Anticipating Flash Floods Under Benign Synoptic Patterns - a WES Study

Bryan Henry and Joe Solomon
WFO Pendleton, Oregon

Introduction

In east Oregon during the summer of 2002, several flash floods occurred under relatively benign synoptic patterns. Heavy rain from slow-moving thunderstorms caused flash floods in east Oregon on June 23, July 18 and 19 and August 25 and 30, 2002. Within the Pendleton forecast area, the most significant events occurred on July 18 and 19, and August 25. On July 18 a mudslide in Wallowa County swept away a dining hall and three vehicles at a Boy Scout camp. In the flash flood cases studied using the Weather Event Simulator, the synoptic pattern involved a slow-moving upper level closed low or short wave trough with only weak forcing for lift. Overall, atmospheric conditions were characterized by relatively weak instability, light steering flow and above normal precipitable water.

Model and Observational Data

In the cases studied, the overall synoptic pattern over the Pacific Northwest and northeast Pacific was benign. Satellite and model data showed either a slow-moving middle to upper level closed low or short wave trough located west to southwest of the areas of interest (Figure 1). The short wave trough events are similar to the Type I events described by Maddox, et al. (1980). The stacking profile of the systems was nearly vertical with little westward tilt with increasing height. This suggests two things. First, significant intensification of these systems was not likely to occur. Second, that the dynamic state of the atmosphere was not very active since there was an absence of a large scale forcing mechanism such as a front or a jet to aid in the intensification of the surface lows or waves. Lift occurred through weak dynamics, differential heating, and/or orographic lift. Most important, atmospheric winds and steering flows were light (Figure 2).

The data suggested nothing out of the ordinary for summertime convection, and widespread severe thunderstorm outbreaks were not expected. CAPE values were generally less than 500 J/kg, and Lifted Index values were marginally unstable, generally between -1 and +1 C degrees. The absence of significant CAPE and low 0-2 km shear values (< 20 kts) showed that the environment was unfavorable for supercell formation. Typical sounding derived storm motions were from the southwest at < 10 kts.

Further analysis showed that a moist environment existed over the area. Precipitable water values were between .5 and 1 inch with an average value of roughly .75 inches for the events studied. Upper air soundings at Boise, ID and Spokane, WA have average precipitable water values for July and August between .55 and .65 inches. A local study at WFO Boise (personal correspondence, 2003) suggests that values above .74 inches are considered to be wet, and values above .91 inches are considered to be very wet. Another indicator of the "wet" environment was shown through the observation of the regional Dew Points. Values across the forecast area generally ranged from the mid 40's to the mid 50's. In the past, dew points as high as the 60's have been observed during such events.

An Analysis Technique

From the study of these events, the following analysis technique has been developed to aid in the determination of flash flood potential.

- Consider the synoptic environment. What type of thunderstorm can be expected (severe, ordinary (wet or dry), or none)? If ordinary, wet thunderstorms are expected, then proceed to the next step.
- Are the precipitable water values across the region .74 inches or higher? If so, then proceed to the next step.
- What is the overall flow like in the lower and middle levels (500 mb and below)? Do VAD wind profiles and/or sounding data show wind speeds extending up and through the middle levels that are less than 20 kts? From forecast sounding data, what are the 0-6 km storm motion values? Are they less than 10 knots? If so, proceed to the next step.
- Where are the thunderstorms expected? Is the terrain beneath the potentially affected area steep (canyons or mountains)?

If wet thunderstorms are expected, and if the answers to these questions are yes, then there is a risk for flash flooding and a flash flood watch should be considered. The risk will be even greater if the potentially affected area has recently received significant rainfall. For example, the soil might already be saturated from a previous day's rain. This would decrease the absorption of water into the soil, leading to a significant increase in runoff.

Discussion

By applying the analysis techniques outlined above and considering the conclusions made in this study, situational awareness of future flash flooding events over the complex terrain of the Pendleton forecast area should be enhanced.

