Estimating Surface Concentrations of NO_2 from TROPOMI Measurements in Finland: First Results

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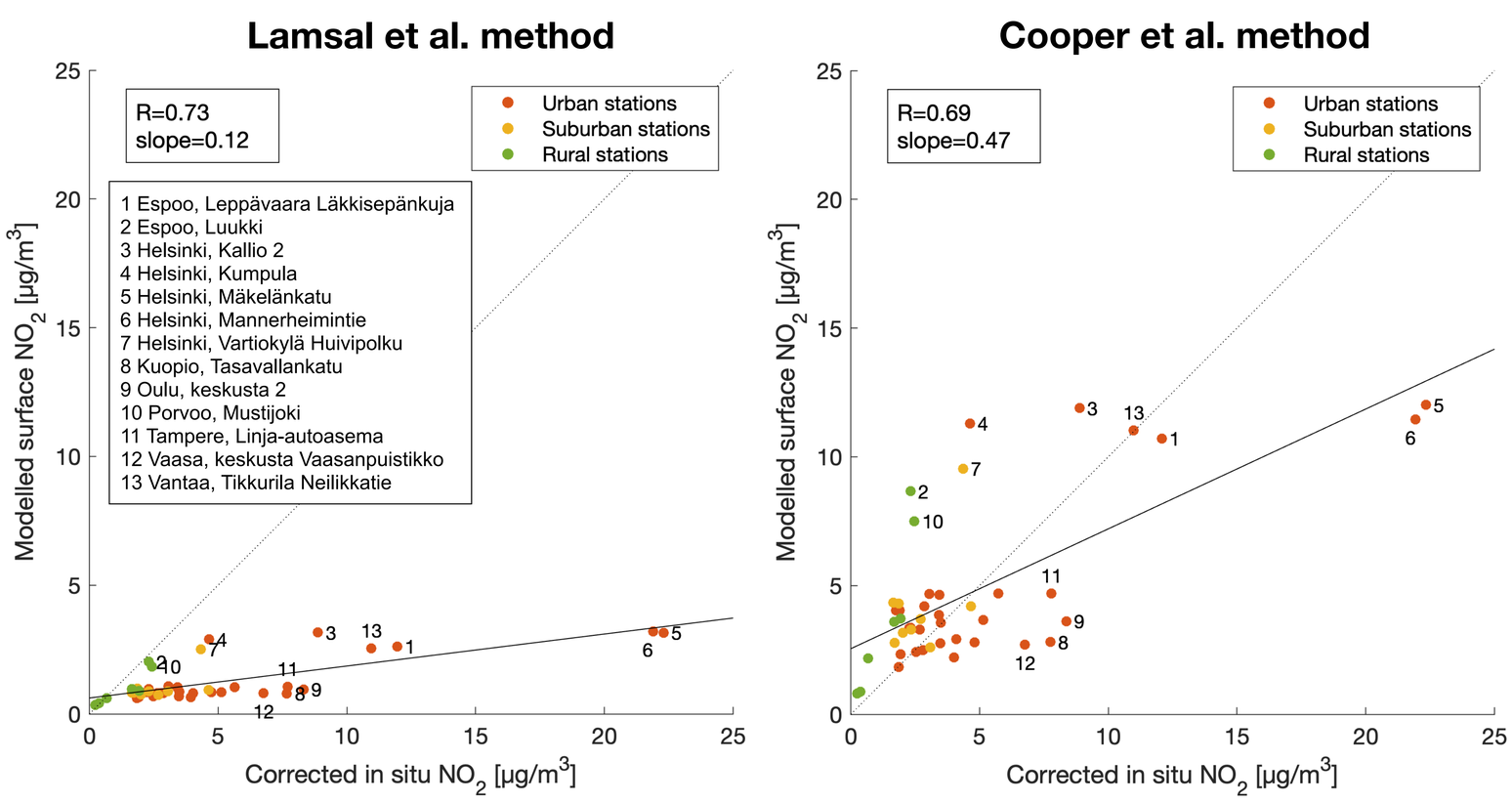
KEY POINTS

- We estimate surface-level concentrations of NO_2 in Finland from TROPOMI tropospheric column measurements using two different methods developed by Lamsal et al. (2008) and Cooper et al. (2020).
- We find that both methods have good correlation with *in situ* stations, but the method by Cooper et al. is less prone to underestimation.
- Both methods underestimate concentrations at highly urban stations.
- Obtained cut-off values for the K correction factor ($1x10^{15}$ to $2x10^{15}$) are significantly lower than what Cooper et al. (2020) obtained for the US, and correspond to the overall lower NO_2 levels in Finland.
- Potential data user is the Finnish Ministry of the Environment, which is already utilising satellite data in EU-level air quality reporting.

