Sensitivity of marginal abatement cost curves to variation of G4M parameters

Mykola Gusti, Nikolay Khabarov and Nicklas Forsell

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Outline

- Introduction
- Method
- Results and discussion
- Conclusions and Challenges
- Questions and answers
Introduction

- MACC – a “tool” for analysis of mitigation policies

Kesicki (2011)

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Introduction

- Model derived MACC: (BAU emissions – Mitigated emissions) against mitigation costs
Introduction

- Model uncertainty and MACC:
  \[(\text{BAU emissions} + \text{Err} - \text{Mitigated emissions} - \text{Err})\]
  \[(\text{BAU emissions} + \text{Err}_1 - \text{Mitigated emissions} - \text{Err}_2)\]
Introduction

• Model uncertainty and MACC:
  
  \( \frac{(BAU \text{ emissions} + \text{Err} - \text{Mitigated emissions} - \text{Err})}{(BAU \text{ emissions} + \text{Err1} - \text{Mitigated emissions} - \text{Err2})} \) 
  
What is sensitivity of the MACCs to selected model parameters?
Introduction

- how the parameter uncertainties can impact GHG abatement policies related to forest sector?

Modified figure from Kesicki (2011)
Generating LUC abatement cost curves: Modeling framework

Basic drivers

Assumptions on GDP, population, bio-energy by world regions

Elaboration of basic drivers

GLOBIOM

Wood prices, land rents, wood demand

Elaboration of projections

Wood production potential, init. prices

Calibration to FAO data

G4M

Forest management

Afroestation, reforestation, deforestation

Trade

Projections of net forestry emissions

Abatement cost curve estimation

Guss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
Method: G4M overview

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Method G4M: LUC decisions

[Diagram showing the relationship between various parameters and decisions within the G4M framework.]

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Method

• “Baseline”: CO2 initial prices starting in 2020 (0, 1, 3, 5, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100, 120 USD/tCO2) and rising 5% / year (CO2 price range: 4-520 USD/ton CO2 in 2050)

• “Sensitivity”: decrease/increase \( cr, w, \) and \( l \) them by 1, 2.5, 5, 10, 50 and 90% one by one for each CO2 price

• Build MACC as a difference of total biomass CO2 emissions at non-zero CO2 price and zero CO2 price in 2030
Results and discussion
Results and discussion

![Graph showing deviation of total MACC due to agriculture land price variation. The x-axis represents USD/tCO2, and the y-axis represents MtCO2/year. Different symbols and colors are used to represent various scenarios and land price variations.](image-url)
Results and discussion

Total emissions sensitivity to agriculture land price globally
Results and discussion

MACC sensitivity to parameter 10% deviations

MACC deviation, MtcO2/year

CO2 price, USD/tCO2
Results and discussion

Graph: Total emissions sensitivity to corruption coefficient globally

Parameter variation, %

CO2 price, $/tCO2

MtCO2/year

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Results and discussion
Impact on policy analysis

Total MACC sensitivity to agriculture land price

C tax

Resulting reduction

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Impact on policy analysis

Resulting C price

Total MACC sensitivity to agriculture land price

C allowances

MtCO2/year

USD/tCO2

Baseline

lm1

lm2_5

lm5

lm10

lm50

lp1

lp2_5

lp5

lp10

lp50

lp90
Final remarks

• Non-linear IAM - MACCs may be sensitive to variation of the model parameters.
• G4M MACCs are much more sensitive to parameter variation at a certain range of CO$_2$ prices, usually low CO$_2$ prices.
• G4M total biomass CO2 MACCs are most sensitive to variation of corruption coefficient and agriculture land price.
• MACC uncertainty can influence outcome of policy analysis.
• Inform experts applying MACCs for policy analysis on MACC uncertainty!

