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Modelling the interaction between hydrology and soil formation in the Santa Clotilde Critical Zone Observatory, Spain

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Interest in modelling pedogenesis has increased greatly over the past few years, with the emergence of detailed pedon-scale models (e.g. Soilgen) on the one hand and landscape-scale models (e.g. marm3D, MILESD, LORICA) on the other. Pore water chemistry and chemical weathering is not (well) represented in the latter and needs to be improved in order to adequately model the evolution of soils and of the critical zone. Here, we present a new spatially distributed water balance model. We show how long-term water balance dynamics can be linked to the spatial distribution of soil properties, such as soil depth and texture, and to chemical weathering processes.
A new model, MILESD2, was developed to integrate the effect of landscape evolution and soil formation. This model is based on a daily spatially-explicit soil water balance and calculates average soil water content, temperature and deep percolation fluxes. Model input (temperature and precipitation) for the last 25 000 years was generated on a daily time by combining palaeoclimate data and the WXGEN weather generator. The soil-landscape model was applied to a 48 km2 semi-natural catchment in Southern Spain, with soils developed on granite.
Observed soil moisture and discharge series from the Santa Clotilde Critical Zone Observatory, S Spain, were used to calibrate the model. Next, soil formation model output was contrasted against experimental data from 67 soil cores across the area. Field data showed an important variation in mobile regolith thickness, between 0,44 and 1,10m, and in chemical weathering rates. Southern slopes were characterized by shallower, stonier and carbon-poor soils, while soils on north-facing slopes were deeper, more fine-textured and had a higher carbon content. Chemical depletion fraction was found to vary between 0,41 and 0,72. The lowest overall weathering intensity was found on plateau positions. South facing slopes revealed slightly lower weathering compared to north facing slopes. We attribute this to higher runoff generation and physical erosion rates on north facing slopes, transporting weathered material downslope. Model results corroborate these findings and show continuously wet soils on north-facing slopes with more runoff generation and a steady deep percolation flux during the wet winter season. On south-facing slopes, infiltration is higher and percolation is more erratic over time. Soils on the footslopes then were shown to be significantly impacted by deposition of sediment through lateral erosion fluxes.