AvRDP CDG (Dec 2015 - Mar 2016) IOP1 Brief

This reports intends to show the benefits of the MET information (nowcast and mesoscale modelling) to the aviation community on CDG airport during the 1st IOP for winter weather, visibility and ceiling.

1. Context

Few words on Paris-CDG airport:

Paris-CDG airport is located inland and mid-latitude in the Northern Hemisphere (49°N, 02°W), North-East from Paris. It has 4 runways suitable for heavy-body aircrafts (2x 2700m, 4200m, and 4215m) : 08L/26R, 08R/26L, 09L/27R, 09R/27L. The world airport classification of 2014 (ACI World) ranked Paris-CDG as the 8th for the total passengers traffic (more than 63M) and the 4th for the international passengers traffic (more than 58M).

During winter, the operations of the CDG-hub are often highly impacted by low ceilings and visibility due to fog and stratus clouds, and by wintry conditions. These weather phenomena require precise and satisfactory forecasting to alleviate ATC services in their effort of avoiding airline delays, terminal area disruption and GA accidents. Thus, good MET information accuracy and refreshment rate are crucial for ATM.

That is why a local NWP model for nowcast and a Collaborative Decision Making weather service (CDM@CDG) have been implemented at operational level by Météo-France. In this document, three case studies over 1st IOP for winter are developed in order to demonstrate the improvements brought by CDM@CDG, AROME-PI (the aforementioned nowcast model), and ANTIGEL, an on-ground icing probability model.

Collaborative Decision Making at Paris-CDG (CDM@CDG):

In case of threatening weather conditions, an emergency committee comprising representatives of Aéroports de Paris, the French civil aviation authority (DGAC), the airlines, and Météo-France gathers and decides what resources will need to be mobilised (manpower, machineries). As a response to CDM users' needs, an innovative solution was set for CDG operations, allowing a common weather hazard awareness. It integrates the impact of weather on hub operations and is performed thanks to human expertise at a fine temporal resolution and a high refresh rate. Through this user-tailored system, Météo-France provides the latest science in forecasting techniques, including probabilistic information.

AROME-PI characteristics:

The nowcast NWP model, called AROME-PI, runs hourly at high temporal and spatial resolutions: 1.3km grid point and 90 vertical levels for a European domain centered around France. The forecasts range from +30min up to +180min with a 5 min refreshment rate and from +180min up to +6h with a 15 minutes refreshment rate. At each run time H, there is a data assimilation window of [H-10min, H+10min] and 20 minutes of processing (via a 3D-Var system) are needed before ouputs are available. AROME-PI is non-cycled (initialization from the regional model AROME-France). It has a non-hydrostatic physical scheme and a complex microphysical scheme called ICE3 comprising 3 frozen hydrometeor categories. In addition to the common weather information available in AROME-France (such as temperature), this model includes several new diagnoses : supercell index, fog and hail probability, etc.

ANTIGEL characteristics:

On-ground icing probabilities are calculated on Paris-CDG airport thanks to a statistical algorithm developped by S. Hugony. The inputs of the computation are the surface temperature, the humidity, the wind, and the nebulosity expertised by the forecasters. It provides an histogram of hourly on-ground icing probabilities up to 30 hours of forecast. Hence, ANTIGEL allows to anticipate an eventual on-ground icing on the day before the icing occurrence.

2. December 13th, 2015 : low visibility and ceiling

There are approximately 40 days of fog per year at Paris-CDG airport, most of them occuring during winter. When the horizontal visibility decreases down to 600 meters and/or cloud ceiling become less than 200 feet, the French ATM (DGAC) applies Low Visibility Procedures (LVP). These LVPs, issued for the early morning hours, allow avoiding incidents thanks to a better spacing out of the airplanes on the ground. This type of procedure cuts down the overall airport capacity by a factor of two or three. Hence, low visibility is one of the weather factors with the best prospects of improving from the perspective of ATM.

On December 12th, a weather system was developing over the Atlantic Ocean (West from Spain) as a strong ridge of high pressure lingered over the French territory (as displayed on FIG1). These anticyclonic conditions brought a lot of humidity patches, along with calm winds, which often triggers the forming of fog on Paris-CDG platform. It has been verified two hours after sunset (18Z) on December 13th. Indeed, as displayed on FIG2, visibility values decreased down to 600 meters (the aforementioned LVP threshold). This phenomenon was well-anticipated by forecasters as visible in the CDM@CDG product.

