

Crop yield estimation by integration of remote sensing and meteorological data

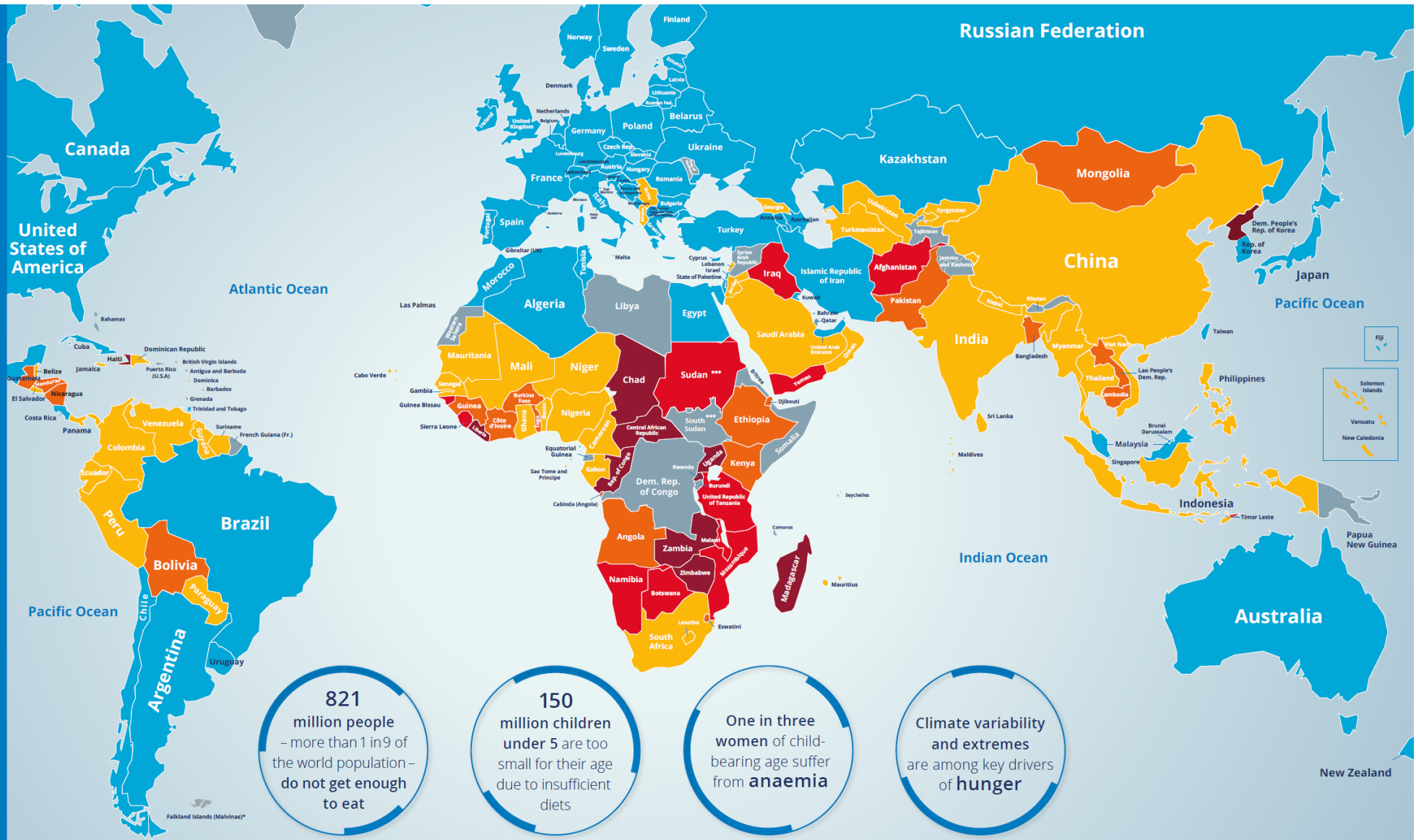
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Outline

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

SAVING LIVES
CHANGING LIVES

Hunger Map 2018



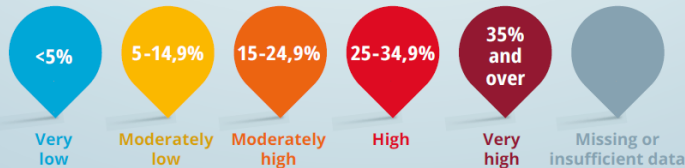
821 million people – more than 1 in 9 of the world population – do not get enough to eat

150 million children under 5 are too small for their age due to insufficient diets

One in three women of child-bearing age suffer from **anaemia**

Climate variability and extremes are among key drivers of **hunger**

PREVALENCE OF UNDERNOURISHMENT IN THE TOTAL POPULATION (PERCENT) IN 2015-17



Undernourishment is defined as the condition in which an individual's habitual food consumption is insufficient to provide the amount of dietary energy required to maintain a normal, active, healthy life. The indicator is reported as the prevalence of undernourishment (PoU), which is an estimate of the percentage of individuals in the total population that are in a condition of undernourishment. To reduce the influence of possible estimation errors in some of the underlying parameters, national estimates are reported as a three-year moving average.
Source: FAO, IFAD, UNICEF, WFP and WHO, 2018. The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome, FAO. Further information is available at www.wfp.org/content/2018-state-food-security-and-nutrition-world-sofi-report

