

From rapid screening to landslide evolution monitoring. Multispectral satellite Earth Observation workflows for landslide emergency response and post-event analysis

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1 - Emergency and post-emergency mapping of shallow landslides through the PANDA methodology

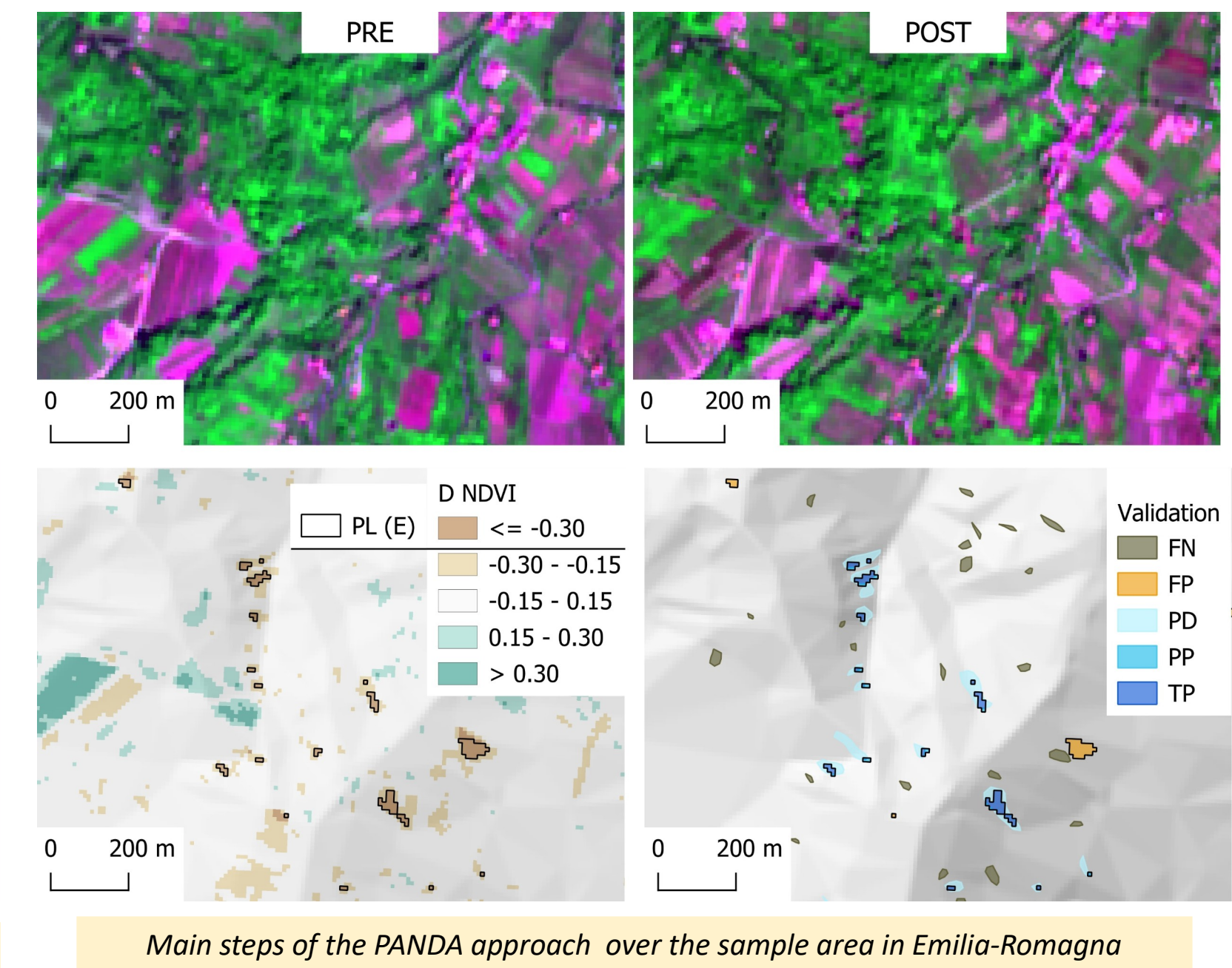
