Novel isotope constraints on nitrate utilization of plants in different landscapes

With the support by the National Natural Science Foundation of China, Prof. Liu XueYan (刘学炎) in Tianjin University, cooperating with the researchers in Kyoto University of Japan and Marine Biology Laboratory of USA, discovered a significant role of nitrate (NO_3^-) for vegetations in arctic tundra and highlighted the direct foliar uptake of atmospheric NO_3^- in low-latitude landscapes, which was published in *PNAS* (2018, 115 (13): 3398—3403).

Nitrogen (N) is often the nutrient that most limits terrestrial plant growth, making plant N use a key component of the N cycle in terrestrial ecosystems. Nitrate is a major N form used by plants worldwide and has pivotal and versatile functions in both plant physiology and nutrition. However, the NO_3^- availability and the importance of soil NO_3^- for plants are unknown in N-limited ecosystems such as Arctic tundra although soil N analyses showed extremely low or even undetectable NO_3^- concentrations and nitrification rates. Even in N-rich ecosystems of low-latitude regions, the realistic use of NO_3^- by plants is difficult to evaluate using measurements of soil NO_3^- because of strong plant-microbe and plant-plant competition for N and the direct foliar uptake of atmospheric-derived NO_3^-.

Natural isotopes ($\delta^{15}N$, $\delta^{18}O$, and $\Delta^{17}O$) of NO_3^- in plant tissues were newly developed by Dr. Liu XueYan et al. (*Environ Pollut*, 2012, 162: 48—55; *Funct Plant Biol*, 2012, 39: 598—608; *Environ Sci & Technol*, 2012, 46: 12557—12566; *Biogeochemistry*, 2013, 114: 399—411). These parameters, combining with isotopes of NO_3^- in soils and atmospheric deposition, opened a new avenue to elucidate plant NO_3^- sources and use mechanisms in natural contexts (see a detailed review by Liu et al., *Frontiers in Plant Science*, 2014, 5: 1—14). Following these fundamental studies, they started to reexamine the mysterious veil of Arctic plant-NO_3^- use mechanisms in Alaskan tundra ecosystems. Unexpectedly, they detected soil-derived NO_3^- in tundra plant tissues and found that tundra plants took up soil NO_3^- at comparable rates to plants from relatively NO_3^--rich ecosystems in other biomes. Moreover, they verified *in situ* NO_3^- assimilation in tundra plants, which accounted for 4% to 52% of species-specific (ca. 1/3) total leaf N of Alaskan tundra plants. This new finding in the *PNAS* paper revealed the importance of soil NO_3^- for tundra plants which has always been neglected and should now be considered in future studies of C and N cycles in Arctic ecosystems, where both C sequestration and climate feedbacks are strongly determined by N availability.

More recently, in the light of globally ever-increasing reactive N emissions and eco-environmental effects, Liu's group focused on the novel applications of isotopic techniques for sources, environmental and biological processes of N pollutants in China (Dong et al., *Environ Pollut*, 2017, 230: 506—515; Liu et al., *Environ Pollut*, 2017, 230: 486—494; Wang et al., *Tellus B*, 2017, 69: 1, 1299672; Zheng et al., *Environ Pollut*, 2018, 239: 392—398; Hu et al., *Journal of Ecology*, DOI: 10.1111/1365—2745.13008).

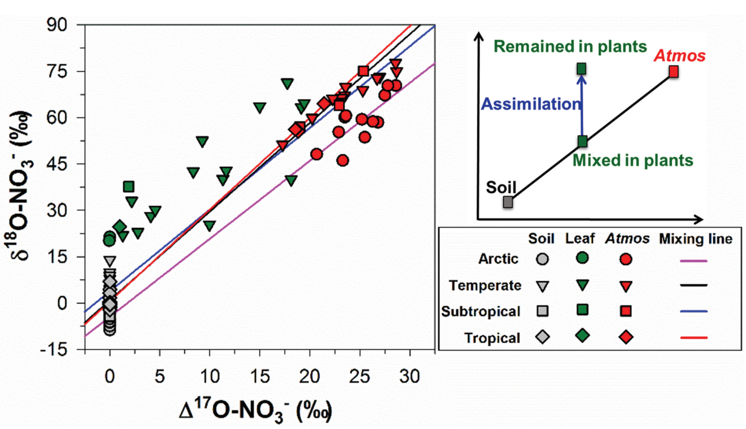

Figure Distributions of $\Delta^{17}O$ and $\delta^{18}O$ in nitrate of atmosphere-plant-soil systems.