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Earth System Dynamics
Discussions

Interactive comment on "Impacts of future agricultural change on ecosystem service indicators" *by* Sam S. Rabin et al.

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Excellent attempt to evaluate scenarios for implications on ecosystem services including trade-off and co-benefits. LandSyMM represents state-of-the-art in modelling of the land-use & vegetation. This type of work is extremely relevant for ecosystem service provision in the context of the Paris Agreement (food-energy-water nexus and beyond). Follows on from earlier studies, e.g. Krause et al., 2017.

Overall I enjoyed reading the manuscript and warrants publication. I found it very informative and represents a substantial amount of work and scientific progress. A minor edit is warranted in the methods section which I found confusing in places. It could be improved as it was difficult to work out exactly how the models link together and

finally the number of runs made. The authors also need to clearly distinguish general text explaining processes from what's actually included in the models. I found the results/discussion section comprehensive and complemented with extremely informative figures. Interesting new advances on attempting to relate flood/drought (see specific comment below), and the link to land loss in biodiversity hotspots.

Minor comments:

28% nitrogen pollution -> aquatic systems, air pollution? Unclear from line 75-90 how nitrogen pollution is quantified/considered in the LPJGUESS (this section is more an introduction to N pollution)

Line 24 "As global environmental and societal changes continue to accelerate over the coming decades,". Somewhat vague. Are we sure changes are and will accelerate. LandSyMM represents state-of-the-art in modelling of the land-use & vegetation. However this advance is not entirely clear. Lines 35-40 could be improved to demonstrate the advance beyond existing IAMs. e.g. "is unique among global land-use change models in the high level of spatial detail that it considers in the response of agricultural yields to management inputs, as well as in allowing short-term over- and under-supply of commodities relative to demand (rather than assuming market equilibrium in every year)" . Vague – what does high-level of spatial detail mean? I wonder if a table contrasting CMIP6 IAMs with LandSyMM would be useful. Also perhaps a real world example can be given to demonstrate the importance of the non-equilibrium assumption (i.e. is this a detail or fundamental). Perhaps the authors can elaborate more on the differences between PLUM and other LU model approaches in section 2.2

Very good coverage of LPJGUESS, however somewhat generic in places. The authors should explicitly state which metrics are calculated for ecosystem services, e.g. how is nitrogen pollution calculated? (at first it gives the impression of some combination of health, water quality, air pollution impacts on vegetation indices; are these processes modelled in LPJGUESS?), i.e. this text gives a more general description of nitrogen

pollution, rather than what is actually modelled in LPJGUESS. Good attempt, but I'm not entirely convinced of the approach for changing flood risk based on monthly runoff – I think this should be raised again in the discussion as a potential limitation/uncertainty. As noted by the authors they apply the Asadieh and Krakauer 2017 approach but use monthly surface runoff data. The authors should state the temporal resolution the model is applied (I assume monthly?). As I understand LPJGUESS outputs per gridcell 1) monthly total N Loss 2) monthly runoff 3) annual land conversion in hotspots, and then interpreted in terms of nitrogen pollution (but no additional metrics used), flood/drought risk (using AK 2017 metric), and loss of land in biodiversity hotspots.

Somewhat confusing section 2.3 on simulation details For example, Line 115-120 "In each scenario, every grid cell is planted with each crop type, each of which is given six different management treatments in a factorial setup: fertilization of 0, 200, and 1000 kgN ha–1 and either no irrigation or maximum irrigation." Why? Somewhat comes out of the blue. Then in 2.3.3 experimental setups Lines 180-190 "In addition to the LPJ-GUESS runs forced with PLUM-output land use and management trajectories (harmonized as described in Sect. 2.3.1), six experimental runs were performed for each scenario, to disentangle the direct effects of climate change (including CO2 concentration increases) from those of land use and management change. " This is another 6 simulations?

Then there's PLUM-forced runs. So I assume this is not the standard approach to running LandSyMM (i.e. PLUM coupled to LPJGUESS), i.e. how frequent is information from LPJGUESS and PLUM exchanged (annually, e.g. potential yields line 167?) Perhaps consider a table with a full list of the simulations would help the reader. Line 140 "The calibration run was forced with climate data from CRU-NCEP version 7 (Le QueÌĄreÌĄ et al., 2016), but with CRU TS3.24 precipitation (Harris et al., 2014) due to problems discovered in the CRU-NCEP precipitation data" What were the problems? (others are using CRUNCEP7 so would gain from this information)

Line 143 IPSL-CM5A-MR – what's the climate sensitivity of the IPSL model? Why

was this selected? (what are the characteristic features of this GCM future prediction), for example which areas are projected to have higher / lower precipitation, as this will govern the simulated flood/drought risk (and affect the other ecosystem services studied?). For example, around line 327 perhaps add some text / speculate on impact of using one climate model for regional runoff. E.g. Figure 5, perhaps it would be useful to include a map of change in precipitation (and temperature) to give the reader a feeling for the importance of choice of GCM.

Line 146 onwards. "Time-evolving historical land use fractionsâĂŤi.e., the fractions of land in each gridcell that are natural vegetation, cropland, pasture, or barrenâĂŤwere taken from the Land Use Harmonization v2 dataset (LUH2; Hurtt et al., in prep.). The MIRCA2000 dataset (Portmann et al., 2010) provided crop type distributions for the year 2000, which were used for all historical years." I'm a bit confused what is used here. So LUH2 give the cropland coverage, but not which crops, that's given from MIRCA2000 and relative proportion of individual crop types stay fixed through time over the historical period?

Lines 168 onwards describe the SSPs. I think this generic text would work better if it came earlier (SSPs have already been mentioned in several places already).

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