ASSESSING THE REPRESENTATION OF HUMAN-MADE STRUCTURES AND DOMINANT GEOMORPHOLOGICAL FEATURES IN HIGH- AND MEDIUM-RESOLUTION DIGITAL TERRAIN MODELS FOR HYDRO-SEDIMENTOLOGICAL MODELLING IN SMALL MEDITERRANEAN CATCHMENTS

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1. INTRODUCTION

Digital terrain models (DTM) provide a continuous mathematical representation of the Earth's bare surface. In catchment **hydrogeomorphological modelling**, DTMs are the most important data inputs. Adequate representation of landscape elements is often limited by intrinsic errors related to the data acquisition process as well as preprocessing steps used to generate the DTM. In fact, DTM dataset characteristics such as **spatial resolution and vertical accuracy**, as well as the accurate filtering of **vegetation and human-made structures**, may importantly affect terrain representation and subsequent modelling.

The objectives are: 1) ground-truth assessment of the vertical accuracy of SRTM C-SAR DEM V3, ASTER GDEM V2, and two different spatial resolution airborne LiDAR DTM datasets; 2) evaluation of the studied DTM sources and characteristics on hydrogeomorphological modelling applications; 3) to investigate the role of characteristic landscape features, including human-made objects and dominant geomorphological features, on the sediment connectivity index at representative plots of each catchment.

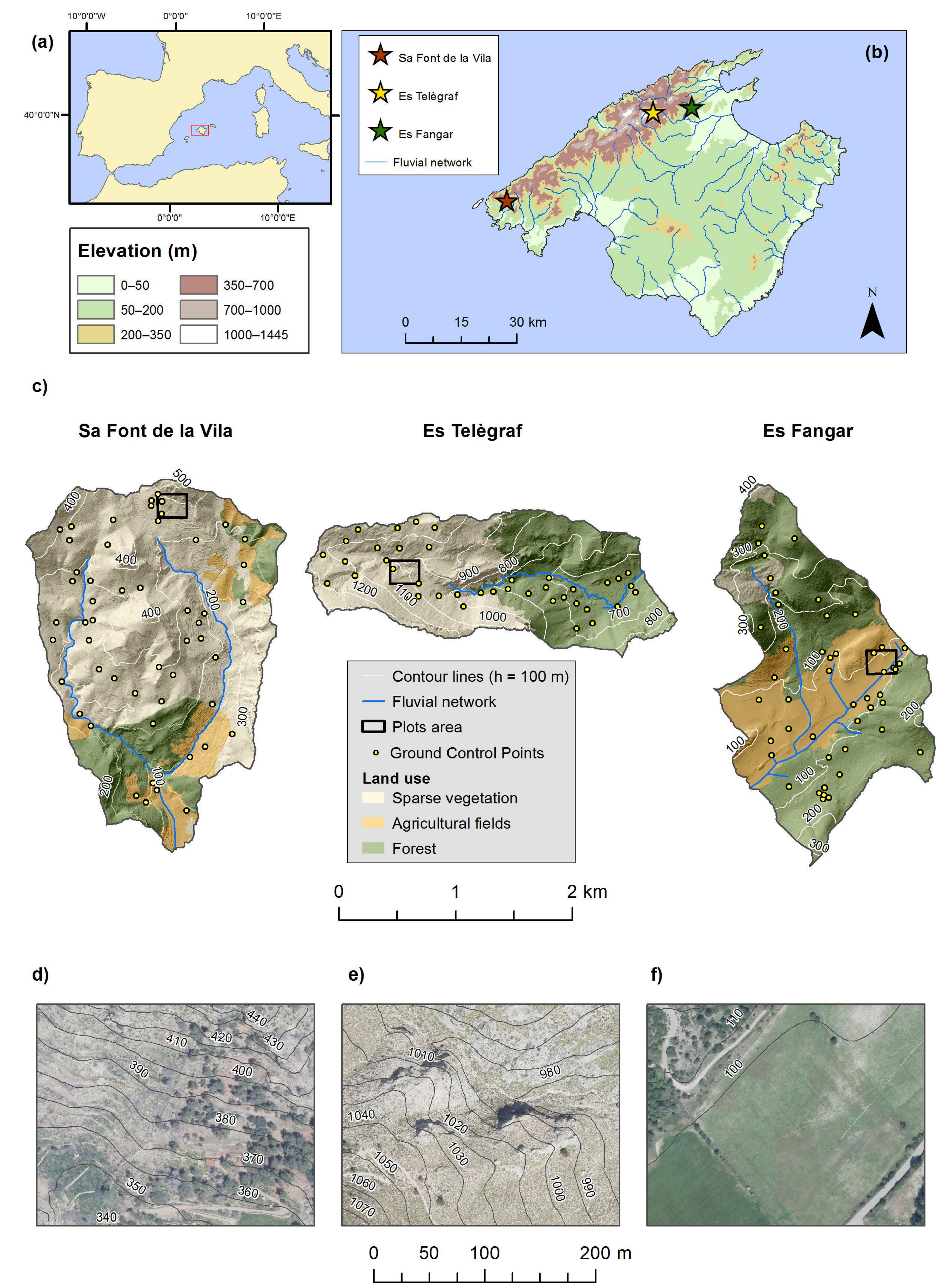

Figure 1. Location of Mallorca within the Western Mediterranean Sea (A). Location of the three contrasting catchments (Island of Mallorca) (B). Detail of Sa Font de la Vila, Es Telègraf, and Es Fangar catchments illustrating the main land uses (following CORINE 2012), contour lines (height interval h = 100 m), and first-order streams (from the 5-m LiDAR DTM) (C). Images of the analyzed representative plots at each catchment (D= Sa Font de la Fila, E= Es Telègraf, F= Es Fangar).

