Second Generation CMORPH Satellite Precipitation Estimates: Real-Time Production

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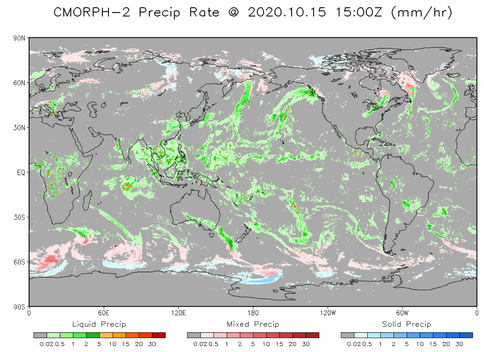
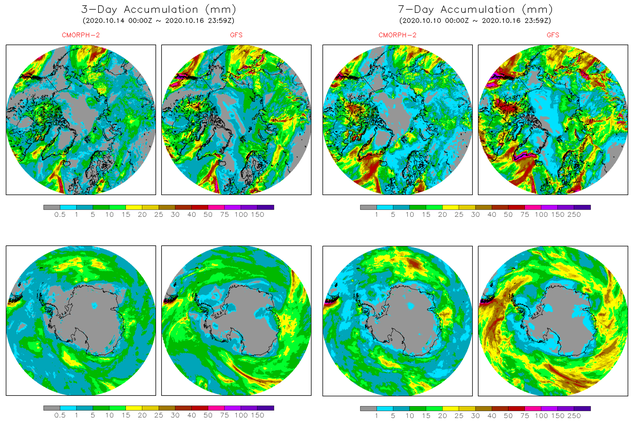
1) 2nd Generation CMORPH Overview

- 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)*
  - *Complete global coverage (90°S-90°N)*
  - *Low production latency (Currently one hour)*
  - *Greatly improved representation of cold season precipitation*
  - *In addition to the total precipitation, fraction of solid precipitation also estimated*
- *CMORPH2 Real-Time Production*
  - *Started real-time production three years ago*
  - *Generated at a latency of one hour, updated once an hour with newly available inputs until 12 hours after the target analysis time*
  - *Pushed into AWIPS for field operations*

2) Sample CMORPH2 Global Precipitation

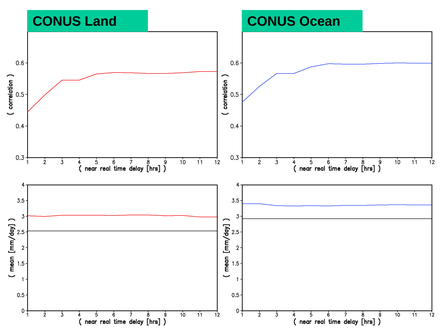


3) Comparison of CMORPH2 with GFS Forecast 3-/7-day Precipitation Accumulation



4) Performance of Real-Time CMORPH2 as a Function of Production Latency

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



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°lat/lon grid box.

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

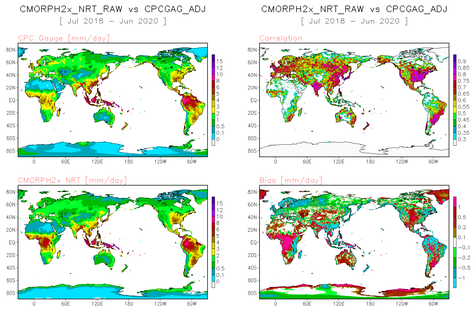
5) Evaluation of Real-Time CMORPH2

We conducted a comprehensive examinations of the CMORPH2 real-time production through comparison against ground observations. These include

- Global land
  - *Comparison against CPC daily gauge analysis*
  - *Daily gauge analysis on 0.25°lat/lon grid over global land*
  - *24-month period from July 2018 to June 2020*
- Taiwan
  - *Comparison against Taiwanese Central Weather Bureau (CWB) radar precipitation estimates*
  - *30-min, hourly and daily precipitation over 0.05°, 0.10°, and 0.25°lat/lon grids over and adjacent to the Taiwan Island*
  - *24-month period from July 2018 to June 2020*
- Alaska
  - *Comparison against CPC daily gauge analysis and Stage IV radar-gauge analysis (virtually based only on gauge observations)*
  - *6-hourly and daily precipitation on 0.25°lat/lon grid*
  - *July 2019*

