Synoptic Meteorology

[MAPH P312]

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Second Semester, 2004–2005

Seminar Room

Dept. of Maths. Physics, UCD, Belfield.

Part 9

Extratropical Weather Systems

These lectures follow closely the text of
Wallace & Hobbs **(Chapter 9).**

Introduction

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We are concerned here with large scale extratropical weather systems — baroclinic waves and the associated extratropical cyclones — and with their embedded meso-scale fronts.

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We will show how atmospheric data are analyzed to reveal the *structure* and *evolution* of weather systems.

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This particular storm system was unusually strong, but it typifies many of the features of the life cycle of baroclinic waves and the associated extratropical cyclones.

Although the storm occurred over the continental USA, it has all the important features of storms which occur in our neighbourhood: it is quite representative of storms which we see in Ireland.

Overview

We will examine and document the large scale structure of the November 10, 1998 storm, with emphasis on the

- **500-hPa height**
- **Sea-level pressure**
- **1000–500-hPa thickness**
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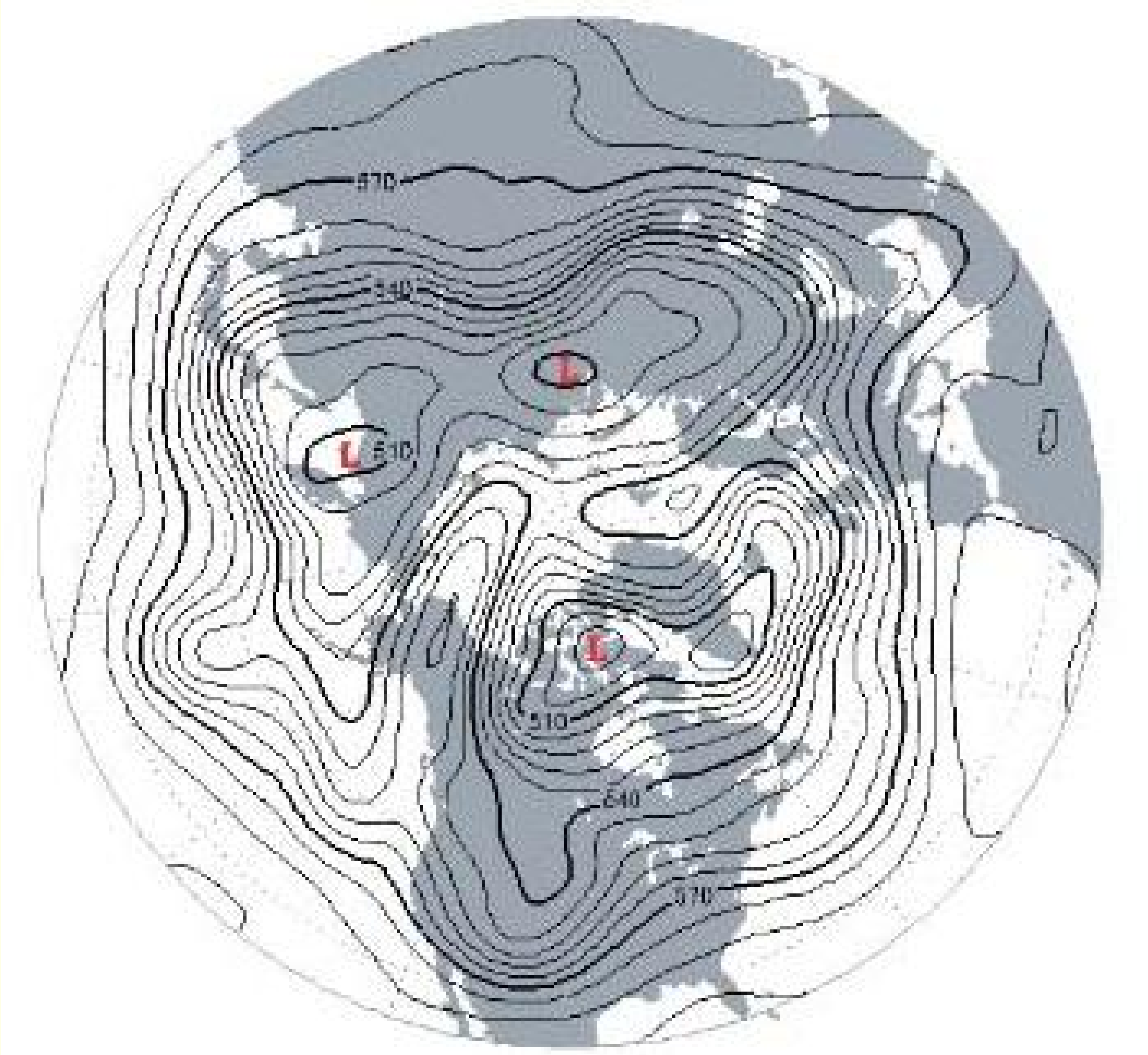
The hemispheric 500-hPa chart for Midnight Universal Time (0000 UTC), November 10, 1998 is shown below.



500-hPa height chart for 00 Nov. 10, 1998. Contour interval 60 m.

