STATUS OF THE AUTOMATIC OBSERVATION ON AERODROME AND ONGOING IMPROVEMENTS IN FRANCE

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ABSTRACT

Météo-France began automatic observations on aerodrome, both for METAR (AUTO) and local reports, in 2001. Contacts with aeronautic users were made before and after the first installation. The users were satisfied. Then, three levels of service were defined with the French Civil Aviation Authorities and applied for the French main airports. 52 airports are currently issuing AUTO METAR continuously or when a human observer is not on duty.

It was decided to code AUTO METAR as complete as possible, therefore a present weather sensor was added to the existing visibility sensors (forward scatter meter and/or transmissomètres) and ceilometers.

Up to 2006, it was not possible to detect and code automatically convective clouds (CB, TCU). A study was conducted to test the capacity of detection of convective clouds from the radar network and the lightning network. Following this study, operational procedures were developed to add convective information in AUTO METAR and AUTO local reports. The main problems to solve were the timing of the calculus and the transmission of information to each airport. Currently, 26 airports are including convective information in the cloud layers. Occurrence of thunderstorm is also added from the lightning network.

Another improvement will be introduced next year with the addition of a state of ground sensor, which will improve the detection and identification of freezing precipitation.

INTRODUCTION

About 15 years ago, a new airport with a cat III equipment was set up in the eastern part of France (LFJL). Traditionally, a human observation is done on such airports, for local reports and METAR/SPECI. But increasing the human resources of the Met. Service for observation was not in the right way of history. Therefore, during a short decade, the met. observation was subcontracted to the local firemen. The "quality" of the human observation was supervised at distance by the nearest met. station. Such a situation was not perfect and might cause responsibility problems, especially after the enlargement of the aerodrome operational hours and the reduction of the working hours in France.

At the same time, Météo-France had an experience with present weather sensors and observation systems, developing our own software for the computer coding the messages.

It was therefore decided to implement AUTO METAR in LFJL, after co-ordinations with the local and the French civil aviation authorities.

PRELIMINARY TO METAR AUTO

The possibilities of automatic observation for an aerodrome and the associated limitations were clearly identified, documented and presented to the users.

The major limitations are :

- The spatial representativeness of the visibility observation, when made by a single sensor, in case of inhomogeneous atmosphere. But in such circumstances, it must be recognized that a human observer has also serious limitations.
- The validity of the cloud layers derived from the analysis of a ceilometer's measurements. Météo-France is using the US ASOS algorithm, which has been deeply analyzed, critiqued and validated by the US ASOS team. Bradley and Lewis showed that the automatic calculation was considered as valid and useful for the user, with no differences between day an night, which may not be the case for a human observer.
- The current impossibility to identify the type of cloud, which must be reported when being a CB and TCU.
- The limited list of present weather codes which can be reported by the current present weather sensors. But the present weather is not a decisional factor for landing and take off. The possible present weather codes covered by the automatic system were clearly identified and documented.
- The automatic detection of SPECI criteria. The US ASOS experience shows a much greater occurrence of SPECI AUTO than from a human observer. We solved the problem very easily, by not issuing SPECI AUTO ! Actually, in Europe, SPECI are not required when METAR are issued every half a hour. Therefore, the solution is to issue METAR AUTO every half a hour.

The major advantages of METAR AUTO are :
- A continuous observation, not depending on human observation availability. With METAR AUTO, observations are available24 hours a day, which is useful, both for the flight planning and the follow up and amendment of TAF.
- "Objective" and reproducible measurements, especially for visibility.
- Staff savings.

METAR AUTO in France

The minimum set of sensors necessary for METAR AUTO in France is : a thermometer (Pt100) and a hygrometer (capacitive sensor), a barometer (currently PTB220, with two pressure cells), a wind sensor (cups and wind vane), a ceilometer (currently WHX05 or CT25K), a present weather sensor (PWD22) which can also be used for visibility, when an additional forward scatter meter is not installed.

