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Temporal Stack Speckle and Target Filtering for Environmental Applications

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► **To cite this version:**

Florent Michenot, Régis Guinvarc'H, Laetitia Thirion-Lefevre. Temporal Stack Speckle and Target Filtering for Environmental Applications. IGARSS 2022, Jul 2022, Kuala Lumpur, Malaysia. 10.13140/RG.2.2.27304.44804 . hal-03771847

HAL Id: hal-03771847

<https://centralesupelec.hal.science/hal-03771847>

Submitted on 7 Sep 2022

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Introduction

- SAR images affected by speckle and ephemeral targets
- Spatial speckle filtering degrades spatial resolution
- **Objective:** filter both from individual images in a temporal stack
 - Modified Frozen Background Reference (FBR) algorithm
 - Temporal interpolation after removal of anomalous dates
- Intensity-only images, for now

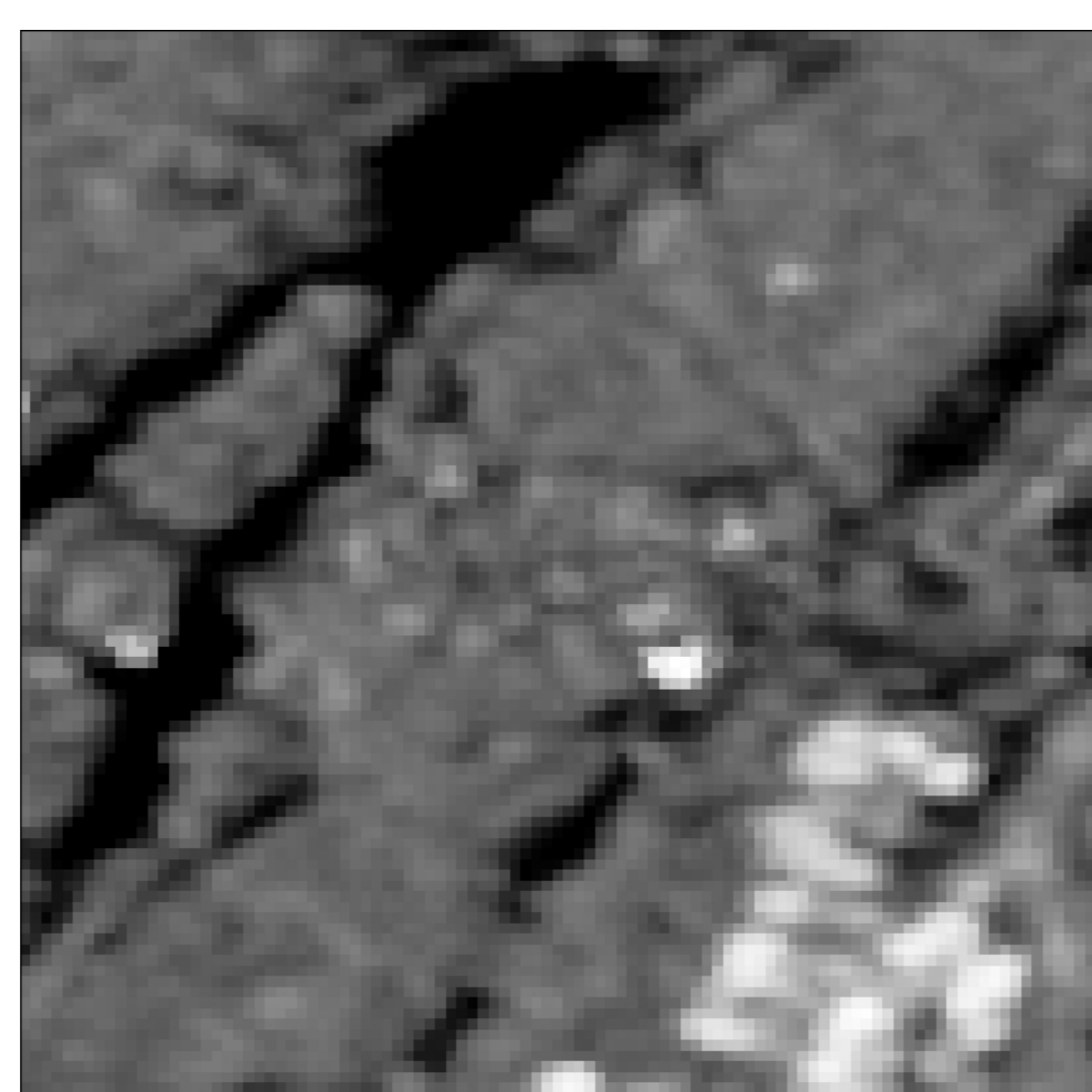
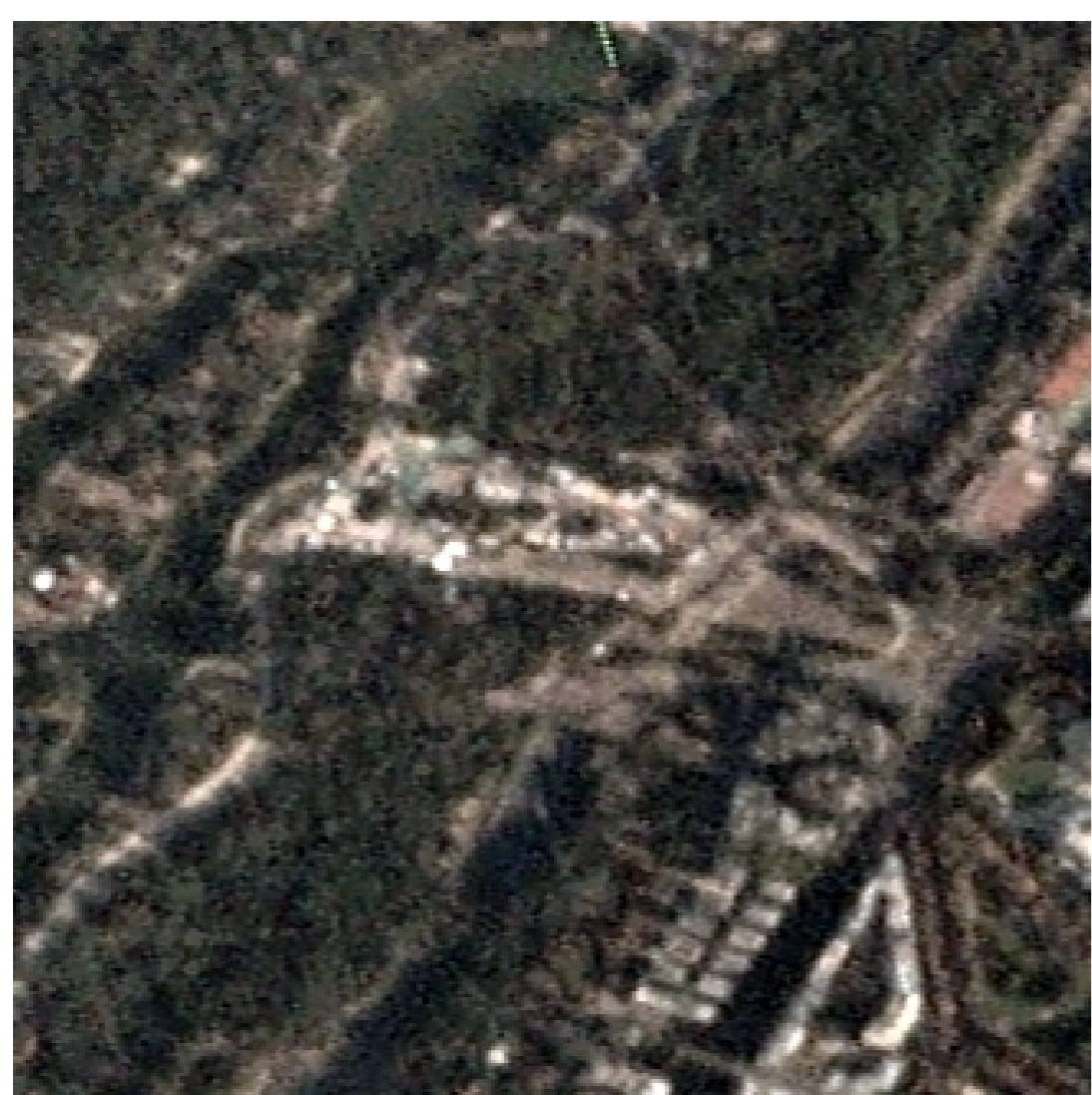


Figure 2: SAR temporal mean over the "Pelouse de la Murette" (ascending VV, 30 dates).

