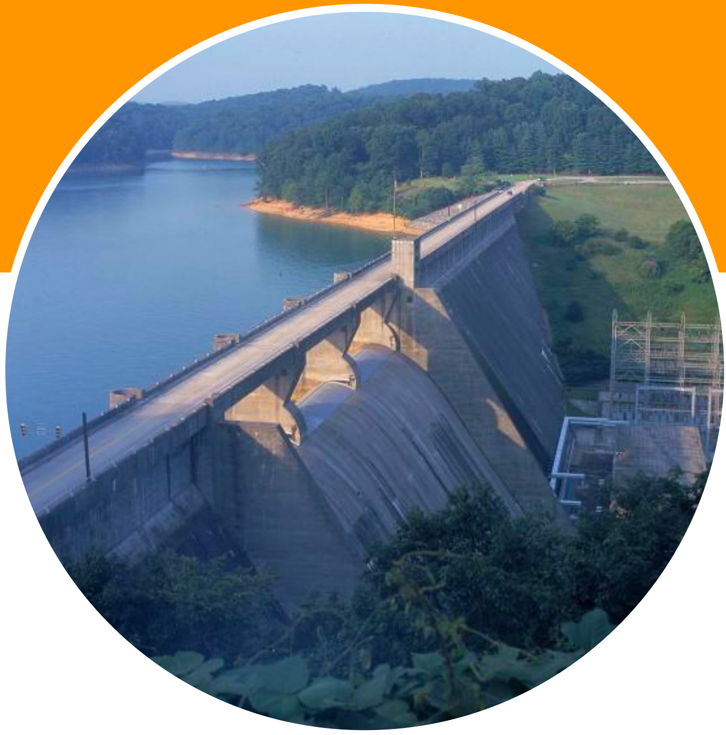
Operational Precipitation Analysis and Prediction Using Satellite Data over Tennessee Valley Authority Watersheds



SUMMARY

Key Points

- The satellite derived precipitation (SDP) product CMORPH is used operationally for precipitation analysis and prediction for watersheds of the Tennessee Valley Authority (TVA)
- GIS technology allows area statistics such as past rainfall accumulation at various time scales (from 24-hr to 180-day) to be provided for each one of the 27 water basins and above each dam of the TVA. Also provided are forecasts of daily precipitation from NOAA GFS (Global Forecast System) for up to 7-day.
- The case provides useful information of current and future hydrological conditions for a wide range of users (government agencies, water resource managers, agriculture, energy suppliers, tourism).

Service

- Agriculture
- Energy
- Flood management

End users

- Government agencies
- Industry
- Local communities

Intermediate user(s)

- Robert Blevins (Meteorological Connections, LLC). Case developer for the TVA.

Application(s)

- The SDP product CMORPH (part of the NOAA CDR program) is used operationally for precipitation analysis and prediction for watersheds of the Tennessee Valley Authority (TVA).
- Derived precipitation products include past rainfall accumulation at various time scales (24-hr, 3-, 7-, 10-, 30-, 90-, 180-day). It also includes forecast of daily precipitation from NOAA GFS (Global Forecast System) for the next 7-day (1-, 2-, 3-, 4-, 5-, 6-, 7-day).
- Information is provided at the watershed level for 27 watersheds of the TVA. The high resolution satellite precipitation product, combined with the use of GIS, allows for the computation of area statistics by water basin above each dam (water resource, agriculture, energy).

Essential Climate Variables

—Atmospere

- Precipitation

—Land

- Lakes
- River discharge

Models

- CMORPH is a SDP at 25-km/1-hr and 25-km/daily resolution. A higher resolution version is also available at 8-km/30-minute resolution (native resolution). The CMORPH datasets at the three above mentioned temporal/spatial resolution are available at:

https://www.ncei.noaa.gov/data/cmorph-high-resolution-global-precipitation-estimates/access/

Satellite observation used

CMORPH is a multi-satellite precipitation product available from 1998 to the delayed present (3-month to the date for the final CDR version and within a day for the Interim ICDR version) that incorporates in-situ observations for bias-adjustment. CMORPH combines precipitation estimates derived from passive microwave (PMW) sensors through the advection of cloud features from more frequently available infrared (IR) measurements (i.e. the morphing technique). The bias-adjusted version of the product uses daily surface gauge analysis from the Climate Prediction Center (CPC) over land (Xie et al. 2010) and the Pentad version of the Global Precipitation Climatology Project (GPCP; also a CDR) over ocean. More details regarding the CMORPH algorithm and precipitation products can be found in the scientific literature (Joyce et al. 2004, Xie et al. 2017, 2018). Different PMW and IR satellite sensors are used to produce CMORPH. Those sensors have been subject to changes depending on the lifespan of the remotely sensed platform that carried those sensors. The CMORPH CDR uses data from the following instruments: AMSR-E, AMSR-2, SSM/I, SSMIS, AMSU-A and -B, MHS, TMI, GMI. It also uses infrared data from five geostationary satellites, including the GOES, Meteosat and GMS series.

