OZONE CONCENTRATION AND CO_2 FLUX MONITORING IN A BELGIAN FOREST

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Context

- There is a *"lack of carbon assimilation data at O_3 monitoring station and vice-versa"* (Proietti, 2016).
- Tropospheric O_3 impact on carbon assimilation remains to be explored especially at ecosystem level.

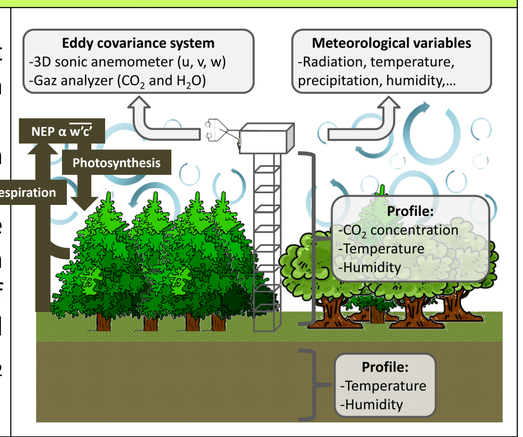
Site description

- Eighty kilometers north from Luxembourg, in east Wallonia (south part of Belgium), half-hourly measurements of net ecosystem productivity (NEP) and ozone concentration ($[O_3]$) are made by two monitoring stations located in a mature mixed forest dominated by beech (coniferous are present).
- Measurements of CO_2 flux (NEP), as well as momentum, sensible heat and H_2O fluxes are continuously made since 1996 by eddy covariance (cfr Method below) at the Vielsalm Terrestrial Observatory (VTO).
- The Vielsalm Air Quality Monitoring Station (VAQMS) is part of the Walloon air quality monitoring network managed by the Scientific Institute of Public Service (ISSeP). Air pollutants are monitored since different dates: 1996 for $[SO_2]$, 1998 for $[O_3]$, 2000 for $[NO_2]$,…

Method

NEP measurement by eddy covariance

- Turbulent transport of CO_2 by eddies in the atmosphere.
- NEP (Net Ecosystem Productivity) is proportional to the covariance between the fluctuations of the vertical wind speed and of the CO_2 concentration.



Conclusion

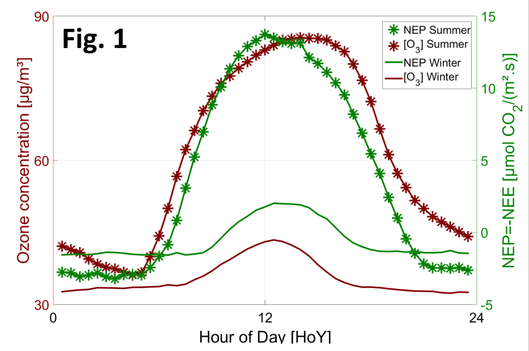
- Daily and annual dynamics explain 40% of the variability observed in half-hourly ozone concentration ($[O_3]$).
- A significant inter-annual decreasing trend is observed for $[O_3]$ between 1999 and 2014, but not for NEP.
- No significant trend was observed in the occurrence of $[O_3]$ extreme values. More than 1/3 of the variability observed in these values was explained by saturation deficit.
- A significant negative relation was found between NEP residual and $[O_3]$. The next step will be to compute ozone stomatal uptake and study of its relation with NEP.

References

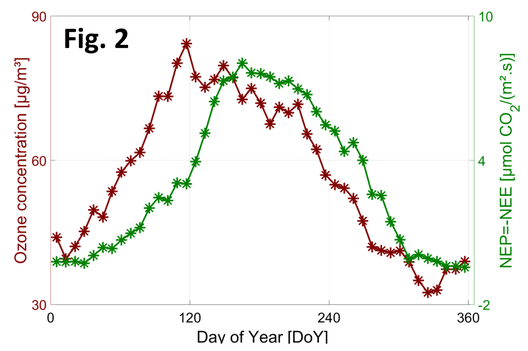
- Proietti C. et al, 2016. A multi-sites analysis on the ozone effects on Gross Primary Production of European forests. *Science of the total environment* (**2016**), 11p.
- Cooper O.R. et al, 2014. Global distribution and trends of tropospheric ozone: An observation-based review. *Elementia: Science of the Anthropocene* (**2**), 28p.
- Koumoutsaris S. et al, 2008. Influence of El Niño–Southern Oscillation on the inter-annual variability of tropospheric ozone in the northern mid-latitudes. *Journal of Geophysical Research* (**113**), D19301, 21p.

