For clarity purpose, we have listed the reviewer's comments in bold italics, authors' response in the normal font. The changes made in the manuscript are in normal italics font.

We have added one new Table 1. Table 3 (old Table 2) has further been modified. In addition, we have added two new figures: Figure 1 (old Figure S1, which has further been modified based on the reviewers comments) and Figure 4 (old Figure S2). The numbers for the rest of the figures have been changed accordingly: Figure 2 (old Figure 1), Figure 3 (old Figure 2); Figure 5 (old figure 3), Figure 6 (old Figure 4), and Figure 7 (old Figure 5).

Authors' Response to Reviewer #2 Comments

1. The evaluation of the (detailed) model does not give a lot of information about what is gained by the complex parameterizations, as a clear benchmark is lacking. A lot of the results shown in figs 1 and 2 can probably also be found using a statistical regression model (see Abramowitz et al, 2008, for a nice demonstration of the added value that is actually added by a model to the information that is already contained in the forcing)

Response: (1) To address your comment, we have now introduced a benchmark experiment (ISAM-Static). The ISAM-Static experiment accounts for the fixed carbon allocation scheme, prescribed LAI from remote sensing data, fixed canopy height, root depth and root allocation fraction in the soil layer. All these static processes were considered in the original version of the ISAM.

The different static processes considered in the ISAM-Static experiment are also calibrated based on the measured data. Thus the comparison of Willmott's index between ISAM-Static and ISAM-Dynamic experiments could indicate how much the carbon and energy flux simulations are improved due to the implementation of dynamic crop growth processes. See the added text at the beginning of section 4.2 for experiments description and section 4.2.1for ISAM-Static result discussion. The results discussions of each other new benchmark experiment are added in the sections 4.2.2, 4.2.3 and 4.2.5, whereas the section 4.2.4 is the same as the text as the section 4.2 of the previous manuscript.

"4.2 The Effects of Different Dynamic Processes on Modeled Results
In this section we evaluate the importance of four dynamic process considered in this study, (1) dynamic carbon allocation, (2) dynamic LAI, (3) dynamic root distribution and (4) dynamic scale height by performing following additional model simulations:
ISAM-Static: This model is based on fixed carbon allocation, prescribed LAI, prescribed canopy height, as well as prescribed root depth and root allocation faction in each soil layer. All these four processes have been included in the original version of ISAM (El-Masri et al., 2013).
ISAM-StaticC: Same as ISAM-Dynamic experiment, but the carbon allocation parameterization is based on fixed carbon allocation scheme as assumed the original version of the ISAM.

ISAM-StaticLAI: Same as ISAM-Dynamic experiment, but uses prescribed LAI development as assumed in the original version of the ISAM.

ISAM-StaticR: Same as ISAM-Dynamic experiment, but uses pre-determined root depth and root fraction for each soil layer in space and time as assumed in the original version of the ISAM.

ISAM-StaticH: fixed canopy height parameterization, but uses fixed canopy height parameterization as assumed in the original version of the ISAM.

In the original version of the ISAM (El-Masri et al., 2013), referred to here ISAM-Static, the carbon allocation fractions for leaf, stem, root and grain pools for each phenology stage are assumed to be the same values as in the case of ISAM-Dynamic but without accounting for limitation of water, light and nutrients (Table A1) and these fraction values are assumed to be the same for each model year run. The LAI is not dependent on the carbon allocation simulation as in the case of ISAM-Dynamic experiment, rather the LAI values in the original version of ISAM are attained from multiyear average site-specific MODIS land product subsets (ORNL DAAC, 2011). The root distribution in the ISAM-Static is calculated based on the root depths at which plants have 50% of their total root biomass and a dimensionless shape-parameter for describing root profile (Schenk and Jackson, 2002). Since the static root distribution case assumes no temporal variation in root fraction in each soil layer, we use average value of three observed corn root profiles (see section 3) to calibrate the static root distribution case. The fixed canopy heights in the ISAM-StaticH experiment are assumed to be the maximum canopy height of specific vegetation type (Ha) from Ameri-Flux data sets (Table A1).

