Long-term interception evaporation from lowland tropical rainforest in Lambir Hills National Park, Sarawak, Malaysia

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Interception evaporation (IE) is the amount of rainfall intercepted by vegetation and evaporated back to the atmosphere during and after rainfall ceases. Long-term quantification of this loss of precipitation (P) is an important step in water balance and forest conversion affects on water yield studies because IE can be as high as 40% of P. Although long-term IE is relatively simple to estimate in homogeneous forests, the heterogeneous canopy of lowland tropical rainforests creates large spatial variability of both the precipitation inside these forests or throughfall (TF) and water running down the tree's stems or stemflow (SF). Poor assessment of such spatial variations may result in unrealistic estimated long-term IE amounts. The objectives of the present IE study carried out in the the lowland tropical rainforest at the crane biology 4-ha plot, hereafter 4-ha plot, in Lambir Hills National Park, Sarawak, Malaysia (4°12′N, 114°02′E) were: 1) to estimate the long-term forest scale IE with the conventional canopy water budget method or comparison of P inside (TF+SF) and outside the forest (P); 2) to compare this estimate with indirect calculations of IE using micrometeorological method; and 3) to determine the contribution of IE to total evaporation by the forest in the 4-ha plot.

The measurements of P, SF and TF, and by difference IE (P-SF-TF), in the 4-ha plot lasted for 3-years: 01 July 2001—17 July 2004. The 4-ha plot, in the middle of which a large jib 85.8 m height crane was built, had been gridded into 400 subplots of 100 m^2 each. In one of these subplots, called Fixed Plot (FP), TF accumulated in 20 raingauges and SF yield by 78 trees, using collar type SF gauges, were recorded daily during the 3-years study. Concurrently, during these same 3-years, in others 22 subplots of the 4-ha plot TF was measured by relocating others 20 raingauges after about a month of observation in a same subplot. Thus, every day TF water accumulated in 40 raingauges (20 in the FP and others 20 in another given subplot of the 4-ha plot) and the SF yield by 78 tress were recorded inside the forest. Outside the forest P caught by 4 raingauges of same type as those used in the TF observation were also recorded daily. In Lambir, rainfall observation with tipping-bucket raingauges and micrometeorological variables needed in evaporation estimation have been conducted since 1999 at the 10-min or higher time resolution.

Analyses of P, TF and SF data collected in the 3-years and methods used to estimate the long-term IE at the 4-ha plot scale are detailed elsewhere (Manfroi et al. 2004a; Manfroi et al. 2004b). Table 1 summarizes the resulting long-term P, TF, SF and IE from these analyses at both the FP and 4-ha plot scales. As shown, at the 4-ha plot about 210 mm/year or 8.5% of P, with few inter-annual variation, were estimated to have been lost as IE, but a somewhat higher, in average 295 mm/year or 12%, with noticeable inter-annual variation were actually observed in the FP.

Table 1 Annual and 3-years TF, SF and IE, as % of P, observed in the FP and 4-ha plot.

	P,mm	FP			4-ha plot		
		TF %	SF %	IE %(mm)	TF %	SF %	IE %(mm)
Year 1	2292.0	82.0	3.5	14.9(340.5)	87.5	3.8	8.7(199.4)
Year 2	2439.0	87.1	2.8	9.7(236.6)	88.0	3.4	8.6(209.8)
Year 3	2668.0	85.5	3.0	11.5(306.9)	88.3	3.4	8.3(221.4)
Average	2466.3	85.0	3.1	12.1(295.0)	87.9	3.5	8.5(210.2)

Using TF and SF measurements in the 4-ha plot, 10-min precipitation observed with tipping-bucket in the top of the crane and micrometeorological calculated potential evaporation with Penman-Monteith method, commonly used models to calculate IE were parameterized and tested. Fig.1 shows results of monthly accumulated IE predicted with the simplest of the tested models, often used in meteorology, and that observed in the 4-ha plot. The calculated average 205 mm/year or 8.3 % with this simple model is similar with the long-term amount suggested by observation in the 4-ha plot (Table 1), or 210 mm/year. The long-term estimation of IE by the models tested was almost solely sensitive to the water storage on the canopy and on trunks parameter suggested, both from observation of TF and SF in the 4-ha plot and automatic tuning of the models, to be about 0.75 mm.

