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Pockmark morphology and turbulent buoyant plumes at a submarine spring

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ABSTRACT

The input flow of groundwater from the seabed to the coastal ocean, known as Submarine Groundwater Discharge (SGD), has been only recently recognized as an important component of continental margin systems. It potentially impacts physical, chemical and biological marine dynamics. Independently of its specific nature (seepage, submarine springs, etc.) or fluid chemical composition, a SGD is generally characterized by low flow rates, hence making its detection and quantification very difficult, and explaining why it has been somewhat neglected by the scientific community for a long time. Along with the growing interest for SGDs emerged the need for in-situ observations in order to characterize in details how these SGDs behave. In this work, we describe the morphology of a pockmark field, detected in the Southern Tyrrhenian Sea (Mediterranean Sea), and provide observational evidences of the presence of active submarine springs over the coastal shelf area. We describe the effect of the fluid seeps on the water column stratification close to the main plumes and in the neighbouring areas, providing quantitative estimates of the intensity of the turbulent mixing and discussing their potential impact on the seabed morphology and pockmark formation in the context of turbulent buoyant plumes analytical modelling.

1. Introduction

The existence of submarine sources of groundwater has been documented for centuries, recognizing their potential relevance for freshwater management issues (e.g. Moore, 2010). However, information on submarine springs were never collected and organized consistently and, for a long time, the scientific community has almost neglected their eventual effects on the coastal environment and potential impacts on coastal dynamics. While this was mainly due to the difficulty in identifying and measuring submarine sources of water of terrestrial origins, a number of studies have highlighted their importance in coastal hydrology, based on modern technologies and/or modelling (e.g. Taniguchi et al., 2003; Lambert and Burnett, 2003; Moore, 1996, 2003; Oberdorfer, 2003; Smith and Zawadzki, 2003; Destouni and Prieto, 2003).

Despite the fact that Submarine Groundwater Discharge (SGD) is estimated to account only for a few percent of the total freshwater flux in the global oceans, mainly occurring through river input and precipitations, springs and diffuse seepage through the sea floor can still represent important contributions to the coastal ecosystem (Zhang and Mandal, 2012). Indeed, SGD not only brings fresh (or less saline) waters through usually undetected pathways, but it can also affect chemical composition of sea water, due to both anthropogenic land use and natural interactions with aquifer and sediments. Coastal SGD can also be contaminated by fertilizers, pesticides or industrial wastes, as well as by sewage and other pathogen substances, potentially diffusing pollution to the ocean, with potentially devastating effects on local ecosystems and related economies (e.g. Laroche et al., 1997; Gobler and Sanudo-Wilhelmy, 2001). SGD can also modify the nutrient availability along the water column (e.g. Slomp and Van Cappellen, 2004) as well as benthic habitats, and low-salinity input may create particular habitats on the sea floor, especially for fishery stock. Besides, Rodellas et al. (2015) have highlighted the importance of SGD as a source of nutrients to the Mediterranean Sea, demonstrating that SGD involve a large volume of freshwater, actually larger in magnitude than riverine discharge. They indicate that SGD represents a major source of dissolved inorganic nitrogen, phosphorous, and silica to the oligotrophic Mediterranean Sea, with relevant impact on the Mediterranean primary productivity.

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