First Guess TAF - FGTAF

Semi-automation in TAF production

by

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1 Introduction

The aviation meteorological services (LMD) at the international airport of Schiphol (Amsterdam) in the Netherlands and at the regional civil airports of Groningen, Maastricht and Rotterdam, are responsible for the supply of accurate meteorological information which is necessary for safety and efficiency in aviation. One of the tasks of the LMD concerns the production and distribution of meteorological forecasts. For reasons of efficiency these meteorological reports or bulletins are distributed in coded form, according to predefined ICAO and WMO regulations. Among these products are the **METAR** - Meteorological Aviation Routine Weather Report - which is provided every half hour and consists of half-hourly observations at the airport, the **TREND** which gives very accurate meteorological information at a specific airport and is indispensable for take-off and touch-down of aircraft within the next 1.5 to 2 hours[1], and the **TAF** or the Terminal Aerodrome Forecast which contains a categorical and probabilistic weather forecast for a specific airport. In this report we shall focuss on TAFs.

In the Netherlands all TAFs for Schiphol [AM] and the regional airports of Groningen [GG], Maastricht [BK], and Rotterdam [RD], are produced at one single location, which at the moment is Schiphol.
The main purpose for the production of TAFs is to support all aviation traffic. For this reason the main elements to be forecasted in a TAF are divided into four groups:

WIND	: Mean wind speed, mean wind direction, gust speed, and probability of gusts above a certain level.
VISIBILITY	: Horizontal visibility (100 m), probability of visibility being below a predefined level.
WEATHER	: Expected significant weather following WMO regulations. Examples are precipitation amounts, rates and type, and probabilistic information on precipitation.
CLOUDS	: Cloud cover at various flight levels, cloud base height, probability of cloud cover below a predefined level.

In coded form an example of a short-TAF for Schiphol airport [EHAM], which is issued at 15h and valid on [16h,01h], might look as follows:

```
FCNL31 EHAM 041500
TAF
EHAM  041601 15005KT 2000 MIFG OVC005 BECMG 1619 0700 BCFG OVC004
       PROB30 1901 0300 FZFB VV002=
```

In this example the forecast is:

Direction of wind 150 degrees, 5kt, visibility 2000m in ground fog and 8/8 cloud cover at 500ft, between 16.00 and 19.00 UTC the visibility decreases to 700m and the clouds fall to 400ft, between 19.00 and 01.00 UTC there is a probability of 30% that the visibility in freezing fog is predominantly 300m with a vertical visibility of 200ft.

For a thorough overview of abbreviations in TAF codes we refer the reader to Hungerink [1997]. For more details on codes see WMO [1998].

In the Netherlands short-TAFs are produced 8 times a day for the 4 civil airports mentioned above [AM,RD,GG,BK]. The short TAFs are issued approximately 1 hour before the time when they become valid and they have a period of

validity of 9 hours. Furthermore, for the airports of [AM,RD,BK] 4 times a day a long-TAF is produced with a period of validity of 18 hours. The long TAFs are issued approximately 8 hours before the time when they become valid. At Schiphol TAFs are produced by the forecaster who uses the Direct Model Output (DMO) from a Numerical Weather Prediction (NWP) model. The model data is interpreted (cloud, significant weather, visibility, wind, etc.), regionalised, and corrected to take into account the latest available observations from various sources such as SYNOP, satellite, and radar.

The production of TAFs is a time consuming business and is partly based on routine. Especially during critical situations when the pressure on the forecaster is very high, it would be desirable to speed up the routine based part by using an automatic procedure than can increase the efficiency of production and at the same time gain in accuracy of the final product. There has been a lot of activity in recent years to come to a semi-automation of TAF production, cf. Lynn [1997]. Due to the exact nature of forecasting cloud and visibility to within predefined threshold values as laid out by ICAO, a full automation of TAF production is unlikely in near future. However semi-automation is certainly possible, with the forecaster having the final input, especially in critical situations. Keeping this in mind we might state that the real issue here is not *whether* TAFs should be automated but the *degree* of automation in TAF production.
Lynn [1997] gives an international survey of World Wide developments in TAF automation. At the moment there are a number of TAF automation systems operational across the world. Some of them are more advanced than others in their development with Germany (DWD), NWS in USA, Sweden and Finland, leading the field. All these systems tend to follow a similar pattern, a combination of Direct Model Output (DMO) and Model Output Statistics (MOS).

In a previous definition study, cf. Verbeek [1997], KNMI has examined the various possibilities of a semi-automation of the TAF production for the aviation meteorological service LMD. It was decided to develop and implement an automated system based on MOS and purchase the development of the underlying statistical interpretation of the model data from Meteo Service Weather Research in Berlin. Meteo Service is a private company especialised in development and application of statistical interpretation methods, cf. Knüppfer [1996]. In recent years this company has developed and implemented a comprehensive software system aiming at the automation of aviation weather forecasts in close cooperation with the German Weather Service (DWD), cf. Knüppfer [1997]. The system consists of the components TAF-guidance and AUTO-TAF. The TAF-guidance is a MOS system, based on model data and observations, and produces forecasts for a specialised TAF oriented predictand set. The AUTO-TAF component translates the TAF-guidance in an alfa-numeric code complying with WMO and ICAO regulations.
The definition study has resulted in the project 'First Guess TAF' whose aim it is to develop and implement the MOS based postprocessing system, for the purpose of semi-automatic TAF production, on model data from the Dutch NWP model HIRLAM and observations from SYNOP and a local bulletin called KLIM.

This report describes part of the development phase, the implementation of the resulting First Guess TAF (**FGTAF**) system in the Automatic Production Line (APL) at KNMI, and some of its preliminary results.
In section 2 of this report we shall discuss some of the general aspects of the MOS related system among which the TAF-guidance, the predictand set, the original DMO predictors, the derived DMO predictors, the observations, the interpretation of the MOS equation, and the AUTO-TAF encoding algorithm. The implementation of FGTAF in the APL is the subject of section 3, and in section 4 the various interconnected modules of the FGTAF system are described in some detail. Finally in section 5 we conclude with some general remarks and recommendations on the use of the FGTAF system.

2 General aspects of FGTAF

FGTAF is a statistical postprocessing model which has especially been developed for a set of aviation oriented predictands such as wind, clouds, visibility and precipitation. These predictands are the elements to be forecasted in the TAF-guidance which is one of the products of the model. Table 2.1 gives an overview of the most important predictands in this TAF-guidance.

Mnemonic	dt	Explanation
T	0	Temperature in deg C
Td	0	Dew Point Temperature in deg C
DD	0	Wind Direction in Deka-Degree: e.g. 9=E, 18=S, 27=W, 36=N
FF/kt___00	0	Wind Speed (10-Min. Average)
FX_X_____t	t	Maximum Gust of Recent t Hours (t = 3,1h)
P_FX_X > *_t	t	Prob of FX_X_____t > * kt (t = 3,1h) (* = 25,40,55)
P_FF > _*_00	0	Prob of FF > * kt (* = 15,25,35)

P_* < **	0	Prob of Cloud Cover * below **:
		* : SCT, BKN, OVC
		**: 2,5,10,15 hft, CAVOK
VIS/100m	0	Visibility in 100m (OK = Visibility > = 10 km)
P_Vis < *	0	Prob of Visibility < * (* = .2,.4,.6,.8,1.5,3,5,8 km)
ww_Code	0-6	ww-Code from Pw*LMH_1, RR/6h, P_VIS < 800m and N
N	0	Total Cloud Cover in Octa
Overcast	0	Overcast Height in hft (OK = NSC or Overcast > CAVOK)
Ceiling	0	Ceiling Height in hft (OK = NSC or Ceiling > CAVOK)
Scattered	0	Scattered Height in hft (OK = NSC or Scattered > CAVOK)
P_* < **	0	Prob of Cloud Cover * below **:
		* : SCT, BKN, OVC
		**: 2,5,10,15 hft, CAVOK
Okta < *	0	Cloud Cover below * (* = 2,5,10,15 hft, CAVOK)
P_Cb %	0	Prob of the Occurrence of Cb Clouds
Pw_*_** _t	t	Probs of Precipitation, Derived from (observed) ww-Code
		t: Valid Time Duration: t=0: Spot Time of Observation
		t=1: Recent Hour, Inclusive t=0
		* : Precipitation Type (* = Any,Str,Con,Ths,Sol,Liq,Frz)
		**: Precipitation Intensity:
		** = LMH: Light or Moderate or Heavy,
		_MH: Moderate or Heavy,
		L__: Light
		RcVc_: Recent/Vicinity (t=1, exclusive t=0)
RR/6__mm/10	6	Precipitation Amount (QPF) in 6 Hours
P_RR6 > *mm	6	Prob of RR/6 > * mm (* = 0,5)

Table 1: Short description of predictands in TAF-guidance.

