Intelligent Modeling the Impact of Unpredictable Adverse Weather on ATM Performance

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Motivation

Adverse weather conditions, e.g. thunderstorms or icing, are responsible for

- about 50% of all delays
- more than at least 10% of all accidents and incidents

Example: Flight AF 447 on May 31, 2009

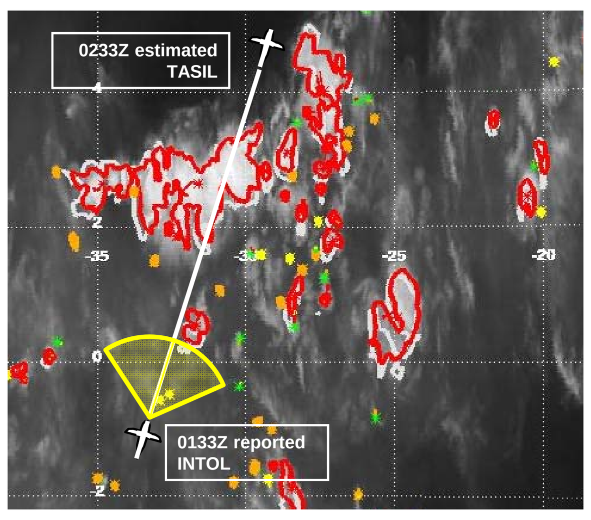


Fig. 1: Weather situation ahead of flight AF 447 at 1:33 UTC as detected by satellite with identified thunderstorms in red. Pilots are not aware of the situation ahead due to the limited radar range (yellow).

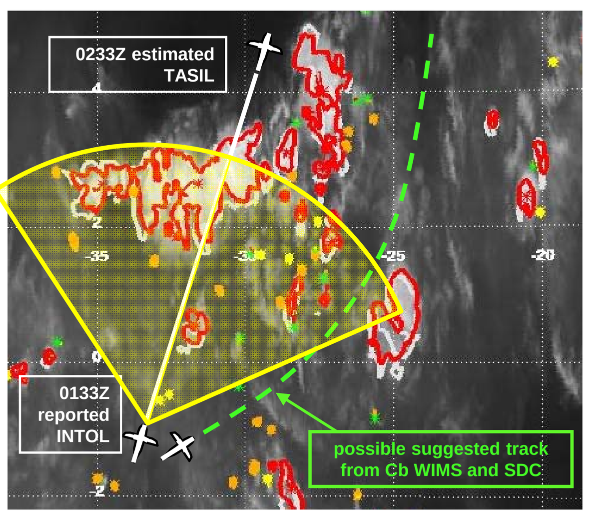


Fig. 2: An enlarged radar field of view, or additional data, e.g. satellite data in the cockpit, will increase substantially the pilot's hazard awareness, enabling them to find an early and safe diversion (green).

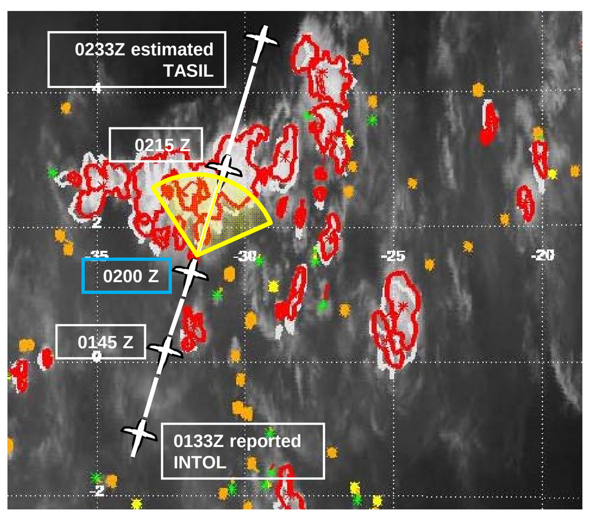


Fig. 3: When the current radar detected the storms they have formed a wall surrounding the aircraft with no recognizable gap.

Figures with courtesy of A. Tafferner, DLR

The objective of any future adverse weather solution for aviation is the reduction of delays and the increase of safety.
Key elements are:

- Diagnosis & forecast of adverse weather
- Assumption of free-flight 4D trajectories
- Proper treatment of the stochastic nature of weather
- Integration of weather in ATM

→ Investigation, exploration and development of an adverse weather ATM solution model DIVMET-ATM

Similar tools in US developed at MIT-Lincoln Lab [1] and at NCAR, Boulder [2].Necessity of these developments results from increased weather related delays.

