Department for Environment Food & Rural Affairs
Department for Business, Energy & Industrial Strategy
Met Office Hadley Centre
Environment Agency

European Circulation Indices: Jet Stream Position and Strength

Introduction to UKCP European Circulation Indices

This is one of a series of factsheets that describe a set of indices representing large-scale drivers of UK weather and climate in UKCP Global (60km) - a product from the latest UK Climate Projections published in 2018 consisting of 28 global climate model simulations. The factsheets and indices data are aimed at users wishing to carry out in-depth analysis of climate model behaviour.

The day-to-day or year-to-year variations in large-scale atmospheric circulation conditions over the Atlantic and wider European region drive significant fluctuations in the rainfall, temperature or wind strength and direction that might be experienced in a particular part of the UK. There are a number of different ways of characterising these large-scale drivers of UK and European climate. The index covered in this factsheet describes the latitude and strength of the Atlantic Jet Stream. Other factsheets describe European weather patterns (sets of 8 and 30) and the North Atlantic Oscillation (NAO). The factsheets are available on the UKCP web pages and the metrics are available through the CEDA Archive.

The European circulation indices provide users with the opportunity to explore the impact of changes in the drivers of variability and future changes on climate variables that may have more direct impacts, such as rainfall, windiness or local temperatures. How the large-scale drivers might respond to a warming atmosphere as a result of increasing greenhouse gases remains uncertain, contributing significantly to uncertainty in future changes in local weather and climate. Exploring projection in this way can improve our understanding of the changes that we see to UK climate in the UK Climate Projections and potentially help us to build confidence in UK climate impacts assessments.

This factsheet provides an introduction to the indices that describe the jet stream. We include some key results from analysis which show how realistically the models used in UKCP Global (60km) represent the strength and latitude of the jet stream compared to observations, and how the strength and latitude of the jet stream changes in the projections of future climate out to 2100 under RCP 8.5.

These indices are available for UKCP Global (60km) under a single high emission scenario (RCP 8.5). This 28-member dataset include 15 variants of the Met Office Hadley Centre's model (referred to here as 'PPE-15') and 13 models from other modelling centres around the world from the Coupled Model Inter-comparison Project 5 (referred to here as 'CMIP5-13'). These two ensembles are combined to form the 28-member UKCP Global (60km) in order to capture uncertainty associated with the choice of model used.

We recommend that users read the UKCP18 Science Overview (Lowe et al., 2018) to understand the different components of the projections and a comprehensive description of the underpinning science, evaluation and results; see the UKCP18 Land Science Report (Murphy et al, 2018).

What is the Jet Stream?

The Atlantic Jet Stream (or the 'eddy-driven jet') is a core of strong winds around 5 to 7 miles above the Earth's surface, blowing from west to east. Shifting jet stream patterns can have a big impact on UK weather, particularly by determining the position of the North Atlantic Storm track in winter. For example, read about the influence of the jet stream on the unusually wet October 2019 (https://blog.metoffice.gov.uk/2019/11/04/the-jet-stream-casts-its-shadow-over-the-uk-duringoctober/).

The winter jet stream over the North Atlantic has 3 'preferred' positions – at around 35-38°N, 45-47°N and 58-60°N Woollings et al. (2010). The position determines the path that weather systems and storms take across the Atlantic. This tri-modal pattern, and the long-term average frequency at which the jet takes each of the three positions, is reasonably well captured by the UKCP Global models[1] (Figure 1).

Figure 2 illustrates the differences in rainfall patterns associated with a strong jet in each of the three positions - when a strong jet is in the 'North' position (50-60°N) it brings wetter-than-average conditions to the northern Europe (Scotland and Scandinavia); conversely in the 'South' position (30-40°N) it is Southern Europe (Spain and Mediterranean Europe) that receive greater than average rainfall. The UK experiences greater-than-average rainfall when a strong jet is in its 'Mid' position (40-50°N).

It's important to note that there is large year-to-year natural variability in the number of days when the jet is in each of these three positions, which is one reason why some years are wetter and/or stormier than others in the UK.

