Real-Time Production of the Second Generation CMORPH

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Outline

- Objectives
- First Generation CMORPH
- Second Generation CMORPH
- Comparison and Verifications
- Summary

Objectives

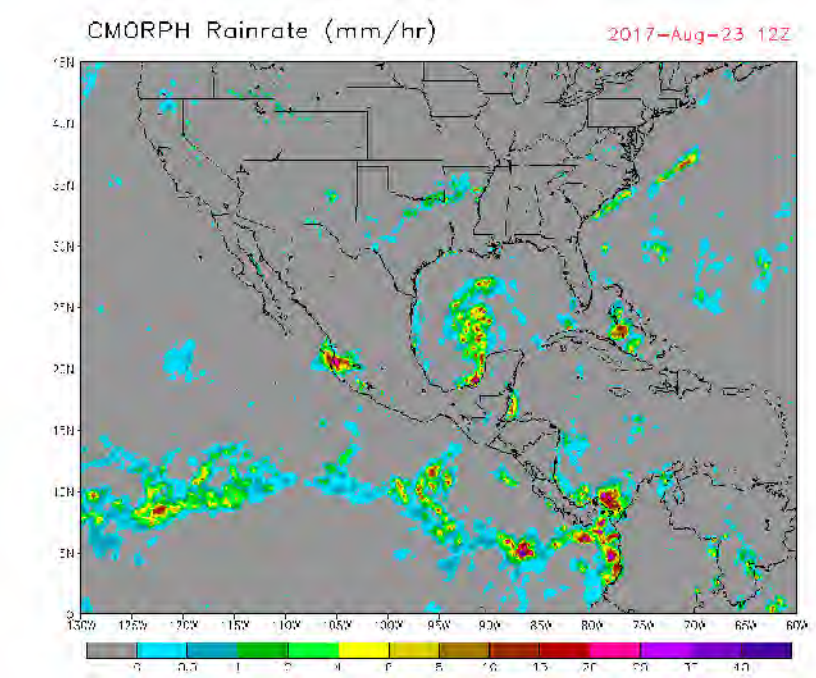
- To introduce the second generation CMORPH integrated satellite pole-to-pole global precipitation estimates and their real-time production; and

- To get feedbacks from our CWB peers, and potential users on the CMORPH precipitation products

First Generation CMORPH

1) Overview

- CPC Morphing technique (Joyce et al. 2004; Xie et al. 2017);
- Constructing high-quality, high-resolution global precipitation through integrating information from multiple GEO / LEO satellite platforms as well as in situ measurements;
- 8kmx8km resolution over the globe (60^oS-60^oN);
- 30-min interval from 1998,
  updated on a quasi real-time
  basis (2-hour delay);
- Excellent skills in detecting and
  quantifying precipitation and
  their temporal / spatial
  variations especially over
  tropics and sub-tropics
  during warm seasons



First Generation CMORPH

2) Shortcomings

- Incomplete Global Coverage
  - *60^oS-60^oN*
  - *Restricted by the use of GEO IR to derive motion vectors*

- Compromised Representation of Cold Season Precipitation and Orographic Rainfall
  - *Restricted by poor performance of PMW retrievals*
  - *No inputs from numerical model simulations / forecasts*

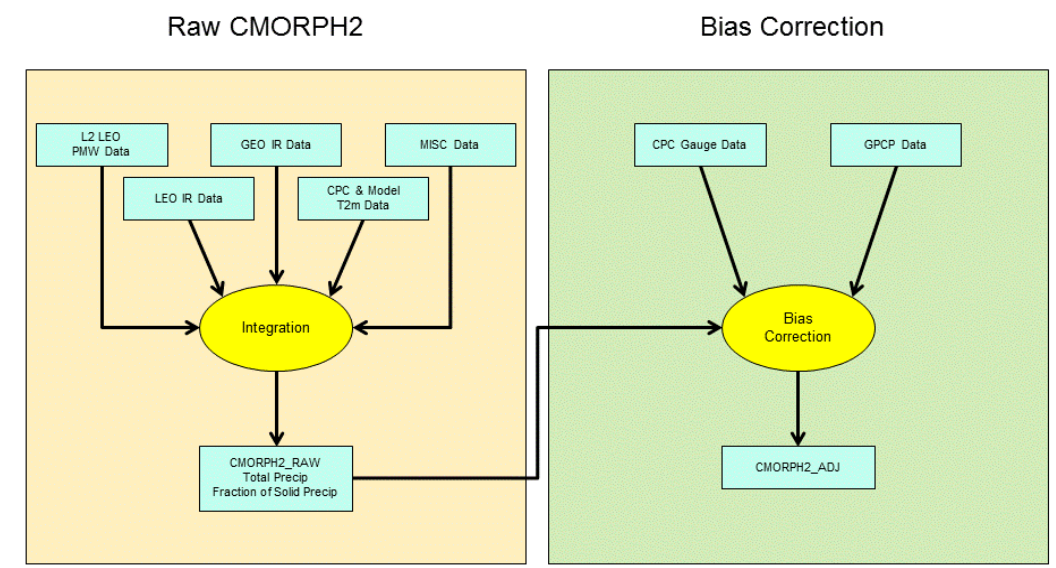
- Information from GEO Platforms Not Fully Utilized
  - *Restricted by the ad-hoc integration framework*
  - *Only the IR images used to derive motion vectors*
  - *No GEO IR based precipitation estimates utilized as inputs*

Second Generation CMORPH

1) The Goals

- Pole to Pole Complete Global Coverage
  - *90°S-90°N*
  - *0.05° lat/lon*
- Improved Representation of Cold Season Precipitation
  - *New Versions of PMW retrievals (MiRS et al)*
  - *PMW Snowfall Rate (SFR) retrievals (STAR/Huan Meng)*
  - *LEO IR based precipitation estimates (in-house)*
- Taking Full Advantage of GEO IR
  - *CPC GEO IR based precip est. infused*
- *Improved Presentation of orographic Rain*

