Estimation of rainfall erosivity using 5- to 60-minute fixed-interval rainfall data from China

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Abstract

The 30-min rainfall erosivity index (EI_{30}) is commonly used in the Universal Soil Loss Equation for predicting soil loss from agricultural hillslopes. EI_{30} is calculated from the total kinetic energy and the maximum 30-min rainfall intensity of a storm. Normally, EI_{30} values are calculated from breakpoint rainfall information taken from continuous recording rain gauge charts, however, in many places in China and other parts of the world the detailed chart-recorded rain gauge data relative to storm intensities are not readily available, while hourly rainfall is readily available. The objective of this study was to assess the accuracy of EI_{30} estimations based on 5-, 10-, 15-, 30-, and 60-min time-resolution rainfall data as compared to EI_{30} estimations from breakpoint rainfall information. 456 storm events from five soil conservation stations in eastern China were used. The values of EI_{30} based on the fixed-time-interval data were less than those calculated from breakpoint data. The average conversion factors (ratio of values calculated from the breakpoint data to those from the fixed-interval data) for the five stations decreased from 1.105 to 1.009 for the estimation of E values, from 1.668 to 1.007 for I_{30} values, and from 1.730 to 1.014 for EI_{30} values as the time resolution increased from 60 to 5 min. The maximum 30-min rainfall intensity was the major source of error in estimating EI_{30} for 60-min fixed-interval data, while storm kinetic energy played a proportionately more significant role as the fixed-interval data decreased from 60 to 5 min.
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Keywords: Rainfall erosivity index; Breakpoint rainfall data; USLE; Soil erosion

1. Introduction

Rainfall erosivity (R) is one of the six factors in the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978) and the Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997) for erosion prediction. It quantifies the ability of rainfall to cause soil loss from hillslopes. Soil loss may be estimated using either the USLE or RUSLE by multiplying R together with the other five factors: soil erodibility (K), slope length (L), slope steepness (S), crop type and management (C), and supporting conservation practices (P). Using a large number of runoff and soil-loss data on an individual storm basis from 37 sites

within the eastern United States, Wischmeier and Smith (1958) found that the product of total storm kinetic energy, E, and the maximum 30-min rainfall intensity in the storm, I_{30}, provided the best correlation between soil loss and 19 other measured rainfall characteristics. As a result, Wischmeier and Smith (1978) further defined R as the average of the annual summations of storm EI_{30} values, excluding storms of less than 12.7 mm total rainfall depth. The 'E' portion of this value represents the rainfall energy, and the 'I_{30}' portion represents the maximum 30-min rainfall intensity during the storm. This index has been widely tested, adopted, and used in some countries and regions, where rainfall is mainly characterized to be of moderate to high intensity, and runoff to be primarily infiltration process (Sharpley and Williams, 1990; Wang and Jiao, 1996; Yu and Rosewell, 1996a; Mikhailova et al., 1997; Yu, 1998; Hu et al.,

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Table 1
Rainfall data summary and station locations

Station name	Number of storm events	Data period (year)	Latitude	Longitude	Elevation (m)	Average annual precipitation (mm)
Binxian	66	1985–1989	45°47′ N	127°27′ E	192.5	568.7
Miyun	162	1993–1998	40°22′ N	116°52′ E	73.1	653.9
Zizhou	146	1961–1969	37°36′ N	110°03′ E	896.0	431.1
Yuexi	48	1984–1991	30°52′ N	116°22′ E	431.0	1479.6
Anxi	34	1999–2000	25°04′ N	118°09′ E	89.4	1587.5
Total	456					

2000; Loureiro and Coutinho, 2001; Yu et al., 2001). Much research done in various areas in China (Jia et al., 1987; Wang, 1987; Huang et al., 1992; Zhang et al., 1992; Wu, 1994; Zhou et al., 1995; Wang and Jiao, 1996; Yang, 1999), has also shown EI_{30} as a reliable index for soil loss prediction.

At best, the calculation of EI_{30} uses breakpoint rainfall intensity data derived from recording rain gauges. Breakpoint data are read manually from graphical charts that are generated by continuously recording rain gauges. Breakpoint data are recorded as pairs of values representing time and cumulative depth of rainfall as measured from the charts. Time intervals between the recorded data pairs represent portions of the storm that exhibit constant or near constant rainfall intensity. Thus the recorded points represent times of discernable "breaks" or changes in the rainfall intensity of the storm.

