River morphological changes detection from drone and radar satellite data

INTRODUCTION

The evaluation of morphological changes occurring in the river channel over space and time is essential to understand rivers' behaviour and support sustainable river management.

Today, a wide range of remote sensing techniques and established methodology are available to quantify channel dynamics. However, due to the costs and logistic complexity these river surveys have often been limited in space and time.

Here, we investigate the potential of radar satellite data to retrieve an indication of the processes occurring within the river channel (such as erosion or deposition) that may occur on a big river (channel width > 20 m) after an important event that caused significant changes. Space-borne synthetic aperture radar (SAR) has been widely used to monitor changes on the earth's surface, promising to be a powerful tool to map geomorphic processes. We exploit radar data collected from Sentinel-1 mission, freely available with a return time of about 5 days in our study area.

Our first attempts show good potential to map morphological changes of the river bar at event vs. seasonal scales, by exploiting time series of coherence estimates between SAR images and backscattering intensity of the radar signal.

STUDY AREA

The site under study was selected along the Po river, in northern Italy. It is characterized by an active and large exposed sediment bar, close to *Isola S. Antonio* hydrological station. Here, we collected UAV images in September 2017 and September 2018.

In March 2018 a big flood caused an avulsion and a new secondary channel was opened. Through the year the bar was periodically inundated and then dried up in the later season.

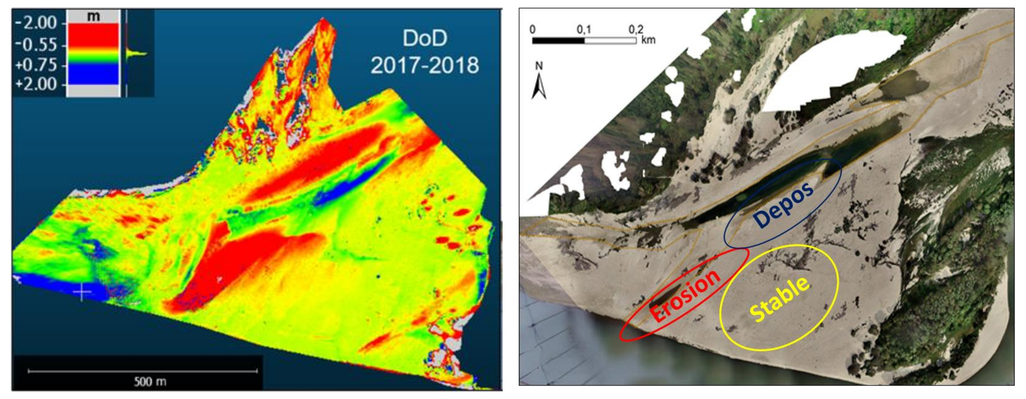
Site under study. Images from planet.com

METHODS

Ground truth data

UAV acquisition

2017-2018



Identification of three distinct areas:

- *Erosional* area: elevation change < - 0.5 m;
- *Depositional* area: elevation change > + 0.5 m;
- *Stable* area: elevation change between 0 and ± 0.4

Satellite data

Sentinel-1 radar data download (IWC, SCL product)

Pre-processing

Geocoded radar data in both polarization (VV, VH), ascending orbit

Masks on the three distincted zones

Maps generation

Coherence analysis: combination of all possible images pairs through a year (October 2017 – October 2018).

Intensity analysis: Spatial distribution of the intensity values on the river bar, comparison between pre-event images and post-event images.