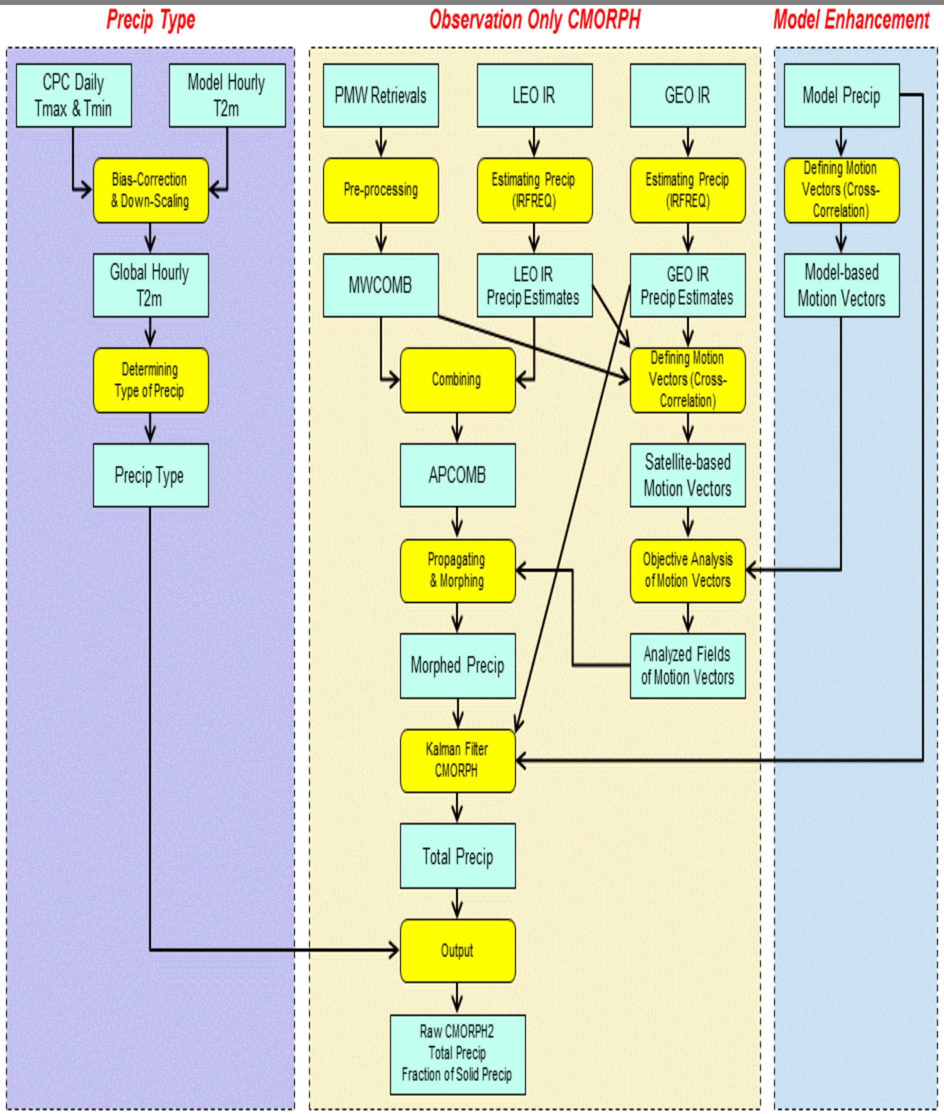
(not yet started working on this)



Second Generation CMORPH

2) Inputs / Algorithms Upgrades

- Improved input satellite retrievals of rainfall and snowfall from NASA and NESDIS/STAR
- Satellite IR based precipitation estimates developed / refined at NOAA/CPC
- Greatly refined integration algorithm at NOAA/CPC
  - *Inter-satellite calibration algorithm*
  - *Precipitation motion vectors*
  - *Kalman Filter analysis framework*
- Newly added technique to determine fraction of solid precipitation from surface meteorology (T_{2m} et al) through collaboration with FSU
  - *Global hourly T_{2m} analysis*



Second Generation CMORPH

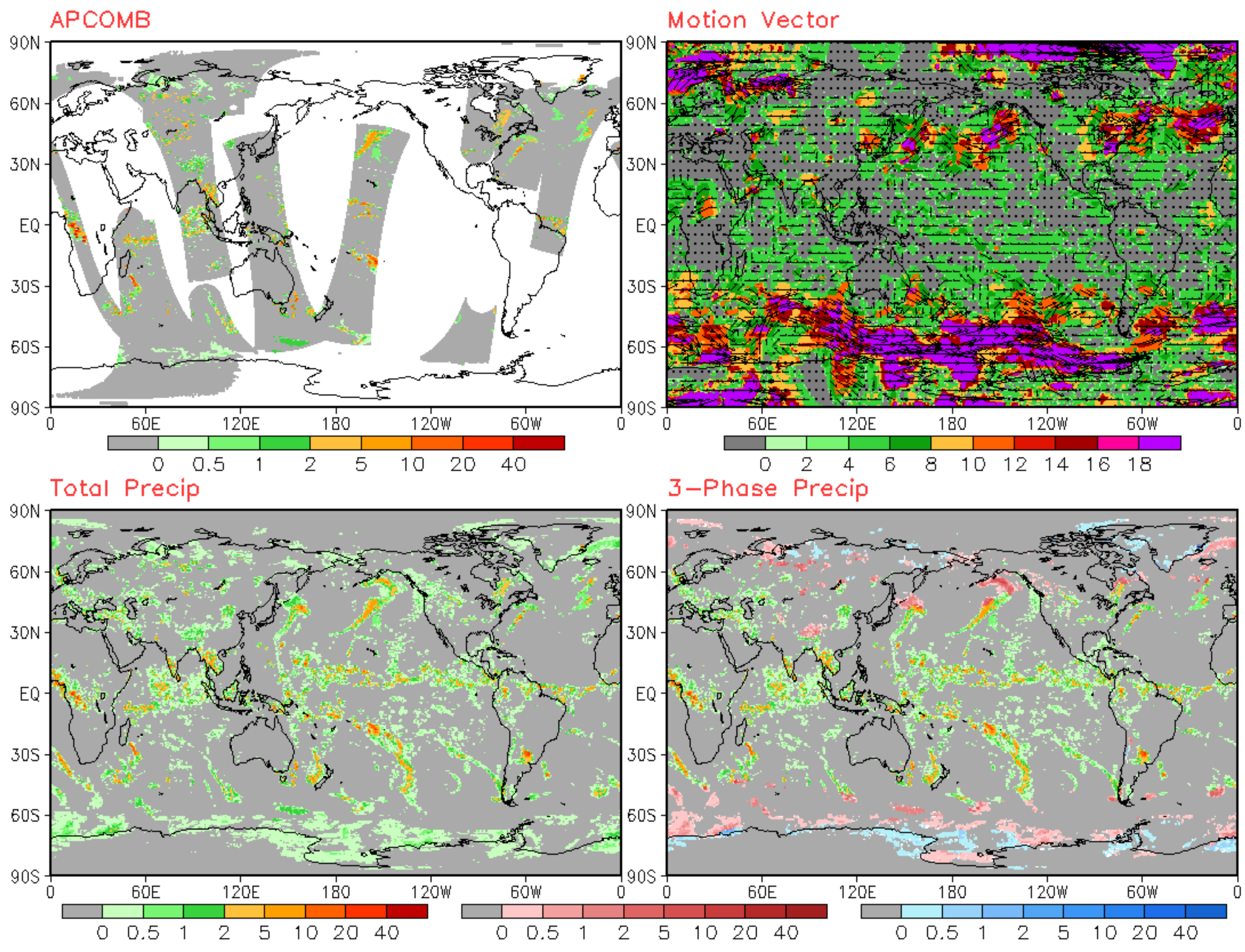
3) Key Algorithm Components Newly Developed

