Summer convective precipitation over the UK and Europe from a regional weather projection.

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A case study of possible future summer convective precipitation over the UK and Europe from a regional climate projection." Gadian et al. Int. Jou. of Climatology, 2018, Article DOI: 10.1002/joc.5336

Aim:

To examine past weather patterns by comparing convectively permitting model simulations with corresponding observations; then to examine patterns in future decades, with specific attention here to summer convective precipitation over Western Europe.

Objectives:

- Description of the experimental set up.
- How well does the weather model represent rainfall in a simulation for the 1990-1996 and how does it compare with observations.
- How does the rainfall change with regard to both convective parameterization and convective permitting simulations in future simulations.
- How does the nature of the rainfall change, and the ensuing weather patterns and meteorology.
- How this approach could be applied to the Indian sub-continent region.

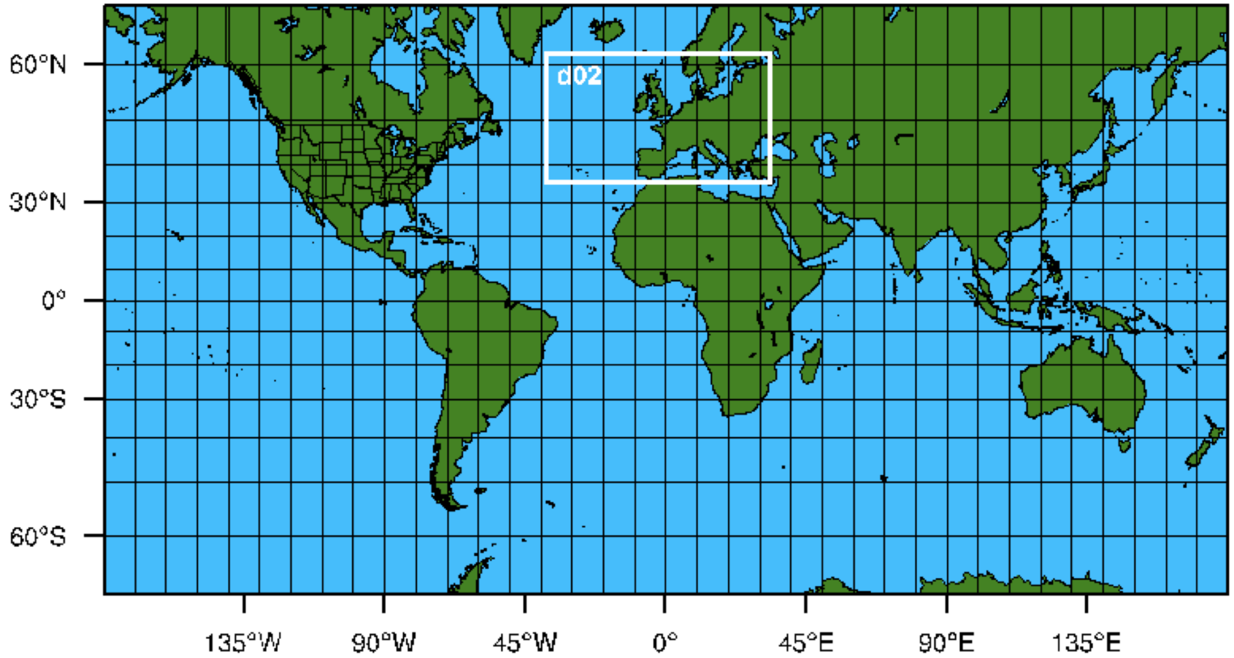


Figure 1.
Domain structure for the simulation. The outer domain (d01) resolution is 20km at +/- 30° and 8km at 68° N/S. The inner domain (d02) is one way nested at a ratio of 5:1

Figure 1 displays the domain structure used, with resolution from < 3.2km and 2.0km at 35^0N and 61^0N in the inner domain, d02, increasing by a factor of five for the outer domain, implying resolutions ~O(3km) and ~O(12km). The outer domain covers 95% of the globe and 51 vertical stretched levels with a lid at 10mb. 1731 E-W grid points in both domains and 907 and 1001 grid points in the N - S directions in the outer and inner domains, respectively. CESM boundary conditions drive the simulations. Kain Fritsch , WSM6 microphysics, YSU boundary layer and IGBP-MODIS, a 4 layer Noah land surface schemes and CAM radiation schemes are used.

