Implications of

1) Length of Background Climatology and 2) Choice of Land Model on

Values of NLDAS Drought Monitor Indicators

Youlong Xia[1,2], Michael B. Ek[1], Kenneth E. Mitchell[3], David Mocko[4], Sujay Kumar[4], Helin Wei[1,2], Jesse Meng[1,2] and Christa D. Peters-Lidard[4]

[1]Environmental Modeling Center, NCEP/NOAA, College Park, MD

[2]IMSG at NCEP/EMC, College Park, MD

[3]Prescient Weather Ltd, State College, PA

[4]Hydrological Sciences Laboratory, GSFC/NASA, Greenbelt, MD

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NCEP/EMC NLDAS Drought Monitor Website

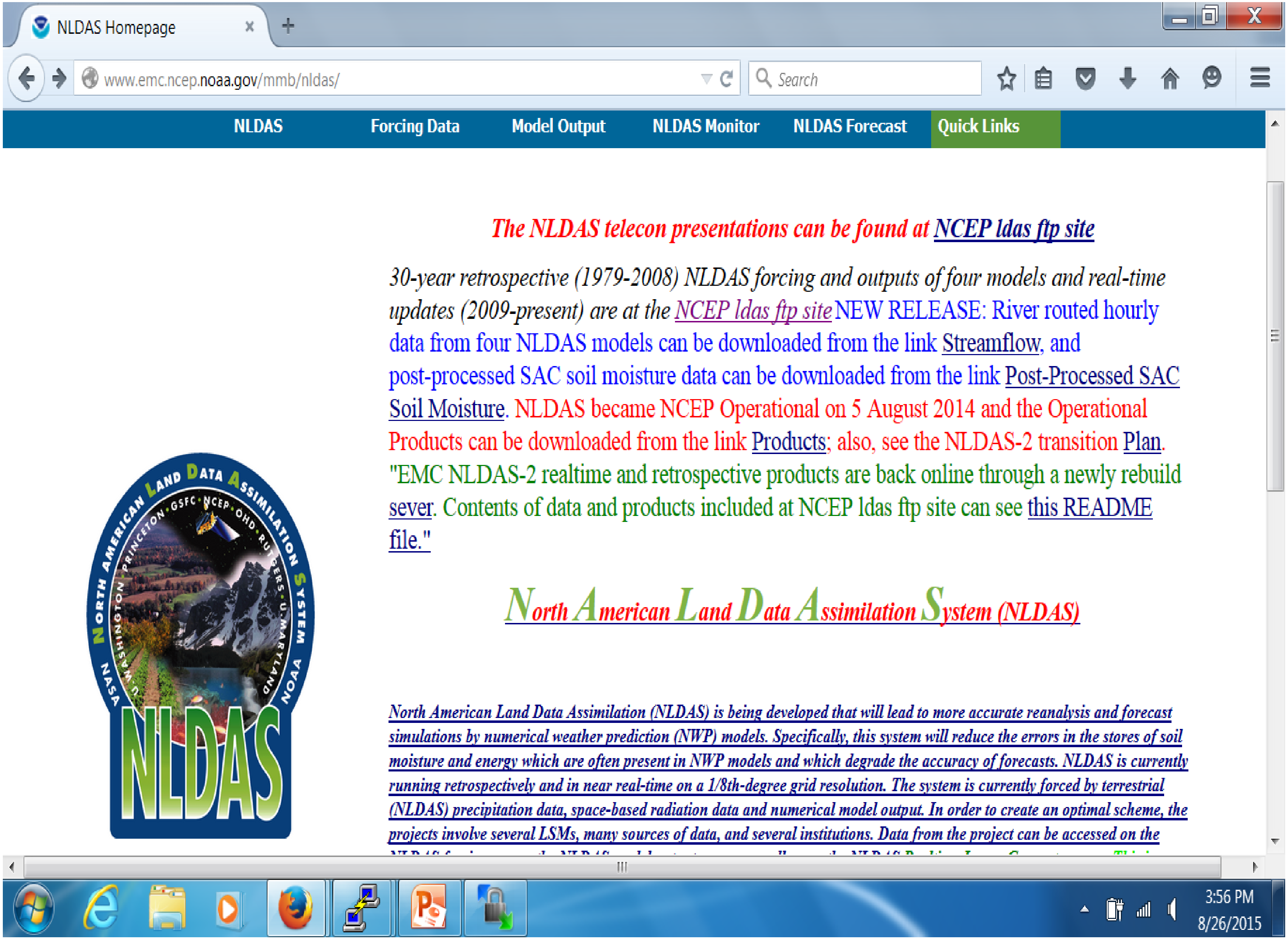
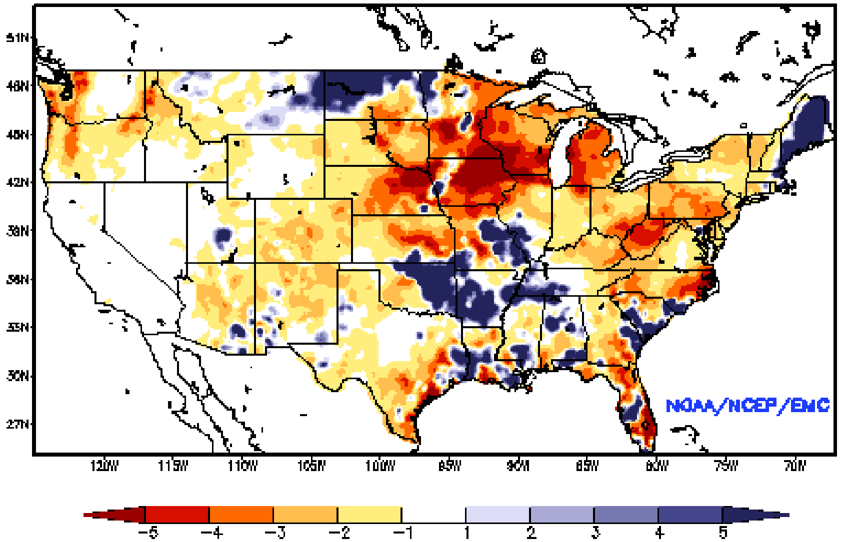


Table 1: Contour levels of anomalies and percentiles for three time scales used in current NLDAS-DM

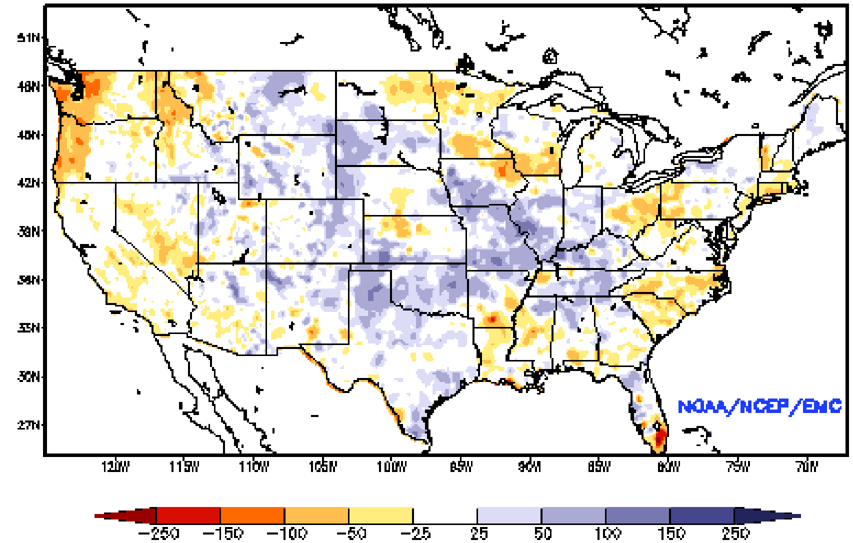
Precipitation anomaly (mm/day)										
Level	-5	-4	-3	-2	-1	1	2	3	4	5
Top 1-meter soil moisture anomaly (mm)										
Level	-125	-75	-50	-25	-12	12	25	50	75	125
Total column soil moisture anomaly (mm)										
Level	-250	-150	-100	-50	-25	25	50	100	150	200
Snow water equivalent anomaly (mm)										
Level	-200	-150	-100	-50	-5	5	50	100	150	200
Total runoff and evapotranspiration anomaly (mm/day)										
Level	-3	-2.1	-1.5	-0.9	-0.3	0.3	0.9	1.5	2.1	3
Streamflow anomaly (m^3/s)										
Level	-400	-300	-200	-100	-10	10	100	200	300	400
Percentile for all variables except for precipitation (%)										
Level	2	5	10	20	30	70	80	90	95	98

NLDAS Drought Monitor Examples - Anomaly

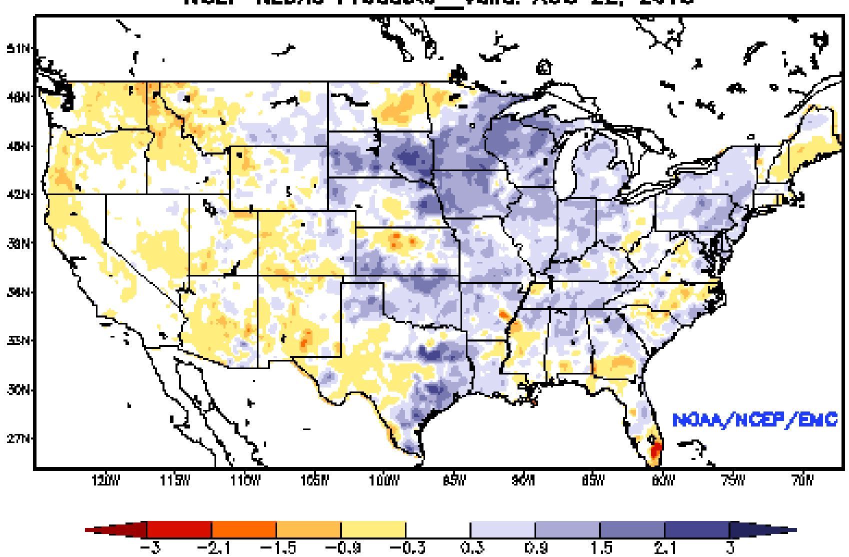
NLDAS – Current Precipitation Anomaly (mm/day)
Valid: AUG 22, 2015



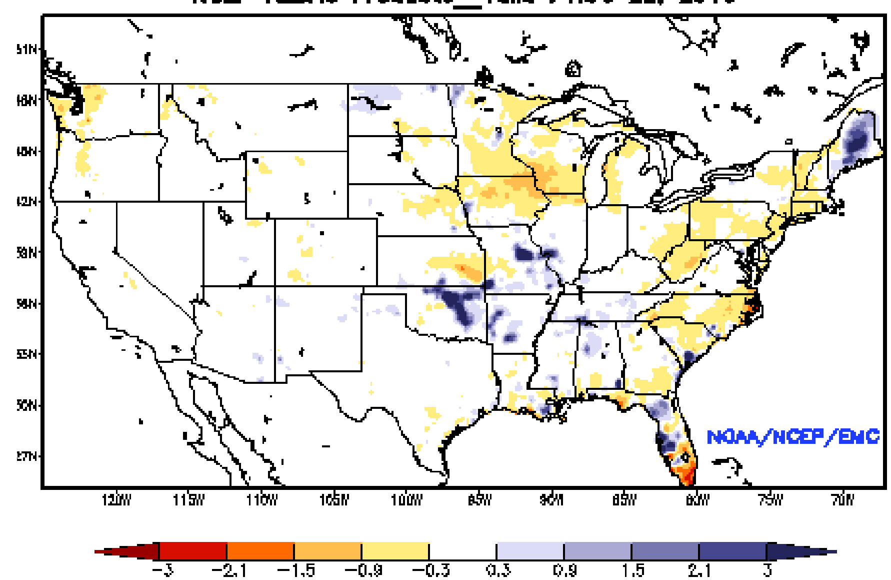
Ensemble-Mean – Current Total Column Soil Moisture Anomaly (mm)
NCEP NLDAS Products___ Valid: AUG 22, 2015



Ensemble-Mean: Current Evaporation Anomaly (mm/day)
NCEP NLDAS Products__Valid: AUG 22, 2015



Ensemble-Mean: Current Total Runoff Anomaly (mm/day)
NCEP NLDAS Products__Valid : AUG 22, 2015