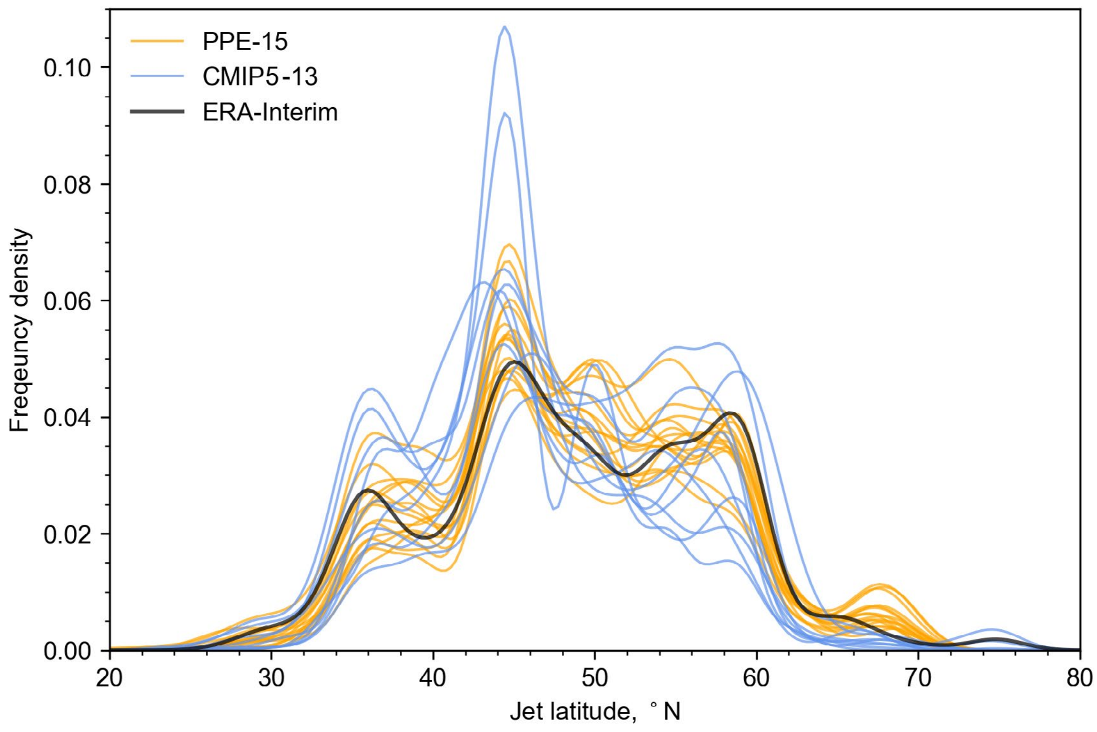

Figure 1 The tri-modal distribution of jet stream latitudes in the UKCP Global ensemble, PPE-15 (orange lines) and CMIP5-13 (blue lines) for the winter season (December, January and February - DJF), and in ERA-Interim reanalysis data (a quasi-observed dataset). The frequency distribution is a smoothed representation of the number of days that the jet sits within a given latitude interval during the period 1981-2000.

[1] We've compared the climate model results with a historical quasi-observed dataset, ERA-Interim. These quasi-observed datasets are produced by combining meteorological observations and a climate model to give a more complete picture of the climate during an observed period. Re-analysis datasets are particularly useful for evaluating how well a climate model simulates aspects of the atmosphere that are difficult to observe directly.

