EuroTempest Climate Signals Factsheet

There are a number of, sometimes competing, climate signals that can influence the weather in the UK. Relationships between the weather experienced in the UK and these signals are generally not strong enough to form the basis of skilful, definitive forecasts but they can often be suggestive of which weather types may be more likely to prevail.

This factsheet provides background information on the climate signals considered in the EuroTempest seasonal forecast assessment and endeavours to explain the processes through which these signals may influence the weather of the UK.

THE NORTH ATLANTIC OSCILLATION

The North Atlantic Oscillation (NAO) is generally regarded as the primary mode of natural variability in the Atlantic. In its simplest form, the NAO describes the variability in the large-scale pressure pattern over the North Atlantic. Typically, high pressure is located over the Azores islands, off the coast of Portugal, while regions of relatively lower pressure are located over Iceland. The NAO describes the fluctuation between periods of relatively larger and smaller pressure differences between these two locations. In turn, changes in the magnitude of the pressure difference are associated with changes in the strength and orientation of the North Atlantic jet stream and therefore the weather experienced across the UK.

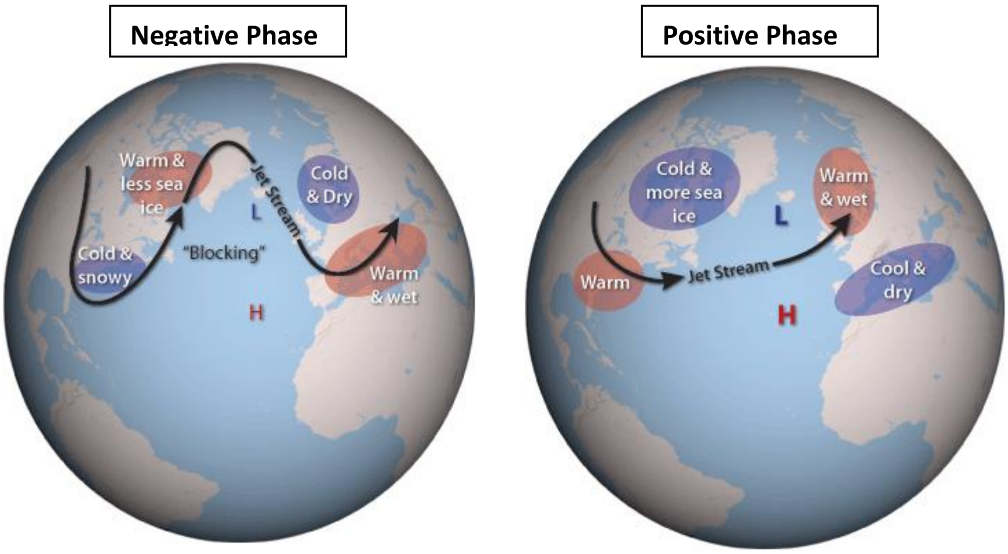

Figure 1: Schematic of the North Atlantic Oscillation. Source: [Met Office]

Implications for the UK

The NAO can be represented as a simple numeric index, negative values of which indicate periods when the pressure difference between the Azores and Iceland is smaller than usual, while positive values indicate the reverse.

During negative phases, the weakened pressure gradient is associated with a weaker North Atlantic jet stream, resulting in the dominance of airmasses from the east and north-east and a reduction in the frequency and intensity of storms being brought in from the west.

Therefore, when the NAO is in a negative phase, the UK is more likely to experience periods of colder and drier weather.

In contrast, during positive phases, the strengthened pressure gradient is associated with a stronger North Atlantic jet stream, resulting in the dominance of westerly air flow and therefore an increased frequency and intensity of North Atlantic storms. Hence, when the NAO is in a positive phase, the UK is more likely to experience periods of stormy, mild and wet weather.

THE ARCTIC OSCILLATION

The Arctic Oscillation (AO) describes the variability in the pressure pattern over the Arctic and is measured in terms of the pressure difference between the Arctic and the midlatitudes.

