Bioclimatic envelope models predict a decrease in tropical forest carbon stocks with climate change in Madagascar

SUPPORTING INFORMATION

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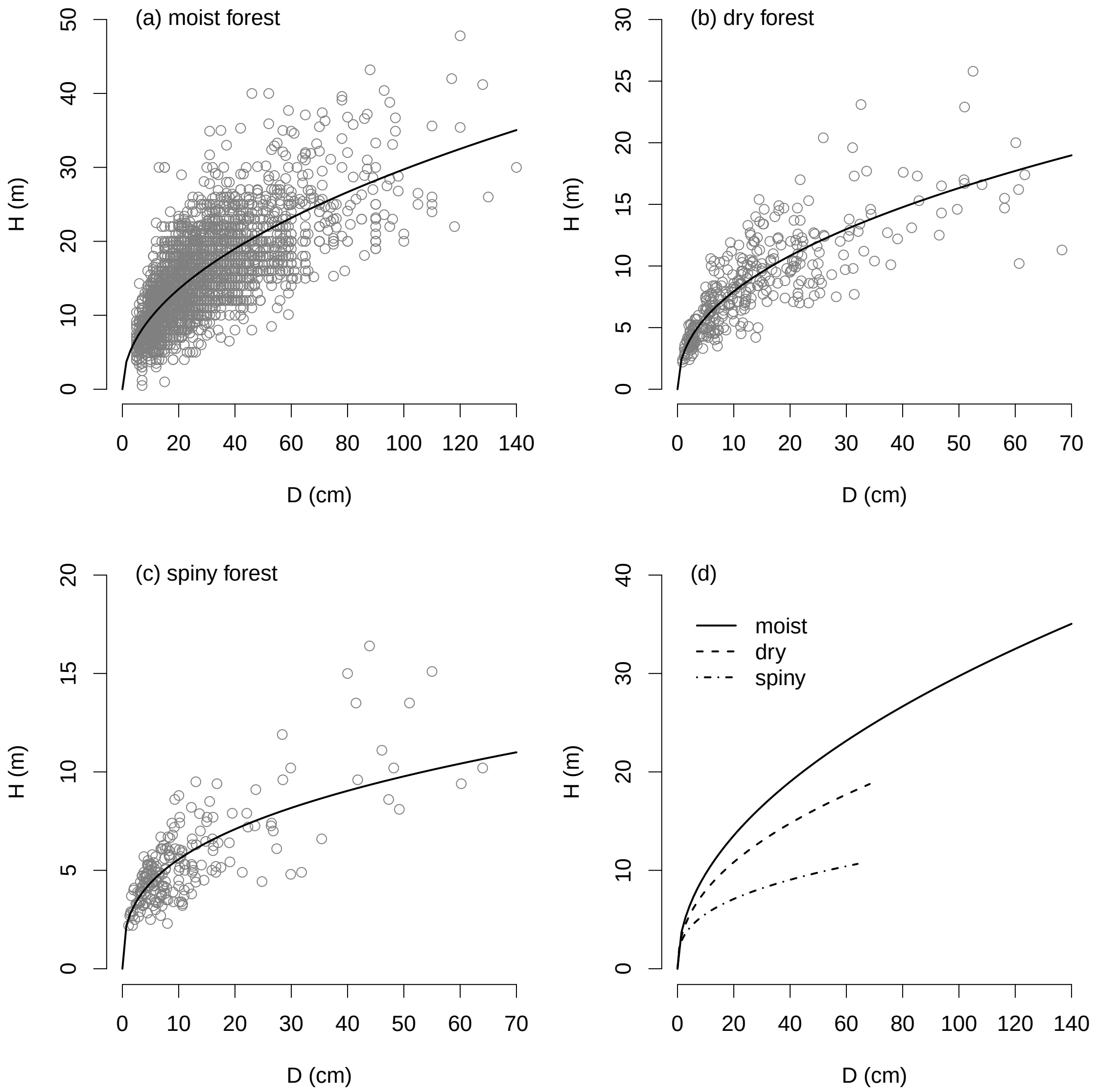

