Q. J. R. Meteorol. Soc. (1994), **120**, pp. 733–734 551.577.52:551.513.1

Comments on 'The parametrization of rainfall interception in GCMs' by A. J. Dolman and D. Gregory (April 1992, **118,** 455–467)

By E. A. B. ELTAHIR and R. L. BRAS*
Massachusetts Institute of Technology, USA

(Received 10 August 1992)

Dolman and Gregory (1992) deal with the problem of parametrization of rainfall interception in General Circulation Models (GCMs). Their paper is a valuable contribution to the study of rainfall interception processes over large areas, since it emphasizes the importance of using observed data for validating parametrizations in climate models. The recent modelling attempts by Dickinson and Henderson-Sellers (1988) and by Lean and Warrilow (1989) were not successful in predicting the partition of evaporation into interception loss and transpiration in a rain-forest environment. Compared with Shuttleworth's (1988) observations both these studies overestimated interception loss. The basic problem in modelling rainfall interception in GCMs has been identified, correctly, by Lean and Warrilow (1989) as 'due to the extension of single-point description to the gridscale area' without considering the effects of spatial variability of rainfall. Dolman and Gregory attempted to solve this problem by studying two interception schemes which included some of the effects of the spatial variability in rainfall. These two interception schemes are the subjects of our comments.

The two schemes use simplified descriptions of rainfall interception at a 'point' (which are described by Eqs. (7a) and (8a) of Dolman and Gregory). The grid-cell mean throughfall is derived supposing that rainfall is exponentially distributed in a space covering a fraction of the total area. Although rainfall is distributed over a small fraction of the grid-cell area (0.1–0.3), the two schemes suppose that the depth of water on the canopy, C, is uniformly distributed over the entire area of the grid cell. It seems inconsistent to model rainfall as spatially variable and then to suppose that the resulting distribution of water on the canopy is uniform. The distribution of C has important effects on some of the rainfall interception processes.

The spatial distribution of the depth of water, C, affects two processes—evaporation of intercepted rain and throughfall. Evaporation of intercepted rain occurs only from the wetted fraction of the grid-cell area. Previous experience in modelling interception (see Rutter *et al.* 1971, 1975), indicates that canopy drainage at a 'point' is exponentially related to the depth of water on the canopy, C. This strong dependence of canopy drainage on C makes it important to account for the spatial variability in C. This is particularly true in deriving expressions for the spatially averaged drainage which contributes most of the throughfall.

The significant spatial variability of convective rainfall results in small areas where the depth of water on the canopy, C, is relatively large, and drainage from the canopy is large at those local sites (owing to the exponential dependence of canopy drainage on C). Hence the average throughfall is enhanced because of the spatial variability in C; this increase in throughfall results in smaller amounts of water being available for evaporation from the leaves of the canopy.

The importance of accounting for the spatial variability of the depth of water on the canopy, C, was demonstrated in our recent study (Eltahir and Bras 1993), in which in Fig. 1 different interception schemes are compared: the Biosphere–Atmosphere Transfer Scheme (BATS) (Dickinson *et al* 1986); the Rutter model developed by Rutter *et al.* (1971); the Shuttleworth scheme described by Dolman and Gregory (1992); and our new interception scheme which includes considerations for the spatial variability in rainfall and in C. Interception loss normalized by total rainfall is plotted against wind speed, which is a surrogate for potential evaporation. Interception loss is calculated from an off-line model of land-surface processes; each point in Fig. 1 represents a 60-days integration. The comparison between these four schemes indicates that a scheme which includes considerations for the spatial variability in rainfall and in C would simulate significantly smaller interception loss than would the other schemes. The Shuttleworth scheme, which supposes that rainfall is spatially variable, but that the depth of water on the canopy is uniform, produces results which are not significantly different from those of 'point' descriptions such as the Rutter model. Hence, rainfall interception schemes would be more accurate if the effects of spatial variability in *both* rainfall and the depth of water on the canopy were taken into account.

---

* Corresponding author: Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, Cambridge, MA 02139, USA.

