CMORPH
Blended Global Precipitation Products

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Team Members
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CMORPH Blended Product Team

Algorithm Team Members

Name	Organization	Major Task
Pingping Xie	NOAA/NWS/CPC	Team Leader, Algo Dvlp, Verifications, Applications, Customer Service
Robert Joyce	NOAA/NWS/CPC Innovim, LLC	Inputs, Algo Dvlp
Shaorong Wu	NOAA/NWS/CPC Innovim, LLC	System Dvlp, System Maintenance, Production, Customer Service
Li Ren	NOAA/NWS/CPC Innovim, LLC	Product Verifications

Input Needs for the CMORPH Algorithm

- Blended Product Name: **CMORPH**

	Data Product Name (Inputs)	Input Data Type (Satellite/Model Forecasts/*In-situ*)	Temporal/ Spatial Resolution, Format	Source(s)
1	Full-Resolution Global Geo TBB	Satellite (merged from 5 GEO platforms)	30-min; 4kmx4km	NWS/NCEP/CPC
2	AVHRR IR TB	Satellite (AVHRR window channel TB)	4kmx4km; orbit	NESDIS/OSPO
3	MiRS L2 Rainfall	Satellite (SNPP)	Satellite FOVs	NESDIS/JPSS
4	MSPPS L2 Rainfall Retrievals	Satellite (N18/19; MetOP A/B)	Satellite FOVs	NESDIS/OSPO
5	GPROF	Satellite (10 LEO platforms)	Satellite FOVs	NASA/GPM
6	JPSS SFR Retrievals	Satellite (SNPP; N18/19; MetOp A/B)	Satellite FOVs	NESDIS/STAR
7	IMS snow / ice Map	Satellite	4kmx4km / Daily	NIC
8	NCEI SST & Sea Ice	Satellite & In situ Blended	0.25°lat/lon; daily	NESDIS/NCEI
9	Pentad GPCP	Satellite & In situ Blended	2.5°lat/lon; 5-day	NWS/NCEP/CPC
10	CPC Daily Gauge Analysis	In situ	0.25°lat/lon; Daily	NWS/NCEP/CPC

CMORPH Algorithm

1. Basic Notion & Flowchart

- CPC Morphing Technique

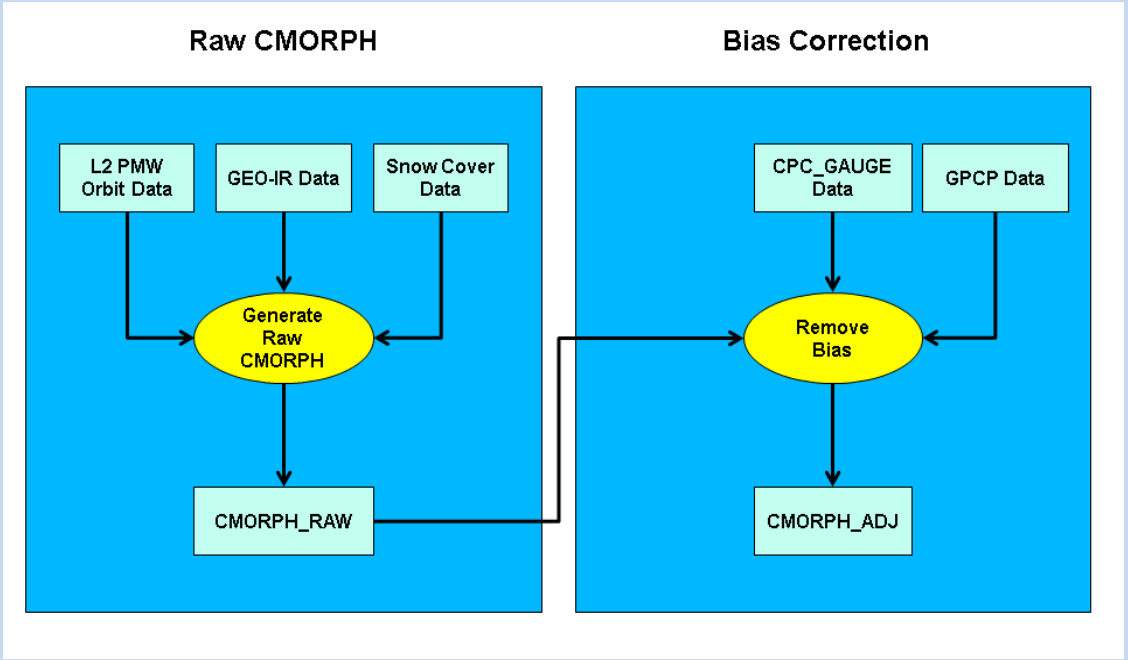
Joyce et al. (2004),Joyce and Xie (2011), Xie and Joyce (2015), Xie et al. (2017)

