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Trace gases over Northern Eurasia: background level and disturbing factors

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Atmospheric air composition over the vast and low inhabited areas of Northern Eurasia is still poorly studied because of lack of the precise direct measurements. This harms to accuracy of both global and regional models which simulate climatological and ecosystem changes in that highly important region. In this work background trace gases (such as O_3, NO, NO_2, CO) concentrations and their variability are considered on base of results of continuous measurements at ZOTTO station in the middle of Siberia which have been carried out since March, 2007. Also factors implying background regime (like long-range transport, wild fires emissions) are analyzed. To compliment study data of TROICA train-based campaigns which have been regularly provided across Russia for many years (1995-2010) are used.

The concentration of ozone has a pronounced seasonal variation with a clear peak in spring (40-45 ppbv in average and up to 80 ppbv in extreme cases) and minimum in winter. Average ozone level is about 20 ppbv that corresponds to the background conditions. Enhanced concentration in March-July is due to increased stratospheric-tropospheric exchange. In autumn and winter distribution of ozone is close to uniform. Photochemical processes under low light and air temperature does not cause the generation of ozone. Sink on the snow surface is very small, and therefore the diurnal variations are absent. In general, seasonal variations correspond to the average seasonal course, which is typical for Russia.

The analysis of diurnal ozone variations in Zotino in different seasons showed that the maximum rate of ozone formation is observed in summer from 9 to 15 h local time and is 1-2 ppbv/hour. It correlates well with the data on the isoprene emissions and others biogenic VOC reacting with OH- radical. Thus they are biogenic VOC emissions that seem to be the main factor of the lower troposphere oxidation power in summer. In other seasons it is significantly lower.

NO_x concentration does not exceed 1 ppb that is typical for background areas but may vary by order and some more in few hours. Higher surface NO_x(=NO+NO_2) concentrations during day time generally correspond to higher ozone when NO/NO_2 ratio indicates on clean or slightly polluted conditions.

If there are carbonaceous admixtures (, methane, VOC, etc.) in atmospheric air during the daytime, the NO level more than 10 - 20 ppb is enough for organic matter chain reactions, which lead to ozone accumulation in the atmosphere, to occur. There are almost no such conditions in the rural Siberia.

Despite the prevailing western transport higher ozone (as well as other trace gases) concentrations are correlated with air of southern origin. Anthropogenic pollutants like NO_x and CO come to Central Siberia mostly from industrial regions of Southern Siberia. Intrusions from China are not typical because of blocking Asian anticyclone.

After analysis of surface ozone concentrations one may conclude that climatic conditions (light, temperature, wind conditions, etc.) and chemical composition of the main polluting components (NO, NO_2, CO, methane, etc.) do not help (with rare exceptions) the active generation of ozone in the atmospheric air over Siberia.

Nocturnal O_3 dry deposition and soil emissions of CO_2, CH4 were estimated for different parts of Siberia from radon measurements in TROICA experiments.

The impact of wildfires on surface air composition over central Siberia is investigated based on near-surface carbon monoxide (CO) measurements conducted at ZOTTO during 2007 and 2008 warm seasons. Seasonal variations of intensity and spatial distribution of wildfires in south of western and eastern Siberia are found to be important factors contributing a substantial part of synoptic and year-to-year variability of background CO levels in the region. The estimated relative CO enhancement in fire plumes with transport times up to 2 days is about 5–25 ppb in springs 2007 and 2008, and 50 ppb in summer 2008, based on the observed median values, with a maximal absolute value of 250 ppb observed in April 2008. Boreal forest fires over the vast areas of central Siberia along with regional anthropogenic sources are found to be the major factors driving short-term (synoptic) variability of near-surface CO during the warm season.

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