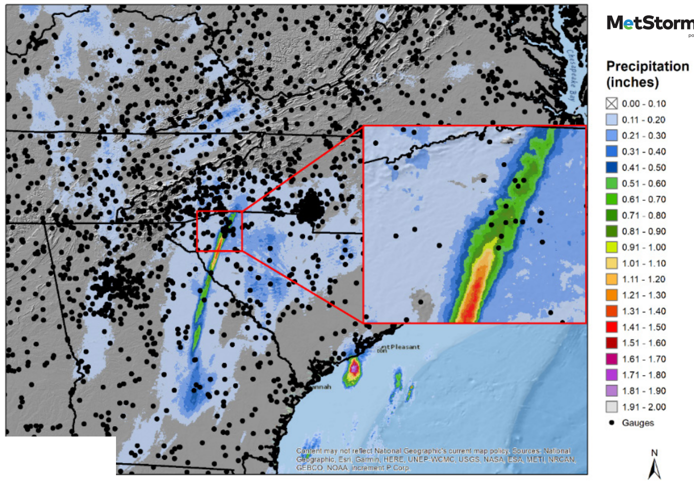
MetStormLive

powered by DTN

Near real-time precision precipitation analytics

www.dtn.com • 877.845.6598

Table of contents



MetStormLive 1-hour Quantitative Precipitation Estimate
Valid 2018-11-15 08UTC - 2018-11-15 09UTC

MetStormLive provides the most accurate, high-resolution near-real-time QPE available in North America. Its algorithms are adaptable world-wide to provide precipitation data globally. DTN is an exclusive owner and operator of MetStormLive.

Introduction

MetStormLive is an expert system that integrates quality-controlled precipitation gauge data, dual-polarimetric (dual-pol) radar-estimated precipitation data, satellite-estimated precipitation data and innovative algorithms for computing precipitation analytics, including Quantitative Precipitation Estimates (QPE). Near real-time QPE support media inquiries, hydrologic modeling calibration and validation, flood responses, forensic cases, insurance claims, emergency management, and situational awareness.

MetStormLive is based on over a decade of research and development. MetStormLive's core data, algorithms and innovations are based on the newest, state-of-the-science technology. MetStorm, a post-storm product, was initially developed as a post storm tool in 2014, based on the need for an updated storm analysis software that has capabilities beyond what was available at the time. MetStormLive was developed in 2015 to meet the demand of near real-time QPE and is continuously being monitored and undergoing improvements. Precision MetStorm analyses are used to create engineering-quality datasets for extreme precipitation projects to support hydro-meteorological applications, such as Probable Maximum Precipitation studies, stochastic flood modeling, hydrologic model calibration/validation, extreme precipitation risk analyses, forensic cases, asset monitoring, situational awareness, insurance claims, and infrastructure design/operation projects.

MetStormLive is a Geographic Information System (GIS) based analysis system that produces gridded precipitation at 5-minute and/or 1-hour intervals over a specified domain (Laro, 2015; Parzybok, 2015) in the robust and reliable Amazon Web Services cloud environment. The relative spatial precipitation patterns are largely governed by DTN Polarimetric Radar Identification System (POLARIS) quantitative precipitation estimates (QPE). The POLARIS QPE is a mosaic of dual-pol radar-estimated precipitation at a spatial resolution of 250 m^2. Meanwhile, the precipitation magnitudes of MetStormLive grids are influenced by quality-controlled rain gauge data from our strategic partner, Synoptic Data Corp. MetStormLive integrates hourly measured precipitation data, thereby providing a high degree of gauge density for "ground truthing." Satellite data, though at a coarser spatial resolution (4 km^2), influences areas void of rain gauge and/or radar data. Innovative algorithms blend the precipitation estimates from the different sources into a seamless GIS grid, which provides the basis for summary statistics, maps, tables, image tiles and plots.

Input data

MetStormLive uses seven (7) key inputs to produce accurate gridded precipitation. Those inputs are briefly described below.