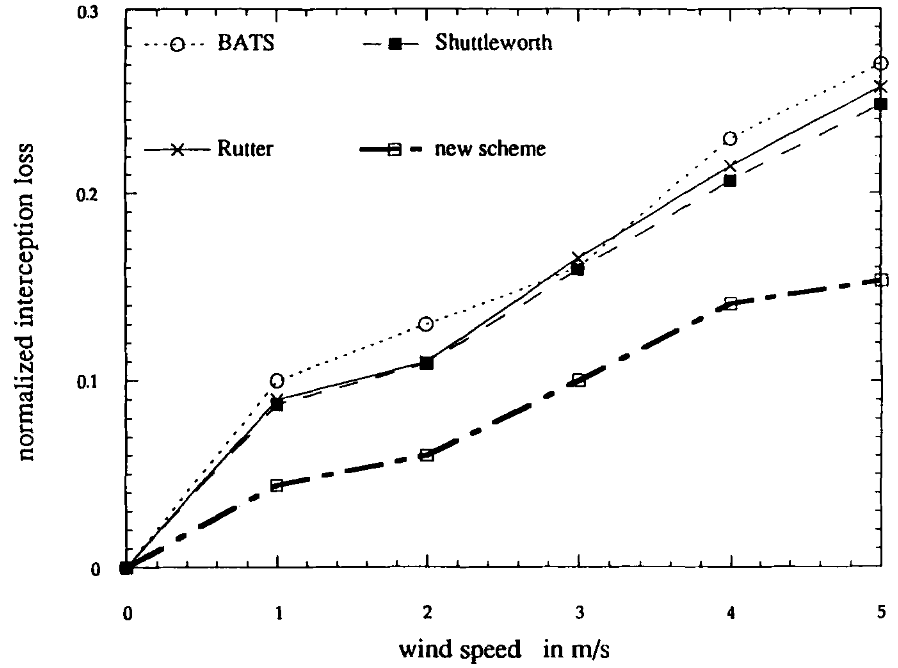

Figure 1. Comparison of interception schemes (Eltahir and Bras 1993); fraction of the grid-cell area which receives rainfall = 0.3, wetted fraction of the canopy = 0.3 (for schemes which include spatial variability).

ACKNOWLEDGEMENT

We acknowledge the support of the National Aeronautics and Space Administration (NASA) (agreement NAG 5-1615). E. A. B. Eltahir is supported through a NASA graduate student fellowship (agreement NGT 30086). The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official NASA position, policy, or decision, unless so designated by other documentation.

REFERENCES

Dickinson, R. E. and Henderson-Sellers, A. 1988 Modelling tropical deforestation: A study of GCM land surface parametrizations, *Q. J. R. Meteorol. Soc.*, **114**, 439–462

Dickinson, R. E., Henderson-Sellers, A., Kennedy, P. J. and Wilson, M. F. 1986 'Biosphere-Atmosphere Transfer Scheme (BATS) for the NCAR community climate model', NCAR Tech. Note, NCAR/TN-275+STR

Dolman, A. J. and Gregory, D. 1992 The parametrization of rainfall interception in GCMs. *Q. J. R. Meteorol. Soc.*, **118**, 445–467.

Eltahir, E. A. B. and Bras, R. L. 1993 A description of rainfall interception over large areas. *J Clim.*, **6**, 1002–1008

Lean J. and Warrilow, D. 1989 Simulation of the regional climatic impact of Amazon deforestation, *Nature*, **342**, 411–413

Rutter, A. J., Kershaw, K. A., Robins, P. C. and Morton, A. J. 1971 A predictive model of rainfall interception in forests, I: derivation of the model from observations in a plantation of Corsican pine. *Agric. Meteorol.*, **9**, 367–384

Rutter, A. J., Morton, A. J. and Robins, P. C. 1975 A predictive model of rainfall interception in forests. II: Generalization of the model and comparison with observations in some coniferous and hardwood stands, *J. Appl. Ecol.*, **12**, 367–380

Shuttleworth, W. J. 1988 Evaporation from Amazonian rainforest, *Proc. R. Soc. London*, **B233**, 321–346