The 17th US-China Carbon Consortium Annual Meeting

Using remote sensing to identify the peak of the growing season at globally-distributed flux sites: A comparison of models, sensors, and biomes

Institution:	**Southwest University**
PhD candidate:	Zhongxi Ge
Supervisor:	Prof. Mingguo Ma

Beibei, Chongqing, China
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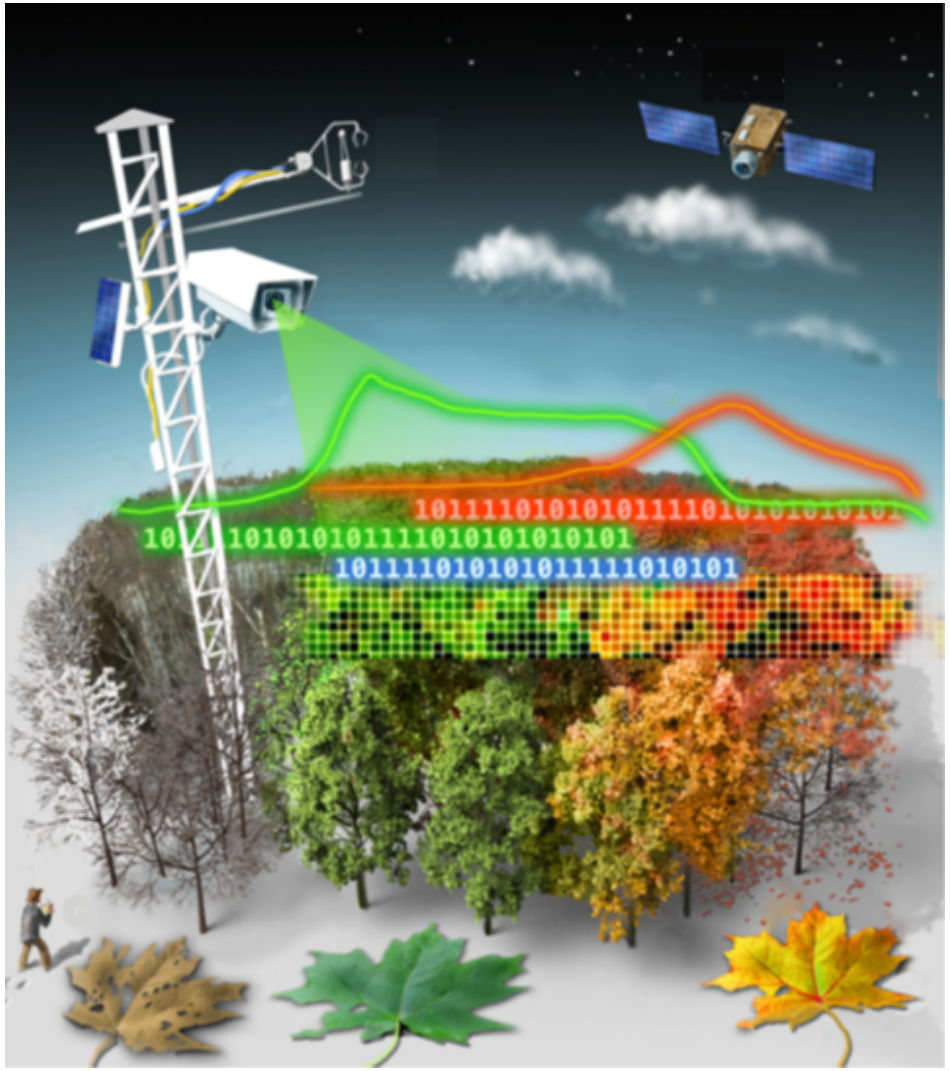
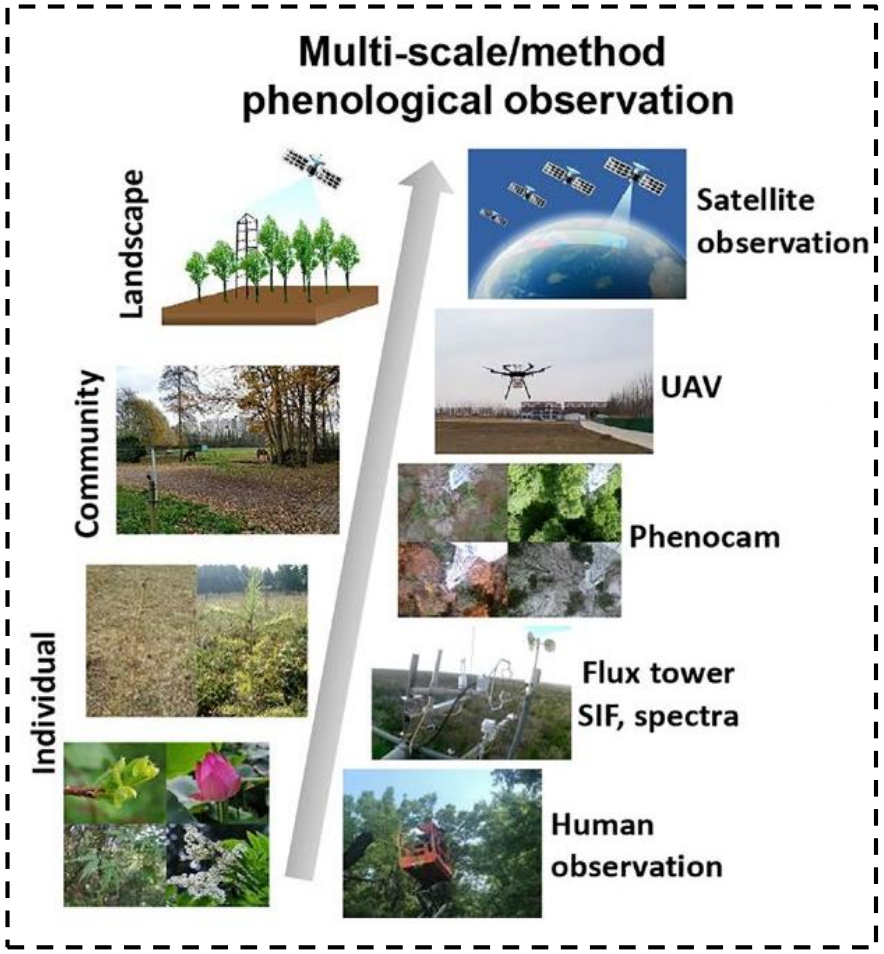
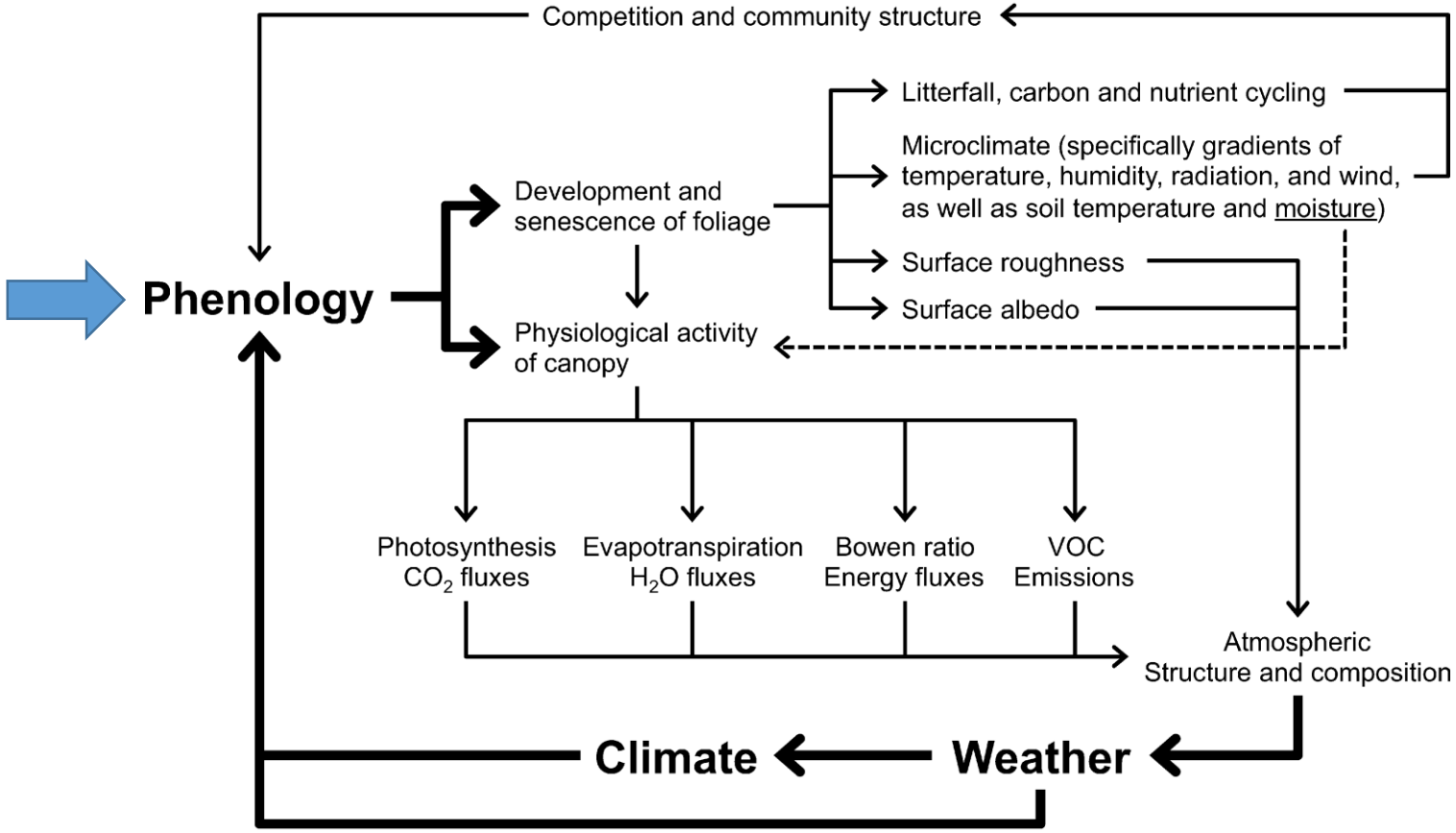
Table of contents



