Interactive comment on "Sensitivity analysis of the GEMS soil organic carbon model to land cover land use classification uncertainties under different climate scenarios in Senegal" by Dieye, Roy, et al.

Response to Anonymous Referee #2

Our responses to Referee #2's interactive comments are below in red.

The paper of Dieye et al. addresses an important and relevant issue for the biogeoscience modeling community which make heavily use of satellite data input for process based models. The paper is well written and clear although the numerical experiments are rather complex. I have few comments that I hope will be addressed by the authors in a resubmission paper :

We thank Referee #2 for her/his positive endorsement of our work.

1. There is a complete lack of "in situ" validation besides some general broad values assessment by literature. I understand that the goal was to assess the GEMS sensitivity but I would have been more confident if some more evidence of measured SOC and NPP data corroborate the model outputs at different spatial scales.

Not Done: It is beyond the scope of our paper to validate the model run outputs by comparison with independently collected ground based SOC or NPP estimates; as Reviewer #2 notes, this paper is a model sensitivity analysis paper. The GEMS model is well established and we do corroborate our model results by comparison with other researcher's results for the study region, specifically we state in Section 7.2.1 (2nd paragraph) with reference to Table 4 and Figs. 3 and 4:

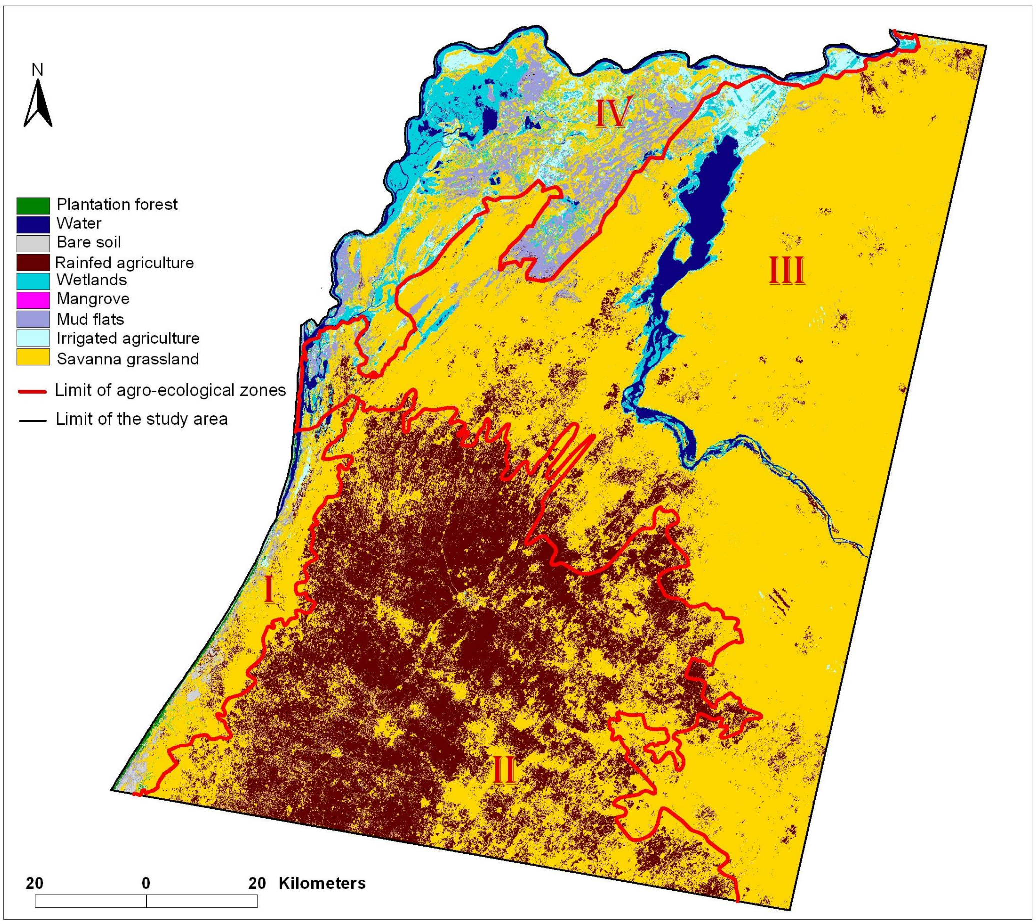
- *"The mean class SOC values range from 480.2 gCm2 (Bare soil) to 1487.5 gCm2 (Irrigated agriculture) with a mean study area SOC of 1219.3 gCm2 or 12.193MgCha which is in general agreement with other worker's Senegalese estimates (Toure, 2002; Manlay et al., 2002; Toure et al., 2003; CSE, 2004). "*
- *"The mean study area NPP is 185.1 gCm2/yr, which is in agreement with the results of Parton et al. (2004) who estimated NPP values up to 200 gCm2/yr in this region using the CENTURY model and coarser 10km resolution input data."*

2. The comparison between large scale and pixel based discussion is very limited, although, at least the spatial scale, seems the most sensible to LULC. I would suggest that for agronomic purposes and in general for the stakeholders needs, it would also be very interesting to work with agro-ecological zones in order to provide at that level the assessment of uncertainties.

