## 4. Influence of SH bred vectors on the forecast skill for the SH atmosphere

In this chapter, we examine the effect of SH bred modes, which are newly obtained by the MRI-EPS system, to improve the forecast skill of medium-range prediction for the SH atmosphere. For this purpose, the BGM cycles of the MRI-EPS were executed to generate four bred modes for each of the NH and SH and two bred modes for the TR during February 2004. Two types of ensemble forecast experiments were then conducted with nine members (one control and eight perturbed members), both of which were started every 12 UTC during February 2004 with a prediction period of 30 days: one experiment (hereafter referred to as NTS) consisted of initial perturbations over the globe (NH+TR+SH region); the other experiment (hereafter referred to as NT) consisted of initial perturbations for the NH and TR regions, but not adding SH perturbations to the initial state.

Figure 6 shows the SH forecast score during the first week for the experiments started

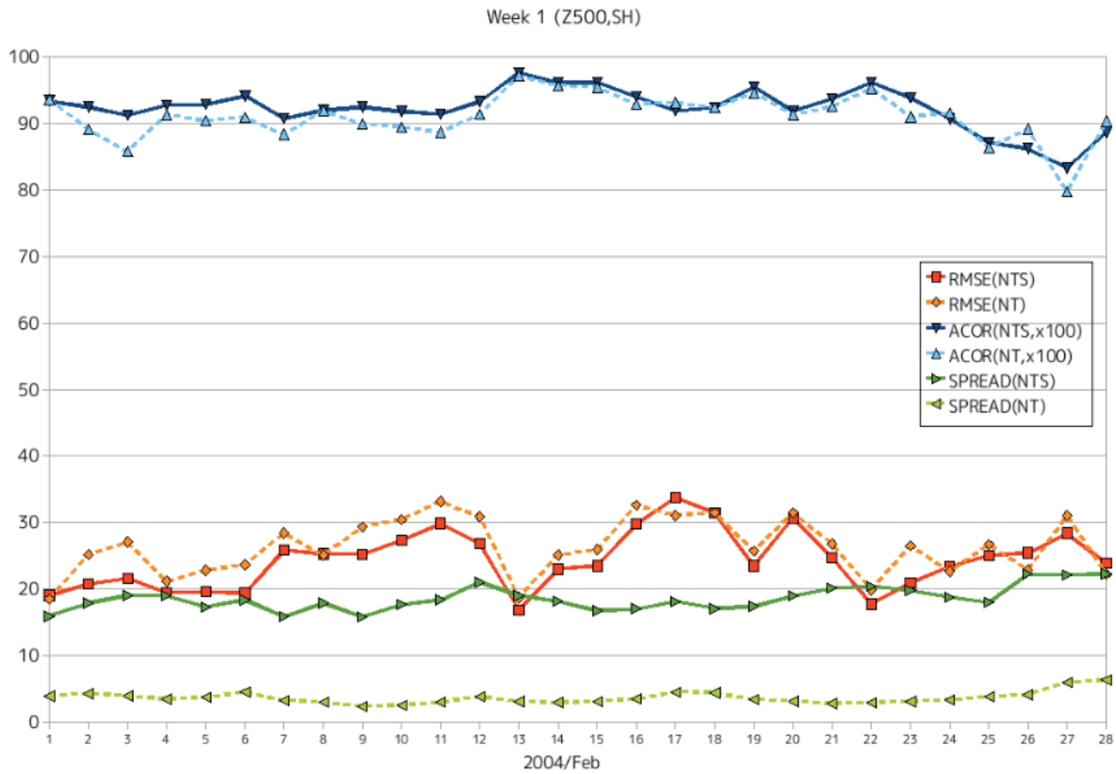


Figure 6: Scores of ensemble mean and ensemble spread (weekly mean Z500 in SH during the first week). Solid and dotted lines refer to the NTS and NT experiments, respectively. ACOR is multiplied by 100. The units of RMSE and SPREAD are meters. The horizontal axis shows the initial date of the ensemble forecast.

every day in February 2004. In this figure, RMSE and ACOR denote root mean square error and anomaly correlation coefficient, respectively, of the ensemble mean forecast for SH 500 hPa height. The magnitude of the ensemble spread is also shown by SPREAD in Figure 6. It is apparent that the ensemble spread is much larger for the NTS than for the NT. This difference reflects the fact that adequate SH initial perturbations were represented in the NTS, whereas very small-magnitude perturbations were added in the SH region of the NT. It is also apparent that the forecast skill of the ensemble mean prediction, assessed on the basis of the RMSE and the ACOR, is better for the NTS experiment than the NT experiment. Figure 6 also shows that the RMSE and SPREAD for the NTS are almost comparable in magnitude, but the SPREAD is slightly smaller than the RMSE.

Figure 7 shows the forecast scores for the second week. Although there are much larger variations among the forecasts compared to the first week, it is again apparent that the SPREAD of the NTS experiments, which is comparable in magnitude to the RMSE, is larger than the NT experiments. Figure 7 also indicates that, based on the RMSE and ACOR, the forecast skill in the SH for the NTS experiment, taking the SH perturbation into consideration, is improved overall compared with the NT experiment.

