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Discussions

Interactive comment on "Intercomparison of Terrestrial Carbon Fluxes and Carbon Use Efficiency Simulated by CMIP5 Earth System Models" *by* Dongmin Kim et al.

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Summary: This paper compares the GPP, NPP, and CUE of 10 CMIP5 models to an 'observation' from MODIS, and evaluates their similarities and differences. Model precipitation and temperature fields are similar to reanalyses, but carbon cycle products are diverse. At the outset, I have a major problem with this paper. The only observation MODIS makes is radiances recorded by reflected sunlight in multiple spectral bands. MODIS does not 'observe' LAI, it calculates it with a model. MODIS does not 'observe' fPAR, it calculates it with an NDVI-type algorithm. MODIS does not 'observe' GPP, it models it using a light-response model (fundamentally different than the enzyme-kinetic models from CMIP5 that are evaluated here). MODIS most certainly does not

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‘observe’ any form of respiration (Ra or Rh), but calculates these as a function of modeled GPP and equations that relate respiration dependence to temperature and moisture. To claim that MODIS-derived quantities are somehow correct compared to other models is just about impossible to defend. We know that MODIS has biases in that the radiances are masked during times of even fairly thin cloud optical depth. This has major impacts in the tropics (where area-mean GPP is just about the highest on the globe), in savanna regions where GPP can respond strongly and rapidly to seasonal rains, and surely in other regions as well. MODIS GPP/NPP/CUE is just another model. With this perspective, there’s not a lot here other than demonstrating that the models are different, but we knew that already. Some of that analysis was already done in the Shao paper.

⇒ We accept the MODIS is not the actual observation but another modeled estimated from satellite radiances. However, there are also many studies in the following suggesting that the gridded MODIS GPP is consistent well with in-situ data and good for the model validation. Moreover, for analyzing global distribution of net primary production (NPP), we have only one available option for the data, which is MODIS. In the original manuscript, we already compared global averaged GPP amount between FLUXNET-MTE and MODIS, showing very small difference less than 1 % of total mean value as well as consistent spatial variations.

- Heinsch et al. (2006) suggested that the tower-based observation using AmeriFlux and MODIS GPP reasonably compared for most vegetation types (L204-206). They also compared the seasonal cycle of GPP over all vegetation types. It also captures the rapid onset of leaf-on and out reasonably.

- Turner et al. (2006) compared MODIS GPP and in-situ observations over multiple years at three sites (e.g., boreal conifer forest, temperate deciduous forest and grassland). Interannual variation of GPP in MODIS agreed with that from ground-based observations.

- Zhao et al. (2005) also suggested that the MODIS GPP fits well with GPP from 12 flux towers over North America. Moreover, Zhao et al. (2006) compared with MODIS GPP forced by original DAO data, ERA-40 and NCEP reanalysis data and forced by observed weather station data in U. S. (n=321). The described GPP by DAO shows the best results compared with other reanalysis data (corr=0.94).

- Chen et al. (2014) evaluated MODIS GPP with different adjustment of parameters in algorithm compared with 21 tower measurements classifying 9 PFTs. Despite parameter change, MODIS GPP is able to capture R-squared values comparing with in-situ data (0.46∼0.89).

- Verma et al. (2014) validated the MODIS GPP and FLUXNET data sets. Except croplands, the MODIS GPP reasonably captured spatial variation in annual mean GPP in every biome.

⇒ To warrant the use of MODIS for the model validation, we also compared carbon use efficiency (CUE) from our studies and previous studies using site-based observations (supplementary figure 1). DNF has the highest CUE values in our study, being consistent with all previous studies. In addition, the plants with short canopy height (SHR, GRA and CROP) have the values around 0.5 and needleleaf forest (ENF, DNF) shows relatively higher values than that of other PFTs, which are also consistent with the findings in other studies. This confirms that MODIS does not have any known significant defect to reject the model validation. We added this discussion L554-564, with the figure 1 in the revised manuscript (It is Table S1 in manuscript)

⇒ Moreover, we also evaluated the MODIS gridded GPP data and GPP station data from FLUXNET(http://fluxnet.fluxdata.org). The comparison of the GPP data at the 53 tower sites (See Supplementary figure 2 below) and same gridded area from MODIS GPP 1 x 1 degree resolution is shown in the supplementary figure 3 below. The r-squared value is about 0.56. It is comparable with other previous studies about evaluating MODIS satellite data.