- Basic Notion

to construct a high-quality, high resolution precipitation analysis over the globe through integrating information from satellite observations as well as in situ measurements and model simulations

- Key Elements

  - *Satellite retrievals of instantaneous precip. rates*
  - *Cloud motion vectors to propagate the fields of instantaneous rates*
  - *In situ / long-term data to perform bias correction*



2. Technical Approach [CMORPH_RAW]

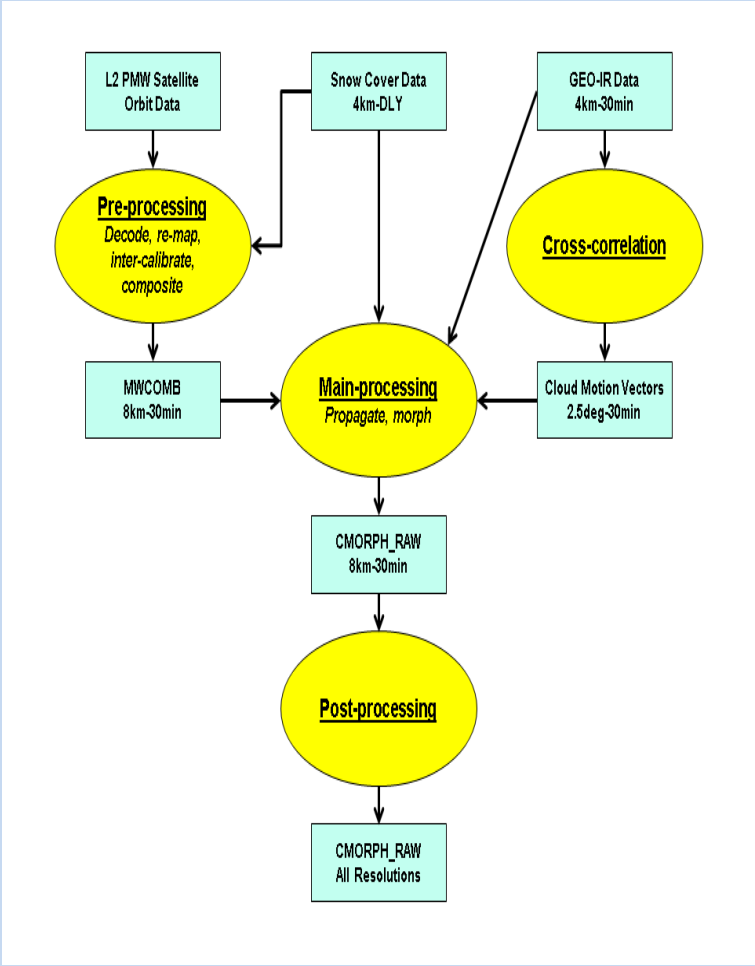
- Input Acquisition and Decoding

  From PDA and other sources

- QC/QA

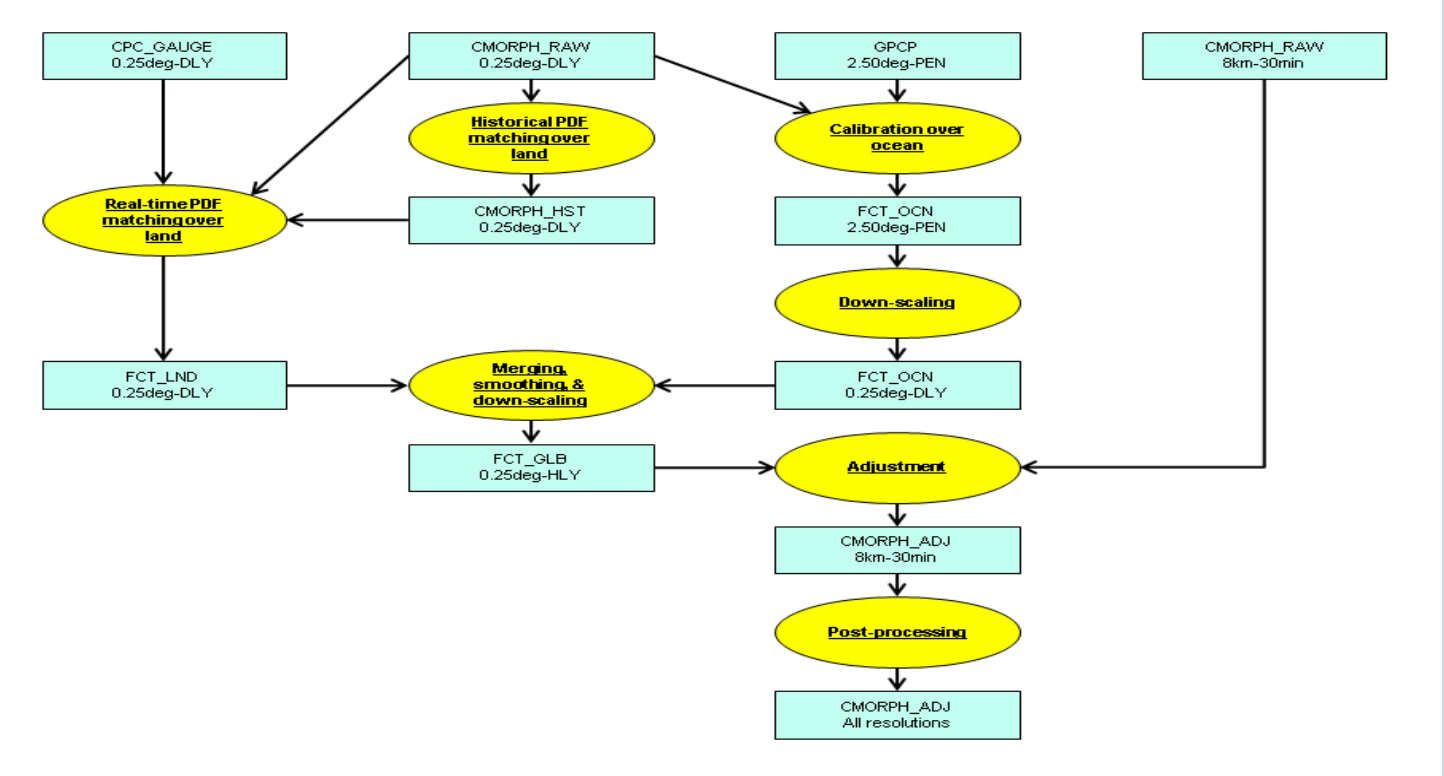
  Eliminating suspicious retrievals over surfaces covered with snow / ice

- Inter-calibration
  - *PDF matching against a reference L2 retrievals (TMI/GMI)*
  - *IR based estimates defined through PDF matching against combined inter-calibrated PMW retrievals*
- Morphing
  - *PMW retrievals propagated in both forward and backward directions along the motion vectors from their respective measurement times to the target analysis time;*
  - *Raw CMORPH defined as weighted mean of the forward and backward propagated PMW retrievals*



