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Uncertainties in Weather Forecast

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Discussion Topic 4: Use of meteorological information by ATM

UNCERTAINTY IN WEATHER FORECAST

(Presented by Hong Kong, China)

SUMMARY

This paper discusses the limitation of existing weather forecast products and invites discussion on how meteorological products could serve air traffic management given these limitations.

1. INTRODUCTION

1.1 The objective of meteorological service for international air navigation is to contribute towards the safety, regularity and efficiency of international air navigation. To support this operation, the meteorological office provides products as required by ICAO Annex 3 which range from alerts that are updated on a minute-by-minute basis to 24-hour aerodrome forecasts.

1.2 For air navigation, the main safety issue is encountering hazardous weather conditions such as windshear, high crosswinds, thunderstorms and low visibility. However, with modern navigation systems, many of the hazardous weather conditions, even the existence of windshear, no longer preclude landing as long as the pilots are alerted to their existence.

1.3 However, to allow for safe operations, the existence of hazardous weather does mean lower acceptance rates of aircraft. For example, the capacity of landing and takeoff at the Hong Kong International Airport (HKIA) is roughly halved under low visibility procedures [visibility less than 550 m and cloud ceiling less than 200 ft] on CAT II operation. The acceptance rate is even lower on single runway operations. Thus with prohibitively expensive oil price, increasingly the concern of the aviation community has shifted to regularity and efficiency issues such as reduction of the need to carry extra fuel to cope with weather-related delays.

1.4 Hazardous convective weather can impact the terminal area as well as the flight routes. Efficient operations involve both air traffic management and aircraft operations, with complex decision-making processes. To support these complex decision processes, air traffic management wants more precise information in both time and space, both at the aerodrome and its vicinity.

1.5 The existing products as defined in Annex 3 which focus on the needs of pilots are not sufficient to fully meet their needs. Some meteorological services have developed or have plans to develop tailored products to support the operation of air traffic management. However, it should be recognized that even with the existing scientific knowledge, it is still impossible to predict in good time the exact location and timing of the hazardous weather.

2. LIMITATION OF WEATHER FORECAST PRODUCTS

2.1 Weather forecasting has come a long way in the last few decades. Numerical weather prediction model has become the basis of modern weather forecasting. With ever increasing computer power and higher model resolution, the skill of the 72-hr forecast by the numerical models are now generally as skillful as the 36-hr forecast 10-20 years ago. Other factors, such as the availability of satellite and radar data, have also contributed to improvement in forecasting skill.

2.2 Yet there are limits as to how far such improvements can be. First, the initial state of the atmosphere is not fully known. Even if we have an ideal data network to specify the initial state, there would always be scales of motion too fine to be fully represented in the numerical model. Thus it is unavoidable that there will be errors in the model output.

2.3 Since large scale features are better represented in numerical models, they are generally better forecast. Therefore outbreak of winter monsoon is better forecast than thunderstorms. Nowcasting techniques are sometimes used to reduce the uncertainty. Nowcast, or forecast for the next few hours, uses extrapolation to determine the future location of the hazardous weather system. However, weather systems, especially small scale systems such as thunderstorms, do not remain steady and the skill of nowcast products decrease rapidly with time

2.4 Some more advanced nowcast systems address this by including some growth and decay element in the system through the integration of numerical model output and/or climatology into the nowcast systems. However the capability of such systems in capturing the exact location where such small scale systems are to develop and whether they would impact the aerodrome or a particular flight route is still very limited.

2.5 A case in point was the thunderstorms which affected the Hong Kong International Airport (HKIA) in the afternoon of 21 July 2005. Under active southwesterlies, thundery showers affected Hong Kong and the South China coastal areas on that day. A squall line, sweeping Hong Kong from west to east, brought severe thunderstorms to HKIA and resulted in 7 diversions that afternoon. Winds gusting up to 43 knots (80 km/hr) were recorded at HKIA. Hail was also reported at Tsing Yi, an island 20 km to the northeast of the airport.

2.6 The radar pictures at 15:30 to 16:30 HKT (Hong Kong Time is 8 hours ahead of UTC) are given in Figure 1. By extrapolating the radar echoes, one would expect the airport western approach to be affected first before the echoes reached the airport at around 16:45 HKT. However, developments ahead of the squall line resulted in the eastern approach to the airport being affected by thunderstorms much earlier. As can be seen from Figure 1, at 16:30 HKT, the eastern approach was already affected by intense echoes and thunderstorms. In fact thunderstorms started to affect the airport from 16:24 HKT. Thus in this case, although showers and the chance of thunderstorms at the airport were foreseen, the exact timing when the airport was affected by severe thunderstorms is beyond the present meteorology.

3. DISCUSSION

3.1 From the above, we could see that while the forecasting tools have advanced a lot in

the past few decades and the meteorological community will continue to try and reduce the uncertainties, forecasting the development of hazardous weather and the accurate timing of when it would affect the airport is still beyond the present day meteorology. While there will inevitably be uncertainties in the weather forecast products, there are still aspects of information that can be useful to ATM operation.

