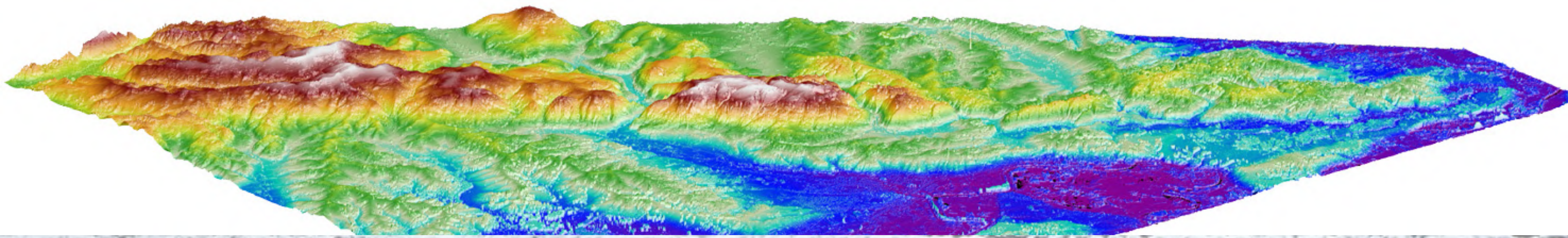




vEGU21: Gather Online | 19–30 April 2021

Comparison between the coseismic surface displacement during the 29 December 2020 Mw 6.4 Petrinja earthquake (Croatia) from optical image correlation and long-term geomorphological observations of cumulative displacements



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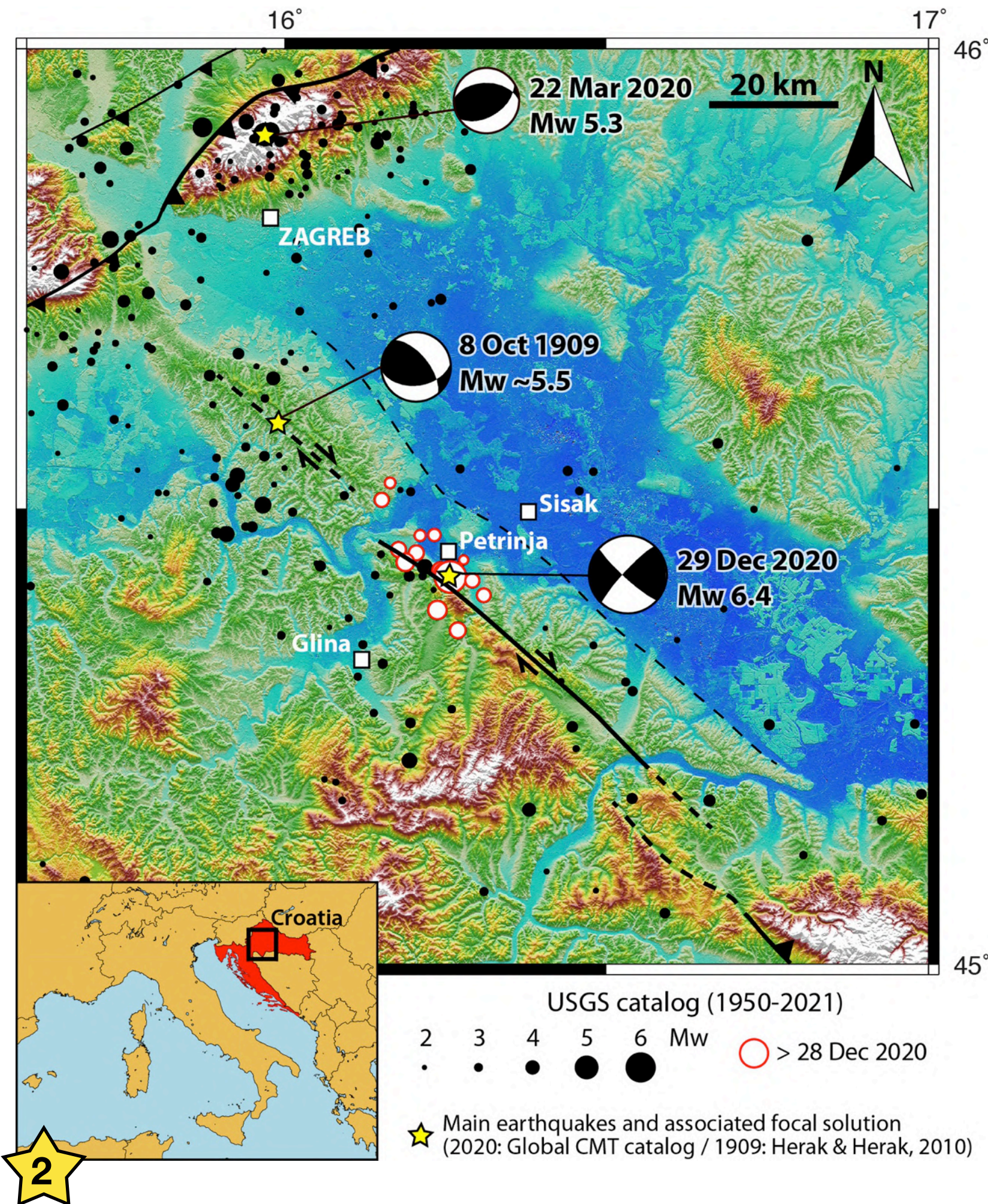
1) Aix Marseille Université, CNRS, IRD, Collège de France, CEREGE, Aix-en-Provence, France

2) Croatian Geological Survey (HGI-CGS), Milana Sachsa 2, 10000 Zagreb, Croatia

3) Université Grenoble Alpes, Université Savoie Mont Blanc, CNRS, IRD, IFSTTAR, Grenoble, France

4) United States Geological Survey, Golden, U.S.A.

5) IRSN, Fontenay-aux-Roses, France



Seismotectonic context

* Central Croatia:

Transition zone between the Eastern Alps, Dinarides and Pannonian basin.

* Petrinja-Pokupsko fault:

NW-SE right-lateral / transpressive.

* Kinematics:

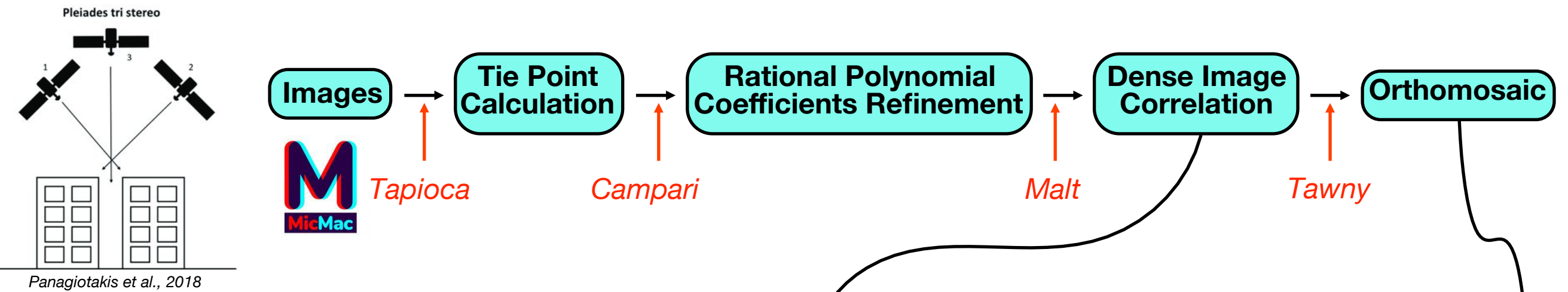
Intraplate reactivation of NW trending fault systems inherited from the opening of the Pannonian basin.

