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Released submarine volcanic gases revealed by COSMO-SkyMed satellite images: the exceptional case of Paleochori Bay (Milos Is., Greece)

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High-hazard volcanoes forming islands, often located within territorial water of several European countries, are a favoured tourist destination, a factor that increases the risk. Consequently, the knowledge of volcanic dynamics through time are crucial for risk assessment and mitigation in coastal areas. Gas vents, black smokers, chimneys and any other form of gas emissions are directly connected to the dynamic behaviour of volcanoes, accordingly, intensity variation of gas-released in hydrothermal systems would provide clues on volcanic activity changes, monitoring of which can be crucial for eruption forecasting. In this study we explored the possibility of detecting any submarine volcanic activity from satellite synthetic aperture radar (SAR) images part of the Cosmo-SkyMed mission operated by the Italian Space Agency. Three test sites have been analysed: 1) the hydrothermal system offshore Nea Kameni and Palea Kameni that are part of the Santorini volcanic group (Aegean Sea); 2) the intense and stationary submarine vents within the Paleochori Bay south to Milos Is. (Aegean Sea); and 3) the Panarea hydrothermal system including the Basiluzzo's "smoking land" (South East Tyrrhenian Sea). Visual analysis of all StripMap HIMAGEs, integrated with the wind model maps (produced by ECMWF ERA5), acquired over the selected sites since 2007 have not allowed the detection of any features associable with gas-sea surface interaction, for all the analysed sites. Instead, Radar Cross Section measurements, performed by internally-developed software, revealed an increased averaged reflectivity over the areas interested by the submarine gas emissions respect to similar sites. Particularly in Nea Kameni and Palea Kameni bays the difference is of 0.233 dB and in Paleochori Bay it is of 0.808 dB. The Normalized Radar Cross Section (NRCS) in Panarea and Basiluzzo was practically not different from nearby sites, here the average difference in reflectivity is close to zero (-0.002 dB). Results give confirmation that only intense and continuous emissions of gas can be detected by Satellite radar. Indeed, sites of Panarea/Basiluzzo and even Santorini are not suitable for this kind of monitoring, at least in the current status, while in Paleochori Bay the vents are continuous and enough intense to create a perturbation of sea surface reflectivity to be recorded by Satellite radar. Amongst all investigated sites Paleochori Bay is the most suitable one for future combined Satellite acquisition and fieldwork survey with underwater systems as ROV, which can give additional valuable elements to the high-risk submarine volcanic systems assessment and to the monitoring protocol definition.