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# A Hydroclimatological Assessment of the Regional Drought Vulnerability: Indiana Drought

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## Abstract

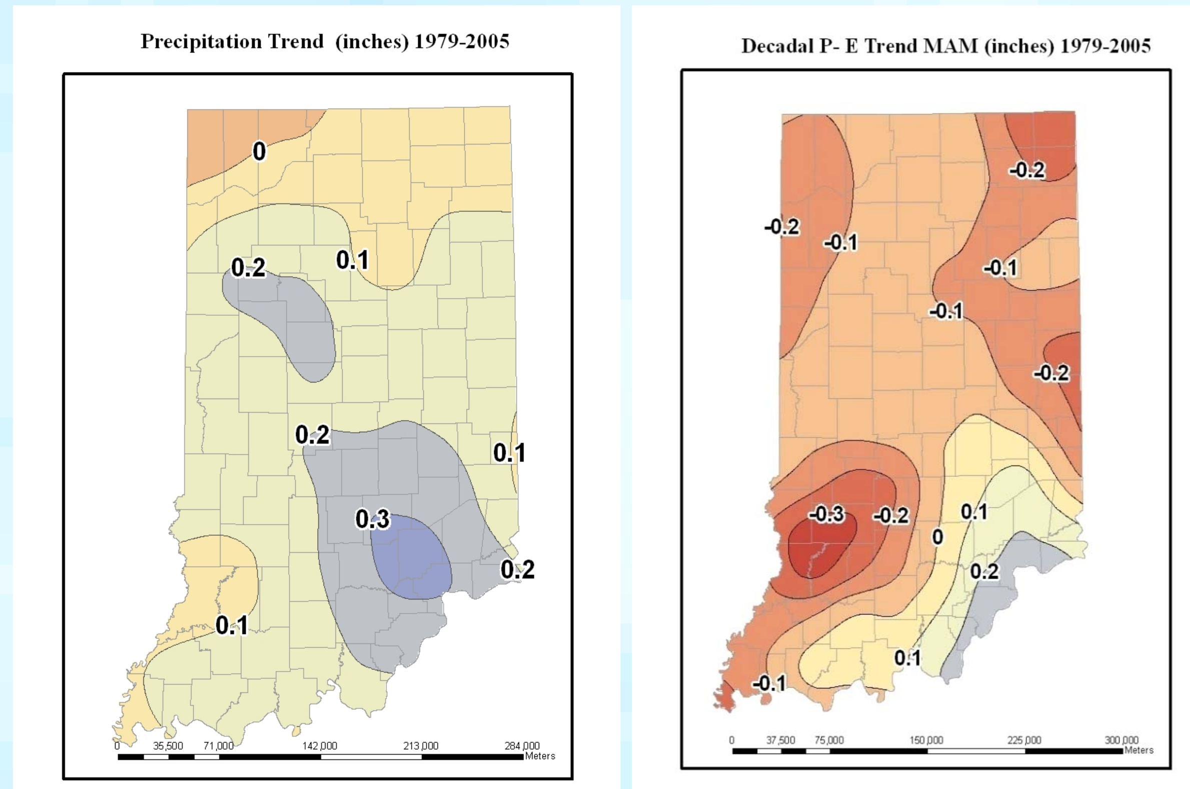
Characterizing and developing drought climatology continues to be a challenging problem. Also as decision makers seek guidance on water management strategies, there is a need for assessing the performance of drought indices. This requires the adaptation of appropriate drought indices that aid in monitoring droughts and hydrological vulnerability on a regional scale. This study aims to assist the process of developing a statewide water shortage and assessment plan (WSP) for the state of Indiana, USA by conducting a focused hydroclimatological assessment of drought variability. Drought climatology was assessed using in-situ observations and regional reanalysis data. A summary of precipitation and evaporation trends, estimated drought variability, worst-case drought scenarios, drought return period, as well as frequency and duration was undertaken, using multiple drought indices and streamflow analysis. Results indicated a regional and local variability in drought susceptibility. The worst-case (200 year return period) prediction showed that Indiana has a 0.5% probability of receiving 45% of normal precipitation over a 12 month drought in any years. Consistent with other studies, the Standard Precipitation Index (SPI) was found to be appropriate for detecting short-term drought conditions over Indiana. This recommendation has now been incorporated in the 2009 Indiana Water Shortage Plan. This study also highlights the difficulties in identifying past droughts from available climatic data, and our results suggest a persistent, high degree of uncertainty in making drought predictions using future climatic projections.


