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OFFICE NOTE 213

A Cautionary Note on the Use of NMC Vertical Velocity Forecasts

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This is an unreviewed manuscript, primarily intended for informal exchange of information among NMC staff members.

Daily analyses and forecasts from the operational forecast model of the National Meteorological Center (NMC) have found increasing use as diagnostic material for research studies. A very recent example is the paper by Blackmon and Lau (1980). Since forecasts and verifying charts can be seen on the national and international facsimile circuits every day most users of this material have a good familiarity with many of its strengths and weaknesses, but not all of them. In this note I will point out a problem that arises in using the shorter range forecast material available up to now and the remedy that will solve it. Research workers using the files of NMC forecasts need to be aware of the problem.

Initial data for the currently operational 7-level hemispheric model are generated from observations by an analysis that produces non-divergent fields of wind. The irrotational part of the wind field produced by the preceding 12-hr forecast is added to the analyzed wind field to form the total initial wind field for the start of the forecast. However, this total wind field is not in complete balance with the newly analyzed mass field. The forecast model itself eventually produces a suitable balance through gradual adjustment as the forecast progresses.

The effect of this initial imbalance on the resulting forecasts from the model seems to be unimportant and indeed unobservable for most purposes. However, in the early stages of the forecast it can create severe problems in the use of the vertical velocities and other dynamic quantities depending on them.

Figure 1 shows an example. This displays the divergent circulation in the plane of the cross sections. The vertical component of each vector is a scaled measure of dp/dt and the horizontal component is the component of the irrotational wind along the pressure surfaces and in the cross section. The speed of each vector can be read as a standard meteorological symbol, i.e., a full barb for ten and a flag for fifty. The scaling for the horizontal component is in tenths of meters per second. Multiply the vertical component by 2.7 to express dp/dt in millibars per day. The cross sections extend along the 100°E meridian, with south at the left. The upper cross section is six hours into the forecast and the lower is for the twelve hour forecast.

The two cross sections have a few similarities, but not many. They look as if they represent altogether different days. Figure 2 shows an example of a derived quantity, the kinetic energy production from the equation $k = -\underset{\sim}{V} \cdot \nabla \phi$, for the same times as the two cross sections. Here again, the differences in a six-hour period are large and unreasonable.

Further studies, not shown here, on this and other forecasts from other periods indicate that this initially rapid variation of the divergent circulation damps rapidly as the forecast progresses, with little observable trace by 24 hours. It seems to have some properties of an oscillation with a period of 10-12 hours. This may explain why this problem has gone unnoticed for a long time, since usually vertical motions are displayed at 12-hour intervals.

The problem of the vertical velocity fluctuations is neatly solved by a change in procedures now under testing for proposed operational implementation at NMC. These consist of an initialization using the nonlinear normal mode initialization of Machenhauer (1977) for a forecast by a global spectral model with a resolution of 30 waves and 12 layers. The cross sections and maps of Figures 3 and 4 were obtained from a forecast prepared in this manner. The problem displayed in Figures 1 and 2 has gone away. The new initialization, by elimination of the gravity modes has produced an initial divergent flow showing good temporal continuity. A forecast made with the spectral model and a nondivergent initialization developed the same vertical velocity problem as the operational forecast, giving further evidence that the operational initialization is at fault.

The fluctuations of the divergent circulations in the operational model ought to have serious consequences in precipitation forecasting for at least the first 12-hour period of the forecast. So far, no one has noticed any, possibly because the problem may be serious only in isolated cases. A detailed comparison of the two initialization and forecast systems used in this presentation will be completed, and may cast light on the precipitation question.

