Optimal estimation of NLDAS climatology

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Estimate Climatology:

Simple Average: Estimate climatology by averaging the data with fixed annual cycle.

Spectral Method: Estimate climatology by regressing the data onto few harmonics

$$y_{SM}(t_i) = a_0 + \sum_{j=1}^{H} \left[a_j \cos(w_j t_i) + b_j \sin(w_j t_i) \right]$$

$i = 1,2,.....N.,w_j = \frac{2pj}{P}$. P is the period.

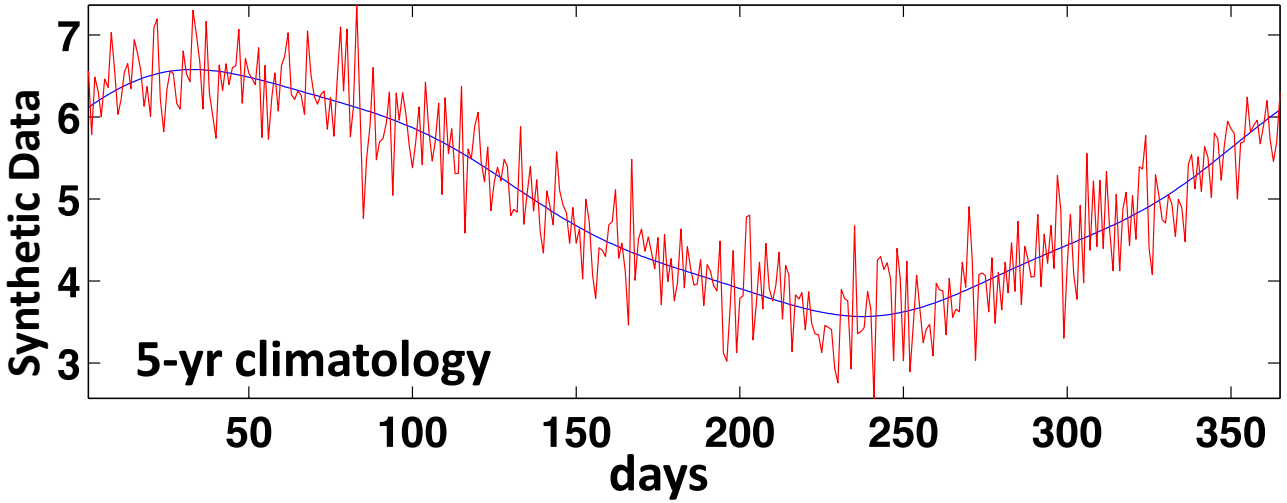
'H' is truncation parameter.

The total number of required parameters = 2*H+1

More *parameters* are needed with Simple Averaging (SA) compared to Spectral Method (SM). *Parameters* are independent values required to express climatological time-series

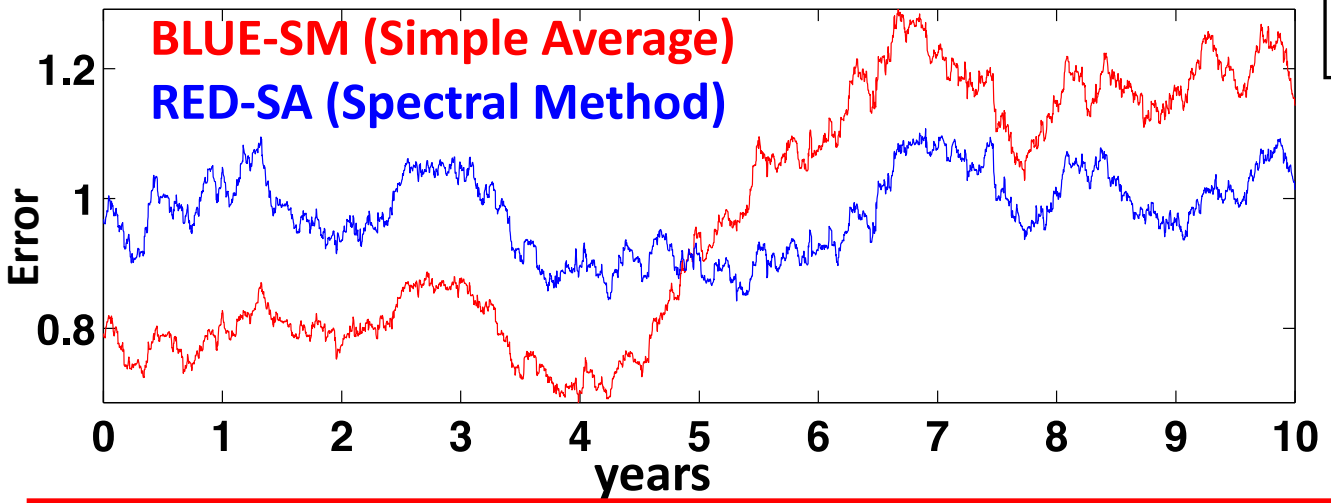
The climatology estimated by Spectral Method predicts independent year with better accuracy

Seasonal anomalies are reliably estimated if we use less number of parameters* to estimate the climatology



*Parameters are independent values required to express climatological time-series

For example, to estimate daily climatology using simple mean, we need 365 parameters (one average value per day)



FPE (Akaike, 1969)

$$1+\frac{1*365}{5*365}=1.2$$

$$1+\frac{2*H+1}{5*365}\approx 1$$

Source: Narapusetty B., DelSole T., and M. K. Tippett, 2009: Optimal Estimation of the Climatological Mean. *J. Clim.,* 22, 4845-4859.

