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CLUES FOR FORECASTING SEVERE WEATHER

This technical attachment documents a case where severe thunderstorms developed in north central Montana. Large hail, strong winds, heavy rains and a tornado were reported during the late afternoon and early evening hours. Observations during the day showed dewpoint temperatures in the mid 60s in eastern Montana and in the mid 50s to near 60 in north central and northwest Montana. Drier air over southwestern Montana was evident with dewpoints generally less than 45°F from Billings to Helena during the day. Temperatures rose to near 100°F in the south and east and into the mid 90s throughout central Montana.

Considering the location of the greatest low-level moisture and highest temperatures, it would be easy to assume that the greatest chance for strong thunderstorm activity would exist throughout eastern Montana. On the contrary, the most significant activity actually occurred in north central Montana, with little, if any, activity throughout the eastern portions of the state. All severe weather reports -including the tornado, two hail reports up to 1-1/2 inches and wind gusts over 50 knots -were situated within the Great Falls (GTF)/Cut Bank (CTB)/Havre (HVR) triangle. What clues suggested that the north central portion of the state would be hardest hit?

Let us first examine the large scale setup as seen on the visible/IR satellite imagery from 19Z June 17th (Figure 1). A strong upper level trough is evident off the west coast with the main weather activity in the Western Region associated with a 90 knot 300 mb jet moving northward through western Oregon and Washington. The jet stream probed well into southern Canada, leaving Montana under weak synoptic scale flow. This is not an atypical pattern for severe weather in Montana.

With the larger scale stage set, we can look closer at the details which suggested that the north central portion of the state would be most active. In particular, there were three indicators:

1) satellite and surface observations of convective development,
2) surface pressure observations, and
3) the relative locations of the surface dry line, topographical boundaries, and organized convergence centers.

Figure 2 was drawn based on the remarks appended to the Montana surface observations at 21Z. Hatching indicates general areas of developing convection. No vertical development was seen at that time over eastern Montana, with only a few cirrus evident. Satellite pictures confirmed the surface observations. In fact, cumulus development was already evident by 19Z east of the Rockies in northern Montana (see Figure 1).

Surface pressure observations were probably the most significant indicator in this case. Figure 3 shows the pressure pattern valid at 21Z. The main surface low is located well west of Montana, apparently in Oregon. Another small low center (referred to as a "subsynoptic low") is seen in west central Montana. Such a subsynoptic low has been documented as being a significant feature associated with thunderstorm development and severe weather (references include Tegtmeier, 1974;

Doswell, 1977, 1980; Moller, 1980; Maddox et al, 1981 and Szoke et al, 1984). Severe weather is most likely to occur from near the center of the low through its northeast quadrant. That the low center was found near Helena at 21Z with developing convection over and east of the mountains, one's attention would naturally be drawn toward north central Montana.

Finally, the more subtle relationship between the dry line, the eastern boundary of the mountains and the organized low-level convergence centers may have also been important. It is plainly evident that at 21Z there is no organized convergence center along the weak surface trough that extends into southeastern Montana. The strongest convergence appears to be around the subsynoptic low, though a mesoanalysis of convergence should have been performed to support this inference. Additionally, the near collocation of the surface dry line (approximated by the dashed line in Figures 3 and 5), the subsynoptic low and the eastern boundary of the high terrain may be highly related to the development of severe weather. The dry line is the approximate boundary between the moist 50-60^{o}F dew point air and the drier 30-40^{o}F dew point air. The possible relationships between severe weather and these thermodynamical and topographical features are dealt with in greater detail in Lussky (1986).

