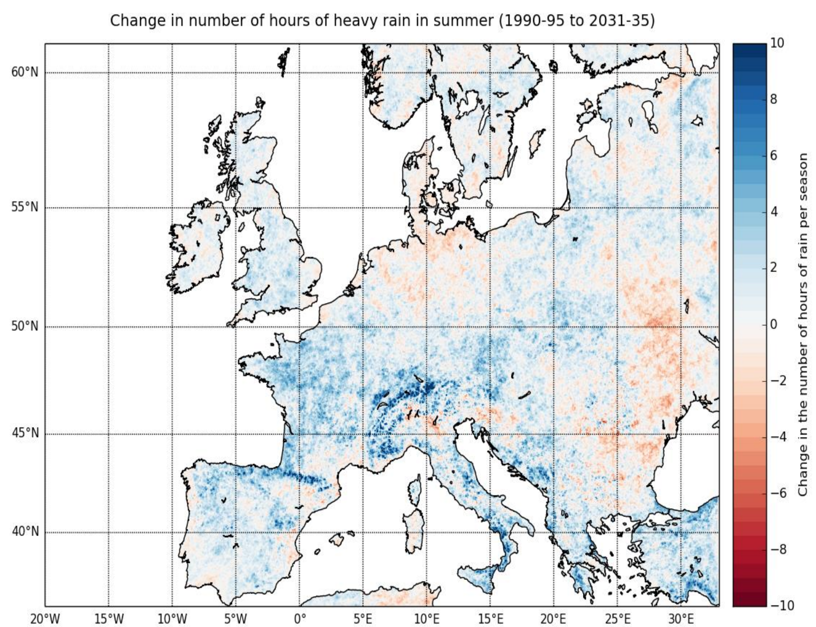
change in rainfall rate for each event (lower panel).

All changes are produced by subtracting the 1991-1995 from the 2031-2035 average values at each pixel.









Summer, JJA, (for domain D02 ~ Europe).

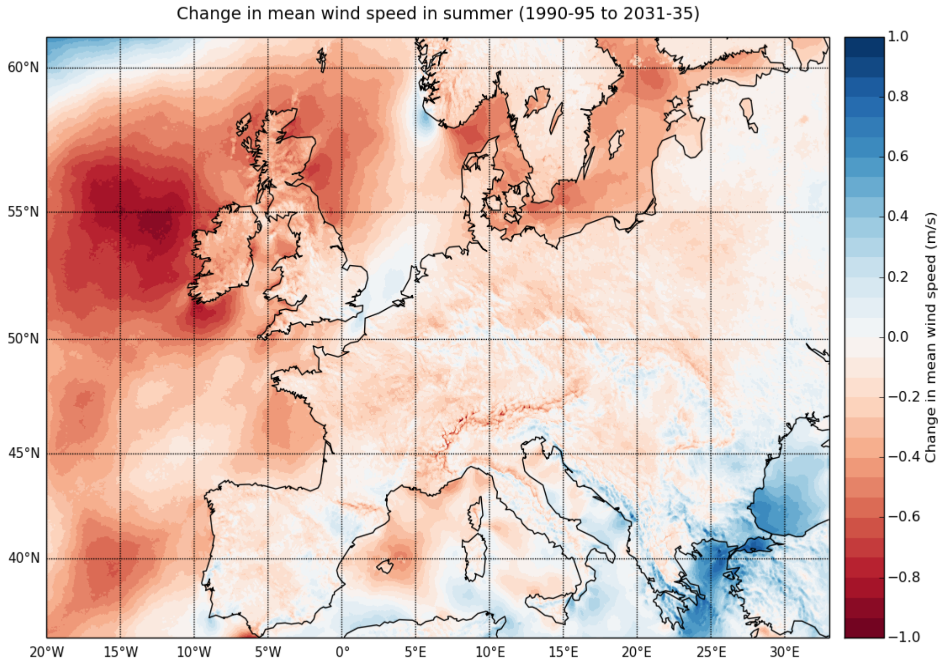
*Change in total rainfall (**upper left**).*

