NOWCASTING OF THUNDERSTORMS WITHIN A WEATHER INFORMATION AND MANAGEMENT SYSTEM FOR FLIGHT SAFETY

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I. INTRODUCTION: THE FLYSAFE PROJECT

FLYSAFE (http://www.eu-flysafe.org/) is a European Commission funded project aiming at improving flight safety through the development of a Next Generation Integrated Surveillance System (NG-ISS). The NG-ISS provides information to the pilot on a number of external hazards which address the three types of threats: traffic collision, ground collision, adverse weather conditions. With regard to the latter, the NG-ISS is coupled to a ground-based Weather Information and Management System (WIMS) that has been designed to provide the best possible nowcast of the most dangerous meteorological hazards over a defined area ranging from high resolution short-range on a local scale to long-range forecasts on a global scale. Individual WIMS have been developed for the weather hazards icing (ICE WIMS), clear air turbulence (CAT WIMS), wake vortex turbulence (VW WIMS) and thunderstorms (CB WIMS; Cb = Cumulonimbus).

All WIMS data are sent to a ground-based weather processor (GWP). By request from an aircraft selected information about a weather hazard tailored to the respective flight corridor is passed through the GWP to the on-board NG-ISS. The NG-ISS fuses the WIMS data not only with on-board weather data, but also with data of the threats terrain and traffic in order to achieve a consolidated picture of the hazard situation. Finally, the situation is presented to the pilot by means of simple, easy to read graphics on a special display together with the possible solution on how to avoid the hazard.

This paper describes the CB WIMS part of the system and its evaluation in operational flight tests.

II. THE CBWIMS APPROACH

Thunderstorms are very complex weather features appearing in various shapes and sizes and corresponding life times from a few tens of minutes to several hours.

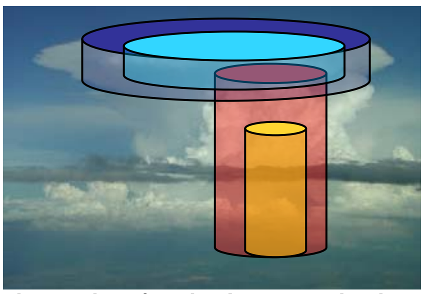

FIG. 1: Photography of a thunderstorm with Cb top (bluish cylinders) and bottom (reddish cylinders) volumes superimposed.

This information must be compiled into simple messages and graphics that are easy to interprete and enable quick decision making. Therefore, the strategy within Cb WIMS is not to describe thunderstorms in any observable detail, but to render hazard areas for aircraft as objects describing the hazard levels "moderate" and "severe", where "severe" indicates a no-go volume of air space. Figure 1 renders a schematic depiction of such thunderstorm hazard objects (re-drawn from Tafferner et al., 2008) . The Cb top volumes represent the turbulent anvil area, while the Cb bottom volumes represent areas with heavy rain, hail, and turbulence. Nested volumes indicate the two severity levels "moderate" and "severe". Note that the horizontal shape of the volumes do not have to be cylinders as depicted here, but can be polygon shaped.

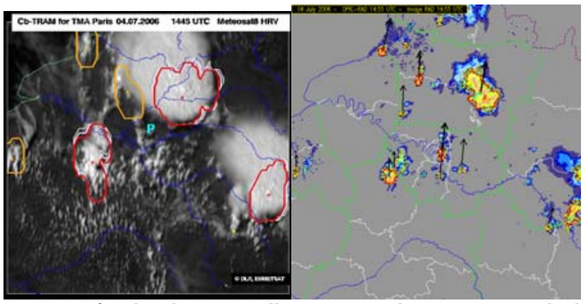

FIG. 2: Left: Thunderstorm cells as seen in the METEOSAT high resolution visible channel within the TMA Paris overlaid with CB top contours for 4th July 2006 1445 UTC. Mature cells in red, rapidly growing in orange. Also shown are the nowcasts for 5 and 10 minutes ahead in time in white and grey contours. Right: Radar reflectivity in shades of colour over the area of TMA Paris. Identified Cb bottom volumes encircled in orange (severity "moderate") and red (severity "severe") contours at 4th July 2006 1455 UTC.

The Cb top volumes are detected by satellite with DLR's cloud tracker Cb-TRAM (Zinner et al., 2008), a fully automated algorithm for the detection and nowcasting of convection using METEOSAT data. The Cb bottom volumes are diagnosed by Météo France's CONO algorithm (Hering et al., 2005) which detects and nowcasts convective cells using radar data. Fig. 2 shows an example of top and bottom volumes over the terminal manoeuvring area (TMA) Paris.

