Analysis of GARP Data Requirements

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A program of numerical experiments has been initiated with the aim of exploring some of the questions posed under the heading of Observing Systems Simulation Experiments in the "Plan for US Participation in GARP",[1] the experiments being conducted with the aid of a two-level numerical model developed by Mintz and Arakawa.[2] The model has a grid spacing of 400 km at middle latitudes, matching the resolution specified in the GARP data requirements.

The first series of experiments has a bearing on the GARP data requirements themselves. This series is concerned with the relation between the errors in the atmospheric measurements and the accuracy of the resulting forecasts, i.e., the predictability. Experiments aimed at the same objective have been reported by Charney[3] and by Smagorinsky and Miyakoda (1969).

The procedure employed in the present experiments is similar to that employed in a study of the uses of satellite-derived temperature data for the calculation of global winds (Charney *et al.*, 1969). First, a hypothetical history of the atmosphere is produced by integrating the Mintz-Arakawa model for 155 days. It is assumed that this history represents the true circulation of the atmosphere, within the limits of the physics of the model and the 400-km resolution. Second, the integration is repeated, starting from day 92 of the original history, but with variations introduced into the initial conditions. The variations take the form of random fluctuations in winds, temperatures, etc., from point to point on the computational grid. These fluctuations are intended to simulate the observational errors in the data to be acquired by the GARP network. The integrations are carried forward from day 92 until the average error in each wind component has grown to 6 m sec^{-1}.

A mean wind error of 6 m sec^{-1} is taken to represent the limit of useful predictability in the forecasts. The reasoning behind this choice is that when the average wind error has a magnitude of 6 m sec^{-1}, the circulation still bears a rough resemblence to the unperturbed or "correct" circulation, with the same major lows and highs in approximately the same locations. However, as the wind error grows beyond 6 m sec, the correlation between the perturbed and the unperturbed circulations disappears rapidly. By the time the error has grown to 8 m sec^{-1}, for example, one or more major highs or lows are present in the perturbed solution and missing from the unperturbed solution, or vice versa.

Several planning documents list the data requirements for the first GARP experiment.[4] The requirements specify that winds are to be measured with an accuracy of ± 3 m sec^{-1} in each component, temperatures with an accuracy of ± 1C, and surface pressure with an accuracy of 3 mb, all with a horizontal resolution of 400 km. Inserting random errors with these magnitudes into the initial conditions of the integration, we find that the mean wind error reaches 6 m sec^{-1}, the predictability limit, in three days. If the initial wind values are smoothed, but still retain maximum errors of 3 m sec^{-1}, the mean wind error reaches 6 m sec^{-1} in four days. These times fall short of the predictabilities that have been the aim of GARP.

Further experiments show that it is the initial wind error of 3 m sec^{-1} that is principally responsible for the short predictability times noted above. If we repeat the experiments with the error in the initial wind data limited to ± 1 m sec^{-1}, but with the same errors retained in temperature and surface pressure as in the previous case, the predictability time increases to eight days.

A further reduction in the wind error below 1 m sec^{-1} does not improve the predictability appreciably unless the errors in temperature and surface pressure are also reduced. In order to gain a two-week predictability, in the sense of the criterion adopted here, the error limits must be tightened to 0.5 m sec^{-1} in winds, 0.5C in temperature, and 0.5 mb in surface pressure.

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