INVESTIGATING THE USE OF PLEAIDES IMAGERY TO DERIVE COASTAL DUNE TOPOGRAPHY

Olivier Burvingt, University of Bordeaux, olivier.burvingt@u-bordeaux.fr
Bruno Castelle, University of Bordeaux, bruno.castelle@u-bordeaux.fr
Vincent Marieu, University of Bordeaux, vincent.marieu@u-bordeaux.fr

INTRODUCTION

Topographic data are widely used to monitor morphological changes over coastal areas and can be collected through different methods and techniques. DGPS data (Harley et al., 2011), airborne LiDAR data (Sallenger et al., 2001), and more recently, satellite imagery (Almeida and al., 2019) can be used to derive Digital Elevation Models (DEMs) for coastal studies. DEMs- derived from DGPS data have usually the best resolution (± 50 cm) and vertical accuracy (± 3 cm), but have a small beach coverage (few kilometers). Airborne LiDAR data offers a relatively good spatial resolution (1 m), an average vertical accuracy (± 10-15 cm) and cover hundreds of kilometers but are costly and thus cannot be often carried out. Until recently, the spatial resolution of satellite imagery was not adapted to study meter scale morphological changes in coastal studies. The emergence of high spatial resolution imagery captured by satellites such as Pleiades-1, WorldView 2/3/4, GeoEye-1, etc. offers the opportunity to study coastal topographic changes with a relatively good resolution (from 0.5 to 1 m) over large spatial areas and at repeated times. The potential use of Pleaides satellite images to monitor coastal dune topographic changes along the south west coast of France is explored here.

METHODS

Several photogrammetry tools and softwares were developed to derive DEMs from satellite stereo image pairs, such as Ames Stereo Pipeline (Shean et al., 2016), MicMac (Rupnik et al., 2017), Agisoft Metashape (Lastilla et al., 2020), and CARS (Michel et al., 2020). These pipelines include different processing steps such as image preprocessing, integer image correlation, sub-pixel disparity refinement, disparity filtering, etc. Using DGPS ground control points, the obtained DEMs were post-processed by applying simulated annealing techniques to implement planimetric and altimetric corrections. Four diverse stretches of dunes that are 10 km long and located along the open and energetic coast of Gironde in SW France were selected as study sites (Figure 1). One DEM was produced at one of these four study sites using the four different tools for one stereo pairs of Pleiades images acquired in 2017. The vertical accuracy of the satellite-derived DEM was assessed by comparing it to one DEM derived from airborne LiDAR data collected a couple of weeks before at the same study site.

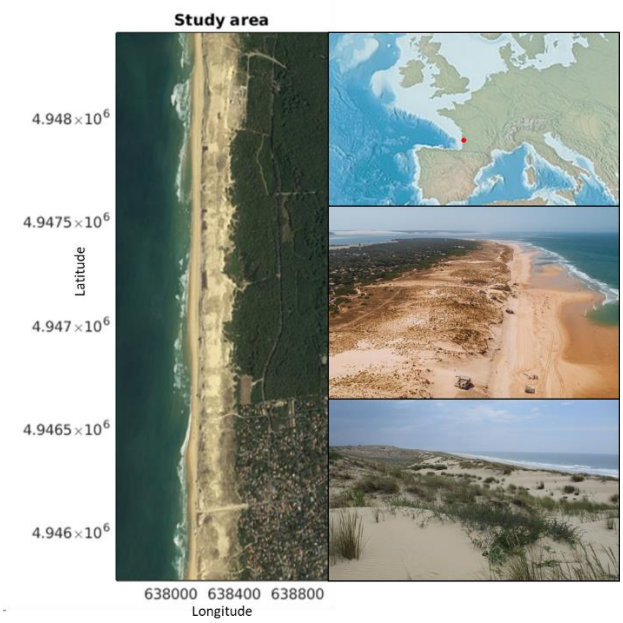

Figure 1 – Location and aerial/ground photography of the first study site at Cap Ferret (Gironde, SW France).