In order to evaluate the performance of integrated effects of dynamic crop growth processes implemented in this study (ISAM-Dynamic case) and the individual dynamic crop growth processes, we compare the Willmott indexes (dr_d) for carbon and energy fluxes based on individual five experiments discussed above with the estimated dr_d for ISAM-Dynamic case (Table 3).

4.2.1 Static versus Dynamic Crop Growth Processes
The Willmott index values (dr_d) for daily mean GPP, Rn, H and LH fluxes in ISAM-Dynamic case are higher than that in ISAM-Static case and several are much closer to 1, except for no apparent improvement in dr_d values for corn GPP and Rn fluxes at the Bondville site (Tables 3). These results suggest that the implementation of dynamic crop growth scheme in ISAM significantly strengthens the ability of model to capture seasonal variability in measured carbon and energy fluxes for crops. No differences in dr_d values for corn GPP and Rn fluxes at the Bondivlle site for ISAM-Dynamic and ISAM-Static experiments are due to that fact that processes considered in both experiments are unable to capture a crop lodging effect, as discussed in section 4.1.

4.2.2 Static versus Dynamic Carbon Allocation
Figures 1b, e, h, k show that the estimated aboveground biomass for corn and soybean are in much better agreement with measurement for ISAM-Dynamic case than for ISAM-StaticC case. In addition, ISAM-Dynamic case better captures the seasonal variability in leaf carbon mass, as indicated by LAI (figures 1a, d, g, j), and the root carbon biomass

(figures 1h, k) than the ISAM-StaticC case. The improvements in estimated seasonal aboveground biomass, leaf and root carbon biomass for ISAM-Dynamic case are more for soybean than for corn at both sites. These results indicate that the dynamic carbon allocation scheme in the ISAM-Dynamic case is able to capture the response of carbon allocation to water, temperature, light stresses, leading to a better simulation of aboveground total biomass and leaf carbon amount. With better simulated seasonal variability in carbon allocations, the dr_d values for GPP, H and LH calculated based on ISAM-Dynamic case are generally closer to 1 than based on ISAM-StaticC case (Table 3), except for corn GPP at Bondville site. No improvement in corn GPP at Bondville for ISAM-Dynamic is because the model is unable to capture the sharp reduction in GPP due to crop lodging with gusty wind, as discussed in section 4.1, even after accounting the dynamic processes. Nevertheless, our results suggest that implementation of the dynamic carbon allocation parameterizations improves the model estimated results for GPP, H and LH fluxes, especially for soybean.

4.2.3 Static versus Dynamic LAI
Figures 1a, d, g, j show that prescribed LAI usually underestimates LAI over the growing seasons at both the Mead and Bondville sites. In addition, prescribed LAI is not able to partition ground vegetation LAI and crop LAI, leading to a wrong estimates of growing season length for the crop. The underestimation of the LAI over the growing season results in underestimation of the amount of solar radiation absorbed by the canopy, leading to underestimation of GPP and LH, but overestimation of H. In contrast, the ISAM-Dynamic version of the model, which accounts for the dynamic green and brown LAI parameterizations, is able to capture observed seasonal variability in LAI (Figures 1a, d, g, j). As a result of this, ISAM-Dynamic based GPP, Rn, H and LH fluxes for corn and soybean at both sites are in much better agreement with the observations than in the case of ISAM-StaticLAI, except for corn GPP and Rn at the Bondville site. The dr_d values for ISAM-Dynamic are higher by 2-13% for Rn, 3-41% for GPP, 18-39% for H and 19-35% for LH at both sites than for ISAM-StaticLAI case (Table 3). The improvement for soybean is usually larger than for corn. The less improvement for corn GPP and Rn at the Bondville can be attributed to the fact that ISAM-Dynamic and ISAM-Static cases are unable to capture gusty wind effect on LAI.

