Kalman-Filtered CMORPH using TRMM to Blend Satellite Rainfall

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International Precipitation Working Group 5
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Outline

1. Current Kalman filter CMORPH approach

2. Evaluation of CMORPH and Kalman filter CMORPH

3. Various PMW satellite scenarios for CMORPH, IR-based rainfall, and Kalman filter CMORPH

4. Conclusions and Future plans

Kalman filter CMORPH approach

1. Withhold 0.25 degree 30 minute TRMM TMI collocated with propagated PMW rainfall and IR-based rainfall

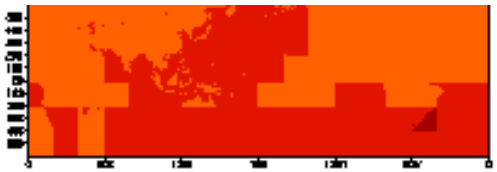
2. ~4 - 5 month periods of TMI-PMW sensor comparisons yield reasonably stable historical weights for each month

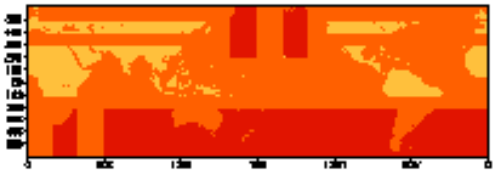
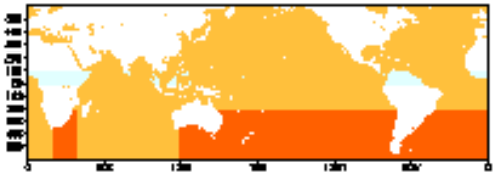
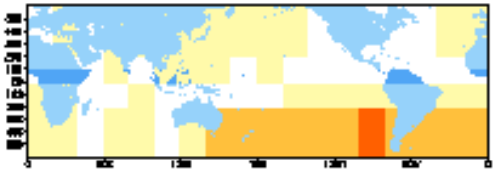
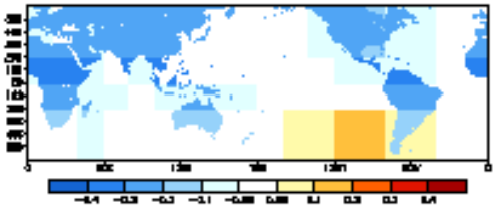
3. Currently evaluating one year of Kalman filter CMORPH (June 2009-May 2010)

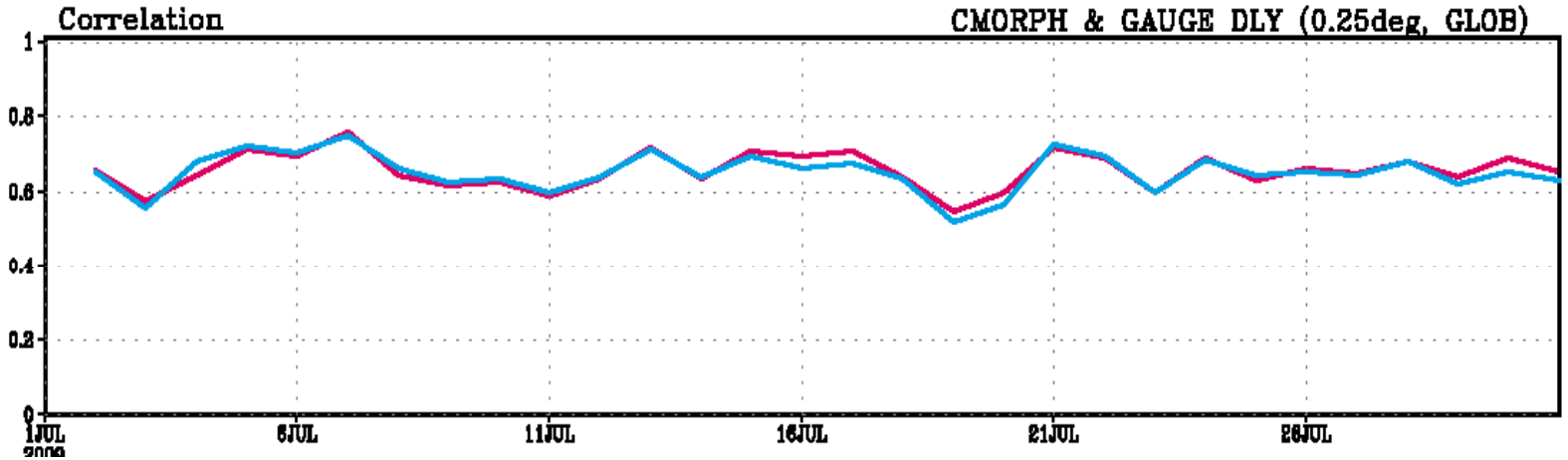
4. Validated with the CPC Unified global daily gauge rainfall analyses

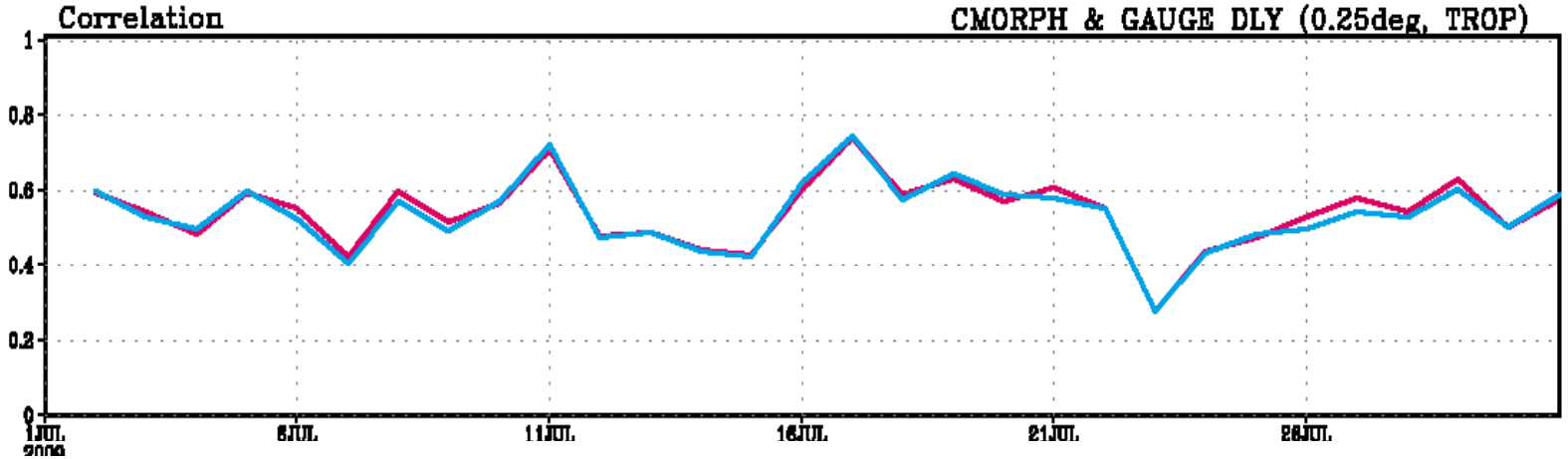
Correlation difference of propagated HQ PMW rainfall relative to IR-based using withheld TRMM TMI for June 2009

