



Testing the response of wheat models to heat stress at anthesis and grain filling

Yan Zhu¹, Bing Liu^{1,2}, Senthod Asseng², Leilei Liu¹, Xiudong Zou¹, and Weixing Cao¹

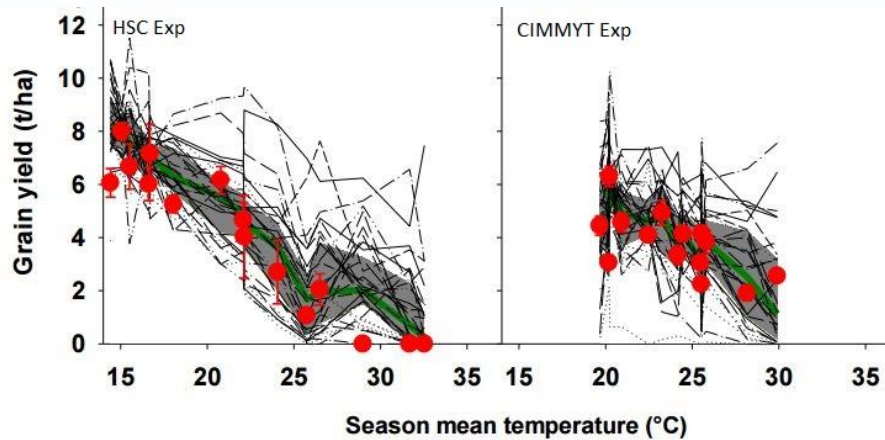
¹National Engineering and Technology Center for Information Agriculture, Nanjing Agricultural University, China. Email: yanzhu@njau.edu.cn

²Department of Agricultural and Biological Engineering, University of Florida, USA

Introduction

- Crop models for assessing climate impacts on crop production.

However, uncertainties of crop models have been reported, especially under extreme high temperature.



(Asseng et al 2015, Nature Climate Change)

Objective:

To evaluate the response of wheat models to heat stress at anthesis and grain filling stages and identify gaps for crop model improvement.

Methods

➤ Environmental controlled phytotron experiments

Cultivar	Growing season	Site	Starting time of treatment	Duration	Temperature regime (T _{min} /T _{max})
Yangmai16	2010-2011	Nanjing	Anthesis, Grain filling	D1 (3d), D2 (6d)	T1 (17°C/27°C), T2 (21°C/31°C), T3 (25°C/35°C), T4 (29°C/39°C)
	2011-2012	Nanjing	Anthesis, Grain filling	D1 (3d), D2 (6d)	T1 (17°C/27°C), T2 (21°C/31°C), T3 (25°C/35°C), T4 (29°C/39°C)
	2012-2013	Nanjing	Anthesis, Grain filling	D1 (3d), D2 (6d)	T1 (17°C/27°C), T2 (21°C/31°C), T3 (25°C/35°C), T4 (29°C/39°C)
	2013-2014	Rugao	Anthesis, Grain filling	D1 (3d), D2 (6d), D3 (9d)	T1 (17°C/27°C), T3 (25°C/35°C), T4 (29°C/39°C), T5 (33°C/43°C)
Xumai30	2011-2012	Nanjing	Anthesis, Grain filling	D1 (3d), D2 (6d)	T1 (17°C/27°C), T2 (21°C/31°C), T3 (25°C/35°C), T4 (29°C/39°C)
	2012-2013	Nanjing	Anthesis, Grain filling	D1 (3d), D2 (6d)	T1 (17°C/27°C), T2 (21°C/31°C), T3 (25°C/35°C), T4 (29°C/39°C)
	2013-2014	Rugao	Anthesis, Grain filling	D1 (3d), D2 (6d), D3 (9d)	T1 (17°C/27°C), T3 (25°C/35°C), T4 (29°C/39°C), T5 (33°C/43°C)



