

# **Developing a capability to estimate the probability of drought recovery**

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## **The Challenge: Forecasting drought recovery in a manner useful for drought decision making**

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Seasonal forecast models have poor skill in predicting drought duration and recovery.

Yet, improved skill in forecasting drought recovery is critical for improved drought management.

A risk-based (probabilistic) drought recovery procedure would allow users to assess their potential decisions in a stronger economic framework.

# 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 (change on click)

Timeline (change on hover)

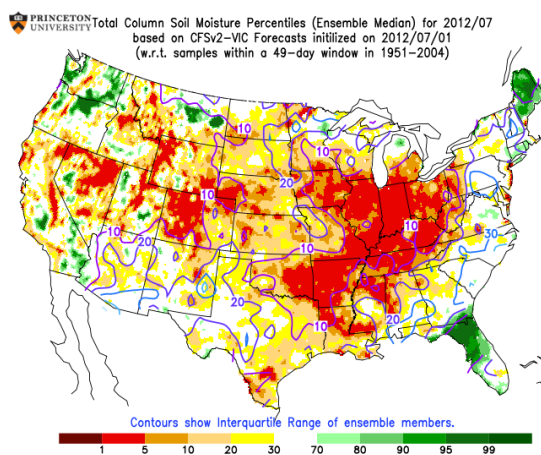
**Monitoring** validated < 2012/09/13 > for ☐ Soil Moisture ☐ Snow ☐ Streamflow ☐ Precipitation  
**Forecast** initialized < 2012/08/01 > for ☒ Soil Moisture ☐ Drought Probability

