EGU22-10292
https://doi.org/10.5194/egusphere-egu22-10292
EGU General Assembly 2022

How do the local meteorology and turbulence influence the nitrogen dioxide concentration in Madrid?

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The pollutant concentration close to the surface at specific sites of a city depends on multiple factors. However, disentangling the relative importance of them using observational data is not an easy task. To deepen into these relationships, in this study we use intensive and multiple data from several urban field campaigns that were developed in the city of Madrid (Spain) during 2020 and 2021 under the framework of the AIRTEC-CM (*) research project (Urban Air Quality and Climate Change Integral Assessment).

Among the most typical pollutants in cities, the nitrogen dioxide (NO_2) is of crucial importance due to its negative impacts on human health. The diurnal cycle of this pollutant is closely related to the anthropogenic emissions in the area and to the local meteorology, as well as to the turbulent transfers in the atmospheric boundary layer. In this work, we analyse the relation between the NO_2 concentration and different meteorological variables, including some turbulent parameters calculated from sonic anemometers: turbulent kinetic energy (TKE) and friction velocity (U_*). In this sense, we have distinguished those situations where the turbulent parameters are more valuable (have better correlation) than the wind speed, which is the meteorological variable typically used to be correlated with the pollutant concentration.

The analysis of the data clearly reveals how the highest NO_2 concentrations are associated with fair-weather (stable) synoptic conditions, as it is already known and expected. However, the detailed analysis of the diurnal cycle in these periods also highlights how the stability favours the appearance of mesoscale diurnal winds (mountain breezes) in the city, increasing the turbulence close to the surface and favouring the pollutants dispersion. This is of key importance because in some cases these processes are not correctly simulated by numerical models, which could lead to wrong predictions (overestimation) of the pollutant's concentrations at specific hours. Specifically, the evening transition and the following hours during stable conditions are the most difficult periods, displaying the highest and quicker variability in NO_2 concentration: very high concentration during calm periods in the transition followed by a rapid cleaning of the air a few

hours later due to the breeze appearance.

(*) AIRTEC-CM research project (S2018/EMT-4329) is funded by The Regional Government of Madrid (Spain).