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Winter wheat and oilseed rape yield estimations using multisource data fusion and crop growth models in Bavaria, Germany

Abstract

Accurate and timely prediction of crop yield at the regional scale is critical to making agricultural activities more sustainable, as well as ensuring food security. Crop growth modeling allows for simulating the physiological processes that result in crop development; however, the lack of spatial information in crop growth models (CGMs) results in uncertainties leading to larger errors in crop yield estimation. Remote Sensing (RS) data, on the other hand, allows crop monitoring at a range of spatial scales but can be hampered by limitations in the data. To accurately derive the crop yield information in Bavaria, the current study integrates different RS NDVI inputs (Raw: MOD13Q1 (250 m), and Synthetic: Landsat (L)-MOD13Q1 (30 m) and Sentinel-2 (S)-MOD13Q1 (10 m)) having 8- and 16-day temporal resolutions, with two widely used CGMs (World Food Studies (WOFOST), and the semi-empiric light use efficiency approach (LUE)) for Winter Wheat (WW) and Oil Seed Rape (OSR) in 2019. The manuscript answers three important questions: Which is the best suitable (i) spatial resolution (10 m, 30 m, or 250 m), (ii) temporal resolution (8 or 16 days), and (iii) CGM (LUE or WOFOST), for yield modeling? The study concludes that the multi-temporal high spatial resolution sensors' (S-MOD13Q1, 10 m, 8-day) observations with LUE model play significant role in accurately yield measuring of WW (R_2 = 0.86, RMSE = 5.03 dt/ha) and OSR (R_2 = 0.82, RMSE = 2.14 dt/ha). The study shows that the simple model (LUE) that requires fewer input parameters to simulate crop yield is highly accurate, reliable, and precise than the complex model (WOFOST) with higher input parameters for both WW (R_2 = 0.81 (LUE)/0.72 (WOFOST), RMSE = 5.17/7.15 dt/ha) and OSR (R_2 = 0.81/0.63, RMSE = 2.42/3.68 dt/ha), respectively.