TRACKING DROUGHT IN TEXAS: KICKING IT DOWN A NOTCH

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6th US Drought Monitor Forum
Austin, Texas
October 7-8, 2009

MOTIVATION

- US Drought Monitor not designed for county-scale representations
- USDM output used by customers for critical decision-making at county scale
  - Example: USDA and drought relief
- Texas in frequent drought, citizens impacted by these decisions
- Need drought indicators at county and sub-county scale

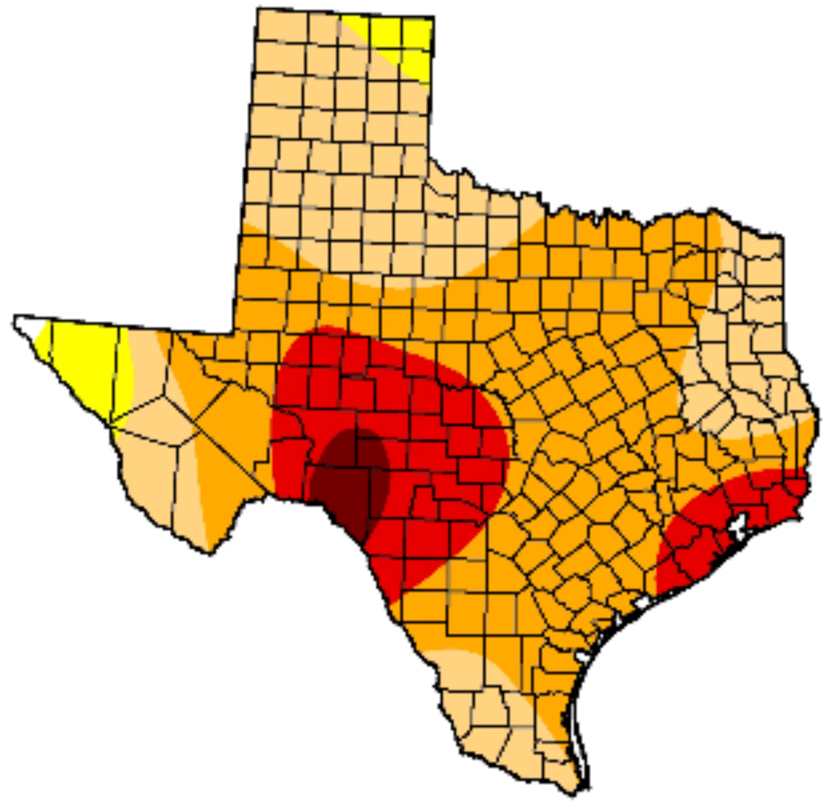
U.S. Drought Monitor

Texas

September 5, 2000
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.2	99.8	96.0	64.3	18.3	2.3
Last Week (08/29/2000 map)	0.2	99.8	70.5	37.2	8.9	0.0
3 Months Ago (06/13/2000 map)	52.0	48.0	34.3	23.6	18.7	0.0
Start of Calendar Year (01/04/2000 map)	2.6	97.4	73.7	51.6	0.0	0.0
Start of Water Year (10/05/1999 map)	--	--	--	--	--	--
One Year Ago (09/07/1999 map)	--	--	--	--	--	--



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements

http://drought.unl.edu/dm

USDA National Drought Mitigation Center

Released Thursday, September 7, 2000

Author: National Drought Mitigation Center

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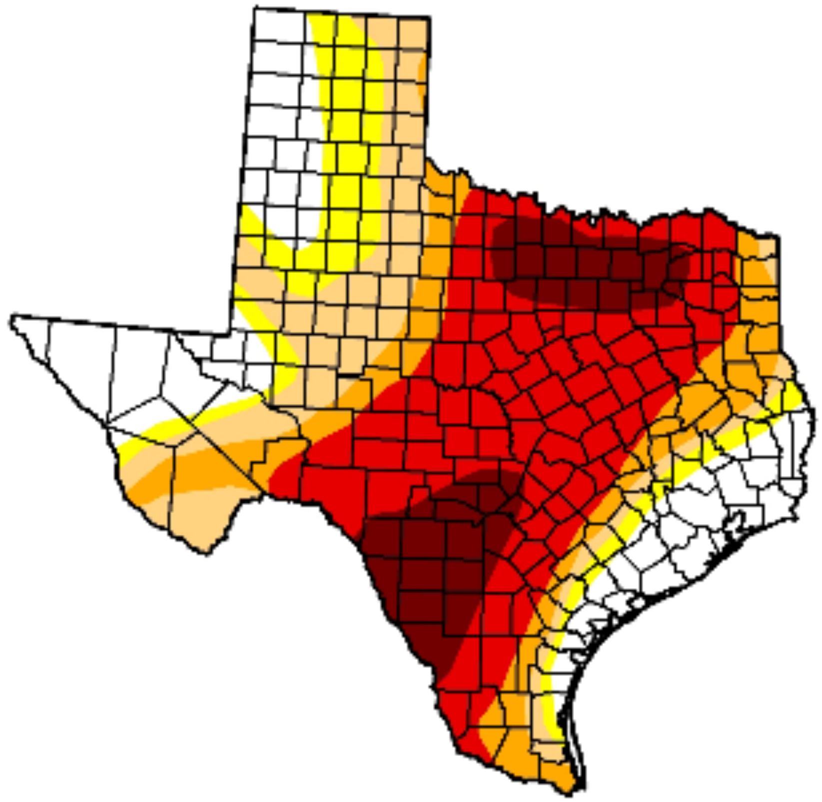

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Released Thursday, September 7, 2006

Author: Brian Fuchs, National Drought Mitigation Center

ESTABLISHED TOOLS

- Climate division scale
  - NCDC standard products
  - CPC soil moisture
  - WRCC SPI
  - Rich Tinker’s Blends
- Gauge scale
  - USGS streamflow
  - ACIS SPI (dot-plots and interpolated)
  - Soil moisture (hi-res, but based on ACIS-like interpolations)
- Satellite tools
  - NDVI (impact indicator)
  - Veg-DRI (hi-res impact, gauge-scale indexing)

THE RAW MATERIALS ARE AVAILABLE TO DO BETTER, BUT…

- Gauges often unrepresentative of county-scale precipitation
  - Example: Grimes County 2006
- Corollary: hi-res soil moisture maps often unrepresentative of county-scale conditions
- High-resolution precipitation analyses exist (Advanced Hydrologic Prediction Service)
  - Not designed for drought monitoring
  - Not in the form of a drought index
    - *Radar rainfall used to generate Texas KBDI
  - No historical reference

OUTLINE OF TALK

- Motivation (done)
- Creating SPI from AHPS
- Verification: strengths and weaknesses
- Beyond SPI: other useful drought products
- Future plans

CREATING SPI FROM AHPS

- Need
  - Analysis of climatological precipitation PDF on 4 km grid
  - Variety of accumulation periods
  - All possible starting dates
- Tools
  - Historical COOP precipitation data from NCDC
  - PRISM analyses from Oregon State University
  - Regional Frequency Analysis (Hosking and Wallis)
    - Used by NOAA for precipitation analysis (100-yr floods, etc.)

STEP 1: CLUSTER ANALYSIS

- Define clustering criteria
  - Location
    - Latitude
    - Longitude
    - Elevation
  - Overall precipitation
    - 1971-2000 annual normal
  - Seasonality
    - (Sine of) starting month of maximum 2-month
    - (Sine of) starting month of minimum 2-month
  - All but last two criteria normalized to range of {0,1}

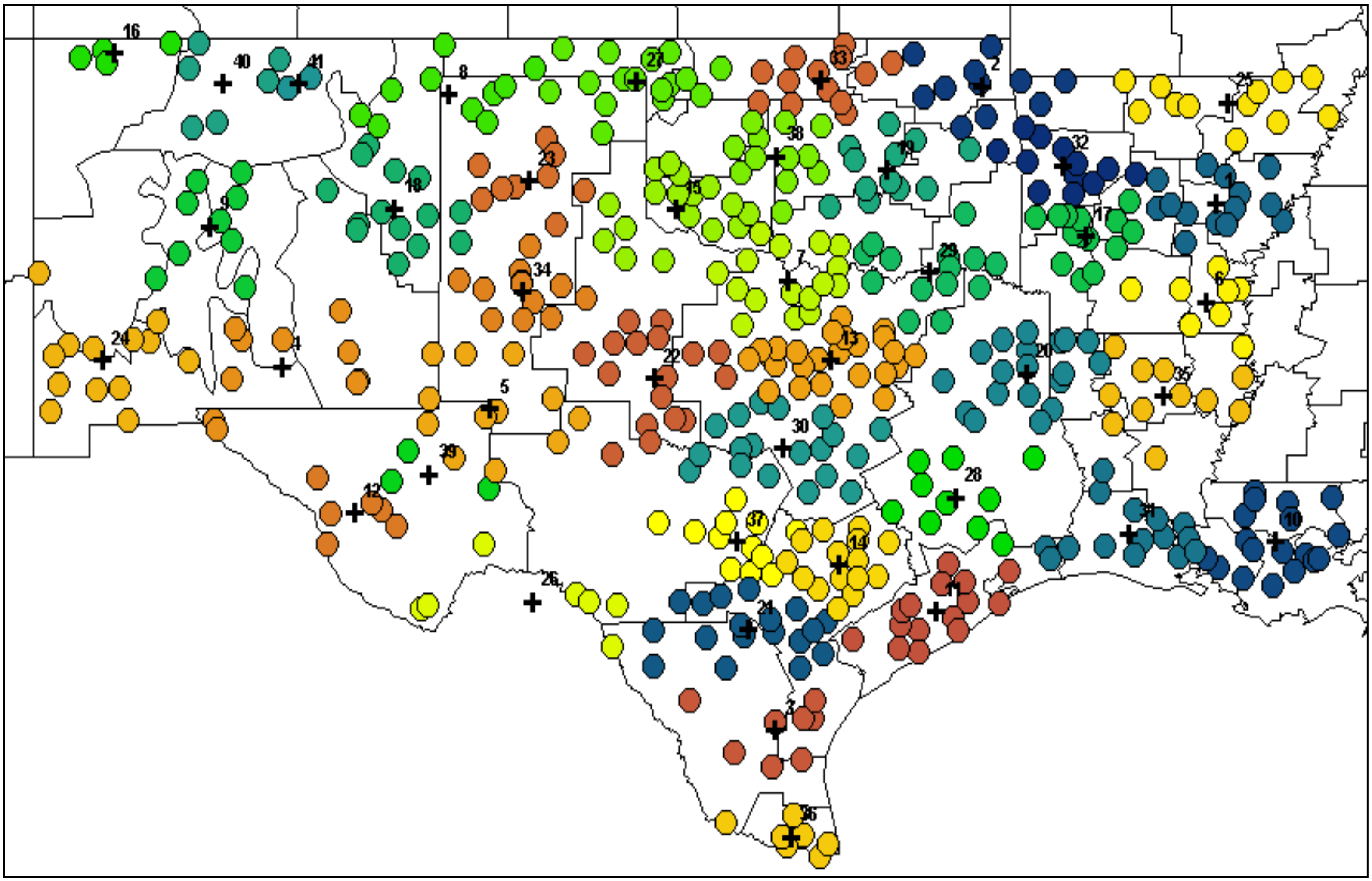
STEP 1: CLUSTER ANALYSIS (CONTINUED)