An automatic weather station feeds a PC, running a software developed by Météo-France, called Caobs. This software is used to input data from a human observer, when he or she is available. It codes METAR and SYNOP. METAR AUTO are coded every half an hour, auto local reports are updated every minute, including visibility, cloud layers and present weather.

When transmissometers (and since 2006 in France, forward scatter meters) are installed for RVR, these RVR values are included in METAR AUTO. If several ceilometers are installed (depending on the size of the airport and number of runways), the measurements from all the available ceilometers are used for the calculation of the cloud layers. But our experience shows few differences between cloud layers calculated from a single or several ceilometers.

Up to now, due to limitations of the AWS, the system is able to manage only one visibility. This will change starting at the end of 2006, with the replacement of the old AWS by a new generation one and a new version of the Caobs software, called Cobalt. Multiple visibility measurements will then be used to get the best assessment of the prevailing visibility and the minimum visibility. As Météo-France is currently replacing his old transmissometers by forward scatter meters (DF320), on large airports with cat III runway(s), multiple MOR (Meteorological Optical Range) measurements will be available, both for visibility and RVR.

To know more about the automation of an aerodrome observation, it is recommended to read the ICAO Doc 9837, "Manual on automatic meteorological observing systems at aerodromes". The techniques used for METAR AUTO in France are quite close to this document.

LEVEL OF SERVICES

ICAO does not define different levels of service. Nevertheless, it is clear that the equipment and the human observation cannot be the same on all the airports (with international flights).

Before 2004, though the code for METAR AUTO was defined in the WMO manual of code, ICAO did not recognize METAR AUTO. Such messages were introduced during non-operational hours in amendment 73 of annex 3 of ICAO, in 2004. They probably will be introduced for operational hours in the next amendment 74 (2007). Coding adaptation were also introduced (by WMO, on request of ICAO) to take into account the automatic nature of an observation.

After the successful METAR AUTO implementation in LFJL started on 1st April 2001, a positive stock of the situation was taken one year after : Regular observations were available permanently, which was not the case before; users were very satisfied by the quality of the observations, even with the known limitations (and sometimes mistakes, mainly for present weather); no major meteorological event significant for the aeronautic user was missed; no degradation of the quality of TAF messages for LFJL was detected. It must be noted that the meteorologists are sometimes the more reluctant people to automatic observations. But the users are satisfied !

The frequency of occurrence of various type of present weather was analyzed over a period of 2 years, for LFJL (AUTO) and two neighboring airports (20-30 km). No differences were found in this short climatology. The correlation between present weather at these airports were also analyzed. In fact, a common way to critic an observation is to compare it with neighboring ones. It was found that for stations at a distance of 20 km, the present weather (main categories, such as snow, rain, drizzle, fog, mist) agrees in 70% of cases and differs in 30% of cases. It was not found more differences between an automatic observation and a human one than between two human observations. Except for freezing drizzle, which was often missed by the automatic system. This is clearly a limitation for airports subject to freezing drizzle.

After these verifications, Météo-France, in co-ordination with the users, each aerodrome and the Civil Aeronautic Agency, decided to implement automatic observation on the majority of the aerodromes (63).

Four levels of services were defined :

- METOBS1 : METAR with human observation nearly 24 hours a day, except during 3 hours in night (METAR AUTO), for the observer rest. But the observer may be set up again on duty, by a forecaster, in case of adverse meteorological conditions.
- METOBS2 : Mixed observation. METAR with human observation, when the observer is on duty, mainly during day. METAR AUTO otherwise.
- METOBS3 : Fully automatic observation. 48 METAR AUTO per day.
- METOBS4 : Occasional METAR with human observation, with no SPECI, when a human observation is available. Such an observation doesn't comply with ICAO requirements and doesn't allow an update of TAF. This level of service exists on some small airport, but must be avoided and stopped.