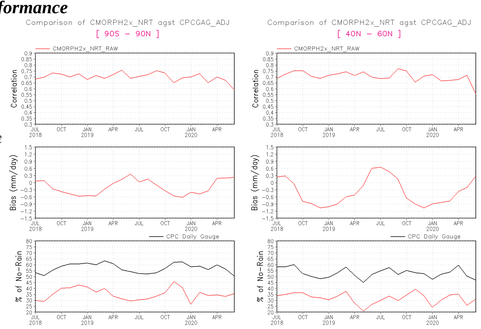
5.1) Evaluation over Global Land

(a) Spatial Performance



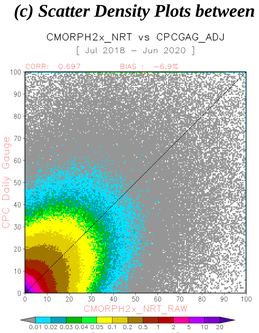
- *CMORPH2 shows very similar spatial distribution patterns of mean precipitation but exhibits bias (over- / under-estimation over tropics / extra-tropics;*
- *Quite high correlation (>0.7) for daily precipitation on a 0.25°lat/lon grid box;*
- *Low correlation over some areas (e.g. equatorial Africa, NW corner of S. America) attributable to poor gauge analysis;*

(b) Temporal Performance



- *CMORPH2 presents very high (>0.7) correlation with the CPC daily gauge analysis;*
- *The correlation is quite stable throughout the correlation, indicating great improvements of the CMORPH in representing cold season precipitation even over high latitudes;*
- *Bias exists and exhibits variations with season;*

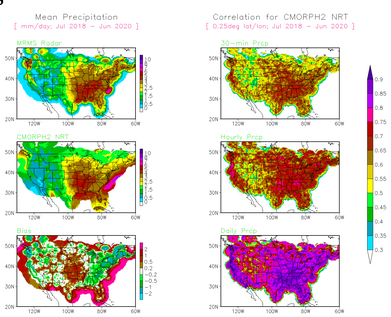
(c) Scatter Density Plots between CMORPH2 and Daily Gauge



- *Quite good agreements between the CMOTPH2 real-time production and CPC daily gauge analysis with a correlation of close to 0.7;*
- *Bias for mean precipitation over the entire global land for the 24-month period is -6.9%;*

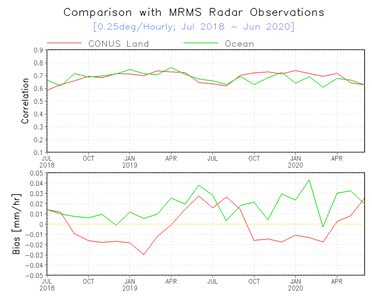
5.2) Evaluation over CONUS

(a) Spatial Performance



- *CMORPH2 reproduced the precipitation observed by the MRMS gauge-corrected rada precipitation quite well;*
- *Temporal variations of precipitation are well captured by CMORPH2 with very high correlation over most of the CONUS except the western mountainous regions;*
- *CMORPH2 tends to over- / under-estimate precipitation over central CONUS / other regions*

(b) Temporal Performance



- *High correlation of ~0.7 for daily precipitation over a 0.25°lat/lon grid box, indicating CMORPH2 capable of capturing spatial variation of precipitation over CONUS throughout the seasons;*
- *Bias exists and presents seasonal variations;*

(c) Correlation as a Function of Temporal/Spatial Scales

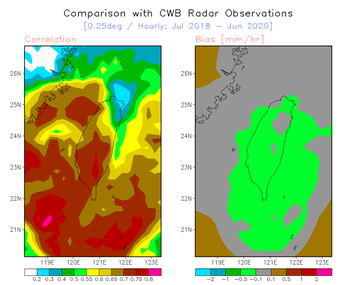
CONUS Land	0.05°lat/lon	0.10°lat/lon	0.25°lat/lon
30-min	0.577	0.580	0.628
Hourly	0.603	0.604	0.667
Daily	0.769	0.781	0.805

CONUS Ocean	0.05°lat/lon	0.10°lat/lon	0.25°lat/lon
30-min	0.489	0.533	0.621
Hourly	0.551	0.593	0.676
Daily	0.788	0.806	0.841

- *Correlation between real-time CMORPH and MRMS radar precipitation estimates;*
- *MRMS estimates for 30-min precipitation are from the uncorrected raw radar data while hourly and daily precipitation is derived from gauge corrected estimations;*
- *Over ocean, only data over grid boxes within 100km of radar sites are included in the comparison;*

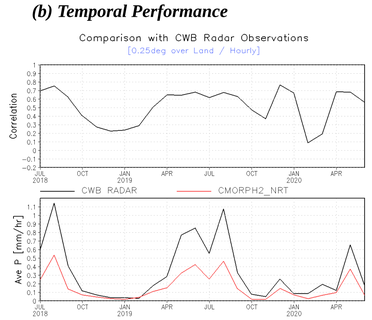
5.3) Evaluation over Taiwan

(a) Spatial Performance



- *Very good correlation over Taiwan, except the NE corner where low correlation (<0.3 for hourly precipitation) is observed;*
- *Overall under-estimation is observed over virtually the entire domain;*

