**Motivation**

- Many key end-users of quantitative precipitation forecasts (QPF) are in need of accurate forecasts (e.g., location, timing, and amount of precipitation) of extreme events (e.g., > 3 in/24 h).
- The current QPF evaluation method (i.e., > 1 in/24 h threat score) is sub-optimal for extreme events which tend to occur less frequently and over smaller areas than weaker precipitation events.

**Objective**

- To develop a QPF evaluation method that is effective for extreme precipitation events and that could be considered for use as a formal performance measure by NOAA.

**Context**

- The Hydrometeorology Testbed (HMT) has led to the development of the data sets used in this study.

**Forecast & Verification Data**

**SITES**

- Northwest river forecast center (NWRFC)
  - 24 sites in WA and OR utilized
- California-Nevada river forecast center (CNRFC)
  - 17 sites in CA utilized

**DATA**

- Winter season: 5 Nov. 2005 to 25 Apr. 2006
- RFC QPFs
  - 24-h forecasts with lead times of 24 h (Day-1), 48 h (Day-2), and 72 h (Day-3)
  - Forecasts made from 12 Z to 12 Z
  - Grid resolution of 4 km
- RFC quantitative precipitation estimates (QPE)
  - Gage-based
  - 12 Z to 12 Z
  - Grid resolution of 4 km

**QPF Performance Measures**

<table>
<thead>
<tr>
<th>Precipitation was measured</th>
<th>Precipitation was not measured</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation was forecast</td>
<td>Hit</td>
<td>False Alarm</td>
</tr>
<tr>
<td>Precipitation was not forecast</td>
<td>Miss</td>
<td>Null</td>
</tr>
</tbody>
</table>

- **POD** (Probability of detection) = Hit/(Hit + Misses)
- **FAR** (False alarm rate) = False alarms/(Hits + False Alarms)
- **CSI** (aka Threat Score) = Hit/(Hit + Misses + False Alarms)
- **MAE** = mean absolute error = mean(abs(QPF-QPE))
- **Bias** = Bias = QPF/QPE

**Extreme Precipitation Sampling**

- An extreme precipitation event occurs at a verification site when the observed precipitation exceeds a predetermined threshold in 24 hours. (Here thresholds are > 3 in/24 h and > 5 in/24 h.)
- During winter 2005-06, CNRFC sites had more extreme events than NWRFC.
- ~50% of CNRFC seasonal precipitation comes from events >2 in/24 h (~23% for > 3 in/24 h)
- ~18% of NWRFC seasonal precipitation comes from events with >2 in/24 h (~7% for > 3 in/24 h)

**Extreme QPF Performance Analysis**

- CNRFC had 16 observed site events > 5 in/24 h but only 2 events were predicted.
- NWRFC had only one observed event > 5 in/24 h.
- CNRFC & NWRFC tend to under-forecast extreme events, especially with longer lead time.

- CNRFC POD decreases and CNRFC FAR increases with lead time and threshold.
- CNRFC POD decreases with lead time faster than CNRFC FAR increases.
- NWRFC POD decreases and NWRFC FAR increases with lead time and threshold.
- MAE increases with lead time and threshold for both RFCs.

**Cooperative Observer Program (COOP) Analysis**

- 24-h accumulated precipitation totals were obtained from 6,088 stations from 1950-2007.
- All records from stations within the boundaries of an RFC region were analyzed together to assess large-area exceedence frequencies for daily precipitation.

**Regional Extreme Precipitation Thresholds**

- Proposed regional extreme precipitation event thresholds (in/24 h) for the 12 CONUS RFCs based on 1% and 0.1% of largest precipitation events.
- Results show 3 tiers of thresholds for extreme events: northern CONUS (yellow), southern & southeastern CONUS plus California-Nevada (green), and the Colorado Basin (orange).

**Conclusions**

- A QPF evaluation method was developed for 24-h accumulated precipitation to assess forecast performance of extreme events.
- Five measures were determined to provide the most useful metrics of extreme QPF performance:
  - POD, FAR, CSI, bias and MAE
- Application of the QPF verification method to the CNRFC and NWRFC regions during HMT 2005/2006 for forecast lead times of 24 h, 48 h, and 72 h indicate:
  - Both RFCs generally under-predicted extreme events
  - POD, FAR, CSI, bias and MAE values became worse with lead time.
- COOP daily precipitation totals were examined to objectively determine regionally relevant thresholds of extreme precipitation events.

**Future Work**

- Evaluation method & regional thresholds will be applied to all CONUS RFCs retrospectively to establish a baseline for future extreme QPF performance.
- In collaboration with NCEP/HPC, method & regional thresholds will be applied to NCEP/HPC gridded QPF data.
- Method & thresholds will be applied to 6-h QPFs to quantify the timing of extreme precipitation within the 24-h accumulation period.