Second Generation CMORPH: An Update

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2nd Generation CMORPH Overview

- **CMORPH**
  - *CPC Morphing technique;*
  - *High-resolution global precipitation estimates constructed by integrating information from multiple GEO and LEO satellites*

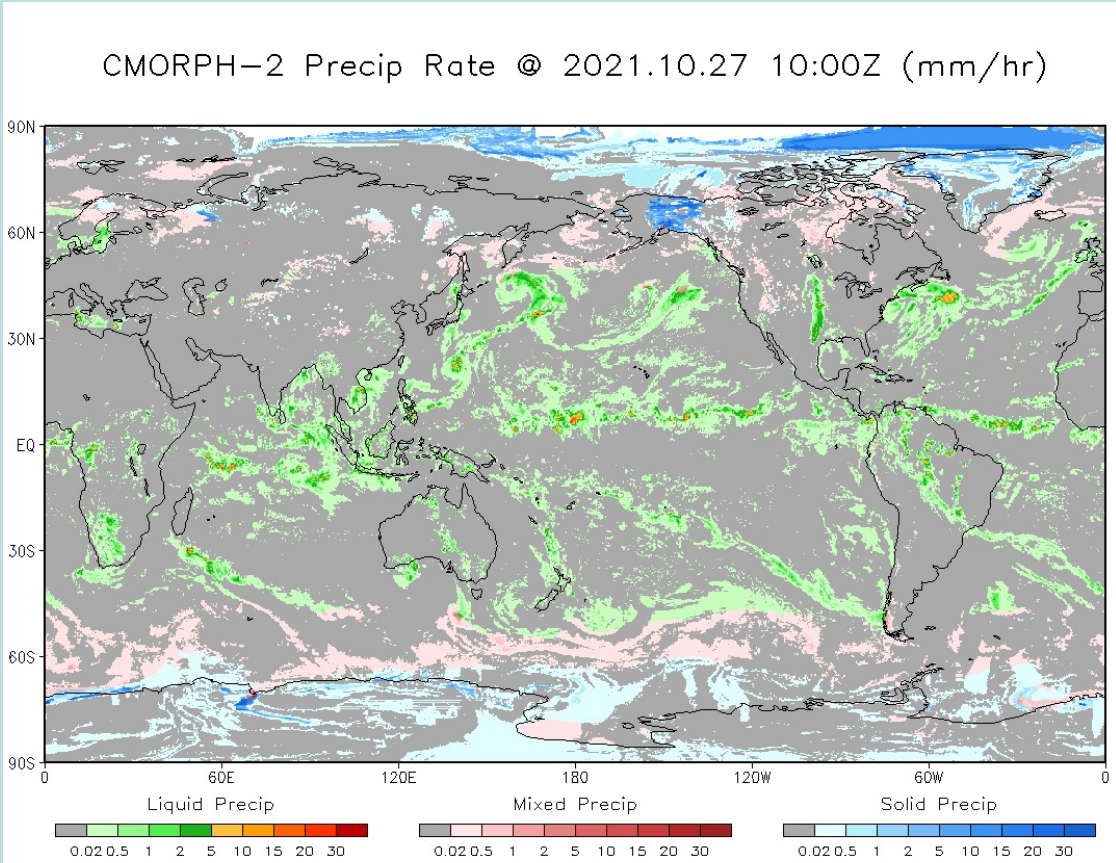
- **Main Features of CMORPH2**
  - *High spatial / temporal resolution (0.05°lat/lon / 30-min) infused with PMW retrievals from LEO satellites and IR observations from LEO & GEO platforms*
  - *Complete global coverage (90°S-90°N)*
  - *Low production latency (One hour, updated once an hour until 12-hour latency)*
  - *Greatly improved representation of cold season precipitation (snowfall)*
  - *In addition to the total precipitation, fraction of solid precipitation also estimated (quantitative estimation of snowfall)*

CMORPH2 Real-Time Production

1) Overview

- **Started real-time production in April 2017**
- **Production Schedule**
  - *Generated at a latency of **one hour**;*
  - *updated once an hour with newly available inputs until 12 hours latency;*
- Pushed into NWS/AWIPS for field operations and to NESDIS Productions for public distribution
- **NOTE:**

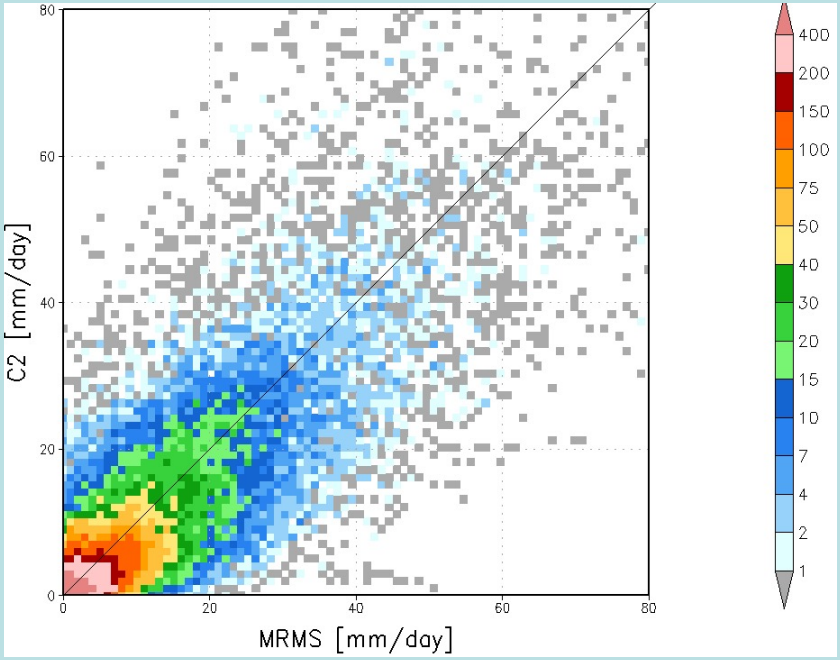
  Current version of CMORPH2_NRT is purely satellite based with **no bias correction**