- GEO IR based precipitation estimates
  - *Xie et al. (2014) EGU (and seminar on Thursday)*
- LEO IR (AVHRR) based precipitation estimates
  - *Joyce et al. (2016) IPWG*
  - *Joyce et al. (2017) AGU*
- Precipitating Cloud Motion Vectors Covering 90^{o}S-90^{o}N
  - *Xie et al. (2015) EGU*
- Kalman Filter based integration algorithm
  - *Joyce and Xie (2011) JHM*
- Determination of fraction of solid precipitation
  - *High-Resolution Global Hourly Surface Air Temperature Analysis (Pan and Xie 2018) CDPW*
  - *Fraction calculation algorithm (Liu et al., 2015)*

Second Generation CMORPH

4) Sample APCOMB, Motion Vectors, & CMORPH2

12:00Z, 10 May 2018



Second Generation CMORPH

5) Real-Time Production Overview

- **Goal**
  - *Get the satellite precipitation estimates produced and delivered as **quickly** as possible with highest possible **quality and quantitative consistency***
- **Strategy**
  - *Start to produce the real-time CMORPH2 at a **very short latency**;*
  - *Update the CMORPH2 **multiple times** with newly available inputs;*
- **Production Schedule**
  - *Latency of initial production:*

    Currently: *1 hour*

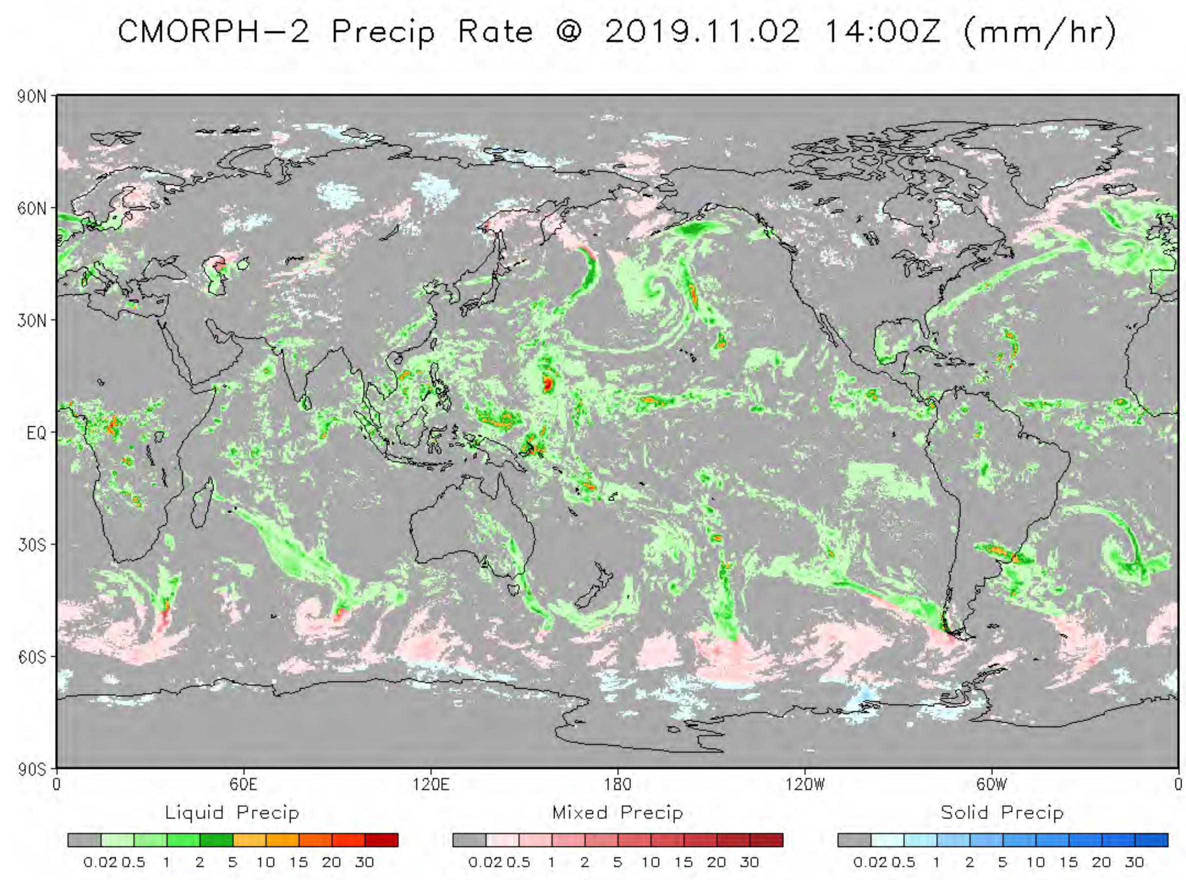
    Full Schedule: *30-45 min*
  - *Frequency of updates:*

    Currently: *1 hour until 12-hour latency*

    Full Schedule: *30-min until 6-hour latency, 1 hour afterwards*
- **Status**
  - *A processing system installed and running on CPC Linux stations;*
  - *CMORPH2 RT production pushed into NWS/AWIPS2*
  - *Work underway to migrate the system to a supercomputer system;*

Second Generation CMORPH

6) Real-Time Animation



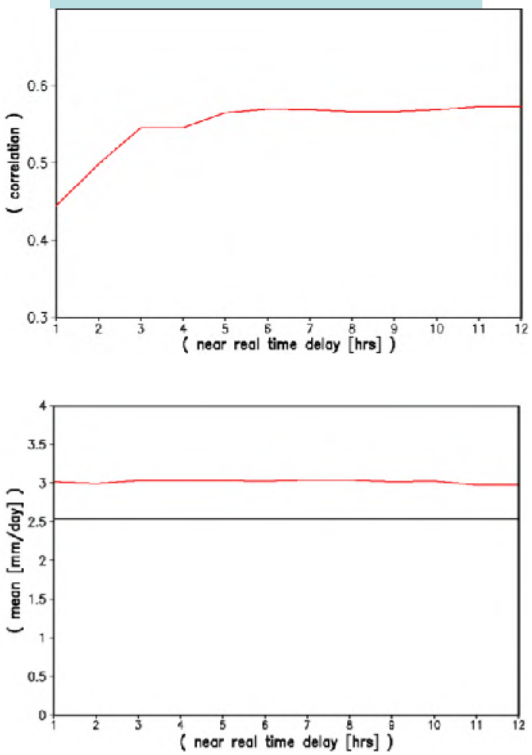
CMORPH2 Real-Time Production Presents Continuous Temporal Evolutions of Global Precipitation System

