SHORT COMMUNICATION

AN APPROACH TOWARDS THE DERIVATION OF A REFERENCE TRAFFIC SEASON FOR SUGARCANE IN SOUTH AFRICA TO MANAGE SOIL COMPACTION

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Abstract

Soil compaction induced by agricultural vehicles is a complex process which requires either extensive measurements or mathematical modelling to quantify the impact. One of the most sensitive and changing variables influencing the degree of soil compaction is soil moisture content, and a thorough knowledge of this variable can be useful in managing compaction. This short communication reports on attempts to link long-term simulations of soil moisture content, derived using the *ACRU* agrohydrological model, to simulations of soil compaction obtained using the SOCOMO model. Soil moisture content and compaction were simulated for a reference soil and a reference agricultural vehicle. The spatially reported results display a discrete traffic season, during which chances of causing severe compaction damage are significantly reduced. This reference traffic season could be used to strategically determine when vehicles should enter sugarcane fields. It must, however, be noted that the reference traffic season may need to be adjusted for different soils, vehicles, land use practices and also rainfall regimes in different seasons.

Keywords: soil compaction, SOCOMO model, *ACRU* model, soil moisture, infield traffic season

Introduction

Soil compaction (SC) induced by agricultural vehicles is a complex process which requires either extensive measurements or accurate mathematical modelling to quantify the impact. The severity of SC is difficult to measure and difficult to predict and several models have been developed to assist in estimating the degree of SC (e.g. Gupta and Larson, 1982; Defossez and Richard, 2002; van den Akker, 2004). One of the most sensitive and changing variables that influences the degree of SC is soil moisture content (SMC), and knowledge of SMC levels can be useful when managing SC. Many models exist to simulate SMC (e.g. Schulze, 1995; Annandale *et al*, 1999).

The aim of this short communication is to illustrate the derivation of maps covering the South African sugarcane belt, which reflect descriptive SC indexes based on long-term climate data, and soil moisture and compaction modelling.

Methods

The SOCOMO SC model (van den Akker, 2004) was used to simulate soil dynamics in a reference sandy clay loam soil with a total water holding capacity of 234 mm/m. The model estimated the depth of plastic deformation under a reference radial tyre with an inflation pressure of 200 kPa and a load of 2000 kg. Plastic deformation is sensitive to SMC, which was simulated by the *ACRU* agrohydrological model (Schulze, 1995). Daily values of SMC were calculated over a period of 50 years and the degree of SC was estimated on each day. Soil compaction was considered critical where the first 80% of plastic deformation exceeded a depth of 300 mm. It was assumed that this would cause severe soil deformation in the critical root growing zone.

Soil moisture was simulated for each Quarternary Catchment in South Africa (Midgley *et al*, 1994) and the above-mentioned criteria for critical soil compaction were calculated for each day over a 50-year period. From this output, four statistics were extracted and mapped:

- *Start of the traffic season*: The first day of the year (DOY) on which SC will, on average, not exceed critical levels;
- *Length of the traffic season*: The number of days from the start of the traffic season to the last DOY on which SC will on average not exceed critical levels;
- *Mean risk*: The average number of times within the traffic season when critical SC levels will be exceeded; and
- *Risk trend*: The slope of risk within the traffic season, i.e. positive values indicate higher risks towards the end of the traffic season, and *vice versa*.

Results

Figure 1a) depicts the start of the reference traffic season (DOY, contour lines) and the length of the traffic season (colour surface) for the area in which sugarcane is grown. Figure 1b) illustrates the average compaction risk during the traffic season (contour lines) and the risk trend (colour surfaces). For example, the traffic season at Noodsberg (indicated by arrows on Figure 1) starts on 8 May (DOY=128) and ends 150 days later on 4 October. On average during the traffic season at Noodsberg the soil will still be compactable beyond critical levels 31% of the time, and this risk remains reasonably stable with no distinctive trend towards the beginning or end of the traffic season ($-0.1<\text{Trend}<0.0$).

With the exception of a few coastal areas where significant amounts of winter rainfall occur (e.g. Zululand), the traffic season generally starts around the beginning of May (DOY 120 to 150). The length of the traffic season, however, differs with distinctive shorter seasons in the south. This implies earlier spring rains in the south than the north. Northern areas also experience lower risks of compacting soils during the traffic season. This is probably due to fewer winter cold fronts causing rain in the north, compared with the south. The trend in risk was generally insignificant, although a large area in northern KwaZulu-Natal has stronger negative trends (i.e. reduced chances of critical compaction later in the traffic season).

