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Supplement of

Volcanic stratospheric sulfur injections and aerosol optical depth from 500 BCE to 1900 CE

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Tables

Table S1: Meta data associated with the ice cores used to produce the Greenland and Antarctic volcanic sulphate flux composites in this work.

Site name	Core name	Latitude	Longitude	Time period	Reference
NEEM	NEEM-2011-S1	77.45 N	51.06 W	87 CE-1900 CE	(Sigl et al., 2013)
	NEEM	77.45 N	51.06 W	500 BCE-144 CE	(Sigl et al., 2015)
NGRIP		75.12 N	42.32 W	191 CE-1999 CE	(Plummer et al., 2012)
GISP2		72.60 N	38.50 W	500 BCE-1900 CE	(Zielinski, 1995; Zielinski et al., 1996)
WAIS	WDC06A	79.47 S	112.09 W	394 BCE-2006 CE	(Sigl et al., 2015)
	WDC05Q	79.47 S	112.08 W	1520 CE-2004 CE	(Sigl et al., 2013)
South Pole	SP01	89.95 S	17.67 E	889 CE-2001 CE	(Budner and Cole-Dai, 2003)
	SP04	89.95 S	17.67 E	200 CE-2003 CE	(Ferris et al., 2011)
DML	DML05	75.00 S	00.02 E	150 CE-1998 CE	(Traufetter et al., 2004)
	DML07	75.58 S	03.43 E	453 CE-1998 CE	(Traufetter et al., 2004)
	B40	75.00 S	00.06 E	500 BCE-2012 CE	(Sigl et al., 2015)
NUS08-4	NUS08-4	82.82 S	18.90 E	1616 CE-2007 CE	(Sigl et al., 2014)
NUS08-5	NUS08-5	82.63 S	17.87 E	338 CE-2000 CE	(Sigl et al., 2014)
NUS07-2	NUS07-2	76.07 S	22.47 E	336 CE-1991 CE	(Sigl et al., 2014)
NUS07-5	NUS07-5	78.65 S	35.63 E	1 CE-1981 CE	(Sigl et al., 2014)
NUS07-7	NUS07-7	82.07 S	54.88 E	7 CE-2005 CE	(Sigl et al., 2014)
Dome F	DF01	77.37 S	39.70 E	1 CE-1903 CE	(Motizuki et al., 2014)
	DFS10	77.40 S	39.62 E	1 CE-2009 CE	(Sigl et al., 2014)
Law Dome	DSS	66.77 S	112.80 E	1 CE-1995 CE	(Plummer et al., 2012)
	W10k	66.75 S	112.83 E	1735 CE-2008 CE	(Sigl et al., 2014)
Dome C	EDC96	75.10 S	123.35 E	1 CE-1995 CE	(Castellano, 2005)
Dome A	DA2005	80.37 S	77.22 E	1 CE-1990 CE	(Jiang et al., 2012)

Table S2: Years of volcanic signals according to the timescales of the eVolv2k, ICI and IVI2 reconstructions for cases of unambiguous matches between all three composites. Volcanic signals after 1900 are ignored in Greenland due to the effects of anthropogenic pollution, but retained for Antarctica. The period before ~1590 was also ignored, except that the 1257/1258 Samalas signal, clearly identified in all 3 composites in both Greenland and Antarctica, was included.

Greenland event dates			Antarctica event dates		
eVolv2k	ICI	IVI2	eVovl2k	ICI	IVI2
			1991	1991	1991
			1982	1982	1982
			1963	1963	1963
			1902	1902	1902
			1886	1886	1886
1883	1883	1883	1883	1883	1883
			1861	1861	1861
1835	1835	1835	1835	1835	1835
1831	1831	1831			
1815	1815	1815	1815	1815	1815
1809	1809	1809	1809	1809	1809
1796	1796	1796			
1783	1783	1783			
1762	1762	1761	1762	1762	1761
1729	1731	1729			
			1695	1694	1693
1673	1673	1673	1673	1673	1673
1640	1640	1641			
1600	1600	1600	1600	1600	1600
			1595	1593	1593
1257	1257	1258	1257	1257	1258