Figure 1: Optical images of the "Pelouse de la Murette": (top) without the fair (2020/04/24). (bottom) with the fair (2020/09/13) © Planet Labs PBC [1]

Method

- Frozen Background algorithm [2] (FBR): thresholding on temporal coefficient of variation (CV)
- Theoretical threshold γ from [3], constant over the stack, function of the Equivalent Number of Looks L (ENL):

$$\gamma = \sqrt{\frac{\Gamma(L)\Gamma(L+1)}{\Gamma(L+1/2)^2}} - 1$$

- Temporal interpolation: conservation of temporal trend
- Different behaviors depending on whether the temporal mean is recomputed at every iteration or not (Fig. 3)

Temporal profile for a pixel of interest (Ascending, VV, dB)

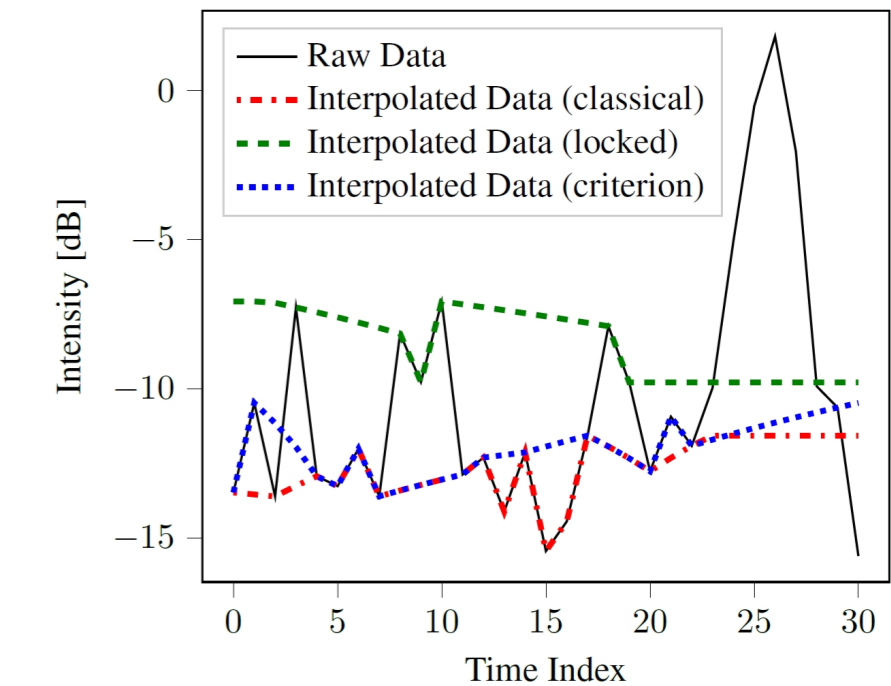


Figure 3: The temporal profile for one pixel and the output profiles for different mean recomputation settings.

