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Supplement of

Impacts of future deforestation and climate change on the hydrology of the Amazon Basin: a multi-model analysis with a new set of land-cover change scenarios

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SUPPLEMENTARY MATERIAL

Models

LPJmL-DGVM (Lund Potsdam Jena managed Land model)

The process-based dynamic global vegetation and hydrology model LPJmL-DGVM calculates carbon and the corresponding water fluxes with a daily time step and a spatial resolution of 0.5 x 0.5 (lat/lon) (Sitch et al., 2003; Gerten et al., 2004b; Bondeau et al., 2007; Rost et al., 2008; Schaphoff et al., 2013). Potential natural vegetation and the main processes controlling its dynamics are calculated from inputs of climate data (temperature, precipitation and cloud cover), atmospheric CO2, and soil texture. The main processes included in LPJmL-DGVM are the water balance, carbon balance, vegetation, establishment, phenology, mortality and fire disturbance. The daily water balance of the soil is calculated by a simple bucket model, consisting of 5 soil layers of 20 cm, 30 cm, 50 cm, 1 m and 1 m depth, resulting in a cumulative depth of 3m. Water from precipitation that is not intercepted by vegetation enters the first soil layer depending on the amount of rainfall and the water saturation of the soil layer. The water that enters the first soil layer either evaporates, transpires or percolates to deeper soil layers. Evaporation from the canopy depends on the intercept water and the leaf area index of the vegetation. Evaporation from soil only occurs on bare soil and depends on the energy available for vaporization (potential evapotranspiration, PET). Plant transpiration is closely coupled to stomatal activity and photosynthesis and is calculated as a function of soil water supply and atmospheric demand (Sitch et al., 2003). All excess water above field capacity runs off as surface or subsurface runoff. The water is simulated to percolate from the first layer through the deeper soil layers based on a storage routine technique (Schaphoff et al., 2013) and is added to the runoff as baseflow component (Gerten et al., 2004b). The runoff is routed through a gridded river network (Vörösmarty et al., 2000), with a constant flow velocity of 1 $m\,s^{-1}$ (Rost et al., 2008). Human processes like irrigation extraction and the operation of large reservoirs is explicitly accounted for (Rost et al., 2008; Biemans et al., 2011). The carbon balance includes a detailed simulation of photosynthesis (based on Farquhar et al. (1980) and Collatz et al. (1992)), autotrophic and heterotrophic respiration, allocation of carbon to the plant compartments, establishment, mortality and phenology (Sitch et al., 2003). These processes are in LPJmL-DGVM calculated for nine plant functional types (PFTs) representing natural vegetation for each grid cell. Each PFT represent an assortment of species classified as being functionally similar. In this study for the Amazon basin, LPJmL-DGVM primarily simulates three of these plant functional types, representing tropical evergreen and deciduous forests and C4 grasses. LPJmL-DGVM also includes crop growth and harvest of so-called crop functional types on managed land as well as managed grassland (Bondeau et al., 2007). LPJmL-DGVM has been proven to reproduce observed patterns of biomass production, the global water balance, river discharge, tropical vegetation dynamics and fire (Cramer et al., 2001; Sitch et al., 2003; Wagner et al., 2003; Gerten et al., 2004a, 2008; Rost et al., 2008; Biemans et al., 2009; Poulter et al., 2009; Fader et al., 2010; Thonicke et al., 2010). It has been shown that the observed patterns in water fluxes (including soil moisture, evapotranspiration and runoff) are comparable to stand-alone global hydrological models (Wagner et al., 2003; Gerten et al., 2004a; Gordon et al., 2004; Gerten et al., 2008; Biemans et al., 2009; Haddeland et al., 2011). Several studies on Amazonia have been conducted showing the effect of climate change on NPP (Poulter et al., 2009), on carbon stocks

(Gumpenberger et al., 2010), on the risk for forest dieback (Rammig et al., 2010) and also on patterns of inundation duration and inundated area (Langerwisch et al., 2013).

INLAND-DGVM (INtegrated model of LAND surface processes)

INLAND-DGVM is premised to be single, physically consistent model that solves the energy, water, carbon, and momentum balance of the soil-vegetation-atmosphere system and can be directly incorporated within Atmospheric Climate models. Based on the LSX package of Thompson and Pollard (1995), it represents canopy and soil physics processes by explicitly diagnosing the temperature of the vegetation in two canopy layers (e.g. trees versus shrubs and grasses) and of its soil layers, as well as air temperature and specific humidity within canopy air spaces, driven by the radiation balance of the vegetation and the ground, and the diffusive and turbulent fluxes of sensible heat and water vapor. In order to resolve the diurnal cycle, the model solves the canopy physics at its shortest time step (depending on the user choice, usually 30 – 60 min). The total amount of evapotranspiration is treated as the sum of three water vapor fluxes: evaporation from the soil, evaporation of water intercepted by the vegetation and canopy transpiration.

The model state description includes 6 soil layers with varying thicknesses (to simulate the diurnal and seasonal variations of heat and moisture in the total soil depth) that are parameterized with biome-specific root biomass distributions of Jackson et al. (1996). This permits a different root length density for each layer in the profile.