1. **Precipitation gauge data** - Measured precipitation from hourly precipitation gauges are a critical and required input to provide a high degree of gauge density for "ground truthing." MetStormLive automatically accesses quality-controlled precipitation gauge data from our strategic collaborator, Synoptic Data Corp, who aggregates, quality controls and archives hourly precipitation gauge data from over 200 networks, resulting in nearly 25,000 gauges, across North America each hour. Synoptic's 1-hour precipitation data are quality-checked using a multi-sensor quality assurance system designed and maintained by DTN.
2. **Basemaps** - Basemaps are independent grids of spatially distributed weather or climate variables that are used to help govern the spatial patterns of hourly precipitation, particularly in areas where radar is either not available or of poor quality. The basemap provides a consistent, stable, and spatial reflection of how the precipitation typically falls over a region. For MetStormLive analyses over complex terrain, climatological basemaps, such as PRISM mean monthly precipitation (Figure 2), are often used given they resolve orographic enhancement and micro-climates. The climatologically-aided interpolation approach used by MetStormLive effectively resolves precipitation among complex terrain.
3. Gridded dual-pol precipitation - MetStormLive uses Quantitative Precipitation Estimates (QPE). These are state-of-the-science dual-polarization (dual-pol) precipitation estimates from DTN Polarimetric Radar Identification System (POLARIS). The POLARIS QPE grids are a mosaic of dual-pol estimated precipitation from all 143 contiguous U.S. and 30 Canadian NEXRAD radar sites. Depending on the precipitation type (e.g. wet snow, light rain, heavy rain, etc.) determined by the dual-pol radar data, an optimized radar-to-precipitation rate algorithm is utilized to compute precipitation at 5-minute intervals at a spatial resolution of 250 m^2 (Figure 3). MetStormLive imposes a gauge-adjustment process on the POLARIS QPE grids to make their magnitude consistent with the precipitation gauge measurements.

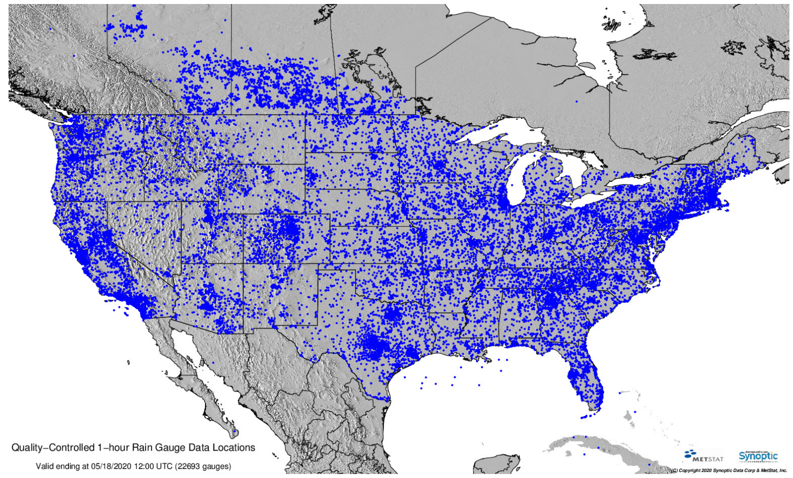


Figure 1: 1-hour precipitation gauge locations used in MetStormLive

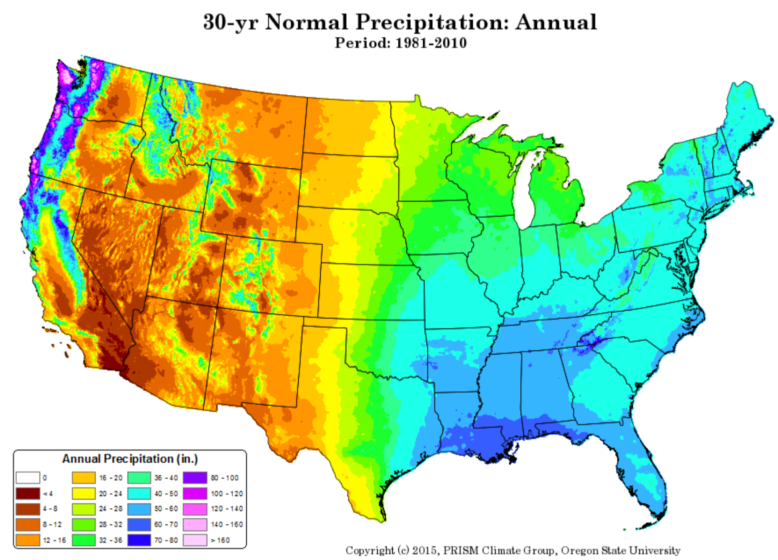


Figure 2: Mean annual precipitation map commonly used as a MetStormLive basemap

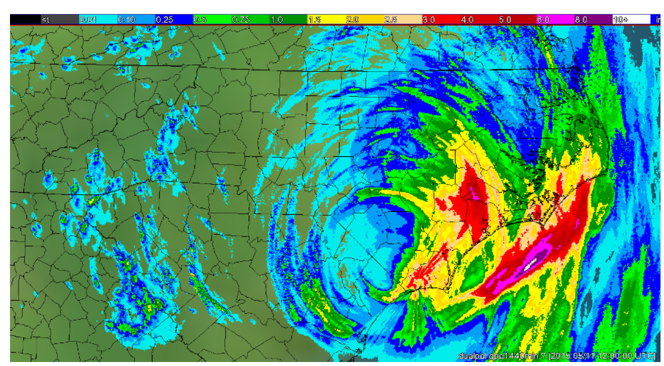


Figure 3: PQPE along coastal North Carolina on May 11, 2015 associated with tropical storm Ana

