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SENSITIVITY OF FORECAST SKILL TO DIFFERENT OBJECTIVE ANALYSIS SCHEMES

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ABSTRACT

Numerical weather forecasts are characterized by rapidly declining skill in the first 48 to 72 h. Recent estimates of the sources of forecast error indicate that the inaccurate specification of the initial conditions contributes substantially to this error.

The sensitivity of the forecast skill to the initial conditions is examined by comparing a set of real-data experiments whose initial data were obtained with two different analysis schemes. Results are presented to emphasize the importance of the objective analysis techniques used in the assimilation of observational data.

INTRODUCTION

The current skill of numerical weather forecast degrades rapidly in the first 48 to 72 h due to inaccurate initial conditions as well as model deficiencies. Recent estimates of the sources of forecast error (e.g., Miyakoda, 1975; Robert, 1976; Somerville, 1976) indicate that inaccurate initial data may contribute substantially to the rapid error growth. Errors in the specification of the initial conditions are due to both inadequacies in the observing systems and data analysis techniques. In this paper we examine the importance of the objective analysis techniques by comparing a set of real-data experiments forecast from initial data obtained with two different analysis schemes.

Data Analysis and Model Initialization

Two different analysis schemes were utilized to obtain the initial conditions for a pair of 72 h forecasts begun from 0000 GMT 11 February 1976. The two analysis schemes are similar in that they apply successive corrections to a first guess field (Cressman, 1959). The Laboratory for Atmospheric Sciences (GLAS) general circulation model (Somerville et al., 1974) was utilized as the forecast model.

One analysis scheme (hereafter referred to as Scheme A) is described in Halem et al. (1978) and will not be discussed in detail here. A second scheme (Scheme B), recently developed, differs in several respects from Scheme A as outlined below.

Successive corrections are made to a first guess geopotential height field in Scheme B, whereas, a temperature analysis is performed in Scheme A. A vertically consistent height analysis is maintained in Scheme B through the use of the hydrostatic equation. Substantially larger scanning radii are used in the successive correction procedure in Scheme B than in Scheme A. In Scheme B, the number of scans and size of the scanning radii vary depending on the particular field analyzed and the number of observational points available in a given radius.

In the data assimilation, Scheme A was applied every 12 h with the GLAS model. Scheme B was applied every 6 h with a model provided by the National Meteorological Center (Stackpole, 1976). No balancing of the mass and velocity fields was performed in either analysis procedure.

Evaluation of the Analysis Techniques

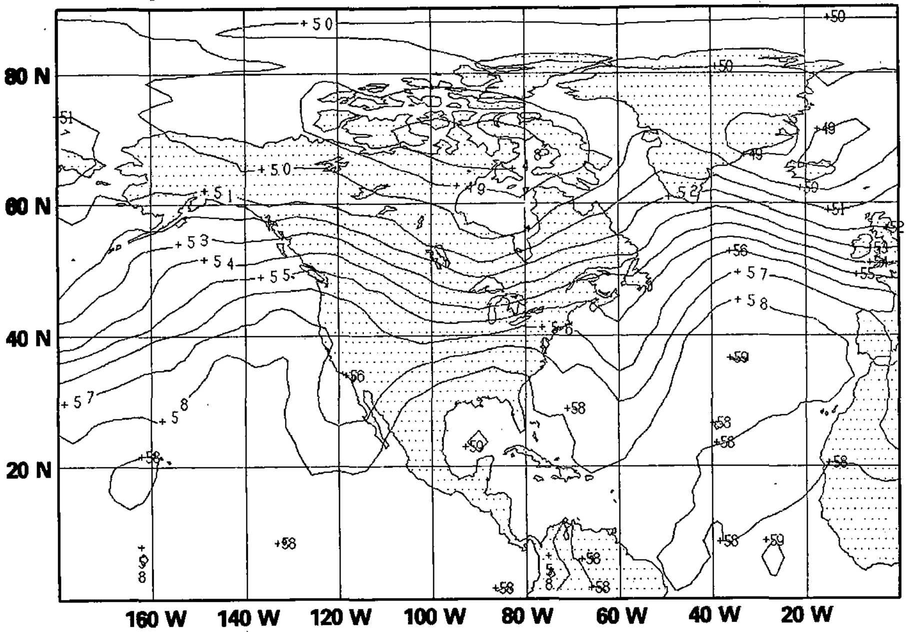
To illustrate the differences in the two analysis schemes, we present in Fig. 1a the 500 mb geopotential height field obtained using Scheme A for 0000 GMT 11 February 1976. The 500 mb geopotential height values for Scheme B are shown in Fig. 1b, and those obtained by the National Meteorological Center (NMC) using the Hough analysis (Flattery, 1971) are illustrated in Fig. 1c.

The differences in the two analysis schemes are reflected in the differences between Fig. 1a and 1b. A nine-point smoother was incorporated into Scheme B, whereas no smoothing was applied in Scheme A. This accounts for the differences in smoothness of the contours in the two plots. In general, Fig. 1b more closely resembles the NMC analysis (Fig. 1c) than does Fig. 1a, particularly in the high latitudes. This is due in large part to the larger scanning radii used in Scheme B in the successive correction procedure.