The dynamics of soil volumetric water content are simulated for each layer. Soil moisture is based on Richards' flow equation, where the soil moisture change in time and space is a function of soil hydraulic conductivity, soil water retention curve, plant water uptake, and upper and lower boundary conditions. The water budget is controlled by the rate of infiltration (Green and Ampt, 1911), evaporation of water from the soil surface, the transpiration stream originating from plants, and redistribution of water in the profile. The modeling of water flow in unsaturated soils requires the description of water uptake by plant roots. Water uptake by roots is represented by a sink term in the macroscopic Richards equation and only considers stress due to dry conditions through a simple heuristic approach that represents the influence of soil water stress on gross photosynthesis rates (Foley et al., 1996). The drainage from the bottom soil layer is modeled assuming gravity drainage and neglects interactions with groundwater aquifers. Foley et al. (1996); Kucharik et al. (2000) give additional descriptions of the IBIS model land surface physics, which is essentially transferred unaltered to INLAND-DGVM.

ORCHIDEE (ORganising Carbon and Hydrology In Dynamic EcosystEms)

ORCHIDEE (Krinner et al., 2005) is the land component of the IPSL (Institut Pierre Simon Laplace) coupled climate model. It simulates the energy and water fluxes between the soil, the vegetation, and the atmosphere through the SECHIBA (Schématisation des Echanges Hydriques à l'Interface entre la Biosphère et l'Atmosphère, Ducoudré et al., 1993; de Rosnay and Polcher, 1998) module, while the CO_2 fluxes and ecosystem carbon cycling are described by the STOMATE (Saclay Toulouse Orsay Model for the Analysis of Terrestrial Ecosystems, Viovy, 1996) module. When coupled with SECHIBA, STOMATE links the fast hydrological and biophysical processes with the carbon dynamics. STOMATE also contains a dynamic vegetation model, but this module was not activated for this study. In each grid cell, up to 12 plant functional types (PFTs) can be represented

simultaneously, in addition to bare soil. LAI dynamics is simulated by STOMATE which models the allocation of assimilates, autotrophic respiration components, foliar development, mortality and litter and soil organic matter decomposition. A factor representing drought stress (McMurtrie et al., 1990) linearly computes the rate of ribulose bisphosphate (RuBP) regeneration and the carboxylation rate.

The drought stress and the leaf age of the vegetation directly influence the photosynthetic capacity (Farquhar et al., 1980; Collatz et al., 1992; Verbeeck et al., 2011; de Weirdt et al., 2012), and the stomatal conductance (Ball et al., 1987), which controls the transpiration and is a function of two profiles: a fixed root density profile for each PFT, and the soil moisture profile (de Rosnay and Polcher, 1998). Canopy interception is proportional to LAI and the corresponding evaporation proceeds at potential rate, like the soil evaporation. In the latter case, however, soil moisture can become limiting if the upward diffusion to the top soil layer cannot supply enough water to sustain the required potential rate.

Soil moisture redistribution is described by a multi-layer scheme to solve the Richards equation for vertical unsaturated flow under the effect of root uptake (de Rosnay et al., 2002; Campoy et al., 2013). The hydraulic conductivity and diffusivity depend on soil moisture following the Van Genuchten (1980) model; the required parameters are taken from (Carsel and Parrish, 1988), and depend on the dominant soil texture in each grid-cell, based on the $1° \times 1°$ texture map by Zobler (1986). The 2-m soil column is divided into 11 layers, with thickness increasing geometrically with depth,while the saturated hydraulic conductivity exponentially decreases with depth, to account for increased compaction and reduced bioturbation (Beven and Kirkby, 1979). The precipitation rate and the soil hydraulic conductivity govern the partitioning between surface runoff and soil infiltration, which involves a time splitting procedure inspired from Green and Ampt (1911) to describe the propagation of the wetting front. The second contribution to total runoff is gravitational drainage at the bottom of the soil.

The routing module (Polcher, 2003; Ngo-Duc et al., 2005; Guimberteau et al., 2012) calculates the daily discharge in each grid-cell and to the ocean. Streamflow routing relies on a series of linear reservoirs along the drainage network, derived from a 0.5° resolution data set (Vörösmarty et al., 2000). The routing scheme also includes a floodplain/swamp parameterization (d'Orgeval et al., 2008), recently improved by Guimberteau et al. (2012) for the Amazon basin, by introducing a new floodplain/swamp map. The simulation of the hydrology by the model ORCHIDEE has been widely tested over the Amazon basin and its catchments (Guimberteau et al., 2012; Getirana et al., 2014; Guimberteau et al., 2014).

References

Ball, J., Woodrow, I., and Berry, J.: A model predicting stomatal conductance and its contribution to the control of photosynthesis under different environmental conditions, in: Prog. Photosynthesis Res. Proc. Int. Congress 7th, Providence. 10-15 Aug 1986. Vol4. Kluwer, Boston., pp. 221–224, 1987.

Beven, K. and Kirkby, M.: A physically based, variable contributing area model of basin hydrology/Un modèle à base physique de zone d'appel variable de l'hydrologie du bassin versant, Hydrol. Sci. Bull., 24, 43–69, 1979.

Biemans, H., Hutjes, R., Kabat, P., Strengers, B., Gerten, D., and Rost, S.: Effects of precipitation uncertainty on discharge calculations for main river basins, J. Hydrometeorol., 10, 1011–1025, 2009.

Biemans, H., Haddeland, I., Kabat, P., Ludwig, F., Hutjes, R., Heinke, J., von Bloh, W., and Gerten, D.: Impact of reservoirs on river discharge and irrigation water supply during the 20th century, Water Resour. Res., 47, W03 509, 2011.

