Role of volcano observatories in a pan-European early-warning system

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1. Introduction

The 2010 Eyjafjallajökull eruption in Iceland demonstrated how vulnerable international aviation is to airborne hazards such as volcanic ash. An EU H2020 research programme entitled European Natural Airborne Disaster Information and Coordination System for Aviation (EUNADICS-AV) aims to **close the significant gap in European-wide data and information availability during airborne hazards**.

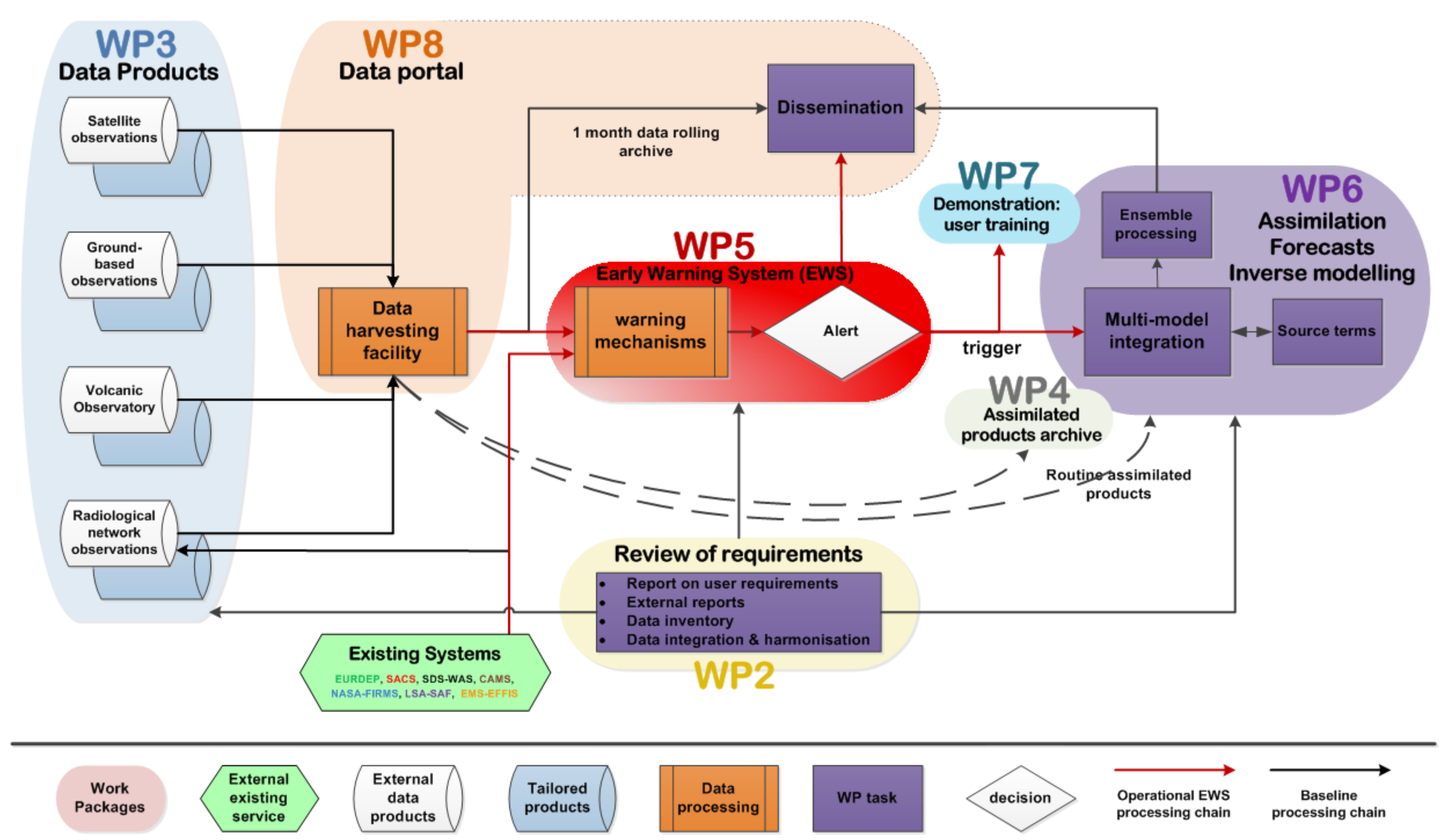
The Icelandic Meteorological Office (IMO) and the Italian National Institute of Geophysics and Volcanology (INGV) are two of twenty-one partners contributing to the EUNADICS-AV project. Our role as volcano observatories, is to furnish our partners with both background and real-time information on the volcanoes under our observation.

