Drivers of interannual variability of vertical ozone fluxes in a deciduous mature forest in Italy

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Multiannual measurements of ozone fluxes were performed from 2012 to 2020 at a mature deciduous forest in the Po valley, Italy. Fluxes were measured on a 41 m tall tower, 15 m above the top canopy with the eddy covariance measuring technique. A flux partition among stomatal and non-stomatal fractions was performed based on concomitant water and carbon dioxide measurements.

Fig. 1 – Site location (a); surroundings (b); view from a zeppelin balloon (c); tower view from below (d)

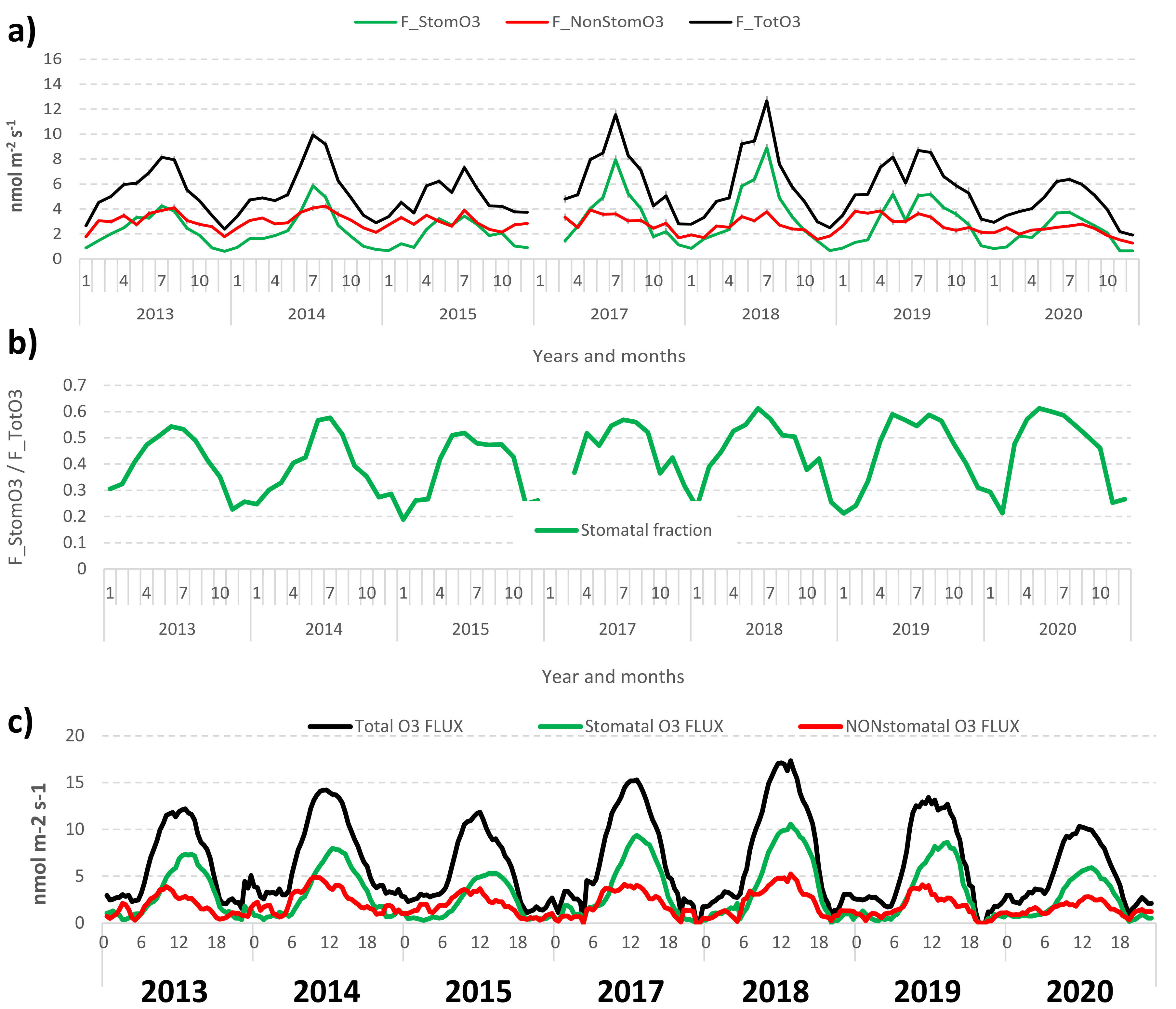

Fig. 2 – Monthly averages of O3 stomatal, non-stomatal and total fluxes in the 7-year campaign (a). Stomatal fraction of O3 deposition: daytime (08:00-18:00) monthly averages for the seven years (b). Summer diel courses of stomatal, non-stomatal and total deposition fluxes in the 7 years (c).