Bondeau, A., Smith, P. C., Zaehle, S., Schaphoff, S., Lucht, W., Cramer, W., Gerten, D., Lotze-Campen, H., Müller, C., Reichstein, M., and Smith, B.: Modelling the role of agriculture for the 20th century global terrestrial carbon balance, Glob. Change Biol., 13, 679–706, 2007.

Campoy, A., Ducharne, A., Cheruy, F., Hourdin, F., Polcher, J., and Dupont, J.: Response of land surface fluxes and precipitation to different soil bottom hydrological conditions in a general circulation model, J. Geophys. Res.-Atmos., 118, 10,725–10,739, 10.1002/jgrd.50627, 2013.

Carsel, R. and Parrish, R.: Developing joint probability distributions of soil water retention characteristics, Water Resour. Res., 24, 755–769, doi:10.1029/WR024i005p00755, 1988.

Cochonneau, G., Sondag, F., Guyot, J., Geraldo, B., Filizola, N., Fraizy, P., Laraque, A., Magat, P., Martinez, J., Noriega, L., Oliveira, E., Ordonez, J., Pombosa, R., Seyler, F., Sidgwick, J., and Vauchel, P.: The Environmental Observation and Research project, ORE HYBAM, and the rivers of the Amazon basin, IAHS-AISH P., 308, 44–50, 2006.

Collatz, G. J., Ribas-Carbo, M., and Berry, J.: Coupled photosynthesis-stomatal conductance model for leaves of C4 plants, Funct. Plant Biol., 19, 519–538, 1992.

Cramer, W., Bondeau, A., Woodward, F. I., Prentice, I. C., Betts, R. A., Brovkin, V., Cox, P. M., Fisher, V., Foley, J. A., Friend, A. D., Kucharik, C., Lomas, M. R., Ramankutty, N., Sitch, S., Smith, B., White, A., and Young-Molling, C.: Global response of terrestrial ecosystem structure and function to CO2 and climate change: results from six dynamic global vegetation models, Glob. Change Biol., 7, 357–373, doi:10.1046/j.1365-2486.2001.00383.x, http://dx.doi.org/10.1046/j.1365-2486.2001.00383.x, 2001.

de Rosnay, P. and Polcher, J.: Modelling root water uptake in a complex land surface scheme coupled to a GCM, Hydrol. Earth Syst. Sc., 2, 239–255, doi:10.5194/hess-2-239-1998, 1998.

de Rosnay, P., Polcher, J., Bruen, M., and Laval, K.: Impact of a physically based soil water flow and soil-plant interaction representation for modeling large-scale land surface processes, J. Geophys. Res.-Atmos., 107, 4118, doi:10.1029/2001JD000634, 2002.

de Weirdt, M., Verbeeck, H., Maignan, F., Peylin, P., Poulter, B., Bonal, D., Ciais, P., and Steppe, K.: Seasonal leaf dynamics for tropical evergreen forests in a process-based global ecosystem model, Geosci. Model Dev., 5, 1091–1108, 2012.

d'Orgeval, T., Polcher, J., and de Rosnay, P.: Sensitivity of the West African hydrological cycle in ORCHIDEE to infiltration processes, Hydrol. Earth Syst. Sc., 12, 1387–1401, 2008.

Ducoudré, N., Laval, K., and Perrier, A.: SECHIBA, a new set of parameterizations of the hydrologic exchanges at the land atmosphere interface within the LMD atmospheric global circulation model, J. Climate, 6, 248–273, 1993.

Fader, M., Rost, S., Müller, C., Bondeau, A., and Gerten, D.: Virtual water content of temperate cereals and maize: Present and potential future patterns, J. Hydrol., 384, 218–231, 2010.

Farquhar, G., von Caemmerer, S. v., and Berry, J.: A biochemical model of photosynthetic CO2 assimilation in leaves of C3 species, Planta, 149, 78–90, 1980.

Foley, J. A., Prentice, I. C., Ramankutty, N., Levis, S., Pollard, D., Sitch, S., and Haxeltine, A.: An integrated biosphere model of land surface processes, terrestrial carbon balance, and vegetation dynamics, Global Biogeochem. Cy., 10, 603–628, 1996.

Gerten, D., Bondeau, A., Hoff, H., Lucht, W., Schaphoff, S., Smith, P., Webb, B., Arnell, N., Onof, C., MacIntyre, N., et al.: Assessment of green water fluxes with a dynamic global vegetation model., in: Hydrology: science and practice for the 21st century. Proceedings of the British Hydrological Society International Conference, Imperial College, London, July 2004., pp. 29–35, British Hydrological Society, 2004a.

Gerten, D., Schaphoff, S., Haberlandt, U., Lucht, W., and Sitch, S.: Terrestrial vegetation and water balance-hydrological evaluation of a dynamic global vegetation model, J. Hydrol., 286, 249–270, 2004b.

Gerten, D., Rost, S., von Bloh, W., and Lucht, W.: Causes of change in 20th century global river discharge, Geophys. Res. Lett., 35, L20 405, 2008.

Getirana, A., Dutra, E., Guimberteau, M., Kam, J., Li, H.-Y., Decharme, B., Zhang, Z., Ducharne, A., Boone, A., Balsamo, G., Rodell, M., Toure, A. M., Xue, Y., Peters-Lidard, C. D., Kumar, S. V., Arsenault, K., Drapeau, G., Leung, L. R., Ronchail, J., and Sheffield, J.: Water balance in the Amazon basin from a land surface model ensemble, J. Hydrometeorol., 15, 2586–2614, 2014.

