Climate Change Impact On Crop Yield In a Rotational System In Michigan

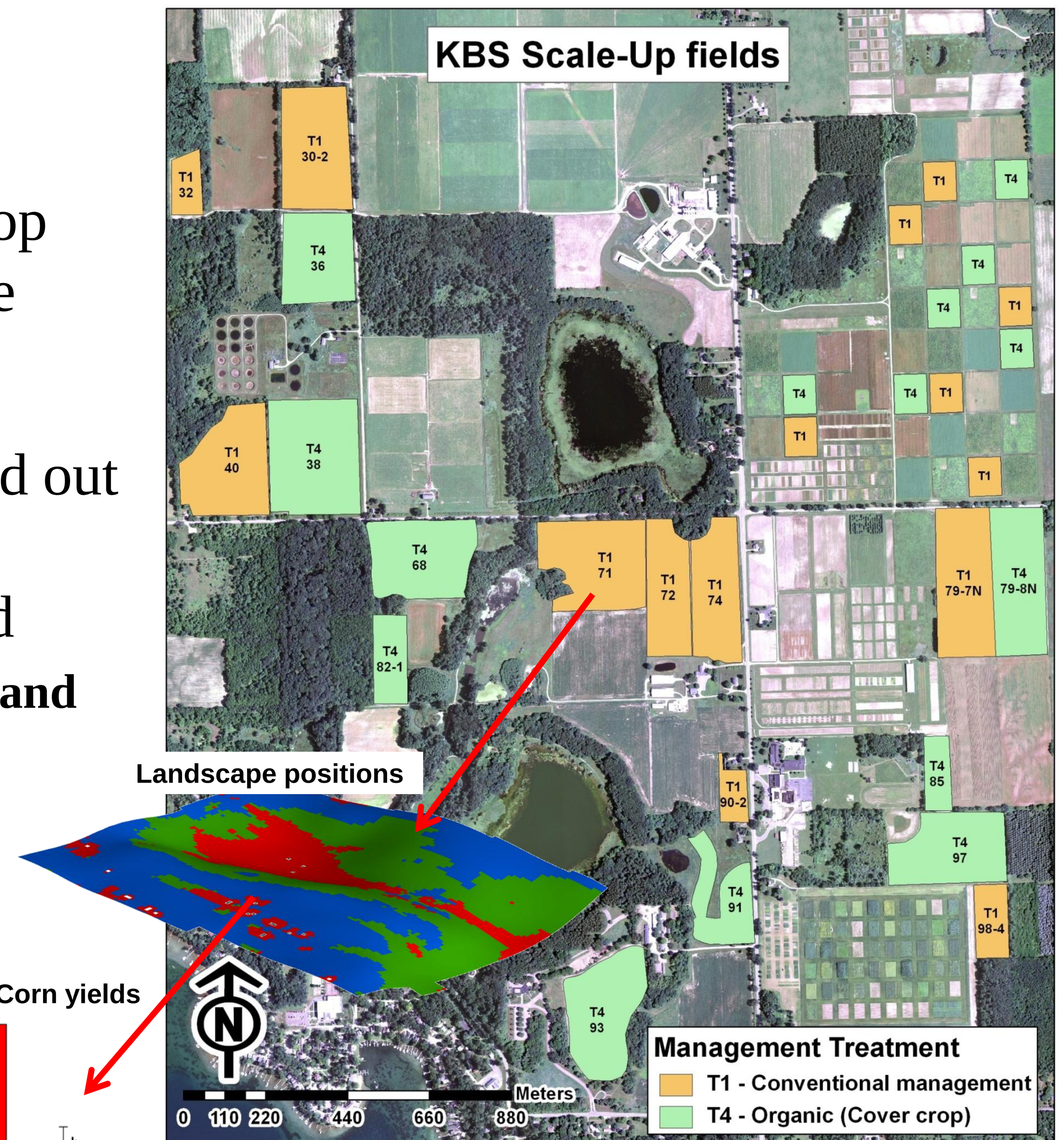
Munoz, J.D. [1], B. Basso [2], J. Winkler [3], J. Andresen [3], A. Kravchenko [1]

[1]Dept. of Crop and Soil Sciences, Michigan State University. [2] Dep. of Crop Systems, Forestry and Environmental Sciences, University of Basilicata.
[3] Dep. Of Geography , Michigan State University.

Motivation: Climate change analysis indicate that cereal agriculture in mid- to high-latitude regions will benefit from moderate increases in temperature **(IPCC, 2007).** However, cereal crop yields demonstrate high variability across diverse terrain **(Fig. 1)**, indicating that the impact of climate change on rotational agricultural systems may vary across landscapes.

