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Statistical emulator to predict crop yield responses to land suitability and climate change

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Abstract

INTRODUCTION - The population growth and the increase of income are only two of the drivers of the so called “nutrition transition” (Kearney, 2010; Garnett, 2013). The global nutrition transition is the trend to ingest more calories, also empty calories (Tilman & Clark, 2015). Many studies have emphasized the expected increment of demand for food (Alexandratos & Bruinsma 2012; Van Kernebeek et al., 2015) as well as the intake of meat, dairy foods and eggs (Tilman & Clark, 2014; Sans & Combris, 2015).

Accordingly, an higher demand for food products (Porkka, 2016) (due to the increase of global population) and a huge demand for animal-sources food (ASF) (van Zanten et al., 2016) are projected. Since cereals are the major feed intake (Keyzer et al., 2002), their associated demand will rise quickly (Delgrado, 2003; Valin et al. 2014) causing future changes in land use (Frank et al., 2014). A huge pressure on finite natural and forest lands is projected to take place by 2050 (Singh & Chhetri, 2016; Frank et al, 2014). At the same time, a global loss of suitable land for agricultural production is provided (Ramankutty et al., 2002; IIASA/ FAO, 2012; Zabel et al., 2014). Based on what has been said so far, the concern for food security is growing among academic scientists. During the last decades, several studies have measured future yields for some agricultural crops with different approaches (Lobell and Burke, 2010; Rosenzweig et al, 2014). Most recent studies have predicted future crop yields with statistical emulators on the basis of climate variables, such as temperature, precipitation and the carbon dioxide concentration (Blanc and Sultan, 2015; Blanc, 2017). However, the doubt is that the expected reduction of average crop yield at local or global level (Frank et al., 2014) is underestimated since there are no studies which consider the land suitability as a predictor of crop yield.

AIM - The aim of the present study is to assess wheat yield with a compact model. More precisely, a statistical emulator in which both wheatear and land suitability features, included

their interactions, are examined. The study has analysed crop yield at province level in different Countries.

METHOD - A statistical model is fitted for wheat crop to a panel of yield produced by GAEZ (IIASA/ FAO, 2012). Information about mean temperature and mean precipitation are provided from GAEZ,

while, data on carbon dioxide concentrations are provided through the RCP 8.5 (Riahi et al., 2007). Either “historical” and “future” period are contemplate in this study.

RESULTS - Preliminary results confirm that crop yield emulator provides an accessible and reliable tool to estimate crop yields under alternative plausible changes in climate. Furthermore, this study shown that land suitability combined with wheatear factors gives more detailed predictions of future crop yields. Future researches should consider both climate and land suitability aspects to avoid underestimation of crop yields and to suggest more effective land-use planning.

Keywords: Climate Change, Crop yield, Land suitability, Statistical emulator

References

- Alexandratos, N., & Bruinsma, J. (2012). World agriculture towards 2030/2050: the 2012 revision (No. 12-03, p. 4). Rome, FAO: ESA Working paper.
- Blanc, É. (2017). Statistical emulators of maize, rice, soybean and wheat yields from global gridded crop models. Agricultural and Forest Meteorology, 236, 145-161.
- Blanc, E., & Sultan, B. (2015). Emulating maize yields from global gridded crop models using statistical estimates. Agricultural and Forest Meteorology, 214, 134-147.
- Delgado, C. L. (2003). Rising consumption of meat and milk in developing countries has created a new food revolution. The Journal of nutrition, 133(11), 3907S-3910S.
- Frank, S., Havlík, P., Valin, H., Deppermann, A., Witzke, P., & Surry, Y. (2014). D2. 1 Global drivers of EU land use. Month.
- Garnett, T. (2013). Food sustainability: problems, perspectives and solutions. Proceedings of the Nutrition Society, 72(1), 29-39.
- IIASA, FAO (2012). Global agro-ecological zones (GAEZ v3. 0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.
- Kearney, J. (2010). Food consumption trends and drivers. Philosophical Transactions of the Royal Society of London B: Biological Sciences, 365(1554), 2793-2807.
- Keyzer, M., Merbis, M., & Pavel, F. (2002). Can we feed the animals? Origins and implications of rising meat demand. Zaragoza (Spain), 28, 31.
- Lobell, D. B., & Burke, M. B. (2010). On the use of statistical models to predict crop yield responses to climate change. Agricultural and Forest Meteorology, 150(11), 1443-1452.
- Porkka, M. (2016). Securing global food supplies with limited resources-Lessons from the past.
- Ramankutty, N., Foley, J. A., Norman, J., & McSweeney, K. (2002). The global distribution of cultivable lands: current patterns and sensitivity to possible climate change. Global Ecology and biogeography, 11(5), 377-392.
- Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A. C., Müller, C., Arneth, A., ... & Neumann, K. (2014). Assessing agricultural risks of climate change in the 21st century in a global

gridded crop model intercomparison. Proceedings of the National Academy of Sciences, 111(9), 3268-3273.

- Sans, P., & Combris, P. (2015). World meat consumption patterns: An overview of the last fifty years (1961–2011). Meat science, 109, 106-111.
- Singh, S., & Chhetri, P. (2016). Agricultural Growth, Productivity and Regional Change in India: Challenges of Globalisation, Liberalisation and Food Insecurity (Vol. 163). Taylor & Francis.
- Tilman, D., & Clark, M. (2014). Global diets link environmental sustainability and human health. Nature, 515(7528), 518-522.
- Tilman, D., & Clark, M. (2015). Food, Agriculture & the environment: Can we feed the world & save the Earth?. Daedalus, 144(4), 8-23.
- Valin, H., Sands, R. D., van der Mensbrugghe, D., Nelson, G. C., Ahammad, H., Blanc, E., ... & Heyhoe, E. (2014). The future of food demand: understanding differences in global economic models. Agricultural Economics, 45(1), 51-67.Frank
- Van Kernebeek, H. R., Oosting, S. J., Van Ittersum, M. K., Bikker, P., & De Boer, I. J. (2016). Saving land to feed a growing population: consequences for consumption of crop and livestock products. The International Journal of Life Cycle Assessment, 21(5), 677-687.
- van Zanten, H. H., Mollenhorst, H., Klootwijk, C. W., van Middelaar, C. E., & de Boer, I. J. (2016). Global food supply: land use efficiency of livestock systems. The International Journal of Life Cycle Assessment, 21(5), 747-758.
- Zabel, F., Putzenlechner, B., & Mauser, W. (2014). Global agricultural land resources–a high resolution suitability evaluation and its perspectives until 2100 under climate change conditions. PloS one, 9(9), e107522.