

Update on optimal estimation of NLDAS climatology

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A quick recap on the previous work

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

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

$$i = 1, 2, \dots, N., w_j = \frac{2\pi j}{P}. P \text{ is the period.}$$

'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

NOAH-LSM

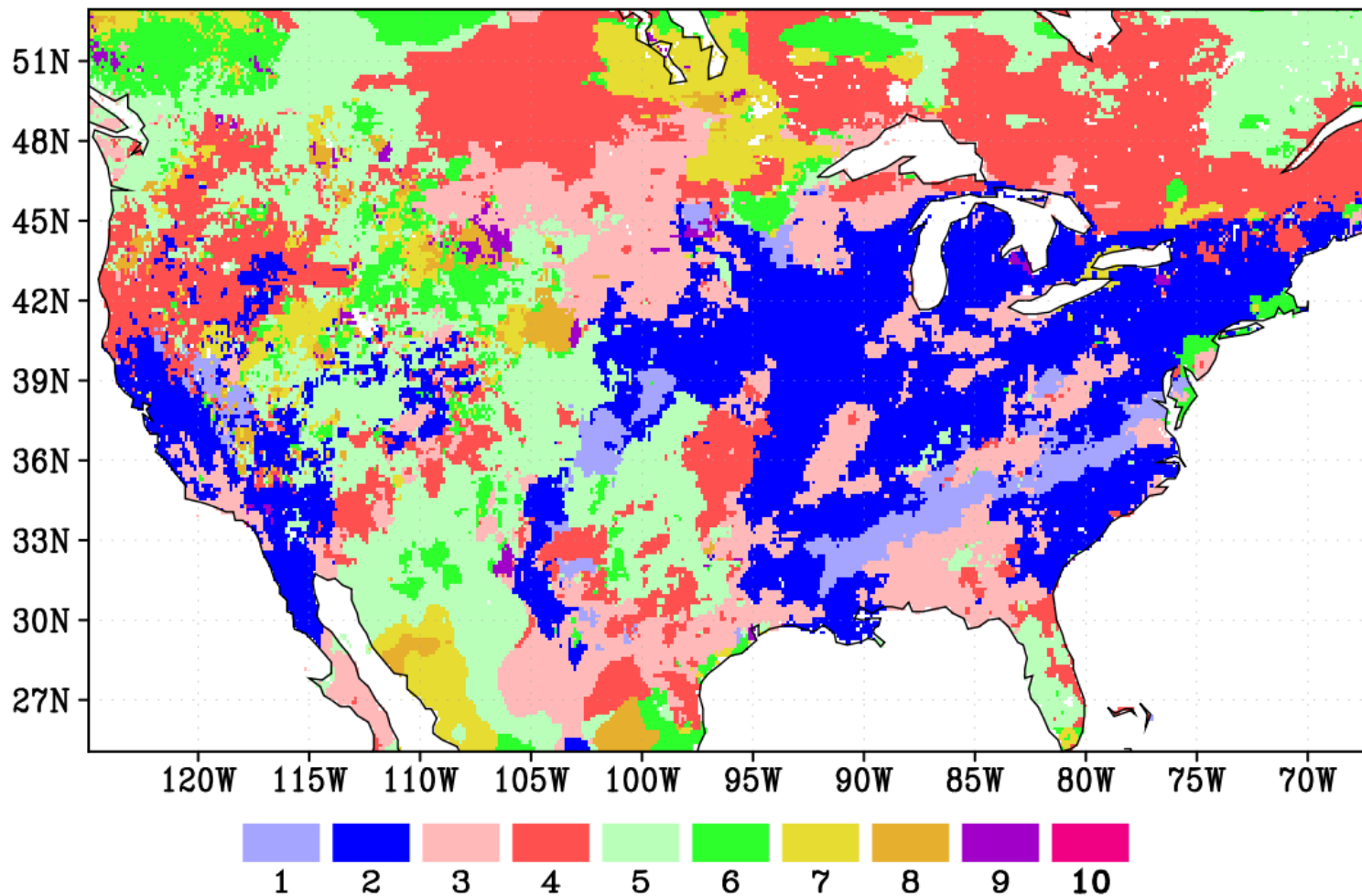
PRECIP

**Climatologies are based on
30years: 1980-2009**

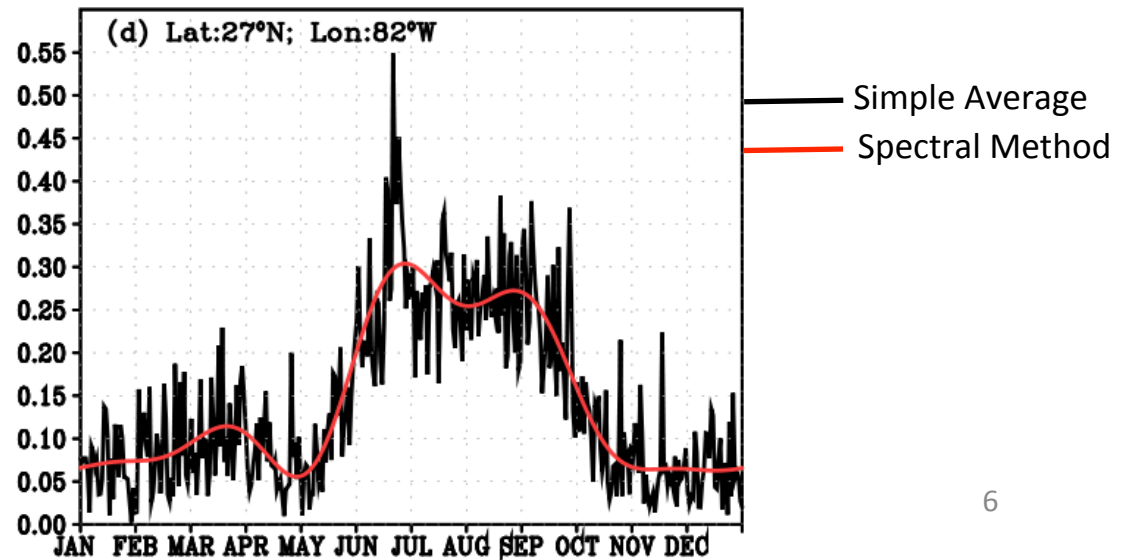
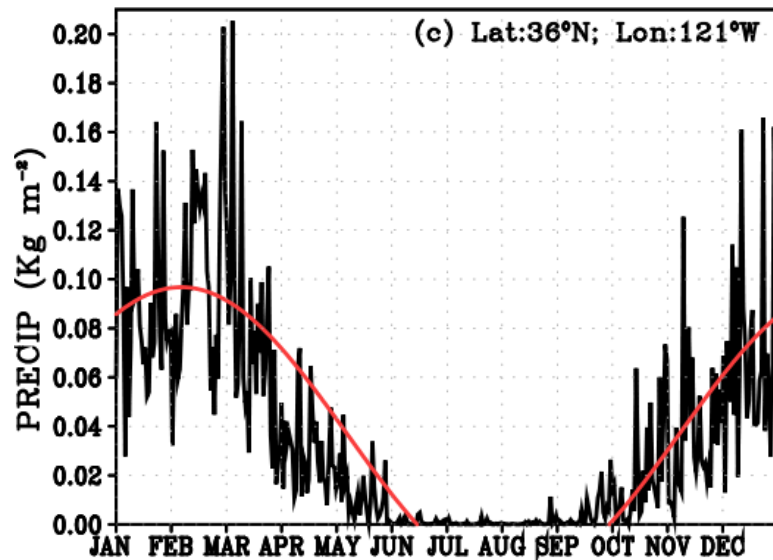
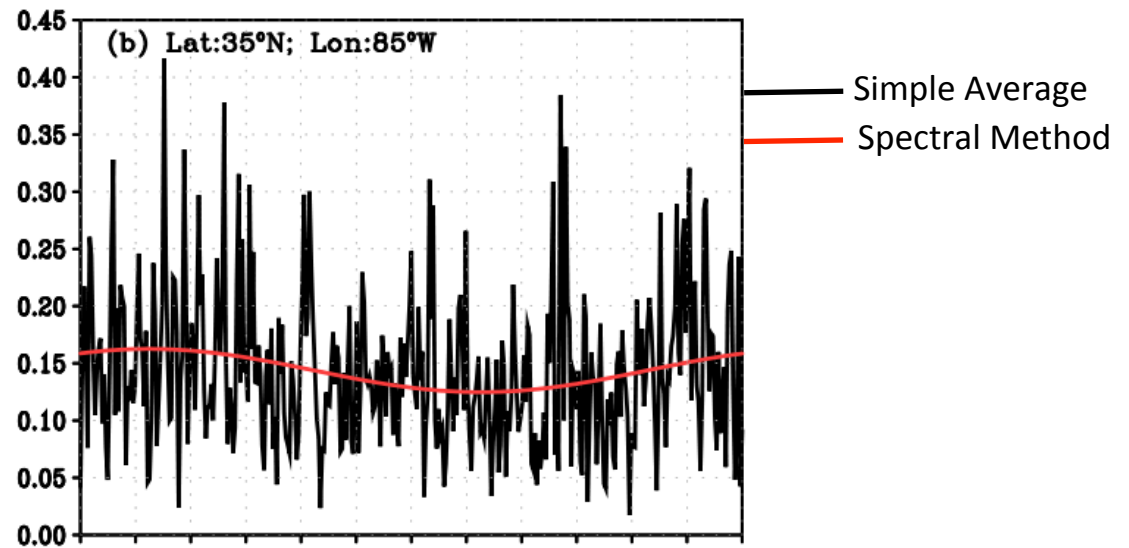
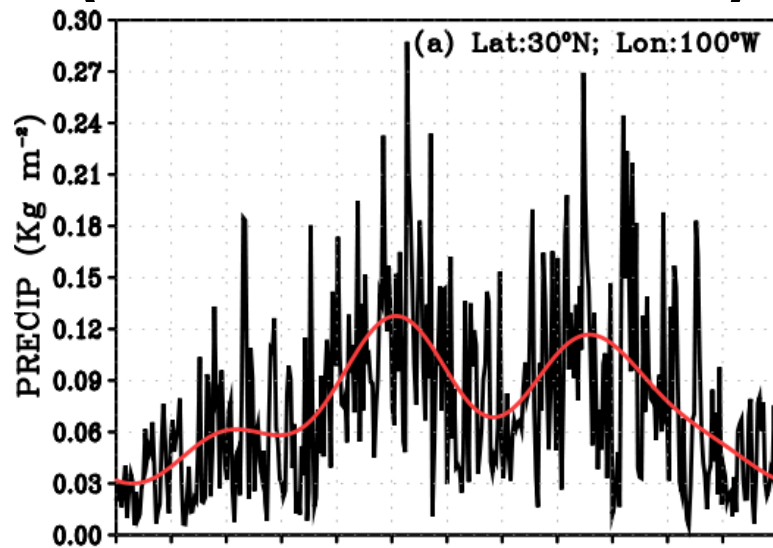
**The hourly data is averaged to produce
daily data**

