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Molecular and stable isotopic compositions of terrestrial biomarkers in fresh snow from Sapporo, northern Japan

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Homologous series of high molecular weight *n*-alkanes, *n*-alkanols and *n*-alkanoic acids are typical biomarkers that originate from terrestrial higher plant waxes (Eglinton and Hamilton, 1967). These organic compounds are easily sloughed off from the leaf surface, and can become airborne. Because the terrestrial biomarkers in the atmosphere are eventually scavenged and deposited over ice sheet and ocean without suffering major modification due to their refractory nature, understandings of their transport processes can provide a base for paleoclimatological studies of ice cores and marine sediments. In the Japan sea-side of the Japanese islands, the cold and dry air of the Asian winter monsoon causes intensive snowfall with the supply of the heat and moisture from warm Tsushima current over the Sea of Japan. Hence, the snow in northern Japan should contain the imprint of aeolian inputs of terrestrial biomarkers. In this study, we investigated molecular distributions of terrestrial biomarkers and stable carbon ($d^{13}C$) and hydrogen (dD) isotope ratios of C_{22-28} *n*-alkanoic acids in fresh snow samples from Sapporo, northern Japan, to better understand their source regions and transport pathways. The snow samples are found to contain higher plant-derived *n*-alkanes, *n*-alkanols and *n*-alkanoic acids as major components. Relative abundances of these three biomarker classes suggest that they are likely derived from higher plants in the Asian continent. The C_{27}/C_{31} ratios of terrestrial *n*-alkanes in the snow samples range from 1.3 to 5.5, being similar to those of the plants growing in the latitudes $>$ 40N of East Asia. The $d^{13}C$ values of the *n*-alkanoic acids in the snow samples (-33.4 to -29.0 per mil) are similar to those of typical C_3 gymnosperm from Sapporo (-34.4 to -30.4 per mil). However, the dD values of the *n*-alkanoic acids (-181 to -165 per mil) are found to be significantly depleted with deuterium (by up to 48 per mil) than those of plant leaves from Sapporo. Such depletion can be most likely interpreted by the long-range atmospheric transport of the *n*-alkanoic acids from vegetation in the latitudes further north of Sapporo because the dD values of terrestrial higher plants tend to decrease northward in East Asia reflecting the dD of precipitation. Together with the results of backward trajectory analyses, this study suggests that the terrestrial biomarkers in the Sapporo snow samples are likely transported from Siberia, Russian Far East and northeast China to northern Japan by the Asian winter monsoon.

Keywords: stable carbon isotopes, stable hydrogen isotopes, terrestrial biomarker, snow, Asian monsoon