Table S3: Dates of matches for volcanic stratospheric sulphate injection greater than 10 Tg [S] between the eVolv2k and IVI2 (Gao et al., 2008) reconstructions. Dates in bold indicate events in either reconstruction with VSSI>10 Tg [S].

eVolv2k event dates	IVI2 event dates	Date difference (IVI2-eVolv2k)
536	**529**	-7
540	**541**	+1
574	567	-7
626	619	-7
682	No match	No match
939	933	-6
1108	No match	No match
1171	**1167**	-4
1182	**1176**	-6
1230	**1227**	-3
1257	**1258**	+1
1276	**1275**	-1
1286	**1284**	-2
1345	1341	-4
1453	**1452**	-1
1458	1459	+1
1600	**1600**	0
1640	**1641**	+1
1695	1693	-2
1783	**1783**	0
1809	**1809**	0
1815	**1815**	0
1831	1831	0
1835	**1835**	0

Table S4: Event matches between EVA(2k) and ICI (Crowley and Unterman, 2013) SAOD reconstructions. Dates given here are the first years of maximum 3-year cumulative SAOD values, so may occur in the year of, or year after an eruption. Events in bold indicate events with cumulative SAOD>0.2.

EVA(2k) event dates	ICI event dates	Date difference (ICI-eVolv2k)
817	814	-3
939	939	0
970	**971**	+1
1108	1112	+3
1171	1170	-1
1182	1184	+2
1230	**1228**	-2
1257	**1257**	0
1276	1276	0
1286	**1286**	0
1345	1345	0
1458	**1456**	-2
1600	**1600**	0
1641	**1641**	0
1673	**1673**	0
1695	**1694**	-1
1783	1783	0
1809	**1809**	0
1815	**1815**	0
1831	1831	0
1835	**1835**	0
1883	**1883**	0

Figures

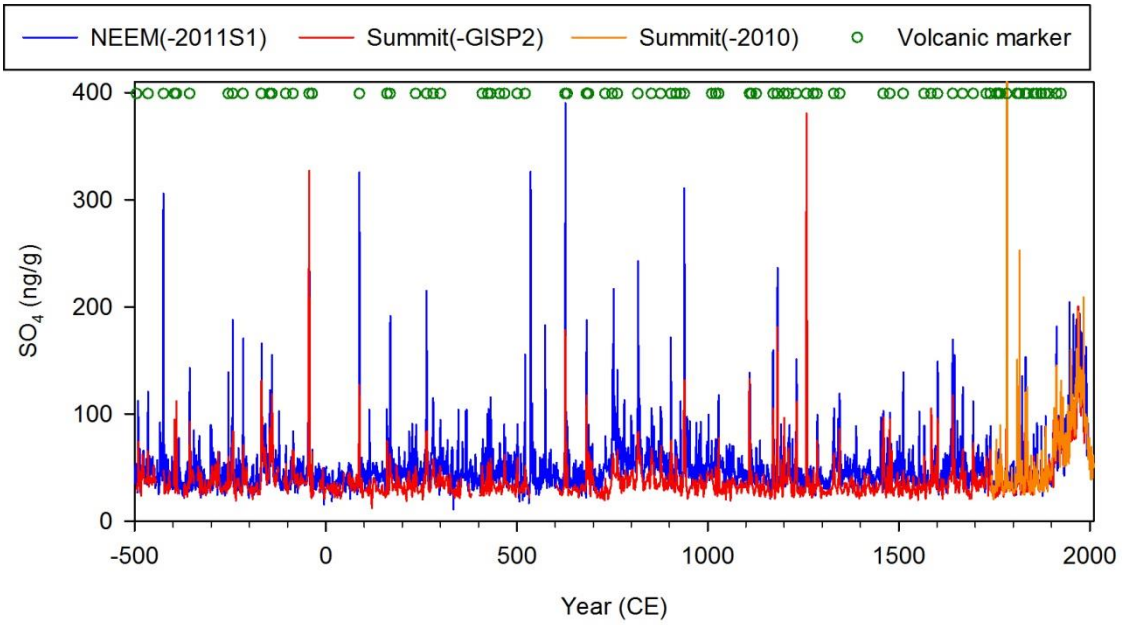


Figure S1: GISP2 SO_4 record from Greenland Summit (Zielinski et al., 1995, 1996) synchronized to the NEEM(-2011-S1) ice core on the NS1-2011 timescale (Sigl et al., 2013, 2015) using 85 volcanic marker horizons (green circles). The GISP2 record has been updated with the Summit(-2010) firn core drilled at the same site in 2010 (Maselli et al., 2017).