In France, 69 airports are equipped by Météo-France who gets for this a part of the airport taxes. For each airport, the required level of service (METOBS1 to METOBS3) has been defined and the necessary equipment installed (mainly a present weather sensor, the other sensors being often already installed). In October 2006, 52 airports are issuing METAR AUTO permanently or during periods without human observation. The objective (end 2006) is 63 airports. The six others will continue to issue METAR with a human observer (very large airports) or need preliminary studies due to local orographic constraints.

ADDING CONVECTIVE INFORMATION (CB, TCU), A MAJOR IMPROVEMENT

Up to 2006, it was not possible to detect and code automatically convective clouds (CB, TCU).

Météo-France owns a lightning network that detect the impact of lightning based on its electromagnetic signature. Considering the density of sensors, the location of lightning is about 1 km. Occurrence of lightning implies occurrence of CB. Unfortunately, occurrence of CB doesn't imply occurrence of lightning. The occurrence of lightning and its localization allows the detection of thunderstorm (TS) at the aerodrome or at its vicinity (VCTS). This information is added to the present weather information.

A weather precipitation radar detects the presence of precipitation (and sometimes even clouds), and quantifies the intensity of precipitation. Very convective cloud cells are clearly visible and result in high reflectivity levels. Therefore the detection of cells with reflectivity above given thresholds are good indicators of the presence of CB or TCU. Unfortunately high levels of reflectivity can also exist during periods with heavy precipitation, without the presence of CB/TCU clouds. But though without CB or TCU clouds, areas with high reflectivity levels are often bothersome or dangerous to aircraft.

In 2003 and 2004, a study was conducted to test the capacity of detection of convective clouds from the radar network and the lightning network.

Currently, there is no definition of the area around the airport, in which CB/TCU clouds must be reported. The current practice (at least in France) of an observer is to report CB or TCU, when he or she has elements to detect CB or TCU. It may be distant lightning, sometimes up to 100 km ! Therefore, different distances to the ARP (Aerodrome Reference Point) have been considered in the study. Different reflectivity levels have also been considered to discriminate between severe convective conditions (related to CB) and moderate conditions (related to TCU). A cell has been defined as a set of adjacent pixels above a given reflectivity level. A minimum size of cell has been defined to avoid the use of isolated pixels, which may be artifacts.

The study has been conducted using a single precipitation radar, located in Trappes, close to Paris. Each half an hour, the last radar data (over a period of 5 minutes) has been used. Radar reflectivity has been used in a circle of 100 km around the radar. All the lightning impacts detected during the last 10 minutes have been used. With this input data, an algorithm calculated the occurrence of CB/TCU in a given circle around an aerodrome and the occurrence of TS at the aerodrome (circle less than 8 km around the ARP) or at vicinity (VCTS, from 8 to 16 km to the ARP). These calculated CB/TCU and TS/VCTS were compared to the METAR, based on human observations, of 7 aerodromes located in the radar overage, including the two Paris airports (LFPG, LFPO, with 24 hours observations).

The comparisons covered a whole year, with a total of 64338 METAR, 1918 of them including TCU and/or CB cloud layers. Several reflectivity thresholds, maximum distance to ARP and cells size have been used. Statistical parameters and curves of simultaneous detection and non-detection by human (METAR) and algorithm were constructed. From these comparisons, reflectivity thresholds, maximum distance to ARP and cells size were selected, so that to optimize the comparability of observations between human and automatic algorithm.

The chosen thresholds were 41 dBZ for CB, 33 dBZ for TCU, 30 km for the maximum distance for detection of CB/TCU.

