Poster 336

Sixth Aviation, Range, & Aerospace Meteorology Symposium,
AMS Annual Meeting, Austin, TX
8 January 2018

AN UPDATE ON THE GLOBAL WEATHER HAZARDS PROJECT AND NEXT STEPS

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Introduction

For the past two years, the Global Weather Hazards (GWH) Project has demonstrated that today's technology allows the uplink of operational weather products into the cockpit of commercial aircraft flying transoceanic routes. During the GWH Project, the two convective products have been shown on a supplementary basis over a global domain and at an update rate of 15 min. The two products, the Cloud Top Height (CTH) and the Convective Diagnosis Oceanic (CDO), are plotted over the navigational maps on the Electronic Flight Bag (EFB) with the planned flight route, thus allowing the pilot to better understand and anticipate the weather situation that is beyond the range of the onboard radar. In addition, standard products such as Significant Meteorological Information (SIGMETs) and Airmen's Meteorological Information (AIRMETs) for convection, turbulence and icing as well as Volcanic Ash Advisories are also plotted to give the pilots information on additional hazards. The weather products are displayed on the EFB that resides on a Microsoft Surface Pro 3 and uses the Lido EnRoute Flight Manual (eRM).

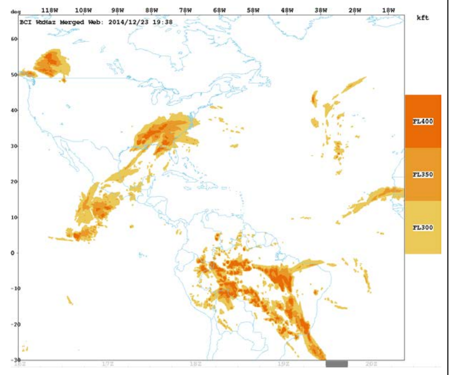
Now that the capability has been proven to uplink and display weather products that are accurate, timely and useful for strategic decision making by pilots, the next steps in the display evolution are shown. Combining the onboard radar display with the satellite-based convective products is discussed and examples shown. Also, gridded turbulence intensity plots, Radar Based 3D Composite Reflectivity, and Echo Top Products have been devised for the EFB and are described and shown. Uplinking additional weather products to the EFB display gives pilots a more complete situational awareness of potential hazards and enhances safety and efficiency.

This poster, describes the overall improvements that will be added to the cockpit by augmenting the onboard cockpit radar with products that present a global situation awareness to avoid the "flying into the box" condition that is a risk with a cockpit weather radar alone.