In Table 2.1, dt denotes the Valid Time Duration for which the predictands are defined,
visibility, ceiling and wind speed are also forecasted under the condition of precipitation - we write *(WX)*: Forecast
for Element '*' under the Condition of Precipitation,
CAVOK: CAVOK-Level: Default: CAVOK = 50 hft,
and the relations between Pw_*-Predictands are:

Pw_Any_* $\qquad$ = Pw_Str_ + Pw_Con_*
Pw_Any_* $\qquad$ = Pw_Liq_ + Pw_Sol_*
Pw_Con_* $\qquad$ ≥ Pw_Ths_*
Pw_Liq_* $\qquad$ ≥ Pw_Frz_*
Pw_Any_LMH_* = Pw_Any_L___* + Pw_Any__MH_*
Pw_Any_LMH_1 = Pw_Any_LMH_0 + Pw_Any_RcVc_

2.1 The HIRLAM-STAT-archive

The underlying statistical technique of FGTAF is Model Output Statistics (MOS). The MOS system is based on
Direct Model Output (DMO) from the NWP model Hirlam and observations from various sources such as SYNOP
and KLIM.[2]

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 2: Hirlam-STAT pressure level parameters on 300, 500, 700, 850, 925, and 1000 hPa.

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 3: Hirlam-STAT surface parameters on 0, 2, and 10 m.

The development of the MOS system requires a tremendous amount of model data in the form of model fields, and observations from each location for which we desire a TAF-guidance. The complete set of Hirlam model data comprises the period [1994,...,1997] and consists of upper-air field data available on various pressure levels (cf. Table 2.2), and surface parameters available on various heights above the surface (cf. Table 2.3). For the purpose of the project 'First Guess TAF' observations are selected from 18 Dutch stations, cf. Table 2.5. The selection includes automatic and visual observations over a period of 10 years, [1987,...,1997], cf. Table 2.4. The model data and observations are part of KNMI's HIRLAM-STAT-archive which is described in more detail in Jacobs [1998].

Code	Meaning	Unit
T	air-temperature	$[0.1\ ^\circ C]$
TN6	min. temperature over the last 6 hours	$[0.1\ ^\circ C]$
	(once every 6 hours)	
TX6	max. temperature over the last 6 hours	$[0.1\ ^\circ C]$
	(once every 6 hours)	
T10	min. temperature at 10 cm over the last 6 hours	$[0.1\ ^\circ C]$
	(once every 6 hours)	
TD	dewpoint-temperature	$[0.1\ ^\circ C]$
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	[degrees], 999 = variable
	period in the preceding hour	
FF	mean speed of the wind over the last 10-minutes	[0.1 m/s]
	period in the preceding hour	
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 4: List of elements in observation files.

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

Table 5: Station list of observations.

2.2 The MOS system

The Hirlam model forecasts and the observations act as predictor sources. They are the independent variables used as input in the MOS system. According to experience the design of a MOS system is first and foremost a synoptical challenge. The better the preparation of the predictors and predictands the better the final results. Besides the set of DMO parameters like T_{2m}, windspeed and direction, precipitation, cloud cover, and upper-air geopotential heights, temperatures, wind and relative humidity, preparation comprises also linear and non-linear transformation of these DMO predictors. Some of these predictors are transformed by the use of simple analytic functions, for example (cf. also Knüppfer [1997]):

- Geostrophic wind and vorticity indices are derived from geopotential heights.
- Wet bulb potential temperatures are calculated from the upper-air predictors.
- Gradients and advections of several parameters are calculated.
- Non-linearly transformed and vertically integrated relative humidity values have been added for cloud cover (ceiling) and precipitation forecasts. In most cases the regression prefers these predictors instead of using DMO cloud cover predictors.
- Thunderstorm indices (TotalTotals, Ko, S, Steinbeck, Darkov) are derived and offered to the statistics as predictors for convective predictands. Most of the indices are defined between 850 and 500 hPa.
- Fog predictors. Non-linear transformations of spread, windspeed and cloud cover are used for the description of potential radiation fog situations. Obstructions to visibility by precipitation are also expressed as predictors.

Other predictors are:

- Persistency of the statistical forecast.
- Statistical forecasts of other elements, e.g. in the TAF project the statistical forecast of P(Cb) is used as predictor for P(Ths).
- Predictors of valid time +/-3 and +/-6 hours.

- Sine and cosine of the day in year.
- Binary predictors which are used to remove the consequences of a change in systematical errors of predictors, e.g. in case of changes of the numerical model.

The challenge in the calculation of the MOS equations is not only a thorough preparation of the input predictors but also the possibility and capability to use a regression algorithm which selects and weightens the predictors in order to combine them in an optimum way. The regression algorithm has been optimised with the goal to minimise the RMSE of the predictands on independent data. This optimisation is based on results of research on statistical overfitting, cf. Carr [1988] and Enke [1988]. Any predictor in the regression equation may be a source of useful information but at the same time a source of statistical overfitting. Statistical overfitting of a regression equation can be considered as artificial skill :

$$AS = [RMSE^{(I)} - RMSE^{(D)}]/ RMSE^{(D)},$$

where $RMSE^{(I)}$ is the expected RMSE of the predictand at independent data. $RMSE^{(D)}$ is the RMSE of the predictand at the development sample. The artificial skill depends on:

- The sample size (number of cases n),
- the number p of predictors in the regression equation,
- The number pp of potential predictors to choose from.

The work of Carr [1988] and Enke [1988] resulted in a criterion when to stop including additional predictors into the regression equation. Enke [1988] derived an approximate formula for a critical correlation coefficient R_{crit} in dependence on a given confidence level S for predictor selection:

$$R_{crit} = \frac{\left\| \ln \left[\frac{S}{pp} \right] \right\|^{0.6135}}{\sqrt{n-1}}. \qquad (1)$$

R_{crit} can be interpreted as a threshold value for predictor selection or rejection in a forward regression scheme. Currently a value of S = 0.18 is believed to give the best results in this cut-off criterion.

In the development phase of FGTAF the regression scheme works as follows:

First a one-predictor-equation is calculated using the predictor which has the highest linear correlation to the predictand. The error of the one-predictor-equation (residual) is the new predictand. The predictor with the highest correlation to the residual is selected as second predictor. The two-predictor-equation is calculated then. The predictor with the highest correlation to its residual is selected next and so on. This procedure stops when a critical value of the correlation to the residual isn't reached any more. This critical value R_{crit} is calculated according to formula (1) which considers the number of cases n and the number of potential predictors pp. The inclusion of the effect of pp on statistical overfitting is not finished yet. It is considered only for stopping the regression procedure but not yet for estimating RMSE at independent data. Thus, all estimates for RMSE are too optimistic.

