# EVAPORATION OF INTERCEPTED SNOW - MODELLING OF THE AERODYNAMIC RESISTANCE

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## INTRODUCTION

Several papers during the last decade have emphasised the importance of evaporation of intercepted snow (Calder 1990, Schmidt 1991, Lundberg and Halldin 1994). When a substantial amount of snow is lost by evaporation, studies of the intercepted snow become important, and studies of this type are presented by Calder (1990), Schmidt (1991), and Lundberg and Halldin (1994).

Details of the modelling of aerodynamic resistance during snow conditions and a theoretical basis are presented in the paper. Data were collected intermittently during the winters of 1983-84 and 1984-85 at the experimental site in Queens Forest near Aviemore in the Highland Region of Scotland.

The results show that the maximum evaporation rate determined by the water budget method (0.56 mm $h^{-1}$ during 7 hours) is much higher than the maximum evaporation from a snow pack (0.06mm $h^{-1}$) reported by Harding (1986) but it is in accordance with the rate (0.5mm/h) reported by Calder (1990). The average evaporation rate (0.24mm/h) is high. A disadvantage of determining evaporation as a residual term from water budget consideration is that the errors in the individual terms have to be added, resulting in a large possible maximum error. The total error estimate for the accumulated evaporation ($E^{ACC}$) for all periods (Table 1) was rather large ($\geq$0.8mm).

However, the relative error for the three-day period was small (13%) while the relative error for 30th March was large (26%). The agreement between the accumulated evaporation determined by the water budget method and the combination equation using the snow aerodynamic resistance was good for the three-day period (17th-19th March) and it was acceptable for the 28th and the 30th. The combination method and standard rain aerodynamic resistance greatly overestimated the evaporation for four out of five days. The snow aerodynamic resistance, 10 times higher than the rain aerodynamic resistance, simulates the evaporation far better than the rain aerodynamic resistance. Some of the snow at the highest branches may have melted. This may have masked any possible differences between new and old snow and possible differences in aerodynamic resistance as a function of canopy storage. A difficulty with determining the evaporation of intercepted snow using the combination equation is that the required accuracy in the determination of vapour pressure is difficult to achieve. This uncertainty might explain the discrepancy between the water budget method and the combination method. The eddy-correlation technique does not suffer from this weakness and has been successfully tested above both snow and forest. This technique may be suitable for future snow interception evaporation studies according to Lundberg and Halldin (1994). The transition from solid to liquid phase is very important when dealing with evaporation of intercepted snow and no existing method can directly be applied (Lundberg 1993) to measure the intercepted mass and to partition it into liquid and solid phases will require further investigation and will probably result in a combination of methods. The comparison of intercepted snow evaporation calculated by the water budget method and the combination method (Penman) using different aerodynamic resistance showed that evaporation of dry intercepted snow calculated by the combination method provided a much larger aerodynamic resistance ($\approx$ 10 times) than when rain aerodynamic resistance is used. The maximum evaporation rate (0.56mm $h^{-1}$) was in accordance with the rate (0.5mm/h) reported by Calder (1990). More accurate measurement of air humidity (at temperatures close to and below zero) and a way to separate liquid from solid interception are required to gain better knowledge of the intercepted snow evaporation process.

## REFERENCES

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Table 1. Estimates of Accumulated Evaporation (mm) with Water Budget Equation and with Combination Equation Using Different Aerodynamic Resistances, March 1985

| Term/Date | 17 | 18 | 19 | 17-19 | 28 | 30 | Average |
|---|---|---|---|---|---|---|---|
| $E_{WB}^{ACC}$ | 5.0 | 1.3 | 4.5 | 10.8 ± 1.4 | 3.9 ± 0.8 | 3.1 ± 0.8 | 0.24 (mm/h) |
| $E_{raS}^{ACC}$ | 3.0 | 3.2 | 3.9 | 10.1 | 2.3 | 1.1 | 0.18 (mm/h) |
| $E_{raL}^{ACC}$ | 5.1 | 10.2 | 12.3 | 27.8 | 7.8 | 1.5 | 0.51 (mm/h) |
| $E_{raS}^{ACC} / E_{WB}^{ACC}$ | 0.60 | 2.46 | 0.86 | 0.94 | 0.59 | 0.35 | |

$E_{WB}^{ACC}$ = calculated by the water budget method.

$E_{raS}^{ACC}$ = calculated by the combination equation and aerodynamic resistance for snow conditions.

$E_{raL}^{ACC}$ = calculated by the combination equation and aerodynamic resistance for rain $r_{aL}$,