

## Reply

JAN PAEGLE

*Department of Meteorology, The University of Utah, Salt Lake City, UT 84112*

20 October 1984

The iterative solutions of the nonlinear balance equation given by Paegle and Tomlinson (1975) use an underrelaxation parameter that accelerates the convergence in two forms of the equation, one of which was previously studied by Arnason (1958) and the other by Miyakoda (1956) and Shuman (1957). We performed linearized convergence analyses only upon Arnason's (1958) approach, but those analyses appeared to anticipate the behavior of the relaxation iteration when applied to all 13 cases that were solved by both methods.

Iversen and Nordeng (1982) and Bijlsma and Hoogendoorn (1983) have separately developed convergence proofs that explain most of the experimental results based on the Shuman (1957) and Miyakoda (1956) approach. As the authors state, both analyses contain simplifications that obviate completely general convergence conclusions, and I see no clear resolution of the difficulties beyond the analysis given on page 1350 of Iversen and Nordeng (1982).

In addition to extending the analysis, both of the more recent studies have pointed to other problems that did not arise in our case studies, probably

because of the particular way that the ellipticity criterion was imposed (see page 533 of Paegle and Tomlinson, 1975). Other impositions of this condition change optimum underrelaxation coefficients in ways that we did not investigate (as shown in Table 1 of Iversen and Nordeng, 1982), and these studies have significantly added to our understanding of the problem.

### REFERENCES

- Arnason, G., 1958: A convergent method for solving the balance equation. *J. Meteor.*, **15**, 220-225.
- Bijlsma, S. J., and R. J. Hoogendoorn, 1983: A convergence analysis of a numerical method for solving the balance equation. *Mon. Wea. Rev.*, **111**, 997-1001.
- Iversen, T., and T. E. Nordeng, 1982: A convergent method for solving the balance equation. *Mon. Wea. Rev.*, **110**, 1347-1353.
- Miyakoda, K., 1956: On a method of solving the balance equation. *J. Meteor. Soc. Japan*, **34**, 364-367.
- Paegle, J., and E. M. Tomlinson, 1975: Solution of the balance equation by Fourier transform and Gauss elimination. *Mon. Wea. Rev.*, **103**, 528-535.
- Shuman, F. G., 1957: Numerical methods in weather prediction. Part I: The balance equation. *Mon. Wea. Rev.*, **85**, 329-332.