Acknowledgements

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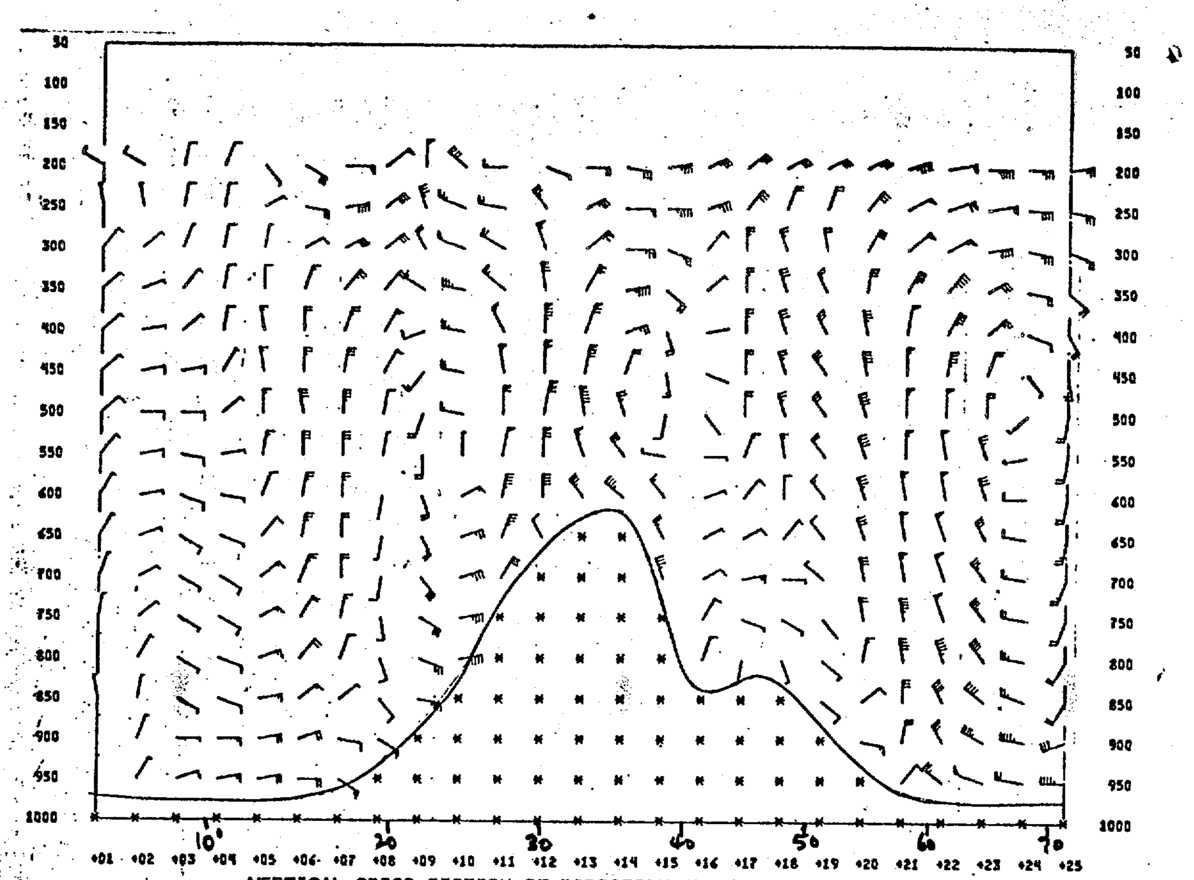
References

