USING MACHINE LEARNING ON CTD DATA TO ASSESS THE NATURAL HAZARD OF ACTIVE SUBMARINE VENTFIELDS: THE CASE OF KOLUMBO NEAR SANTORINI ISLAND

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Background Info

Almost 75% of known volcanic activity on Earth occurs in underwater locations. The presence of active hydrothermal vent fields in such environments is a potential natural hazard for the environment, the society, and the economy. Despite its importance for risk assessment and risk mitigation, monitoring of the activity is impeded by the remoteness and the extreme conditions of underwater volcanoes.

Kolumbo, NE of Santorini Island, is an underwater volcano featuring an active hydrothermal vent field (Sigurdsson et al., 2006) (Fig. 3), which has shown near-explosive dynamics in the recent years. It has a well-defined 1500 m-wide crater and a crater floor ≈500 m below sea level (Nomikou et al., 2012).

CTD (Conductivity, Temperature, Depth) time series from an earlier expedition in 2010–2011, were recorded mainly in the northern part of the vent field and have been used to develop an advanced mathematical model based on the *Generalized Moments Method* (*GMM*) to describe the underlying mechanisms governing the hydrothermal vent activity (Bakalis et al., 2017). The model was further tested successfully in the Abyss inactive caldera near Nisyros Island (Bakalis et al., 2018).

This work reports on the CTD data recorded during a recent GEOMAR expedition, which will be firstly used to provide a detailed mapping of the active hydrothermal vent field inside Kolumbo. As the next step, the data will provide the playground for the development of a machine learning algorithm able to predict the level of natural hazard based on recorded CTD time series over the hydrothermal vent field. Besides GMM, additional non-stochastic mathematical approaches will be employed (multifractal etc)

The GEOMAR expedition 2017

In March 2017, a joint GEOMAR/University of Athens expedition used an Autonomous Underwater Vehicle (AUV) to investigate the evolution of the NE–trending Santorini–Kolumbo line. The mission lasted 25 days, 19 of which were onboard operations. The working area was within [37–36 ºN,25–26 ºE] and the water depths varied between 100–500 m inside the Exclusive Economic Zone (EEZ) of Greece and within the 6 n.m. limit. Conductivity, Temperature, Depth (CTD) data were recorded with a 4 Hz Seabird SB E49 FastCAT sensor aboard the AUV, scanning the water column above the vent field at various depths (Fig. 1).

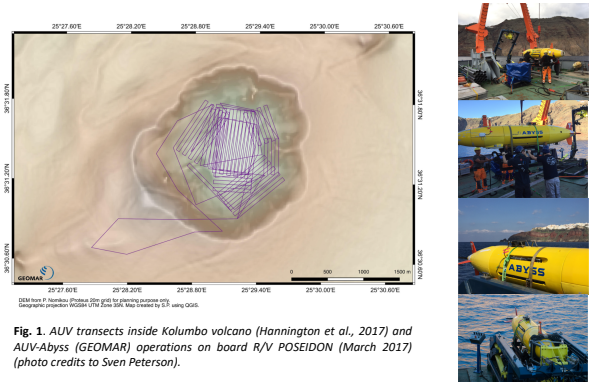

Fig. 1. *AUV transects inside Kolumbo volcano (Hannington et al., 2017) and AUV-Abyss (GEOMAR) operations on board R/V POSEIDON (March 2017) (photo credits to Sven Peterson).*

