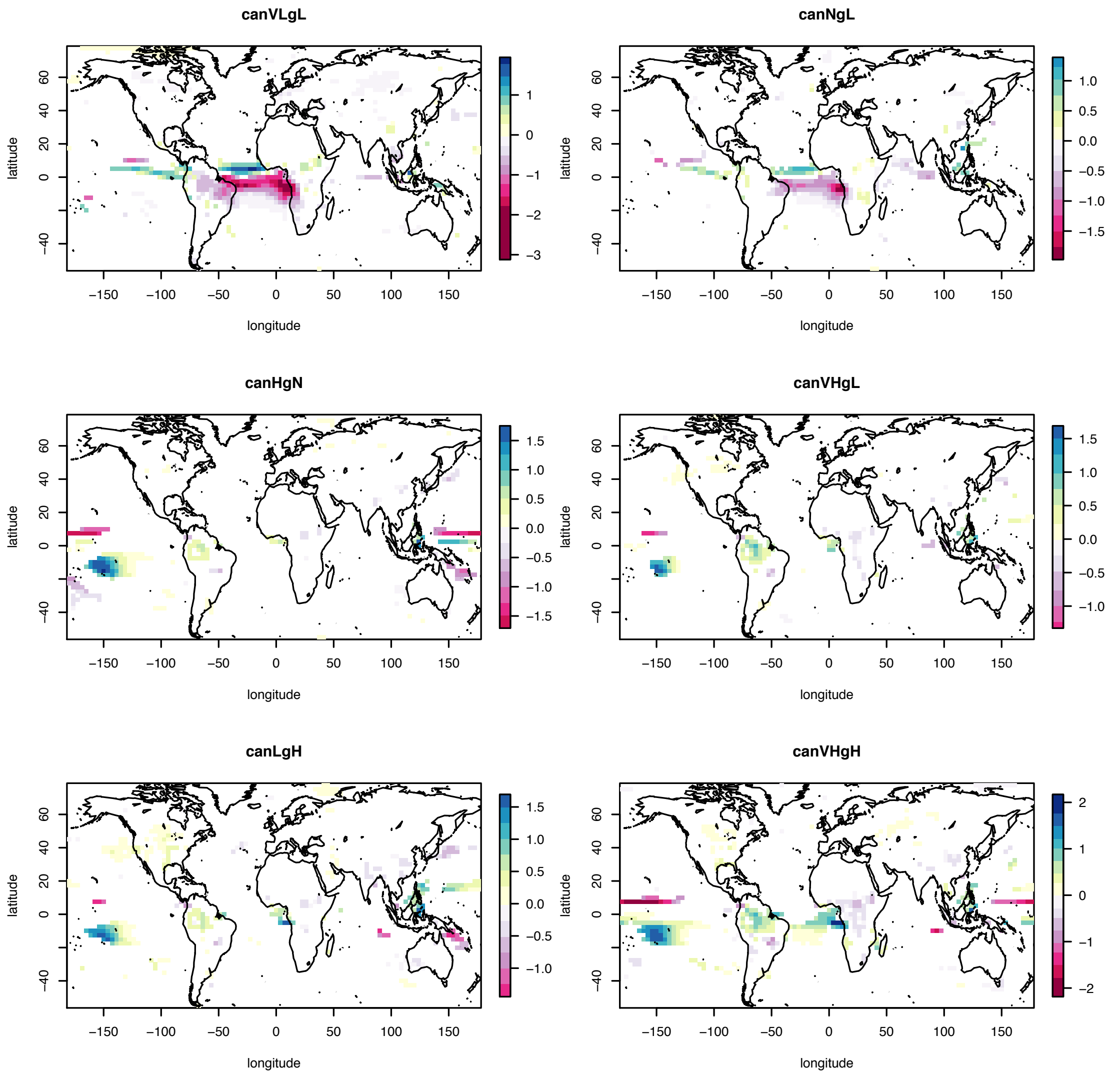
Supplementary Information 1

The results for the FixVeg and EqVeg ensembles' precipitation are quite similar overall, though the details vary slightly (compare Fig. 4 to SI Fig. 1).



