GLOBAL HYDRO ESTIMATOR (GHE) SATELLITE-BASED PRECIPITATION ESTIMATES

The Global Hydro Estimator (GHE) is a satellite-based precipitation product from National Oceanic and Atmospheric Administration - National Environmental Satellite, Data, and Information Service (NOAA NESDIS). GHE provides hourly accumulations (mm) of precipitation with latency of a few minutes (up to 20 minutes globally) and with resolution of approximately 4 km by 4 km at the equator. The Hydro-Estimator has been an operational precipitation algorithm since 2002 to produce precipitation estimates for the entire globe using five different geostationary satellites.

The presently available HE precipitation estimates are based on procedures that evolved from the earlier auto-estimator formulations and include enhancements for atmospheric moisture effects, orography, convective equilibrium levels for warm-top convection, local pixel brightness temperature difference with surroundings, and distinguishing between convective core and no-core regions. Several of these enhancements use information from operational numerical weather prediction (NWP) models.

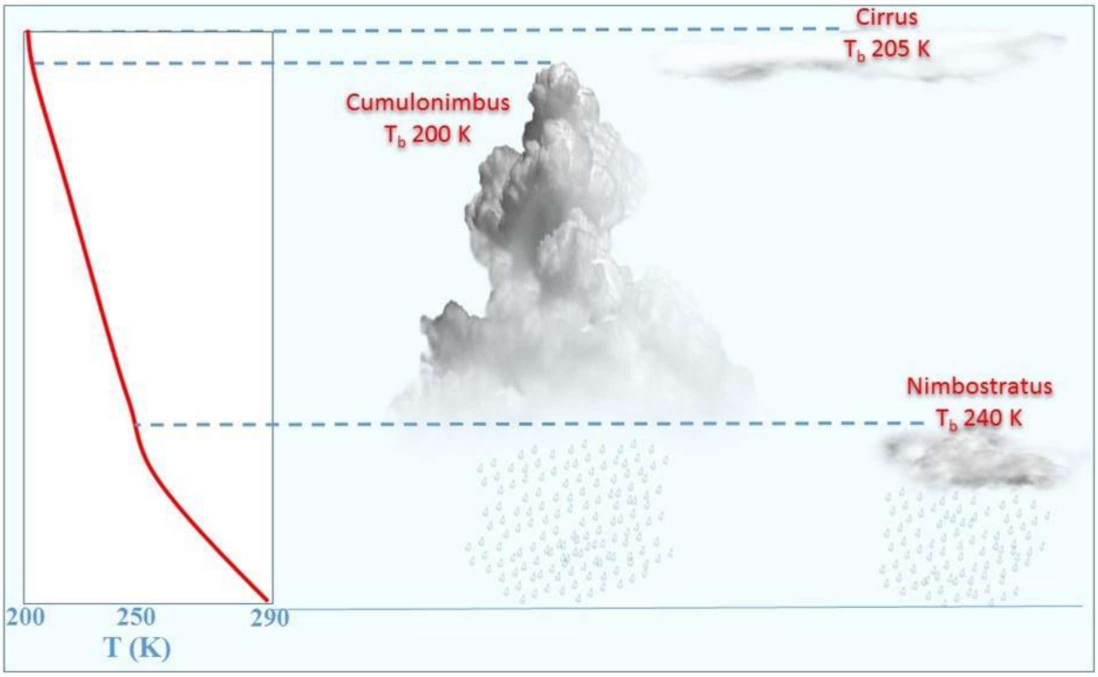
Like other infrared-based algorithms, the GHE uses the brightness temperature (Tb) or cloud top temperature in the infrared (IR) window channel (10.8 µm) to determine raining areas and rain rates.

Three basic assumptions are used for estimating rainfall using infrared data from satellites:

→ Cloud-top brightness temperature is inversely related to cloud-top height: colder clouds have higher tops and warmer clouds have lower tops.

→ Cloud-top height is related to the strength of the convective updraft (higher-topped clouds have stronger updrafts).

