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Nationwide estimation of personal exposure to air pollution using activity-based field-agent modelling

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Estimating personal exposure to air pollution is important in investigating the impact of air pollution on chronic diseases such as diabetes or cardiovascular disease. Long-term personal exposures estimates from large cohorts are required to reliably identify the relation between chronic air pollution exposure and non-communicable disease outcomes. Using e.g. yearly averaged concentrations at fixed locations such as the home address may result in incomplete quantification of personal exposure as persons move in space and time. An appropriate estimation involves mapping of space-time variation of concentrations as well as incorporating several activities of individuals at different locations and the mobility of individuals along their space-time paths. While for small surveys detailed information is often available (e.g. home and work address, GPS tracking data and travel mode), this abundance of data is not available for large-scale personal exposure assessment. Thus, for large-scale exposure assessment the first challenge is the design of model representations of individual mobility for which parameters can be identified with relatively limited observational data on individual mobility. The second challenge is the execution of such large-scale models over large populations.

We address these challenges by developing a modelling framework on top of Campo (https://campo.computationalgeography.org) that combines the space-time mapping of pollution and activity-based mobility simulation of individuals. To represent data sparse information on individuals, we use personal activity schedules. Air pollution is based on land use regression models. Our modelling approach contains the following key components: a) an activity schedule generator allowing to express the type, location and duration of an individual's activity as a function of a person's profile defined by e.g. age, gender or occupation, and b) a spatial context generator providing the location of an individual during a particular activity. Activities cover residence in certain areas (home, work, leisure) or along routes using different travel modes (car, bicycle, on foot), and c) an exposure estimator. Exposure estimation is subsequently the combination of the spatial contexts for each activity with air pollution concentrations at

corresponding times.

Using these decoupled but interacting components provides the flexibility to express a broad range of representative time spans and spatial residences, required e.g. to represent uncertainty of unknown work locations or travelled routes. We present concepts and the model using a nationwide cohort from Switzerland.