Figure S1: **Height-diameter relationship by forest type.** We fitted a height-diameter model for each forest type in Madagascar (moist, dry and spiny forest) using a log-log relationship: $\log(H_i) = \beta_0 + \beta_1 \log(D_i) + \varepsilon_i, \varepsilon_i \sim \mathcal{N}ormal(0, \sigma^2)$. For a given diameter, trees are higher in the moist forest, then in the dry forest, and then in the spiny forest. To estimate model's parameters, we used 4307 observations from 87 genus for the moist forest (356/53 and 216/22 for the dry and the spiny forest respectively). We obtained the following parameters for the moist forest: $\beta_0 = 1.106$, $\beta_1 = 0.489$ and $\sigma^2 = 0.071$ (1.012/0.448/0.056 and 0.880/0.350/0.058 for the dry and the spiny forest respectively).

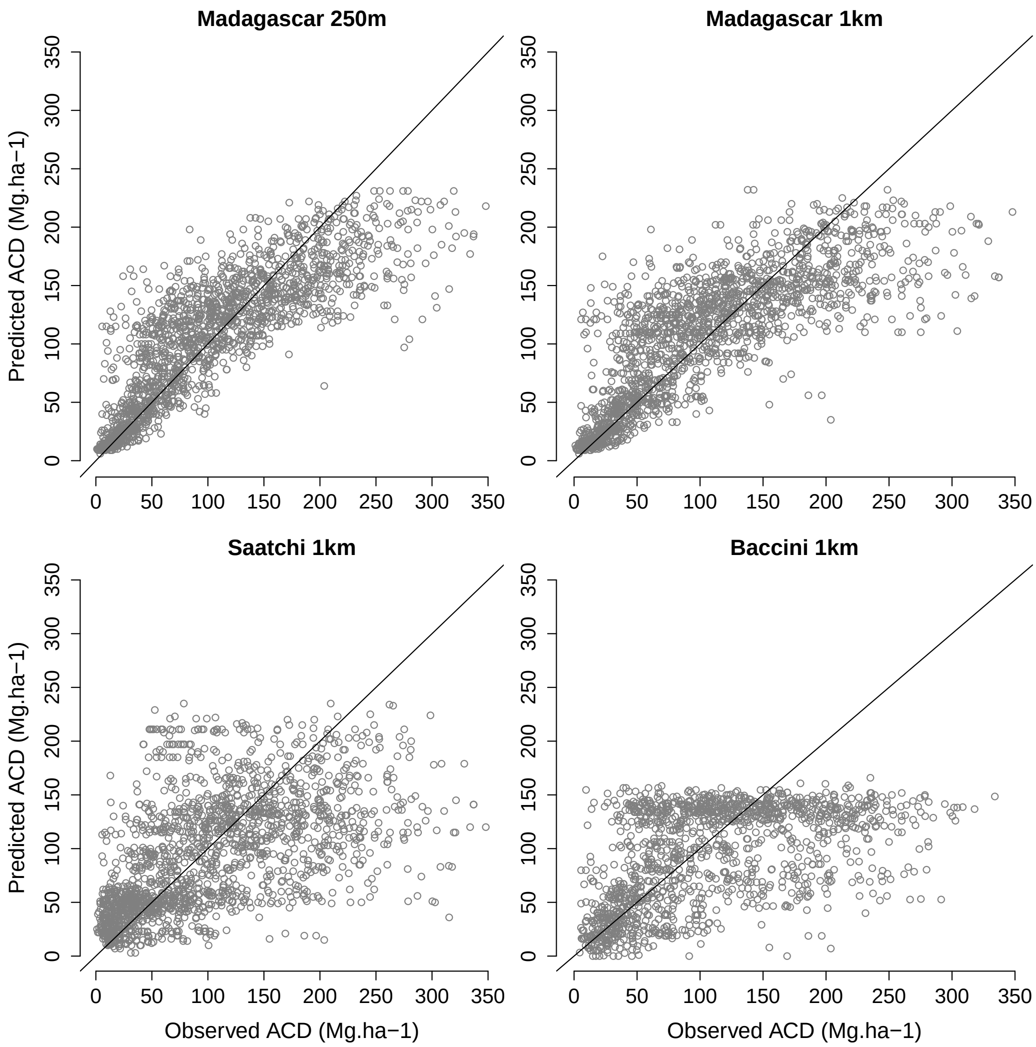

Figure S2: **Comparison between ACD observations and model predictions.** We compared ACD values computed from forest inventories with predicted ACD values from different sources: our map at 250 m resolution derived from the Random Forests model, our map resampled at 1 km resolution, Baccini's map resampled at 1 km resolution and Saatchi's map at 1 km resolution. At 1 km resolution, our model provided much more accurate predictions of ACD values ($R^2 = 0.64$, RMSE = 44 Mg.ha^{-1}) than Saatchi's or Baccini's model ($R^2 = 0.26$, RMSE = 64 Mg.ha^{-1} and $R^2 = 0.17$, RMSE = 63 Mg.ha^{-1} respectively). The best predictions were obtained using our model at 250 m resolution ($R^2 = 0.70$, RMSE = 40 Mg.ha^{-1}). Because Baccini's map does not cover the whole Madagascar, comparison was done for only 1383 plots against 1771 plots for our maps and Saatchi's map.

