Development of an Ultra High Resolution Global NWP Model

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1) Introduction

The Japan Meteorological Agency (JMA) has been operating a MPI parallel version of a T213L40 global spectral model (GSM) on the supercomputer HITACHI SR8000E1 since March 2001. GSM supports the official one-week forecast and provides the lateral boundary condition for the JMA Regional models. In order to provide regional scale forecast with a unified model about five years later, we are developing an ultra high resolution GSM which corresponds to a 20km mesh model. We have executed several experimental runs of T319 (38km mesh), T426 (28km mesh), T639 (18km mesh) and T682 (17km mesh) models on the HITACHI SR8000E1.

2) MPI parallel version of JMA GSM

The operational GSM T213 is executed with 16 nodes (PEs) to perform 24-hour forecast within 7 minutes of wall clock. The strategies for parallelization are 1) a simple structure is preferable, 2) instruction loads should be well balanced among nodes, and 3) reproducibility must be guaranteed even if the number of nodes changes. Therefore one-dimensional decomposition in cyclic order is adopted. Fig.1 shows the schematic design of the parallelization. The variable array is decomposed by latitudes in grid space and by zonal wave numbers in spectral space so that all values needed for the summation in both Fourier and Legendre transformations are localized in a node.

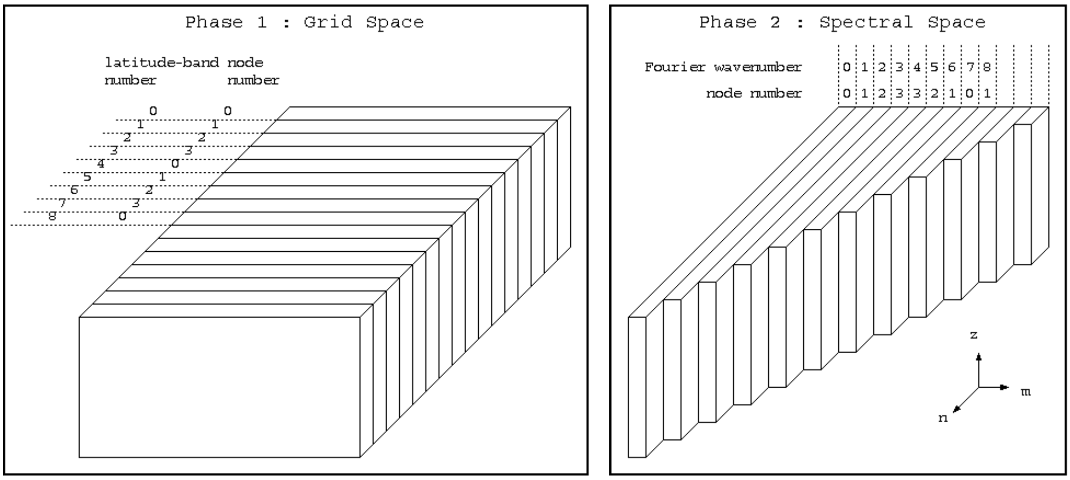

Fig.1 Schematic design of the parallelization.
The number of nodes used is assumed to be 4 in this example.

3) Performance of the Ultra High Resolution GSM

We have executed several experimental runs of T319, T426, T639 and T682 models. T319, T426 and T639 models were computed with 40 nodes, while T682 model was computed with 64 nodes on SR8000E1. Fig.2 shows how computational cost increases as the horizontal resolution increases. T639 takes 32.5 times larger than T213 (ideal computational cost is 3x3x3=27). Fig.3 shows ratio for execution time in major components of GSM. As the horizontal resolution increases, the ratio of physical process (PHYSCS) is reduced while that of dynamical process (TNDNCY) increases. It should be noted that the moist process (GMOIST) includes both moist physical processes and wave-grid transformation. TINTGS includes the process related to semi-implicit time integration which is computed on wave space. Fig.4 shows the mean sea level pressure and 12-hour precipitation at 48hours forecast with T213, T426 and T682 models. The heavy precipitation around the typhoon T0115 (Danas) is found in T426 and T682 model, and the smaller scale precipitation patterns are found over Japan Island in T682. The central pressure of T0115 in T682 model is 5hPa lower than T213 model.

