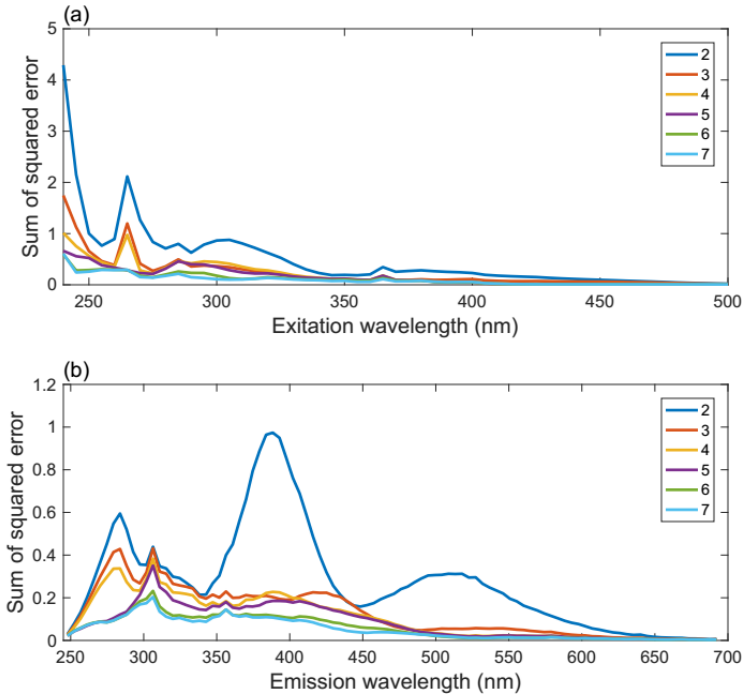

Figure S1. Residual analysis of two- to seven-component PARAFAC models, **(a)** excitation wavelength and **(b)** emission wavelength.

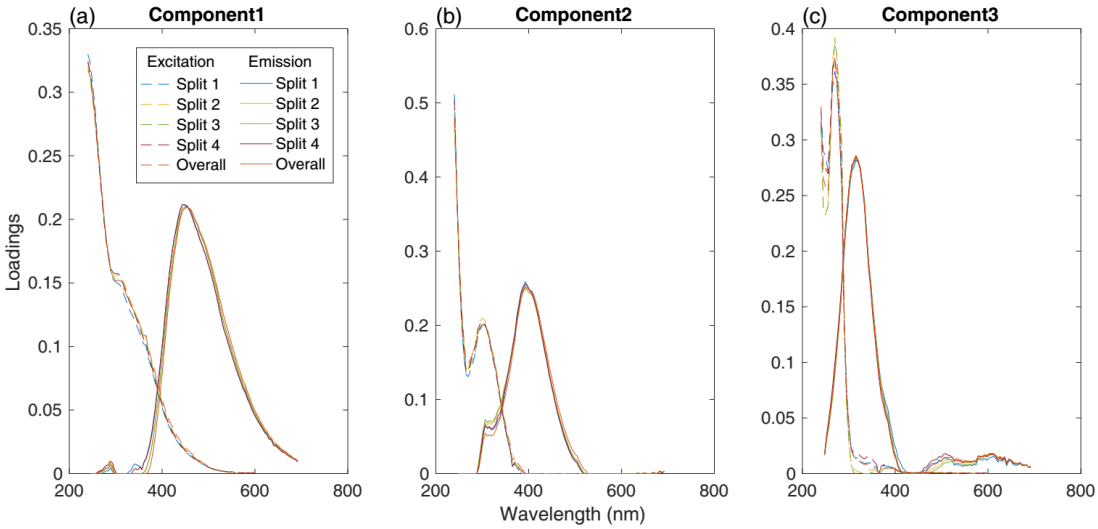

Figure S2. Split half analysis of three-component PARAFAC model with the split style of "$S_4C_4T_2$".