Currently the major product of volcano observatories is the VONA: Volcano Observatory Notice for Aviation which, amongst other things, includes the aviation colour codes:

GREEN	Volcano is in normal, non-eruptive state. *or, after a change from a higher level*: Volcanic activity considered to have ceased, and volcano reverted to its normal, non-eruptive state.
YELLOW	Volcano is exhibiting signs of elevated unrest above known background levels. *or, after a change from higher level*: Volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
ORANGE	Volcano is exhibiting heightened unrest with increased likelihood of eruption, *or*, Volcanic eruption is underway with no or minor ash emission *[specify ash-plume height if possible]*.
RED	Eruption is forecast to be imminent with significant emission of ash into the atmosphere likely. *or*, Eruption is underway with significant emission of ash into the atmosphere *[specify ash-plume height if possible]*.

2. Contribution from monitoring

Whilst the majority of the EUNADICS-AV project revolves around modelling atmospheric dispersion of airborne hazards (i.e. volcanic ash), our contribution relies on observational data. This is both to provide crucial **inputs to the models** (e.g. start time of eruption, and plume height), and to **validate** the models by providing a "ground-truth".

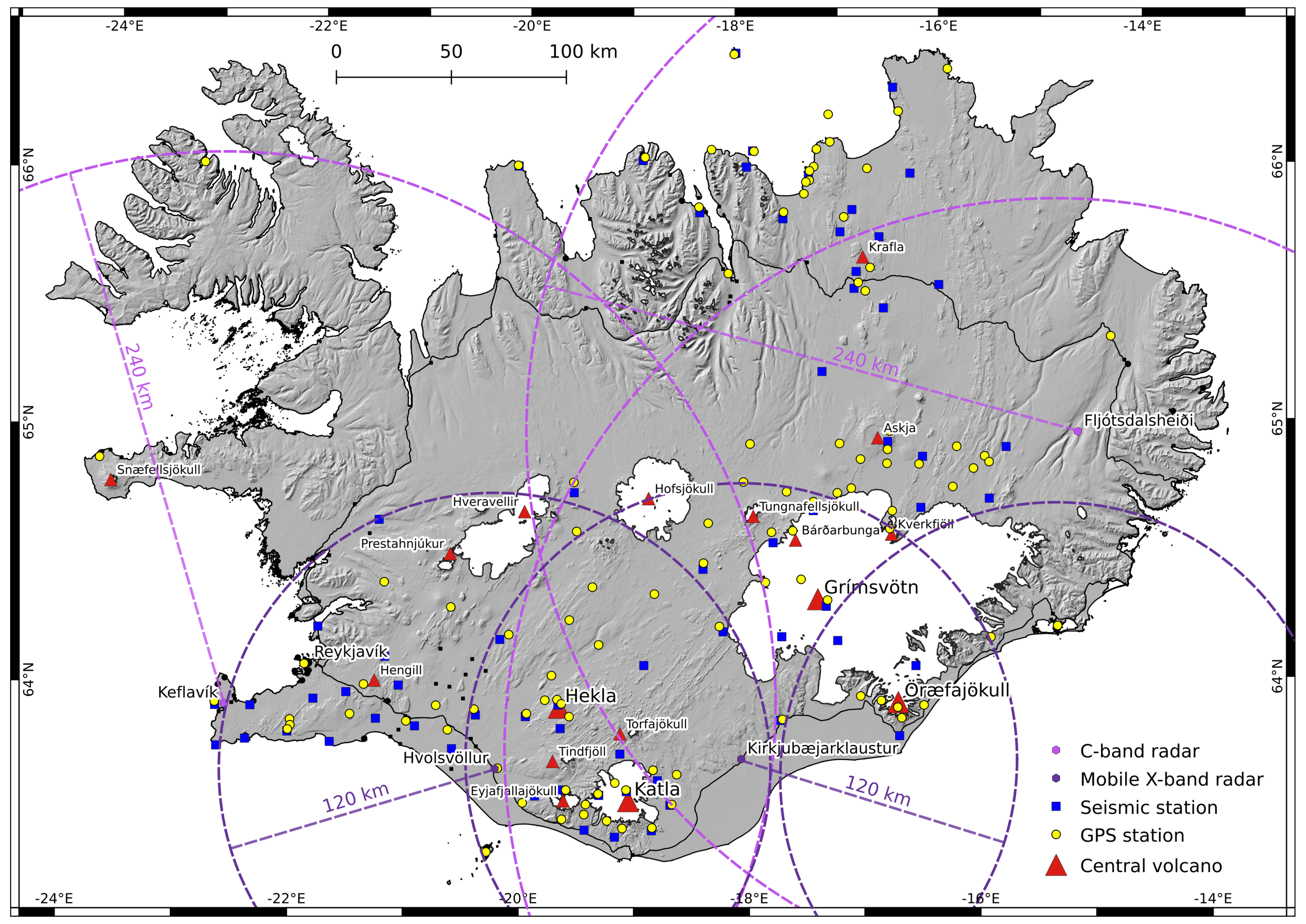


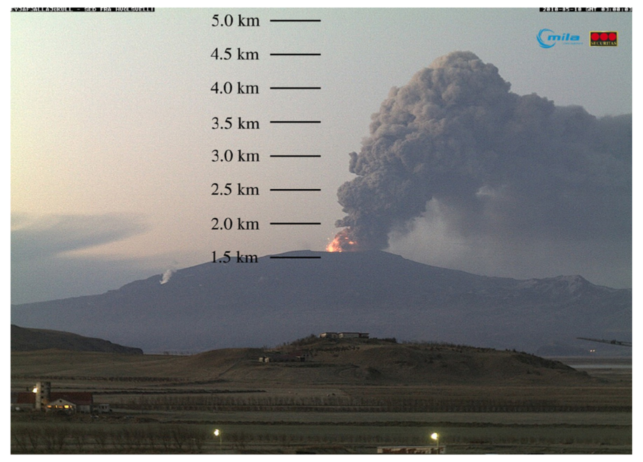
The data flow chart of EUNADICS-AV divided into the original project work packages. Data provided by the volcano observatories is processed by the data harvesting facility and is utilised both as an input and as a control.

3. Monitoring networks - Iceland

Both IMO and INGV monitor multiple volcanoes but the scale is very different. Iceland hosts 32 active volcanic systems spread out across the country, each with a central volcano, fissure system(s), or both[1]. An eruption is possible anywhere within the volcanic systems but particular attention is paid to Hekla, Katla, Grímsvötn, Öræfajökull, and Bárðarbunga which have all produced very large eruptions in the Holocene.

Öræfajökull has displayed an increase in activity since 2017. Bárðarbunga has exhibited continued seismicity and inflation, since shortly after the 2014–2015 fissure eruption within the Holuhraun plain (photo below).