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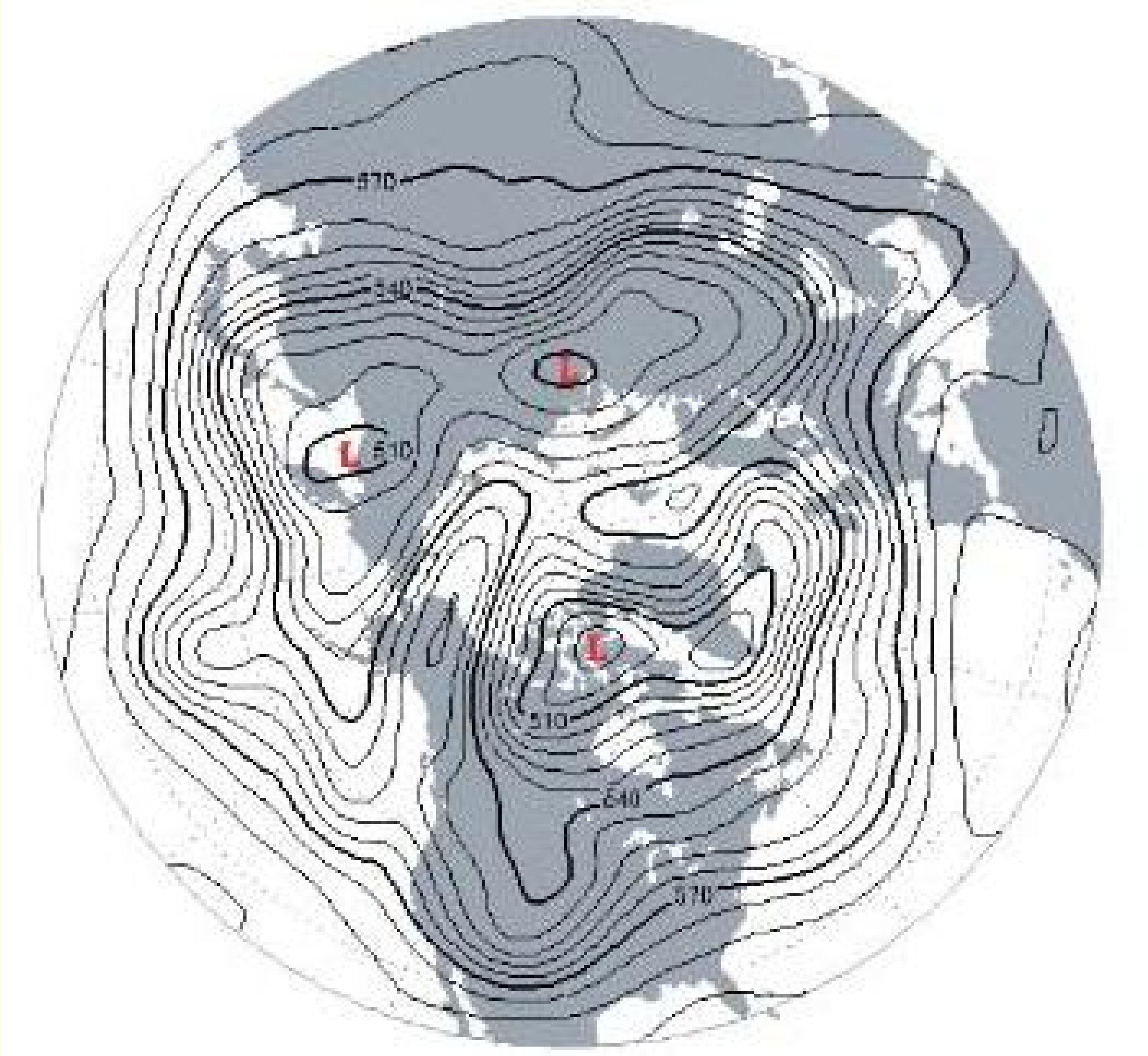
Pronounced troughs are evident over

- **The Black Sea**
- **Japan**
- **The central Pacific**
- **the United States Great Plains**

with several weaker troughs at other locations.



500-hPa height chart for 00 Nov. 10, 1998. Contour interval 60 m.

There are about eight troughs (counting the weaker ones) around the parallel of latitude at 45° North.

Thus, the typical distance between successive troughs is

$$\frac{360^\circ}{8} = 45^\circ \qquad \textbf{or about 45 degrees of longitude.}$$

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The length of the parallel at 45°N is

$$2\pi a \cos 45^\circ = 4 \times 10^7 \times \cos 45^\circ \approx 28{,}000\,\mathrm{km}$$

So, the wavelength at 45°N is one-eight of this:

$$L(45^\circ\mathrm{N}) = \frac{28{,}000}{8} \approx 3500\,\mathrm{km}$$

The scale of 3500 km corresponds approximately to the theoretically predicted *wavelength of baroclinic waves*.

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Baroclinic waves tend to propagate eastward with a phase speed on the order of 10 m s^{-1}, which corresponds to the wintertime climatological-mean zonal wind speed around the 700-hPa level.

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Taking the wavelength as $L = 3500\,\mathbf{km}$ and the phase speed as $c = 10\,\mathbf{m\,s}^{-1}$, the period is

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The interval may be *as short as a day or two* if the steering flow is very strong, and it may be *a week or longer* if the westerlies aloft are interrupted by blocking.

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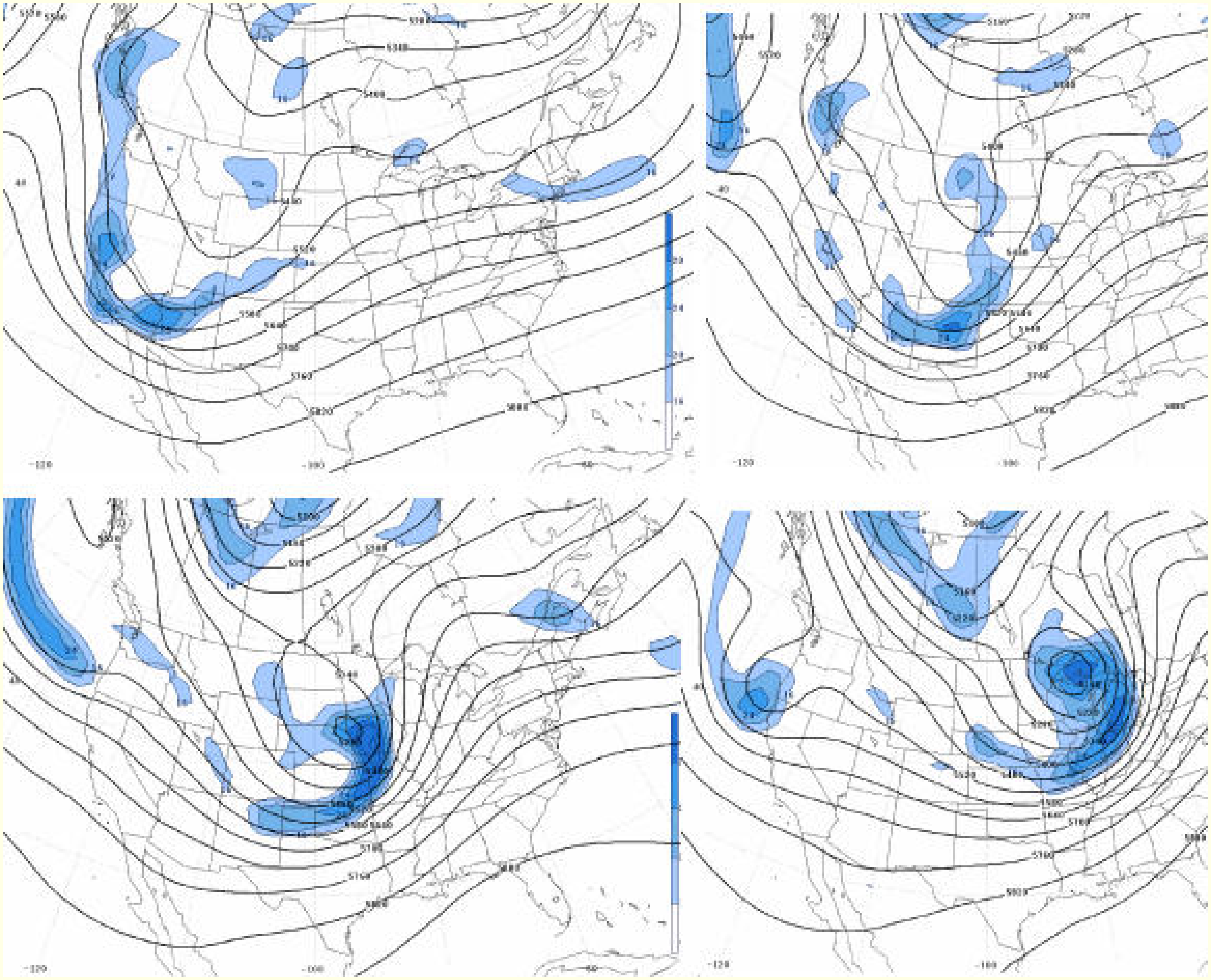
A more detailed view of the 500-hPa height pattern for 00 UTC, 10 November over the North American sector is shown below, together with charts for 12 hours earlier and 12 and 24 hours later.