(b) Temporal Performance

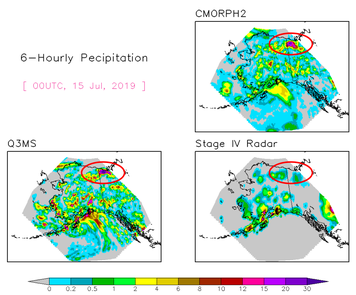


- *Under-estimation by a large percent;*
- *Quite high correlation for most of the seasons with rainfall;*

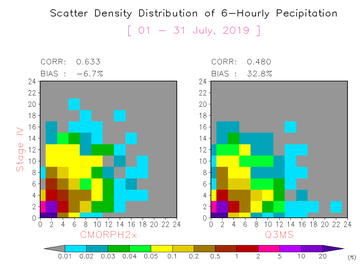
5.4) Evaluation over Alaska

(a) Sample 6-Hourly Precipitation

- *Overall reasonable agreements in large-scale distribution patterns among the three data sets;*
- *CMORPH2 agrees quite well with Stage IV, while the experimental Q3MS shows a ran band over N AK with shifted position;*



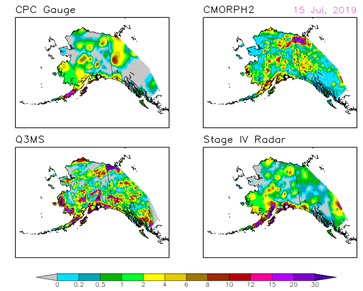
(b) Scatter Plots of 6-Hourly Precipitation



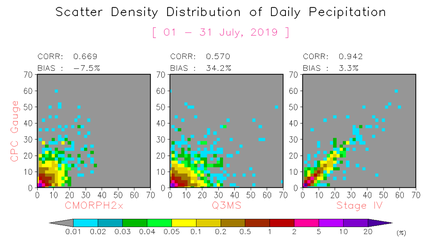
- *Only data pairs over 0.25°lat/lon grid boxes with one or more gauges are included in the comparison;*
- *CMORPH2 (with no gauge correction in this version) shows better performance than Q3MS, with higher correlation and smaller bias;*

(c) Sample Daily Precipitation

- *CMORPH2 shows quite good agreements with CPC daily gauge and Stage IV precipitation analyses, with more details;*
- *Under-estimations in the southern coastal areas with substantial orographic enhancements;*



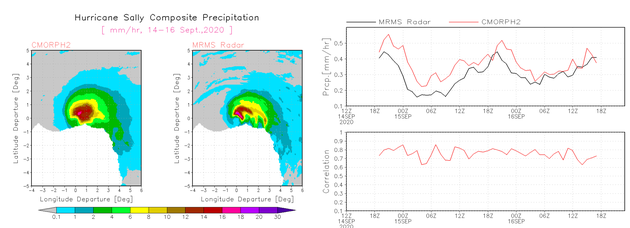
(d) Scatter Plots of Daily Precipitation



- *Stage IV radar, which is virtually a gauge analysis of 6-hourly precipitation by gauge, shows the best agreements with CPC daily gauge analysis, with a correlation of 0.942, and a bias of minor magnitude;*
- *CMORPH2 exhibits quite good correlation of 0.669, and a negative bias of -7.5%;*
- *Q3MS analysis presents quite large scatters, with a correlation of 0.570 and large over estimates of 34.2%;*

6) CMORPH2 Captures Hurricane Sally

- Movement and evolution of Hurricane Sally well captured by CMORPH2
- Spatial pattern of precipitation very close to that in the radar observation (bottom-left, composite precipitation)
- Diurnal variations in mean precipitation detected very well (bottom-right, mean precipitation within 500 km of hurricane center)
- Overall very high correlation with the radar precipitation (bottom-right, correlation for hourly precipitation on 0.25°lat/lon grid)



7) Summary

- Real-time CMORPH2 shows quite good skills in capturing the spatial patterns and temporal evolution of precipitation over the globe;
- In particular, the 2nd generation presents substantial improvements in detecting and quantifying precipitation over extra-tropics and during cold seasons;
- Bias exists in the 2nd generation CMORPH and varies with regions and seasons;
- Work is underway:
  - *To perform bias correction through comparison against gauge observations over land and adjustment against GPCP merged analysis over ocean;*
  - *To perform retrospective analysis for the CMORPH2 for a 30-year period from 1991*
    - *1991 – 1997: Daily / 0.05°lat/lon*
    - *1998 – present: 30-min / 0.05°lat/lon*