Second Generation CMORPH

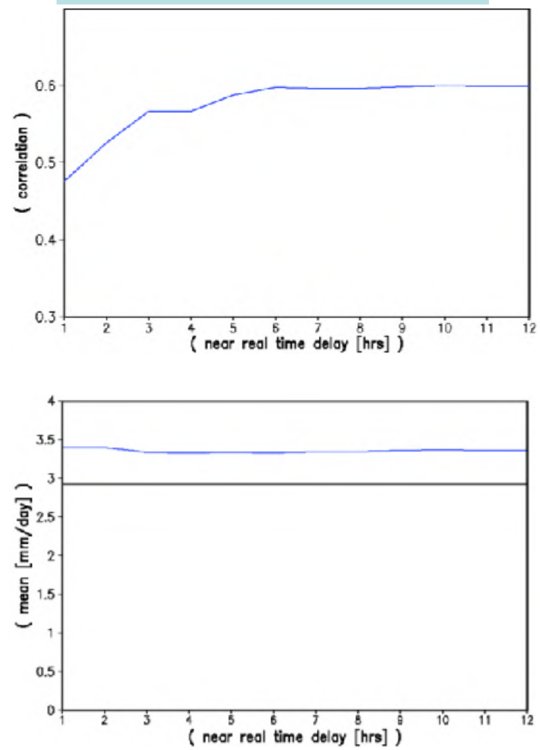
7) Quality and Quantitative Consistency

CMORPH2 Real-Time Production Improves with Production Latency but Maintains Good Quantitative Consistency among Productions of Different Latencies

CONUS Land



CONUS Ocean



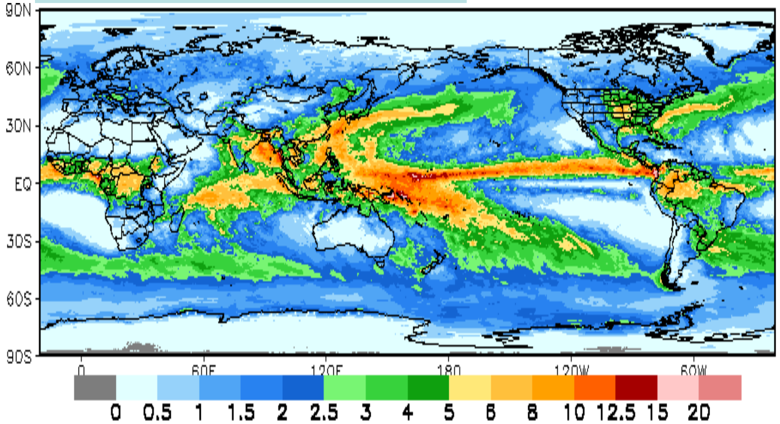
Comparison of the real-time 2nd generation CMORPH generated at various latency levels against the MRMS radar precipitation July, 2019, over CONUS land (left) and adjacent oceans (right) Comparisons are conducted for hourly precipitation on a 0.25^{o}lat/lon grid box.

Top and bottom panels show correlation and mean, respectively. Black Lines in the bottom are radar precipitation.

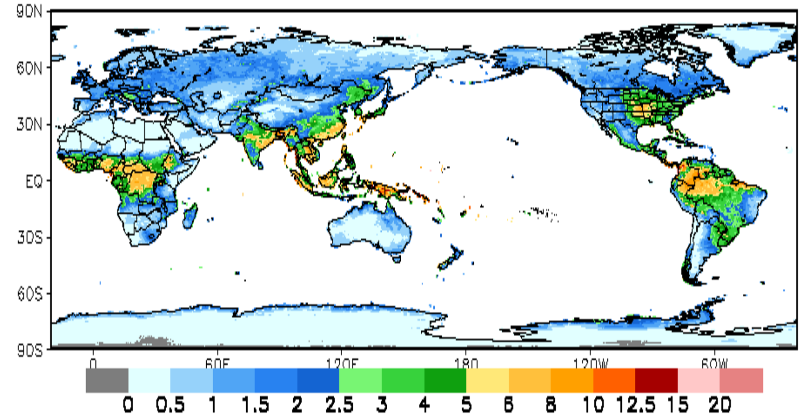
Comparison and Verifications

1) Mean Precipitation [Feb. – Sep.,2019]

