Detection of Drought at High Spatial Resolution Using Bias-Adjusted Stage IV Precipitation

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The Problem of Drought Detection

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- How can you detect what you can’t define?

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- In situ hydrologic observations
  - Streamflow
    - Isolating drought effects
  - Soil moisture
    - Representativeness

The Problem of Drought Detection

- How can you detect what you can't define?
- In situ hydrologic observations
- Remote sensing
  - Soil moisture
  - Vegetation health
  - Gravity anomalies

The Problem of Drought Detection

- How can you detect what you can't define?
- In situ hydrologic observations
- Remote sensing
- Calculation from meteorological observables
  - Land surface model
  - Drought index

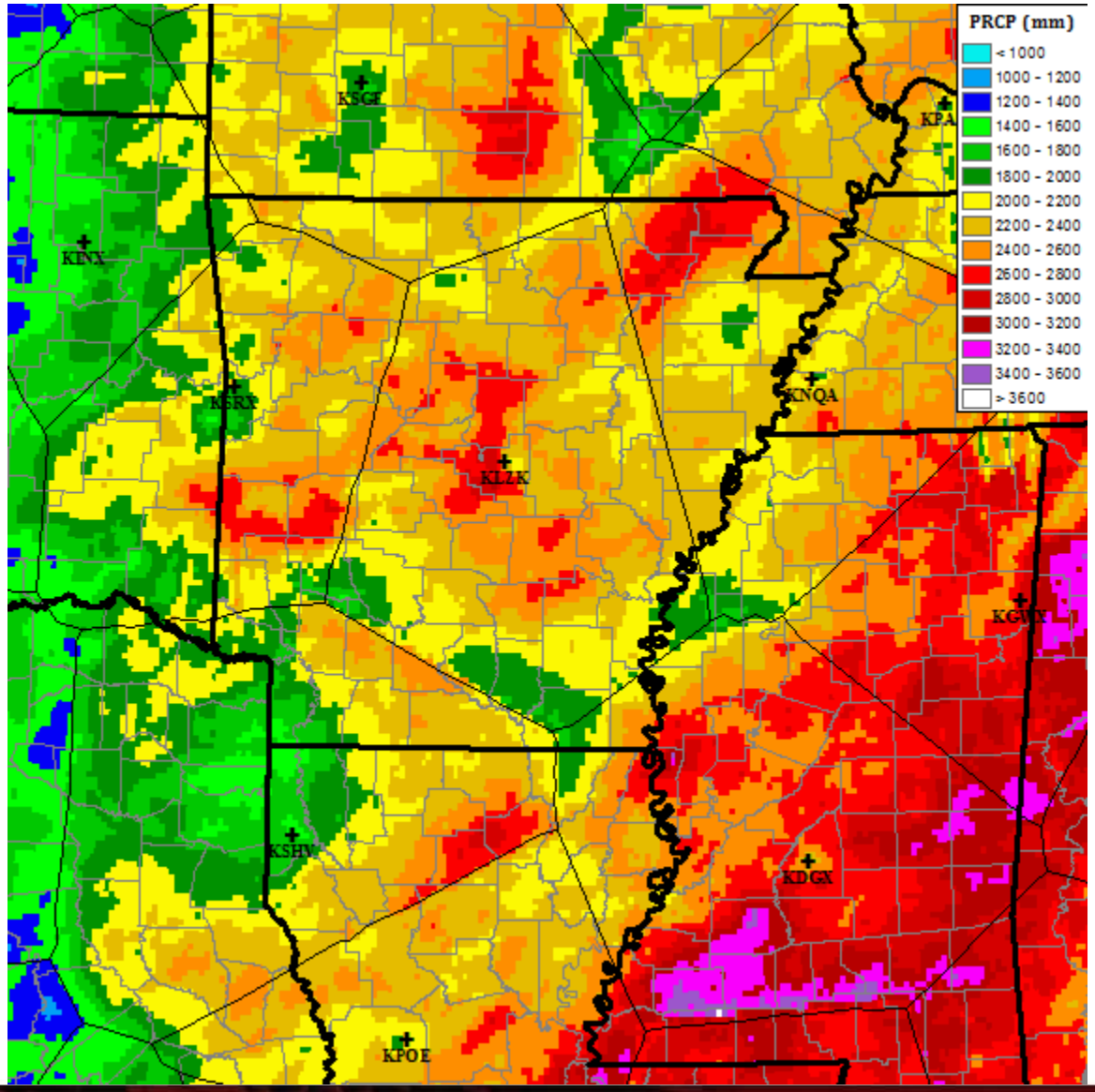
This talk:

- Part 1: Better observables as input to drought index or land surface model
- Part 2: A better drought index

Previous Work

- National composite precipitation analyses from NWS RFC inputs
- Historical precipitation frequency analysis using COOP stations
- High-resolution climatology from PRISM
- Citation: McRoberts, D. B., and J. W. Nielsen-Gammon, 2012: The use of a high-resolution SPI for drought monitoring and assessment. *J. Appl. Meteor. Clim.*, **51**, 68-83, doi:10.1175/JAMC-D-10-05015.1
- Web sites:
  - http://atmo.tamu.edu/osc/drought
  - http://www.nc-climate.ncsu.edu/drought

Stage IV Precipitation



Philosophy

- Radar errors often have known causes and known structures
- Eliminate as many of these as possible
- Apply 2-D gauge adjustment to remaining field

Beam blockage

- Interception of radar beam by non-meteorological targets:
  1. Tall buildings
  2. Trees
  3. Terrain

