TECHNICAL MEMORANDUM

36

Maximum vorticity and maximum tendency charts: Two tools to identify areas of cyclonic activity in a medium range forecast

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Maximum Vorticity and Maximum Tendency Charts: Two Tools to Identify Areas of Cyclonic Activity in a Medium Range Forecast

1. INTRODUCTION

The vast number of forecast fields produced daily by the ECMWF operational forecasting system makes it desirable to make available tools to enable the bench forecaster to identify quickly areas of cyclonic activity in the medium range. Such charts should contain compressed information on the intensity, the phase speed and the tendency of filling or deepening of systems as well as their time of occurrence. This would provide the forecaster with a quick-look of the anticipated evolution and draw his attention to areas of interest. The present study suggests the use of two fields as indicators of cyclonic activity, namely:

a. the maximum value of relative geostrophic vorticity at the 1000mb level predicted at each gridpoint over a period of time, and

b. the maximum value of pressure fall at the surface predicted for the same time interval.

The combination of these parameters has several advantages over the use of only one of them, since local effects (typically caused by interpolation over high ground) in the vorticity field can be checked using the tendency chart, and the vorticity field helps to identify stationary systems as well as to distinguish between rapidly moving and locally deepening lows.

2. METHODS USED TO PRODUCE THE DESCRIBED FIELDS

2.1 Maximum Vorticity Charts

For all 12-hour post processing time steps in the forecast period (e.g. 3 or 5 days centred around 12z on day 5) the relative geostrophic vorticity

$$\xi = \frac{1}{f} \nabla^2 \Phi$$

where f is the Coriolis parameter and Φ the geopotential

at 1000 mb for the European and Atlantic area (see Figs. 1-5) is approximated by a simple 5-gridpoint algorithm for the ∇^2 operator,

$$\text{where } \xi_g \; (I,J) = \frac{1}{f} \; \frac{\phi(I+1,J) + \phi(I-1,J) + \phi(I,J+1) + \phi(I,J-1) - 4\phi(I,J)}{(dx)^2}$$

represents an approximation of the relative geostrophic vorticity at the gridpoint (I,J) with dx being the grid distance in metres.

At a timestep, the vorticity actually calculated is compared to the previously predicted value and the higher value is retained. This value is then compared to the actual value for the following timestep and so on to the end of the chosen period. After a loop over all timesteps in the period has been performed, a field of the maximum vorticity predicted for this period is obtained. The example shown in Fig. 2 for the 5-day period from 12z on 30 July to 12z on 3 August 1981 (forecast from 27 July 1981) represents the maximum vorticity in units of $10^{-6}\ s^{-1}$, omitting values of less than 30 and more than 90 (for better reading).

2.2 Maximum Tendency Charts

Similar to the Maximum Vorticity field, 1000mb fields in 12 hour intervals are used to construct tendencies over this period. No conversion to Mean Sea Level pressure is undertaken since absolute values are of less interest than the qualitative information. The maximum falling tendency at each gridpoint is then retained over the chosen forecast period and plotted as contours of dekameters/ 12 hours for values of more than 3 dam/12 hours (see Fig. 3).

2.3 Record of time of occurrence of maximum values

For both fields, a record is kept of the number of the 12 hour timesteps at which a relative maximum of the parameter within a 5 x 5 grid-box was predicted. This number of the time-step (ranging from 1 to 9 for a 5-day chart, for example) is then plotted onto the contour field to help identify tracks of particular features and their time of occurrence.

