1.The description of four modeled components

Component 2 (C2) closely resembles a tyrosine-like peak B fluorophore with a excitation peak at a wavelength of 270 nm, and a emission peak at a wavelength of 308 nm. It reflects the highly biogenic degradation of amino acid containing DOM (Coble et al., 1998;Fellman et al., 2010a). Component 3 (C3) matches the traditional humic-like fluorescent peak M (Cory and McKnight, 2005).Component 4 (C4) is composed of two excitation maxima at 240 nm and 290 nm and an emission maximum at 340 nm, which are similar to the components of the tryptophan-like fluorescent peak T (Coble et al., 1998). Component 1 (C1) had two excitation maxima at ＜230nm and 285 nm and an emission maximum at 322 nm. This emission maximum lies between those of the tryptophan-like and tyrosine-like fluorescence components. These fluorescent characteristics cannot be interpreted directly on the basis of previous studies for lake and marine samples. However, the fluorescent characteristics of C1, which have been identified in other glaciers (Dubnick et al., 2010), could be considered as a mixed protein-like peak including both the tryptophan-like fluorescent peak T and the tyrosine-like fluorescence peak B.

Table S1. Relevant common fluorophores identified in previous studies (Coble et al., 1990;Coble et al., 1998;Dubnick et al., 2010;Fellman et al., 2010a;Fellman et al., 2010b;Parlanti et al., 2000;Cory and McKnight, 2005)

Component	Flurophore peak label	Excitation maxima nm	Emission maxima nm	Description
Tyrosine-like	B	270-275 (＜240)	304-312	Amino acid, free or bound in proteins, fluorescence resembles free tyrosine, may indicate more degraded peptide material
Trytophan-like	T	270-280 (＜240)	330-368	Amino acid, free or bound in proteins, fluorescence resembles free Trytophan, may indicate intact protein or less degraded peptide material
Humic-like	M	＜250	388-425	Oxidized, humic-like, low molecular weight corrrelated with aliphatic C content, associated with autochthonous production, potential photoproduct of terrestrial DOM
UVC humic-like	A	＜260	448-480	High molecular weight and aromatic humic, widespread, but highest in wetlands and forested environment
UVC humic-like	C	320-360	420-460	Hight molecular weight humic, widespread, but highest in wetlands and forested environments

Table S2. Average assigned molecular formula of van Krevelen chemical classes and mass content of carbon (C_m) in each average formula.

Sample type	lipids (C_m)	protein (C_m)	carbohydrates (C_m)	unsaturated hydrocarbons (C_m)	lignins and tannins (C_m)	condensed aromatics (C_m)
Fresh snow	$C_{21}H_{37.7}N_{0.3}O_{4.5}$ (0.689)	$C_{18.5}H_{34.3}N_{0.2}O_{7.8}$ (0.578)	$C_{12.3}H_{25}N_{0.5}O_{9.5}$ (0.445)	$C_{29.7}H_{30.3}N_{0.1}O_{1.8}$ (0.885)	$C_{22.2}H_{28.7}N_{0.2}O_{6.3}$ (0.668)	$C_{27.6}H_{15.3}N_{0.1}O_{3.1}$ (0.833)
Fine firn	$C_{21.2}H_{38.3}N_{0.3}O_{4.2}$ (0.699)	$C_{18.1}H_{34}N_{0.2}O_{7.6}$ (0.578)	$C_{11}H_{21.8}N_{0.4}O_{8.7}$ (0.440)	$C_{28.7}H_{20.2}N_{0.1}O_{1.9}$ (0.869)	$C_{19.8}H_{25.9}N_{0.2}O_{5.4}$ (0.674)	$C_{28.1}H_{15.4}N_{0.04}O_{3.1}$ (0.837)
Coarse firn	$C_{21.1}H_{37.7}N_{0.3}O_{4.4}$ (0.693)	$C_{19.8}H_{36.3}N_{0.2}O_{8.1}$ (0.585)	$C_{11.2}H_{22.1}N_{0.4}O_{8.8}$ (0.444)	$C_{32}H_{32.9}N_{0.2}O_{1.9}$ (0.853)	$C_{20.2}H_{26.7}N_{0.3}O_{5.9}$ (0.659)	$C_{30.1}H_{18.7}N_{0.1}O_{2.3}$ (0.864）
Granular ice	$C_{21}H_{37.8}N_{0.3}O_{4.4}$ (0.692)	$C_{19.8}H_{36.2}N_{0.3}O_{8.2}$ (0.581)	$C_{11.9}H_{24.4}N_{0.7}O_{9.1}$ (0.443)	$C_{26.8}H_{28.2}N_{0.1}O_{1.7}$ (0.850)	$C_{20.8}H_{27.5}N_{0.3}O_{6.3}$ (0.653)	$C_{28.2}H_{15.4}N_0O_{2.7}$ (0.852)