Objectives: Simulate the effect of climate change **(Precipitation and temperature)** on conventional and certified organic row-crop systems across three contrasting landscape positions.

Materials and Methods: The study was carried out at the Kellogg Biological Station **(KBS)** in southwest Michigan **(Fig. 2)**. We considered three landscape positions **(Depression, Slope and Summit)** and two management systems **(Conventional and Organic).**
We simulated yield production in a rotational system from 1970 to 2099 using SALUS model **(Basso *et al*, 2006).** Historic climate and two future climate scenarios **(Winkler *et al*, 1997)** were used for simulations **(Fig. 2).**



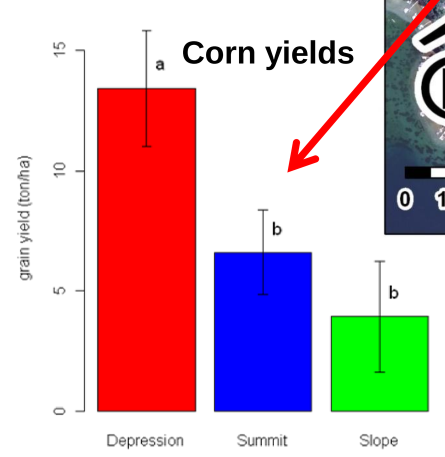


Figure 1. Location of experimental fields at KBS. Example of field topographical classification and corn yields at different landscape positions.

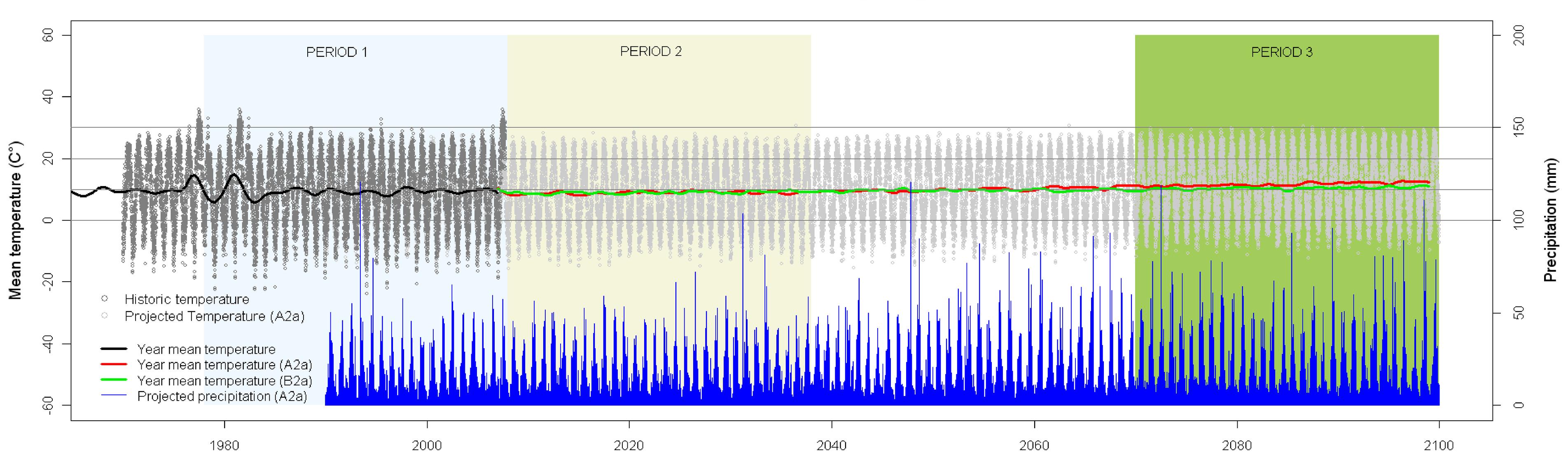


Figure 2. KBS temperatures and future trends for 2 climate scenarios: A2 (high increase in population, fragmented world) and B2 (lower rate of growth, environmental oriented).

