A Study of Estimating Winter Wheat Yields by Using Satellite Data Assimilation with Crop Growth Model

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Accurate information of crop yield is important for production planning in agriculture. Although we can comprehend crop growth situation by simulation of crop growth model, crop growth model is difficult to use because a lot of information such as climate and cultivation management, cultivar specific parameters (CSPs) are required. Accordingly, we use the Moderate Resolution Imaging Spectroradiometer (MOSIS) data for two types of utilization to provide necessary information for Decision Support Systems Agrotechnology Transfer (DSSAT) which is one of the representative crop growth models in the world. The objective of this study is developing a method of estimating winter wheat yield in Hokkaido, Japan and Henan, China without adequate information of the field. The first use is estimation of solar radiation, which is required as input data into DSSAT. Since MODIS has observed most of the earth surface everyday, it can estimate solar radiation in a region where an advanced climate observation system is not developed. The second use is data assimilation that provides appropriate parameter of CSPs to DSSAT. MODIS Leaf Area Index (LAI) and Dry Matter Production (DMP) estimated from MODIS Gross Primary Production (GPP) are assimilated into DSSAT. Before developing data assimilation, we have accomplished sensitivity analysis of DSSAT. As the result of the analysis, we found that planting date and amount of applied fertilizer have correlated strongly with growth of LAI and Dry Matter (DM) for specific growth period. Based on the result, we estimated winter wheat yield by assimilating MODIS LAI and DMP observed during the specific period. In contrast, previous studies have used satellite data which was observed during the whole growth period, to assimilate crop growth model to estimate crop yields. Three different assimilation schemes were achieved to verify the accuracy of our method: independent usage of LAI, synergic usage of LAI and DMP observed for specific or whole growth period. Our results showed that the estimated winter wheat yield agreed very well with the Japanese agricultural experiment station data. Among different scenarios, the best results were obtained when MODIS LAI and DMP which were observed during specific growth period, were assimilated. The Root Square Mean Error (RMSE) of this estimation method was 406.52 kg ha^2. Including only LAI or both LAI and DMP which were observed during whole growth period, performed with more than 700 kg ha^2 of RMSE. Our study showed that the method of assimilating remotely sensed data with crop growth model successfully predicted winter wheat yields.

Keyword: MODIS, DSSAT, Data Assimilation, Solar Radiation, Winter Wheat