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Simulating an abrupt termination of the Holocene African Humid period using an optimised configuration of HadCM3

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The Holocene 'greening' and subsequent, possibly abrupt desertification of the Sahara is a fascinating example of natural environmental change. It was driven by a gradual decline in summer insolation but with land-atmosphere coupling by vegetation likely providing additional reinforcing feedbacks. However, the majority of general circulation models (GCMs) cannot produce enough precipitation to sustain a 'Green' Sahara, and the transient evolution through the Holocene has therefore only been studied with a few models. We present a suite of transient simulations with the coupled atmosphere-ocean GCM HadCM3, the CMIP3 version of the Met Office's Hadley Centre model. These simulations cover the Holocene from 10,000 years before present, and optionally include recently developed optimisations of the atmospheric convection and dynamic vegetation parameterisations. In the model run with both optimisations, HadCM3 shows a convincing 'greening' for the first time. This is followed by a series of abrupt oscillations in vegetation cover and hydrology, that culminates in an abrupt collapse at around 6000 years before present. We compare the behaviour in four model versions and make a detailed evaluation with available geological evidence. Our results show that the stability of climate models is determined by chosen parameter values and formulations. We conclude that novel methods of inferring suitable model state-space regions using both present day observations and palaeoclimate reconstructions are needed.