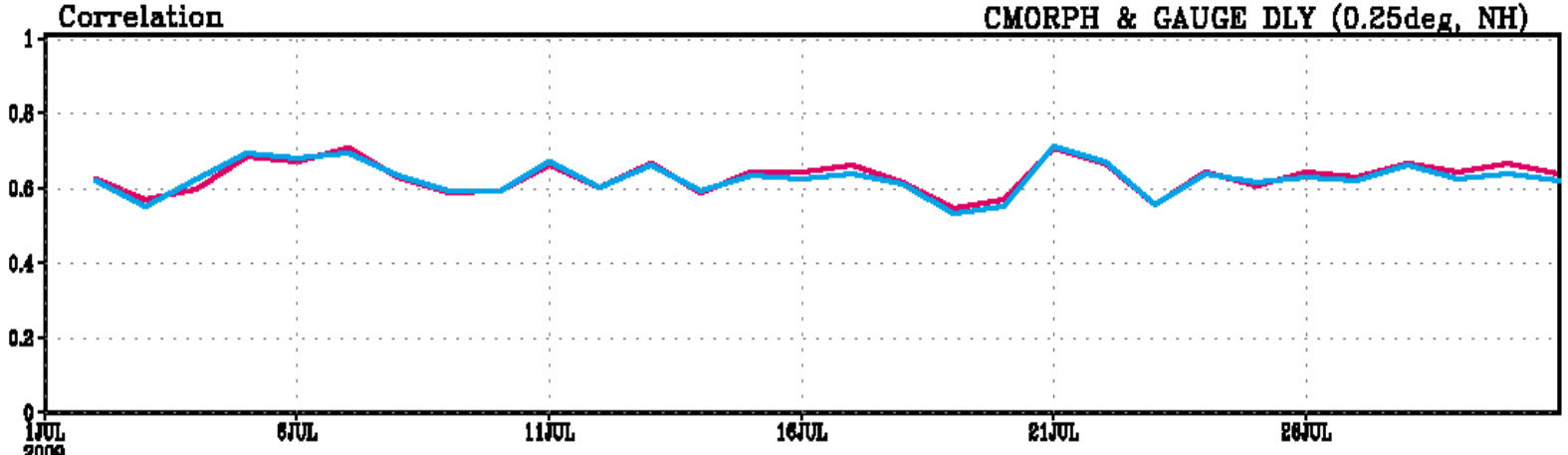
Instantaneous PMW

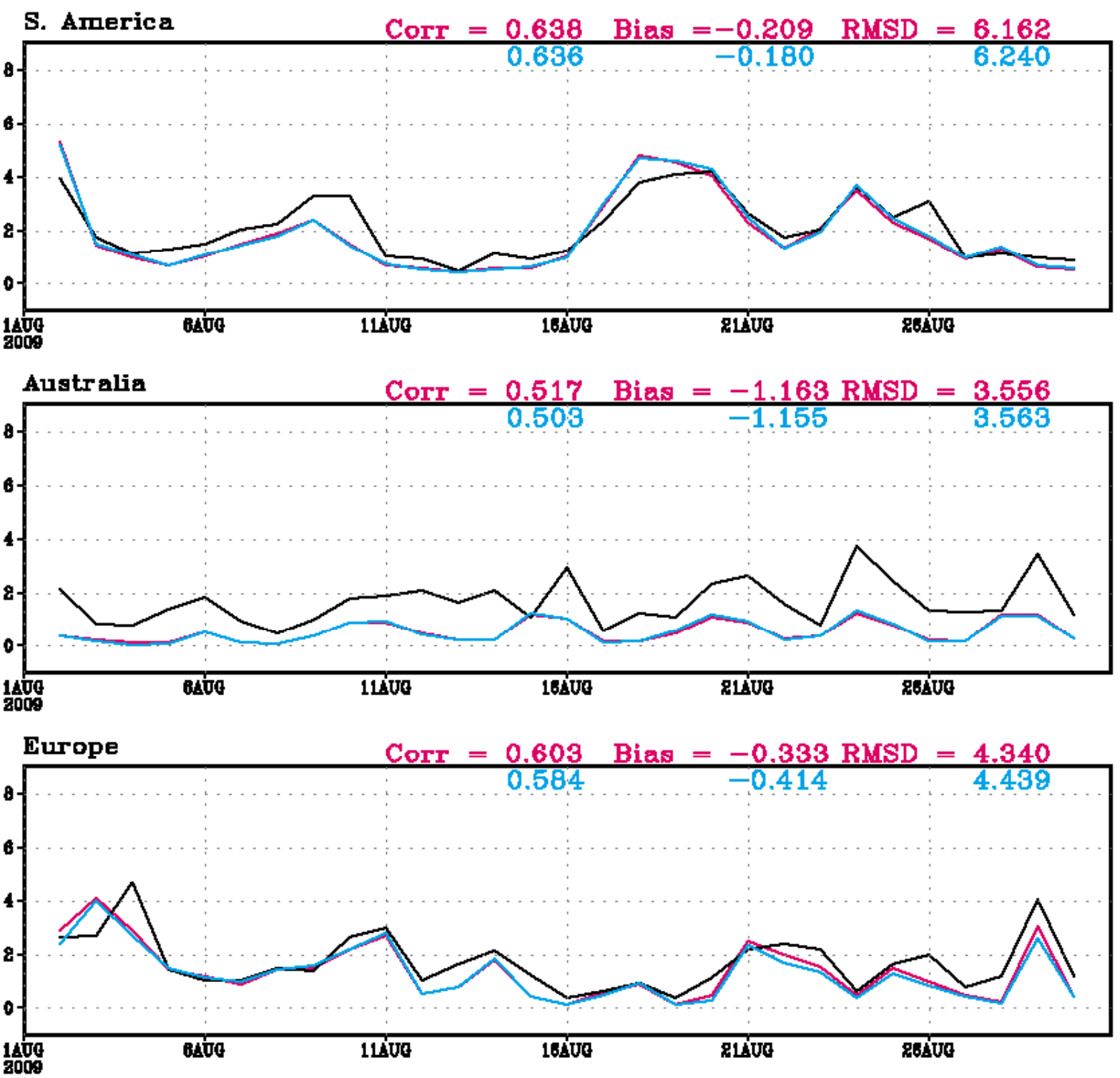


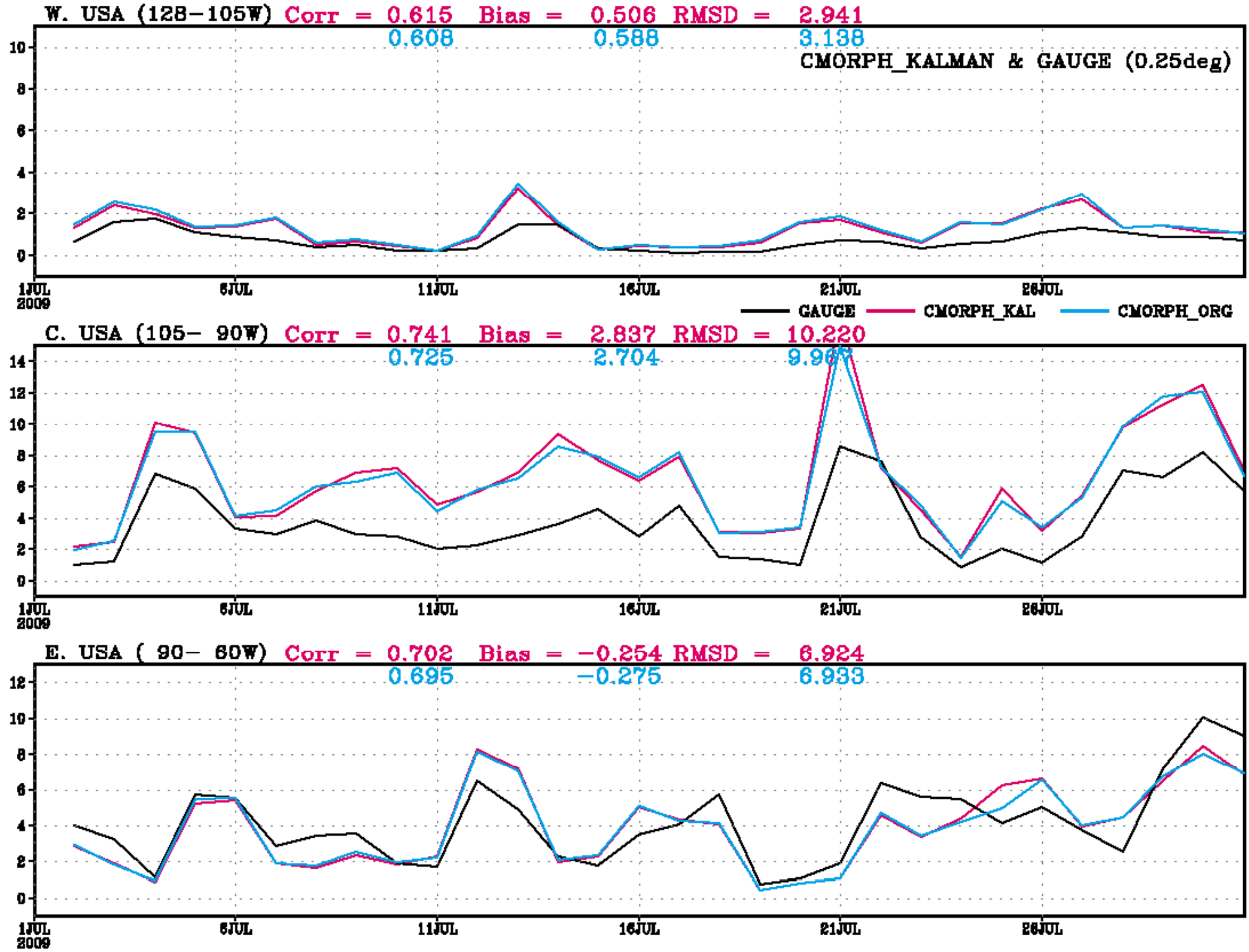
Backward propagation		Forward propagation
30 minutes		30 minutes
60 minutes		60 minutes
90 minutes		90 minutes
120 minutes		120 minutes


Correlation
CMORPH & GAUGE DLY (0.25deg, GLOB)
1
0.8
0.6
0.4
0.2
0
1JUL
2008
6JUL
11JUL
16JUL
21JUL
26JUL


Correlation
CMORPH & GAUGE DLY (0.25deg, TROP)
1
0.8
0.6
0.4
0.2
0
1JUL
2008
6JUL
11JUL
16JUL
21JUL
26JUL


Correlation
CMORPH & GAUGE DLY (0.25deg, NH)
1
0.8
0.6
0.4
0.2
0
1JUL
2008
6JUL
11JUL
16JUL
21JUL
26JUL


S. America
Corr = 0.638 Bias =−0.209 RMSD = 6.162
0.636 −0.180 6.240
Australia
Corr = 0.517 Bias = −1.163 RMSD = 3.556
0.503 −1.155 3.563
Europe
Corr = 0.603 Bias = −0.333 RMSD = 4.340
0.584 −0.414 4.439
0
2
4
6
8
1AUG
2009
6AUG
11AUG
16AUG
21AUG
26AUG

