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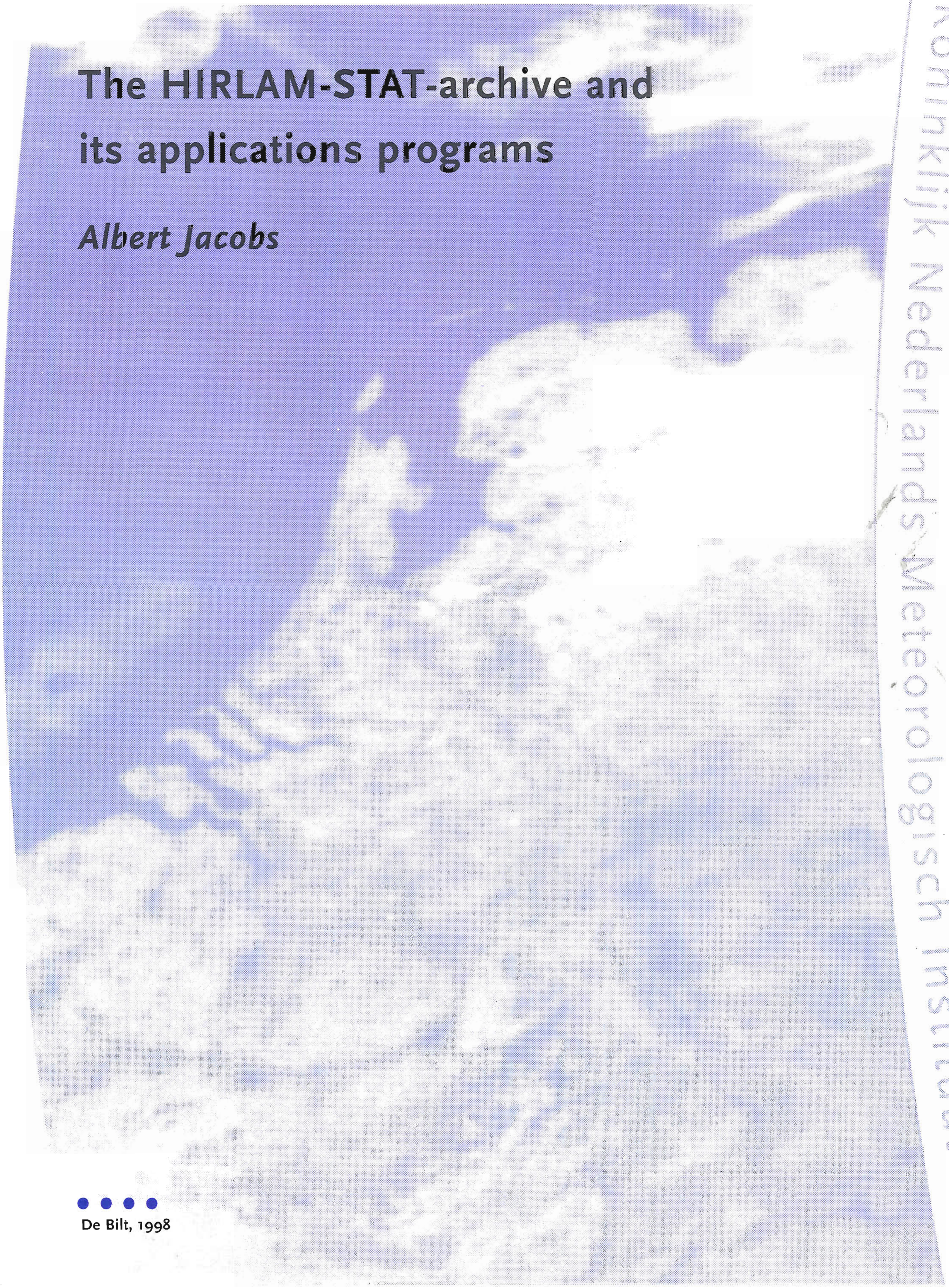
The HIRLAM-STAT-archive and its applications programs

Albert Jacobs



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The HIRLAM-STAT-archive and its application programs.

by

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Contents

1 Introduction

Statistical postprocessing based on Direct Model Output (DMO) requires a tremendous amount of model data in the form of model fields and model time series over a period of at least two or three years. Besides DMO we need also observations from various sources, such as SYNOP and KLIM[1], in order to calibrate our statistical models.
This report describes the contents of the STAT-archive, an archive of interpolated Hirlam field data, time series data, and observations from various Dutch stations. The archive is especially prepared for the use of statistical applications such as e.g. Model Output Statistics (MOS) and Kalman filters, but it is useful for even more general statistical and/or physical methods and applications at KNMI.

