Research report no. 93

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Meteorological observations in the experimental catchment 'Hupselse Beek'

Period 1976 - 1987

A description of correction procedures of available data- and evapotranspiration files

J. Wentholt
april 1989

opdrachtgever:
rijkswaterstaat
dienst binnenwateren / riza

Wageningen Agricultural University

REPORT

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This report has been prepared under contract

of the State Public Works, the Netherlands.

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CONTENTS

1 INTRODUCTION

This report describes in full detail the procedures of data handling and calibration. Data are from the automated meteorological station in the experimental catchment 'Hupselse Beek'. It also summarizes what methods have been used to calculate actual and potential evapotranspiration. The report covers roughly a period of ten years of data collecting. Not all timeseries of the different meteorological variables cover the same period. Also during the ten year-period instrumental changes have been made, the measuring interval has been adapted and new measurements have been started while others have been stopped of were of incidental character.

It is fully described in this report.

Of course no results will be presented in this report. The report must be considered as a document of how the whole dataset has been managed and, important to safeguard the reproducibility of the original datasets.

Corrected data and results from the calculations by different ET-methods are all stored on magnetic tapes.
All this information is freely available on request through the State Public Works in Arnhem, Department of Inland Watermanagement, full address:

Rijkswaterstaat DBW/RIZA
P.B. 9072
6800 ED Arnhem
The Netherlands
Tel.: 085-688911

Over a period of ten years missing values or periods inevitably exist in such long time series due to a break-down of the collecting system or problems with one or more sensors. Much attention has been paid to complete the separate time series, as much as possible, using additional information from the meteorological site itself or from other related stations.

2 AVAILABLE RAW DATA OF THE METEOROLOGICAL STATION 'ASSINK', HUPSELSE BEEK

2.1 General

Data handling as discussed in this report concentrates on the system of automatic data collection and storage. Also a second system of data collection is in operation for several meteorological variables. The ideas behind this are that incompleteness of data files can be avoided as much as possible and comparison between the data from these systems will always be possible. The recordings by this second system differs from measurement to measurement. Most of these recordings are registered on charts and are not regularly processed.

The available raw data set for the whole period, from February 25, 1976 till March 3, 1987, can be subdivided in four sub-periods. Each subperiod will be discussed in the next sections. Over the full period close cooperation existed between the Department of Inland Watermanagement (DBW/RIZA) of the State Public Works and the Agricultural University of Wageningen (LUW) to bring the management of such a huge data-set to a good end. From March 1987 DBW/RIZA is coordinating the data-system on its own.

In table 2.1 all the measured variables are summarized and conveniently arranged.

2.1 Period 1976-1978

The first period from February 25, 1976 to December 31, 1978, comprises hourly data. Although originally some data were collected every 15 minutes and other data every 60 minutes the definite raw data set is fixed to hourly values.

Table 2.1 A Summary of the available raw data and the measuring program.

Name	Sampling strategy	Interval (minutes)	Range	Units	Data collection	Type of instrument
Global radiation (short wave incoming)	A*	20	790404-870303	W/m^2	Tape	Kipp-solarimeter
Net radiation	A	60	760225-781231	W/m^2	Tape	Csiro CN1 net radiometer
		1440	790101-790404	W/m^2	**	-
	A	20	790404-870303	W/m^2	Tape	Csiro CN1 net radiometer
Precipitation	C	15	760225-781231	0.1 mm	punched paper t.	Fischer and Porter
		1440	790101-790404	0.1 mm	**	Recover snow gauge
	C	20	790404-870303	0.1 mm	Tape	Recover rain gauge
Ground water level meteorological site 'Assink'	I	60	760225-781231	mm-mv	Tape	Data logger
		1440	790101-790404	mm-mv	**	Fischer and Porter
	I	20	790404-870303	mm-mv	Tape	Data logger
Ground water level arable land near 'Assink'	I	60	760225-781231	mm-mv	Tape	Data logger
		1440	790101-790404	mm-mv	**	Fischer and Porter
	I	20	790404-870303	mm-mv	Tape	Data logger
Dry bulb temperatures at 0.10, 1,50 and 3.00 m****		60	760415-781231	0.1 K	Tape	Thermistor
Dry bulb temperature difference between 1.30 m and 3.15 m	A	20	790404-841009	0.01 K	Tape	Frankenb.***** Psychrometer
Dry bulb temperature at 3.15 m above groundlevel	I	60	760225-781231	0.1 K	Tape	Thermistor
		1440	790101-790404	0.1 K	**	-
	I	20	790404-850421	0.1 K	Tape	Frankenberger Psychrometer
at 2.30 m above groundlevel	I	20	850422-870303	0.1 K	Tape	-
Dry bulb temperature difference between 7.14 m and 3.15 m	A	20	790404-841009	0.01 K	Tape	Frankenberger Psychrometer

*A: Averaged value
C: Cumulative value
I: Instantaneous value

Name	Sampling strategy	Interval (minutes)	Range	Units	Data collection	Type of instrument
Wet/dry bulb temperature difference between 1.30 and 3.15 m	A	20***	790404-841009	0.01 K	Tape	Frankenberger Psychrometer
Wet/dry bulb temperature at 3.15 m above groundlevel	I	20	790404-850421	0.1 K	Tape	Frankenberger Psychrometer
at 2.30 above groundlevel	I	20	850422-870303	0.1 K	Tape	-
Wet/dry bulb temperature difference between 7.14 and 3.15 m	A	20**	790404-841009	0.01 K	Tape	Frankenberger Psychrometer
Wind velocity difference between 2.14 and and 3.97 m	A	20	790404-841009	0.1 counts/ sec.	Tape	Thiess cup-anemometer/ KNMI anemomtr
Wind velocity at 2.00m above groundlevel	A	60	760225-781231	0.1 counts/ sec.	Tape	Cup-anemometer integrating
2.00 m above groundlevel		1440	790101-790404	0.1 counts/ sec.	**	Lambrecht anemometer
3.97 m above groundlevel	A	20	790404-850421	0.1 counts/ sec.	Tape	Thiess cup-anemometer/ KNMI anemomtr
1.80 m above groundlevel	A	20	850422-870303	0.1 counts/ sec.	Tape	Thiess cup-anemometer/ KNMI anemomtr
Wind velocity difference between 9.48 and 3.97 m	A	20	790404-841009	0.1 counts/ sec.	Tape	Thiess cupanemometer/KNMI cupanemometer
Surface temperature	I	20	1979-1983 June-Sept.	0.1 K	Tape	Heiman-KT16
Relative humidity	I	60	760225-781231	0.1%	Tape	Hair-hygrogr.
		1440	790101-790404	0.1%	**	-
	I	20	790404-870303	0.3%	Tape	Lambrecht hair hygrom.
Sunshine duration		1440	760225-800426	0.1%	Chart.	Campbell stokes
	C	20	800426-870303	0.1%	Tape	Haenni-solar meter

Name	Sampling strategy	Interval (minutes)	Range	Units	Data collection	Type of instrument
Winddirection	A (10min)	20	800305-870303	degrees	Tape	Lambrecht wind vane
Soil heat flux calculated from the temperature profile in the soil	I	60	760225-781231	$^0C \rightarrow W/m^2$	Tape	Thermistors at 2-5-10-25-60 and 250 cm below groundlevel
"		1440	790101-790404	$^0C \rightarrow W/m^2$	Tape	Thermistors at 6 levels in the ground
"	I	20	790404-811231	$^0C \rightarrow /Wm^2$	Tape	Thermistors at 6 levels in the ground
Soil heat flux (directly measured)	A	20	810601-870303	W/m^2	Tape	Flux plates
Reflected short wave radiation	A	20	820322-841009	W/m^2	Tape	Kipp-solarimeter

** For this period no measurements were done because of reorganisation of the measuring scheme and a new calibration of all the sensors.

*** Wet bulb temperatures are measured form April 1 till October 1, otherwise dry bulb temperature are measured.

**** Large periods of missing data.

***** Instrument thoroughly modified.

The hourly collected data are:

GRWTBL	:	Groundwaterlevel, arable land near the Meteorological station (mm)
GRWAPV	:	Groundwaterlevel at the Meteorological station (mm)
NEERS	:	Precipitation (mm); (resolution amounts 0.12 mm)
RELVO	:	Relative humidity at 1.5 m above groundlevel
NSTRA	:	Net radiation at 1.0 m above groundlevel (W/m^2)
Temp. 10+	:	Air temperature at 1.0 m above groundlevel (C)
Temp. 150+	:	Air temperature at 1.5 m above groundlevel (C)
Temp. 300+	:	Air temperature at 3.9 m above groundlevel (C)
Wind	:	Wind velocity at 2.0 m above groundlevel (m/sec)
Soil temp.	:	At six levels; 2, 5, 10, 25, 60 and 250 cm below soil surface (C)

2.3 Period January till April 1979

For the second period, from January, 1, 1979 to April, 4, 1979, no data were collected. This was due to the fact that the meteorological site at Assink was reorganized. The network in Hupsel was expanded for a more diversified determination of actual and potential evapo-piration.

To obtain data for this missing period Meijles (1983) reconstructed for the most important parameters daily values, such as:

Net radiation
Relative humidity
Air temperature at 1.5 m above groundlevel
Wind velocity
Soil heat flux
Groundwaterlevel grassland Assink
Precipitation

2.4 Period April 1979 till October 1984

The third period contains the raw data collected from April, 4, 1979 to October, 19, 1984. These data were collected every 20 minutes and recorded both on cassette tape and on paperprint.

Twenty different measurements were carried out and recorded, although not all the measurements were carried out for the full period; see again table 2.1 for more details. Dry and wet bulb temperatures and wind velocity were measured at three levels.

Wet bulb temperatures were recorded only during the growing season.

Concerning the determination of the soil heat flux there are two periods to be distinguished, see Appendix A for the exact formulation.

- From April, 4, to June, 13, 1981, daily soil heat flux has been calculated from a change in heat storage of the soil.

- From June, 14, 1981, soil heat flux has been measured directly by three flux plates which have been installed approximately at 5 cm depth.

2.5 Period October 1984 till March 1987

During the fourth period, from October. 10, 1984, to March, 3, 1987, dry bulb temperature, wet bulb temperature and wind velocity were measured at only one level. This means that actual evapotranspiration could no longer be estimated directly over this period during the growing season. The end of the fourth period was again marked by a reorganization of the meteorological site and of the process of data correction, verification, calibration and processing. Presently the Department of Inland Watermanagement (DBW/RIZA) is fully responsible for it.

3 CORRECTIONS OF THE RAW DATA FILES INTO A BASIC DATA FILE

Corrections of hourly or 20 minutes raw data values cover:

- Quality control of the raw data.
- Insertation of missing values in the data series, if possible.
- Systematic correction of zero point drift and by calibration curves or calibration factors.

See Appendix B for a flow diagram of the dat control and data processing.

3.1 Quality control and incidental corrections

The applied procedure was to carry out visually a first quality control. At this stage irregularities, jumps or default values in the data series were detected. Special attention was paid to the profile-measurements of temperature and windvelocity. After the quality control has been carried out, insertion of correct data happened. If only a small array of missing values in the data file occurred, approximately less than five, then these missing values were calculated through linear interpolation or otherwise estimated. No data were supplemented to the profile measurements.

3.2 Systematic corrections and calibrations

Systematic correction of the data exists of zero point corrections, due to drift of the sensors, and of a correction by calibration factors or calibration curves. These corrections are the result of calibration measurements periodically done by the TFDL (Technical-Physical Service Organization) to either calibrate a sensor or to adjust a sensor. The calibration intervals of the different sensors differ and range from once a year (net radiometer, solarimeter, etc.) to about eight times a year (dry and wet bulb temperatures, zero point levels of several instruments).

The corrections, described in Appendix C (in Dutch) are the result of these calibration activities.

3.3 Conversion of precipitation and wind velocities

Special attention will be given to precipitation and wind velocities.

Precipitation in the raw data file has been registered as a cumulative value adjusted to the rain gauge. To get the correct amount of precipitation the following conversions must be carried out. First the random process of registration-oscillation during dry weather conditions is tracked and eliminated. These oscillations create deviations of plus or minus one registration unit. In Appendix E the applied computer program for these corrections is given. Secondly the differences between the consecutive values, multiplied by a calibration factor 0.12, yield the amount of precipitation in mm.

In the raw data file wind velocity differences between 2.14 m and 3.97 m, between 9.48 m and 3.97 m and the wind velocity at 3.97 m, above the soil surface have been registered in pulses per second. In the basic data files these values have been converted to absolute wind velocities (m/sec) at the three separate levels.

3.4 Basic data files

The result of the incidental and systematic corrections is a set of basic data files. These basic data files of variables still show series of missing values. From 1976 to 1978 the data are available for hourly values and from 1979 tot 1987 for 20-min. values. Two small samples of the definite data files are shown in Appendix E.

These data files permit direct calculations of actual evapotranspiration (chapter 4) and of daily values of the variables (chapter 5). Subsequently potential evapotranspiration can be calculated from the daily values (chapter 6).