3. SCOPE AND LIMITATIONS OF THE METHOD

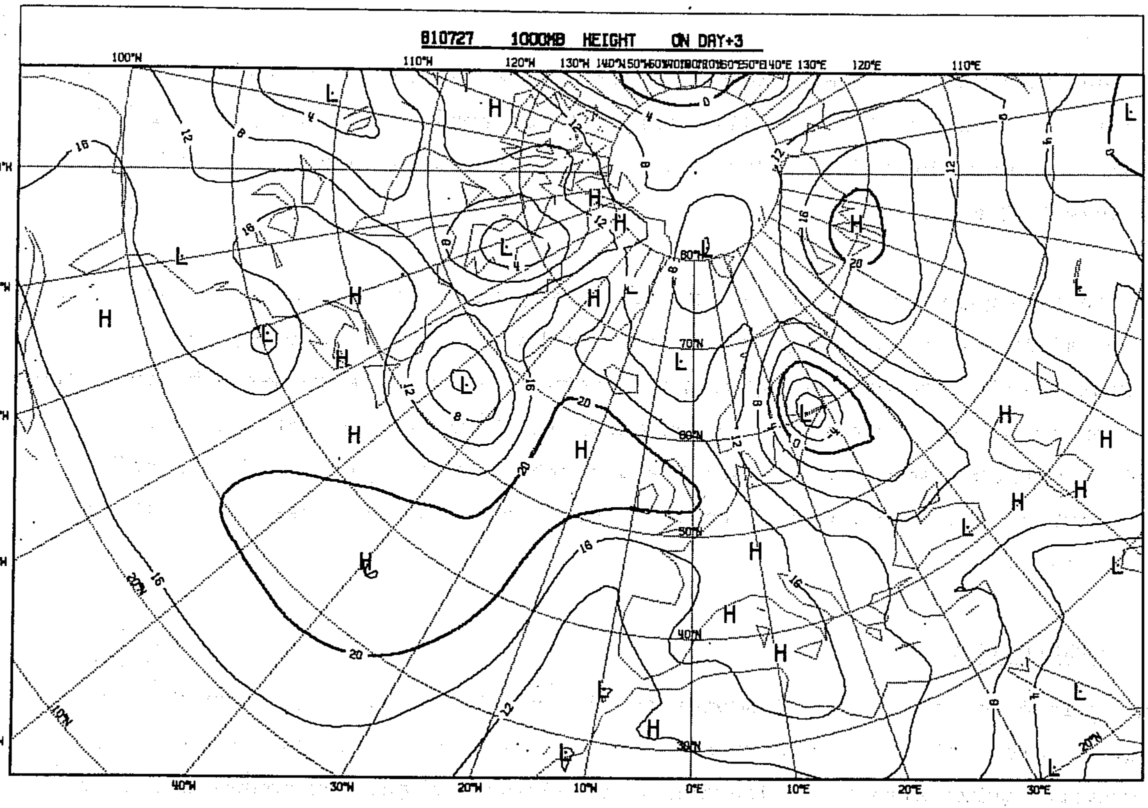
The combination of these two fields gives a fair indication of the intensity and track of vortices predicted by the model. Fig. 1 depicts the forecast evolution of the 1000mb height field from 12z on day 3 to 12z on day 7 of the forecast from 12z on 27 July 1981. The Maximum Vorticity field (Fig. 2) indicates cyclonic activity mainly over the north-east of the North American continent, the Greenland area, Scandinavia and the Bay of Biscay. Minor centres are also shown over the Alps and in the lower righthand corner of the map.

A comparison with the Maximum Tendency chart (Fig. 3) supports the evidence of activity over the Great Lakes and Hudson Bay area, the Scandinavian and eastern Baltic region as well as the western and central European areas (Alps, Biscay). The absence of contour lines in the tendency chart over the lower righthand parts of the map as well as the rather random times of occurrence in the vorticity map (Fig. 2) indicate that the vorticity features shown in this area, and to some extent also over Greenland, are caused by interpolation effects in areas of steep gradients of the model's topography. This interpretation is further supported by the fact that these features have appeared in practically all cases tested so far.

The general impression of more noise distorting the vorticity field in comparison to the fairly smooth tendency chart can also be explained partly by the stationary influence of the topographic features that are eliminated by the time-differences used to obtain the tendencies. It should be noted too that the simple algorithm used to calculate the geostrophic vorticity, being a second derivative of the height field, tends to highlight any roughness in the 1000mb height field.

4. CONCLUSIONS

The combined use of Maximum Tendency and Maximum Vorticity charts can be used to highlight areas of cyclonic activity during a time period in medium range forecasts, giving also an indication of the intensity and horizontal scale of systems. The indicated times of occurrence are useful to detect cyclone-tracks and thus they help to define the confidence level in a predicted activity zone. Higher numbers indicate that the predicted feature falls later in the forecast where the location and intensity of cyclones can be affected by phase- and amplitude-errors of the forecast.



