**Supporting Information for**

**A three-dimensional model of the marine nitrogen cycle during the Last Glacial Maximum constrained by sedimentary isotopes**

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**Supporting Information Figure Captions:**

**Figure S1**. Example of the subgrid-scale bathymetry scheme at 130 meters depth: (top) model grid bathymetry (i.e. value 1 means sea floor exists at model grid depth of 130 meters), subgrid-scale sea floor fraction applied to sinking detrital organic matter to calculate sedimentary N-loss in the (center) PIctl and (bottom) LGMctl.

**Figure S2**. Preindustrial zonal model-data comparison in the (left) Atlantic, (center) Indian, and (right) Pacific of (top) ∆14C (Key et al., 2004), (center) dissolved oxygen (O2) (Garcia et al., 2010a), and (bottom) nitrate (NO3) (Garcia et al., 2010b).

**Figure S3**. (left) Zonal and (right) meridional wind stress used in the (top) preindustrial control (PIctl) and (bottom) LGM control (LGMctl), which were averaged from 7 models that participated in the Paleoclimate Modeling Intercomparison Project (Muglia and Schmittner, 2015).

**Figure S4**. (left) Plot of logarithm of atmospheric iron flux vs logarithm of soluble iron flux (g Fe m-² s-1) calculated by an atmospheric model (Luo et al., 2008), which represents the functional form of iron solubility. High values of iron flux are better represented by a power law (linear fit in the logarithmic plot, red line), but low values are better described by a constant, 2 % solubility (green line). (right) Scatter plot of surface soluble Fe flux (Luo et al. 2008) and dissolved iron in the upper ocean, simulated using a different model that includes iron as a prognostic variable (Nickelsen et al., 2015). The red line is a power law fit that empirically approximates dissolved iron changes from atmospheric soluble Fe flux.

**Figure S5**. LGM bottom water (left) salinity and (right) temperature of Last Glacial Maximum control (LGMctl) minus preindustrial control (PIctl) with proxy observational estimates (circles) (Adkins et al., 2002;Insua et al., 2014).

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