# DATA QUALITY OF SENTINEL-1A IW SLC IMAGES AND ARTIFICIAL TWIN BACKSCATTERERS DESIGNED FOR 3D SURFACE CHANGE MONITORING WITH THE FUSION OF PSI AND GNSS TECHNOLOGIES

ID 995

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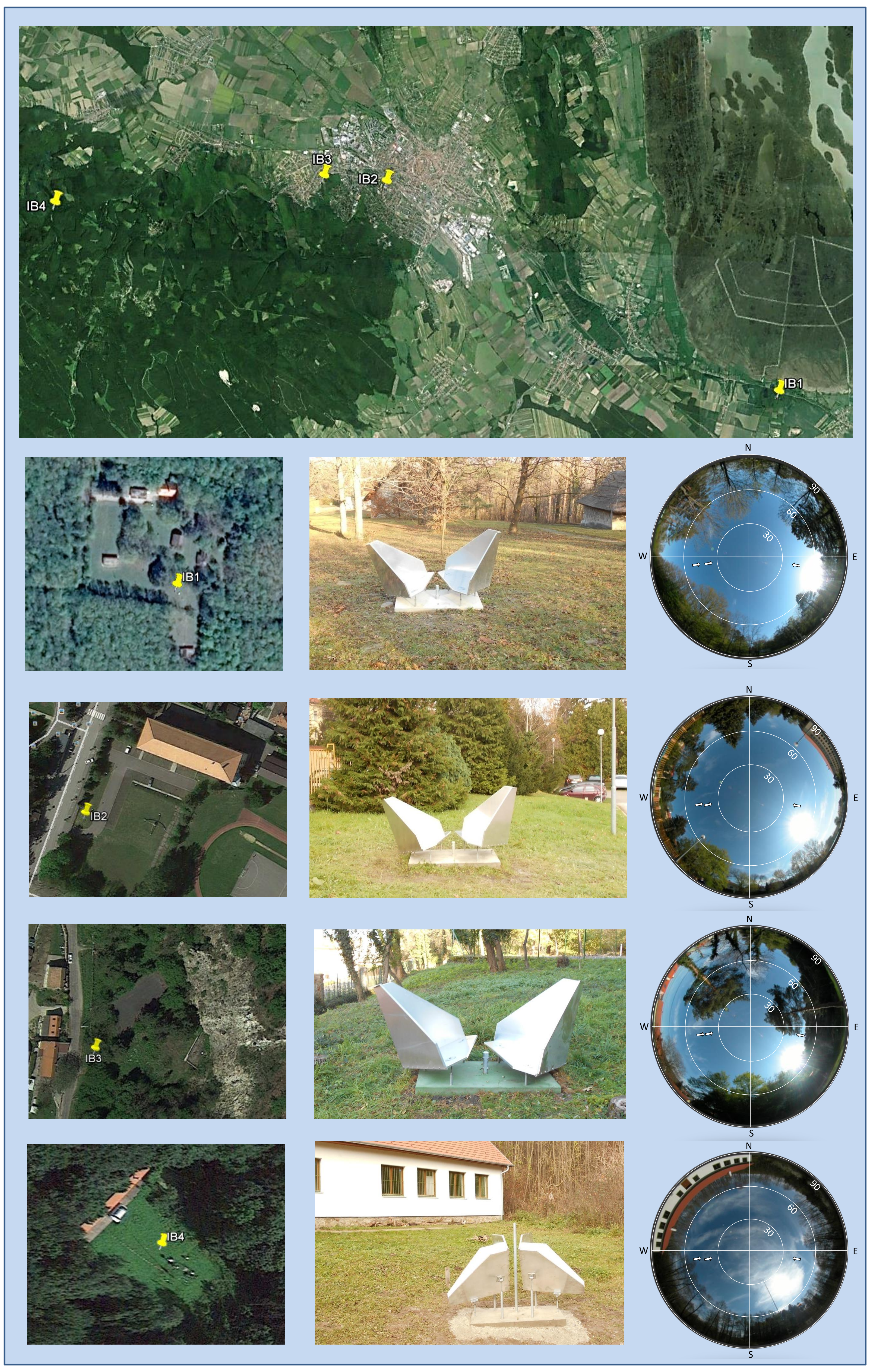
### Introduction and motivation