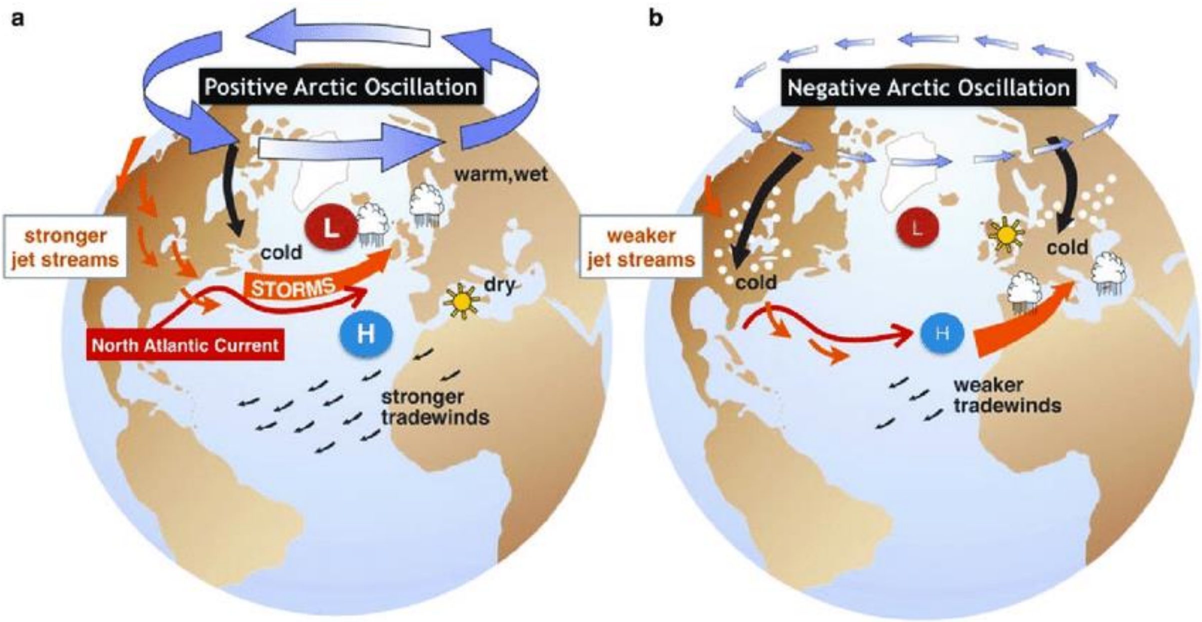

Figure 2 - Schematic of the Arctic Oscillation. Source: Campos and Horn 2018

Implications for the UK

The AO can be represented as a simple numeric index, negative values of which indicate periods when the pressure difference between the Arctic and the midlatitudes is smaller than average, while positive values indicate a larger than average pressure difference.

Similarly to the NAO, during negative phases of the AO, the weakened pressure gradient results in a weakened North Atlantic jet stream, resulting in a reduction in the frequency and intensity of storms being brought in from the west. Therefore, when the AO is in a negative phase, the UK is more likely to experience periods of colder and drier weather.

In contrast, during positive phases, the strengthened pressure gradient is associated with a stronger North Atlantic jet stream, resulting in the dominance of westerly air flow and therefore an increased frequency and intensity of North Atlantic storms. Hence, when the AO is in a positive phase, the UK is more likely to experience periods of stormy, mild and wet weather.

THE POLAR VORTEX

Typically, low surface pressure over the Arctic results in an anticyclonic circulation over the Arctic high up in the stratosphere, known as the Polar Vortex (PV). The strength of this circulation fluctuates due to changes in the depth of the Arctic low and can determine the ability of Arctic air to influence the weather of the UK. Due to the relationship between the strength of the PV and the low pressure over the Arctic, the PV can be disrupted by the phase of the AO.

