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Using Conditional Analysis to Investigate Spatial and Temporal patterns in Upland Rainfall

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The seasonality and characteristics of rainfall in the UK are altering under a changing climate. Summer rainfall is generally decreasing whereas winter rainfall is increasing, particularly in northern and western areas (Maraun et al., 2008) and recent research suggests these rainfall increases are amplified in upland areas (Burt and Ferranti, 2010). Conditional analysis has been used to investigate these rainfall patterns in Cumbria, an upland area in northwest England. Cumbria was selected as an example of a topographically diverse mid-latitude region that has a predominately maritime and westerly-defined climate. Moreover it has a dense network of more than 400 rain gauges that have operated for periods between 1900 and present day. Cumbria has experienced unprecedented flooding in the past decade and understanding the spatial and temporal changes in this and other upland regions is important for water resource and ecosystem management.

The conditional analysis method examines the spatial and temporal variations in rainfall under different synoptic conditions and in different geographic sub-regions (Ferranti et al., 2009). A daily synoptic typing scheme, the Lamb Weather Catalogue, was applied to classify rainfall into different weather types, for example: south-westerly, westerly, easterly or cyclonic. Topographic descriptors developed using GIS were used to classify rain gauges into 6 directionally-dependant geographic sub-regions: coastal, windward-lowland, windward-upland, leeward-upland, leeward-lowland, secondary upland. Combining these classification methods enabled seasonal rainfall climatologies to be produced for specific weather types and sub-regions.

Winter rainfall climatologies were constructed for all 6 sub-regions for 3 weather types - south-westerly (SW), westerly (W), and cyclonic (C); these weather types contribute more than 50% of total winter rainfall. The frequency of wet-days (>0.3mm), the total winter rainfall and the average wet day rainfall amount were analysed for each rainfall sub-region and weather type from 1961-2007 (Ferranti et al., 2010). The conditional analysis showed total rainfall under SW and W weather types to be increasing, with the greatest increases observed in the upland sub-regions. The increase in total SW rainfall is driven by a greater occurrence of SW rain days, and there has been little change to the average wet-day rainfall amount. The increase in total W rainfall is driven in part by an increase in the frequency of wet-days, but more significantly by an increase in the average wet-day rainfall amount. In contrast, total rainfall under C weather types has decreased. Further analysis will investigate how spring, summer and autumn rainfall climatologies have changed for the different weather types and sub-regions.

Conditional analysis that combines GIS and synoptic climatology provides greater insights into the processes underlying readily available meteorological data. Dissecting Cumbrian rainfall data under different synoptic and geographic conditions showed the observed changes in winter rainfall are not uniform for the different weather types, nor for the different geographic sub-regions. These intricate details are often lost during coarser resolution analysis, and conditional analysis will provide a detailed synopsis of Cumbrian rainfall processes against which Regional Climate Model (RCM) performance can be tested. Conventionally RCMs try to simulate composite rainfall over many different weather types and sub-regions and by undertaking conditional validation the model performance for individual processes can be tested. This will help to target improvements in model performance, and ultimately lead to better simulation of rainfall in areas of complex topography.

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