Documentation in support of MARSOP 4

Version 2016-07-22

AMDAC manual

Preface

Models of Yield Production is one of the fields covered by the *Agriculture Project* of the Institute for Remote Sensing Applications at the Joint Research Centre of the Commission of the European Communities in Ispra (Italy). The goal of one of the studies in this field (see operation 3.2 in the *MARS Project Call for Proposals:General Conditions and Detailed Specifications* of August 1990) was to provide the Agriculture Project with a software package able to perform decoding, filing and quality evaluation of actual meteorological data which are used as input for agro-meteorological models. For this purpose the **Actual Meteorological Database Construction (AMDaC)** package is developed by MeteoConsult (Wageningen, The Netherlands), which is described in this manual.

Contents

1 Introduction

The **Actual Meteorological Database Construction (AMDaC)** package is a software package developed for the *decoding, filing* and *quality evaluation* of *meteorological data*. In conformity with the functions specified in operation 3.2 of the *MARS Project Call for Proposals: General Conditions and Detailed Specifications* (August 1990) the AMDaC package is able to:

- decode INTERMEDIATE-hour and MAIN-hour SYNOP-reports (FM 12-VIII) and METAR-reports (FM 15-VIII) from weather stations in the EC-countries, circulating on the Global Telecommunication System (GTS);
- check the quality and correct the obvious errors in the received weather reports;
- store the coded and decoded information in two separate databases with direct access files;
- perform time consistency checks to compare the values of reported parameters with those previously or subsequently reported for the same station;
- correct automatically obvious errors detected while performing consistency checks;
- fill up automatically gaps in the database through interpolation based on time consistency criteria;
- flag errors and dubious observations which can not automatically be corrected, and write these to a log file;
- extraction or calculation and storage of the following parameters in a separate database:
- sunshine duration;
- total 24 hour precipitation (6 UTC - 6 UTC);
- daily mean cloud cover;
- daily mean wind speed at 10 metres;
- daily mean vapour pressure;
- air temperature and vapour pressure at 6, 9, 12, 15 and 18 UTC;
- maximum and minimum temperature;
- total cloud cover during daytime (i.e. 6-18 UTC);
- mean daytime visibility;
- state of the soil;
- calculated daily mean vapour pressure deficit and slope of the saturated vapour pressure vs. temperature curve;
- calculated amount of shadow clouds during daytime (i.e. 6-18 UTC);
- calculated sunshine duration;
- calculated global radiation;
- calculated evapotranspiration according to the modified Penman formula.

The AMDaC package consists of six programs (see also Fig. 1.1):

- EXDEC: this program (1) extracts weather reports needed for the Actual Meteorological Database (AMD) from the input file GTS:I*yymmdd*.DAT, (2) checks and (whenever possible) corrects the construction of the extracted reports, (3) stores the (corrected) coded observations in the database CODED, (4) decodes the observations and (5) stores the extracted and some derived data in the database DECODED;
- CHECK: this program (1) performs time and space consistency checks on the observations in the CODED and DECODED databases, (2) automatically corrects obvious errors and (3) detects other possible errors which can be corrected later on by the operator through the OBSCON program;
- OBSCON: this program offers an operator the possibility of viewing coded (stored In CODED), decoded and derived element values (both stored in DECODED). Furthermore, errors which were not automatically corrected by the CHECK program can be displayed, and if necessary values can be added to or modified in the database DECODED. For the representation of data various lay-outs are available;
- INTER: this program tries to fill up gaps in the database DECODED through Interpolation based on time consistency;
- SELECT: this program (1) selects element values of the AMD stations from the database DECODED, (2) calculates some AMD parameter values and (3) writes all AMD parameter values to the file DAILY:S*yymmdd*.DAT;
- FINAL: this program performs a final check of the AMD parameter values in the file DAILY:S*yymmdd*.DAT;

In this manual a description of the AMDaC programs is given.

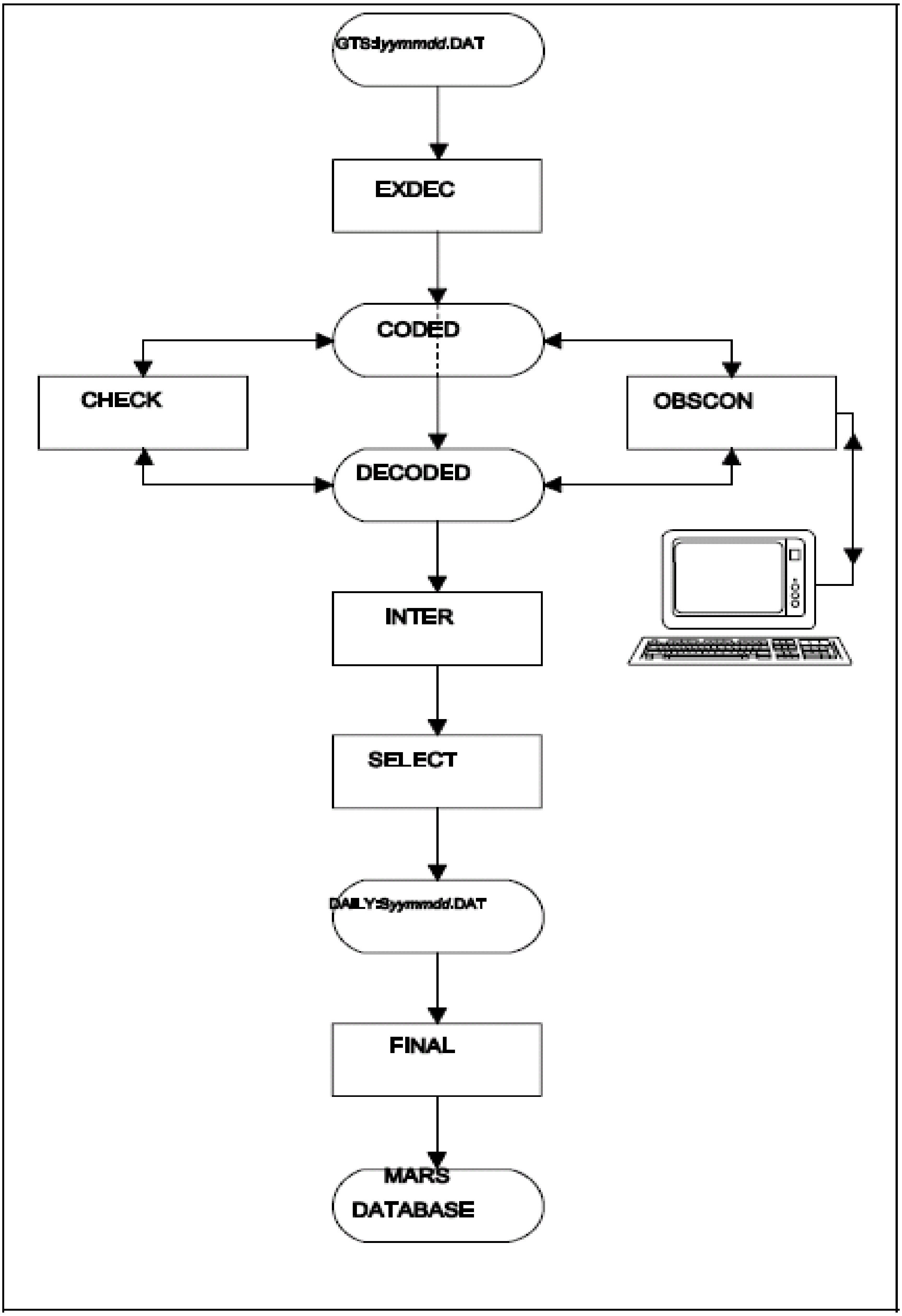


Fig. 1.1. *The AMDaC software package.*

2 Extraction and decoding of data

2.1 Introduction

The program EXDEC takes care of the extraction and decoding of the weather reports needed for the construction of the Actual Meteorological Database (AMD). The input for the EXDEC program consists of a file named GTS:Iyymmdd.DAT (yy=year, mm=month, dd=day). This file contains the MAIN-hour and INTERMEDIATE-hour SYNOP (FM 12-VIII) and METAR (FM 15-VIII) reports of all countries of interest of one day, received through the GTS (Global Telecommunication System). In this chapter the tasks performed by the EXDEC program are described.

2.2 Bulletin-checking

Before extracting the weather observations from the file GTS:I*yymmdd*.DAT the EXDEC program checks the bulletins on specific errors and removes these errors. Note that this is not a check on the correctness of the observations (see chapter 3), but a check on the correctness of the bulletin construction. First a bulletin (regardless whether it is a SYNOP or METAR) is checked on:

- the presence of *empty lines*, which are removed from the bulletin;
- the presence of the *NNNN* sequence at the end of the bulletin, which is removed from the bulletin;
- the presence of lines which only contain an *=-sign*. The =-sign is moved to the end of the previous line and the empty line thus created is removed from the bulletin;
- the presence of *single* or *multiple spaces* at the beginning of a line, which are removed from the bulletin.

After this step the program checks whether the bulletin is a SYNOP-report or a METAR-report, and SYNOP-checking or METAR-checking is performed.

2.2.1 SYNOP-checking

The SYNOP-report is checked consecutively on:

- the presence and correctness of the *AAXX* identification, which is added when missing or modified when wrong;
- the presence of the sequence *100EEE*, which is removed;
- the presence of *alphabetical characters* (except AAXX and NIL), which are converted to their telex number equivalent;
- the presence of *commas*, which are replaced by spaces;
- the presence of *strange characters* in front or at the end of a group which does not consist of 5 digits. These characters are replaced by spaces;
- *mutilation* of the *333* identification group (e.g. '3 3 3' or ' 33 '), which is corrected;
- the presence of *single characters*, which are replaced by a single space;
- the presence of *multiple spaces*, which are reduced to a single space;
- the presence of groups of *8, 10 and 11 characters* (i.e. an identification group attached to a normal group, two normal groups attached to each other or two normal groups not separated by a space), which are separated into two groups;
- the presence of a *double =-sign* at the end of a line, which is reduced to a ingle one.

After this step the corrected SYNOP-report is ready for the actual data extraction.

2.2.2 METAR-checking

Since mistakes in a METAR-report are very rare, the METAR-report is only checked on:
- the presence of *multiple spaces*, which are reduced to a single space.

After this step the corrected METAR-report is ready for the data extraction.

2.3 Data extraction

The objective of the data extraction process is to select only those observations from the bulletins which are of importanAce for the construction of the Actual Meteorological Database. In Appendix A a list of meteorological stations is given. Each station is marked with an **F** or an **S** which denotes its status concerning the construction of the database. Observations of stations marked with:

F: are not decoded because these stations are not located in the area of interest;
S: are decoded and will become part of the AMD if on the day under consideration: - at least the 6 and 18 UTC bulletins are provided;
- at least values for air temperature, dew-point temperature, wind speed, total cloud cover, pressure and precipitation are reported.

The result of the data extraction process is that the *coded observations* of the stations marked with **S** extracted from the file GTS:I*yymmdd*.DAT are added to an intermediate database named **CODED**. This database consists of three files:
- an index file (REALDATA:CODED.IDX)
- a data file (REALDATA:CODED.BIN)
- a file with a pointer to the last written datarecord (REALDATA:CODED.PTR).

In CODED the extracted MAIN-hour and INTERMEDIATE-hour observations of the past seven days are stored.
The data extraction process follows the same steps for SYNOP-reports and METAR-reports, except for a *date-time* check on SYNOP-reports: reports older than three days are skipped. The date-time check is not possible for METAR-reports because these reports do not contain the date (only time is included). From the bulletin one line is read, which in principle contains the observations of one station. The program checks if the line contains a *complete* observation, which is assumed to be the case if one of the following criteria is met:
- the line is the *last* line in the bulletin
- the line ends with an *=-sign*
- the line contains the string *NIL* (only for SYNOP-reports)
- the *next line* contains the string *NIL* (only for SYNOP-reports)
- the line and the next line contain together more than *132 characters* in a METAR-report and more than *172 characters* in a SYNOP-report
- the *next line* starts with a *station number* which is *legal* in this bulletin and the *fourth group* (the temperature group) starts with *'1'* (only for SYNOP-reports)

If the observation is complete and also proves to be a *real* observation (i.e. the line does not contain NIL) the *station identification* is checked. The station identification must:
- have an *integer* value in a SYNOP-report or a *code* in a METAR-report
- be a *legal* station identification
- be *permitted* to occur in a bulletin from this country
- *not* be denoted with an *F* in the station list (Appendix A)
- *not yet* be *decoded* with the same coded observation, or in case of a METAR-report, no SYNOP-report of the same station is decoded already

Only if all foregoing criteria are met the observation is stored in the database **CODED** and submitted to the decoding procedure.

2.4 Data decoding

The observations which are stored in the database CODED are also submitted to the decoding process. After this process the *decoded observations* are stored in the intermediate database **DECODED**. This database has the same structure as the database CODED (index file: REALDATA:DECODED.IDX, data file:
REALDATA:DECODED.BIN, pointer file: DECODED.PTR) and contains the extracted decoded observations of the past seven days.

2.4.1 SYNOP-decoding

Before decoding a SYNOP-observation the EXDEC program tries to find and correct more errors in the coded observation. The correct structure of an SYNOP-observation is given in Fig. 2.1.

SECTION 1 IIiii i_Ri_xhVV Nddff (00fff) $1s_nTTT$ { $2s_nT_dT_dT_d$ or 29UUU } $3P_oP_oP_oP_o$

{ 4PPPP or $4a_3hhh$ } 5appp $6RRRt_R$ { $7wwW_1W_2$ or $7w_aw_a$// } $8N_hC_LC_MC_H$ 9hh//

SECTION 2 $222D_sv_s$ .....

SECTION 3 333 (0....) $(1s_nT_xT_xT_x)$ $(2s_nT_nT_nT_n)$ (3Ejjj) (4E'sss)

$(5j_1j_2j_3j_4$ $(j_5j_6j_7j_8j_9))$ $(6RRRt_R)$ (7....) $(8N_sCh_sh_s)$

$(9S_pS_ps_ps_p)$ (80000 (0....) (1....) .....)

SECTION 4 444 $N'C'H'H'C_t$

SECTION 5 555 Groups to be developed nationally

Fig. 2.1. *FM 12-VIII, SYNOP - Report of surface observation from a land station. Section 2 contains maritime data and is of no importance.*

The observation is checked consecutively on:

- the presence of *identical groups* after the Nddff group. If two consecutive groups are equal one group is deleted;
- a *missing* I_rI_xhVV or *Nddff* group. If $1s_nTTT$ is the third group, $2s_nT_dT_dT_d$ the fourth group and $3P_oP_oP_oP_o$ or 4PPPP the fifth group a dummy group '///// ' or two dummy groups '///// ///// ' are inserted;
- the presence of *no more than three groups before* the *$1s_nTTT$* group. If $1s_nTTT$ is the fifth group, $2s_nT_dT_dT_d$ the sixth group and $3P_oP_oP_oP_o$ or 4PPPP the seventh group there is one group to many. The double group is removed, and if no double group is found the fourth group is removed;
- the presence of a *'1' as first character of the fourth group* ($1s_nTTT$). If no '1' is present and the fifth group is $2s_nT_dT_dT_d$ a '1' is added in front of the fourth group (when it

consists of four characters) or its first character is modified into '1' (when it consists of five characters);

- the presence of a *'2' as first character of the fifth group* ($2s_nT_dT_dT_d$). If no '2' is present and the fourth group is $1s_nTTT$ and the sixth group is $3P_oP_oP_oP_o$ or 4PPPP a '2' added in front of the fifth group or its first character is modified into '2';
- the presence of a *'3' as first character of the sixth group* ($3P_oP_oP_oP_o$). If no '3' is present and the fourth group is $1s_nTTT$, the fifth group is $2s_nT_dT_dT_d$ and the seventh group is 4PPPP a '3' is added in front of the fifth group or its first character is modified into '3';
- the correctness of the *sequence* of the *groups in section 1*. A wrong sequence is modified whenever there is no doubt about the mistake, otherwise the groups at wrong positions are ignored;
- the presence and position of the *333 identification group*. If this group is missing it is inserted, and if it is at a wrong position it is moved to the correct position;
- the presence of a $1s_nT_xT_xT_x$ group or a $2s_nT_nT_nT_n$ group in section 3 of the 6 UTC and 18 UTC bulletin and the correctness of the *identifiers* of these groups. A '1' as identifier in the 6 UTC bulletin is modified into a '2' when the next group does not start with a '2' (some countries provide both $1s_nT_xT_xT_x$ and $2s_nT_nT_nT_n$ in the 6 UTC bulletin). A '2' as identifier in the 18 UTC bulletin is always modified into a '1'.