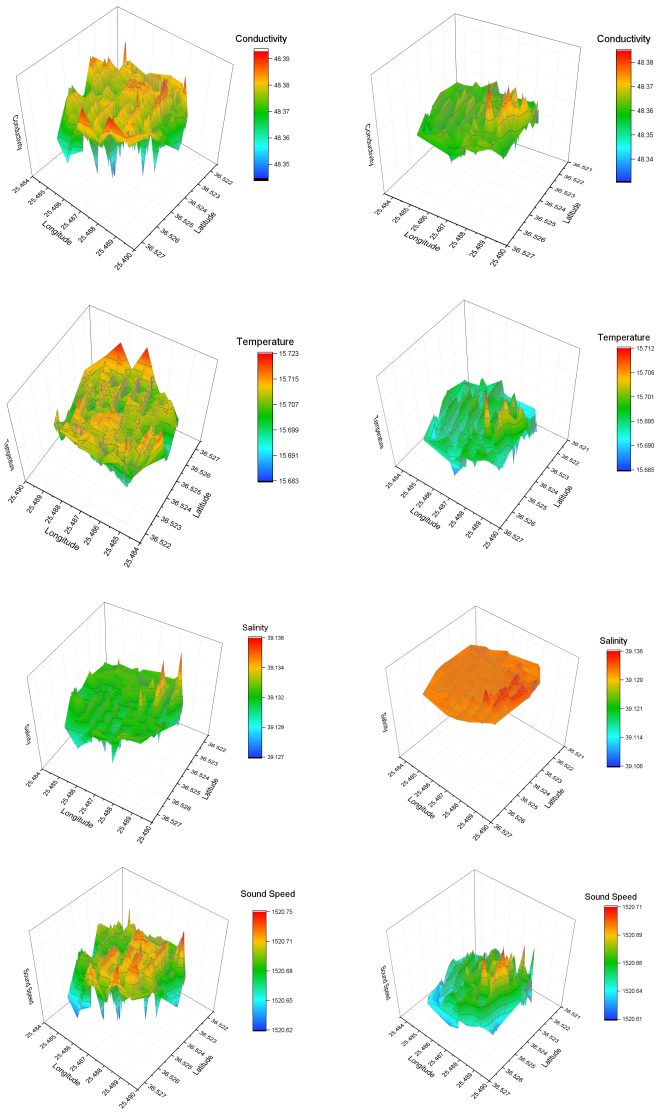

Fig. 2. *Reconstructed 3D maps from recorded data of conductivity (S/m), temperature (˚C), salinity and sound velocity (m/s), for two separate days in March 2017: the 23rd (left) and the 24th (right).*

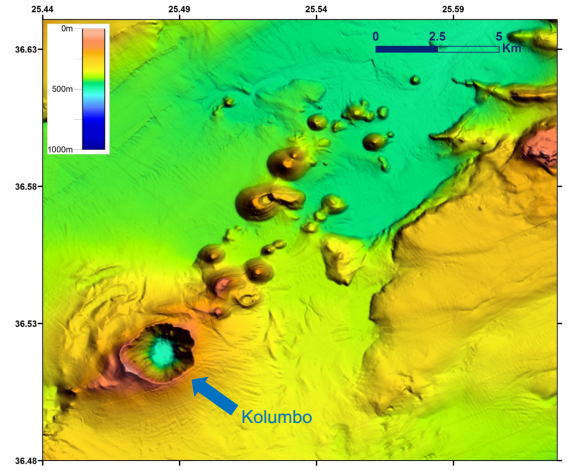

Fig. 3. *High resolution bathymetric Map of Kolumbo volcanic chain (Nomikou et al., 2012).*

Analysis/Results

The AUV investigated the area inside the Kolumbo volcano on March 23rd and March 24th 2017. In Fig. 2 we present the reconstructure 3D maps for each day respectively, for all water column parameters: Conductivity, Temperature, Salinity, Sound Speed at a fixed depth of (420 ± 2) m. An apparent anomaly in each property can be seen at the exact same position (Longitude: 25.489 E), above the hydrothermal vents. The changes from one day to another are also obvious. On the second day, all values slightly drop throughout the entire area, except those directly above the locations with hydrothermal activity.

As the present results are the first ones produced from this expedition, they provide strong motivation for further investigation. The next step is to confirm the present results with the corresponding ones from 2010-11 campaigns in terms of the underlying dynamical mechanisms. Then a supervised machine–learning algorithm will be constructed, optimized and tested in near-real time to provide a reliable description of the dynamic conditions over the hydrothermal vent field. This is a crucial step towards building up capacity to predict explosive conditions based on plain CTD time series. The impact on developing appropriate mechanisms and policies to avoid the associated natural hazard is expected to be immense.

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