Done: We agree that the most appropriate scale is the one that we use but that consideration of agro-ecological zones is useful. Accordingly, we have included new results and revised Figure 1 to show agro-ecological zones. **Note that by doing this we also partially address Referee #1 comment 3 concerning the dominant land covers in the study area.**

We request that Figure 1 be replaced with the following revised version that shows the 4 agro-ecological zones in red:

Figure 1 *Landsat 28.5m hard decision tree classification of the study area in north-western Senegal, covering 1560 km^2 lying 15º24' - 17º00' W and 15º00' - 16º42' N. Dry and wet season 2002 Landsat data were classified using a bagged decision tree classification procedure into 9 land cover land use classes (plantation forest, water, bare soil, rainfed agriculture, wetlands, mangrove, mud flats, irrigated agriculture, and savanna grassland). The study area is shown bounded by a black vector. White shows unclassified (clouds, cloud shadows, settlement areas, or no Landsat data). The boundaries of the four main agro-ecological zones (I: Niayes; II: Peanut Basin; III: Sandy Ferlo; and IV: Senegal River Valley) are shown as red vectors.*



We request that Line 27 of Page 6592 and Line 1 of Page 6593 be changed
FROM:
"In order to summarize the region succinctly we refer to the Senegalese ecoregions defined by Tappan et al. (2004). The study area encompasses four of the 13 ecoregions, and these are described below."

TO:

"In order to summarize the region succinctly we refer to the Senegalese agro-ecological zones defined by Tappan et al. (2004). The study area encompasses four zones, and these are illustrated in Fig. 1 and are described below."

We wish to include a new table, now named Table 5, that tabulates for each agro-ecological zone the minimum, mean and maximum SOC derived for the 9 LCLU classes within each zone and the percentage cover of each LCLU class in each zone. Please include this new table:

Table 5 Comparison by agro-ecological zone of the minimum, mean and maximum SOC (gC/m^2) (Fig. 3) for the 9 LCLU classes using the year 2000 hard classification (Fig. 1). The LCUC percentage area in each zone is shown in parentheses. Only pixels where SOC was modeled are considered (i.e., not water bodies, clouds, cloud shadows, settlement areas, or where there was no Landsat data).

	Agro-ecological zone											
	Niayes			**Peanut basin**			**Sandy Ferlo**			**Senegal River Valley**		
LCLU classes	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**
Plantation forest	452	948.6 (3.36%)	1522	1108	1373.0 (0.01%)	1471	454	1296.1 (0.4%)	1525	452	1164.3 (1.2%)	1525
Bare soil	358	534.9 (6.1%)	1491	358	991.3 (0.1%)	1487	370	688.0 (0.01%)	1411	370	654.1 (0.2%)	1478
Rainfed agriculture	519	1385.8 (5.7%)	1858	518	1422.3 (56.7%)	1890	519	1390.2 (5.8%)	2183	534	1407.2 (0.1%)	2655
Wetlands	371	948.6 (0.9%)	1512	379	1075.1 (0.02%)	1471	353	1040.0 (2.4%)	2064	262	1106.7 (22.8%)	2088
Mangrove	455	969.3 (0.01%)	1474	–	– (0.0%)	–	–	– (0.0%)	–	483	1084.7 (0.01%)	1573
Mud flats	353	682.5 (7.4%)	1535	358	944.5 (2.2%)	1522	353	669.7 (2.0%)	1537	370	639.8 (21.66%)	1537
Irrigated agriculture	417	1174.6 (3.0%)	1830	576	1328.2 (0.03%)	1590	417	1507.7 (2.7%)	4138	417	1356.8 (12.67%)	2390
Savanna	411	1205.3 (73.53%)	1538	416	1258.6 (40.94%)	1541	411	1210.6 (86.69%)	1543	411	1127.2 (41.36%)	1543
Over all the study area	353	1124.5 (100%)	1858	358	1344.3 (100%)	1890	353	1214.3 (100%)	4138	262	1046.1 (100%)	2655

