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Radiative Transfer in Climate Models

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Radiation is a key physics element in both the maintenance of the climate as well as in driving climate change. The absorption of the Sun's radiant energy by the surface-atmosphere system in the ultra-violet, visible and near-infrared spectral regions, and the absorption and emission of infrared radiation by the surface and atmosphere, together govern the planetary energy balance. The importance of radiative processes enters in both the "forcing" of the climate system and in the "feedbacks" that amplify the response to perturbations of the energy balance. As examples, we will examine the natural and anthropogenic radiative forcings that have occurred over the 20^{th} century, our understanding of the governing processes and the challenges in representing them in climate models. The quantitative description comprises the determination of the forcing at the surface and in the atmosphere due to: emissions of the long-lived greenhouse gases (e.g., carbon dioxide), ozone precursors, and pollution particulates (e.g., sulfate and black carbon); changes in land surface properties; changes in solar irradiance; and particulates arising due to episodic volcanic eruptions. The various types of forcings are governed by fundamentally different underlying mechanisms, have distinct space-time dependencies and uncertainties, and exert varying signatures in terms of the climate system responses.