Gordon, W., Famiglietti, J., Fowler, N., Kittel, T., and Hibbard, K.: Validation of simulated runoff from six terrestrial ecosystem models: Results from VEMAP, Ecol. Appl., 14, 527–545, 2004.

Green, W. H. and Ampt, G.: Studies on soil physics, 1. The flow of air and water through soils, J. Agr. Sci., 4, 1–24, 1911.

Guimberteau, M., Drapeau, G., Ronchail, J., Sultan, B., Polcher, J., Martinez, J. M., Prigent, C., Guyot, J. L., Cochonneau, G., Espinoza, J. C., Filizola, N., Fraizy, P., Lavado, W., De Oliveira, E., Pombosa, R., Noriega, L., and Vauchel, P.: Discharge simulation in the sub-basins of the Amazon using ORCHIDEE forced by new datasets, Hydrol. Earth Syst. Sc., 16, 911–935, 10.5194/hess-16-911-2012, 2012.

Guimberteau, M., Ducharne, A., Ciais, P., Boisier, J.-P., Peng, S., De Weirdt, M., and Verbeeck, H.: Testing conceptual and physically based soil hydrology schemes against observations for the Amazon Basin, Geosci. Model Dev., 7, 1115–1136, 10.5194/gmd-7-1115-2014, 2014.

Gumpenberger, M., Vohland, K., Heyder, U., Poulter, B., Macey, K., Rammig, A., Popp, A., and Cramer, W.: Predicting pan-tropical climate change induced forest stock gains and losses–implications for REDD, Environ. Res. Lett., 5, 014 013, 2010.

Haddeland, I., Clark, D. B., Franssen, W., Ludwig, F., Voß, F., Arnell, N. W., Bertrand, N., Best, M., Folwell, S., Gerten, D., Gomes, S., Gosling, S. N., Hagemann, S., Hanasaki, N., Harding, R., Heinke, J., Kabat, P., Koirala, S., Oki, T., Polcher, J., Stacke, T., Viterbo, P., Weedon, G. P., and Yeh, P.: Multimodel Estimate of the Global Terrestrial Water Balance: Setup and First Results., J. Hydrometeorol., 12, 869–884, doi:10.1175/2011jhm1324.1, http://dx.doi.org/10.1175/2011jhm1324.1, 2011.

Jackson, R., Canadell, J., Ehleringer, J., Mooney, H., Sala, O., and Schulze, E.: A global analysis of root distributions for terrestrial biomes, Oecologia, 108, 389–411, 1996.

Jung, M., Reichstein, M., Ciais, P., Seneviratne, S., Sheffield, J., Goulden, M., Bonan, G., Cescatti, A., Chen, J., De Jeu, R., Johannes Dolman, A., Eugster, W., Gerten, D., Gianelle, D., Gobron, N., Heinke, J., Kimball, J., Law, B. E., Montagnani, L., Mu, Q., Mueller, B., Oleson, K., Papale, D., Richardson, A. D., Roupsard, O., Running, S., Tomelleri, E., Viovy, N., Weber, U., Williams, C., Wood, E., Zaehle, S., and Zhang, K.: Recent decline in the global land evapotranspiration trend due to limited moisture supply, Nature, 467, 951–954, 2010.

Krinner, G., Viovy, N., de Noblet-Ducoudre, N., Ogee, J., Polcher, J., Friedlingstein, P., Ciais, P., Sitch, S., and Prentice, I.: A dynamic global vegetation model for studies of the coupled atmosphere-biosphere system, Global Biogeochem. Cy., 19, 1–33, 10.1029/2003GB002199, 2005.

Kucharik, C. J., Foley, J. A., Delire, C., Fisher, V. A., Coe, M. T., Lenters, J. D., Young-Molling, C., Ramankutty, N., Norman, J. M., and Gower, S. T.: Testing the performance of a dynamic global ecosystem model: water balance, carbon balance, and vegetation structure, Global Biogeochem. Cy., 14, 795–825, 2000.

Langerwisch, F., Rost, S., Gerten, D., Poulter, B., Rammig, A., and Cramer, W.: Potential effects of climate change on inundation patterns in the Amazon Basin, Hydrol. Earth Syst. Sc., 17, 2247–2262, 2013.

McMurtrie, R., Rook, D., and Kelliher, F.: Modelling the yield of Pinus radiata on a site limited by water and nitrogen, Forest Ecol. Manag., 30, 381–413, 1990.

Ngo-Duc, T., Polcher, J., and Laval, K.: A 53-year forcing data set for land surface models, J. Geophys. Res.-Atmos., 110, D06 116, doi:10.1029/2004JD005434, 2005.

Polcher, J.: Les processus de surface à l'échelle globale et leurs interactions avec l'atmosphère, Habilitation à diriger des recherches, 2003.

Poulter, B., Heyder, U., and Cramer, W.: Modeling the sensitivity of the seasonal cycle of GPP to dynamic LAI and soil depths in tropical rainforests, Ecosystems, 12, 517–533, 2009.

Rammig, A., Jupp, T., Thonicke, K., Tietjen, B., Heinke, J., Ostberg, S., Lucht, W., Cramer, W., and Cox, P.: Estimating the risk of Amazonian forest dieback, New Phytol., 187, 694–706, 2010.

Rost, S., Gerten, D., Bondeau, A., Lucht, W., Rohwer, J., and Schaphoff, S.: Agricultural green and blue water consumption and its influence on the global water system, Water Resour. Res., 44, W09 405, doi:10.1029/2007wr006331, 2008.