4 CALCULATION OF THE ACTUAL EVAPOTRANSPIRATION USING THE 60-MIN AND 20-MIN DATA, AVAILABLE DURING THE GROWING SEASONS

For the years 1976 to 1984 actual evapotranspiration has been calculated for the period of the growing season (April 15 to September 14). For the years 1976 to 1978 hourly, instantaneous, data of temperature at three levels and the wind velocity were used. From these data the hourly sensible heat flux could be calculated by applying Monin-Obukhov theory. From the energy balance evapotranspiration, λE, could be estimated indirectly following the expression:

$$\lambda E = R_n - G - H$$

in which:

R_n = net radiative flux (W/m^2)
G = soil heat flux (W/m^2)
H = sensible heat flux (W/m^2)

From the results daily values of λE were calculated. Full account of the method is given in Stricker and Brutsaert (1977) and Geraedts (1980).

For the years 1979 to 1984 the 20-min averaged dry and wet bulb temperature differences and wind velocity differences were applied for calculating the actual evapotranspiration. Again the same method, as explained before, could be applied and also the Bowen ratio-energy budget method in case wet-bulb temperature measurements were available.
The 20-min results were added to daily values. A full description of methods can be found in Chatillon (1988). Results are also demonstrated in Report no. 4 of CHO-TNO (1984).

5 CALCULATION OF THE DAILY VALUES OF THE MEASURED VARIABLES

From the basic data files (the corrected and calibrated hourly or 20 minutes values) daily data are calculated. Due to missing values in the basic data files, missing values in the daily data files occur too. In this chapter an account will be given of how data completion of the daily data files has been achieved having data from the same or another meteorological station.

One should realize that not all the variables measured are computed into daily values. Especially for the temperature profile and the windprofile it is of no meaning to compute daily values. These data are only used for computation of the actual evapotranspiration. For the dry bulb temperature, the wet bulb temperature and the windvelocity daily values are computed from the measurements carried out at about 2 meter above the soil surface. See table 5.1 for the available data.

- For the precipitation and the sunshine duration daily values are the cumulative hourly or 20 minutes values from 00.00 hour up to 23.00 respectively 23.40 hour.

Much effort has been spent on the completion of the daily data files. Different authors, i.e. Jongerius (1984), Chatillon (1988) and this author have followed the same approach.

In case of missing values several expressions for substitution are used. The applied relations originated either from corresponding variables from the back up system installed at the meteorological site either from the KNMI meteorological station at Winterswijk (10 km apart from Hupsel) or either from the meteorological station of the Agricultural University in Wageningen (80 km apart).

Table 5.1 Summary of the available daily data of the Hupselse Beek.

Name	Period	Remarks
Global radiation (A)*	1979-1987	
Net radiation (A)	1976-1987	
Precipitation (C)*	1976-1987	)Till 1982 instantanoues
Groundwater level at		)values at 0.00 hour
met. station Assink (M, A)*	1976-1987	)From 1982 daily averaged
Ground water level near		)values
met. station Assink at		
arable land (M, A)	1983-1987	measured from 1976
Dry bulb temperature (A)	1976-1987	
Wet bulb temperature (A)	1983-1987	measured from 1979, summer period
Wind velocity (A)	1976-1987	
Relative humidity (A)	1976-1987	
Sunshine duration (C)	1977-1980	
Soil heat flux (A)	1976-1987	Till 1982, calculated by soil temperatures at six levels. From 1982 measured by three flux plates

A = averaged value
C = cumulative value
M = momentaneous value

5.1 Global radiation

A good correlation exists between the measured daily values at the meteorological station in Wageningen and 'Assink', Hupsel. See for example Chatillon (1988), page 46-47. The following expressions and correlations were found:

January 1983 : Rgh = 0.99*Rgw + 0.355, corr. coeff. = 0.98

July 1983 : Rgh = 1.00*Rgw + 2.55, corr. coeff. = 0.89

With Rgh: daily global radiation at Hupsel meteorological station [W/m^2]

Rgw: daily global radiation at Wageningen meteorological station [W/m^2]

Missing values for global radiation in the daily data set of Hupsel were completed by converting the values measured in Wageningen and applying the given expressions.

5.2 Net radiation

For the period March, 1976, till January, 21, 1979 missing daily values of net radiation for Hupsel have been completed with net radiation data measured in Wageningen. For the missing period January 1979 till April 4 1979 the same procedure has been followed applying the regression formula (1), see below.
For the period April 1979-1982 missing values have been calculated by a regression equation, formula (2), between global radiation and net radiation, both from Hupsel. For the period 1983-1987 missing values have been calculated from net radiation measured in Wageningen, formula (2) or, if both values failed, it has been calculated from global radiation measured in Hupsel, formula (3).
From Meijles (1983, page 3) and Chatillon (1988, page 45-46) the following relations have been derived:

(1) $Rnh = 0.775 * Rnw - 1.8$ $[W/m^2]$, corr.coeff. = 0.91
(2) $Rnh = 01.08 * Rnw - 7.15$ $[W/m^2]$, corr.coeff. = 0.99
(3) $Rnh = 0.48 * Rgh + 2.0$ $[W/m^2]$, corr.coeff. = 0.98

With Rnh and Rnw: net radiation from respectively Hupsel and Wageningen. $[W/m^2]$
Rgh : global radiation from Hupsel $[W/m^2]$

5.3 Precipitation

Several rain gauges have been installed at the meteorological station 'Assink'. For the completion of missing values in the daily time series of the Recover-rain gauge the values collected with the Snowrecover are used. An important reason for taking the Snow Recover is that most missing values in the Recover data happens during the winter period. The snow Recover is a rain gauge of the same type but with a snow head during winter period and heating facilities from November till April.
Lineair regression on data in the winterperiods of 1979, 1980 and 1981 gives the relation between the Snowrecover (SNRER) and the Recover (RECO):

RECO = 0,03 + 0,98 * SNRE; [mm/day]; corr. coeff. = 0,98

However, it may be said that missing values of precipitation were not frequent in number.

5.4 Groundwaterlevel at 'Assink' and near 'Assink' (arable land)

For missing values in both time series lineair interpolation is used when it only concerns a limited dry period (hours). Longer periods with missing values still have to be completed by using data of other observation wells in the catchment. However, not many data were missed.

5.5 Dry bulb temperature

Missing values in the daily time series for the dry bulb temperature can be completed directly by analyzing the chart registration of the thermohygrobarograph in Hupsel. Good agreement exists. However, both Jongerius (1984, page 11) and Chatillon (1988, page 49) applied also the following relation between temperature data from Hupsel (Tdh) and Wageningen (Tdw).

Tdh = 0.99*Tdw + 0.05, corr.coeff. = 0.99

They conclude that daily dry bulb temperature values measured in Wageningen can substitute directly missing daily values in Hupsel.

Consequently in practise larger periods with missing values were completed by data from Wageningen and short periods with missing values by values, obtained by the instrument in Hupsel.

5.6 Wet bulb temperature

During the winterseason no wet bulb temperature has been measured. In the period from April, 1, till October, 1, no completion of the data has been undertaken. One can easily compute missing values of wet bulb temperature by using dry bulb temperature and relative humidity. Both are available in

the records.
The relations are:

$$e = R.Hum \times e_s(T_d) \quad \text{with } e_s(T_d) = f(T_d)$$
$$e = e_s(T_w) - \gamma(T_d - T_w) \quad \text{with } e_s(T_w) = f(T_w)$$

e = actual vapour pressure at average daily dry bulb Temp [mbar]
e_s = sat. vapour pressure at average daily dry and wet bulb Temp [mbar]

$$\gamma = 0.66 \left[\frac{mbar}{^oK.}\right]$$

5.7 Windvelocity at 2 meter height

From the 20 minutes data of wind velocity at three levels daily values are computed for wind velocity at 2 meter height. From April 1985 measurements at 2 meter height have been carried out directly.
Wind velocity at 2 meter has been derived by applying logarithmic windprofile theory as a fair approximation. Departing from the daily values at the 3.97 m the following expression is valid for conversion to wind velocity at 2.00 m:

$$u(3.97)/u(2.00) = \ln 3.97/\ln 2.00 = 1.12$$

These 2.00 m data will be used in the potential evapotranspiration expressions in chapter 6.

Completing scarcely missing values in the daily data file wind velocity values at 2 meter height from Wageningen are used according to the relation derived by Chatillon (page 48):

$$Uh = 0.72\ Uw + 1.10\ [m/sec],\ corr.coeff. = 0.94$$

with Uh: windvelocity in Hupsel
Uw: windvelocity in Wageningen

5.8 Relative humidity

For short periods missing daily values have been collected from the thermohygrobarograph.

For longer periods missing relative humidity data have been taken from either Winterswijk directly (1976 to 1982) or Wageningen (1983 to 1987). Chatillon (page 49) found that average daily water vapour deficit values for Hupsel and Wageningen agree well. In section 5.6 it is already said that dry bulb temperature values from Wageningen agree very well to Hupsel. Because of these good relationship R.H.-values from Wageningen can be transferred to Hupsel.

5.9 Sunshine duration

As mentioned before, sunshine duration was measured by a Haenni solarmeter.
In case of (scarcely) missing values in the daily sunshine duration record values of the Campbell Stokes observations in Hupsel have been used. If both registrations were defect sunshine duration from Wageningen has been taken. The following lineair relation is valid:

sh = 0.85 * Sw + 0.03, corr.coeff. = 0.92
Sh: Sunshine duration Hupsel [hours]
Sw: Sunshine duration Wageningen [hours]

5.10 Wind direction

No daily values have been calculated for the winddirection.

5.11 Soil heat flux

Missing values of the soil heat flux (G) have been derived from a lineair relation between net radiation (Rnh) and dry bulb temperature (Tdh). The linear relationship is given by Chatillon, page 48:

$$G = 0.08 * Rnh + 0.4 * Tdh - 4.60 \text{ [W/m2]}, \text{ corr.coeff.} = 0.7$$

Supplementary, a second regression calculation has been done for values surrounding the missing period. A systematic difference between measured and calculated values for the surrounding values has been taken as an additional correction.

6 POTENTIAL EVAPOTRANSPIRATION ABOVE GRASS

6.1 The formulations

There are many formulae available for estimating potential evapotranspiration. In this chapter Penman, Thom & Oliver, Priestley & Taylor and Makkink will be reviewed.

Table 6.1 Summary of available daily evapotranspiration data from the 'Hupselse Beek' catchment.

Name	Period	Remarks
Actual evapotranspiration	1976-1984	only during summer period and about 10% missing values
Penman	1976-1987	with "weak' windfunction
Priestley and Taylor	1976-1987	with α = 1.28 and only May, June,July,August and September
Thom and Oliver	1976-1987	
Makkink 1 (standard)	1979-1987	
Makkink 2 (including soil heat flux)	1982-1987	

Input variables consist of daily values measured at 2 meter above ground surface, or converted values which are representative for measurements carried out at 2 meter height.

For the vapour pressure of air at saturation (Es) or for the slope of the saturated vapour pressure curve at air temperature (S) the Claustro Clapeyron expression is used.

Es = 1.333 * (aa + as*T + at*T**2 + au*T**3 + av*T**4)   [mbar]

and with S = d Es/d T

s = 1.333 * (as + 2*at*T + 3*au*T**2 + 4*av*T**3)   [mbar/K]

The constants are:

aa = 4.58

as = 0.333

at = 0.1065

au = 0.0001873

av = 0.00000322

6.2 Penman

The Penman formula is expressed by:

$$ETPE = s/(s+\gamma)*(Rn-G) + \gamma/(s+\gamma)*f(u)*DE$$

with:

ETPE : Penman potential evapotranspiration in W/m^2

s : slope of the curve relating the saturation vapour pressure versus the air temperature

γ : psychrometric constant = 0.66 mbar/K

DE : water vapour pressure deficit in the air
$DE = ES-E=Es(1-E/Es)=Es*(1-RH)$

f(u) : the wind function, here the weak wind function is used
$f(u)=0.26*(0.5 + 0.54u)$

u : mean wind speed at 2 meter height in m/sec

6.3 Thom and Oliver formula

Thom and Oliver (1977) proposed a formulation for the potential evapotranspiration which includes the effects of regional surface roughness and bulk stomatal resistance of the vegetation. The formulation is:

$$ETTO = s/(s+\gamma*(1+n)) * (Rn-G) + m*\gamma/(s+\gamma*(1+n)) * f(u)*DE \qquad [W/m^2]$$

f(u) : the wind function, here the strong wind function is used
$f(u)=0.26*(1.0+0.54*u)$

n=rc/ra : ratio of the canopy resistance (rc) to the aerodynamic resistance (ra) of water vapour transport rc = 65 s/m, for grass under well watered circumstances

ra = 4.72*[ln(z/z0)]**2/f(u)

m : ratio of the aerodynamic resistance of water as expressed by Penman to the aerodynamic resistance over grass

m = [ln(z/zop)/ln(z/zo))]**2

z = 2.00 meter :

z0 = 0.01 meter : aerodynamic roughness of a grass surface

zop = 0.00137 meter: surface aerodynamic roughness of water

The formulation of Penman and Thom & Oliver can be applied during the whole year in principle.

6.4 Priestley and Taylor

The idea behind this formulation is that latent heat fluxes are strongly governed by the net radiation. This leads to the following expression:

ETPE = α * s/(s+γ) * (Rn - G)

For the parameter α originally the value a = 1.26 was proposed, but may be somewhat higher. Here 1.28 has been used.

