# Monitoring morphological changes in coastal dunes with Unmanned Aerial Vehicles

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## Introduction

Coastal dunes are depositional features whose growth is dominated by long-term processes, namely by the relatively slow input of sand blown from an adjacent beach. However, they can also experiment rapid changes when they are impacted by storm waves. Due to their importance as ecosystem service providers, it turns critical to develop tools capable of capturing the evolution of these systems at different time scales, for example improving the accuracy of the digital elevation models (DEM) obtained using Unmanned Aerial Vehicles (UAVs).

UAV are commonly used to monitor morphological changes, providing a cost-effective survey tool for topographic mapping and measurement of coastal morphologies, such as beaches and dunes.

Here, the level of accuracy that can be obtained from UAV derived products will be explored to better understand the vertical resolution and thus the scale of temporal changes that can be identified with support to UAVs.

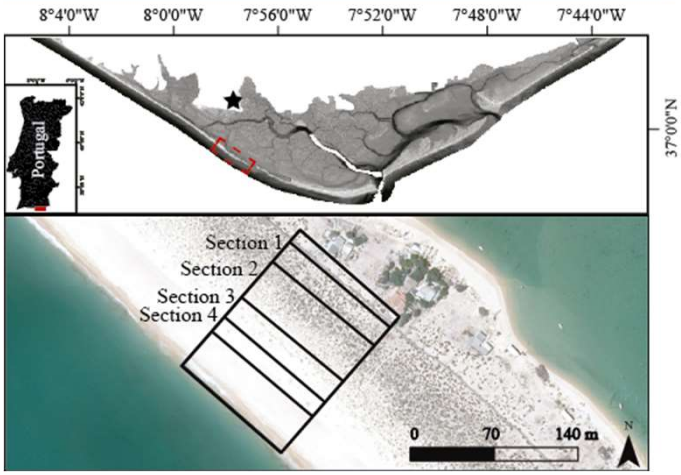
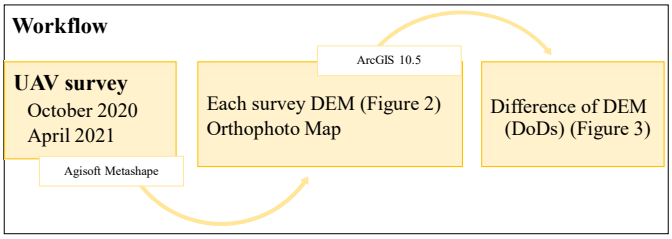


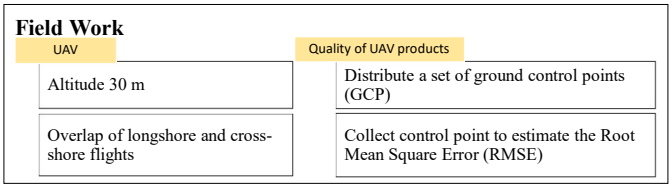

**Figure 1** Location of the study area. **Upper panel:** the Ria Formosa barrier island system with the red line indicating the location of the study area. **Lower panel:** survey area.

## Methods

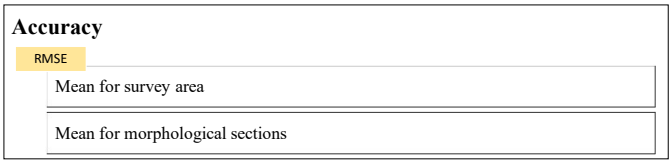
### Workflow




### Field Work




### Accuracy




## Results and discussion

Overall, the estimated accuracies for the generated products (i. e. DEM) indicate that the results are acceptable with RMSE of 0.07 m and 0.04 m in October 2020 and in April 2021, respectively (Table 1). The RMSE spatial distribution shows relatively high differences across the dune, mainly for the survey carried out in October 2020. The accuracy differences between October 2020 and April 2021 could be explained by the difference of sun radiation during each day survey.

In terms of DoDs, the results show that sections 3 and 4 suffered minor changes while major changes were detected in section 2, which corresponds to the dune crest (Figure 3A). However, these changes are in the order of the RMSE. It is possible to observe that in sections 3 and 4 the greater vertical differences concentrated in the bare sand zones (Figure 3B), demonstrating that this methodology allows to map relatively small vertical changes in sandy areas.

**Table 1** Total RMSE for each survey and by section according to Figure 1.

| RMSE (m) | October 2020 | April 2021 |
|---|---|---|
| Survey area | 0.07 | 0.04 |
| Section 1 | 0.10 | 0.02 |
| Section 2 | 0.05 | 0.03 |
| Section 3 | 0.06 | 0.02 |
| Section 4 | 0.06 | 0.05 |

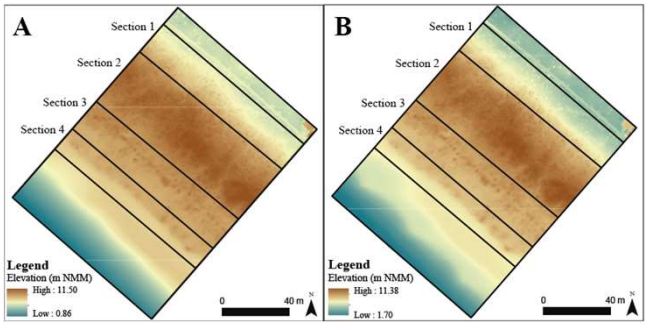



**Figure 2 A** DEM obtained in October 2020. **B** DEM obtained in April 2021.

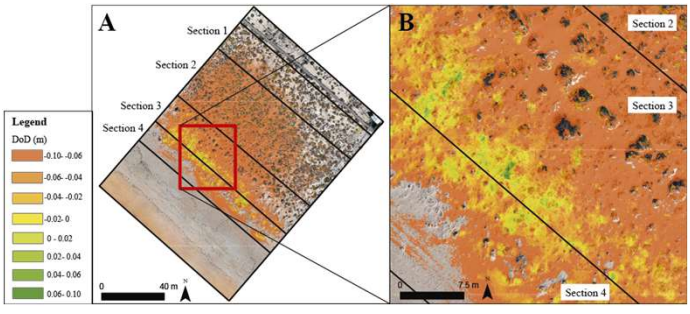



**Figure 3 A** Difference of DEM (DoD) over the orthophoto map from October 2020. **B** detail of DoD.

## Conclusion

The use of UAV to monitor morphological changes over time in coastal dunes is useful, showing promising results that allow resolutions within the rate of interannual change of these systems. However, it is important to notice that part of the observed changes might not represent morphological changes, but vegetation changes, and vice versa, as sedimentation might occur within the plants, in particular shrubs, which cannot be isolated from the DEM. In addition, it is worth noticing that the error might be very close to the sedimentation rates within these systems, challenging this methodology.

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