

Temporal and spatial variations of atmospheric carbon dioxide and methane over Siberia

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For a better understanding of the role of the terrestrial ecosystems in the global carbon cycle, atmospheric carbon dioxide (CO₂) and methane (CH₄) mixing ratios have been observed by air sampling method using aircraft over the wetland region near Surgut (61N, 73E) since 1993, over the forest/cultivated area near Novosibirsk (55N, 83E) since 1997 and over the forest area near Yakutsk (62N, 130E) since 1996.

Extremely large seasonal CO₂ variations were seen at 1km over Surgut with peak-to-peak amplitude of 22.0 ppm, whereas the amplitude at 7km was 10.7 ppm. Clear delay of summer minimum was found in seasonal variations, the difference being about half month between 1km and 7km. Steep negative gradients were observed in July and August with the difference in CO₂ mixing ratios between 0.5km and 7km of 6.9 ppm in July and 6.3 ppm in August. On the other hand, positive gradients were seen from November to April, suggesting that steady CO₂ emission was exist even in cold season in Siberia. The CO₂ increase over Surgut was only 0.3 ppm/year in 2010 but was returned to 1.2 ppm/year in 2011. The averaged growth rate of CO₂ from 1993 to 2011 over Surgut was 1.9 ppm/year.

The seasonal variations of CH₄ over Surgut were large at lower altitudes and no clear seasonal variations were observed in upper troposphere. At the altitudes of 0.5 km and 1 km over the western Siberia, maximum concentration was observed both in summer and winter. On the other hand, minimum concentrations were observed in summer at lower altitudes over Yakutsk. Observed high CH₄ in summer season was mainly resulted in CH₄ release from the wetland. Vertical differences in annual mean CH₄ between 7 and 0.5 km are 60 ppb over Novosibirsk and 85 ppb over Surgut, suggesting that large amount of CH₄ was released at ground surface especially from wetland near Surgut. Long-term trends of CH₄ observed over Siberia show rapid increase from 1997 to 1988 and stabilization after that. Siberian CH₄ started to increase again from 2007. At the altitude of 1 km, atmospheric CH₄ levels were highest over Surgut within 3 sites in Siberia, reflecting the strength of CH₄ emission around the observed area.

Keywords: CO₂, CH₄, aircraft, Siberia, carbon cycle, wetland