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# Integration of ROV-based acoustic and optical high-resolution remote sensing survey for a multiscale geomorphological seafloor mapping approach: an Arctic Cold seep case study

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Multibeam echosounders (MBES) mounted on remotely operated vehicles (ROVs) can acquire sub-metric resolution bathymetry in deep water environments. However, a general lack of complexity measurements of peculiar seafloor morphologies (sub-metric and centimetric resolution) represents a knowledge gap that can be mitigated through an innovative image analysis technique: Structure from Motion (SfM). 3D photogrammetry is becoming more relevant in land and marine imaging research, opening new opportunities for the extraction of fine-scale terrain variables and high-resolution habitat mapping that may contribute to understanding the functioning of extreme deep-sea environments, such as cold seeps habitats.

Cold seeps are seafloor areas where reduced compounds from subsurface hydrocarbon reserves either enrich sediment fluids or emanate freely as gas from the seabed. Numerous underwater landscapes and various chemosynthetic communities are associated with these biodiversity hotspots, which were uncovered during the last decades of seafloor exploration.

In this work, we integrated ROV-based MBES bathymetric datasets with multi-dimensional, high-resolution seafloor models obtained from ROV photogrammetry to improve (i) the understanding of the geospatial context of Cold Seeps distribution and (ii) their spatial extent from a multiscale perspective.

An arctic cold seep on Svyatogor Ridge, offshore Svalbard, was explored using Ægir6000, a work-class ROV equipped with a Kongsberg EM 2040 MBES and 8 HD and composite video camera inputs, which provide a fully operational vision with a zoom and focus capability able to film the ocean floor at different angles. The lighting capacity includes ten dimmable lights and has a maximum total load of 2300 W.

ROV-based multibeam micro-bathymetry was performed on a selected area at 45 m of altitude from the seafloor at a speed of 0,5 knot to map the near bottom environments in detail. Sub-portions of the same areas were then mapped using a photogrammetric workflow. The ROV moved at a constant speed of 0,2 knot, following predefined routes to guarantee optimal lateral overlap between adjacent transects. A photogram every two seconds was automatically extracted from the nadiral camera's videos. The images were later processed in Agisoft Metashape®, following a well-established photogrammetry workflow. As final outputs, we obtained 3D meshes, orthomosaics and DTMs at ultra-high-resolution (mm), which allowed us to get detailed morphometric maps.

These data permit us to reconstruct accurate georeferenced 3D models representing a variety of small-scale seabed features. Such ultra-high-resolution models can provide essential information for a better understanding of the spatial pattern associated with seafloor biogeochemical and physical processes. Furthermore, the opportunity to accurately locate push core sampling sites on ROV photomosaic allows us to investigate closer spatial relationships between measured methane fluxes and associated seafloor habitats.

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