## Methodology

The study used the geographic information system (GIS) and statistical methods for extreme value analysis to determine the normals, trends, and probability of drought periods over Indiana using gridded reanalysis and insitu observation data. The drought severity, duration and frequency have been classified and counted by the different indices, the Standard Precipitation Index (SPI), the Palmer Drought Standard Index (PDSI) and the Palmer Hydrological Drought Inde (PHDI) over eight Indiana climate divisions for the past 100 years (Table-1). High resolution land surface data assimilation system (HRLDAS) was also used to simulate drought conditions at a finer scale.

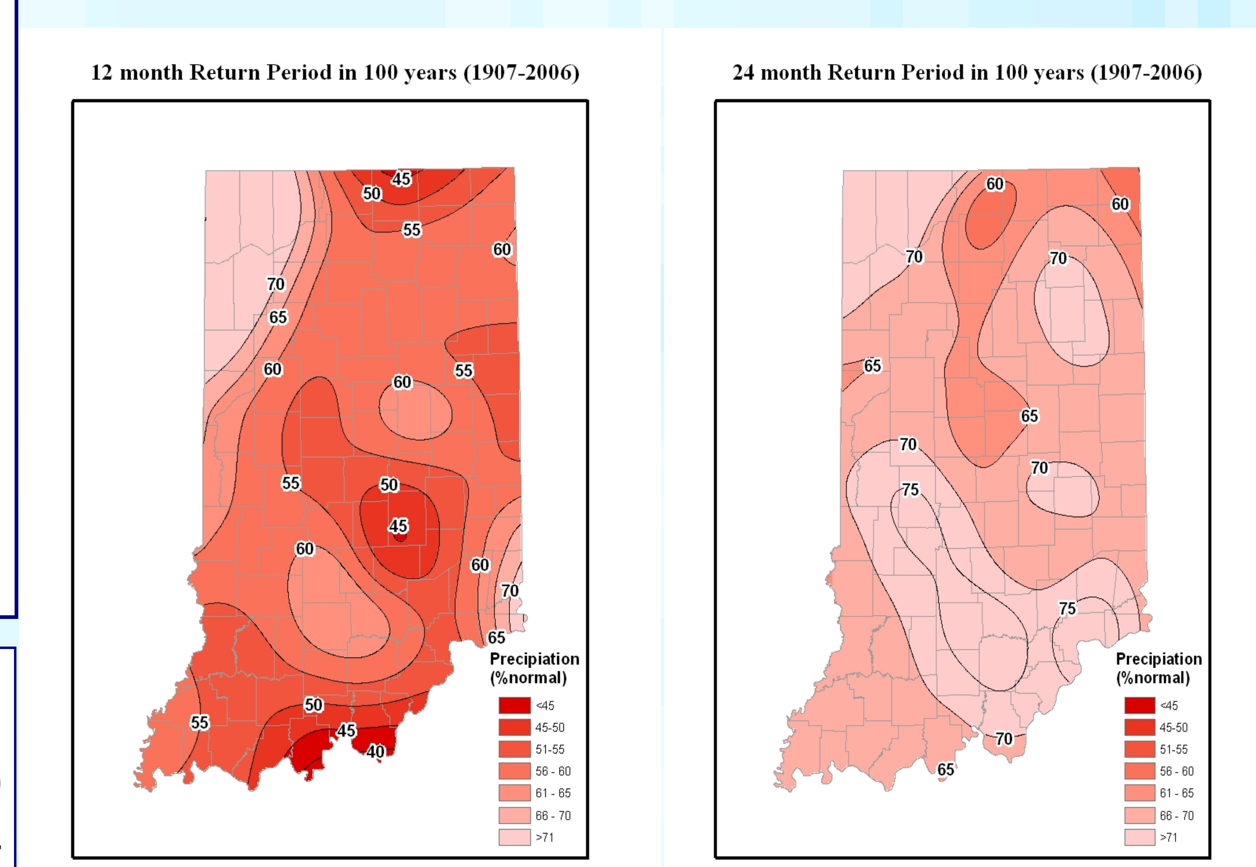
## Table 1. Drought Categories

| *Level* | *SPI* | *PDSI&PHDI* |
|---|---|---|
| Drought watch | - 1.0 to -1.49 | -2.99 - -1.00 |
| Drought warning | - 1.5 to -1.99 | -3.00 - - 4.99 |
| Drought emergency | - 2.0 and less | -4.99 and less |