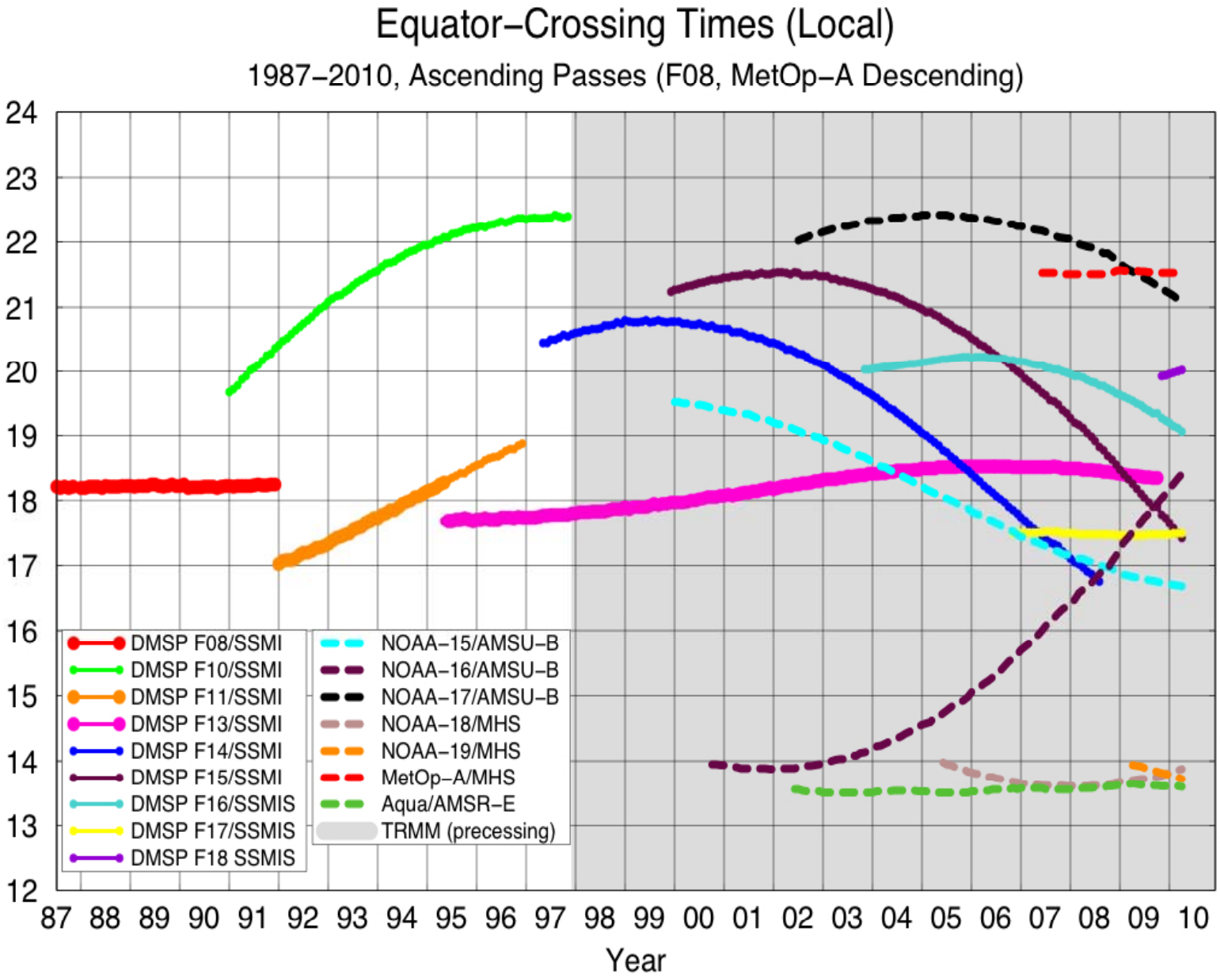

W. USA (128–105W) Corr = 0.615 Bias = 0.506 RMSD = 2.941
0.608 0.588 3.138
CMORPH_KALMAN & GAUGE (0.25deg)
1JUL 2009
6JUL
11JUL
16JUL
21JUL
26JUL
GAUGE
CMORPH_KAL
CMORPH_ORG
C. USA (105– 90W) Corr = 0.741 Bias = 2.837 RMSD = 10.220
0.725 2.704 9.96
E. USA (90– 60W) Corr = 0.702 Bias = −0.254 RMSD = 6.924
0.695 −0.275 6.933

Various PMW satellite scenario trials

1. operational CMORPH reconfigured to run a 1, 2, 4, 7, and full 9 PMW satellite ingest for July and August 2009

2. IRFREQ for the 1 and 2 PMW satellite approach reconfigured to PDF match with just those data

3. NSSL Q2 radar rainfall (5 minute 1 km) used for validation of CMORPH, IR-based rainfall and Kalman filter CMORPH



C-Train:

METOP-A, NOAA17

B-Train:

DMSP-13, NOAA15&16

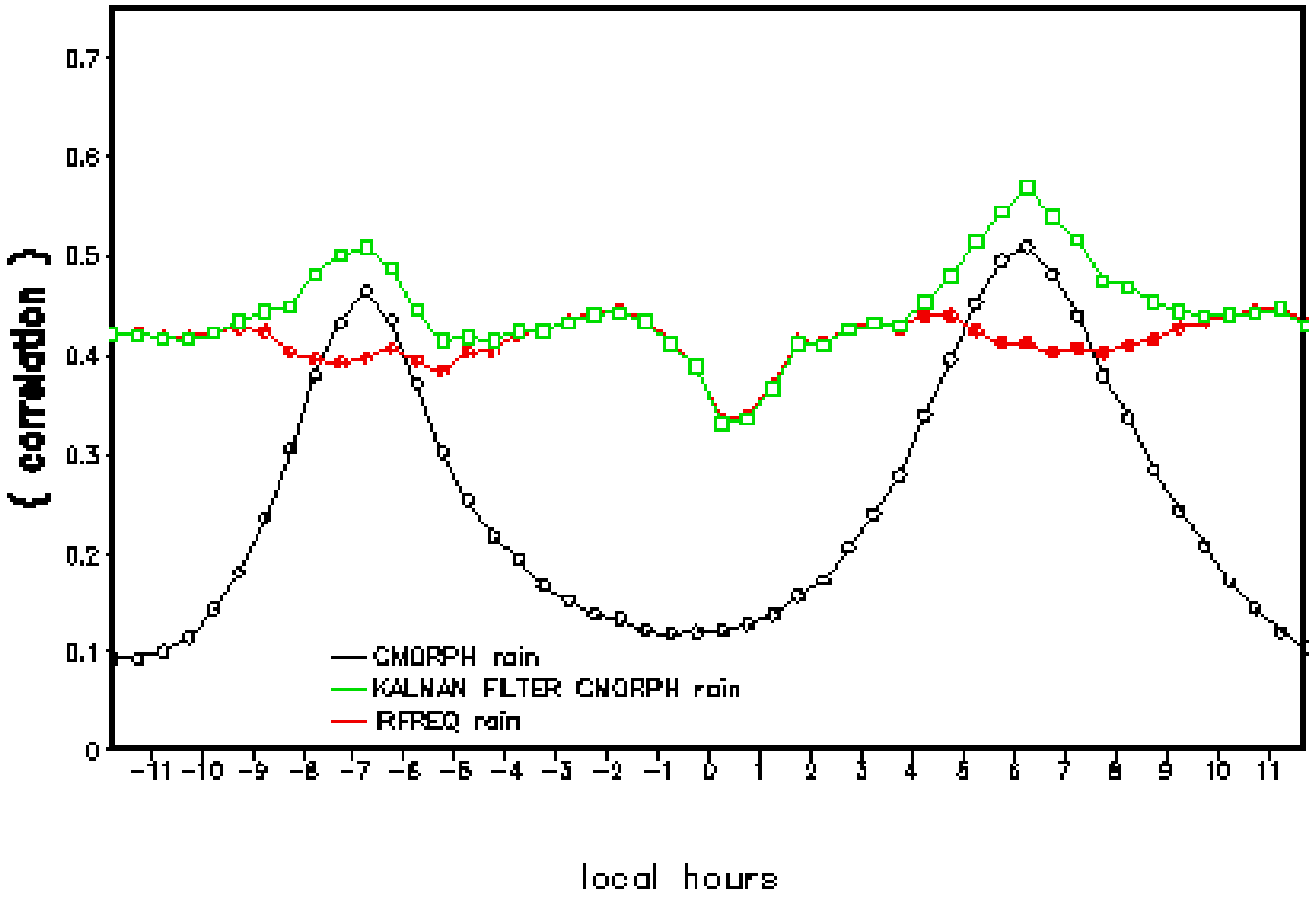
A-Train:

AQUA, NOAA18&19

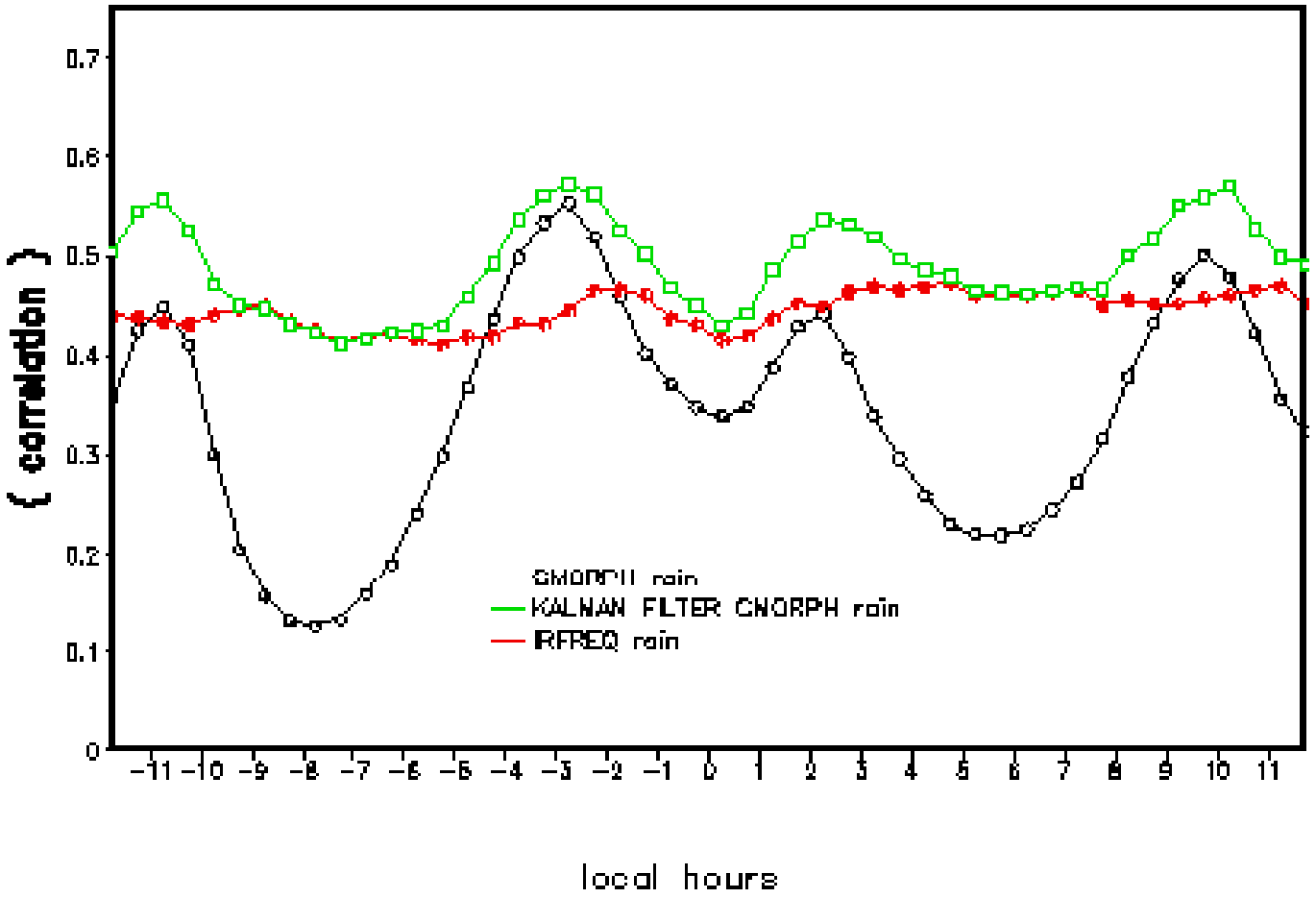
Thickest lines denote GPCP calibrator.