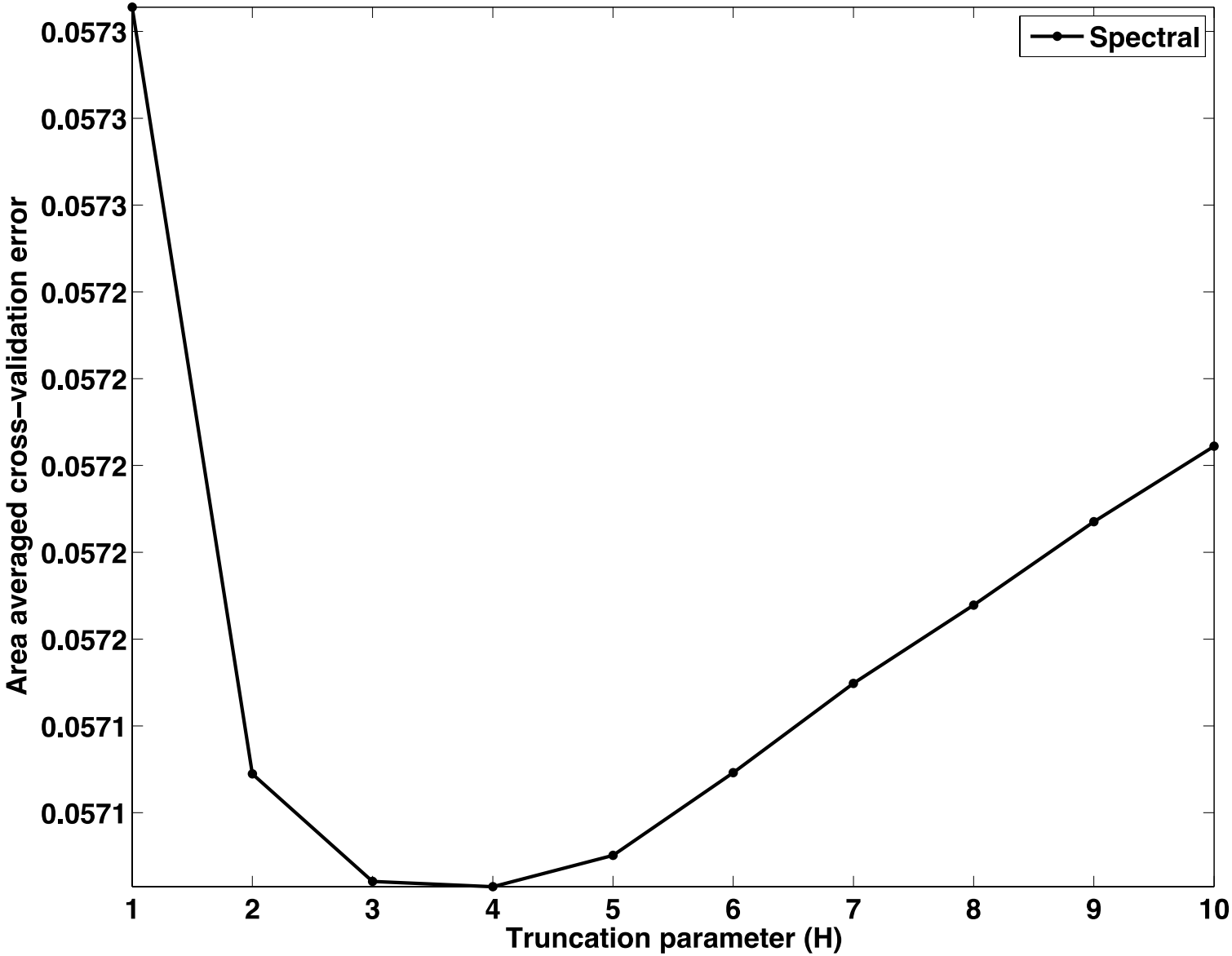
NOAH-LSM

PRECIP

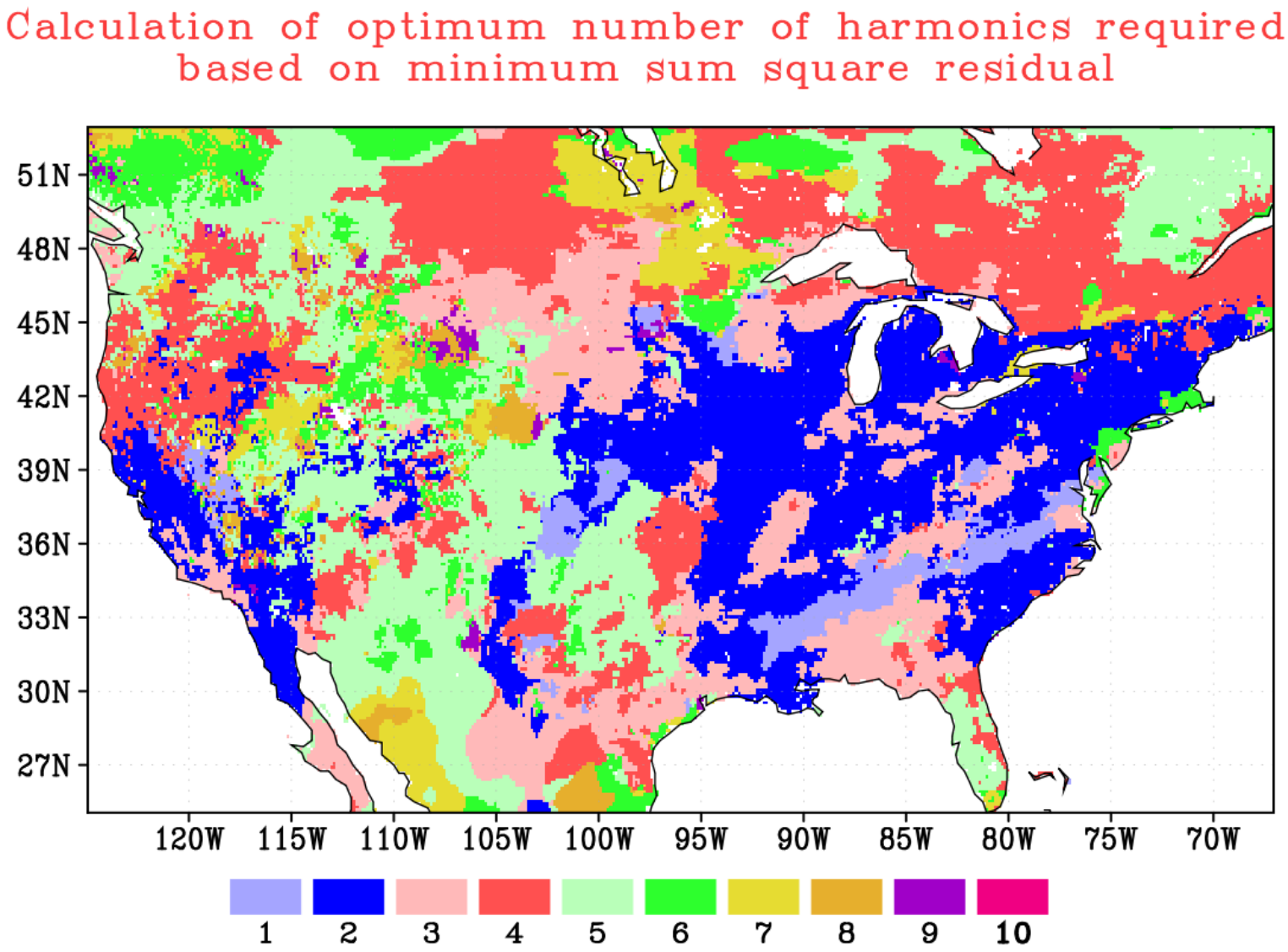
Climatologies are based on
30years: 1980-2009
36years: 1979-2014

The hourly data is averaged to produce daily data

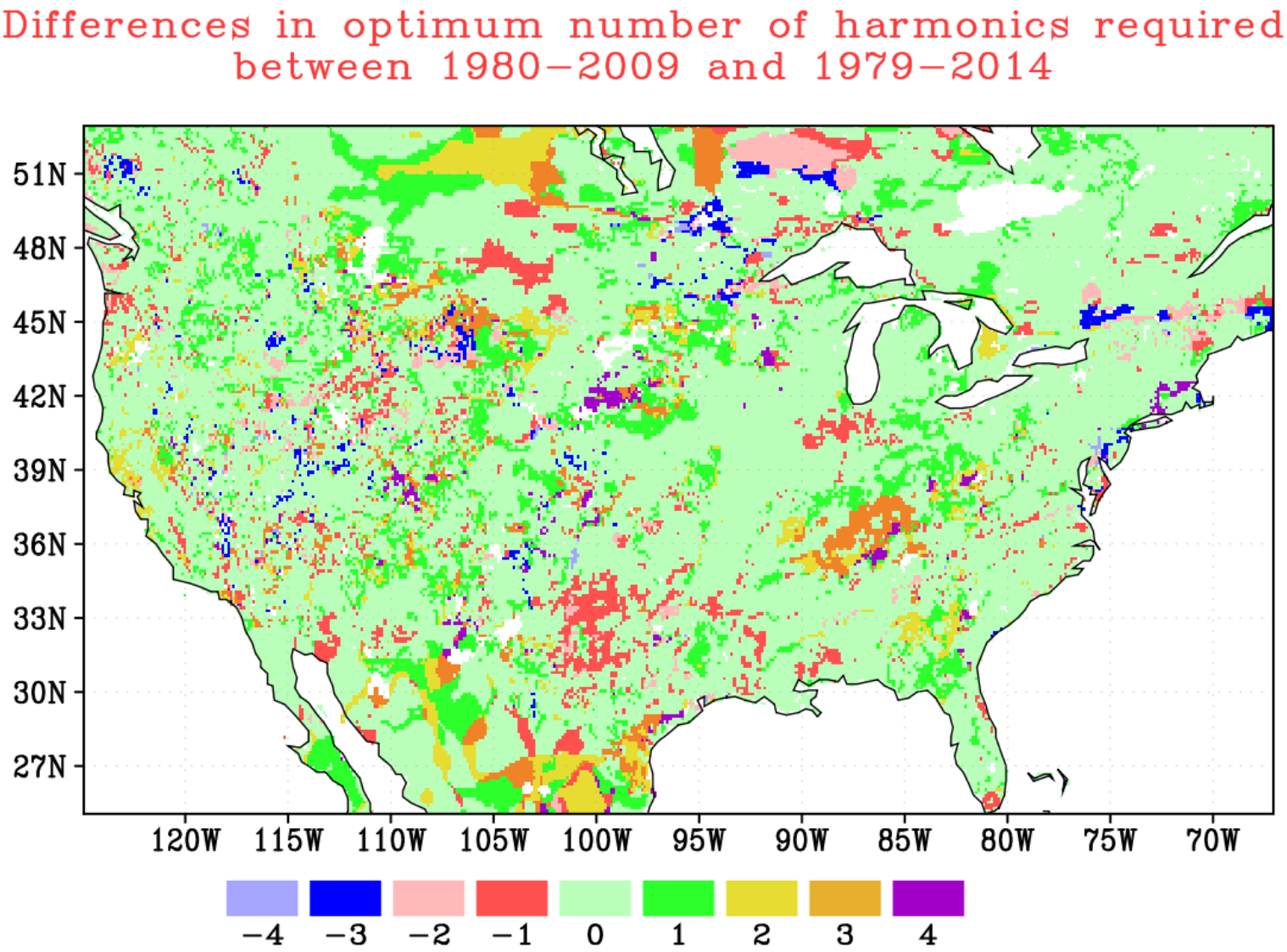
The optimal number for ‘H’ is 4 based on area-averaged Cross-validation error over CONUS