- Define data set
  - 1511 COOP stations in Texas and surrounding states
    - Screened for length of record
    - 497 sufficiently complete (40 years or more)
- Identify clustering technique
  - Ward's Minimum Variance Method
    - Minimizes variance within clusters
    - Tends to produce clusters of similar size
    - Avoids isolated single-station clusters

STEP 1: CLUSTER ANALYSIS (CONTINUED)

- Determine appropriate number of clusters
  - Minimize number of discordant stations (D_i)
  - Obtain large number of similarly-sized clusters
  - Choice: 38
- Test and adjust clusters
  - Compare with results from 500 Monte Carlo simulations of homogeneous clusters with same number of stations and periods of record
  - Rearrange station clusters to remove discordant stations and require $H < 2$

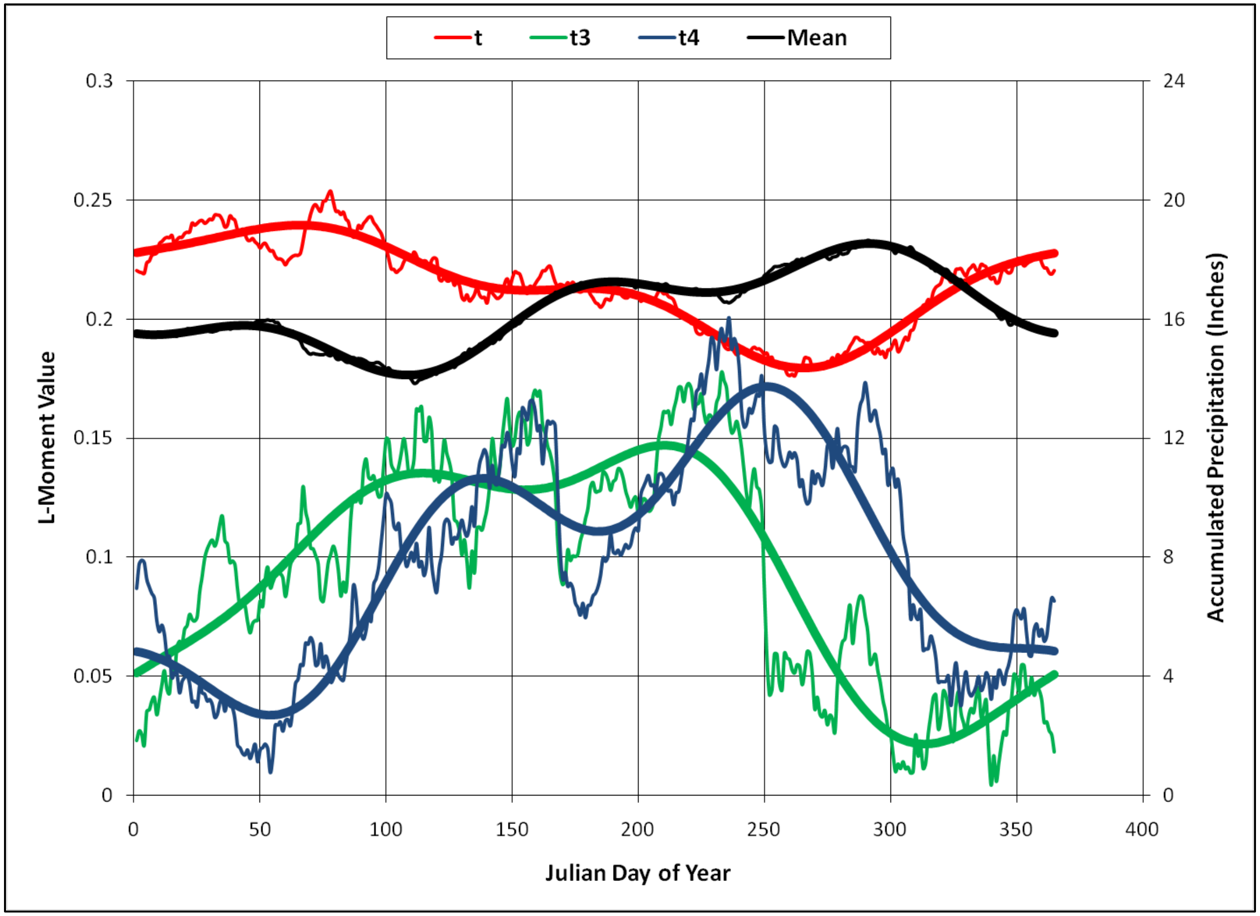
FINAL CLUSTERS WITH CENTROIDS



STEP 2: COMPUTE FREQUENCY DISTRIBUTIONS

- Calculate station L-moments
  - Arbitrary accumulation periods
  - Arbitrary ending dates
  - 1-24 month accumulations for subsequent testing
- Calculate L-moment ratios
- Smooth L-moment ratios using first three harmonics of annual cycle
- Create composite L-moment ratios for each cluster
  - Weight station L-moment ratios by length of record

SMOOTHING EXAMPLE: AUSTIN MABRY 180-DAY PRECIPITATION



STEP 2: COMPUTE FREQUENCY DISTRIBUTIONS (CONTINUED)

- Test candidate frequency distributions
  - Generalized Extreme-Value
  - Generalized Logistic
  - Generalized Normal
  - Generalized Pareto
  - Pearson Type III
- Compare L-kurtosis to Monte Carlo output
- Measure goodness-of-fit
- Pearson Type III provides best fit across range of climates and accumulation periods

Step 2: Compute Frequency Distributions (continued)

- Test Pearson Type III for accurately identifying extreme values
  - Compare 1.5th percentile accumulation at each station/period/ending date to that predicted from Pearson Type III distribution
- Test result: Pearson Type III slightly underestimates extreme drought severity
  - 45.5% of the sample 1.5th percentile precipitation accumulations are greater than the 2nd percentile of the PDF

STEP 3: PRODUCE HIGH-RESOLUTION GRIDDED FREQUENCY DISTRIBUTIONS

- Problem: cluster-scale analysis insufficient for precipitation climatology
  - Large gradients in West Texas topography
  - Coastal influences, Balcones escarpment
  - Higher-order moments are not so bad
- Use PRISM for precipitation climatology
  - 1971-2000 normals define "location" of PDF
    - Philosophical issue
  - Daily PRISM values inappropriate for computing higher-order moments
- Use cluster analysis for higher-order moments
  - Interpolate to grid from 4 nearest stations using inverse distance weighting

STEP 4: PRODUCTION

- Download daily AHPS precipitation analysis
- Compute accumulations
- Compute SPI and related products
- Generate 4 km and county-aggregated versions
- Post on Web
- Web site:
  - http://atmo.tamu.edu/osc/drought

