Introduction

In resent years, a massive computer has developed. In the last 20th century, it became that its theoretical performance has tera FLOPS, its main memory has giga byte and its storage has tera byte. It is evidence that in the early 21st century we will be able to do the super massive calculation which we have never considered to do. What should we do using its capability of calculation? We can say that one of aspects of meteorology and atmospheric science is the pursuit for faster and more massive numerical models. A cloud model is a model, which expresses complicate interactions between the atmosphere as continuum and water vapor and the particles of cloud and precipitation in the atmosphere. It is one of the most massive numerical model in meteorology and atmospheric physics.

Study on cloud and precipitation using computer science has just begun to develop. Here, we name the meso-scale meteorology using computer 'computing meso-scale meteorology', it is still done by very few researchers. There are so many unknown things which are the formulation of the physical processes, the methods of calculations which are efficient and fewer error, the problems on the calculations and so on. Atmospheric phenomena are various and complicated, and there are a lot of unknown and undiscovered things. Using numerical models, we should be able to understand the various phenomena. However, we could have spent insufficient time and efforts for the 'computing meso-scale meteorology.'

What is it necessary for development of the study of the 'computing meso-scale meteorology?' Various numerical models must be created from various points of view. A large number of numerical experiments and verifications with the models are necessary for the development of the 'computing meso-scale meteorology.' We hope that the models develop over the various findings based on enormous calculations.

In resent, models develop to be very massive and complicate. It is impossible and inefficient that an individual researcher makes a such model from the beginning. Researchers have respective purposes, which are to create the method of calculation of numerical model and physical processes, to do the simulation of realistic phenomena, to experiment in the forecasts of meteorology and so on. The basic model is necessary for the purposes. If we are easy to use the basic model, it is possible that we study various problems by using the basic model, respectively. We develop the numerical model for clouds and meso-scale meteorological phenomena in Special Coordination Funds for Promoting Science and Technology (SCF), 'Study on Advanced Simulations of Down Burst Phenomenon' (research representative: Prof. Nobuhiko Kamiya) . The purpose of this model is to be the platform of studies as mentioned above.

In resent, some models which can represent clouds with non-hydrostatic and compressible equations including cloud physical processes have been developed. We referred Advanced Regional Prediction System (ARPS), which was developed by the University of Oklahoma, and the non-hydrostatic meso-scale model developed by the Meteorological Research Institute in Japan for the development of this model. Our works for development of the model are based on knowledgements from previous studies. We would like to pay our respects to the previous efforts.

Computers are rapidly developing, especially for hard wears. A fast single vector processor was mainly used for massive calculations until a few years ago. In resent, parallel computers with multiple processors become often to be used. Our model is designed to get a high efficiency of calculation on a parallel computer. The cloud model includes many physical processes with a high resolution, while its calculation domain is smaller than those of global and climate models. Then, the parallel computer is very useful for the huge calculations with the cloud model.

Our model: ***CReSS*** (Cloud Resolving Storm Simulator) can reproduce clouds and simulate meso-scale precipitation systems organized from the clouds. ***CReSS*** (Cloud Resolving Storm Simulator) has a high resolution in horizontal and vertical, and expresses physical processes of clouds and precipitation as sufficient as possible. Processes of clouds and precipitation still has been clarified insufficiently. Both observational studies and the development of the cloud model are needed to get the further understandings of clouds and precipitation systems in the future. The goal of the development of ***CReSS*** is to contribute for a prediction of heavy rainfalls based on those understandings.

CReSSis full open for public as the open provisions. This guide concretely describes the program codes and the way of the use of ***CReSS***. We hope that this guide is useful for all of ***CReSS*** users. The guide, however, should be revised with the improvement of the numerical model. Since the explanations of the guide may be insufficient, we hope that you give us any advices about our model and this guide.

This work is conducted as one of 'Study for Advanced Simulation of Down Burst Phenomenon' with Special Coordination Funds for Promoting Science and Technology; 'development of parallel softwares for large-scale simulation to predict the global climate change with high resolution.' The leader of this research project is Prof. Nobuhiko Kamiya, school of community policy, Aichi Gakusen University. We got an opportunity to develop ***CReSS*** by courtesy of Prof. Nobuhiko Kamiya. We thank for the support by the Agency for Science and Technology, and Research Organization for Information Science and Technology. Especially, we have been supported by Prof. Akimasa Sumi, Center of Climate System Research, University of Tokyo, Prof. Takao Takeda, Nagoya University and Dr. Yonejiro Yamagishi and Mr. Nakamura at the Research Organization for Information Science and Technology from the beginning of this project. We exchanged many informations with Mr. Takashi Arakawa at Research Organization for Information Science and Technology.

CReSS is developed in Institute of Hydro-spheric-Atmospheric Science. We use the HITACHI SR8000 at Information Technology Center, University of Tokyo, FUJITSU VPP5000 at Information Technology Center, Nagoya University, HITACHI SR2201 and NEC SX4 at Japan Atomic Energy Research Institute, numerical wind tunnel at National Aerospace Laboratory of Japan and Compaq Computer Corporation work stations. We are also supported for software by CTI Co., Ltd. The authors express their appreciation to all of them.

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By April 2001, 'Institute of Hydrospheric-Atmospheric Science' is reorganized by 'Hydrospheric Atmospheric Research Center'.

For the second edition

The first edition of this ***CReSS***User's Guide was published at September 22, 2000. That was a material for the first seminar of meteorological model for parallel computing sponsored by the Foundation of Research Organization for Information Science and Technology. We have since developed the ***CReSS***, so the second seminar was to be taken place sponsored by the foundation. We added to write some new contents in the second edition of ***CReSS***User's Guide: the method of numerical computation, the process between the boundary layer of atmosphere and surface and the result of the simulation of the squall line.

CReSS have be developed to adopt processes of cloud physics, turbulence, atmospheric boundary layer and land surface. ***CReSS*** become to develop a model which reproduces most meteorological phenomena excepting stratus clouds in which the radiation is important. We are doing the forecast experiment by using the three dimensional and time-various data as the initial and lateral boundary values. We have carried through the first stage of the development of the cloud resolving model although a number of problems to develop are remained. We will advance the revision of User's Guide with the development of the model. The second edition of ***CReSS*** User's Guide includes the latest informations for the present ***CReSS***.

We would like to develop the User's Guide so that many researchers understand and use ***CReSS***.

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