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Investigation of ozone deposition to vegetation under warm and dry conditions near the Eastern Mediterranean coast

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Dry deposition of ozone (O_3) to vegetation is an important removal pathway for tropospheric O_3, while O_3 uptake through plant stomata negatively affects vegetation, which can in turn influence climate. Both processes are controlled by vegetation characteristics and ambient conditions via complex mechanisms. Recent studies have revealed that these processes can be fundamentally impacted by coastal effects[1], and by dry and warm conditions in ways that have not been fully characterized, largely due to lack of measurements under such conditions[2,3]. Hence, we hypothesized that measuring dry deposition of O_3 to vegetation along a sharp spatial climate gradient, and at different distances from the coast, can offer new insights into the characterization of these effects on O_3 deposition to vegetation and stomatal uptake, providing important information for afforestation management and for climate and air-quality model improvement. To address these hypotheses, several measurement campaigns were performed at different sites, including pine, oak, and mixed Mediterranean forests, at distances of 4–59 km from the Eastern Mediterranean coast, under semiarid, Mediterranean and humid Mediterranean climate conditions[3,4]. The eddy covariance technique was used to quantify vertical O_3 flux (F_{tot}) and its partitioning to stomatal flux (F_{st}) and non-stomatal flux (F_{ns}). Whereas F_{st} tended to peak around noon under humid Mediterranean and Mediterranean conditions in summer, it was strongly limited by drought under semiarid conditions from spring to early winter, with minimum average F_{st}/F_{tot} of 8–11% during the summer, reflecting minimal negative effects on vegetation and on, in turn, carbon assimilation, under semiarid conditions. F_{ns} in the studied area was predominantly controlled by relative humidity (RH), whereas increasing F_{ns} with RH for RH $<$ 70% indicated enhancement of F_{ns} by aerosols, via surface wetness stimulation, apparently combined with biogenic volatile organic compound emission, few km from the sea during daytime. At night, efficient turbulence due to sea and land breezes, together with increased RH, resulted in strong enhancement of F_{tot}, dozens of kilometers from the sea. We further show that nitrogen oxides (NO_x = [NO] + [NO_2]) from elevated emission sources can reduce O_3 deposition, and even lead to a positive O_3 flux, demonstrating the importance of adequately taking into account the impact of air pollution on O_3 deposition to vegetation. Extreme dry surface events, some induced by dry intrusion from the upper troposphere, resulted in positive F_{ns} events.

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