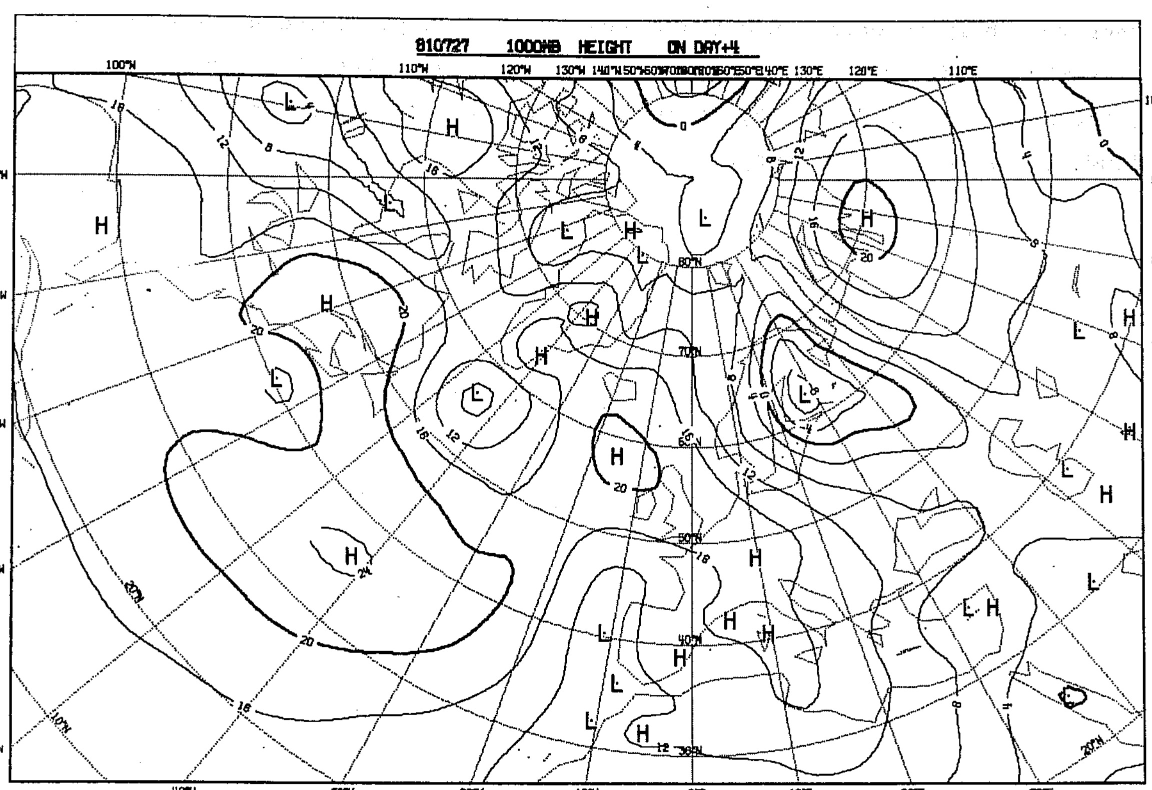
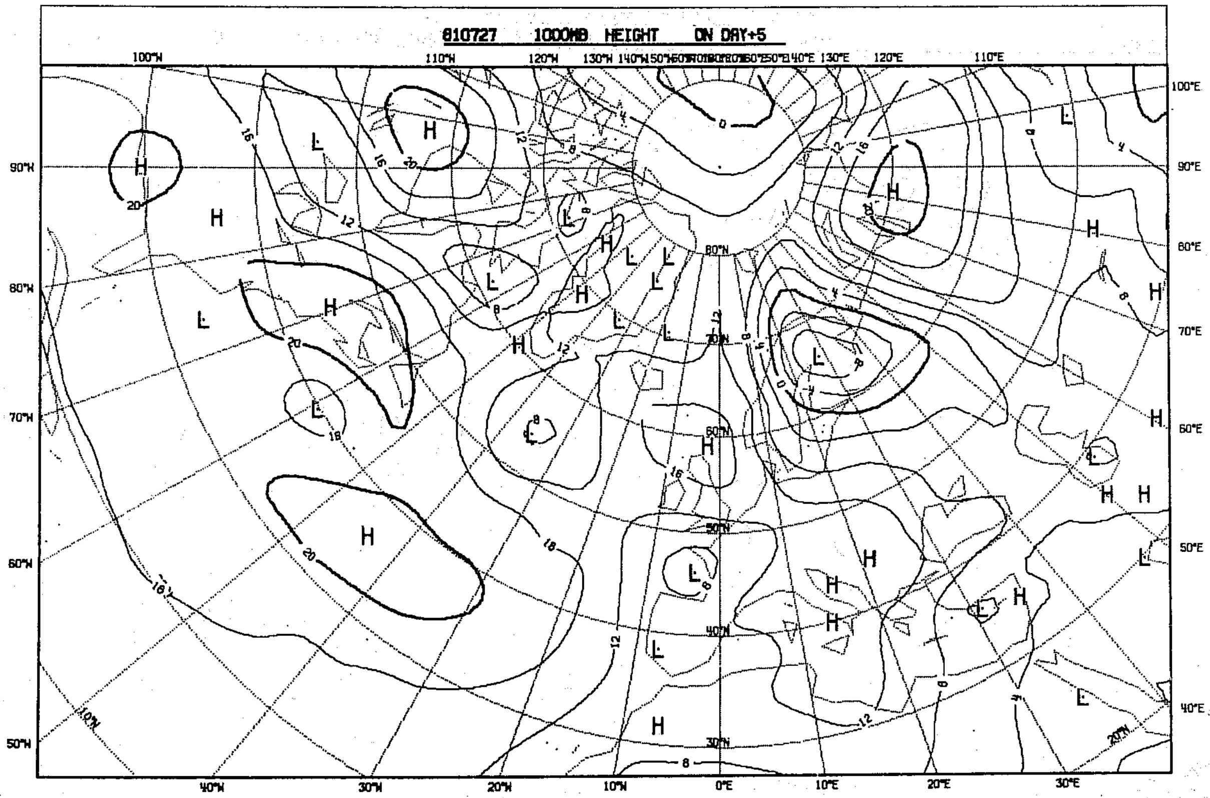