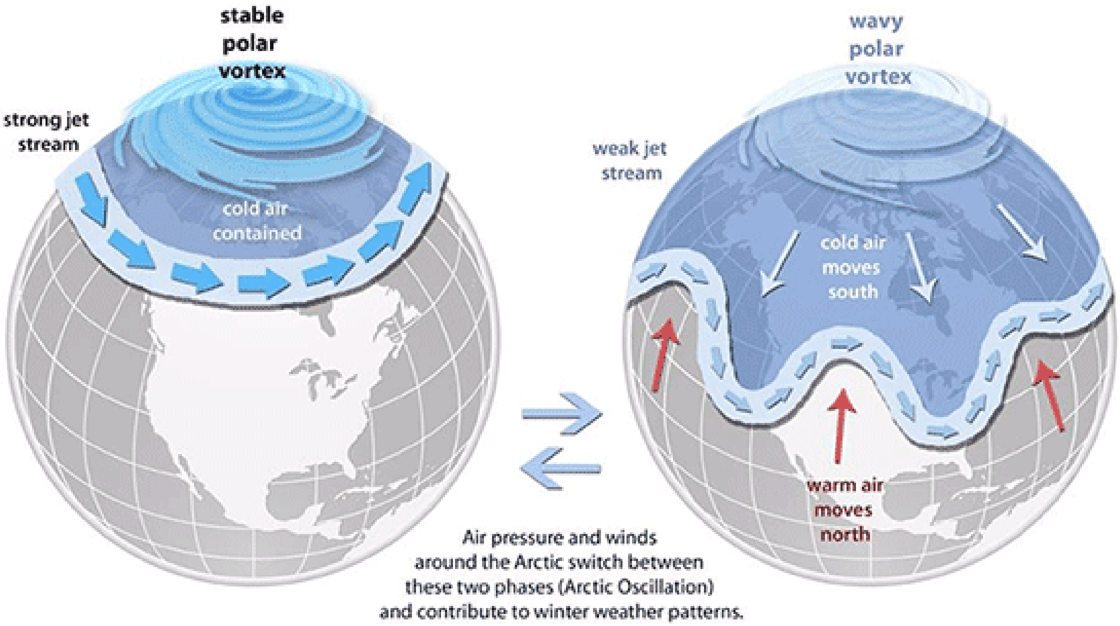

Figure 3 - Schematic of the Polar Vortex during times when the polar vortex is strong (left) and when it is weak (right). Source: NOAA

Implications for the UK

When the low pressure centre is weaker than normal, for example during the negative phase of the AO, the PV weakens allowing the southward penetration of cold arctic air over the UK. During periods where the PV completely breaks down, due to the presence of high pressure over the Arctic, Sudden Stratospheric Warming events can occur. Therefore when the PV is weaker than normal, the UK is more likely to experience periods of colder and drier weather.

When the low pressure over the Arctic is deeper than normal, for example during the positive phase of the AO, the PV is strengthened. A strong PV reduces the likelihood of cold Arctic air flowing southwards and allows the North Atlantic jet stream to strengthen, bringing mild, wet and stormy conditions to the UK.

NORTH ATLANTIC SEA SURFACE TEMPERATURES

Sea surface temperatures (SSTs) in the North Atlantic basin primarily influence the weather of the UK via the impact of the ocean on the atmospheric pressure distribution and therefore the characteristics of the NAO.

Implications for the UK

When SSTs are colder than average in the North Atlantic basin, a negative NAO is favoured resulting in weaker and less frequent storms reaching the UK. In contrast, when SSTs are warmer than average in the North Atlantic, a positive NAO is favoured increasing the likelihood of stormy, mild and wet weather for the UK.

EURASIAN SNOW AND ARCTIC SEA ICE EXTENT

High snow cover increases the proportion of incoming solar radiation that is reflected back to space, therefore cooling the surface and the lower atmosphere and in turn, increasing atmospheric pressure. Depending on the location of the snow, variation in the extent of cover can influence atmospheric circulation patterns and therefore the weather experienced.

Sea ice insulates the ocean, reducing the transfer of heat from the ocean to the atmosphere when concentrations are large and vice versa. During periods of low sea ice, the transfer of heat from the ocean to the atmosphere is anomalously high resulting in the production of atmospheric waves which also influence circulation patterns.

Implications for the UK

Changes in Eurasian snow cover extent during autumn have been found to influence the UK weather during the subsequent winter months. When Eurasian snow cover is high, high pressure over Siberia is more likely to intensify, resulting in an increased chance of blocking events over Europe as well as a weakening of the PV. Both blocking events and a weakened PV are associated with cold and dry conditions over the UK. In addition, when high Eurasian snow cover coincides with low Arctic sea ice extent the associated atmospheric circulation changes resemble negative periods of the AO and NAO, further suggesting an increased likelihood of cold and dry conditions. In contrast, when Eurasian snow cover is low and Arctic sea ice is above average, positive NAO events are favoured, resulting in an increased likelihood of warm, wet and stormy weather across the UK.

THE EL NINO SOUTHERN OSCILLATION (ENSO)

ENSO is considered to be the major mode of climatic variability globally. In it's simplest form, ENSO describes the fluctuation of sea surface temperature distribution across the Pacific Ocean and the resultant response of atmospheric pressure to these changes. In neutral conditions, SSTs are warmer in the western part of the Pacific basin and colder in the east, resulting in wetter conditions being favoured in the west and drier conditions in the east. During a La Nina event, this pattern is exacerbated while under El Nino conditions the western equatorial Pacific becomes cooler and the eastern equatorial Pacific warmer, therefore shifting the preferred location of precipitation.