Due to the limited availability of breakpoint rainfall data, many simple methods for estimating EI_{30} have been developed by using yearly, monthly and daily rainfall data (Ateshian, 1974; Arnoldus, 1977; Richardson et al., 1983; Ferro et al., 1991; Renard and Freimund, 1994; Yu and Rosewell, 1996b; Zhang et al., 2002). It is apparent that the more detailed the rainfall data used, the more accurate will be the computed EI_{30}. With the development of automatic weather stations, fixed-interval rainfall data are becoming more easily available and widely used. Automatically recorded rainfall data in fixed time intervals, such as 60-min, 15-min, and even higher time resolution interval data, may provide the preferred substitution of breakpoint data for EI_{30} estimation over such data as yearly, monthly, or daily.

There have been several studies that have investigated the potential use of fixed-interval (e.g., fixed-time-interval) rainfall data to calculate EI_{30}. In these studies, conversion methods between $(EI_{30})_{bp}$, and $(EI_{30})_{\Delta t}$ were developed, where $(EI_{30})_{bp}$ was the computed EI_{30} value from the breakpoint data and $(EI_{30})_{\Delta t}$ was the estimated EI_{30} value estimated from fixed-interval rainfall data for the same storm, where Δt represents the time interval used (e.g., 5, 10, 15, 30, or 60 min). Some of these studies have focused on EI_{30}, while others have detected the I_{30} or E terms separately. Weiss (1964) obtained conversion factors

Fig. 1. Rainfall data stations used in this study: Binxian, Miyun, Zizhou, Yuexi, and Anxi.
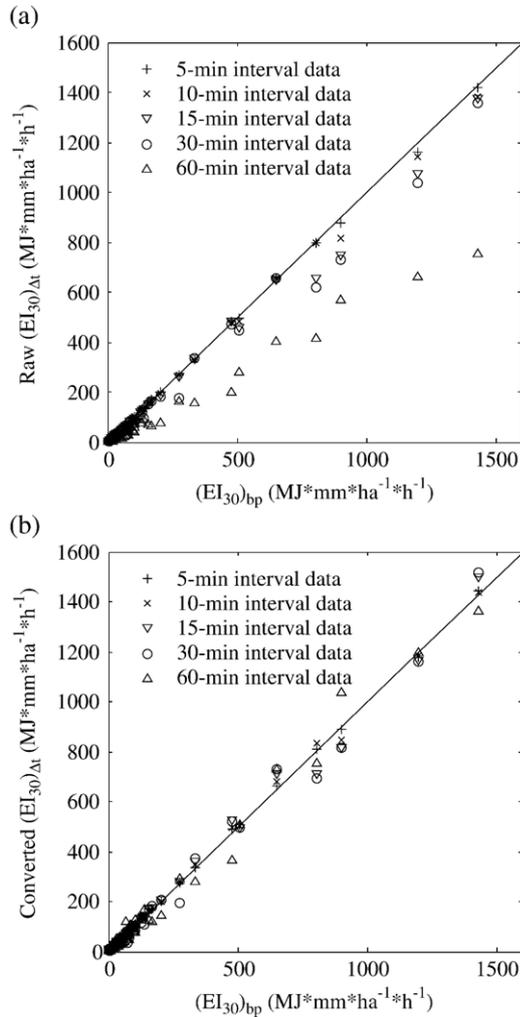
Fig. 2. Values for $(EI_{30})_{\Delta t}$ calculated using fixed-interval rainfall data vs. $(EI_{30})_{bp}$ values calculated from breakpoint rainfall data. (a) shows the raw values of $(EI_{30})_{\Delta t}$ and (b) shows the values after application of the conversion factors from Table 3. Data are from the Zizhou station.

between $(I_{30})_{bp}$ and $(I_{30})_{\Delta t}$, using a probabilistic method assuming that the occurrence of the true peak rainfall intensity is statistically independent of clock intervals. For example, the conversion factor between $(I_{30})_{bp}$ and $(I_{30})_{15}$ Weiss gave was 1.0667. Istok and McCool (1986)

presented a highly significant linear correlation between $(EI_{30})_{15}$ and $(EI_{30})_{60}$ by using 15-min and 60-min interval data from 3 sites located in a small watershed in western Oregon. The conversion factors between $(EI_{30})_{15}$ and $(EI_{30})_{60}$ varied from 1.193 to 1.378 and showed statistical difference among three sites.

