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Analysis of secondary inorganic aerosols over the greater Athens area using the EPISODE–CityChem source dispersion and photochemistry model

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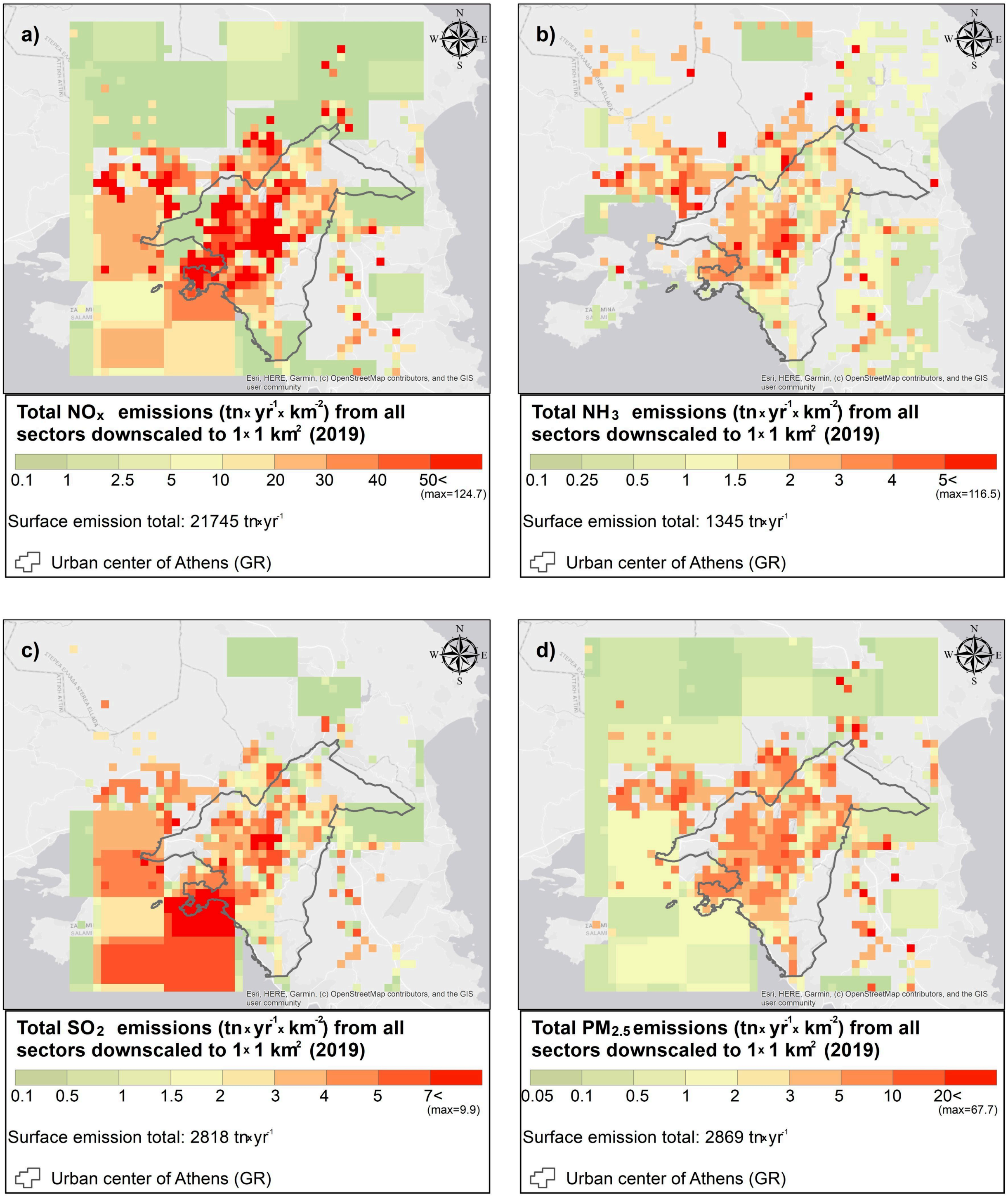
Supplementary Figures