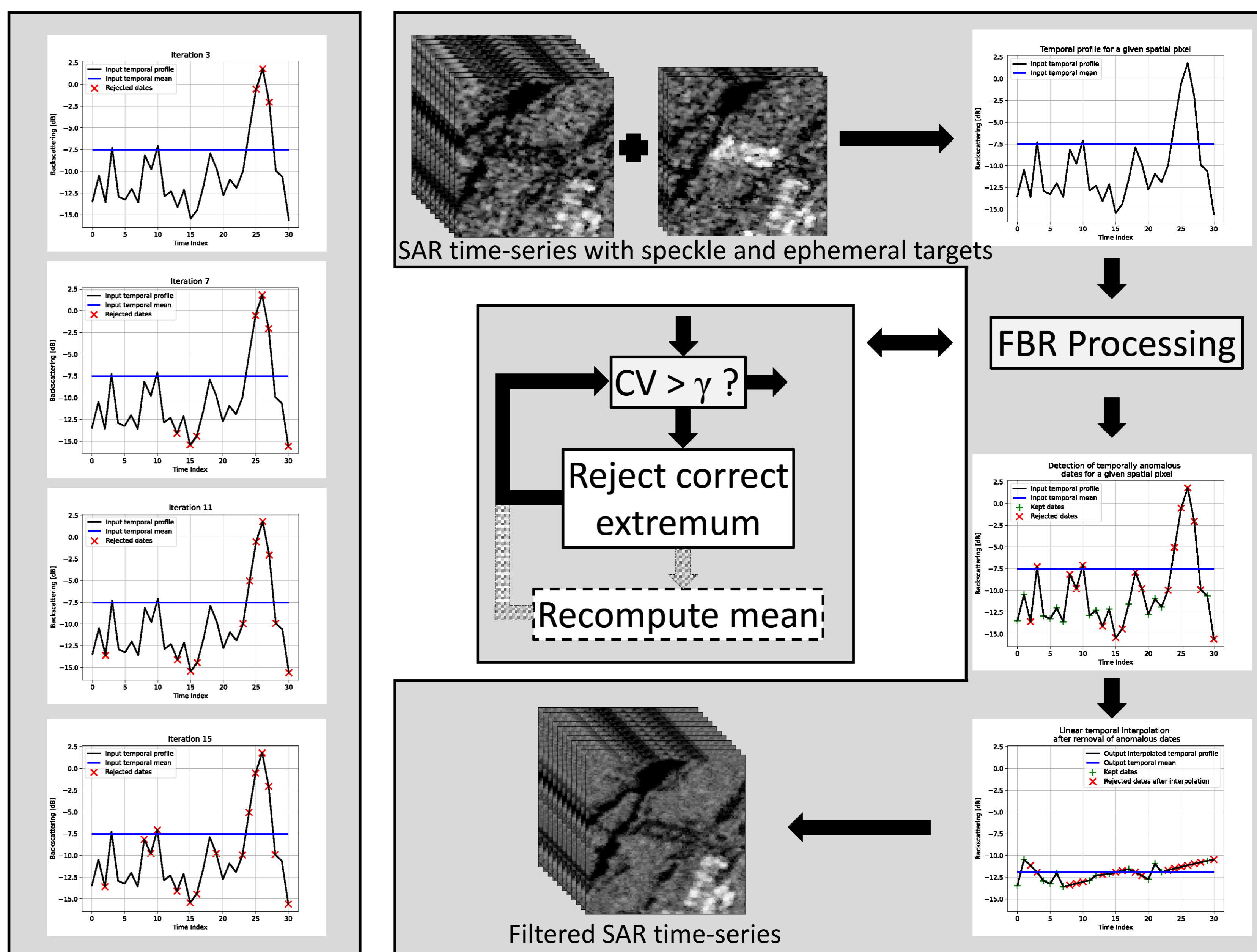


Figure 4: Graph of the process, applied to the "Pelouse de la Murette". The temporal profile plotted is for an individual pixel affected by the fair (peak on the right).

Application: Pelouse de la Murette, Paris, France

Area of interest:

- "Pelouse de la Murette", western part of Paris, France
- A fair takes place there for less than **2 months** every year
- Temporal stack of 30 Sentinel-1 images (ascending pass, VV polarisation) covering **one year**
- Two images taken from the input stack (Fig. 5a and 5b), along with their output images (5c and 5d)

Target and speckle filtering:

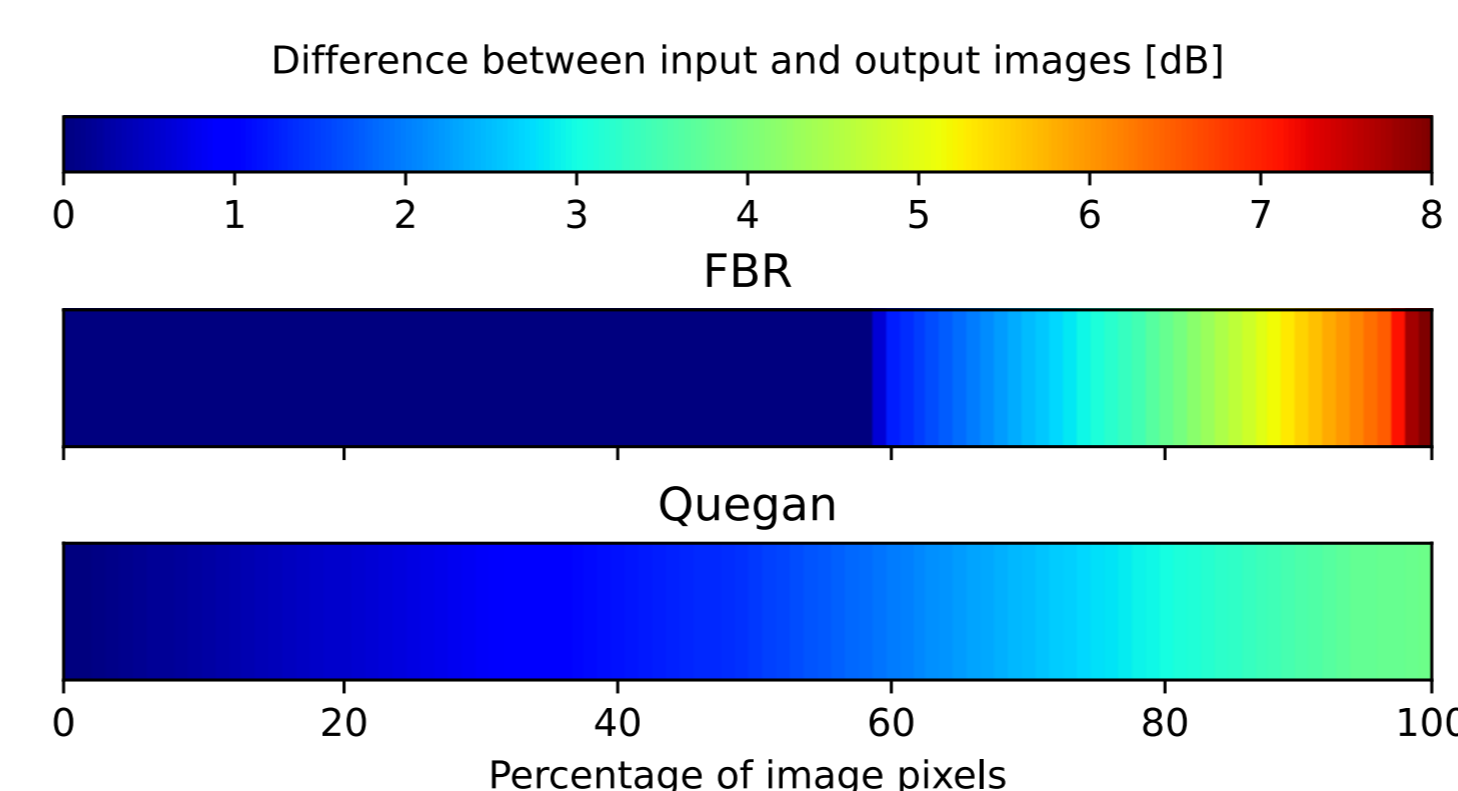


Figure 6: Difference (in dB) between input and output images. The large dark blue area shows the high percentage of pixels that are unaffected by the algorithm. Quegan filter [4] for reference.

Temporal trends conservation:

