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Soil process modelling in CZO research: gains in data harmonisation and model validation

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Various soil process models were applied to four European Critical Zone observatories (CZOs), the core research sites of the FP7 project SoilTrEC: the ***Damma*** glacier forefield (CH), a set of three forested catchments on geochemically contrasing bedrocks in the ***Slavkov Forest*** (CZ), a chronosequence of soils in the former floodplain of the Danube of ***Fuchsenbigl/Marchfeld*** (AT), and the **Koiliaris** catchments in the north-western part of Crete, (GR). The aim of the modelling exercises was to

- apply and test soil process models with data from the CZOs for calibration/validation,
- identify potential limits to the application scope of the models,
- interpret soil state and soil functions at key stages of the soil life cycle, represented by the four SoilTrEC CZOs,
- contribute towards harmonisation of data and data acquisition.

The models identified as specifically relevant were:

- The Penn State Integrated Hydrologic Model (***PIHM***), a fully coupled, multiprocess, multi-scale hydrologic model, to get a better understanding of water flow and pathways,
- The Soil and Water Assessment Tool (***SWAT***), a deterministic, continuous time (daily time step) basin scale model, to evaluate the impact of soil management practices,
- The Rothamsted Carbon model (***Roth-C***) to simulate organic carbon turnover and the Carbon, Aggregation, and Structure Turnover (***CAST***) model to include the role of soil aggregates in carbon dynamics,
- The Ligand Charge Distribution (***LCD***) model, to understand the interaction between organic matter and oxide surfaces in soil aggregate formation, and
- The Terrestrial Ecology Model (***TEM***) to obtain insight into the link between foodweb structure and carbon and nutrient turnover.

With some exceptions all models were applied to all four CZOs. The need for specific model input contributed largely to data harmonisation. The comparisons between the CZOs turned out to be of great value for understanding the strength and limitations of the models, as well as the differences in soil conditions between the CZOs. The CZO modelling led to further developments of the PIHM, with incorporation of functionality for karstic fracture flow (Koiliaris) and fracture flow anisotropy (Damma). The Damma case also provided experience on how to use results from geophysical investigations in model refinement. The SWAT modelling showed variability among the CZOs in hydraulic conductivity, the curve number that determines how fast rainfall results in runoff, and soil moisture capacity. Roth-C and CAST showed carbon sequestration fluxes to be low for old cultivated soils (Koiliaris) and high for new soils (Damma), where the latter site also had very high turnover rates. The LCD modelling, so far limited to the calcareous floodplain soils in Austria, explains differences in C-sequestration capacity between forest and agricultural soils from competition between phosphate and soil organic matter for adsorption sites on Fe-(hydr)oxides. The wide variety of soil (eco)system conditions challenged the TEM model and showed important

directions for refinement: 1) differentiating between various fractions of organic matter and concomitant microbial decomposition pathways, and 2) the need to better define the physiological traits of the organisms in relation to local environmental conditions.