CMORPH2 Real-Time Production

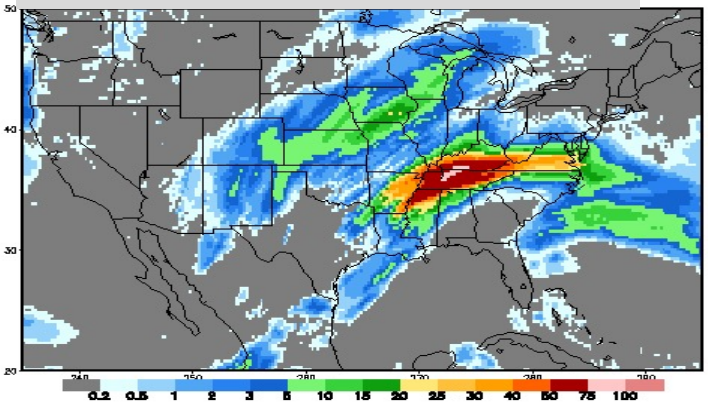
2) Snow Storm Case of Feb., 2019

CMORPH2 NRT captured the precipitation associated with the winter storm of February 2019 very well, with a correlation of **0.753** for daily precipitation over a 0.25°lat/lon grid box.

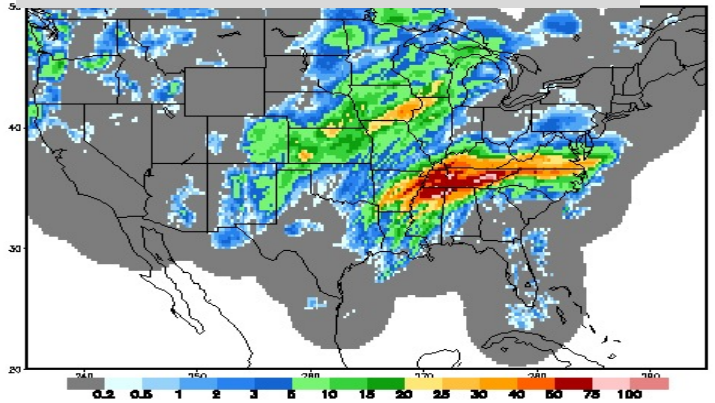


Scatter density plots between the MRMS radar observations (X-axis) and CMORPH2_NRT estimates (Y-axis) of daily precipitation over 0.25°lat/lon grid boxes over the CONUS for 1 – 28 February, 2019.