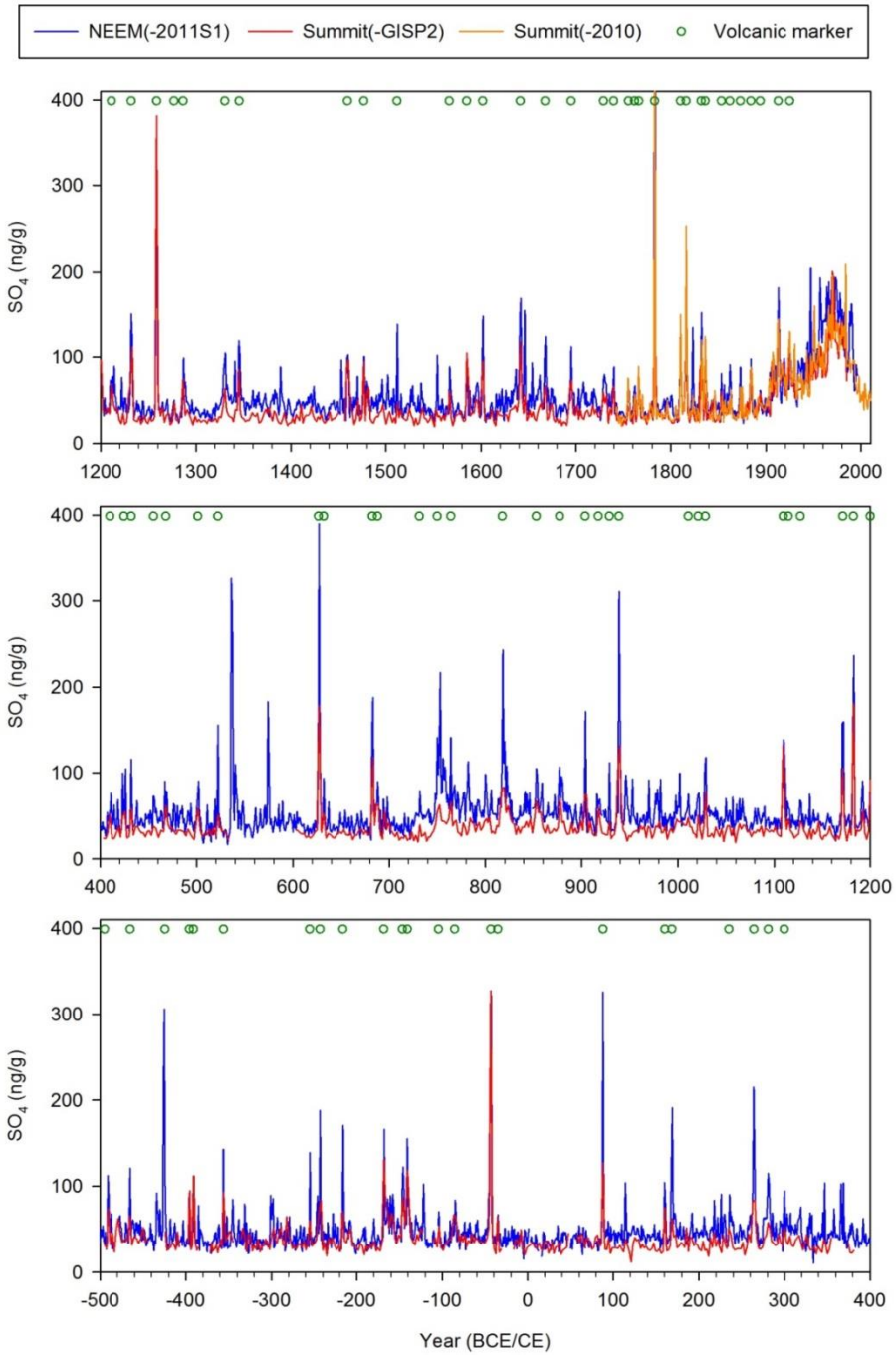


Figure S2: As Fig. S1 for the three time periods (from top): 1200-2010 CE, 400-1200 CE and 500 BCE-400 CE.

