Crop yield estimation by integration of remote sensing and meteorological data

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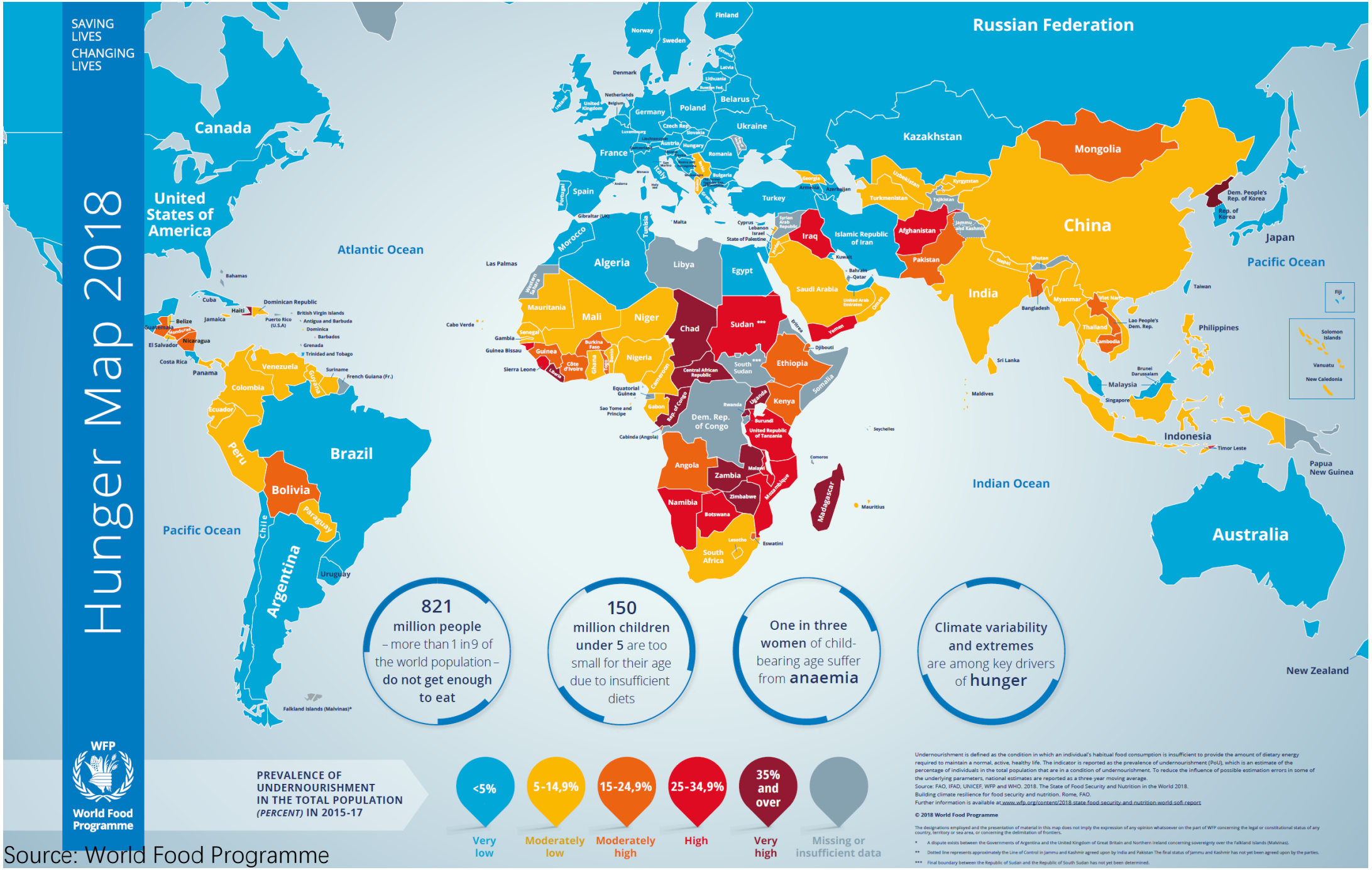
Outline

- **Introduction**
- Study area and data
- Method
- Result and discussion
- Conclusion



Source: World Food Programme

Introduction

- Biomass is closely related with crop condition and yield;
- Biomass plays an important role in the global carbon cycle;
- It is essential to estimate crop biomass at high spatial resolution in regions with high farmland fragmentation.
- The objective of our research is to find out an efficient methods for biomass and yield prediction which can be operationalized and benefitted many less developed countries