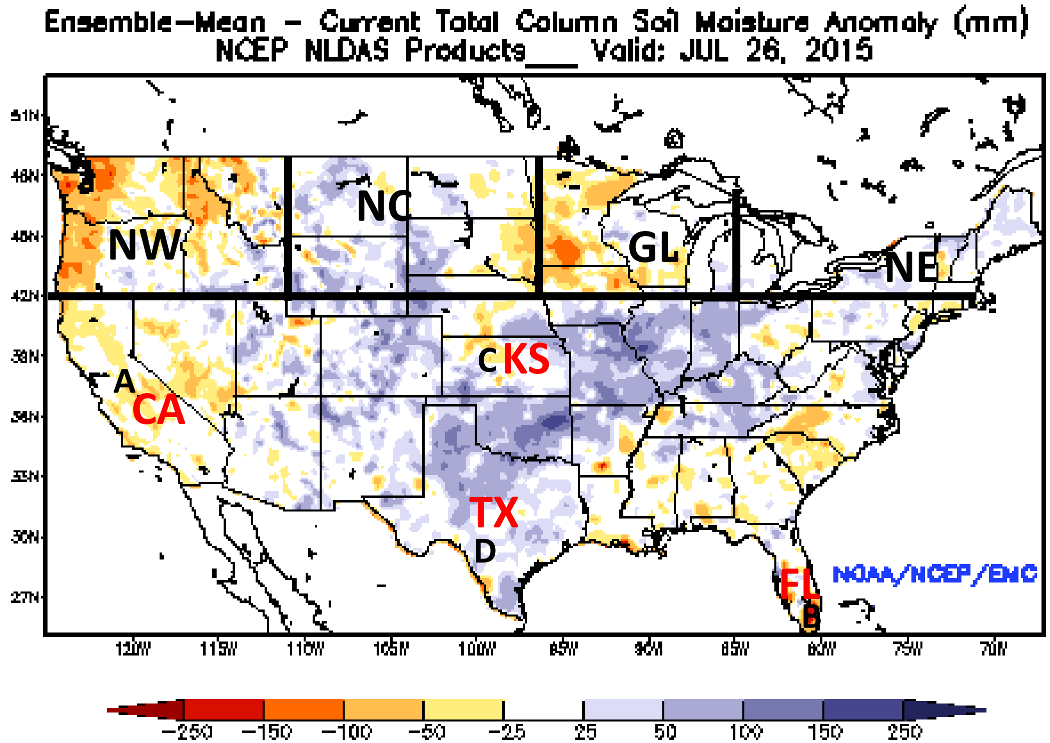


Figure 1: Four-model ensemble mean total soil moisture anomaly (mm) in current NLDAS Drought Monitor website (1980-2007, 28-year climatology). Four regions: Northwest (NW), North Central (NC), Great Lakes (GL), Northeast (NE) for snow water equivalent comparison. Four states: California (CA), Kansas (KS), Florida (FL), and Texas (TX) are used as examples for this study. Four points: A, B, C, and D are used for cumulative Density Function (CDF) comparison analysis.

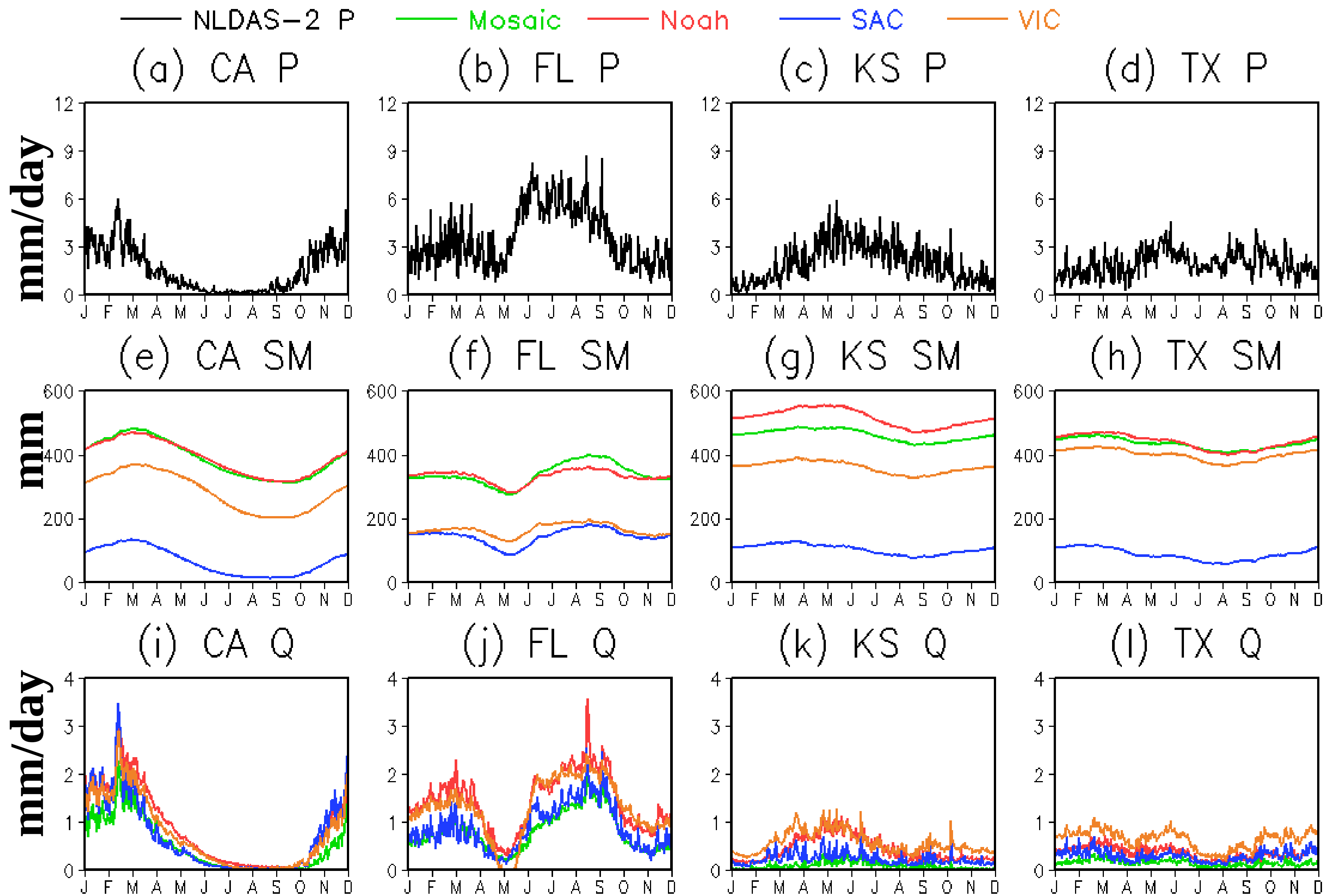


Figure 2: 28-year (1980-2007) **daily climatology** for: precipitation (top, unit: mm/day), total column soil moisture (middle, unit: mm), and total runoff (bottom, unit: mm/day) for the four states of CA, FL, KS, and TX (from left to right).

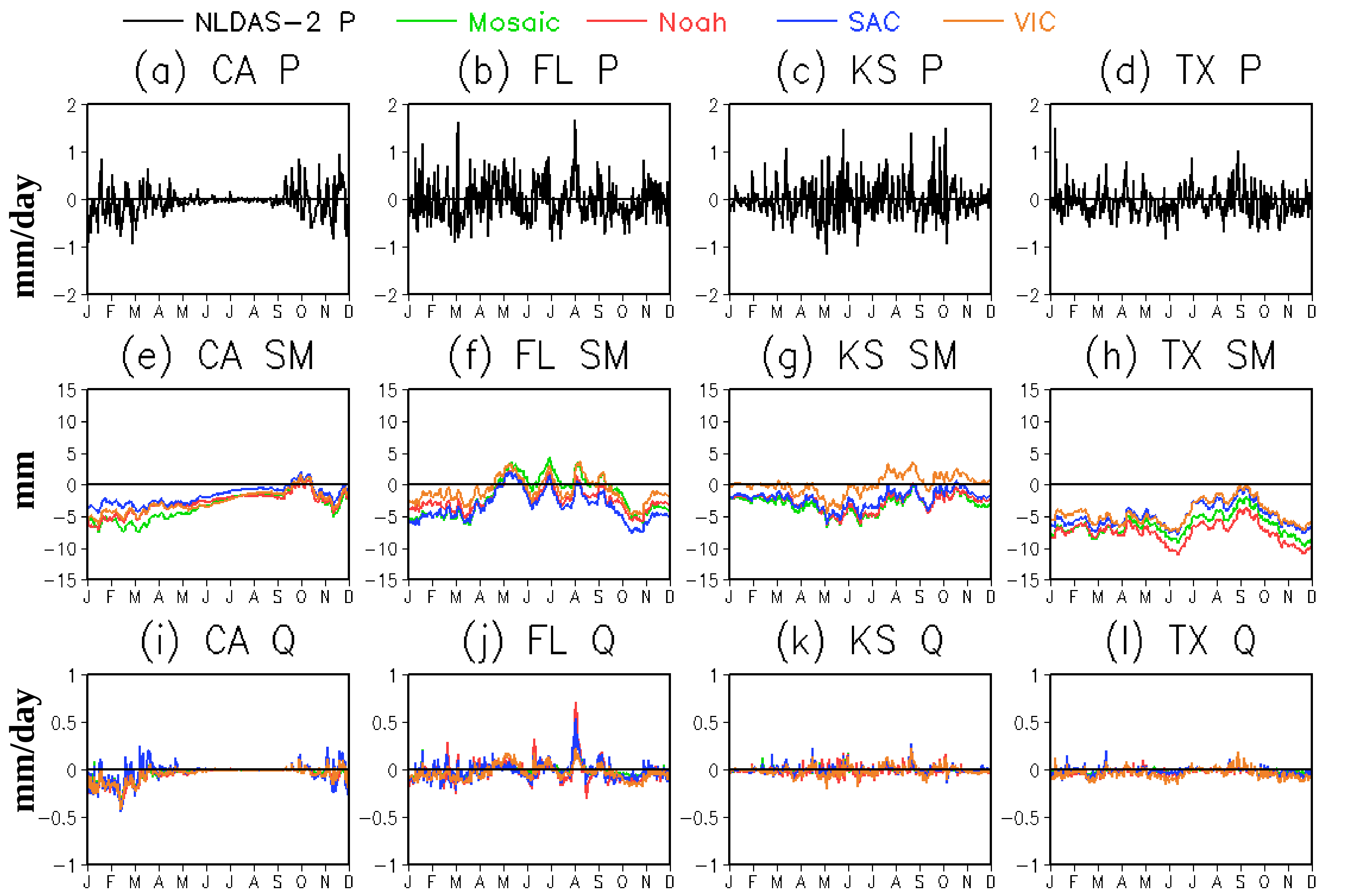


Figure 4: **Mean daily difference** between 36-yr (1979-2014) and 28-yr (1980-2007) daily climatology for precip (mm/day, top panel), total column soil moisture (mm, middle panel), and total runoff (mm/day, bottom panel) for the four states of CA, FL, KS, and TX (from left to right).

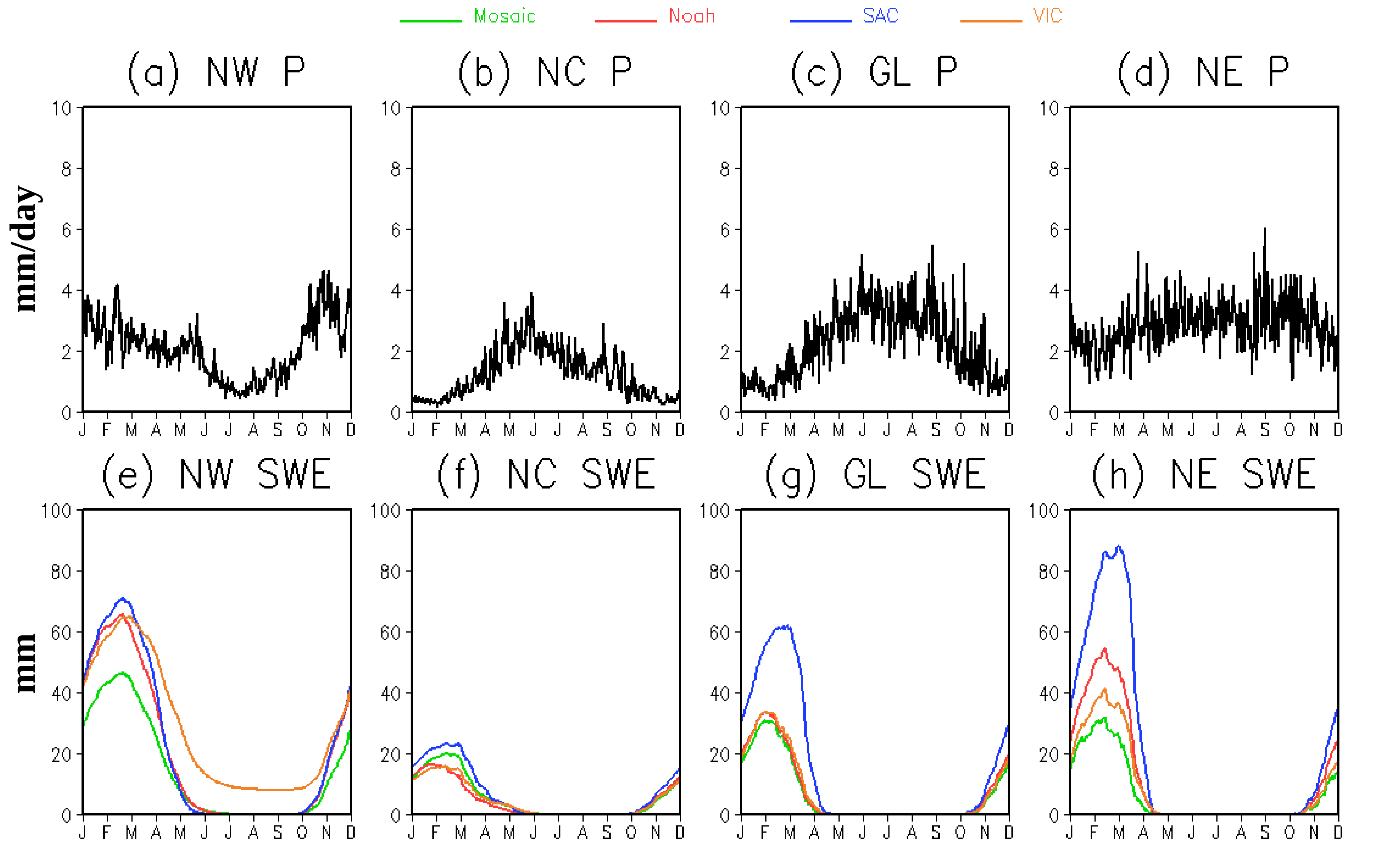


Figure 5: 28-year (1980-2007**) daily climatology** of precipitation (top, unit: mm/day) and snow water equivalent (bottom, mm) in the four northern CONUS regions of NW, NC, GL, and NE (from left to right).

