

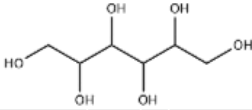
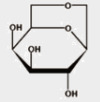
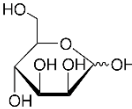
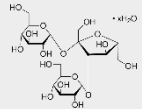
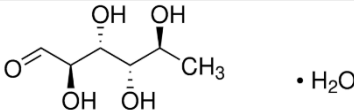
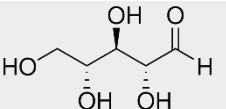
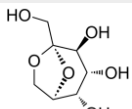
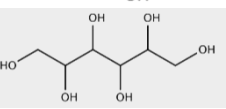
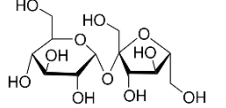
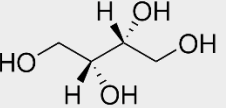
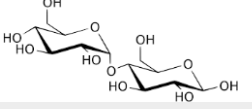
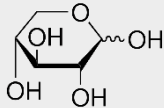
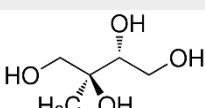
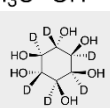
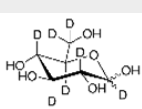
Supplementary data

Table S1: Summary of main sources of sugars in atmospheric aerosol. Many of the links between chemical species and sources proposed in the literature are still tentative and a comprehensive overview is still missing. Modified from Barbaro et al. 2015 and Vincenti et al. 2022.

Compound	Sources	References
ANHYDROSUGARS		
Levoglucosan and its isomers Mannosan and Galactosan	Thermal decomposition of cellulose and hemicellulose including biomass burning	(Kirchgeorg et al., 2014; Simoneit et al., 2004; Simoneit and Elias, 2001; Zennaro et al., 2014)
ALCOHOL-SUGARS	Lichens and bacteria	(Medeiros et al., 2006)
Arabitol	Fungal spores and lichens	(Bauer et al., 2008; Gosselin et al., 2016)
Erythritol	Biomass burning Fungal spores	(Li et al., 2016; Nirmalkar et al., 2019)
Glycerol	Biomass burning Soil	(Zangrando et al., 2016; Zhao et al., 2020)
Inositol	Biomass burning Fungal spores and plant metabolism	(Nirmalkar et al., 2019; Zhu et al., 2015)
Mannitol	Lichen, fungal spores, algae, and higher plants	(Bauer et al., 2008; Gosselin et al., 2016)
2-Methyl-tretol	Plants	(Emygdio et al., 2018)
Trehalose	Fungal spores	(Bauer et al., 2008; Marynowski et al., 2020)
Threitol	Biomass burning and plants	(Emygdio et al., 2018)
Xylitol	Biomass burning Plants, biota	(Nirmalkar et al., 2015, 2019)
SUGARS	Natural biogenic detritus	(Elbert et al., 2006, p.200; Fu et al., 2013; Medeiros et al., 2006; Simoneit et al., 2004; Tominaga et al., 2011)
Arabinose	Biomass burning	(Pietrogrande et al., 2014)
Fructose	Pollen	(Fu et al., 2012; Marynowski et al., 2020; Yttri et al., 2007)
Galactose	Biomass burning	(Pietrogrande et al., 2014)
Glucose	Vascular plants Pollen	(Cowie and Hedges, 1984; Fu et al., 2012; Marynowski et al., 2020; Yttri et al., 2007)
Maltose	Biomass burning Plants	(Ren et al., 2020)
Sucrose	Plant flowering Airbone pollen granules	(Bieleski, 1995; Fu et al., 2012; Pacini, 2000; Yttri et al., 2007)
Trehalose	Yeasts, fungal spores Biomass burning	(Ren et al., 2020) (Nirmalkar et al., 2015)
Xylose	Biomass burning Plants	(Zhao et al., 2020) (Schmidl et al., 2008)
Carbohydrates	Marine organic particles generated by sea spray	(Hawkins and Russell, 2010)

Table S2 : Chemical information of target compounds. S: sugar; SA: sugar alcohol; AS: anhydrosugar; IS: internal standard.

