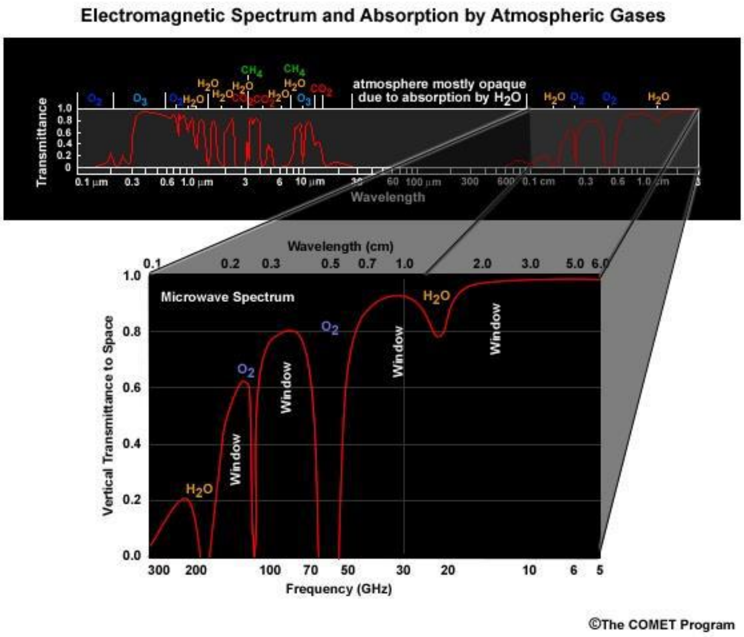
MicroWave adjusted Global Hydro Estimator (MWGHE) Satellite Precipitation Estimates

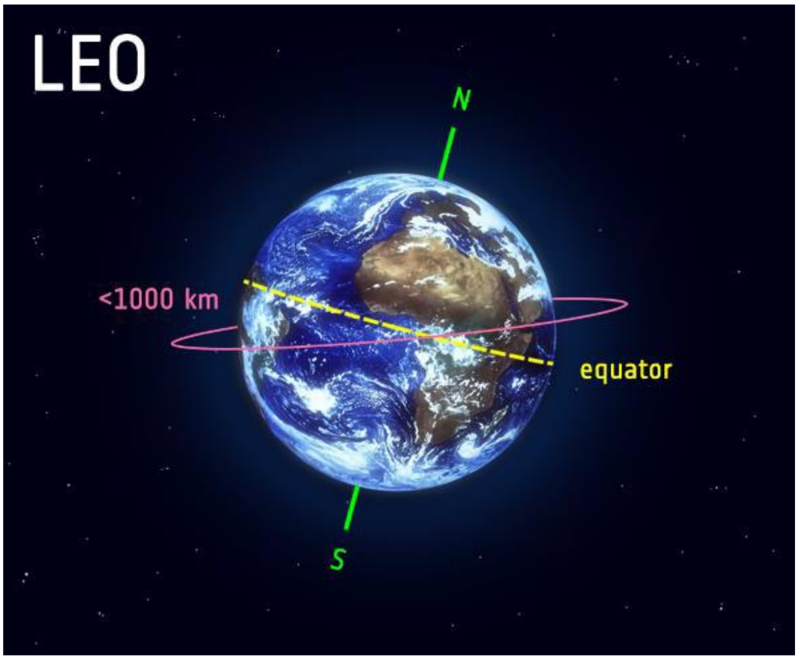
Microwave satellite sensors like Advanced Microwave Sounding Unit (AMSU) have fundamentally changed how we discern cloud properties and measure precipitation particles from satellites because they directly detect precipitation in clouds - an advantage over IR-techniques, which have difficulty distinguishing between precipitating and non-precipitating clouds. Microwave detection of precipitation uses several channels, which are usually described by their frequency in gigahertz (GHz). Some channels are located in window regions where the atmospheric gases absorb very little radiation. These windows allow the satellite sensors to "see" the surface of, even though, the clouds. Both the window and high absorption regions are used to derive various products for identifying surface and cloud properties.