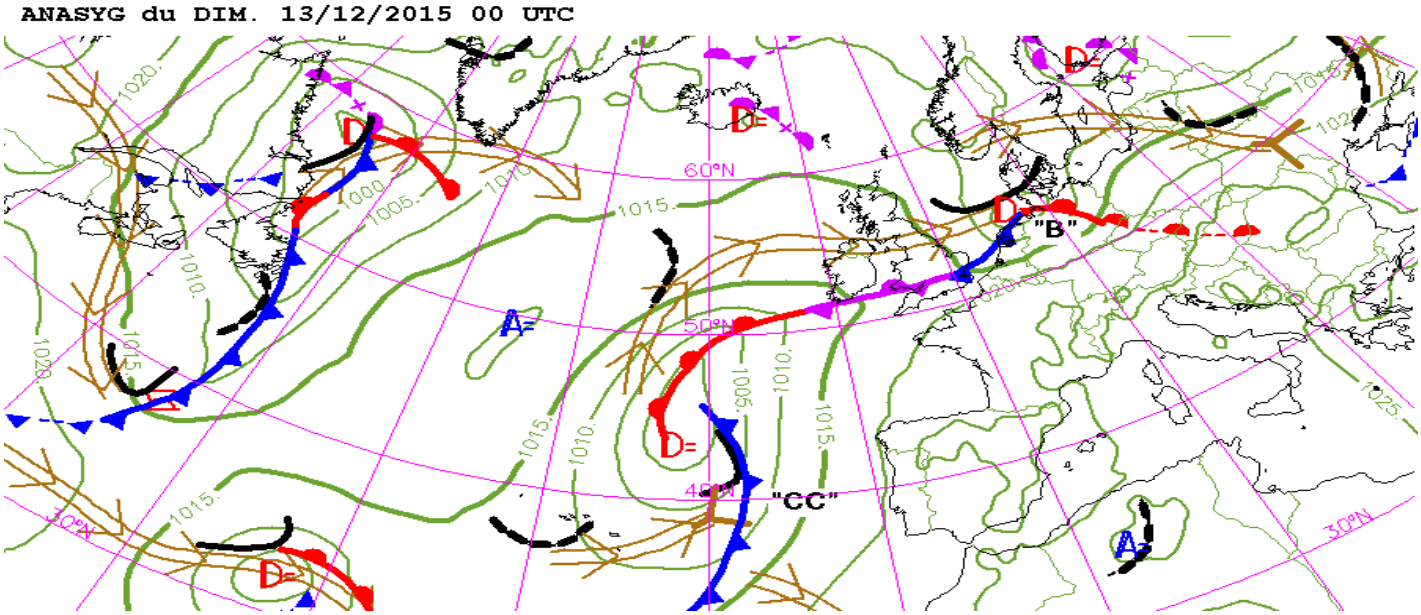

FIG1: Chart of weather front analysis for Europe on December, 13th 2015 at 00Z.
Green lines show the isobars. Red lines represent the warm fronts, blue lines, the cold fronts, purple lines, the stationary fronts and black lines, the tropopause anomalies. Brown arrows display the jet streams.

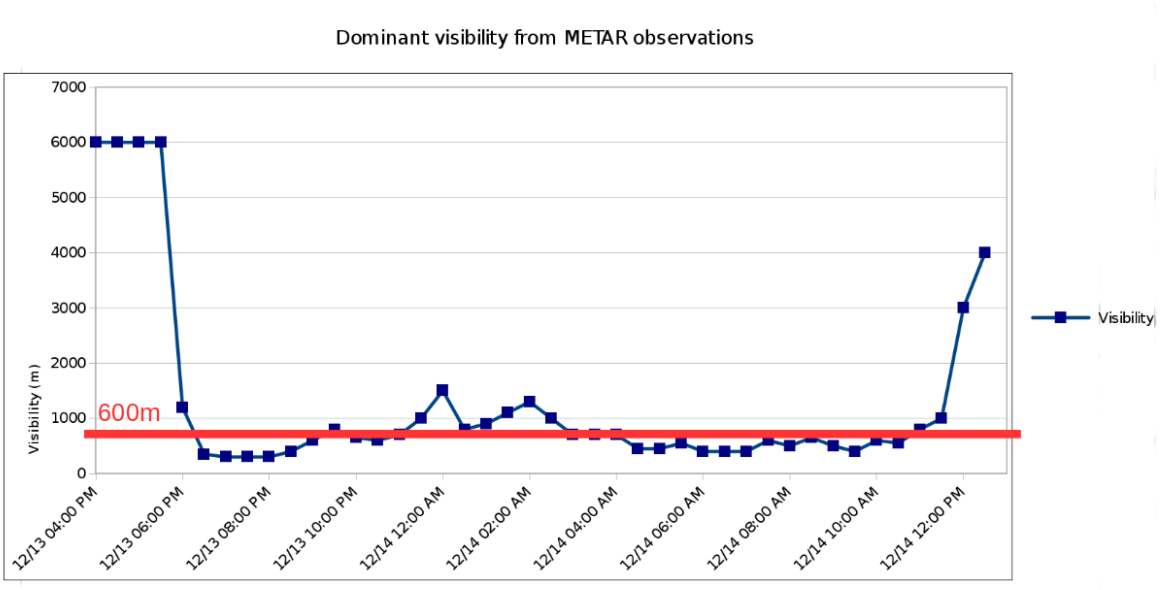

FIG2: Observed dominant visibility for the study period (in meters).

The forecast available at 17Z (FIG3, red frame) shows a mist threat beginning at 18Z, closely followed by the occurrence of fog at 20Z. The worst impairing of visibility begun a little

earlier than expected but yet the forecast was accurate and provided an efficient fog warning to the ATM.

