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Quantifying the climatological impact of deforestation in the Congo Basin for the middle of the 21th century

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1. Objective

To refine existing impact assessments by replacing the primary forest by a typical combination of successional fallow vegetation types observed for the Congo Basin

Figure 1. Example of shifting cultivation ("slash-and-burn") agriculture in western Democratic Republic of Congo (B.G. Marcot, 2013).

2. Method

- the COSMO-CLM regional climate model coupled to a state-of-the-art soil-vegetation-atmosphere transfer model (Community Land Model) using ECHAM5 boundary conditions
- 20-year period present-day (1990-2009) and future (2040-2059)
- SRES-A1B scenario forcing
- 210 x 180 points; Δx=~25km
- Evaluation see Akkermans et al. (2013b)

3. Deforestation scenario

- Justice et al. (2001): spatially explicit character, the use of high-resolution input data and the inclusion of small-scale processes
- Adjusted using an intermediate projection for estimated total amount of forest loss by 2050 (-16%).
- Compatible with emission scenario (SRES-A1B scenario). (i) a market-oriented, (ii) absence of a coordinated environmental impact mitigation strategy, (iii) an intermediate projection, (iv) roughly similar population sizes

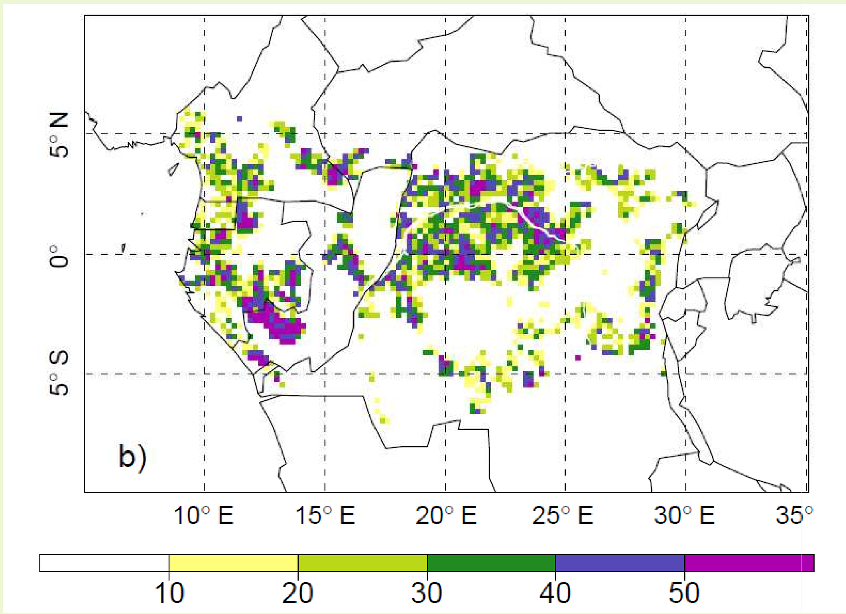

Figure: 2 Rainforest removal in the scenario from Justice et al. (2001) [% decrease per grid cell]

4a. Successional vegetation

- Field campaign to DR Congo (2012) to identify ground truth successional vegetation (Fig 3; photographed during field campaign)
- Identification of successional vegetation: 5% bare soil, 22% crops, 9% grass, 33% forest regrowth and 30% secondary forest
- More details : Akkermans et al. (2013a)

