A Probabilistic Framework for Assessing Drought Recovery

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CAZALAC

ICIWaRM

International Expert Symposium "Coping with Droughts"
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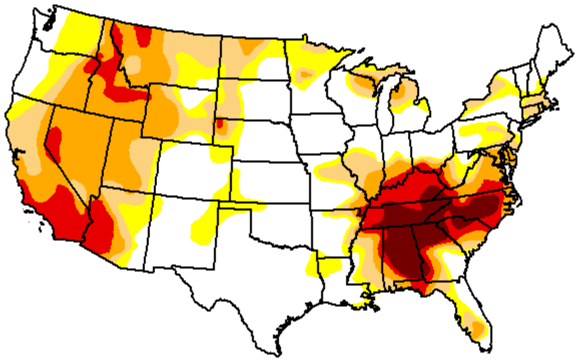
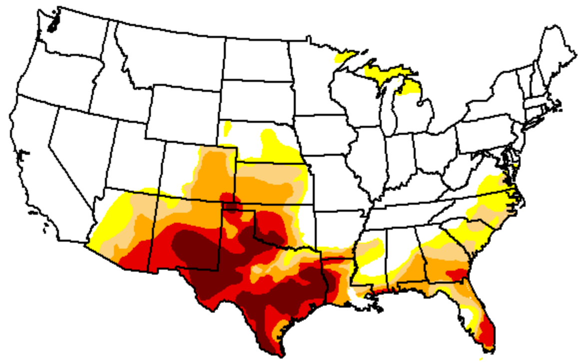
Background: Some Recent Droughts in US

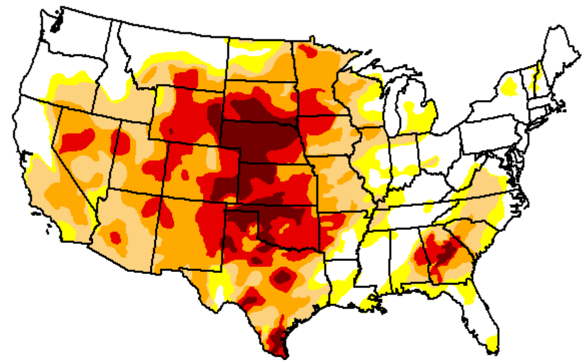
2007 Southeast

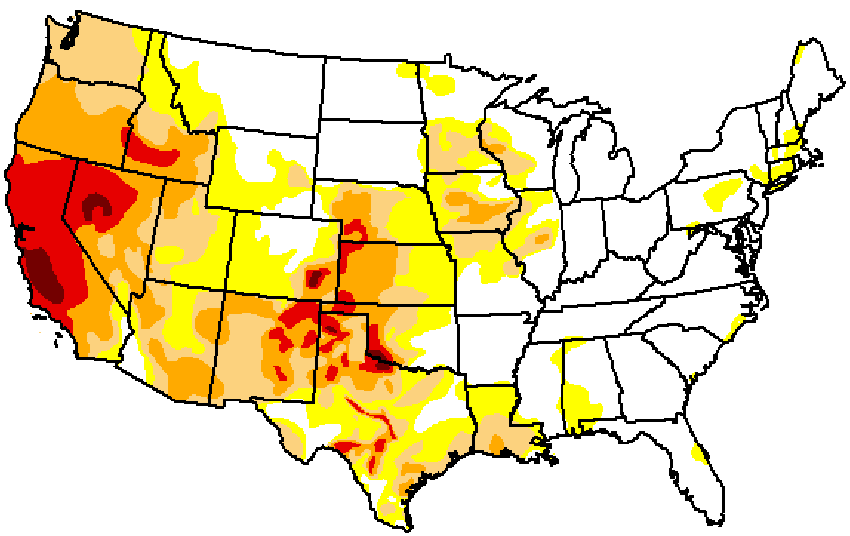


2011 Texas



2012-2013 Central US





Background

Drought Monitoring and Hydrologic Forecasting with VIC

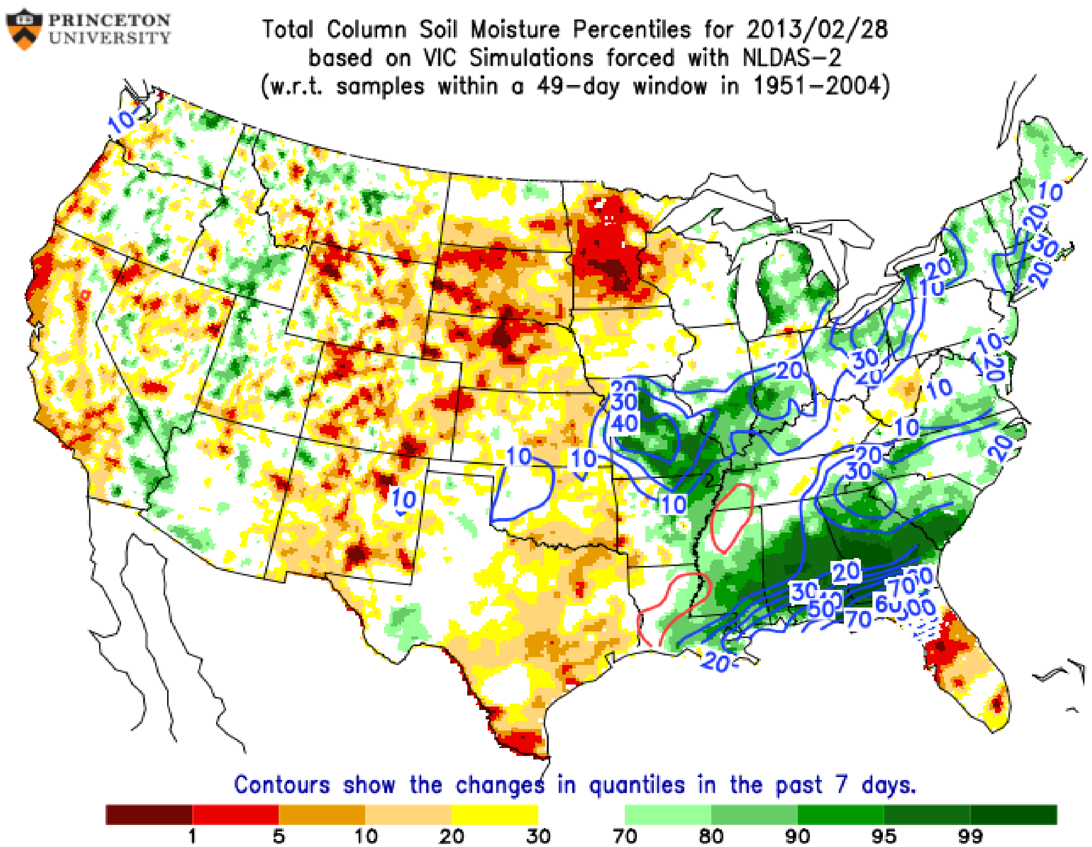
Nowcast/Forecast | Historical Droughts/Hindcast | Documentation | About the Project

As of 2012/05/01, CFS forecasts are switched to CFSv2. Hover mouse on items to see more info.