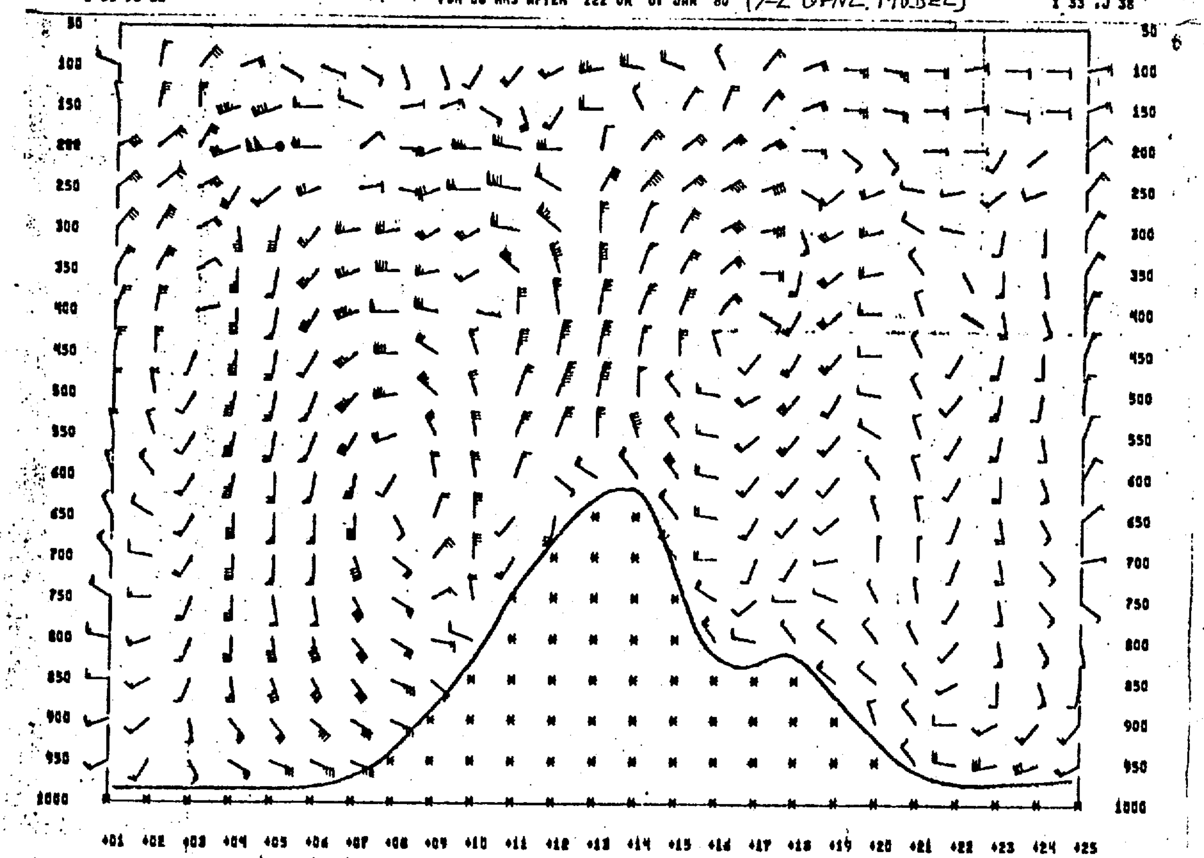
Blackmon, M. L. and Lau, N.C., 1980: Regional characteristics of the northern hemisphere wintertime circulation: A comparison of the simulation of a GFDL general circulation model with observations. J. Atmos. Sci., 37, 497-514.

Machenhauer, B., 1977: On the dynamics of gravity oscillations in a shallow water model with applications to non-linear normal mode initiallization. Beitr. Phys. Atmos., 50, 253-271.



