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Civil aviation management during explosive volcanic eruptions: A survey on the stakeholders' perspective on the use of tephra dispersal models

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ABSTRACT

Impacts of explosive volcanic eruptions on civil aviation were reconsidered after the 2010 Eyjafjallajökull eruption in Iceland, which caused unprecedented disruptions of air traffic operations in Europe. During and after the aviation breakdown of April–May 2010, communication between the involved stakeholders was recognized as a major concern. Due to the complexity and multidisciplinary nature of the topic, a great number of actors are involved, which often have little interaction outside these exceptional events. In this work, we aim at identifying the relationships between the stakeholders involved in aviation management during eruptions, as well as their needs and priorities. We perform an anonymous on-line survey, focused mainly on the use of tephra dispersal models for civil aviation purposes. We collect feedback on recent developments including our current impact assessment research, which produced a GIS-based software tool to estimate impacts on aviation based on tephra dispersal forecasts. Answers allow identifying stakeholders' requirements on ash dispersal forecasts and their use for aviation management purposes. We underline the main differences between three homogeneous groups (aviation managers and employees, modellers and field scientists, other stakeholders) and identify main end-user requirements for developing tools similar to ours. This work provides useful insights for the development of tools to support aviation stakeholders during volcanic eruptions.

1. Introduction

Impacts of explosive volcanic eruptions on civil aviation were reconsidered after the 2010 Eyjafjallajökull eruption in Iceland, which caused unprecedented disruptions of air traffic operations in Europe. Such aviation breakdown highlighted some weaknesses of the scientific and operational knowledge in both volcanology (Bonadonna et al., 2011) and civil aviation management (Bolić and Sivčev, 2012) communities. In particular, communication and information flow between such communities was identified as a major concern (Bonadonna et al., 2011, 2013). These limitations also contributed to increasing the socio-economic impacts on passengers and business enterprises, due to the difficulties of airlines in communicating their policy (Miller, 2011). The weaknesses in communication can be partially explained by the relatively low frequency of explosive volcanic events, if compared to other events that jeopardize air traffic (e.g. storms, fog, snow). Given the strong increase on air traffic activity during the last decades and the frequency of explosive volcanic eruptions at global scale (Simkin and Siebert, 1994), the amount of aviation disruptions due to ash-contaminated airspace is likely to increase in the future (Guffanti et al., 2008; Prata and Tupper, 2009). In addition, during emergency most of the stakeholders need to perform tasks differently from their everyday work, and specific information flows are put in use in case of eruption. Low risk perception during "peace time", the variety of stakeholders, and the complexity of relationships implemented during emergencies contribute to increasing the vulnerability of the aviation system (Bolić and Sivčev, 2012).

Stakeholders directly or indirectly involved in aviation management during explosive eruptions can include volcanologists, meteorologists, atmospheric scientists and modellers, aviation and airline managers, pilots, dispatchers, air traffic controllers, and aviation authorities. Since 2010, aviation stakeholders are taking volcanic eruptions and the impact on air traffic into account in their risk management plans. Moreover, many sectors indirectly impacted by aviation disruptions are now interested in developing strategies to lower socio-economic impacts (Jones and Bolivar, 2011). Thus, the range of involved stakeholders is being enlarged to include representatives of activities and institutions (local/regional authorities, insurance companies, citizen organizations, service providers, etc.), which should be considered in a comprehensive impact assessment analysis (Scaini et al., 2014a).

Two stakeholder groups made a significant effort in the development of new strategies to improve their preparedness: the scientific community which includes volcanologists, meteorologists, atmospheric dispersion modellers, volcanic risk managers, monitoring and field scientists; and the aviation community, which includes national and

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international aviation organizations, airlines, air traffic controllers and Air Navigation Service Providers (ANSPs). On one hand, the scientific community is improving some aspects of ash dispersal models and related short-term forecasting strategies (see Folch (2012) for a detailed review). In addition, long-term hazard assessments tailored for aviation needs are being produced with the aim of supporting civil aviation management and operations (Folch and Sulpizio, 2010; Scaini et al., 2012; Sulpizio et al., 2012; Bonasia et al., 2013; Biass et al., 2014), which allow the estimation of expected impact on civil aviation network (Scaini et al., 2014a). On the other hand, international aviation organizations such as ICAO (International Civil Aviation Organization) and EUROCONTROL (the European Organisation for the Safety of Air Navigation and European Network Manager) established new procedures for operations in the presence of volcanic ash in the North Atlantic and European region (Bolić and Sivčev, 2012; IVATF-4, 2012). The new ICAO's Volcanic Ash Contingency Plan for the region allows airlines to operate in ash-contaminated airspace if the corresponding Civil Aviation Authority approves a Safety Risk Assessment (SRA) for such operations (ICAO, 2012). However, many open challenges remain (Bonadonna et al., 2011; Bolić and Sivčev, 2012; Bonadonna et al., 2013). First, there is no universal consensus on the ash concentration threshold for flight avoidance. Second, spatial and temporal uncertainties of forecasts are still significant and of concern to the scientific community (Bonadonna et al., 2011, 2013), which is looking into techniques such as data assimilation (i.e. updating model input parameters with data coming from real or near real-time observations) or ensemble forecast (i.e. merging results of multiple simulations with different model inputs) in order to reduce and quantify these uncertainties (Folch, 2012). Detection and retrieval algorithms for volcanic ash and volcanogenic SO_2 (Pavolonis et al., 2006; Carn et al., 2009; Prata, 2009; Corradini et al., 2010) have an increasingly important role in this process (Bonadonna et al., 2013). Finally, a probabilistic framework is being included in the risk management plans through the adoption of probability-based methodologies (Marzocchi et al. (2007, 2012); Sobradelo and Martí, 2010; Sandri et al., 2011; Sobradelo et al., 2011) that define a priori scenarios at active volcanic areas across different time scales.