Simulation-Validation: The crop model was validated with field data **(here 2 fields are shown)** taken from **2007** to **2010.** Soil properties and crop yields were measured at each landscape position of each field. Management conditions used in the SALUS model were based on the field operations from **2007** to **2010** and the KBS research protocols **(Robertson and Bronson, 2011).**

Result 1: There is a good agreement between measured and SALUS simulated yields in both managements systems and landscape positions for all three studied crops **(Fig. 3).**

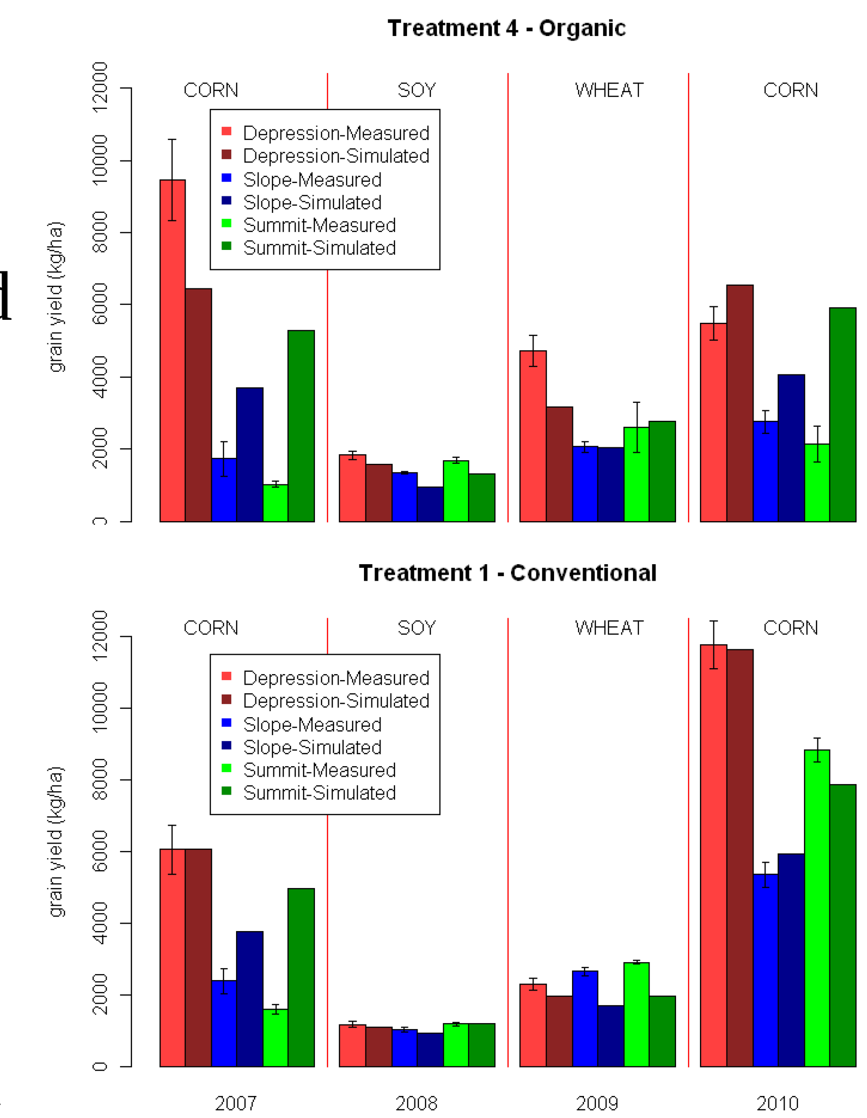


Figure 3. Simulation in organic and conventional management. Crop yield response in two fields using actual weather data from **2007** to **2010.**

