[Paleoceanography and Paleoclimatology]

Supporting Information for

Orbital- and Millennial-Scale Variability in Northwest African Dust Emissions Over the Past 67,000 years

Christopher W. Kinsley[1], Louisa I. Bradtmiller[2], David McGee[1], Michael Galgay[2], Jan-Berend Stuut[3,4], Rik Tjallingii[5], Gisela Winckler[6], and Peter B. deMenocal[6,7]

[1]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA, [2]Department of Environmental Studies, Macalester College, St. Paul, MN, USA, [3]NIOZ Royal Netherlands Institute for Sea Research, Texel, The Netherlands, [4]Faculty of Science, Department of Earth Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands, [5]GFZ German Research Centre for Geosciences, Section 'Climate Dynamics and Landscape Evolution', Potsdam, Germany, [6]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA [7]Woods Hole Oceanographic Institution, Woods Hole, MA, USA

Corresponding author: Christopher W. Kinsley (ckinsley@mit.edu)

Contents of this file

Text S1
Figures S1 to S4

Introduction

This supporting information provides additional text and four figures to support the conclusions in the manuscript. The newly collected data associated with this manuscript are available for download from the National Oceanic and Atmospheric Administration National Centers for Environmental Information Paleoclimatology archive (https://www.ncdc.noaa.gov/paleo/study/33572) and described in Kinsley et al. (2021a). A compilation of all data (including previously published data) for the CHEETA core sites (GC37, GC49, and G68) and ODP Hole 658C are available for download from Zenodo (https://doi.org/10.5281/zenodo.5652188) and described in Kinsley et al. (2021b).

Text S1. Resuspended coarse-grained shelf material input at LGM to GC68

We do not think that inputs of resuspended coarse-grained shelf material are likely a large contributor to the GC68 dust flux record during the LGM low sea level stand and subsequent rise (including through H1) for three reasons:

- coarse-grained detrital fluxes during the LGM low sea level stand at 20 ka are within uncertainty of the coarse-grained detrital fluxes during the late Holocene, despite 123 m lower sea level during the LGM (Waelbroeck et al., 2009)
- H1 in GC68 is marked by peaks in biogenic opal and organic carbon fluxes alongside the peak in coarse-grained detrital fluxes, in proportions similar to other dust-opal-organic carbon correlations throughout the core (McGee et al., 2013))
- the larger H1 peak relative to the YD is reproduced in the dust % fraction of cores south of GC68 (Collins et al., 2013)

