Field methods

The 7.94-m firn core used in this study was collected in December 2010 using a 3-inch diameter Pico hand auger. Core physical properties (dimensions, mass, temperature) were measured on site as each ~1-m section was retrieved. Diameter was measured with digital calipers (1 mm accuracy), length was measured with a meter stick (5 mm accuracy), and mass was measured on a digital balance (0.1 g accuracy). Density was calculated by dividing the weight of each core section by the corresponding volume, resulting in a down-core depth-density profile. Density varied from 0.23 $g \cdot cm^{-3}$ at the surface to 0.54 $g \cdot cm^{-3}$ at 8-m depths. Temperature profiles were taken by inserting a thermistor probe (0.2°C accuracy) into the core approximately every 40 cm as it was retrieved. Temperature varied between -13 and -18 °C. Core sections were bagged in layflat tubing, stapled shut, and packed in core tubes inside ice-core boxes with temperature data loggers for shipping. Loggers recorded temperatures every 30 minutes (±0.1°C accuracy). During transit, samples maintained an average temperature of -21.1°C, and never exceeded -15.8°C.

Core dating and accumulation rates

Age-depth relationship and accumulation rates were established using the $\delta^{18}O$ firn-core record (Figure 2) tuned with University of Wisconsin Automatic Weather Station (AWS) temperature data (http://amrc.ssec.wisc.edu/). The Byrd and WAIS Divide (WSD) sites were the nearest *in situ* AWS sites to our core location (Figure 1). Temperature data from the two stations (~100 km apart) were highly correlated (r^2 = 0.91). Thus, despite being further from the DIV2010 coring site, Byrd AWS data were

used in this study because this dataset had fewer gaps in the time series. AWS air temperatures were recorded 3 m above the ground at 10-minute intervals using a platinum resistance thermometer (0.5°C accuracy). Three-hourly data were available for most months, with 10-minute data used where 3-hourly data were unavailable. Daily and monthly temperature means were calculated from averaged 3-hourly and 10-minute datasets. Annual maxima and minima in the $\delta^{18}O$ record were pinned to annual maxima and minima in the AWS temperature data to define mid-summer and mid-winter, respectively, and intervening dates were then linearly interpolated. This method relies on the strong high-latitude temperature modulation of the isotopic composition of precipitation [*Jouzel et al.*, 1997; *Schneider et al.*, 2005].

Annual accumulation rates were derived by multiplying densities by the core length per year (or season, for seasonal accumulation rates). Annual accumulation at the core site is relatively equally distributed seasonally. From 2002–2010, average summer (Oct–Mar) accumulation rate was 40 $g \cdot cm^{-2} \cdot yr^{-1}$ (σ = 16 $g \cdot cm^{-2} \cdot yr^{-1}$), and average winter (Apr–Sep) accumulation rate was 33 $g \cdot cm^{-2} \cdot yr^{-1}$ (σ = 12 $g \cdot cm^{-2} \cdot yr^{-1}$). This is equivalent to ~7-cm snowfall each month, greater than our 3-5-cm core sampling scheme. The temporal resolution of our core is ~monthly, similar or better to that of other recent, like ice-core studies (e.g. *Abram et al.*, 2011; *Sneed et al.*, 2011). MSA and Cl^- times series were matched directly to this age-depth chronology based on the $\delta^{18}O$ record.

The 8-m DIV2010 core dates from October 2001 to December 2010. We calculated a local mean accumulation rate of ~39 $g \cdot cm^{-2} \cdot yr^{-1}$ over the core record (σ = 8.7 $g \cdot cm^{-2} \cdot yr^{-1}$). The minimum and maximum mean annual accumulation rates are 26.2 $g \cdot cm^{-2} \cdot yr^{-1}$ (2009) and 55.5 $g \cdot cm^{-2} \cdot yr^{-1}$ (2008), respectively. These accumulation rates are

47 similar to those reported from previous West Antarctic studies in the region. The ITASE
48 cores geographically nearest to the DIV2010 site are sites 2001-2 and 2001-3.
49 Accumulation rates at ITASE sites 2001-2 and 2001-3 are 42.5 $g \cdot cm^{-2} \cdot yr^{-1}$ (1890–2002)
50 and 32.7 $g \cdot cm^{-2} \cdot yr^{-1}$ (1859–2002), respectively [*Dixon et al.*, 2004]. A separate study
51 based on the ITASE cores showed that accumulation increases almost linearly across the
52 divide between the Ross and Amundsen sectors of WAIS (increasing accumulation rate
53 in the direction of the Amundsen sector) [*Conway and Rasmussen*, 2009]. However,
54 accumulation rate estimates closest to the area of our study (>34 $g \cdot cm^{-2} \cdot yr^{-1}$) are
55 comparable to our estimates, as well as to the estimates of others [*Banta et al.*, 2008;
56 *Dixon et al.*, 2004; *Neumann et al.*, 2008]. Accumulation rates from other ITASE cores
57 along the same divide, but 300 km farther inland from our core site (2000-1), are
58 substantially lower (21 $g \cdot cm^{-2} \cdot yr^{-1}$) [*Banta et al.*, 2008]. A modern accumulation rate
59 estimate at the WAIS Divide drill site (Figure 1) is 22 $g \cdot cm^{-2} \cdot yr^{-1}$ [*Fegyveresi et al.*,
60 2011].
61
62 **Lab Methods**
63 The core was subsampled using an acid-cleaned hand saw in a -25°C freezer room
64 5 months after collection. Discrete samples were stapled in plastic layflat tubing and
65 stored at -25°C. For $\delta^{18}O$ analyses, firn-core samples were melted in ambient clean lab
66 temperatures (20°C), transferred into 2-mL glass autosampler vials, and sealed with septa
67 screw caps. Sample isotope ratios were standardized using three working standards
68 calibrated against the IAEA standards VSMOW and SLAP. Final $\delta^{18}O$ values are
69 reported on the VSMOW/SLAP scale.

Before the day of MSA and Cl^- analysis, the outer 2 cm of each firn sample was physically removed by scraping the surface with a microtome blade (cleaned with deionized (DI) water) in a -25°C freezer room. Core samples were transferred to cleaned melting containers, melted in ambient clean lab temperatures (20°C) under a laminar flow hood, and refrozen in DI-cleaned accuvettes. On the day of analysis, core samples were re-melted in the accuvettes and transferred to 0.5-mL autosampler vials using a DI-cleaned micropipette. DI water used in all analyses had a resistivity ≥18.2MΩ-cm. Gloves were used at all times and plastic-ware was used for all steps of sample preparation (following [*Curran and Palmer*, 2001]). Pre-cleaned plastic-ware was rinsed and twice soaked overnight in DI water and subsequently dried in a laminar flow hood. Prior to use, all plastic-ware and vials were rinsed again with DI water and dried in a laminar flow hood. Autosampler caps and vials were stored in DI water.

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