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Dynamic vegetation modeling of tropical biomes during Heinrich events

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Heinrich events are thought to be associated with a slowdown of the Atlantic Meridional Overturning Circulation (AMOC), which in turn would lead to a cooling of the North Atlantic Ocean and a warming of the South Atlantic Ocean (the "bipolar seesaw" hypothesis). The accompanying abrupt climate changes occurred not only in the ocean but also on the continents. Changes were strongest in the Northern Hemisphere but were registered in the tropics as well. Pollen data from Angola and Brazil showed that climate changes during Heinrich events affected vegetation patterns very differently in eastern South America and western Africa.

To understand the differential response in the terrestrial tropics, we studied the vegetation changes during Heinrich events by using a dynamic global vegetation model (TRIFFID) as part of the University of Victoria (UVic) Earth System-Climate Model (ESCM). The model results show a bipolar seesaw pattern in temperature and precipitation during a near-collapse of the AMOC. The succession in plant-functional types (PFTs) showed changes from forest to shrubs to desert, including spreading desert in northwest Africa, retreating broadleaf trees in West Africa and northern South America, but advancing broadleaf trees in Brazil. The pattern is explained by a southward shift of the tropical rainbelt resulting in a strong decrease in precipitation over northwest and West Africa as well as in northern South America, but an increase in precipitation in eastern Brazil.

To facilitate the comparison between modeled vegetation results with pollen data, we diagnosed the distribution of biomes from the PFT coverage and the simulated model climate. The biome distribution was computed for Heinrich event 1 and the Last Glacial Maximum as well as for pre-industrial conditions. We used a classification of biomes in terms of "mega-biomes", which were defined following a scheme originally proposed by BIOME 6000 (v 4.2). The biome distribution of the Sahel region changed from warm temperate forest during the last glacial maximum to the grassland and dry shrubland, suggesting a drier climate during Heinrich event 1. In south-western Africa savanna and dry woodland changed into boreal forest and boreal-temperate forest suggesting wetter conditions.

The biomes diagnosed from the control-run, were compared to the modern vegetation reconstruction of BIOME 4 (http://www.bridge.bris.ac.uk/resources/Databases/BIOMES_data). Consistent biome patterns were simulated for the tropical forests of western and south-western Africa and the grasslands of northern Africa. On the other hand, in southern Europe, where the BIOME 4 vegetation reconstruction is dominated by warm temperate and temperate forest, our model shows a strong bias towards the grassland.