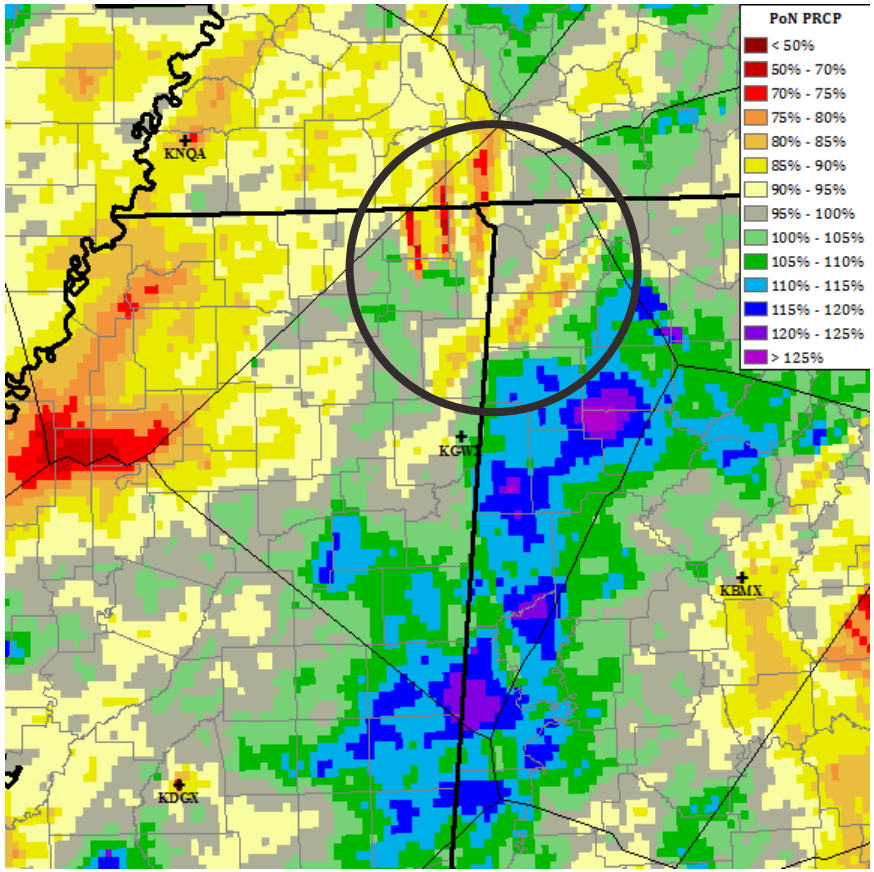
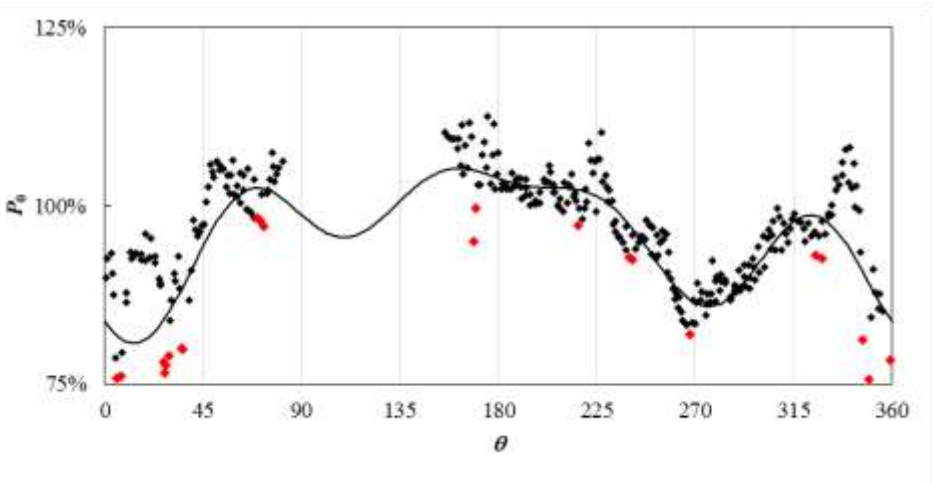


Image: UCAR COMET program

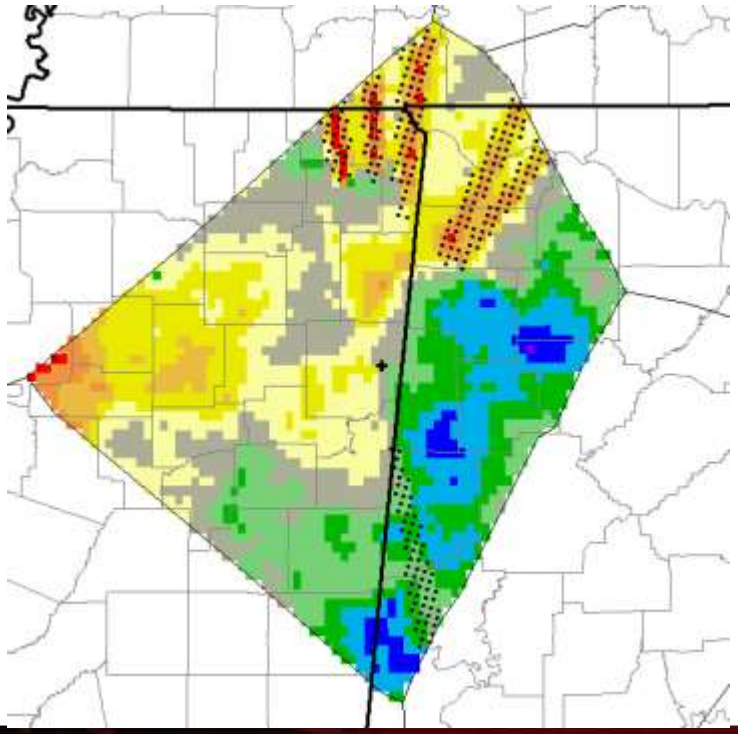
Beam Blockage Procedure

- Find relatively low values at fixed ranges



Beam Blockage Procedure

- Find relatively low values at fixed ranges
- Identify continuous sectors of flagged values