Fig. 1 1000mb height forecast from 12z 27 July 1981

top: D + 3 bottom: D + 4



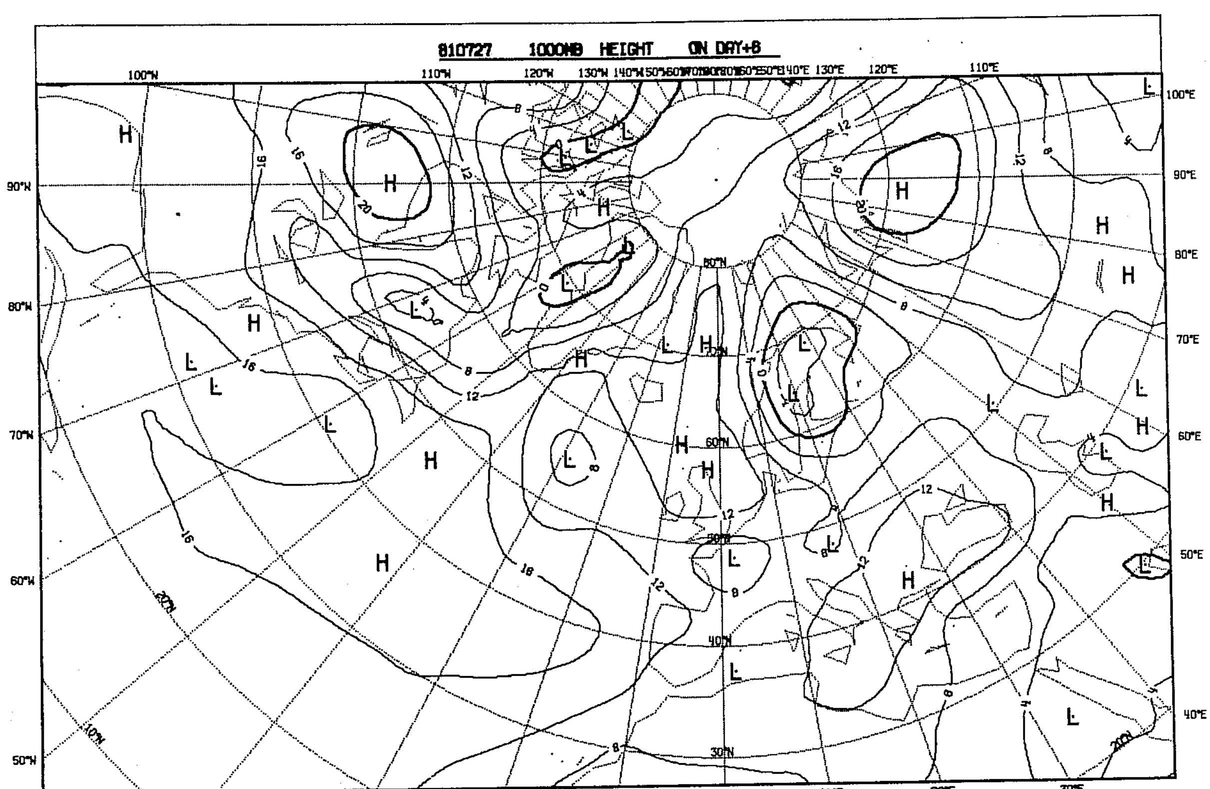


