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One-dimensional Radiative-Convective Model with Precipitation

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Modelling of atmospheric dynamics is complicated both physically and mathematically. Concerning with enormous computing cost, we establish a one-dimensional model rather than a three-dimensional one to reveal the most significant factors that change our climate in a long-term time scale.

For vertical momentum equation, hydrostatic approximation is applied because of large time scale and small velocity scale, from which pressure is obtained as function of total mass of air above current layer. Vertical velocity is evaluated from continuity equation and equation of thermal conservation. For thermal balance equation, three main kinds of heat sources are taken into account: radiative absorption of water vapor and carbon dioxide; latent heat flux; turbulent heat flux. To calculate radiation flux we solve the differential equations associated with upward irradiance and downward irradiance, respectively. Absorption coefficients of greenhouse gases in dependence of temperature and pressure are obtained from HITRAN database and bilinear interpolation is applied to utilize these coefficients in the differential equations. We consider uniform size distributed droplets at certain layer, with equation of diffusion of water vapor, equation of motion for droplets and phase change criterion we get the droplets distribution over height, and at the same time latent heat can be calculated. For calculation of turbulent heat transfer, we use modern theory to parameterize horizontal velocity profile, define the boundary layer height and calculate eddy viscosity, eddy conductivity and eddy diffusivity.

On the top layer of atmosphere density, pressure, concentration of water and gradient of temperature are set to zero, downward irradiance is set to input solar irradiance in dependence of time. On the surface boundary, ocean-atmosphere interface and land-atmosphere interface are considered separately, for both situations input and output of irradiance, thermal conductivity and latent heat are balanced on the interface.

With help of this model we can analyze the influences of atmospheric turbulence and surface boundary conditions on the long-term temperature distribution. How carbon dioxide effects global temperature is widely discussed, this model is being built to understand the role of greenhouse gases in global warming.