Reconciling multiple constraints on late Cenozoic erosion and weathering fluxes: Can we do it?

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Records of geochemical tracers in late Cenozoic marine sediments show large changes, the causes of which have been the subject of intense interest in the geoscience community. Intensive tracers include ^{87}Sr/^{86}Sr, ^{187}Os/^{188}Os, δ^{18}O, δ^{13}C, ^{44}Ca/^{42}Ca, ^{26}Mg/^{24}Mg δ^{11}B, Ge/Si, δ^{30}Si and ^{10}Be/^{9}Be. Information from these tracers needs to be integrated with elemental mass balance constraints such as Mg/Ca in forams, sediment accumulation rates, changes in the CCD, and reconstructions of $p\mathrm{CO}_2$. To date, a quantitative and self-consistent scenario that successfully integrates this diverse and increasingly detailed set of observations has been elusive. All of the isotopic tracers are subject to provenance effects, i..e. values can vary as a function of source, and the mix of sources changes in time. The stable isotope tracers are additionally subject to fractionation at the source via changes in weathering processes and/or biological cycling. They can be further impacted by fractionation during incorporation into sediment archives.

Studies at the small watershed scale suggest that several of the tracers (^{87}Sr/^{86}Sr, ^{26}Mg/^{24}Mg, Ge/Si, δ^{30}Si) can be used to identfy particular mineral weathering reactions and/or identify the effects of biocycling. Integrating this information over larger spatial and temporal scales is not straigtforward. Biocycling effects can be important over short time scales but their impact is reduced over time scales much longer than the residence time of the tracer in regolith-soil-plant system.

Recycling of the sedimentary mass is a major source of the erosional flux, and can be particularly significant for tracers significantly stored in carbonate rocks, as these are nearly quantitatively recycled during erosion. While the late Cenozoic shift in δ^{13}C has received relatively little attention comparted to some other tracers, a decrease in $\delta^{13}\mathrm{C}_{\mathrm{SW}}$ beginning in the mid–Miocene is consistent with both a proportional and absolute increase in the weathering flux of carbonates. A mid-Miocene acceleration in sediment recycling appears at least consistent with most of the available constraints from other tracers of weathering and erosion, and a model can be used to make testable predictions for other tracer systems. Since each system is individually underconstrained, a quantitative approach that attempts to satisfy multiple tracer records is necessary.

Spatial vegetation patterns, catastrophic shifts and desertification in arid ecosystems under land use and climate regimes

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Desertification currently affects the livelihood of more than 200 million people. A primary aim of the international community is to stop desertification to enhance agricultural productivity and combat hunger of many millions of people.

Desertification, especially the shift of productive semi-deserts into non-productive full-deserts, can have a 'sudden' or 'catastrophic' character, indicating the existence of critical transitions over 'thresholds' or 'tipping points'

These catastrophic events result from the interplay between two different ecological interactions among the plants making up the vegetation in semi-desert ecosystems. The first is facilitation, where plants support each other in terms of collectively attracting water and nutrients and provide the soil with organic matter compounds. Facilitation acts at relatively small spatial scales. Second, there is competition between plants for the same resources (water, nutrients), but then on a relatively large spatial scale. The process of facilitation helps plants to survive, together, under harsh conditions. Such survival under harsh conditions requires though a critical vegetation biomass, below which the plants cannot adequately acquire the necessary resources. Similarly, when conditions becomes gradually harsher (e.g. less resources, higher grazing intensity), then at a critical point, the vegetation cannot attract enough resources anymore to survive and the ecosystem will collapse into a non-vegetation bare soil desert ecosystem.

We will present the outcome of a study in which spatial explicit models that simulate desertification is combined with field observations on semi-deserts under various land use and climate regimes. The results showed that particular non-random patterns in the spatial distribution of the vegetation are indicative the proximity of a critical threshold. The model results closely resembled the patterns that were observed in the field trials.

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