WESTERN REGION TECHNICAL ATTACHMENT
NO. 98-30
AUGUST 11, 1998

HIGH INTENSITY SHORT DURATION PRECIPITATION, FLASH FLOODING, AND THE WSR-88D

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Introduction

Flash floods are a significant forecast challenge in the complex terrain of the western U.S.. Typical flash flood events are caused by slow moving, training, or nearly stationary cells. Other types of flash flooding may be caused by relatively fast moving storms that produce brief but high intensity rains, hence the designation High Intensity Short Duration Precipitation (HISDP). HISDP events are fairly common in the Intermountain West during the late spring and summer months, especially when a subtropical moisture plume arrives. Unusually high precipitable water, moderate instability, and a shortwave trigger are the ingredients for many western U.S. flash flood events (Maddox 1980). Some of these showers are quite brief, lasting for only 10-20 minutes, but are intense. Rainfall amounts may be in the .50 to .75 inches - amounts not normally associated with flash flooding. As the reader will discover, the amount of precipitation is important, but so is the intensity and duration of the precipitation.

What does the mountain weather forecaster have to help identify HISPD events on the WSR-88D? The primary diagnostic tools on the WSR-88D available to the forecaster for issuing a flash flood warning are one-hour precipitation (OHP) loops and vertically-integrated liquid (VIL) images. These products may be used in tandem with local flash flood guidance (FFG) based on past events. Flash flood guidance can be dynamic and change day to day based on antecedent conditions and forecast rainfall, or it can be static based exclusively on terrain and/or past events. Boise, and much of the West, has the static-type of FFG. Unfortunately, FFG is usually limited to hourly amounts.

The OHP and VIL products can have shortcomings in certain situations. The OHP consists of a course pixel image and small areas of short duration intense precipitation can be difficult to pick out, especially if there are overlapping storm tracks or many storms occurring simultaneously. VIL is a better instantaneous indicator of heavy rain potential but has some short comings too. These shortcomings include inappropriate Z-R relations, hail contamination, anomalous propagation, range bias, and evaporation.

This paper discusses how the available products were used for a flash flood case in Idaho and recommends strategies for their use in the future. A new product under development, Area Mean Basin Estimated Rainfall (AMBER), is discussed as a solution to current product shortcomings.

11 September 1997 HISDP event

On 11 September 1997, a HISDP event in the Boise foothills (Crane Creek and Hulls Gulch just north of Boise) dropped ~.60 inches of rain in 9 min - the result of an untimely cell merger. Significant flash flooding resulted. OHP totals were consistent with amounts reported by foothill gauges. FFG for the foothills was originally set at .80 inches per hour and 2 inches per hour for the larger surrounding area.

OHP loops in VCP 11 were marginally useful in identifying the HISDP event. A storm track indicated by the OHP panels (Fig. 1) can be seen just north of Boise between the towns of Emmett and Star and was not associated with flash flooding. In fact, there were several tracks on the radar during this time period (not shown) that looked quite similar in terms of time, space, and quantity of precipitation. However, most of the area of concern had static FFG of more than 2.00 inches per hour. Maximum amounts in the OHP were well under .80 inch per hour so this event was viewed as non-threatening. The flash flood event is indicated by the rapid increase in precipitation amounts between 0114 and 0119 LT (Fig. 1) in the area immediately west of rain gauge #5624. One problem with the use of this product is that it is often very difficult to visually pick out frame-to-frame data pixel changes from a large, busy field, especially when only one or two pixels are involved.

The VIL provided some guidance as well. It clearly showed a rapid increase in the cell's intensity (Fig. 2; panels 2 and 3). Also, low filtered lowest elevation angle reflectivity loops (not shown) helped identify the area of intense short duration precipitation. However, estimating the amount of rain that fell using VIL or reflectivity alone is difficult.

Discussion

Flash flooding can occur with high intensity short duration precipitation events - durations as small as 9 or 10 minutes with amounts as small as .60 inches. These events can be produced by intense cells that move relatively fast - at 15 knots or more as in the Boise case. Durations as small as 9-10 minutes provide a real challenge. The OHP product by itself does not clearly identify HISDP events. OHP is, after all, an hourly summary of precipitation not an instantaneous measure of precipitation. VIL and reflectivity products can help, but do not quantify precipitation amounts.

Here is a suggestion: use a combination of VIL and OHP. To do so, use the following steps:

- Place a loop of VIL on the right screen and the latest OHP on the left.

- Stop the loop and focus on high VIL values. Match the cross hair on both screens.

- Change the OHP frame to a 4-panel and display the four previous OHP products in separate quadrants.

- Look for large incremental changes that satisfy FFG in the OHP corresponding to the intense spot on VIL.

This is tedious, but it works. The addition of local terrain features to PUP background maps also help determine flash flood potential.