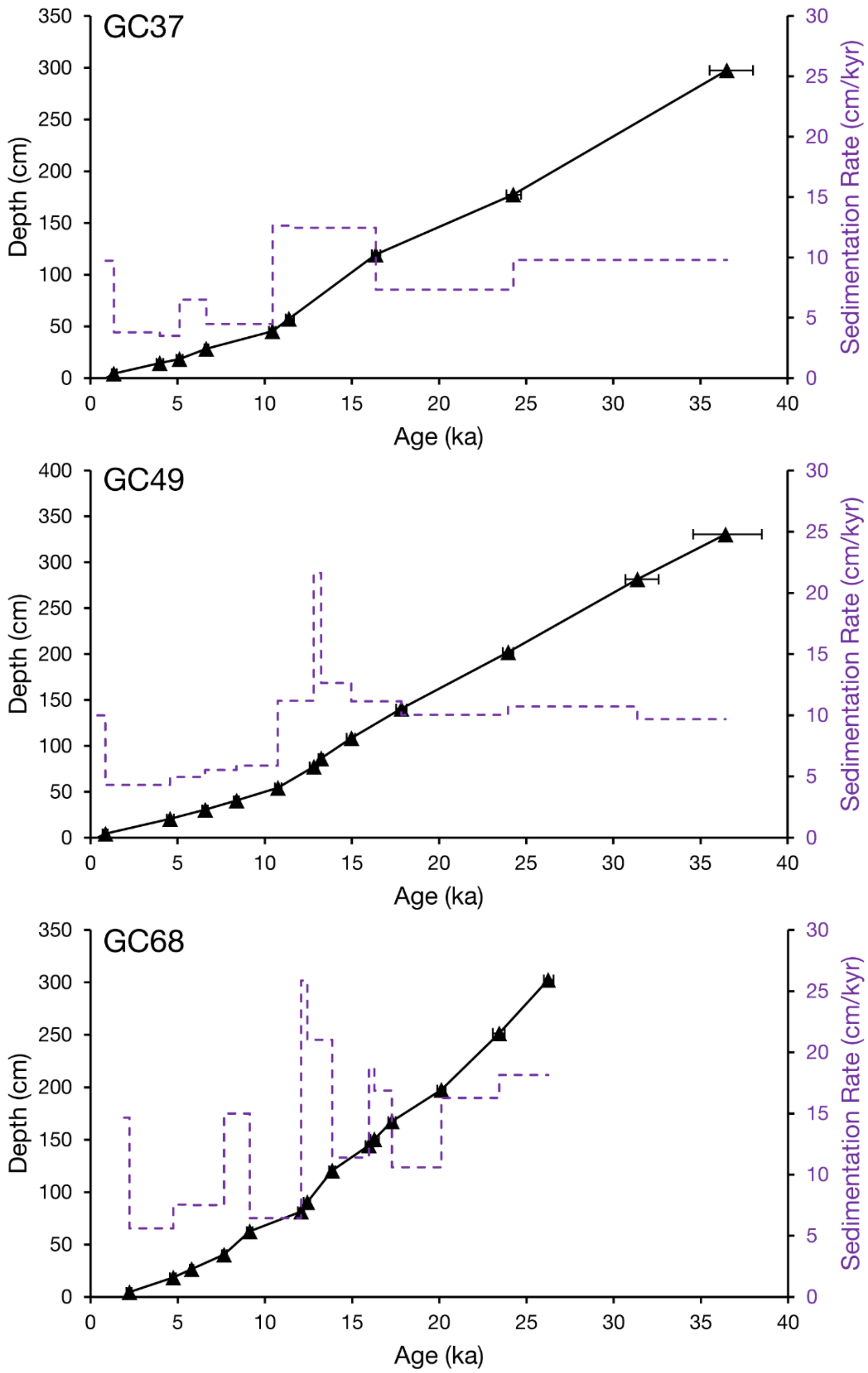

Figure S1. Age-depth plot (black line) and sedimentation rate (purple dashed line) for CHEETA core sites GC37, GC49, and GC68, as labeled. ^{14}C tie points shown as black triangles with1σ uncertainties, from McGee et al. (2013) and Tierney et al. (2017).