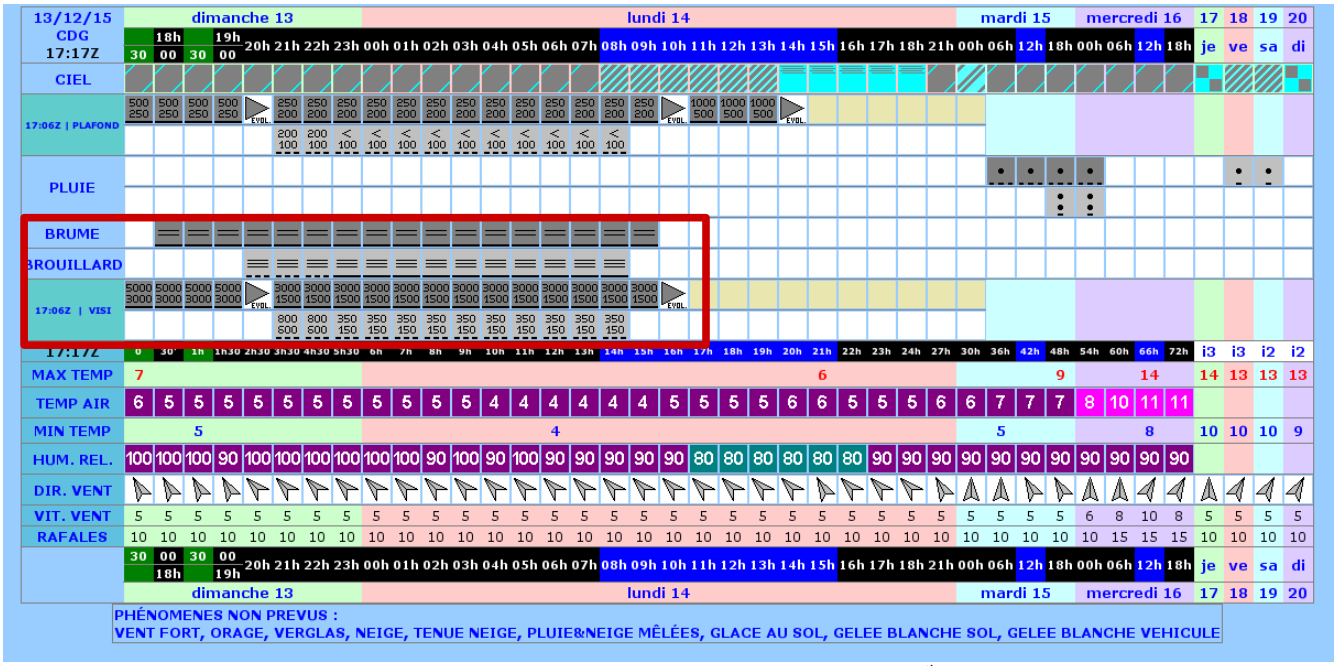

FIG3: Weather predictions from the CDM@CDG tool updated on December, 13th 2015 at 17:17Z

This accuracy was achieved thanks to Meteo-France's nowcast model AROME-PI, whose frequent refreshment rate allows injecting the latest observations in the model running. The eventual forecast bias (depending on the weather situation) from the regional model can be offset via this method.

On December, 13th, AROME-PI humidity fields were more pessimistic than the ones of the regional model AROME, whose fields were drier than in reality. FIG4 displays the fields of fog probability around the area of Paris-CDG at 19Z and 20Z from the run of December, 13th at 17Z from AROME-PI. The risk of fog onset is suggested at 19Z by the fog diagnosis of the nowcast model, which is earlier than the forecast of the regional model. In this case, the nowcast model brought an extra information concerning the timing of the reduction of visibility.