Product/Date/Variable (click to change)

Monitoring validated < 2013/02/28 > for ◉ Soil Moisture ○ Snow ○ Streamflow ○ Precipitation

Forecast initialized < 2013/02/01 > for ○ Soil Moisture ○ Drought Probability



Link to Image

Timeline (click & hover to change)

	2012/12/13
	2012/12/20
	2012/12/27
Preceding	2013/01/03
Monitoring	2013/01/10
	2013/01/17
	2013/01/24
	2013/01/31

Forcast	CFS	CPC	ESP	Verif
2013/02	0.5mo	0.5mo	0.5mo	0.5mo
2013/03	1.5mo	1.5mo	1.5mo	1.5mo
2013/04	2.5mo	2.5mo	2.5mo	2.5mo
2013/05	3.5mo	3.5mo	3.5mo	3.5mo
2013/06	4.5mo	4.5mo	4.5mo	4.5mo
2013/07	5.5mo	5.5mo	5.5mo	5.5mo

Monitoring from other centers:

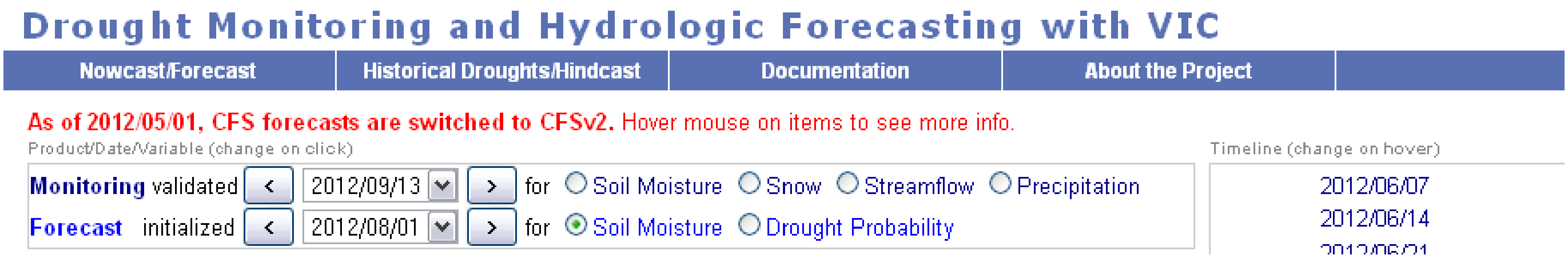
- US Drought Monitor
- USGS Streamflow/Drought
- CPC Drought Severity
- CPC Soil Moisture
- UW Surface Water Monitor
- NLDAS Drought Monitor

Website created by **Lifeng Luo** and maintained by **Ming Pan**
EEWR/CEE, **Princeton University**
Last update: Wed Feb 6 12:52:11 2013 EST

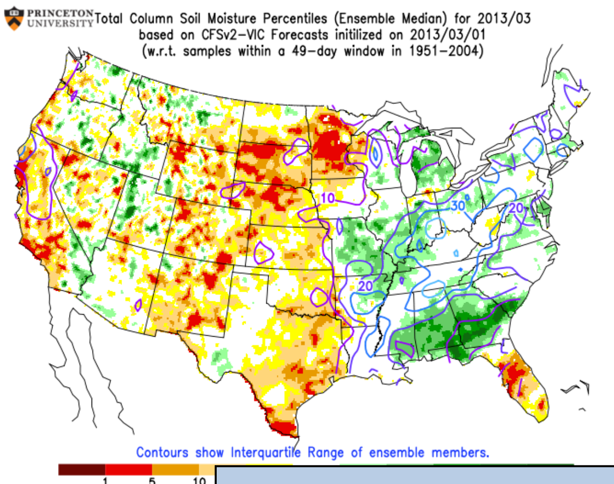
The Challenge

How can we provide useful (skillful) forecasts of drought recovery that would include meteorological drought, agricultural drought and hydrological drought?

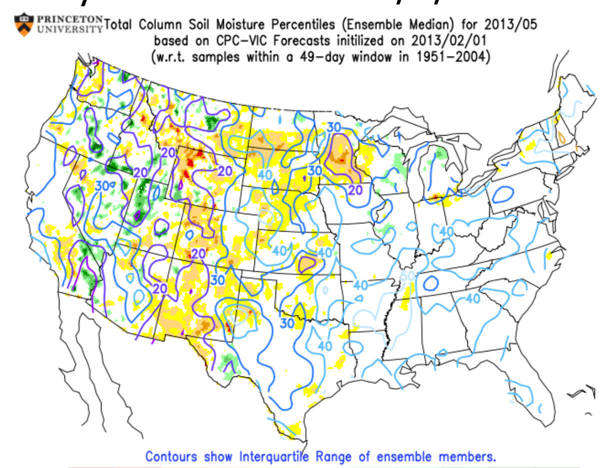
(i) Using dynamical seasonal forecast models
(ii) Using ESP: "Ensemble Streamflow Prediction" approach based on historical analogues