1. Introduction

➢The importance of phenology



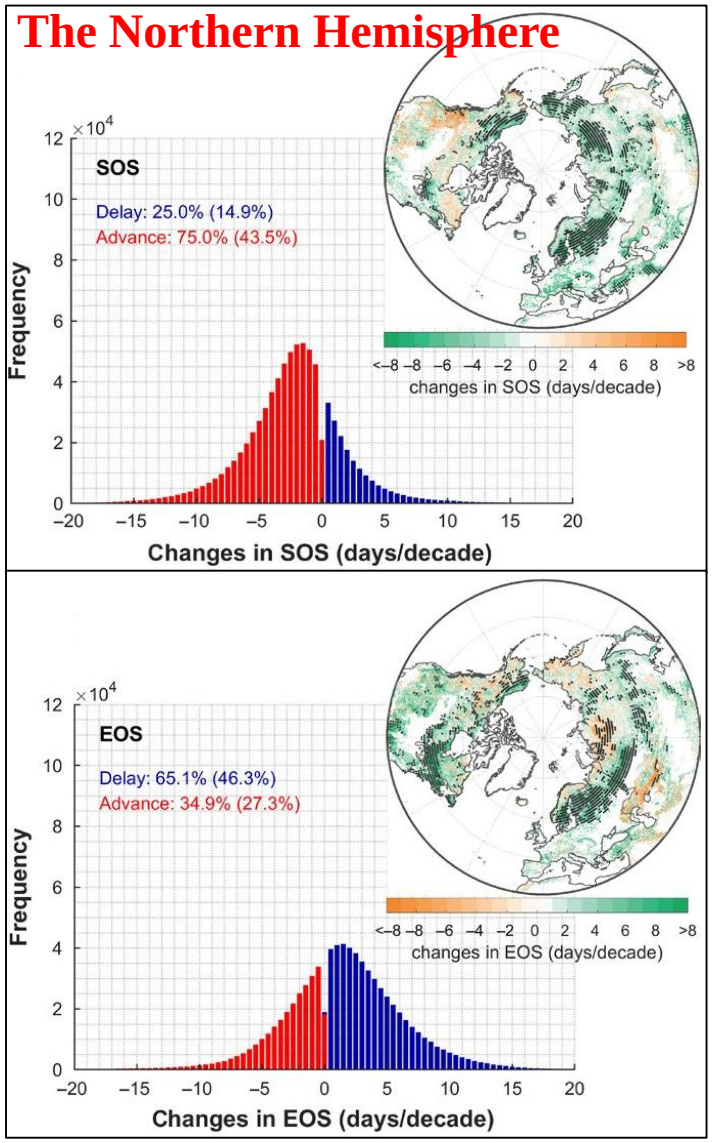


(Richardson et al., 2013, *AGR FOREST METEOROL*)

1. Introduction

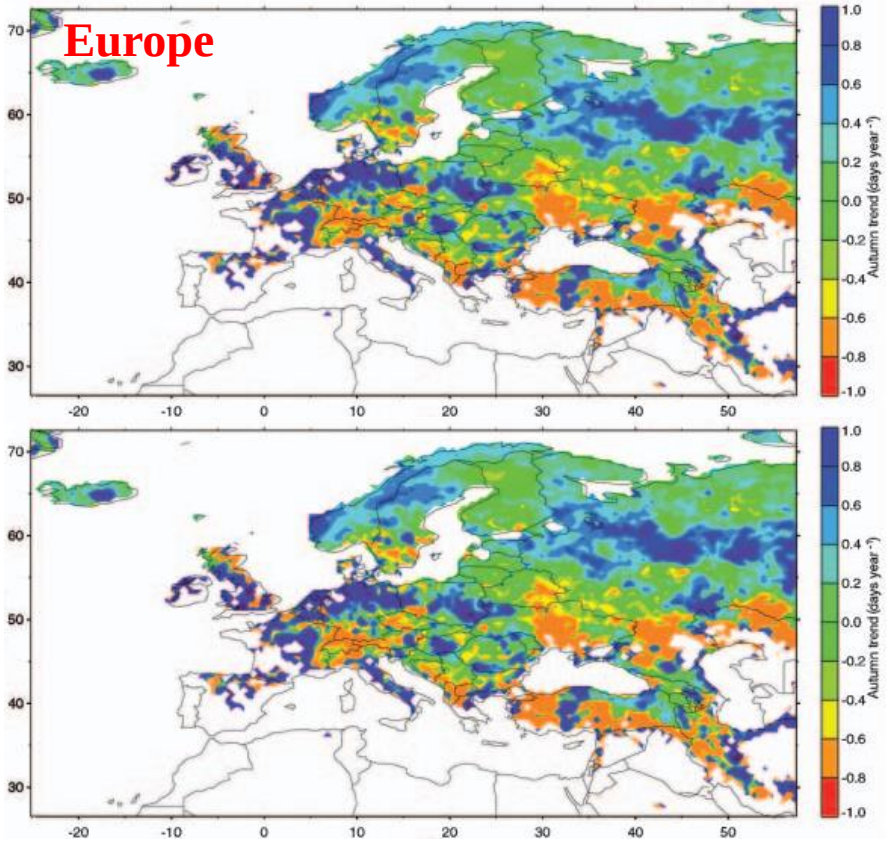
➢Research progress on phenology

The Northern Hemisphere



(Piao et al., 2019, ***Glob Chang Biol***)

Europe



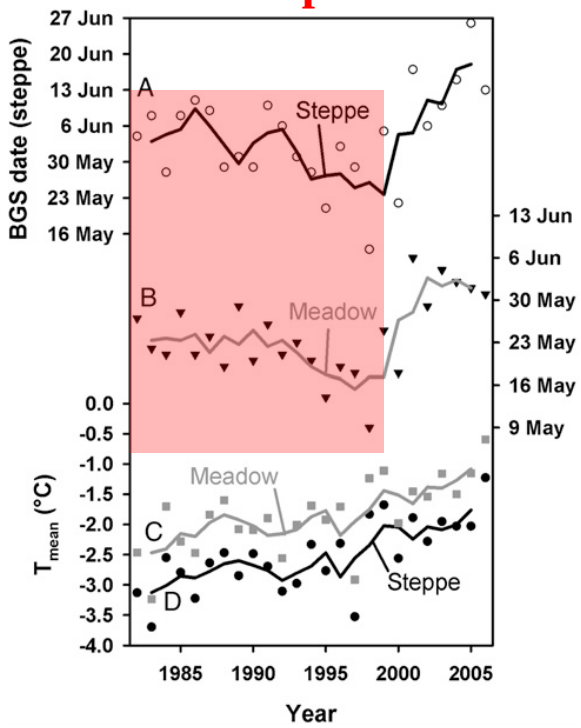
(Stockli et al., 2004, ***Int J Remote Sens***)

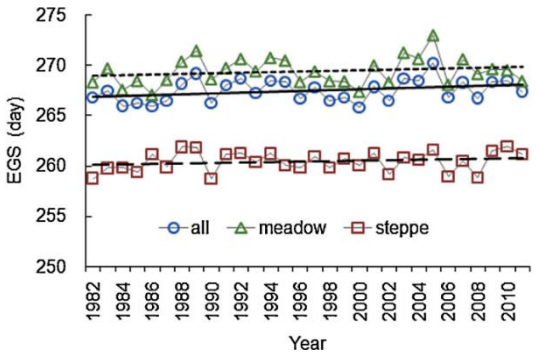
Advanced SOS (Start of growing season)

Delayed EOS (End of growing season)

Longer LOS (Length of growing season)

Tibetan plateau

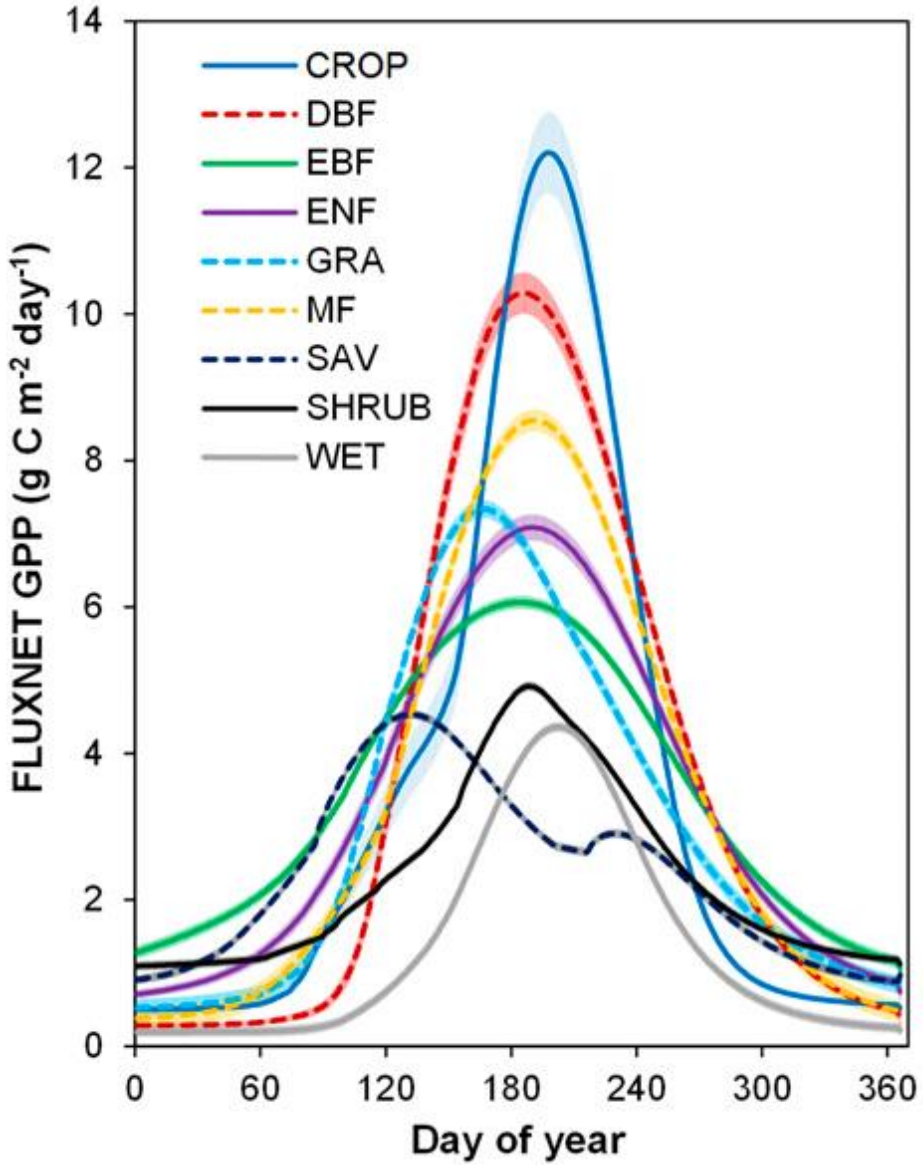




(Yu et al., 2010, ***PNAS***)

1. Introduction

➢The significance of the peak of growing season (POS)



