WORLD METEOROLOGICAL ORGANIZATION

AeroMetSci 2017

AERONAUTICAL METEOROLOGY SCIENTIFIC CONFERENCE

Data-driven influence model of weather condition in airport operational performance

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6 to 10 November 2017, Météo-France, Toulouse

INTRODUCTION

- Adverse weather conditions are a major cause of flight delays and cancellations. It is still lacking of quantitative models supporting decision-making processes.

- The aim is **to integrate the meteorological information into the ATM decision-making process** by means of a meteorological indicator, based on actual or forecasted data, to describe the operational situation.

- This study provides a data-driven model to assess weather impacting on airport operational performance. The output is an integrated indicator.

METHODOLOGY

The process starts with empirical values both for the thresholds of the different meteorological parameters and the impact those on the operation, which allows the definition of the integrated meteorological indicator itself.

The thresholds are modified in an iterative process based on genetic algorithms, improving the thresholds in order to achieve a better relation with the airport performance metrics.

METHODOLOGY

The indicator is composed by different inputs coming from the METAR:

1) wind,
2) shear wind conditions,
3) visibility,
4) meteorological phenomena and
5) cloudiness.

Each of these categories has different weights and the final value of the indicator will be the sum of each individual category value.

A set of colours related to the meteorological risk is defined, and the different indicator and categories values are assigned to the ranges of colours.

METHODOLOGY

As an example of parameter, threshold and weights:

1.1. CLOUDINESS

Table 1. Summary of cloudiness contribution to the indicator value

METAR Field	Threshold	Contribution
Cloud Height	< Minimum Threshold	0 – Maximum Cloud Height Contribution
Cloud Quantity	FEW	Cloud Quantity Multiplier* 0.5
	SCT	Cloud Quantity Multiplier* 1.5
	BKN	Cloud Quantity Multiplier* 2.5
	OVC	Cloud Quantity Multiplier* 4
Cumulonimbus	Appearance of CB/TCU	CB Multiplier

There are a total of 22 thresholds and contributions optimized in the study .

THRESHOLDS COMPUTATION

Genetic algorithms are search algorithms based on natural selection and genetics features Their behaviour is based on the **survivability of the strongest individual**. In this specific application, the best individuals will be **the thresholds providing the best results**.

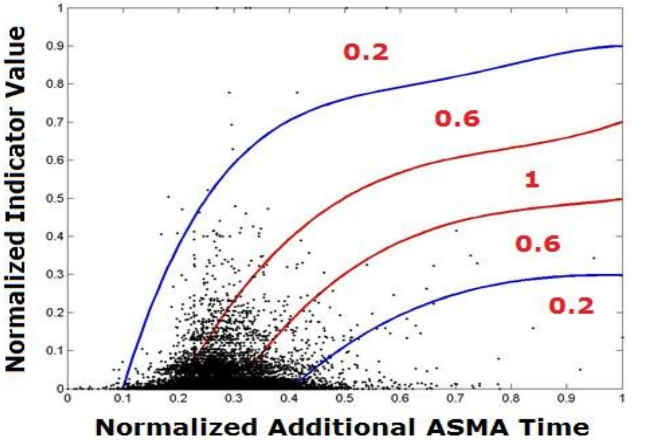
The genetic algorithm starts with an empiric population and starts performing different steps until reaching the best possible outcome. These steps may include the so-called tournaments (facing pair of results and discarding the worst) and mutating (test best obtained values mutating different thresholds to create a new population).

The total number of iterations to be performed was set to free, so the algorithm stopped when all the individuals were equal to the best possible.

In the problem faced in this paper, the best outcome will be the best representation of the reality with respect to the ASMA metric.

The algorithm searches to adjust each point (with coordinates based on the indicator and the metric values) to an area indicating the best expected outcome.
Locating a point inside an area will sum up a value depending on the area (1 for optimum area, 0.6 for intermediate areas and 0.2 for outside areas).

The best individuals will be the ones whose total sum is higher.



INDICATOR COMPUTATION

Once the validation has provided the thresholds, the defined methodology is applied to each METAR message, obtaining the different values of the indicator.

A range of 6 colours is defined for the indicator value, while only 4 colours are defined for each of its categories (wind, wind shear, visibility, phenomena and cloudiness). The different thresholds of each colour are summarized in the following table:

	Green	Cyan	Yellow	Orange	Red	Black
Indicator	0	>0	>2	>4	>8	>12
Wind Speed	0	-	>0	>4	>8	-
Wind Shear	0	-	1	-	2	-
Visibility	0	-	>0	>3	>6	-
Phenomena	0	-	>0	>3	>6	-
Cloudiness	0	-	>0	>3	>6	-

INDICATOR RESULTS

The first example reflects the indicator obtained for April 24th of 2014 at the airport of Madrid. The corresponding METAR for that moment is the following

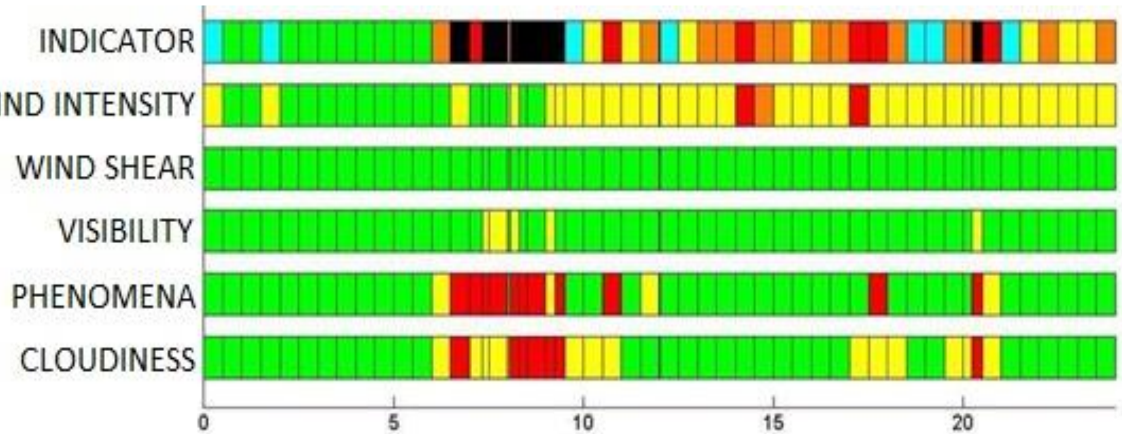
METAR LEMD 241800Z 27011KT 240V310 9999 FEW030CB BKN055 12/06 Q1016 NOSIG

Indicator	
Wind Speed	
Wind Shear	
Visibility	
Phenomena	
Cloudiness	

INDICATOR RESULTS

Figure shows the indicator values obtained for April 12th of 2014 at the airport of Madrid. The indicator itself is shown in the bar at the top and the different components are shown below it.

This visualization allows analysing which are the causes of having bad meteorological conditions.



CONCLUSIONS

- The proposed methodology develops a meteorological airport indicator based on METAR messages. The provision of a meteorological indicator to the ATM side is a help to check quickly the meteorological conditions.

- The methodology proposed by this study can be introduced into the ATM decision-making loop in the airport environment. This model will be specific for each airport, providing specific meteorological assistance to the Air Traffic Controller decision-making process.

- The positive results obtained with this innovative approach show great potential for operational usage within the airport domain.

Thank you