Storm Precipitation Analysis System Real-Time (SPASRT)

Introduction

The Storm Precipitation Analysis System Real-Time (SPASRT) program is a state-of-the-science, operational real-time precipitation analysis tool that produces comprehensive temporal and spatial precipitation information. Designed by Metstat, Inc., Weather Decision Technologies, Inc. (WDT) and Applied Weather Associates, LLC, SPASRT is based on a decade of research, development and application on over 100 storm analyses which have been the foundations of numerous Federal and State approved probable maximum precipitation studies (PMP), forensic meteorological and hydrological cases, and hydrologic model calibration and validation.

Overview

SPASRT is a state-of-the-science system that distributes precipitation in time and space through the combination of observed precipitation and radar data. Utilizing quality controlled Level-II radar and precipitation gauge data, SPASRT develops and applies optimized rainfall-reflectivity (ZR) algorithms on an hourly basis. SPASRT then uses climatological precipitation maps to resolve precipitation in areas with inadequate radar coverage. Additionally, local biases in the ZR relationship are applied. Preliminary results based on hourly precipitation data are available in near real-time, while final precipitation maps/grids are produced daily based on both hourly and daily observed precipitation data.

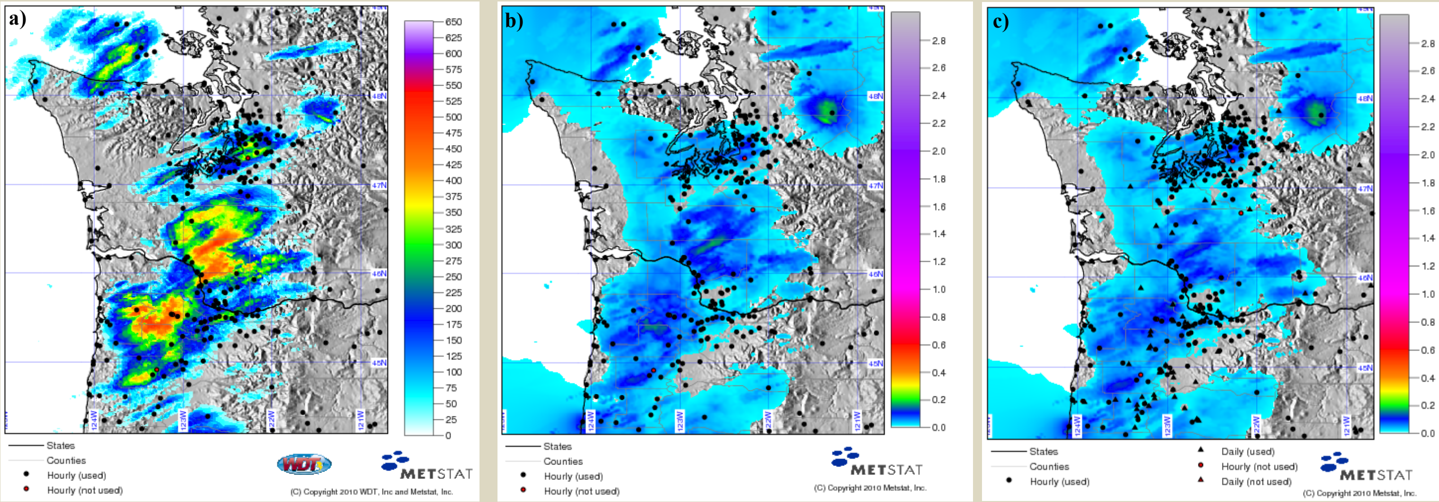

Figure 1. A succession of SPASRT maps: a) 1-hour radar reflectivity (DBZ), b) preliminary 1-hour precipitation (inches) and c) final 1-hour precipitation (inches) for western Washington and Oregon ending at 24 February 2010 2300 UTC.

Quality Control

SPASRT utilizes and implements numerous quality control (QC) measures on both the radar data and precipitation gauge data.