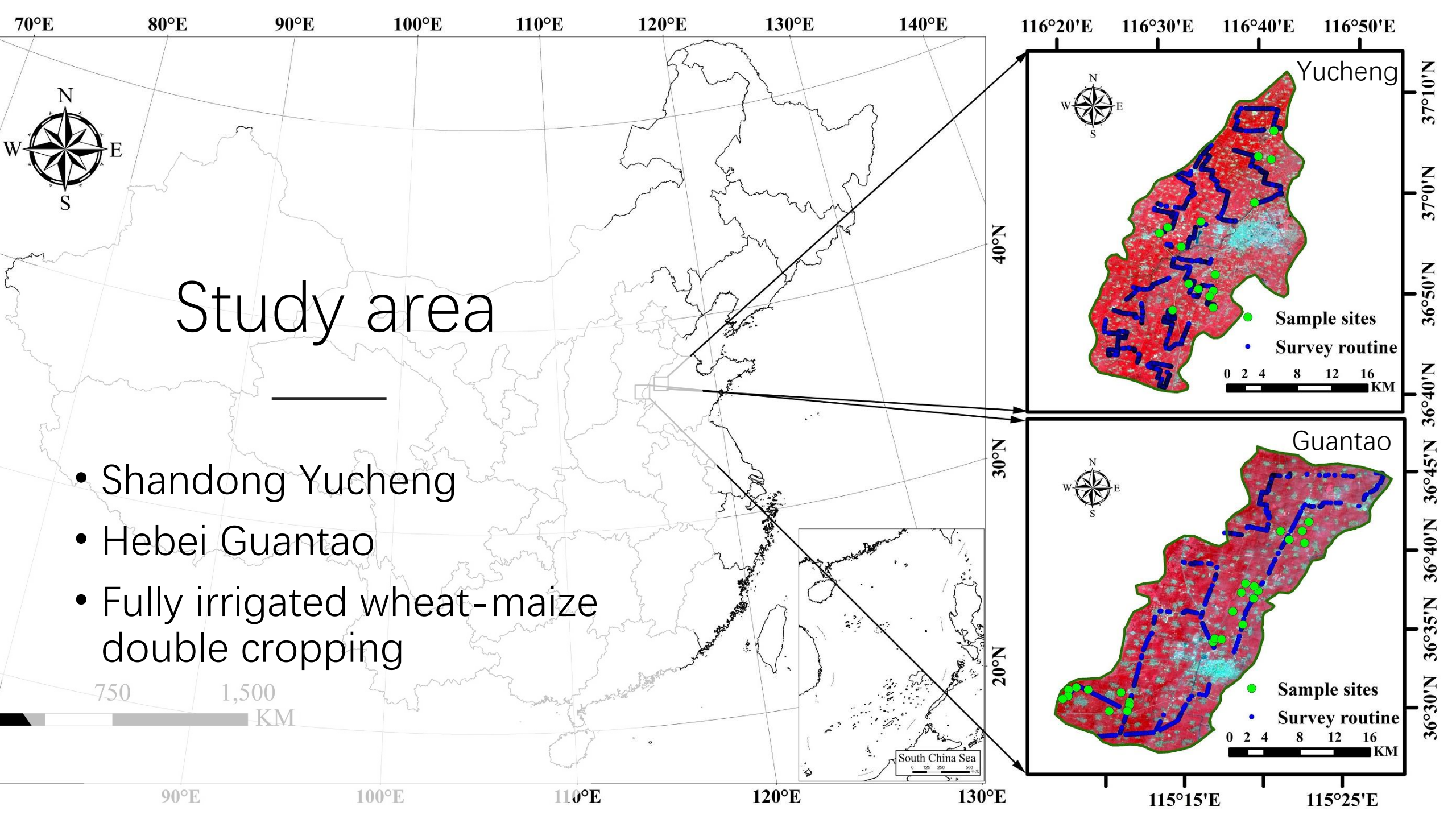
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The designations employed and the presentation of material in this map does not imply the expression of any opinion whatsoever on the part of WFP concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.
* A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).
** Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.
*** Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

Introduction

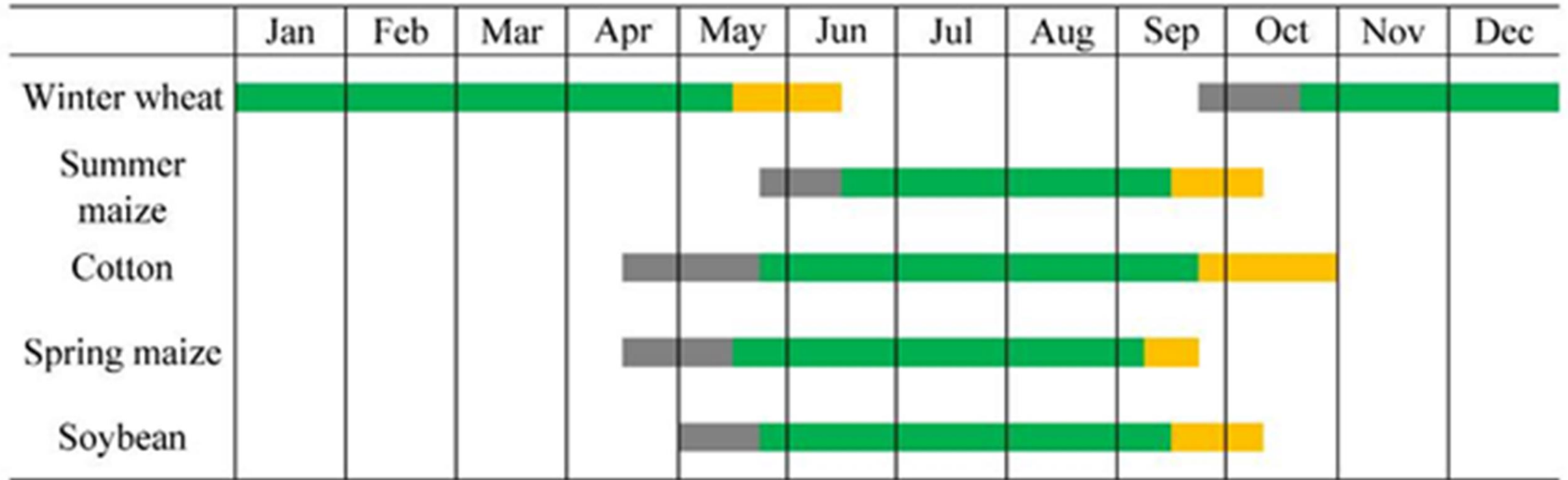
- Biomass is closely related with crop condition and yield;
- Biomass plays an important role in the global carbon cycle;
- It is essential to estimate crop biomass at high spatial resolution in regions with high farmland fragmentation.
- The objective of our research is to find out an efficient methods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

Outline

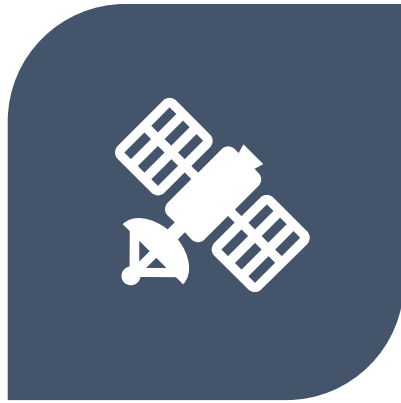
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Crop calendar



