Integrating the satellite-based biophysical model and environmental zonation scheme to estimate rice yield gap in Northeast China

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Yield gap analysis is a powerful method to reveal the difference between the actual crop yield and yield potential, and to understand the possible yield increase for fulfilling the growing food demand. It used to be restricted to small geographic areas in previous studies, and thus the scope of untapped yield often remains unclear at macro scale. To this end, we proposed an improved remote sensing approach to better assess the regional rice yield gap in northeast China. A biophysical model based on satellite-retrieved LAI and crop classification map was used to derive the actual yield and its spatial patterns. In addition, a machine-learning zonation scheme was developed to further evaluate the attainable potential yield for farmers within domains having similar climatic, geomorphic, and edaphic context. Results indicated that the satellite-based biophysical model can provide reliable estimates of rice yields, with RMSE all below 20 percent at the county level from 2006 to 2017; and the zonation scheme enabled better portrayal of the spatial variation in potential yield. To identify areas with the greatest potential for narrowing the yield gap, northeast China was divided into four parts with different priorities for future yield improvement. In general, south of northeast China possessed substantial yield gaps with the primary priority to be explored; whereas in the north, the actual yield already approximating yield potential, further yield increase was limited and challenging. Quantile regression model provided a complete view of relationships between natural factors and potential yield, and revealed the significant limiting effects of growing degree days, cumulative solar radiation and elevation. This study demonstrates the potential of remote sensing for agricultural decisions, and will aid planners to recognize the macro-scale food production capacity and security situation, to prioritize regions and needs for research and exploitation, and to evaluate the impact of future scenarios such as climate change.

Keywords: remote sensing, crop yield, yield gap, biophysical process model, environmental zonation scheme, Northeast China