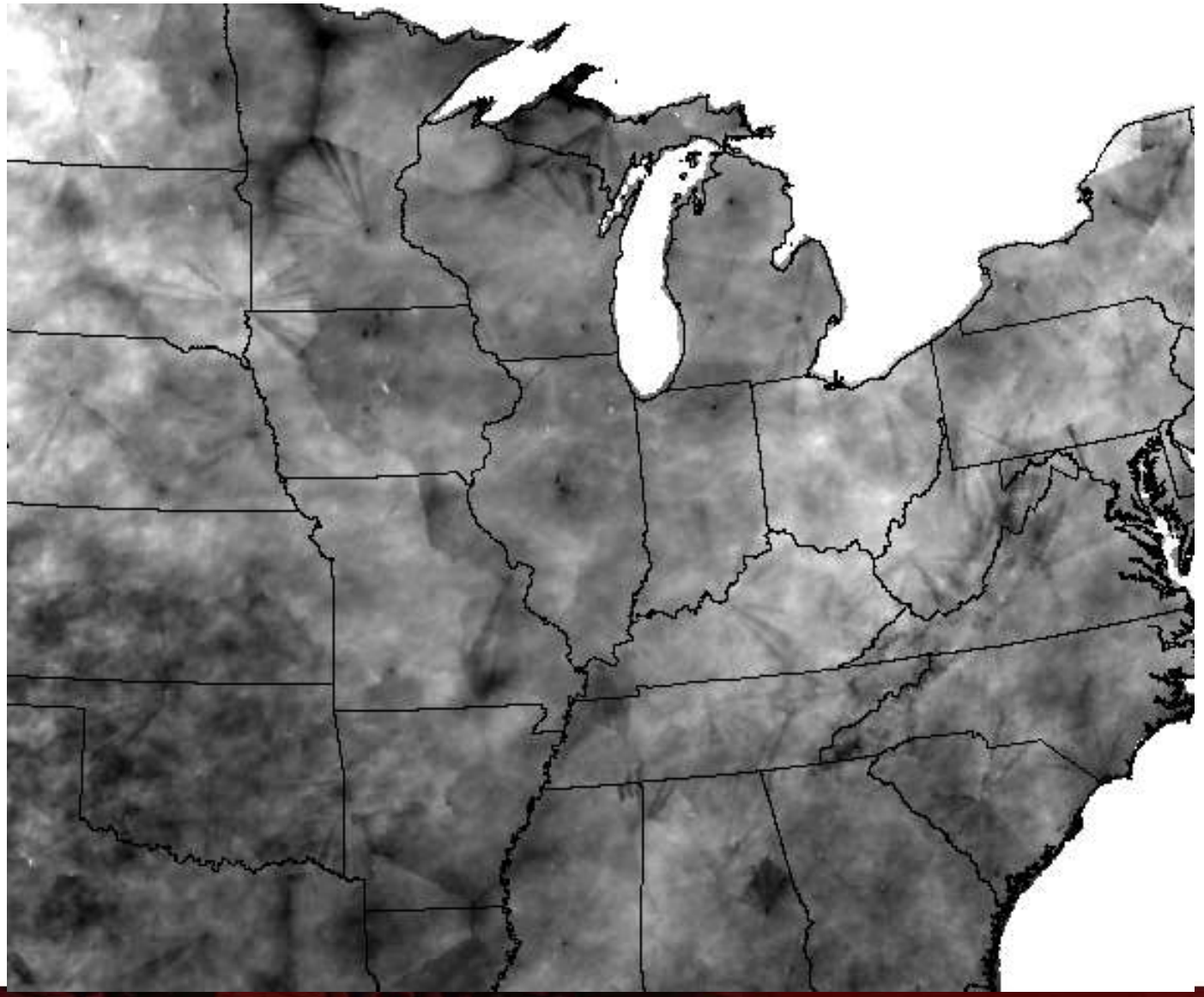


Beam Blockage Procedure

- Find relatively low values at fixed ranges
- Identify continuous sectors of flagged values
- Interpolate using neighboring values