Total ozone fluxes revealed an interannual variability that was mainly driven by the stomatal activity (Fig. 2 a,c). Despite this variability, the stomatal fraction of the total ozone deposited on the forest was fairly constant around 42% on a 24-hours basis and around 60% in the daylight hours (Fig. 2 b).

Surface conductances show both a marked seasonal variation (Fig. 3 a) and a clear interannual variation (Fig. 3 b). Factors which influence stomatal conductance were responsible for the flux variability, with soil water availability being the main physiological driver among all (Fig. 4 a).

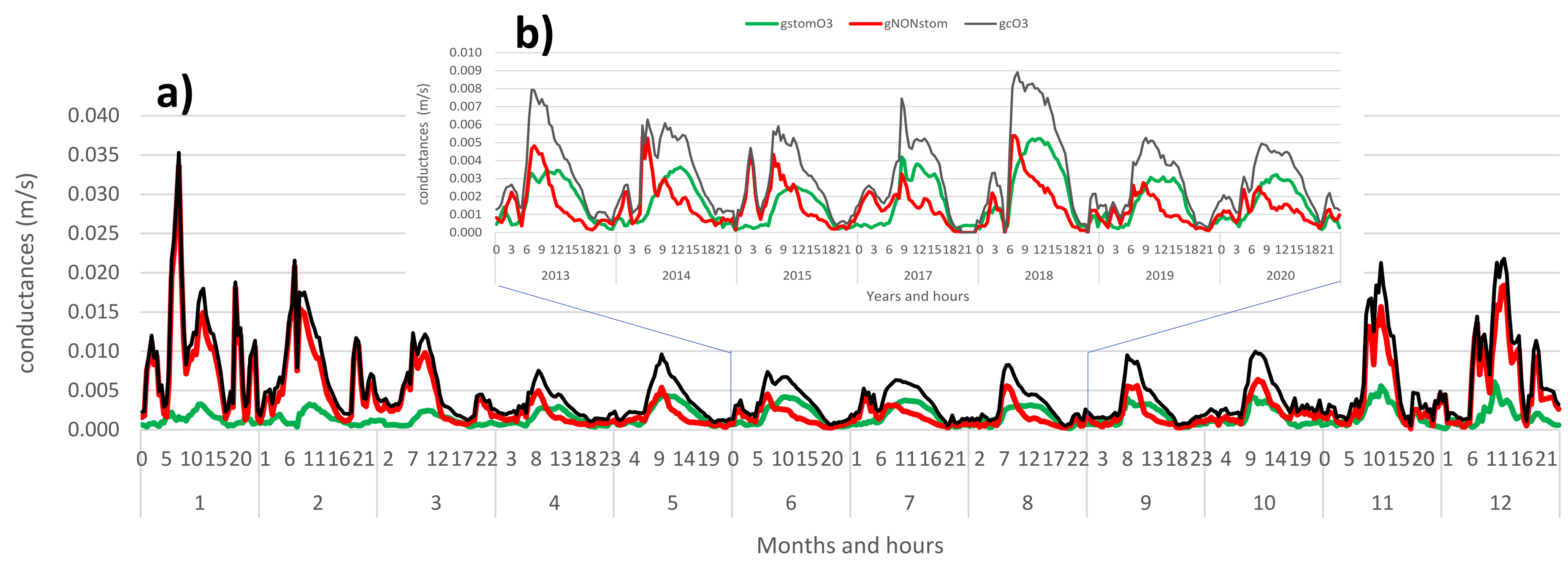

Fig. 3 – Mean diel cycles of surface conductances in the different months (average year of 7-years) (a). Interannual variation of stomatal, non-stomatal and total conductances in summer: mean summer diel cycles (b).