Current open issues are subject to on-going debate amongst the different stakeholders, and a lot of effort was put in organizing specific working groups such as the ICAO's task force (IVATF, 2010). However, these meetings are usually organized by and for a specific subset of stakeholders (e.g., scientists, aviation managers), and research and development activities are often developed independently from other related communities. There is still a gap between scientific and aviation communities, particularly regarding the use of ash dispersal forecasts for aviation purposes. Recently, EUROCONTROL developed the EVITA tool (European Crisis Visualization Interactive Tool for ATFCM) that acts as a web visualisation tool for ash dispersal forecasts and air traffic operating in the European airspace (Sivčev, 2011; Gait and Sivčev, 2011). Following this trend, we have developed a GIS-based software tool focused on evaluating the expected impacts of ash-producing eruptions on civil aviation (Scaini et al., 2013; Scaini et al., 2014b). This tool aims at linking scientific and aviation management communities, and promoting the usage of ash dispersal forecasts amongst the aviation stakeholders. However, these pioneering initiatives need further development in order to be useful to the aviation stakeholders and support the definition of response strategies.

After 2010, higher attention was given to the definition of requirements for end-users of tephra dispersal forecasts and other ash-related information (including outputs of EVITA and similar tools). The Volcanic Ash Strategic Initiative Team (VAST) project performed a survey of requirements amongst users of ash dispersal forecasts and related products in 2012 (VAST, 2013). The survey identified the usage patterns among operational and research communities. On the other hand, the issues in air traffic management during volcanic eruptions were addressed in interdisciplinary meetings. During recent VOLCEX exercises (periodic aviation exercises focused on volcanic ash and aviation, which involve airlines, ANSPs, meteorological offices and Volcanic Ash Advisory Centres (VAACs)) a survey on the usefulness of the EVITA tool was conducted (Bolić and Sivčev, 2012). Finally, during the 2nd IUGG–WMO Workshop on Ash Dispersal Forecast and Civil Aviation (November 2014, Geneva), a preliminary survey on current issues and research challenges was performed (Bonadonna et al., 2013). However, studies comparing the opinions of specific groups involved in tephra dispersal forecasts and their use for civil aviation management during volcanic eruptions do not exist yet. Such a study would give a more comprehensive picture of the needs and interactions between stakeholders facing the problem.

This work presents a survey aimed at identifying the main priorities of involved stakeholders and critical aspects of the information flow between scientific (volcanologists, meteorologists and atmospheric dispersal modellers) and aviation (air traffic managers, airline managers, service providers, aviation employees) communities. We survey the stakeholders through an anonymous on-line questionnaire, collect the results and present the main findings. The focus of this analysis is on tephra dispersal models and their usage for civil aviation purposes. The survey was sent to stakeholders involved in aviation management worldwide. Furthermore, we aim at gathering participants' opinions on cutting-edge modelling/measuring techniques coming from the

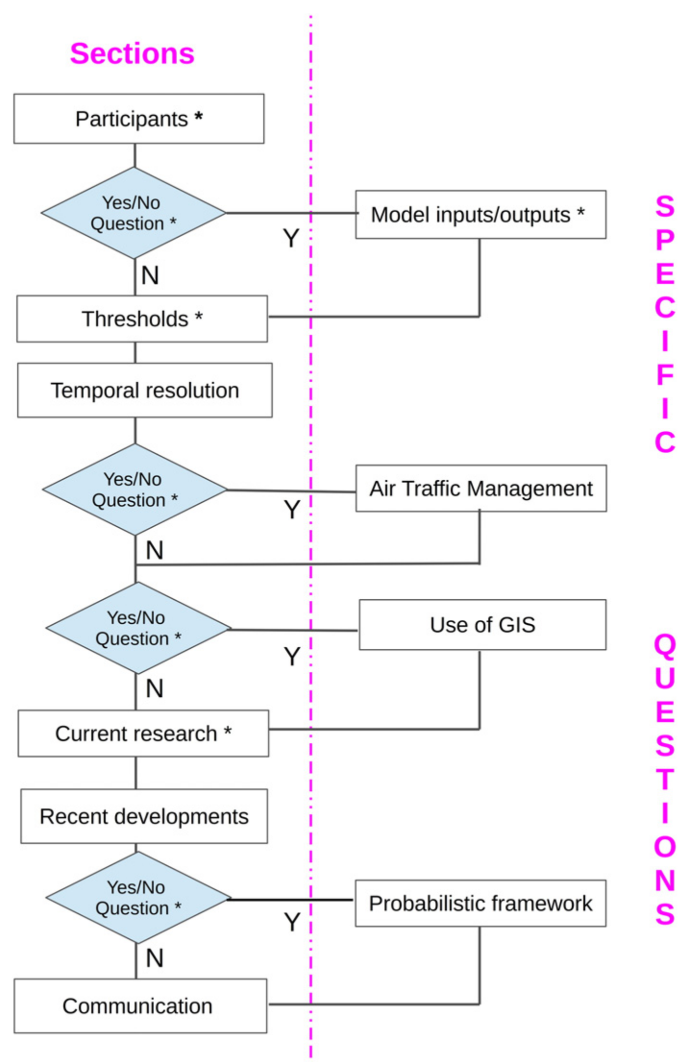

Fig. 1. Flow chart of the survey, constituted by 10 thematic sections, containing different question focused on specific groups of respondents (right). Sections that contain mandatory questions are signalized by a * in the figure and in the attached survey (Appendix A).