Note: lack of equivalent tools to support ATM in adverse weather conditions in Europe

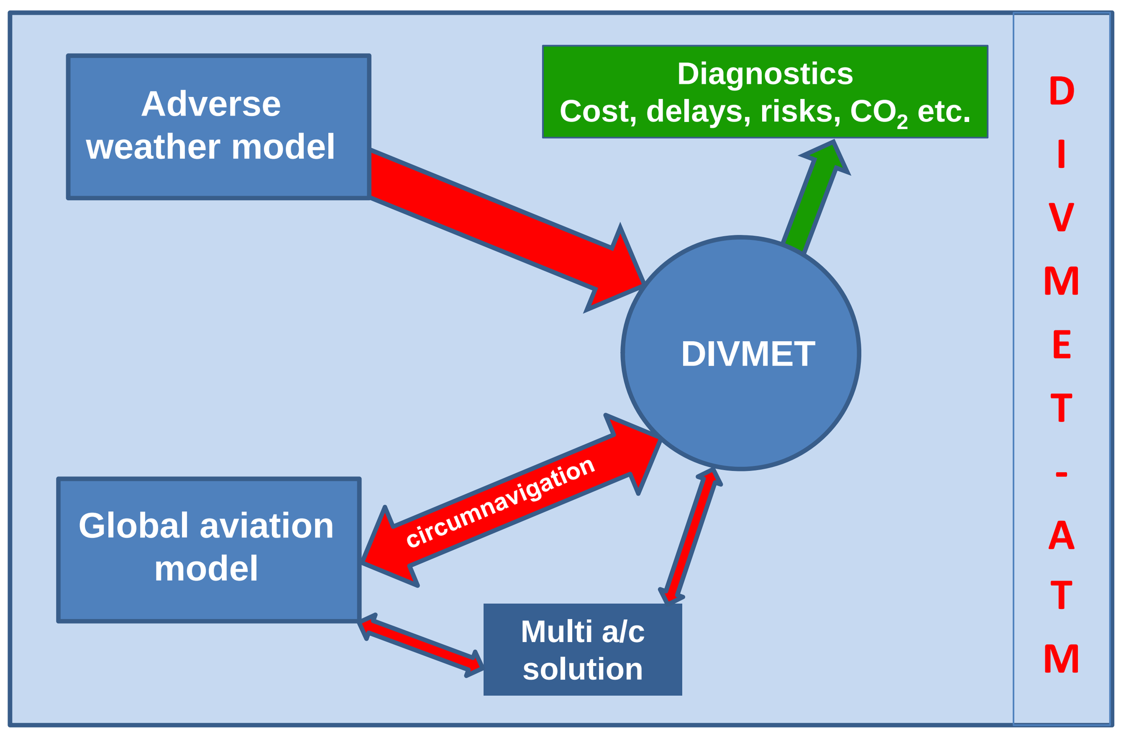
Objectives and expected outcomes

Main objectives

- Understanding the interaction of the two complex systems ***air traffic*** and ***adverse weather***
- Modeling approach

Development of the DIVMET-ATM model

- Provision of an adverse weather diagnosis and forecast model and its extension to account for the stochastic nature of weather
- Selection of an appropriate global air traffic model
- DIVMET algorithm: circumnavigation of adverse weather



Research topics

- Modeling realistic routes and weather related diversions. Do they match observed ones?
- Effect of increased adverse weather knowledge
- Worst case weather scenarios
- Best ATM strategies to account for the stochastic nature of the problem

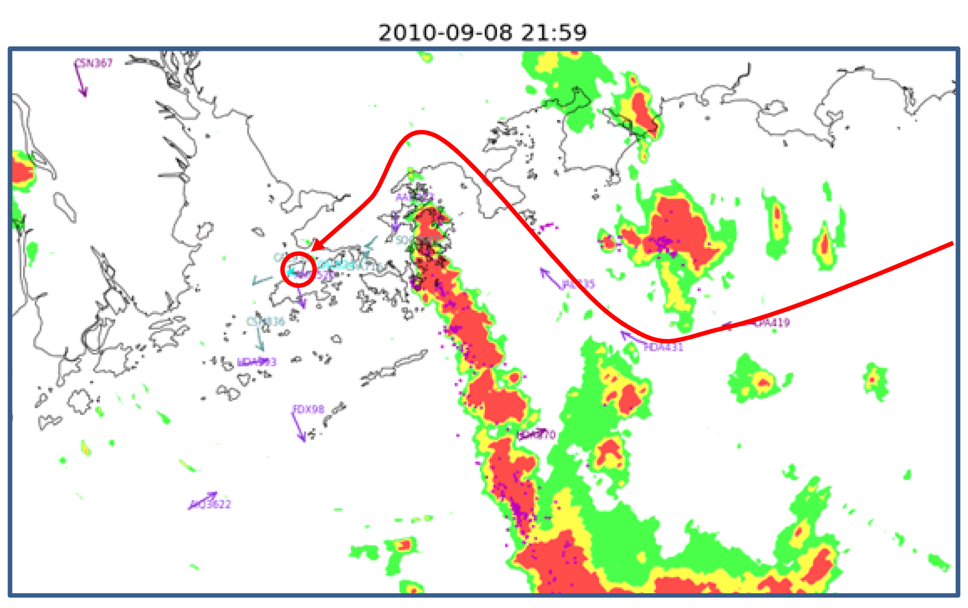


Fig. 4: Observed air traffic and radar data in the terminal area of Hong Kong International Airport (red circle) in the evening of the 8th of September 2010. Convective cells moved southwestward across the airport. Those conditions forced the approaching aircraft to circumnavigate around the clouds. Such a circumnavigation should be modeled and serve as a guidance for ATC and pilots.