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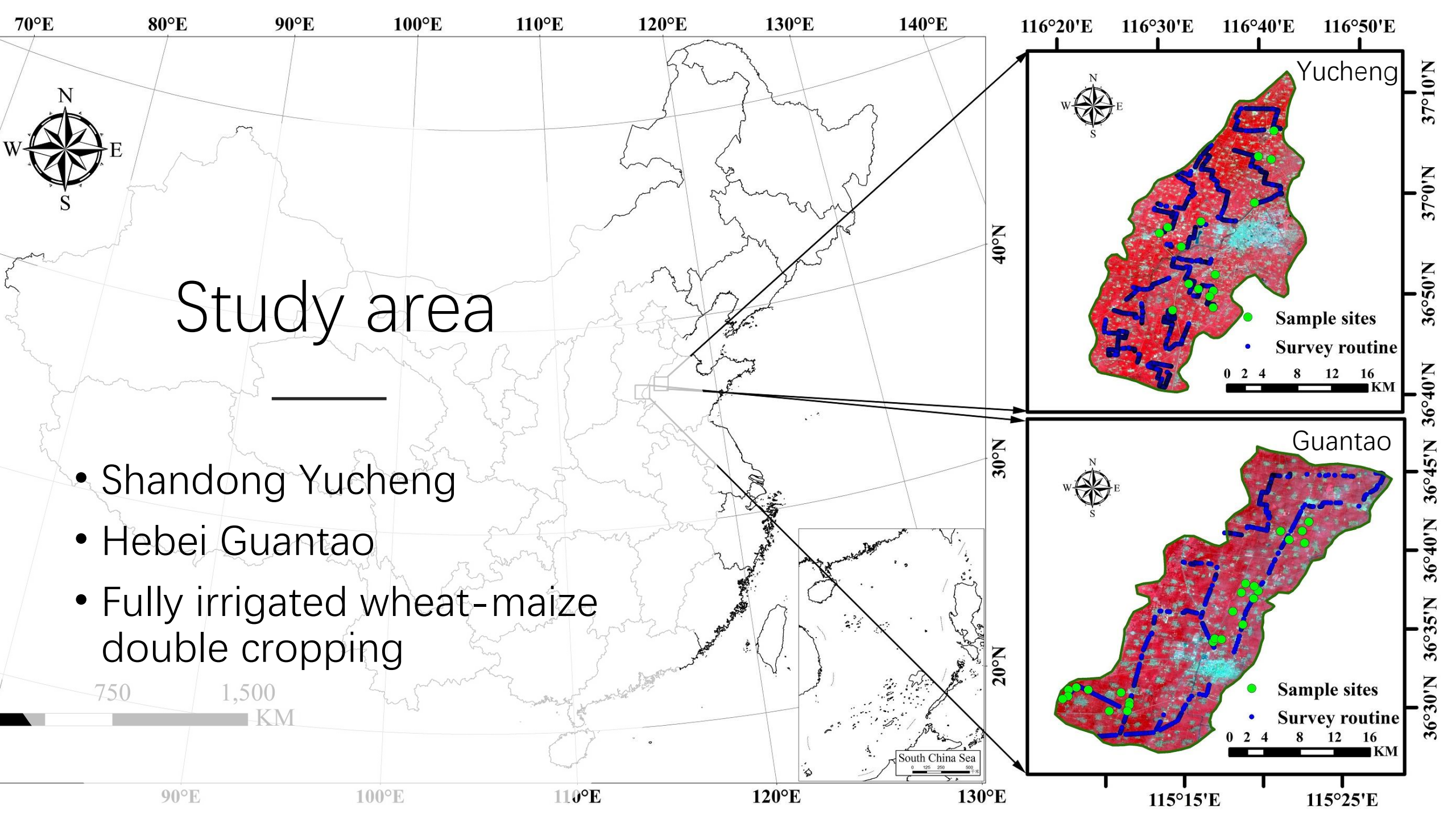
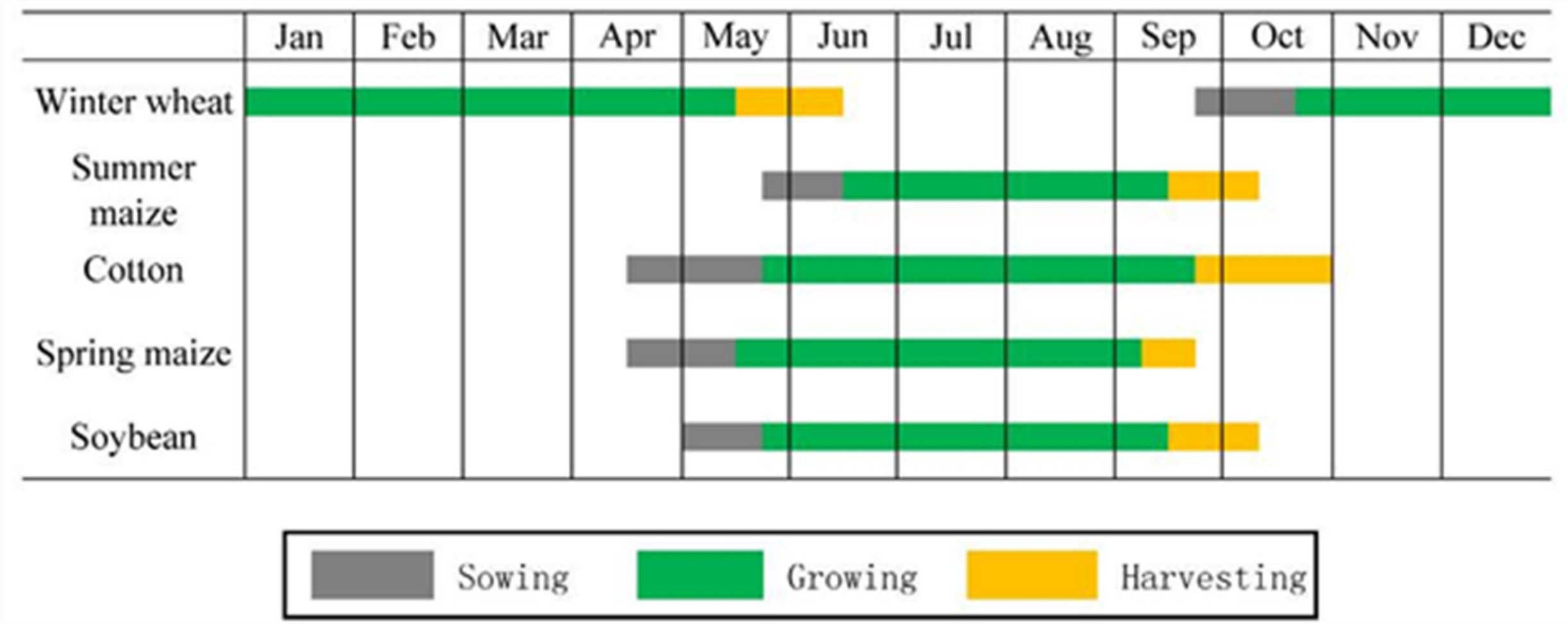


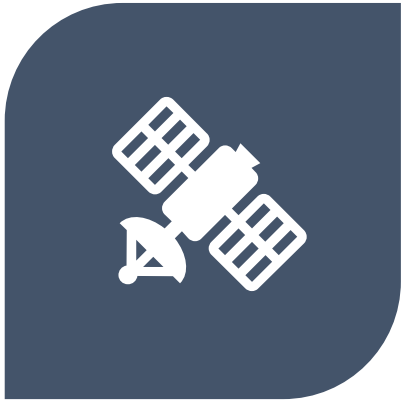
Study area

- Shandong Yucheng
- Hebei Guantao
- Fully irrigated wheat-maize double cropping

Crop calendar



Data



SATELLITE DATA

PROBA-V 100- and 300-m top of canopy (TOC) reflectance

METEOROLOGICAL DATA

Daily temperature, and sunshine duration

IN-SITU MEASUREMENTS

Dry biomass and yield by crop cutting over 25 fields and at booting, flowering and harvest