Methods

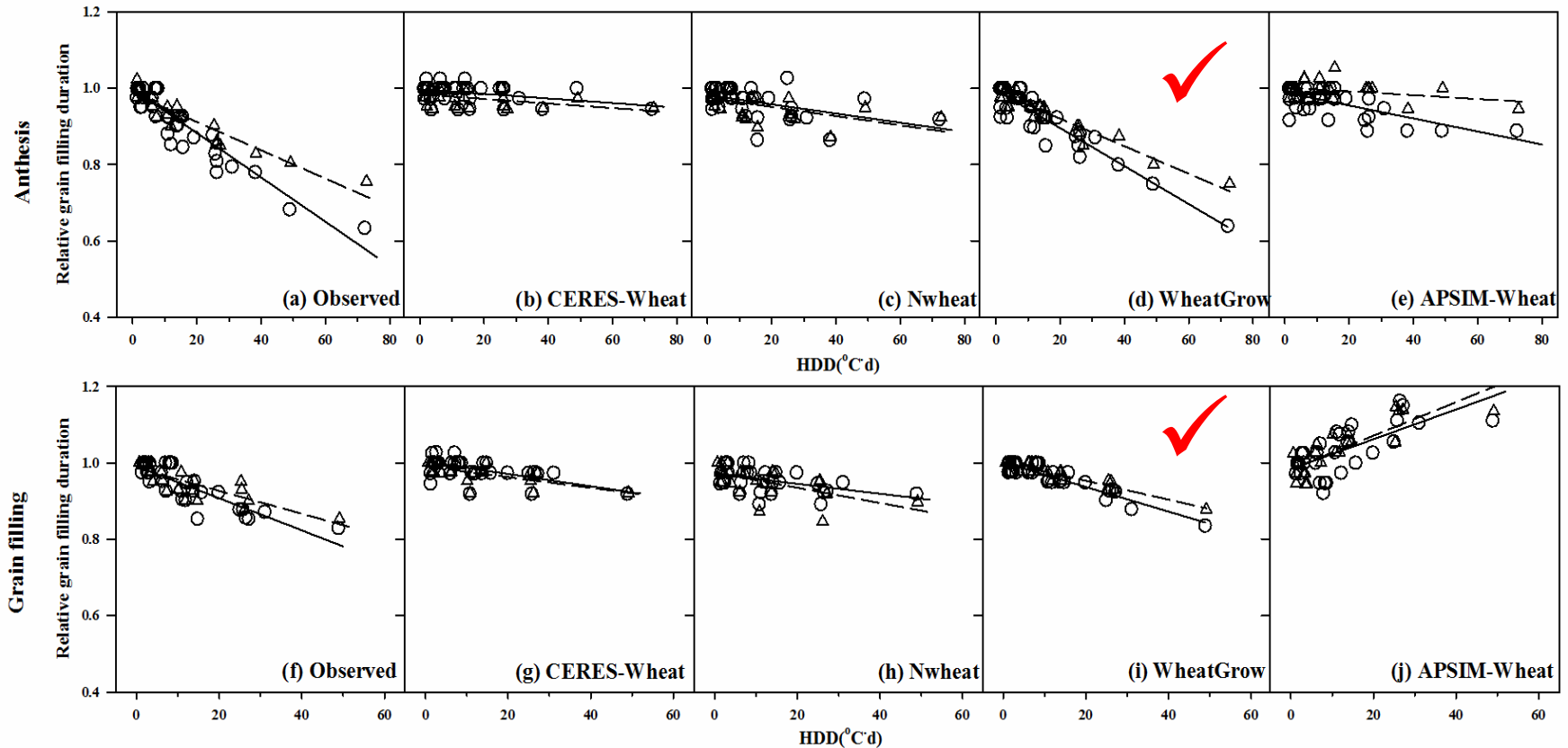
➤ **Wheat crop models:**

- (1) DSSAT-CERES-Wheat
- (2) DSSAT-Nwheat
- (3) APSIM-Wheat
- (4) WheatGrow

