Spatial Downscaling of Hourly NLDAS-2 Precipitation for NLDAS3: Spatial Variance Analysis at Monthly, Daily and Hourly Time Scales

Youlong Xia[1,2], Michael B. Ek[1], Kenneth E. Mitchell[3], and Ying Lin[1]

[1] Environmental Modeling Center (EMC), National Centers for Environmental Prediction (NCEP), College Park, Maryland, USA

[2] I. M. System Group (IMSG at EMC/NCEP, College Park, Maryland, USA

[3] Prescient Weather Ltd, State College, Pennsylvania, USA

15 July 2015

Data Used

- Hourly NLDAS-2 precipitation (gauge-based with PRISM bias correction, 0.125 degree)
- Hourly Stage IV precipitation (HRAP grid ~ 4 km)
- Hourly Stage II precipitation (~ 4 km) [Stage IV: CONUS hourly radar + gauge analysis mosaicked from regional analysis received from River Forecast Centers. Excluding NWRFC & CNRFC areas. Some manual QC at RFCs. Stage II: CONUS hourly analysis produced directly from radar + gauge data received at NCEP. No manual QC]
- Monthly NCDC precipitation (gauge-based, 0.0417 degree)

Validation Data

- Hourly MRMS (radar-based with gauge precipitation bias correction, 1 km)
- Daily PRISM data (gauge-based + Stage IV, 0.0417 degree)
- Monthly NCDC precipitation (gauge-based, 0.0417 degree)

Mask

Land-Sea mask, Inland water mask, River Forecast Center mask

Method

From 2002-present, NLDAS2 hourly precipitation at 1/8th-degree will be used as a backbone. We use hourly spatial variation of Stage IV product to spatially downscale NLDAS2 precipitation to 1/32nd-degree NLDAS3 grid using a spatial weight method. First, both NLDAS2 (1/8th-degree) and Stage IV (4-km HRAP) hourly precipitation data are interpolated into 1/32nd-degree grid, and then missing Stage II data will be filled with interpolated NLDAS2 hourly precipitation. Second, for each NLDAS3 grid i at a given 1/8th-degree grid box j (including 16 NLDAS3 grids) for each hour t, a weight value $W_{i,j,t}$ will be calculated as below:

$P_{1,j,t}$	$P_{2,j,t}$	$P_{3,j,t}$	$P_{4,j,t}$
$P_{5,j,t}$	$P_{6,j,t}$	$P_{7,j,t}$	$P_{8,j,t}$
$P_{9,j,t}$	$P_{10,j,t}$	$P_{11,j,t}$	$P_{12,j,t}$
$P_{13,j,t}$	$P_{14,j,t}$	$P_{15,j,t}$	$P_{16,j,t}$

$$W_{i,j,t} = \frac{P_{i,j,t}(Stage\ IV)}{1/16\sum_{i=1}^{16} P_{i,j,t}(Stage\ IV)}$$

Third, weight values can be multiplied with 1/8th-degree hourly NLDAS precipitation to get hourly value at each NLDAS3 grid. This way can keep conservative water at a given NLDAS2 grid with reasonable spatial variation derived from Stage II product.

$$P_{i,j,t}(NLDAS3) = W_{i,j,t} P_{j,t}(NLDAS2)$$

The spatial downscaling method is simple and straightforward

(1) Keep the radar precipitation errors and spatial variability

(2) Keep water conservative for each NLDAS-2 grid

(3) Easily be implemented into operations

(4) Using many operational precipitation products such NLDAS-2, Stage II, Stage IV, and NCDC monthly product

Experiment Design

a. TEST1 - Water Budget Interpolation (benchmark), b. TEST2 - NCDC, c. TEST3 - Stage II, and d. TEST4 - Stage IV (Using NCDC monthly precipitation spatial variability for all hours at a given month)

Test Period: 1 January -31 December 2014

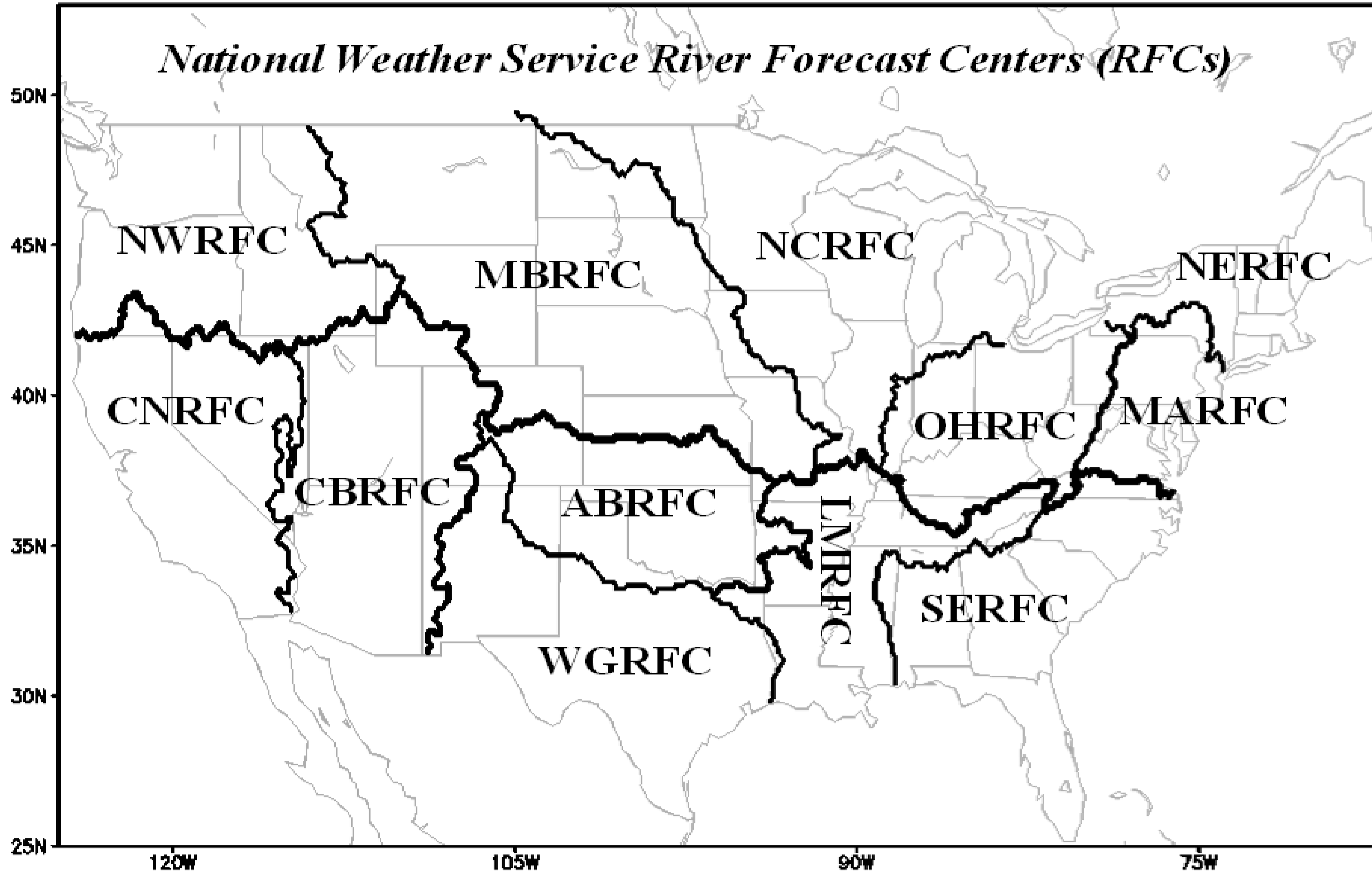

Figure 1: Twelve National Weather Services' River Forecast Center (RFCs)

Spatial Variance Calculation

For each given RFC R and time t, the spatial variance is calculated as

$$\sigma_{R,t} = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(P_{i,j,R,t} - \overline{P}_{R,t})^2}{MxN}}$$

where i and j is ith and jth NLDAS3 grid (0.03125 degree), M and N is total grid number in X and Y direction at a given RFC R. The $\overline{P}_{R,t}$ *is* the spatially averaged precipitation at a given RFC R.

$\sigma_{R,t}$ can represent spatial variability of precipitation at a given time scale t.