Fig. 1 (continued)

top: D + 5 bottom: D + 6

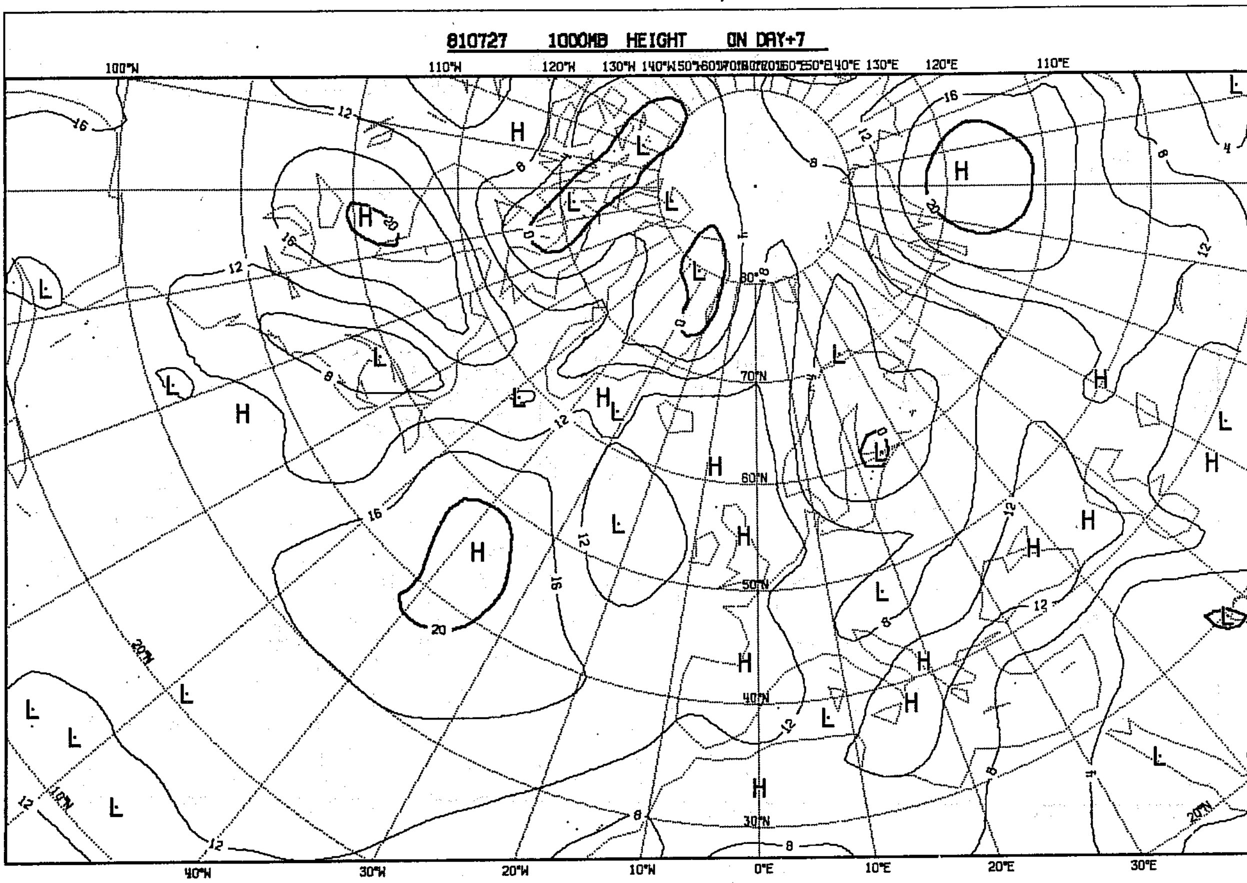


Fig. 1 (continued)

