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

European Circulation Indices: Weather Patterns

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 European weather patterns (sets of 8 and 30). Other factsheets describe the Atlantic jet stream (strength and latitude) 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 projections 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 use of weather patterns to describe the variability in European weather and climate. We include some key results from analysis which show how realistically the models used in UKCP Global (60km) represent the frequencies of these weather patterns compared to observations, and how the weather pattern frequencies 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 are weather patterns?

The atmospheric circulation over the North Atlantic and European region is highly variable from day to day. Many methods exist to describe this variability, however one method which is particularly illustrative is weather typing. In this approach a set of representative weather patterns are generated which describe the main patterns of daily atmospheric circulation over a region. They can be considered to show typical conditions, giving a simplified picture of the variety of conditions experienced.

The set of patterns described here was generated by categorising daily mean sea-level pressure (MSLP) (changes compared to the 1981-2000 average) into 30 weather patterns. Each day is classified by a weather type value 1-30. This is an iterative process, in which a series of sets of patterns were evaluated by meteorologists to ensure that a full range of circulation types affecting Europe were adequately represented (Neal et al., 2016).

These 30 weather patterns are also provided as an amalgamated set of 8 weather patterns. The 8 weather patterns are generally considered to be sufficient for exploring long-term trends where subtle differences in regimes are less important and they are shown in Figure 1. The larger set of 30 are more useful where greater differentiation between weather regime characteristics are important.

