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# Comment on "Carbon farming in hot, dry coastal areas: an option for climate change mitigation" by Becker et al. (2013)

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**Abstract.** Becker et al. (2013) argue that an afforestation of $0.73 \times 10^9$ ha with *Jatropha curcas* plants would generate an additional terrestrial carbon sink of 4.3 PgC $yr^{-1}$, enough to stabilise the atmospheric mixing ratio of carbon dioxide ($CO_2$) at current levels. However, this is not consistent with the dynamics of the global carbon cycle. Using a well-established global carbon cycle model, the effect of adding such a hypothetical sink leads to a reduction of atmospheric $CO_2$ levels in the year 2030 by 25 ppm compared to a reference scenario. However, the stabilisation of the atmospheric $CO_2$ concentration requires a much larger additional sink or corresponding reduction of anthropogenic emissions.

## 1 Introduction

In their paper entitled "Carbon farming in hot, dry coastal areas: an option for climate change mitigation" by Becker et al. (2013), the authors argue that a hypothetical afforestation of an area of $0.73 \times 10^9$ ha with *Jatropha curcas* plants would be enough to stabilise the atmospheric mixing ratio of carbon dioxide ($CO_2$) at current levels. While clearly not the central conclusion of the study by Becker et al. (2013), in view of its potential policy implications, such a statement requires a correction, since it is not consistent with our understanding of the dynamics of the global carbon cycle.

Given the uptake rate of 2.16 kg $CO_2$ $m^{-2}$ $yr^{-1}$ as estimated by Becker et al. (2013) from measurements, such an area would sequester 4.3 PgC $yr^{-1}$ during the growing phase of the plants. This corresponds to 2 ppm $yr^{-1}$ distributed over the entire atmosphere. While 2 ppm $yr^{-1}$ indeed correspond to a typical growth rate of atmospheric $CO_2$ over the last decades, introducing such a sink, as explained below, would not stabilise the atmospheric $CO_2$ concentration.

## 2 Elementary carbon cycle dynamics

The current atmospheric carbon budget is not only controlled by anthropogenic sources, but also by substantial sinks in the ocean and in the land biosphere, which, over the last decades, remove almost 50 % of the total anthropogenic emissions from fossil fuel burning, cement production and changes in land use (Ballantyne et al., 2012). Since these sinks depend on the growth rate of atmospheric $CO_2$, any reduction of the latter also reduces the strength of these sinks. Hence adding a sink of 4.3 PgC $yr^{-1}$ would reduce the atmospheric growth rate but would by no means stabilise atmospheric $CO_2$ levels. Indeed, stabilising atmospheric $CO_2$ levels requires a much larger additional sink or corresponding large emission reductions, as already noted a long time ago (e.g. Siegenthaler and Oeschger, 1978).

The effect is illustrated using a simple global carbon cycle model, the Bern2.5CC model (Joos et al., 2001), as used in a response function representation by the International Panel for Climate Change for the calculation of global warming potentials (Forster et al., 2007). The model is driven by the historical anthropogenic emissions reaching 9.3 PgC $yr^{-1}$ during the recent decade (Le Quéré et al., 2013). Figure 1 shows the effect of abruptly adding a sink of 4.3 PgC $yr^{-1}$ in the year 2010 (green line), while increasing the anthropogenic emissions according to a reference emission scenario (red line) (Riahi et al., 2007). The addition of the extra sink

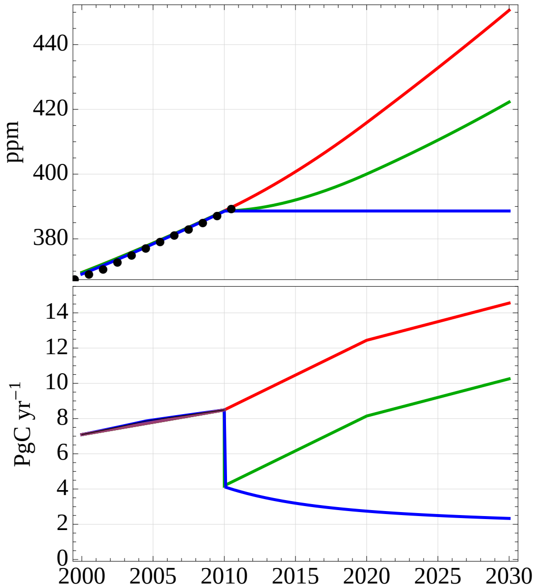


**Fig. 1.** Global carbon cycle model simulations with the Bern2.5CC model (Joos et al., 2001). Upper panel: atmospheric mixing ratio; lower panel: corresponding total anthropogenic emissions. Red lines: RCP 8.5 reference scenario (Riahi et al., 2007); green lines: effect of adding an additional sink of 4.3 PgC yr$^{-1}$ in the year 2010; blue lines: a scenario with an assumed stabilisation at an atmospheric $CO_2$ level of 390 ppm after the year 2010. The black dots show the atmospheric observations.

reduces the atmospheric growth rate temporarily, but does not lead to a stabilisation. By the year 2030 atmospheric $CO_2$ levels are only 25 ppm lower than in the reference case. The lower panel shows the corresponding emissions. For comparison, the emissions are also shown that are needed to stabilise the atmospheric $CO_2$ at the current level (390 ppm) (blue lines). Indeed, according to this model, a reduction of the total emissions until the year 2030 by 75 % with respect to 2010 is needed for stabilisation.

## 3 Conclusions

The simple dynamics of the global carbon cycle described here are robust and have been known for a long time (e.g. Watson et al., 1990). Clearly, a much larger carbon sequestration sink is needed to impact the global growth of $CO_2$ significantly than is assumed in Becker et al. (2013).

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