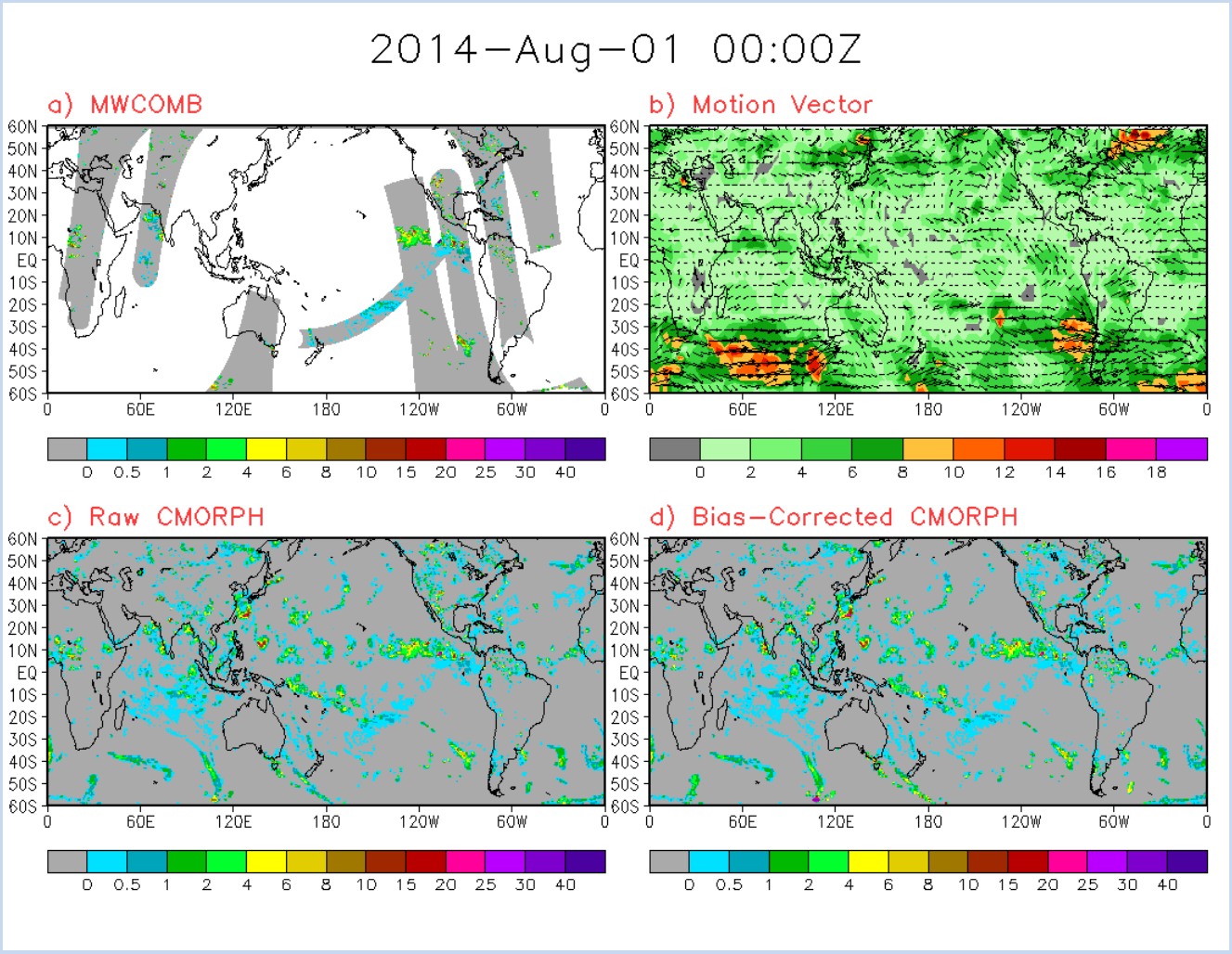
2. Technical Approach [CMORPH_CRT]

- Bias Correction for the purely satellite based raw CMORPH
  - ***Over land:*** *PDF matching against CPC daily gauge analysis*
  - ***Over Ocean*** *Calibration against pentad GPCP analysis*