4. Radar reflectivity - Level-II radar reflectivity is the native data analytic provided by NEXRAD weather radars across the United States. WDT supplies mosaiced and quality-controlled radar reflectivity data to MetStormLive, which translates it into a traditional radar-estimated precipitation rate using a standard Z-R algorithm. Our research and development has shown the combination of PQPE and traditional radar-based QPE provide better a precipitation estimation among complex terrain compared to POLARIS QPE alone.
5. Radar reflectivity heights - In order to quantify the quality of the radar data (both POLARIS QPE and reflectivity) across the analysis domain, MetStormLive uses the lowest altitude (above mean ground level) of the radar beam. Generally speaking, a radar beam sampling precipitation closest to the ground is most reliable. Therefore, a function between a radar weight (ranging from 0 to 1) and radar beam height is imposed to create a radar-weight grid; this provides MetStormLive with an objective means for determining where gauge-adjusted radar-estimated precipitation can be relied upon more than a purely basemap-driven interpolation of precipitation.
6. Satellite precipitation - Satellite-based estimates of rainfall have been used since the late 1970s, especially in areas where rain gauge or radar data are unreliable or unavailable. Similarly, MetStormLive uses satellite-estimated precipitation data, though coarse spatial resolution (4 km^2), to influence areas void of rain gauge and/or radar data. MetStormLive ingests 1-hour satellite rainfall estimates (see Figure 6) known as "Hydro-Estimator" from NOAA's Center for Satellite Applications and Research (STAR), but could be adapted to accept other satellite-precipitation products. The Hydro-Estimator uses infrared (IR) satellite data from NOAA's Geostationary Operational Environmental Satellites (GOES) to estimate rainfall rates. The estimated rainfall rates are most accurate during the warm season in areas of deep convection (thunderstorms). The relative magnitudes of satellite rainfall are used for aiding the spatial interpolation of gauge data in MetStorm.

