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Modelling of deposited black carbon with the Lagrangian particle dispersion model FLEXPART in backward mode

Sabine Eckhardt, Massimo Cassiani, Espen Sollum, Nikolaos Evangeliou, and Andreas Stohl
NILU - Norwegian Institute for Air Research, Kjeller, Norway (sec@nilu.no)

Lagrangian particle dispersion models are popular tools to simulate the dispersion of trace gases, aerosols or radionuclides in the atmosphere. If they consider only linear processes, they are self-adjoint, i.e., they can be run forward and backward in time without changes to the source code. Backward simulations are very efficient if the number of receptors is smaller than the number of sources, and they are well suited to establish source-receptor (s-r) relationships for measurements of various trace substances in air. However, not only the air concentrations are of interest, but also the s-r relationships for deposition are important for interpreting measurement data. E.g., deposition of dust is measured regularly in ice cores, partly also as a proxy to understand changes in aridity in dust source regions. Contamination of snow by black carbon (BC) aerosols has recently become a hot topic because of the potential impact of BC on the snow albedo. To interpret such deposition measurements and study the sources of the deposited substance, it would be convenient to have a model that is capable of efficient s-r relationship calculations for such types of measurements. We present here the implementation of such an algorithm into the Lagrangian particle dispersion model FLEXPART, and test the new scheme by comparisons with results from forward simulations as well as comparisons with measurements. As an application, we analyse source regions for elemental carbon (EC) measured in snow over the years 2014-2016 in the Russian Arctic. Simulations using an annual constant black carbon inventory based on ECLIPSE V5 and GFED (Global Fire Emission Database), have been performed. The meteorological data used in the simulation are 3 hourly operational data from the European Centre of Medium Range Weather Forecast (ECMWF) on a 1 degree grid resolution and 138 vertical levels. The model is able to capture very well the measured concentrations. Gas flaring and residential/commercial combustion can be identified as the most important sources. High concentrations measured near the Ob River (up to 170 ng g^{-1}) can be associated with air masses coming from Europe.