Boundary Data	Domain / Source	Period of Simulation	Seasonal Average Precipitation
Era-Interim	d01 ~ O (12km)	(1990-1995)	236 mm
Era-Interim	d02 ~ O (3km)	(1990-1995)	221 mm
CESM version 1	d01 ~ O (12km)	(1990-1995)	225 mm
CESM version 1	d02 ~ O (3km)	(1990-1995)	204 mm
CEH observations	**Met Off. data**	**(1990-1995)**	**205 mm**
CESM version 1	d01 ~ O (12km)	(2031-2036)	188 mm
CESM version 1	d02 ~ O (3km)	(2031-2036)	182 mm

Table 1:

Six year average UK precipitation totals for summer months JJA for the control period (1990-1995) from the CEH observations and from the model simulations. Precipitation averages for the period (2031-2036) are also included for both domains.

Boundary Data	Domain / Source	Period of Simulation	Seasonal Average Precipitation
CESM version 1	d01 ~ O (12km)	(1990-1995)	264 mm
CESM version 1	d02 ~ O (3km)	(1990-1995)	196 mm
CESM version 1	d01 ~ O (12km)	(2031-2036)	254 mm
CESM version 1	d02 ~ O (3km)	(2031-2036)	177 mm

Table 2:

Six year average European domain precipitation average totals for summer months JJA for the control period (1990-1995) and for the period (2031-2036), for the low and high resolution simulations.

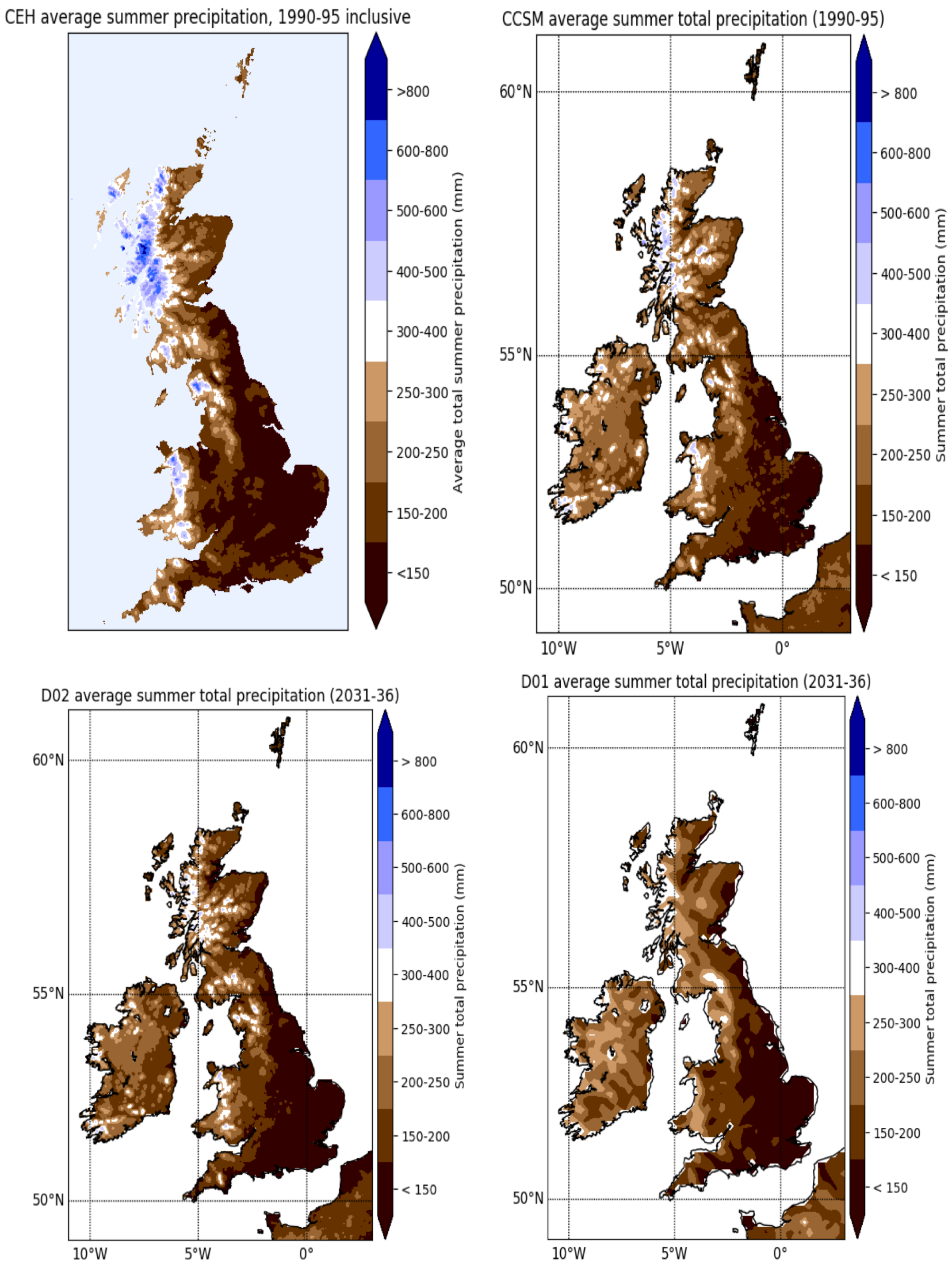


Figure 2.