Study objectives

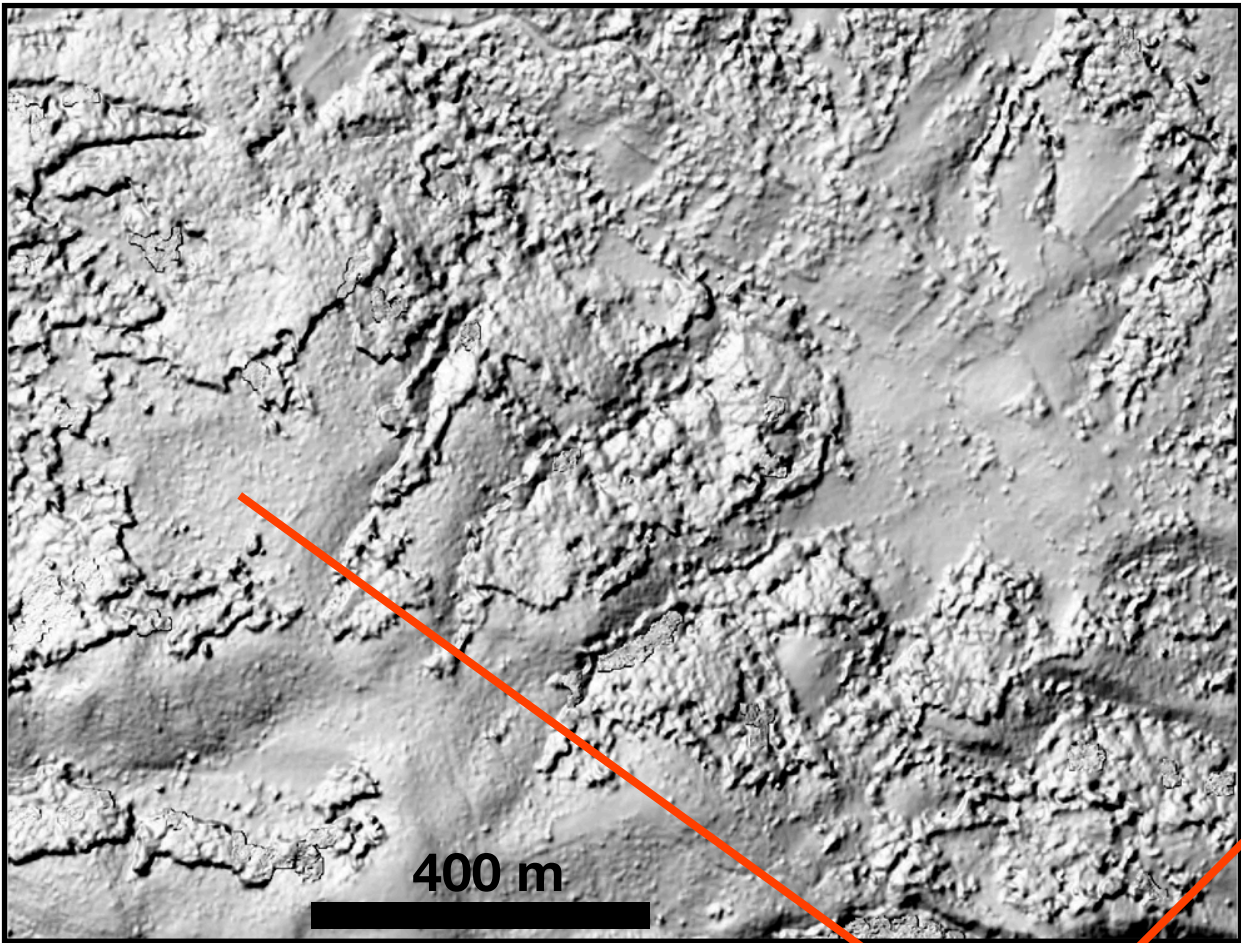
> Characterization of the long term active fault trace (cumulative displacements, segmentation, ...).

> Comparison with the co-seismic surface displacements extracted from image correlation and surface rupture observations.

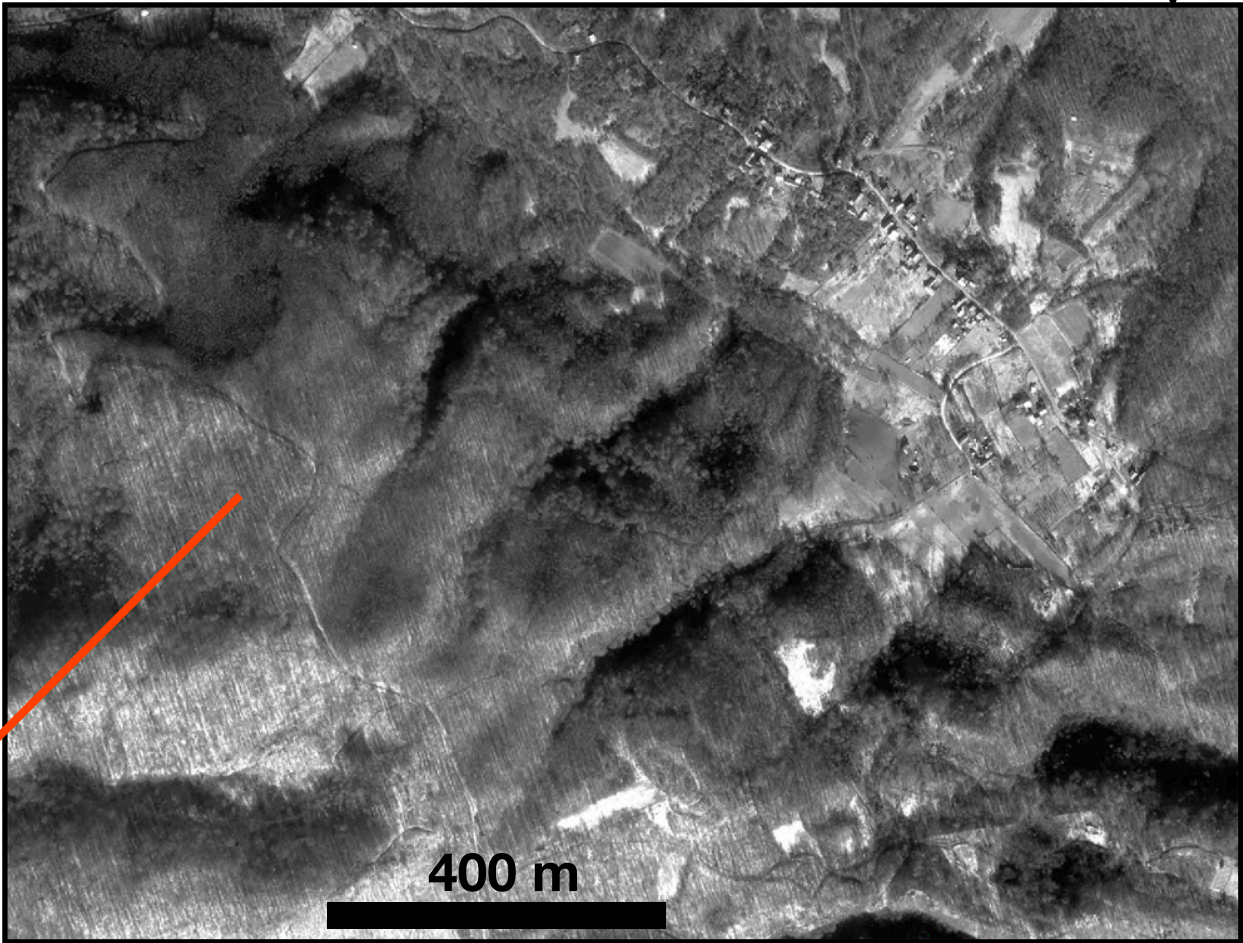
Photogrammetry (*MicMac*): DEM extraction from tri-stereo Pléiades optical images