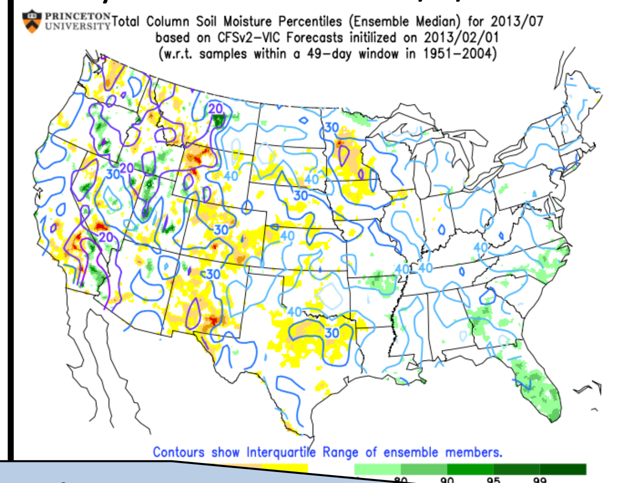
March 2013 initialized 3/1/2013



May 2013 initialized 3/1/2013

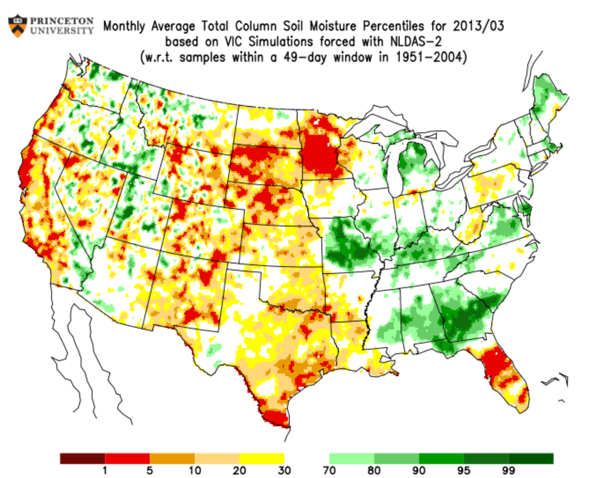


July 2013 initialized 3/1/2013

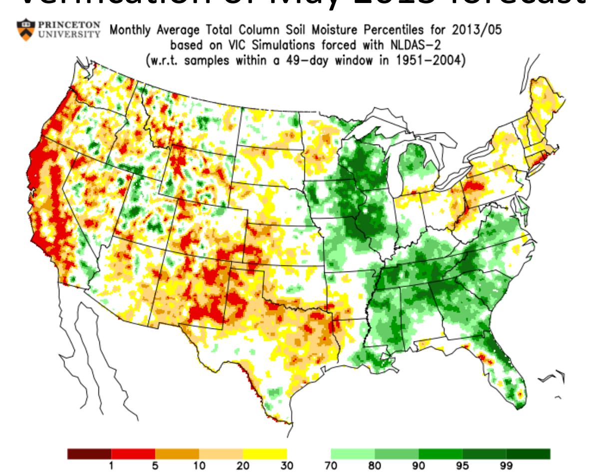


NOAA'S forecast model didn't hold drought conditions.