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Methods

1

Crop mapping

2

Biomass model

3

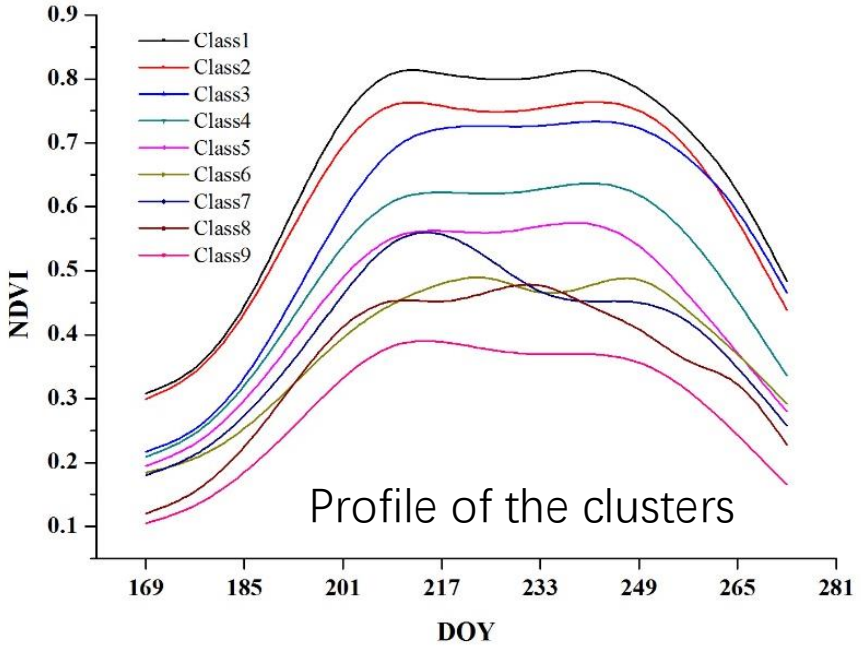
Harvest Index

4

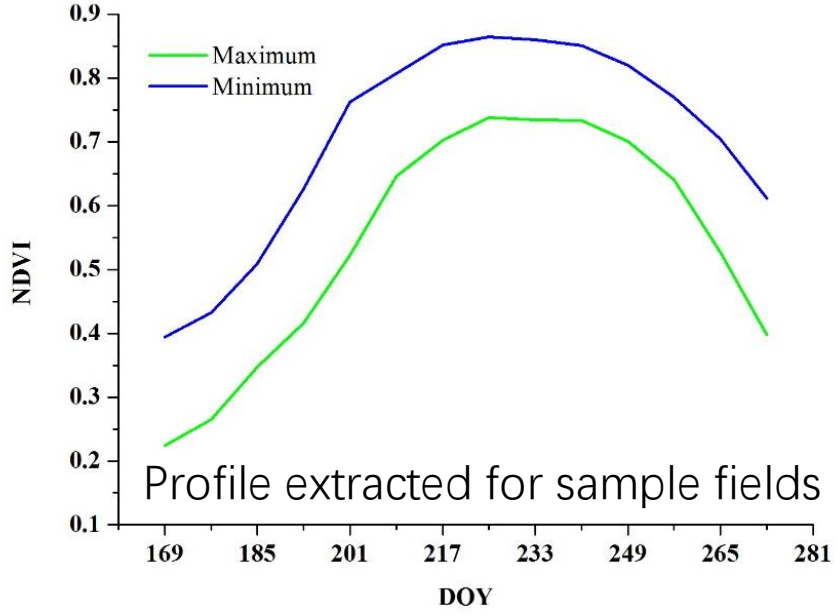
Yield

Crop mapping based on time series clustering

- Savitzky-Golay (S-G) filtering were used to smooth time-series NDVI
- MLC) and ISODATA unsupervised methods were undertaken to cluster the time-series smoothed NDVI
- The crop fields were extracted based on from the clusters by the similarity of the profiles to crop profiles from sampled fields



Profile of the clusters



Profile extracted for sample fields

Biomass based on modified LUE model

- The accumulation of aboveground biomass is proportional to accumulated APAR
- Two temperature limiting factors and one water limiting factor were considered when calculating actual light use efficiency

$$\mathrm{AGB} = \mathrm{R} \times \mathrm{LUE} \times \sum_{t=0}^{N} (\mathrm{APAR}(\Delta t) \times \Delta t)$$

$$\mathrm{APAR} = \sum_{t=0}^{N} (\mathrm{PAR} \times \mathrm{FPAR}) \times \Delta t$$