It is important to note that convective flash flood events can occur on days when the atmospheric flow is greater than 20 kts. During these type events, back building with echo training is a key feature to look for on radar and satellite data. If training of thunderstorms is occurring over a given location, ground truth should be obtained from nearby spotters (if possible). One hour precipitation totals should also be monitored to see if rainfall rates exceed 1 inch/hour. One must keep in mind that neighboring radars may have better estimates than the local radar, and that radar rainfall estimates can be skewed by hail contamination. Neighboring radars can also provide storm track motions for cells entering the forecast area as well as supplemental information in areas with poor radar coverage.

References

Maddox, R., Canova, F., and Hoxit, R., 1980: Meteorological Characteristics of Flash Flood Events over the Western United States.

Egger, T., and Vasiloff, S., 1998: High Intensity Short Duration Precipitation, Flash Flooding, and the WSR-88D. Western Region Technical Attachment No. 98-30.

Figure 1

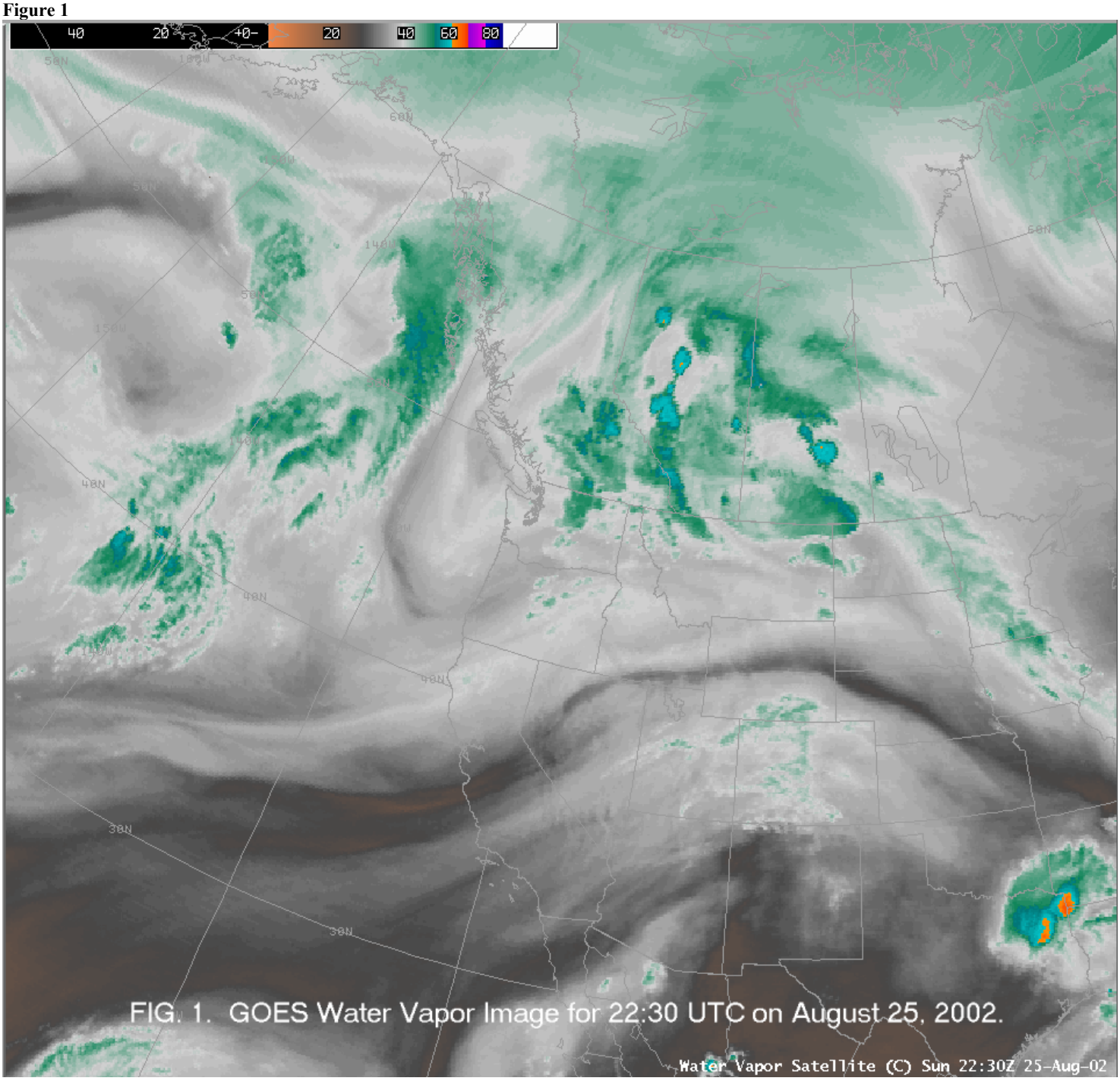
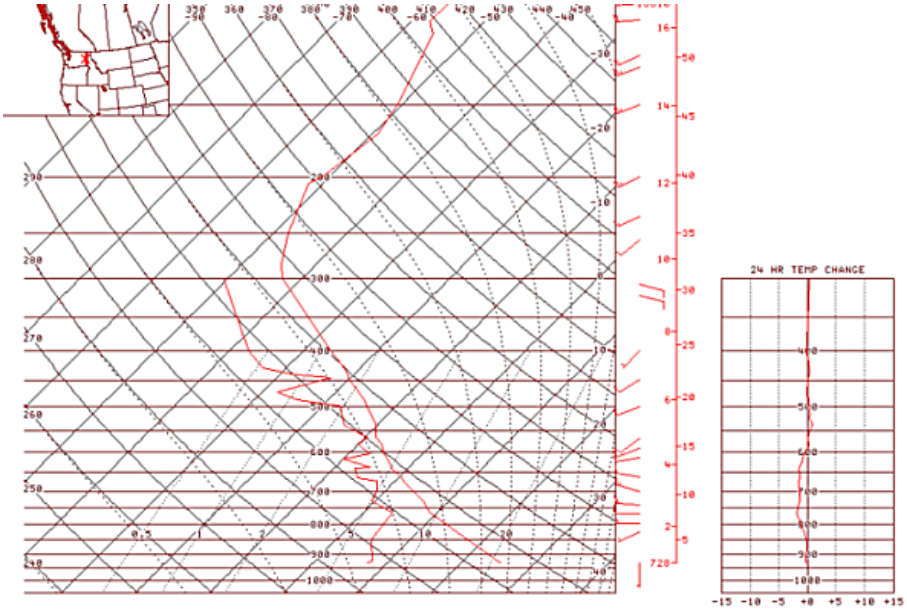
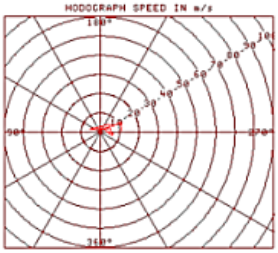