➤ **HDD:** degree days above 30°C

Results - Grain filling duration

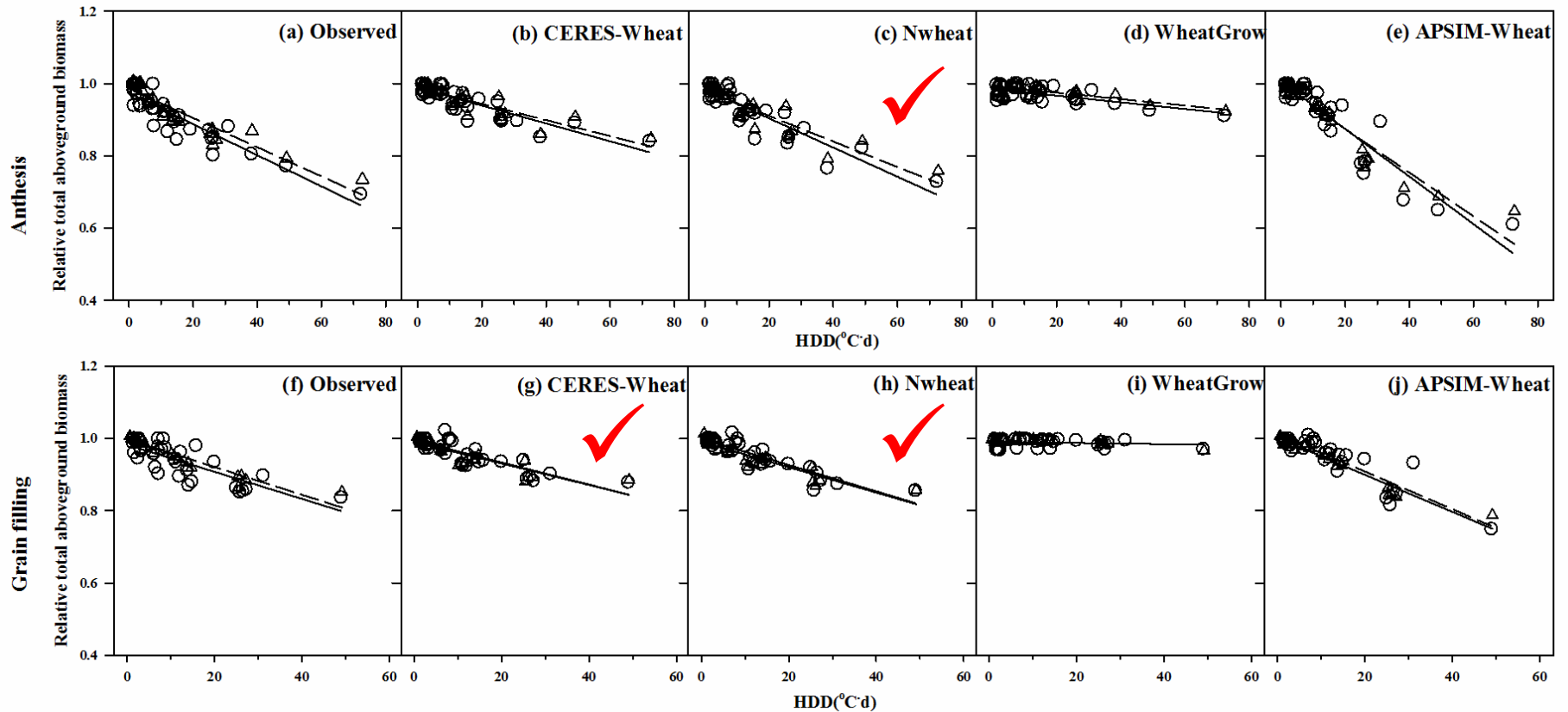
Observed | Simulations ...



