

VYUŽÍVANIE RADAROVÝCH (SAR) ÚDAJOV NA ÚZEMÍ SLOVENSKA

Juraj PAPČO, Matúš BAKOŇ, Richard CZIKHARDT, Martin LEŠKO

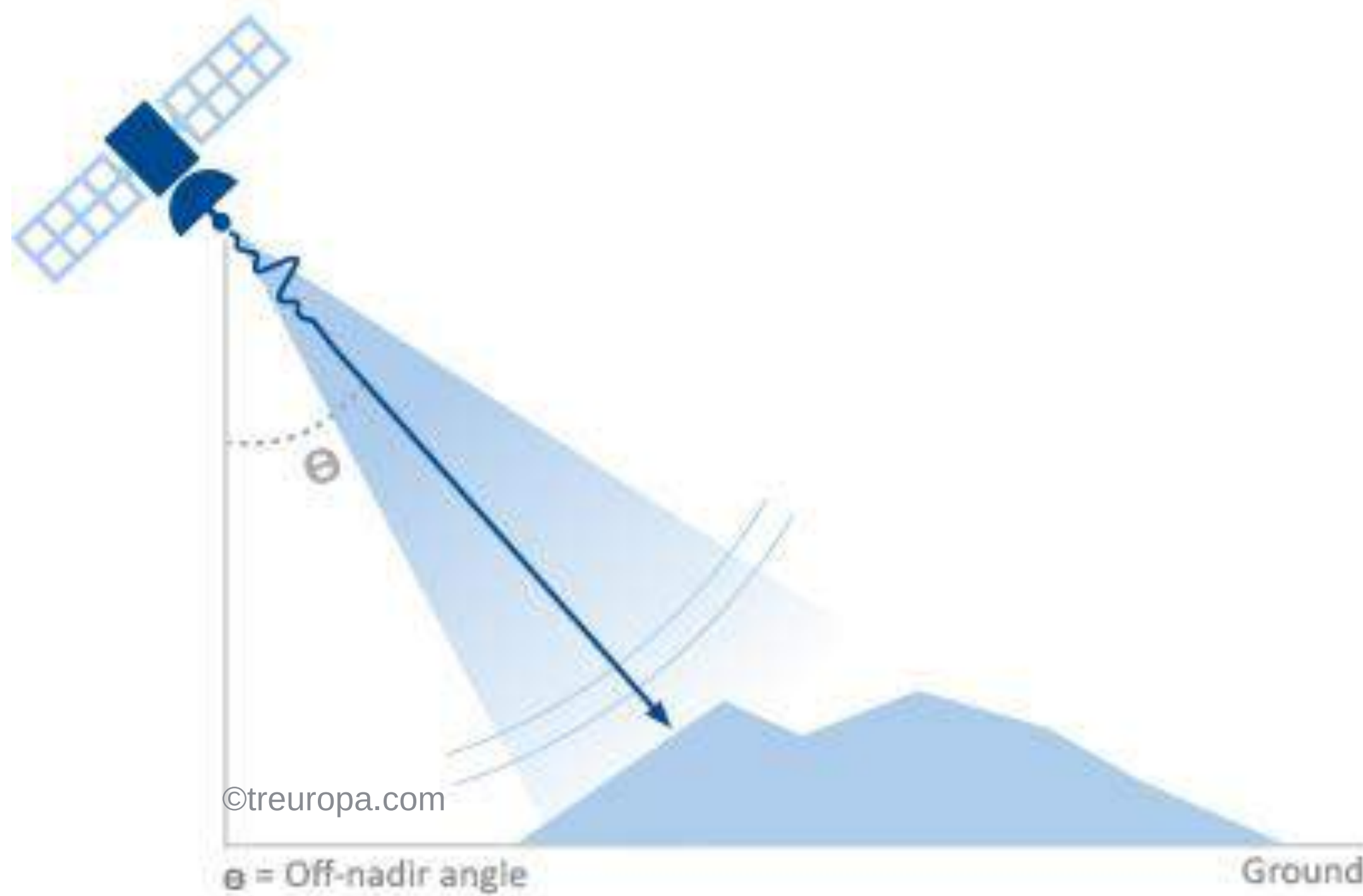
Katedra geodetických základov, Slovenská technická univerzita v Bratislave

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Interferometric Synthetic Aperture Radar

Interferometrický radar so syntetickou apertúrou

- Meranie počas dňa aj noci, nezávisle od počasia
- Veľké priestorové pokrytie
- Intenzívne časové pokrytie + historické dáta
- **Bez nutnosti použitia akýchkoľvek prístrojov a meračskej skupiny na Zemi**
- **Presnosť porovnateľná s klasickými geodetickými metódami (GNSS, nivelácia)**





Sentinel-1 A

(since October 2014)

→ 12-days temporal resolution



Sentinel-1 B

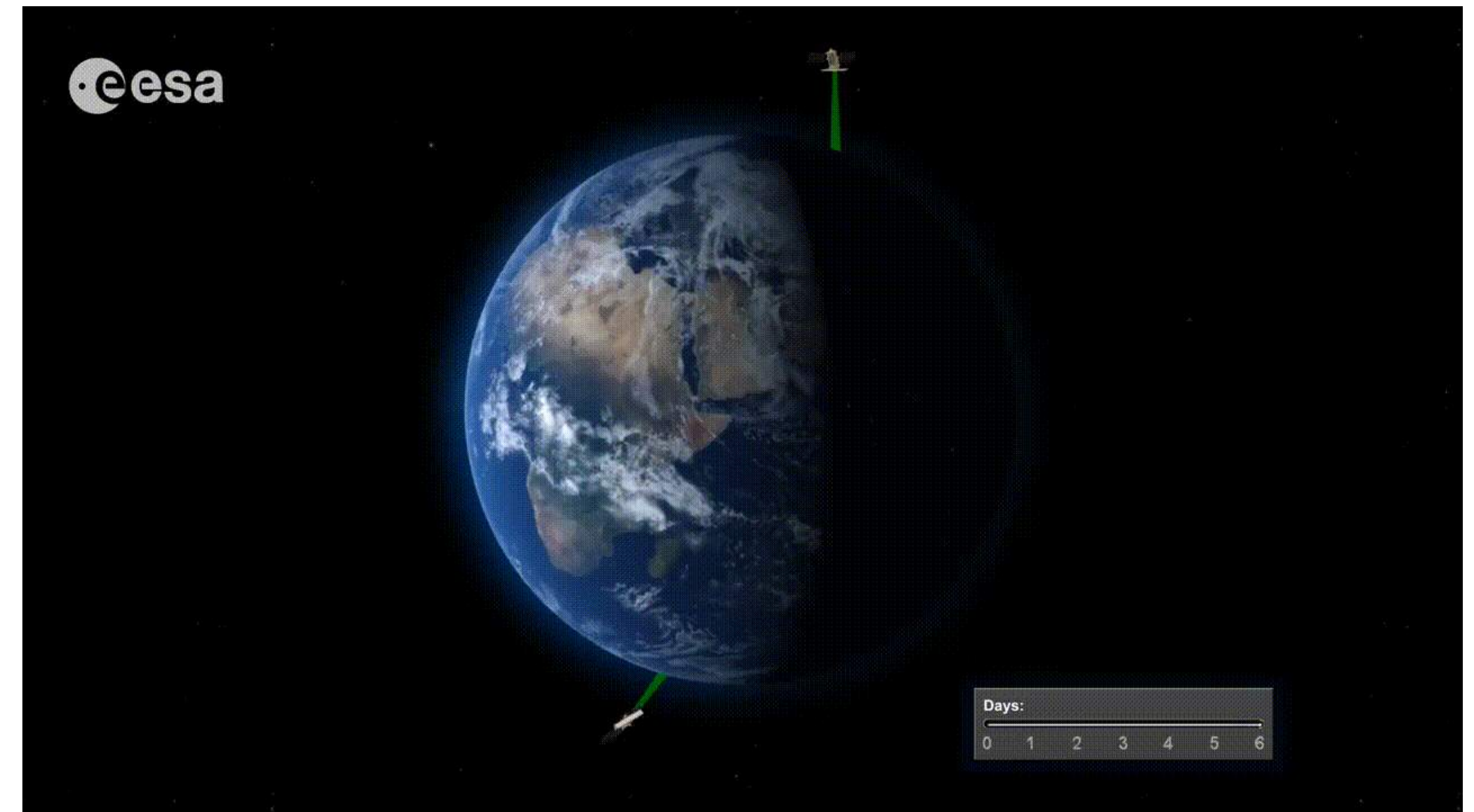
(since October 2016)

→ 6-days temporal resolution

FREE WORLDWIDE DATA ACCESS!



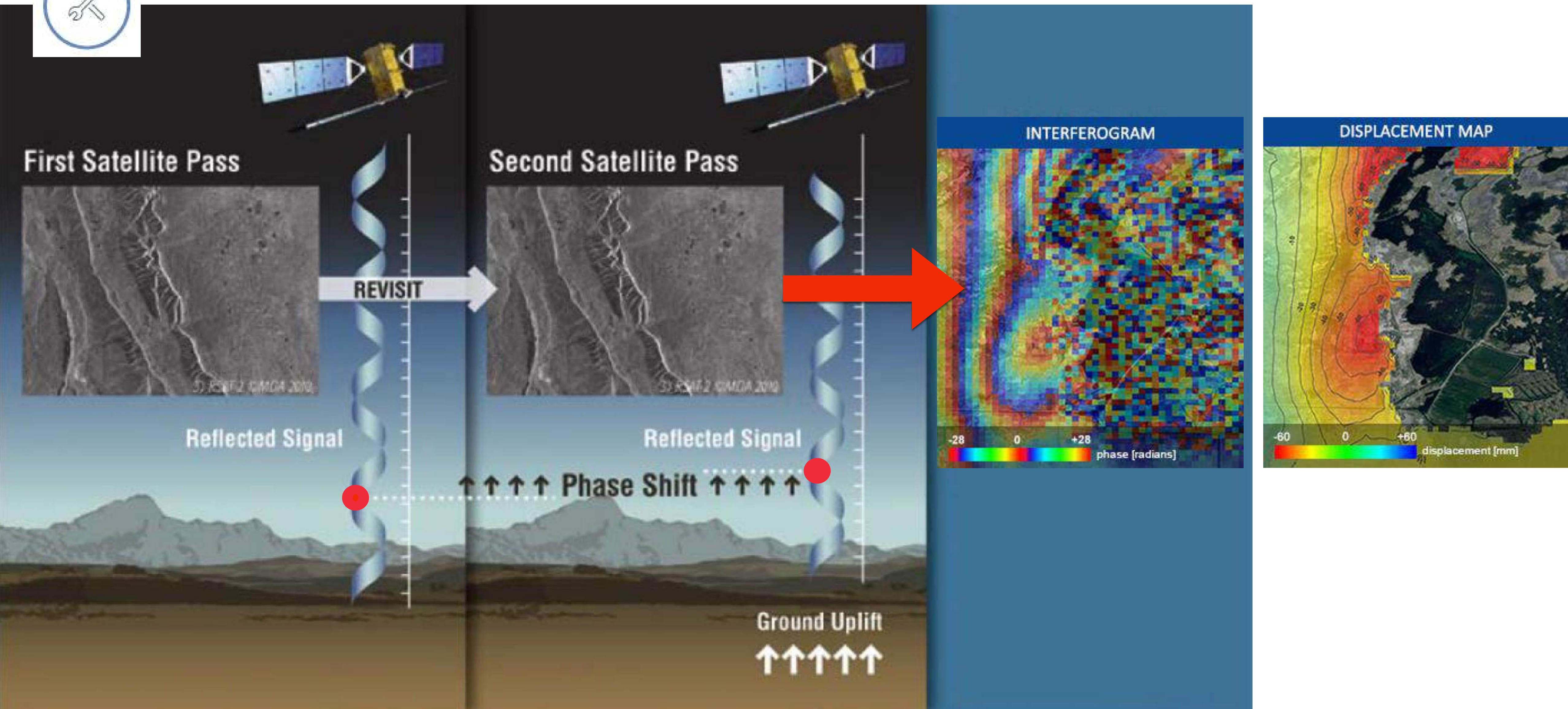
$$|u| = |u_0| \cdot \exp(-\alpha r)$$



ÚVOD - TEORETICKÉ ASPEKTY RADAROVÝCH MERANÍ - DIFERENČNÝ INSAR (DINSAR)

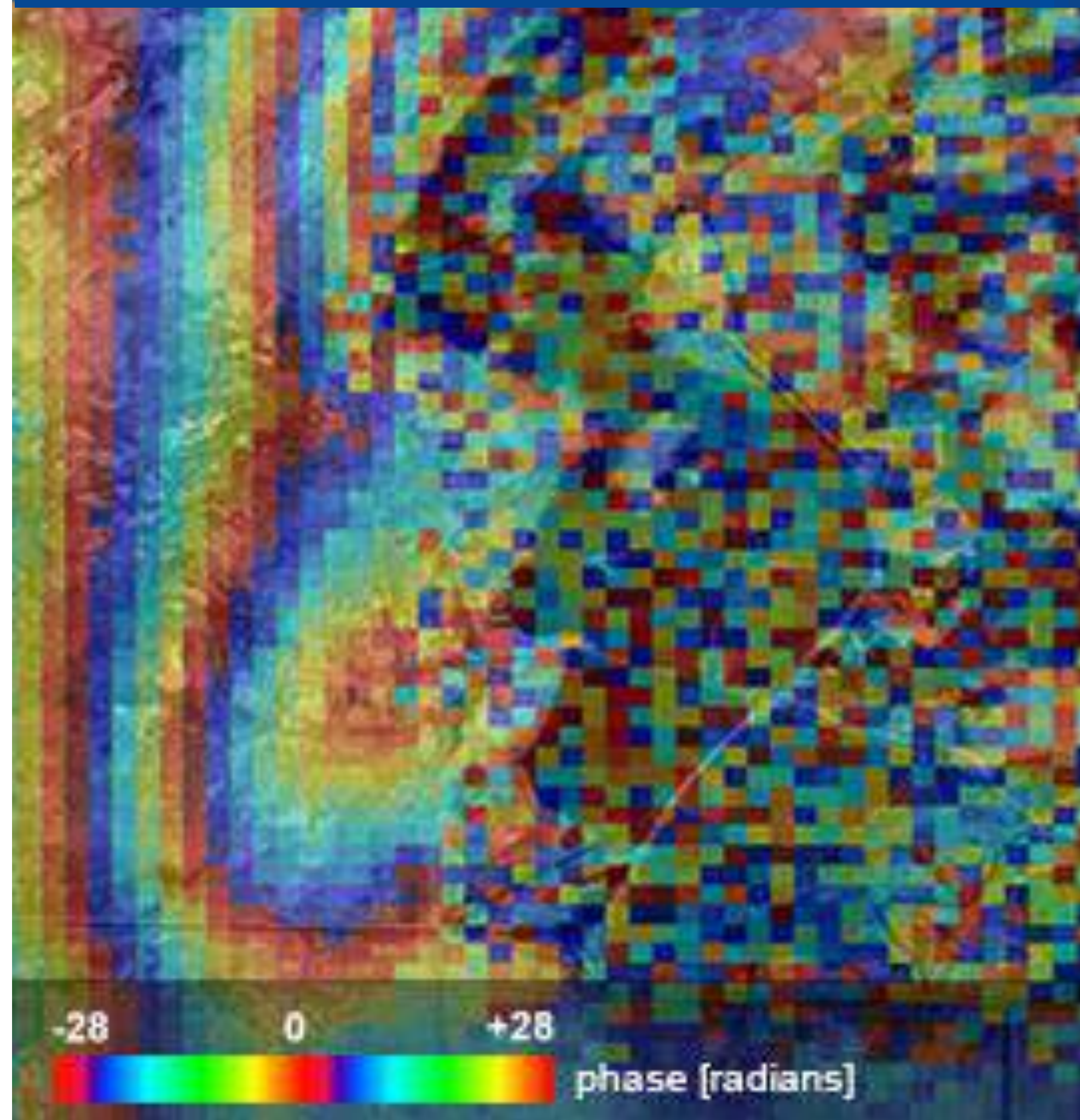


$$(\varphi_1 - \varphi_2) = \Delta\varphi = W\{\varphi_{fE} + \varphi_{Topo} + \varphi_{Defo} + \varphi_{Error}\} \approx \frac{4\pi}{\lambda} \Delta r$$