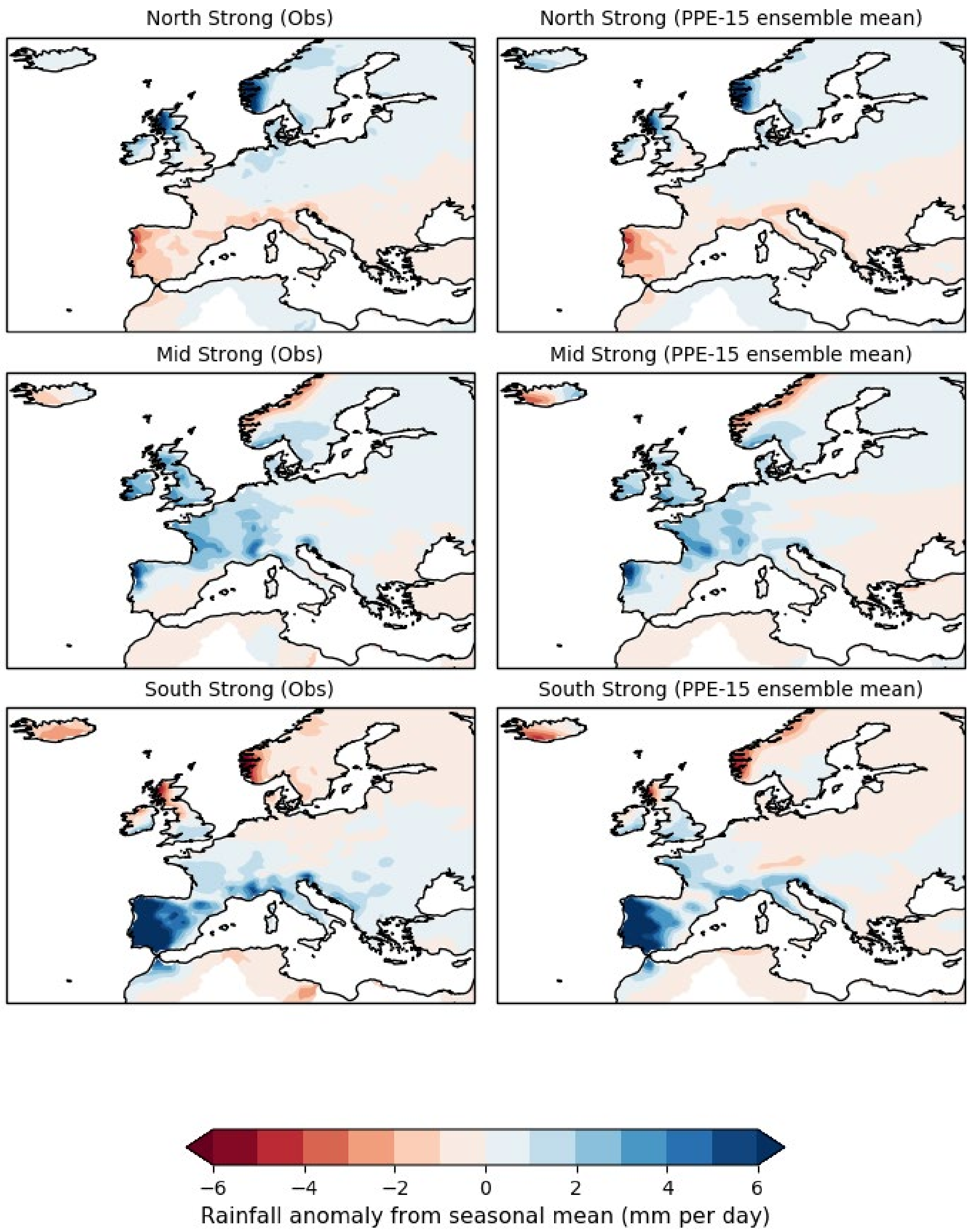

Figure 2 Average winter rainfall anomalies on days when there is a strong jet in each of the three "preferred" latitudes of the jet stream compared to the average winter rainfall (mm/day) for the period 1981-2000. 'North' indicates jet latitude is between 50-60°N, 'Mid' is 40-50°N, and South is 30-40°N and 'strong' means the jet strength is greater than 15 ms^{-1}. The observed results are shown on the left, and the average of all the models in the UKCP Global PPE-15 ensemble are shown on the right. Comparing the observations and the models indicates that the UKCP Global models capture the pattern of rainfall changes for each jet position quite well.

How does the strength and position location of the jet stream change in projections of future climate?

The projections show some degree of a shift towards more northern positions of the jet stream during the Autumn (SON) and Summer (JJA) seasons (Figure 3).

