AMAZALERT Delivery Report

Title	**Datasets of baseline ensemble of DGVM runs**
Work Package Number	**WP2**
Delivery number	**D2.1**
First author	**Hans Verbeeck**
Co-authors	**Hannes De Deurwaerder** **Celso von Randow,** **Anja Rammig, Bradley Christoffersen,** **David Galbraith, Matthieu Guimberteau,** **Bart Kruijt**
Date of completion	1 September 2013
Name leading Work Package Leader	**Hans Verbeeck**
Approved by the Leading Work Package Leader	YES

To complete by the Coordinator

Approved by the Coordinator	YES / NO
Date of approval by the Coordinator	

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Abbreviations and acronyms

AAI	Andes-Amazon Initiative, Moore Foundation
AGB	Above-ground biomass
DGVM	Dynamic Global Vegetation Model
ESM	Earth System Model
ET, Evap, or **E**	Evapotranspiration
GCM	General Circulation model
GFDL-ESM2M	Geophysical Fluid Dynamics Laboratory – Earth System Model Modular Ocean
HadGEM2-ES	Hadley Global Environment Model 2 - Earth System
HYBAM	Geodynamical, hydrological and biogeochemical control of erosion/alteration and material transport in the Amazon basin
IBIS	Integrated Biosphere Simulator
ISI-MIP	Inter-Sectoral Impact Model Intercomparison Project
INPE	Instituto Nacional de Pesquisas Espaciais
IPSL	The Institut Pierre Simon Laplace
IPSL-CM5A-LR	IPSL Climate Model – Low Resolution
MCWD	Maximum climatological water deficit
MIROC-ESM-CHEM	Model for Interdisciplinary Research On Climate - Japan Agency for Marine-Earth Science and Technology
MOSES	Met Office Surface Exchange Scheme
NorESM1-M	Norwegian Earth System Model
NPP	Net primary production

PIK	Potsdam Institute for Climate Impact Research
RCP	Representative Concentration Pathways
TRMM	Tropical Rainfall Monitoring Mission
UEDIN	The University of Edinburgh
UGENT	University of Ghent
UNIVLEEDS	University of Leeds

Introduction

This deliverable presents the database containing the baseline model runs preformed with the 4 DGVMs used in AMAZALERT WP2. In the text below we briefly describe the modeling protocol for the historical and future model runs, the four DGVMs and the resulting database with model runs which is now available. In addition we illustrate the content of the database by showing a few maps presenting the forcing data and some historical model outputs of the four models as an example. The future model runs are still ongoing. An assessment of potential climate scenarios has been performed and the results of this assessment are included in the report. Results from the future model runs are not yet available.

Protocol

For model set-up and spin-up for the historical runs the protocol of the Moore Foundation Andes-Amazon Initiative (AAI) project was used with supplementation of some extra outputs (mainly hydrology related outputs) required for AMAZALERT. The protocol text was slightly adapted and made available for all AMAZALERT WP2 partners (see full protocol in appendix). The document contains not only all structural details for the model set-up and spin-up, but also information about the conventions for historical and future runs. Format of the output files and variable units are described to ensure standardization with the objective of easy of data exchange and analysis.

Historical runs

Each model has performed 2 historical runs.

- Potential vegetation: A (fire) or B (no fire) from the Moore Protocol
- Full change: D from the Moore Protocol.

Future scenario runs

Each model will perform multiple future runs based on the ISI-MIP protocol. The ISI-MIP project provides along with the protocol several bias corrected climate scenarios based on multiple GCMs and RCPs.

The four DGVMs

Orchidee (IPSL/UGENT)

ORCHIDEE is the land-surface scheme of the IPSL. This scheme is the result of the coupling of the SECHIBA land-surface scheme, which is dedicated to the surface energy and water balances, and the carbon and vegetation model STOMATE. More information can be found in: Krinner et al. 2005, Verbeeck et al. 2011.

Jules (UNIVLEEDS/UEDIN)

The Joint UK Land Environment Simulator (JULES) is a process-based model that simulates the fluxes of carbon, water, energy and momentum between the land surface and the atmosphere. This is developed from the Met Office Surface Exchange Scheme (MOSES). It can be used as a stand-alone land surface model driven by observed forcing data, or coupled to an atmospheric global circulation model. More information can be found in: Best et al. 2011, Clark et al. 2011, and Powell et al., 2013.

LPJmL (PIK)

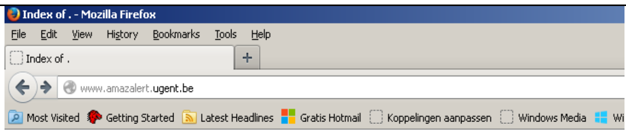
LPJ is a dynamic global simulation model of vegetation biogeography and vegetation/soil biogeochemistry. Taking climate, soil and atmospheric information as input, it dynamically computes spatially explicit transient vegetation composition in terms of plant functional groups, and their associated carbon and water budgets. More information can be found in: Sitch et al., 2003

Inland (INPE)

The Integrated Model of Land Surface Processes (INLAND) is the land surface package for the Brazilian Earth System Model. INLAND is based on the Integrated Biosphere Simulator (IBIS), and represent a number of land surface processes. More information can be found in: Powell et al., 2013.

Database

Web address	*http://www.amazalert.ugent.be/*
Site description	*The site is constructed user friendly, using a simple and straightforward lay-out with unambiguous filenames, ensuring the users to find the preferred data or information dissipating little of time and energy. Summaries of the file contents and associated useful information are listed in the text file on top of the webpage (readme file). Aside from reports, publication list, action plan, forcing data and model outputs, researchers may also find validation datasets for different variables origination from independent studies and datasets. To ensure that only Amazalert co-workers can access the data, all data folders are password protected. Data and documents can be updated or uploaded by all co-workers and will become public when verified and accepted by the work-package leader.*
Fair use policy:	*All data on www.amazalert.ugent.be is freely available to all AMAZALERT WP2 researchers.* *Where data or model outputs are used for publications, the scientist collecting the data or performing the model runs will be credited appropriately, either by co-authorship or by citation. The co-ordinators, model and data-providers should be informed of publication plans well in advance of submission of a paper, given an opportunity to read the manuscript, and be offered co-authorship. In cases where data or model outputs from other investigators are a minor contribution to a paper, the data should be referenced by a citation. Users of the data will always have to state the source of the data. For some particular datasets a specific fair use policy is described in the folder of the dataset.*

Site lay-out	 **Filename** 1_readme_AMAZALERT_WP2_baseline_runs.txt 2_WP2_planned_publication_list.xlsx 3_WP2_action_plan_july_2013.docx ET_data GPP_data HYBAM ISI_MIP TRMM baseline_model_runs_historical biomass_data flux_data land_use_future land_use_historical protocols regional_forcing_sheffield reports_meetings_and_teleconfs site_level soil_data upload.php **Total 19 files**

Forcing data

All DGVMs were run using the Sheffield forcing data, which has been analyzed to ensure the correctness for use. Pattern analysis for all variables, including rainfall, temperature, specific humidity and radiation, were performed. For illustrative purpose some figures are included below.

As a second test, independent datasets comprising the amount of rainfall in Latin America were compared with the rainfall data of the Sheffield dataset.

- **TRMM (3B43):**
  TRMM is a joint space mission between NASA and Japan's National Space Development Agency designed to monitor and study tropical and subtropical precipitation. Five instruments are used for sampling: Precipitation Radar (PR), TRMM Microwave Imager (TMI), Visible Infrared Scanner (VIRS), Clouds & Earths Radiant Energy System (CERES) and Lightning Imaging Sensor (LSI).

- **HYBAM:**
  Hybam data is the result of an extrapolation of point measurements to the entire Amazon basin. Measuring devices are conventional tipping gauges scattered over different geographical locations within the Amazon basin.

When comparing the three different datasets for monthly and yearly rainfall sums and for their respective anomalies with the long term mean, regional patterns on the maps are similar with only small dissimilarity’s origination from the manner of data sampling.

In the figures below some examples of meteorological forcing variables of the Sheffield dataset (Fig 1-4) are shown. In addition Rainfall data of the Sheffield data (Fig 5) is compared with HYBAM and TRRM data (Fig 6-7).