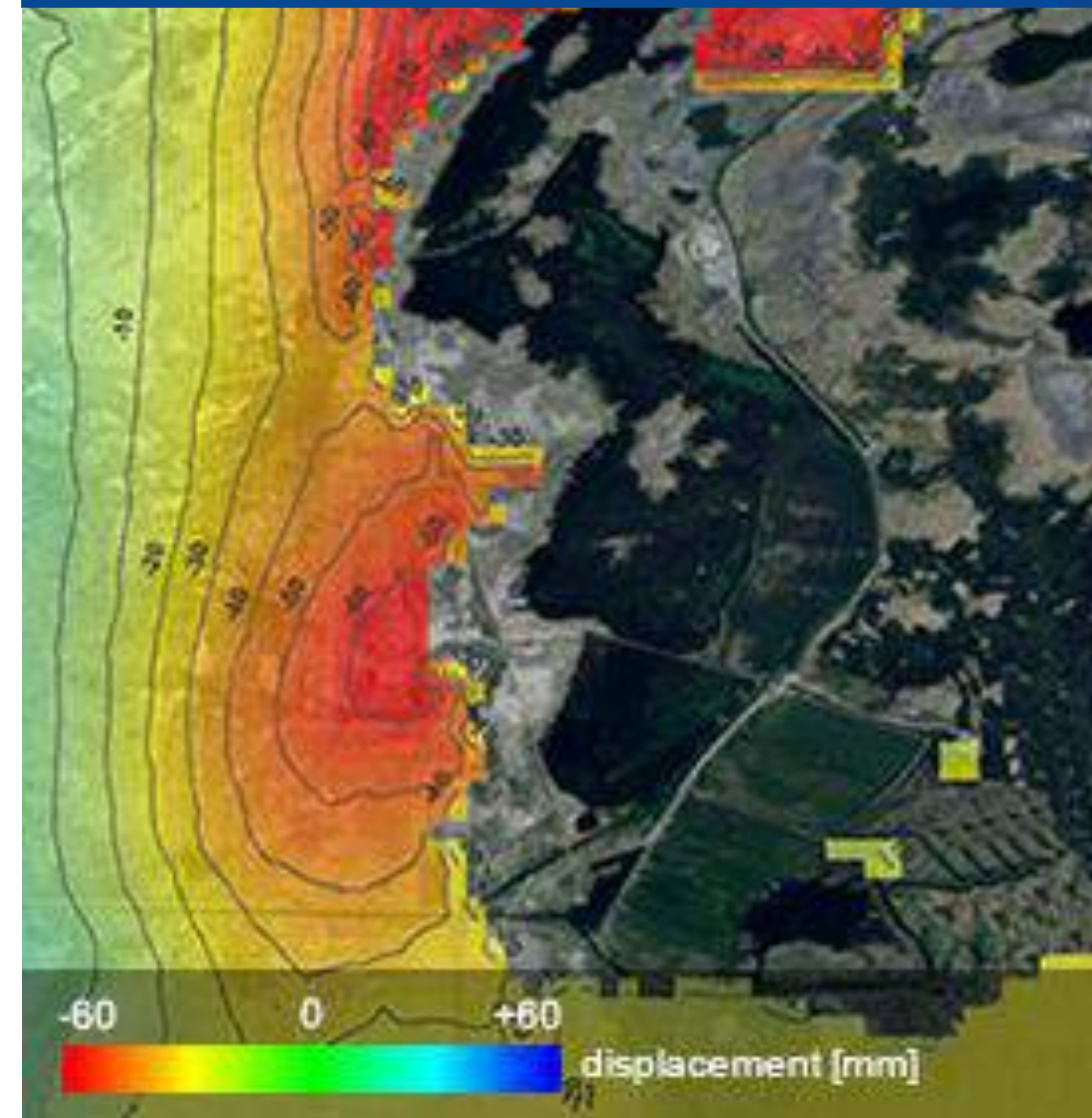




INTERFEROGRAM



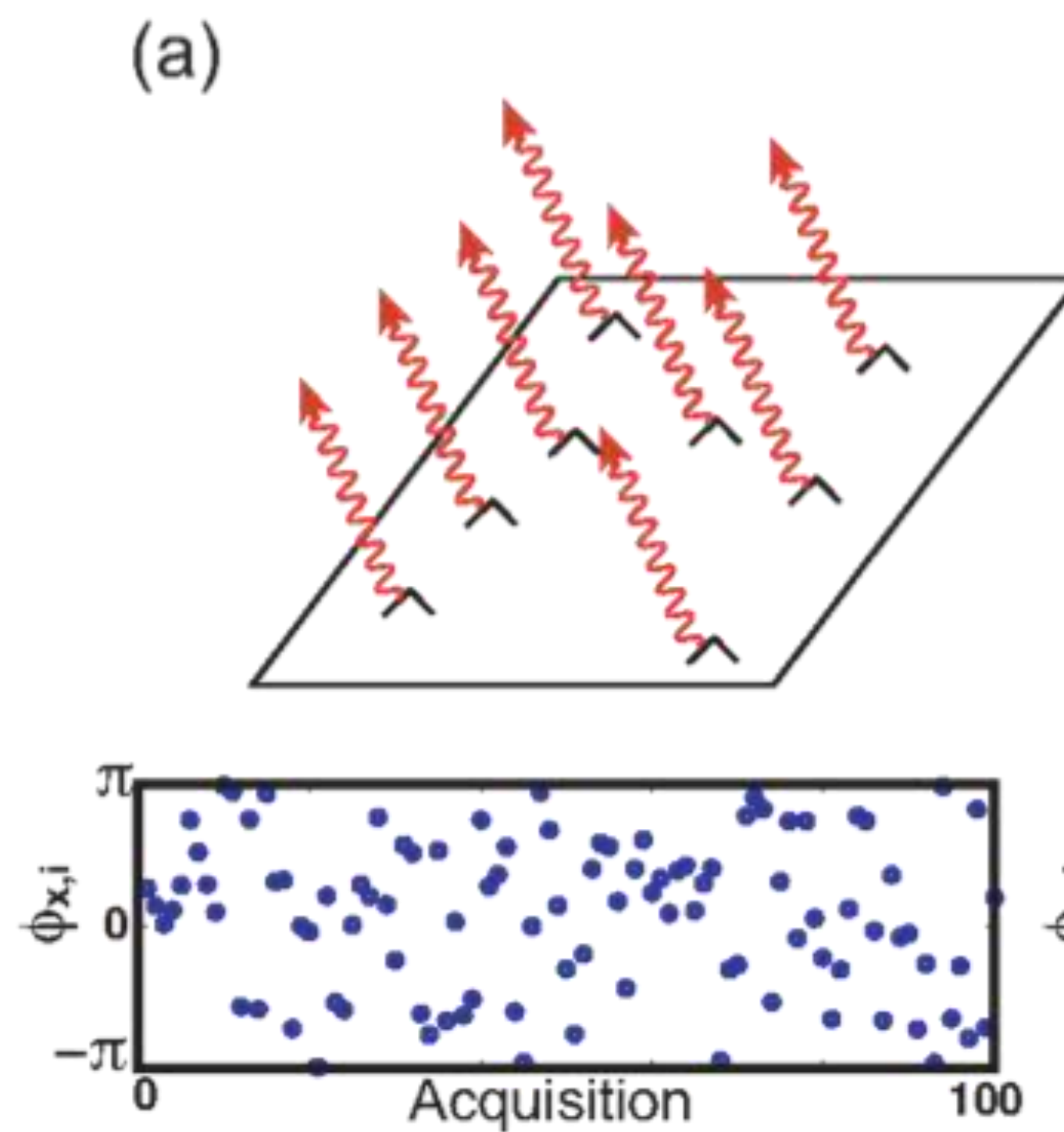
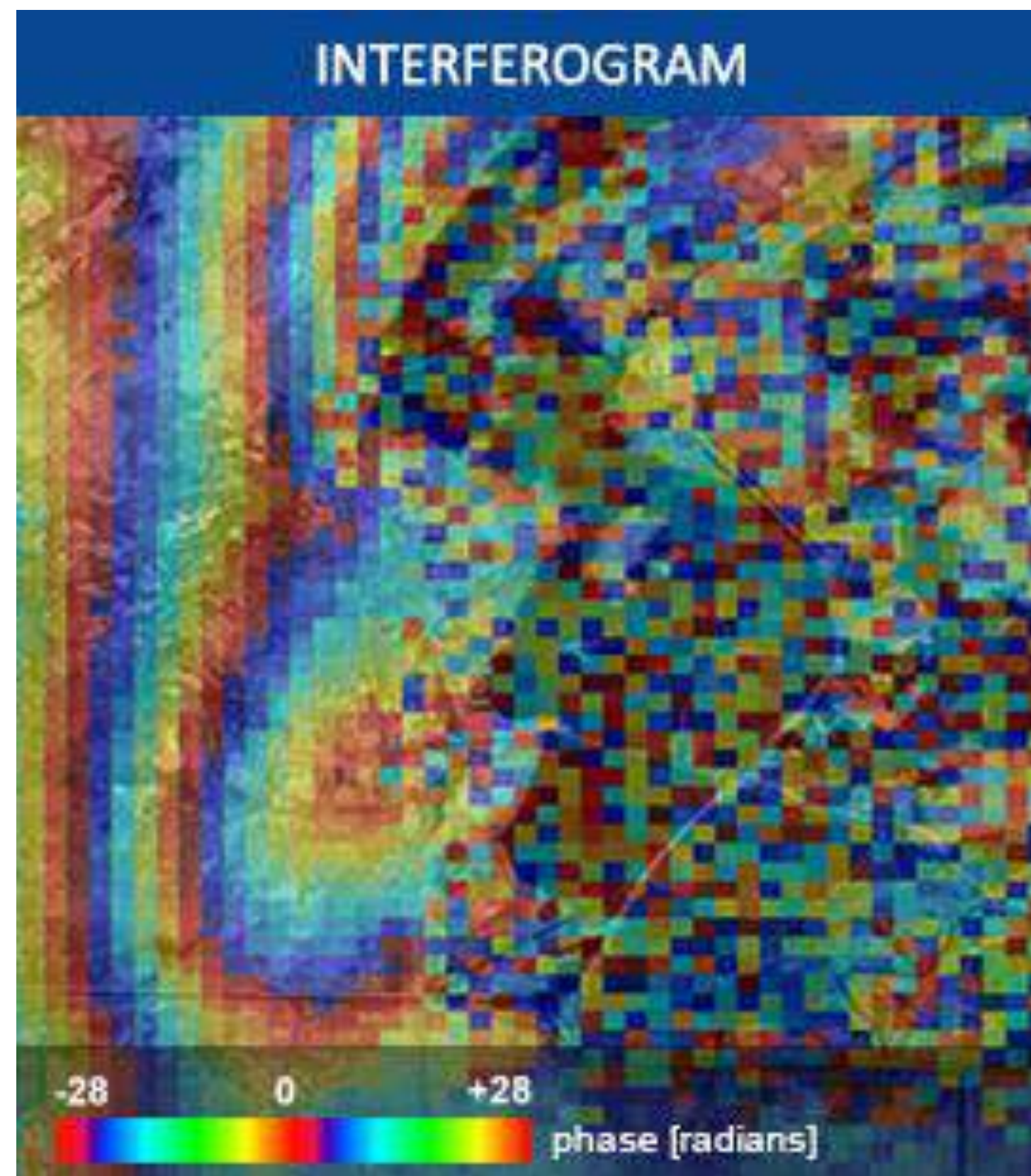
DEFORMAČNÁ MAPA



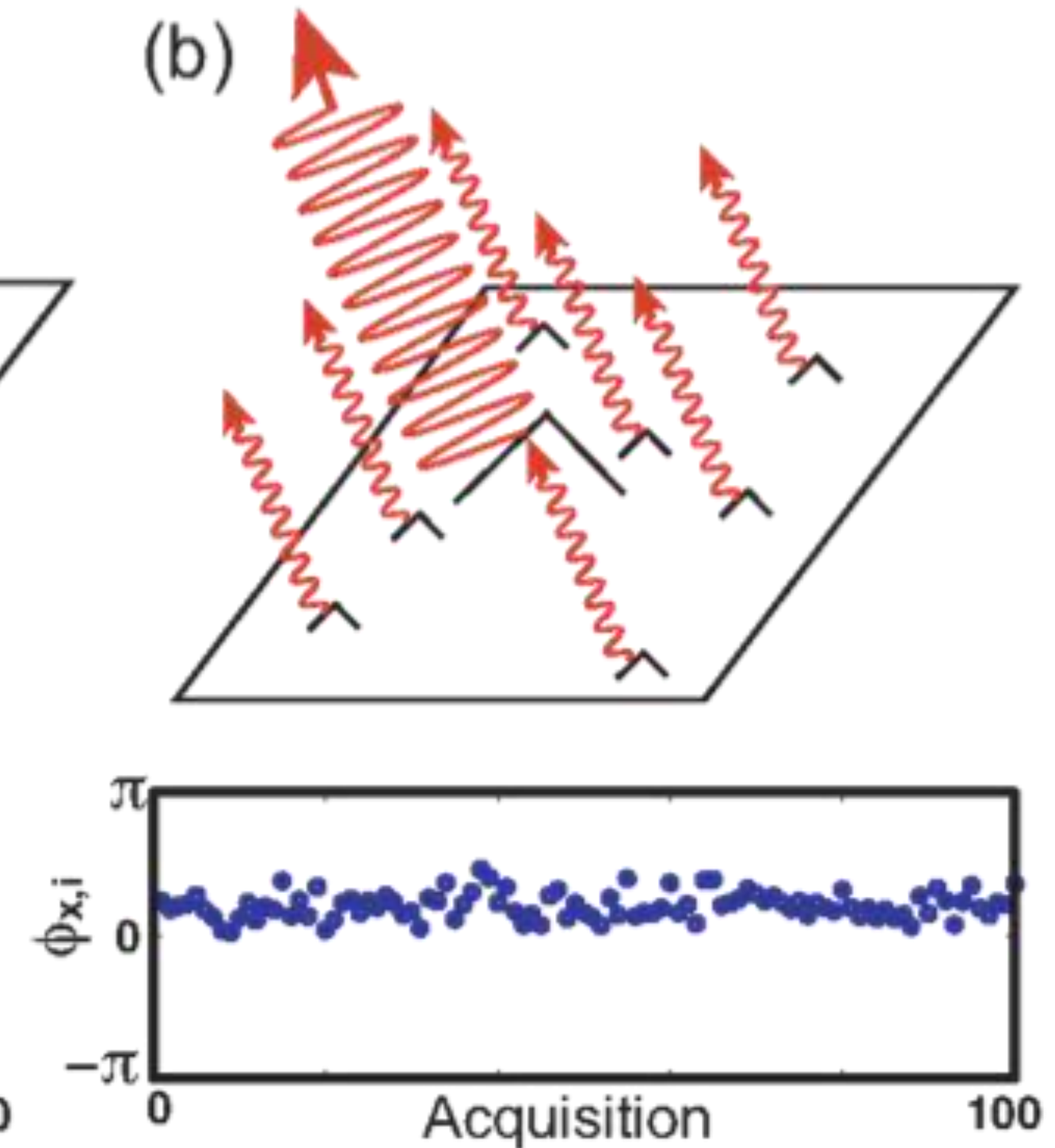


Persistent Scatterer InSAR

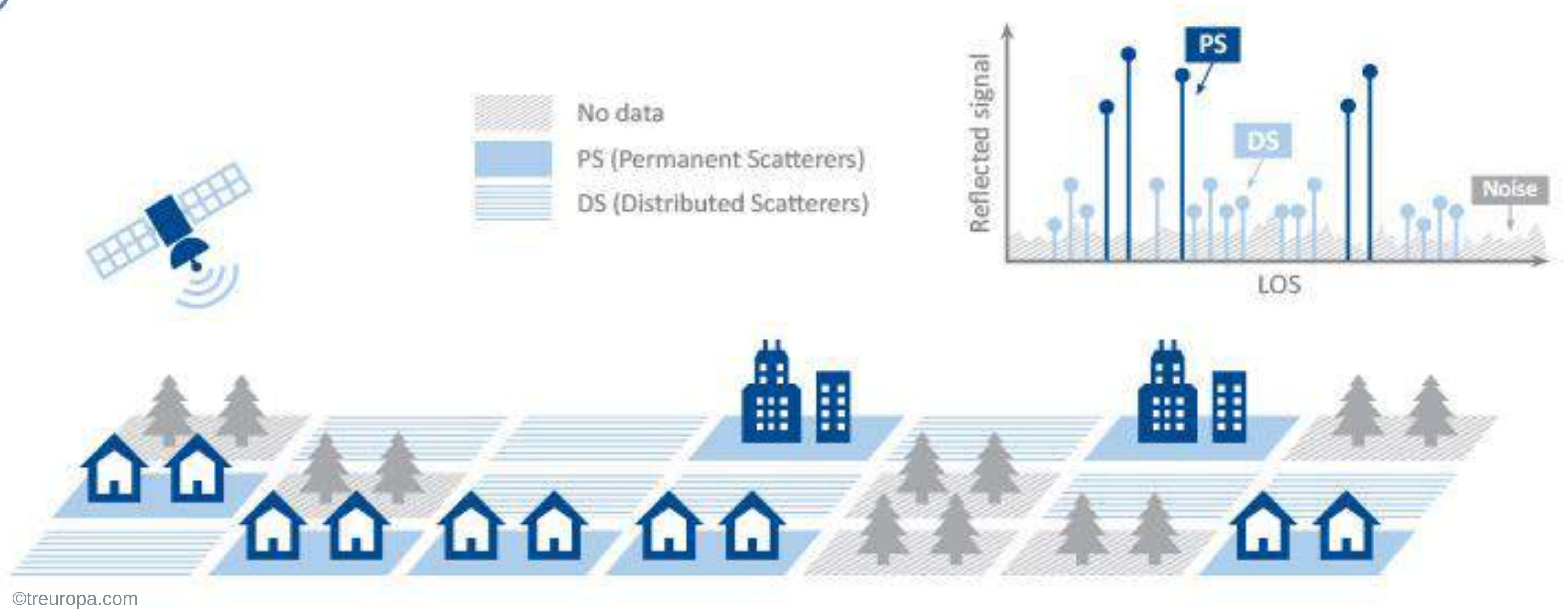
Radarová interferometria s využitím stabilných odrážačov

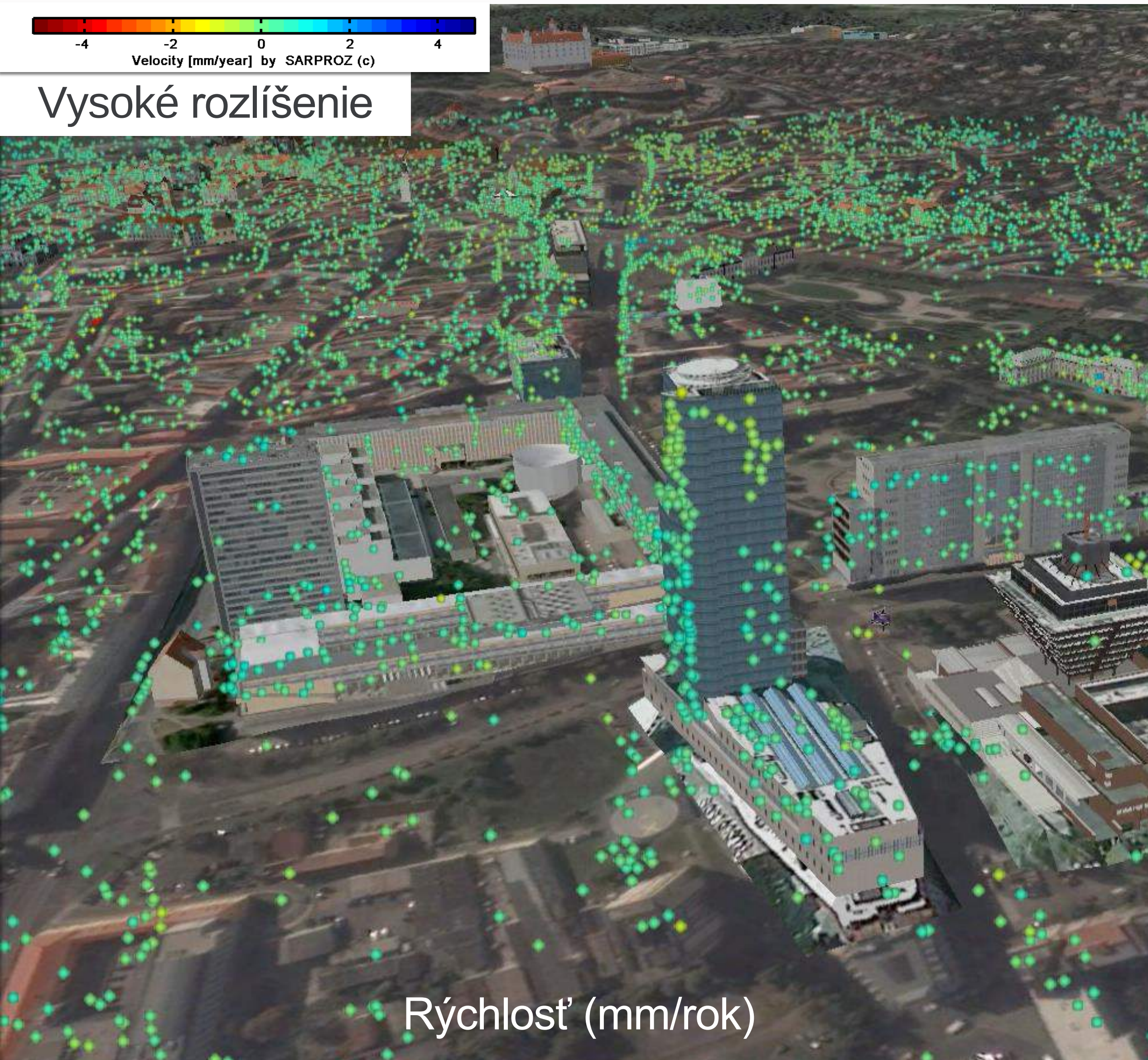


Rozptýlený odrazový prvok

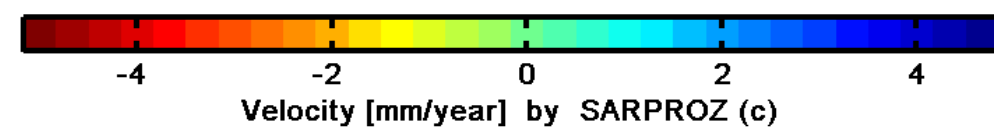


Stabilný odrazový prvok

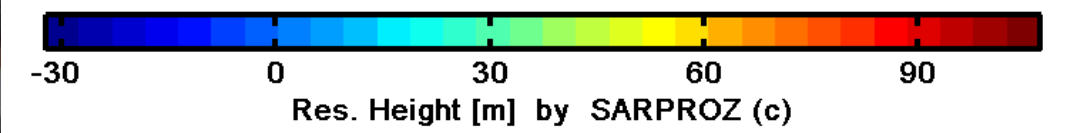




PSINSAR - POKROČILÉ METÓDY MONITOROVANIA DEFORMÁCIÍ



Vysoké rozlíšenie

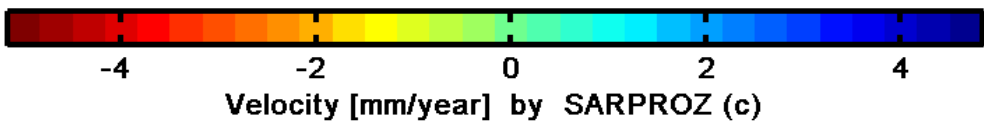


Vysoká presnosť

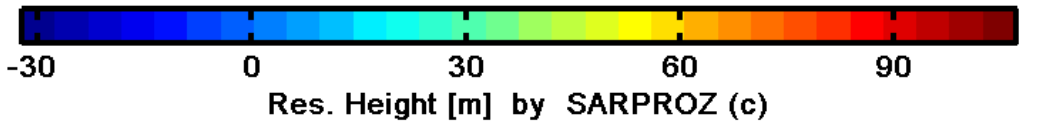


Výška nad referenčným DMR (m)