Comparison of current and future precipitation patterns for the UK (JJA). Upper left panel indicates the UK precipitation amounts for summer (1990-1995) from the Centre of Ecology and Hydrology [CEH].

Upper right panel indicates the corresponding values from the high resolution ~ O(3km) driven by CESM data for (1990-1995).

The lower panels show the model output data for years (2031-2036) driven by CESM data, for the inner and outer domains, with resolutions ~O(3km) and ~O(12km) respectively.

All plots use the same colour scale.

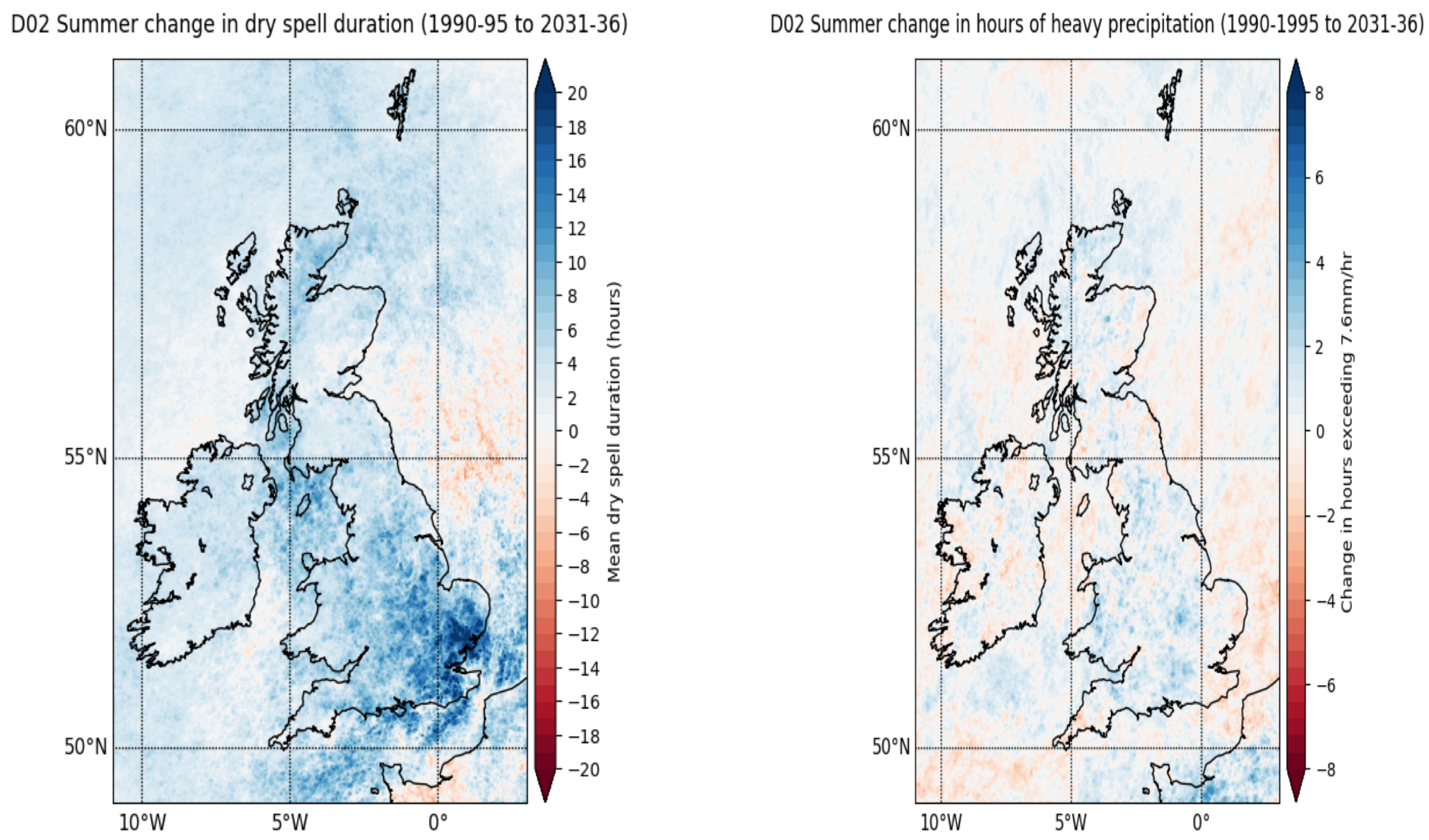


Figure 3.