In section 2 the contents of the STAT-archive will be described in all its details. The complete set of Hirlam model data consists of upper-air field data available on various pressure-levels, surface parameters available on various heights above the surface, and time series available for 15 elements at various Hirlam (gridpoint) locations. With respect to the observations, only a minor selection is added to the archive. A selection which is made for the purpose of the project "First Guess TAF" (automation of a TAF-guidance). The selection includes automatic and visual observations from 24 Dutch stations with a time period varying from 4 years for 6 stations, to 10 years for 18 stations. Observations of different elements, and for other locations/ time periods, can be retrieved easily from KNMI's general observations database called KIS[2].

In section 3 we describe various application programs which are added to the archive in order to read the dat-tapes, and to read, extract and visualise the contents of each file in the archive. Extraction of data in the archive means reading the data and presenting it in a suitable ascii-format. The extraction and visualisation tools can perform the following tasks:

- Extraction of complete model fields for given pressure/height–level and parameter.
- Extraction of profiles (upper-air and surface parameters) for given location.
- Extraction of model time series for given location.
- Visualisation tools for model fields for given pressure/height–level and parameter.

[1]KLIM is a national bulletin at KNMI.
[2]Klimatologisch Informatie Systeem.

2 The HIRLAM-STAT-archive

2.1 Introduction

The STAT-archive contains interpolated Hirlam model fields, model time series, and observations from various Dutch stations originating from SYNOP and KLIM.[3]
The names for the STAT-fields (asimof files)

STAT_FMT_${dtm}${hh}00_0${tf}00_AB,

and the STAT-timeseries (TSF files)

STAT_TBA_${dtm}${hh}00_00000_TW,

are specified according to the standard APL[4] convention. Here $dtm = yymmdd$ is the date, $hh \in \{00, 06, 12, 18\}$ is the hour of the day (corresponding with the periodic Hirlam runs), and $tf \in \{00, 06, 12, 18, 24, 30, 36\}$ the forecast period. From $dtg = 97010100$ on, we extended the maximum forecast period in the archive with +42 and +48 fields, and the time series up to +48 hours.

The observations for various periods over the last 10 years are supplied for 24 Dutch stations and are written in ascii format in files with names

taf_${statcode}h.obs,

for the automatic observations, and

taf_${statcode}v.obs,

for the visual observations. Here *statcode* is the 5-digit stationcode, following WMO regulations. The observations are specially collected for the purpose of automation of TAFs (Terminal Aerodrome Forecasts) but are usefull for other purposes as well. More details about the observations are given later on.

For reasons of portability, the modeldata and observations are supplied on both 90m-dat-tapes (TLZ06 cassette Tape Drive) and 120m-dat-tapes (TLZ07 cassette Tape Drive), 2Gb, compressed 4 Gb. Software for reading the tapes is available. The observations are written on a separate tape. Furthermore, one year of Hirlam field– and time series data is written on one tape. The meteorological field data is packed on tape in GRIB-code (gridded binary) as defined by the WMO standard GRIB-92-IX. The time series data is written in KNMI's TSF standard. Software for extraction of Hirlam model data in ascii format is included.

[3]KLIM is a national bulletin at KNMI.
[4]APL is the Automatic Production Line at KNMI.

