Supplementary Information (SI) for Environmental Science: Atmospheres.
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Supplement: EA-ART-07-2025-000083. TITLE: AN UNREGULATED SOURCE OF NITROUS OXIDE FROM RECREATIONAL USE IN HO CHI MINH CITY, A FUTURE SOUTHEAST ASIAN MEGACITY IN VIETNAM

Fig. S1: Results of extended linearity test for N_2O/CO-23d. The top panel shows the residuals of the fit shown in the bottom panel. The x-axis represents the percentage of the flow that is made up of the high concentration standard, with the remainder being 'N_2O-free' air.

Fig. S2. Time variation plot showing patterns in air temperature for HCMC for the period of the N_2O observations. Generated in Openair (Carlslaw, 2019).

Fig. S3. Time variation plot showing patterns in relative humidity for HCMC for the period of the N_2O observations. Generated in Openair (Carlslaw, 2019).

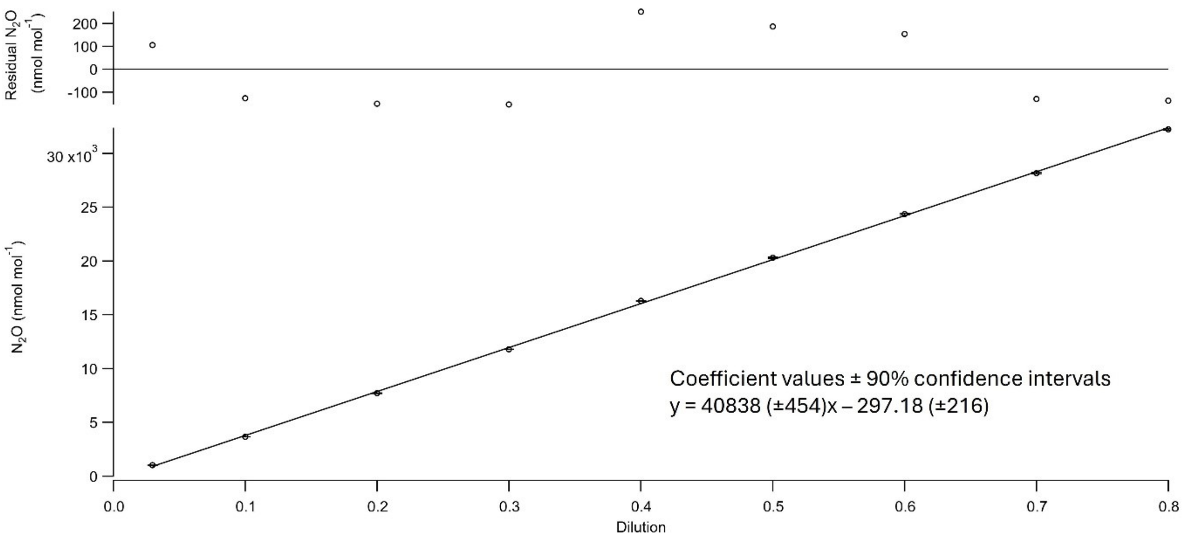
Fig. S4: The diurnal profile of hourly boundary layer height for the 0.25° x 0.25° grid square containing the in-situ measurement site from ERA5 for October 2018 to March 2019. The red shaded area represents the 90% confidence interval. Generated in Openair (Carlslaw, 2019).

Fig. S5: Picture showing the standard size of an N_2O 'party' balloon sold in the Bui Vien Walking Street. Source: Rampant use of "laughing balls" in HCM City's Bùi Viện Walking Street. VIETNAMNET GLOBAL, 17th of August 2022. https://vietnamnet.vn/en/rampant-use-of-laughing-balls-in-hcm-city-s-bui-vien-pedestrian-street-2050458.html

Fig. S6: The diurnal cycles of N_2O mole fractions for each wind sector by day of the week for the period 1st of October 2018 to 1st of March 2019. Generated in Openair (Carlslaw, 2019)

Fig. S7: The diurnal variation in normalised traffic counts for Ho Chi Minh City for different vehicle types.

