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Fast and slow components of millennial-scale climate changes

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Despite a substantial body of evidence on millennial-scale climate variability during Marine Isotope Stage 3, uncertainty remains over the precise sequence of changes in different parts of the climate system, and ultimately their causes. Here, we present results of joint marine and terrestrial proxy analyses from the Portuguese Margin, showing the typical succession of cold stadials and warm interstadials over the interval 35-57 ka, with most extreme changes occurring during Heinrich Stadials (HS). The planktonic and benthic foraminiferal isotope records map onto Greenland and Antarctic temperature variations, respectively, while the pollen record bears a close similarity to changes in the Asian summer monsoon, atmospheric methane and dust concentrations, indicating coupled changes in hydroclimate in middle-to-low latitudes. Closer inspection of HS4 and HS5 reveals considerable structure, with a relatively fast transition to maximum cooling and aridity associated with a peak in ice-rafted detritus, containing detrital carbonate grains originating from the Hudson Strait. This was followed by an interval of slowly increasing sea-surface temperatures (SST) and moisture availability, in line with evidence indicating a gradual evolution in low-latitude hydroclimate. A climate model experiment closely reproduces the gradual increase in SST and precipitation in W. Iberia during the final part of HS4 as a result of the recovery of the Atlantic overturning circulation, but does not capturethe abrupt warming in Greenland. What emerges is a diversity of response timescales, from centuries in low-to-mid latitude SST and precipitation to decades in Greenland temperatures.