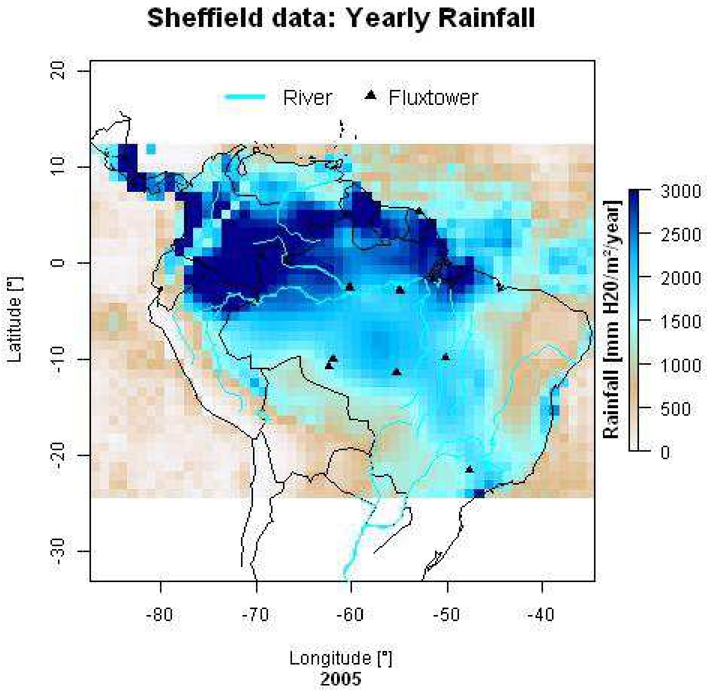


Figure 1. **Total rainfall [mm H_2O/m^2/year] during the year 2005 covering the northern part of Latin - America. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.**

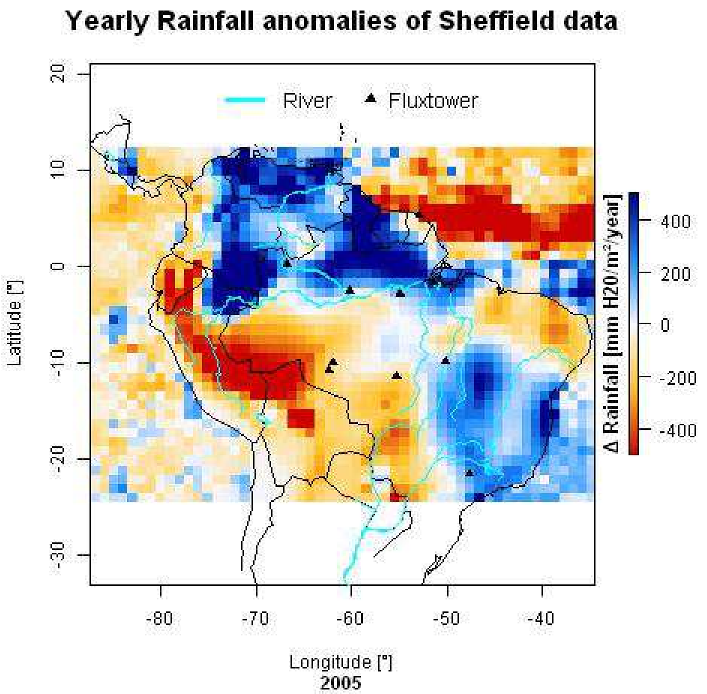


Figure 2. **Rainfall anomalies: total rainfall sum of the drought year of 2005 covering the northern part of Latin – America, are subtracted by the long term mean rainfall sum of all years of the Sheffield dataset (1970-2008). The difference per geographical location is given in mm H_2O/m^2/year. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.**

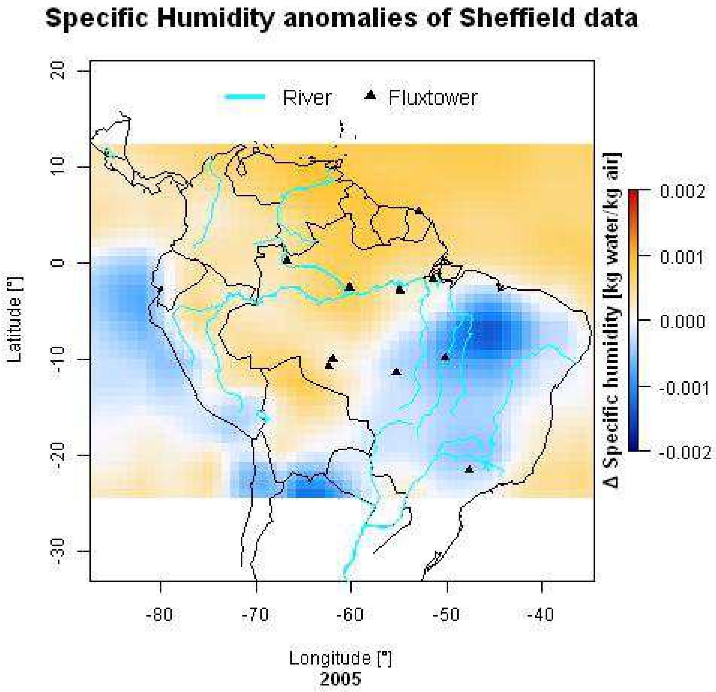


Figure 3. Per grid cell, the mean specific humidity in 2005 is subtracted by the long term mean specific humidity of all years of the Sheffield dataset (1970-2008). The difference per geographical location are given in kg water/kg air. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.

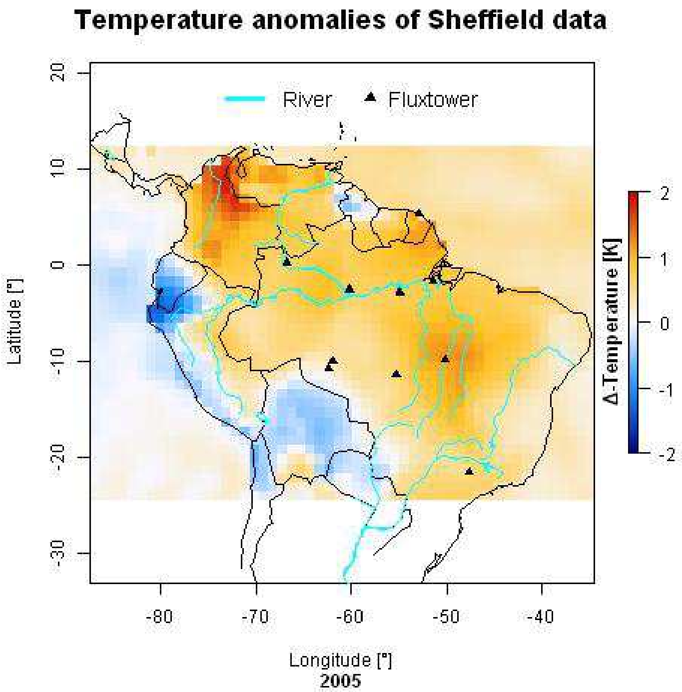


Figure 4. Per grid cell, the mean temperature in 2005 is subtracted by the long term mean temperature of all years of the Sheffield dataset (1970-2008). The difference per geographical location are given in K. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.

