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Reactive and dissolved meteoric ^{10}Be/^{9}Be ratios in the Amazon basin

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Recently, the ratio of the meteoric cosmogenic nuclide ^{10}Be to stable ^{9}Be has been established as a weathering and erosion proxy where meteoric ^{10}Be/^{9}Be ratios in reactive phases of secondary weathering products leached from detrital Amazonian river sediment were measured[1]. For this dataset, we derived a new ^{10}Be-based mass balance, which compares the fluxes exported during erosion and weathering, F_{out}, calculated by the sum of $[^{10}Be]_{reac}$ multiplied by gauging-derived sediment discharge and $[^{10}Be]_{diss}$multiplied by water discharge, to the meteoric depositional flux F_{in}. This assessment allows evaluating the weathering state of the Amazon basin. Further, in order to assess equilibration of reactive phases in the water column, we measured $(^{10}Be/^{9}Be)_{reac}$ ratios leached from suspended sediments for two depth profiles of the Amazon (55m depth) and Madeira (12m depth) Rivers, their corresponding surface dissolved ^{10}Be/^{9}Be ratios, as well as dissolved ratios of smaller Amazon tributaries (Beni, Madre de Dios) to compare with published reactive ratios[1]. In these rivers, modest pH and salinity fluctuations help to constrain a "simple" system that might however still be affected by seasonally changing isotopic compositions between water and suspended sediment[2] and seasonal fluctuations of TSS and TDS[3].

The ^{10}Be-based mass balance shows that in Andean source areas $F_{out}/F_{in} \approx 1$, indicating a balance between ingoing and exported flux, whereas in the Shield headwaters, F_{out}/F_{in}=0.3, indicating a combination of decay of ^{10}Be during storage and little export of ^{10}Be associated with particulate and dissolved loads. In central Amazonia, the export of ^{10}Be decreases slightly relative to its atmospheric flux as evidenced by F_{out}/F_{in}=0.8 for the Amazon and Madeira Rivers. This value is interpreted as being close to steady state, but its modification could be due to additions of Shield-derived sediment to sediment carried in the main river[4].

Regarding the depth profiles, our preliminary findings stress that the $(^{10}Be/^{9}Be)_{reac}$ for the Amazon River (n=3, Avg.= 5.4x10^{-10}with SD=3.7x10^{-11}) and the Madeira River (n=3, Avg.= 4x10^{-10}with SD=2.1x10^{-11}) do not change significantly within the water column. These depth-dependent reactive ratios compare well with ^{10}Be/^{9}Be ratios of surface waters and sediments and with published data available for the Negro and Orinoco[5]: For all these large rivers, surface $(^{10}Be/^{9}Be)_{reac}$ vs. $(^{10}Be/^{9}Be)_{diss}$agree very well ($R^2 \approx 1$). For smaller tributaries like the Apure, La Tigra, Beni and Madre de Dios, $(^{10}Be/^{9}Be)_{reac}$are 2-3 times lower than $(^{10}Be/^{9}Be)_{diss}$. As pH values are similar for all these rivers, one possibility is that in smaller river systems mixing of sediment and water between the channel and the floodplain is less thorough, potentially resulting in reactive and dissolved phases that are not fully equilibrated. For large rivers, however, our depth-invariant $(^{10}Be/^{9}Be)_{reac}$ data indicate consistent and probably early equilibration of Be with depth. We also do not observe potentially divergent ^{10}Be/^{9}Be ratios due to e.g. floodplain remobilization or different erosion rates in the source area. From this, we infer a thorough mixing of the clay/silt fraction within large rivers, with the different ^{10}Be/^{9}Be ratios of Madeira and Amazon Rivers fingerprinting the different prevailing denudation rates of the source areas (Andes and Brazilian Shield). The here presented results suggest that one surface sample, either reactive or dissolved, would be sufficient to determine denudation rates of an entire catchment.

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