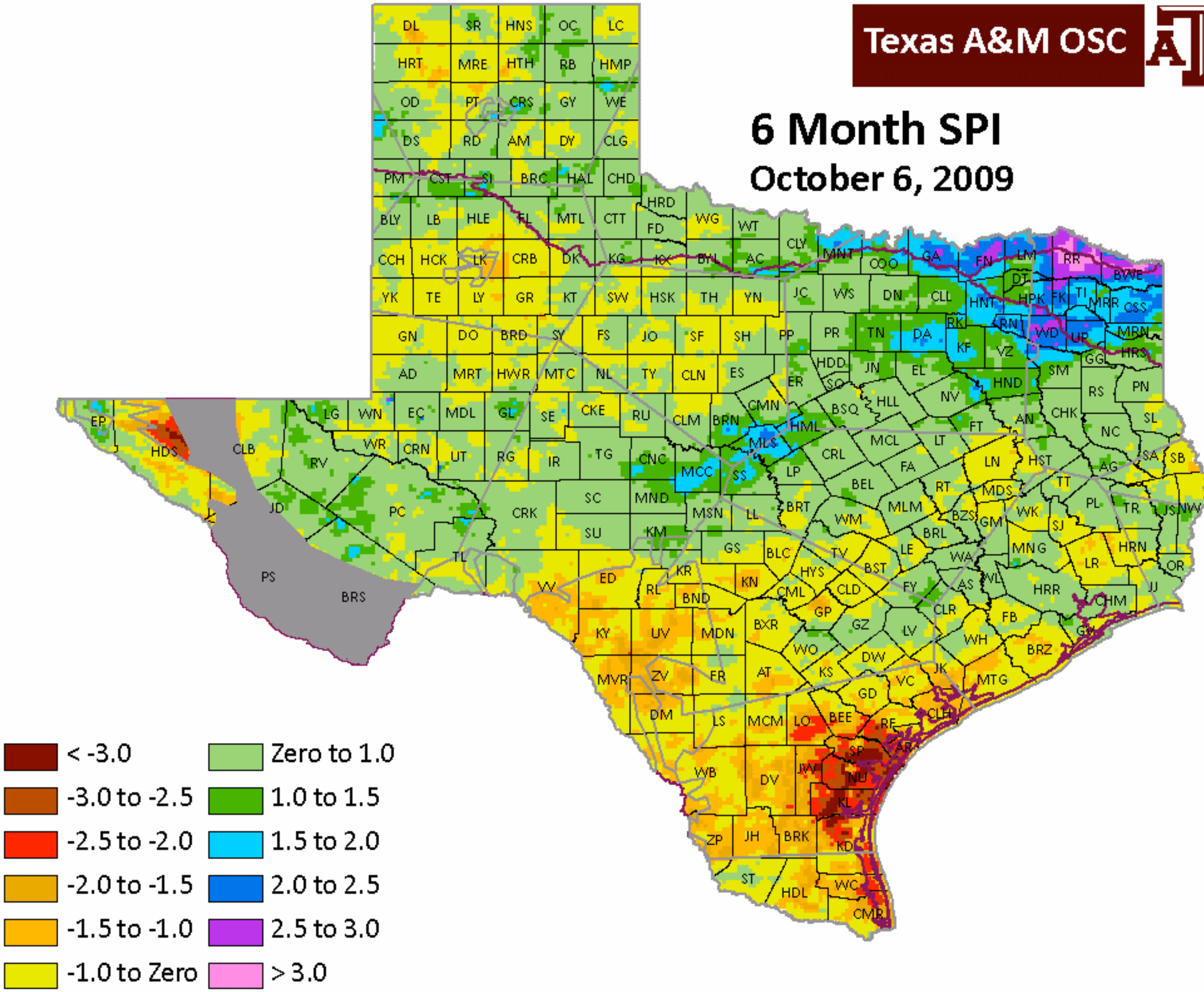
STEP 5: VALIDATION

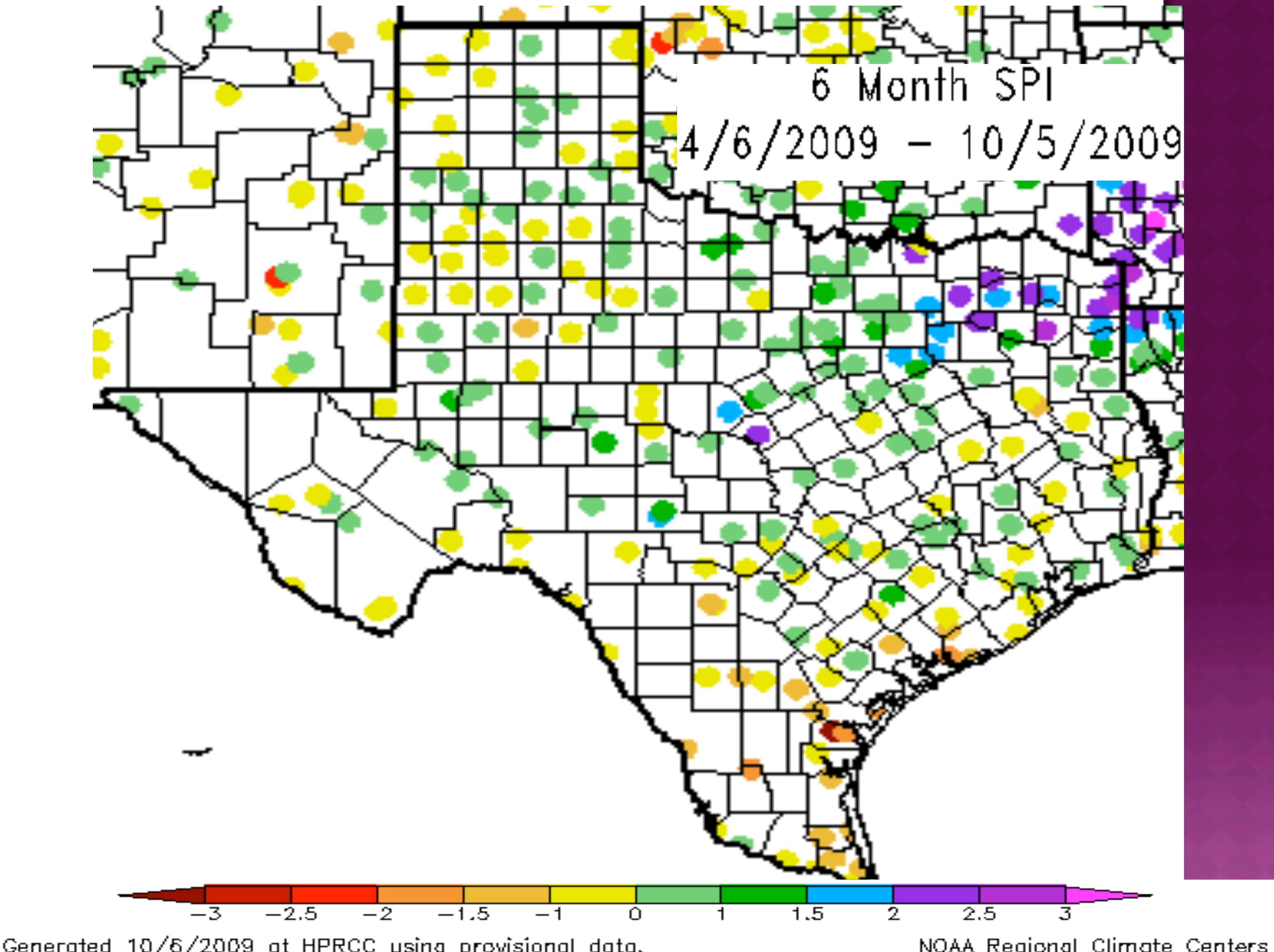
- So far, case by case
- SPI color table and thresholds match ACIS SPI color table
- SPI blend product (see later) color table and thresholds match DM color table

Texas A&M OSC

6 Month SPI

October 6, 2009




6 Month SPI
4/6/2009 - 10/5/2009
-3 -2.5 -2 -1.5 -1 0 1 1.5 2 2.5 3
Generated 10/6/2009 at HPRCC using provisional data.
NOAA Regional Climate Centers

SPI COMPARISON TALKING POINTS

- Winter Garden area
- San Antonio area
- Panhandle area
- Trinity River area

CURRENT SPI PRODUCT SUITE

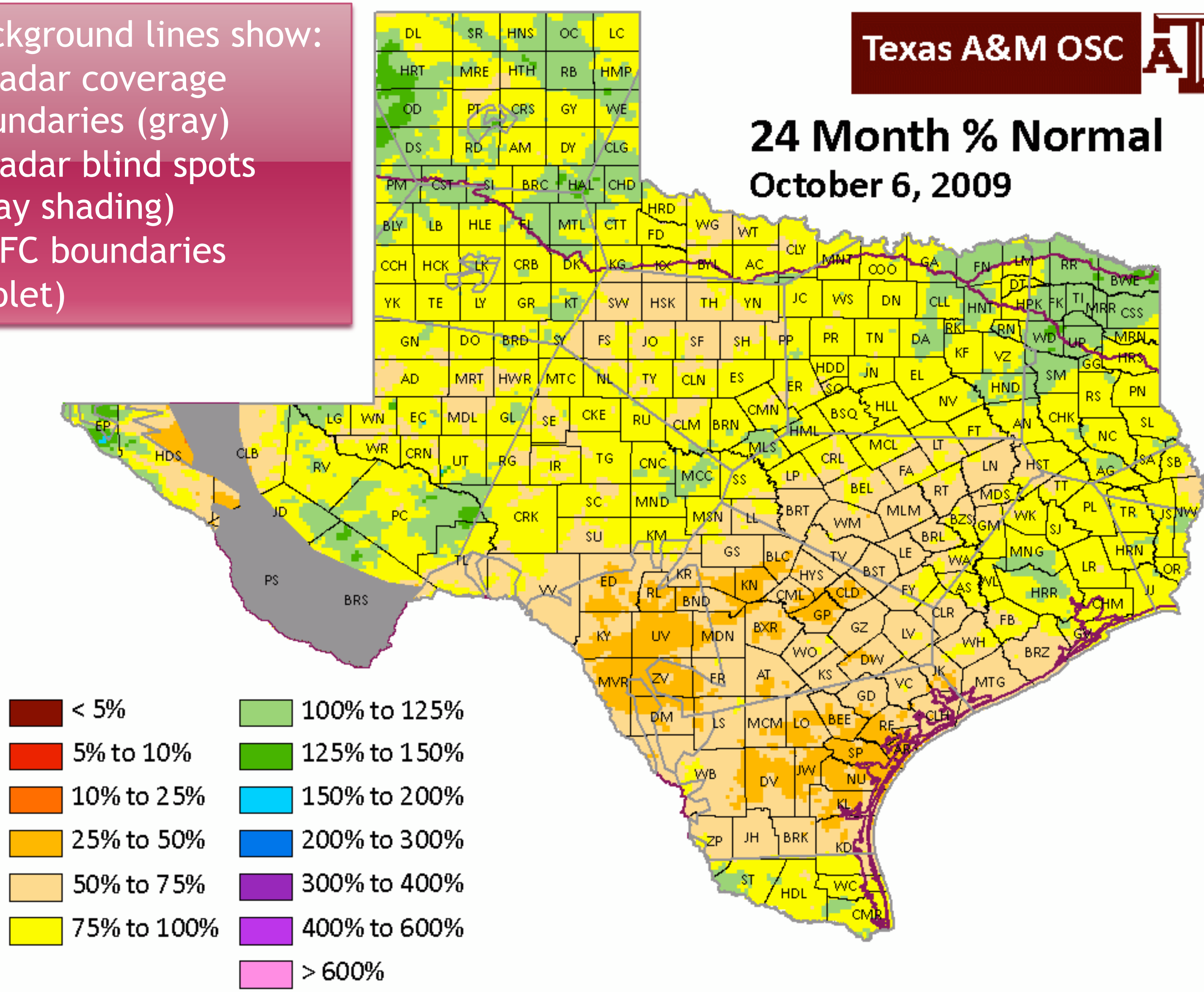
- 2 months
- 6 months
- 12 months
- 18 months
- 24 months
- Accumulated precipitation also available
  - Differences with ACIS SPI attributable to analyzed vs. measured precipitation (neither automatically better) and/or different approaches for computing PDFs

Background lines show:
- Radar coverage boundaries (gray)
- Radar blind spots (gray shading)
- RFC boundaries (violet)