⇒ Moreover, we compared GPP from CMIP5 ESMs at same sites in Supplementary figure 4 below. The range of r-squared values in CMIP5-ESMs is 0.25 – 0.43. It is significantly lower than MODIS satellite data. It means that the GPP from MODIS is comparable dataset to evaluate numerical models.

Furthermore, there are multiple instances where the grammar and prose are incorrect. I appreciate that to write a scientific manuscript in a non-native language can be a challenge, but there are resources to help with this. The authors must find and utilize these resources to ensure that the manuscript meets English language grammar and usage requirements. Peer-review is for scientific content, not proofreading. For these reasons, I must recommend rejection of this manuscript. The assumption of MODIS 'correctness' permeates the document, and the grammar errors are too many to mention.

⇒ We carefully revised the manuscript once again.

Suggestion: The authors have obviously put a lot of work into the analysis, and I believe it may have value as a resubmission. The idea of a comparison between the light-response MODIS model and the various enzyme-kinetic CMIP5 models interests me. I have not worked with the CMIP5 data directly myself, but I imagine that gridded CO2 values are part of the output suite. I wonder if it would be possible to pull out gridcells that contain CO2 flask sites and compare mean annual cycles from the models to those observations? I'm pretty sure I've seen MODIS-based predictions of global CO2 fields, and this might provide an interesting comparison of models to an actual observation. I looked for an article like this in the currently published CMIP5 literature, but did not find one. Perhaps an opportunity exists here. I do not think a full inversion or data assimilation project would be necessary, but perhaps something like Wang et al. (2016), where comparisons were made between models and observed CO2 concentration at several flux sites.

⇒ We appreciate your suggestions. However, the MODIS-based global CO2 data are

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also used MODIS GPP and NPP data for input forcing to predict global CO2 data (Potter et al., 2012; Guo et al., 2012). It induces more complexity and uncertainty of carbon fluxes using MODIS satellite data. Moreover, the atmospheric CO2 concentration is closely related with carbon fluxes from terrestrial biosphere. Despite of not perfect, the evaluation of performance of simulation skill of terrestrial carbon cycle in CMIP5-ESMs is needed and valid to improve the carbon cycle in the numerical models and statement of our knowledge of terrestrial carbon cycle.

⇒ Even though, MODIS GPP and NPP are light use based "model". It is best and only one data to evaluate global distribution of CUE in ESMs. For more accurate and realistic validation of numerical models, more fine spatial and temporal in-situ based observation data are needed. We added this discussion in L548-550 and L592.

Specific comments: Map figures should be broken at the date line, not the prime meridian. Currently, a large fraction of the middle of these plots is blank Pacific Ocean, and it is hard to discern behavior in Africa and Europe.

⇒ We modified it.

Figure 2: it is not necessary to show both the 2000-2005 and 1983-2005 maps. You can show the 2000-2005 map and just say that the longer-period map is similar.

⇒ We decided to keep the figure as in the original, as the data sampling issue might be an important issue to some of readers concerning the interannual variability such as ENSO. Reanalyses of temperature and humidity are observationally-based, but precipitation, even for a reanalysis is based at least to some extent on models. I'm not sure how reliable any global precipitation map is, even the observational/satellite products like GPCP or TRMM

⇒ The surface air temperature and precipitation data are not based on model or reanalysis but the gridded observations from CRU (L241-245).

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Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/bg-2016-536/bg-2016-536-AC2-supplement.pdf

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	Kim et al. (2017)	Delucia et al. (2007)	Amthor (2000)	Choudhury (2000)	Zhang et al. (2009)	Average (STD)
ENF	0.59	0.41	0.61	-	0.56	0.54 (0.09)
EBF	0.41	0.32	0.54	0.42	0.32	0.40 (0.09)
DNF	0.63	0.59	0.76	-	0.59	0.64 (0.08)
DBF	0.42	0.46	0.67	-	0.51	0.52 (0.11)
MF	0.60	0.45	-	-	0.41	0.49 (0.10)
SHR	0.54	-	0.50	0.45	0.52	0.50 (0.04)
GRA	0.54	-	0.49	0.52	0.51	0.51 (0.02)
CROP	0.52	-	0.45	0.56	0.52	0.51 (0.05)

