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Reactive trace gas emissions from stressed plants: a poorly characterized major source of atmospheric volatiles

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Vegetation constitutes the greatest source of reactive volatile organic compounds in the atmosphere. The current emission estimates primarily rely on constitutive emissions that are present only in some plant species. However, all plant species can be induced to emit reactive volatiles by different abiotic and biotic stresses, but the stress-dependent emissions have been largely neglected in emission measurements and models. This presentation provides an overview of systematic screening of stress-dependent volatile emissions from a broad range of structurally and physiologically divergent plant species from temperate to tropical ecosystems. Ozone, heat, drought and wounding stress were the abiotic stresses considered in the screening, while biotic stress included herbivory, chemical elicitors simulating herbivory and fungal infections. The data suggest that any moderate to severe stress leads to significant emissions of a rich blend of volatiles, including methanol, green leaf volatiles (the lipoxygenase pathway volatiles, dominated by C6 aldehydes, alcohols and derivatives), different mono- and sesquiterpenes and benzenoids. The release of volatiles occurs in stress severity-dependent manner, although the emission responses are often non-linear with more severe stresses resulting in disproportionately greater emissions. Stress volatile release is induced in both non-constitutive and constitutive volatile emitters, whereas the rate of constitutive volatile emissions in constitutive emitters is often reduced under environmental and biotic stresses. Given that plants in natural conditions often experience stress, this analysis suggests that global volatile emissions have been significantly underestimated. Furthermore, in globally changing hotter climates, the frequency and severity of both abiotic and biotic stresses is expected to increase. Thus, the stress-induced volatile emissions are predicted to play a dominant role in plant-atmosphere interactions in near future. Quantitative models that link stress severity, plant volatile emissions and climatic feedbacks are currently being developed, and this presentation argues that incorporating stress-dependent feedbacks in Earth system models in inevitable to simulate future climates.