Heavy Mountain Rainfall and Flooding across Southeast Arizona: January 26-28, 2008

Tina Stall and Glenn Lader
NOAA/NWS Forecast Office, Tucson, Arizona

Meteorological Overview:

This event stemmed from a persistent longwave trough off the west coast of the United States. This trough allowed tropical moisture into Arizona from the ITCZ (Figure 1). Precipitable water values in the source region were about 2 inches (during the event precipitable water values were 1-1.25" over Arizona). Given the warm nature of this system, snow levels were very high for most of the event, staying above the mountaintops. A strong south-southwesterly low level jet with 30 knots at 850mb (Figure 2) and 50-60 knots at 700mb caused immense moisture convergence and orographic lift, not only against the Mogollon Rim, but also on the Catalina Mountains where over 8 inches of rain fell. Not only was orographic lift a major part of this event, but also rain shadowing. Tucson International Airport was heavily shadowed by the Santa Rita Mountains, where only 0.04" was recorded for the whole event. Most of the Tucson Metro, outside the mountain rain shadows, had between a one quarter and one half inch of rainfall. Safford, which is in a rain shadow from the Pinaleno Mountains, had slightly more rainfall at 0.14".

The existing snowpack on Mt. Lemmon was minimal which reduced the potential runoff from the mountain into the valley washes. However, with such excessive rainfall in a 12-18 hour period, significant problems still occurred, especially on the mountain itself, with numerous reports of flooding, sinkholes and rockslides. This caused about $750,000 worth of damage on Mt. Lemmon. Sabino Creek rose slightly above 6 feet, which is its moderate flood stage. The interesting thing about the normally flash flood-prone Sabino Creek is that it took quite awhile for the flow to drop below flood stage, most likely because this was a longer duration event.

The other flooding occurred due to runoff from the Mogollon Rim and the Upper Gila River Watershed. The only site to go above flood stage was the Blue River north of Clifton. WFO Tucson (TWC) issued River Flood Warnings for the San Francisco River at Clifton and later the Gila River at Duncan, but both sites rose to just below flood stage.

Model Guidance and Office Summary plus BOIVerify and WR QPF/PoP High Impact Forecast Verification Webpage:

The extended range guidance had a tough time until five days before the event. Initially it seemed that the system would move quickly through the western United States and not acquire a tropical tap. However, additional energy dug into the trough (Figure 1) and helped it maintain a position off the Western U.S. coast for considerably longer than the

models had initially forecast. That resulted in ample time for the system to tap into the deep moisture to the south. It should be noted that the models continually delayed the timing of the precipitation. Both the GFS and ECMWF were too fast, even within one day of the event they brought moisture in too fast, and kicked the trough too quickly to the east.

From a QPF standpoint, TWC did best in its northern zones, while overforecasting some in the southern areas where rain shadowing was a major player. BOIVerify graphics further highlighted the major forecasting issue of this event (Figure 3). According to the both the WR High Impact Forecast Verification Webpage and BOIVerify, TWC actually overforecasted the event as a whole, while underforecasting precipitation amounts in the higher terrain of the Catalina, Pinaleno and Huachuca mountains. The overforecasting of the event is most likely due to the fact that the TWC CWA consists of mostly valley-type terrain. The office seemed to have overforecasted these areas because QPF was not reduced enough to account for the rain shadow effects.

TWC did not make many changes to QPF forecasts as the event approached. The models were also steady in their QPF forecasts, although too fast in their timing. The ECMWF proved to be the model of choice trend-wise, but TWC still found ways to improve upon the model dry bias in the mountains. Interestingly enough, even BOIVerify verification did not pick up on how large the ECMWF model and TWC forecasts underforecast mountain QPF. Although TWC and the models forecasted around an inch or less in many of our mountains, those areas actually received closer to eight inches over the duration of the storm (Figure 4). Among the short-term models, the NAM12 had a better handle on the QPF. The main factor for this was most likely the higher resolution of the model which depicted the smaller scale orographic effects better than the lower resolution GFS/ECMWF.

On the PoP side, TWC, while forecasting below climatology (climatology = 12%) 5+ days out, quickly picked up on the approaching storm and ramped up PoPs to between 70% and 80% at 4.5 days before the event (Figure 5). This large of a jump in forecast PoP is rare, especially so far in advance, but was well-collaborated with the other Arizona offices that recognized the potential magnitude of the event. However, the highest average forecast PoP was slightly below the verifying value of 95%. For this event as a whole, TWC was well-collaborated with the other Arizona offices, but not quite as well with the neighbors to the east.

