ANALYSIS OF THE CONTRIBUTION OF POLARIMETRIC PERSISTENT SCATTERER INTERFEROMETRY ON SENTINEL-1 DATA FOR DEFORMATION MEASUREMENT

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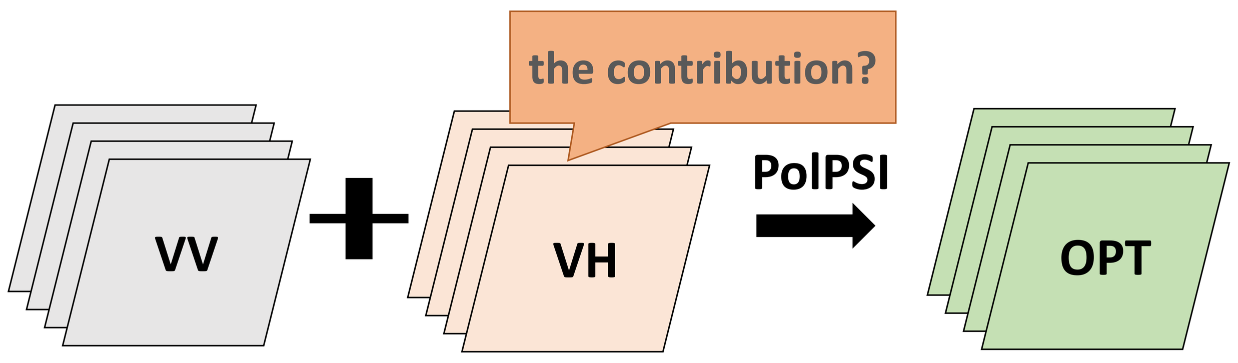
Introduction

Sentinel-1 (S1) images include two polarimetric channels :

VV — Most works in monitoring displacements of the Earth surface only use VV channel

VH — VH channel is discarded for its lower amplitude

Thanks to the development of polarimetric persistent scatterer interferometry (PolPSI) methods, we can integrate multi-polarisation channels into a single optimal (OPT) one.



The obtained OPT channel can be used in practical applications including deformation monitoring

Objectives

For exploiting the contribution of VH channel, we try to answer the following questions by using 4-5 years S1 data sets over Barcelona, Alcoy and Murcia :

1. **How does the VH channel in S1 data help increase the PS density?**
2. **What are the impacts of the improvement of PS points?**
3. **Is the contribution general for different scenarios or just particular of some cases?**

Method

1. For each pixel in S1 images, a vector k is defined as

$$k = [VV, VH]^T \quad (1)$$

2. With complex weight vector ω, PolPSI methods can project each vector k into a new scalar μ (OPT channel)

$$\mu = \omega^{*T} k = [\omega_1, \omega_2] k \quad (2)$$

$$OPT = \omega_1 \, VV + \omega_2 \, VH$$

Find the unknown parameter according to Eq.(3)

3. Searching for the optimum parameters in ω to minimise the selection criterion D_A, which is calculated for the whole stack of single look images

$$D_A = \frac{\sigma_a}{\bar{a}} = \frac{1}{\overline{|\omega^{*T} k|}\sqrt{N-1}} \sqrt{\sum_{i=1}^{N} (|\omega^{*T} k_i| - \overline{|\omega^{*T} k|})^2} \quad (3)$$