Figure 4 shows the severe weather reports in Montana during the evening of the 21st. The 00Z surface analysis (Figure 5) shows that the subsynoptic surface low and the dry line tracked northeastward with the severe weather during the early evening hours. The satellite photo from 0031Z June 18th (Figure 6) was taken approximately in the middle of the severe weather episode. The strongest convection- and those thunderstorms which produced the severe weather - are those extending to the north and east from the low center. The convection to the southwest of the low did not become severe and produced less frequent lightning activity than those thunderstorms to the north and east of the low. No severe weather occurred in eastern Montana where the temperatures and surface dewpoints were highest. In contrast, severe weather did develop where the air mass was a little more stable, probably because of the dynamical forcings mentioned above. This indicates the need to evaluate the mesoscale situation of each potential severe weather episode to determine its most likely location. In turn, this should result in better forecast and warning services to the public.

References

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[7] Tegtmeier, S.A., 1974: The role of the surface, subsynoptic low pressure system in severe weather forecasting. M.S. Thesis, Dept. Meteor., University of Oklahoma, Norman, 66 pp.

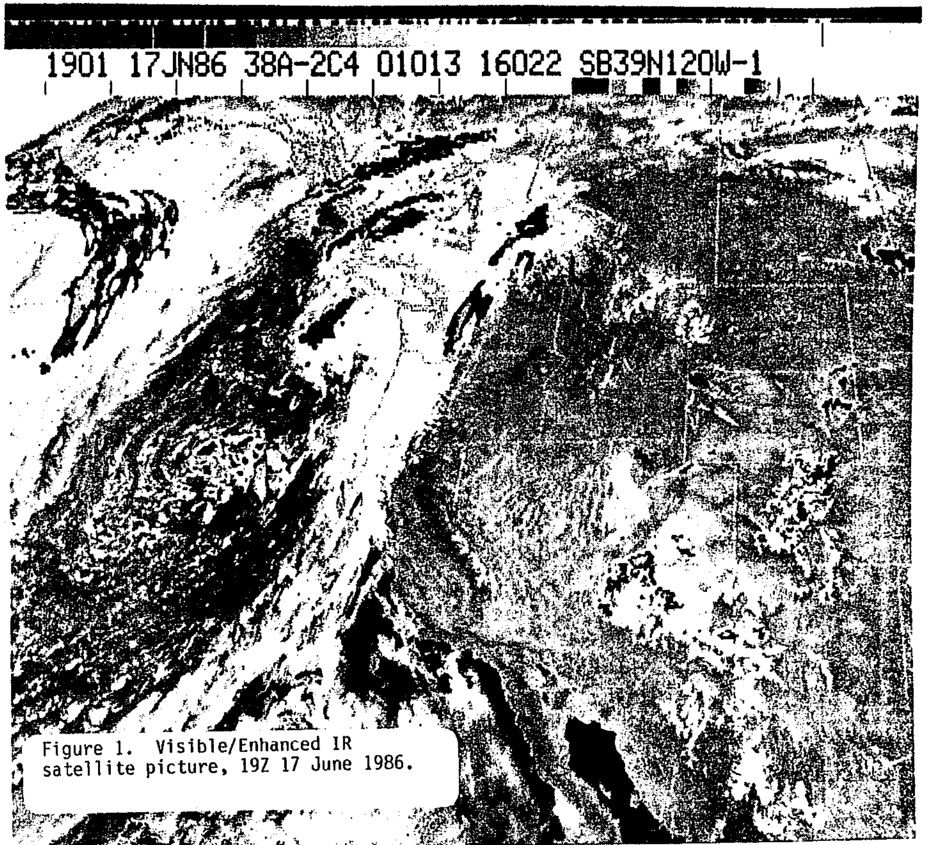


Figure 1. Visible/Enhanced IR satellite picture, 19Z 17 June 1986.