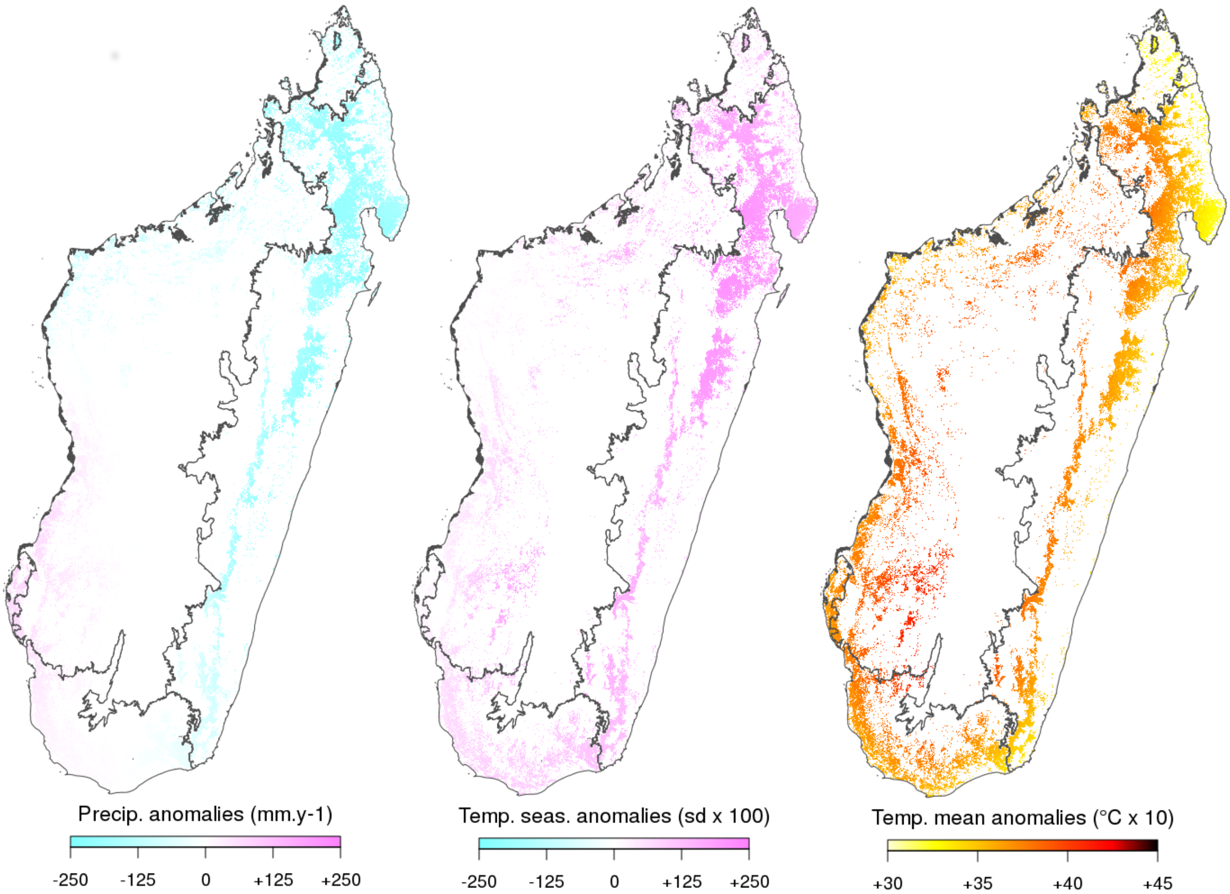

Figure S3: **Predicted climatic anomalies between years 2010 and 2080 in Madagascar forests.** Anomalies have been computed for annual precipitation (mm.y^{-1}), temperature seasonality (standard deviation of monthly temperatures $\times$ 100) and mean annual temperature (°C $\times$ 10). We compared the current climate in Madagascar forests with the average climate projected in 2080 by seven IPCC CMIP5 global climate models following the RCP 8.5. Climatic data were obtained from the MadaClim website (http://madaclim.org) which provides WorldClim current (1950–2000) climate data and CCAFS GCM future climatic data specifically for Madagascar. Temperature seasonality and mean annual temperature are supposed to increase while precipitation is supposed to decrease over almost the whole forest in Madagascar.

Id	Model	RCP	Year	ACD (Gg)	ACD loss (Gg)	ACD loss (%)
1	ac	45	2050	816059	-57028	-7
2	cc	45	2050	860816	-12270	-1
3	gs	45	2050	847309	-25778	-3
4	he	45	2050	774797	-98289	-11
5	ip	45	2050	785950	-87137	-10
6	mc	45	2050	789968	-83118	-10
7	no	45	2050	818660	-54426	-6
8	ac	45	2080	765363	-107723	-12
