Flight Planning with Respect to Meteorological Conditions

Planiranje leta u odnosu na meteorološke uvjete

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Summary

The paper "Flight planning with respect to meteorological conditions" describes how flight planning in commercial air transport depends on meteorological conditions. In first part, the article describes satellite products for meteorological analyses such as IR technologies. In next parts authors are talking about thunderstorm, icing and volcanic ash detection methods in atmosphere. In the last part of the paper are shown some modern diagnostic system for identifying dangerous meteorological phenomena and their potential for flight panning.

KEY WORDS

Flight planning
meteorological conditions
IR technologies
satellite scanning

Sažetak

Rad „Planiranje leta u odnosu na meteorološke uvjete" opisuje kako planiranje leta u komercijalnom zračnom prijevozu ovisi o meteorološkim uvjetima. U prvom dijelu rada opisani su satelitski proizvodi za meteorološke analiza poput IR tehnologija. U sljedećem dijelu autori govore o metodama otkrivanja grmljavine, leda i vulkanskog pepela u atmosferi. U zadnjem dijelu rada prikazani su neki moderni dijagnostički sustavi za identifikaciju opasnih meteoroloških fenomena i njihov potencijal za planiranje leta.

KLJUČNE RIJEČI

planiranje leta
meteorološki uvjeti
IR tehnologije
satelitsko skeniranje

INTRODUCTION

Satellite products have become widely available and are an essential component of most modern meteorological analyses. For the most part, however, satellite data sets are only used in the form of simple cloud masks (cloud or no-cloud), cloud top heights, or other basic properties.

Clouds can also be tracked for making wind estimates. While these seemingly simple parameters are widely used, improved satellite observing systems and new analysis techniques can be combined to produce improved basic products (cloud masks, cloud classification analyses, and cloud top heights) that can be transferred directly, and quickly, to existing operational analysis systems. While accurate observations of cloud top height are critical for many aviation applications, the specific products that are needed can vary from a simple statute height above ground level (or sea level), to a separate cloud top pressure product which is appropriate for en-route aircraft flying above 18,000 ft (5625 m).

IR SYSTEMS

The IR window technique is based on using the 11 µmthermal IR temperature to estimate the temperature at cloud top, combined with an atmospheric sounding to convert the temperature value to a corresponding pressure and height. Figure shows an example of this GOES (Geostationary operational environmental satellite) imager-based cloud top pressure product.

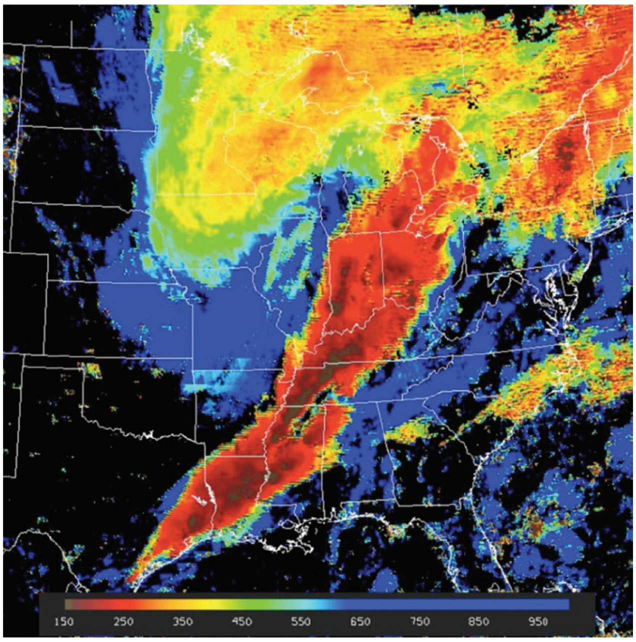

Figure 1 GOES-12 IR-based imager

Figure shows the GOES-12 Imager (top-red) and GOES-12 Sounder (bottom-blue), as well as NASA Cloud Physics Lidar (CPL) (black) cloud-top heights. The Imager heights show better agreement with the CPL than the Sounder heights due to the increased spatial resolution of the Imager. The best agreement for both satellite instruments is for mid-level clouds, while both the Sounder and Imager underestimate the CPL cloud-top height both for semi-transparent high clouds, and warm low-level clouds.

