STAR PRECIPITATION VALIDATION SYSTEM

DOCUMENTATION

Overview:

An operational, swath-based validation system for STAR/NESDIS precipitation products is created by CISESS/UMD Cal-Val Team.

- **Region of Interest: Con**tinental **U**nited **S**tates (CONUS)
- **Reference Products:**
  - Multi-Radar/Multi-Sensor System (MRMS) – Real-time data available at https://mrms.ncep.noaa.gov/data/2D/
    - Spatial Resolution: **1 km**
    - Temporal Resolution: **2-minutes**
    - Products used: **PrecipRate, PrecipFlag, RadarQualityIndex**
      [Description available at:
      https://www.nssl.noaa.gov/projects/mrms/operational/tables.php]
  - Stage-IV Multi-Radar/Multi-Sensor (MRMS) System – Real-time data available at https://nomads.ncep.noaa.gov/pub/data/nccf/com/pcpanl/prod/
    - Spatial Resolution: **4 km**
    - Temporal Resolution: **Hourly**
    - Products used: **Hourly Precipitation Accumulation**

STAR/NESDIS Satellite-based precipitation products:

1. **Goddard PROFiling 2010 (GPROF2010) Rainfall Rate**
   GCOM-W AMSR2 Algorithm Software Processor (GAASP)
   Validation output available at: **ftp://rain.umd.edu/precip/gprof/amsr2/**
   File name convention: AMSR2_MRMS_<yyyymmdd>-<hhmmss>.png
   Date (yyyymmdd) and time (hhmmss) – overpass year and time (in UTC)
   Spatial resolution: **~6 km**
   Temporal resolution: **Instantaneous [time to scan CONUS: 10-14 minutes]**
   Number of CONUS overpasses: **8 times a day**
   Revisit time: **twice a day**

   Validation methodology:
   - Instantaneous estimates from AMSR2 are collocated with the 2-minute MRMS product within the overpass.
   - Weighted-mean of MRMS precipitation estimates over the 36-GHz channel footprint is used as the reference precipitation.

2. **Blended Rain rate** (BRR)
   Validation output available at: **ftp://rain.umd.edu/precip/brr/**
   Real time data available at:
   https://satepsanone.nesdis.noaa.gov/pub/product/blended-hydro/netcdf/

   File name convention: BRR_MRMS_<yyyymmdd>-<hhmmss>-<hhmmss>.png
   Date (yyyymmdd) – start time (hhmmss) – end time (hhmmss) – overpass year and time (in UTC)
   Spatial resolution: **~15 km gridded product**
   Temporal resolution: **Instantaneous**

   Validation methodology:
   - BRR estimates are compared with the 2-minute MRMS product within 10-minutes of the satellite overpass.
   - MRMS reference precipitation rate is calculated by averaging the MRMS precipitation estimates within the BRR grid.

3. **Microwave Integrated Retrieval System (MiRS)**
   a. **ATMS at NOAA-20 [ftp://rain.umd.edu/precip/mirs/n20/]**
   b. **ATMS at Suomi-NPP [ftp://rain.umd.edu/precip/mirs/npp/]**
   File name convention: <N20/NPP>_MRMS_<yyyymmdd>-<hhmmss>.png
   Date (yyyymmdd) and time (hhmmss) – overpass year and time (in UTC)
   Spatial resolution: **15-70 km** (depending on viewing angle)
   Temporal resolution: **Instantaneous**
   Number of CONUS overpasses: **8 times a day**
   Revisit time: **twice a day** (each sensor)

   Validation Methodology:
   - Instantaneous estimates from ATMS are matched with the 2-minute MRMS product within the overpass.
   - Weighted-mean of MRMS pixels within the ATMS footprint is used as the reference precipitation.

