

Time Series Analysis of 20 Years of Hourly Precipitation in Southwest Michigan

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ABSTRACT. Hourly precipitation data from Oshtemo Township, Michigan, located approximately 55 km east of the lee shore of Lake Michigan, for the period of April 1980 through March 2000 were examined. Diurnal analysis of precipitation as well as time series analysis of precipitation were performed on the study period. An overall nocturnal maximum in the mean accumulation of precipitation was detected during the 2-hour periods before 2000 LST and 2200 LST. Elevated spring and fall accumulations were responsible for this evening maximum. Elevated summer and winter accumulations were responsible for a weak secondary morning maximum. An overall morning maximum in the mean precipitation hours was detected during the 2-hour period before 1000 LST. ARIMA modeling verified that both precipitation accumulations and counts, for all times of the day, were significant at the 5% level. A storm event model was developed from the time series, the resulting values of which can be used as input in mesoscale climate, hydrological, and agricultural computer models: the mean pulse duration was 2.44 hours; the mean interlude between pulses was 37.64 hours; the mean event accumulation was 4.1 mm; and the mean rate was 1.8 mm/hr. Finally, inter-annual analysis performed for the period of 1981 to 1999 showed that there was no statistically significant change in precipitation over the period.

INDEX WORDS: Precipitation variability, precipitation diurnal cycle, precipitation seasonality, Michigan.

INTRODUCTION

Precipitation plays a crucial role in the hydrologic budget of southwest lower Michigan and the larger Great Lakes drainage basin. High temporal and spatial variability make surface observations of precipitation very important for complementing radar and satellite observations. Climatologically, the largest average accumulations of precipitation in Michigan occur in the southwest portion of the Lower Peninsula (Eichenlaub *et al.* 1990). This is due in part to late fall and winter “lake-effect” precipitation events that are caused by modifications of cold air masses moving over the relatively warm surface of Lake Michigan, and in part to year-round synoptic-scale weather systems that stream moisture northward from the Gulf of Mexico. Lake-effect snows occur throughout the winter months but are relatively more productive in December when there is a greater temperature contrast between the

lake surface and the overrunning air (Changnon 1968). Some locations in Southwest Michigan can average in excess of 250 cm of snow per year (Eichenlaub *et al.* 1990) and individual storm totals can often exceed 25 cm. Abnormally low snowfall amounts have been known to occur during El Niño years (Kunkel *et al.* 2000). Spring and summer are characterized by warm and humid air masses that allow for the common occurrence of convective rain and thunderstorm activity. These storms can frequently weaken because of enhanced atmospheric stability resulting from warm air masses moving over the relatively cool lake waters. In fact, mean annual precipitation accumulations over Lake Michigan have been estimated to be 6% less than that which is found over its surrounding basin (Changnon 1972). Nevertheless, southern Michigan storms should never be underestimated, as they can be quite severe both in terms of their magnitude and their impact on human lives (Foltman 1995).

