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Climate patterns associated with high and low river flow across the northern North Atlantic region

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To assess the sensitivity of high and low river flows to climate change and variability, improved understanding is needed of contemporary associations between large-scale climate variation and hydrological response. This is particularly important for the northern North Atlantic region, as high latitude areas such as this are predicted to be especially vulnerable to climate change. Furthermore, despite increasing interest in the apparent correlation of atmospheric circulation patterns with river flow (such as the North Atlantic Oscillation, NAO), relatively little is known about the processes underpinning such statistical hydroclimatological relationships across the northern North Atlantic region (defined here as encompassing northern Europe and northeastern North America). To address this research gap, composite analysis of large-scale climatic controls on high and low monthly river flows for the period 1968-1997 is performed. High and low flows are focused upon because these often have the greatest hydrogeomorphological, ecological and socio-economic impacts. As an organisational framework for the analysis, composite analysis is performed on a regional basis, with regions of similar inter-annual river flow variation identified using hierarchical cluster analysis.

Composite analysis shows that the occurrence of high and low flows across northern Europe is linked to geopotential height variation in the Azores High and Icelandic Low. From November to April, this variation is consistent with a positive correlation of the NAO and river flow. River flow in northeastern North America is more closely associated with the East Coast pressure trough. In November, the geopotential height patterns associated with high and low flows for northern European and North American flow regions are consistent with opposing influences of the NAO (positive

for northern Europe and negative for North America). These, are accompanied by contrasting precipitation anomalies between northern Europe and North America. An inverse relationship between large-scale climate and river flow is also found between northern and southern regions in northern Europe. This occurs in April, May, and from July to November, and appears to be influenced by the physical barrier of the Norwegian mountains and their effect on the passage of weather systems across Scandinavia. During November, this inverse climate-river flow relationship is also linked to the Scandinavian atmospheric circulation pattern.

These newly defined spatial patterns in river flow and associated atmospheric drivers help define the climate drivers of high and low river flows across the northern North Atlantic region. Furthermore, the apparent NAO and Scandinavian pattern signals in river flow suggest that these modes of variation may provide potentially powerful analogues for identifying how predicted changes in large-scale atmospheric fields will downscale to regional river flow variation.