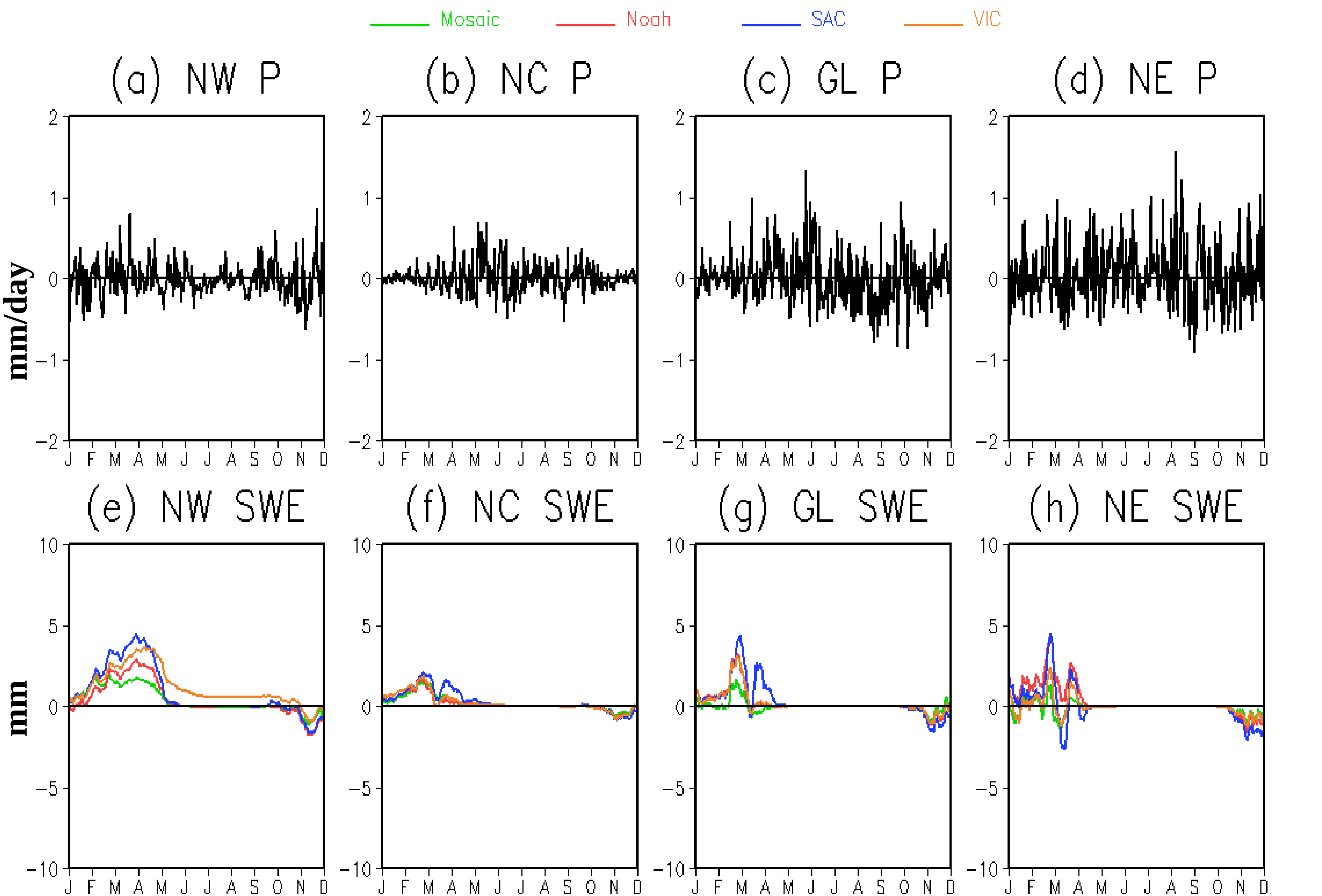
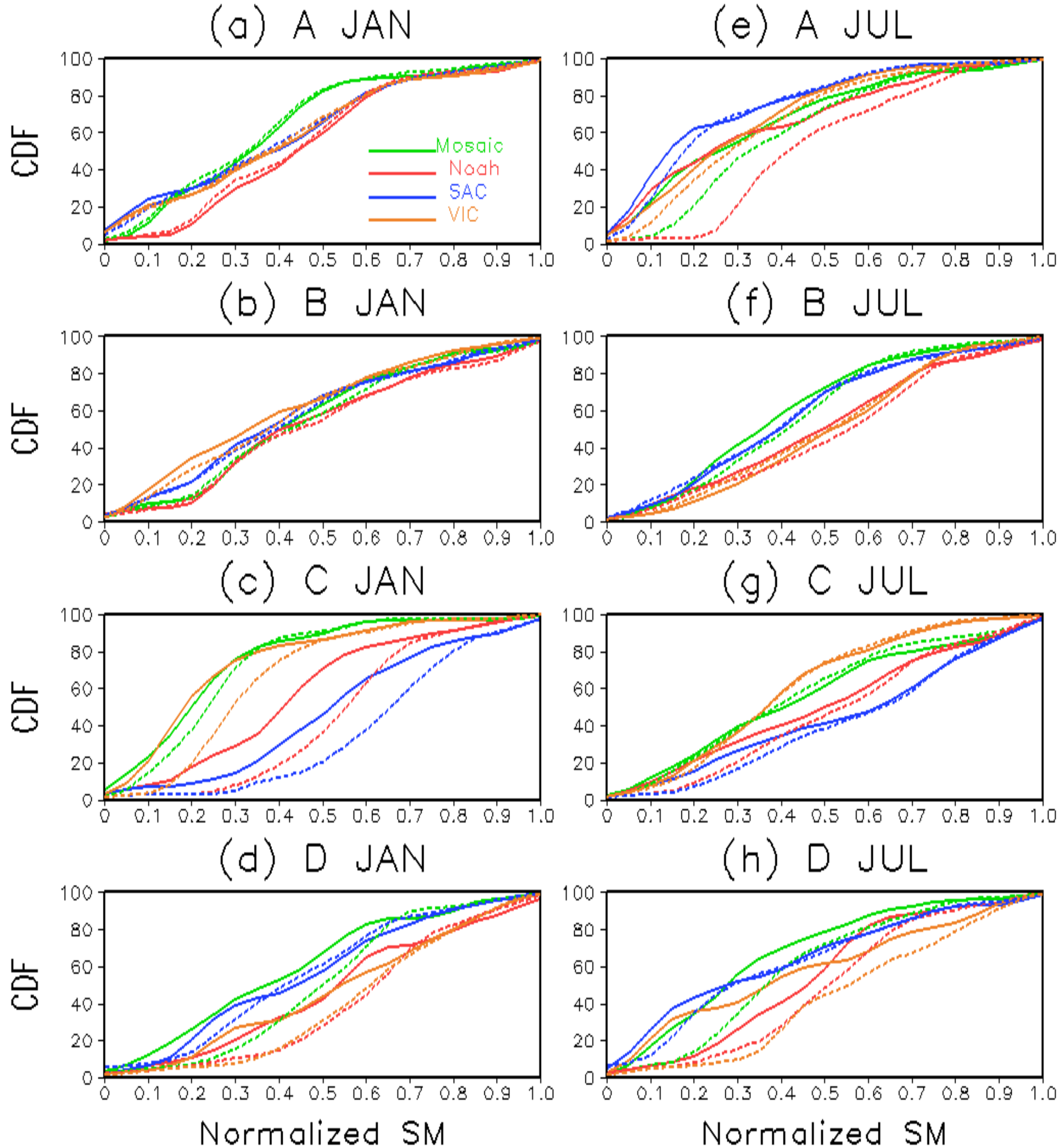


Figure 6: **Mean daily difference** between 36-year and 28-year climatology for precipitation (mm/day) and snow water equivalent (SWE, mm) for the four regions of NW, NC, GL, NE (from left to right).



For the four point-wise locations defined earlier in Figure 5.

Figure 7: Difference of cumulative density function (CDF) of normalized total column soil moisture between 28-year (solid line) and 36-year (dotted line) climo for each of the four LSMs

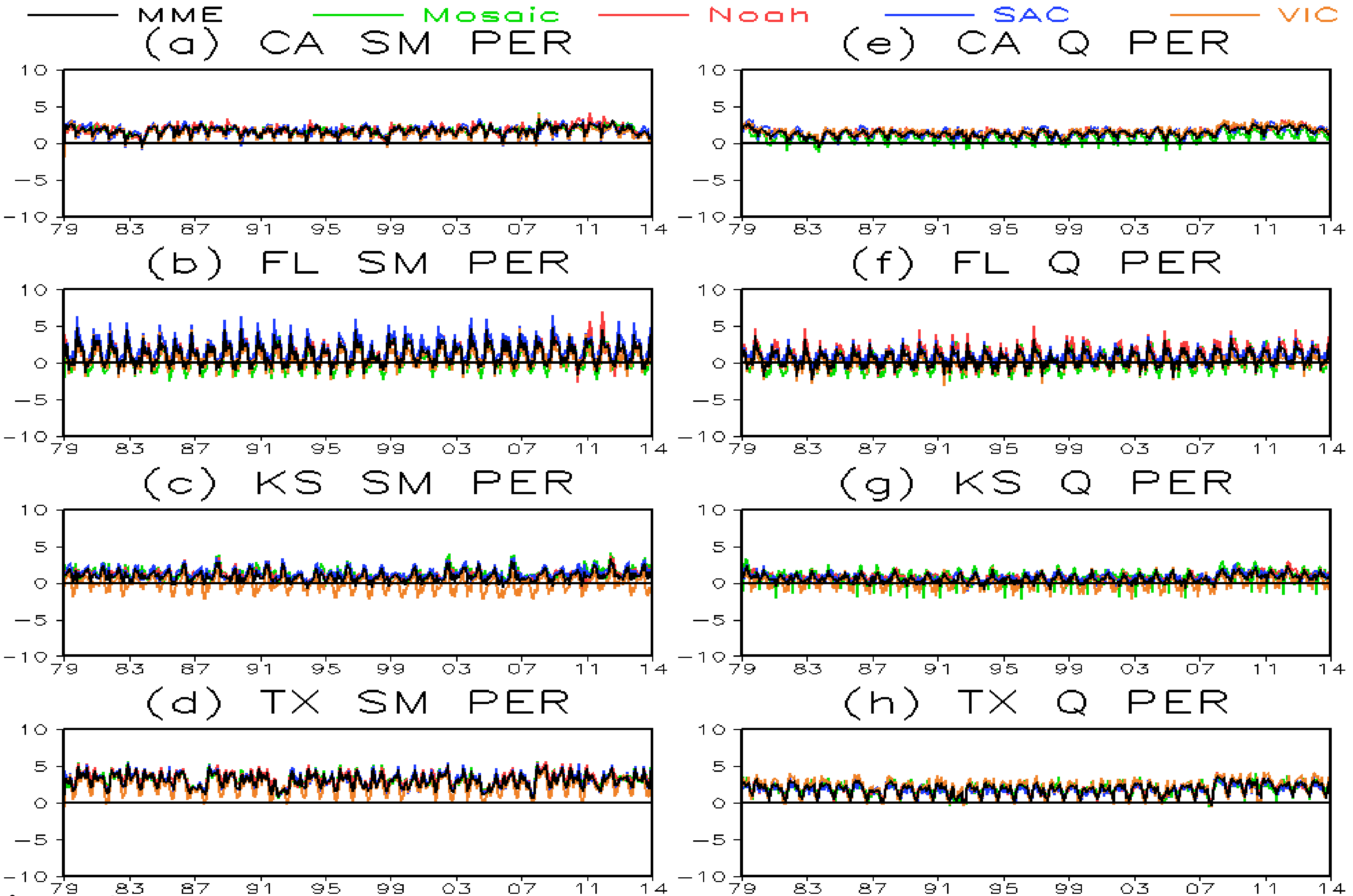


Figure 8: **Difference of monthly mean percentiles** between 36-yr and 28-yr climo for monthly mean total column soil moisture (left panel) and total runoff (right panel) for the four states of CA, FL, KS, TX (from left to right) and for MME and the four LSMs (MME- black, Mosaic –green, Noah – red, SAC – blue, and VIC – orange)