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

Calculation of optimum number of harmonics required based on minimum sum square residual



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



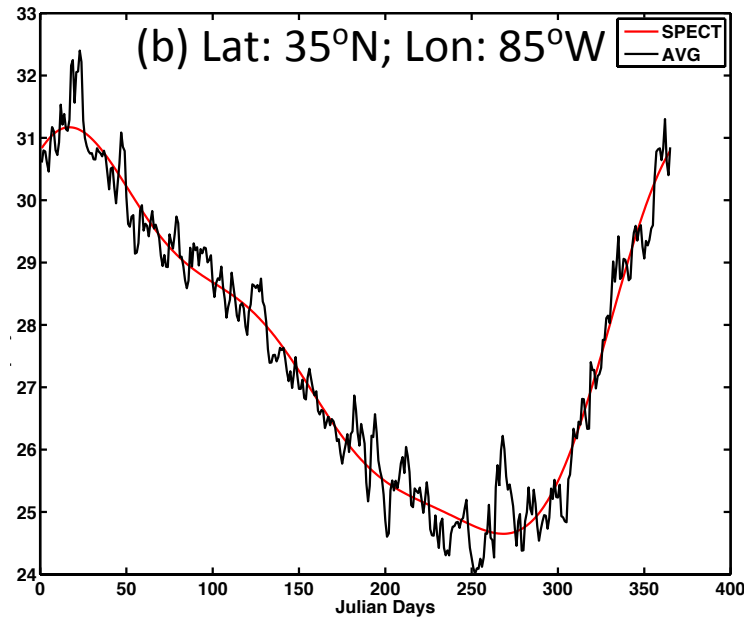
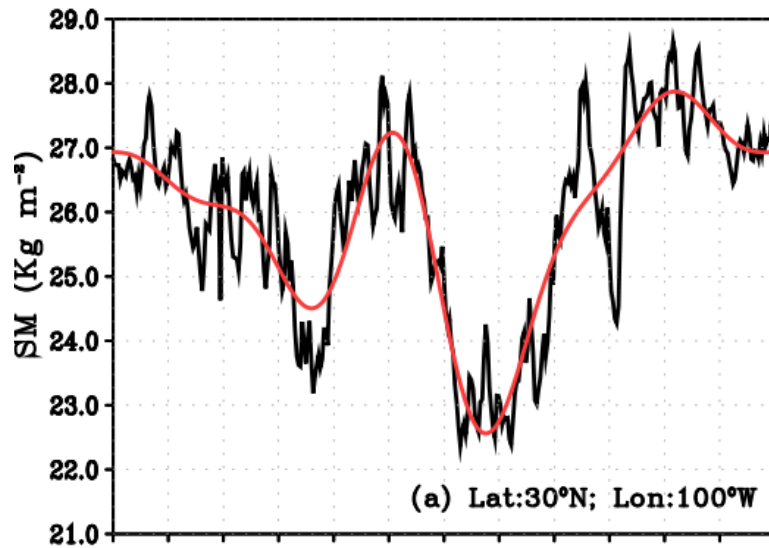
NOAH-LSM