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

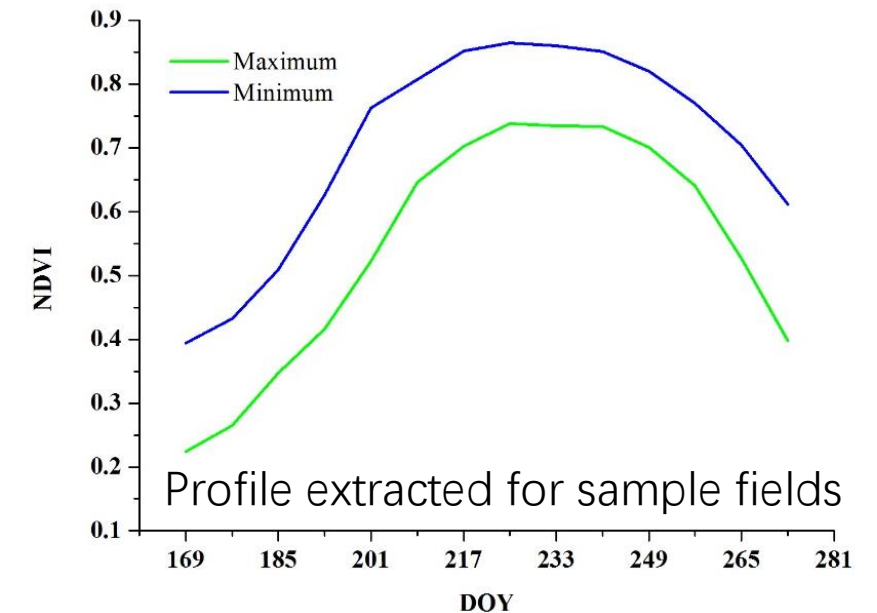
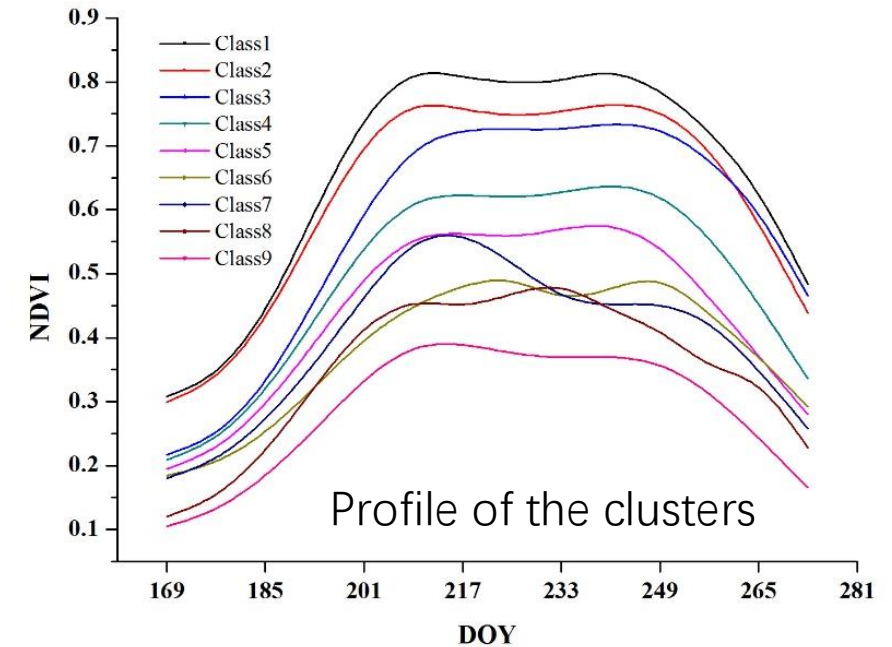
Harvest
Index

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



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

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

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

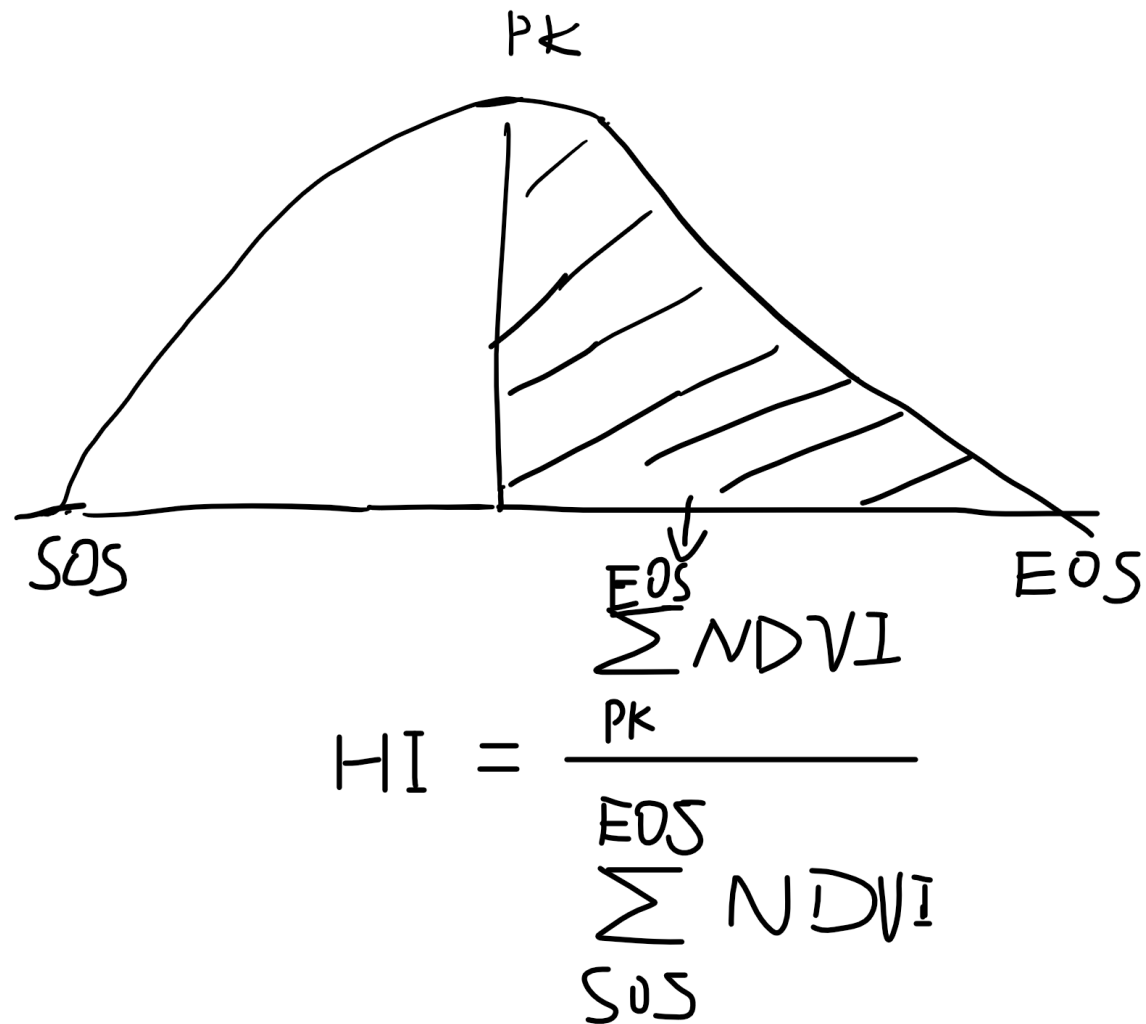
$$LUE(x, t) = \cdot \varepsilon^* \times T_{\varepsilon 1}(x, t) \times T_{\varepsilon 2}(x, t) \times W_{\varepsilon}(x, t) .$$

