Development of an atmospheric general circulation model for moist planets as an idealization of Jupiter and numerical experiments

Yasuhiro MORIKAWA[1]; Ko-ichiro SUGIYAMA[2]; Yoshiyuki O. Takahashi[3]; Masatsugu Odaka[1]; Masaki Ishiwatari[1]; Kensuke Nakajima[2]; Yoshi-Yuki Hayashi[3]

[1] Department of Cosmosciences, Hokkaido Univ.; [2] Dept. of Earth & Planetary Sci., Faculty of Sci., Kyushu Univ.; [3] Department of Earth and Planetary Sciences, Kobe Univ.

Our goal is to understand circulation structures of various moist atmospheres from the viewpoint of geophysical fluid dynamics with performing numerical experiments on planets which have various moist processes. With plotting various moist atmospheres including terrestrial planets, outer planets, and extrasolar planets on a parameter space of planet radius, solar constant, and so on, we try to abstract dynamical structures embedded in various moist atmospheres. In this presentation, we show the current status of our development of a general circulation model (GCM) and a result of a preliminary experiment aiming for numerical experiments on outer planet atmospheres.

In calculating general circulation of moist atmospheres, GCM are obliged to use parameterization of phase change processes such as cloud convections due to the shortage of spatial resolution. For GCMs of terrestrial atmospheres, parameterization schemes can be usually tuned by the use of observational results. For outer planet atmospheres, observational results of detailed atmospheric structure are limited. We attempt to abstract some fundamental features of the circulation dynamics with performing a number of numerical experiments using various parameterization schemes and/or various model parameters used in each scheme and extracting robust structures of atmospheric circulation. Numerical models used for various moist atmospheres including outer planets are desired to have flexibility of changing parameterization schemes of moist processes in addition to external parameters such as radius of the planet and solar constant.

In order to construct a numerical model with flexibility of changing numerical schemes and model settings, we are developing a numerical model by object oriented programming with the use of the module and the derived-type of Fortran 90/95 (2007, JPGU). We have designed a program structure which enables us to attach and detach processes composing GCM easily and have implemented physical processes in our general circulation model DCPAM (Dennou-Club Planetary Atmosphere Model).

We are now attempting to perform a preliminary experiment of a virtual moist planet with DCPAM aiming for a numerical calculation of Jovian cloud layer. We adopt model settings used in two dimensional calculation of Sugiyama (2007, doctor thesis): Gravitational acceleration is set to the value of Jupiter, surface pressure is 30 atm, and atmospheric major component is hydrogen. Surface temperature and amount of the surface moisture are fixed to constant values. Constant cooling rate is given to layers from 2 to 0.1 atm. Moisture is only condensable component. With performing the experiment, flexibility of changing numerical schemes and model settings is tested and the difference of behaviors of moist convections in the Earth-like situation and a Jupiter-like situation are examined.