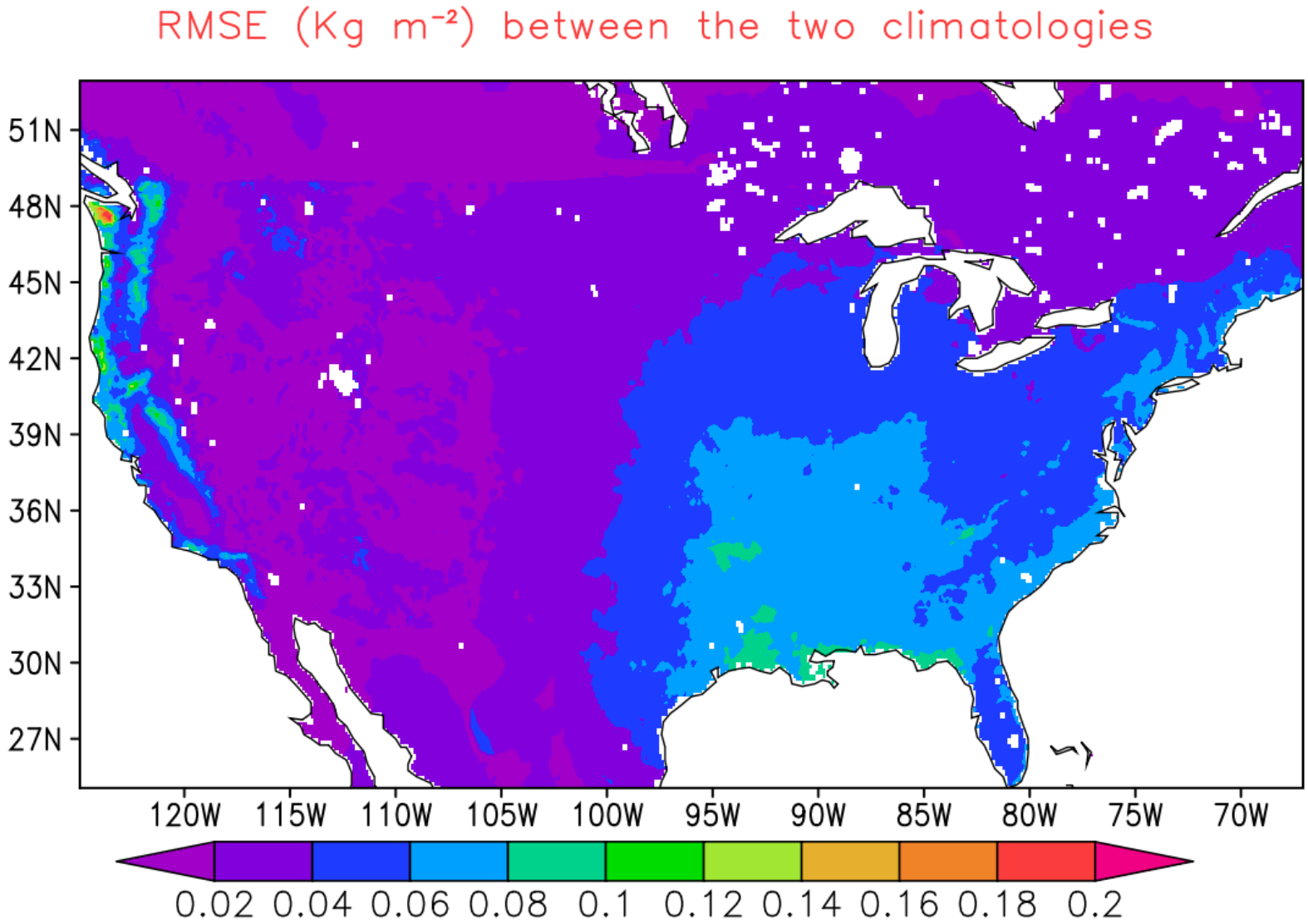
The gridded map of truncation parameter ‘H’ as required in Spectral Method (based on 1980-2009)



Differences in the gridded map of truncation parameter ‘H’ between 1980-2009 and 1979-2014

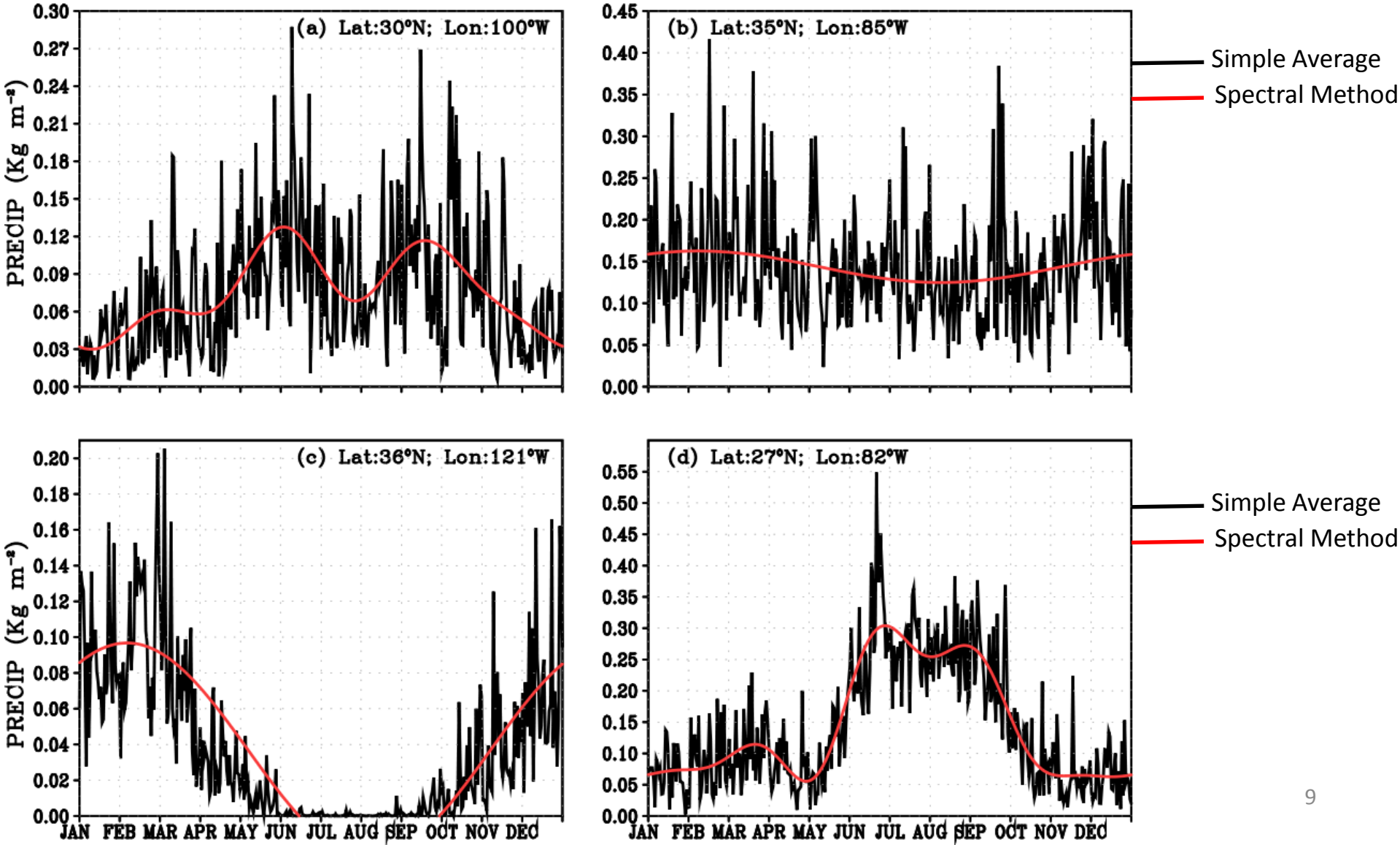


RMSE differences between the Simple Average and Spectral Method estimated climatolgies (based on 1980-2009)

