GLASS Global LAnd Surface Satellite 产品用户大会（2022）

UNCERTAINTY IN SIMULATING REGIONAL GROSS PRIMARY PRODUCTIVITY FROM SATELLITE-BASED MODELS OVER NORTHERN CHINA GRASSLAND

Min Liu* & WenXiao Jia

Shanghai Key Laboratory for Urban Ecological Processes and Eco-Restoration, School of Ecological and Environmental Sciences, East China Normal University, Shanghai 200241, PR China

***Corresponding Author**: mliu@re.ecnu.edu.cn

INTRODUCTION

- Gross primary production (GPP) defined as the overall rate of fixation of carbon through the process of vegetation photosynthesis is the largest global CO_2 flux driving several ecosystem functions.
- Large-scale estimation of regional terrestrial gross primacy production (GPP) can improve our understanding of carbon cycle.
- To develop robust simulation of terrestrial GPP, a thorough understanding of model uncertainties should lead to a critical review of current modeling performance and avenues to improve known limitations.

OBJECTIVES

Grassland in northern China (2.38 million km^2) accounts for 9.92% of the world's total grasslands. Simulations of GPP in northern China grassland are fundamental for the understanding of carbon storage and biogeochemical dynamics of terrestrial ecosystems.

The specific objectives were :

- to determine the accuracy of satellite-based models in simulating GPP and provide a relatively objective large-scale GPP simulation in northern China grassland;
- to quantify the relative uncertainty of regional GPP simulation caused by various model approaches.

METHODS

- We chose eight satellite-based models to capture the spatial-temporal patterns of grassland GPP in northern China and analyze their uncertainty propagated from different model structures.

Table 1. Eight satellite-based models for GPP estimation

Model	Model structure	References
TG	$GPP = m \times (EVI_S \times LST_S)$	Sims et al. (2008)
GR	$GPP = m \times EVI \times PAR + b$	Gitelson et al. (2006)
VPM	$GPP = PAR \times fPAR \times LUE_{max} \times T_s \times W_s \times P_s$	Xiao et al. (2004)
VI	$GPP = m \times (EVI)^2 \times PAR$	Wu et al. (2010)
CFIX	$GPP = PAR \times fPAR \times LUE_w \times T_s \times (CO_2)fert$	Veroustraete et al. (2002)
ECLUE	$GPP = PAR \times fPAR \times LUE_{max} \times \min(T_s,W_s)$	Yuan et al. (2007)
VPRM	$GPP = PAR \times fPAR \times \frac{1}{(1 + PAR / PAR_0)} \times LUE_{max} \times T_s \times W_s \times P_s$	Mahadevan et al. (2008)
MODIS-GPP	$GPP = PAR \times fPAR \times LUE_{max} \times T_s \times W_s$	Running et al. (2000)

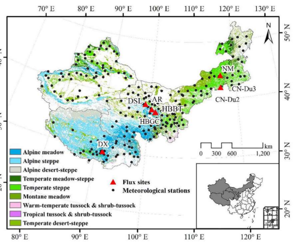

Figure 2. The spatial distribution of 8 eddy covariance flux sites and 225 meteorological stations over northern China grassland.

- **Absolute uncertainty** of grassland GPP for each pixel was determined by standard deviation.
- **Relative uncertainty (RU)** of grassland GPP across the study region was determined as the absolute uncertainty divided by the mean value。

$$GPP_h = \frac{1}{8}\sum_{i=1}^{8} GPP_{hi} \quad RU_h(\%) = \frac{\sigma_h}{GPP_h} \times 100$$

RESULTS

MODEL PERFORMANCE

Modeled data exhibited significant correlations with observed GPP across these eight model forms (R^2 = 0.64–0.89, p < 0.001) and ECLUE model performed best.

Table 2. The performances of joint-sites GPP models in northern China grassland

GPP models	Parameters[a]	R^2/pseudo R^2	p	ΔAIC
VPM	[2.47, 50.00, 18.00]	0.74	< 0.001	63.6
VI	1.90	0.78	< 0.001	2.1
TG	5.91	0.78	< 0.001	3.8
GR	[0.78,1]	0.72	< 0.001	139.4
CFIX	1.94	0.64	< 0.001	147.1
ECLUE	1.59	0.89	< 0.001	0
VPRM	7.87	0.71	< 0.001	84.5
MODIS-GPP	1.52	0.76	< 0.001	6.8

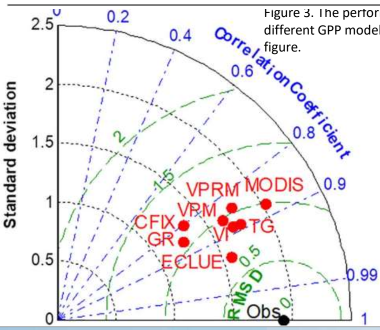

Figure 3. The performances of different GPP models in Taylor figure.

ENVIRONMENTAL CHANGES TAKE DIFFERENT RESPONSES TO SIMULATION RESULTS ACCORDING TO VARIOUS MODEL STRUCTURES

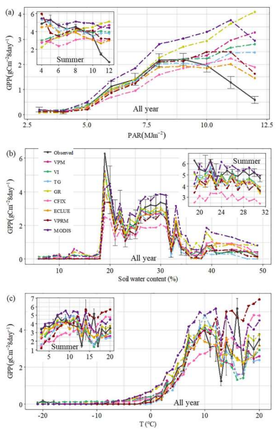

Figure 4. Variation of GPP and its model simulation with different environmental stresses.

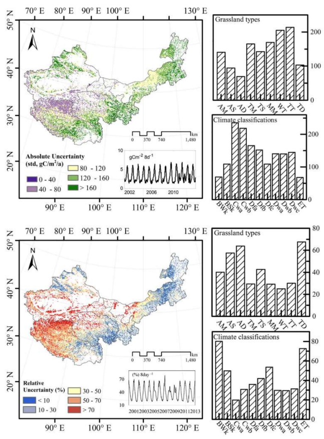

Figure.4 Spatial patterns of absolute and relative uncertainty of GPP pixel level in northern China grassland across grassland types and climate classifications.

UNCERTAINTY OF GPP SIMULATION IN ALPINE GRASSLAND AND ARID COLD AREA ON REGIONAL GRASSLAND GPP SHOULD BE FOCUSED

CONCLUTIONS

- The annual grassland GPP in northern China during 2001–2013 was 241.8 g C m^{-2} a^{-1} .
- Spatial pattern of grassland GPP was high in the west and low in the east, with a mean relative uncertainty of 49%.
- Larger relative uncertainty occurred in area with lower grassland GPP density due to data-self, capture ability of satellite data and model application under different environmental condition.
- Plant physiological adaptive mechanisms under the limited environmental factors need to be focused for the model improvement and more attention should be paid to the simulation uncertainty in alpine grassland and arid cold area on regional grassland GPP.

Acknowledgements: The AR and DSL dataset was generated from HiWATER (http://www.heihedata.org/ data/). Du2 and Du3 datasets were from global Fluxnet (https:// fluxnet.ornl.gov/). Other data were from the ChinaFLUX Website (http://www.chinaflux.org). We thank all site investigators, their funding agencies, ChinaFLUX, and the Fluxnet project, whose work and support is essential for obtaining the measurements without which the analyses conducted in this study would not be possible. Besides, the authors would like to thank Dr. Wenping Yuan for valuable help on the GPP modeling.