PRECIPITATION AND TEMPERATURE EXTREMES TRENDS IN A HILLY AREA IN THE NORTHERN-ITALY APENNINES

VARIAZIONI TEMPORALI DI ESTREMI DI TEMPERATURA E PRECIPITAZIONI IN UN'AREA COLLINARE DEL NORD ITALIA

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Abstract
The Centonara watershed (44° 28'N, 11° 28'E), a small semi-agricultural watershed in the Italian Apennines, has been monitored for the last 20 years, to study the characteristics of rainfall related to soil erosion. Starting from this dataset air temperature, annual and seasonal, as average and extremes, heat waves, precipitations, annual and seasonal, were analyzed, to verify the existence of a significant trend in the annual and seasonal amounts, duration, number of events, number of extreme events, intensity, etc. The results show a significative increase of all the indexes regarding temperature, and no clear signals regarding precipitations and precipitation extremes.

Keywords: Precipitation extremes; temperature extremes; heat waves; Mann-Kendall test; soil conservation.
Parole chiave: Estremi di temperatura; estremi di precipitazione; ondate di calore; Mann-Kendall; conservazione del suolo.

Introduction

Several studies have been conducted on the effects of climate change on soil erosion using computer simulation models, but with so many interlinked variables to take into account that the simulation effectiveness may be not guaranteed. In this paper data from a small semi-agricultural watershed in the Italian Apennines, that has been monitored for the last 21 years to study the characteristics of rainfall related to soil erosion, will be analyzed in their evolution in time, looking for trends in all the main rainfall and temperature climate change indices. The results will then be used to understand the variations that climatic changes will cause on soil erosion, soil fertility and then on agricultural practices in hilly areas.

Materials and Methods

The experimental site is in the hills near Bologna (Italy) at an altitude of 200 m a.s.l. Meteorological data were collected in an agrometeorological station with thermoigrometer, pluviometer, gonioanemometer and solar radiation sensors. A continuous database (1992-2012) allowed the characterization of the area. For precipitation the year 1998 was not used because too many days of data were unavailable.
The area has a mean air temperature of 15°C and a mean total annual rainfall of 735 mm y^{-1}.
DATA ELABORATION. The annual maximum, minimum and mean air temperature (Tx, Tm, Tn), annual and seasonal (Seasons were defined as: Winter = Jan+Feb+Mar, etc.) and the number of yearly days with Tx > 95th and 99th percentile were calculated. The number of heat waves (HW), calculated as the sum of days with daily Tx > Tx(med1992-2012)+3°C for ≥ 6 consecutive days, were counted (Perry and Hollis, 2005).
The annual (Pyear), seasonal and monthly rainfall were calculated for each year. The number of rainy days (P_d days with P ≥ 2 mm), P_e mean rainfall per event (precipitation event is defined as the period with P > 0; two events are separated by 6 hours without precipitations), P_{ey} number of events per year, D_e mean event duration, I_{me}, I_{xe} mean and maximum rainfall intensity per event were calculated.
Precipitation extreme events were defined as follows:
• number of rainfall events with amount > 75th and 95th percentile,
• number of rainfall events with duration > 75th and 95th percentile,
• number of events with maximum intensity > 75th and 95th percentile (max extreme intensity);
• number of events with average intensity > 75th and 95th percentile (mean extreme intensity).
Seasonal average of the quantity, duration, mean and maximum intensity per event were also calculated.
All the meteorological quantities time series were evaluated with the non-parametric Mann–Kendall test (Sneyer, 1990), which reliably identifies monotonic linear and non-linear trends in non-normal data series (Helsel and Hirsch, 1992).

Results and Discussion

TEMPERATURE. The 21 year dataset shows a significative increase of Tx, Tm, Tn (Fig.1). Analyzing the seasonal temperatures is clear that the increase is mainly in Spring and Summer. The dataset is too short in time to be considered as climatological, but has the important characteristic to come

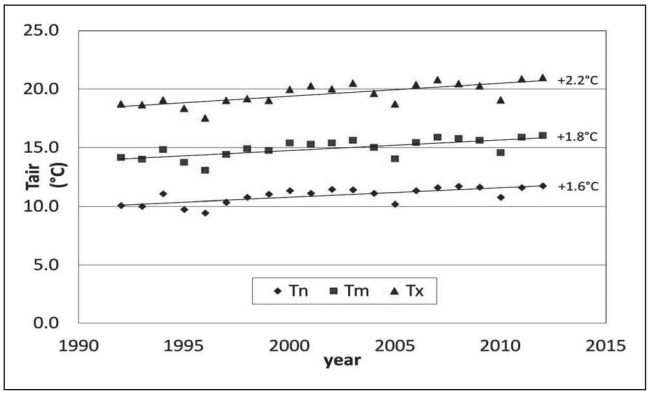


Fig. 1 - Air temperature in Ozzano (BO).
Fig. 1 - Temperature dell'aria ad Ozzano (BO).