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Contact information

Mykola Gusti
Ecosystem Services and Management
International Institute for Applied Systems Analysis
Schlossplatz 1, A-2361 Laxenburg, Austria
Phone: (+43 2236) 807 534
Fax: (+43 2236) 71 313
Web: http://www.iiasa.ac.at
Email: gusti@iiasa.ac.at
Results and discussion

Total emissions sensitivity to wood price for Brazil
Results and discussion

Total emissions sensitivity to wood price for Indonesia
Results and discussion

Total emissions sensitivity to wood price for Mexico
Results and discussion

Deviation of DF MACC due to wood price variation

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Results and discussion

Deviation of FM MACC due to wood price variation

MtCO2/year vs. USD/tCO2
Results and discussion

Deviation of AF MACC due to wood price variation
Model comparison

Kindermann et al. 2008: Global emission reduction

(avoided deforestation)

USD / t CO₂

CO₂ emission reduction, Mt CO₂/year
Method (details*)

*Gusti et al., 2012, Simulation of REDD+ options using IIASA model cluster, iEMSs-2012
Modeling framework

Basic drivers

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Assumptions on GDP, population, bio-energy by world regions

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Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
Modeling approach

Half degree grid cells

G4M Forestry

Potential harvest
Carbon stocks
Initial NPV(s) and wood price

World regions

GLOBIOM Land use

Change in NPV(s) and Wood price
Wood demand

Simulation units

EPIC Agriculture

Crop yields Management params

Afforestation
Deforestation

Agriculture land

GDP and Pop. density
Calib. to FAO FRA 2010 and Forest Loss Map

Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
G4M: Modeling approach

Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
G4M: Modeling approach

Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
G4M: FM targets and options

• FM targets:
  – Harvest demanded amount of wood on country scale
  – Harvest demanded amount of wood + maximize biomass comparing to baseline (NPV->max)

• FM options:
  – Tune rotation length: max MAI – max biomass
  – Change harvest location (depending on CAI)
Results: Global forest area change (baseline)

- Net forest area decreases until 2015
- But increases after 2020
Results: Global LUC removals and emissions (baseline)

- Afforested areas accumulate carbon slowly
- Net LUC emissions > 0 until 2045
Results: Global forest area change

Def. area rel. 2010 under non-zero C price

Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
Results: Global net forest area change

- FAO level is met but trend is different
- Already in baseline global forest area increases after 2020
Results: Global net forest area change

- FAO level is met but trend is different
- Already in baseline global forest area increases after 2020
- Afforestation stays rather constant, declining after 2020
- Deforestation decreasing
Results: Baseline development global forestry emissions

- Deforestation emissions expected to decline constantly
- Afforestation (start in 2000) kicking in late
- Therefore net land use change emissions negative only after 2040
Results: Baseline development global forestry emissions

- Deforestation emissions expected to decline constantly
- Afforestation (start in 2000) kicking in late
- Therefore net land use change emissions negative only after 2040
- Forest sink declining due to ageing forest
- Overall emissions rather stable

Forest biomass emissions in Mt CO2

Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
Results: Global net forest area change under different C prices

- If carbon has a price, net area loss declines more rapidly and area gain after 2020 is higher.
- A price of 30 USD increases net gain by factor four.
- Strongest effects at medium C prices (20-50 USD).

Net forest area change in M ha

- net baseline
- 10
- 20
- 30
- 50
- 70
- 100
- FAO
Results: Potential and costs for additional storage in non-Annex I

- CO₂ storage in comparison to baseline at different C price levels
- Afforestation potential negligible (high baseline, time lag)
- Reduced deforestation puts pressure on remaining forest (harvest increases) resulting in negative cost curve

Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
Sensitivities: Corruption factor effects for non-Annex I

- Country specific corruption factors (based on World Bank data) lower potential in baseline
- To be interpreted as efficiency of USD spent on emission reduction
- Without corruption effects potentials can be doubled for lower carbon prices

Graph: Average emission reduction until year 2030

- Baseline
- Without corruption effects

Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
Comparison to historic estimates

- Global emissions (Pg C)
- Similar estimates for land use change emissions
- Underestimation of sink by G4M
- Opposing fluxes lead to big difference in net flux

**Land use change**

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<td>1990-1999</td>
<td>-2,0</td>
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<td>2000-2007</td>
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**Forest sink**

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<tr>
<td>2000-2007</td>
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**Global net sink**

<table>
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<tr>
<th>Year</th>
<th>Pan et al. 2011</th>
<th>G4M baseline 2011</th>
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<tbody>
<tr>
<td>1990-1999</td>
<td>1,0</td>
<td>0,5</td>
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<tr>
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Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013
Results: Effect of integrated MACC curves in Annex I countries

Average emission reduction until year 2030

Fuss et al. An approach to assessing benefits of advanced global carbon observation system. ICDC 2013 - Beijing – 3-7 June 2013