The formulation fails under circumstances when evapotranspiration is strongly determined by large scale advection and less by radiation. So from September/October till April/May it is better to avoid the use of the expressure for our latitude.

6.5 Makkink

Makkink developed an experimental formula. The main purpose was to get a reasonable accurate estimate of potential evapotranspiration by a formula which only depends on a few, easily measurable, variables.

The expression proposed is:

$$ETM1 = C1 * s/(s+\gamma) * Rg + C2$$

C1 and C2 are constants in the expression.

Here the value of C1 is 0.65 and C2 is 0.

If the soil heat flux is taken into account, with the same weight as in the Priestley and Taylor expression, the following formula is obtained:

$$ETM2 = C1 * s/(s+\gamma) * (Rg - 2G)$$

More recent analysis shows that the expressions of Priestley & Taylor and Makkink can be fairly reasonable explained by atmospheric behaviour.
A computer program, containing the formulations, can be found in Appendix F.

LITERATURE

1. Chatillon, D. (1988). Methods for calculation of actual and potential evapotranspiration. Landbouwuniversiteit Wageningen, Hydraulica en afvoerhydrologie, publication No. 84.
2. Geraedts, J.M. (1980). Verdamping in het stroomgebied van de Hupselse Beek. Scriptie Vakgroep Hydraulica en afvoerhydrologie, 63 pp.
3. Hooghardt, J.C. (ed) (1984). Vergelijking van modellen voor het onverzadigde grondwatersysteem en de verdamping. CHO-TNO rapport no. 13.
4. Jongerius, J. (1984). Verslag van het gebruiksgereed maken van de meteorologische gegevens afkomstig van het meetstation 'Assink' over de jaren 1979 tot en met 1982. Landbouwhogeschool Wageningen.
5. Meijles, J.G. (1983). Aanvulling, controle en correctie van meteorologische gegevens en schatting van de verdamping te Hupsel in de periode van 1 januari t/m 4 april 1979. WWZO notitie 83.Q, Arnhem.
6. Stricker, H. and Brutsaert, W. (1978). Actual evapotranspiration over a summer in the 'Hupsel Catchment'. Journal of hydrology, 39: 139-157.
7. Warmerdam, P.M.M. and Stricker, J.N.M. and Kole, J. (1982). Current research in the experimental catchment Hupselse Beek, in the Netherlands. In hydrological research basins and their use in water resources planning, Vol. 1., Bern.
8. Wesselink, B. (1982). Proefgebieden Sleen en Hupsel. Draaiboek en logboek, WWZO Nota 82.20 Arnhem.
9. Hydrological research in the catchment of the Hupselse Beek Netherlands (April 1972 - April 1974). No. 3, Studygroup Hupselse Beek, Arnhem.
10. Hydrological research in the catchment of the Hupselse Beek Netherlands (April 1974 - April 1976). No. 4, Studygroup Hupselse Beek, Arnhem.
11. Jaarverslagen studiegroep Hupselse Beek, 1979 t/m 1987, Studiegroep Hupselse Beek, Arnhem.

12. Makkink, G.F. (1957). Testing of the Penman formula by means of lysimeters. Journal Int. of Eng., 11: 277-288.
13. Thom, A.S. and Oliver, H.R. (1977). On Penman's equation for estimating regional evaporation. Q.J. Royal Met. Soc., 103: 345-357.
14. De Bruin, H.A.R. (1987). From Penman to Makkink. CHO-TNO. Proc. and Information. No. 39: 5-30.

APPENDIX A: CALCULATION OF SOIL HEAT FLUX

Period March 1976 till June 1981 (except the period of the 1st of January 1979 till the 5th of April 1979).

Method : calorimetric method

Description: From soil temperature profiles at 0.00 h. and 24.00 h. the change of heat storage is calculated. Storage change is a function of soil heat capacity, including soil moisture.

Expression : $$G(t) = \sum_{i=1}^{n} \{(\bar{T}_{24}(i) - \bar{T}_{0}(i) * c(i,t) * z(i)\}$$

with : G = daily soil heat flux

n = number of compartments

$\bar{T}_{24}$, $\bar{T}_{0}$ = mean temperature of compartment i at time 24.00 h. and 0.00 h. respectively

z = thickness of compartment i

c = heat capacity of compartment i at time t

Remark : Because the lowest compartment between 0.6 and 2.50 m is extremely large with respect to the upper layers, the lowest compartment has been averaged over 10-days period. This is to avoid too large, unrealistic fluctuations of soil heat flux by the lowest compartment.

Period 14 june 1981 till March 1987

Method : Direct measurement of soil heat flux

Description: Special prepared plates, which have conductivities comparable with the soil type at soil moisture content of 20%. Three plates in serial combination. Depth at 5 cm.

Expression : Philip (1961)

$$H_{soil} = H_{plate} * \frac{1 + (\epsilon - 1) H}{\epsilon} \quad (A)$$

and $H = 1 - 1.92\ T/D$ and $\epsilon = \lambda_{plate}/\lambda_{soil}$

with H_{soil} : soil heat flux [W/m^2]

H_{plate} : plate heat flux measured

λ_{plate} : 0.45 W/mk; conductivity of the plates

λ_{soil} : conductivity of the soil

$4.2 \times 10^2 ((4.05 \times 10^{-3}) * \theta + 2.17 \times 10^{-3})$ W/mk

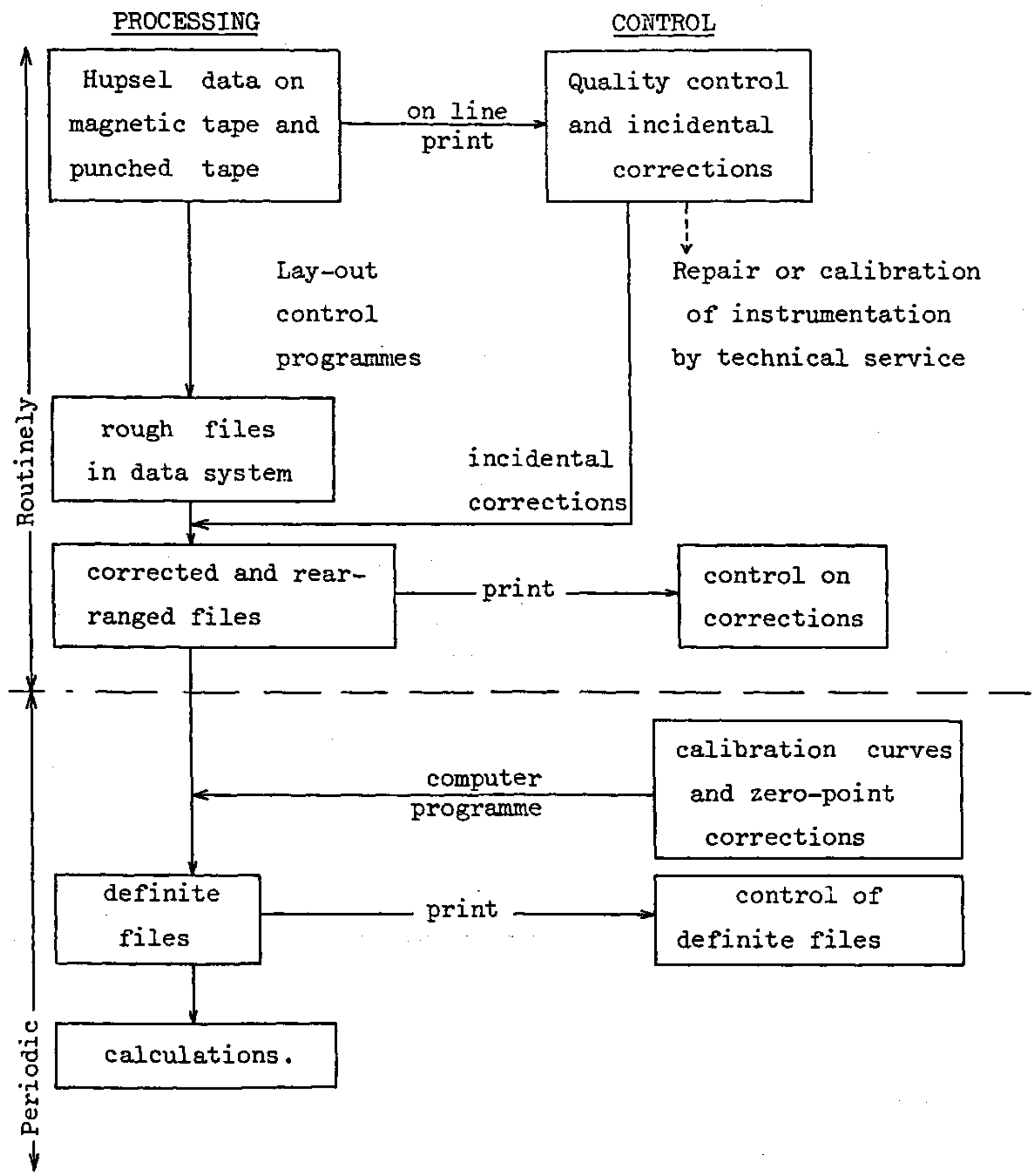
θ soil moisture content

Remark : For θ between 10% and 30% it follows from expression (A):

$H_{soil}/H_{pl} = 1.18 \pm 0.07$

That means that all the measurements get finally a correction factor of 1.18 as a mean value.

APPENDIX B: SCHEME OF DATA PROCESSING AND DATA CONTROL OF THE "HUPSELSE BEEK"



From: Warmerdam a.o. (1982)

APPENDIX C: CORRECTIE OP DE RUWE METEOROLOGISCHE GEGEVENS
CORRECTION OF THE RAW METEOROLOGICAL DATA BY CALIBRATION

Periode maart 1976 t/m december 1979

Netto straling (W/m^2): gem. uur intensiteit
Yking: TDFL, 1976
Correcte meetwaarde = meetwaarde x 1.087

Windsnelheid (dm/sec) : uurgemiddelde
Yking: 12 oktober 1978 en 22 maart 1979 in windtunnel van de vakgroep Natuur- en weerkunde.
Correcties zijn in tabelvorm uitgevoerd over intervallen van het windsnelheidstraject.
De gebruikte ijkrelaties staan vermeld in het computerprogramma behorende bij de scriptie van J.M. Geraedts (1980). De ingevoerde standaard relatie voor de Thiess-anemometer was 2 pulsen/sec = 1 m/sec windsnelheid. Hierop is dus gecorrigeerd.

Grondwaterstand op 'Assink' meteoveld
Idem als voorgaande.

Relatieve luchtvochtigheid
Tot 8 juni 1977 geen correcties noodzakelijk.
Vanaf 9 juni 1977 t/m 31 december 1978 zijn er geen correcte uurwaarnemingen i.v.m. defect aan de haarhygrometer.

Neerslag
- Cumulatief gemeten.
- Willekeurig optredende flotter-fluctuaties tijdens droog weer (jutteren) van plus of minus één registratie-eenheid zijn geëlimineerd.
- De uurwaarden van de neerslag zijn berekend door twee opeenvolgende cumulatieve waarden van elkaar af te trekken en te vermenigvuldigen met de conversiefactor 0.12.

  Het resultaat is op 0.1 mm afgerond.

Temperaturen

A. Op hoogten 10, 150 en 300 cm boven maaiveld.

De sensoren zijn geijkt op 30 maart 1977 en 15 april 1979. Op 17 mei 1977 is de sensor op 300 cm vervangen. De resultaten van de ijkingen zijn de volgende en tevens wordt aangegeven hoeveel de geregistreerde temperatuur gecorrigeerd moet worden (ΔT).

	IJKINGEN 30 maart			17 mei			15 april		
	gereg. temp.	ijk-temp.	ΔT	gereg. temp.	ijk-temp.	ΔT	gereg. temp.	ijk-temp.	ΔT
T10	0.0	-0.22	-0.2				0.0	-0.03	0
	10.4	10.17	-0.2				12.1	12.12	0
	20.6	20.40	-0.2				18.9	19.00	+0.1
	30.0	29.91	-0.1				30.0	30.10	+0.1
T150	0.0	-0.08	-0.1				0.0	-0.025	0
	10.2	10.12	-0.1				12.1	12.12	0
	20.3	20.25	0				19.0	19.0	0
	29.9	29.89	0				30.0	30.1	+0.1
T300	0.0	-0.23	-0.2	0.0	0.01	0	0.0	0.02	0
	10.7	10.45	-0.2	11.3	11.37	+0.1	10.5	10.62	+0.1
	20.5	20.27	-0.2	20.5	20.47	0	19.9	19.97	+0.1
	30.1	29.96	-0.1	32.9	32.90	0	30.0	30.13	+0.1

De correcties op de temperaturen zijn als volgt verwerkt. Over de periode van april 1976 tot 17 mei 1977 zijn de temperaturen gecorrigeerd op basis van de ijking van 30 maart 1977. Geen tijdsverloop is aangebracht.

Over de periode 17 mei 1977 t/m 31 december 1978 zijn de correcties aangebracht op grond van de ijkingen van 30 maart 1977 en april 1979 voor de voelers op 10 en 150 cm. Er is in de tijd lineair geïnterpoleerd, stapsgewijs. Voor de voeler op 300 cm zijn de ijkingen van 17 mei 1977 en april 1979 gebruikt.

