Future land use in Brazil under increasing demand for bioenergy

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Introduction

An important current debate is whether bioenergy from dedicated crops is still sustainable when land use change (direct and indirect) is taken into account, in view of, e.g., carbon emissions, rising food prices, and biodiversity. Impacts of a future increase in demand for bioenergy depend on the magnitude, location and pattern of energy cropland expansion. As processes herein act on global (e.g., economy) as well as local (e.g., potential yield) levels, we apply an integrated model.

We aim at:
1. projecting the magnitude and spatiotemporal pattern of sugar cane expansion and the effect on other land use types in Brazil towards 2030, and
2. assessing the uncertainty herein.

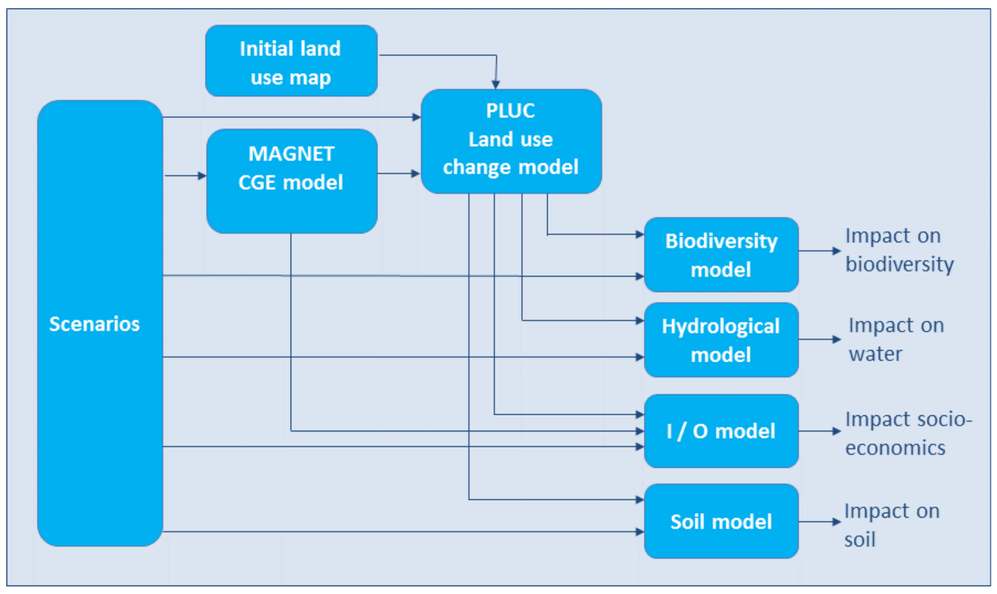

Figure 1: Model chain. The scenarios and Magnet (computable general equilibrium model)are global, while the rest of the analysis is specific for Brazil.

Methods

For the spatio-temporal projection, four model components are used (Figure 1):

1. an initial land use map that shows the initial amount and location of sugar cane and all other relevant land use types in Brazil,
2. a computable general equilibrium (CGE) model, Magnet, simulating the economy of the whole world to project the quantity of change of all land uses in Brazil,
3. a spatially explicit land use model, PLUC, is calibrated with agricultural statistics data (Figure 3) to finally determine the location of change of all land use types (Figure 4), and
4. several models evaluating the impacts of land use change on biodiversity, water, socio-economics, and soil, performed by the other three PhD students in project F09.001