A MOS equation example

Let us look at some more detail to a regression output list for the predictand TTT, i.e. 2m temperature, of the FGTAF TAF-guidance:

Loc=06240		(luv=290)		Issue=04 +008		(valid=12z)		TTT	
SEASON: win									
MV	SD	R_Pd	R_Res	Name	dRVI	Co	Wgt	Ctr	
38.9	40.1	0.92	0.92	DMO_T2M	84.8	0.81	56	66	
11.1	74.2	-0.15	0.37	Sin_2*Dag	13.3	0.08	10	-2	
-1.0	3.5	-0.42	-0.29	Rel_Div_10m	7.6	-1.32	-8	4	
3.9	9.2	-0.12	0.15	Grad_ThW_850_V	0.4	0.18	3	0	

| 45.8 | 46.0 | 0.83 | 0.27 | TTT(-24)Obs | 18.6 | 0.24 | 19 | 20 |
| -10.9 | 42.5 | 0.43 | 0.16 | T_850 | 1.3 | 0.07 | 5 | 3 |

Const. = -0.2	#Cases = 412	RV(HC) = 91	SD%(8) = 7
MV(Pd) = 44.5	#PotPr = 150	E(RVI) = 90	RMSE = 13.3
SD(Pd) = 45.2	#Reject = 10	RVI_opt =	E(RMSI)= 14.1

The output list consists of three parts: (a) Headline, (b) Statistical description of the predictors and their forecasting value, and (c) the Summary line with regression results and characteristics.

The headline gives the station number, 06240 for Schiphol airport, the prevailing onshore wind direction of 290 degrees for this station, the issue time 04h, the lead time +08hrs, the time of validity, 12h, and the mnemonic of the predictand, TTT for T_{2m}. The issue time of 04h means that the observation of 03h is the most recent persistency information. All times in the headline are in UTC. The MOS system computes the equations for 4 different seasons. This example concerns winter season.

In the statistical description of the predictors the columns are:

MV : Mean values of the predictors and predictand.

SD : Standard deviation of the predictors and predictand.

R_Pd : Linear correlation coefficient between predictor and predictand.

R_Res : Linear correlation between the residual of the (n-1)-predictor-equation and the predictand.

Name : Name of the predictor.

dRVI : Additional expectation of reduction of variance of the predictand of the n-predictor-equation as compared to the (n-1)-predictor-equation.

Co : Regression coefficient.

Wgt : Normalised weight of predictor, Wgt(Pr) = 100% Co(Pr) SD(Pr) _Pr Co(Pr) SD(Pr).

Ctr : Contribution of the predictor to the total reduction of variance , Ctr(Pr) = 100% R_Pd Co(Pr) .

The weights of the predictors are calculated in order to get an idea about the importance of a single predictor in the regression equation. Therefore, the regression coefficients are multiplied with the standard deviation of the predictor. This product is normalised such that the sum of the absolute values of the weights is equal to 100(%). The sign of the weight is the same as the sign of the regression coefficient. Ctr is an expression for the 'isolated' contribution of a predictor to the total reduction of variance of the regression equation. The sum of all Ctr values is equal to the RV (reduction of variance) of the predictand. Its definition follows from the formula for the calculation of the reduction of the variance of a one predictor regression equation. Negative Ctr values of some predictors indicate that they help other predictors reducing the variance of the predictand. Wgt and Ctr values are important figures for the interpretation of the regression equation.

At the end of the output list we find the regression results and its characteristics. The meaning of the values is: Const., the regression constant; MV and SD, the Mean Value and Standard Deviation of the predictand; RMSE, the RMSE of the regression equation; E(RMSI), the Expected RMSE at Independent data; RV, the Reduction of Variance based on RMSE and SD; E(RVI), Expected Reduction of Variance at Independent data; RVI_opt, Expected Reduction of Variance as compared to the optimum persistency forecast; Cases, the Number of observations; and PotPr, the number of Potential Predictors.

Now let us discuss the regression results of the example.

The winter season is defined from 15 Nov till 27 Feb. DMO_T2m is the Hirlam model variable with the highest absolute correlation to the predictand. It can be expected to reduce 84.8% of the original error variance. As the original error variance equals $[Sd(Pd)]^2$ on independent data, after reduction the SD of the 1-predictor equation is 17.6, compared to the original 45.2 of the predictand. DMO_T2m has a date-dependent error which is described by Sin_2∗Dag. This sine funtion is equal to -100 at about 15 Nov, zero at 01 Jan and +100 at about 15 Feb. The positive correlation between Sin_2∗Dag and the residual (R_Res=0.37) indicates that DMO_T2m tends to be too high in early winter and/or too low in late winter. The inclusion of the sine-function reduces 13.3% of the error variance of the 1-predictor equation which is 100% - 84.8% = 15.2%. Now 13.3% of 15.2% is about 2% of the total error error variance. The coefficient of 0.08 shows that to each MOS forecast without date-dependent predictor this predictor

subtracts $0.8\,^{\circ}$C in November and adds $0.8\,^{\circ}$C in February, since the unit of the predictand is $0.1\,^{\circ}$C.
A next correction of DMO_T2m is possible with Rel_Div_10m. The 2-predictor equation has a positive bias when Rel_Div_10m is positive. The last model predictor Grad_ThW_850_V reduces the variance only very little (0.4% of the variance of the 3-predictor equation). Now the cut-off criterion for predictor selection (critical correlation) is reached. In this stage of the regression equation development persistency predictors are allowed to enter the regression equation. In this case, the persistency of the observation of yesterdays 12h-temperature gives a significant reduction of variance. After the inclusion of this predictor another model variable T_850 exceeded the critical correlation to the residual of the 5-predictor equation. Usually, now persistency of statistical forecast is allowed to enter the regression equation. Since T+008 is the first valid time of the long TAF there is no persistency of statistical forecast available, and the regression equation is finished. The regression constant is $0.02\,^{\circ}$C.

The sum of the regression coefficients of all temperature predictors is $0.81 + 0.24 + 0.07 = 1.12$. This is mainly since the standard deviation of the leading predictor DMO_T2m is 12% lower than the standard deviation of the predictand. From the weight column you can see, that the equation is dominated by DMO_T2m (56% of the predictor weight), followed by TTT(-24)Obs with 19%. The negative contribution of Sin_2∗Dag does not indicate that this is a 'bad' predictor: This predictor helps DMO_T2m to get a higher coefficient and thus a higher contribution. Without Sin_2∗Dag the contribution of DMO_T2m might have been only 62% in this equation. Negative contributions are always connected with different signs of R_Pd and R_Res. The expected RMSE on independent data is $1.41\,^{\circ}$C. The expected reduction of variance on independent data is 90%, since $[E(RMSI)]^2=(14.1)^2$ is about 100-E(RVI)=10% of $[SD(Pd)]^2=(45.2)^2$.

2.3 The TAF-guidance

From the beginning of August 1998, when the FGTAF system became semi-operational, the first TAFs, TAF-guidance and TAF-code, have been produced for 18 selected locations (cf. Table 2.5) with the FGTAF system at KNMI. The most recent available Hirlam model data and the latest SYNOP/KLIM observations as described in section 2.1 have been used as general predictors for the system.

TAF-guidance ma 03.08.1998 10z 06240 EHAM Amsterdam Intl								General			
	OBS	ma 03		di 04					KLIMA 92-97		
PREDICTAND	09z	18	21	00	03	06	09	12	00	06	12	18
T	18	18	16	16	16	16	18	19	17	17	23	22
Td	13	14	16	16	16	16	15	13	15	16	15	15
DD	20	22	22	23	25	28	30	31	25	19	2	32
FF/kt___00	10	15	14	15	12	10	12	13	6	6	10	9
FX_X____03		26	25	24	22	17	20	22	11	11	17	17
FX_X(WX)03		24	26	24	21	19	17	22				
P_FX > 25_03	0	59	58	59	40	29	22	33	4	4	13	14
P_FX > 40_03	0	6	9	4	2	1	1	2	0	.3	.3	.7
P_FX > 55_03	0	0	2	0	0	0	0	0	0	0	0	0
VIS/100m	OK	OK	OK	94	80	84	OK	OK	OK	OK	OK	OK
VIS(WX)		55	53	45	48	47	74	66				
P_Fog_1h	0	0	0	3	2	1	0	0	2	7	0	0
P_VIS < 5 km	0	25	24	27	27	26	10	2	15	24	7	5
P_VIS < 3 km	0	16	12	14	13	15	4	1	7	14	3	2
P_VIS < 1.5km	0	6	6	6	5	5	1	0	3	7	.4	.4
P_VIS < 800m	0	0	0	1	0	0	0	0	1	.5	0	0
N_total	2	8	8	8	8	7	7	6	3	5	4	4
Ceiling	OK	48	27	8	11	14	32	37	OK	OK	OK	OK
Ceiling(WX)		25	17	8	11	13	18	24				
P_BKN < CAVOK	0	52	88	91	93	92	78	73	17	28	20	14
P_BKN < 1500ft	0	13	30	83	87	55	21	9	7	12	7	4
P_BKN < 1000ft	0	13	30	62	36	22	7	3	5	7	2	1
P_BKN < 500ft	0	0	3	6	6	4	2	0	.8	3	0	0
P_BKN < 200ft	0	0	0	0	0	1	0	0	0	0	0	0
P_BKN < 100ft	0	0	0	0	0	0	0	0	.1	.1	0	0
Pw_Any_LMH_1	0	54	71	66	62	43	29	15	11	10	11	12