- POS is also considered as a good proxy for the ***timing of maximum resource availability*** of vegetation.
  (Guerscherman et al., 2003, *ECOL APPL*)

- The value of POS, for example, as measured by gross primary productivity (GPP), is one of the critical variables which ***controls the spatiotemporal variability of terrestrial GPP***
  (Xia et al., 2015, ***PNAS***)

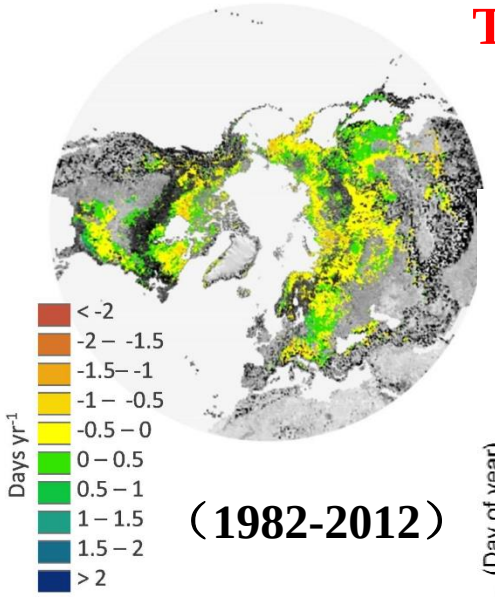
- POS is recognized as ***a useful indicator*** of climate change.
  (Xu et al., 2016, ***Glob Chang Biol***)

- It indicates the ***time*** when seasonal ***photosynthetic capacity reaches the maximum***
  (Gonsamo et al., 2018 , ***Glob Chang Biol***)

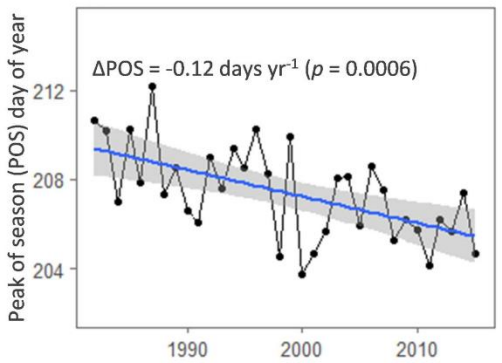
1. Introduction

➢Research progress on POS

The Northern Hemisphere

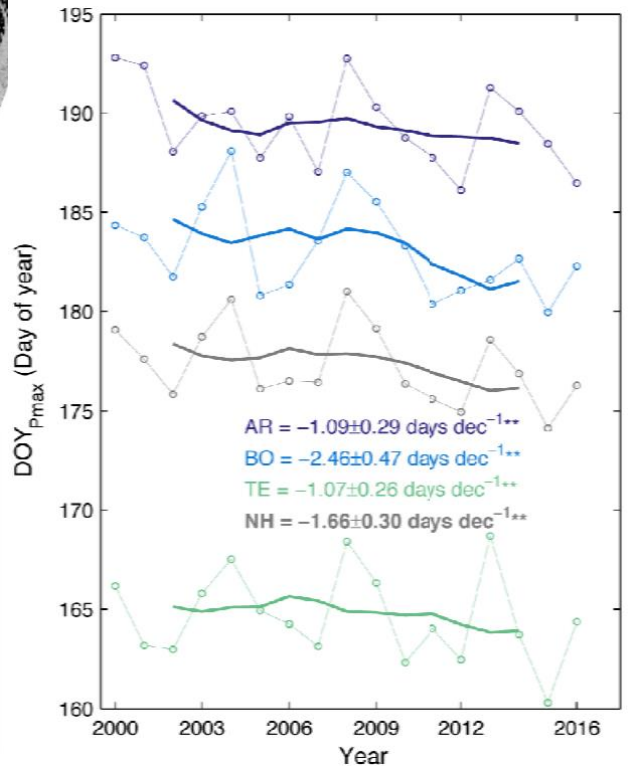


（1982-2012）

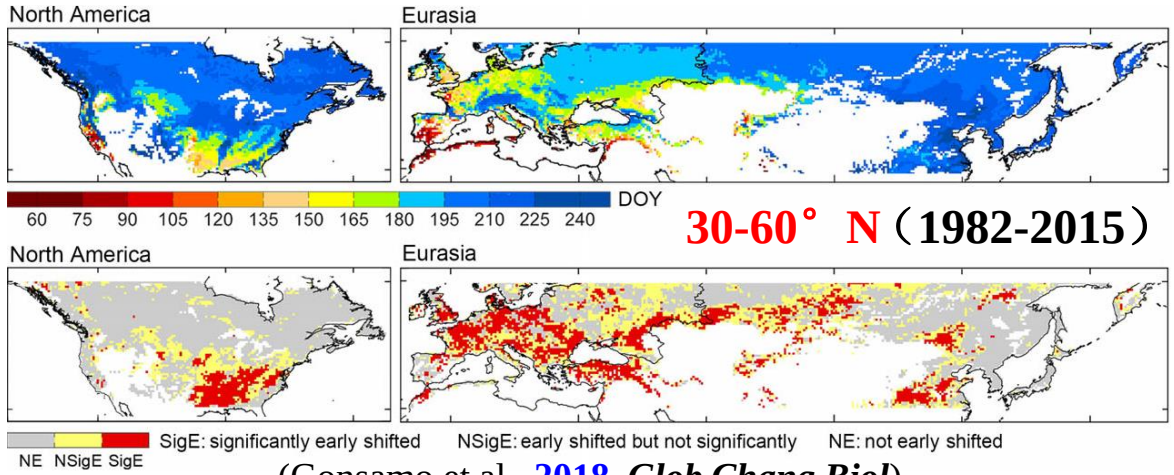


(Xu et al., **2014**, ***Glob Chang Biol***)

（2000-2016）



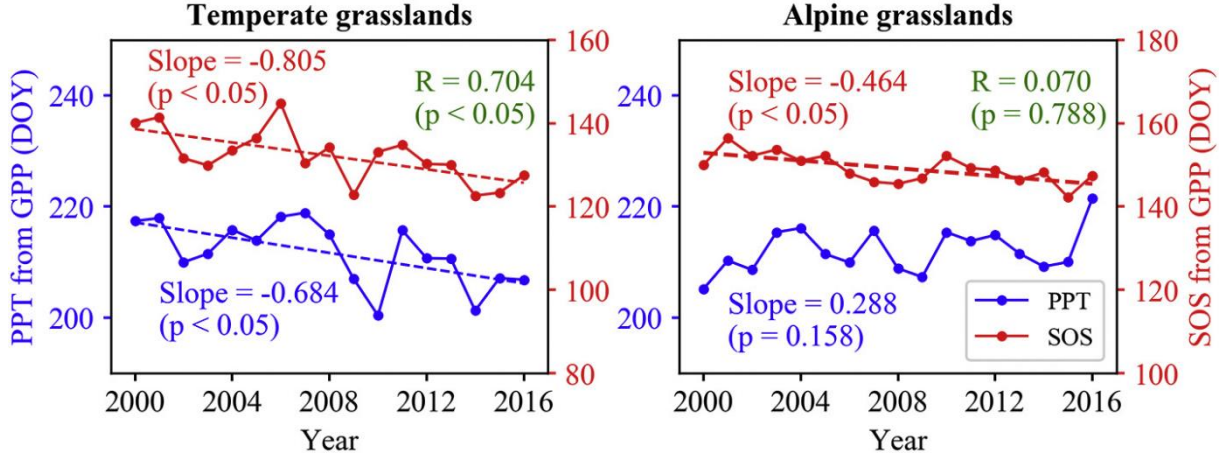
(Park et al., **2019**, ***Glob Chang Biol***)



30-60° N（1982-2015）

(Gonsamo et al., **2018**, ***Glob Chang Biol***)

Alpine and temperate grass in China（2000-2016）



(Yang et al., **2019**, ***Remote Sens Environ***)

1. Introduction

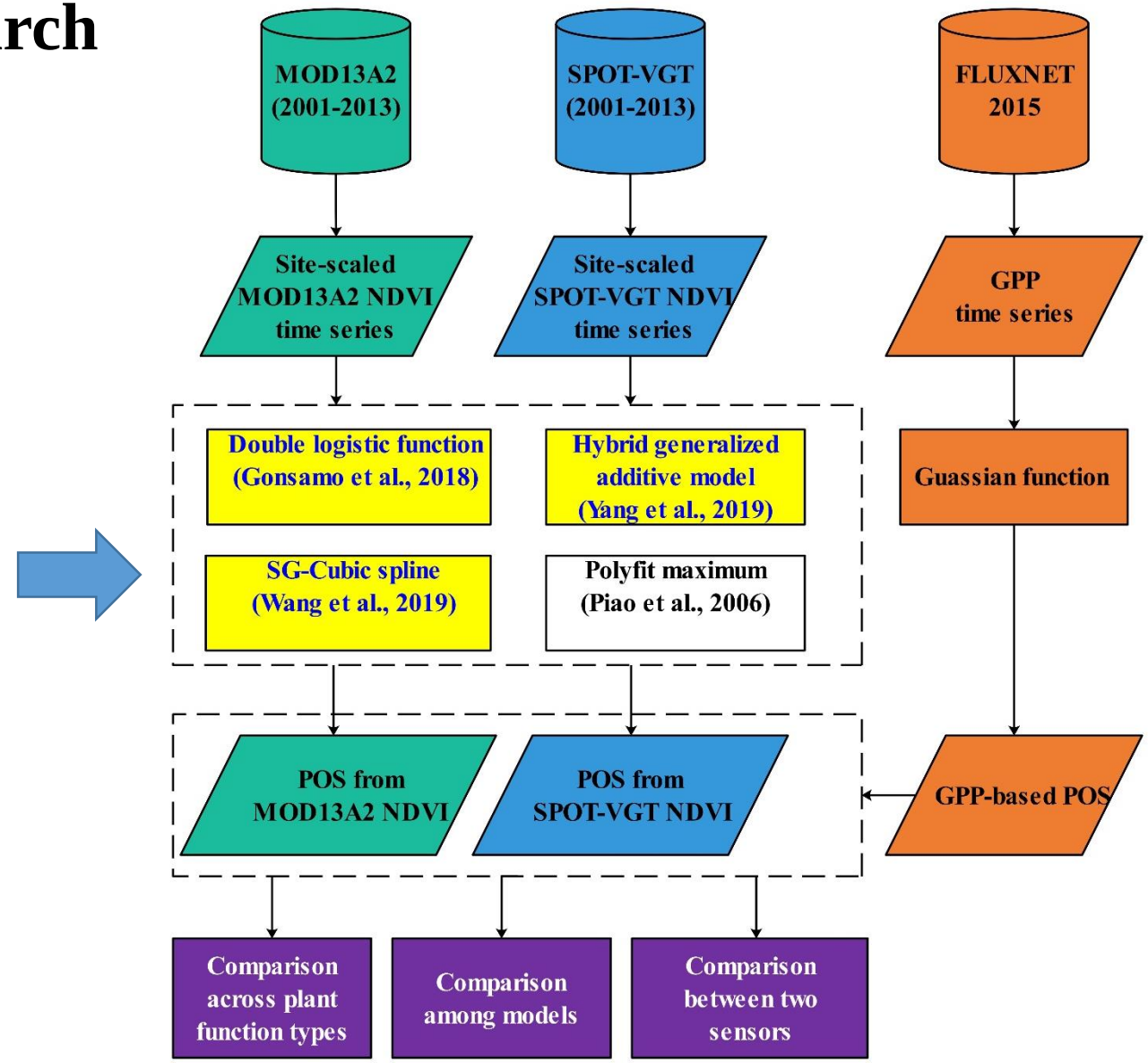
➢Deficiencies in current POS research

The performance of newly proposed models has ***not been compared***

Current research focus on ***regional scale***

Previous work only use NDVI from ***one sensor***

If NDVI-based POS is ***a good proxy*** of the peak photosynthetic timing has not been proved