2012/06/07

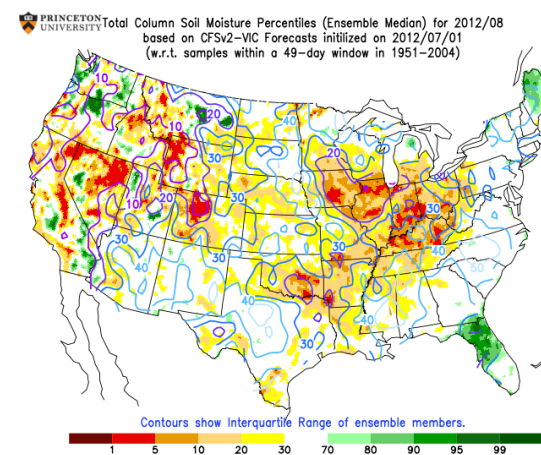
2012/06/14

2012/06/21

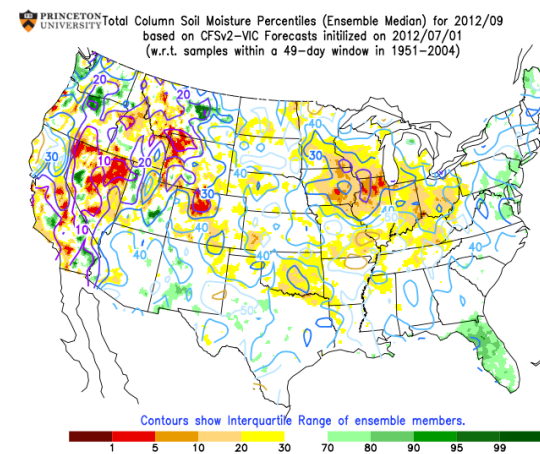
## July 2012 initialized 7/1/2012



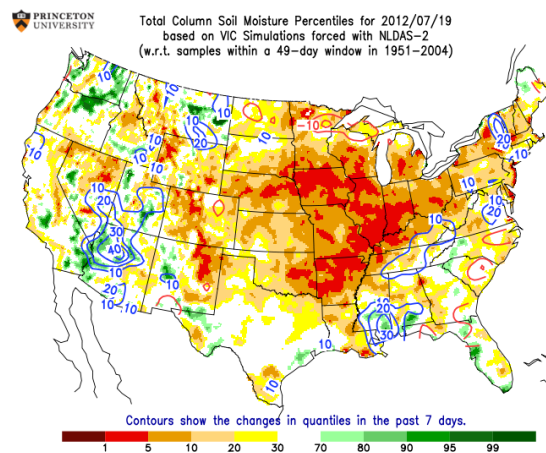
## Aug. 2012 initialized 7/1/2012



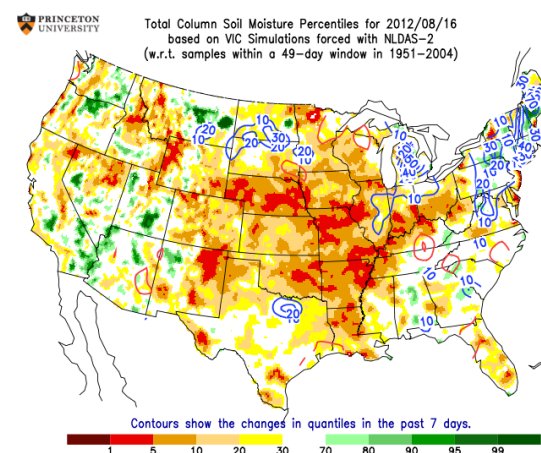
## Sept. 2012 initialized 7/1/2012



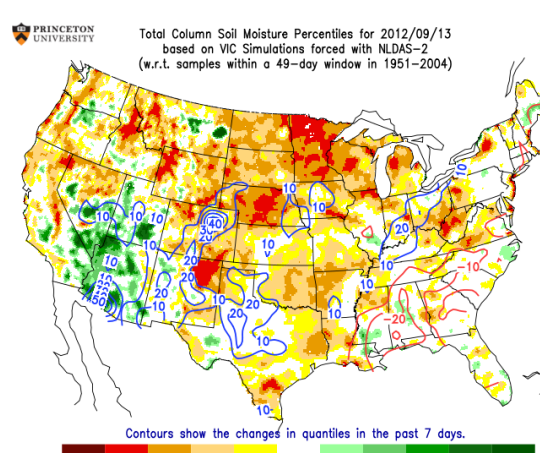
## Verification of Jul. 2012 forecast



## Verification of Aug. 2012 