Finally, a new system under development, the Area Mean Basin Estimated Rainfall (AMBER) system (Jendrowski and Davis 1998), holds great promise of relieving the forecaster of the time-consuming task of picking out small color pixels from a large field and mentally overlaying them with terrain. Essentially, the system provides radar-derived precipitation rates over small watersheds. These rates can then be graphically compared to FFG. Examples of the application of AMBER can be found in Davis (1998). In one case, they found that watersheds as small as 2 mi^{-2} must be defined. The AMBER system is currently being merged with NSSL's Warning Decision Support System and is scheduled to be integrated into AWIPS.

Recommendations:

1) Each office should carefully re-evaluate their flash flood guidance criteria. In the 11 September event, the criterion of .80 inches per hour was insufficient for issuing a warning. Due to local terrain, vegetation factors, and intensity experiments it was found after the event that new criteria for the affected area included a rainfall rate of only .60 inches in 10 min. Ideally, guidance criteria should include temporal units much less than one hour.

2) Anticipate flash flooding. Will there be a combination of high precipitable water, moderate instability, and a shortwave trigger present in your forecast area? If so, you may want to consider a flash flood watch early in the day, well ahead of the potential event. It can be argued that flash flood watches save more lives than warnings. Many canyons and gulches are in radio blackout. A watch, if issued early in the day, can reach many more people and cause a change in plans for many outdoor enthusiasts considering a hike or picnic into flash flood prone areas.

3) Identify flash flooding on radar. To assist in identifying HISDP on the WSR-88D, consider using the OHP in tandem with VIL or low-filtered reflectivity loops. The VIL or low-filtered reflectivity products will help to focus your attention, then return to the OHP and move between OHP frames looking for large incremental changes that correspond to the VIL "hot spot". If the amount is true and satisfies FFG, then issue a flash flood warning.

Acknowledgments

Discussions with the Boise staff were very helpful in producing this paper, especially John Jannuzzi, Rusty Billingsley, Carl Weinbrecht, Ken Parker, and Mary Mellema.

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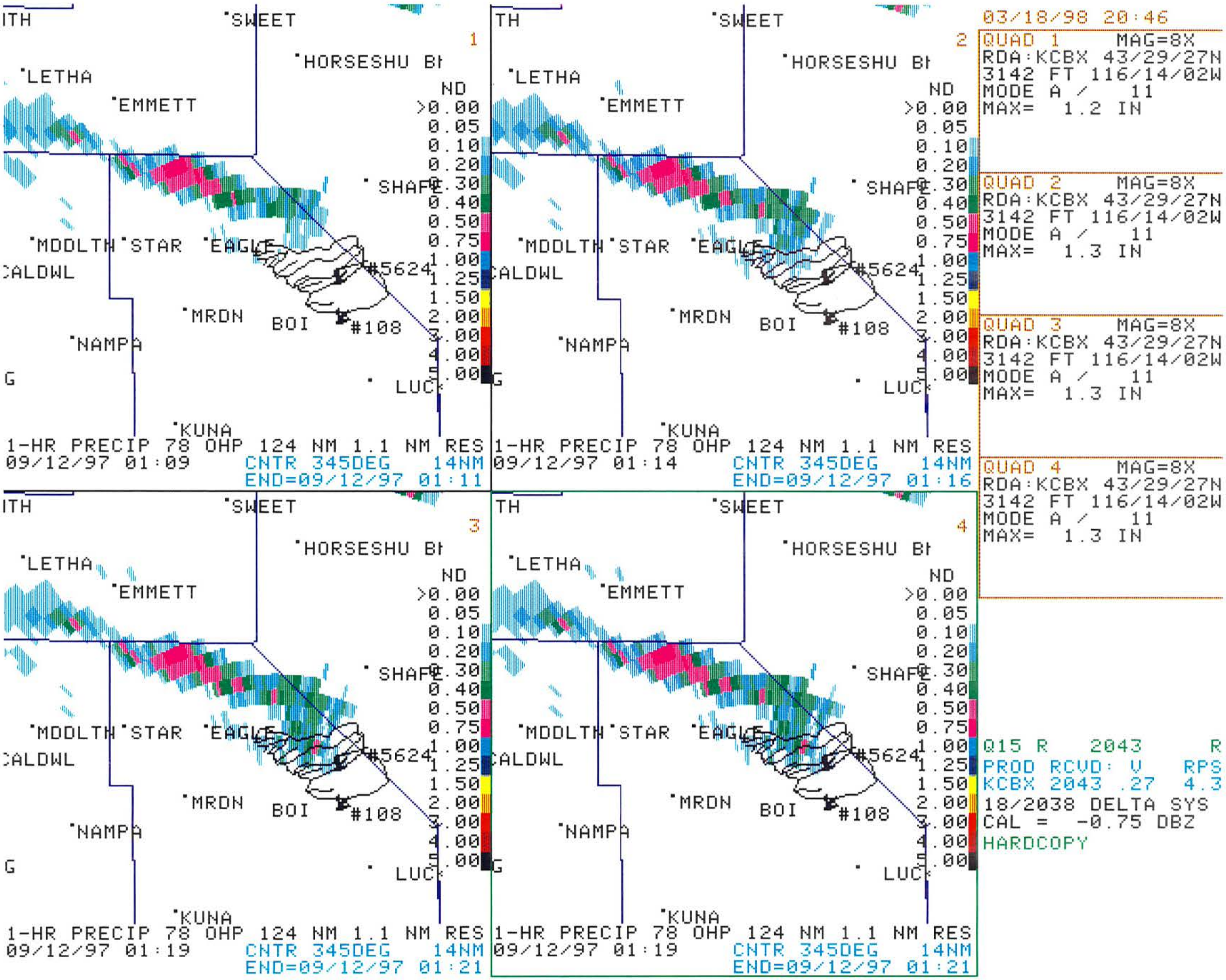