Fig. 1. Comparison of averaged CUE for each PFTs. ENF is evergreen needleleaf forest, EBF is evergreen broadleaf forest, DNF is deciduous needleleaf forest, DBF is deciduous broadleaf, MF is mixed forest, SHR

STN	Lon	Lat	STN	Lon	Lat	STN	Lon	Lat	STN	Lon	Lat
BE-Bra	4.52	51.31	DE-Hai	10.45	51.08	IT-SRo	10.28	43.73	US-Syv	-89.35	46.24
BE-Vie	6.00	50.31	DE-Geb	51.10	10.91	NL-Loo	5.74	52.17	US-Ton	-120.9	38.43
BR-Sa3	-54.97	-3.02	DE-Tha	13.57	50.96	RU-Fyo	32.92	56.46	US-UMB	-84.71	45.56
CA-NS1	-98.48	55.88	DK-Sor	11.64	55.49	US-Blo	-120.6	38.90	US-Var	-120.9	38.41
CA-NS2	-98.52	55.91	DK-ZaH	-20.55	74.47	US-Cop	-109.3	38.09	US-WCr	-90.08	45.81
CA-NS3	-98.38	55.91	FI-Hyy	24.30	61.85	US-GBT	-106.2	41.37	US-Wi0	-91.08	46.62
CA-NS4	-98.38	55.91	FI-Jok	23.51	60.90	US-Ha1	-72.17	42.54	US-Wi3	-91.10	46.63
CA-NS5	-98.49	55.86	FI-Sod	26.64	67.36	US-Los	-89.98	46.08	US-Wi4	-91.17	46.74
CA-NS6	-98.96	55.92	FR-Pue	3.60	43.74	US-MMS	-86.41	39.32	US-Wi6	-91.30	46.62
CA-NS7	-99.95	56.64	IT-Col	13.59	41.85	US-Ne1	-96.48	41.17	ZA-Kru	31.50	-25.02
CA-Qfo	-74.34	49.69	IT-Cpz	12.38	41.71	US-Ne2	-96.47	41.16	ZM-Mon	23.25	-15.44
CA-SF2	-105.8	54.25	IT-La2	11.29	45.95	US-Ne3	-96.44	41.18			
CA-SF3	-106.0	54.09	IT-Ren	11.43	46.59	US-NR1	-105.5	40.03			
CH-Dav	9.86	46.82	IT-Ro1	11.93	42.41	US-PFa	-90.27	45.95			

Fig. 2. Locations of 53 FLUXNET GPP tower sites.