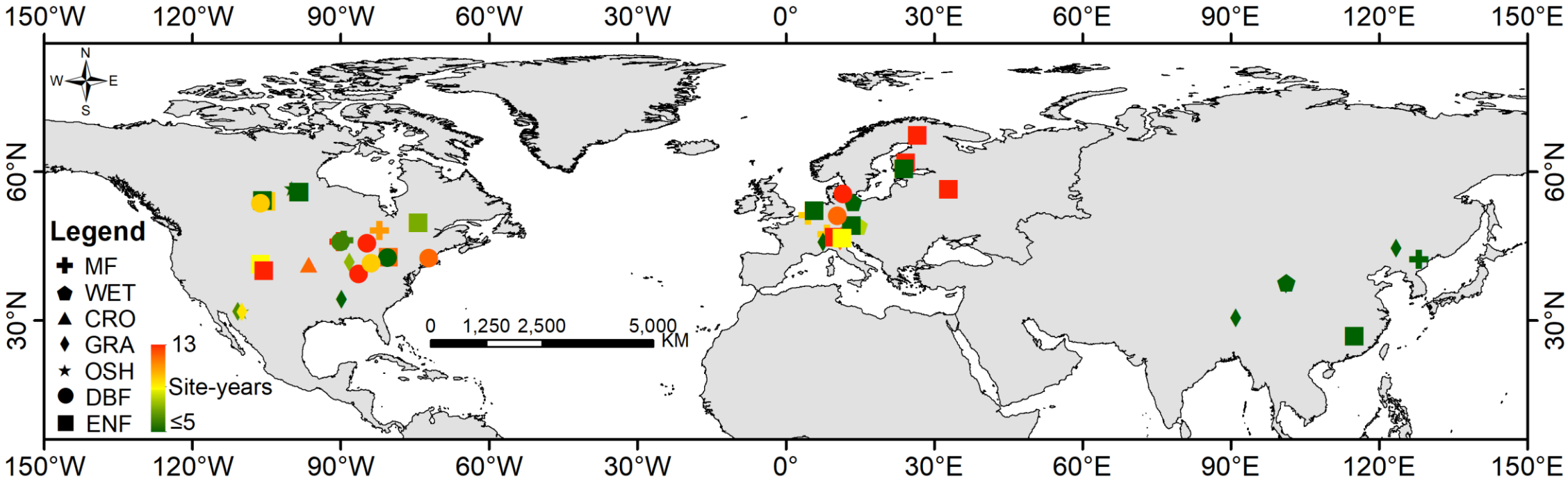


Flow chart of this research

2. Data and methods

➢2.1 Data

- GPP: FLUXNET2015 (54 sites, 434 site-years)
- NDVI: SPOT-VGT (1km, 10d), MOD13A2 (1km, 16d)



2. Data and methods

➢2.2 Methods

●POS estimation methods

Double logistic function (DLF)

$$f(t) = \alpha_1 + \frac{\alpha_2}{1 + e^{-\partial_1(t-\beta_1)}} - \frac{\alpha_3}{1 + e^{-\partial_2(t-\beta_2)}}$$

(Gonsamo et al., 2018, ***GCB***)

Hybrid general additive model (HGAM)

Modified S-G filter + Generalized additive model

(Yang et al., 2017, ***RSE***)

SG-cubic spline

Modified S-G filter + cubic spline

(Wang et al., 2018, ***AFM***)

Polyfit maximum

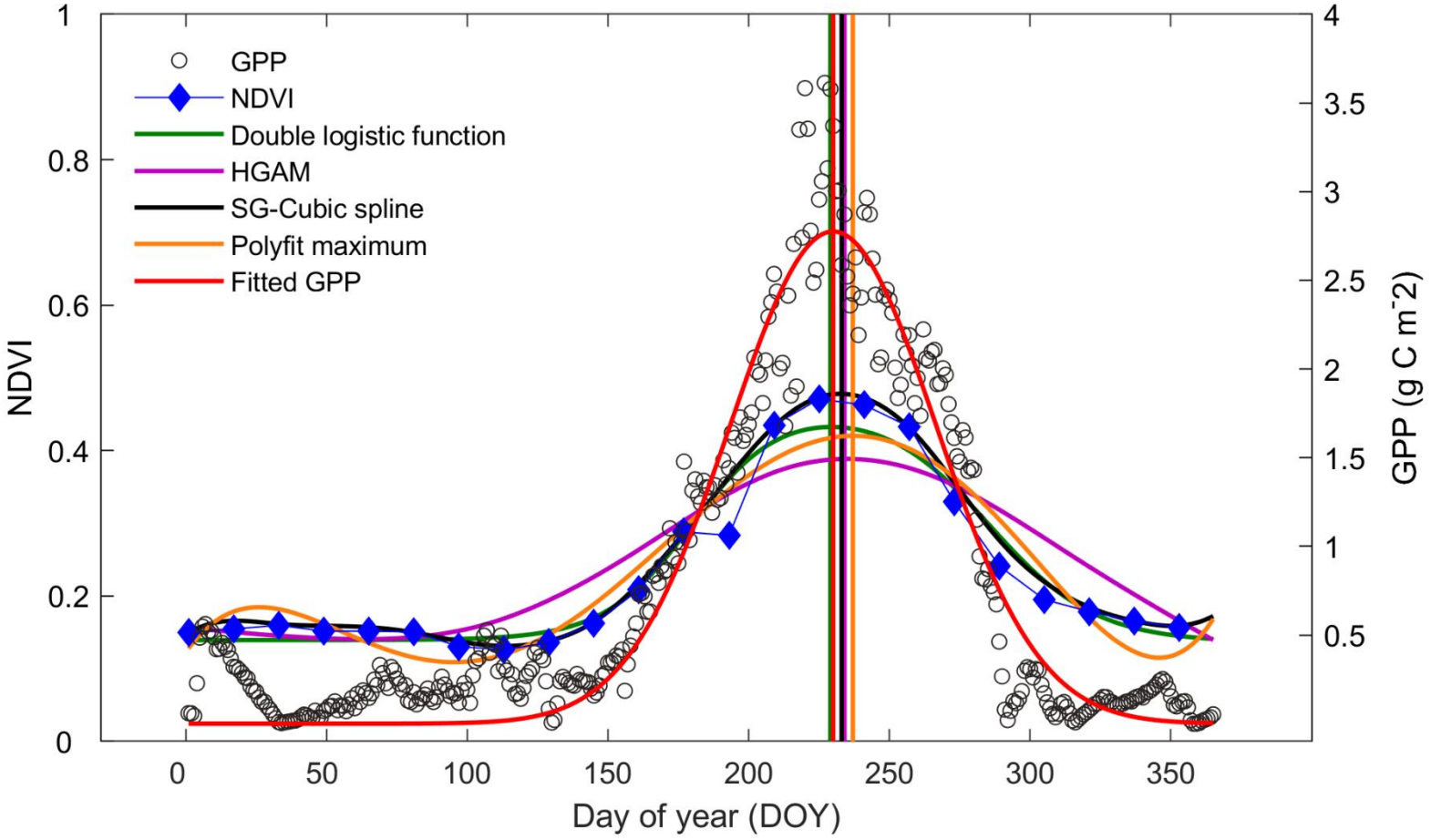
$$f(t) = a + a_1 t^1 + a_2 t^2 + a_3 t^3 + \cdots + a_6 t^6$$

(Piao et al., 2006, ***GCB***)