Summer, (JJA), UK plots. Left: changes in dry spell duration, for the high resolution ~ O(3km) , domain, D02, Right: changes in heavy precipitation (>7.6mm/hour) for high resolution; the changes are produced by subtracting the (1990-1995) from the (2031-2036) average values at each pixel.

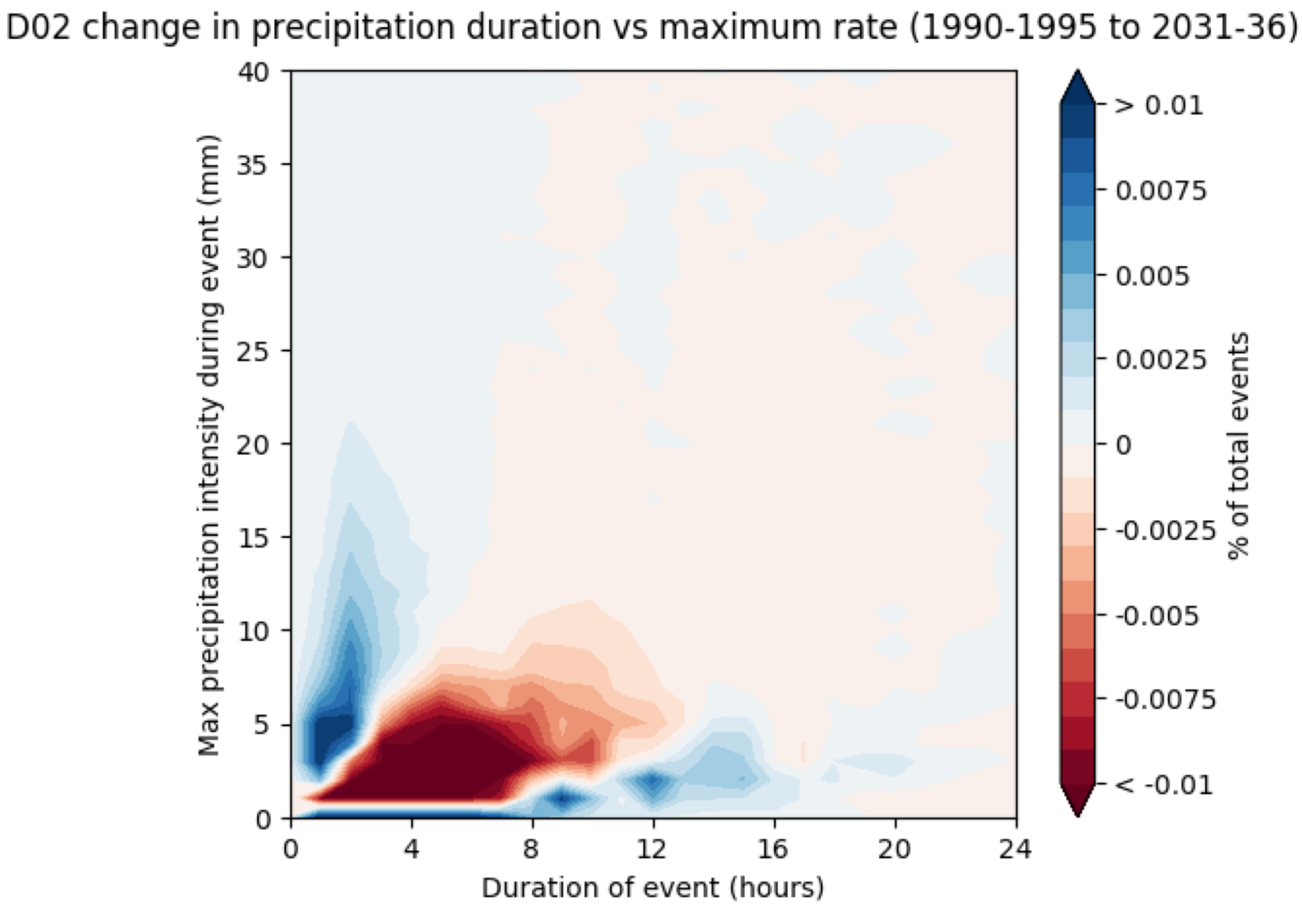


Figure 4.

