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F.A.B.

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FINITE DIFFERENCE OPERATORS AND THEIR USE IN NUMERICAL FORECASTING

by D. Jenssen

Dr. Ditmar Jenssen of the Meteorology Department, University of Melbourne, opened his talk with a lengthy preamble setting the background for the work to be discussed. The role of finite difference approximations to various simple partial derivatives was examined very generally. Examples were selected from the fields of Numerical forecasting, integration, iterative solution of partial D.E.'s, estimation of a numerical value of complex differential functions, and finally two-dimensional interpolation.

The derivation of the difference analogues was then briefly outlined. Using a one-dimensional Taylor's series it was shown how standard operators were developed: the theory was then extended to two-dimensions, and the importance of cross terms such as $\partial^2/\partial x\partial y$ indicated. Analogues to ∇^2 and $\partial/\partial x$ were discussed in relative detail. The results of the testing of these operators on single components of a double Fourier field followed. Slides were shown giving the dependency of the analogue accuracy on the wavelength scale of the field upon which they act.

The formulation of a mathematical simulation of a 500 mb chart was then treated, and its features discussed. The results of applying the analogues to such 'ideal' meteorological data were shown and the best difference operators for this typical flow pattern determined.

A brief treatment of the use of the various finite difference approximations to the Laplacian to the iterative solution of Poisson's equation was then undertaken. It was shown that the accuracy of the solution was determined not primarily by the number of iterations (provided this is sufficiently large) but by the accuracy of the analogue employed. The speed of solution was also discussed, and by making a compromise between speed and accuracy the most efficient analogue for utilisation in this iterative scheme was chosen. The talk concluded with an outline of further planned work. This included the possible development of three- and four-dimensional operators, and a detailed examination of the iterative solution of equations other than Poisson's, particularly those involving the bi-harmonic operator.

During the question period, it was suggested by Mr. Wallington that a profitable further line of investigation would be the topic of 'compatibility': that is, would the analogues, when substituted into a differential equation, change the nature of that equation to such an extent that the results obtained were virtually useless?

Dr. Radok suggested that it may be more expedient to specify meteorological fields by two-dimensional Fourier analysis, rather than by a direct mathematical simulation such as the one discussed in the talk.

The usefulness of high-accuracy analogues in numerical forecasting, when the initial data could have a relatively high error, was discussed by Mr. Budd, other participants and the speaker. It was decided that the better the difference operator, the less likely it would be that the initial errors would amplify, and therefore the better the forecast would be.

Dr. Berson referred to the slide giving analogue accuracy as a function of wavelength, and pointed out that the wavelength of, say, the 500 mb field would not be the same in both the x and y directions. Dr. Jenssen agreed this would be so, but stated that the results obtained showed that the shorter wavelength was the dominant one in fixing the accuracy of the analogue, and it was therefore legitimate to speak of analogue accuracy as a function of a single wavelength.