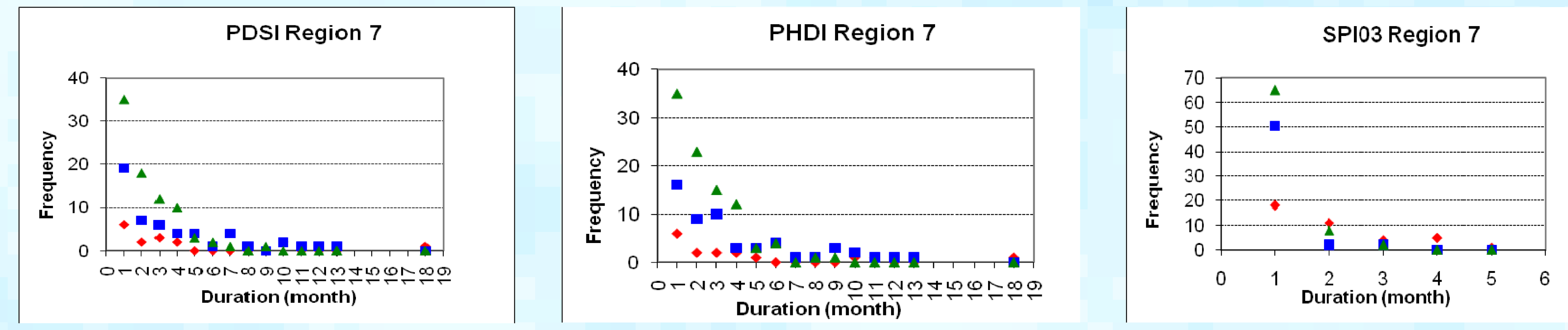

## Figure 1

Decadal precipitation trends and decadal precipitation minus evaporation trends from 1979 to 2005. Precipitation has increased between 0.1-0.3 inches per decade. During the spring, drought vulnerability may have increased due to the decreasing trend of the precipitation



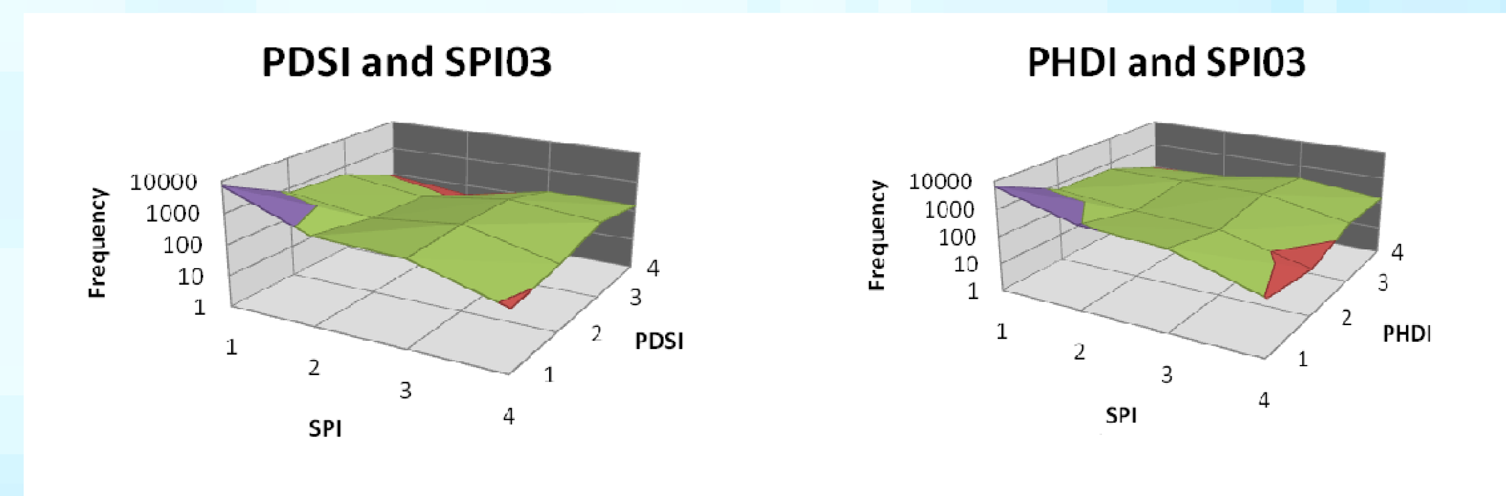

## Figure 2

12-month and 24-month precipitation in a 100 year recurrence interval were 45% of the normal and 60% of the normal. These have been estimated from the 10 driest precipitation periods of all 10 decades from 1906 to 2006 for 24 stations across Indiana.



