Multi-scale Thermal Detection of Submarine Groundwater Discharge in Critical Coastal Ecosystems of Volcanic Islands

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Submarine groundwater discharge (SGD), or the flow of groundwater from land to sea, is an important transporter of different constituents to the coast, such as nutrients, chemicals, and dissolved metals. In volcanic regimes, groundwater might have especially high concentrations of these constituents, as it is hydrothermal in origin. One site defined by volcanic features is the Verde Island Passage, which lies within the Coral Triangle in the western Pacific. This region has been designated a marine protected area, as it is home to over thousands of different species of fish and coral reefs. Interactions of this constituent-rich groundwater with coastal waters through fractured volcanic rock can either pose a threat to or promote coastal ecosystem productivity and health. Because of this setting, it is known that SGD is a prevalent source of constituents, but how much and specifically where it is occurring is unknown. Thermal Infrared (TIR) remote sensing has gained popularity as a method of detecting SGD as it helps to resolve spatial variability issues that are inevitably accompanied by this phenomenon.

Here, we investigate the use of TIR satellite and airborne remote sensing, coupled with ground-based field measurements including thermistors and fiber-optic distributed temperature sensing to identify and quantify submarine groundwater discharge in a coastal area of the Verde Island Passage. This study utilizes USGS Landsat 8 TIR sensor to regionally denote SGD plumes via temperature measurements of ocean water, as well as local airborne TIR remote sensing which provides a finer spatial resolution than its satellite counterpart. This study also employs a 1 km-long fiber optic cable to continuously measure temperature along the coast for the very first time in this region, and thermistors buried in the seabed under 20-30 feet of water to measure vertical temperature flux. Results from these approaches reveal multiple SGD signals in both the intertidal and subtidal zones, and 260 feet offshore, with temperatures reaching up to 80°C and estimated fluxes reaching as high as 1.5 m/d. This study serves as a foundation for mapped SGD locations which can be used in conjunction with flux estimations in future temperature and flux modelling of SGD in the region.

Keywords: Submarine groundwater discharge, thermal infrared remote sensing, volcanic coastal ecosystems, distributed temperature sensing

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