CMORPH Algorithm

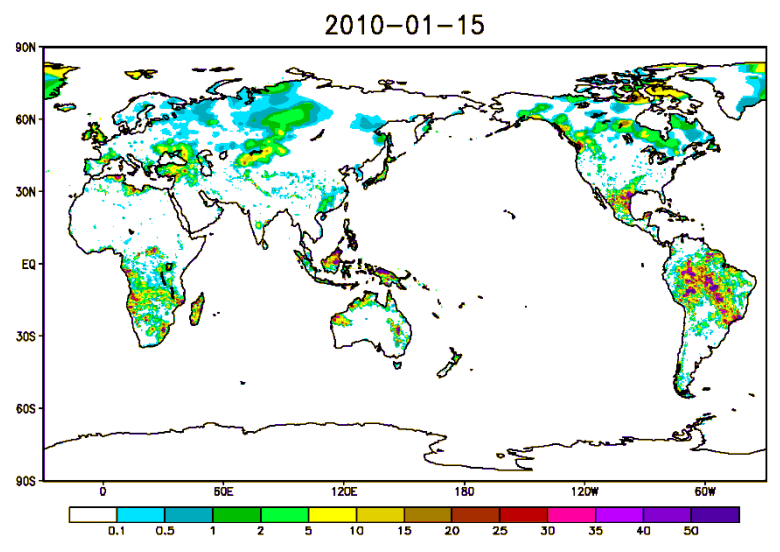
2. Technical Approach [Sample Process]

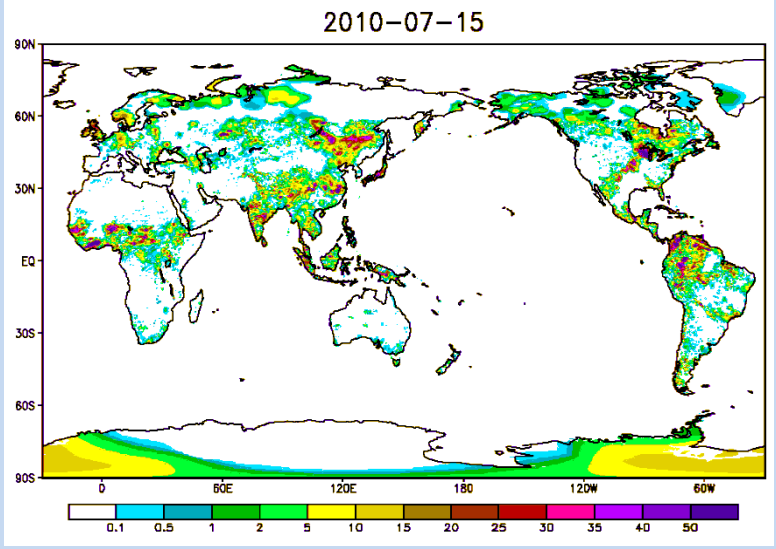


CMORPH Algorithm

2. Technical Approach [CMORPH_BLD]

- Bias Corrected CMORPH Further Blended with Gauge Analysis
  - *Optimal Interpolation (OI)*
  - *Bias corrected CMORPH used as the first guess*
  - *Gauge data utilized to refine the first guess*