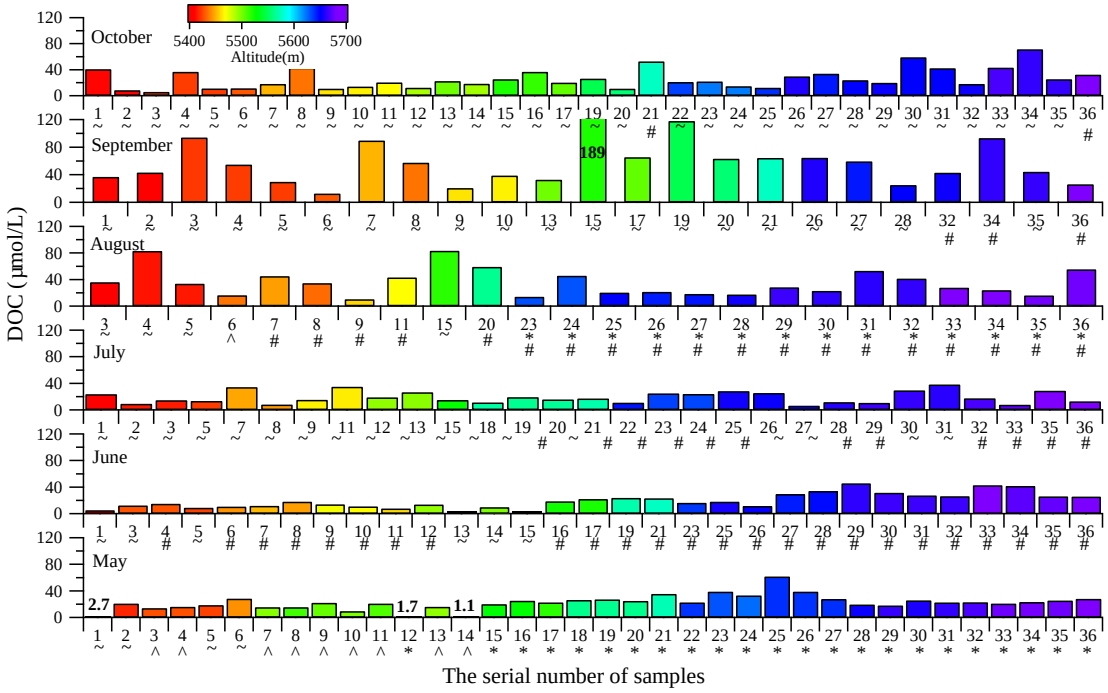

Figure S1. DOC concentration in each snow/ice sample in different monthscolored according to sampling altitude. The number of the samples obtained in each month was normally 36, but one or two samples were omitted due to running out of for other measurement. The symbol under the number of each sample denotes its physical properties (* fresh snow, ^ fine firn, # coarse firn, ~ granular ice).

