Abstract

CB and TCU form a hazard for aviation. Their detection near airports is a requirement to limit hazardous flying conditions. This paper presents a detection algorithm of Cb and Tcu based on a synergetic system of radar observations and satellite observed radiances as implemented since March 2011.

Based on feedback from end-users, the detection method could be improved. Numerical Weather Prediction (NWP) information is introduced to reduce the number of False Alarm Ratio introduced by frontal rain bands. Unfortunately the filtering with NWP information also has a slight negative impact on the Probability Of Detection.

Introduction

CB and TCU form a hazard for aviation. Their detection near airports is a requirement to limit hazardous flying conditions. The CB and TCU observations were predominantly done by human observers. These were replaced in 2007 by automated observations at two airports: Maastricht-Aken and Groningen. The performance was poor hence in March 2011 an improved automated detection was introduced based on a synergetic system of radar and satellite (MSG) observations.

The request came to extend this method to all airports and platforms where landing and take-off occurs based on KNMI information, the so-called Flight Information Region. This paper captures this extension and introduces a method to reduce the False Alarms by using NWP information.

Method

Only radar and satellite observations provide the spatial and temporal coverage required to identify and track CB and TCU. These observation methods cannot distinguish between Cb and Tcu. Therefore only one cloud type, Cb is classified, capturing both the Tcu and Cb occurrence.

For the area of interest, a circle of 15 km around an airfield (ARP), a number of variables were derived. They are from both radar, reflection signal, and satellite observations, the range between minimum and maximum in HRV channel during day light, and fraction of the collocation area with a difference between the 3.9 and 10.8 um channels lower than zero for night time. These variables were determined from a logistic regression study, de Valk, Eumetsat Data user conference Oslo, 2011, to have a significant correlation with Cb occurrence.

The Cb occurrence data set was created thanks to the significant effort of forecasters who evaluated some 500,000 cases for all the stations, (Figure 1), using data from, NWP, lightning, radar, satellites, and radio sondes, for 2010 with a 30 minutes time separation. After the automated Cb detection NWP information, the CAPE (convective available potential energy), is used to filter the results. When the CAPE is not over 50 J/kg, the Cb classification
is labelled as False. This is a conservative value and it is introduced to distinguish frontal rain from convective rain.

Results

Due to the increase of locations the spatial coherence between the coefficients of the predictors could be studied. As the evaluation did not comprehend a full year yet the results are intermediate.

A qualitative assessment of the coefficients showed a dependence on the distance to the radars, the closer the ARP is to the radar the higher the coefficient, see table, where the value of satellites predictors coefficients remains approximately constant over the area of interest. Remote sea stations show a relative low coefficient values for the radar predictors, compare DV and PG.

The impact of the CAPE on the results is shown for one location Eindhoven airport, Figures 2 and 3. Predominantly the CAPE filtering method has a positive impact on the performance due to the reduction of the FAR. There is however also a slight reduction of the POD.

<table>
<thead>
<tr>
<th>station</th>
<th>Constant</th>
<th>Radar R (dBz)</th>
<th>Satellite S (HRVmax-HRVmin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EH land</td>
<td>-6.06</td>
<td>0.67</td>
<td>0.024</td>
</tr>
<tr>
<td>PG sea</td>
<td>-5.12</td>
<td>0.28</td>
<td>0.019</td>
</tr>
<tr>
<td>DV sea</td>
<td>-5.01</td>
<td>0.22</td>
<td>0.020</td>
</tr>
</tbody>
</table>

Table. Predictor coefficients used in $P=1/(1+\exp(-c_1\times R + c_2\times S))$ for daytime conditions at various locations see Figure 1.

![Figure 1. Areas with flight activities, Airport reference points](image)

Outlook

The coherence between the coefficients suggests that interpolation between the stations could be possible, especially above sea, where the surface characteristics are uniform. An extrapolation will enable a Cb detection outside the collocation areas around ARP's. Above land the in-homogeneity of the land surface can deteriorate the interpolation possibility. Still some cautious classification close to ARP's could be made.
Figure 2 and 3. Impact on the performance for EH by filtering by CAPE in a Probability of Detection (POD) and False Alarm Ratio (FAR) diagram. The upper left corner corresponds to a high POD and a low FAR. Bootstrapping on an independent set resulted in Red line with dots average score for probability threshold from 0.1 (upper right) to 0.5 (lower left) in steps of 0.05, black line denotes the median for the same probabilities as the red line, dark grey denoted 66 percentile of all bootstrapped cases, and light grey denoted the 95 percentile. Note that a lower FAR in Figure 3 also shows a lower POD.