Noah Model

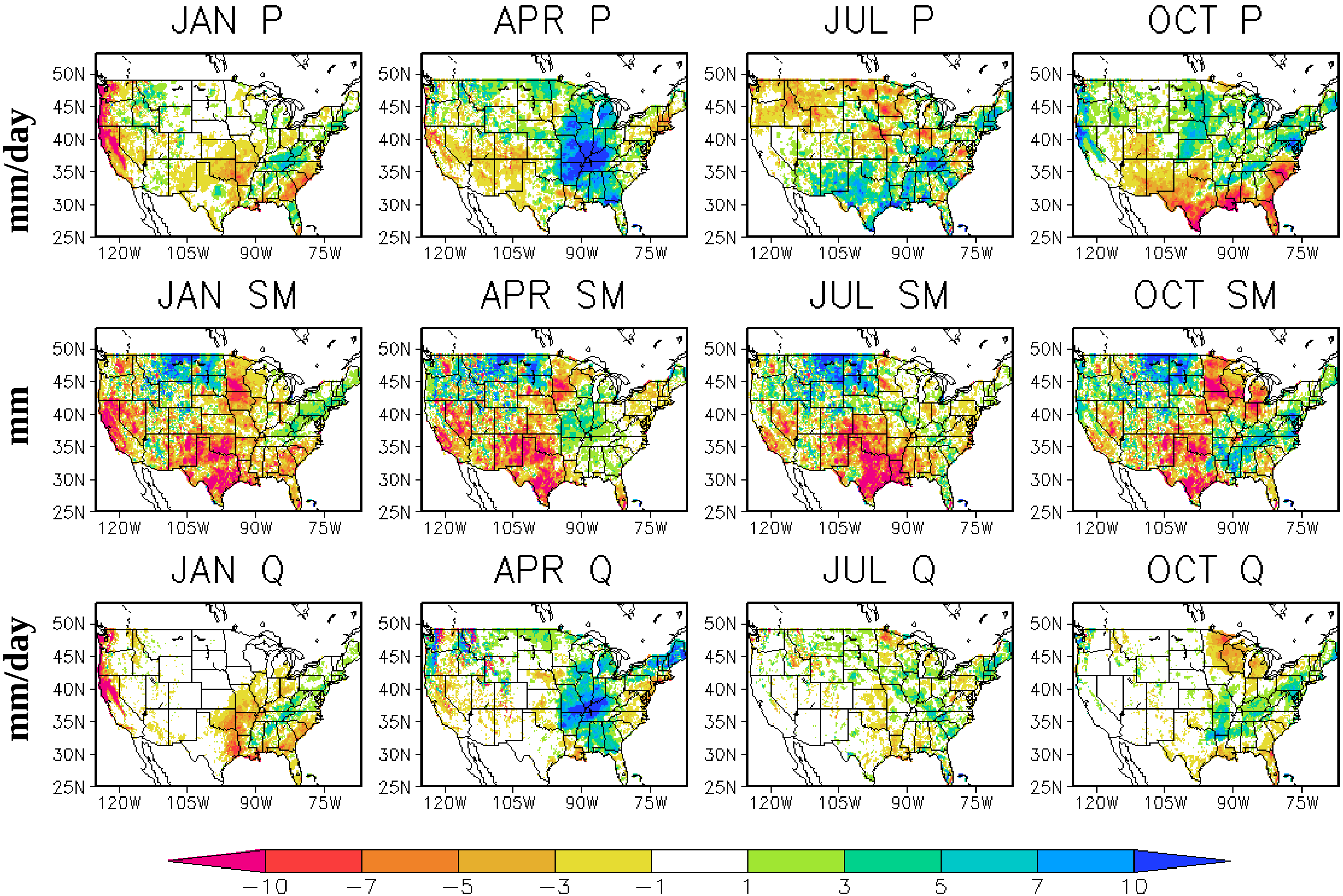


Figure 9: Spatial distribution of **difference of monthly mean** between 36-yr and 28-yr climatology for **precipitation (**mm/month, **top panel)**, Noah-simulated total column **soil moisture** (mm, **middle panel**), and Noah-simulated **total runoff** (mm/month, **bottom panel**) for January, April, July and October (from left to right).

Noah Model

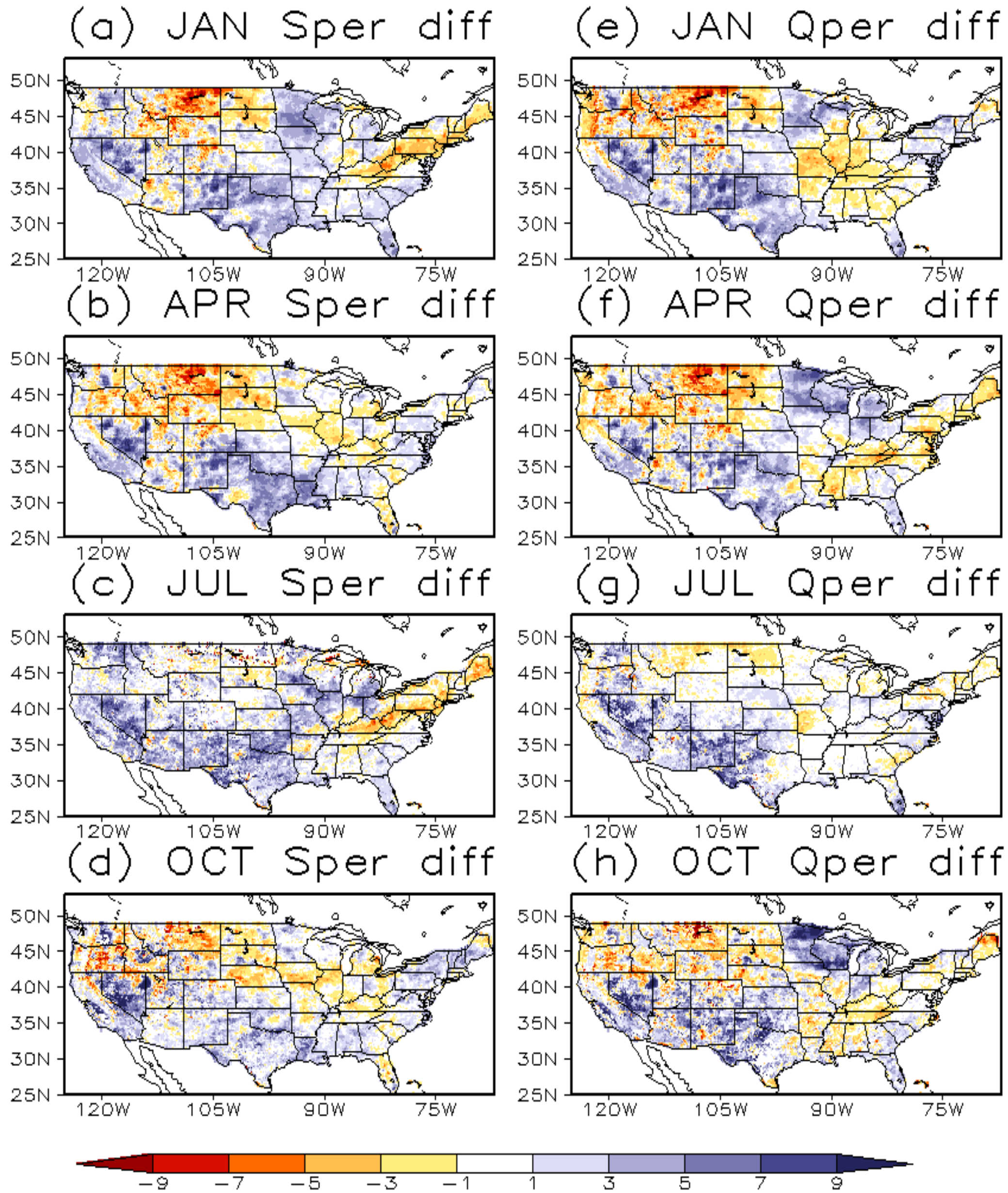


Figure 10: Spatial distribution of difference of mean monthly **total column soil moisture percentile** (%, left panel) and **total runoff percentile** (%, right panel) between 36yrs and 28yrs climatology calculated from Noah model for four months of January, April, July and October (from top to bottom).

MME SM Percentile

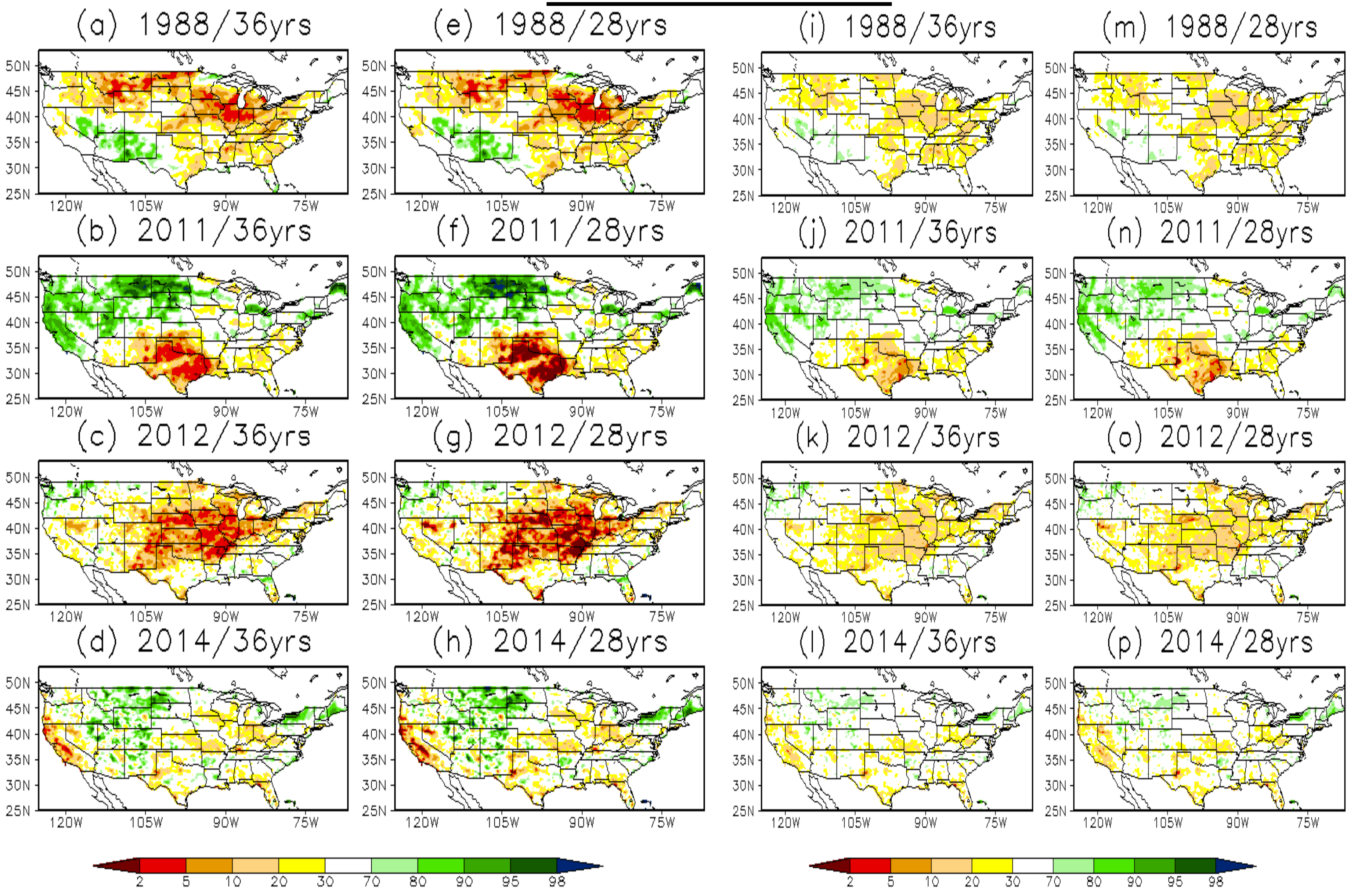


Figure 11: Comparison of monthly (August) total column soil moisture percentiles (left two panels) and total runoff percentiles (right two panels) calculated from four-model ensemble mean (MME) for four typical examples.