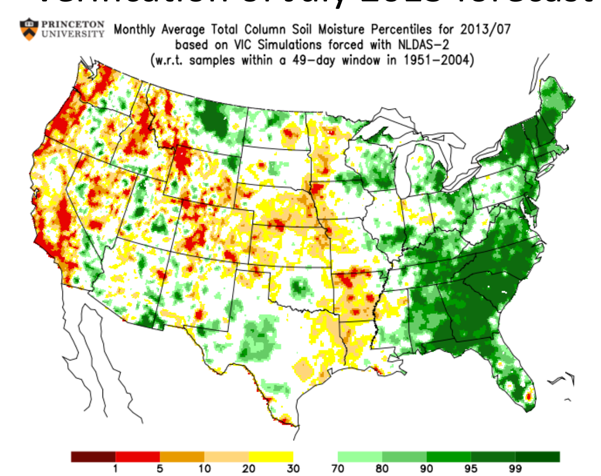
Verification of Mar 2013 forecast



Verification of May 2013 forecast



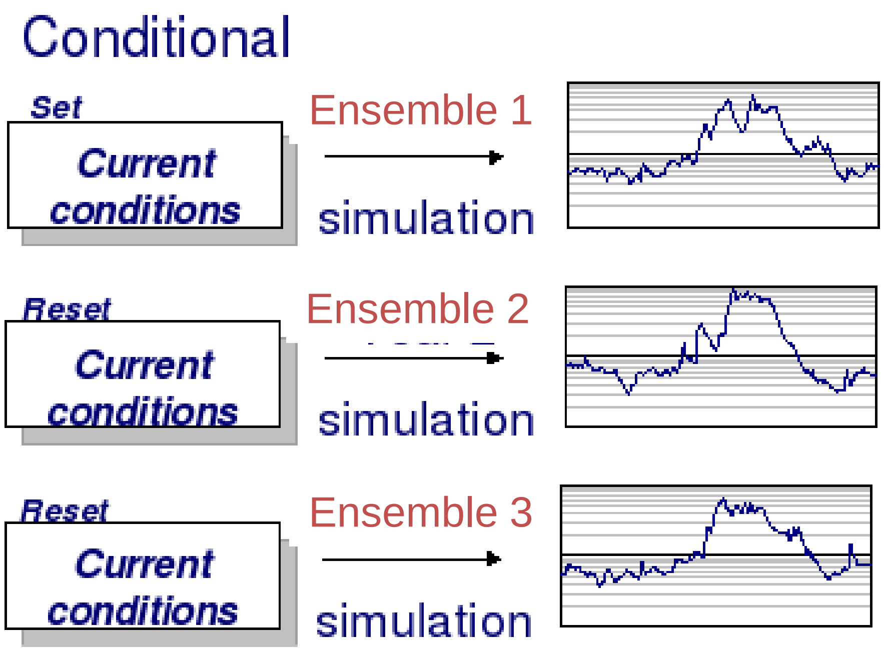
Verification of July 2013 forecast



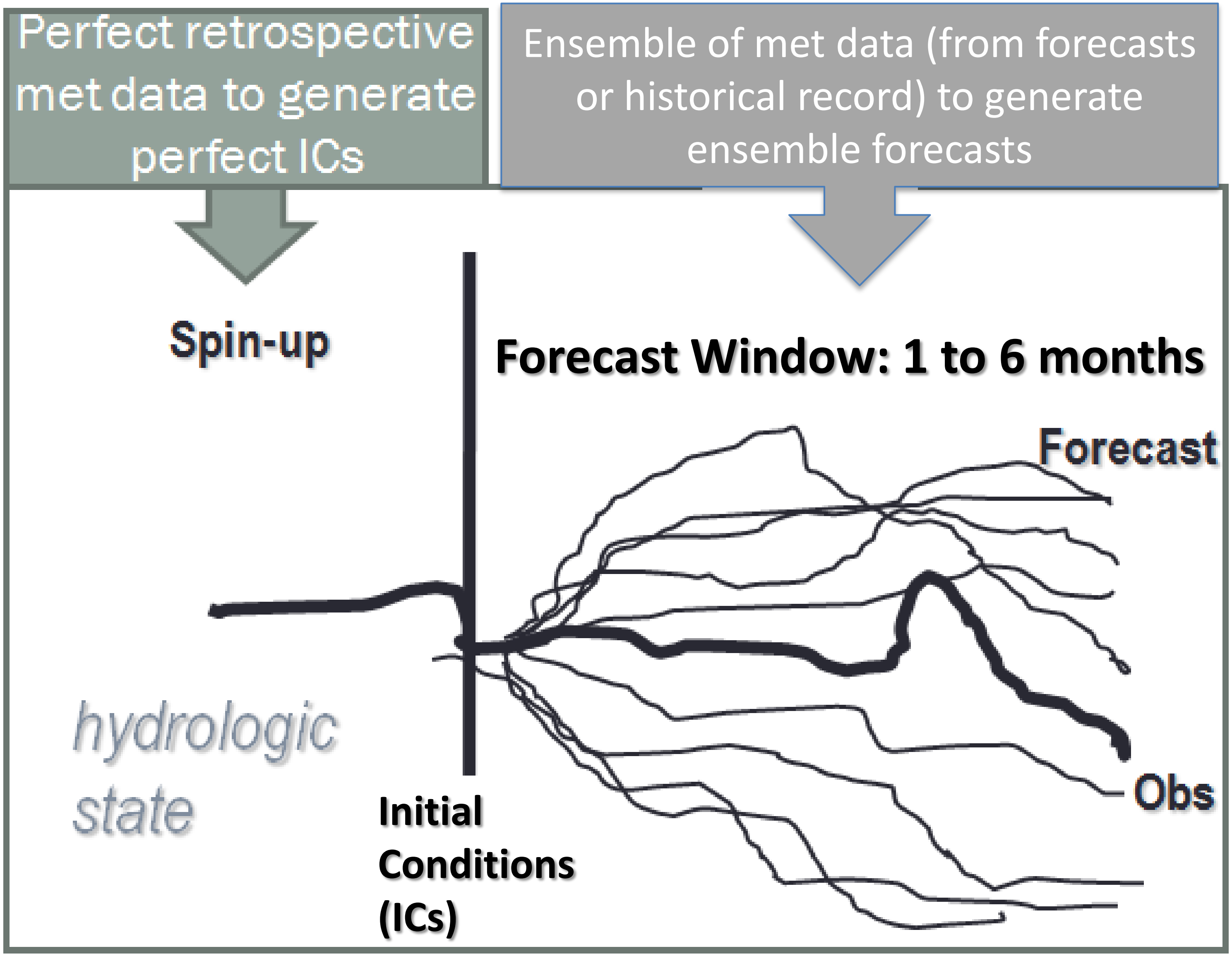
ESP Technique

ESP scenario (ensemble) simulation uses current hydrologic states with resampling historical or forecast meteorology

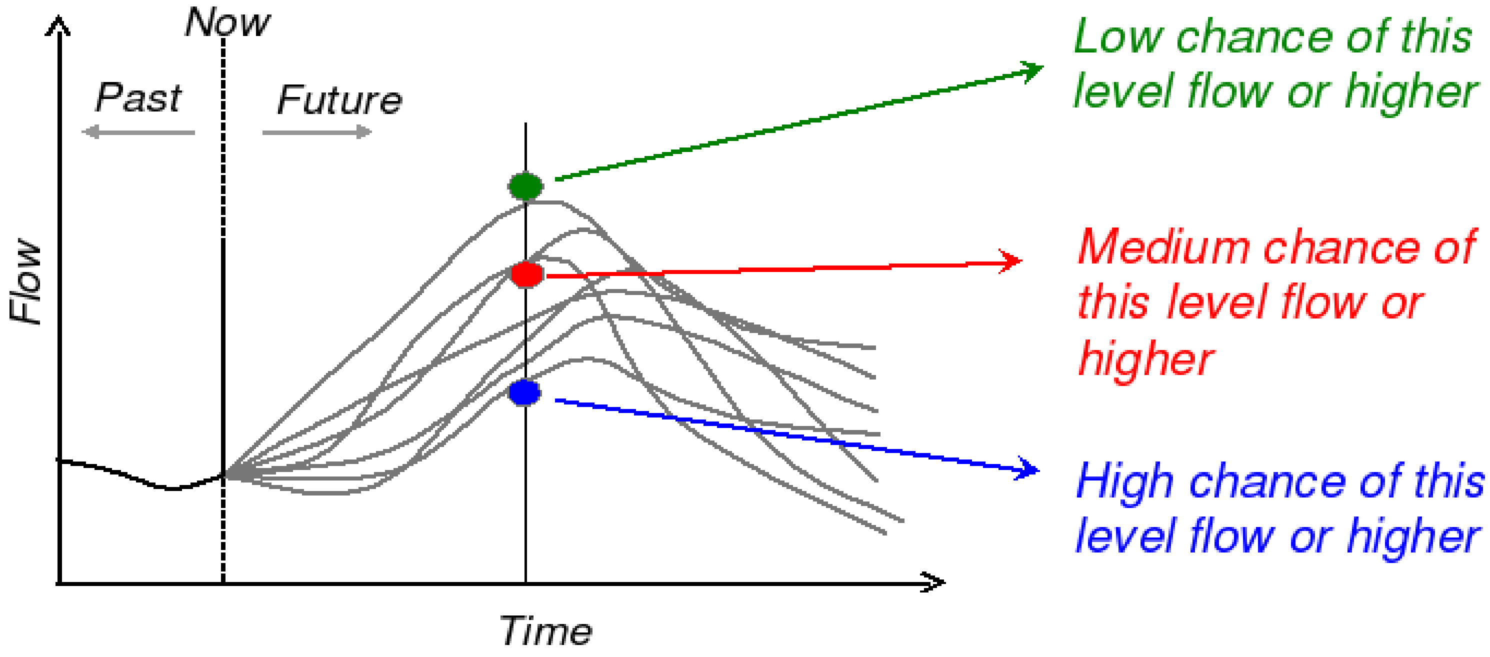
- Starts the model at current model states
- Resets to the current model states for each year
- Each simulation begins with the same conditions