B: Temperaturen in de bodem op respectievelijk 2, 5, 10, 25, 60 en 250 cm. Hierop zijn geen correcties aangebracht. Deze waren onbekend en bovendien is bij de berekeningen gewerkt met temperatuurverschillen in de tijd (1 dag of 10 dagen) voor dezelfde voeler. Aangenomen wordt dat met deze aanpak een minimale fout wordt gemaakt in de berekeningen van de bodemwarmteflux tengevolge van afwijkingen van de temperatuurvoelers.

Periode april 1979 t/m maart 1987

1 OPMERKINGEN VOORAF

2 SYSTEMATISCHE CORRRECTIE 20 MINUTEN WAARDEN

2.1	Kanaal	1	Globale straling [w/m^2].
2.2	Kanaal	2	Netto straling [w/m^2].
2.3	Kanaal	3	Neerslag [mm]
2.4	Kanaal	4	Grondwaterstand Proefveld [mm-mv]
2.5	Kanaal	5	Grondwaterstand bouwland [mm-mv]
2.6	Kanaal	6	Droge bol temperatuur op 1.30 m hoogte [0.01 K]
2.7	Kanaal	7	Droge bol temperatuur op 3.15 m hoogte [0.01 K]
2.8	Kanaal	8	Droge bol temperatuur op 7.14 m hoogte [0.01 K]
2.9	Kanaal	9	Natte bol temperatuur op 1.30 m hoogte [0.01 K]
2.10	Kanaal	10	Natte bol temperatuur op 3.15 m hoogte [0.01 K]
2.11	Kanaal	11	Natte bol temperatuur op 7.14 m hoogte [0.01 K]
2.12	Kanaal	12	Windsnelheid op 2.14 m hoogte [cm/sec]
2.13	Kanaal	13	Windsnelheid op 3.97 m hoogte [cm/sec]
2.14	Kanaal	14	Windsnelheid op 9.48 m hoogte [cm/sec]
2.15	Kanaal	15	Oppervlakte temperatuur [0.1 K]
2.16	Kanaal	16	Relatieve luchtvochtigheid [vol %]
2.17	Kanaal	17	Zonneschijnduur [0.1%]
2.18	Kanaal	18	Windrichting [in graden t.o.v. het noorden]
2.19	Kanaal	19	Bodemwarmtestroom [w/m^2]
2.20	Kanaal	20	Gereflecteerde kortgolvige straling [w/m^2]

1 OPMERKINGEN VOORAF

Bij het gebruik van data afkomstig van het meteorologisch station Assink te Hupsel behoort men zich te realiseren dat deze data de nodige bewerkingen ondergaan hebben. Het doel van deze bewerkingen is om de data zo aan te leveren dat een willekeurige gebruiker deze direct kan gebruiken zonder zich nog te behoeven bekommeren om de juistheid van deze data.

De data worden elke 20 minuten ingewonnen. De ruwe data worden allereerst visueel nagelopen op onbetrouwbare waarnemingen zoals default waarden, onverklaarbare sprongen en extremen t.g.v. defecte sensoren. Na deze correcties worden hiaatinvullingen verricht op de 20 minuten cijfers, mits deze invullingen een beperkt aantal tijdstappen betreffen en uit andere, correcte kanalen een "trend" te analyseren valt.

Vervolgens worden op de 20 minuten data de systematische correcties toegepast. Aan de hand van ijkingen, verricht door o.a. de TFDL, worden per kanaal en voor een bepaalde periode de ijkcorrecties uitgevoerd. Deze bewerking bestaat, afhankelijk van het kanaal, uit het bewerken van de data of uit het omwerken naar gangbare eenheden, zoals bij de neerslag en bij de windsnelheid.

In deze bijlage worden de systematiche correcties op de gegevens beschreven. Er zal regelmatig verwezen worden naar een rapport van Jongerius (1984). Dit rapport beschrijft in extenso het gebruiksgereed maken van een aantal kanalen voor de periode april 1979 t/m 1982. Het rapport werd opgesteld ten behoeve van de berekeningen van actuele en potentiële verdamping voor de vergelijking van onverzadigde modellen (CHO-TNO rapport, 1984).

2 SYSTEMATISCHE CORRECTIE 20-MINUTENWAARDEN

2.1 Kanaal 1 Globale straling [w/m^2]

790404 - 14.40 t/m 801124 - 10.00
meetw. ≤ 0 → correcte waarde = 0
meetw. ≥ 0 → correcte waarde = (meetw. + 4) * 1.01

801124 - 10.20 t/m 810326 - 10.20
meetw. ≤ 0 → correcte waarde = 0
meetw. ≥ 0 → correcte waarde = (meetw. + 2) * 1.02

810326 - 10.40 t/m 821231 - 23.40
meetw. ≤ 1 → correcte waarde = 0
meetw. ≥ 1 → correcte waarde = (meetw. - 1) * 1.026

830101 - 00.00 t/m 840315 - 10.40
meetw. ≤ 1 → correcte waarde = 0
meetw. ≥ 1 → correcte waarde = (meetw. - 1)

840315 - 11.00 t/m 840507 - 10.00
meetw. ≤ 1 → correcte waarde = 0
meetw. ≥ 1 → correcte waarde = (meetw. - 1) * 0.975

840507 - 10.20 t/m 850614 - 10.20
meetw. ≤ 1 → correcte waarde = 0
meetw. ≥ 1 → correcte waarde = (meetw. - 1) * 1.02

850614 - 10.40 t/m 870303
meetw. ≤ 1 → correcte waarde = 0
meetw. ≥ 1 → correcte waarde = (meetw. - 1) * 1.02

2.2 Kanaal 2 Netto straling $[w/m^2]$

790404 - 14.40 t/m 790430 - 23.40

meetw. > 0 → correcte waarde = (meetw. - 9) * 0.9975

meetw. = 0 → correcte waarde = (meetw. - 11) * 0.9975

meetw. < 0 → correcte waarde = (meetw. - 13) * 0.9975

790501 - 00.00 t/m 790531 - 23.40

meetw. > 0 → correcte waarde = (meetw. - 9) * 0.995

meetw. = 0 → correcte waarde = (meetw. - 11) * 0.995

meetw. < 0 → correcte waarde = (meetw. - 13) * 0.995

790601 - 00.00 t/m 790630 - 23.40

meetw. > 0 → correcte waarde = (meetw. - 9) * 0.9925

meetw. ≤ 0 → correcte waarde = (meetw. - 11) * 0.9925

790601 - 00.00 t/m 800904 - 19.20

meetw. > 0 → correcte waarde = (meetw. - 9) * COEFF

meetw. ≤ 0 → correcte waarde = (meetw. - 11) * COEFF

Voor COEFF gelden de volgende waarden:

7906 : 0.9925
7907 : 0.99
7908 : 0.9875
7909 : 0.985
7910 : 0.9825
7911 : 0.98
7912 : 0.9775
8001 : 0.975
8002 : 0.9725
8003 : 0.97
8004 : 0.9675
8005 : 0.965
8006 : 0.9625
8007 : 0.96
8008 : 0.9575
8009 : 0.955

800909 - 14.20 t/m 800930 - 23.40
meetw. > 0 → correcte waarde = (meetw. * 0.955) + 4
meetw. ≤ 0 → correcte waarde = meetw. * 0.95

801001 - 00.00 t/m 801031 - 23.40
correcte waarde = meetw. * 0.9525

801101 - 00.00 t/m 801103 - 23.40
correcte waarde = meetw. * 0.955

801104 - 00.00 t/m 801106 - 07.40
meetw. > 0 → correcte waarde = (meetw. - 7) * 0.95
meetw. = 0 → correcte waarde = (meetw. - 9) * 0.95
meetw. < 0 → correcte waarde = (meetw. - 11) * 0.95

801124 - 16.00 t/m 801210 - 15.00
meetw. > 0 → correcte waarde = (meetw. * 0.95) + 2
meetw. = 0 → correcte waarde = meetw. * 0.95
meetw. < 0 → correcte waarde = (meetw. * 0.95) - 2

810201 - 00.00 t/m 810201 - 09.20
correcte waarde = (meetw. - 2) * 0.945

810212 - 11.20 t/m 810326 - 10.20
meetw. > 0 → correcte waarde = (meetw. * 0.945) + 1

meetw. = 0 → correcte waarde = meetw. * 0.945
meetw. < 0 → correcte waarde = (meetw. * 0.945) - 3

810327 - 14.20 t/m 810428 - 23.40 : def. meetw. = (meetw. - 2) x 0.94
810429 - 0.00 t/m 810601 - 8.40 : def. meetw. = (meetw. - 9) x 0.94
810601 - 15.00 t/m 810719 - 23.40 : def. meetw. = 0.94 x meetw.
810720 - 0.00 t/m 810807 - 21.00 : def. meetw. = (meetw. - 2) x 0.94
810807 - 21.20 t/m 810816 - 14.00 : def. meetw. = (meetw. x 0.94) - 15
810816 - 14.20 t/m 810818 - 2.00 : def. meetw. = meetw. x 0.94
810818 - 2.20 t/m 810820 - 19.40 : def. meetw. = (meetw. x 0.94) - 15

810820 - 20.00 t/m 810821 - 0.40 : def. meetw. x 0.94
810821 - 1.00 t/m 810830 - 7.20 : def. meetw. = (meetw. x 0.94) - 15
810830 - 7.40 t/m 810831 - 0.00 : def. meetw. = meetw. x 0.94
810831 - 0.20 t/m 810901 - 14.40 : def. meetw. = (meetw. - 15) x 0.94
810901 - 15.00 t/m 810902 - 23.40 : def. meetw. = meetw. x 0.94
810903 - 0.00 t/m 810903 - 23.40 : def. meetw. = (meetw. - 15) x 0.94
810904 - 0.00 t/m 810904 - 23.40 : def. meetw. = meetw. x 0.94
810905 - 0.00 t/m 810906 - 6.40 : def. meetw. = meetw. x 0.94
810906 - 17.00 t/m 810906 - 18.00 : def. meetw. = meetw. x 0.94
810906 - 18.20 t/m 810907 - 20.20 : def. meetw. = meetw. x 0.94
810907 - 20.40 t/m 810909 - 14.40 : def. meetw. = (meetw. - 15) x 0.94
810909 - 15.00 t/m 810911 - 14.40 : def. meetw. = meetw. x 0.94
810911 - 14.20 t/m 810912 - 8.40 : def. meetw. = (meetw. - 15) x 0.94
810912 - 9.00 t/m 810912 - 19.20 : def. meetw. = meetw. x 0.94
810912 - 19.40 t/m 810913 - 16.40 : def. meetw. = (meetw. - 15) x 0.94
810913 - 17.00 t/m 810915 - 9.40 : def. meetw. = meetw. x 0.94
810915 - 10.00 t/m 810918 - 23.00 : def. meetw. = (meetw. - 15) x 0.94
810918 - 23.20 t/m 810919 - 6.40 : def. meetw. = meetw. x 0.94
810919 - 7.00 t/m 810923 - 9.40 : def. meetw. = (meetw. - 15) x 0.94

- Van 23 september 15.20 uur t/m 27 oktober 10.00 uur staat dit gegeven tijdelijk op kanaal 31 van datalogger in het DT BEST. Correcties op dit gegeven over deze periode:
  correcte meetwaarde = meetwaarde x 3.57 en afronden op hele waarde.
- Vanaf 27 oktober 1981 om 15.20 uur staat gegeven weer op kanaal 2 van datalogger in DT BEST.
  Correcties op het gegeven over de navolgende perioden:
  van 27 oktober 1981 - 15.20 uur t/m 21 maart 1982 - 23.40 uur:
  correcte meetwaarde = meetwaarde - 1
  Van 22 maart 0.00 uur 1982 t/m 31 december 1982 - 23.40 uur:
  correcte meetwaarde = meetwaarde

830101 - 00.00 t/m 831231 - 23.40 correcte waarde = meetw. - 1
840101 - 00.00 t/m 840315 - 10.40 correcte waarde = meetw. * 1.04
840315 - 11.00 t/m 840507 - 10.00 correcte waarde = meetw. * 1.17

840507 - 10.20 t/m 840613 - 23.40 correcte waarde = meetw. * 1.04

840614 - 00.00 t/m 840831 - 23.40 correcte waarde = meetw. * 1.04

- Tijdens neerslag tussen 19.00 uur en 8.00 uur
  → op hiaatwaarde (9999).
  Nadat neerslag = 0, gedurende de 8 volgende tijdstappen
  → op hiaatwaarde.
- Neerslag tussen 08.20 uur en 18.40 uur
  → op hiaatwaarde.
  Nadat neerslag = 0, gedurende de volgende 5 tijdstappen
  → op hiaatwaarde.

840901 - 00.00 t/m 841231 - 23.40 correcte waarde = meetw. * 1.04

- Tijdens neerslag en de 8 volgende droge tijdstappen
  → op hiaatwaarde.
  Indien hierna de relatieve vochtigheid (meetwaarde) ≥ 93.5%
  → op hiaatwaarde.