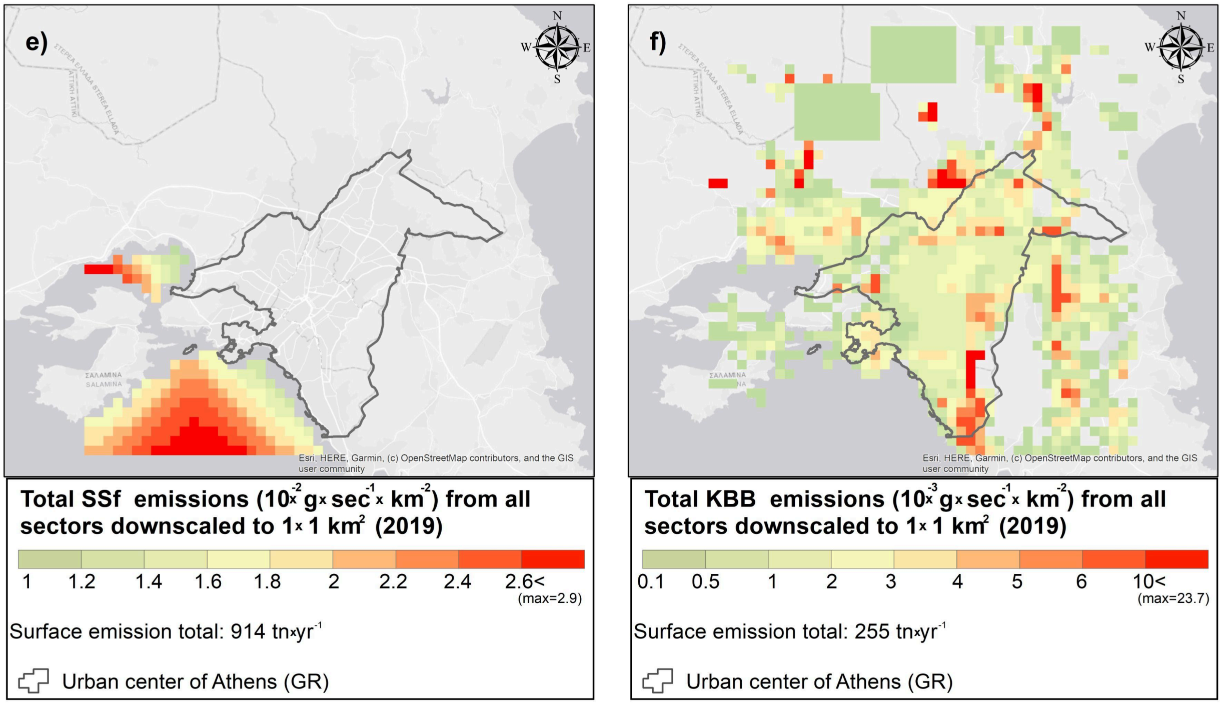


Figure S1: Maps of total annual emission fields of: a) total NO_x emissions, b) total NH_3 emissions, c) total SO_2 emissions, d) total $PM_{2.5}$ emissions, e) fine-mode sea salt emissions (SSf), and f) potassium (K^+) emissions from domestic burning (Kbb). The database used is CAMS regional anthropogenic emissions, which are spatially disaggregated (to 1 km^2) by the UrbEm approach (Ramacher et al., 2021); sea salt emissions are calculated online based on Vignati et al. (2010) parameterizations along with available updates (see text); K^+ emissions are derived based on non-sea salt $K^+/PM_{2.5}$ concentration ratios are derived from filter-based $PM_{2.5}$ measurements in the center of Athens by Paraskevopoulou et al. (2014) (see text).

