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Simulation of the Intertropical Convergence Zone Displacement and Impacts During the Eemian and Heinrich Events

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The location and characteristics of the Intertropical Convergence Zone (ITCZ) impact the tropical ocean circulation through atmosphere-ocean interactions. In this study, we use the Community Climate System Model version 3 (CCSM3) to compare the impact of an expected shift in the ITCZ during two different periods. We simulate the Eemian and Heinrich event 1 (H1), both of which are believed to have experienced a southward shift in the ITCZ, but for different reasons. Previous studies of proxy data have shown measurable impacts on local precipitation and climate. In this study, we also look at the impact of the ITCZ on ocean circulation, which may have the potential for teleconnections and feedbacks.

During the Eemian, the ITCZ shifted due to corresponding shifts in the seasonal pattern of insolation. Specifically, we simulate the period from 125 ka to 115 ka. In this period summer insolation in the Northern Hemisphere decreased, cooling the Arctic. The resulting change in meridional temperature gradients increases demand for northward transport of energy, triggering a southward shift in the ITCZ from a relatively northward displacement.

During H1, the southward shift in the ITCZ is expected due to similar changes in meridional surface temperature gradients. In this case the northern latitudes of the Atlantic are thought to cool because of a substantial slow-down of the Atlantic Meridional Overturning Circulation. Due to a similar increased demand for northward heat transport, the ITCZ is expected to shift to the South.

Using CCSM3 simulations of these two periods, we compare the processes responsible for the southward displacement of the ITCZ. We examine the shifts in temperature gradients, as well as the convergence in surface winds that define the ITCZ. For the Eemian simulation, we are able to favorably compare changes in continental precipitation with reconstructions, from ocean sediment cores, assessing the ability of CCSM3 to reproduce the expected changes.

Finally, we analyze the shifts in surface currents due to the changing position of the ITCZ and the corresponding wind stress. The surface circulation of the tropical Atlantic is seasonal and heavily influenced by the strength and position of the winds associated with the ITCZ. Because of the proximity of this current system to significant sources of freshwater, such as the Amazon, the advection of coastal waters into or away from the Gulf Stream has a potentially large impact on the global circulation.