PREDICTAND	OBS 09z	18	21	00	03	06	09	12	00	06	12	18
Pw_Any__MH_0	0	5	1	4	6	1	1	1	2	0	.7	3
Pw_Str_LMH_1	0	51	61	61	57	33	12	7	6	5	4	4
Pw_Con_LMH_1	0	3	10	5	5	10	17	8	5	5	8	8
Pw_TS__LMH_1	0	0	1	2	0	1	0	0	1	1	.3	3
Pw_Sol_LMH_1	0	0	0	0	0	0	0	0	.1	0	0	0
Pw_Lqd_LMH_1	0	54	71	66	62	43	29	15	11	10	11	12
Pw_Frz_LMH_1	0	0	0	0	0	0	0	0	0	0	0	0
Pw_Any_LMH_0	0	54	61	40	28	21	7	5	6	5	5	7
Pw_Any_L___0	0	49	61	36	22	20	6	4	4	5	4	5
Pw_Any_RcVc_	0	0	10	26	34	22	22	11	5	5	6	4
RR_Duration%	0	11	20	15	22	17	0	0	4	2	3	4
RR1__mm/10	0	0	1	1	3	0	0	0	1	.2	.4	.8
RR6__mm/10	0	4		7		20		4	5	6	3	4
P_RR6 > .0mm	0	62		83		69		50	18	19	23	21
P_RR6 > 5 mm	0	0		2		0		0	4	3	2	2

Table 6: General forecast information TAF-guidance example.

TAF-guidance ma 03.08.1998 10z 06240 EHAM Amsterdam Intl Detail	OBS	ma 03		di 04					KLIMA 92-97			
PREDICTAND	09z	18	21	00	03	06	09	12	00	06	12	18
FF(WX)__00		13	14	14	10	8	9	12				
P_FF > 15_00	0	55	57	61	30	23	34	34	5	5	18	13
P_FF > 25_00	0	12	2	3	2	1	3	4	.1	.4	.9	.5
P_FF > 35_00	0	1	0	0	0	0	0	0	0	.1	0	0
FX_X____01	14	25	23	22	19	16	18	20	10	10	16	15
P_FX > 25_01	0	52	41	42	23	18	22	23	3	3	11	9
P_FX > 40_01	0	6	3	2	1	0	1	1	0	.3	.1	.1
P_FX > 55_01	0	0	0	0	0	0	0	0	0	0	0	0
P_VIS < 8 km	0	36	40	43	50	48	19	7	26	36	14	12
P_VIS < 5 km	0	25	24	27	27	26	10	2	15	24	7	5
P_VIS < 3 km	0	16	12	14	13	15	4	1	7	14	3	2
P_VIS < 1.5km	0	6	6	6	5	5	1	0	3	7	.4	.4
P_VIS < 800m	0	0	0	1	0	0	0	0	1	.5	0	0
P_VIS < 600m	0	0	0	0	0	0	0	0	.8	.1	0	0
P_VIS < 400m	0	0	0	0	0	0	0	0	.4	.1	0	0
P_VIS < 200m	0	0	0	0	0	0	0	0	.3	.1	0	0
Okta < CAVOK	2	4	7	8	8	7	6	5	1	2	2	2
Okta < 1500ft	0	1	3	4	5	4	3	2	.6	1	.6	.4
Okta < 1000ft	0	1	2	3	3	2	1	0	.4	.7	.2	.1
Okta < 500ft	0	0	0	0	1	1	0	0	.1	.3	0	0
Okta < 200ft	0	0	0	0	0	0	0	0	0	0	0	0
Okta < 100ft	0	0	0	0	0	0	0	0	0	0	0	0
Overcast	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Ceiling	OK	48	27	8	11	14	32	37	OK	OK	OK	OK
Scattered	OK	32	14	8	9	12	14	31	OK	OK	OK	OK
P_OVC < CAVOK	0	16	30	46	41	31	25	14	4	9	4	3
P_OVC < 1500ft	0	5	16	26	30	20	12	6	1	5	1	.7
P_OVC < 1000ft	0	1	9	15	17	12	6	2	.8	3	0	0
P_OVC < 500ft	0	0	0	2	4	3	1	0	0	.1	0	0
P_OVC < 200ft	0	0	0	0	0	0	0	0	0	0	0	0
P_OVC < 100ft	0	0	0	0	0	0	0	0	0	0	0	0
P_SCT < CAVOK	0	82	88	91	93	92	84	80	21	36	35	20
P_SCT < 1500ft	0	18	51	83	87	70	53	23	10	16	10	7
P_SCT < 1000ft	0	18	38	76	58	27	20	4	5	11	4	2
P_SCT < 500ft	0	1	5	8	9	7	4	0	1	4	0	.1
P_SCT < 200ft	0	0	0	0	0	1	0	0	0	0	0	.1

P_SCT < 100ft	0	0	0	1	0	0	0	0	.3	.1	0	0
P_Cb	0	3	5	3	3	6	5	2	3	3	2	6

Table 7: Detail forecast information TAF-guidance example.

Tables 2.6 and 2.7 show an example of one of the first TAFs produced by the FGTAF system at KNMI. The example is of a long-TAF issued at 03-08-1998 at 10h for Schiphol airport (StationCode = EHAM, WMO-Nr.). The first lead time is +08hrs and the times of validity are given in the table with a 3h time interval. The last column gives the corresponding climatology based on 6 years of observations in the period [1992,...,1997]. The observations during the period of validity [18h, 12h] are given in Table 2.8 for temperature (T), wind direction (DD), windspeed (FF), maximum windspeed in the preceding hour (FX), Ceiling (first layer with cloud cover ≥ 5/8), visibility (VV) and WW-code for present weather.

Observations for EHAM: ma 03 and di 04 August 1998								
	OBS	OBS ma 03		OBS di 04				
PREDICTAND	09h	18	21	00	03	06	09	12
T	179	190	180	167	172	163	172	179
DD	200	230	230	230	260	300	310	300
FF	50	80	100	70	60	40	70	80
FX	40	80		80	60	50	70	80
CEILING	OK	OK	21	7	6	38	OK	OK
VV	82	80	75	32	30	64	81	83
WW			21	59	59	21		

Table 8: SYNOP and KLIM observations for TAF-guidance example in Table 2.6 and 2.7.

The TAF or TAF-code based on the TAF-guidance was generated with the TAF encoding algorithm and reads for EHAM:

```
 EHAM  031812 23015G25KT 9000 SCT010 BKN020 TEMPO 2304 4500 RA
        FM05 30010KT 9999 SCT010 BKN025=
```

The general interpretation of this TAF is straightforward with G25KT meaning maximum gusts of 25kt, the TEMPO group indicates that between 23h and 04h UTC the visibility drops to 4500m in rain RA, from 05h UTC (FM05) the direction of the wind changes to 300 degrees with a reduction of the windspeed to 10kt, the visibility increases to 9999m and the amount of clouds changes only slightly.
The meteorological TAF for this example was not available at the moment of this writting.

Let us point out some of the shortcomings of the TAF encoding algorithm.
It is remarkable that in the encoded TAF low ceiling is not included, while the guidance indicates a ceiling of 800 ft at 00h UTC, 1100 ft at 03h UTC and 1400 ft at 06h UTC. Encoded was not worse than 2000 ft, while the 800 ft in the guidance is two classes worse. In daily forecasting this would be equivalent for an immediate amendment. It is not yet clear why the TAF encoding algorithm does not include a lower ceiling like BKN008 in the TEMPO 2304 group.