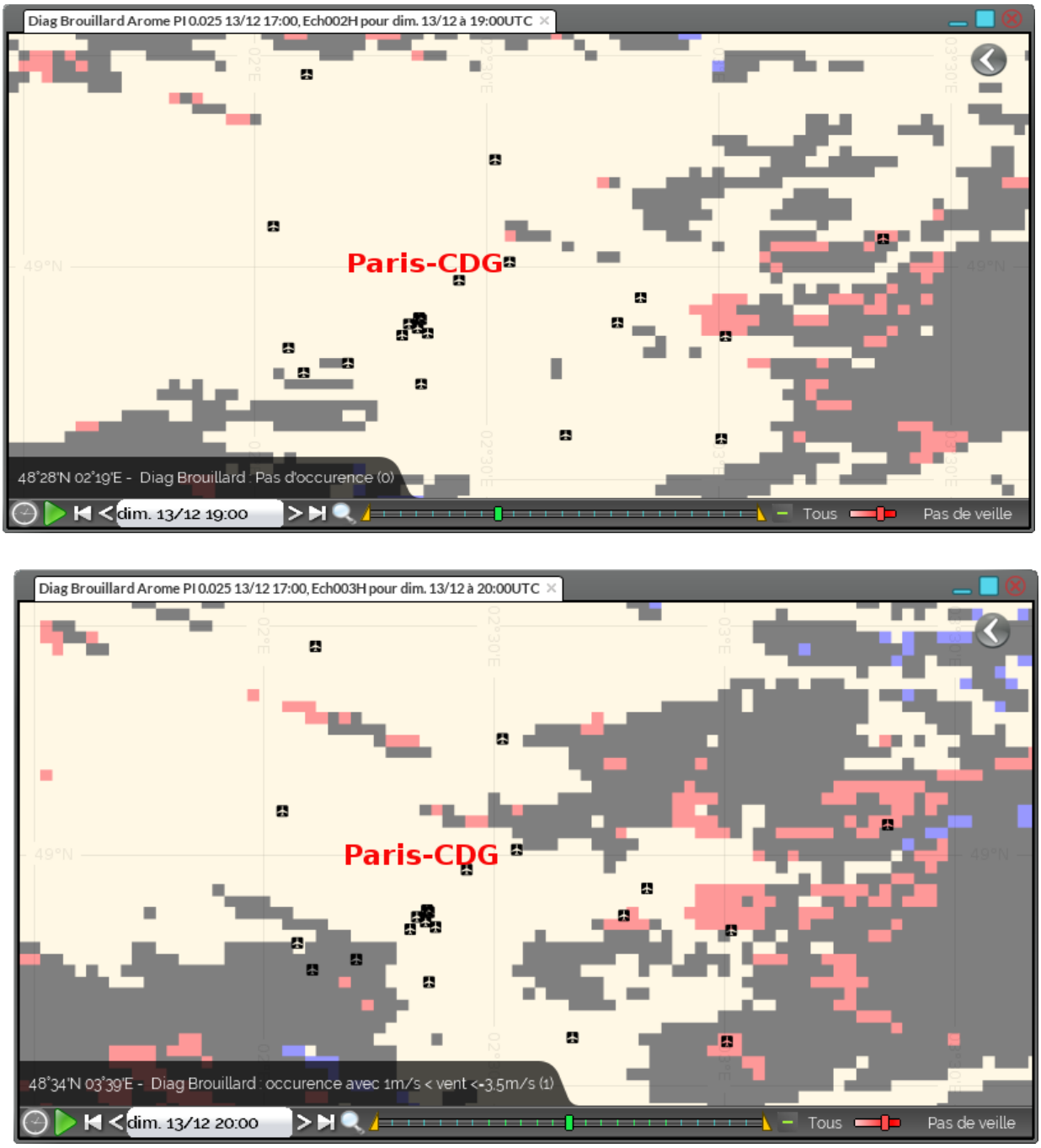

FIG4: Fog diagnoses from AROME-PI on 12/13/2015 at 19Z (top) and 20Z (bottom). Run of 12/13/2015 at 17Z. Grey colors represent great probability of fog forming. Blue and pink colors show areas where the wind force doesn't match the conditions of fog forming (respectively too high an too low winds).

The nominal departure capacity of Paris-CDG airport is 71 departures per hour. It decreased down to 48 departures per hour immediately after the fog onset on December, 13th at 19Z. This persistent fog disturbed flight management until December 14th at 10Z. Thus, a LVP procedure was applied and as required, visibility forecasts were issued by Météo-France during the morning on December 13th. FIG5 shows the LVP product of 8Z on December, 14th.

METEO-FRANCE ROISSY CDG
BULLETIN LVP DE 8H UTC (9H LEGALE)
DATE : 14/12/2015 A 07:50 UTC

	TRANCHES HORAIRES EN HEURES UTC			
	08:00	08:30	09:00	10:00
RISQUE LVP	08:30	09:00	10:00	11:00
CERTAIN	XXXXXXXXXX			
PROBABLE		XXXXXXXXXX		
IMPROBABLE			XXXXXXXXXX	XXXXXXXXXX
EXCLU				

Signification du "RISQUE LVP" :

CERTAIN ..... Conditons LVP prévues avec certitude.
PROBABLE .... Conditons LVP prévues, mais non certaines.
IMPROBABLE .. Conditons LVP non prévues, mais non exclues.
EXCLU .... Conditons LVP non prévues avec certitude.

FIG5: LVP forecast issued by Paris-CDG forecasters on 12/14/2015 at 08Z.

This case study enlightens the interest of using nowcast models to better forecast low visibilities and hence alleviate the ATM for threatening conditions.

3. January 20th, 2016 : surface and airframe icing

On-ground icing is one of the most cost-impacting threats at Paris-CDG. The airport manager Aéroports de Paris is responsible for aircraft de-icing operations, performed by service providers on 20 dedicated areas and with 50 de-icers.

Hence, this phenomenon is predicted by the forecasters in the CDM@CDG tool. ANTIGEL, an on-ground icing probability model, provides more MET information to the forecaster for edition of the CDM@CDG base. It has proved its good accuracy and is often

used during the winter season.

On January, 20th 2016, weather conditions were anticyclonic over France (as shown on FIG6), conducive to cold conditions and clear skies in winter. Humidity patches from a decaying front lingered until Janurary, 21st: favorable conditions for vehicle icing were gathered.