Results and discussion

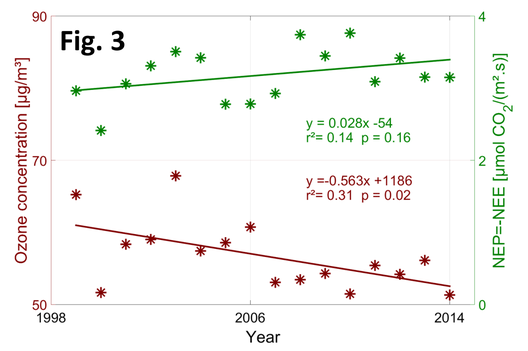
NEP and $[O_3]$ dynamics at daily, yearly and inter-annual scale



-NEP and $[O_3]$, as climate variables, have a pronounced daily dynamic (**Fig. 1**).
-NEP is negative at night (respiration only) and positive during the day (photo-synthesis > respiration) even in winter.



-NEP and $[O_3]$ yearly dynamics are only similar during the full vegetation period. NEP starts increasing later than $[O_3]$ as the leaves only appear on beech around the 1st of May in east Belgium (**Fig. 2**).

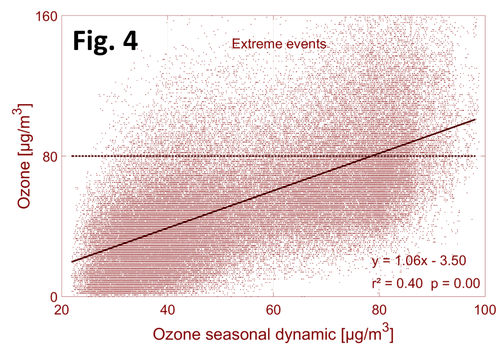


-A significant ($p<0.05$) decreasing trend is observed for $[O_3]$ between 1999 and 2014 (**Fig. 3**), in agreement with what is reported in the literature (Cooper, 2014).
-No significant trend is observed for NEP.

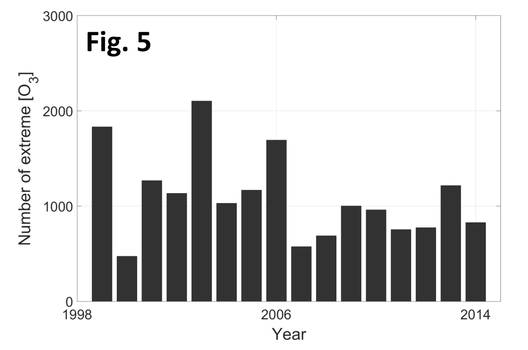
Extreme events identification and frequency

-Only the data from the full vegetation period (DoY 150 to 270), when the leaves were fully developed, were considered.
-An half-hour measurement was considered extreme if :
- $[O_3]$ was higher than 80 µg/m³;
- $[O_3]$ was higher than the "expected" $[O_3]$ for the given half-hour (based on the seasonal dynamic of $[O_3]$).

-The seasonal dynamic of $[O_3]$ was obtained by using a 10 days mobile window and by computing the median of $[O_3]$ for each half-hour and for each day (considering the data from 1999 to 2014).

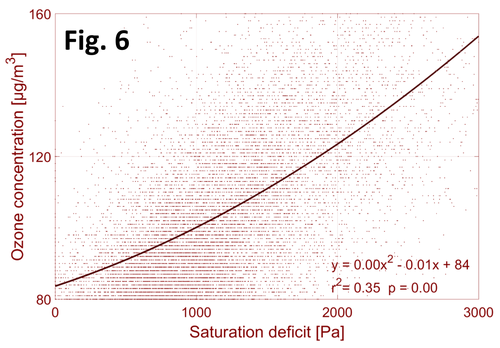


-Seasonal dynamic explains more than 40% of the variability observed in $[O_3]$ during the full vegetation period (**Fig. 4**).
-Extreme events considered occur 20% of the time during the full vegetation period.

