Potential for Summer Precipitation Extremes (wet/dry) forced by North Atlantic Sea Surface Temperature Gradients and Local Soil Moisture-Precipitation Feedbacks

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The European Alpine region is often referred to as Europe’s water tower because of its vast water resources. Mean annual precipitation totals are on average around 1100 mm during the late 20th century, where summer is the wet season, except for the very Southern parts of the domain. Although changes in the mean amount of summer precipitation and drivers thereof are investigated on a broad basis, interannual variability is given less attention. Yet increases in interannual variability and hence potential extreme events in the wet season may stress water resources through pluvials and potential local and large scale flooding on one side as well as drought and water scarcity on the other. Changes in precipitation variability might have crucial implication for various water resource depending elements of human society, without any changes in the mean state.

Mean summer precipitation in the Alpine Region has not changed over the last 140 years as there is no significant linear trend verifiable. However, significant low frequency variations of the interannual variability summer precipitation are apparent, which synchronize with the Atlantic Multidecadal Oscillations periodicity of ~50 years with a time lag of 17 years. Interannual variability was particularly high during 1945-1964 and most recently (1999-2018) and rather low from 1975-1994. Analyzing atmospheric circulation characteristics over the Alpine Region revealed a see-saw of enhanced/reduced meridional flow which alters the interannual variability of summer precipitation through an enhanced/reduced potential for soil moisture-precipitation feedbacks. The circulation seesaw itself is mainly steered by different manifestations of sea surface temperature gradients in the mid-latitude North Atlantic. Particularly large variations of the meridional gradient during the 20th century influence the location of the polar jet stream, hence altering the atmospheric flow downstream in the Alpine Region and driving the seesaw. The lagged response to the Atlantic Multidecadal Oscillation is rooted in the spatially inhomogenious warming/cooling phases of the North Atlantic which are subject to intrinsic modes of variability acting on different spatial and temporal scales.