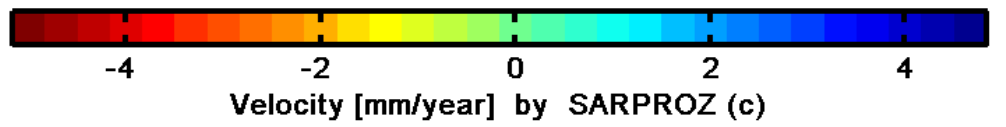
PSINSAR - POKROČILÉ METÓDY MONITOROVANIA DEFORMÁCIÍ



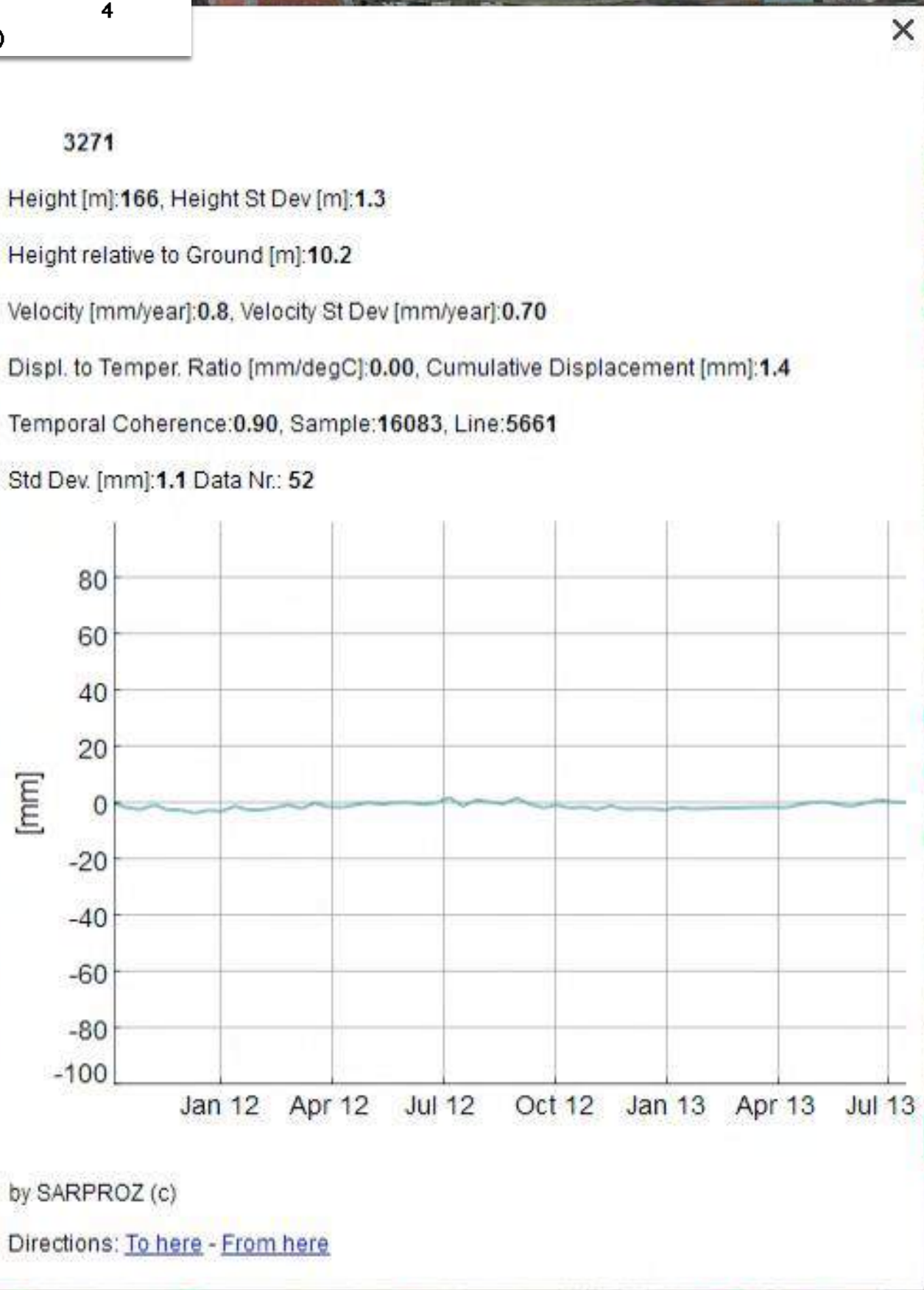
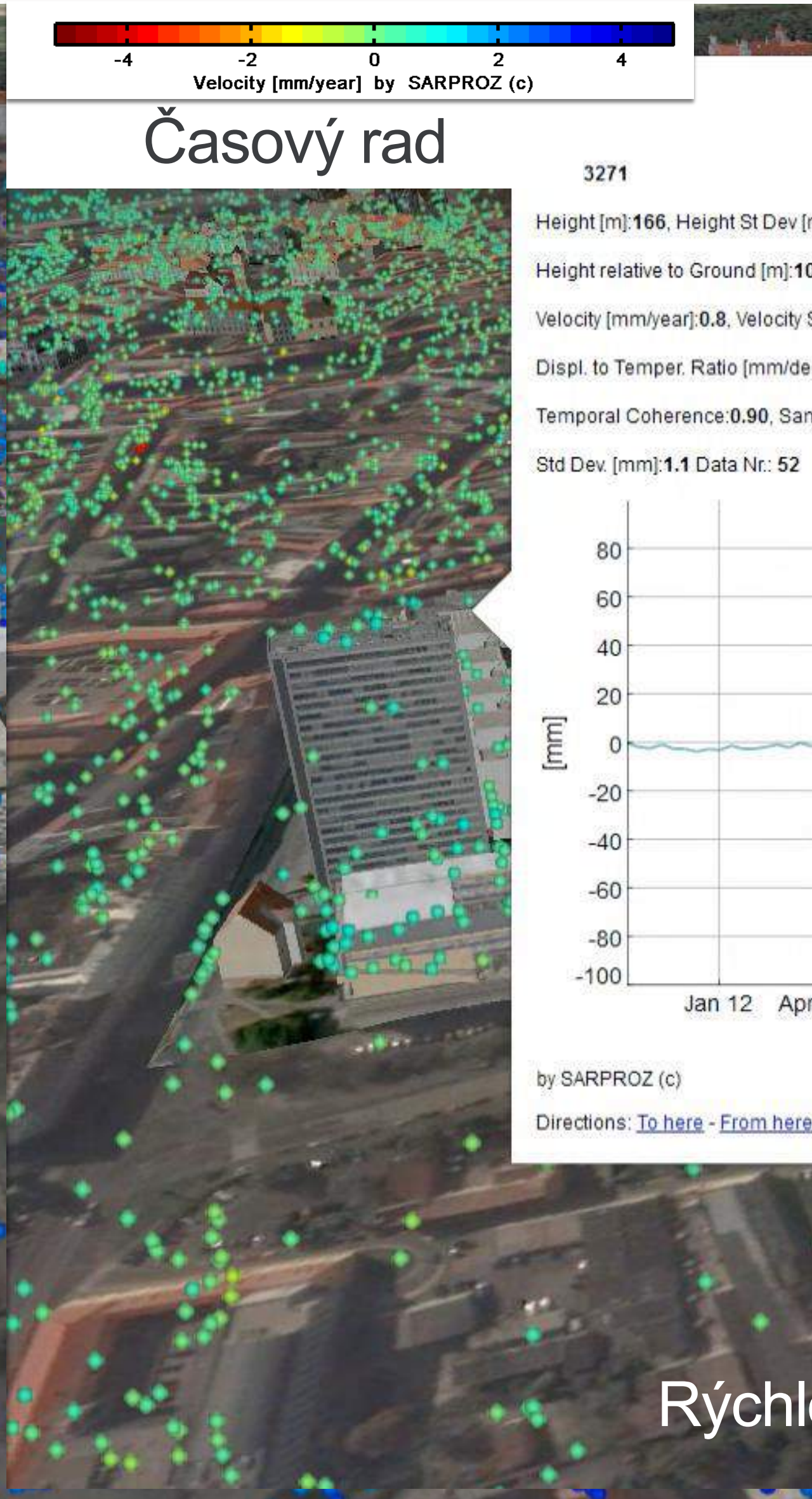
Vysoké rozlíšenie



Vysoká presnosť



Časový rad

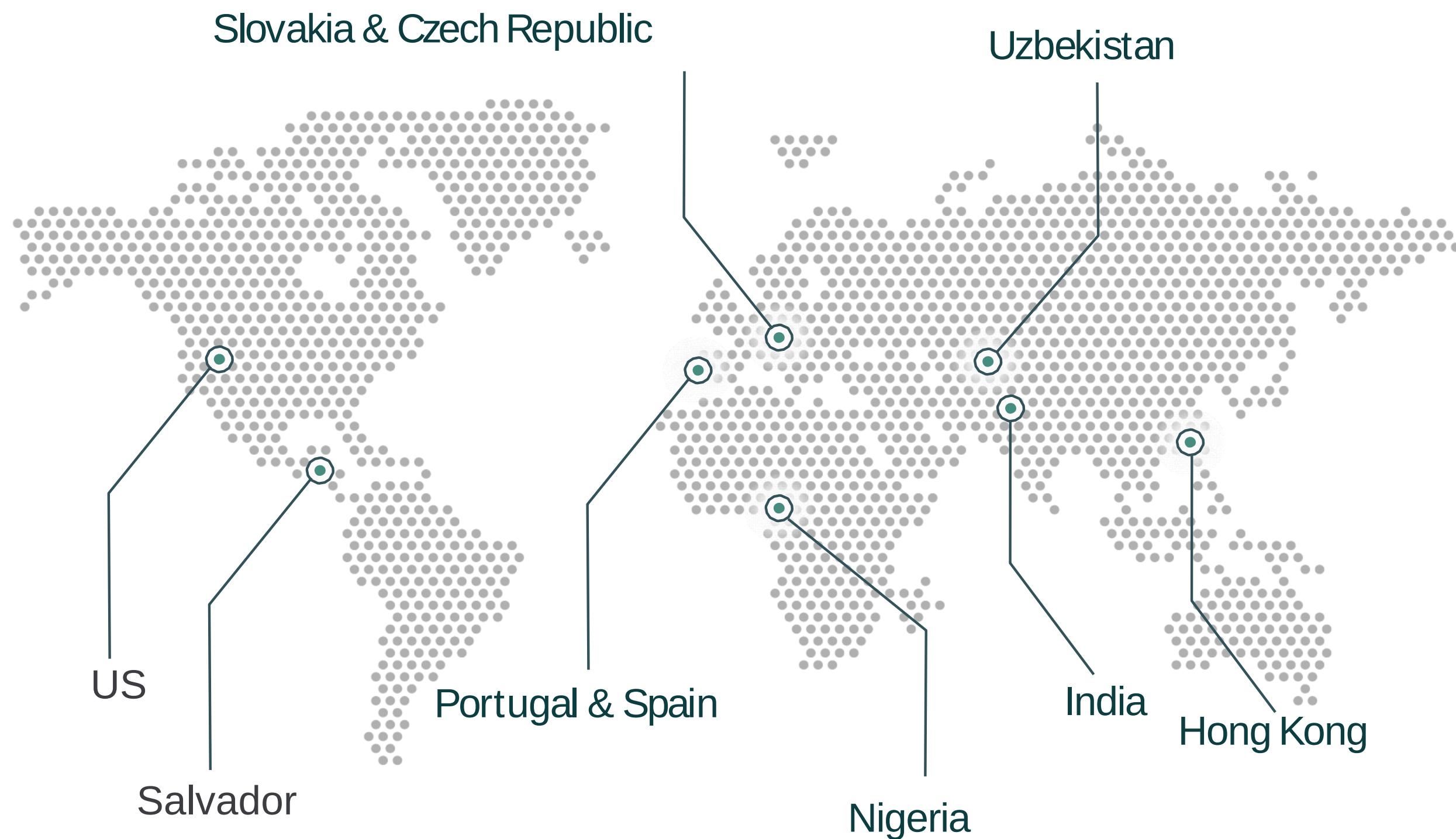


Rýchlosť (mm/rok)

MONITOROVANIE DEFORMÁCIÍ TECHNOLOGIOU INSAR

CELÝ SVET

Analýzy nezávislé od polohy na Zemi

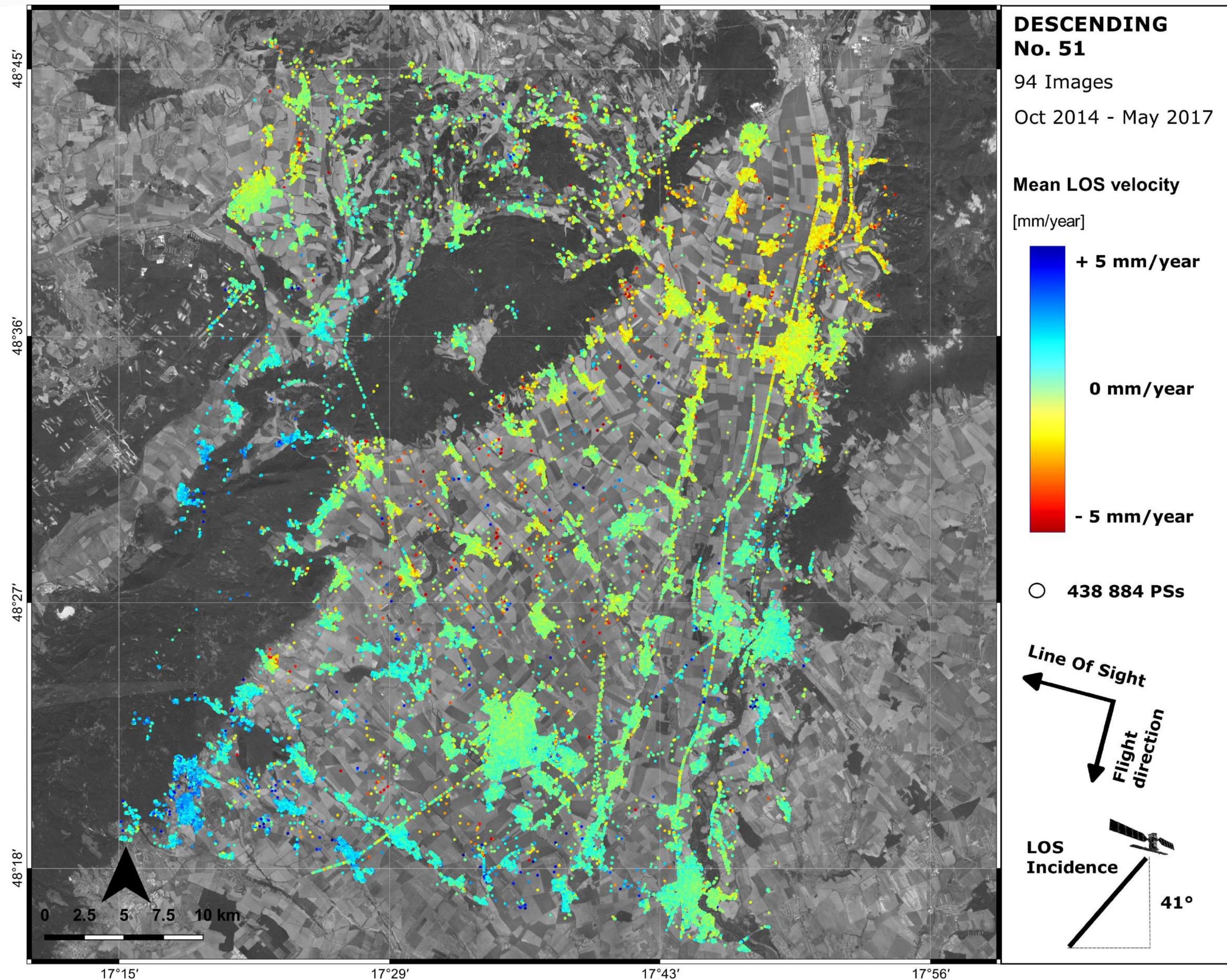


PREDMET VÝSKUMU

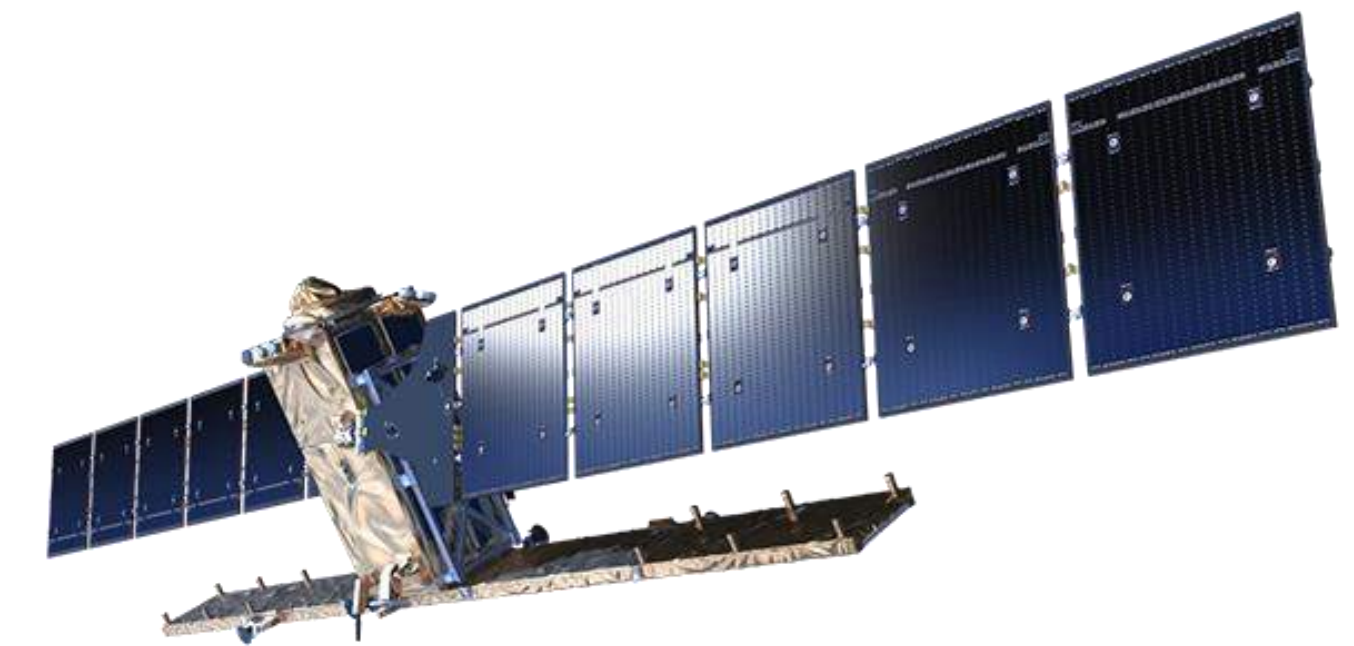
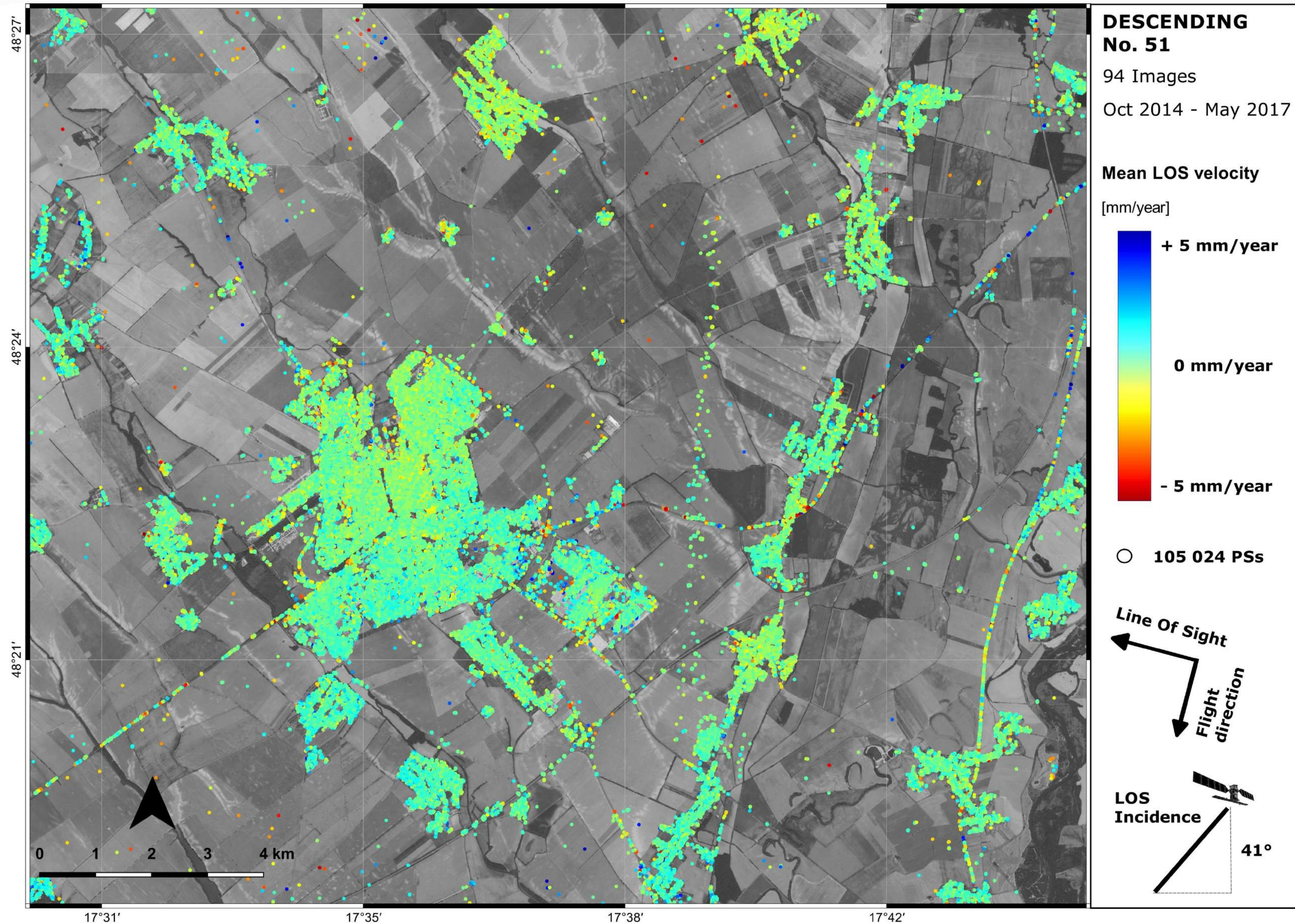
Monitorovanie deformácií