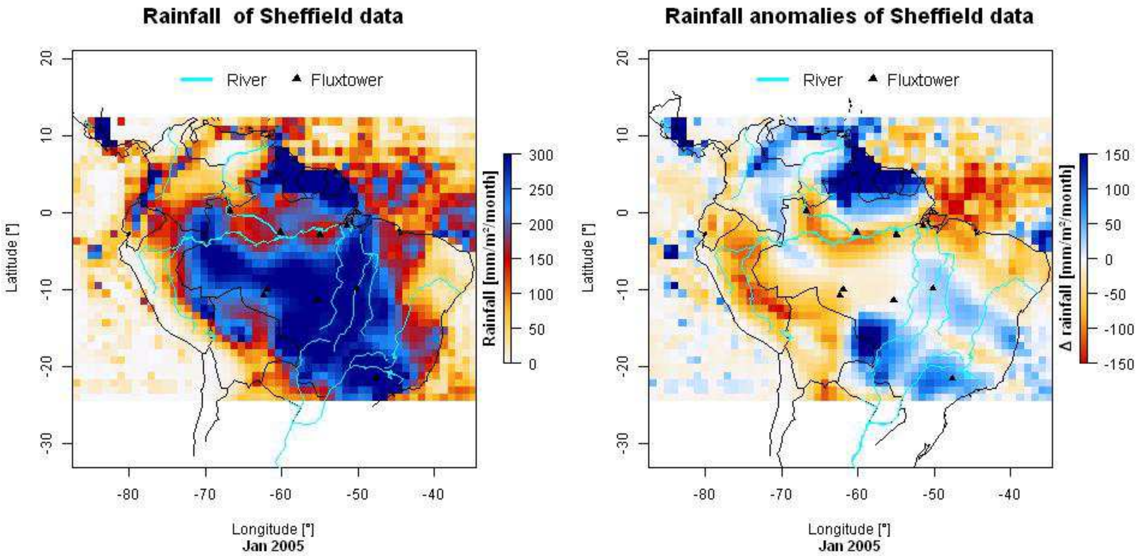


Figure 5. Using the Sheffield data, the total amount of rainfall [mm/m²/month] for January 2005 is shown on the left map. The right map represents the rainfall sum for January 2005 subtracted by the long term mean rainfall sum of all months of January for all years of the Sheffield dataset (1970-2008). The difference per geographical location are given in mm H_2O/m²/year. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.

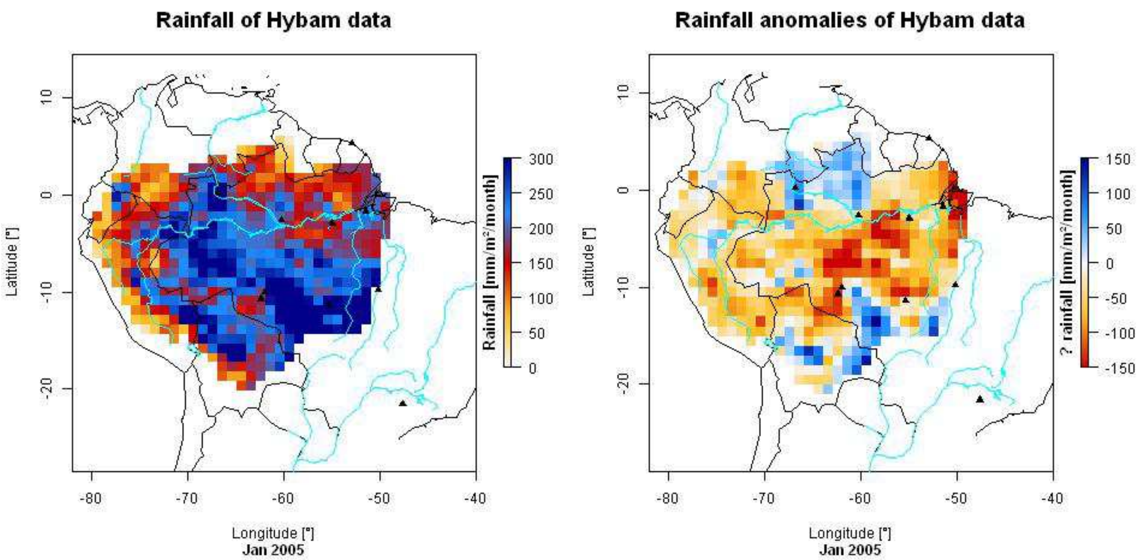


Figure 6. Using the Hybam data, the total amount of rainfall [mm/m²/month] for January 2005 are shown on the left map. The right map represents the rainfall sum for January 2005 subtracted by the long term mean rainfall sum of all months of January for all years of the Hybam dataset (1980-2009). The difference per geographical location are given in mm H_2O/m²/year. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.

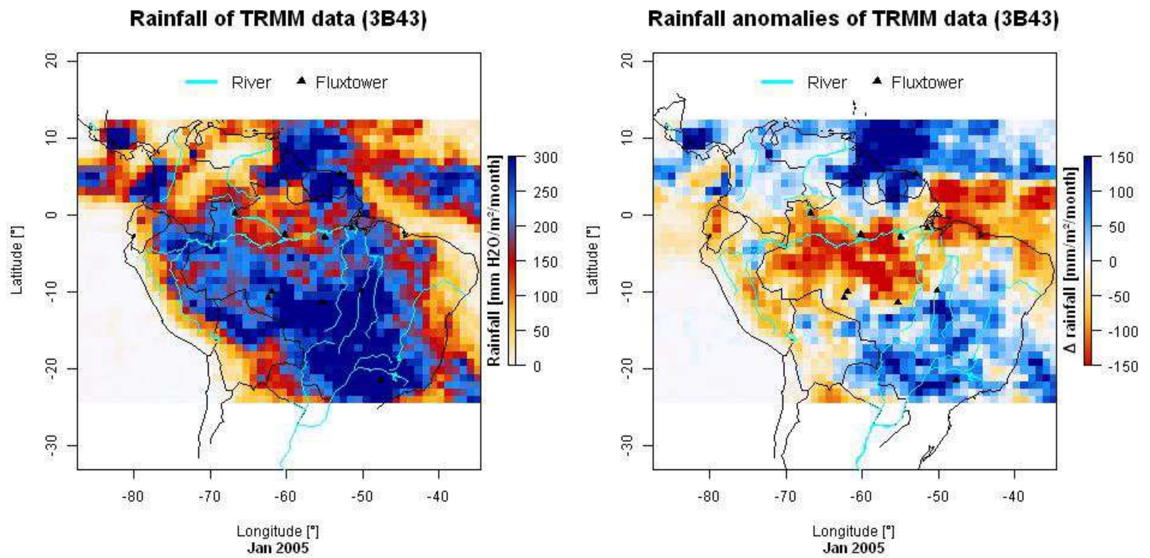


Figure 7. Using the TRMM data, the total amount of rainfall [mm/m²/month] for January 2005 are shown on the left map. The right map represents the rainfall sum for January 2005 subtracted by the long term mean rainfall sum of all months of January for all years of the TRMM dataset (1998-2012). The difference per geographical location are given in mm H_2O/m^2/year. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.

Historical runs

Both historical runs for the four DGVMs have been completed and the resulting outputs are uploaded and shared on the site under the folder "baseline_model_runs_historical" in the database. A detailed analysis has been performed to ensure correctness and usability of the outputs. The ranges of the variables were compared between the different model run outputs as well as with literature, to look for inequalities or nonsense data. Again pattern analysis on plotted maps of the DGVMs outputs were opposed to each other, of which some figures can be found below for NPP, ET and AGB (Fig 8-10).

Table 1. This table indicates which historical runs have been completed and for which models the additional runs with river-routing have been finished.

	A	B	C	D	River-Routing
Orchidee		x		x	x
Jules		x		x	ongoing
LPJmL	x			x	x
Inland	ongoing			ongoing	