$$W_{\varepsilon}(x, t) = \cdot (1 + LSWI) / (1 + LSWI_{\max}) .$$

$$FPAR = \cdot \frac{(SR - SR_{\min}) \times (FPAR_{\max} - FPAR_{\min})}{SR_{\max} - SR_{\min}} + FPAR_{\min} .$$

$$SR = \cdot NIR/RED = (1 + NDVI) / (1 - NDVI) .$$

Pixel based harvest index



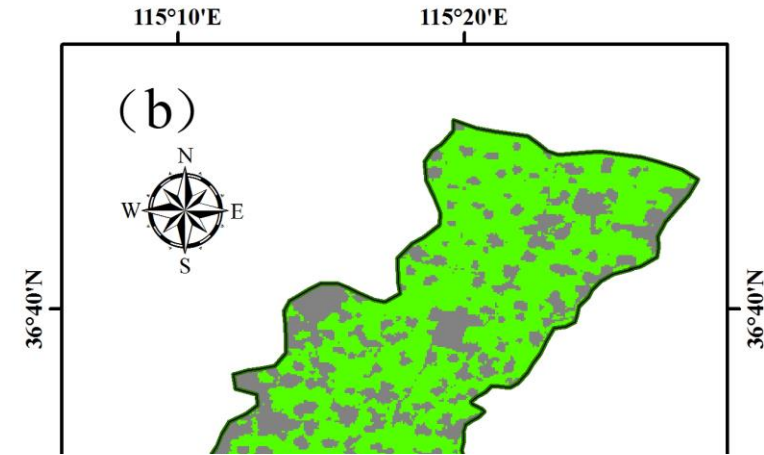
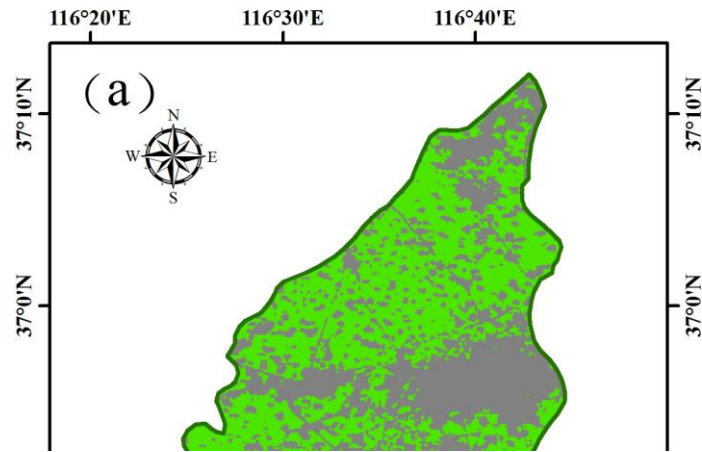
Yield