After this enhancement procedure the observation is decoded. Decoded values are obtained for the elements listed in table II.1. Derived values are computed from observed values using the equations given in Appendix B. All values are stored in the database DECODED.

Table II.1. *Elements which are decoded or derived from a SYNOP-report.*

Element	Description	Units
Observed		
IIiii	Station number	code
h	Height of the base of the lowest cloud	code
VV	Horizontal visibility	code (codes 90-99 are converted: 90=0, 91=1, 92=2, 93=5, 94=10, 95=20, 96=40, 97=60, 98=70, 99=84
N	Total cloud cover	oktas
dd	Wind direction	degrees
ff	Wind speed (at 10 metres)	knots
TTT	Air temperature	°C
$T_dT_dT_d$	Dew-point temperature	°C
UUU	Relative humidity	%
$P_oP_oP_oP_o$	Pressure at station level	hPa
PPPP	Pressure at sea level	hPa
a	Characteristic of pressure tendency during the three hours preceding the time of observation	code
ppp	Amount of pressure tendency at station level in the three hours preceding the observation time	hPa
RRR	Amount of precipitation fallen during the period preceding observation time, as indicated by t_R	millimetres
t_R	Duration of period of reference for amount of precipitation	hours
ww	Present weather	code

Element	Description	Units
Observed (continued)		
W1	Past weather	code
W2	Past weather	code
N_h	Amount of CL clouds present or, if no CL cloud is present, the amount of CM cloud present	oktas
C_L	Clouds of genera Stratocumulus, Stratus, Cumulus, and Cumulonimbus	code
C_M	Clouds of genera Altocumulus, Altostratus and Nimbostratus	code
Observed (continued)		
C_H	Clouds of genera Cirrus, Cirrocumulus and Cirrostratus	code
$T_xT_xT_x$	Maximum temperature	°C
$T_nT_nT_n$	Minimum temperature	°C
$55j_2j_3j_4$	Duration of sunshine	hours
E	State of the soil	code
Derived		
$P_oP_oP_oP_o$	Pressure at station level	hPa
T_w	Wet bulb temperature	°C
Θ_w	Wet bulb potential temperature	°C
N_S	Amount of shadow clouds	oktas
RH	Relative humidity	%
e	Vapour pressure	hPa
Δe	Vapour pressure deficit	hPa
$\partial e_s/\partial T$	Slope of saturation vapour pressure vs. temperature curve	hPa/°C

2.4.2 METAR-decoding

The structure of a METAR-observation is given in Fig. 2.2. The observation is directly subjected to the decoding procedure, in which decoded values are obtained for the elements listed in table II.2. Derived values are computed from observed values as described in Appendix B. All values are stored in the database DECODED.

KMH or
CCCC YYGGggZ dddffG$f_m f_m$ KT or $d_n d_n d_n V d_x d_x d_x$
{ MPS }

$RD_R D_R / V_R V_R V_R V_R i$ $N_s N_s N_s h_s h_s h_s$ or
VVVVD_v $V_x V_x V_x V_x D_v$ or w'w' VV$h_s h_s h_s$ or
or { $RD_R D_R / V_R V_R V_R V_R V V_R V_R V_R V_R i$ { SKC
{ CAVOK

WSRWY$D_R D_R$
TT/$T_d T_d$ Q$P_H P_H P_H P_H$ REw'w' or
{ WSALLRWY

w'w' $N_s N_s N_s h_s h_s h_s$ or
KMH or VVVV or VV$h_s h_s h_s$ or
(TTTTT TTGGgg dddffG$f_m f_m$ KT or or { NSW } { SKC (or NSC)
or { MPS } { CAVOK
{ NOSIG)

Fig. 2.2. *FM 15-VIII, METAR - Aviation routine weather report.*

Table II.2. *Elements which are decoded or derived from a METAR-report.*

Element	Description	Units
Observed		
CCCC	Station code	code
GGgg	Time of observation	Hours and minutes (UTC)
ddd	Wind direction	degrees
ff	Wind speed (at 10 metres)	knots
VVVV	Horizontal visibility	code (converted from metres to VV-code in SYNOP-report)
N	Total cloud cover (addition of Ns of CL, CM and CH clouds)	oktas
CAVOK	Word replacing visibility, present weather and cloud data under specified conditions	VV = 60 ww = 1 N = 1
w'w'	Significant present and forecast weather	code (converted from text to ww-code in SYNOP-report according to table II.3)
T'T'	Air temperature	°C
$T_d'T_d'$	Dew-point temperature	°C
$P_HP_HP_HP_H$	Pressure at station level	hPa
Derived		
$P_oP_oP_oP_o$	Pressure at station level	hPa
T_w	Wet bulb temperature	°C
Θ_w	Wet bulb potential temperature	°C
N_S	Amount of shadow clouds	oktas
RH	Relative humidity	%
e	Vapour pressure	hPa
Δe	Vapour pressure deficit	hPa
$\partial e_s/\partial T$	Slope of the saturation vapour pressure vs. temperature curve	hPa/°C

Table II.3. *Translation of weather in METAR-report to ww-code of SYNOP-report.*

METAR	SYNOP	METAR	SYNOP	METAR	SYNOP
FU	04	-SS	31	+RADZ	59
HZ	05	-DS	31	-RA	61
SA	06	SS	31	RA	63
DU	07	DS	31	+RA	65
PO	08	+SS	34	-FZRA	66
RESS	09	+DS	34	FZRA	67
REDS	09	-MIBLSN	36	+FZRA	67
BR	10	MIBLSN	36	-RASN	68
MIBCFG	11	+MIBLSN	37	-SNRA	68
MIFG	12	-BLSN	38	RASN	69
VCSH	16	BLSN	39	SNRA	69
TS	17	+BLSN	39	+RASN	69
SQ	18	VCFG	40	+SNRA	69
FC	19	BCFG	41	-SN	71
REDZ	20	-FG	43	SN	73
RESG	20	FG	45	+SN	75
RERA	21	MIFZFG	48	IC	76
RESN	22	FZFG	49	SG	77
RERASN	23	-DZ	51	PE	79
RESNRA	23	DZ	53	-SHRA	80
REFRRA	24	+DZ	55	-RASH	80
REFRDZ	24	-FZDZ	56	SHRA	81
RESHRA	25	FZDZ	57	+SHRA	81
RESHSN	26	+FZDZ	57	++SHRA	82
RESHGR	27	-DZRA	58	-SHRASN	83
RESHGS	27	-RADZ	58	-SHSNRA	83
RESHPE	27	DZRA	59	SHRASN	84
REFG	28	+DZRA	59	SHSNRA	84
RETS	29	RADZ	59	+SHRASN	84
+SHSNRA	84	RARETS	92	TSSN	95
-SHSN	85	+RARETS	92	-TSGR	96
SHSN	86	-SNRETS	93	-TSPE	96
+SHSN	86	-GRRETS	93	-TSGS	96
-SHPE	87	-PERETS	93	TSPE	96
-SHGS	87	SNRETS	94	TSGS	96
SHPE	88	+SNRETS	94	+TSRA	97
SHGS	88	GRRETS	94	+TSSN	97
+SHPE	88	+GRRETS	94	TSSS	98
+SHGS	88	PERETS	94	TSDS	98
-SHGR	89	+PERETS	94	+TSSS	98
SHGR	90	-TSRA	95	+TSDS	98
+SHGR	90	-TSSN	95	+TSGR	98
-RARETS	91	TSRA	95	+TSPE	98
				TSGS	99

2.5 Messages

Messages generated by the EXDEC program are written to a **log file**. In table II.4 the possible messages are described. Also, the module which performs the *OBSERVATION-checking* writes the original observation line and the changed line to the log file if changes are made.

Table II.4. *Description of the messages generated by the EXDEC program*.

Message	Module	Description
%I-DEC AAXX ⇔ header not correct <HEADING>	SYNOP-checking	Heading SYNOP-report is mutilated
%I-DEC synop not accepted <HEADING>	Data extraction SYNOP	SYNOP-report older than three days
%I-DEC NIL next <HEADING>	Data extraction SYNOP	Observation assumed complete: next line contains NIL
%I-DEC 172 <HEADING>	Data extraction SYNOP	Observation assumed complete: line plus next line exceed 172 characters
%I-DEC no next <HEADING>	Data extraction SYNOP	Observation assumed complete: next line has legal station number
%I-DEC no int <HEADING>	Data extraction SYNOP	Station number not an integer
%I-DEC no unknown <HEADING>	Data extraction SYNOP	Station number unknown
%I-DEC no mismatch <HEADING>	Data extraction SYNOP	Station number not permitted in bulletin of this country
%I-DEC metar not accepted <HEADING> METAR	Data extraction	Invalid hour reference in header
%I-DEC code next <HEADING>	Data extraction METAR	Observation assumed complete: next line has legal station code
%I-DEC 132 <HEADING>	Data extraction METAR	Observation assumed complete: line plus next line exceed 132 characters
%I-DEC code unknown <HEADING>	Data extraction METAR	Station code unknown
%I-DEC code mismatch <HEADING>	Data extraction METAR	Station code not permitted in bulletin of this country

3 Data consistency checks

3.1 Introduction

The program **CHECK** performs consistency checks on the data in the database. To check the data of a certain day, the observations from 18 UTC of the previous day until 06 UTC of the next day are needed. Consequently, CHECK can only be used after the data of the next day are added to the database with the program EXDEC. Only the data of the stations which will be part of the database (i.e. the stations marked with S) are subjected to the consistency checks. The values of the following observation elements are checked: air temperature, dew-point temperature, pressure at sea level, wind speed, amount of precipitation, amount of CL clouds (or CM clouds if no CL clouds are present), duration of sunshine, snow depth and amount of global radiation. Obvious errors in the observations are automatically corrected and a message is written to the log file REALDATA:CHECK.LOG. Other possible errors are also written to this log file. These latter messages can be read by the OBSCON program, which also offers an operator the possibility of modifying the data. After the observations of a station are checked (and if necessary corrected) the derived parameters are recalculated and the data are written back to the database DECODED.
For a number of weather elements, the observed values are checked against a first guess that serves as reference values. For the first guess hight quality short range forecasts for the particular location of weather station are sues. These forecasts are obtained through a technique called MOS (Model Output Statistics).
Meteorological forecast models, e.g. the ECMWF model, compute the physical status of the atmosphere on a grid, and the results represent the expected situation per grid box. A MOS uses statistical relationships between the observations of a particular station and historic model forecasts for surrounding grid points. Each observing location has its own statistics, which are applied onto the grid point results of one or more physical models of the atmosphere. That way, the very local situation on an observing station can be mimicked.
AMDAC uses these individual location forecasts to define time- and location-dependent thresholds for the trustworthiness of station reports, for the elements air temperature (including minimum and maximum), dew point (applies to all derived measures for the humidity of the air), precipitation and wind speed, respectively. That way, the thresholds consider season, climatology and even the actual weather pattern. A welcome side effect is the high spatial consistency of the statistical MOS approach and therefore of the thresholds. Individual MOS forecasts is used for all stations (4600, state June 2016) which are used within MARSOP-4.
For the temperatures, the humidity measures and wind speed the consecutive reporting of a value, e.g. due to broken equipment or data encoding issues, is usually detected by the daily checks.

These first guess MOS data are kept in and read from a separate database. MOS data are available for all weather stations that are included in the deliveries for Marsop-4. Nevertheless, the checking algorithms are designed so that they also perform well in case of absent MOS first guess data.

3.2 Air temperature, maximum temperature and minimum temperature

A number of checks are performed on the temperature values, both the hourly values and the minimum and maximum values. Through effectively comparing and combining the outcomes of the various checks, the subroutine is to a certain degree capable of drawing conclusions on whether a value is right or wrong. Remaining doubtful cases are left for the operator to decide on.

The following checks are performed:

1. The minimum and the maximum values of the observed hourly air temperature TTT of the latest 24-hour period (from 6 UTC until 6 UTC the next day) are calculated: TT_{min} and TT_{max}. If these are equal to each other while there is more than one observation of TTT, all temperature values are considered wrong and are discarded, i.e. changed into NOT DEFINED ('/').
2. Check the minimum temperature $T_nT_nT_n$ on possible sign errors using the observed hourly air temperatures TTT between 18 and 6 UTC.
   (a) If
      i. the minimum value TT_{min} of TTT is positive <u>and</u>
      ii. $T_nT_nT_n$ is negative <u>and</u>
      iii. the difference between these two values is more than 4°C <u>and</u>
      iv. the opposite value of $T_nT_nT_n$ is less than TT_{min},

   the minus sign of $T_nT_nT_n$ is changed into a plus sign.

   (b) If
      i. the maximum value TT_{max} of TTT is less than 0°C <u>and</u>
      ii. $T_nT_nT_n$ is positive,

   the plus sign of $T_nT_nT_n$ is changed into a minus sign.
3. If no MOS temperature value is present, steps 4, 5 and 6 are skipped.
4. Compare TTT to the corresponding MOS value (TT_{mos}).
   (a) If the absolute value of the difference is greater than 10 °C, TTT is considered wrong and set to NOT DEFINED
   (b) If the absolute value of the difference is greater than 8.5 °C but less than or equal to 10 °C, TTT is suspicious. A logical variable LTC is set to TRUE.
   (c) If, in addition to *(b)*, TTT is equal to the lowest value of TTT, this value is suspicious. A logical variable LTCN is set to TRUE.
   (d) If, in addition to *(b)*, TTT is equal to the highest value of TTT, this value is suspicious. A logical variable LTCX is set to TRUE.
   (e) If, in addition to *(b)*, all suspicious differences have the same sign, a logical variable LTCS is set to TRUE.
5. Compare $T_nT_nT_n$ to the corresponding MOS value (TN_{mos}).
   (a) If the absolute value of the difference is greater than 10 °C, $T_nT_nT_n$ is considered wrong and set to NOT DEFINED
   (b) If the absolute value of the difference is greater than 8.5 °C but less than or equal to 10 °C, $T_nT_nT_n$ is suspicious. A logical variable LTN is set to TRUE.
   (c) If the difference has the same sign as in 4(e) <u>and</u> both LTN and LTCS are TRUE, a logical variable LNS is set to TRUE.
6. Compare $T_xT_xT_x$ to the corresponding MOS value (TX_{mos}).
   (a) If the absolute value of the difference is greater than 10 °C, $T_xT_xT_x$ is considered wrong and set to NOT DEFINED
   (b) If the absolute value of the difference is greater than 8.5 °C but less than or equal to 10 °C, $T_xT_xT_x$ is suspicious. A logical variable LTX is set to TRUE.
   (c) If the difference has the same sign as in 4(e) <u>and</u> both LTX and LTCS are TRUE, a logical variable LXS is set to TRUE.