Image by Eric Nelkin (SSAI), 19 April 2010, NASA/Goddard Space Flight Center, Greenbelt, MD.

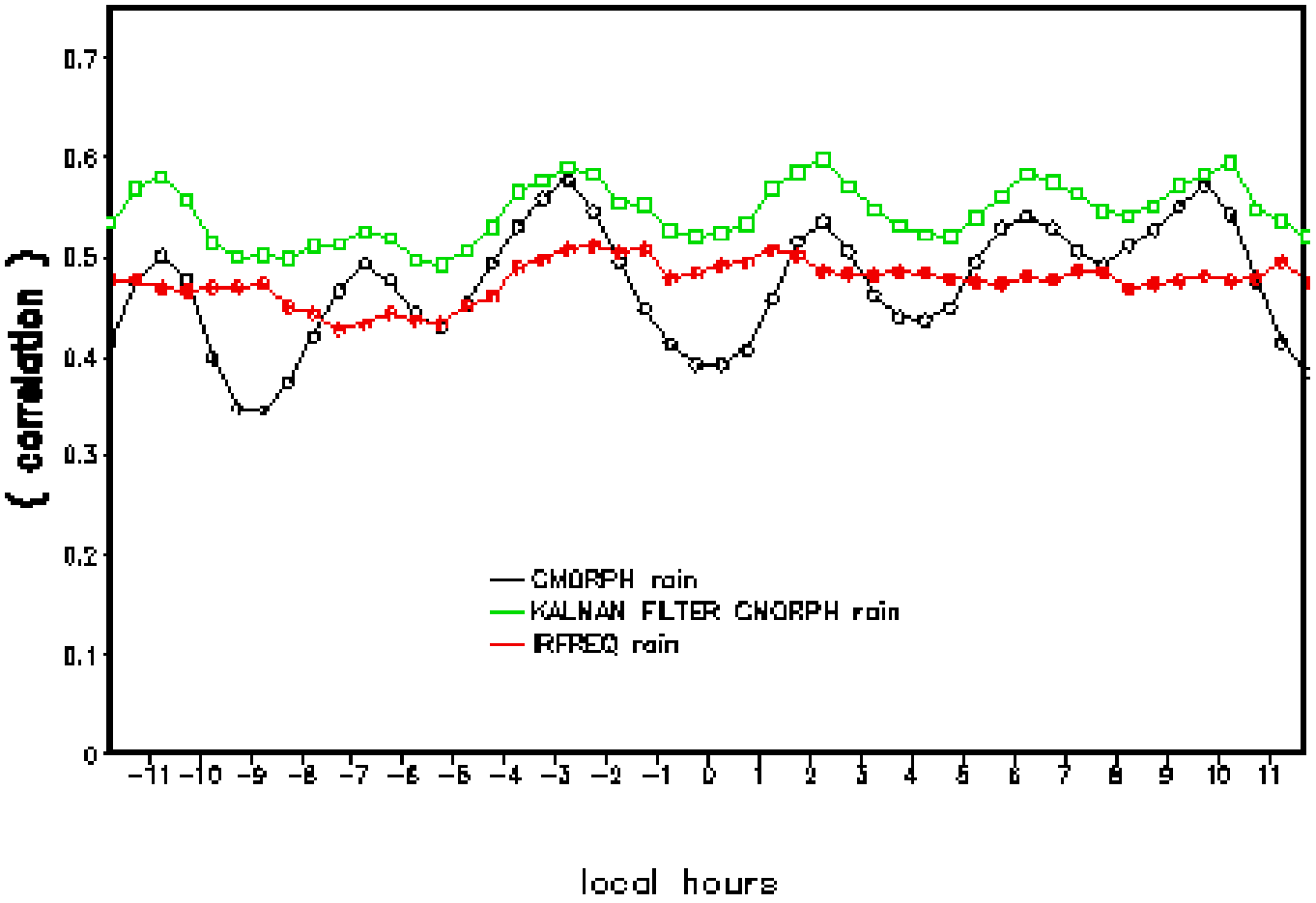
Correlation of Q2 with a 1 PMW satellite (NOAA-16) configuration for July - August 2009



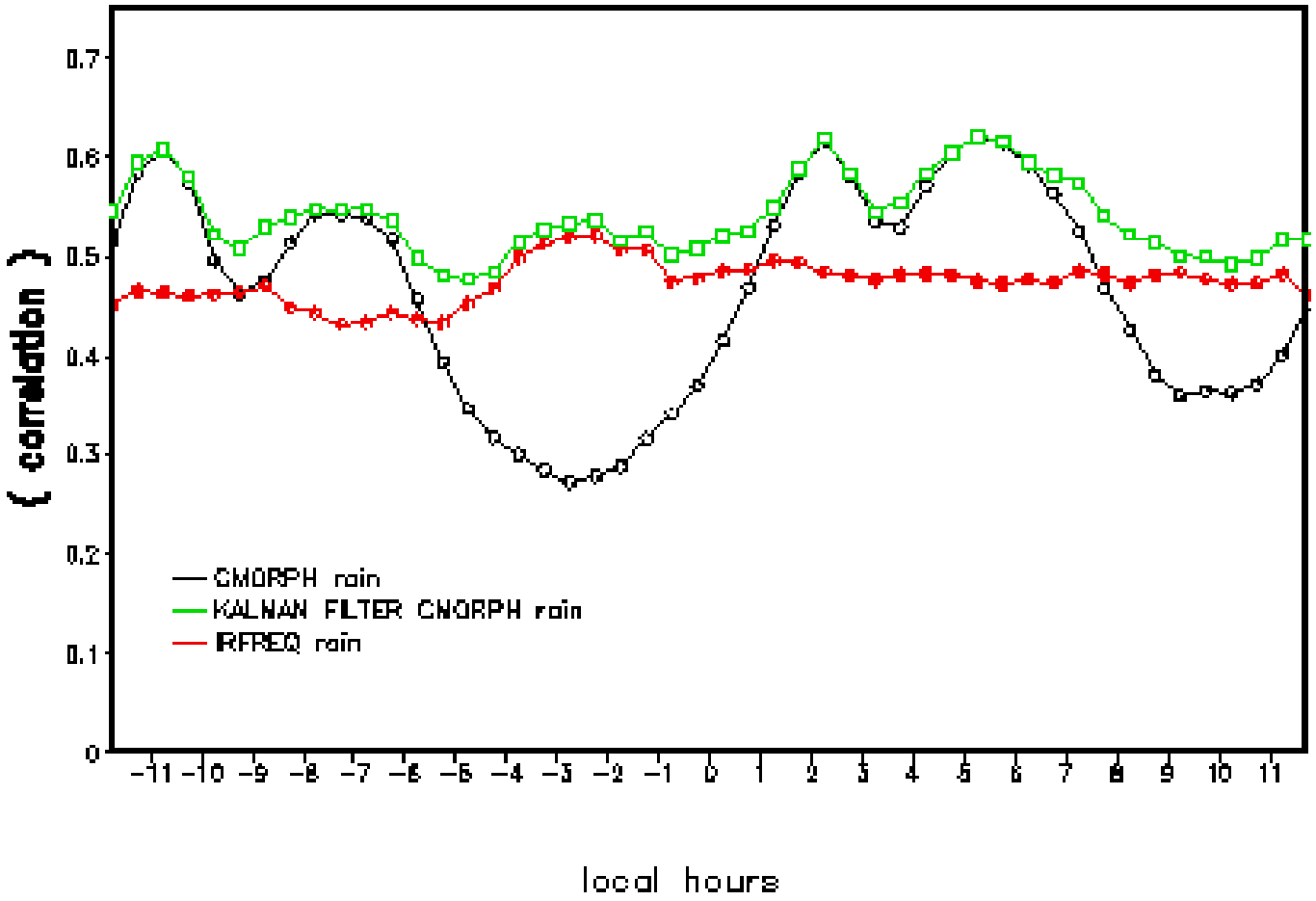
Correlation of Q2 with a 2 PMW satellite (METOP-A & AQUA) configuration for July & August 2009



