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Diagnosing differences in Bjerknes compensation in the IPSL-CM6A-LR model

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Planetary heat transport can be separated into the oceanic and atmospheric components and plays a major role in shaping the climate. In a climate in equilibrium, the net heat flux at the top of the atmosphere is constant and the rate of change in ocean heat content is negligible. In such conditions, anomalies in the ocean heat transport are accompanied by changes in the atmosphere of the same magnitude but opposite sign [Bjerknes, 1964], known as Bjerknes compensation (BJC). BJC remains a hypothesis since it has not been found in observations due to the length of time series and large errors compared to the observed heat transports. Nevertheless, BJC has a great number of applications in climate sciences, especially in climate predictability. Here we study the BJC in the IPSL-CM6A-LR model and contrast its properties in piControl and abrupt-4xCO2 experiments. In order to address this goal, we characterize the different time scales dependence and explore BJC dynamics linked to the Atlantic Meridional Overturning Circulation (AMOC) changes and Intertropical Convergence Zone (ICTZ) shifts. We improve the BJC diagnostics by introducing the Turner Angle between ocean and atmospheric anomalies: this allows both to quantify the BJC strength and to distinguish the contributions of ocean and atmosphere. In the IPSL-CM6A-LR model, we found two regions of stronger BJC corresponding to the mid-latitudes storm track region and the Marginal Ice Zone. The strong forcing in abrupt-4xCO2 leads to an AMOC reduction of 60% compared to the control experiment and dampening of the centennial signal of heat transport, however, the role of BJC in AMOC recovery in this experiment remains unclear. The ocean dominates BJC at decadal and centennial timescales both in natural and forced experiments. BJC is associated with the co-variability between AMOC strength and ITCZ location. Other forms of heat compensation are found in this model, such as a Bjerknes-like compensation between Atlantic and Indo-Pacific centennial ocean heat transport in the South Hemisphere.