District-level crop model calibration in southern Sweden using evapotranspiration and observed crop yield data

Xueying Li[1], Wenxin Zhang[1], Minchao Wu[1], Hao Zhou[1], Stefan Olin[1], El Houssaine Bouras[1], Shangharsha Thapa[1], Zheng Duan[1]
[1]Department of Physical Geography and Ecosystem Science, Lund University, Lund, Sweden

1. Introduction

Dynamic global vegetation models (DGVMs) represent growth and development of vegetation based on the understanding of underlying physical and physiological processes, which are efficient tools to assess impacts of climate change and human management on vegetation response to these variations.

One of the process-based DGVMs LPJ-GUESS (Lund-Potsdam-Jena General Ecosystem Simulator) has shown its acceptable performance in simulating crop yield at global and regional scales. However, no studies have comprehensively investigated the added value of using multi-source data, particularly satellite-derived estimates for calibrating LPJ-GUESS at the district level.

We aim to bridge this gap by calibrating LPJ-GUESS using both observed crop yield data and satellite derived evapotranspiration (ET) data, to improve the model performance of simulating winter wheat and spring barley yield in southern Sweden.

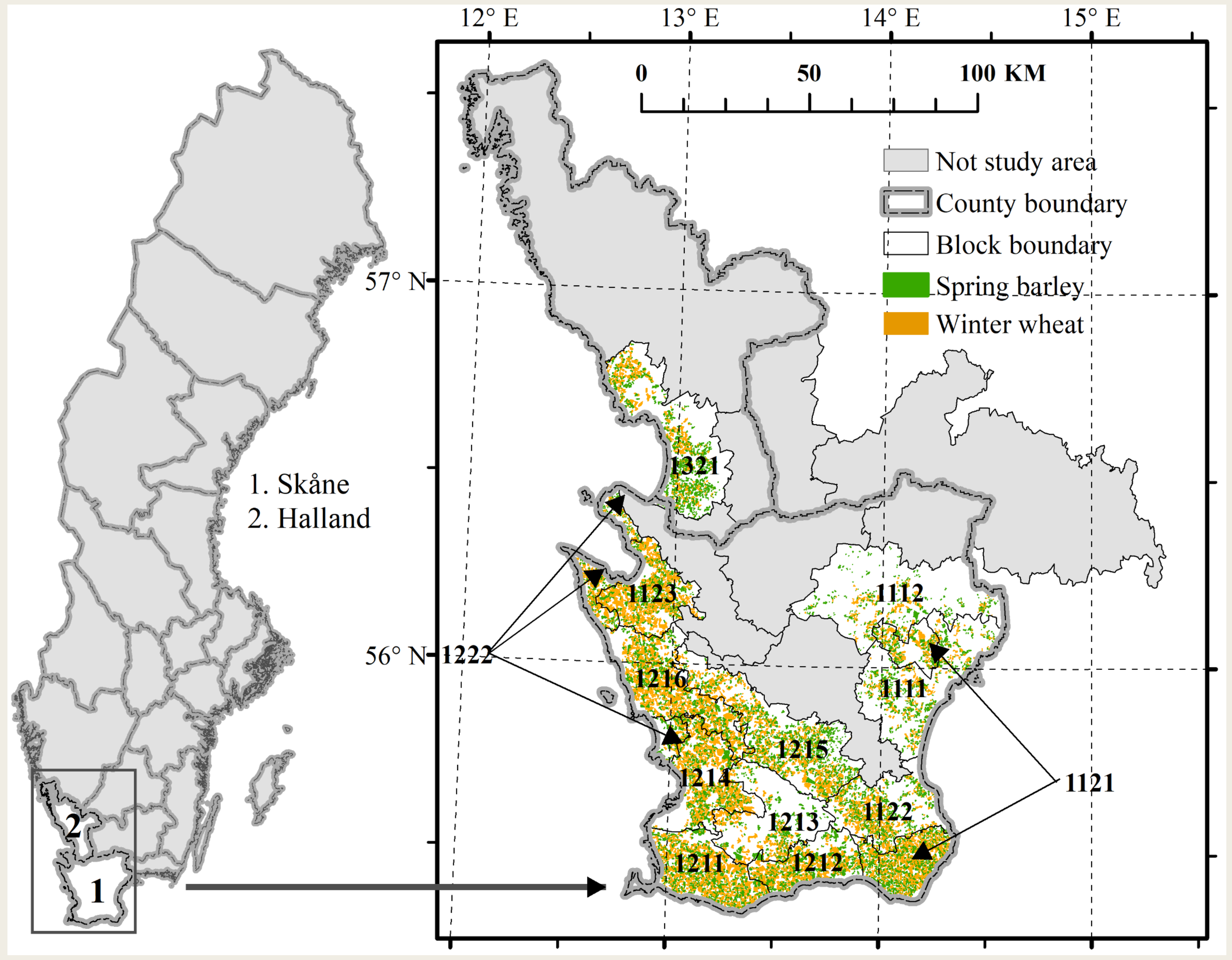

Figure 1 Cropping map of winter wheat and spring barley in southern Sweden

Contact
xueying.li@nateko.lu.se
https://www.researchgate.net/profile/Xueying-Li-9
https://portal.research.lu.se/en/persons/xueying-li
Lund University
Department of Physical Geography and Ecosystem Science
Sölvegatan 12, S-223 62 Lund, Sweden

2. Data and Methodology

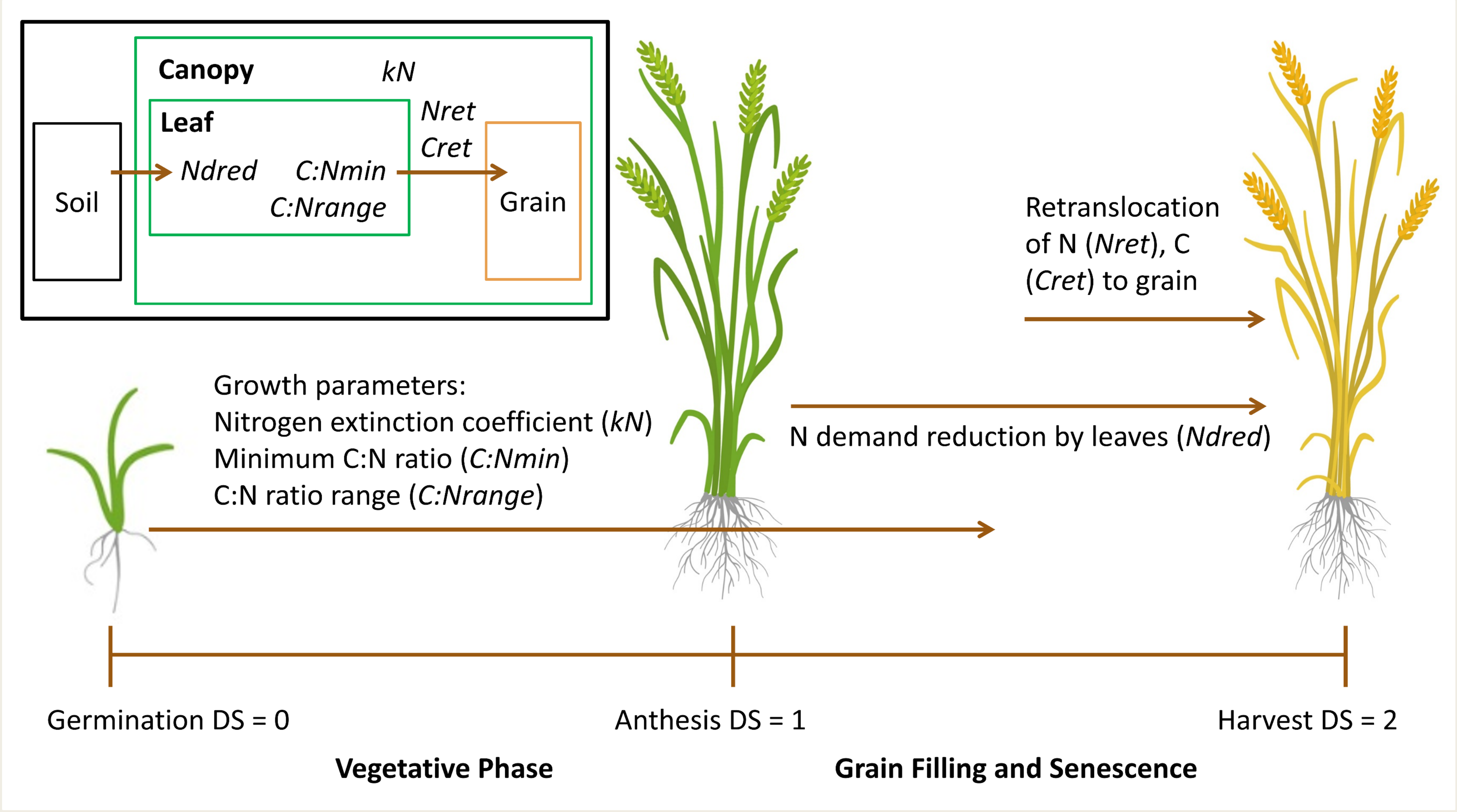

Figure 2 The relationship between parameters and plant organs during different developmental stages (DS)