Monthly Results Analysis

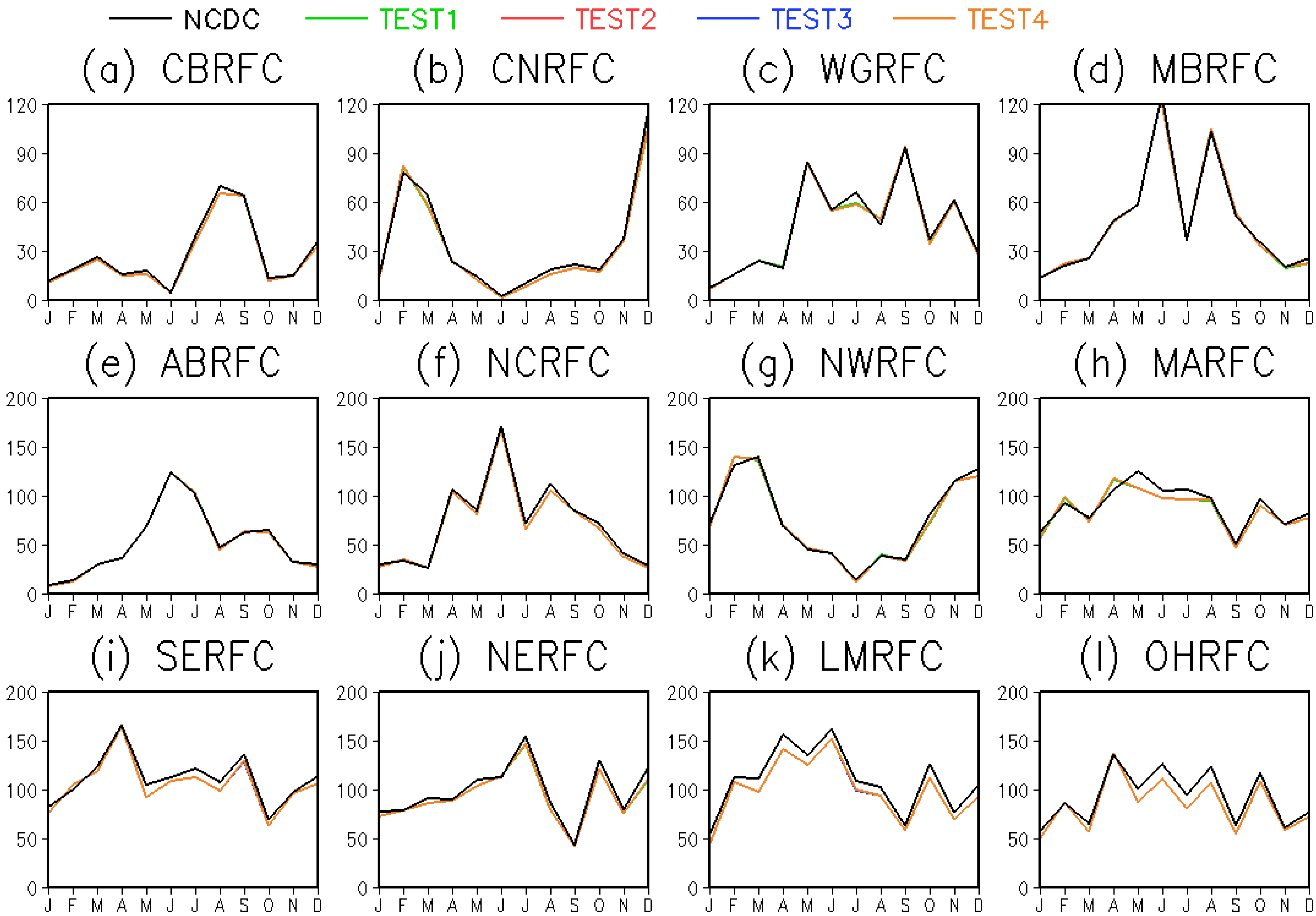

Figure 2:Basin-Wide Averaged Monthly Precipitation Comparison in 2014 (mm/month)

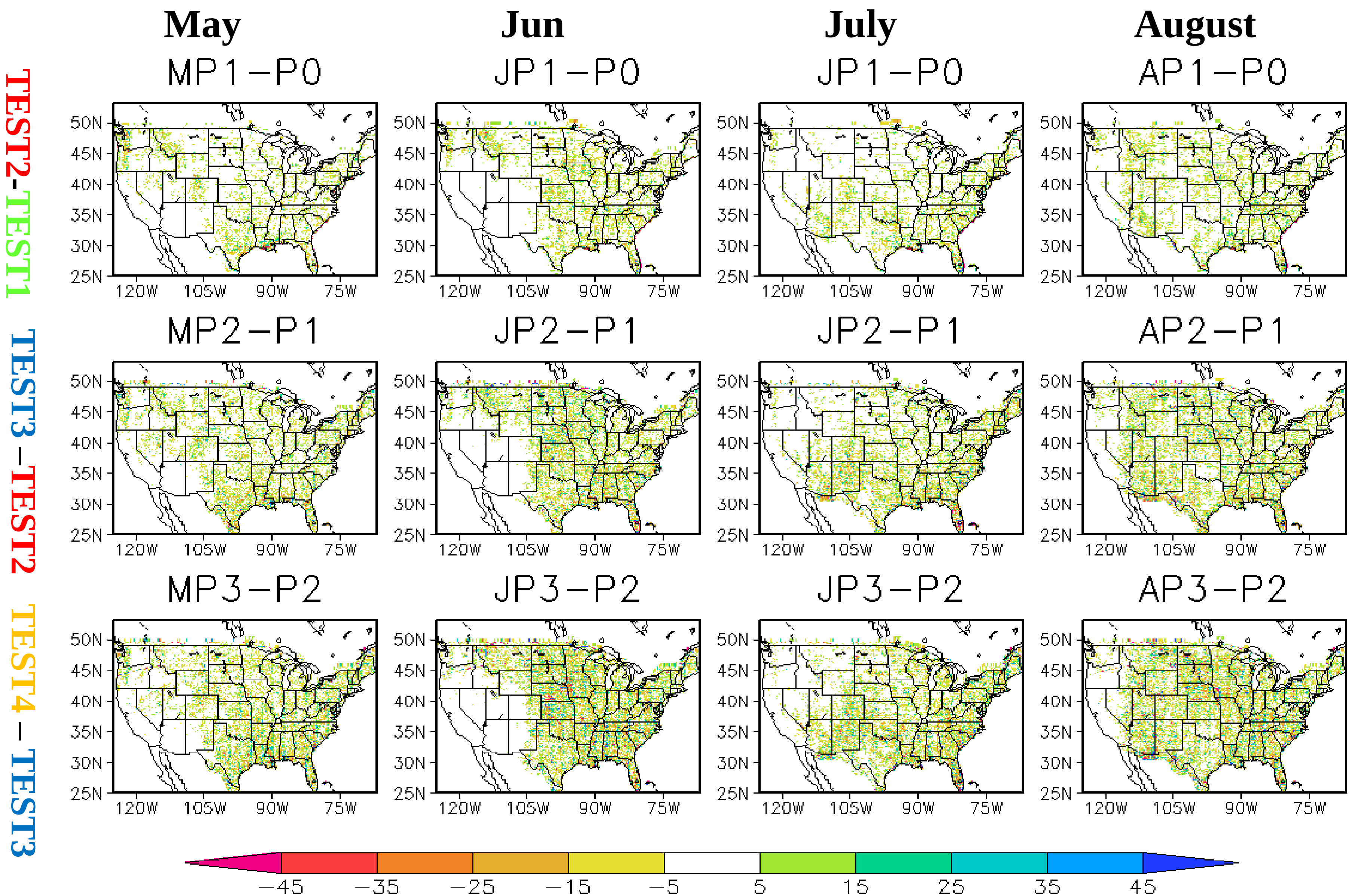

Figure 5: Difference of monthly precipitation between four tests for May, June, July and August 2014 (mm/month)