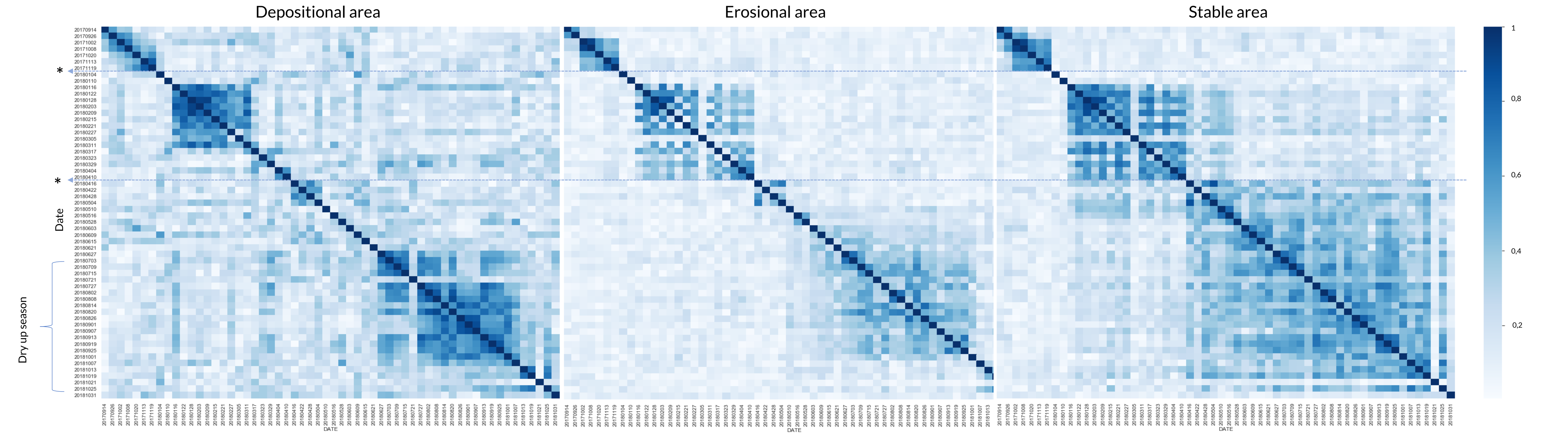
Outputs

Morphological changes?

Qualitative validation using high resolution RGB images, hydrological and metereological data

