MOSART-inundation: Model development and application over the Amazon

Hong-Yi Li, Xiangyu Luo, L. Ruby Leung, and Teklu K. Tesfa

Objective

Flood events change land cover types and impact plant physiological processes, hence affecting the exchange of energy and matter (e.g., vapor, carbon dioxide, methane, etc.) between the land surface and atmosphere. Moreover, river inundation also influences the interactions between surface water and groundwater, as well as the river – floodplain mass exchange. This important land-surface process was represented with a large-scale inundation scheme which was coupled with the MOSART river routing model. The MOSART-inundation model was applied in the Amazonia.

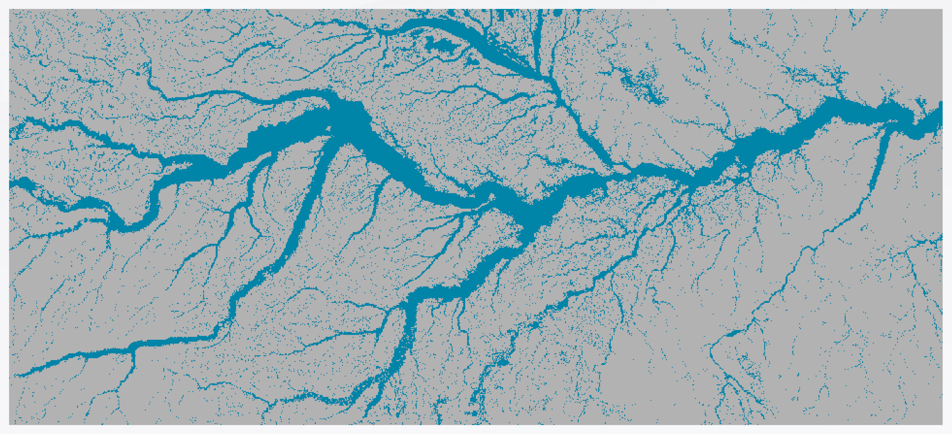

Figure 1. Floodable area (indicated by blue color) derived from high-resolution satellite images in the central Amazon region (72ºW, 0ºN ~ 54ºW, 8ºS) [*Hess et al., 2003*].

The Amazonia accounts for about one-fifth of the world's total river discharge entering the ocean. The amount of carbon being outgassed from water surface is estimated to be comparable to the amount of carbon absorption by the Amazon forests [*Richey et al., 2002*]. Seasonal floods play a significant role in the water, carbon and energy cycles in this basin.