Schaphoff, S., Heyder, U., Ostberg, S., Gerten, D., Heinke, J., and Lucht, W.: Contribution of permafrost soils to the global carbon budget, Environ. Res. Lett., 8, 014 026, doi:10.1088/1748-9326/8/1/014026, http://dx.doi.org/10.1088/1748-9326/8/1/014026, 2013.

Sitch, S., Smith, B., Prentice, I., Arneth, A., Bondeau, A., Cramer, W., Kaplan, J., Levis, S., Lucht, W., Sykes, M., Thonicke, K., and Venevsky, S.: Evaluation of ecosystem dynamics, plant geography and terrestrial carbon cycling in the LPJ dynamic global vegetation model, Glob. Change Biol., 9, 161–185, 2003.

Thompson, S. L. and Pollard, D.: A global climate model (GENESIS) with a land-surface transfer scheme (LSX). Part I: Present climate simulation, J. Climate, 8, 732–761, 1995.

Thonicke, K., Spessa, A., Prentice, I., Harrison, S., Dong, L., and Carmona-Moreno, C.: The influence of vegetation, fire spread and fire behaviour on biomass burning and trace gas emissions: results from a process-based model., Biogeosciences, 7, 1991–2011, 2010.

Van Genuchten, M. T.: A closed-form equation for predicting the hydraulic conductivity of unsaturated soils, Soil Sci. Soc. Am. J., 44, 892–898, 1980.

Verbeeck, H., Peylin, P., Bacour, C., Bonal, D., Steppe, K., and Ciais, P.: Seasonal patterns of CO2 fluxes in Amazon forests: Fusion of eddy covariance data and the ORCHIDEE model, J. Geophys. Res.-Biogeo., 116, G02 018, 10.1029/2010JG001544, 2011.

Viovy, N.: Interannuality and CO2 sensitivity of the SECHIBA-BGC coupled SVAT-BGC model, Phys. Chem. Earth, 21, 489–497, 1996.

Vörösmarty, C. J., Fekete, B., Meybeck, M., and Lammers, R.: Geomorphometric attributes of the global system of rivers at 30-minute spatial resolution, J. Hydrol., 237, 17–39, 2000.

Wagner, W., Scipal, K., Pathe, C., Gerten, D., Lucht, W., and Rudolf, B.: Evaluation of the agreement between the first global remotely sensed soil moisture data with model and precipitation data, J. Geophys. Res.-Atmos., 108, 4611, doi:10.1029/2003jd003663, 2003.

Zobler, L.: A world soil file for global climate modeling, Tech. Rep. 87802, NASA, 1986.

Location	Station Name	Abbreviation	River Name	Abbreviation	Latitude	Longitude	Area (km^2)
MAIN	Óbidos	OBI	Amazonas	AMAZ	-1.95	-55.30	4,680,000
SOUTH	Fazenda Vista Alegre	FVA	Madeira	MAD	-4.68	-60.03	1,293,600
	Guajará-Mirim	GMIR	Mamoré	MAM	-10.99	-65.55	532,800
	Itaituba	ITA	Tapajós	TAP	-4.24	-56.00	461,100
	Altamira	ALT	Xingu	XIN	-3.38	-52.14	469,100
WEST	Tamshiyacu	TAM	Upper Solimões	UPSO	-4.00	-73.16	726,400
	Lábrea	LAB	Purus	PUR	-7.25	-64.80	230,000
	Gavião	GAV	Juruá	JUR	-4.84	-66.85	170,400
NORTH	Caracaraí	CARA	Branco	BRA	+1.83	-61.08	130,600

Table S1. List of the gauging stations for the studied catchments. Sources: SO HYBAM (Observation Service of the Geodynamical, hydrological and biogeochemical control of erosion/alteration and material transport in the Amazon, Orinoco and Congo basins, Cochonneau et al., 2006).

	Basin	Model	Relative bias (%)		Correlation coefficient		NRMSE (%)	
			Q	ET	Q	ET	Q	ET
MAIN	AMAZ	INLAND-DGVM	-22.4	-1.8	-	0.60	-	14.1
		LPJmL-DGVM	-21.9	+1.9	0.77	0.55	36.6	25.0
		ORCHIDEE	-5.9	-4.6	0.91	0.58	14.1	17.2
SOUTH	MAD	INLAND-DGVM	-28.3	+0.2	-	0.89	-	13.6
		LPJmL-DGVM	-2.2	-9.5	0.89	0.83	33.5	28.9
		ORCHIDEE	-5.5	-1.7	0.99	0.88	20.2	15.2
	MAM	INLAND-DGVM	-60.9	+0.92	-	0.99	-	15.0
		LPJmL-DGVM	+14.0	-14.8	0.73	0.91	47.4	30.6
		ORCHIDEE	-22.2	-3.0	0.91	0.98	43.4	18.0
	TAP	INLAND-DGVM	+10.5	-3.0	-	0.02	-	13.4
		LPJmL-DGVM	+25.1	-6.8	0.90	0.45	53.9	34.0
		ORCHIDEE	+16.6	-3.3	0.96	0.11	47.5	11.5
	XIN	INLAND-DGVM	+47	-1.9	-	0.17	-	14.9
		LPJmL-DGVM	+59.1	-5.9	0.83	-0.01	66.6	34.5
		ORCHIDEE	+34.1	-4.4	0.94	0.31	46.1	12.6
WEST	UPSO	INLAND-DGVM	-57.4	+2.2	-	0.32	-	22.9
		LPJmL-DGVM	-45.2	-0.9	0.93	0.87	86.0	18.5
		ORCHIDEE	-17.2	-10.0	0.96	0.31	23.9	25.5
	PUR	INLAND-DGVM	+9.3	+2.6	-	0.83	-	9.8
		LPJmL-DGVM	+18.6	+1.7	0.86	0.27	39.3	24.0
		ORCHIDEE	+15.8	-0.9	0.96	0.79	31.6	10.1
	JUR	INLAND-DGVM	+9.3	-0.05	-	0.86	-	9.3
		LPJmL-DGVM	+10.2	+7.3	0.89	0.02	29.7	17.0
		ORCHIDEE	+39.4	-4.1	0.96	0.82	40.1	10.4
NORTH	BRA	INLAND-DGVM	+47.1	+17.1	-	0.74	-	21.0
		LPJmL-DGVM	+53.3	+12.5	0.99	0.06	51.3	33.1
		ORCHIDEE	+69.3	+10.9	0.96	0.61	58.8	15.0