2.2 Model data

The interpolated Hirlam model data is supplied for the years 1994, 1995, 1996, and 1997. Our purpose is to update the STAT-archive once every year with recent model fields, model time series, and observations.
A few more technical details:

Resolution in Space: (see figure 2.1 for the STAT-area)

The STAT-grid is a regular latitude/longitude grid with equidistant cylindrical projection (pole on 90°).
Corner points: 60° North, 3° West to 48° North, 9° East.
Scanning mode: North-West to South-East.
(points scanned in $+i$, $-j$ direction. Adjacent points in i direction are consecutive).
Resolution (increments): 0.5° along a parallel (West-East direction),
0.25° along a meridian (North-South direction).
Number of points: NX=25, NY=49.
$X(i) = -03.000 + 0.5 \times (i-1), \qquad i = 1, 2, \cdots, 25,$
$Y(j) = 48.000 + 0.25 \times (j-1), \qquad j = 1, 2, \cdots, 49.$
Interpolation technique: Bi-linear with substitution of data (missing or outside the domain).

Remark:
The Hirlam u and v components of the wind field are destaggered before interpolated horizontally to the STAT-grid.

Resolution in Time:

all field elements:
$T + 00, +06, +12, +18, +24, +30, +36$ (fielddata 1994, 1995, and 1996),
$T + 00, +06, +12, +18, +24, +30, +36, +42, +48$ (fielddata 1997).

The STAT-timeseries are available for various gridpoints (with a maximum of 32) in TSF-format with a fixed timestep of 30 minutes. A tool is available to extract the time series in ascii-format. To run this tool, the user should specify the lat/lon coordinate of the point of interest, and the type of the Hirlam point for which to search (land/sea/all). The application extracts the time series of the nearest (available) Hirlam point of the specified type from the TSF file.