Texas A&M OSC

24 Month % Normal

October 6, 2009

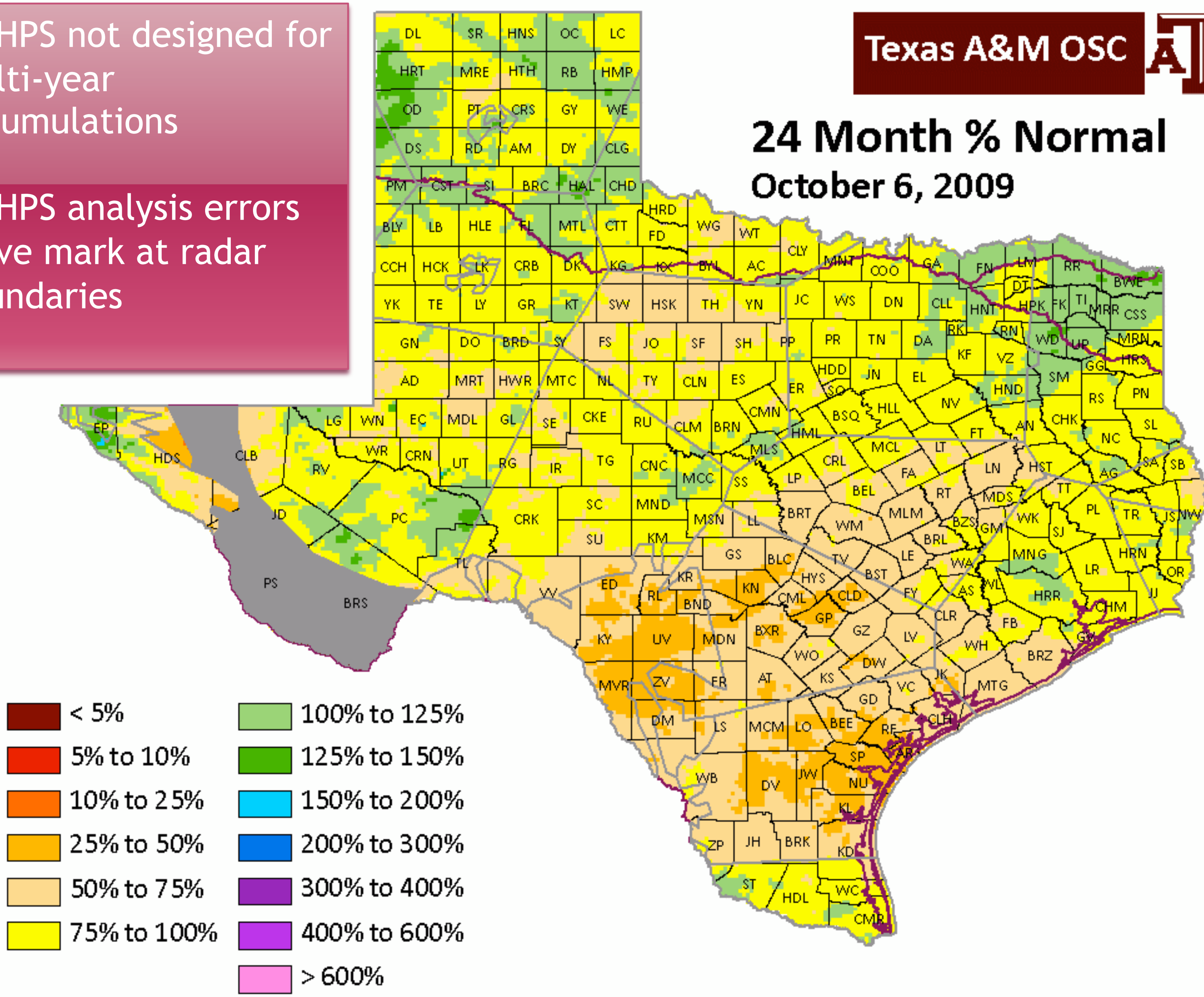


- AHPS not designed for multi-year accumulations
- AHPS analysis errors leave mark at radar boundaries

Texas A&M OSC

24 Month % Normal

October 6, 2009



Texas A&M OSC

24 Month % Normal

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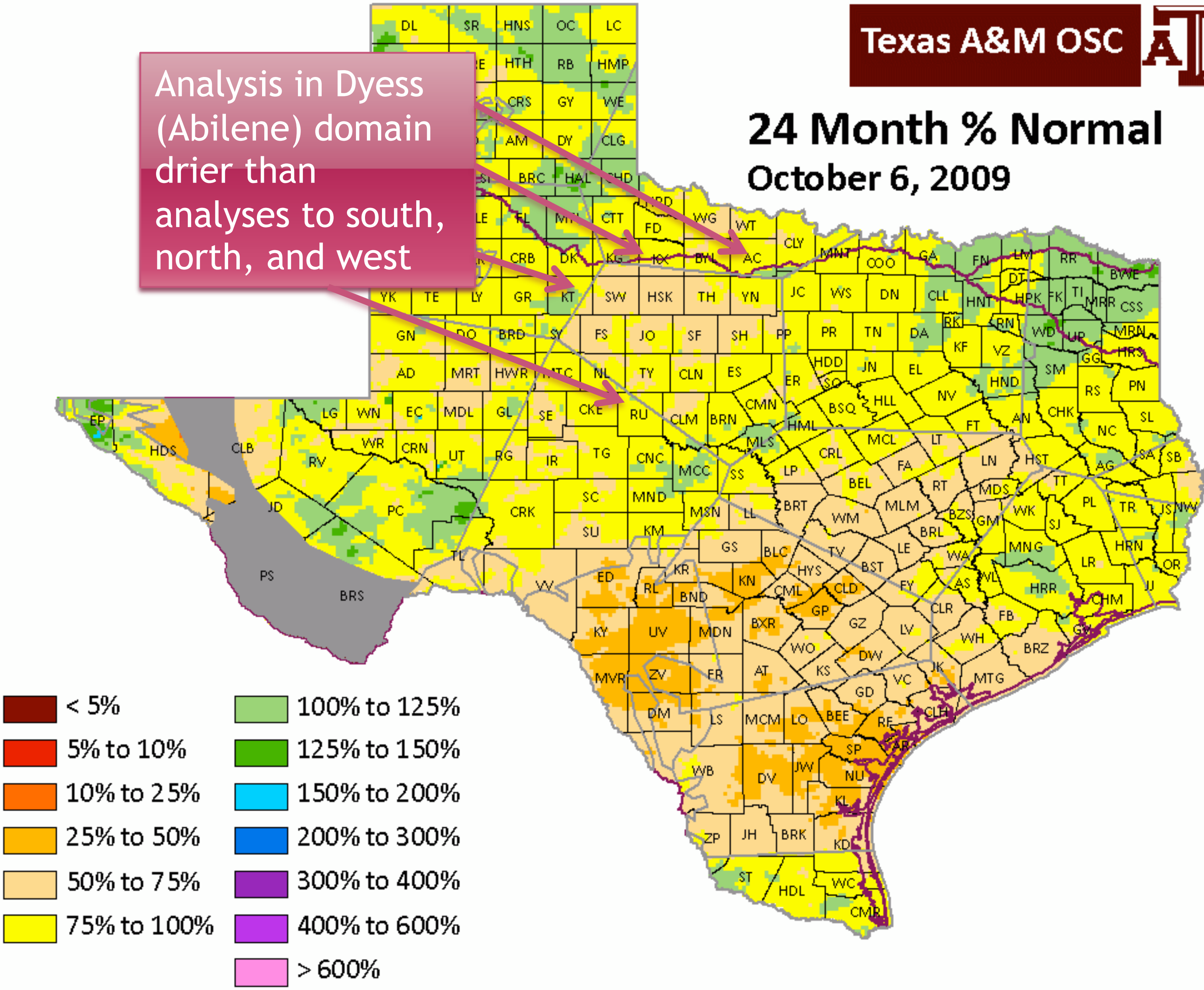

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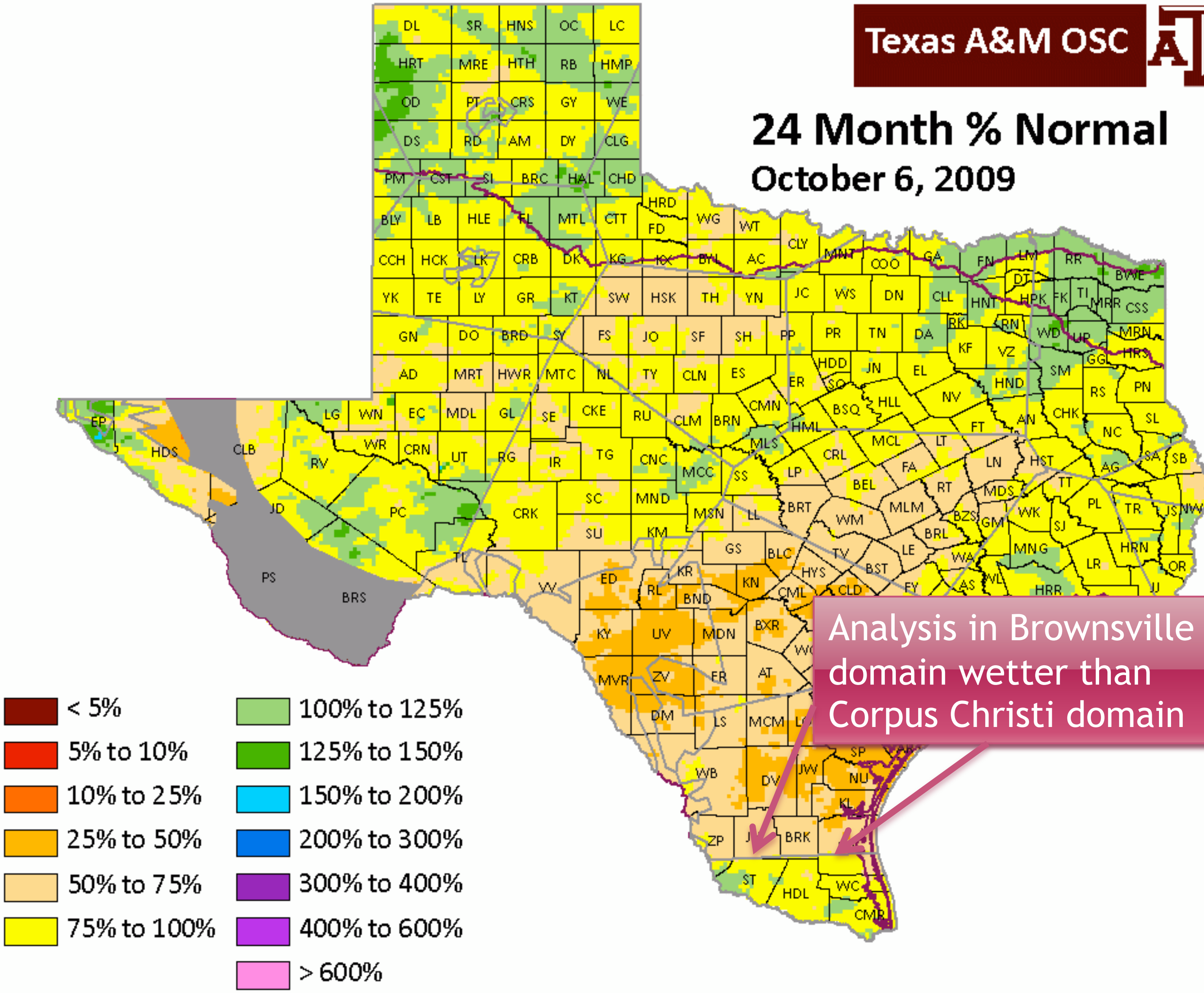
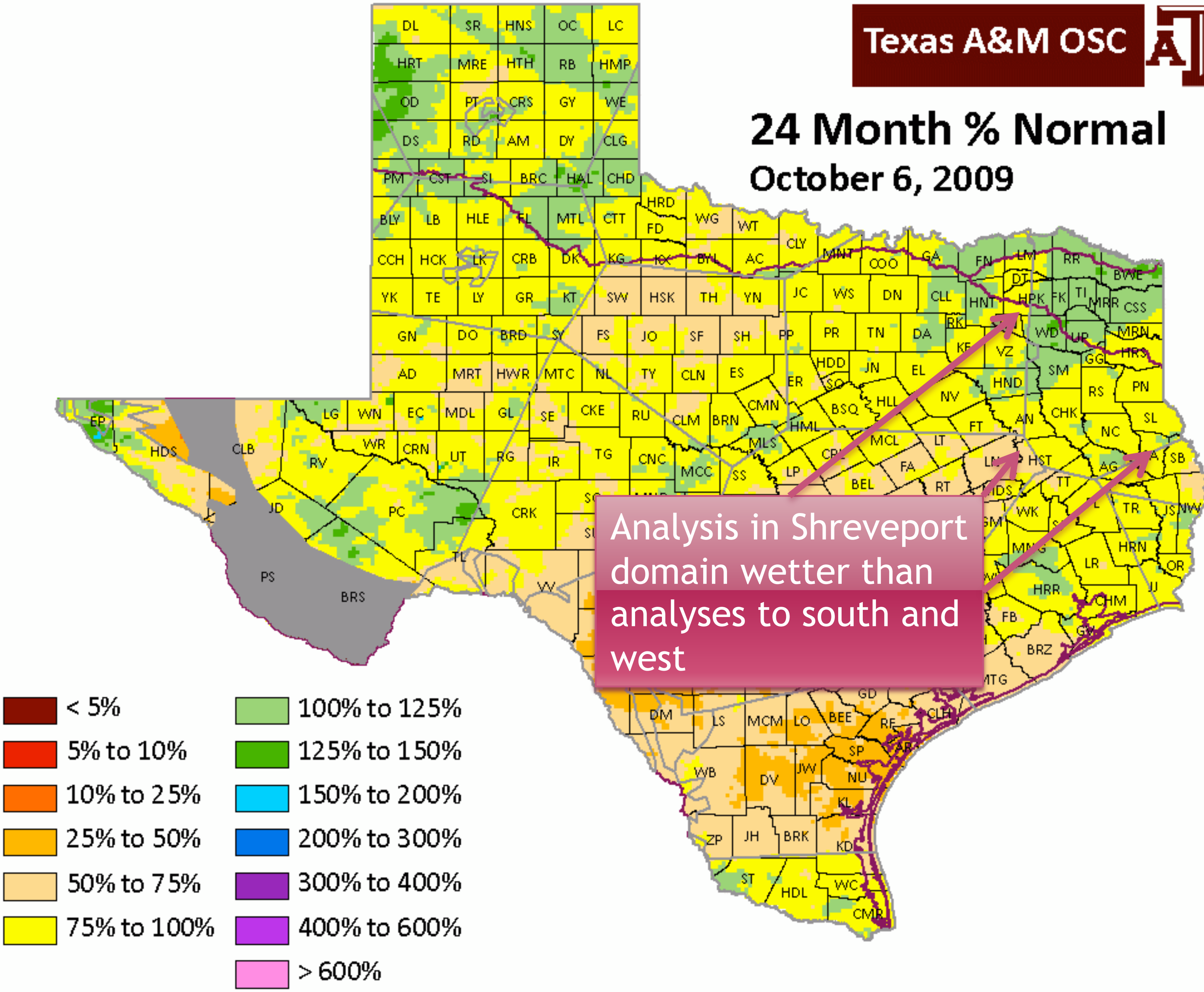


