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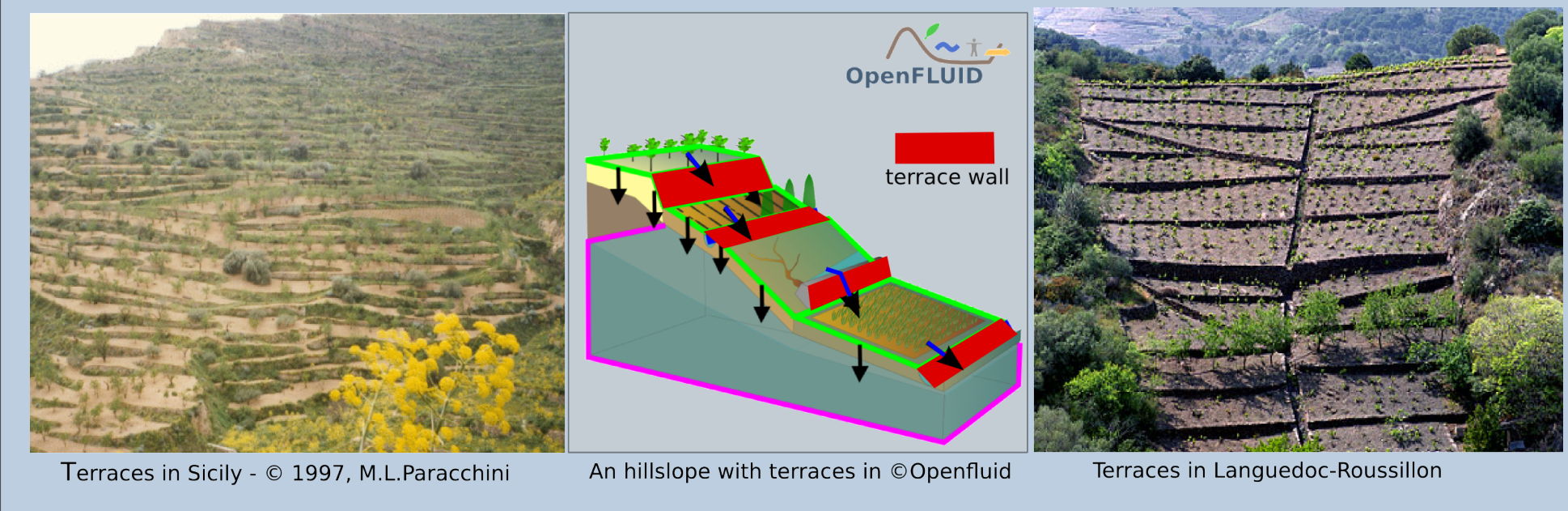
# FARMLAND TERRACE SLOPE DETECTION FROM PLEIADES DIGITAL ELEVATION MODELS