Top-layer soil moisture

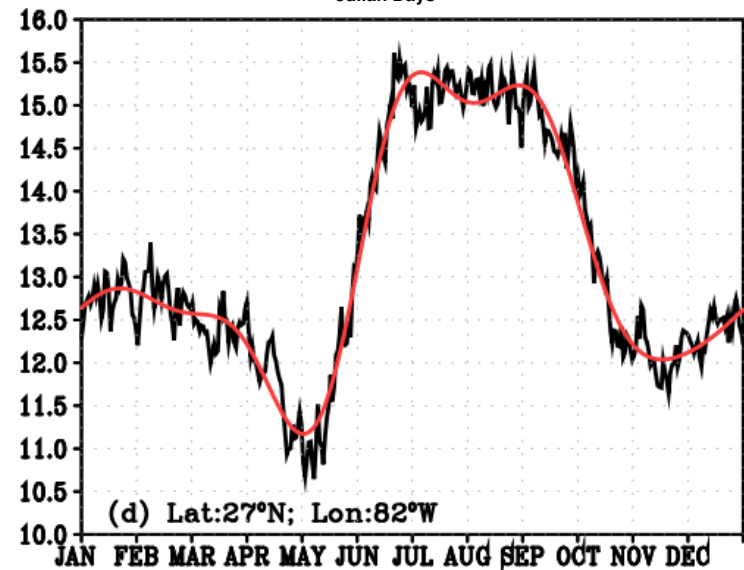
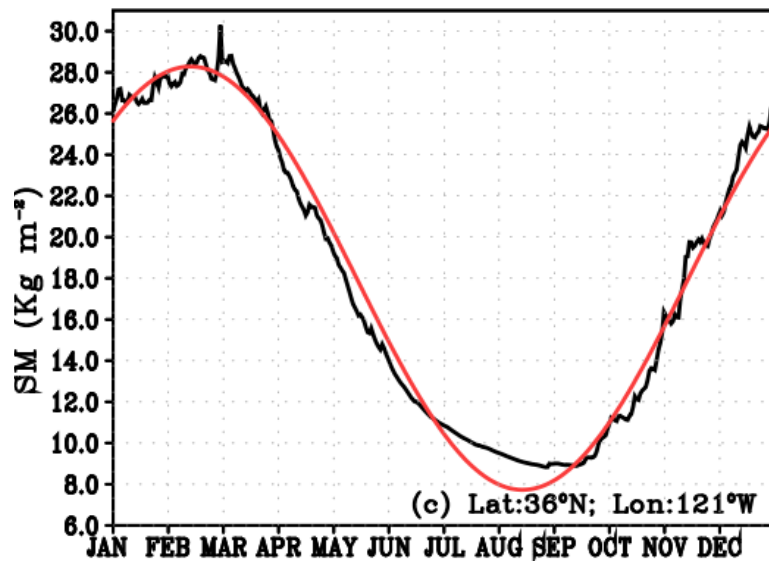
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— Simple Average
— Spectral Method



— Simple Average
— Spectral Method

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.