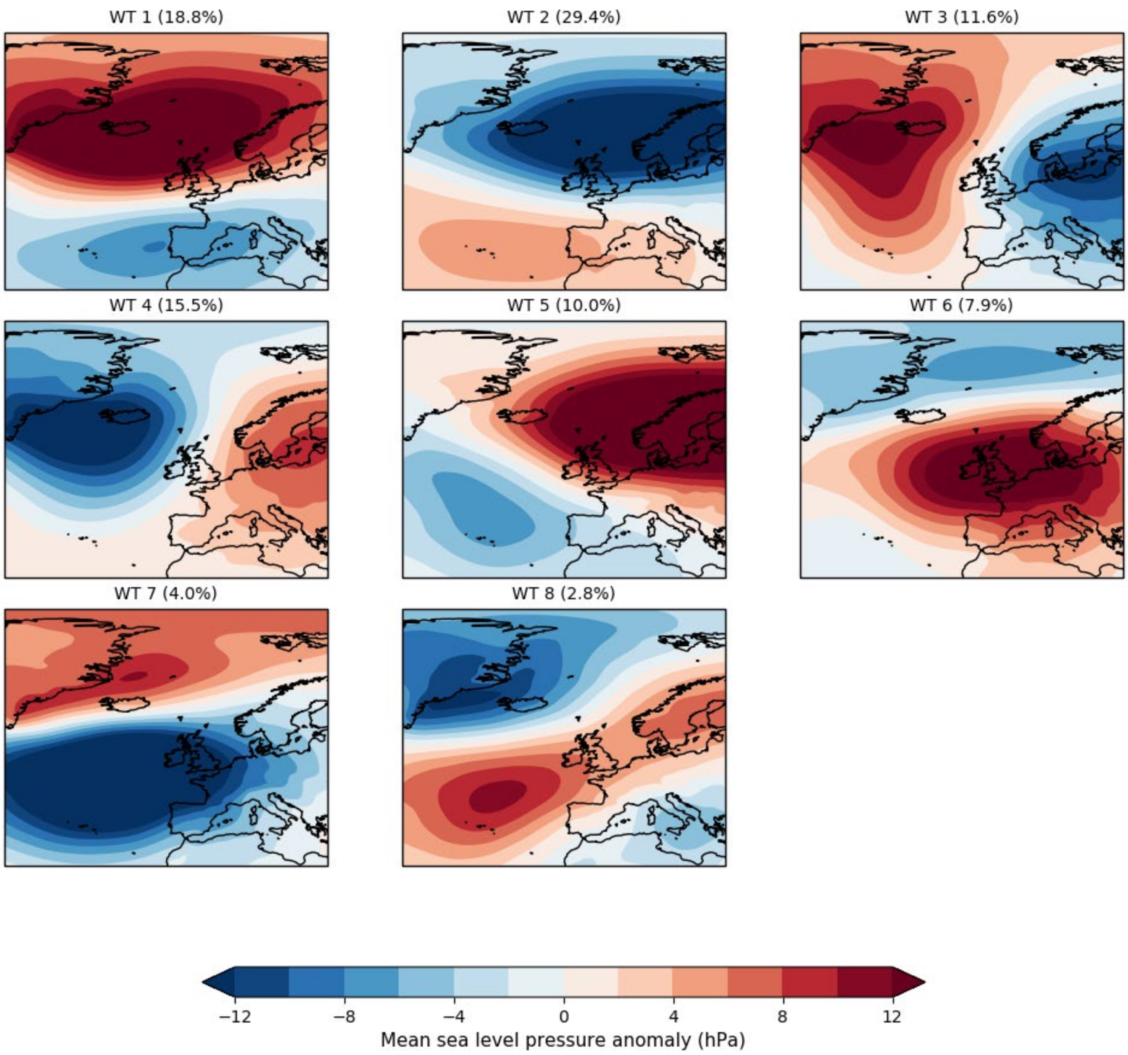

Figure 1 Observed mean sea level pressure anomaly or weather pattern for weather types (WT) 1-8, averaged over 1981-2000. Numbers in brackets are percentage of days when the WT occurs in winter (DJF) during 1981-2000.

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How realistically are the weather patterns represented in the models?

The UKCP Global models capture both the relative frequencies of the different patterns and their seasonal variations. For example, WT 2, which is characterised by low pressure over the UK and typically brings unsettled weather, occurs during a higher proportion of days in winter than in summer (Figure 2). However, there can be strong interannual and interdecadal variability in the relative frequencies of these weather patterns.