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## Introduction

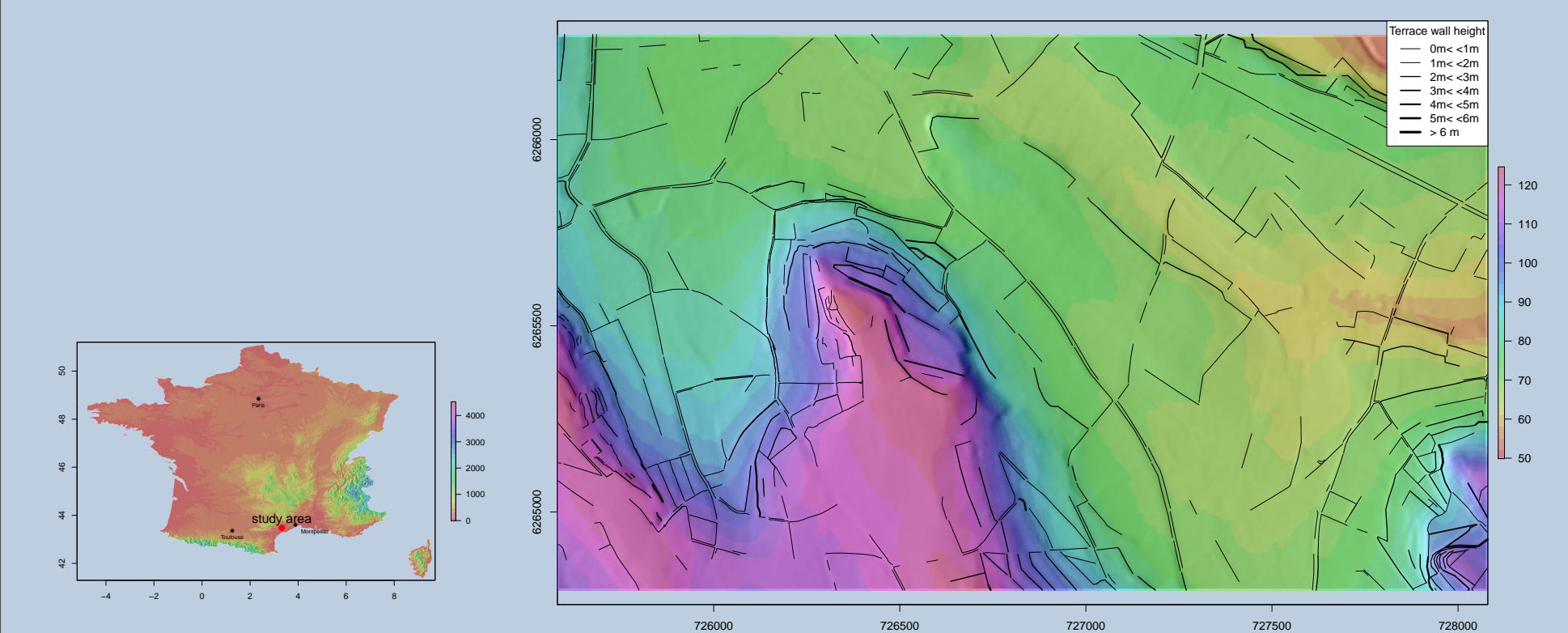
Mediterranean farmers have adopted from Roman time soil conservation practices. By decreasing slope intensities and lengths, terraces are one these soil conservation practices. The spatial pattern of terrace slopes is heterogeneous and depends on natural terrain slope. In erosion and hydrological studies, maps of terraces slopes may be needed [1]:

- How to map these landscape elements from remote sensing ?
- Is a Pleiades derived DEM suitable and accurate enough to map these landscape elements ?



## Materials and Methods

Reference terrace data, Pleiades images and a LIDAR 1 m DSM-DTM were acquired on the Peyne Catchment (Languedoc-Roussillon). A DSM was built from a stereo pairs of Pleiades images (January 2013, 29 degrees incidence) using the Mic-Mac IGN suite with low regularization and resampled at 1 m resolution. DTM was generated from DSM after closing operations.



Terrace slopes consisting in an abrupt linear change in elevation on plot lattice.