VERTICAL CROSS-SECTION OF DIRECTION AND SPEED OF FLOW

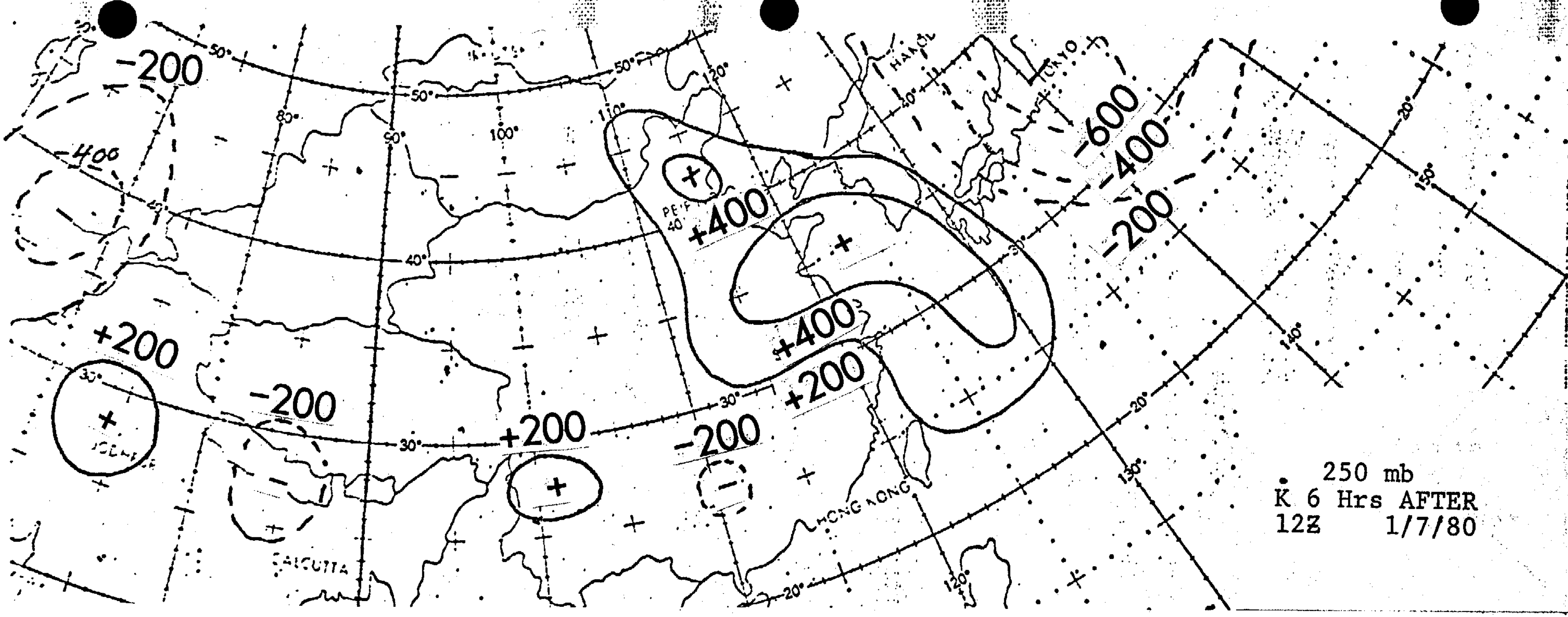
I 33 ,J 62 FOR 06 HRS AFTER 12Z ON 07 JAN 80 (7-L OPNL MODEL) I 33 ,J 38



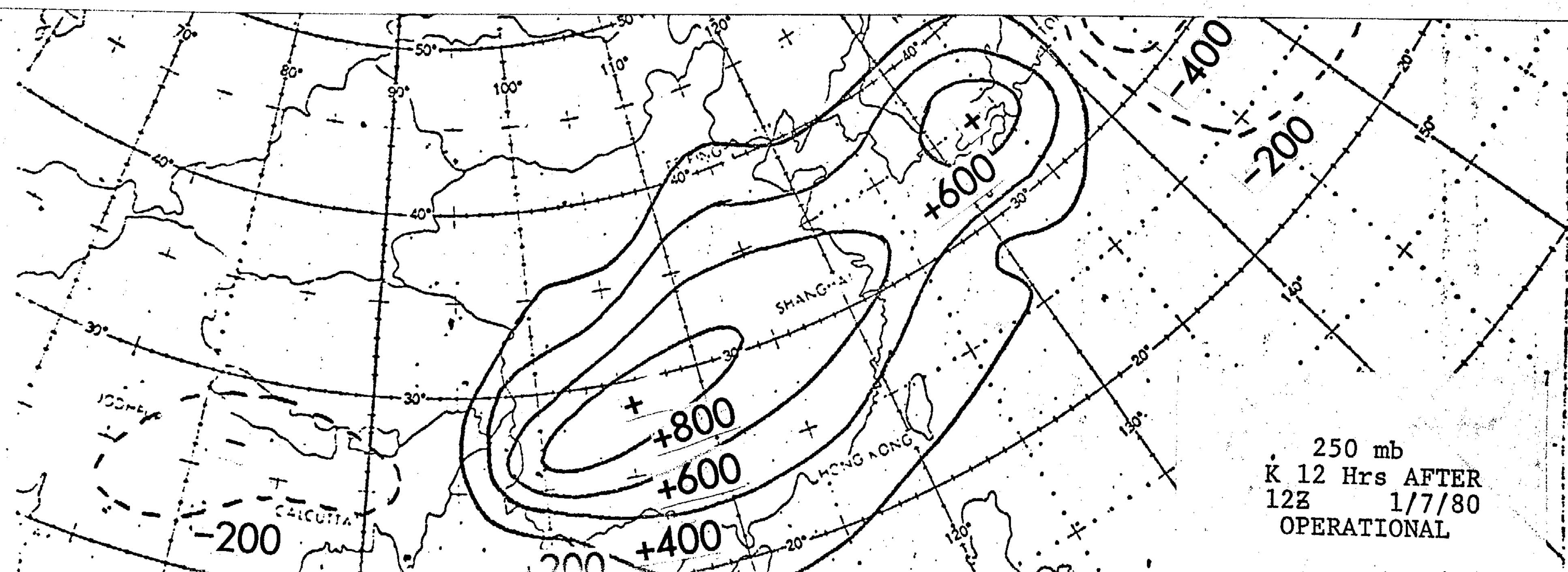
VERTICAL CROSS-SECTION OF DIRECTION AND SPEED OF FLOW