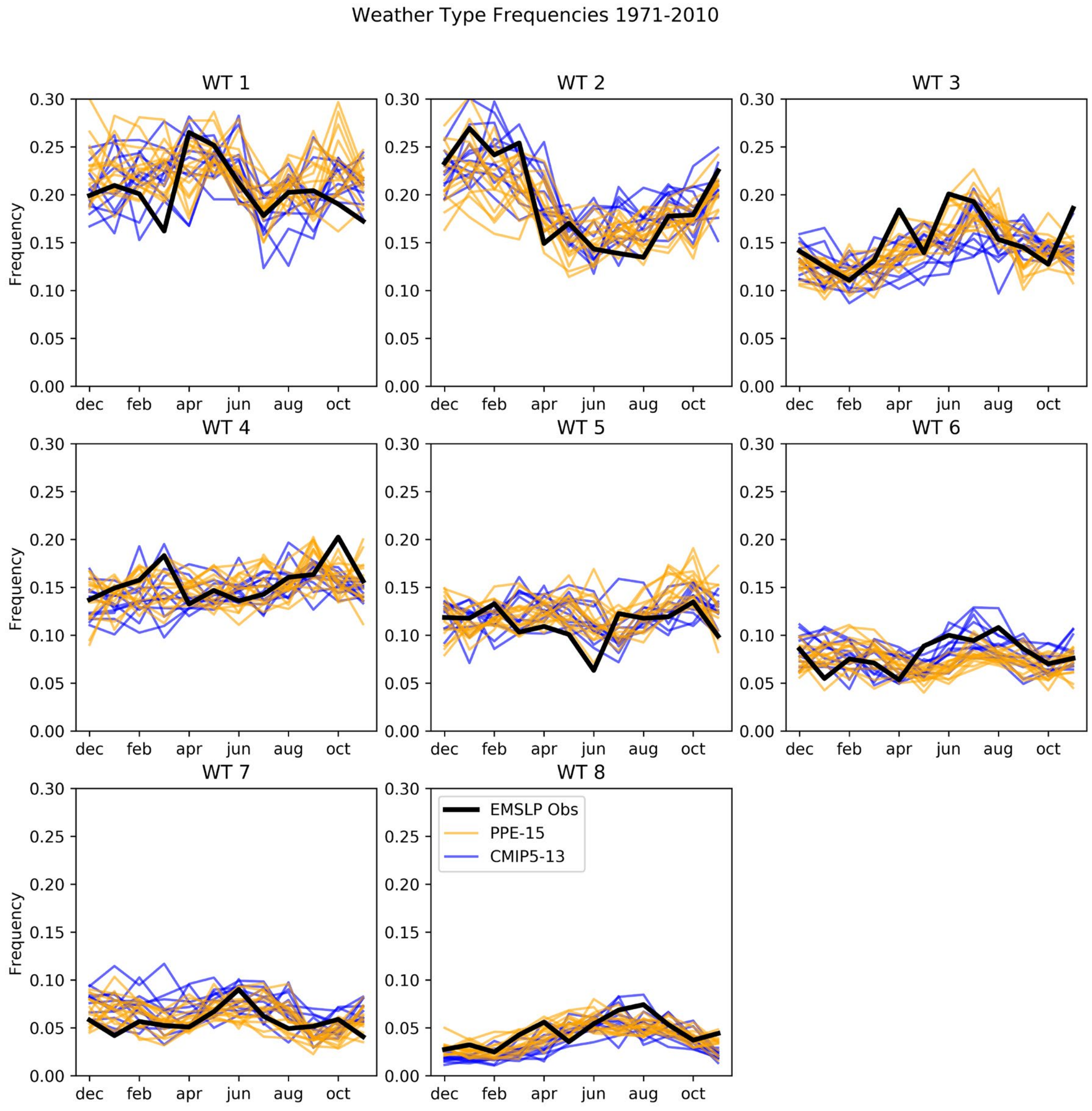

Figure 2 Frequency (proportion of days) when each of the 8 weather patterns occurs, by month of the year, in observed data (EMSLP Observations, black line) and the PPE-15 (orange) and CMP5-13 (blue) ensembles that comprise the UKCP Global datasets. Averaged over 1971-2010.

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How do the projections suggest the weather patterns to change in the future?

The response of the typical patterns and their variability to a warming atmosphere as a result of increasing greenhouse gases remains uncertain, contributing significantly to uncertainty in future changes in variables which have more direct impacts, such as precipitation, temperature and wind.

We can express the future changes in atmospheric circulation in terms of the changed frequency of each weather pattern, but also as changes in the characteristics of the weather associated with each synoptic weather pattern. Using weather patterns in this way can be useful because it helps us to separate the direct regional effects of a warmer atmosphere on our climate ('thermodynamic changes') from those that result from changes in regional circulation ('dynamical' changes'). This is useful because uncertainties in how the regional circulation might respond to climate change can contribute to significant uncertainties in key variables – for instance, whether a region might experience an overall increase or decrease in rainfall.

The projected changes in frequency of these weather patterns is shown in Figure 3. The PPE-15 ensemble members suggest more WT 2 days, which bring mild, unsettled conditions in the UK, and fewer WT 1 days (settled, dry conditions) in future winters (DJF), whilst the opposite is projected for summer months). These changes can be described as 'dynamical' changes'. The CMIP5-13 members however do not indicate such a clear set of 'dynamical' changes. The two sets of models, PPE-15 and CMIP5-13, between them therefore capture a wide range of uncertainty in the dynamical response. Users of UKCP might, for example, explore this uncertainty in the dynamical response by contrasting the different responses between PPE-15 and CMIP5-13.

The 'thermodynamic' changes are those that affect the weather experienced under a given weather pattern in a warmer climate. For example, the daily temperature associated with every weather pattern is expected to be warmer than in the current climate.