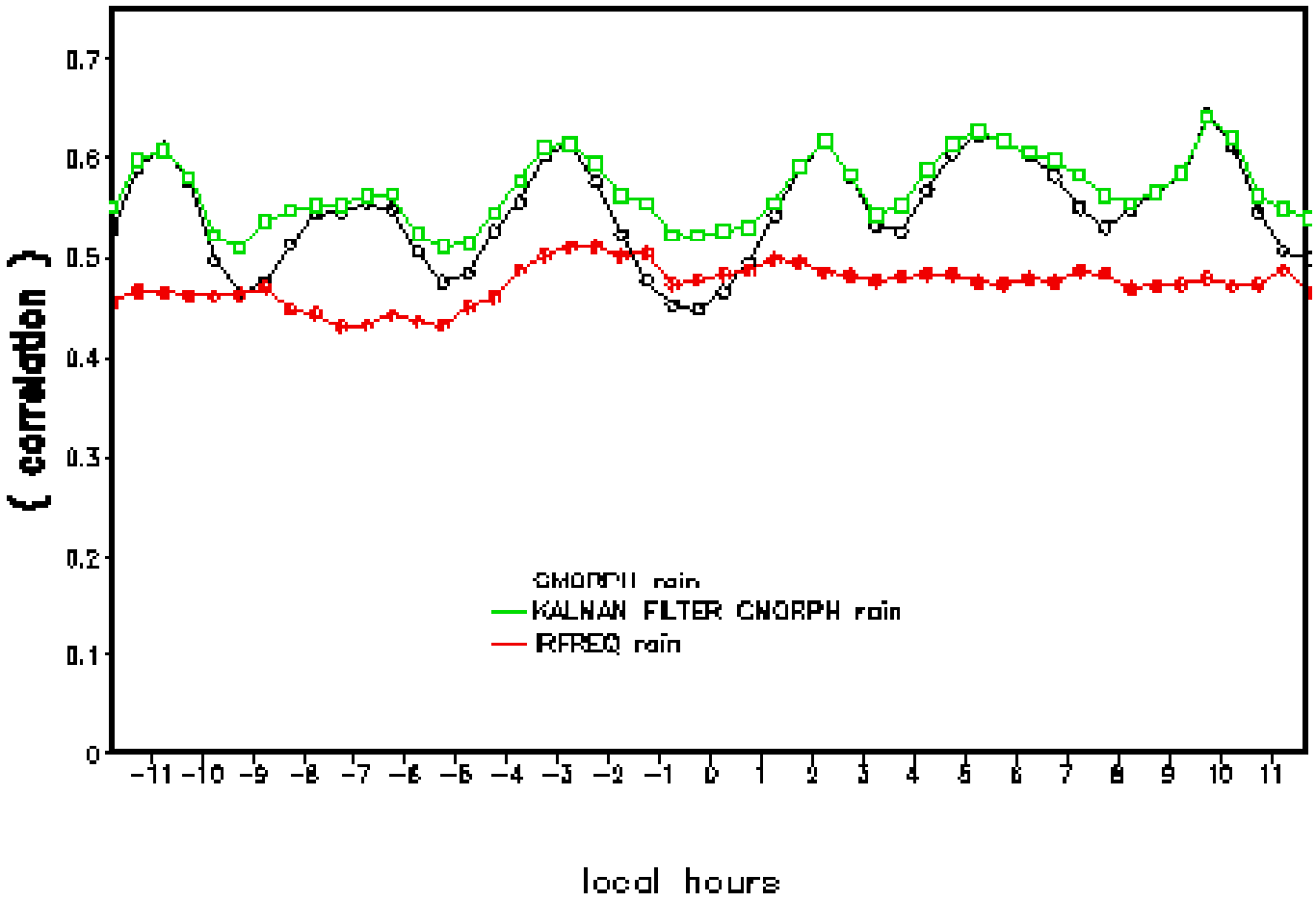
Correlation of Q2 with a 4 PMW satellite (TRMM, METOP-A, NOAA-16, & AQUA) configuration for July & August 2009



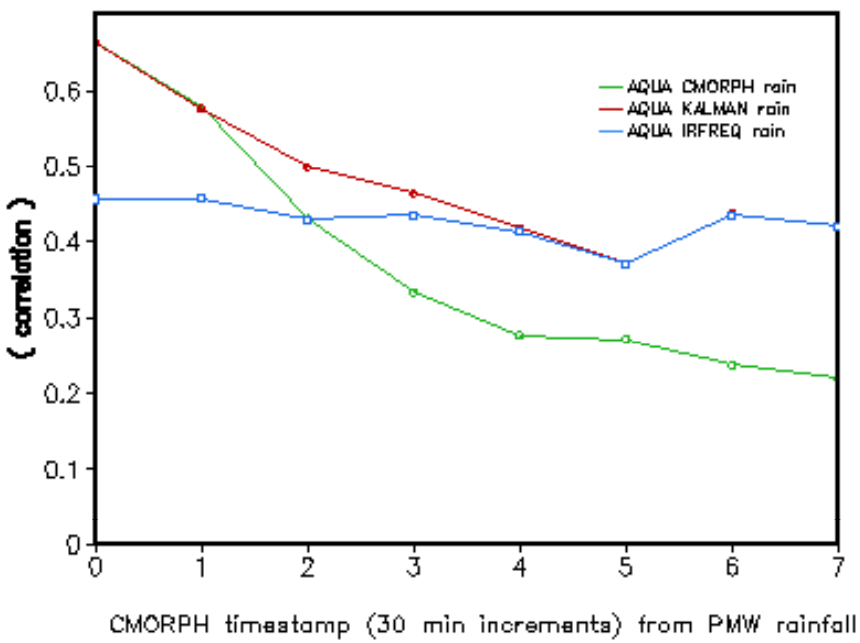
Correlation of Q2 with a 7 PMW satellite (no METOP-A & NOAA-17) configuration for July & August 2009