Cultivar: ○ Yangmai16 △ Xumai30

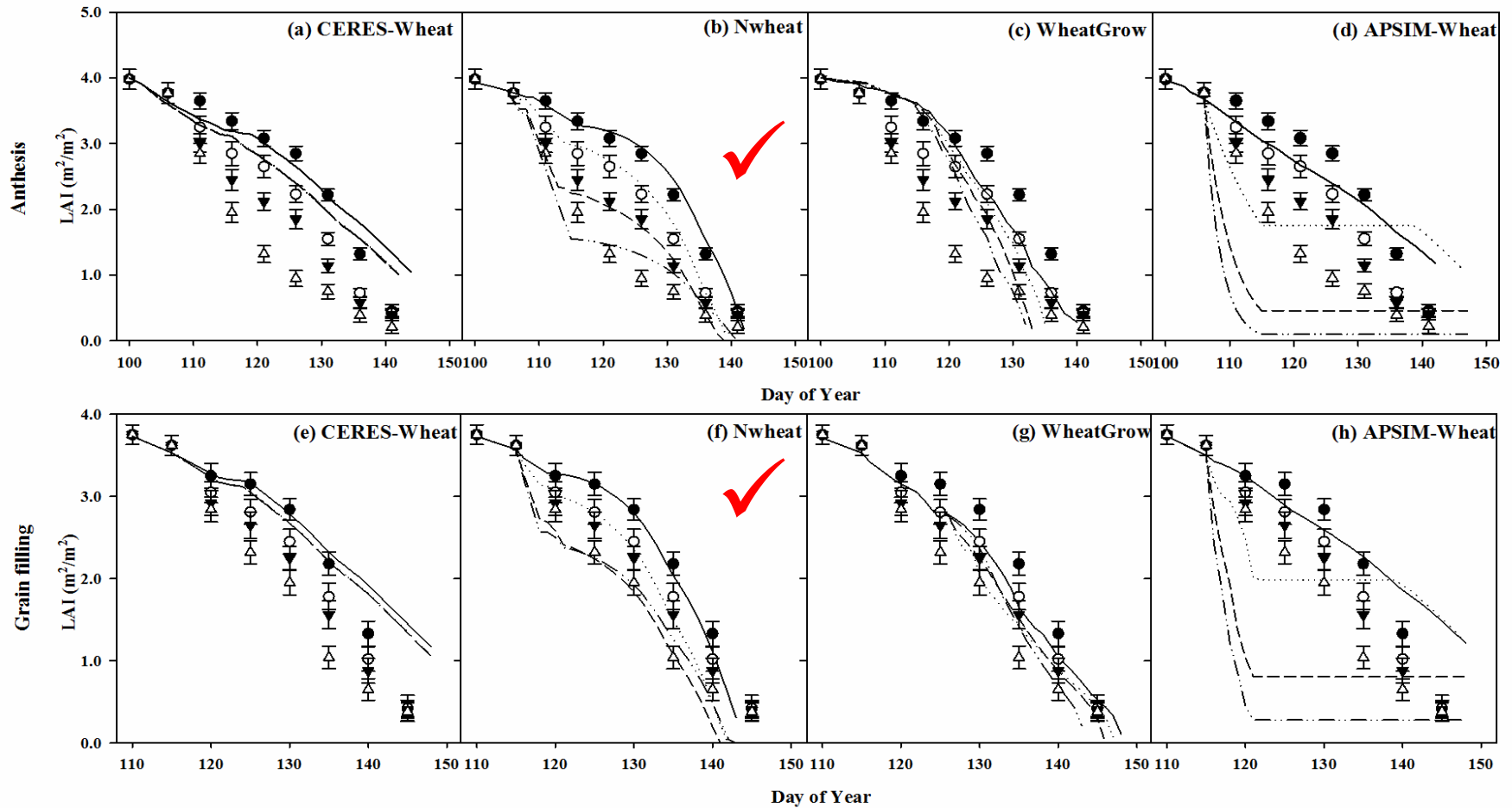
Results - Total above-ground biomass

Observed | Simulations ...