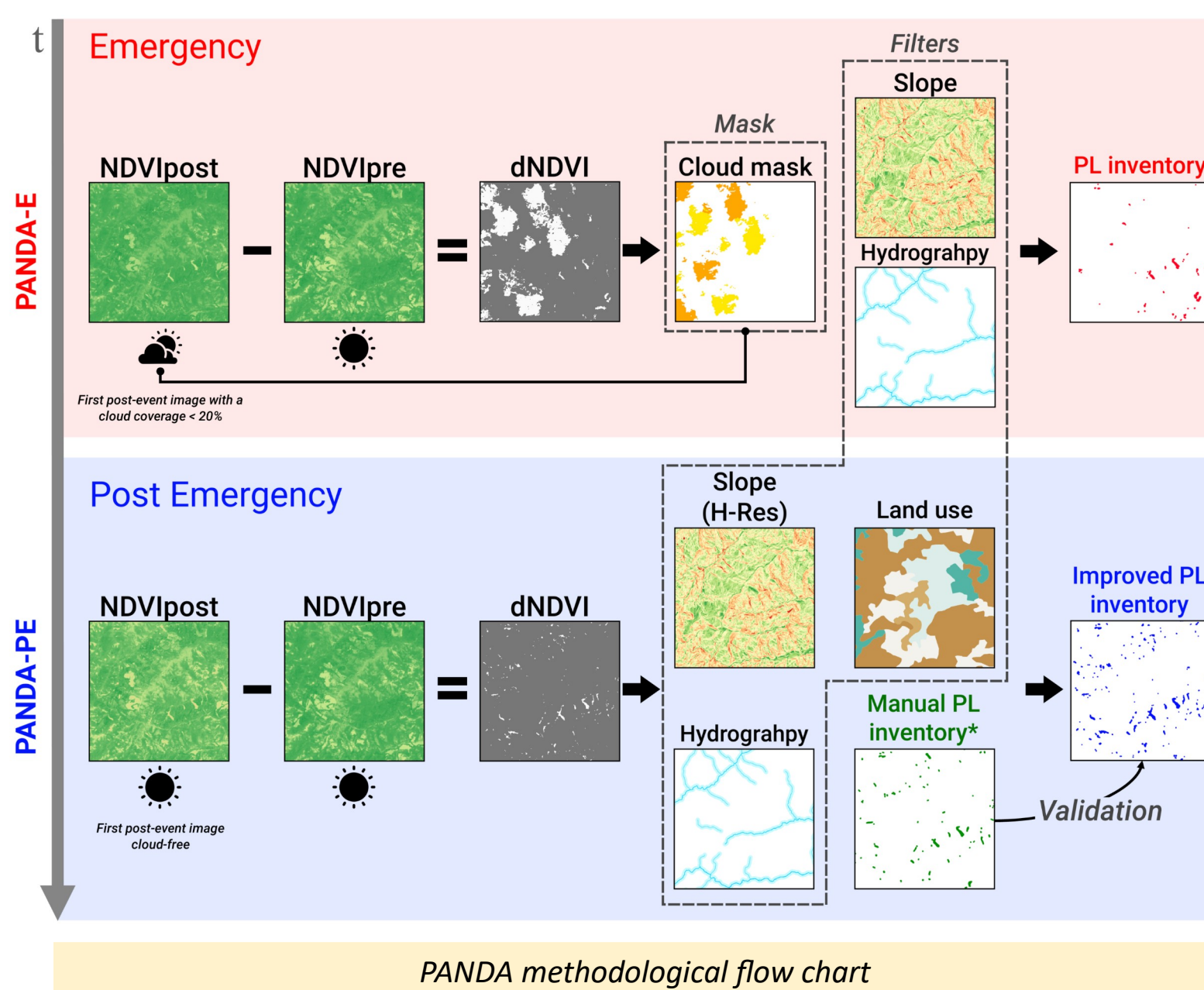
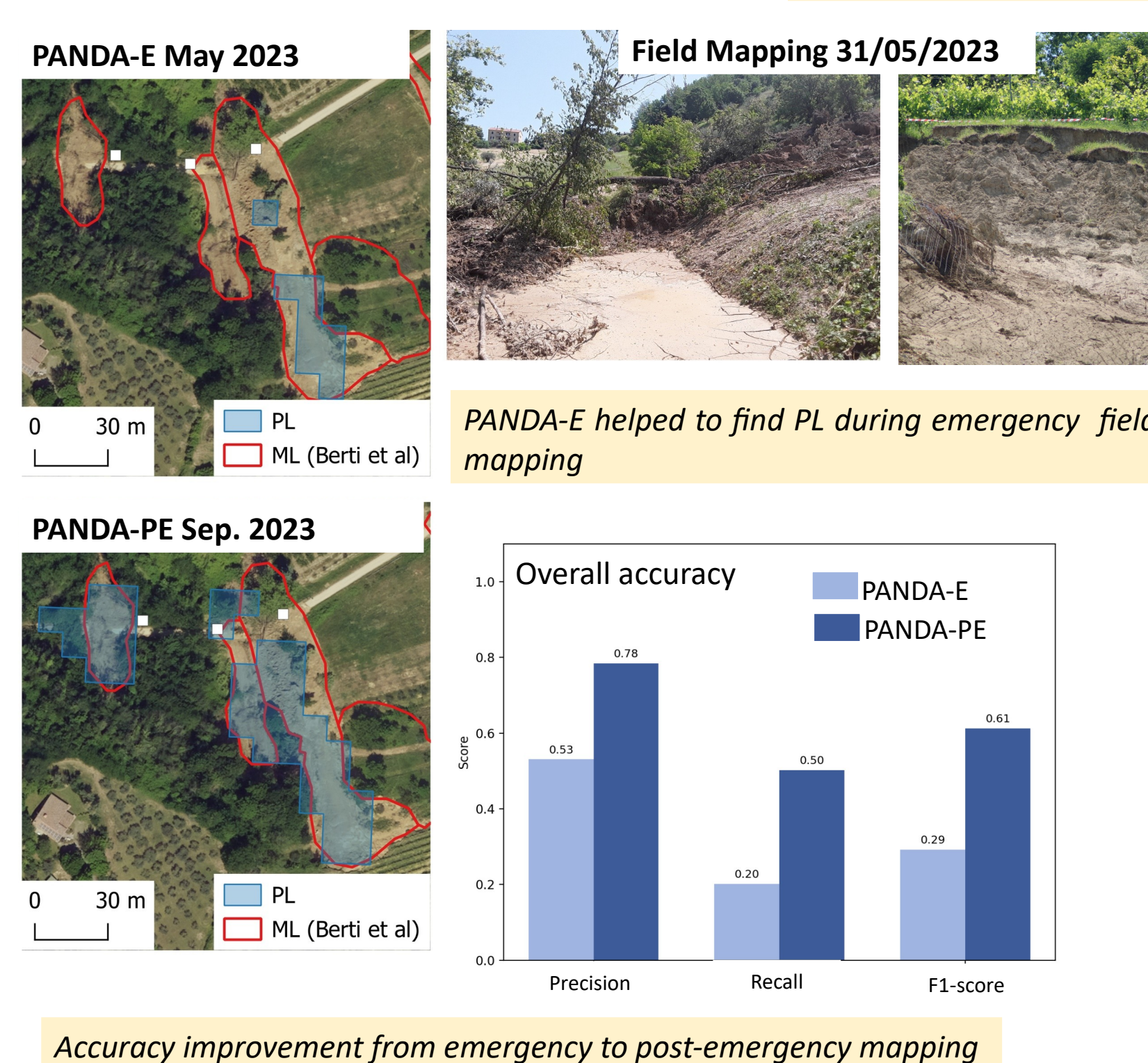
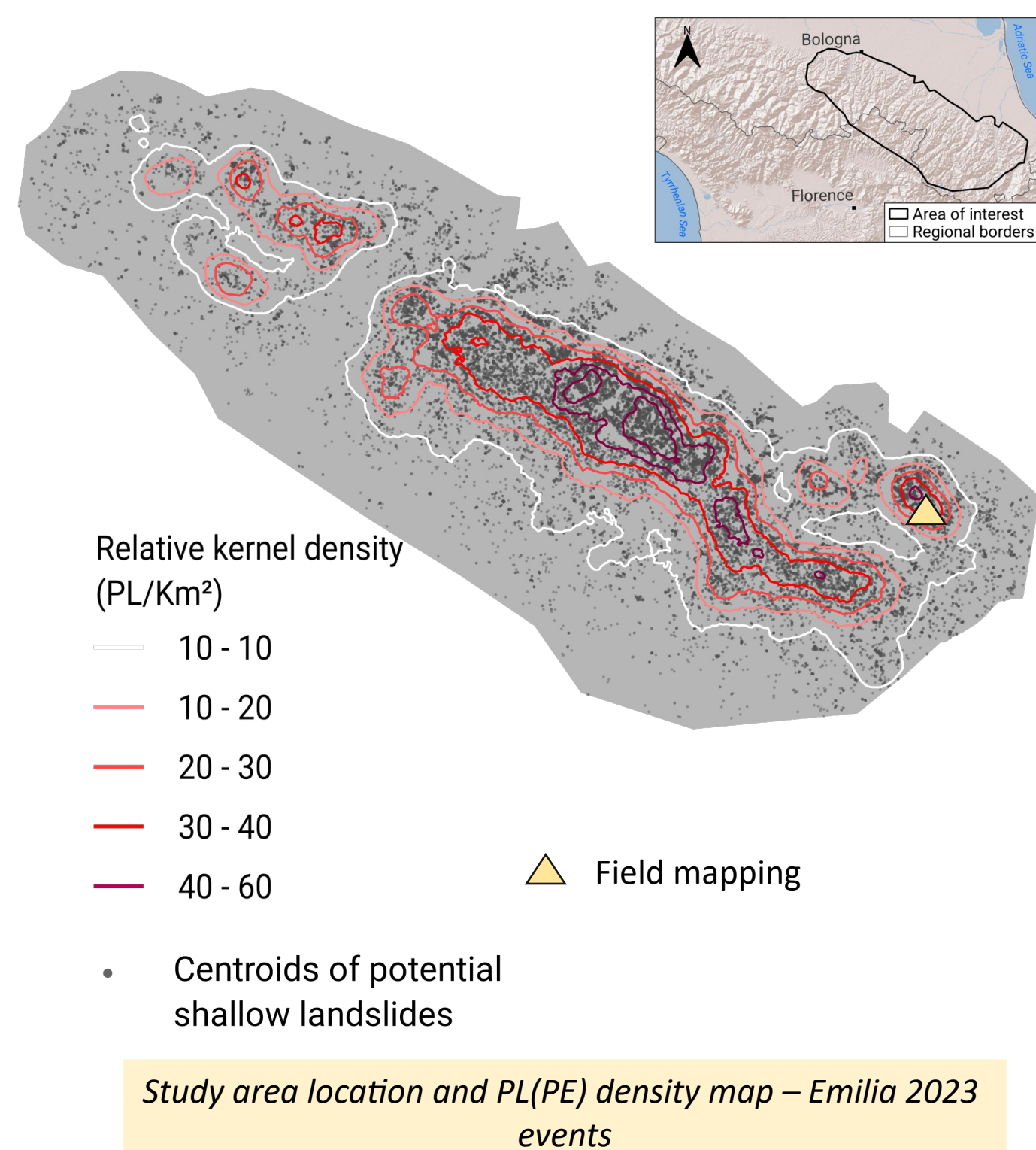
Heavy rains, earthquakes, and snowmelt can trigger shallow landslides, causing substantial damage to communities, economies, and the environment. Assessing landslide occurrence is essential for making key management decisions immediately and after such disasters.