Compound	Type	Molecular mass (g/mol)	Structure	CAS number	Water solubility at 25°C (g/L)
Adonitol	SA	150.9		488-81-3	1000
Arabinose	S	148.9		5328-37-0	1000
Arabitol	SA	150.9		7643-75-6	1000
Erythritol	SA	120.9		149-32-6	1000
Erythrulose	S	119		533-50-6	300
Fructose	S	178.9		57-48-7	977
Galactosan	AS	160.9		644-76-8	781
Galactose	S	178.9		59-23-4	1000
Glucose	S	178.9		50-99-7	1000
Glycerol	SA	90.9		56-81-5	1000
Inositol	SA	178.9		87-89-8	1000
Lactose	S	341		64044-51-5	1000
Levoglugosan	AS	160.9		498-07-7	781
Maltitol	SA	343		585-88-6	1000
Maltose	S	341		6363-53-7	1000

Compound	Type	Molecular mass (g/mol)	Structure	CAS number	Water solubility at 25°C (g/L)
Mannitol	SA	180.9		69-65-8	1000
Mannosan	AS	160.9		14168-65-1	781
Mannose	S	178.9		3458-28-4	1000
Melezitose	SA	503		207511-10-2	50
Rhamnose	S	162.9		10030-85-0	1000
Ribose	S	148.9		50-69-1	1000
Sedoheptulosan	AS	190.9		469-90-9	816
Sorbitol	SA	180.9		50-70-4	1000
Sucrose	S	341		57-50-1	1000
D-Threitol	SA	120.9		2418-52-2	1000
Trehalose	S	341		99-20-7	1000
Xylose	S	148.9		58-86-6	1000
2-methyl-D-Erythritol	SA	135		58698-37-6	
<i>myo</i> -Inositol (1,2,3,4,5,6-D ₆ , 98%)	IS	168.2		68922-44-1	-
D-Glucose (1,2,3,4,5,6-D ₇ , 97-98%)	IS	187.2		66034-51-3	-

Compound	Type	Molecular mass (g/mol)	Structure	CAS number	Water solubility at 25°C (g/L)
Levoglucozan (Levoglucozan) (U-13C6,98%)	IS	168.1		478518-93-3	-

Table S3 : Results for the 21 sugars for NIST® SRM® 2786 (“Fine Atmospheric Particulate Matter”). N.D: no detected.

	Mean concentration (mg/kg) (n=3)	RSD (%) (n=3)
Adonitol	27.9	14.1
Arabitol	599.7	17.6
Erythrulose	1.3	42.6
Fructose	2.7	30.6
Glucose	151.3	0.3
Glycerol	475.2	48.5
Inositol	60.9	2.2
Lactose	83.5	1.3
Levoglucozan	523.3	2.6
Maltitol	N.D	N.D
Maltose	31.2	1.0
Mannitol	367.5	13.9
Mannose	N.D	N.D
Melezitose	25.9	5.7
Rhamnose	3.7	16.9
Sedoheptulosan	N.D	N.D
Sorbitol	27.5	111.7
Sucrose	547.1	5.0
Trehalose	84.2	5.4
Xylose	N.D	N.D
2-methyl-tetrols	10.8	13.9

Table S4: Jungfrauojoch (JFJ) results from 2011 to 2016. Winter: December, January and February; Summer: June, July and August.

	Field blank (n=11) (ng/m ³)	Field LOQ (ng/m ³)	JFJ 2011-2016 concentrations (ng/m ³)				
			Min (n=136)	Max (n=136)	Median (n=136)	Winter mean concentration (n=33)	Summer mean concentration (n=34)
Adonitol	<LOD	<LOD	<LOD	0.04	0.01	0.01	0.02
Arabinose	0.03	0.07	0.04	0.21	0.13	<LOD	0.13
Arabitol	0.01	0.01	<LOD	2.04	0.22	0.03	0.79
Erythrulose	<LOD	<LOD	0.00	0.18	0.03	0.01	0.06
Fructose	0.03	0.03	<Field LOQ	0.58	0.09	0.21	0.17
Galactose	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Glucose	0.14	0.30	<Field LOQ	2.83	0.62	0.24	1.15
Glycerol	3.94	9.40	0.42	69.78	10.14	31.81	2.76
Inositol	<LOD	<LOD	<LOD	0.23	0.04	0.04	0.07
Lactose	<LOD	<LOD	0.01	0.77	0.05	0.03	0.07
Levoglucozan	0.01	0.03	0.04	76.72	1.39	1.44	5.07
Maltitol	<LOD	<LOD	<LOD	0.40	0.08	0.02	0.14
Maltose	0.06	0.08	<LOD	0.39	0.06	0.15	0.11
Mannitol	<LOD	<LOD	<LOD	3.15	0.57	0.07	1.27
Mannose	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Melezitose	<LOD	<LOD	0.01	0.09	0.01	<LOD	0.02
Rhamnose	0.03	0.03	<LOD	0.24	0.04	0.05	0.06
Ribose	<LOD	<LOD	0.08	0.18	0.13	<LOD	0.13
Sedoheptulosan	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Sorbitol	<LOD	<LOD	0.00	0.38	0.11	0.10	0.18
Sucrose	0.78	0.80	0.04	12.37	0.62	0.12	<LOD
Trehalose	<LOD	<LOD	0.07	1.27	0.43	0.16	0.66
Xylose	0.14	0.23	<LOD	<LOD	<LOD	<LOD	<LOD
2-methyl-tetrols	0.06	0.16	0.03	27.31	3.09	0.39	7.06