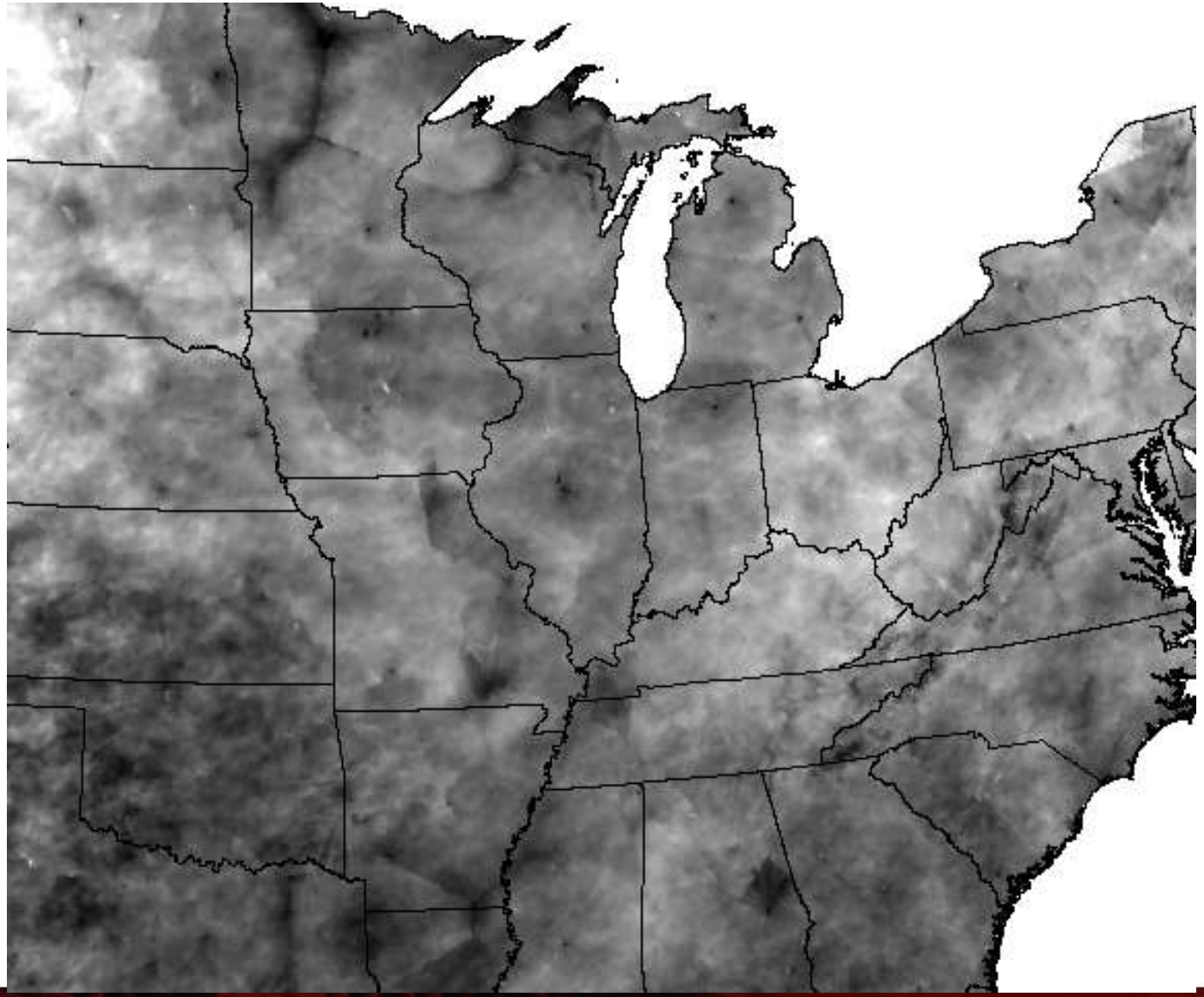
Beam Blockage Detection and Correction

Stage IV 36-month PoN precipitation ending 31 December 2012

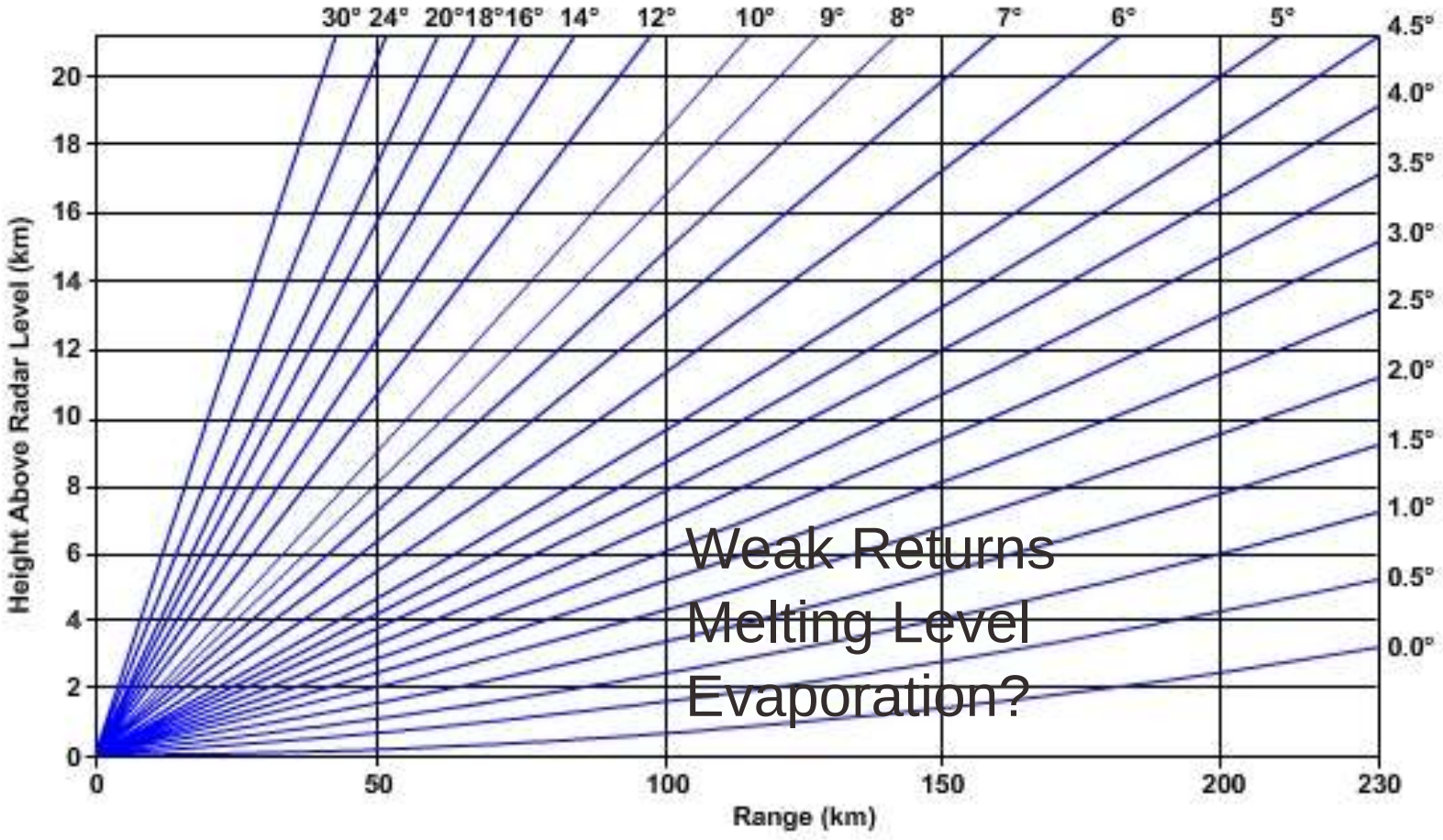


Beam Blockage Detection and Correction

