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Direct observations of reactive atmospheric gases at ZOTTO station in the middle of Siberia as a base for large-scale modeling of atmospheric chemistry over Northern Eurasia

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Direct observations of atmospheric air composition are very important for a comprehensive understanding of atmospheric chemistry over Northern Eurasia and its variability and trends driven by abrupt climatic and ecosystem changes and anthropogenic pressure. Atmospheric air composition (including greenhouse gases and aerosols), its trends and variability is still insufficiently known for most of the nearly uninhabited areas of Northern Eurasia. This limits the accuracy of both global and regional models, which simulate climatological and ecosystem changes in this highly important region.

From that point of view, the Zotino Tall Tower Observatory (ZOTTO) in the middle of Siberia (near 60N, 90E), launched in 2006 and governed by a scientific international consortium plays an important role providing unique information about concentrations of greenhouse and reactive trace gases, as well as aerosols. Simulations of surface concentrations of O_3, NO_x and CO performed by global chemical-transport model GEOS-Chem using up-to-date anthropogenic and biogenic emissions databases show very good agreement with values observed at ZOTTO in 2007-2012.

Observed 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.

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.

CO surface concentration has a vivid seasonal course and varies from about 100 ppb in summer till 150 ppb in winter. But during polluted cases which are quite regular CO may increase till 400 ppb and more.

Most uncertainties are due to the wild fires, which are often in different regions of Siberia. Numerical assessment of climatically important natural and anthropogenic emission sources influencing observed CO and O_3 concentrations and their seasonal variability was made using GEOS-Chem model. According to the results, during the cold period CO concentrations in the surface layer is largely driven atmospheric transport from anthropogenic sources in Western Europe (up to 20 ppb), south of European Russia (up to 35 ppb) and south-western Siberia (up to 28 ppb). During the warm season they are usually affected by air transport from eastern Siberia, where the main contribution to the CO emissions are biogenic VOC oxidation (up to 15 ppb) and wildfires (up to 12 ppb). Transport of pollutants from south-western Siberia can add about 2,5 ppb to the ozone summer level in Central Siberia. In wintertime this factor leads to a reduced surface ozone level by 2 ppb. The contribution of large remote emission sources (Europe) is estimated within 1 ppb. Generally the simulation results indicate a significant role of long-range air transport in addition to regional natural and anthropogenic sources of air pollution which determine the total balance of surface CO. These processes need to be considered in quantitative analyses of the factors that determine the long-term photochemical system evolution in the lower troposphere over the continental regions of Northern Eurasia.

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