A radar image or a radar image composite is not always perfect and can contains errors such as echoes from stationary objects, extremely widespread echoes or a bright band (liquid/solid transition). There exist techniques to reduce such errors and they have to be applied for "cleaning" the radar data, to limit their influence on the quality of the CB/TCU detection.
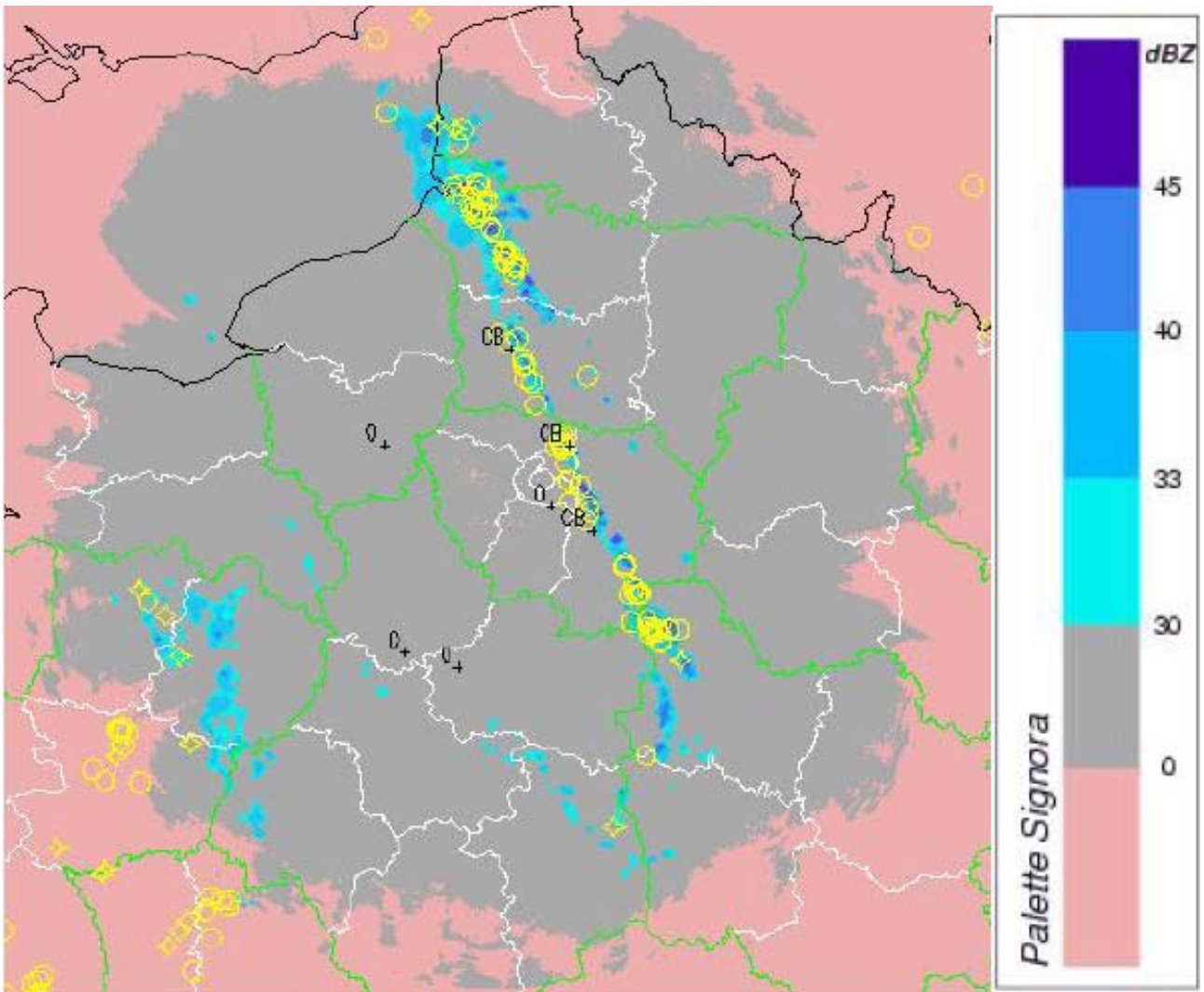
Example of analysis, 30/07/2002 12h00. In yellow are the lightning impacts. In blue are different levels of radar reflectivity. Three aerodromes reported CB. One (LFPO, 3rd aerodrome in France) did not report CB nor TCU, though a high reflectivity (> 45 dBZ) cell and lightning were present at less than 20 km. The human observations has also limits.