Supplement



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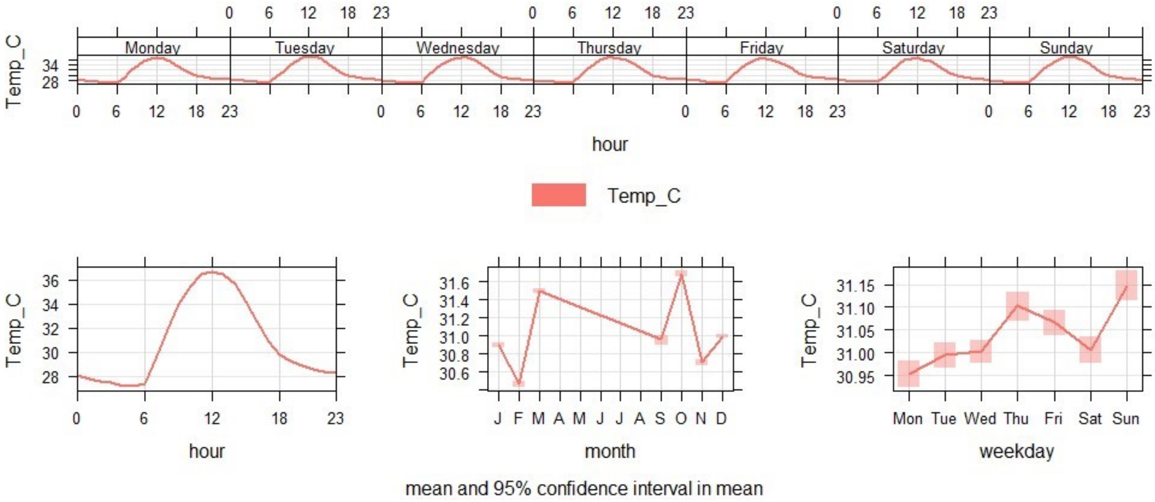