$$Yield = HI * \sum_{n=N_0}^{n=N_1} AGB_t$$

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Crop maps

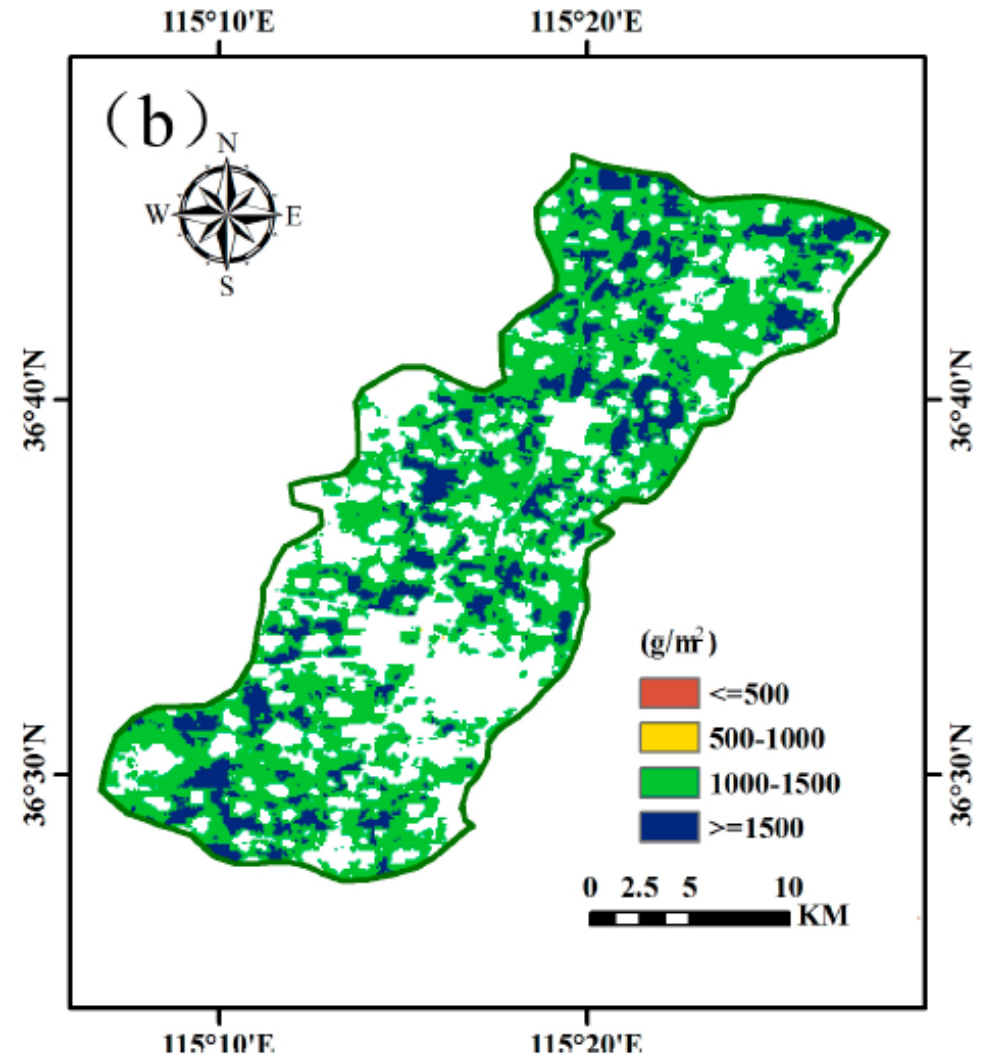
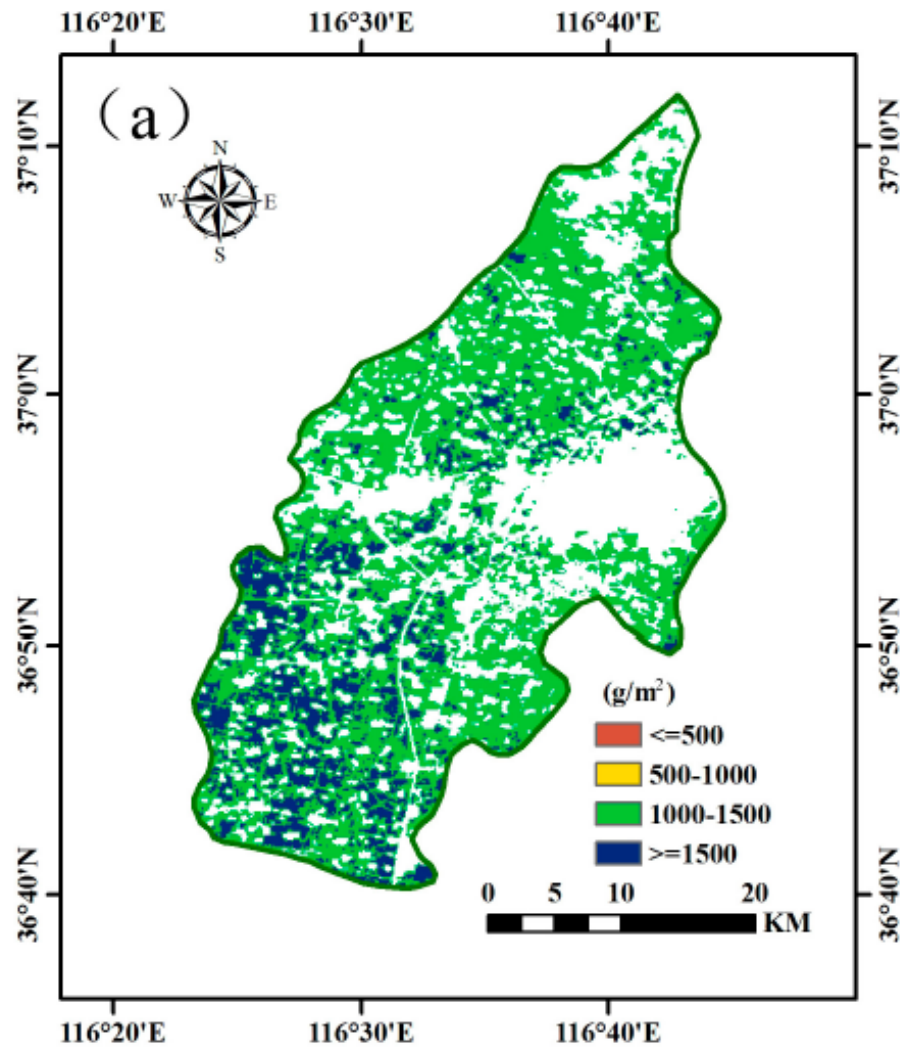