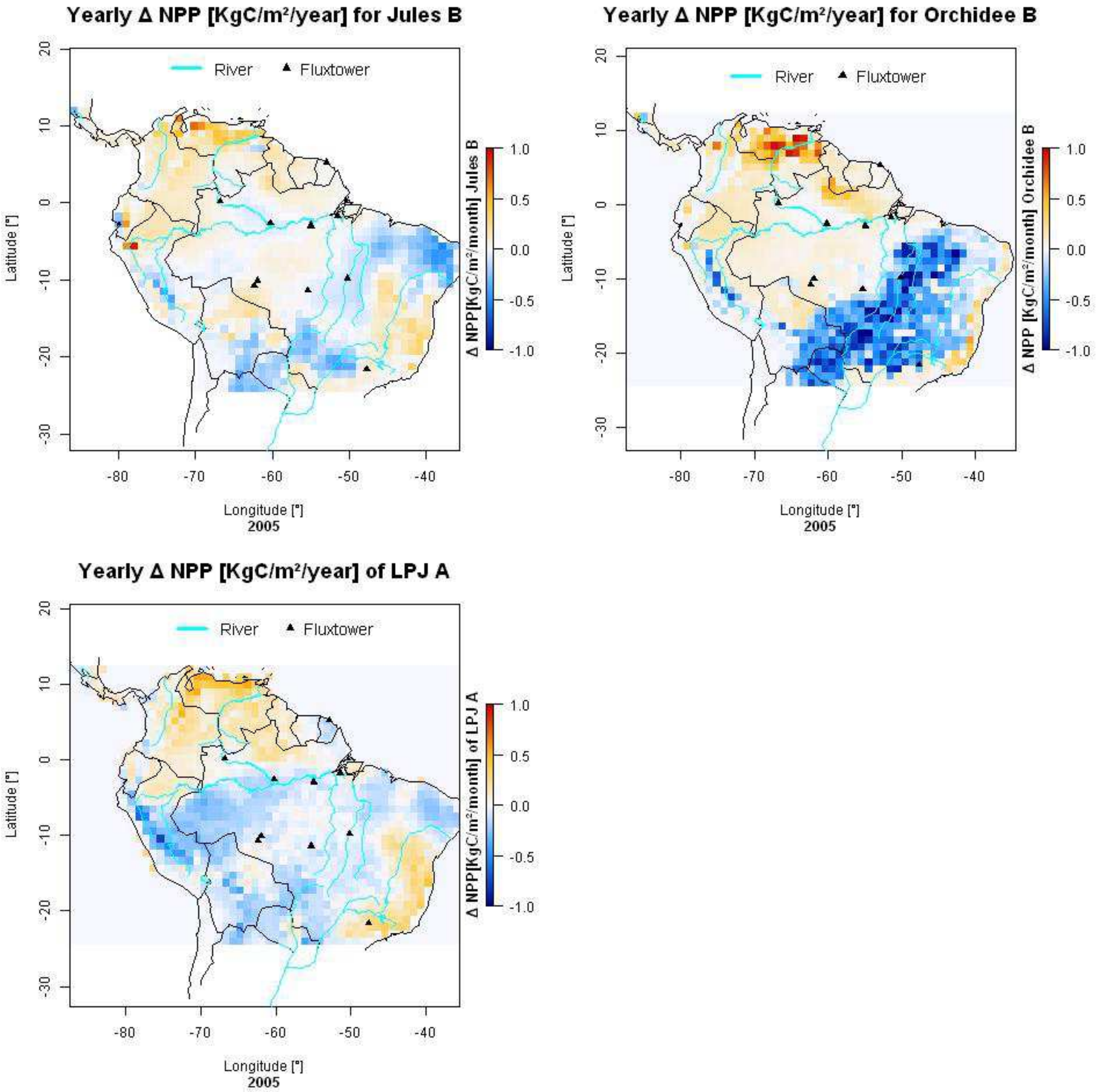


Figure 8. NPP anomalies for 2005. The total sums of netto primary production map (NPP) [KgC/m²/year] for 2005 minus the long term mean modelled NPP are given for all four DGVMs. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.

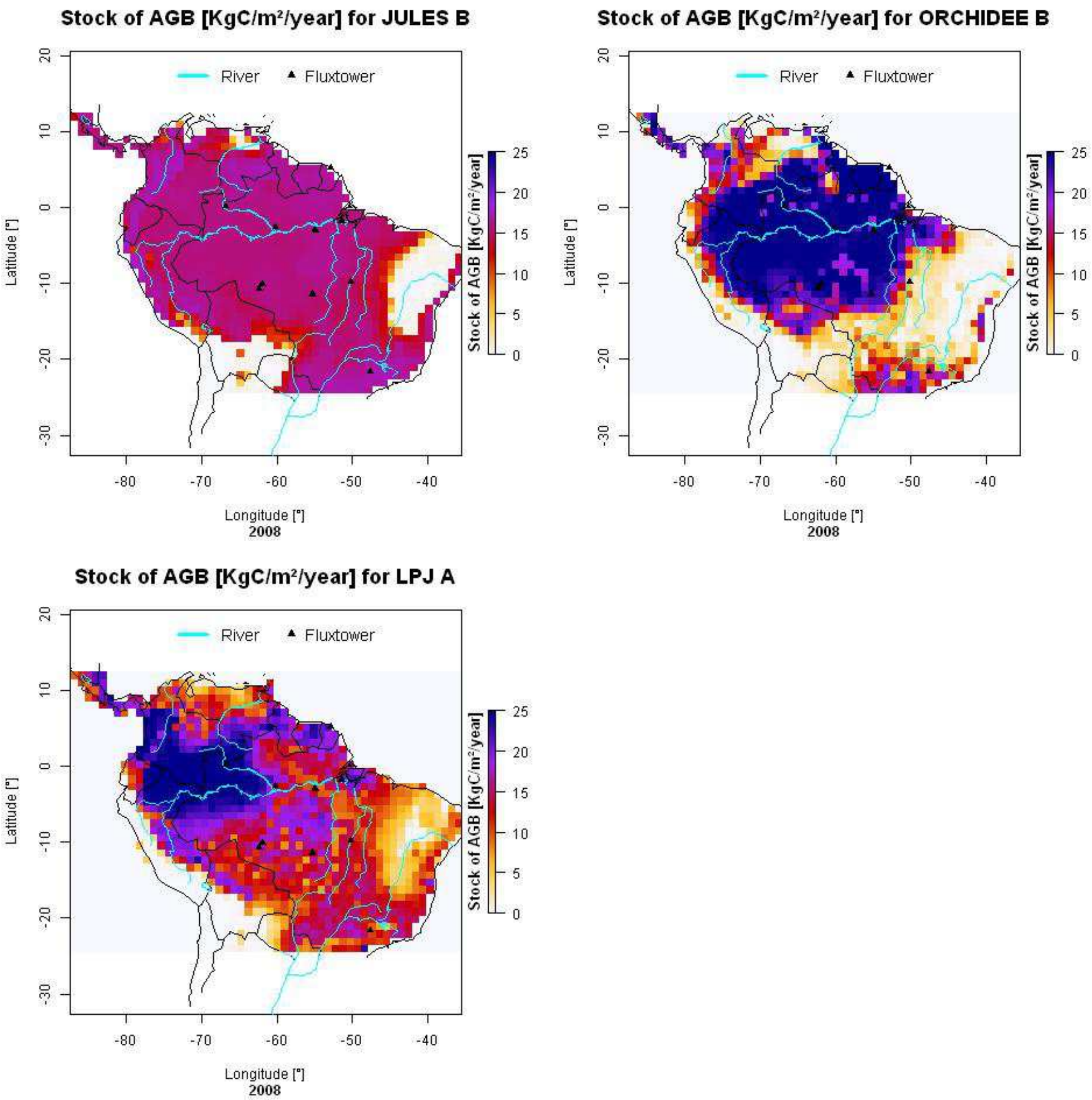


Figure 9. The mean stock of above ground biomass (AGB) [KgC/m²/year] for the last simulated year (2008) given for all four DGVMs. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.