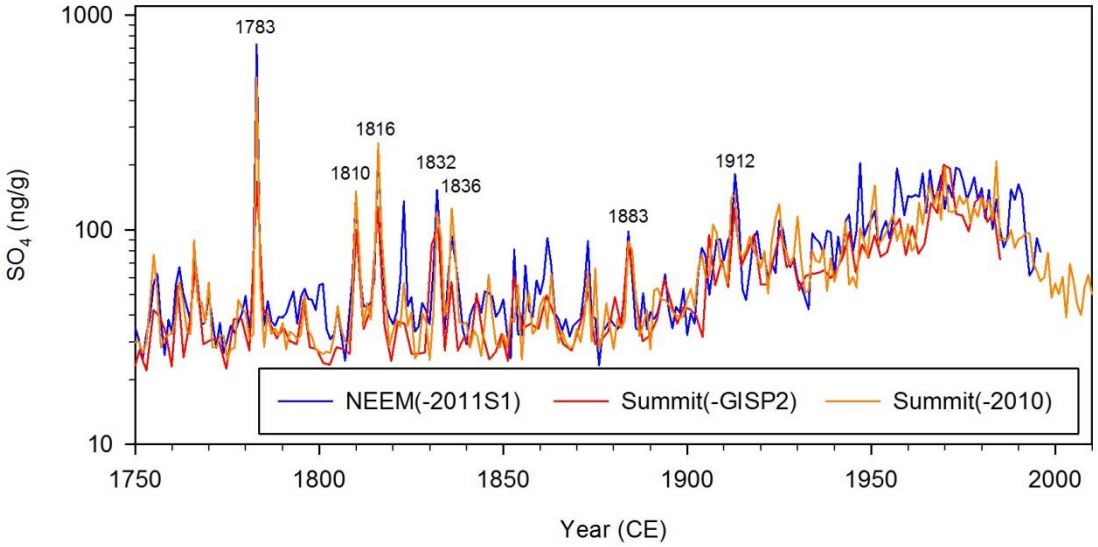


Figure S3: As Fig. S1 but for the time period 1750-2010 CE with concentrations on a logarithmic scale and the seven largest volcanic sulphate deposition events denoted.