MME SM – Agricultural Drought Extent

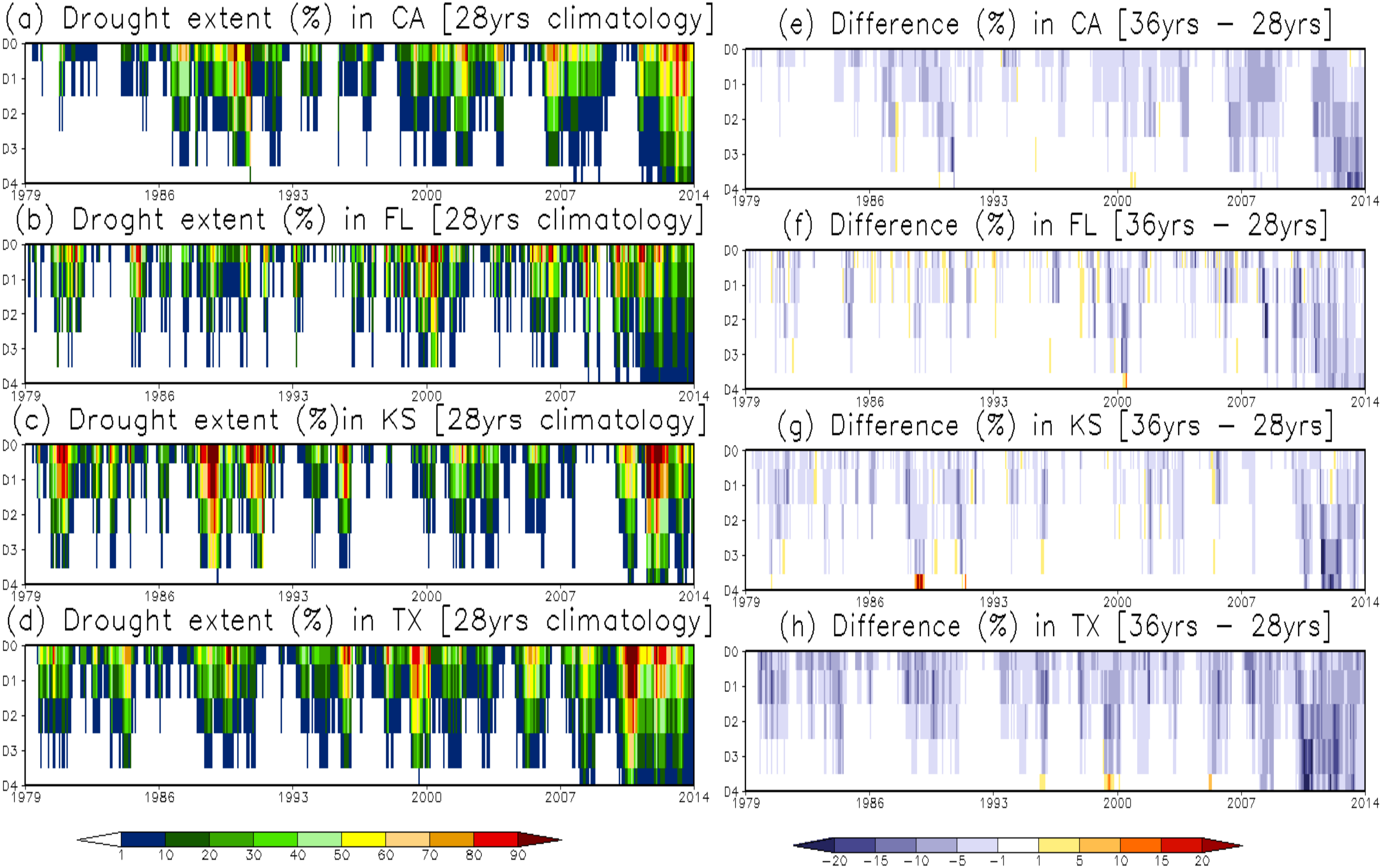


Figure 12: Monthly variation of drought extent calculated from MME for 28yrs climatology (left panel) and difference between 36yrs and 28yrs climatology (right panel) when monthly total column **soil moisture** is used. Here mainly focus on agricultural drought.

MME Q – Hydrological Drought Extent

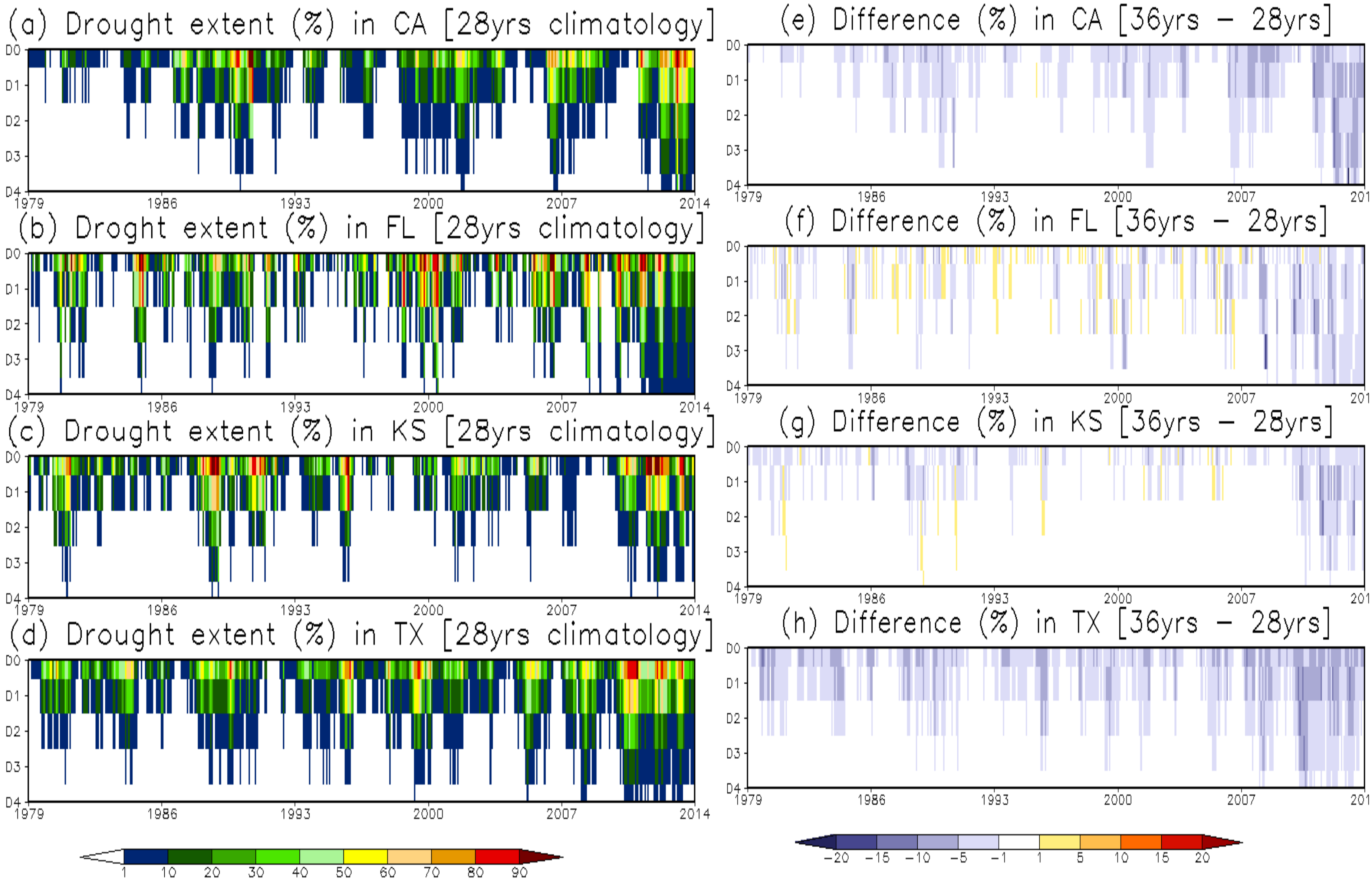


Figure 13: Monthly variation of drought extent calculated from MME for 28yrs climatology (left panel) and difference (right panel) between 36yrs and 28yrs climatology when monthly **total runoff** is used. Here mainly focus on hydrological drought.