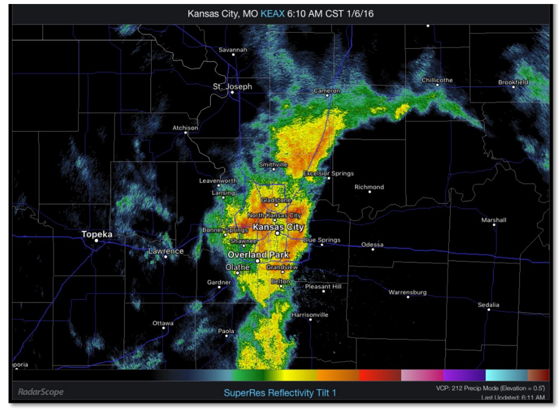


Figure 4: High-resolution radar reflectivity Sample from January 6, 2016

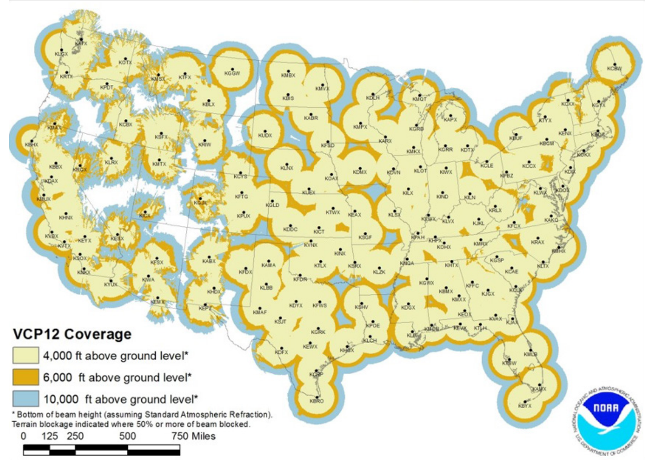


Figure 5: Map of U.S. radar locations and extent of coverage

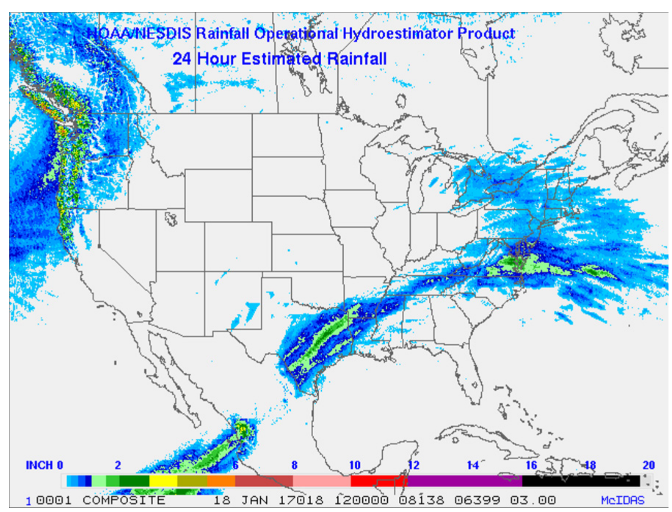


Figure 6: STAR satellite-estimated precipitation from January 18, 2017

7. Radar beam blockage mask - It is widely understood that radar coverage is often compromised by terrain or other tall features (e.g. buildings). To over-come this, we have developed a radar beam blockage mask using a climatology of radar echoes. The mask (white areas in Figure 7) identifies areas that have no or poor radar coverage that MetStormLive infills using a GIS function, thereby providing a seamless grid of precipitation across varied terrain.

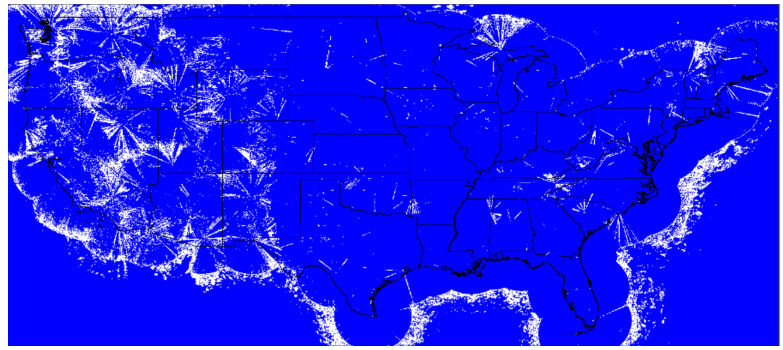


Figure 7: Radar beam blockage mask applied during MetStormLive processing. White areas are frequently blocked or beyond reliable radar coverage and require infilling.

Methods

MetStormLive is an integrated expert system that leverages the strengths of the DTN radar data, Synoptic's gauge data and over a decade of R&D at DTN. The integration and use of each of the inputs is conveyed in Figure 8. The MetStormLive system, as well as the independent gauge acquisition, consolidation, and QC system, operate in the Amazon Web Services Cloud environment. This provides a scalable, fast, and reliable computing platform for the heavy computations associated with MetStormLive. To leverage the large sample size of standardly reported 1-hour gauge precipitation, MetStormLive creates gauge-adjusted grids of precipitation each hour, then has the ability to disaggregate them into 5-minute intervals.

MetStormLive provides a quick-look ("min0"), preliminary ("min15)" and a final ("min360") QPE product each hour with a greater emphasis on accuracy versus latency. The "quick-look" product is available within approximately 30 minutes after the hour, whereas the preliminary and final products are available 1 and 7 hours after the valid hour.