Summer, (JJA), UK plots. Intensity versus event duration plot for the difference in high resolution data ~ O(3km) , domain, D02. Difference in precipitation intensity for (1990-1995) and (2031-2036); Changes are produced by subtracting the (1990-1995) from the (2031-2036) average values at each pixel.

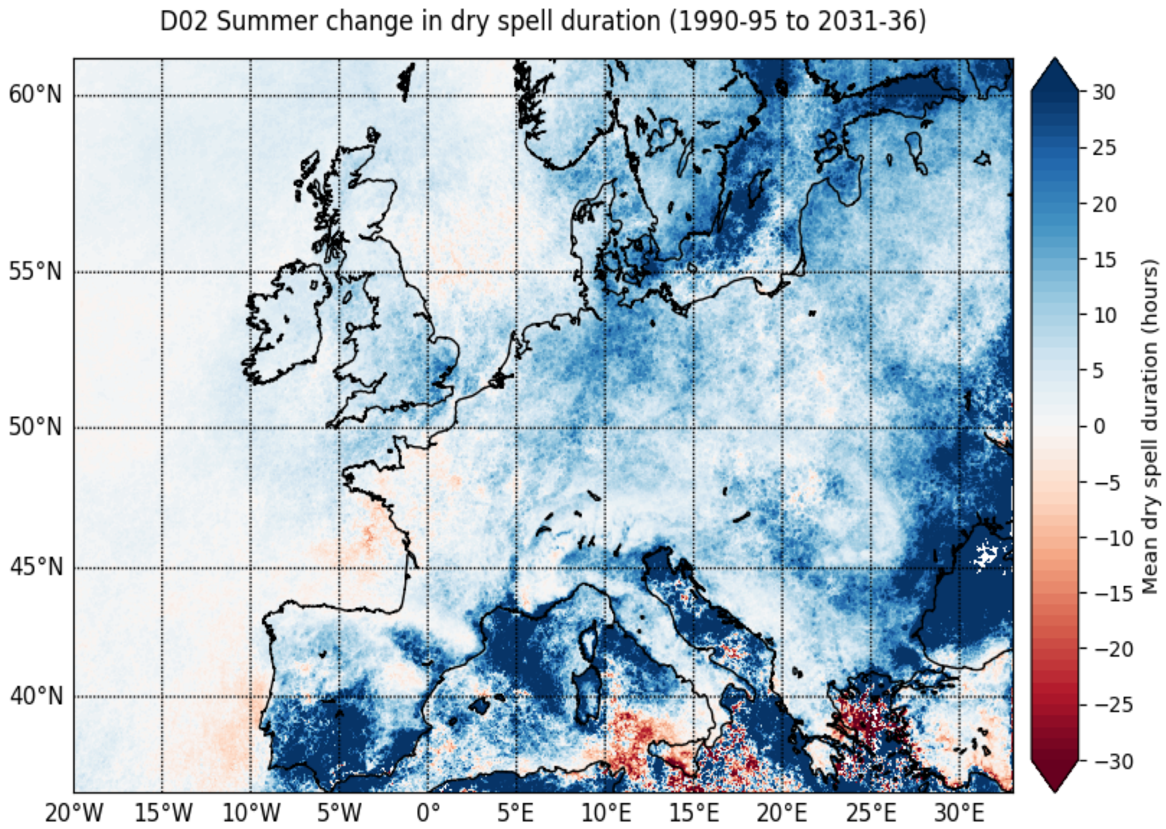


Figure 5.

Summer, JJA: Change in dry spell event duration, for high resolution simulations, The changes are derived by subtracting the (1990-1995) from the (2031-2036) average values at each pixel.