The proposal "Integrated Sentinel-1 PSI and GNSS technical facilities and procedures for determination of 3D surface deformations caused by environmental processes" was accepted for implementation by the ESA. The main objective of the proposal is to combine Sentinel-1 IW images processed by integrated Persistent Scatter Interferometry (Ferretti at al. 2001, Hooper et al. 2012) with additional GNSS observations on those important areas, where the use of traditional PSI methods are limited due to complex and unstable ground coverage. This problem can be handled by properly designed artificial backscatterers. If these backscatterers can be used for both ascending and descending satellite passes the vertical and east components of the displacement can be estimated (Savio et al. 2005). These estimates may be biased by the unknown north component. This limitation can be solved by integrated campaign measurements carried out by systematic GNSS observations.



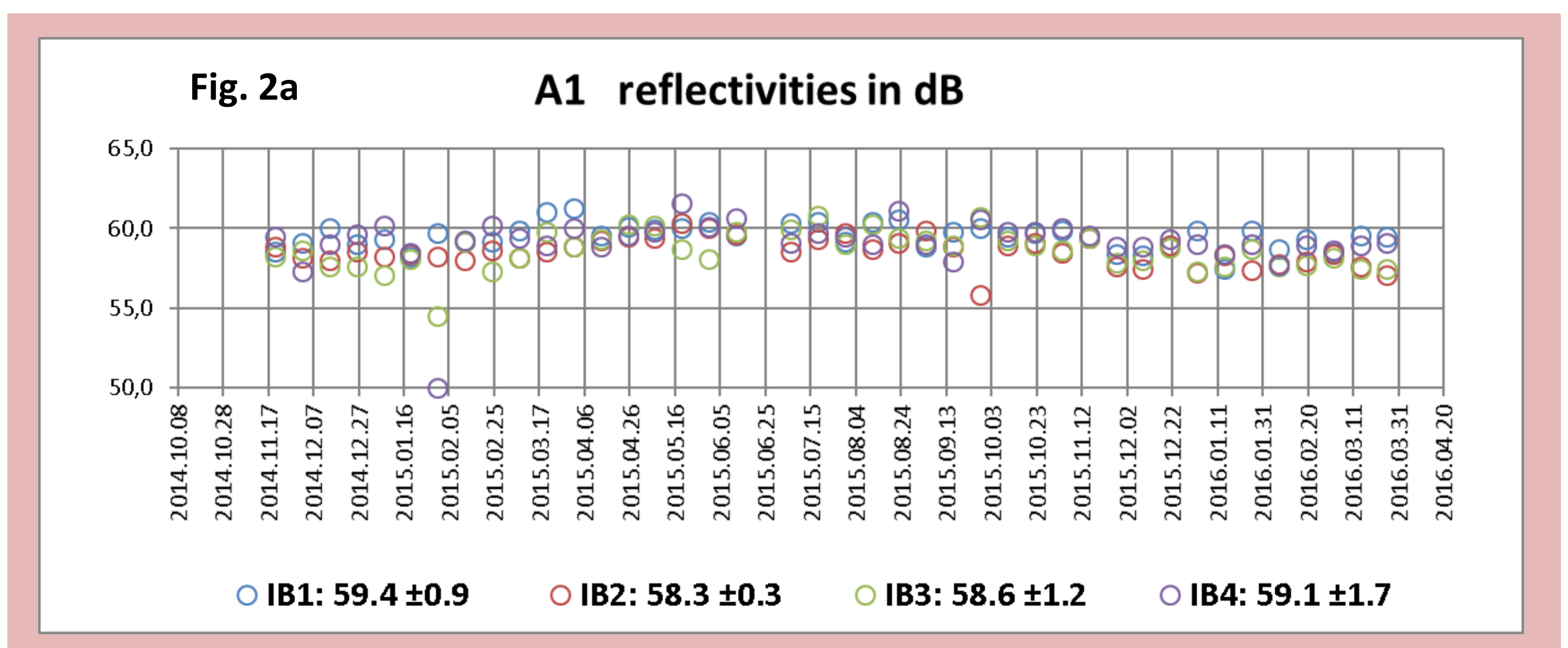


**Fig. 2a** **A1 reflectivities in dB**

○ IB1: 59.4 ±0.9 ○ IB2: 58.3 ±0.3 ○ IB3: 58.6 ±1.2 ○ IB4: 59.1 ±1.7

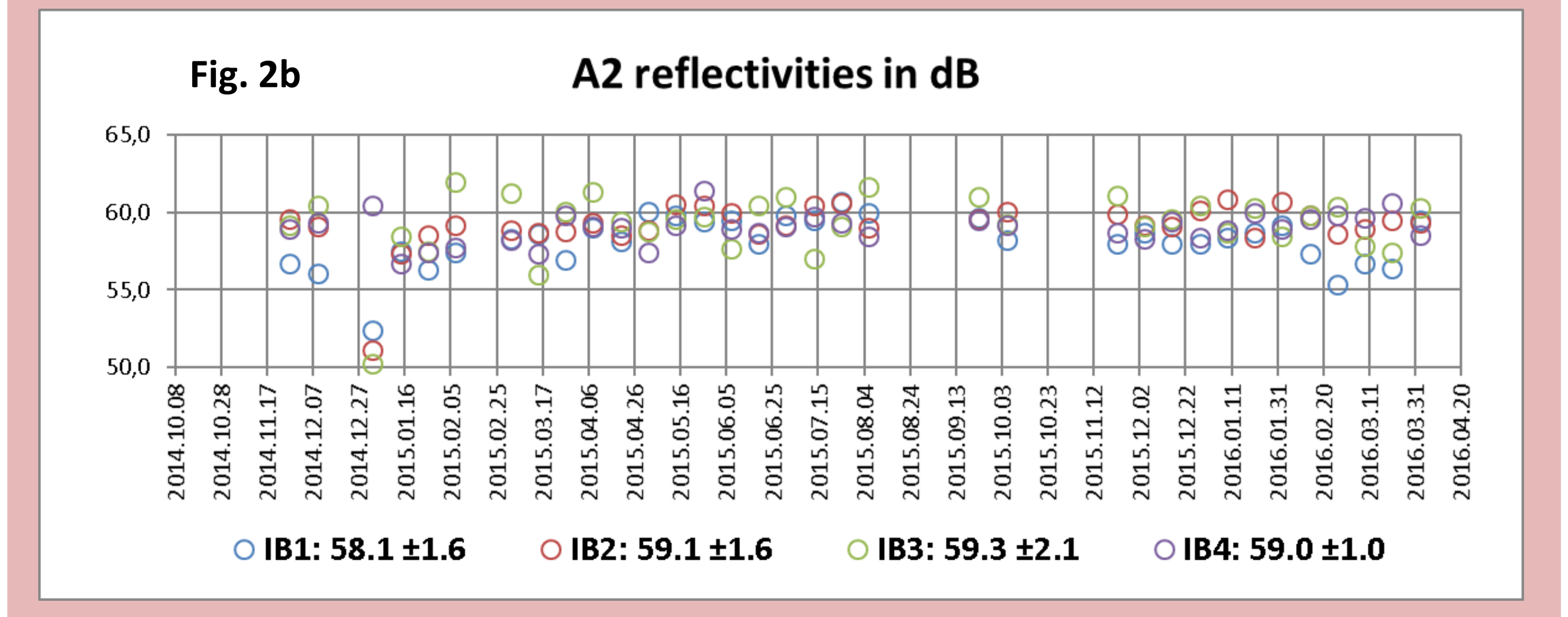


**Fig. 2b** **A2 reflectivities in dB**

○ IB1: 58.1 ±1.6 ○ IB2: 59.1 ±1.6 ○ IB3: 59.3 ±2.1 ○ IB4: 59.0 ±1.0

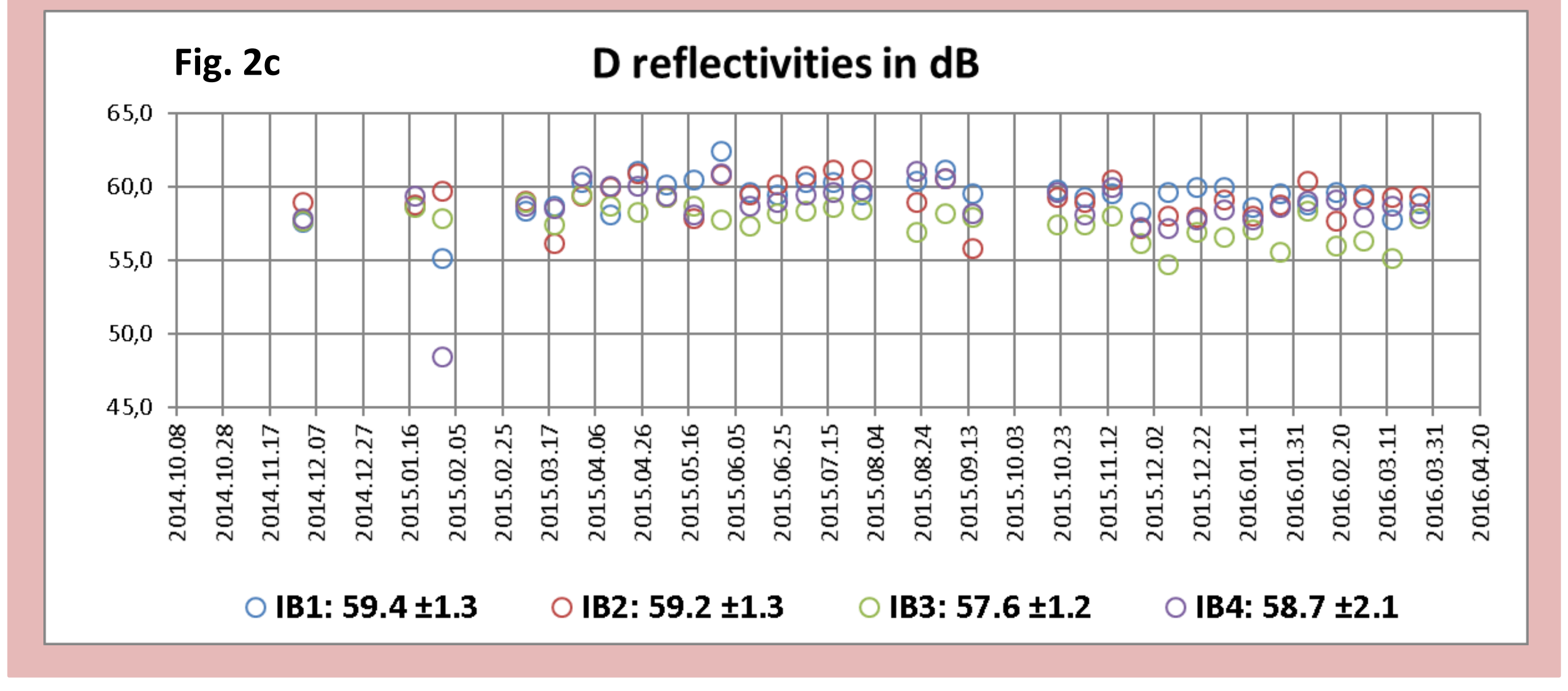


**Fig. 2c** **D reflectivities in dB**

○ IB1: 59.4 ±1.3 ○ IB2: 59.2 ±1.3 ○ IB3: 57.6 ±1.2 ○ IB4: 58.7 ±2.1

### Data and methods

In this poster the preliminary practical results of the proposal are summarized which are based on the first prototypes of trimmed twin corner reflectors (TCR) installed at the Sopron Test Network (Fig. 1). The TCRs are placed on one square meter surface of reinforced concrete block supported by adapters for GNSS, traditional geodetic and gravimetric measurements. It is called as integrated geodetic or geodynamic benchmark (IB). The TCRs are standing on three legs allowing proper orientation into the average satellite positions. They are oriented to the chosen ascending (A1) and descending (D) directions. The geometric properties and the geo referencing of IBs are controlled by predicted satellite orbits (included in SLC annotation files) and the GNSS derived coordinates of IBs given in WGS-84 coordinate system (Tables 1-4) using the method of closest approach.

The reflectivities are determined by the SNAP Sentinel-1 Toolbox provided by the ESA using the „split, deburst, spatial subset from view and upgrade geo reference" modules (Fig. 2a-c).

The interference of in front standing TCRs are numerically investigated (Fig. 3.)

**Fig. 1**

The Sopron Test Network is located in safe places covering approximately 20 Km by 5 Km area including forest and urban environment.