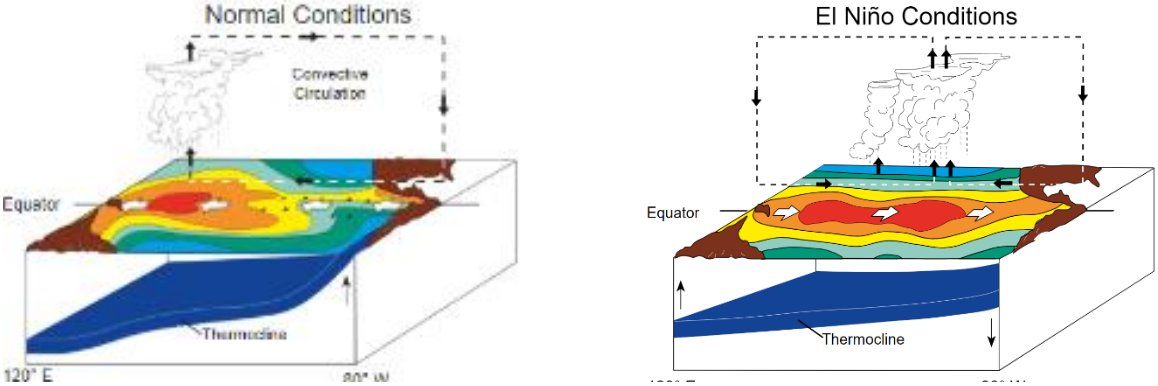

Figure 4 - Schematic of the El Nino Oscillation during a neutral phase (left) and an El Nino phase (right). Source: NOAA

Implications for the UK

Despite each ENSO event being unique, the impacts of ENSO are relatively well defined in many parts of the world. Although the signal is less clear in the UK, there is some evidence linking El Nino events to an increased likelihood of positive NAO conditions during early winter months, therefore suggesting stormier, milder and wetter conditions for the UK during these events. However evidence has also been proposed by the Met Office which suggests an increase in high pressure over the UK during El Nino during the later winter months, resulting in the increased likelihood of cold, dry weather during the January, February, March period.

THE QUASI-BIENNIAL OSCILLATION

The Quasi-Biennial Oscillation (QBO) is a regular oscillation between westerly and easterly phases of the equatorial winds in the stratosphere. The state of the QBO influences the strength of the North Atlantic jet stream and therefore can impact the weather experienced by the UK.

Implications for the UK

During westerly phases of the QBO, the jet is more likely to be strong, resulting in an increased likelihood of stormy, mild and wet weather for the UK. In contrast, during easterly phases of the QBO, the chance of the jet stream being weak increases, resulting in fewer storms and colder and drier conditions for the UK. In addition, during easterly phases of the QBO sudden stratospheric warming events are more likely to occur, therefore increasing the chance of cold conditions over the UK.

THE MADDEN JULIAN OSCILLATION

The Madden Julian Oscillation (MJO) describes the eastward propagation of regions of enhanced (active phase) and supressed (supressed phase) precipitation around the tropics. The MJO is characterised by 8 different phases which describe the location of the increased precipitation, primarily over the Indian and Pacific Oceans.

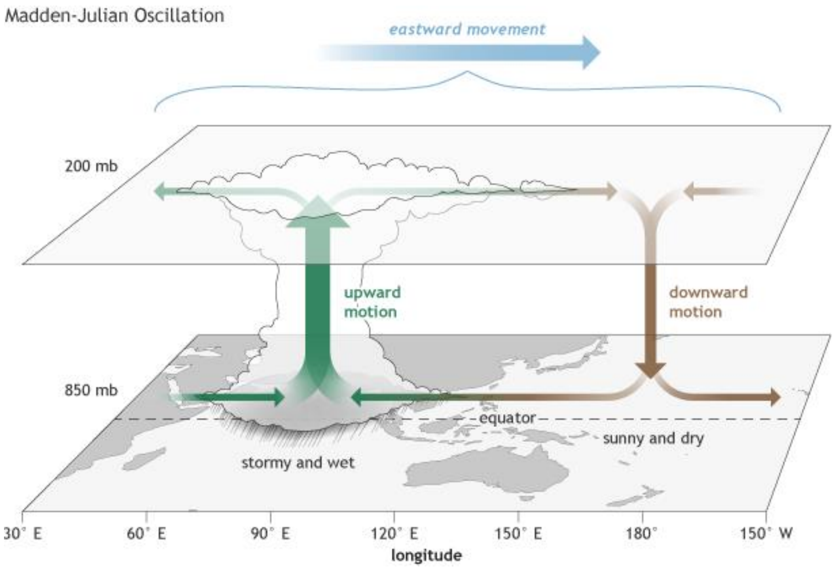

Figure 5 - Schematic of the Madden Julian Oscillation. Source: NOAA

Implications for the UK

Despite occurring in the tropics, the MJO has been found to impact the weather of the UK (as well as many other places around the world). The impact of the MJO on the UK weather depends on its phase:

- Negative NAO events are more likely to occur following phases 6 and 7 (active phase moving eastwards over the Pacific and weakening), resulting in cold and dry conditions over the UK.
- Positive NAO events are more likely to occur following phase 3 (MJO in its active phase over Africa, the Indian Ocean and parts of the Indian subcontinent), resulting in stormier, milder and wetter weather for the UK.