PRELIMINARY RESULTS

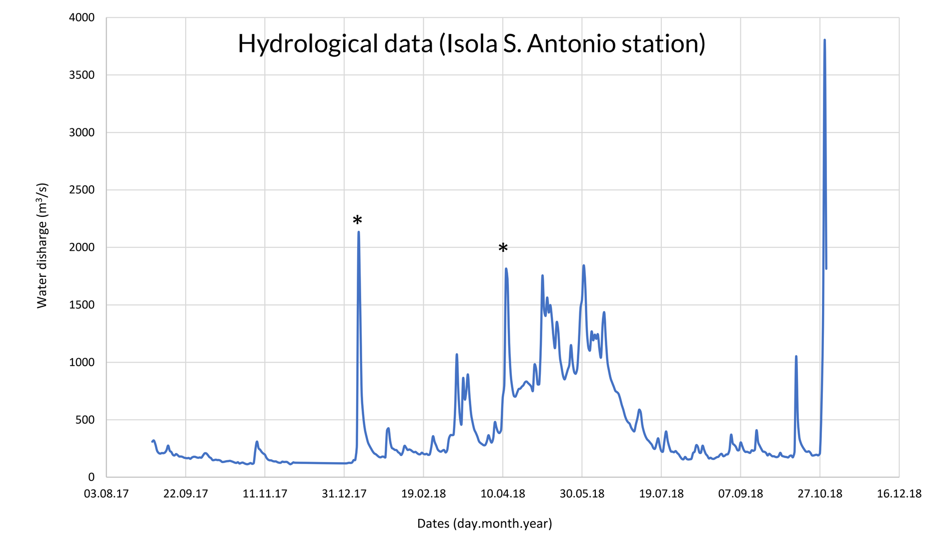
Coherence Analysis



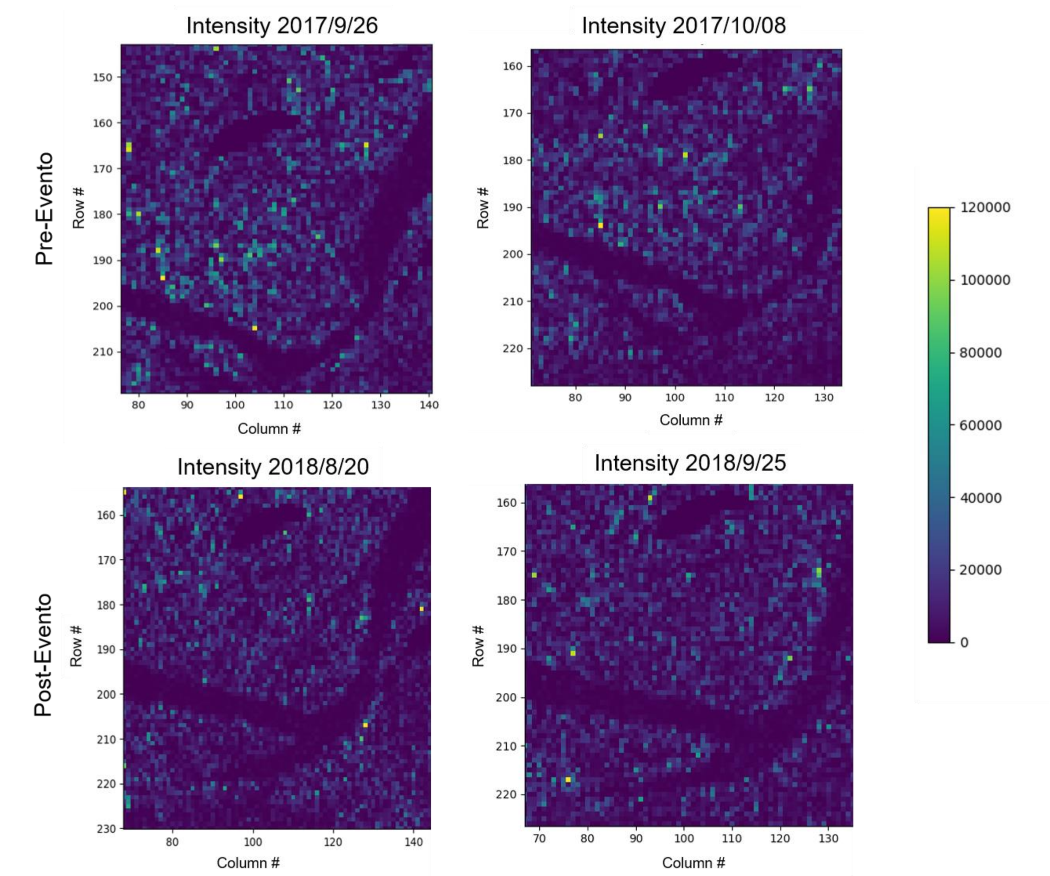
Coherence map: each pixel of the map (one for each area) represents the coherence value between the corresponding dates in the axes. The map is simmetric, along the diagonal is the coherence of one image with itself. In dark blue, coherence values close to 1, are those pixels where the condition of the bar was 'similar' in the two dates considered. Low coherence values (lighter color), instead, indicate that the condition of the bar was somehow different in the two dates considered.

- These maps are useful to study the intra-annual and seasonal differences throughout the year in the selected areas of the bar. For instance, it can be noted that the 'Stable' area remained stable (high coherence) for a longer time period. Indeed, was the less inundated area of the bar.

- Detection of specific days where a coherence loss occurred and identification of the possible causes, with the support of additional data such as high-resolution optical images and hydrological data.



Intensity Analysis



Overall decrease in the pixels intensity values of the bar in the post-event dates, in comparison to the pre-event dates. The monthly variation in pixel intensity is lower than the the variation in a year. However, several factors canmodify the backscattered signal.

So far:

- We exclude that the intensity decrease is due to soil moisture linked to previous precipitation, because the Sentinel 1 images were selected avoiding days following rainy times;
- We exclude an important contribution of the vegetation growth in the modification of the intensity values.

By comparing the ortophotos it is evident that the vegetation coverage on the bar is almost the same at a distance of a year.

CONCLUSION

The high revisit time and the low cost of the Sentinel-1 satellite data open up the possibility to observe not only intra-annual and seasonal differences during a given year but also morphological activity over multiple years. This approach is promising to develop proxies of river morphological processes that can support the understanding of their distribution and drivers through space and time. Further analyses are needed, by exploiting both the coherence and the intensity data of the radar signal, to discriminate the different contributions to the radar signal and confirm the connection with morphological changes.

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