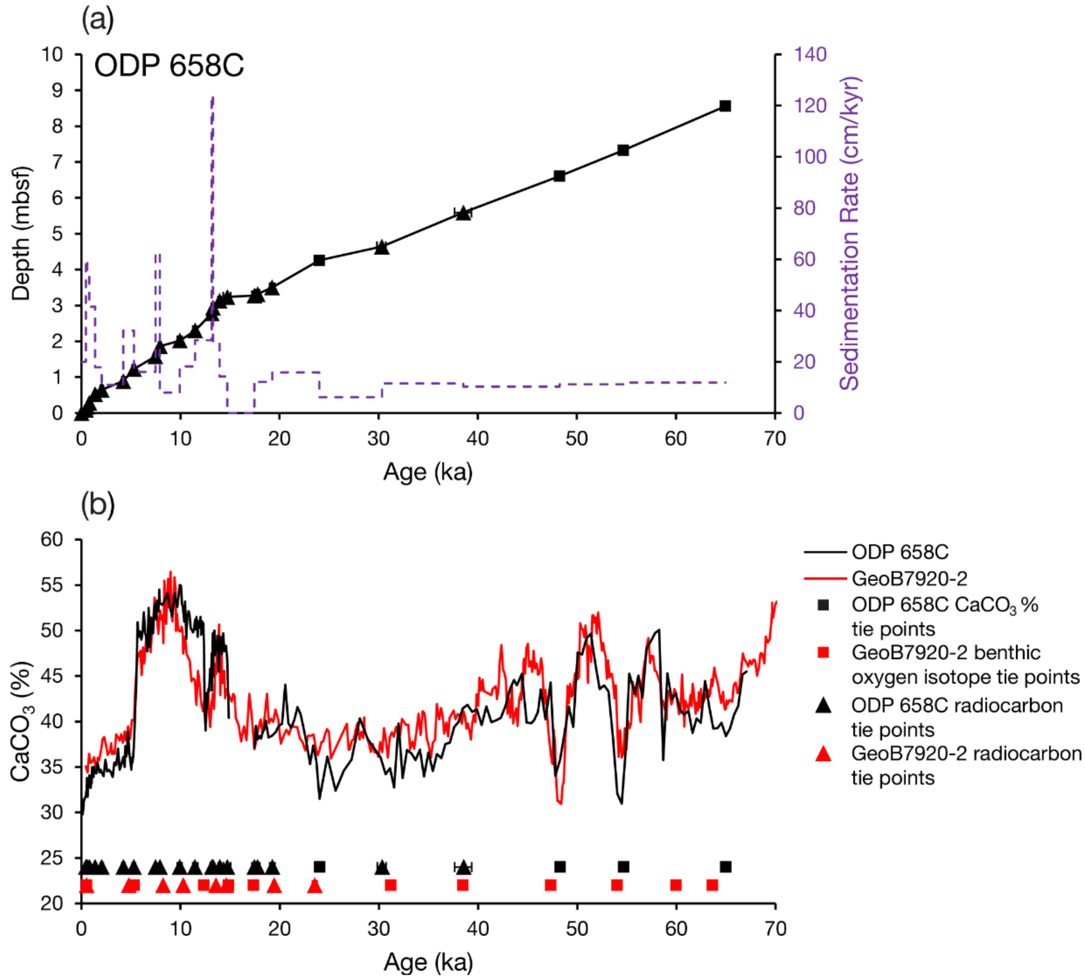

Figure S2. (a) Age-depth plot (black line) and sedimentation rate (purple dashed line) for ODP Hole 658C. ^{14}C tie points and 1σ uncertainties shown as black triangles, $CaCO_3$ % tie points shown as black squares. The ^{14}C tie points < 20 ka are a subset of the 31 ^{14}C ages from deMenocal et al. (2000). The core top was assumed to be 0 ka. The depth scale (mbsf) is based on the cumulative section lengths which were recorded by ODP when the core was split for analysis, with sample depths taken as the mid-point of the sampled interval. There is a hiatus in Core 1 Section 3 indicated by closely spaced ^{14}C ages at 3.28 mbsf and 3.24 mbsf with ages of 17.456 ka and 14.722 ka, respectively; in accordance with deMenocal et al. (2000) we placed the hiatus between the depths of 3.28 mbsf and 3.26 mbsf. (b) Stratigraphic carbonate comparison of ODP 658C $CaCO_3$ % (black line) with GeoB7920-2 calibrated XRF $CaCO_3$ wt% (red line). ODP 658C ^{14}C tie points shown as black triangles with 1σ uncertainties, ODP 658C $CaCO_3$ % tie points to the GeoB7920-2 calibrated XRF $CaCO_3$ wt% record shown as black squares. ^{14}C tie points < 20 ka from deMenocal et al. (2000). GeoB7920-2 ^{14}C tie points shown as red triangles with 1σ uncertainties smaller than the width of the tie point markers, GeoB7920-2 calibrated XRF $CaCO_3$ wt% tie points to the benthic (*Cibicidoides wuellerstorfi*) $\delta^{18}O$ record of marine sediment core MD95-2042 shows as red squares, with the $\delta^{18}O$ stratigraphy of MD95-2042 on the GRIP ss09sea age scale (Tjallingii et al., 2008).