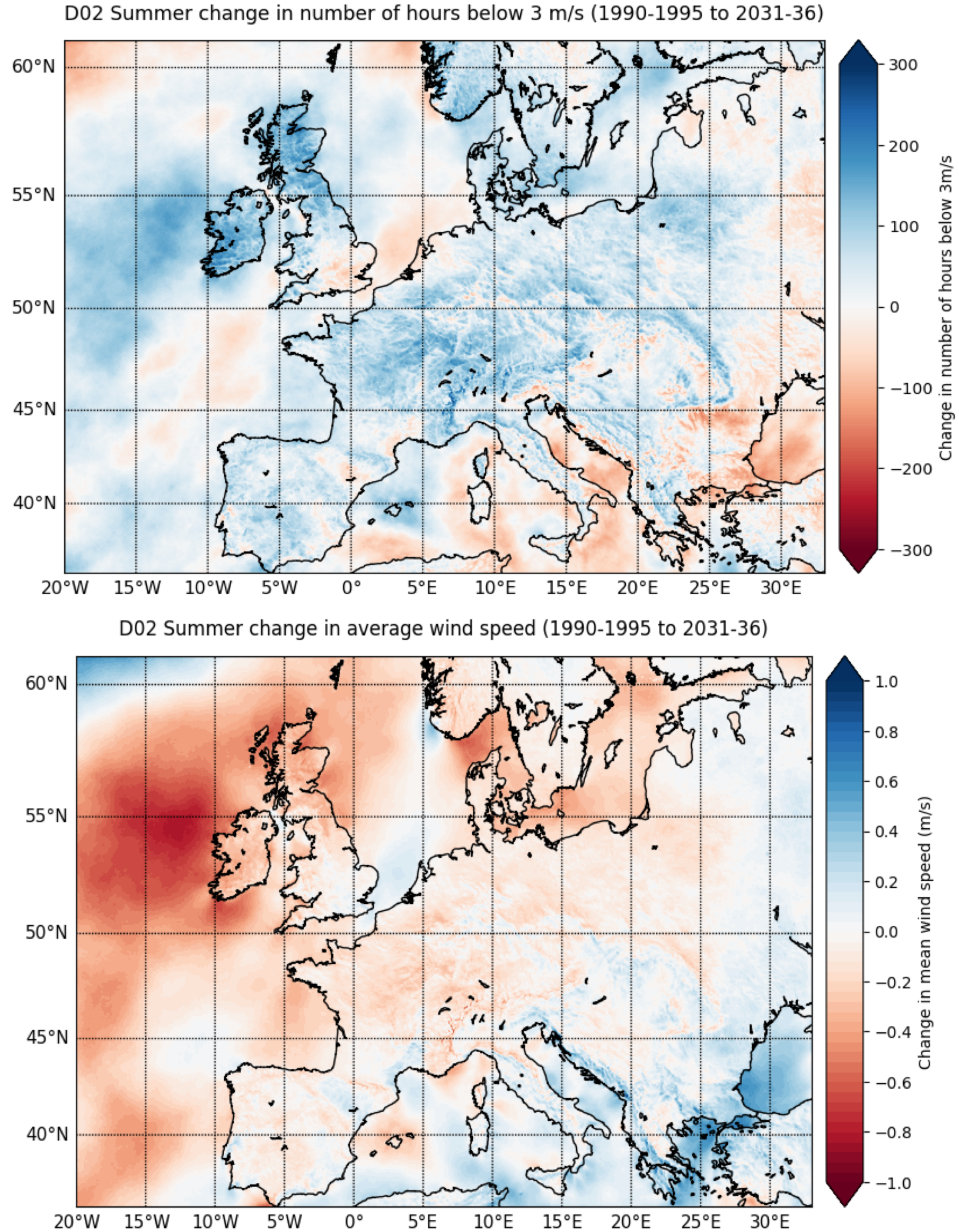


Figure 6.

Summer, JJA, changes in 10m wind and the change in the number of hours where the wind speed is less than 3ms^{-1} at 10m, using the high resolution ~ O(3km) simulations

Summary and Key Points.

This is an analysis of convective precipitation over the whole European domain, (the inner model domain) which large enough to enable several day cycles, using time steps that can explicitly resolve air motions.

The results from the high resolution convection permitting simulation ~ O(3km) suggests that the lower resolution K-F convective parameterisation ~ O(12km) simulations do not always replicate the convective changes and produce a larger effective precipitation efficiency.

The UK only results for (1990-1995) are in good agreement with the six year observed precipitation totals with the convection permitting simulations.

For the future simulation (2031-2036), especially in the south east of the UK, the results suggest that the summers will possibly be drier, with longer dry spells, shorter wet spells and heavier precipitation.

