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Comment on acp-2021-310

Anonymous Referee #2

Referee comment on "Urban inland wintertime N_2O_5 and $ClNO_2$ influenced by snow-covered ground, air turbulence, and precipitation" by Kathryn D. Kulju et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-310-RC1, 2021

The manuscript "Urban inland wintertime N2O5 and ClNO2 influenced by snow covered ground, air turbulence, and precipitation" describes a set of measurements taken during winter in southern Michigan (USA). Observations of N2O5 and ClNO2 are needed in order to achieve a better understanding of the chemistry of these species, especially during winter, a known undersampled season. The focus of this paper on the effects of micrometeorology provides a novel, and very interesting, look at the ClNO2/N2O5 system. The paper is generally well written and the subject is within the scope of ACP. I recommend publications of the manuscript, after the authors have addressed the following points.

MAJOR COMMENTS

Most of the analysis presented in this paper uses 30 minutes averaged data. Is this appropriate for this type of study? For example, the periods of fog and snowfall discussed on pages 14-16 are of the order of 1 hour, so maybe higher frequency data would provide more accurate information. I think the authors should comment on this point early on in the paper.

In section 2.2 the authors say that Cl2 and HNO3 were being measured. However these species do not seem to be mentioned in the rest of the paper. If the reason is that they were not observed, I suggest this part of the method is removed. If they were observed, I wonder why they were not used in the subsequent analysis.

In section 3, it would be good to better define the conditions encountered during the campaign. From figure 1, it seems there was only 1 case of clear sky, 1 of snowfall, 1 of fog and 1 of rain during the entire period, but I suppose these are only selected case studies. What were the conditions on the other days? How were the case studies selected (i.e. are they truly representative of the respective conditions)? Related to this point, it should be clarified how are the statistics in the first part of section 3.1 - including table 1 -

calculated: do they refer to the 4 case study nights only, or include other similarly classified periods? This is important to understand how representative are the numbers and how robust is the analysis.

I find the discussion in section 3.2 (effects of turbulence) a bit lacking, in the sense that it is not immediately clear what the authors think is the effect of turbulence on N_2O_5 and $ClNO_2$. Sure, high or low turbulence results in higher or lower concentrations, but why? Is it due to deposition, advection or some other physical process? Likewise the first part of section 3.4 (page 21) can be a bit expanded: how do all the factors (turbulence, ground conditions, etc...) tie together and relate to the observed values of N_2O_5 and $ClNO_2$? A short summary at the end of each section would help driving the point home.

MINOR COMMENTS

line 161: do these times correspond to sunset and sunrise?

lines 202-203: doesn't this introduce a bias? Isn't it better to exclude these data from analysis?

lines 215-220 (and elsewhere in section 3.1): are the 18:00-8:00 averages discussed here?

lines 365-367: if there is no significant difference between high and low turbulence, I think it is a bit misleading to say that values are on average a bit higher with high turbulence. More in general, can the authors speculate on why turbulence does not seem to affect N_2O_5 levels before 2:00?

table 1: maybe add bare/snow ground?

table 2: add the expected scavenging coefficient based on solubility? Otherwise a statements such as line 285 and 318-319 makes little sense.