Analysis in Brownsville domain wetter than Corpus Christi domain

Texas A&M OSC

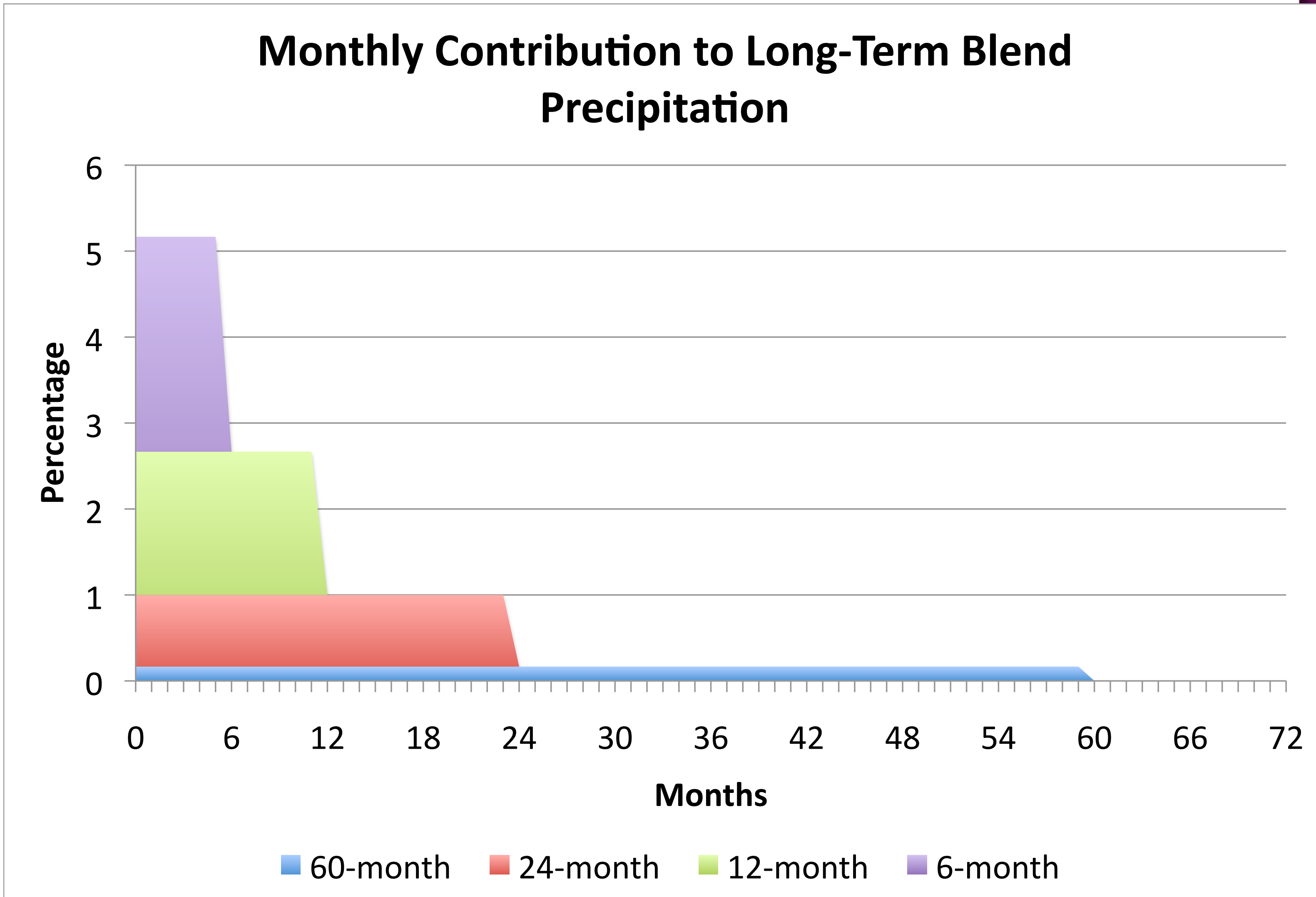
24 Month % Normal

October 6, 2009



RICHARD TINKER'S BLENDS

- Weighted combination of drought indicators, then converted to historic percentiles
- Example: Long-term Blend
  - 15% 6-month precipitation
  - 10% CPC soil moisture
  - 20% 12-month precipitation
  - 25% Palmer Hydrologic Index
  - 20% 24-month precipitation
  - 10% 60-month precipitation
  - (65% purely precipitation-based)


Monthly Contribution to Long-Term Blend Precipitation
Percentage
0
1
2
3
4
5
6
0
6
12
18
24
30
36
42
48
54
60
66
72
Months
60-month
24-month
12-month
6-month

Byun and Wilhite's (1999) Recommendations

- Avoid arbitrary duration
- Use daily calculations
- Characterize soil moisture and water supply separately
- Recent precipitation more important than precipitation long ago
- Using precipitation alone keeps it simple
- Generate a variety of information

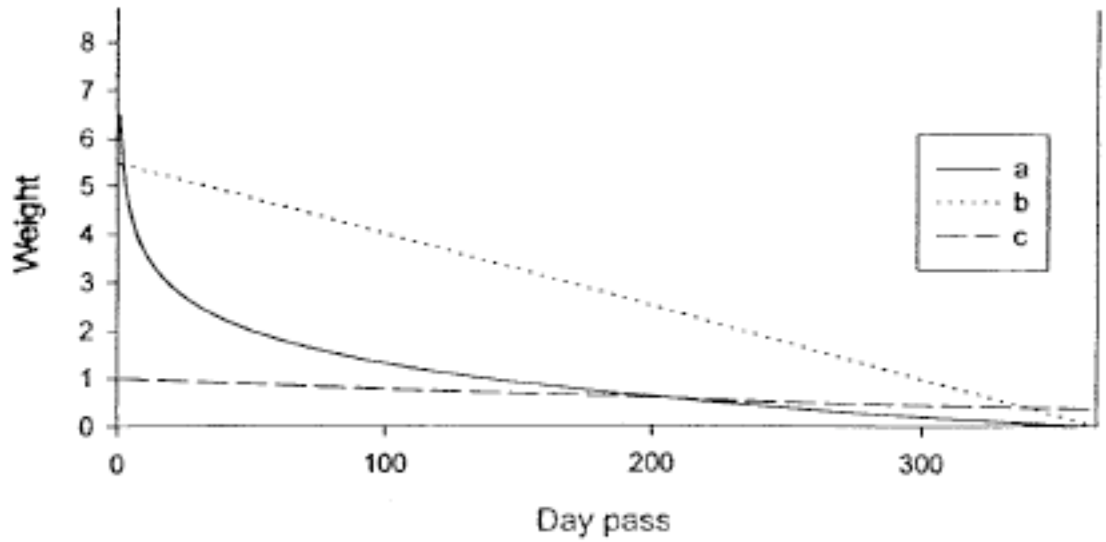
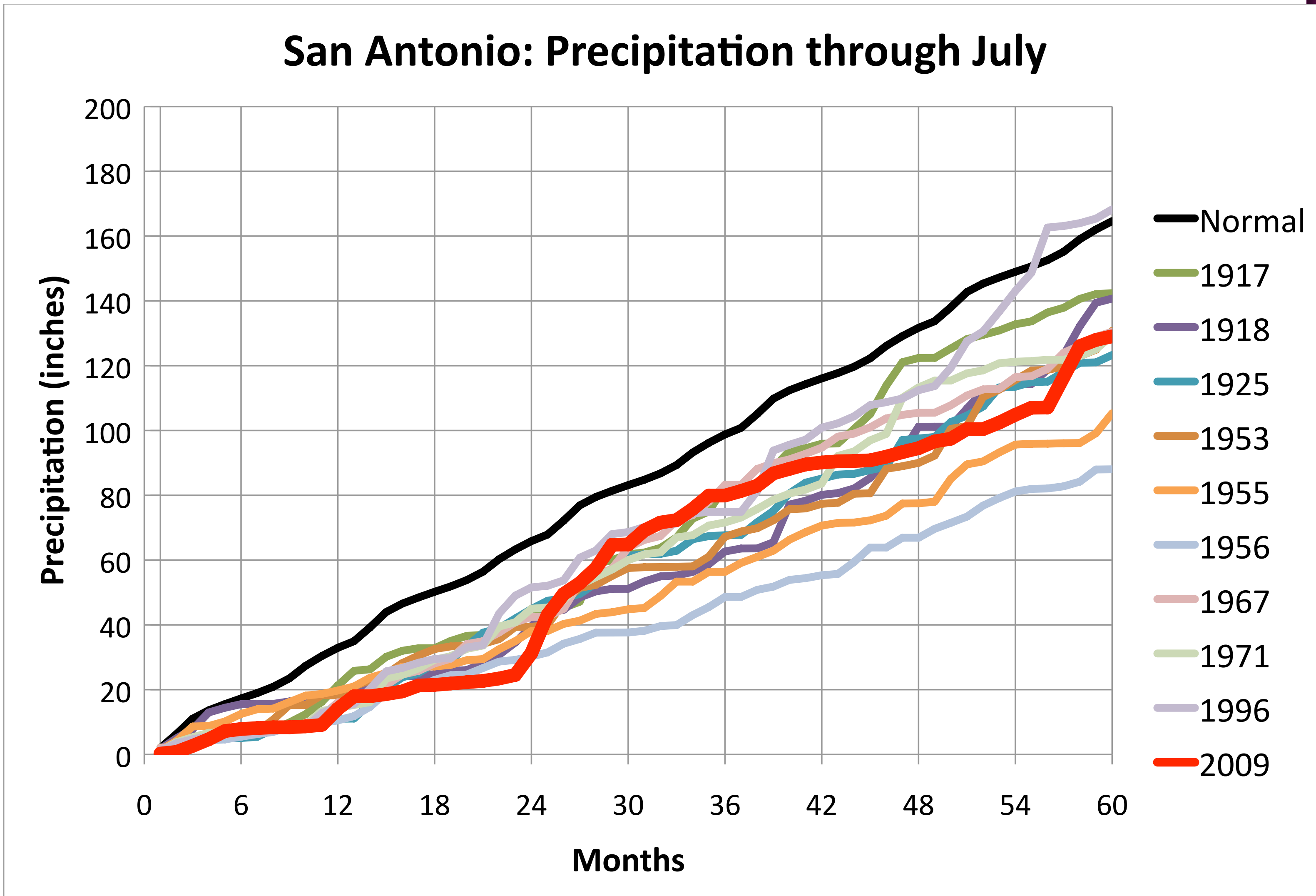


