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Astronomical forcing as a trigger of abrupt climate changes at the end of interglacials

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Many paleoclimate records show that the end of interglacials of the late Pleistocene was marked by abrupt cooling events and increased millennial variability. Strong abrupt cooling occurring when climate was still in a warm interglacial condition is puzzling and its cause remains uncertain. In this study, we performed transient climate simulations for all the eleven interglacial (sub)stages of the past 800,000 years with the model LOVECLIM1.3 (Yin et al., 2021). Our results show that there exists a threshold in the astronomically induced insolation below which abrupt changes at the end of interglacials occur. When the summer insolation in the Northern Hemisphere (NH) high latitudes decreases to a critical value, it triggers a strong, abrupt weakening of the Atlantic meridional overturning circulation (AMOC) and a strong cooling in the NH followed by high-amplitude variability. The mechanism involves sea ice feedbacks in the Northern Nordic Sea and the Labrador Sea. Similar abrupt oscillations happen in the simulated temperature, precipitation and vegetation from low to high latitudes. Our simulated results are supported by observations from many marine and terrestrial records, including for example the planktic d18O record from the Iberian Margin, the Greenland ice core record and the Chinese speleothem records. Our study shows that the astronomically-induced slow variation of insolation could trigger abrupt climate changes. The insolation threshold occurred at the end of each interglacial of the past 800,000 years, suggesting its fundamental role in terminating the warm climate conditions of the interglacials. Our results show that the next insolation threshold will occur in 50,000 years, suggesting an exceptionally long interglacial ahead, which is in line with what has been suggested by previous modelling studies.

Reference: Yin Q.Z., Wu Z.P., Berger A., Goosse H., Hodell D., 2021. Insolation triggered abrupt weakening of Atlantic circulation at the end of interglacials. Science, 373, 1035-1040, DOI: 10.1126/science.abg1737