

Evaluating Remotely Sensed Phenological Metrics in a Dynamic Ecosystem Model. *Remote Sensing*, 2014, 6, 4660–4686

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In order to examine the impact of data source on the phenology algorithms, we used two other MODIS products (*i.e.*, MOD13A1, which is a 16-day vegetation index, and MCD43A4, which is a BRDF-corrected surface reflectance with an eight-day update and a 16-day composite window) that have the same spatial resolution as the product used in the manuscript (*i.e.*, MOD09A1) to retrieve phenology with the same processes. For MCD43A4, those data that produced a zero or negative VI were considered bad when applying the smoothing algorithm [S1].

Figures S1 and S2 and Tables S1–S4 show the performance of the two datasets. In general, phenology retrieved using MOD13A1 has large inter-annual variability and bias, which might be due to the lower temporal resolution. Phenology retrieved using MCD43A4 has even larger variability and bias. Although MCD43A4 is BRDF-corrected, which might reduce the effect of understory to some extent, it has other issues in addition to the lack of quality state. For example, the same data could be used for two adjacent composite periods because there is an overlap of the composite window. Because the date on which the data were used for the composite is not provided, we need to assume the date arbitrarily (we used the first day of each composite period here). Our results suggest that MOD09A1 has relatively good performance, which is consistent with [S2].

Figure S3 is an example of how the performance of a method could be improved by adjusting the parameters used. It shows the onset derived using LOGISTIC2 method with EVI from MOD09A1. The amplitude between the minimum and maximum fitted VI, at which the onset is determined, was changed from 50%–25%. The RMSD between observed and remotely sensed onset is 3.3 days, and the Spearman's rank correlation coefficient is 0.74.

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Figure S1. Ground observed phenology with remotely sensed onset from NDVI (a), onset from EVI (b), offset from NDVI (c), and offset from EVI (d). Satellite data used to retrieve phenology is MODIS MOD13A1 product. Error bars indicate the standard deviation of observation. Methods used to retrieve phenology are as follows: (A) MIDPOINT, (B) LOGISTIC1, (C) LOGISTIC2, (D) MOVING, (E) DERIVATIVE, and (F) CAMELBACK.