Stage IV 36-month PoN precipitation ending 31 December 2012



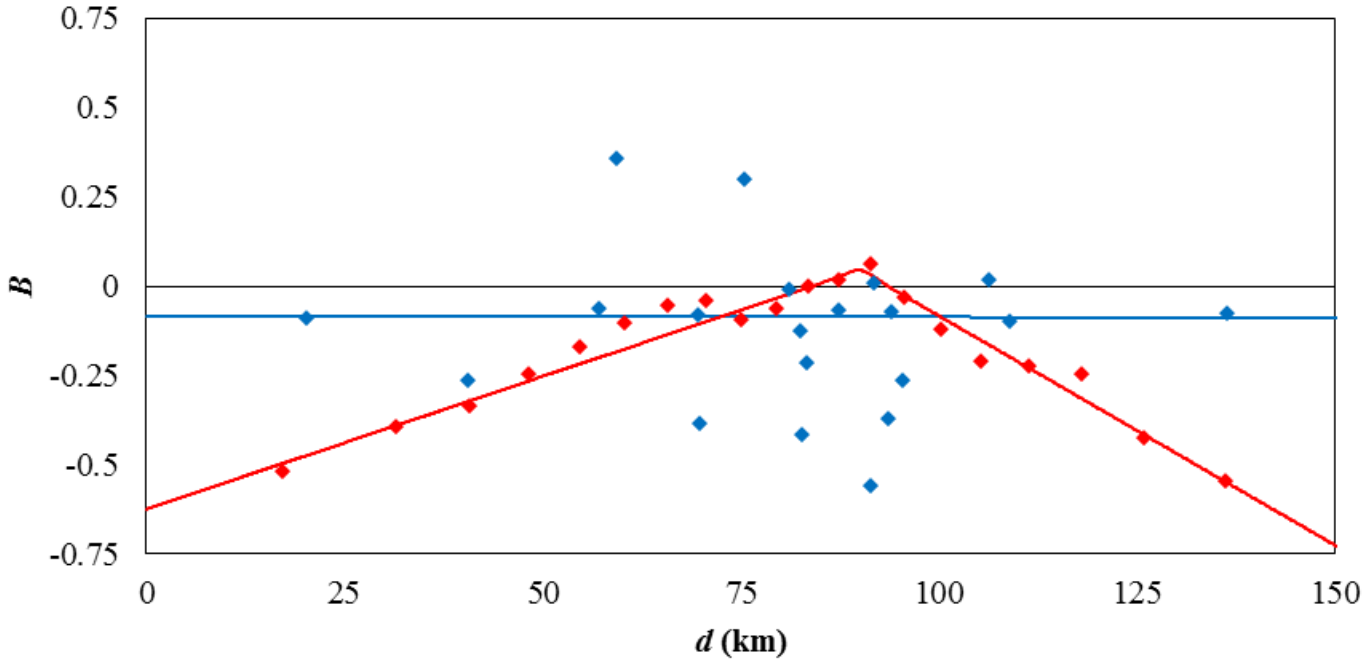
Range-Dependent Errors



Modeling Mean-Field and Range-Dependent Biases

- Starting point: Krajewski et al. (2011) 5-parameter statistical model of climatological VPR of range