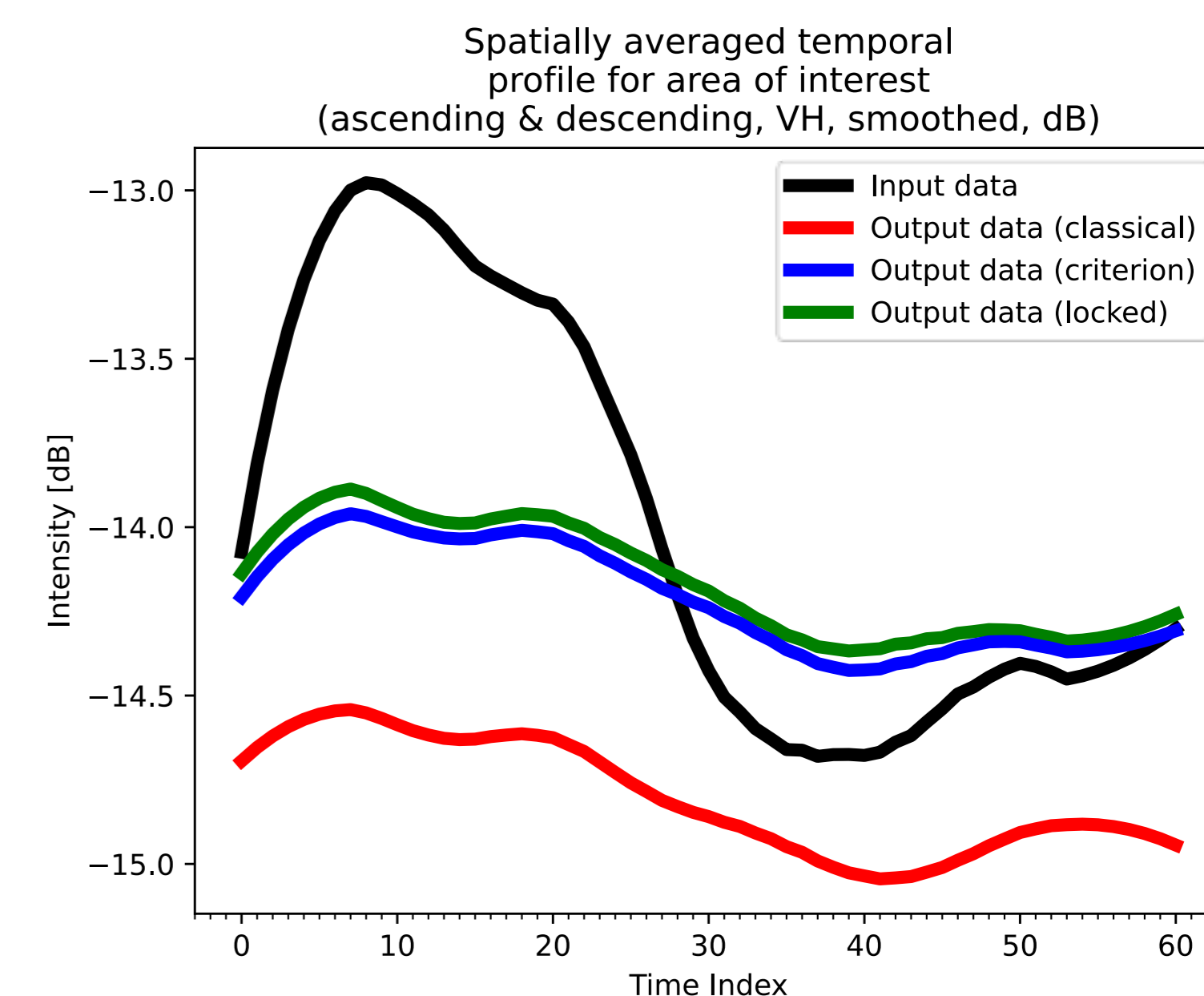


Figure 7: Temporal profile of forested area of interest (ascending and descending VH, 30 dates each, smoothed).