FIG. 1. Variation of the weight of precipitation to EP along the day pass, which is considered in (a) Eq. (2), (b) Eq. (2), and (c) Eq. (1). The abscissa axis reflects day pass. Ordinate axis shows a multiplied number to the rainfall amount along the day-pass to calculate the EP. For example, in (a), precipitation 1 day before being added to the EP after having been multiplied by 6.4, but one 365 days before is added after multiplication by 1/365. Here 6.4 is the sum of $1/n$ when n varies from 1 to 365.

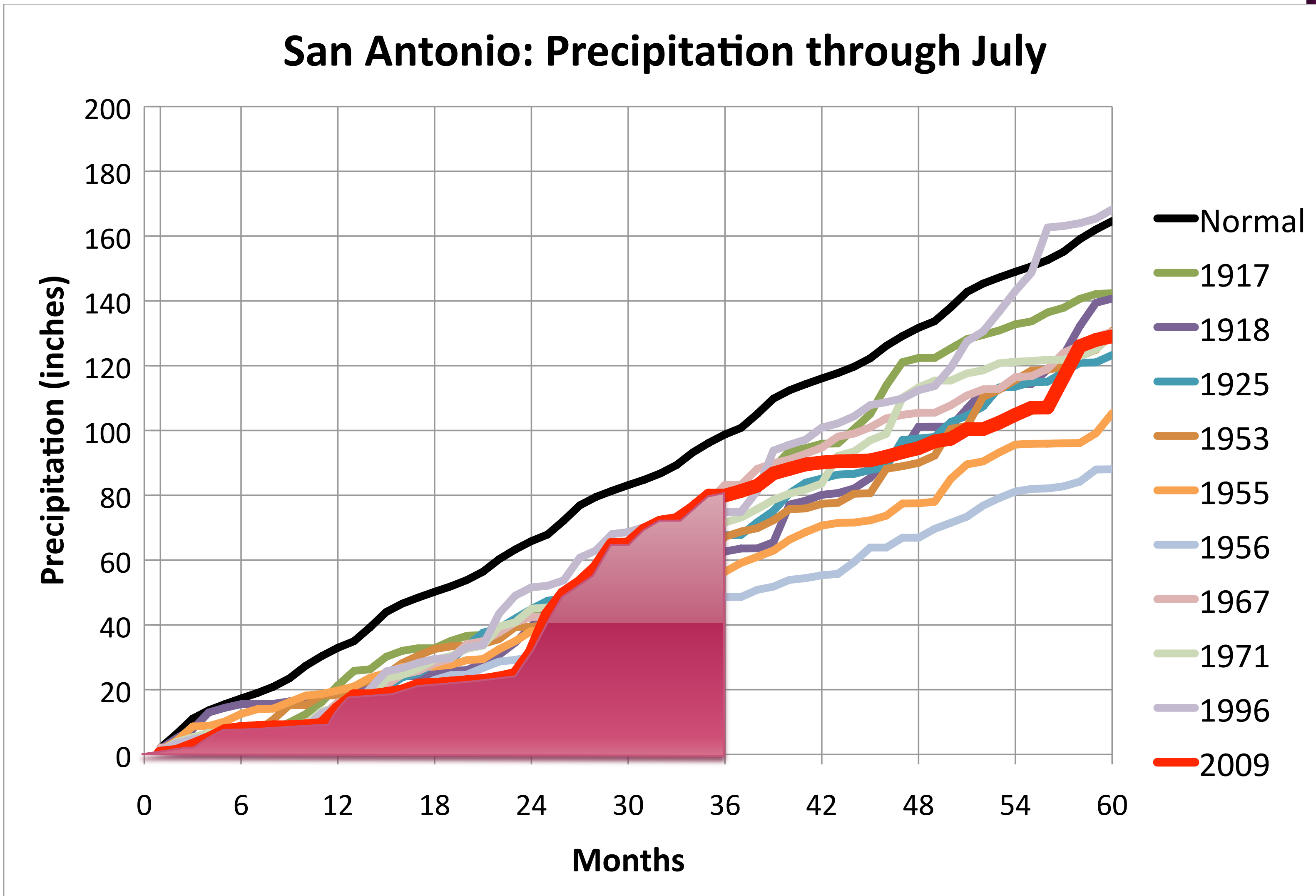
Byun and Wilhite: (1) Calculate weighted accumulation of precipitation (choices b and c work best) (2) Calculate departure from normal (3) Standardize

INTEGRATED DROUGHT COMPARISON

- Examine precipitation accumulations at full range of periods
- The event with the smallest accumulations over the longest interval of time can be interpreted as the most severe drought



