EGU2020-7366, updated on 01 Mar 2021
https://doi.org/10.5194/egusphere-egu2020-7366
EGU General Assembly 2020

Evaluation of agricultural field traffic by modelling traffic intensity and related soil compaction risk

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Soil compaction by field traffic is one of the main threats to all agricultural soils. Besides lower biomass productivity, compacted soils have a reduced regulation function which affects the air, water and nutrient cycles. To evaluate and mitigate soil degradation by field traffic, it is important to know where, when and to what extent soil compaction may occur during certain traffic events.

This study presents an approach to assess soil compaction risk at the field scale, considering the spatio-temporal changes of soil strengths and the machinery-induced changes in load and stress. Two newly developed models, the field traffic model “FiTraM” and the spatially explicit soil compaction risk assessment model “SaSCiA”, were used to evaluate the individual soil compaction risk for each field traffic activity during the maize cropping season. RTK-GPS data recorded by all farm vehicles served for the spatial calculation of traffic intensity and changing wheel loads at high spatial resolution (< 30 cm). These data were subsequently used for soil compaction risk assessment based on readily available soil and weather data.

Our model results indicated that nearly 95% of a field was trafficked throughout the maize-season; harvest traffic at high wheel load contributed to more than the half of the total trafficked area. Furthermore, the analyses showed that soil compaction risk varies greatly within individual fields. Soil moisture and soil texture variation inside the field results in varying soil strength and, therefore, in varying effects of field traffic on soil functions. Thus, one part of a field can be negatively affected by field traffic through an increase in dry bulk density and a decrease in hydraulic conductivity, while the other part is not affected.

In addition to the spatio-temporal assessment of field traffic intensity and soil compaction risk, the presented approach enables the calculation of maximum allowable wheel load until no harmful soil degradation occurs. Thus, the approach may support farmers in their decision-making for a more sustainable soil management.