Step 1: Parameter Calibration on District 1214

Forcing data:
0.5 degree cru meteorological data till 2015;
Alnarp station measured data from 2016 to 2022

C:Nmin 10 10.5 11 11.5 12 12.5 13 (15 as default)
C:Nrange 2 2.1 2.2 2.3 2.4 2.5 (2.78 as default)
Nret 0.05 0.1 0.15 (0.2 as default)
Cret 0.05 0.1 0.15 (0.1 as default)
kN 0.25 0.3 0.35 (0.2 as default)
Ndred 0 2 4 6 8 (10 as default)

7*6*3*3*3*5 = 5670

Filter top 500 combinations with lowest RMSE in:
(1) Crop yield simulation:
(2) ET simulation
(3) Crop yield + ET simulation

Reference data:
Crop Yield:
Annual total yield (kg/ha) at the district level from Statistics Sweden (SCB)
ET:
0.05 degree PML-V2 (mm/year)

Step 2: Validation on Other Districts

Forcing data:
0.1 degree ERA5-Land hourly data till 2022
Expected outcomes:
The simulated crop yield **after calbrating using crop yield**
The simulated crop yield **after calbrating using ET**
The simulated crop yield **after calbrating using crop yield + ET**

3. Current Results (Step 1)

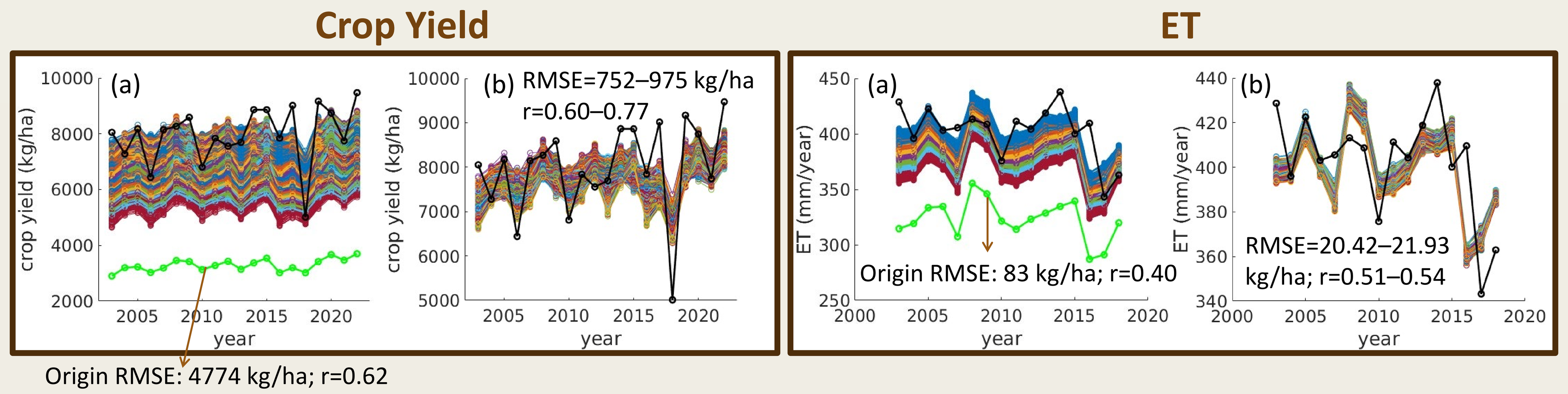

Figure 3 (a) Simulated crop yield (left) and ET (right) of all combinations (b) Simulated crop yield (left) and ET (right) of top 500 combinations with lowest RMSE