Results

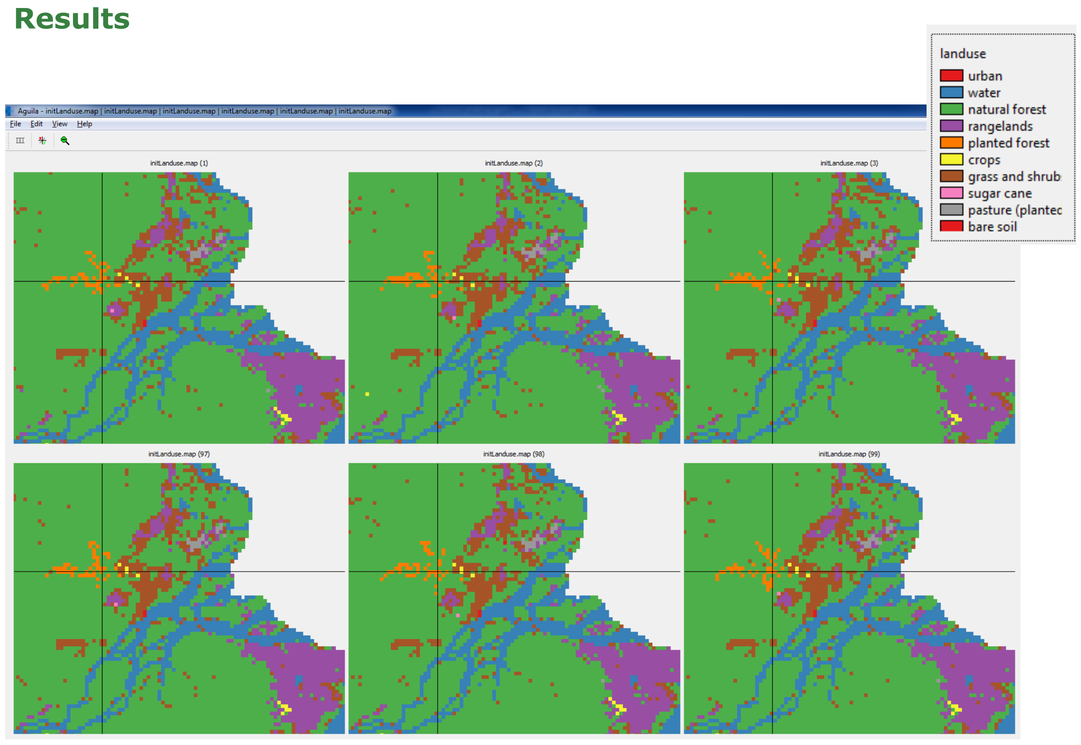

Figure 2: No recent accurate land use map is available for Brazil, so municipal census data and the global land cover map GlobCover are combined to create the initial land use map. The census data available per municipality are disaggregated stochastically using GlobCover as a probability surface, to obtain an ensemble of initial land use raster maps for 2006. Shown here in the visualization software the model is connected to, Aguila (pcraster.geo.uu.nl), is a detail of the initial land use map of Brazil, the mouth of the Amazon river, for six ensemble members. The total areas of the different land use types in the six ensemble members are similar, but the shapes of the patches differ. See for example the shape of the patch of planted forest (orange).

