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## Remote sensing applicability in geomorphological investigations of beaches

Beaches are coastal forms consisting of unconsolidated material of varying sizes. Since they are formed on the seashore, processes from both the land and the sea, combined with anthropogenic influences, affect their morphological changes. Beaches have an important socio-economic significance for tourism, so it is necessary to take care of their stability. Beach monitoring has proven to be one of the most appropriate methods for studying their morphological changes. It is usually carried out with the help of remote sensing techniques, which are increasingly used nowadays and may provide a huge database of relatively high-quality images. If the UAV images are connected with a GNSS data, sub-centimetre precision can be obtained. This paper revealed the accuracy of remote sensing methods and their application in the study of beach evolution on the island of Hvar in Croatia.

Measurements were carried out at 20 sites over a 10-year period (2011–2021) using Google Earth Pro, the Croatian State Geodetic Administration geoportal and fieldwork (UAV and GNSS receiver). Since the models generated by photogrammetric techniques from the UAV are the most precise, they were used as reference values, so the measurements from different remote sensing data sources were compared with them. By comparing the measurements from all data sources, a strong correlation was calculated ( $r^2=0.98$ ). It was found that the average RMSE for beach area was 7.2% and length was 2.5%, a relatively accurate measurement that can be used for beach surveys when the calculated error is taken into account (Mićunović *et al.*, 2021).



In order to study evolution of beaches using archival data (maps, photographs and orthophotos) and more recent remote sensing data several beaches were selected. The oldest, the Franciscan cadastre, dates from 1834, photographs and orthophotos from the mid-20<sup>th</sup> century, and more recent remote sensing data (UAV and satellite) from 2021. All beaches had the largest area in the 19<sup>th</sup> century, which gradually decreased until recent period. There is a trend towards severe erosion of the beaches. On average, beaches have lost 32% of their area. For example, the pebble beach Lučišće has lost 45% of its area while Mola Milna 27%.

Various remote sensing data sources proved to be very good for accurate beach measurement surveys. In combination with archival data, they provide useful information for the study of beach evolution which is necessary for further sustainable coastal management.

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### **References**

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