



## **Systemic effects of geoengineering by terrestrial carbon dioxide removal on carbon related planetary boundaries**

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The planetary boundaries framework as proposed by Rockström et al. (2009) provides guidelines for ecological boundaries, the transgression of which is likely to result in a shift of Earth system functioning away from the relatively stable Holocene state. As the climate change boundary is already close to be transgressed, several geoengineering (GE) methods are discussed, aiming at a reduction of atmospheric carbon concentrations to control the Earth's energy balance. One of the proposed GE methods is carbon extraction from the atmosphere via biological carbon sequestration. In case mitigation efforts fail to substantially reduce greenhouse gas emissions, this form of GE could act as potential measure to reduce atmospheric carbon dioxide concentrations.

We here study the possible influences of human interactions in the Earth system on carbon related planetary boundaries in the form of geoengineering (terrestrial carbon dioxide removal). We use a conceptual model specifically designed to investigate fundamental carbon feedbacks between land, ocean and atmosphere (Anderies et al., 2013) and modify it to include an additional geoengineering component. With that we analyze the existence and stability of a safe operating space for humanity, which is here conceptualized in three of the 9 proposed dimensions, namely climate change, ocean acidification and land-use.

### References:

- J. M. Anderies et al., The topology of non-linear global carbon dynamics: from tipping points to planetary boundaries. *Environ. Res. Lett.*, 8(4):044048 (2013)
- J. Rockström et al., A safe operating space for humanity. *Nature* 461 (7263), 472-475 (2009)