

3. How to execute ensemble forecast experiments with the MRI-EPS

In this chapter, we briefly describe a standard procedure for executing ensemble forecast experiments with the MRI-EPS on the MRI supercomputer system. Users of the MRI supercomputer system can also refer to the Appendix of this report, written in Japanese, in which a detailed description is provided of technical information such as execution commands and configuration files for the experiments.

3.1 Preparation of the computational configuration

Before initiation of the BGM cycle and/or an ensemble forecast experiment with the MRI-EPS, computation configurations are constructed by preparation of necessary files. After a compressed system file named MRIBGM.tar.gz has been obtained, copied to a specific directory, and uncompressed the file, the system directory (hereafter denoted by \$BGMDIR) for the BGM cycle and the ensemble prediction is accessible. The directory contains shell script files to perform the experiments, execution files such as programs to compute the norm of bred modes, programs that describe the atmospheric model, and various utility program files mentioned in subsequent sections.

Next, analysis data must be prepared for the atmosphere and land conditions, SST, and distribution of sea-ice. These data are needed as input data for the experiments. It should be noted that these analysis datasets should be provided with the same data format as is used in the operational JMA system, namely NuSDaS format. The JRA-25 reanalysis data, land surface data from the JMA/CPD offline analysis, and COBE-SST sea-surface data (see also Table 2) during the specified experimental period (including the period for the pre-BGM cycle) should be stored in some directories of the supercomputing system of the MRI before starting the experiments. It should be noted that in this version of the MRI-EPS the land surface data are given by the climatology and are rearranged on reduced-Gaussian grid points the grid spacing of which depends on the specification of the atmospheric model.

Table 2: Analytical data used in the experimental system

	dataset name	time interval	spatial resolution	reference
Atmosphere	JRA-25 reanalysis	6 hourly	1.25x1.25 degs 23 p-levels	Onogi et al. (2007)
Land	JMA/CPD offline analysis	12 hourly	TL159 reduced-gaussian grid	JMA/CPD (Tokuhiro)
Sea surface	COBE-SST dataset	daily (18UTC)	1 x 1 degs	Ishii et al. (2005)

3.2 Execution of the NH BGM cycle

If there is no previously obtained bred mode, the pre-cycle must be executed first. In that case, a shell script file named `pre_nh*p.sh` in `$BGMDIR` (* corresponds to 4 or 25) is properly edited and executed. Adequate computational configurations for the pre-cycle for 4 or 25 bred modes on the MRI system should then exist. Each pre-cycle for a NH perturbation can then be started. A flow chart for each pre-cycle is shown in Figure 3. Here, “Bg” stands for a 12-h or 6-h forecast job. For example, Bg1200 means a control run starting from 12 UTC, whereas Bg0001p is a perturbed run (mode number 01) starting from 00 UTC. “Stan” job rescales the mature perturbation after evaluating its norm at 00 UTC and 12 UTC. “Cpcycl” job saves the generated perturbation in the pre-cycle and prepares for the transition to the next pre-cycle. The part denoted by “lsub_bgm_nh1p” in Figure 3 obtains the first perturbation of the pre-cycle from the difference field between the 6-h (BG0600 job) and 12-h (Bg00pre job) forecast. In contrast, “lsub_bgm_nh1” constructs the main part of the pre-cycle for each bred mode.