San Antonio: Precipitation through July
Precipitation (inches)
200
180
160
140
120
100
80
60
40
20
0
0
6
12
18
24
30
36
42
48
54
60
Months
Normal
1917
1918
1925
1953
1955
1956
1967
1971
1996
2009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200
180
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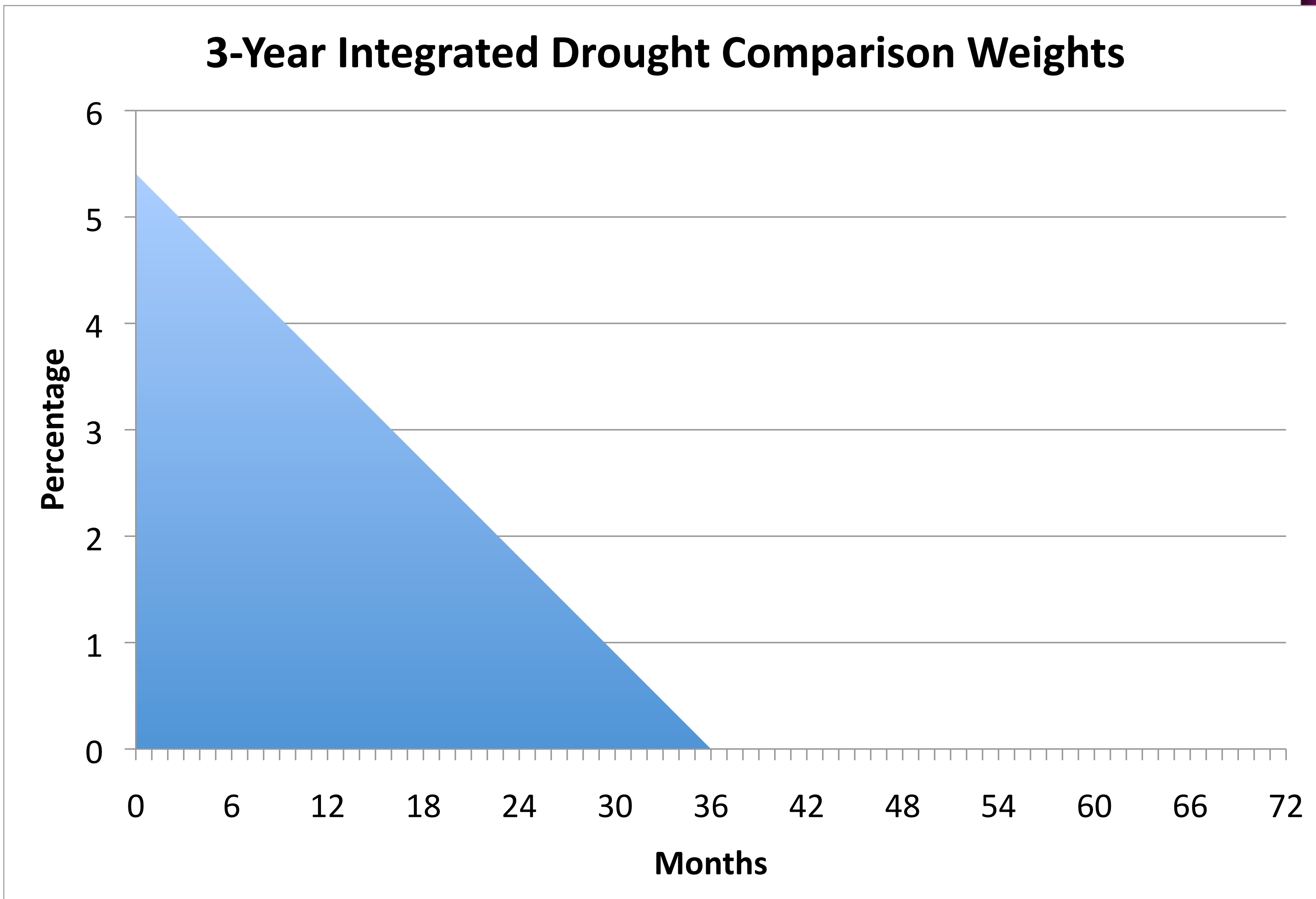
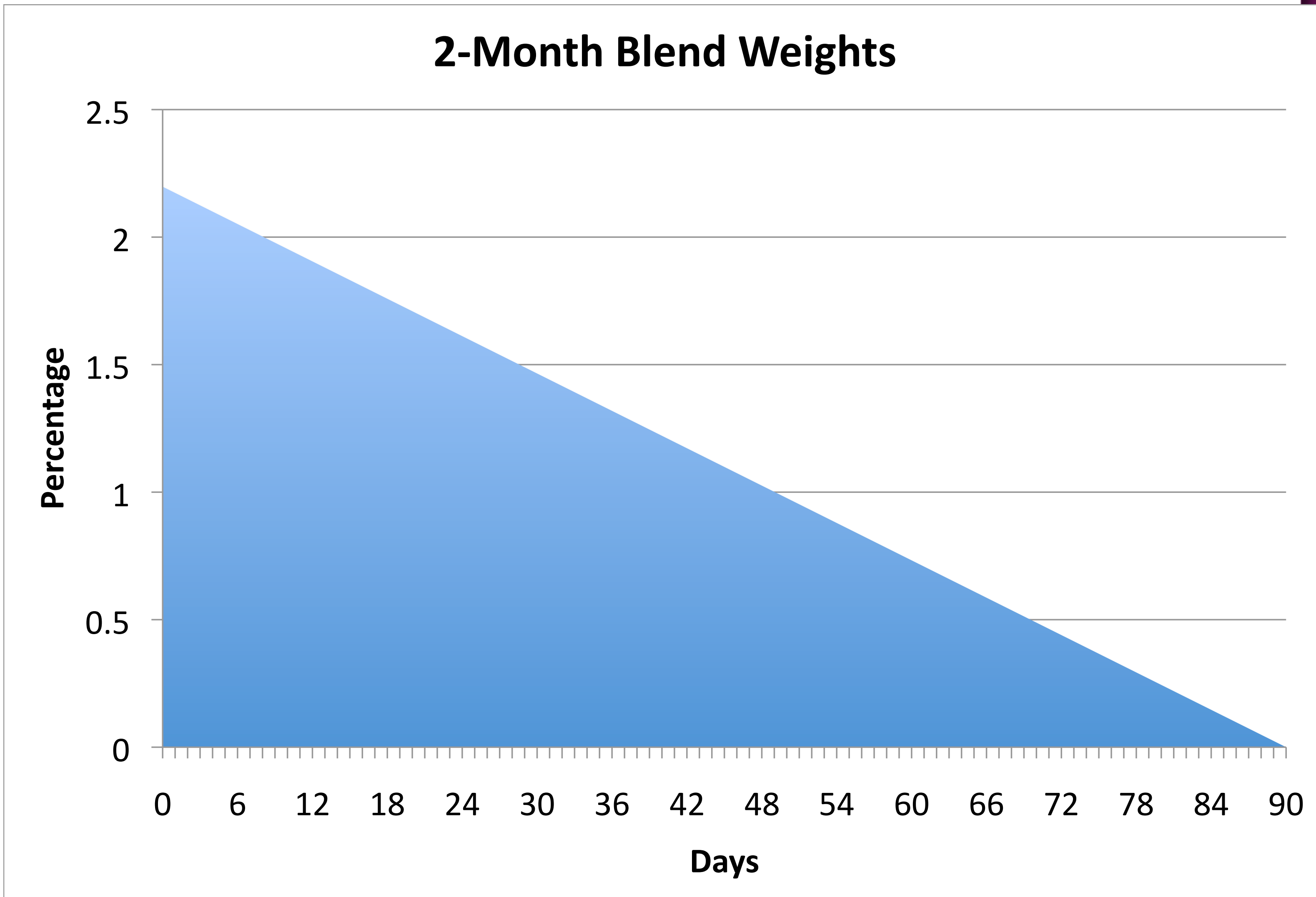
100
80
60
40
20
0
0
6
12
18
24
30
36
42
48
54
60
Months
Normal
1917
1918
1925
1953
1955
1956
1967
1971
1996
2009

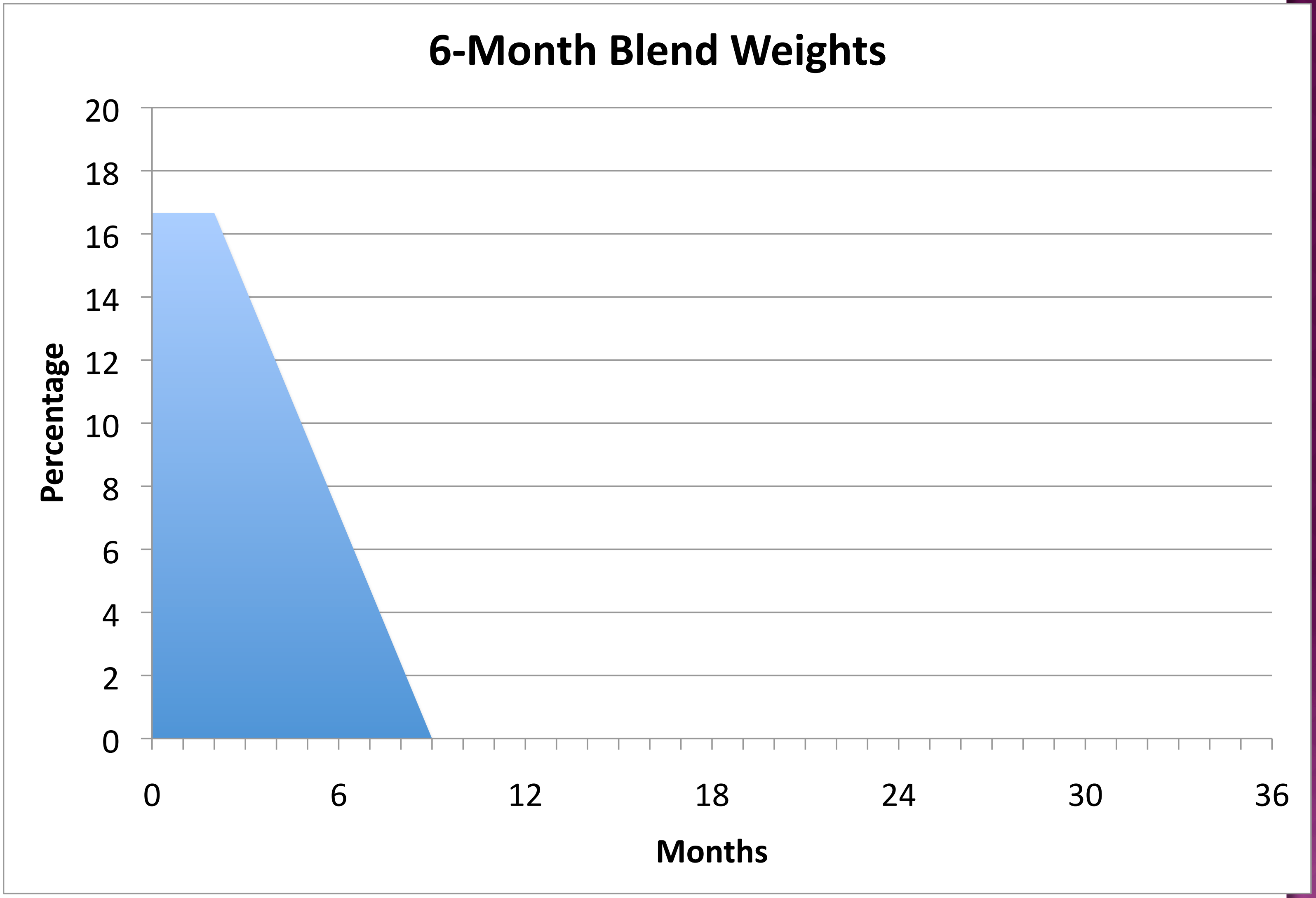


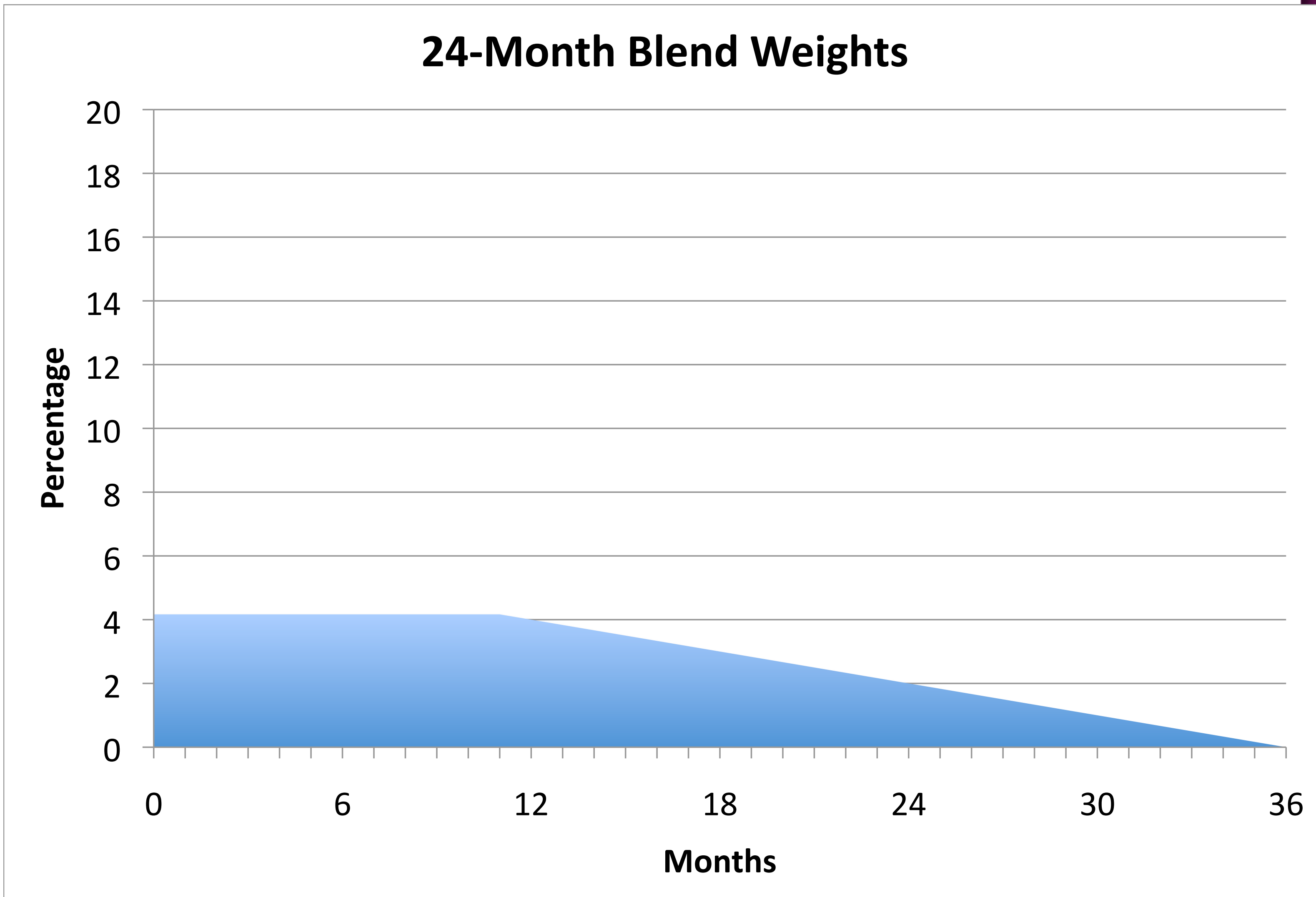
3-Year Integrated Drought Comparison Weights
Percentage
0
1
2
3
4
5
6
0
6
12
18
24
30
36
42
48
54
60
66
72
Months