2. Data and methods

➢2.2 Methods

- POS estimation methods



An example for POS determination at CN-Dan (Grassland) in 2005

2. Data and methods

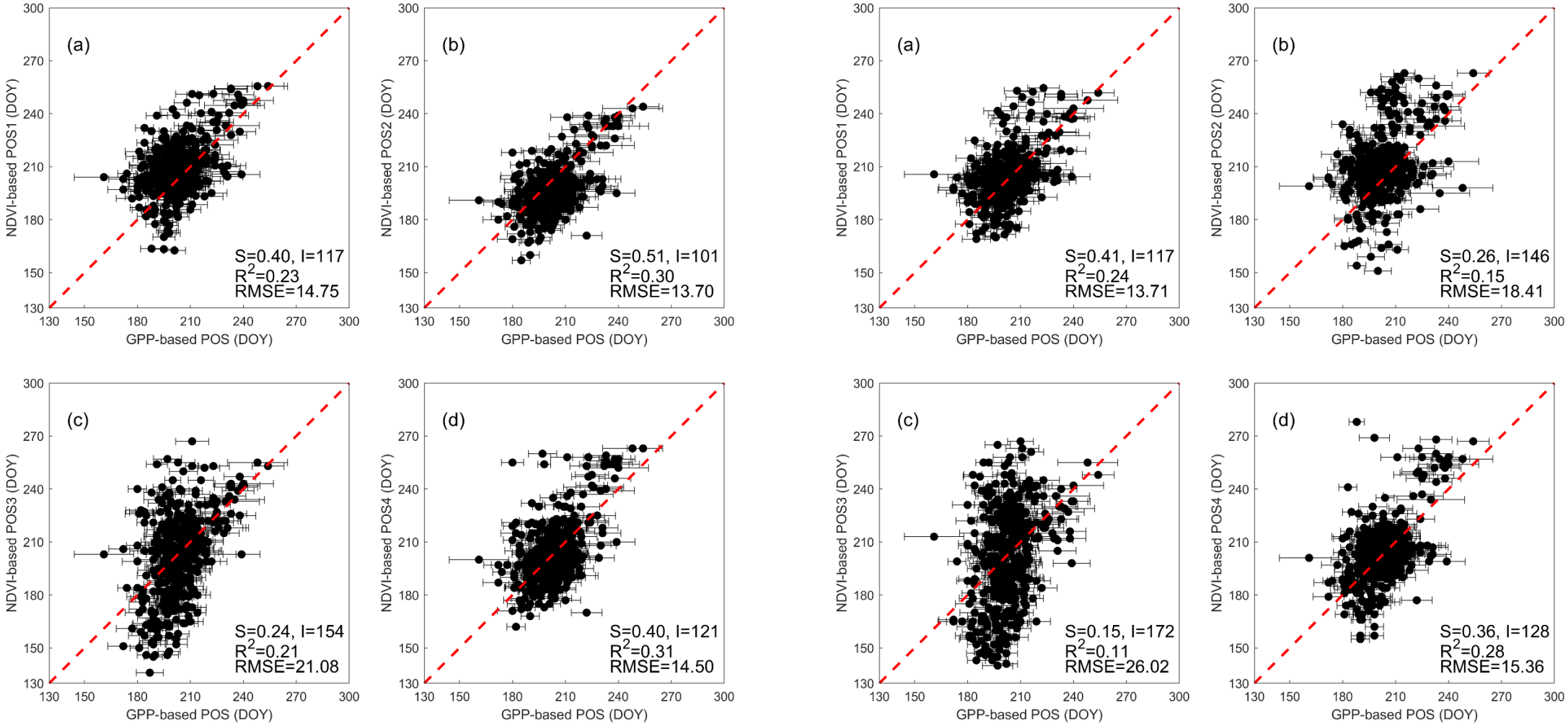
2.2 Methods

- Models prediction performance
  - ***R^2 and p-value***
  - ***RMSE***

- Prediction difference between four models
  - ***ANOVA*** (analysis of variance)

3. Results

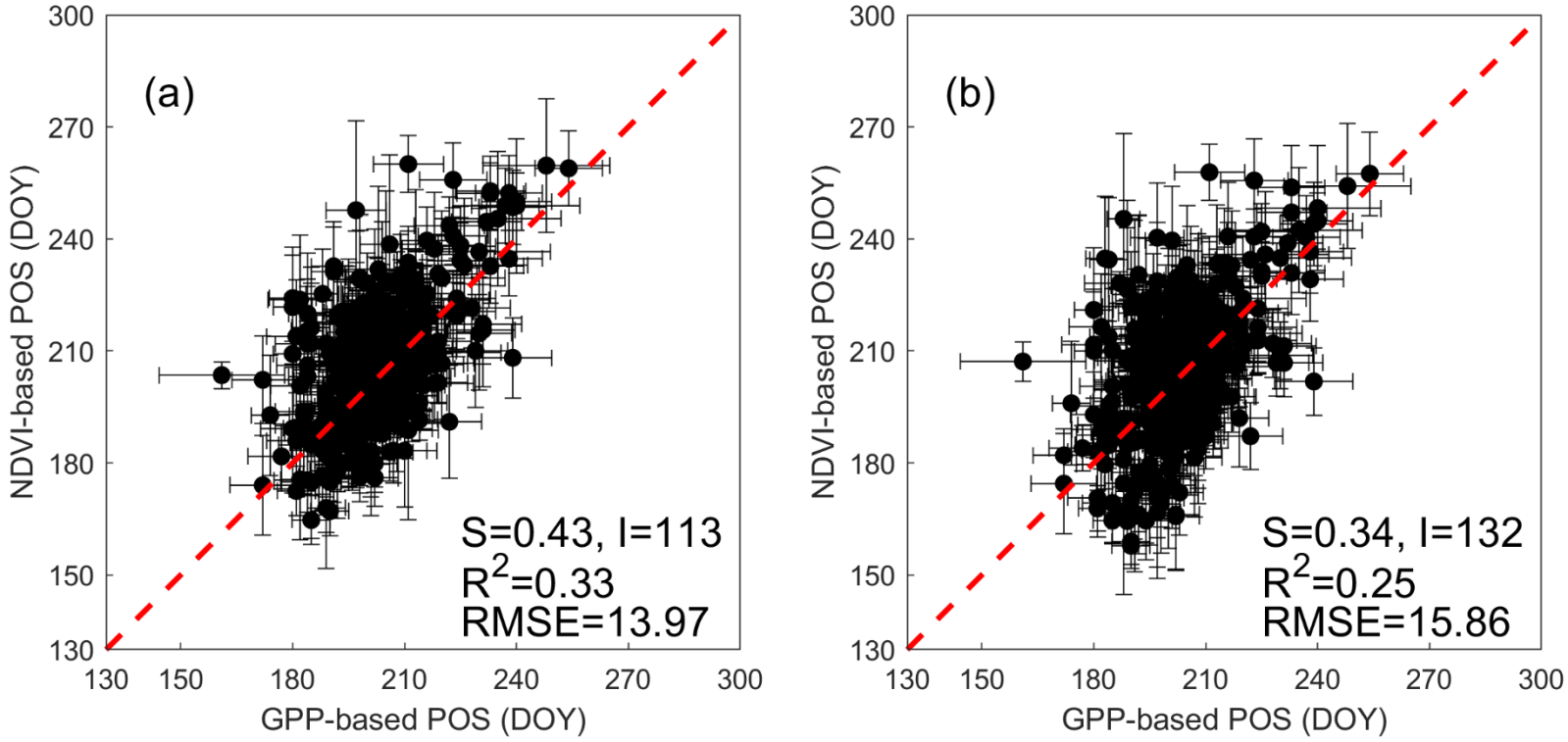
3.1 POS estimates from NDVI



Correlations between the NDVI-based POS and GPP-based POS. Left panel is for MOD13A2, right panel is for SPOT-VGT. (a) double logistic function (DLF), (b) hybrid generalized additive model (HGAM), (c) SG-cubic spline, and (d) polyfit maximum.

3. Results

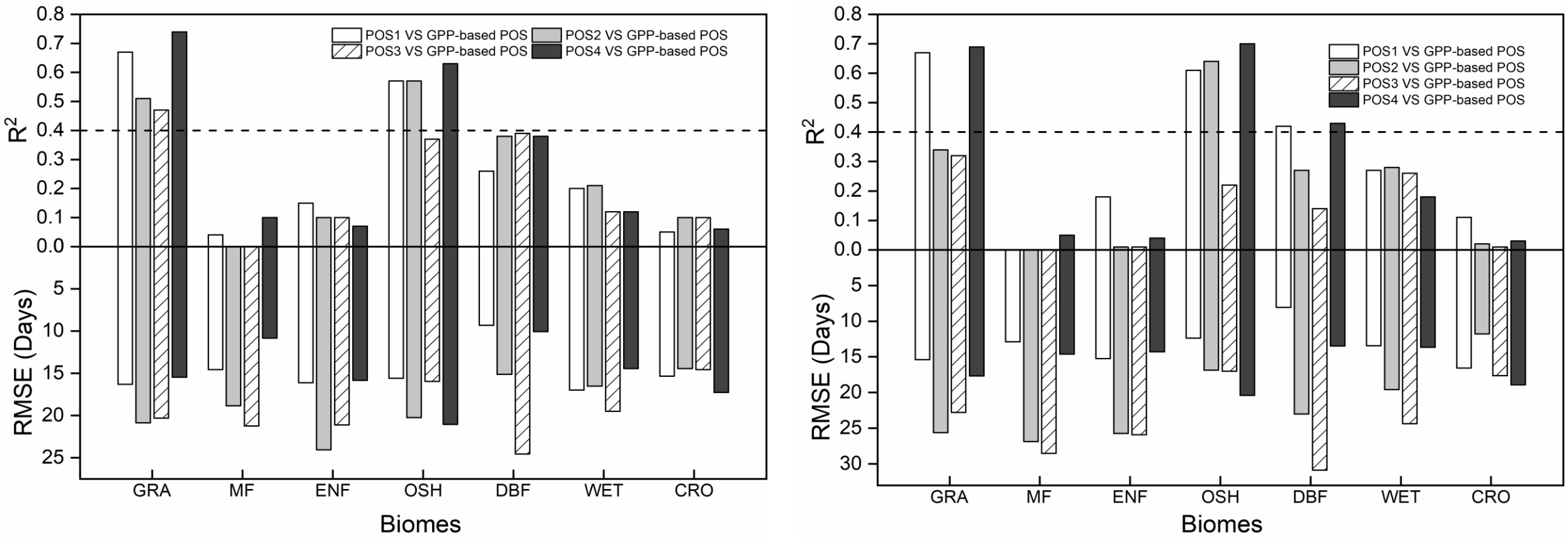
3.1 POS estimates from NDVI



Correlations between the average POS from the four models, and the GPP-based POS: (a) using MODIS data, and (b) using SPOT-VGT data.

3. Results

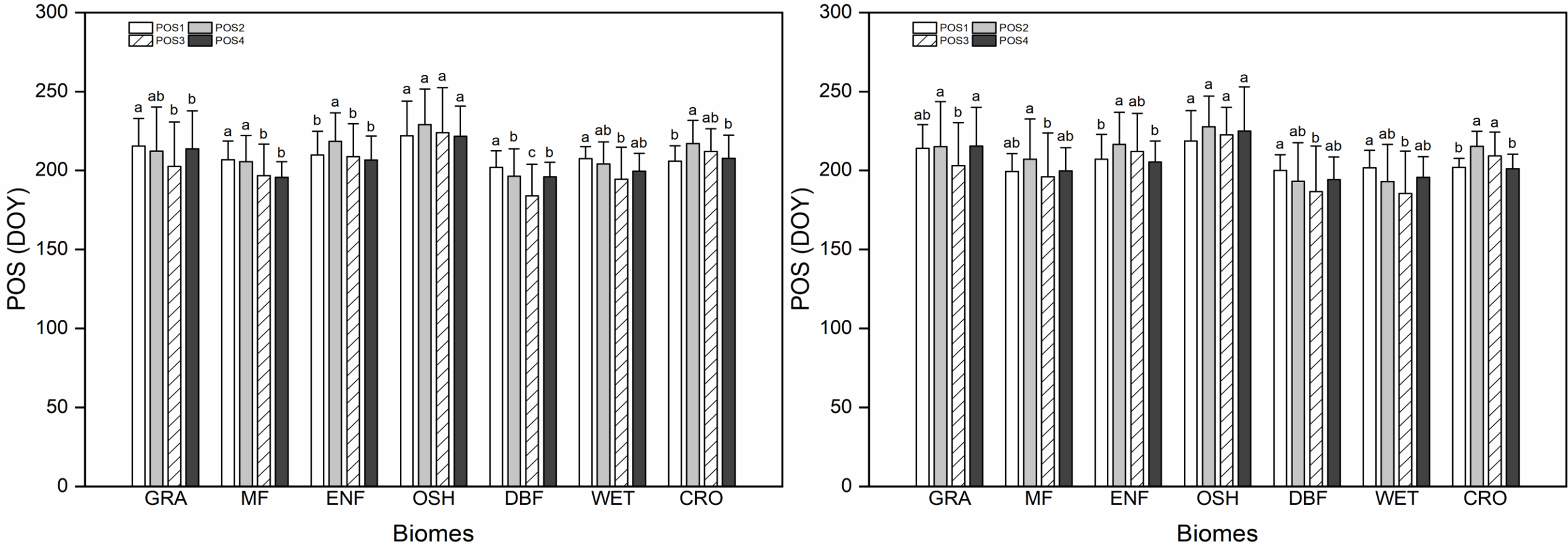
3.2 Comparison across biomes



Correlations between NDVI-based POS and GPP-based POS for each biome (Left is for MOD13A2 and right is for SPOT-VGT). POS1, POS2, POS3 and, POS4 are the results of the different modeling methods used to predict DLF, HGAM, SG-cubic spline, polyfit maximum, respectively. Dash line represents R^2 is equal to 0.4.