Tablet Display of the CTH

Mission Support display of CTH

Lufthansa Airlines A380 EFB

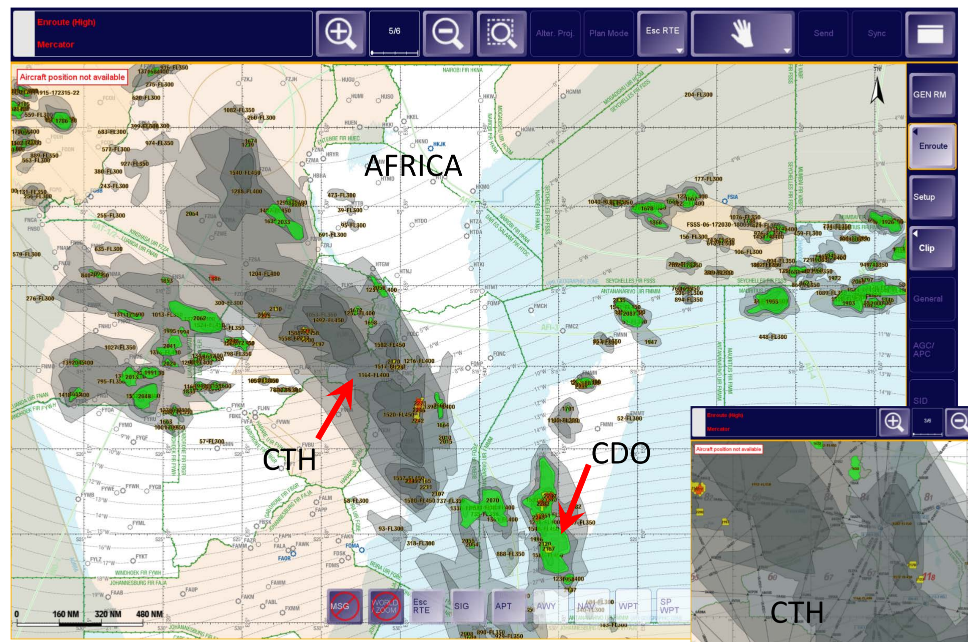


Cloud Top Height (CTH) Polygons
eFlightOps Atlantic Domain

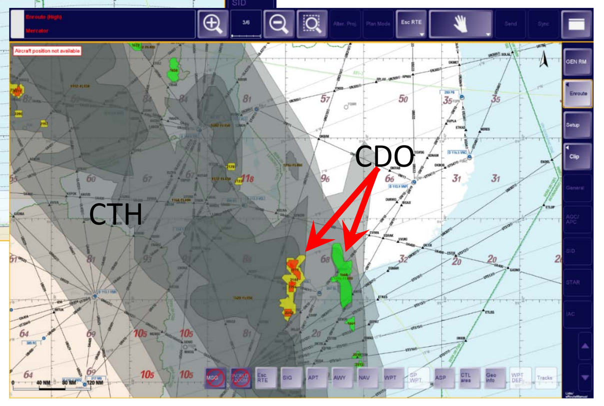
Global Weather Hazards Project

In 2015 and following the successful eFlightOps Atlantic Weather Hazard Trial, a real time operational demonstration to uplink two convective weather products into the flight deck of transoceanic aircraft began with Lufthansa Airlines, BCI, NCAR and MeteoStar collaborating as partners (Kessinger et al. 2017a; Kessinger et al. 2017b). The Global Hazards Weather project began with expansion to a global domain over latitude limits of 50S to 75N using data from six geostationary satellites (see far upper right panel). A second product, the Convective Diagnosis Oceanic (CDO), was added because of its skillful detection of convective hazards, giving additional information to the CTH. Used together, the CTH and the CDO give pilots a more complete picture of the convective storm structure and hazard locations.

The CDO and CTH products are displayed on an EFB in Lufthansa Airlines B747-8 aircraft, comprised of a Microsoft Surface Pro 3, using the Lido EnRoute Flight Manual (eRM), shown below.



eRM display showing CTH (gray polygons) and CDO (green, yellow, red shapes)

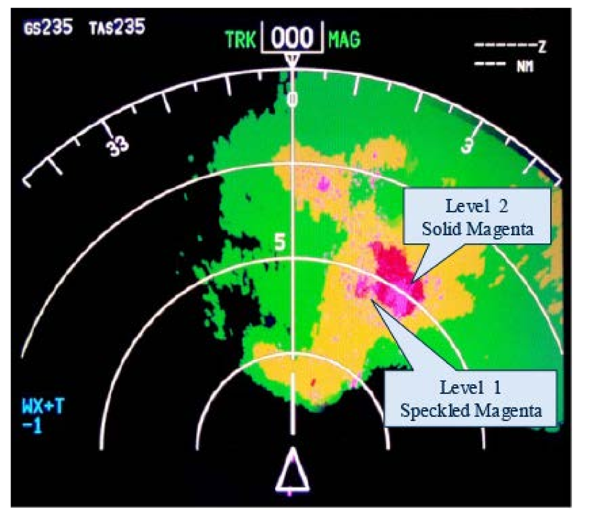


Magnified view of large storm.