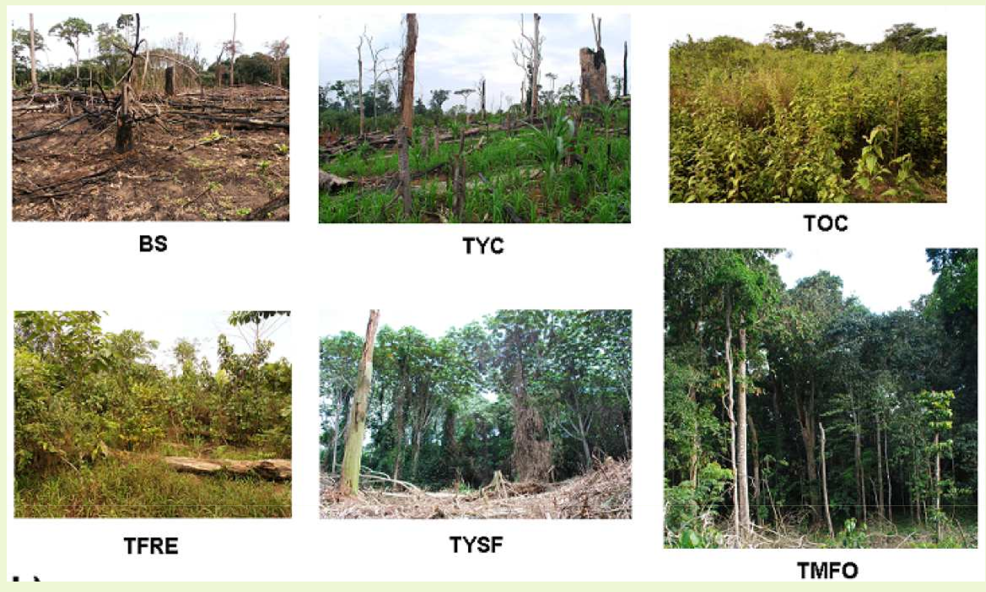

Figure 3. Observed successional vegetation classes: BS: Bare Soil; TYC: Tropical Young Cultivated; TOC: Tropical Old Cultivated; TFRE: Tropical Forest Regrowth; TYSF: Tropical Young Secondary Forest; TMFO: Tropical Mature Forest.

4b. Successional vegetation

Realistic successional vegetation results in smaller change compared to earlier used complete basin-wide conversion of forest to e.g. pasture or crops

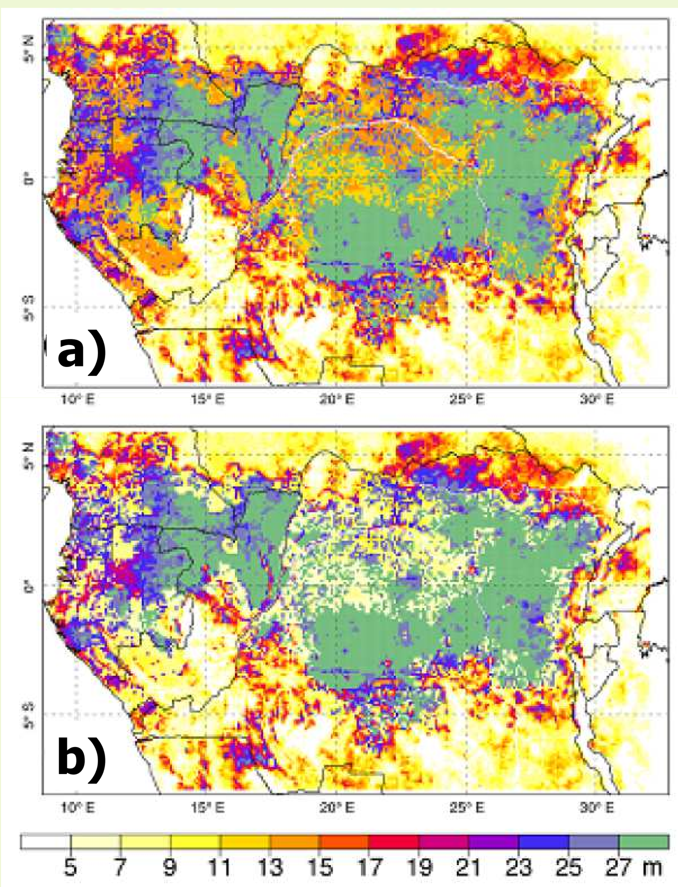

Figure 4: Future projection of canopy height for 2050, replacing the portion primary forest (a) by a mix of successional vegetation types or (b) by cropland.

