A perspective for observations on ecosystem response in the Arctic

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Arctic and sub-Arctic ecosystems are exposed to a larger magnitude of warming in comparison with the global average, as a result of warming-induced environmental changes. Understanding the sensitivity of tree growth to climate in these ecosystems is an important factor in the accuracy of future projections of the terrestrial carbon cycle, and also of global climate. However, it is not certain how these ecosystems respond to these changes.

We have conducted research on tree growth response to climate change over the Arctic and sub-Arctic ecosystems using ring width indices (RWI) from a tree-ring width dataset accessed through the International Tree-Ring Data Bank (ITRDB) and found that the responses differed among regions, depending on the characteristics of each region. Tree radial growth decreased with recent rapid warming in southern boreal forests located on continental dry climate region such as inner Alaska and Canada, southern part of Europe, southern part of Lena river basin of eastern Siberia and Mongolia. Conversely, radial growth increased in the Arctic ecosystems. It is clear that spatial heterogeneity in Arctic and sub-Arctic ecosystems response to climate change existed.

However, we still have following questions with regard to advancing our understanding of these ecosystems response; (i) to which extent does the clear spatial heterogeneity in those ecosystems response deduced from RWI data set correspond to that from other kinds of data set?; (ii) what is controlling factor for the spatial heterogeneity in those ecosystems response?; (iii) how can we expect future carbon cycling in the Arctic and sub-Arctic ecosystems?

To answer these questions, we plan to conduct observation-based multilateral study in which we investigate relationship among tree-ring parameters, i.e., ring width (RWI) and stable carbon isotope ratio, remotely sensed spectral vegetation indices, i.e., normalized difference vegetation index (NDVI) and CO_2 flux observations. The comparisons are conducted for linking those data sets each other and for obtaining better estimate of vegetation activity response to climate change over Arctic and sub-Arctic ecosystems. For example, our comparative analysis between RWI and NDVI (Tei et al., in preparation) showed disagreement in their trends over extensive areas; the accelerated RWI trend over some regions did not correlate with greening and, inversely, with browning where tree experienced a slower growth. Comparison of such proxies with direct CO_2 flux observational data set is also useful to know what NDVI and RWI represent at the ecosystem level, how to optimally integrate them each other, and what related challenges need to overcome. Such efforts are expected to improve our understanding of forest carbon cycling in the Arctic and sub-Arctic ecosystems and place current developments into a long-term perspective. It could also help to evaluate the performance of earth system models regarding the simulated magnitude and dynamics of forest carbon uptake, and inform these models about growth responses to climatic drivers.

Keywords: Arctic and sub-Arctic ecosystems, carbon cycle, tree ring, CO2 flux, remote sensing