- ZASTAVANÉ OBLASTI
- VEĽKÉ STAVEBNÉ OBJEKTY
- PRIEHRADY & VODNÉ DIEĽA
- DOPRAVNÁ INFRAŠTRUKTÚRA
- PODDOLOVANÉ & ZOSUVNÉ ÚZEMIA

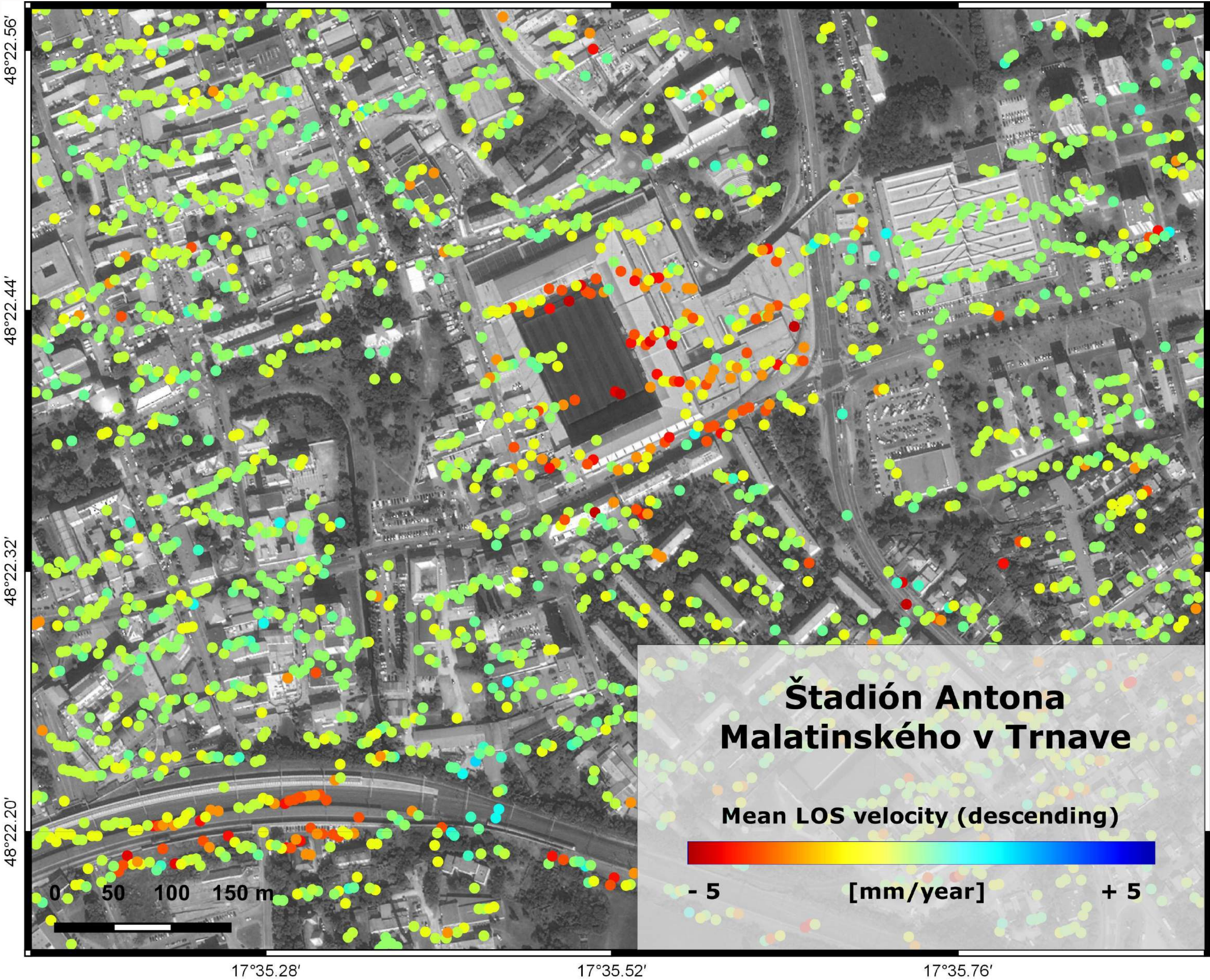
ZASTAVANÉ ÚZEMIA- MONITOROVANIE TRNAVSKÉHO REGIÓNU

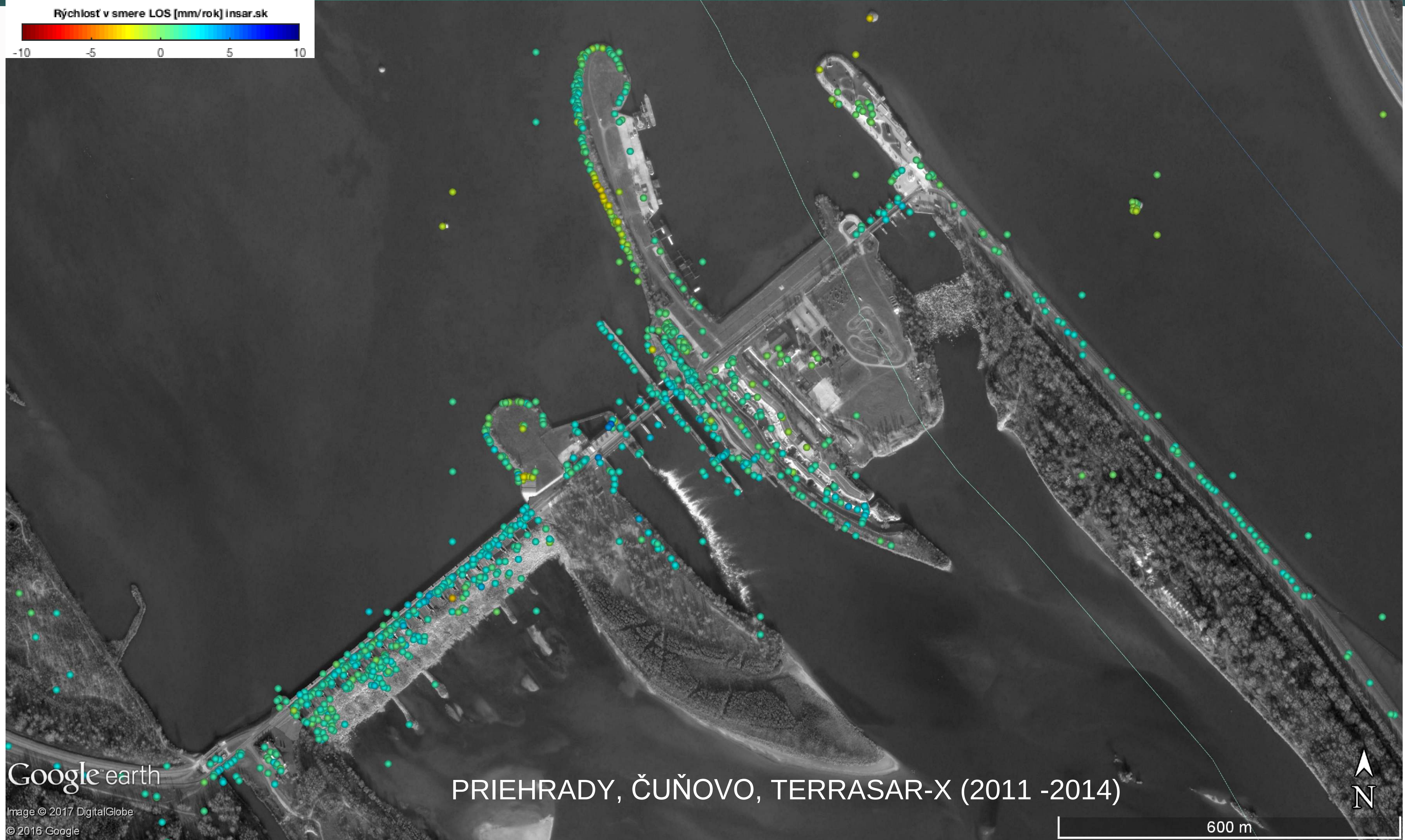


ZASTAVANÉ ÚZEMIA- MONITOROVANIE TRNAVSKÉHO REGIÓNU



VEĽKÉ STAVEBNÉ OBJEKTY – CITY ARÉNA TRNAVA





Google™ earth

Image © 2017 DigitalGlobe
© 2016 Google

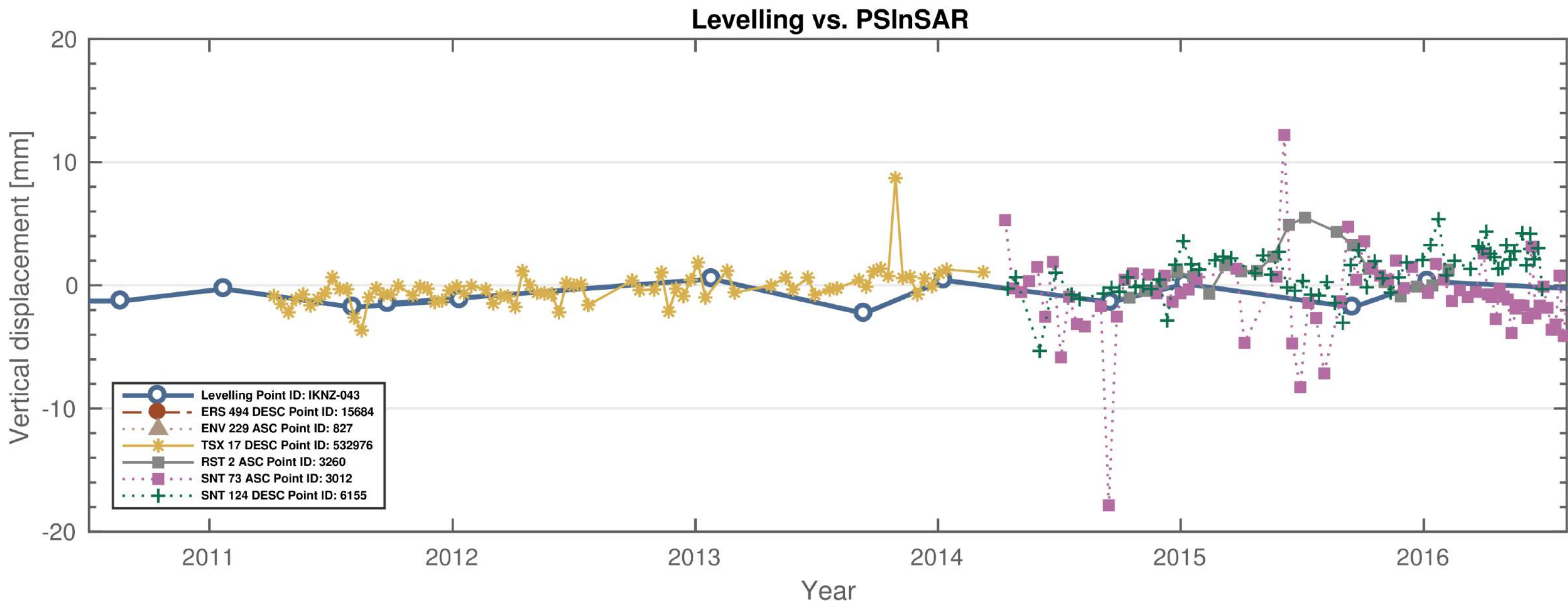
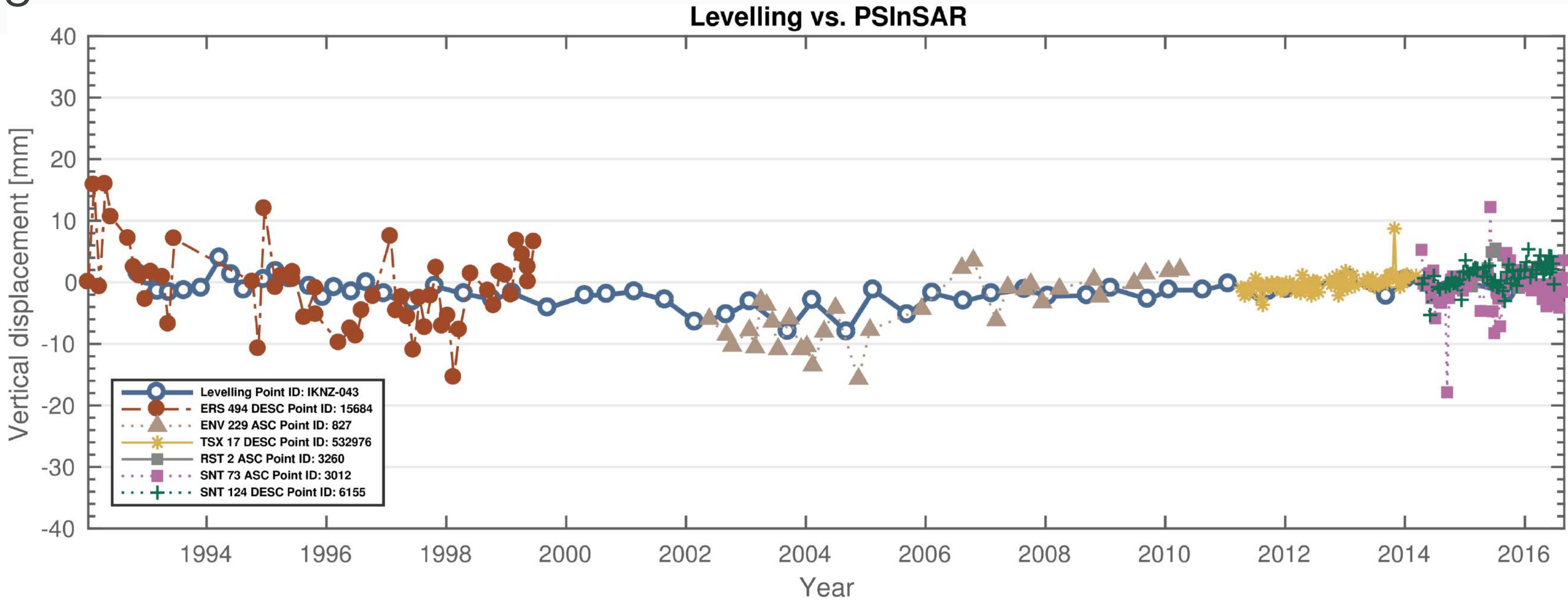
PRIEHRADY, ČUŇOVO, TERRASAR-X (2011 -2014)

600 m



PRIEHRADY, ČUŇOVO – ERS-1/2, ENV, TSX, RDS-2, SNT-1

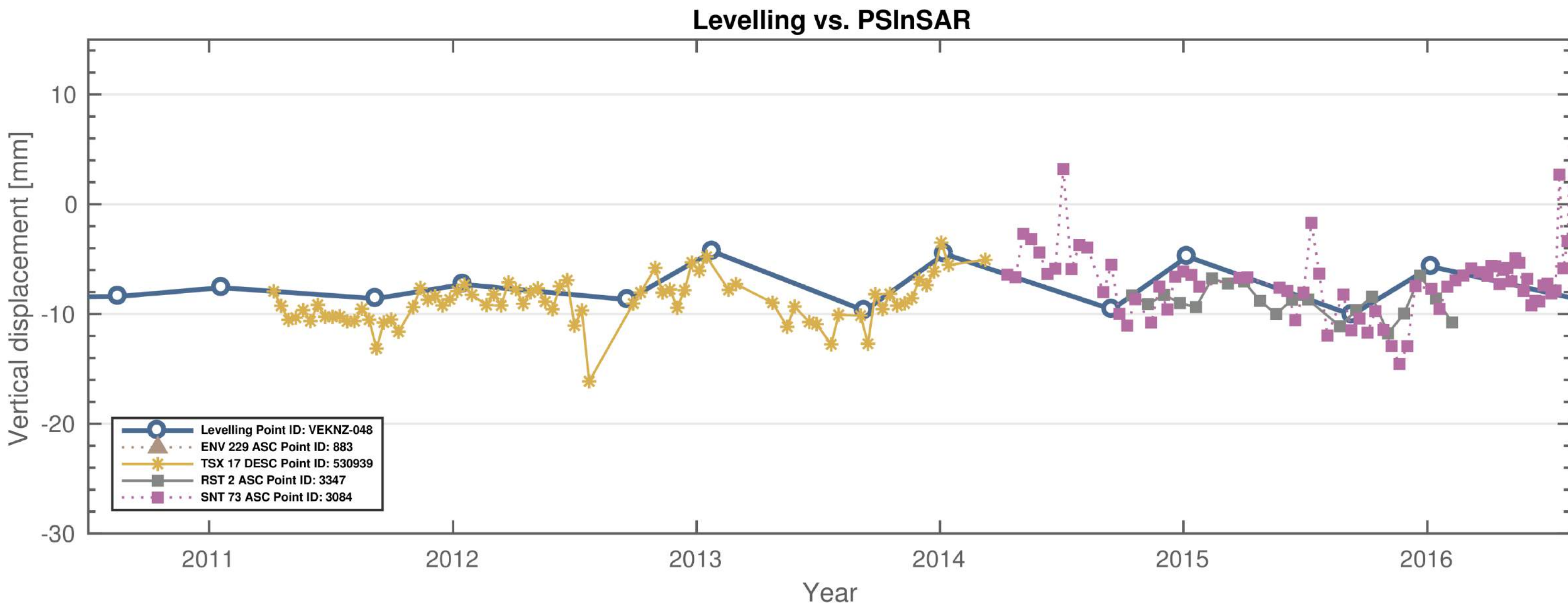
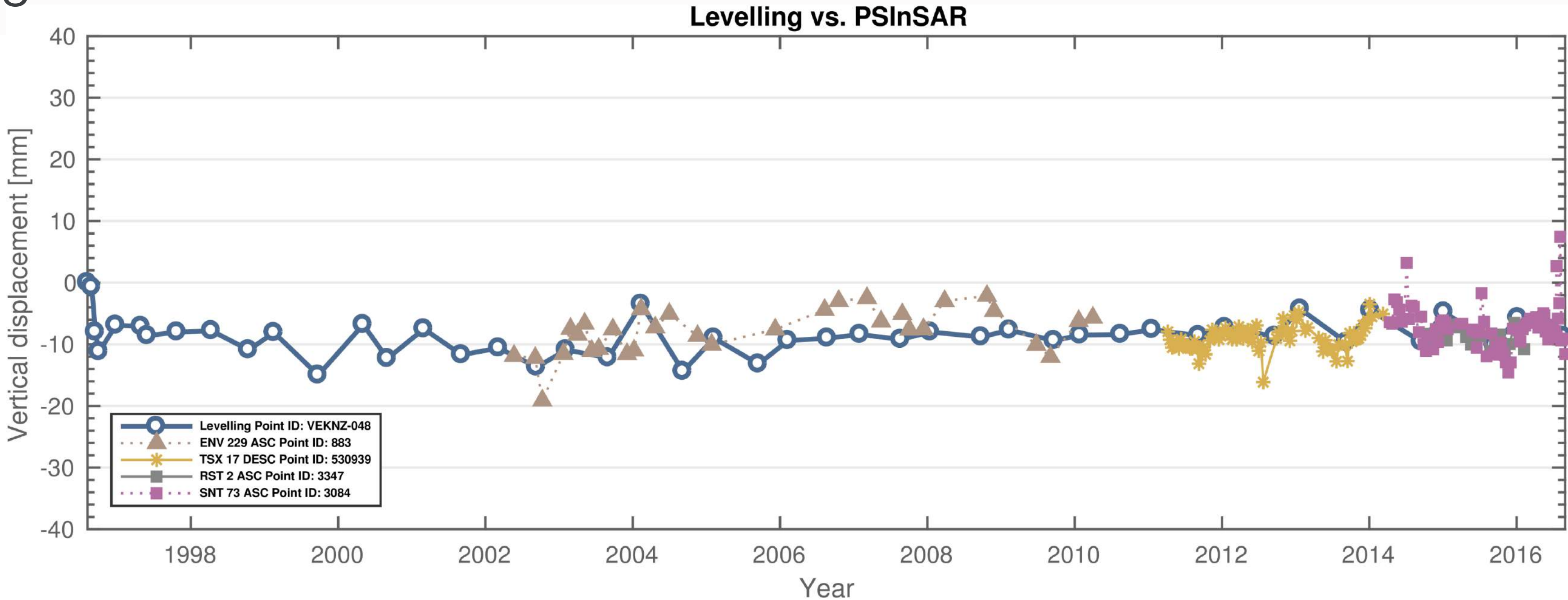
POROVNANIE S VP NIVELÁCIOU