WFO Tucson's overall forecasting performance for this event was excellent. Coordination with HPC occurred via Goto Meeting 2 to 3 days prior to the event which helped the Arizona offices better collaborate QPF. Although the QPF forecast wasn't perfect (nor would it ever be), especially considering the extreme elevation and precipitation difference between Tucson International Airport to Mt. Lemmon, TWC did an fabulous job capturing the larger picture that a high impact, high magnitude heavy rainfall event would occur. Hazardous Weather Outlooks outlined well in advance of the event that there would be heavy rainfall and perhaps some flooding issues. A Snow Advisory, which was issued for Northern Greenlee County, didn't quite work out as snow

levels remained too high. The lack of snowfall in Northern Greenlee County ended up being a prime reason why minor flooding occurred on the Blue River. Much of the precipitation in the southern White Mountains, although mostly freezing on the pre-existing, deep snow pack, started to melt a bit of the pack before temperatures dropped and the storm departed. Only a few more hours of warm temperatures could have resulted in a significant, long duration flood event on the upper Gila River.

The important message to be taken away from this event is that in strong orographic, slow-starting storms, forecasters should not hesitate to raise mountain QPF totals higher than the models suggest, and subsequently lower the valley totals slightly. With this extra knowledge, the forecaster is able to correct for the models' terrain resolution shortcomings and produce better PoP and QPF forecasts.

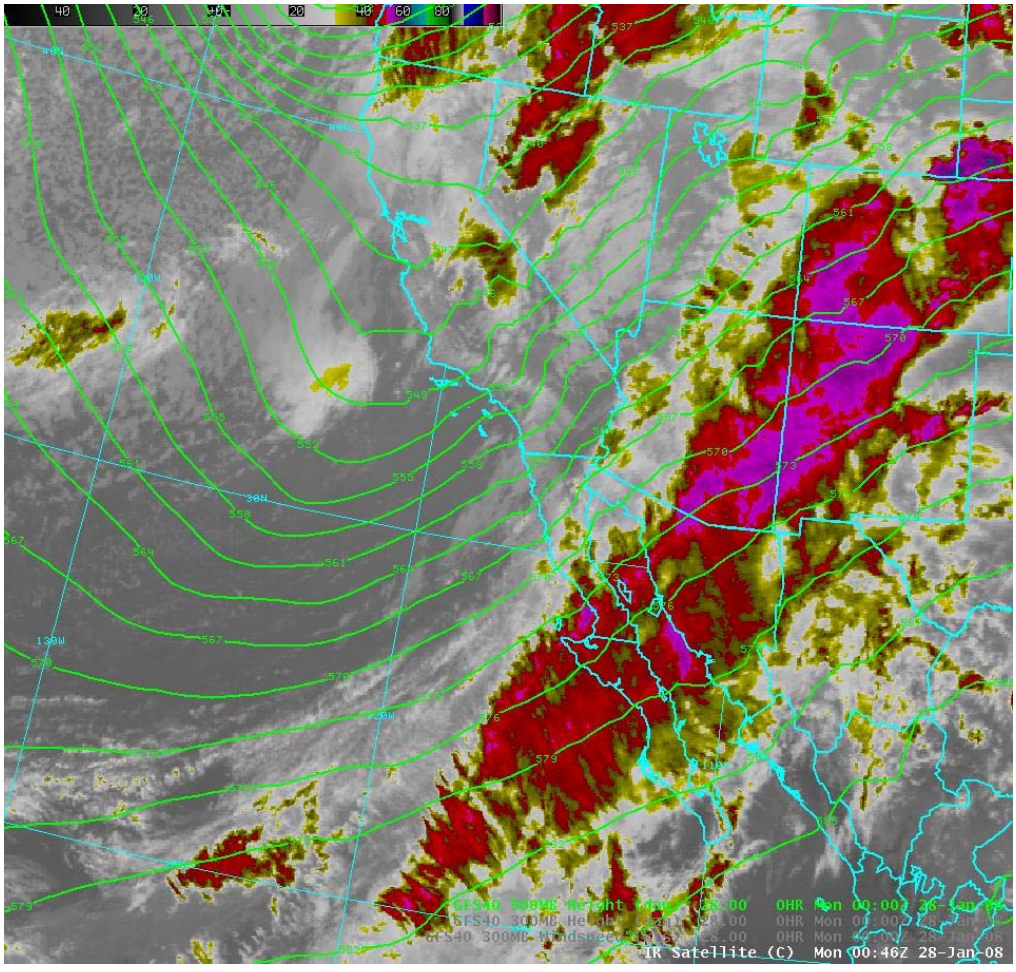

Figure 1: Infrared Satellite imagery and GFS 500mb heights valid 00Z January 28th showing southwesterly flow transporting deep moisture from the tropics into Arizona. Note the piece of additional energy off the southern California coast west of Point Conception, which helped to delay the arrival of the system into Arizona.