500-hPa height and absolute vorticity (coloured shading) at 12 hour intervals, starting at 12 UTC Nov. 9, 1998.

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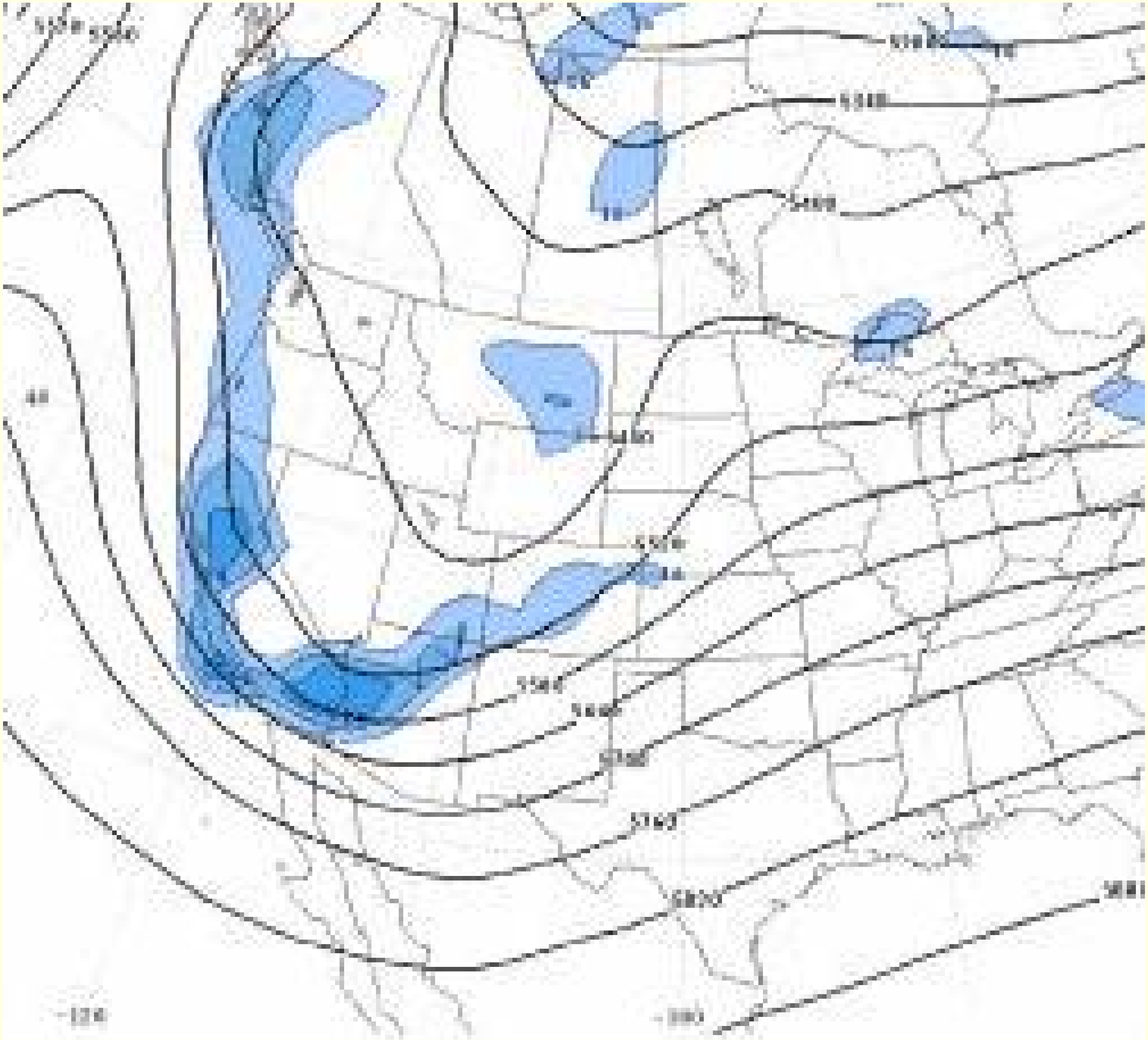
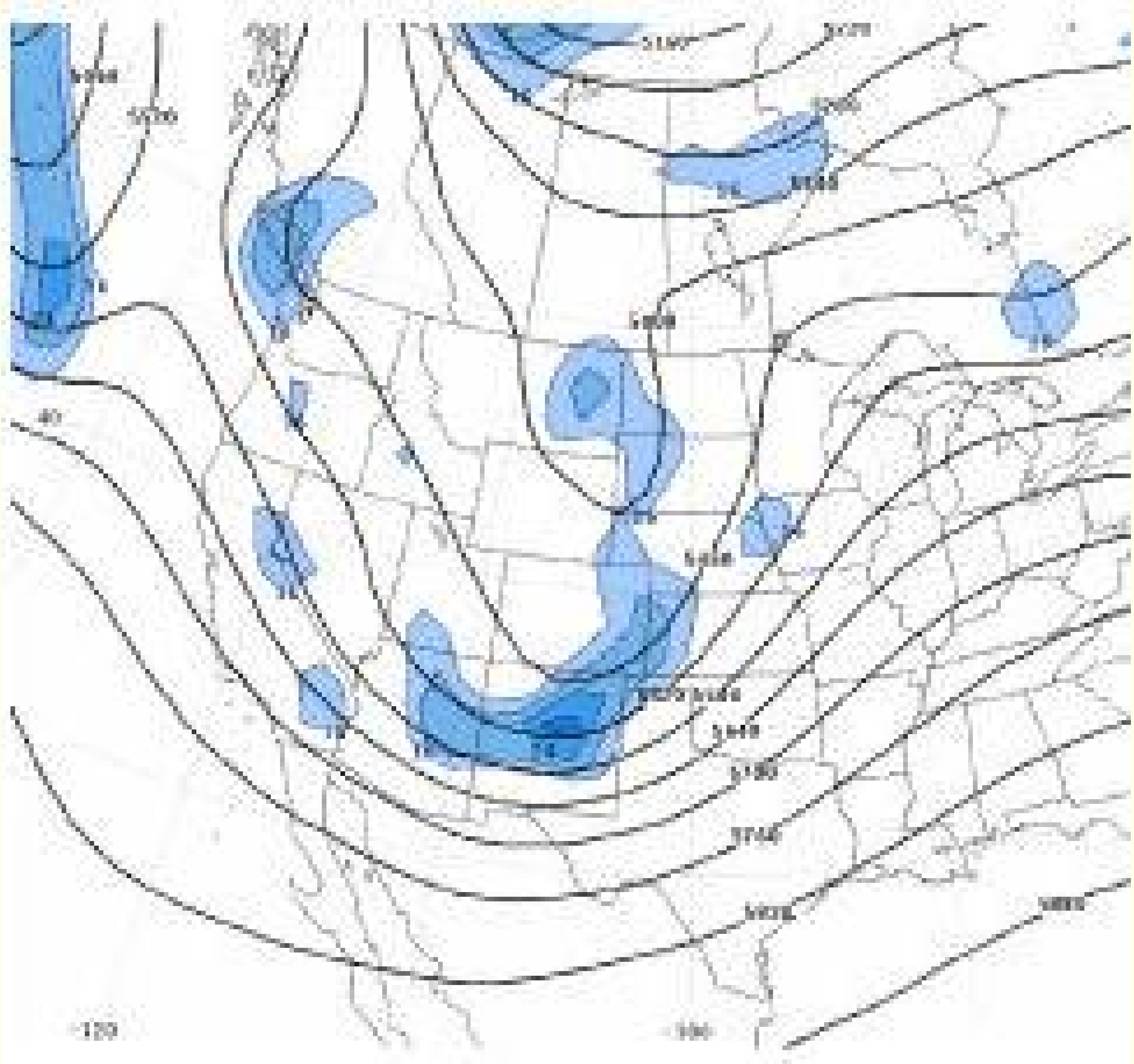
Let us look in more detail at the sequence. The contours are 500-hPa height and the coloured areas are regions with high values of absolute vorticity ($f + \zeta$).



