Is vegetation in Africa in equilibrium with environmental conditions?

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BACKGROUND

Climate is likely changing faster than during the last millions of years. For some scenarios, climate models project even accelerating rates of change. Rates of ecological processes can, however, lag behind rates of environmental change. We asked:

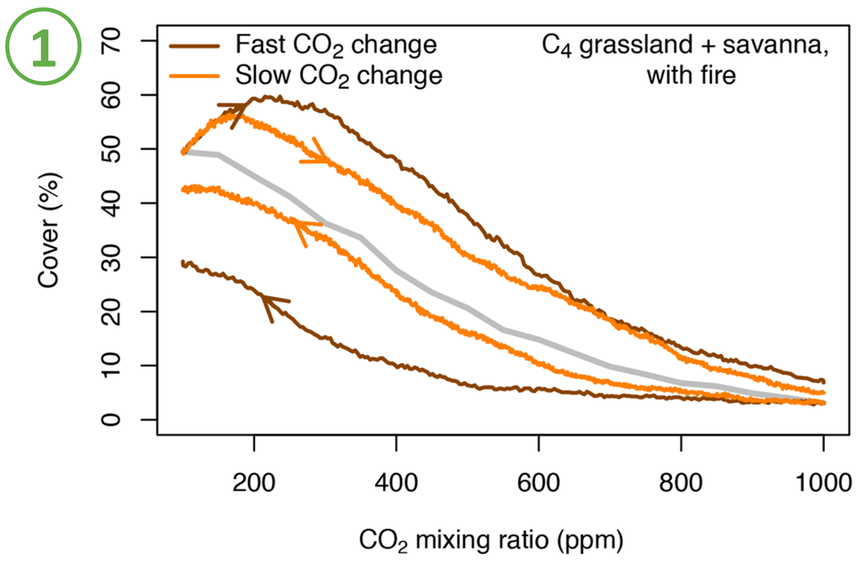
- Is vegetation in Africa in equilibrium with environmental conditions?
- At which CO_2 concentrations is vegetation most sensitive to further CO_2 changes?
- Do transient vegetation states follow a virtual trajectory of equilibrium vegetation states?
- What are the time lags between transient and most similar equilibrium vegetation states?

APPROACH

- We used aDGVM (Scheiter and Higgins 2009), a dynamic vegetation model developed for tropical and sub-tropical ecosystems.
- In a first model experiment, we simulated vegetation for different constant atmospheric CO_2 concentrations until vegetation reached an equilibrium state.
- Then, we conducted transient simulations by increasing and decreasing atmospheric CO_2 between 100ppm and 1000ppm at different rates.
- We classified vegetation into biomes, and quantified differences in cover fractions in transient and equilibrium simulations.
- In a second model experiment, we simulated equilibrium vegetation for each decade between the 1970s and the 2090s using downscaled climate data from the MPI-ESM.
- Then, we conducted transient simulations for this period.
- We calculated Euclidian distance between equilibrium and transient scenarios to identify decades with most similar vegetation states.