III. CB WIMS EVALUATION

During sumer 2008, the real time Cb WIMS production as well as the data flow to the GWP and up to the cockpit have been tested involving two research aircraft: the

ATR42 from SAFIRE French atmospheric research aircraft unit (http://www.safire.fr/) and a Metro Swearingen II operated by the dutch NLR (http://www.nlr.nl). Here, we present results from the SAFIRE flights which was devoted to the recording of in-situ and conventional onboard radar data for off-line evaluation of the products from CB WIMS (as well as ICE and CAT WIMS). Setting up a digitized recording of the full on board radar data on SAFIRE proved to be intractable in the time schedule of the project. Therefore, a video recording of the on-board radar screen was settled. The Cb WIMS data were then superimposed on the recorded on board radar images.

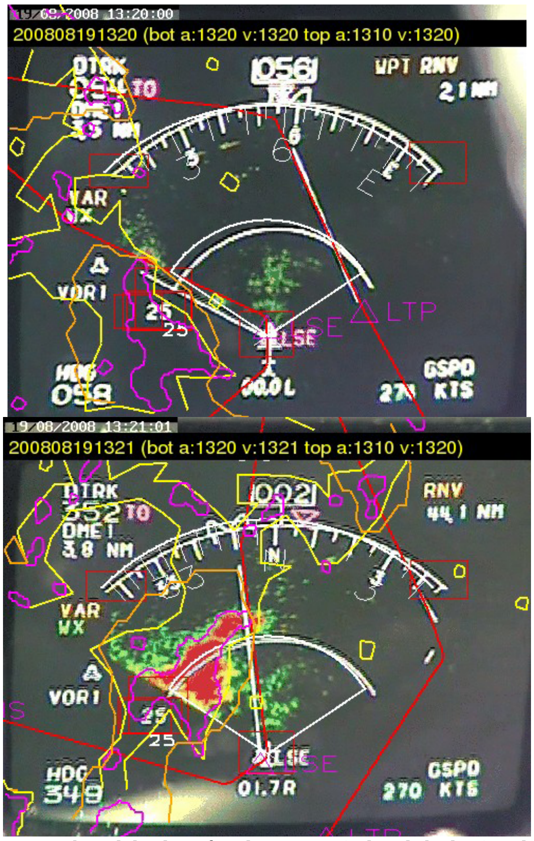

FIG. 3: On board display of radar images (colored shading) and CB WIMS objects (colored contours) during a sharp turn. Cb top objects are indicated in orange, Cb bottom objects with severity “moderate” in yellow and with severity “severe” in magenta. The flight path of the aircraft is marked by a red line with the aircraft’s position indicated by a white aircraft symbol. LSE is a waypoint near Lyon. Top image at 13h20'0" on August 19th, bottom image 61 seconds later. Objects are diagnosed using data from 13h20.

The on-board radar scans ahead of the aircraft over a sector which is usually 90 to 120° degrees wide. When the aircraft has to turn sharp, this can cause a temporary blindness which can be detrimental to the safety, or at least to the smoothness of aircraft operations. Fig. 3 shows an example of such a case: on August, 19th, the aircraft reached Lyon (LSE waypoint) at 13h20'00" (top panel) where it turned left sharply. The WIMS CB objects were depicting level “severe” bottom objects and a top object close to the aircraft path (red line), at a location not yet covered by the on-board radar. Some 61 seconds later, the on-board radar showed a strong reflectivity pattern which matched very well the bottom object, and was also confirmed at later times. In such a case, where the WIMS CB objects also showed that convection was scattered at longer ranges ahead of the aircraft (see bottom panel), such an information could have helped in delaying the turn for safer operations. Another situation where this extended spatial coverage could significantly help pilots is the take-off and landing maneuvers where strong turns are much more constrained for aligning with the runways and can occur also without any visibility in case of embedded convection.

IV. FURTHER RESULTS AND CONCLUSIONS

Further results of the evaluation showed that CB WIMS objects can give valuable additional information to the pilot in cases where CBs are located in lines one after the other and the on board radar is attenuated by the CB located closest to the aircraft. CB WIMS objects also help to distinguish ground clutter from thunderstorms in the on board signal. Expert pilots were involved in the assessment of the new products. They recognized the potential operational value of WIMS Cb, and pointed out that among WIMS CB objects, severity “moderate” bottom objects and top objects can be seen as areas outside which there is definitely no hazard. They took note that accuracy and details of the on-board radar data is nevertheless of fundamental value at shortest ranges, and that more than two levels of WIMS CB objects severity could be used.

Overall, it can be concluded that:

- Thunderstorms can be represented by relatively simple bottom and top volumes in a meaningful way for aviation (pilots and controllers)
- CB WIMS objects generally agree well with the on board radar depiction
- Cb WIMS information is free of ground clutter which is not the case for the on board radar
- Cb WIMS objects provide valuable information beyond and outside of the on board radar range
- Cb WIMS objects provide valuable information on Cbs which are attenuated by closer Cbs in the on board radar
- Cb WIMS top objects especially valuable in radar void areas or in situations when a CB is in its developing phase and can not yet be detected by radar.

V. AKNOWLEDGMENTS

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