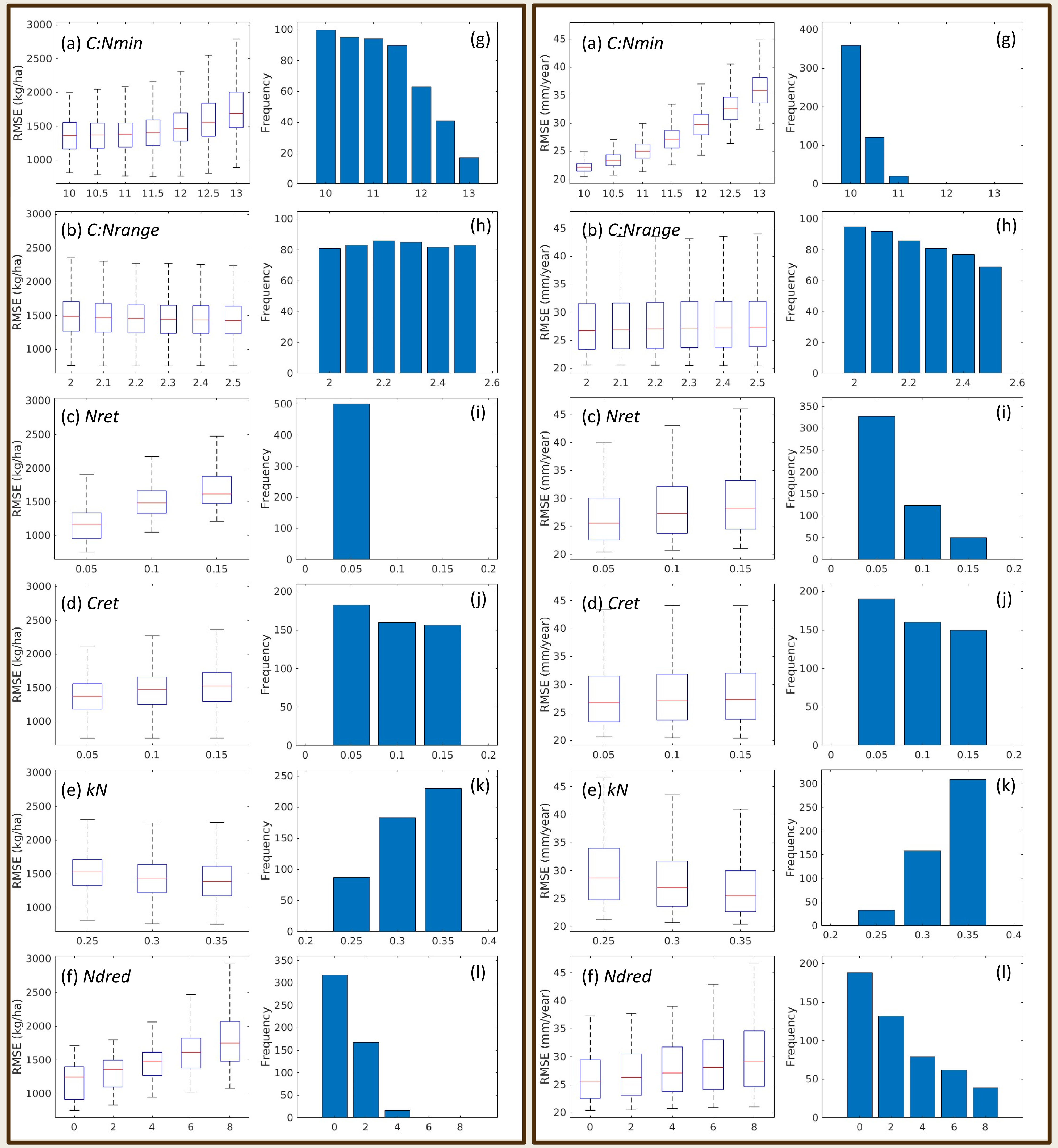

Figure 4 (a)–(f) Parameter sensitivity in crop yield (left) and ET (right) simulation of all combinations (g)–(l) Frequency of each parameter value of top 500 combinations with lowest RMSE in crop yield (left) and ET (right) simulation

4. Conclusions

(1) The calibration process truly improved the performance of both crop yield and ET simulation (i.e., RMSE and r) for winter wheat.

(2) Four parameters, including Minimum C:N ratio (*C:Nmin*), Retranslocation of N (*Nret*), Nitrogen extinction coefficient (*kN*), and N demand reduction by leaves (*Ndred*) were sensitive in both crop yield and ET simulation.

(3) 191 of the top 500 combinations with lowest RMSE overlapped between crop yield and ET simulation.

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