Explained variance of climatology

Top-layer soil moisture Vs. Precipitation

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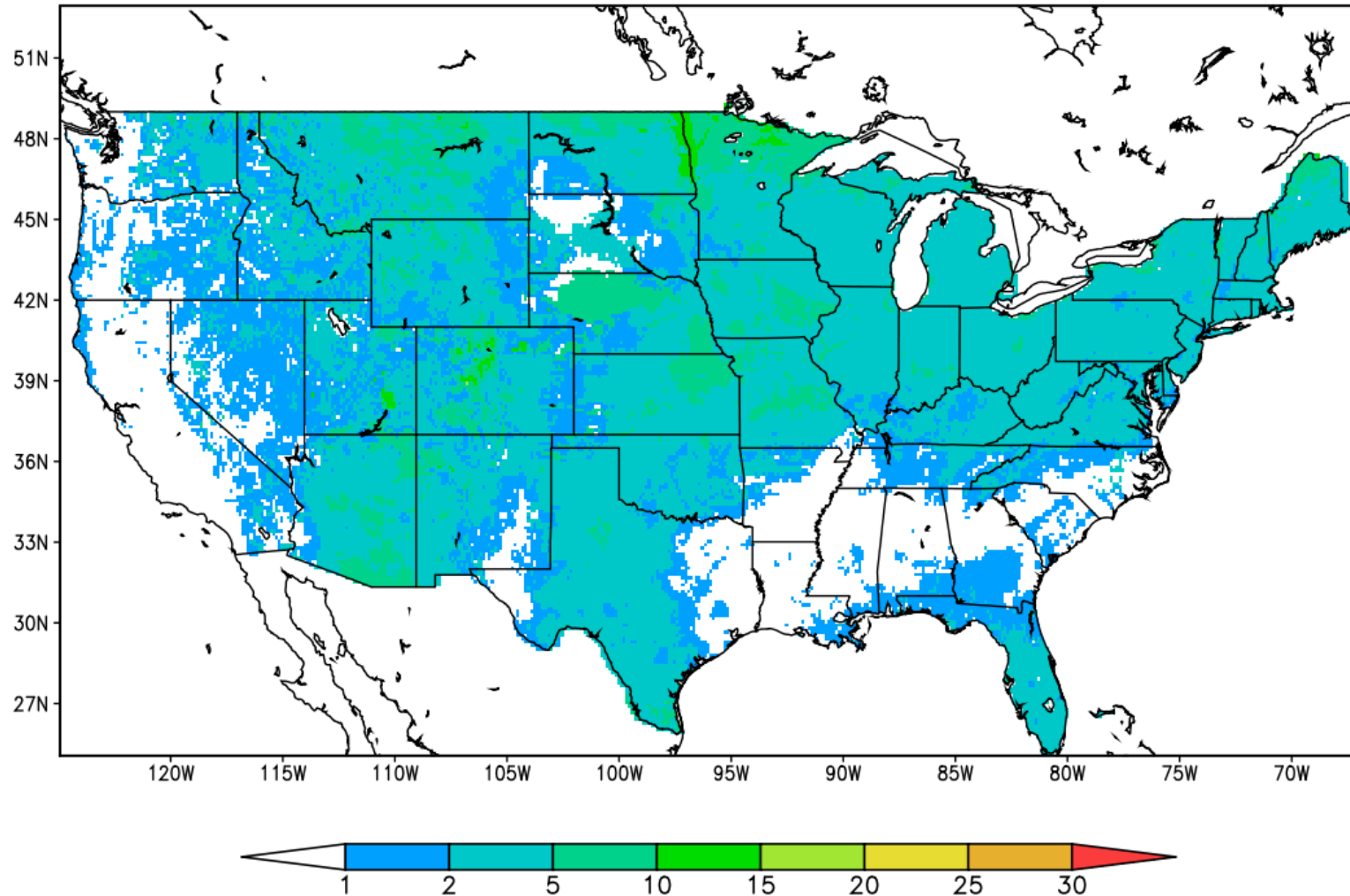
The intra-seasonal variability is non-negligible in soil-moisture => higher harmonics (3-6) have variability that cannot be ignored