Sustainability of service (demonstration or ongoing)

This Use Case process continues to be used operationally.

DESCRIPTION

Gridded satellite precipitation products (SPPs) can be used for multiple applications. Their constantly increasing period of record make them now suitable for hydrological and hydro-climatological applications. Unlike in-situ observations that provide only point measurement which makes it difficult to capture convective precipitation, gridded SPPs provide area average precipitation. In many cases and applications in hydrology, energy, agricultural modeling, and water resources among others, area precipitation is as critical if not more critical than the point observation.

The SDP product CMORPH (part of the NOAA CDR program) is used operationally for precipitation analysis and prediction for watersheds of the Tennessee Valley Authority (TVA). The work consists in integrating and comparing precipitation to typical (precipitation normal) and/or other years for several periods of accumulation (anomalies). The use of GIS technology allows area statistics to be provided for each one of the 27 water basins and above each dam of the TVA (Figure 1). The area averaging of precipitation tends to mitigate the absolute errors of the SDP data which are known to chronically under estimates high rainfall values and over estimates low rainfall values. It takes advantage of the relative high resolution and grid characteristics of the gridded SPP to minimize the uncertainties associated with individual pixels. Moreover, using SDP in a comparative sense such as anomalies and percent of normal precipitation provides information useful for analysts and decision makers.