In RUSLE (Renard et al., 1997), 713 stations with 15-min data were firstly collected to estimate R-factor, then, to use more widely available hourly rainfall data for R-factor calculation in western U.S.A., $(EI_{30})_{60}$ values for 1082 stations with hourly data were first adjusted to $(EI_{30})_{15}$ by using regression relationships between $(EI_{30})_{15}$ and $(EI_{30})_{60}$. Regression slope coefficients ranged from 1.08 to 3.16, varying greatly between the different climatic zones in the United States. Then $(EI_{30})_{15}$ values were adjusted to $(EI_{30})_{bp}$ by assuming the same total kinetic energy and multiplying Weiss' conversion factor, 1.0667, between $(I_{30})_{bp}$ and $(I_{30})_{15}$ (Weiss, 1964). For the same purpose, in Oregon State University's report on the spatial grids of R-factor submitted to the U.S. Environmental Protection Agency, data from 23 USDA sites were used to test Weiss' conversion factor (Christopher and George, 2002). The overall mean ratio of $(I_{30})_{bp}$ to $(I_{30})_{15}$ for all storms at the 23 sites was 1.034, which was statistically different from Weiss' 1.0667 ($\alpha = 0.05$). This ratio showed no statistically significant differences among the 23 sites. Therefore, the overall mean ratio of 1.034 was adopted by that group. Williams and Sheridan (1991) also produced significant linear regressions between $(EI_{30})_{bp}$ and $(EI_{30})_{\Delta t}$, but showed strong regional differences for the regression coefficients. There was little discussion in that study on what different roles E and I_{30} might play in EI_{30} estimation using fixed-interval rainfall data instead of breakpoint data. None of these studies have looked specifically at the relationships between $(E)_{bp}$ and $(E)_{\Delta t}$.

There is significant interest in China and other parts of the world for developing better tools and data for the prediction of soil erosion. The limited availability of breakpoint rainfall data in China and elsewhere greatly limits precise determination of rainfall erosivity, and hence limits ability to accurately predict soil erosion. On the other hand, hourly rainfall data are widely and readily available in China. The primary objective of this study

Table 2
Coefficients of determination, r^2, for regression relationships between values by $(E)_{bp}$, $(I_{30})_{bp}$ and $(EI_{30})_{bp}$ based on breakpoint data and $(E)_{\Delta t}$, $(I_{30})_{\Delta t}$ and $(EI_{30})_{\Delta t}$ based on fixed-interval data

Interval step	E					I_{30}					EI_{30}				
(min)	60	30	15	10	5	60	30	15	10	5	60	30	15	10	5
Binxian	0.99	0.99	1.00	1.00	1.00	0.94	0.96	0.99	1.00	1.00	0.97	0.98	1.00	1.00	1.00
Miyun	0.99	1.00	1.00	1.00	1.00	0.97	0.96	0.99	1.00	1.00	0.98	0.99	1.00	1.00	1.00
Zizhou	0.99	0.99	1.00	1.00	1.00	0.97	0.98	0.99	1.00	1.00	0.99	0.99	1.00	1.00	1.00
Yuexi	0.99	1.00	1.00	1.00	1.00	0.77	0.91	0.99	1.00	1.00	0.88	0.97	0.99	1.00	1.00
Anxi	0.99	1.00	1.00	1.00	1.00	0.85	0.98	0.99	0.99	1.00	0.83	0.99	0.99	1.00	1.00
Average	0.99	1.00	1.00	1.00	1.00	0.90	0.96	0.99	1.00	1.00	0.93	.98	0.99	1.00	1.00

Table 3
Slope coefficients, $c_{E\Delta t}$, $c_{I\Delta t}$ and $c_{EI\Delta t}$, of regression equations through the origin between values of $(E)_{bp}$, $(I_{30})_{bp}$ and $(EI_{30})_{bp}$ based on breakpoint data and $(E)_{\Delta t}$, $(I_{30})_{\Delta t}$ and $(EI_{30})_{\Delta t}$ based on fixed-interval data

