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Investigating physical drivers and dynamics of midlatitude circulation biases in climate reanalysis ensembles

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The projected response of the atmospheric circulation to increasing greenhouse gas concentrations is highly uncertain. One of the primary reasons for this is that the state-of-the-art models we employ to investigate these responses struggle to represent basic features of the midlatitude circulation. Biases also have detrimental effects on predictive skill at climate prediction time scales of seasons to decades. Despite this, physical understanding both of the controls on these features and the drivers of their biases is still limited. The present study investigates ensembles of climate hindcast simulations performed by the Norwegian Earth System Model. This is the model used in the CMIP6 endorsed Decadal Climate Prediction Project. These ensembles are compared to both free runs and AMIP-style simulations with ERA-Interim serving as ground truth. We examine the North Pacific and North Atlantic jets in both winter and summer. We also identify where the observations lie within the predictive distribution of the ensemble. Results show that the wintertime North Atlantic jet is too zonal, extends too far into Europe and is shifted northwards. Virtually the entire North Atlantic sector lies outside the predictive distribution of the ensemble and performance actually degrades in simulations with tighter constraints on the assimilation. By contrast the wintertime North Pacific jet is rather better represented both with respect to pattern as well as magnitude of the biases. This is likely due to the better-represented teleconnections between the tropical and extratropical Pacific. However, there is an asymmetry to the biases with the North Pacific showing the largest biases in summer and the North Atlantic showing the largest biases in winter. Further investigation suggests the biases reside in the atmospheric component of the model and too weak ocean-atmosphere interactions. In particular the surface fluxes from ocean to atmosphere appear to be a prime culprit with implications for storm development and hence eddy mean flow interactions aloft. Physical mechanisms and dynamics are investigated through investigation of baroclinic processes and in particular diabatic processes.