Using video images to study Haima cold seep bubble plumes

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Cold seep is a widespread geological process mainly caused by hydrocarbon fluid migration. Methane bubble plumes released from cold seeps are often observed at the seafloor. These methane bubbles might be released into the atmosphere and have a huge effect on climate changes. It is of great significance for understanding the fate of these methane bubble plumes.

Many kinds of methods have been used to observe the methane bubble plumes, e.g., acoustical, geochemical, and optical methods. Video imaging is a kind of optical methods widely used in methane bubble plume studies. Compared to other methods, video imaging is a non-intrusive, high-resolution, and quick-collected method. Many studies have estimated bubbles' size, rise velocities, behavior, and the fate of bubbles by analyzing video images manually. However, manual analysis is time-consuming, one dimension, and has not been able to determine temporospatial changes in a two-dimension profile perspective.

In this study, we applied the manual analysis method and the particle image velocimetry (PIV) method to analyze in-situ video image sequences of Haima cold seep bubble plumes, a newly discovered, active cold seep in the Qiongdongnan Basin of the northern South China Sea during 2019. Quantitative and temporospatial change information about the plume flow filed is obtained. The results show that the sizes of bubbles in the plume range from 2.556 ~ 4.624 mm, with a rising velocity of ~ 0.26 m/s. The flux for an individual bubble stream is ~ 94.8 ml/min. The flow velocity field of the bubble plume is consistent with the manual analysis, and it reveals that the bubble plume's flow field is a multiscale turbulent flow field. The bubble plumes are usually V-shaped. Through carrying the adjacent water column, the bubble plumes swell and change rapidly. The direction and velocity of the bubble plume flow change with time, and its streamlines are sinuous. The max velocity of the bubble plume flow field changes at a 6.6 s period cycle.

Although there is some indetermination, our results show that the PIV method is feasible for calculating the bubble plume flow field and that it has some unique advantages, e.g., it is fast, non-invasive, it provides two-dimension temporospatial change images, and it has a high resolution. The images of the bubble plume flow field provide a new perspective to observe the cold seep systems. We hope that this method can be improved and widely applied in cold seep plume studies in the future.