Interval step	E					I_{30}					EI_{30}				
(min)	60	30	15	10	5	60	30	15	10	5	60	30	15	10	5
Binxian	1.107	1.054	1.031	1.022	1.010	1.658	1.101	1.024	1.011	1.005	1.789	1.198	1.039	1.023	1.011
Miyun	1.124	1.071	1.038	1.026	1.008	1.653	1.079	1.030	1.022	1.007	1.668	1.094	1.051	1.040	1.015
Zizhou	1.091	1.057	1.030	1.018	1.009	1.731	1.078	1.051	1.023	1.009	1.811	1.117	1.088	1.041	1.016
Yuexi	1.123	1.070	1.043	1.022	1.010	1.627	1.152	1.046	1.026	1.009	1.814	1.257	1.099	1.048	1.020
Anxi	1.080	1.049	1.030	1.020	1.009	1.673	1.072	1.054	1.030	1.005	1.568	1.139	1.114	1.069	1.010
Average	1.105	1.060	1.034	1.022	1.009	1.668	1.096	1.041	1.022	1.007	1.730	1.161	1.078	1.044	1.014

These are equivalent to conversion factors for converting fixed-interval values of $(E)_{\Delta t}$, $(I_{30})_{\Delta t}$ and $(EI_{30})_{\Delta t}$ to corresponding breakpoint calculated values of $(E)_{bp}$, $(I_{30})_{bp}$ and $(EI_{30})_{bp}$.

was to develop relationships for relating breakpoint-calculated EI_{30} values to those estimated from fixed-interval data measured from storms occurring in eastern China in order to calculate the R-factor more accurately from existing data. The different roles that E and I_{30} play in EI_{30} estimation when using fixed-interval data were also analyzed. Results from study are compared to those from previous studies. The results are intended to be used to improve the estimation of rainfall erosivity indices, and hence prediction of soil erosion, in places where similar rainfall data exist.

2. Data and methods

Recording rain gauge measurements from 456 storm events from five soil conservation experimental stations in eastern China were collected (Table 1, Fig. 1). First, breakpoint data for each storm were extracted by eye from the charts for each storm as pairs of values representing time and cumulative depth of rainfall, where the recorded points represented times of discernable changes in the rainfall intensity of the storm. Then, fixed-interval data were derived from the breakpoint data in intervals of 60-min, 30-min, 15-min, 10-min and 5-min. This was done by dividing the storm into the specified set of time increments starting at time zero when rainfall began.

Brown and Foster's equation was used for the calculation of rainfall kinetic energy, E (MJ·ha^{-1}) (Brown and Foster, 1987) for both the breakpoint and fixed-interval data as:

$$E = \sum_{r=1}^{k} 0.29[1-0.72\exp(-0.05i_r)](\Delta V)_r \tag{1}$$

where each storm was divided into k parts according to either the breakpoint time increments or fixed-interval time increments, i_r (mm·h^{-1}) was the breakpoint or fixed-interval rainfall intensity for the rth part of a storm, and $(\Delta V)_r$ (mm) was the rainfall depth for the rth part of a storm. The energy, E (MJ·ha^{-1}), was designated as either $(E)_{bp}$ for the breakpoint or $(E)_{\Delta t}$ for the fixed-interval data.

The maximum 30-min (0.5-h) intensity, I_{30} (mm·h^{-1}), for both the breakpoint and fixed-interval rainfall data was calculated as:

$$I_{30} = \frac{(P_{30})}{0.5\text{h}} \tag{2}$$

where P_{30} (mm) was the maximum 30-min rainfall depth. The I_{30} (mm·h^{-1}) was designated as either $(I_{30})_{bp}$ for the breakpoint or $(I_{30})_{\Delta t}$ for the fixed-interval data. Taking 10-min interval data as an example, $(P_{30})_{10}$ was the maximum accumulated rainfall depth in three contiguous 10-min intervals. For the 60-min fixed-

