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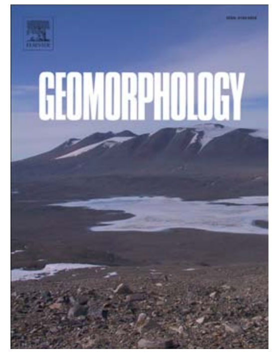

Climate regulates the erosional carbon export from the terrestrial biosphere

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PII: S0169-555X(16)30122-2
DOI: doi: 10.1016/j.geomorph.2016.03.028
Reference: GEOMOR 5560

To appear in: *Geomorphology*

Received date: 4 August 2015
Revised date: 24 March 2016
Accepted date: 25 March 2016

Please cite this article as: Hilton, Robert G., Climate regulates the erosional carbon export from the terrestrial biosphere, *Geomorphology* (2016), doi: 10.1016/j.geomorph.2016.03.028

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ACCEPTED MANUSCRIPT

Climate regulates the erosional carbon export from the terrestrial biosphere

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Abstract: Erosion drives the export of particulate organic carbon from the terrestrial biosphere ($POC_{biosphere}$) and its delivery to rivers. The carbon transfer is globally significant and can result in drawdown of atmospheric carbon dioxide (CO_2) if the eroded $POC_{biosphere}$ escapes degradation during river transfer and sedimentary deposition. Despite this recognition, we lack a global perspective on how the tectonic and climatic factors which govern physical erosion regulate $POC_{biosphere}$ discharge, obscuring linkages between mountain building, climate, and CO_2 drawdown. To fill this deficit, geochemical ($\delta^{13}C$, ^{14}C and C/N), hydrometric (water discharge, suspended sediment concentration) and geomorphic (slope) measurements are combined from 33 globally-distributed forested mountain catchments. Radiocarbon activity is used to account for rock-derived organic carbon and reveals that $POC_{biosphere}$ eroded from mountain forests is mostly <1300 ^{14}C years old. Annual $POC_{biosphere}$ yields are positively correlated with suspended sediment yields, confirming results from Taiwan and a recent global analysis, and are high in catchments with the steepest slopes. Based on these relationships and the global distribution of slope angles (3-arc-second), it is suggested that topography steeper than 10^{o} (16% of the continental area) may contribute ~40% of global $POC_{biosphere}$ erosional flux.

Climate is shown to regulate $POC_{biosphere}$ discharge by mountain rivers, by controlling hydrologically-driven erosion processes. In catchments where discharge measurements are available (8 of the 33) a significant relationship exists between daily runoff (mm day^{-1}) and $POC_{biosphere}$ concentration (mg L^{-1}) ($r = 0.53$, $P < 0.0001$). The relationship can be described by a single power law and suggests a high connectivity between forested hillslopes and mountain river channels. As a result, annual $POC_{biosphere}$ yields are significantly correlated with mean annual runoff ($r = 0.64$, $P < 0.0001$). A shear-stress $POC_{biosphere}$ erosion model is proposed which can explain the patterns in the data. The model allows the climate sensitivity of this carbon flux to be assessed for the first time. For a 1% increase in annual runoff, $POC_{biosphere}$ discharge is predicted to increase by ~4%. In steeper catchments, $POC_{biosphere}$ discharge increases more rapidly with an increase in annual runoff. For reference, the same change in annual runoff is predicted to increase carbon transfers by silicate weathering solute fluxes in mountains by 0.4-0.7%. Depending on the fate of the eroded $POC_{biosphere}$, river export of $POC_{biosphere}$ from mountains may act as an important negative feedback on rising atmospheric CO_2 and increased global temperature. Erosion of carbon from the terrestrial biosphere links mountain building and climate to the geological evolution of atmospheric CO_2, while the carbon fluxes are sensitive to predicted changes in runoff over the coming century.

Keywords: carbon cycling; physical erosion; mountain rivers; radiocarbon; climate and runoff

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