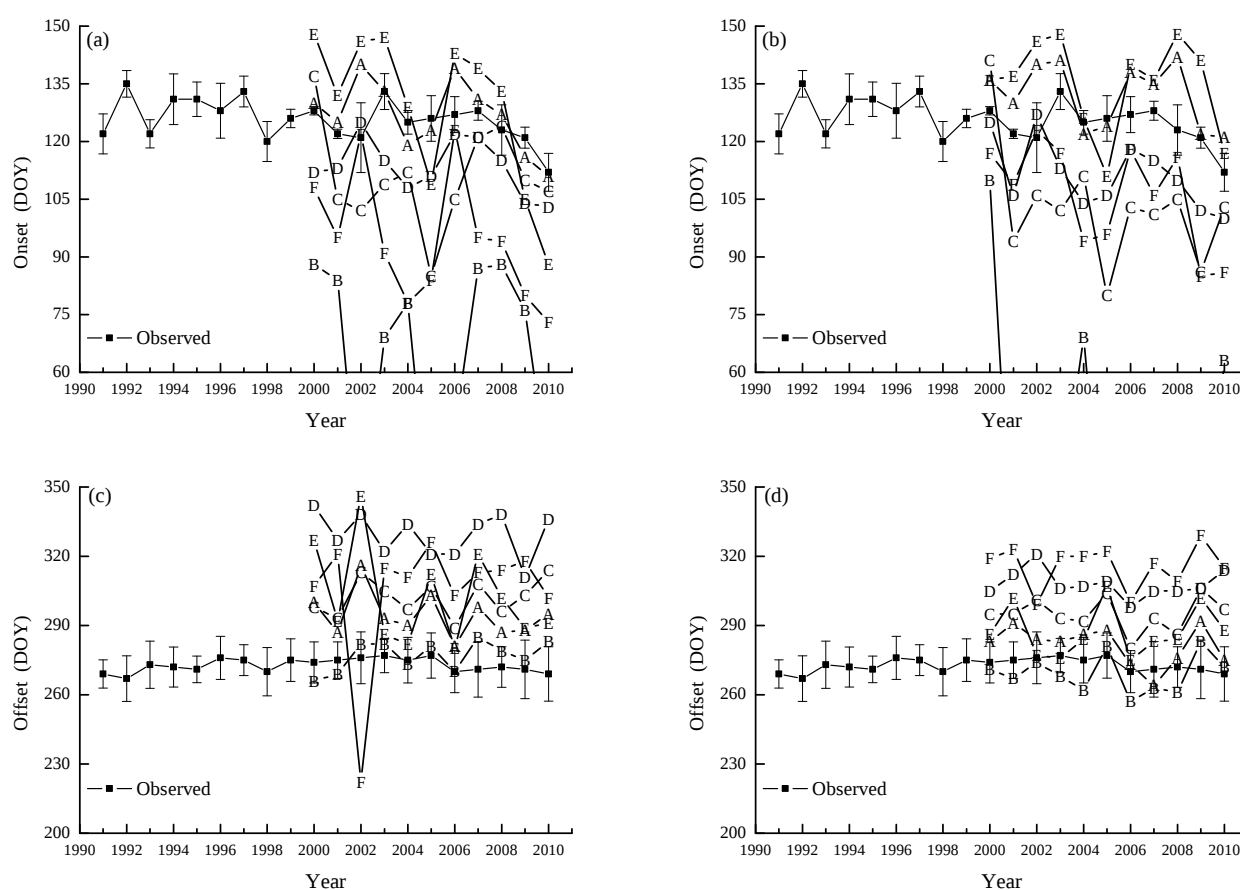


Figure S2. Ground observed phenology with remotely sensed onset from NDVI (a), onset from EVI (b), offset from NDVI (c), and offset from EVI (d). Satellite data used to retrieve phenology is MODIS MCD43A4 product. Error bars indicate the standard deviation of observation. Methods used to retrieve phenology are as follows: (A) MIDPOINT, (B) LOGISTIC1, (C) LOGISTIC2, (D) MOVING, (E) DERIVATIVE, and (F) CAMELBACK.