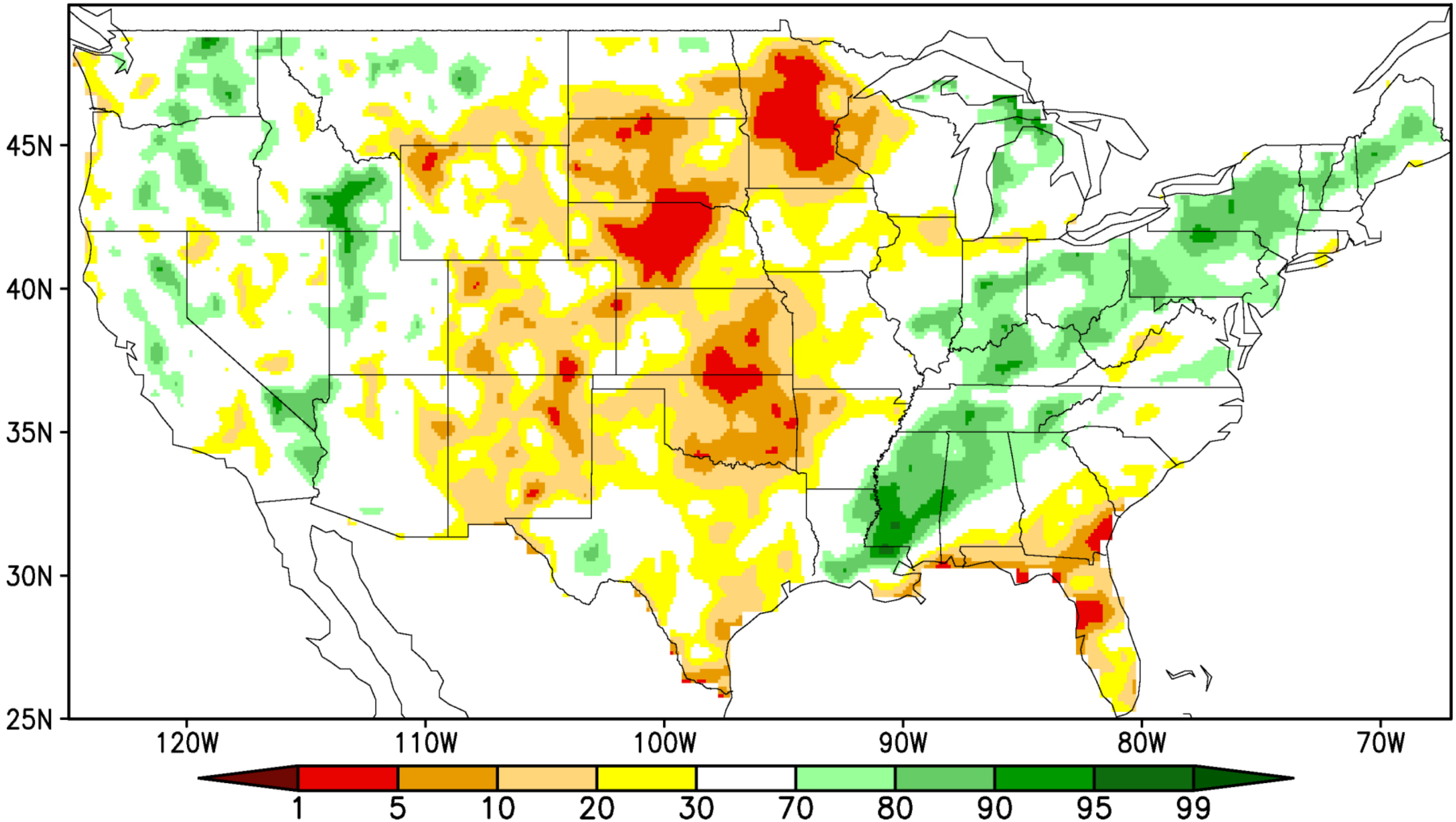
ESP Approach



ESP Technique → Risk Assessment

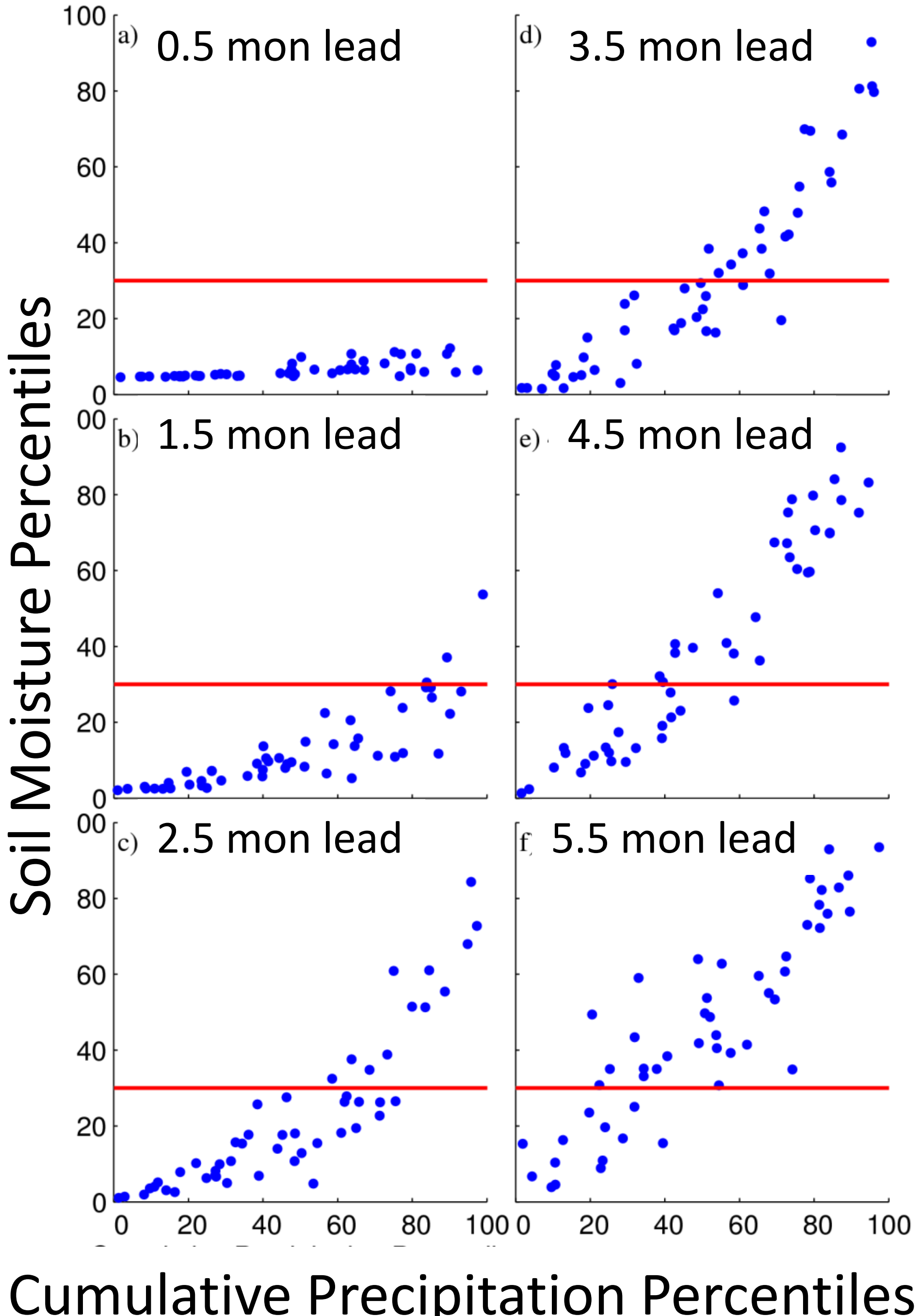


Application: Recovery from the 2012 USA drought



Soil Moisture percentile for January 2013.