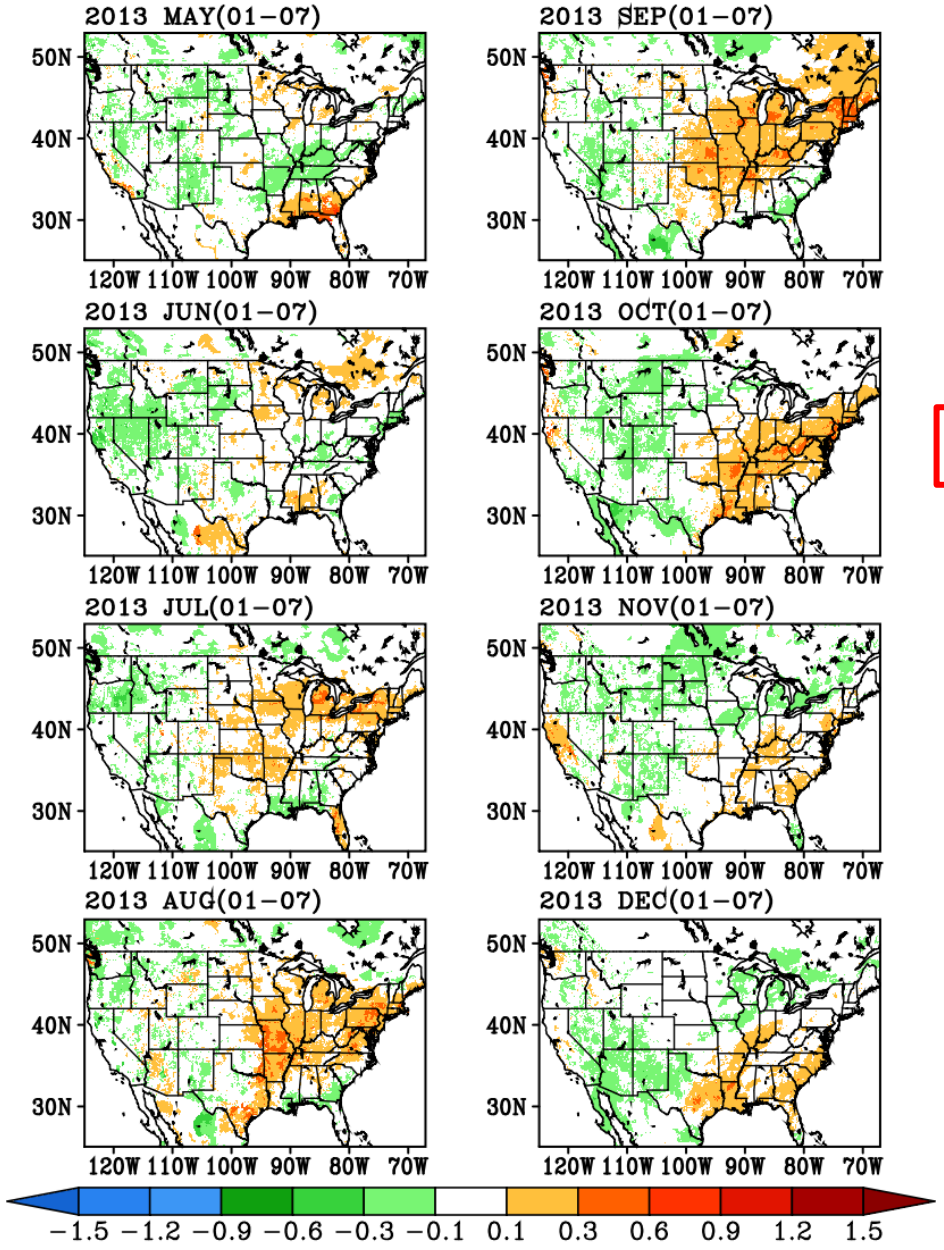


Note: RMSE differences mount up to 30% of the mean values

Estimated daily climatologies (Simple Average in black and Spectral Method in red) at different locations over CONUS (based on 1980-2009)



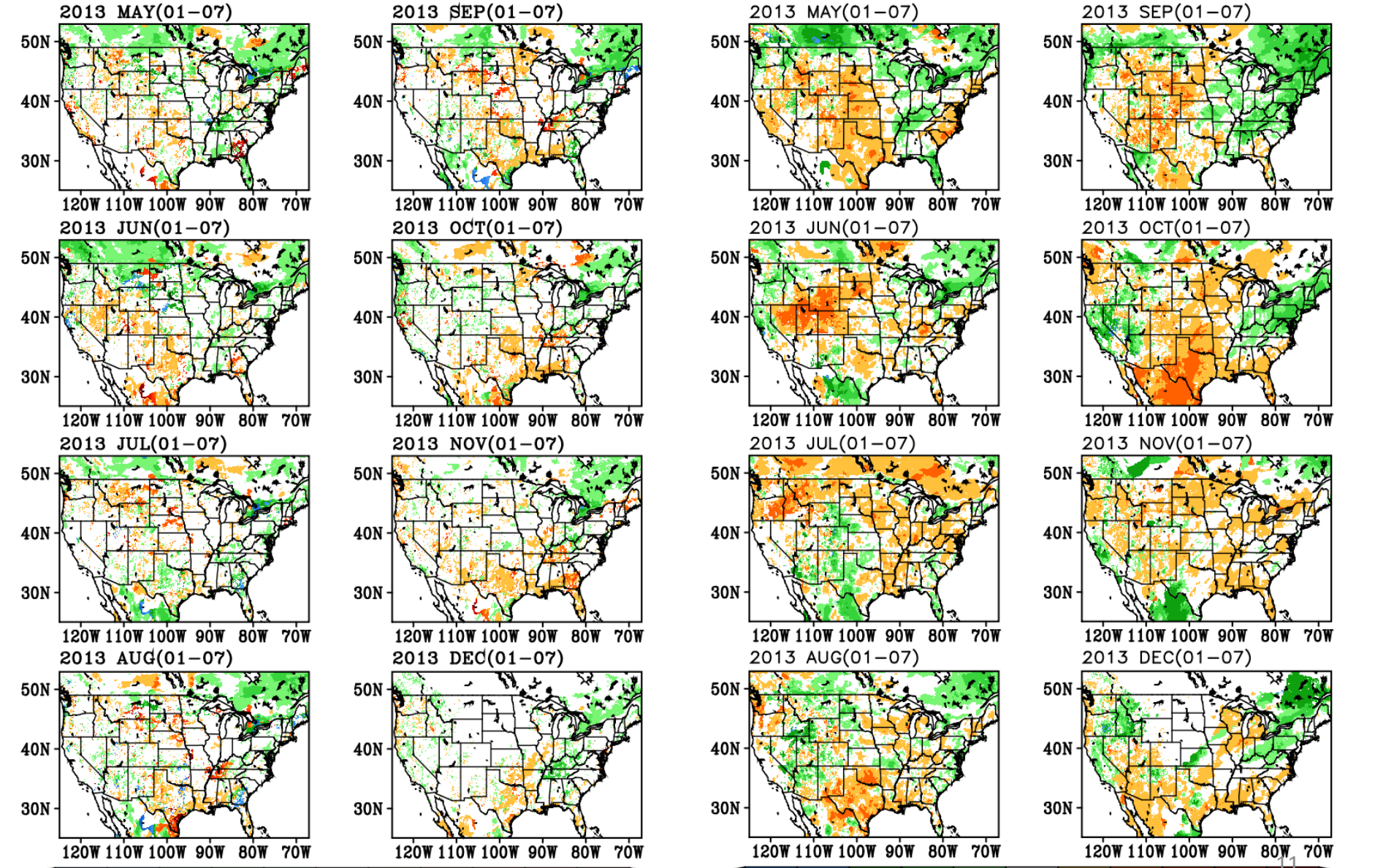
Differences in standard anomalies (aggregated to weekly) between the two approaches in the year 2013 based on 1980-2009 climatologies.



Simple Average – Spectral Method

Differences in standardized anomalies (*5) computed based on 30-year (1980-2009) and 36-year (1979-2014) climatologies