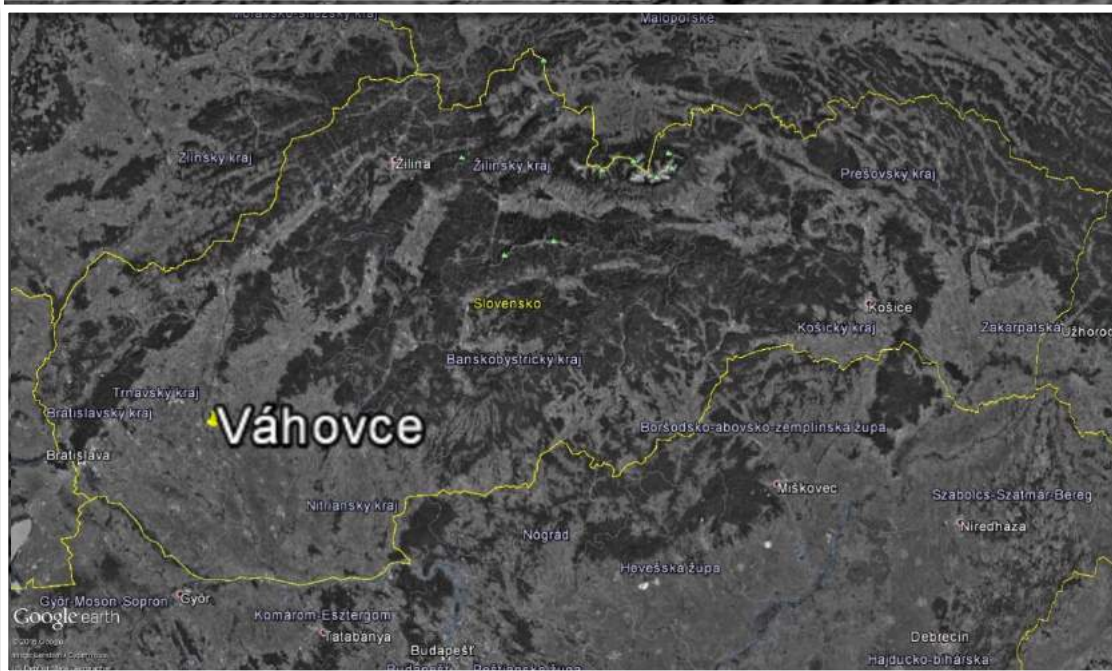
Prvý a kol., TBD VVB (2017)

PRIEHRADY, ČUŇOVO – ERS-1/2, ENV, TSX, RDS-2, SNT-1

POROVNANIE S VP NIVELÁCIOU



Prvý a kol., TBD VVB (2017)



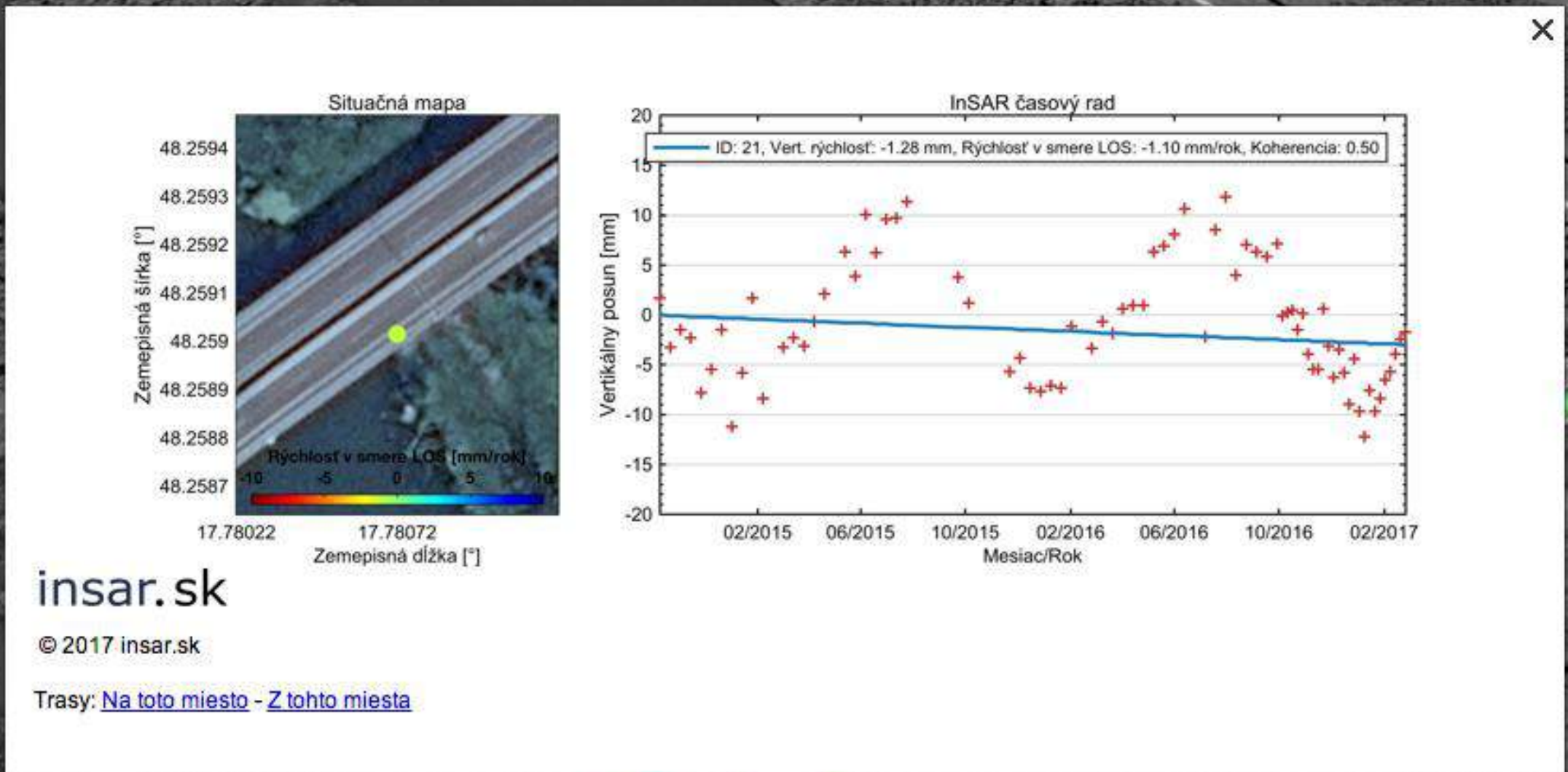
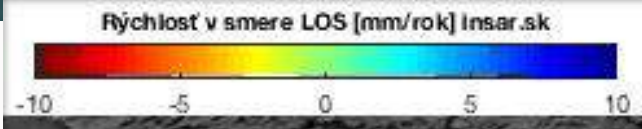
Google earth

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Image © 2017 CNES / Airbus

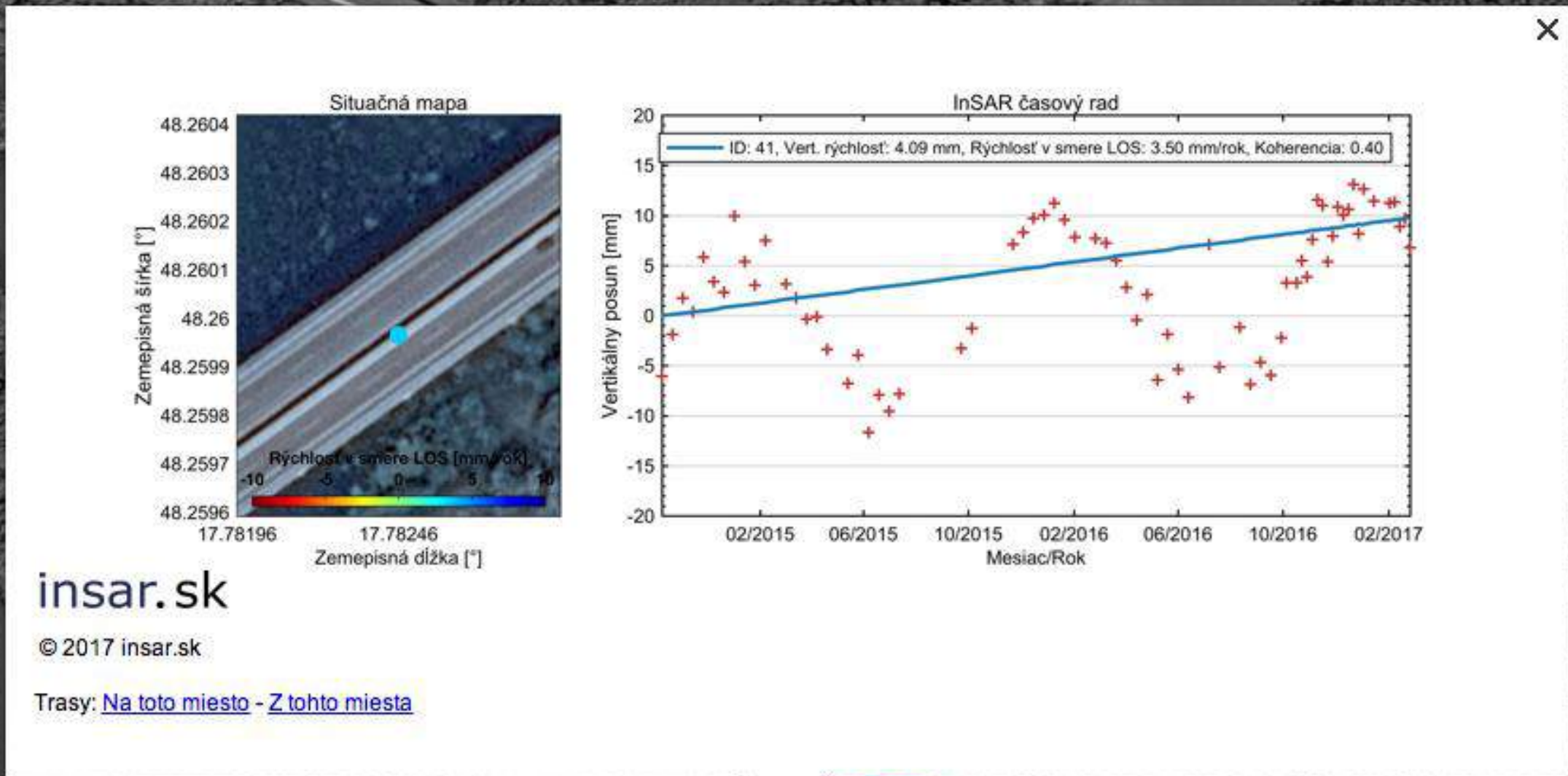
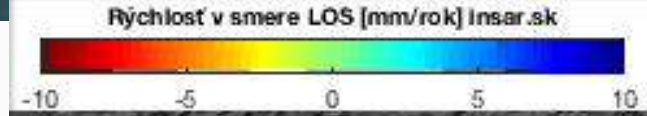
DOPRAVNÁ INFRAŠTRUKTÚRA, VÁHOVCE, SENTINEL-1 (2014 -2017)



100 m

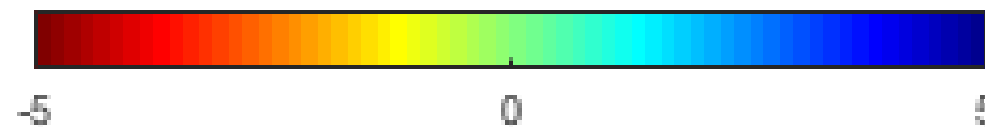


DOPRAVNÁ INFRAŠTRUKTÚRA, VÁHOVCE, SENTINEL-1 (2014 -2017)





Rýchlosť v smere LOS [mm/rok] insar.sk



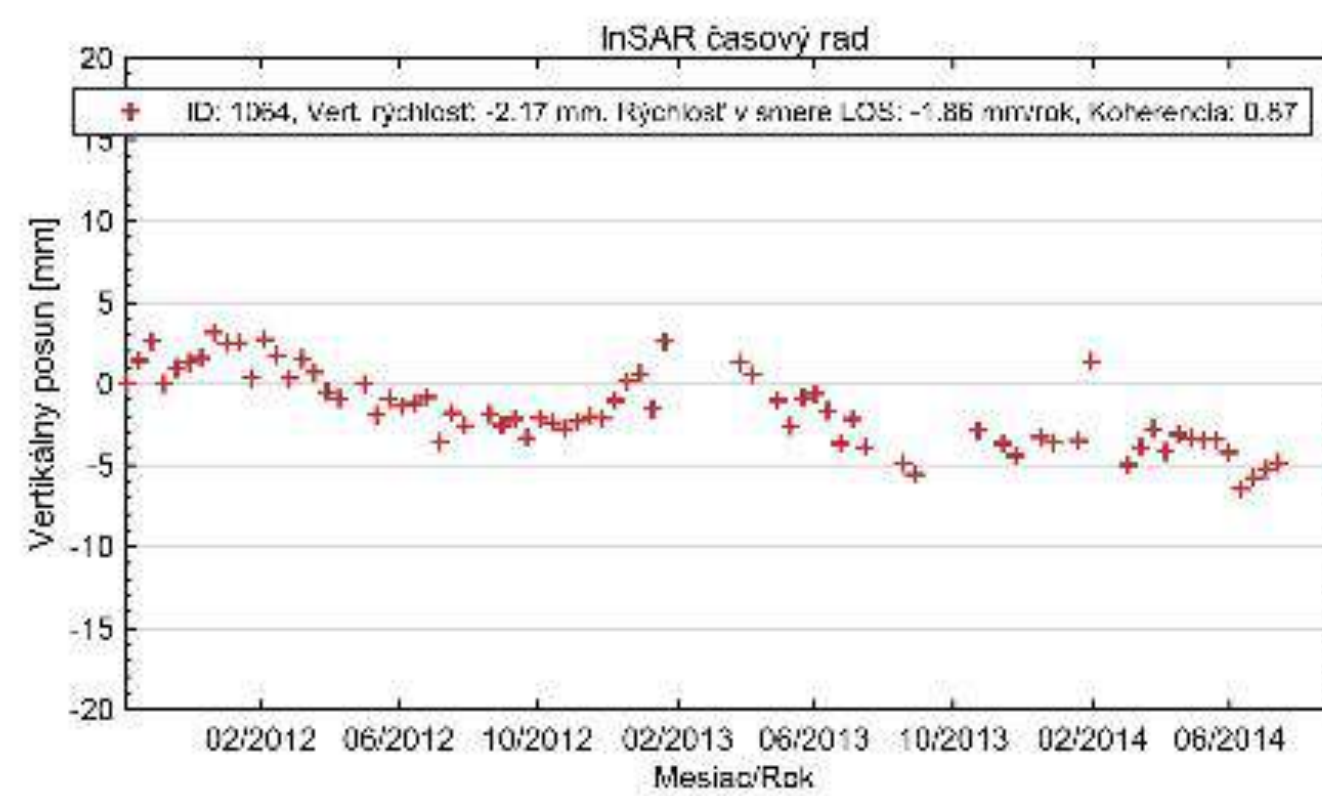
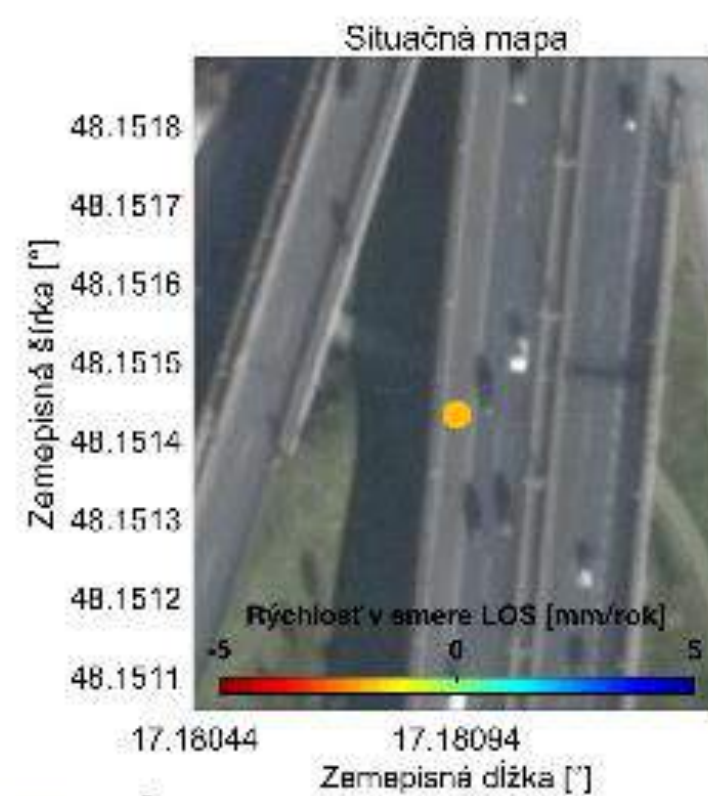
DOPRAVNÁ INFRAŠTRUKTÚRA, BRATISLAVA, TERRASAR-X (2011 -2014)

Hrušov

ĎALNICE, BRATISLAVA, TERRASAR-X (2011 -2014)



DOPRAVNÁ INFRAŠTRUKTÚRA, BRATISLAVA, TERRASAR-X (2011 -2014)



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Trasy: [Na toto miesto](#) - [Z tohto miesta](#)

Google earth

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Image © 2017 DigitalGlobe

300 m





DOPRAVNÁ
INFRAŠTRUKTÚRA,
BRATISLAVA,
TERRASAR-X (2011 -2014)