Cultivar: ○ Yangmai16 △ Xumai30

Results - Leaf area index (LAI) dynamic

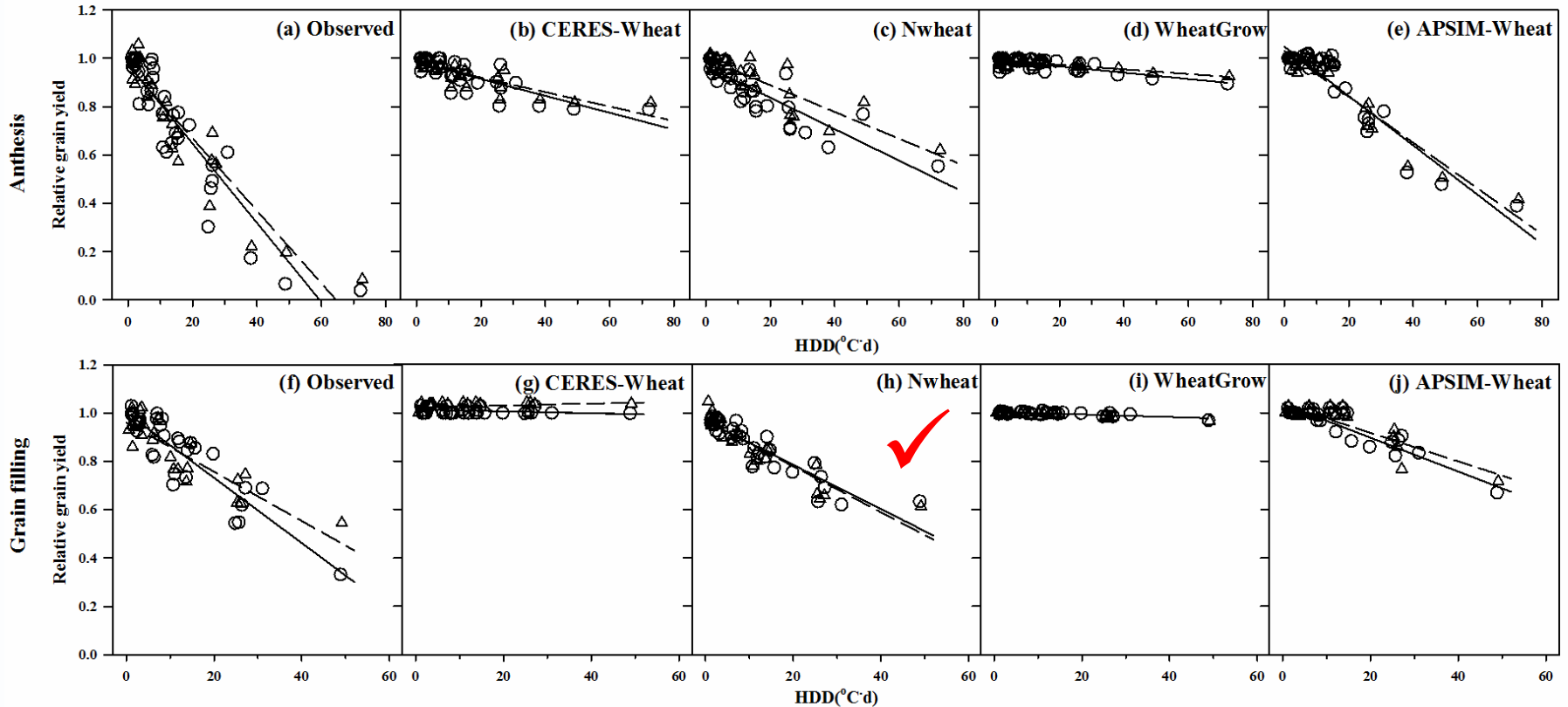