Explained variance by annual cycle

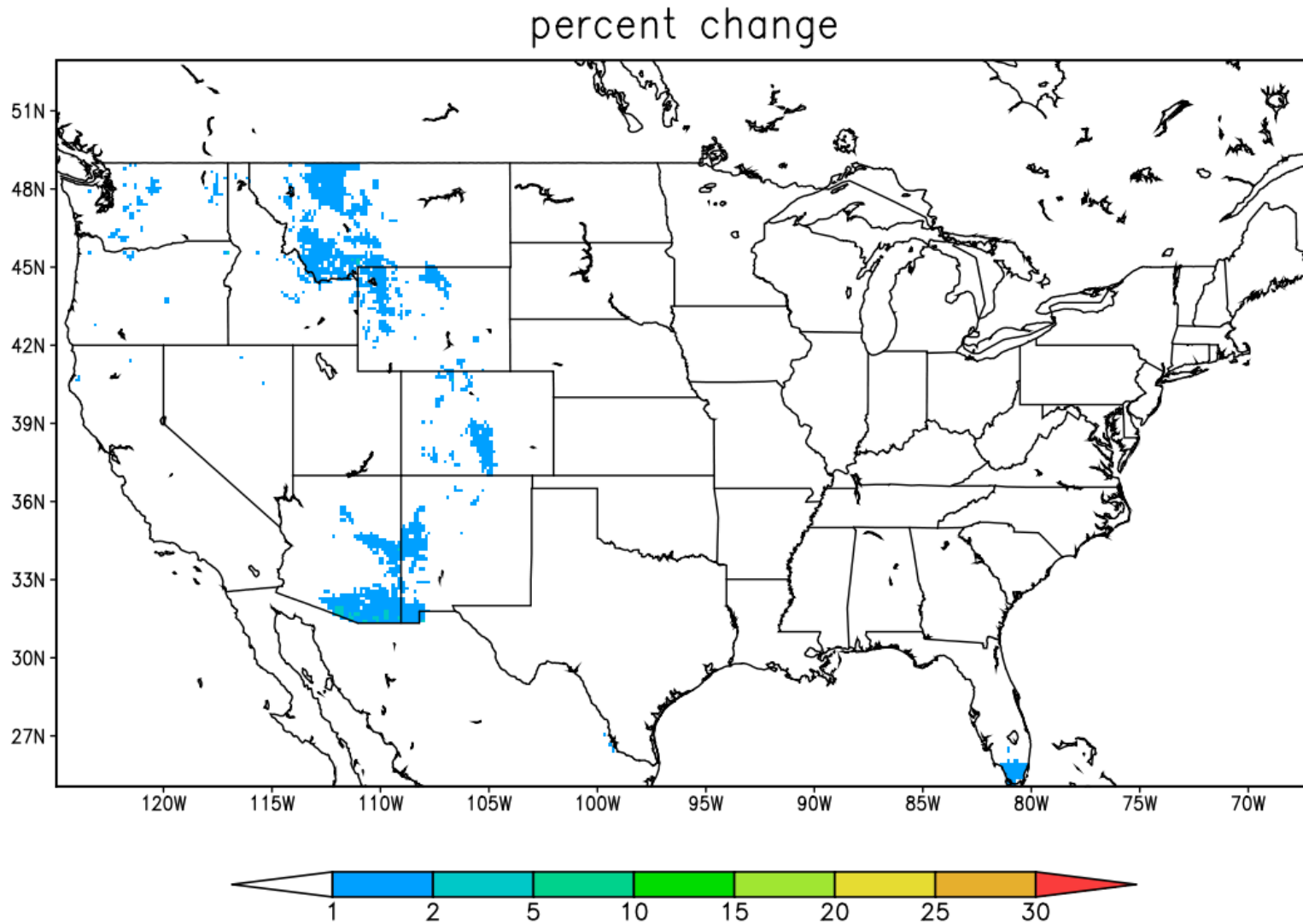
$$EV = 1 - \frac{(\mathbf{y} - \mathbf{y}_c)^T (\mathbf{y} - \mathbf{y}_c)}{(\mathbf{y}^T \mathbf{y} - \bar{\mathbf{y}}^T \bar{\mathbf{y}} N)},$$

The intra-seasonal variability is non-negligible in soil-moisture => higher harmonics (3-6) have variability that cannot be ignored; **H=6 Vs. 2 : 13 Vs. 5 parameters**