North West Region

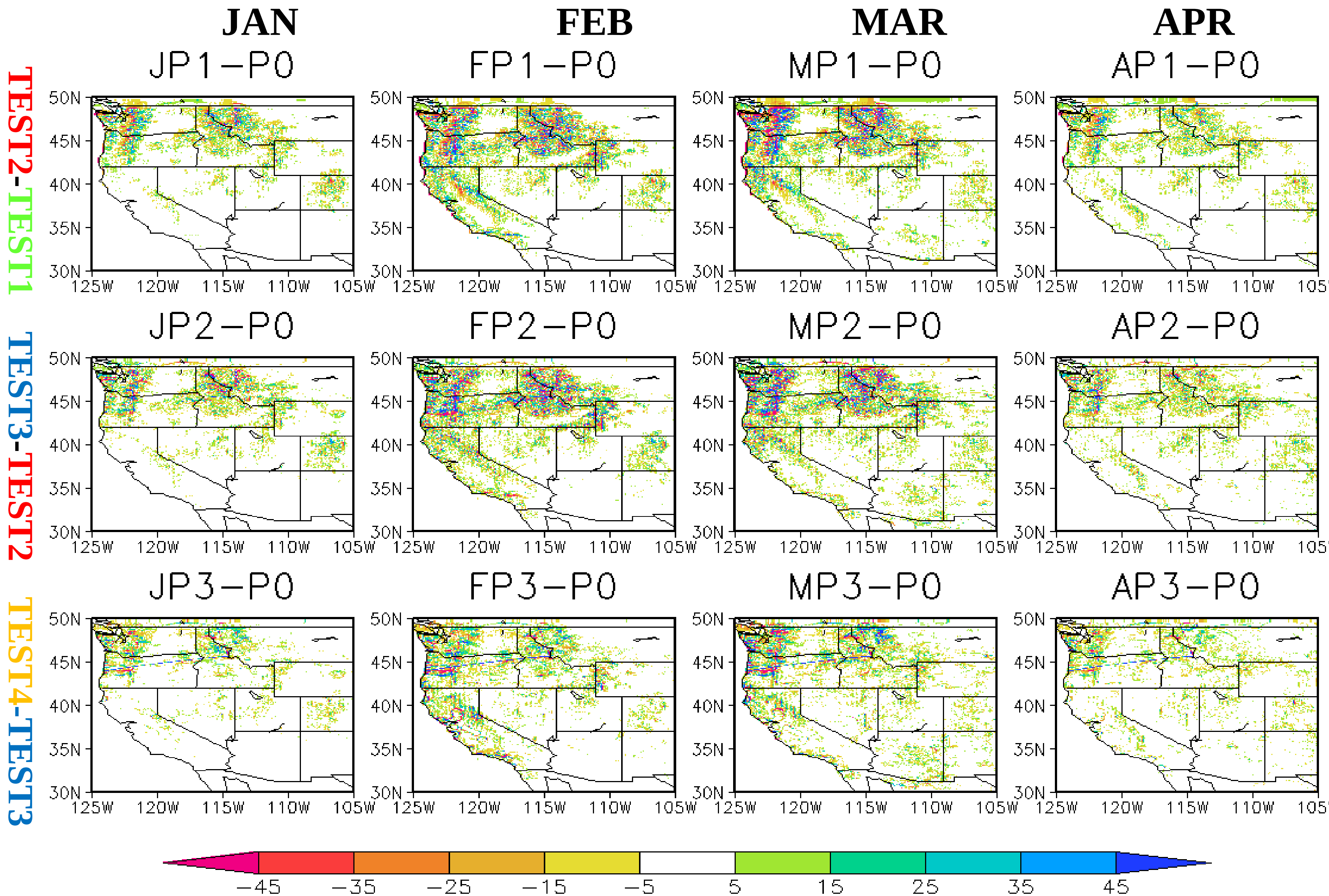

Figure 6: Difference of monthly downscaled precipitation (mm/month) for the four tests in January, February, March and April 2014

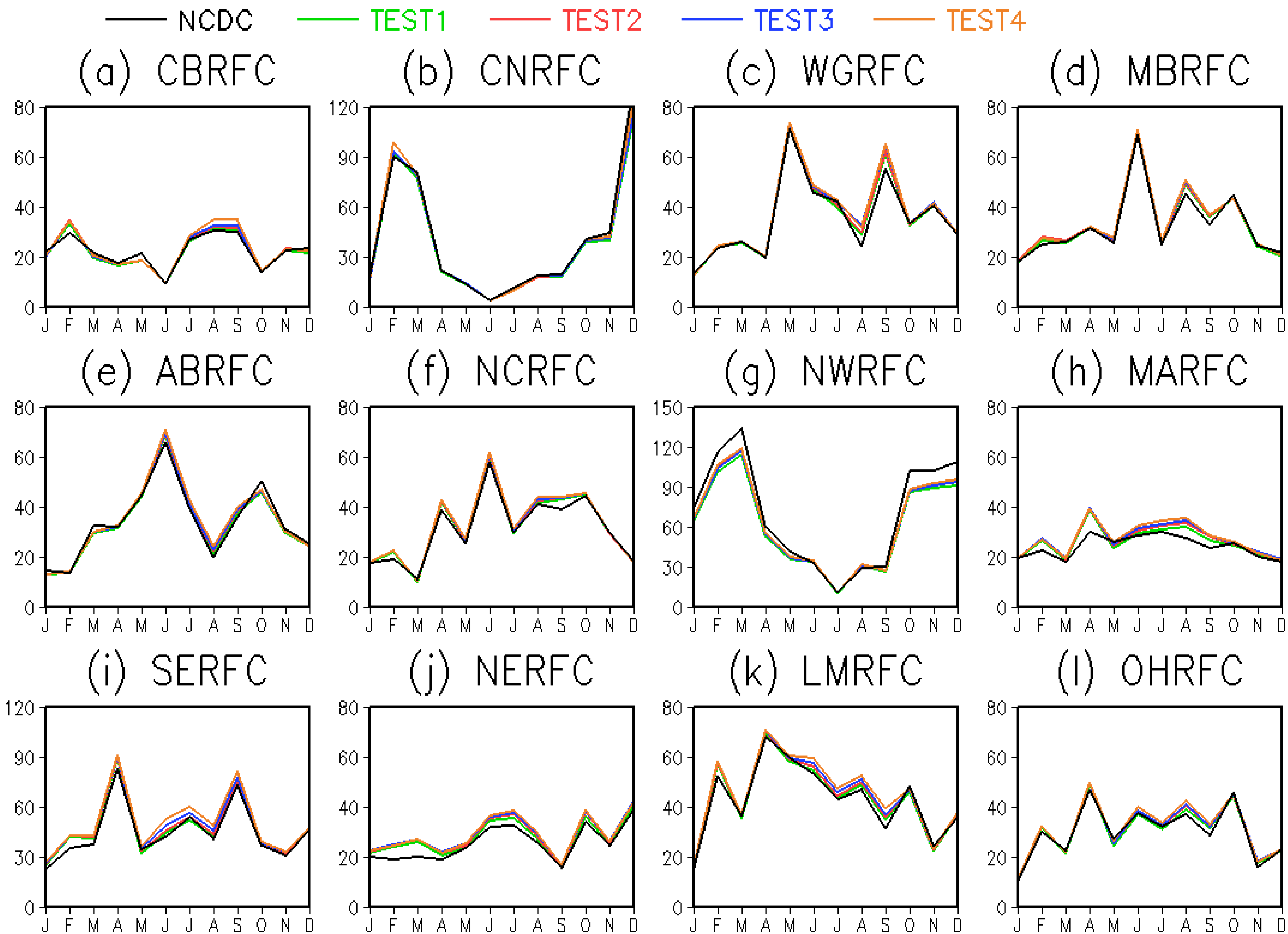

Figure 7: Month variation of spatial variance for 12 RFCs (mm/month)