1m resolution DEM



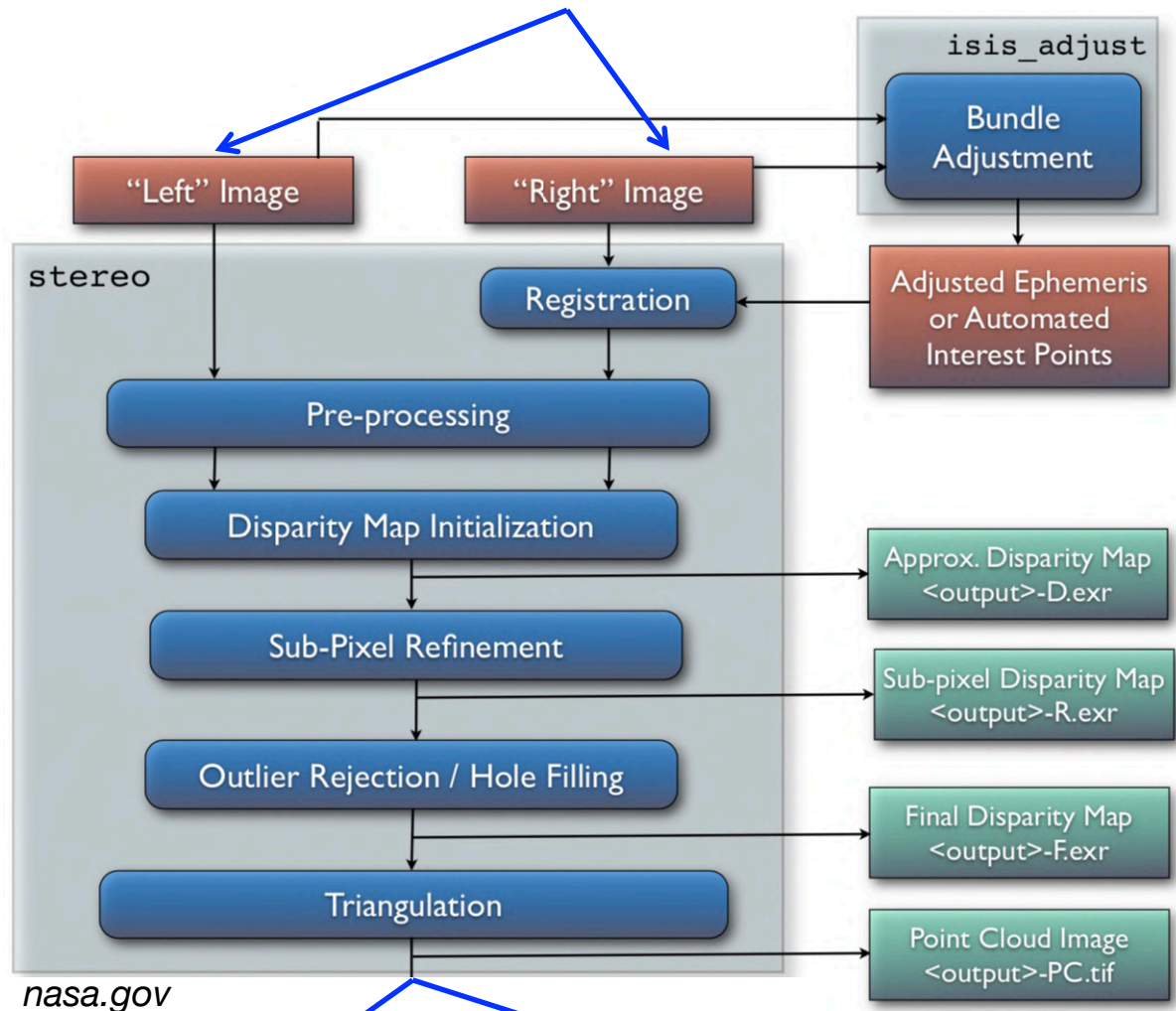
50 cm resolution orthomosaic



Pléiades images acquired in February 2021 (leafless trees)
=> ground detected over ~50 % of the forest areas

Photogrammetry (ASP): 1) DEM extraction from stereo WorldView-2 optical images (Ames Stereo Pipeline) 2) Image correlation from pre/post EQ WorldView-2 images

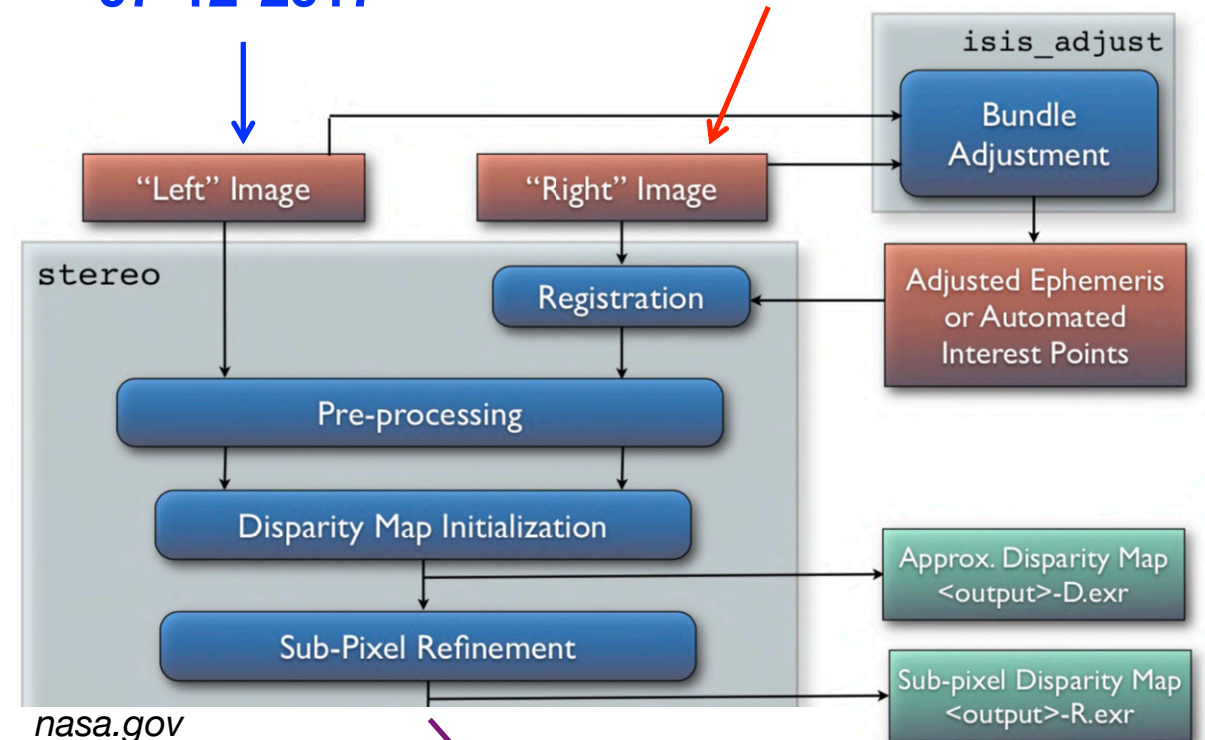
1) Stereo pair Pre-EQ images WorldView-2 (~50 cm) 07-12-2017



2)

Orthorectified
Pre-EQ image
WorldView-2
07-12-2017

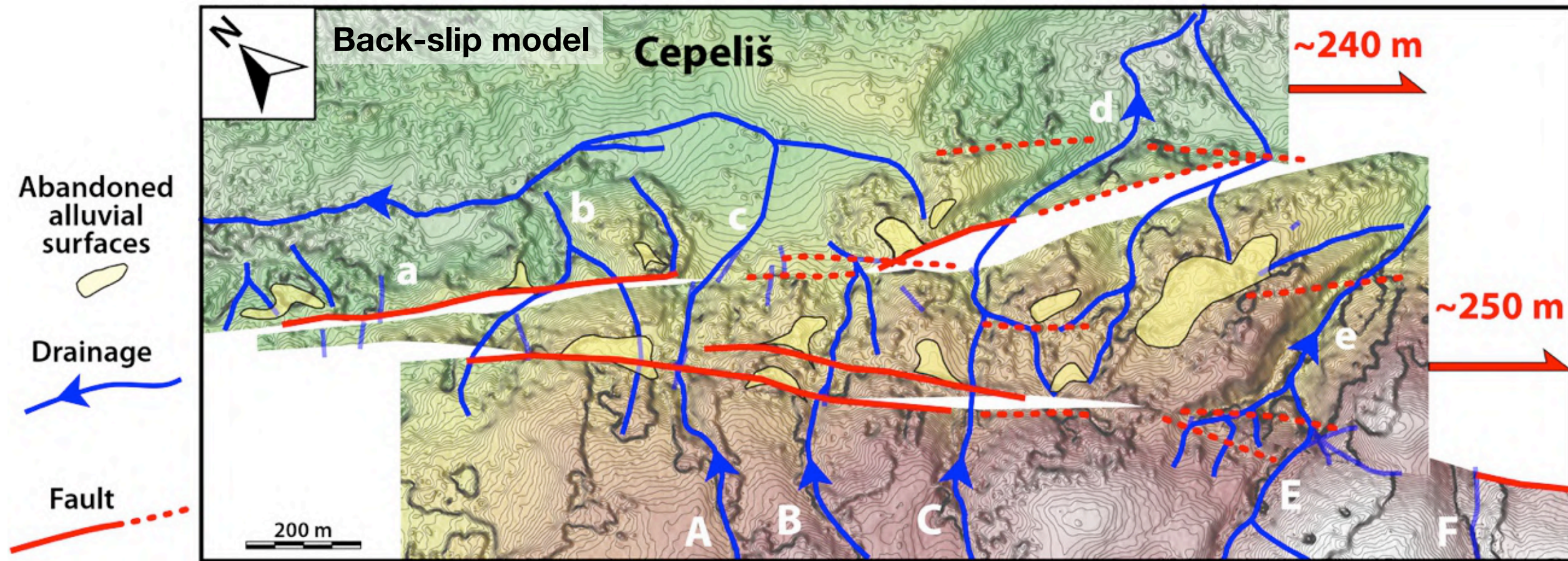
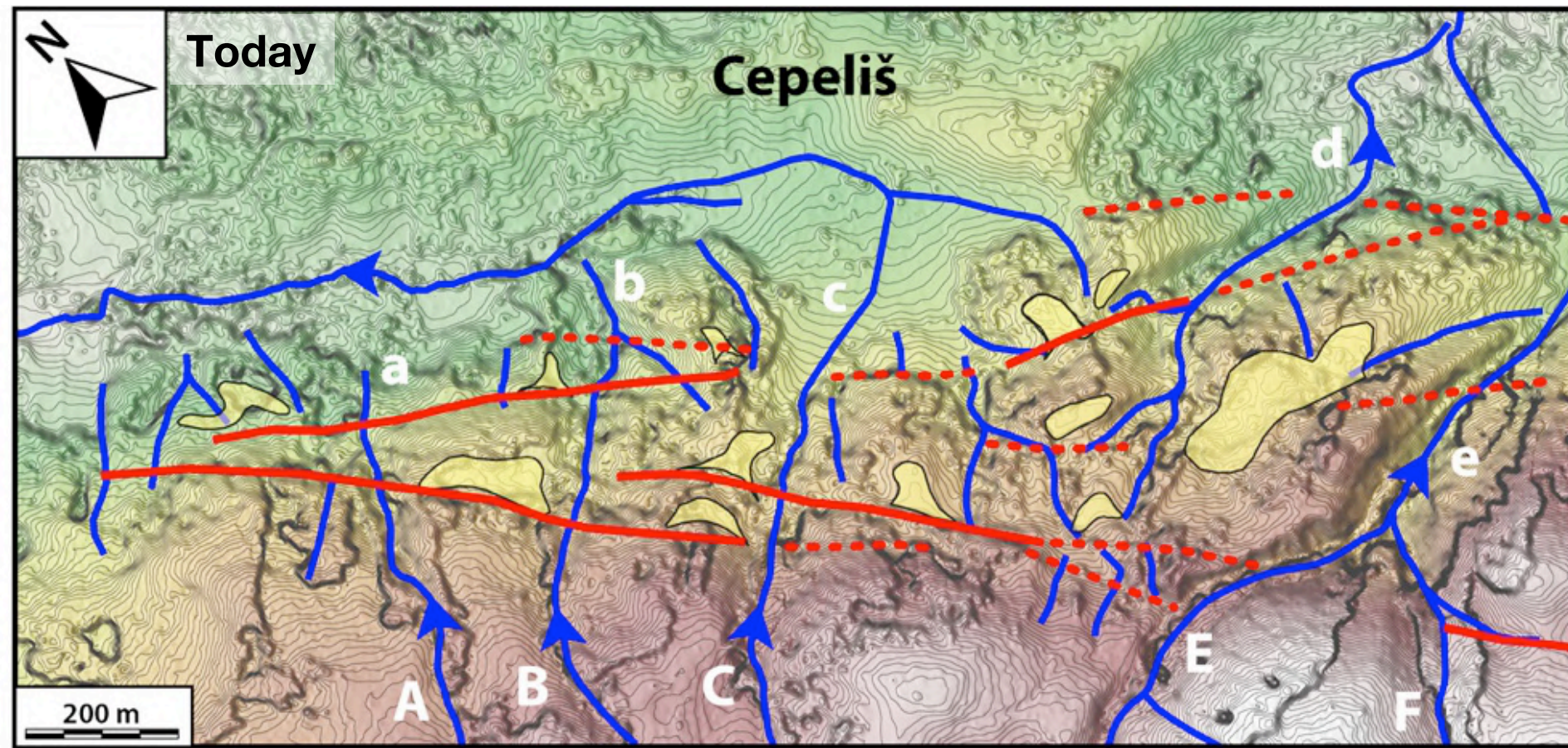
1 Post-EQ image
WorldView-2
15-01-2021
Orthorectified with the
WorldView pre-EQ DEM