12 UTC, 9 Nov., 1998.



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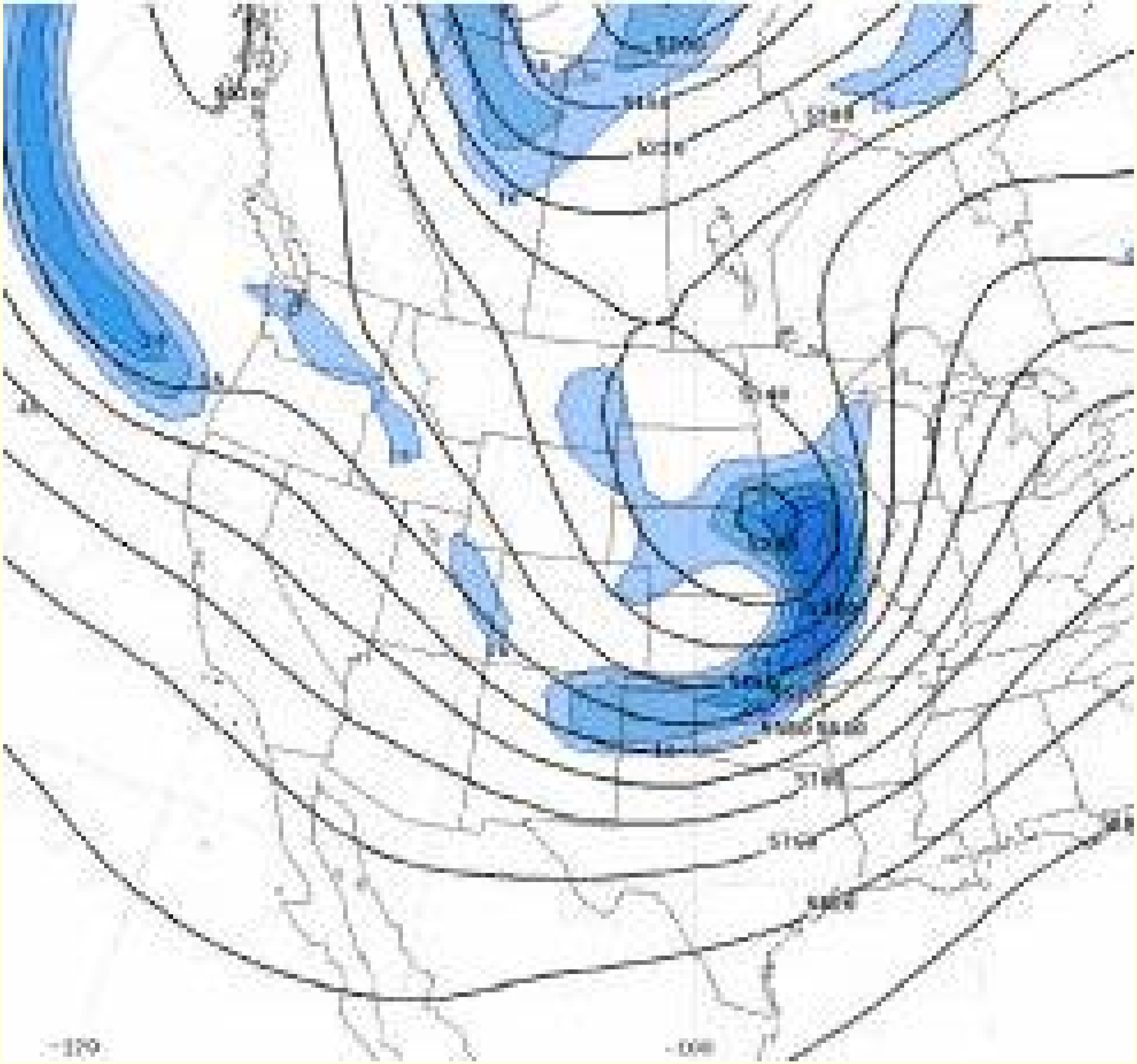

