Reply on CC1

Xueyuan Gao et al.

Author comment on "Exploration of a novel geoengineering solution: lighting up tropical forests at night" by Xueyuan Gao et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2021-85-AC1, 2021

Thank you for your comments! The calculation of the energy requirement for capturing one ton of carbon is as follow:

E = (Power X Area X Hours) / Carbon

where E is the energy requirement for capturing one ton of carbon per year;

Power is 200W/m^2 (nighttime lighting power);

Area is the tropical forest area 10.71 X 10^{10}m^2 (CESM2 output);

Hours is the amount of nighttime lighting hours per year: 365 X 11;

Carbon is the net carbon uptake per year (Figure 2-f) simulated by CESM2.

There is no assumed data in this calculation.

In another word, if we give DACC 100 units of energy (100MWh) per year, DACC could fix 3-12 ton carbon per year. If we give forests 100 units of extra energy per year, forests could fix around 19.5 ton carbon per year on average (15-year average: 29 ton carbon in the first year and 10 ton carbon in the 15th year due to an increase of soil respiration); however, only 17 units of energy are actively used to fix carbon, and the rest 83 units of energy end up as heat which increases local temperature (Lines 205-221). Therefore, the energy use efficiency of this strategy is low, which is a major drawback.

Other than the direct lighting energy, this strategy requires additional energy associated with manufacturing and installing lamp networks, constructing electricity transmission devices, so on and so forth. To make a direct comparison to DACC, we only focus on the energy requirement specifically for carbon capture. Therefor, we didn't include the energy costs associated with engineering aspects, as the estimation of DACC's energy requirement does not include the energy costs required for carbon transport, storage, and utilization. We assume this strategy only uses clean energy coming from solar, wind or nuclear farms. In this study, we also mainly focus on the physical understanding of tropical forest ecosystem's responses to nighttime artificial lighting, so we didn't have much discussion on engineering aspects (how such a network of lamps could be

constructed) as well as costs estimates. Nevertheless, the estimation of additional energy costs and the engineering feasibility are important, and we will attempt to address these issues in future studies.

Another critical aspect is the potential negative impacts, or side effects of this strategy. We quantified the local temperature increase (lines 129-132, 205-221) and the CO_2 outgassing rate and amount after a sudden and sustained termination of the lighting experiment (lines 185-188, 222-239). However, the ecological damage (e.g., damage to local wildlife and biodiversity) is hard to quantify, although it is important. Therefore, our discussion (lines 242-246) is more qualitative on this aspect.

We will incorporate the above calculation into the manuscript. Thank you very much again for your comments and suggestions.