Yucheng

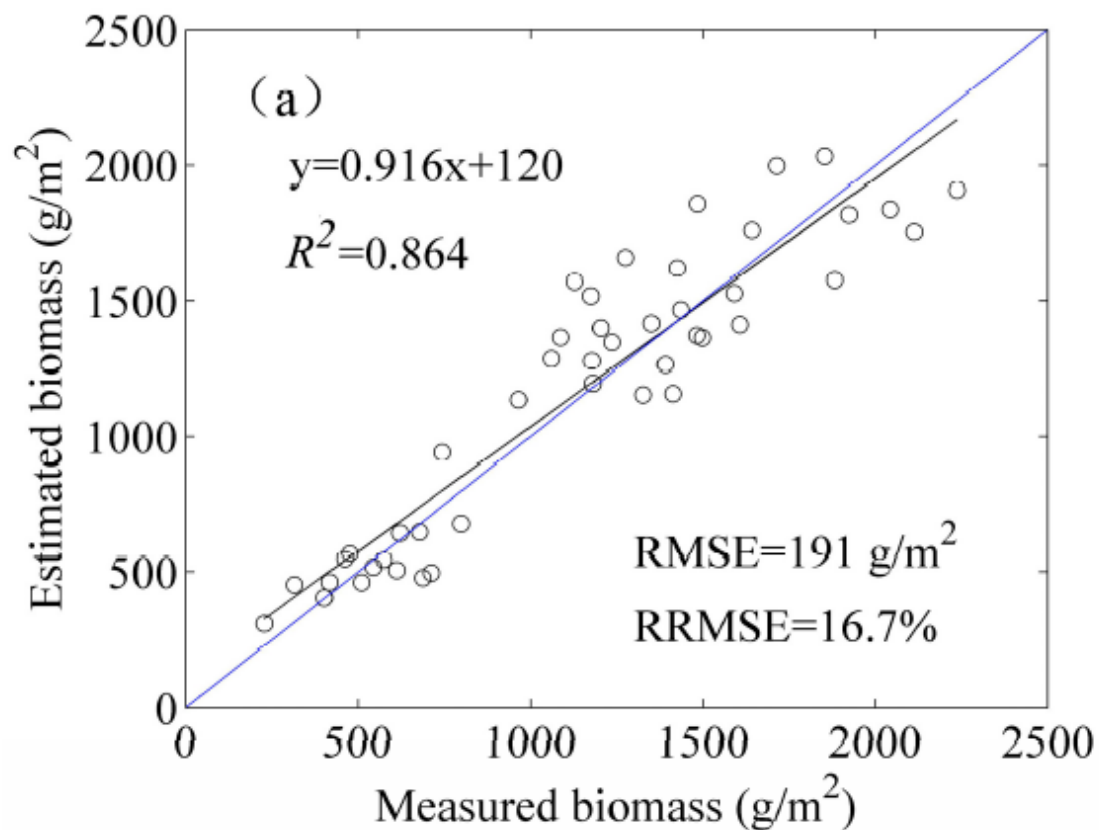
Guantao

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		

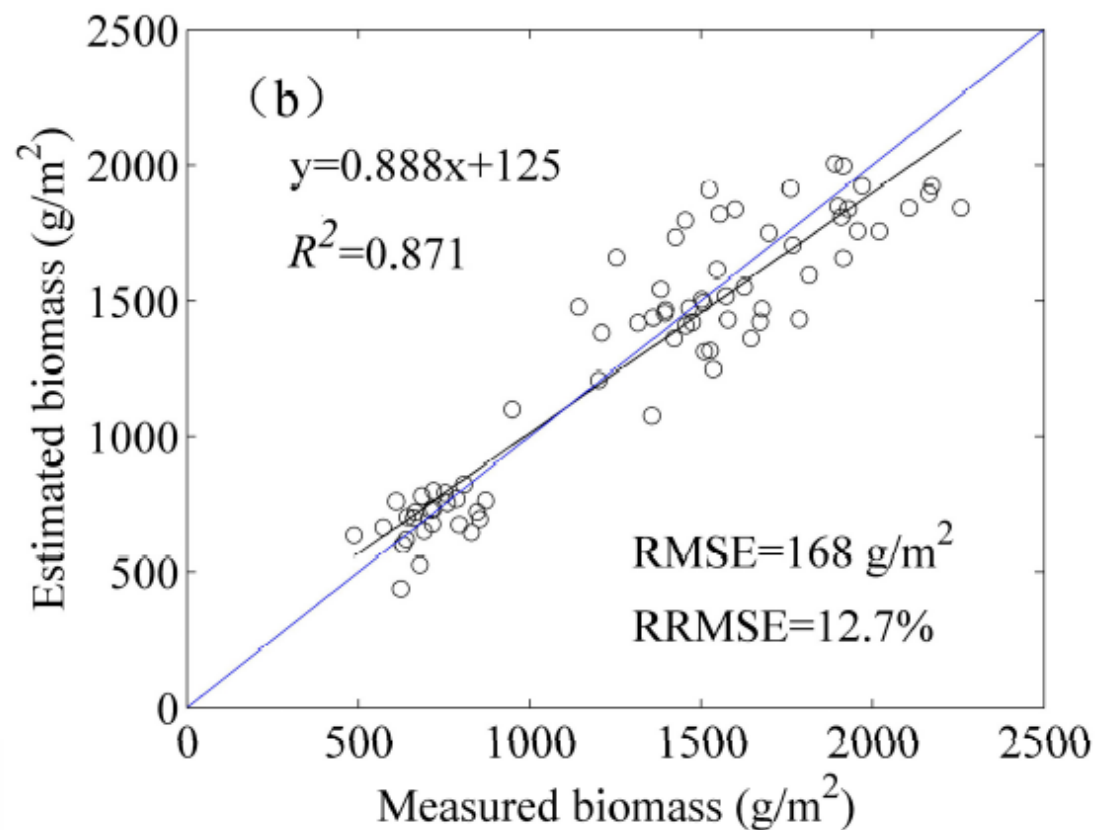
Wheat biomass



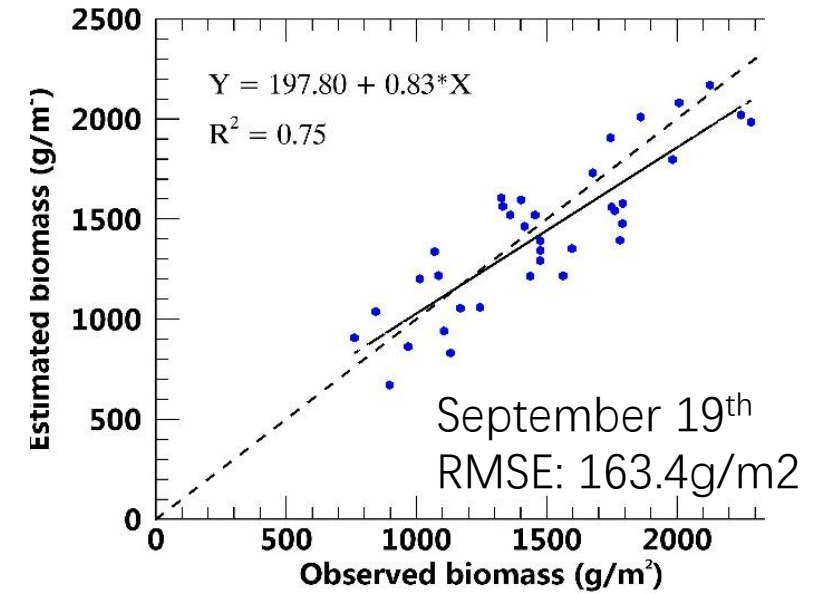
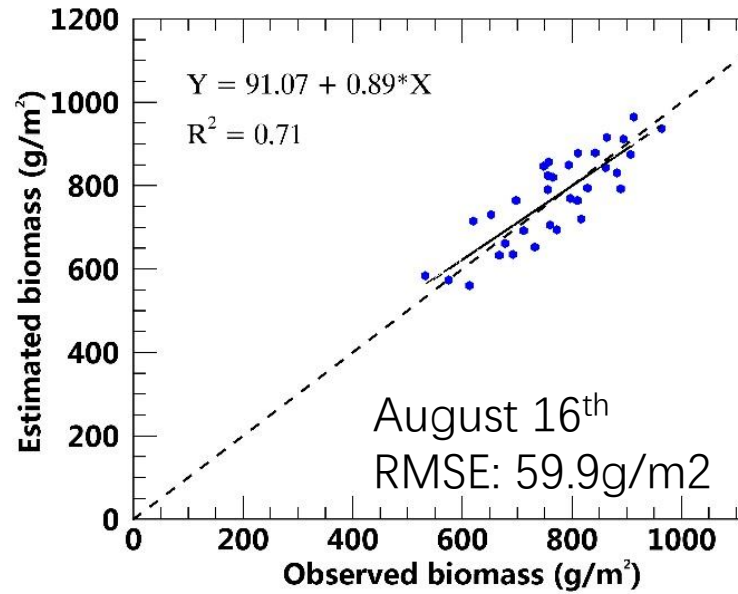
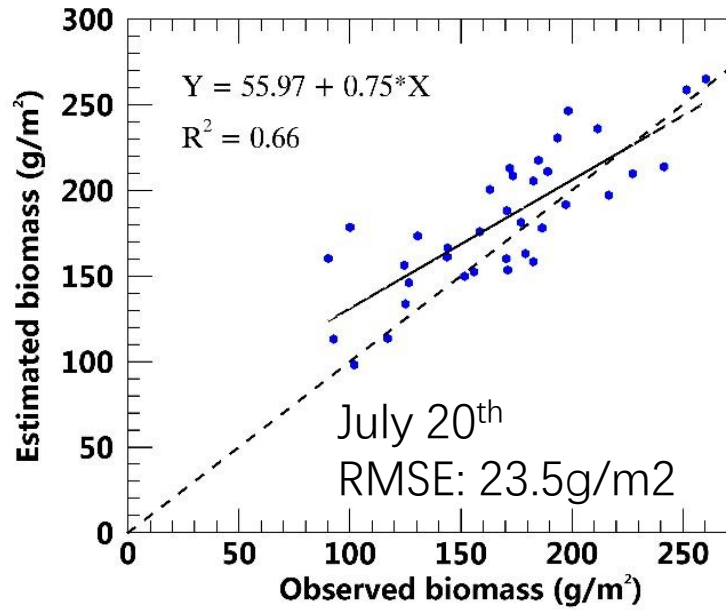
Accuracy of wheat biomass