Better Decisions for Safety and Flight Efficiency achieved by augmenting the Cockpit WxRadar with Global/Regional Wx Products

Conventional Cockpit Based Radar Display
Weather Phenomena limited to line of site

Real-time Data Display
125 NM Look Ahead
Reliable On-Board Feed
Approved for Navigation
Best tool for flying through Wx



Limited Lateral Awareness
~ 120 Degree Cone
Limited Range
125 NM Look Ahead
Lacks global awareness
Adds potential of "flying into box"

Trans-Oceanic Flight Routes demand Regional to Global Weather Products

An example is shown of a flight reroute made to avoid severe convective storms on a flight from Orlando, Florida to Frankfurt, Germany on 29 April 2016 (Kessinger et al. 2017b). In Figure 1, the CTH and CDO polygons are displayed on the eRM at 0140 UTC, about 3 hrs prior to take-off at 0428 UTC. In Figure 2, the eRM is shown at 0525 UTC shortly before the pilot received an amended flight route from the New York Oceanic Control Center. Convective SIGMETs are indicated by tan polygons under the CTH and CDO shaded polygons. In Figure 3, the pilot photographed the onboard radar display as the GOUGH waypoint was passed on the amended flight route. The approximate area of the radar scan is displayed over the eRM for comparison of the CTH and CDO polygons to the radar reflectivity.