We might conclude that the TAF-code is not a very good representation of the cloud data provided in the guidance. Experience at the German Weather Service (DWD) has shown that low cloud base, i.e. the predictand P_BKN < ∗, read "Probability of ceiling below ∗ feet", is encoded to pessimistic in the TAF. However improvements are to be made to the TAF encoding algorithm, especially for the use of BECMG and TEMPO groups, later this year.

2.4 The TAF encoding algorithm AUTO-TAF

The AUTO-TAF subsystem has been developed to produce the coded TAFs directly from the predictand set in the TAF-guidance. The encoding is according to ICAO and WMO regulations and furthermore it is controlled by two conflicting criteria:

1. The loss of relevant information due to the encoding must be minimised.
2. The code must be as short as possible.

In order to keep the TAFs as short as possible but otherwise containing all the necessary information from the guidance, a bonus/penalty system has been developed which goal it is to control the optimisation in the process of AUTO-TAF generation. Summarising, this system works as follows:

1. For each of the four weather groups (wind, visibility, significant weather, clouds) an average forecast for the valid time of the whole AUTO-TAF is produced.
2. Penalty points for this TAF are calculated as follows: For each hour, the difference between the TAF-guidance and the AUTO-TAF is squared and multiplied by a weighting factor. The weighting factor depends on the importance of the element and can be configured by the user.
3. A trigger tries to separate the weather groups into two or three using BECMG (BECoMinG). BECMG indicates a significant change in forecast conditions, during a specified time interval, which can be at a regular or irregular rate.
4. The penalty points for the TAF are recalculated including the penalty points for creating the new groups. The latter can be configured by the user which gives him/her the possibility to control the average length of the AUTO-TAF.
5. The most effective change, i.e. the one with the highest reduction in penalty points, is executed and the system goes back to point 2.
6. If no more usefull BECMG can be added then the system tries to put together BECMGs into FM (FroM). FM is used if one set of weather conditions is expected to change more or less completely to a different set of conditions. FM is used instead of BECMGs if it reduces the total number of penalty points.
7. Now the system continues with the inclusion of PROB (PROBability) and TEMPO (TEMPOrary) groups. Here TEMPO is interpreted as a probability of 40%. A combination of TEMPO PROB or PROB TEMPO can be interpreted as probabilities lower than 30%, e.g. PROB30 TEMPO is interpreted as 12%, i.e. $40*30/100$. The efficiency of PROB and TEMPO group using can be configured by the user. The standard AUTO-TAF configuration is optimised in cooperation with the German Weather Service DWD. The first verification results of the DWD TAFs are already available. The results together with a detailed description of the verification system can be found in Balzer [1994], [1996].
8. Finally the TAF is selected that gained the least penalty points.

The principles 1 to 8 above describe the main processing points of the encoding algorithm. The TAFs that are being produced with the AUTO-TAF system are often too pessimistic, especially regarding low clouds, poor visibility, and thunderstorms. Optimisation and configuration of the TAF encoding system is one of our tasks in near future and this can partly be done by adapting trigger and threshold values in the TAF configuration files.

3 The operational forecast scheme of FGTAF in the APL

The purpose of FGTAF in the APL is to make an automatic first guess for Short-TAFs and Long-TAFs, based on Hirlam model field data, and the latest available observations (automatic and visual) from SYNOP and KLIM. The TAFs are produced several times a day, 8 Short-TAFs and 4 Long-TAFs, for 18 Dutch stations, cf. Table 2.5. The APL products for FGTAF are (a) the TAF-guidance, which contains a weather forecast related to the main elements in aviation (wind, visibility, significant weather, and clouds), and (b) the TAF-code, an alfa-numeric summary of the guidance.
The forecasts are produced based on input from the latest available Hirlam model field data. The Hirlam data is refreshed 4 times a day, and available at successively 03h, 09h, 15h, and 21h GMT, approximately 3 hours after a Hirlam run has been started. Recent observations from SYNOP and KLIM are supplied to the FGTAF system each hour of the day by extraction from the 'Real Time Observation Database' (RTWNDB).

Tables 3.1 and 3.2 show the operational runscheme for TAF-guidance and TAF-code production in the APL for the Short-TAFs and the Long-TAFs respectively. The Short-TAFs are produced 8 times a day and are issued approximately 1 hour before the time when they become valid. As the operational forecaster needs approximately 0.5 hour to check the results of the guidance and to take some necessary actions, for the Short-TAFs in the APL we have proposed the operational runscheme as shown in Table 3.1.
The Long-TAFs are produced 4 times a day and are issued approximately 7 hours and 15 minutes before the time when they become valid. If we add an additional 45 minutes for surveillance by the forecaster, in the APL we have the operational runscheme as shown in Table 3.2. Note that the issue time in the tables is the APL issue time of the first guess, i.e. the guidance and the alfa-numeric code, and that is not the final issue time of the operational TAF which is issued by the aviation forecaster.

Short-TAFs	Issue	Last	Hirlam	Forecasting Lead Times relatively to Issue Times

valid periods	Time	Obs	Model Run	
[01h,10h]	23:30	23h	18h	+00:30 +01:30 +02:30 …… +09:30 +10:30
[04h,13h]	02:30	02h	18h	+00:30 +01:30 +02:30 …… +09:30 +10:30
[07h,16h]	05:30	05h	00h	+00:30 +01:30 +02:30 …… +09:30 +10:30
[10h,19h]	08:30	08h	00h	+00:30 +01:30 +02:30 …… +09:30 +10:30
[13h,22h]	11:30	11h	06h	+00:30 +01:30 +02:30 …… +09:30 +10:30
[16h,01h]	14:30	14h	06h	+00:30 +01:30 +02:30 …… +09:30 +10:30
[19h,04h]	17:30	17h	12h	+00:30 +01:30 +02:30 …… +09:30 +10:30
[22h,07h]	20:30	20h	12h	+00:30 +01:30 +02:30 …… +09:30 +10:30

Table 9: The operational runscheme for Short-TAFs in the APL.

Long-TAFs valid periods	Issue Time	Last Obs	Hirlam Model Run	Forecasting Lead Times relatively to Issue Times
[00h,18h]	16:00	15h	12h	+08 +11 +14 +17 +20 +23 +26
[06h,24h]	22:00	21h	18h	+08 +11 +14 +17 +20 +23 +26
[12h,06h]	04:00	03h	00h	+08 +11 +14 +17 +20 +23 +26
[18h,12h]	10:00	09h	06h	+08 +11 +14 +17 +20 +23 +26

Table 10: The operational runscheme for Long-TAFs in the APL.

Figure 3.2 gives a clear survey of the daily operational runscheme of FGTAF in the APL, and the interconnection of the main modules within the system. The TAF processing scheme is depicted in some more detail in figure 3.1. Only on this level Meteo Service software for reading modeldata (**gp**), reading observations and computing the TAF predictands (**oper**), reading climatology (**har**), writing the TAF-guidance (**fcs**), and producing the TAF-code (**taf**), comes into the picture. All source codes of this software (in fortran) are available at KNMI.
Finally the operational subscheme as given in figure 3.3 keeps track of the status of each module, archives some of the TAF dependent files such as the guidance and the code, and removes old files from the FGTAF system.