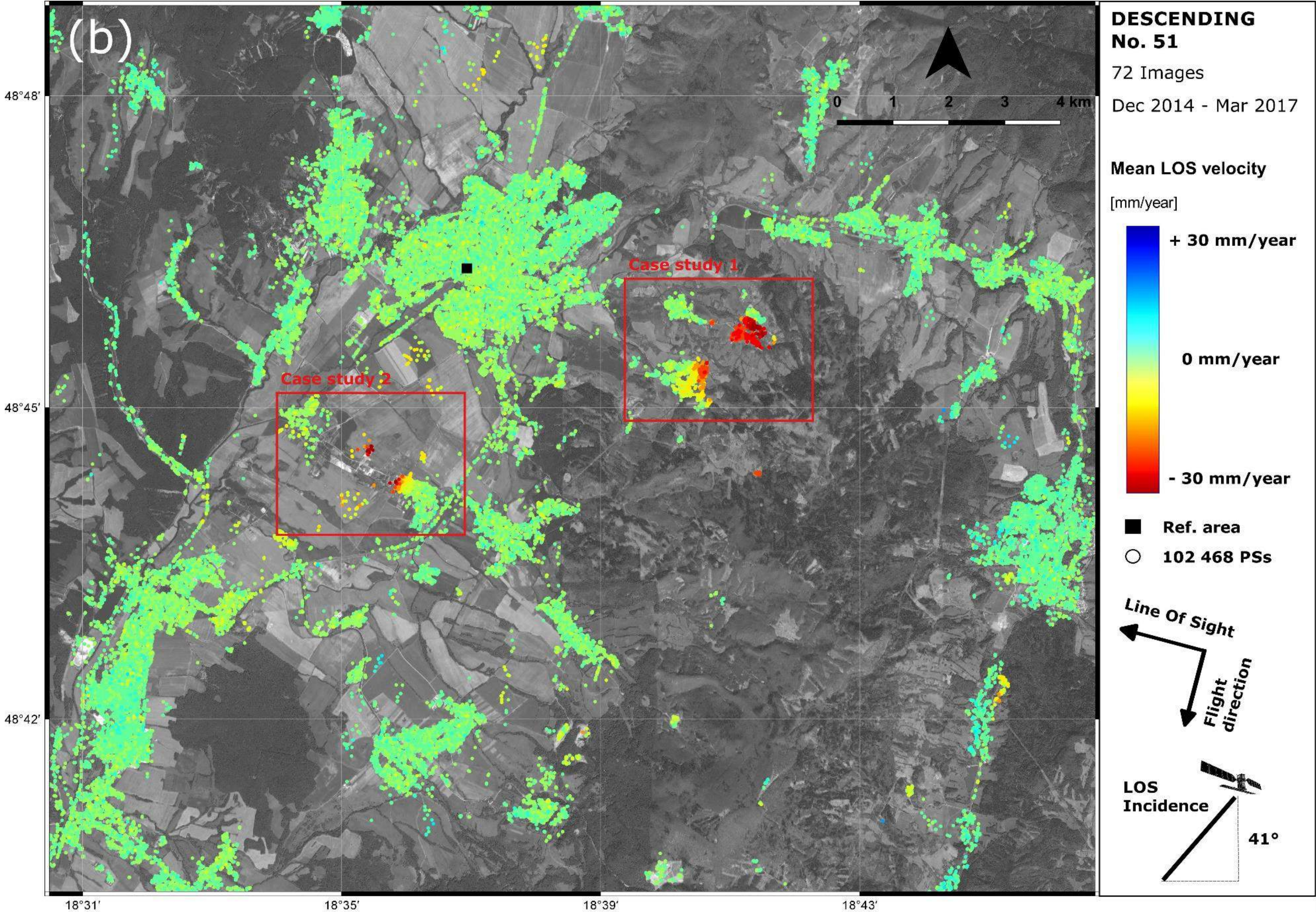
Google earth

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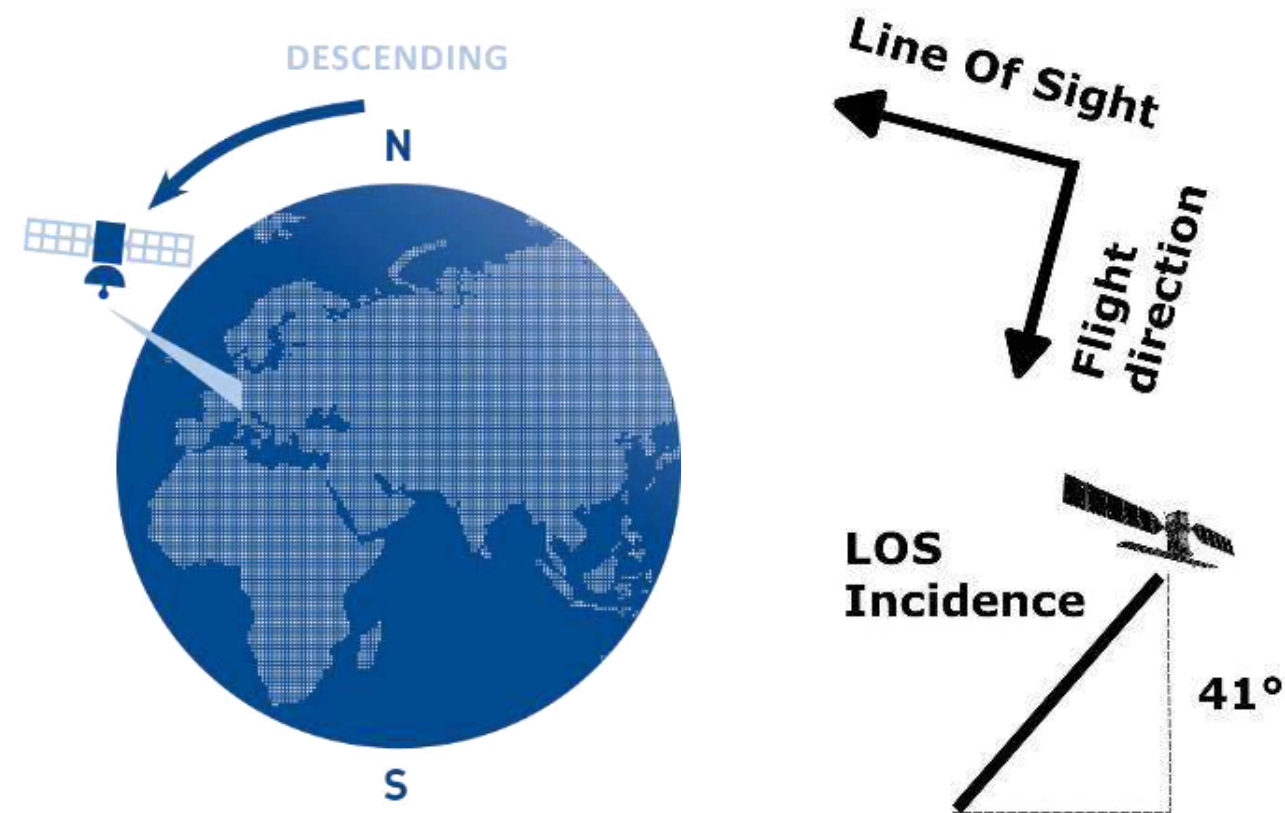
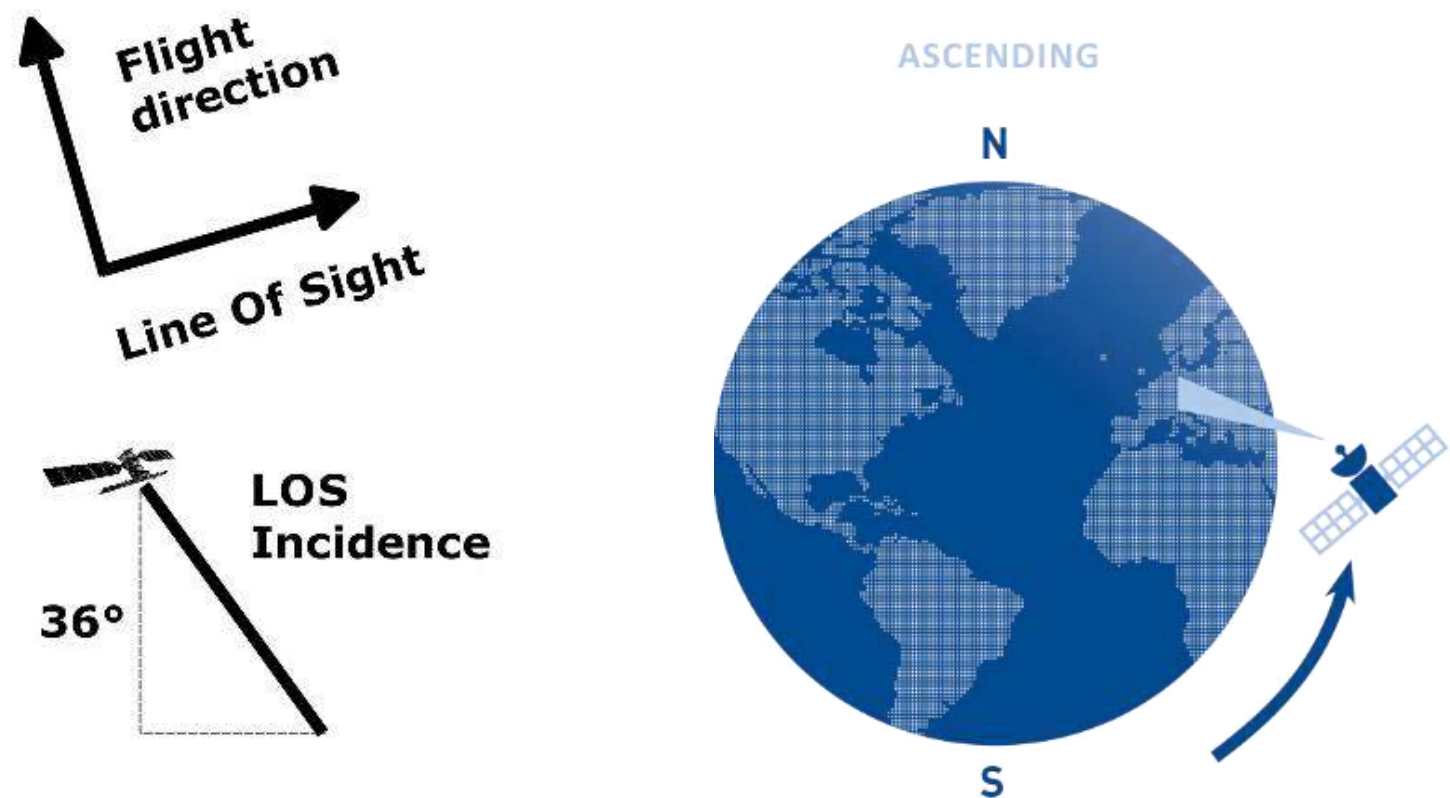
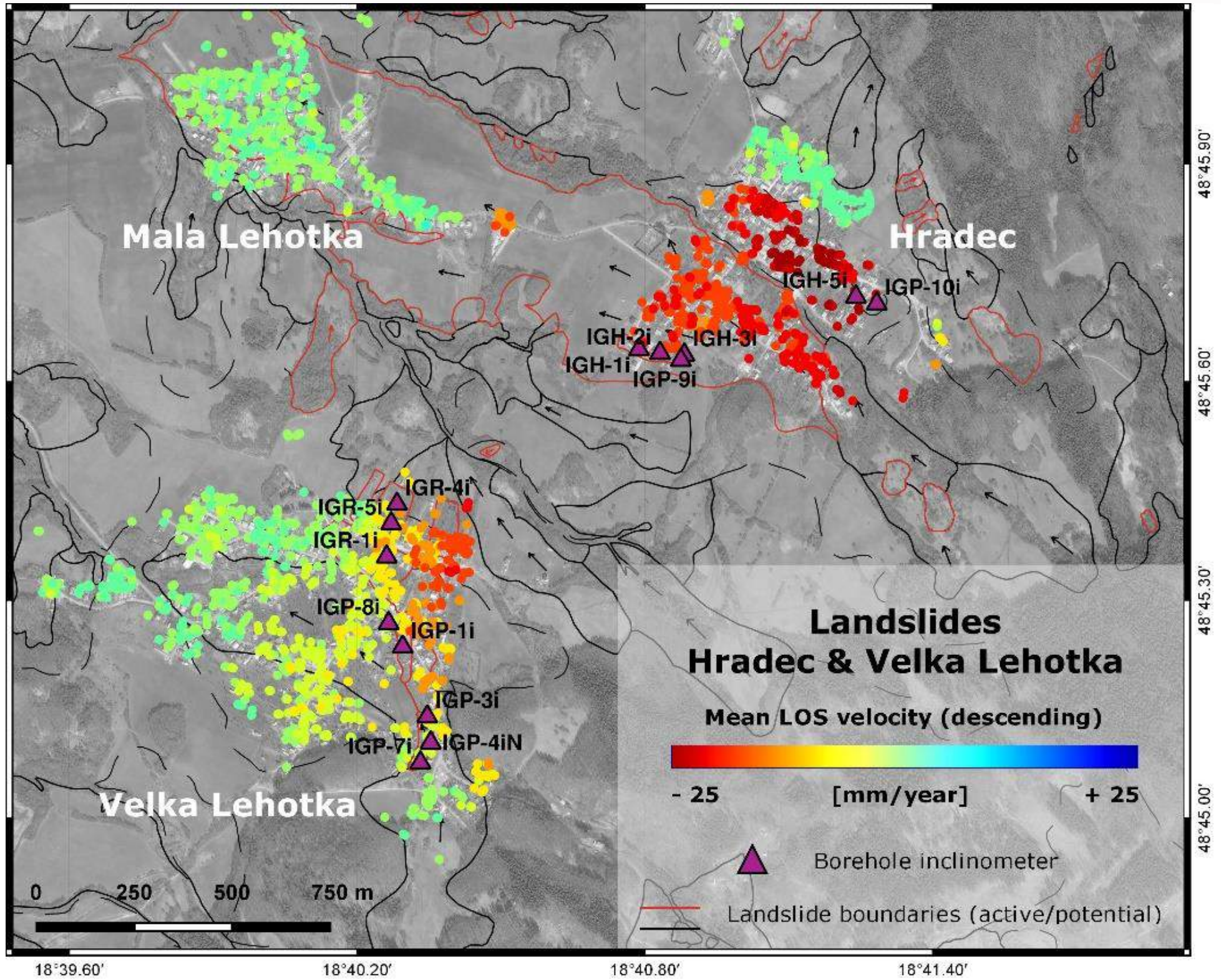
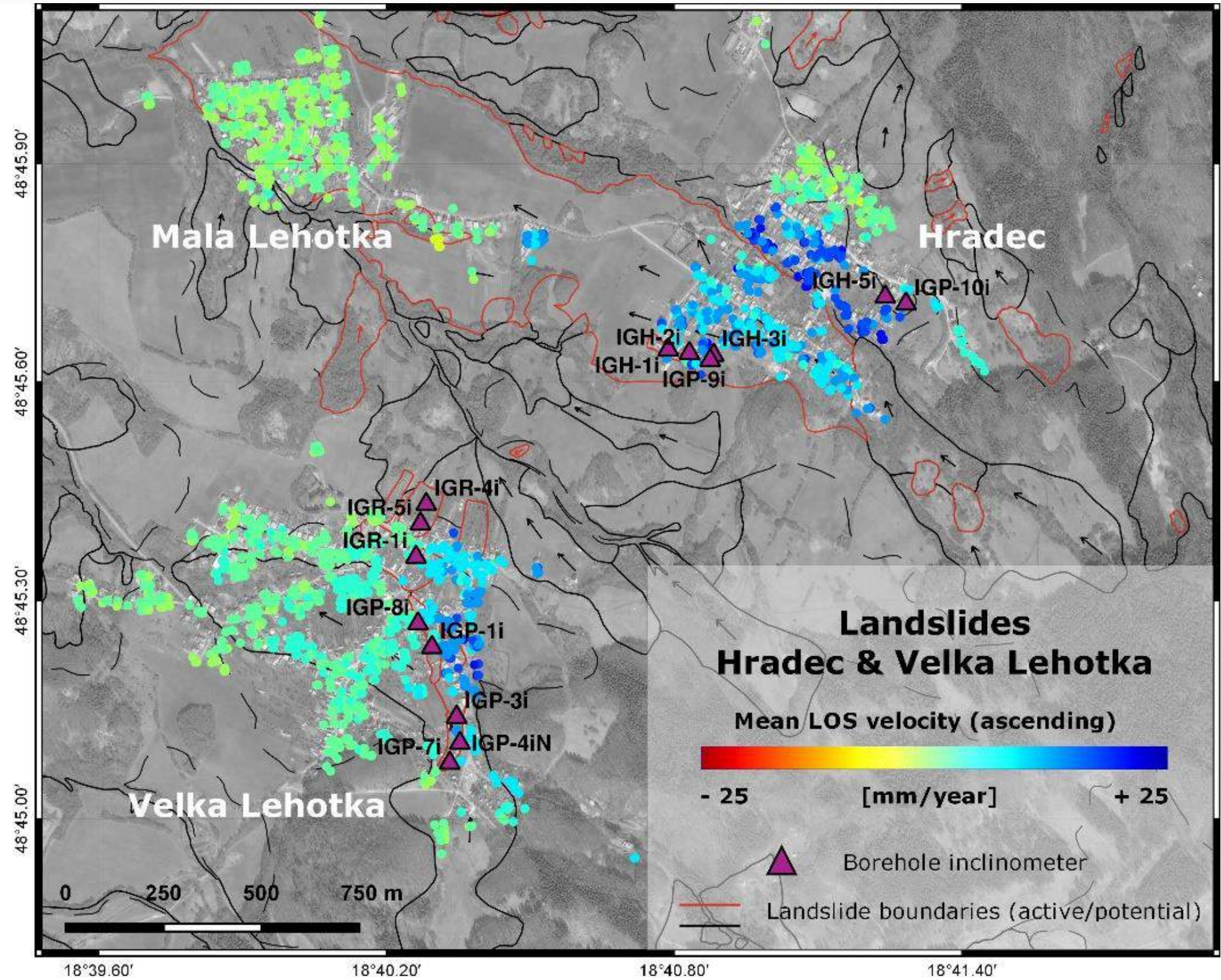


