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ICOS stations focus on specific agro-pedoclimatic conditions. Calibrated and validated on measured data, modelling studies enable to extrapolate field experiments to contrasted agronomic management or pedoclimatic conditions such as climate change impact. With this goal in mind, we used the outputs of the soil-crop model STICS in its standard pre-parameterized version to model (*i*) the Gross Primary Productivity (GPP), derived from the autotrophic respiration and the Net Primary Productivity, which is computed through the daily change in plant carbon (C) pools; (*ii*) the Ecosystem Respiration (RECO), with the autotrophic component being derived from the plant biomass, plant nitrogen concentration and GPP, and the heterotrophic component from the mineralization of residues and organic matter; and (*iii*) the Net Ecosystem Exchange, equal to the sum of GPP and RECO. The generic approach is transferable to any soil-crop model and was validated on the 16-year crop rotation of the ICOS BE-LON site (winter wheat, sugarbeet, maize, potato, cover crop). The comparison of simulations with field observations indicates that the model is able to simulate accurately daily CO2 fluxes originating from a long-term and diversified crop rotation (efficiency EF equal to 0.79 for GPP, 0.59 for RECO and 0.67 for NEE). Concerning the C budget of the 16-year rotation, the model evaluates it accurately for RECO, with a slight underestimation (normalized deviation ND = 15.7%), and very accurately for GPP (ND = 5.12%). But for NEE, the relative overestimation is higher (ND = 62.2%), indicating that a more precise estimation of HR is required to obtain reliable net C budgets. The model also succeeds to capture the trends in the influence of several environmental drivers on CO2 fluxes. It globally proves to be a valuable tool in the investigation of CO2 exchanges of crop rotations in historical and future climatic conditions.