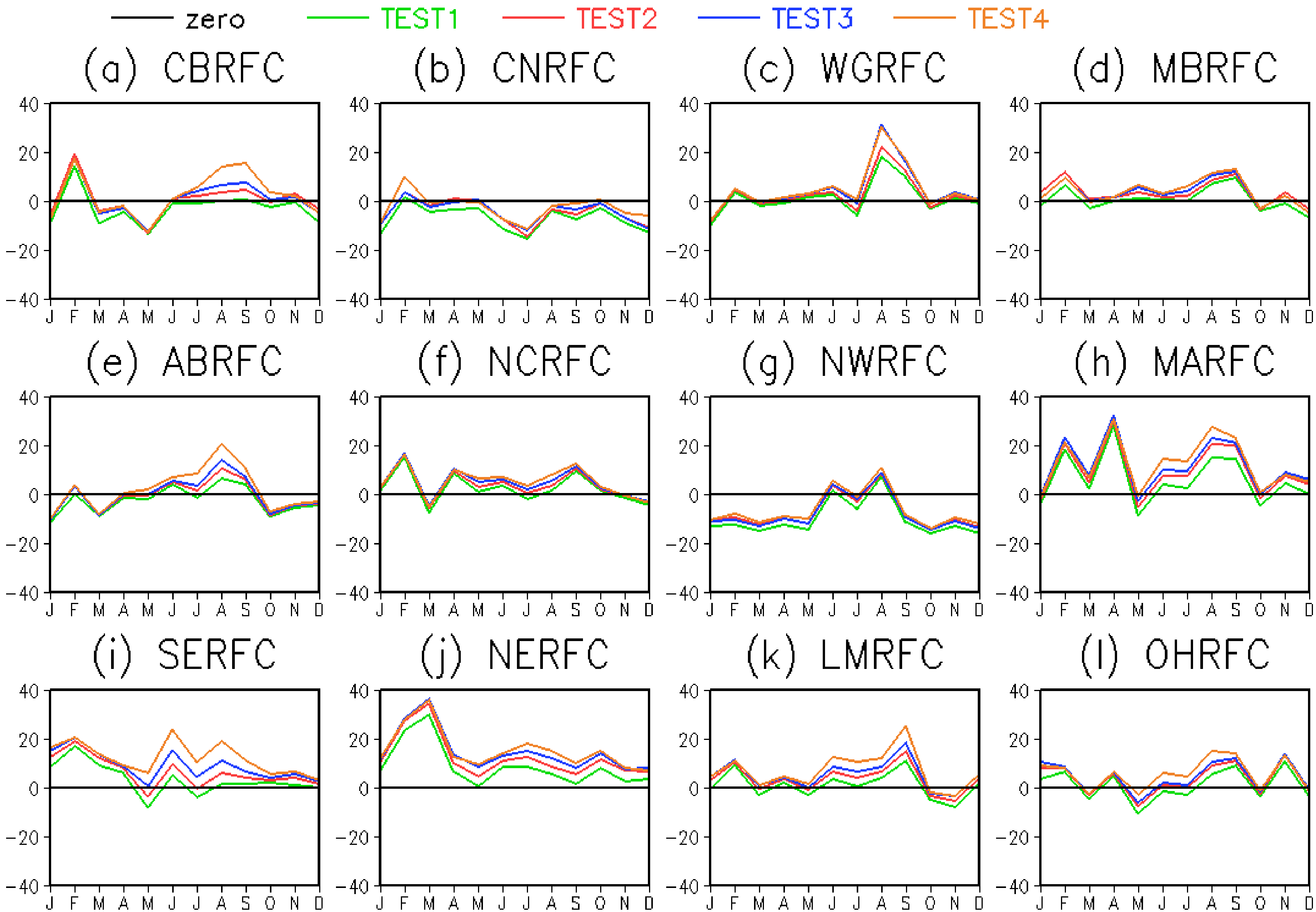

Figure 8: Monthly relative variance difference (%) – [difference between test case and NCDC is divided by NCDC]

Daily Result Analysis

1, 10, 20, 30 (from let to right) January daily precipitation difference (mm/day)
P0- water budget, P1 – monthly NCDC, P2 – Stage II, P3 –Stage IV

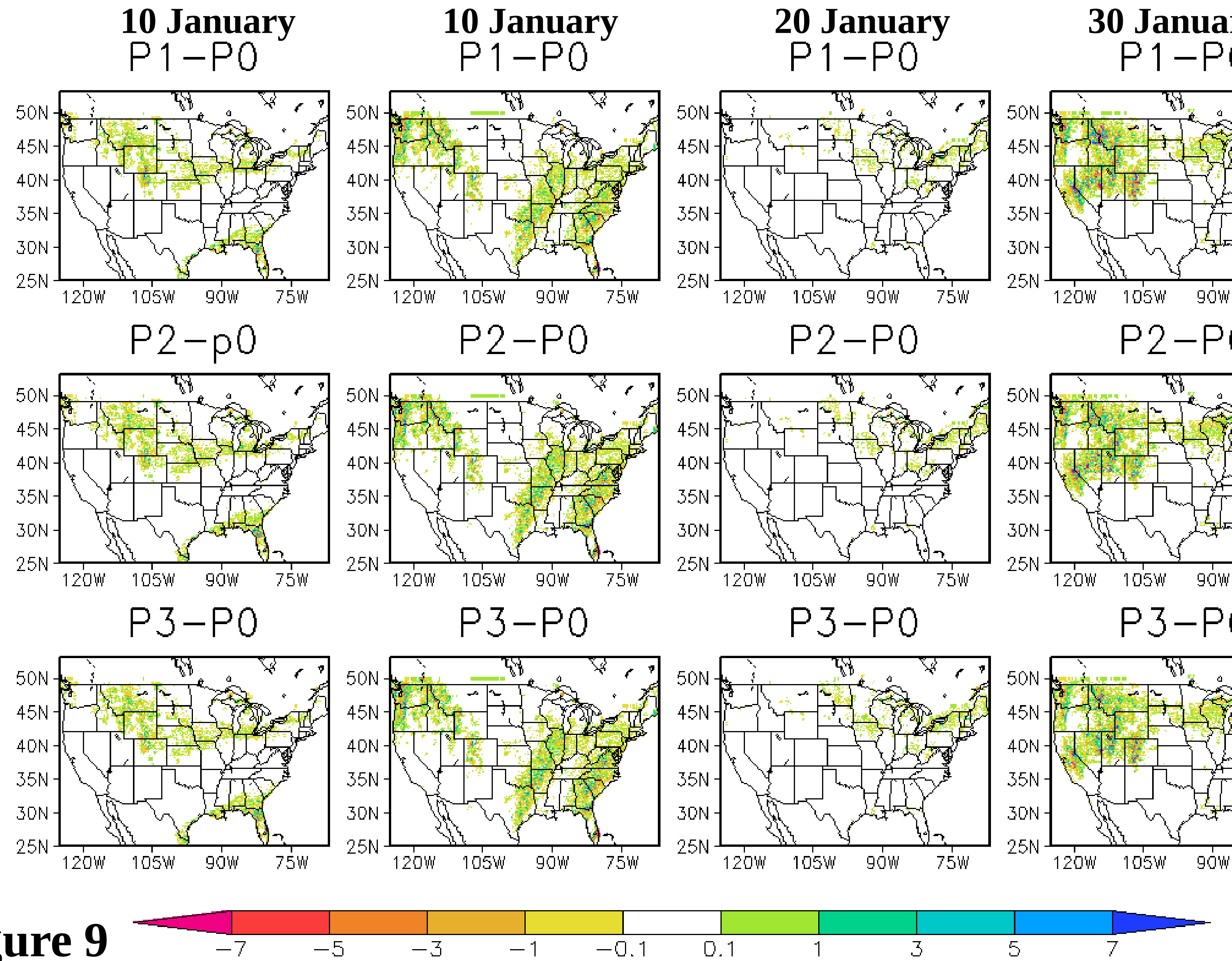

Figure 9

1, 10, 20, 30 July daily precipitation difference (mm/day)