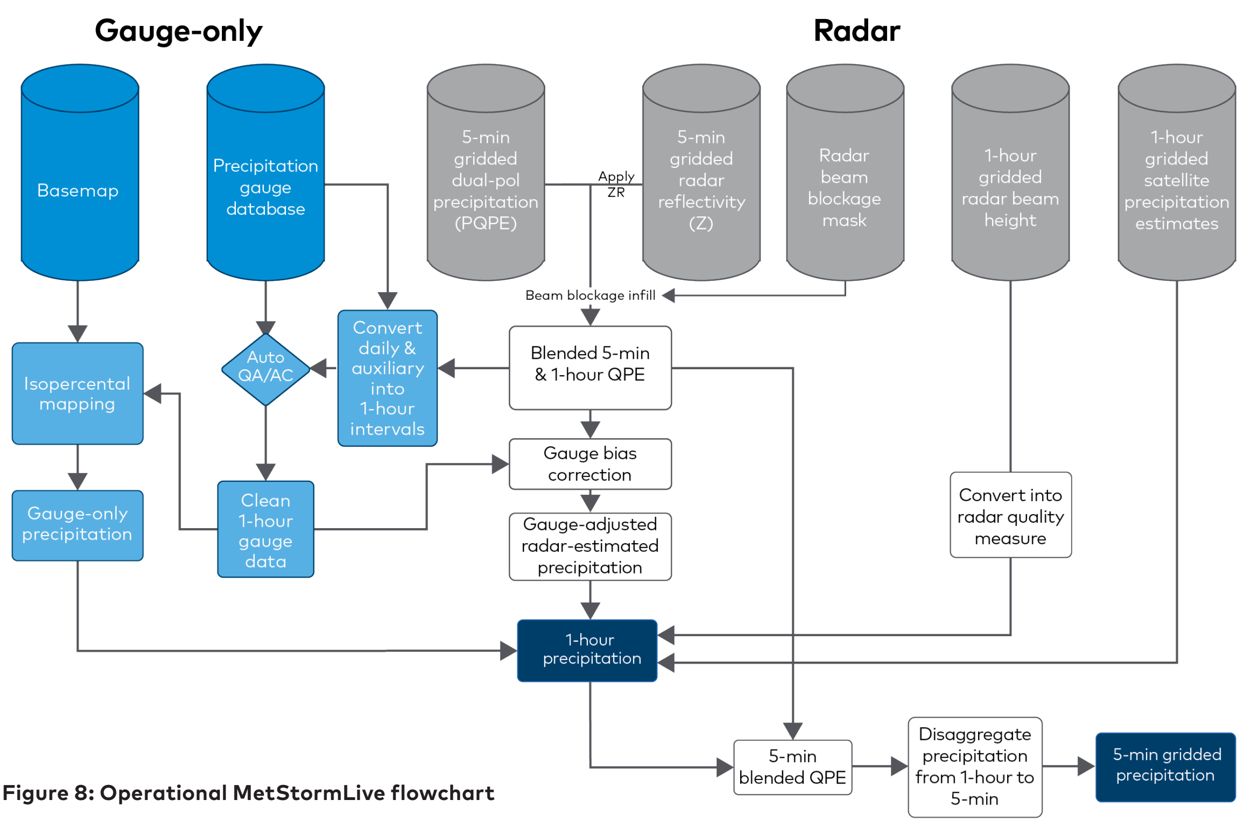


Figure 8: Operational MetStormLive flowchart

Output

MetStormLive produces high-resolution (250m^2) 1-hour grids of precipitation that serve as the basis for a variety of formats and accumulation periods (e.g. 24-hour). The native output of MetStormLive are ESRI ASCII grids in a generic projection; this is a convenient format for importing into GIS, MapServers and other applications. MetStormLive content is also easily reformatted to meet customized client needs. The QPE content is available via several delivery methods, including:

- AWS S3
- HTTPS (See example in Figure 9)
- FTP
- APIs (Climate Analysis API)
- Online interfaces/dashboards (e.g. WeatherOps, iMap – See example in Figure 10)
- ESRI Map Server
- Mobile Apps
- Local Data Manager (LDM)

For more information about MetStormLive and/or its output options, please contact us at info@DTN.com or (970) 460-6401.