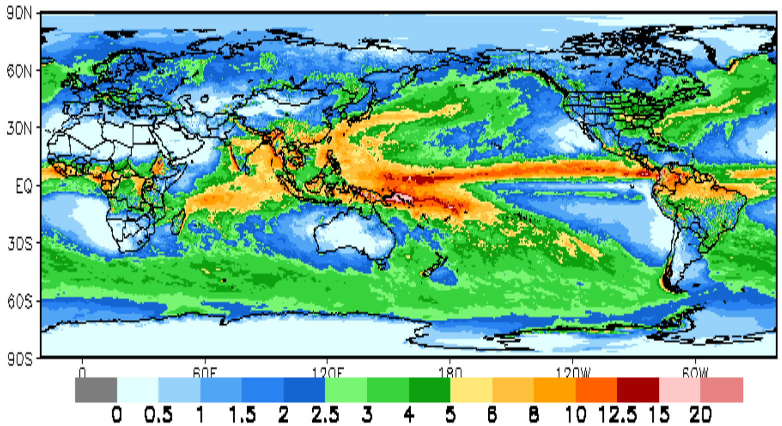
CMORPH2



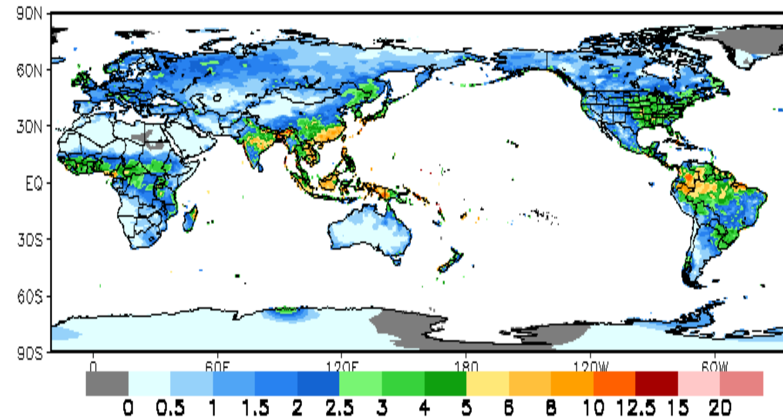
CMORPH2



GFS

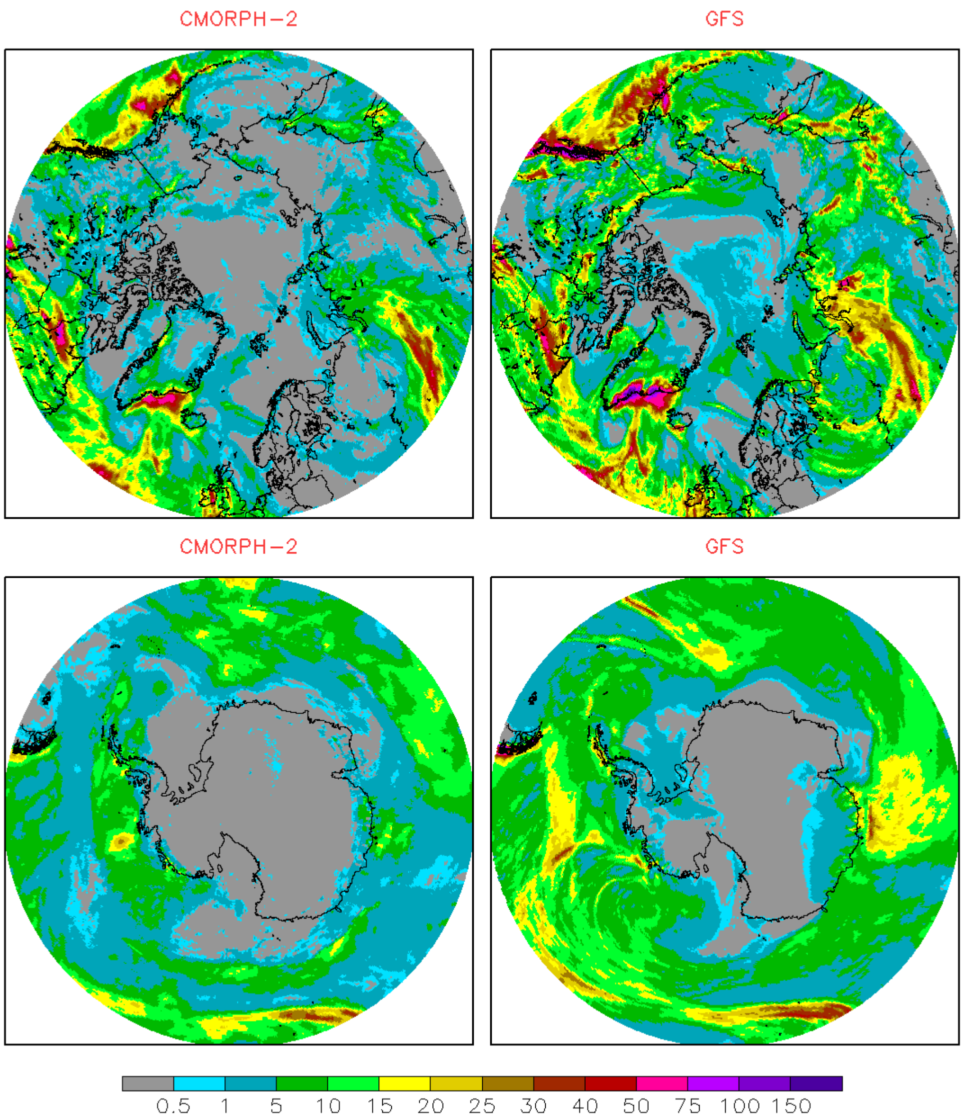


Gauge



Comparison and Verifications

2) Polar Precipitation



- Accumulated precipitation (mm) for 21-23 Sept., 2019;
- Overall very similar spatial patterns with GFS;
- Narrower raining areas than GFS especially over the Arctic;
- Differences in the magnitude of accumulated precipitation (usually smaller than GFS)

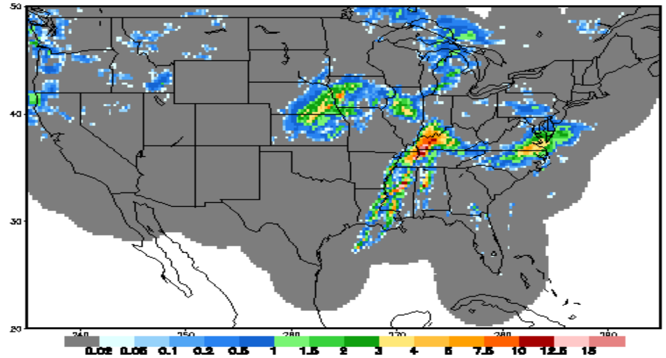
Comparison and Verifications

3) Winter Case over CONUS [1/3]

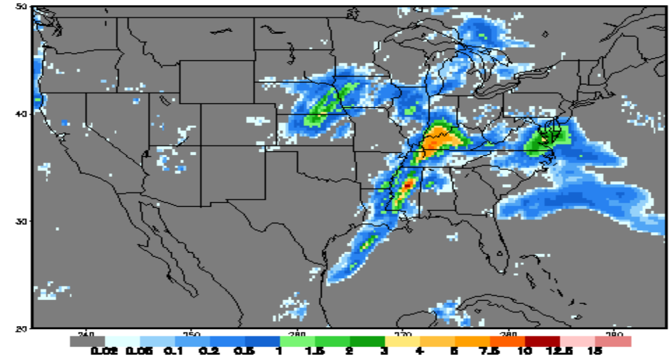
Mean precipitation rate (mm/hr)

for a ***30-miute period*** *starting at 00:00UTC, 24 February, 2019*

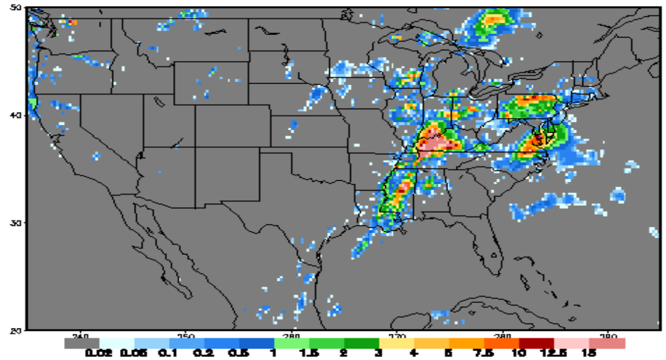
MRMS Radar Estimates



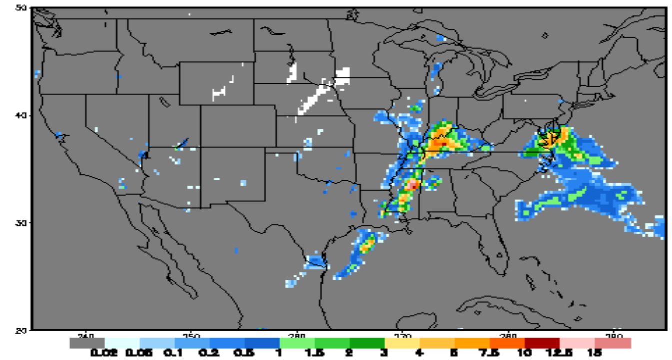
CMORPH2



NASA / IMERG



CMORPH1



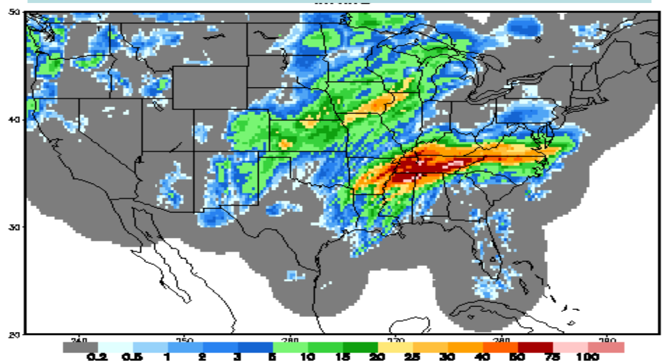
Comparison and Verifications

4) Winter Case over CONUS [2/3]