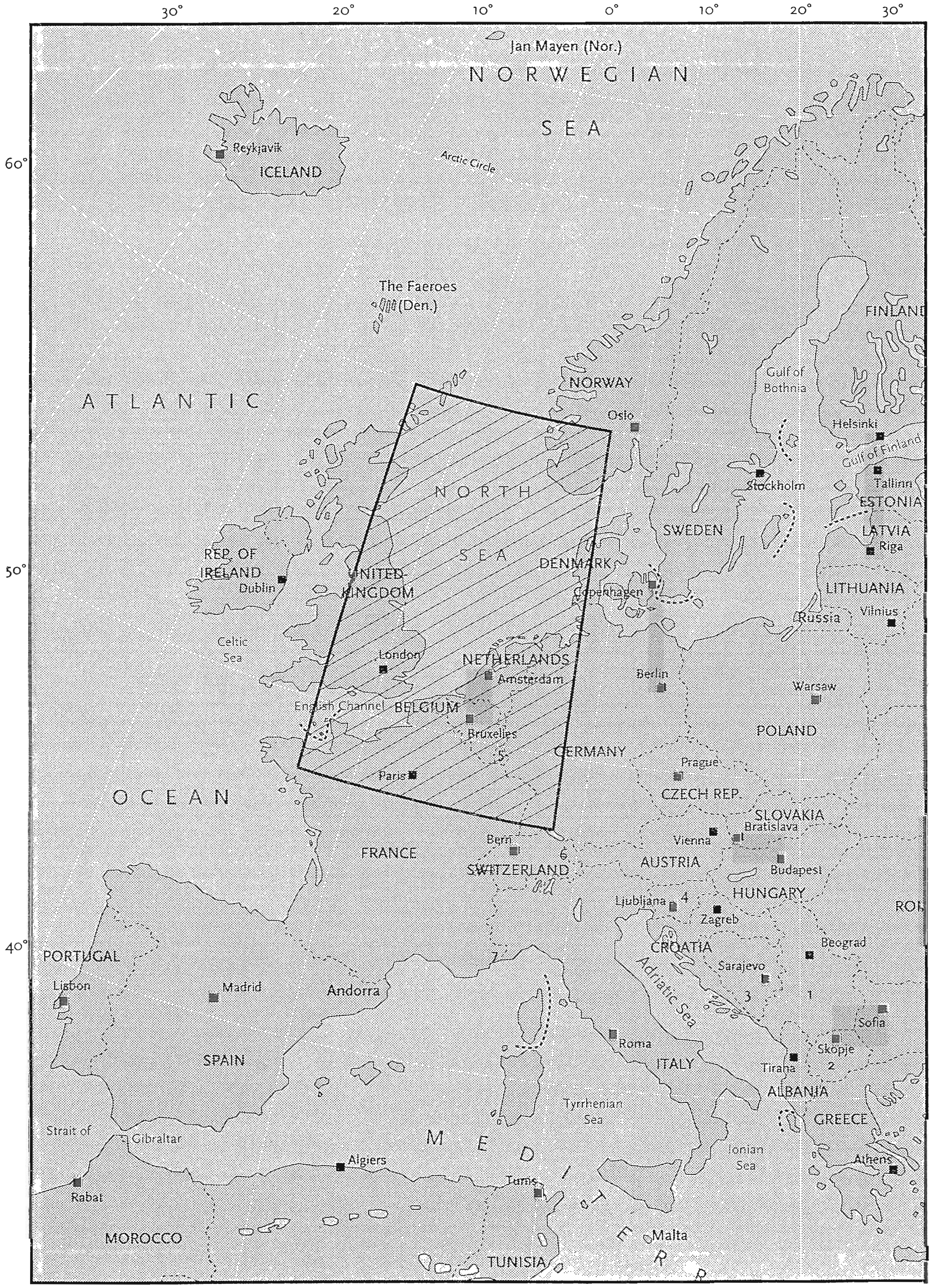

Figure 2.1: The STAT-area.

STAT-fields

Pressure-levels
Upper-air field data is available on pressure-levels 300, 500, 700, 850, 925, and 1000 hPa.
Leveltype: LTP = 100, isobaric surface (pressure in hPa).

Parameter name	Unit	Parameter code (PAR)
geopotential height	[m]	7
temperature	[K]	11
relative humidity	[%]	52
u-comp. wind	[m/s]	33
v-comp. wind	[m/s]	34
w-comp. wind	[Pa/s]	39
relative vorticity	[s^{-1}]	43
relative divergence	[s^{-1}]	44

Table B.1: Hirlam-STAT pressure level parameters.

Surface parameters
Surface parameters are available on various heights above the surface: 0, 2, and 10 m.
Leveltype: LTP = 105, specified height level above ground (height in meters).
LTP = 103, specified altitude above mean sea level (altitude in meters).
Note that in table B.2 precipitation is accumulated over the forecast period.

Parameter name	Unit	Parameter code (PAR)	LTP	Height (H)
pressure (ground level)	[Pa]	1	105	0
pressure (mean sea level)	[Pa]	1	103	0
large scale precipitation	[kg/m^2]	62	105	0
convective precipitation	[kg/m^2]	63	105	0
total precipitation	[kg/m^2]	61	105	0
total cloud cover	[okta/8]	71	105	0
soil moisture content	[kg/m^2]	86	105	0
temperature (0 m)	[K]	11	105	0
temperature (2 m)	[K]	11	105	2
specific humidity (2 m)	[kg/kg]	51	105	2
u-comp. wind speed (10 m)	[m/s]	33	105	10
v-comp. wind speed (10 m)	[m/s]	34	105	10
rel. vorticity (10 m)	[s^{-1}]	43	105	10
rel. divergence (10 m)	[s^{-1}]	44	105	10

Table B.2: Hirlam-STAT surface parameters.

Remark:
In old Hirlam files (before dtg=95041200) orography (PAR=6), i.e. geopotential on 0 m, is not available. As a consequence postprocessing, i.e. vertical interpolation, on the pressure levels 300 and 925 hPa is not possible. Therefore this fielddata is missing in the STAT-archive. For

the same reason the vertical velocity component w, i.e. PAR=39, is missing on all pressure levels.

STAT-timeseries

STAT-timeseries data is available for 15 elements and for various Hirlam locations with a maximum of 32. The elements are specified in the table below.
Note that also in the time series precipitation is accumulative over the forecast period.
For extraction in ascii-format, for the moment, only 10 descriptors are selected.

