Radiative transfer calculation for various planetary atmospheres: Application to a general circulation model

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A lot of exoplanets have been discovered. One of the interesting questions on those exoplanets is its surface environment and circulation structure. A first step to understand surface environments is an investigation of radiative budget of the planets. Further, now a days, several general circulation models are used to simulate surface environments of various planets. But, calculation of radiative transfer of various planets have several difficulties. One of those is huge computational cost, and another is uncertainty of radiative properties of atmospheres which is very different from Earth's atmosphere. In this study, we are developing a radiation model which can be applied to various planetary atmospheres and try to implement it into our general circulation model.

In developing a radiation model for atmospheric circulation models, a line-by-line model is developed, first. The line-by-line calculation requires huge computational cost. In our line-by-line model, we assign several atmospheric layers to each MPI process to perform parallel computation. In typical calculation conditions, number of atmospheric layers is order of 10 to 100. Our calculation scales very well if the computation is performed with this number of processors. In order to validate the model, radiative fluxes and tendencies are calculated for the Earth, Venus, present Mars, and early Mars.

After the validation of the line-by-line calculation, we develop a radiation model based on correlated k-distribution method, which require much fewer computational cost and can be implemented into a general circulation model. In the presentation, comparison of radiative fluxes and tendencies calculated by our model with those by observation and/or by other models will be presented. In addition, some examples of general circulation model simulations will be presented, too.

Keywords: planetary atmosphere, radiative transfer, Earth, Mars, Venus