D + 7

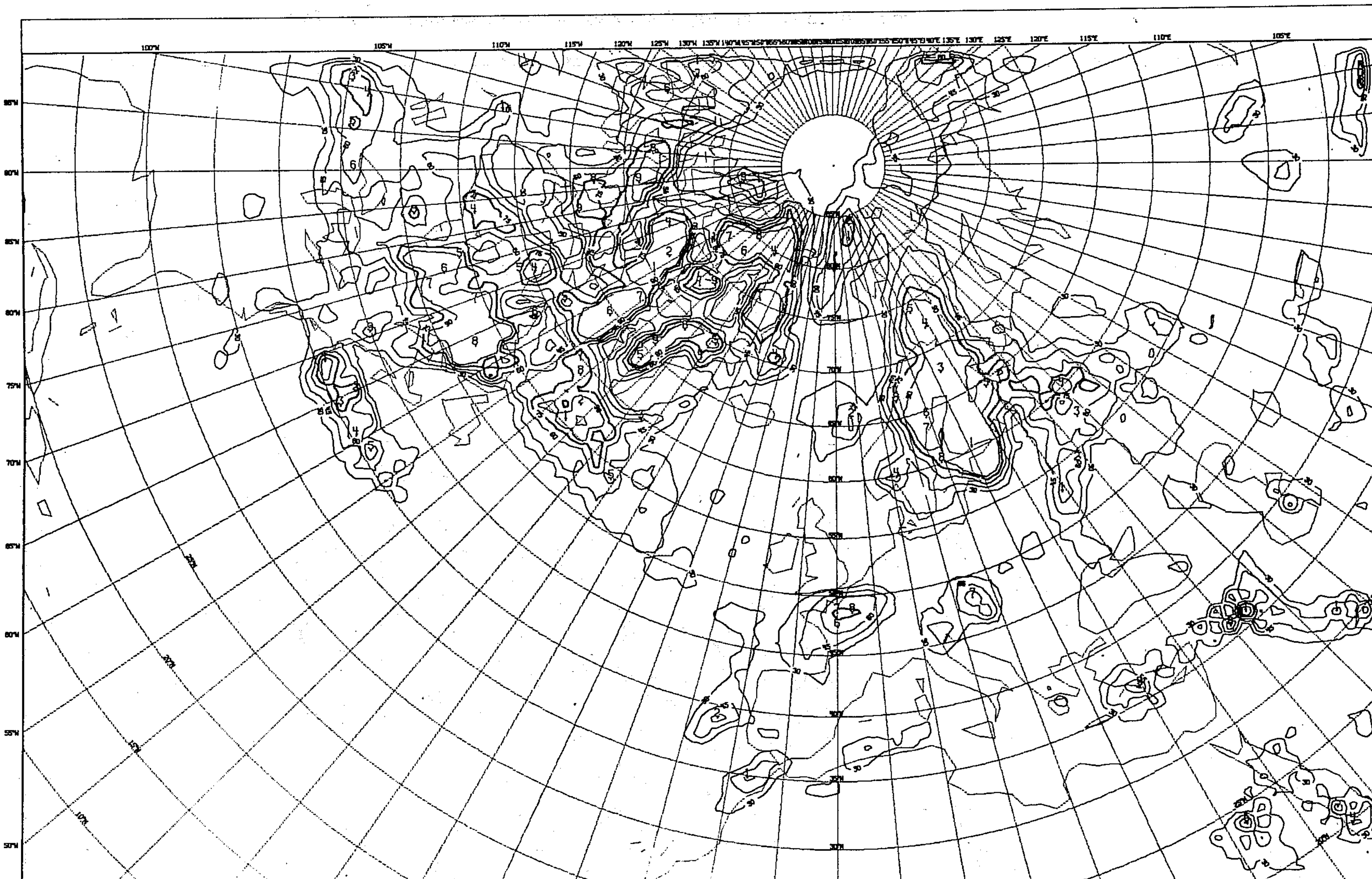


Fig. 2 1000mb Maximum Geostr. Vorticity for the period from day 3 to day 7 of the forecast from 12z 27 July 1981