Spectral Method | **Simple Average**



NOAH-LSM

Top-layer soil moisture

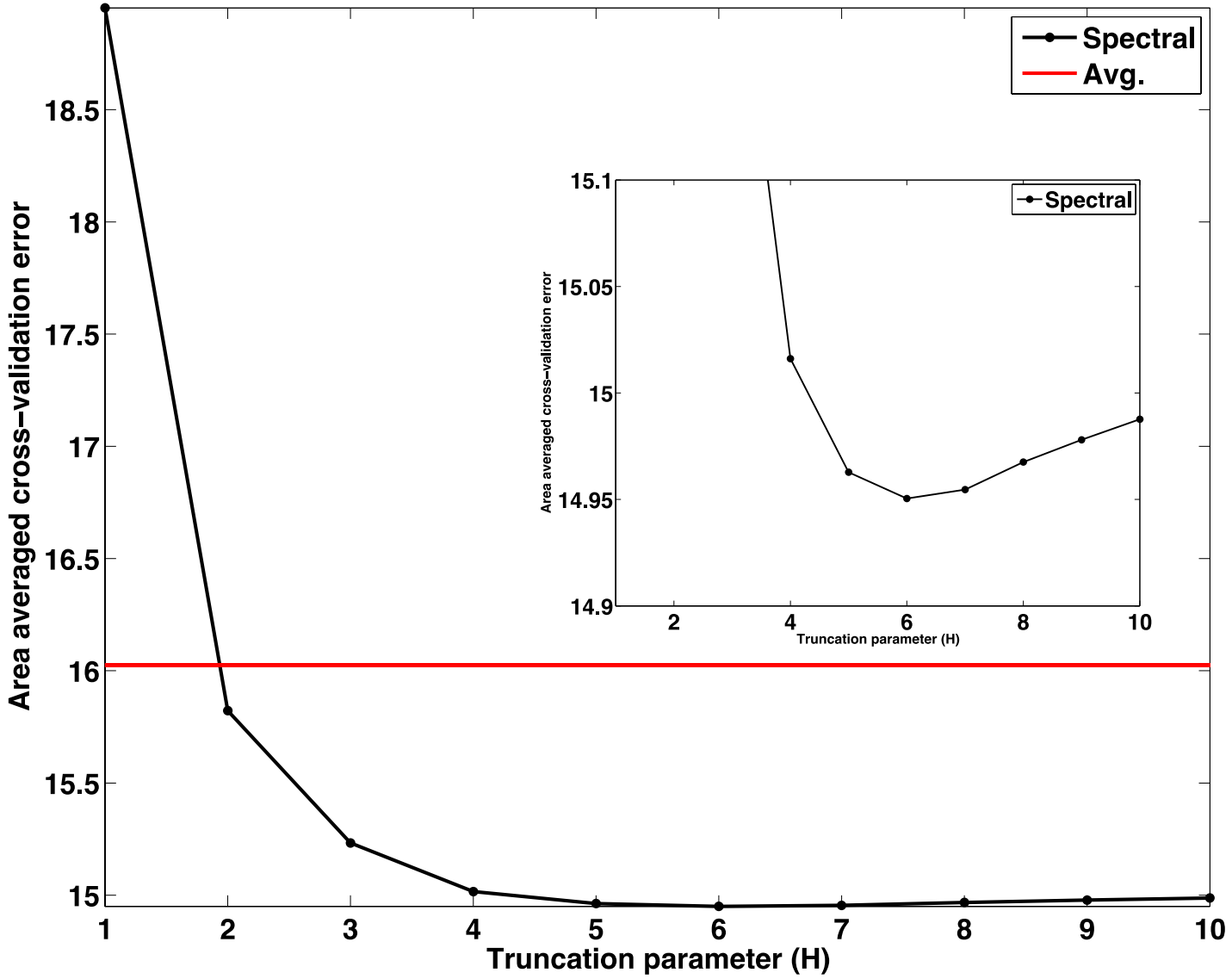
Climatologies are based on

30years: 1980-2009

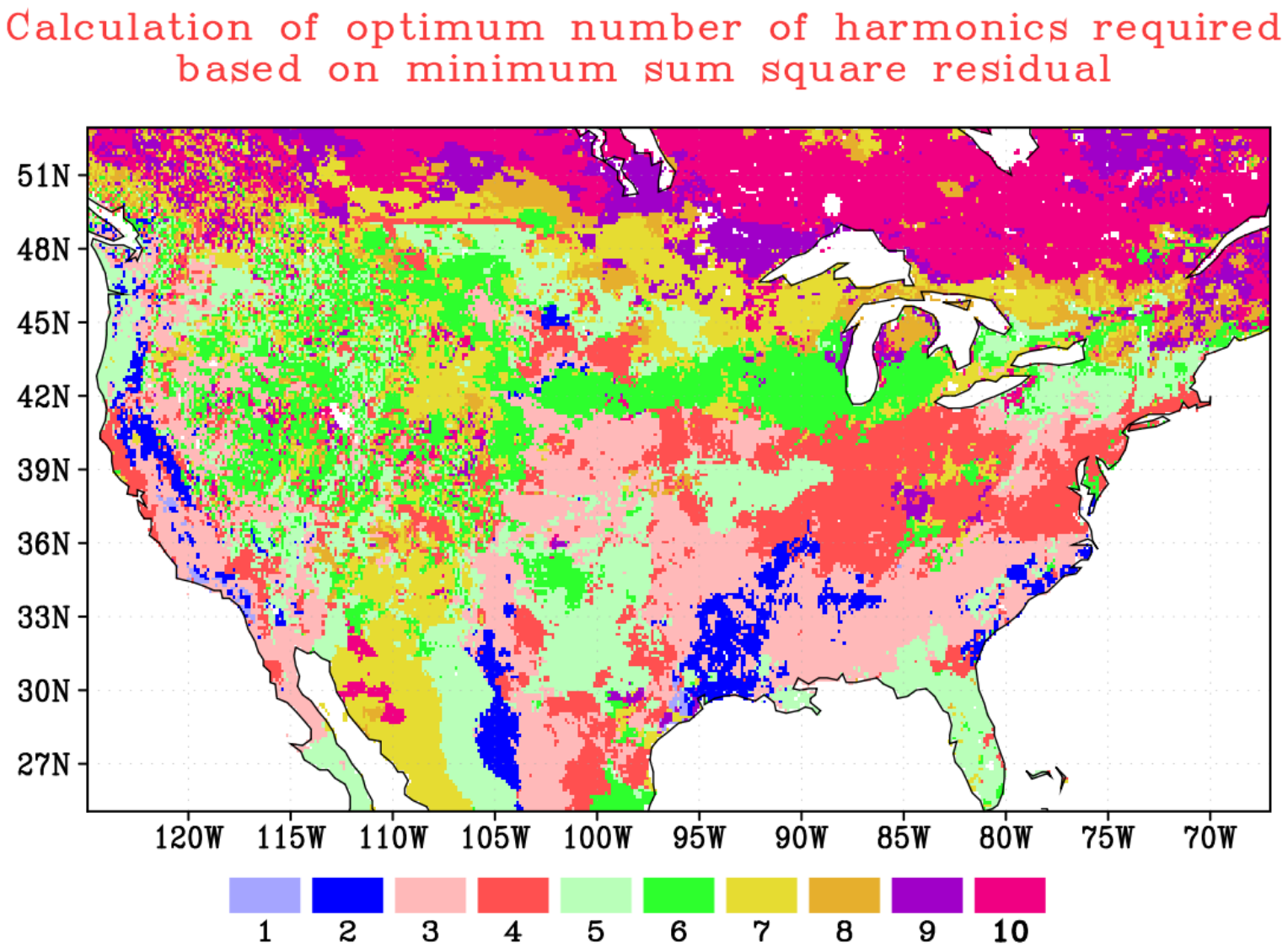
36years: 1979-2014

The hourly data is averaged to produce daily data

The optimal number for ‘H’ is 6 based on area-averaged Cross-validation error over CONUS



The gridded map of truncation parameter ‘H’ as required in spectral approach (based on 1980-2009)



