Supplementary Information

Asynchrony between Antarctic temperature and CO$_2$ associated with obliquity over the past 720,000 years

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Supplementary Figures 1-5
References for Supplementary Information
Supplementary Figure 1. δD records from the DF2 and EDC ice cores

The δD records of the DF2 (10-cm sampling, blue) and EDC cores (55-cm sampling, red)\textsuperscript{1} for (a) 300-450 kyr BP, (b) 450-600 kyr BP and (c) 600-750 kyr BP. The light-red line indicates high-resolution (11-cm sampling) data\textsuperscript{2} covering MIS 11 (these δD values are shifted by 10‰ for clarity). Numbers indicate Marine Isotope Stages. Dots represent raw data.
Supplementary Figure 2. Enlarged profiles of the $\delta D$, $\Delta T_{\text{site}}$ and $\Delta T_{\text{source}}$ records from the DF2 core

Records of $\delta D$ (black), $\Delta T_{\text{site}}$ (red) and $\Delta T_{\text{source}}$ (blue) from the DF2 core for (a) 300-450 kyr BP, (b) 450-600 kyr BP and (c) 600-750 kyr BP. Numbers indicate Marine Isotope Stages.
Supplementary Figure 3. Deuterium excess and $\Delta T_{\text{source}}$ records from the DF1 and DF2 ice cores

(a) The $d$ record using the traditional linear definition$^3$ of the DF1 (grey) and DF2 (black). (b) Same as (a), but for the logarithmic definition of $d$, $d_{\ln}$. (c) DF $\Delta T_{\text{source}}$ record (blue) shown with the stacked SST record (black) with its uncertainty interval (area shaded grey).
Supplementary Figure 4. DF $\Delta$T$_{source}$ and SST records from the moisture source region

(a) $\Delta$T$_{site}$ (red) record from the DF cores. The black line indicates the stacked SST record from the moisture source region with its uncertainty interval (area shaded grey). Data were resampled at a 2-kyr interval. (b) Same as (a), but for the $\Delta$T$_{source}$ (blue) record from the DF cores. (c) Individual SST records used to produce the stacked SST record (Methods). (d) Number of SST data series.
Supplementary Figure 5. Cross-spectral analyses of ΔT_{site} vs. δD and ΔT_{site} vs. ΔT_{source}

(a) Power spectrum of ΔT_{site} (red) and δD (black dotted). (b) Phase shown in units of degrees. (c) Same as (a) but shown using units of kyr. Negative values indicate that δD leads ΔT_{site}. (d) Coherence between ΔT_{site} and δD. (e)-(h), same as (a)-(d) but for ΔT_{site} (red) and ΔT_{source} (blue). Positive values indicate that ΔT_{source} lags ΔT_{site}. The spectral analyses were conducted using 100-yr resampled data.

Supplementary References

1. Jouzel, J. et al. Orbital and Millennial Antarctic Climate Variability over the Past 800,000 Years. *Science* **317**, 793-796, doi:10.1126/science.1141038 (2007).
2. Pol, K. et al. Links between MIS 11 millennial to sub-millennial climate variability and long term trends as revealed by new high resolution EPICA Dome C deuterium data - A comparison with the Holocene. *Climate of the Past*, **7**, 437-450, doi:10.5194/cp-7-437-2011 (2011).
3. Dansgaard, W. Stable isotopes in precipitation. *Tellus*, **16**, 436-468 (1964).