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Overview on the 'Atmospheric Emissions from Volcanoes' Special Issue

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I. INTRODUCTION

The session 'Atmospheric Emissions from Volcanoes' formed part of the 2014 General Assembly of the European Geosciences Union (EGU), held in Vienna from 27 April to 2 May. This special issue presents some of the work that was discussed during the session.

Volcanoes are a pathway between the lithosphere and atmosphere and are prodigious sources of fine ash < 63 micron diameters) and gases. It is estimated that they emit 1200 (+/-500) MT of H_2O and 600 (+/-200) MT CO_2 into the atmosphere annually [Burton et al., 2013], as well as a range of trace gases, including 9 (+/-1.5) MT SO_2 and H_2S [Halmer et al., 2002], and less well constrained amounts of halogen-bearing species, including HCl, HF, HBr and other gases [Symonds et al., 1994]. Volcanic plumes are complex, multi-phase physico-chemical environments and there are many reasons why it is important that we understand, monitor and predict their evolution. They provide an opportunity to investigate subsurface processes [e.g. Aiuppa et al., 2007; Holland et al., 2011]; they can have a profound impact on the local environment, affecting human, animal and crop health [e.g. Delmelle, 2003; Hansell et al., 2006]; they can affect both local and regional climate [e.g. Robock, 2000; Oppenheimer, 2003; Gao et al., 2008] and they can present a significant hazard to aviation [e.g. Casadevall, 1994; Prata and Tupper, 2009; Thomas and Prata, 2011].

Satellite remote sensing has been used to detect [Prata, 1989] and quantify [Wen and Rose, 1994] the presence of volcanic ash and SO_2 for decades, facilitating the creation of global inventories such as that compiled by Carn et al. [2003]. More recently, the eruption of Eyjafjallajokull in April and May 2010 highlighted the need to incorporate interpretations from satellite remote sensing data into operational procedures. The eruption also demonstrated some of the risks in using SO_2 as a proxy for volcanic ash, a practice sometimes followed because SO_2 is typically more straightforward (relative to ash) to detect in infrared observations, which are readily available day and night [Thomas and Prata, 2011]. In fact, when ash and SO_2 are co-erupted it can be challenging to separate their individual signals [Prata and Kerkmann, 2007; Corradini et al., 2009; Kearney and Watson 2009]. Recently launched hyperspectral imagers such as AIRS and IASI provide new opportunities for more advanced retrievals of ash, SO_2 and other species associated with volcanic eruptions

[Carn et al., 2009; Carboni et al., 2012; Mackie and Watson, 2014]. Ground based instrumentation is also used for monitoring volcanic ash, both near and far from the volcanic source. Weather radar has historically provided data that can be used to infer volcanic plume properties [e.g. Harris and Rose, 1983; Marzano et al., 2010]. LIDAR and sun-photometer networks covering large geographical areas provide valuable measurements that can often provide information on parameters that are useful to the interpretation of satellite observations, and can well-constrained estimates of plume concentration and altitude [e.g. Ansmann et al., 2010; Gasteiger et al., 2011, Scollo et al., 2012]. In addition, ground based instruments have the advantage of providing a different perspective in the case of thick volcanic plumes, particularly when these are at higher altitudes [Scollo et al., 2014], since they are generally most sensitive to the base and lower layers of a volcanic plume, while satellite-borne instruments are generally more sensitive to the uppermost part of the plume. Observations from ground-based instrumentation have been used to validate dispersion models and satellite-derived estimates of plume characteristics [e.g. Devenish et al., 2012]. Dispersion models are used to predict the evolution of a volcanic plume in space and time and form the basis of advice issued by Volcanic Ash Advisory Centres (VAACs). Different VAACs use different models [Witham et al., 2007], and there is a growing effort to incorporate observation data from satellite and/or ground-based systems in order to constrain the model predictions [Stohl et al., 2010].

II. SPECIAL ISSUE CONTENT

In this special issue, Koukouli et al. report on a satellite-based observation system for monitoring volcanic emissions, which is validated using observations from air- and ground-based instrumentation. Corradini et al. present a comparison between inversion procedures for the volcanic ash and SO_2 retrievals using synthetic multispectral satellite-based measurements. A technique for exploiting the output from dispersion models to constrain the ash properties retrieved from satellite data is presented by Steensen et al., and Spinetti et al. presents a study examining estimates of SO_2 flux from lava fountains on Mount Etna that are inferred from observations made by different satellite sensors, and by a ground-based observation network. Advancements in the exploitation of radar measurements of volcanic plumes are proposed and demonstrated by Marzano et al., and Aranzulla et al. present a demonstration of how the Global Positioning System can be used to monitor volcanic emissions. Trace elements present in volcanic plumes are investigated through soil analysis in a study by Daskalopoulou et al., and through biomonitoring by Calabrese et al. Four studies focusing on dispersion modelling are also presented. Wilkins et al. demonstrate a method for the assimilation of satellite-derived ash properties into a dispersion model, while Egan et al. present a case study focusing on SO_2 dispersion, and Pattantyus et al. and Businger et al. use an ensemble approach to model SO_2 and sulphate aerosol dispersion.

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