Project: **1404**
Project title: **Model-informed assessment of the risk of Amazon rainforest dieback**
Principal investigator: **Julia Pongratz**
Report period: **2025-11-01 to 2026-10-31**

In this project we aim to investigate the Amazon rainforest climate “tipping points”, as part of the EU Horizon project ClimTip. For this assessment, we perform numerical simulations with MPI-ESM to better understand the response of the forest to different drivers, such as global warming and deforestation, as well as the climate feedbacks associated with forest loss. The data from these simulations will also be used by other work packages of ClimTip, focusing on different aspects related to socio-economical and biodiversity impacts of crossing these tipping points.

In the reporting period, several experiments with various Amazon Rainforest (ARF) scenarios were performed. These experiments were performed under stable 2ºC of global warming. Additional experiments with imposed north Atlantic hosing (with and without Amazon rainforest removal) were performed, to simulate an AMOC slow down. The output of these experiments were combined with the previously produced output (piControl, stable 2ºC global warming and stable 2º global warming with complete ARF removal, all publicly available at https://zenodo.org/records/16784935) for the production of three manuscripts at different production stages led by this working group. Other studies led by partners at the ClimTip project also used the output generated by the DKRZ project bm1404.

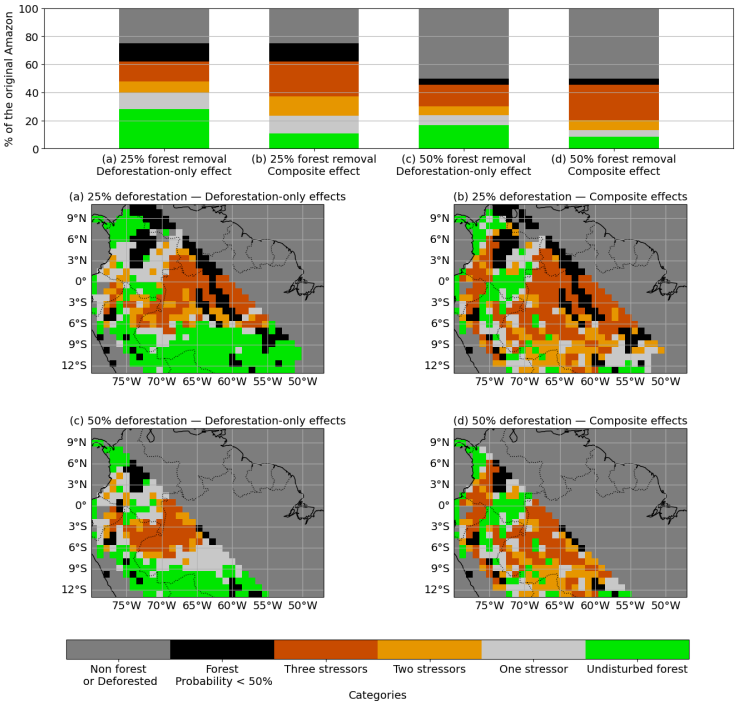


Figure 1 - Fraction of the Amazon rainforest that is significantly disturbed and that is undisturbed under 25% deforestation considering deforestation only (a) and the composite effect of deforestation and warming (b); same for 50% deforestation considering deforestation-only (c) and composite (d) effects. Each map and their associated column are two visualizations of the same data. Significant disturbance, as classified here, comes from deforestation (in gray), forest probability below 50% using the Mean Annual Precipitation (MAP) and the method by Hirota et a. (2011) (in black), or deviations larger than 0.5 * STDDEV (following Papastefanou et al., 2022) for one, two or three of the other “stressors” (Dry Season Length, Mean Climatological Water Deficit and top 10 cm Soil Moisture) (in light gray, orange or red, respectively). Non forest refers to areas where forest cover was below 40% even in piControl.

In Ferreira Correa et al. (2026) we compared scenarios with 25%, 50%, 75% and 100% deforestation with and without 2ºC warming to a non-deforested reference. We used a similar methodology of Papastefanou et al. (2022) to

estimate the hydroclimatic stress imposed on the vegetation in each scenario. Our results show that under 25% deforestation and 2ºC of global warming, 89% of the forest is under statistically significant hydroclimatic stress. This is a > 30% increase in the area under hydroclimatic stress in comparison to what was observed by Papastefanou et al. (2022) in the three strongest droughts in the first two decades of the century in the ARF. In other words, this projects that under these conditions, the average drought will affect a larger area of the forest than the strongest droughts observed in the last decades. Our results also indicate that the area affected by the composite effects of 25% deforestation + 2ºC global warming is larger than the area affected by the deforestation-only effects of 50% forest removal. This highlights how not only deforestation, but also global warming represents a major threat to the forest in the future. The 25% and 2ºC marks are especially important, as they might be both achieved before the middle of the century (Walker et al., 2019; Lee et al., 2021). Figure 1 illustrates the results discussed in this paragraph. This manuscript is under review at Earth System Dynamics.

In another manuscript soon to be submitted to Communications Earth & Environment, we compare the effects of upwind and downwind deforestation over an untouched strip of forest in central Amazon. As expected, the strongest effects occur when deforestation occurs upwind of the untouched forest. In this study we additionally quantify these differences and describe the chain of processes that amplify the effects when deforestation occurs upwind, leading to significant changes in the vertical structure in the troposphere. A third manuscript that uses empirical relationships of Precipitation, Dry Season Length and forest cover to attribute climate niches to all Amazon gridboxes is in preparation. In this study we analyze 11 different deforestation scenarios and verify how these climate niches change with increasing deforestation. Through this approach we can discuss the effects of deforestation in terms of forest stability.

The data produced by this working group in the scope of project bm1404 has also been used for dynamical and machine learning downscaling by partners in the ClimTIp project. These were used by Hermoso et al. (2026) and Hess et al. (2026) in studies about the AMOC tipping and global tipping points, respectively, both under review and available as preprints.

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