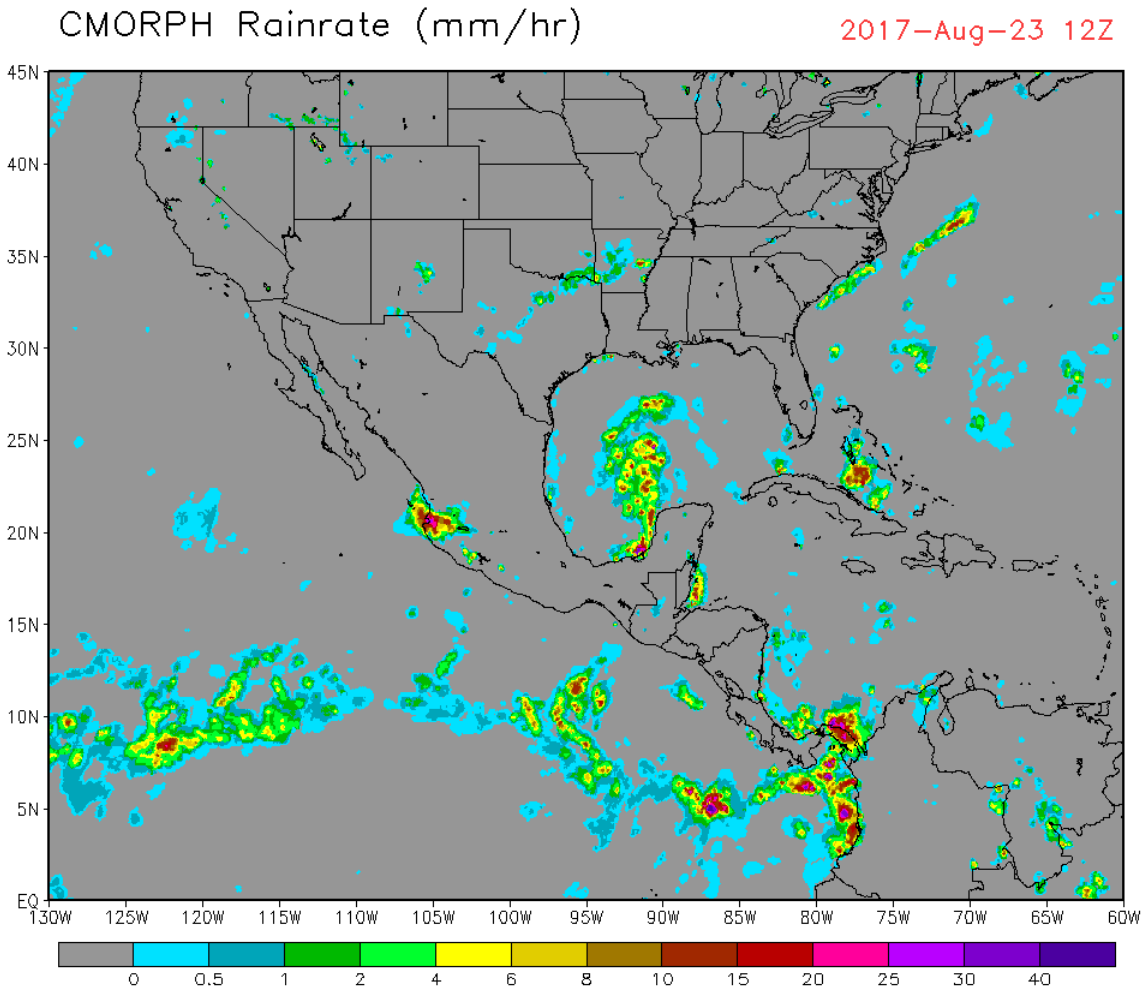




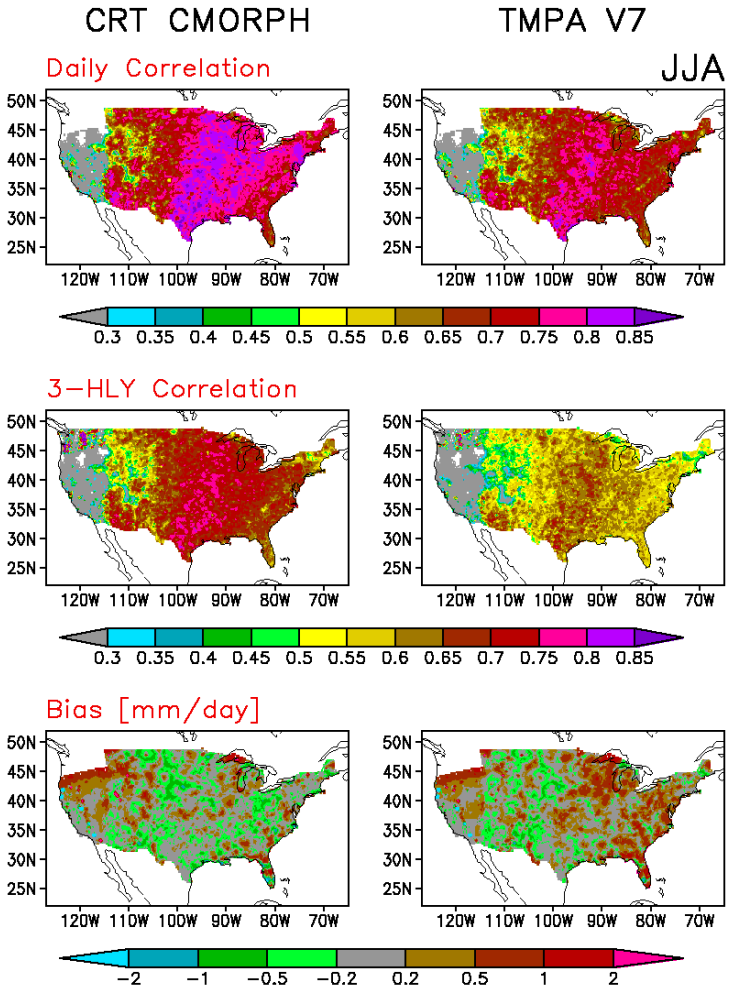
CMORPH Examples/Outputs

	Blended Data Product Name (Outputs)	Output Data Type (Satellite; Model Forecasts; In-situ)	Spatial, Temporal Resolution, Format	Source(s)	Latency of Real-Time Production
1	Full-Res GEO IR	Satellite	4kmx4km; 60°S-60°N 30-min; from 1998	GEO	45 min
2	Bias Corrected CMORPH	Satellite	8kmx8km; 60°S-60°N 30-min; from 1998	GEO, LEO	2 hours