Fig. 2. shows a comparison of micrometeorological estimates of total evaporation in the present study site (L), a study in Pasoh forest Peninsular Malaysia (P) and in Reserva Ducke, Brazilian Amazon (A) with catchment's water balance results in several lowland tropical rainforest sites of the world. As shown, interception evaporation gives a much smaller contribution than transpiration to total evaporation; in Lambir, for example, transpiration was estimated at 1193 mm/year (Kumagai et al. 2005). Our 4-ha plot observational and micrometeorological long-term IE estimates are similar with observational results for the Amazonian study, where IE of 8.9% of P was reported and that estimated by micrometeorological means at that site or 12%. The slight higher IE estimated in Pasoh forest of 242 mm/year is sensible because leaf area index can be as high as 11 m^2/m^2 in Pasoh, against a maximum of 8 m^2/m^2 in Lambir.

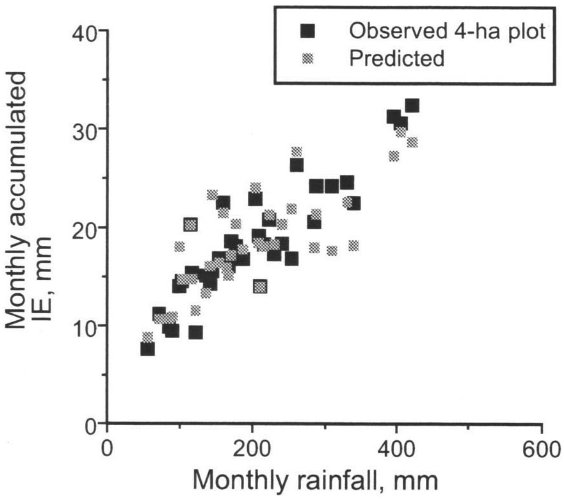

Fig. 1 Comparison of observed monthly IE in the 4-ha plot with monthly totals predicted by micrometeorological means.

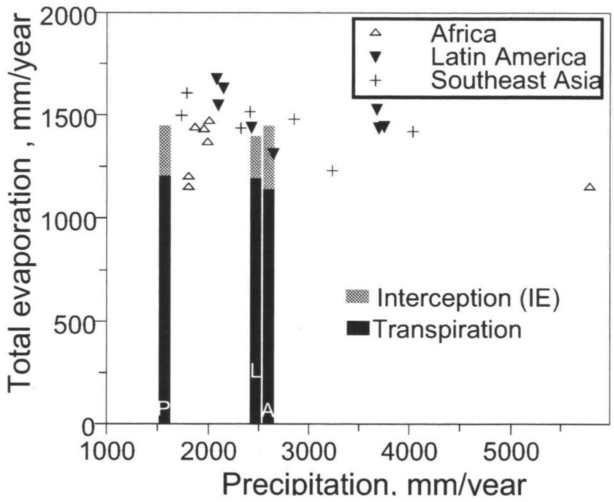

Fig. 2 Comparison of total evaporation estimated by micrometeorological methods (bars) and with the catchment's water balance method in Lowland tropical rainforests (modified after Tani et al. 2003). L-Lambir; P-Pasoh and A-Amazon.

REFERENCES

Kumagai, T.et al., 2005. Annual water balance and seasonality of evapotranspiration in a Bornean tropical rainforest. Agri. For. Meteorol., 128(1-2): 81-92.

Manfroi, O. J. et al., 2004. Comparing yearlong rainfall interception loss in small and large plot of a lowland tropical forest in Lambir, Sarawak, Malaysia. Proceedings of Forests and Water in Warm, Humid Asi, Kota Kinabalu, Malaysia. 274p.

Manfroi, O. J. et al., 2004. The Stemfow of Trees in a Bornean Lowland Tropical Forest. Hydrol. Process., 18: 2455-2474.

Tani, M. et al., 2003. Long-term estimation of evapotranspiration from a tropical rain forest in Peninsular Malaysia. Proceedings of Water Resources Systems Water Availability and Global Change, Sapporo, Japan, IAHS, 267-274p.