**Supplementary material for ‘Polar ice core organic matter signatures reveal reactive atmospheric carbon compositions across ancient and modern scales’**

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This document includes supplemental tables and figures (Tables S1-2 and Fig. S1-4) used for data interpretation of all ice core organic matter, comparisons, and spatiotemporal overlaps of WDsupp with GISP2 used for comparisons in Fig. 5 and Fig. 6.

**Table S1.** Comparisons of ice core parallel factor modeled components calculated by their excitation and emission spectral loading shift- and shape sensitive congruence coefficients (SSC) (Wünsch and others, 2019). Arctic Circle Traverse 2010 (ACT-10), West Antarctic Ice Sheet Divide (WD), the Greenland Ice Sheet Project 2 (GISP2), and Agassiz Ice Cap of Ellesmere Island, Canada, (Agassiz). Component numbers for each ice core model are given as C1, C2, and C3, respectively. SSC > 0.9 are formatted in bold.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ACT-10 C1 | ACT-10 C2 | ACT-10 C3 | WD C1 | WD C2 | WD C3 | GISP2 C1 | Agassiz C1 |
| ACT-10 C1 | 1 | 0.5558 | 0.0907 | 0.1991 | 0.1109 | **0.9502** | 0.2357 | 0.2216 |
| ACT-10 C2 |  | 1 | 0.4997 | 0.6907 | 0.4267 | 0.4756 | 0.6634 | 0.6044 |
| ACT-10 C3 |  |  | 1 | 0.6935 | **0.9021** | 0.0413 | **0.9254** | **0.9186** |
| WD C1 |  |  |  | 1 | 0.5253 | 0.1524 | 0.8167 | 0.7224 |
| WD C2 |  |  |  |  | 1 | 0.0548 | 0.8151 | 0.8307 |
| WD C3 |  |  |  |  |  | 1 | 0.1567 | 0.1436 |
| GISP2 C1 |  |  |  |  |  |  | 1 | **0.9849** |
| Agassiz C1 |  |  |  |  |  |  |  | 1 |

**Table S2**. Comparisons of ice core parallel factor modeled components calculated by their (a) Tucker congruence coefficients (Tucker, 1951, Lorenzo-Seva & ten Berge, 2006) of the excitation spectral loadings and (b) shift- and shape sensitive congruence coefficients (Wünsch and others, 2019) of the emission spectral loadings. Arctic Circle Traverse 2010 (ACT-10), West Antarctic Ice Sheet Divide (WD), the Greenland Ice Sheet Project 2 (GISP2), and Agassiz Ice Cap of Ellesmere Island, Canada, (Agassiz). Component numbers for each ice core model are given as C1, C2, and C3, respectively. Tucker and shift- and shape sensitive congruence coefficients > 0.9 are formatted in bold.

**a**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ACT-10 C1 | ACT-10 C2 | ACT-10 C3 | WD C1 | WD C2 | WD C3 | GISP2 C1 | Agassiz C1 |
| ACT-10 C1 | 1 | 0.7201 | 0.7693 | 0.6409 | 0.6282 | **0.9848** | 0.8134 | 0.7913 |
| ACT-10 C2 |  | 1 | 0.8244 | **0.9616** | 0.6799 | 0.7126 | **0.9154** | 0.8504 |
| ACT-10 C3 |  |  | 1 | 0.7189 | **0.9594** | 0.7326 | **0.9615** | **0.9634** |
| WD C1 |  |  |  | 1 | 0.5647 | 0.6518 | 0.8260 | 0.7353 |
| WD C2 |  |  |  |  | 1 | 0.5788 | 0.8504 | 0.8633 |
| WD C3 |  |  |  |  |  | 1 | 0.7853 | 0.7573 |
| GISP2 C1 |  |  |  |  |  |  | 1 | **0.987** |
| Agassiz C1 |  |  |  |  |  |  |  | 1 |

**b**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ACT-10 C1 | ACT-10 C2 | ACT-10 C3 | WD C1 | WD C2 | WD C3 | GISP2 C1 | Agassiz C1 |
| ACT-10 C1 | 1 | 0.2554 | -0.7611 | -0.5304 | -0.6774 | 0.7899 | -0.5125 | -0.5083 |
| ACT-10 C2 |  | 1 | 0.2282 | 0.3938 | 0.2134 | 0.1166 | 0.4236 | 0.4081 |
| ACT-10 C3 |  |  | 1 | **0.9114** | **0.9039** | -0.6632 | 0.8857 | 0.8628 |
| WD C1 |  |  |  | 1 | 0.8403 | -0.4477 | **0.9499** | **0.9298** |
| WD C2 |  |  |  |  | 1 | -0.5996 | 0.8454 | 0.8505 |
| WD C3 |  |  |  |  |  | 1 | -0.4432 | -0.4392 |
| GISP2 C1 |  |  |  |  |  |  | 1 | **0.9839** |
| Agassiz C1 |  |  |  |  |  |  |  | 1 |