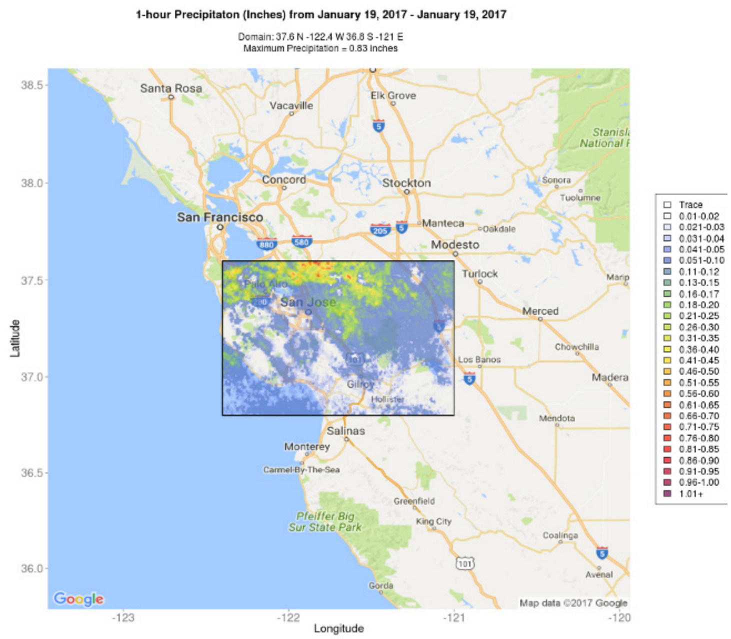


Figure 9: Sample 1-hour clipped QPE map image provided via HTTP

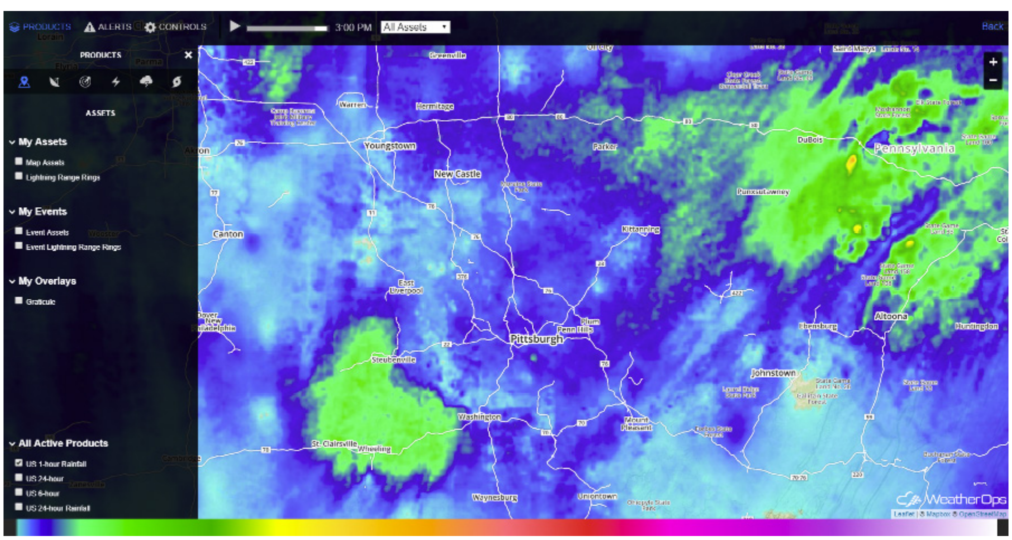


Figure 10: Sample 1-hour MetStormLive QPE in WeatherOps Commander online interface

Comparisons

There are several gauge-adjusted Quantitative Precipitation Estimates (QPE) available for the Continental United States (CONUS). What makes MetStormLive stand out is its innovative algorithms, which blend several gridded and point precipitation estimates together, as well as the underlaying quality-controlled gauge network which anchors the MetStormLive QPE magnitudes, and lastly, its high spatial resolution. The gauge network leveraged is not only quality controlled prior to integration in the MetStormLive algorithm, but it is also far denser than any used by other gauge-adjusted QPE products available. The following figures are 1-hour comparisons of MetStormLive QPE (Figure 13) to the National Centers for Environmental Prediction (NCEP) Stage IV QPE (Figure 11) and to the National Severe Storms Laboratory (NSSL) Multi-Radar Multi-Sensor (MRMS) QPE (Figure 12) for a sample hour. Also included below are figures of the gauge influence map for the MRMS QPE (Figure 14) as compared to the gauges used in MetStormLive QPE (Figure 15).

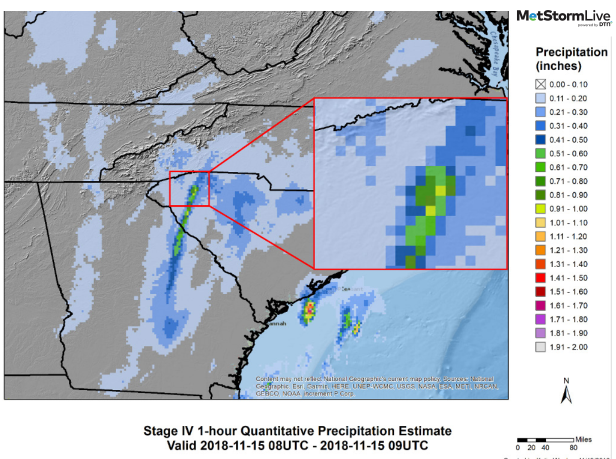


Figure 11: Stage IV 1-hour QPE valid at 09 UTC on November 15, 2018

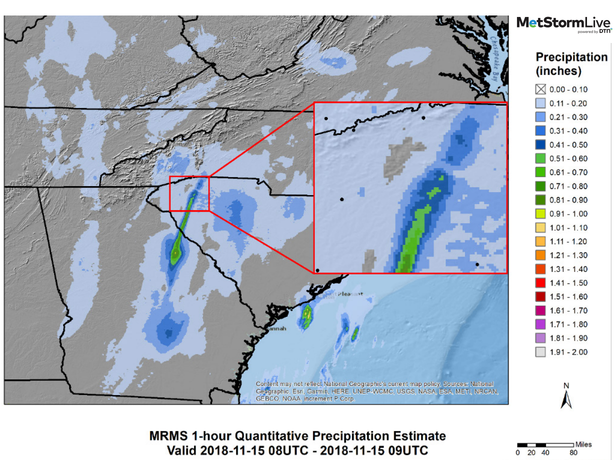


Figure 12: MRMS 1-hour QPE and gauge locations (inlay) valid at 09 UTC on November 15, 2018