MME SM – Agricultural Drought Extent

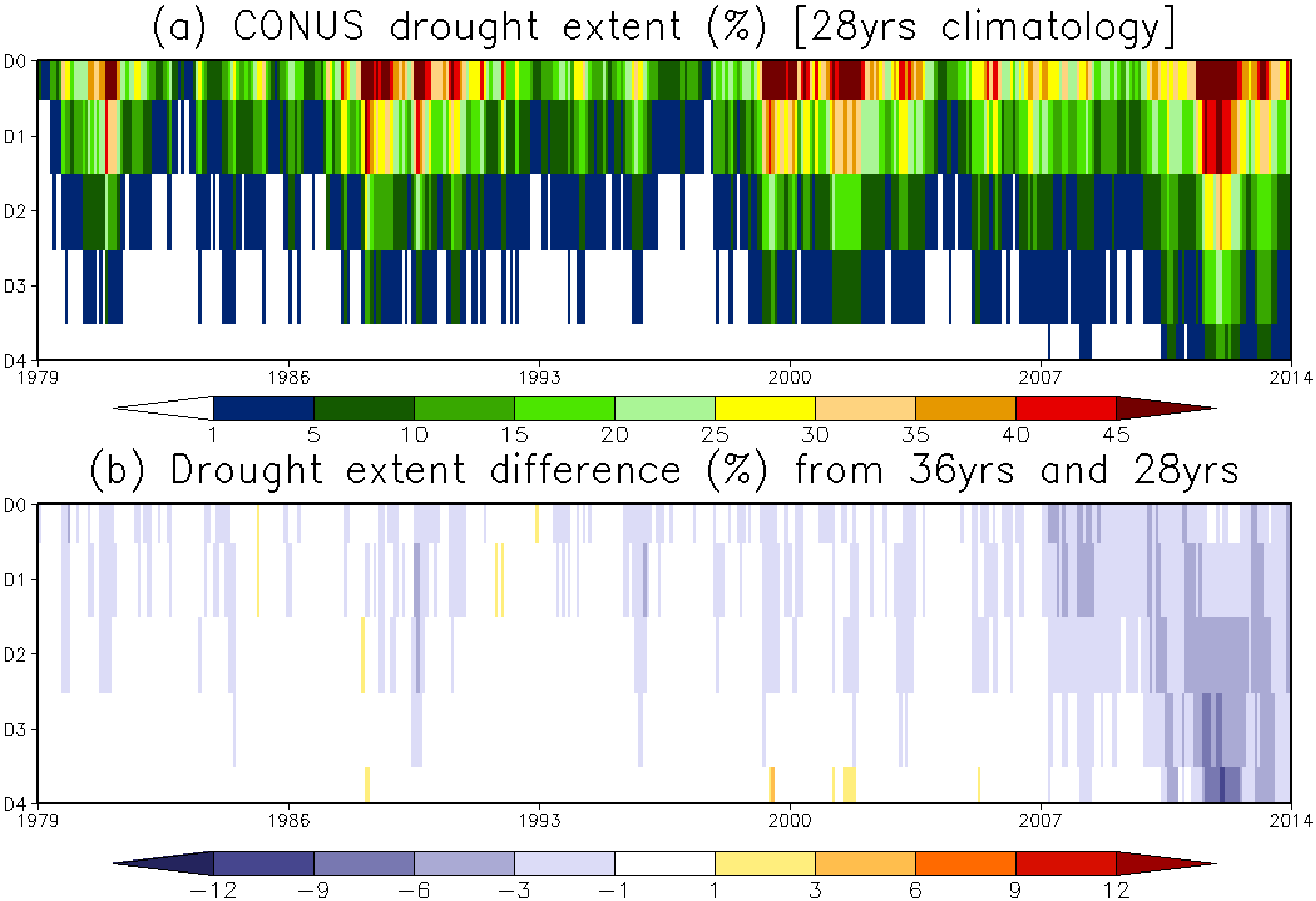


Figure 14: The same as Figure 12 but for CONUS

MME SM- Wetness Extent

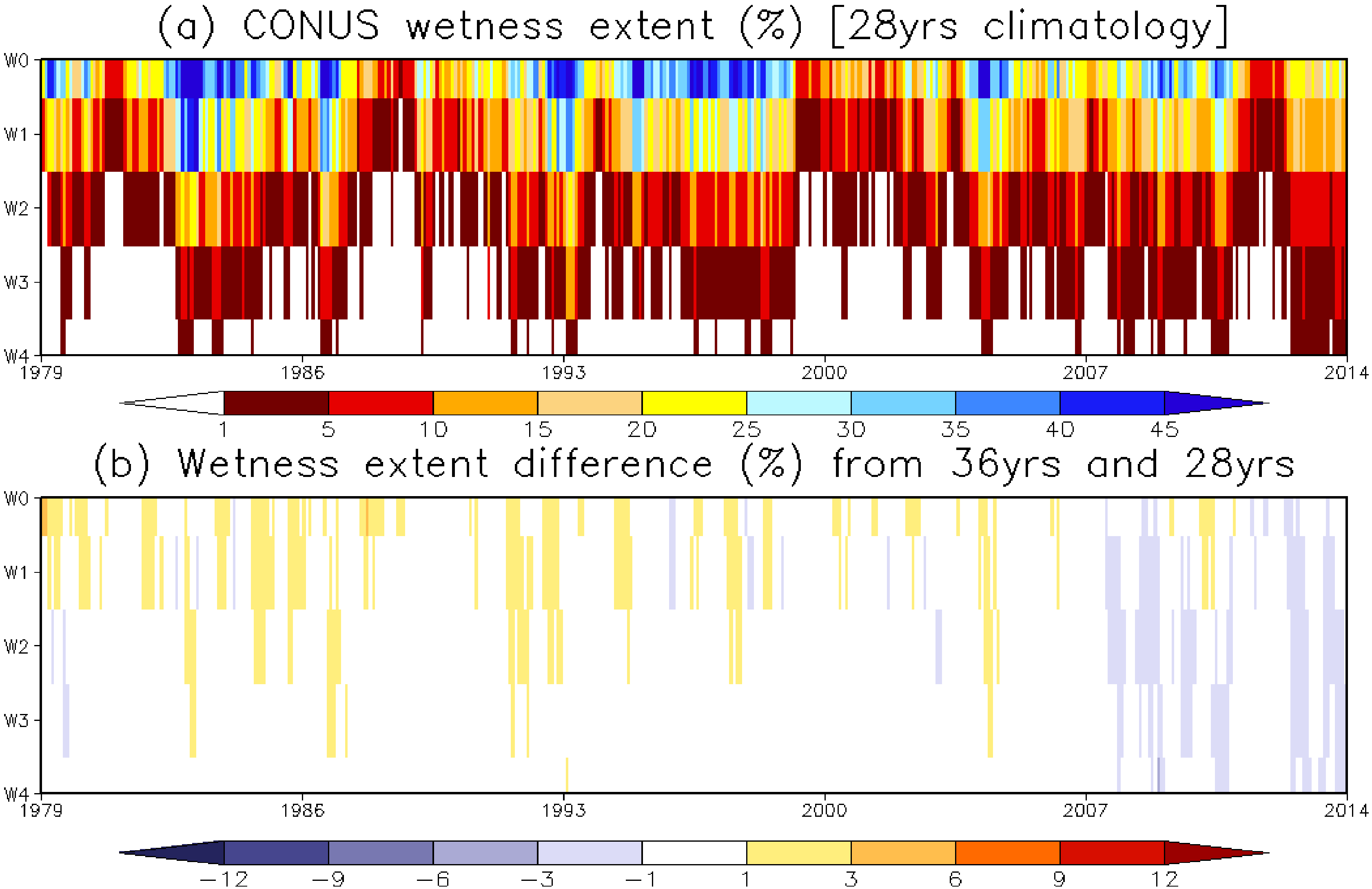


Figure 15: Monthly variation of CONUS wetness extent calculated from MME for 28yrs climatology (top panel) and difference (bottom panel) between 33yrs and 28yrs climatology when monthly soil moisture is used.

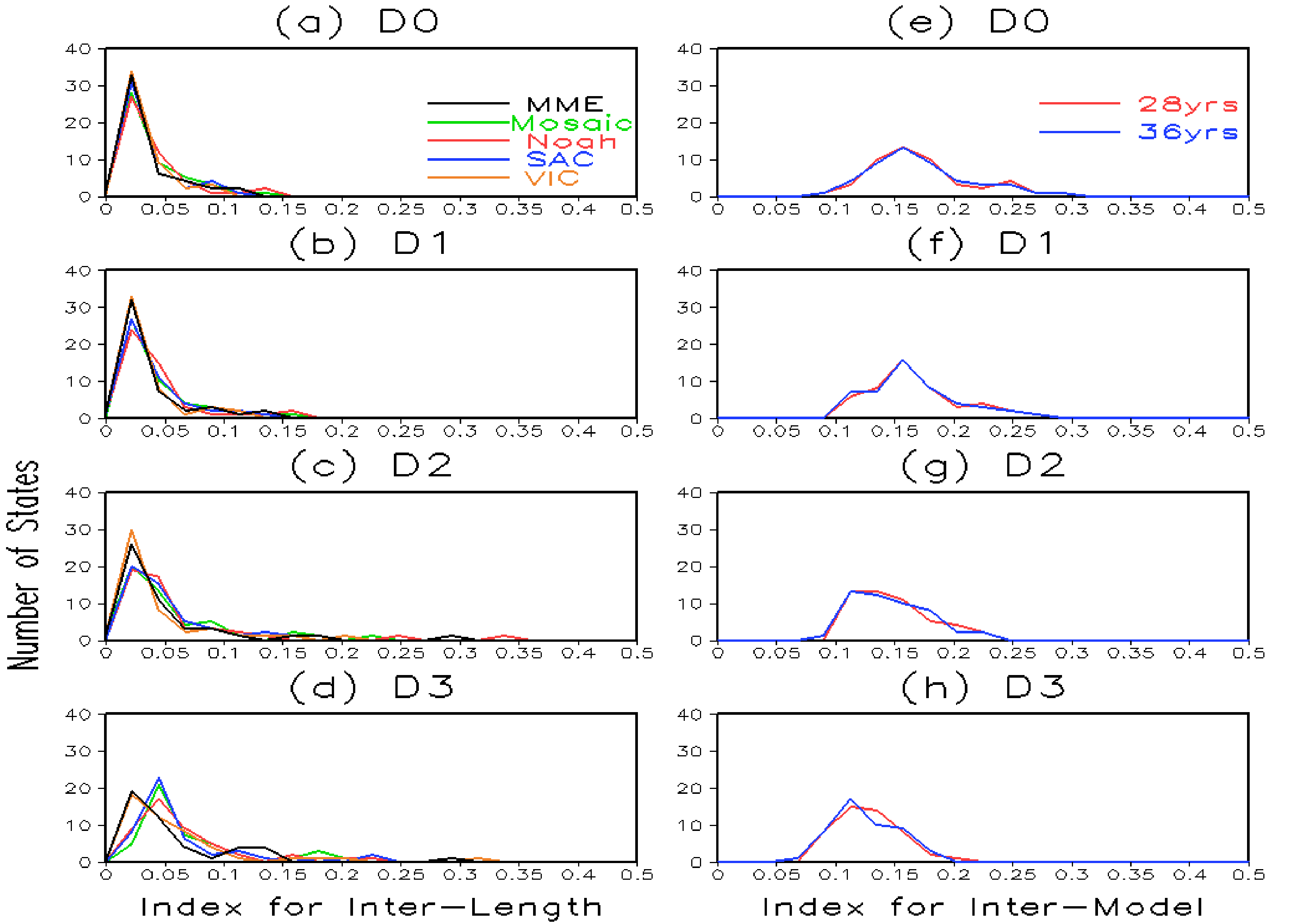


Figure 16: Inter-length and inter-model spread of CONUS drought extents for four drought categories when MME total column **soil moisture** percentiles are used. Small spread values indicate small uncertainties.

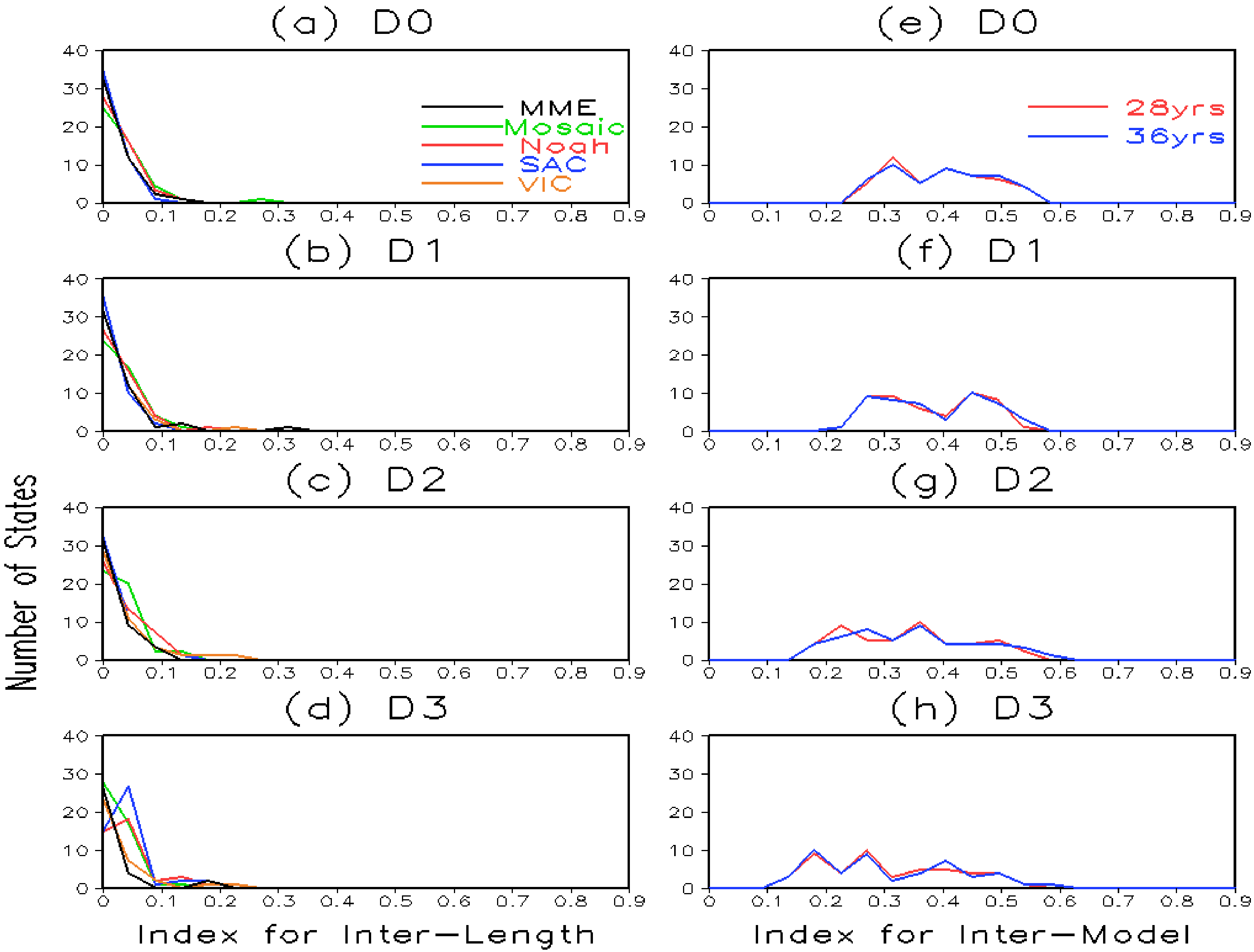


Figure 16: The same as Figure 12 but CONUS drought extent calculated by using monthly mean total **runoff** percentile when hydrological drought is considered.

Noah Model

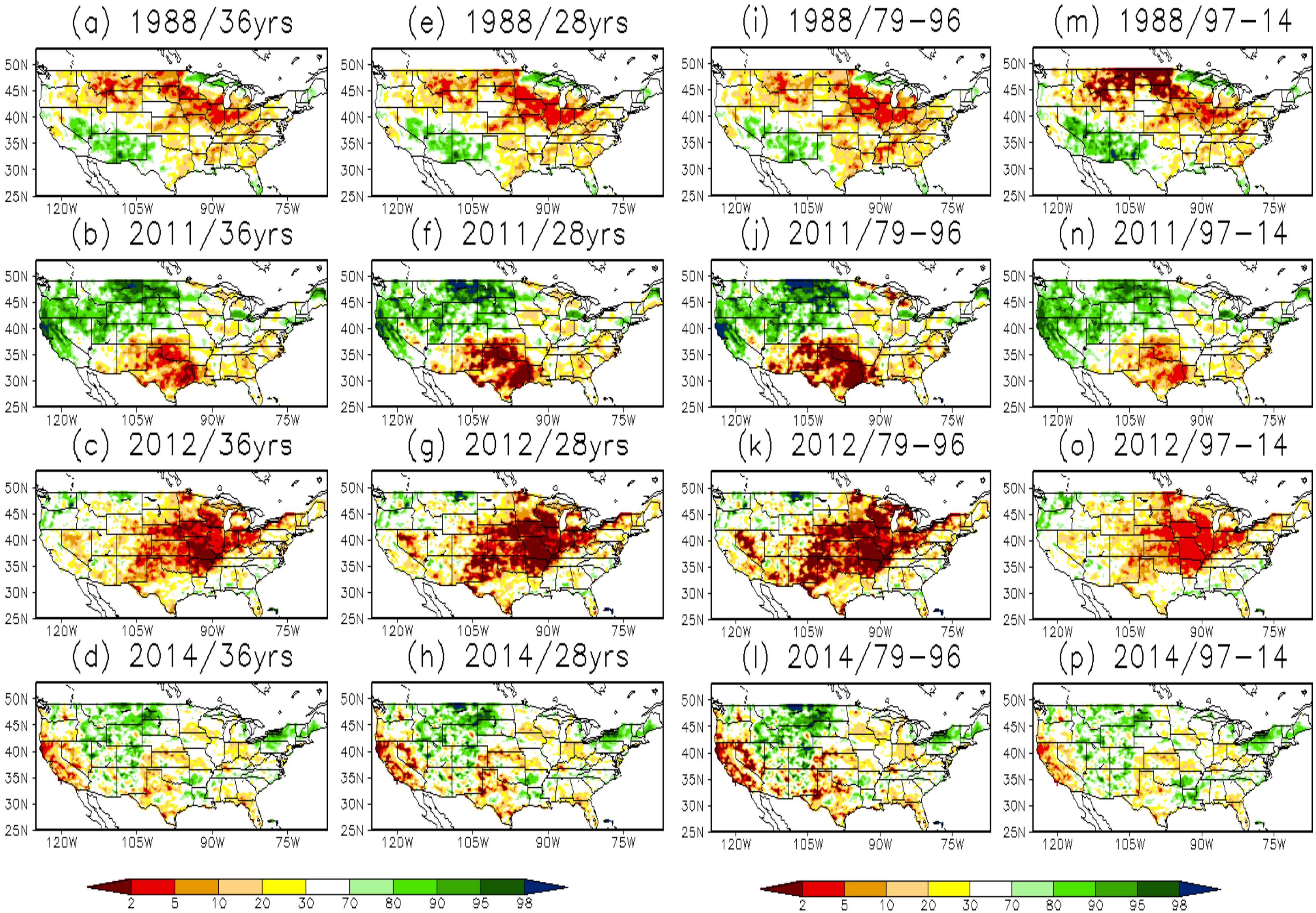


Figure 15: Comparison of monthly total column **soil moisture** percentiles simulated from Noah when different climatologies are used.