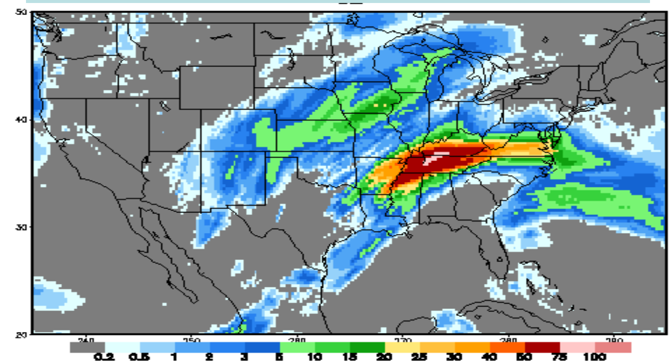
Daily precipitation (mm)

for 23 February, 2019

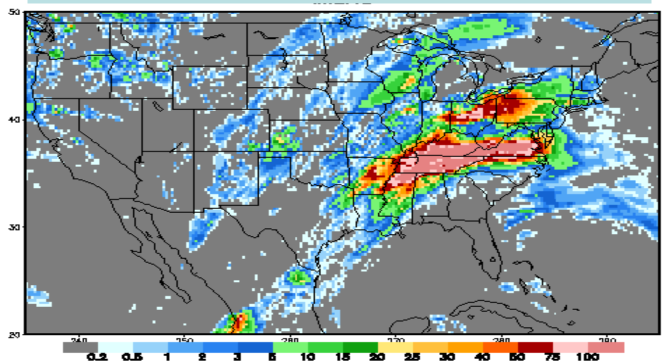
MRMS Radar Estimates



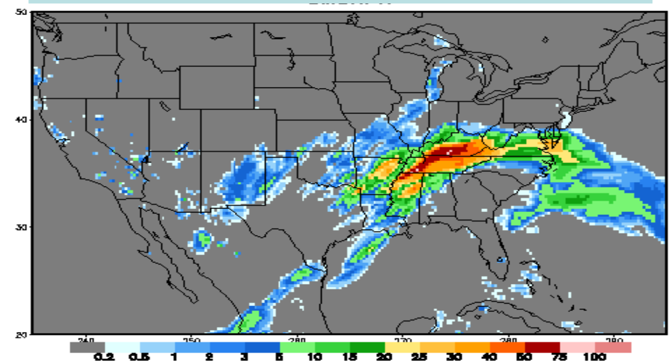
CMORPH2



NASA / IMERG



CMORPH1



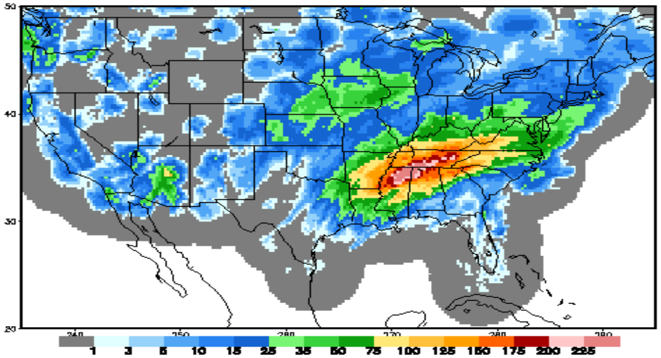
Comparison and Verifications

5) Winter Case over CONUS [3/3]

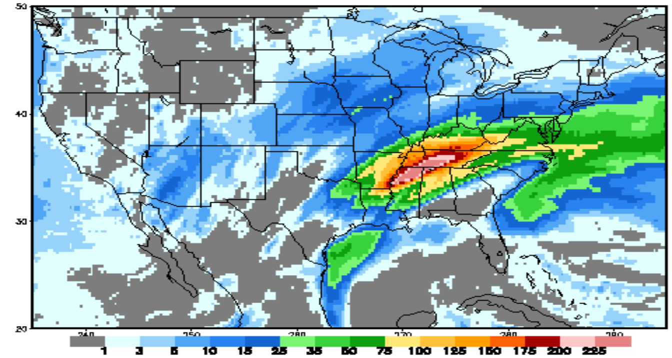
Accumulated precipitation (mm)