5

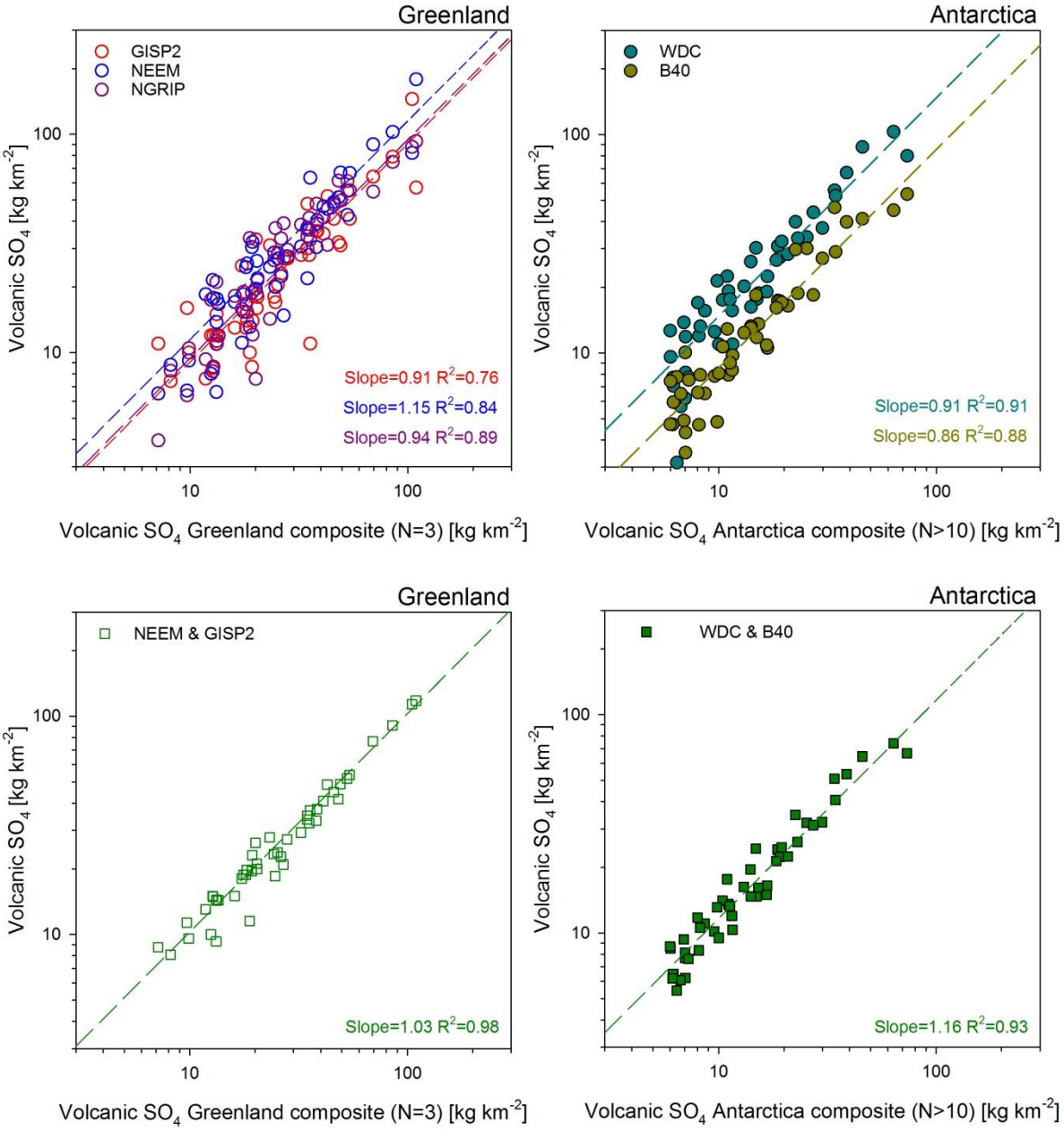


Figure S4: Upper panels: Scatterplot between volcanic sulphate flux for individual ice cores and ice-core composite records for Greenland (left) and Antarctica (right); lower panels: as above for the pairs of ice cores used for reconstruction prior to the Common Era. Included in the analysis are all events common to all three ice cores from Greenland and all events for Antarctica with sampling coverage of the composite >10 ice cores.

