Soil Erodibility (K-factor) in Europe

Methodology for K-factor Estimation

One key parameter for modelling soil erosion is the soil erodibility, expressed as the K-factor in the widely used soil erosion model, the Universal Soil Loss Equation (USLE) and its revised version (RUSLE). The K-factor, which expresses the susceptibility of a soil to erode, is related to soil properties such as organic matter content, soil texture, soil structure and permeability.

With the Land Use/Cover Area frame Survey (LUCAS) soil survey in 2009 a pan-European soil dataset is available for the first time, consisting of around 20,000 points across 25 Member States of the European Union. The aim of this study is the generation of a harmonized high-resolution soil erodibility map (with a grid cell size of 500 m) for the 25 EU member states. Soil erodibility was calculated for the LUCAS survey points using the nomograph of Wischmeier and Smith (1978).

\[ K = (12.1 \times 10^{-4} \times M^{1.14} \times (12 - OM + 3.25 \times (s - 2) + 2.5 \times (p - 3)) / 100)^{0.1317} \]

Where:
- \( M \): the textural factor with \( M = (\text{msilt} \times \text{mfs})^{1/2} + \text{mc} \);
- \( \text{msilt} \% \): silt fraction content (<0.002 mm);
- \( \text{mfs} \% \): very fine sand fraction content (0.002 – 0.05 mm);
- \( \text{mc} \% \): the organic matter content;
- \( s \): the soil structure class (s=1: very fine granular, s=2: fine granular, s=3: medium or coarse granular, s=4: blocky, platy or massive; Table 1);
- \( p \): the permeability class (p=1: very rapid, ... p=6: very slow).

A Cubist regression model was applied to correlate spatial data such as latitude, longitude, remotely sensed and terrain features in order to develop a high-resolution soil erodibility map.

Cubist approach for the interpolation of 20,000 LUCAS points

Cubist is tree model where each terminal leaf contains a linear regression model. The prediction is made using the linear regression model at the terminal nodes of the tree smoothed by taking into account the predictions from previous nodes of the tree. Cubist makes an average of the sample value over a given neighbor. In the next stage, the residuals from the Cubist model were interpolated using Multilevel B-Splines (MBS).

The high-resolution soil erodibility map (500m) version 2014 incorporates certain improvements compared to past methodologies:
- High resolution dataset (500m) and application of Cubist regression-interpolation (better spatial accuracy);
- Soil structure was for the first time included in the K-factor estimation;
- Coarse fragments were taken into account for the better estimation of soil permeability;
- Surface stone content which acts as protection against soil erosion was for the first time included in the K-factor estimation. This correction is of great interest for the Mediterranean countries wherestoniness is an important regulating parameter of soil erosion;
- The estimated soil erodibility dataset is verified against local, regional and national data found in the literature (21 Studies).

Results

The mean K-factor for the 25 Member states was calculated as 0.033 t ha h^{-1} MJ^{-1} mm^{-1} with a standard deviation of 0.069 t ha h^{-1} MJ^{-1} mm^{-1}. Range: 0.004 – 0.076 t ha h^{-1} MJ^{-1} mm^{-1}

Cubist regression model predicted the of the K-factor with a good performance (\( R^2 = 0.4 \). The interpolation using MBS further increased the prediction performance of the K-factor to an \( R^2 \) of 0.94 for the fitting dataset.

The spatial pattern of areas with high soil erodibility largely follows the Less map of Europe 1:2,500,000.

Comparison between the resulting K-factors and the textural classes of the European Soil Database shows that the highest mean values of the K-factors are in the medium-fine textural class, followed by the fine and medium classes, while the lowest mean values are recorded for coarse and very fine classes.

The resulting K-factor map (incorporating Stoniness) is slightly different compared to the K-factor map. The mean K-factor value is 0.027 t ha h^{-1} MJ^{-1} mm^{-1}.

The application of the stoniness correction factor (SU) reduces the K-factor on average by 15%.

The comparison of our K-factor against National and Regional studies shows a deviation of about 14.3% in absolute terms.

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