Global Soil Erosion Modelling, First Results

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Background

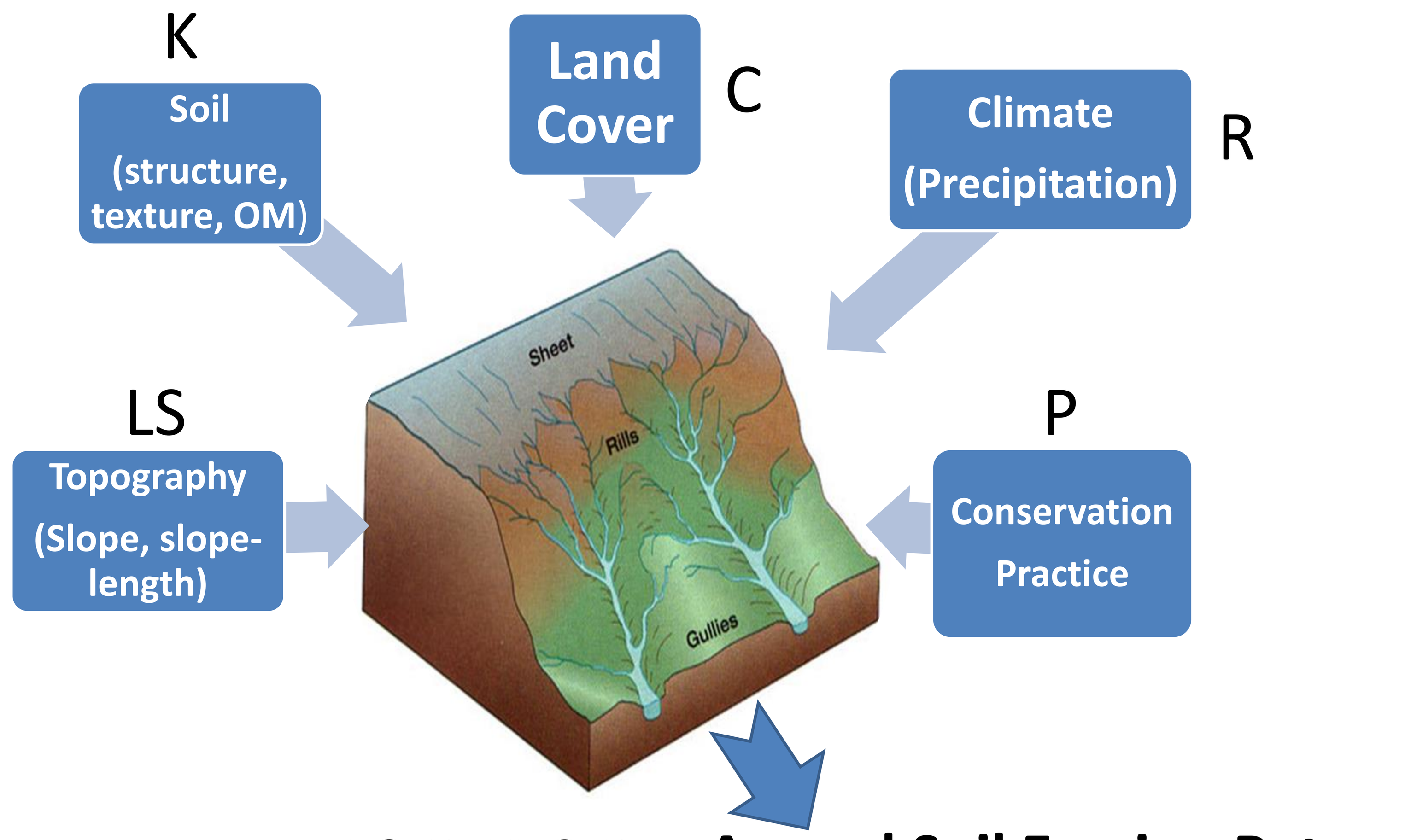
In this study we try to understand the effects of soil erosion on the global carbon cycle in different climate and land-use scenarios

Aim of the study: To model large scale historical soil erosion events and their impacts on the carbon cycle