3	Gauge – CMORPH Blended Analysis	In situ – Satellite Blended	0.25olat/lon; 90°S-90°N Daily; from 1998	Gauge, GEO, LEO	1 day

Sample Bias Corrected CMORPH



Product Evaluation/Validation/Tools



Comparison statistics for the CMORPH (left column) and TMPA Version 7 (right column) precipitation estimates against the NCEP Stage IV radar estimates. The statistics are computed for each grid box of 0.25°lat/lon grid over the CONUS using data for all 12 months over the June-July-August period from 2002 to 2015. Correlation for daily precipitation, 3-hourly precipitation, and bias (mm/day) are shown in the upper, middle, and bottom panels, respectively.

Identified Issues/Risks/Mitigations

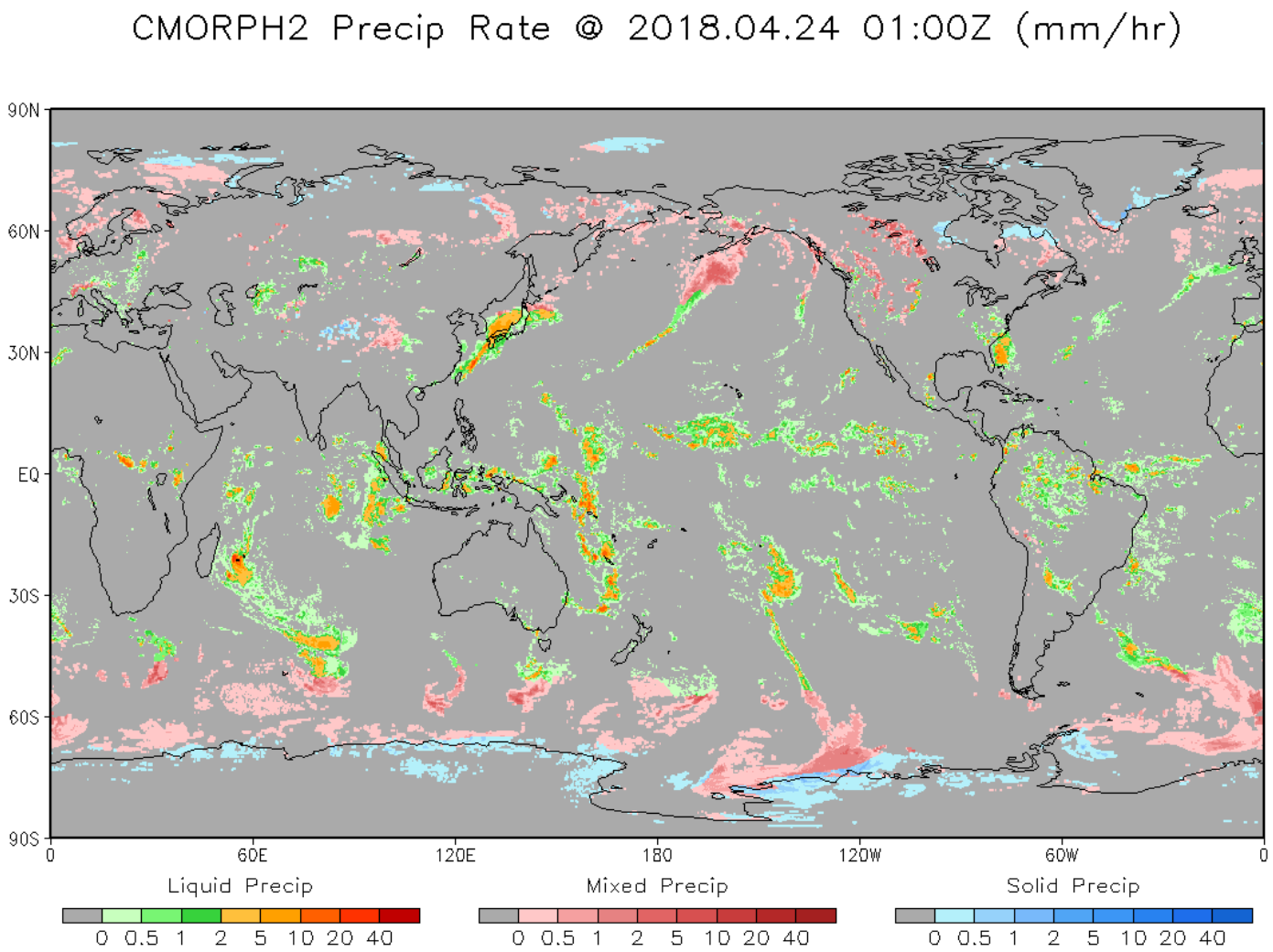
- Provide a list of identified risks/issues/mitigations and any examples identifying artifacts.