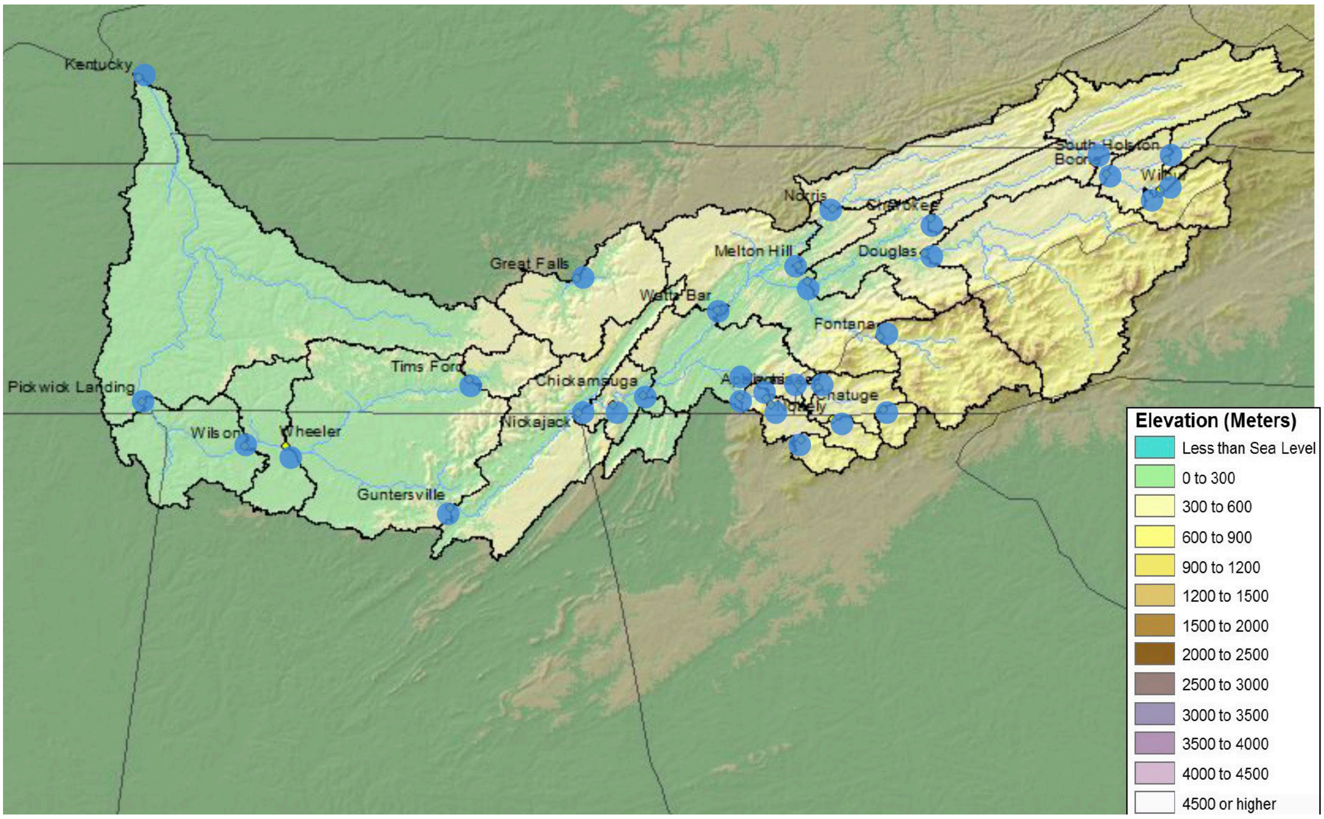


Figure 1. TVA watershed analysis: elevation and terrain (1 km elevation data).

The analysis component of the use case consists in the development of added value products derived from CMORPH. Figure 2 displays a selection of the added value products such as total precipitation at various scales (*24-hr, 7-, 30-, 18-day, month to date*) and precipitation anomalies (*180-day*). Results of the precipitation analysis derived from CMORPH is provided at each one of the watershed of the TVA (Figure 3).