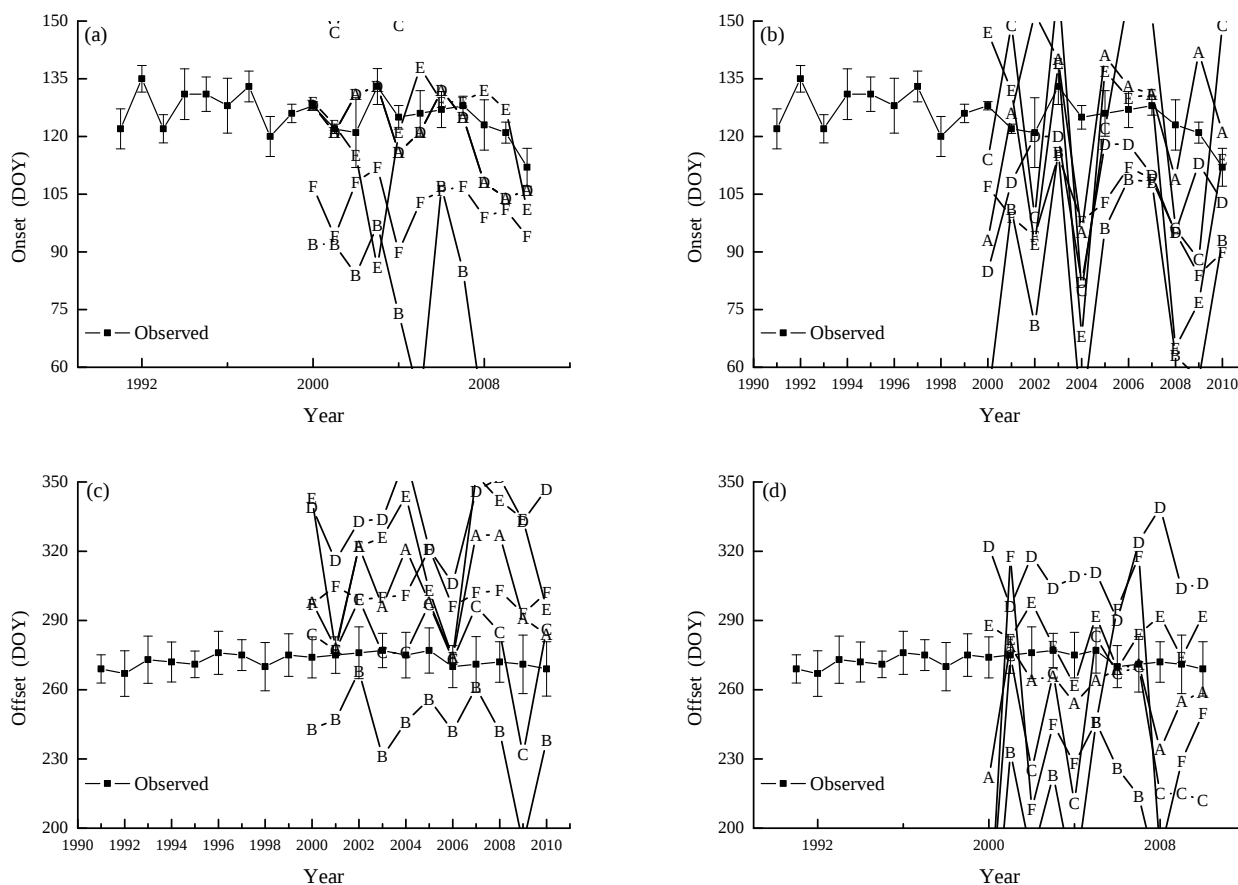


Figure S3. Ground observed phenology with remotely sensed onset using LOGISTIC1 with EVI (MOD09A1). The amplitude used to determine the onset is 25%. RMSD = 3.3 days; $\rho = 0.74$.

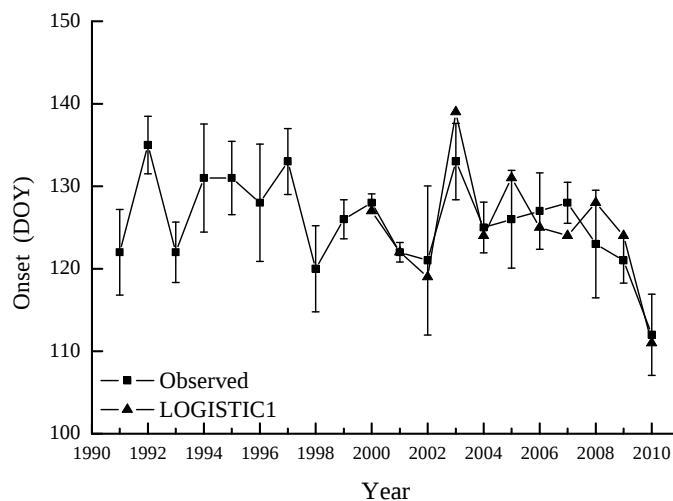


Table S1. Performance of remotely sensed onset using MOD13A1.

Leaf Onset	NDVI		EVI	
	RMSD	Correlation	RMSD	Correlation
LOGISTIC1	67.3	0.30	102.7	0.27
LOGISTIC2	18.8	0.32	25.9	0.06
MIDPOINT	7.5	0.50	10.4	0.45
MOVING	12.4	0.37	15.0	0.50
DERIVATIVE	16.3	0.66	15.5	0.06
CAMELBACK	33.0	0.34	21.3	0.39

Table S2. Performance of remotely sensed offset using MOD13A1.

Leaf Onset	NDVI		EVI	
	RMSD	Correlation	RMSD	Correlation
LOGISTIC1	7.6	−0.03	8.8	0.25
LOGISTIC2	29.8	0.06	22.4	0.20
MIDPOINT	22.6	0.41	10.6	0.52
MOVING	56.9	−0.03	35.1	0.37
DERIVATIVE	35.2	0.24	17.8	0.06
CAMELBACK	41.8	0.41	43.3	0.30

Table S3. Performance of remotely sensed onset using MCD43A4.

Leaf Onset	NDVI		EVI	
	RMSD	Correlation	RMSD	Correlation
LOGISTIC1	54.6	0.68	47.6	0.39
LOGISTIC2	33.7	0.29	28.4	0.49
MIDPOINT	8.5	0.68	19.4	−0.17
MOVING	14.9	0.59	22.3	0.11
DERIVATIVE	15.5	0.24	30.2	0.62
CAMELBACK	22.9	0.56	24.3	0.93

Table S4. Performance of remotely sensed offset using MCD43A4.

Leaf Onset	NDVI		EVI	
	RMSD	Correlation	RMSD	Correlation
LOGISTIC1	35.7	0.37	84.4	0.42
LOGISTIC2	18.2	0.24	53.2	0.33
MIDPOINT	33.6	0.26	22.1	0.07
MOVING	63.9	−0.15	40.1	0.09
DERIVATIVE	53.1	0.05	14.3	0.15
CAMELBACK	29.0	0.30	58.9	−0.25

References

- S1. Chen, J.; Jönsson, P.; Tamura, M.; Gu, Z.; Matsushita, B.; Eklundh, L. A simple method for reconstructing a high-quality NDVI time-series data set based on the Savitzky–Golay filter. *Remote Sens. Environ.* **2004**, *91*, 332–344.

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