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Climate Features of a Retrograde Rotating Earth

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What would the climate of the Earth look like if it would rotate in the reversed (retrograde) direction? Which of the characteristic climate patterns in the ocean, atmosphere or land that are observed in a present-day climate are the result of the direction of Earths' rotation? In experiments with the Max Planck Institute Earth System Model (MPI-ESM), we investigate differences in the climate between a prograde and a retrograde rotating Earth. For this we compare experiments with pre-industrial climate conditions and the normal (CTRL) and retrograde rotation (RETR).

The expected consequence is a reversal of the zonal wind patterns resulting in easterly jets and westward trade winds. Similarly, the ocean gyres reverse their directions and the boundary currents shift to the opposite side of the ocean basin. Due to the reversed winds in RETR the continents in the subtropics and midlatitudes become colder on their western and warmer on the eastern margins. This strong warming is accompanied by a strong drying in the lee of the Andes over south America, the North China Plain in East Asia and the east-southeast coast of the US. In contrast, the climate in North Africa becomes cooler and wetter in RETR and the Sahara greens.

One of the most prominent differences between RETR and CTRL is in the Meridional Overturning Circulation (MOC). The Atlantic MOC collapses in the RETR experiments, while a strong overturning cell emerges in the Pacific. The Pacific MOC in RETR is similar in structure but slightly stronger than the Atlantic MOC in CTRL. The breakdown of the Atlantic MOC and the associated decrease in meridional heat transport leads to a southward extension of sea ice in the North Atlantic and a significant cooling over Europe. In contrast, the Pacific MOC in RETR, characterized by an enhanced northward transport of heat along the West coast of North America, results in a significant warming of the North Pacific. The reversed atmospheric circulation advects this heat anomaly into the eastern parts of Russia. Changes in the ocean circulation are also reflected in the pattern of biogeochemical tracers. Despite similar zonal means, we find an increase in biological production and subsequent changes in climate-relevant parameters in the Indian Ocean.
Another pronounced feature is the shift from a double ITCZ in CTRL towards a single ITCZ in RETR, as a result of zonal asymmetries in the structure of the tropical circulation. Further, the ITCZ is shifted southward in RETR due to differences in air-sea interactions and stationary eddies. In particular, the southern hemispheric Tropical Atlantic ITCZ is maintained by cold water along the equator in association with the direction reversal of the subtropical high and cold advection from the North Atlantic western boundary current region.