A screenshot of a cell phone

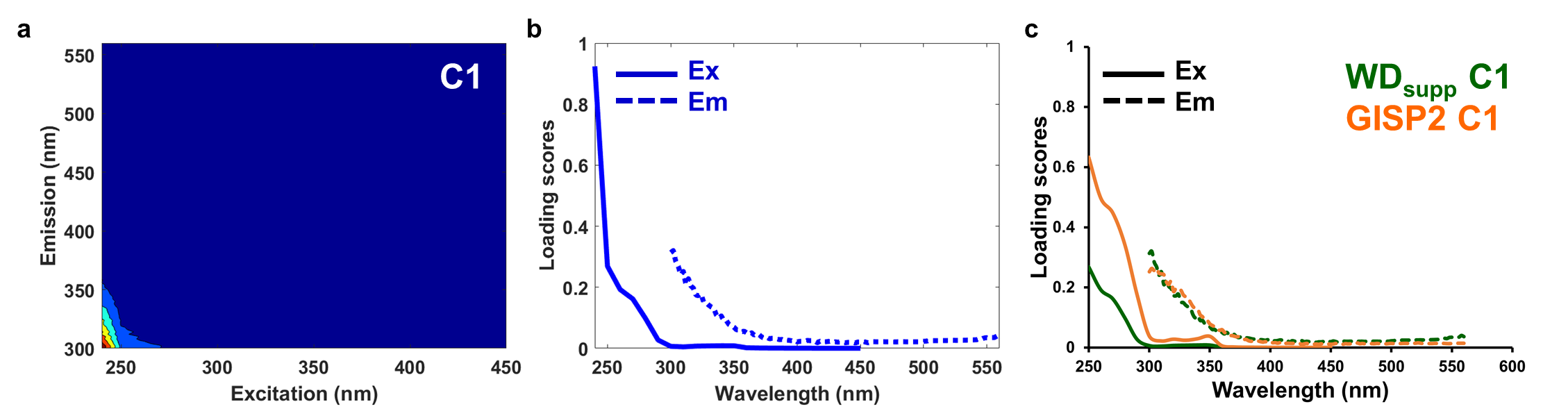
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**Fig. S1**. Excitation emission matrices (EEMs) generated of (top panel) commercially available laboratory chemicals (phenylalanine, tyrosine, tryptophan, and vanillic acid) and (bottom panel) more complex organic matter (OM) samples found in the environment including International Humic Substances Society fulvic acids Suwannee River (Georgia, USA) and Pony Lake, (Antarctica) and semi-arid Montana soil OM and the Yellowstone River OM (western Montana, USA). The chemical structures are provided in the top panel and detailed sample preparations and descriptions of Suwannee River fulvic acid, Pony Lake fulvic acid, and semi-arid Montana soil OM characterization were previously reported (D'Andrilli and others, 2013, Romero and others, 2017). The Yellowstone River sample was filtered (0.2µm) prior to fluorescence spectroscopy. The bottom panel examples are ordered from left to right based on the longest to shortest emission wavelength positions of fluorescence maxima.

A picture containing application

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**Fig. S2**. Excitation emission matrices (EEMs) examples of fluorescent core organic matter representing diverse signatures for the (a) Arctic Circle Traverse 2010 (ACT-10) samples dated 1990, 2002, and 2009 of the late Holocene (Miège and others, 2013), (b) West Antarctic Ice Sheet Divide (WD) ice core samples dated 26.221, 12.650, and 9.401 kyr BP representing three climate periods: the Last Glacial Maximum, the last deglaciation, and the early-to-mid Holocene (reproduced from D’Andrilli and others (2017a)), dating scale WDC06A-7(WAIS Divide Project Members, 2013), (c) Greenland Ice Sheet Project 2 (GISP2) ice core samples dated 18.65 and 18.462 kyr BP (Meese and others, 1997), and (d) the Agassiz Ice Cap ice core samples dated 1942 and 1978 of the late Holocene (Fisher and others, 2016, Lecavalier and others, 2017). Fluorescent intensities were reported in Raman units (R.U.; z-axis colorscale).



**Fig. S3**. Supplemental parallel factor (PARAFAC) analysis model results for a deglaciation subset (n=25 for samples between~19-17 kyr BP; dating scale WDC06A-7 (WAIS Divide Project Members, 2013) of fluorescence data from the West Antarctic Ice Sheet Divide (WD) shown as (a) component one (C1; i.e. all fluorescence calculated (Raman units) from the PARAFAC model), (b) PARAFAC C1 loading scores for excitation and emission wavelength fluorescence spectra, and (c) PARAFAC C1 comparisons of the supplemental WD (WDsupp) and the Greenland Ice Sheet Project 2 (GISP2) data. In (c) excitation and emission spectral loadings are shown in paired dashed and continuous lines of the same color (WDsupp: green and GISP2: orange).

A close up of a mans face

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***Fig. S4.*** *Parallel factor modeled component organic matter fluorescent intensities over time for ice cores from the Arctic Circle Traverse 2010 components one, two, and three (C1-C3) for (a) basin A and (b)*

*basin B. Time is provided as dated years of the late Holocene (Miège and others, 2013) Fluorescent intensities are reported in Raman units (R.U.).*

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