We request that the following Table 5 explanatory text be inserted as a new final paragraph to Section 7.2.1 (i.e. inserted after Line 10, Page 6609):

"Table 5 summarizes the LCLU class minimum, mean and maximum SOC defined by the hard classification, and LCLU class percentage area, for each agro-ecological zone (Fig. 1). Comparison with the corresponding Table 4 study area LCLU class SOC statistics reinforces that geographic differences in the GEMS input data introduce SOC variability for any given LCLU class. For example, the savanna grassland class is highly prevalent in all four zones (varying from 41% to 87%), and although the mean savanna SOC for the entire study area is 1212 gC/m^2 *(Table 4) the zonal mean savanna SOC varies from 1127* gC/m^2 *(Senegal River Valley) to 1259* gC/m^2 *(Peanut Basin) (Table 5). The agro-ecological zone with the highest mean SOC is the Peanut basin (1344 g* C/m^2*), followed by the Sandy Ferlo (1214 g* C/m^2*), Niayes (1124 g* C/m^2*) and the lowest is the Senegal River Valley (1046 g* C/m^2*). This pattern reflects the SOC of the predominant LCLU classes. For example, the Peanut basin is predominantly rainfed agriculture (57%) and savanna (41%) which have high mean study area SOC (Table 4) and the Senegal River Valley zone includes the greatest proportion of mud flats (22%) which has nearly the lowest mean study area SOC (Table 4)."*

As consequence of adding this new Table 5, the subsequent tables should be renamed. Thus, Table 5 in page 6609 line 15 should read Table 6; Table 5 in page 6609 line 23 should read Table 6; Table 6 in page 6611 page 25 should Table 7; and Table 6 in page 6612 should read Table 7.

3. The findings of the paper refer to GEMS modeling framework, but how to generalize this finding to other process based models?

Done: We request that the following sentence be added to Line 6, Page 6613, after "…. under different climate scenarios.":

"The approach could be utilized by other biogeochemical models that use spatially explicit LCLU parameterizations."

and, related, please change Line 6, Page 6613, "The study was undertaken…" to "*This study was undertaken* …".

We request that the following new short paragraph be added as the final revised paper paragraph at the very end of the conclusion:

"This research has demonstrated a method to estimate the variability of GEMS modeled SOC due to satellite classification errors. The method can be applied to other biogeochemical models that use spatially explicit land cover land use (LCLU) parameterizations by running the model with a single hard and multiple soft LCLU classification inputs to infer model sensitivity. The Senegalese findings described in this paper can only be generalized to other process based

models by repeating the described method with the new model. This is because of the non-linear dependency of the GEMS SOC estimates on LCLU and because, as we have demonstrated for specific LCLU classes at the study area scale and for four agro-ecological zones, the SOC uncertainty due to satellite classification errors is dependent not only on the LCLU classification errors but also on where the LCLU classes occur relative to the other biogeochemical model inputs.

4. The conclusion section needs to be shortened and focused. Most of the text repeat the goals and methods of the paper and not the real conclusions. Such as added value of the findings for the modeling community, large versus pixel scale, possible new space sensors better addressing local scale etc.

Done: We request the following shortening and focusing changes (in addition to the new conclusion text we request to be added as above):

Remove the second paragraph of the Conclusion (Lines 10-23, Page 6613).

Remove the third paragraph of the Conclusion (Lines 24-29, Page 6613 and Lines 1-3, Page 6614).

Add the following text to the end of Line 7, Page 6615:

"There are a number of recent and planned spaceborne sensors with very high (<10m) spatial resolution (Norris 2011) and in conjunction with next generation freely available Landsat and similar high spatial resolution systems designed for land cover monitoring (Wulder et al. 2008, 2011) they provide opportunities for high resolution LCLU biogeochemical model parameterization and LCLU mapping uncertainty assessment. "

Wulder, M. A., White, J. C., Goward, S. N., Masek, J. G., Irons, J. R., Herold, M., .Cohen, W.B.; Loveland, T.R.; Woodcock, C.E. , 2008, Landsat continuity: issues and opportunities for land cover monitoring, Remote Sensing of Environment. 112: 955-969.

Wulder, M.A., White, J.C., Masek, J.G., Dwyer, J., Roy, D.P., 2011, Continuity of Landsat observations: Short term considerations, Remote Sensing of Environment, 115: 747-751.

Norris, P., 2011, Developments in high resolution imaging satellites for the military, Space Policy, 27:44-47.