Following this study, Meteo-France decided to implement operationally the calculation. Instead of a single radar, our national radar composite is used. Our lightning network is also covering the whole territory.

Inclusion of CB or TCU in AUTO METAR is an indication that radar and/or lightning data have detected convective activity at or near the airfield that is sufficiently intense to present a risk to air navigation.

This inclusion of convective activity depends on the results of fusion between radar and lighting data as summarized in the following table. This inclusion does not however indicate that this type of cloud has actually been observed as it would be by a human observer. In AUTO METAR, convective activity classified as TCU corresponds to the level generally observed in the presence of towering Cumulus and the CB classification corresponds to the convective activity generally observed in the presence of Cumulonimbus clouds. In both cases, the user is advised to exercise caution in respect of any convective meteorological phenomena likely to affect his flight.

		Lightning				
		Lightning impact(s) in an area of 8 km around the aerodrome	Lightning impact(s) in an area from 8 km to 16km around the aerodrome	Lightning impact(s) in area from 16 km to 30 km around the aerodrome	No lightning impact	No data
Level of radar reflectivity in an area of 30km around the aerodrome	Reflectivity of 5 closely pixels >41 dBZ	CB TS	CB VCTS	CB	CB	CB No information
	33 ≤ Reflectivity of 5 closely pixels <41 dBZ	CB TS	CB VCTS	CB	TCU	TCU No information
	Reflectivity of 5 closely pixels ≤ 33 dBZ	CB TS	CB VCTS	CB		No information
	No data	CB TS	CB VCTS	CB	No information	No information No information

Lightning information and a five minutes radar composite are available centrally in Toulouse. The compositing of radar data is a separate process, so is the lightning analysis. An additional automatic computing process to combine radar and lightning data over the areas of interest is activated each 30 minutes, let us call H this time. The combining process is therefore activated at H-1. The last five minutes radar composite is used, or the previous one if not available. Therefore the radar data used is 5 or 10 minutes old (H-5 or H-10). All the lightning impacts between H-10 and H-2 are taken into account. This H-2 limit was chosen after pre-operational tests which showed that above this limit, the computation time of lightning data could lead to miss the H-1, especially during periods with numerous lightning impacts (cloud to ground). A list of aerodrome with ICAO indicator and geographic coordinates is used by the process. Therefore adding a new aerodrome in the list is enough to extend the calculation to this aerodrome.

The telecommunication link between each aerodrome and the national centre in Toulouse is either an IP connection (Intranet) or a Public Telephone Line (for "small" airports). Before coding the METAR, Caobs connects itself to Toulouse to get the CB/TS information described above. Depending on the type of link, this connection is initiated between H-20 seconds and H+2 min. This information is added to the cloud layers calculated from the ceilometer(s) data and to the present weather groups. The METAR AUTO is issued at a fixed time (H+1, H+2 or H+3), depending on the telecommunication link. With Public Telephone lines, due to the limited number of input lines reserved for such transmissions in Toulouse (20), it is necessary to share the lines between several stations of the network. This explain the different scheduled times.
With such a schedule, it is important that both radar and lightning are available in Toulouse in due time and that the combining process in Toulouse stays fast, so that the CB/TS information is available when Caobs connects to Toulouse. These timings were tested (and adjusted !) during a 3 months pre-operational test.

