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Impact of vegetation dynamics on short and long-term erosion and carbon dynamics using COPLAS

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Erosion processes can deplete soil carbon and nutrients affecting agriculture and decreasing productivity. They can also lead to siltation of watercourses, water quality problems, and affect infrastructure and ecosystems. Vegetation modifies erosion/deposition processes and water re-distribution, but its dynamic nature is seldom included in models. Traditional erosion models (e.g. universal soil loss equation - USLE, Watershed Erosion Prediction Project – WEPP) and Landform Evolution Models (LEMs) have been used for erosion estimation but they normally include basic representations of vegetation that do not account for the dynamic character of biomass variability across annual and inter-annual scales, and its connections with erosion processes. Here we present a new model, COPLAS, which couples a LEM (SIBERIA) with dynamic vegetation and carbon pools modules. The vegetation module includes a coupled photosynthesis-stomatal conductance representation to estimate Net Primary Production (NPP) that is allocated into six carbon pools: leaves, wood, roots, litter, slow and fast-cycling soil carbon.
We use our model to investigate the influence of vegetation dynamics on both short and long-term erosion and carbon dynamics in Howard Springs (Northern Territory, Australia). Simulations at the hillslope scale were run for 1000 years, using a daily time step. The model was calibrated using several datasets available in this Ozflux site. We compared the relative importance of several key processes that link vegetation cover and erosion, particularly the effect of plants on (1) soil erodibility particularly through root biomass, (2) soil diffusivity (e.g. rain splash or creep), (3) flow resistance, and (4) soil infiltration affected by changes in soil carbon. We find that when considering vegetation dynamics erosion is considerably reduced, as opposed to when considering an equivalent but constant vegetation cover. This is due to the protective effect of biomass cover, which is highest during the wet season. The overall reduction in erosion is of the order of 30%, and is mostly driven by the effects of the decrease in flow resistance (which contributes a 16% reduction in erosion). We found that in this ecosystem, the variability in soil infiltration has a negligible effect in erosion and deposition processes (just 1% contribution). Overall, this study highlights the importance of including a detailed representation of dynamic vegetation and carbon pools in order to understand and better predict erosion/deposition processes and to be able to consider future consequences of climate variability and climate change.