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Utilization of Satellite Data in Mesoscale Models of Severe Weather

Final Report for NASA Grant NSG 5205 for the period 4/1/82 through 3/31/83

by

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1. Introduction

Research supported by this grant has focussed on a number of areas related to numerical prediction and understanding of severe weather with special emphasis on intense mesoscale precipitation events. Specific areas of study are summarized as follows:

a) Investigation of the impact of the diagnostic initialization of divergence on short-range precipitation forecasts produced by a model.
b) Numerical study of the "President's Day" storm of 18-19 February 1979.
c) Collaborative modeling and diagnostic studies with NASA/GLAS scientists (Uccellini and Brill) dealing with May 1973, low-level jet case.
d) Numerical investigation of the impact of SEASAT surface wind data used in the static initialization of the North Atlantic Storm of 9-10 September 1978 (The Queen Elizabeth II Storm).

The following sections of this report will summarize the results investigations in each of these areas and will list the publications that have appeared in the literature and that are in preparation.

2. Diagnostic initialization of the divergent wind component.

One of the limitations in our current ability to produce accurate short-range quantitative precipitation forecasts using mesoscle and synoptic-scale models relates to our inability to specify correctly the initial divergent component of the wind velocity. A technique that diagnoses this divergent wind component has been developed at Penn State and has undergone testing using two case studies. The most recent work was performed by producing quantitative precipitation predictions during the SEASAME III period-specifically 25-26 April 1979. Various techniques were used to specify the initial divergent windfield for the Penn State Mesoscale Model and the resulting impact on the 6-hr precipitiation prediction was assessed. The procedure that diagnosed the divergent wind from an omega equation that contained a diabatic heating term proved to be superior to the more conventional procedures. It was found that an essential element of this new initialization procedure was the use of the diabatic term

in the omega equation. This term was specified in this research by assuming a vertical profile of the latent heating rates, given gage data of hourly rain rates. In an operational setting, this rain-rate data could be obtained from real-time satellite observations. A summary of this study is attached as Appendix A in the form of a manuscript which appeared in Preprints of the Sixth Conference on Numerical Weather Prediction, Omaha, Nebr. June 6-9, 1983. An M.S. thesis and a manuscript to be submitted for publication in an AMS journal are in preparation.

3. Numerical study of the President's Day Storm of 18-19 February 1979.

The case of intense east-coast cyclogenesis that occurred on 18-19 February 1979 has been studied using the Penn State mesoscale model. Model performance studies have been completed and sensitivity studies designed to isolate the importance of various meteorological processes to the storm development are underway. A summary of some of the model performance results can be found in Appendix B to this report which has also been excerpted from the Preprints of the 6th Conference on NWP. As an additional illustration of the sensitivity of the precipitation prediction to model configuration, Figure 1 compares the 3 h precipitation amounts for the period 0900-1200 GMT 19 February for two versions of the model. One employed a bulk parameterization of the planetary boundary layer with physics and numerics equivalent to the LFM, while the other had considerably higher vertical resolution in the planetary boundary layer (PBL) with a high resolution parameterization of PBL fluxes. The precipitation rates during this period were predicted much better by the version with the high-reslution PBL. Predicted precipitation amounts in eastern Virginia near the coast were three times greater (~ 1 inch of snow per hour) with the high-resolution PBL.

4. Diagnostic study of the 10 May 1973 low-level jet case.

This case has been simulated using the Penn State Mesoscale Model and is being analyzed using the AOIPS system at GSFC, under the direction of Dr. Louis Uccellini and Mr. Keith Brill. A manuscript dealing with the analysis and interpretation of this case is being prepared for publication in an AMS Journal.

5. Numerical investigation of the impact of SEASAT surface wind data used in a static initialization.

The impact on numerical forecast accuracy of using high horizontal-resolution low-level winds, such as those measured by SEASAT, in a static initialization of a three-dimensional numerical model was investigated. The Queen Elizabeth II (QEII) storm of 9-10 September, 1978 was selected for study because actual SEASAT data are available for the early stages of storm development. The Penn State mesoscale model was used in both data-simulation and real-data experiments. In the data-simulation studies, a complete set of conventional and unconventional observations was used to initialize a 24-h control simulation. Model output fields at 12 h were retained to represent a dynamically balanced set of initial conditions. The boundary-layer windfield from this set of initial conditions was then modified using three different methods. Twelve-hour simulations were initiated using these modified initial conditions and the predictions were compared with the control simulation in order to determine the impact of the horizontal and vertical structure of the initial, low-level wind field. For the real-data experiments, the hemispheric analysis from the National Meteorological Center (NMC) was used as the first-guess field for the initial-data analysis. Two different procedurs for initializing the low-level model wind field without SEASAT data were used in two 24-h control forecsts. SEASAT wind observations were then inserted, where available, into these basic analyses and two additional 24-h forecasts were performed. Each of these forecast was then compared with its analog that was based only on the hemispheric

wind analysis. The mass field was identical for both cases and was defined based on the NMC hemispheric analysis.