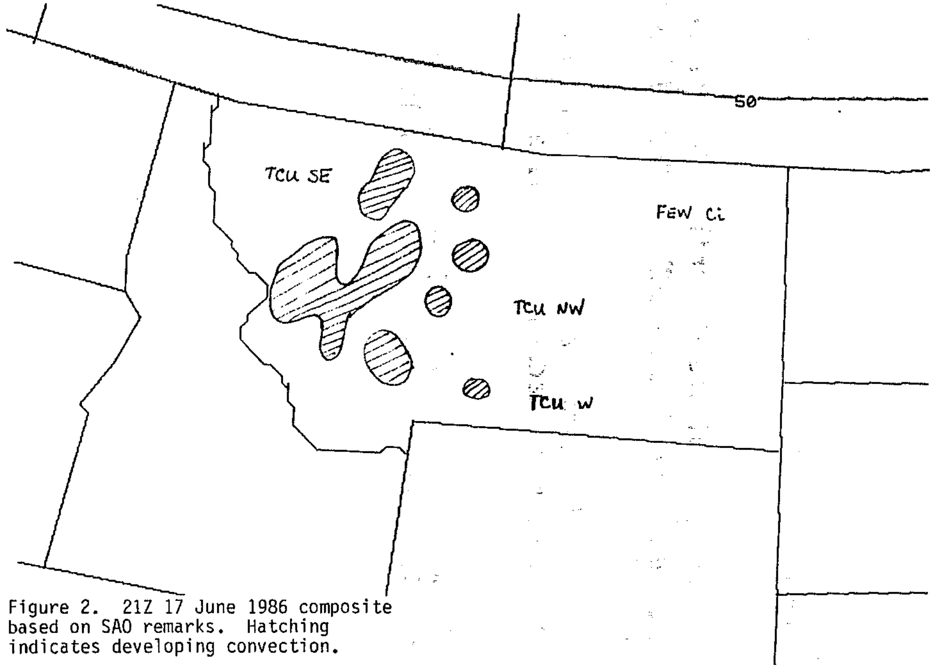


Figure 2. 21Z 17 June 1986 composite based on SAO remarks. Hatching indicates developing convection.

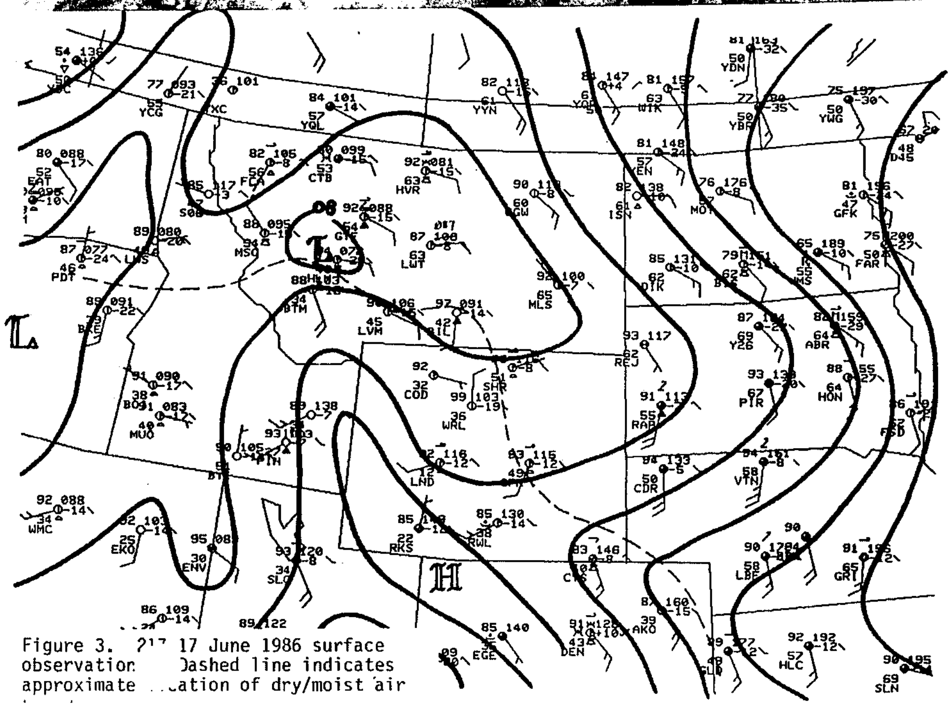
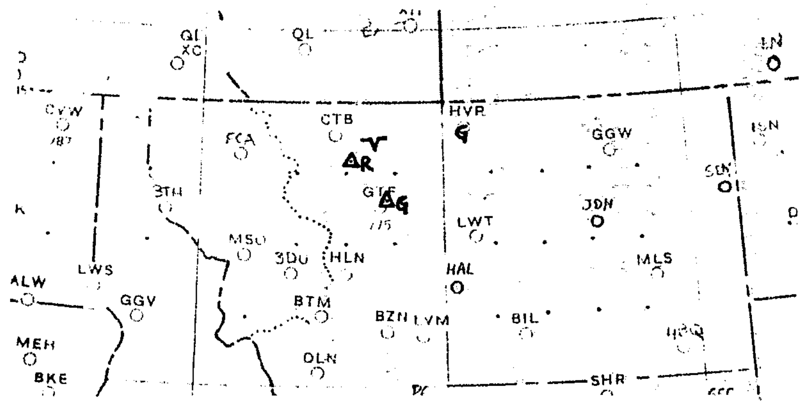