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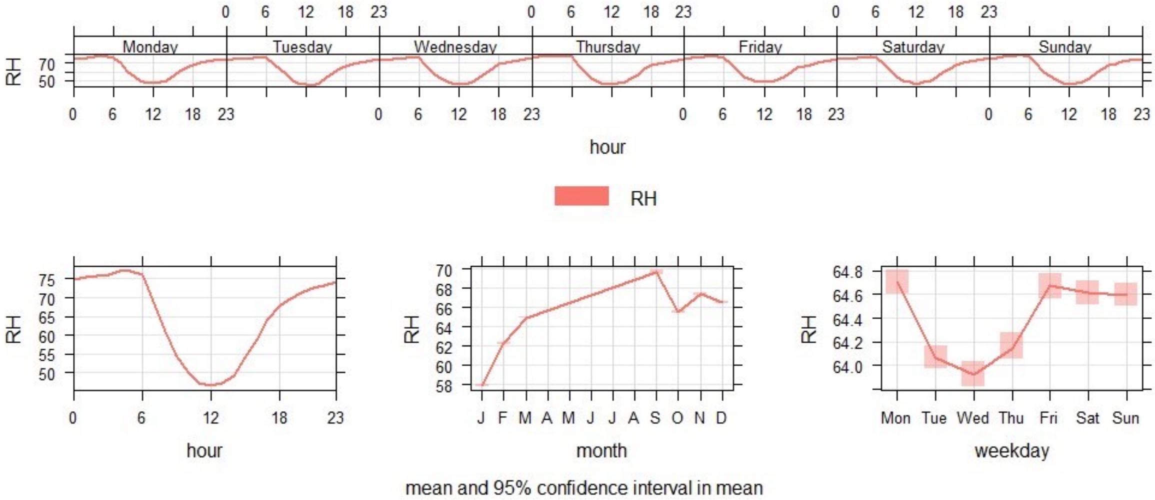
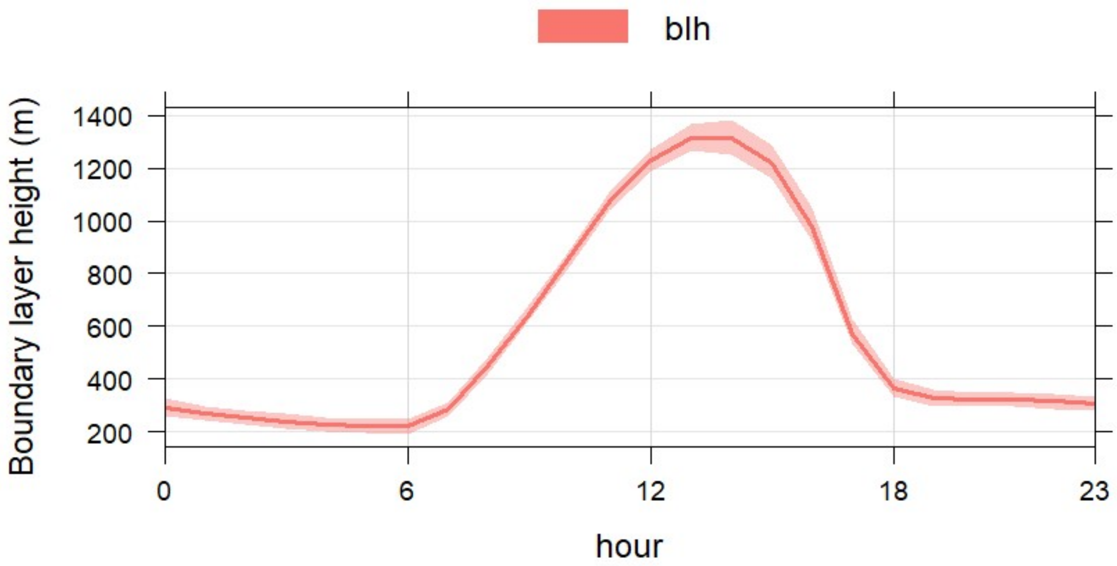


Fig. S3. Time variation plot showing patterns in relative humidity for HCMC for the period of the N_2O observations. Generated in Openair (Carlslaw, 2019).



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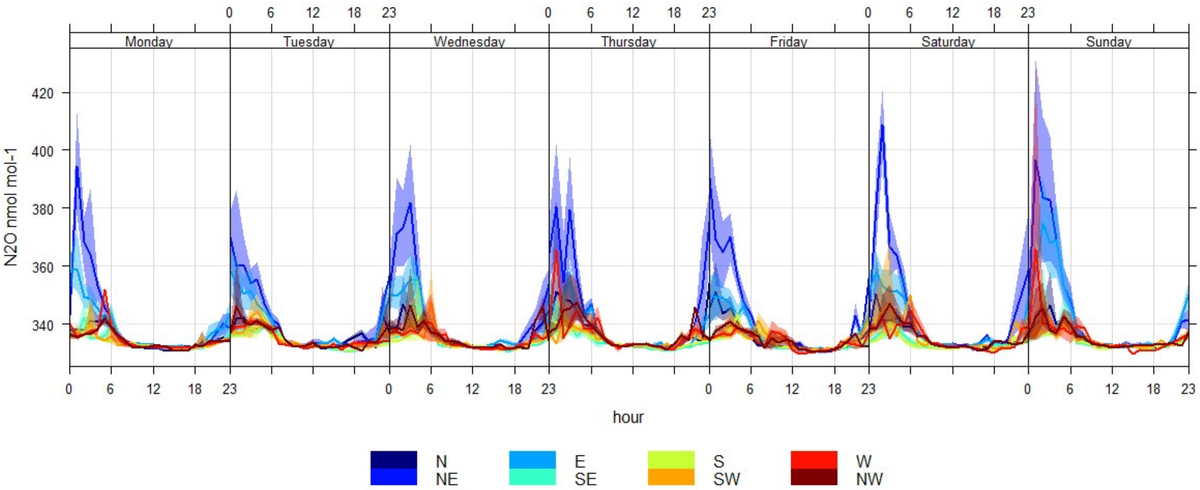