Table 4
Conversion factors for converting fixed-interval values of $(E)_{\Delta t}$, $(I_{30})_{\Delta t}$ and $(EI_{30})_{\Delta t}$ to corresponding breakpoint calculated values of $(E)_{bp}$, $(I_{30})_{bp}$ and $(EI_{30})_{bp}$ from various studies

| Interval step	E					I_{30}					EI_{30}				
(min)	60	30	15	10	5	60	30	15	10	5	60	30	15	10	5
Istok and McCool (1986)	–	–	–	–	–	–	–	–	–	–	>1.289	–	–	–	–
RUSLE (Renard et al., 1997)	–	–	1	–	–	–	–	1.0667	–	–	1.15–3.37				
Christopher and George (2002)	–	–	1	–	–	–	–	1.034	–	–	–	–	–	–	–
Weiss (1964)	–	–	–	–	–	–	1.1429	1.0667	1.0435	1.0213	–	–	–	–	–
Williams and Sheridan (1991)	1.130	1.084	1.047	1.036	1.020	1.843	1.219	1.045	1.044	1.018	1.837	1.313	1.121	1.090	1.042
Current study	1.105	1.060	1.034	1.022	1.009	1.668	1.096	1.041	1.022	1.007	1.730	1.161	1.078	1.044	1.014
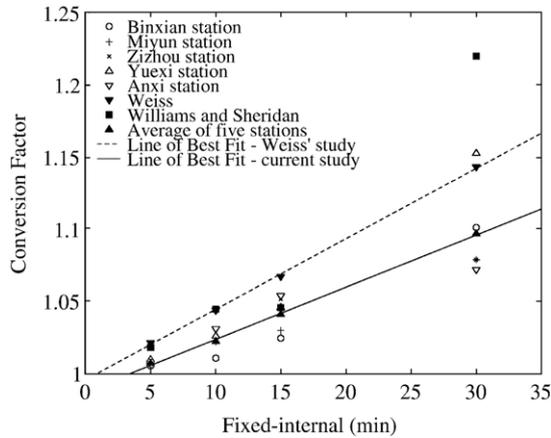
Fig. 3. Regression lines between fixed-interval time increments used in calculating I_{30} values and the corresponding conversion factors for converting those values to breakpoint-calculated I_{30} values. Results are shown from the current study and for studies of Weiss (1964) and Williams and Sheridan (1991). The two regression lines for Weiss' and current study were nearly parallel.

interval data, however, $(I_{30})_{60}$ (mm·h^{-1}) was estimated as:

$$I_{30} = \frac{P_{60}}{1.0\text{h}} \tag{3}$$

where P_{60} (mm) was the maximum 60-min rainfall depth in the storm.

The values of EI_{30} for every storm were calculated for the breakpoint as:

$$(EI_{30})_{bp} = (E)_{bp} \cdot (I_{30})_{bp} \tag{4}$$

and from the fixed-interval data as:

$$(EI_{30})_{\Delta t} = (E)_{\Delta t} \cdot (I_{30})_{\Delta t} \tag{5}$$

The linear equations relating E, I_{30} and EI_{30} values from interval data to those from breakpoint data were set up as follows:

$$(E)_{bp} = c_{E\Delta t}(E)_{\Delta t} \tag{6}$$

$$(I_{30})_{bp} = c_{I\Delta t}(I_{30})_{\Delta t} \tag{7}$$

$$(EI_{30})_{bp} = c_{EI\Delta t}(EI_{30})_{\Delta t} \tag{8}$$

where $c_{E\Delta t}$, $c_{I\Delta t}$ and $c_{EI\Delta t}$ were slope coefficients based on linear regression through the origin. Thus, the parameters $c_{E\Delta t}$,

$c_{I\Delta t}$ and $c_{EI\Delta t}$ may be taken as conversion factors for converting fixed-interval values of $(E)_{\Delta t}$, $(I_{30})_{\Delta t}$ and $(EI_{30})_{\Delta t}$ to corresponding breakpoint values of $(E)_{bp}$, $(I_{30})_{bp}$ and $(EI_{30})_{bp}$.

Some of the previous studies on the calculations of I_{30} using fixed-interval data reported results in terms of linear regression between the conversion factor values for various fixed time intervals to the duration of the fixed-interval. To compare our study results with those previous studies, we also made the regression analyses for:

$$c_{I\Delta t} = \beta_0 + \beta_1 \cdot \Delta t \tag{9}$$

where β_0 was the intercept of the line and β_1 was the slope. In this case we used the average of the conversion factors for all of the five stations.

