3.1 ANNUAL AND SEASONAL STORM STRUCTURE ACROSS THE UNITED STATES

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1. INTRODUCTION

The most commonly recorded storm characteristic is depth of precipitation received at a point. However, this characteristic, which is normally reported for a 24-hour period, does not adequately describe a storm's potential for impacting hydrological processes such as stream flow and soil erosion. The structure of a storm described by storm total precipitation, storm duration, storm precipitation intensity, storm precipitation energy (e_r), storm maximum 30-minute precipitation intensity(I_{30}), and total storm erosivity (EI) provide a better measure of potential increases in stream flow and soil erosion in a region. The number of storms that occur in a region during each season of the year and the total year is an important statistic that is needed to estimate total soil erosion or stream flow.

The objective of this paper is to present a climatology, for the United States, of the precipitation storm characteristics important for hydrological processes. Two climatologies are presented, one for all storms regardless of the total storm precipitation amount or maximum rainfall intensity, and one for storms with precipitation totals greater than 12.7 mm or with a maximum rainfall intensity greater than 25.4 mm hr^{-1}. These later conditions describe storms that are included in the computation of soil erosion losses using the Universal Soil Erosion Loss Equation (Wischmeier and Smith, 1978).

2. METHOD

The National Climate Data Center 15-minute precipitation data (TD-3260) were used to evaluate the precipitation characteristics of individual storms (Huff, 1967). A set of 1409 stations were chosen that had less than 25 percent of the data missing and with a station record greater than 18 years. A storm was defined as any 15-minute period of precipitation separated from preceding and succeeding precipitation by 6 hours or more (Huff, 1967).This set was used for the mean calculations based on individual storms. The calculation of mean statistics for the number of storms in a season or year required additional quality control procedures because of its cumulative nature, resulting in only 478 to 666 stations being available, depending on the season. These stations were required to have less than 25% data missing in the 1970s and 1990s, and have at least 15 individual years with less than 25% data missing. The raw numbers of storms in years meeting these criteria were prorated for the percentage of missing data, and only these years were used to calculate the mean number of storms at a station.

The annual and seasonal storm characteristics were examined by mapping the seasonal (winter, spring, summer, and autumn) mean values of the two storm types. The general patterns of these maps were examined with respect to potential mechanisms for seasonal variations.

The mean storm characteristics, other than number of storms, were computed using all the storms at a station. Storm structure descriptions are presented for all storms in each season and for the entire year, and for just those storms with rainfall greater than 12.7 mm or a 15-minute rainfall intensity greater than 25.4 mm hr^{-1} for each of the four seasons and for the entire year. The stations used included all 15-minute stations with identifiable latitudes, longitudes, elevations and station names that met the prescribed missing data and length of record requirements. The characteristics included the mean total storm precipitation, mean storm duration, mean storm precipitation intensity across the entire storm, the mean storm kinetic energy (e_r), the mean maximum 30-minute rainfall intensity (I_{30}), mean storm erosivity (EI_{30}) value, and the number of storms in the year of season. The mean e_r was computed using Brown-Foster (Brown and Foster, 1987) equation with an exponential coefficient of 0.82.

3. RESULTS

For the sake of brevity only the annual maps of the characteristics studied are presented in this extended abstract. The seasonal characteristics will be included in the presentation.

The mean storm total precipitation ranges from more than 16 mm to less than 5 mm when averaged over all storms throughout the year (Figure 1a). For storms with precipitation greater than 12.7 mm, the mean total precipitation ranges from 18 to 36 mm. The largest storms occur during spring along the Gulf of Mexico coast.

Storm duration on an annual basis for all storms ranges from 2 to 5 hours (Figure 1b). The longest storm durations exist along the Northwest Coast and range from 3 hours in the summer to 6 hours in the winter.

The mean storm intensity, measured by the average rainfall rate over the entire storm, ranges from 6 to 10 mm hr^{-1} for the all storms for the entire year (Figure 1c). The seasonal range is least during winter with a range of 6 to 9 mm hr^{-1}, and greatest in the summer with a range of 7.5 to 12 mm hr^{-1}. During the transition seasons the range is similar to the mean for the entire year with little change in the pattern of storm intensity between spring and autumn. The least intense storms are located along the Pacific Coast.

The storm kinetic energy in MJ ha^{-1} for all storms during the year ranges from 1.0 to 3.5 MJ ha^{-1} (Figure 1d).