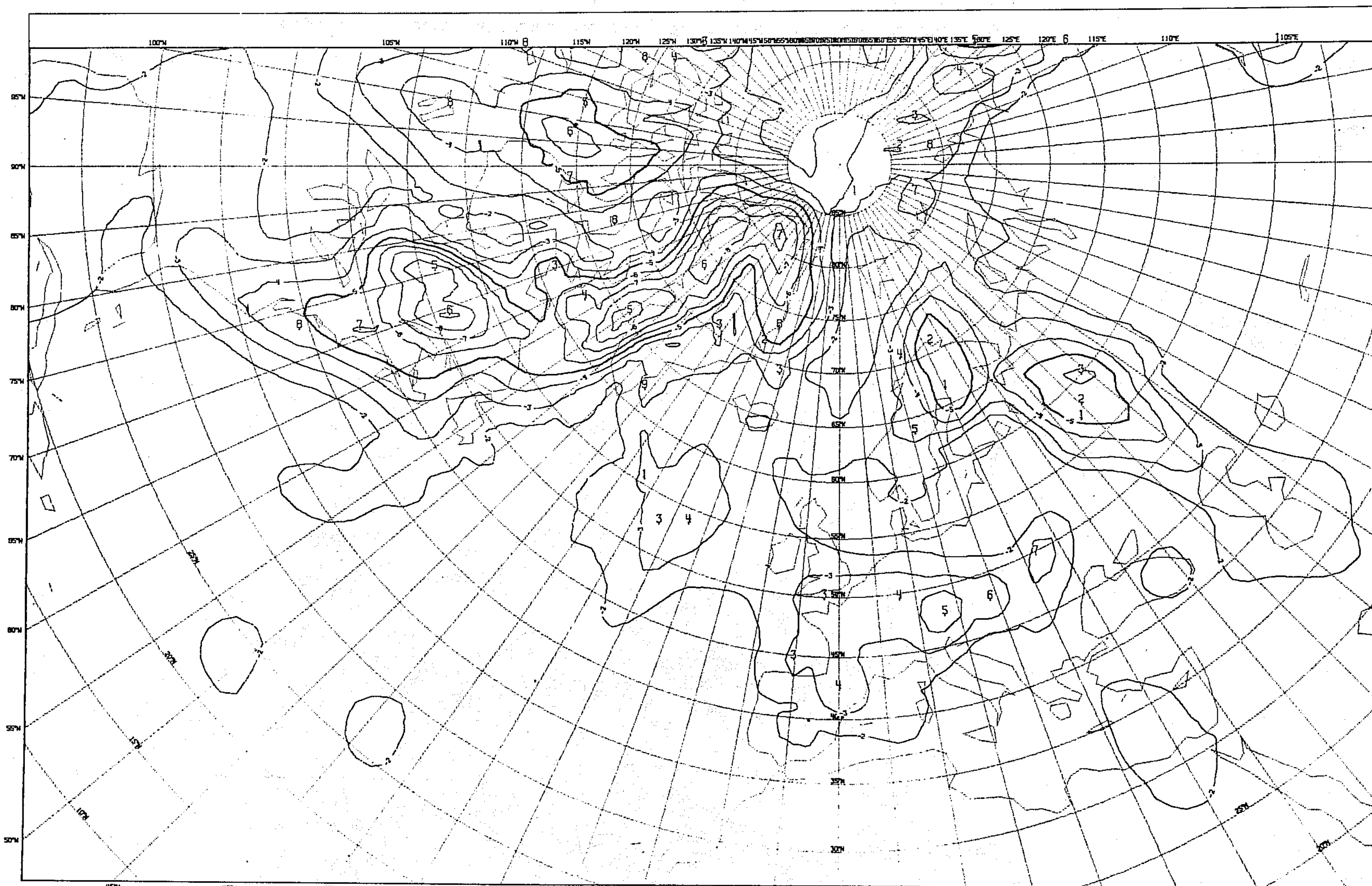


Fig. 3 1000mb Maximum Tendency for the period from day 3 to day 7 of the forecast from 12z 27 July 1981