Here we discuss:

- How to model soil erosion processes
- How to make RUSLE applicable on global scale – focusing on the scale dependency of topography
- Uncertainties that are related to the used methods

Tool: RUSLE Model *(Renard et al., 1997)*

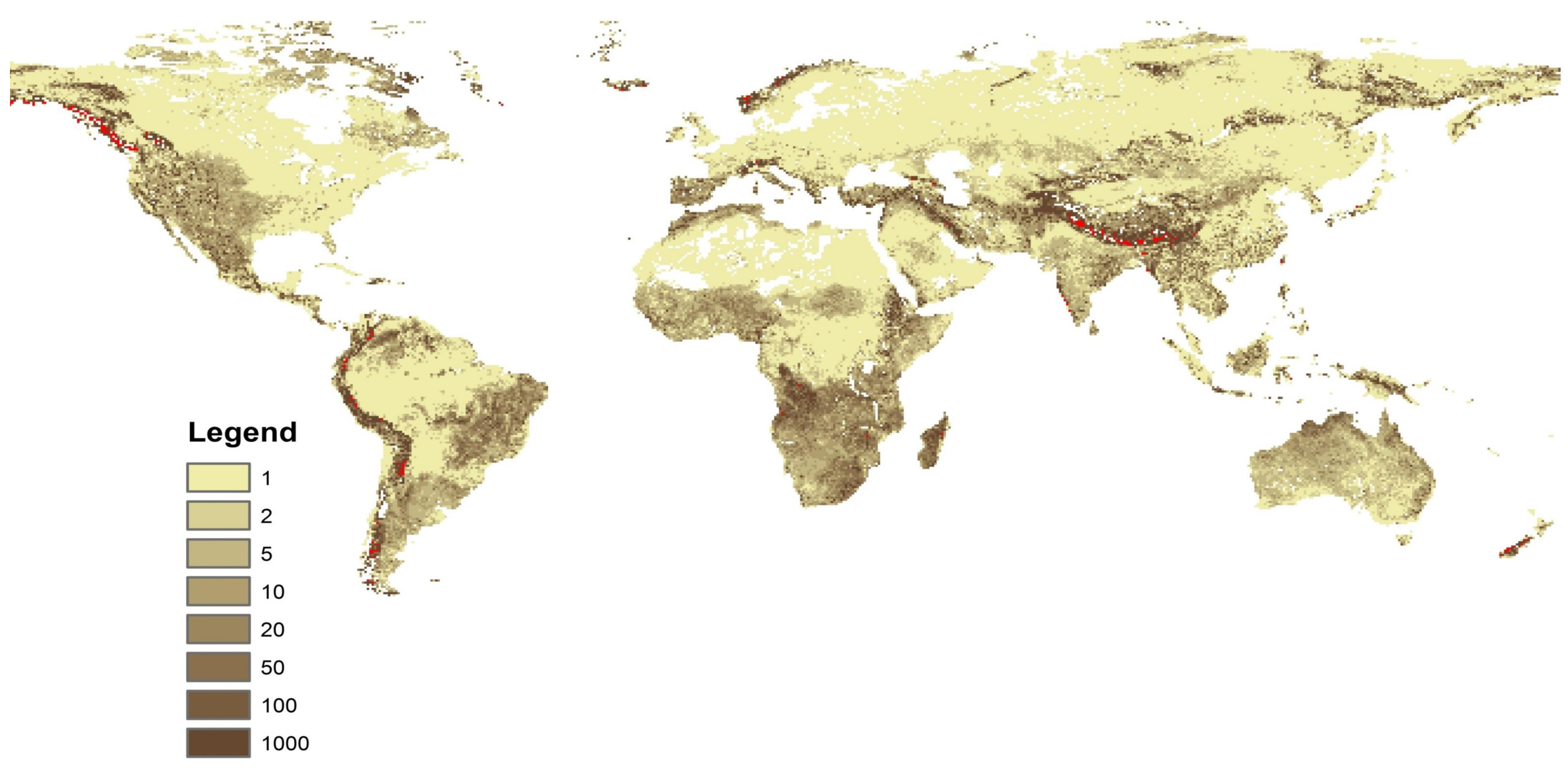


LS*R*K*C*P = Annual Soil Erosion Rates

- RUSLE is a semi empirical/process-based model
- Parameterized for agricultural areas on the plot scale
- Does not simulate deposition and sediment transport