Analyses of Covariance (Snedecor and Cochran, 1989) were used to examine: (1) whether the linear regressions of E, I_{30} and EI_{30} values from interval data to those from breakpoint data were the same for the five sites, and (2) whether the linear equations relating the conversion factor $c_{I\Delta t}$ to the time interval Δt were the same between our study and other studies. The residual variances were compared first by Bartlett's test. On the basis of homogeneity of residual variances, the slope coefficients were compared by F test to examine if the regression lines were parallel. If the investigation of slope showed no significant difference, an F test for intercept of the lines were followed to see if the regression lines can be regarded to be the same.

3. Results

The values of EI_{30} based on the fixed-time-interval data were less than those calculated from breakpoint data for the same storm. Taking the Zizhou station as an example, all the values of $(EI_{30})_{\Delta t}$ were less than the corresponding values of $(EI_{30})_{bp}$ (Fig. 2a). The regression models between fixed-interval values of $(E)_{\Delta t}$, $(I_{30})_{\Delta t}$ and $(EI_{30})_{\Delta t}$ and corresponding breakpoint calculated values of $(E)_b$, $(I_{30})_b$ and $(EI_{30})_b$ were significant, with r^2 in all cases greater than 0.98 for E, greater than 0.77 for I_{30}, and greater than 0.82 for EI_{30} (Table 2). The conversion factors $c_{E\Delta t}$, $c_{I\Delta t}$ and $c_{EI\Delta t}$ based on the regression slope coefficients from Eqs. (6) (7) and (8) are listed in Table 3 for each of the rainfall measurement locations. The average values of all three conversion coefficients for all five of the rainfall stations

Table 5
Conversion factors based on fixed-time interval data from the Anxi station using a) "Beginning data" wherein the time intervals begin with the beginning of the storm, and b) "Clock data" wherein the time intervals are based on time of collection within the hour

Interval step	E					I_{30}					EI_{30}				
(min)	60	30	15	10	5	60	30	15	10	5	60	30	15	10	5
Initial data	1.080	1.049	1.030	1.020	1.009	1.673	1.072	1.054	1.030	1.005	1.568	1.139	1.114	1.069	1.010
Clock data	1.075	1.049	1.030	1.019	1.008	1.54	1.116	1.022	1.014	1.005	1.468	1.070	1.033	1.020	1.009
r^2	0.99	1.00	1.00	1.00	1.00	0.85	0.98	0.99	0.99	1.00	0.83	0.99	0.99	1.00	1.00
r^2 (clock)	0.99	1.00	1.00	1.00	1.00	0.82	0.90	0.99	1.00	1.00	0.85	0.98	1.00	1.00	1.00

For example, data for the 60-min fixed-time increments would be collected in periods starting at each hour and ending at the beginning of the next hour.

increased as the fixed-interval time steps increased from 5 to 60 min, indicating a larger under-estimation error in the calculation of the erosivity parameters for coarser resolution rainfall data (Fig. 2), as would be expected. There was a marked reduction in the conversion factor between the 60-min data and the 30-min data (Table 3).

Statistical analyses of covariance (Snedecor and Cochran, 1989) showed that the residual variances of the regression equations for EI_{30} among five locations were different ($\alpha = 0.05$). This indicates that the data from all sites should not be pooled.

The dominant role that I_{30} played, as compared to E, in terms of the error in estimating EI_{30} using fixed-interval data was apparent for the 60-min fixed-interval data. The average conversion factors were 1.105 for E, 1.668 for I_{30} and 1.730 for EI_{30} (Table 3). However, the influence that E had was increasingly significant over EI_{30} estimation as the fixed-interval decreased from 30 to 5 min. For 30-min fixed-interval data, the average conversion factors were 1.060 for E, 1.096 for I_{30} and 1.161 for EI_{30}. For 5-min fixed-interval data, the average conversion factors were 1.009 for E, 1.007 for I_{30} and 1.014 for EI_{30} (Table 3), indicating that the two factors (E and I_{30}) were about the same in terms of producing estimation errors for this case.