CMORPH2_NRT



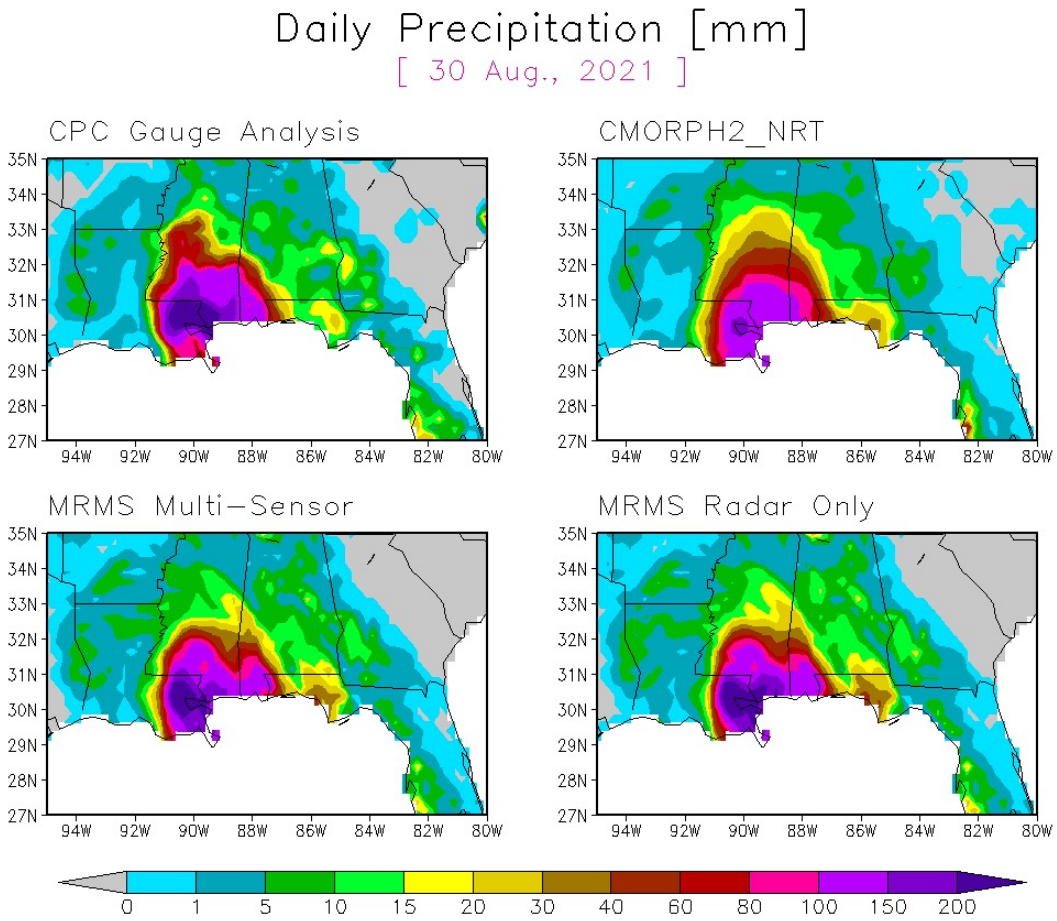
MRMS Radar Estimates

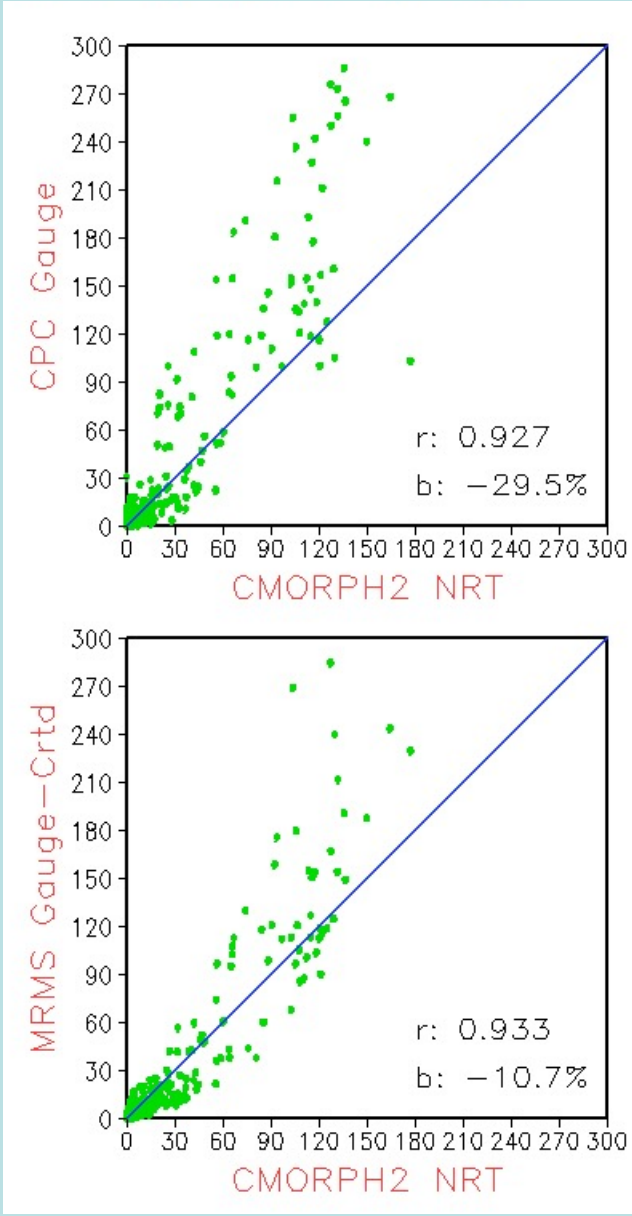


Daily precipitation (mm) for 23 Feb.,2019, derived from CMORPH2 NRT production (top), and MRMS radar observations (bottom)