for 17-23 February, 2019

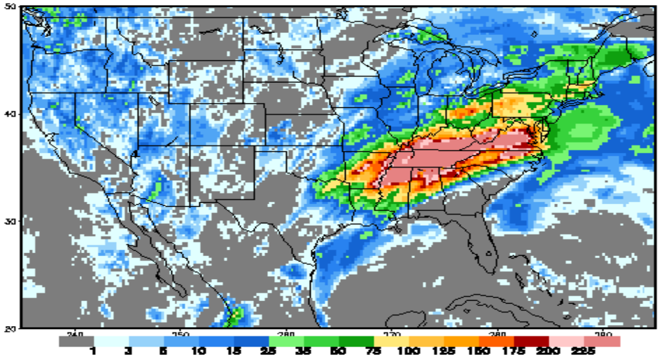
MRMS Radar Estimates



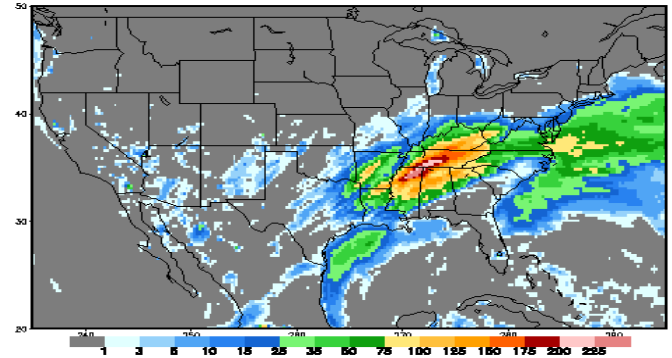
CMORPH2



NASA / IMERG



CMORPH1



Comparison and Verifications

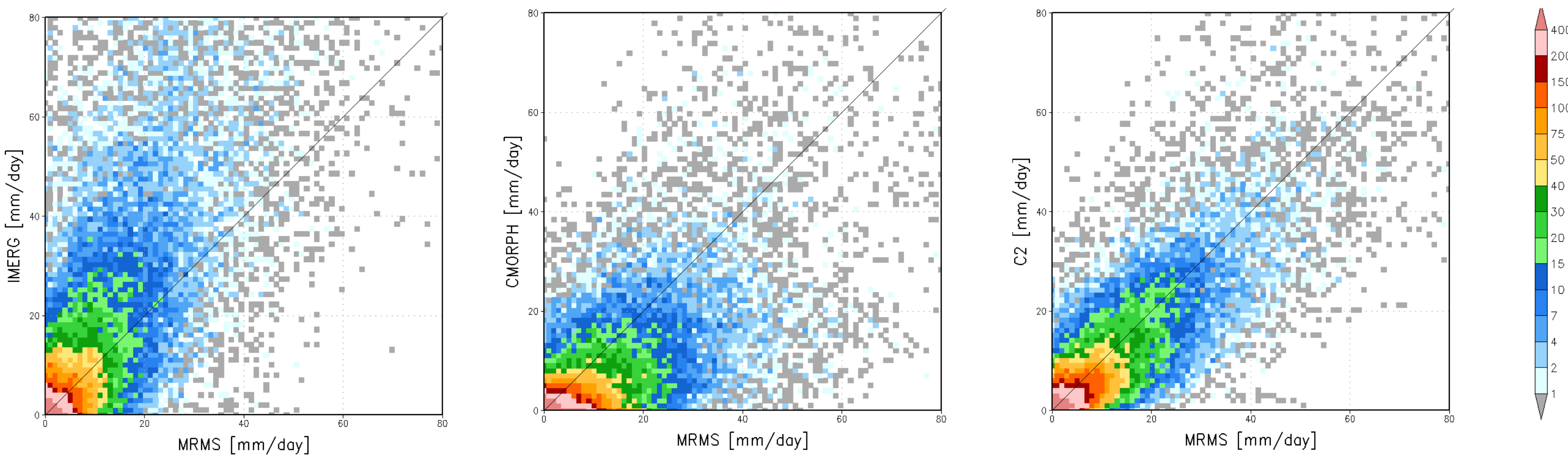
6) Comparison of three Satellite Products against Radar

Scatter density plots between the MRMS radar observed precipitation (X-axis) and estimates from the three satellite products (Y-axis). Comparisons are for daily precipitation over 0.25° lat/lon grid boxes over the CONUS for 1 – 28 February, 2019.

IMERG: *r* = 0.611

CMORPH1: *r* = 0.532

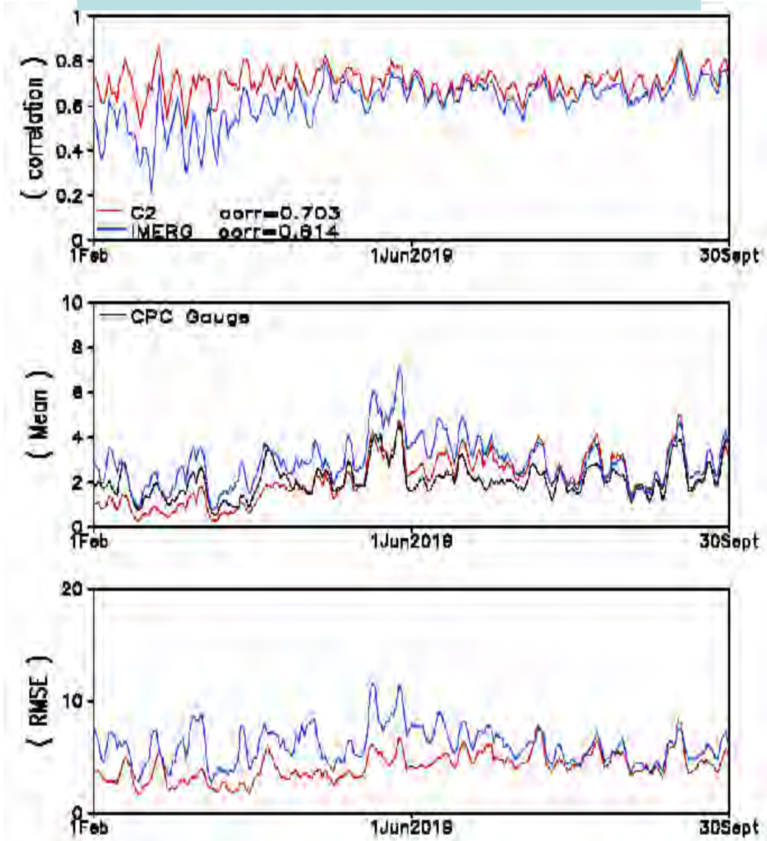
CMORPH2: *r* = 0.753



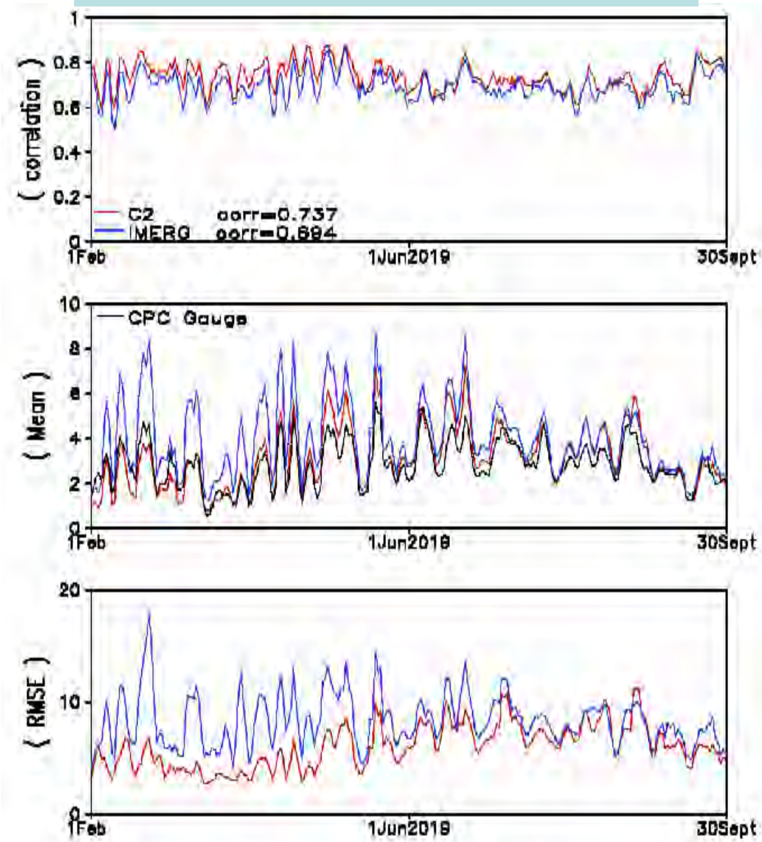
Comparison and Verifications

7) Comparison with Gauge Analysis [1/2]