I 33 ,J 62 FOR 12 HRS AFTER 12Z ON 07 JAN 80 (7-L OPNL) I 33 ,J 38

FIGURE 1



250 mb
K 6 Hrs AFTER
12Z 1/7/80



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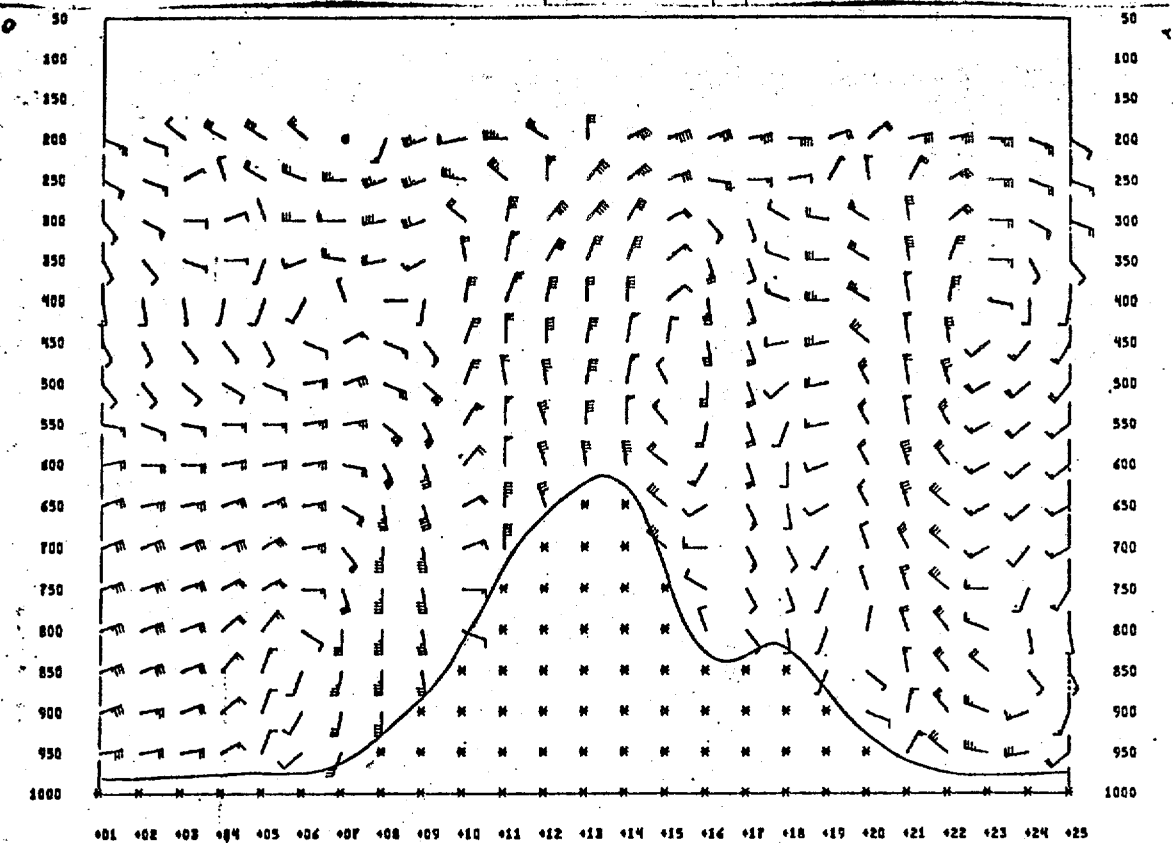
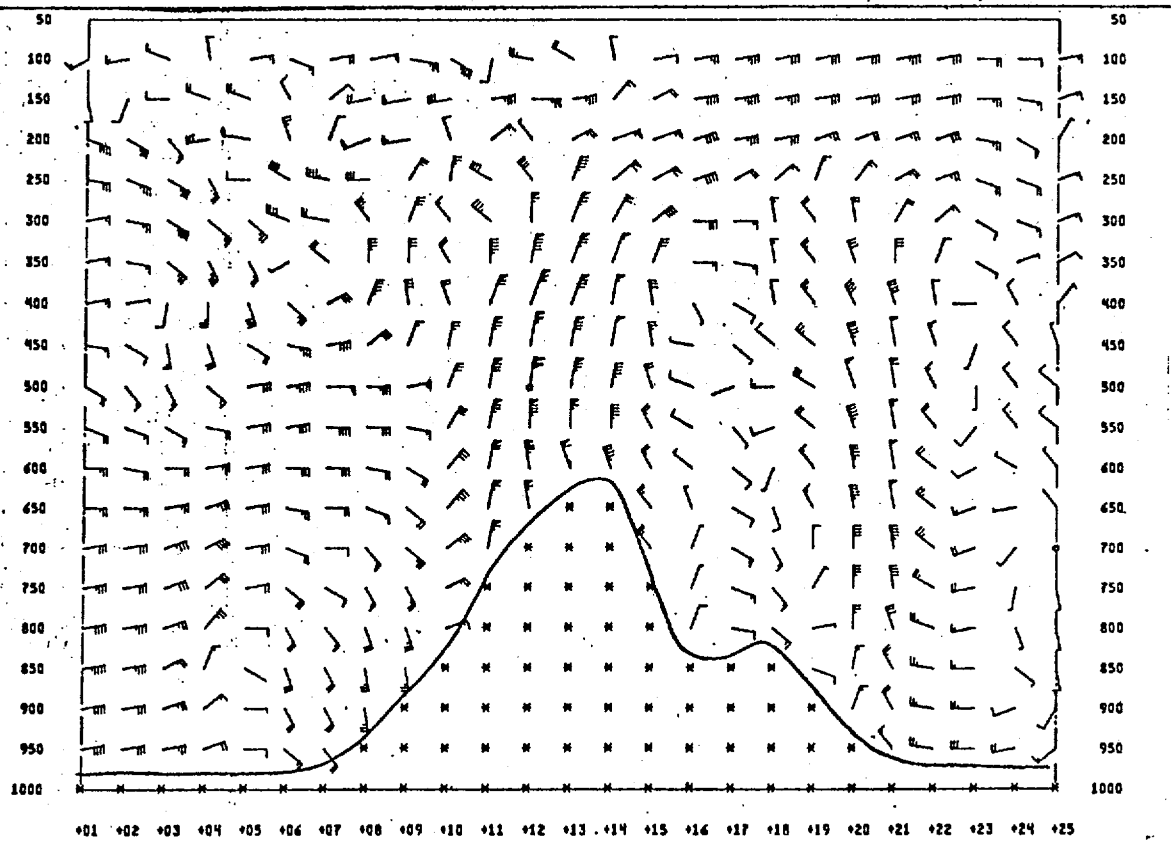
K 12 Hrs AFTER
12Z 1/7/80
OPERATIONAL