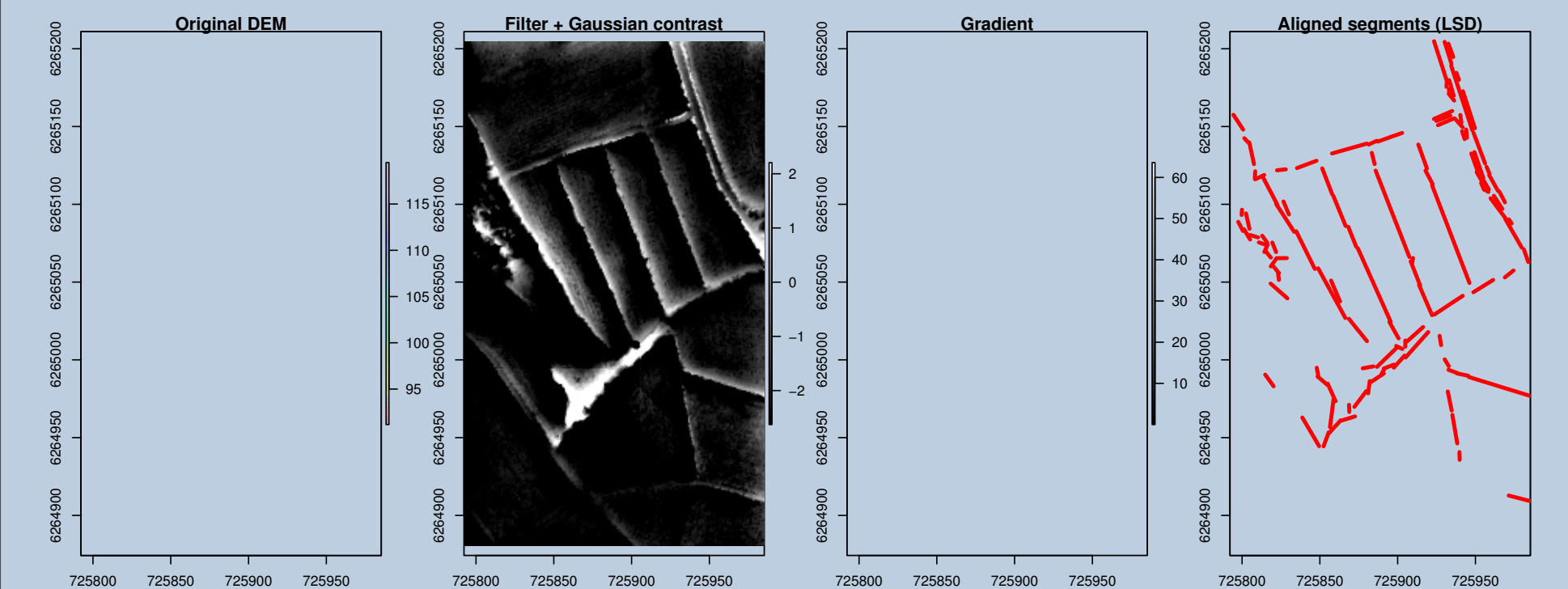
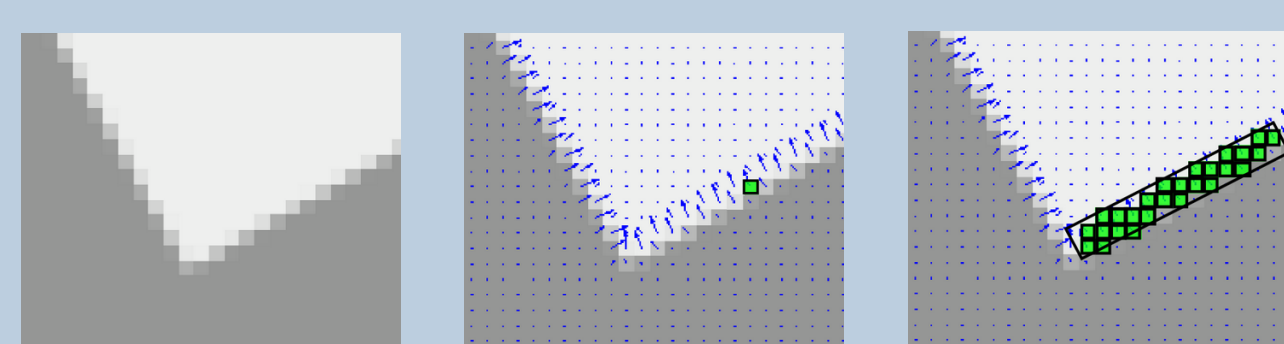


Figure 1: Terrace walls detection process

The DEM process relies on:

1. a fast line segment detector algorithm to detect aligned abrupt change from gradient image [2].
2. or a curvature thresholding technique to detect terrace slopes [3] followed by a vectorisation process.
3. a post-processing filtering step using plot lattice distances.



