Toward development of a radiative transfer model for a planetary atmosphere general circulation model

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A lot of exoplanets have been discovered since late 1990s. One of the interesting open questions on those exoplanets is its surface environment and circulation structure. Exoplanets would have a wide variety of surface environment and circulation, since discovered exoplanets have a variety of orbital parameters, and composition and mass of atmospheres which may be significantly different from those of planets in solar system.
In order to investigate surface environment and circulation structure on exoplanets, the most important and difficult point is calculation of radiative transfer in its atmospheres. One of the difficulties to calculate accurate radiation field is to perform integration over wavenumber accurately. In the Earth's climate studies, many radiation models use the correlated k-distribution method to decrease calculation cost. As for a study of exoplanetary climate, we have to implement the k-distribution method for a wide variety of atmospheric composition and mass.
In order to investigate diversity of surface environment and circulation structure of exoplanetary atmospheres, we are trying to develop a radiative transfer model which can be used in atmospheric circulation models for various planetary atmospheres. In this study, as a first step, we are developing a longwave radiative transfer model for the Earth's atmosphere.
In developing a radiation model for atmospheric circulation models, a line-by-line model is developed, first. Then, we develop a radiation model based on correlated k-distribution method. In developing the correlated k-distribution model, the line-by-line model is used as a reference. The line-by-line calculation is performed with Voigt line profile calculated with Humlicek (1982) method. Gas absorption line parameters are obtained from HITRAN2012 (Rothman et al., 2013). Continuum absorption is considered by the use of the MT_CKD model (Mlawer et al., 2012). The line-by-line model is validated based on ICRCCM longwave radiation model intercomparison of Ellingson et al. (1991). In developing our longwave correlated k-distribution model, we set number and wavenumber ranges of bands and number of bins as the same as those of RRTM (Mlawer et al., 2012), which is a well-developed Earth's atmosphere radiation model. The developed correlated k-distribution model is validated by comparing flux and heating rate with those by our line-by-line model. In the presentation, details of the developed line-by-line model and the correlated k-distribution model will be presented. We will show some calculated results for the Earth's atmosphere, too.

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