Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2017-416-RC1, 2017

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observations of ozone depletion events in a Finnish boreal forest" *by* Xuemeng Chen et al.

Anonymous Referee #1

Received and published: 23 July 2017

This study interrogates an impressive long-term 20-year (1996-2016) high temporal resolution dataset of vertical ozone concentration profiles within and above a canopy in a boreal forest in southern Finland. The analyses focus on understanding and characterizing "ozone depletion events", when the ozone concentration drops below 10 ppbv (and even lower) for > sustained 30-minutes period. The study further examines relationships between key meteorological and some associated chemical variables to gain further insight into the underlying mechanisms of the ozone behaviour in and around the canopy. The statistical analyses are rigorous and solid. The Figures are clearly presented and readable. The paper deserves to be published in Atmospheric Chemistry and Physics. I have some further comments and questions below that are mostly to stimulate further discussion.

1. The depletion events occur in Autumn and Winter when the temperature is low and relative humidity is high. No plant photosynthesis/production occurs during this period (i.e. no stomatal uptake of ozone). Also no substantial BVOC emissions occur during the winter at cold T. The ozone depletion events appear to be mostly driven by dynamics under the shallow winter boundary layer conditions. The ozone must be sticking to the plant and soil surfaces and draining away. Is there snow on the ground during the periods? Why does the human population care about these ozone depletion events in the winter? The ozone concentrations are actually quite high in and around the canopy in the spring and summer.

2. The median ozone concentrations at all levels are rather high in spring ($\sim$40 ppbv) and summer ($\sim$35 ppbv). Conventional knowledge has indicated that the ozone concentrations should be lower than these values in "pristine" forested environments. These values suggest that there is net production of ozone occurring under the forest conditions. Are the BVOC emissions contributing to this production? People generally believe, perhaps wrongly, that BVOCs in "pristine" forested environments reduce ozone levels by direct reaction. This dataset seems to suggest otherwise? Can we learn anything about the preindustrial atmosphere from these results?

3. I am surprised by the measured NOx concentrations. It is somewhat difficult to see exactly from Figure 10, but it looks like NOx is in 1-3 ppbv range increasing to 5ppbv in sporadic dynamical events. Where do these relatively high NOx levels come from in this environment?

4. Figure 7 is intriguing. Ozone concentrations have a very strong positive relationship with temperature, but not so much with global shortwave radiation. The higher ozone concentrations show relatively limited relationship with global radiation, while the lower ozone concentrations show a weak positive trend with increasing shortwave. What is the cause of this behaviour?

5. Some other previous studies do report very low measured ozone concentrations in

the Amazon forest canopy, which certain global models are unable to reproduce (e.g. Pacifico et al., ACP, 2015).

6. In the past 20 years, massive global environmental change has taken place. Is there any evidence for trends in the ozone concentrations and their drivers across the past 2 decades?

7. Page 1, Line 38: "The loss processes of tropospheric ozone include dry and wet deposition". Please correct. Ozone itself does not wet deposit. Ozone precursors do wet deposit.

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