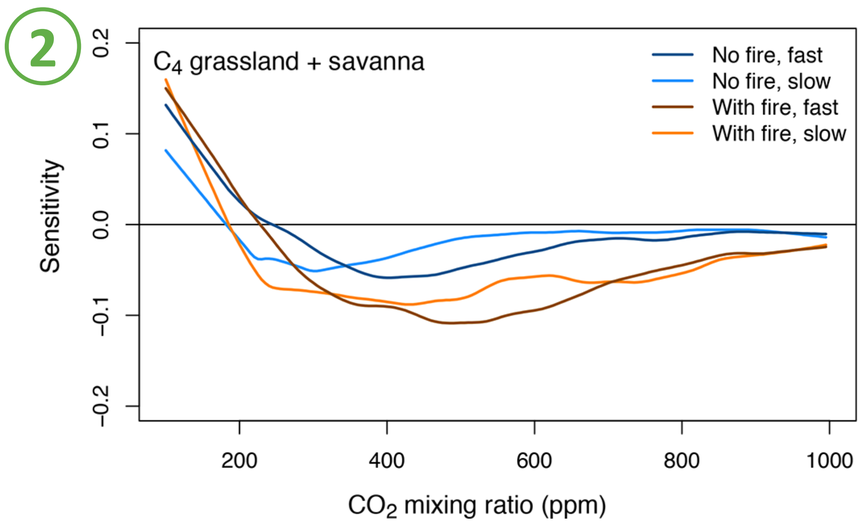
RESULTS

1



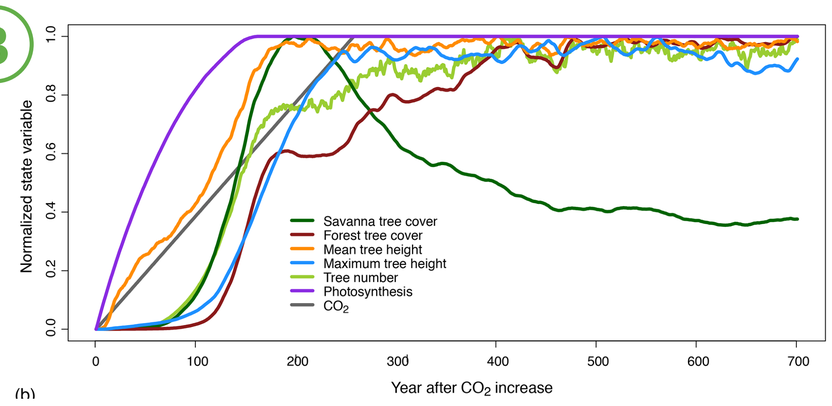
The cover of C_4 grassland and savanna in transient simulations deviates from cover fractions in equilibrium conditions (grey line). The rate of CO_2 change influences deviation.

2



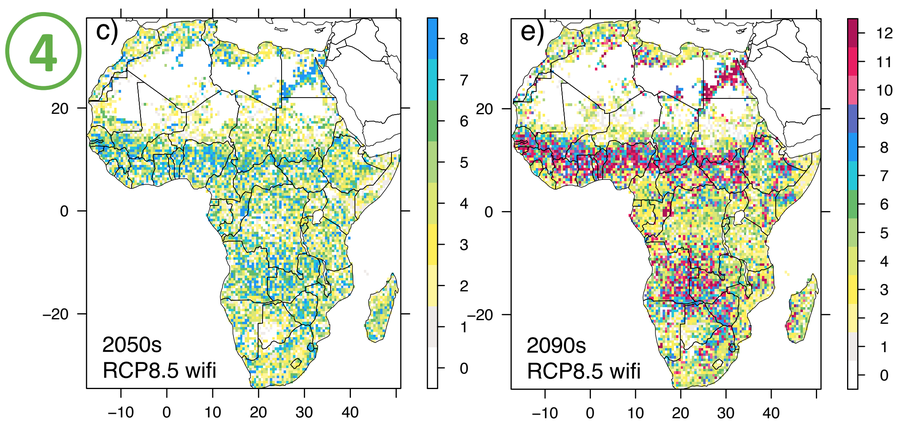
C_4 grassland and savanna cover is most sensitive to CO_2 change under current and near-future conditions, with variation between scenarios.