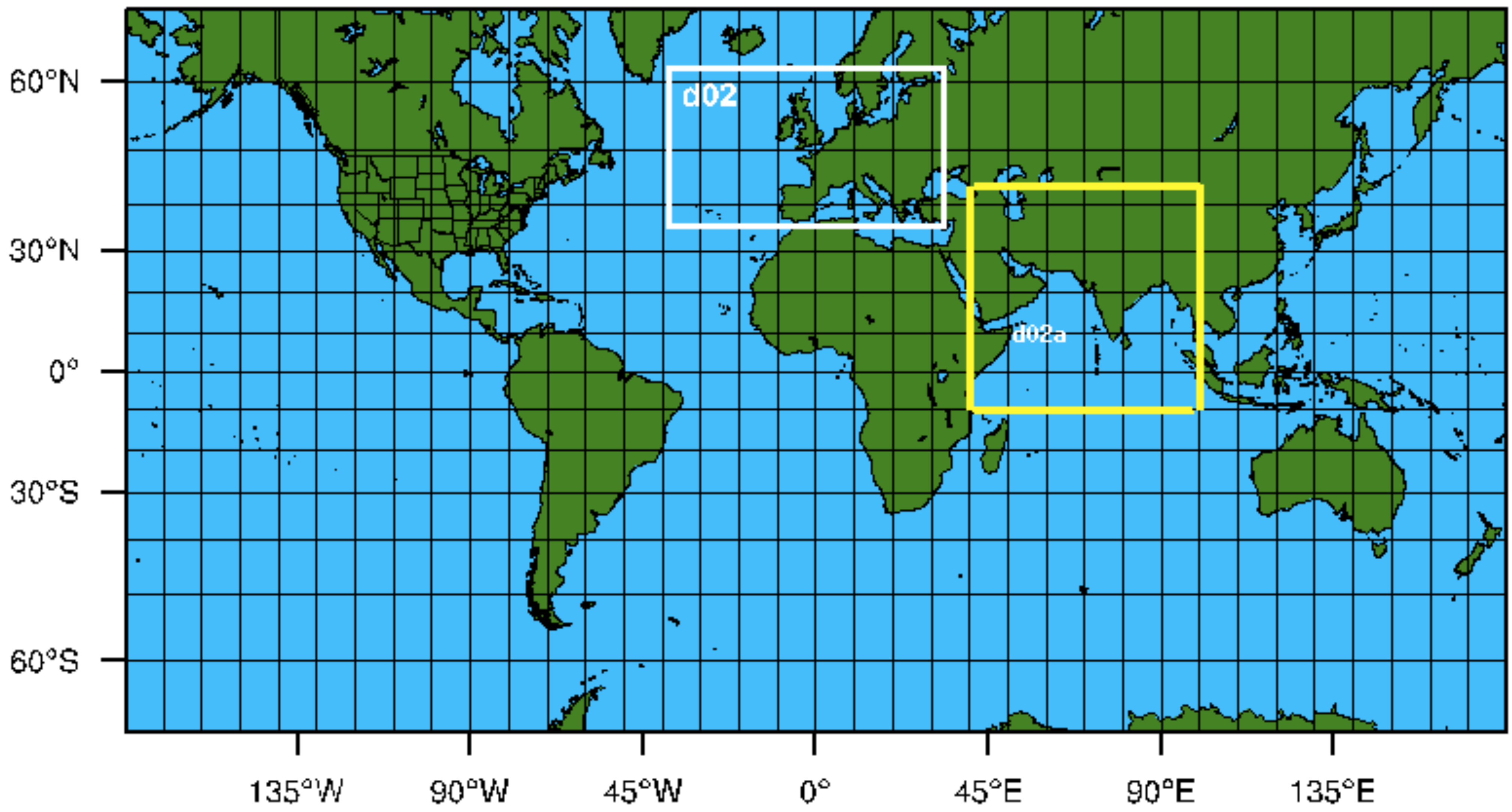
Overall, the UK will be ~ 10% dryer for the summer periods assessed.

The K-F convection parameterisation simulations underestimates the importance of short, (< 4 hours) heavy precipitation (>7.6mm/hour) events, which is more apparent in the future time period.

The convection permitting solutions capture about ~ 10 times as many of these short heavy precipitation events, and both convection approaches suggest a ~ 20% increase in their contribution to precipitation by (2031-2036). The average precipitation intensity per event increases.

The UK domain results are mirrored in the European domain. With longer drier periods and shorter wet events suggested, the results are possibly more pronounced. The increase in average precipitation for each event is even more apparent over the European domain. This will result in more flash floods over Europe in restricted catchments areas and have implications for agriculture.

Associated with this is an average increase of approximately 150 hours in the occurrence of 10m summer wind speeds of less than $3ms^{-1}$.



Suggestion (2) nested sub-domain, d02a for the Indian sub-continent region. This region will be adjusted to encompass the dynamical processes. The outer domain runs are completed (for domain d01) and only the inner domain needs to be calculated. Data in the outer domain is at a resolution of < 20km, but uses convective parameterization. The outer domain data is already available.