Sub-pixel image correlation
E-W and N-S components

Long term cumulative displacement from DEM analysis: Cepeliš site

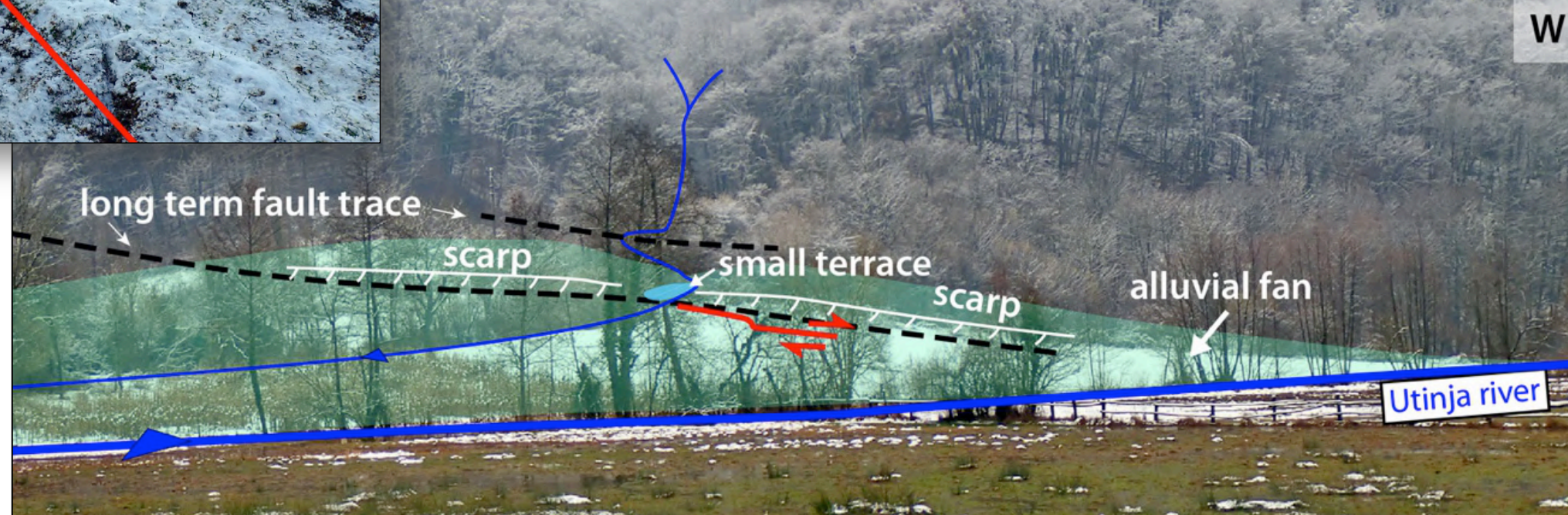
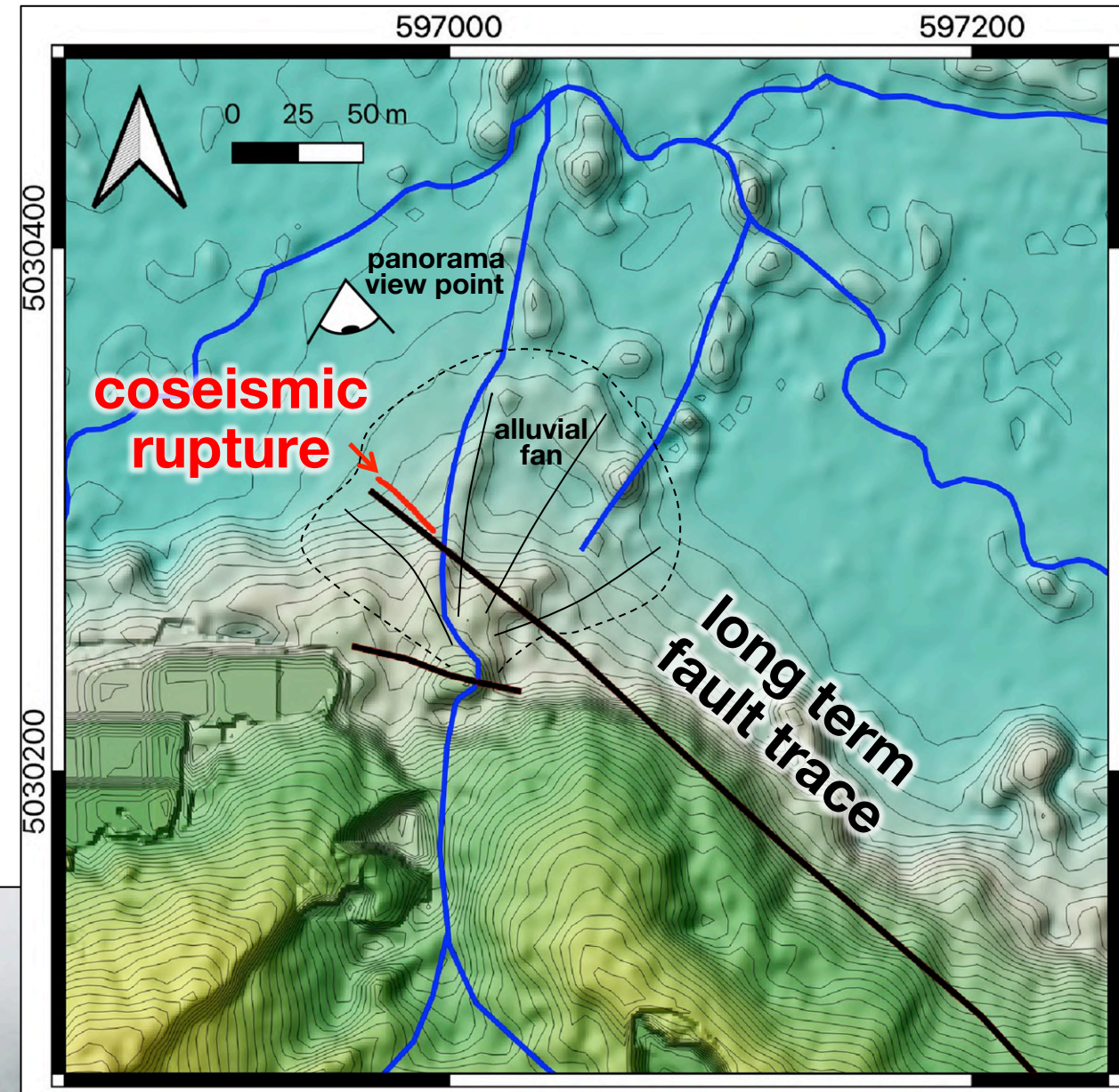
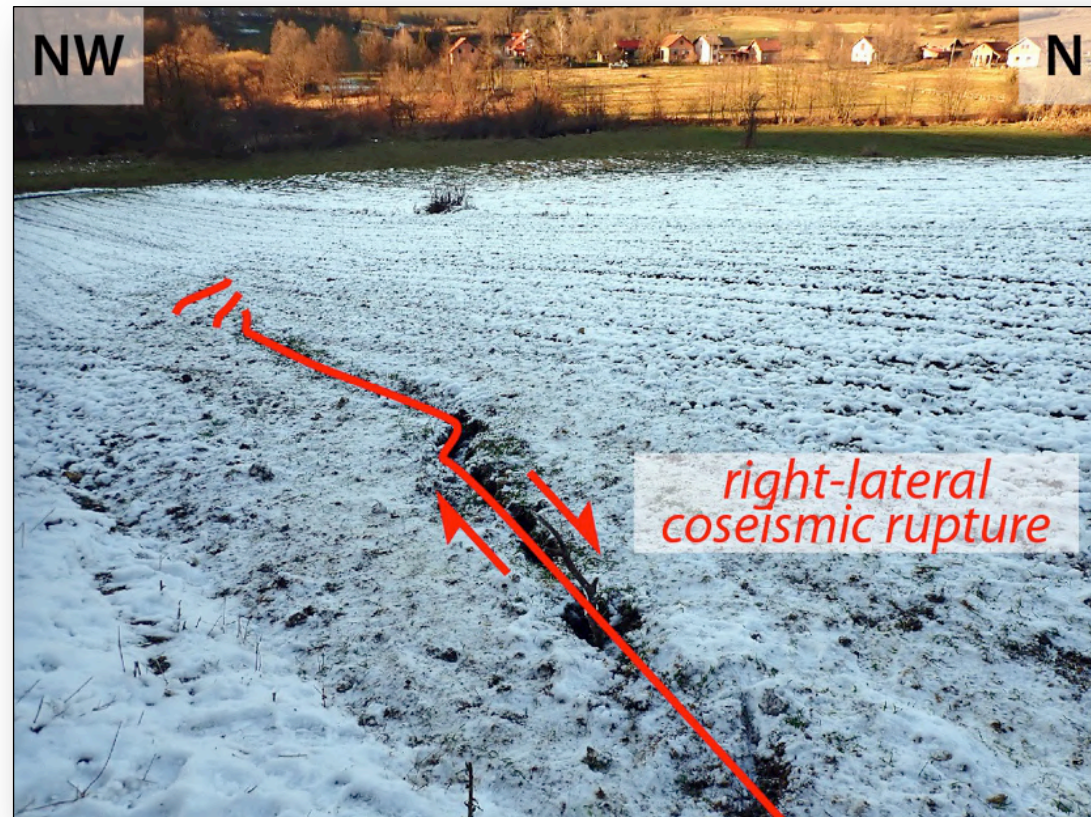
- ✓ Total back-slipping of about 490 m on 2 fault branches
- ✓ Possible stream connections:
 - > upstream A-B / downstream c
 - > upstream C / downstream d