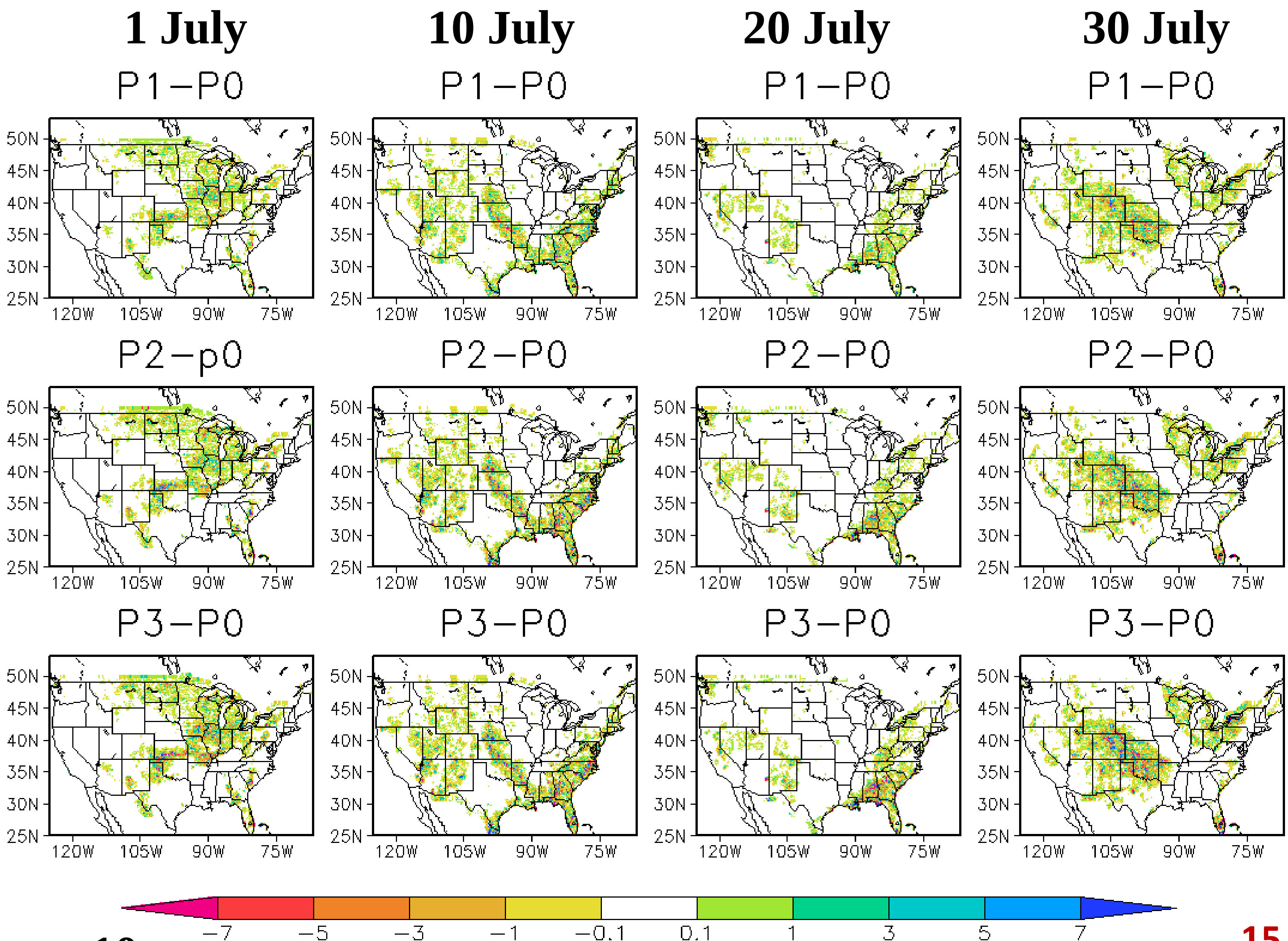

Figure 10

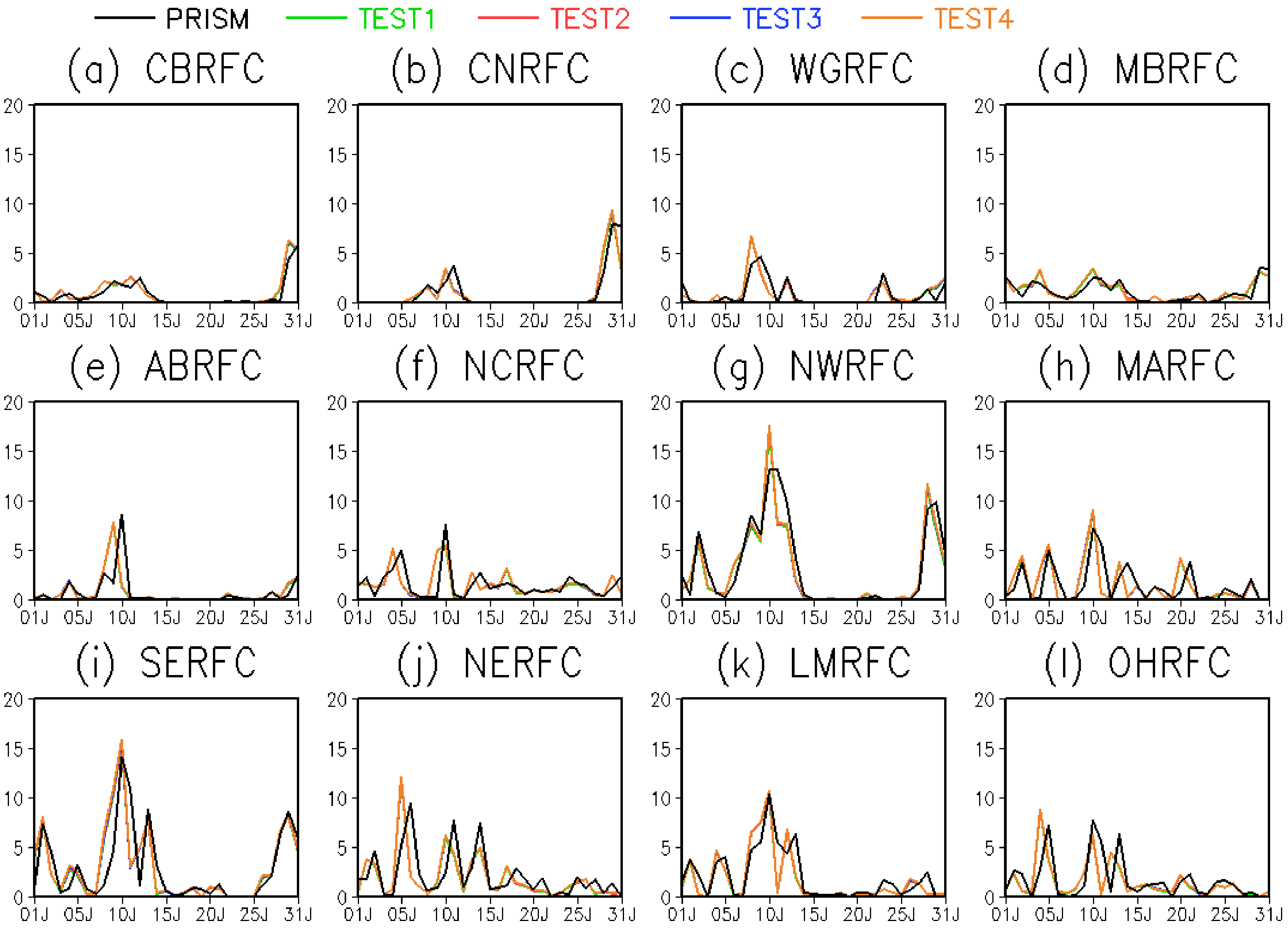

Figure 11: Comparison of Basin-wide spatial variance in January 2014 (mm/day)

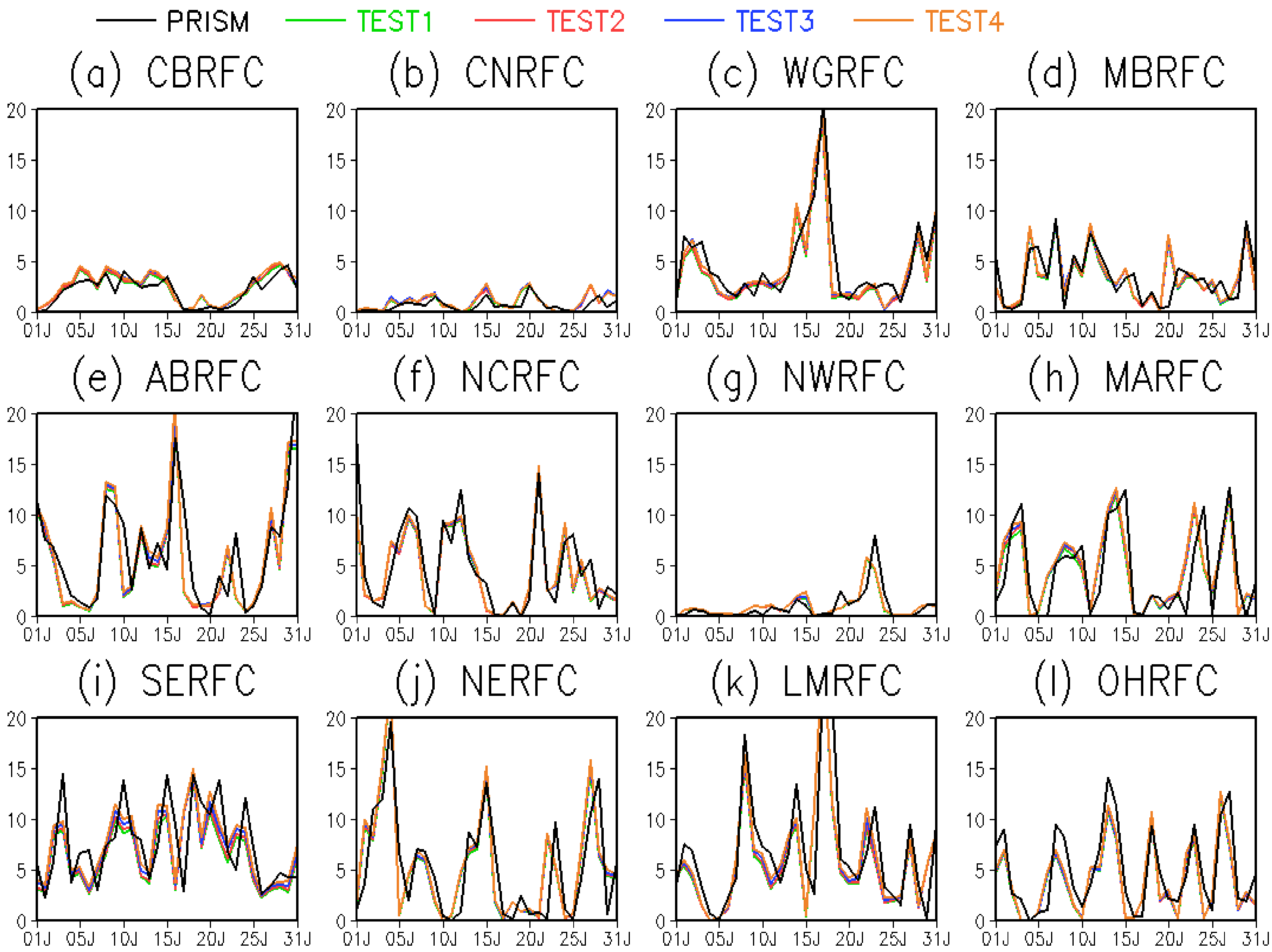

Figure 12: Basin-wide spatial variance comparison in July 2014 (mm/day)

