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Urban population exposure to NO_2 emissions from local shipping in three Baltic Sea harbour cities – a generic approach

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Introduction
Ship emissions in ports can have a significant impact on local air quality (AQ), population exposure and therefore human health in harbour cities. In the frame of the BONUS SHEBA project the impact of emissions from ships in harbours on local AQ and population exposure in the Baltic port cities Rostock, Riga and the urban agglomeration of Gdansk-Gdynia for 2012 was determined. An urban AQ study was performed using a city-scale Chemical Transport Model (CTM) simulating NO_2 concentrations in 2012 with the aim to determine the impact of local shipping activities to outdoor population exposure in Baltic Sea harbour cities. To account for daily activity patterns of individuals we calculated exposure in different microenvironments (MEs), which describe locations in which human exposure takes place, such as, e.g. home or workplace.

Air quality modelling
The urban AQ modelling was performed with the EPISODE-CityChem model using 3D boundary concentrations derived from simulations with the regional scale AQ model CMAQ. Local emission inventories for all sectors following SNAP nomenclature were compiled with data from local authorities and complemented by downscaling regional scale emissions. Local ship emissions were generated with the STEAM model based on AIS position data with hourly variation and a grid resolution of 250 m. The urban domains were setup with grid resolutions of 400 x 400 m^2 in Rostock and Riga and with 1000 x 1000 m^2 in the urban agglomeration of Gdansk-Gdynia and simulations with and without ship emissions were performed.

Exposure modelling
Based on simulated concentrations, dynamic population weighted outdoor exposure to NO_2 for all urban domains was calculated in different selected MEs (home, work, port, traffic, other) using a newly developed generic exposure model. The developed exposure model follows state-of-the-art exposure modelling approaches and combines (1) a generic diurnal time profile for population activity, (2) EUROSTAT population density for Europe, (3) land use classifications for different MEs derived from Copernicus Urban Atlas 2012 classifications, (4) differentiation between indoor and outdoor MEs and (5) statistical domain-specific population data which is publicly available. The results are hourly ME-specific population grids with a spatial resolution of 100 m^2 which are then multiplied with pollutant concentration fields.

Results
The CityChem simulations were evaluated at available measurement stations in all urban domains and showed good statistical performances for NO_2 as well as fulfillment of model quality objectives as defined in the JRC FAIRMODE Delta tool. We created maps of concentration and population exposure to NO_2 in different MEs to analyse the influence of local shipping emissions. The local shipping impact on NO_2 concentrations is found to be relevant for AQ regulations with 22%, 11% and 16% contribution to the total annual averaged grid mean concentration for Rostock, Riga and Gdansk-Gdynia respectively. When it comes to ME specific exposure, shipping has high impact in the port ME while the influences on other MEs are lower. Besides this, the newly developed generic approach allows for dynamic population weighted outdoor exposure calculations in European cities without the necessity of large-scale surveys on population data.