Geophysical Research Abstracts
Vol. 17, EGU2015-5855, 2015
EGU General Assembly 2015

Future climate impact on unfavorable meteorological conditions for the dispersion of air pollution in Brussels

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Belgium is one of the several countries in Europe where air quality levels of different pollutants such as ozone, NO_x, and Particulate Matter (PM) still exceed the prescribed European norms multiple times a year (EEA, 2014). These pollution peaks have a great impact on health and environment, in particular in large cities and urban environments. It is well known that observed concentrations of air pollutants are strongly influenced by emissions and meteorological conditions and therefore is sensitive to climate change. As the effects of global climate change are increasingly felt in Belgium, policy makers express growing interest in quantifying its effect on air pollution and the effort required to meet the air quality targets in the next years and decennia (Lauwaet et al., 2014).

In this study, two different stability indices are calculated for a 9-year period using present (1991-1999) and future (2047-2055) climate data that has been obtained from a dynamically downscaling of Global Climate Model data from the Arpège model using the ALARO model at 4 km spatial resolution. The ALARO model is described in detail in previous validation studies from De Troch et al. (2013) and Hamdi et al. (2013). The first index gives a measure of the horizontal and vertical transport of nonreactive pollutants in stable atmospheric conditions and has been proposed and tested by Termonia and Quinet (2004). It gives a characteristic length scale l which is the ratio of the mean horizontal wind speed and the Brunt-Väisälä frequency. In this way low values for l in the lower part of the boundary layer during an extended time span of 12 hours, correspond to calm situations and a stable atmosphere and thus indicate unfavorable conditions for the dispersion of air pollution. This transport index is similar to an index used in an old Pasquill-type scheme but is more convenient to use to detect the strongest pollution peaks. The well known Pasquill classes are also calculated in order to provide a reference. Both indices are calculated for the gridpoint of Uccle, located some 6 km from the city centre of Brussels. As the transport index only applies for stable conditions which mostly occur during the winter season, our analyses focuses on the DJF winter months.

First results from a sensitivity analyses show higher frequencies in low transport lengths (i.e. stable conditions) for future winter climate under the A1B scenario. This shift to more stable and hence possibly favorable conditions for pollution peaks is also confirmed by the frequency distributions of the Pasquill classes, showing higher frequencies in the stable E and F classes for the future period. These results show that more pollution peaks are to be expected by the middle of the 21^{st} century in Brussels.