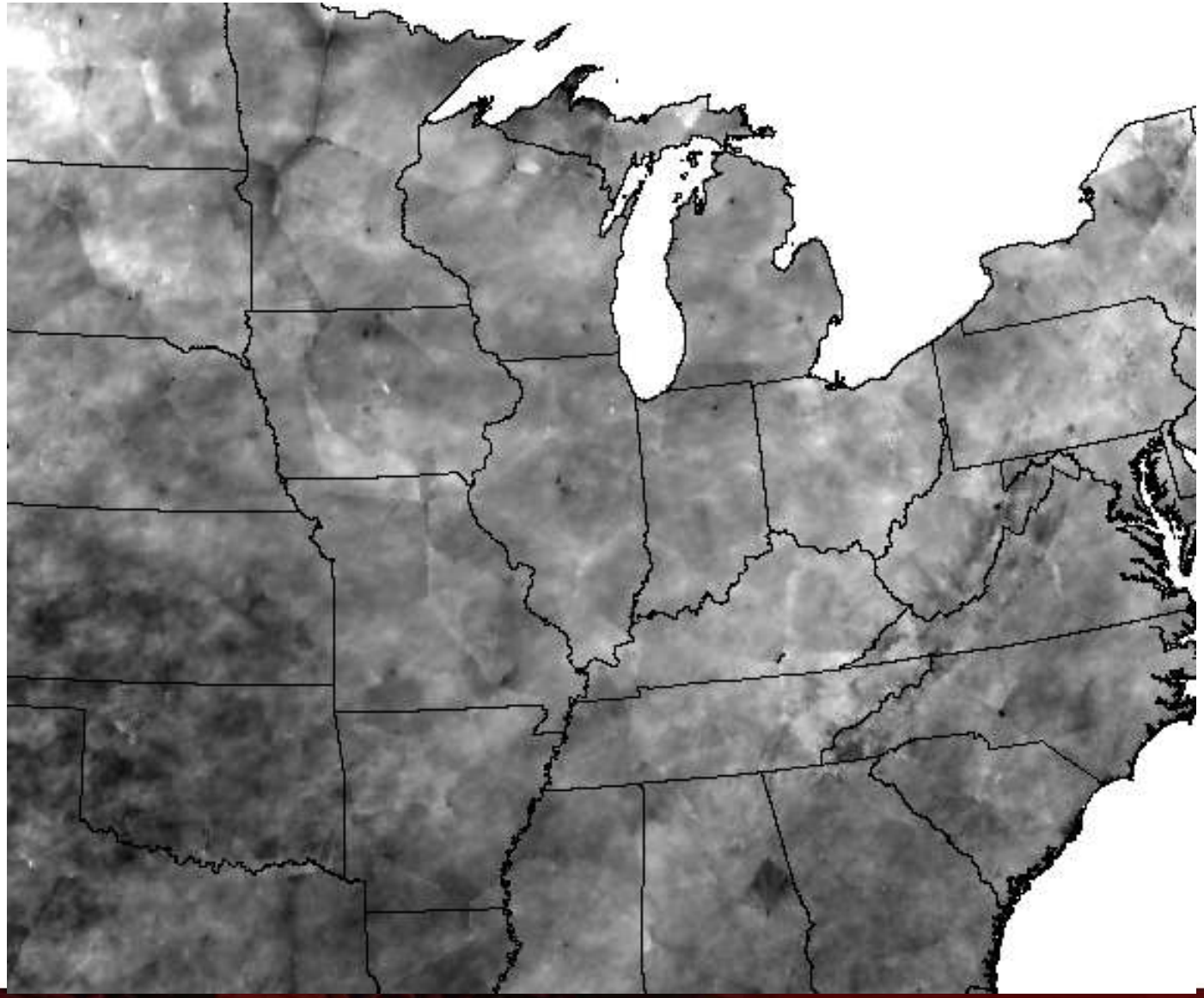
- **Our model: Conditional VPR (conVPR) model**
  - Single straight line model form: No VPR maximum
  - Merged maximum model form: VPR maximum exists



Two sources of range-dependent bias information

- Radar-gauge intercomparison
- Azimuthally-averaged radar percent of normal
- Combine both estimates; weight based on goodness-of-fit

After Bias Correction



Last Steps in Part 1

- Use Kriging of radar-gauge differences to minimize unstructured biases
- Apply to:
  - Drought monitoring
  - Land surface modeling (joint NLDAS project with NOAA)

Part 2: Improving the SPI

- Standardized Precipitation Index:
  - Drought severity represented by normalized anomalies of accumulated precipitation

Part 2: Improving the SPI

- Standardized Precipitation Index
- Choose your period:
  - 1 month to 4 month SPI for agriculture
  - 6 month to 36 month SPI for water supply

Part 2: Improving the SPI

- Standardized Precipitation Index
- Choose your period
- Problems:
  - A range of periods requires several separate SPI maps/values
  - Timing of precipitation is irrelevant