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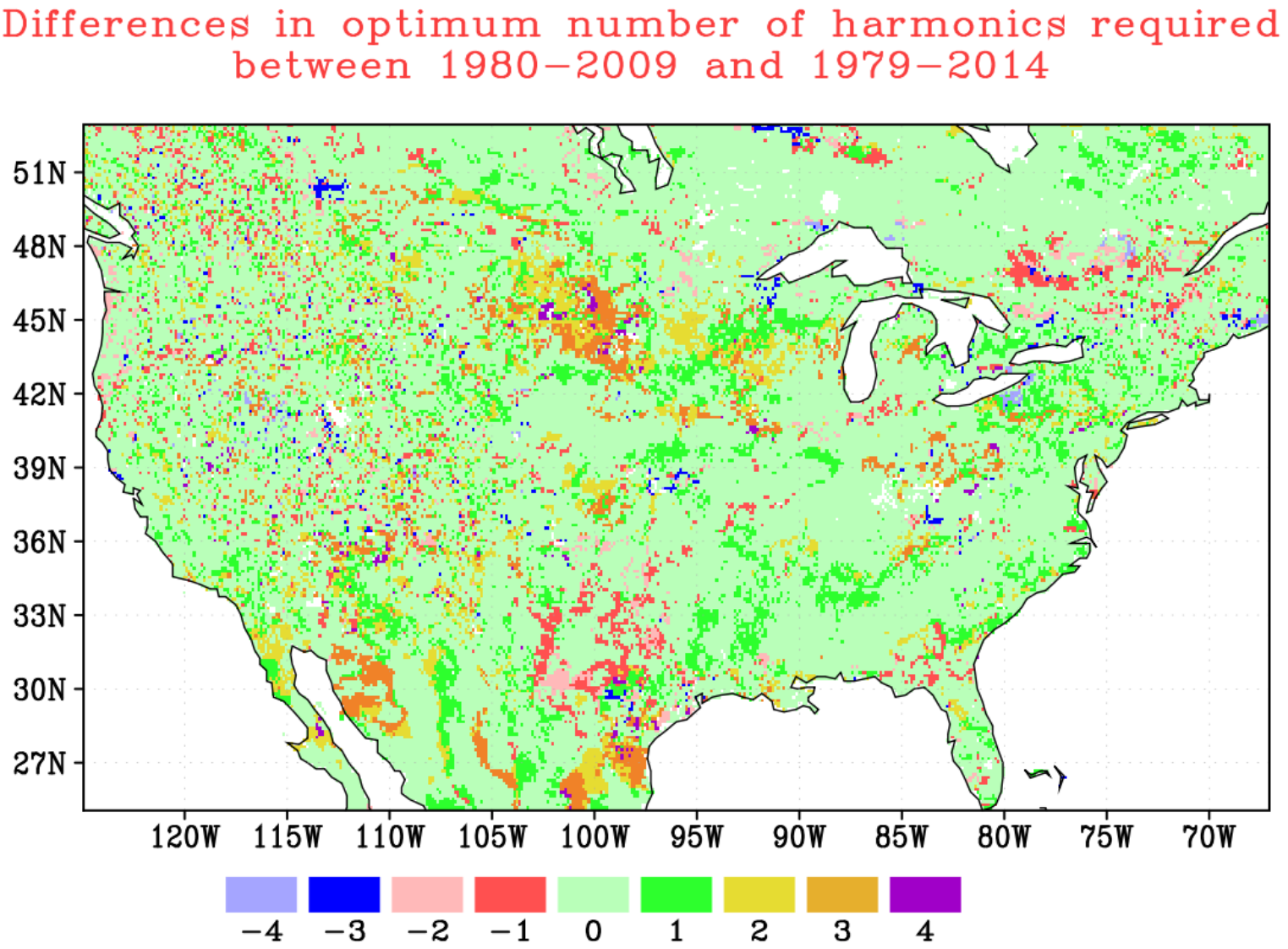
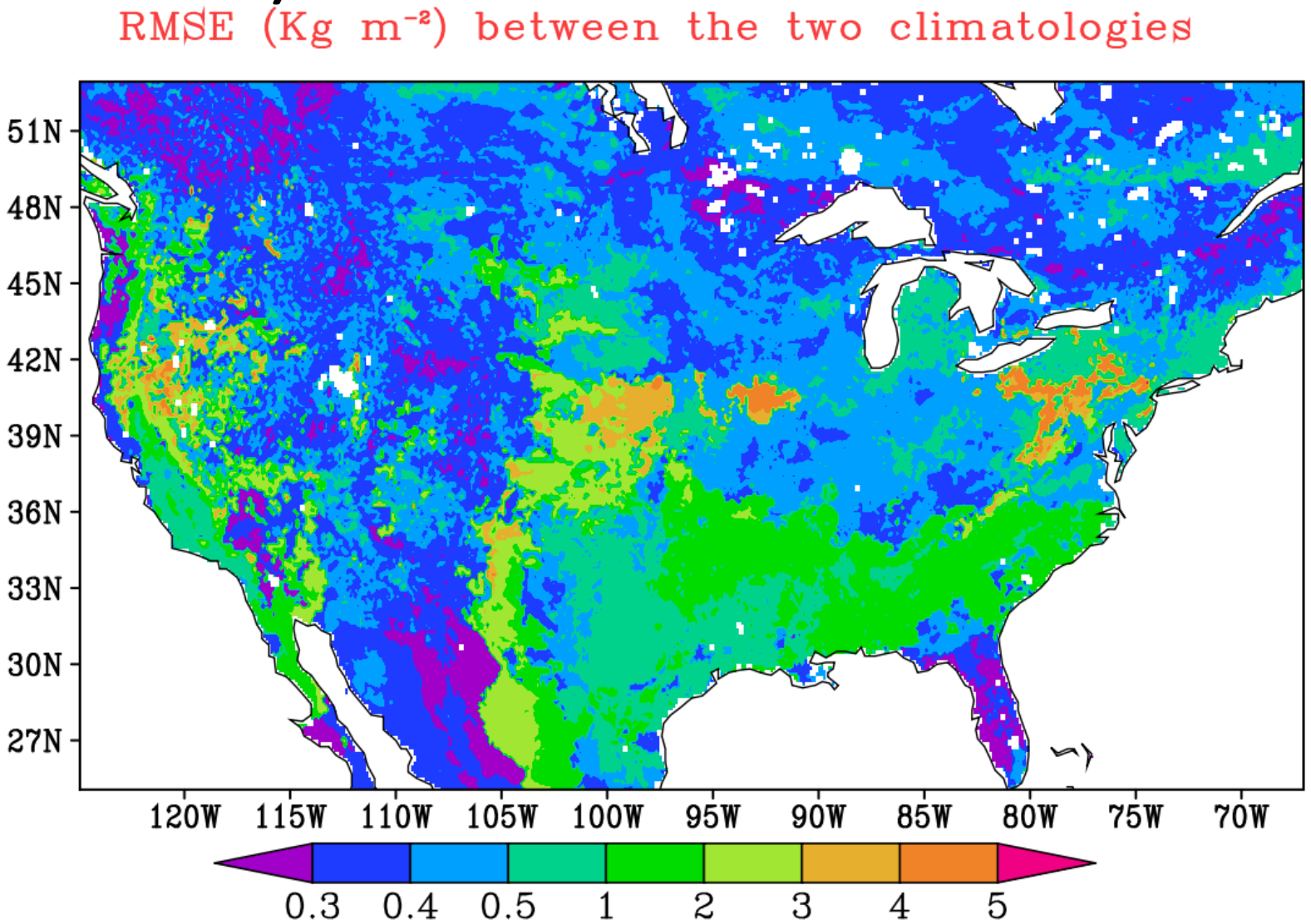
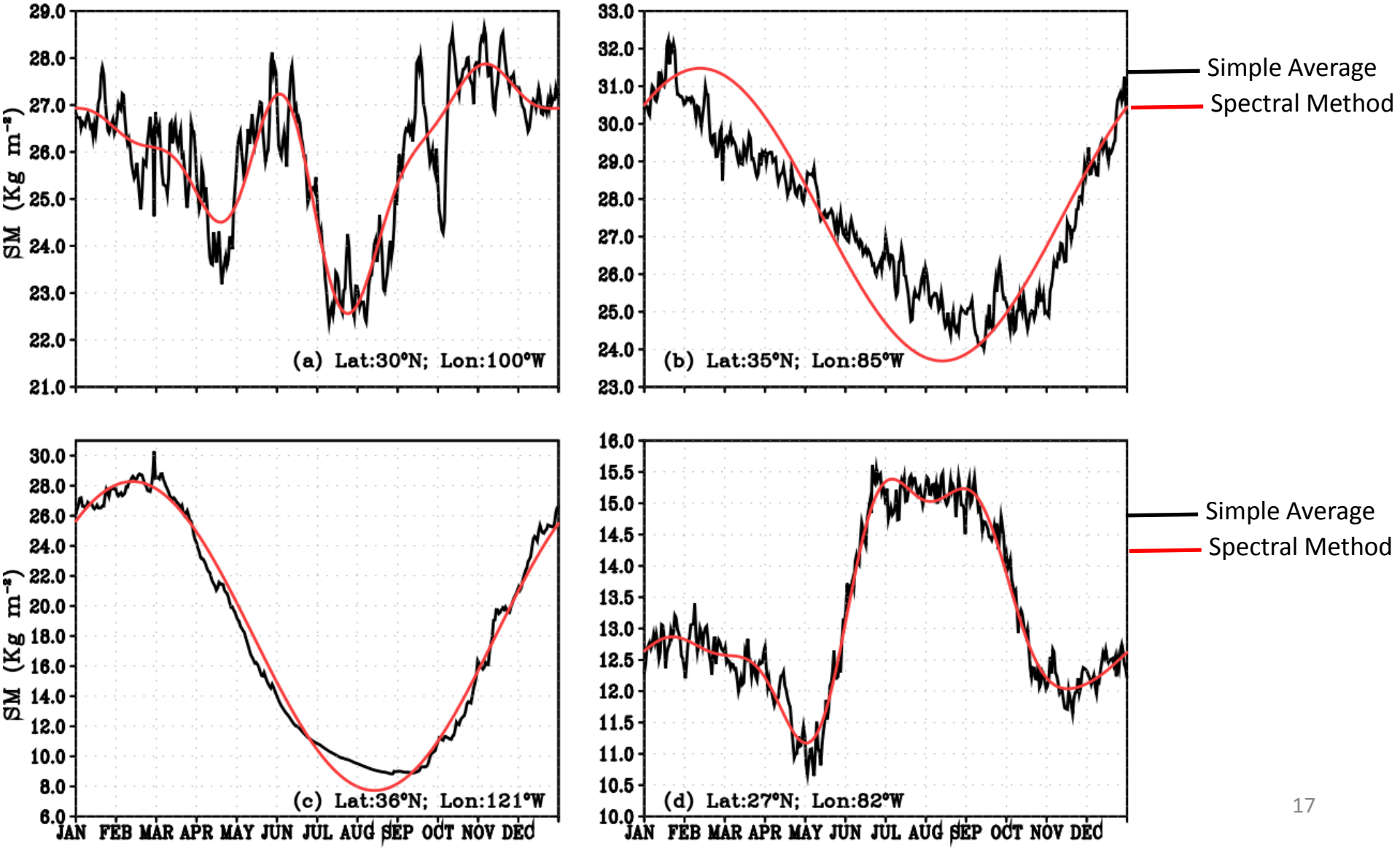