4. **Self-Calibrating Multivariate Precipitation Retrieval (SCaMPR)**
   Validation output available at: **ftp://rain.umd.edu/precip/scampr/**
   Real time data available at: https://www.star.nesdis.noaa.gov/smcd/emb/ff/SCaMPR.php
   File name convention: SCaMPR_MRMS_<yyyymmdd>-<hhmmss>.png
   Date (yyyymmdd) and time (hhmmss) – overpass year and time (in UTC)
   Spatial resolution: **2 km** (0.02 degrees)
   Temporal resolution: **10 minutes**
   Revisit time: **every 10 minutes**

Validation Methodology:
- SCaMPR estimates are matched to the nearest 2-minute MRMS product.
- Average MRMS precipitation estimates within the SCaMPR field-of-view is considered as the reference precipitation.

5. **Snowfall Rate (SFR)**
   a. **ATMS at NOAA-20 [ftp://rain.umd.edu/precip/sfr/n20/]**
   b. **ATMS at Suomi-NPP [ftp://rain.umd.edu/precip/sfr/npp/]**

Reference product: MRMS and Stage-IV.
File name convention: <N20/NPP>_<MRMS/ST4>_<yyyymmdd>-<hhmmss>.png
Date (yyyymmdd) and time (hhmmss) – overpass year and time (in UTC)
Spatial resolution: **15-70 km** (depending on viewing angle)
Temporal resolution: **Instantaneous**
Number of CONUS overpasses: **8 times a day**
Revisit time: **twice a day** (each sensor)

Validation Methodology:
MRMS:
- Instantaneous estimates from ATMS are compared to the spatially-collocated, 30-min delayed, MRMS product. The 30-minute delay is added to account for the time taken by the snow to reach the surface.
- MRMS pixels that are identified as "snow" by MRMS PrecipType are used to calculate the weighted-mean within the ATMS footprint.

STAGE-IV:
- Stage-IV estimates that include the overpass time are chosen as the reference. If overpass time is within 15 minutes of the end of hour [minute>45], a 30-minute delay is applied to the Stage-IV product.
- Weighted mean of the Stage-IV precipitation estimates within the ATMS footprint is used as the reference.

Validation methods:

Detection Performance:

- $R_{sat} \geq R_{min}$ and $R_{ref} \geq R_{min}$ – **Correct Detection/Agreement**
- $R_{sat} \geq R_{min}$ and $R_{ref} = 0$ – **False Alarm/Satellite only**
- $R_{sat} = 0$ and $R_{ref} \geq R_{min}$ – **Missed Detection/Reference only**

Where, R_{sat} – precipitation rate estimates by satellite-based product, R_{ref} – precipitation rate estimates by ground-based reference product. R_{min} is the minimum threshold. Minimum threshold depends on the satellite-based product.

Minimum threshold (R_{min}) values considered:

1. GPROF2010 AMSR2   – 0.5 mm/h
2. Blended Rain Rate   – 0.5 mm/h
3. MiRS NOAA-20 and Suomi NPP – 0.5 mm/h
4. SCaMPR   – 1.0 mm/h
5. SFR NOAA-20 and Suomi NPP – 0.2 mm/h

Note: SFR validation using Stage-IV does not provide detection performance maps since satellite-based SFR is used as a reference when identifying precipitation phase.

Quantification Performance:

Quantification performance are computed using histogram, scatterplot and statistical metrics. These are calculated only for **correct detection/agreement pixels**.

Statistical Metrics considered are as follows:

1. Pearson Correlation: $r = \dfrac{\sum(R_{sat} - \overline{R_{sat}})(R_{ref} - \overline{R_{ref}})}{\sqrt{\sum(R_{sat} - \overline{R_{sat}})^2 \, \sum(R_{ref} - \overline{R_{ref}})^2}}$

2. Root Mean Square Deviation: $RMSD = \sqrt{\sum \dfrac{(R_{sat} - R_{ref})^2}{N}}$

3. Bias: $\dfrac{1}{N}\left(\sum R_{sat} - \sum R_{ref}\right)$

4. Relative Bias: $10 log\left(\dfrac{\sum R_{sat}}{\sum R_{ref}}\right)$

5. Percent Bias: $\dfrac{\sum R_{sat} - \sum R_{ref}}{\sum R_{ref}} \times 100$

Note: Negative values of Bias, Relative Bias and Percent Bias signify underestimation while the positive values indicate overestimation.

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