In the next section the main modules of the FGTAF system and their interconnection are described in more detail. A list of filenames and their contents can also be found in that section.
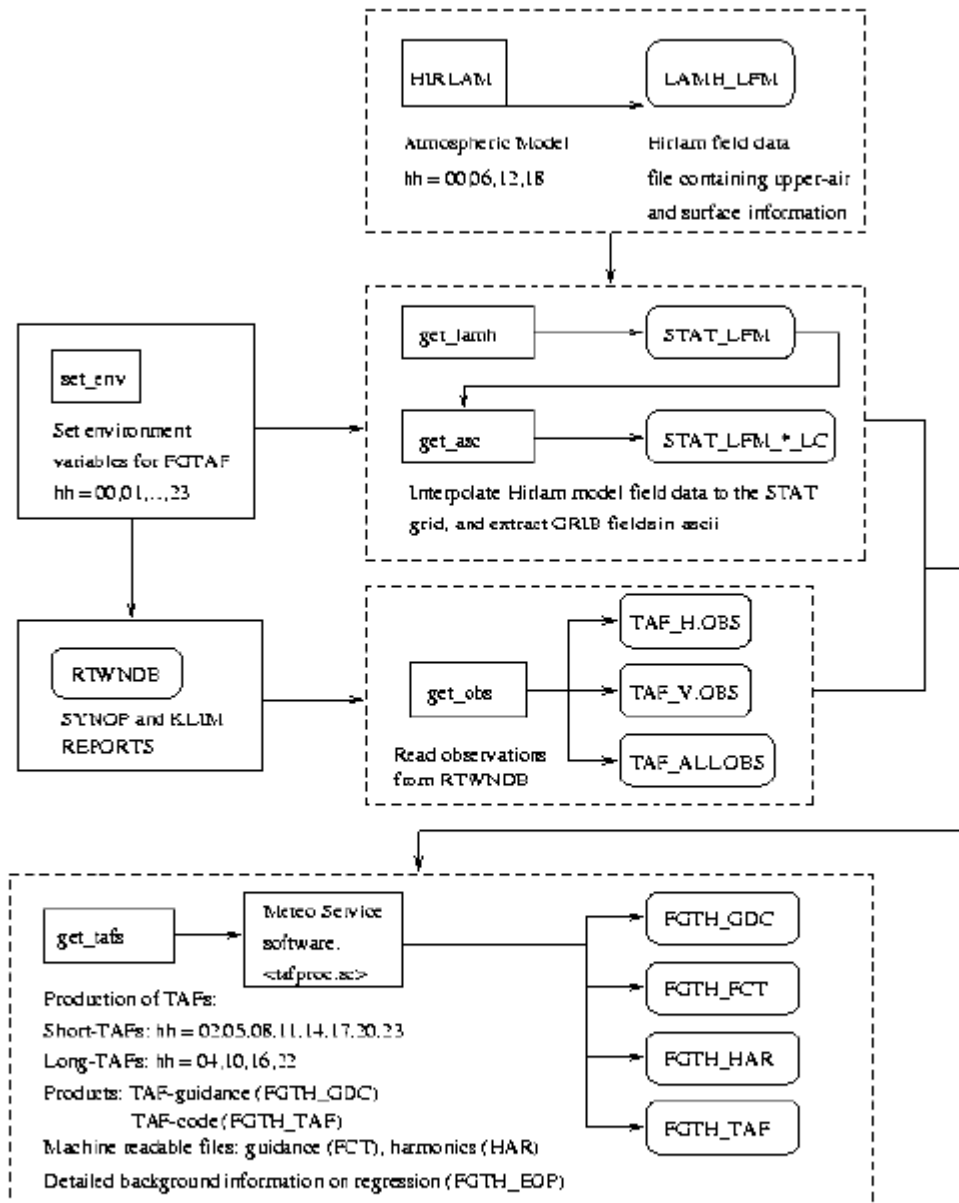
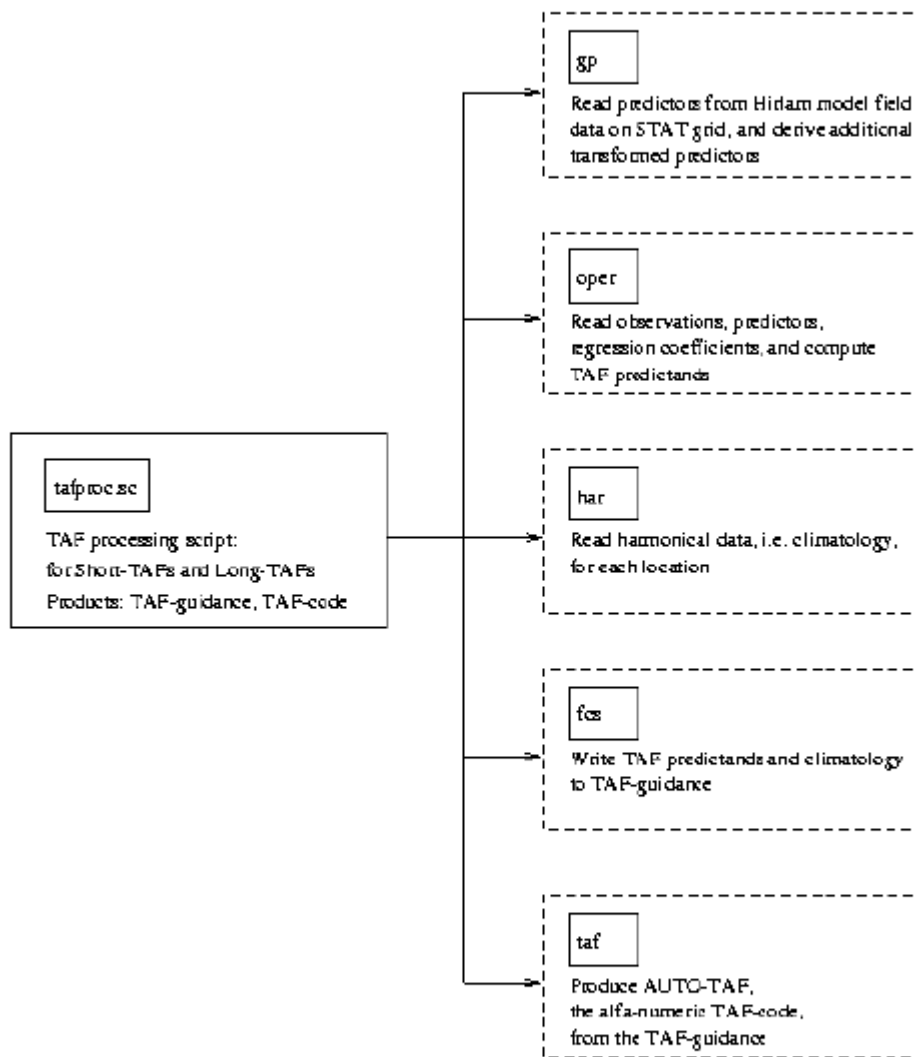Figure 3.1: The operational TAF processing submodule.

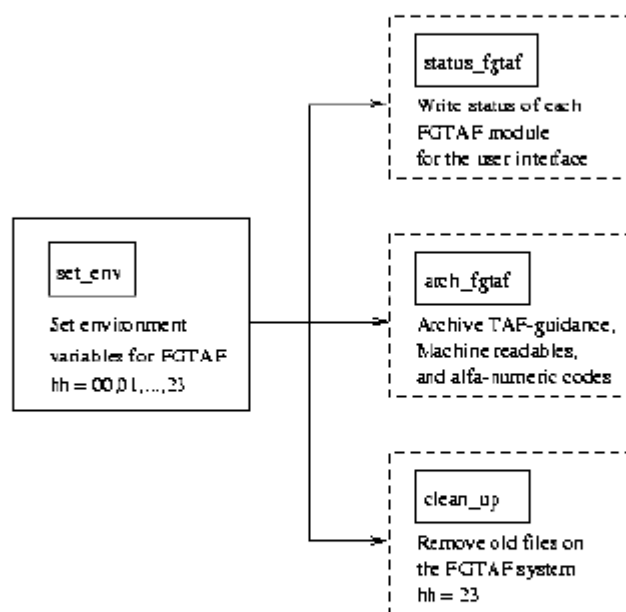Figure 3.2: The daily operational runscheme of **FGTAF** in the APL.

Figure 3.3: The operational subscheme of **FGTAF**.

4 A description of the FGTAF modules in the APL

The operational FGTAF system in the APL consists of various interconnected modules. The TAF processing submodule < **tafproc.sc** > is the heart of the system. Each of the modules in the system has its own well defined task, and is called by the FGTAF supervisor script < **oper_fgtaf.psc** > at predefined times. The supervisor script also keeps track of the status of these modules, and writes a statusreport for the userinterface after each operational run.

