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Image seafloor mosaics: Acquisition, processing and role on deep-sea observatory planning and implementation

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Near-bottom, high-resolution geophysical surveys carried out by remotely operated vehicles (ROVs) provide unprecedented resolution of the seafloor structure, either from multibeam acoustic systems or from imagery (video and electronic still images). Limitations in image processing techniques and capabilities have greatly restricted the exploitation of these data to date. We present a set of seafloor image mosaics of the Lucky Strike hydrothermal field (Mid-Atlantic Ridge, 37.25°N), which extends over a surface of $\sim$1 km^2. The image mosaics have a pixel resolution of $\sim$10 mm, and are built from >60,000 digital images acquired during near-bottom surveys in 1996 (ARGO-II towed system, Lustre'96 Cruise), 2006, 2008 and 2009 (VICTOR ROV with Module Route, Momareto'06, MoMAR'08 and Bathyluck'09 cruises). These data provide a coverage that varies from $\sim$25% to practically 100% of the seafloor, depending on the survey and the zone of the study. Individual images are corrected for uneven illumination, they are then globally aligned using both the vehicle navigation and the correspondences among images identified through image processing, and different surveys are geographically co-registered. Image processing is thus critical to overcome the limitations of underwater acoustic positioning systems, which have location errors (up to 10 m) that are much larger than the resolution of the acquired geophysical data (10 mm pixels in case of imagery). To generate the final mosaic we use graph cuts and gradient-domain processing to obtain a single seamless image. As the resulting mosaics are large, reaching >100.000x100.000 pixels, this imagery can be viewed and exploited using a dedicated viewer which allows also the extraction of information (digitization, extraction of georeferenced images, etc.). The method developed here is applied to the Lucky Strike hydrothermal field, where a pilot seafloor observatory will be installed in 2010 (MoMAR node of the ESONET program). It demonstrates that it is now feasible to systematically map with digital cameras large areas of the seafloor (in the order of 1 km^2) in hydrothermal systems, cold seeps, and other areas of interest, and to obtain georeferenced images. These can then be used to identify and quantify geological and biological processes, and to guide and map the installation of seafloor instrumentation and infrastructures associated with deep-seafloor observatories. Repeated surveys can be now precisely co-registered, and used to study temporal variability of natural systems or of human impact, including scientific activities.