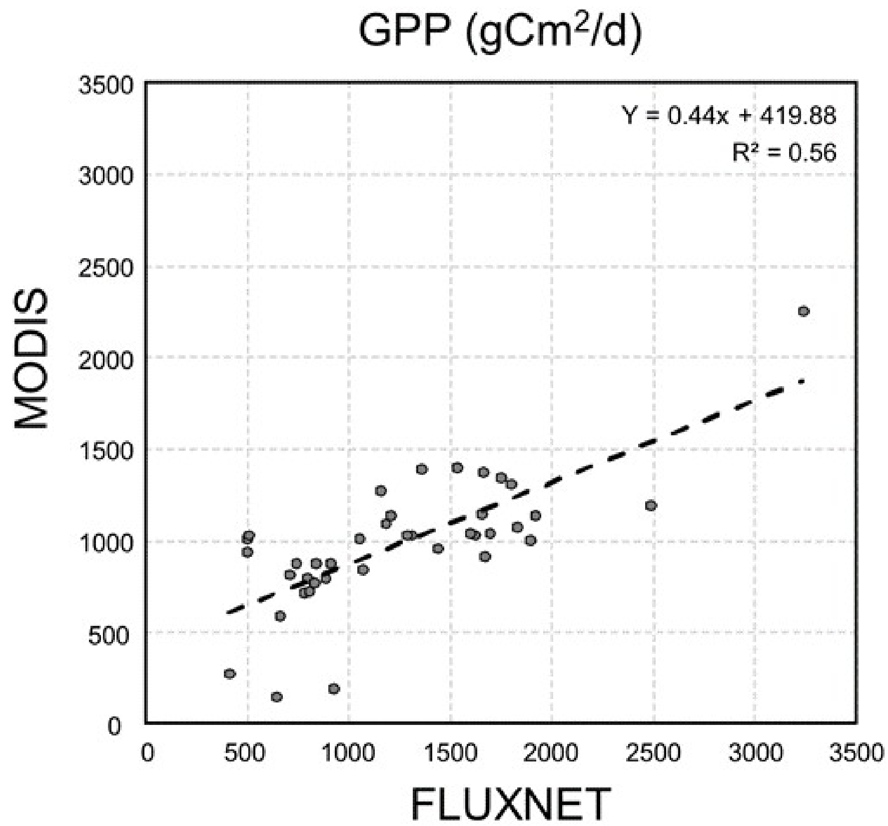

Fig. 3. Comparison of averaged GPP measured for 6 years (2000-2005) at the 53 tower sites and MODIS GPP gridded areas which are coincided with tower sites.

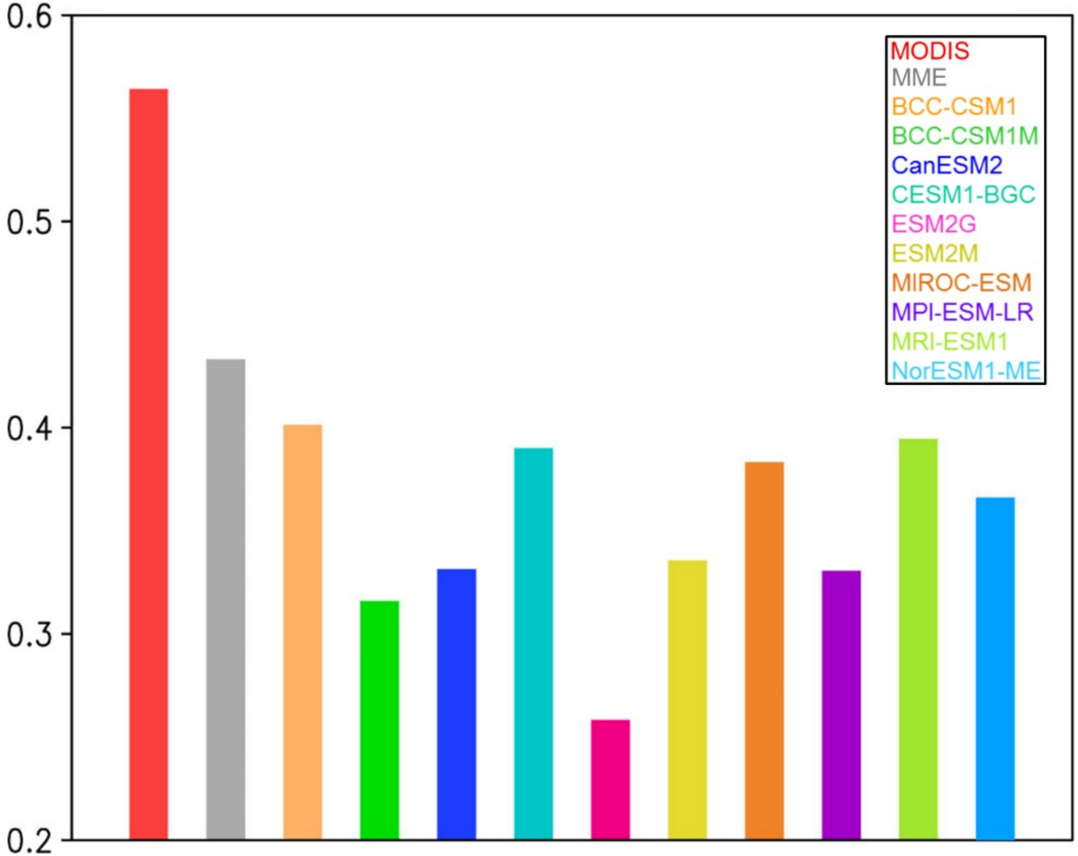

Fig. 4. R-squared values of GPP at 53 tower sites, MODIS and 10 CMIP5-ESMs.

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