7. The value of $T_nT_nT_n$ is checked by comparing it to the air temperatures TTT between 18 and 6 UTC.
   (a) If there are two or more values of TTT below the minimum temperature, the value of $T_nT_nT_n$ is changed into NOT DEFINED ('/').
   (b) In case only one observation of TTT is below the minimum temperature,
      i. if the difference is less than 0.5°C: the value of $T_nT_nT_n$ is changed into this value
      ii. if the lowest value for TTT occurs at 6 UTC and is not more than 3°C below $T_nT_nT_n$: the value of $T_nT_nT_n$ is changed into this value
      iii. if the lowest value for TTT is higher than the MOS value TN_{mos} the $T_nT_nT_n$ is substituted by the MOS value
      iv. in all other cases; a logical variable LNGT is set to TRUE.
8. Similarly, the maximum temperature $T_xT_xT_x$ is compared to the observed air temperatures TTT between 6 and 18 UTC.
   (a) If there are two or more values of TTT above the maximum temperature, the value of $T_xT_xT_x$ is changed into NOT DEFINED ('/').
   (b) In case only one observation of TTT is above the maximum temperature,
      i. if the difference is less than 0.5°C: the value of $T_xT_xT_x$ is changed into this value
      ii. if the highest value for TTT occurs at 18 UTC and is not more than 3°C above $T_xT_xT_x$: the value of $T_xT_xT_x$ is changed into this value
      iii. if the highest value for TTT is lower than the MOS value TX_{mos} the $T_xT_xT_x$ is substituted by the MOS value
      iv. in all other cases; a logical variable LXLT is set to TRUE.
9. If no MOS value is available, the values of the air temperature TTT between 6 UTC of the day under consideration and 6 UTC of the next day are checked using a temperature curve. This curve is based on the two minimum temperatures and the maximum temperature reported in this period. If one or more of these values are not available they are simulated as follows:
   (a) the minimum temperature $T_nT_nT_n$ is set at a value of 1°C below the air temperature TTT which is observed at the observation time closest to the time of sunrise plus half an hour. If this value is not available, $T_nT_nT_n$ is set at 1°C below the value observed three hours earlier. Furthermore, $T_nT_nT_n$ must be lower than all values of TTT between 18 and 6 UTC. If necessary, the value of $T_nT_nT_n$ is changed into the lowest observed value.
   (b) the maximum temperature $T_xT_xT_x$ is set at 1°C above the air temperature TTT which is observed at the observation time closest to the time of high noon plus two hours. If this value is not available, $T_xT_xT_x$ is set at 2°C above the value of TTT observed three hours later. Furthermore, $T_xT_xT_x$ must exceed all values of TTT between 6 and 18 UTC. If necessary, the value of $T_xT_xT_x$ is changed into the highest observed value.

   Note that these computed values of $T_nT_nT_n$ and $T_xT_xT_x$ are used only for the construction of the temperature curve, but are not stored in the database. The temperature curve is constructed only when values for both minimum temperatures and the maximum temperature could be determined (i.e. none of these values is NOT DEFINED).

   Two instants t1 and t2 are now defined as follows:

   t1 the hour that lies closest to the instant “half an hour after sunrise”

   t2 the hour closest to the instant that lies halfway between “two hours after high noon” and sunset.

   Between t1 and t2, a sine function is used:

$$TTT(t) = T_nT_nT_n + 1^oC + \left[\left(T_xT_xT_x - 1^oC\right) - \left(T_nT_nT_n + 1^oC\right)\right] * \sin(90\frac{t-t_1}{t_2-t_1})$$

where TTT(t) is the air temperature at time t (t1 ≤ t ≤ t2) and $T_nT_nT_n$ is the minimum temperature observed at 6 UTC of the day under consideration.

An exponential curve is used from time t2 until time t3 (=t1 + 24 hours):

$$TTT(t) = TTT(t_2) - \frac{TTT(t_2) - \left(T_nT_nT_n' + 1^oC\right)}{1 - \exp(-3)} * \left[1 - \exp\left(-3\frac{t - t_2}{t_3 - t_2}\right)\right]$$

where t is the observation time (t2 ≤ t ≤ t3) and $T_nT_nT_n'$ is the minimum temperature observed at 6 UTC of the day after the day under consideration.

The observed values of the air temperature TTT are then compared to the values obtained from the temperature curve.

- *(c)* If the absolute value of the difference is greater than 10 °C, TTT is considered wrong and set to NOT DEFINED
- *(d)* If the absolute value of the difference is greater than 8.5 °C but less than or equal to 10 °C, TTT is suspicious. A logical variable LTC is set to TRUE.
- *(e)* If, in addition to *(b)*, TTT is equal to the lowest value of TTT, this value is suspicious. A logical variable LTCN is set to TRUE.
- *(f)* If, in addition to *(b)*, TTT is equal to the highest value of TTT, this value is suspicious. A logical variable LTCX is set to TRUE.
- *(g)* If, in addition to *(b)*, all suspicious differences have the same sign, a logical variable LTCS is set to TRUE.
- *(h)* When there is one TTT below $T_nT_nT_n$ and this TTT differes for more that 8.5 °C from the constructed curve and from the MOS Minimum TN_{mos} the TTT is removed.
- *(i)* When there is one TTT above $T_xT_xT_x$ and this TTT differes for more that 8.5 °C from the constructed curve and from the MOS Maximum TX_{mos} the TTT is removed.

10. If $T_xT_xT_x$ is less than $T_nT_nT_n$, a logical variable LXLN is set to TRUE. This test must be performed for the minimum temperatures of both the night preceding and the one following the day under consideration, using the same value for $T_xT_xT_x$ in both cases.
11. If $T_nT_nT_n$ is 5°C or more below all values for TTT in the corresponding period from 18 until 6 UTC and there are at least 3 of such observations of TTT, a logical variable LTNS is set to TRUE.
12. If $T_xT_xT_x$ is 5°C or more above all values for TTT in the period from 6 until 18 UTC and there are at least 3 of such observations of TTT, a logical variable LTXH is set to TRUE.
13. If $T_nT_nT_n$ is equal for the last 3 days $T_nT_nT_n$ is set to NOT DEFINED.
14. If $T_xT_xT_x$ is equal for the last 3 days $T_xT_xT_x$ is set to NOT DEFINED.
15. Now the outcomes of all tests are combined.
    - *(a)* If both LNGT and LTCN are TRUE and LTN is FALSE: TT_{min} is wrong and set to NOT DEFINED (‘/’). The logical variables LNGT and LTCN are then set to FALSE.
    - *(b)* If both LXLT and LTCX are TRUE and LTX is FALSE: TT_{max} is wrong and set to NOT DEFINED (‘/’). The logical variables LXLT and LTCX are then set to FALSE.
    - *(c)* If both LNGT and LTN are TRUE and LTCN is FALSE: $T_nT_nT_n$ is wrong and set to NOT DEFINED (‘/’). The logical variables LNGT and LTN are then set to FALSE.
    - *(d)* If both LXLT and LTX are TRUE and LTCX is FALSE: $T_xT_xT_x$ is wrong and set to NOT DEFINED (‘/’). The logical variables LXLT and LTX are then set to FALSE.
    - *(e)* If LTNS is TRUE
        - i. If LTN is TRUE: $T_nT_nT_n$ is wrong and set to NOT DEFINED (‘/’). The logical variables LTNS and LTN are then set to FALSE.
        - ii. Else, if the absolute value of the difference between $T_nT_nT_n$ and TNmos is less than 2.5°C, $T_nT_nT_n$ is correct. The logical variable LTNS is then set to FALSE.
    - *(f)* If LTXH is TRUE
        - i. If LTX is TRUE: $T_xT_xT_x$ is wrong and set to NOT DEFINED (‘/’). The logical variables LTXH and LTX are then set to FALSE.

ii. Else, if the absolute value of the difference between $T_xT_xT_x$ and TXmos is less than 2.5°C, $T_xT_xT_x$ is correct. The logical variable LTXH is then set to FALSE.

(g) If LXLN is TRUE <u>and</u> LNGT or LTN is TRUE (or both): $T_nT_nT_n$ is wrong and set to NOT DEFINED ('/'). The logical variables LXLN, LNGT and LTN are then set to FALSE.

(h) If LXLN is TRUE <u>and</u> LXLT or LTX is TRUE (or both): $T_xT_xT_x$ is wrong and set to NOT DEFINED ('/'). The logical variables LXLN, LXLT and LTX are then set to FALSE.

(i) If LNS is TRUE: $T_nT_nT_n$ and TTT are correct. The logical variables LTN and LTC are then set to FALSE.

(j) If LXS is TRUE: $T_xT_xT_x$ and TTT are correct. The logical variables LTX and LTC are then set to FALSE.

(k) If LTC is TRUE:

i. If LTN is TRUE <u>and</u> the deviations of $T_nT_nT_n$ and TTT from their corresponding MOS values have the same sign: $T_nT_nT_n$ and TTT are correct. The logical variables LTN and LTC are then set to FALSE.

ii. If LTX is TRUE <u>and</u> the deviations of $T_xT_xT_x$ and TTT from their corresponding MOS values have the same sign: $T_xT_xT_x$ and TTT are correct. The logical variables LTX and LTC are then set to FALSE.

(l) If LTC is TRUE <u>and</u> LTCN or LTCX is TRUE (or both): TTT is wrong and set to NOT DEFINED ('/'). The logical variables LTC, LTCN and LTCN are then set to FALSE.

(m) If LNGT is TRUE <u>and</u> TT_{min} - 1 < TNmos < TT_{min} <u>and</u> LTN is FALSE: $T_nT_nT_n$ is replaced by TNmos. The logical variable LNGT is then set to FALSE.

(n) If LXLT is TRUE <u>and</u> TT_{max} + 1 > TXmos > TT_{max} <u>and</u> LTX is FALSE: $T_xT_xT_x$ is replaced by TXmos. The logical variable LXLT is then set to FALSE.

(o) In all remaining cases:

i. LTN, LNGT or LTNS is TRUE: TN is suspicious. An error message is written to the log file for the operator to check the value.

ii. LTX, LXLT or LTXH is TRUE: TX is suspicious. An error message is written to the log file for the operator to check the value.

iii. LTC is TRUE: TT is suspicious. An error message is written to the log file for the operator to check the value.

iv. LXLN is TRUE: TN or TX is suspicious. An error message is written to the log file for the operator to check the values.

3.3 Dew point temperature

A number of checks is performed on the dew point temperature values. Through effectively comparing and combining the outcomes of the various checks, the subroutine is to a certain degree capable of drawing conclusions on whether a value is right or wrong. Remaining doubtful cases are left for the operator to decide on.

The following checks are performed:

1. The minimum and the maximum values of the observed hourly dew point temperature $T_dT_dT_d$ of the latest 24-hour period (from 6 UTC until 6 UTC the next day) are calculated: TD_{min} and TD_{max}. If these are equal to each other while there is more than one observation of $T_dT_dT_d$, all dew point values are considered wrong and are discarded, i.e. changed into NOT DEFINED ('/').
2. The observed dew point $T_dT_dT_d$ is checked against the corresponding MOS value, if present.

   - *(a)* If the absolute value of the difference is greater than 15°C, $T_dT_dT_d$ is considered wrong and set to NOT DEFINED.
   - *(b)* If the absolute value of the difference is greater than 11°C but less than or equal to 15°C, $T_dT_dT_d$ is suspicious. The value of priority variable PR is set to '5'.
3. The observed dew point (now called TD2) is checked for great jumps.
   - *(a)* If the observations of both 3 hours earlier (TD1) and 3 hours later (TD3) are present
     - i. If these differ by 8°C or more in absolute value from TD2
       - a. If TD1 and TD3 differ less than 8°C: TD2 is considered wrong and set to NOT DEFINED.
       - b. Else, TD2 is suspicious. The value of priority variable PR is set to '2'.
   - *(b)* If only TD1 is present and it differs by more than 8°C from TD2 (more than 10°C for stations above altitude 750m), TD2 is suspicious. The value of priority variable PR is set to '3'.
   - *(c)* If only TD3 is present and it differs by more than 8°C from TD2 (more than 10°C for stations above altitude 750m), TD2 is suspicious. The value of priority variable PR is set to '4'.
4. The observed dew point $T_dT_dT_d$ is compared to the air temperature TTT at the same time: $T_dT_dT_d$ must be less than or equal to TTT. If not, and:
   - *(a)* $T_dT_dT_d$ exceeds TTT by less than 1.0°C, the value is set equal to the value of TTT.
   - *(b)* Else, the operator must decide whether $T_dT_dT_d$ or TTT is wrong. The value of priority variable PR is set to '1'.
5. An error message is written to the log file. If for a certain hour more than one message should be generated, only the one with the lowest value for PR is written.

3.4 Amount of CL clouds (or CM clouds if no CL clouds present)

The program checks whether the amount of C_L clouds (or C_M clouds if no C_L clouds are present) N_h is less than or equal to the total cloud cover N. When this is not the case the value of N_h is changed to the value of N.

3.5 Amount of precipitation

A number of checks are performed on the precipitation values. The structure of the check is that there are done some basic checks of the precipitation amount and then an analysis is made over the data we have. From several points of few booleans are (re)set. At the end depending on these Booleans messages are generated.
Through effectively comparing and combining the outcomes of the various checks, the subroutine is to a certain degree capable of drawing conclusions on whether a value is right or wrong. Remaining doubtful cases are left for the operator to decide on. The following checks are performed:

1) Precipitation values are checked for all 3-hourly time stamps, both at so-called Main and Intermediate Hours.
2) If a negative precipitation sum is reported, this value is set to NOT DEFINED.
3) When 2 to 5 consecutive observations have the same value (larger than 0.05 mm) a logical variable SUSPICIOUS is set to TRUE.
4) When 6 or more consecutive observations have the same value (larger than .05mm) they are set to NOT DEFINED.
5) If MOS values for the precipitation are not available (RRR_{MOS} for the expected value and $RRRX_{MOS}$ for the maximum expected value): a logical variable LMOS is set to FALSE.

6) Otherwise:
   a) LMOS is set to TRUE.
   b) Calculate SD = 5 * max(0.2mm , RRR_{MOS}).
   c) Then calculate SD = min(SD , max(1.0mm , abs($RRRX_{MOS}$ – RRR_{MOS}))).
   d) If, with RRR_{OBS} being the observed precipitation value:
      i) abs(RRR_{OBS} - RRR_{MOS}) > 6 * SD and
      ii) RRR_{OBS} > 20mm and
      iii) (RRR_{OBS} - RRR_{MOS}) / RRR_{MOS} > 5

      RRR_{OBS} is wrong and set to NOT DEFINED; a logical variable WRONG is set to TRUE. An error message is written to the log file.
   e) Otherwise, if abs(RRR_{OBS} - RRR_{MOS}) > 6 * SD:
      i) If
         (1) RRR_{OBS} > RRR_{MOS} and
         (2) (RRR_{OBS} ≤ 10mm and RRR_{MOS} ≥ 0.5mm) or (RRR_{OBS} ≤ 15mm and RRR_{MOS} ≥ 2.5mm)

         RRR_{OBS} is correct; the logical variable SUSPICIOUS is set to FALSE.
      ii) Otherwise, RRR_{OBS} is possibly wrong; a logical variable SUSPICIOUS is set to TRUE.
7) If RRR_{OBS} reported for the six hour period (i.e. t_R =6) is equal to the amount reported for the twelve hour period (t_R = 12), no further checking is done, as it is unlikely that the same mistake was made twice. A logical variable L12 is set to TRUE. An exception is made for precipitation amounts above 30 millimetres: these amounts must always be checked. In that case, L12 remains FALSE.
8) If there has only been fog in the period t_R and no other source of precipitation (i.e. all ww-codes present are between 40 and 49 and all W1-codes are less than or equal to 4), no more than 1 millimetre of precipitation is allowed. When RRR_{OBS} exceeds this value in such a case, it is set to 0.5mm. An error message is written to the log file.
9) The observed weather conditions (i.e. ww, W1 and W2) are used for some more checks.
   a) If observations for neither ww, W1 nor W2 are available, a logical variable LWW is set to FALSE.
   b) Otherwise, LWW is set to TRUE.
   c) In Table III.1, relative precipitation intensities are given for all values of ww, W1 and W2, which are used when fog is not a source of precipitation or not the only source in the period t_R. For every observation of a station in the period t_R for which at least the present weather ww or the past weather W1 is available, the total precipitation intensity is found by adding the intensities corresponding with ww, W1 and W2. Furthermore, the maximum intensity is determined from ww, W1 or W2. When ww and W1 are not observed or NOT DEFINED ('/'), the total intensity is set to "1" for that particular observation, while the maximum intensity remains "0". Next, the total intensities of all observations of a station in the period t_R are added to give the overall intensity IWSOM and the maximum intensity IWMAX during this period is determined.

