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INFORMATION PAPER

MEETING OF THE METEOROLOGY PANEL (METP) WORKING GROUP MOG (WAFS)

SEVENTH MEETING

Offenbach, Germany, 11 to 13 April 2018

Agenda Item 3.5: Science Capabilities
3.3.2 Modelling developments and new capabilities.

HIGH ALTITUDE ICE CRYSTAL ICING FORECASTS

(Presented by the WAFC Provider States)

SUMMARY

This paper presents information regarding the status of High Altitude Ice Crystal Icing forecasting

1. INTRODUCTION

1.1 High Altitude Ice Crystal (HAIC) Icing has been associated with aircraft engine power loss and damage above the altitudes typically associated with icing caused by super-cooled water droplets. Instead small ice crystals associated with strong convective activity can be lifted high into the troposphere, causing problems when they partially melt and stick to warm engine surfaces. These high concentrations of small ice crystals are invisible to on board weather radar and can therefore be difficult to avoid.

1.2 Please note that HAIC (and its associated aviation hazard) is also referred to as High Ice Water Content (HIWC), ice crystal icing and engine icing.

1.3 Both WAFCs are currently carrying out independently funded research on the HAIC phenomena.

2. DISCUSSION

2.1 Research on HAIC is currently 3 to 4 years away from maturity, however the WAFCs recognise that there is some independent research under way which may be being used in the operational aviation environment. This is not endorsed by the WAFCs as research is not mature yet and the user requirements have not yet been fully defined.

2.2 Appendix A contains information on the status of the WAFC research, and some demonstration information.

2.3 The WAFCs would like to receive more information from potential future users of HAIC forecasts and guidance from IATA in order to shape their research work.

2.4 It is anticipated that a nowcasting approach is most appropriate for HAIC forecasting, however this is outside of the current remit of the WAFCs. When appropriate, the WAFCs will direct their completed research to METP-WG/MISD so that any future operational need for HAIC forecasts can be determined

2.5 It is also understood that engine manufacturers are also looking at an engineering solution to the HAIC problem which may render HAIC forecasts unnecessary. The WAFCs currently have no intention of publishing a WAFC HAIC forecast data unless asked to by METP-WG/MISD.

3. ACTION BY THE METP-WG/MOG

a) The METP-WG/MOG is invited to note the information contained in this paper

APPENDIX A

High altitude ice crystals (HAIC) are small ice particles found at high altitudes and cold temperatures. These ice crystals have low radar reflectivity and are typically observed in the vicinity of deep convective clouds. There have been over 100 engine power-loss events since the 1990s which have been associated with aircraft flying through regions with a high mass concentration of these ice particles. Total air temperature (TAT) anomalies have also frequently been observed during engine events and can be used as a possible indication of HAIC. The majority of engine events that have been examined have occurred within mesoscale convective systems originating over oceanic regions (Strapp et al., 2016).

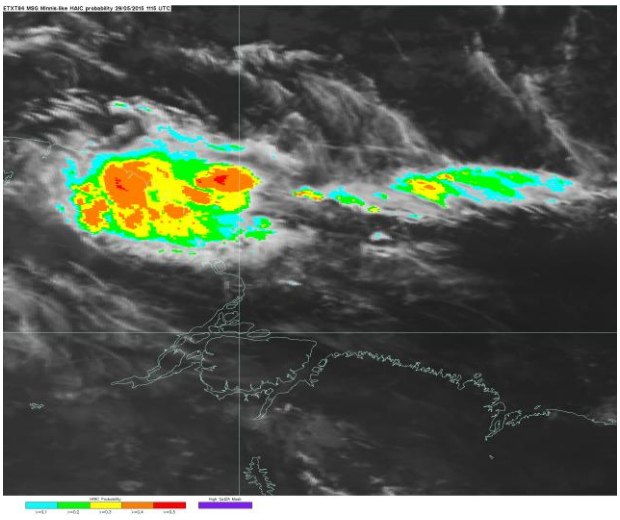
HAIC has significantly grown as a research area in the last decade or so due to the safety and cost implications to the aviation industry. There are a number of ongoing HAIC research projects at institutions across the international meteorological and aviation research communities. Previous work in this area includes collaborative efforts under the High Ice Water Content (HIWC) project, involving NASA, the FAA and The Boeing Company among others, and a 4-year European HAIC project coordinated by Airbus and involving 34 partners from Europe, Australia, Canada and the US (http://www.haic.eu). These two projects worked in partnership running flight campaigns with subsequent data analysis. Key outcomes from the HAIC project included improvements to cloud microphysics probes, assessment of flight certification envelopes, development of satellite detection tools and engineering developments in test facilities such as in the implementation of ice crystals generation systems. Many of the organisations who were involved are continuing with their research, building on the findings from this project. Other companies are also studying the hazard, with some commercial weather companies already making products available to airlines based on satellite imagery.

From the meteorological perspective, research efforts to date have largely concentrated on the detection of the HAIC hazard. The key areas of focus to date could be broken down into four categories:

1) Testing and optimising on-board instrumentation for measuring the icing conditions of interest
2) Analysing in-situ measurements from aircraft to better understand ice particle characteristics associated with the hazard
3) Developing methods and tools for detecting HAIC using satellite and radar data
4) Developing tools to provide nowcasts (short-term forecasts) of areas at risk of HAIC

However the fundamental physical mechanisms by which the HAIC phenomena occur is still not well understood by the HAIC research community. There are various theories around possible processes and features associated with updrafts in deep convective systems, but in depth studies are required to better understand the conditions under which it may form.

The current status of WAFC London research (funded by the CAA) includes the availability of a real-time satellite product to detect HAIC regions and a nowcast product that advects these regions forward in time and space to provide a short-term (1-2 hour) forecast of likely regions of risk. An example image from the satellite product is shown here. More work is required in order to better verify these products and extend them to a full global coverage. Initial studies have also been done to assess Numerical Weather Prediction model fields in their ability to capture HAIC. This showed the ability of regional models to simulate high values of ice water content with low radar returns, but with further avenues to investigate, particularly around more detailed analysis of correlations with global model fields which could be used to generate a relevant model



diagnostic for HAIC. Work is planned to investigate this further in the next 2 years as well as more research into the formation mechanisms of these small ice particles in and around areas of deep convection.

Although progress has been made in the detection and measurement of HAIC in terms of the presence and characteristics of ice particles, there is currently limited published information on the exact atmospheric conditions that may subsequently result in an engine event, beyond more general descriptions of common observations. Naturally there are external factors in play here, such as engine design, but there could be more opportunities to improve knowledge of the specific atmospheric conditions conducive to this risk to engines, including factors such as the effects from length of exposure within these regions of risk. This is beginning to be looked at in more detail in the research community but is in some part dependent on the availability and accessibility of data from engine events.

The verification of some HAIC detection products to date has been carried out using in-situ measurements of ice water content, such as from the flight campaigns carried out in the HAIC-HIWC projects. Verification of HAIC products against actual engine event occurrences has proved difficult due to the limited accessibility and availability of the data for reported events.

References

Strapp, J. W., Korolev, A., Ratvasky, T., Potts, R., Protat, A., May, P., Ackerman, A., Fridlind, A., Minnis, P., Haggerty, J., Riley, J. T., Lyle, E., Lilie, E. and Isaac, G. A., 2016. The High Ice Water Content Study of Deep Convective Clouds: Report on Science and Technical Plan. FAA Report, DOT/FAA/TC-14/31