

PAST SUMMER RAINFALL FROM OXYGEN ISOTOPES IN TREE-RINGS

Water is vital for the wellbeing of the environment and Humankind. Too little summer rainfall can damage plants and crops and too much causes flooding and prevents crops from ripening. Temperatures are rising and predicted to rise further, but what affect will these changes have on summer rainfall in the United Kingdom (UK)?

To predict changes in future rainfall, it is important to understand natural long-term changes, especially through known periods of past climate change. However, reconstructing past rainfall has proved extremely difficult, especially in mid-latitude regions such as the UK. Instrumental rainfall records are not long enough to understand natural variability. While, rainfall reconstructions from proxy sources, such as tree rings, are unreliable. Our team at Swansea University is pursuing an alternative approach, of analysing the chemical properties of the annual rings of oak trees: to allow us to understand, more clearly, past changes in summer rainfall.

Trees can store a record of past climate in their annual growth rings. Ring widths are normally measured, but as you move away from extreme environments, such as high mountains or desert margins, the signal contained in ring widths becomes weaker. In locations such as the UK, tree ring widths contain little information about past climate. However, it is possible to measure other aspects of tree growth, including the isotopes of the major elements that make up wood (carbon, oxygen and hydrogen).

Trees use water from summer rainfall to grow and produce annual rings. This water is made of Hydrogen and Oxygen (H_2O). The Oxygen atoms contained within water molecules can vary very slightly in mass, depending on the relative amounts of the heavy (^{18}O) and light (^{16}O) isotopes they contain. In summer rainfall, this variability is strongly linked to the prevailing weather conditions, and especially summer rainfall. Wet UK summers are dominated by westerly airflow from the North Atlantic, during such summers rainfall is isotopically light. Dry summers are dominated by easterly airflow and what rainfall there is will be isotopically heavy (Figure 1, overleaf).

The isotopic signal of summer rainfall is preserved within the wood that trees use to make the rings of each year. We can extract cores from living trees and archaeological wood, such as ancient timbers from buildings. These cores are then cut into individual rings and the oxygen isotopes are analysed. We use the wood from several trees for each year (c. 10) to refine the signal.

The England and Wales precipitation (EWP) series is the longest of its type in the world beginning in 1766CE. The statistical match between the summer EWP and annual measures of oxygen isotopes, from multiple trees, across England and Wales, is strong and stable over the full length of the EWP. The statistical match over such a long period (c. 250 years) means that we will have a high level of confidence in our reconstruction (Figure 2, overleaf).



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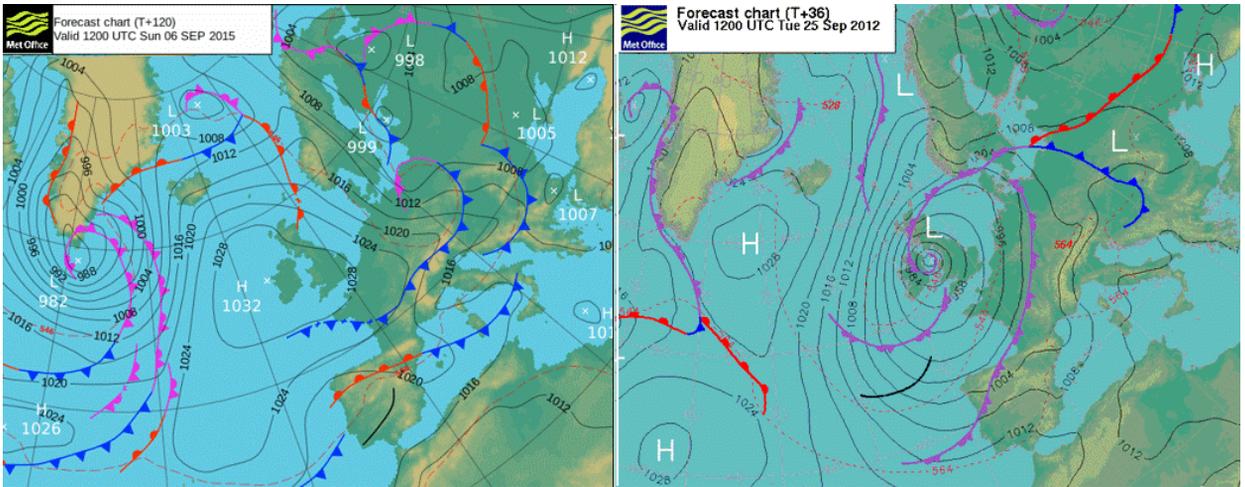


Figure 1. Dry summer conditions with easterly airflow and light oxygen isotopes (left). Wet summer conditions with westerly airflow and heavy isotopes (right).

Calibration period	2016-1891 CE	1890-1766 CE	2016-1766 CE
Verification period	1890-1766 CE	2016-1891 CE	
Calibration R ²	0.50	0.53	0.51
Verification RE	0.45	0.48	
Verification CE	0.47	0.51	

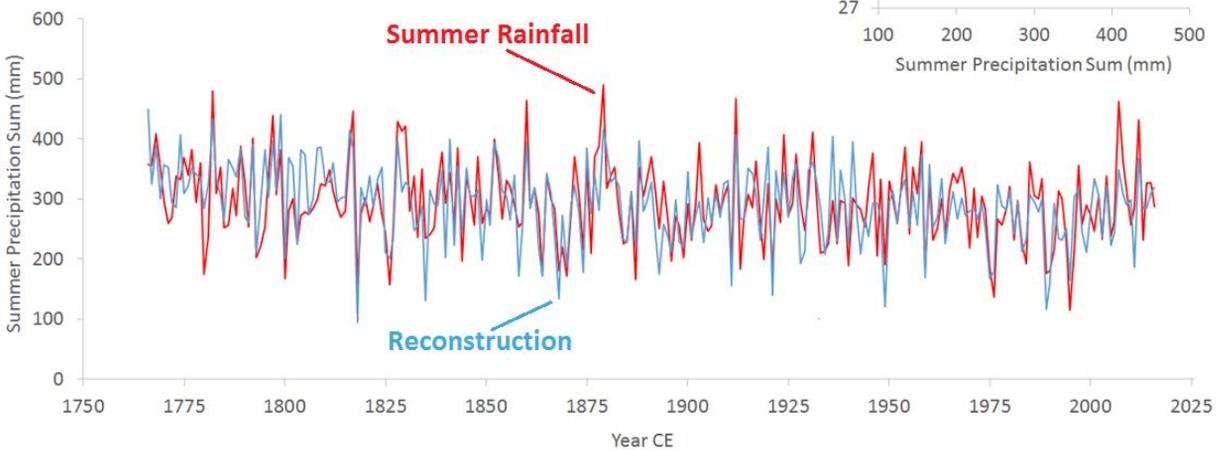
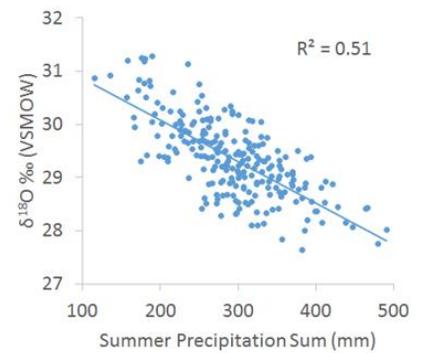


Figure 2. Relationship between oak tree-ring oxygen isotopes and summer rainfall. Upper left calibration statistics. Upper right scatterplot of rainfall against oxygen isotopes. Lower panel, oxygen isotopes used to reconstruct summer England and Wales precipitation (red line).