CONVECTIVE INITIATION, THUNDERSTORMS

Thunderstorms account for most of the air traffic delays in the U.S. and cost the aviation industry many millions of dollars annually in lost time, fuel and efficiency through delayed, cancelled and rerouted flights. In response to this need, the FAA's Convective Weather Product Development Team is working to develop reliable 0-8 hour probability forecasts of convective weather and automated 0-2 hour high-resolution deterministic forecasts over the continental United States. The Advanced Satellite Aviation Weather Products (ASAP) team is currently working with the FAA Convective Weather PDT to develop and transfer satellite-based techniques for detecting, tracking, and monitoring the early development of small cumulus in order to improve thunderstorm initiation forecasts. [1]

Figure shows the clustering results for a GOES image over the central U.S. Large-scale convective complexes are visible along with smaller cumulus and stratiform clouds. The classifier is able to detect the smaller convective clouds. Additionally, the isolated overshooting cumulus tops can be seen in red.

IN-FLIGHT ICING CONDITIONS

In icing conditions, extra power is needed because of increased aerodynamic drag and fuel consumption for heating. Other than extra fuel, keeping the aircraft as light as possible is more likely useful not just for minimizing fuel burn. The more weight to carry, the slower the climb and the more time spent in ice.

It is important to consider that safety has a significant cost. Indeed the amount of air bled from the engine for ice protection, along with conditioning and cabin pressurization can represent 5% to 10% of the core engine mass flow[2], half of which is for anti-icing purpose alone. Additionally, bleed-air collection induces engine performance penalties such as increase of specific fuel consumption, power loss and increase in turbine gas temperature. [3]

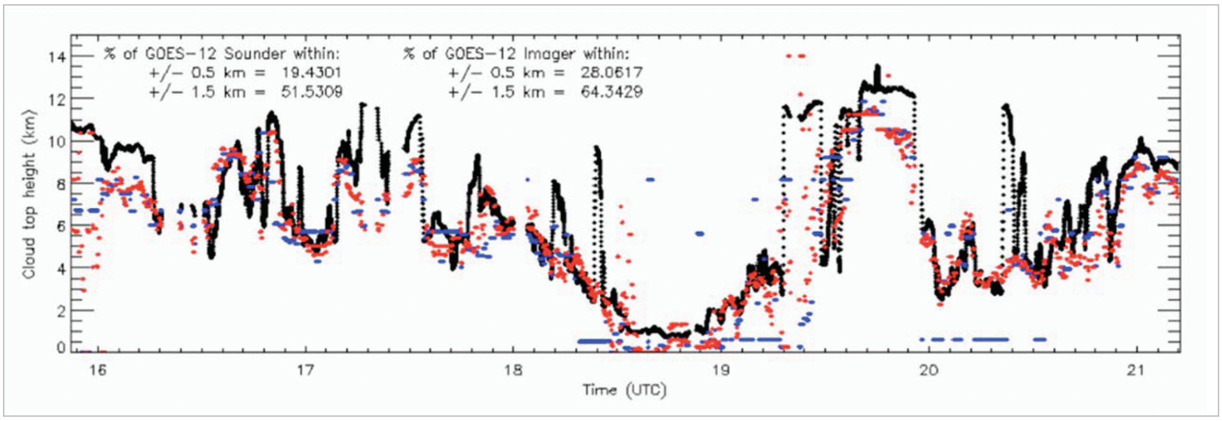

Figure 2 GOES-12 Sounder (blue), GOES-12 Imager (red) and CPL (black) derived cloud top height for the entire flight of the NASA ER-2