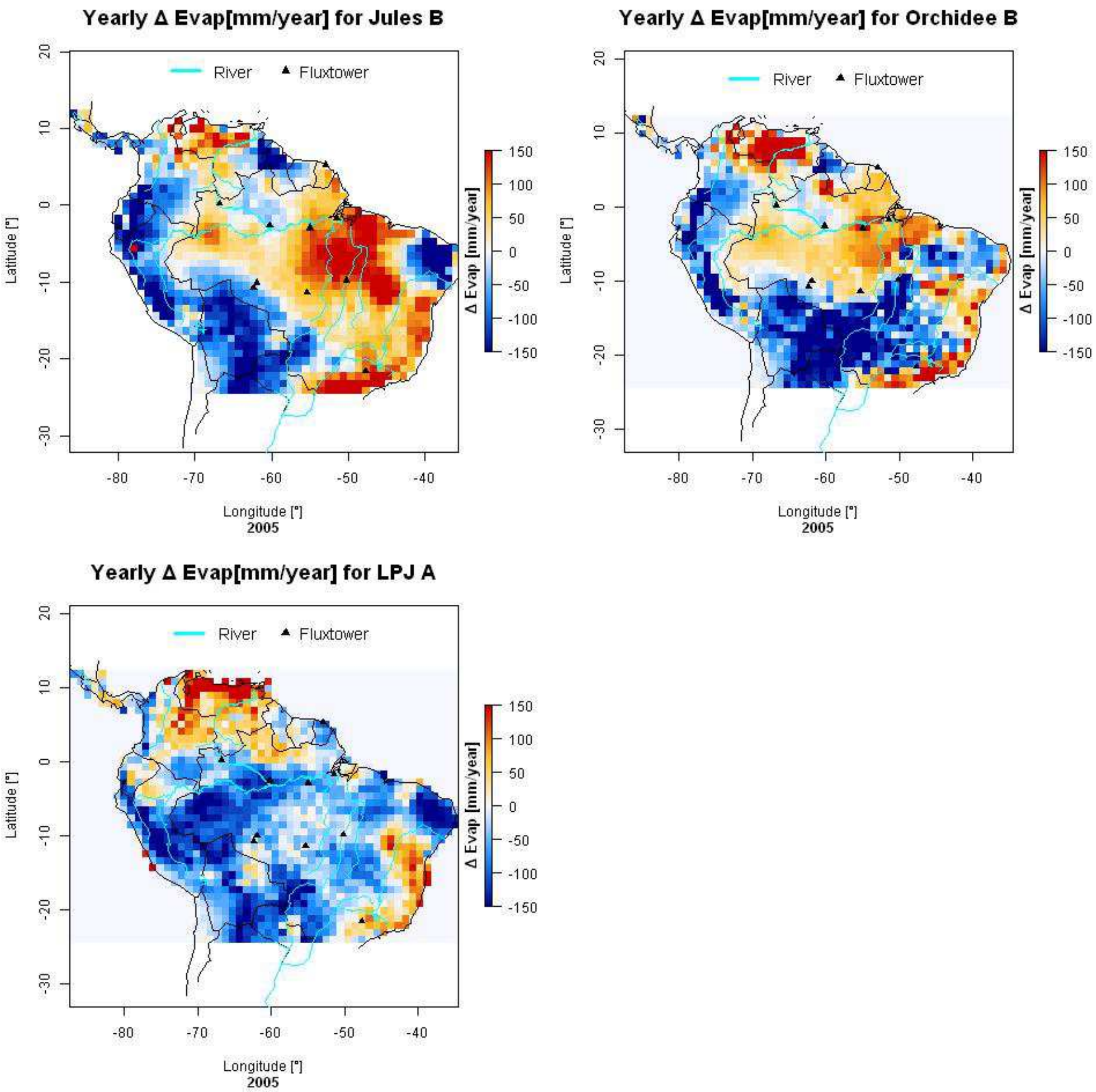


Figure 10. ET anomalies for 2005. The total annual evapotranspiration (Evap) [mm/year] values for the year 2005 minus the long term mean are given for all four DGVMs. Black triangles and the cyan-blue lines represent flux-towers and the river and water bodies respectively.

Future scenario runs

The ISI-MIP protocol is based on newly developed climate scenarios. Currently, it provides global climate scenarios from five General Circulation Models (GCMs)/Earth System Models (ESMs) and four Representative Concentration Pathways (RCPs). The five GCMs include GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM and NorESM1-M. The four RCPs include RCP2P6, RCP4P5, RCP6P0 and RCP8P5, where the number denotes the increase in radiative forcing in the year 2100 (2.6, 4.5, 6.0, and 8.5 W/m², respectively). In order to decide which of the scenarios should be used in the scope of AMAZALERT, the climate scenarios were evaluated regarding their projections of future changes in precipitation in the Amazon region (Figure 11 and 12). Additionally, changes in the length of the dry season (Figure 13) and in the maximum climatological water deficit (after Malhi et al. 2009; Figure 14) were assessed. The results indicate a strong increase in temperature in Amazonia in all future projections (Figure 11 and 12). Precipitation changes are not as pronounced and show a strong variation among regions in all future projections (Figures 11-14). To explore the range of extreme climate possibilities, all vegetation models within AMAZALERT will be run for RCP8.5. If computational effort allows for more scenario runs, these will be performed for the other RCPs as well.

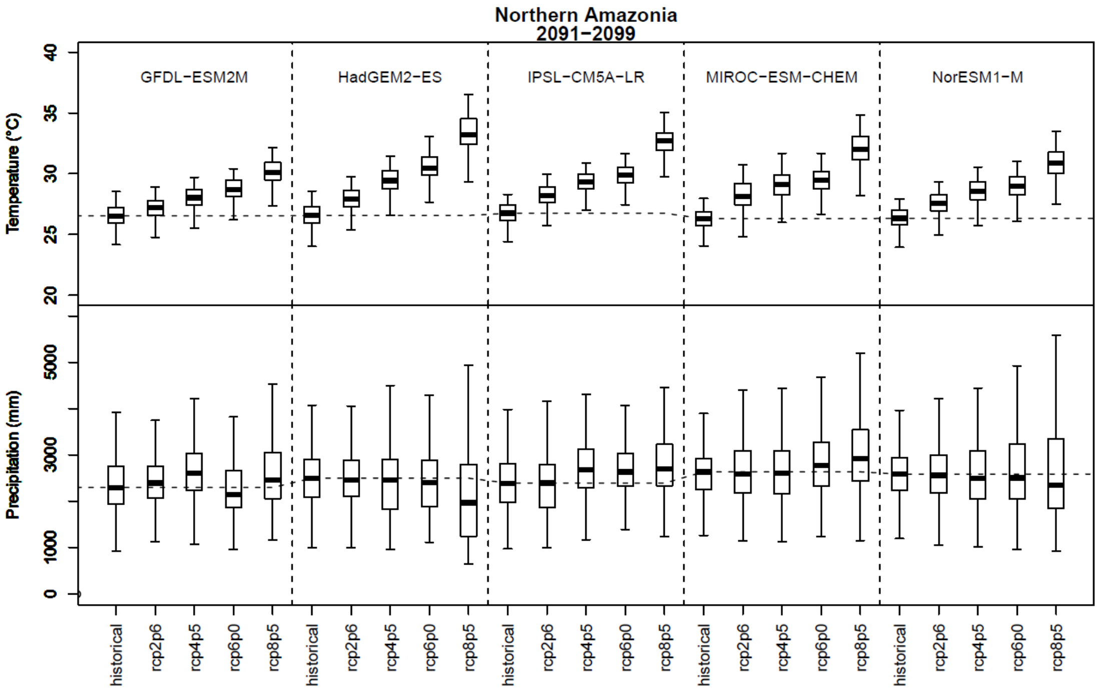


Figure 11: Range of temperature (upper row) and precipitation (lower row) change in Northern Amazonia as projected from five GCMs and for four RCPs for 2091-2099 in comparison to the historical time period (first boxplot per column) 1991-2000. The boxplots display the range of temperature and precipitation over all grid cells in the region. The black line within the box denotes the median, the box gives the upper and lower quartile, which contains 50% of the data and the whiskers give the minimum and maximum of the data. The dashed line shows the median for the historical time period.

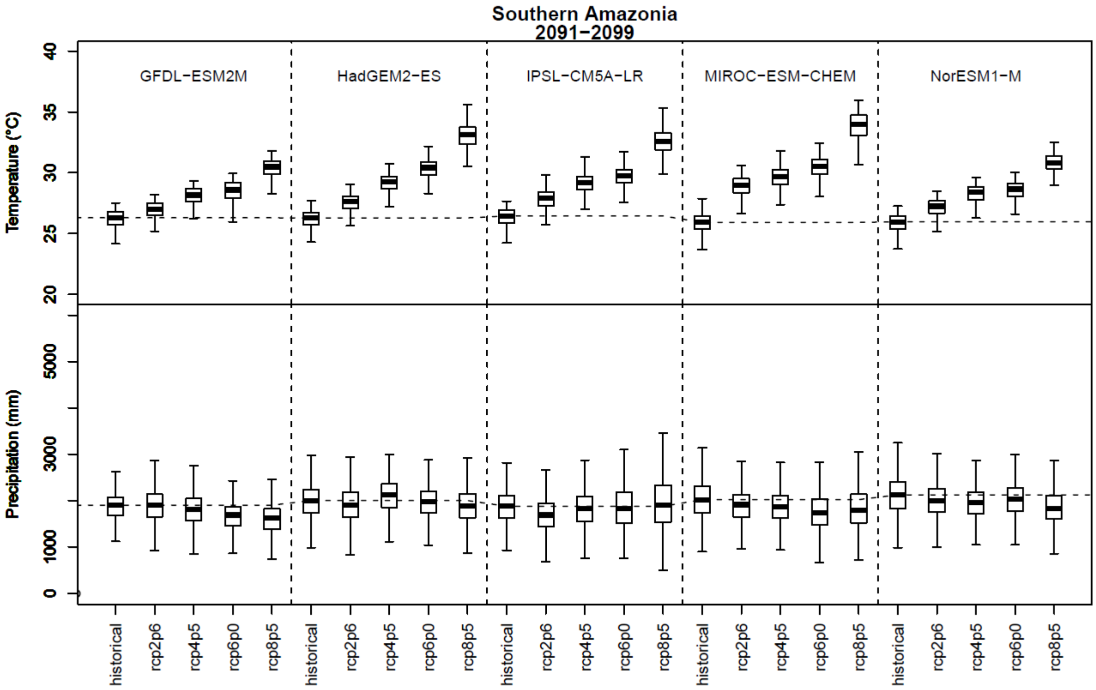


Figure 12: Range of temperature (upper row) and precipitation (lower row) change in Southern Amazonia as projected from five GCMs and for four RCPs for 2091-2099 in comparison to the historical time period (first boxplot per column) 1991-2000. The boxplots display the range of temperature and precipitation over all grid cells in the region. The black line within the box denotes the median, the box gives the upper and lower quartile, which contains 50% of the data and the whiskers give the minimum and maximum of the data. The dashed line shows the median for the historical time period.