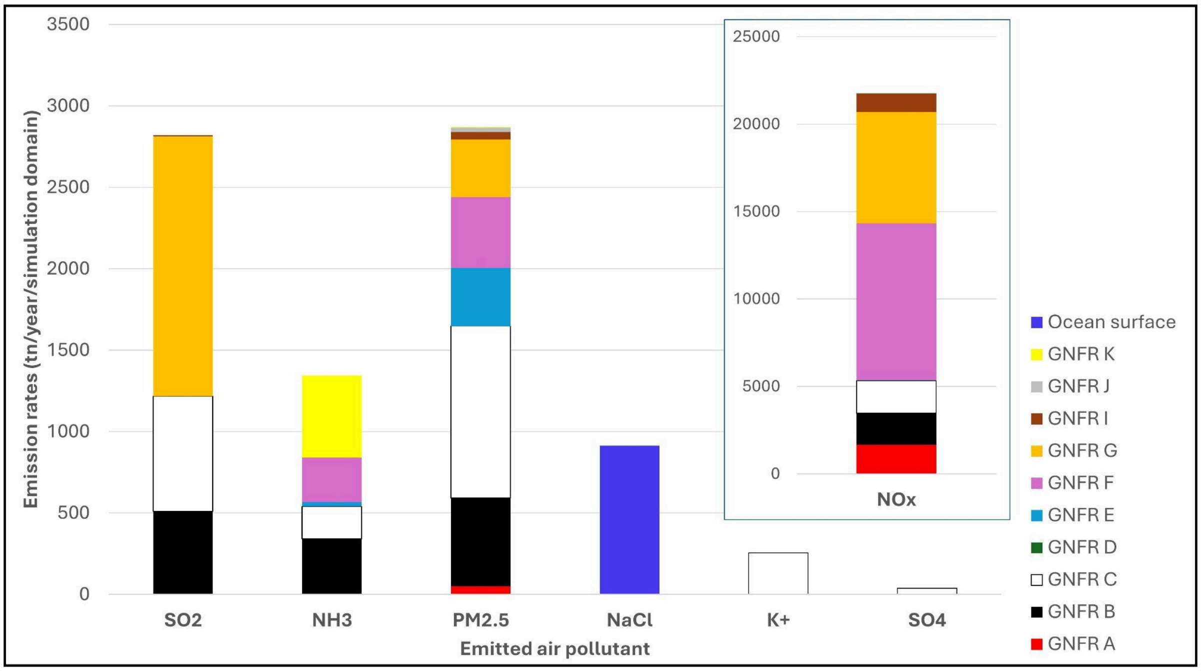


Figure S2: Spatio-temporal totals of SIA-related tracer emissions for SO_2, NH_3, $PM_{2.5}$, Sea-Salt (expressed in NaCl), Potassium (K^+), SO_4^{2-}, and NOx (in tonnes per year per simulation domain), and the contribution of each source sector (GNFR category A: power plants; B: industrial sources; C: other stationary combustion; D: fugitives; E: solvents; F: road transport; G: shipping; H: aviation; I: off-road; J: waste; K: agriculture)

Supplementary Tables

Table S1: Average values of main meteorological parameters, including statistics against measurements from the NOA/Meteo meteorological stations in Athens.

Parameter	**Observations Mean**	**Model Mean**	**Mean Bias**	**Mean Absolute Error**	**Correlation**
Temperature (^{o}C)	18.5	18.7	0.2	1.5	97%
Pressure (hPa)	1013.8	993.7	-20.1	20.2	97%
Specific Humidity (g/kg)	8.5×10^{-3}	8.2×10^{-3}	-3.0×10^{-4}	1.2×10^{03}	87%
Wind Speed (m/s)	2.0	4.7	2.8	2.9	63%

WRF simulates the 2m temperatures in good agreement with observations, with a very low mean bias and a very good correlation. The atmospheric pressure is also well predicted, with a very good correlation. However, there is a significant bias in the pressure, which is caused by altitude deviations due to the complex landscape. These deviations are not well reproduced within the model, even at 1 km resolution. As a result, the pressure bias is close to zero in coastal stations, while in mountain stations the bias may be over 100 hPa. On the other hand, the simulated specific humidity is in line with the observations and shows a good correlation. The average normalized mean bias for all stations is -3%, indicating that the WRF slightly underestimates the atmosphere's water content. There are, however, large deviations between the modeled and observed wind speeds. The average observed wind speed is 1.97 m/s, while the modeled wind speed is 4.72 m/s for all stations. The average normalized mean bias is around 180%, indicating a significant discrepancy. This can also be seen in the high mean absolute error, while the correlation is moderate. One important factor contributing to this discrepancy is that the anemometers of the NOA/Meteo network are at a height of 5 m, while the WRF wind speed used for evaluation is at a height of 10 m. Since most of these stations are located in inhabited areas surrounded by buildings, it is expected that the wind speed changes significantly within the first few meters above the ground. Therefore, a good portion of the deviations is due to the way wind speed is measured by the NOA/Meteo network. To address this, the WRF wind speed was further evaluated against measurements from 3 stations of the Hellenic National Meteorological Service located in airports, far away from buildings, with anemometers at a height of 10 m. In these stations, the average normalized mean bias was found to be 47%. This indicates that, at least outside the urban area, the model has a real deviation much lower than what was shown in the comparison with the NOA/Meteo stations. However, there is still some discrepancy, which is possibly caused by the complex geography of the area, local sea breezes, and the urban landscape.

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