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Preliminary evaluation on using direct RCM outputs in crop modelling

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Introduction

- Crop growth simulation models, like Decision Support System for Agrotechnology Transfer (DSSAT) (Jones et al. 1998), have been widely applied to assess climate change impacts on cropping systems and agricultural production.
- Daily maximum and minimum temperature, precipitation and incident solar radiation are required as minimum climate input to drive crop models. Future climate scenarios are necessary input for using DSSAT to evaluate climate change impacts.
- Using daily outputs from regional climate models (RCMs) may meet such a need. This study evaluates the potential of using RCM outputs in crop modelling, based on comparing DSSAT simulated crop production with observed historical weather data and modelled weather data from two RCMs.

Materials & methods

Observed climate data consisted of 30-yr daily maximum, minimum temperatures, precipitation and incident solar radiation for the baseline period (1961-1990) at 7 selected stations across agricultural regions in Canada (Fig.1).

Direct RCM outputs at the nearest grid to each station from CRCM and HRM3 for 1968-1997 were obtained from NARCCAP (Mearns et al. 2007), being deemed as modelled weather data at the location for the baseline period.

Crop growth modules in DSSAT were used to simulate crop production and growth for major crops at the locations, with conventional management and the most common soil at each location.

Comparisons were carried out for 7 sites (Fig. 1) representing diverse climates and 5 major crops (barley, spring wheat, corn, soybean and potato).

Statistical *t*- and *F*- tests were used to verify if significant differences exist between the simulations with observed and modelled weather data from RCMs.

Crop models: Crop System Models in DSSAT v4.0

Weather input: CRCM, HRM3, station observed

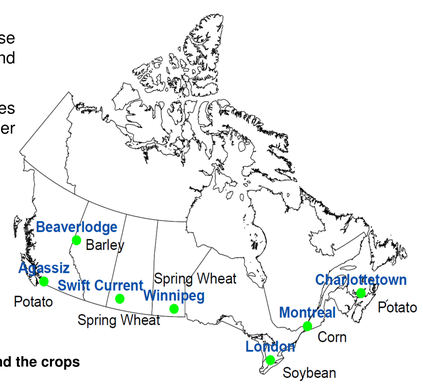

Fig. 1 Crop simulation sites and the crops across Canada

Results & Discussion

Fig. 2 Comparison of modelled means and standard deviations of crop biomass and yield simulated with observed weather station data and direct daily output at the nearest grid from CRCM and HRM3. Values in red are statistically different at the 5% level.

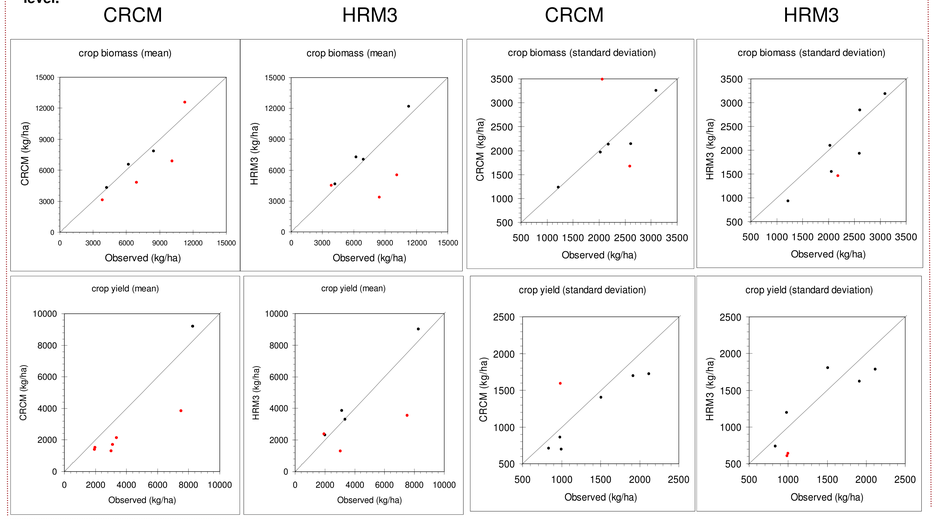

Table 1 and Fig. 2 are examples of simulation results based on observed and modelled weather data from RCMs. Statistically significant differences were often found – both in the means and in the variances. Some results using the RCM data were encouraging, with modelled yields close to those with observed weather station data.

Conclusions

Crop model simulations with observed weather station data and modelled weather data at a nearby RCM grid, often showed significant differences, with regard to planting date, crop maturity date, as well as final biomass and grain yield at maturity. However, in 5 out of 14 cases the simulated crop yields were fairly comparable when direct RCM outputs were used to replace observed weather station data. Therefore, improved direct RCM outputs may have some promise as input to crop models, but, currently, localization of the RCM outputs, for example, through bias correction or using a stochastic weather generator, is still required.

Table 1. Comparison of crop planting and maturity dates, biomass and grain yield simulated with 30-yr observed station- and 30-yr modelled weather data for spring wheat at Swift Current, SK and soybean at London, ON

Location (crop)		Planting (DOY)	Maturity (DOY)	Biomass (kg/ha)	Grain yield (kg/ha)
Mean					
Swift Current (spring wheat)	station	125	224	4223	1996
	CRCM	136*	258*	4305	1502*
	HRM3	127	216*	4666	2309
London (soybean)	station	135	262	3839	1945
	CRCM	151*	281*	3112*	1401*
	HRM3	133	265	4518*	2387*
SD					
Swift Current (spring wheat)	station	8.6	6.3	2183	996
	CRCM	11.3	19.5*	2131	696
	HRM3	10.2	9.2*	1456*	640*
London (soybean)	station	7.0	6.9	1222	836
	CRCM	8.3	8.3	1236	707
	HRM3	9.1	9.0	934	736

* Values with an asterisk for means and SDs (standard deviations) from simulations with modelled weather data are statistically different from the corresponding values from simulations with observed weather station data at the 0.05 significance level in statistical *t*- and *F*- tests.

References

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Mearns, L.O., et al., 2007, updated 2011. The North American Regional Climate Change Assessment Program dataset, National Center for Atmospheric Research Earth System Grid data portal, Boulder, CO. Data downloaded on April 18th, 2010.

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