forecast



## Verification of Sept. 2012 forecast



# A probabilistic approach for assessing drought recovery

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GEOPHYSICAL RESEARCH LETTERS, VOL. 40, 3637–3642, doi:10.1002/grl.50728, 2013

## A probabilistic framework for assessing drought recovery

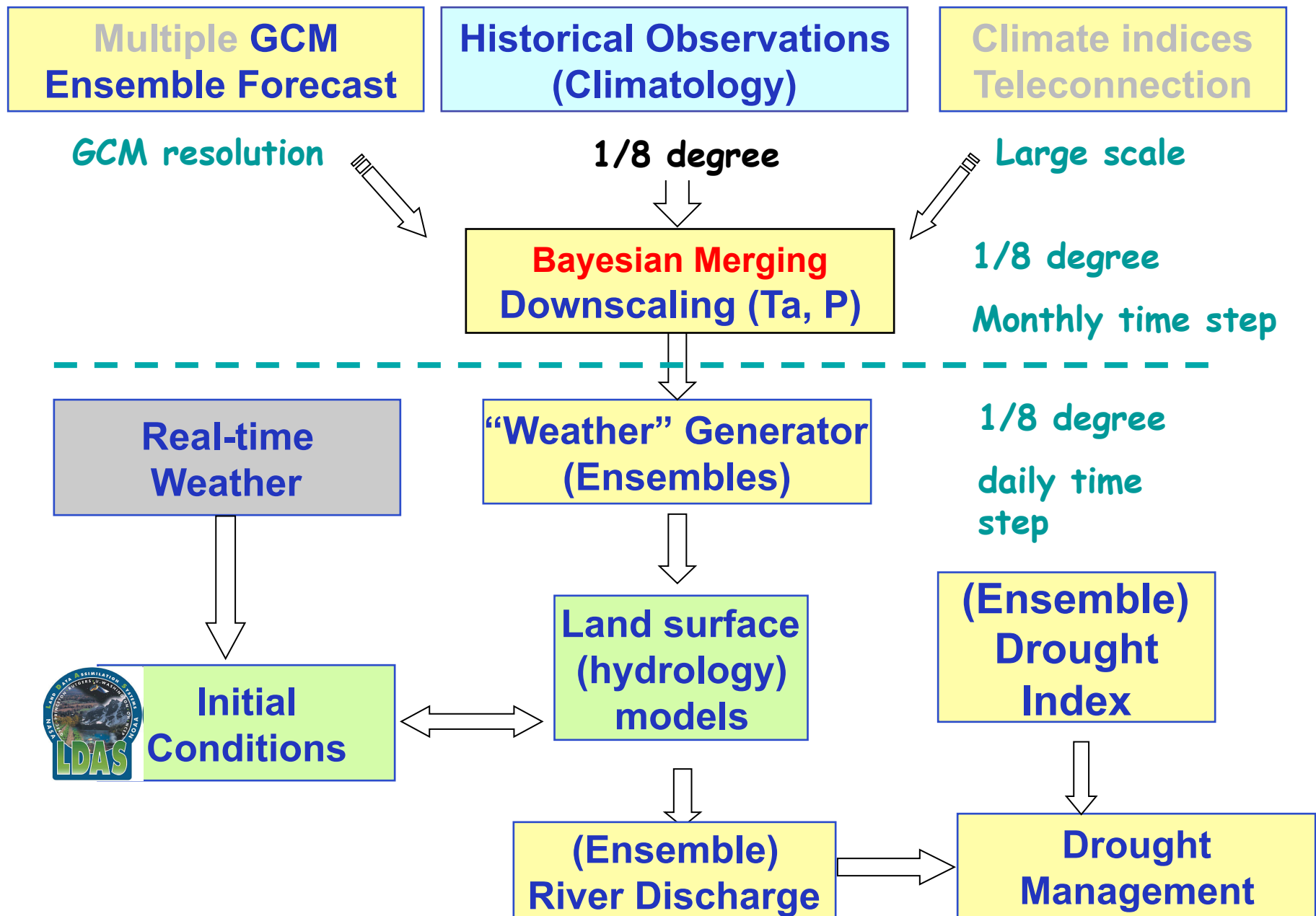
Ming Pan,<sup>1</sup> Xing Yuan,<sup>1</sup> and Eric F. Wood<sup>1</sup>