4.2.4 Static versus Dynamic Root Distribution
Text in this section is same as it was in the original manuscript(section 4.2)

4.2.5 Static versus Dynamic Canopy Height
Table 3 shows that dr_d values have small differences between ISAM-StaticH and ISAM-Dynamic cases, relative to comparisons discussed above, indicating that the implementation of dynamic canopy height simulation does not apparently improve the carbon and energy fluxes for these crops. This is perhaps due to the fact that there is no large seasonal variability in canopy height for corn and soybean. Thus, replacing prescribed canopy height to seasonally variable canopy height does not significantly change the atmospheric turbulence above the crop canopy or the carbon and energy fluxes.

Table 3. The Willmott index (dr_d) to quantify the degree to which observed daily mean GPP and energy fluxes are captured by the model for corn and soybean at the Mead and Bondville sites. The n is the number of observation at the daily step.

Data	Sites	Crop	n	dr_d (ISAM-Dynamic)	dr_d (ISAM-Static)	dr_d (ISAM-StaticC)	dr_d (ISAM-StaticLAI)	dr_d (ISAM-StaticR)	dr_d (ISAM-StaticH)
GPP	Mead, NE	Corn	235	**0.86**	0.50	0.77	0.61	0.57	0.84
		Soybean	232	**0.83**	0.60	0.70	0.63	0.72	0.83
	Bondville, IL	Corn	232	**0.71**	0.69	0.71	0.69	0.71	0.71
		Soybean	207	**0.92**	0.81	0.83	0.83	0.81	0.92
Rn	Mead, NE	Corn	235	**0.89**	0.81	0.89	0.84	0.88	0.89
		Soybean	232	**0.90**	0.80	0.87	0.82	0.88	0.86
	Bondville, IL	Corn	232	**0.83**	0.82	0.82	0.81	0.83	0.82
		Soybean	193	**0.93**	0.81	0.81	0.82	0.81	0.92
H	Mead, NE	Corn	235	**0.71**	0.31	0.66	0.57	0.30	0.71
		Soybean	232	**0.68**	0.47	0.46	0.49	0.50	0.68
	Bondville, IL	Corn	178	**0.47**	0.19	0.29	0.40	0.19	0.40
		Soybean	135	**0.77**	0.61	0.61	0.62	0.61	0.77
LH	Mead, NE	Corn	235	**0.87**	0.50	0.81	0.70	0.55	0.80
		Soybean	232	**0.77**	0.57	0.63	0.59	0.64	0.76
	Bondville, IL	Corn	178	**0.50**	0.37	0.42	0.42	0.40	0.49
		Soybean	135	**0.88**	0.65	0.65	0.65	0.64	0.87

(2) We agree with your comment "**A lot of the results shown in figs 1 and 2 can probably also be found using a statistical regression model**" However, the purpose of this study is to build a more advanced process based model, which could capture the dynamic response of the crop growth under the different environmental conditions and thus could improve the ability of ISAM land surface model to explore the interactions between crop growth and climate change at global scale. On the other hand, statistical models may be able to simulate the observed behavior at a site level, but these models cannot be used to study the interactive feedback mechanisms. Therefore, instead of using a statistical regression model, here we use a process based land surface model.

2.A second point that needs additional attention is the seemingly large bias in the sensible heat flux. Details on how the energy balance is solved in this model are not given, but I assume that the model preserves energy and that the mismatch in sensible heat is compensated by a large mismatch in soil heat flux, and thus that there may be a problem in partitioning heat between soil and atmosphere. That is not clear from the discussion and the treatment of the observations/model outputs.

Response: Your assumption is correct. The energy is conserved in the ISAM
We agree with you that the mismatch in modeled H is compensated by the mismatch in soil heat fluxes. To clarify this point, we added a statement.

"In addition, the overestimated H is also partly attributed to the mismatch in energy partitioning between soil and atmosphere. We find that the model underestimates ground heat flux, leading to an overestimation of H fluxes (not shown)."

3.I would suggest to reorganise the manuscript by focusing on this root allocation procedure, where you can define a clear benchmark experiment by comparing the two strategies and calculate the statistical significance of the difference between the two simulations.

