

Orbital responses in North Atlantic ice-rafted debris records and links with overturning circulation

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The obliquity and precession responses of several North Atlantic ice-rafted debris (IRD) proxy records are analyzed over the past 1 Myr to evaluate ice sheet responses to orbital forcing and links between IRD and Atlantic overturning changes. However, not all IRD proxies yield the same results. A record of bulk carbonate $\delta^{18}\text{O}$ from IODP Site U1308 [1] shows IRD maxima in phase with June perihelion and very little obliquity power. Si/Sr at the same site shows strong responses to both obliquity and precession, although Si/Sr may also be affected by changes in productivity [1]. The two proxies have different implications for orbital responses in ice sheets and their links to Atlantic overturning changes as measured in benthic $\delta^{13}\text{C}$ [2, 3]. Bulk carbonate $\delta^{18}\text{O}$ suggests that obliquity forcing has little effect on rates ice sheet calving while precession forcing drives large calving events (and possibly meltwater) into the North Atlantic that delay overturning responses to ice volume change. In contrast, the Si/Sr record suggests that ice sheet responses and overturning are tightly coupled in both orbital bands but does not indicate whether calving (and meltwater) caused circulation changes, or vice versa, as has been proposed for Heinrich Event 1 [4, 5].

[1] Hodell *et al* (2008) *Paleoceanography* **23**, PA4218. [2] Lisiecki *et al* (2008) *Nature* **456**, 85–88. [3] Lisiecki (2014) *Paleoceanography*, in press. [4] Marcott *et al* (2011) *PNAS* **108**, 13415. [5] Alvarez-Solas *et al* (2011) *Clim. Past* **7**, 1297.