5a. Results

- The deforestation, expected for the middle of the 21th century, induces a warming of 0.7°C, with local hot spots of up to 1.25˚C warming
- This is about half of the greenhouse gas-induced surface warming, given the medium SRES-A1B scenario forcing and using ECHAM5 boundary conditions
- Decreasing precipitation amounts by about 5 to 10% in this region due to heat low development: surface warming due to deforestation → heat low → low-level convergence → dynamical redistribution of moisture in the boundary layer → weakening atmospheric instability → weakening of convection intensity
- This underlines the necessity of taking into account deforestation in order to obtain realistic future climate projections.

20-year mean difference of ground surface temperature [K] (left) and relative difference of precipitation [%] (right)

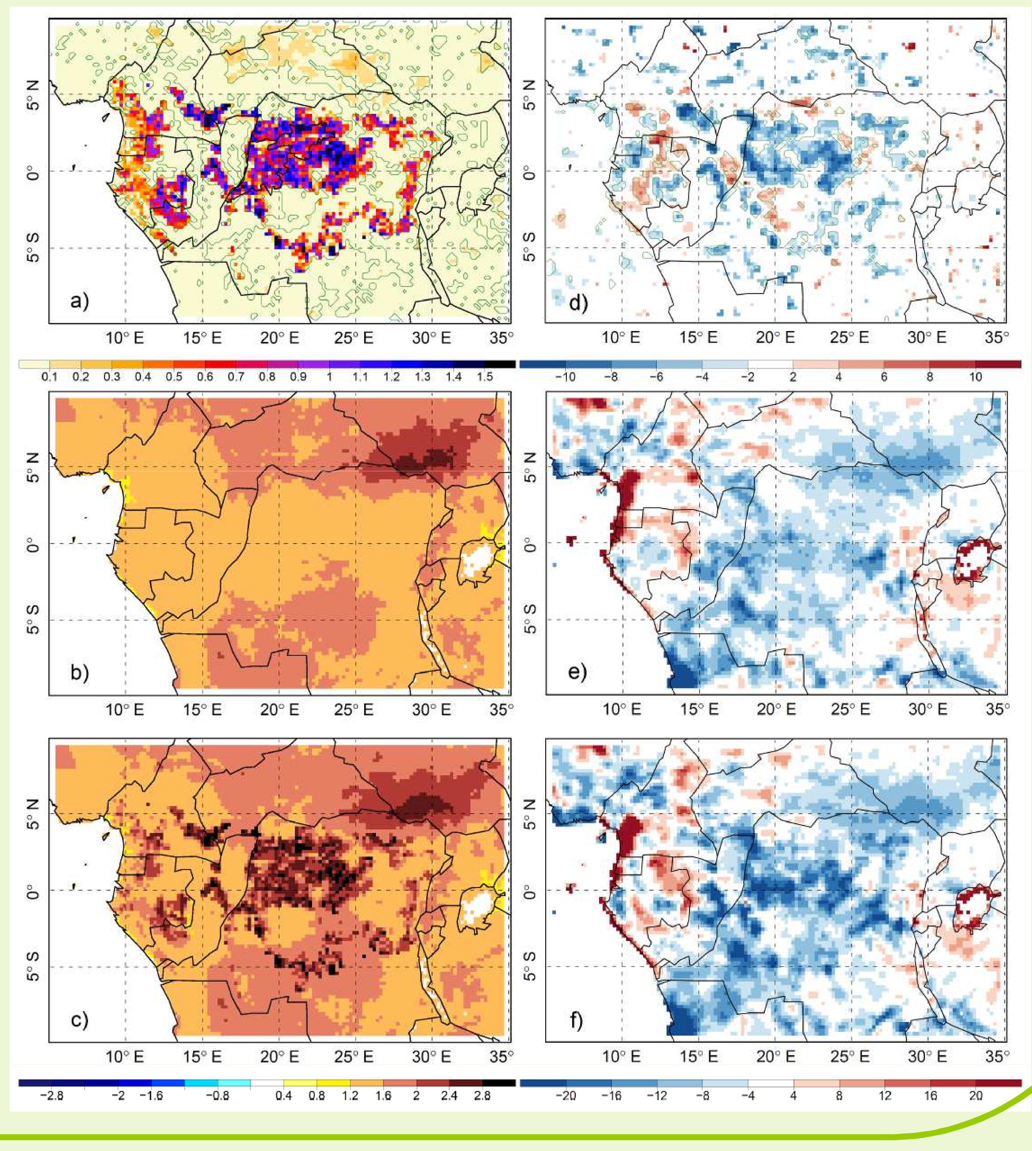

Fig. 5 : The change due to (a, d) deforestation, (b, e) GHG imposed by the SRES-A1B scenario forcing, using ECHAM5 boundary conditions and (c, f) both GHG and deforestation.