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 index is established from the forecast ensemble using the copula method, which allows arbitrary marginal distributions and fine-tuned correlation structure. Then, questions like “how much precipitation is needed for recovery and its uncertainty?” and “what is the likelihood that a specified drought index threshold be surpassed given specified cumulative precipitation over a fixed period?” are studied. The application investigates how the 2012–2013 drought over central United States may recover during the forecast period from February to July 2013. The ensemble streamflow prediction method is used to create the ensemble forecast, with soil moisture percentile against climatology as

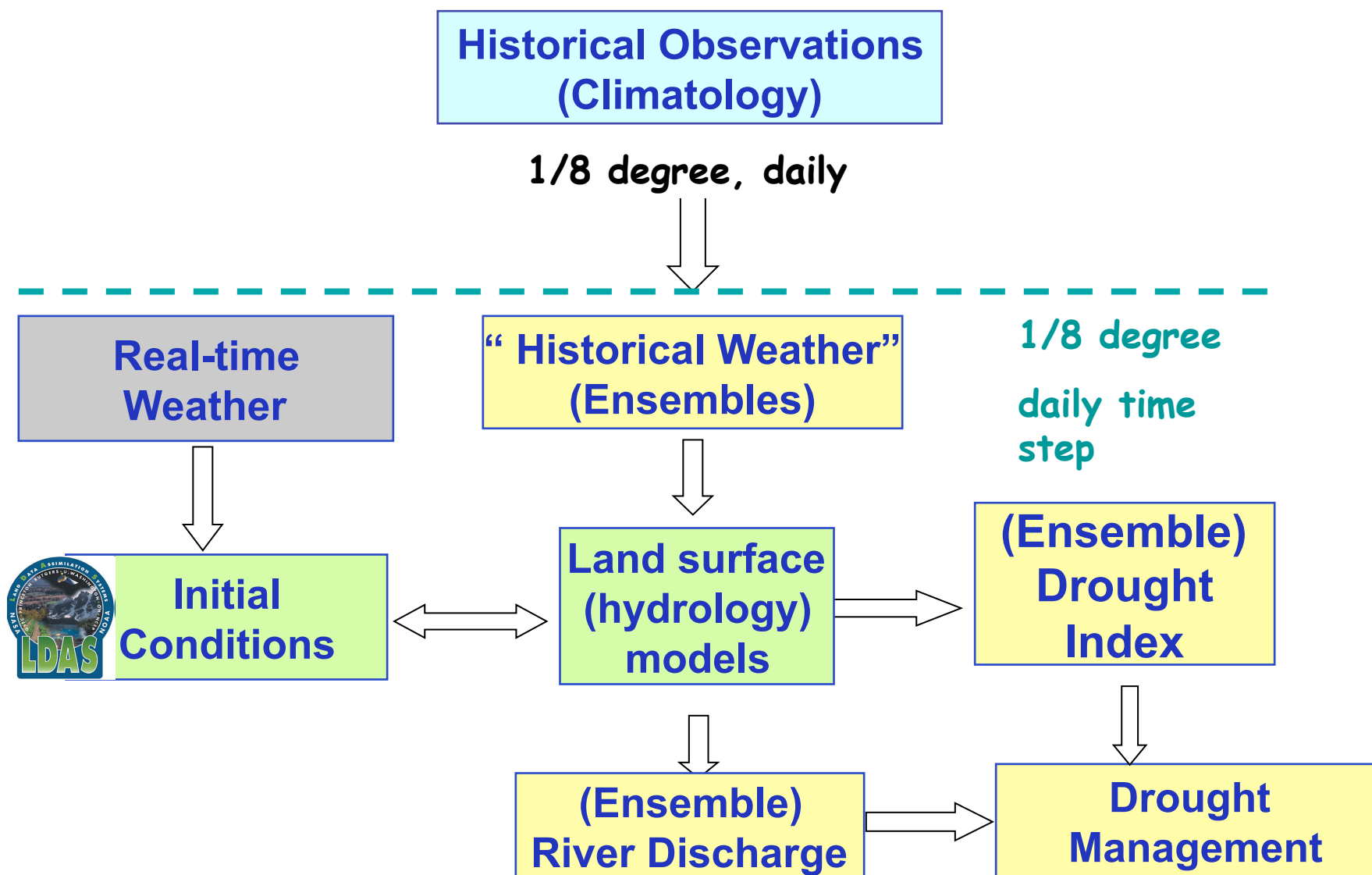
[3] Drought management would benefit greatly if more risk-based information is available on how a region in drought may recover [Karl *et al.*, 1987], e.g., the likelihood of recovery under different precipitation scenarios and the related uncertainty. Hydrologically, several factors such as the initial moisture condition, the amount and timing of precipitation, and the temperature will control the recovery process. Also, an LSM-based forecast system would be an ideal tool for resolving the interplays among these factors and predict the moisture states [Wood and Lettenmaier, 2006]. The surface meteorological inputs to the system can be either taken from a dynamic forecast model like the Climate Forecast System version 2 [Yuan *et al.*, 2011; Mo *et al.*, 2012] or randomly selected from historical meteorological records as done by the ensemble streamflow predic-