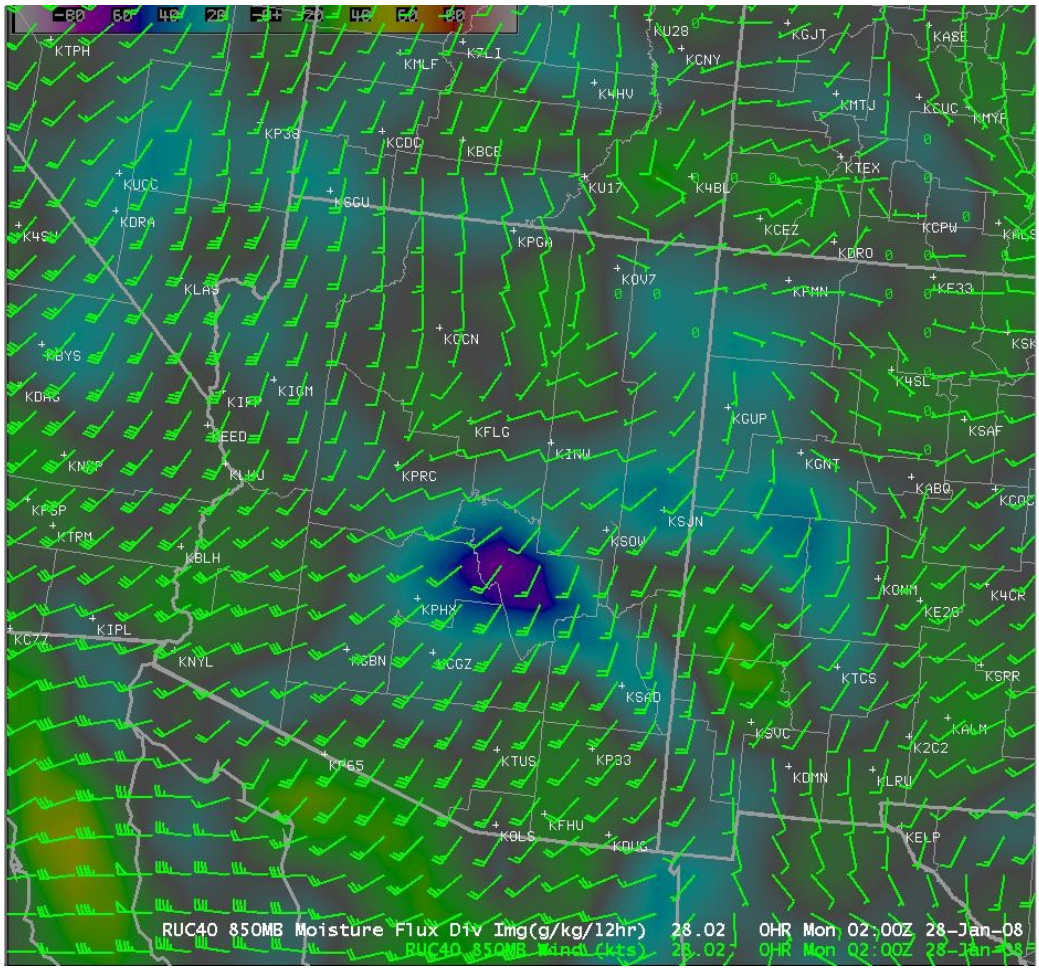

Figure 2: RUC40 model initialization, valid 02Z January 28th, showing low level, southwest upslope flow up to 35kts into the southeast and central Arizona mountains, and intense moisture flux convergence against the Mogollon Rim. Similarly, extreme moisture convergence was likely occurring in the other Southeast Arizona mountains which are not resolved well by the 40km RUC grid spacing.