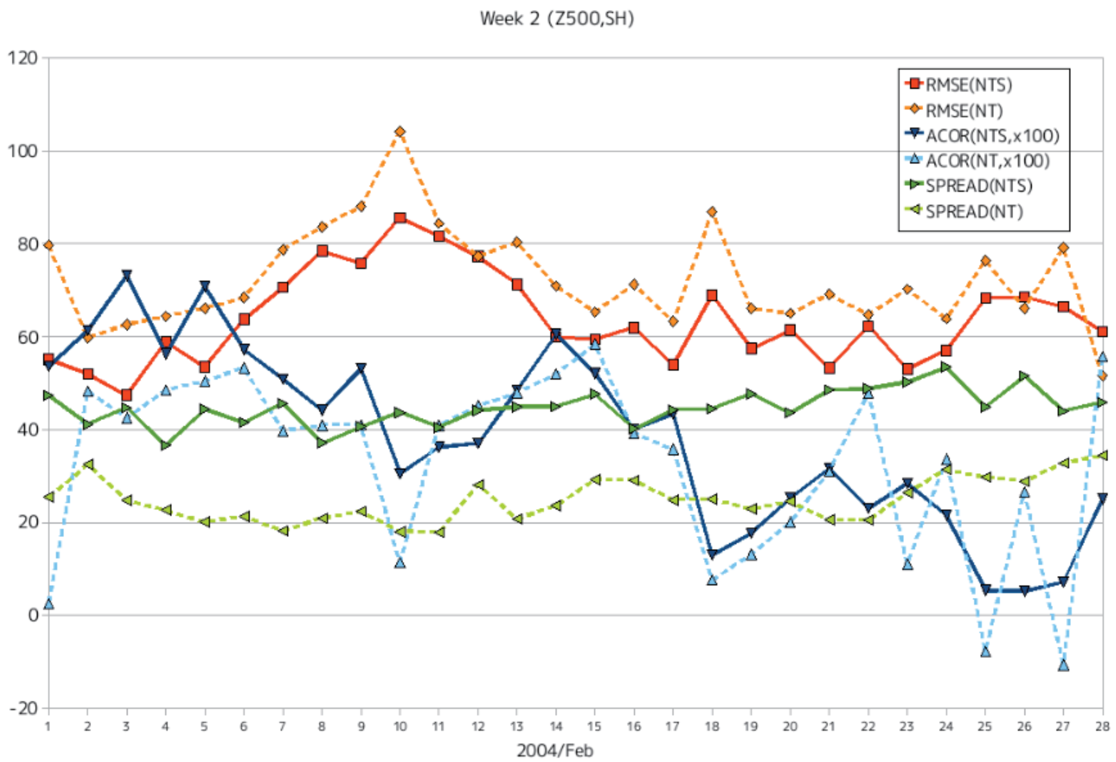


Figure 7: Same as Figure 6 except for the second week

Table 3 indicates the forecast skill and ensemble spread of the NTS and the NT experiments averaged over 28 forecasts, starting every day during February 2004. Here, W1 and W2 denote the mean value over the first and the second week, respectively. These data reconfirm that the forecast skill (RMSE and ACOR) is better and the ensemble spread (SPREAD) is larger for the NTS experiment than the NT experiment. Moreover, unlike the NT experiment, the average SPREAD for the NTS is similar in magnitude to the RMSE. The differences of the skill between the two experiments is statistically significant at the 99.9% confidence level, except for the ACOR in the second week.

From Table 3, it is also apparent that the SPREAD is smaller in magnitude than the RMSE, even for the NTS experiment. The small number of ensemble members (nine) may account for this difference. However, the rescaling factor for the SH BGM cycle, specified in the same way as for the NH cycle, may have been smaller than expected. If true, this would be another reason for the difference. Because the sparseness of observations in the SH lead to larger analytical errors compared to the NH, it is plausible that a larger rescaling factor should be specified for the SH. Moreover, consideration should be given to the fact that using an imperfect NWP model generally causes a smaller ensemble spread than using a perfect model (uncertainty of models, or parameterizations of the physical processes in the model, e.g. Buizza *et al*., 1999).

Finally, we also examined the forecast skill and ensemble spread of the weekly mean Z500 in the NH by using the same dataset of ensemble forecast experiments (i.e., NTS and NT). However, we found that there was no significant improvement in the NH score, although the SH perturbations were included in the NTS (not shown here).

Table 3: Forecast skill of ensemble mean forecast and ensemble spread.
(ACOR is multiplied by 100. The units of the RMSE and SPREAD are meters.)

| Ptb. type | RMSE (W1) | ACOR (W1) | SPREAD (W1) | RMSE (W2) | ACOR (W2) | SPREAD (W2) |
|---|---|---|---|---|---|---|
| NTS | 24.37 | 92.31 | 18.59 | 63.72 | 38.31 | 44.74 |
| NT | 26.30 | 91.09 | 3.63 | 72.40 | 33.10 | 24.92 |