Each of the separate modules is called with an identifier $actdtg, the actual calling time of the module. Note that $actdtg = yymmddhh, which is the date/time label of the run. This identifier is used to label the intermediate and final products of each model run, and to combine the corresponding model field data, observations, climatology, and regression coefficients in a correct way. From figure 3.2 it is clear that the general operational runscheme for FGTAF can be divided into two seperate parts: (1) Preparation of TAF production by interpolating the Hirlam model fields on the STAT grid and extracting the observations from the RTWNDB, and (2) Computation of a Short-TAF or a Long-

TAF whenever this is required. The modules in part (1) are described in section 4.1 and the heart of the system, the computation of the TAF-guidance and the TAF-code, is subject of section 4.2. Finally in section 4.3 the subsystem is discussed.

4.1 Preprocessing of model data and observations

Before we can produce TAFs in the FGTAF system, some necessary preprocessing of model data and observations is required. Preprocessing of model data is controlled by means of the scripts < **get_lamh** > and < **get_asc** > . The preprocessing of observations is controlled by < **get_obs** > . We start the preprocessing steps by defining some specific locations in the FGTAF-directory tree, cf. figure 4.1. We do this by running the script < **set_env** > , which sets the environment variables for the system.

Now the preprocessing steps are:

1. Interpolation of Hirlam model field data: < **get_lamh** >

    If at hh-hour, new Hirlam model field data files LAMH_LFM are available, we interpolate the upper-air and surface parameters, as specified in tables 2.2 and 2.3, to the STAT-grid. Before the interpolation is performed, we compute some additional parameters such as relative vorticity and relative divergence. The components of the wind field (u,v) at each pressure level are destaggered before the interpolation is performed. We process the model fields on a 6 hourly time interval and with a maximum lead time of 48 hours. The result of this interpolation is written to STAT_LFM_$dtg files, with $dtg = yymmddhh the time label of the corresponding LAMH_LFM file. For operational use the resolution in space and time of the STAT-grid is identical as in the archive, i.e.

    Corner points: 60° North, 3° West to 48° North, 9° East.
    Scanning mode: North-West to South-East.
    Resolution (increments):

    Resolution in Time: +06 hour.

    Note: This script is not called when Hirlam is running, i.e. at hh = 02h, 08h, 14h, 20h.

2. Extraction of interpolated model field data in ascii: < **get_asc** >

    The purpose of this script is to read GRIB field data and write its contents to the ascii file STAT_LFM_${dtg}00_00000_LC. In this script general ASIMOF extraction software, such as **asix**, is used to read the GRIB fields.

    Note: This script is not called when Hirlam is running, i.e. at hh = 02h, 08h, 14h, 20h.

3. Extraction of automatic and visual observations from RTWNDB: < **get_obs** >

    Each hour this script extracts from the "Real Time Observation Database" (RTWNDB) observations for 18 Dutch stations. A quality check of the observations has not yet been implemented. This is one of the tasks in near future. The observations are written to separate files, TAF-H_${dtg}.OBS for the automatic observations and TAF-V_${dtg}.OBS for the visual observations. The additional file TAF_ALL_${dtg}.OBS contains all the observations over the last 24 hours. Here $dtg = yymmddhh is the time label of the last available observations.

<u>Filenames</u>:

In the filenames $dtg = yymmddhh is the time label of the files, and $fp = hh the lead time of the forecasts relative to $dtg.

LAMH_LFM_${dtg}00_0${fp}00_AB Hirlam model field data file (binary)
STAT_LFM_${dtg}00_0${fp}00_AB File with model data interpolated on STAT-grid (binary)

STAT_LFM_${dtg}00_00000_LC   FGTAF model field data file with all lead times (ascii)

TAF-H_${dtg}.OBS   File with automatic observations at $actdtg (ascii)

TAF-V_${dtg}.OBS   File with visual observations at $actdtg (ascii)

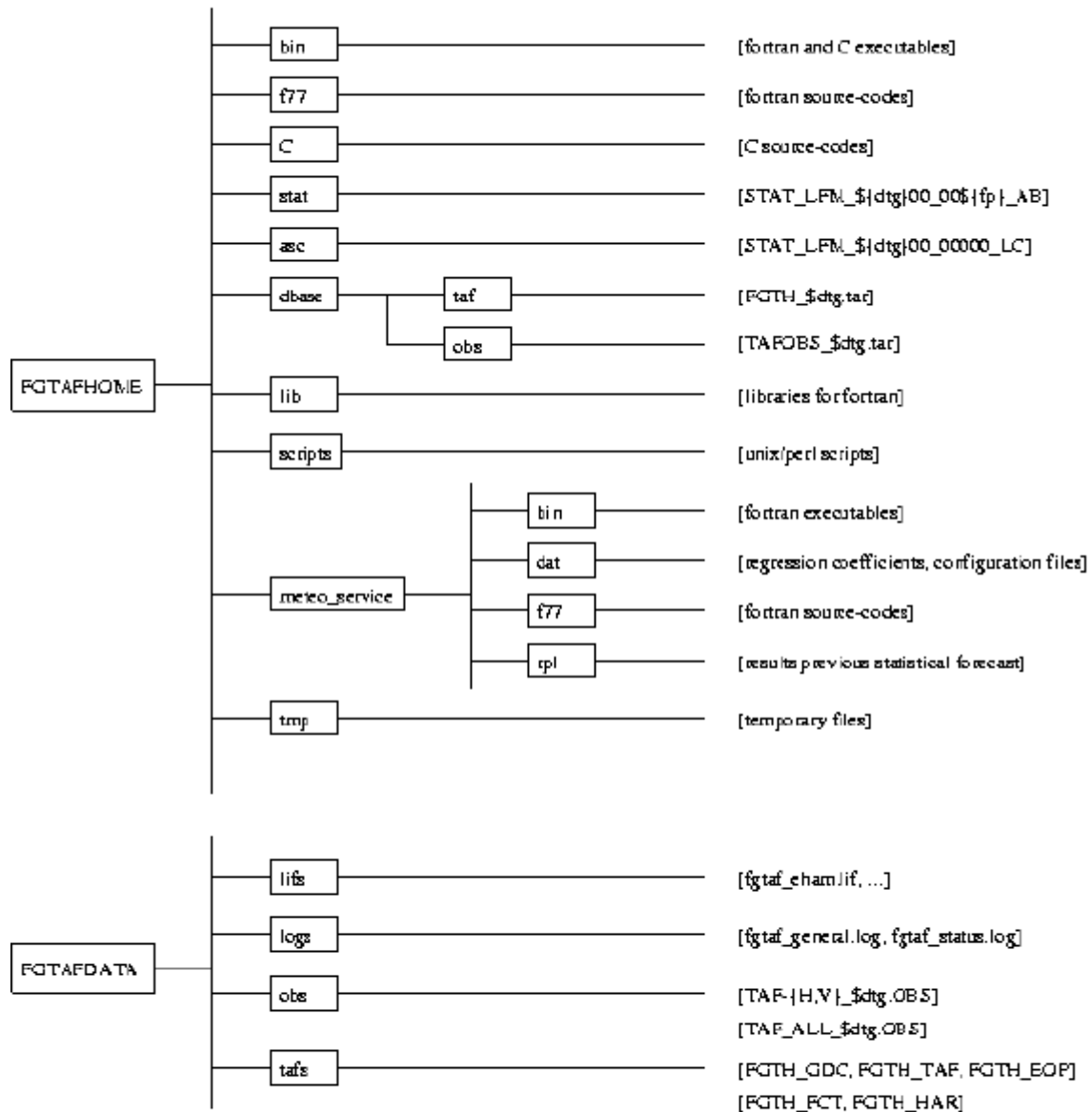TAF_ALL_${dtg}.OBS   File with observations over the last 24 hours (ascii)

Figure 4.1: The **FGTAF** directory tree in the APL.