Applying ESP for Drought Recovery



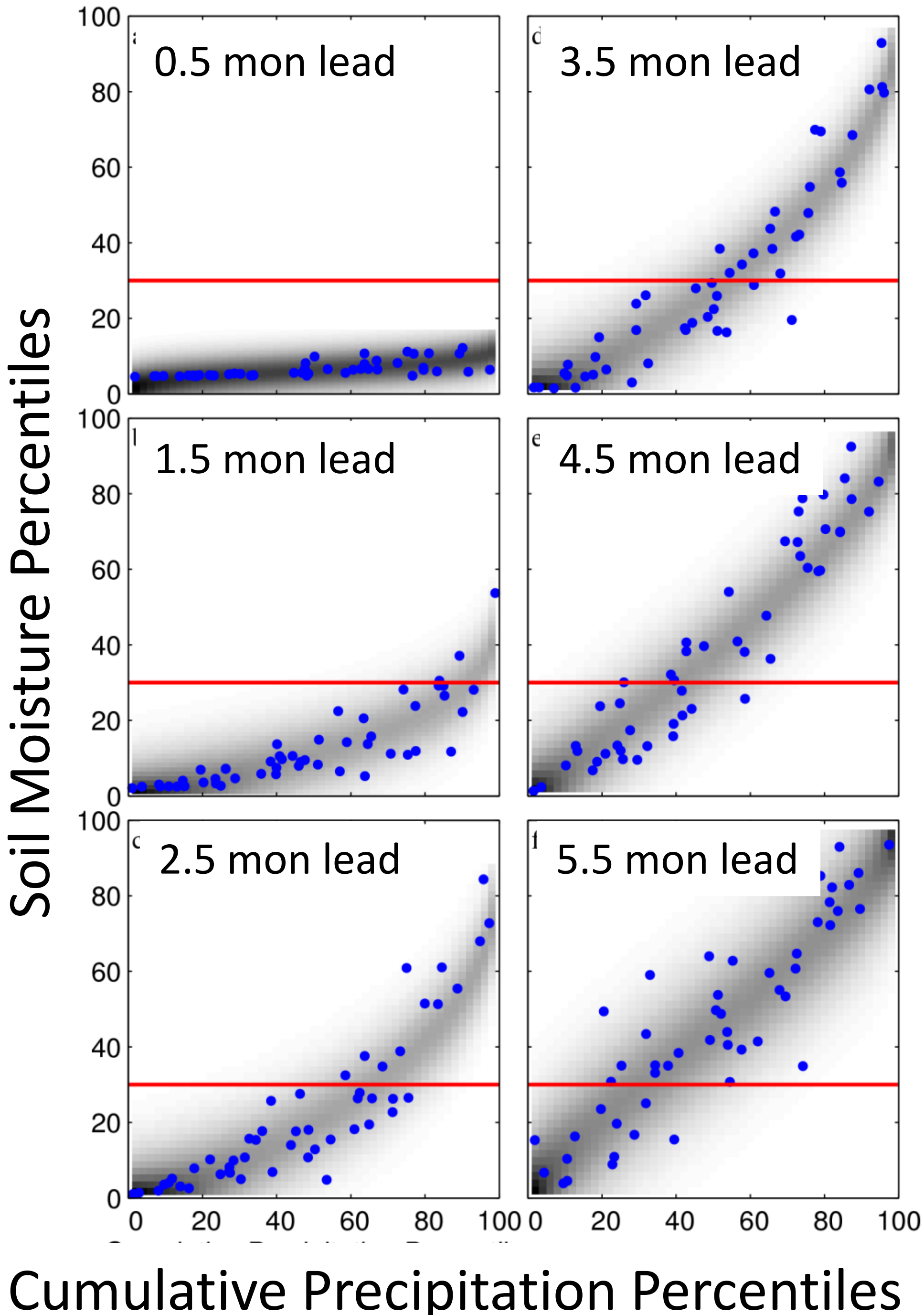
1. Using current hydrologic conditions (soil moisture from January 2013), run ESP scenarios using historic meteorological forcings (50 years).
2. For specific forecast lead times, convert soil moistures values (for a location or region) and cumulative precipitation amounts to percentiles.
3. Fit joint probability distributions using copula functions.

Copula for Constructing Joint Distribution

Sklar's theorem:

$$F_{X,Y}(x, y) = C(F_X(x), F_Y(y))$$

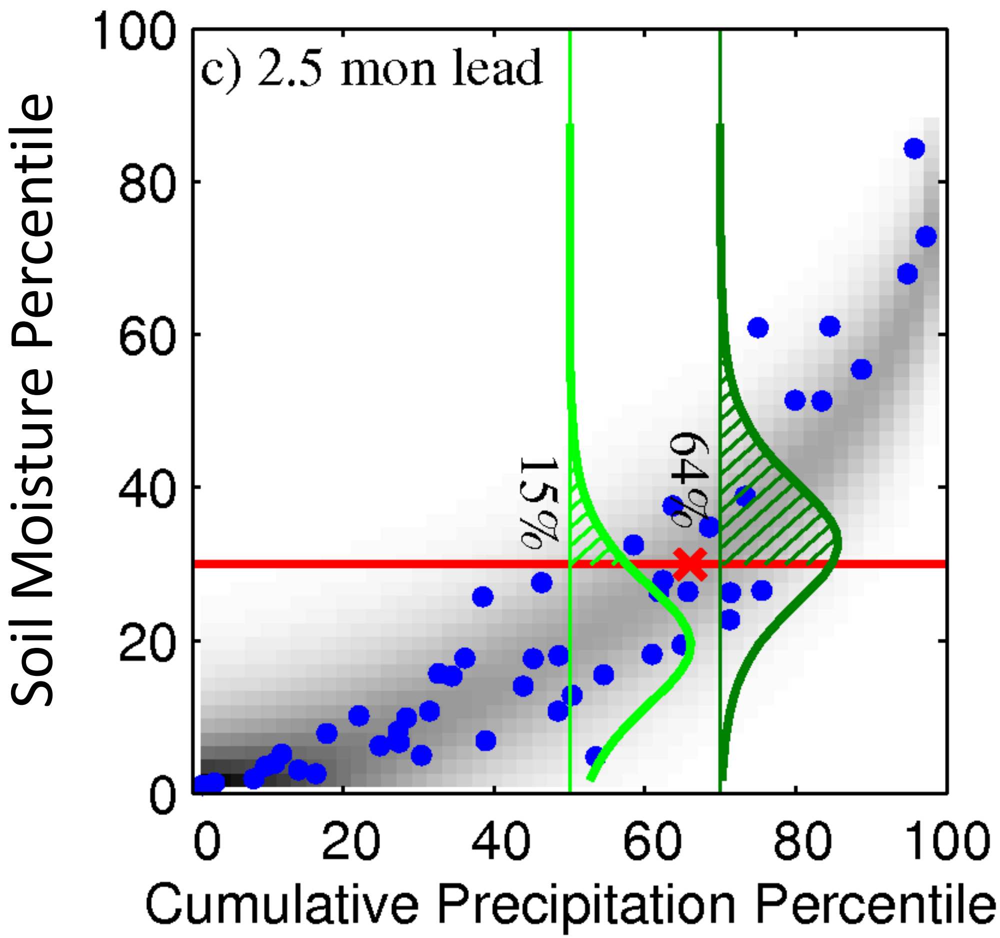
$F_{X,Y}$	:	joint CDF
F_X	:	marginal CDF of X
F_Y	:	marginal CDF of Y
C	:	copula function



Applying ESP for Drought Recovery

4. Fitting a joint distribution to the ESP simulations results in a smooth distribution that provides an estimate of recovery (above a drought threshold) and the uncertainty (risk) of recovery conditioned on the cumulative precipitation.