Nr.	Table reference	Meaning of element
1	008012	Land / Sea mask (Old Hirlam [dtg < 96101700] land=1, sea=0) (New Hirlam [dtg >= 96101700] land=0, sea=1)
2	010001	Surface (geopotential) height (m)
3	010051	Mean sea level pressure (Pa)
4	013011	Total precipitation (kg/m^2)
5	055132	Convective precipitation (kg/m^2)
6	013013	Snow depth (m)
7	055110	Roughness length (m)
8	012004	2 m temperature (°C)
9	011011	10 m wind direction (degrees)
10	011012	10 m wind speed (m/s)
11	055100	Surface pressure (Pa)
12	055120	Surface temperature (°C)
13	055130	Surface relative humidity (%)
14	055039	2D total cloud cover (octa)
15	012006	2 m dewpoint temperature (°C)

Table B.3: Single element descriptors for Hirlam TSF files.

2.3 Observations

STAT-observations

For the purpose of the project "First Guess TAF" (automation of a TAF-guidance) we have selected observations (automatic and visual) from 24 Dutch stations.
Let us give some technical specifications:

Source of observations: SYNOP and KLIM.

Time Period: July 1st 1987 until June 30th 1997 for the first 18 stations (see table B.4) , and July 1st 1993 until June 30th 1997 for the last 6 stations.
10 years for climatology and 4 years for derivation of Model Output Statistics (MOS).

Resolution in Time: 1 hour.

Station list:

WMO-Nr.	Latitude	Longitude	Code	Name	Altitude	Type
06210	5211 n	425 e	EHVB	VALKENBURG	0	sur
06235	5255 n	447 e	EHKD	DE KOOY	0	sur
06239	5451 n	444 e	EHFD	F3	0	sur
06240	5218 n	446 e	EHAM	AMSTERDAM AP	-4	sur
06242	5315 n	455 e	EHVL	VLIELAND	4	sur
06265	5208 n	516 e	EHSB	SOESTERBERG	12	sur
06270	5313 n	546 e	EHLW	LEEUWARDEN	0	sur
06275	5204 n	553 e	EHDL	ARNHEM/DEELEN	50	sur
06280	5308 n	635 e	EHGG	GRONINGEN AP	4	sur
06290	5217 n	654 e	EHTW	TWENTE	36	sur
06310	5127 n	336 e	EHFS	VLISSINGEN	8	sur
06320	5156 n	340 e	EHGO	LICHTEILAND GOEREE	19	sur
06340	5127 n	421 e	EHWO	WOENSDRECHT	15	sur
06344	5157 n	426 e	EHRD	ROTTERDAM	-5	sur
06350	5134 n	456 e	EHGR	GILZE RIJEN	11	sur
06370	5127 n	525 e	EHEH	EINDHOVEN	20	sur
06375	5139 n	542 e	EHVK	VOLKEL	20	sur
06380	5055 n	547 e	EHBK	MAASTRICHT	114	sur
06240	5218 n	446 e	EHAM	AMSTERDAM AP	-4	sur
06344	5157 n	426 e	EHRD	ROTTERDAM	-5	sur
06210	5211 n	425 e	EHVB	VALKENBURG	0	sur
06260	5206 n	511 e	EHDB	DE BILT	2	sur
06225	5228 n	434 e		IJMUIDEN	12	sur
06269	5227 n	532 e		LELYSTAD AWS	-4	sur

Table B.4: Station list of observations.

List of elements:

Code	Meaning	Unit
T	air-temperature	[0.1 °C]
TN6	min. temperature over the last 6 hours (once every 6 hours)	[0.1 °C]
TX6	max. temperature over the last 6 hours (once every 6 hours)	[0.1 °C]
T10	min. temperature at 10 cm over the last 6 hours (once every 6 hours)	[0.1 °C]
TD	dewpoint-temperature	[0.1 °C]
RH	total amount of precipitation during the last hour	[0.1 mm]
DR	duration of RH	[0.1 hour]
DD	mean direction of the wind over the last 10-minutes period in the preceding hour	[degrees], 999 = variable
FF	mean speed of the wind over the last 10-minutes period in the preceding hour	[0.1 m/s]
FH	hourly mean of wind speed in the preceding hour	[0.1 m/s]
FX	max. wind speed in the preceding hour	[0.1 m/s]
VV	horizontal visibility (minimum over all directions)	[code]
WW	ww-code for present weather	[code]
W1	fog in preceding hour	[0 = no, 1 = yes]
N	total cloud cover	[okta]
CL	low cloud	[code]
N1	cover of cloud-layer 1	[okta]
N2	cover of cloud-layer 2	[okta]
N3	cover of cloud-layer 3	[okta]
N4	cover of cloud-layer 4	[okta]
C1	genus of cloud-layer 1	[code]
C2	genus of cloud-layer 2	[code]
C3	genus of cloud-layer 3	[code]
C4	genus of cloud-layer 4	[code]
H1	height cloud base of cloud-layer 1	[code]
H2	height cloud base of cloud-layer 2	[code]
H3	height cloud base of cloud-layer 3	[code]
H4	height cloud base of cloud-layer 4	[code]
SS	total depth of snow	[code, 0.1 m]