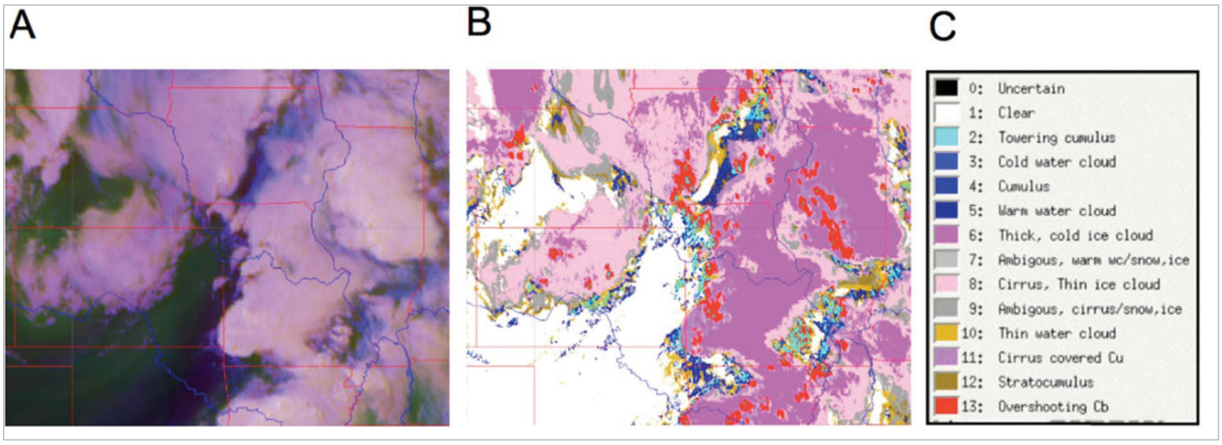

Figure 3 Texture-based clustering of GOES imagery - three band RGB image is shown in A), the color-coded clustering classifier results are shown in B), and the legend is shown in C)

While the microphysical conditions that result in in-flight icing hazards are generally well understood, it has proved challenging to develop reliable techniques for operationally diagnosing icing conditions or forecasting their occurrence.

Satellite-based methods using combinations of visible reflectance and infrared emittance can be used to estimate cloud properties such as hydrometeor size and liquid water path (LWP)[4][5]. Vivekanandan et al.[4], and Minnis et al.[6] have suggested that in addition to characterizing the location, size and depth of cloud systems, satellite observations can be used to monitor the cloud-top phase (i.e. ice or liquid), water content, and droplet diameter all properties that are of interest in diagnosing possible icing conditions. [7]

TURBULENCE

Turbulence has long been considered a priority problem for operators of aircrafts and is the single greatest cause of injuries to flight crew and passengers as well as having the potential to cause structural damage to aircraft. Turbulence affecting aircraft is a small-scale phenomenon with length scales of tens to hundreds of meters. This makes it particularly difficult to observe with conventional observing systems, models, or satellites. It may be possible, however, to use satellite observations to identify larger scale features or conditions that can lead to clear air or convectively induced turbulence. In this case, the satellite "products" or "interest fields" would need to be integrated with other observational systems and model output to produce an operationally useful warning product. Figure illustrates a GOES Layer Average Specific Humidity (GOES-12 Geostationary operational environmental satellite) field over the United States. Areas of yellow and red indicate subtropical air, while areas of blue and purple identify areas of dry polar air. Estimated areas of tropopause folding are represented as gray ribbons of uniform width, based on an assumed average size of tropopause folds. As a turbulence "interest field" this sort of product is integrated with model-generated fields to assign height limits for the folding, and to put this possible source of turbulence into a broader context.

VOLCANIC ASH

While ash clouds are sometimes quite impressive in visible satellite imagery, it is frequently difficult to distinguish ash clouds from natural, non-volcanic water and ice clouds. Fortunately, suspended ash particles have some distinct spectral signatures that can be used to enhance their detection through multi-spectral image processing. The most commonly used multi-spectral technique is based on a strong 12-µm [8]absorption signature which causes a negative 11-µm—12-µm brightness temperature difference. This technique is often termed the reverse absorption method, and has been the basis for a number of different detection techniques.[9]