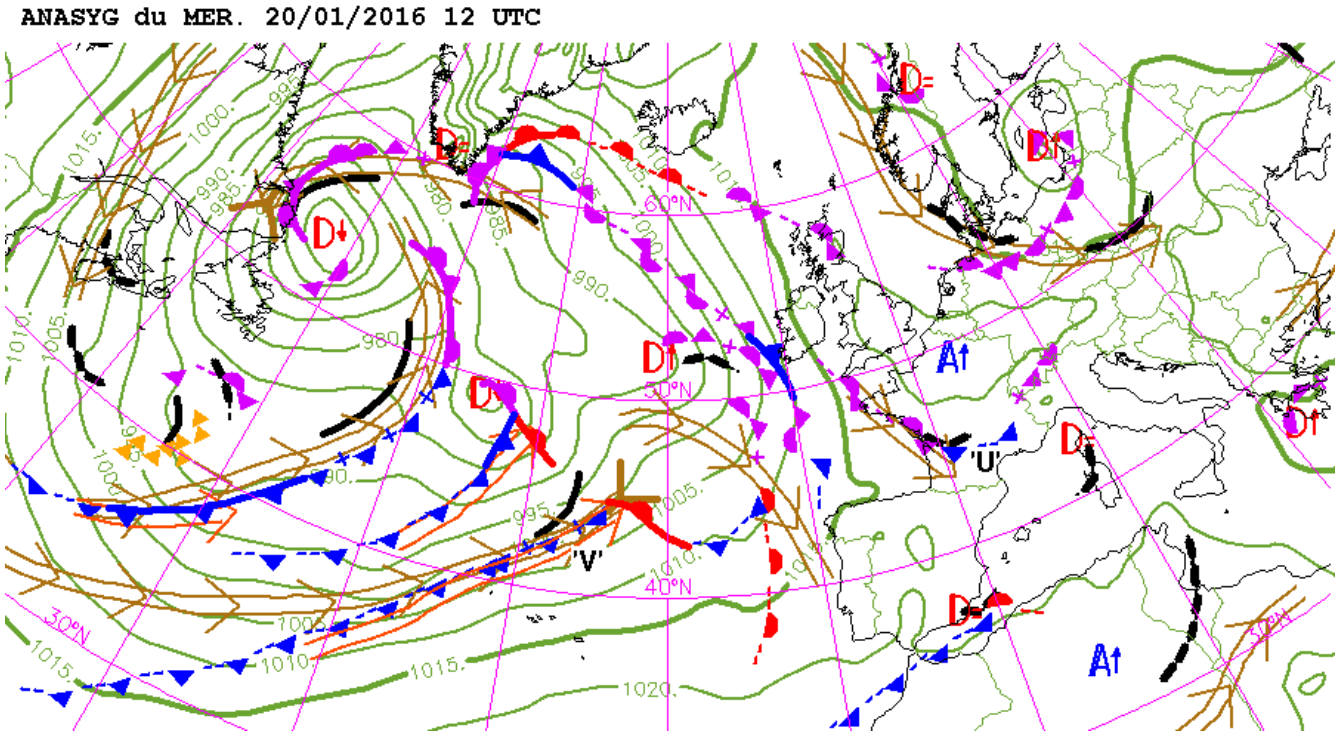

FIG6: Chart of weather front analysis for Europe on January, 20th 2016 at 12Z.
Green lines show the isobars. Red lines represent the warm fronts, blue lines, the cold fronts, purple lines, the stationary fronts and black lines, the tropopause anomalies. Brown arrows display the jet streams.

Indeed, LVP productions were issued by Paris-CDG forecasters for icing fog on January, 20th from 0235Z to 0650Z and on January, 21st from 0540Z to 1005Z. An accurate vehicule icing risk with a quite high probability of occurrence from January, 20th 21h up to January, 21th 4h was set in the CDM@CDG tool (in the red frame on FIG7).

It allowed the airport manager to anticipate the de-icing operations of airframes, and the ATM to better manage disturbances of traffic. De-icing operations, numerous during these two days:

- 162 de-icing operations on January, 20th

- 128 de-icing operations on January, 21st

These operations caused considerable delays and costs during the period, as the airport departure capability decreased significantly (as shown on FIG8).

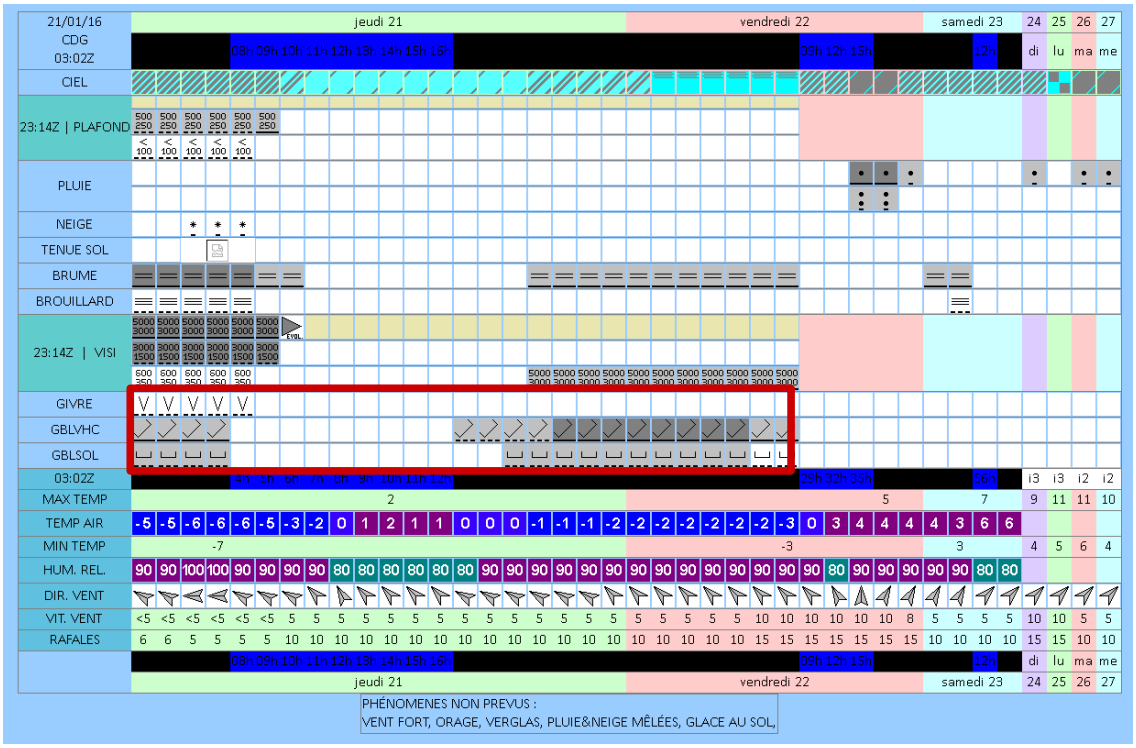

FIG7: Weather predictions from the CDM@CDG tool updated on January, 21st 2016 at 03:02Z