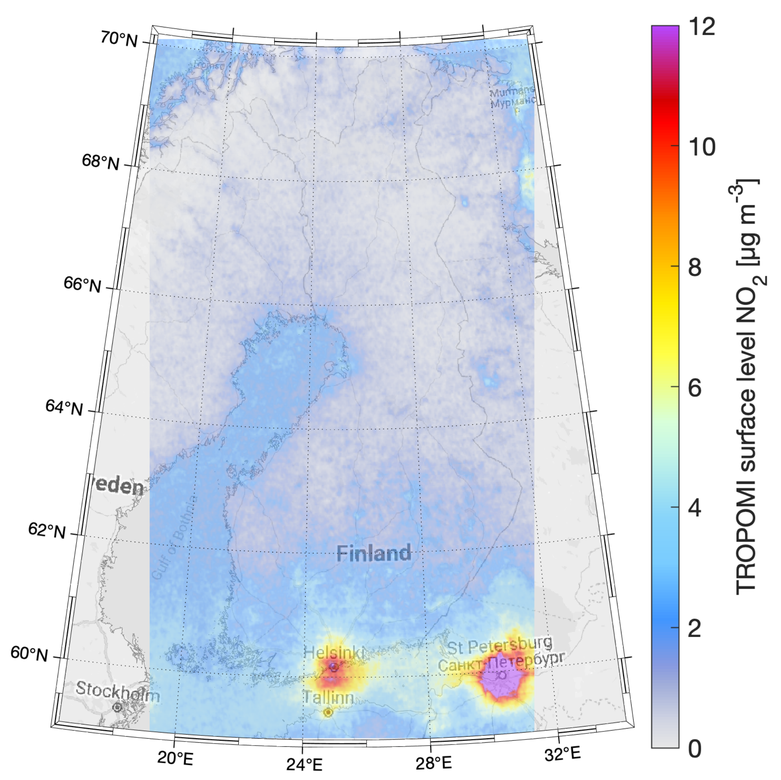
DATA & METHODS

- Both methods are based on a surface-to-column ratio obtained from a chemical transport model. We used the open source GEOS-Chem model at 0.25° x 0.3125° resolution (lat x lon, ~28 x 17 km at 60°N).
- The methods also correct for NO_2 variability finer in scale than the model resolution (TROPOMI has a resolution of 7.0 x 3.5 km).
- In addition, Cooper et al. (2020) correct for height of most NO_2 variability with a linearly scaled correction factor K. The cut-off values for the scaling were obtained with a sensitivity test maximising both correlation and slope between annual station measurements.
- Comparisons to chemiluminescence-based *in situ* measurements include NO_y correction according to Lamsal et al. (2008).