The non-stomatal deposition was mainly driven by air humidity (Fig. 5 a), by chemical sinks such as reaction of ozone with the NO emitted by soil in summer or advected in the trunk space in winter (Fig. 5 b), and by surface wetness (Fig. 5 e). On the other hand, the non-stomatal deposition resulted unaffected by wind speed or turbulence intensity (Fig. 5 d), as well as by surface temperature (Fig. 5 c), and this would exclude impact or thermal decomposition on surfaces from being important drivers of the total fluxes. Deposition on leaf cuticles was the main ozone removal pathway in the evening and during the first night hours (Fig. 6).

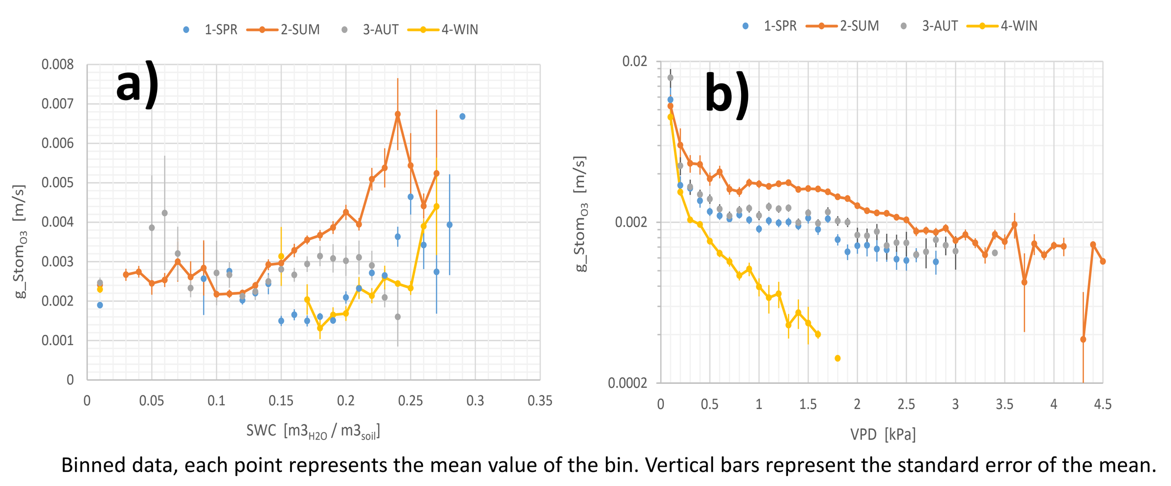

Fig. 4 – Drivers of the stomatal conductance. Seasonal relationship of g_StomO3 with soil water content (a) and vapor pressure deficit (b) (gStomO3 in log-scale).