σ_a-standard deviation ; $\bar{a}$ -mean value; N-Number of images

4. Points with DA lower than an established threshold will be selected as persistent scatterer candidates (PSC)

5. Employed PSI processing method coherent pixels technique (CPT) for getting deformation result

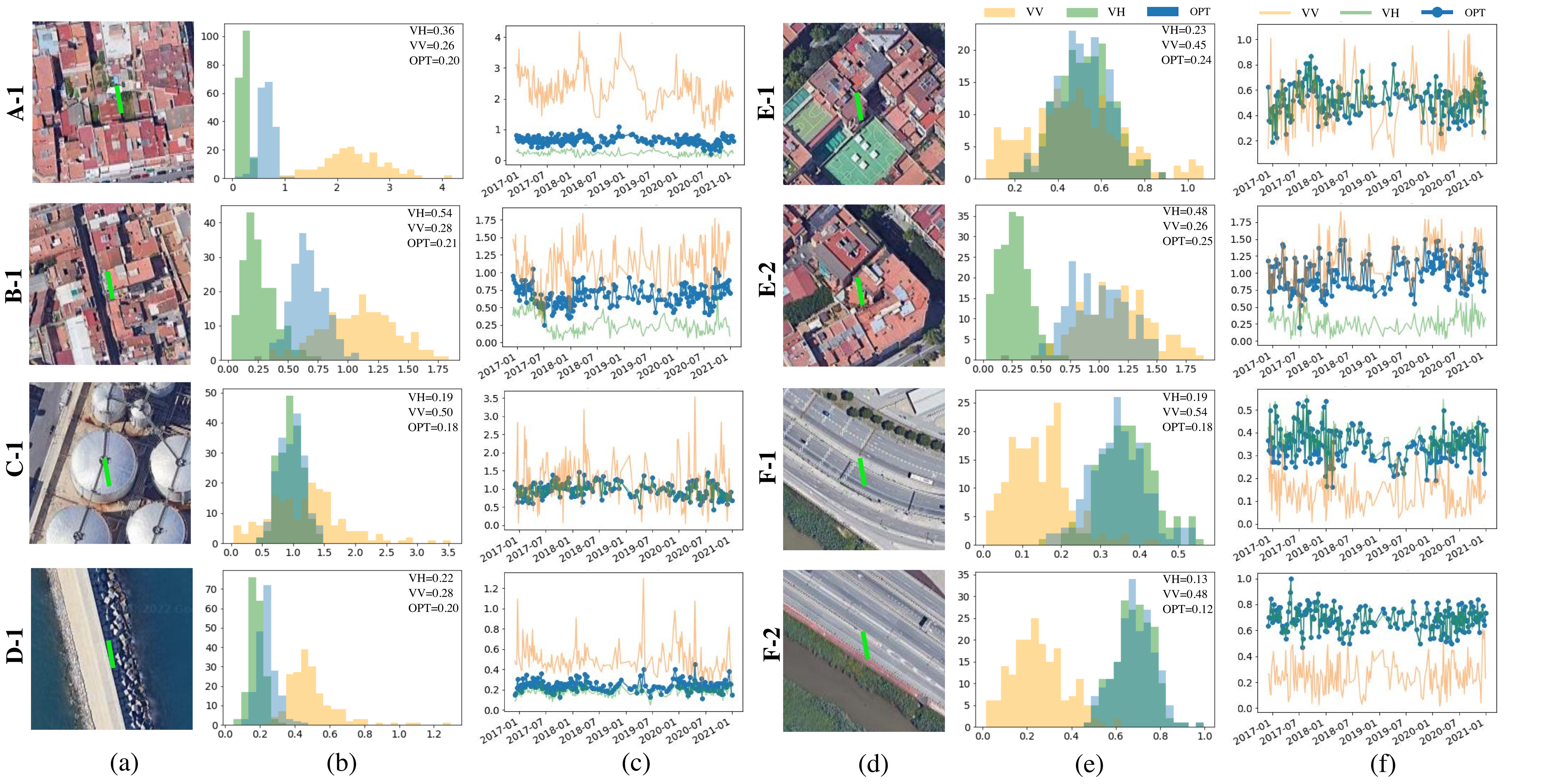


Figure 1. Selected pixels over Barcelona. (a)(d) Corresponding ground target on optical image; (b)(e) Histogram of amplitude and DA value for each channel; (c)(f) Time series of amplitude.