Methodology. PANDA exploits NDVI changes (based on multispectral, free satellite data) combined with geomorphological filters (e.g., slope, river network) to detect bare-soil disturbances caused by potential shallow landslides (PL) (Notti *et al.*, 2023).

In its emergency-response phase (PANDA-E), the method prioritises speed, delivering a first reconnaissance map to support field teams within days of image acquisition.

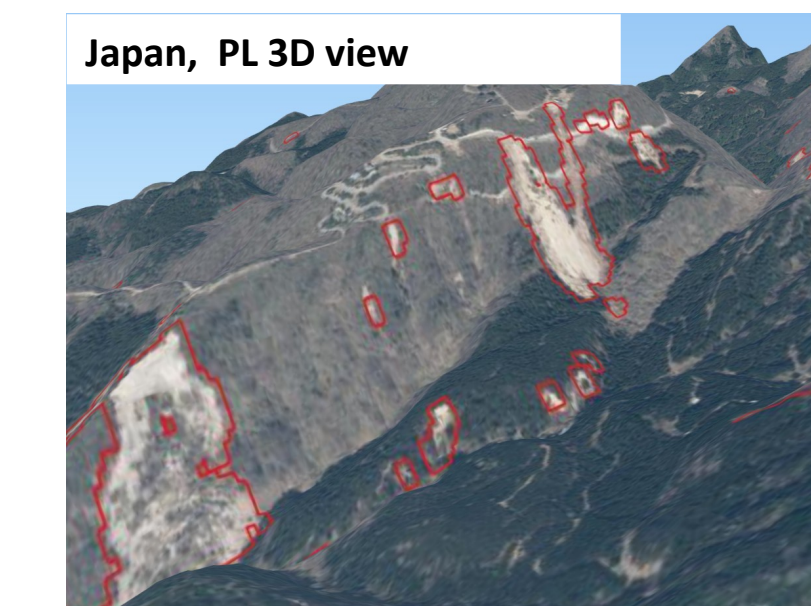
In the post-emergency phase (PANDA-PE), the PL inventory is enhanced using cloud-free imagery, iterative NDVI/slope thresholding, and, if available, new images to filter false positives related to land use change and improved ancillary data (e.g., high-resolution DTM)