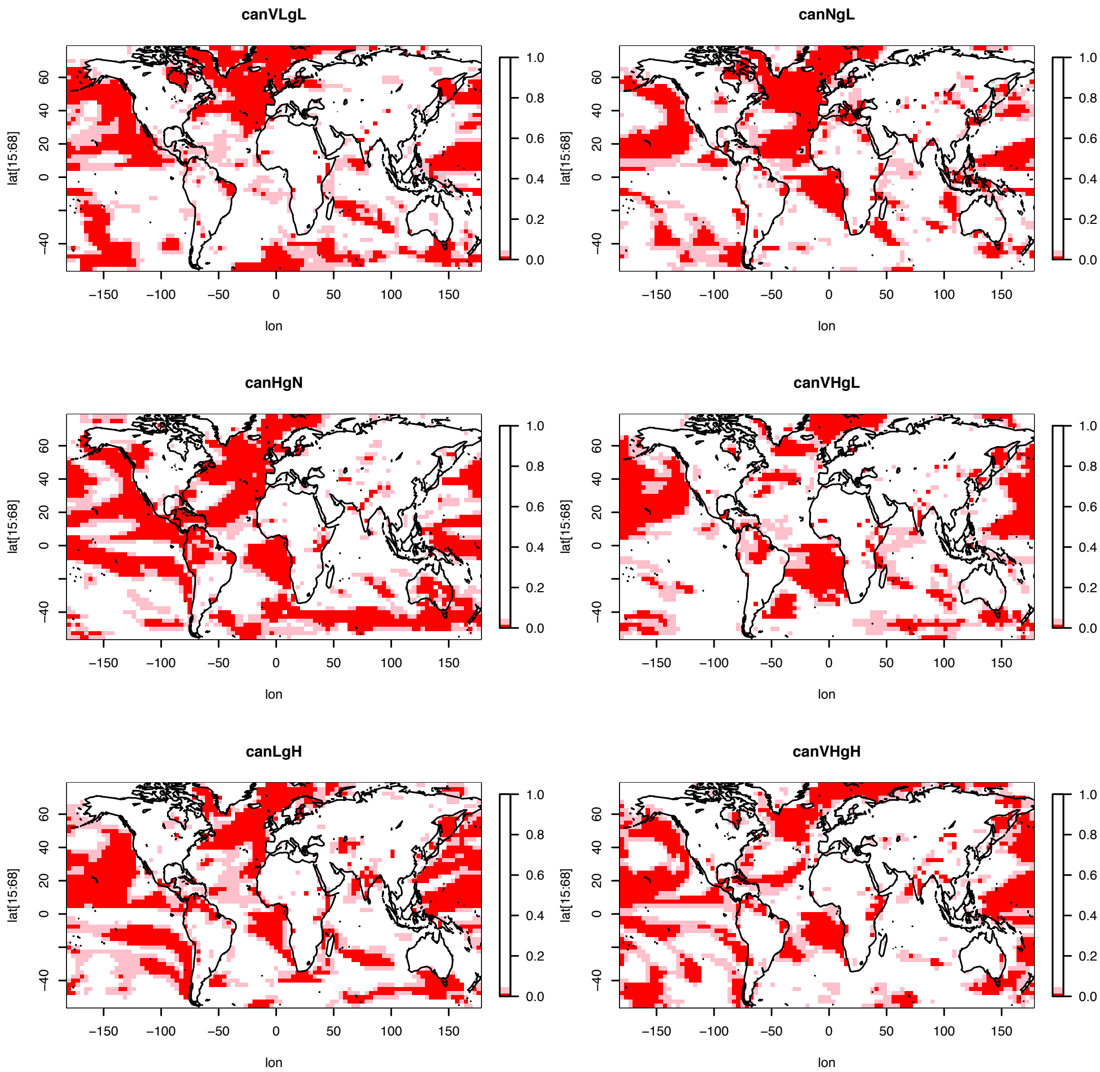
SI Fig. 1 Results from the last 30 years of the FixVeg simulations for mean annual daily precipitation anomalies. The anomalies are shown in mm day^{-1}, compared to the control (canNgN). Only areas statistically significant at $p<0.01$ using a Wilcoxon rank sum test are shown. The colour scale is the same for all the plots above and the same as Fig. 4. (FixVeg precipitation) to allow for comparison.

