2.034 Ozone deposition degrades water-use efficiency across multiple ecosystems.

Early Career Scientist

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Abstract:

Surface ozone (O_3) is an air pollutant and greenhouse gas that is toxic to plants, reducing their growth and ability to regulate water loss. Past controlled, single-species experiments have shown that current atmospheric O_3 levels degrade water-use efficiency (WUE), which is the ratio of carbon uptake in photosynthesis to water loss in transpiration, in several crop and tree species. This implies that O_3 air pollution modifies the terrestrial water cycle and precipitation, but no prior studies have documented the O_3 impact on WUE at the ecosystem level.
We correlate WUE with stomatal O_3 uptake and meteorological factors at 23 eddy-covariance flux towers in the US and Europe that span a wide range of temperate forest and crop ecosystems. After removing the mean seasonal cycle of all variables, we find that daily anomalies in stomatal O_3 uptake degrade WUE by 1-3% at most sites ($p < 0.05$), in addition to the expected dependencies on temperature, humidity, and photosynthetically active radiation (PAR). This O_3 impact on WUE is similar to that found in controlled, single-species experiments and of the same magnitude as the response to daily variations in temperature, humidity and PAR. Affected ecosystems include broadleaf crops and all forest types, indicating that O_3 impacts are widespread among many species that have not been studied individually and that the aggregated effects across an ecosystem are similar to those of individual species. The largest impacts on WUE occur in ecosystems with high stomatal conductance, such as broadleaf forests, humid climates, or irrigated crops, rather than where surface O_3 concentrations are highest. The weakest O_3 impacts occur in ecosystems with large populations of C4 plants, but longer data records are needed to confirm this at the ecosystem level. Ongoing work is exploring how well land biosphere models can simulate these effects of O_3.