P1 – water budget interpolation, P2 – monthly NCDC, P3 – hourly Stage II, P4- hourly Stage IV

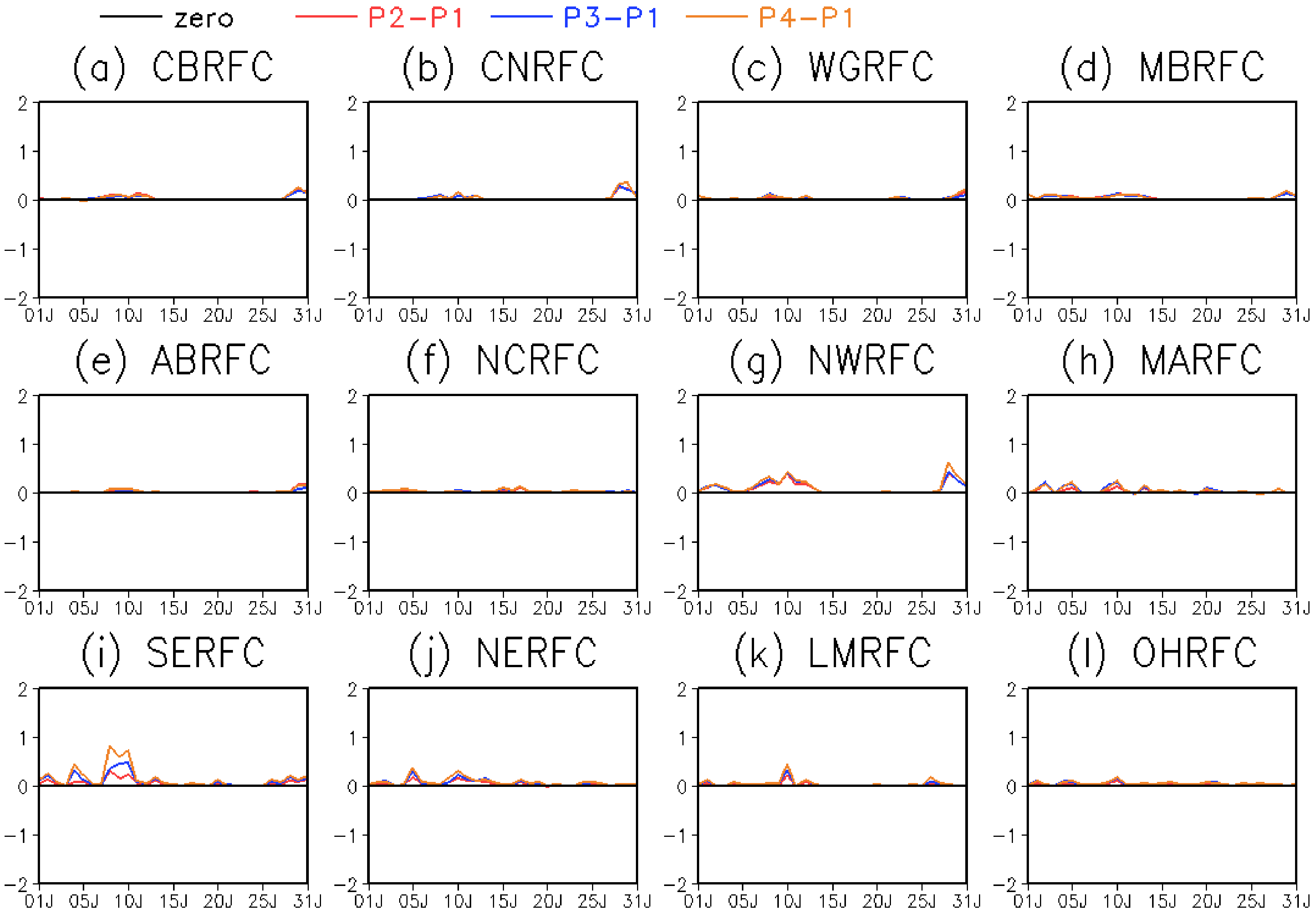

Figure 13: JAN2014 Variance Difference (mm/day)

P1 – water budget interpolation, P2 – monthly NCDC, P3 – hourly Stage II, P4- hourly Stage IV

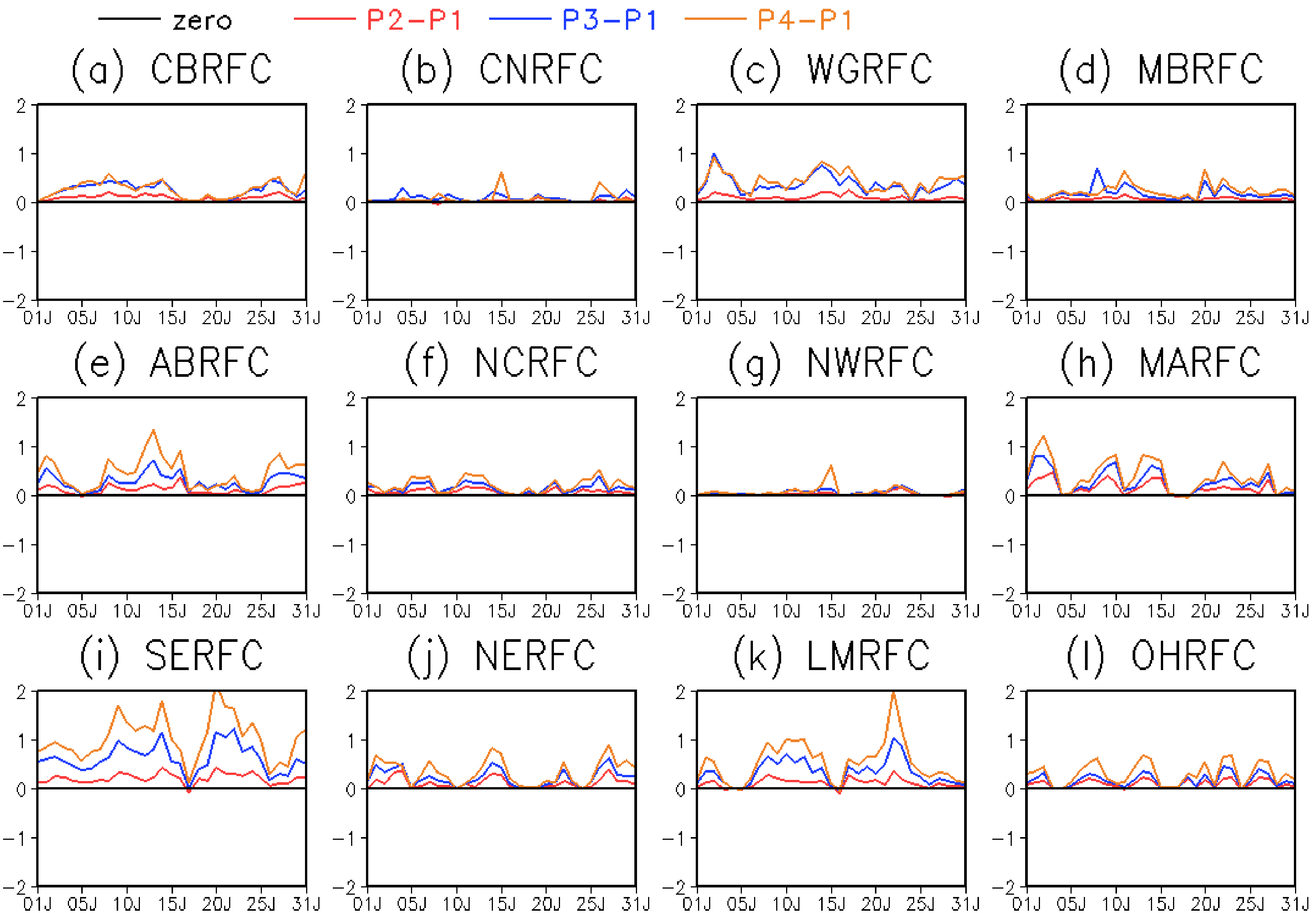

Figure 14: JUL2014 Variance Difference (mm/day)