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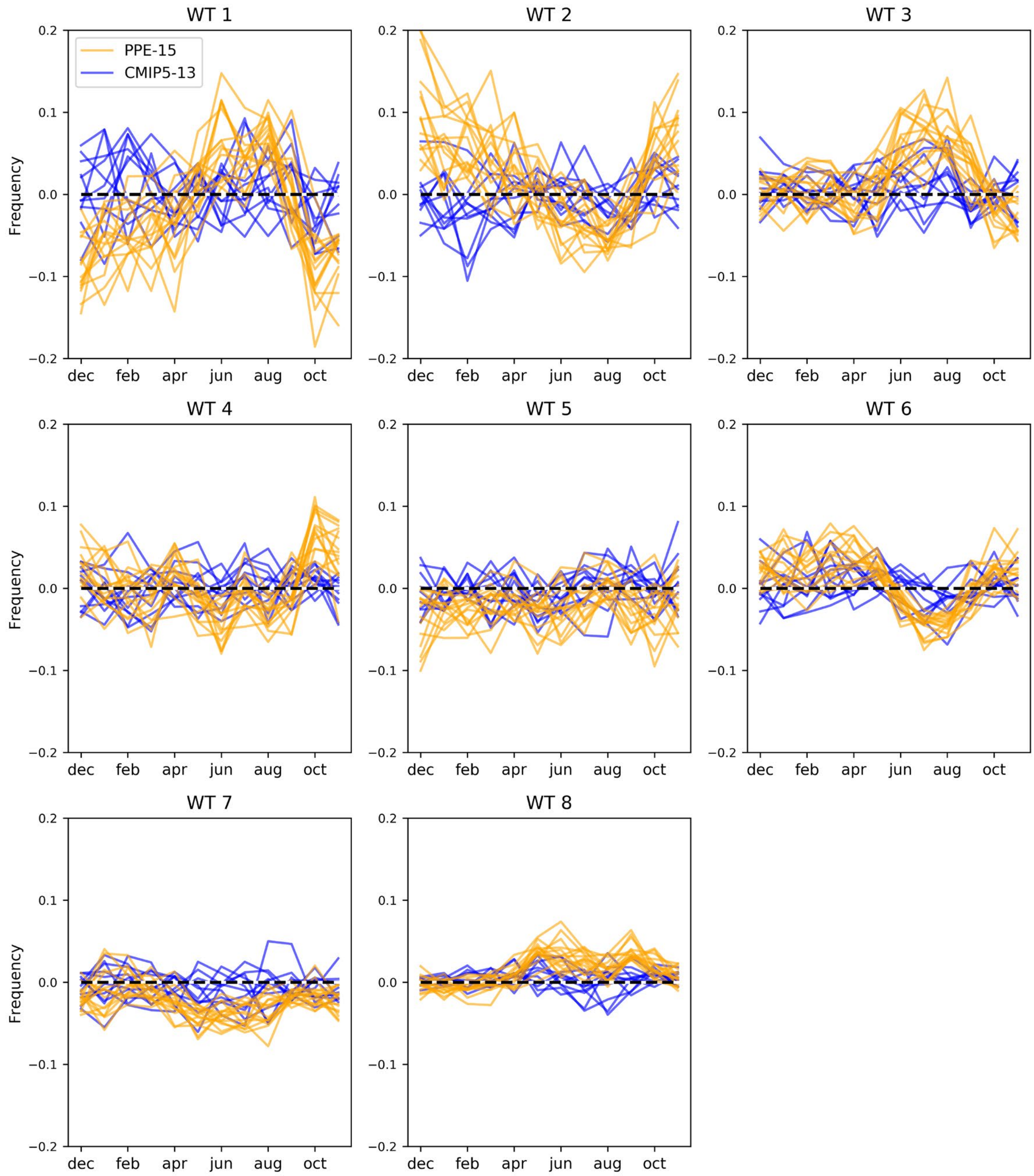

Figure 3 Projected changes in the proportion of days when each of the 8 weather patterns occurs, by month of the year, in UKCP Global (PPE-15 and CMIP5-13) by 2061-2100 compared to 1971-2010. Projections under RCP 8.5.

Examples of use

There are a number of examples of the use of weather patterns in weather forecasting (see Neal et al, 2016; 2018). The use of weather patterns is starting to gain popularity in climate change studies. For example, Kendon et al. (2020) explores the conditions that led to record winter temperatures being recorded in February 2019, when temperatures of 20°C were recorded in multiple locations around the UK. This broke existing records by 1.5°C, raising the question whether this was an indicator of future UK climate in a warming world. Kendon et al. (2020) analysed the meteorological set up that created the conditions behind that temperature record and then used the weather patterns to assess the role of dynamic forcing behind the occurrence of future winter temperature records.

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What weather pattern data are available?

The data available contain a daily timeseries of weather type (a numerical value of 1 to 8 or 1 to 30) for each member of UKCP Global using the RCP 8.5 scenario for the period December 1899 to November 2099. The weather patterns are not available for ensemble members 17 and 21. The data can be downloaded from the CEDA Archive.

Further information on the weather patterns can be found on the Met Office website and the 8 weather patterns are displayed in Figure 1.

This document can be cited as:

McSweeney, C. and Thornton, H. (2020) UKCP European Circulation Indices: Weather Patterns. UKCP Factsheet. Met Office.

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