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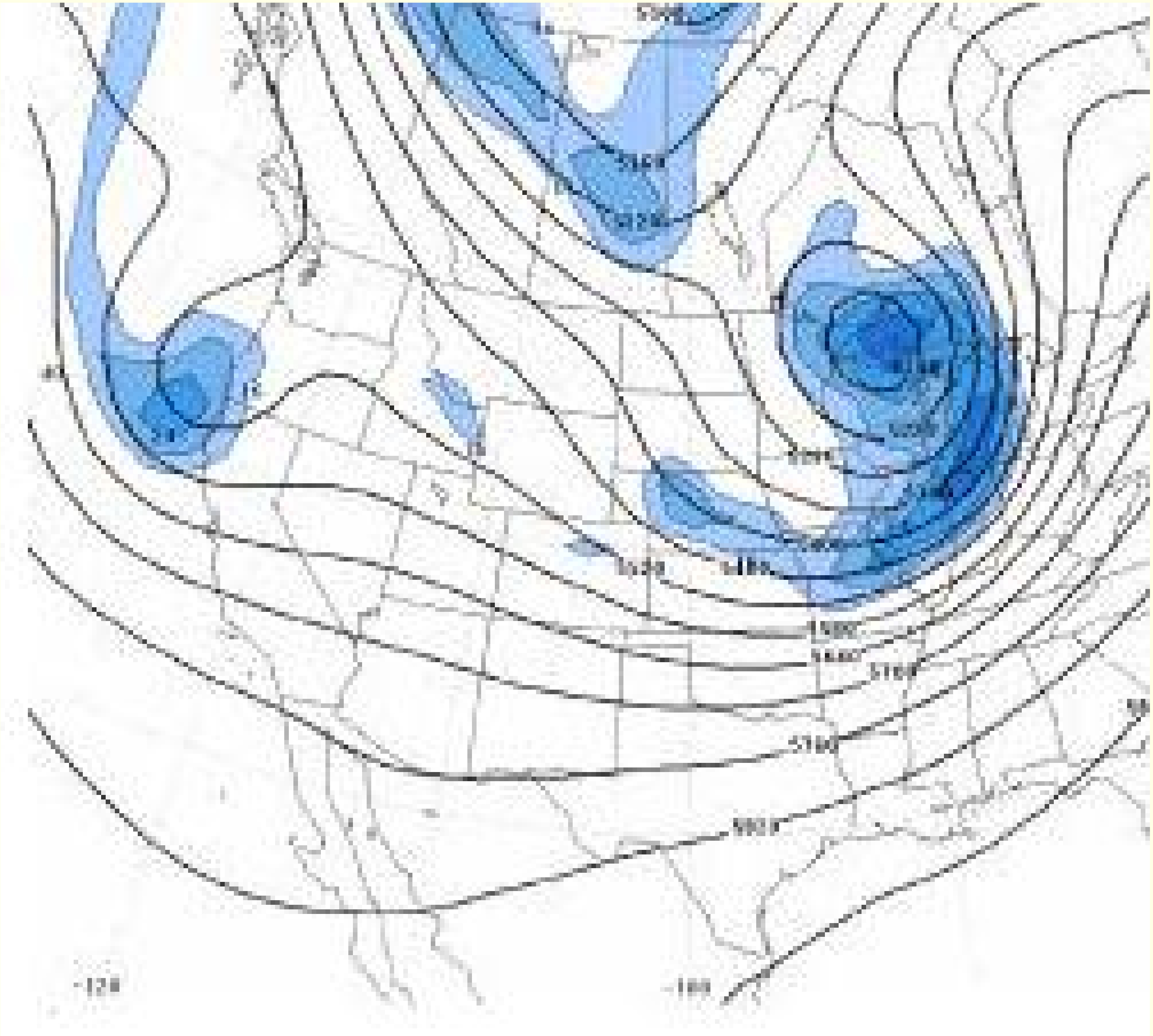