Copula provides probability of drought recovery



ESP Ensemble

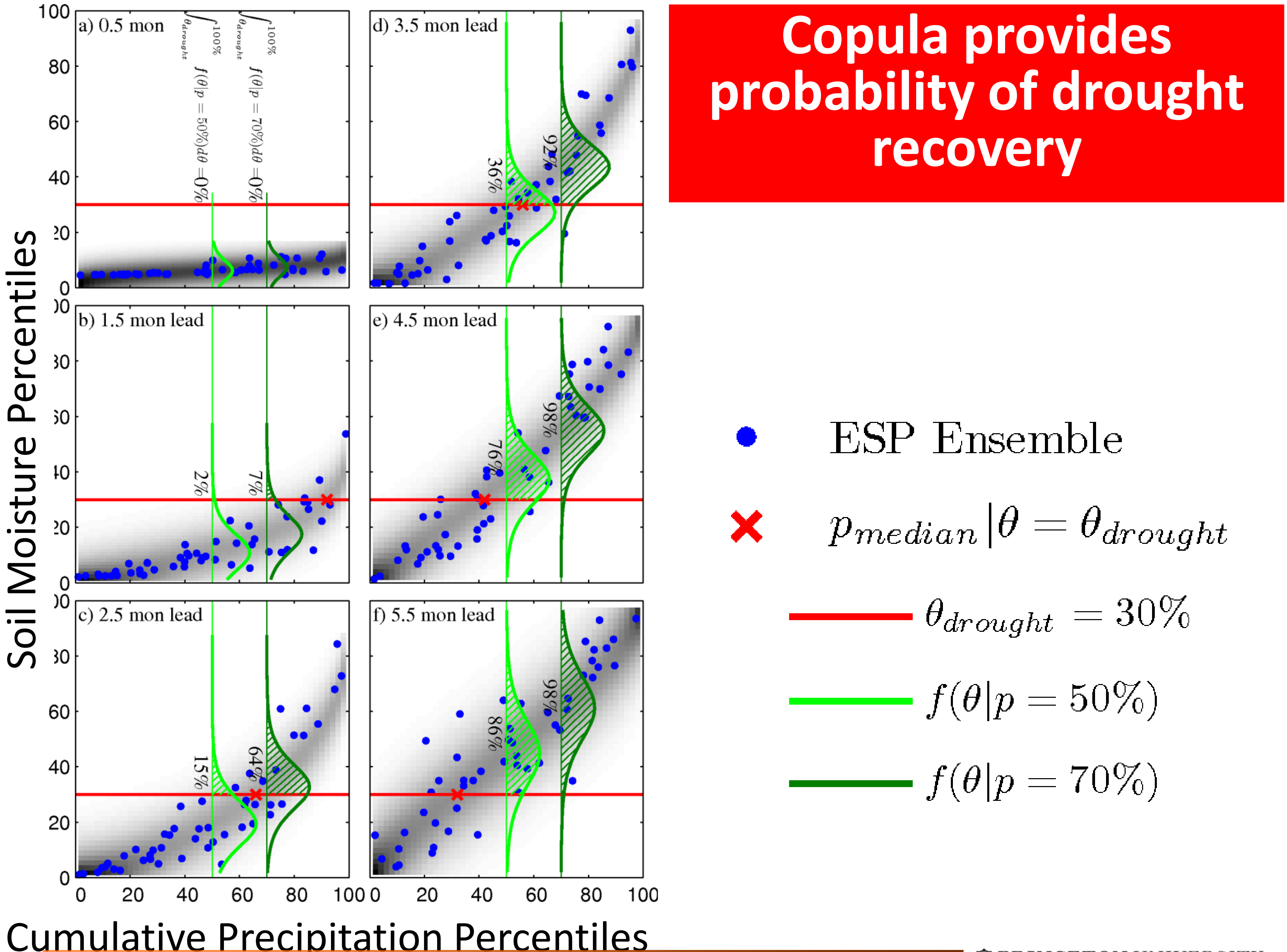
$p_{median} | \theta = \theta_{drought}$