Table B.5: List of elements in observation files.

3 Application programs

The model data and observations are provided on dat-tapes, both 90m and 120m. Each year of Hirlam model data is written on a separate tape, and the observations are written on a separate tape too. Software for reading the tapes is available.

3.1 Reading the Tapes

Model data

Each year of model data is written in compressed form on a single tape in several, let's say, containers. Such a container consists of one month of Hirlam model data, the smallest unit available on the tape. The script **ReadTape** can be used to read the contents of the tape:

Usage: <ReadTape $*yy* $*mm*>

with *yy* the year and *mm* the month of interest.
After reading one month of data, on your system you will find a subdirectory *yymm* together with its contents, the files STAT_${yymmdd}.tar, where *dd* is the day of the month *mm*. Each file STAT_${yymmdd}.tar is a tar-archive which consists of Hirlam model data, fields and time series, (projected onto the STAT-grid) for 1 day. The contents of this tar-archive can be extracted by using the **tar** command:

Usage: <tar –xvf STAT_${yymmdd}.tar>

This gives us the complete STAT-archive for 1 day, as described in section 2.1.

Observations

The observations for 24 Dutch stations are written on a separate tape. The script **ReadObs** can be used to read the contents of this tape:

Usage: <ReadObs $*statcode*>

with *statcode* the 5-digit station-identification code, following WMO regulations. These codes can be found in column 1 of table B.4. After reading the data from one station, the results are put on your system disk in the subdirectory *statcode*. The automatic observations can be found in the file taf_${statcode}h.obs, and the visual observations in the file taf_${statcode}v.obs. The order (cf. table B.5) of the elements is: T, T10, TN6, TX6, TD, DR, RH, DD, FF, FH, FX, VV, W1, WW, N, for the automatic observations, and C1, C2, C3, C4, CL, H1, H2, H3, H4, N1, N2, N3, N4, SS, for the visual observations. The values are printed in code or in integers.

3.2 Reading File Information

There are various utilities to read and print information about the contents of an ASIMOF-file, and a TSF-file.
Diasim.x reads all fields in an ASIMOF-file and displays the header of each GRIB message:

Usage: <diasim.x [–h] [–s] $filename>,

with *filename* a single ASIMOF format input-file, *–h* the option for standard file information, and *–s* the option for extended file information.
Readtsf.x reads and prints the information about the contents of a TSF-file. This information includes e.g. time levels, numbers and coordinates of data-points, and the number and meaning of the single element descriptors.

Usage: <readtsf.x $filename>,

with *filename* a TSF format input-file.

3.3 Extraction Tools

The extraction tools that are added to the STAT-archive can be divided into two groups: (1) ASIMOF database manipulation programs, such as **asix.x** for fields, and **asimextr.x** for profiles, and (2) TSF file manipulation software such as **hrlxtr.x** for Hirlam time series. Each program is embedded in a script (C-shell or Perl) so that each task can be performed by an easy to call user-routine.

<u>Environment variables</u>

Before using the ASIMOF database manipulation programs, set the environment variable $ASIMPATH,

<setenv ASIMPATH $asimprogs/asimpath.h>,

with *asimprogs* the root of the ASIMOF extraction software, where the environment-settings file asimpath.h can be found. In the asimpath.h file the user should also change the environment variables $USERDIR to the user-directory, and $ASIMROOT to his or her local asimprogs di-

rectory.
Similarly, if using the TSF file manipulation software, set the environment variable $STATTSF,

<setenv STATTSF my–TSF–source–directory>,

where the source directory contains all TSF sources such as hrlxtr.x.

