AUTOMATIC CB DETECTION FOR METAR WEATHER MESSAGES USING RADAR AND NWCSAF PRODUCTS IN FINNISH METEOROLOGICAL INSTITUTE

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Abstract

METAR messages are used to disseminate information of the existence of Cumulonimbus clouds. METAR messages were traditionally constructed manually from human observations, but automatization of this process is a growing trend. For example, in Finnish Meteorological Institute, an operational automatic detection of Cb for METAR, based solely on weather radar data, is in use. We examine the possibility to add value to radar-based detection with satellite products from NWCSAF. Furthermore, the verification of Cb detection is challenging as good ground truth data is not often available, and the use of Latent class analysis for statistical estimation of relevant verification parameters is explored.

INTRODUCTION

For aviation, locating Cumulonimbus cloud (Cb) is very important and mandatory (ICAO Annex 3). Cb causes gusty winds and thunder, which may lead to disaster during the take-off and landing. The standard way of dissemination of Cb information is through METAR messages, traditionally from human observations. However, training observers and having staff in three shifts is costly and not feasible especially at airports, which have less traffic. And observing Cb only by viewing at the aerodrome is not without its problems. For instance, Cbs embedded in frontal system are often invisible for human observers. Therefore, automatization of this process is a growing trend.

In this paper we explore the added value from EUMETSAT's Nowcasting Satellite Application Facility (NWCSAF) products. First, products could be used to minimize the number of false alarms and misses: Even simple cloud masks can help in radar anomaly removal and reduce the number of false alarms. More advanced products, such as Convective Rainfall Rate (CRR) or Rapid Development Thunderstorms, might be useful in detecting Cb, especially jointly with lightning data. Second, the satellite-only Cb detection could be used even when parts of the radar network are momentary unavailable, and outside the coverage of radar network.

THE CURRENT RADAR-BASED CB DETECTION IN FMI

Polar volume radar data of 8 c-band radars is used for the Cb detection. Doppler filtered data of each elevation is first post-processed using dedicated anomaly removal filter (Peura 2002). Possible Cb range gates are recognized by using two distance dependent reflectivity thresholds and vertical consistency criteria. The process is repeated every five minutes, and detections in radar network are combined to create final Cartesian Cb detection grid of 1 km resolution. The radar-based algorithm is under development. New data sources, for example, products derived from dual polarization quantities are considered.

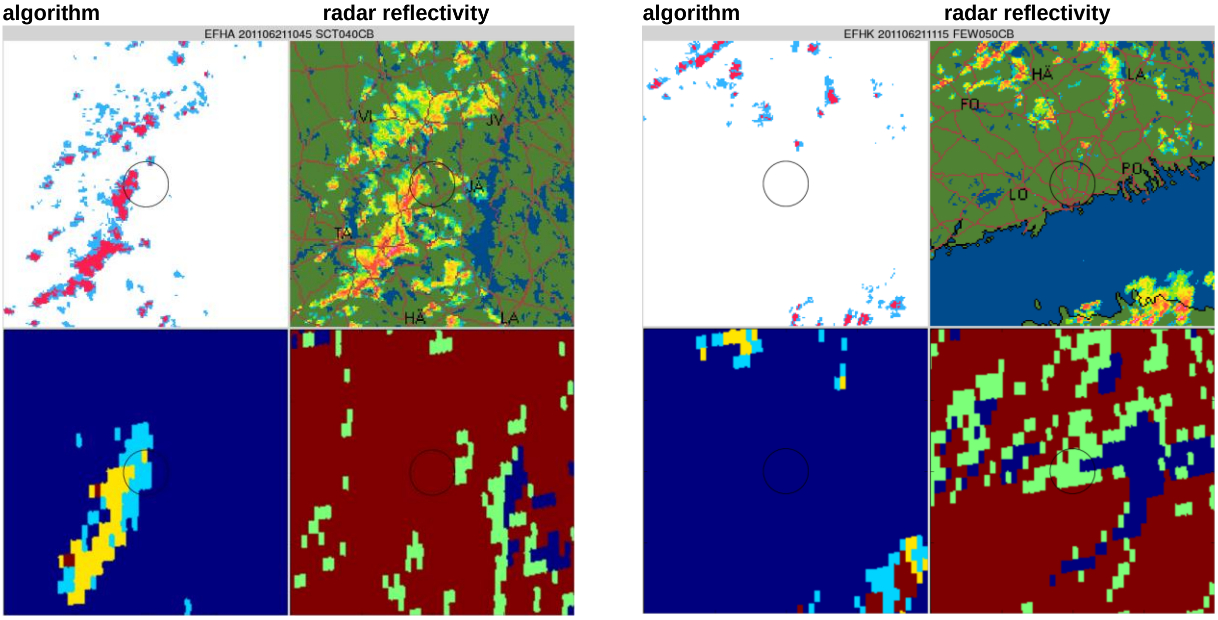
A QUALITATIVE EXAMPLE OF RADAR AND SATELLITE PRODUCTS

An example of a successful detection and a false alarm are shown in Figure 1. In the successful case (Figure 1 a) both the radar-based detection system and human observer agreed that Cb was in the vicinity of the airport (inside the circle). Satellite-based products agree also.