$\theta_{drought} = 30\%$

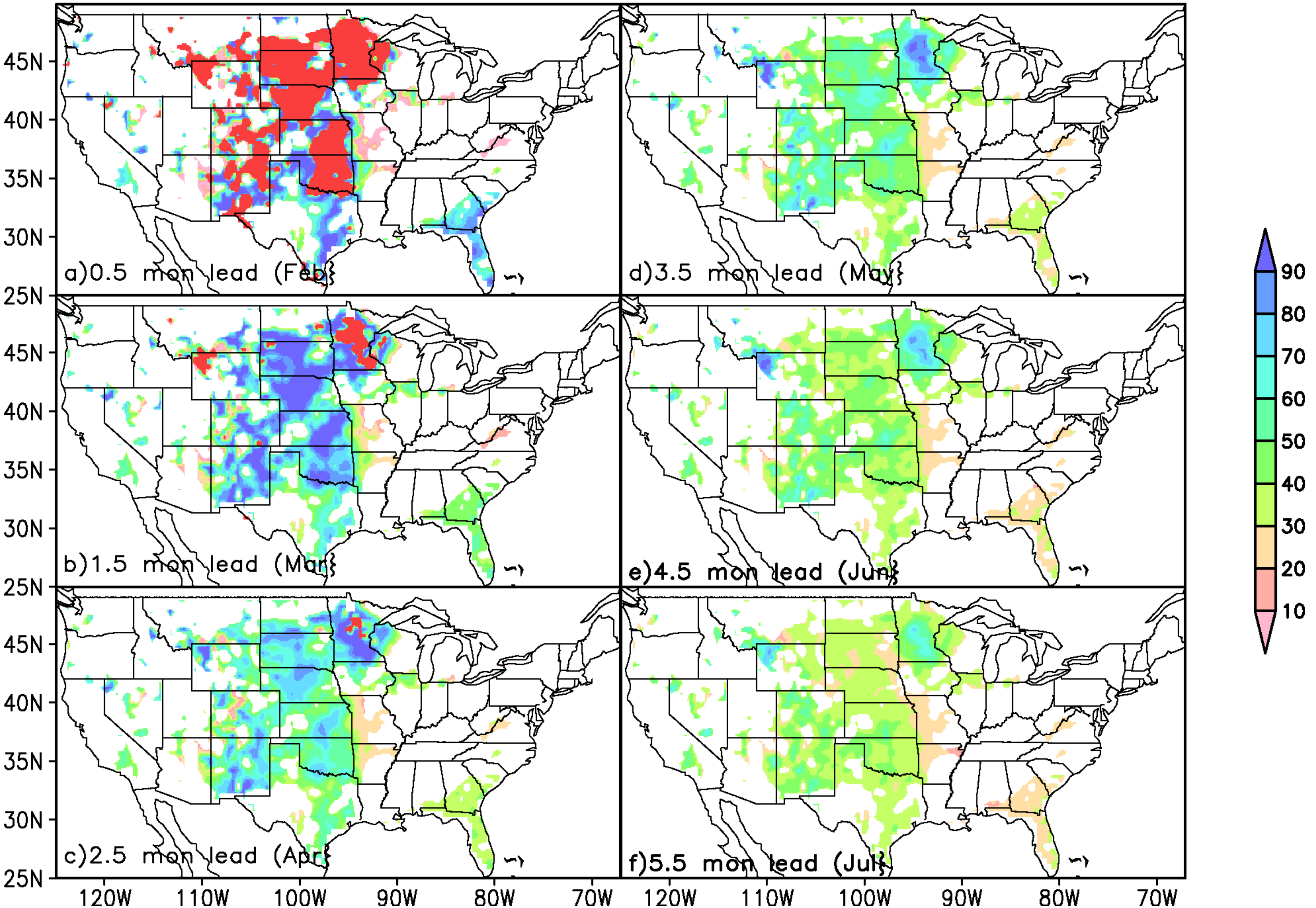
$f(\theta | p = 50\%)$

$f(\theta | p = 70\%)$

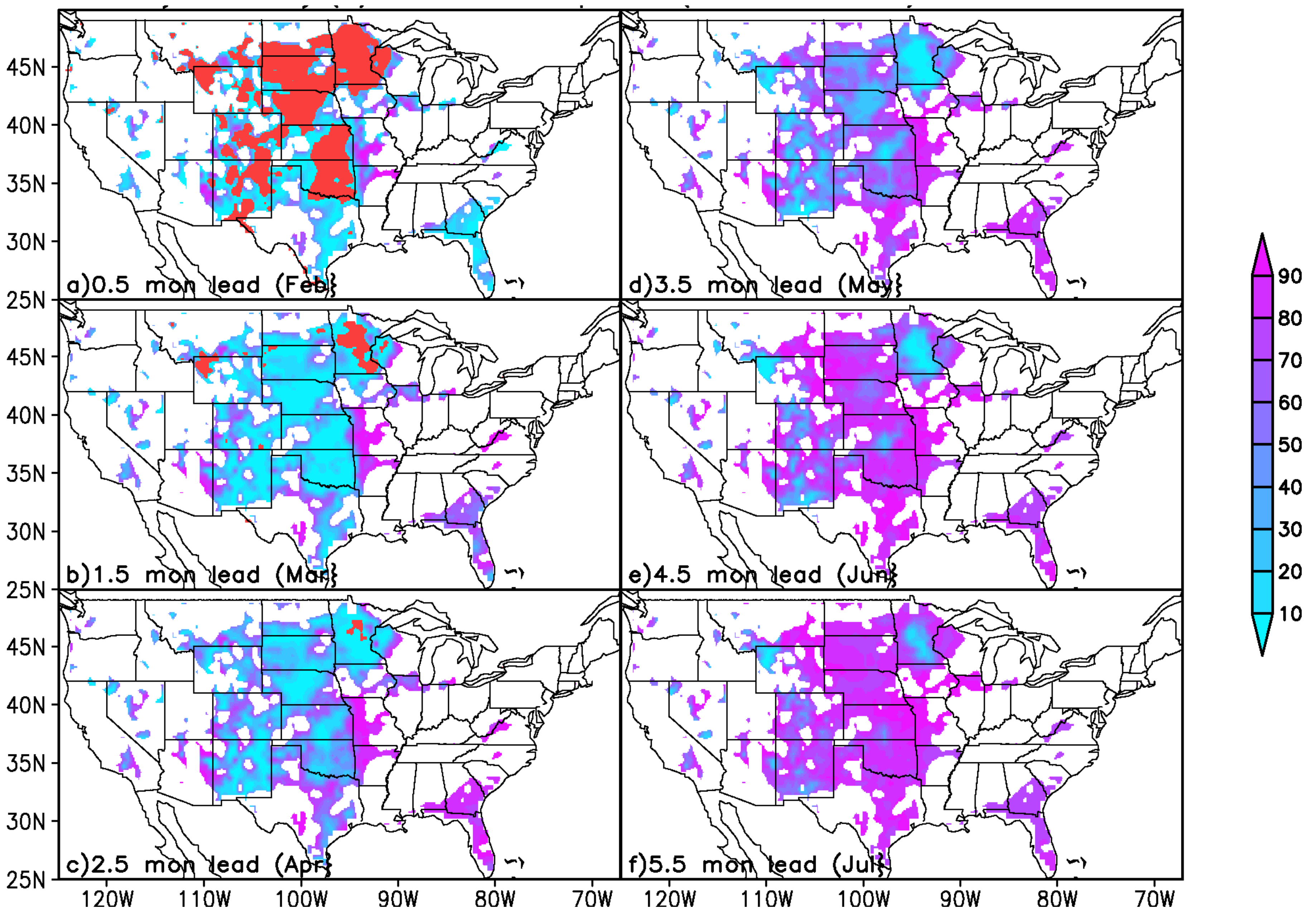
Copula provides probability of drought recovery



Median precipitation percentile for recovery (red: irrecoverable)



Recovery probability % at median precipitation (red: irrecoverable)



Summary

A method has been developed and tested that provides a probabilistic assessment of agricultural drought recovery based on ESP;

This allows for quantifying the risk, which can help agricultural decision making;

The approach can be augmented to include forecasts during drought events related to crop yield, streamflow, stream tempertures, or reservoir levels.

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A probabilistic framework for assessing drought recovery

Ming Pan,[1] Xing Yuan,[1] and Eric F. Wood[1]

Received 18 June 2013; revised 8 July 2013; accepted 8 July 2013; published 26 July 2013.

[1] A probabilistic framework is proposed to explore drought recovery and its uncertainty based on any ensemble forecast. First, the joint distribution between precipitation and drought

[3] Drought management would benefit greatly if more risk-based information is available on how a region in drought may recover [*Karl et al.*, 1987], e.g., the likelihood