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Interactive comment on "Description of the MIROC-ES2L Earth system model and evaluation of its climate–biogeochemical processes and feedbacks" *by* Tomohiro Hajima et al.

Anonymous Referee #2

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This article presents the CMIP6 version of the MIROC Earth system model. I appreciate this work, because a detailed description and evaluation of the CMIP6 models helps to interpret their results and raises the scientific value of this major community effort. The article is written clearly and is quite extended (73 pages), but I guess that just a complete description of the complex model would require several hundred pages. Therefore, the authors concentrate on those aspects in the biogeochemical part of the model that are new in comparison to the CMIP5 version of the model. I completely agree with this approach, but it should be followed more consequently. I suggest two steps in this direction. First, the results of the physical model should be evaluated at one place (i.e. merge subsections 3.1.1 and 3.1.4). This can go along with a comment

that these results are presented first as a basis for the assessment of the biogeochemical results and the climate-carbon cycle feedbacks. Second, I see some potential to shorten the subsection 3.1.4, e.g. fig. 7 (SST) can be skipped as fig. 5 (2m temperature) is very similar. Also the title may be adapted towards the biogeochemical focus.

Scientific questions - section 3.1.1: For a more complete view on the simulated climate, please specify the strength of the AMOC and the amplitude of ENSO as these two features of the physical system also affect the simulated carbon cycle quite profoundly. Just mention the numbers. - line 527-530: Uncertainty in land carbon uptake (estimated from data) is smaller if calculated from the global carbon budgets (following $CL = CE - CA - CO$, s. line 435) than if it is calculated from the uncertainties in LUC emissions and the natural land sink. The uncertainty in CO is 20 PgC (s. line 550). The uncertainties in CE (derived directly from inventory data) and CA (derived from precise and representative measurements) are even smaller. Thus, the uncertainty in CL is much smaller than 90 PgC. - line 531-542: I'm not an expert in ocean biogeochemistry, but as far as I understand, a buildup of the ocean sediment reduces alkalinity in the ocean water, so that the ocean on the long term will outgas CO2 to the atmosphere and ocean water + ocean sediment looses carbon after the sedimentation process has been switched on (and the loss in alkalinity is not compensated by riverine input). By contrast, in the manuscript it is mentioned, that the ocean carbon uptake in the control run is partly explained by the sediment extracting carbon from the ocean bottom. - line 766-769: I don't understand, why the different treatment of the vertical SOC profile in the model and WISE30sec explains the large difference in the amount of SOC in the boreal range. I think, that has to do with permafrost. It should be mentioned here, if the model includes freezing in the soil and how this affects SOC. - section 3.2.2: The simulations NO-NR, NO-NRD, and NO-FD are only 100 years long. Do you've analyzed, if the signals that are based on these simulations and discussed in section 3.2.2 are already stable after 100 years? Or are they still very transient?

Minor corrections - line 18: "article describes" instead of "study developed" - line 176: Figure 1 is not helpful. Please specify for each model component whether it represents atmosphere, ocean, or land. You can also add for each model component the elements that are handled prognostically (C,N for VISIT-e, C,N,P,Fe,Ca,O for OECO-v2?, Fe,S for SPRINTARS?) and indicating by labeled arrows which elements are passed from each component to others (e.g. N,P from VISIT-e to OECO-v2). I think, this would result in a nice overview schematic, how the components are coupled concerning biogeochemistry. - line 201: Please indicate the horizontal resolution of the ocean model (e.g. average size of a grid box in km or the number of grid boxes of the global field). - line 210: What is a "snow-derived wetland"? - line 257: "of vegetation (each represented on a separate tile) in each land grid box" instead of "of tile in each land grid" - line 277: "transported by rivers" instead of "transported rivers" - line 305: The phosphorous cycle has also no analog to denitrification. - line 346: It would be nice to mention how the DMS affects the climate (I guess as sulfate aerosol in MATSIRO that affects radiation). - line 364, 372, 373: I would not use the word "detect" in that way. Please substitute it by e.g. "except that the prescribed CO_2 increase affects only the carbon cycle processes". - line 403: last 4 lines of table 1, NO-NRD Configurations "N depositions" instead of "Fe depositions", NO-FD Configurations "Fe depositions" instead of "de depositions". - line 438: "coupled" instead of "entire" - line 448,449: The denominator should be T. The common unit of Gamma is PgC/K (s. also table 6). - line 471: "deviations of the model results from HadCRUT4" instead of "discrepancies between the model result and HadCRUT4" - line 555: "in the HIST run" instead of "at the end of the HIST run" - line 606: "4.2 TgN yr-1" instead of "4.5 TgN yr-1" - compare with line 11 of table 3 - line 644: "decay of biomass in the LUC-product pools" instead of "decay of LUC-product pools" - line 701: "concentration minimum" instead of "concentration peak" - line 721: Please mention that the model (obviously) simulates no deep water formation in the Labrador Sea. - line 738: "high" instead of "higher" - line 755: "GPP in these regions is captured reasonably well by the model (Fig. 10a and 10b). Thus, the overestimation" instead of "Considering the GPP in these regions is

captured reasonably well by the model (Fig. 10a and 10b), the overestimation" - line 760: "products" instead of "product" - line 784: unit of SOC is missing - line 875: I see also some regions north of the equator, where GPP is reduced by climate change (e.g. South Asia). Please remove "of the Southern Hemisphere". - line 879-890: Please comment on the strong reduction of GPP by LUC in the tropics. - line 917: I think, it would be good to mention that the NPP increase in the open ocean by N input from rivers mainly occurs in the Atlantic. - line 973: "CO2-induced ocean acidification and warming-induced deoxygenation" instead of "warming-induced ocean acidification and deoxygenation" - line 1002,1003: This sentence is better placed at the end of the paragraph. - line 1022,1023: This sentence is just repetition. You can remove it to shorten the article. - line 1026: "climate, carbon cycle, and coupled climate-carbon cycle system" instead of "climate, carbon cycle, and climate-carbon cycle system" - line 1130: "confirmed to be captured well" instead of "confirmed captured well"

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