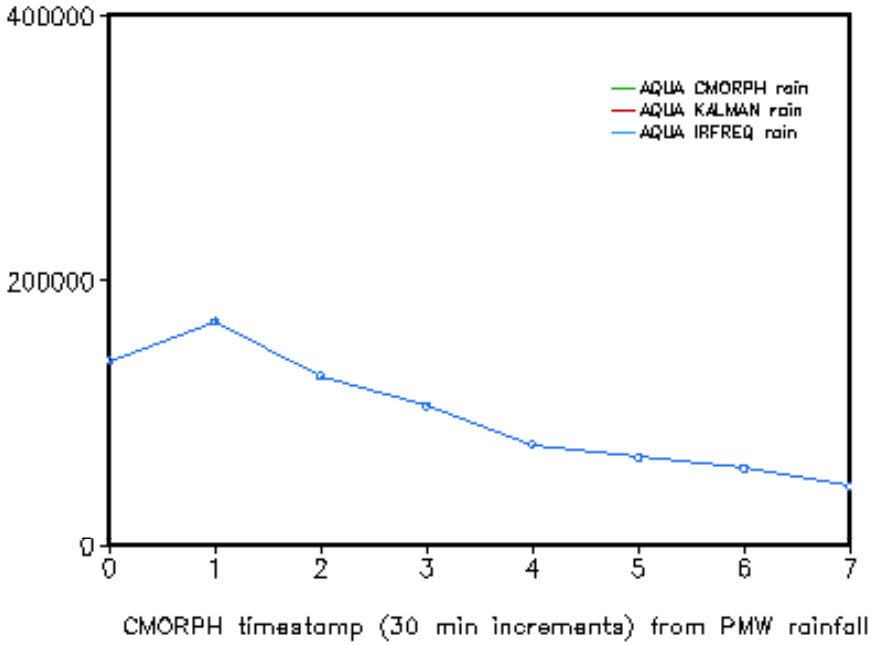


Correlation of Q2 with a 9 PMW satellite configuration for July & August 2009

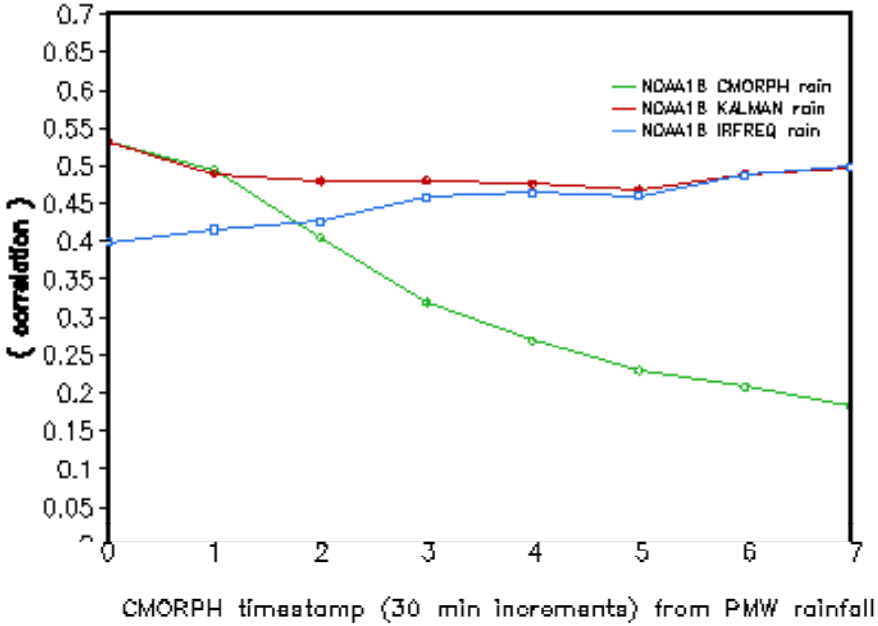


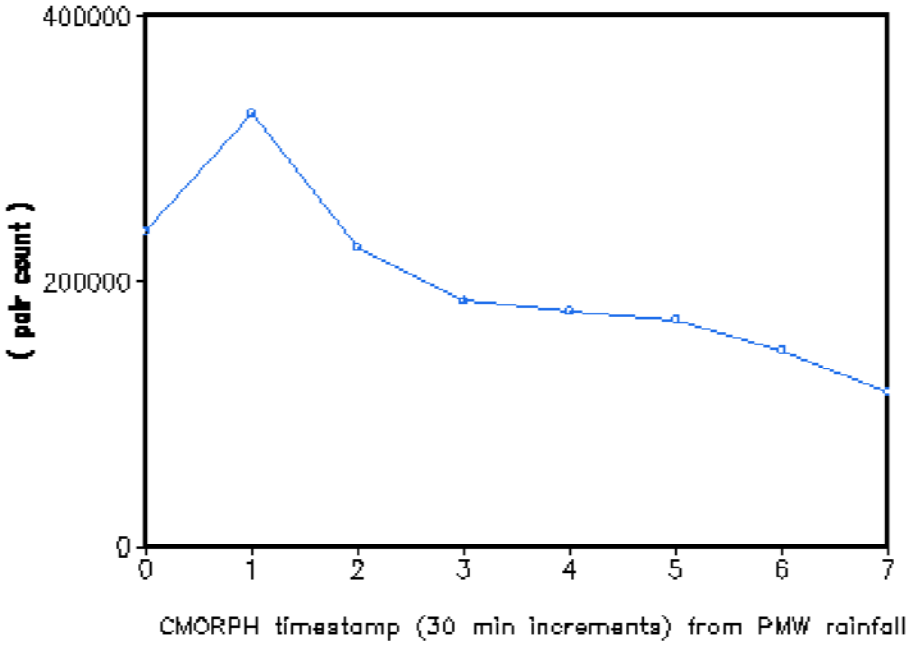
Correlation of Q2 with AQUA CMORPH





Correlation of Q2 with METOP-A CMORPH

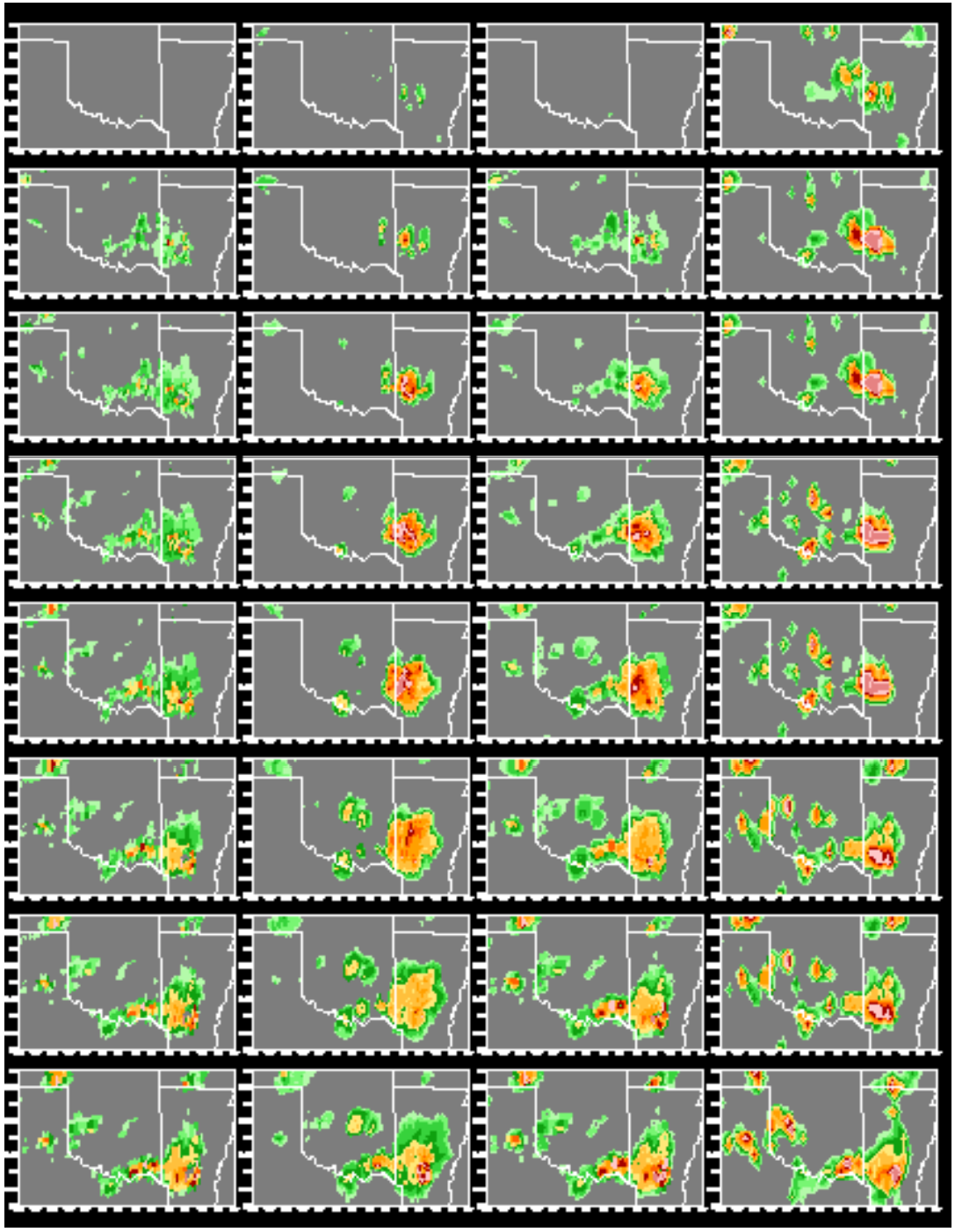




- 16 July 2009

•CMORPH •IRFREQ •KALMAN •RADAR

- 19:30-20:00 UTC
- 20:00-20:30 UTC
- 20:30-21:00 UTC
- 21:00-21:30 UTC
- 21:30-22:00 UTC
- 22:00-22:30 UTC
- 22:30-23:00 UTC
- 23:00-23:30 UTC



