EGU21-14400
https://doi.org/10.5194/egusphere-egu21-14400
EGU General Assembly 2021

Nocturnal surface fluxes of N2O and CH4 determined from atmospheric measurements at the Cabauw tall tower

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The agricultural emissions are the dominant sources of N_2O and CH_4 in the Netherlands. In this study, we have estimated nocturnal surface fluxes of both N_2O and CH_4 using atmospheric measurements at the Cabauw tall tower (4.927° E, 51.971° N, - 0.7 m a.s.l.). The nocturnal N_2O and CH_4 surface fluxes were derived using two different methods, the vertical gradient method (VGM), i.e. the sum of the storage flux and the turbulent flux, and the radon-tracer method (RTM), for the period of March 2017-December 2018 and 2016-2018, respectively. For N_2O, we show that a few events occurring between May 30 and June 4 in 2018 dominated the monthly means. Using the VGM, we have estimated the annual mean nocturnal surface flux to be 0.59 ± 0.38 g/m^2/yr (1 σ, the same as below) and 0.53 ± 0.19 g/m^2/yr with and without events, respectively. The fluxes are high in the summer and low in the winter, with a seasonal amplitude of around 1.0 g/m2/yr and 0.5 g/m^2/yr, with and without events, respectively, which is likely caused by the seasonality of agricultural activities. For CH_4, the annual mean nocturnal surface flux is 12.1 ± 3.3 g/m^2/yr and the amplitude is around 9.9 g/m^2/yr. Using the RTM, the mean fluxes of the whole period for N_2O and CH_4 are estimated to be 1.18 ± 2.25 (1.08 ± 1.29, without the events) g/m^2/yr and 26.9 ± 24.8 g/m^2/yr, respectively; in contrast to the VGM, no apparent seasonal pattern has been found. However, there is a good linear correlation between the estimated N_2O fluxes from the two methods and the monthly means show a similar pattern when the same nights are considered; the R-squared value is around 0.9 with events and 0.6 without events, and the slope varies from 1.9 to 0.8 when different estimates of radon fluxes are used. Furthermore, we found that large N_2O fluxes are related to the amount of rainfall occurring days before, with the correlation coefficient of around 0.6 (p value<0.01). For CH_4, there is no correlation between the estimated CH_4 fluxes from the two methods. Our findings demonstrate that nocturnal N_2O and CH_4 fluxes in the Cabauw area are highly variable and vary over different seasons, and that both VGM and RTM are useful to quantify regional N_2O and CH_4 fluxes.