The cloud group(s) in METAR AUTO may appear in the following forms:

Condition : The system is unable to detect CB and TCU (as before the 1st June 2006)	Cloud group(s)
Cloud layer(s) computed from the ceilometer(s)	NNNhhh///
No clouds detected by the automatic system	NCD
Ceilometer data unavailable	/////////
Condition : The system is able to detect CB and TCU	
Cloud layer(s) computed from the ceilometer(s) and no CB or TCU is detected	NNNhhh
No clouds detected by the automatic system and no CB or TCU is detected	NSC
Ceilometer data unavailable and no CB or TCU is detected	//////
Cloud layer(s) computed from the ceilometer(s) and CB detected	NNNhhh/// //////CB
Cloud layer(s) computed from the ceilometer(s) and TCU detected	NNNhhh/// //////TCU
Ceilometer data unavailable and CB is detected	//////CB
Ceilometer data unavailable and TCU is detected	//////TCU

The TS or VCTS in METAR AUTO may appear in the following forms:

Condition : The system has detected lightning at the aerodrome (TS)	Present weather group(s)
If no precipitation in the present weather groups	TS group added at the beginning
If one precipitation group without SH and FZ	TS added in the first group with precipitation
If one precipitation group with SH	SH is replaced by TS
If one precipitation group with FZ	TS is added at the end of other groups
If present weather information is not available	TS
Condition : The system has detected lightning at the aerodrome vicinity (VCTS)	VCTS is added at the end of other groups
If present weather information is not available	VCTS
Condition : The system has not detected lightning (or is unable to detect lightning)	No modification

In October 2006, 26 French airports (LFRK, LFRG, LFRO, LFRT, LFRQ, LFTW, LFMT, LFRD, LFRN, LFLX, LFOT, LFLS, LFGJ, LFMH, LFBA, LFRC, LFRH, LFJL, LFOB, LFBZ, LFLN, LFLB, LFPN, LFTH, LFMV, LFPB) can indicate that convection is detected or not in AUTO METAR which are issued.

Before the end of this year, 59 French airports will be able to provide AUTO METAR including an indication about convective phenomena. The system allows easily to update the list of aerodromes for which convective information can be added.

Apart the scientific basis of the process, the difficult step now solved in France is the setup of an operational system with a respected time scheduled. The system follow-up shows that more than 99 per cent of the METAR AUTO issued by a system (currently 26) have been coded with the convective information available.

This automatic CB/TCU and TS/VCTS information is also used in local reports.

IMPROVING THE DETECTION AND IDENTIFICATION OF FREEZING PRECIPITATION

Another limitation of the automatic system is the detection of freezing precipitation, especially drizzle, which is often not detected by the present weather sensor.

One possibility is to add an icing detector, such as the Rosemount icing sensor used in US ASOS systems. The management of heating of this sensor is not very easy and Météo-France had difficulties to buy this sensor. Nevertheless it is a possibility, with some other sensor under test.

An instrument selected by Météo-France is a state of ground sensor (SOLIA300). A prototype was developed several years ago and proved to be efficient to identify the state of ground : dry, humid, wet, snow, frozen. The sensor emits modulated light and detects the reflected and the backscattered light. Liquid water (or frozen water) generates a high level of reflected light (specular reflection) with very few backscattered light. Snow generates high levels of both reflected and backscattered lights.
Now manufactured, this sensor will be introduced operationally in the network at the end of 2007 and will improve both the detection and the identification of freezing precipitation. It will also indicate the presence of snow at ground, but this is not required for aeronautic purposes.

CONCLUSION

METAR AUTO are well accepted in France, may be due to a previous co-ordination with aeronautic users and the French Civil Aeronautic Administration. Apart the main aerodromes taken in charge by Météo-France, several "smaller" airports are interested in such an automatic observation to improve their own level of service to pilots and airline companies. Some have began, including several aerodromes in the French oversea territories.
France, as some other countries, is in "advance" compared to the ICAO regulation (but differences have been notified), but ICAO is now taking into account the possibilities and performances of automation. Improvements of automatic observation, such as the detection of convective clouds described above, should help this transition towards automation.