The Global Biosphere Management Model (GLOBIOM)

Stefan Frank, Petr Havlík, Hugo Valin and many others...
Background - GLOBIOM

- **Developed at International Institute for Applied Systems Analysis** in Austria since the early 2000s
- **Partial Equilibrium Model** - offspring of US FASOM model developed by Bruce McCarl
  - Global bottom-up supply side coverage (>10,000 Simulation Units)
  - Agriculture: major agricultural crops and livestock products
  - Forestry: managed forests for sawnwood, and pulp and paper production
  - Bioenergy: 1st, 2nd generation biofuels, solid biomass
- **Optimization model** (maximize consumer & producer surplus)
  - Runtime ~1 hour up to 2050
  - Computational cluster at IIASA allows up to 200 scenarios to be run in parallel
- **Data sources** - FAOSTAT, complemented with spatially explicit bottom-up sectoral models (EPIC, G4M etc.) for production parameters and land cover information
- GLOBIOM is developed and maintained at IIASA in the Integrated Biosphere Future Research Group by around 25 *interdisciplinary scientists* - on access strategy under development
- However, **many national collaborators/users** that develop regional model versions such as in Argentina, Brazil, China, Colombia, India, Indonesia, Mexico, Russia, US, ...
Bridging geographical and temporal scales

2000 2010 2020 2030 2040 2050 2060 2070 2080 2100

Validation period  Policy Impact Assessment  Long-Term Outlook  Climate stabilization pathways
Global Biosphere Management Model (GLOBIOM)

- Partial equilibrium model
- Trade: spatial equilibrium
- Homogenous goods
- Flexible demand regions aggregates (37 regions)
- Spatially explicit supply
- Leontief production functions
- Recursively dynamic: 1 to 10 years time step
- Optimization model
- Linear programming
- GAMS
Key model features for biofuel assessments

Detailed representation of land
- Associated uses (and non-uses)
- Carbon stocks
- Marginal yield values from biophysical model

Yield endogenous response
- Intensification (change in management systems)
- Irrigation
- Intra-regional reallocation

Endogenous demand response & substitution effects (e.g. vegetable oils)

AFOLU GHG emission sources and globally consistent accounting

Detailed representation of biofuel processing technologies

Bilateral trade
Crop production systems: EPIC

Spatially explicit production functions

In every SimU:

- Up to 18 possible crops in the global model version & 4 crop managements
- Parameters (yield, fertilizer and irrigation input requirement) estimated with biophysical models
e.g., EPIC model (Izaurralde et al., 2006)

Balkovic et al. (2014)
Livestock Production Systems: RUMINANT

Source: Herrero et al. 2013, PNAS
GLOBIOM woody biomass use in 2010

- GLOBIOM covers the main primary feedstocks, by-products, and semi-finished HWP products.
- Wood flows as of 2010 is calibrated according to FAOSTAT.

Source: Lauri et al., 2017
Biofuel processing chains

**Food crop-based biofuels**
- Starch crops: barley, corn & wheat
- Sugar crops: sugar cane & sugar beet
- Oil crops: rapeseed, soybean, oilpalm & sunflower

**Advanced biofuels**
- Residues: cereal straw & forest residues
- Short rotation coppices: poplar, willow & eucalyptus
- Grassy crops: miscanthus & switchgrass
Land cover change

- Land cover change endogenous depending on relative profitability

Full AFOLU GHG accounting

Forest carbon biomass

Source: Valin et al., 2013

Source: Kindermann et al., 2008
Policy assessments

Biofuels Assessments
- EU ILUC & ILUC2 assessment
- ICAO CORSIA biofuel modelling

EU Energy & Climate Policies
- EU Reference scenarios 2013, 2016, 2020
- 2020 & 2030 Climate and Energy Package
- 2050 Long Term Strategy - A Clean Planet for All
- Fit for 55 package
- …

The global nexus of food-trade-water sustaining environmental flows by 2050
A. V. Pastor, A. Palazzo, P. Havlik, H. Biemans, Y. Wada, M. Obersteiner, P. Kabat and F. Ludwig

Reconciling regional nitrogen boundaries with global food security
Jinfeng Chang, Petr Havlik, David Leclère, Wim de Vries, Hugo Valin, Michael Obersteiner

Bending the curve of terrestrial biodiversity needs an integrated strategy
David Leclère, Michael Obersteiner, ... Lucy Young

China’s future food demand and its implications for trade and environment
Hao Zhao, Jinfeng Chang, Petr Havlik, Michiel Charlotte Janssens, Lin Ma, Zhaohai Bai, Mario H Michael Obersteiner

Tackling food consumption inequality to fight hunger without pressuring the environment
Tomoko Hasegawa, Petr Havlik, Stefan Frank, Amanda Palazzo and Hugo Valin

Global hunger and climate change adaptation through international trade
Charlotte Janssens, Petr Havlik, Tamás Krisztin, Justin Baker, Stefan Frank, Tomoko Hasegawa, David Leclère, Sara Ohrel, Shaun Ragnauth, Erwin Schmid, Hugo Valin, Nicole Van Lipzig and Miet Maertens
Thank you!