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- Standardized Precipitation Index
- Choose your period
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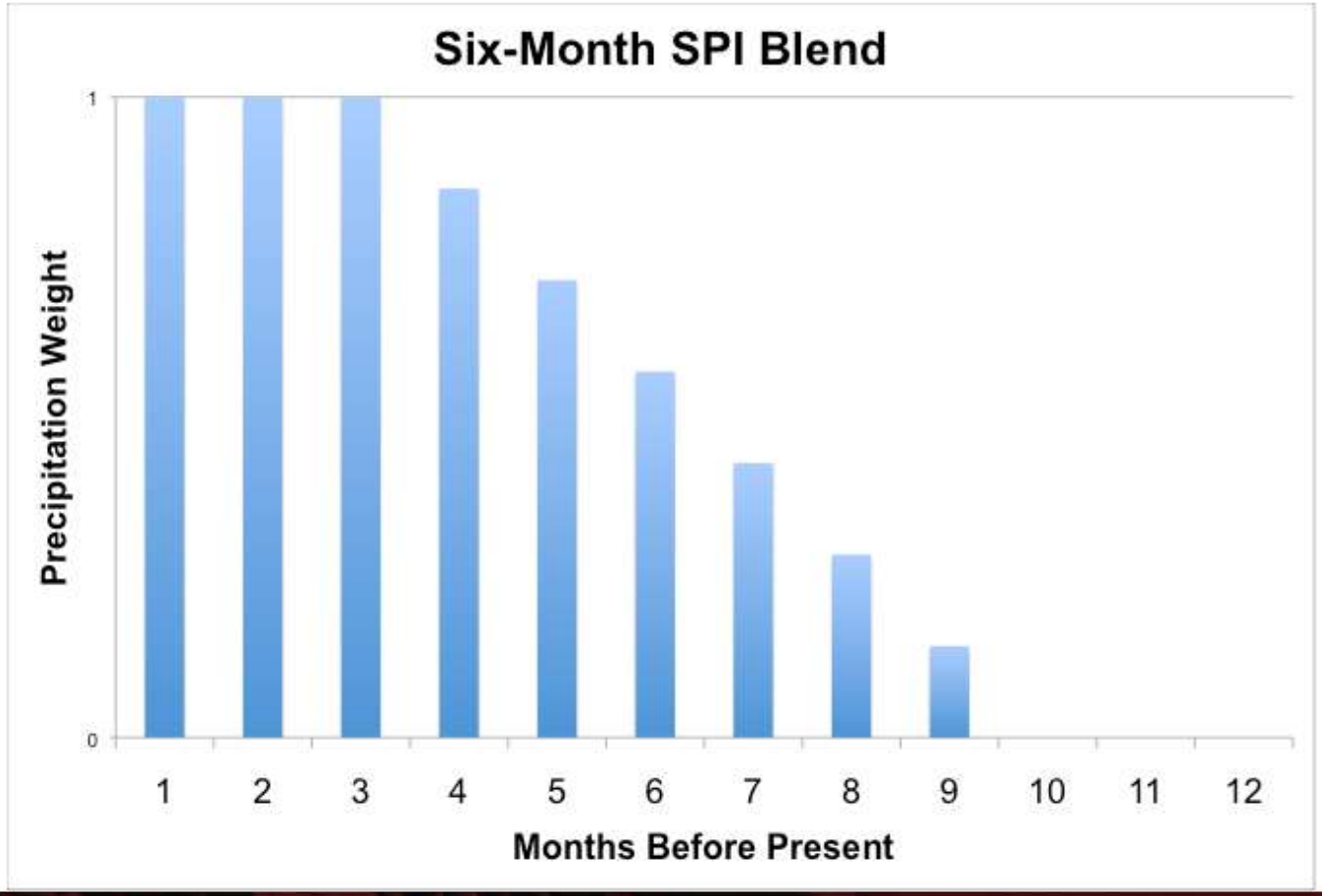
  - Timing of precipitation is irrelevant
- Solution: Compute a single SPI value from a range of accumulation periods

The *Rashomon* of Drought Indices

- It's a blend!
- Example: 6-month SPI blend
  - Average of 3-m SPI, 4-m SPI, 5-m SPI, 6-m SPI, 7-m SPI, 8-m SPI, 9-m SPI
  - But…averaging would eliminate normalization
  - Solution
    - For period of record, calculate 3-m accumulated precip, 4-m accumulated precip, etc.
    - Sum the results
    - Compute normalization from historical values of sum