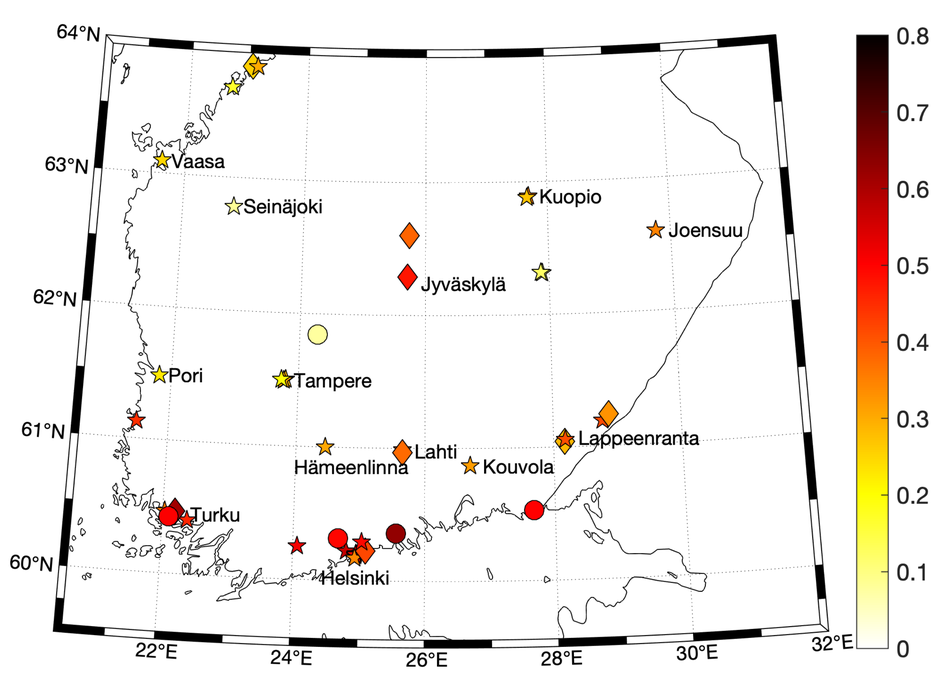
RESULTS



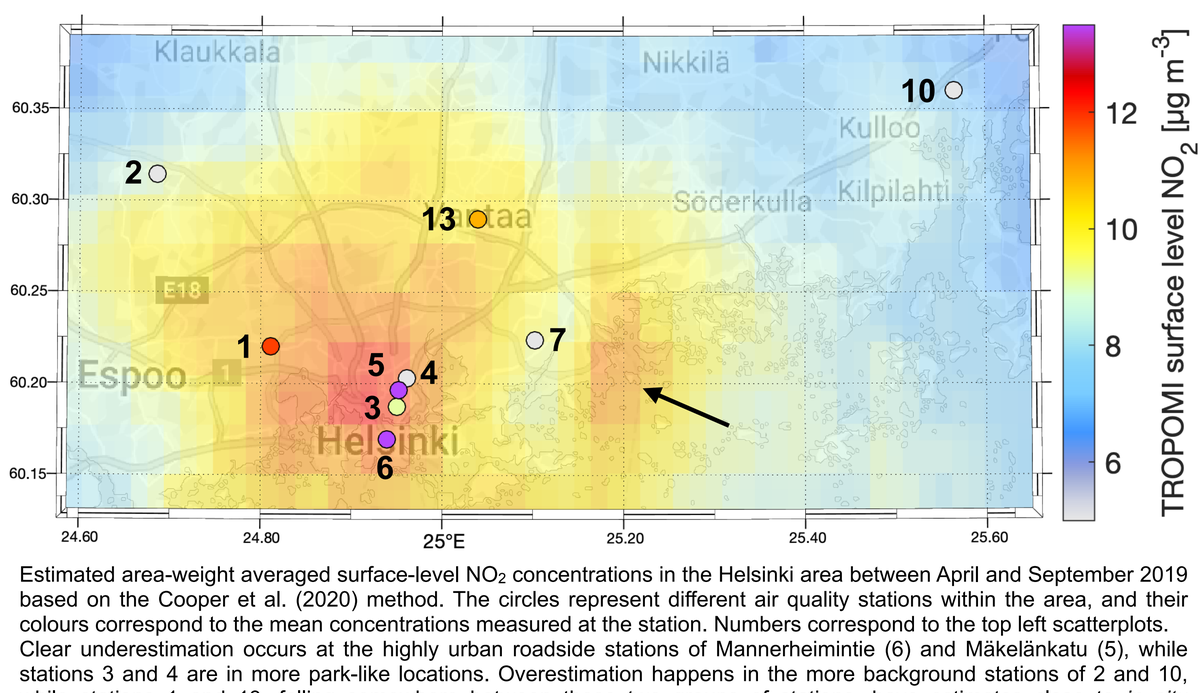
Mean of estimated surface-level NO_2 concentrations for 2018–2019 at Finnish air quality stations as a function of corresponding mean *in situ* measurements (NO_y corrected). Exact 1:1 correspondence is marked with a dotted line. Both models have good correlation with *in situ* measurements, but the method by Cooper et al. is much less prone to underestimation. Overall, underestimation is observed at urban stations with high mean concentrations, overestimation at background rural stations, while the suburban stations are somewhere in between.



Estimated area-weight averaged surface-level NO_2 concentrations in Finland between April and September 2019 based on the Cooper et al. (2020) method. Winter months have been excluded to prevent artefacts resulting from the coarse-resolution NISE snow/ice flag used in the TROPOMI retrieval.



Station-specific correlations in 2018–2019 between estimated surface-level NO_2 concentrations (Cooper et al. method) and *in situ* measurements. Stars represent urban stations, diamonds suburban stations, and circles rural stations. No clear relationship exists between type of station and correlation, but correlation is generally better in the south and close to the coasts. This may be due to a stronger signal (higher concentrations) in the south.



Estimated area-weight averaged surface-level NO_2 concentrations in the Helsinki area between April and September 2019 based on the Cooper et al. (2020) method. The circles represent different air quality stations within the area, and their colours correspond to the mean concentrations measured at the station. Numbers correspond to the top left scatterplots. Clear underestimation occurs at the highly urban roadside stations of Mannerheimintie (6) and Mäkelänkatu (5), while stations 3 and 4 are in more park-like locations. Overestimation happens in the more background stations of 2 and 10, while stations 1 and 13, falling somewhere between these two groups of stations, have estimates close to *in situ* measurements. The area around the Vuosaari thermal power station (marked with arrow) is visible east of Helsinki and more prominent than in TROPOMI data alone.

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References: Cooper, M. J., Martin, R., McLinden, C. A., & Brook, J. R. (2020): Inferring ground-level nitrogen dioxide concentrations at fine spatial resolution applied to the TROPOMI satellite instrument. *Environmental Research Letters*, **15**, 104013. https://doi.org/10.1088/1748-9326/aba3a5
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