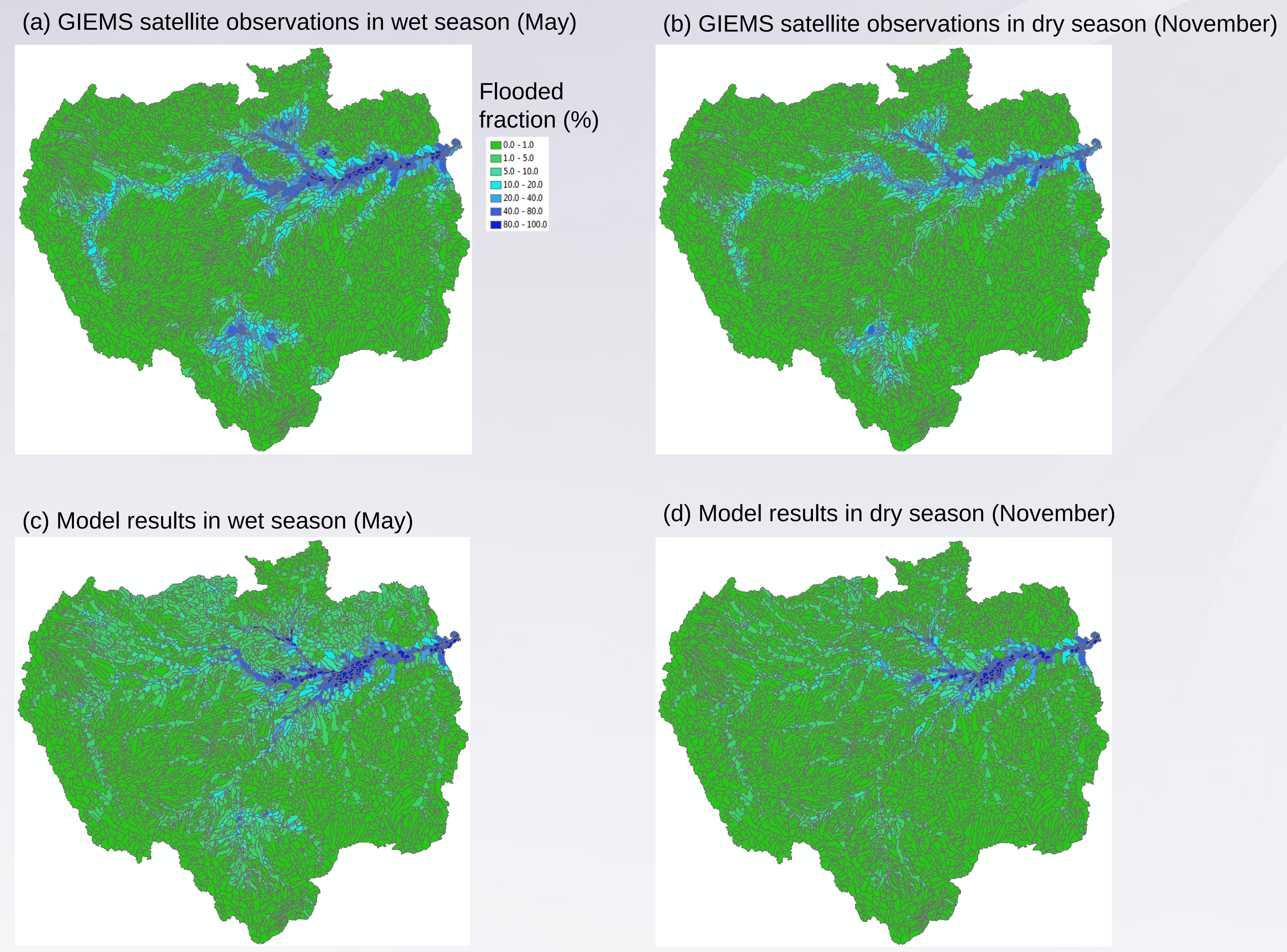

Figure 3. Wet-season (May) and dry-season (November) flooded fractions for all sub-basins. The figures show average values of 12 years (1993 – 2004). The original grid-based satellite data (GIEMS) were mapped to the sub-basins. The model results were from the simulation "DW-grad-corDEM" (i.e., the simulation using the diffusion-wave routing method, the gradual exchange algorithm and the corrected DEM) (Table 1).

Approach

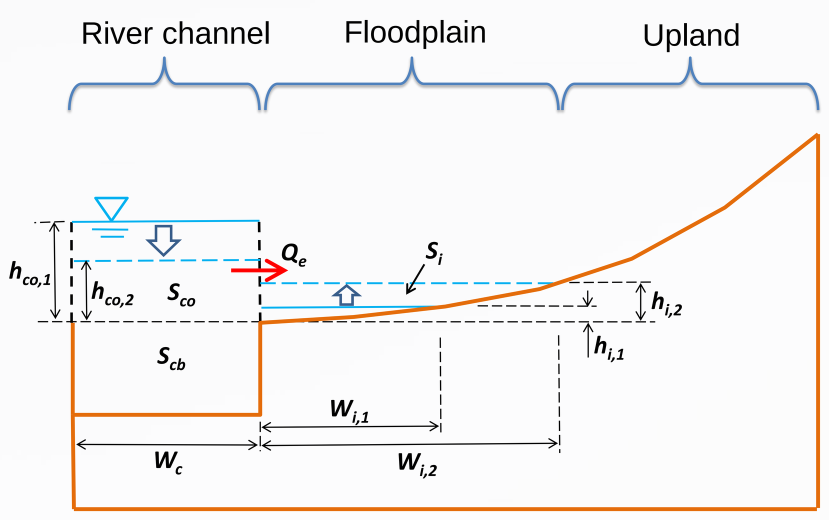

Figure 2. River channel – floodplain exchange.

Table 1. Setup of the four simulations.