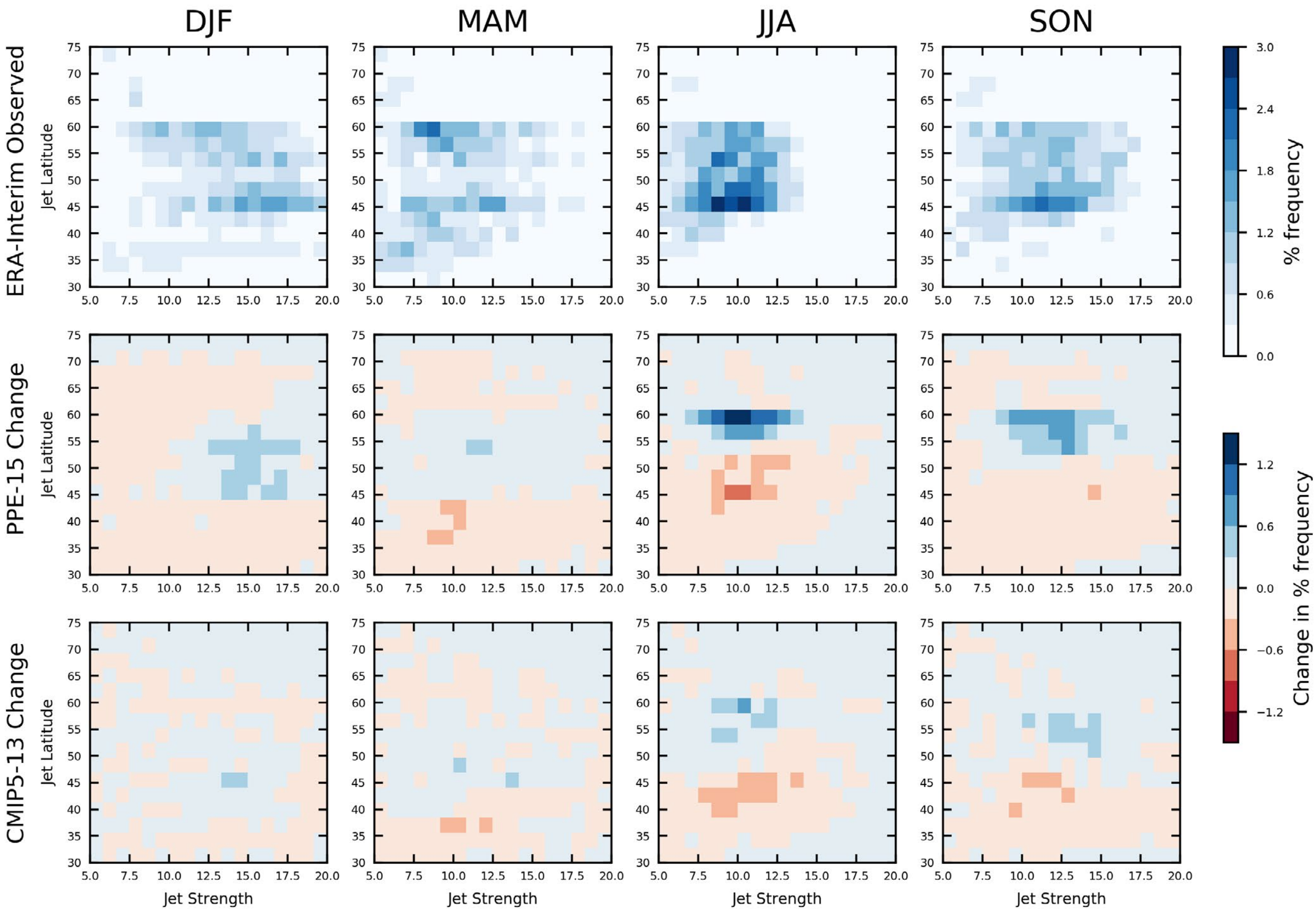

Figure 3 Projected changes in jet stream latitude and strength indices in the ensemble mean of the UKCP Global projections – changes are calculated between 1971-2010 and 2061-2100 under RCP 8.5. Also shown are 'present-day' frequencies of jet stream strength and latitude for the reference period 1970-2010 in ERA-Interim re-analysis (quasi-observations)[1]. PPE-15 refers to the 15 variants of the Met Office Hadley Centre's model, and CMIP5-13 refers to the 13 models from other modelling centres around the world from the Coupled Model Inter-comparison Project 5. Results are shown for winter (December, January February), spring (March, April, May), summer (June, July, August) and autumn (September, October, November).

What jet stream data are available?

Daily values of jet stream latitude (i.e. its location) and jet stream strength (i.e. wind speed) are available for UKCP Global under the RCP 8.5 emissions scenario for the period December 1899 to November 2099 from the CEDA Archive. The jet stream indices are not available for ensemble members 17 and 18.

The indices are calculated first by smoothing the tropospheric (850 hPa) zonal wind speed in the North Atlantic sector (0–60°W, 15-75°N) using a 5-day moving window. The location and magnitude of the maximum value in this smoothed daily field indicate the latitude and strength of the jet stream respectively. Further details can be found in Woollings et al. (2010).

This document can be cited as:

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References

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