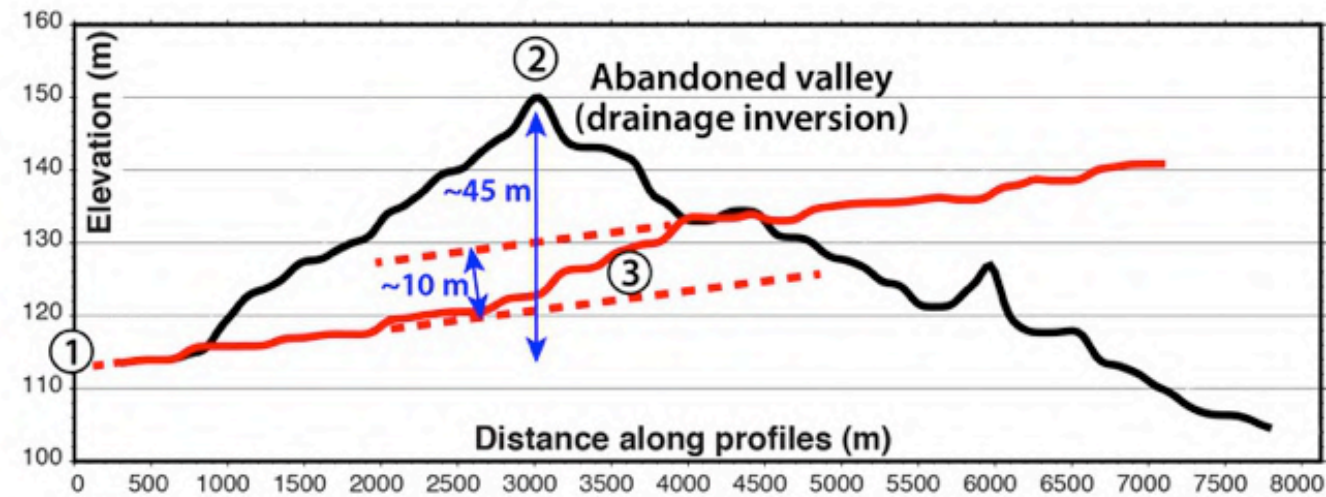
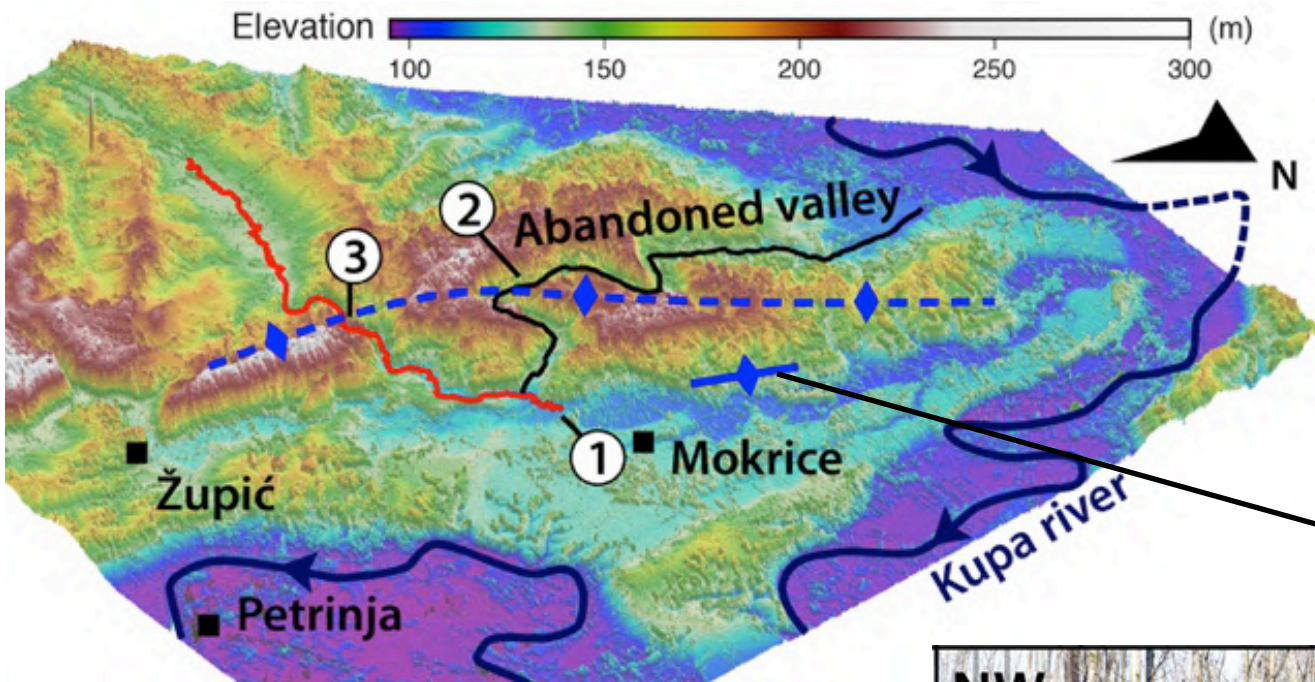
Long term cumulative displacement from DEM analysis & field observations: Križ site

- ✓ Long term offset of the alluvial fan by a NW-trending fault segment.
- ✓ The coseismic surface rupture follows the long term fault trace.