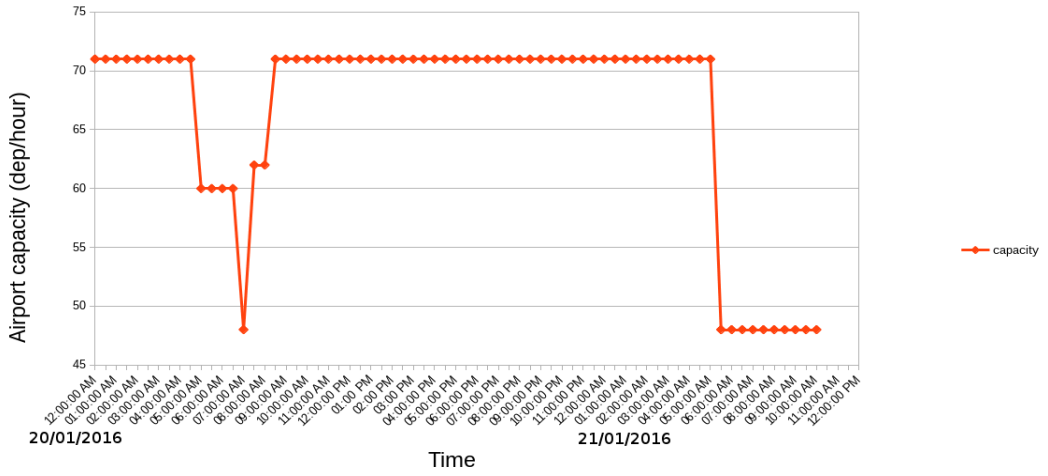

FIG8: Paris-CDG airport departure capacity from January, 20th 2016 at 0Z to January, 21st at 12Z. During fair periods, the mean airport departure capabitily is shown (71 departures per hour).

The forecast of these threatening conditions was performed (among other products) thanks to the aforementioned on-ground airframe icing (rime, frost)-probability model, as shown on FIG9. It suggested a high risk of on-ground icing with a good chronology of the event.

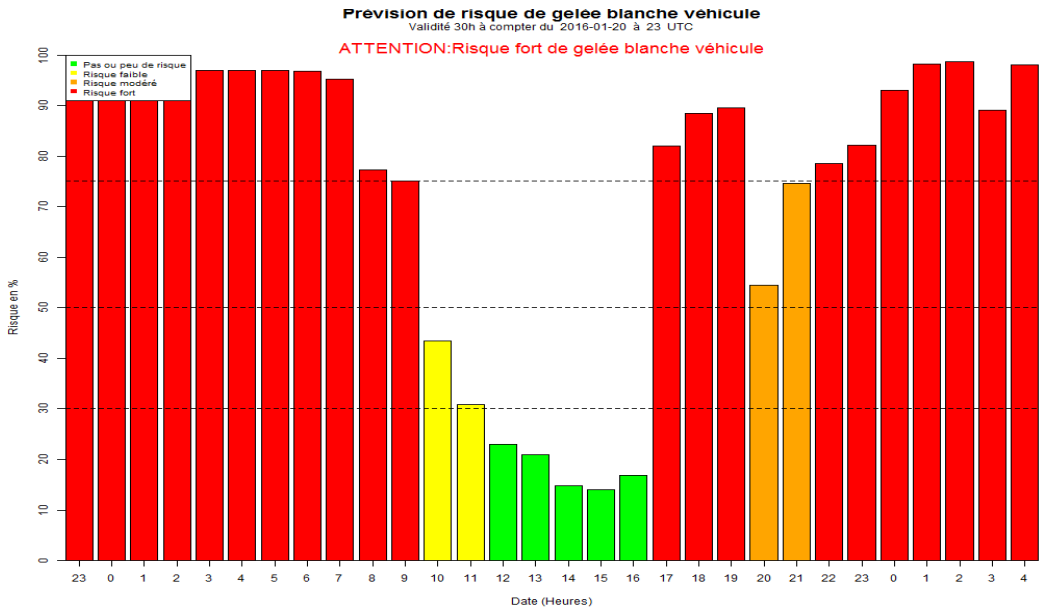

FIG9: Display of the on-ground airframe icing model (ANTIGEL) of Météo-France available on January, 20th at 23Z.

This case study enlightens the interest of using tailor-made models to better forecast airframe icing and hence alow the ATM to better manage the de-icing operations.

4. March 5th, 2016 : wintry precipitations

Although not daily at Paris-CDG, wintry precipitations (snowfall, graupel, ice) fall from time to time during winter, mostly from December to March. A snow plan is activated as soon as any weather-related risk becomes apparent. The CDM team meets and convenes to decide what resources will need to be mobilised (manpower, machinery). The runways, taxiways and aircraft parking stands are cleaned when they are unoccupied. These operations are under the responsibility of the airport manager, performed thanks to 174 snow-clearing vehicules (“snow trains” as displayed on FIG10). The runways (depending on their length) can be cleaned in 20-30 minutes, during which the traffic on the runway is suspended, seriously reducing the airport capacity.

FIG10: A "snow-train", (approximatively 13 snow-clearing vehicules, depending on the situations) working on a frozen runway of Paris-CDG.

March, 5th is a good illustration of such snowy conditions on Paris-CDG : a front lingered over France during the whole night between the 4th and the 5th and the following day (as shown on FIG11). LVP conditions occurred from 0430Z to 0515Z, and it snowed from 0330Z to 1100Z and there were graupel showers from 1600Z to 2030Z.

