Response to Referee#1

Thank you very much for the very useful and constructive comments and suggestions. Below is a list of all comments with corresponding replies.

Specific comments:

1. Section 3.1.1 introduces the reference datasets (e.g., Table 5). It would be informative to also include a brief discussion about the uncertainties associated with these datasets/variables, if possible.

- In case of the ERA5 and ERA5-Land dataset no uncertainty characterization was performed and is therefore not available. The GPCP dataset includes information of the error and standard deviation, which is now included in the analysis. Regarding the MODIS uncertainty the following was added to line 200 of the revised manuscript:

  "A comprehensive overview of the limitations and uncertainties of the MODIS data is provided by Disney et al. 2016. The MODIS standard deviation of LAI and FaPAR are displayed in the Appendix (Figure A2 and A2), together with the GPCP precipitation error (Figure A1) "

2. While terrestrial water storage (TWS) reflects the performance of land hydrology, I wonder if it's also helpful to examine surface soil moisture and evapotranspiration in the model.

- Soil moisture is indeed an important variable to consider. However, since the focus is on the performance of the hydrology model rather than on the comparison of soil moisture in the uppermost layers (up to 2.89 m as in the ERA5 data set) only, but on the water content of the entire soil including the root zone and runoff, TWS was chosen as the evaluation variable. Furthermore, a direct comparison between EMAC/SRF and EMAC/JSBACH soil moisture is not possible, as this variable is not available from the bucket model of EMAC/SRF.

- Evapotranspiration is analyzed indirectly in Section 4.1, where the land surface temperature (LST) is analyzed. Since the vegetation cover does not change significantly between the simulations and the leaf area index (LAI) in the EMAC/JSBACH simulation is on average lower than in the EMAC/SRF simulation, no increase in transpiration is expected. However, as soil moisture is significantly increased in the new coupled model, an increase in evaporation would be plausible and indeed requires a closer analysis. Therefore, evaporation was included in the LST analysis in section 4.1. For further discussion see below (comment 3) .

3. For land surface temperature (LST), it would be interesting to include a discussion about why the latent heat fluxes in EMAC/JSBACH are somewhat overestimated (lines 264-269). For instance, does the overestimated TWS partially contribute to this? Also, latent heat alone may not be sufficient to explain LST. I wonder if other energy fluxes, such as surface shortwave and longwave radiative fluxes, and sensible heat are examined as well.

- Table 3 gives a general overview of the model's performance with respect to other energy fluxes, such as radiative and surface heat fluxes. The comparison of the global mean values of radiative fluxes and heat fluxes shows the largest discrepancy between observation and simulation for the latent heat flux. As a result, the latent heat flux is analyzed in more detail with regard to the lower LST. Since the main driver for the surface latent heat flux is evaporation plus transpiration, indeed the overestimated TWS may have major contribution to the cooler LST.

Evapotranspiration also includes transpiration of vegetation, the latter is not significantly increased compared to the EMAC/SRF simulation and reference data sets. Instead, soil moisture is drastically increased, which most likely affects surface evaporation. Figure 5 was modified, and includes now the evaporation derived from both simulations and reanalysis data of ERA5. The following sentences in line 273 of the revised manuscript:

" Evapotranspiration has a cooling effect on the surface, due to the energy absorbed during the phase change of the water. As a result, cooler LST values are found in regions where evapotranspiration is more intense, such as the tropics and extra-tropics."

were replaced by:

"Evapotranspiration, the sum of evaporation and transpiration, has in general a cooling effect on the evaporating surface due to energy absorption during the phase change of water. Fig. 5 displays besides LST and latent heat flux, the surface evaporation which is strongest in the tropics and sub-tropics. This is in line with cooler LST values in those regions. The partially overestimated TWS could be the cause of the stronger latent heat flux, as more water is available for evaporation. As the moisture content of the soil in EMAC/JSBACH is in general much larger than in EMAC/SRF, increased evaporation in the coupled simulation is plausible."

4. Section 2.1, consider adding information about soil layers and their depths.

- In Line 78-80 of the revised manuscript the following sentence: "It provides a complex soil hydrological transport model including percolation and storage of water in several soil depths, which gives a realistic estimate of soil desiccation and corresponding soil temperature and moisture."

  has been replaced by:

  "It provides a complex soil hydrological transport model including percolation and storage of water in several soil depths, reaching down to 9.8m with increasing layer thickness of 0.065m, 0.254m, 0.913m, 2.902m and 5.7m for the first to fifth layers respectively. This gives a realistic estimate of soil desiccation and corresponding soil temperature and moisture."

5. Line 97-108, I wonder if it's possible to include a schematic to demonstrate these processes.

- An schematic is attached below and was added to the Supplement. The following sentence was added in line 100 of the revised manuscript :

  "An schematic overview of JSBACH as new submodel in EMAC and corresponding process calls is given in the Supplement."

6. Line 161, no values in Table 3 are shown in bold…

- In Table 3 the corresponding values are now displayed in bold.

7. Line 175, are aerosol concentrations prescribed?

- Yes, aerosol concentrations are prescribed. For clarification the following sentence was added in line 180 of the revised manuscript :

" Aerosol concentrations are prescribed for all simulations based on Tanré et al (1997)."
(Tanré, D., Kaufman, Y. J., Herman, M., & Mattoo, S. (1997). Remote sensing of aerosol properties over oceans using the MODIS/EOS spectral radiances. Journal of Geophysical Research: Atmospheres, 102(D14), 16971-16988.)

8. Line 291, the soil depth in the ERA5 is much shallower than the EMAC/JSBACH, 2.89 m vs 9.8 m. How does this affect the comparison of TWS?

- It does not affect the TWS comparison, since TWS includes also the runoff. TWS represents all water of the soil per gridbox. This is the main reason why TWS was chosen as evaluation variable.

9. Line 372, "cloud occurrence… remain the same", the differences in LST and latent heat may affect cloud distribution.

- Thanks for pointing this out. Since we tune the models top of atmosphere radiation balance by adjusting the cloud characteristics, of course cloud occurrence has changed. Therefore line 387 of the revised manuscript was adjusted to

  "Since there are no significant differences between the EMAC/SRF and EMAC/JSBACH surface albedo, no significant differences in Rad_TOA are expected."

10. In terms of TOA fluxes, have you considered using CERES? Or are ERA5 TOA fluxes assimilated with observations?

- ERA5 TOA fluxes are assimilated with observations, and to ensure consistency among evaluation variables such as surface albedo, we persisted with the ERA5 dataset.

11. Line 408, are the prescribed SSTs the same in the EMAC/JSBACH and EMAC/SURFACE runs?

- Yes, EMAC/JSBACH and EMAC/SRF use the same sea surface temperature and sea ice datasets. In Line 185 of the revised manuscript the following sentence:

  " The sea surface temperature and ice concentration is derived from ERA5 six hourly data from 1940 to present (Hersbach et al., 2020) . "

  has been replaced by:

  " The sea surface temperature and ice concentration is based on ERA5 six hourly data from 1940 to present (Hersbach et al., 2020) and are the same for all performed simulations."

Technical corrections:

1. Line 240, 0.1° by 0.1°?

- "0.1° x0.1°" has been replaced by "0.1° by 0.1°"

2. Fig. 3 captions, "LST trend" is somewhat misleading as no trends are calculated. Maybe "LST time series"?

- In the caption of Figure 3 and Figure 7, the word "trend" has been replaced by "time series".

Schematic (Comment 5) :