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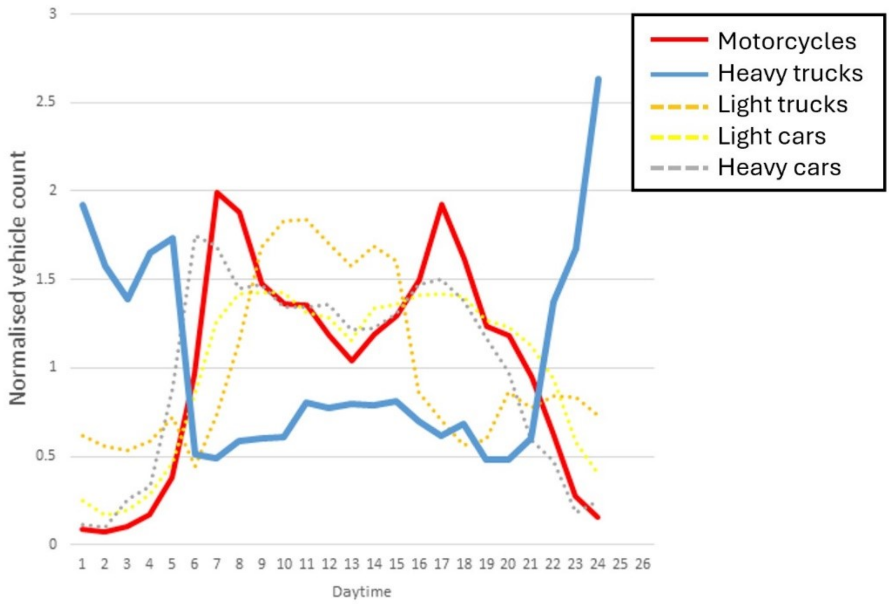

Fig. S7: Diurnal variation in normalised traffic counts for Ho Chi Minh City for different vehicle types.

S1. Description of bespoke software produces calibrated data

The raw data from the OA-ICOS analysers described in 2.2 were logged using bespoke software built at the University of East Anglia. The purpose of this software was to take the raw analyser output for ambient air measurements and convert it into calibrated mole fractions for N_2O, CO, CH_4 and CO_2. To achieve this, the software retrieved raw data from the analysers and controlled a multiport stream select valve (Valco valve) to control which air stream was being introduced to the analyser (i.e. ambient air or calibration gas). The software was written in C sharp, and a copy is available online from a GitHub repository (https://github.com/UEA-envsoft/GGA-Calculations.git). This section gives an expanded description of how the software converted the analyser's raw output to produce calibrated mole fractions using a set of calibration gases traceable to WMO calibration scales.

S1.1. Deriving a response curve for each gas species

To derive a response function for the analyser for N_2O, CO, CH_4 and CO_2, three calibration gas mixtures with well-defined mole fractions traceable to the WMO scales were introduced to the gas analyser. This calibration was performed every 23 hours, and the gases were introduced to the analysers using a stream select valve (Vici Valco). Each 20-minute run of a calibration cylinder was bracketed by a working reference, which is a cylinder of dry compressed air, to account for any instrumental drift whilst running the set of calibration gases. The last 15 minutes of the reported dry mole fractions for each species, for each calibration cylinder run, were used to calculate the ratio of each calibration gas to the bracketing working reference. From this, a calibration response curve of ratio vs. assigned mole fraction was derived, where a ratio of 1 is equal to the mole fraction of the working reference.

S.1.2. Converting ambient air raw data to mole fraction

The response function derived from S.1.1 was used to calibrate the raw analyser output when ambient air was being sampled by the analysers. Firstly, the ratio of raw ambient air measurements to the working reference was calculated. Secondly, this ratio was converted to mole fraction using the response curve generated in S1.1. The working reference was routinely run at 6-hourly intervals to correct the temporal drift in the analyser response.