

# **2020 PETRINJA EARTHQUAKE SEQUENCE: 2.5 DEFORMATION FIELD RECONSTRUCTION**

# **GEOSES PROJECT: INSAR STATUS REPORT**

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## CONTENT





# **INSAR BASICS**

### **Concepts and Applications**











### Advantages

- Submillimeter accuracy
- Various Ground-Range Resolution

Vavelength ( $\lambda$ ), cm	Frequency ( $\nu$ ), GH <sub>z</sub> (10 <sup>9</sup> cycles · sec <sup>-1</sup> )
0.8 to 1.1	40.0 to 26.5
1.1 to 1.7	26.5 to 18.0
1.7 to 2.4	18.0 to 12.5
2.4 to 3.8	12.5 to 8.0
3.8 to 7.5	8.0 to 4.0
7.5 to 15.0	4.0 to 2.0
15.0 to 30.0	2.0 to 1.0
30.0 to 100.0	1.0 to 0.3

$$\Delta arphi = egin{array}{c} 4\pi \ \lambda \ \Delta D_0 + rac{4\pi}{\lambda} \ rac{HB_{\perp}}{R\sin heta} + rac{4\pi}{\lambda} B_{//} + \Delta arphi_{atm} + + \Delta arphi_{pn} + 2n\pi \end{array}$$

- Weather and day/night independent

**Excellent tool to perform Earth Observation (EO) /** Surface deformation monitoring







## **SAR EO missions**

### Accessibility

- Commercional vs. Free-access
- On-demand vs. request vs open API

### Characteristics

- Frequency
- Ground range resolution (~2 cm ... 100 m)
- Revisiting time (standalone  $\rightarrow$  constellation)

### Characteristics

- Environmental monitoring
- Emergency observation
- Infrastructure/Industry/Defense

### **Recent study utilizes Sentinel-**1AB IW mode data











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## Input data and management

### SAR Level-1 SLC products

- Interferometric researches requires SLC products
- Copernicus Schihub (archive data on request)
- Alaska Satellite Facility (ASF) quick access

### Auxiliary data

- Digital Elevation Model (DEM) 1 arcsec
- Precise orbit data
- Ground Control Points, AOI metadata

### Softwares

- GAMMA Remote Sensing (all modules)
- ANACONDA + required packages
- PC: Ubuntu 18.04, SERVER: DEBIAN 10









### GAMMA REMOTE SENSING ANACONDA.







# 2020 PETRINJA EARTHQUAKE SEQUENCE Balint Magyar



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## Petrinja Earthquake Sequence 2020

### Started in 2020-12 and lasted Q1 of 2021, max Mw > Mw 6 in 2020-12



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### Significant human and economical losses.







## **Geological background**

























## Phase Unwrapping strategy

### 8.

- Normalized complex differential interferogram (wrapped)
- Goldstein-Werner filter (ADF kernel: 128 rng px)

### 9/a

- Fast-spatial filetered (FSPF kernel: 25 rng px)  $\rightarrow$  noise supression
- Unwrapped filtered differential phase obtained via MCF approach

9/b - 9/c

- Obtained residual phases (wrapped)
- Unwrapped residual phases, indicating non-modeled def. and noise

### 9/d - 10.

- Deriving true unwrapped differential phases (!), scale to LOS def.
- Compensate effect of Spatial Reference Point (SRP)

### **NOTE:** motion away(!) from the radar is positive (blue [10])









## Line-of-sight (LOS) results

### A146.20201224\_20201230

- Positive LOS deformation pattern in Petrinja and along River Kupa - Negative LOS displacements can be identified n the mountainous area between Slana and Gora







### D124.20201223\_20210104

- Slight positive LOS displacements can be identified near the valley and estuary of River Glina (Glinska Poljana and Slana)

- Negative LOS deformation pattern detected in the town of Petrinja.









## **Quasi E-W and U-D deformation components**

### Evaluation of 3D deformation field Underdetermined







# **GEOSES PROJECT: STATUS REPORT**

### Balint Magyar, Roland Horvath, Sandor Toth, Istvan Hajdu, **Ambrus Kenyeres**











## **GeoSES Objectives**

### Dedication

- ENI Cross-border Cooperation Programme 2014-2021
- Extension of the operational Space Emergency System

### Partners

- Hungary: Self Government of SZSZB County / BME (+LTK)
- Slovakia (UPJS), Romania (UTC-N), Ukraine (UZHNU lead)

### Specified objectives

- Monitoring natural and anthropogenic geo-processes
- Integration innovative and advanced techniques, including EO

### Personal roles

- InSAR processing (AOIs, preliminary, core region)
- Scientific publication in related topics

### **Period extended due to Covid-19**



















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- Model refinement (phase comps.) - Model parameter optimization (lef) - Determine refined phase components





### **PDIFF**

 $\{O\}$ 



**OPTIMIZE** 

oOoU

- Read inputs to PSCs
- Estimate baselines
- Form differential interferometric point stacks
- Perform spatial and temporal unwrapping
- Initial estimation of orbit, athmosheric, height-dependent and residual phase component
- Initial mask conditions







## Line-of-sight results 1.











## Line-of-sight results 2.









# OUTLOOK









## **Ongoing researches**

### Workflow development

- Purpose-specific GAMMA RS workflow development
- Automated workflows (ML + CV)

### Technology transfer

- Integrate and dissemniate the most up-to-date technologies/approaches in recent workflows

### Projects

- HUSKROUA/GEOSES
- EGMS, EPND, FIR (former),

## **Technology and know-how transfer between LTK<sup>[1]</sup> and BME<sup>[2]</sup>**



### **Event-specific InSAR processing**

- Coseismic deformation monitoring (ie.: Ridgecrest, Petrinja)
- Testing different techniques to retriev 3D ENU def. (AZPO)

### Large scale InSAR processing

- Regional and multi-year stack processing, SBAS/PS
- Corresponding wf. Development and automation

### Publication

- Scientific publications and consultancies
- Educational presentations







## **PhD Topic**

## **Geodetic interpretation and implementation of the Hungarian Ground Motion** Service based on Sentinel-1 TOPS SAR data

### Nationwide, full-resolution InSAR (PSI/SBAS) processing

- Processing shall be carried out via the most up-to-date techniques, and the end-products shall be consistent with the EGMS

### Geodetic and Geophysical interpretation

- Investigating the representative neotectonic processes of the Carpathian Basin and integrating the latest advances of the Hungarian Geodynamic GPS Network. Identifying the background deformation trends with tools of mathematical geosciences,

### Objectives

- LTK-BME service build-up in the frame of the Co-operative Doctoral Program of the Ministry for Innovation and Technology



- using the available Sentinel-1 AB acquisition over Hungary (2014-2021), designing and implementing the optimal processing chain

- Different benchmarks regarding the applicability of the technology and the derived HGMS products, regarding the geodetic/geophysical interpretation







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És Innovációs Hivatai













## **Discussion: Q&A**





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# Thank you for your attention!

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