5b. Results

Decomposition of deforestation-induced warming, using a linearised form of the energy balance equation:

$$\delta T_c = \frac{1}{4\epsilon\sigma T_c^3}(-SW_i\delta\alpha + (1-\alpha)\delta SW_i + \delta LW_i - \delta LE + \delta H_{res} - \delta H_{tmp} - \delta G - \sigma T_c^4 \delta\epsilon)$$

The warming signal at the canopy top is decomposed into individual contributions:

- Increased albedo has a minor cooling impact of -0.25˚C
- Decreased evapotranspiration is responsible for +1 to +1.25˚C
- The resulting energy excess is about equally divided between an increased sensible heat flux to the atmosphere and a localized heating resulting in increasing outgoing longwave radiation.

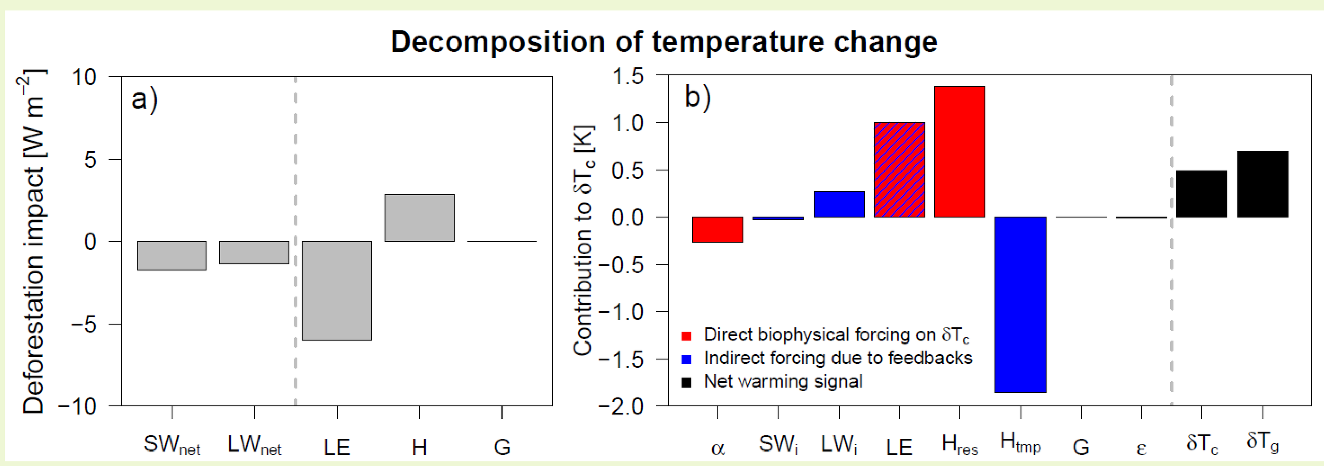

Fig. 6. (a) Deforestation-induced change in surface energy balance and (b) parameter or flux component responsible for the temperature sensitivity to deforestation

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