Radar

Level-II base reflectivity NEXRAD radar data from WDT has a temporal resolution of 5 minutes, a spatial scale of 1x1 kilometers and reported at a precision of 0.50 dBZ. WDT utilizes the Radar Data Quality Control Algorithm (RDQC), which removes non-precipitation artifacts from base Level–II radar data. The RDQC algorithm uses sophisticated data processing and a Quality Control Neural Network (QCNN) to delineate the precipitation echoes caused by radar artifacts (Lakshmanan, 2004). Beam blockages due to terrain are mitigated by using elevation data. In areas of radar coverage overlap, a distance weighting scheme is applied to assign reflectivity to each 1 km grid. Once the data from individual radars have passed through the RDQC, they are merged to create a seamless mosaic. By mosaicking multiple radar sites the system has a built in redundancy should there be any single radar outage. A multi-sensor quality control (QC) is applied by post-processing the mosaic to remove any remaining "false echoes".

Precipitation

Observed precipitation data is gathered from the Meteorological Assimilation Data Ingest System (MADIS), which is an integrated, reliable, and operational database containing real-time and archived weather observations; SPASRT is also configurable to access real-time precipitation data from other networks. MADIS operates and executes its own QC since the data is used in National Weather Service forecasts and monitoring products. In addition, SPASRT conducts three additional phases of QC to the MADIS data; the data are removed from the analysis if all QC measures are not meet.

- Spatial – SPASRT utilizes an innovative and effective technique for identifying gauge data that are inconsistent with surrounding stations. (red dot Figure 2)
- High radar reflectivity, but no precipitation – Zero precipitation gauge reports that are grossly inconsistent with the radar data are identified. (yellow dots Figure 2)
- Statistical – Utilizing the ZR relationship, stations are identified that are statistical outliers. (brown dot Figure 2)

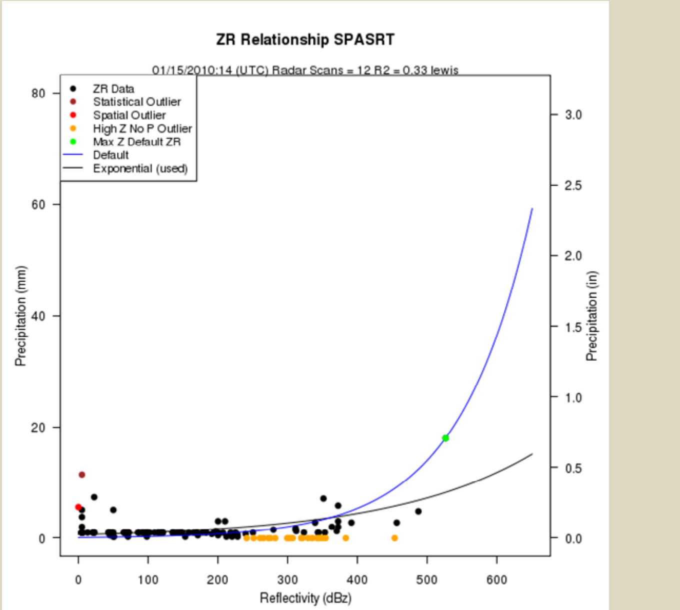

Figure 2. Sample best-fit hourly ZR plot and QC

Dynamic ZR (radar-rainfall) Algorithm

Unlike any other real-time radar-estimated precipitation system, SPASRT calibrates radar with concurrent observed precipitation data each hour which achieves improved accuracy. If sufficient precipitation and radar data are available, a least squares fit is created between the radar reflectivity and gauge precipitation (See Figure 2). When insufficient data are available or the resulting least squares fit has poor statistical characteristics, then SPASRT defaults to either the prior hour ZR relationship or a user-defined ZR relationship. Once a ZR equation is established, it is applied to the radar data to create an initial hourly precipitation grid which is then adjusted to account for local variations in ZR relationship and/or areas with poor/no radar coverage.

Spatial Interpolation

SPASRT utilizes innovative techniques to resolve precipitation in areas with poor radar coverage and/or no gauge data. SPASRT computes an independent grid of hourly precipitation based on the observed gauge data and a climatologically-aided spatial interpolation technique. This technique uses relationships between a “base map,” such as gridded mean monthly precipitation or numerical weather prediction model data, and observed precipitation to spatially distribute precipitation. Each hour, SPASRT blends the gauge-adjusted radar precipitation with the climatologically-aided precipitation to result in an accurate, seamless and consistent precipitation grid. When radar data is unavailable, SPASRT will continue to create gridded precipitation based on the climatologically-aided technique.