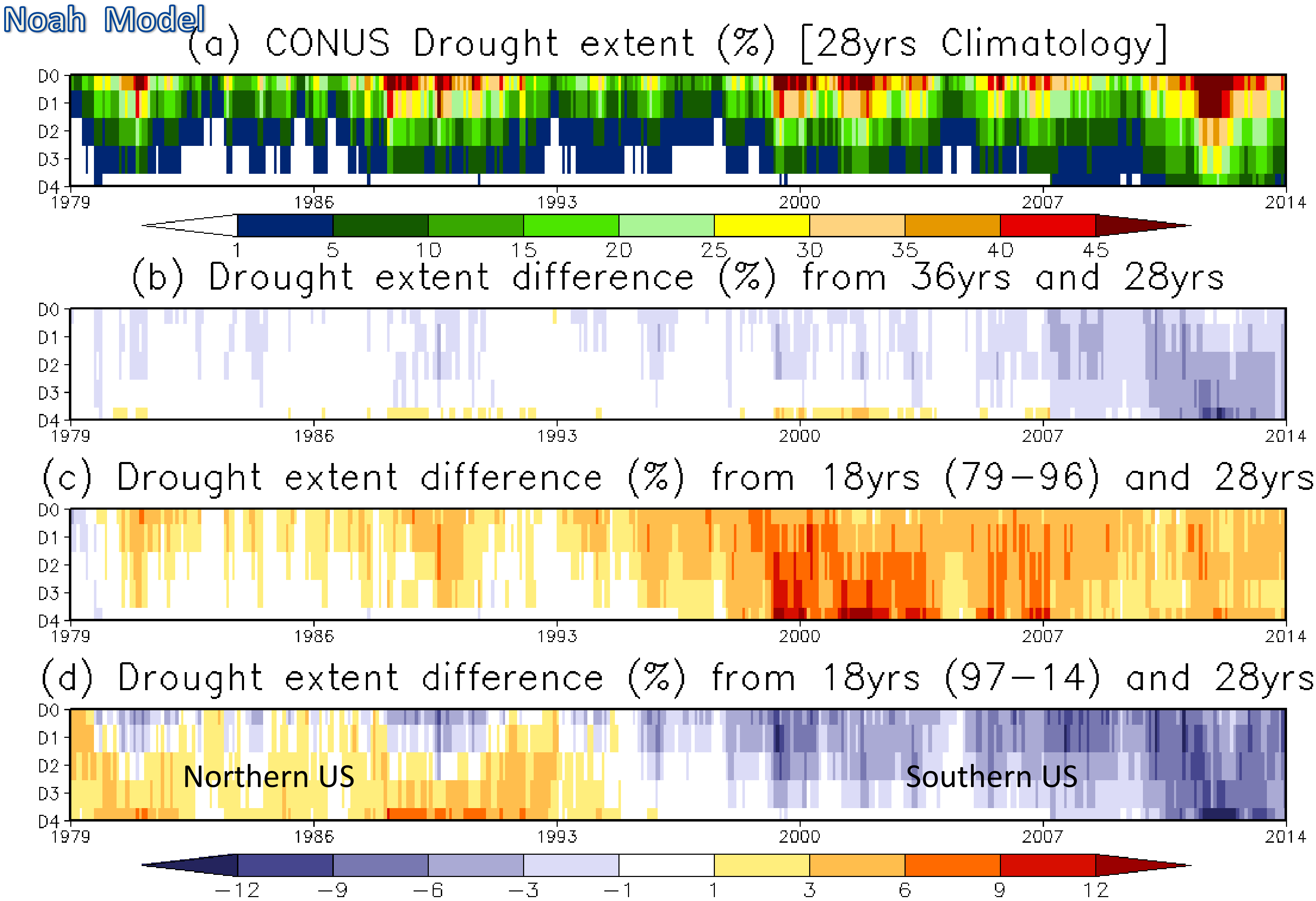


Figure 17: Monthly variation of drought extent over CONUS calculated from 28yrs CDF climatology and differences during 1979 and 2014 .

Noah Model

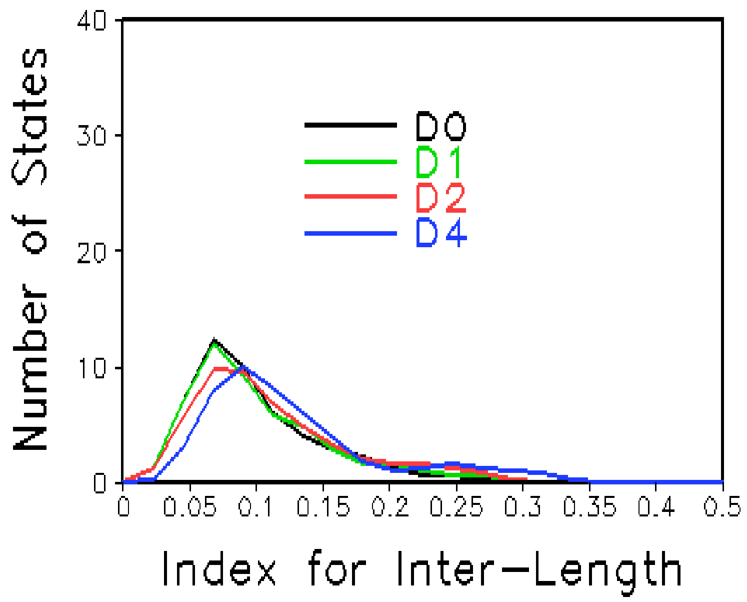


Figure 18: Inter-Length spread index of CONUS drought extents for four drought categories when four different CDF climatologies (1979-1996, 1997-2014, 1980-2007, 1979-2014) are used.

Impact of length of climatology on percent of annual precipitation occurring in given month or season in each region of CONUS

The next 4 slides illustrating above were created and provided in mid-Sep 2015

by Rich Tinker of CPC

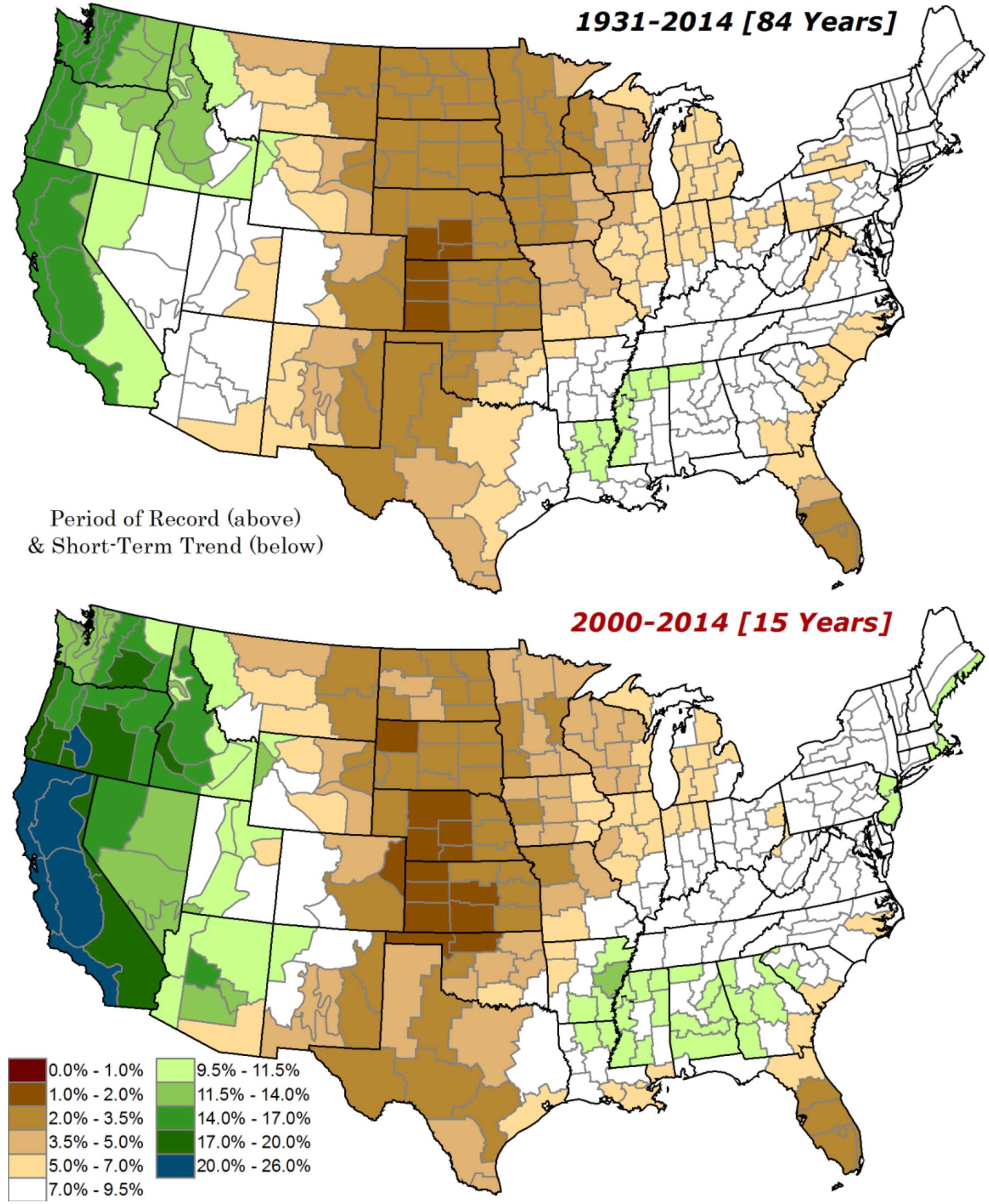
Each of next 4 slides has two frames as follows:

Top Frame:	based on <u>84-year</u> CONUS precipitation climatology (1931-2014)
Bottom Frame:	based on <u>15-year</u> CONUS precipitation climatology (2000-2014)

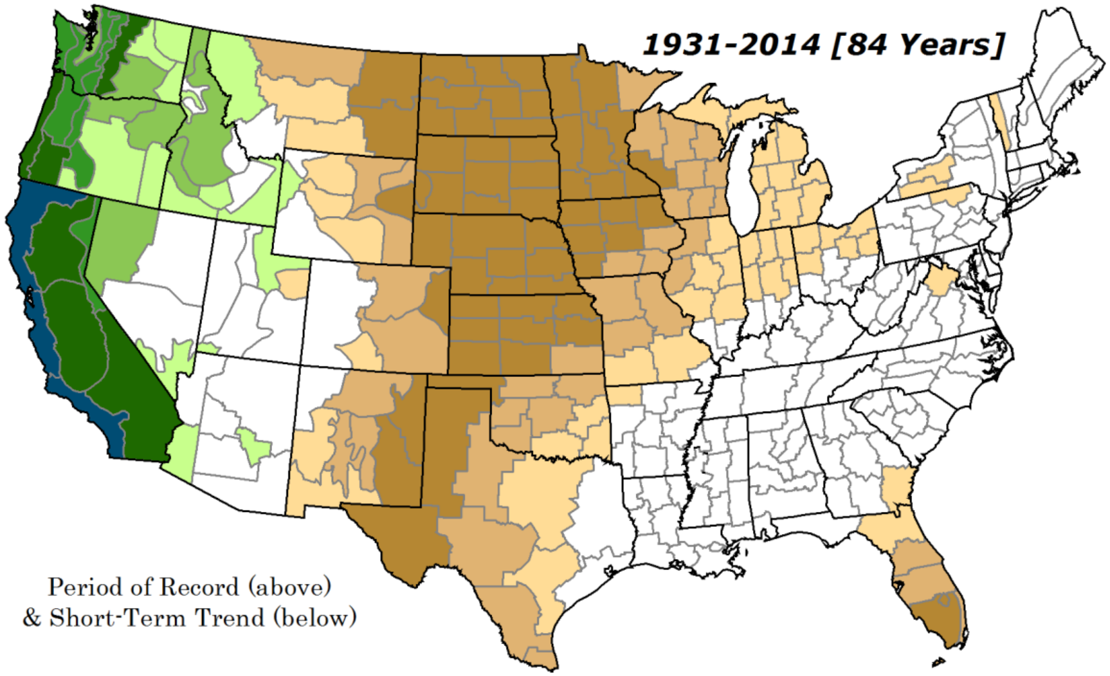
Note 1: The 15-year period of climatology in bottom frame is last 15 years of 84-year period in top frame.