The Emilia case study. PANDA (Notti *et al.*, 2024) was applied to the May 2023 extreme rainfall events in the northeastern Apennines, covering about 4,000 km² and mapping about 40'000 potential landslide (PL) densities of up to 50 landslides/km² in the worst-hit sectors. Validation against an independent, high-resolution inventory showed good accuracy, especially in forested areas.

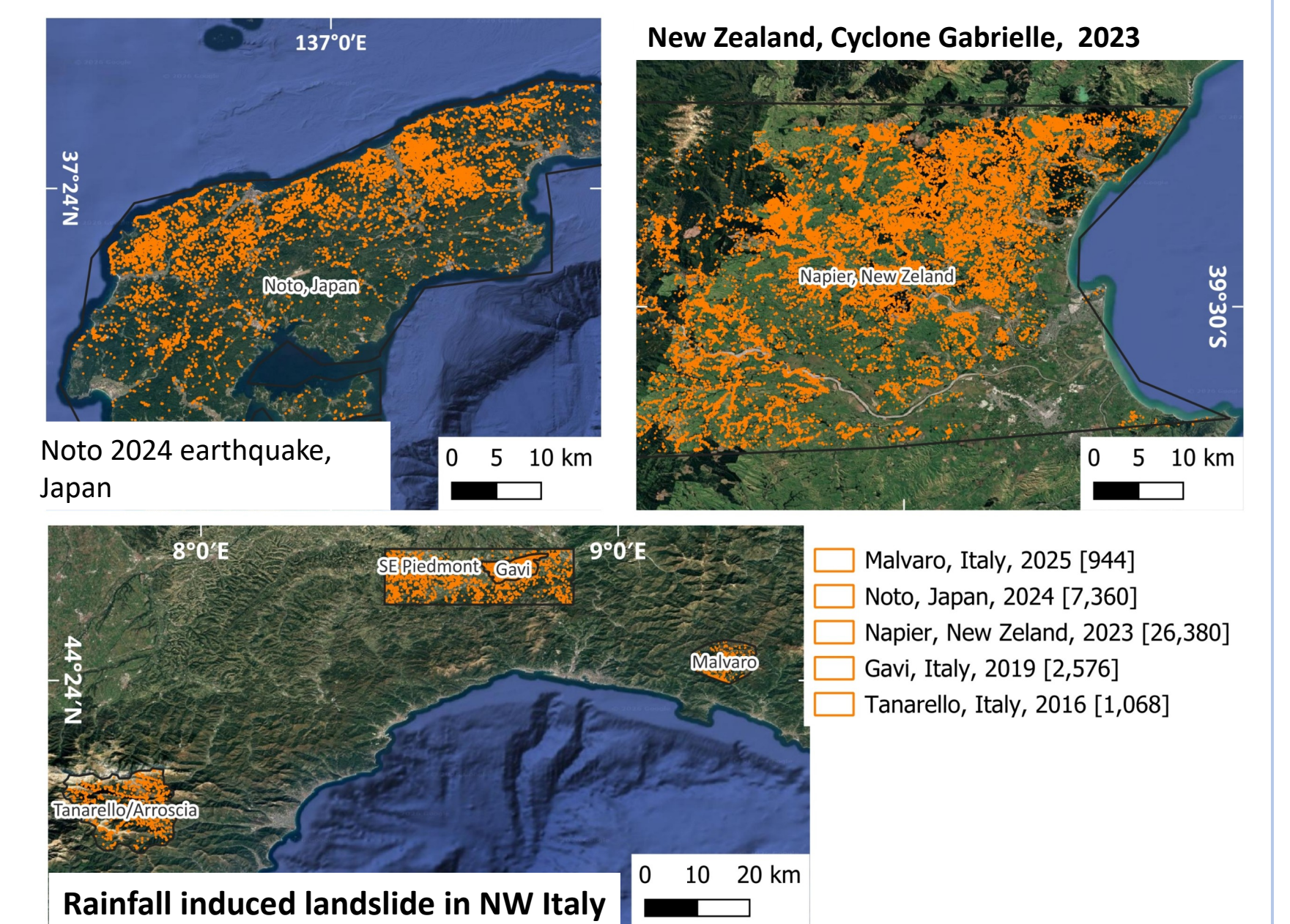


We also tested PANDA in other areas of Italy and worldwide. Some cases include earthquake-induced landslides in Noto, Japan and the effects of 2023 Cyclone Gabrielle in Northern New Zealand.