Tab. 1 - Extreme events definition: percentiles.
Tab. 1 - Definizione degli eventi estremi: percentili.

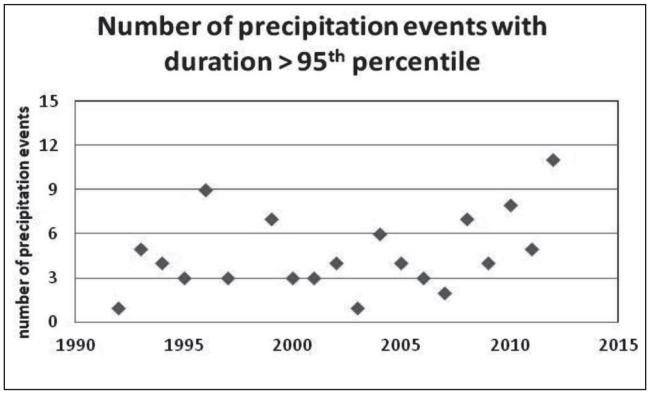
PERCENTILE	P_e mm/event	D_e hh.mm.ss	I_{me} mm/h	I_{xe} mm/h
75^{th}	9.4	9.40.00	2.1	6.0
95^{th}	32.8	25.54.53	5.5	27.4

Tab. 2 - Extreme events were calculated on a seasonal basis: there was a trend only in some cases.
Tab. 2 - Gli eventi estremi sono stati calcolati anche su base stagionale: è stato verificato un andamento significativo solo in alcuni casi.

		P_e mm/event	D_e hh.mm.ss	I_{me} mm/h	I_{xe} mm/h
Winter	75^{th}	No trend	Trend +	No trend	No trend
	95^{th}	Trend +	Trend +	No trend	No trend
Spring	75^{th}	No trend	No trend	Trend +	No trend
	95^{th}	No trend	No trend	Trend +	No trend
Summer	75^{th}	No trend	No trend	No trend	No trend
	95^{th}	No trend	No trend	No trend	Trend +
Autumn	75^{th}	No trend	No trend	No trend	No trend
	95^{th}	Trend +	Trend +	No trend	No trend

from a station in an area far from urbanization, and whose land use did not change in the considered time spell. The number of days per year with temperature higher than the 95^{th} percentile (equal to 34.2°C) and the 99^{th} percentile (37.3°C) increased too, going from about 1 to 30 the former, and from about 0 to 9 the latter. The warmest years, according to this indicator, are 2003, with 51 days with T>34.2°C, and 2012, with 54 days. The HW index takes into account not only the extent of the temperature, but also the number of consecutive days with high temperatures. The number of heat waves shows a significative increase in the 21 years, going from about 0 to about 4 per years, with an average total duration of the Heat Waves from about 0 to about 54 days per year. For this index the worst year was 2007, with 8 Heat Waves (63 days) followed by 2012 with 7 Heat Waves (69 days). These data are in agreement with what was found in the literature, for example in Tomozeiu et al., 2006.

Fig. 2 - Yearly number of precipitation events greater than 95th percentile.
Fig. 2 - Numero annuo di eventi di precipitazione con durata maggiore del 95th percentile.



PRECIPITATION. Most of the general yearly means of rainfall characteristics, describing the precipitation pattern as measured in the Ozzano agrometeorological station, showed no sign of change with time, as a result of Mann-Kendall tests. Only the annual number of precipitation events and the mean event intensity show a significative trend, positive the former, negative the latter. These results are in contrast with literature (for example Alpert et al., 2002), that usually shows an increase of intensity. This may be due to the unsuitability of the database (only 21 years).
The indexes characterizing the precipitation extremes were calculated anyway (Tab.1). Considering as extreme the events with P_e, D_e, I_{me} and I_{mx} greater than 75^{th} or 95^{th} percentile, there is only a significative positive trend with the number of precipitation events duration (95^{th} percentile).
Trends in time of the extreme events indexes, calculated for the seasons, are not verified by Mann - Kendall tests in most cases (Tab. 2). We can see some positive variation of intensity (increase of I_{me} and I_{xe}) in Spring and Summer, and a rise of P_e and D_e in Winter and Autumn.

Conclusions

The present research analyzes 21 years of temperature and precipitation data from an agrometeorological station in the hills next to Bologna. The aim was to recognize trends influencing, negatively or positively, soil erosion, and related to climate change. Results shows important increases in temperature, as mean and as extremes, and no signals for precipitation, apart from an increase of intensity in Spring/Summer and of quantity in Winter/Autumn. Both these results may have negative impact on soil erosion, increasing the fragility of the ecosystem.

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