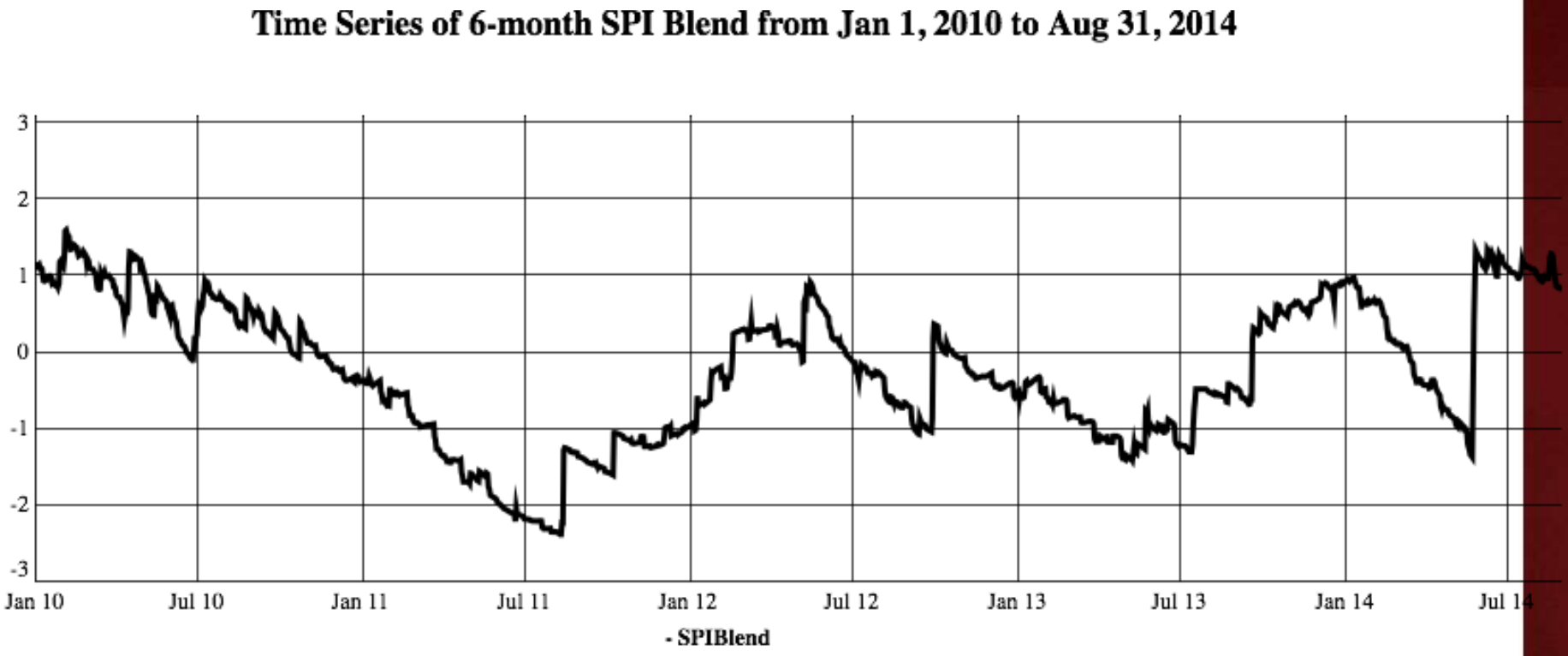
The *Rashomon* of Drought Indices

- It's a weighted average!

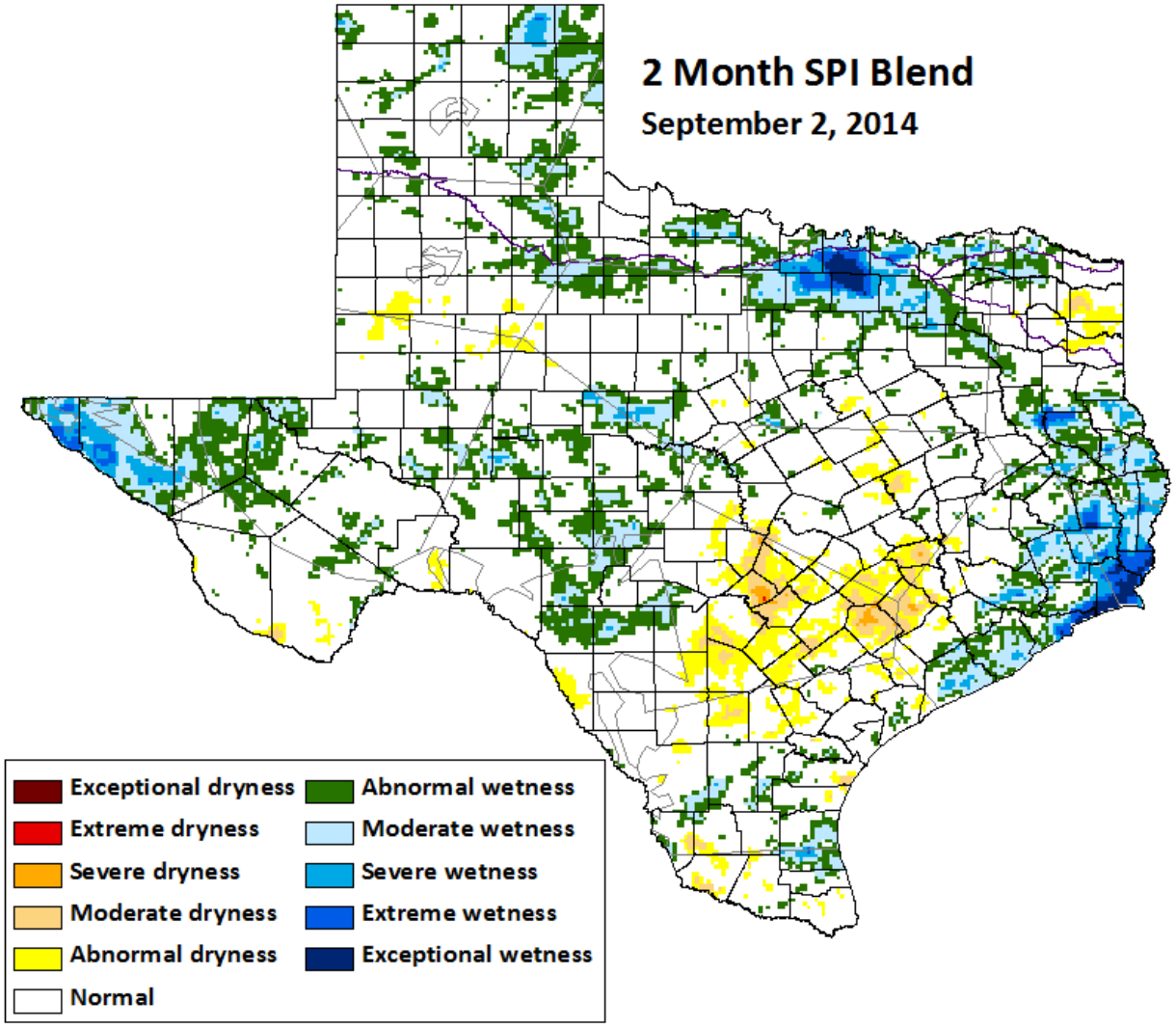


The *Rashomon* of Drought Indices

- It approximates evolution of soil moisture



Sample Final Product



Summary

- Developed bias correction technique for radar-estimated precipitation based on spatial structure of common radar biases
- Developed improved drought index based on blending (or weighted precipitation)
- n-g@tamu.edu
- http://climatexas.tamu.edu