

## Overview

The work by Davies-Barnard and colleagues evaluates the Biological Nitrogen Fixation (BNF) simulated by CMIP6 models against observation. The authors also assess the influence of BNF on projected changes in the terrestrial carbon storage simulated by the CMIP6 models under the SSP370 scenario. This work presents the principal abilities and limitations of state-of-the-art earth system models in representing BNF fostering the future improvement of BNF in earth system models. At this stage, the manuscript requires some missing information and deeper discussion before being ready for publication, as described in the following sections.

## General comments

The representation of BNF is divided between direct use of Cleveland et al. (1999) parameterization and models with more complex techniques. The first case, then, represents a well-established description of BNF, while the latter depicts the effort in improving the process-based representation of BNF. Are the models departing from the Cleveland et al. (1999) parameterization improving the BNF computation?

Similarly, does the separate modelling of symbiotic BNF and free-living BNF improve the simulated BNF?

A deeper discussion of these points would emphasize the effort needed to improve BNF representation in the current Earth System Models at global and local scales.

In the local comparison between model and observation, are there any differences in land cover type between model and observations, and among models? In fact, models with vegetation closer to the observed one could reach better results thanks to the land cover representation despite the BNF parameterization.

The authors should also present the land-only and future scenario simulations in the methodology section (section 2.1). Moreover, the authors should explain the choice of ssp370 as the future scenario. Why don't you analyze other future scenarios?

## Specific comments

Line 21: should be Eyring et al., 2016 instead of Taylor et al., 2012.

Line 120: SI Table 1 is not available in the supplement link of the manuscript.

Figure 1: "T The global" remove the initial "T"

Figure 1: add information about the panels in the caption.

Figure 1: the second row has the name of the model truncated due to the figure caption.

Reshape the figure.

Lines 139-140: "which [...] tropical forest BNF". Rephrase.

SI Figure 2: second line in the caption "CM5" should be "CLM5"

SI Figure 2: Why do you compute the values over the 2005-2014 period, while the reference period is 1980-2014 in the paper?

SI Figure 3: explain the grey lines of panel a in the caption.

Figure 3, line 484: “reported by the paper”. Which paper?

Figure 4: panels c, d and e are missing.

Lines 261-262: “Some models [...] nitrogen cycle”. Rephrase.