Table S2. Bias (%), correlation and NRMSE (Normalized Root Mean Square Error) (%) against the observations, of discharge and ET, for each catchment, for HIST period. Observed discharge comes from SO HYBAM and ET is estimated by the product of Jung et al. (2010).

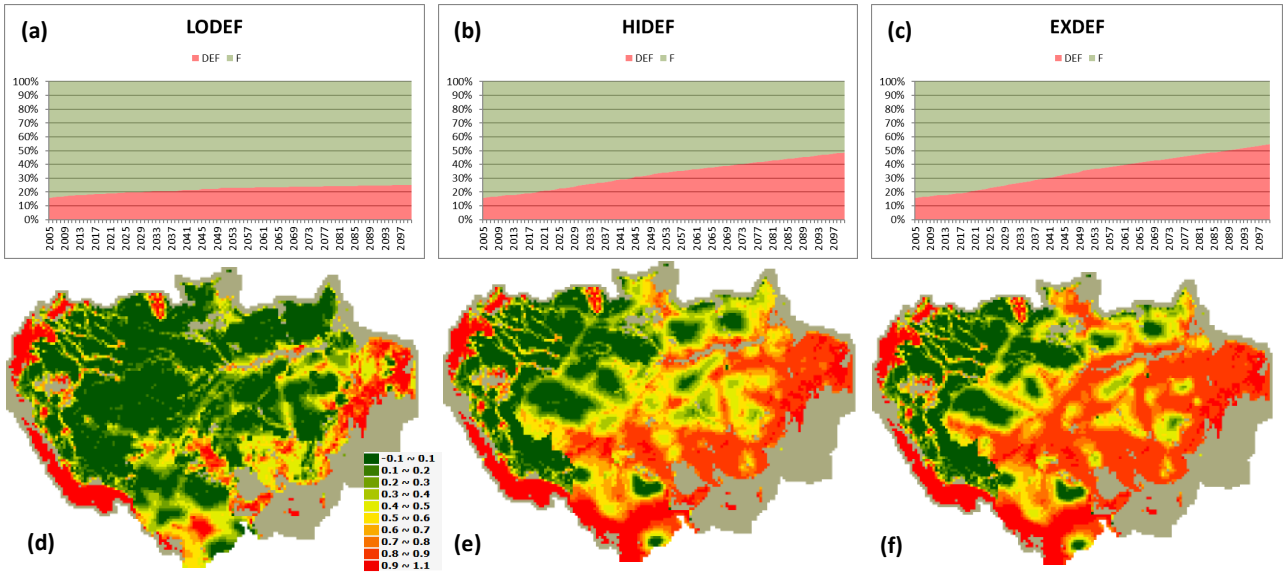

Figure S1. Deforested area (%) in each 25 x 25 km^2 for the LCC scenarios LODEF (**a** and **d**), HIDEF (**b** and **e**) and EXDEF (**c** and **f**).