Response: As discussed above, we have now introduced a series of benchmark experiments to evaluate the statistical significance of each of the implemented dynamic crop growth process (See our detailed response to comment#1).

4.9902-22: the Smith et al (1976) is an old reference. Is there newer literature that supports their findings?

Response: As suggested, we have now added additional reference (Kennedy and Johnson, 1981), which supports the findings of Smith et al (1976).

The full information of new added reference is as follows:
Kennedy, R. A. and Johnson, D.: Changes in photosynthetic characteristics during leaf development in apple, Photosynth. Res. 2, 213-223, 1981.

5.9905-22: to a non-agronomist "silk emergence" is not a clear term. Please explain

Response: We have added a brief explanation.

"As a plant with separate male and female flowering parts, the ear represents the female flower of the corn plant. The silks are the functional stigmas of a corn plant, which collect pollen and transmit the male genetic material to ova and produce viable kernels. Silk emergence from the ear shoot is a critical process in the production of corn grain (Aldrich et al., 1986)."

6.Eq 1: the storage term is a bit strange here: it depends on the time scale how large this term is: at the seasonal time scale S should be zero: what is stored has to come out eventually. But in your equation S seems to be a systematically positive term (S ~ Rn and the mean of Rn > 0) which is physically not consistent. Please discuss the time scale issue of S

Response: We agree that the storage term S over the growing season is zero. The equation (Eq. 1) is applied for data at hourly time interval over two growing seasons for each crop. So, the term S could be positive during certain hours of the day, but not always. According to Meyers and Hollinger (2004), the hourly S during the morning time (UTC 6:00-12:00) of growing season of corn and soybean are estimated to be 14% and 8% of hourly *Rn* at the Bondville site, and gradually reduce to 2% and 0% of hourly Rn by the time of UTC 17:00.

To clarify the time scale of S term, we have revised the equation and text (See Pages 13-14, Lines 412-422).

$$f = \frac{\sum_{i=1}^{i=N}(Rn_i - G_i - S_i)}{\sum_{i=1}^{i=N}(LH_i + H_i)}$$

Eq.1

where f is the correction factor. N is the total number of available data at hourly time interval over two growing seasons for each crop. Thus, f shows an overall evaluation of energy balance closure over two growing seasons for each crop. The corrected LH or H is calculated by multiplying the measured LH and H fluxes with f. All the energy flux terms, except for storage energy term (S), are measured at the two sites. We assume S for the Bondville site to be 14% and 8% of hourly Rn during the morning time (UTC 7:00-12:00) of growing seasons for corn and soybean, respectively (Meyers and Hollinger, 2004). This fraction of hourly S gradually reduces to 2% and 0% of hourly Rn by the end of UTC 17:00. For the Mead site, Suyker and Verma (2010) have estimated the corrected energy fluxes for the period 2001-2006, which we apply here.

7.Eq 2: please discuss the implication of Wilmott's metric before presenting the equation (move 9910-10 to 14 upward). Does this metric subtract the climatological cycles (seasonal, diurnal) before evaluating the skill? Otherwise high skill can already be obtained if the first order cycles are represented, which is not difficult to achieve

Response: As suggested, we have moved the sentence related to implication of Willmott's metric before presenting the equation.

We agree with your comment that without subtracting seasonal and diurnal climate variability high skill can be easily obtained. But, the Wilmott metric does not subtract the climatological cycles before evaluating the skill. In this study Willmott index analyzes hourly/half hourly time-series data. This point has already been addressed at the beginning of section 3.3 of the original manuscript.

8.The reason why S1 and S2 are placed in a Supplement is not clear to me. Why not included in the main text? Please reconsider when the structure of the paper is revised

Response: We have moved the figures S1 and S2 (Now Figures 1 and 4) and corresponding discussion to the main text of the revised manuscript. In addition, we have further modified the Figure 1 based on the reviewers' comments

9. 9913-13 (and more places): replace "daily pattern" by "seasonal cycle"

Response: We have replaced the "***daily pattern" by "seasonal cycle"*** wherever it is appearing in the manuscript.