CMORPH2 Real-Time Production

3) Hurricane Ida: Landing on 30 Aug., 2021



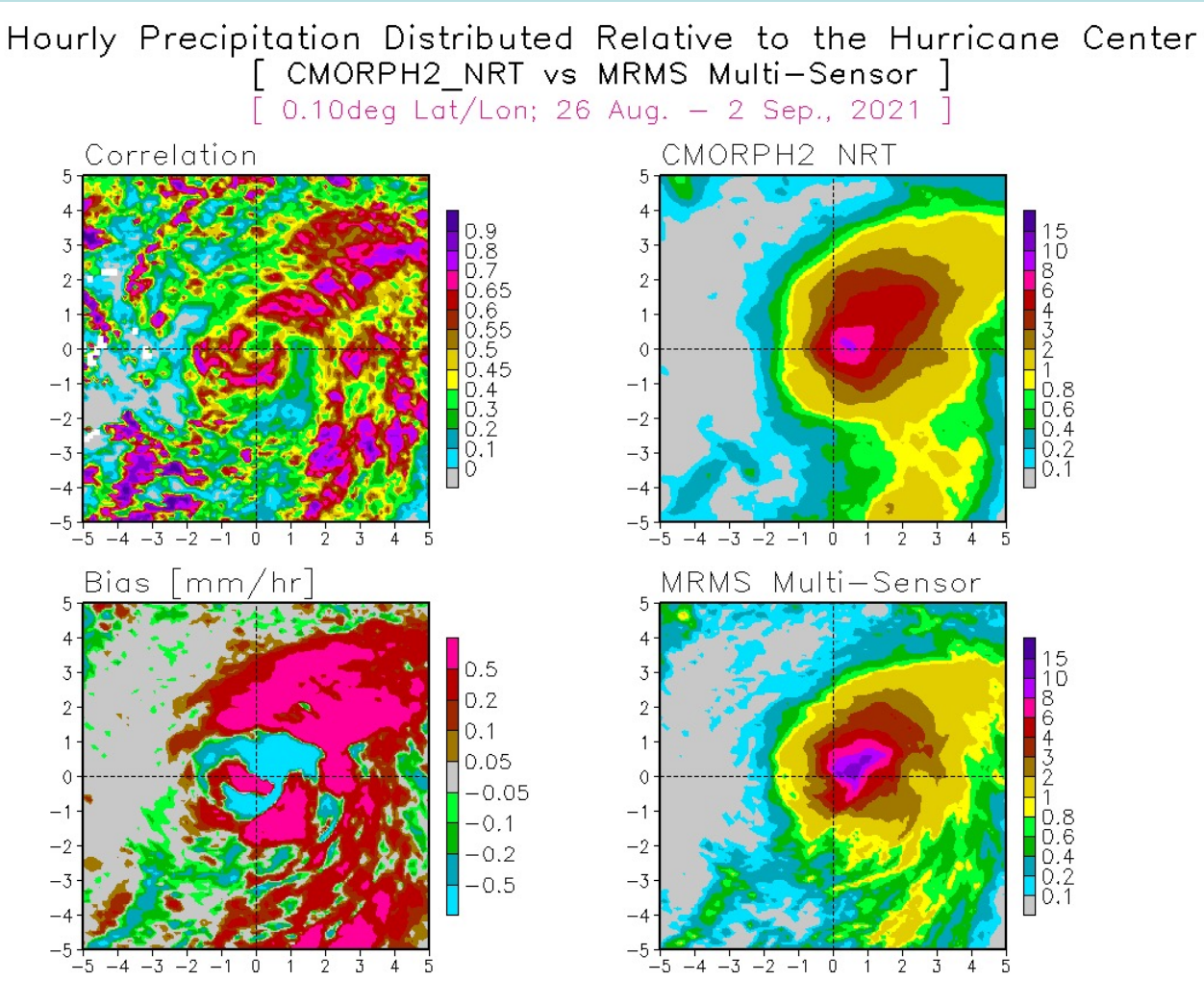


(top) *Da ily precipitation (mm) from (top-left) CPC daily gauge analysis; (top-right) CMORPH2_NRT; (bottom-left) MRMS Multi-Sensor; and (bottom-right) MRMS Radar-Only.*

(Right) *Scatter plots between CMORPH2 NRT and CPC gauge (top) / MRMS Multi-Sensor (bottom) for daily precipitation on a 0.25°lat/lon grid box.*

CMORPH2 Real-Time Production

4) Hurricane Ida: Spatial Pattern Relative to the Hurricane Center

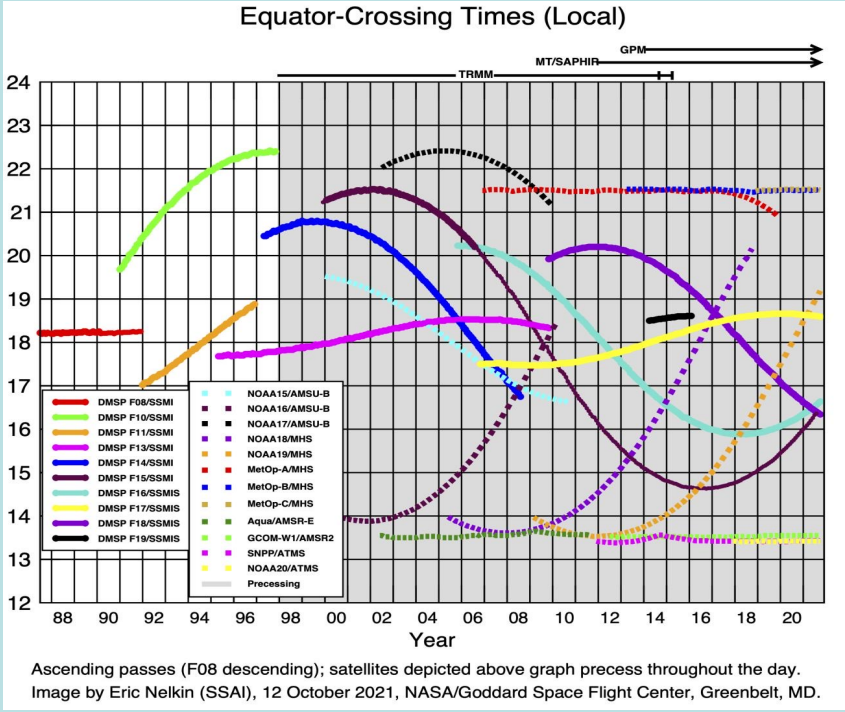


- *CMORPH2 presents spatial pattern of precipitation very similar to that of the MRMS Multi-Sensor QPE, with the heavy rainfall located mostly over the NE section to the storm center;*
- *Correlation is quite high, reaching more than 0.8 for hourly rainfall over a 0.1º lat/lon grid boxes over many portions of heavy rainfall;*
- *CMORPH2 tends to under-estimate the extreme rainfall over and near the storm center;*

Retrospective Analysis

1) Overview

- **Target Period**
  - 1991 to the present
    - *1998 to the present:*
      - *Sufficient number of satellites (5-12)*
      - *Same time / space resolution as those in the real-time production*
    - *1991 to 1997*
      - *Less PMW satellites (3-5);*
      - *Daily / 0.25°lat/lon;*
- **Products**
  - Bias corrected CMORPH2;
    - *0.05°lat/lon / 30-min*
    - *Total precipitation and fraction of solid precipitation*
  - Bias corrected blended with daily gauge analysis
    - *0.25°lat/lon / daily*
- **Current Status**
  - Completed algorithm development / adjustment
  - In process of working on a retrospective analysis for a pilot period 2017 – the present



Ascending passes (F08 descending); satellites depicted above graph precess throughout the day.
Image by Eric Nelkin (SSAI), 12 October 2021, NASA/Goddard Space Flight Center, Greenbelt, MD.