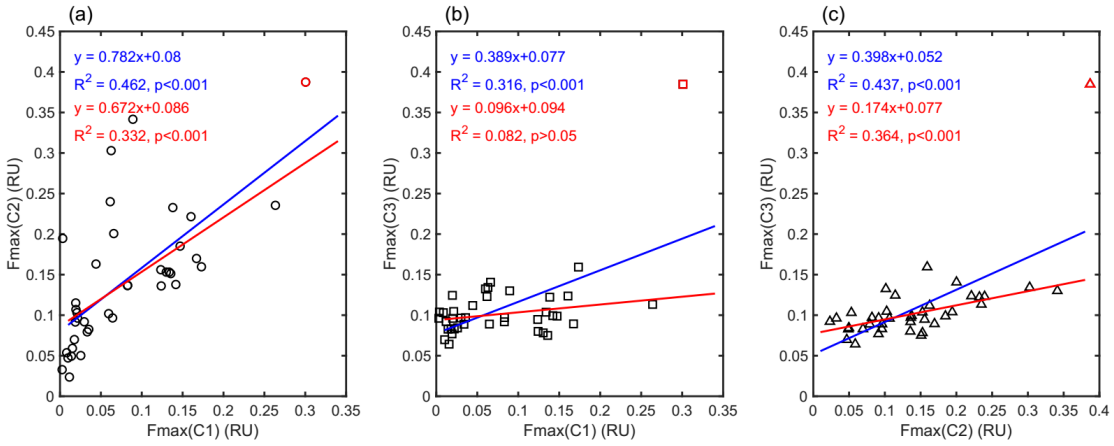

Figure S3. The linear relationships between intensities of **(a)** C1 and C2, **(b)** C1 and C3, **(c)** C2 and C3. The blue lines show the fit of the entire dataset, and the red line shows the fit of data excluded site 67 (shown as markers in red). The corresponding fitting parameters are exhibited in the same color, including the equations, correlation coefficients and p-values.

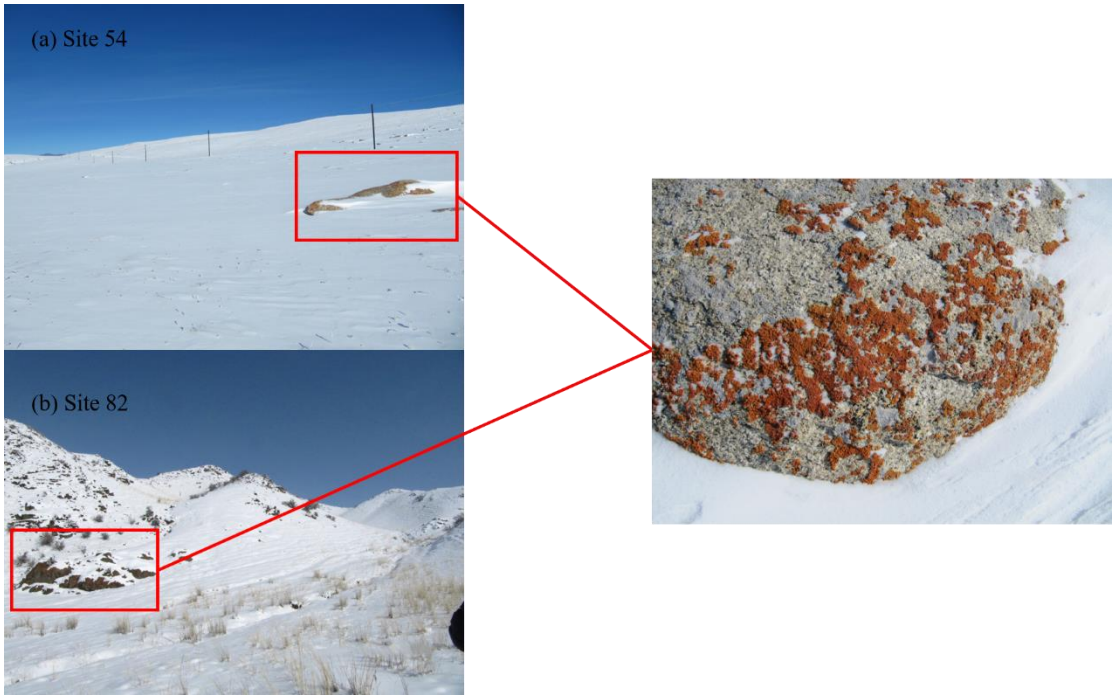

Figure S4. Pictures of alga growing on rocks near sites **(a)** 54 and **(b)** 82.