Figure shows the results of applying both the Pavolonis et al. algorithm and the standard reverse absorption technique to a 2004 eruption of Manam in Papua New Guinea. The new approach is able to identify ice clouds that are heavily contaminated with volcanic aerosols even though these clouds generally lack a reverse absorption signature. The reverse absorption results only detect the portions of the low level ash plume that are quite near the volcano, while having many small areas of negative brightness temperature

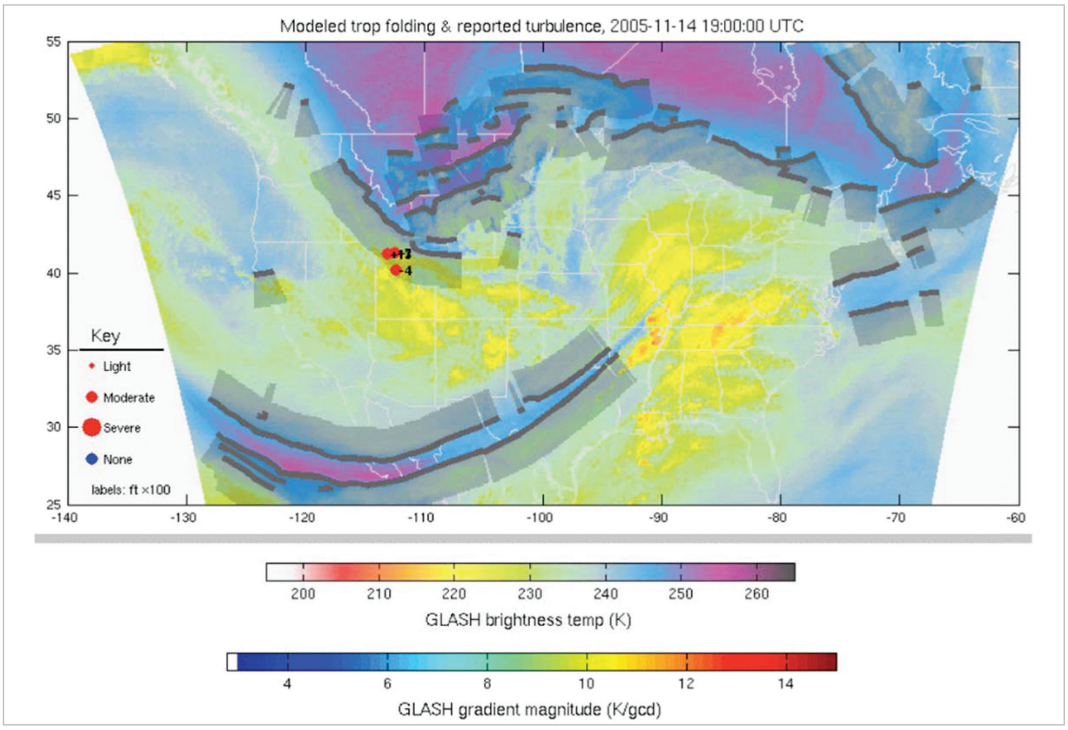

Figure 4 Sample CAT-prediction model

difference showing up in the nearby convective clouds. In contrast, the new algorithm produces a clean, false alarm-free integrated product.

In order to speed the initial detection of explosive eruptions, ASAP investigators are also examining untraditional approaches, such as using Department of Defense's infrared surveillance satellites. These satellites are the backbone of the global missile early warning system and make observations of the Earth in the short wave infrared regions, with 10-second resolution.

AMDAR TECHNOLOGY

The higher level of standard in decreasing fuel consumption and precise determination of time of arrival but also for increasing safety of flight can be achieved. Key factor is bring modern technologies into practice. Collaboration high end satellite scanning and modern postproduction process can provide opportunities for precise flight planning. Will be possible to have more accurate time of arrival, improved fuel management and reach confident level of comfort on board.

Satellite technologies are not new and we can look for another more accurate source of information about weather. Using live data from weather radar on board and other sensors (pressure, ambient air pressure air temperature, wind speed and wind direction)

In addition to the acquisition of weather data from land and sea surface stations as well as via upper-air soundings and radar and satellite observations, meteorological data have also been recorded by commercial aircraft during the ascent, en-route and descent phases at flight levels of up to 12,000 m since the mid-1980s. This measuring network is known around the world as Aircraft meteorological data relay (AMDAR).