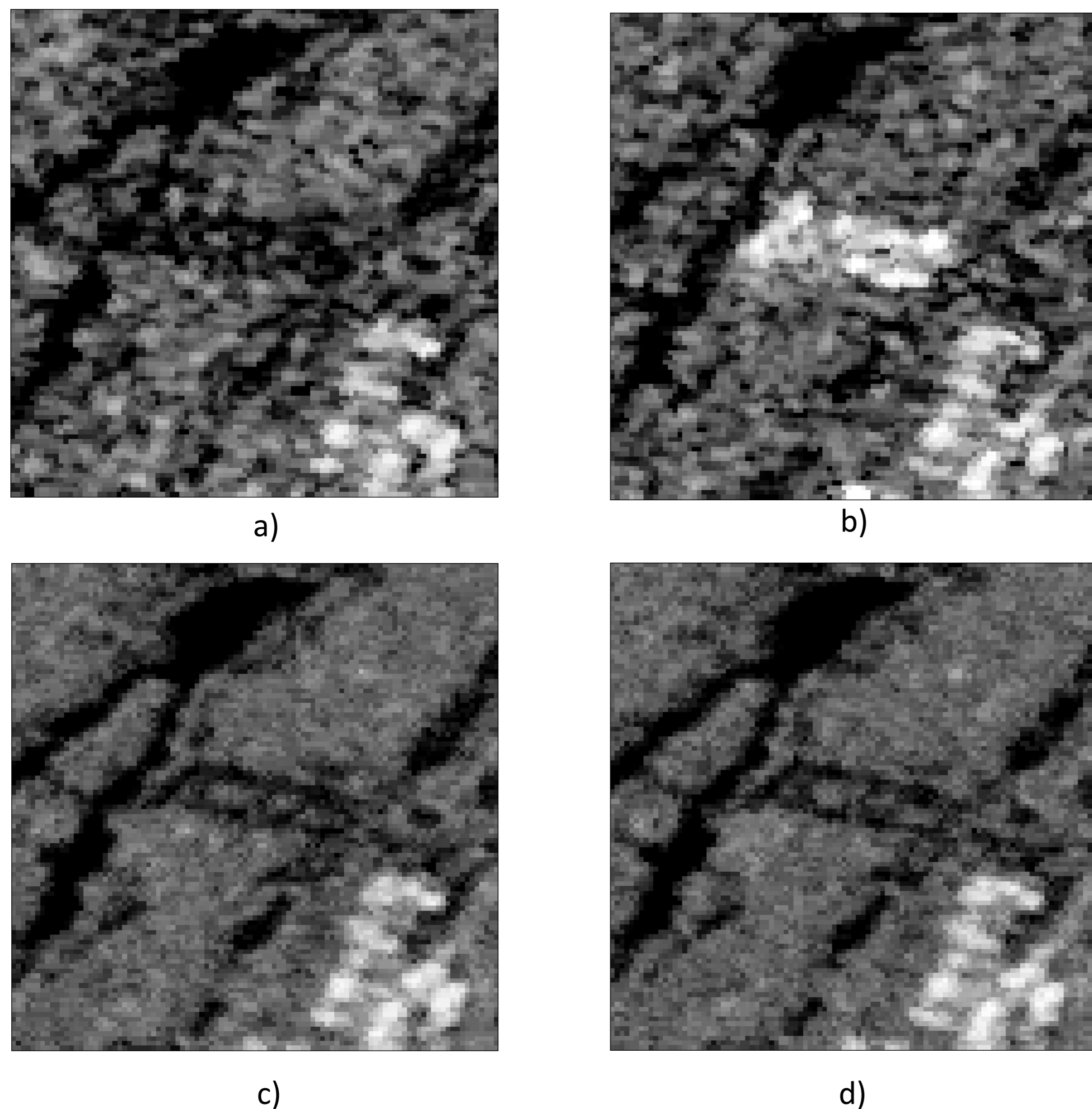


Figure 5: SAR images of the "Pelouse de la Murette": (a) taken on 2020/04/22, ascending VV, without the fair. (b) taken on 2020/09/13, ascending VV, with the fair. (c) output of (a), mostly speckle reduction. (d) output of (b), speckle reduction and removal of the fair

Conclusion

- Speckle and ephemeral target filtering over SAR time-series
- Conservation of spatial resolution
- Conservation of temporal trends (FBR over window)
- Intensity-only, phase (or phase difference) of rejected pixels could be interpolated
- Ephemeral targets could be reintroduced, if discriminated from speckle

References

- [1] Planet Team, "Planet Application Program Interface: In Space for Life on Earth," 2017–.
- [2] Thibault Taillade, Laetitia Thirion-Lefevre, and R gis Guinvarc'h, "Detecting ephemeral objects in SAR time-series using frozen background-based change detection," Remote Sensing, vol. 12, no. 11, pp. 1720, 2020.
- [3] Elise Colin Koeniguer and Jean-Marie Nicolas, "Change detection based on the coefficient of variation in SAR time-series of urban areas," Remote Sensing, vol. 12, no. 13, 2020.
- [4] Shaun Quegan, Thuy Le Toan, Jiong Yu, Florence Ribbes, and Nicolas Floury, "Multitemporal ERS SAR analysis applied to forest mapping," IEEE Transactions on Geoscience and Remote Sensing, vol. 38, no. 2, pp. 741–753, 2000.