Microwave portion of the EM spectrum and its relative location on the EM spectrum

The AMSU passive MW instrument has been flying on the NOAA and European Metop polar-orbiting satellite series as part of a cooperative agreement between NOAA and European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). AMSU is composed of two separate instruments, the AMSU-A and –B; each instrument is equipped with channels that sense at frequencies between 23 and 190 GHz. Different channels of MW instrument measure either the scattering of high-frequency radiation by hydrometeors or the absorption of low frequency radiation by raindrops.

Present technology only allows MW instruments on board low-orbit satellites, which poses difficulties for their use in real time hydrologic forecasting, as they are not adequate for detecting the rapidly changing rainfall patterns at a single location (sampling problem).



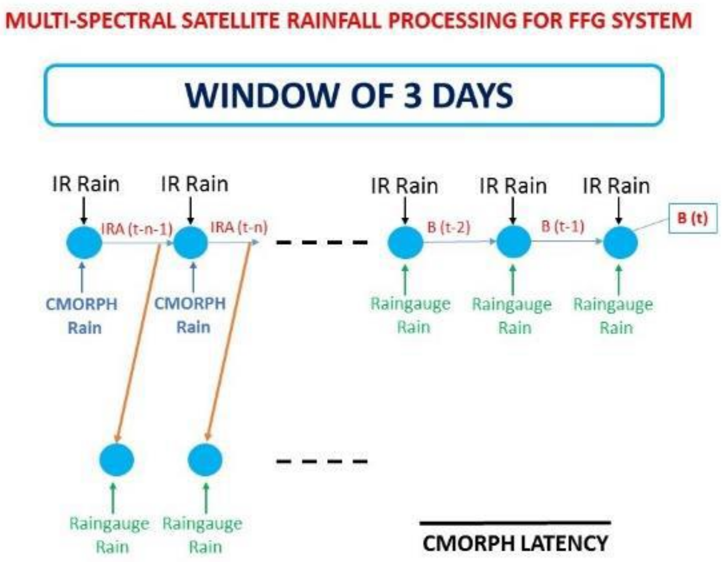
Low Earth Orbit (European Space Agency)

Also, MW measurements have a relatively large footprint (from 5 to more than 50 km), which in convective conditions may cause an incomplete beam-filling errors.

CMORPH, short for the Climate Prediction Center (CPC) morphing method, does not use IR precipitation estimates; rather it uses IR-based cloud top temperature (to be explained in the next section) to derive propagation vectors for cloud tops to interpolate the MW-based precipitation estimates and to produce half hourly 8 km resolution precipitation estimates. The CMORPH technique holds great promise for small-scale applications. Current public availability of the CMORPH precipitation estimates from the NOAA CPC has approximately 18-hour latency.

Half-hourly analysis of CMORPH at a grid resolution of 8 km (at equator) have been produced since 22 November 2002. Some modifications have been made since the processing became operational, most importantly the implementation of an improved snow-screening process (Joyce et al., 2004).

A major caveat with the CMORPH for operational application that aims to develop warnings for flash flood events is the long latency of the half-hourly 8 km rainfall estimates. However, it is anticipated that for times when both HE and CMORPH estimates are available and at spatial scale of CMORPH, valid hourly estimates of CMORPH may be used to adjust those of HE, and to develop adjustments that may also be used during times when CMORPH is not available because of latency. With this premise, the following strategy was applied to potentially improve the HE estimates of rainfall.