RESULTS

The spatial distribution and the quantity of ground control points required to perform altimetric and planimetric corrections, and their impact on the accuracy of the resulting DEMs will be presented at the conference. Among the four pipelines tested here, the Ames Stereo Pipeline provided the most accurate results when comparing the topographic values derived from the satellite DEMs to the ones derived from airborne LiDAR data at the first study site (R = 0.98; RMSE = 0.53 m) (Figure 2). Results show that the highest errors can be observed at the steepest parts of the dunes, corresponding to the face and lee side of the dune (Figure 2), and giving insight on how photogrammetry tools can be improved. The exact same analysis will be carried out at the three other study sites and on other Pleiades images acquired in 2018 and 2021 to statistically define which pipeline provides the most accurate DEMs, and to verify if similar accuracy is obtained from different satellite images over diverse stretches of coastal dunes. Alike the first analysis presented here, airborne LiDAR datasets collected in 2018 and 2021 will served as references to determine the vertical accuracy of the satellite-derived DEMs.

CONCLUSIONS

The preliminarly results of this study shows that the vertical accuracy of high-resolution optical Pleiades imagery can reach 50 cm using the Ames Stereo Pipeline, suggesting

that Pleiades imagery could represent a cost-effective and time-efficient complementary alternative to traditional on-site methods such as airborne LiDAR data. Although the vertical accuracy of satellite-derived DEMs remains significantly smaller than the accuracy of airborne LiDAR data, satellite imagery offers both repeatability and scalability, which can represents a strong advantage for large scale coastal studies.

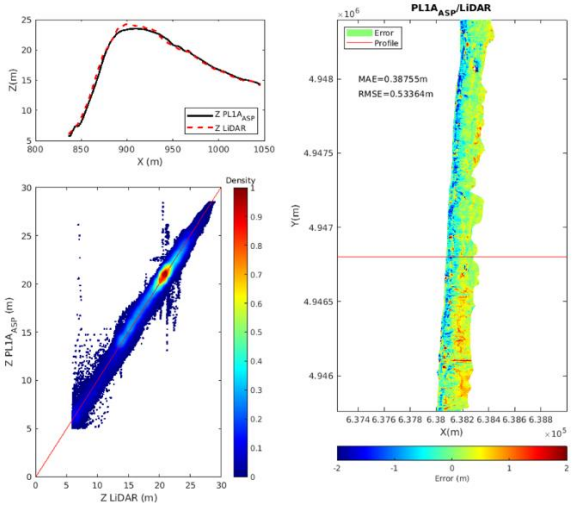

Figure 2 – Example of two dune profiles extracted from the satellite-derived and the airborne LiDAR DEMs (upper left panel). Comparison of all the dune topographic values of the satellite-derived and the airborne LiDAR DEMs, the colorscale indicating the density for each value (lower left panel). Difference of the satellite-derived and the airborne LiDAR DEMs showing errors on a colorscale comprised between -2 and 2 m (right panel).

REFERENCES

Harley, Turner, Short, Ranasinghe (2011): A re-evaluation of coastal embayment rotation: the dominance of cross-shore versus alongshore sediment transport processes, Collaroy-Narrabeen Beach, SE Australia. J. Geophys. Res. Earth 116, F04033.

Sallenger, Krabill, Swift, Brock (2001): Quantifying hurricane-induced coastal changes using topographic lidar. Coastal Dynamics '01 Proceedings. American Society of Civil Engineers, Reston, Virginia, USA, pp. 1007-1016.

Almeida, Almar, Bergsma, Berthier, Baptista, Garel, Dada, Alves (2019): Deriving High Spatial-Resolution Coastal Topography From Sub-meter Satellite Stereo Imagery. Remote Sensing, vol. 11, 590.

Rupnik, Daakir, Pierrot Deseilligny (2017): Micmac – a free, open-source solution for photogrammetry. Open Geospatial Data Softw. Stand., vol. 2 (14), pp. 1-9.

Lastilla, Ravanelli, Crespi (2020): First test of Agisoft Metashape satellite image processing for DSM generation: A case study in Trento with Pléiades imagery. Proceedings of IEEE International Geoscience and Remote Sensing Symposium, pp. 897-900.

Michel, Sarrazin, Youssefi, Cournet, Buffe, Delvit, L'Helguen (2020): A new satellite imagery stereo pipeline designed for scalability, robustness and performance. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. 2, pp. 171-178.

Shean, Alexandrov, Moratto, Smith, Joughin, Porter, Morin (2016): An automated, open-source pipeline for mass production of digital elevation models (DEMs) from very-high-resolution commercial stereo satellite imagery. ISPRS Journal of Photogrammetry and Remote Sensing, vol. 116, pp. 101-117.