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Monitoring landslide deformation with Pleiades very-high resolution satellite images at decimeter accuracy

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Recent advances in image-matching techniques and VHR satellite imaging theoretically offer the possibility to measure Earth surface displacements with decimetric precision. However, this possibility has yet not been explored and requirements of ground control and external topographic datasets are generally considered as important bottlenecks that hinder the application of optical image correlation for displacement measurements on a regular base. This study combines approaches for spaceborne stereo-photogrammetry, orthorectification and sub-pixel image correlation to analyze a series of Pleiades satellite images and measure the horizontal surface displacement of three large landslides (La Valette, Poche, Super-Sauze) located in the Barcelonnette basin (Southern French Alps). The influence of the number of ground-control points on the accuracy of the image orientation, the extracted surface models and displacement rates is quantified through comparisons with airborne laser scans and global navigation satellite measurements at permanent stations. The comparison shows a maximum error of 0.13 m which is one order of magnitude more accurate than what has been previously reported with spaceborne optical images. A series of 4 stereo-pairs is analyzed to capture the seasonal displacement rates over a period of 1.5 years providing valuable insights into the diverse and dynamic deformation patterns of the three observed landslides. The obtained results indicate that the approach can be applied without significant loss in accuracy when no ground control points are available and, therefore, greatly facilitate regular measurements for a broad range of applications.