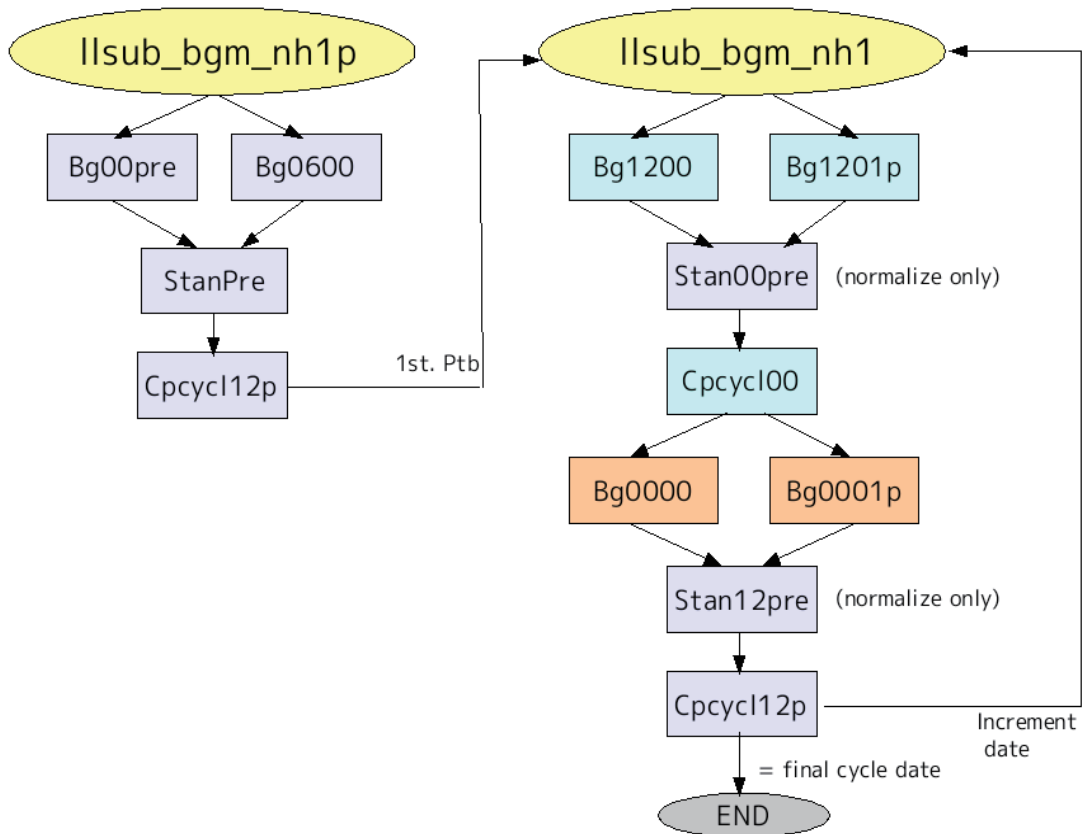


Figure 3: Flow chart of the pre-cycle for the NH perturbation

The main BGM cycle cannot be started until the initial perturbations have been obtained with the (4 or 25) series of pre-cycles. And it is ensured that there will be adequate computational configuration for the NH BGM cycle (to generate 4 or 25 bred modes) by proper edit and execution of a shell script file named \$BGMDIR / pre_nh*.sh (* = 4 or 25). After those steps, the main BGM cycle can be started. Figure 4 illustrates a flow chart of the NH BGM cycle for four bred modes. In the main BGM cycle, the control forecast (Bg\$\$00) and four perturbed forecasts (Bg\$\$##p) can be carried out simultaneously if there are sufficient computer resources. Here, \$\$ indicates the initial UTC time (00 or 12), and ## indicates the bred mode number (from 01 to 04). The perturbations are only normalized at every 00 UTC by Stan00 job and orthonormalized to each other at every 12 UTC by Stan12 job. The obtained bred modes are stored in a directory specified in the shell script every 12 hours by Cpcycl jobs. At every 12 UTC, initial perturbations for the subsequent ensemble forecast experiment are created in addition to the perturbations needed to start the next BGM cycle. The former perturbations differ from the latter in the following two ways: (1) to retain the characteristics of each mode generated by the forecast model, there is no orthogonalization between perturbations; (2) the rescaled perturbations are multiplied by a weight factor to represent the global