Procedure for processing CMORPH data

Starting from the current time t, a processing window extending back to three days from present time is defined. During part of that window, both HE and CMORPH estimates are available for processing while during the rest of the time until present, only HE is available due to the period of CMORPH latency. During the time when both estimates are available, the HE estimates are adjusted to match those of the CMORPH at the scale of 8 km throughout the domain of the FFGS. This results in adjusted HE estimates. During this period adjustment factors are computed for HE, which are then applied to the HE estimates during the rest of the time until present when no CMORPH data is available. In that way, the HE estimates are adjusted for the biasing the estimates relative to the CMORPH data up to the present time.

The Microwave-adjusted Global Hydro Estimator (MWGHE) Satellite-based precipitation product provides Global Hydro Estimator (GHE) satellite-based accumulated precipitation estimate (IR-based) adjusted by available MW-based satellite precipitation estimates to improve GHE accuracy. It is important to note that in some conditions the MW based CMORPH precipitation estimate may underperform compared to the HE. For example, the CMORPH precipitation estimate is masked in areas with snow cover. In addition, large uncertainties in the CMORPH precipitation estimate has been reported in coastal regions and during small scale local convective precipitation events.

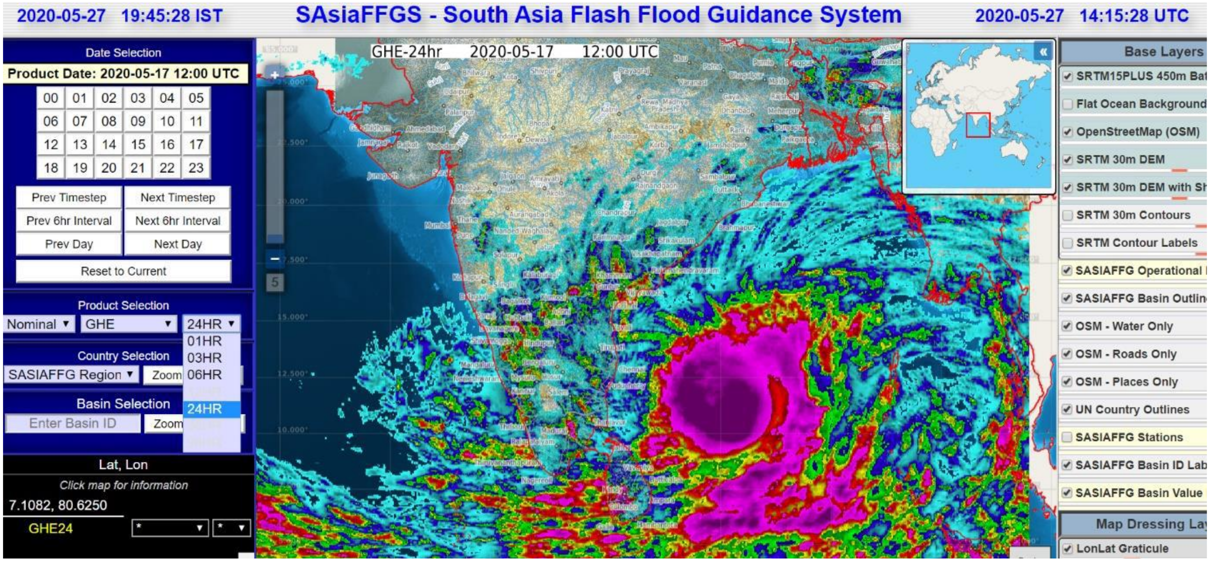
The images and text in the FFGS provide gridded 1-hour, 3-hour, 6-hour and 24-hour accumulations of satellite-based rainfall estimates (mm) ending on the current hour from this MWGHE product (NOAA-NESDIS Global HydroEstimator (IR-based) and adjusted by the NOAA-CPC CMORPH MW-based satellite rainfall product).