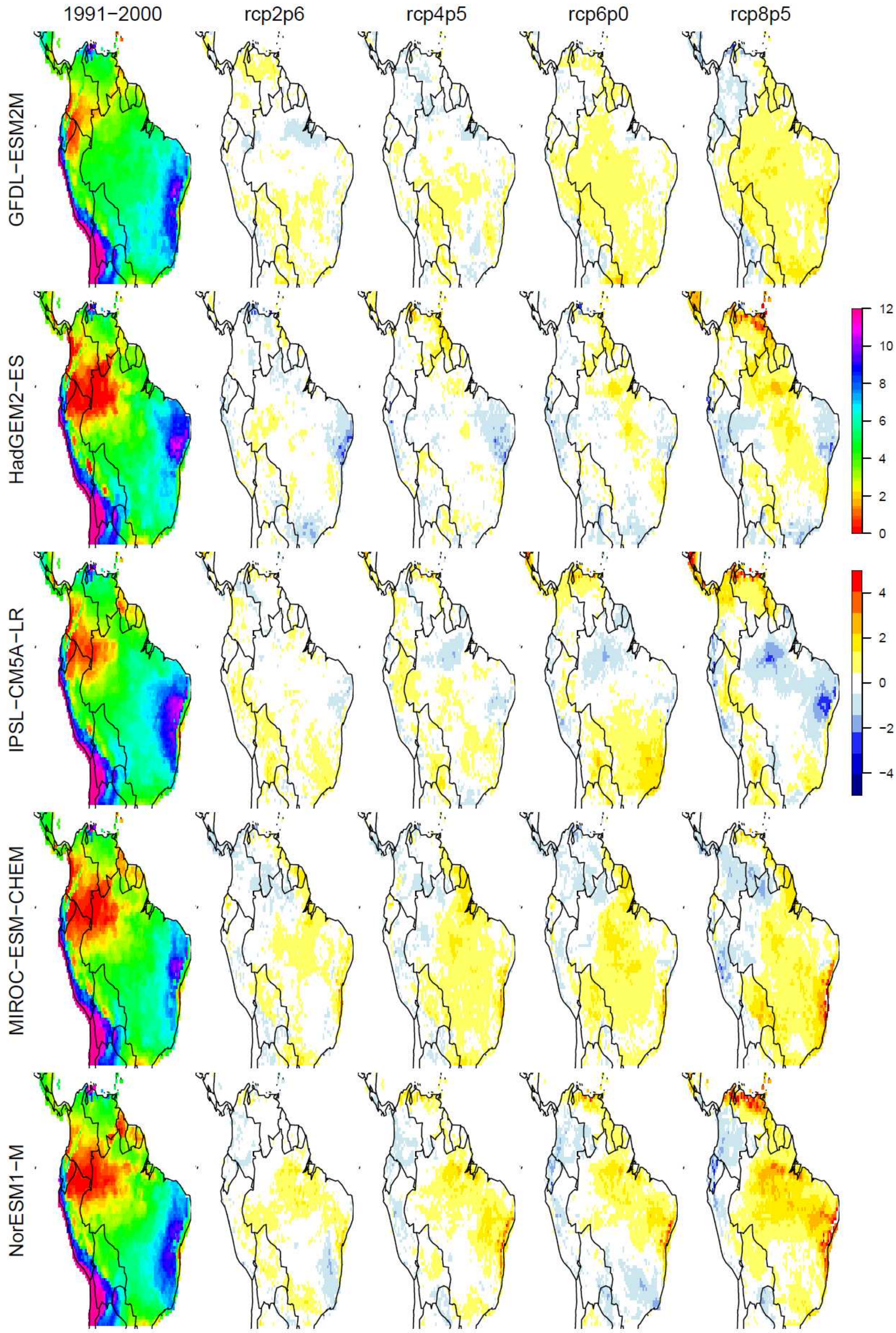


Figure 13: Length of the dry season (in months) in Amazonia for the historical time period (first column) and potential future changes (following columns). For future changes, positive values indicate an extension of the dry season length, negative values indicate a shortening of the dry season length (in months) in comparison to the historical period. In rows are the results for the five climate models.