Figure 1. Four panel of 6-min updates of OHP product. The upper left is for 0109 LT, upper-right is for 0116, and the bottom two are for 0121.

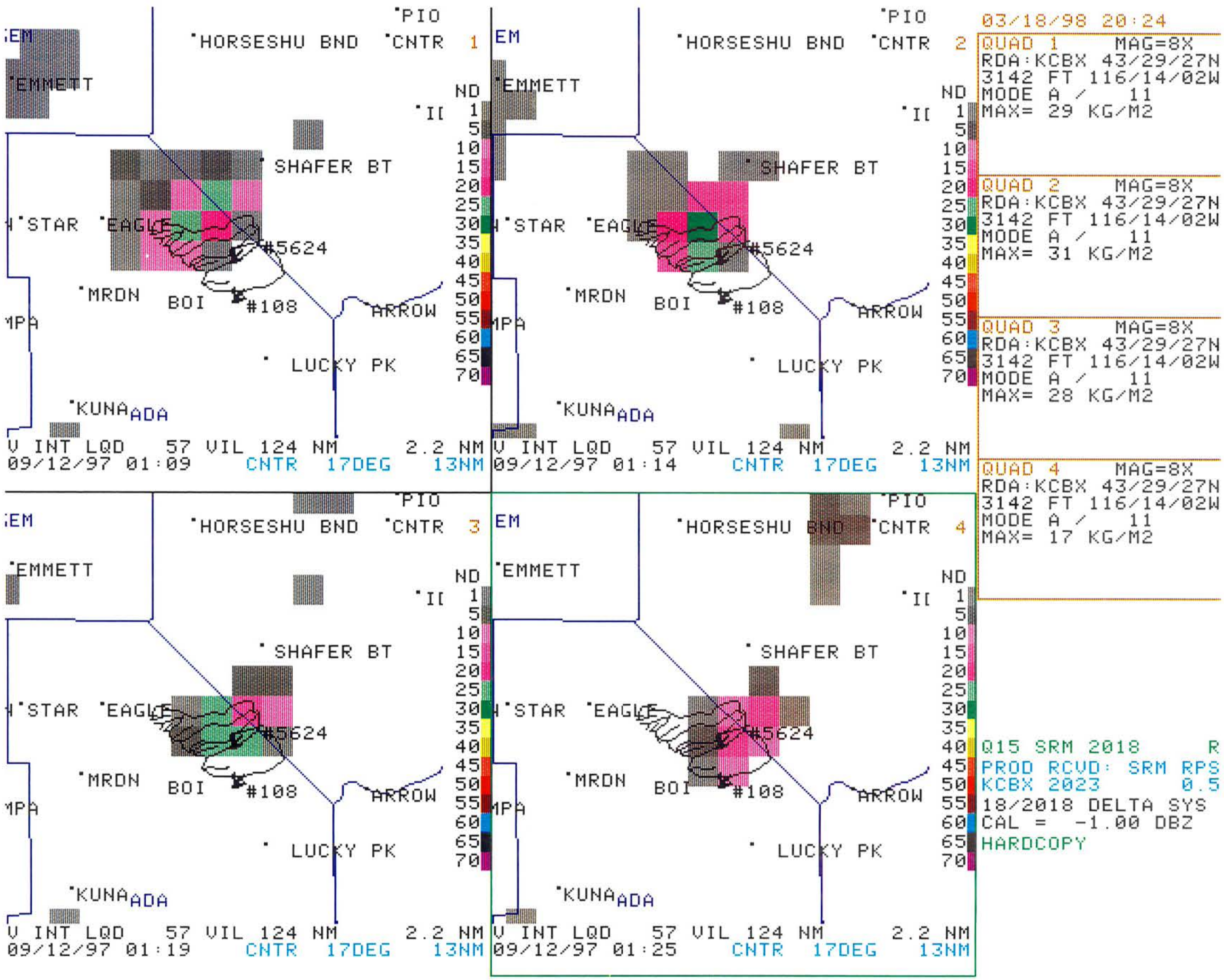

Figure 2. Four panel of VIL images. The upper-left is for 0109 LT, upper-right is for 0114, lower-left is for 0119, and the lower-right is for 0125.