Methodology

Development of the DIVMET algorithm

- Simulates the CDM between pilot and ATC
- Proposes a realistic route through a field of adverse weather

Needs

- Transformation of adverse weather into weather objects
- Impenetrable for aircrafts
- Account for motion, decay and generation of weather objects with time
- Validation is planned to be performed by demonstrations together with pilots and controllers

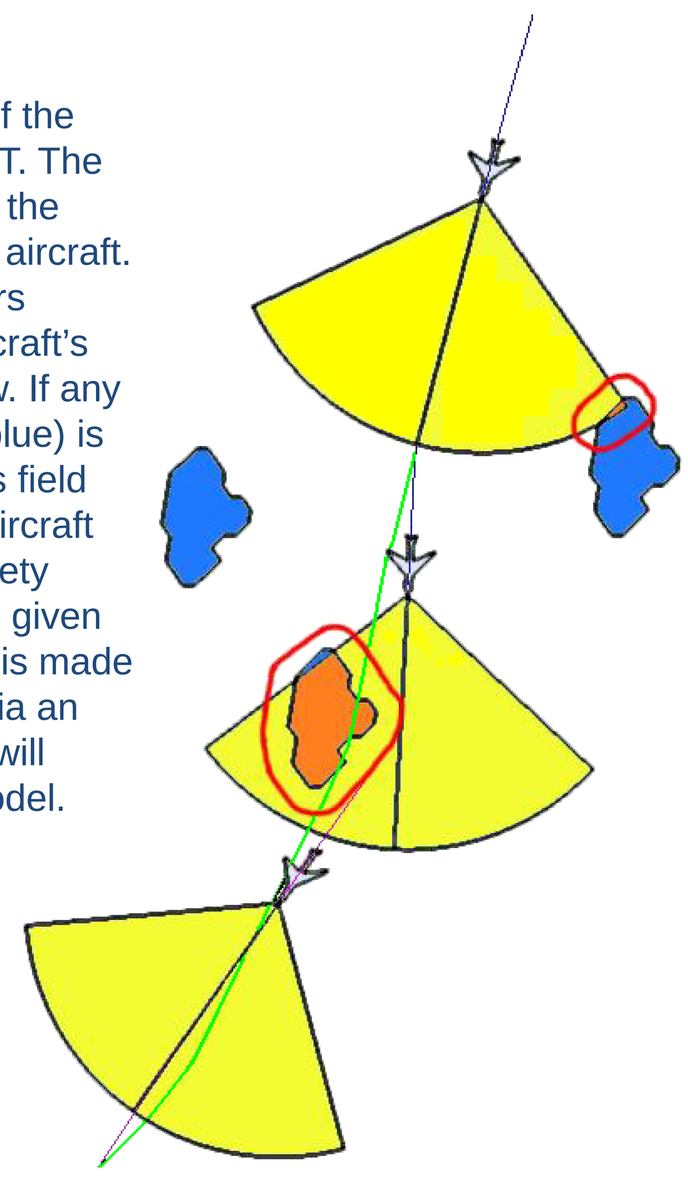


Fig. 5: Concept of the algorithm DIVMET. The green line shows the given route of an aircraft. The yellow sectors represent the aircraft's radar field of view. If any weather object (blue) is recognized in this field of view and the aircraft will hit it or its safety zone (red) on the given route, a decision is made and a rerouting via an heading change will happen in the model.

DIVMET-ATM applications

- Optimum routing strategies in unpredictable adverse weather
- Vulnerability of air traffic
- Provide guidance for controllers and pilots to find a safe and efficient route through a field of thunderstorms ahead

References

[1] NAWPC, *National Aviation Weather Program Strategic Plan. Prepared by the Joint Action Group for Aviation Weather, for the National Aviation Weather Program Council.* OFCM Document FCM-P32-1997

[2] Bernstein, B. C., *Integrated Icing Diagnostic Algorithm* (WEB address: http://www.rap.ucar.edu/largedrop/integrated)

[3] Rokitansky, C. H., *VDL Mode 2 Capacity Analysis through Simulations: WP3.B – NAVSIM Overview and Validation Results.* Edition 1.2, 2005

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