Responses to Referee #1

The Referee's suggestions were thoughtful and constructive, and the revised manuscript is much improved as a result. Specific responses are detailed below.

Comment #1) *The authors indicate in Section 1 of their paper that emissions from LULCC are not the same as the flux of carbon between the land and atmosphere, but that it is difficult to separate this flux into the net emissions attributable to LULCC and those attributable to natural and indirect human effects. However, they do not give many details of how each model attempts to separate these effects when computing their estimates of emissions from LULCC. They do hint on this a little in Section 6, but some further information (if available) about the attribution methods in these models would be useful (i.e., do they compare simulations both with and without land-use, compare results both with and without climate change, etc).*

Response: We have added the following paragraphs to the paper:

While bookkeeping models use rates of growth and decay that are fixed (time-invariant) for different types of ecosystems, process-based models simulate these processes as a function of climate variability and trends in atmospheric CO2. Most modeling analyses present results from several different runs (including, for example, climate alone, climate with CO2, LULCC alone, etc.). We chose those results which represented most closely the net flux of carbon from LULCC as defined by the bookkeeping approach by Houghton (2003). In particular, we used estimates that do not include the response of (managed and unmanaged) vegetation to an increase in atmospheric CO2 concentrations and to climate changes. For example, Arora and Boer (2010) included these responses in their "land use flux" but not in their "bookkeeping flux", which is the estimate we used. Strassmann et al. (2008) also provided both options. Estimates from Piao et al. (2009) and Van Minnen et al. (2009) were exceptions: they did not include an analysis without CO2 and climate effects) (Table 1). Most process-based models were usually run with and without LULCC, and the difference between the two runs was taken to yield the net effects of LULCC. The exercise is not perfect, because the effects of CO2 fertilization on undisturbed forests may differ, for example, from the effects on croplands or on secondary forests recovering from agricultural abandonment.

Estimates also differ with respect to assumptions about climate and atmospheric CO2 concentrations. Some estimates determine the LULCC flux under a static climate (e.g. a preindustrial climate); others determine it under a realistically evolving climate driven by anthropogenic emissions and natural variability. Because effects are partly compensating (e.g. deforestation under increasing CO2 leads to higher emissions because CO2-fertilization has increased carbon stocks, but regrowth is also stronger under higher CO2 concentrations), a CO2 fertilization effect is not likely a major factor in differences among emission estimates (McGuire et al, 2001). Over the industrial era, the combined effects of changes in climate and atmospheric composition by one estimate have increased LULCC emissions by about 8% (Pongratz, this study, Fig. 1, and Table 1). There are doubtlessly other interactions, as well, between environmental changes and management, making comparisons and attribution difficult. It is worth noting that, if CO2 has a fertilization effect, terrestrial carbon sinks attributable to LULCC (as calculated here) will not necessarily be equivalent to sinks measured by eddy covariance or by successive forest inventories, both of which include environmental effects.

Comment #2) *The various methods of estimating changes in land-cover area that are given in Section 2 only appear to include FAO and satellite data. However, both of these sources of data are only available a few decades back in time and no additional information is given about how estimates of changes in land-cover area are determined before that.*

Response. We have added the following paragraph to the paper:

The data used to drive LULCC before 1990 in these analyses were from one of three data sets or revisions to them (Houghton, 2010). The data sets are those compiled by Houghton (2003), by Ramankutty and Foley (1999) (the SAGE data set), and by Klein Goldewijk (2001) (the HYDE data set). Recent data sets, such as the one compiled by Hurtt et al. (2006) and Pongratz et al (2008), are based on combinations of these earlier three, including updates. The data were obtained from historical narratives and national land-use statistics. They were distributed spatially on the basis of population densities (Klein Goldewijk, 2001) and hind-casting of the current distribution of agricultural lands (Ramankutty and Foley (1999).

Comment #3) *In Section 3.2 the authors describe the importance of legacy fluxes on the estimates of current emissions and state that if most carbon cleared during previous land uses is burnt (i.e. sent straight to the atmosphere), that the legacy fluxes will be small. However, the resulting impact on the carbon density of that land today might be quite large, and this in turn could effect the current (contemporary) emissions from LULCC.*

Response. We have added the following paragraph:

Legacies affect not only the current sources and sinks of carbon through the accumulation of decaying pools and secondary forests, but through the current distribution of biomass density. Forests with a long history of use, for example, may have lower biomass density than undisturbed forests, and the emissions of carbon from degraded forests, when they are deforested, will be lower than the emissions from intact forests. In this respect fluxes of carbon from LULCC are sensitive to the start times of analyses (i.e., the history of previous use) (Hurtt et al., 2011).

Comment #4) *In Section 4.1 the authors discuss the effect of including emissions from forest degradation (wood harvesting and shifting cultivation) in models. They give some estimates of emissions that result from including these processes in models, but don't really specify how the magnitude and spatial pattern of wood harvesting and shifting cultivation is determined. They do mention in Section 2.2.1 that rates of deforestation for shifting cultivation can be determined from satellite data, but is this the only way to determine this (especially before the satellite record)? They might be interested in the paper of Hurtt et al. 2011 (in Climatic Change) which gives details of the harmonized land-use datasets being used by models for the IPCC Fifth Assessment Report. The paper describes how the authors produced estimates of historical national wood harvest demand as well as their subsequent spatial allocation of this demand to various land-use* *areas. Also in this paper is a sensitivity study that shows the impact of including wood harvest and/or shifting cultivation on model estimates of committed emissions, secondary land area/age, etc. The impact of the historical start date for model estimates is also included in this sensitivity study (which might be relevant for item 3 above).*

Response: We have added the following paragraph:

Rates of wood harvest are reported nationally by the FAO after 1960. Before that time, rates have been estimated from historical narratives and national forestry statistics. Lands under shifting cultivation and changes in their areas are difficult to determine. Different approaches have been used to infer increases or decreases, including differences between FAO data sets (Houghton and Hackler, 2006) and changes in population density. Hurtt et al. (2011), in a harmonization of land-use data for earth system models, describe the sensitivity of flux estimates to alternative assumptions concerning the distribution and magnitude of wood harvests and shifting cultivation.

Comment #5) *Also in Section 4.1, the authors state that constant rates of logging and subsequent recovery will lead to a net flux of zero. However, won't this depend on the relative rates of logging vs. recovery and whether the logged forests are allowed to recover fully before being logged again?*

Response. Whether a constant rate of logging will achieve a neutral carbon balance or not depends not on the relative rates of logging and recovery, but on whether those rates are changing over time. It may take a very long time to reach equilibrium with constant rates, but in theory a new equilibrium will be reached. Similarly, whether forests recovery fully or not matters less than whether the rates of recovery are changing or have changed during the course of an analysis. These points seem minor to the discussion, and we have omitted the sentence from the paper.