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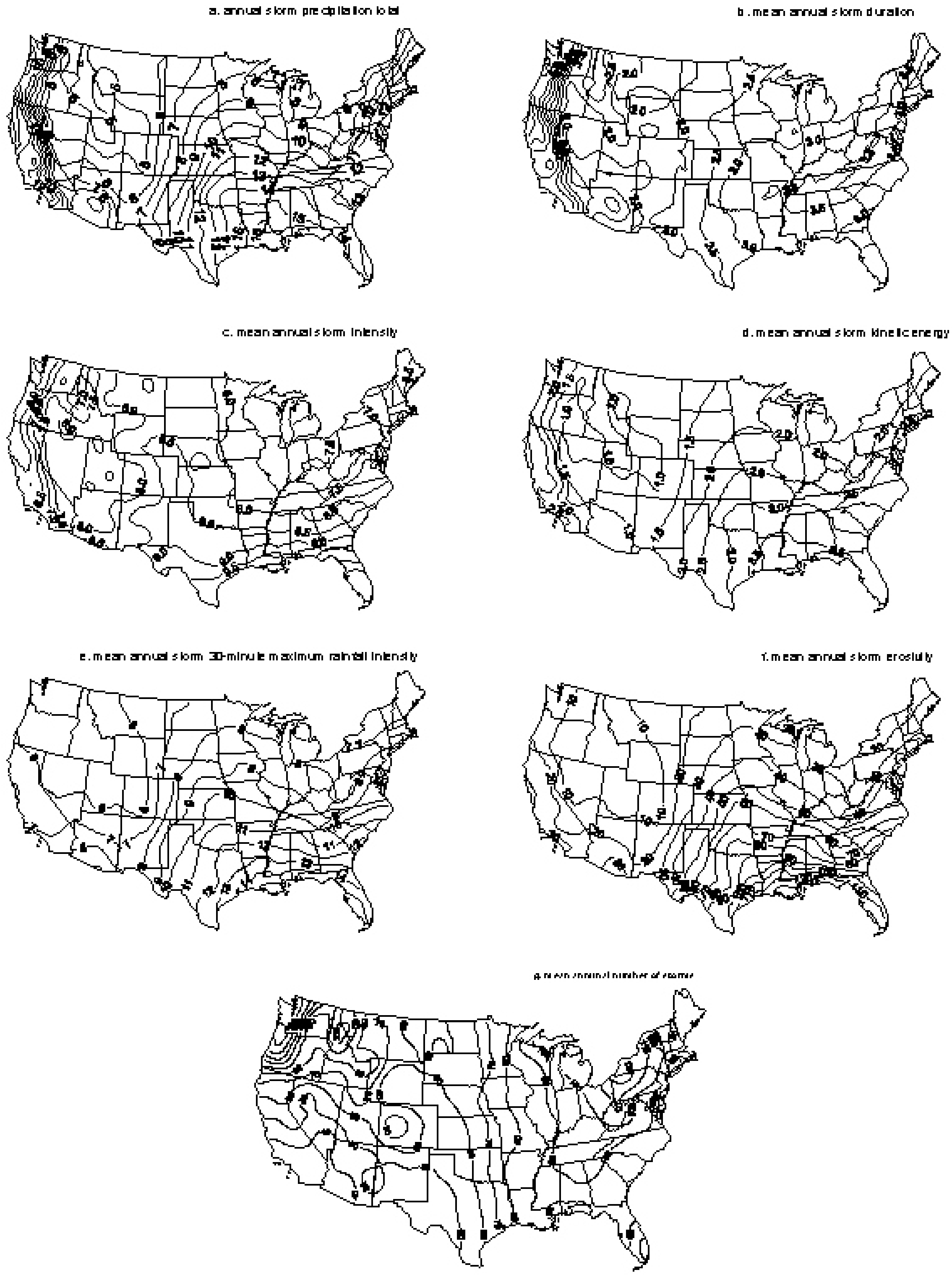

Figure 1. Maps of mean annual storm characteristics from 1971 to 1999 for a) storm totals (mm), b) storm duration (h), c) storm intensity (mm h^{-1}), d) rainfall kinetic energy (MJ ha^{-1}), e) maximum storm 30-minute rainfall intensity (mm h^{-1}), f) storm erosivity (MJ mm ha^{-1} h^{-1}), and g) number of storms.

The storms with the greatest kinetic energy occur in the southeastern U.S., the region where the mean storm total precipitation is greatest, and least in the Mountain States. The general patterns of the mean storm kinetic energy are similar to the storm total precipitation patterns, indicating that the amount of rainfall in a storm has a greater impact on the kinetic energy than the rainfall intensity.

The storm kinetic energy is multiplied by the 30-minute maximum precipitation intensity (I_{30}) to calculate the total erosivity (EI_{30}) of a storm. This has the effect of weighting each storm by the period of greatest rainfall intensity and increasing the erosivity of a storm over what would have occurred if only the mean rainfall intensity is used. The range of the mean storm I_{30} is 6 to 15 mm hr^{-1} (Figure 1e). The highest rainfall intensity occurs in all seasons of the year in the southeastern U.S., and the lowest in the Great Basin and Pacific Northwest states. The lowest I_{30} occurs in the winter and the highest in the summer. Maps of the mean EI_{30} show a range of 10 to 110 MJ mm ha^{-1} hr^{-1} for all storms during the year (Figure 1f), 10 to 160 MJ mm ha^{-1} hr^{-1} for all storms during the spring, and 10 to 140 MJ mm ha^{-1} hr^{-1} for all storms in both the summer and autumn. Along the Gulf Coast, the EI_{30} is the largest and is relatively constant across all seasons. During the summer, the mean EI_{30} increases to a maximum of 60 to 90 MJ mm ha^{-1} hr^{-1} in the Midwest, and as high as 30 to 40 MJ mm ha^{-1} hr^{-1} along the front range of the Rocky Mountains. These values apply to a mean that includes all large and small storms.

The total number of storms during the year range from 40 in the Southwest to greater than 130 in the Northwest (Figure 1g). The total number of storms in a year increases from 50 in the Rocky Mountain States to 90 in the Midwest and Southeast. In the Middle Atlantic states the number of storms exceeds 120 during the year. In the Midwest the spring and summer season have more storms than the autumn and winter. Along the West Coast the fewest storms occur during the summer, reflecting the Mediterranean climate of the region.

4. SUMMARY

Plots of the means of the storm characteristics that contribute to the computation of the storm's erosivity show that mean storm precipitation total, storm kinetic energy, 30-minute maximum rainfall intensity, and storm erosivity have similar geographic distributions. Because the mean storm erosivity is the product of the storm kinetic energy times the 30-minute maximum rainfall intensity, the similarity of the geographic distributions of these characteristics is expected.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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