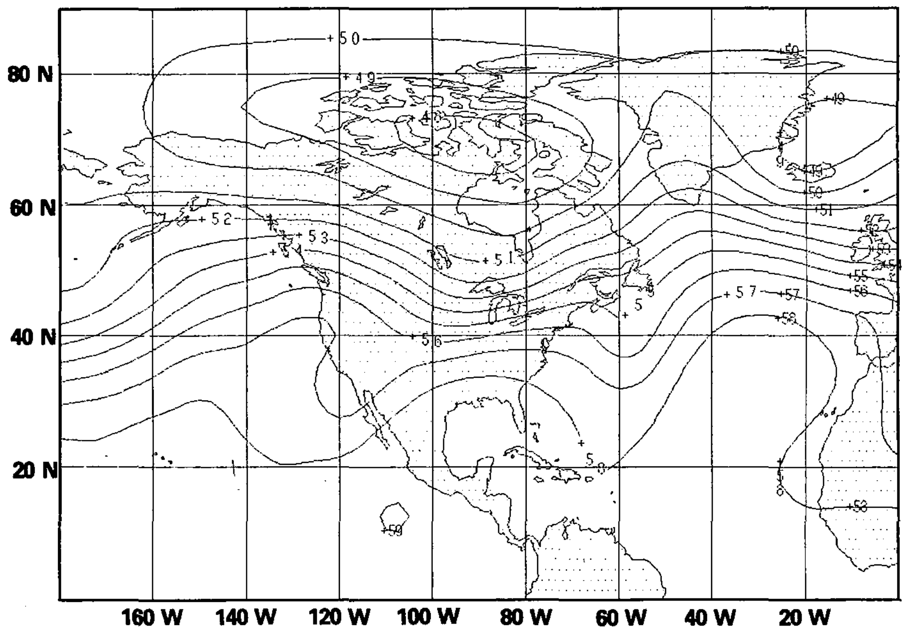
To illustrate the improvement in forecast skill, the 72 h sea level pressure RMS and S1 statistics over North America are shown in Table 1. The smaller values with Scheme B indicate an improvement in forecast skill.

The refinements in the analysis procedure (Scheme B) are responsible for this improvement and indicate the importance of the objective analysis techniques used in the assimilation of observational data.

(a) Scheme A for 0000 GMT 11 February 1976



(b) Scheme B for 0000 GMT 11 February 1976



(c) NMC Analysis for 0000 GMT 11 February 1976

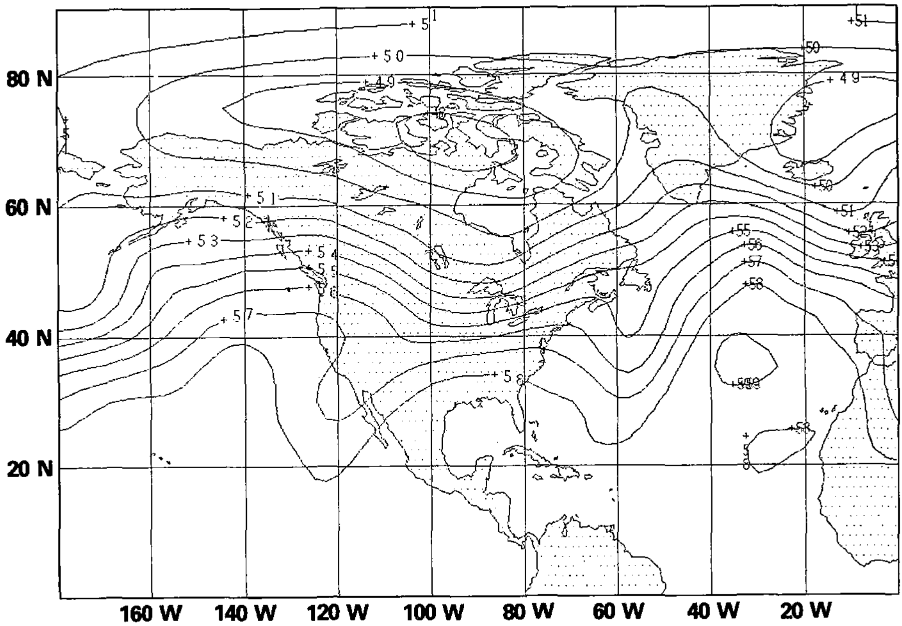


Fig. 1. 500 mb geopotential height in units of 10^2m.

Table 1. 72 h sea level pressure RMS and S1 statistics over North America for 0000 GMT 14 February 1976.

A		B	
RMS	S1	RMS	S1
8.4	75.7	5.6	67.2

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REFERENCES

Cressman, G. P., 1959: An operational objective analysis system. Mon. Wea. Rev., 85, 367-374.

Flattery, T. W., 1971: Spectral models for global analysis and forecasting. Air Weather Service Tech. Rep. 242, 42-54.

Halem, M., M. Ghil, R. Atlas, J. Susskind, and W. J. Quirk, 1978: The GISS sounding temperature impact test. NASA Tech. Memo. 78063, Goddard Space Flight Center, Greenbelt, Maryland, 421 pp.

Miyakoda, K., 1975: Weather forecasts and the effect of the subgrid scale processes. Seminars on Scientific Foundation of Medium Range Weather Forecasts, European Centre for Medium Range Weather Forecasts, Reading, England, 380-593.

Robert, A., 1976: Sensitivity experiments for the development of NWP models. Proc. Eleventh Stanstead Seminar, Publ. Meteor. No. 114, McGill University, 68-81.

Somerville, R. C. J., 1976: Sensitivity of large-scale numerical weather forecasts to deficiencies in models. Ann. Meteor. (NF), 11, 266-268.

__________, P. H. Stone, M. Halem, J. E. Hansen, J. S. Hogan, L. M. Druyan, G. Russell, A. A. Lacis, W. J. Quirk, and J. Tenenbaum, 1974: The GISS model of the global atmosphere. J. Atmos. Sci., 31, 84-117.

Stackpole, J. D., 1976: The National Meteorological Center nine-layer global forecast model. Preprints Conf. on Wea. Forecasting and Anal., Albany, NY, Amer. Meteor. Soc., 112-116.