FIGURE 2



VERTICAL CROSS-SECTION OF DIRECTION AND SPEED OF FLOW

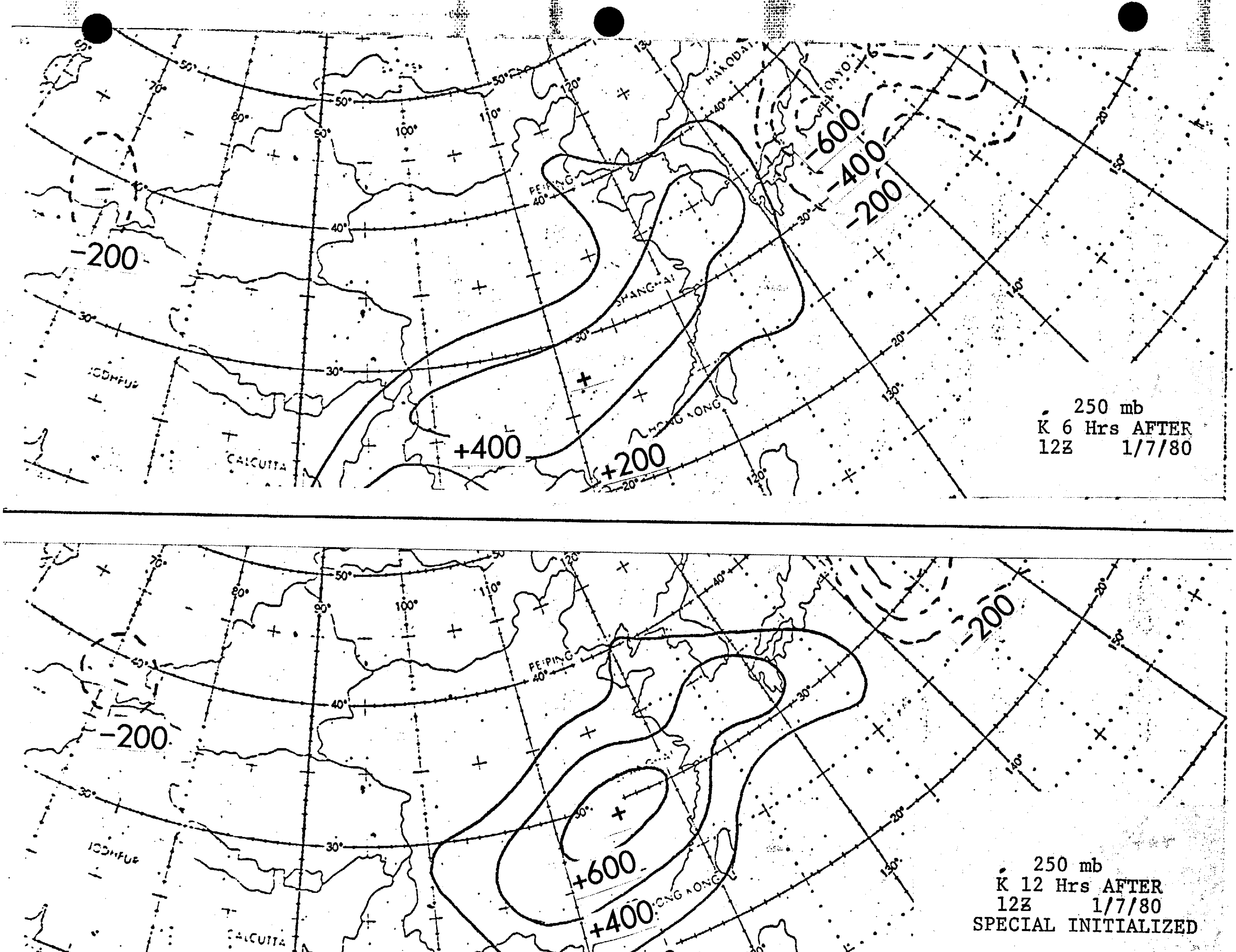
I 33 J 62 SPECTRAL MODEL FOR 06 HRS AFTER 12Z ON 07 JAN 80 NORMAL MODE INITIALIZATION I 33 J 38



VERTICAL CROSS-SECTION OF DIRECTION AND SPEED OF FLOW

I 33 J 62 SPECTRAL MODEL FOR 12 HRS AFTER 12Z ON 07 JAN 80 NORMAL MODE INITIALIZATION I 33 J 38

FIGURE 3



-200
-600
-400
-200
+400
+200
PEIPING
SHANGHAI
HONG KONG
CALCUTTA
250 mb
K 6 Hrs AFTER
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-200
-200
+600
+400
200
PEIPING
CALCUTTA
250 mb
K 12 Hrs AFTER
12Z 1/7/80
SPECIAL INITIALIZED

FIGURE 4