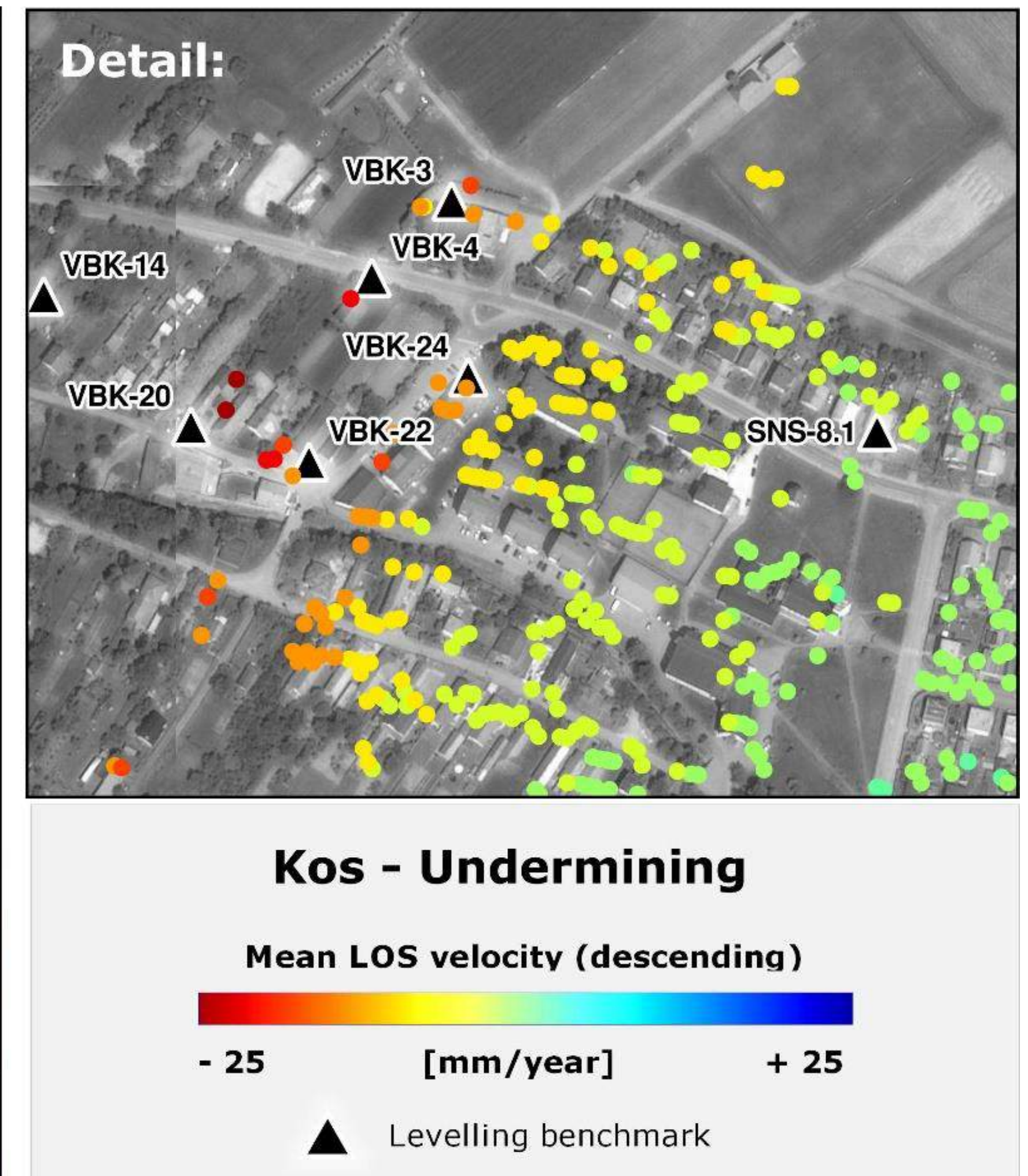
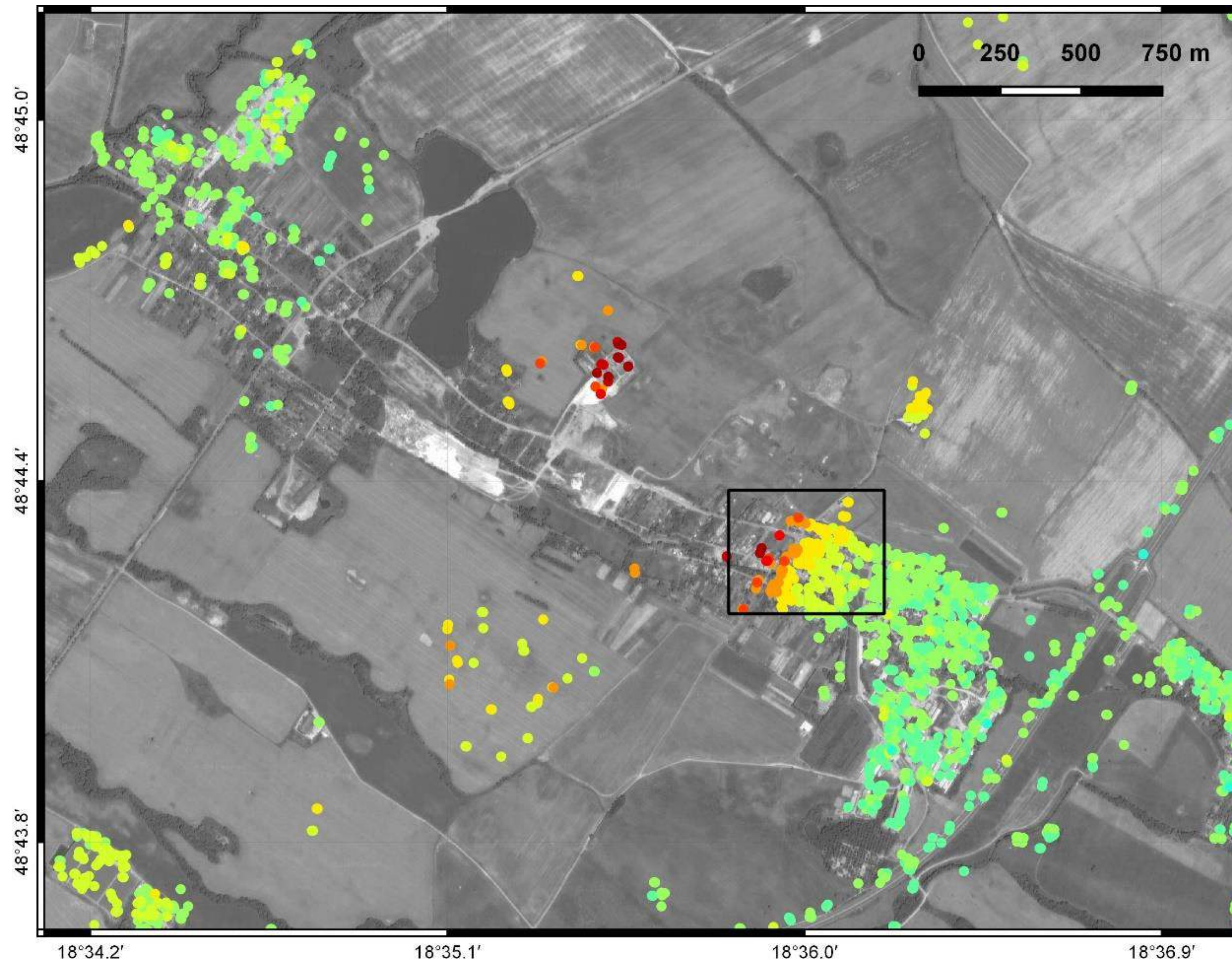
300 m

PODDOLOVANÉ & ZOSUVNÉ ÚZEMIA – HORNÁ NITRA



PODDOLOVANÉ & ZOSUVNÉ ÚZEMIA – HORNÁ NITRA





**ASCENDING
No. 175**

56 Images

Nov 2014 - Jan 2017

Mean LOS velocity

[mm/year]

- from -5.0 to -4.0
- from -4.0 to -3.0
- from -3.0 to -2.0
- from -2.0 to -1.0
- from -1.0 to 0.0
- from 0.0 to 1.0
- from 1.0 to 2.0
- from 2.0 to 3.0
- from 3.0 to 4.0
- from 4.0 to 5.0

▲ GNSS ref. point

□ Swath

○ **130 197 PSs**

Flight
direction

Line Of Sight

LOS
Incidence
43.5°

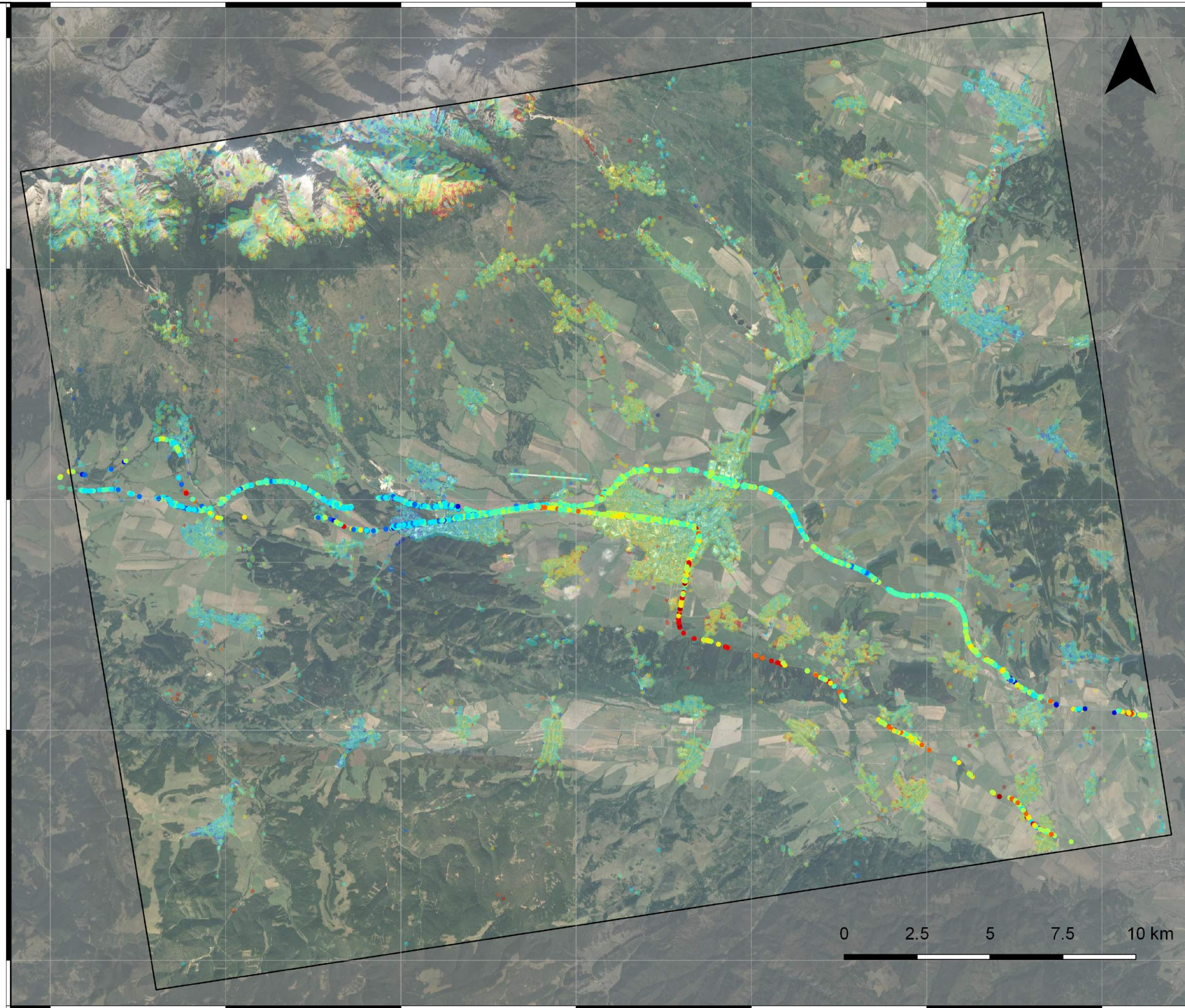


REGIONÁLNE
POKRYTIE

DOPRAVNÁ
INFRAŠTRUKTÚRA

POPRADSKÁ
KOTLINA

SENTINEL-1
(2014 -2017)



0 2.5 5 7.5 10 km

49°12'

49°8'

49°4'

49°0'

48°56'

20°0'

20°5'

20°10'

20°15'

20°20'

20°25'

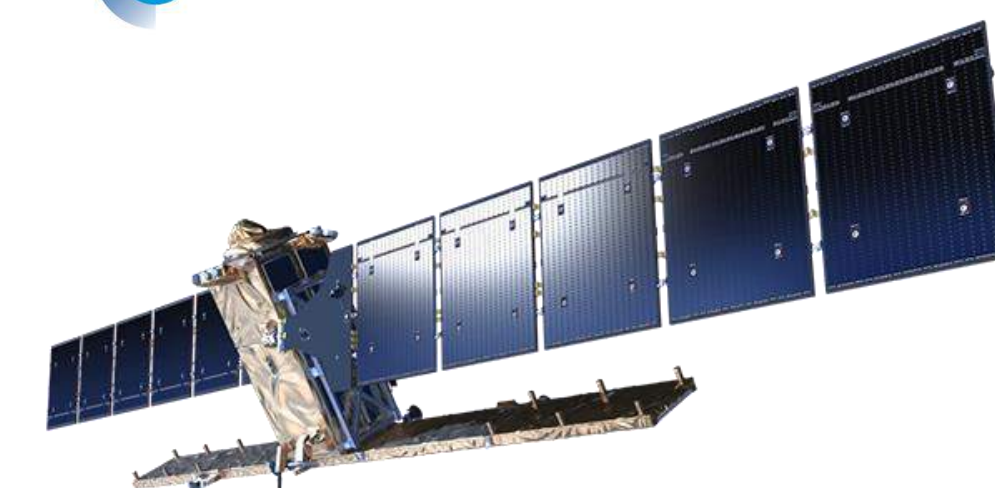
20°30'

REGIONÁLNE
POKRYTIE

DOPRAVNÁ
INFRAŠTRUKTÚRA

POPRADSKÁ
KOTLINA

SENTINEL-1
(2014 -2017)



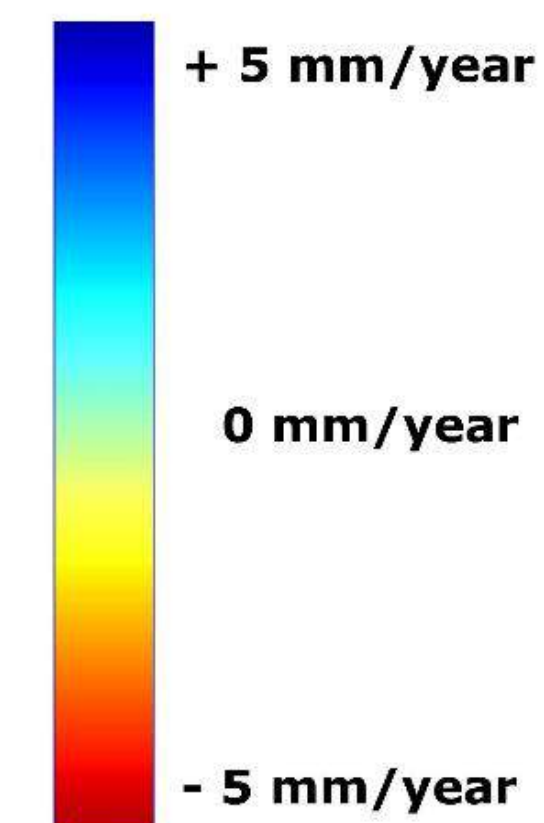
**DESCENDING
No. 51**

55 Images

Dec 2014 - Jan 2017

Mean LOS velocity

[mm/year]