Hourly Result Analysis

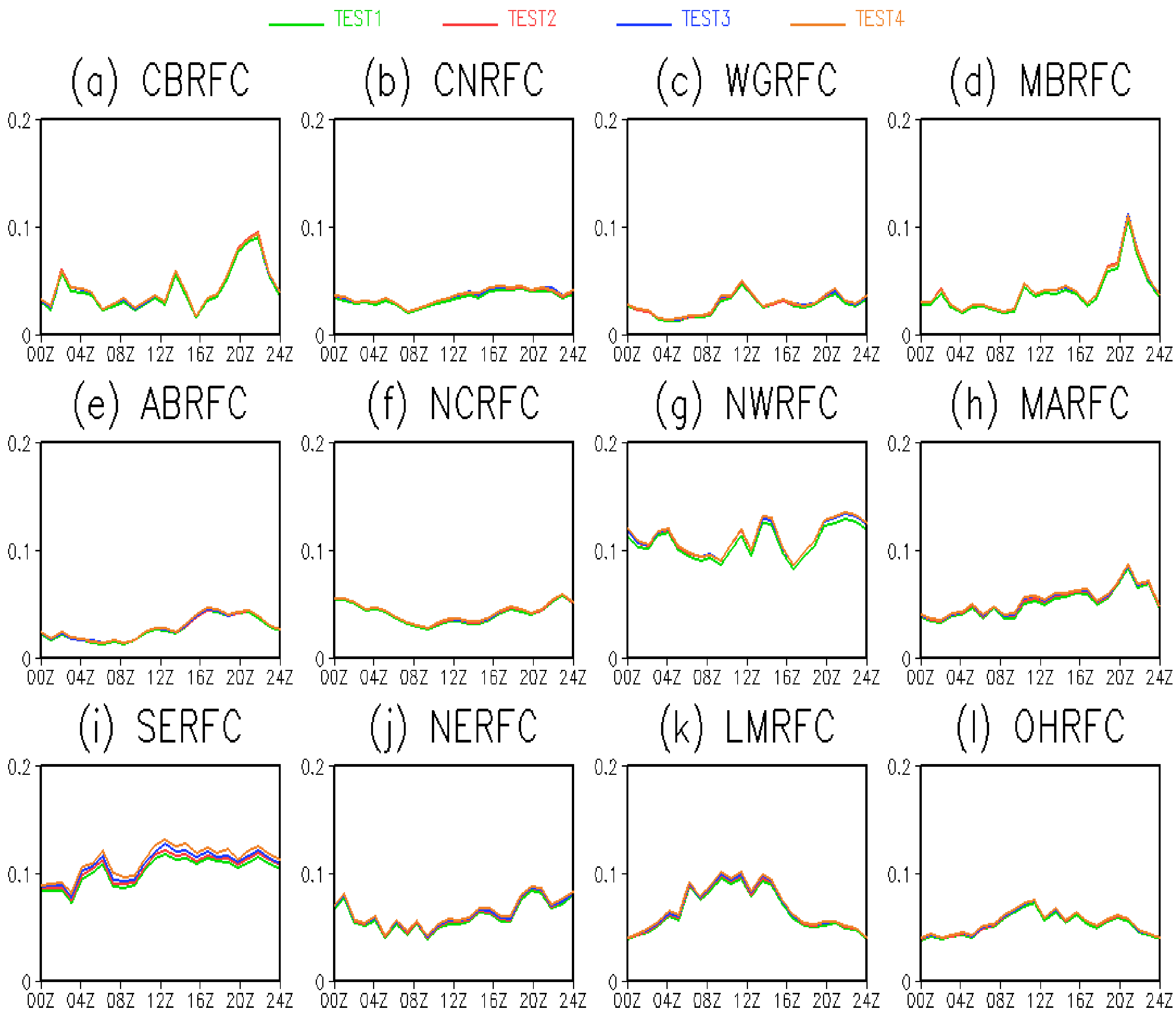

Figure 15: Spatial variance of monthly mean precipitation diurnal cycle in January 2014

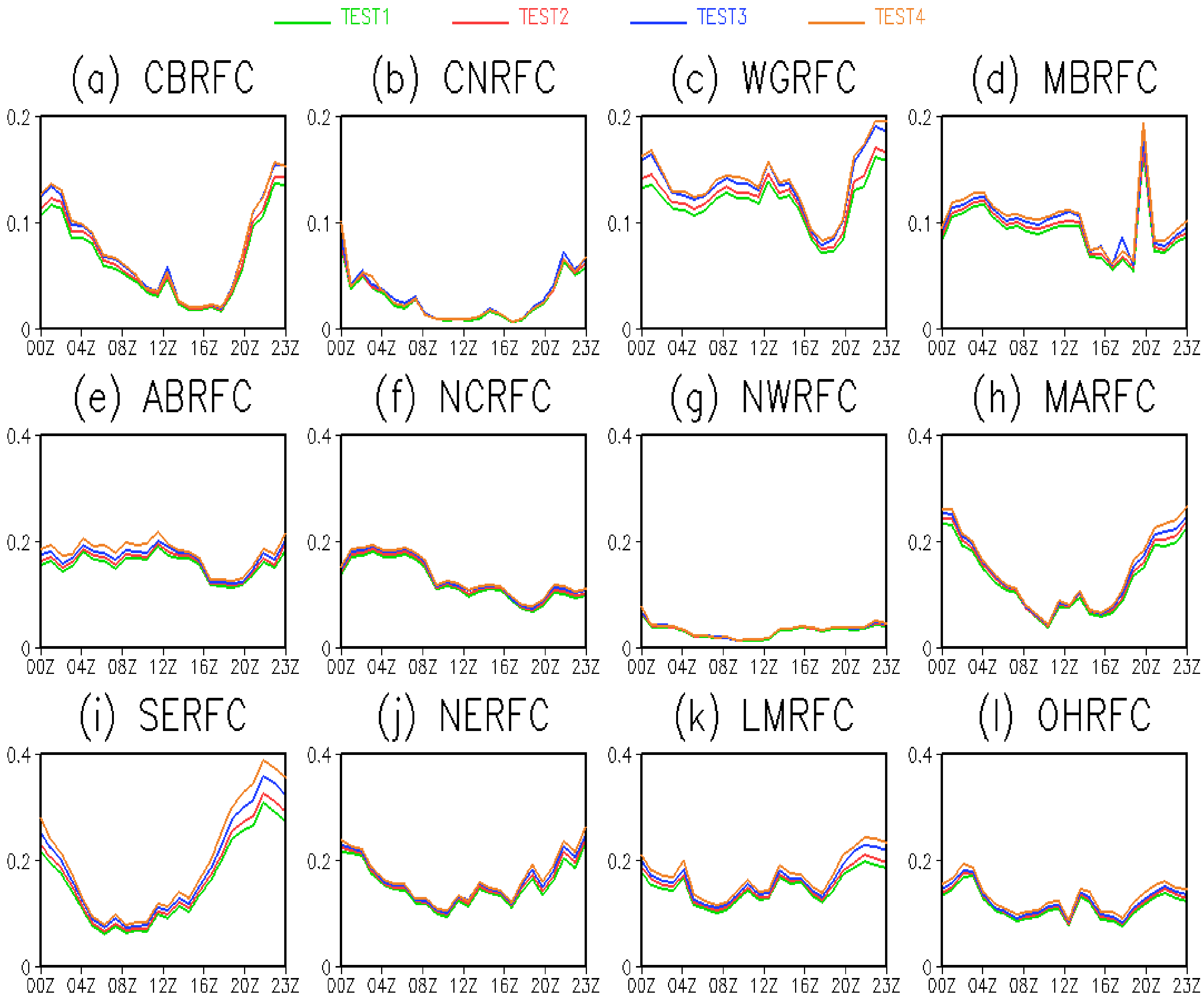

Figure 16: Spatial variance of monthly mean precipitation diurnal cycle in July 2014