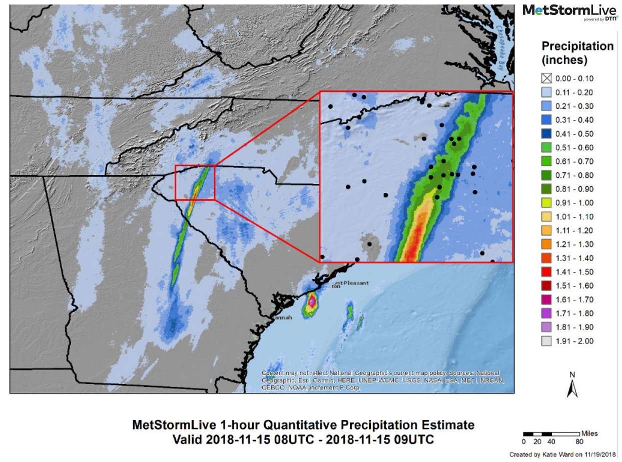


Figure 13: MetStormLive 1-hour QPE and gauge locations (inlay) valid at 09 UTC on November 15, 2018

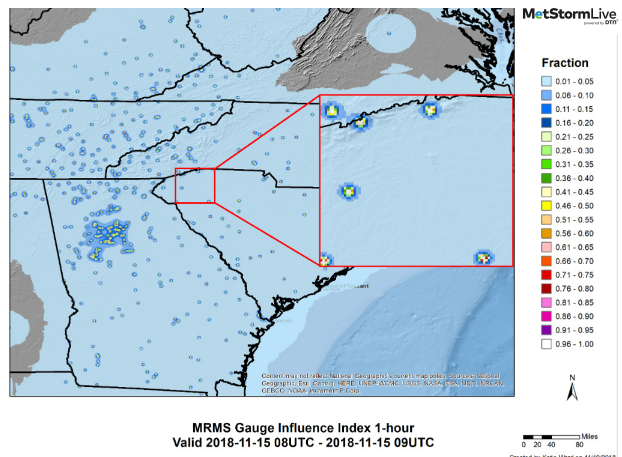


Figure 14: MRMS 1-hour gauge influence index valid at 09 UTC on November 15, 2018

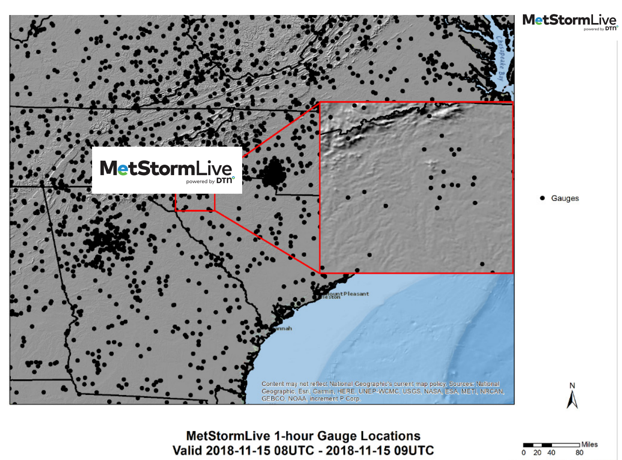


Figure 15: MetStormLive 1-hour gauge data valid at 09 UTC on November 15, 2018

Daily station integration

In early 2018, an advancement to the MetStormLive algorithm was developed to incorporate daily station data from the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network. CoCoRaHS is a volunteer citizen science network comprised of observers from all over the country. This network is critical in anchoring the gridded MetStormLive QPE in remote and/or complex terrain areas, where observers are located but automated gauge networks don't exist. Inclusion of this network is also beneficial to help adjust the sometimes-underreporting hourly gauges. Automated tipping buckets, which are many of the hourly gauges used in QPE products, can be susceptible to underestimating precipitation, particularly in high intensity precipitation events as the tipping mechanism cannot keep up with the amount of rain funneling through the gauge. Below are figures comparing MetStormLive QPE without and with the CoCoRaHS network over the state of Colorado over a 24-hour period ending 12 UTC June 18, 2018.

