Modeling Carbon Dynamics in Amazonia with the Dynamic Global Vegetation Model LPJmL
Input, Transformation, and Output of Fluvial Carbon

Fanny Langerwisch, Stefanie Rost, Ben Poulter, Heike Zimmermann-Timm, Wolfgang Cramer | Potsdam Institute for Climate Impact Research , Potsdam, Germany | fanny.langerwisch@pik-potsdam.de

ABSTRACT During annual flooding the terrestrial and riverine components of the Amazon basin are closely connected and an intense replacement/exchange of organic material occurs. The quality and quantity of these fluxes can be altered by land use and climate change. To understand the fluxes and the modification in this exchange we are using the Dynamic Global Vegetation Model LPJmL. This terrestrial biosphere model is representing key ecosystem processes in a realistic manner. For our purpose we adapted the model and provide a framework for a new module that links terrestrial processes with riverine fluxes. Our objective is to study the impact of land use change and climate variability on carbon dynamics and carbon dioxide emissions.

INTRODUCTION

- Some Facts about the Amazon Basin -

Area:	6 Mill. km² more than 4% of the Earth´s land surface
River Length:	nearly 6,400 km
Water discharge:	5,500 $km^3\ yr^{-1}$ at Obidos☆ nearly 15% of global fresh water[a]
Carbon discharge:	40 Tg C yr^{-1} to the ocean[e] 400 Tg C yr^{-1} to the atmosphere[f]
Flow velocity:	0.25 to 2 m s^{-1}[b-d]

The Amazon basin is one of the potential future *'tipping elements'*[g] in the climate systems where small changes can potentially alter the state of the system. During the last century 17.3% of the Amazonian rain forest has been deforested. These modifications of vegetation structure result in changes in evapotranspiration, precipitation, and temperature, which can be followed by reduced carbon stocks and altered carbon flows to the atmosphere and the Atlantic ocean.

MODEL

Modeling carbon dynamics in Amazonia means to understand the main components of the carbon flow (Fig.A):

- **production** in the terrestrial system
- **interaction** between terrestrial and aquatic system parts
  - flood dynamics
  - transport and conversion of organic matter
- **export** of carbon from the riverine system to the atmosphere and the ocean

All these processes can be affected by land use and climate change.

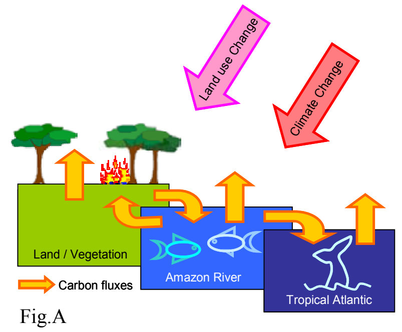

Fig.A

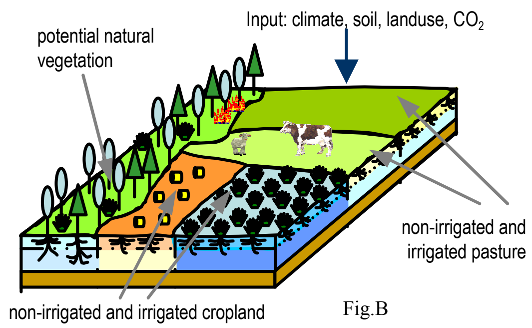

Fig.B

LPJmL[h] (Fig.B) simulates growth, abundance, and vegetation dynamics of natural vegetation and agricultural crops[i]. It includes a river routing module that simulates the river network[jk]. Recently landform types were added (see RESULTS) to improve simulated river discharge and to mask floodplain area[l], which is crucial to include the land-water-interaction to the model.

RESULTS

Floodplain area

We include the floodplain area as a new input (Fig.C) to our model to calculate the area from which mobile terrestrial fixed carbon (soil and litter carbon) can be exported to the river as well as the amount of exported carbon.

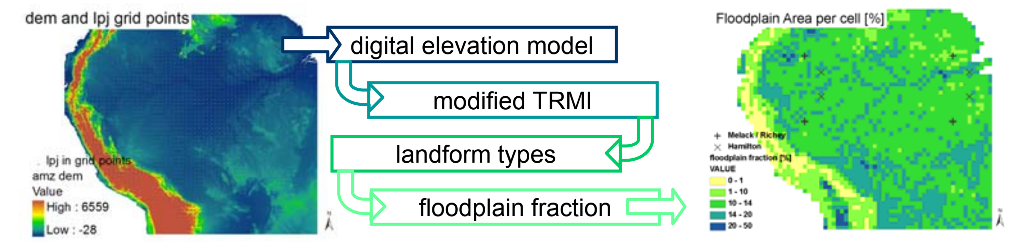

Fig.C

Floodplain area was validated with published data[fmn] (Fig.D). The agreement is necessary for the calculation of exported carbon.