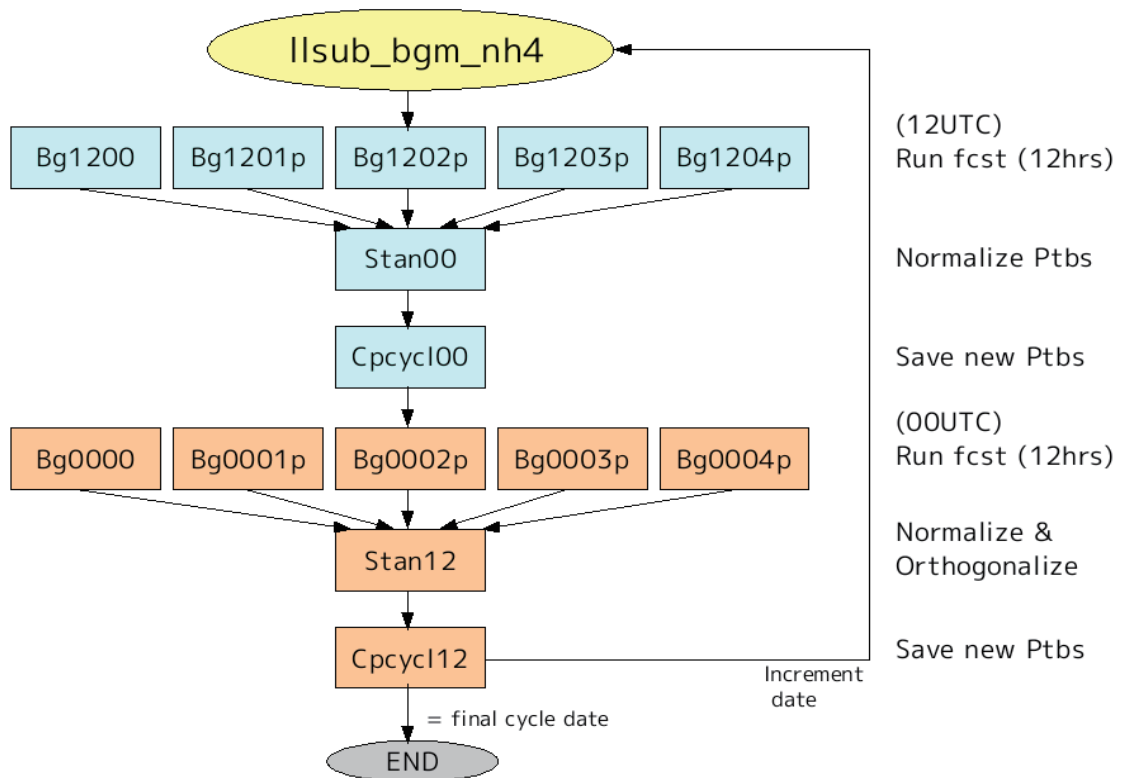


Figure 4: Flow chart of the NH BGM cycle (4-mode version)

distribution of analysis error in the atmosphere⁵, because the reliability of the analysis data is not uniform on the globe.

When it is desired to extend a BGM cycle terminated normally or to restart a cycle unexpectedly terminated for a certain reason, it is necessary to replace the start date written in the shell script file with the first target date of the restart BGM cycle and to set the perturbation data directory so that it is identical to the perturbation directory used in the previous cycle. After those steps, the BGM cycle can be executed continuously.

3.3 Execution of the TR BGM cycle

If there is no proper initial perturbation to start the TR BGM cycle, the NH bred modes are used to start the cycle. A program located in the BGM Tool directory (\$BGMDIR/Tool) is available to convert a NH bred mode into the initial perturbation needed to start the TR BGM cycle. The program will change only the metadata information about the region where the perturbation data are applied.

When the TR BGM cycle is started, a shell script file named \$BGMDIR/pre_tro.sh must be properly edited and executed. Then there will be adequate computational configurations for the TR BGM cycle generating two TR bred modes. At that point, the main TR BGM cycle can be started on the supercomputer system of the MRI. Figure 5 illustrates a flow chart of the TR BGM cycle. It has basically the same structure as the NH BGM cycle shown in Figure 4. After control (Bgtr00) and