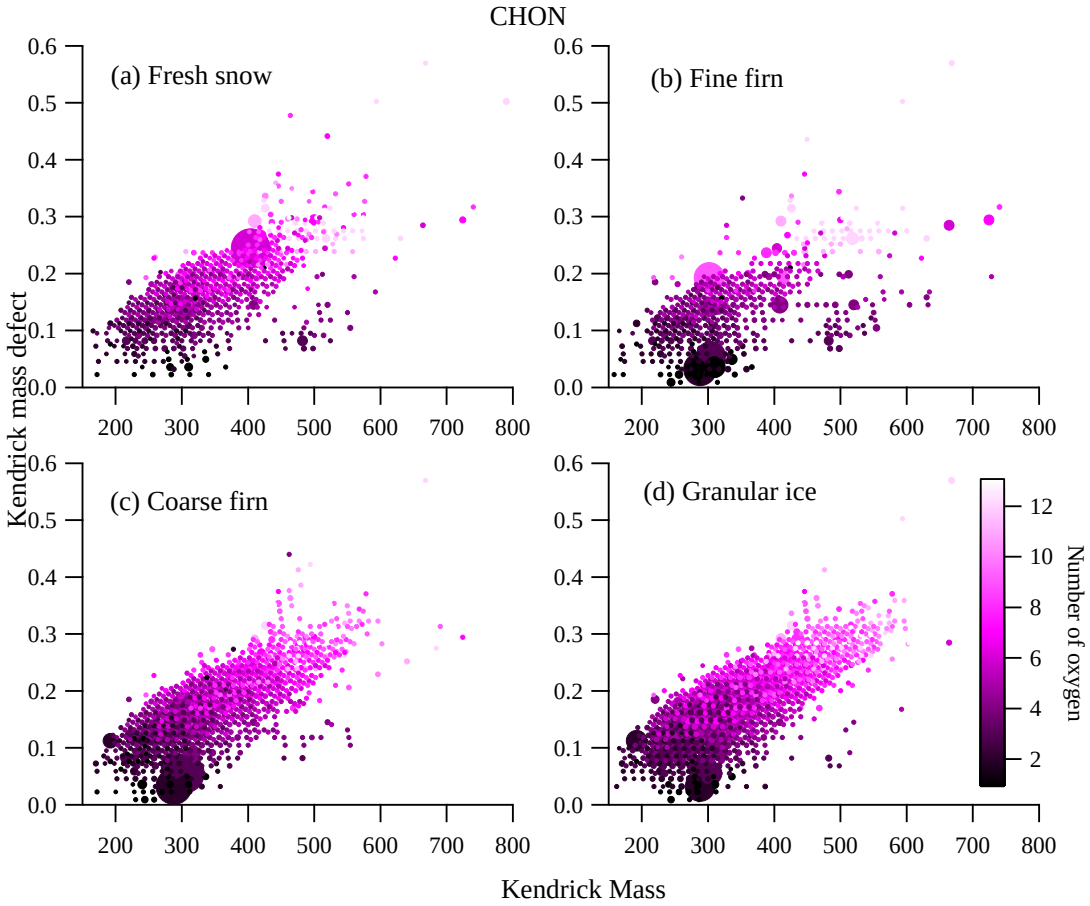

Figure S2. Kendrick mass defect analysis (using CH_2 group) of CHON class, colored according to the number content of oxygen for (a) fresh snow, (b) fine firn, (c) coarse firn, and (d) granular ice.

Reference

Coble, P. G., Green, S. A., Blough, N. V., and Gagosian, R. B.: Characterization of dissolved organic matter in the Black Sea by fluorescence spectroscopy, 1990.

Coble, P. G., Del Castillo, C. E., and Avril, B.: Distribution and optical properties of CDOM in the Arabian Sea during the 1995 Southwest Monsoon, Deep Sea Research Part II: Topical Studies in Oceanography, 45, 2195-2223, 1998.

Cory, R. M., and McKnight, D. M.: Fluorescence spectroscopy reveals ubiquitous presence of oxidized and reduced quinones in dissolved organic matter, Environmental science & technology, 39, 8142-8149, 2005.

Dubnick, A., Barker, J., Sharp, M., Wadham, J., Lis, G., Telling, J., Fitzsimons, S., and Jackson, M.: Characterization of dissolved organic matter (DOM) from glacial environments using total fluorescence spectroscopy and parallel factor analysis, Annals of Glaciology, 51, 111-122, 2010.

Fellman, J. B., Hood, E., and Spencer, R. G.: Fluorescence spectroscopy opens new windows into dissolved organic matter dynamics in freshwater ecosystems: A review, Limnology and Oceanography, 55, 2452-2462, 2010a.

Fellman, J. B., Spencer, R. G., Hernes, P. J., Edwards, R. T., D'Amore, D. V., and Hood, E.: The impact of glacier runoff on the biodegradability and biochemical composition of terrigenous dissolved organic matter in near-shore marine ecosystems, Marine Chemistry, 121, 112-122, 2010b.

Parlanti, E., Wörz, K., Geoffroy, L., and Lamotte, M.: Dissolved organic matter fluorescence spectroscopy as a tool to estimate biological activity in a coastal zone submitted to anthropogenic inputs, Organic Geochemistry, 31, 1765-1781, 2000.