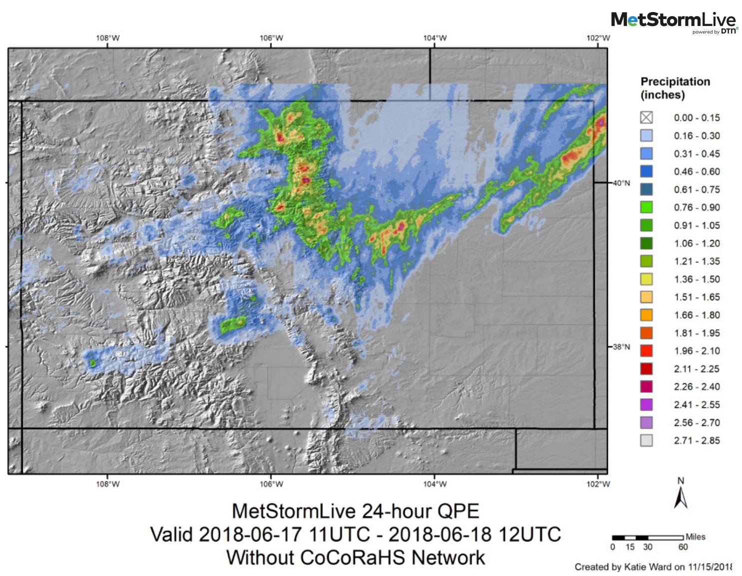


Figure 16: MetStormLive 24-hour QPE without the inclusion of the CoCoRaHS network

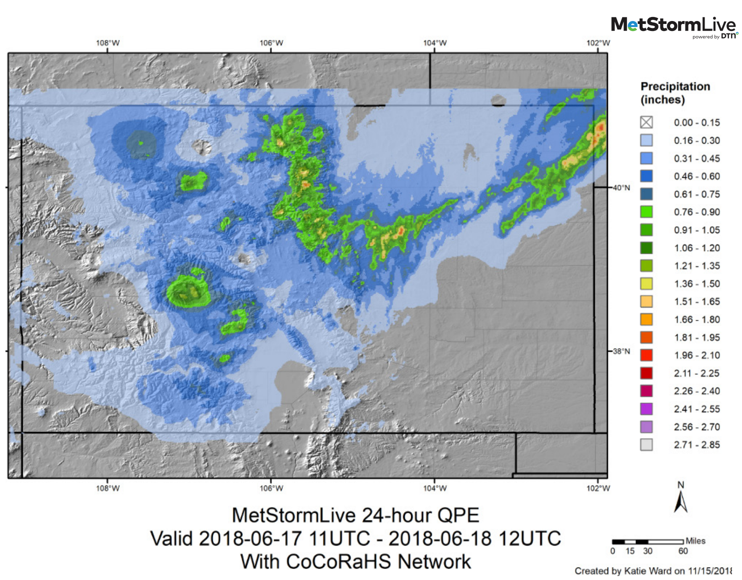


Figure 17: MetStormLive 24-hour QPE with the inclusion of the CoCoRaHS network

References

McGee, T., Katie Ward, Tye Parzybok, David St. John, 2019: "Development of Continuous Learning, Artificial Intelligence Algorithms for Quality Control, and Autocalibration of Haptic Rain Gauge Sensors Using Near-Real-Time Precipitation Products." 99th American Meteorological Society Annual Meeting, January 7-10, 2019, Phoenix, AZ.

Laro, K., T. Parzybok, C. Porter, A. MacKenzie: Cloud Computing for Near Real-time Precipitation Analytics. 2017 National Hydrologic Warning Council Annual Meeting, June 5-8, 2017, Squaw Creek, Olympic Valley, CA

Laro, K., B. Wells, T. Parzybok, C. Galli, J. Young: Nationwide Precipitation Gauge Measurement Acquisition, Quality Control, and Integration into Hydrometeorological Applications. AMS 2017, January 2017, Seattle, WA.

Parzybok, T., K. Laro, R.J. Caldwell, M. Schaefer, G. Taylor and E. Tomlinson: Advances in Extreme Precipitation Methodologies. In Proc. ASDSO Dam Safety 2016, Sept 15, 2016, Philadelphia, PA.

Parzybok, Tye, Katie Laro, Alyssa Hendricks, and Jason Caldwell, 2016. "Latest Perspective on Extreme Storm Precipitation Analysis." World Environmental & Water Resources Congress, Invited Speaker, May 22-26, 2016, West Palm Beach, FL.

Laro. K., T. Parzybok, A. Hendricks: A MetStorm® Analysis on the Lower Mississippi River Valley Storm of March 2016. The National Hydrologic Warning Council Transmission April 2016.

Hendricks, A.D., Parzybok, T.W., Laro,K.L., Mokry, W, 2015. MetStormLive - Near Real-Time Storm Precipitation Analytics. Presented at GIS in the Rockies Conference, Denver, CO, September 2015.

Laro, Katie and T. Parzybok. 2015: MetStorm:® Near Real-time Storm Precipitation Analytics. 11th National Hydrologic Warning Council Training Conference and Exposition. Indianapolis, Indiana. June 15-18, 2015.

Parzybok, T., N. A. Lock, C. W. Porter, K. Laro, A. D. Hendricks, and W. Mokry Jr. 2015: MetStorm:® Near Real-time Storm Precipitation Analytics Using Dual-pol Radar Data. 37th Conference on Radar Meteorology. Norman, OK. September 13-18, 2015.