# Princeton's Hydrologic Monitoring and Prediction System

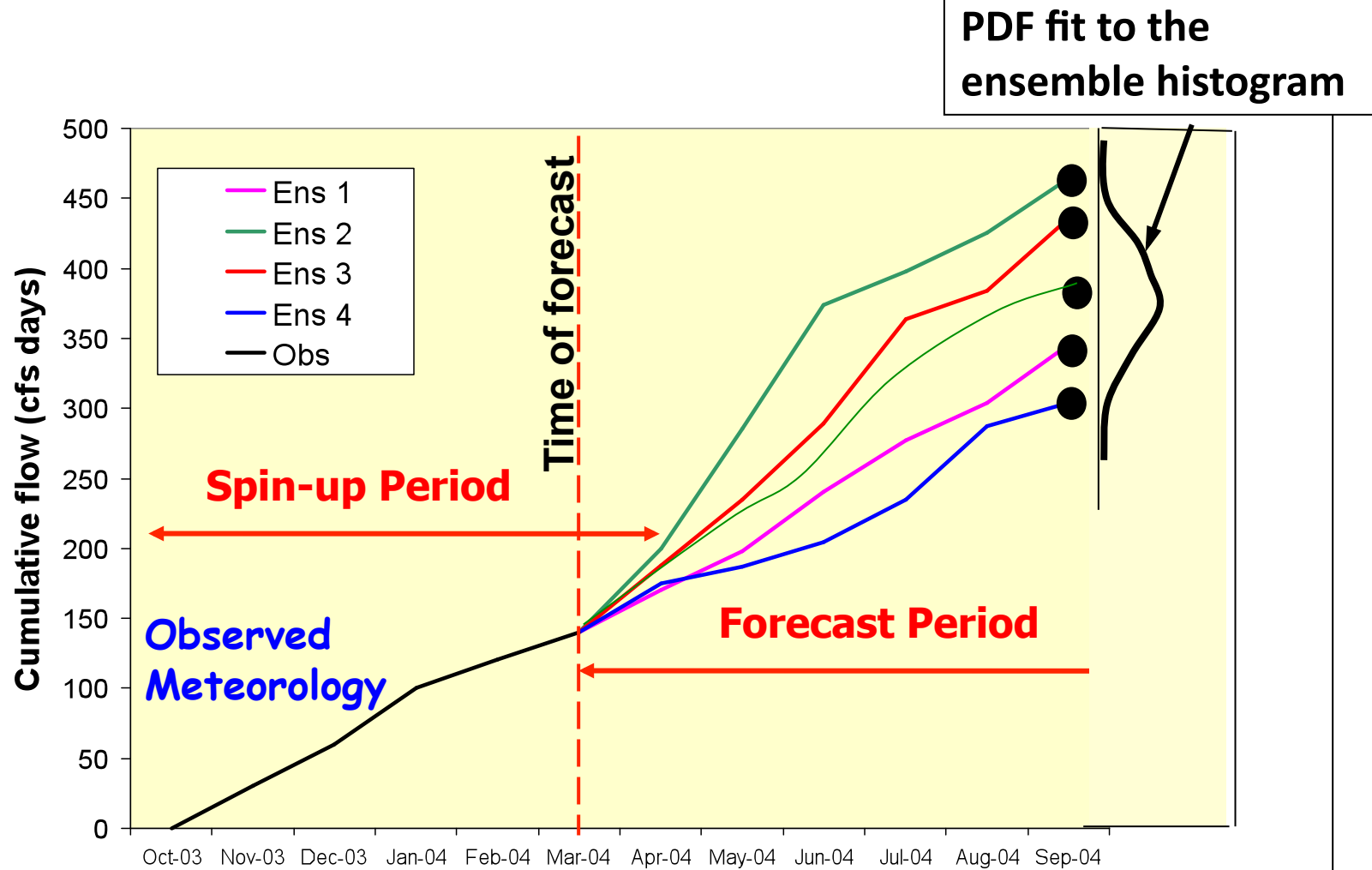


# ESP Hydrologic Prediction System

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# Hydrologic Ensemble Forecasting





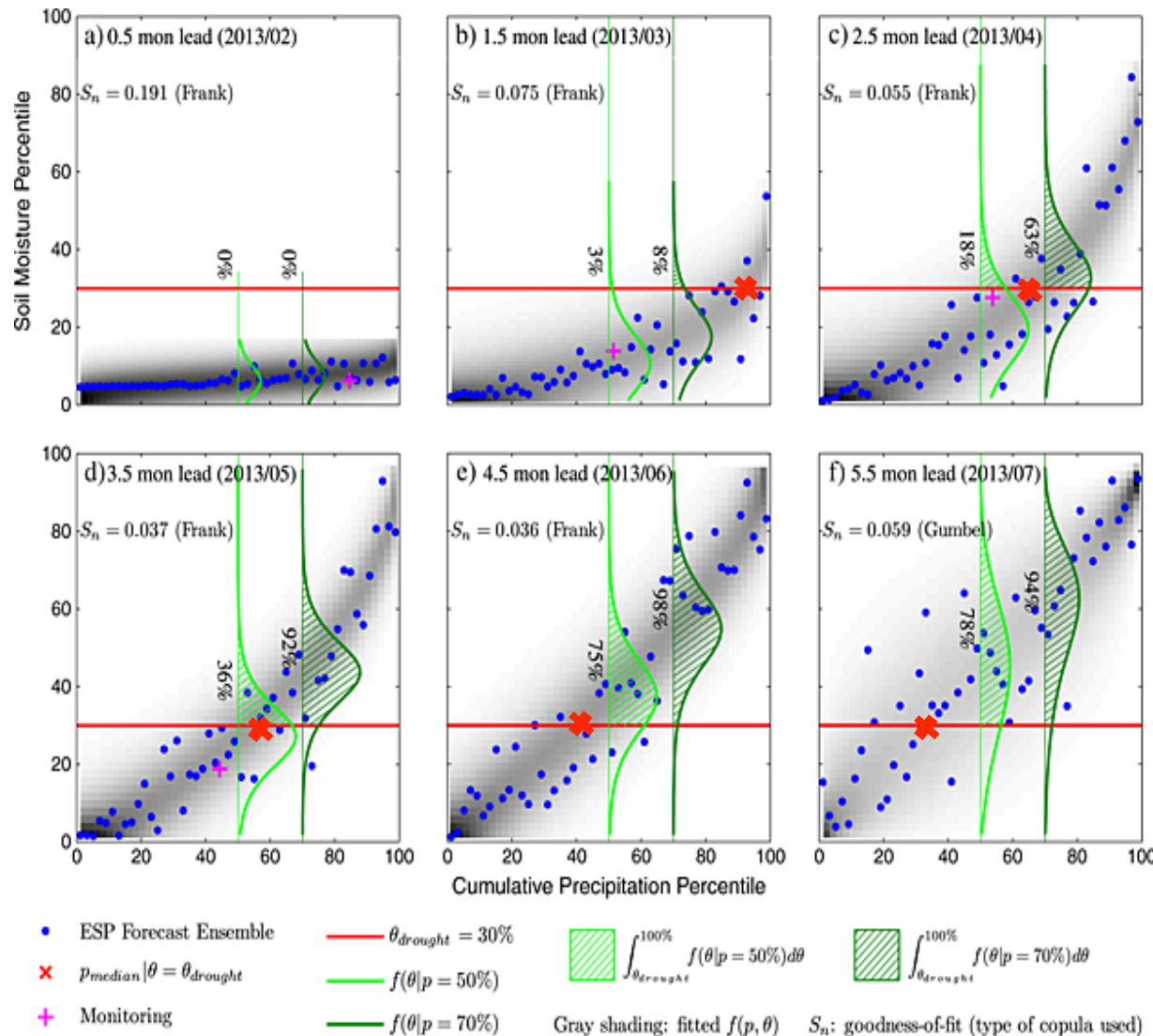
# Results for the 2012-2013 upper mid-west drought

Pan, Ming; Yuan, Xing; Wood, Eric F 2013A probabilistic framework for assessing drought recovery  
*Geophys. Res. Letts.* 40(14): 3637-3642 DOI: 10.1002/grl.50728, July28.