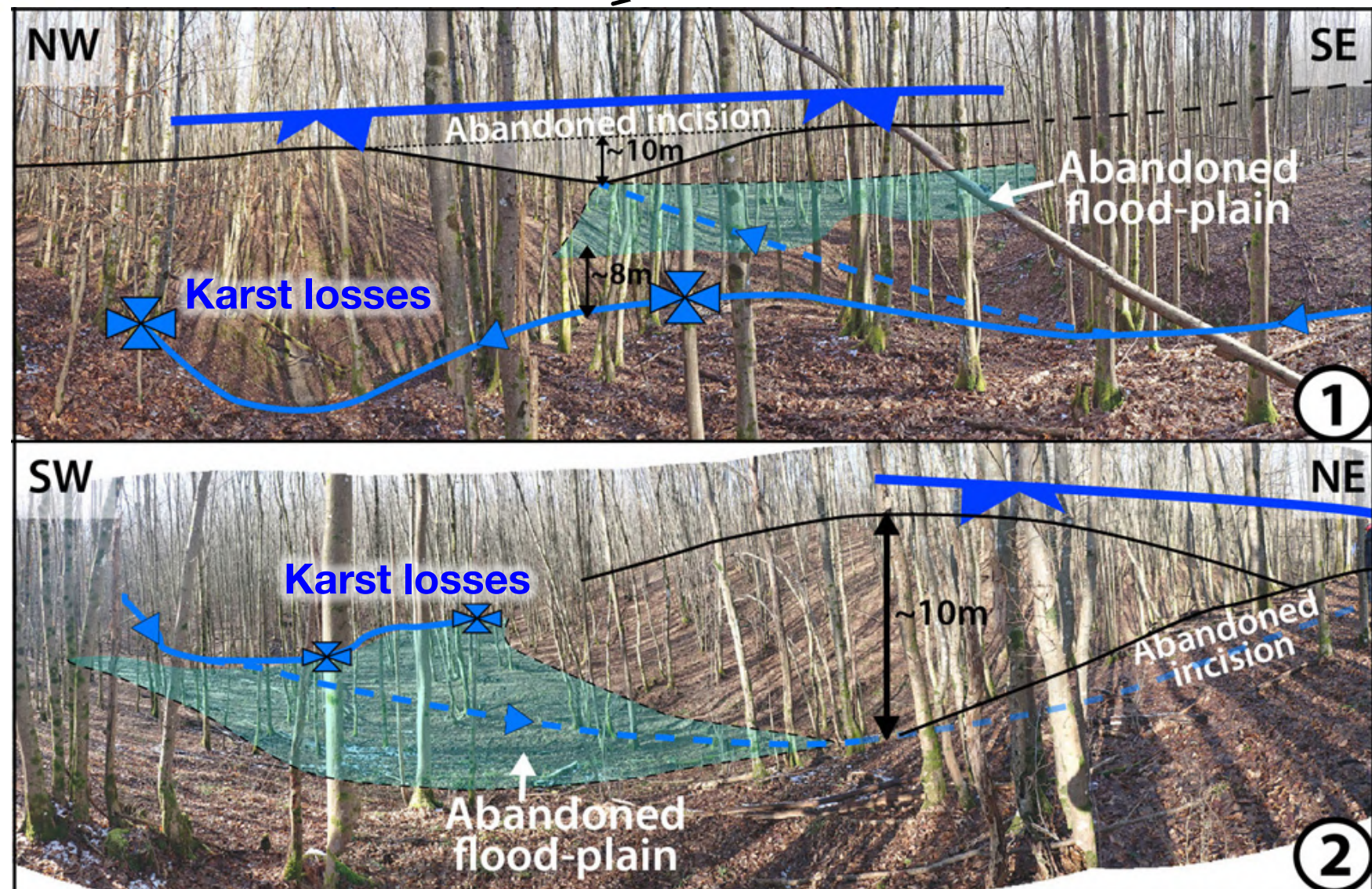
>> Potential site for future paleoseismic studies.



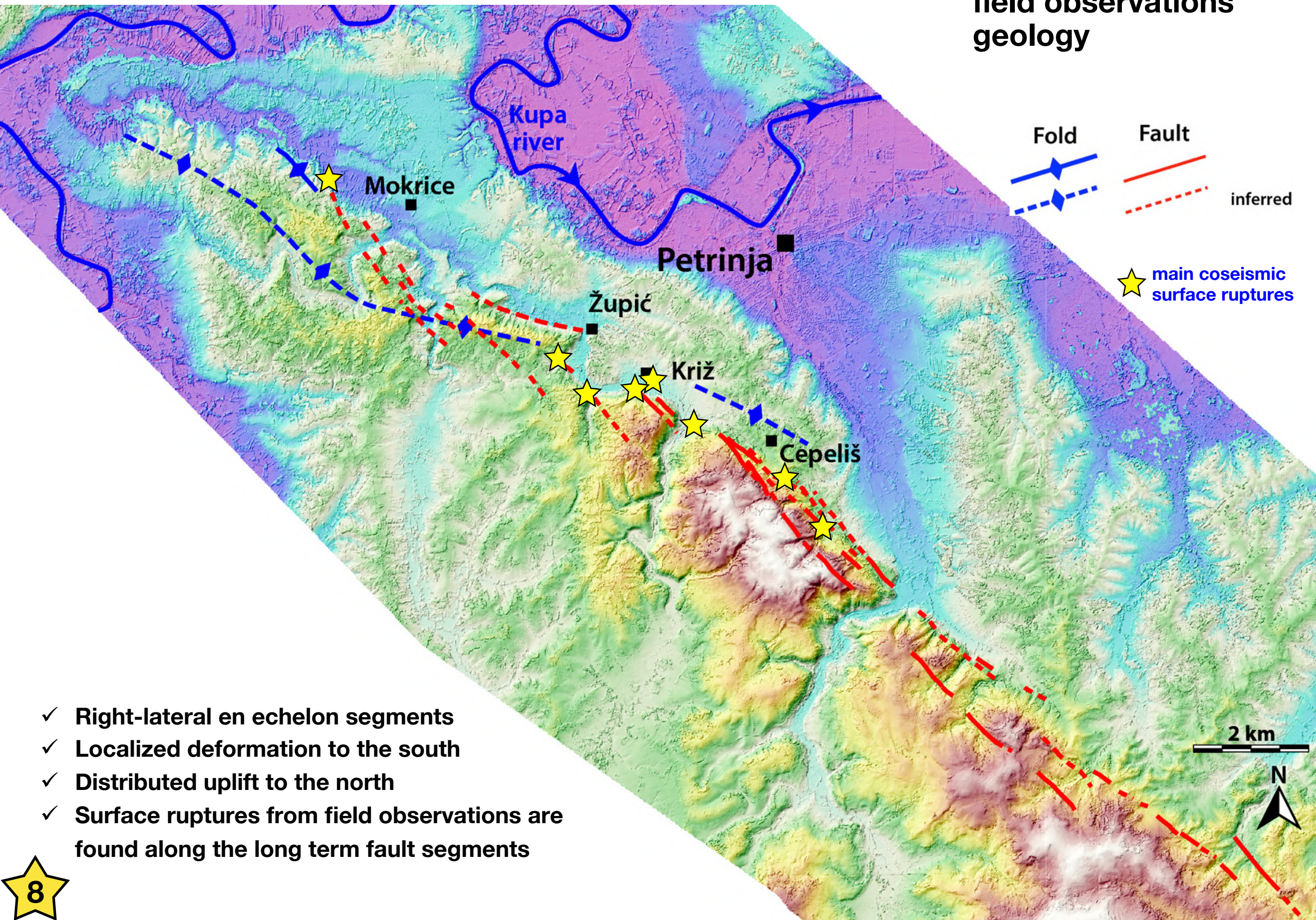
Long term uplift of the NW part of the Petrinja fault system



- ✓ Abandoned valley (drainage inversion) parallel to the actual Kupa river.
- ✓ Evidences of perched abandoned valleys seen in the field 10 m above the actual river course.
- ✓ Drainage network disturbances suggest active uplift in this area.



Geometry of the Petrinja-Pokupsko fault segments according to high resolution DEM field observations geology