IB1 - Széchenyi István Geophysical Observatory (GGI)
IB2 – University of West Hungary, Informatics Institute
IB3 – Geodynamic Observatory (GGI)
IB4 - University of West Hungary, Hydrological station

The locations and IBs are showed in subsequent pictures. The arrows in fish eye photos and the Tables 1-4 show the S1-TCR azimuths, incidence angles and ranges computed in the topocentric coordinate system attached to the IBs on WGS-84 ellipsoid.

**Table 1.**

| Asc/Desc | azimut | incidence | S1 range | Δ range |
|---|---|---|---|---|
| A1 | 81º 08’ 04”<br>±02” | 45º 22’ 01”<br>±10” | 952946 m<br>±42 m | -4.9 m<br>±2.5 m |
| A2 | 79º 37’ 13”<br>±03” | 36º 41’ 28”<br>±14” | 852691 m<br>±33 m | -4.7 m<br>±1.0 m |
| D | 279º 46’ 30”<br>±02” | 40º 20’ 06”<br>±13” | 890345 m<br>±44 m | -4.3 m<br>±0.9 m |

**Table 2.**

| Asc/Desc | azimut | incidence | S1 range | Δ range |
|---|---|---|---|---|
| A1 | 81º 02’ 27”<br>±02” | 44º 52’ 23”<br>±10” | 946089 m<br>±40 m | -4.9 m<br>±2.4 m |
| A2 | 79º 31’ 27”<br>±03” | 36º 05’ 47”<br>±14” | 847045 m<br>±32 m | -4.6 m<br>±1.0 m |
| D | 279º 39’ 45”<br>±02” | 40º 50’ 20”<br>±13” | 897670 m<br>±45 m | -4.6 m<br>±0.9 m |

**Table 3.**

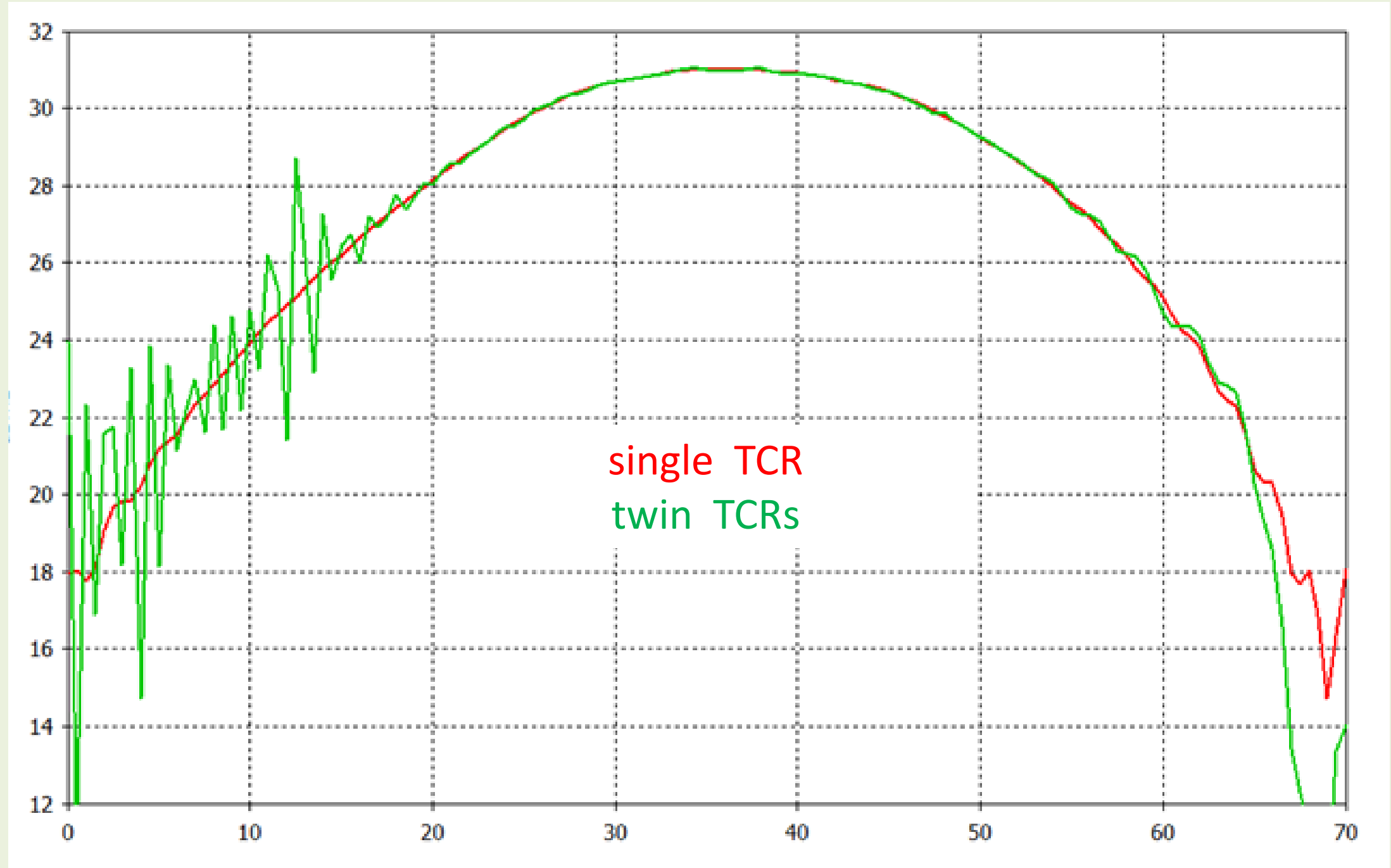
| Asc/Desc | azimut | incidence | S1 range | Δ range |
|---|---|---|---|---|
| A1 | 81º 01’ 29”<br>±02” | 44º 47’ 25”<br>±10” | 944938 m<br>±40 m | -5.1 m<br>±2.5 m |
| A2 | 79º 30’ 29”<br>±03” | 35º 59’ 42”<br>±14” | 846085 m<br>±32 m | -4.5 m<br>±1.0 m |
| D | 279º 38’ 46”<br>±02” | 41º 05’ 02”<br>±13” | 898735 m<br>±45 m | -4.4 m<br>±0.8 m |