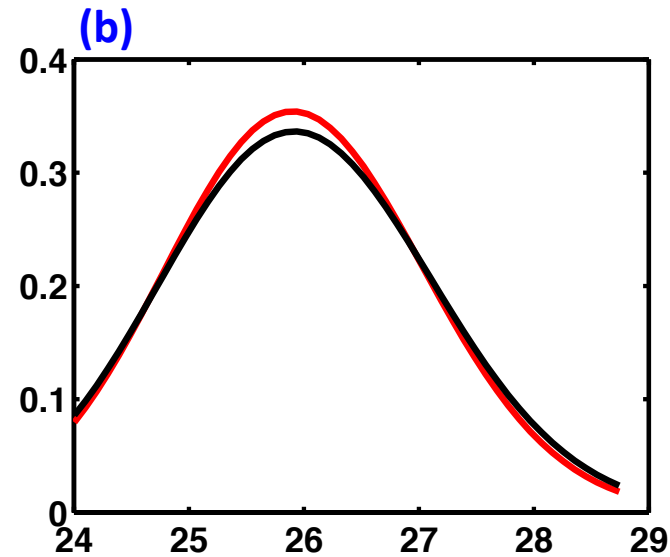
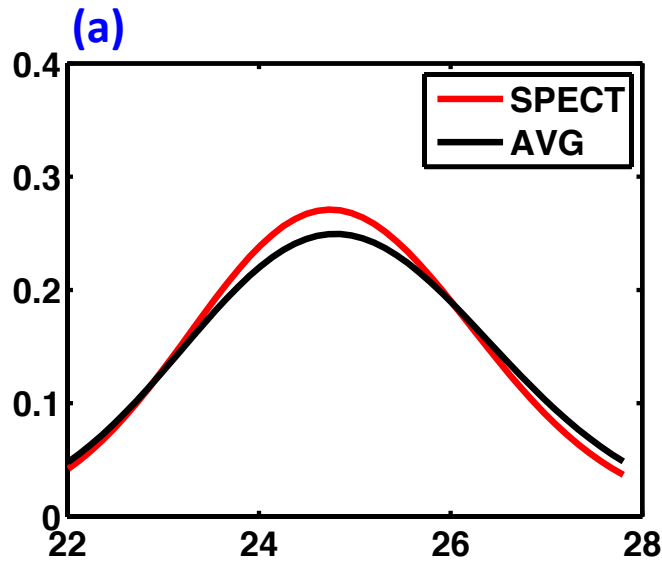
(EV (H=6)-EV(H=2))*100



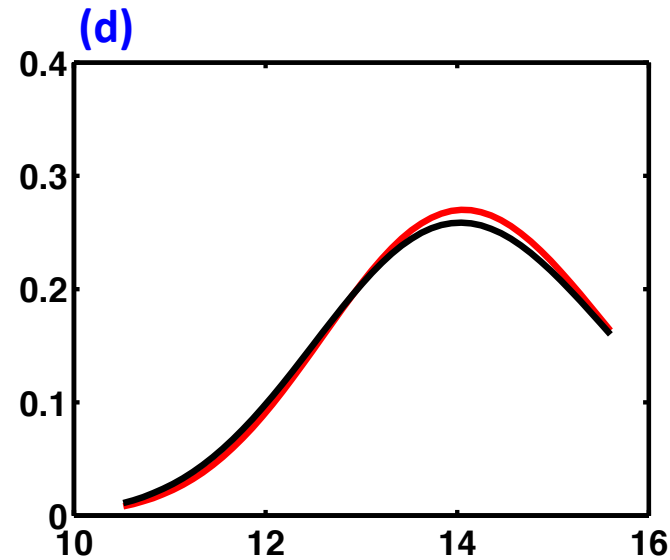
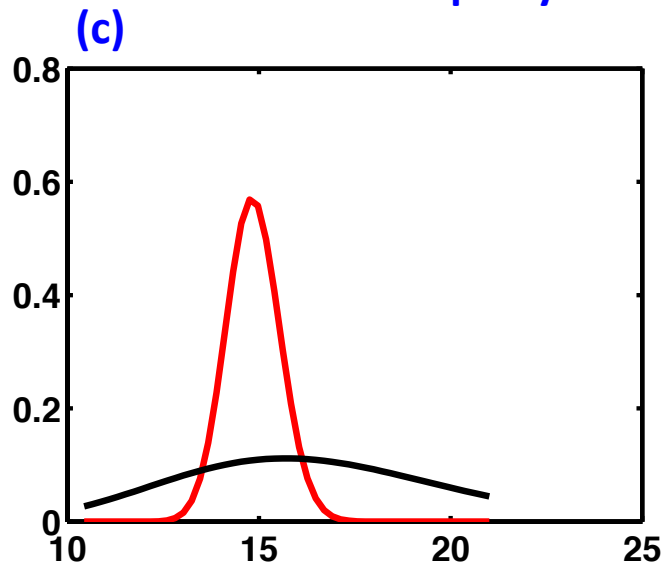
.... which is not the case for Precipitation:
First two harmonics (5 parameters) provide 98% of EV