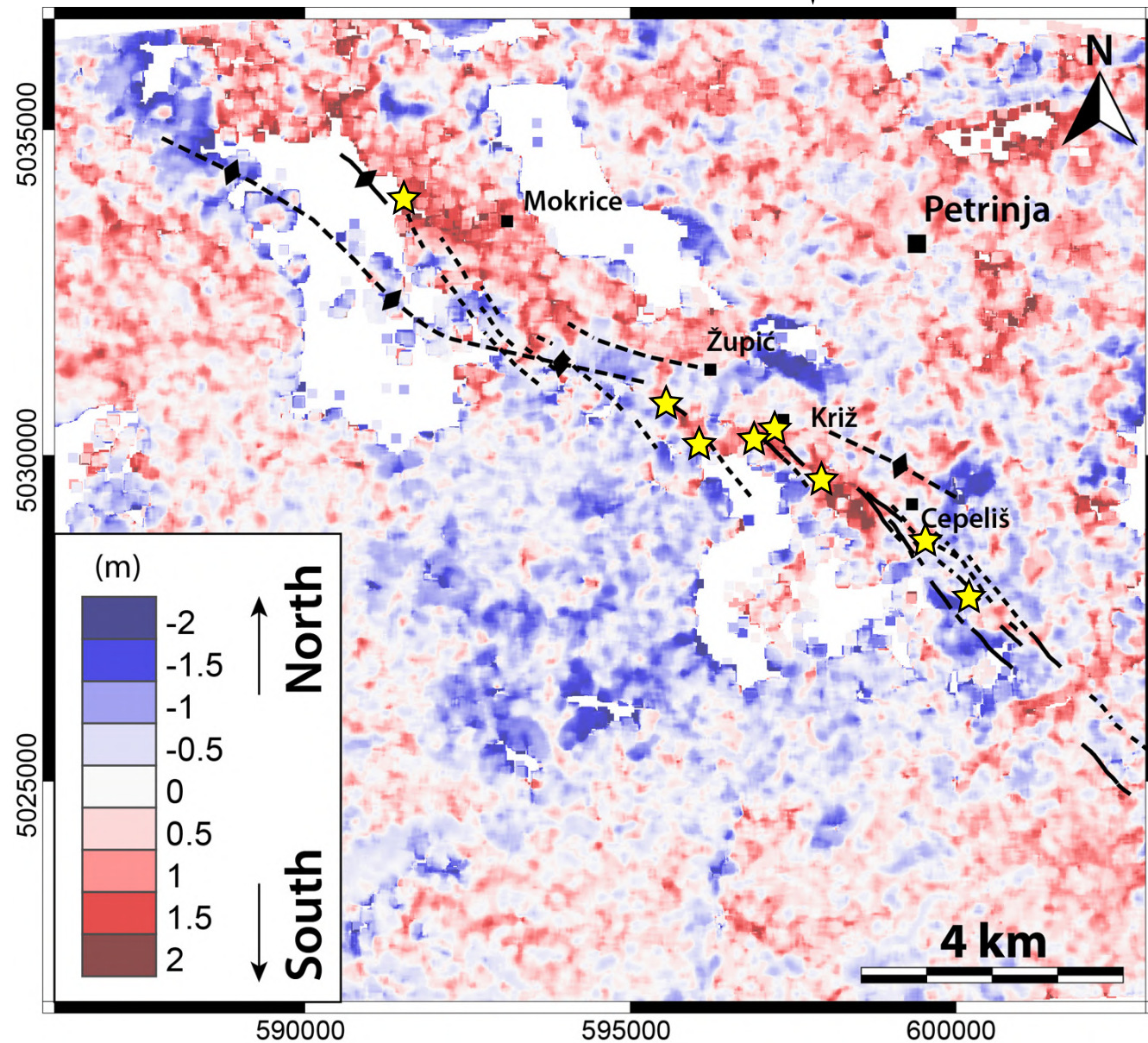
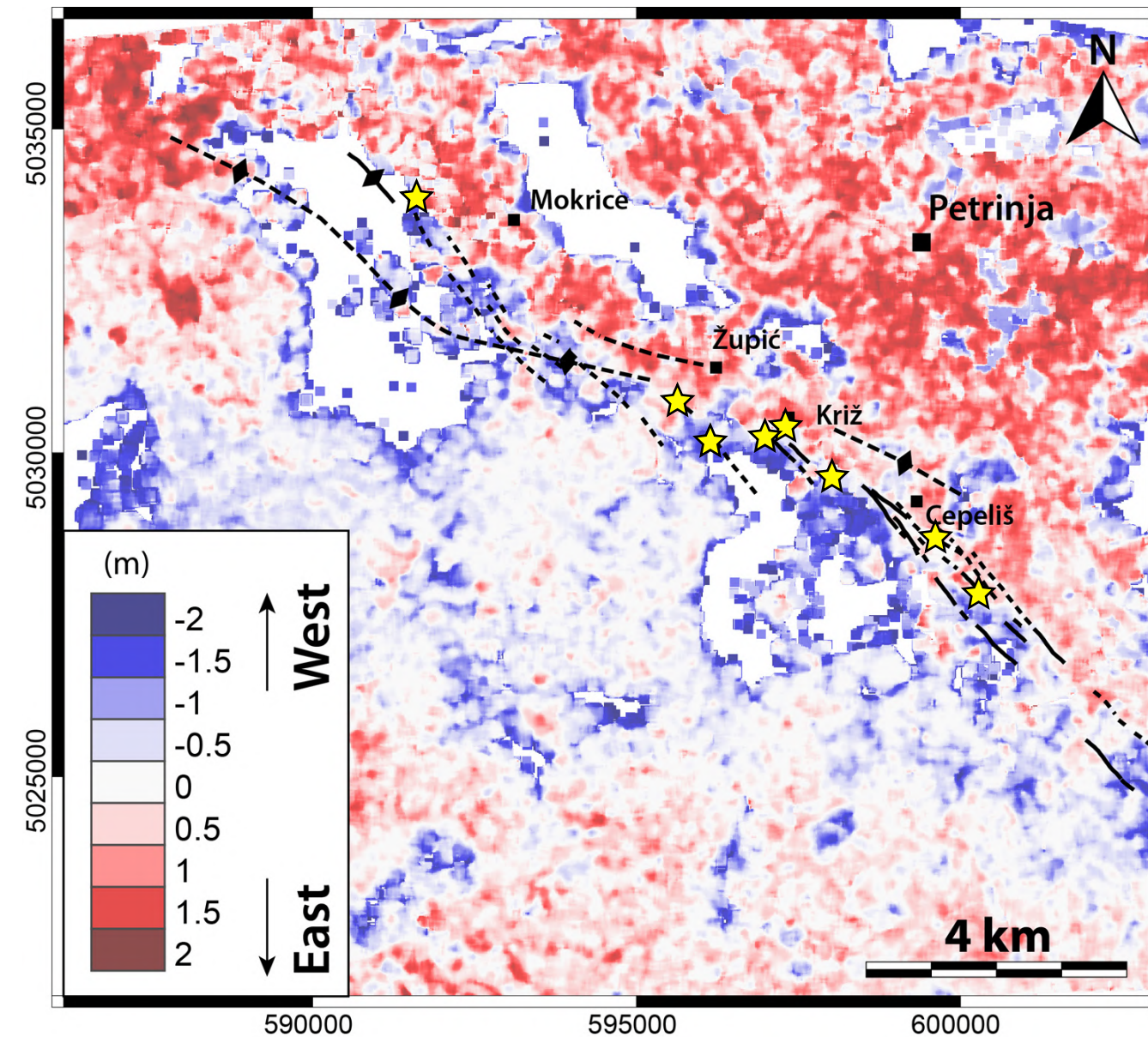
- ✓ Right-lateral en echelon segments
- ✓ Localized deformation to the south
- ✓ Distributed uplift to the north
- ✓ Surface ruptures from field observations are found along the long term fault segments