▲ GNSS ref. point

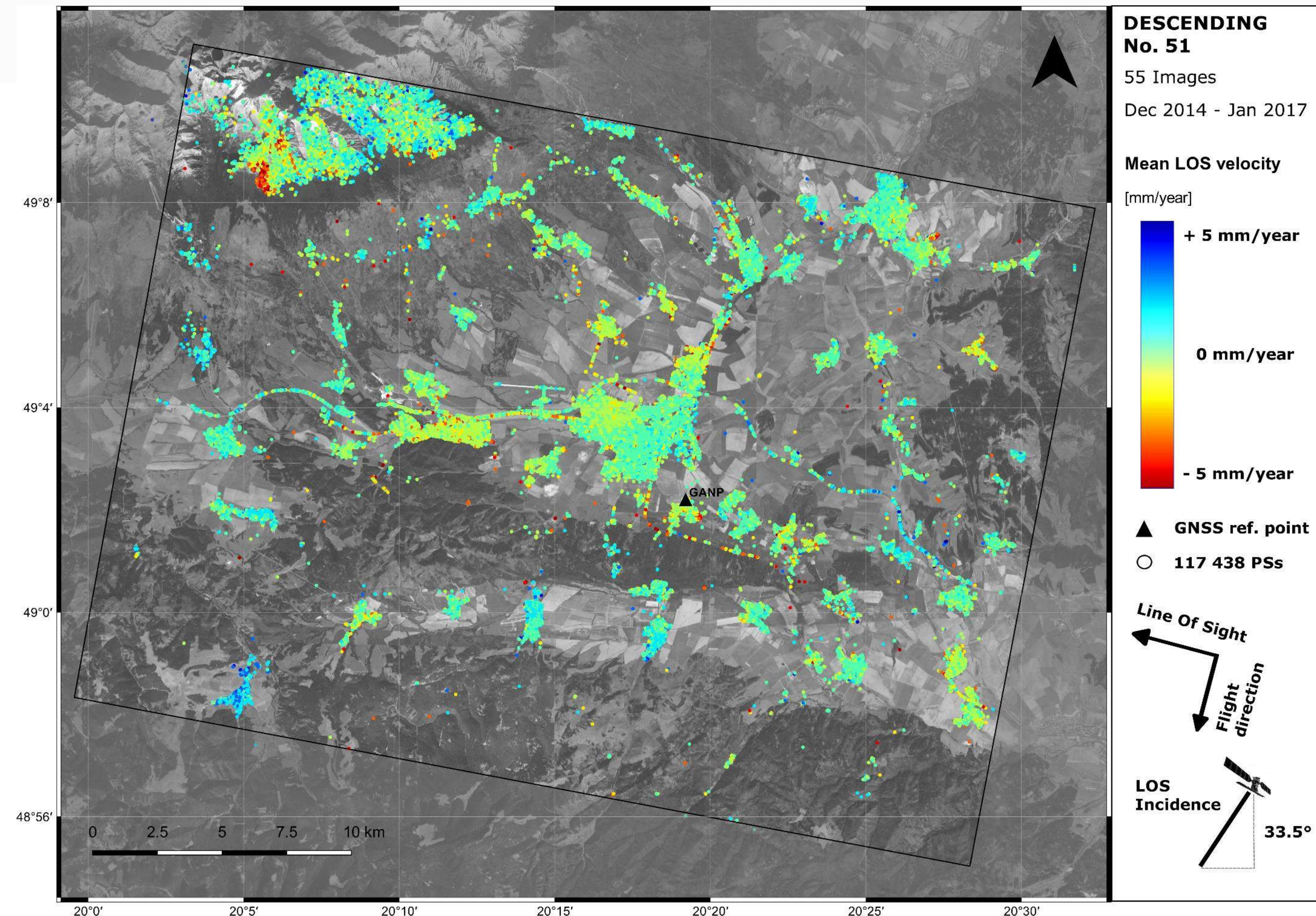
○ 117 438 PSs

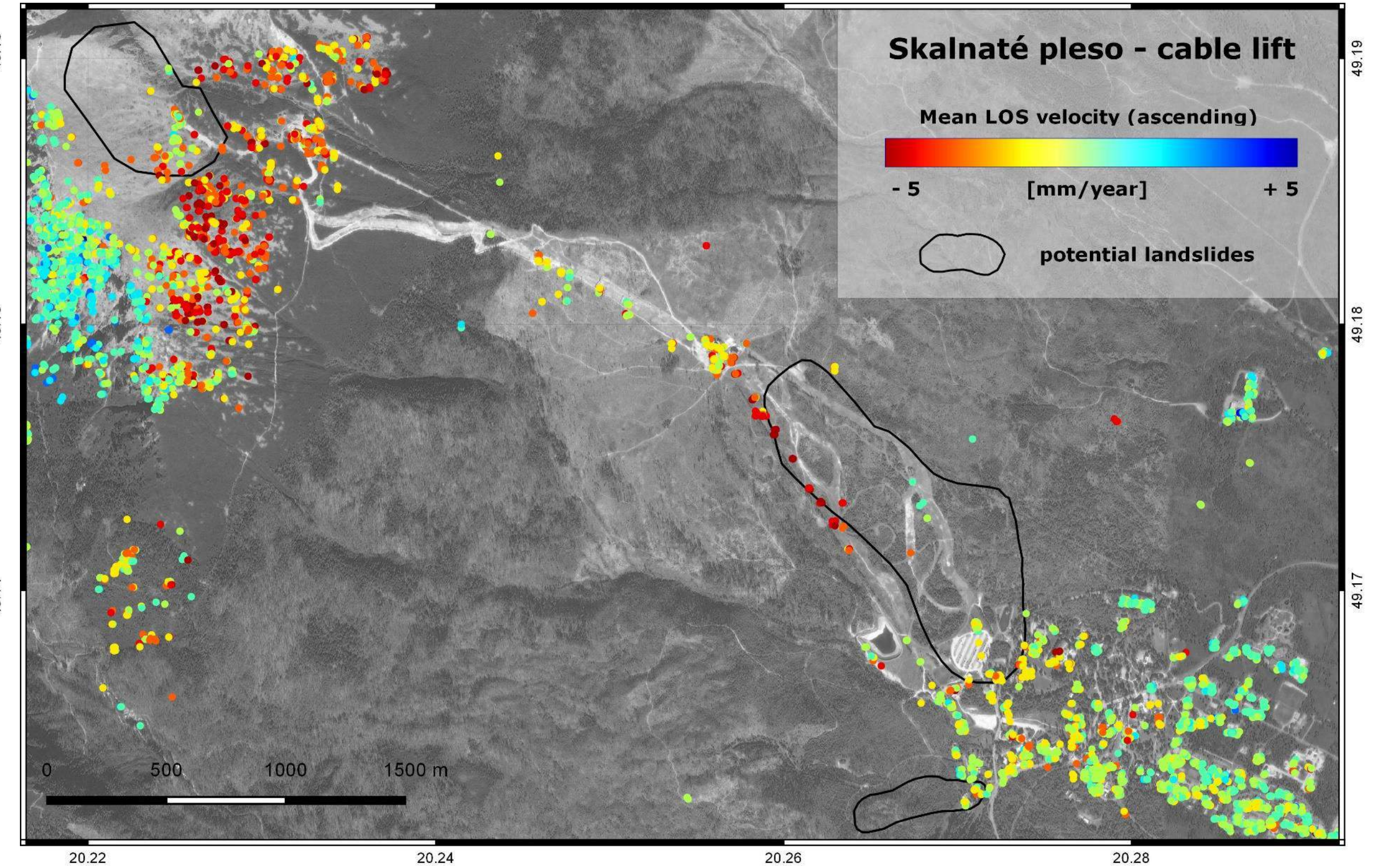
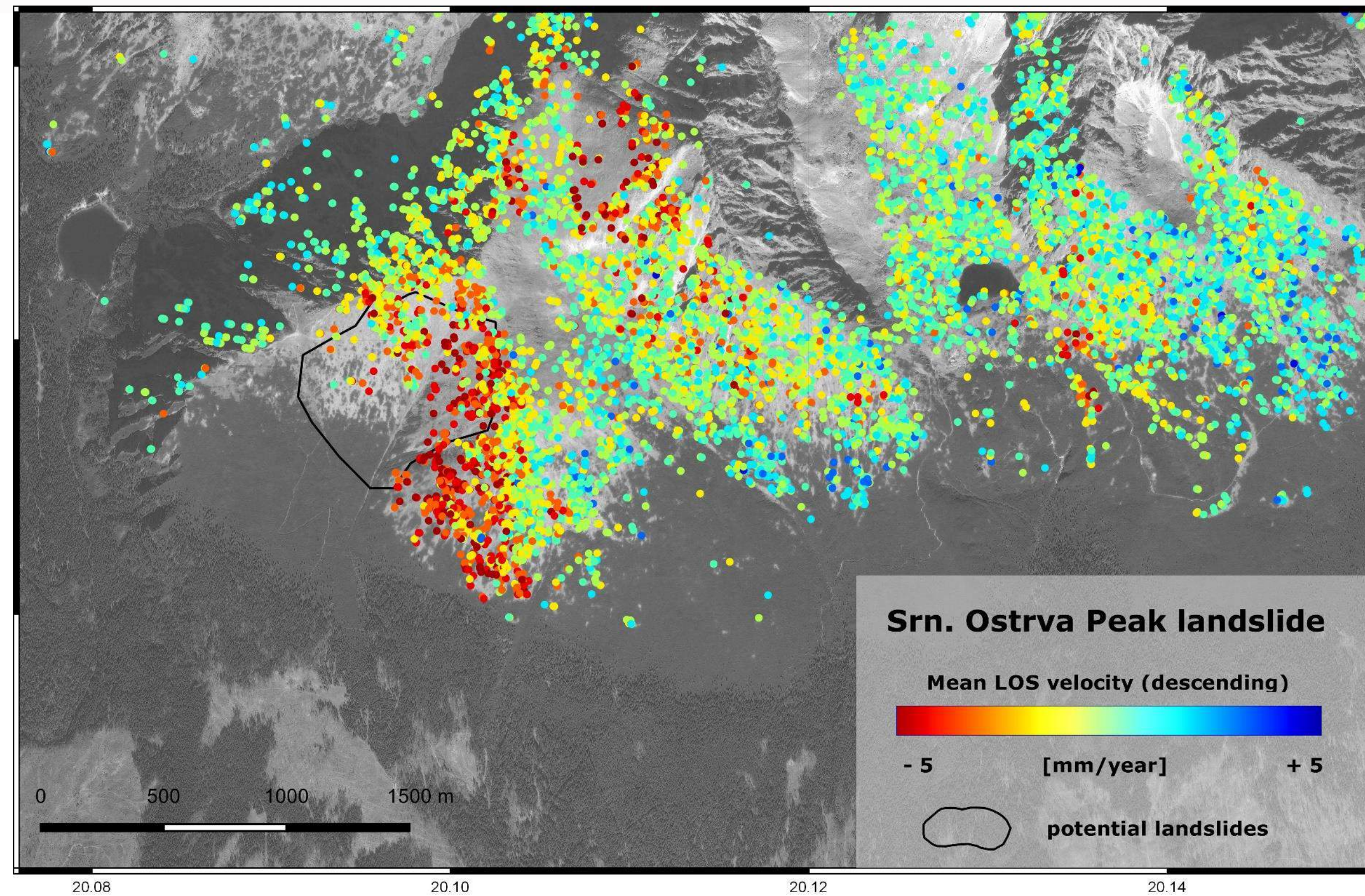
Line Of Sight

Flight
direction

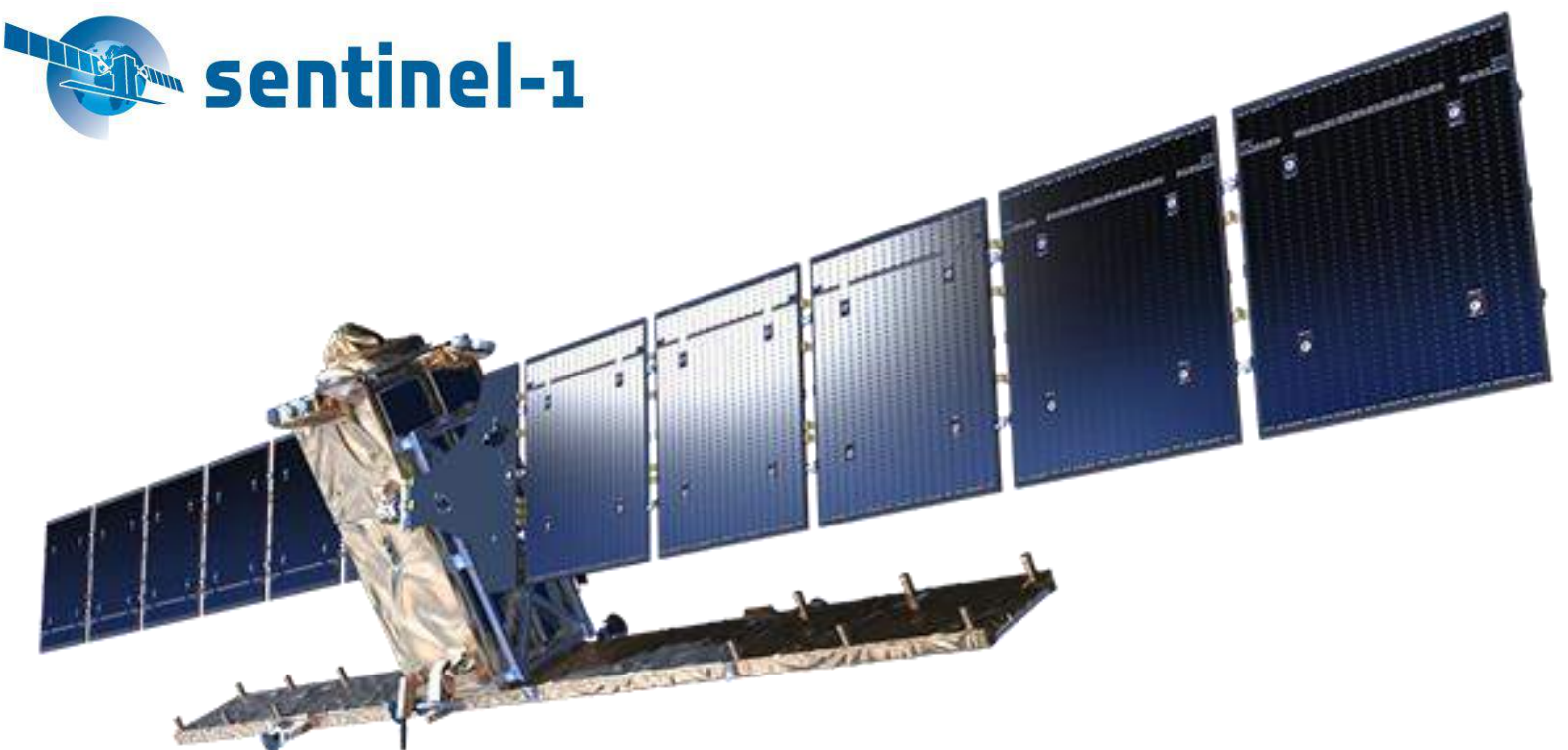
LOS
Incidence

33.5°



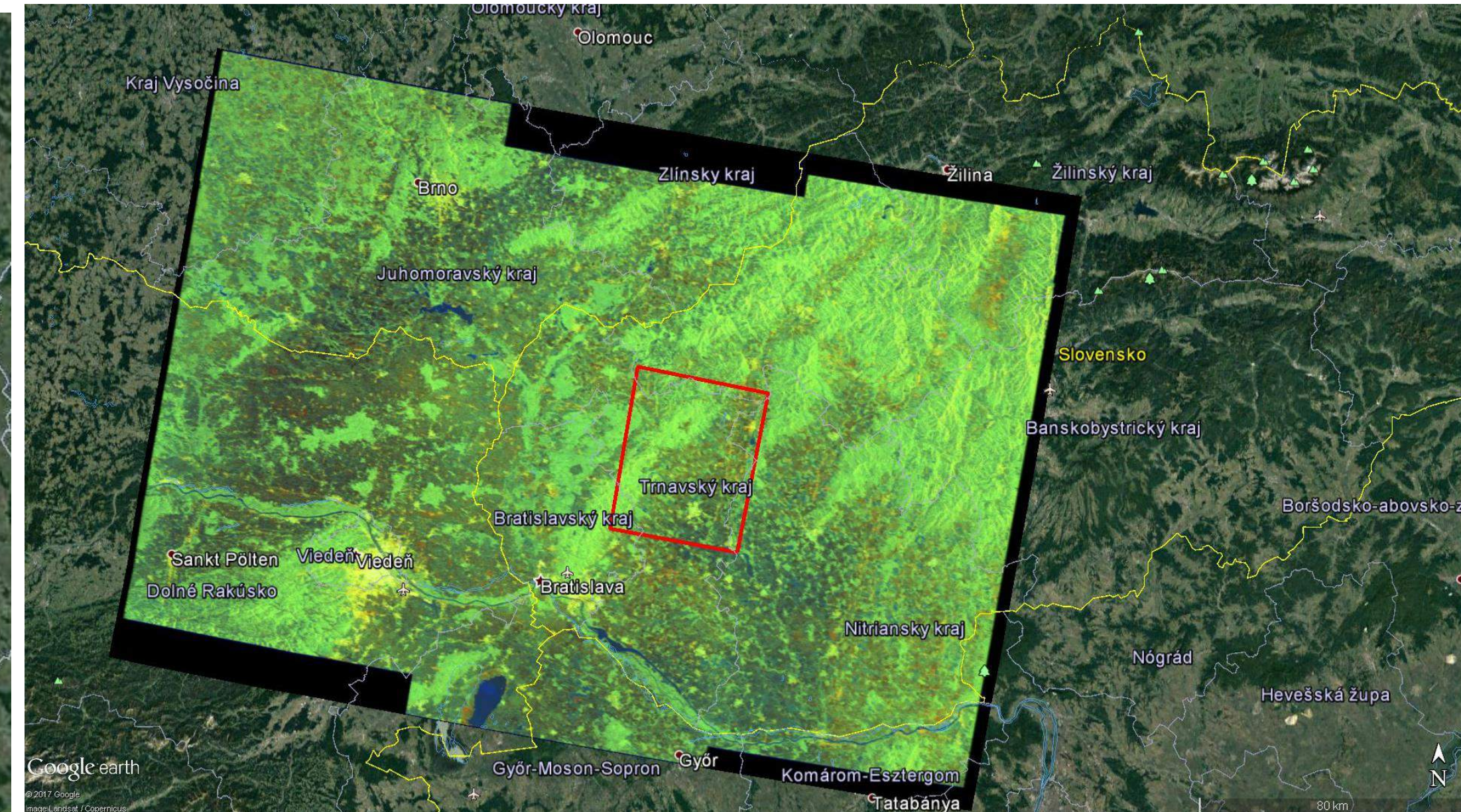
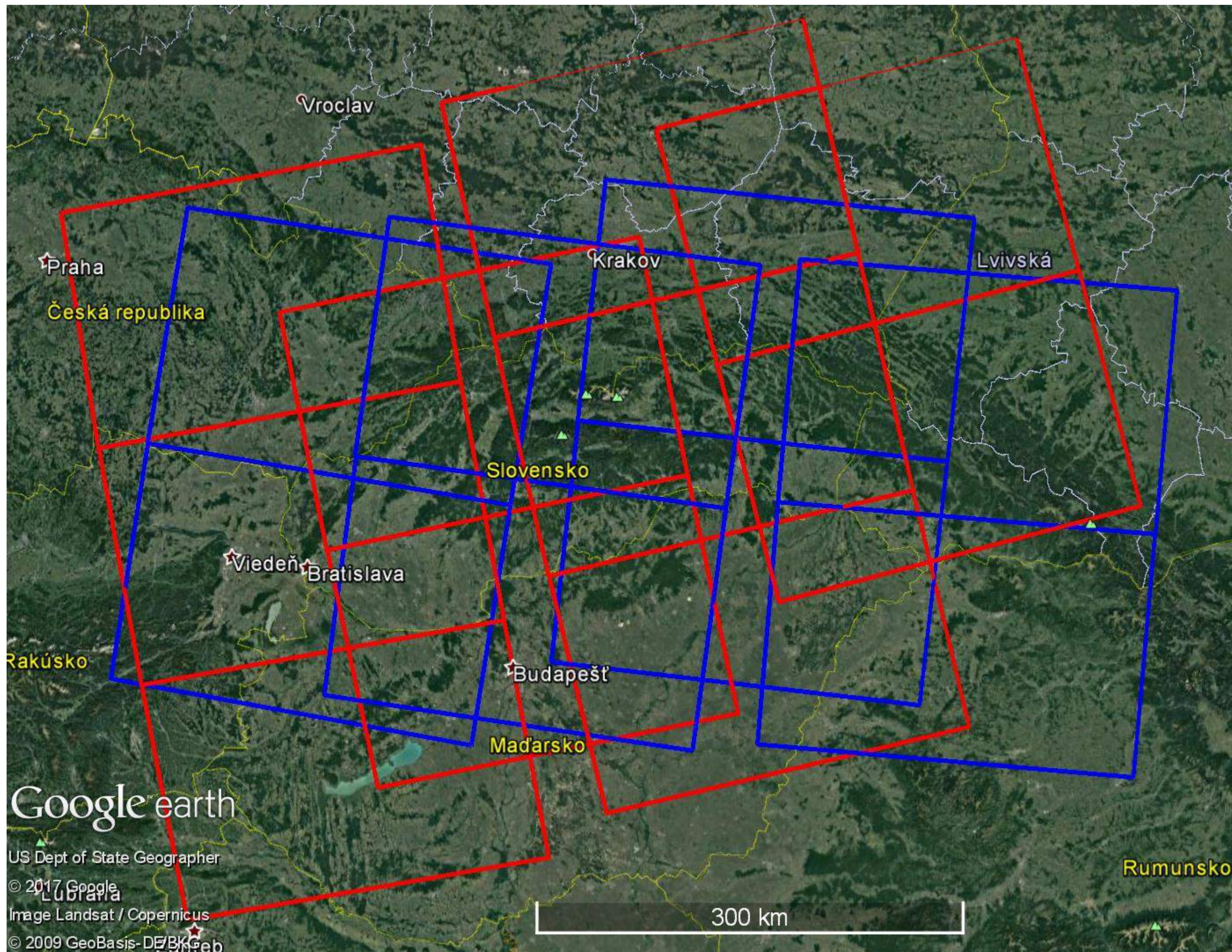


REGIONÁLNE POKRYTIE
LOKÁLNY PROBLÉM
POPRADSKÁ KOTLINA
SENTINEL-1 (2014 -2017)



PERSPEKTÍVA

Slovensko - Sentinel-1A/B - 2300 SLC snímok – 11.5 TB





Vyhľadávanie pohybov a možných deformačných rizík s využitím družice Sentinel-1

Retrieval of Motions and Potential Deformation Threats using Sentinel-1

“Operačné nasadenie technológie InSAR s využitím družice Sentinel-1 na monitorovanie pretvorení a deformácií štruktúr a infraštruktúr s vyhľadávaním pohybov a možných deformačných rizík s charakteristikou presnosti a zakomponovaním požiadaviek odberateľov.”

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STU

AtoS

Slovakia in the Plan for European Cooperating State (PECS) of European Space Agency (ESA)



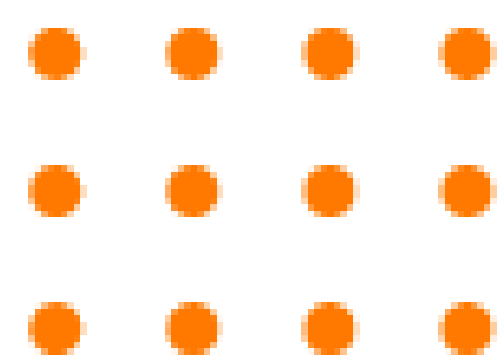
Národný InSAR Workshop

28.6.2018

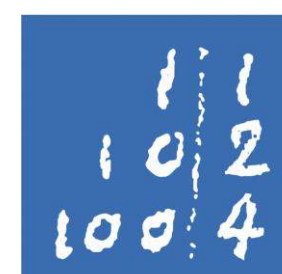
bit.ly/insar_workshop



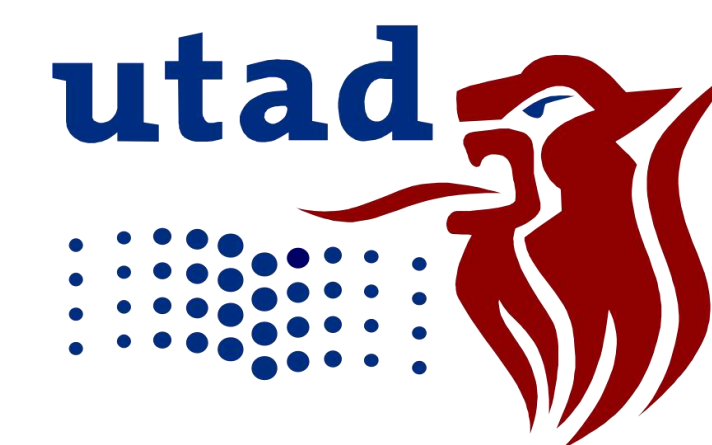
ĎAKUJEME ZA POZORNOSŤ



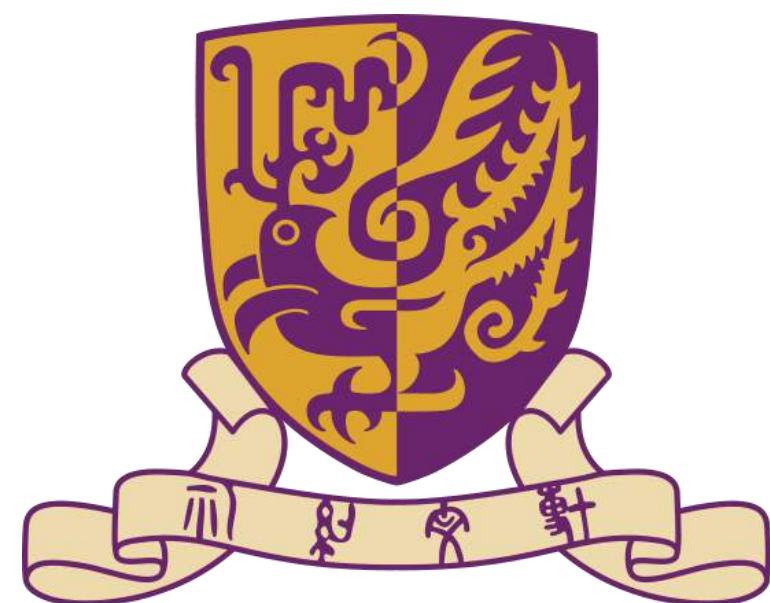
STU
SvF



Leibniz
Universität
Hannover



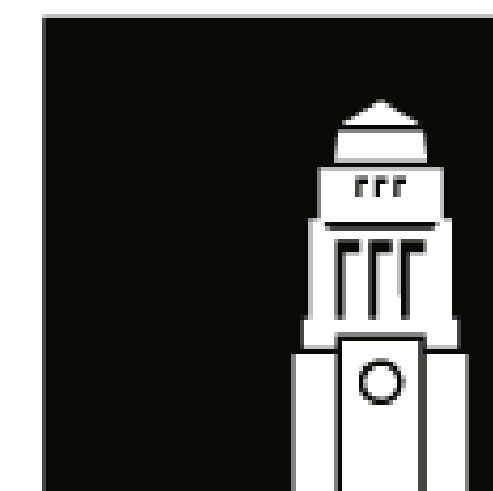
Geodetický a kartografický ústav
Bratislava



Vodohospodárska
výstavba

Odbor geodetických meraní

Úsek TBD



ĎAKUJEME ZA POZORNOST

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