Observed = symbols

Simulation = lines

Results - Grain yield

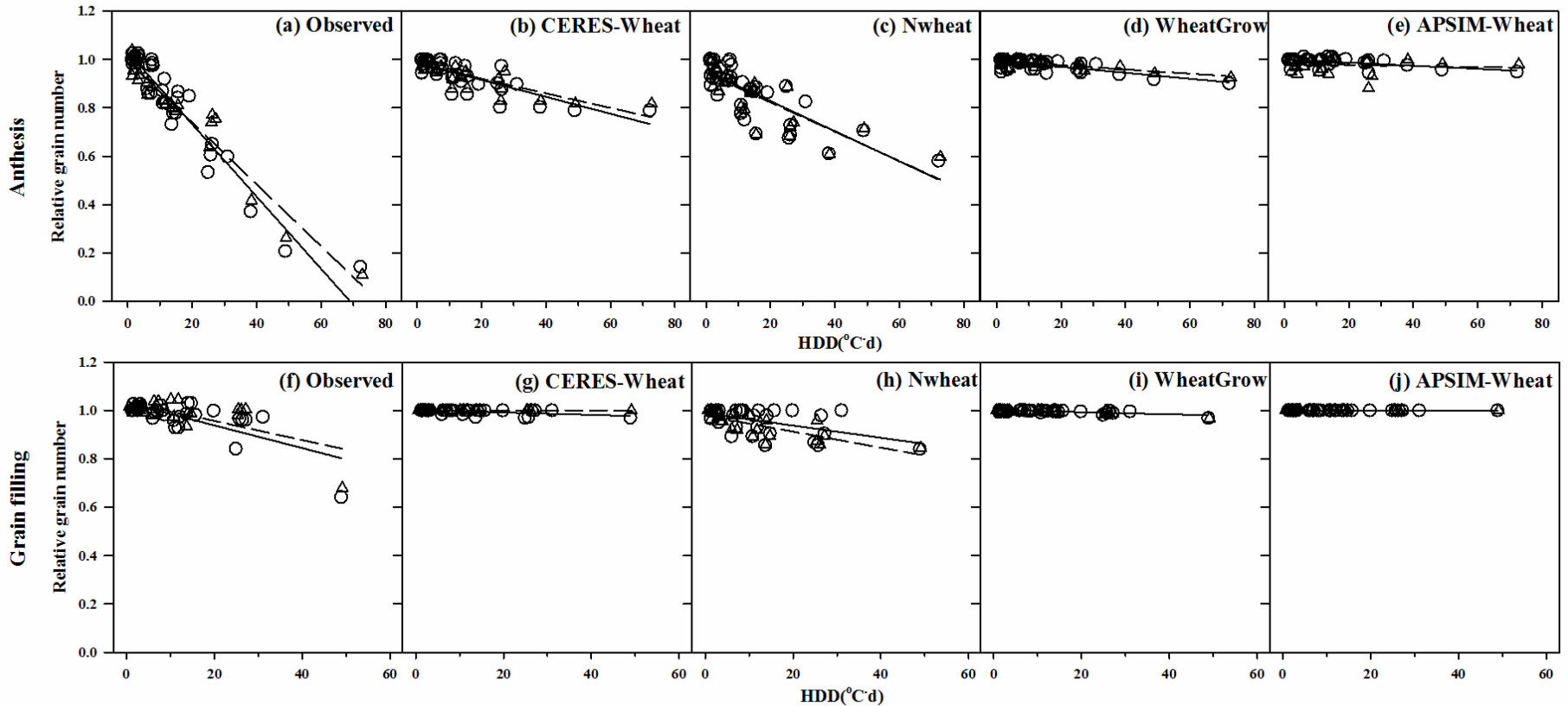
Observed | Simulations ...