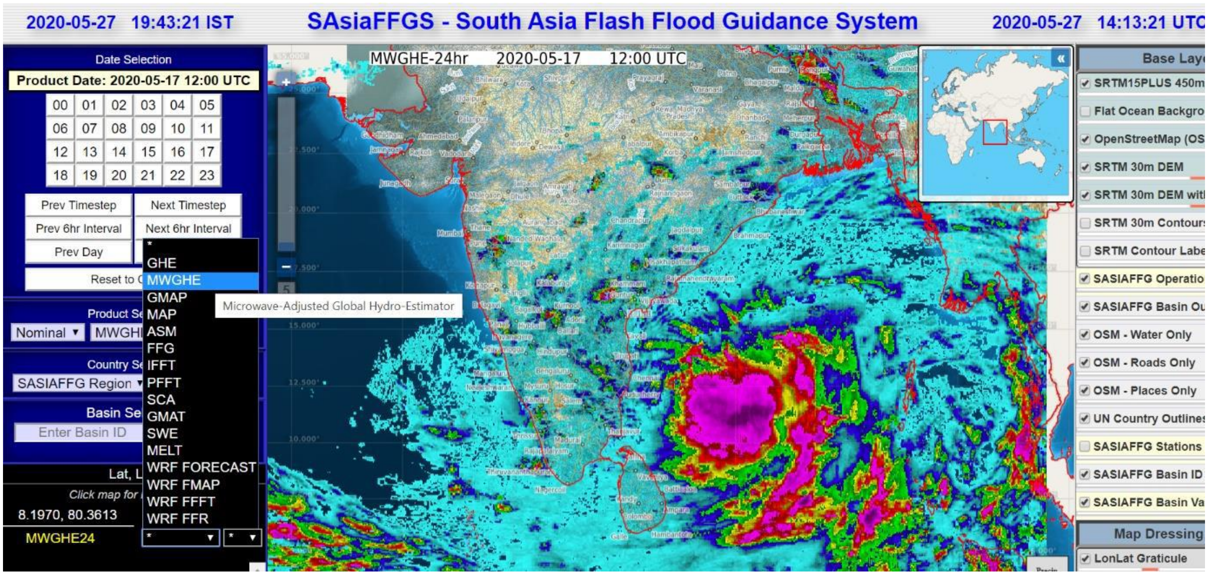
The satellite-based rainfall estimates are provided on a grid which is displayed over a background of the system sub-basin boundaries. The MWGHE data products are updated every hour with a latency of approximately 45 minutes and no adjustment for bias is precipitation bias is made for the gridded products. A bias correction is applied during the computation of mean areal precipitation (MAP) as will be described in a subsequent section.

Each of the 3-, 6- and 24-hour MWGHE accumulations are produced from the 1-hour MWGHE rainfall input products summed over the corresponding interval, ending on the navigation hour.

Each of these accumulations requires the availability of at least 50% of the 1-hour MWGHE products over the corresponding interval. If more than 50% of the 1-hour products are missing or unavailable over any accumulation interval, a grey image is shown to indicate insufficient 1-hour satellite input data were available.

Examples of 24-hour GHE precipitation accumulations for the South Asia region without and with (MWGHE) CMORPH adjustment are shown below.





FFGS GHE precipitation accumulations without (GHE) and with (MWGHE) CMORPH adjustment

In the example shown, there are significant changes evident in the 24-hour GHE and MWGHE products (the GHE showed much heavier rainfall).

For more information please read:

Joyce, R.J., J.E. Janowiak, P.A. Arkin, P. Xie, 2004: CMORPH: A method that produces global precipitation estimates from passive microwave and infrared data at high spatial and temporal resolution. Journal of Hydrometeorology 5: 487–503.

This document was prepared by WMO-FFGS team using South East Europe Flash Flood Guidance System Forecaster Guide[1], FFGS Operational Output Product Descriptions available in the FFGS Real-Time Product Console developed by the Hydrologic Research Center and National Oceanic and Atmospheric Administration (NOAA) materials and documents.

[1] https://www.wmo.int/pages/prog/hwrp/flood/ffgs/documents/SEEFFGS_Forecaster_Guide-Final_ES_TM-AS-PM.pdf