Retrospective Analysis

2) Bias Correction Algorithm

- **Objective:**
  - *To remove the bias in the raw (purely satellite-based) CMORPH2 global precipitation estimates*

- **Methodology:**
  - *Modifications from the bias correction algorithms for CMORPH1 (Xie et al. 2017);*

  - ***Over land***

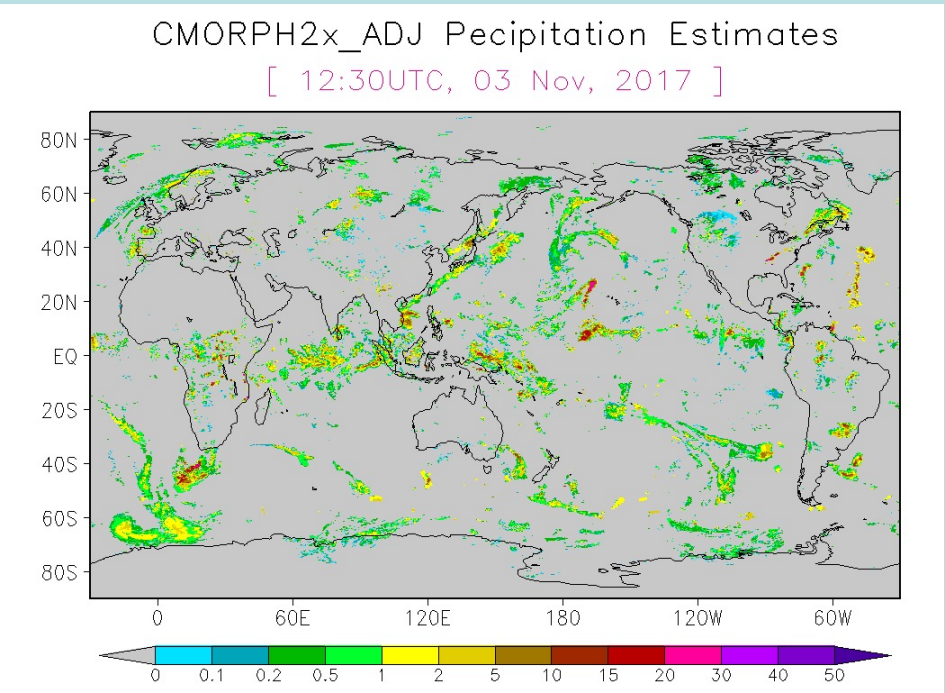
    matching the probability density function (PDF) of the raw CMORPH2 against that of CPC daily gauge analysis

  - ***Over ocean***

    adjusting the raw CMORPH2 against a long-term reference analysis of stable magnitude at coarser resolution (GPCP Version 3.1, monthly / 0.5^{o}lat/lon)

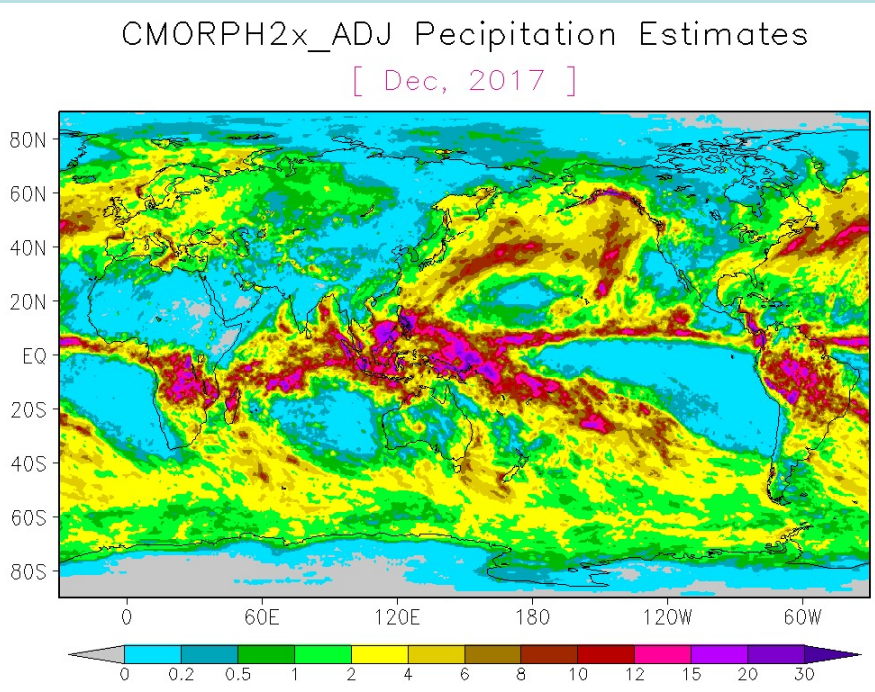
Retrospective Analysis

3) Sample Bias Corrected Global Fields



- *Bias correction algorithm tested for a 24-month period from Dec. 2017 to Nov., 2019*
- ***(left)** Bias corrected CMORPH2 for a 30-min period starting at 12:30 UTC, 03 Nov., 2017*
- ***(Bottom)** Bias corrected CMORPH2 for December 2017*