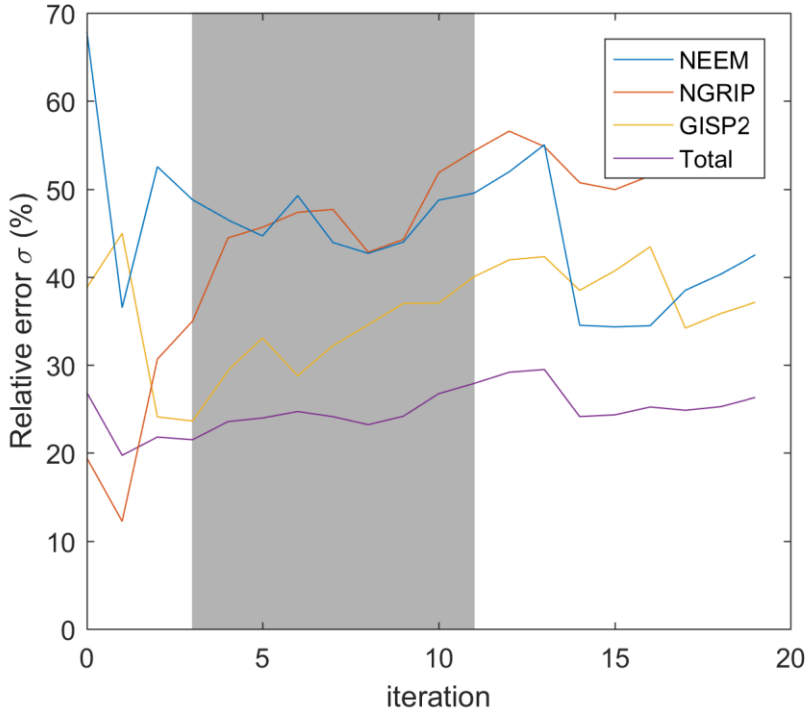


Figure S5: Percent errors estimated for each of the three Greenland ice core sulphate records using the method described in Appendix A. The first iteration of the analysis used the 48 strongest sulphate signals present in all three cores; each subsequent iteration removed from consideration the event with the largest average value across the three cores. The values of estimated error for each ice core record, and the estimated total error of the mean, are plotted as a function of iteration number (or, equivalently, number of largest values removed from the analysis). The grey shaded region denotes the range of relative stability in the error estimates, over which the values were averaged to produce best estimates of the random error in each ice core record.

