Catena 137 (2016) 161–172

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Spatio-temporal analysis of rainfall erosivity and erosivity density in Greece

Panos Panagos [a,*], Cristiano Ballabio [a], Pasquale Borrelli [a], Katrin Meusburger [b]

[a] European Commission, Joint Research Centre, Institute for Environment and Sustainability, Via E. Fermi 2749, I-21027 Ispra VA, Italy
[b] Environmental Geosciences, University of Basel, Switzerland

ARTICLE INFO

Article history:
Received 25 September 2014
Received in revised form 16 September 2015
Accepted 23 September 2015
Available online 3 October 2015

Keywords:
R-factor
Seasonality
Rainfall intensity
Monthly erosivity density
Soil erosion
RUSLE

ABSTRACT

Rainfall erosivity considers the effects of rainfall amount and intensity on soil detachment. Rainfall erosivity is most commonly expressed as the R-factor in the Universal Soil Loss Equation (USLE) and its revised version, RUSLE. Several studies focus on spatial analysis of rainfall erosivity ignoring the intra-annual variability of this factor. This study assesses rainfall erosivity in Greece on a monthly basis in the form of the RUSLE R-factor, based on a 30-min data from 80 precipitation stations covering an average period of almost 30 years. The spatial interpolation was done through a Generalised Additive Model (GAM). The observed intra-annual variability of rainfall erosivity proved to be high. The warm season is 3 times less erosive than the cold one. November, December and October are the most erosive months contrary to July, August and May which are the least erosive. The proportion between rainfall erosivity and precipitation, expressed as erosivity density, varies throughout the year. Erosivity density is low in the first 5 months (January–May) and is relatively high in the remaining 7 months (June–December) of the year. The R-factor maps reveal also a high spatial variability with elevated values in the western Greece and Peloponnesus and very low values in Western Macedonia, Thessaly, Attica and Cyclades. The East–West gradient of rainfall erosivity differs per month with a smoother distribution in summer and a more pronounced gradient during the winter months. The aggregated data for the 12 months result in an average R-factor of 807 MJ mm ha^{-1} h^{-1} year^{-1} with a range from 84 to 2825 MJ mm ha^{-1} h^{-1} year^{-1}. The combination of monthly R-factor maps with vegetation coverage and tillage maps contributes to better monitor soil erosion risk at national level and monthly basis.

1. Introduction

Soil erosion is serious environmental and public health problem that human society is facing, as every year at global scale almost 10 ha of cropland are lost due to soil erosion (Pimentel, 2006). To design efficient policies, land use planners and decision makers need, among others, information on the on-site private costs and the offsite consequences (desertification, rural depopulation, siltation of waterways and reductions in biodiversity) plus data on soil erosion (Colombo et al., 2005).

The empirical Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997), which predicts the average annual soil loss resulting from raindrop splash and runoff from field slopes, has widely been used as a tool for predicting soil erosion at large spatial scales (Kinnell, 2010; Panagos et al., 2015a). Among the factors used within RUSLE, the rainfall is accounted by rainfall erosivity (R-factor) which combines the influence of precipitation duration, magnitude and intensity. The R-factor is a multi-annual average index that measures rainfall's kinetic energy and intensity to describe the effect of rainfall on sheet and rill erosion (Wischmeier and Smith, 1978).

Of all the erosion factors, rainfall erosivity and land cover/management factor are considered to be the most dynamic. By capturing the variability of those two factors, it is possible to have a more realistic and precise soil erosion assessment. For instance, a rainstorm may cause severe soil loss in the fallow period but hardly any damage during the growing season. A monthly estimation of precipitation and rainfall intensity has been used for assessing the temporal variability of rainfall erosivity in Ethiopia (Nyssen et al., 2005) and Switzerland (Meusburger et al., 2012). Furthermore, the spatial and the temporal variability of the R-factor have been important in risk assessments in Andalusia (Renschler et al., 1999) and in recent developments of G2 soil erosion model in Strymonas catchment (Panagos et al., 2012) and Crete (Panagos et al., 2014).

As for rainfall erosivity, Greece is a very interesting study area due to the high climate diversity mainly attributed to high relief variability. The main objective of this study is to assess the spatio-temporal variability

* Corresponding author.
E-mail address: panos.panagos@jrc.ec.europa.eu (P. Panagos).

http://dx.doi.org/10.1016/j.catena.2015.09.015

of rainfall erosivity in Greece based on precipitation data with a high temporal resolution. Specific aims of this study are to:

a) compute monthly rainfall erosivity on 80 precipitation stations in Greece;
b) produce linear regression functions that can predict monthly R-factor on station basis;
c) interpolate station R-factor values to produce 12 monthly R-factor maps using a Generalised Adaptive Model and spatial covariates which among others can potentially be used for monthly soil erosion modelling; and
d) identify spatial and temporal patterns to map the relationship between the R-factor and the precipitation (monthly erosivity density).

2. Data and methods

2.1. Study area

Greece is classified as Mediterranean climate type according to Köpper classification (Kööppen, 1918): mild and rainy winters, relatively warm and dry summers, and l extended periods of sunshine throughout most of the year. The orographic and topographic influences, along with the influence of the Mediterranean waters (warmer than the adjoining land in winter and cooler in summer) cause an uneven temporal and spatial distribution of precipitation (Hatzianastassiou et al., 2008).

