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The Nature of the Preferred Positions in the North Atlantic Eddy-driven jet: the Importance of Greenland

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It has previously been observed that the North Atlantic winter-time eddy-driven jet exhibits three preferred latitudinal positions, or 'regimes'. A jet latitude index was used to study the distribution of the latitude of the maximum daily zonal mean zonal wind in the Atlantic region, illuminating these 3 preferred positions. Previous research has associated the southernmost of these 'regimes' to Greenland blocking; however, a robust explanation for the existence of the northern peak is yet to be established. Here we study the response of the North Atlantic jet regimes, or preferred positions, to various forcings, and present an explanation for the presence of the northern regime. Using the WACCM model, we manipulate model orography and explore the impacts on the Atlantic jet latitude index: without the presence of Greenland orography, the bi-modality of the central and northern peaks disappears. Shifting Greenland northward by 4 degrees latitude results in a similar shift in the latitude of the northern peak. Further analysis with ERA-interim data strongly suggests that the existence of the northern peak in jet latitude index is indeed due to the orographic forcing of Greenland, in particular the Greenland Tip Jet. We also show that these preferred latitudinal positions of the jet are found only at lower levels: the jet latitude index at 500mb shows only a single peak. We thus conclude that the distinct northern and central peaks in the jet latitude index are because of the interaction of the local circulation with orography, not because of any intrinsic dynamical behaviour of the eddy-driven jet. Using this new understanding, we attempt to explain why many CMIP5 models are unable to reproduce this observed multi-modal distribution of the North Atlantic jet latitude index, including analysis of the WACCM model forced with coupled model SSTs. We also use the WACCM model to study possible future changes in the preferred positions of the Atlantic eddy-driven jet under 4xCO_2 conditions, including consideration of the reduction of height of the Greenland ice sheet.