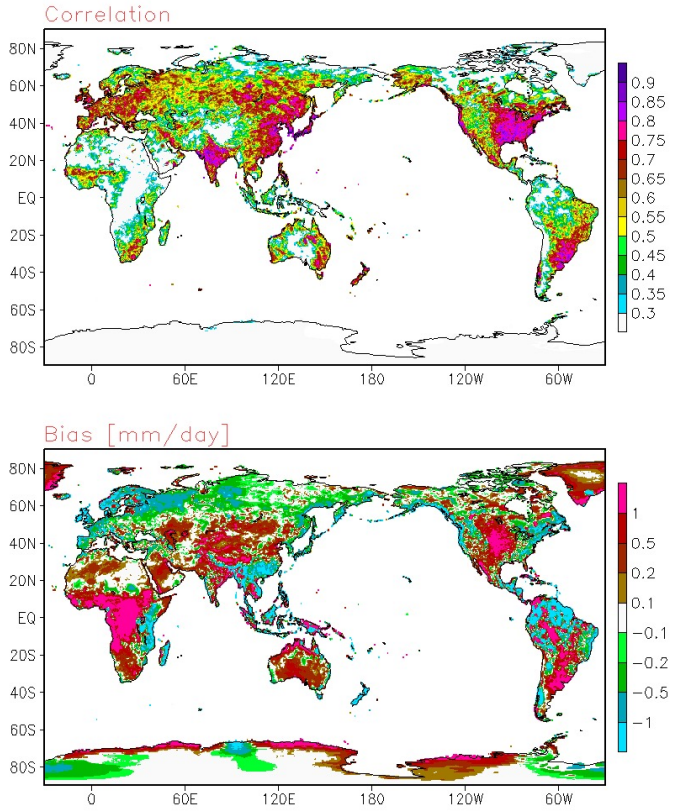
- ***Complete global coverage at a very fine time / space resolution;***
- ***Fine structure of global precipitation patterns are well depicted;***



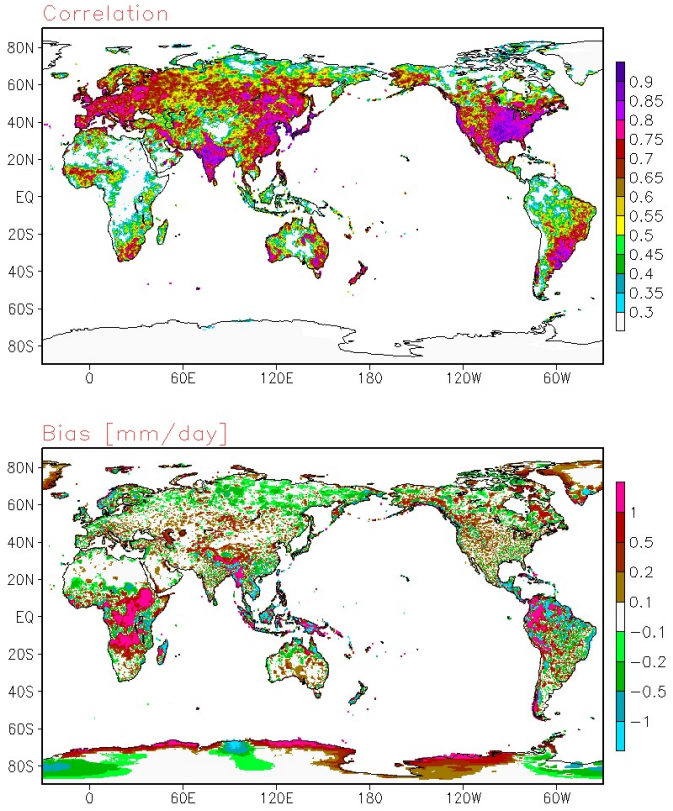
Retrospective Analysis

4) Validation against gauge analysis over land – Spatial

Before Bias Correction



After Bias Correction

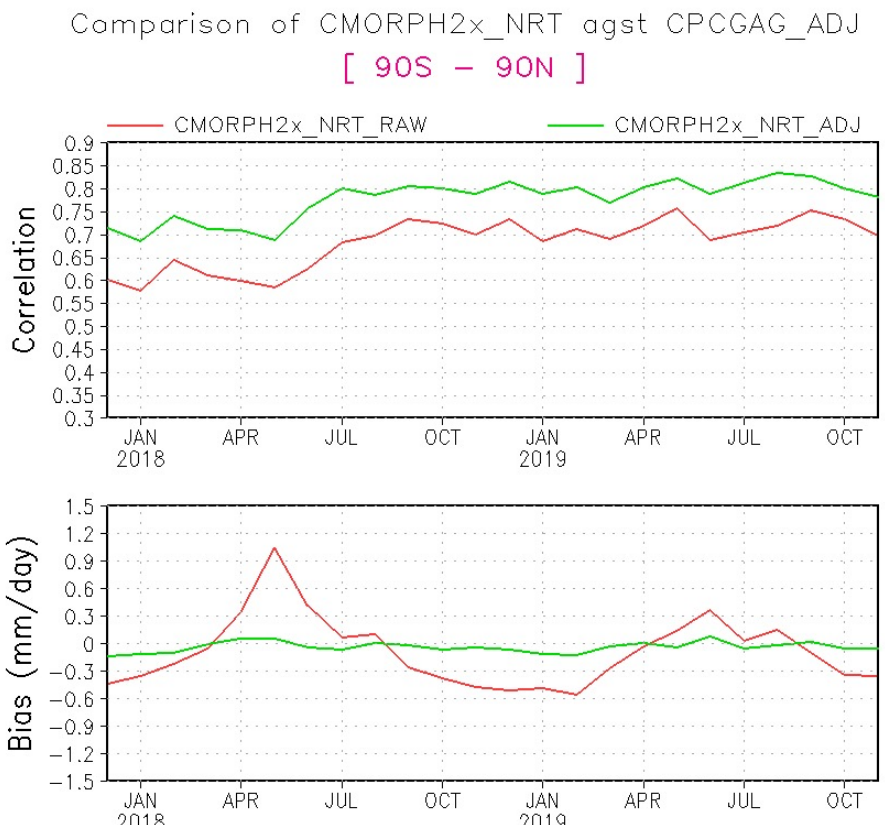


- *The raw and bias corrected CMORPH2 are compared against CPC daily gauge analysis for a 24-month period from Dec. 2017 to Nov. 2019;*
- ***(bottom panels)** Large-scale patterns of bias in the raw CMORPH2 are removed clearly as shown in the bottom-right panel;*
- ***(top panels)** Correlation for the bias corrected CMORPH2 is further improved compared to that for the raw CMORPH, with the highest reaches 0.8 or higher for daily precipitation on a 0.25^{o}lat/lon;*