3. Results

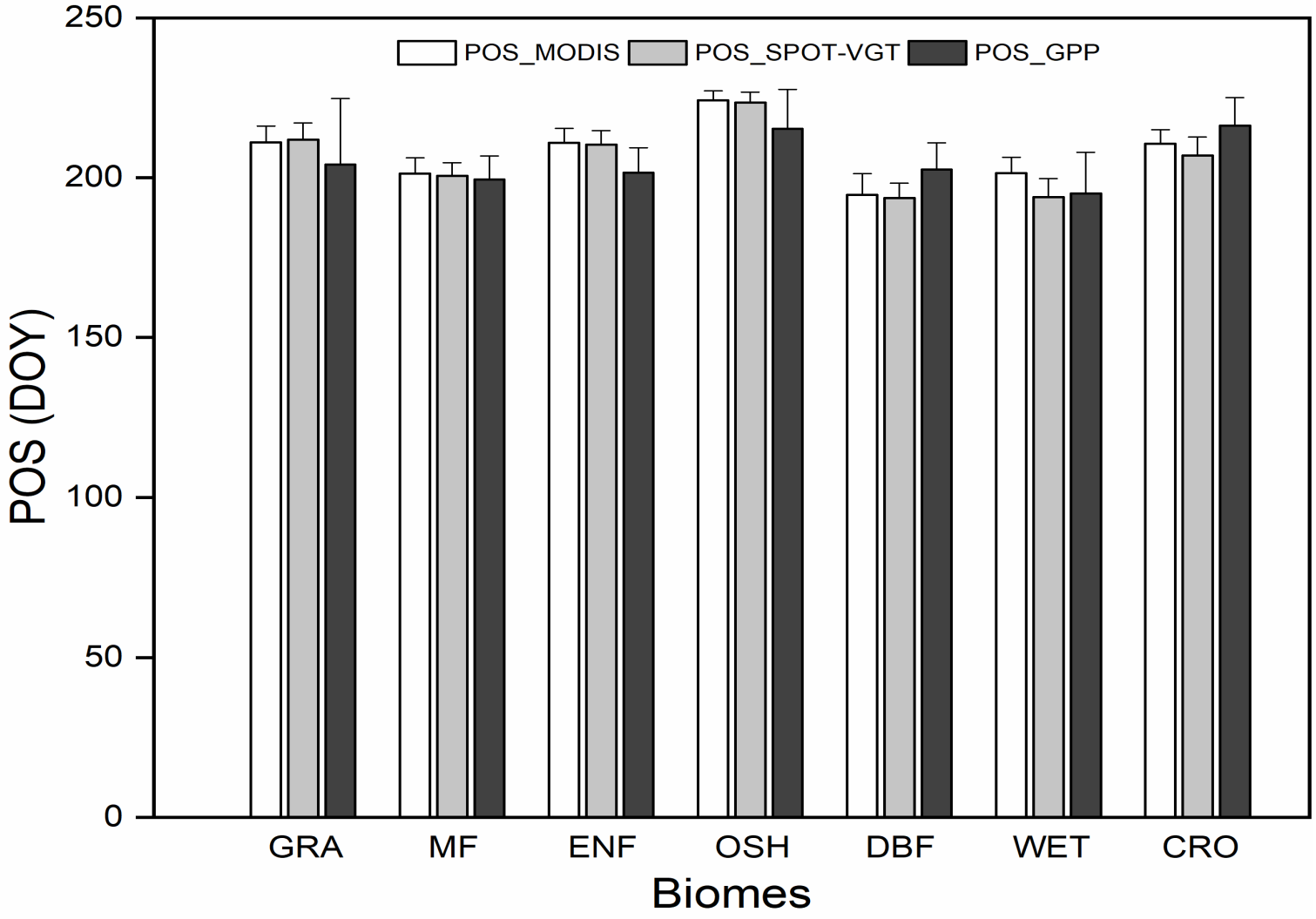
3.3 Comparison of the predictive methods



Comparison of the NDVI-based POS modeled by the four approaches using MOD13A2 (Left) and SPOT-VGT (right) for each biome. The lower-case letters from ANOVA analysis show whether there is a significant difference between POS modeled from the different methods (significance level was set to 0.05).

3. Results

3.4 Comparison of the POS estimates from different sensors



Comparison between the NDVI-based POS and GPP-based POS for each biome

4. Discussion

4.1 Impact of the modeling method selection

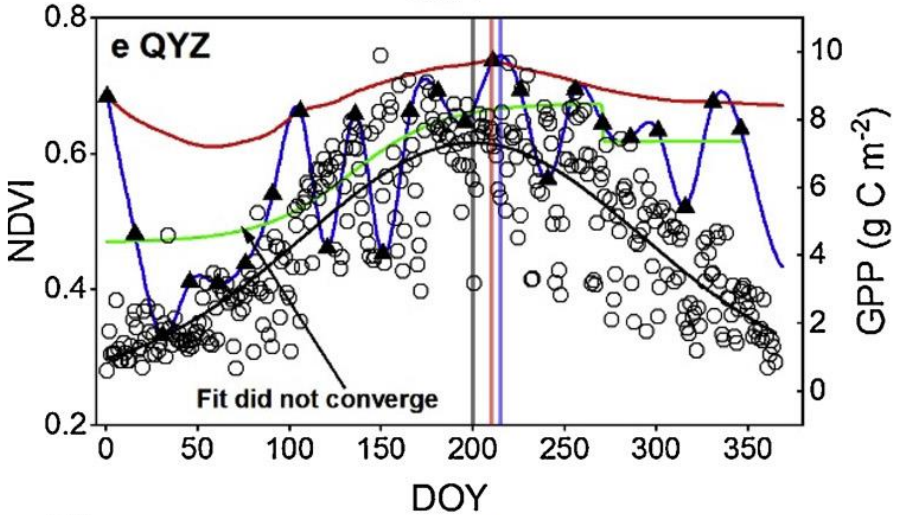


Fig Double logistic function fails to fit the NDVI in Qianyanzhou flux site (ENF)