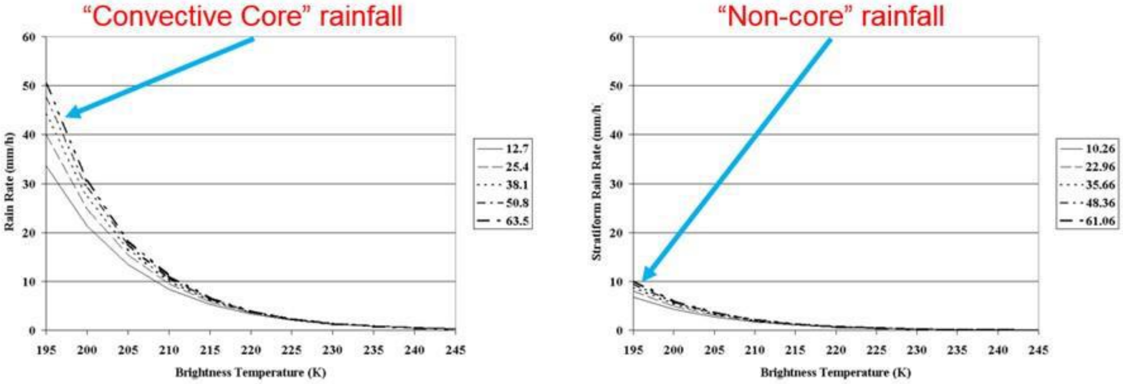
→ Clouds with stronger updrafts are transporting moisture upward more rapidly and thus producing heavier rain than clouds with weaker updrafts.



Infrared signal and rain rate relationship

The assumption regarding the relationship between cloud-top temperature and rainfall rate is reasonable for convective clouds (i.e., warm season showers, thunderstorms), but incorrect identification of cold cirrus clouds as raining is a significant problem. This results in the overestimation of the extent of heavy rainfall in many IR-based algorithms. Second, stratiform clouds usually do not have very cold tops in IR imagery but can produce significant rainfall that will be underestimated (or even not detected) by IR algorithms.

The GHE also uses relative temperature to determine the rain rate. It assumes that the pixels closest to coldest pixels are at the centre of the convective core and have the highest rain rates, whereas pixels farther away have a lower rain rate for a given brightness temperature. The plots on the bottom compare the rainfall rates, which are on the y-axis, with brightness temperature, which is on the x-axis. The rain rates get higher as the clouds get colder, but for the “core” pixels, the rain rates for a given brightness temperature are higher than for the “non-core” pixels.



Relationship between rain rates, brightness temperature and convective (non-)core rainfall

Convective equilibrium level temperature is used to identify regions where strong updrafts and heavy rain can occur even if the thermodynamic profile does not support very cold clouds.

The HE algorithm accounts for orographic effects by using digital elevation model and upper-level winds (850 hPa) to derive the vertical component of wind, which is then scaled into a multiplicative adjustment to the rainfall rate. The HE identifies regions where the terrain will cause the air to flow upward or downward and adjusts the rain rates to moisten the areas with upward motion and to dry out areas with downward motion.

