NHM Tutorial
Part 0. Introduction

Syugo HAYASHI
(Forecast Research Department /
Meteorological Research Institute)

Overall Index (Tutorial_0~3)

- 0. What is the NHM?
  - *NHM_Tutorial_0.ppt (this file)*
- 1. Brief usage of the NHM
  - *NHM_Tutorial_1.ppt*
- 2. Practical Exercise
  - *NHM_Tutorial_2.ppt, NHM_Tutorial_3.ppt*
  - 2.0 Installation of the NHM
    - prepare the external files, compile the model and tools, and install the visualization tools
  - 2.1. Idealized Experiments
  - 2.2. Realistic Experiments

Attention!

(NHM isn't completely free to use.)

- If you want to use the NHM for research, you have to send a letter to MRI/JMA and then you'll receive the NHM.
  - for operational usage, please contact JMA.
- If you need a sample form of the letter and more information, please contact Dr. Saito at MRI/JMA and download below.
  - http://www.mri-jma.go.jp/Project/Kashinhi_seasia/nhminfo/index.htm
- Contact Person (for research use of the NHM):
  - Dr. Tadashi TSUYUKI
    Director, Forecast Research Department
    Meteorological Research Institute
    1-1 Nagamine, Tsukuba, 305-0052, JAPAN

0. What is the NHM?

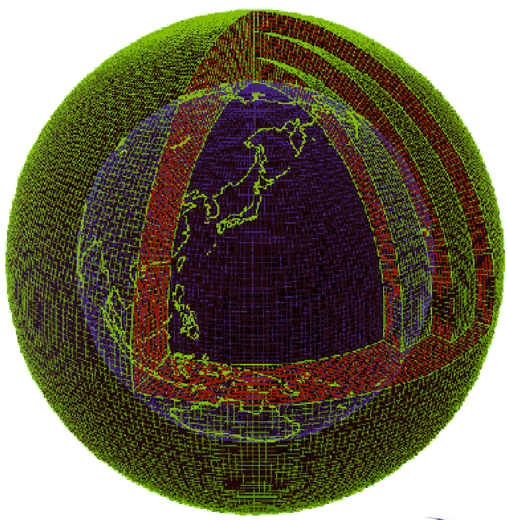
- What is a Numerical Model?
- What can we do using a Model?
- What is a mesoscale model?

What is a Numerical Model?

- Numerical weather prediction (called "NWP") is the science of predicting the weather using "models" of the atmosphere and computational techniques. Manipulating the huge datasets and performing the complex calculations necessary to do this on a resolution high enough to make it accurate requires some of the most powerful supercomputers in the world.
- The “model” is one or more computer programs that output meteorological information for future times. Many weather forecasting organizations have developed their own models. Every model has its quirks and biases, and human intervention and interpretation is often needed to remove these from forecasts prior to dissemination. (by wikipedia ☺)

Overview of a Numerical Model

- Dividing the Earth’s atmosphere into a 3D grid with discrete grids. (see right figure)
- The forecasts are computed using mathematical equations that describe the physics and dynamics of the atmosphere. The model calculates how the atmosphere will change in each grid with time, and how each grid affects its neighbors, making a forecast.



What can we do the Model?

- Real time (operational) NWP (Numerical Weather Prediction)
  - short range, week range, month range and climate prediction…
  - Very useful tool for weather prediction.
- Forecast research
  - We can conduct simulations reflecting either realistic atmosphere or idealized situation easily.
  - Sensitive experiments also conduct easily. (for example; remove mountains, change sea surface temperature. It is very difficult to confirm these effect in the real atmosphere.)
- Teaching weather system
  - For example, we will simulate mountain wave today. So we can confirm mountain wave structure visually.

Kind of Numerical Weather Models

- For the restricted computing power, we use the models properly. (Even if we have the fastest computer in the world, we can't get sufficient computing power for a weather prediction.☺)
- Global Model (Δx=200~20km)
  - This model can simulate global circulation and synoptic scale.
- Regional Model (Δx=20km~)
  - Hydrostatic model(Δx=~10km)
  - Non-hydrostatic model (Δx=5km~?00m) (Cloud Resolving Model)
  - These model can simulate severe weather, but boundary conditions for them are provided by global model or another regional model.
- LES model (100~?m)
  - This model can simulate micro scale. Because it needs enormous computing power in realistic simulation, it doesn't use weather prediction.

Mesoscale Models

- Today, we use meso-scale model. There are many meso-scale models in the world.
- Let me introduce major models.
  - NHM: The JMA mesoscale model. The details will introduce later.
  - WRF: The Next-generation meso-scale numerical weather prediction system is developed by NCAR, NCEP and many researchers.
  - MM5: The PSU/NCAR mesoscale model (older than WRF). Many users switch to WRF from MM5 now. However, MM5 is most popular meso-scale model in the world.
  - And, UM(UKMO), LM(=COSMO, DWD), AROME(Met. Fr.), GEM(=HIMAP, MSC), GRAPES(CAMS) …
  - ARPS: The ARPS was developed at the CAPS at the Univ. Oklahoma. Many users switch to WRF now.
  - RAMS: The RAMS was developed at Univ. Colorado. Many users switch to WRF now.

