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Source-receptor-sensitivity based reconstruction of point measurement scenarios based on gridded emission inventories

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The comparison of point measurements with model simulations based on gridded emission inventories constitutes one of the most common atmospheric transport model applications in environmental sciences. The traditional computation procedure involves forward simulations with – mostly Eulerian – transport models using the emission inventory as model input. In case non-linear chemical reactions do not play a role, and in the (quite common) case that the number of monitoring stations is smaller than the number of emission grid cells, the most efficient way to address this problem lies in the utilization of backward (adjoint) modeling approaches. For every measurement taken at a monitoring station, so called Source-Receptor-Sensitivity (SRS) fields are computed with backward runs of a Lagrangian Particle Diffusion Model (LPDM). The SRS fields can subsequently be post-processed by combining them with a gridded emission inventory, yielding the adjoint-model-predicted (or backward-reconstructed) concentration values pertaining to these measurements. The adjoint-model-predicted measurement scenario can then be compared with available observations to investigate the validity of the underlying emission inventory. This approach has several advantages. It is efficient because all computation efforts are restricted to the available measurements. The SRS post-processing (backward-reconstruction) step is very fast, since it just involves multiplication of SRS values with source strengths for all source grid cells touched by the underlying retro-plume (SRS > 0). Several emission inventories can be implemented and the resulting measurements be reconstructed without repeating the computationally more demanding transport modeling part. Furthermore, the novel computation scheme is, from its very concept, particularly accurate close to the measurements (in space as well as time), while the forward modeling approach is particularly accurate close to the major emission grid cells. The capabilities of our scheme shall be demonstrated in two recently conducted case studies. Firstly, high-precision measurements of Noble Gases (Radio-Xenon) in the arctic region were related to emissions in the reactor regions of the mid-latitudes. Secondly, cesium detections in Canada over a period of two years were related to forest-fire induced re-suspension. In both cases, realistic gridded emission inventories were worked out and subsequently validated.