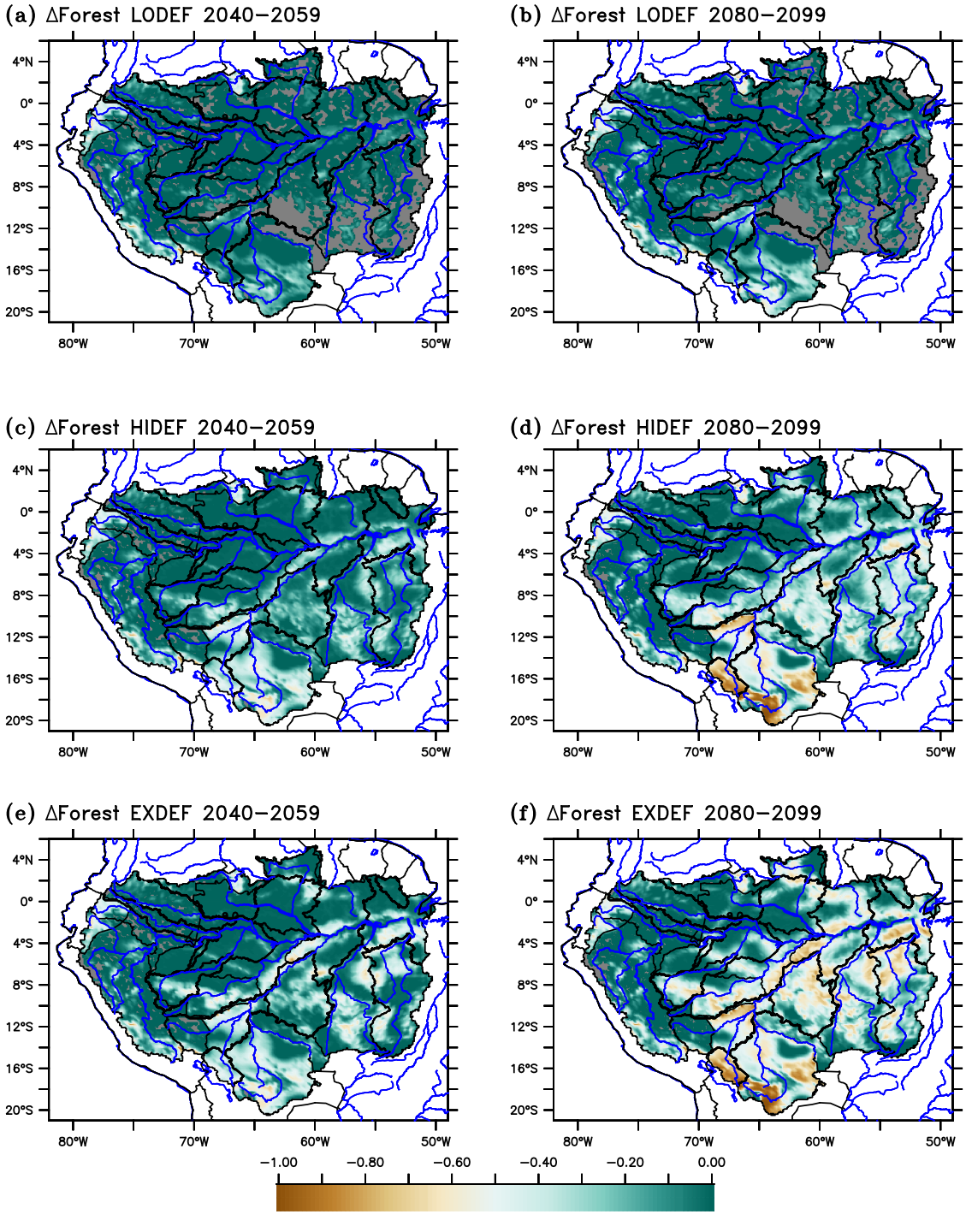

Figure S2. Decrease of forest fraction for the three LCC scenarios (for the two time periods) compared with the NODEF scenario in 2009 over the Amazon basin. Grey colour indicates no change of forest fraction.