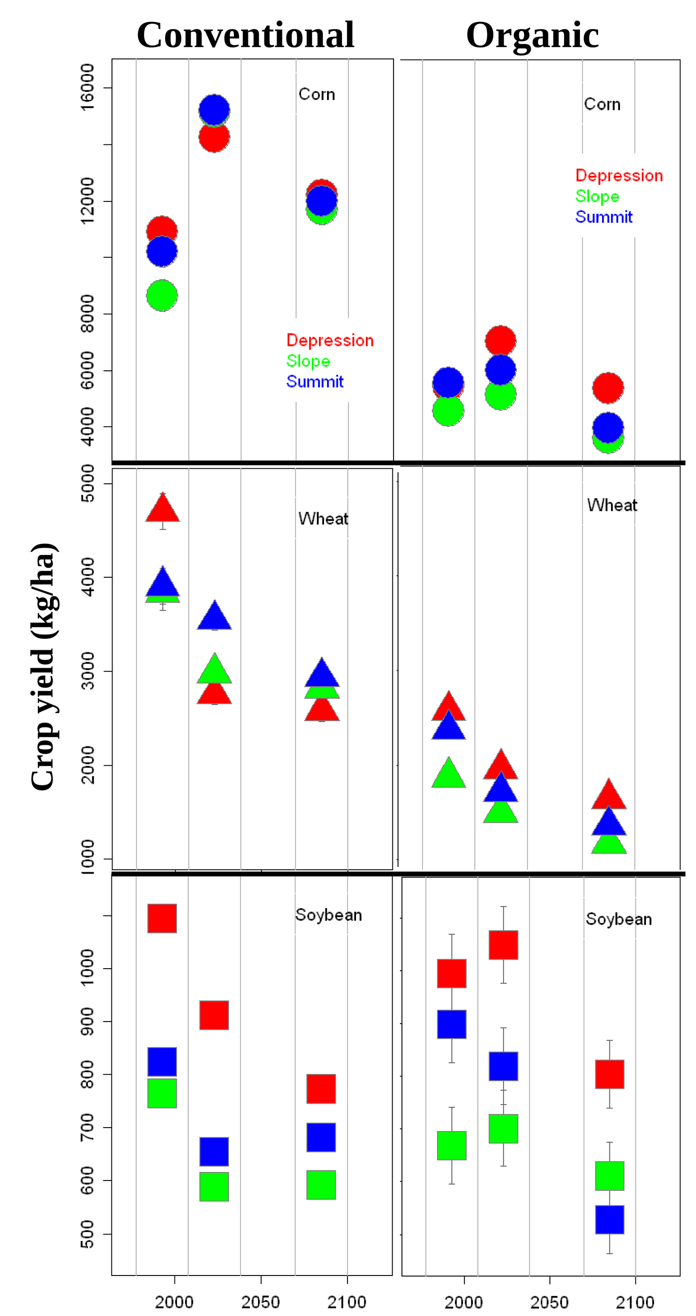


Figure 4. Model predictions for past and future climate scenarios. 30-year yield means are shown for each time period. Bars mark standard error for means within each period.

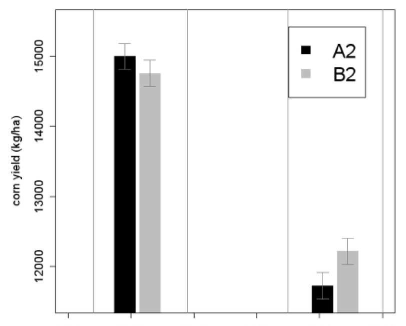


Figure 5. Model predictions for corn using scenarios A2 and B2.

Simulation-past and future scenarios: Crop simulations were ran for three periods **(Fig. 2),** using historic data **(1978-2008)** and future scenarios **(2008-2038 and 2070-2099)**. Yield mean for each period, crop position and management were extracted **(Fig. 4)**

Result 2: Corn yields were affected by weather scenarios and topographical positions **(Fig. 4).** Wheat and soybean yields were considerably reduced. Corn yields increased from period 1 to period 2, possibly explained by the moderate increase in temperature **(~1ºC).** However, a larger increase **(~2.5ºC),** could reduce corn yields **(IPCC, 2007),** as was observed in period 3. During **2070-2099,** scenario B2 produce higher corn yields as compared to scenario A2 in the conventional management **(Fig. 5).**

References:
IPCC, 2007: Climate Change 2007. M. Parry, O. Canziani, J. Palutikof, P. van der Linden and C. Hanson, Eds., Cambridge Uni. Press, UK, 976pp.
Basso, B., J. Ritchie, P. Grace, and L. Sartori. 2006. Simulation of tillage systems impact on soil biophysical properties using SALUS. Int. J. Ag. 4:677-688.
Robertson, P., & Bronson, J. 2011. KBS059: LTER Scale-up experiment. Protocol LTER (Accessed: 2011, Oct 18. http://lter.kbs.msu.edu/datatables/)
Winkler, J., J. Palutikof, J. Andresen, C. Goodess, 1997: Simulation of Daily Temperature Time Series from GCM Output. J. Climate, 10, 2514–2532.

Acknowledgement: Support for this research was provided by USDA NIFA Ecosystem Services program **(AFRI Competitive Grant 2010-65615-20614).** Additional support provided by the NSF Long-Term Ecological Research Program at the Kellogg Biological Station, "The Great Lakes Bioenergy Research Center (GLBRC)" program .

LTER
USDA United States Department of Agriculture National Institute of Food and Agriculture
MICHIGAN STATE UNIVERSITY
MICHIGAN AGRICULTURAL EXPERIMENT STATION
GLBRC Great Lakes Bioenergy Research Center

This work was funded in part by the NSF LTER Program at KBS and the Michigan Agricultural Experiment Station