Sensitivity of southern African maize yields to the definition of sowing dekad in a changing climate

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Abstract Most African countries struggle with food production and food security. These issues are expected to be even more severe in the face of climate change. Our study examines the likely impacts of climate change on agriculture with a view to propose adaptation options, especially in hard hit regions. We use a crop model to evaluate the impact of various sowing decisions on the water satisfaction index (WSI) and thus the yield of maize crop. The crop model is run for 176 stations over southern Africa, subject to climate scenarios downscaled from 6 GCMs. The sensitivity of these simulations is analysed so as to distinguish the contributions of sowing decisions to yield variation. We compare the WSI change between a 20 year control period (1979–1999) and a 20 year future period (2046–2065) over southern Africa. These results highlight areas that will likely be negatively affected by climate change over the study region. We then calculate the contribution of sowing decisions to yield variation, first for the control period, then for the future period. This contribution (sensitivity) allows us to distinguish the efficiency of adaptation decisions under both present and future climate. In most countries rainfall in the sowing dekad is shown to contribute more significantly to the yield variation and appears as a long term efficient decision to adapt. We discuss these results and additional perspectives in order to propose local adaptation directions.

1 Introduction

Several studies have focussed on the impacts of climate change on agriculture for selected areas within southern Africa. Gbetibouo and Hassan (2005) measured the
economic impact of climate change on major South African crops. They used a Ricardian approach to highlight the sensitivity of yield to temperature and rainfall change based on the last 30 years of the 20th century. Though they concluded that net revenue might either increase (e.g. Free State, Northern Cape) or decrease (e.g. Gauteng, Kwazulu Natal), they noted that both major crops and the cropping calendar may be affected by climate change. More recently Walker and Schulze (2008) simulated the variability of yield, risk and soil organic nitrogen levels over three South African climate regions (Christana, Bothaville and Piet Retief). They focussed on the maize production and simulated the potential outcome of 9 different \( CO_2 \) concentration scenarios, concluding that climate scenarios show negative impacts over parts of the country, especially in the drier western areas. Lobell et al. (2008) studied crop adaptation in selected regions around the world using multiple General Circulation Models (GCMs). They concluded that southern Africa is one region that is likely to suffer negative impacts on several staple crops, including maize. These studies were conducted over specific regions within southern Africa or utilised large-scale climate data from GCMs.

Climate change is expected to intensify existing problems in developing countries where communities are directly dependent on the natural environment (Parry et al. 2001; Ziervogel et al. 2008; Brown and Funk 2008), though, changes in climate may have either a positive or negative impact depending on their location and timing. Projected changes in temperature and rainfall will likely change the future agricultural activities of communities, especially in poor rural regions that depend on rain-fed crops (Tadross et al. 2003). Positive changes in rainfall characteristics (e.g. reduced number of dry spells) can increase agricultural production but negative changes would require adaptation measures such as changing cropping patterns. In rural regions however, adapting to change can be a very slow process and rural farmers can find it difficult to cope with the changes as they have limited resources. National and regional decision makers within southern Africa are thus looking for adaptation guidelines and decision making tools to help moderate potential negative impacts in these vulnerable regions.

Coping with climate change raises the prospect of novel behaviour and perceptions to cope with changes in the climate. Risbey et al. (1999) study was concerned with the crop type decision at the farm and national level. It shows that using seasonal forecast information is significantly overpassing mean, trends and hedge baseline behaviours. It concludes on the importance of climate information for tactical decision making. But these novel behaviour and perceptions may also involve changes in sowing dates, how sowing dates are defined, changes in the application of fertiliser and water at different periods of the crop growth cycle etc. (see for example FAO 2007; Leavy et al. 2008). Additionally such changes will depend on the location, its local climate characteristics, the crop and farm management systems in order to maximise the benefit to agriculture. This is particularly true for rain fed agriculture in southern Africa, where yields are low and the success of the cropping season depends the timing of sowing relative to the start of the rainfall season. One of the most important decisions, therefore, is when to plant and the crop sowing dekad (1 dekad equals 10 days) over southern Africa is often chosen when rainfall exceeds certain thresholds. In our particular case, two parameters defining the sowing dekad are of interest, \( x_1 \) which is the expected rainfall within the sowing dekad and \( x_2 \).