RMSE differences between the Simple Average and Spectral Method estimated climatolgies (based on 1980-2009)



Note: RMSE differences mount up to 15% of the mean values

Estimated daily climatologies (Simple Average in black and Spectral Method in red) at different locations over CONUS (based on 1980-2009)



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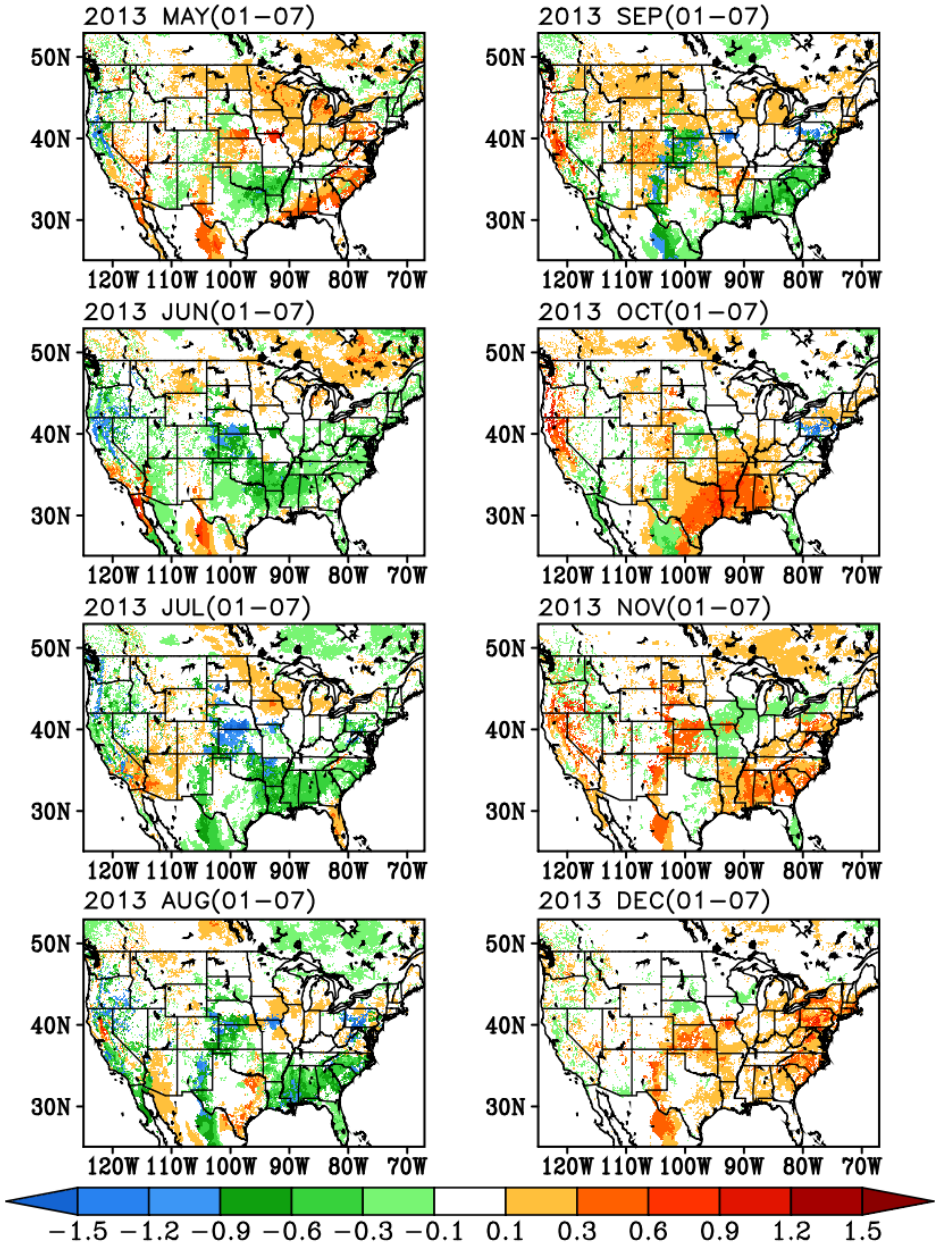
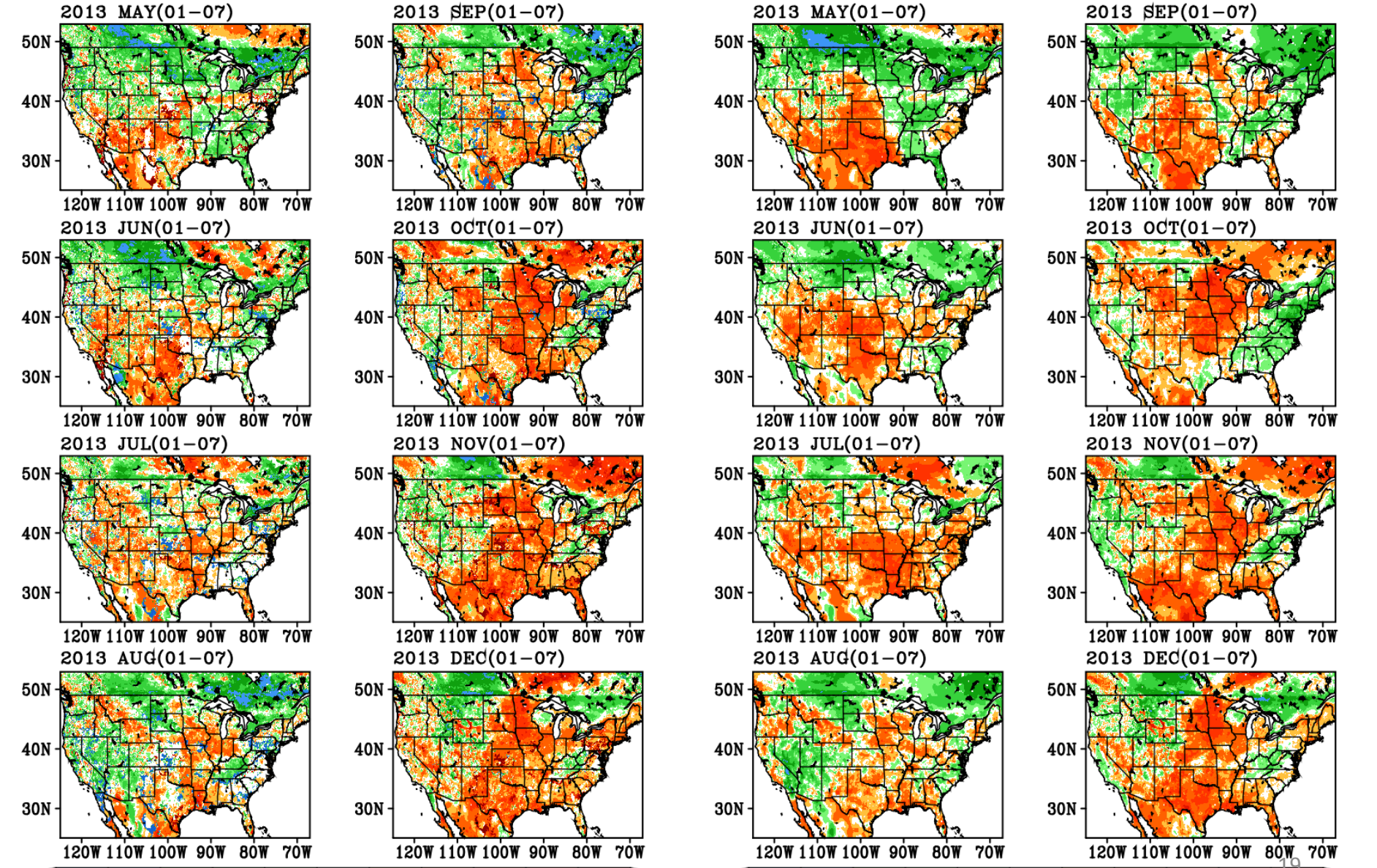


Simple Average – Spectral Method

Differences in standardized anomalies (*5) computed based on 30-year (1980-2009) and 36-year (1979-2014) climatologies