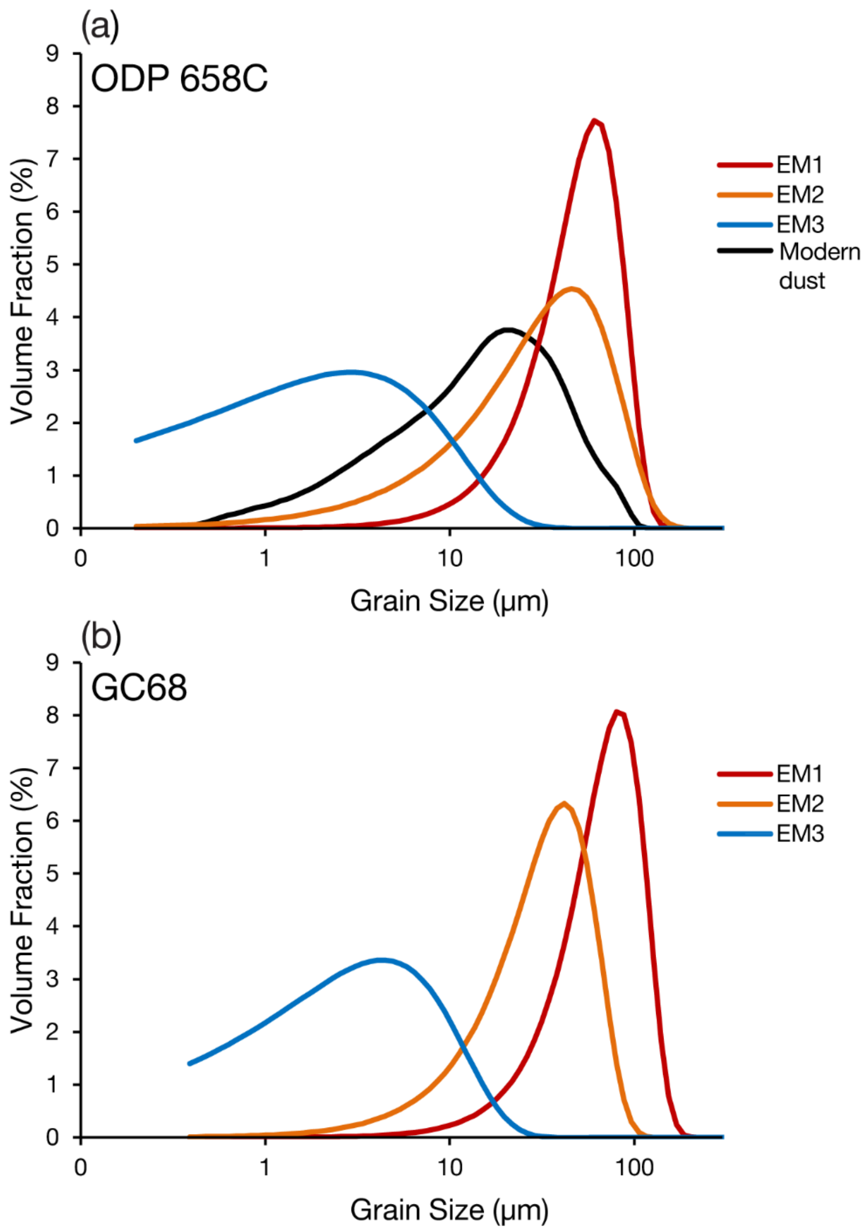

Figure S3. (a) Best fit endmember Weibull distributions used to model the grain size distributions for ODP 658C, with EM1 (red line) and EM2 (orange line) representing coarser endmembers and EM3 (blue line) representing a fine endmember. The modern-day grain size distribution of nearby dust collected using dust traps (black line; Stuut et al., 2005) shows the similarity between this local dust and the modeled endmembers for the core site. (b) Best fit endmember Weibull distributions used to model the grain size distributions for GC68 (McGee et al., 2013), the closest studied site to ODP 658C, with EM1 (red line) and EM2 (orange line) representing coarser endmembers and EM3 (blue line) representing a fine endmember. There is clear consistency between the modeled endmembers for these nearby core sites.

