Geophysical Research Abstracts
Vol. 16, EGU2014-10151, 2014
EGU General Assembly 2014

Spectral Fingerprinting: The potential of VNIR-SWIR spectral characteristics for tracing sediment sources in a Spanish mesoscale catchment

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Knowledge on the origin of suspended sediment can greatly facilitate erosion prevention and thus sustainable watershed management. One approach providing information on the origin of suspended sediments is the fingerprinting technique. It is based on the assumption that potential sediment sources can be discriminated and that the contribution of these sources to the sediment can be determined on the basis of distinctive characteristics (fingerprints). Recent studies indicate that VNIR-SWIR reflectance characteristics of soil may be a rapid, inexpensive alternative to traditional fingerprinting properties such as e.g. geochemical composition.
In this study, we aim at further assessing the potential of this innovative sediment tracing technique, specifically whether (a) potential sediment sources can be reliably identified based on spectral features, (b) field derived source information (more rapid) is sufficient for spectral fingerprinting, (c) spectral fingerprints permit the quantification of source contribution, and (d) to examine changes in the relative contributions from different sources both, between and within individual storm events.
Therefore, samples were collected in the Isábena catchment (445 km^2) in the central Spanish Pyrenees: 1) soil samples from the main potential source areas and 2) suspended sediment samples during four flood events in autumn 2011 and spring 2012 at the catchment outlet and at several subcatchment outlets. In addition, 3) artificial mixtures of known proportions were produced from soil samples for testing of key assumptions in a controlled environment. Soil samples (1) were spectrally measured in the field using an ASD spectrometer and subsequently all samples (1-3) were dried and spectrally measured in the laboratory using the same equipment. Colour parameters and physically based features with relation to organic carbon, iron oxide and clay content were calculated from field- and laboratory spectra. Principal component analyses (PCA) were applied to determine natural clustering of samples and discriminant function analyses to assess source discrimination potential of features. Mixture modelling was applied to determine source contribution.
We found that three source types could be reliably discriminated based on spectral parameters, whereas aggregation of source types that could not be discriminated did not improve unmixing results. Despite providing similar discrimination accuracies as lab source parameters, in-situ derived source information was found insufficient for contribution modelling. Lab-measured spectral fingerprints permitted the quantification of source contribution to artificial mixtures, whereas introduction of source heterogeneity decreased modelling accuracies. Suspended sediment sources were found to vary between as well as within flood events, whereas badlands were always the major sources, forests and grasslands contributed little and other sources (not further determinable) up to 40 %. The analyses further suggested that sediment sources differ between the subcatchments and that subcatchments comprising relatively large proportions of badlands contributed most to the four flood events analysed in detail.
From this study, we conclude that spectral fingerprints provide a rapid, cost-efficient and non-destructive alternative to classic fingerprint properties. However, since composites of fingerprint characteristics were found most promising in previous studies, a combination of spectral with further fingerprint properties could potentially permit discrimination of a higher number of source types.