Figure 3. 21Z 17 June 1986 surface observation. Dashed line indicates approximate location of dry/moist air



SEVERE WEATHER REPORTS

Time rec'd	Type of weather	Location
2245Z	A 3/4", R+	Conrad (36 SSE CTB)
2330Z	A 1-1/2", G55	4 NE GTF
0125Z	Tornado	SE of Shelby (26 ESE CTB)
0130Z	G52	1 S HVR

Figure 4. Severe weather reports, 17-18 June 1986.

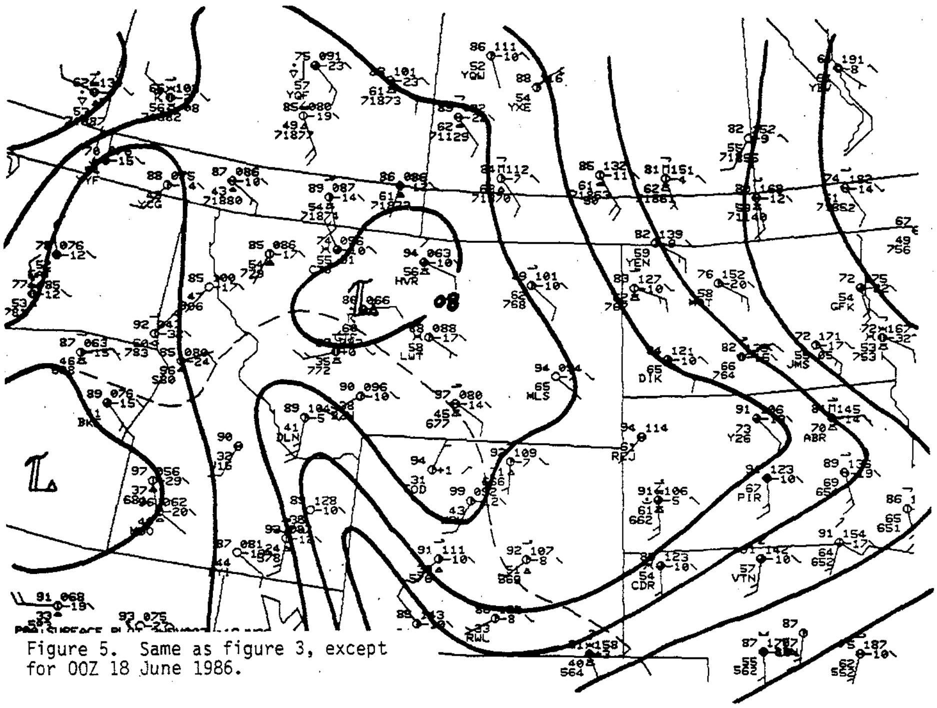


Figure 5. Same as figure 3, except for 00Z 18 June 1986.

