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A method for simulating risk profiles of wheat yield in data-sparse conditions

Bracho-Mujica Gennady[1] (gennady.brachomujica@uni-goettingen.de), Hayman Peter T.[2], Sadras Victor O.[2], Ostendorf Bertram[3]

[1] *TROPAGS, Georg-August-Universität Göttingen, Göttingen, Germany;* [2] *SARDI, Urrbrae, South Australia, Australia;* [3] *School of Biological Sciences, The University of Adelaide, Adelaide, South Australia, Australia*

Introduction

Crop simulation models can be used to generate risk profiles (i.e. probability curves of crop yield) for multiple genotype, environment and management combinations. However, robust simulations of risk is limited when high-quality weather data is sparse. In this study, we aimed to determine whether and to what extent a simple method for scaling daily weather data (Liddicoat et al., 2012) could be applied to estimate robust risk profiles of modelled crop yield in data-sparse conditions. To do this, we examined an extreme situation of having one single location with high-quality weather data (reference site), and a number of locations of varying distance to the reference site with only averaged data available (study sites). Weather data from the reference site was adjusted using a simple delta method, using delta factors (adjustment factors) to represent the difference between the reference and each study site. We explored the effect of the record length of averaged climate data on (i) the accuracy of adjustment factors, and (ii) the matching of simulated risk profiles curves of wheat yield.

Materials and Methods

We focused on 49 wheat-growing sites within the Australian grain-belt. Risk profiles were generated using wheat yield simulated with APSIM model (Holzworth et al., 2014). At each study site, two weather data sets were used as model input: measured and adjusted. Both data sets included daily values for the variables: precipitation, maximum and minimum temperatures, and solar radiation. Adjusted data refers to perturbed weather values from the reference site using a delta method. For each climate variable, adjustment factors represent the difference of averaged data from the reference and a study site. Snowtown (South Australia) was used as reference site due to the availability of high-quality data and its agricultural importance. To mimic the problem of short climate series, adjustment factors were computed using a variable record length (i.e. 10, 20, ..., 100 years) for the long-term period 1901-2000. Risk profiles were built using a combination of adjustment from the most simple (adjusted series of precipitation only) to the most detailed (adjusted series of all climate variables).

Results and Discussion

Overall, all adjustment factors were sensitive to the record length of the averaged climate data. Adjustment factors for precipitation were the most sensitive, with departures ranging from -10 to 10% for record lengths of 40 or more years. Adjustment factors for both temperatures were mostly underestimated, but departures remained within -0.5 and 0.5 ºC with record lengths of 20 or more years. Adjustment factors for solar radiation was the less sensitive to the record length. The proportion of test sites in which the risk profiles were estimated with biases within -10% and 10%, consistently increased as the number of climate variables adjusted increased (Fig. 1).

Conclusions

Results indicated that although record length of climate data have an impact on the accuracy of adjustment factors, adjustment of all climate variables (i.e. precipitation, temperatures and solar radiation) produced the most reliable estimations of simulated risk profiles of crop yield across a large area, encompassing a diversity of climates.

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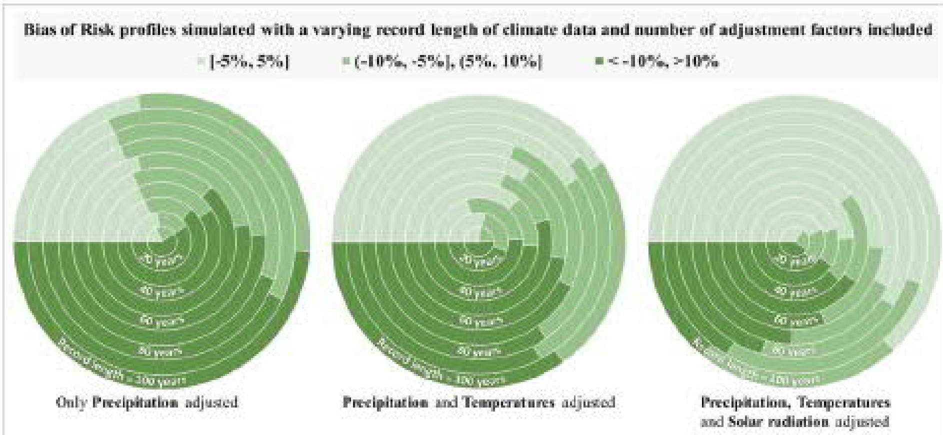

Effect of record length on the matching of risk profiles modelled with measured weather data and those modelled with adjusted data. Number of adjustments increases from left to right. Bias is expressed in percentage.
Each ring represents the bias for a given record length, starting in the center with a record length=10 years until the last ring of 100-years (period 1901-2000).

Keywords: climate risk, weather data, APSIM, delta method.

References:

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