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MEASURED SOIL MOISTURE DURING THE 1999-2000 DROUGHT IN ILLINOIS

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1. INTRODUCTION

The 1999-2000 drought in Illinois began in July 1999 and continued into autumn 1999 with large precipitation deficits. This occurred during the time when water demand is typically high from the standpoint of human and crop consumption. By autumn, impacts were felt in soil moisture, surface water, and groundwater supplies. While near-average precipitation prevailed in winter, below-average precipitation returned in spring 2000. Near-surface moisture conditions responded quickly to the precipitation increase, but large moisture deficits below 1 meter continued across parts of northern and central Illinois into early 2001. Because of the timing of the drought, beginning in the middle of the 1999 growing season and ending at the early stages of the 2000 growing season, the impact on agriculture was minimized. Thus, most of the water-deficit impacts were related to stream flow and municipal water supplies. Fortunately, precipitation was above average for May and June 2000, allowing for a recovery of the water cycle to begin.

The object of this presentation will be to examine the behavior of soil moisture over time during the drought in Illinois using a unique set of soil moisture measurements. The results of the soil moisture analysis will be compared with more traditional measures of drought such as precipitation departures and the Palmer drought indices.

2. DATA AND METHODOLOGY

Soil moisture measurements have been taken since 1981 at 17 sites across Illinois using a neutron probe. The observations are made twice a month during the growing season (March-September) and once a month during the remainder of the year. These measurements are made over grass and extend down to 2 meters. With the exception of one sandy site, the soil textures are predominantly silty loam or silty clay loam. A more detailed description of the methodology is found in Hollinger and Isard (1996). The soil moisture measurements allow for a unique, three-dimensional view of the impact of the drought of 1999-2000 on soil moisture over time. In addition, the availability of soil moisture data back to 1981 allows for calculating departures from average and comparisons with the benchmark drought of 1988 in Illinois.

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3. RESULTS

Before the start of the 1999-2000 drought, statewide precipitation was actually above average for the first half of 1999 (58 cm, which is 119% of average). As a result, soil moisture, lakes, streams, and groundwater were all at or above their average for that time of year. In retrospect, the drought began in July 1999 when statewide precipitation in Illinois was only 63% of average. August 1999 was 70% of average and September 1999 was 68% of average (Fig. 1). As a result, soil moisture started to drop below average in the top 100-cm layer (Fig. 2) and in all layers down to 180 cm. Below-average precipitation continued into October and November 1999. At this time, soil moisture in the top 100 cm dropped to their lowest levels, relative to normal, during the entire drought.

Much of the northern two-thirds of Illinois is heavily tiled to remove excess near-surface water from saturated soils for agricultural operations to occur. Once soil moisture was depleted, runoff, percolation, and tile flow were essentially halted. Therefore, streamflow and groundwater levels began to drop as well. Although crop use and surface evaporation combined for a considerable moisture sink during late summer and early autumn, these water draws became dormant after harvest and with the approach of cooler seasons.

Precipitation from December 1999 to February 2000 was 117% of average, resulting in a modest recovery of soil moisture and groundwater while streamflow by the end of February remained at 54% of median flow.

Dry weather returned to Illinois in March and April 2000. March temperatures were 2.6°C above average and precipitation was 61% of average. April temperatures were near average and precipitation was 78% of average. Even so, the soil moisture in the 0-15 cm layer was at or above average for that time of year. In addition, the 0-50 cm layer had made a major recovery. As a result, the impact on corn and soybeans was minimal because there was enough moisture for germination after planting that occurred mostly in mid to late April. However, the deeper layers had not had the opportunity to recharge as they normally do over the winter months. Both the 50- to 100- cm and 100- to 180-cm layers showed large portions of Illinois with below-average soil moisture. Areas near St Louis and Peoria showed soil moisture at or below 25% of normal in the lowest

layer. This was a major concern because as the corn and soybeans developed, they would require the use of soil moisture from the lower layers.

A major shift in weather patterns in mid-May led to May 2000 precipitation being 113% of average. The June 1 soil moisture showed that the 0- to 50-cm layer was above average for the first time since July 1999. However, the layers below 50 cm were still showing no significant recovery.

June 2000 precipitation was 171% of average and essentially ended the drought in terms of soil moisture, streamflow, and groundwater. The end of June soil moisture showed soil moisture in the top 50 cm as ranging from 100 to 200 percent of average across Illinois. The 50- to 100-cm layer showed above-average soil moisture except for the Peoria area. The 100- to 180-cm layer showed above average soil moisture except in areas near St Louis and Peoria.

The state-wide Palmer drought index (PDSI) showed a steady deterioration through November 1999 (Fig. 3). From there until April 2000, Illinois remained in the "moderate drought" category. By the end of May, the PDSI had responded rapidly to the May rainfall. The Palmer Hydrological Drought Index (not shown) behaved in a similar manner through April 2000. As expected, it did not respond as quickly to the May and June 2000 rainfall, showing a return to near-normal conditions at the end of June rather than the end of May like the PDSI did.

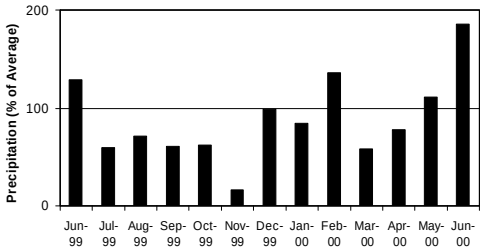

Figure 1. Percent of average precipitation across Illinois during the drought of 1999-2000. Values below 100% represent a shortfall in precipitation for that month.

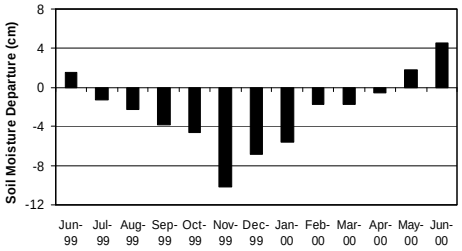

Figure 2. State-wide soil moisture departure (cm) in Illinois for the top 100 cm during the 1999-2000 drought.

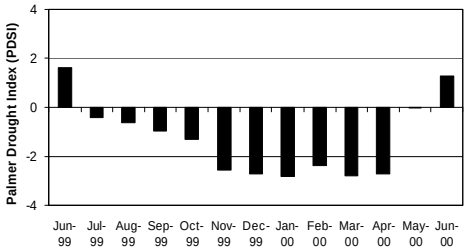

Figure 3. State-wide Palmer drought index (PDSI) for Illinois during the 1999-2000 drought.

4. CONCLUSIONS

Soil moisture measurements across Illinois during the 1999-2000 drought provide a unique look at the response of soil moisture at various depths to precipitation deficits. While the precipitation and Palmer drought indices are in agreement with the decline in soil moisture through November 1999, they do not capture the degree of recovery experienced by soil moisture in the top 50 cm during the winter and spring of 2000. Because of the favorable recovery of surface soil moisture in the spring of 2000, the impact on the 2000 growing season was minimal. This situation illustrates the value of actual soil moisture measurements in monitoring drought conditions.

5. REFERENCES

Hollinger, Steven E., Scott A. Isard, 1994: **A Soil Moisture Climatology of Illinois.** *Journal of Climate*: Vol. 7, No. 5, pp. 822–833.