SPASRT generates precipitation grids/maps every 5 minutes based purely on radar data then conducts a preliminary gauge-corrected analysis each hour (Figure 1b). Once a day, daily precipitation data is added and a gauge-adjusted SPAS run is conducted to produce final grids (Figure 1c). The latency on the 5 minute, preliminary and final grids is about 1 minute, 20 minutes and 24 hours respectively.

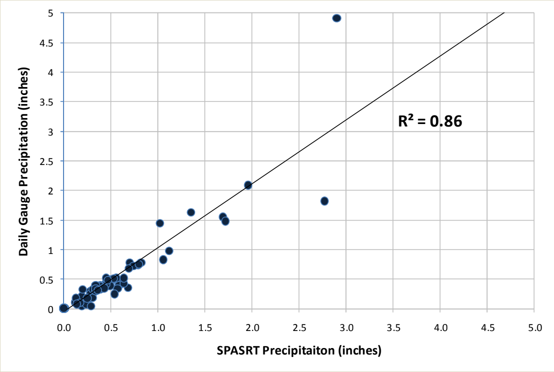

Figure 3. Sample 24-hour validation plot for western Washington and Oregon on 15 Jan 2010.

Validation

Objective comparisons between SPASRT gridded precipitation and independent gauge observations are made daily to assess and verify the performance of SPASRT (Figure 3). Once-a-day observed precipitation (at daily gauges) are compared to the same 24 hour period of accumulated SPASRT hourly preliminary grids. After the validation results have been collected, the once-a-day observations are incorporated into the precipitation database and a final SPASRT run is conducted. This provides a clean reanalysis dataset for future use.

Output

The accurate, high temporal and spatial resolution grids from SPASRT have a multitude of different applications including hydrologic modeling, flood warning systems and reservoir inflow monitoring. Additionally, SPASRT produces two unique products in real-time:

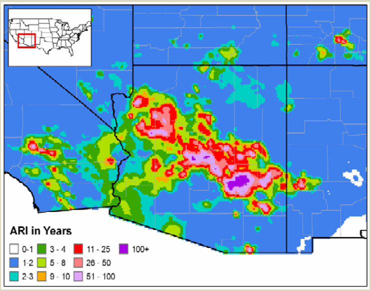

Figure 4. 24-hour ARI of precipitation ending 22 Jan 2010 12Z.

- **Average recurrence interval (ARI) maps** – To make precipitation data more meaningful, SPASRT includes an innovative technique for translating near real-time precipitation grids into “return period” grids (Figure 4). Knowing how much precipitation fell at a particular location during a certain amount of time is useful, but expressing the rarity of precipitation in terms of a “return period” provides an objective and useful perspective of the precipitation. See http://www.metstat.com/Metstat_ARI_FactSheet.pdf
- **Depth-Area-Duration (DAD) analysis** – DAD curves provide a powerful, objective, easy-to-understand three dimensional perspective of storm precipitation (Figure 5). Unlike point precipitation observations, a DAD provides the areal magnitude of a storms precipitation over space and time. Comparisons of the areal size, magnitude and duration of an unfolding precipitation event to other historic storm DADs can be made to aid in decision making processes.

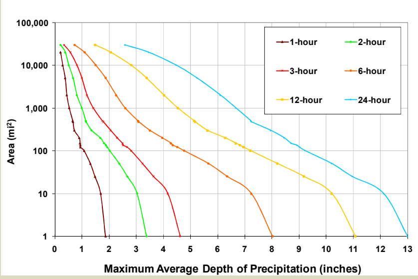

Figure 5. Sample DAD plot.

SPASRT Related References

(Available for download at http://www.appliedweatherassociates.com/)

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Metstat, Inc. - 4764 Shavano Dr - Windsor, CO 80550 - 970.686.1253
Web: http://www.metstat.com
Email: tyep@metstat.com

Applied Weather Associates - PO Box 680 - Monument, CO 80132 - 719.488.9117
Web: http://www.appliedweatherassociates.com/
Email: edtomlinson@appliedweatherassociates.com