850101 - 00.00 t/m 850605 - 23.40 correcte waarde = (meetw.+ 1) * 1.04

- Tijdens neerslag en de 8 volgende droge tijdstappen
  →op hiaatwaarde.
  Indien hierna de relatieve vochtigheid (meetwaarde) ≥ 93.5%
  → op hiaatwaarde.

850606 - 00.00 t/m 850719 - 23.40 correcte waarde = (meetw. + 1) * 1.04

850720 - 00.00 t/m 860326 - 23.40 correcte waarde = (meetw. + 1) * 1.04

- tijdens neerslag en de volgende 8 droge tijdstappen
  → op hiaatwaarde.
  Indien hierna de relatieve vochtigheid (meetwaarde) ≥ 93.5%
  → op hiaatwaarde.

860327 - 00.00 t/m 870303 correcte waarde = (meetw.+ 2)* 1.04

2.3 Kanaal 3 Neerslag [mm]

De hoeveelheid neerslag wordt bepaald aan de hand van de niveaustijging van een vlotter in het opvangbassin. Voordat omgerekend wordt van het niveauverschil naar een hoeveelheid regen moet men bedacht zijn op een aantal verstoringen.

- Een ingrijpende verstoring van het vlotterniveau is het ledigen van de tank.

- Een vaak voorkomende verstoring is het zogenaamde jutteren van de vlotter. Dit wordt veroorzaakt doordat zonder enige aanleiding het niveau van de vlotter één eenheid stijgt of daalt onder droog weersituaties.

Na correctie voor deze verstoringen moet men uit de stijging van het vlotterniveau de hoeveelheid neerslag bepalen. Hierbij komt één eenheid overeen met 0.12 mm neerslag.

2.4 Kanaal 4 Grondwaterstand Proefveld [mm-mv]

Correcte waarde = meetwaarde.

2.5 Kanaal 5 Grondwaterstand Bouwland [mm-mv]

Correcte waarde = meetwaarde.

2.6 Kanaal 6 Droge bol temperatuurverschil* tussen 1.30 m en 3.15 m boven het maaiveld. [0.01]

830101 - 00.00 t/m 830607 - 09.00	correcte waarde = meetw. + 2
830607 - 09.20 t/m 830816 - 08.20	correcte waarde = meetw. + 4
830816 - 08.40 t/m 831231 - 23.40	correcte waarde = meetw. + 3
840507 - 15.00 t/m 840606 - 23.40	correcte waarde = meetw. + 3
840607 - 00.00 t/m 840824 - 10.00	correcte waarde = meetw. - 1
840829 - 10.40 t/m 841009 - 10.00	correcte waarde = meetw. + 1

Na 841009 zijn geen verschilmetingen meer uitgevoerd.

2.7 Kanaal 7 Droge bol temperatuur op 3.15 m hoogte [0.01]
vanaf 850422 is de droge bol temperatuur op 2.30 m hoogte gemeten

* Voor kanalen 6, 8, 9, 10 en 11 zijn de correcties op de meetwaarde voor de periode 1979 t/m 1982 vermeld in Jongerius (1984).

Correcties:

- *Periode 4 april 1979 t/m 24 september 1979 - 9.40 uur:*

a. Indien meetwaarde < 0, dan correcte meetwaarde = meetwaarde.
b. Indien meetwaarde tussen 0 en 100, dan correcte meetwaarde = meetwaarde x 1,04 en correcte meetwaarde afronden op gehele waarde.
c. Indien meetwaarde > 100, dan correcte meetwaarde = meetwaarde + 4.

- *Periode 25 september 1979 - 12.40 uur t/m 22 oktober 1979 - 10.40 uur:*

a. Indien meetwaarde ≤ 0, dan correcte meetwaarde = meetwaarde.
b. Indien meetwaarde groter dan 0 en kleiner dan of gelijk aan 200, dan correcte meetwaarde = meetwaarde + 1.
c. Indien meetwaarde groter dan 200, dan correcte meetwaarde = meetwaarde.

- *Periode 24 oktober 1979 - 16.40 uur t/m 3 september 1980 - 9.20 uur:*

a. Indien meetwaarde ≤ 0, dan correcte meetwaarde = meetwaarde.
b. Indien meetwaarde ≤ 50, en groter dan 0, dan correcte meetwaarde = meetwaarde x 1.06 en afronden op gehele waarde.
c. Indien meetwaarde groter dan 50 en kleiner dan 150 dan correcte meetwaarde = meetwaarde + 2.
d. Indien meetwaarde groter dan 150 of gelijk aan en kleiner dan 250, dan correcte meetwaarde = meetwaarde + 1.
e. Indien meetwaarde groter dan of gelijk aan 250, dan correcte meetwaarde = meetwaarde.

- *Periode 3 april 1980 - 14.20 uur t/m 14 augustus 1980 - 9.20 uur:*

a. Indien meetwaarde < 0, dan correcte meetwaarde = meetwaarde.
b. Indien meetwaarde ≥ 0, en kleiner dan 50, dan correcte meetwaarde = (meetwaarde + 1) x 1,04.
c. Indien meetwaarde ≥ 50 en kleiner dan 100, dan correcte meetwaarde = meetwaarde + 3.

d. Indien meetwaarde ≥ 100 en kleiner dan 200, dan correcte meetwaarde = (0.98 x meetwaarde) + 5.

e. Indien meetwaarde ≥ 200, dan correcte meetwaarde = meetwaarde.

- *Periode 14 augustus 1980 - 13.40 uur t/m 20 oktober 1980 - 9.20 uur:*

a. Indien meetwaarde < 0, dan correcte meetwaarde = meetwaarde.

b. Indien meetwaarde ≥ 0 en kleiner dan 100, dan correcte meetwaarde = (meetwaarde + 2).

c. Indien meetwaarde ≥ 100 en kleiner dan 200, dan correcte meetwaarde = (098 x meetwaarde) + 5.

d. Indien meetwaarde > 200, dan correcte meetwaarde = meetwaarde.

- *Periode 20 oktober 16.40 uur t/m 31 december 1982*

Correcte meetwaarde = meetwaarde
Vanaf 20 oktober - 16.40 uur geldt: de correcte waarde = meetwaarde

2.8 Kanaal 8 Droge bol temperatuurverschil tussen 7.14 m en 3.15 m boven het maaiveld. **[0.01K]**

830101 - 00.00 t/m 830607 - 09.00 correcte waarde = meetwaarde + 1
830607 - 09.20 t/m 840507 - 14.40 correcte waarde = meetwaarde
840507 - 15.00 t/m 840606 - 23.40
meetwaarde > 0 → correcte waarde = meetwaarde
meetwaarde < 0 → correcte waarde = meetwaarde - 2
840607 - 00.00 t/m 840823 - 10.40 correcte waarde = meetwaarde
840823 - 10.20 t/m 840919 - 09.00 correcte waarde = meetwaarde + 1
840919 - 09.20 t/m 841009 - 10.00 correcte waarde = meetwaarde + 7

Na 841009 zijn geen verschilmetingen meer uitgevoerd.

2.9 Kanaal 9 Natte bol temperatuurverschil [0.01K]
Alleen gedurende de periode van 1 april tot 1 oktober of korter.
Verschil tussen 1.30 m en 3.15 m boven het maaiveld.

830101 - 00.00 t/m 830607 - 09.00 correcte waarde = meetwaarde + 1
830607 - 09.20 t/m 841003 - 08.00 correcte waarde = meetwaarde
841003 - 08.20 t/m 841009 - 10.00 correcte waarde = meetwaarde - 10

Na 841009 zijn geen verschil metingen meer uitgevoerd.

2.10 Kanaal 10 Natte bol temperatuur op 3.15 m hoogte [0.1 K]
Alleen gedurende de periode van 1 april tot 1 oktober of korter.
Vanaf 850422 is de natte bol temperatuur op 2.30 m hoogte gemeten.

Vanaf 1983, de correcte waarde = meetwaarde.
Behalve van:
841003 - 08.20 t/m 841009 - 10.00 correcte waarde = meetwaarde + 1

2.11 Kanaal 11 Natte bol temperatuurverschil [0.01K]
Alleen gedurende de periode van 1 april tot 1 oktober of korter.
Verschil tussen 7.14 m en 3.15 m boven het maaiveld.

830101 - 0.00 t/m 830607 - 09.00 correcte waarde = meetwaarde.
830607 - 09.20 t/m 831231 - 23.40
temp. ≤ 50 → correcte waarde = meetwaarde + 1
50 < temp. ≤ 150 → correcte waarde = meetwaarde + 2
150 < temp. ≤ 225 → correcte waarde = meetwaarde + 3
temp. > 225 → correcte waarde = meetwaarde + 4

840101 - 00.00 t/m 840507 - 14.40 correcte waarde = meetwaarde
840507 - 15.00 t/m 840606 - 23.40
temp. ≤ 50 → correcte waarde = meetwaarde + 3
50 < temp. ≤ 150 → correcte waarde = meetwaarde + 4
150 < temp. ≤ 300 → correcte waarde = meetwaarde + 5

840607 - 00.00 t/m 841003 - 08.00

temp.(11) < 0 → correcte waarde = meetwaarde + 3

temp.(11) > 0 → correcte waarde = meetwaarde + 1

841003 - 08.20 t/m 841009 - 10.00 correcte waarde = meetwaarde - 1

Na 841009 zijn geen verschil metingen meer uitgevoerd.

2.12 Kanaal 12 Windsnelheid op 2.14 m hoogte (cm/sec)

Deze wordt berekend uit het windsnelheidsverschil tussen de metingen op 2.14 m en 3.97 m boven maaiveld. Op 3.97 m wordt de absolute windsnelheid geregistreerd (zie kanaal 13). De berekening gaat in twee stappen:

1. bepaling van het juiste aantal pulsen/sec. (p)
2. omrekening van pulsen/sec naar windsnelheid (u) via ijkcurven.

ad 1. 790404 t/m 801124 - 09.00 uur:

p = meetwaarde kan. 13 + 4 + (meetwaarde kan. 12 - 4)/10

801124 - 09.20 uur t/m 810327 - 15.20 uur:

p = meetwaarde kan. 13 + 2 + (meetwaarde kan. 12 - 2)/10

810327 - 15.40 uur t/m 810804 - 08.40 uur:

p = meetwaarde kan. 13 + meetwaarde kan. 12/10

810804 - 09.00 uur t/m 810806 - 15.20 uur:

alle meetwaarden op hiaat

810806 - 15.20 uur - 810923 - 15.00 uur:

p = meetwaarde kan. 13 x 0.9

810923 - 15.20 uur - 841009 - 23.40 uur:

p = meetwaarde kan. 13 + meetwaarde kan. 12/10

ad 2. 790304 t/m 810226 - 23.49 uur (Thiess anemometer):

$p < 13$ $u = 5 * p + 20$ (cm/sec)

$13 \leq p < 78$ $u = 4,89 * p + 29$

$p \geq 78$ $u = 4,5 * p + 59$

810227 - 00.00 uur t/m 810923 - 15.00 uur:

$p < 19$ $u = 5.36 * p + 20$

$19 \le p < 33$	$u = 5{,}26 * p + 22$
$33 \le p < 76$	$u = 5{,}02 * p + 30$
$p \ge 76$	$u = 4{,}66 * p + 57$

810923 - 15.20 uur t/m 821231 - 23.40 uur (KNMI-anemometer):

$u = 9{,}72 * p + 17$

830101 - 00.00 uur t/m 840316 - 12.00 uur:

$u = 10{,}043 * p + 16$

840316 - 12.20 uur t/m 841009:

$u = 9{,}76 * p + 23$

Na 841009 geen waarnemingen meer op deze hoogte.