AMDAR reports are automatically distributed via the Global Telecommunication System (GTS) of WMO. They include:

- identification number, date and time,
- position and flight level (i.e. ambient air pressure),
- air temperature, wind speed and wind direction.

This set of values is recorded by technical systems that are used anyway in all types of commercial aircraft for their operation:

- navigation system,
- attitude reference system,
- static pressure measurements,
- impact pressure measurements,
- total temperature measurements.

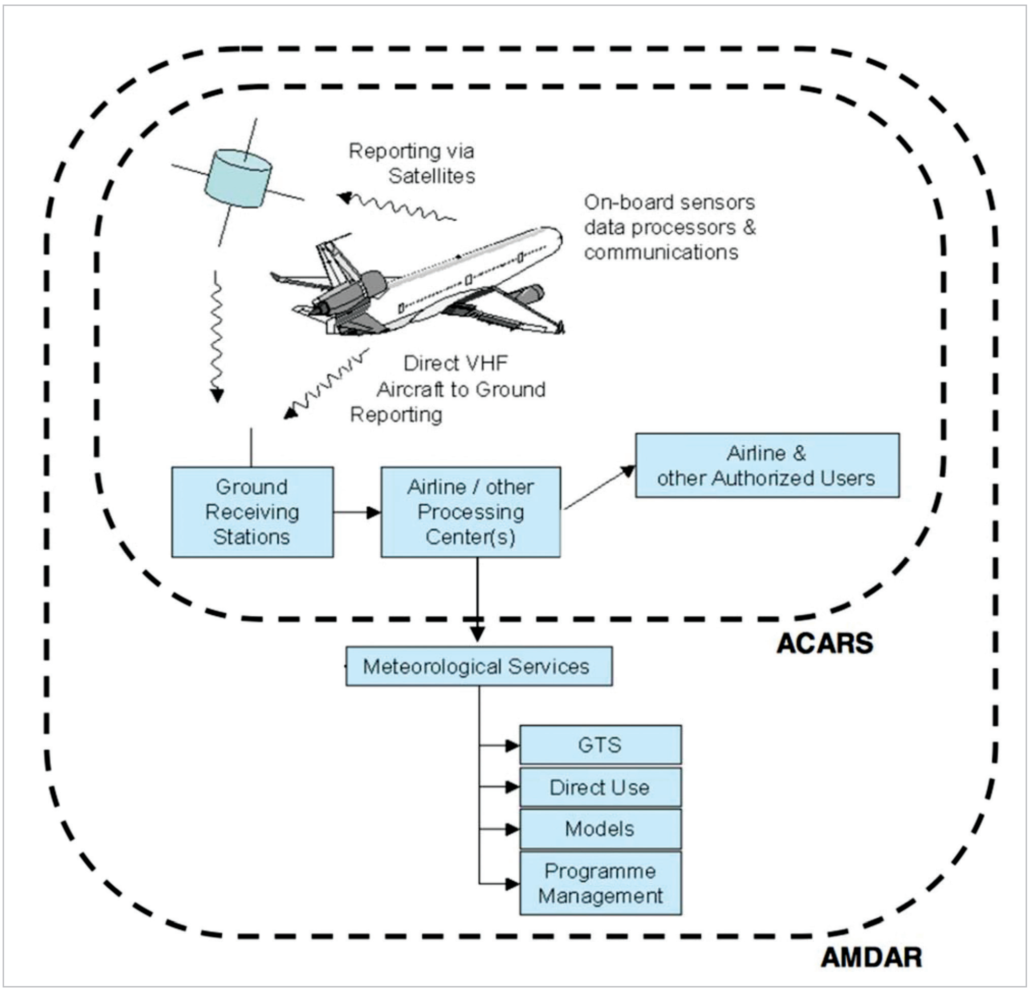

Figure 5 AMDAR stands for the use of air traffic communication systems

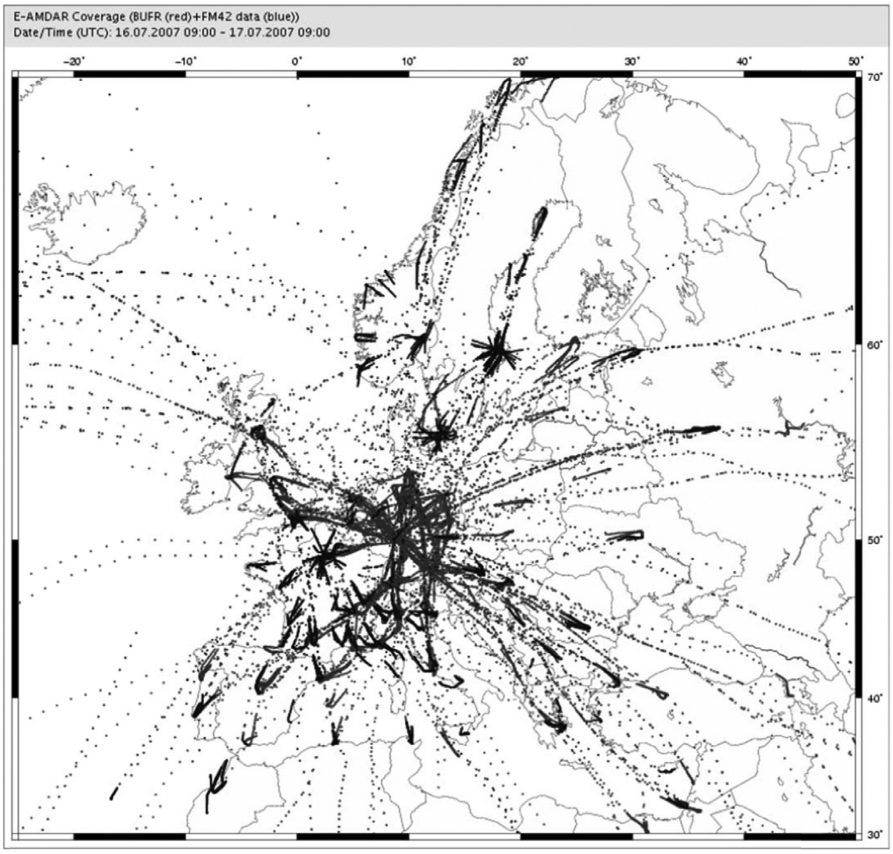

Figure 6 The typical coverage of Europe with E-AMDAR measuring points

E-AMDAR

Within the European EUMETNET-AMDAR (E-AMDAR) programme, with the participation of the DWD and 13 other National Meteorological Services in Europe, there are nearly 35,000 meteorological reports transmitted every day from 530 active aircraft (Air France, British Airways, KLM, Lufthansa and SAS).

The potential for the extension of AMDAR's benefit

Expansion and densification of the network on a global level

- inclusion of more airlines,
- greater use of night-time starts and landings,
- international standards for aircraft producers to achieve AMDAR configuration ex works.

Aircraft providing additional measurable variables

- humidity,
- turbulence,
- icing,
- geometric height (GPS, GLONASS, GALILEO, etc.),
- atmospheric chemistry parameters.

In order to reach the same type of data set as provided by the radiosondes in use around the world, highest priority must be given to including the parameter 'air humidity' into AMDAR measurements. This would make it possible to complement and also replace to a large extent the comparably expensive radiosoundings.[10]

CONCLUSION

Accurate, optimized flight plans can save airlines millions of gallons of fuel every year without forcing the airlines to compromise their schedules or service. Airlines can realize their benefits by investing in a higher-end flight planning system. The best way to save costs and increase safety in aviation transport is an investment into satellite scanning technology. The main benefit of this technology is to plan flights more secure because it can detect the seemingly invisible meteorological phenomena such as turbulence, volcanic ash and others.

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