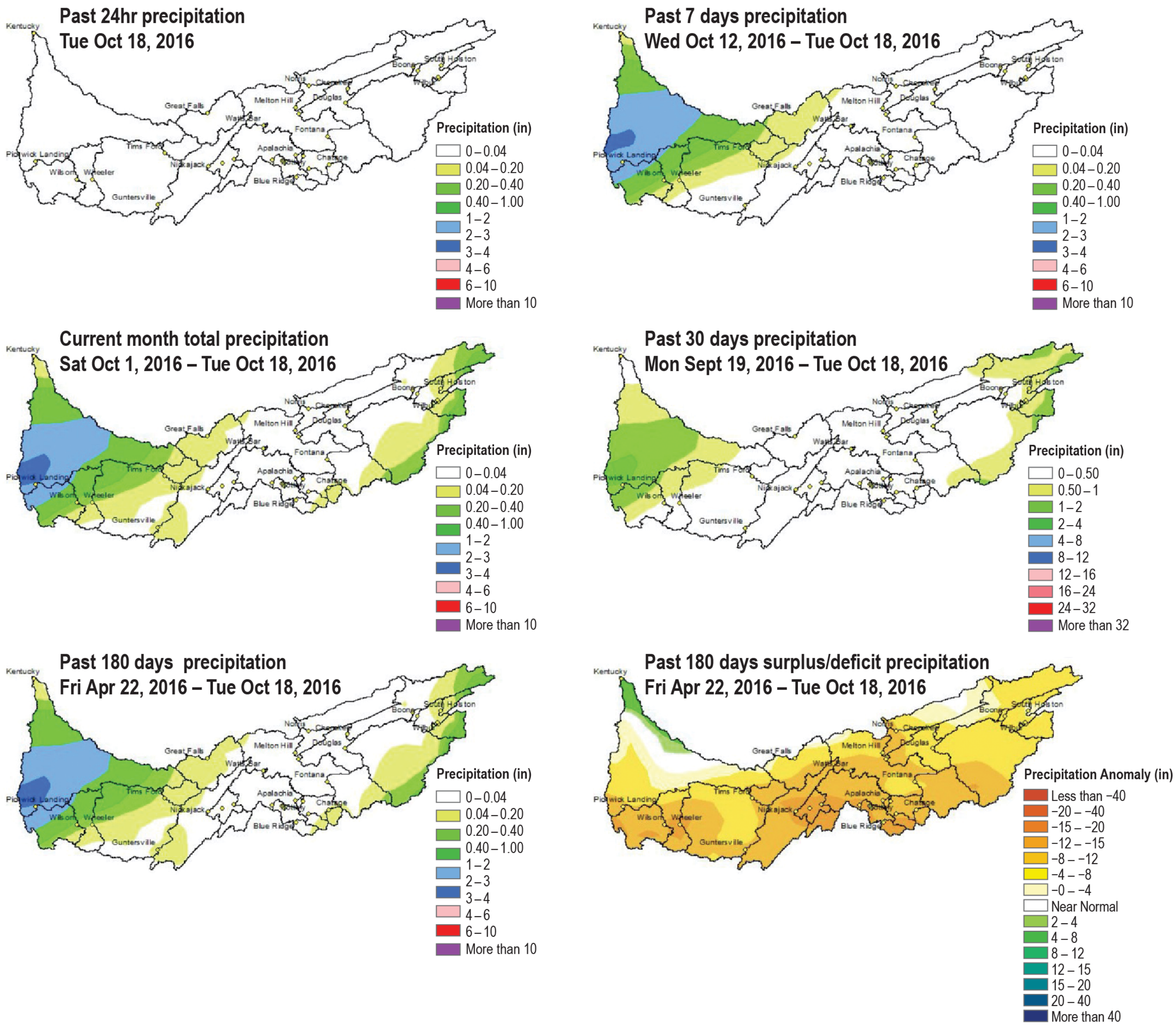


Figure 2. TVA watershed analysis derived from CMORPH. Past 24hr precipitation on October 18, 2016; past 7 days precipitation from October 12, 2016 to October 18, 2016; current month rainfall accumulation from October 1, 2016 to October 18, 2016; past 30 days precipitation from September 19, 2016 to October 18, 2016; past 180 days precipitation from April 22, 2016 to October 18, 2016; and past 180 days surplus/deficit precipitation from April 22, 2016 to October 18, 2016.

TVA Basins	Total Precipitation					
	Past 180 Days	Past 90 Days	Past 30 Days	Current Month	Past 10 Days	Past 7 Days
Wilson	19.58	7.56	0.49	0.48	0.48	0.48
Wheeler	18.64	6.52	0.20	0.18	0.17	0.16
Watts Bar	15.05	4.36	0.08	0.01	0.01	0.01
Watauga	13.49	4.15	0.94	0.27	0.00	0.00
Tims Ford	17.93	7.33	0.34	0.31	0.31	0.31
South Holston	14.87	4.62	0.63	0.12	0.00	0.00
Raccoon Mountain	10.99	4.08	0.07	0.01	0.01	0.00
Pickwick Landing	18.87	6.95	0.74	0.74	0.74	0.74
Ocoee	11.11	4.04	0.14	0.00	0.00	0.00
Nottley	9.58	2.60	0.12	0.03	0.00	0.00
Norris	16.92	6.03	0.23	0.02	0.01	0.01
Nickajack	8.87	3.16	0.12	0.00	0.00	0.00
Melton Hill	14.52	4.44	0.11	0.02	0.02	0.02
Kentucky	25.99	12.26	1.07	1.05	1.04	1.03
Hiwassee	11.64	2.83	0.22	0.02	0.00	0.00
Guntersville	13.74	4.21	0.07	0.05	0.04	0.02
Great Falls	16.98	5.99	0.13	0.11	0.11	0.11
Fort Patrick Henry	14.65	4.30	0.49	0.08	0.00	0.00
Fort Loudoun	14.43	4.39	0.12	0.02	0.01	0.01
Fontana	11.67	2.96	0.29	0.03	0.00	0.00
Douglas	12.72	4.01	0.35	0.10	0.00	0.00
Chickamauga	12.10	4.57	0.14	0.00	0.00	0.00
Cherokee	14.78	4.63	0.56	0.10	0.00	0.00
Chatuge	11.29	2.77	0.31	0.03	0.00	0.00
Boone	14.26	4.02	0.43	0.07	0.00	0.00
Blue Ridge	10.47	3.44	0.14	0.00	0.00	0.00
Appalchia	12.50	3.01	0.24	0.01	0.00	0.00