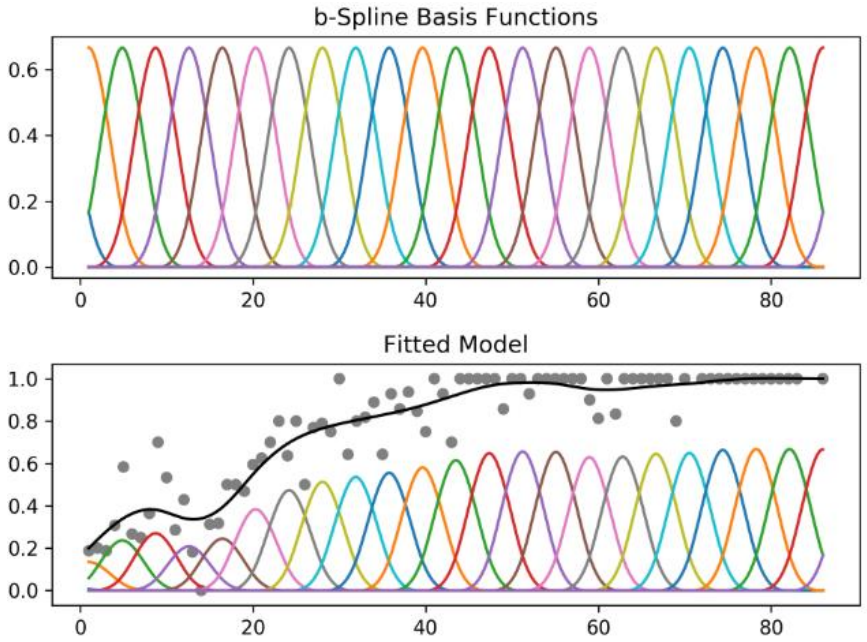


Fig Generalized additive model could get high fidelity by using basis functions

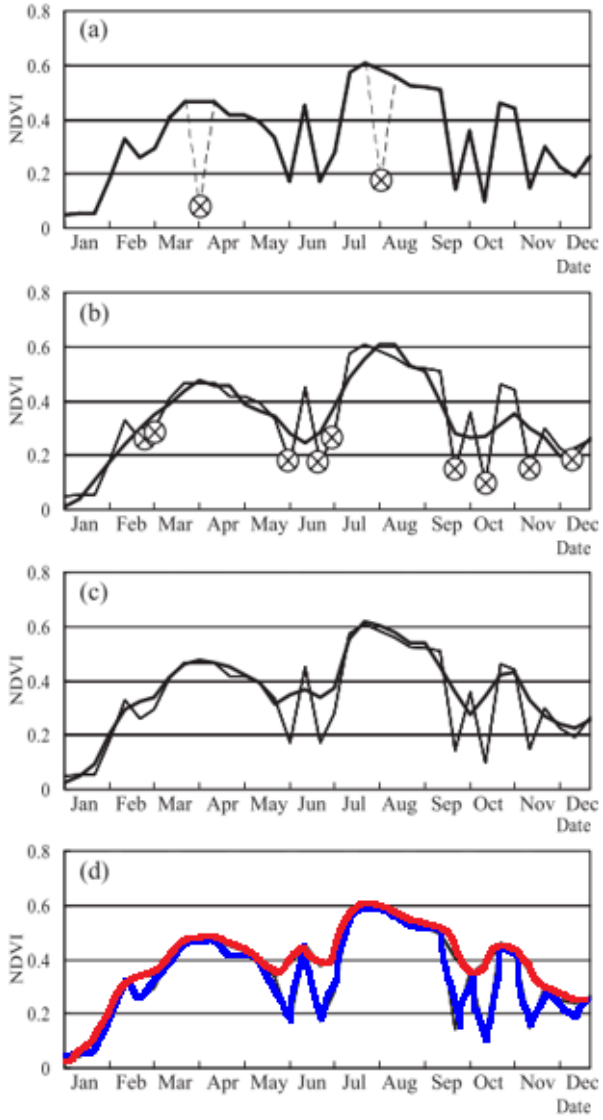
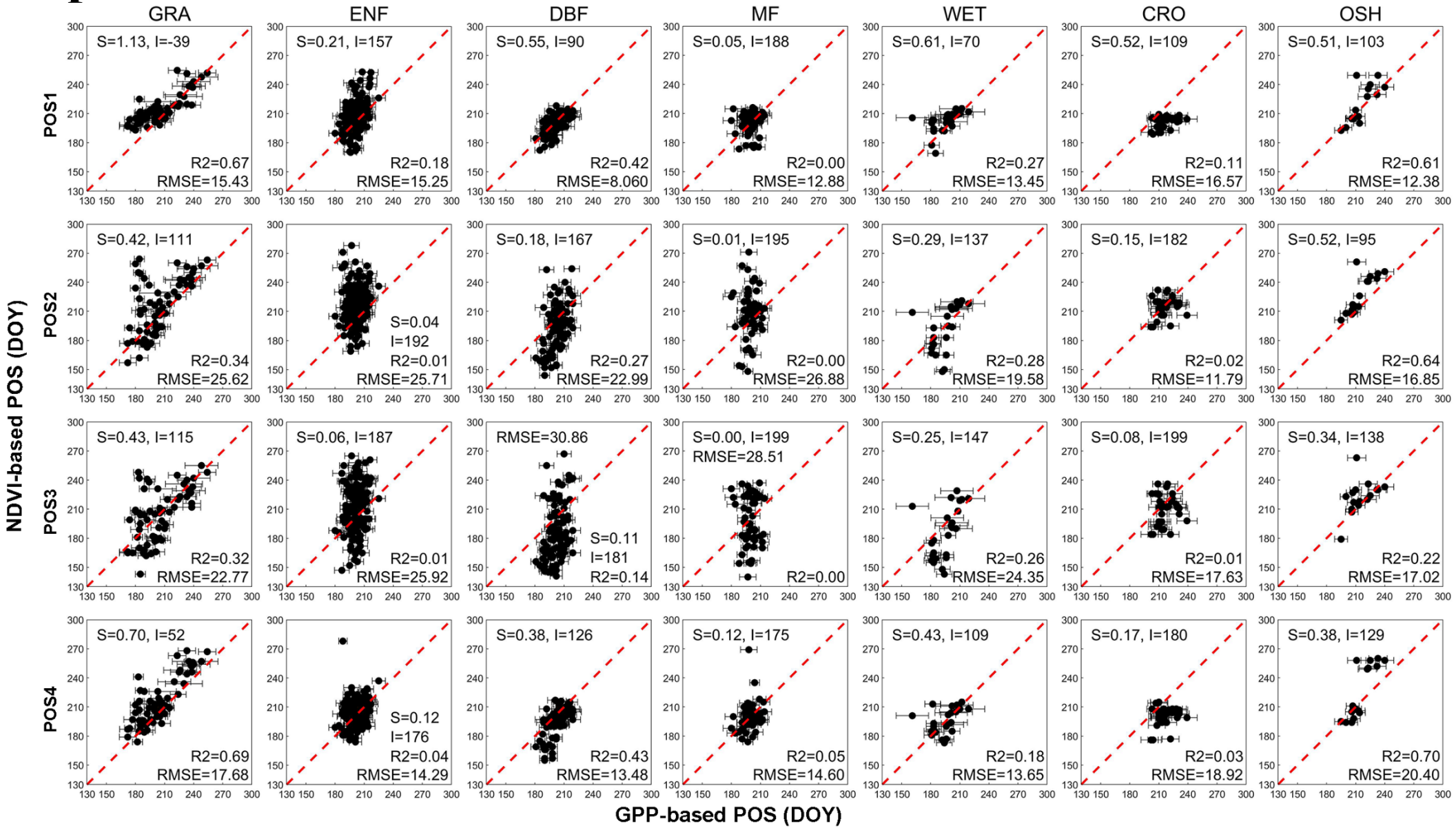


Fig. Modified S-G filter is integrated in HGAM and SG-cubic spline models

(Chen et al., 2004, *Remote Sens Environ*)