Model fields

Statfield.sc extracts model fields for a specified parameter on a given pressure-level, or for a specified surface parameter,

Usage: <statfield.sc $dtg $fp $key>,

where the key value should be chosen from the file ASIM_KEY_0000000000_00000_LC. A copy of this file is given in table C.2. In this table the key values can be found in column 1. Column 2 specifies whether the quantity is a scalar (character 's') or a vector (character 'v'), and the other columns identify the fields in the database (see also tables B.1 and B.2).
Asix.x extracts its data specified by the user supplied variables $dtg, $fp, and $key, from the input-file STAT_FMT_${dtg}00_0${fp}00_AB, and writes the field data in ascii-format to the output-file STAT_FMT_${dtg}00_0${fp}00_LC. In the output-file the first 3 lines contain all the information that is necessary to interpret the contents of the rest of the file. Most important in this context is the spatial resolution and the scanning mode (North-West to South-East) as described in subsection 2.2. Considering the format of the output-file, i.e. 7 columns, the point with coordinates $(X(i), Y(j))$, cf. section 2.2, can be found in

$$(\text{row, column}) = \left(\text{int}\left[\frac{(49-j)*25+i-1}{7}\right]+1,\ (49-j)*25+i-\text{int}\left[\frac{(49-j)*25+i-1}{7}\right]*7\right).$$

Model profiles

Statprof.sc extracts profiles along all available pressure levels, and for all specified surface parameters. Locations and parameters are read from the input-file STAT_PARLOC.INP.

Usage: <statprof.sc $dtg $fpend>,

with *dtg* the date and time of the Hirlam modelrun, and *fpend* the maximum forecast period.
Asimextr.x performs the extraction and loops over all ASIMOF database files with names STAT_FMT_${dtg}00_0${fp}00_AB, where the forecast period starts with *fp* = +00 and finishes with *fp* = +*fpend*. The resulting field data in ascii-format is written to the output-file

STAT_PRF_${dtg}00_00000_LC. The header of the output-file is rather self explanatory. The multiple level parameters are given on pressure-levels 300, 500, 700, 850, 925, and 1000 hPa, if available. The surface parameters are given on only one level. The locations (stations) are included with its corresponding nearest Hirlam gridpoint in lat/lon coordinates. The columns of data consist of the time levels starting at $fp = +00$ until $fp = +fpend$, with a timestep of +6 hours. The explanation of the multiple level parameters and surface parameters, can be found in table C.1, cf. also tables B.1 and B.2.

During ASIMOV extraction procedures, error-messages can be found in the corresponding log-files.

Parameter name	Parameter codename
Multilevel parameters:	
geopotential height	geo
temperature	t
relative humidity	rh
u-comp. wind	u
v-comp. wind	v
w-comp. wind	w
relative vorticity	rvt
relative divergence	rdv
Surface parameters:	
pressure (ground level)	pgrl
pressure (mean sea level)	pmsl
large scale precipitation	lppb
convective precipitation	cppb
total precipitation	tppb
total cloud cover	tcc
soil moisture content	smc
temperature (0 m)	tt0m
temperature (2 m)	tt2m
specific humidity (2 m)	sh2m
u-comp. wind speed (10 m)	uu10
v-comp. wind speed (10 m)	vv10
rel. vorticity (10 m)	vt10
rel. divergence (10 m)	dv10

Table C.1: Profile parameter codenames.

