

Analysis of Factors Controlling Erosion Rates on a Global Scale Using DEMs and GIS

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The sediment cycle is one of the major processes on earth, where eroded material is transported into the oceans, subducted into the mantle and then returns to the surface through uplift and volcanism. This means that estimates of erosion rates are a vital component of both sediment and geochemical mass balance studies. Since the geochemical mass balance includes carbon cycle, as erosion of silicates and carbonate minerals serves as a transformer of carbon dioxide between the atmosphere and lithosphere, understanding the mechanisms and controlling factors of erosion rates will help understand not only the sediment mass balance and landscape evolution, but looking at the geochemical aspect, the carbon cycle, and as such, climate change. Erosion rates and their controlling factors have been the subject of research for decades. A variety of factors were identified ranging from slope and basin area, to precipitation and vegetation coverage. Due to limitation of available data in the past, the analysis tended to be relatively basic. Thanks to abundant newly obtained erosion rate data, combined with high resolution DEMs (Digital Elevation Models) on a global scale, a more complete and comprehensive analysis can be made, and correlations of erosion rates with factors related to basin morphometry, climate and tectonics are possible. This is the first comprehensive study to analyze erosion rate data derived from a number of different methods and a 1 arc second resolution on a global scale. The study is based on previously obtained and published erosion rate data, including those from ¹⁰Be, a cosmogenic radionuclide, and sediment yield measurements published by the U.S. Geological Survey, and uses ArcGIS and JPM Pro to analyse these data. All together 2683 data points in 211 basins were included in this study.

The following five characteristics were identified: 1) The most important factors within the basin morphometry is mean basin-wide slope, however, this characteristic should be used with caution as it cannot account for complex distribution of slopes within a basin. 2) Erosion rates are dependent on climate factors, in particular basin average yearly precipitation. 3) Examination of the correlation of erosion rates to vegetation types and coverage indicates that these factors do not directly affect erosion rates; rather, they represent a secondary effect dependent on precipitation. 4) Erosion rates are strongly correlated with factors related to tectonic activity. 5) A multivariate stepwise regression indicates a dependence of erosion rates on latitude.

Although erosion rates are dependent on many different factors, this study emphasizes the importance of two factors in particular: precipitation and distance to tectonic plate boundary. Even though they are part of extensive systems and the precise way in which they affect erosion is complex, both are easily obtained parameters.

Keywords: GIS, Erosion rate , Basin morphometry, Climate, Tectonic activity