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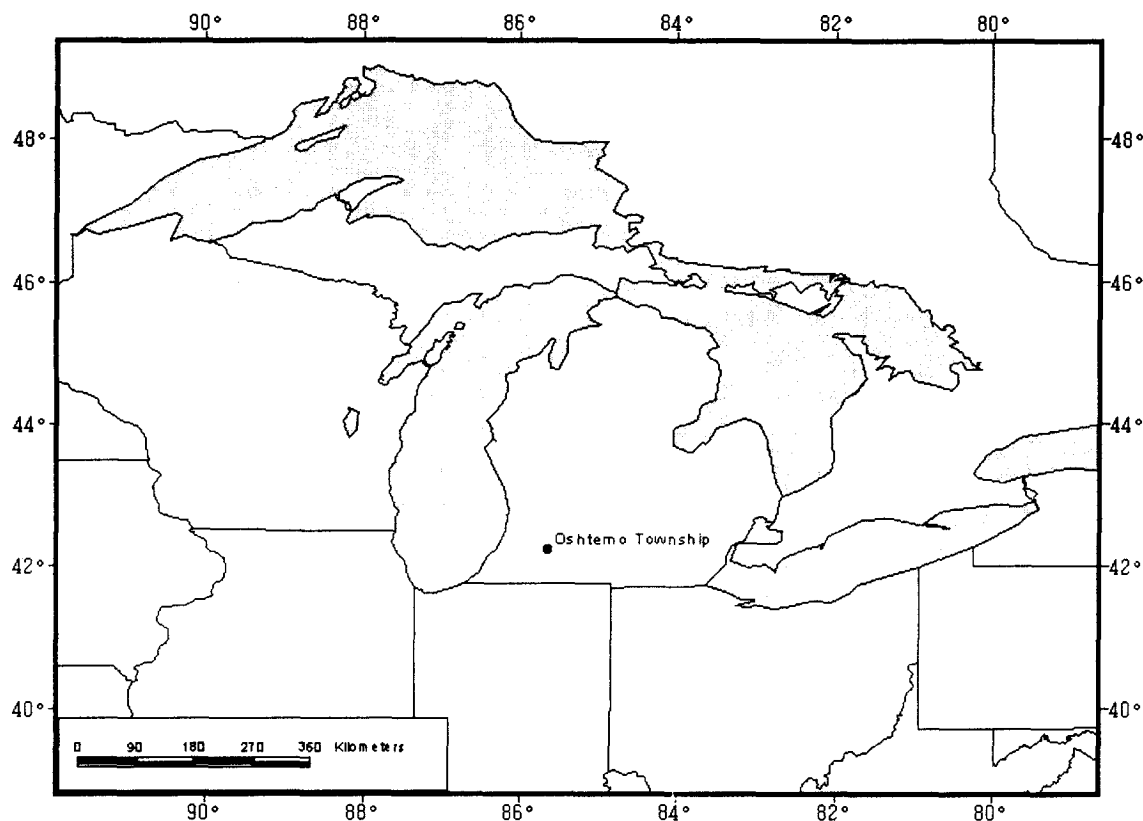


FIG. 1. Site location of Osthemo, Michigan

climatological station in Osthemo Township, Michigan, since 1979. Precipitation records from this station were processed and analyzed to provide a better understanding of the local precipitation regime and its structure. The site is located at 42° 16' N Latitude, 85° 44' W Longitude (Fig. 1). This is approximately 55 km east of the western shoreline of Lake Michigan and 6.4 km west of the Kalamazoo city limit. The station is in a ridge at the southern edge of the Kalamazoo moraine. It sits at an elevation of 294 m above mean sea level.

The recording precipitation gauge, or pluviograph, registers the data with an ink trace on rectangular paper charts containing hours and dates along the x-axis and precipitation accumulations in inches along the y-axis. Seven days of data are recorded on each chart. The gauge record began on 18 July 1979 at 0400 Eastern Daylight Time (EDT) and continues to this date. The values were always recorded in local time (LT). All values reported during local daylight time (LDT) were converted to local standard time (LST) for this study. The record contains some missing data (Table 1). Overall, the dataset set

contained less than 11% missing recording hours per year after 1980. Less than 5% missing hours occurred in 15 of the years. Four years had complete records. Data recorded before 1 April 1980 were excluded from this study due to their sporadic availability. There were potential sources of error as a result of the subjective aspect of chart reading and systematic instrument error, although the credibility of the precipitation record was addressed by comparing the monthly totals to those of a nearby station.

This study aims to determine:

1. the monthly, seasonal, and annual variability of the diurnal precipitation cycle in Osthemo Township;
2. a representative "storm event" model to describe the structure of the precipitation amount, intensity, duration, and interlude; and
3. the inter-annual variability of precipitation.

The methods in this study are based on those used in a time-series analysis of hourly rainfall au-