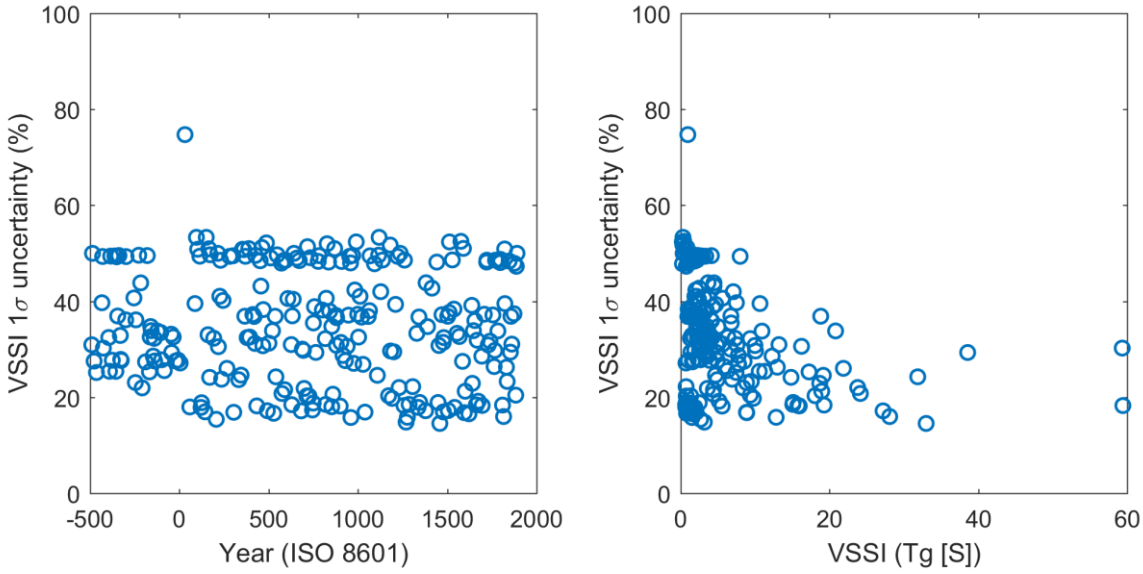
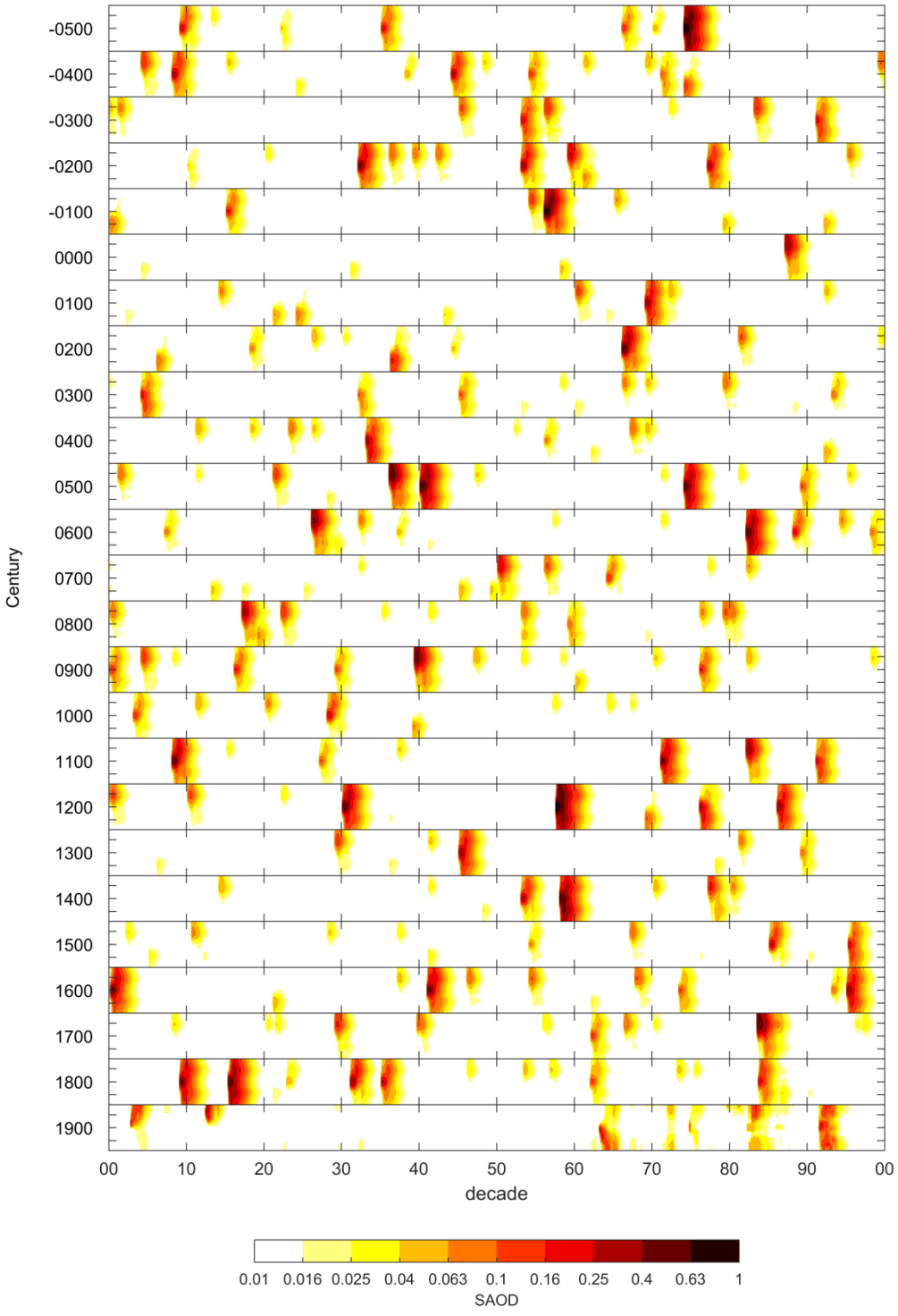


Figure S6: Estimated 1sigma uncertainties in eVolv2k VSSI data set plotted as a function of (left) year, and (right) VSSI.


Century
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0.063
0.1
0.16
0.25
0.4
0.63
1
SAOD

Figure S7: Zonal mean stratospheric aerosol depth as a function of time (x) and latitude (y) for the 500 BCE to 1900 CE period, as reconstructed using the eVovl2k volcanic stratospheric sulphur injection estimates and the EVA forcing generator. 20th century SAOD values from the CMIP6 historical simulation are appended to extend the SAOD time series to the year 2000. Tick marks on the y-axis of each panel mark 45°S, 0 and 45°N.

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