Many of the previous studies assumed that the value of EI_{30} depended entirely on that of I_{30} and the conversion factor for E was 1 (Renard et al., 1997; Christopher and George, 2002). Therefore, the results for I_{30} are compared to those from other studies. The conversion factors converting fixed-interval values of $(E)_{\Delta t}$, $(I_{30})_{\Delta t}$ and $(EI_{30})_{\Delta t}$ to corresponding breakpoint calculated values of $(E)_{bp}$, $(I_{30})_{bp}$ and $(EI_{30})_{bp}$ from several studies are listed in Table 4.

The conversion factors from five stations showed that almost all conversion factors are lower than those from Weiss' study (Fig. 3). By regressing Weiss' (1964) conversion factors for I_{30} from 5-, 10-, 15-, and 30-min fixed-interval data following Eq. (9), we obtained:

$$c_{I\Delta t} = 0.005 \cdot \Delta t + 0.999 \quad r^2 = 0.999 \tag{10}$$

A similar assessment with results for I_{30} using the 5-, 10-, 15-, and 30-min fixed-interval data from our average of conversion factors resulted in:

$$c_{I\Delta t} = 0.004 \cdot \Delta t + 0.988 \quad r^2 = 0.999 \tag{11}$$

Statistical analyses (Snedecor and Cochran, 1989) in both cases indicated that the regression slopes were significantly different from zero ($\alpha = 0.05$). The results also showed significant ($\alpha = 0.05$) differences for the intercept β_0, but no significant differences for the regression slope, β_1, when Eqs. (10) and (11) were compared (Fig. 3).

Istok and McCool (1986) analyzed relationships of EI_{30} values between 15-min and 60-min fixed-interval data, and suggested a factor of 1.289 difference between the two sets of results. But it was mentioned that this factor would be greater if breakpoint data were used instead of 15-min fixed-interval data. In RUSLE (Renard et al., 1997), the conversion factors between EI_{30} values estimated based on breakpoint data and those on 60-min interval data varied from 1.152 to 3.37 in different climatic zones. Our conversion factor of EI_{30} for the 60-min fixed-interval data was 1.730, which was within that range.

When using time-increment data where breakpoint data are not available, the data collected are generally based on a specified clock interval. For example, data may be collected in periods starting at each hour and ending at the beginning of the next hour. This contrasts with the data used in this study where the fixed-interval data start at the beginning of the storm. In order to assess the potential use of such data we used time-interval clock data from the Anxi station, which was the only station where such data were available. Results are shown in Table 5. Conversion factors were slightly smaller for the clock data as compared to the data based on the beginning time of the storm. The difference was relatively negligible for all except the 60-min data, where the conversion factor for the clock data was 7% smaller. This factor should be taken into consideration when applying the results of this study.

4. Conclusion

The results of this study provide guidance for using fixed-interval time precipitation data for estimating rainfall erosivity. This can be helpful when in the application of erosion prediction technology, such as the USLE or RUSLE, in areas where extensive breakpoint precipitation data are unavailable. This study represents the first time that such an attempt has been made in China, where erosion problems are extensive and data are limited in certain geographic regions of the country. Results indicated that the average conversion factors for the five stations decreased from 1.105 to 1.009 for the estimation of E values, from 1.668 to 1.007 for I_{30} values, and from 1.730 to 1.014 for EI_{30} values as the time resolution increased from 60 to 5 min. The dominant role that I_{30} played relative to E in terms of the error in estimating EI_{30} using fixed-interval data was apparent for 60-min fixed-interval data. However, the role that E played was increasingly significant in EI_{30} estimation error as the interval decreased from 60 to 5 min. At the five sites studied, r^2 between EI_{30} estimated from the 60-min fixed-interval data and those from breakpoint data ranged from 0.83 to 0.99, and ranged from 0.97 to 0.99 for the 30-min fix-interval data. The 60-min rainfall data can be successfully used to estimate rainfall erosivity where no finer time-resolution data are available and there was a marked improvement in predictions between the 60-min data and the 30-min data. However, improvements in statistical fit were less when moving to time increments of less than 30 min, which meant it may not be necessary to sample less than on a 30-min frequency to obtain reliable erosivity estimations in this region, when cost-benefit tradeoffs must be considered relative to precipitation measurements.

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