TVA Basins	Surplus/Deficit Precipitation					
	Past 180 Days	Past 90 Days	Past 30 Days	Current Month	Past 10 Days	Past 7 Days
Wilson	−9.54	−5.30	−2.80	−1.25	−0.59	−0.37
Wheeler	−7.99	−4.40	−2.80	−1.29	−0.69	−0.49
Watts Bar	−7.72	−4.87	−2.69	−1.16	−0.70	−0.46
Watauga	−5.31	−3.58	−1.34	−0.90	−0.63	−0.39
Tims Ford	−8.18	−3.36	−2.55	−1.13	−0.56	−0.32
South Holston	−4.11	−3.33	−1.41	−0.91	−0.59	−0.39
Raccoon Mountain	−12.16	−5.49	−2.74	−1.21	−0.72	−0.45
Pickwick Landing	−10.70	−6.34	−2.57	−1.02	−0.38	−0.09
Ocoee	−11.29	−5.35	−3.01	−1.29	−0.73	−0.48
Nottley	−12.05	−6.47	−3.11	−1.28	−0.64	−0.42
Norris	−4.07	−2.43	−2.16	−1.02	−0.60	−0.39
Nickajack	−14.58	−6.73	−2.99	−1.25	−0.74	−0.44
Melton Hill	−7.82	−4.50	−2.54	−1.10	−0.64	−0.40
Kentucky	−2.80	0.40	−2.27	−0.80	−0.15	0.18
Hiwassee	−9.54	−5.99	−2.88	−1.25	−0.67	−0.42
Guntersville	−10.27	−5.45	−2.69	−1.27	−0.72	−0.49
Great Falls	−7.31	−3.89	−2.55	−1.16	−0.65	−0.44
Fort Patrick Henry	−4.49	−3.69	−1.66	−0.96	−0.60	−0.39
Fort Loudoun	−7.29	−4.51	−2.63	−1.15	−0.67	−0.44
Fontana	−9.19	−5.46	−2.63	−1.19	−0.62	−0.39
Douglas	−6.93	−4.08	−2.24	−1.06	−0.64	−0.42
Chickamauga	−10.57	−4.88	−2.85	−1.22	−0.74	−0.49
Cherokee	−4.79	−3.56	−1.68	−0.94	−0.60	−0.39
Chatuge	−9.46	−5.60	−2.65	−1.20	−0.61	−0.39
Boone	−4.57	−3.80	−171	−0.99	−0.62	−0.40
Blue Ridge	−11.70	−5.87	−3.14	−1.35	−0.71	−0.48
Appalchia	−8.68	−5.85	−2.85	−1.27	−0.69	−0.44

Figure 3. TVA watershed precipitation analysis by basin (inches) derived from CMORPH. Precipitation accumulation is computed up to two-day to the present date. Only non-zeros values are reported in this figure.

Another aspect of the work consists in short term precipitation forecasts. Using daily precipitation outputs from the NOAA Global Forecast System (GFS), forecasts of daily precipitation for up to 7-day from the present day are also provided for the different watersheds of the TVA (Figure 4). This use case is fully operational and provides useful (past/current/near-future) information for government agencies, water resource managers (agriculture, dam), energy suppliers (dam), and tourism.

Improvement of SDP product analysis would consist in extending the process to other available SDP products. In particular, the use of Kriging methods would allow to integrate different SDPs together, to integrate SDPs with surface and radar observations.