3



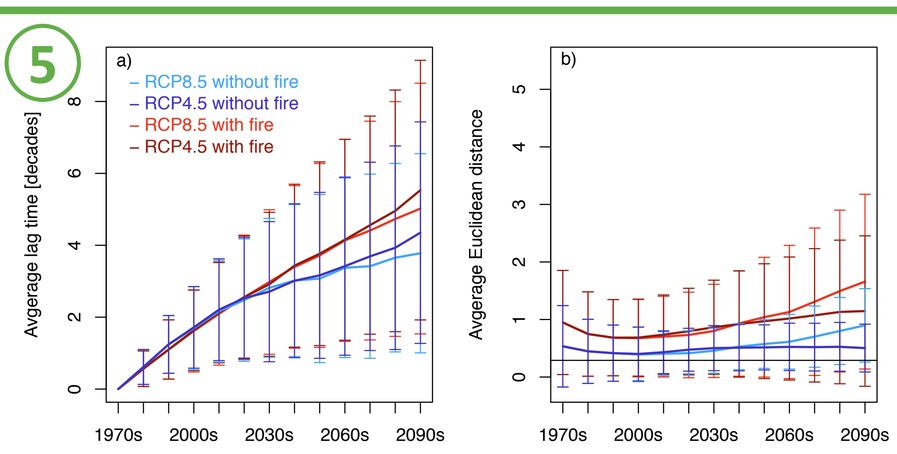
Different processes and aDGVM model variables respond at different rates to CO_2 increase.

4



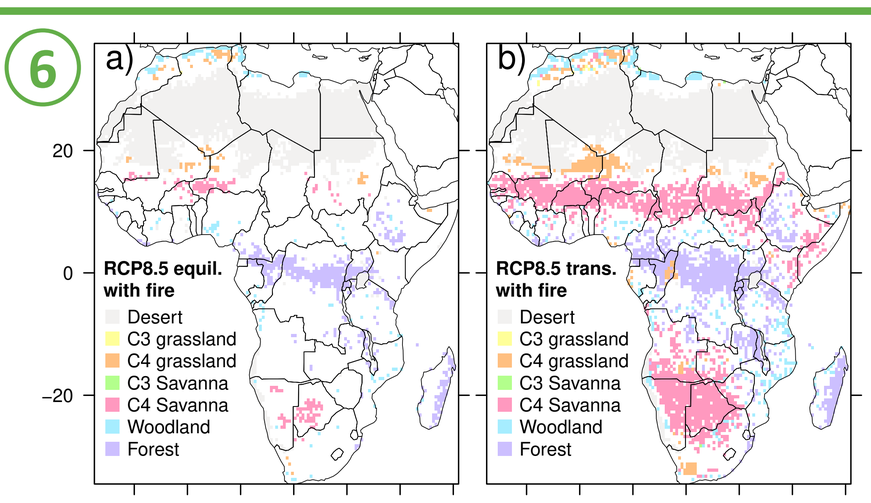
Lag time between transient and most similar equilibrium vegetation state increases towards the end of the century, and is highest in savannas and grasslands (RCP8.5 with fire).

5



Lag time and distance between transient and most similar equilibrium vegetation states increase towards the end of the century. Figures show averages and standard deviation for Africa in different scenarios.

6



Areas with only one biome type between the 1970s and 2090s in equilibrium and transient simulations for RCP8.5 with fire.

KEY MESSAGES

- Vegetation will continue to change even if the climate system stabilizes.
- Savanna vegetation is most sensitive to CO_2 change at current and near-future CO_2 levels.
- Transient vegetation states do generally not follow virtual trajectories of equilibrium states.
- Management needs to consider delayed vegetation responses and committed vegetation change.

REFERENCES

Pfeiffer M, Kumar D, Martens C, Scheiter S (2020) Climate change will cause non-analogue vegetation states in Africa and commit vegetation to long-term change. *Biogeosciences*, **XX**, XXXX-XXXX.
Scheiter S, Higgins SI (2009) Impacts of climate change on the vegetation of Africa: an adaptive dynamic vegetation modelling approach. *Global Change Biology*, **15**, 2224-2246.
Scheiter S, Moncrieff GR, Pfeiffer M, Higgins SI (2020) African biomes are most sensitive to changes in CO_2 under recent and near-future CO_2 conditions. *Biogeosciences*, **17**, 1147-1167.

support
GEFÖRDERT VOM Bundesministerium für Bildung und Forschung
DLR Projektträger
Emmy Noether-Programm DFG

project region
SPACES II Science Partnerships for the Adaptation to Complex Earth System Processes in Southern Africa
RSA

partners
University of Limpopo
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SPACES II Midterm, 21 October 2020