First Results

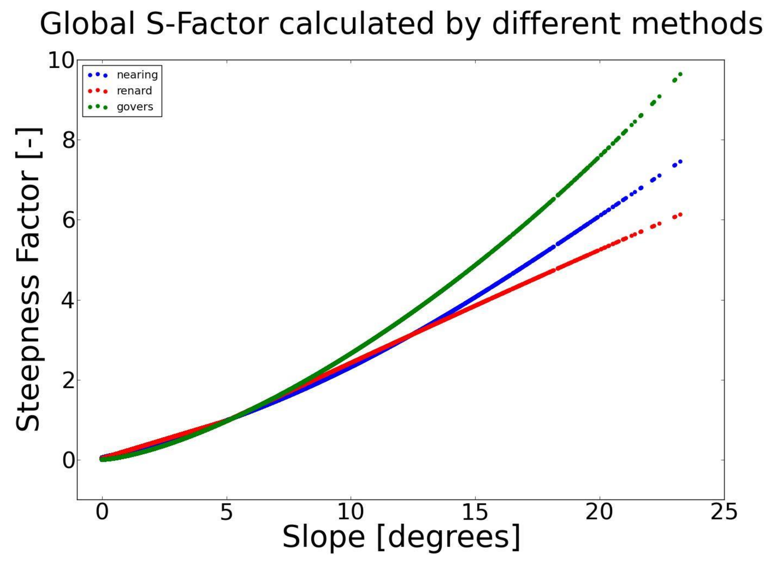
Global mean soil erosion rates for July 2012, on a 0.5 degree scale

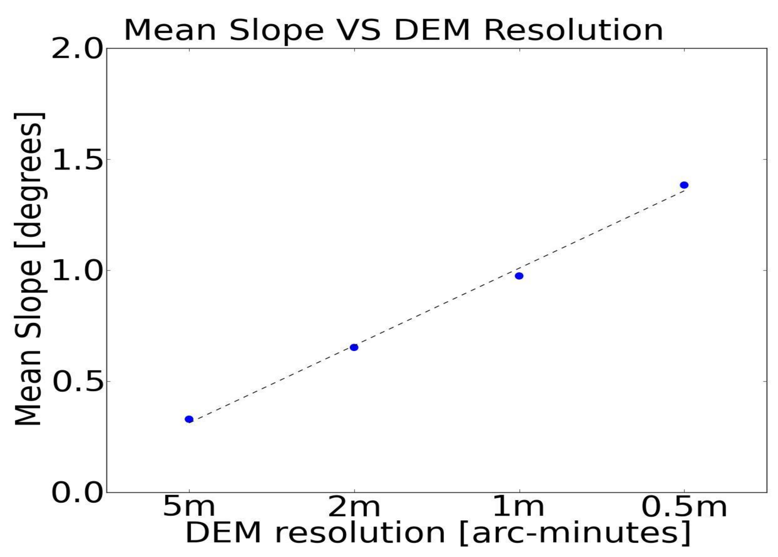


- Global mean soil erosion July 6.3 ton ha^{-1} $year^{-1}$ and December 11.1 ton ha^{-1} $year^{-1}$
- We found a general underestimation of erosion on agricultural areas due to the coarse scale of the datasets compared to the local scale of erosion
- We also found unrealistic high erosion rates in mountainous areas due to the absence of a "limit" to erosion in the model

Scale dependency of the steepness factor (S)

- The S factor can be calculated by different methods, which show the largest deviation for large slopes *(figure right panel)*
- The S factor is a function of slope and the slope is highly dependent on the spatial resolution of the Digital Elevation Model, DEM *(figure left panel)*





Fractal method for deriving high resolution slope from coarse-scale data *(Zhang et al., 1999)*

$$S = \alpha d^{1-D}$$

S = percentage slope
α = coefficient
d = grid resolution in meters
D = fractal dimension