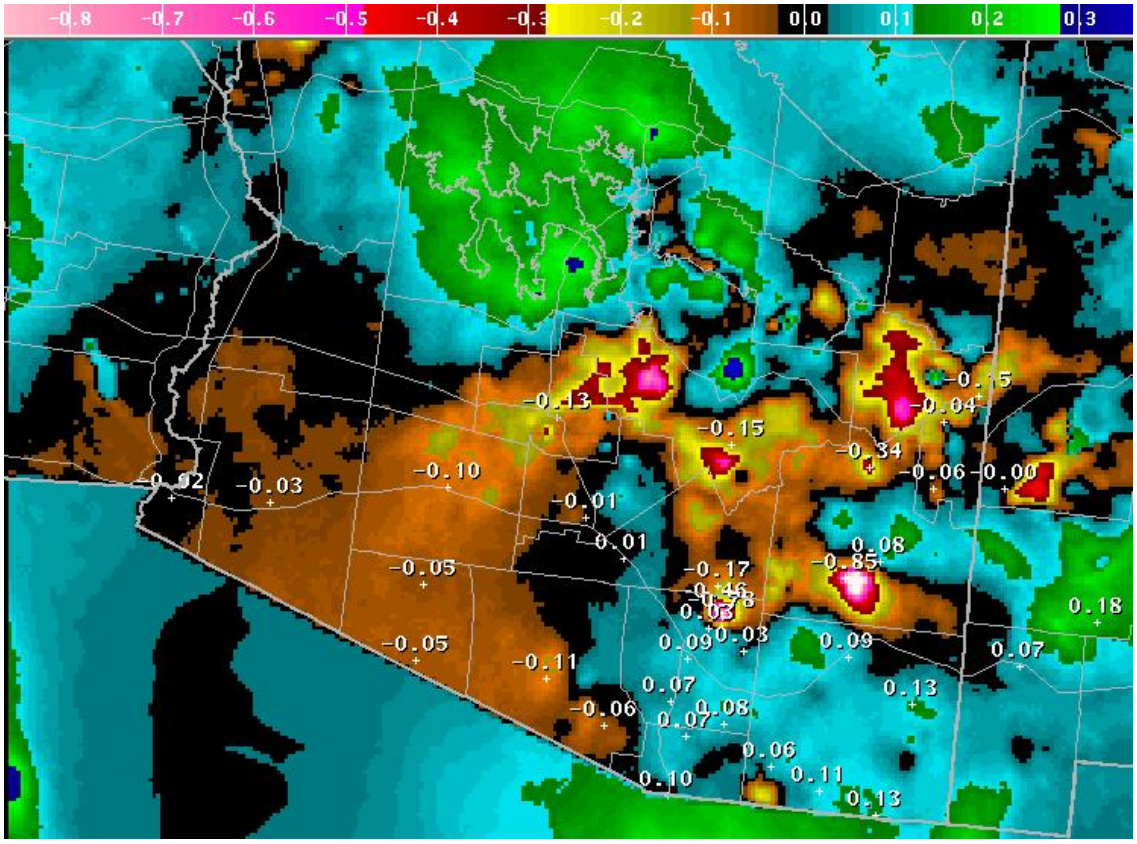

Figure 3: BOIVerify Grid Stats verification output for the TWC Official forecast at 00Z on January 27th. Note the large, dry bias, "bullseyes" in the Catalina, Pinaleno and Huachuca Mountains, and the slight wet bias around Tucson, and valleys to the south and east of Tucson.