9	cc	45	2080	855673	-17413	-2
10	gs	45	2080	832278	-40808	-5
11	he	45	2080	756343	-116743	-13
12	ip	45	2080	789498	-83589	-10
13	mc	45	2080	779082	-94004	-11
14	no	45	2080	826546	-46541	-5
15	ac	85	2050	771138	-101949	-12
16	cc	85	2050	853052	-20034	-2
17	gs	85	2050	819948	-53138	-6
18	he	85	2050	741090	-131996	-15
19	ip	85	2050	778823	-94263	-11
20	mc	85	2050	781529	-91557	-10
21	no	85	2050	848100	-24986	-3
22	ac	85	2080	688071	-185015	-21
23	cc	85	2080	808724	-64362	-7
24	gs	85	2080	725905	-147181	-17
25	he	85	2080	670387	-202699	-23
26	ip	85	2080	717316	-155770	-18
27	mc	85	2080	667073	-206014	-24
28	no	85	2080	769131	-103955	-12

Table S1: **Forest carbon stock projections using seven IPCC CMIP5 global climate models.** We used seven IPCC CMIP5 global climate models (GCMs) to project the forest carbon stocks in years 2050 and 2080 following two representative concentration pathways (RCPs): RCP 4.5 and RCP 8.5. The seven GCMs used for the study were: ACCESS 1.0 (ac), CCSM4 (cc), GISS-E2-R (gs), HadGEM2-ES (he), IPSL-CM5A-LR (ip), MIROC5 (mc) and NorESM1-M (no). All models predicted a decrease of forest carbon stock in the future (up to -24% in 2080 for RCP 8.5).