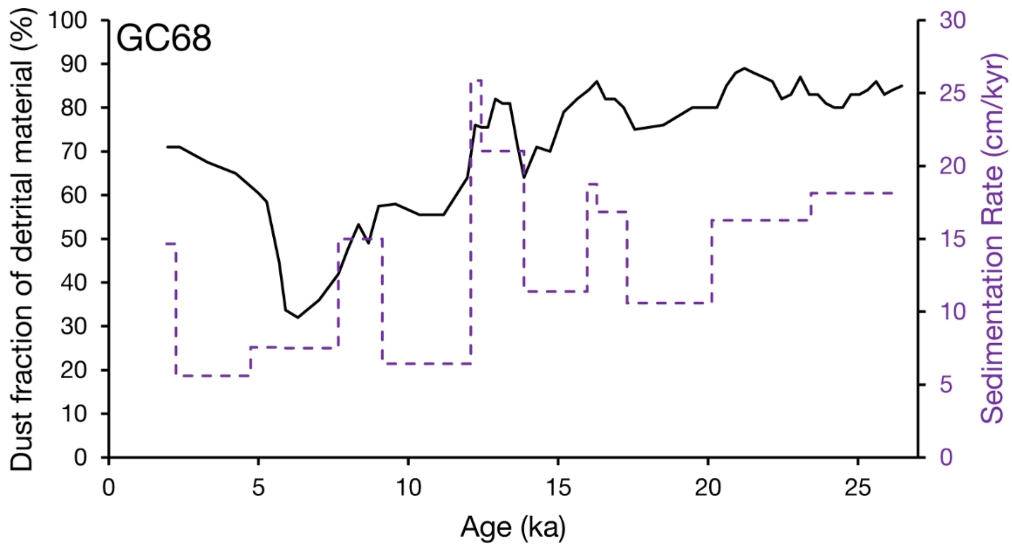

Figure S4. Dust fraction of the detrital material (black line) and sedimentation rate (dashed purple line) for GC68. From 26 to 12 ka the average sedimentation rate is 17 cm/kyr, and over this same time interval the dust fraction of the detrital material averages 81 %.

References

Collins, J. A., Govin, A., Mulitza, S., Heslop, D., Zabel, M., Hartmann, J., … Wefer, G. (2013). Abrupt shifts of the Sahara-Sahel boundary during Heinrich stadials. *Climate of the Past*, *9*(3), 1181–1191. https://doi.org/10.5194/cp-9-1181-2013

deMenocal, P. B., Ortiz, J., Guilderson, T., & Sarnthein, M. (2000). Coherent high- and low-latitude climate variability during the holocene warm period. *Science*, *288*(5474), 2198–2202. https://doi.org/10.1126/science.288.5474.2198

Kinsley, C. W. ., Bradtmiller, L. I. ., McGee, D. ., Galgay, M. ., Stuut, J.-B. ., Tjallingii, R. ., … DeMenocal, P. . (2021a). North African Dust Deposition Flux Data over the last 67,000 Years. *National Oceanic and Atmospheric Administration National Centers for Environmental Information Paleoclimatology Archive*. Retrieved from https://www.ncdc.noaa.gov/paleo/study/33572

Kinsley, C. W. ., Bradtmiller, L. I. ., McGee, D. ., Galgay, M. ., Stuut, J.-B. ., Tjallingii, R. ., … DeMenocal, P. . (2021b). Orbital- and Millennial-Scale Variability in Northwest African Dust Emissions Over the Past 67,000 years — Datasets. *Zenodo*. Retrieved from https://doi.org/10.5281/zenodo.5652188

McGee, D., DeMenocal, P. B., Winckler, G., Stuut, J. B. W., & Bradtmiller, L. I. (2013). The magnitude, timing and abruptness of changes in North African dust deposition over the last 20,000yr. *Earth and Planetary Science Letters*, *371–372*, 163–176. https://doi.org/10.1016/j.epsl.2013.03.054

Stuut, J. B., Zabel, M., Ratmeyer, V., Helmke, P., Schefuß, E., Lavik, G., & Schneider, R. (2005). Provenance of present-day eolian dust collected off NW Africa. *Journal of Geophysical Research: Atmospheres*, *110*(4), 1–14. https://doi.org/10.1029/2004JD005161

Tierney, J. E., Pausata, F. S. R., & De Menocal, P. B. (2017). Rainfall regimes of the Green Sahara. *Science Advances*, *3*(1), 1–10. https://doi.org/10.1126/sciadv.1601503

Tjallingii, R., Claussen, M., Stuut, J. B. W., Fohlmeister, J., Jahn, A., Bickert, T., … Röhl, U. (2008).

Coherent high- and low-latitude control of the northwest African hydrological balance. *Nature Geoscience*, *1*(10), 670–675. https://doi.org/10.1038/ngeo289

Waelbroeck, C., Paul, A., Kucera, M., Rosell-Melé, A., Weinelt, M., Schneider, R., … Turon, J. L. (2009). Constraints on the magnitude and patterns of ocean cooling at the Last Glacial Maximum. *Nature Geoscience*, *2*(2), 127–132. https://doi.org/10.1038/ngeo411