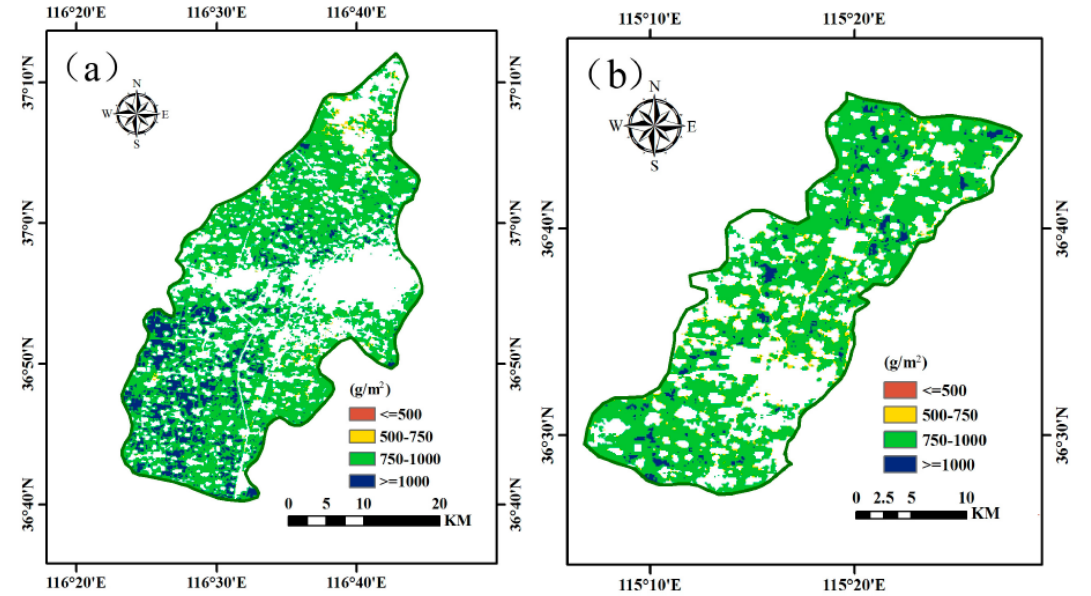
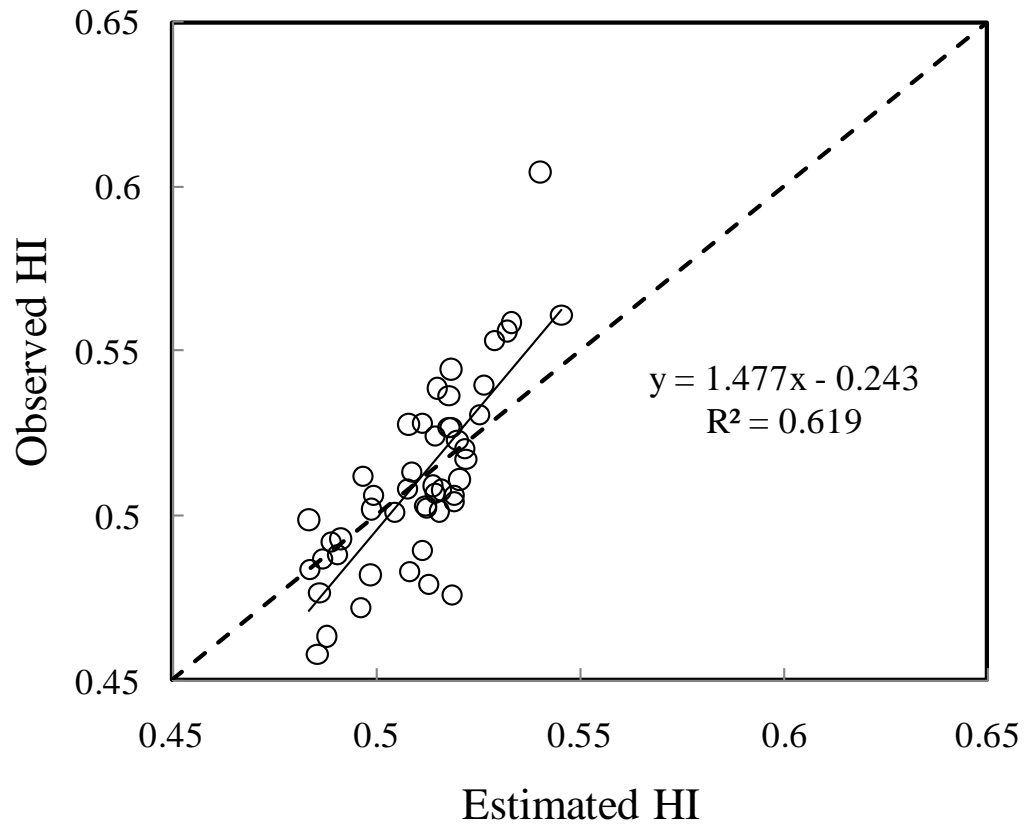
Yucheng