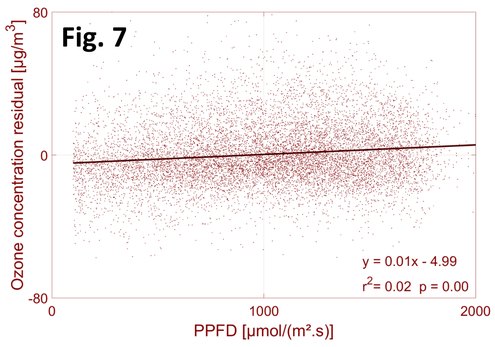


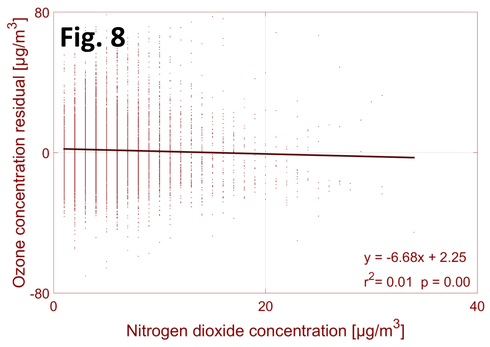
-No significant trend observed in the number of extreme events (**Fig. 5**). Higher numbers have been observed in 1999 (related to El Niño by Koumoutsaris (2008), 2003 and 2006 (related to heat waves).

Relation to climate variables



-More than 1/3 of the variability observed in $[O_3]$ during extreme events was related to the saturation deficit (**Fig. 6**).

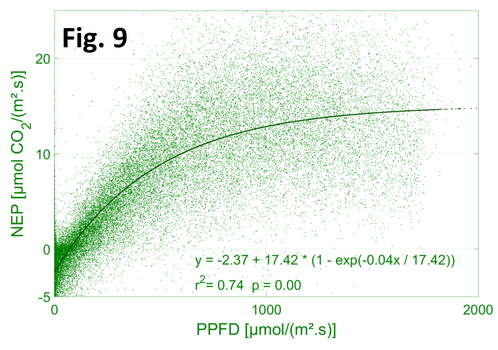




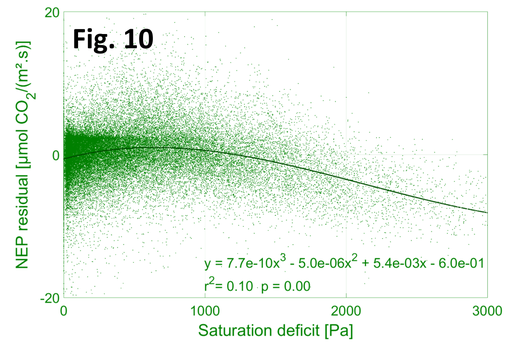
-Significant relations were found between residuals and other variables (**Fig. 7** & **Fig. 8**), such as photosynthetic photon flux density (PPFD) and nitrogen dioxide concentration ($[NO_2]$). However these relations did not explain a lot of the variability observed.

Relation between NEP and $[O_3]$

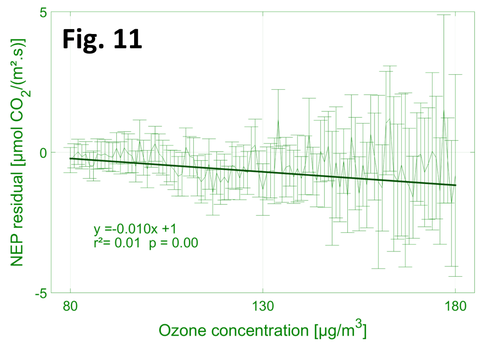
-$[O_3]$ and NEP have similar daily and yearly dynamics to those of temperature, radiation and saturation deficit.
→To study the relation between $[O_3]$ and NEP, the dependency to climate variables has to be removed.



-Misterlich equation was used for the light response curve of NEP (**Fig. 9**) and a cubic relation was used for the response of NEP residual to saturation deficit (**Fig. 10**).
-Mean NEP residual was then analyzed by ozone concentration class (**Fig. 11**).



-Even after the removal of NEP dependency to climate variables, a significant negative relation was found with $[O_3]$, in agreement with recent results obtained by using forest productivity derived from MODIS data (Proietti, 2016).



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