The first data simulation experiment showed that even a large modification to the low-level wind field had only a slight effect on the evolution of the simulated storm. A rapid simultaneous adjustment of the low-level wind and mass fields seemed to occur as the model restored a significant amount of correct structural detail to the low-level wind field that was highly smoothed initially. The boundary-layer wind field modifications produced little difference in storm track and only a slight difference in central pressure and surface wind pattern. Although verfication data are not plentiful. the SEASAT data used in the real-data experiments seemed to have a slight positive impact on forecast accuracy when used directly in a static initialization.

A more detailed summary of this effort is attached as Appendix C, and represents a paper published in the Preprints of the 6th NWP Conference.

Note that this research effort was also partly supported by the Office of Naval Research.

6. Publications

The following publications resulted from research supported entirely or in part by NASA Grant NSG 5205, during the period 4/1/82 through 3/31/83. All are being submitted to a peer-reviewed AMS journal for publication.

Aune, R.M. and T.T. Warner, 1983: Impact of SEASAT wind data on a statically initialized numerical model. Preprints - Sixth Conference on Numerical Weather Prediction, Omaha, NE, June 6-9, 1983.

Nappi, A.J. and T.T. Warner, 1983: A numerical investigation of the President's Day storm of February 18-19, 1979. Preprints - Sixth Conference on Numerical Weather Prediction, Omaha, NE, June 6-9. 1983.

Salmon, E.M. and T.T. Warner, 1983: The impact of the diagnostic initialization of divergence on short-term precipitation forecasts produced by a mesoscale model. Preprints - Sixth Conference on Numerical Weather Prediction, Omaha, NE, June 6-9, 1983.