The shift in precipitation at the ITCZ remains a prominent feature. However, the link across the Atlantic between the Amazon and Sahel varies in strength between the ensemble members. In the EqVeg ensemble, the strongest changes are in the higher C_m ensemble members (e.g. canVHgH). In the FixVeg ensemble, the opposite is true: the strongest changes are in the low C_m ensemble members. We hypothesize that this is related to the changes in tree cover in the EqVeg simulations. The FixVeg simulations retain the same vegetation cover, whereas the EqVeg simulations have some 'Amazon dieback' in the reduced C_m simulations (e.g. canVLgL) and the increased C_m simulations grow more Amazon forest than the FixVeg (e.g. canVHgH).

The Amazon dieback phenomenon is well known in HadCM3 but is likely to be specific to this model (see for instance, Cox et al. 2003; Betts et al. 2004; Cox et al. 2004; Huntingford et al. 2008; Malhi et al. 2009). The change in C_m appears to trigger a similar mechanism and the change in forest fraction slightly enhances it.

Supplementary Information 2

For statistical testing, we use the annual mean datasets, first tested for temporal autocorrelation using the Box-Ljung test. This test has a null hypothesis of independence. Since the effect we are looking for is primarily over the land, we disregard autocorrelation over the ocean. The results shown in SI Fig. 2 are typical of the pattern that emerges. We would expect around 1% of the area over land to reject the null hypothesis by chance at $p<0.01$, and 5% at $p<0.05$. Over the land, this criteria is, for the most part, met.

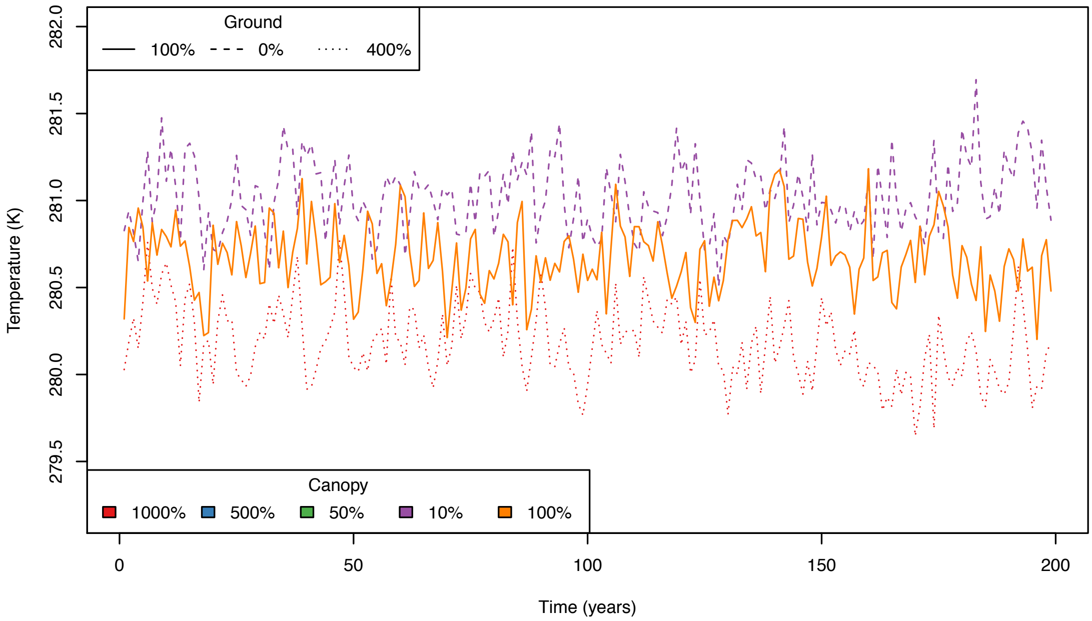


SI Fig. 2 Results of Box-Ljung test for EqVeg mean annual temperature of the last 30 years of the simulations. Grid boxes where the null hypothesis of independence is rejected at $p<0.01$ are shown in red, $p<0.05$ as pink. Areas of white do not reject the null hypothesis of independence. The pattern of independence over the land is typical of the whole dataset. It is notable that the ensemble members with the most change to C_m are the least autocorrelated.

