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Forecasting volcanic ash dispersal and coeval resuspension during the April–May 2015 Calbuco eruption

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ABSTRACT

Atmospheric dispersion of volcanic ash from explosive eruptions or from subsequent fallout deposit resuspension causes a range of impacts and disruptions on human activities and ecosystems. The April–May 2015 Calbuco eruption in Chile involved eruption and resuspension activities. We overview the chronology, effects, and products resulting from these events, in order to validate an operational forecast strategy for tephra dispersal. The modelling strategy builds on coupling the meteorological Weather Research and Forecasting (WRF/ARW) model with the FALL3D dispersal model for eruptive and resuspension processes. The eruption modelling considers two distinct particle granulometries, a preliminary first guess distribution used operationally when no field data was available yet, and a refined distribution based on field measurements. Volcanological inputs were inferred from eruption reports and results from an Argentina–Chilean ash sample data network, which performed in-situ sampling during the eruption. In order to validate the modelling strategy, results were compared with satellite retrievals and ground deposit measurements. Results indicate that the WRF-FALL3D modelling system can provide reasonable forecasts in both eruption and resuspension modes, particularly when the adjusted granulometry is considered. The study also highlights the importance of having dedicated datasets of active volcanoes furnishing first-guess model inputs during the early stages of an eruption.

1. Introduction

The April–May 2015 Calbuco eruption (Chile) affected vast regions of Argentina, with prevailing winds causing substantial tephra fallout in proximal locations and dispersal of ash clouds across the country. As occurred during the 2011 Cordón Caulle event (Folch et al., 2014), coeval resuspension of ash from fresh deposits highlighted the importance of this secondary hazard at arid and windy areas such as the Argentinian Patagonia. Up to date, resuspension of ash from Calbuco deposits severely affects the normal development of activities on windy days, especially in the province of Neuquén (Argentina) and in the regions of Biobío, Araucanía, and Los Lagos (Chile). In Argentina, periodic episodes of resuspension are associated with the regional strong westerly winds. In Chile, episodes of resuspension are often related to the "Puelche", a warm easterly wind that blows across the Andes. These emissions of ash have caused periodic impacts on public health and agriculture and tourism sectors. The concentration of fine particles (PM_{10} and $PM_{2.5}$) frequently exceeds air quality standards (Folch et al., 2014) and environmental conditions during windy days often forced people to remain indoors. Schools in the region were closed for almost four months after the eruption.

Volcanic ash dispersal can trigger multiple impacts on human life and ecosystems (e.g. Wilson et al., 2011), including respiratory problems (Baxter, 1999), air quality deterioration, dysfunction of energy lines (Johnston et al., 2001), contamination of water bodies, or disruption of ground and air transportation networks. Volcanic ash poses a serious threat on civil aviation (e.g. Casadevall, 1993), compromising aircraft safety (Witham et al., 2007) and affecting the operability of airports (Guffanti et al., 2009). To face these hazards, Volcanic Ash Advisory Centers (VAACs) make use of reports, observations and operational model forecasts to advise civil aviation authorities and stakeholders on the presence and evolution of ash clouds. In