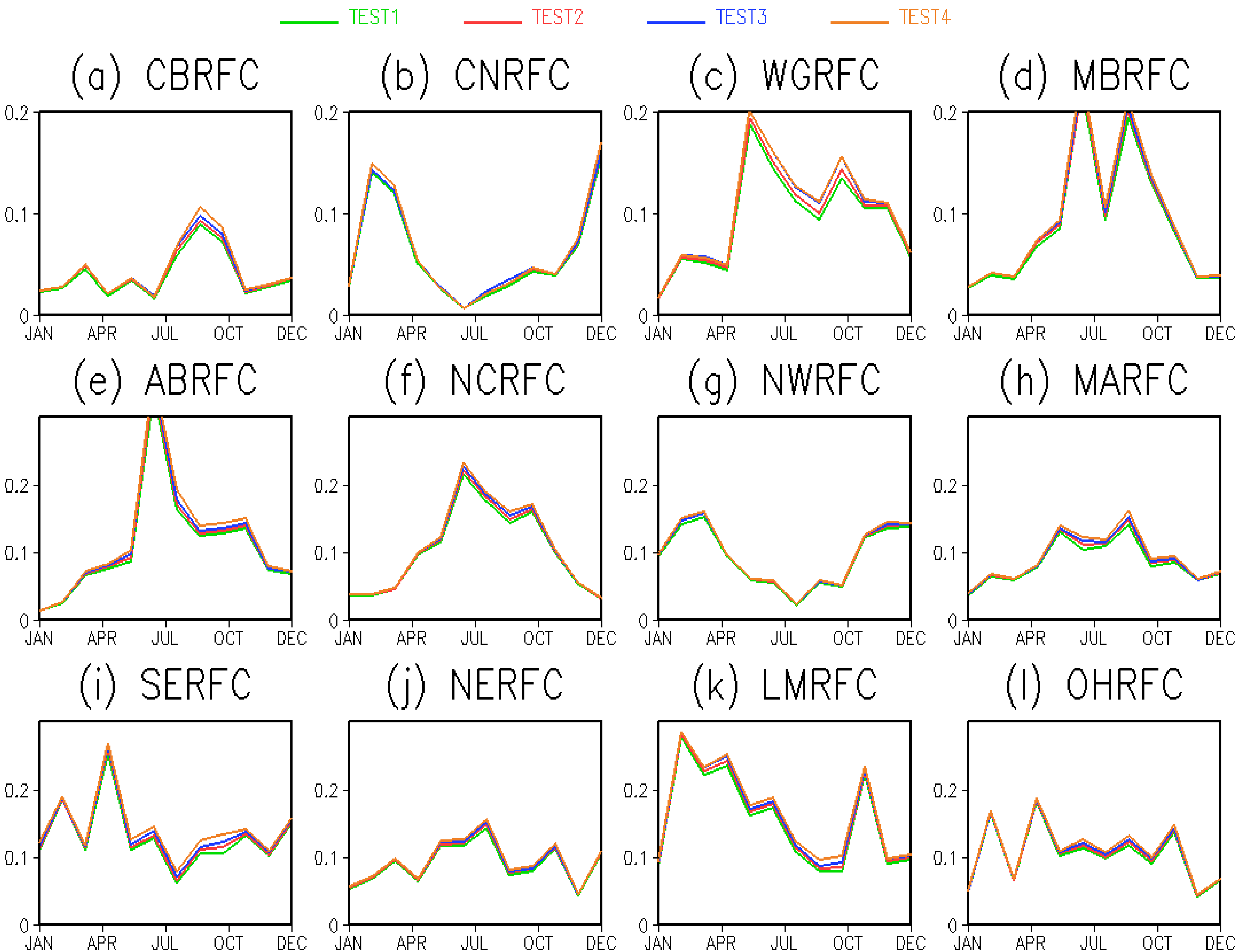

Figure 17: 06Z (night time) spatial variation comparison for 12 RFCs

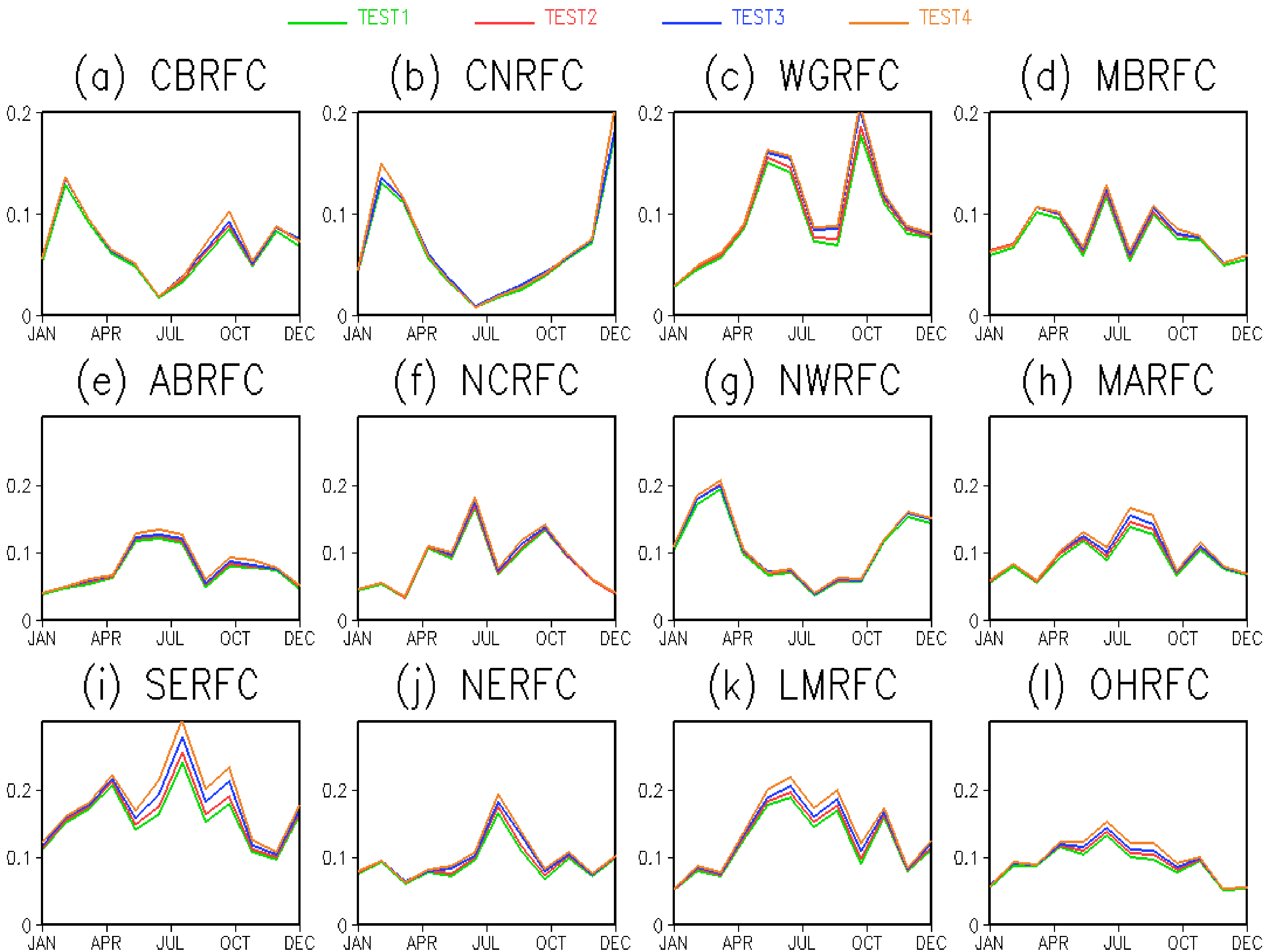

Figure 18: 18Z (day time) spatial variation comparison for 12 RFCs

Summary and Conclusion

1. This study has shown that this simple spatial weight method works for spatial downscaling of hourly NLDAS-2 into NLDAS3 grid (0.03125 degree).

2. Hourly downscaled precipitation by using hourly Stage IV precipitation has the most spatial variability, following by hourly Stage II, Monthly NCDC, and water budget interpolation.

3. Analysis of spatial variance at different time scales from daily to monthly show that conclusion #2 keeps for all three time scales, suggesting results are robust.

Future Work

1. Go ahead to process 36+ years hourly NLDAS-2 precipitation using Stage IV (January 2002-present), Stage II (January 1996 – December 2001), and NCDC (January 1979 to December 1995) to produce hourly NLDAS3 precipitation for NLDAS domain

2. To produce hourly NLDAS3 air temperature by using hourly NLDAS-2 air temperature and daily PRISM air temperature (some preliminary thoughts need to be tested)

Welcome to submit an abstract to "Land Data Assimilation Session" at 96th AMS annual meeting, New Orleans, LA, 10-14 January 2016

Talk to you in next NLDAS Teleconference (16 September)