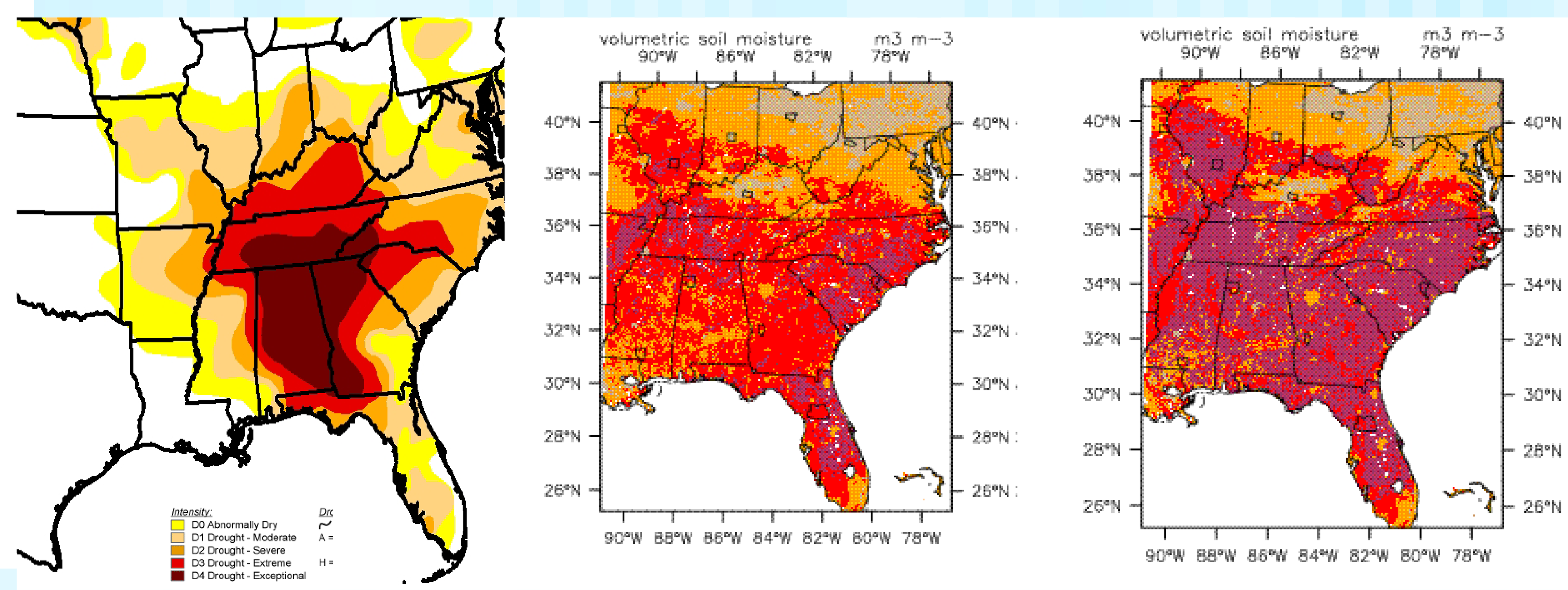

## Figure 3

The PHDI and PDSI detected 1 month-drought warnings 35 times, drought watchs 20 times and drought emergencies 8 times in climate division 7 (south-western Indiana). The longest duration of meteorological drought in Indiana was 18 months. While the 3 month-SPI could detect higher frequency of drought within a shorter time period in Indiana as compared to the PDSI and PHDI index in most climate divisions.




## Figure 4

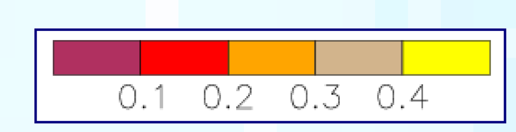
Example showing current drought criteria used in Indiana based on PHDI is inappropriate as it fails to detect drought while the 3-month SPI indicated a drought watch for 605 events and a drought emergency for 91 events.




**Observed from U.S. drought monitoring (August,21,2007)**

**HRLDAS –DEFAULT**

**HRLDAS –GEM**




## Figure 5

An example of high resolution land data assimilation system with MODIS land use was able to capture severe drought conditions across the U.S. for August, 2007. The LDAS is configured with 4 km grid space and 1 year spin up from 2001-2002 to stabilize the model. The model has been improved using a photosynthesis scheme (GEM, Niyogi, 2009) for transpiration and water cycle. The results show the GEM/MODIS method is better at estimating drought conditions than the current default version used by the Drought Monitor.

## Conclusions

- ♣ The southern part of Indiana appears to be getting more vulnerable to drought conditions.
- ♣ These results show that the SPI efficiently detects drought emergency and warning and identification of drought severity in its early stages.
- ♣ The inconsistency of no drought (PDSI and PHDI = 1) and emergency drought condition (SPI = 4) decreases when the time scale of the SPI increases.
- ♣ The study recommendations for using SPI as a drought trigger and monitoring