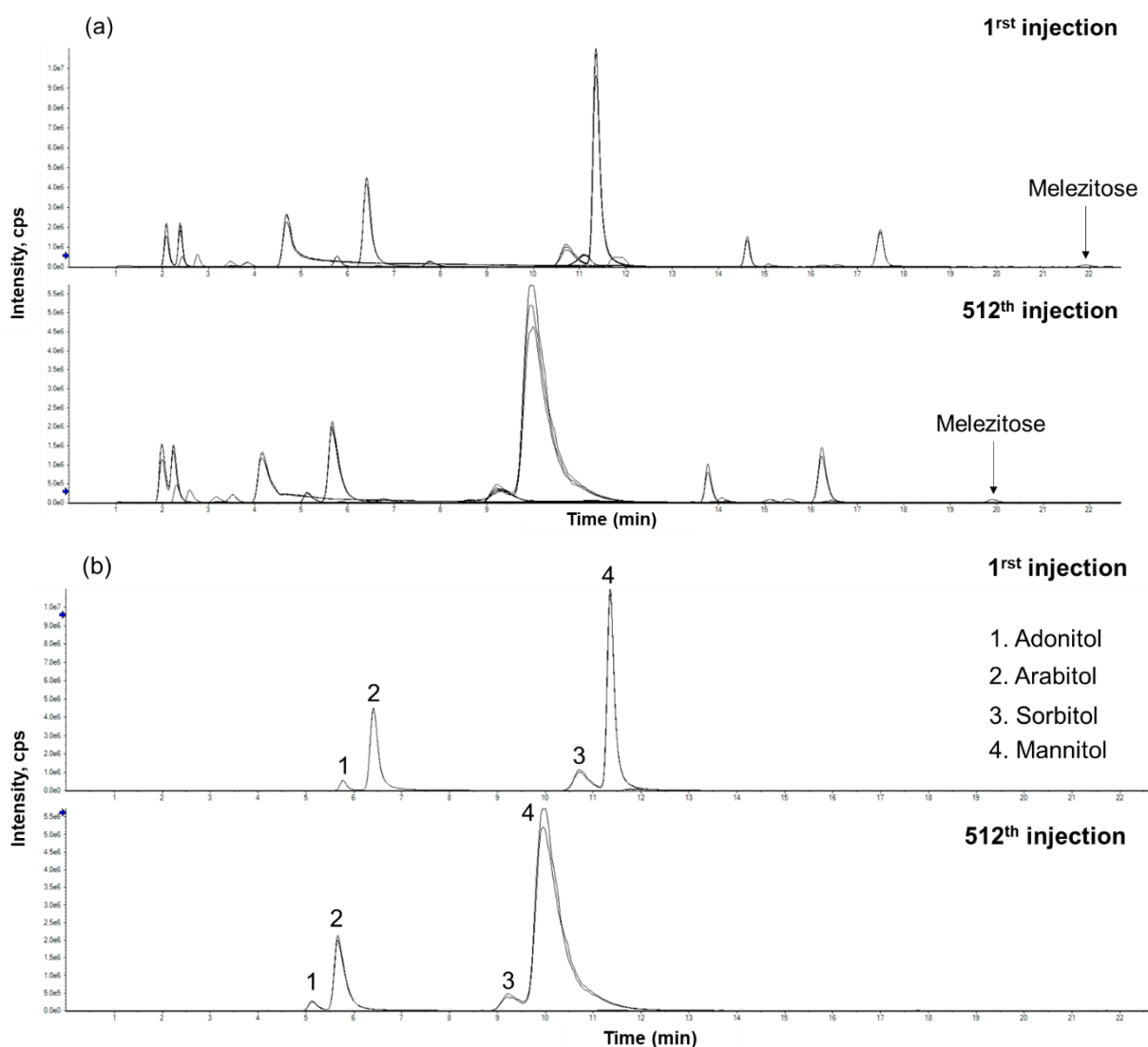


Figure S1: Evolution of sugars separation according to the column ageing. A. Drift of retention time observed between the 1st injection and more than 500 injections (with an average of 0.5 min which can go up to 2.2 min for the case of melezitose). B. Focus on the criteria to put aside an aged column: the compounds adonitol/arabitol and sorbitol/mannitol tend to co-eluate.

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