2.13 Kanaal 13: Windsnelheid op 3.97 m hoogte (cm/sec) en vanaf 850422 op 1.80 m hoogte

ad 1. Voor het correcte aantal pulsen gelden de uitdrukkingen voor kanaal 12 met weglating van '+ meetwaarde kan. 12/10' en voor de periode 810806 - 810923 de factor 0.9

ad 2. 790404 t/m 810226 - 23.40 uur (Thiess anemometer):

$p < 23$	$u = 12 + 5{,}52 * p$
$23 \le p \le 93$	$u = 26 + 4{,}92 * p$
$p > 93$	$u = 61 + 4.53 * p$

810227 - 00.00 uur t/m 810923 - 15.00 uur:

$p < 21$	$u = 10 + 5{,}73 * p$
$21 \le p < 85$	$u = 22 + 5{,}14 * p$
$p \ge 85$	$u = 64 + 4.65 * p$

810923 - 15.20 uur t/m 820708 - 09.00 uur (KNMI-anemometer):

$p < 11$	$u = 10{,}36 * p + 13$
$p \ge 11$	$u = 9{,}82 * p + 19$

820708 - 09.20 uur t/m 850415 - 14.20 uur:

$p < 13 \quad u = 15 + 10{,}1 * p$

$13 \leq p < 100 \quad u = 18 + 9{,}9 * p$

$p \geqslant 100 \quad u = 35 + 9{,}64 * p$

850422 t/m 870303:

$u = 26 + 9.92 * p$

2.14 Kanaal 14 Windesnelheid op 9,48 m hoogte (cm/sec)

Deze wordt berekend uit het windsnelheidsverschil tussen de metingen op 3.97 m en 9.48 m. **Op 3.97 m wordt de absolute windsnelheid geregistreerd.** De berekening gaat ook weer in twee stapppen:

1. bepaling van het correcte aantal pulsen /sec (p);
2. omrekening van pulsen/sec naar windsnelheid (u) via ijkcurven.

ad 1. Zie de werkwijze onder 2.12. Vervang hierbij kan. 12 door kan. 14 in alle uitdrukkingen. Ook de factor 0.9 is geldig.

ad 2. 790404 t/m 791210 (Thiess anemometer):

$p < 35 \quad u = 24 + 4{,}99 * p$

$35 \leq p < 80 \quad u = 26+ + 4{,}93 * p$

$p \geqslant 80 \quad u = 58 + 4{,}52 * p$

791211 t/m 810226 - 23.40 uur:

$p < 71 \quad u = 27 + 5{,}05 * p$

$p \geq 71 \quad u = 55 + 4{,}65 * p$

810227 t/m 810923 - 15.00 uur:

$p < 62 \quad u = 21 + 5{,}03 * p$

$62 \leq p < 111 \quad u = 53 + 4{,}52 * p$

$111 \leq p < 176 \quad u = 62 + 4{,}44 * p$

$p > 176 \quad u = 48 + 4{,}52 * p$

810923 - 15.20 uur t/m 820319 - 9.20 uur (KNMI-anemometer):

$p < 10$	$u = 16 + 10{,}08 * p$
$10 \le p < 26$	$u = 20 + 9{,}68 * p$
$26 \le p < 33$	$u = 18 + 9{,}77 * p$
$p \ge 33$	$u = 16 + 9{,}82 * p$

820319 - 09.40 t/m 831231 - 23.40 uur:

$p < 8$	$u = 10 + 10{,}62 * p$
$8 \le p < 48$	$u = 19 + 9{,}60 * p$
$48 \le p < 75$	$u = 16 + 9{,}66 * p$
$p \ge 75$	$u = 21 + 9{,}59 * p$

840101 - 00.00 uur t/m 840316 - 12.00 uur

$u = 30 + 9{,}66 * p$

840316 - 12.20 uur t/m 841009:

$u = 16 + 9{,}64 * p$

Na 841009 geen waarnemingen meer op deze hoogte.

2.15 Kanaal 15 Oppervlakte temperatuur [0.1K]

Periode 1979:

correcte waarde = meetwaarde

Periode 1980

800605 - 00.00 t/m 800814 - 15.20 correcte waarde = meetwaarde

800814 - 15.40 t/m 800814 - 15.20:

meetw. ≤ 130 → correcte waarde = meetwaarde - 20
130 < meetw. ≤ 180 → correcte waarde = meetwaarde - 10
180 < meetw. ≤ 220 → correcte waarde = meetwaarde - 5
220 < meetw. ≤ 270 → correcte waarde = meetwaarde
270 < meetw. ≤ 320 → correcte waarde = meetwaarde + 5
meetw. > 320 → correcte waarde = meetwaarde + 10

Periode 1981

Maand juli:

meetw. < 50 → correcte waarde = meetwaarde
50 ≤ meetw. < 150 → correcte waarde = meetwaarde + 0.2
150 ≤ meetw. < 250 → correcte waarde = meetwaarde + 0.4
250 ≤ meetw. < 350 → correcte waarde = meetwaarde + 0.6
meetw. ≥ 350 → correcte waarde = meetwaarde + 0.8

Maanden augustus, september en oktober:

meetw. < 50 → correcte waarde = meetwaarde
50 ≤ meetw. < 75 → correcte waarde = meetwaarde + 0.3
75 ≤ meetw. < 350 → correcte waarde = meetwaarde + 0.65
meetw. ≥ 350 → correcte waarde = meetwaarde + 0.70

Periode 1982

meetw. < 25 → correcte waarde = meetwaarde - 7
25 ≤ meetw. < 75 → correcte waarde = meetwaarde - 5
75 ≤ meetw. < 125 → correcte waarde = meetwaarde - 4
125 ≤ meetw. < 175 → correcte waarde = meetwaarde - 5
175 ≤ meetw. < 225 → correcte waarde = meetwaarde - 3.5
225 ≤ meetw. < 275 → correcte waarde = meetwaarde - 3
275 ≤ meetw. < 325 → correcte waarde = meetwaarde - 2
325 ≤ meetw. < 375 → correcte waarde = meetwaarde - 2
meetw. ≥ 375 → correcte waarde = meetwaarde - 1.5

Periode 1983

Correcte waarde = meetwaarde * 0.962 + 9.6

Na het jaar 1983 is op dit kanaal niet meer gemeten.

2.16 Kanaal 16 Relatieve luchtvochtigheid [0.1%]

Periode 1979, niet gemeten.

800305 tot 800612 op hiaatwaarde.

800612 - 00.00 t/m 811028 - 23.40

meetw. $\leq$ 590 $\rightarrow$ correcte waarde = meetwaarde - 40 - 0.25 * (590 - meetw.)

meetw. $\geq$ 590 $\rightarrow$ correcte waarde = meetwaarde - 40

811029 - 00.00 t/m 821231 - 23.40

meetw. $\leq$ 590 $\rightarrow$ correcte waarde = meetwaarde - 40 - 0.25 * (590 - meetw.)

590 $\leq$ meetwaarde $\leq$ 850 $\rightarrow$

correcte waarde = meetw. - 80 + 0.1115 * (850 - meetw.)

meetw. $\geq$ 850 $\rightarrow$ correcte waarde = meetwaarde - 80 + 0.10 * (meetw. - 850)

830101 - 00.00 t/m 850614 - 10.20

correcte waarde = 1.083 * meetwaarde - 163

850614 - 10.40 t/m 870303

correcte waarde = 1.083 * meetwaarde - 110

2.17 Kanaal 17 Zonneschijnduur [0.1%]

correcte waarde = meetwaarde

meetw. $\leq$ 0 $\rightarrow$ correcte meetwaarde = 0

meetw. > 1000 $\rightarrow$ correcte meetwaarde = 1000

2.18 Kanaal 18 Windrichting (in graden t.o.v. het noorden).

correcte waarde = meetwaarde

meetwaarde < 0 $\rightarrow$ correcte meetwaarde = meetwaarde + 360

meetwaarde > 360 $\rightarrow$ correcte meetwaarde = meetwaarde - 360

2.19 Kanaal 19 Bodemwarmtestroom (w/m^2)

Met fluxplaatjes (aantal = 3)

810601 - 00.00 t/m 810613 - 23.40 correcte waarde = (meetw./3) * 1.18

810614 - 00.00 t/m 810710 - 23.40 correcte waarde =

((meetw. - 15)/3) * 1.18

810708 - 00.00 t/m 810923 - 09.40 correcte waarde = (meetw./3) * 1.18

810923 - 15.30 t/m 811027 - 10.00 correcte waarde = (meetw./1095) * 1.18

811027 - 16.00 t/m 840713 - 15.00 correcte waarde = (meetw./3) * 1.18

840823 - 13.00 t/m 840828 - 23.40 op hiaatwaarde

840829 - 00.00 t/m 841231 - 23.40 correcte waarde = (meetw./30) * 6.4 * 1.18

850101 - 00.00 t/m 870303 correcte waarde = ((meetw. -1)/30) * 6.4 * 1.18

2.20 Kanaal 20 Gereflecteerde kortgolvige straling (w/m^2)

Tot en met 21 maart 1982 niet gemeten.

820322 - 00.00 t/m 831231 - 23.40 correcte waarde = meetwaarde - 2

840101 - 00.00 t/m 841231 - 23.40 correcte waarde = meetwaarde

Na 1984 is op dit kanaal niet meer geregistreerd.

APPENDIX D

HOURLY DATA OF THE HUPSELSE BEEK AREA YEAR : 1977

GRWTBL : GROUNDWATER LEVEL , ARABLELAND (MM)
GRWAPV : GROUNDWATER LEVEL , GRASSLAND (MM)
NEERS : PRECIPITATION (MM) DIFFERENCE BETWEEN CONSECUTIVE VALUE *0.120
RELVO : RELATIVE HUMIDITY AT 1.5M ABOVE GROUNDLEVEL (0.1%)
NSTRA : NETTO RADIATION AT 1.0M ABOVE GROUNDLEVEL (W/M2)
TEMP10+ : AIR TEMPERATURE AT 0.1M ABOVE GROUNDLEVEL (CENTIGRADES)
TEMP150+ : AIR TEMPERATURE AT 1.5M ABOVE GROUNDLEVEL (CENTIGRADES)
TEMP300+ : AIR TEMPERARURE AT 3.0M ABOVE GROUNDLEVEL (CENTIGRADES)
WIND : WINDVELOCITY AT 2.0M ABOVE GROUNDLEVEL (M/SEC.)

DAGNR	GRWATRBL	GRWATRPV	NEERS	RELVO	NSTRA	TEMP10+	TEMP150+	TEMP300+
	1292.	1217.	427.	961.	-7.00	10.68	10.72	10.77
158.	1290.	1205.	432.	961.	-11.00	11.38	11.53	11.67
	1286.	1188.	455.	961.	-4.00	11.48	11.63	11.67
	1282.	1173.	490.	965.	-9.00	10.28	10.22	10.27
	1279.	1153.	496.	965.	-12.00	10.58	10.82	10.77
	1274.	1135.	497.	965.	-11.00	10.88	10.92	11.27
	1272.	1120.	510.	965.	-4.00	10.38	10.52	10.87
	1269.	1107.	514.	965.	15.00	10.48	10.82	10.97
	1267.	1095.	516.	947.	32.00	10.98	11.32	11.37
	1264.	1085.	527.	930.	50.00	9.68	10.12	10.07
	1263.	1075.	529.	795.	211.00	11.28	12.13	11.96
	1261.	1066.	529.	728.	255.00	15.40	14.64	14.34
	1259.	1058.	529.	713.	187.00	12.89	13.13	13.15
	1257.	1052.	529.	675.	211.00	13.79	13.93	13.94
	1255.	1047.	529.	757.	161.00	15.19	14.84	14.63
	1254.	1043.	529.	608.	300.00	14.29	14.43	14.53
	1253.	1040.	529.	615.	178.00	14.39	14.43	14.34
	1251.	1039.	529.	591.	218.00	16.10	15.84	15.52
	1251.	1038.	529.	651.	92.00	14.29	14.43	14.53
	1251.	1038.	529.	564.	48.00	13.59	13.93	14.14
	1250.	1038.	529.	572.	-9.00	12.89	13.53	13.64
	1250.	1038.	529.	751.	-40.00	10.28	11.12	11.37
	1250.	1038.	529.	886.	-64.00	7.08	8.22	8.66
	1249.	1037.	529.	942.	-60.00	4.98	7.42	8.36
	1248.	1036.	529.	946.	-53.00	5.28	7.22	7.85
159.	1247.	1035.	529.	912.	-55.00	6.68	7.62	7.95
	1246.	1034.	529.	852.	-35.00	8.48	9.02	9.26
	1246.	1034.	531.	848.	-16.00	8.18	8.82	9.06
	1246.	1034.	538.	933.	-14.00	7.58	8.02	8.16

CALIBRATED DATA 20 minutes data of the Hupselse Beek area.
****

Date : in 840010000, 84=year, 001=number of the day, 0000 means 00h00min
Rg : global radiation (W/m2)
Rn : net radiation (W/m2)
Rain : precipitation (mm)
G1 : groundwater depth below soil surface at meteorological site (mm)
G2 : ---------------------------------- 150m north of meteorological site (mm)
D13 : dry-bulb temperature difference between 1.30m and 3.15m above the soil surface (0.01K)
W13 : wet-bulb --
D3 : dry-bulb temperature at 3.15m above the soil surface (0.1K)
W3 : wet-bulb --
D73 : dry-bulb temperature difference between 7.14m and 3.15m above the soil surface (0.01K)
W73 : wet-bulb --
U2 : wind velocity at 2.14m above the soil surface (cm/s)
U3 : wind velocity at 3.97m ------------------------------
U9 : wind velocity at 9.48m ------------------------------
Ts : surface temperature (0.1K)
RH : relative humidity (0.1%)
SD : sun duration (0.1%)
WD : wind direction (degrees with respect to the north)
: soil heat flux (W/m2)
Rso : short-wave radiation outgoing (W/m2)

