*Supplemental Information*[*]

# Annual Patterns within Tree Rings of the Arctic Middle Eocene (~45 Ma): Isotopic Signatures of Precipitation, Relative Humidity and Deciduousness

**A. Hope Jahren**
Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218 USA
**Leonel S.L. Sternberg**
Department of Biology, University of Miami, Coral Gables, FL 33124 USA

*Supplemental Information*

Bulk organic matter from all fossils was acidified and lyophilized prior to combustion following previous methods e.g., Jahren et al., 2004) The cellulose content of fossil wood was closely comparable to the mass-percent cellulose isolated from modern conifer wood (56 % *vs*. 60-63 %; Leavitt and Long, 1991). Pure α-cellulose was isolated from fossil wood within AH2, and subsequently subjected to nitration procedure using classical methods that we have modified for application to Eocene wood (Cullen and MacFarlane, 2005; Jahren and Sternberg, 2003). Bulk and α-cellulose $\delta^{13}C$ values were measured *via* online combustion; and $\delta^{18}O$ values of α-cellulose were measured *via* on-line pyrolysis; δD values were measured *via* dual inlet analysis of $H_2$ resulting from the reduction of water produced during the combustion of cellulose nitrate. All measurements were performed using an Isoprime IRMS at the Johns Hopkins University. Isotopic values are reported in δ-notation [‰] against Vienna standards VPDB (carbon) and VSMOW (oxygen and hydrogen). Analytical uncertainty associated with $\delta^{13}C$, $\delta^{18}O$ and δD values = 0.1, 0.2 and 1.0 ‰, respectively.

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[*] *GSA Data Repository* contribution

To detect periodicity of the $\delta^{13}C$ value in each fossil transect, we calculated the Lomb normalized periodogram, which determines spectral power as a function of frequency for unevenly spaced data (pages 569-573 within Press et al., 1992). Spectral power is determined relative to the confidence level at which cyclicity for a given frequency is constrained by the data. This analysis quantified an apparent annual pattern in $\delta^{13}C$ values; spectral power for one cycle per growing season exceeded the 90% confidence interval in all cases. Spectral analysis of the $\delta^{18}O$ and $\delta D$ values in each fossil transect within AH2 revealed an annual pattern, albeit one with relatively low spectral power; results for one cycle per growing season exceeded the 75% confidence interval in all cases.

Figure Captions:

Figure S1. Maps of all areas north of the Arctic Circle (66˚33' N) at present (left) and 45 Ma (right), marking the southern limit of the area where the sun does not rise on the winter solstice, nor set on the summer solstice. The Fossil Forest site is presently located at 79° N; it was located at 78.6° N ± 1.6° during the Eocene (Irving and Wynne, 1991).

Figure S2. Hours of daylight shown as a function of calendar day, calculated using the CMB model of Forsythe et al. (1995). White and black colors represent periods of constant daylight and constant night, respectively. The black and white dashed line is located at 78.6 degrees north latitude, the reconstructed location of the Fossil Forest during the Middle Eocene (Irving and Wynne, 1991; McKenna, 1980). Light-transitional

seasons are shown to be particularly short, lasting about 60 days twice per year (i.e., spring and fall).

Figure S3. Exceptionally preserved conifer fossil wood from the Fossil Forest (A), some of which exhibits concentric ringed structure ("AH1"; B); within this study we exploited particularly thick-ringed samples (e.g., "AH3"; C).

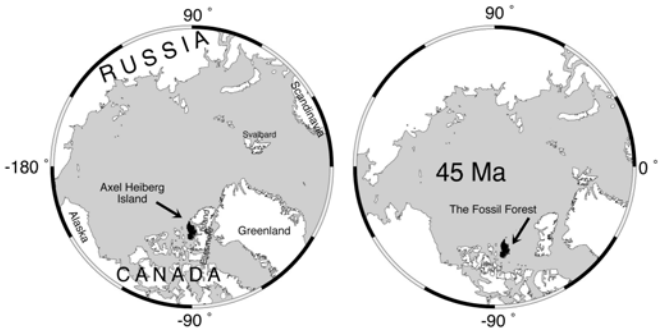
90 °
RUSSIA
Scandinavia
Svalbard
-180 °
Axel Heiberg
Island
Alaska
Greenland
CANADA
-90 °
90 °
45 Ma
0 °
The Fossil Forest
-90 °

Figure S1.

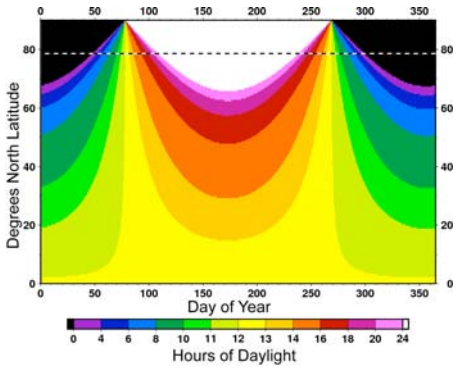
Degrees North Latitude
Day of Year
Hours of Daylight
0 4 6 8 10 11 12 13 14 16 18 20 24

Figure S2.

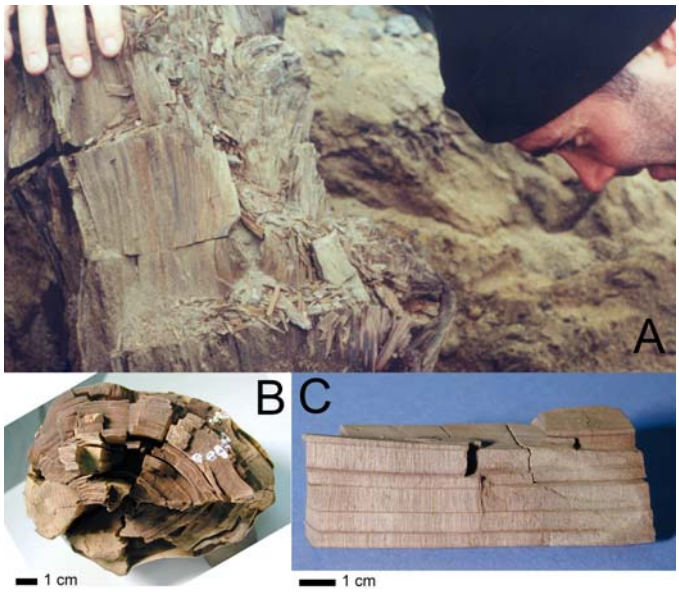


Figure S3.

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