DEVELOPMENTS IN AGRICULTURAL
AND MANAGED–FOREST ECOLOGY 9

# comparison of forest water and energy exchange models

S. HALLDIN
(EDITOR)

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# Preface

Numerous ecological models have been presented during recent years, but only few of these have been comprehensively compared and tested against independent field data. This book contains results from an IUFRO (International Union of Forestry Research Organizations) workshop with the goal of performing such tests on micrometeorological and hydrological forest models.

The workshop was initiated by Prof. A. Baumgartner and Dr. K. Perttu as part of the cooperation within the IUFRO research group on Atmospheric Environment (S1.03-01). The aim of comparing all models using the same input data was fulfilled by using the ECODATA data base system and the SIMP simulation package. This meant that all models not developed within the SWECON Project had to be implemented at the SWECON Computer Centre using these systems. The tedious work of implementation and modification was aptly carried out by the SWECON modellers G. Ågren, P-E. Jansson, Å. Lindgren, T. Lohammar and the undersigned.

I have tried to edit the results of this successful workshop in such a fashion that it will be of interest to a wide range of readers. There are many detailed results for the specialist involved in problems of micrometeorology, hydrology, soil science and plant physiology, and I hope the reader will appreciate the treatment of the different model "philosophies" and process formulations. Had it not been for the unsuspected and remarkable discrepancy reported in the second to last paper, the book would probably have been in print earlier. However, this paper greatly contributes to the value of the book, and, since the delay was reasonable, I felt that inclusion of the paper was beneficial.

Among those who assisted in preparation of this book I should mention Ms. L. Heiwall who served excellently as workshop secretary and later Ms. A. Stålhammar who diligently and patiently carried this work through the typewriting phases. N. Rollison made the language conform to standard English, and Ms. B. Myrvik prepared most of the drawings. The textile artist, Ms. A-B Nylander, created the exceptional woven picture on the front cover. This supporting staff, the authors and all other persons who made this book possible all deserve my profound appreciation.

Material and financial resources generously supplied by the Swedish Coniferous Forest (SWECON) Project made the workshop possible. Additional financial support was granted by the National Council for Research in Agriculture and Forestry and the Planning and Budgeting Committe at the Faculty of Forestry, the Swedish University of Agricultural Sciences.

*Uppsala, August 1979* SWEN HALLDIN

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# Contents

## Section IV: Comparison of Models

# Foreword

Within the frame of the IUFRO (International Union of Forestry Research Organization) research group Atmospheric Environment (S1.03-01) a workshop on Energy Exchange Simulation Models was arranged in Uppsala, Sweden, September 25-30, 1978. This research group, conducted by K. Perttu, Sweden and L.W. Gay, USA, is one of 12 sections within division S1. There are 6 divisions in the IUFRO. An organization plan is presented in the IUFRO Annual Report 1977 (available from the IUFRO-secretary, A-1131 Vienna, Austria).

During frequent correspondence with Prof. Dr. Albert Baumgartner, Munich the idea of arranging a workshop in Sweden took form. Prof. Baumgartner suggested that the workshop should deal with energy exchange simulation models, which was a topic of the abiotic group within the Swedish Coniferous Forest Project (SWECON). During a hydrology meeting in Göttingen in October 1977, the first preliminary plans were discussed with Prof. Baumgartner and Dr. H. Keller (leader of the IUFRO research group S1.03-02 on Forest Hydrology). These discussions resulted in a suggestion that a limited number of scientists dealing with such simulation models, should be invited. A list of specially invited scientists was then drawn up.

The main purpose of the IUFRO workshop was to compare different energy exchange models by using the same input data. These data were taken from the main research site of SWECON. The comparison was made on the SWECON computer by means of the ECODATA program package and the SIMP simulation package. The first section of the book presents all these data and computer prerequisites for the workshop.

During the late winter 1978, nine models from different countries were accepted to be run during the workshop. The models were sent to Uppsala, where the SWECON modellers prepared them for implementation on the PDP 11/45 computer in Uppsala. In some cases the implementation was preceded by comprehensive modifications of the model concerned to fit the Scots pine forest instead of the vegetation, for which it was originally constructed. The intensive work of modification and implementation was usually done after several contacts with the model constructor.

The IUFRO-workshop opened on September 25 with a two-day visit to the Jädraås Ecological Research Station, where measurements of driving and validation data were discussed. The precise aim of this field trip was to provide a background to the data used for the simulations and to give the participants time to become acquainted. During the field trip the detailed programme for the group sessions

| Model | Output resolution | | Radiation | | | Heat (and vapour) exchange | | | Profiles in canopy air[1] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <day | ≥day | Long-wave | Short-wave | Net | Sens-ible | Latent | Dew | Tempe-rature | Vapour pressure | Leaf temp | Stem & branch temp. | Wind | $CO_2$ |
| MICROWeather | X | | X | X | X | X | X | X | X | X | X | X | X | (X) |
| ALLAMI | X | | | | X | X | X | | X | X | X | | X | (X) |
| SHORTWave | X | | | X | | | | | | | | | | |
| CANOPY | X | | X | | | X | X | X | X | X | X | X | | |
| HEJMDAL | X | | | | X | | X | X | | | | | | |
| SIM5T/12 | X | X | | | | | X | | | | | | | |
| WATREG | | X | | | | | X | | | | | | | |
| ETGRASs | | X | | | | | X | | | | | | | |
| SOIL | | X | | | | | X | | | | | | | |

1) Profiles in CANOPY model is one layer only.

| Model | Plant | | | | | Snow dynamics | Inter-ception | Soil profiles | | | | | | Perco-lation to ground water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water content | Water poten-tial | Water uptake | Photo-syn-thesis | Stomatal regula-tion | | | Water flux | Heat flux | Frost | Temp. | Water content | Water poten-tial | |
| MICROWeather | X | X | X | X | X | | | | X | | X | | | |
| ALLAMI | | | | (X) | | | | | | | | | | |
| SHORTWave | | | | | | | | | | | | | | |
| CANOPY | | | | | X | X | X | | | | | | | |
| HEJMDAL | X | X | X | | X | | X | X | | | | X | X | X |
| SIM5T/12 | | | | | X | | X | | | | | | | |
| WATREG | | | X | | | | X | | | | | X | | X |
| ETGRASs | | | X | | | | X | X | | | | X | | X |
| SOIL | | | X | | | X | X | X | X | X | X | X | X | X |

| Model | Input resolution | | Driving variables | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | <day | ≥day | Potential evapotrans-piration | Surface resistance | Net radia-tion | Incoming longwave | Global radiation | Wind speed | Relative humidity | Air tempe-rature | Precipita-tion |
| MICROWeather | X | | | | X | | X | X | X | X | X |
| ALLAMI | X | | | X | X | | | X | X | X | |
| SHORTWave | X | | | | | | X | | | | |
| CANOPY | X | | | | | X | X | X | X | X | X |
| HEJMDAL | X | (X) | | | X | | X | X | X | X | X |
| SIM5T/12[2] | | X | | | X | | | X | X | X | X |
| WATREG[3] | | X | X | | (X) | | | (X) | (X) | (X) | X |
| ETGRASs[3] | | X | X | | (X) | | | (X) | (X) | (X) | X |
| SOIL[3] | | X | X | (X) | (X) | | X | (X) | (X) | X | X |

2) Potential evapotranspiration is calculated within the model.
3) Calculation of potential evapotranspiration normally requires information of variables within brackets.

Table: Brief description of models with respect to processes treated, required input data and temporal resolution of input and output variables.