These conditions led to the treatment of the runways from 0500Z to 0615Z, causing the reduction of the airport departure capacity down to 24 (the nominal rate is 71). Also, de-icing of 119 aircrafts was necessary to sustain safe travel conditions.

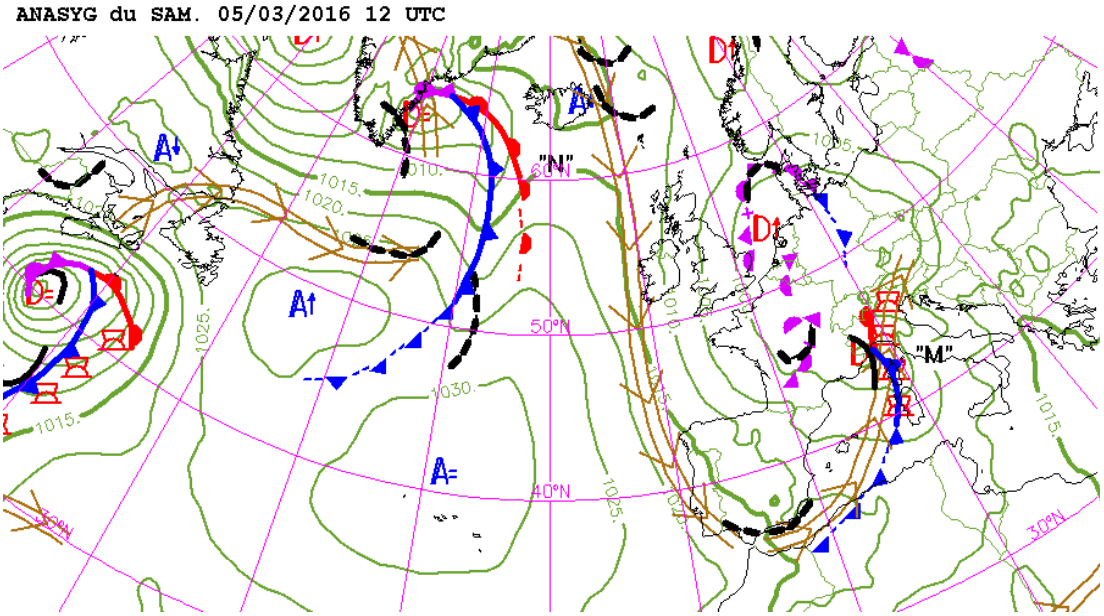

FIG11: Chart of weather front analysis for Europe on March, 5th 2016 at 12Z.
Green lines show the isobars. Red lines represent the warm fronts, blue lines, the cold fronts, purple lines, the stationary fronts and black lines, the tropopause anomalies. Brown arrows display the jet streams.

The snowfall risk was well anticipated by forecasters in the CDM@CGD tool (FIG12) until 10Z. An airport warning was also issued (FIG13) at 0200Z, forecasting snow between 0330Z and 1130Z, which exactly corresponded to the observed snowfall time.