WorldClim statistics (Hijmans et al., 2005) reports 698 mm as the mean annual precipitation, 189 mm as the standard deviation, and from 380 to 1406 mm as the range of annual precipitation values in the study area (Fig. 1). The weather in Greece varies from the dry climate of Attica (Athens' greater area) and of East Greece, to the wet climate of Northern and Western Greece (HNMS, 2014).

In Greece, the year can be broadly subdivided into two main seasons: The cold and rainy period lasting from mid-October until the end of March, and the warm and dry season lasting from April until September. The wettest months are January (94.8 mm) and December (107.6 mm), whereas the driest ones are July (19.6 mm) and August (16.3 mm) according to the WorldClim data. The precipitation regime in Greece has been extensively studied in past, further climatic details are provided by Bartzokas et al., 2003; Tolika and Maheras, 2005; Pnevmatikos and Katsoulis, 2006.

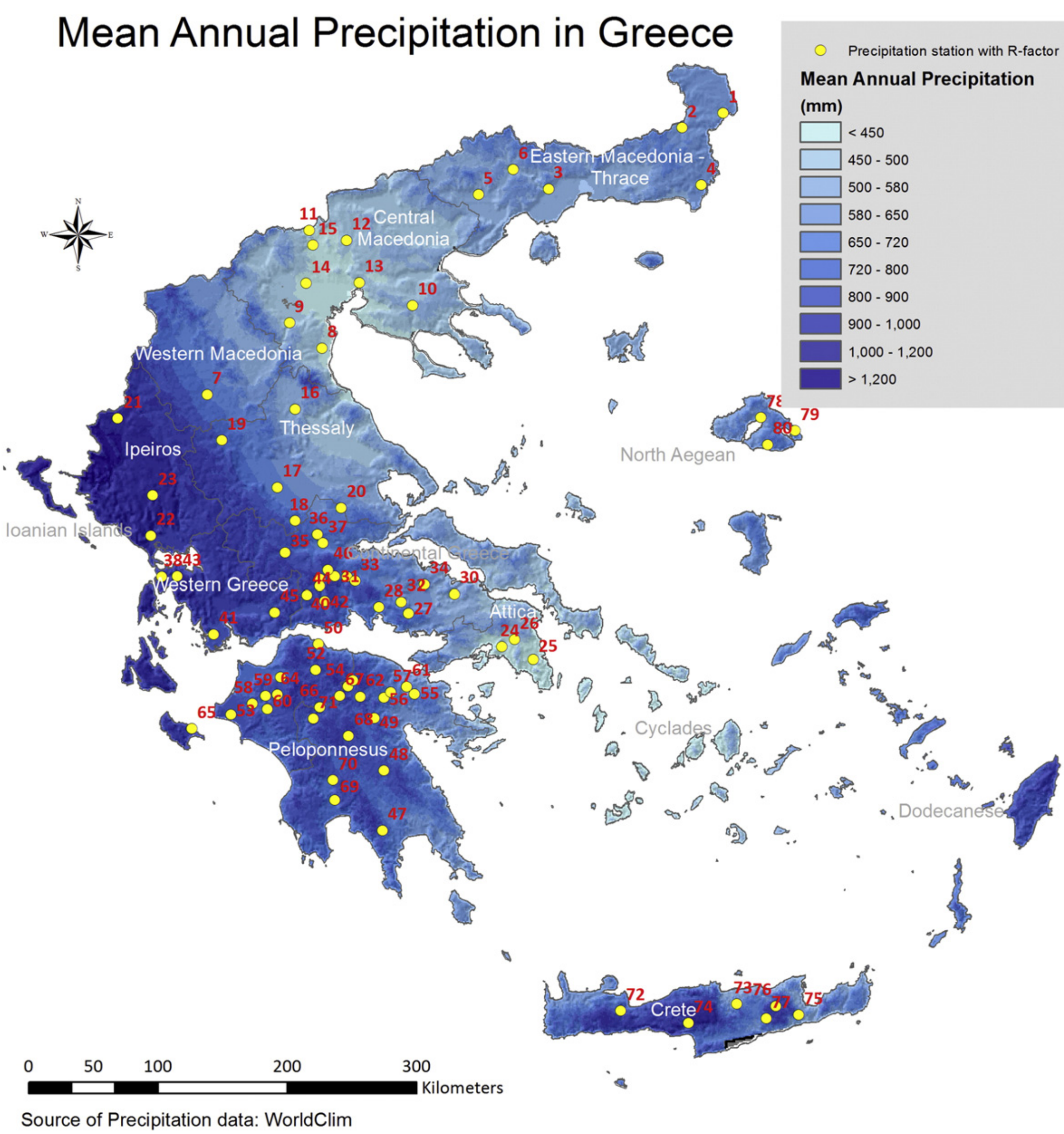

Fig. 1. Spatial distribution of mean annual precipitation and stations (Numbers refer to the station id in the Appendix) used for the R-factor calculation in Greece.