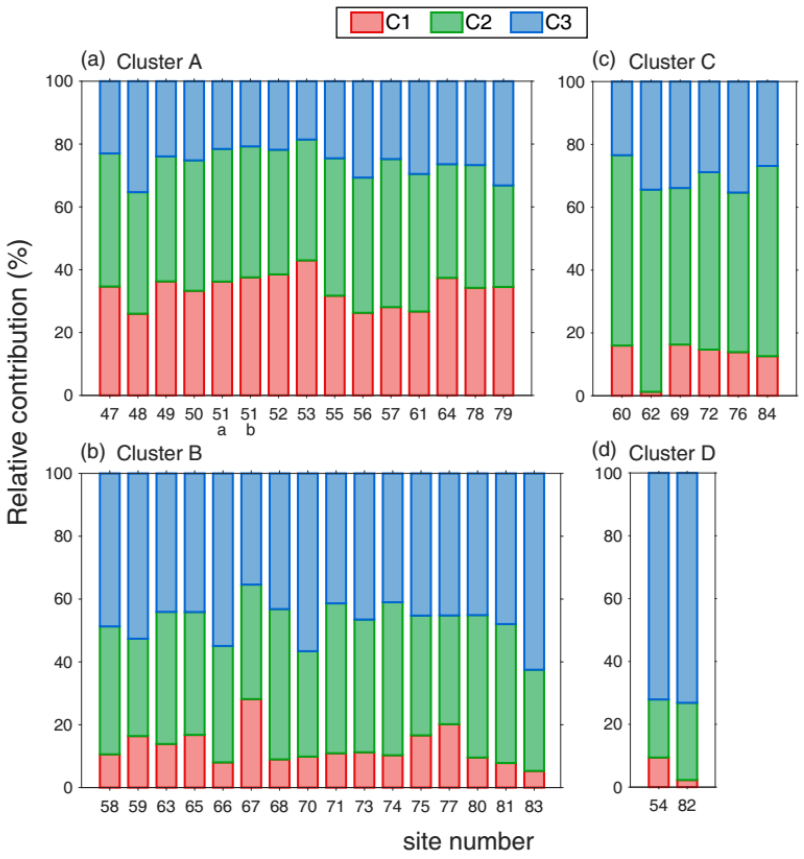

Figure S5. The relative contribution of three fluorescence components in each cluster.