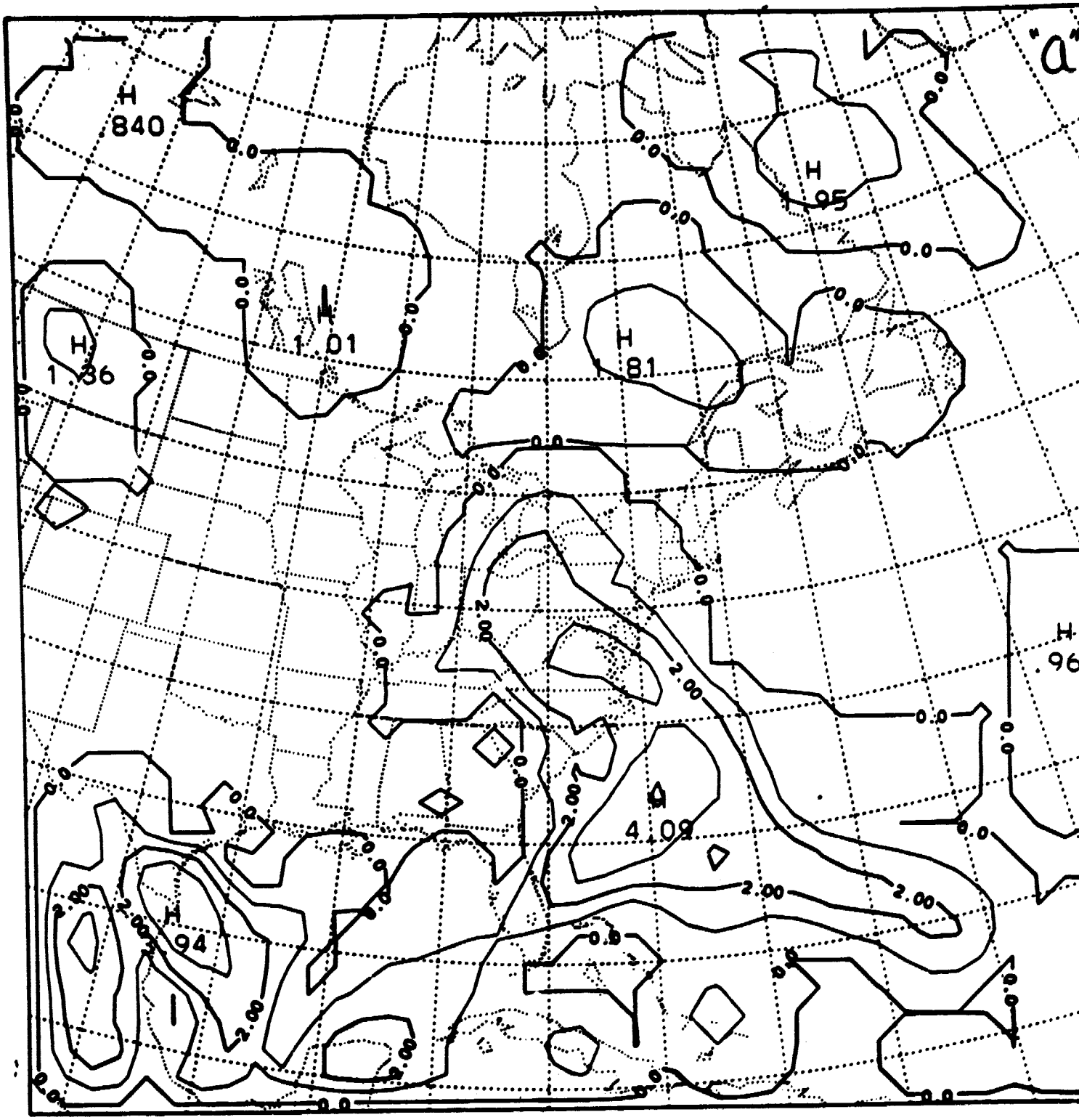
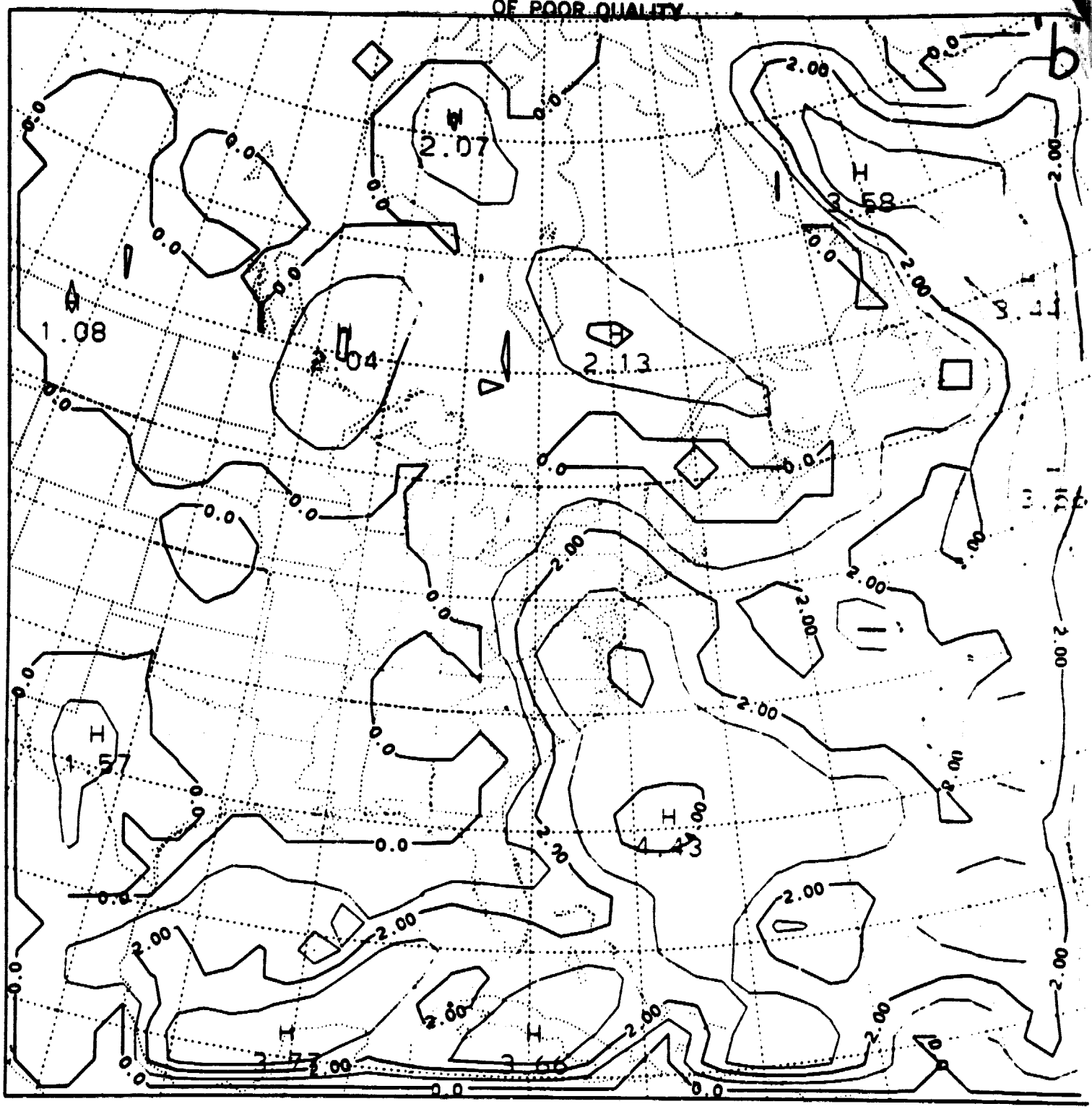


Figure 1. Predicted precipitation amounts for the period 0900-1200 GMT 19 February 1983. The contour labels represent the following precipitation amounts: 1 - .02cm, 2 - .07cm, 3 - .19cm, 4 - .54cm. A bulk parameterization of PBL was used to produce simulation "a" and a high resolution PBL parameterization produced simulation "b".



CONTOUR FROM 0.00000 TO 4.0000 CONTOUR INTERVAL OF 1.0000 PT(3,3)= 0.23235