- *Assumption 1*: Topography obeys fractal statistics
- *Assumption 2*: Standard deviation of elevation independent of DEM resolution

Slope derived from 1km DEM

Fractal slope derived from 1km DEM using grid resolution of 30m

- We find a clear gain in detail in the 30m fractal slope derived from the 1km DEM compared to the original slope derived from the 1km DEM

Scale dependency of the slope-length factor (L)

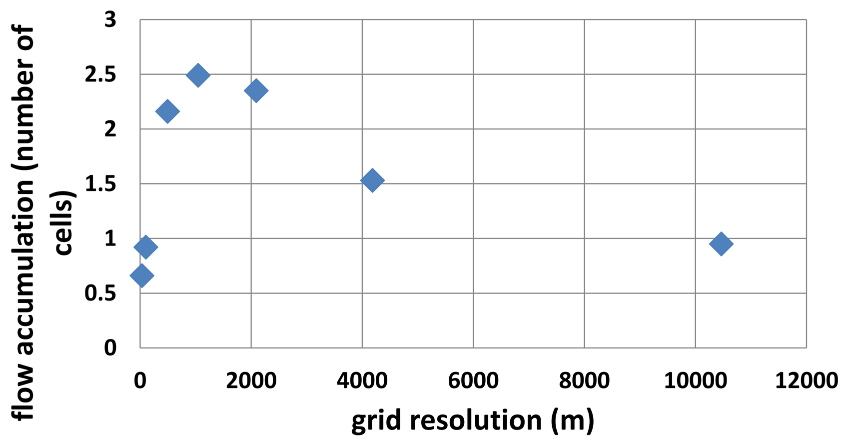
- The L factor can be estimated by different methods, among which flow accumulation is for high resolution and local scale, and Yang (2001) method for the hydrological catchment scale
- The L factor is a function of slope and slope-length and therefore depends on the spatial resolution

Method for calculation of L	Global Mean	Global Standard-deviation
L – Flow Accumulation	7.73	26.92
L – Yang (2001)	1.48	1.31
L - slope length = 100 m	1.30	0.35

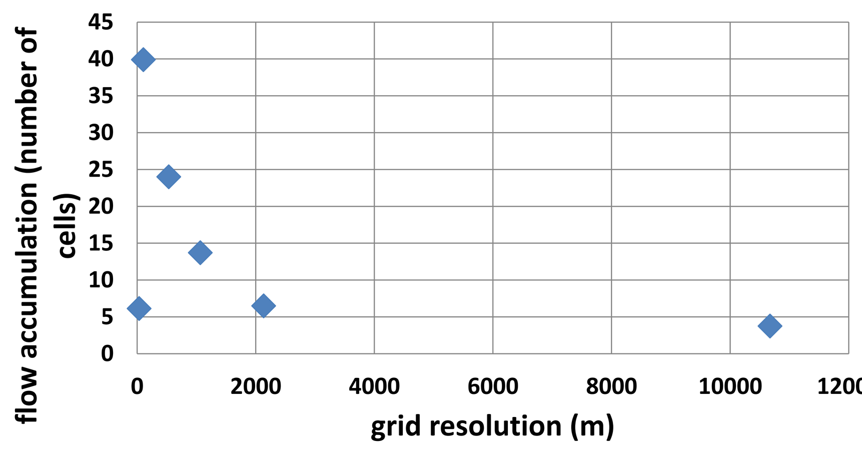
Method 1: slope-length = flow accumulation * grid resolution

- This does not apply for very coarse datasets (global scale) due to the large grid resolution

Flow accumulation vs grid resolution for a 1 by 1 degree flat area



Flow accumulation vs grid resolution for a 1 by 1 degree hill area



Take-Home Messages

- **This study reveals the strong dependence of soil erosion modeling on the spatial resolution**
- **The scale dependency, as showed for topography, is also expected to play an important role for the other RUSLE factors**
- **To make RUSLE applicable on global scale both temporal and spatial scaling of the RUSLE factors is needed**

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