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Generation of high-resolution digital elevation models and orthomosaics from historical aerial photographs and LiDAR: quality assessment in the coastal beach-dune system of Es Trenc (Mallorca, Spain)

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The availability of high spatial resolution historical remote sensing products and advances in Structure from Motion (SfM), Multi-View Stereopsis (MVS) and LiDAR (Light Detection And Ranging) techniques offer a wide range of applications to understand landscape evolution and to monitor geomorphological changes. In this work, we apply an optimised SfM-MVS workflow based on minimising georeferencing error on black and white and colour historical photographs acquired in 1945 (American flight series A), 1979 (Spanish Interministerial Order), 1991 (Spanish Coastal Directorate General) and 2006 (PNOA flights) to generate 3D point clouds, Digital Elevation Models (DEM) and orthomosaics at 1 m resolution for the beach-dune system and coastal area of Es Trenc (southern Mallorca). In addition, we applied LiDAR techniques on the Airborne Laser Scanning (ALS) point clouds collected by the PNOA LiDAR flights in 2014 and 2019 to generate DEMs. The use of these products in multi-temporal analysis requires quality control of their spatial accuracy due to the diversity of sources and technologies used. The first quality control was based on evaluating the SfM sparse cloud optimisation process in the orthomosaic georeferencing step by calculating the RMSE between the Ground Validation Points (GVP) surveyed with Global Navigation Satellite System (GNSS) readings and the predicted height values at the closest point of each SfM sparse cloud. The second quality control was based on systematically assessing the vertical accuracy of the dense MVS and ALS clouds as a step prior to point interpolation to generate DEMs at 1 m resolution. The height errors of these clouds were estimated by calculating the RMSE between the Ground Test Points (GTP) read by GNSS on the ground and the predicted values at the respective nearest point for each of the MVS and ALS cloud series. Preliminary results show that the optimised SfM-MVS method applied on historical imagery can generate high-resolution orthomosaics and DEMs with acceptable accuracy: RMSE in z ranges from 0.2 to 10 m, with the lower accuracy obtained for the 1945 DEM, due to the lower resolution and coarse grain size (texture) of the photographs used. Overall, these products in combination with current LiDAR-derived DEMs have great potential for monitoring historical landscape evolution in coastal ecosystems.