Cultivar: ○ Yangmai16 △ Xumai30

Results - Grain number

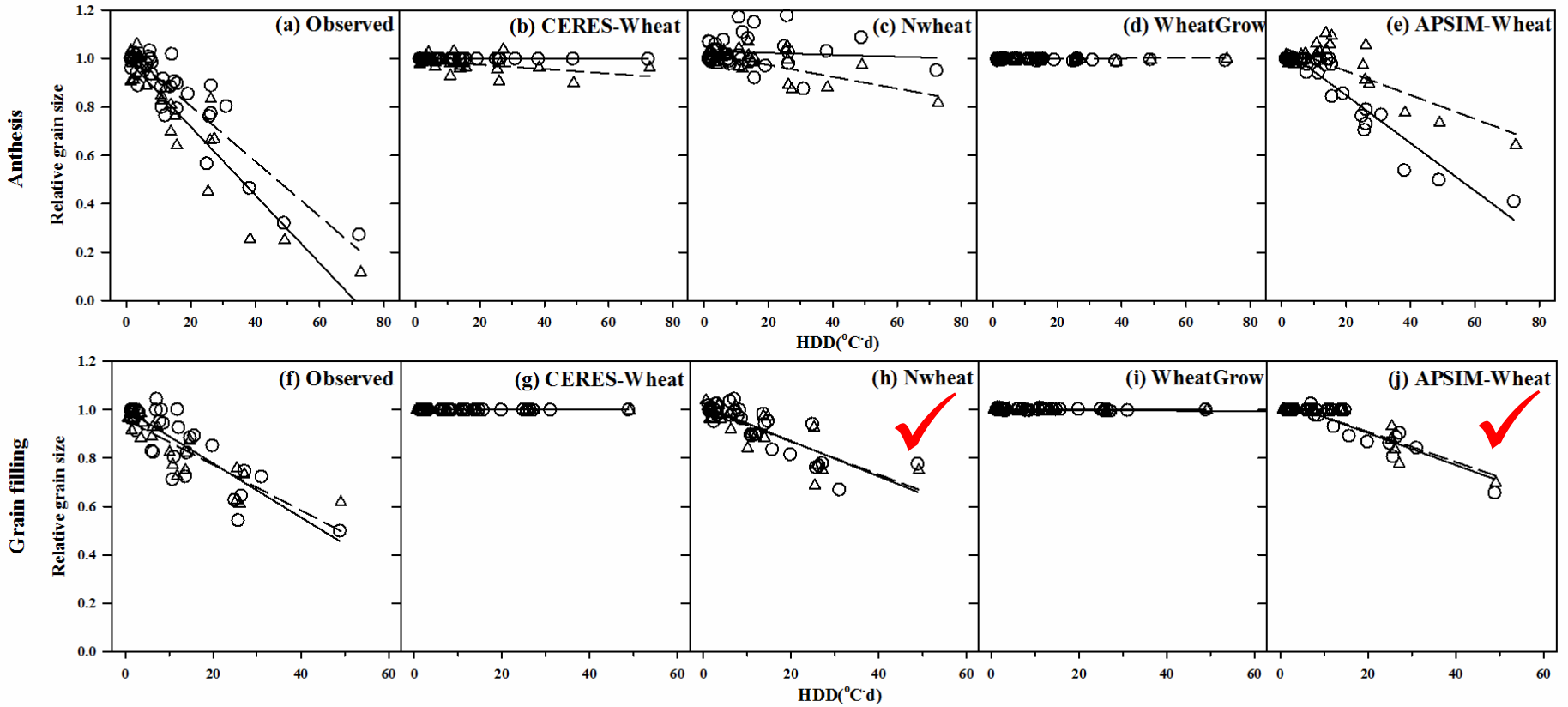
Observed | Simulations ...



Cultivar: ○ Yangmai16 △ Xumai30

Results - Grain size

Observed | Simulations ...



Cultivar: ○ Yangmai16 △ Xumai30



Conclusions

- Heat stress at anthesis reduced observed grain numbers and grain size, while heat stress during grain filling mainly decreased the grain size.
- The tested 4 models could reproduce some of the observed reductions in grain filling duration, final total aboveground biomass and grain yield due to heat stress.
- Most of the crop models tended to reproduce heat stress impacts better during grain filling than at anthesis.
- Some of models require improvements in the response to heat stress during grain filling, but all models need improvements in simulating heat stress effects on grain set during anthesis.
- The observed genetic variability in wheat response to heat stress needs to be considered in future simulation studies.

Liu, B., Asseng, S., Liu, L., Tang, L., Cao, W., & Zhu, Y. (2016). Testing the responses of four wheat crop models to heat stress at anthesis and grain filling. *Global Change Biology*.