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Crust formation on sandy savanna cropland soils and their potential to reduce dust emissions

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After the conversion to cropland, dust emissions can lead to the degradation of agricultural soil. There are also offsite effects of dust emission due to the impact of dust on climate, human health, and global biogeochemistry. The sandy croplands in the Free State of South Africa have been identified by Eckardt et al. (2020) as one of the main dust sources in South Africa. The Free State is a semi-arid province that is dominated by grassland plains and 31% of the land is utilized for agriculture. The emission of dust from sandy Luvisols and Arenosols, which are typically used for crop farming, is mainly controlled by the cropping cycle. In general, the fields are left bare from at least July until December. When the fields have low surface roughness and stubble cover, the presence of physical soil crusts could be one of the main factors protecting the surface against wind erosion. Crusts can form before or during the growing season, before the vegetation cover is too extensive and protects the soil from raindrop impact. The aim of this study was to investigate the occurrence and strength of physical soil crusts on cropland soils in the Free State, to identify the rainfall required to form a stable crust, and to test their impact on dust emissions. Crust strength was measured using a fall cone penetrometer and a torvane, while laboratory rainfall simulations were used to form experimental crusts. Dust emissions from non-crusted and crusted soils were measured and compared with a Portable In-Situ Wind Erosion Laboratory (PI-SWERL).

Our results show that crusts with sufficient strength to limit dust emissions form on bare Arenosols and Luvisols in the field, illustrating their potential impact on dust emissions. The laboratory rainfall simulations showed that stable crusts could be formed on these soils by 15 mm of rainfall, which is a common amount for single events during the rainy season in the Free State. The PI-SWERL experiments illustrated that the PM10 emission flux of such crusted soils is between 0.14% and 0.26% of that of a non-crusted Luvisol and Arenosol, respectively. The presence of loose sand on the crust acts as an abrader and can increase the emissions up to 4% and 8 % of the non-crusted dust flux. Overall, our study shows that crusts in the field are potentially strong enough to protect the soil surfaces against wind erosion during a phase of the cropping cycle when the soil surface in not protected by plants. These conclusions are not limited to the converted grasslands in the Free State. This indicates that applying farming techniques on croplands that protect crusts or enhance crust formation could be considered as soil management approach to minimize dust emission from dryland sandy soils.