INTERNATIONAL VOLCANIC ASH TASK FORCE (IVATF)

FIRST MEETING

Montréal, 27 to 30 July 2010

Agenda Item 6: Improvement of ash detection/avoidance systems (Science sub-group)
6.1: Ways and means to improve ground ash detection systems
6.3: Ways and means to improve space-based ash detection systems

ASPECTS OF THE USE OF REMOTE SENSING FOR DETECTION AND TRACKING OF VOLCANIC-ASH CLOUDS

(Presented by the United States)

SUMMARY

Some aspects of the use of satellite-based remote sensing and ground-based radar for detection and tracking of volcanic ash clouds are discussed. A main point is that owing to variability in environmental conditions in the atmosphere and volcanic cloud composition, it is difficult to determine a universally applicable detection limit for volcanic-ash concentration from satellite data.

1. INTRODUCTION

1.1 Satellite-based remote sensing has a large role in the detection and tracking of volcanic-ash clouds. Some aspects of the use of satellite remote sensing for these purposes, as well as ground-based radar to characterize volcanic plumes, are discussed.

2. DISCUSSION

2.1 Defining the boundaries of hazardous ash contaminated airspace, forecasting the movement of this zone, and determining the time-related decrease in extent of this hazard zone is a complicated problem that has traditionally been addressed in the operational environment by combining the analysis of volcanic ash transport and dispersion models (VATD) with satellite and/or pilot observations. The VATD models typically predict a much larger geographical extent of the ash cloud as compared to satellite observations, due to the way in which ash fall is currently modelled (e.g. as single particles rather than aggregates).

2.2 At present, satellite data is used to determine whether an eruption has produced an ash cloud, to estimate eruption cloud height, to observe the cloud movement. Operational satellite data can also be used to estimate the total column abundance of volcanic ash, sulfur dioxide gas, ice, and in some case sulfate aerosol (i.e. from the conversion of sulfur dioxide gas). However, there are some notable limitations: 1) Determination of cloud height from operational satellite data can be difficult for cloud that reach the upper tropopause/lower stratosphere (~8+ km in the polar regions to ~16 km in the tropics) where many aircraft operate. Furthermore, it can be tens of minutes to hours after the start of the eruption until it is observed by satellite. 2) Satellites can retrieve the total column abundance of volcanic cloud constituents (mass per area), but concentration (mass per volume) requires independent knowledge of the geometric thickness of the cloud. 3) Satellite detection of volcanic ash can be masked by a number of factors including ingestion of abundant water into an eruption cloud, mixing with or obscuration by meteorological clouds, and poor thermal contrast between the volcanic cloud and the surface beneath it (for standard thermal infrared algorithms). Due to the variability in environmental conditions and volcanic cloud composition, it is difficult to determine a universally applicable detection limit for volcanic ash concentration solely from satellite data.

2.3 Recent large North Pacific eruptions of Okmok, Kasatochi, and Sarychev Peak produced long-lived drifting volcanic clouds that were dispersed over large regions of the Northern Hemisphere and were observed by pilots and detected by various satellite sensors for several weeks. These clouds were likely comprised primarily of sulfate aerosols with small amounts of ash, but were clearly visible in satellite data and to pilots. Uncertainty about the specific composition of these clouds, as well as the lack of procedures for warning messages for volcanic aerosol clouds lead to some disruption to aviation in North America. These episodes further emphasized the need to improve the real-time characterization of volcanic clouds (altitude, composition, particle size, and concentration) and to better understand the impacts of volcanic ash, gases and aerosols on aircraft, flight crews, and passengers.

2.4 Ground-based radar remote sensing can provide valuable, time-critical information that can improve the forecasts of ash contaminated airspace. Radar observations of the recent explosive eruptions of Augustine and Redoubt, have further demonstrated that volcanic clouds can reach aircraft cruise altitudes (~10 km asl) within 4 minutes of seismic onset. Further, radar can help to quickly determine whether ash is being produced, the eruption cloud height, variations in cloud height, and when the event is over. Estimates of the erupted mass as a function of time can be determine from the cloud height or directly from the intensity of the radar signal. The resulting ash cloud can typically be tracked for tens of minutes to hours depending upon the size of the eruption, and the power and distance of the radar. Analysis of the cloud height over time can possibly help constrain the rate of ash aggregation in the column and the resulting depletion of fine-grained ash in the drifting cloud.

3. ACTION BY THE IVATF

3.1 The IVATF is invited to note the information in this paper.

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