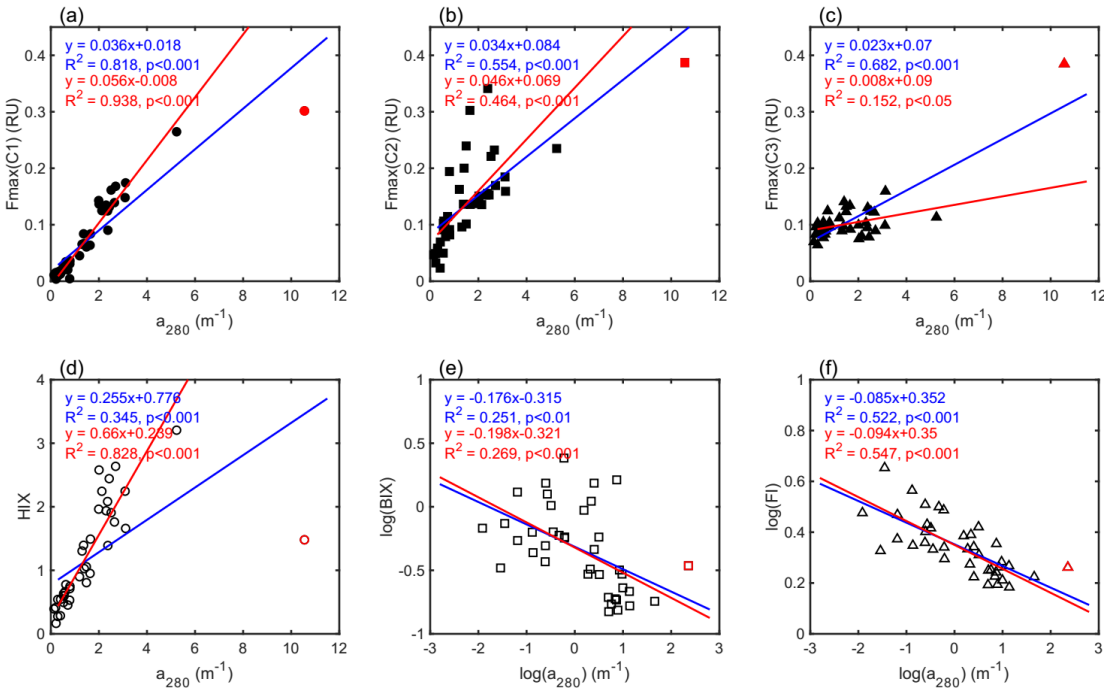

Figure S6. The relationships between a_{280} and the intensities of **(a)** C1, **(b)** C2, **(c)** C3 and the fluorescence-derived indices: **(d)** HIX, **(e)** BIX, **(f)** FI. The blue lines show the fit of entire data, and the red line shows the fit of data excluded site 67 (shown as markers in red). The corresponding fitting parameters are exhibited in the same color, including the equations, correlation coefficients and p-values.

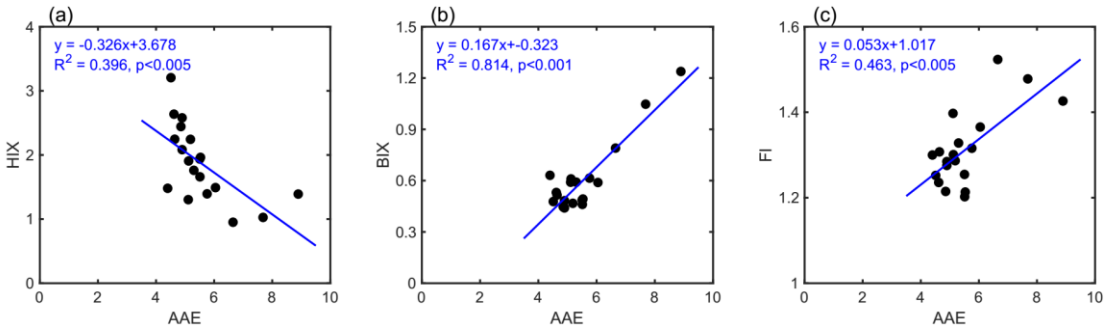

Figure S7. The relationship between AAE and **(a)** HIX, **(b)** BIX and **(c)** FI