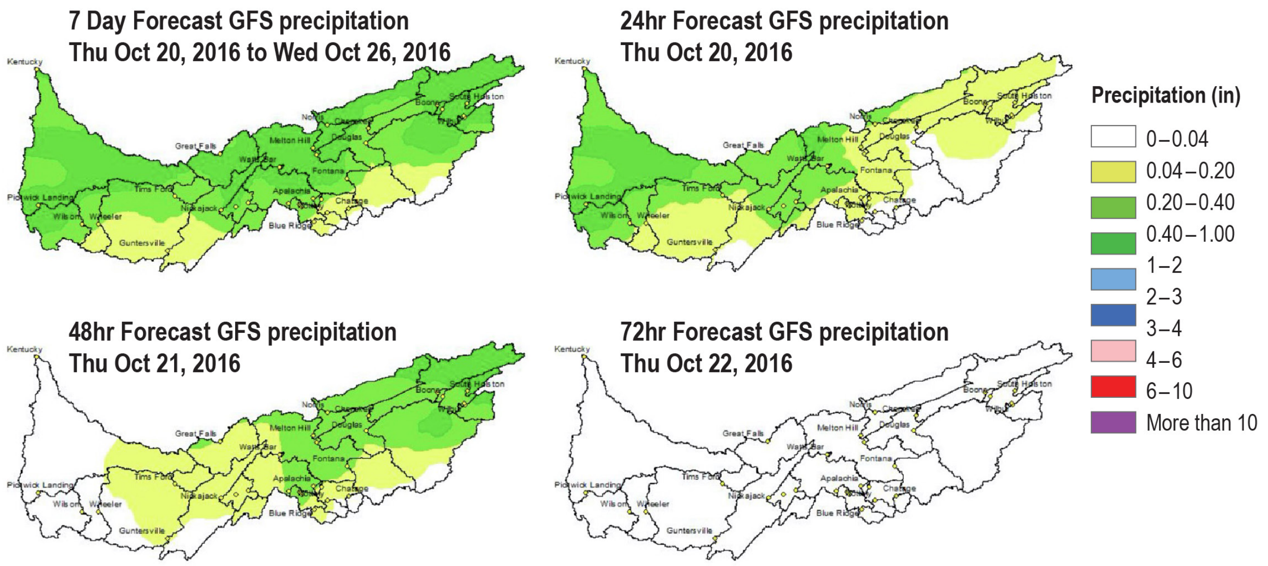
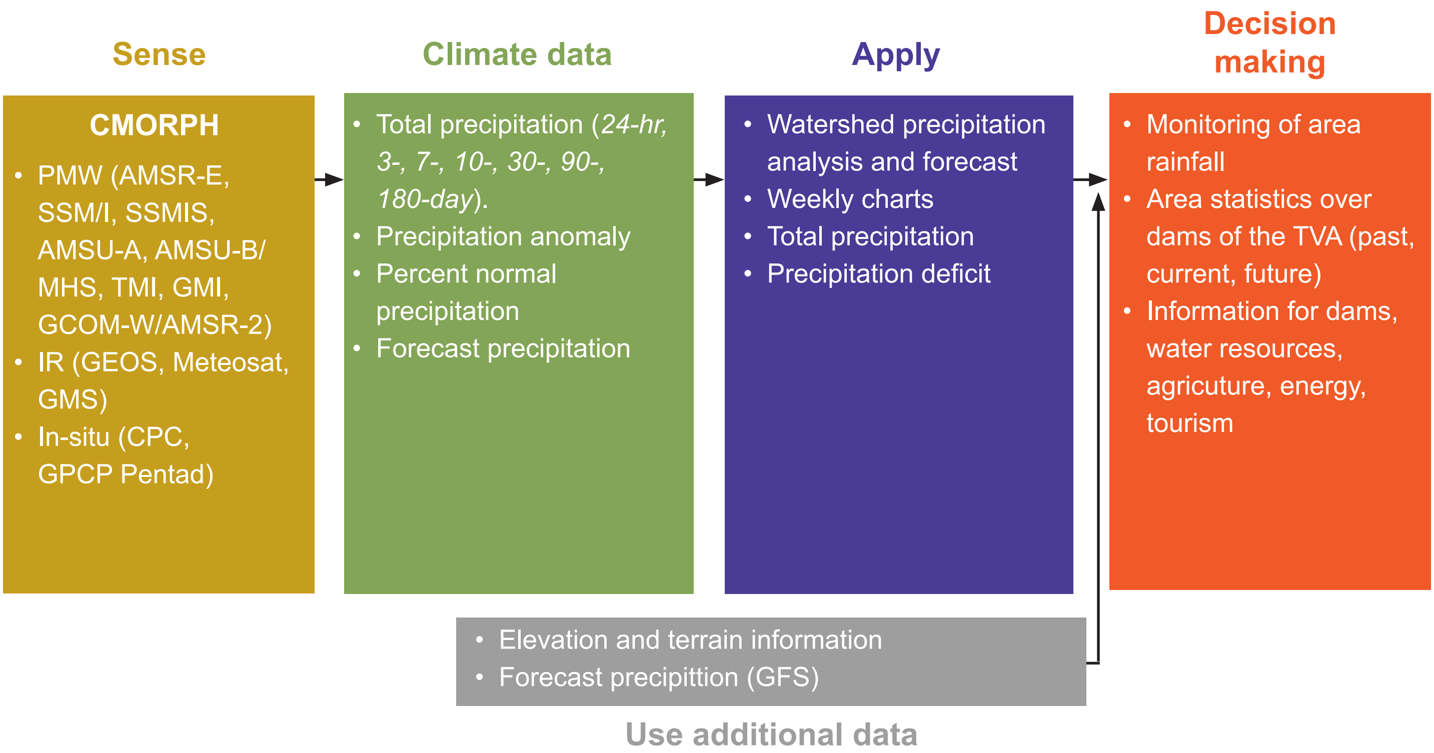


Figure 4. TVA watershed forecast precipitation analysis by basin (inches) derived from GFS (valid as of 00Z). Results are for 7 Day forecast for October 20, 2016 to October 26, 2016; for 24 Hour forecast for October 20, 2016; for 48 Hour forecast for October 21, 2016; and for 72 Hour forecast for October 22, 2016.

INFORMATION FLOW



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