Table III.1. *Relative precipitation intensities associated with ww, W1 and W2*

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
ww	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	1	0	0
20	1	1	1	1	1	1	1	1	0	1
30	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
50	1	1	1	1	2	2	1	1	1	1
60	1	1	1	2	3	3	1	2	1	2

70	1	1	1	2	2	3	1	1	1	1
80	1	2	4	1	2	1	2	2	2	3
90	2	2	2	4	4	4	4	4	4	4
W1	0	0	0	0	0	1	1	1	3	4
W2	0	0	0	0	0	1	1	1	3	4

If one of the following criteria is met:

- IWSOM is 8 or more and RRR_{OBS} is less than 30 millimetres
- IWSOM is 7 or more and RRR_{OBS} is 20 millimetres or less
- IWSOM is 6 or more and RRR_{OBS} is 15 millimetres or less
- IWSOM is 5 or more and RRR_{OBS} is 10 millimetres or less
- IWSOM is 4 or more and RRR_{OBS} is 8 millimetres or less
- IWSOM is 3 or more and RRR_{OBS} is 6 millimetres or less
- IWSOM is 2 or more and RRR_{OBS} is 4 millimetres or less
- IWSOM is 1 or more and RRR_{OBS} is 3 millimetres or less
- the amount of precipitation is less than 1 millimetre

When an observation is suspicious and it matches both sum and maximum derived from the observation, then we approve this observation. RRR is considered correct and a logical variable LWS is set to TRUE. Otherwise, when the observation is suspicious and it is not approved by the sum derived from the weather codes in the observation, not the maximum amount, the observation is removed, LWS is set to FALSE.

d) If one of the following criteria is met:

- IWMAX is 4 or more and RRR_{OBS} is less than 70 millimetres
- IWMAX is 3 or more and RRR_{OBS} is 20 millimetres or less
- IWMAX is 2 or more and RRR_{OBS} is 8 millimetres or less
- IWMAX is 1 or more and RRR_{OBS} is 3 millimetres or less

RRR is considered correct and a logical variable LWM is set to TRUE; otherwise, LWM is set to FALSE.

10) Time period consistency is checked. If t_R(HH) is 12, 18 or 24 <u>and</u> t_R(HH-6) = t_R(HH) - 6, with HH the hour of observation <u>and</u> if RRR_{OBS}(HH) < RRR_{OBS}(HH-6) - 0.05mm:
   a) If RRR_{OBS}(HH) < 1mm: RRR_{OBS}(HH) is set equal to RRR_{OBS}(HH-6). An error message is written to the log file.
   b) If RRR_{OBS}(HH-6) > RRR_{OBS}(HH) + 50mm: RRR_{OBS}(HH-6) is wrong and set to NOT DEFINED. An error message is written to the log file.
   c) Otherwise: a logical variable L6 is set to TRUE.
11) Now the outcomes of all tests are combined. If WRONG is FALSE <u>and</u> L12 is FALSE:
   a) If SUSPICIOUS and LWW are both TRUE <u>and</u> LWS and LWM are both FALSE: RRR_{OBS} is wrong and set to NOT DEFINED; an error message is written to the log file. (When the observation is suspicious and it is not approved by the sum derived from the weather codes in the observation, not the maximum amount, remove the observation.)
   b) If SUSPICIOUS is FALSE <u>and</u> LWS or LWM is TRUE: RRR_{OBS} is considered correct. (When an observation is not suspicious and it matches both sum or maximum derived from the observation, then we approve this observation)
   c) If SUSPICIOUS and LWS and LWM are all TRUE: RRR_{OBS} is considered correct; the logical variable SUSPICIOUS is set to FALSE.
   d) If LMOS is FALSE and LWW is FALSE and RRR > 10mm:

the operator must decide; an error message is written to the log file. (When there is no mos to compare the observation and there is no weather code defined to derive an amount, let the meteorologist decide)

e) If SUSPICIOUS is TRUE:
   the operator must decide; an error message is written to the log file.
f) If L6 is TRUE: the operator must decide; an error message is written to the log file.
g) When the observation is 70mm or more, let the meteorologist decide.

3.6 Pressure at sea level

The value of the pressure at sea level PPPP must lie between 950 hPa and 1060 hPa. When PPPP is less than 950 hPa or more than 1060 hPa, the value of PPPP is changed to NOT DEFINED ('/'). Furthermore, the values of the amount of pressure tendency ppp and of the pressure at station level $P_oP_oP_oP_o$ are also changed to NOT DEFINED.

If the pressure at sea level is between 950 and 1060 hPa the pressure tendency ppp is checked: when the absolute value of ppp exceeds 15 hPa per three hours, ppp is changed to NOT DEFINED. Since it is very likely that there are also errors in the pressure at sea level and the pressure at station level, the values of PPPP and $P_oP_oP_oP_o$ are also changed to NOT DEFINED.

Finally, if the pressure at sea level is between 950 and 1060 hPa and the pressure tendency is less than 15 hPa per three hours, PPPP is compared to the observation of three hours before. When the difference between the PPPP of three hours before and the PPPP under consideration exceeds the pressure tendency ppp more than 2 hPa, the values of PPPP, $P_oP_oP_oP_o$ and ppp are changed to NOT DEFINED.

3.7 Wind speed

The actual observations of the wind speed (FF) are compared with the observations that are nearest in time at the same station and with MOS reference values, if available.

First, FF is compared with the observed value of three hours before (or, if not present, 6 hours before). The program checks on a difference (absolute value) in FF of more than 40 knots (or, for stations at a height of more than 750m above mean sea level, 80 knots). If such a difference occurs, FF is considered wrong and is set to NOT DEFINED ('/'). An error message is written to the log file.

If this is not the case, FF is compared to the corresponding MOS value. If the difference (absolute value) is more than 40 knots, FF is considered wrong and is set to NOT DEFINED ('/'). An error message is written to the log file.

In the following of the remaining cases, FF is marked as suspicious:
- the absolute difference with the previous observation (3 or 6 hours before) is more than 25 knots (or, for stations at a height of more than 750m above mean sea level, 40 knots)

- the absolute difference with the corresponding MOS value is more than 25 knots
- FF = 0 and at least one of the following conditions is met:
    - the previous observation (3 or 6 hours before) is greater than 18 knots
    - the following observation (3 or 6 hours after) is greater than 18 knots
    - the corresponding MOS value is greater than 18 knots
- the ratio between FF and the corresponding MOS value lies between 1.75 and 2.25, indicating there could be a coding error concerning the unit of wind speed (meters per second instead of knots or vice versa)

In such cases, the operator must check FF; an error message is written to the log file.

In case no wind speed of three/six hours before/after is known and no MOS value is available, FF is only checked on its value:

- If FF > 80 knots, FF is considered wrong and is set to NOT DEFINED; an error message is written to the log file.
- If FF > 40 knots, FF is considered suspicious and must be checked by the operator; an error message is written to the log file.

3.8 Duration of sunshine

The program checks whether the observed duration of sunshine $55j_2j_3j_4$ exceeds the calculated time between sunrise and sunset.

If the observed sunshine duration is more than 25% longer than this computed day length, the sunshine duration is set at NOT DEFINED ('/'). An error message is written to the log file.

Otherwise, if the observed sunshine duration is more than 6% longer than this computed day length, the sunshine duration is suspicious and has to be checked by the operator. An error message is written to the log file.

If the observed sunshine duration is less than 0.1 hours, the following additional tests are performed:

- If at least one cloud cover observation during the daytime period is less than 7 oktas, the sunshine duration is suspicious and has to be checked by the operator. An error message is written to the log file.
- If no cloud cover observations are available during the daytime period and:
    - The observed daily amount of global radiation is more than 35% of the calculated theoretical maximum for the day and station under consideration, the sunshine duration is suspicious and has to be checked by the operator. An error message is written to the log file.
    - The difference between the minimum and maximum temperature is more than 5C, the sunshine duration is suspicious and has to be checked by the operator. An error message is written to the log file.

3.9 Snow depth

The program checks whether the snow depth value matches either the temperature or the precipitation or the previous observation.

First, the following elements are determined from observations made during the preceding 24-hour period:

TT_{ave}:	average temperature, calculated as the mean of the minimum and maximum temperature
TN:	observed minimum temperature
TX:	observed maximum temperature
RRR12:	amount of precipitation accumulated during the preceding 12 hours
RRR24:	amount of precipitation accumulated during the preceding 24 hours
RRR36:	amount of precipitation accumulated during the preceding 36 hours
RRR48:	amount of precipitation accumulated during the preceding 48 hours
SNOW:	observed actual snow depth
D_SNOW:	difference between the actual snow depth and the observation made 24 hours earlier; if the latter is not available, the actual snow depth is taken

Next, the following tests are done:

- If D_SNOW > 0cm and:
  - TN > 5C: an error message is written to the log file. If the observation time is 18:00 UTC, an additional criterion must be fulfilled, demanding that the actual temperature equals 1C or more. Background: it is not likely that snow is accumulated while temperatures are constantly well above freezing.
  - TTave > 10C: an error message is written to the log file. Background: it is not likely that snow is accumulated while the average temperature lies far above freezing.
  - If <u>all</u> of the following conditions are met:
    - no snow depth observation 24, 36 or 48 hours earlier is available
    - SNOW < 100cm
    - RRR24 < 0.05mm

    the observation is approved, <u>else</u>:
    - If D_SNOW < 0.2*RRR <u>and</u> both TN and TX are less than 0C, an error message is written to the log file. Background: when temperatures are constantly below freezing, all precipitation must result in a corresponding fresh snow layer, not just a small fraction. Normally, 1mm precipitation results in 1cm snow.
    - If D_SNOW > 4*RRR, an error message is written to the log file. Background: fresh snow must originate from precipitation. Normally, 1mm precipitation results in 1cm snow. It is not likely that this ratio is highly exceeded.
  - If D_SNOW < -50cm, the observation is discarded and an information message is written to the log file. Background: a decrease of snow depth of more than 50cm is very unlikely under any circumstance.
  - If SNOW ≥ 900cm <u>and</u> RRR ≥ 200mm, the observation is discarded and an information message is written to the log file. Background: both values are unusually high, which is very unlikely to coincide.
  - If either of the following conditions is met:
    - SNOW ≥ 500cm
    - D_SNOW ≥ 200cm
    - SNOW ≥ 200cm <u>and</u> RRR ≥ 100cm

    SNOW will be marked as suspicious. An information message is written to the log file. Background: the values are unusually high but yet possible.

3.10 Daily global radiation

The program checks whether the observed daily amount of global radiation (RAD24) is in accordance with the minimum and maximum possible amounts. First, the maximum radiation (CRAD), which should occur if the sky would be constantly clear during the day of the observation, is calculated. For this, a formula is used that takes both the date and the geographical latitude into account.

Then, the following tests are performed:

- If RAD24 > 1.25*CRAD, the observation is discarded and an information message is written to the log file. Background: it is unlikely that the amount of radiation exceeds the calculated maximum by more than 25%. Else:
    - If RAD24 < 0.06*CRAD, the observation is discarded and an information message is written to the log file. Background: even under a constantly cloudy sky, it is unlikely that the amount of radiation is less than 6% of the calculated maximum possible amount.
    - If RAD24 > 1.10*CRAD
        - If the observed duration of sunshine (if available) is less than the calculated length of the daylight period minus one hour, RAD24 is wrong and discarded. An error message is written to the log file.
        - If the daytime mean cloud cover (if available) is greater than 4 oktas, RAD24 is wrong and discarded. An error message is written to the log file
        - Otherwise: the operator has to check RAD24. An error message is written to the log file. Background: under certain conditions it is possible that RAD24 exceeds CRAD somewhat.

3.11 Messages

The messages generated by the CHECK program are written to the file REALDATA:CHECK.LOG. In table III.2, the possible messages are described. Note the difference between %I-messages (information messages on automatically corrected errors) and %E-messages (error messages to be handled by an operator).

Table III.2. *Description of the messages generated by the CHECK program*

Message	Description
@I-Check TT: constant Date: <DTG> No : <NO> TTmin : <TTMN> TTmax : <TTMX> TT : <TT>	All temperature values exactly the same (there is more than one value): all discarded and changed to '/'.
@I-Check TN: - sign Date : <DTG> No : <NO> TNold : <TNOLD> TTmin : <TTMIN> TNnew : <TNNEW>	Sign error in minimum temperature: minus sign is automatically changed to plus sign.

Message	Description
@I-Check TN: + sign Date : <DTG> No : <NO> TNold : <TNOLD> TTmin : <TTMIN> TNnew : <TNNEW>	Sign error in minimum temperature: plus sign is automatically changed to minus sign.
@I-Check TT: TT-mos>12 Date : <DTG> No : <NO> TT : <TT> TTmos: <MOS.TT>	Temperature deviates from MOS value by more than 12 degrees. Observation discarded: changed to '/'.
@I-Check TN: TN-mos>12 Date : <DTG> No : <NO> TN : <TN> TNmos: <MOS.TN>	Minimum temperature deviates from MOS value by more than 12 degrees. Observation discarded: changed to '/'.
@I-Check TX: TX-mos>12 Date : <DTG> No : <NO> TX : <TX> TXmos: <MOS.TX>	Maximum temperature deviates from MOS value by more than 12 degrees. Observation discarded: changed to '/'.
@I-Check TN: 2*TT<Tn Date : <DTG> No : <NO> TN : <TN> TTmin: <TTMIN>	At least two hourly temperature values lower than reported minimum. Observed minimum discarded: changed to '/'.
@I-Check TN: 1*TT<Tn Date : <DTG> No : <NO> TN : <TN> TTmin: <TTMIN>	One hourly temperature value lower than reported minimum; difference less than 0.5C. Minimum changed to this hourly value.
@I-Check TN: 1*TT<Tn Date : <DTG> No : <NO> TN : <TN> TTmin: <TTMIN> TT : <TT>	One hourly temperature value lower than reported minimum; observation hour 06 UTC and difference less than 3C. Minimum changed to this hourly value.
@I-Check TX: 2*TT>Tx Date : <DTG> No : <NO> TX : <TX> TTmax: <TTMAX>	At least two hourly temperature values higher than reported maximum. Maximum discarded: changed to '/'.

Message	Description
@I-Check TX: 1*TT>Tx Date : <DTG> No : <NO> TX : <TX> TTmax: <TTMAX>	One hourly temperature value higher than reported maximum; difference less than 0.5C. Maximum changed to this hourly value.
@I-Check TX: 1*TT>Tx Date : <DTG> No : <NO> TX : <TX> TTmax: <TTMAX> TT : <TT>	One hourly temperature value higher than reported maximum; observation hour 18 UTC and difference less than 3C. Maximum changed to this hourly value.
@I-Check TN: TN=TNmos Date : <DTG> No : <NO> TN : <TN> TTmin: <TTMIN> TNmos: <MOS.TN>	Reported minimum temperature changed to MOS value.
@I-Check TX: TX=TXmos Date : <DTG> No : <NO> TX : <TX> TTmax: <TTMAX> TXmos: <MOS.TX>	Reported maximum temperature changed to MOS value.
@I-Check TT: TT-cur>12 Date : <DTG> No : <NO> TT : <TT> TTcur: <TTS>	Temperature deviates from constructed curve value by more than 12 degrees. Observation discarded: changed to '/'.
@I-Check TT: TT<Tn Date : <DTG> No : <NO> TN : <TN> TTmin: <TT>	Temperature value lower than reported minimum and discarded: changed to ‘/’.
@I-Check TT: TT>Tx Date : <DTG> No : <NO> TX : <TX> TTmax: <TT>	Temperature value higher than reported maximum and discarded: changed to ‘/’.
@I-Check TN: 12c Date : <DTG> No : <NO> TN : <TN>	One hourly temperature value lower than reported minimum; minimum deviates from MOS value by more than 8.5C whereas hourly value does not. Minimum is discarded: changed to ‘/’.