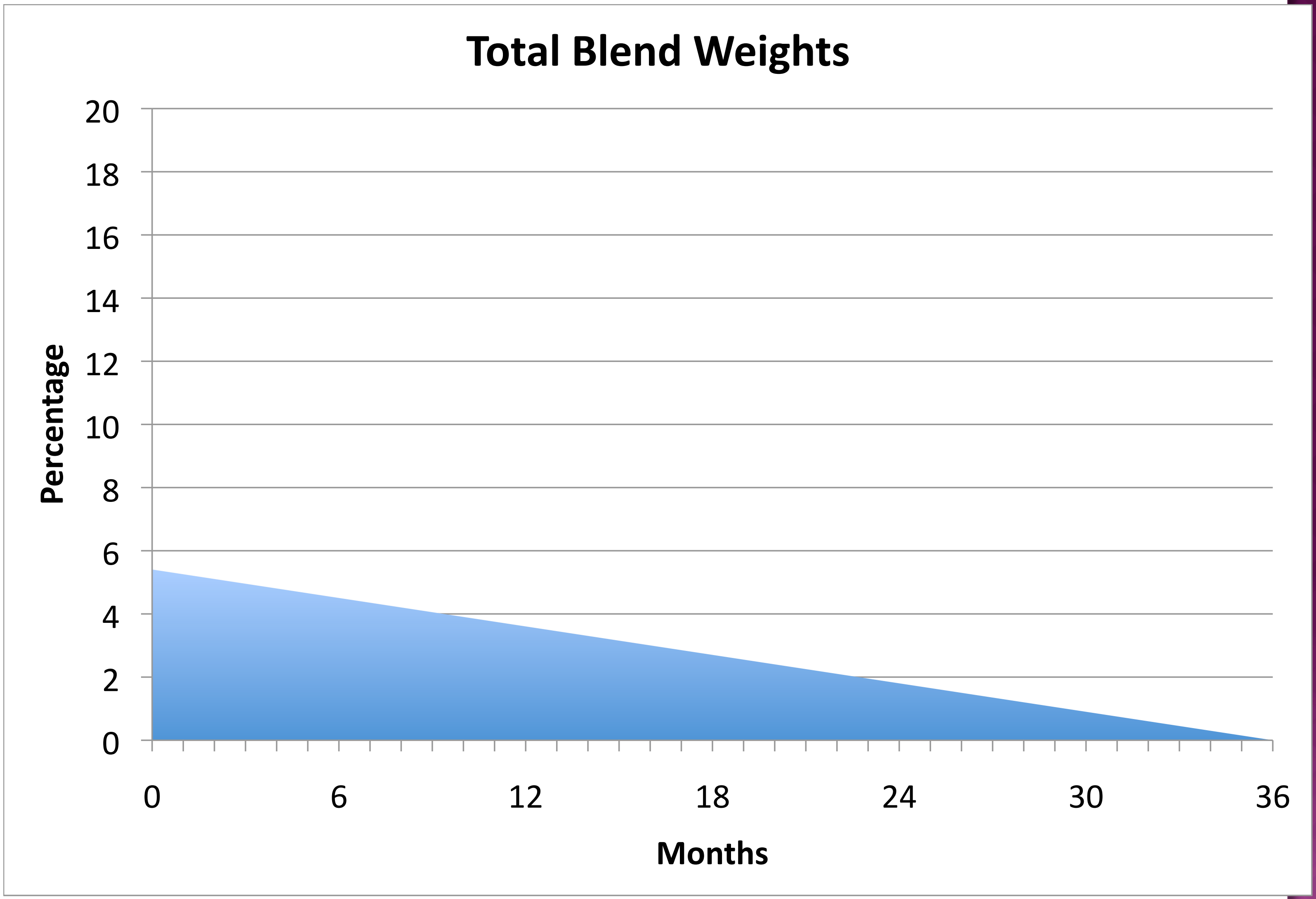
SPI BLENDS

- Add together precipitation accumulations over a variety of time periods
  - Equivalent to higher weighting of more recent precipitation
- Perform cluster analysis of PDF of weighted accumulations, as in standard SPI
- Plot D-levels of blended precipitation


2-Month Blend Weights
Percentage
2.5
2
1.5
1
0.5
0
0 6 12 18 24 30 36 42 48 54 60 66 72 78 84 90
Days


6-Month Blend Weights
Percentage
20
18
16
14
12
10
8
6
4
2
0
0
6
12
18
24
30
36
Months


24-Month Blend Weights
Percentage
20
18
16
14
12
10
8
6
4
2
0
0
6
12
18
24
30
36
Months



Total Blend Weights
Percentage
20
18
16
14
12
10
8
6
4
2
0
0
6
12
18
24
30
36
Months

CURRENT PRODUCTS

- Percent of normal precipitation
- SPI
- SPI Blends
- SPI Blend one-week changes
- Radar coverage overlays
- Options
  - 4 km scale or county aggregation
  - Overlay of current Drought Monitor

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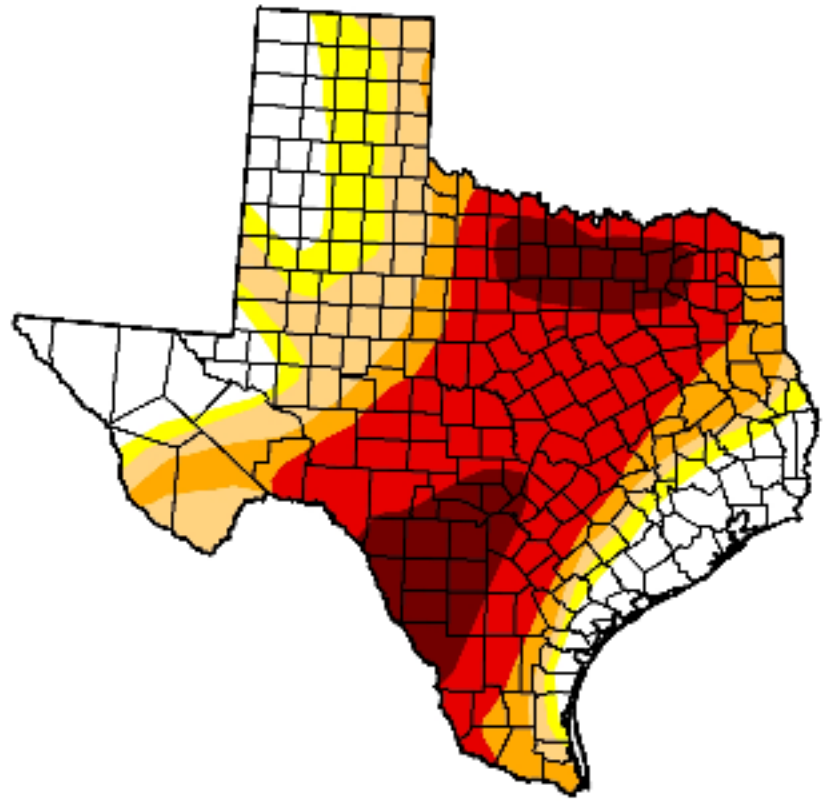

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Texas

September 29, 2009
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Last Week (09/22/2009 map)	62.5	37.5	28.5	22.9	15.5	3.8
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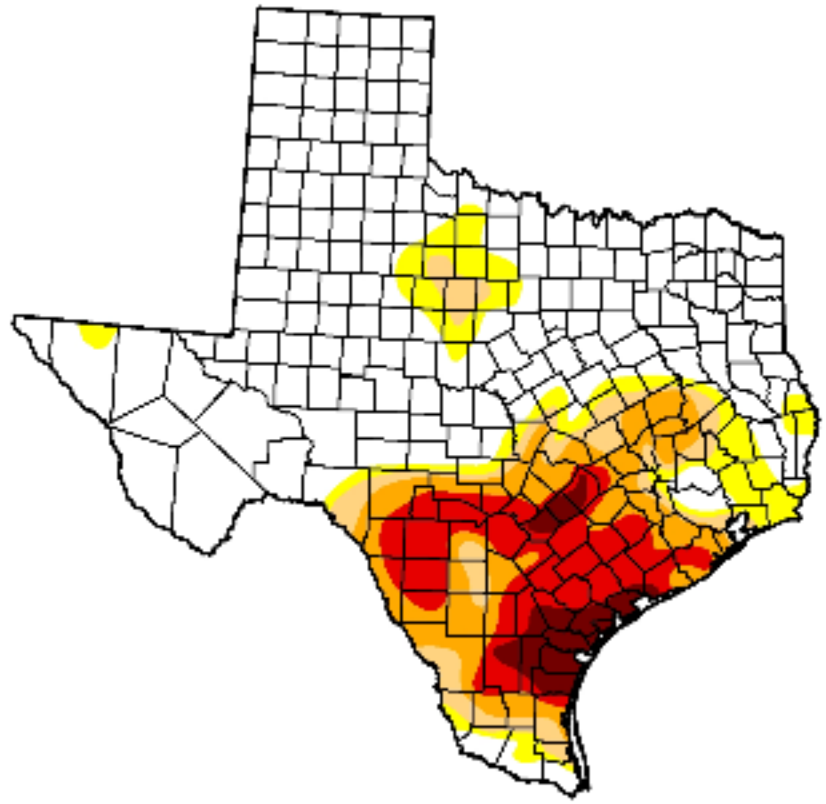

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USDA National Drought Mitigation Center

Released Thursday, October 1, 2009

Author: D. Miskus, JAWF/CPC/NOAA

FUTURE WORK

- Expand to south-central US
- Add verification overlays (gauge precipitation)
- Experiment with blending techniques
- Add animations
- Add automation

The 2008-2009 Texas Drought at its worst (so far…)

Texas A&M OSC