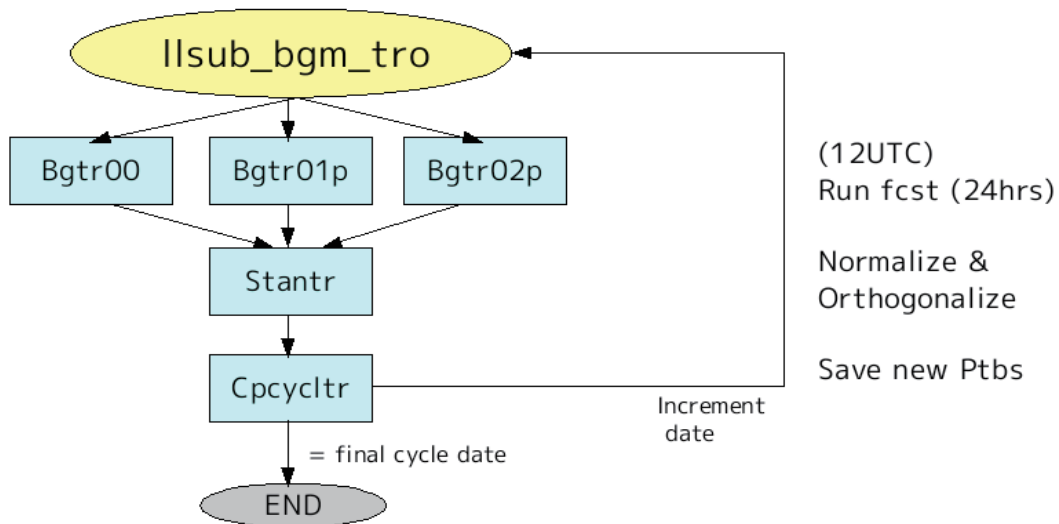


Figure 5: Flow chart of the TR BGM cycle

⁵ MRI-EPS makes use of the same distribution of the weight factor for the analysis error (only in the NH) as is used in the JMA-BGM. See Kyoda (2000).

perturbed (Bgtr##p) forecasts for the prediction period of 24 hours (here, ## corresponds to a mode number) have been conducted, normalization and orthogonalization of the perturbations for the tropical region are carried out using a norm based on χ_{200} (Stantr). The orthonormalized perturbations are stored every 12 UTC in a specified directory (Cp cycltr) and are used to continue the TR BGM cycle. As is the case for the NH BGM cycle shown in Section 3.2, every 12 UTC another set of initial perturbations is also created, without conducting the orthogonalization process, for the following ensemble forecast experiment.

3.4 Execution of the SH BGM cycle

The SH BGM cycle to generate initial perturbations for the SH is performed in exactly the same manner as the NH BGM cycle: after a shell script file \$BGMDIR/pre_sh*p.sh (* = 4 or 25: number of modes) has been properly edited and executed, there are adequate computational configurations for conducting the SH pre-BGM cycle and obtaining the initial perturbations for the main SH BGM cycle. The main SH BGM cycle is started by editing and executing a shell script file \$BGMDIR/pre_sh*.sh (* = 4 or 25). Figure 4 is a flow chart of both the SH and NH BGM cycles. The obtained SH initial perturbations are stored every 12 hours in a specified directory.

3.5 Execution of the ensemble prediction experiment

The following is the procedure for conducting an ensemble forecast experiment by using the numerical atmospheric model (GSM) described in Section 2.4 from several perturbed initial conditions obtained with the BGM cycles described in Sections 3.2, 3.3, and 3.4. First, control and perturbed initial conditions must be established to start the forecast. After preparing the perturbation data and the analysis data (which have already been used in the BGM cycle), a shell script file \$BGMDIR/make_lfin.sh must be properly edited, specifying preferable regions where initial perturbations are considered: a global perturbation for the NH, TR, and SH regions; a combination of perturbations for the NH+TR or SH+TR regions; and a perturbation for a single region (NH or SH). After the script has been executed, initial data from which numerical integrations of the GSM will be started are created for all ensemble members every day during a specified period.

To perform the forecast experiment, a shell script file \$BGMDIR/pre_fcst.sh must be edited and executed. The control and perturbed runs are then executed by updating the initial date with an increment of 24 hours; the runs are carried out in parallel jobs if computing resources are available. Results of the forecasts describing predicted variables at specific pressure levels in the JMA NuSDaS data format are stored in a directory, specified in the script file, where results of each forecast member from each initial date are outputted in separate data directories.