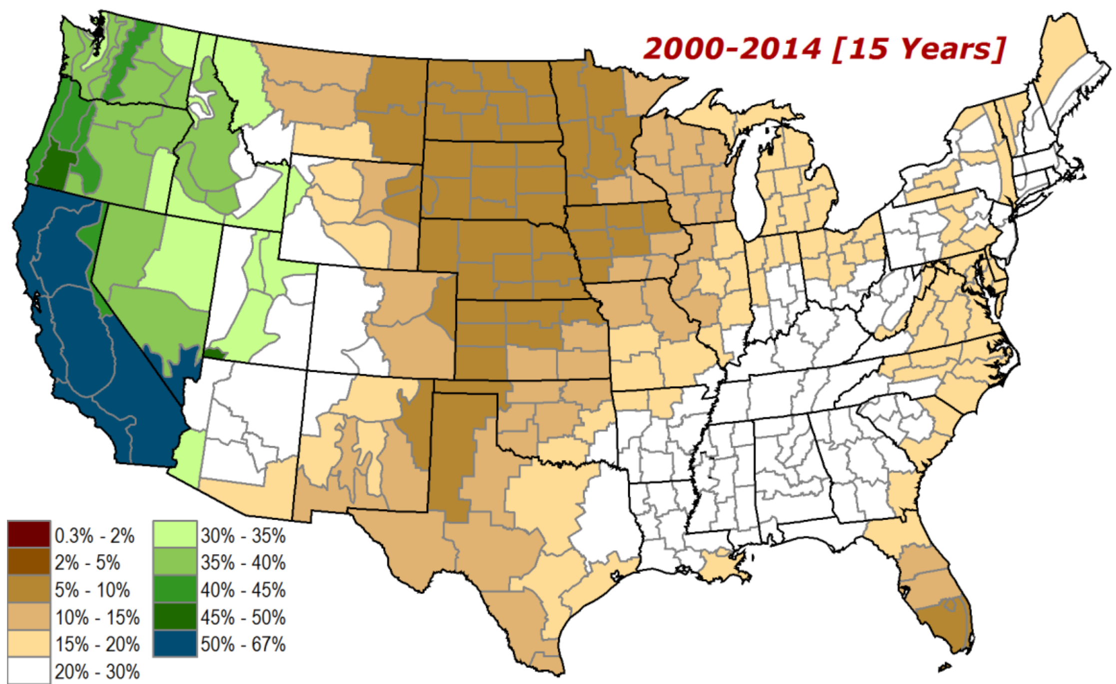
Note 2: Notice A) percent of annual California precip falling in Dec & DJF is much higher based on the 15-year versus 84-year climo and B) the percent of annual Texas precip falling in May & MJJ is much lower based on the 15-year versus 84-year climo (likely due to severe 2011- early 2015 drought in Texas).

Median Percent of Annual Precipitation -- December

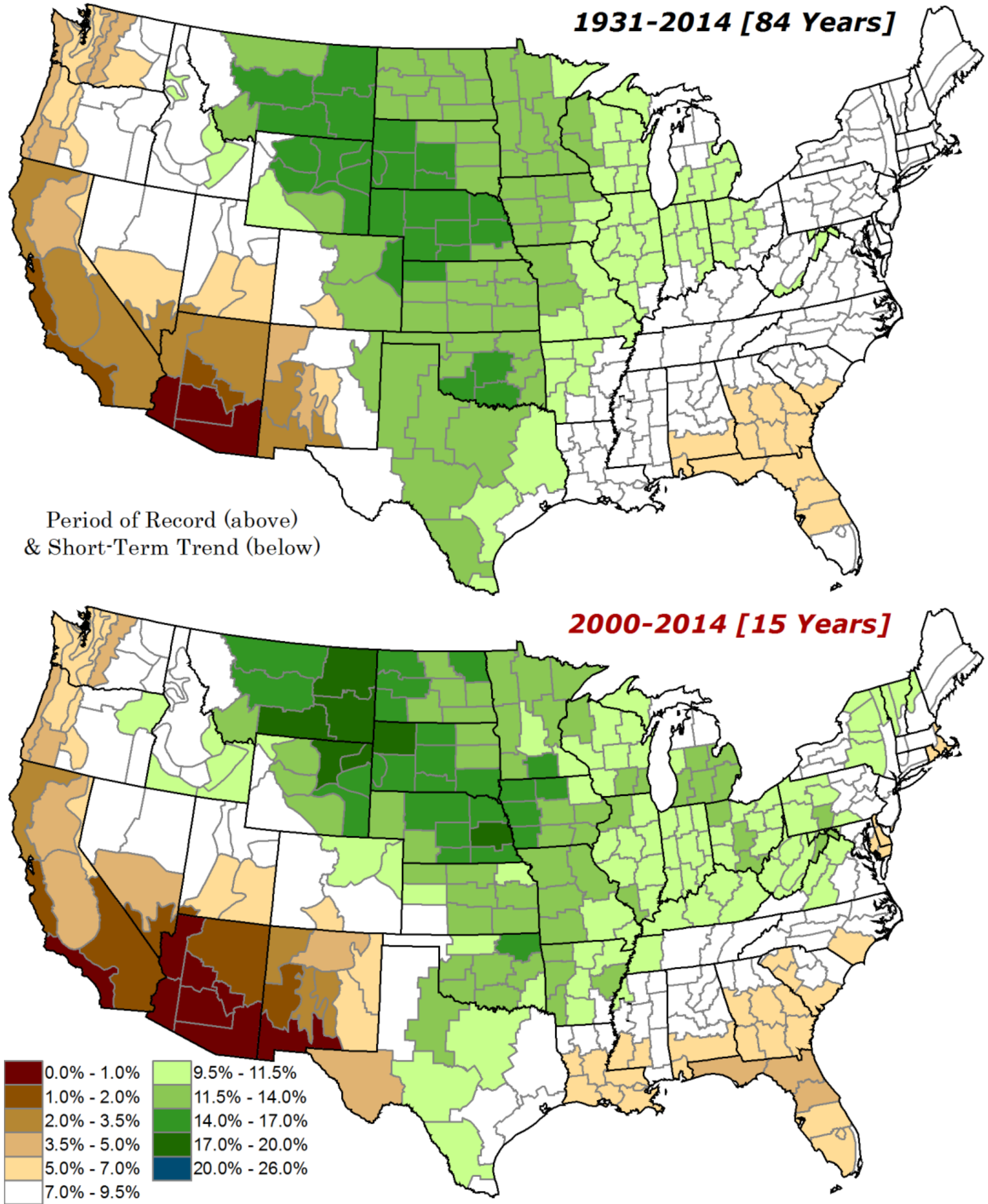


Median Percent of Annual Precipitation -- DJF

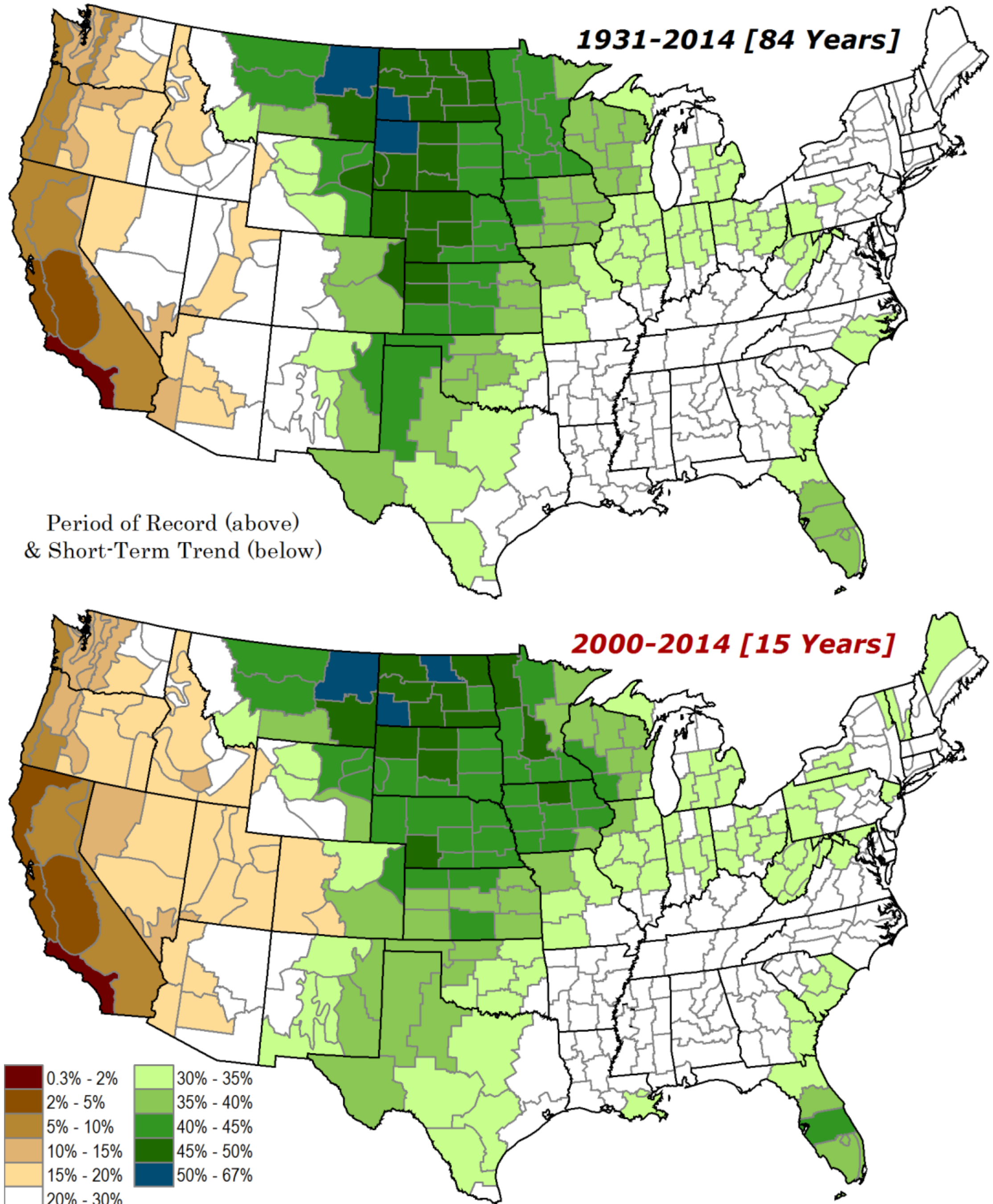




Median Percent of Annual Precipitation -- May



Median Percent of Annual Precipitation -- MJJ



Summary and Conclusion

1. Using 36yrs climatology average for NLDAS Drought monitor has small-to-moderate effects (based on contour levels) on anomaly metrics at three time scales when compared with current NLDAS drought monitor with 28yrs climatology average.

2. Using 36yrs climatology CDF to calculate percentiles for NLDAS drought monitor shows large impacts for extreme events when compared with current NLDAS drought monitor with a 28yrs CDF. As many extremely strong drought events in recent several years are introduced to CDF climatology, if updated, both drought extents and intensity will be decreased as expected. This case is true for both agricultural and hydrological drought monitoring.

3. To compare the inter-length spread (from different climatologies) with inter-model spread (from different models), models have larger uncertainties than different climatologies for both agricultural and hydrological drought extents. As demonstrated in Xia et al. (2012a, 2014), hydrological drought extents have the largest uncertainties as they have the largest spread values.

4. The further investigation with two independent 18 years (1979-1996, 1997-2014) for Noah model displays that CONUS drought extent has large differences when compared to 28yrs CDF climatology, suggesting significant impact on drought area and intensity estimates.

Optimal Climatology Estimation – a Possible Solution

1. **Spectral Smooth Method:**
   Narapusetty, B., T. DelSole, and M. K. Tippett, 2009: Optimal Estimation of the Climatological Mean. J. Climate, 22, 4845-4859. – David Mocko is working with B. Narapusetty to test this method for NLDAS-2 data

2. Using 1980-2009 to recalculate NLDAS-2 Climatology to replace 1980-2007 or just keep current climatology for NLDAS drought monitor??

3. Community support to provide a reasonable method to calculate "optimal" climatology