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# Simulation and validation of long-term changes in soil organic carbon under permanent grassland using the DNDC model

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Modelling approach can minimise variability of soil organic carbon (SOC) in agricultural soils by quantifying its changes consistently over time. This could help identify whether the ecosystem is a source or sink of atmospheric $CO_2$ and its potential to offset greenhouse gases as well as contributing to strategies for enhancing carbon sequestration in soils. The Denitrification-Decomposition (DNDC95) model was used to simulate SOC density () and its annual changes ($\Delta$SOC) over 45 years in temperate grassland soils managed with inorganic fertilizer and animal slurry. Simulated SOC and $\Delta$SOC were compared with field observations, and their sensitivity to soil and management variables were tested. The measured data for SOC at 0-15 cm depth for both unfertilized and urea-fertilized fields (73-77 t C ha-1) were significantly higher, than simulated values (54-55 t C ha-1) and attributed to a contribution from plant roots or measurement errors. Despite some variations between the measured and simulated data, SOC was observed to be higher from cattle (88-99 vs. 66-116 t C ha-1) than from pig slurry (75-78 vs. 55-69 t C ha-1), increasing with application rate. Both measured and simulated values correlated significantly well with measured ones (R2 = 0.63, p<0.0001), with insignificant individual differences, apart from pig slurry applied at the lowest rate. Measured data for the annual $\Delta$SOC tended to be more variable and the estimates from simulated values revealed increased C sequestration with increase rates of added C. Measured rates for unfertilized and urea-fertilized fields were significantly higher and, for animal slurry were similar to simulated values, resulting in average sequestration rates of 0.46 $\pm$ 0.06 and 0.37 $\pm$ 0.01 t C ha-1 yr-1, respectively. For the simulated values variations in SOC could be explained by differences in applied N (63%) that were linked to differences in C (62%), rainfall (15%) and air temperature (11%). There was strong correlation (p<0.05-<0.0001) with the sensitivity of the model to soil variables, demonstrating that SOC density increased with increasing soil bulk density, inherent SOC concentration and clay fraction (R2 = 0.77-0.99). Annual changes in SOCp, decreased with bulk density and SOC concentration (R2 = -0.99), and increased with clay fraction and pH (R2 = 0.89-0.97). These findings show that a new SOC equilibrium was not reached in these grassland soils over 45 years, and that DNDC95, although requiring more improvement, could provide an accurate representation of the effect of soils, climate and management practices on SOC and its change over time.