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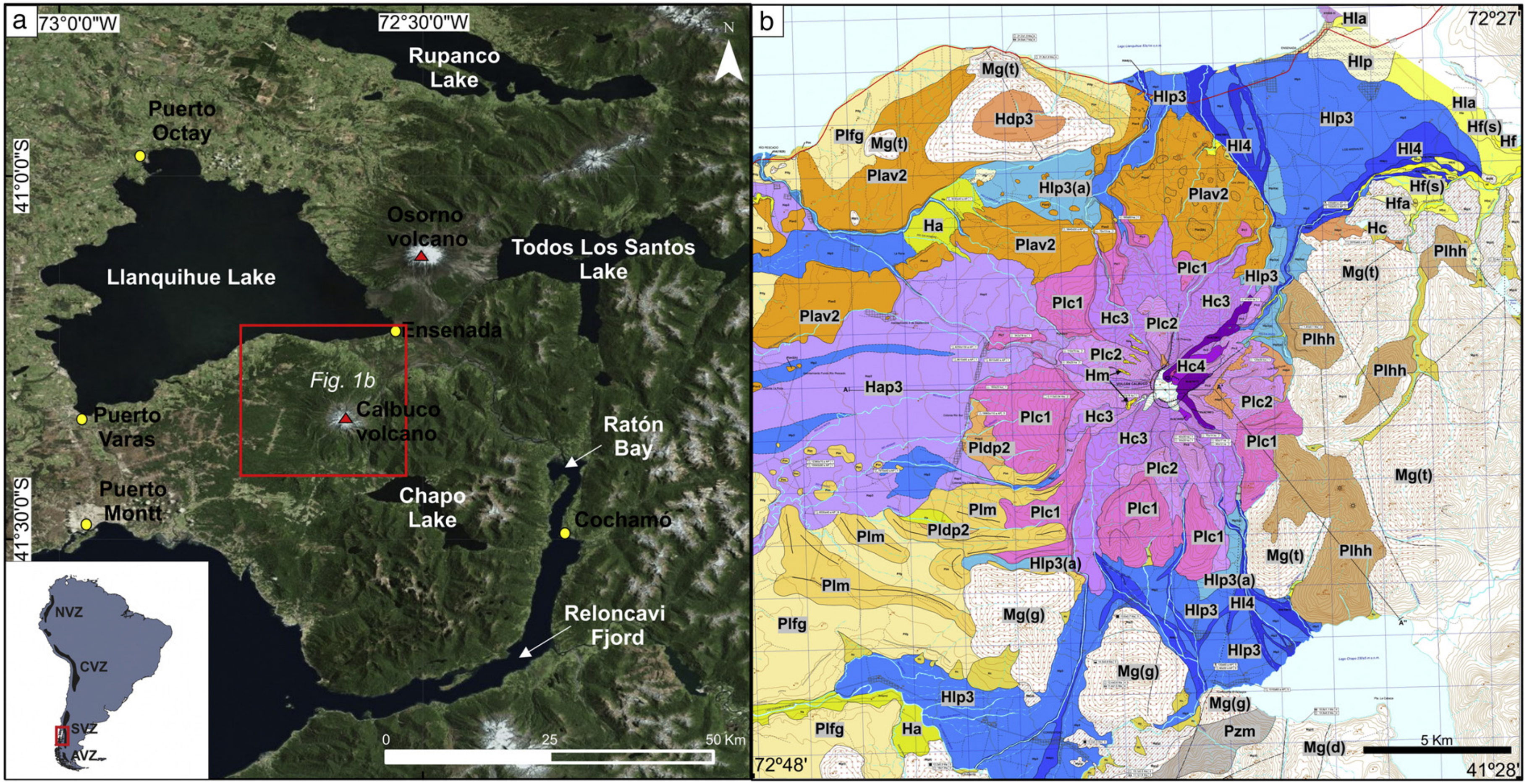

Fig. 1. (a) Location of Calbuco volcano. The red square shows the extent of the geological map. Volcanic zones were included in South America map (lower left corner): NVZ: North Volcanic Zone, CVZ: Central Volcanic Zone, SVZ: Southern Volcanic Zone; AVZ: Austral Volcanic Zone. (b) Geological map of Calbuco volcano after Sellés and Moreno (2011). References: Pzm: Upper Palaeozoic meta-sedimentary rocks; Mg(t): Neogene tonalites; Mg(d): Neogene diorites; Mg(g): Neogene granites; Plhh: Early Pleistocene volcanic and volcano-clastic sequences; Plc1: Calbuco 1, Middle–Upper Pleistocene, basaltic-andesite lava flows with volcanoclastic deposits interbedded; Plc2: Calbuco 2, Upper Pleistocene, lava flows and pyroclastic rocks; Pldp2: Calbuco 2, Upper Pleistocene, flow and fall pyroclastic deposits; Plav2: Calbuco 2, Upper Pleistocene, volcanic avalanche deposits; Hc3: Calbuco 3, Upper Pleistocene–Holocene, lava flows interbedded with breccia and tuffs; Hap3: Calbuco 3, Upper Pleistocene–Holocene, Alerce ignimbrite and volcanoclastic deposits; Hdp3: Calbuco 3, Upper Pleistocene–Holocene, undifferentiated pyroclastic deposits; Hlp3: Calbuco 3, Upper Pleistocene–Holocene, lahars and pre-historic pyroclastic flows; Hc4, Calbuco 4, Holocene, dome-cone and associated lava flows. Others Holocene deposits: Hl4: recent and historic lahars; Plm: moraines; Plfg: fluvioglacial deposits; Hfa: ancient fluvial deposits; Hf recent fluvial deposits; Hlp marsh and lacustrine deposits; Hm: recent moraines; Ha: alluvial deposits; Hpl: recent playa lake deposits and Hc: colluvial deposits.