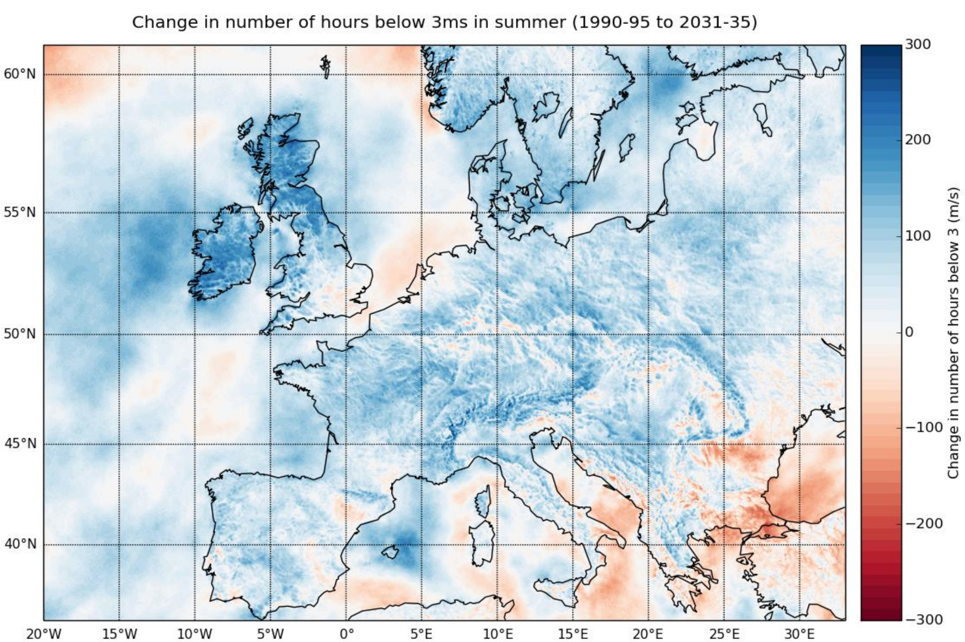
*Change in mean rainfall rate for each event (**upper right panel**).*

*Change in heavy (> 7.6mm/hr) rainfall (**lower left panel**).*

Changes derived by subtracting the 1991-1995 from the 2031-2035 average values at each pixel.

As with the UK, the shorter convective events have higher precipitation rate, although no evidence for an increase in the peak value.





Summer, JJA, (for domain D02) changes in 10m wind speed and the change in the number of hours where the wind speed is less than 3ms^{-1} at 10m.

All changes are produced by subtracting the 1991-1995 from the 2031-2035 average values at each pixel.

The changes in precipitation are accompanied by an increase in the prevalence of calmer and more stable conditions. This supports the argument that these events arise from short lived convection, rather than precipitation cells embedded in synoptic events.

Calm anti-cyclonic weather, especially with stable boundary layers can indicate a likelihood of poorer air quality and is often associated with high pressure conditions.

CONCLUSIONS

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•A large data set has been constructed, completed in summer 2016, using a convection permitting (~2.5km) model over Western Europe and embedded in a global channel model at resolution of less than 20km, for years 1989 – 1995, 2030 – 2036 and 2020 - 2025. This data set will be available for open access.

•Comparison, of model rainfall simulation results, for ERA-Interim and CESM boundary conditions and observational climatology for the UK domain is relatively good for the years 1990 – 1995.

•Results of precipitation changes are shown over the UK and for the whole of the European area. The changes differ in different parts of the European continent.

•Evidence is provided that in the ***summer*** months (2031 – 2035) there is more average rainfall per event, but little change in each maximum rainfall rate. There are longer dryer spells, shorter wet spells and a generally dryer climatology. These results also appear to a lesser extent in the (2021-2025) data. Over much of Europe (not Northern Germany) there is an increase in the number of hours (~ 8hours) over the summer season.

•Evidence, not shown, of more rainfall in the ***spring*** months (2031 – 2035).

•10m mean wind speeds appear to be reduced, and there is an increase of 2 hours per day in the number of hours when the wind in less than $3ms^{-1}$ over much of Europe.

•The proposal is to use the extended data to input to the EFAS model, to compare with known floods in 1990-1995 and suggest possible changes in future decades.