Date DATUM	TIJD	Rg RKRT	Rn RNET	Rain NRSLG	G1 GWSG	G2 GWSB	D13 DT2M	D3 TEMP	D73 DT10M	W13 DT2MN	W3 TEMPN	W73 DT10MN	U2 U2.14	U3 U3.97	U9 U9.48	Ts Topp	RH RVO	SD ZON	WD WINDR	G BFLUX	Rso RKRT
830607	200	0.	-66.	0.0	1138.	835.	9999.	101.	67.	-74.	101.	68.	229.	283.	351.	10.	826.	0.	98.	-19.	9999.
830607	220	0.	-68.	0.0	1138.	835.	9999.	100.	60.	-62.	100.	60.	251.	302.	378.	10.	826.	0.	92.	-19.	9999.
830607	240	0.	-69.	0.0	1138.	835.	9999.	96.	50.	-57.	95.	50.	236.	283.	355.	10.	830.	0.	102.	-19.	9999.
830607	300	0.	-67.	0.0	1138.	835.	9999.	94.	62.	-70.	94.	62.	214.	263.	331.	10.	853.	0.	90.	-20.	9999.
830607	320	0.	-69.	0.0	1138.	836.	9999.	93.	58.	-61.	93.	58.	224.	273.	349.	10.	854.	0.	99.	-20.	9999.
830607	340	0.	-68.	0.0	1138.	837.	9999.	91.	60.	-67.	91.	60.	222.	273.	340.	10.	880.	0.	95.	-20.	9999.
830607	400	0.	-70.	0.0	1138.	838.	9999.	91.	48.	-50.	91.	47.	272.	322.	397.	10.	867.	0.	95.	-20.	9999.
830607	420	1.	-70.	0.0	1138.	839.	9999.	87.	40.	-43.	86.	40.	266.	312.	386.	10.	867.	0.	101.	-20.	9999.
830607	440	9.	-61.	0.0	1138.	838.	9999.	83.	50.	-51.	83.	50.	226.	273.	340.	10.	871.	0.	105.	-20.	9999.
830607	500	30.	-43.	0.0	1139.	839.	9999.	85.	51.	-57.	85.	51.	180.	224.	288.	10.	876.	429.	84.	-20.	9999.
830607	520	56.	-28.	0.0	1139.	839.	9999.	89.	28.	-30.	88.	30.	251.	293.	361.	10.	855.	1000.	90.	-19.	9999.
830607	540	91.	-7.	0.0	1139.	840.	9999.	92.	10.	-13.	92.	12.	292.	332.	392.	10.	823.	1000.	98.	-17.	9999.
830607	600	132.	22.	0.0	1139.	840.	9999.	97.	1.	-2.	97.	3.	294.	332.	384.	10.	787.	1000.	103.	-14.	9999.
830607	620	180.	53.	0.0	1139.	841.	9999.	105.	-5.	5.	104.	-2.	313.	351.	401.	10.	742.	1000.	101.	-12.	9999.
830607	640	233.	89.	0.0	1139.	842.	9999.	111.	-8.	8.	110.	-5.	393.	430.	475.	10.	706.	1000.	102.	-9.	9999.
830607	700	289.	127.	0.0	1139.	842.	9999.	119.	-12.	13.	118.	-8.	431.	479.	541.	10.	664.	1000.	99.	-6.	9999.
830607	720	338.	163.	0.0	1139.	843.	9999.	127.	-16.	17.	126.	-12.	406.	449.	495.	10.	633.	1000.	108.	-2.	9999.
830607	740	392.	203.	0.0	1139.	843.	9999.	132.	-15.	21.	132.	-14.	421.	469.	519.	10.	584.	1000.	113.	0.	9999.
830607	800	444.	240.	0.0	1139.	844.	9999.	141.	-20.	22.	141.	-17.	466.	518.	581.	10.	552.	1000.	122.	5.	9999.
830607	820	493.	274.	0.0	1140.	844.	9999.	143.	-17.	25.	143.	-17.	455.	498.	547.	10.	520.	1000.	130.	8.	9999.
830607	840	479.	263.	0.0	1139.	844.	9999.	148.	-17.	21.	148.	-17.	515.	567.	620.	10.	530.	1000.	126.	13.	9999.
830607	900	483.	226.	0.0	1140.	845.	9999.	153.	9999.	9999.	153.	9999.	394.	430.	477.	10.	507.	807.	362.	18.	9999.
830607	920	532	276.	0.0	1140.	845.	9999.	158.	9999.	9999.	158.	9999.	9999.	9999.	9999.	10.	472.	800.	80.	26.	9999.
830607	940	560.	327.	0.0	1140.	846.	9999.	162.	9999.	9999.	161.	9999.	9999.	9999.	9999.	10.	458.	800.	162.	32.	68.
830607	1000	598.	377.	0.0	1140.	846.	9999.	169.	-25.	9999.	167.	-20.	414.	449.	488.	10.	448.	834.	183.	38.	143.
830607	1020	758.	447.	0.0	1140.	847.	9999.	176.	-23.	9999.	174.	-19.	474.	508.	540.	10.	463.	1000.	149.	42.	176.
830607	1040	775.	465.	0.0	1140.	847.	9999.	171.	-35.	9999.	170.	-28.	408.	430.	481.	10.	425.	980.	50.	51.	176.
830607	1100	793.	466.	0.0	1141.	847.	44.	179.	-28.	47.	178.	-22.	457.	498.	538.	10.	430.	1000.	113.	55.	178.
830607	1120	833.	493.	0.0	1141.	848.	37.	182.	-27.	39.	180.	-23.	429.	459.	506.	10.	430.	1000.	136.	59.	186.
830607	1140	847.	499.	0.0	1141.	848.	38.	186.	-26.	40.	186.	-21.	429.	459.	506.	10.	422.	1000.	137.	63.	186.

DAILY DATA OF THE HUPSELSE BEEK CATCHMENT 770101 - 771231

(DAILY MEAN , DAILY TOTAL OR 0.00 HRS VALUE)

MEANING OF ABBREVIATIONS:

GRWL	= GROUNDWATER LEVEL	(CM BELOW FIELDLEVEL)	
TEMP	= AIR TEMPERATURE AT 1,5 M ABOVE FIELDLEVEL	(CENTIGRADES)	
SUNDUR	= SUNSHINE DURATION	(HOURS * 0.1)	
WIND	= WINDVELOCITY AT 1,5 M ABOVE FIELDLEVEL	(M / S)	
RELHUM	= RELATIVE HUMIDITY AT 1,5 M ABOVE FIELDLEVEL	(%)	
GLORAD	= GLOBAL RADIATION AT 1,0 M ABOVE FIELDLEVEL	(W / M2)	
NETRAD	= NET RADIATION AT 1,0 ABOVE FIELDLEVEL	(W / M2)	
SOILHF	= SOIL HEAT FLUX	(W / M2)	
EPOT	= POTENTIAL EVAPOTRANSPIRATION	(MM)	
EACT	= ACTUAL EVAPOTRANSPIRATION	(MM)	zero-values are missing values
PRECIP	= PRECIPITATION	(MM)	
DISCHR	= DISCHARGE	(MM)	

NOTE : ALL PARAMETERS RELATE TO THE METEOROLOGICAL STATION " ASSINK "
WITH THE EXCEPTION OF DISCHR WHICH RELATES TO THE ENTIRE
CATCHMENT (AREA 650 HECTARES, MEASURED AT WEIR 10A)

DATE	NR	GRWL	TEMP	SUNDUR	WIND	RELHUM	GLORAD	NETRAD	SOILHF	EPOT	EACT	PRECIP	DISCHR
770604	155	121	12.4	0	2.6	84	0	48	-2	1.5	1.7	.1	.144
770605	156	121	11.7	0	2.6	88	0	38	-5	1.2	1.7	1.9	.143
770606	157	122	12.0	0	2.1	73	0	97	-1	2.6	3.1	9.4	.144
770607	158	104	12.1	0	3.6	81	0	70	-1	2.1	3.0	12.3	.156
770608	159	105	13.7	0	2.6	69	0	132	19	3.4	4.0	1.2	.178
770609	160	106	16.5	0	2.1	80	0	77	25	2.1	.0	18.4	.162
770610	161	76	15.8	0	2.6	82	0	74	25	1.9	.0	6.8	.419
770611	162	85	14.8	0	1.5	67	0	106	25	2.9	.0	.0	.599
770612	163	93	18.6	0	1.9	68	0	155	25	4.2	.0	.0	.488
770613	164	99	23.7	0	2.6	66	0	163	25	5.3	.0	.0	.419
770614	165	98	18.1	0	2.3	77	0	81	3	2.9	3.1	12.6	.315
770615	166	84	15.8	0	2.1	92	0	23	-19	1.0	.0	5.6	.328
770616	167	67	15.7	0	2.3	95	0	27	-5	.8	.0	5.8	.496
770617	168	71	13.6	0	1.7	92	0	45	-8	1.1	.0	.0	.635
770618	169	73	14.5	0	1.4	89	0	42	-2	1.1	.0	.0	.580
770619	170	77	14.4	0	2.1	93	0	29	-1	.9	.0	.4	.494
770620	171	79	11.8	0	1.8	86	0	41	-27	1.4	.0	.0	.378
770621	172	86	14.2	0	1.2	74	0	109	31	2.5	2.2	.0	.315
770622	173	90	15.7	0	1.8	80	0	72	22	2.1	1.9	.0	.243
770623	174	94	13.6	0	1.6	82	0	113	12	2.5	2.9	.0	.207
770624	175	97	15.1	0	1.4	85	0	107	20	2.3	2.6	.0	.176
770625	176	96	14.9	0	1.4	88	0	52	-7	1.5	2.1	3.6	.163
770626	177	94	13.2	0	1.9	92	0	34	-16	1.0	1.6	2.7	.155
770627	178	95	14.5	0	2.2	73	0	109	5	3.0	3.2	.0	.144
770628	179	97	16.3	0	2.3	71	0	120	18	3.4	3.2	.0	.141
770629	180	80	13.9	0	1.6	87	0	46	-11	1.4	1.7	12.4	.152

DAILY DATA OF THE HUPSELSE BEEK AREA YEAR; 1983

S: missing values

DATUM	RKRT W/m2	RNET W/m2	NRSLG mm	GWSG mm	GWSB mm	TEMP (0.1k)	TEMPN (0.1k)	U3.97 (cm/sec)	RVO (0.1%)	ZON (hours)	BFLUX W/m2
830430	242.	99.	0.0	1042.	912.	115.	115.	201.	683.	11.60	15.
830501	92.	41.	5.0	1041.	900.	115.	116.	353.	860.	1.25	9.
830502	158.	75.	4.4	1026.	925.	92.	92.	428.	809.	3.00	5.
830503	47.	S 24.	S 5.3	S 1021.	S 921.	S 84.	S 9999.	519.	S 890.	S 0.00	S 1. S
830504	144.	S 58.	S 0.8	S 1016.	S 918.	S 81.	S 9999.	260.	S 830.	S 3.50	S 3. S
830505	258.	113.	0.0	1011.	914.	77.	77.	200.	750.	9.23	11.
830506	186.	86.	0.1	1048.	927.	123.	123.	389.	675.	5.14	11.
830507	57.	24.	4.2	1061.	936.	122.	122.	237.	906.	0.00	8.
830508	169.	86.	4.8	1036.	935.	118.	118.	268.	833.	2.95	12.
830509	153.	81.	1.4	1022.	931.	122.	122.	366.	753.	2.57	9.
830510	228.	112.	7.0	1026.	937.	97.	97.	364.	736.	6.75	8.
830511	133.	63.	3.9	1007.	927.	96.	96.	374.	801.	1.41	3.
830512	101.	35.	6.3	964.	915.	102.	102.	510.	810.	0.73	0.
830513	173.	74.	0.0	947.	890.	116.	116.	408.	738.	3.24	8.
830514	208.	102.	0.0	1006.	906.	128.	128.	296.	711.	5.43	15.
830515	136.	58.	0.4	1040.	926.	127.	127.	242.	812.	3.23	9.
830516	53.	15.	7.5	1057.	951.	105.	105.	245.	904.	0.67	1.
830517	122.	54.	2.9	1002.	936.	119.	119.	186.	852.	0.77	14.
830518	200.	97.	5.0	963.	911.	119.	119.	322.	814.	5.84	13.
830519	185.	79.	0.2	965.	899.	121.	120.	297.	757.	4.57	10.
830520	196.	S 99.	S 2.4	S 982.	S 906.	S 122.	S 9999.	276.	S 780.	S 5.30	S 8. S
830521	41.	6.	9.8	998.	912.	115.	115.	205.	948.	0.00	3.
830522	211.	104.	0.0	901.	822.	113.	113.	218.	768.	5.19	15.
830523	215.	101.	3.1	968.	828.	115.	115.	194.	739.	6.09	12.
830524	34.	6.	8.3	950.	803.	102.	103.	488.	951.	0.00	-1.
830525	28.	9.	5.1	874.	713.	96.	97.	502.	954.	0.00	0.
830526	27.	7.	28.2	718.	568.	91.	91.	514.	959.	0.00	-2.
830527	89.	43.	0.0	606.	402.	88.	88.	297.	878.	0.00	3.
830528	166.	76.	0.5	790.	455.	92.	92.	304.	826.	1.66	6.
830529	101.	44.	2.7	858.	474.	93.	93.	237.	892.	0.28	6.
830530	185.	92.	0.0	925.	529.	114.	114.	205.	771.	2.02	14.
830531	276.	146.	0.0	973.	579.	164.	164.	268.	623.	11.74	22.
830601	249.	136.	0.0	1011.	618.	198.	198.	371.	612.	9.11	20.
830602	209.	108.	0.4	1048.	670.	158.	158.	407.	767.	5.22	13.
830603	279.	142.	0.0	1074.	719.	156.	156.	255.	686.	9.89	18.
830604	247.	135.	0.0	1092.	753.	190.	190.	301.	671.	7.74	20.
830605	256.	122.	1.5	1110.	784.	155.	155.	285.	723.	7.47	20.
830606	297.	137.	0.0	1126.	818.	130.	130.	429.	661.	10.71	9.
830607	317.	142.	0.0	1142.	846.	163.	163.	396.	S 587.	14.93	15.
830608	209.	100.	4.2	1158.	871.	199.	199.	243.	627.	6.65	18.
830609	172.	84.	9.9	1122.	810.	169.	169.	308.	805.	2.48	13.
830610	183.	84.	0.0	1121.	823.	147.	146.	265.	745.	3.64	7.
830611	298.	155.	0.0	1140.	867.	162.	162.	267.	653.	11.28	17.
830612	249.	128.	0.0	1164.	900.	181.	180.	237.	654.	7.34	19.
830613	214.	S 161.	S 0.0	S 1178.	S 930.	S 148.	S 9999.	244.	S 675.	S 5.40	S 3. S
830614	151.	S 91.	0.0	1192.	959.	134.	134.	356.	698.	4.75	-1.
830615	206.	S 100.	6.5	1193.	986.	111.	111.	365.	742.	5.09	0.
830616	197.	90.	0.0	1200.	1009.	108.	108.	309.	710.	3.18	2.