4.2 The automatic computation of the First Guess TAF

The actual computation of the TAF-guidance and the corresponding TAF-code, for 18 selected stations, is controlled by the TAF processing script **tafproc.sc**. The purpose of this script is to compute the TAF-guidance and the TAF-code for the Short- and the Long-TAFs at predefined hours. On input the HIRLAM-STAT model field data file STAT_LFM_${dtg}00_00000_LC, and the observation file TAF_ALL_${dtg}.OBS, which contains the observations for all 18 stations over the last 24 hours, are used. The software from Meteo Service is integrated in this script and used to carry out the main computations of this module. The TAF computation can be performed on single station

level with location WMO-Nr. as input, e.g. 06240 for Schiphol, or for the 18 selected stations simultaneously, with location number 99999.
The TAF processing modules are configured by means of various configuration files:

sys.cfg   The general system configuration file
gp.cfg   The model data configuration file
pr.cfg   The predictor configuration file
stf.cfg   The statistically forecasted predictand configuration file
st.cfg   The station configuration file
obs.cfg   The observation configuration file
taf.cfg   The TAF encoding configuration file
fc.cfg   The guidance forecasted elements configuration file
fcs.cfg   The TAF output list configuration file
fctlst.cfg Description of configuration file fcs.cfg

The various processing steps in TAF production are:

1. Reading model data and derive additional predictors: < **gp** >

    The **gp** program reads all available model field data as provided in the file STAT_LFM_${dtg}00_00000_LC and computes the necessary derived and transformed predictors, cf. section 2.2.

2. Computation of TAF predictands: < **oper** >

    The **oper** program reads all observations over the last 24 hours that are provided in the file TAF_ALL_{dtg}.OBS, reads the predictors, reads the regression coefficients from the files i${xx}99999.cof with $xx = $hh + 1 (which is always 1 hour later than $hh in $dtg), and computes the TAF predictands. Detailed background information on the regression is written to the eop-files.

3. Read harmonical data: < **har** >

    The **har** program reads the harmonical data, i.e. climatology, for all stations from the file har99999.cof.

4. Write the TAF-guidance: < **fcs** >

    The **fcs** program writes the TAF predictands and climatology for each location to a separate TAF-guidance gdc-file. A machine readable version, the fct-file, is also available which is used for the purpose of the TAF presentation and user interface module.

5. The TAF encoding: < **taf** >

    The **taf** program translates the TAF-guidance for each separate location into an alfa-numeric code according to specified regulations. This program uses various trigger and threshold values that can be found in the standard AUTO-TAF configuration file taf.cfg. For optimal use the user of the TAF encoding system, i.e. the aviation forecaster, needs to optimise the configuration of this system according to some national requirements and KNMI standards. The results of the TAF encoding is written to the taf-file.

Filenames:

In the filenames below $dtg = yymmddhh is the time lable of the files, $xx = $hh + 1, $loccode is the 5-digit location code - e.g. 06240 for Schiphol and 99999 for all 18 stations simultaneously, and $valper is the period of validity for each TAF.

FGTH_GDC_${loccode}_${dtg}00_${valper}_LC TAF-guidance (ascii)
FGTH_TAF_99999_${dtg}00_${valper}_LC   TAF-code (ascii)
FGTH_FCT_99999_${dtg}00_${valper}_LC   Machine readable guidance (ascii)
FGTH_HAR_99999_${dtg}00_${valper}_LC   Machine readable harmonics (ascii)

FGTH_EOP_${loccode}_${dtg}00_${valper}_LC Detailed information on regression (ascii)

i${xx}99999.cof   Regression coefficients for hour $xx (ascii)

4.3 The FGTAF subscheme

The operational subscheme checks the status of each FGTAF-run, removes old files on the system, and archives TAF-guidance files and observations.

1. Check the status of the main modules: < **status_fgtaf** >

   This script checks the existence of various files on the FGTAF-system, and checks the status of preprocessing the model data and the observations, and the computation of the TAFs. The results are written to the file **fgtaf_status.log**.
2. Remove old files on the system: < **clean_up** >

   This script removes old files on the FGTAF-system, removes old crontab information, log-information, and status-information. TAF-guidance forecast files are removed after 2 days.
3. Archive forecasts and observations: < **arch_fgtaf** >

   This script archives the 'First Guess TAF' model forecasts (guidance and TAF-code), and the observations from SYNOP and KLIM. The model forecasts are written to a file FGTH_${dtm}.tar, with $dtm the date, and the observations to TAFOBS_${dtm}.tar.

Filenames:

In the filenames $dtm = yymmdd is the date.

fgtaf_status.log   Status-information for FGTAF runs (ascii)

fgtaf_general.log   General log-information for FGTAF runs (ascii)

FGTH_${dtm}.tar   Archive of model forecasts (ascii)

TAFOBS_${dtm}.tar Archive of TAF observations (ascii)

5 General Remarks and Recommendations

From our preliminary results and from experience over the last two years at the German Weather Service DWD we have learned that the statistical interpretation method from Meteo Service has a high potential for semi-automation in the production of aviation forecasts. The main problem at the DWD in the beginning was the acceptance of these new products. But now that the forecasters have seen that the MOS products offer an adequate interpretation of the NWP model output for aviation forecast applications, there has been a positive respons from the aviation forecast community.

We believe that especially the TAF-guidance is very useful for semi-automation and not only in aviation forecasting, but in meteorological forecasting practice in general. Our intention in the near future is for semi-automation of TAF production where the "First Guess TAF" plays an important role in efficiency of production and in increase of accuracy of the final product. It will be the job of the forecaster to monitor the "First Guess TAFs" and only intervene in complex weather situations.

The weak point of the system is currently the TAF encoding algorithm. From our first results we have learned that too much information from the TAF-guidance is lost during the process of encoding. An improvement of the TAF encoding algorithm can be expected at the end of this year. For the time being it is our task to optimise the configuration of the encoding system in order to satisfy some of our most urgent requirements.

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Klaus Knüpffer and Dik Haalman from Meteo Service Weather Research has greatly supported our knowledge and understanding of the FGTAF MOS system which resulted in a detailed description of the system in this report.

References

[] Balzer, K., *TAF-Verifikation - Eine Dokumentation der Methodik.*
German Weather Service, DWD, Berlin - Potsdam, 1994.

[] Balzer, K., *First Comparative Verification of Auto-TAFs.*
German Weather Service, DWD, Berlin - Potsdam, 1994. Personal communication.

[] Carr, M.B., *Determining the Optimum Number of Predictors for a Linear Prediction Equation.*
Mon. Wea. Rev., 116, 1623-1640.

[] Enke, W., *Ein erwartungstreues lineares Selbstorganisationsmodell.*
Z. Meteor., 35, 308-314.

[] Hungerink, O., *TAF, METAR, TREND.*
Luchtvaart Meteorologische Dienst (LMD) Schiphol, The Netherlands, Schiphol, March 1997. Unpublished Manuscript in Dutch.

[] Jacobs, Albert, *The HIRLAM-STAT-archive and its applications programs.*
Technical Report KNMI, TR-206, De Bilt, 1998.

[] Knüppfer, K., *Methodical and Predictability Aspects of MOS Systems.*
Preprints of the 13th Conference on Probability and Statistics in Atmospheric Sciences. Feb. 13-23, 1996, San Francisco California.

[] Knüppfer, K., *Automation of Aviation Forecasts - The projects Auto-TAF and Auto-GAFOR.*
To be published at the Seventh Conference on Aviation, Range, and Aerospace Meteorology, 77th AMS Annual Meeting, 2-7 February 1997, Long Beach, California.

[] Lynn, K.J., *International survey of TAF automation systems.*
Forecasting Systems 9, Meteorological Office London RD, Bracknell, Berkshire, UK, June 1997. Unpublished Report.

[] Verbeek, Koos, *Definitiestudie First Guess TAF.*
Intern document LMD, KNMI, oktober 1997. Unpublished Manuscript.

[] WMO, *International Codes Volum I.1, Part A - Alphanumeric Codes.*
International Codes, WMO, WMO-No.306, 1998.

Footnotes:

[1] The TREND is added to the METAR.

[2] KLIM is a national bulletin at KNMI.

File translated from T$_E$X by [T$_T$H](), version 1.58.