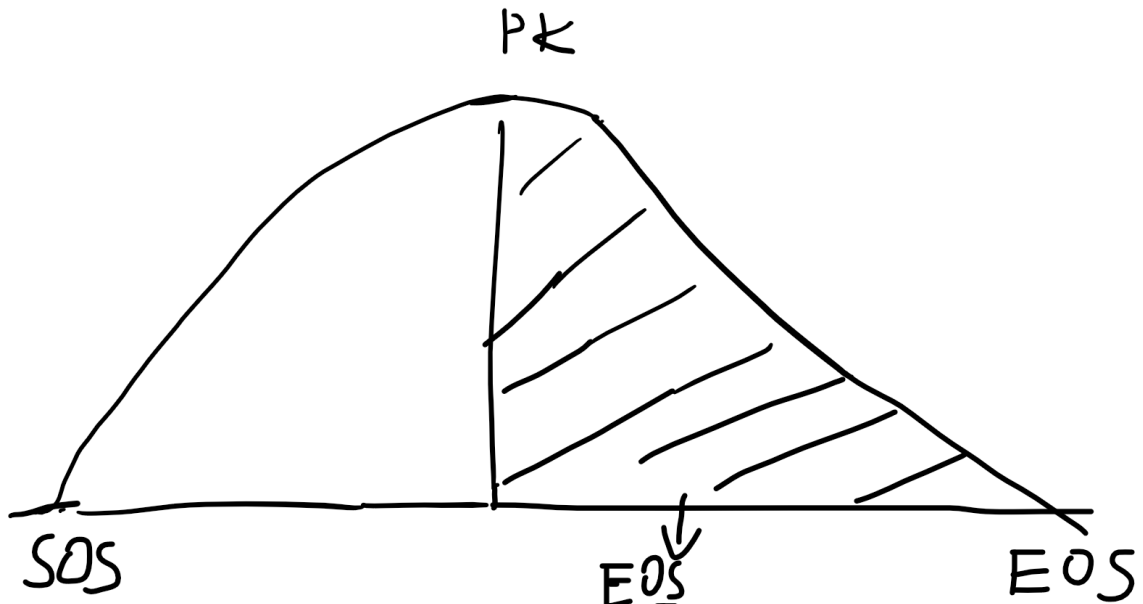
$$\mathrm{LUE}(x,t) = \varepsilon^{*} \times T_{\varepsilon 1}(x,t) \times T_{\varepsilon 2}(x,t) \times W_{\varepsilon}(x,t)$$

$$W_{\varepsilon}(x,t) = (1 + \mathrm{LSWI})/(1 + \mathrm{LSWI}_{\max})$$

$$\mathrm{FPAR} = \frac{(\mathrm{SR} - \mathrm{SR}_{\min}) \times (\mathrm{FPAR}_{\max} - \mathrm{FPAR}_{\min})}{\mathrm{SR}_{\max} - \mathrm{SR}_{\min}} + \mathrm{FPAR}_{\min}$$

$$\mathrm{SR} = \mathrm{NIR}/\mathrm{RED} = (1 + \mathrm{NDVI})/(1 - \mathrm{NDVI})$$

Pixel based harvest index



$$HI = \frac{\sum_{SOS}^{PK} NDVI}{\sum_{SOS}^{EOS} NDVI}$$

Yield

$$\text{Yield} = \text{HI} * \sum_{n=N_0}^{n=N_1} \text{AGB}_t$$

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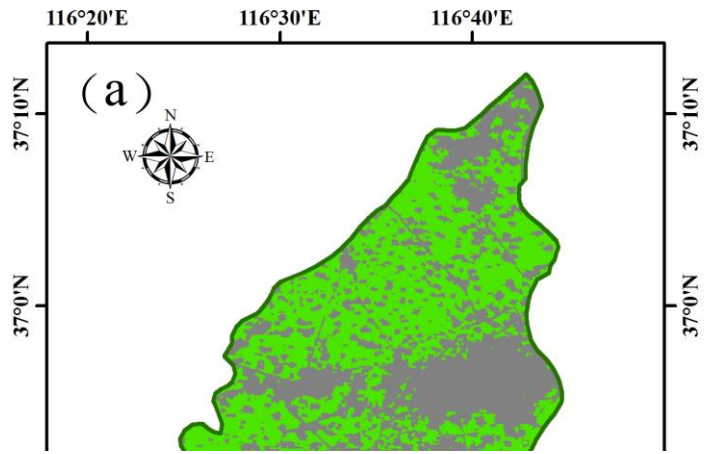
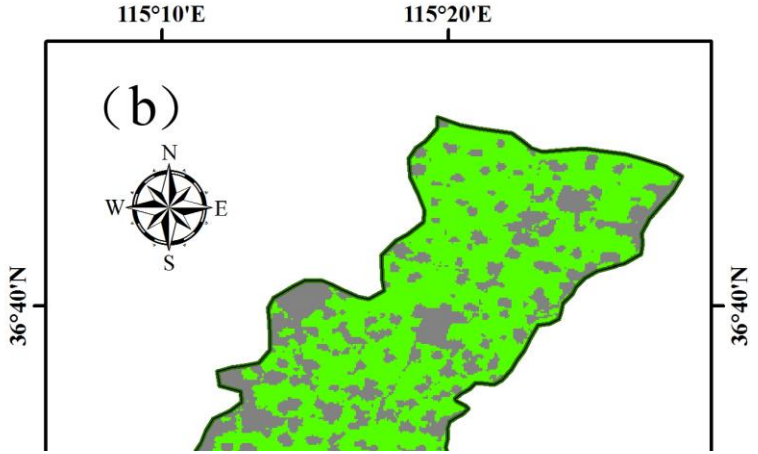
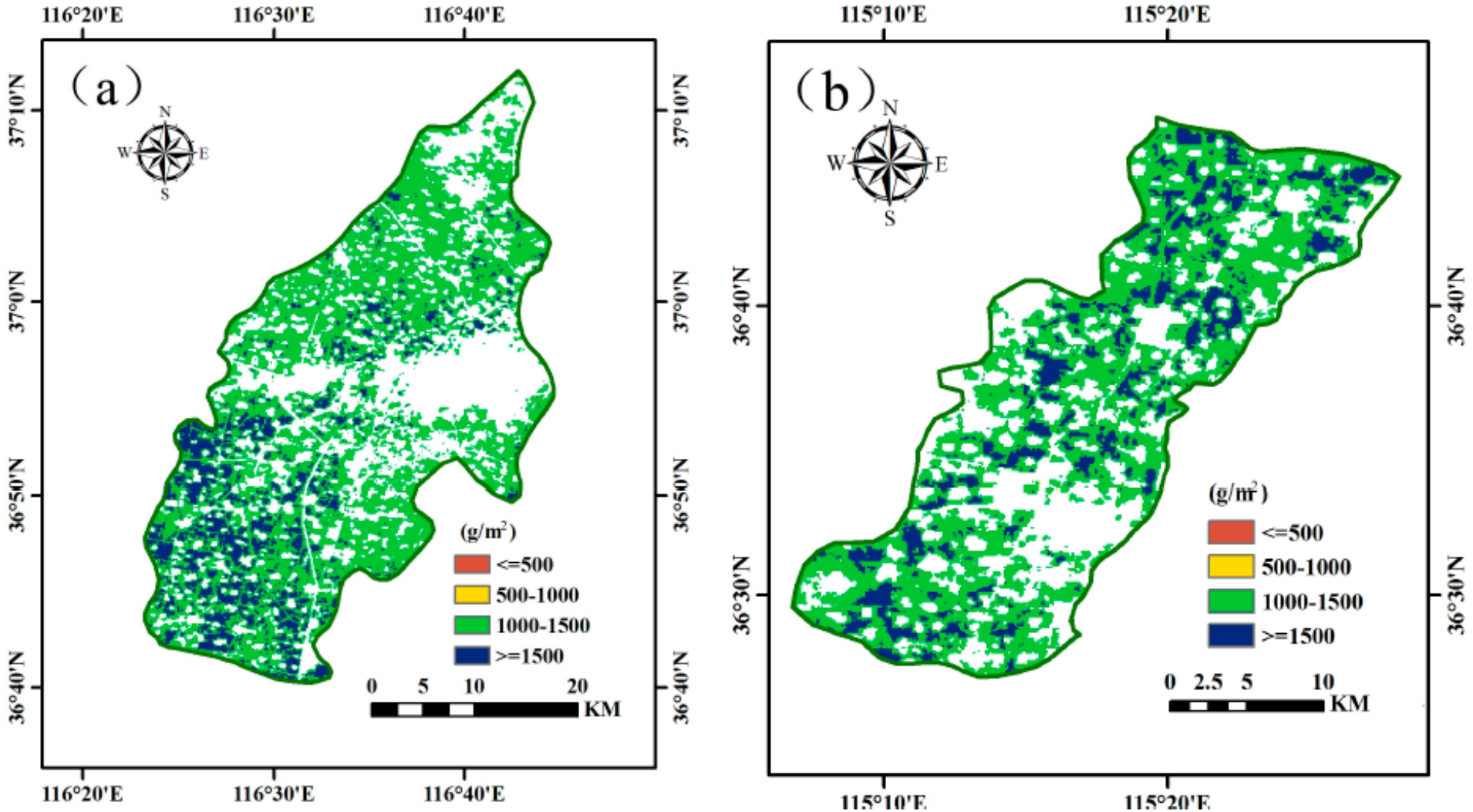
Crop maps