Image correlation: E-W and N-S ground deformation maps

E-W component



N-S component



* Long wavelength bias due to satellite vibrations are not corrected

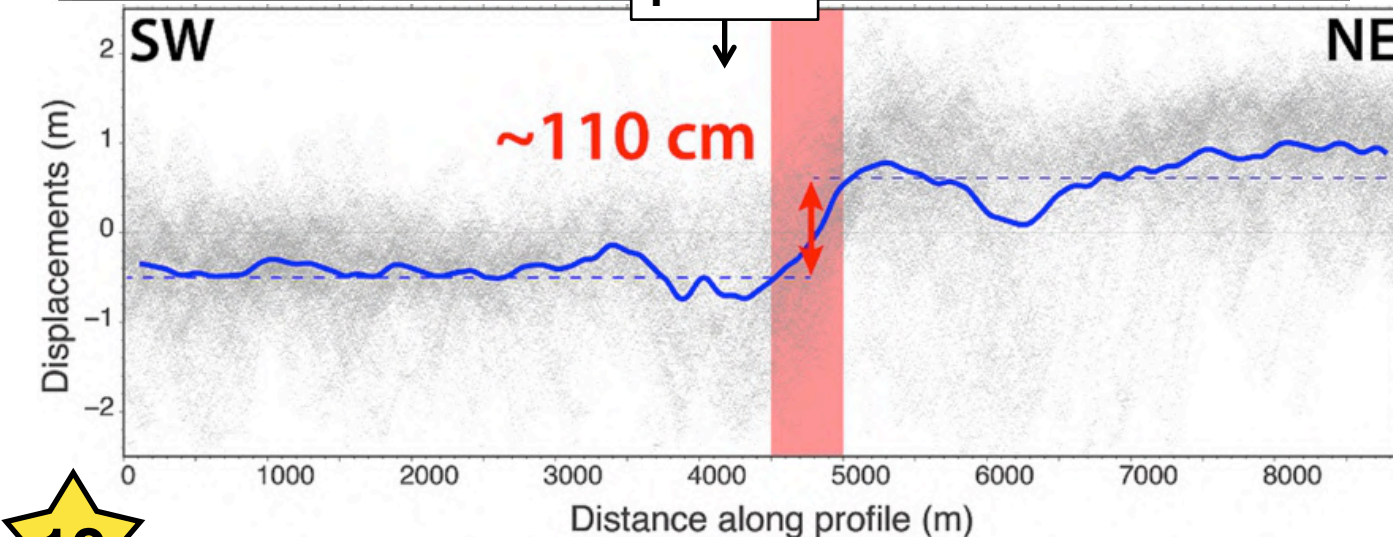
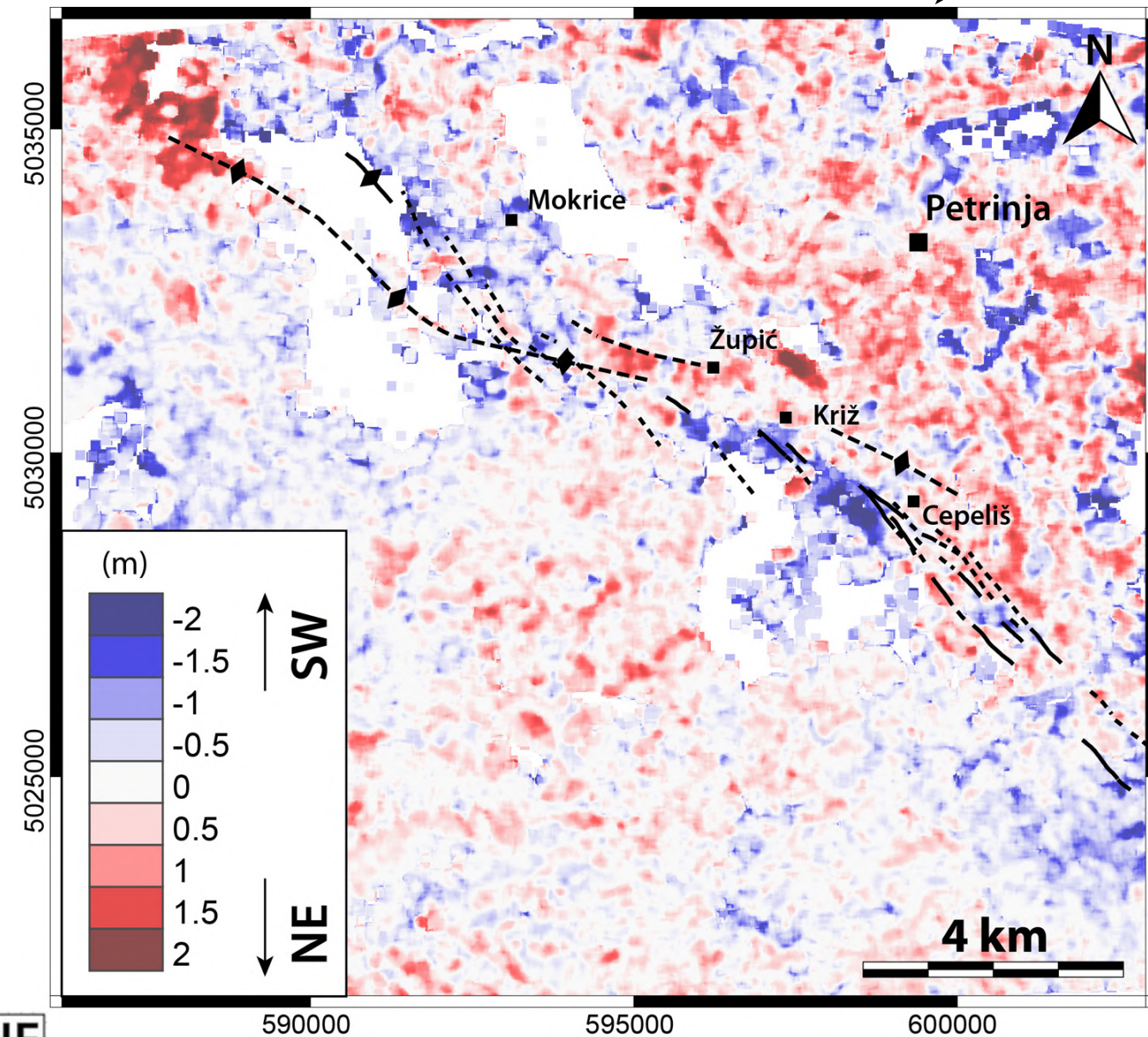
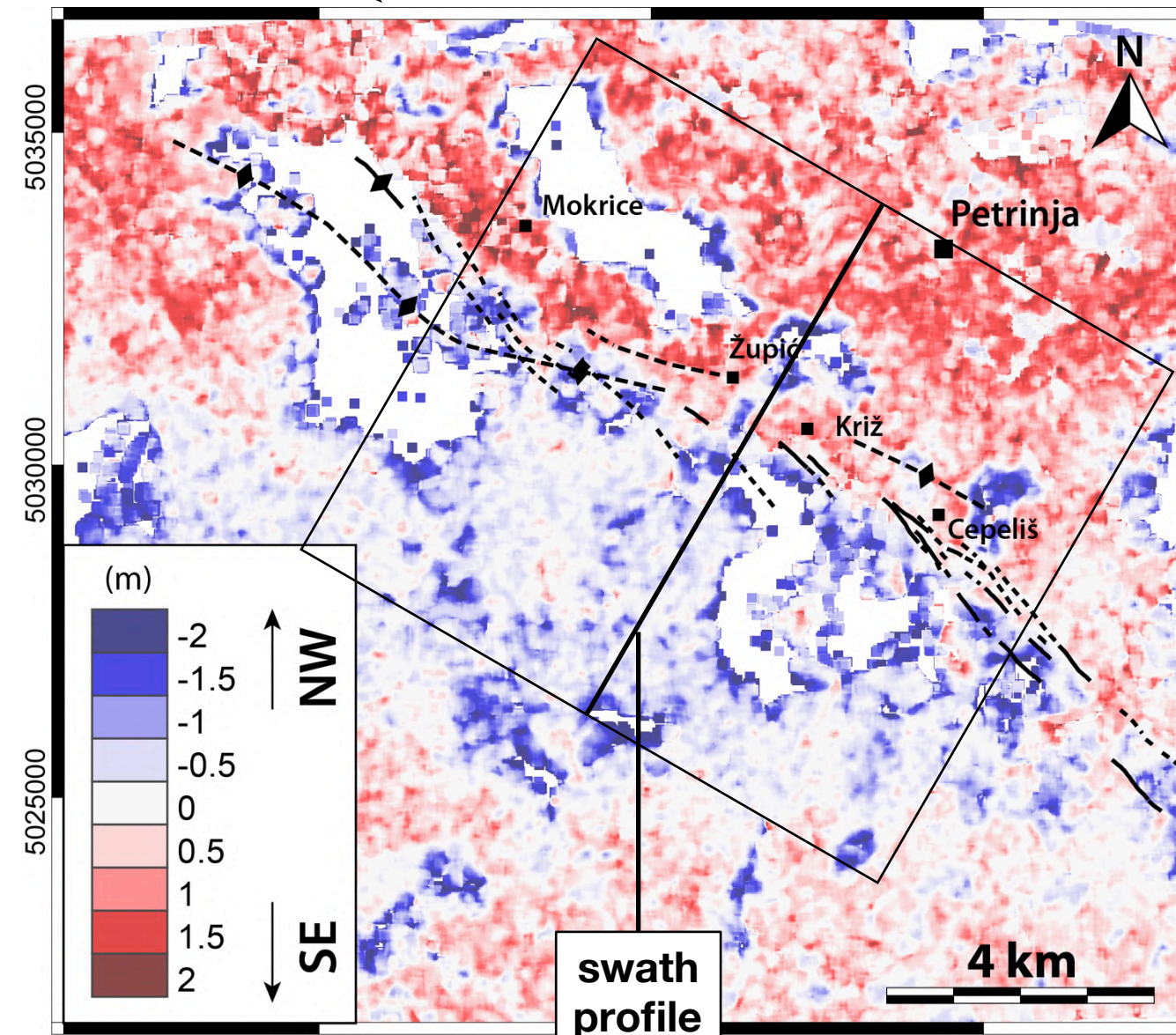
★ main coseismic surface ruptures

- ✓ Good agreement between the morphotectonic trace of the Petrinja fault and the ground displacements from image correlation data.
- ✓ Surface ruptures from field observations are found along the long term fault segments and match with the image correlation results.

Image correlation: Fault-parallel and Fault-normal ground deformation maps

Fault-parallel component

Fault-normal component



- ✓ Good agreement between the morphotectonic trace of the Petrinja fault and the ground displacement.
- ✓ Mean right-lateral displacement of ~110 cm + small extensional dip-slip component?
- ✓ Extensional dip-slip component south of Župić due to a slight bending of the fault?

CONCLUSIONS

- We mapped the morphotectonic trace of the Petrinja-Pokupsko fault using high-resolution DEMs, field observations, and geomorphology.
- We identified several cumulative right-lateral geomorphic offsets of ~250 m.
- Coseismic surface rupture is coincident with morphotectonic fault traces recording long-term cumulative offsets.
- The ground displacements extracted from optical image correlation show a mean right-lateral displacement of ~110 cm consistent with the long term fault trace and surface rupture observations
- The northern section of the Petrinja fault system shows a poor localisation of the deformation relative to the SE portion, but clear evidences of ongoing uplift. The gentle bending of the fault near Župić could explain this local change of kinematics.

Thank you for your attention!