## Grid-scale analysis of recovery (from 2/2013)

### Approach uses

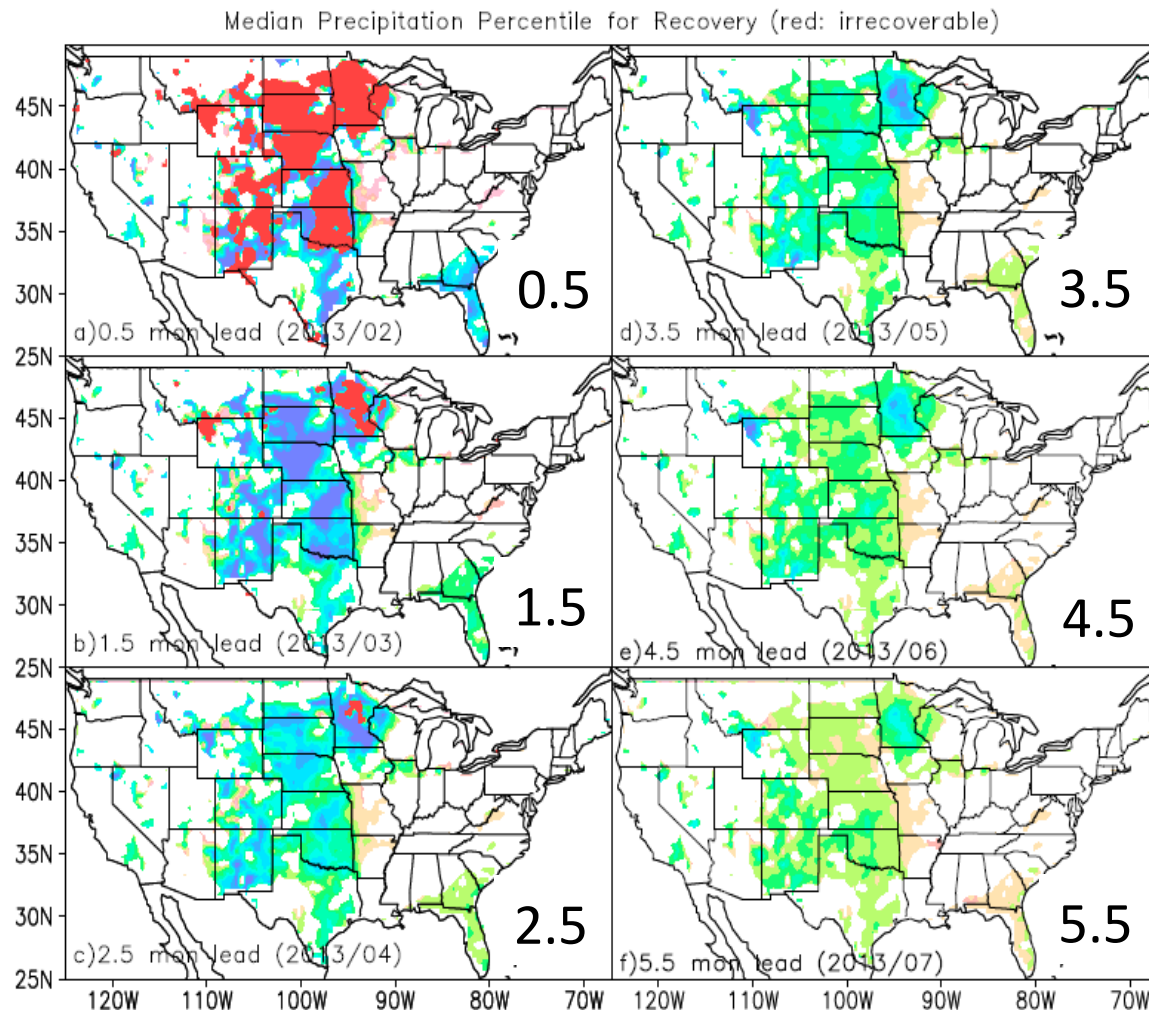
1. Resampling of the historical precipitation and temperature record,
2. Land surface modeling and
3. Copula statistics to compute the probability that soil moisture will exceed a specified threshold.