Message	Description
@I-Check TX: 12d Date : <DTG> No : <NO> TX : <TX>	One hourly temperature value higher than reported maximum; maximum deviates from MOS value by more than 8.5C whereas hourly value does not. Maximum is discarded: changed to ‘/’.
@I-Check TN: 12e Date : <DTG> No : <NO> TN : <TN>	Minimum temperature lower than lowest hourly value by more than 5C, while less than 3 hourly values absent. Minimum deviates from MOS value by more than 8.5C. Minimum discarded: changed to ‘/’.
@I-Check TX: 12f Date : <DTG> No : <NO> TX : <TX>	Maximum temperature lower than lowest hourly value by more than 5C, while less than 3 hourly values absent. Maximum deviates from MOS value by more than 8.5C. Maximum discarded: changed to ‘/’.
@I-Check TN: 12g Date : <DTG> No : <NO> TN : <TN>	Maximum temperature lower than minimum. One hourly temperature value lower than minimum and minimum deviates from MOS value by more than 8.5C. Minimum discarded: changed to ‘/’.
@I-Check TX: 12h Date : <DTG> No : <NO> TX : <TX>	Maximum temperature lower than minimum. One hourly temperature value higher than maximum and maximum deviates from MOS value by more than 8.5C. Maximum discarded: changed to ‘/’.
@I-Check TN/TT: 12k Date : <DTG> No : <NO> TN : <TN> TNmos: <MOS.TN> TT : <TT>> TTmos: <MOS.TT>	Minimum temperature and at least one hourly value differ from MOS by more than 8.5C. All deviations from MOS have the same sign, for all present temperature values within applicable time interval. No observations changed or discarded.
@I-Check TX/TT: 12k Date : <DTG> No : <NO> TX : <TX> TXmos: <MOS.TX> TT : <TT>> TTmos: <MOS.TT>	Maximum temperature and at least one hourly value differ from MOS by more than 8.5C. All deviations from MOS have the same sign, for all present temperature values within applicable time interval. No observations changed or discarded.
@I-Check TT: 12l Date : <DTG> No : <NO> TT : <TT> TTmos: <MOS.TT>	Hourly temperature deviates from MOS value by more than 8.5C. Minimum or maximum also does. Hourly observation discarded: changed to '/'.

Message	Description
@I-Check TN: 12m Date : <DTG> No : <NO> TTmin: <TTMIN> TNmos: <MOS.TN>	One hourly temperature value lower than reported minimum; MOS minimum temperature lower than this hourly value by less than 1 degree. Minimum changed to MOS value.
@I-Check TX: 12n Date : <DTG> No : <NO> TTmax: <TTMAX> TXmos: <MOS.TX>	One hourly temperature value higher than reported maximum; MOS maximum temperature higher than this hourly value by less than 1 degree. Maximum changed to MOS value.
%E-Check TN: Check Tn Date : <DTG> No : <NO> TN : <TN> TTmin: <TTMIN> TNmos: <MOS(UU).TN>	Reported minimum temperature suspicious; MOS value available. Observation to be checked by meteorologist.
%E-Check TN: Check Tn Date : <DTG> No : <NO> TN : <TN> TTmin: <TTMIN>	Reported minimum temperature suspicious; no MOS value available. Observation to be checked by meteorologist.
%E-Check TX: Check Tx Date : <DTG> No : <NO> TX : <TX> TTmax: <TTMAX> TXmos: <MOS.TX>	Reported maximum temperature suspicious; MOS value available. Observation to be checked by meteorologist.
%E-Check TX: Check Tx Date : <DTG> No : <NO> TX : <TX> TTmax: <TTMAX(UU)>	Reported maximum temperature suspicious; no MOS value available. Observation to be checked by meteorologist.
%E-Check TT: Check TT Date : <DTG> No : <NO> TT : <TT>> TTmos: <MOS.TT>	Reported hourly temperature suspicious; MOS value available. Observation to be checked by meteorologist.
%E-Check TT: Check TT Date : <DTG> No : <NO> TT : <TT>> Curve: <TTS(UU)>	Reported hourly temperature suspicious; no MOS value available. Observation to be checked by meteorologist.

Message	**Description**
@I-Check TD: constant Date: <DTG> No : <NO> TDmin: <TDMN> TDmax: <TDMX> TD : <TD>	All dew-point temperature values exactly the same (there is more than one value): all discarded and changed to '/'.
@I-Check TD: mos Date: <DTG> No : <NO> TD : <TD> TDmos: <MOS.TD>	Dew-point temperature deviates from MOS value by more than 15C. Observation discarded: changed to '/'.
@I-Check TD: jump Date : <DTG> No : <NO> TD-3 : <TD1> TD : <TD2> TD+3: <TD3>	Dew-point temperature deviates by 8C or more from dew-point temperature three hours before and three hours after, while the latter two values differ less than 8C: dew-point temperature automatically changed to '/'.
@I-Check TD: TD > TT Date : <DTG> No : <NO> TD : <TD> TT : <TT>	Dew-point temperature exceeds air temperature by 1C or less: dew-point temperature automatically changed to air temperature.
%E-Check TD: TD > TT Date : <DTG> No : <NO> TD : <TD> TT : <TT>	Dew-point temperature exceeds air temperature by more than 1C. Observation to be checked by meteorologist.
%E-Check TD: jump Date : <DTG> No : <NO> TD-3 : <TD1> TD : <TD2> TD+3: <TD3>	Dew-point temperature deviates by 8C or more from dew-point temperature three hours before and three hours after, while the latter two values differ at least 8C. Observation to be checked by meteorologist.
%E-Check TD: jump Date : <DTG> No : <NO> TD-3 : <TD1> TD : <TD2>	Dew-point temperature differs more than 8C from dew-point temperature three hours before. Observation to be checked by meteorologist.
%E-Check TD: jump Date : <DTG> No : <NO> TD : <TD2> TD+3 : <TD3>	Dew-point temperature differs more than 8C from dew-point temperature three hours later. Observation to be checked by meteorologist.

Message	Description
%E-Check TD: mos Date: <DTG> No : <NO> TD : <TD> Mos : <MOS.TD>	Dew-point temperature deviates from MOS value by more than 11C, but no more than 15C. Observation to be checked by meteorologist.
@I-Check DD: DD > 360 Date: <DTG> No : <NO> DD : <DD> FF : <FF>	Wind direction greater than 360 degrees: changed automatically to '/'.
@I-Check FF: d(u-3)>40 or 80 Date: <DTG> No : <NO> FF-3: <FF-3> or <FF-6> FF : <FF>	Wind speed increased by more than 40 knots (or 80 knots for mountain stations) compared to three (or six) hours before: changed automatically to '/'.
@I-Check FF: d(mos)>40 Date: <DTG> No : <NO> FF : <FF> Mos : <MOS.FF>	Wind speed deviates by more than 40 knots from MOS value: changed automatically to '/'.
%E-Check FF: d(u-3)>25 or 40 Date: <DTG> No : <NO> FF-3: <FF-3> or <FF-6> FF : <FF>	Wind speed increased by 25-40 knots (or by 40-80 knots for mountain stations). Observation to be checked by meteorologist.
%E-Check FF: d(mos)>25 Date: <DTG> No : <NO> FF : <FF> Mos : <MOS.FF>	Wind speed deviates by 25-40 knots from MOS value. Observation to be checked by meteorologist.
%E-Check FF: 0 d(u-3) Date: <DTG> No : <NO> FF-3: <FF-3> FF : <FF>	Wind speed equal to zero, but higher than 18 knots three (or six) hours before. Observation to be checked by meteorologist.
%E-Check FF: 0 d(u+3) Date : <DTG> No : <NO> FF : <FF> FF+3: <FF+3>	Wind speed is equal to zero, but is higher than 18 knots three (or six) hours later. Observation to be checked by meteorologist.
%E-Check FF: 0 d(mos) Date: <DTG> No : <NO> FF : <FF> Mos : <MOS.FF>	Wind speed is equal to zero, but MOS value is higher than 18 knots. Observation to be checked by meteorologist.

Message	Description
%E-Check FF: kts-mps? Date: <DTG> No : <NO> FF : <FF> Mos : <MOS.FF>	Wind speed deviates by more than 20 knots from MOS value. Difference is approximately factor 2 and could be due to wrong unit for wind speed (knots instead of meters per second or vice versa). Observation to be checked by meteorologist.
@I-Check NH: NH > N Date: <DTG> No : <NO> N : <N> NH : <NH>	Amount of CL (or CM) clouds exceeds total cloud cover: value changed automatically to value of total cloud cover.
@E-Check RRR: <0 Date: <DTG> No : <NO> TR : <TR> RRR : <RRR>	Precipitation amount less than zero. Observation discarded: changed to '/'.
%E-Check RRR: >140 Date: <DTG> No : <NO> RRR: <RRR>	Precipitation amount greater than 140 millimetres. Observation marked as suspect and to be checked by meteorologist.
@I-Check RRR: mos Date: <DTG> No : <NO> RRR: <RRR> Mos : <MOS.RRR>	Precipitation amount equal to 20 millimetres or more and deviates too much from MOS value. Observation discarded: changed to '/'.
@I-Check RRR: fog Date: <DTG> No : <NO> TR : <TR> RRR: <RRR>	Fog is only source of precipitation in period t_R and precipitation amount is more than 1 millimetre. Observation discarded: changed to '/'.
@I-Check RRR: -6 Date: <DTG> No : <NO> RRR-6: <RRR-6> RRR : <RRR>	Amount of precipitation reported six hours ago is less than 1 millimetre, but exceeds current amount while the latter should include the former. Value of six hours ago automatically changed to current value.
@I-Check RRR: 50 Date: <DTG> No : <NO> RRR-6: <RRR-6> RRR : <RRR>	Amount of precipitation reported six hours ago exceeds current amount of precipitation by more than 50 millimetres: value of six hours ago is automatically changed to '/'.
%E-Check RRR: -6 Date: <DTG> No : <NO> RRR-6: <RRR-6> RRR : <RRR>	Amount of precipitation reported six hours ago at least 1mm and exceeds current amount while the latter should include the former, but by no more than 50mm. Observation to be checked by meteorologist.
@I-Check RRR: MOS/WW	Amount of precipitation does not match MOS

Date: <DTG> No : <NO> TR : <TR> RRR : <RRR> Mos : <MOS.RRR> IWmax: <IWMAX> IWsom: <IWSOM>	value and does not correspond with reported weather type (precipitation intensity). Observation discarded: changed to '/'.

Message	Description
%E-Check RRR:no mos/wx Date: <DTG> No : <NO> RRR: <RRR>	Amount of precipitation greater than 10 millimetres; no MOS value or reported weather type available. Observation to be checked by meteorologist.
%E-Check RRR: mos Date: <DTG> No : <NO> RRR: <RRR> Mos : <MOS.RRR> IWmax: <IWMAX> IWsom: <IWSOM>	Amount of precipitation suspicious, but not definitely wrong. Observation to be checked by meteorologist.
@I-Check PPP: Date: <DTG> No : <NO> PPP: <VALUE>	Pressure at sea level is less than 950hPa or more than 1060hPa: values of pressure at sea level, pressure at station level and pressure tendency changed to '/'.
@I-Check APP: Date: <DTG> No : <NO> APP: <VALUE>	Pressure tendency exceeds 15hPa per three hours: values of pressure at sea level, pressure at station level and pressure tendency changed to '/'.
@I-Check PPP: app Date: <DTG> No : <NO> PPP-3: <PPP-3> APP : <APP> PPP : <PPP>	Difference between pressure at sea level with value of three hours before exceeds pressure tendency with more than 2hPa: values of pressure at sea level, pressure at station level and pressure tendency changed to '/'.
@I-Check SUN: > 25% Date: <DTG> No : <NO> SUN: <SUN> DAYL: <DAYL>	Observed sunshine duration exceeds the calculated day length by more than 25%: sunshine duration automatically changed to '/'.
%E-Check SUN: < 25% Date: <DTG> No : <NO> SUN: <SUN> DAYL: <DAYL>	Observed sunshine duration exceeds the calculated day length by less than 25%, but more than 6%. Observation to be checked by meteorologist.
@I-Check SNOW: >900 Date: <DTG> No : <NO> Snow: <Snow depth> RRR: <Precipitation amount>	Unusually high observed snow depth, coinciding with unusually high precipitation amount; automatically changed to '/'.
@I-Check SNOW: jump Date: <DTG> No : <NO> Snow: <Snow depth> Snow-1: <Snow depth yesterday>	Unlikely jump of snow depth (decrease by more than 50cm): observed snow depth automatically changed to '/'.

Message	Description
%E-Check SNOW: >500 Date: <DTG> No : <NO> Snow: <Snow depth>	Unusually high observed snow depth, but still possible. Observation to be checked by meteorologist.
%E-Check SNOW+: >200 Date: <DTG> No : <NO> Snow: <Snow depth> Snow+: <Change of snow depth>	Unusually high increase of snow depth, but still possible. Observation to be checked by meteorologist.
%E-Check SNOW: >200 Date: <DTG> No : <NO> Snow: <Snow depth> RRR: <Precipitation amount>	Unusually high observed snow depth in combination with unusually high precipitation amount, but still possible. Observation to be checked by meteorologist.
%E-Check SNOW: TN > 5 Date: <DTG> No : <NO> Snow: <Snow depth> TN: <Minimum temperature>	Too warm conditions for increase of snow depth (minimum temperature above 5C). Observation to be checked by meteorologist.
%E-Check SNOW: TTave>10 Date: <DTG> No: <NO> Snow: <Snow depth> TTave: <Average temperature>	Too warm conditions for increase of snow depth (average temperature above 10C). Observation to be checked by meteorologist.
%E-Check SNOW: <RRR*.2 Date: <DTG> No: <NO> Snow+: <Snow depth> RRR: <Precipitation amount>	Too small increase of snow depth: less than 0.2 times the corresponding amount of precipitation, under constantly freezing conditions. Observation to be checked by meteorologist.
%E-Check SNOW: >RRR*4 Date: <DTG> No: <NO> Snow+: <Snow depth> RRR: <Precipitation amount>	Too large increase of snow depth: more than 4 times the corresponding amount of precipitation. Observation to be checked by meteorologist.
@I-Check RAD: > 125% Date: <DTG> No : <NO> RAD: <RAD24> RDMax: <CRAD>	Unlikely high value for daily global radiation, exceeding calculated maximum possible amount by more than 25%: observation automatically changed to ‘/’.
@I-Check RAD: < 10% Date: <DTG> No : <NO> RAD24: <RAD24> RDMax: <CRAD>	Unlikely low value for daily global radiation, less than 6% of the calculated maximum possible amount: observation automatically changed to ‘/’.

Message	Description
@I-Check RAD: dayl Date: <DTG> No : <NO> RAD24: <RAD24> RDmax: <CRAD> DayL: <DAYL> Sun : <SUN>	High value for daily global radiation, exceeding the calculated maximum possible amount by more than 10% but less than 25%, while sunshine duration more than 1 hour below calculate daylight period: observation automatically changed to '/'.
@I-Check RAD: n>4 Date: <DTG> No : <NO> RAD24: <RAD24> RDmax: <CRAD> N : <N>	High value for daily global radiation, exceeding the calculated maximum possible amount by more than 10% but less than 25%, while average cloud cover greater than 4 oktas: observation automatically changed to '/'.
%E-Check RAD: < 110% Date: <DTG> No: <NO> RAD24: <RAD24> RDMax: <CRAD>	Suspiciously high value for daily global radiation, exceeding the calculated maximum possible amount by more than 10% but less than 25%. Observation to be checked by meteorologist.