40ºN-60ºN



20ºN-40ºN

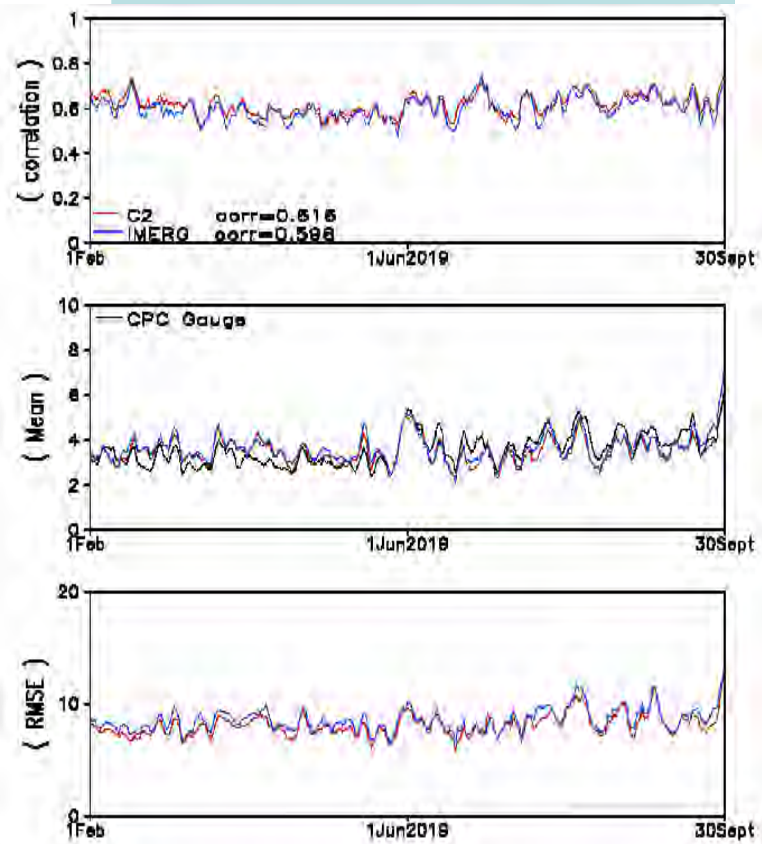


CMORPH2 (red) presents consistently higher correlation and closer magnitude with gauge analysis than the NASA/IMERG (blue), especially over high latitudes during cold season;

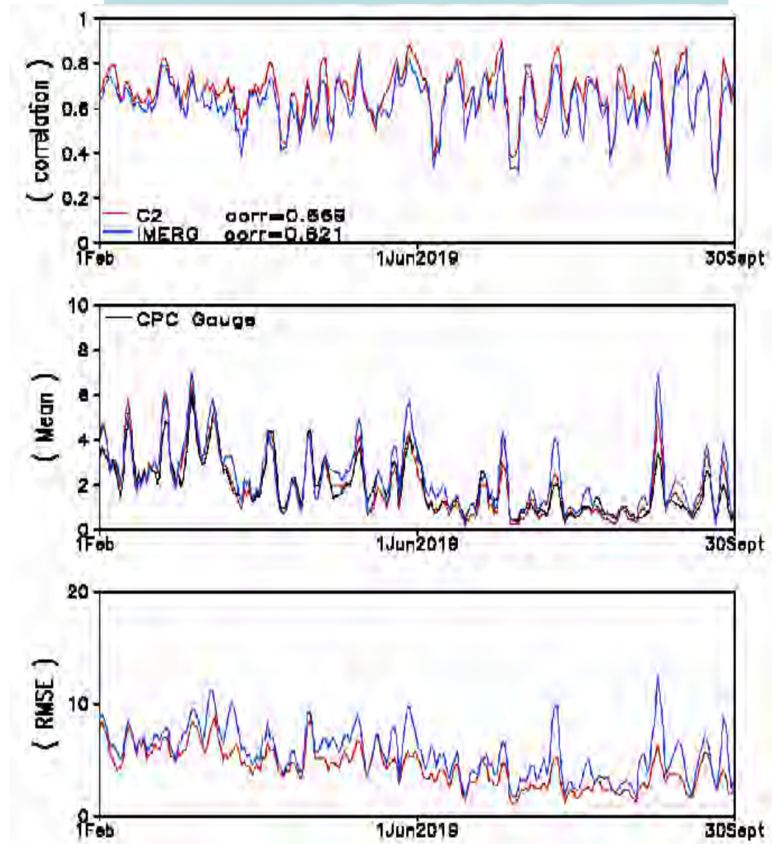
Comparison and Verifications

8) Comparison with Gauge Analysis [2/2]

20ºN-20ºS



20ºS-40ºS



CMORPH2 (red) presents consistently higher correlation and closer magnitude with gauge analysis than the NASA/IMERG (blue), especially over high latitudes during cold season;

Summary

1) Current Status

- **Algorithm Development**
  - *Completed the development of all algorithm components*

- **Real-time Production**
  - *Constructed a processing system to generate CMORPH2 on a real-time basis;*
  - *Installed the real-time system on CPC workstations;*
    - *CMORPH2 is produced first at a latency of one hour;*
    - *The real-time CMORPH2 is updated once an hour with newly available inputs until at the latency of 12 hours;*
  - *Work is under way to migrate the real-time production system to the WCOSS;*

- **Pilot Reprocessing**
  - *Pilot re-processing is under way for a period from May 2017 to the present;*
  - *A thorough examination will be conducted when the reprocessed CMORPH2 is available;*
  - *The purpose is to make sure all algorithm components work well;*

Summary

2) Product Availability

- **First Generation CMORPH**
  - *Bias Corrected CMORPH*
    - *8kmx8km, 30-min*
    - *0.25^{o}lat/lon / hourly*
    - *0.25^{o}lat/lon daily*
    - *1998 to the present*
  - *Gauge-CMORPH Blended*
    - *0.25^{o}lat/lon, daily*
    - *1998 to the present*
  - *ftp.cpc.ncep.noaa.gov/precip*
- **Second Generation CMORPH**
  - *Real-time production available upon requests*
  - *0.05^{o}lat/lon, 30-min*

- Sample Real-Time CMORPH2 (Globe)
- Sample Real-Time CMORPH2 (Antarctica)
- Sample Real-Time CMORPH2 (Arctic)

Summary

3) Work Underway

- **Thorough examinations of pilot retrospective processing**
  - **We will use the CWB radar data for validation of CMORPH2**

- **Improving representation of orographic effects**
  - *CWB radar and gauge data will be very useful to investigate the optimal algorithm and for validation*

- **Full-scale retrospective processing from at least 1998**