Take home message:

- **For summer convective precipitation in future decades in Western Europe, there will be longer dry spells with shorter wet spells with more shorter but heavier wet events. Convectively permitting solutions capture ~ 10 times more than convectively parameterised simulations, with 20% increase in their total precipitation contribution; Europe will be 10% dryer.**

- **The current data is being used to look at storm tracks, precipitation in other seasons, meso-scale dynamics and blocking structures etc.**

- **The basic outer domain can be used to look at the changes in weather patterns at 20km resolution over most parts of the world, although the convective parameterization results are not as good. Importantly, a new inner domain can be spawned to analyse convective permitting models to examine, for example, changes to the Indian monsoon and precipitation patterns.**

- **This data set is available for different areas of the globe, and has potential to be run a high resolution simulation for application to the Indian sub-continent.**

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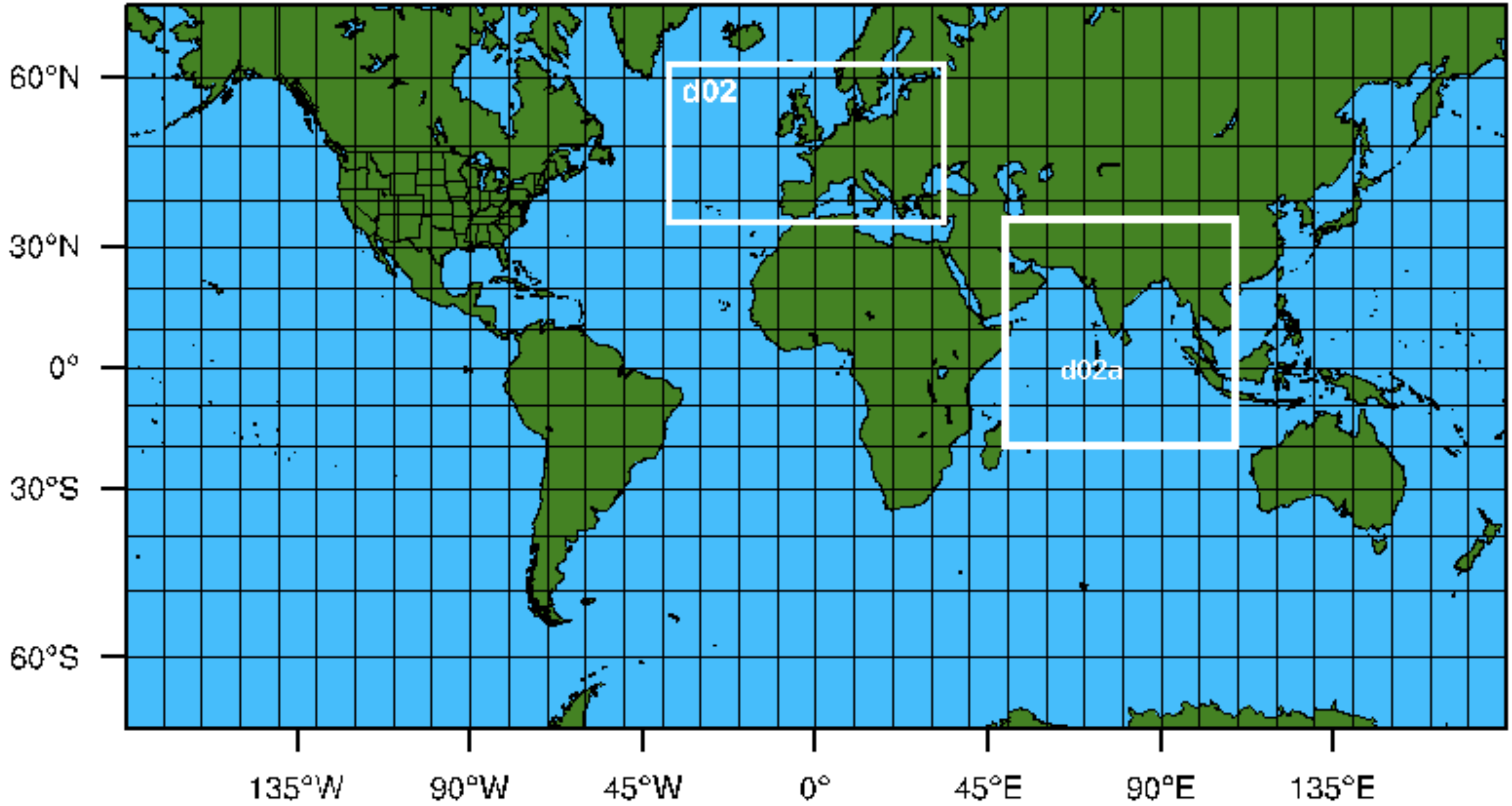

Suggested nested sub-domain, d02a for the Indian sub-continent region. This region will be adjusted to encompass the dynamical processes. The outer domain runs are completed (for domain d01) and only the inner domain needs to be calculated. Data in the outer domain is at a resolution of < 20km, but uses convective parameterization. The outer domain data is already available