3.2 To facilitate the use of weather forecast products by air traffic management, some meteorological services provide probabilistic forecasts or include real-time verification results together with the forecast products. This hopefully would facilitate air traffic management to adjust how much trust they should place on that product at that particular time. An example of such weather forecast product is the Integrated Terminal Weather System (ITWS) used in the U.S. (see Figure 2). The introduction of such new forecast products may lead to reductions in weather-related delays if the information are integrated into the decision-making process of air traffic management. Air traffic management might like to consider whether similar products, if provided, could facilitate their decision-making process and thus improve our overall services to the aviation community.

4. ACTION

4.1 The meeting is invited to note the information provided in this paper and exchange views on the subject.

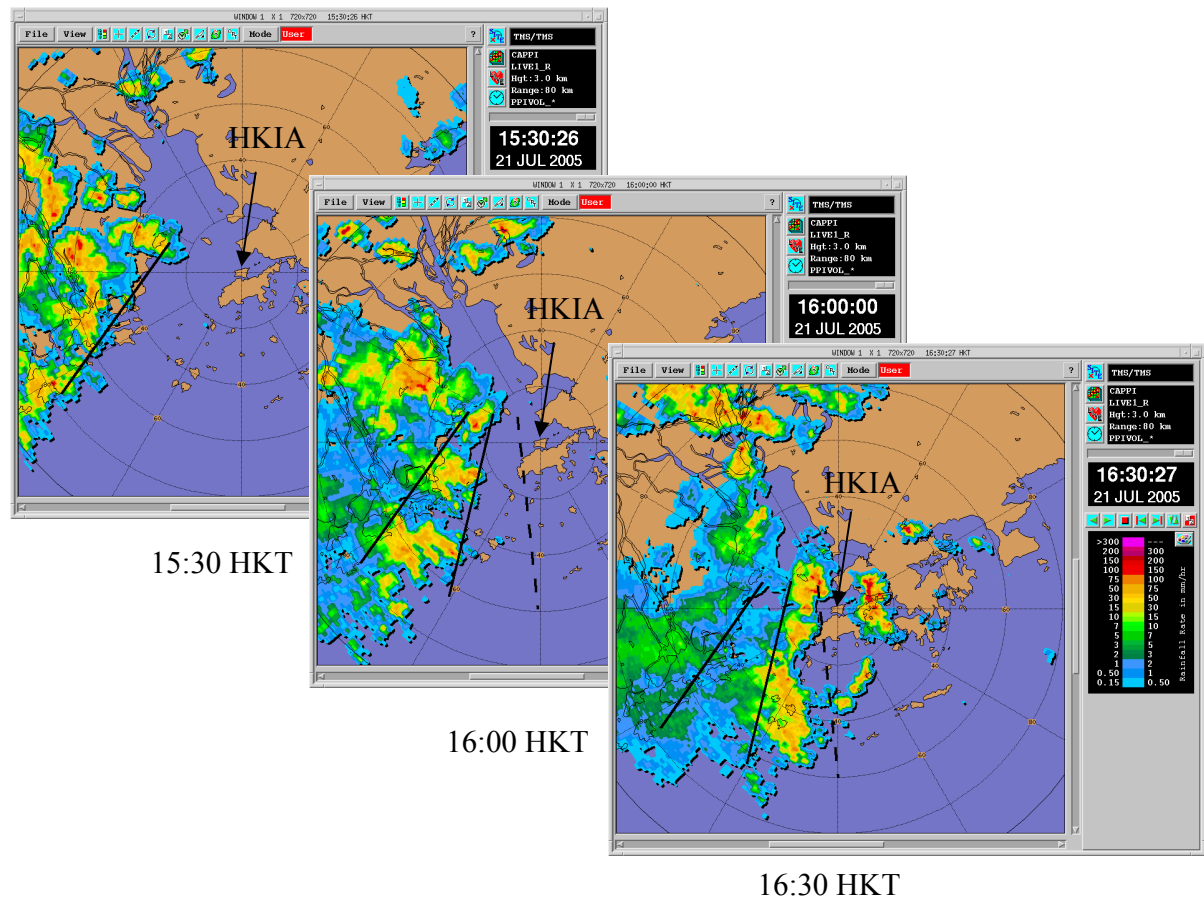


Figure 1 3-km CAPPI radar picture at 15:30 – 16:30 HKT 21 July 2005. The black lines marked the leading edge of the intense echoes. The dotted line is the forecast position of the echoes at 16:30 HKT based on extrapolation of the past echo movement.

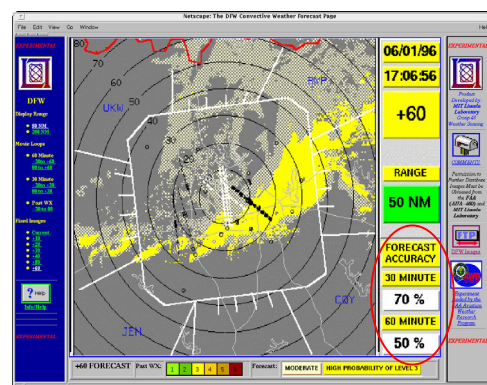


Figure 2 Forecast radar picture from ITWS with the forecast accuracy of past 30- and 60-minute forecasts indicated on the lower right hand corner.