LSD: looking for aligned regions with equal gradient angle  
 ©http://ubec.enseiht.fr/vision/ELSD/

## References

- [1] Francesc Gallart, Pilar Llorens, and Jerome Latron. Studying the role of old agricultural terraces on runoff generation in a small mediterranean mountainous basin. *Journal of Hydrology*, 159(1-4):291 – 303, 1994.
- [2] R Grompone Von Gioi, Jeremie Jakubowicz, Jean-Michel Morel, and Gregory Randall. Lsd: a line segment detector. *Image Processing On Line*, 2012.
- [3] Giulia Sofia, Giancarlo Dalla Fontana, and Paolo Tarolli. High-resolution topography and anthropogenic feature extraction: testing geomorphometric parameters in floodplains. *Hydrological Processes*, 28(4):2046–2061, 2014.
- [4] Paolo Tarolli, Federico Preti, and Nunzio Romano. Terraced landscape: from an old best practice to a rising land abandoned-related soil erosion risk. In *EGU General Assembly Conference Abstracts*, volume 15, page 3355, 2013.

## Results: Pleiades DEM vs Lidar DEM

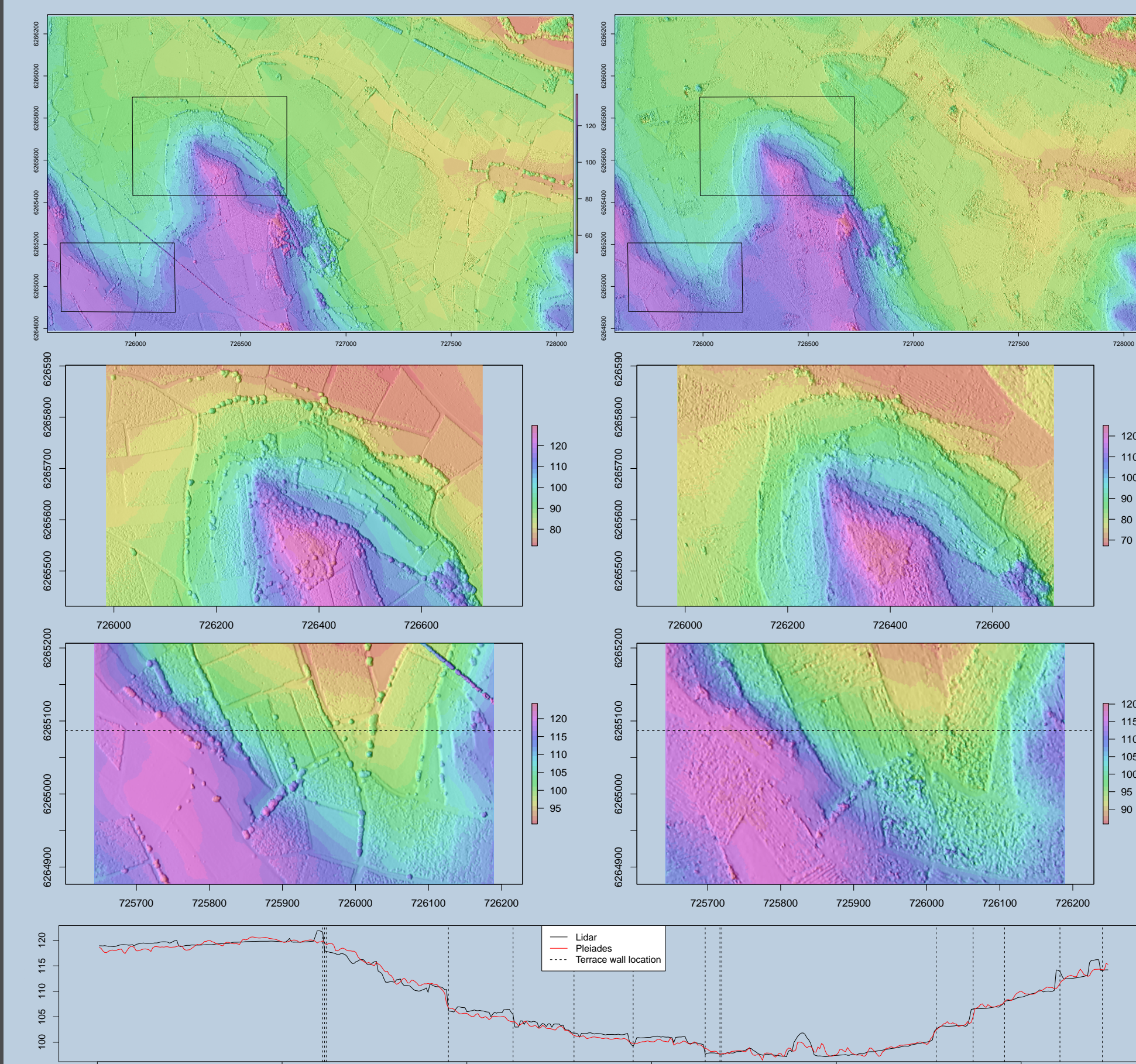
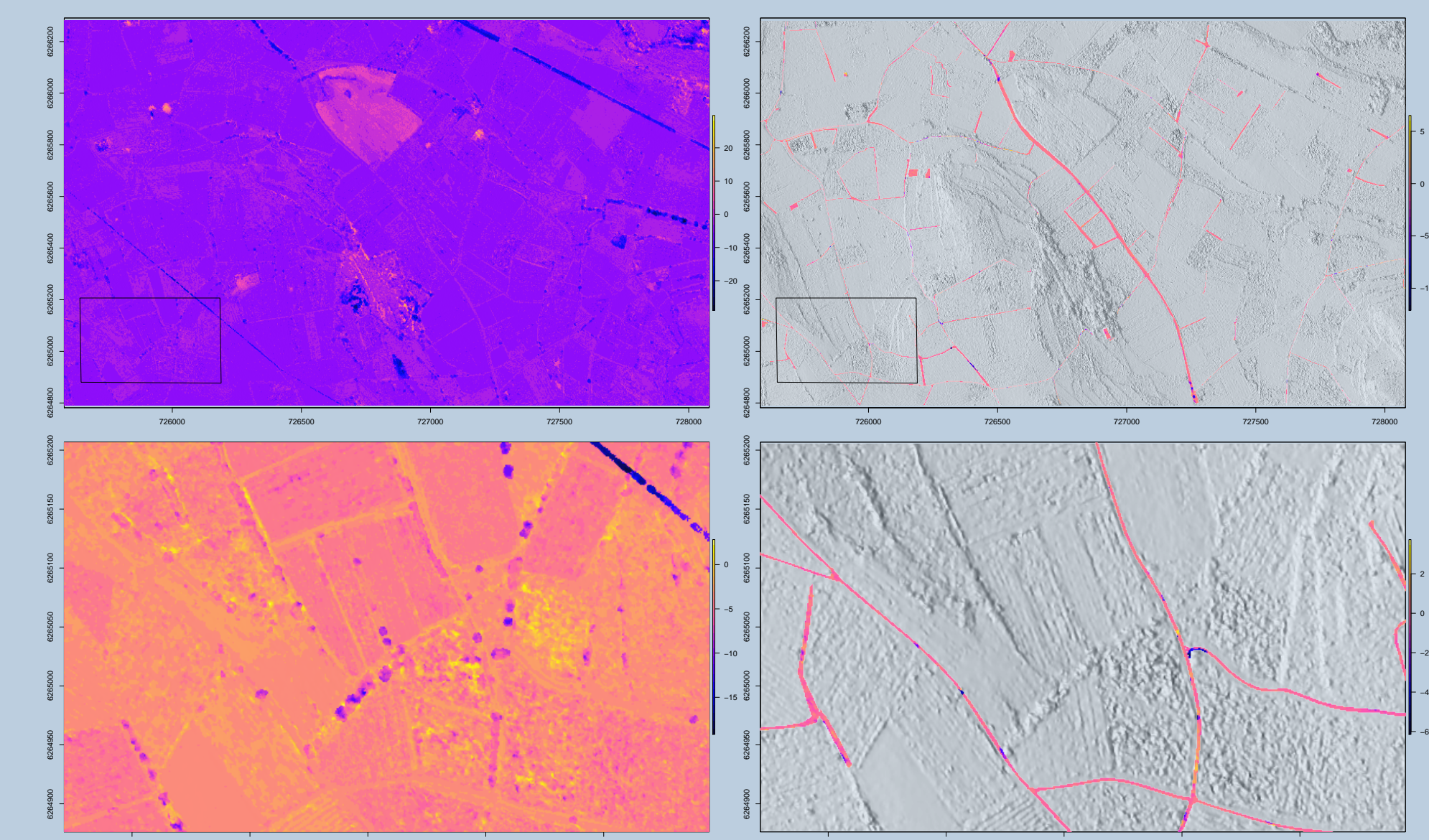