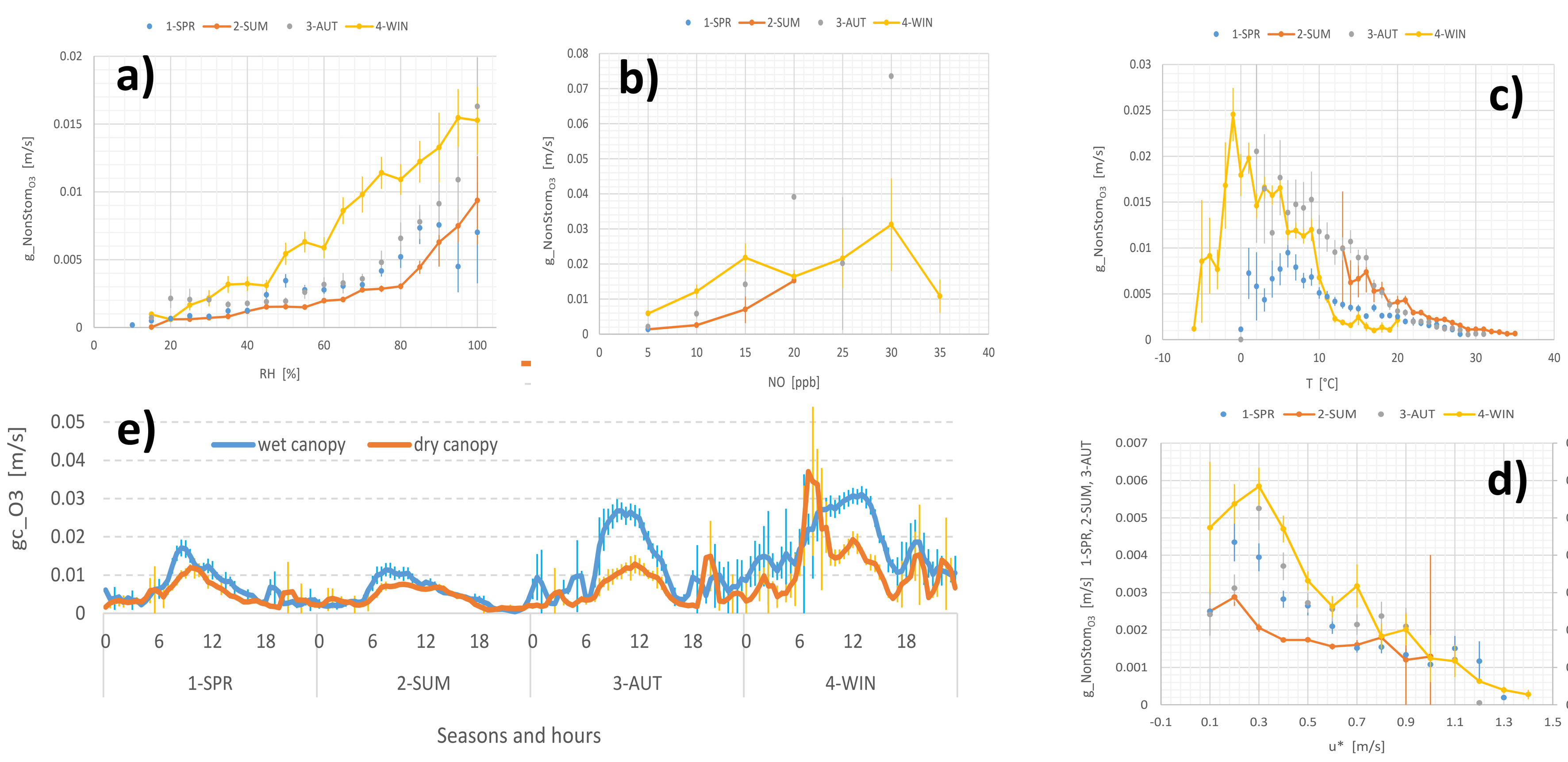

Fig. 5 – Drivers of the non-stomatal conductance. Seasonal relationship of g_NonStomO3 with relative humidity (a), concentration of NO (b), air temperature (c) and friction velocity (d). Seasonal mean diel courses of the surface conductance with wet and with dry canopy (air temperature up to 2°C above Tdew) (e). Vertical bars represent the standard error of the mean.

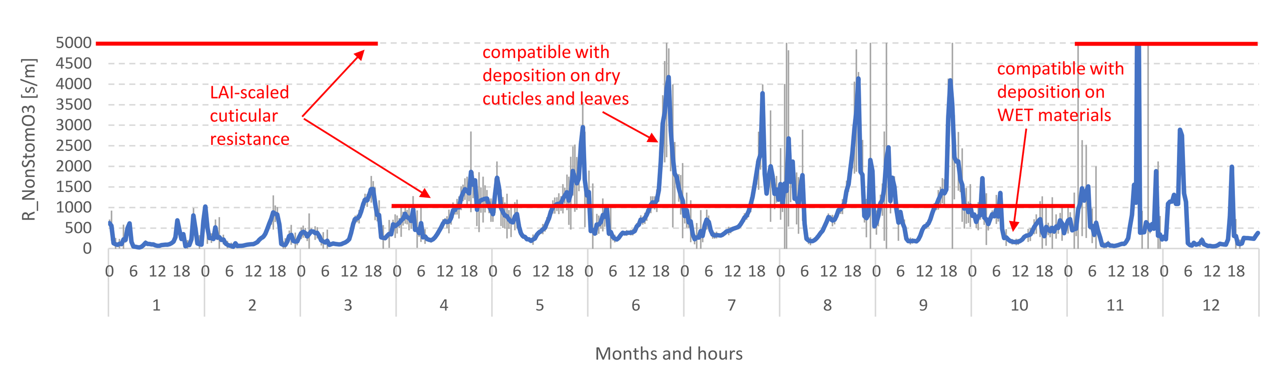

Fig. 6 – Mean diel courses of non-stomatal resistance in the different months, averaged over the 7 years.

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