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基于遥感信息与作物模型集合卡尔曼滤波同化的区域冬小麦产量预测

Regional winter wheat yield forecasting based on assimilation of remote sensing data and crop growth model with Ensemble Kalman method

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中文摘要：

　　区域作物产量预测是国家粮食安全评估的重要内容。遥感虽能获取大面积地表信息，却难以反映作物生长发育的内在过程。作物生长模型已经在单点尺度能成功模拟作物的生长发育过程，但是区域尺度作物关键参数的获取仍很困难。遥感信息与作物模型结合的数据同化已经成为区域产量预测的最有效途径。该文选择河北省衡水地区冬小麦为研究对象，在WOFOST模型标定与区域化的基础上，利用WOFOST模型描述冬小麦生育期内叶面积指数（LAI）变化规律。针对MODIS数据的混合像元造成反演的LAI产品偏低的系统误差，利用实测LAI样本点融合MODIS-LAI趋势信息修正MODIS-LAI数据产品。采用集合卡尔曼（EnKF）算法同化冬小麦返青到抽穗期的MODIS-LAI与WOFOST模拟的LAI以获得时间序列最优的LAI，并以此重新驱动WOFOST模型估算区域冬小麦产量。结果表明，EnKF同化后的冬小麦产量比未同化的产量预测精度有显著提高，与县平均统计产量相比，在潜在模式下，决定系数由0.13提高到0.38，均方根误差由2 480下降到880 kg/hm2。研究表明，遥感信息与作物模型的EnKF同化是1种有效的作物产量预测方法，并在区域尺度应用上具有广阔的应用潜力。该研究可为区域尺度的作物估产提供参考。

英文摘要：

　　Regional crop production prediction is a significant component of national food security assessment. Remote sensing has the advantage of acquiring soil surface and crop canopy radiation information, however it is hard to reveal the inherence mechanism of crop growth and yield formation. Crop growth models based on the crop photosynthesis, transpiration, respiration, nutrition are successfully applicable for yield forecasting in simple point scale, however, they are hampered by the deriving of regional crop key input parameters. Data assimilation method which combines crop growth model and remotely sensed data has been proved the most potential approach in regional yield estimation. Hengshui district was taken as the study area. Based on the calibration and regional of WOFOST, the WOFOST model had been used to express the characteristic of time series LAI in crop growth season. To solve the system errors of MODIS-LAI due to the mixed pixels effect, the corrected MODIS-LAI was implemented by combining the field measured LAI data and the MODIS-LAI temporal trend information. Time-series LAI was assimilated through combined corrected MODIS-LAI and WOFOST simulated LAI from green-up to heading stage with EnKF algorithm. The assimilated optimal LAI was used to drive the WOFOST model per-pixel to estimate the regional yield. The results indicated that the precision of yield forecasting was obviously improved with EnKF assimilation, compared with the statistical yield, the coefficient of determination was improved from 0.10 to 0.45 and RMSE was reduced from 2 480 kg/hm2 to 860kg/hm2. The results showed that assimilation of the remotely sensed data into crop growth model with EnKF can provide a reliable approach for prediction regional crop yield and had great potential in agricultural applications. The research can provide an important reference value for the regional crop production estimation.

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