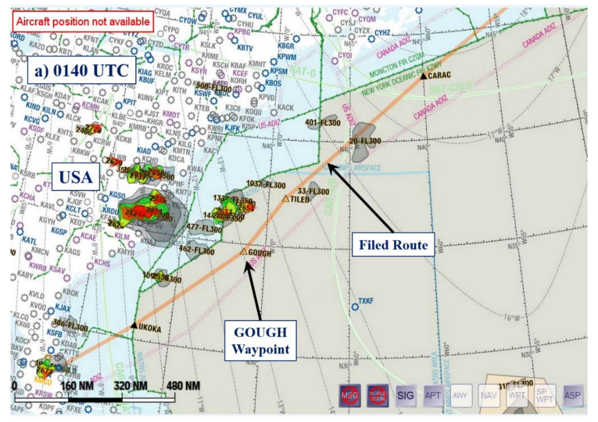


Figure 1

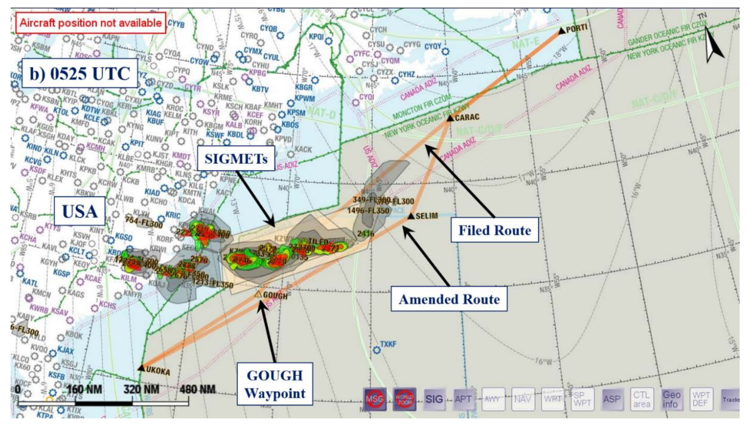


Figure 2

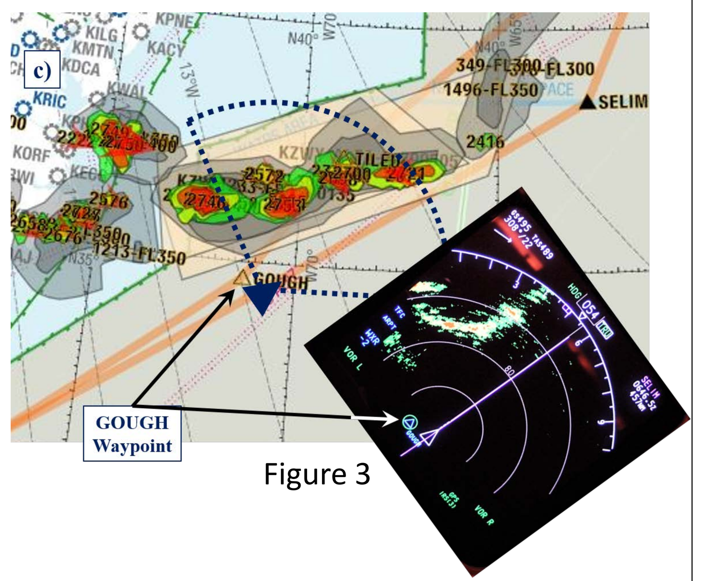


Figure 3

Flight Cross Section is available for specific weather products. MeteoStar's Global Composite Turbulence Guidance (GCTG), with a nested GTG 3.0, is one turbulence product available that has a 1000 foot vertical interval, generated hourly with 9 forecast hours (Figure 4, left). NCEP and NSSL developed the next phase of the NEXRAD processing with the Multi-Radar Multi-Sensor product (Smith et al. 2016; Zhang et al. 2016). The MRMS product produces a higher resolution Composite Reflectivity Product (Figures 4 and 5, right; Figure 6) while preserving the Base Reflectivity scans to present a detection based vertical product (Figure 5, left). When used in-flight, pilots can make subtle changes earlier to flight paths and avoid flying into a box. The vertical cross–section also assists in identifying the pertinent weather.

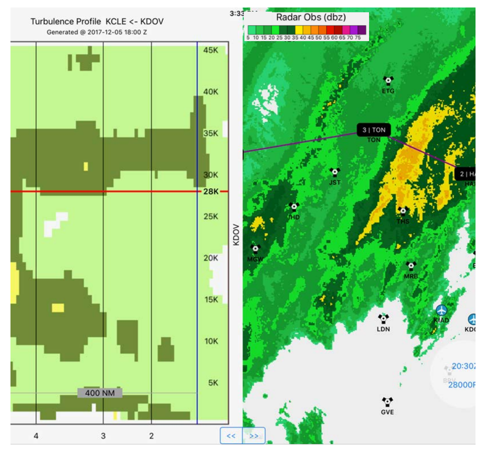


Figure 4:
GCTG (left) and
MRMS Composite Reflectivity (right)

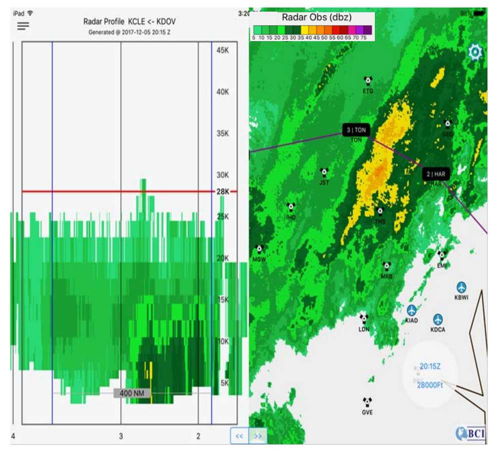


Figure 5:
3D MRMS (left) and
MRMS Composite Reflectivity (right)

