2.011 Impacts of ozone-vegetation coupling and feedbacks on surface ozone air quality.

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Abstract:

Surface ozone is one of the most significant air pollutants due to its damaging effects not only on human health, but also on vegetation and crop productivity. Chronic ozone exposure has been shown to reduce photosynthesis and interfere with gas exchange in plants, which in turn affect the land-atmosphere exchange of energy and water, as well as surface processes that may ultimately influence the concentrations of ozone and other atmospheric constituents. Ozone damage on vegetation can thus have major ramifications on climate and atmospheric composition, including possible feedbacks onto ozone concentration itself, but the importance of such two-way ozone-vegetation coupling is not well understood. Here we examine the impacts of ozone-vegetation coupling on surface ozone through various biogeochemical and meteorological feedback mechanisms. Using the Community Earth System Model, we find that inclusion of online ozone-vegetation coupling modifies simulated ozone concentration up to +6 ppbv in China, North America and Europe, suggesting that ozone damage on vegetation constitutes a positive feedback that further enhances ozone. We find that the majority of the feedback is caused by the ozone-induced decrease in leaf stomatal conductance, which directly increases ozone by suppressing dry deposition. Reduced conductance also lowers transpiration, which increases surface temperature and thus biogenic isoprene emission, further enhancing ozone indirectly. The dry deposition-driven biogeochemical pathway and the transpiration-driven meteorological pathway contribute roughly equally to the overall positive ozone-vegetation feedback. Our work demonstrates the importance of including ozone-vegetation coupling and feedbacks in understanding and projecting future ozone air quality under climate and land cover changes over the next few decades.