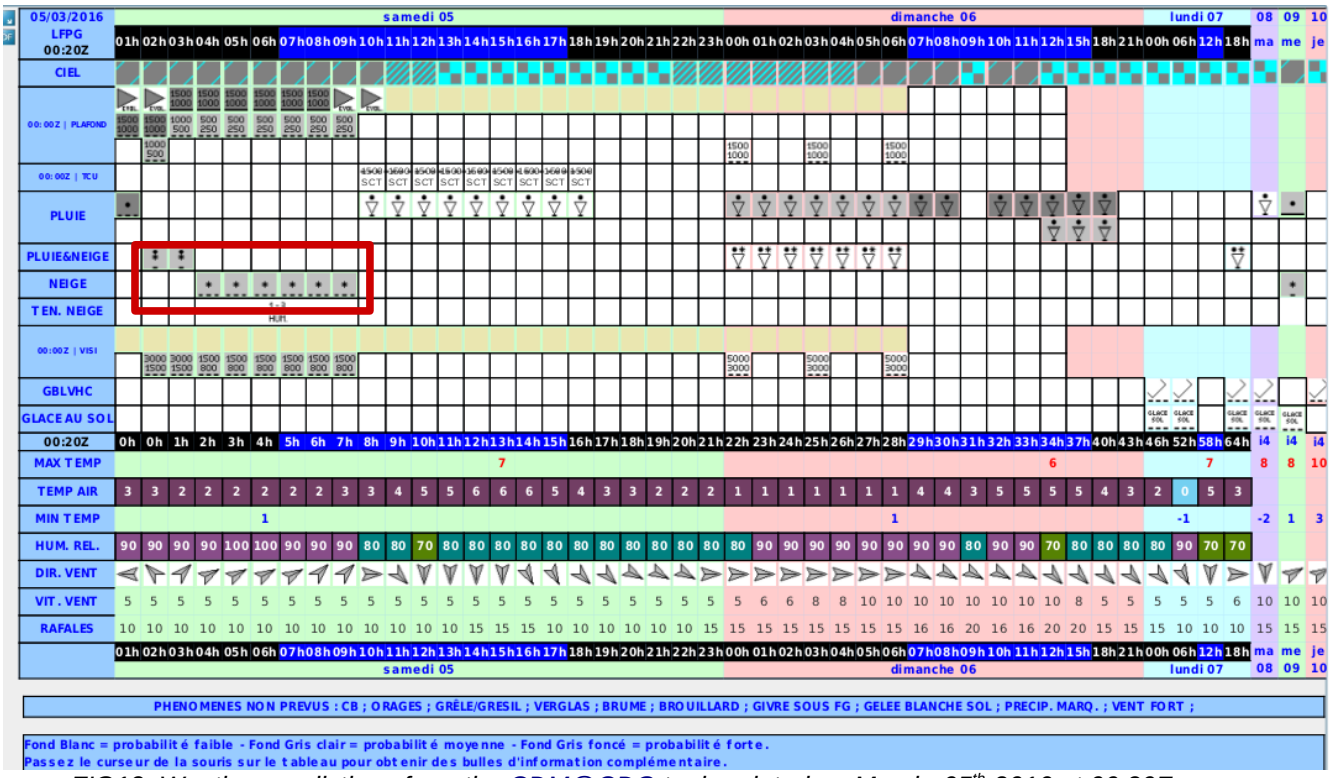

FIG12: Weather predictions from the CDM@CDG tool updated on March, 05th 2016 at 00:20Z

FIG13: Weather warning (MAA, aeronautical message) updated on March, 05th 2016 at 04:11Z

This good forecast was performed thanks to Météo-France's nowcast model AROME-PI, but also the regional model AROME-France (FIG14). Indeed, the run of March, 5th a 00Z of AROME-France showed a risk of snowfall at 03Z. The vehicule-icing model provided also a relevant information to the forecasters, and hence, to the ATM-operators.

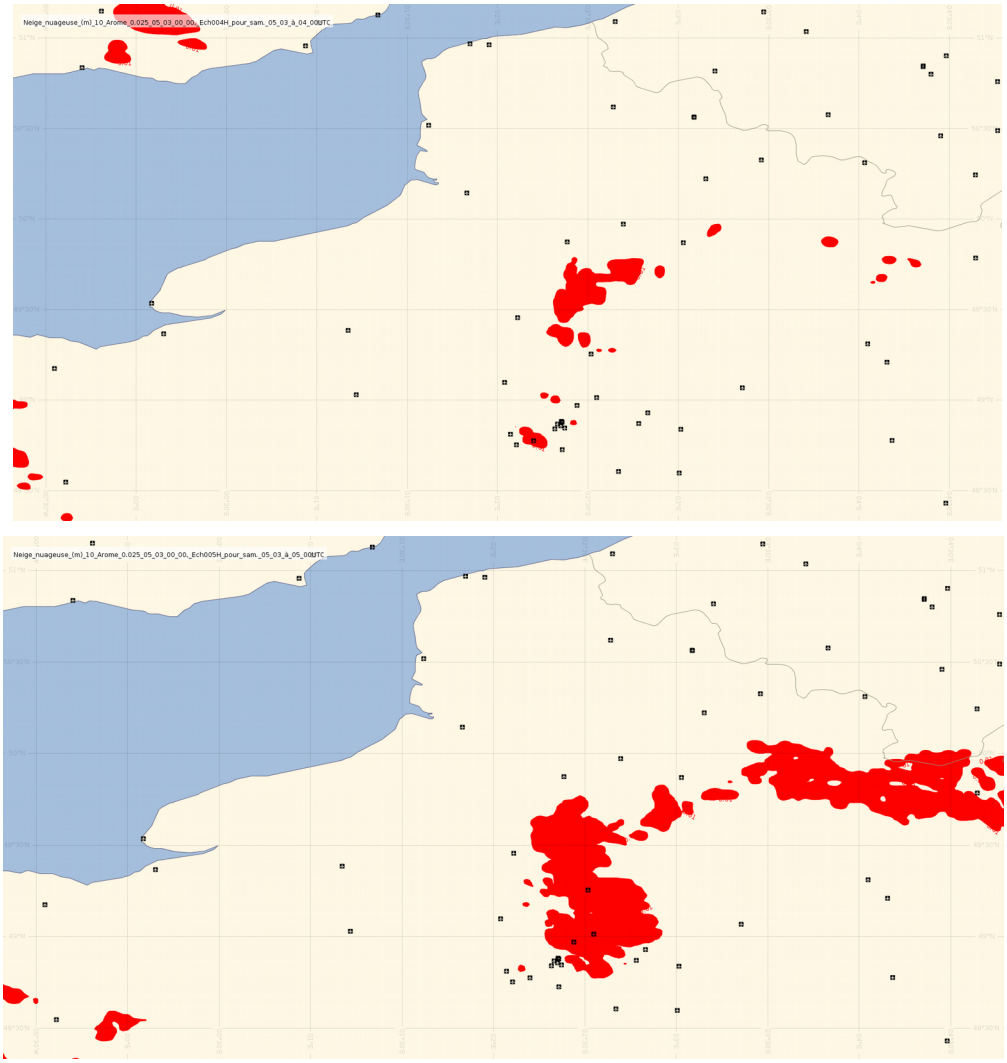

FIG14: Cloud snow fields (in red) from the AROME-France model. Run of March, 5th 2016 at 00Z, fields at 04Z and 05Z.

This case study enlightens the interest of using tailor-made models in the ATM in case of wintry precipitations.

5. Conclusion

This report illustrates the positive impact to the ATM operations of the extra information provided by state-of-the-art models such as Meteo-France's nowcasting model AROME-PI and ANTIGEL, the vehicule icing statistical model over a high-traffic airport during bad weather situations through the CDM@CDG tool.

A better management of flight arrivals and departures in case of LVP conditions, on-ground icing conditions, snowy runways is hence allowed thanks to an improved assessing of the timing of such events and their severity.