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The Nonlinear Nature of Atmospheric Chemistry

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When scientific or policy-relevant questions involve atmospheric chemistry, one often hears "nonlinear" being invoked to describe the problem in a vague unspecific way. The precise nature of the nonlinearity is never delineated, and we are left with the fuzzy impression that nonlinear problems are difficult to solve or have no simple answer. For differentiable systems, nonlinear behavior can be expressed through a Taylor expansion whereby any of the 2nd order terms (x^2 , y^2 or xy) are the first nonlinear parts. In this lecture we shall explore a range of scientific discoveries or developments in atmospheric chemistry where the nonlinear nature was critical to understanding the problem. I select a set of problems worked on by many colleagues and myself over the last four decades. These include: multiple solutions in stratospheric chemistry; depletion of ozone; numerical methods for tracer transport; our developing understanding of methane; chemical feedbacks and indirect greenhouse gases; and finally the rich heterogeneity of gases that drives tropospheric chemistry. I hope to convince you that by embracing the nonlinear nature of atmospheric chemistry and understanding when it is important and when it is not, we can advance the field.