Geophysical Research Abstracts
Vol. 14, EGU2012-4401, 2012
EGU General Assembly 2012

Assessing uncertain human exposure to ambient air pollution using environmental models in the Web

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Ambient air quality can have significant impact on human health by causing respiratory and cardio-vascular diseases. Thereby, the pollutant concentration a person is exposed to can differ considerably between individuals depending on their daily routine and movement patterns. Using a straight forward approach this exposure can be estimated by integration of individual space-time paths and spatio-temporally resolved ambient air quality data. To allow a realistic exposure assessment, it is furthermore important to consider uncertainties due to input and model errors.

In this work, we present a generic, web-based approach for estimating individual exposure by integration of uncertain position and air quality information implemented as a web service. Following the Model Web initiative envisioning an infrastructure for deploying, executing and chaining environmental models as services, existing models and data sources for e.g. air quality, can be used to assess exposure. Therefore, the service needs to deal with different formats, resolutions and uncertainty representations provided by model or data services. Potential mismatch can be accounted for by transformation of uncertainties and (dis-)aggregation of data under consideration of changes in the uncertainties using components developed in the UncertWeb project. In UncertWeb, the Model Web vision is extended to an Uncertainty-enabled Model Web, where services can process and communicate uncertainties in the data and models. The propagation of uncertainty to the exposure results is quantified using Monte Carlo simulation by combining different realisations of positions and ambient concentrations.

Two case studies were used to evaluate the developed exposure assessment service. In a first study, GPS tracks with a positional uncertainty of a few meters, collected in the urban area of Münster, Germany were used to assess exposure to PM10 (particulate matter smaller 10 μm). Air quality data was provided by an uncertainty-enabled air quality model system which provided realisations of concentrations per hour on a 250 m x 250 m resolved grid over Münster. The second case study uses modelled human trajectories in Rotterdam, The Netherlands. The trajectories were provided as realisations in 15 min resolution per 4 digit postal code from an activity model. Air quality estimates were provided for different pollutants as ensembles by a coupled meteorology and air quality model system on a 1 km x 1 km grid with hourly resolution. Both case studies show the successful application of the service to different resolutions and uncertainty representations.