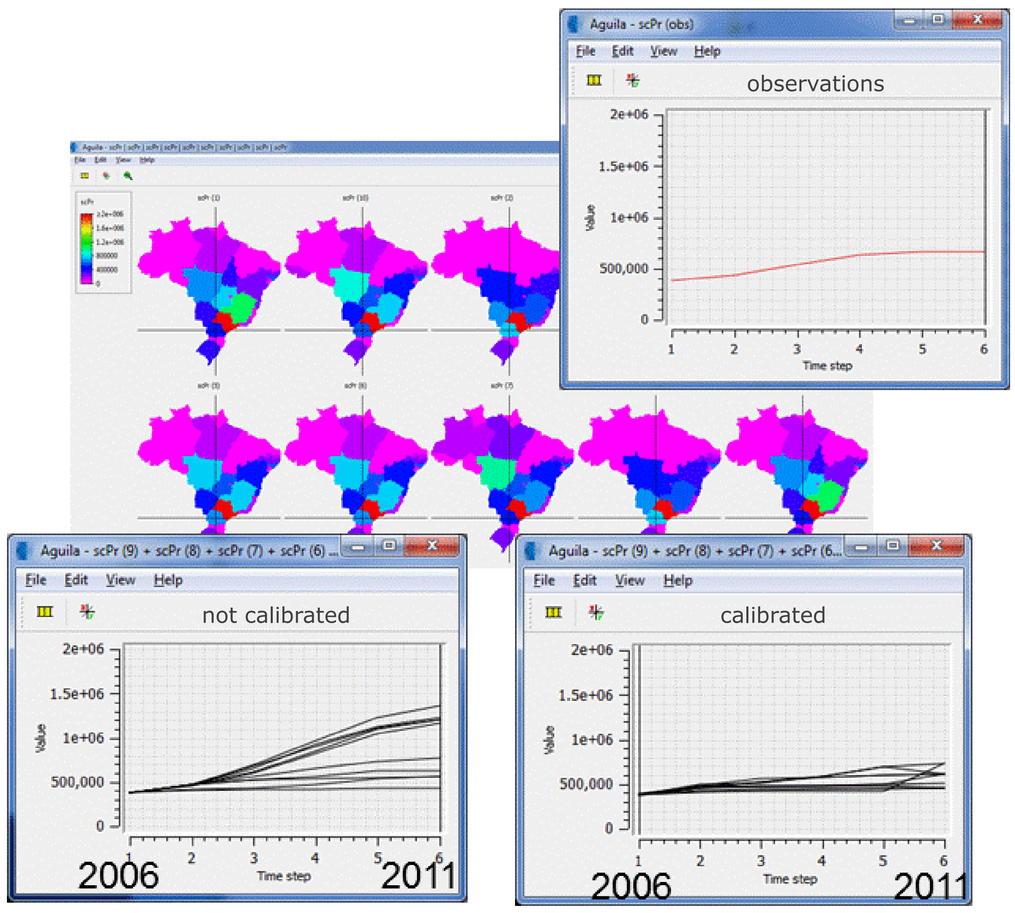

Figure 3: Using a Bayesian data assimilation technique and census data from 2007 to 2011 as observational data, PLUC is calibrated. The ensemble of maps shows the total area of sugar cane per state projected for 2011 by the calibrated ensemble of model runs. The variance in total area of sugar cane in the state Parana given by the ensemble of model runs for the not calibrated model (left hand graph) is more than twice as large as the spread given by the calibrated model (right hand graph). Also, the ensemble of the calibrated model predicts values closer to the observed values (upper graph).

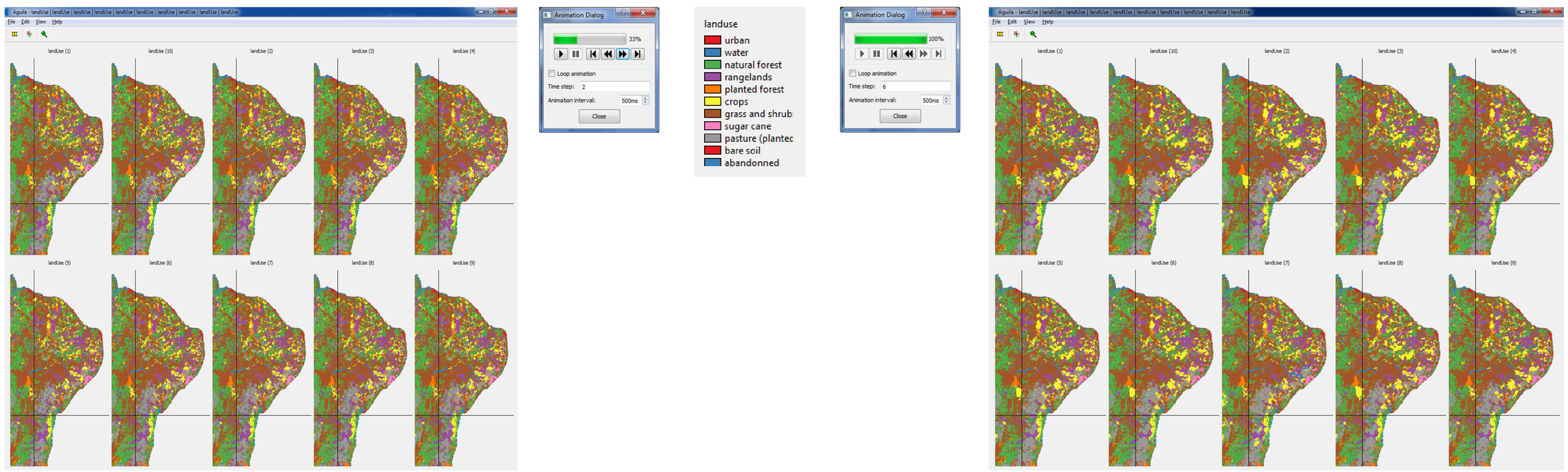

Figure 4: Land use in North-Eastern Brazil in 2007 (left) and 2011 (right) projected by the ensemble of model runs. The difference among the ten samples is larger in 2011 than in 2007, because of error propagation over time. For example the lower centre ensemble member in 2011 shows some abandoned cropland in the centre (blue) that is reallocated in the south (yellow), while the other members do not show that.

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