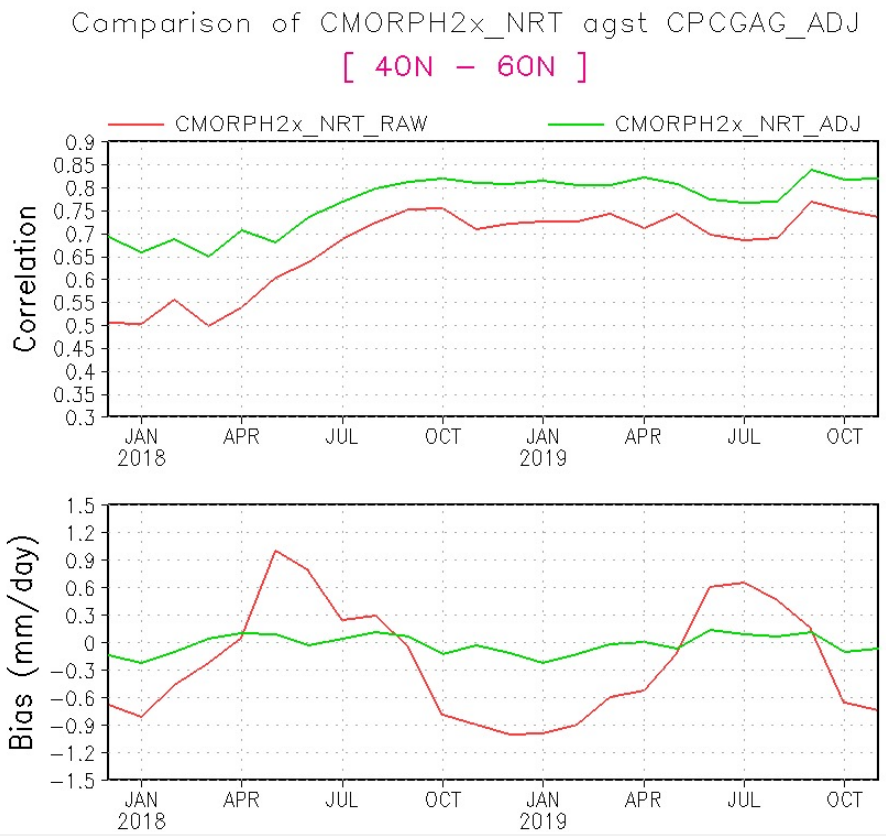
Retrospective Analysis

5) Validation against gauge analysis over land – Temporal

Global Land



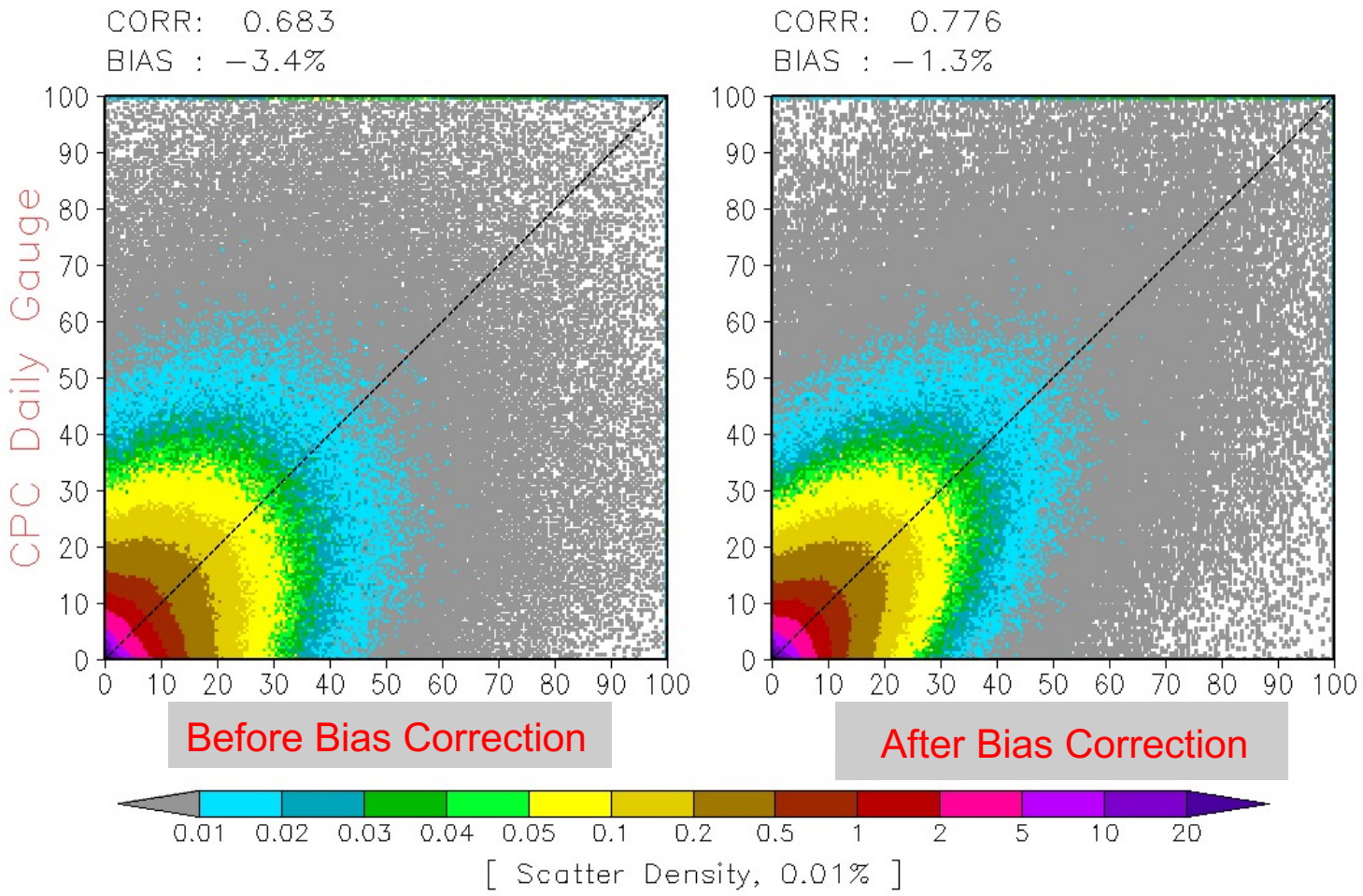
Middle Latitude Land



- ***(bottom panels)*** *Seasonally changing bias in the raw CMORPH2 is removed;*
- ***(top panels)*** *Correlation for the bias corrected CMORPH2 is further improved by close to 0.1 compared to that for the raw CMORPH, with the highest reaches 0.8 or higher for daily precipitation on a 0.25°lat/lon;*

Retrospective Analysis

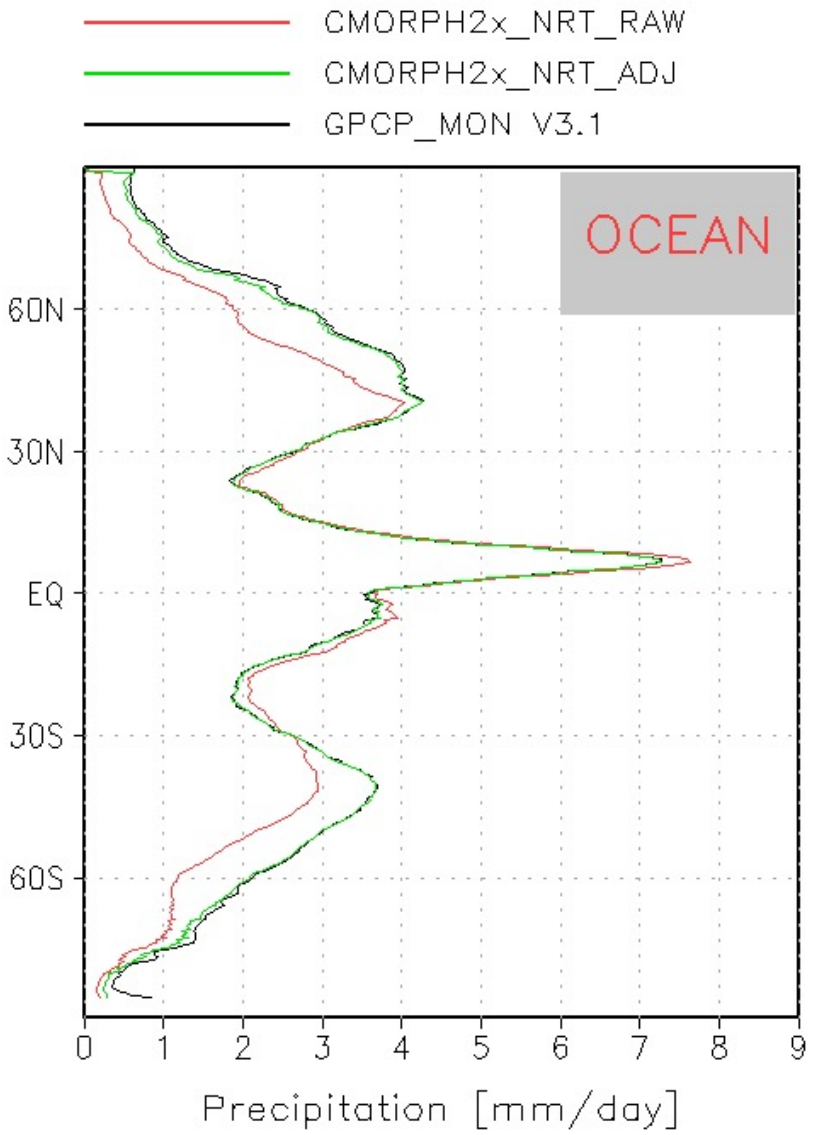
6) Scatter Density Plots for Daily Precipitation on 0.25°lat/lon



- *Bias correction improves the correlation and removes the bias substantially;*

Retrospective Analysis

7) Comparison against GPCP V3.1 over ocean



- *Comparison of the raw and bias corrected CMORPH2 against the GPCP V3.1 (calibrator) over ocean to ensure the oceanic algorithm works;*
- *Comparison of the zonal mean precipitation averaged for the 24-month period from Dec. 2017 to Dec. 2019;*
- *After the bias correction, CMORPH2 matches closely with GPCP V3.1, ensuring overall magnitude agreement as well as long-term temporal homogeneity for climate applications;*
- *Independent verifications will be conducted through comparison against buoy measurements and occasional ship radar observations;*

Summary

- Real-time CMORPH2 has been operational for four years and show good skills in estimating cold season precipitation as well as in capturing severe rainfall storms;

- Bias correction further improves the performance of CMORPH2, especially in accurately quantifying the magnitude of precipitation;

- We are in process of:

  – Migrating the CMORPH2 real-time production system from CPC Linux work stations to WCOSS; and

  – Constructing retrospective CMORPH2 for a 30+ year period;