REMOTE SENSING EROSION ESTIMATION

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1. INTRODUCTION

High topography and hardly accessible terrains make field studies on a large-scale cumbersome. An integrative approach, employing several remote sensing techniques combined with field studies, and experimental and numeric simulations, provides tools for the understanding of coupled processes [1]. New remote sensing technologies have the capability of measuring physical parameters, such as precipitation, land use, vegetation coverage, soil moisture, and uplift with an area-wide coverage and high spatial resolution. Numerical modeling, based on properties from experimental simulations and with remotely acquired area-wide parameter input, provides a powerful tool to understand the acting processes in mountain belts. Our work indicates that existing remote sensing methods, allowing an estimation of erosion, largely underestimate erosion in tectonically active areas [1]. In very active areas, a non-negligible part of erosion is directly tectonically linked and occurs by landsliding and base flow. We are working on remote sensing methods allowing a better constraint on overall erosion in active areas [2]. An estimation of erosion rates will help us to localize zone of tectonic uplift but also allow the quantification of uplift rates as shown previously (stream power law). We are currently calibrating parameters such as precipitation intensities based on remote sensing measurement such a TRMM. We also developed new methods for the remote sensing estimation of soil type using support vector machines [3].

2. EMPIRICAL APPROACH

RUSLE is the most extensively used empirical soil erosion model. Like its predecessor, the Universal Soil Loss Equation (USLE), it is an erosion prediction model designed to predict the long-term average annual soil loss from specific field slopes in land management and land use systems. The equation can be written as:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P \quad (1)$$

where A is the averaged quantity of soil erosion in $t \cdot ha^{-1} .yr^{-1}$. Factor R is the precipitation erosivity ($M J \cdot mm \cdot ha^{-1} \cdot h^{-1} \cdot yr^{-1}$), which can be described as the energy that is applied to a soil type during a rain or storm event. In this study, R is based on dataset from TRMM, providing a calibration-based scheme for combining precipitations from multiple satellites at fine scales (Fig.5). Parameter K ($M J^{-1} . m^{-1}$), the soil erodibility factor, is calculated on the base of the FAO soil map or nonlinear classifications [3]. The (usually combined) factor LS equals slope-length (L) by slope-steepness (S) and is calculated from DEMs (e.g. SRTM). The remaining parameter C and P are crop and erosion control practices factors. The cover management factor C represents the landuse and is derived by calculating and comparing various vegetation indices like NDVI, EVI, SAVI and LAI calculated on the base of Landsat and MODIS data. Parameters R and K have units, while LS, C and P remain dimensionless. The main reason for applying the RUSLE model is that all main factors, which influence soil processes, can be evaluated fairly accurately via remote sensing.

3. NON EMPIRICAL APPROACH

We are also developing a new approach based on a non empirical approach.

The drainage system mor phology depends on 2 parameters, i.e. uplift and incision rates.
incision is defined by :

- an altitude variation balanced by "erosion"

$\frac{\partial h}{\partial t} = -\nabla.(\mathbf{n}q_s)$ (2)

- an effective rain flowing downwards, driven by gravity

$\nabla.(\mathbf{n}q) = \alpha$ (3)

where **n** is the unit vector directed along negative surface gradient, i.e.

$$\mathbf{n} = \frac{-\nabla \mathbf{h}}{S} = \frac{-\nabla \mathbf{h}}{\|\nabla \mathbf{h}\|}$$

S being the slope, and h the surface elevation, qs the sediment discharge per unit width, q the magnitude of fluid discharge per unit width and α the effective rainfall

The sediment discharge can be simply written as the sum of diffusive hillslope development and incision

$q_s = \kappa S + cq^n S$ (4)

Where κ is the hillslope diffusivity, c a fluvial transport coefficient and n a parameter quantifying the dependency of sediment flux on local slope.

by replacing S using (2) and (4)

$\frac{\partial h}{\partial t} = -\nabla.(\nabla h(\kappa + cq^n))$ (5)

Here we show that incison depends on the second derivative of the topography (derivative of the slope), hillslope diffusivity (which is null on steep area or where water inflow is important, i.e. no deposition), the fluvial transport coefficient and the water discharge.

We are now working on the estimation of the real surface water discharge via remote sensing. This depends on several parameters including precipitation energy (intense rainfall causes more erosion, do not infiltrates etc.), soil type (sandy soils erodes easier) and land-cover (vegetation reduces erosivity). This will lead us to the development of a new formulation of erosion, not unlike RUSLE but taking the nonlinearity of the involved factors in account.

11. REFERENCES

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