We then use a Wilcoxon rank sum test to exclude areas that accept the null hypothesis that there is no difference between the control and the other ensemble member distributions (where p<0.01). The Wilcoxon rank sum test is a non-parametric test similar to the parametric Student t test. However, unlike the t test is does not make any assumptions about what the distribution is. Climate data often has a non-normal distribution and different variances (especially variables such as precipitation that tend to have long low tails) and the Wilcoxon rank sum is not affected by this, making it more robust. (For more about the Wilcoxon rank sum and the Student t test, please see Sawilowsky 2005).

Supplementary Information 3

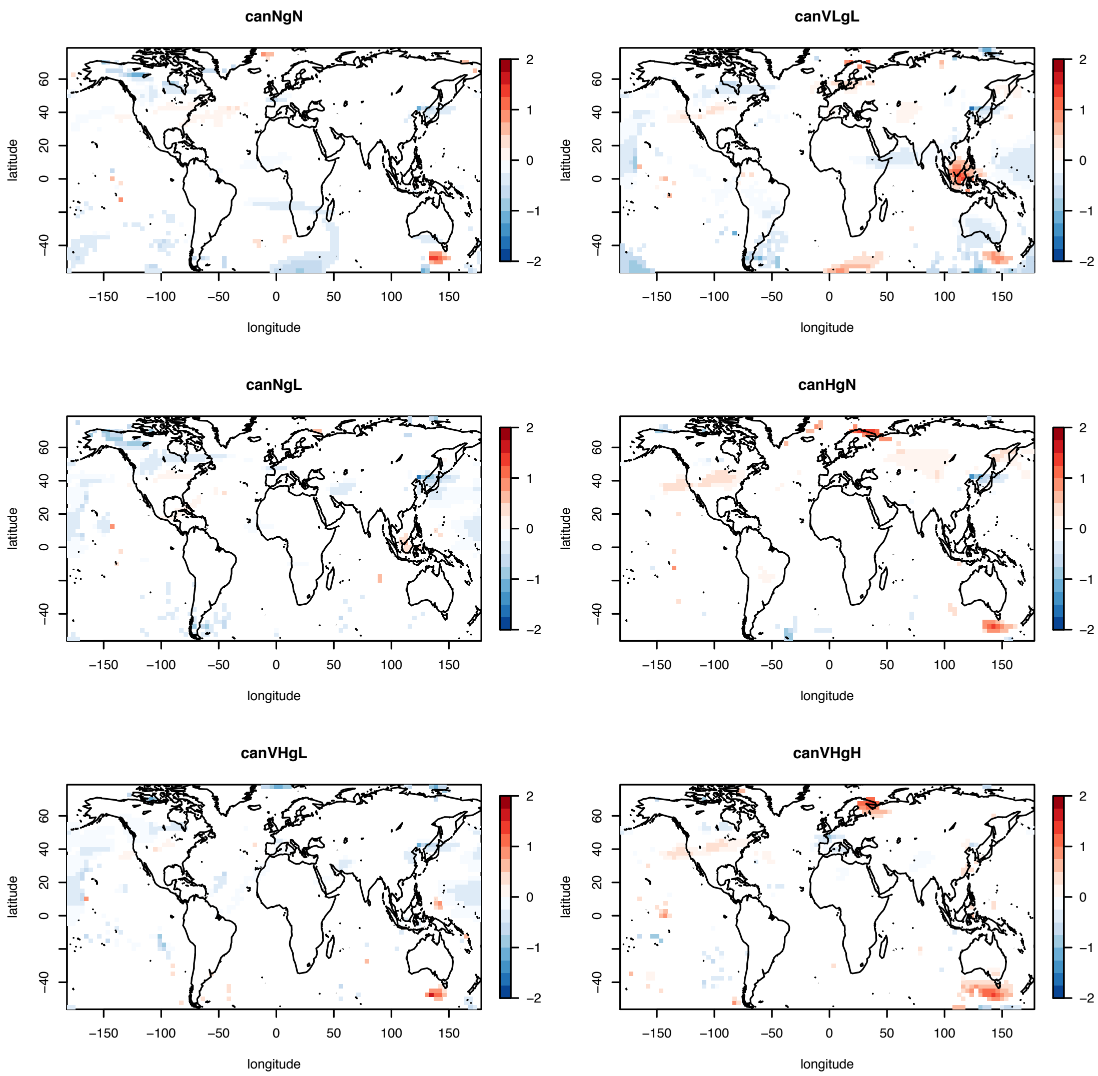
The time series of mean annual global temperature over land (see SI Fig. 3) shows that the extremes of change in C_m are outside of the natural inter-annual variability of the default parameterisation.