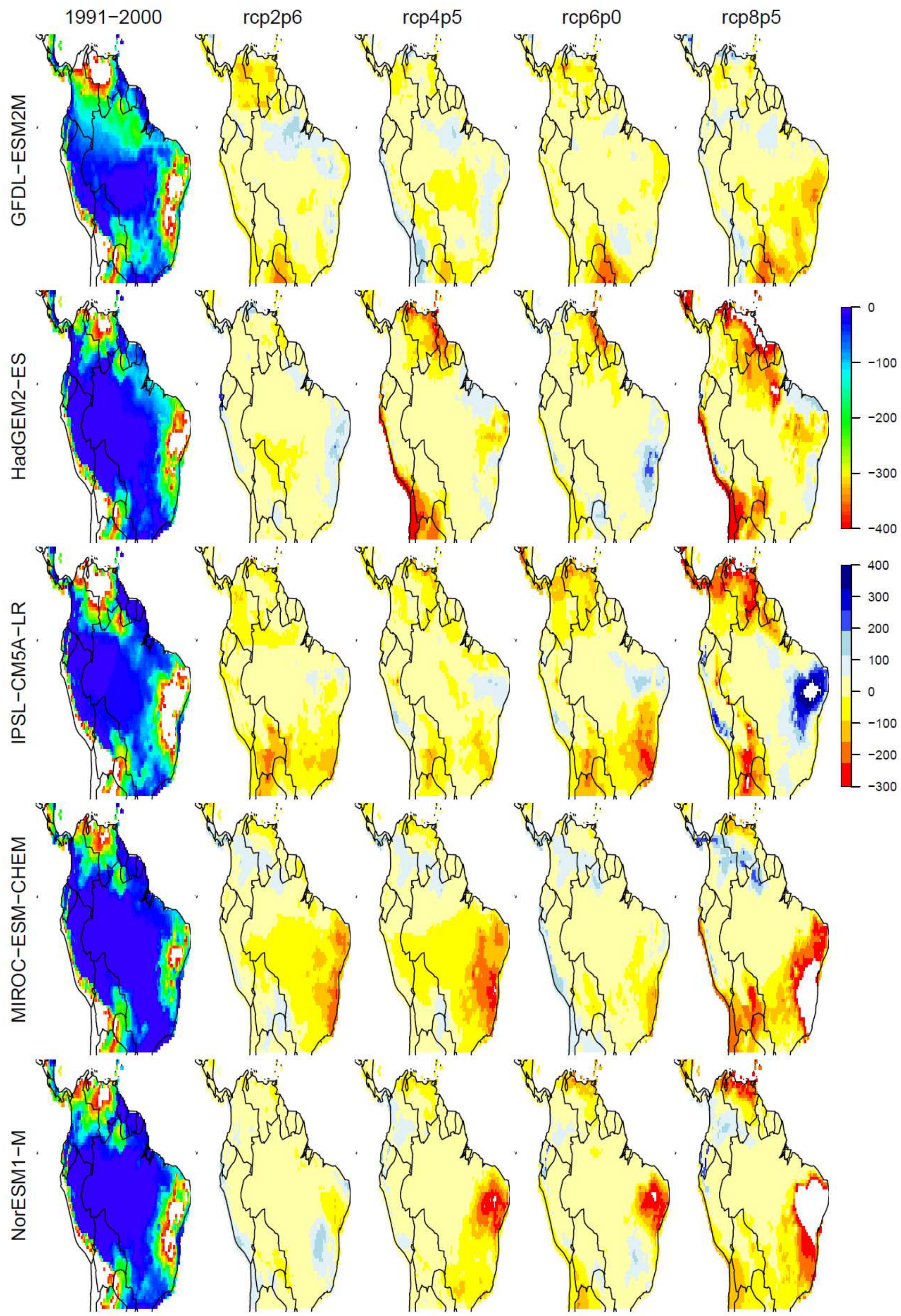


Figure 14: Maximum climatological water deficit (MCWD). MCWD describes the accumulated water stress for forests, with values close to 0 indicating no or little water stress and negative values indicating high water stress. MCWD is calculated as the monthly change in water stress + precipitation (P) (mm/month) – evapotranspiration (E) (mm/month) and from the monthly values the most negative value over is determined. E is thereby set to 100 mm/month (after Malhi et al. 2009). Positive values are set to 0. The first column displays MCWD for the historical period. The second to last column display changes in MCWD in the future compared to the historical period. Positive values thereby indicate reduced water stress, negative values indicate enhanced water stress.

Conclusions

Historical DGVM runs are now available in a database for all AMAZALERT partners. These runs are currently being analyzed and improved model runs will be added by the end of the project. In the coming months the database will be extended with future scenario runs.

References

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Appendixes

MODEL SET-UP, SPIN-UP AND VALIDATION PROTOCOL FOR REGIONAL SIMULATIONS

January 2012

Ke Zhang, Andrea Castanho, David Galbraith and Gabriel Moreno

Updated for AMAZALERT Januari 2013

Hans Verbeeck

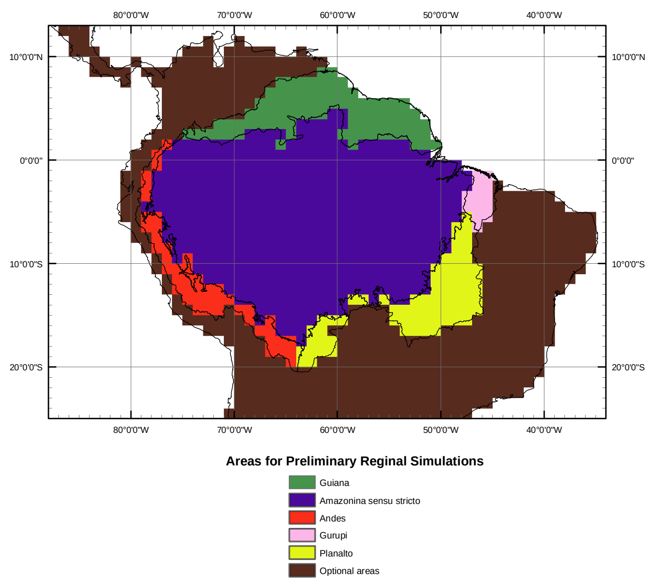
1. Objectives

The objectives of regional simulations include: (1) produce the same forcing and model set-up, spin-up and validation protocol for the Amazon regional simulations so as to compare outputs from the different biomass models and analyze model-related variations; (2) simulate and evaluate how land-use change and changes in climate affected the composition, structure and functioning of Amazonian ecosystems in the past three centuries with focus on the recent four decades; (3) predict how land-use change and changes in climate will impact the composition, structure and functioning of Amazonian ecosystems over the 21st century.

2. Model Set-up

2.1. Simulation Region

The simulation region is defined as a region spanning a longitudinal range from 88°W to 34°W and a latitudinal range from 13°N to 25°S (see below map). The spatial resolution is set to 1°×1°. Guiana, Amazonia sensus stricto, Andes, Gurupi and Planalto are mandatory simulation regions, while the rest areas are optional.



2.2. Simulation Phases

The regional simulations are divided into three stages: long-term spin-up (Spin-up), historical simulations from 1715 to 2008 (Historical Simulations), and predictions for the 2009-2099 period (Prediction Simulations).

2.3. Input Datasets

(1) Soil Data

- Soil depth is set to 10 meters for each grid cell.
- Number of soil layers are determined by each individual model.
- Percent sand and clay values are invariant in depth and are produced as a blend of Quesada's Amazon soil data and IGBP-DIS global soil data;
- Soil texture is derived from the percent sand and clay values and classified into 12 USDA soil textural classes;
- The rest soil parameters are calculated from percent sand and clay values using the same set of pedotransfer functions for the site-level simulations or derived from the soil texture values.

(2) Land-use Data

- Historical land-use data from 1715 to 2008 are derived from Hurtt et al. land-use data.
- Future land-use data are from Soares-Filho et al. and include two scenarios: business-as-usual (BAU) and governance (GOV).

(3) Meteorological Forcing

- Historical met forcing: Sheffield et al. bias-corrected NCEP data at 1-degree resolution from 1970 to 2008 (hereinafter called SHEF).
- Future met forcing (2009- 2099): 21st century GCM projections under IPCC AR4 SRES A2 emission scenario, including bias-corrected NCAR-PCM, bias-corrected CCSM, Hadley AR4 (likely) and CPTEC (likely).

(4) Atmospheric CO_2 concentrations

- Pre-industrial constant atmospheric CO_2 concentration (278 ppm) is used for model spin-up.
- Changing atmospheric CO_2 concentrations derived from ice core data and observations from 1715 to 2008 are used for historical simulations.
- Atmospheric CO_2 concentrations under IPCC SRES A2 scenario are used for prediction simulations.

(5) Open water fraction

- Open water fraction data are derived from remote sensing data and river network maps.

2. Spin-up Procedure

Long-term (up to 500 years) spin-up with pre-industrial atmospheric CO_2 (278ppm) from near bare ground is applied to each one-degree grid cell by recycling the 39-year SHEF meteorological forcing. No land-use changes are applied for model spin-ups. The rest input data are listed in section 2.3. The methods and criteria for steady-state condition detection are the same as these used by the site-level spin-ups, but steady-state condition detection is only applied to aboveground biomass of each plant function type.

3. Historical Simulations

- Initial states: the steady states determined by the spin-up procedures.
- Time period of model simulations: 1715-2008.
- Met driver: recycling the 39-year SHEF driver.
- Time period of model output: 1970-2008
- Model output format: see Section 5.
- Design of simulations:

  Simulation A (*Potential vegetation A*): natural disturbances + no land-use change + changing climate (recycling the SHEF driver) + changing CO_2.

  Simulation B (*Potential vegetation B*): natural disturbances by excluding fire + no land-use change + changing climate (recycling the SHEF driver) + changing CO_2.

  Simulation C (*Changing climate*)**:** This simulation need to be achieved by two steps: 1) natural disturbances + no land-use change + changing climate (recycling the SHEF driver) + changing CO_2 from 1715 to 1970; 2) natural disturbances + no land-use change + changing climate + constant CO_2 (=325.713 ppm) from 1970 to 2008.

Simulation D (*Full changes*): natural disturbances + land-use change + changing climate + changing CO2.

4. Prediction Simulations

- Initial states: the states in 2008 from the historical "full changes" simulation (i.e. Simulation D).
- Time period of model simulation: 2009-2099
- Met drivers: NCAR-PCM, CCSM and HadCM3+ETA
- Design of simulations:

  Simulation A (*Potential vegetation A*): natural disturbances + no land-use change + changing climate + changing CO_2.

  Simulation B (*BAU land-use change*): natural disturbances + BAU land-use change + changing climate + changing CO_2.

  Simulation C (*GOV land-use change*): natural disturbances + GOV land-use change + changing climate + changing CO_2.

  Simulation D *(Changing climate*): natural disturbances + no land-use change + changing climate + constant present-day CO_2 (=386.222 ppm).

  Simulation E (*Potential vegetation B*): natural disturbances by excluding fire + no land-use change + changing climate + changing CO_2.