POTENTIAL EVAPOTRANSPIRATION YEAR: 1983

DATUM	ETPE	ETTO	ETPT	ETM1	ETM2
	Penman	Thom & Oliver	Priestley and Taylor	Makkink 1	Makkink 2
(W/m^2)					
830429	43.56	41.90	37.88	50.81	45.73
830430	67.99	70.49	61.90	90.56	79.33
830501	31.39	31.57	23.58	34.43	27.69
830502	57.02	48.86	48.59	55.69	52.17
830503	24.83	22.50	15.61	16.20	15.51
830504	40.21	37.38	37.02	49.23	47.17
830505	66.56	60.50	67.88	87.19	79.76
830506	77.35	77.31	56.36	70.98	62.58
830507	16.02	18.22	11.99	21.70	15.61
830508	55.64	50.74	54.94	63.71	54.66
830509	66.24	63.59	53.98	58.25	51.39
830510	80.75	70.54	73.17	81.45	75.74
830511	50.98	46.75	42.10	47.39	45.25
830512	42.13	40.49	24.95	36.56	36.56
830513	65.37	63.06	48.76	64.90	58.90
830514	76.12	75.16	66.16	80.32	68.74
830515	42.75	44.39	37.17	52.40	45.46
830516	14.44	16.58	10.06	19.34	18.61
830517	32.08	33.46	29.77	46.11	35.52
830518	65.11	58.00	62.51	75.58	65.76
830519	60.46	59.89	51.60	70.26	62.66
830520	70.80	65.44	68.22	74.61	68.52
830521	4.99	7.16	2.21	15.34	13.10
830522	66.05	62.80	65.26	78.57	67.40
830523	67.03	66.03	65.59	80.46	71.48
830524	9.53	9.68	4.99	12.31	13.03
830525	10.23	9.67	6.31	9.98	9.98
830526	9.60	8.76	6.23	9.49	10.90
830527	30.51	28.12	27.46	31.03	28.94
830528	51.28	45.45	48.59	58.51	54.28
830529	27.60	25.89	26.45	35.70	31.46
830530	59.11	57.93	57.34	69.06	58.61
830531	112.62	115.15	101.99	115.28	96.91
830601	126.70	133.47	101.66	110.81	93.01
830602	87.79	81.46	77.19	86.24	75.51
830603	104.28	102.19	100.34	114.64	99.85
830604	111.16	114.55	99.38	108.39	90.84
830605	89.02	87.50	82.36	104.97	88.57
830606	114.80	103.24	97.80	115.23	108.25
830607	129.73	128.82	104.25	132.14	119.64
830608	89.55	104.74	71.99	93.17	77.12
830609	65.21	64.85	58.98	72.56	61.59
830610	68.82	70.29	61.12	73.77	68.13
830611	118.39	116.21	113.05	123.97	109.83

APPENDIX E: COMPUTER PROGRAM

```
      PROGRAM POTEVAP
C
CCC   DIT PROGRAMMA BEREKENT DE POTENTIELE VERDAMPING VOLGENS
CCC   PENMAN, THOM EN OLIVER, PRIESTLEY EN TAYLOR EN MAKKINK
C
CCC   LUDOLPH WENTHOLT
CCC   OKTOBER 1983
C
      PARAMETER (IPAR=366)
C
      INTEGER IDAG(IPAR),IF(11)
C
      REAL RKRT(IPAR),RNET(IPAR),TEMP(IPAR),WINDSN(IPAR),BFLUX(IPAR)
      REAL ETPE(IPAR),ETTO(IPAR),ETPT(IPAR),ETM1(IPAR),ETM2(IPAR)
      REAL E(IPAR),ES(IPAR),DE(IPAR),S(IPAR),RA(IPAR),N(IPAR),M,GAMMA
C
      DIMENSION TEKST(33)
C
      CHARACTER INDEX(11)
.
CCC   PARAMETERS
C
      RC    = 65.
      M     = 1.9
      GAMMA = 0.66
C
      OPEN(UNIT=21,STATUS='OLD',FILE='1983DAG.DAT')
      OPEN(UNIT=22,STATUS='NEW',FILE='DAGVERD83.DAT')
      OPEN(UNIT=23,STATUS='NEW',FILE='DEF1983DAG.DAT')
C
      READ(21,900) TEKST
      WRITE(23,900) TEKST
C
      WRITE (22,907)
C
      DO 100 I = 1,IPAR
C
        READ(21,901,END=999) IDAG(I),RKRT(I),IF(1),RNET(I),IF(2),
     +  RNRSLG,IF(3),GWSG,IF(4),GWSB,IF(5),TEMP(I),IF(6),
     +  TEMPN,IF(7),WINDSN(I),IF(8),RVO,IF(9),ZON,IF(10),
     +  BFLUX(I),IF(11)
C
        OUTTD = TEMP(I)
        OUTTW = TEMPN
        OUTWS = WINDSN(I)
        OUTRH = RVO
C
        DO 10 K =1,11
          IF (IF(K).LT.1) THEN
             INDEX(K) = ' '
          ELSE
             INDEX(K) = 'S'
          END IF
10      CONTINUE
C
CCC     TEMPERATUUR IN HELE GRADEN CELCIUS, WINDSNELHEID IN M/SEC
CCC     RELATIEVE LUCHTVOCHTIGHEID UITGEDRUKT TOV. 1
C
CCC     WINDSNELHEID OMREKENEN VAN 3.97 METER HOOGTE NAAR
CCC     DE WINDSNELHEID OP 2.00 METER HOOGTE, VIA HET LOGARITMIASCHE
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```
CCC     WINDPROFIEL! ,D.W.Z. U3.97/U2.00 = 1.12
CCC     N.B. HIAAT OPVULLING GELDT WEL VOOR 2 METER HOOGTE.
C
        IF (TEMP(I).NE.9999.) THEN
           TEMP(I) = TEMP(I)/10.
        END IF
        IF (TEMPN.NE.9999.) THEN
           TEMPN = TEMPN/10.
        END IF
        IF (WINDSN(I).NE.9999.) THEN
           WINDSN(I) = WINDSN(I)*0.01
C            OMREKENEN VAN 3.97M NAAR 2.00M
           IF (IF(8).LT.1) THEN
             WINDSN(I) = 0.88 * WINDSN(I)
           END IF
       END IF
        IF (RVO.NE.9999.) THEN
           RVO = RVO/1000.
        END IF

CCC     CLAPEYRON'S COEFFICIENTEN
C
        AA = 4.58
        AS = 0.333
        AT = 0.01065
        AU = 0.0001873
        AV = 0.00000322
C
CCC     BEREKENEN VAN S(I)
C
        IF (TEMP(I).NE.9999.) THEN
          S(I) = 1.333 * ( AS + (2*AT*TEMP(I)) + (3*AU*TEMP(I)**2)
     +             + (4*AV*TEMP(I)**3))
        ELSE
          S(I)=9999.
        END IF
C
CCC     BEREKENEN VAN DE
CCC       DE = ES * (1 - RVO) = ES * (1 - E/ES)
C
        IF (TEMP(I).NE.9999.) THEN
           ES(I) = 1.333 * ( AA + (AS*TEMP(I)) + (AT*TEMP(I)**2) +
     +                 (AU*TEMP(I)**3) + (AV*TEMP(I)**4))
        ELSE
           ES(I) = 9999.
        END IF
C
        IF ((ES(I).LT.9999.).AND.(OUTRH.LT.9999.)) THEN
            DE(I) = ES(I)*(1. - RVO)
        ELSE
            DE(I) = 9999.
        END IF
C
        IF ((ES(I).LT.9999.).AND.(OUTRH.EQ.9999.)) THEN
           IF (TEMPN.LT.9999.) THEN
             E(I) = 1.333 * (AA + (AS*TEMPN) + (AT*TEMPN**2) +
     +       (AU*TEMPN**3) + (AV*TEMPN**4)) - GAMMA * (TEMP(I)-TEMPN)
C
           RVOB = E(I)/ES(I)
           DE(I) = ES(I)*(1.-RVOB)
```

```
            INDEX(9) = 'B'
C
            OUTRH = RVOB*1000.
C
            END IF
C
         END IF
C
CCC      BEREKENEN VAN RA:
C
         RA(I) = (4.72*(ALOG(2.14/0.01))**2)/(1.+0.54*WINDSN(I))
C
CCC      BEREKENEN VAN N:
C
         N(I) = RC/RA(I)
C
CCC
CCCC     BEREKING VOLGENS PENMAN
CCC
C
         ETPE(I) = (S(I)/(S(I)+GAMMA)) * (RNET(I)-BFLUX(I)) +
     +   (GAMMA/(S(I)+GAMMA)) * (3.7+4*WINDSN(I))*DE(I)
C
CCC
CCCC     BEREKENING VOLGENS THOM AND OLIVER
CCC
C
         ETTO(I) = (S(I)/(S(I)+GAMMA*(1.+N(I))))*(RNET(I)-BFLUX(I))+
     +   (M*GAMMA/(S(I)+GAMMA*(1.+N(I)))) * (7.4+4*WINDSN(I))*DE(I)
C
CCC
CCCC     BEREKENING VOLGENS PRIESTLEY AND TAYLOR
CCC
C
         ETPT(I) = 1.28 * (S(I)/(S(I)+GAMMA)) * (RNET(I)-BFLUX(I))
C
CCC
CCCC     BEREKENING VOLGENS MAKKINK
CCC
C
         ETM1(I) = 0.65 * (S(I)/(S(I)+GAMMA))*RKRT(I)
C
         ETM2(I) = 0.65 * (S(I)/(S(I)+GAMMA)) * (RKRT(I)- 2.*BFLUX(I))
C
CCC      HIAATEN
C
         IF ((RNET(I).EQ.9999.).OR.(BFLUX(I).EQ.9999.)) THEN
            ETPE(I) = 9999.
            ETTO(0) = 9999.
            ETPT(I) = 9999.
         END IF
         IF ((WINDSN(I).EQ.9999.).OR.(DE(I).EQ.9999.)) THEN
            ETPE(I) = 9999.
            ETTO(I) = 9999.
            ETPT(I) = 9999.
         END IF
         IF (S(I).EQ.9999.) THEN
            ETPE(I) = 9999.
            ETTO(I) = 9999.
            ETPT(I) = 9999.
```

```
            ETM1(I) = 9999.
            ETM2(I) = 9999.
         END IF
         IF (RKRT(I).EQ.9999.) THEN
            ETM1(I) = 9999.
            ETM2(I) = 9999.
         END IF
         IF (BFLUX(I).EQ.9999.) THEN
            ETM2(I) = 9999.
         END IF
C
         IF (OUTTW.EQ.9999.) THEN
            INDEX(7) = ' '
         END IF
C
         IF (GWSB.EQ.9999.) THEN
            INDEX(5) = ' '
         END IF
C
CCC      PRIESTLEY TAYLOR geldt alleen van april t/m september
C
         IF ((I.LE.90).OR.(I.GT.273)) THEN
            ETPT(I) = 9999.
         END IF
C
         WRITE(23,902) IDAG(I),RKRT(I),INDEX(1),RNET(I),INDEX(2),RNRSLG,
     +   INDEX(3),GWSG,INDEX(4),GWSB,INDEX(5),OUTTD,
     +   INDEX(6),OUTTW,INDEX(7),OUTWS,INDEX(8),OUTRH,
     +   INDEX(9),ZON,INDEX(10),BFLUX(I),INDEX(11)
C
         WRITE(22,903) IDAG(I),ETPE(I),ETTO(I),ETPT(I),ETM1(I),ETM2(I)

100   CONTINUE
C
900   FORMAT(33A4)
901   FORMAT(1X,I7,2(F6.0,I3),F7.1,I3,4(F6.0,I3),7X,2(F6.0,I3),
     +F7.2,I3,F6.0,I3)
902   FORMAT(1X,I7,2(F6.0,A3),F7.1,A3,6(F6.0,A3),F7.2,A3,(F6.0,A3))
:
903   FORMAT (1X,I6,2X,5(F7.2,2X))
907   FORMAT('  DATUM     ETPE      ETTO      ETPT      ETM1      ETM2',/)
999   PRINT *,'GESLAAGD EINDE V/D POTENTIELE VERDAMPINGS BEREKENINGEN'
      STOP
      END
```