Brief history of the NHM (1)

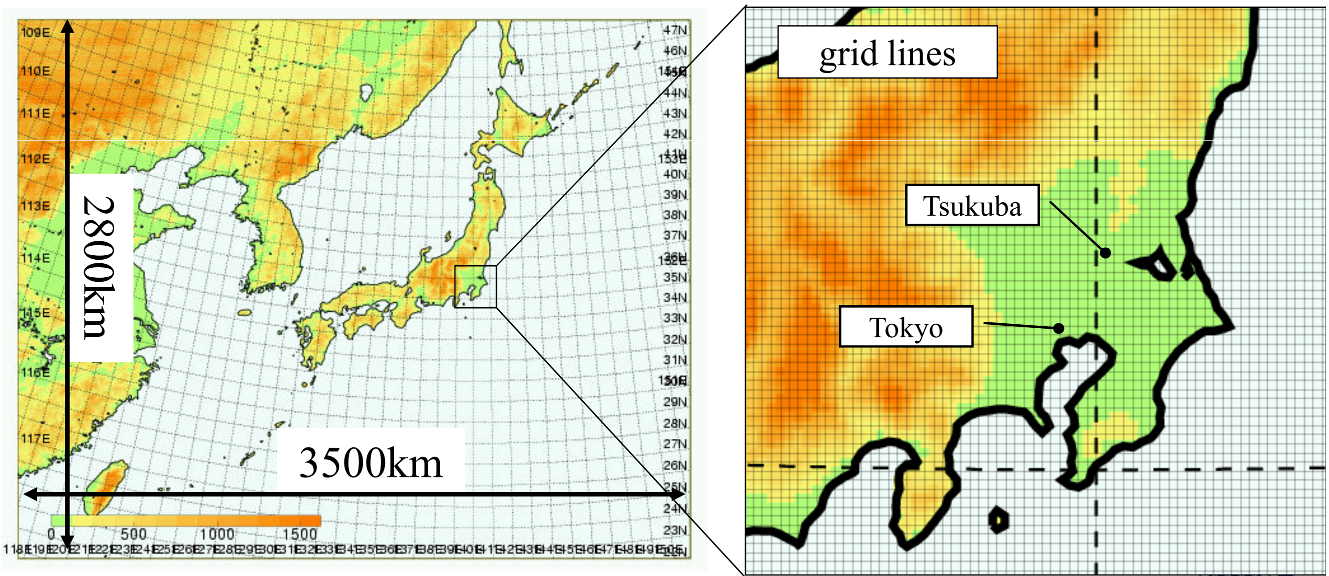
- In Meteorological Research Institute (MRI/JMA) Nonhydrostatic Model (MRI-NHM) was developed by Ikawa (1984).
- On the other hand, another model was developed by Goda and Kurihara (1991) in Numerical Prediction Department (NPD/JMA) .
- A joint work between MRI and NPD was started in February 1999. A unified model (MRI/NPD-NHM) was completed in 2000.

Brief history of the NHM (2)

- Development of community model for numerical weather prediction and research was started 2001 (NHM).
- Operational run was started on 1 September 2004. Model specifications were 10km in horizontal resolution, 18hr forecast and 4 times/day. Forecast domain is 3500km x 2500km (Japan area).
- Operational run was update to 5km in horizontal resolution from 10km on 1 March 2006. It was 15hr forecast and 8 times/day with same domain (see next slide).
- March 2007, we have run 33hr forecast 4 times/day and 15hr forecast 4 time/day.

JMA Meso-Scale Model (NHM) Operational Domain now.

- Operational domain and grid space (719x575grid.dx=5km)



Specifications of the NHM (1)

- Dynamical Frame
  - Fully compressible equations with conformal map factors
  - HE-VI (time splitting scheme)
  - Advection terms
    - Horizontal : fourth order , Vertical : second order
    - Modified centered difference advection scheme
  - The terms responsible for sound and gravity waves
    - The lower components of the advection terms are adjusted at each short time step.
  - Targeted Moisture Diffusion (TMD)

Specifications of the NHM (2)

- Physical Process (Moist)
  - Cloud microphysics: Bulk method : qc,qr,qci,qs,qg
    - Box-Lagrangian particle fall scheme included
  - Cumulus parameterization
    - Kain-Fritsch scheme : originally developed by Kain and Fritsch (1993). adopted in NHM by courtesy of Dr. Kain. Revision described in Kain (2004)
    - Other cumulus parameterization schemes (A-S, Grell) are available.
- Physical Process (Dry)
  - Surface processes
    - computation of bulk coefficients : Over land : change from Sommeria to Louis. Over sea : Kondo
  - Boundary layer process
    - Non-local effect is considered. mixing length is determined using PBL height
  - Turbulent kinetic energy
    - Diagnosis of turbulent energy. solving the TKE equation on the condition of the local equilibrium

If you want to know more details about the NHM, See below references...

- **References:**

  - Saito, K., T. Fujita, Y. Yamada, J. Ishida, Y. Kumagai, K. Aranami, S. Ohmori, R. Nagasawa, S. Kumagai, C. Muroi, T. Kato, H. Eito, and Y. Yamazaki, 2006: The operational JMA nonhydrostatic model. *Mon. Wea. Rev.*, **134,** 1236-1298.
  - Saito, K., J. Ishida, K. Aranami, T. Hara, T. Segawa, M. Narita and Y. Honda, 2007: Nonhydrostatic atmospheric models and operational development at JMA. J. Meteor. Soc. Japan, 85B, 271-304.
  - Kazuo Saito, Teruyuki Kato, Hisaki Eito and Chiashi Muroi, 2001: Documentation of the Meteorological Research Institute / Numerical Prediction Division Unified Nonhydrostatic Model. http://www.mri-jma.go.jp/Publish/Technical/DATA/VOL_42/42_en.html
  - Motohki Ikawa, Kazuo Saito, 1991: Description of a Nonhydrostatic Model Developed at the Forecast Research Department of the MRI. http://www.mri-jma.go.jp/Publish/Technical/DATA/VOL_28/28_en.html