**Table 4.**

| Asc/Desc | azimut | incidence | S1 range | Δ range |
|---|---|---|---|---|
| A1 | 80º 57’ 16”<br>±02” | 44º 25’ 29”<br>±11” | 939863 m<br>±40 m | -4.2 m<br>±2.4 m |
| A2 | 79º 26’ 13”<br>±03” | 35º 32’ 45”<br>±15” | 481839 m<br>±32 m | -3.9 m<br>±1.0 m |
| D | 279º 34’ 43”<br>±02” | 41º 28’ 34”<br>±14” | 903129 m<br>±45 m | -3.8 m<br>±1.0 m |

**Fig. 3**

Reflectivity of single and twin TCRs in dB computed in the vertical symmetric plain in function of elevation angle with respect to the ground plain of reference TCR



### Primary result and conclusions

The pixels of TCRs can be identified very easily on the VV polarised intensity images. The reflectivities of TCRs are typically 59 ±1-2 dB in VV polarization (Fig. 2a-c). The VH polarizations are significantly worse (30 ± 5 dB), sometimes the complex numbers cannot be estimated.

The identification of TCRs on the differential interferograms (using the SNAP coregistration, interferogram formation, deburst, topographic phase removal and update geo reference modules) are similar.

The geometric repeatability of SLC images are ±2-3 arcsec in azimuth, ±10-15 arcsec in incidence angle and ± 32-45 m in spatial ranges (Tables 1-4). The Δ ranges are the differences between the closes approach derived and SAR S1 spatial ranges, where no atmospheric and phase centre corrections are applied.

Since the ascending TCRs are oriented into A1 directions, the A2 images differ from the ideal case with 2º in azimuth and 9º in incidence angle, however, the average reflectivities are similar, only their dispersions are little bit worse.

In the case of IB4, the twin TCRs are back side standing, where contrary to in front standings no interference can be expected. According to Fig. 2a-c and Fig. 3 the possible interference can not be experienced. The smaller reflectivity of IB3 (Fig. 2c) is the consequence of the rock wall in east side.

These primary results prove that the prototype IBs and the stability of the Sentinel-1A images can fulfil the supposed requirements. At the moment the missing images, experienced during the test computations, seems to be major limitation, which hopefully will be mitigated when the system will be declared fully operational.

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**References**
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