Detection of diffuse sea floor venting using structured light imaging

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Structured Light Overview

Identifying and localizing active diffuse low temperature sea floor venting at hydrothermal sites is difficult and inefficient. Typically, such sites are identified by a temperature induced optical shimmering visible during direct visual inspections by a remotely operated vehicle (ROV) working within meters of the sea floor. Such an approach prevents efficient surveys over broad areas and complicates establishing spatial relations between areas of float activity.

Our recent work with a structured light laser system indicates that venting can be detected in survey images in an automated and systematic fashion. During the summers of 2010 and 2011 the EY Nautilus and ROV Hercules surveyed several active vent sites which provide examples of vent detection.

Vent Detection Algorithm

A structured light laser system, consists of a camera and verged sheet laser projected at the sea floor with a known relative geometry. Images of the line can be collected at altitudes between 2 and 5 meters with a high frame rate, greater than 10Hz. The position of the laser line in images can be extracted with standard computer vision techniques and is typically used to determine the 3D height of the bottom along the laser line. A bathymetric survey map can then be created from the individual profiles extracted in a batch process.

In the presence of sea floor venting, temperature anomalies refract the laser sheet, causing the laser line to appear blurred instead of crisp and clear within the image. By identifying and quantifying this blurring it is possible to identify areas of venting. Our current method uses weighted moments of the laser intensity relative to the peak amplitude detected in each image column. Larger moment values correspond to a spreading of the laser line indicative of heat related refraction.

Further work: Our current method uses weighted moments of the laser intensity relative to the peak amplitude detected in each image column. Larger moment values correspond to a spreading of the laser line indicative of heat related refraction.

Kolumbo Vent Field, 2010

During the 2010 EY Nautilus expedition active vents were surveyed within the Kolumbo crater, located about 7km from the coast of Santorini, Greece. At a depth of 500 meters there are numerous chimney vents with temperatures up to 230°C surrounded by larger areas of lower temperature diffuse venting (30°-60°C). The background water temperature in the crater is 16°C. A laser survey was completed over large sections of the vent field, which created dramatic diffraction (Fig 3b).

Further work: This data set provided vents that were easy to detect and isolate. The significant distortion of the laser line however made it harder to reliably estimate the bathymetry over the active vents. Future work will investigate the magnitude of the induced bathymetry errors.

Kolumbo Vent Field, Poet’s Candle 2011

Within the Kolumbo crater, the around the Poet’s Candle vent, there is a region of diffuse venting and associated coverage by a white bacteria mat (Fig 7). A 2011 laser survey over the area was able to capture lower temperature venting, measured 25°-45°C above ambient.

Further work: Over this area the detection of venting coincided with the coverage of the white bacterial mat. Over the mat the laser line was likely subject to blurring from both the temperature refraction and a general “blooming” due to the highly reflective and somewhat opaque bacteria. We are currently investigating ways to differentiate these two effects.

Palinuro Seamount, Tyrrhenian Sea, 2011

Small active vents discharging shimmering water were discovered on the western flank of the large Palinuro seamount in the Tyrrhenian Sea at depths of 600m. Maximum fluid temperatures were 68°C in two rocky areas where tubeworm colonies were growing (Fig. 12).

Further work: Additional work will seek to relate the laser image statistic to the vent intensity in a more quantitative way.

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