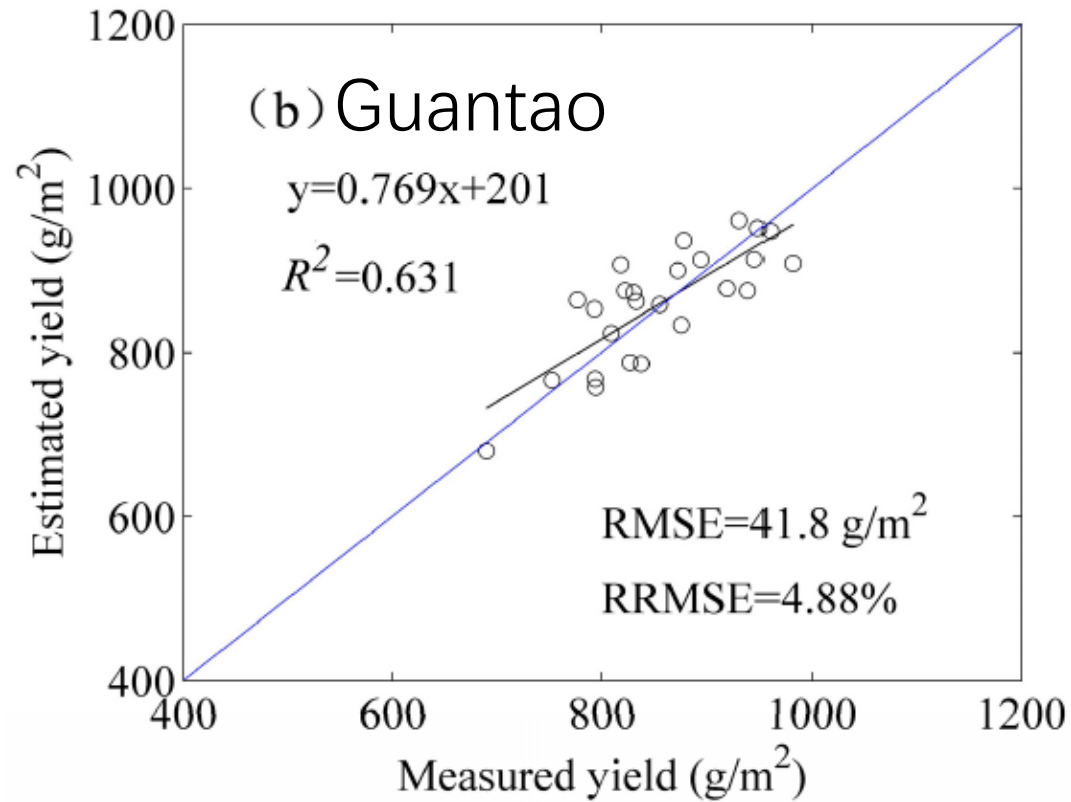
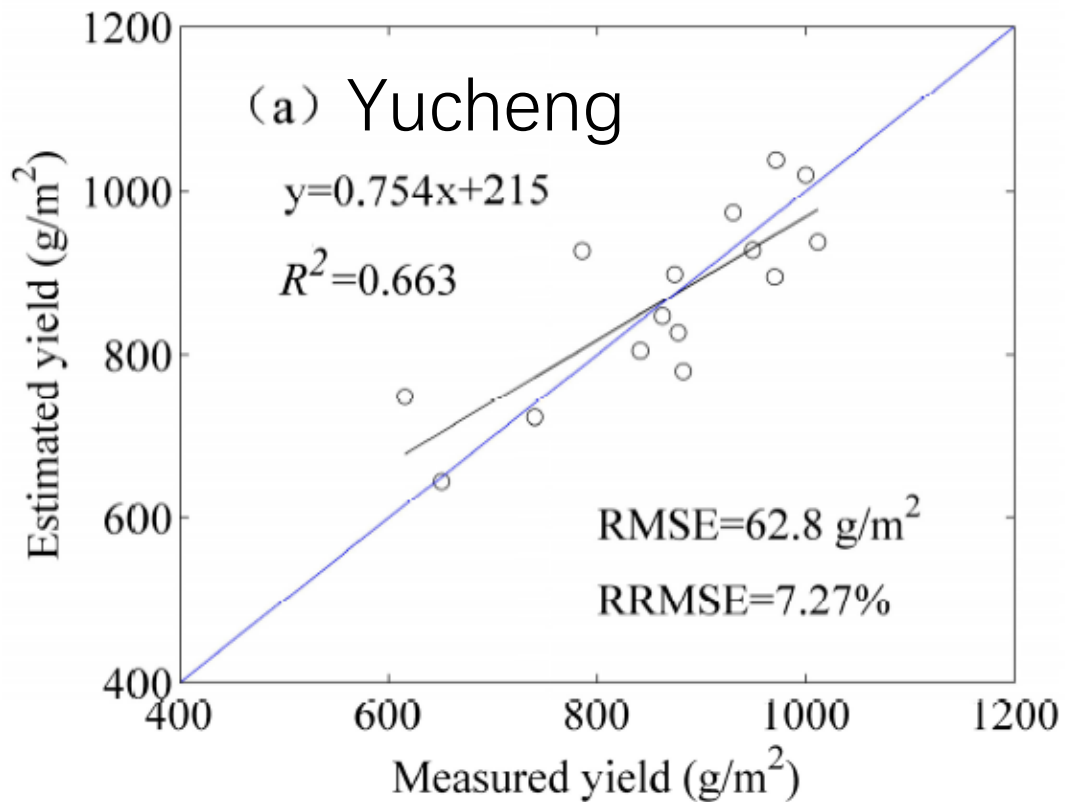
Guantao



Accuracy of maize biomass



Harvest index and yield



Accuracy of crop yield

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

Limitations

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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