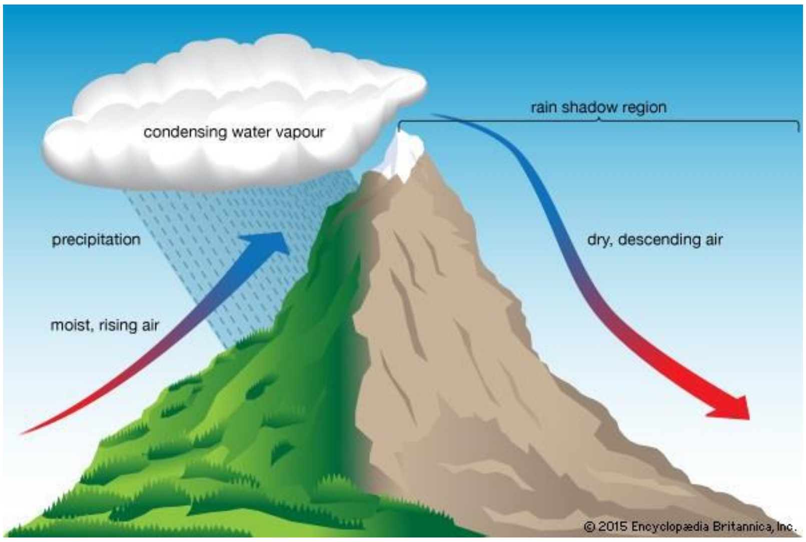


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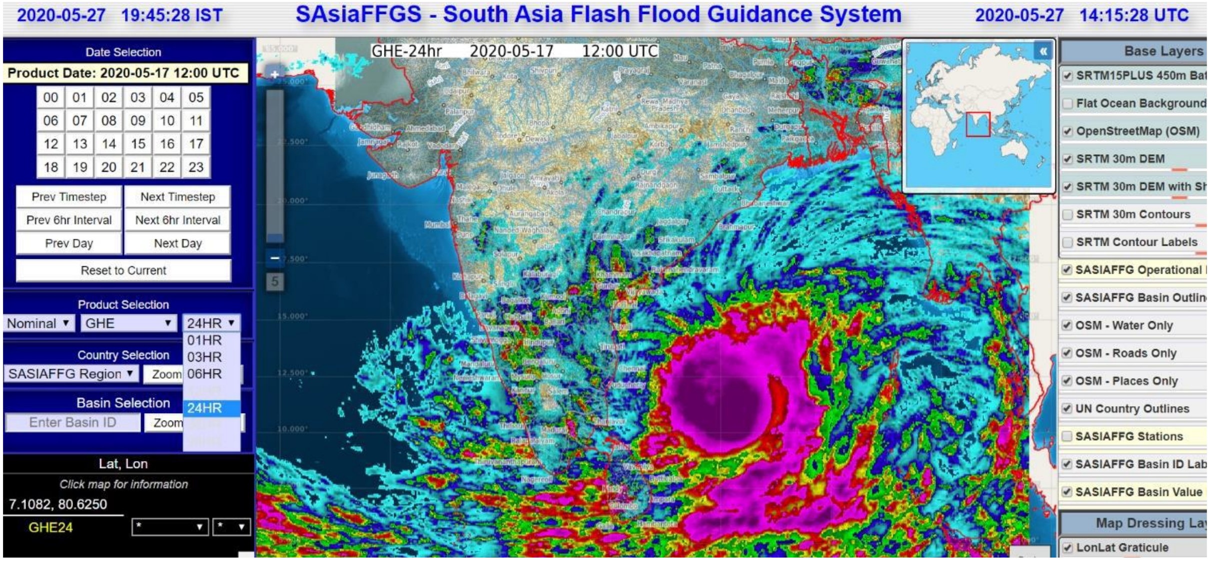
Illustration of orography effect

Details on the algorithm, which also uses data from numerical weather prediction models to correct for evaporation of raindrops, topographic influence on rainfall, and other factors, can be found at the Technique Description link and in Scofield and Kuligowski (2003).

The NOAA/NESDIS provides a 1-hour precipitation accumulation that is then used in the FFGS to determine 1-hour, 3-hour, 6-hour and 24-hour accumulations of satellite-based rainfall estimates (mm) ending on the current hour from the HE. The satellite-based rainfall estimates are provided on a grid which is displayed over a background of system sub-basin boundaries. The data products are updated every hour with a latency of approximately 25 minutes and the gridded products are not bias-corrected.

The image below shows the GHE-24-hour product, which was current between 12:00 UTC of 16th of May 2020 and 12:00 UTC of 171th of May 2020 for the Southern Africa region domain.



Accumulations of rainfall estimates from the GHE over the last 24 hours ending on the current navigation hour

Each of the 3-, 6- and 24-hour GHE accumulations are produced from the 1-hour GHE 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 GHE observations over the corresponding interval. If more than 50% of the 1-hour GHE observations are missing or unavailable over any accumulation interval, a grey image is shown to indicate insufficient 1-hour satellite input data were available.

If the 1-hour GHE input product is unavailable or missing, the sub-basin boundaries are displayed in red.

GHE precipitation estimates are used in the FFGS as backup to the Microwaved-adjusted Global Hydro-Estimator (MWGHE) for model forcing and flash flood treat analysis. Because the satellites provide spatially uniform coverage and low data latency for rainfall rate estimation, they are critical features for supporting FFGS.

For more information please read:

Scofield, R. A., and R. J. Kuligowski, 2003: Status and outlook of operational satellite precipitation algorithms for extreme-precipitation events. Monthly Weather Review 18: 1037-1051.

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.

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