4 Observation control

4.1 Introduction

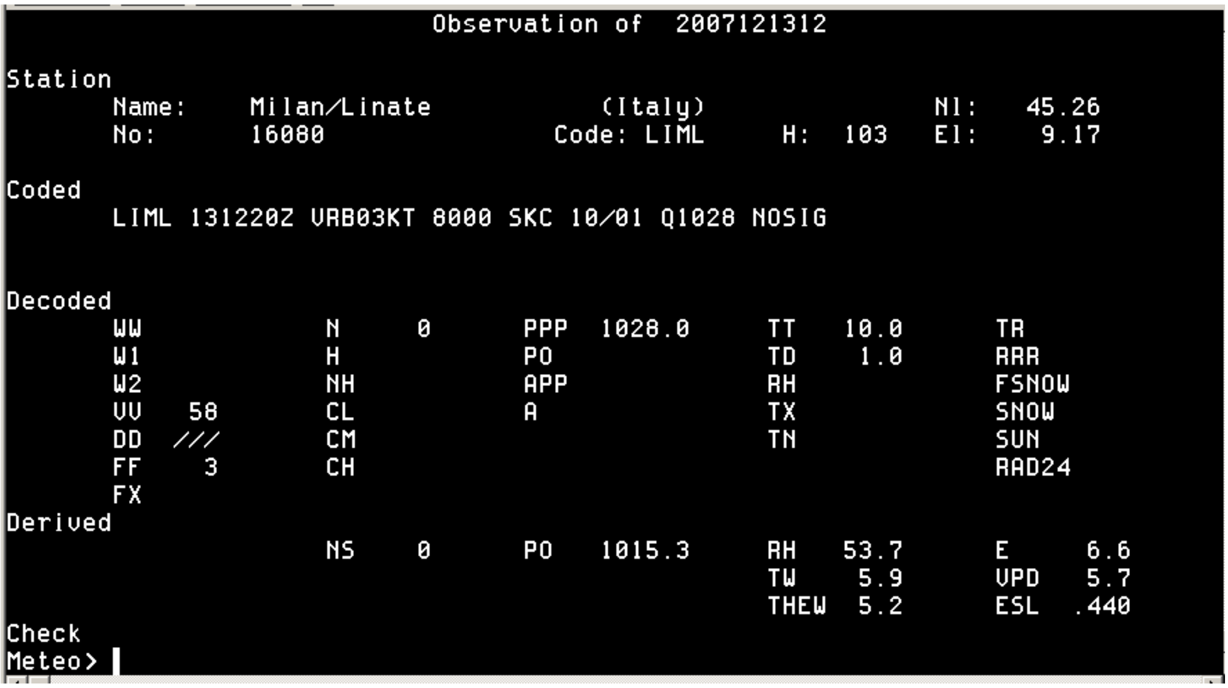
The program **OBSCON** offers the operator the possibility of viewing coded (stored in the database CODED), decoded and derived element values (both stored in the database DECODED). Furthermore, errors which were not automatically corrected by the CHECK program can be displayed, and if necessary values can be added to or modified in the database DECODED. For the representation of the data it is possible to choose various lay-outs.

4.2 Screen lay-outs

Four lay-out types are available for the representation of the decoded and derived element values: *station observation*, *diagram*, *map* and *table*.

4.2.1 Station observations

This lay-out displays the decoded and derived element values of a single station for a selected date and time on the screen. An example is given in Fig. 4.1.
At the top of the screen the date and time of the observation is given (YYMMDDHH in UTC). Below this some station information is listed: station name, number, code, geographical coordinates (N.L. and E.L. are positive) and the altitude above sea level (H in metres). Next the (enhanced) coded observation (stored in the database CODED) and the decoded observation (stored in the database DECODED) are given. Finally, the derived parameters are listed (also stored in the database DECODED).
Observations coded with NO OBSERVATION (POSSIBLE) and parameters which could not be derived due to these missing data are represented by forward slashes '///'. The symbols **c**, **s** and **t** behind element values denote that the coded value is automatically corrected by the program CHECK (c) or the value is obtained through interpolation in time (t). Observation elements which are not coded get no value at all.
Note that it is possible to have a decoded observation without a corresponding coded observation because of the interpolations performed.



```
                            Observation of  2007121312

Station
       Name:    Milan/Linate          (Italy)                Nl:   45.26
       No:      16080              Code: LIML     H:  103   El:    9.17

Coded
       LIML 131220Z VRB03KT 8000 SKC 10/01 Q1028 NOSIG


Decoded
       WW            N     0      PPP  1028.0     TT   10.0      TR
       W1            H            PO              TD    1.0      RRR
       W2            NH           APP             RH             FSNOW
       VV    58      CL           A               TX             SNOW
       DD   ///      CM                           TN             SUN
       FF     3      CH                                          RAD24
       FX
Derived
                     NS    0      PO   1015.3     RH   53.7      E     6.6
                                                  TW    5.9      VPD   5.7
                                                  THEW  5.2      ESL   .440
Check
Meteo>
```

Fig. 4.1. *Example of a station observation*

4.2.2 Diagrams

This lay-out shows a diagram of the values of a single element during the past seven days for a selected station. The Y-axis of the diagram automatically adapts itself to the values represented. An example is presented in Fig. 4.2.

Above the diagram some station information is listed: station name, number, code, geographical coordinates (N.L. and E.L. are positive) and the altitude above sea level (H in metres). Below the station information the selected element (observed or derived) is shown.

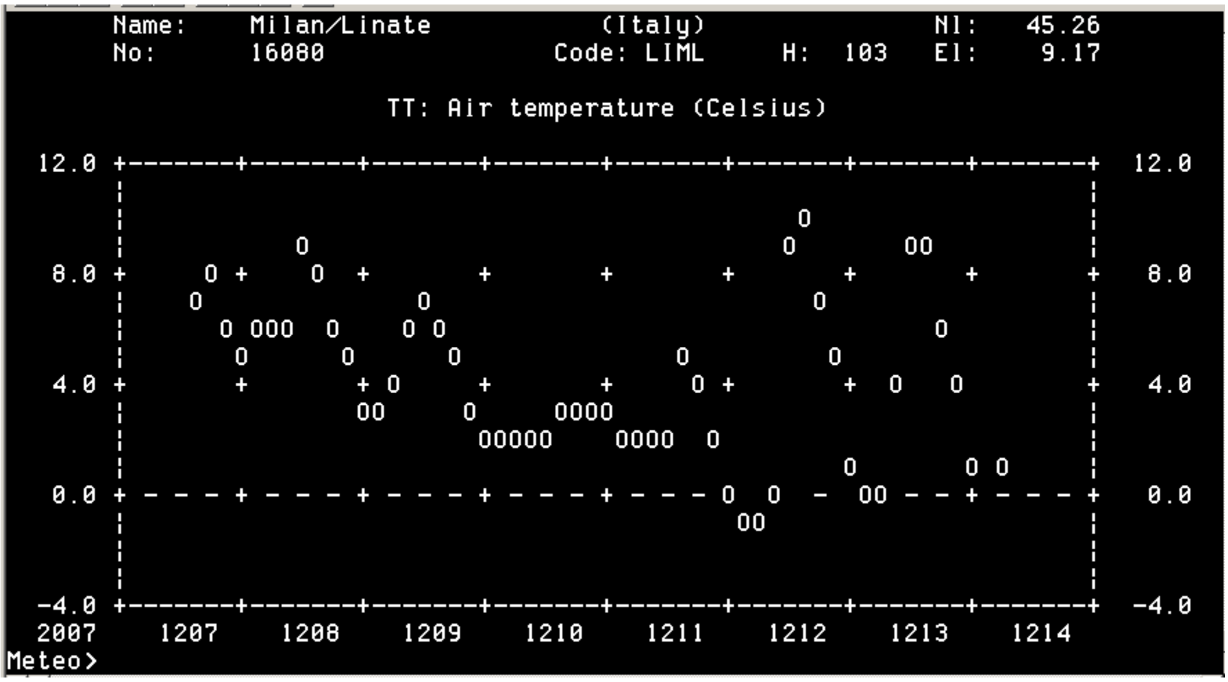


Fig. 4.2. *Example of a diagram*

4.2.3 Maps

This lay-out shows a geographical map with values of a single element for a selected date and time on the screen. Several maps are available (see section 4.4.11.). An example is given in Fig. 4.3.
In the heading of the map the date and time of the observation (YYMMDDHH in UTC), the selected map and the selected element (observed or derived) are shown.

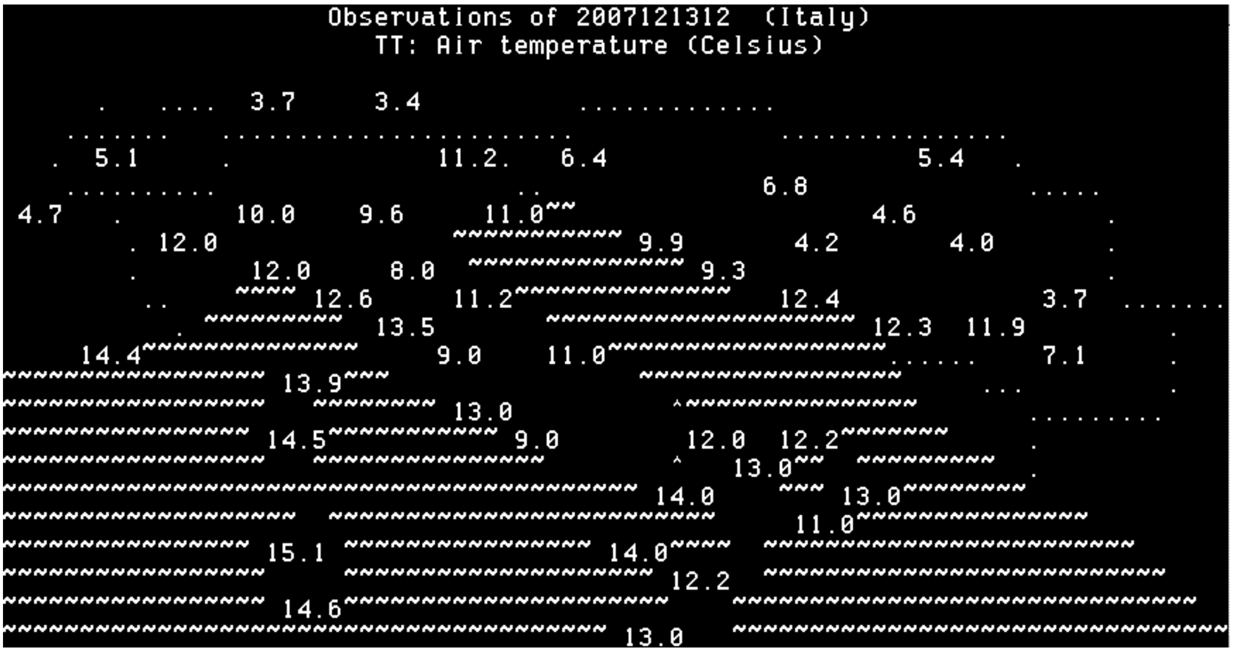


Fig. 4.3. *Example of a map*

4.2.4 Tables

This lay-out displays a table of 3-hourly values of a single element on the screen. Several tables are available, each with a different selection of stations. In Fig. 4.4. an example of a table is given.
In the heading of the table the specified date and time (YYMMDDHH in UTC), the selected table and the selected element (observed or derived) are displayed. In a table the stations are listed according to station number, and observations are shown back to 24 hours from the selected date-time.
When a table contains more information than can be displayed on a screen, the <RETURN>-key or the <Q>-key must be pressed: <RETURN> displays the rest of the table and <Q> terminates displaying the table.

Observations of 2007121312 (Italy)
TT: Air temperature (Celsius)

No\Date	1212	1215	1218	1221	1300	1303	1306	1309	1312
13452	13.4	10.9	10.2	10.0	9.7	9.6	8.9	10.9	12.3
13462	11.0	8.9	9.7	9.6	9.3	9.6	8.9	10.8	11.9
13586	6.8	6.3	5.9	5.2	5.7	5.8	5.7	7.3	7.1
16045	6.4	6.8						6.6	11.2
16059	11.8	11.1	5.7	1.7	.4	1.0	-.2	1.2	12.0
16080	8.7	9.9	6.6	4.8	1.2	-.4	.2	3.5	10.0
16090	4.6	6.2	4.0	3.4	2.8	1.8	-.4	1.4	9.6
16105	3.6	5.5	4.2	3.9	2.5	1.7	2.3	4.2	11.0
16120	13.1	14.0	11.4	11.5	10.5	9.7	11.2	10.3	12.0
16140	8.7	8.0	6.5	6.0	4.0	1.9	2.0	4.9	8.0
16149	6.0	6.5	8.6	7.8	11.1	10.8	11.0	11.2	11.2
16158	10.8	12.0	8.0	4.8	5.4	4.4	.6	4.6	12.6
16170	13.8	12.0	7.5	4.6	7.0	2.6	11.3	12.4	13.5
16181	9.0	8.0	5.0	6.0			6.0	7.0	9.0
16191	7.5	8.1	10.3	10.4	10.4	10.2	9.8	10.7	11.0
16242	13.1	11.7	8.7	7.9	7.4	7.3	6.8	10.0	13.0
16252	3.8	2.8	1.8	1.8	1.4	1.0	1.4		
16270	8.6	10.8	10.6	7.3	7.5	7.4	7.1	9.7	12.0

Meteo> Press <Return> to continue and <Q> to quit ...

Fig. 4.4. *Example of a table*

4.3 Observation elements and derived elements

In table IV.1 a list of observation elements and derived elements available in the OBSCON program is given.

Table IV.1. *Available elements in the OBSCON program*

Element	Description	Units
Observed		
NO	Station number	code
H	Height of the base of the lowest cloud	code
VV	Horizontal visibility	code
N	Total cloud cover	oktas
DD	Wind direction (not in maps)	degrees
FF	Wind speed (at 10 metres)	knots
DDFFF	Wind direction and speed (in maps)	tens of degrees and knots
TT	Air temperature	°C
TD	Dew-point temperature	°C
RH	Relative humidity	%
PO	Pressure at station level	hPa
PPP	Pressure at sea level	hPa
A	Characteristic of pressure tendency during the three hours preceding observation time	code
APP	Amount of pressure tendency at station level during the three hours preceding observation time	hPa
RRR	Amount of precipitation fallen during the period preceding observation time as indicated by TR	millimetres

Element	Description	Units
TR	Duration of period of reference for amount of precipitation	hours
WW	Present weather	code
W1	Past weather	code
W2	Past weather	code
NH	Amount of CL clouds present or, if no CL cloud is present, the amount of CM clouds	oktas
CL	Clouds of genera Stratocumulus, Stratus, Cumulus and Cumulonimbus	code
CM	Clouds of genera Altocumulus, Altostratus and Nimbostratus	code
CH	Clouds of genera Cirrus, Cirrocumulus and Cirrostratus	Code
TX	Maximum temperature	°C
TN	Minimum temperature	°C
SUN	Duration of sunshine	hours
E	State of the soil	Code
Derived		
D_PO	Pressure at station level	hPa
D_TW	Wet bulb temperature	°C
D_THEW	Wet bulb potential temperature	°C
D_NS	Amount of shadow clouds	oktas
D_RH	Relative humidity	%
D_E	Vapour pressure	hPa
D_VPD	Vapour pressure deficit	hPa
D_ESL	Slope of the saturation vapour pressure vs. temperature curve	hPa/°C

4.4 Commands

4.4.1 ADD

Command: ADD [ELEMENT] [NEWVALUE] <*RETURN*>

This command adds a value to the database DECODED. The commands STATION and DATE are used to set the pointer at the observation to which the value has to be added. [ELEMENT] specifies the *observation* element (see section 4.3.) and [NEWVALUE] is the value to be added. Added element values are denoted by the character **m** behind the element value. Values for derived elements can not be added to an observation.
When an element already has a value or is not defined (i.e. denoted by '///'), the command MODIFY can be used to change this value.

4.4.2 BACK

Command: BACK <*RETURN*>

Abbreviation: BA

This command returns the observation of the first available station with a lower station number. It only works if the screen lay-out is a station observation or a diagram.

4.4.3 BEGIN

Command: BEGIN <*RETURN*>

Abbreviation: BE

This command only works after the command CHECK has been entered (see also there) and returns the observation of the first error message from the file REALDATA:CHECK.LOG created by the check program. It displays the message on the bottom line of the screen with the corresponding observation. The sequential number of this message must read "1".