SI Fig. 3 Mean annual global temperature over land for canNgN (default), canVLgL (lowest C_m) and canVHgH (highest C_m) for the 200 years of the simulations. The colour scheme is as for Fig. 2. The default (control) ensemble member is in the middle in yellow, decreased C_m is above in purple and increased C_m is below in red.

Supplementary Information 4

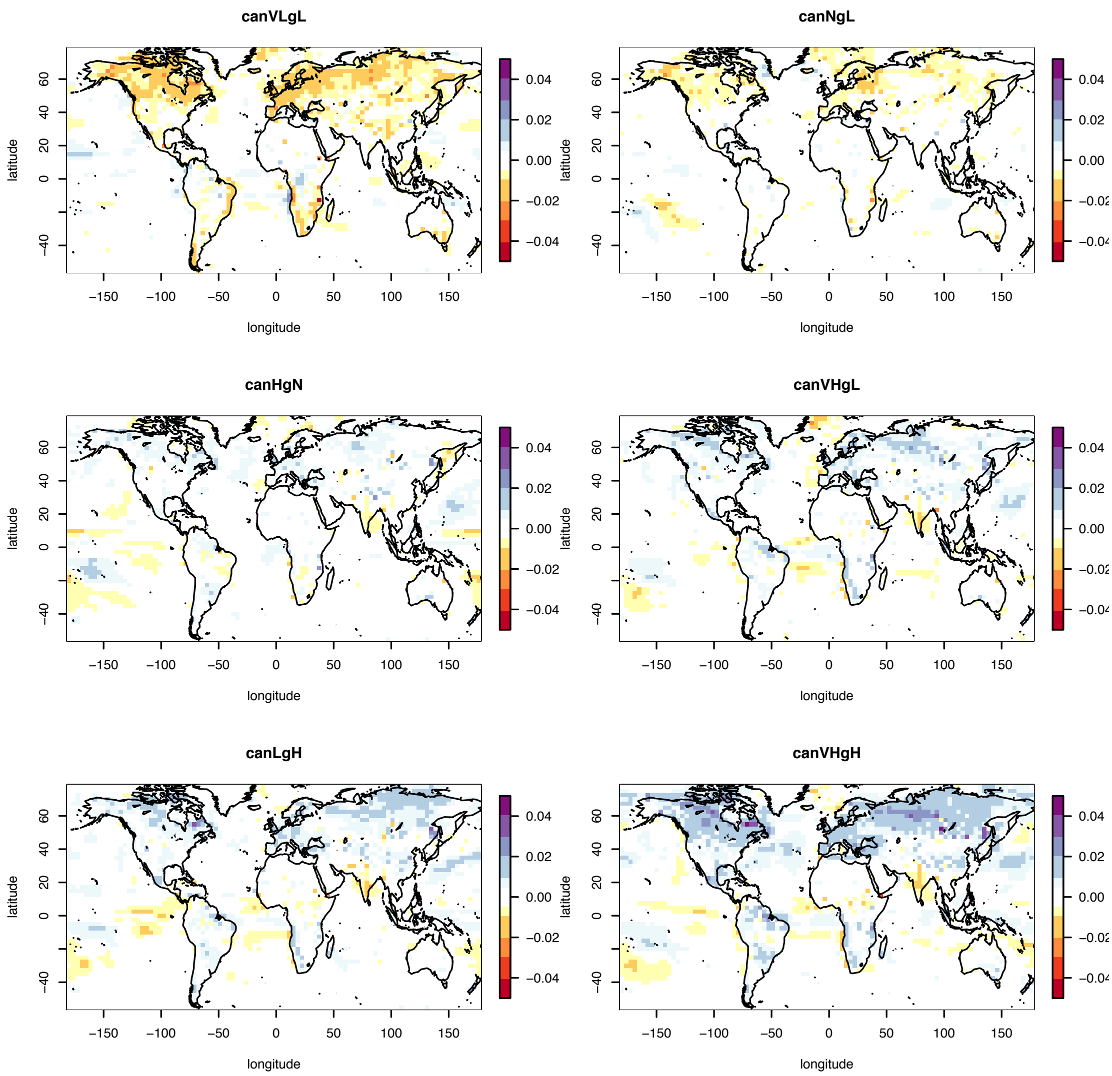
The two ensembles differ in that one has static vegetation (FixVeg) and the other allows the TRIFFID dynamic vegetation model to determine the vegetation cover (EqVeg). Changes in vegetation can result in significant changes to the overall climatology. However, in this case there is little evidence that there are any significant differences between the two ensembles. SI Fig. 4 shows that the areas of statistically significant differences between the equivalent ensemble members are not systematic spatially, and do not have a consistent overall signal between the different ensemble members.