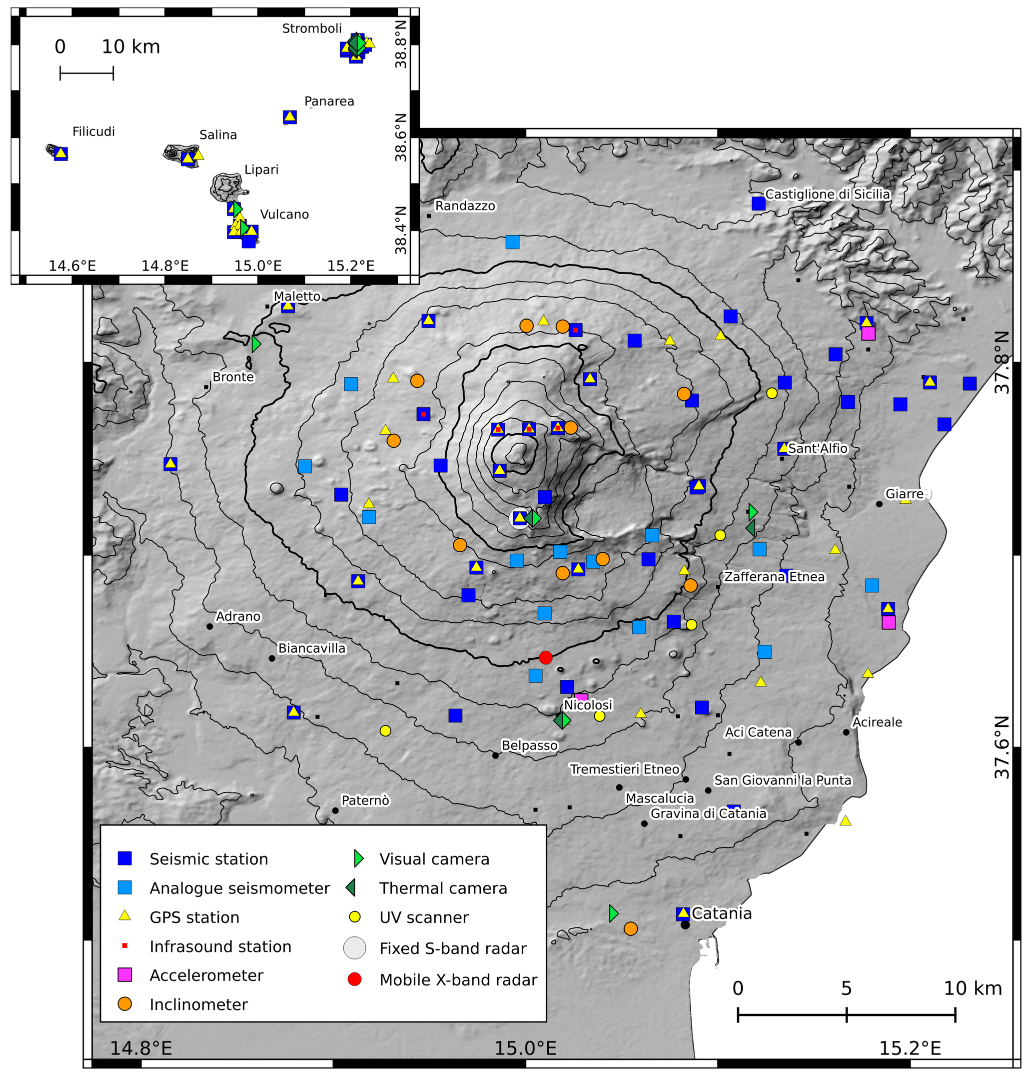


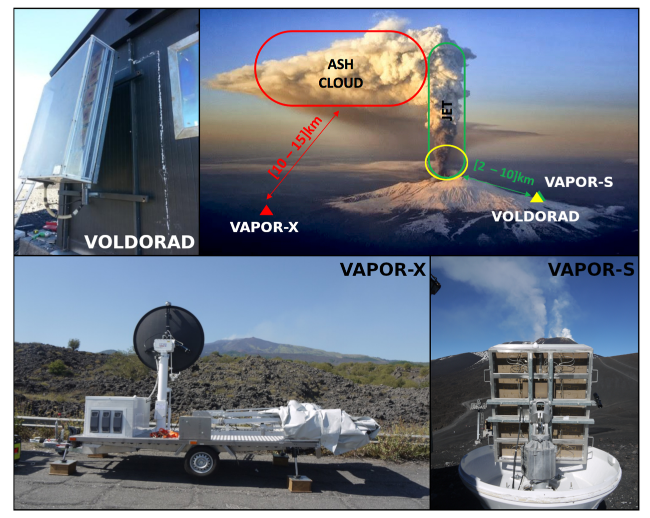
During the 2010 eruption of Eyjafjallajökull, calibrated web cameras were placed in order to measure the plume height[2]. Now a new automated plume height retrieval system, VESPA, uses data from Iceland's two fixed position C-band radars, and two mobile X-band radars (shown above). Future data products will include real-time ceilometer and lidar measurements.

4. Monitoring networks - Etna

INGV Osservatorio Etneo is responsible for monitoring both Etna and the volcanoes of the Aeolian Islands. Etna is one of the most active volcanoes in the world with over 200 eruptions in the past 35 years[3].

Activity at Etna has increased in the last few decades and ranges in style from passive degassing, through fire-fountaining, to subplinian and Plinian eruptions, although the latter has not occurred since 122 BC. The majority of recent eruptive episodes are characterized by a paroxysmal phase, lasting on average about one hour, preceded by mild strombolian activity and lava flows. Every paroxysm produced an eruption column ranging in height from several km to a maximum of about 15 km above sea level.





Plume features are measured through either calibrated visual/thermal cameras or by radar. The novel radar setup includes fixed S- and L-band instruments for measuring flux rates, and a mobile X-band instrument for analysing the downwind ash cloud.

Future data products will include information on the grain-size distribution derived from the AMPLE lidar system (shown on left).

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