4.4.4 CHECK

Command: CHECK <*RETURN*>

Abbreviation: CH

This command reads the error messages of not automatically corrected errors from the file REALDATA:CHECK.LOG created by the check program and displays each message on the bottom line of the screen with the corresponding observation and a sequential number. The operator can decide to add or modify data in the database DECODED using the ADD or MODIFY command. To continue to the next error message the operator must type FOLLOWING (abbr.: FO). In order to go back to the previous message, the command PREVIOUS (abbr.: PR) must be used. The command CURRENT (abbr.: CU) can be used to show the station observation of the current error message. Using the command BEGIN, the operator can go to the first error message. By entering the command END, he/she can go to the last error message. This allows him/her to see the total number of error messages to be checked, as this is equal to the sequential number of the last message. See Section 3.9 for an explanation of the error messages.

4.4.5 DATE

Command: DATE [YYMMDDHH] <*RETURN*>

Abbreviation: DA, DTG

This command initializes the program to show the information of a specified date and time (in UTC). If this parameter is not specified the program is initialized at the most recent date and time for which data are available in the database. It is allowed to specify only part of the parameter (i.e. HH, DDHH or MMDDHH). Then the program completes the parameter requiring the result to be the most recent date-time group compared to the last date and time for which data are available in the database. Furthermore, time can be changed by adding or subtracting hours from the current time using

Input: DTG [II] <*RETURN*>

where [II] represents a positive or a negative integer value.

Examples: DTG 91030112, DA 6, DTG -3, DA +18

4.4.6 DELETE

Command: DELETE [ELEMENT] [OLDVALUE] <*RETURN*>

Abbreviation: DEL

This command removes the value [OLDVALUE] of observation element [ELEMENT] of the observation selected with the commands STATION and DATE from the database DECODED. Values of derived elements can not be removed. To delete the complete observation [ELEMENT] must be set to *ALL*, in which case [OLDVALUE] needs not to be specified.

4.4.7 DIAGRAM

Command: DIAGRAM <*RETURN*>

Abbreviation: DI

This command initializes the program to show a diagram of the observations of the past seven days selected with the commands STATION and ELEMENT. Default a diagram of the air temperature is displayed.

4.4.8 ELEMENT

Command: ELEMENT [ELEMENT] <*RETURN*>

Abbreviation: EL

This command returns the values of the element specified by [ELEMENT] (see section 4.3.), and is used for diagrams, maps and tables.

4.4.9 END

Command: END <*RETURN*>

Abbreviation: EN

This command only works after the command CHECK has been entered (see also there) and returns the observation of the last error message from the file REALDATA:CHECK.LOG created by the check program. It displays the message on the bottom line of the screen with the corresponding observation. The sequential number of this message is equal to the total number of error messages to be checked.

4.4.10 EXIT/QUIT

Command: EXIT <*RETURN*>
QUIT <*RETURN*>

Abbreviation: EX, QU

These commands end the program.

4.4.11 FIRST

Command: FIRST <*RETURN*>

Abbreviation: FI

This command returns the observation of the first station in the database DECODED for the date-time specified with the command DATE. It only works if the screen lay-out is a station observation or a diagram.

4.4.12 FOLLOWING

Command: FOLLOWING <*RETURN*>

Abbreviation: FO

This command only works after the command CHECK has been entered (see also there) and returns the observation of the following error message from the file REALDATA:CHECK.LOG created by the check program.

4.4.13 HELP

Command: HELP <*RETURN*>

Abbreviation: HE

This command returns general information about the program OBSCON. Specific information about the commands can be obtained by typing

Input: HELP [COMMAND] <*RETURN*>

4.4.14 LAST

Command: LAST <*RETURN*>

Abbreviation: LA

This command returns the observation of the last station in the database DECODED for the date-time specified with the command DATE. It only works if the screen lay-out is a station observation or a diagram.

4.4.15 MAP

Command: MAP [NAME] <*RETURN*>

This command initializes the program to display a geographical map with observations for the date and time specified with the command DATE. Default a map with air temperatures is displayed, but other elements can be chosen using the command ELEMENT. A particular map is selected with [NAME]. The options are listed in table IV.2.

Table IV.2. *Available maps*

[NAME]	**Map**
AUS	Austria
BEL	Belgium and Luxemburg
FRA	France
GER	Federal Republic of Germany
GRE	Greece
ITA	Italy
NET	The Netherlands
SCA	Scandinavia
SPA	Spain and Portugal
SWI	Switzerland
UK	United Kingdom and Ireland

4.4.16 MODIFY

Command: MODIFY [ELEMENT] [OLDVALUE] [NEWVALUE] <*RETURN*>

Abbreviation: M

This command modifies a value in the database DECODED. The commands STATION and DATE are used to set the pointer at the observation in which a value has to be modified. [ELEMENT] specifies the *observation* element (see section 4.3.), and [OLDVALUE] is the old value which has to be changed into the new value [NEWVALUE]. Values of derived elements can not be modified. Modified element values are denoted by the character **m** behind the value. If no correct value is available for a wrong element value, it is better to modify it into NOT DEFINED using the forward slash '/' than to delete it from the decoded observation. In case an observation element is not present (i.e. has no value and is not denoted by '///'), the command ADD can be used to add this element to the database.

4.4.17 NEXT

Command: NEXT <*RETURN*>

Abbreviation: NE

This command returns the observation of the first available station with a higher station number. It only works if the screen lay-out is a station observation or a diagram.

4.4.18 OBSERVATION

Command: OBSERVATION <*RETURN*>

Abbreviation: OB

This command initializes the program to show the observation of a single station selected with the command STATION for the date and time specified with the command DATE.

4.4.19 PREVIOUS

Command: PREVIOUS <*RETURN*>

Abbreviation: PR

This command only works after the command CHECK has been entered (see also there) and returns the observation of the previous error message from the file REALDATA:CHECK.LOG created by the check program.

4.4.20 SHOW

Command: SHOW <*RETURN*>

Abbreviation: SH

This command returns the last requested data back on the screen. It is especially implemented to return from the help facility to the data.

4.4.21 STATION

Command: STATION [IDENTIFICATION] <*RETURN*>

Abbreviation: ST

This command returns the observation of a particular station selected with the parameter

[IDENTIFICATION]. [IDENTIFICATION] must be a station number (four or five digits) or a station code [four characters].

Examples: ST 6260, ST 16080, ST EHAM

4.4.22 TABLE

Command: TABLE [NAME] <*RETURN*>

Abbreviation: TA

This command initializes the program to show a table with the observations back to 24 hours from the datetime specified with the command DATE. Default a table with air temperatures is displayed, but other elements can be selected using the command ELEMENT. A particular table is specified with [NAME]. The options for [NAME] are listed in table IV.3.

Table IV.3. *Available tables*

[NAME]	**Table**
AUS	Austria
BEL	Belgium and Luxemburg
FRA	France
GER	Federal Republic of Germany
GRE	Greece
ITA	Italy
NET	The Netherlands
SCA	Scandinavia
SPA	Spain and Portugal
SWI	Switzerland
UK	United Kingdom and Ireland

5 Computation of missing values

5.1 Introduction

The program **INTER** tries to fill up gaps in the database DECODED through interpolation based on time consistency of the data. INTER must only be used after the observations are checked and corrected with CHECK and OBSCON. The interpolation procedure is only performed for those stations which will be selected for the AMD (i.e. the stations marked with S in the list).

5.2 Interpolation in time

For the interpolation in time the observations of the AMD stations between 18 UTC of the foregoing day and 12 UTC of the next day (i.e. a 42-hour period) are retrieved from the database DECODED. The interpolation is performed for the following elements: air temperature (including computation of maximum and minimum temperature), dew-point temperature, wind speed, total cloud cover, amount of C_L clouds (or C_M clouds if no C_L clouds are present) and pressure at sea level. The interpolation procedures are described in sections 5.1.1 - 5.1.6. After the interpolation the derived parameters are computed and all new values are stored in the database DECODED.

5.2.1 Air temperature, maximum temperature and minimum temperature

Missing values for the minimum and maximum temperature are calculated from air temperature values as follows:

- the minimum temperature is set at a value of 1°C below the air temperature which is observed at the observation time closest to the time of sunrise plus half an hour. When this value is not available te minimum temperature is set at 1°C below the value observed three hours before. Furthermore, the minimum temperature must be lower than all values of air temperature between 18 and 6 UTC and if necessary the value of the minimum temperature is changed to the lowest observed value. In case both values of air temperature near sunrise are not available the minimum temperature is set at NOT DEFINED;
- the maximum temperature is set at 1°C above the air temperature which is observed at the observation time closest to the time of high noon plus two hours. When this value is not available the maximum temperature is set at 2°C above the value of air temperature observed three hours later. Furthermore, the maximum temperature must exceed all values of air temperature between 6 and 18 UTC and if necessary the value of the maximum temperature is changed to the highest observed value. In case both values of air temperature near high noon plus two hours are not available the maximum temperature is set at NOT DEFINED.

To obtain values for missing air temperatures a temperature curve between 6 UTC of the day under consideration and 6 UTC of the next day is constructed. This curve can only be constructed when values for the minimum and maximum temperature of the day under consideration and for the minimum temperature of the next day are available (i.e. none of these values is NOT DEFINED).
From the whole hour closest to the time of sunrise plus half an hour (t_1) until the whole hour closest to half way between high noon plus two hours and sunset (t_2) a sine function is used:

$$TT(t) = TN + 1°C + ((TX - 1°C) - (TN + 1°C))\sin\left(90\frac{t - t_1}{t_2 - t_1}\right) \quad 1$$

where TT(t) is the air temperature at time t ($t_1 \leq t \leq t_2$) and TN the minimum temperature observed at 6 UTC of the day under consideration. An exponential curve is used from time t_2 until time t_1 + 24 hours (t_3):

$$TT(t) = TT(t_2) - \frac{(TT(t_2) - (T'N + 1°C))}{1 - \exp(-3)} \left(1 - \exp\left(-3 \frac{(t - t_2)}{(t_3 - t_2)} \right) \right) 2$$

where t is the observation time ($t_2 \leq t \leq t_3$) and TN' is the minimum temperature observed at 6 UTC of the day after the day under consideration.

Next the differences between observed air temperatures and values obtained with the temperature curve for the same time are calculated. To find the differences at every hour a linear interpolation is performed. If necessary the differences are corrected to avoid temperatures below the minimum or above the maximum temperature. Finally, the missing air temperatures are computed by adding the temperature obtained from the curve and the corresponding difference. These interpolated values are compared with the dew-point temperatures. When the air temperature is lower than the dew-point temperature, the air temperature is changed to the value of the dew-point temperature.

5.2.2 Dew-point temperature

Missing values for the dew-point temperature are computed using linear interpolation. The interpolation is performed only when the gap between two known values is no more than 18 hours (i.e. maximum of five missing values). The computed dew-point temperature must be lower than or equal to the air temperature at the same time, otherwise the dew-point temperature is set equal to the air temperature.

5.2.3 Wind speed

Missing values for the wind speed are obtained through linear interpolation when the gap between two known values is more than 12 hours (i.e. four or more missing values). Linear interpolation is also used when the gap between two known values is 12 hours or less and the difference between the two known values is less than 10 knots. For differences in wind speed larger than 10 knots the interpolation is based on the curve shown in figure 5.1.

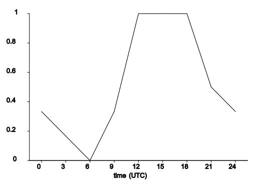


Fig. 5.1. *Relative wind speed as a function of time.*

5.2.4 Total cloud cover

Missing values for the total cloud cover are computed using linear interpolation. The interpolation is performed only when the gap between two known values is no more than 18 hours (i.e. maximum of five missing values).

5.2.5 Amount of CL clouds (or CM clouds if no CL clouds present)

Missing values for the amount of C_L (or C_M) clouds are computed using linear interpolation.

The interpolation is performed only when the gap between two known values is no more than 18 hours (i.e. maximum of five missing values).

5.2.6 Pressure at sea level

Missing values for the pressure at sea level are obtained through linear interpolation. The interpolation is performed only when the gap between two known values is no more than 18 hours (i.e. maximum of five missing values).

5.3 Messages

Messages generated by the INTER program are also written to the log file. In table V.2 the possible messages are described.

Table V.2. *Description of the messages generated by the INTER program.*

Message	Description
%I-Time TN: 03 <DTG> <NO> <TN>	Minimum temperature <TN> for station <NO> at time <DTG> computed from air temperature at 3 UTC
%I-Time TN: 06 <DTG> <NO> <TN>	Minimum temperature <TN> for station <NO> at time <DTG> computed from air temperature at 6 UTC
%I-Time TX: 15 <DTG> <NO> <TX>	Maximum temperature <TX> for station <NO> at time <DTG> computed from air temperature at 15 UTC
%I-Time TX: 18 <DTG> <NO> <TX>	Maximum temperature <TX> for station <NO> at time <DTG> computed from air temperature at 18 UTC
%I-Time TT: <DTG> <NO> <TT>	Temperature <TT> for station <NO> at time <DTG> obtained through interpolation in time
%I-Time TD: <DTG> <NO> <TD>	Dew-point temperature <TD> for station <NO> at time <DTG> obtained through interpolation in time
%I-Time FF: <DTG> <NO> <FF>	Wind speed <FF> for station <NO> at time <DTG> obtained through interpolation in time
%I-Time N: <DTG> <NO> <N>	Total cloud cover <N> for station <NO> at time <DTG> obtained through interpolation in time
%I-Time NH: <DTG> <NO> <NH>	Amount of C_L clouds (or C_M clouds if no C_L clouds are present) <NH> for station <NO> at time <DTG> obtained through interpolation in time
%I-Time PPP: <DTG> <NO> <PPP>	Pressure at sea level <PPP> for station <NO> at time <DTG> obtained through interpolation in time

6 Selection of AMD stations and calculation of AMD parameters

The program SELECT reads the element values of all stations marked with an S from the database DECODED and writes the values of the parameters for the Actual Meteorological Database to the file DAILY:S*yymmdd*.DAT. Some of the parameters can directly be written to this file, while others are calculated first (i.e. daily means, daily totals and derived parameters). Parameter values which are NOT DEFINED are represented by -99.0. The AMD parameters are listed and described in table VI.1.

Table VI.1. *Parameters in the Actual Meteorological Database.*

Parameter	Units	Description	Calculation method
NO	-	station number (four or five digits)	directly available
day	-	day number of the year under consideration (1 January = 1, 2 January = 2, ... etc.)	directly available
N	oktas	daily mean of total cloud cover	calculated from values between 0-24 UTC
Msun	hours	sunshine duration for the day specified with day	directly available
Mrad	$MJ\ m^{-2}\ day^{-1}$	measured global radiation	not available yet
Tn	°C	minimum temperature	directly available
Tx	°C	maximum temperature	directly available
e	hPa	daily mean vapour pressure	calculated from values between 0-24 UTC
ff10	m/s	daily mean wind speed at 10 metres	calculated from values between 0-24 UTC
RRR	mm	amount of precipitation between 6 UTC on the day specified with day and 6 UTC of the next day	directly available
TT06	°C	air temperature at 6 UTC	directly available
RH06	%	relative humidity at 6 UTC	directly available
TT09	°C	air temperature at 9 UTC	directly available
RH09	%	relative humidity at 9 UTC	directly available
TT12	°C	air temperature at 12 UTC	directly available
RH12	%	relative humidity at 12 UTC	directly available
TT15	°C	air temperature at 15 UTC	directly available
RH15	%	relative humidity at 15 UTC	directly available
TT18	°C	air temperature at 18 UTC	directly available
RH18	%	relative humidity at 18 UTC	directly available

Parameter	Units	Description	Calculation method
state soil	code:	state of the soil:	directly available
	0	surface of ground dry	
	1	surface of ground moist	
	2	surface of ground wet	
	3	flooded	
	4	surface of ground frozen	
	5	glaze on ground	
	6	loose dry dust or sand not covering ground completely	
	7	thin cover of loose dry dust or sand covering ground completely	
	8	moderate or thick cover of loose dry dust or sand covering ground completely	
	9	extremely dry with cracks	
vpd	hPa	daily mean vapour pressure deficit	calculated from values between 0-24 UTC
slope	hPa °C^{-1}	daily mean slope saturation vapour pressure vs. temperature curve	calculated from values between 0-24 UTC
N	oktas	daytime mean of total cloud cover	calculated from values between 6-18 UTC
Nh	oktas	daytime mean amount of C_L clouds or, if no C_L clouds are present, the daytime mean amount of C_M clouds	calculated from values between 6-18 UTC
NS	oktas	daytime mean amount of shadow clouds	calculated from values between 6-18 UTC
Csun	per cent	calculated sunshine duration	see Appendix B
Crad	MJ m^{-2} day^{-1}	calculated global radiation	see Appendix B
ETP	mm day^{-1}	Penman evaporation	see Appendix B
VV	km	daytime mean visibility	calculated from values between 6-18 UTC

7 Final check of AMD parameter values

The program **FINAL** performs a final check on the values of the AMD parameters in the file DAILY:S*yymmdd*.DAT. The constraints are listed in table VII.1. When a parameter value is out of the specified range this is written to the log file. In case errors are found in the log file, these can be corrected using the program OBSCON. Afterwards, the programs SELECT and INTER must be run again in order to create the new file DAILY:S*yymmdd*.DAT.

