Hydro-Estimator

1. **Description/Theory:** The Hydro-Estimator (H-E) is a single-channel (11-μm) rain rate algorithm whose origins go all the way back to the semi-automated Interactive Flash Flood Analyzer (IFFA) which was originally developed in the late 1970's. Many of the IFFA's features were automated into the Auto-Estimator (A-E) in the late 1990's, including rainfall rate as a function of IR window brightness temperature (calibrated against radar) and corrections for atmospheric moisture (the product of precipitable water (PW) in inches and decimal relative humidity (RH), orography (enhancements in upslope regions and reduction in downslope regions), and convective equilibrium level (enhances rain rates in regions where the convective equilibrium level height is low but strong updrafts can still occur). However, the A-E frequently assigned high rain rates to cold (but nonraining) cirrus clouds, leading to the H-E which replaced the A-E in 2002. The H-E assigns rainfall only to pixels that are colder than the average of the surrounding cloudy pixels in order to eliminate cirrus clouds, and also uses separate PW and RH corrections to reduce cold-season overcorrection.

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

Vicente, G. A., R. A. Scofield, and W. P. Menzel, 1998: The operational GOES infrared rainfall estimation technique. *Bull. Amer. Meteor. Soc.*, **79**, 1883-1898.

-----, J. C. Davenport, and R. A. Scofield, 2002: The role of orographic and parallax corrections on real time high resolution satellite erainfall rate distribution. *Int. J. Remote Sens.*, **23**, 221-230.

2. **Strengths and Weaknesses**

Strengths: The H-E was originally calibrated for convective rainfall associated with organized mesoscale systems and performs best for such systems. The moisture corrections generally perform quite well at eliminating rainfall from highly arid regions where rainfall evaporates prior to reaching ground level.

Weaknesses: The relationship between IR window cloud-top brightness temperatures and surface rainfall rates is quite weak for stratiform precipitation, and consequently the algorithm generally does not perform well for cool-season precipitation. Rainfall from extremely warm-top convection such as that which occurs on tropical islands (e.g., Hawaii, Puerto Rico) is also frequently undetected by the algorithm.

3. Algorithm Inputs

A. Satellite Data

1. Geostationary

NOAA/NESDIS/STAR operationally extracts geostationary satellite IR window brightness temperature information through the Man-computer Interactive Data Access System (McIDAS) archive available from NOAA/NESDIS/OSDPD/SSD. NESDIS/STAR maps each satellite IR image to a Mercator grid at approximately 4 km resolution, corrects for parallax-induced mis-navigation of clouds at higher satellite zenith angles (Vicente et al. 2001) and corrects for the effects of large zenith angles (limb darkening; Joyce et al. 2001).

Joyce, R. J., J. E. Janowiak, and G. J. Huffman, 2001: Latitudinally and seasonally dependent zenith-angle corrections for geostationary satellite IR brightness temperatures. *J. Appl. Meteor*., **40**, 689-703.

A. GOES-12 Imager (every 15 min – 10.7 µm, 15-30 min delay)
B. GOES-11 Imager (every 15 min – 10.7 µm, 15-30 min delay)
C. METEOSAT-9 SEVIRI (every 30 min – 11.2 µm, 15-30 min delay—note: these data are available every 15 min but only processed every 30 due to computational constraints)
D. METEOSAT-7 Imager (every 30 min – 11.5 µm, 15-30 min delay)
E. MTSAT-1 Imager (every 60 min – 10.8 µm, 15-30 min delay—note: these data are available for the Northern Hemisphere every 30 min, but only the hourly full-disk data are processed due to computational constraints.)

2. Low Earth Orbit

None.

B. Ancillary Data

1. Model Data

A. Total column precipitable water from the NOAA/NWS/NCEP North American Model (NAM) or Global Forecast System (GFS). Model Identification (products used source/latency)
B. Mean-layer relative humidity for the lower third of the model domain from the same models.
C. Vertical profiles of temperature and specific humidity from the same models (used to compute the convective equilibrium level).
D. 850-hPa u and v components of wind from the same models (used to compute the orographic correction)..

2. In Situ

None.

3. Other

A. Digital elevation maps (4-km horizontal over CONUS, 10-km horizontal elsewhere, 20-m vertical resolution.)

4. Processing

A. Product Development Level 1

1. Create adjustment fields for the Hydro-Estimator
   A. Create equilibrium temperature field from model temperature and specific humidity profiles ;
   B. Create orographic correction field from 850-hPa winds and digital terrain;

B. Product Development Level 2

1. Run-H-E code to retrieve rain rates for each satellite
   A. Apply orographic (CONUS only) and equilibrium-level adjustments to brightness temperatures;
   B. Identify pixels with adjusted brightness temperatures below average of nearby cloud pixels;
   C. Compute rain rates for raining pixels based on absolute and relative brightness temperature and precipitable water;
   D. Reduce rain rates according to layer-averaged relative humidity.

2. Mosaic rain rate estimates from all satellites into a global field.

5. Output Products

A. Final Product 1 Identification

1. **Temporal/Spatial Resolution:** 4-km in GOES coverage region; global file is 0.045 degrees lat/lon.

2. **Spatial Coverage:** Global between 60°S and 60°N.

3. **Dedicated Product Web Page Location:**
   http://www.star.nesdis.noaa.gov/smcd/emb/ff/auto.html

4. Processing Specifics (if possible)

   A. **Latency** (45 minutes)
   B. **Update Frequency:** 15 min North America, 30 min elsewhere.

5. Operational Availability of Product

   A. **Source:** Web page
   B. **Latency** (60 minutes or more, due to uncertainty of internal / external web server transfer)
   C. **Update Frequency:** 15 min North America; 30 min elsewhere
   D. **Available Record Length:** Online archive beginning 22 August 2006; CONUS archive beginning 1 April 2003.

6. Historical Availability of Product

Same as (5) above.

6. **Planned Modifications/Improvements:** None at this time.

7. **Capability of Producing Retrospective Data:** Back to 2001 over CONUS and surrounding areas; no current capability outside this region.

8. **Contact Personnel:** Bob Kuligowski, Bob.Kuligowski@noaa.gov

9. **Additional Comments:** none.