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A Process-Based Insight into the Severity of 'Super' Storm Desmond

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Climate warming is projected to increase winter rainfall and societally-impactful flood frequency across the British-Irish Isles (BI). The dynamical explanation for this change is linked to the North Atlantic (NA) storm track, with projections indicating both an enhanced frequency of wintertime extratropical cyclones ('cyclones'), and an increase in their average precipitation. The latter is, in part, a result of more intense moisture transport in cyclones' warm sectors by 'Atmospheric Rivers' (ARs), thermodynamically-driven by enhanced absolute humidity consistent with the Clausius-Clapeyron relation. It is against this backdrop that we scrutinise the physical drivers of the record-breaking rain and flood event associated with 'Storm Desmond' in December, 2015. We find that more than 3,500 km^2 experienced rainfall in excess of the mean annual maximum during the storm's passage. The exceptional rain amounts were due to an AR more intense than any other in our observational record (1979-2015). However, we find that its unparalleled strength was as much a consequence of strong wind speeds as high humidity, so its severity cannot be attributed so simply to climate warming. This position is made clearer through a Lagrangian air mass tracking procedure, where we show that most (67%) of the moisture that precipitated out over BI during Desmond's passage evaporated from sea surfaces that were cooler than their 1951-1980 average. We therefore conclude that 1) the process-based observational approach applied here can provide valuable insight into climate change attribution assessments; and 2) Storm Desmond – despite being the most severe on record - was perhaps moderated by the anomalously cool NA sea-surface temperatures, which may have suppressed evaporation and vapour transport. The capacity for an even more impactful AR should SSTs in the sub-polar NA return to even their 20th Century averages, given otherwise identical synoptic circulation, should therefore be appreciated by planners and policy makers alike.