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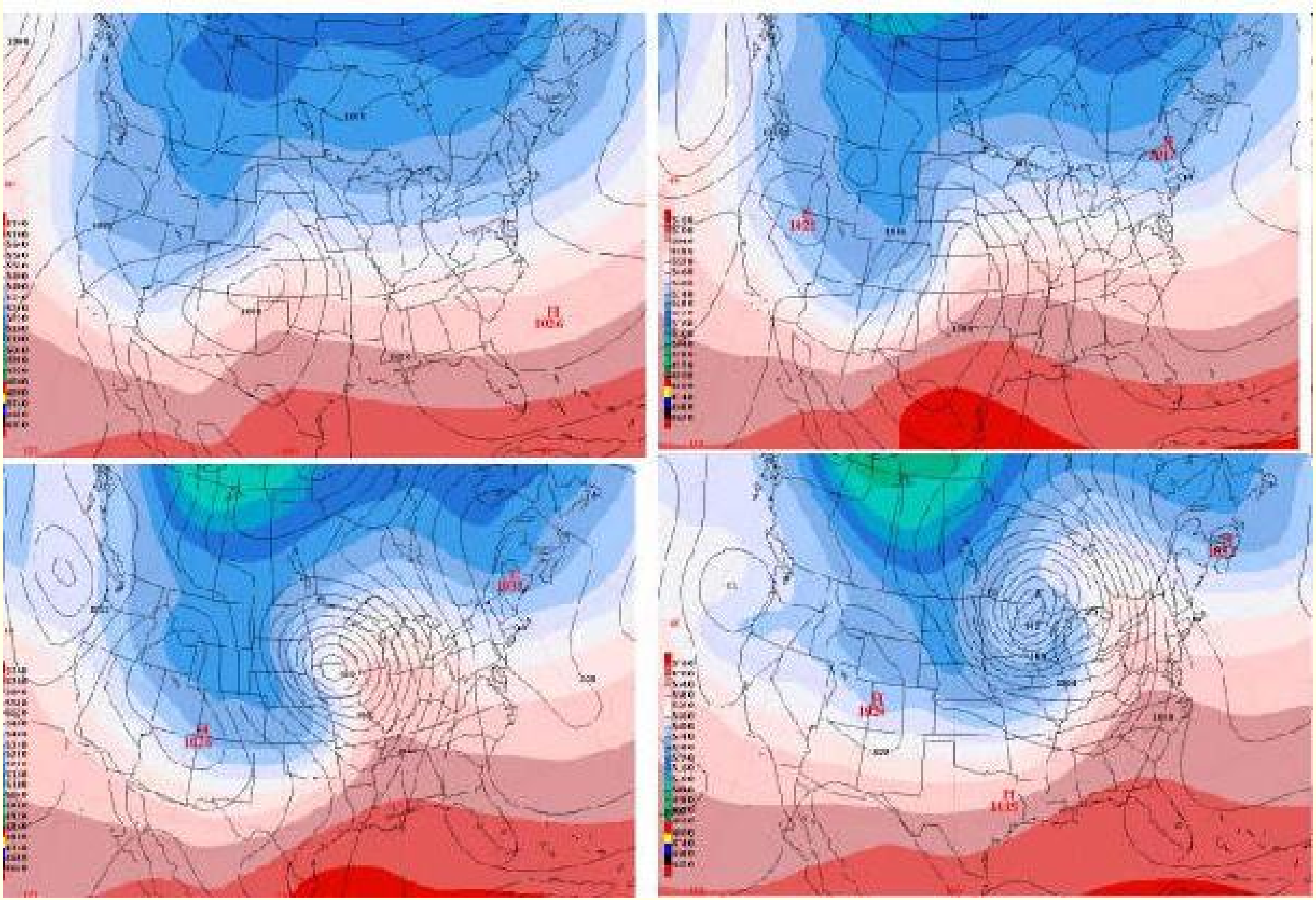
The intensification of the trough at the 500-hPa level is accompanied by the deepening of the corresponding low pressure center in sea-level pressure field (shown below).



Sea-level pressure (contours) and 1000–500 hPa thickness (shading).

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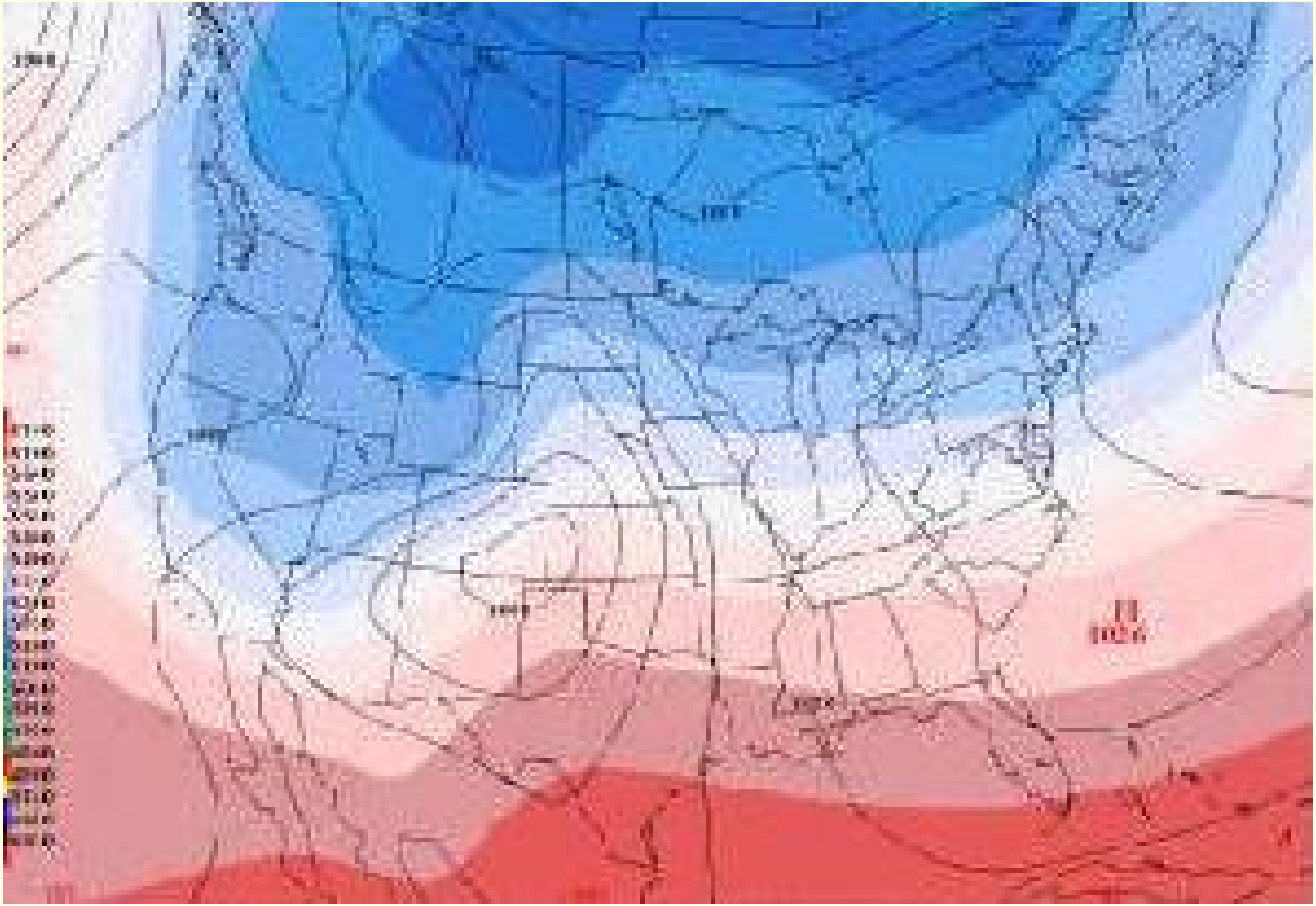
In the first two charts of the sequence the developing surface low is located well to the east of the corresponding trough in the 500-hPa height field.