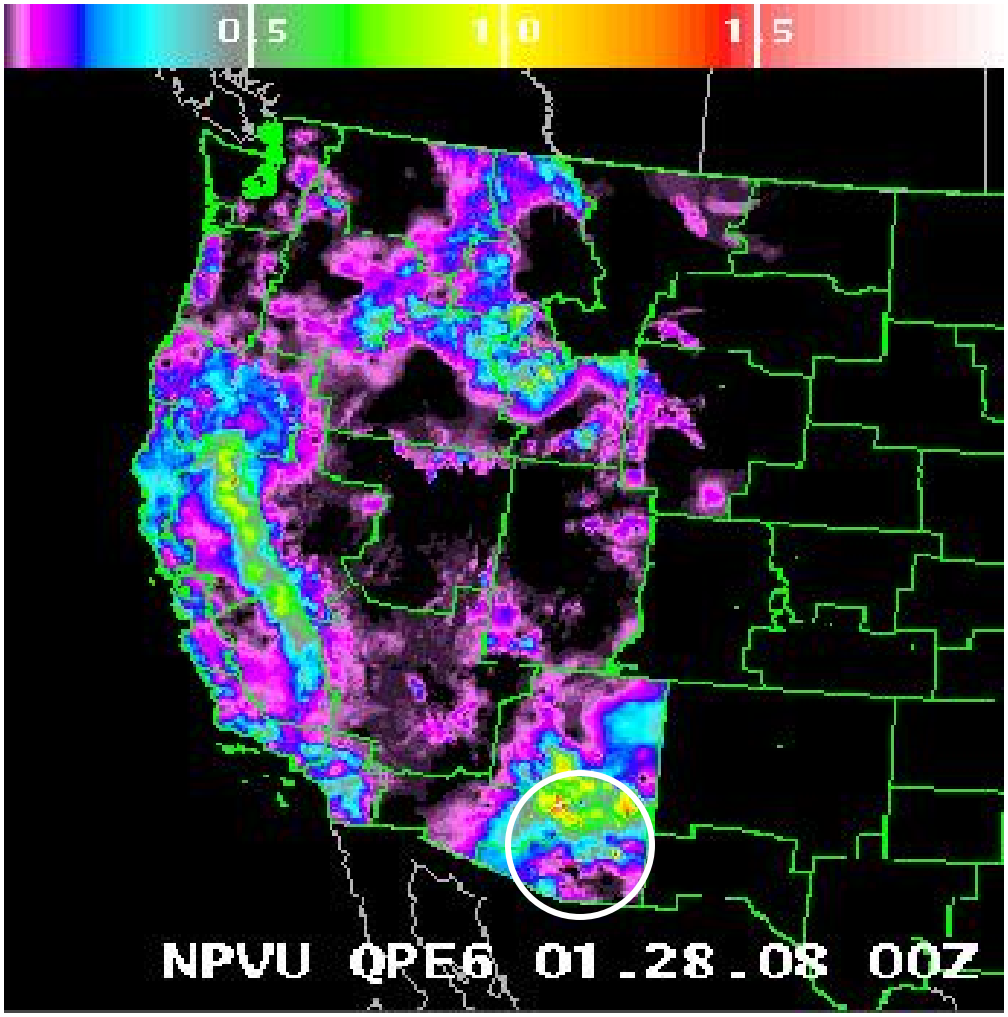

Figure 4: 6-hour observed precipitation snapshot valid 00Z on January 28, 2008 showing the enhancement of precipitation in the Catalina and Pinaleno Mountains and the large rain shadow in the valleys. Note that the 8-inch observed precipitation value mentioned in the text is a storm total amount.

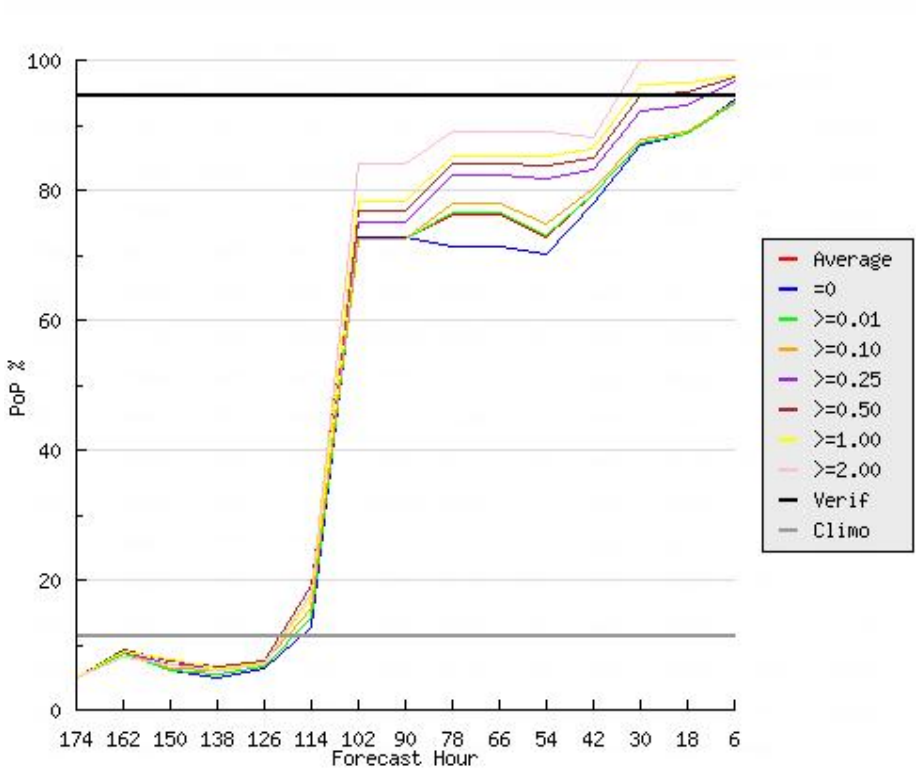

Figure 5: Graph of PoP versus forecast hour before the event showing TWC's trend leading up to the event. Note that all areas which received over 2.00 inches had PoPs at 100% within 30 hours of the event, with areas receiving over 1.00 inch at near 100% PoP. Late January, 12 hour, climatological PoP for the Tucson CWA is around 12 percent.