Figure 2: Lidar (06-2001) & Pleiades (01-2013)



to LiDAR DEM	Conf. 95% (m)	Conf. 68% (m)	Median dev. (m)
Pleiades	[-2.91,1.54]	[-0.45,0.58]	0.35
Aerial	[-4.76,1.37]	[-0.38,0.68]	0.46

Table 1: Deviation statistics on elevation

## Results: Terrace walls extraction from DEMs

Method	DEM Type	TP	TN	FP 1	FP 2	QI (1)
LSD	dtm	0.95	0.05	0.20	0.33	<b>0.79</b>
LSD	dsm	0.75	0.25	0.40	0.61	<b>0.54</b>
Curv	dtm	0.98	0.02	0.36	0.68	<b>0.72</b>
Curv	dsm	0.76	0.24	0.31	0.70	<b>0.58</b>

Table 2: LiDAR performances

Method	DEM Type	TP	TN	FP 1	FP 2	QI (1)
LSD	dtm	0.62	0.38	0.23	0.68	<b>0.50</b>
LSD	dsm	0.44	0.56	0.20	0.58	<b>0.37</b>
Curv	dtm	0.65	0.35	0.26	0.79	<b>0.52</b>
Curv	dsm	0.50	0.50	0.22	0.87	<b>0.41</b>

