Reply to the referee comments on the paper “MIROC-ESM: model description and basic results of CMIP5-20c3m experiments”

Dear Dr. Boucher,

We would like to thank you for providing constructive comments on our paper. In the following our response to the comments are underlined.

Many Earth System modelling groups have chosen to refer to their model using numbered
versions, eg MIROC-ESMv1 could be composed of MIROC-AGCMv2, SPRINTARSv3.1,
COCOv2.1 etc: : : Have the authors considered doing something similar?

We have decided to use numbered versions for several components, but not for others. In other literatures the present version of MIROC-ESM and MIROC-ESM-CHEM would be referred to MIROC-ESM 2010 and MIROC-ESM-CHEM 2010. We have revised the text associated with this change.

The description of some of the model components is a bit succinct. The authors should consider giving more details, eg for the NPZD model. There is relatively little on how the C fluxes between the different reservoirs have been parametrised. In places a few equations may help.

We added more on the ocean biogeochemstry description.

What is particularly important in an ESM is not just the model components, but also how they have been coupled together. Sometimes this information is provided, eg deposition of BC on snow, sometimes not, eg do DMS emissions depend on the ocean biogeochemistry or not? The manuscript could give more details on the coupling strategy
(what is coupled and what is not, and why these choices have been made). Are there any coupling between the C cycle and the atmospheric chemistry? Eg does vegetation changes affect SOA? Or dust emissions? Etc: : :

Due to given large uncertainty in coupling processes and given limited time to perform

CMIP5 runs, the present version of MIROC-ESM-CHEM does not include many coupling processes, which are potentially important in the Earth system. For example:
DMS emissions do not depend on the ocean biogeochemistry at present.
The atmospheric chemistry is not directly coupled with the C cycle at present.
Vegetation changes affect dust emissions, but SOA is not included in the CMIP5 runs.

One problem of spinning up the chemistry model separately from the C cycle model is that chemistry can affect the model climatology, which in turn affects the C cycle. Was that not a problem?

It was not a problem in our case. The pre-industrial mean climatology of MIROC-ESM that is used for the C cycle spin-up and of MIROC-ESM-CHEM was actually similar to each other, because ozone distribution in these models is similar. At least, we did not find any apparent changes in ecosystems before and after the chemistry coupling.
We have revised the text to clarify this point.

The validation focuses on comparing some of the model variables with observed quantities
or in some cases reanalysis products. However the strength of an ESM is in the couplings between the model components and these are not really validated. Can the authors comment on this?

We are going to examine the strength of carbon cycle feedbacks on climate of our model with the combinations of the results from 20c3m, future (RCPs) scenarios, and other sensitivity tests. They will be described elsewhere.

Other comments:
P1066, l6: change to “river routine” to “river routing scheme”

We have revised the text following your suggestion.

P1066, l14: delete “time”

We have revised the text following your suggestion.

P1067, l7: is the advection scheme conservative?

Yes, it is conservative.

P1068, l18: fliq might be better suited as a variable. Are the equations correct? I would expect all water to be liquid when T exceeds a threshold, not the other way around. Is there a discontinuity when T = Tm?

Thanks for pointing out this. We have corrected the equation. All water freezes below T = Tm, otherwise water partially freezes or becomes perfectly liquid when T > Ts.

P1068, l22: can you say a bit more? Is the diffusion not adapted or not applied to tracers?

Indeed, “adapted” was a mistake. The horizontal diffusion is not “applied” to tracers since the tracer advection scheme is separated from the spectral dynamical core of MIROC-AGCM.

P1073, l16: what is the unit of the absorption coefficients?

The values in line 16 (0.012 for soil dust and 0.988 for black carbon) are not the absorption coefficients themselves, but a relative strength of absorption.
So that the text was revised.
Thus, the unit of the values (0.012 and 0.988) is non-dimensional.
They were estimated from the absorption coefficients of dust and soot, used in SPRINTARS.

P1077, l1-3: sentence not clear. What was done?

We have clarified this sentence.

P1077, l8: was the stratospheric aerosol climatology superimposed on the SPRINTARS stratospheric aerosols (from non-volcanic emissions).

SPRINTARS does not consider background stratospheric aerosols, which is mainly made from carbonyl sulfide (OCS). Another version of CHASER calculates production of the background stratospheric aerosols from OCS, but it is not used in the CMIP5

simulations in order to avoid the double-counting problem. The optical thickness of volcanic stratospheric aerosols does include the stratospheric background aerosols, and we use it in radiation calculations and heterogeneous chemistry calculations as the optical thickness per unit altitude can be converted into surface area density of aerosols. We have added these explanations to the text.

P1082, l11: How was the RF calculated (double radiation call or quasi-forcing)? why is the RF strongly positive over the Sahara? Is it because of changes in dust or absorption by BC/biomass burning advected from adjacent regions?

The radiative forcing of the aerosol direct effect is calculated by the double radiation call. The strong positive forcing attributes a slight increase of dust as shown in Fig. 14.

P1083, l5: this is a bit of a circular argument. MIROC matches the IPCC estimate which relies on models like MIROC.

It could be a kind of circular. But our intention is just to show and emphasize the consistency of our model result with other modeling studies in the context of model inter-comparison.

P1103: can table indicate which biogeochemical fluxes are passed from the surface models to the chemistry?

We modified the table list on this.

P1107, Fig 2: this diagram underplays the importance of the C cycle (both land and ocean). Could the diagram be amended to reflect the coupling between the C cycle and the other components?

Since Fig 2 is basically used to show the structure of the chemistry and aerosol part and busy already, we don't include relationship with C-cycle in it.