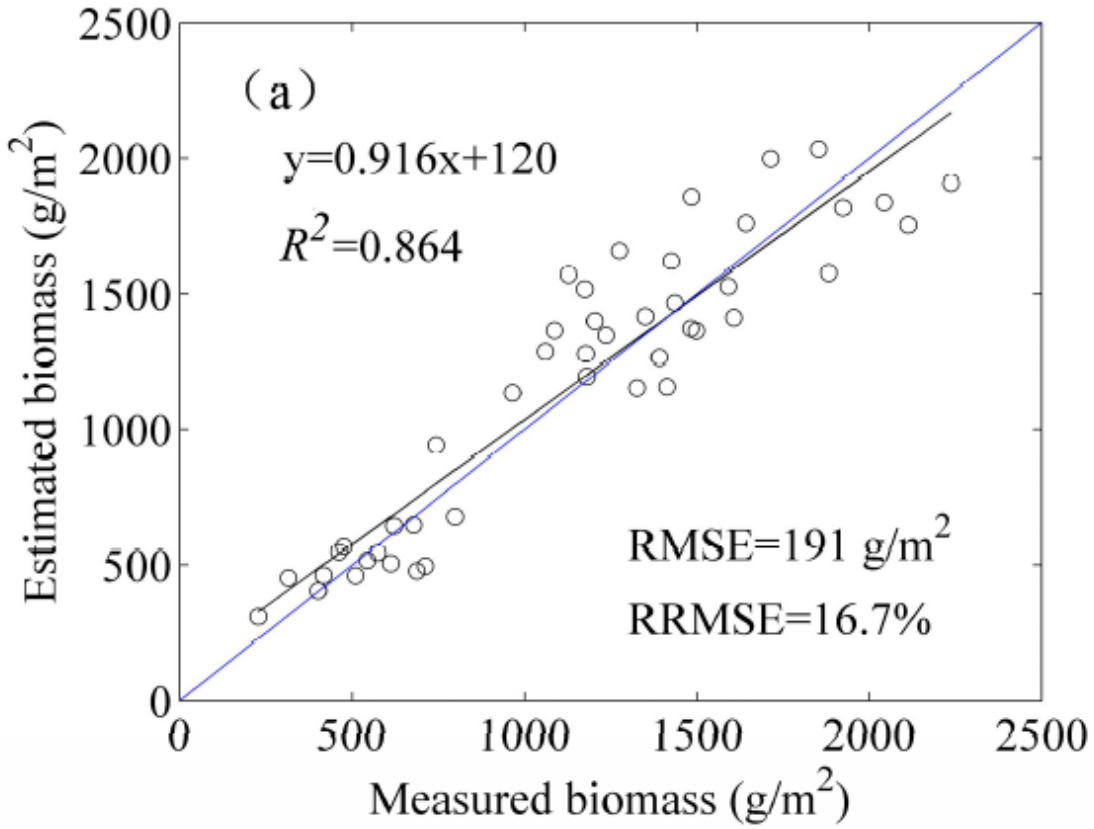


Class	Yucheng		Guantao	
	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy
Wheat	86.96%	81.63%	80.95%	73.91%
Others	82.69%	87.76%	76.62%	83.1%
	Overall Accuracy: 84.69%; Kappa: 0.7198		Overall Accuracy: 78.57%; Kappa: 0.5708	