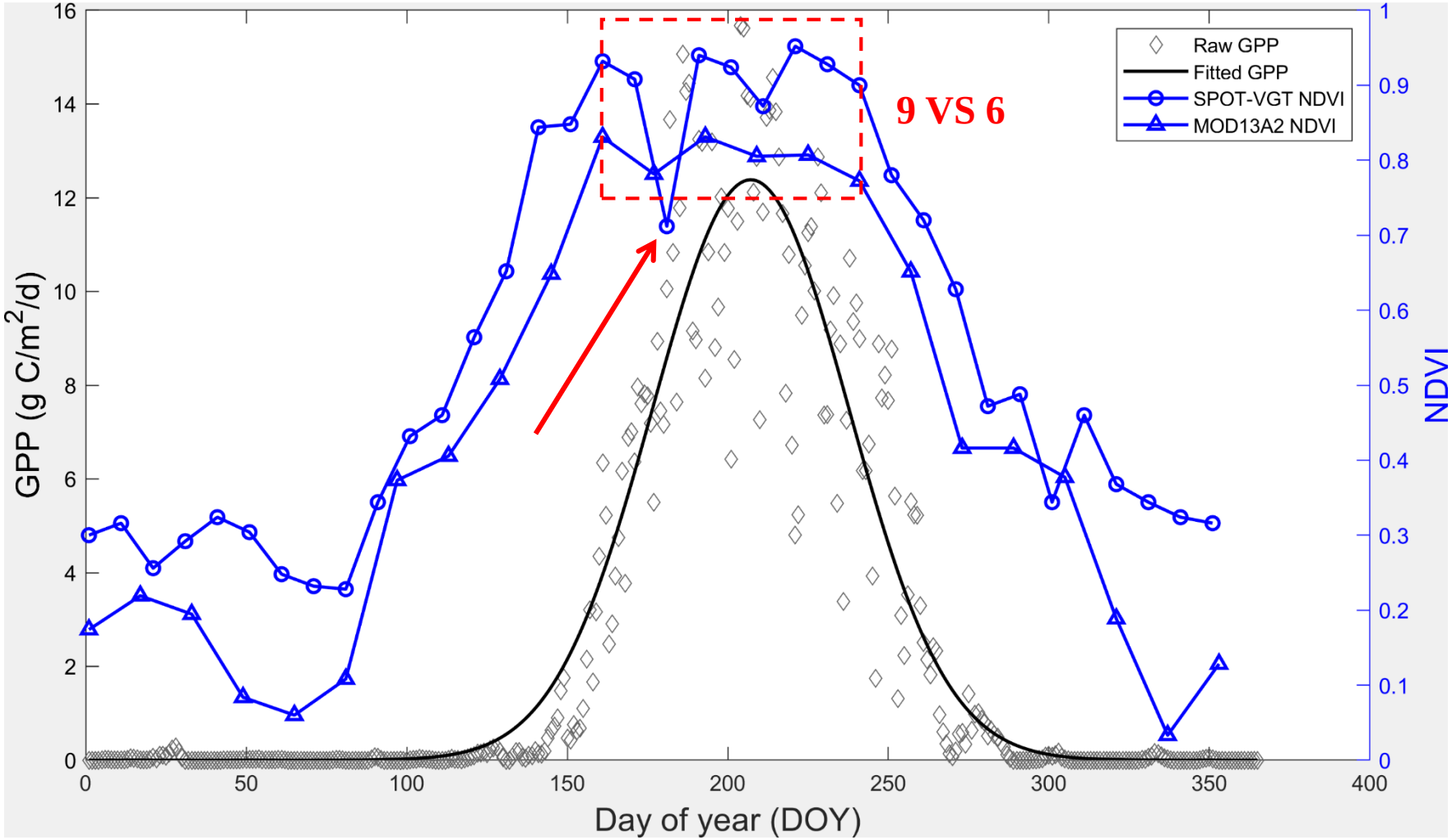
4. Discussion

4.2. Impact of the biomes



4. Discussion

4.3. Impact of sensor selection for model data

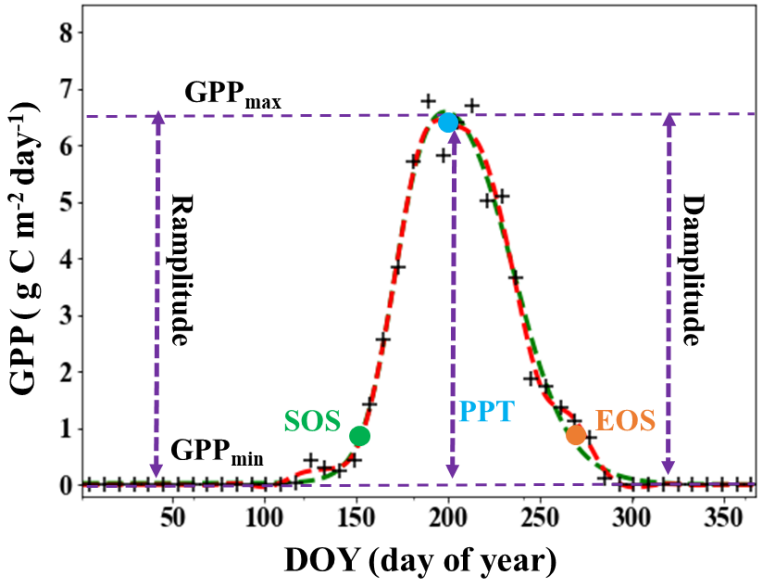


4. Discussion

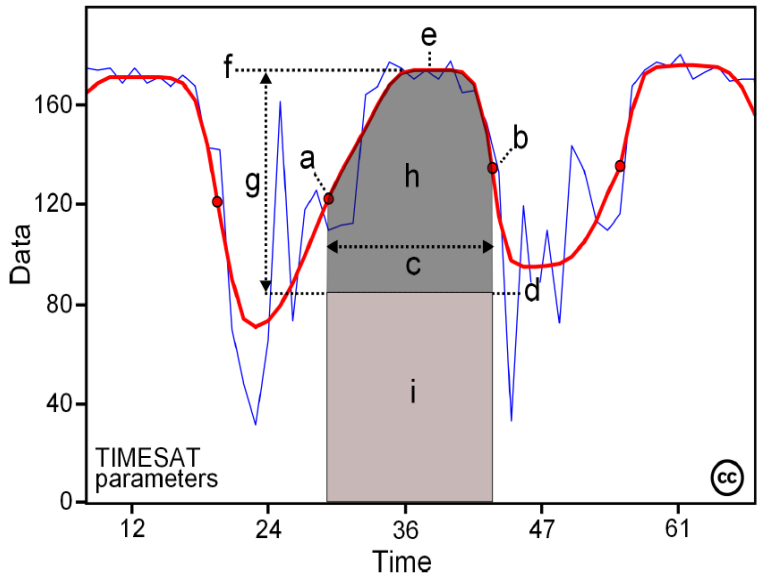
4.4. Limitations and uncertainties

➢ **Different definition and rules are used to calculated POS**

Definition 1: The DOY of **a point** with maximum value on the fitted GPP curve

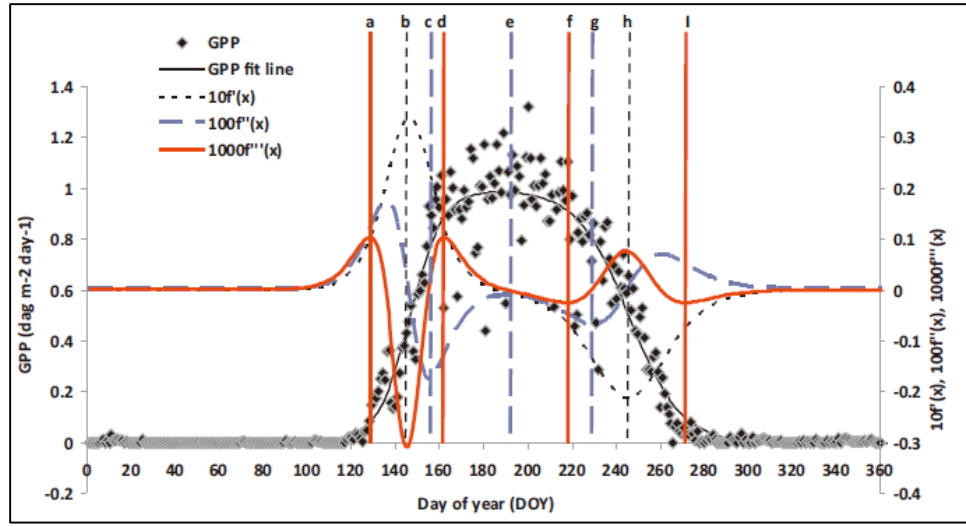


Definition 2: The DOY of **an average** of two specific stages



(TIMESAT software manual)

Definition 3: The DOY of **the third derivative local maximum and minimum**

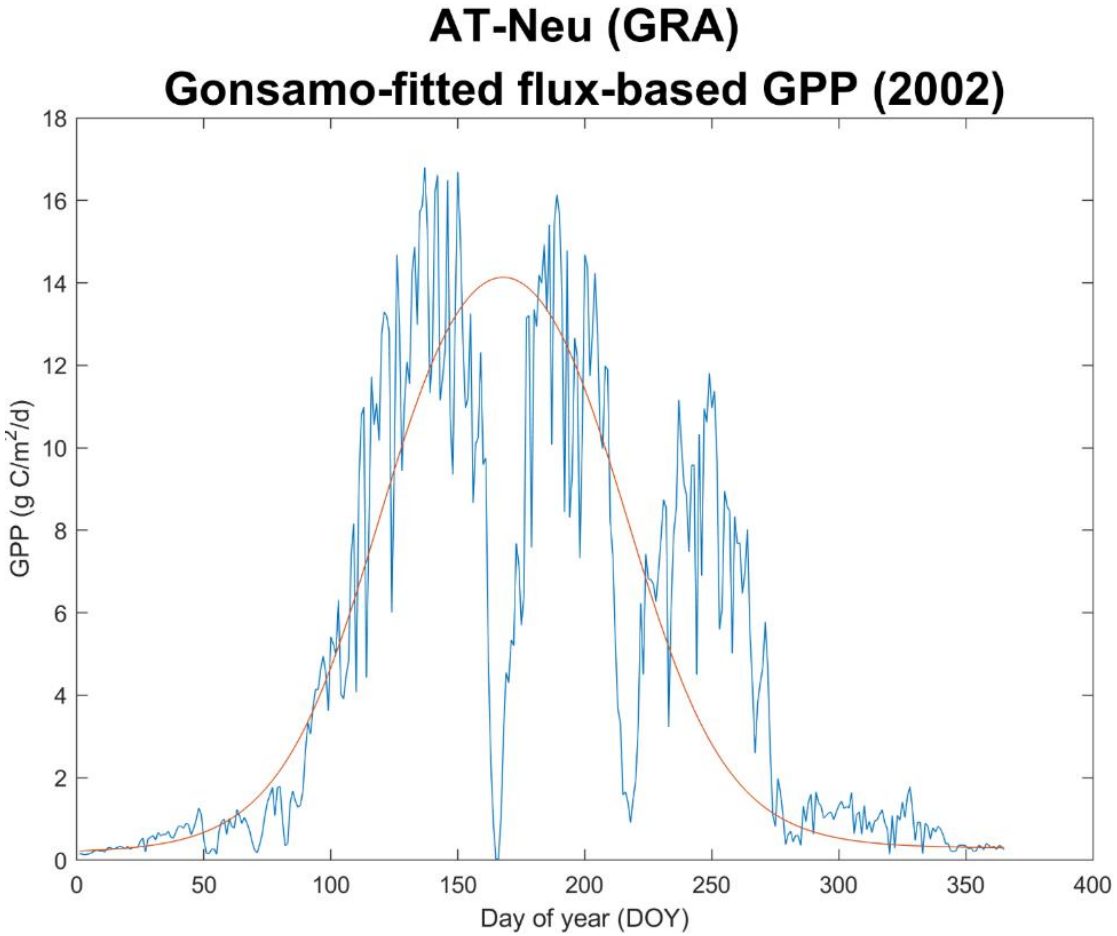


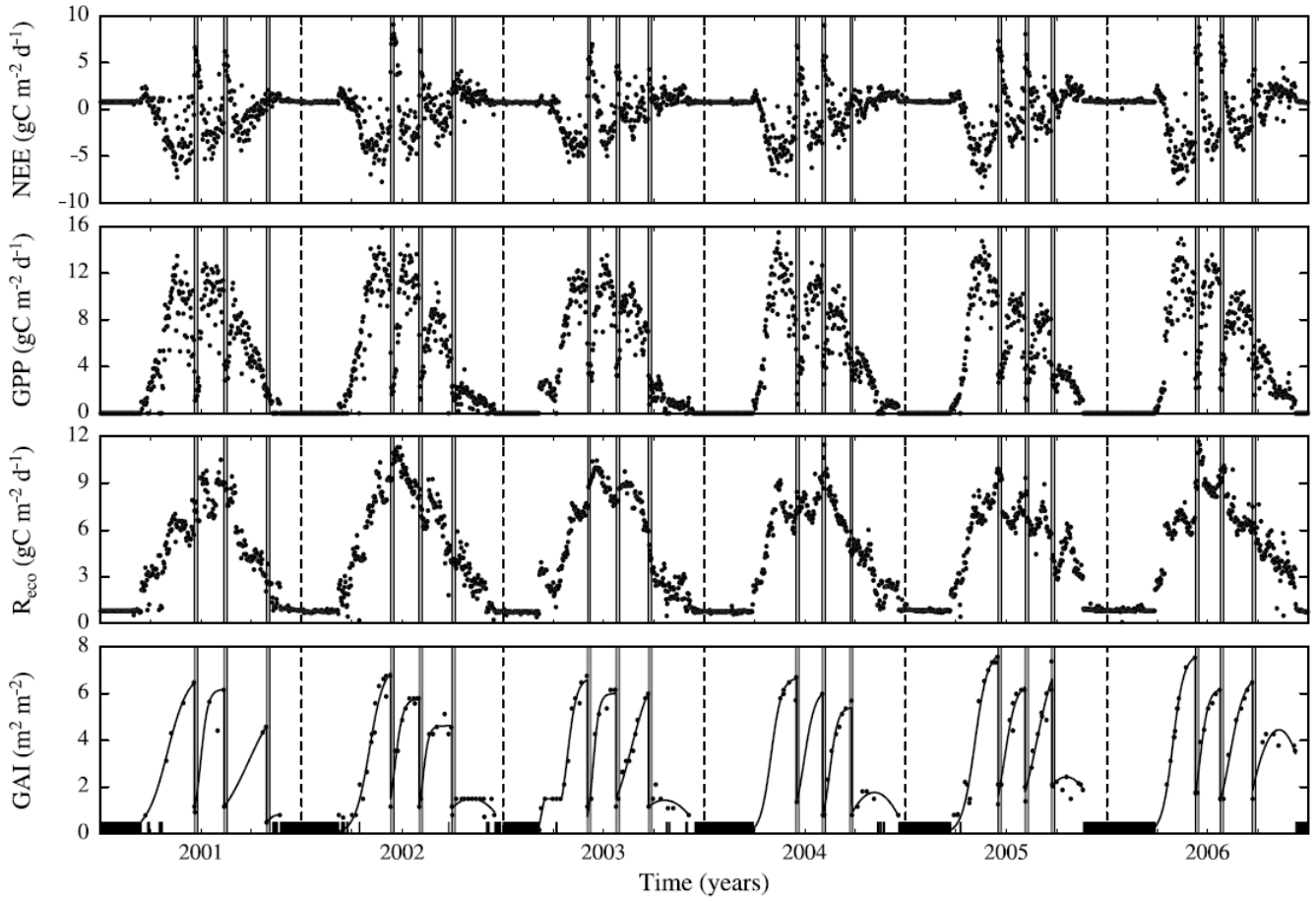
(Gonsamo et al., 2018, ***Glob Chang Biol***)

4. Discussion

4.4. Limitations and uncertainties

- **Multiple growing season are overlooked**





(Wohlfahrt et al., 2009, *J GEOPHYS RES-ATMOS*)

5. Conlusions

1. The more recently proposed methods did not perform as expected, and some of them performed even worse than the commonly used approach

2. POS modeled from MODIS data performed slightly better than that from SPOT-VGT data

3. When the models are combined, they can reliably estimate POS for grasslands, deciduous broadleaf forests, and open shrublands, but not necessarily for other biomes

4. NDVI-based POS is not a good proxy of flux-based POS

Thanks for your attention