5. Format of Output Files

- File Format: NetCDF
- Spatial resolution: 1°×1°
- Time step: **monthly in UTC (i.e., output should be monthly mean or sum)**
- Data organization
  - **One file per year per set of simulation**
  - **Data dimensions (see Table 1)**
  - **Missing/fill values: -9999.9**
- Variables: Table 1

- Output file name convention for AMAZALERT:

  VegModel_ClimateScenario_Simulation_Year.nc
  For Historical runs, an example would be 'JULES_Historical_D_2008.nc' while some examples of future runs are 'JULES_CCSM_B_2060.nc' or 'JULES_PCM_E_2074.nc'.

Table 1. Variables and organization of model output files for regional simulations.

Variable		Description	Units	NetCDF Dimensions
Dimension Variables	nlat*	Length of the latitude vector (=38; 12.5° ~ -24.5°)	N/A	scalar
	nlon*	Length of the longitude vector (=54; -87.5° ~ -34.5°)	N/A	scalar
	nsoil*	Length of the soil layer vector (model specific)	N/A	scalar
	npft*	Length of plant function type vector (model specific)	N/A	scalar
	ntime*	Length of time vector (=12; Jan - Dec)	N/A	scalar
	lat	Vector of central latitudes of grid cells from north to south (12.5° ~ -24.5°)	Degrees	nlat
	lon	Vector of central longitudes of grid cells from west to east (-87.5° ~ -34.5°)	Degrees	nlon

	soil	Vector of soil layer (=1:nsoil; from top to bottom)	N/A	nsoil
	pft	Vector of plant function types (=1:npft; please list the names of plant function types of your models in the attributes of this variable)	N/A	npft
	time	Time vector (=1:12)	Months	ntime
Energy Components	Qle	Latent heat flux	W/m^2	nlat×nlon×ntime
	Qh	Sensible heat flux	W/m^2	nlat×nlon×ntime
	Evap	Total evapotranspiration	mm/month	nlat×nlon×ntime
	Qs	Surface runoff	mm/month	nlat×nlon×ntime
Water Components	Qsb	Sum of subsurface runoff and groundwater recharge (i.e. drainage)	mm/month	nlat×nlon×ntime
	Qt	Total runoff rate (i.e. Qs + Qsb)	mm/month	nlat×nlon×ntime
	DelSoilMoist	Change in total soil moisture	Kg Water/m^2	nlat×nlon×ntime
	DelIntercept	Change in canopy interception storage	Kg Water/m^2	nlat×nlon×ntime
	VegT	Vegetation canopy temperature	K	nlat×nlon×ntime
	z_top	Top of each soil layer	m	nsoil
Surface /subsur	z_bottom	Bottom of each soil layer	m	nsoil

	z_node	Layer node depth	m	nsoil
	SoilMoist	Soil moisture in each soil layer for the whole grid cell (i.e. water fraction is included)	Kg Water/ m^2	nlat×nlon×nsoil×ntime
	SoilMoistLand	Soil moisture in each soil layer for the land fraction of each grid cell (i.e. water fraction is excluded)	Kg Water/ m^2	nlat×nlon×nsoil×ntime
	SoilTemp	Soil temperature in each soil layer	K	nlat×nlon×nsoil×ntime
	GPP	Gross primary production	KgC/m^2/month	nlat×nlon×ntime
	NPP	Net primary production	KgC/m^2/month	nlat×nlon×ntime

Carbon Budget Components	GPP_PFT	Gross primary production by plant function type	KgC/m^2/month	nlat×nlon×npft×ntime
	NPP_PFT	Net primary production by plant function type	KgC/m^2/month	nlat×nlon×npft×ntime
	AutoResp_PFT	Autotrophic respiration by plant function type	KgC/m^2/month	nlat×nlon×npft×ntime
	NPPLeaf	Net primary production of leaves	KgC/m^2/month	nlat×nlon×ntime
	NPPRoot	Net primary production of roots	KgC/m^2/month	nlat×nlon×ntime
	NPPWood	Net primary production of wood	KgC/m^2/month	nlat×nlon×ntime
	NEE	Net ecosystem exchange	KgC/m^2/month	nlat×nlon×ntime
	AutoResp	Autotrophic respiration	KgC/m^2/month	nlat×nlon×ntime
	HeteroResp	Heterotrophic respiration	KgC/m^2/month	nlat×nlon×ntime
	SoilResp	Soil Respiration	KgC/m^2/month	nlat×nlon×ntime
	LitterFall	Leaf drop	KgC/m^2/month	nlat×nlon×ntime
	LAI	Leaf area index	m^2/m^2	nlat×nlon×ntime
	LAI_PFT	Leaf area index by plant function type	m^2/m^2	nlat×nlon×npft×ntime
Biomass and Other State Variables	LAIUpper	Leaf area index of upper vegetation layer; The upper vegetation is defined as all plants with height ≥ 2m.	m^2/m^2	nlat×nlon×ntime
	LAILower	Leaf area index of lower vegetation layer; The lower vegetation is defined as all plants with height < 2m.	m^2/m^2	nlat×nlon×ntime
	AGB	Total above-ground biomass	KgC/m^2	nlat×nlon×ntime
	NamePFT	List of the names of plant function types used in the models (model specific).	N/A	npft

	AGB_PFT	Above-ground biomass by plant function type	KgC/m^2	nlat×nlon×npft×ntime
	AGBWood	Above-ground biomass of woody tissues	KgC/m^2	nlat×nlon×ntime
	CanopyH	Canopy height	m	nlat×nlon×ntime
	RAGBlu	Annual lost AGB caused by land use change	KgC/m^2	nlat×nlon
	RAGBfire	Annual lost AGB caused by fire	KgC/m^2	nlat×nlon

*The five scalars can be retrieved from the netcdf files and don't need be written into the netcdf files.

Table 2. Additional variables for AMAZALERT: hydrology, meteoforcing (rewrite them in the output for consistency checks), albedo

Variable	Description	Units	NetCDF Dimensions
Esoil	bare soil evaporation	mm/month	nlat x nlon x ntime
Tveg	vegetation cover transpiration	mm/month	nlat x nlon x npft x ntime
Ecanop	evaporation of water intercepted by the leaves	mm/month	nlat x nlon x npft x ntime
Ewater	open water evaporation	mm/month	nlat x nlon x ntime
Dis	river discharge	m3/s	nlat x nlon x ntime
Qt_riv	Total runoff rate taking into account swamp and floodplain effect	Mm/month	nlat x nlon x ntime
Rainf	rainfall rate	mm/month	nlat x nlon x ntime
Snowf	snowfall rate	mm/month	nlat x nlon x ntime
Wind	near surface wind speed	m/s	nlat x nlon x ntime
Tair	surface air temperature	K	nlat x nlon x ntime
Swdown	downward short-wave radiation flux	W/m^2	nlat x nlon x ntime
Lwdown	downward long-wave radiation flux	W/m^2	nlat x nlon x ntime

Qair	near surface specific humidity	kg/kg	nlat x nlon x ntime
Albedo	albedo	-	nlat x nlon x ntime

6. Validation Data Sets of Regional Simulations

6.1. Key Diagnostic Variables

- Carbon fluxes
  - GPP/NPP
  - NPP partitions
  - NEE
  - Soil respiration
- Ecological stock and state variables
  - AGB
  - Canopy height
  - LAI
  - Litterfall
- Hydrological components
  - Total runoff/discharge
  - Water Storage Change
  - Evapotranspiration (ET)

6.2. Validation Data Sets

- Ecological stock and state Variables
  - AGB
    - Remote sensing and field plot measurements based AGB map by Saatchi et al. 2007 and Saatchi et al. 2011
    - Plot-based AGB data set from Malhi et al. 2006 and Baker et al. 2004
    - WHRC airborne lidar based AGB
  - Canopy height
    - GLAS canopy height
    - Asner airborne lidar canopy height
  - LAI: MODIS LAI, site-level measurements

  - NPP partitions: ground measurements from Aragao et al. 2009 and Malhi et al. 2009
  - Litterfall: ground measurements from Chave et al. 2010
  - GPP: MODIS GPP and Beer et al. flux tower upscaled GPP data
  - Soil respiration: RAINFOR ground measurements
- Hydrological components
  - Discharge: ground gauge observations
  - Water Storage Change: GRACE data
  - Evapotranspiration (ET)/latent heat (LE): Inferred annual ET from basin-scale P minus runoff ; Jung et al. 2010 flux tower upscaled LE data; Fisher et al. 2010 Amazon region ET estimates.