Figure 2





PRECIP WATER= 0.91 in
K-INDEX= 31
TOTALS INDEX= 50
SWEAT INDEX= 94
DRY MICROBURST POT=2: GST < 30 kts
FREEZING LEVEL= 11924 ft ASL
WET-BULB ZERO HGT= 11309 ft ASL
0-6 KM AVG WIND= 257°/7 kts
0-6 KM STM MTN (30R75)= 287°/5 kts
0-3 KM STM REL HELICITY= 13 m²/s²
FORECAST MAX TEMP=NA
TRIGGER TEMP= 25°C/78°F
SOARING INDEX=NA
MDPI/WINDEX = 0.23/30

-PARCEL- T=SFC;Td=SFC
INIT PARCEL P= 934 77 45 ° mb
INIT PARCEL T/Td= 77/45°F;25/7°C
CONVECTIVE TEMP= 82°F
LIFTED INDEX= -0.4
CCL= 10703 ft ASL/ 691 mb
LCL= 9719 ft ASL/ 716 mb
LFC= 12056 ft ASL/ 655 mb
MAX HAILSIZE= 0.0 cm/0.0 in
MAX VERTICAL VELOCITY= 13 m/s
EQUIL LEVEL= 29291 ft ASL/324 mb
APPROX CLOUD TP= 34776 ft ASL
POSITIVE ENERGY ABV LFC= 105 J/KG
NEGATIVE ENERGY BLW LFC= -69 J/KG
BULK RICHARDSON NUMBER= 16.9

FIG. 2.

KOTX Skewt Mon 00:00Z 26-Aug-02