The results, compared with manual inventory or HR images, confirm its adaptability to other geological contexts.



PANDA worldwide Applied

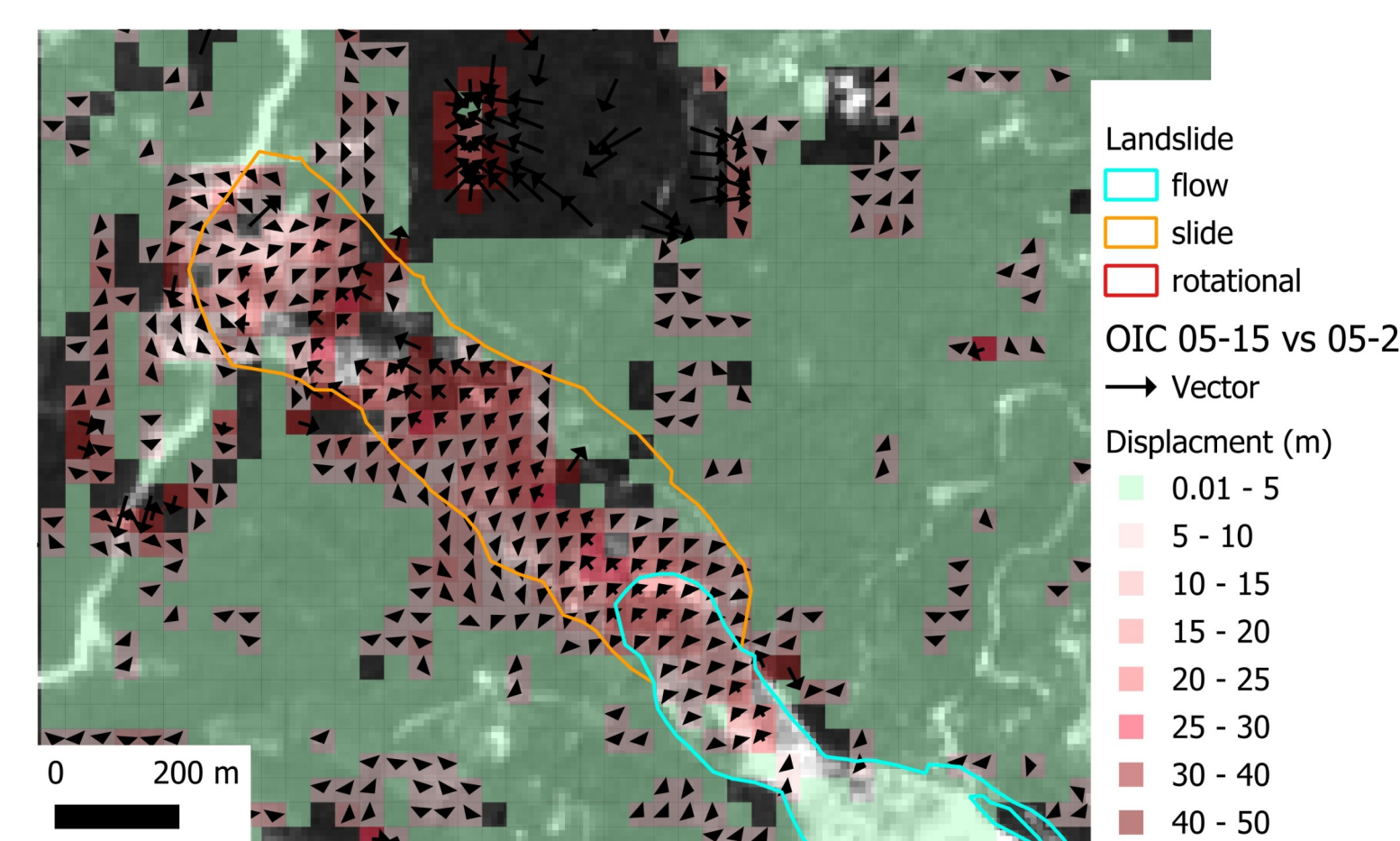
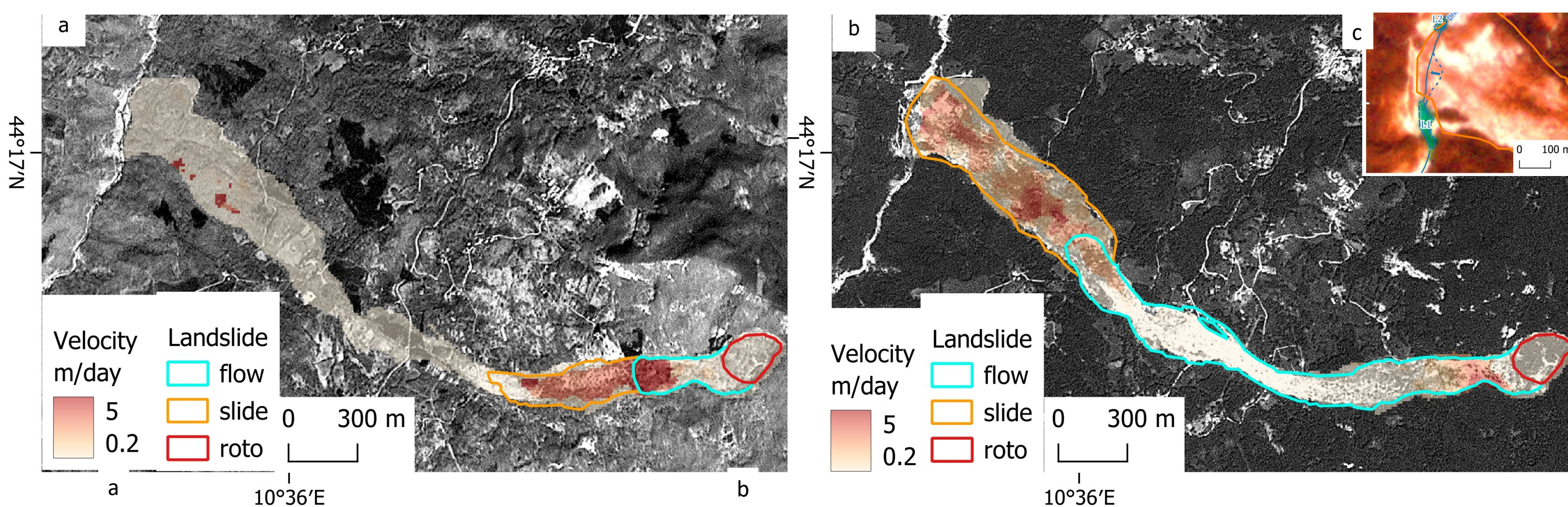