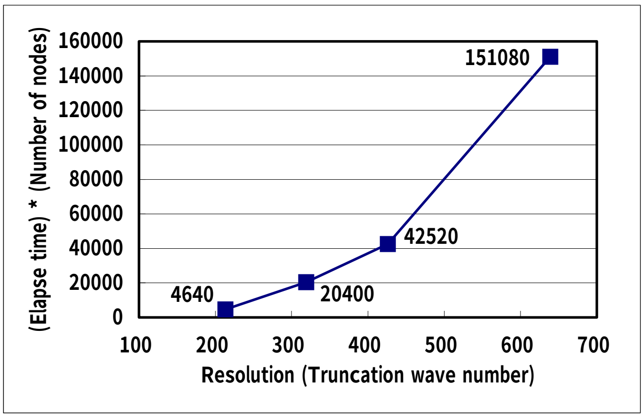

Fig.2 The relation between horizontal resolution (truncation wave number) and total elapse time (in seconds) for 24-hour forecast

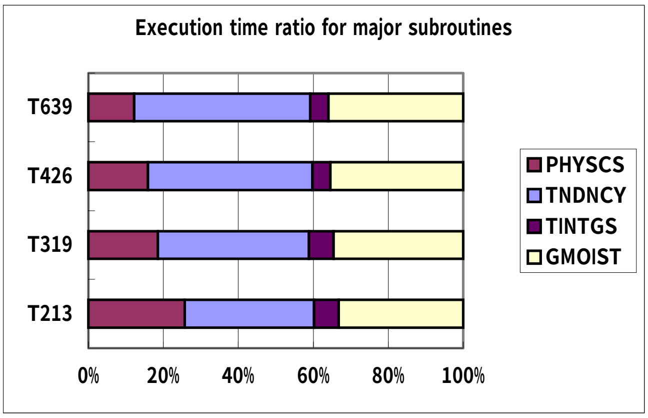

Fig.3 The execution time ratio for major subroutines with different horizontal resolution

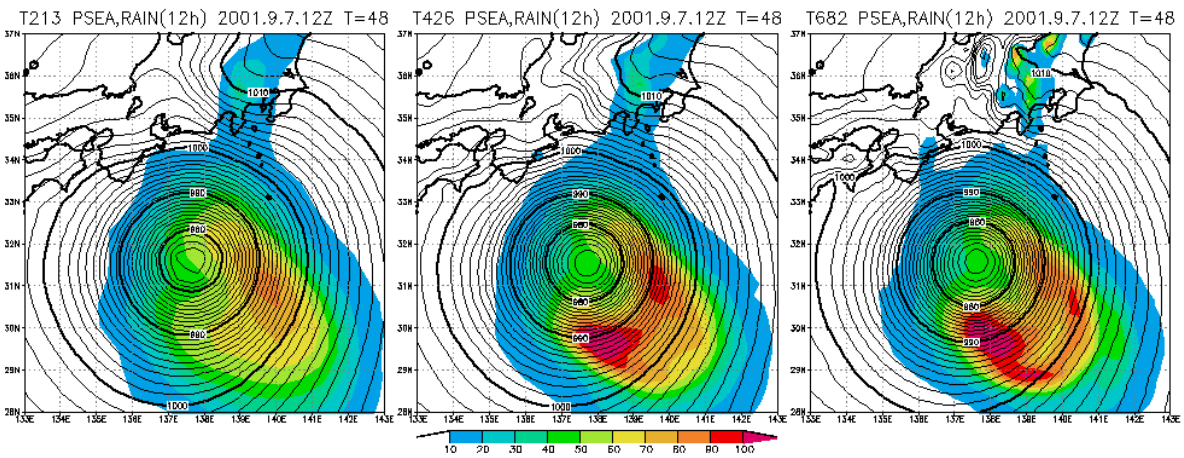

Fig.4 Mean sea level pressure (contour) and 12hour precipitation (shaded) in T213 (left), T426 (middle) and T682 (right) model. 48 hour forecasts of the typhoon T0115 Danas.

4) Future plan

We are trying to execute longer time range forecasts (1-week, 1-month…) with the T682 model, and investigating its forecast fields.

The development of a semi-Lagrangian GSM is also under way at JMA. It is expected that the semi-Lagrangian GSM which corresponds to 20km mesh resolution will be executed on the next JMA supercomputer system.