Table 3: Pleiades performances

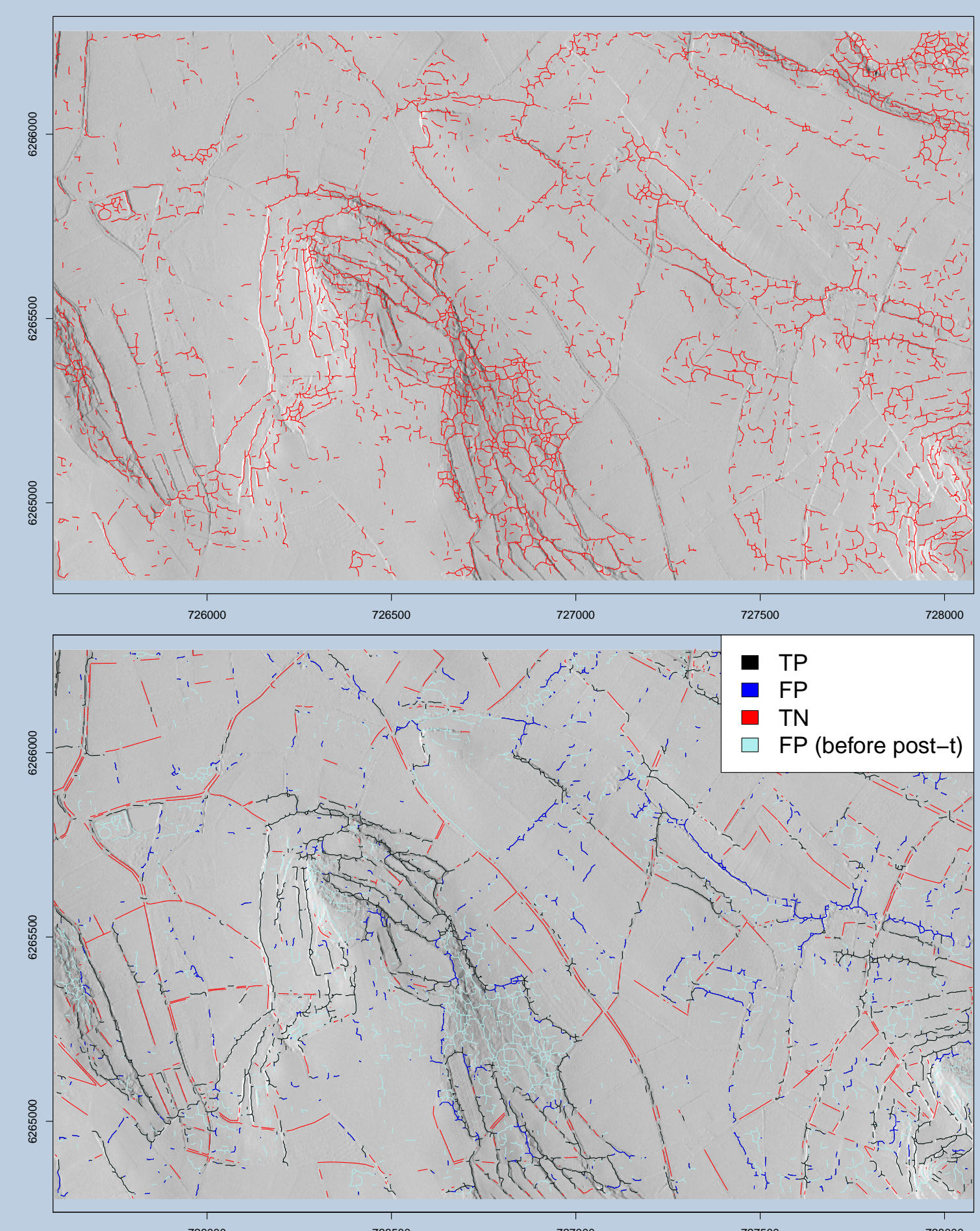
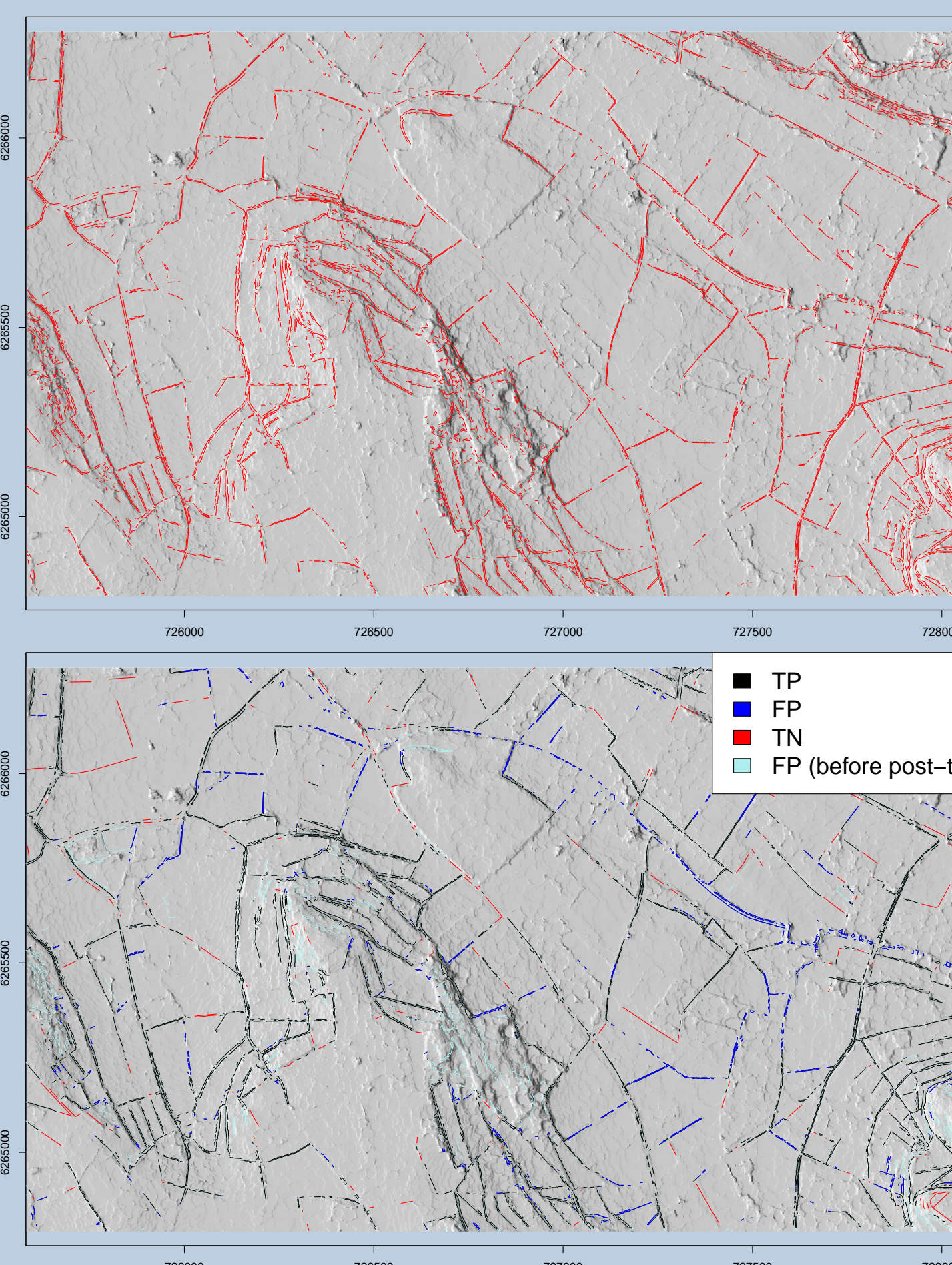