Identified Risk/Issues	Action/Mitigation
Poor capacity in detecting / quantifying snowfall and cold season rainfall	Infusing L2 retrievals of SFR in the 2nd generation CMORPH
Orographic rainfall	Exploiting geophysical info in numerical models in the end generation CMORPH
Under-estimation for heavy precipitation over small time/space domain	Improving representation with refined L2 retrievals

Future Algorithm Improvements

- 2nd Generation CMORPH
  - Main Features:
    - *Complete global coverage (90°S-90°N);*
    - *Much improved representation of snowfall rate and cold season rainfall*
    - *Refined spatial resolution (0.05°lat/lon)*
  - Currently under Parallel real-time production
  - Complete fine-tuning in 4-6 months
  - Reprocessing for May 1, 2017 to the present
  - Comprehensive evaluation for the 2nd generation
    - CPC daily gauge analysis over the global land
    - CPC hourly gauge analysis over CONUS
    - Radar precipitation estimates over CONUS et al

Sample CMORPH2



Summary and Path Forward

- CMORPH is a technique to produce high-quality, high-resolution precipitation estimates over the globe through integrating information from multiple satellite and in situ platforms
- The first generation CMORPH has been reprocessed for a 20-year period and updated on a near real-time basis at a latency of 2 hours
- The second generation CMORPH is under parallel real-time production tests with substantial improvements
- Efforts underway to push CMORPH to AWIPS

Backup Slides

Quality Flags

- Defined Quality Flag(s)
  - Variable, description, value, verification

Quality Flag	Description	Value
Missing	Missing values	-999.0

Implementation Status

- Discuss current status of implementation including the availability in AWIPS or alternatives.
  - First Generation CMORPH implemented on a 7/24 operational environment
- Algorithm version/LUTs
  - Version 1_CRT: Bias corrected
  - Version 1_BLD: Blended with gauge
- Processing environment and resources required for implementation or porting.
  - Linux
- Future plans on implementations including AWIPS or alternatives
  - Finalizing 2nd generation CMORPH

Importance/Benefits/Users

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
NHC	NOAA/NWS	Hurricane/tropical analysis	
EMC	NOAA/NWS	Land Surface Model Model verifications	
CPC	NOAA/NWS	Climate Monitoring / Analysis Model verifications	
NWC	NOAA/NWS	Precipitation forcing	
NSSL	NOAA/OAR	Filling radar gaps	
USDA	USDA	Agricultural	
AFWA	AFWA	Weather monitoring Land Surface Model	
WMO	WMO	Space based weather and climate monitoring	