As these features amplify, they come into vertical alignment in the later charts of the sequence.



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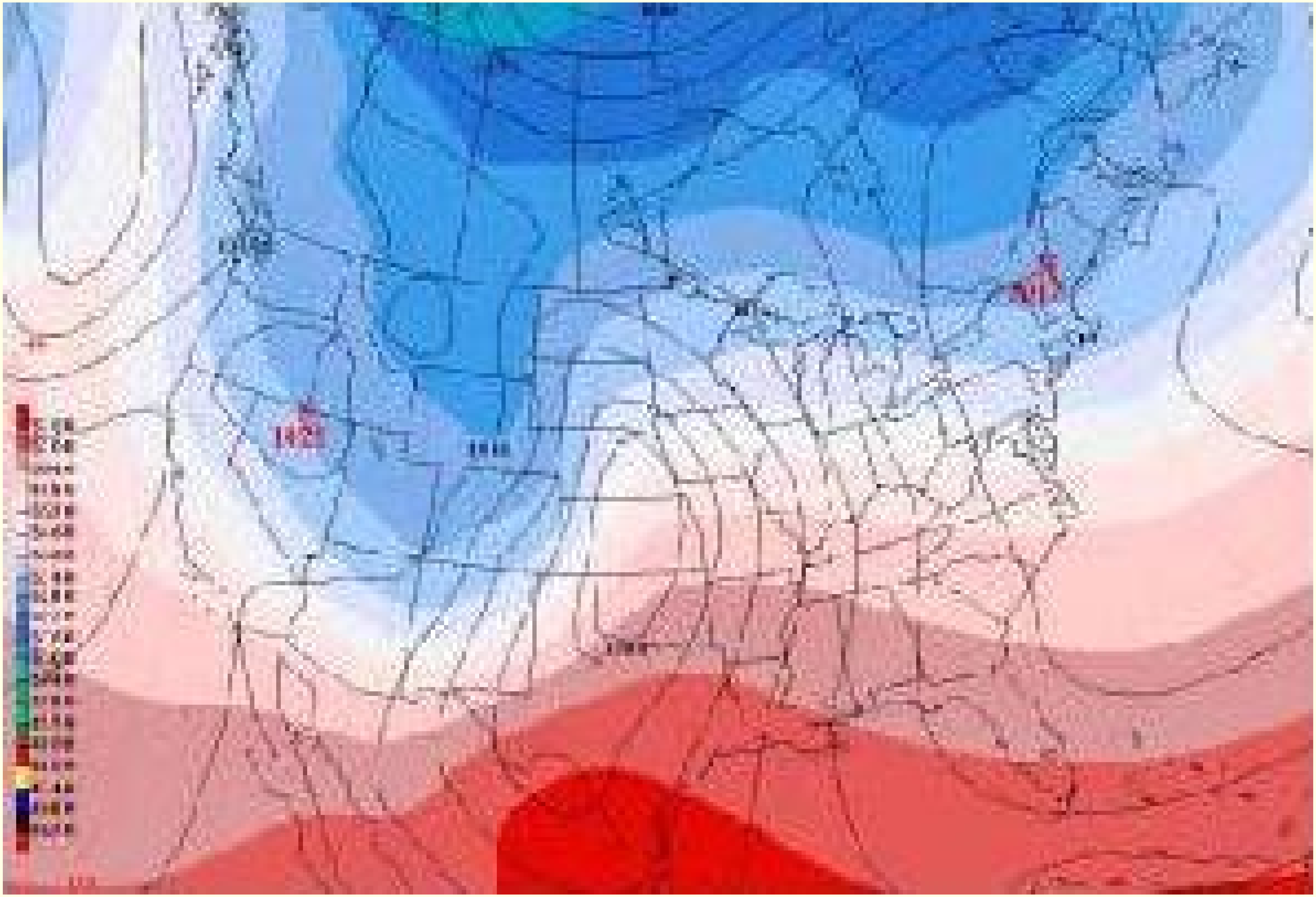