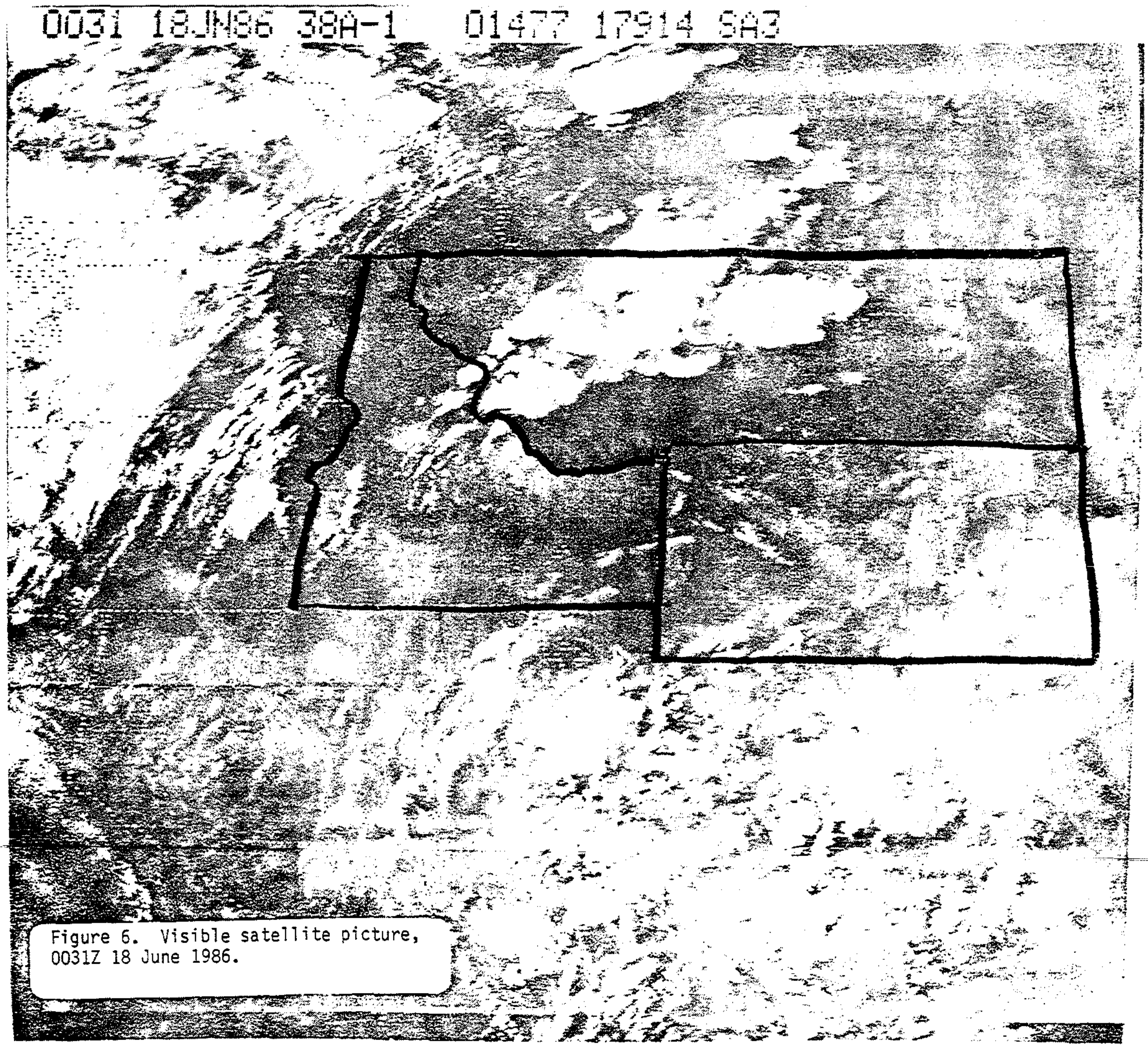


Figure 6. Visible satellite picture, 0031Z 18 June 1986.