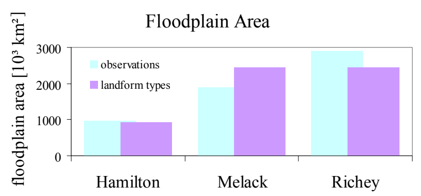

Fig.D

Hydrology module

We adapted the LPJmL hydrology module (heterogeneous flow velocity) to improve simulated spatial and temporal water fluxes. The comparison (R^2) of observed with simulated discharge (for 43 sites in the basin) shows the better agreement (Fig.E) especially for high discharge sites. The agreement for seasonal dynamics in Obidos is shown in Fig.F.

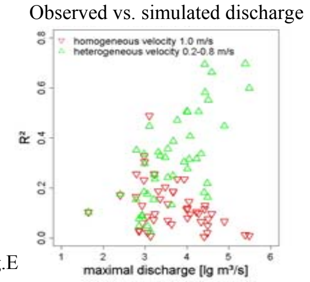

Fig.E

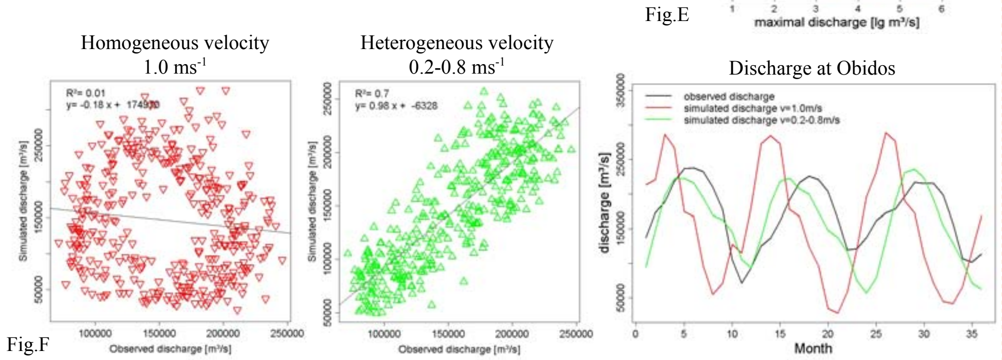

Fig.F

Aquatic carbon model

We are developing an aquatic carbon model to quantify the transport and transformation of organic carbon in the river. This model will include export of mobile organic carbon, transformation of organic carbon in the river network and export to the atmosphere and to the ocean.

low autochthonous primary production P/R<1[s] litterfall: 5.89 Mg C $ha^{-1}\ yr^{-1}$[p] watershed export: 31.5 kg DOC $ha^{-1}\ yr^{-1}$ 17.6 kg POC $ha^{-1}\ yr^{-1}$[p] DOC: 80 µM[q]	high aut. PP P/R>1[s] tributary export: 28 Tg C yr^{-1}[e] DOC: 270-720 µM[r] 500-1000 µM[e] TOC: 500 µM[r]	low aut. PP P/R<1[s] Amazon export: 32.7 Tg C yr^{-1}[e] DOC: 350 µM[q] 150-550 µM[e] TOC: 500µM[r]
uppper reaches	middle reaches	lower reach

carbon fixation carbon export carbon storage

a) Gaillardet et al. 1997 *ChemGeolog* b) Birkett et al. 2002 *JGR* c) Coe et al. 2002 *JGR* d) Hu et al. 2004 *DeepSeaRes* e) Moreira-Turcq et al. 2003 *HydrolProc* f) Richey et al. 2002 *Nature* g) Lenton et al. 2008 *PNAS* h) Sitch et al. 2003 *GCB* i) Bondeau et al. 2007 *GCB* j) Rost et al. submitted *WRR* k) Langerwisch et al. submitted l) Langerwisch et al. in prep. m) Hamilton et al. 2002 *JGR* n) Melack et al. 2004 *GCB* p) Johnson et al. 2006 *HydrolProc* q) Hedges et al. 2000 *LimnolOcean* r) Hedges et al. 1994 *LimnolOcean*