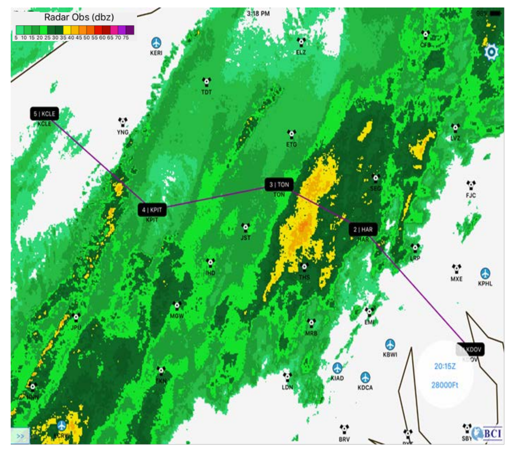


Figure 6:
MRMS Composite Reflectivity

Radar Based Echo Tops versus Satellite Based Cloud Top Heights is a subject of continued investigation. The MRMS 3D reflectivity product essentially delivers the derived Echo Top product. The Cloud Top Height (CTH) product delivers a complete picture of storm structures above 25kft as seen by geostationary satellite. The left panel of Figure 5 (above) and Figure 8 (below) shows the vertical cross section of the MRMS 3D reflectivity with the highest points becoming the "Echo Top" product shown below in Figure 7. Limitations of this or any Radar product include line of sight and coverage termination due to scheduled and unscheduled outages. In these situations, there is no clear indication for the user to discern between "good weather" and "no coverage". The corresponding CTH product, taken at about the same time (Figure 9) shows that the satellite indicates a much larger cloud with higher heights, when compared to the radar-based echo top height, as is expected.

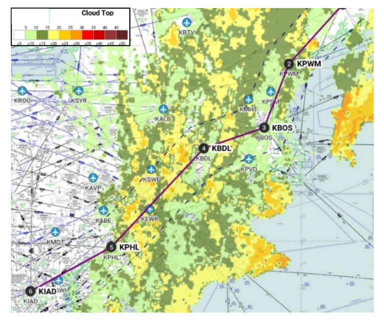


Figure 7: MRMS Echo Top

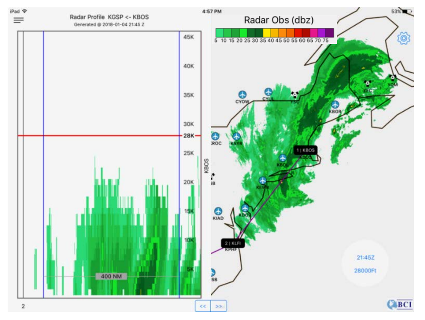


Figure 8: MRMS 3D Reflectivity (left) and
MRMS Composite Reflectivity (right).

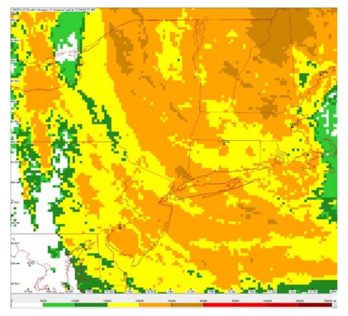
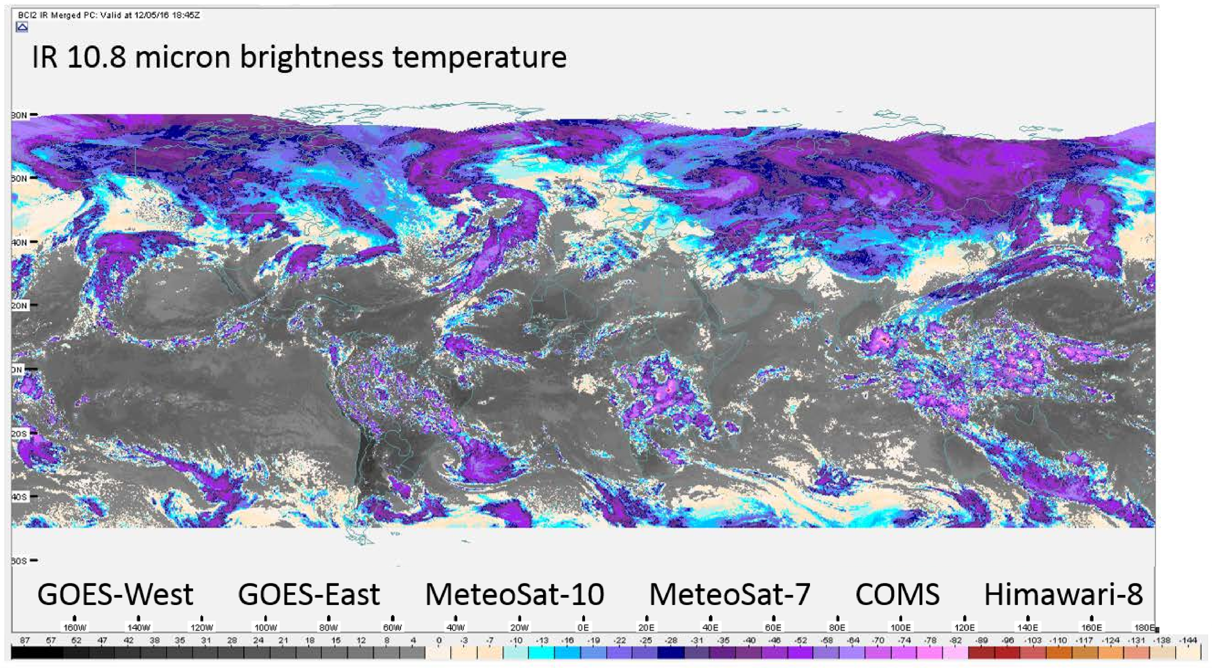