Simulation No.	1	2	3	4
River routing method	Kinematic wave	Diffusion wave	Diffusion wave	Diffusion wave
River channel – floodplain exchange algorithm	Instanta-neous	Instanta-neous	Gradual	Instanta-neous
DEM	Corrected	Corrected	Corrected	Original
Abbreviations	KW-inst-corDEM	DW-inst-corDEM	DW-grad-corDEM	DW-inst-oriDEM

Note: The original DEM is the 3-second HydroSHEDS DEM. The corrected DEM is generated through lowering the original DEM by 50% of the vegetation heights.

The Model for Scale Adaptive River Transport (MOSART) river routing model was extended with a large-scale inundation scheme which explicitly represented the water exchange between river channels and floodplains. Besides the kinematic wave routing method, the diffusion wave routing method was also implemented in the model in order to account for the back water effects in flat watersheds (e.g., the Amazon Basin).

The river channel – floodplain water exchange was simulated with two optional approaches: instantaneous exchange algorithm and gradual exchange algorithm.

The model was used to conduct four 13-year simulations (1992-2004) in the Amazon Basin. Uncertainties in the DEM data were considered. The input surface and subsurface runoff data were generated by the ISBA land surface model. The simulated flood extent results were compared with the GIEMS satellite dataset.

Impact

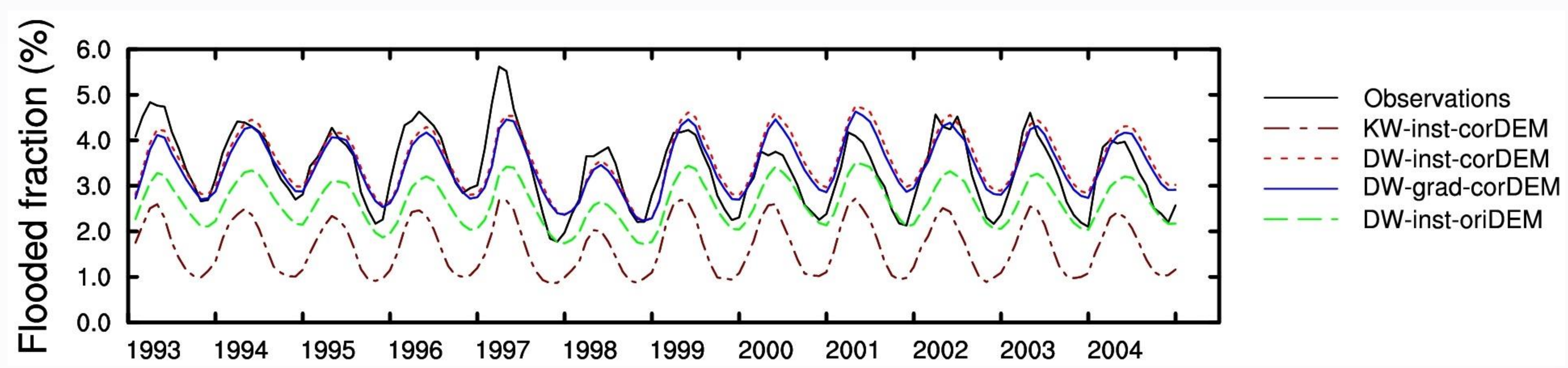

Figure 4. Monthly whole-basin flooded fractions from 1993 to 2004.

1. The simulated results show that this model can satisfactorily capture the whole-basin inundation dynamics in the Amazon Basin (Simulations DW-inst-corDEM and DW-inst-corDEM).
2. The spatial pattern of flood extent is also represented reasonably well (Figure 3).
3. It is necessary to account for the back water effects when modeling the inundation dynamics in the Amazon Basin (KW-inst-corDEM versus DW-inst-corDEM).
4. The vegetation-caused errors embedded in the DEM data have significant effects on the inundation modeling (DW-inst-corDEM versus DW-inst-oriDEM).
5. The effect of the river channel – floodplain exchange algorithm on the whole-basin total flood extent is not obvious (DW-inst-corDEM versus DW-grad-corDEM). The effect is more evident in some sub-regions (e.g., the main stem region; results not shown here).
6. Further efforts are needed to handle the uncertainties in the input data and the observed data used for evaluating the model.

ACME Accelerated Climate Modeling for Energy

For additional information, contact:

Hong-Yi Li
Scientist

Pacific Northwest National Laboratory
(509) 375-6914
hongyi.li@pnnl.gov

climatemodeling.science.energy.gov/acme

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