Figure 3: Maps of the detected terrace slope of LiDAR DTM using the LSD method (left) and from the Pleiades DSM when using the geomorphometric method (right). Resulting TP elements in black, TN elements in red, filtered FP elements in blue and non filtered FP elements in light blue (down)

## Conclusion

Detection of terrace slopes was performed using two methods based on the linearity of features (LSD) or their convexity (geomorphometric). Four major results were obtained from this study. The automatic mapping of terrace slopes from Pleiades DEMs is reliable for terrace slopes that are higher than 2 m and. The LiDAR detection performances are systematically higher than the Pleiades performances, especially when using a LiDAR DTM. The DSM to DTM filtering processes used for the Pleiades data do not result in better terrace slope detection. The geomorphometric algorithm is more robust than the LSD algorithm when applied to noisy digital elevation models.

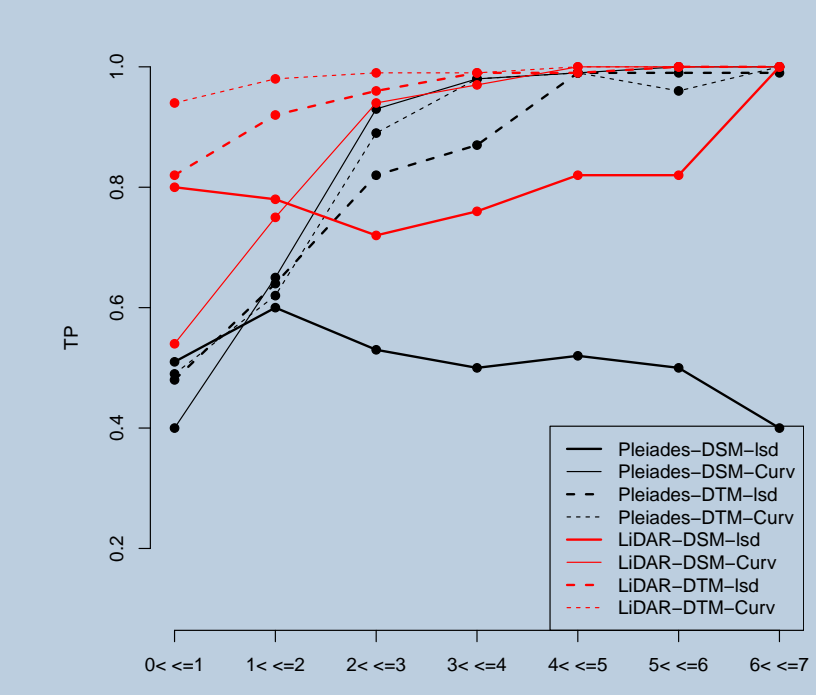


Figure 4: Detection rate as a function of terrace height

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