Table VII.1. *Constraints for final check of AMD parameter values.*

Parameter	Constraint
Daily mean of total cloud cover: N	0 - 8 oktas
Measured sunshine duration: Msun	0 - 24 hours
Measured global radiation: Mrad	0 - 36 MJ $m^{-2}day^{-1}$
Minimum temperature: Tn	
north of 35N latitude	-35 - 30°C
between 15N and 35N as well as south of 15S	-10 - 35°C
between 15N and 15S	0 - 35°C
Maximum temperature: Tx	
north of 35N latitude	-20 - 45°C
between 15N and 35N as well as south of 15S	0 - 50°C
between 15N and 15S	5 - 45°C
Daily mean vapour pressure: e	
north of 35N latitude	0 - 30 hPa
between 15N and 35N as well as south of 15S	0 - 20 hPa
between 15N and 15S	0 - 35 hPa
Daily mean wind speed at 10 metres: ff10	0 - 15 m/s
Amount of precipitation from 6 UTC-6 UTC: RRR	
north of 35N latitude	0 - 75 mm
between 15N and 35N as well as south of 15S	0 - 140 mm
between 15N and 15S	0 - 140 mm
Air temperature: TT	
north of 35N latitude	-35 - 45°C
between 15N and 35N as well as south of 15S	-10 - 50°C
between 15N and 15S	0 - 45°C
Relative humidity: RH	
north of 35N latitude	10 - 100%
between 15N and 35N as well as south of 15S	5 - 100%
between 15N and 15S	10 - 100%
State of the soil	0 – 9
Daily mean vapour pressure deficit: vpd	
north of 35N latitude	0 - 40 hPa
between 15N and 35N as well as south of 15S	0 - 60 hPa
between 15N and 15S	0 - 50 hPa
Daily mean slope of saturation vapour pressure vs. temperature curve:slope	0 - 3 hPa $°C^{-1}$
Daytime mean of total cloud cover: N	0 - 8 oktas
Daytime mean amount of C_L (or C_M) clouds: N_h	0 - 8 oktas
Daytime mean amount of shadow clouds: N_S	0 - 8 oktas
Calculated sunshine duration: C_{sun}	0 - 100%
Calculated global radiation: C_{rad}	-
Penman evaporation: ETP	
north of 35N latitude	0 - 10 mm day^{-1}
between 15N and 35N as well as south of 15S	0 - 25 mm day^{-1}
between 15N and 15S	0 - 20 mm day^{-1}
Visibility: VV	-

8 Installation Procedure in Unix Environment

In order to install the AMDAC software in a Unix environment successfully the following steps have to be executed:

1. Create an empty directory.

2. Copy the file Amdac.zip and unzip it in the directory.

3. Most important file is logicals.sh. We are used to make use of logicals/exports, so there is no fixed directory structure in the program. The customer can decide what the structure should be that fits the most to its organization of the disc space. Please take a look at that file and it can be seen which logicals are being used. The definition we have made testing the Amdac software on our system can be found there. If another structure is wished the logicals.sh file can be modified.

4. Please create the directories for the logicals in this file.

5. Create the logicals with the command . ./logicals.sh.

6. Create the library with common functions with the command ./create.sh.

7. Create the programs with the command ./link.sh.

8. No error messages or warnings should occur. We have added the command – check all - because we want to be sure that no programming mistake was made. These checks could slow down running the scripts, but this is expected to be just a minor thing.

9. Now some data files have to be copied to the data directories. Please unzip ispgts.zip in the directory $ISPGTS, ispmos.zip in the directory $ISPMOS and isprealdata in the directory $ISPREALDATA.

10. Next step is creating AmDac database files with the command ./database.sh.

11. The previous steps have to be done only once, the next steps are the operational part. To check the data we have provided test files for 5-jan-2014. You can find them in the directories $ISPMOS and $ISPGTS.

12. The first operational step is inserting the data of a new day into the database. This is done with the command ./input.sh <issue> with the test data its ./input.sh 20140105.

13. A lot of messages will scroll over your screen. They are also logged in a file. This can be changed as wished, we have just created this as an example. A logging can be found in the directory $ISPLOG.`

14. A Next step is the task of the meteorologist, who is taking a look at the observations which have been flagged as suspicious. This is done with an interactive tool which can be started with the command ./jrc_obscon. This tool has a help command and it is well described in the manual. With the command “check” the file $ISPLOG:isp_check_mos.log is opened and the first observation with a suspicious value will is received. With the commands “following” and “previous” you can move through the messages. With the command “modify” you can changes values. These modifications are stored in the file $ISPREALDATA/obscon.mod

15. When these values have been approved or corrected the daily output file can be created with the command ./output.sh <issue>. In this case ./output.sh 20140105.

16. There are several steps done in that command file. First a time interpolation of missing observations is made, second step is creating the daily output file and at last a final check is performed on this file. The output file is $ISPDAILY/s<issue>.dat and the logging of the final check is $ISPLOG/f<issue>.log.

Appendix A: Station list

The station list has been excluded from the documentation and can be found in the separate document AMDAC_manual_stationlist.pdf.

Appendix B: Calculation of derived parameters

Appendix B. Calculation of derived parameters

a. Pressure at station level ($P_0P_0P_0P_0$, D_PO)

The pressure at station level $P_0P_0P_0P_0$ (in hPa) for a station at h metres above sea level is calculated using

$$P_0P_0P_0P_0 = PPPP \,/\, \exp\left(\frac{g * h}{R_d * TTT}\right) \qquad (1)$$

where PPPP is the pressure at sea level (in hPa), $g = 9.81\ m\ s^{-2}$ is the standard gravitational acceleration, $R_d = 287.05\ J\ kg^{-1}\ K^{-1}$ is the specific gas constant for dry air and TTT is the air temperature (in K).

Reference:

Macintosh, D.H. and A.S. Thom, 1981: Essentials of Meteorology. The Wykeham Science Series 3, Taylor and Francis Ltd. London, UK, 240 pp.

b. Vapour pressure (e, D_E)

The vapour pressure e (in hPa) is calculated using

$$e = e_s(T_dT_dT_d) = 6.1078 * \exp[\frac{L_v}{R_v} * (\frac{1}{273.15} - \frac{1}{T_dT_dT_d})] \quad (2)$$

where R_v = 461.51 J kg^{-1} K^{-1} is the specific gas constant for water vapor, $T_dT_dT_d$ is the dew-point temperature (in K) and L_v is the latent heat of vapourization (in J kg^{-1}). L_v is computed from

$$L_v = (597 - 0.566 * TTT) * 4186 \quad (3)$$

where TTT is the air temperature (in °C)

Reference:

Dutton, J.A., 1976: The Ceaseless Wind: An Introduction to the Theory of Atmospheric Motion. McGraw-Hill Book Company, New York, U.S.A., 579 pp.

c. Vapour pressure deficit (Δe, D_VPD)

The vapour pressure deficit Δe (in hPa) is calculated from

$$\Delta e = e_s(TTT) - e_s(T_dT_dT_d) \quad (4)$$

where $e_s(T_dT_dT_d)$ = e is the vapour pressure of the air (see section b). $e_s(TTT)$ is the saturation vapour pressure which is obtained by replacing the dew-point temperature $T_dT_dT_d$ by the air temperature TTT in equation (3).

Reference:

MacIntosh, D.H. and A.S. Thom, 1981: Essentials of Meteorology. The Wykeham Science Series 3, Taylor and Francis Ltd. London, UK, 240 pp.

d. Slope of the saturation vapour pressure vs. temperature curve (∂e_s/∂T, D_ESL)

The slope of the saturation vapour pressure versus temperatue curve at air temperature TTT is calculated using

$$\frac{\partial e_s}{\partial T} = \frac{238.102 * 17.32491 * e_s(TTT)}{(TTT+238.102)^2} \quad (5)$$

where TTT is the air temperature (in °C) and $e_s(TTT)$ is the saturation vapour pressure which is obtained by replacing the dew-point temperature $T_dT_dT_d$ by the air temperature TTT in equation (3).

e. Relative humidity (RH, D_RH)

The relative humidity RH (in per cent) is calculated using

$$RH = \frac{e_s(T_dT_dT_d)}{e_s(TTT)} * 100. \qquad (6)$$

where $e_s(T_dT_dT_d)$ = e is the vapour pressure of the air (see section b). $e_s(TTT)$ is the saturation vapour pressure which is obtained by replacing the dew-point temperature $T_dT_dT_d$ by the air temperature TTT in equation (3).

Reference:

Macintosh, D.H. and A.S. Thom, 1981: Essentials of Meteorology. The Wykeham Science Series 3, Taylor and Francis Ltd. London, UK, 240 pp.

f. Wet bulb temperature (T_w, D_TW)

The wet bulb temperature T_w (in °C) is calculated from

$$T_w = TTT - \frac{(1000 * P_oP_oP_oP_o) * (TTT - c_1 + c_2 + c_3 + c_4)}{(2 * P_oP_oP_oP_o)} \qquad (7)$$

with

$$c_1 = TTT * e * (1.81 * 10^{-4} * TTT + 9.36 * 10^{-5} * e - 1.779 * 10^{-2})$$

$$c_2 = e * (0.007 * e - 1.005)$$

$$c_3 = TTT * (4.58 * 10^{-3} * TTT - 0.696)$$

$$c_4 = 5.91$$

where TTT is the air temperature (in °C), e the vapour pressure (in hPa) and $P_oP_oP_oP_o$ the pressure at station level (in hPa).

g. Wet bulb potential temperature (Θ_w, D_THEW)

The wet bulb potential temperature Θ_w (in °C) is calculated using

$$\theta_w = \left(1 + \frac{(P_oP_oP_oP_o - 1000)}{1355}\right) * (T_w - 70) + 70 \qquad (8)$$

where $P_oP_oP_oP_o$ is the pressure at station level (in hPA) and T_w the wet bulb temperature (in °C).

h. Amount of shadow clouds (N_S, D_NS)

The amount of shadow clouds N_S (in oktas) is assumed to be equal to the total cloud cover N if no clouds of the genera Cirrus, Cirrocumulus or Cirrostratus are observed or when the parameter N_h is not observed. N_S is assumed to be the average of N and N_h if clouds of the genera Cirrus, Cirrocumulus or Cirrostratus are observed. Finally, N_S is taken equal to N_h when N is not observed.

i. Sunshine duration (Csun)

The calculated sunshine duration Csun (in per cent) is taken equal to the measured sunshine duration 55|[illegible] (in hours) divided by the day length τ (in hours). τ is computed using

$$\tau = 12 * (1 + \frac{2}{\pi} * \arcsin(\frac{\sin(\lambda) * \sin(\delta)}{\cos(\lambda) * \cos(\delta)}) \qquad (9)$$

where λ is the geographical latitude and δ the declination angle of the sun calculated from

$$\delta = -\arcsin[\sin(23.45) * \cos(\frac{360 * (DAY + 10)}{365})]$$

with DAY denoting the day number (1 January = 1, 2 January = 2, ... etc.). When no measured sunshine duration is available Csun is calculated from cloud cover data:

$$Csun = (1 - \frac{N_{sun}}{8}) * 100 \qquad (10)$$

where N_{sun} is the mean amount of shadow clouds during daytime (i.e. 6-18 UTC). It should be noted that conversion of cloud cover to sunshine duration is rather unreliable.

Reference:

Reinds, G.J., 1991: DBMETEO: a program to store, retrieve and analyze meteorological data sets. User Manual. The Winand Staring Centre, Wageningen, 30 pp.

j. Global radiation (Crad)

The global radiation Crad (in MJ m^{-2} day^{-1}) is calculated using the Angström formula

$$Crad = Crad_o * (\alpha + \beta * Csun) \tag{11}$$

$$\alpha = 0.4885 - 0.0052 * \lambda$$

$$\beta = 0.1563 + 0.0074 * \lambda$$

where Csun is the sunshine duration (expressed as a fraction), λ is the geographical latitude and $Crad_o$ (in MJ m^{-2} day^{-1}) is the amount of global radiation reaching the top of the atmosphere computed from

$$Crad_o = 0.00137 * \phi * (1 + 0.033 * \cos(\frac{360 * DAY}{365})) \tag{12}$$

DAY denotes the day number (1 January = 1, 2 January = 2, ...etc.) and φ the daytime integral of the sine of the sun height (in s day^{-1})

$$\phi = 3600 * [\ \tau * \sin(\lambda) * \sin(\delta) + \frac{24}{\pi} * \cos(\lambda) * \cos(\delta) * \sqrt{1 - (\frac{\sin(\lambda) * \sin(\delta)}{\cos(\lambda) * \cos(\delta)})^2}\ ]$$

where δ the declination angle of the sun and τ the day length (see section i).

k. Penman evaporation (ETP)

The evaporation according to Penman ETP (in mm day^{-1}) is calculated from

$$ETP = \frac{(\frac{\partial e_s}{\partial T})_m * \frac{R_n}{L_v} + \gamma * 0.26 * \Delta e_m * f(u)}{(\frac{\partial e_s}{\partial T})_m + \gamma} \qquad (13)$$

where $(\partial e_s/\partial T)_m$ is the daily mean slope of the saturated vapour pressure vs. temperature curve (in hPa/°C), Δe_m the daily mean vapour pressure deficit (in hPa), γ = 0.65 hPa/°C is the psychrometric constant and L_v = 2.47 MJ kg^{-1} is the latent heat of vapourization of water. The net radiation R_n is computed from the radiation balance

$$R_n = (1-\alpha) * Crad - \sigma * T_m^4 * (c - d * \sqrt{e_m}) * (e + f * Csun) \qquad (14)$$

where α = 0.2 is the surface albedo, Crad the global radiation (in J (!) m^{-2} day^{-1}), σ = 0.0049 J m^{-2} K^{-4} day^{-1} the Stefan-Boltzmann constant, T_m (in K) the average of the minimum temperature (T_n) and maximum temperature (T_x), e_m the daily mean vapour pressure (in hPa) and Csun the sunshine duration (expressed as a fraction). The values of the coefficients c and d are 0.56 and 0.08 respectively. The values of e and f depend on the geographical latitude:

- north of 45° N.L. e = 0.1 and f = 0.9
- south of 45° N.L. e = 0.3 and f = 0.7

Finally, the wind function f(u) is given by

$$f(u) = 1 + 0.4 * ff_{10} \qquad (15)$$

where ff_{10} is the wind speed at 10 metres height (in m/s).

I. Dew-point temperature ($T_dT_dT_d$)

The dew-point temperature $T_dT_dT_d$ (in °C) can be calculated directly from the vapour pressure e (in hPa) using

$$T_dT_dT_d = -237.3 * \left(\frac{\ln(e) - 1.8094}{\ln(e) - 19.0789} \right) \tag{16}$$