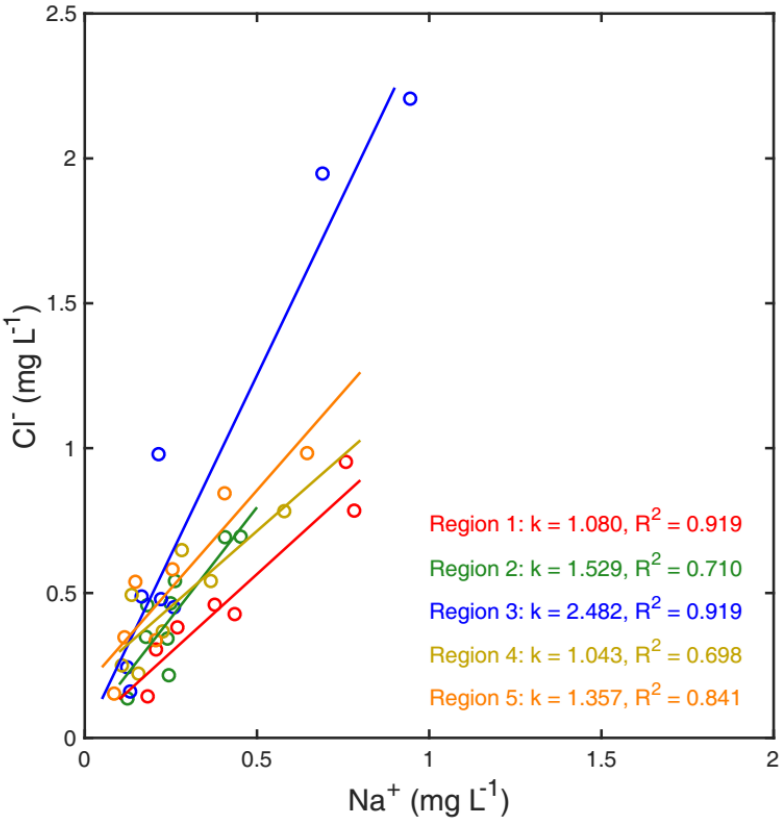

Figure S8. Ratios of Cl^- and Na^+ for the surface snow samples in each region.

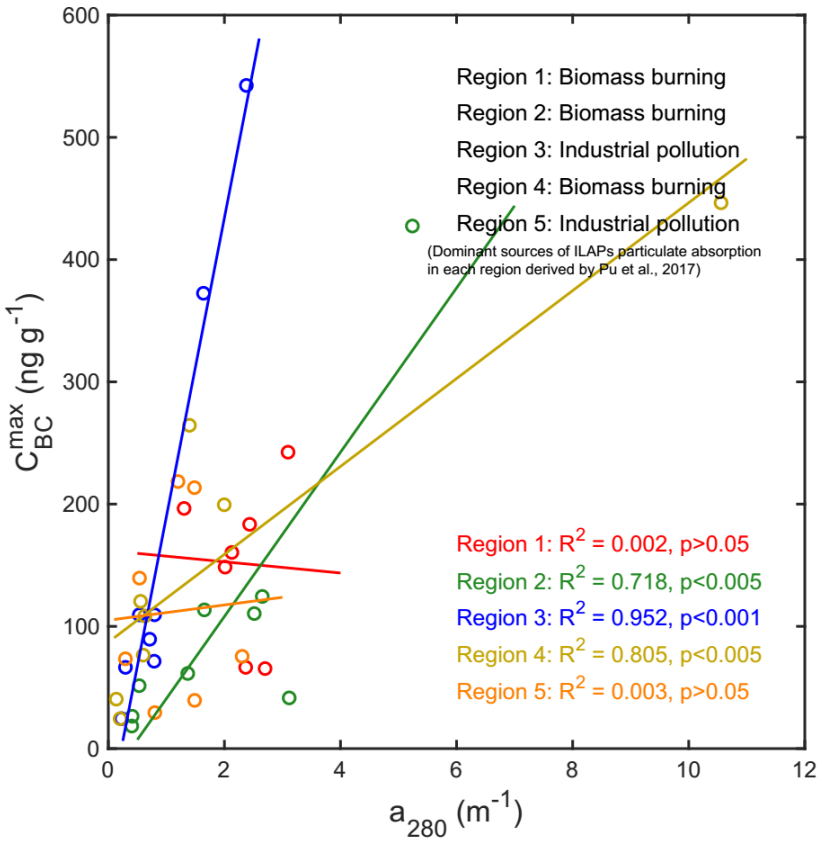

Figure S9. The relationships between particulate absorption of ILAPs and a_{280} in Region 1-5. Note: The dominant sources of ILAPs particulate absorption in each region are also presented, which was derived from Table 5 in Pu et al. (2017).

Table S1. Relative contribution of different fluorescence components in each cluster

Cluster	C1(%)	C2(%)	C3(%)
A	34±5	41±3	26±5
B	13±6	40±6	47±6
C	12±5	57±5	30±4
D	6±4	22±3	73±1

References

Pu, W., Wang, X., Wei, H. L., Zhou, Y., Shi, J. S., Hu, Z. Y., Jin, H. C., and Chen, Q. L.: Properties of black carbon and other insoluble light-absorbing particles in seasonal snow of northwestern China, The Cryosphere, 11, 1213-1233, 2017.