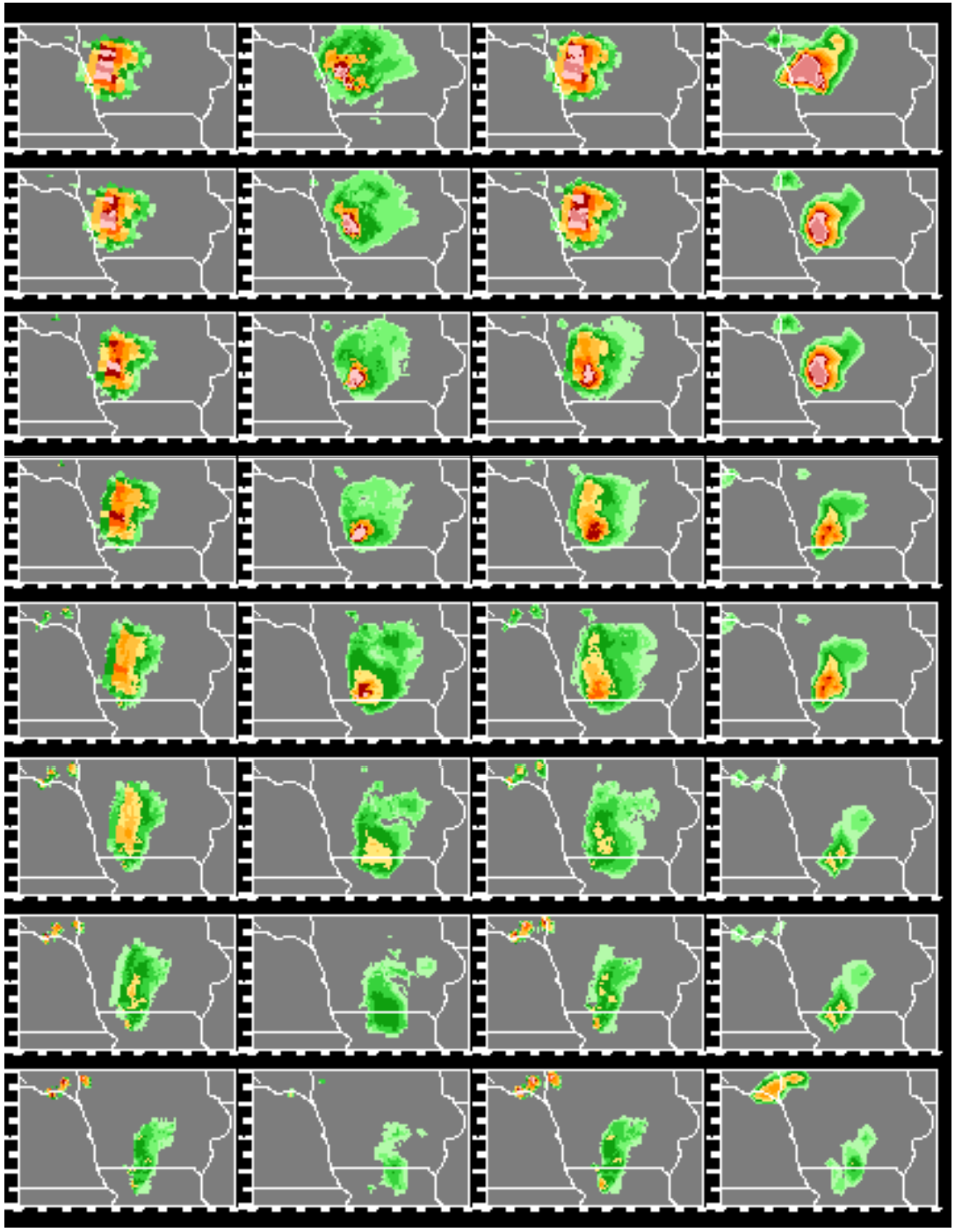
•PMW OB

•PMW OB

- 9 July 2009

•CMORPH •IRFREQ •KALMAN •RADAR

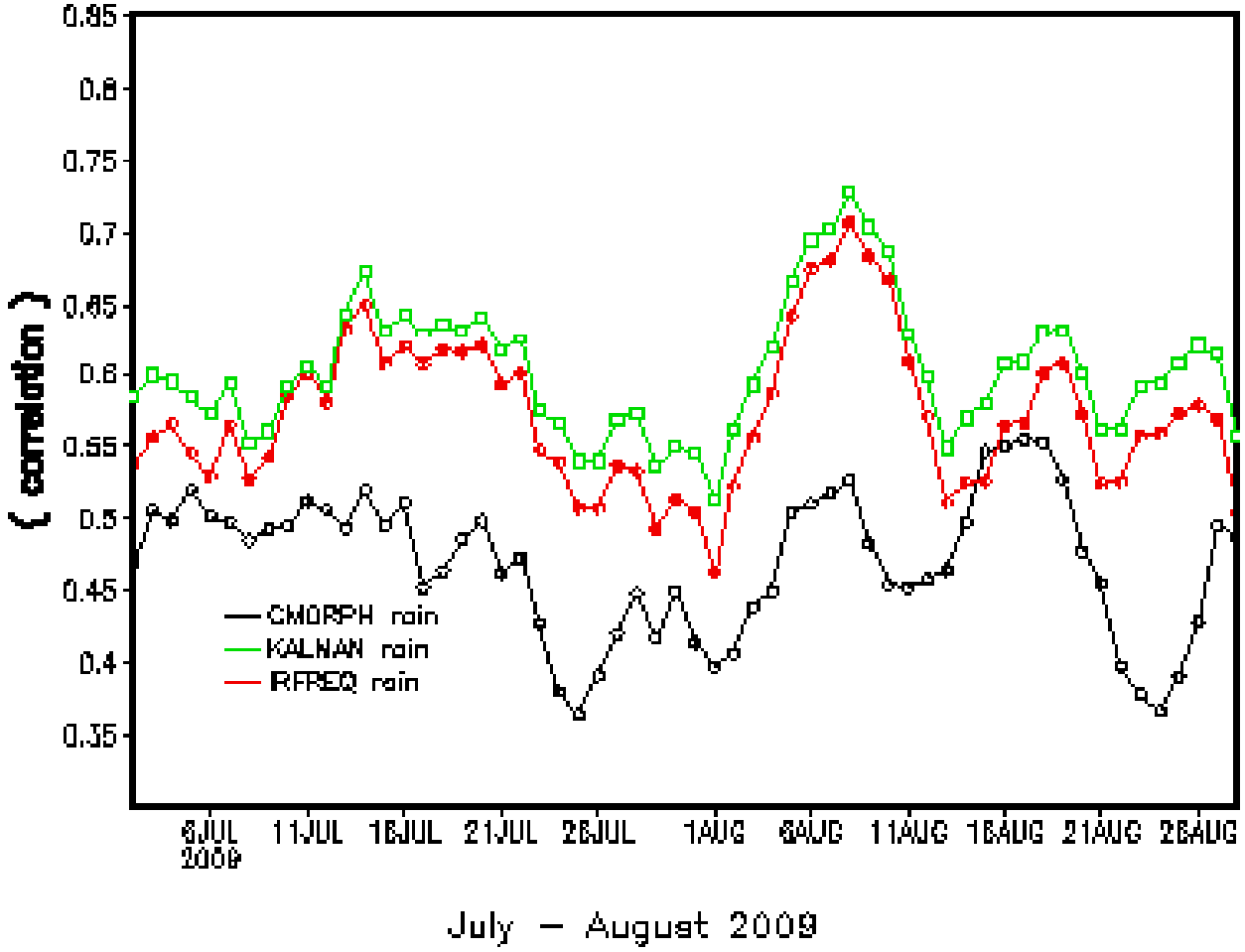
- 15:30-16:00 UTC
- 16:00-16:30 UTC
- 16:30-17:00 UTC
- 17:00-17:30 UTC
- 17:30-18:00 UTC
- 18:00-18:30 UTC
- 18:30-19:00 UTC
- 19:00-19:30 UTC



•PMW OB

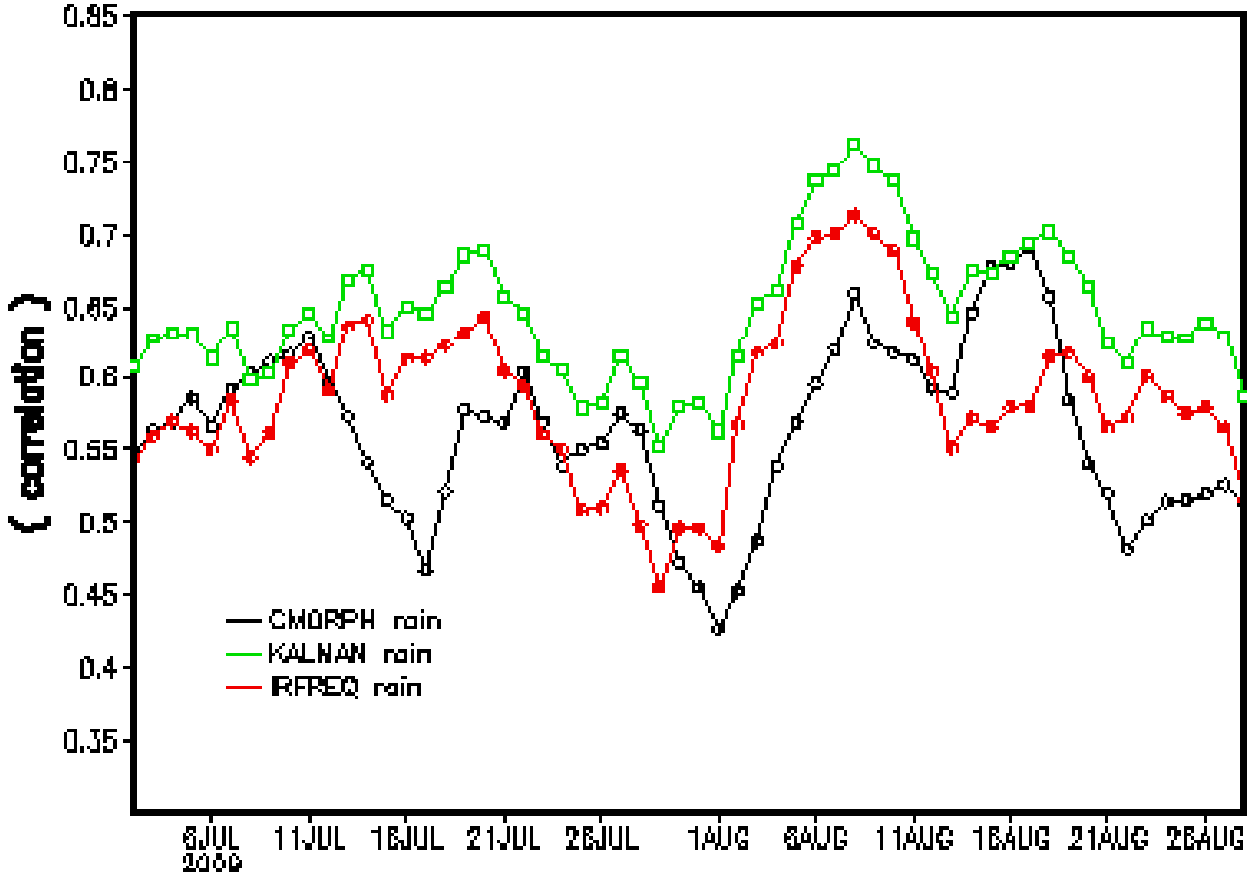
•PMW OB

Daily 0.25 degree correlation of Q2 with a 1 PMW satellite (NOAA-16) configuration

