Atmospheric Chemistry Models

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This lecture gives a broad overview of the different types of atmospheric chemical models, how they operate, their central equations, the processes included, the model assumptions, their limitations, diagnostic tools to help understand their output and some interesting examples of scientific problems which they address. We start with an overview of the different types of model, from box-models up to full General Circulation Models (GCMs) and discuss which types of questions can be addressed with which types of models. We discuss the central chemical equations which calculate chemical concentrations by estimating chemical production rates (e.g. via gas-phase and heterogeneous chemistry, surface emissions, physical processes such as lightning etc.) and chemical loss rates (e.g. via gas-phase and heterogeneous chemistry, dry and wet deposition, escape processes etc.). Coupling between chemical and dynamical processes is also discussed e.g.chemistry can influence radiative gases hence temperature gradients and transport, whereas advection can deliver or remove chemical species. We then present scientific applications of photochemical models to specific problems in atmospheric chemistry in the Solar System and beyond e.g. the methane lifetime puzzle on Mars, or the "missing" UV absorber on Venus, or the need for better constrained gas-phase chemical rates on exoplanetary hot Jupiters. Finally we present an overview of recent chemical modelling results for Earth-like exoplanets and some outlook for the future.