Of course, Cb should not be reported if it is too far from the airport. However, for the human observer it is often hard to judge the distance. And Cb too far is often reported, just to be on the safe side. In the false alarm case (Figure 1b), radar and satellite products strongly imply that Cb is not close enough to be reported, but the human observer reported Cb all the same.

a) Successful detection by all methods | b) False alarm by human observer

Cb detection algorithm | **CAPPI of radar reflectivity** | **Cb detection algorithm** | **CAPPI of radar reflectivity**



CRR from NWCSAF | **NWCSAF Cloud Mask** | **CRR from NWCSAF** | NWCSAF Cloud Mask

Figure 1: **Radar and satellite products from 21 June 2011 show examples of (a) successful Cb detection and (b) a false alarm by a human observer. The circle (r=16km) indicates the area where Cb should be reported.**

TENTATIVE QUANTITATIVE VALIDATION WITHOUT GROUND TRUTH

There is no ground truth as all methods have their strengths and weaknesses. However, for discrete classes ("Cb", "no Cb") Latent class analysis (LCA) can be used to estimate the not-observed or latent class. Then, in the terminology of Jolliffe and Stephenson (2012), LCA estimates Base rate (*s*) of this latent class and Hit rate (H) and False alarm rate (F) for different data sources. For two classes, this is possible if three or more data sources are available. Standard verification measures can then be calculated as all measures can be shown as the function of H, F, and *s*. We compute Heidke Skill Score (HSS) and the ratio H/F that can be used calculate the odds of Cb in the vicinity of the airport: a detection increases odds by H/F and a non-detection decreases them by (1-H)/(1-F). In this study the poLCA library of Linzer and Lewis (2011) was used for LCA. The assumption is that the data sources are independent.

Tentative results for Helsinki airport and summer 2011, using radar, CRR, lightning and human observations are presented here. Analyses were performed with different radii around airport. Automatic observations are independent, but human observers have used radar images (but not automatic radar product used here!), so human observations are not as independent as we would like them to be.

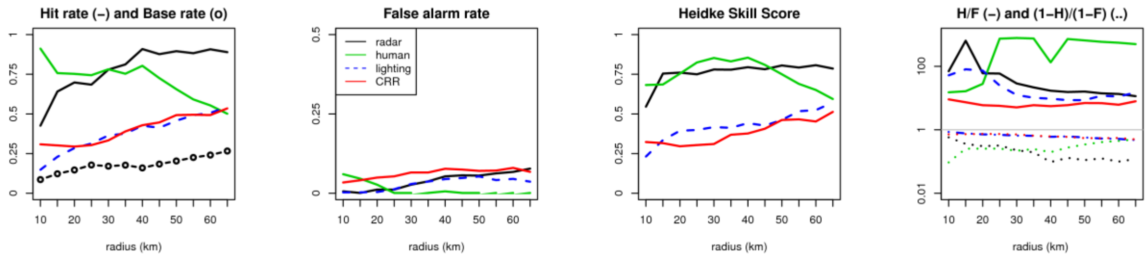


Figure 2: **Hit rate H, False alarm rate F and Base rate *s* as the function of the radius of the area around the airport. Results are computed with Latent class analysis for different observations and Heidke Skill Score and ratios H/F and (1-H)/(1-F) are then computed from LCA results.**

In Figure 2, results with the different radii are shown. For human observations, H drops at large distances while, for automatic methods, H and *s* grow as the radius (and the area) grows. This is as expected, because as the area grows, potentially more Cb can be detected. Radar has the best H overall.

For F, radar and lightning give better results than CRR. And again, for automatic methods, F grows as distance grows. At large distances, human observations give almost no false alarms.

According to HSS, radar observations and humans have similar skill, while lightning and CRR have lower skill.

For automatic methods, detection by radar and lightning increases the odds of CB most, but non-detection by radar decreases them much more. So the detection of Cb by either radar and lightning gives good evidence of Cb, but the non-detection by radar gives better evidence of the absence of Cb. And interestingly, for larger distances, human observations increase the odds most (but officially we should be interested only in the radius = 16 km!).

SUMMARY AND OUTLOOK

We have explored the added value of NWCSAF products for Cb detection. However, these products are not designed for Cb detection per se, so use of derived cloud physical properties (such as cloud optical thickness, effective radius, and cloud phase) can more beneficial for Cb detection (Henken et. al 2011) and should be examined in future work.

Tentative results show that LCA can give reasonable results when no ground truth is available. However, the assumptions of methods should be taken seriously. For example, in this data set the independence of human and radar observations might be violated. More advanced, for example Bayesian, methods that can take this kind of information in account should be explored.

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