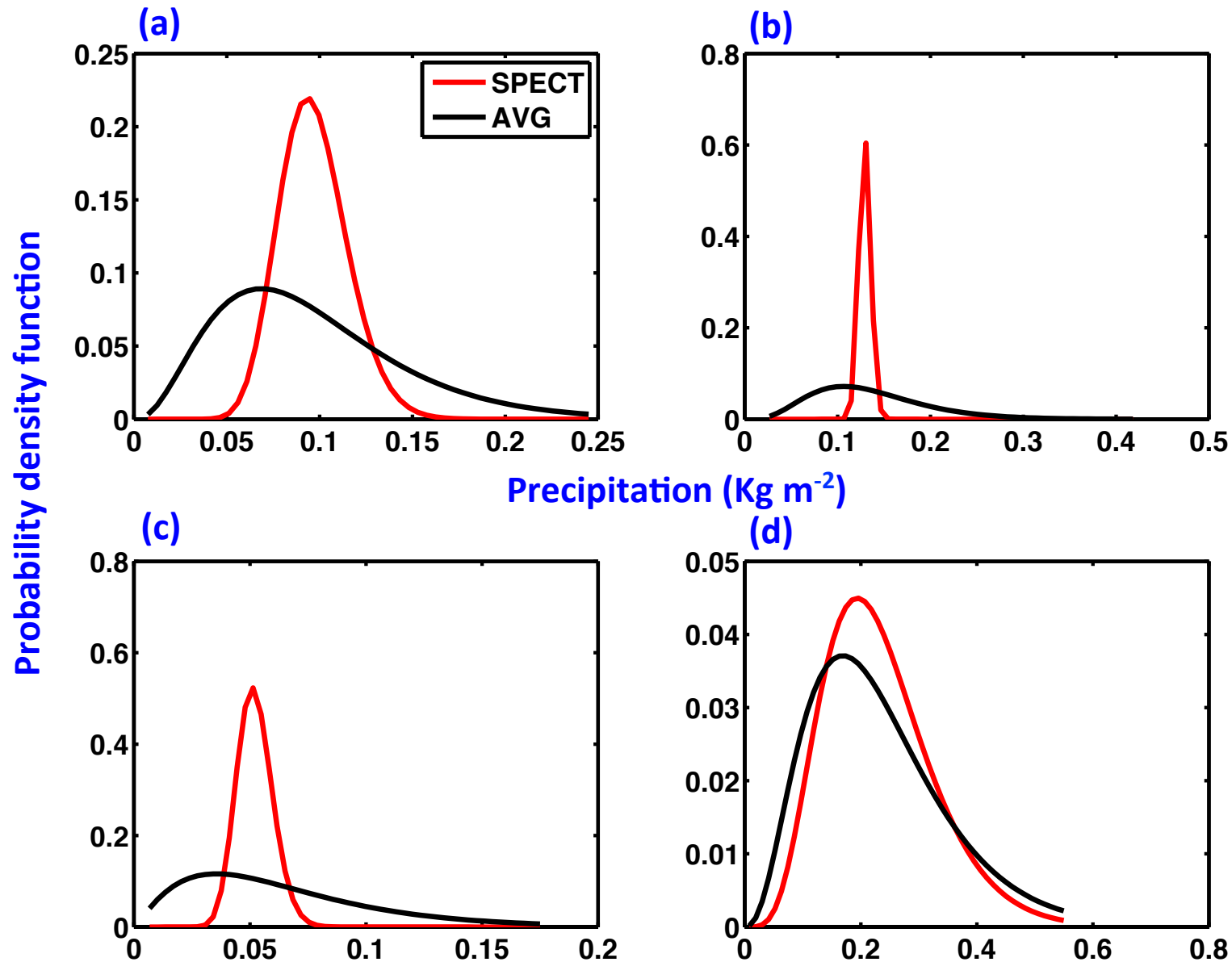
Gamma-fitted JJAS soil moisture show very few outliers in the averaged climatology



Top-Layer Soil Moisture (Kg m^{-2})



Simple Averaging show higher outliers in the pdf of Precipitation climatology



Summary

- ✓ Spectral Method estimated climatology has well defined ranges of distribution whereas the simple averaging has many outliers – this is specifically shown in precipitation where the largest variance is explained by first two harmonics in the spectral method

Future Work

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