Key value	Quantity	Parameter code (PAR)	LTP	Pressure Level or Height
'geo1'	's'	7	100	300
't1'	's'	11	100	300
'rh1'	's'	52	100	300
'u1'	's'	33	100	300
'v1'	's'	34	100	300
'w1'	's'	39	100	300
'rvt1'	's'	43	100	300
'rdv1'	's'	44	100	300
'geo2'	's'	7	100	500
't2'	's'	11	100	500
'rh2'	's'	52	100	500
'u2'	's'	33	100	500
'v2'	's'	34	100	500
'w2'	's'	39	100	500
'rvt2'	's'	43	100	500
'rdv2'	's'	44	100	500
'geo3'	's'	7	100	700
't3'	's'	11	100	700
'rh3'	's'	52	100	700
'u3'	's'	33	100	700
'v3'	's'	34	100	700
'w3'	's'	39	100	700
'rvt3'	's'	43	100	700
'rdv3'	's'	44	100	700
'geo4'	's'	7	100	850
't4'	's'	11	100	850
'rh4'	's'	52	100	850
'u4'	's'	33	100	850
'v4'	's'	34	100	850
'w4'	's'	39	100	850
'rvt4'	's'	43	100	850
'rdv4'	's'	44	100	850
'geo5'	's'	7	100	925
't5'	's'	11	100	925
'rh5'	's'	52	100	925
'u5'	's'	33	100	925
'v5'	's'	34	100	925
'w5'	's'	39	100	925
'rvt5'	's'	43	100	925
'rdv5'	's'	44	100	925
'geo6'	's'	7	100	1000
't6'	's'	11	100	1000
'rh6'	's'	52	100	1000
'u6'	's'	33	100	1000
'v6'	's'	34	100	1000
'w6'	's'	39	100	1000
'rvt6'	's'	43	100	1000
'rdv6'	's'	44	100	1000
'pgrl'	's'	1	105	0
'pmsl'	's'	1	103	0
'lppb'	's'	62	105	0
'cppb'	's'	63	105	0
'tppb'	's'	61	105	0
'tcc'	's'	71	105	0
'smc'	's'	86	105	0
'tt0m'	's'	11	105	0
'tt2m'	's'	11	105	2
'sh2m'	's'	51	105	2
'uu10'	's'	33	105	10
'vv10'	's'	34	105	10
'vt10'	's'	43	105	10
'dv10'	's'	44	105	10

Table C.2: Field key values.

Model time series

Gettsf.psc extracts Hirlam time series from a 30-minute Hirlam TSF-file.
For given (lattitude,longitude) coordinates, the information is extracted from the nearest Hirlam-point of an user specified type, (land, sea, or all). A descriptor-list specifies the information needed for the extraction procedure.

Usage: <gettsf.psc $path $tsffile $lat $lon $type>,

with *path* the path of files, *tsffile* the 30-minute Hirlam TSF-file, *lat* the lattitude of the user specified point, *lon* the longitude of the user specified point, and *type* the type of Hirlam-point for which to search (land, sea, all). The output-file consists of 15 columns, with in the first 5 columns the date and time (year, month, day, hour, and minute), following the 10 selected descriptors with numbers 8, 15, 12, 4, 5, 10, 9, 14, 13, and 2, in that precise order (cf. also table B.3).

3.4 Visualisation Tools

The visualisation tool which is added to the STAT-archive is based on KNMI's **asiplot**. Asiplot is an application program based on MAGICS. It reads user specified GRIB-fields in an ASIMOF-file and plots the result, together with a map of the forecast-area, to a postscript output-file or to the screen. Asiplot has been adapted in order to add some special features, and therefore has been given a new name, **aspect.x**. The new plotting application can be called by the user-routine **plotfield.sc**. Before using this application, set the environment variable $PRESPATH,

<setenv PRESPATH $presprogs/prespath.h>,

with *presprogs* the root of the visualisation software, where the environment-settings file prespath.h can be found. In prespath.h also specify your local $USERDIR and make sure that the directory $USERDIR/tmpdata exists. Plotfield.sc uses this directory as a temporary input/output directory.

Usage: <plotfield.sc $model $dtg $fp $par $lev $height>,

with *model* the model identification name (for STAT applications $model = stat), *dtg* the date and hour of the forecast run ($dtg = *yymmddhh*), *fp* the forecast period (*fp* = 00, 06, 12, 18, 24, 30, 36, 42, 48), *par* is the parameter code, *lev* is the leveltype, *height* is the height (in m for surface parameters, and in hPa for pressure-levels). For the key that specifies the field, i.e. the threesome ($par,$lev,$height), we refer the user to the tables B.1 and B.2.
Asiplot reads the fields from the input-file STAT_FMT_${dtg}00_0${fp}00_AB in the directory $FIELDDIR, and returns a postscript-file STAT_${dtg}00_0${fp}00_AB.ps to the directory

$PSDIR.

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