Figure 9: GWH Cloud Top Height product

Wx Product Improvements and their positive impact with Flight Safety

BCI's original work with Lufthansa Airlines entailed the use of data from five primary geostationary satellites, plus others for backup, to construct a global mosaic. The original set included: GOES-15 (West), GOES-13 (East), MeteoSat-10, MeteoSat-7, and MTSAT-2. The MTSAT-2 and GOES-13 have been replaced with Himawari-8 and GOES-16, respectively. In both cases, the coverage, resolution and update rates have been greatly improved. In the case of GOES-16, some areas located in South America with previous update rates of 1 to 2 hours are now 15 minutes. These improvements, along with others, allow the use of satellite data in circumstances previously reserved for radar.



Preliminary Indications of Pilot Behavior (Radar Composite Reflectivity Versus Satellite products)

A limited number of weather scenarios were presented to domestic pilots in a laboratory setting to examine how their selection of a flight route might change depending on the weather products presented to them. Weather products used in the study included the national NEXRAD composite reflectivity, the satellite based Cloud Top Height product and the satellite/lightning based Convective Diagnosis Oceanic product. The test cases were optimized by ensuring that all radar and satellite tiles contributed to the respective products such that high product quality was maintained. At the time of these tests, GOES-13 was the primary satellite in the region.

The scenarios were based on familiar flight routes with varying weather conditions. One such scenario was a U.S. based, spring-time cold front stretching from the Gulf of Mexico northward through Louisiana into Tennessee. First, the pilots plotted a flight path through the weather scenario using the national NEXRAD composite reflectivity product. After the pilots plotted a flight path, they were then shown the Cloud Top Height Product and all flight paths were modified. They were then presented with the third convective product, the Convective Diagnosis Oceanic, which yielded yet another set of modifications to the flight paths.

This brief and unstructured test was conducted to examine a preconceived notion that in general, commercial pilots tend to have high confidence in radar reflectivity data. This was verified by the pilot's responses where a high degree of confidence was achieved with their initial flight path selection that was based solely on radar reflectivity. The introduction of CTH and CDO added a level of interest and some initial confusion but ultimately confidence in the subsequent flight paths. As pilots become familiar with these new products, their confidence in the use of them should increase as has been demonstrated during the Global Weather Hazard project with Lufthansa Airlines.

An understanding of the short-comings of radar based and satellite based products should always be included within pilot training material. Also, an understanding of product latency needs to be fully explained.

Future Work

The increase in product resolution and decrease in product latency coupled with the increase in bandwidth availability to the Cockpit has created a positive environment where a more complete weather picture can be presented to the pilot. However, this same scenario has also created a situation of potential data overload to the pilot. Pilots are not meteorologists and the goal here is to produce a uniform set of products that leverage the best available data, globally. Different weather products will be examined to investigate their utility for flight advisory. While different products were originally developed for different intents, they will be further reviewed for a single common use.

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Acknowledgements

This research is supported by Basic Commerce and Industries, Inc. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of BCI. MeteoStar is thanked for providing geostationary satellite, global numerical model results and global lightning data. Lufthansa Airlines is thanked for providing images of the eRM display. The National Center for Atmospheric Research is sponsored by the National Science Foundation.