Discussion and Conclusion

The modelled results reported in this paper provide a good benchmark of soil compaction under a uniform soil and using a single vehicle configuration. Soil compaction, however, is highly sensitive to many other variables, which were kept constant in this study. These results, therefore, provide only a reference traffic season and readers are cautioned not to use these outcomes without further investigation. Results may need to be adjusted for different soil textures, vehicle and tyre configurations, wheel loads, levels of organic matter, trash blankets and slopes. The long-term traffic season may also not always provide the best solution within a particular season. This is the first of a series of maps to ease the management of problems such as compaction. The authors would appreciate any feedback to enhance the value of these maps.

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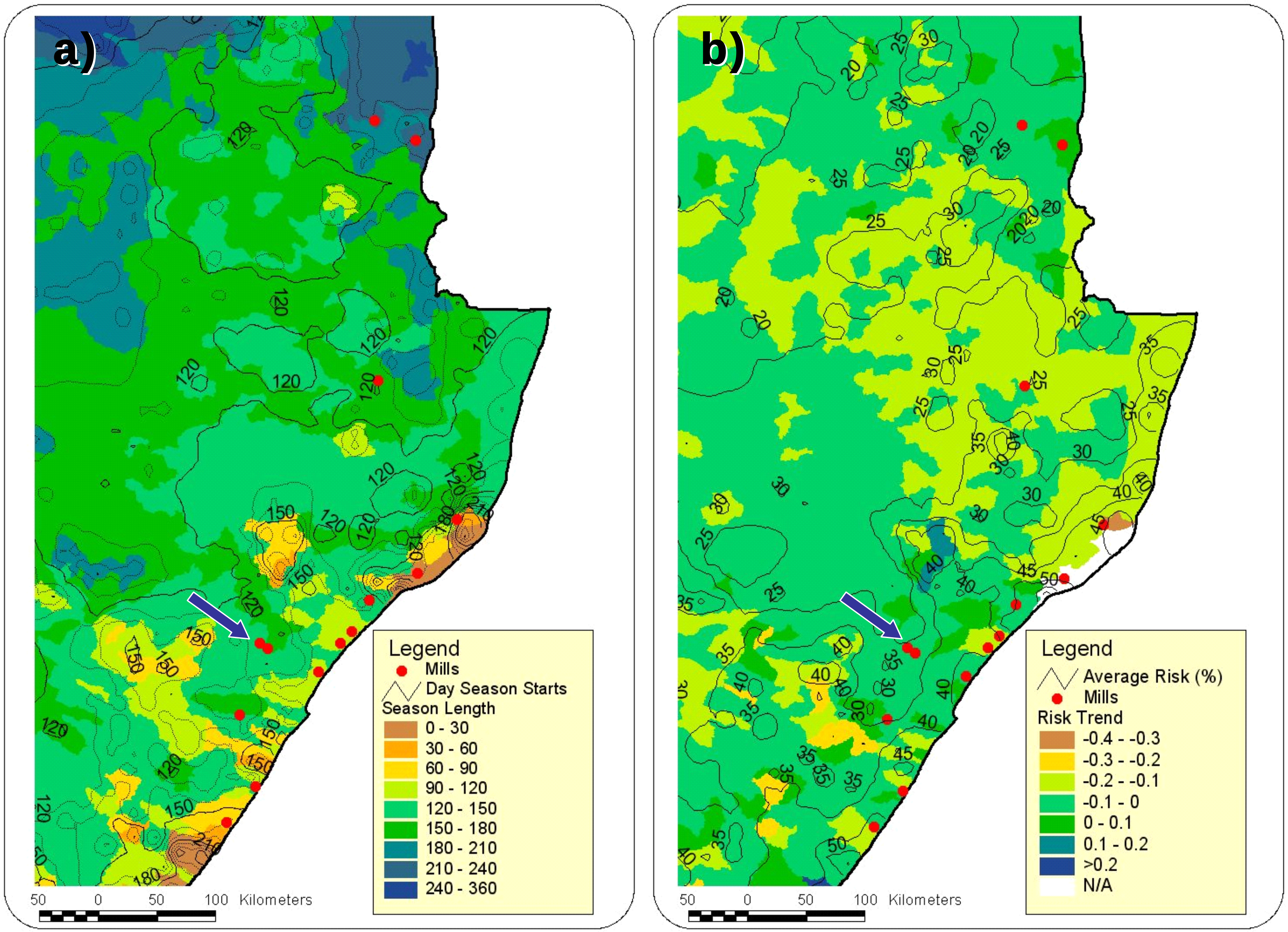

Figure 1. The start and length of a reference traffic season (Map a) and the risk and risk trend associated with this traffic season (Map b).