Spectral Method | **Simple Average**



Explained variance of climatology

Top-layer soil moisture Vs. Precipitation

Climatologies are based on 30years: 1980-2009

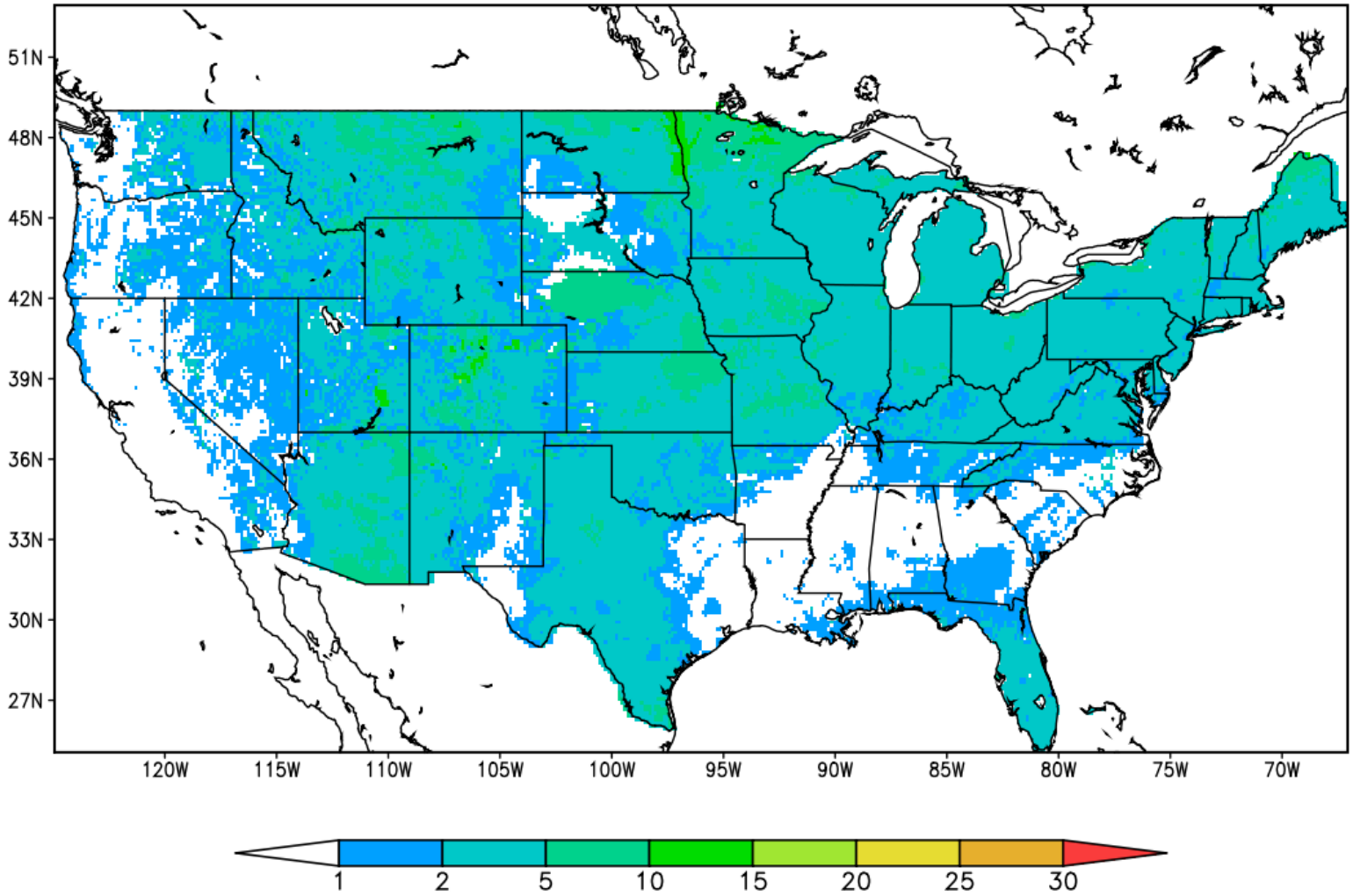
The intra-seasonal variability is non-negligible in soil-moisture => higher harmonics (3-6) have variability that cannot be ignored

Explained variance by annual cycle

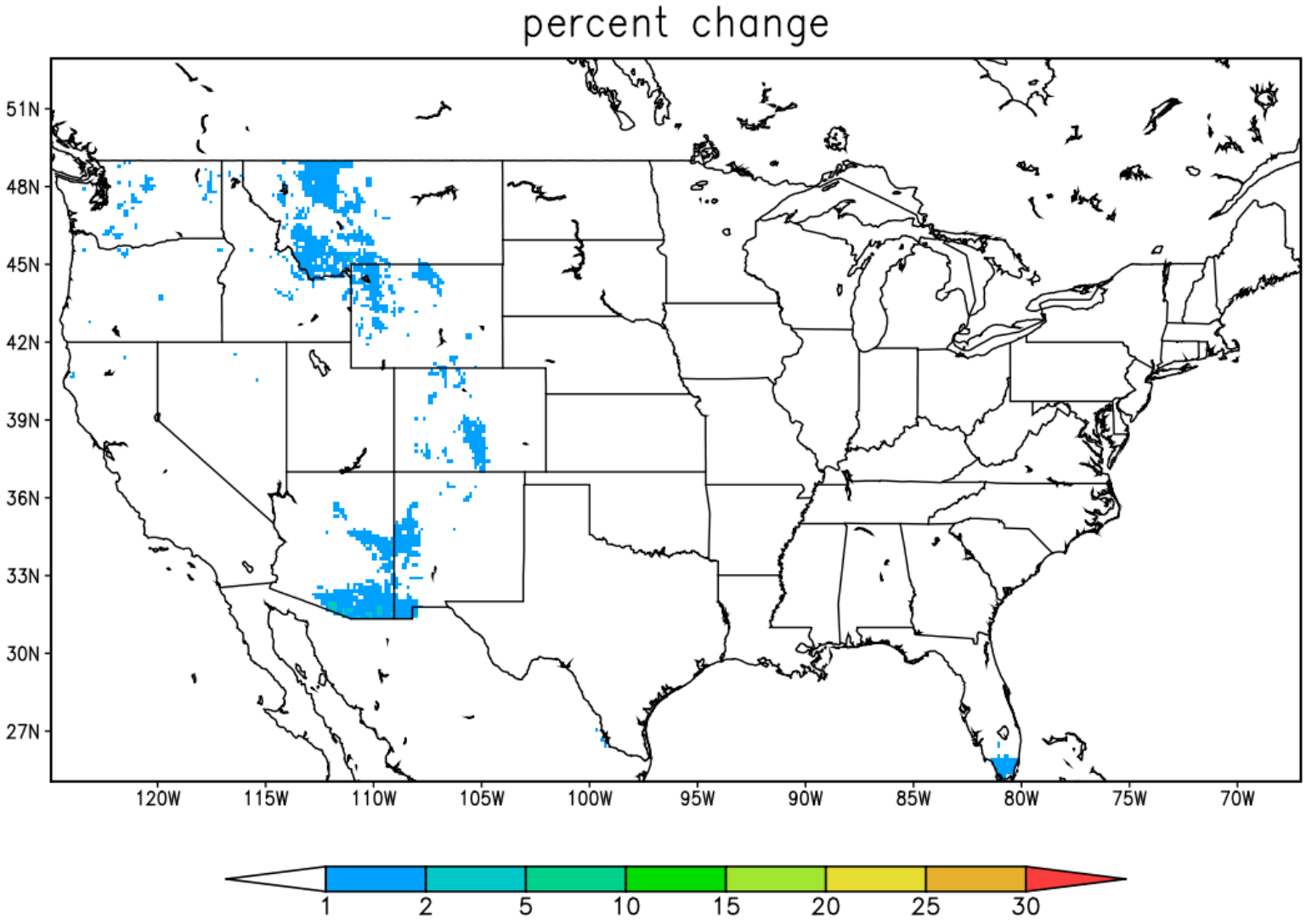
$$\mathrm{EV} = 1 - \frac{(\mathbf{y} - \mathbf{y}_c)^{\mathrm{T}}(\mathbf{y} - \mathbf{y}_c)}{(\mathbf{y}^{\mathrm{T}}\mathbf{y} - \overline{\mathbf{y}}^{\mathrm{T}}\overline{\mathbf{y}}N)},$$

The intra-seasonal variability is non-negligible in soil-moisture => higher harmonics (3-6) have variability that cannot be ignored

(EV (H=6)-EV(H=2))*100



.... which is not the case for Precipitation



Summary

- ✓Spectral Method estimates climatology with 2H+1 parameters, while the Simple Averaging requires 365 independent parameters for daily and 12 independent parameters for monthly climatology.

- ✓Spectral method is far-less sensitive to leap years and missing data.

- ✓The cross validation error calculations show Spectral Method represents independent data with less mean square error.

- ✓Spectral Method is ideal for smaller datasets.

- ✓Spectral Method is useful for hypotheses testing.

Future Work

- ✓Extend the Spectral Method based climatology estimations to total column moistures, Runoff and Evapotranspiration and apply the method to update the NLDAS drought monitor

- ✓Estimate the required number of optimal parameters based on cross-validation errors over seasonal time-scales and area averages

- ✓Extend the new optimal estimation based climatology based estimations to the other participating LSMs in NLDAS