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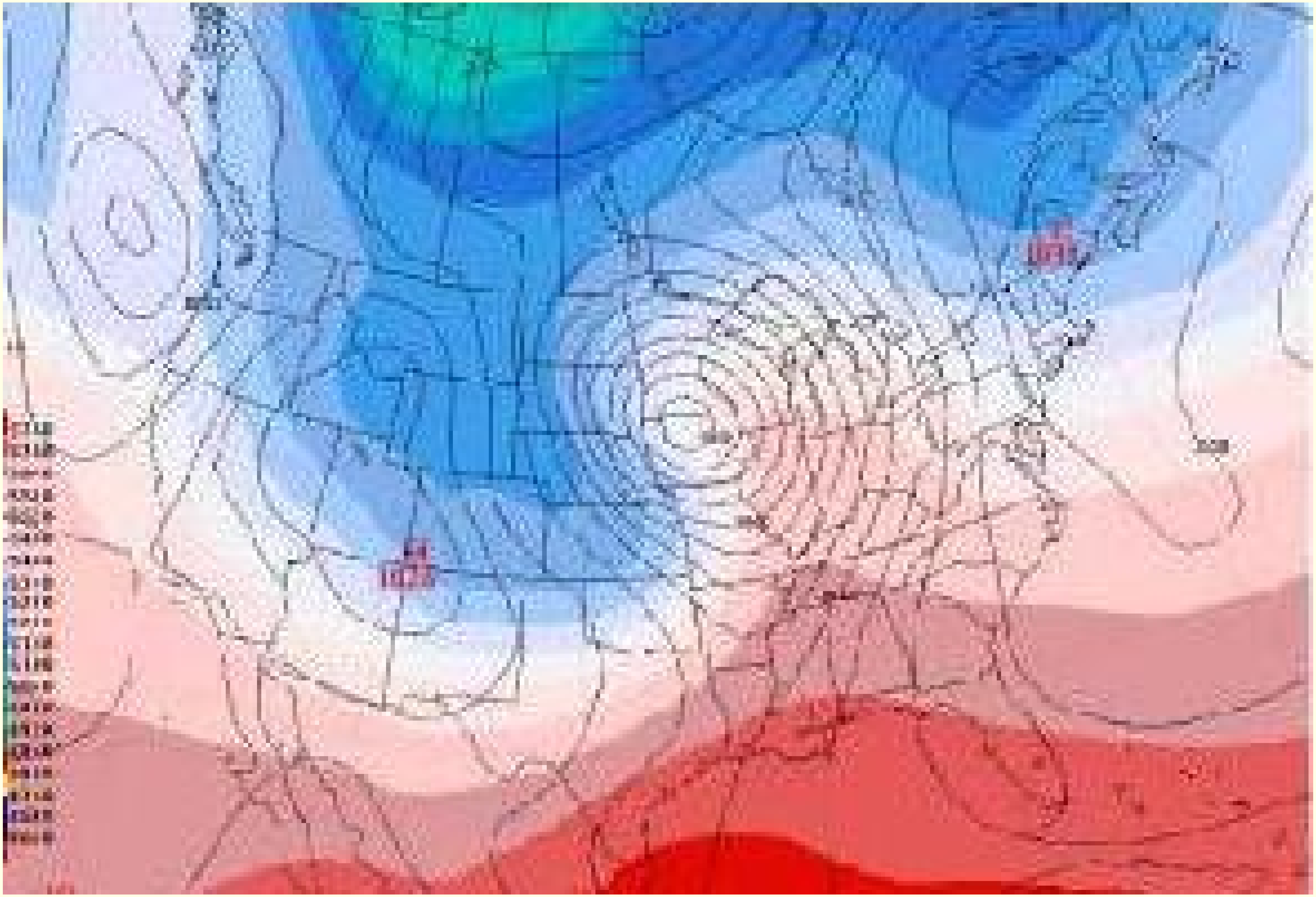

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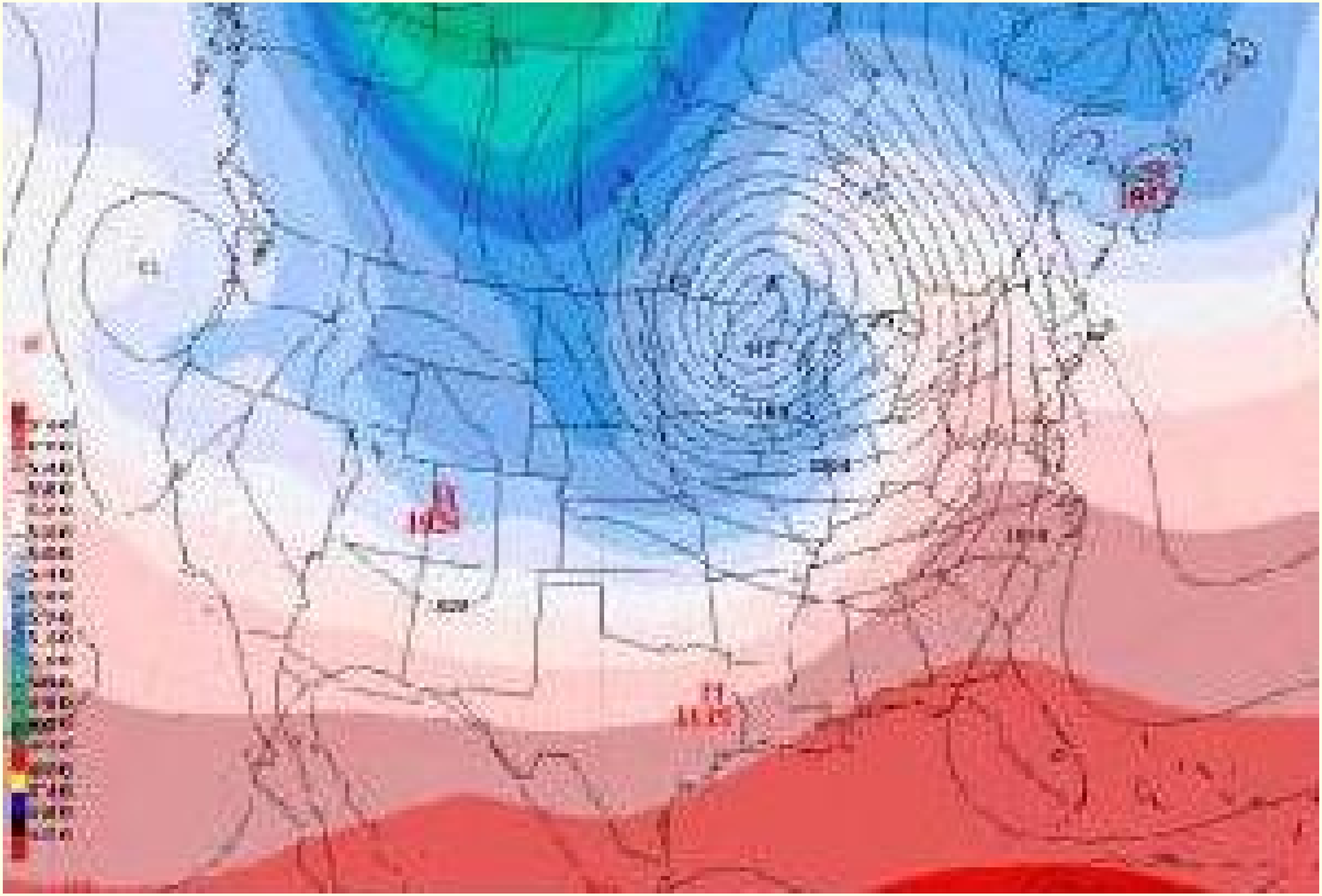

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