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Is millennial-scale climate variability statistical "red noise"?

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Several simple models have been proposed to explain the statistical properties of the Greenland and Antarctic ice core records and their relationship. Some component of noise forcing is required to account for the observations, but previous studies have not generally addressed the amplitude or origin of the noise (e.g. Alley et al., 2000; Roe and Steig, 2004; Wunsch, 2003). We find that a simple stochastic climate model with 100-year averaged white noise forcing of amplitude ˜0.5 K is sufficient to account for the millennial scale variability in the Antarctic records. Importantly, the amplitude of the noise forcing need not be larger in glacial compared with interglacial climate, although longer timescale persistence, perhaps provided by ice sheets or a more sluggish ocean circulation, is required. This result casts doubt on the idea that the variability seen in Antarctic records on these timescales is a response to the abrupt climate changes in Greenland, since these are absent in the Holocene. This suggests a local rather than global source of the noise forcing, which in turn casts doubt on hypothesized external forcing mechanisms such as solar variability The question that arises is whether ˜0.5 K is a plausible amplitude for internally generated white-noise variability, since this is significantly larger than found in unforced climate model simulations (e.g. Manabe and Stouffer, 1995). A possibility is that Antarctic sea ice may act as a local amplifier of atmospheric white noise, with persistence provided by a combination of ice sheet dynamics and deep ocean convection. This does not address the evidence for a statistical link between the Greenland and Antarctic records (at least during the largest millennial-scale events). However, it has similarly been argued that the amplitude and rapidity of the Greenland Dansgaard-Oeschger events require a threshold response of sea ice to small changes in ocean heat transport. The Greenland D-O events could therefore be thought of as response to the background red noise variability in the climate system, as expressed in the Antarctic records. The 1500-year

cycle in the GISP2 record remains enigmatic, but if actually present in the climate system, must be in addition to, not in place of, the red noise variability.