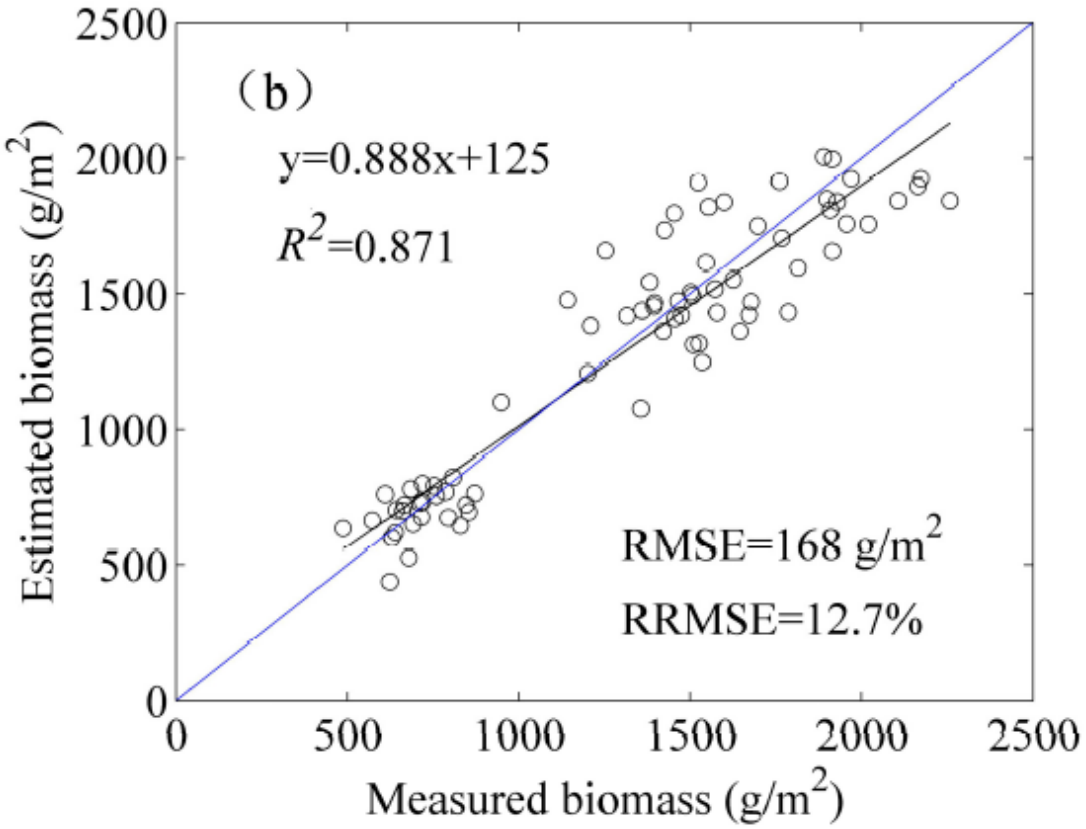
Wheat biomass



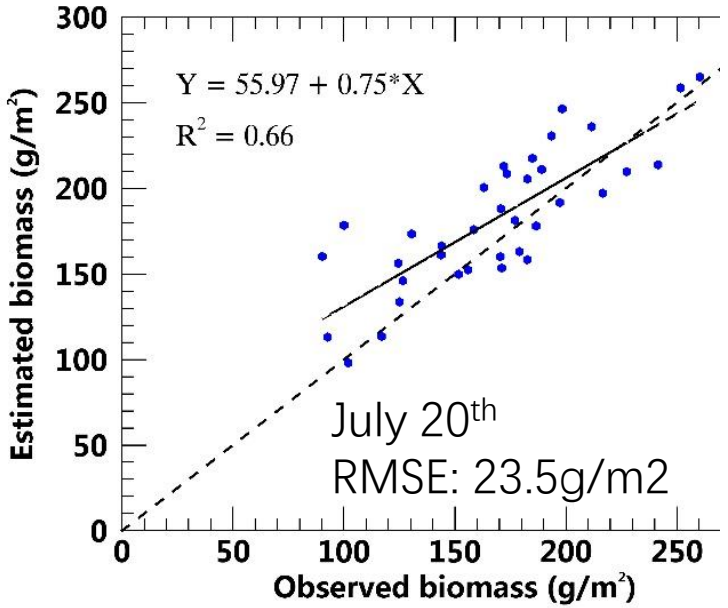
Accuracy of wheat biomass

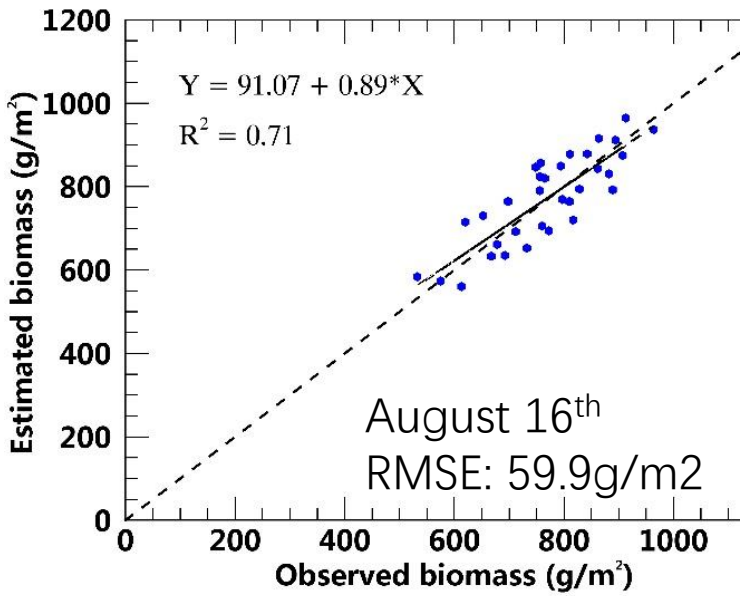


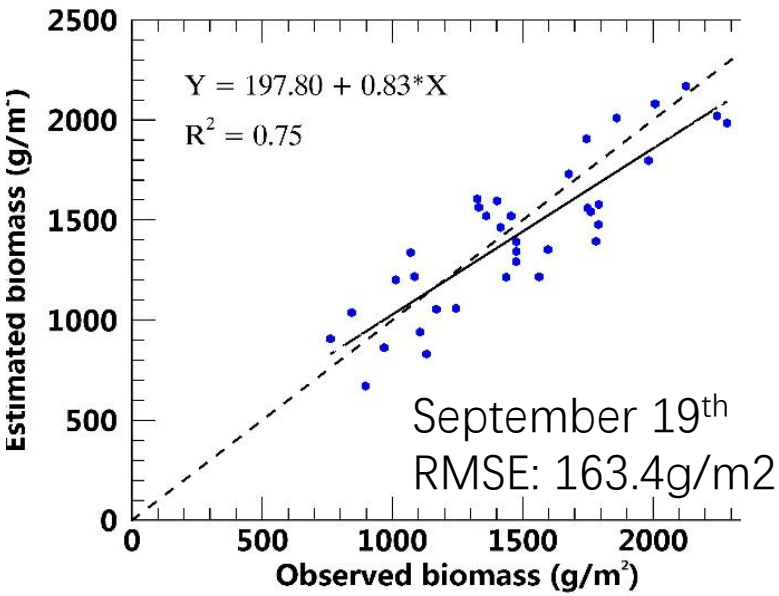
Yucheng



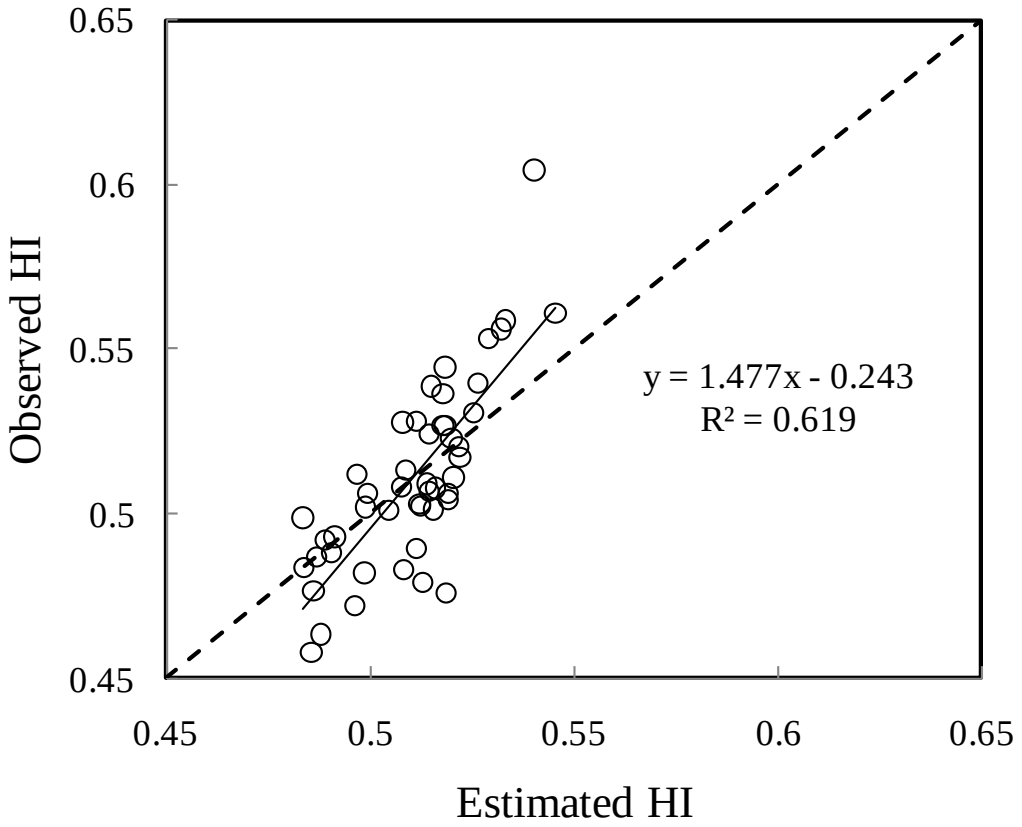
Guantao

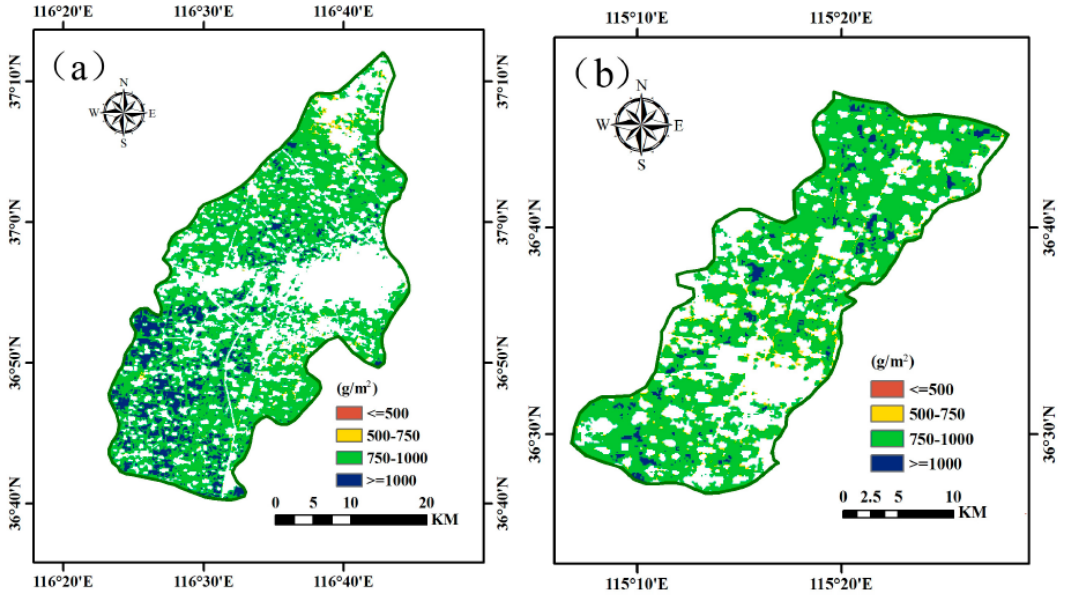




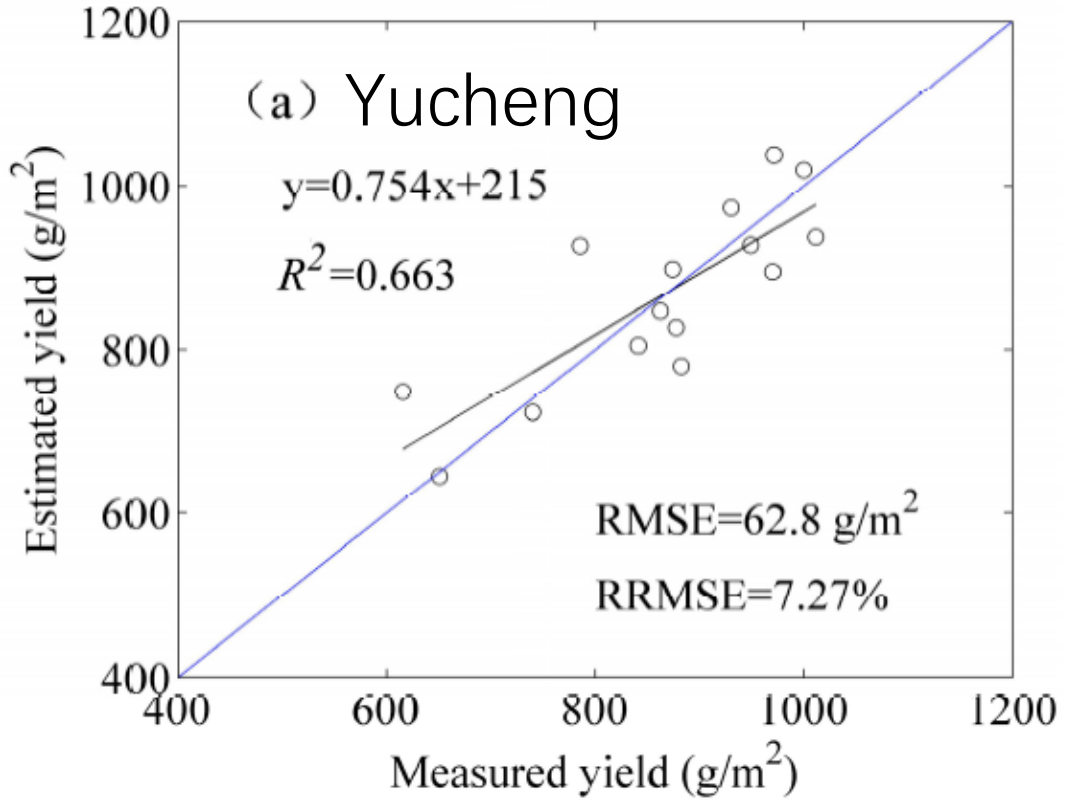


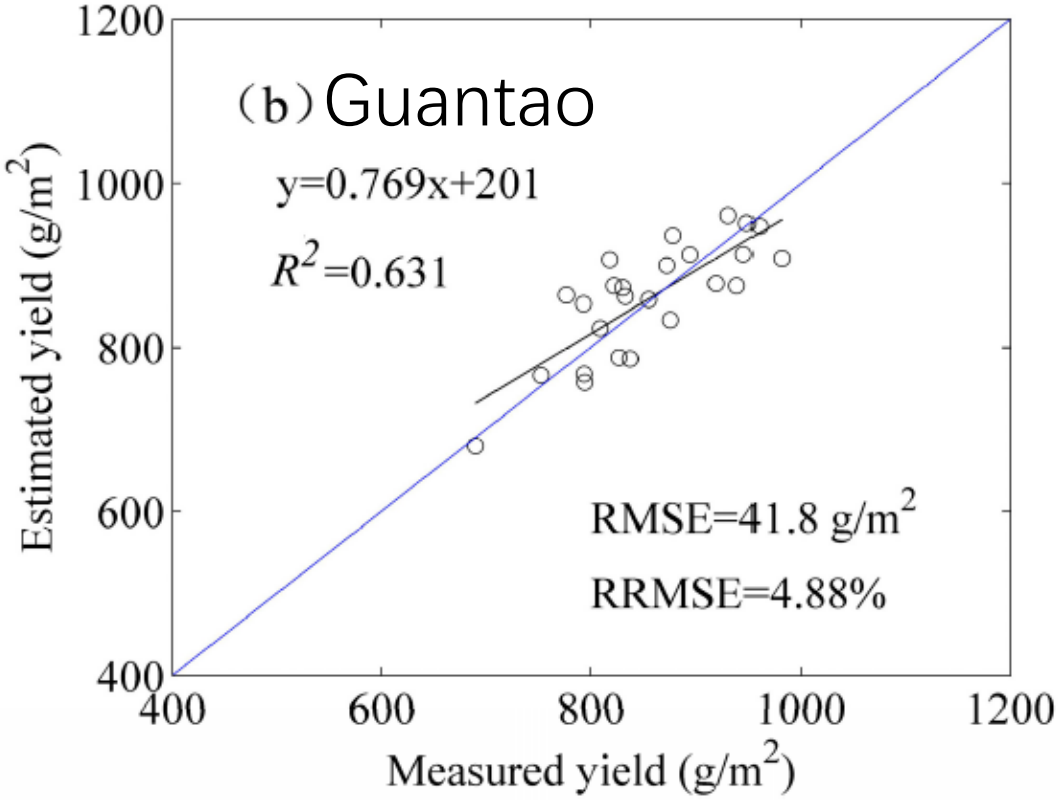
Accuracy of maize biomass





Harvest index and yield





Accuracy of crop yield

Limitations

01

Harvest index can only be derived at the end of growing season

02

Only one meteorological station for each site

03

NDVI data is used but is saturated at peak season

04

Water limiting factor does not differ much since mostly irrigated

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Conclusion

Proba-V 100 meter images provide an intermediate spatial resolution that is complementary for the existing data sources in yield prediction

The proposed biomass-harvest model provides accurate biomass estimates at different growing stage and yield prediction

Meteorological data mainly contributed to the accumulated biomass while remote sensing data can offer pixel based SOS, EOS, peak time, and time series VIs