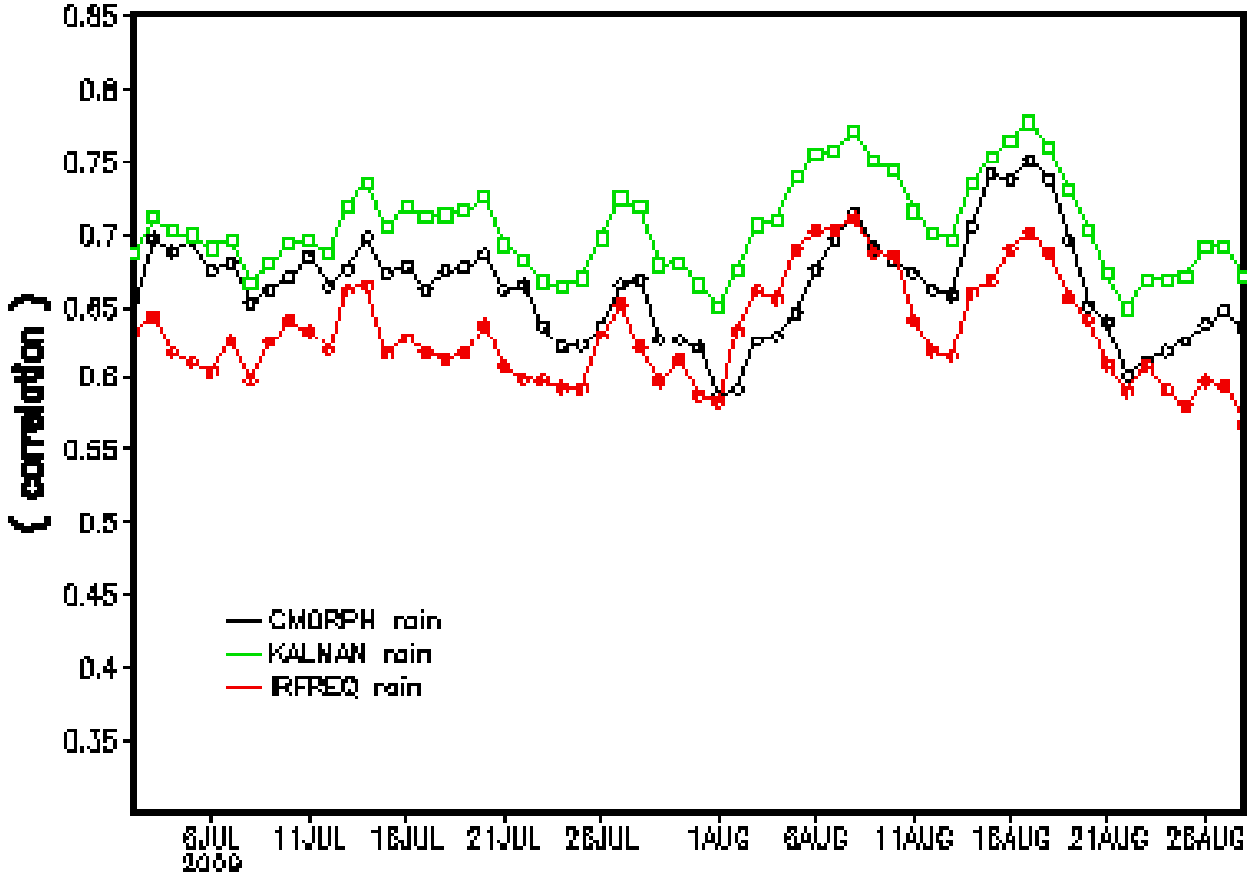


July – August 2009

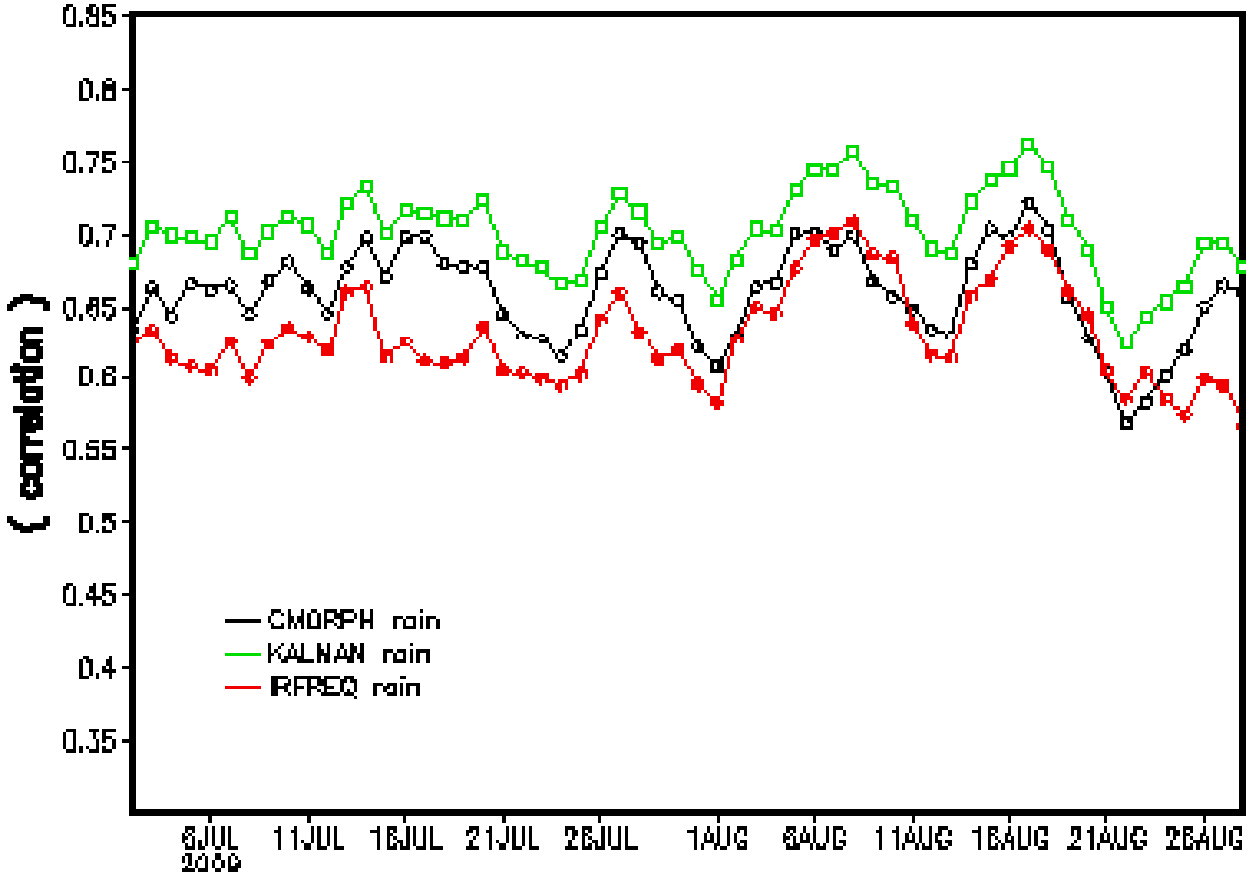
Daily correlation of Q2 with a 2 PMW satellite (METOP-A & AQUA) configuration



Daily correlation of Q2 with a 4 PMW satellite (TRMM, METOP-A, NOAA-16, & AQUA) configuration

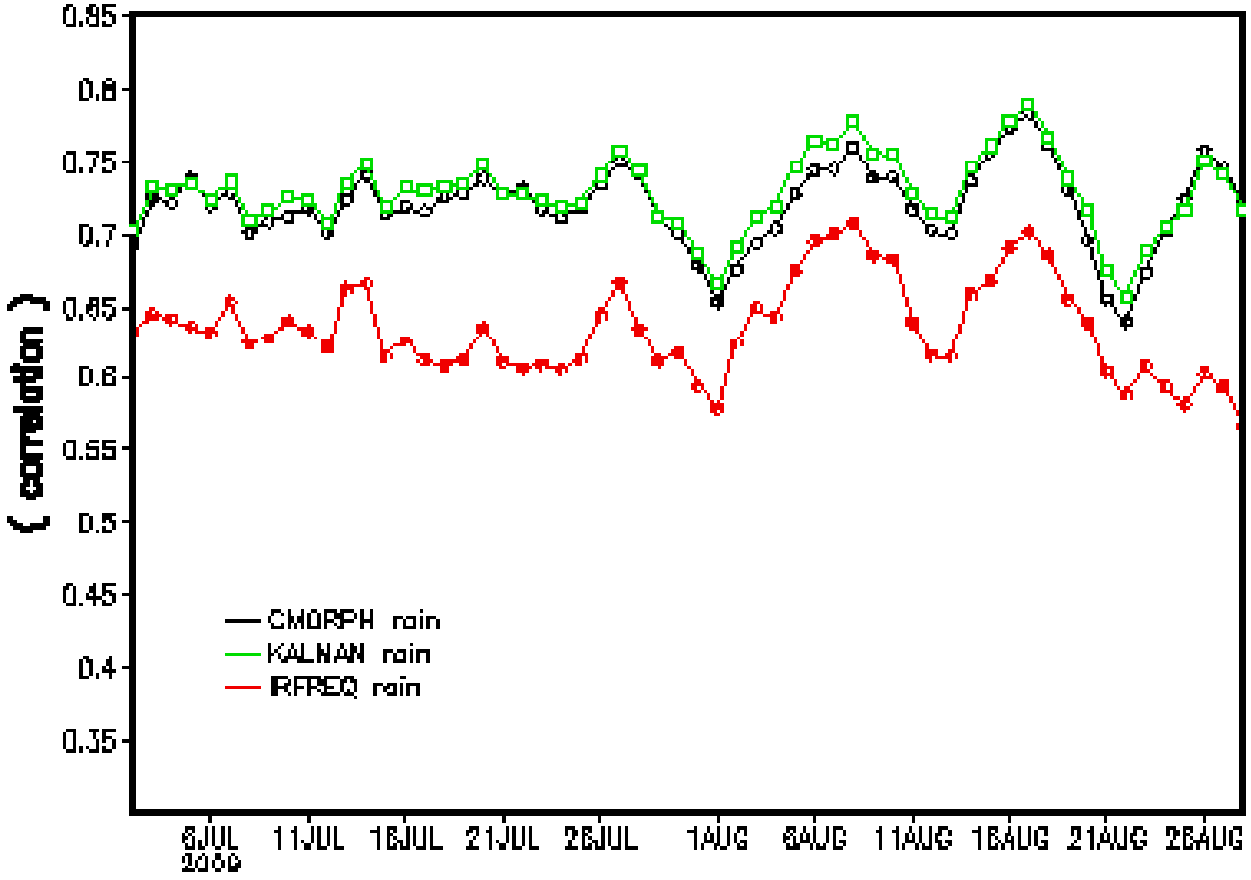


Daily correlation of Q2 with a 7 PMW satellite (no METOP-A & NOAA-17) configuration



July – August 2009

Daily correlation of Q2 with a 9 PMW satellite configuration



Correlation of daily 0.25 degree NSSL Q2 radar rainfall with CMORPH, IRFREQ, Kalman filter CMORPH for July & August 2009

PMW Satellite Configuration	CMORPH	IRFREQ	Kalman Filter CMORPH
1 satellite	0.47	0.57	0.60
2 satellites	0.56	0.58	0.64
4 satellites	0.66	0.63	0.70
7 satellites	0.66	0.63	0.70
9 satellites	0.72	0.63	0.73

Summary

1. The Kalman filter slightly increases the skill of CMORPH for a full PMW satellite configuration, however skill improvements can be substantial for gaps remaining between PMW scans.

2. For a reduced PMW microwave satellite fleet, overall skill in a blended satellite rainfall algorithm substantially depends on the satellite crossing time configuration.

3. A Kalman filter version of CMORPH would be an absolute necessity for a greatly reduced number of PMW satellites. Retrospective CMORPH reprocessing is currently in 1999 (backward from December 2002 inception). However it appears a 1 or 2 PMW satellite Kalman filter CMORPH data set (back to 1987? 1992?) would be useful.

ATTN: See Soo-Hyun's poster in the morning session:
"Combining High-Resolution Satellite Estimates with Gauge Observations

Future Plans

•Make the current Kalman filter CMORPH version operational.

•Investigate the cost developing and potentially implementing a "current collocation comparison" Kalman filter relative to the current historical set (advantage now is that each month's comparison seasonally centered).

• work on extending CMORPH to pole to pole (current latitude bounds are 60N/S

• GPM-Day1 contributions

• development of more accurate PMW rainfall propagation vectors