# Results for the 2012-2013 upper mid-west drought (2013/2)

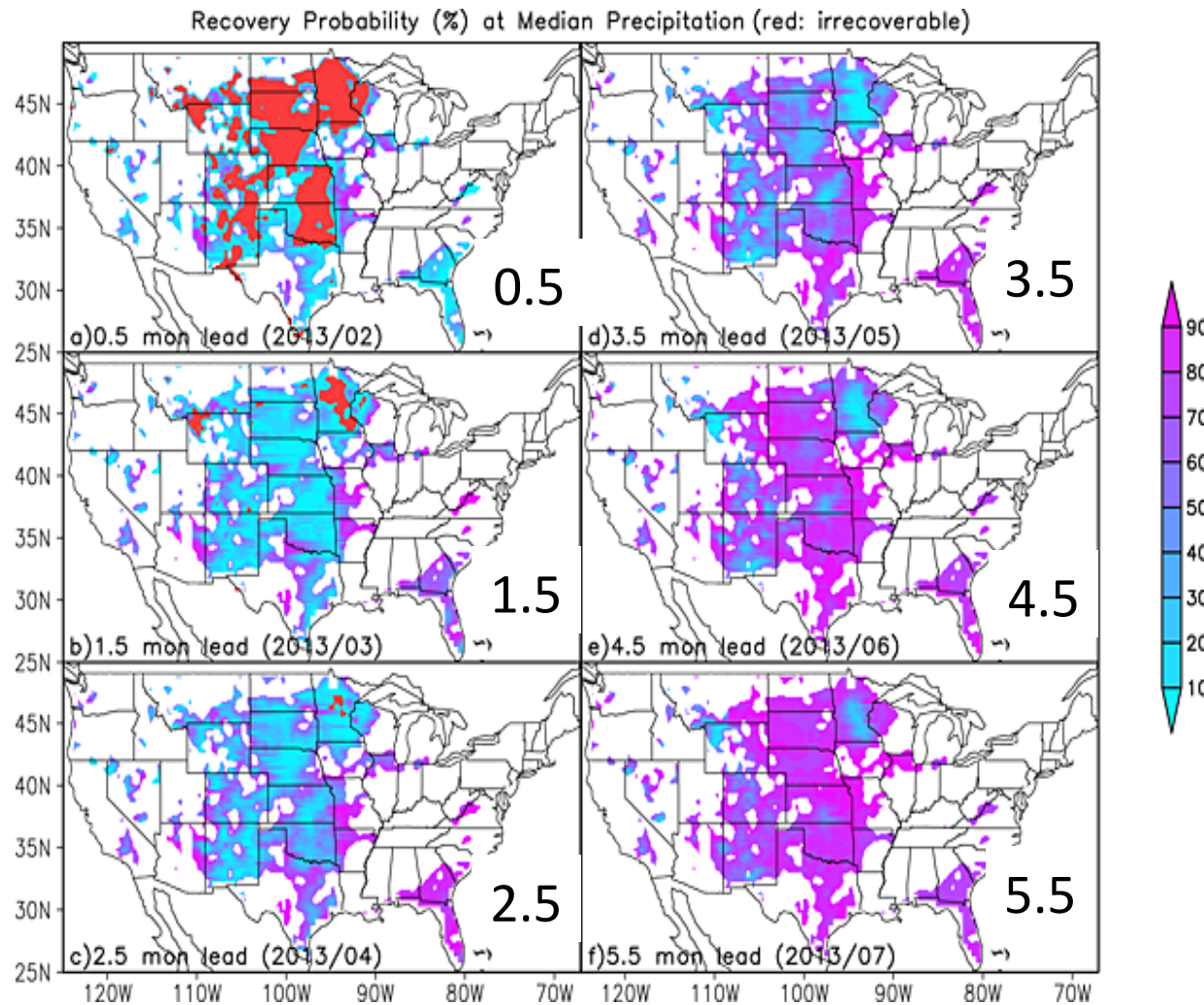
Pan, Ming; Yuan, Xing; Wood, Eric F 2013A probabilistic framework for assessing drought recovery  
*Geophys. Res. Letts.* 40(14): 3637-3642 DOI: 10.1002/grl.50728, July28.



CONUS analysis of recovery probability above a threshold (30<sup>th</sup> percentile) given the median probability of the required accumulated precipitation (red **x** in the first figure) over the forecast period