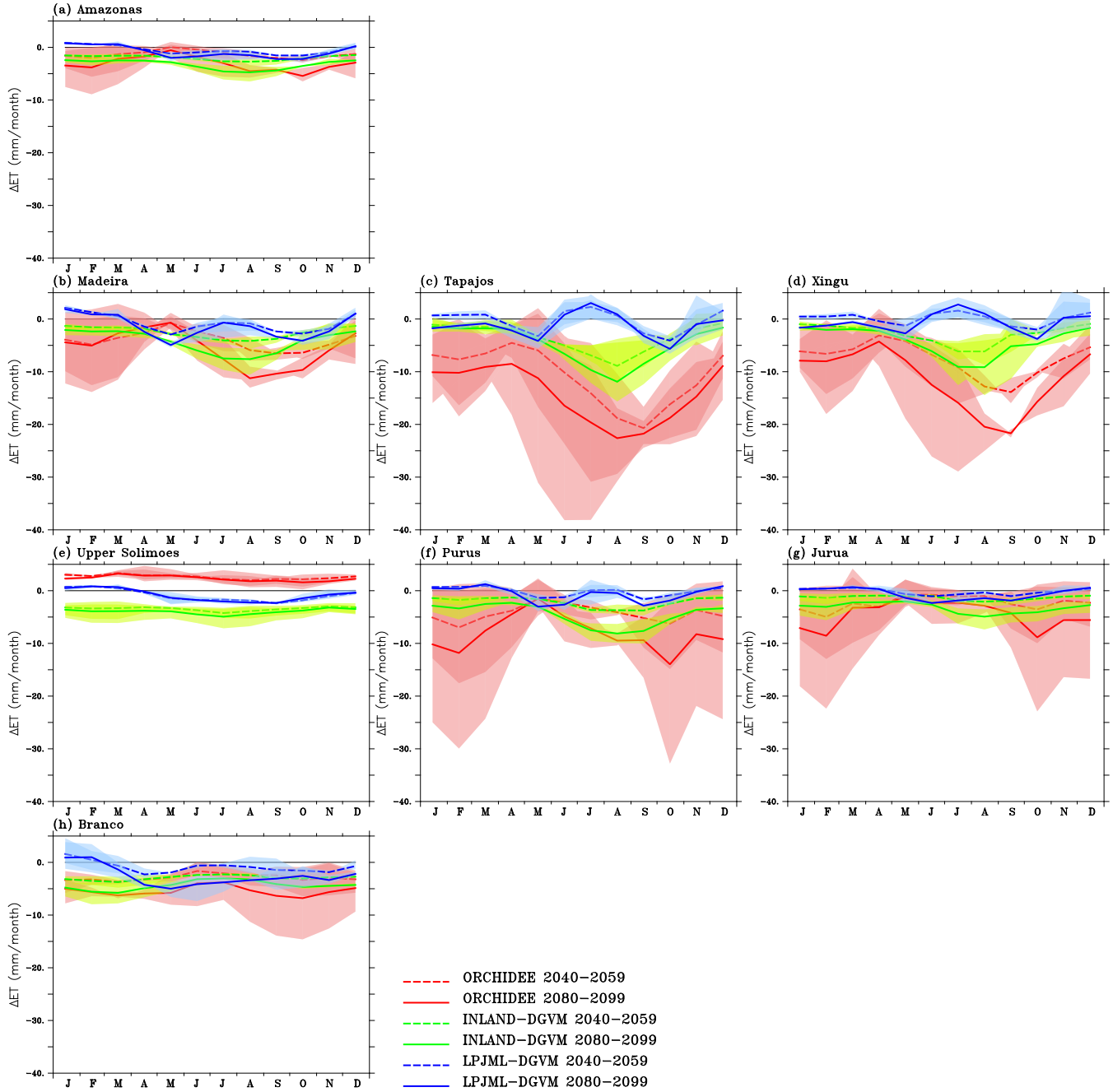

Figure S3. Seasonal change in ET (mm month^{-1}) due to deforestation combined with climate change (EXDEF) simulated by the three LSMs over the Amazon basin and its catchments, averaged over the two future periods. For a given LSM and period, the shaded area defines the envelope enclosing the range with plausible climate futures.

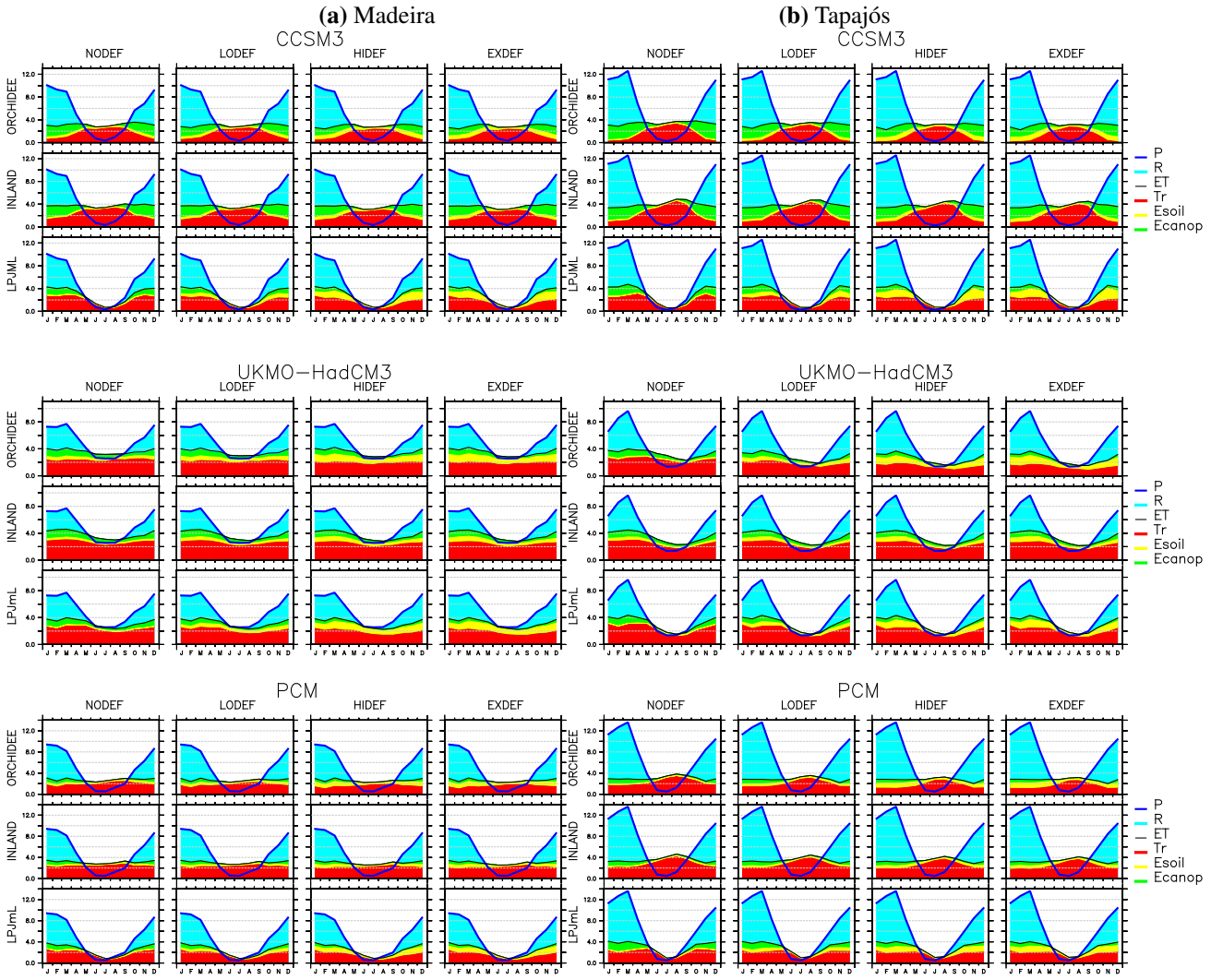

Figure S4. For each GCM-forcing, monthly mean seasonalities of the water budget components (including the ET components) ($mm\,d^{-1}$) from the three LSMs (rows) and for each NODEF and LCC scenarios (columns) over **(a)** the Madeira and **(b)** the Tapajós catchments. The variables of the water budget are: precipitation (P), runoff (R) and evapotranspiration (ET). The variables of the ET components are: transpiration (Tr), soil evaporation (Esoil) and evaporation of canopy interception (Ecanop).