2 - Optical Image Correlation (OIC) to track the displacement of the rapid landslide reactivation

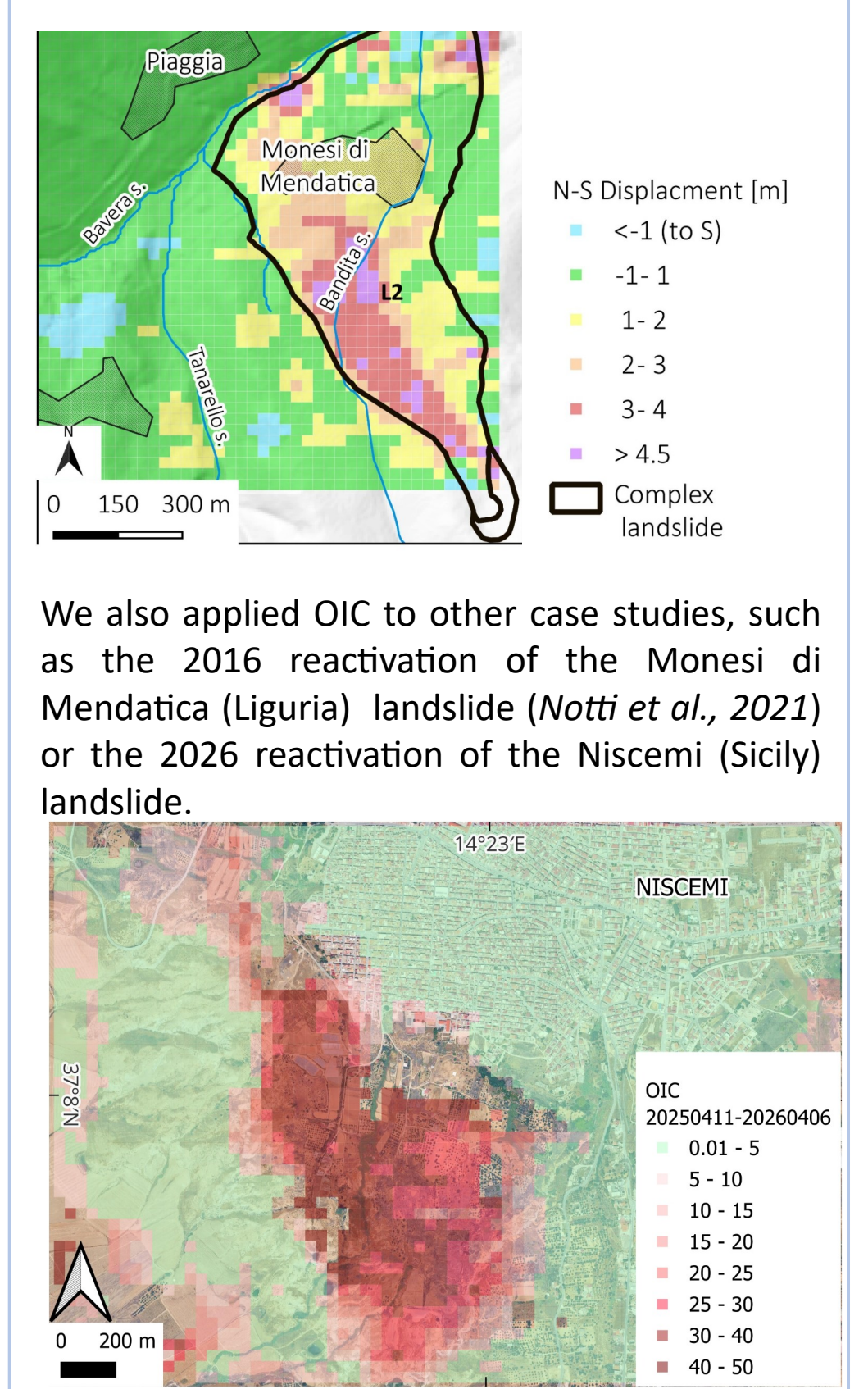
Methodology. A large landslide can undergo paroxysmal reactivation, with displacement occurring in a single step or over time. Satellite images can be used to measure horizontal displacement and direction using Optical Image Correlation (OIC) techniques such as LAMMA (Dematteis *et al.*, 2022) or a user-friendly tools such as IMCORR in SAGA GIS. Such applications aim to support rapid landslide assessment during emergencies, especially in contexts where field access is limited or restricted.

The Boccassuolo case study. In spring 2025, following a particular wet period, a reactivation of a complex landslide affected the hamlet of Boccassuolo, in the NE Apennines (Italy). The OIC used Sentinel-2 and PlanetScope imagery, combined with ancillary data and rainfall analysis, to reconstruct the landslide reactivation sequence (Notti *et al.*, 2026).

The Boccassuolo landslide evolved from a rotational failure to a fast earthflow and then an earth slide, reaching velocities above 80 m/day. According to OIC analysis, the main activity lasted from March until early June 2025. The landslide reactivation caused severe damage, destroyed roads, a bridge and some buildings and it formed landslide-dammed lakes along the Dragone Stream.



OIC is an adaptable tool



CONCLUSION – The role of optical-EO in the DRM

Together, the two experienced outline a scalable optical Earth Observation workflow spanning two important aspects of Disaster Risk Management (DRM):

- **PANDA** is not a machine learning or AI approach, nor is it a manually created inventory from HR images. Still, it is a low-cost, low-time-consuming, and user-friendly tool; for those not experienced in remote sensing image processing, this makes it an evidence-based, scalable DRM tool.
- **OIC shows** the value of optical satellite data as a reliable and timely tool for monitoring landslide reactivation and evolution, thereby contributing to hazard assessment and emergency management in complex, rapidly evolving landslide scenarios.

Both approaches are achievable with freely or low-cost commercially available multispectral satellite data.

We are confident that the new satellite constellations, such as ASI-IRIDE, will likely increase the capability of these tools.

References and dataset

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