Adapting Afforestation Patterns Considering Their Local Biogeophysical Induced Cooling and Warming

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1. Motivation

- Land-based options are hoped to play a key role in mitigation efforts.
- Scenario building models currently neglect their BGP impact.

2. Tools

Optimizing global agriculture with the land-use model MAgPIE for a range of possible developments both in climate (RCPs) and society (SSPs).

3. Method

The carbon equivalent of BGP induced temperature changes will be added as incentive/penalty to afforestation driven by the carbon price.

Objective

Reevaluate afforestation as a mitigation option considering BGP effects as an incentive or penalty.

4. Results

- Marked difference in afforestation development and patterns.
- High sensitivity to the onset of BGP effects.

BGP – Biogeophysical
MAgPIE - Model of Agricultural Production and its Impact on the Environment

RCP – Representative Concentration Pathways
SSP – Shared Socioeconomic Pathways
1. Findings
   a) Endogenous BGP consideration influences the onset, slope, and resulting afforestation area.
   b) Resulting afforestation area is sensitive to the timing of BGP effects.

2. Setup
   - SSP1
   - Unrestricted afforestation
   - Annual BGP impact estimates from observation-based studies\textsuperscript{1,2}.
1. Findings
a) Increase in total area pushes afforestation mostly in the tropics.
b) Afforestation becomes more robustly viable over SSPs in central Africa/America, and China.

2. Outlook
• Model runs with higher resolution
• More scenarios (SSPs) and carbon price pathways.
• Assessment of the BGP induced change in absolute CO2 removal.
Method 1/2 BGP as a Cost Incentive / Penalty

Incentive / Penalty

The cost incentive or penalty of the BGP effects of afforestation is derived by multiplying the carbon price by the carbon equivalent of BGP induced temperature changes (see next slide). This allows the model (MAgPIE) to endogenously adapt afforestation decisions informed by BGP effects.
The Carbon Equivalent Metric

We compute the carbon emission equivalent ($C_{eq}^{BGP}$) that would theoretically produce the same temperature response as the temperature change induced by local BGP effects\(^1\),\(^2\) ($\Delta^\circ C^{BGP}(i,j)$). We obtain the local contribution by dividing by the global surface area ($A_{SFC}$). The local climate sensitivity to carbon emissions (TCRE($i,j$)) is derived by the CMIP5 +1% annual CO2 increase experiments\(^3\).

\[
C_{eq}^{BGP}(i,j) = \frac{\Delta^\circ C^{BGP}(i,j)}{TCRE(i,j)} \times \frac{1}{A_{SFC}}
\]

**Example of one grid-cell**

\[
\frac{10tCeq}{ha} = \frac{1}{510 \times 10^8 \text{ ha}} \times (-1^\circ C + 2.5^\circ C) = \frac{1,2}{3} = -1^\circ C.
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