SI Fig. 4 Mean annual temperature anomaly results, over the last 30 years of the simulations, for the anomaly of the FixVeg ensemble compared to the equivalent ensemble member for the EqVeg ensemble. Only areas statistically significant at $p<0.01$ using a Wilcoxon rank sum test are shown.

Supplementary Information 5

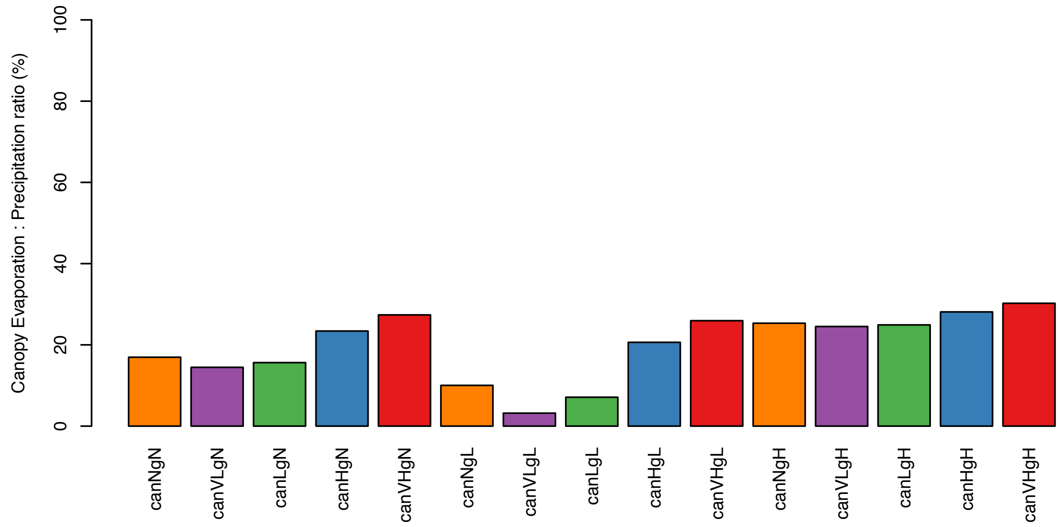
The top of atmosphere albedo changes have a good spatial correlation with temperature changes in the mid to high latitudes (SI Fig. 5).



SI Fig. 5 Results from the last 30 years of the EqVeg simulations for the mean annual top of atmosphere albedo anomalies. The anomalies are shown compared to the control (canNgN).

Supplementary Information 6

The mean global interception loss values (SI Fig. 6) are broadly consistent with the values from the measurement literature that suggests a mean interception loss (canopy evaporation to precipitation ratio) for the tropics and extra tropics of around 20% (Wang et al. 2007; Schlesinger and Jasechko 2014). Although the default parameterisation has a relatively small C_m value, it gives fair agreement to the interception loss, at 17%. To obtain the 7% global interception loss value of the Miralles et al. (2010) satellite product, a much smaller C_m value is required, e.g. canNgL (10%) or canLgL (7%). However, even the highest increase of C_m (canVHgH) is still within the feasible limits of interception loss generally given (10 – 35%), at 30% (Miralles et al. 2010; Schlesinger and Jasechko 2014).



SI Fig. 6 The global mean annual canopy evaporation as a percentage of total precipitation (i.e. the interception loss) for each of the ensemble members, including the control (canNgN). The positive and negative indicators above the bars indicate the scale of change in C_m of that ensemble member, compared to the default. They are categorized as a small increase (+), a small decrease (-), a big increase (++) or a big decrease (--).

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