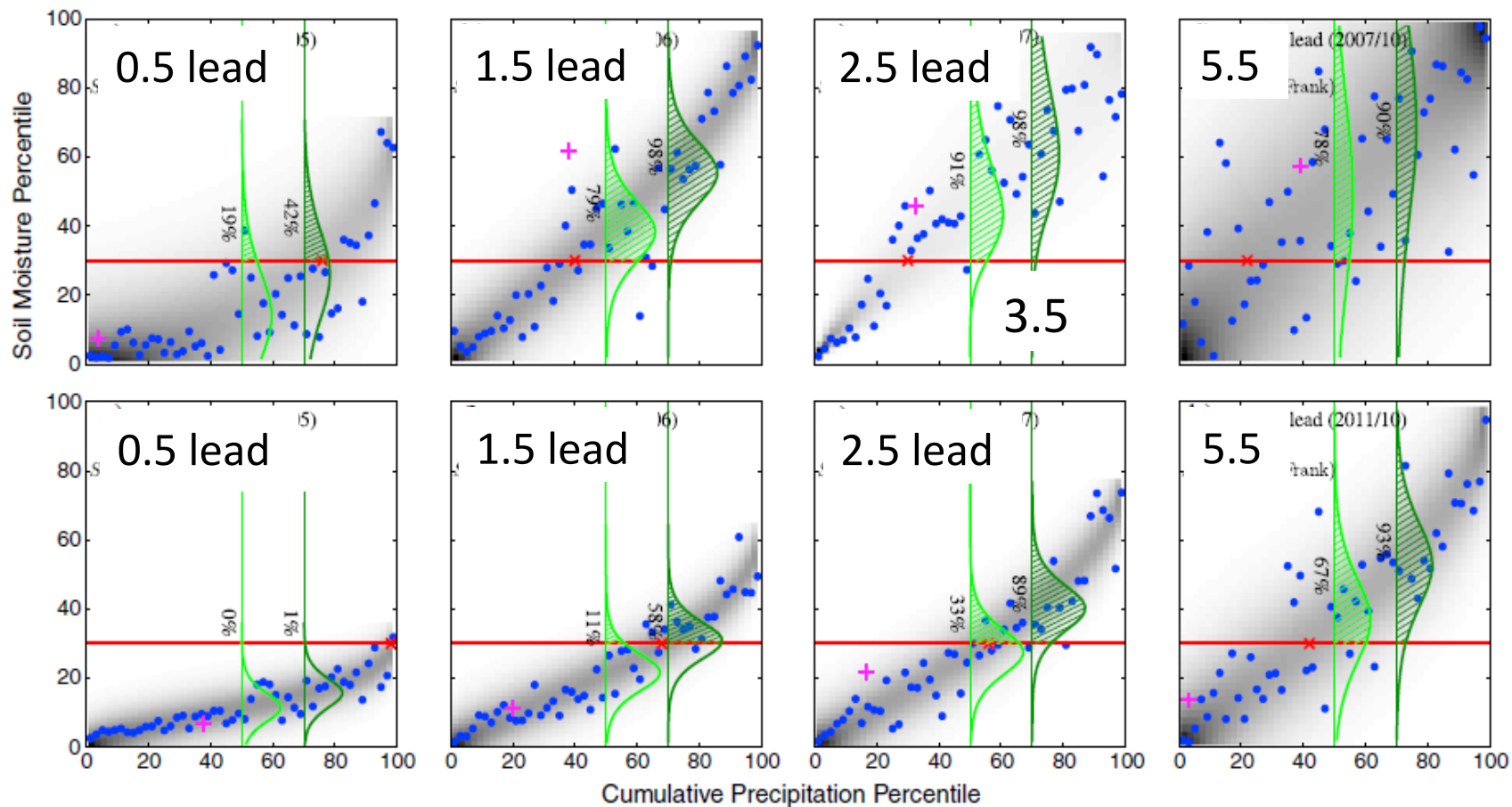
# Results for the 2012-2013 upper mid-west drought (2013/2)

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CONUS analysis of recovery above a threshold (30<sup>th</sup> percentile) given that the accumulated precipitation equaled the median over the forecast period

# Drought recover analysis (0.5-degree boxes): top, Georgia initialized May 2007; bottom Texas initialized May 2011.



• ESP Forecast Ensemble

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

✚ Monitoring

—  $\theta_{drought} = 30\%$

—  $f(\theta|p) = 50\%$

—  $f(\theta|p) = 70\%$

$\int_{\theta_{drought}}^{100\%} f(\theta|p = 50\%)d\theta$

$\int_{\theta_{drought}}^{100\%} f(\theta|p = 70\%)d\theta$

Gray shading: fitted  $f(p, \theta)$

$S_n$ : goodness-of-fit (type of copula used)

# Summary

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NLDAS research at Princeton University has developed seasonal drought monitoring and forecasting products that have been transitioned to EMC/NCEP, CTB/CPC/NCEP and NCO operations;

These NLDAS procedures can be used for probabilistic drought recovery forecasting using ESP methodology. The approach has been demonstrated with historical droughts.

The approach can be used to increase the operational capabilities of CPC for providing drought guidance, and could be used with CFSv2 forecasts, in an ESP re-sampling approach, or a combined merged approach.