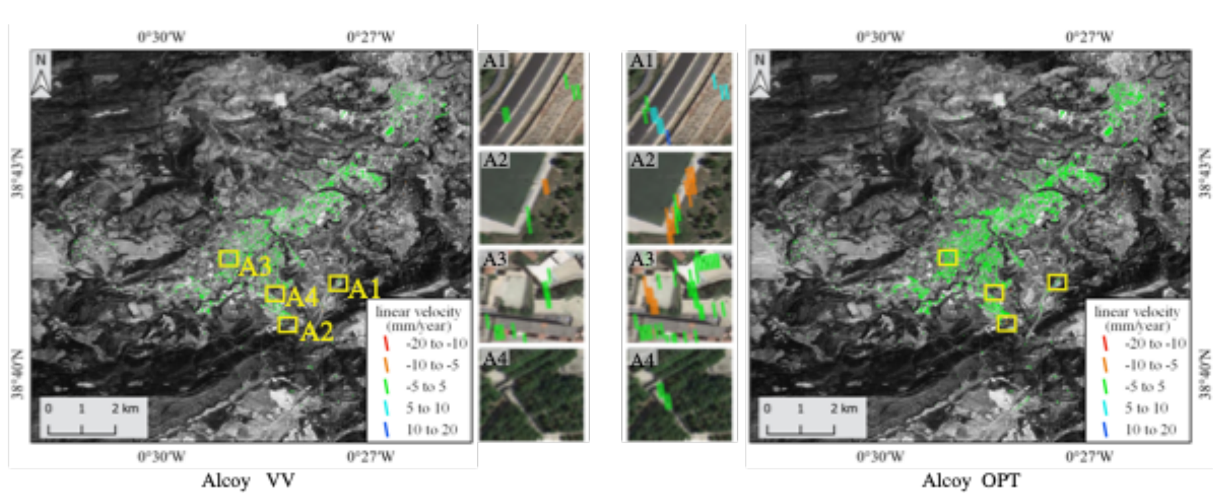


Figure 2. Linear velocity maps for VV and OPT channels over Alcoy.

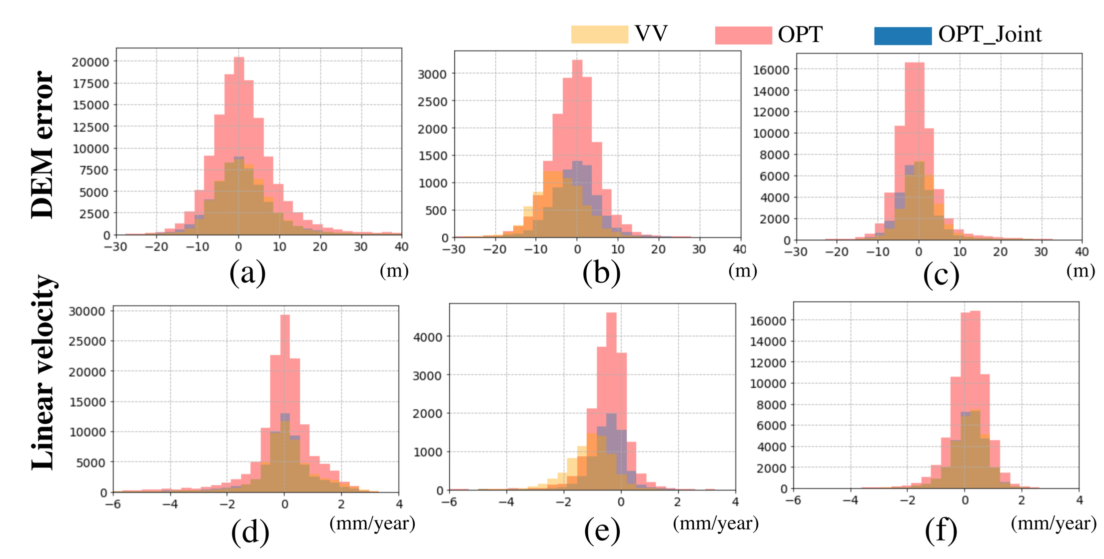


Figure 3. Histograms PS points selected in VV or OPT channel. Joint means PS points selected both in VV and OPT channel. (a) and (d) for Barcelona, (b) and (e) for Alcoy, (c) and (f) for Murcia

Results

1. Associating the increased PS points with physical features

we marked eight pixels in six small areas in Figure. 1
Area A–D : the response of the VV is much higher than the VH, but VH still contributes to increase the number of PS points, because VH offers an enhanced stability of this kind of pixels, for example in A-1, B-1 (Buildings with orientation parallel to the radar flight direction) and C-1, D-1 (Isolated peaks)
Area E, F : the response of the VV is similar or even smaller than VH, most of the points in this area benefit from the increased mean amplitude (F-1, F-2), while some points benefit from the stable response of VH channel (E-1).

2. Deformation results

Deformation areas in Alcoy city are quite isolated. After using the OPT channel, the density of pixels have increase and the deformation estimates are more reliable in Figure 2.
In Figure 3 both VV and OPT provide same distributions for Murcia and Barcelona.
In Alcoy, the direct consequence of the sparse network built by linking all selected pixels is that histograms of both DEM error and velocity in VV channel do not follow a Gaussian distribution with zero-mean.

Conclusions

The tests carried out have allowed us to answer the questions stated in 'Objective':

1. **Two cases**
   a. **VH response is high (scatterers rotated with respect to the incidence plane),**
   b. **VH amplitude is low but stable (most cases).**
2. **The improvements come from**
   a. **pixel density,**
   b. **new active deformation areas,**
   c. **more reliable estimates.**
3. **The improvement has been found in three urban areas with different physical properties and deformation phenomena**

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Reference

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