2. STUDY AREAS

Figure 1 illustrates the following small contrasted catchments as study areas; located in Mallorca, Spain:

Sa Font de la Vila (4.8 km^2)
- ✓ Massive presence of **abandoned** traditional **agricultural terraces**. Afforestation process.
- ✓ Severe wildfires. Current land use is dominated mainly by agriculture, sparsely vegetated terrains, and forests.

Es Telègraf (3 km^2)
- ✓ The **highest relief** energy and **steepest hillslopes**.
- ✓ Vegetation shows a sharp contrast between the headwaters (sparse vegetation), and the lower forested parts.

Es Fangar (3.2 km^2)
- ✓ **Combination of** geological **structures**.
- ✓ **Different land uses,** including forests, sparsely vegetated areas, and agricultural fields.
- ✓ Presence of check-dam terraces and surface-leveled fields.

Three small 5-ha plots, including characteristic landscape elements of the three catchments (***Figure 1***), were selected to assess how accurate DTM representation of typical Mediterranean landscape elements—induced by natural conditions or human activities—can affect small-detail hydro-geomorphological modelling by using a hydro-sedimentological connectivity index

3. METHODS

- 1. DTM Datasets

The present study compares the widely used satellite-derived SRTM DEM V3 and ASTER GDEM V2 datasets (1-arcsecond spatial resolution both) and 2 Spanish airborne LiDAR DTM datasets (5- and 1-m spatial resolution).

- 2. Vertical accuracy assessment

It was assessed by collecting ground control points (GCPs) using a Real-Time Kinematic Global Positioning System (RTK-GPS, Leica GPS Series 1200) with a base station placed at central locations of the study catchments and (cm absolute accuracy) in September 2017. Then, the vertical accuracy of the DTM datasets was expressed as error statistics. Robust measures such as the normalized median deviation (NMAD) and the RMSE between GPS- and DTM-derived elevation were computed.

- 3. Quality Assessment of DTMs for Hydro-geomorphological Modelling

A broad variety of hydro-geomorphological statistics and descriptors were analyzed to explore the feasibility of the studied DTMs for hydro-geomorphological modelling. These indicators encompassed basic terrain characteristics, stream network and flowpath properties, as well as small-detail arrangement patterns of water and sediment fluxes.

4. RESULTS

- ***4.1. DTM Vertical Accuracy*** Significant errors in elevation for all the analyzed datasets were observed by comparing DTM-derived elevation values against those elevation values obtained in our dGPS-derived GCPs (***Table 1***). Accuracy increased from ASTER over SRTM to the 5-m and 1-m IGN LiDAR models. A systematic overestimation of elevation values was observed for all datasets

	SRTM DEM	ASTER GDEM	IGN 5 m	IGN 1 m
All sites (n = 140)				
RMSE	6.98	16.10	1.73	1.55
NMAD	5.27	11.23	0.84	0.44
All open terrain sites (agricultural + sparse vegetation cover, n = 87)				
RMSE	7.38	16.26	1.59	1.41
NMAD	5.22	10.82	0.93	0.61
All densely vegetated sites (forest cover, n = 53)				
RMSE	6.28	15.84	1.94	1.76
NMAD	5.31	11.46	0.73	0.33
Sa Font de la Vila catchment (n = 53)				
RMSE	8.28	9.62	2.09	2.03
NMAD	5.59	7.63	0.98	0.62
Es Telègraf catchment (n = 40)				
RMSE	7.76	26.77	1.59	1.25
NMAD	5.76	12.17	0.89	0.49
Es Fangar catchment (n = 47)				
RMSE	4.06	7.62	1.35	1.10
NMAD	2.98	7.72	0.71	0.26

Table 1. Vertical accuracy assessment expressed as root mean squared error (RMSE) and normalized median deviation (NMAD) between the GPS-measured elevation values and those values derived from the different DTM datasets (in m).

- ***4.2. DTM Hydrogeomorphic Modelling Performance***
- ***4.2.1. Stream Networks***

Remarkable differences were observed for Es Telegraf and Es Fangar, while a better consistency between the models was obtained for Sa Font de la Vila (***Figure 2***). At smaller scales, the streams derived from the IGN tended to reproduce the natural flow patterns of the landscape, while the SRTM and ASTER streams partly deviated from those (***Figure 2***).

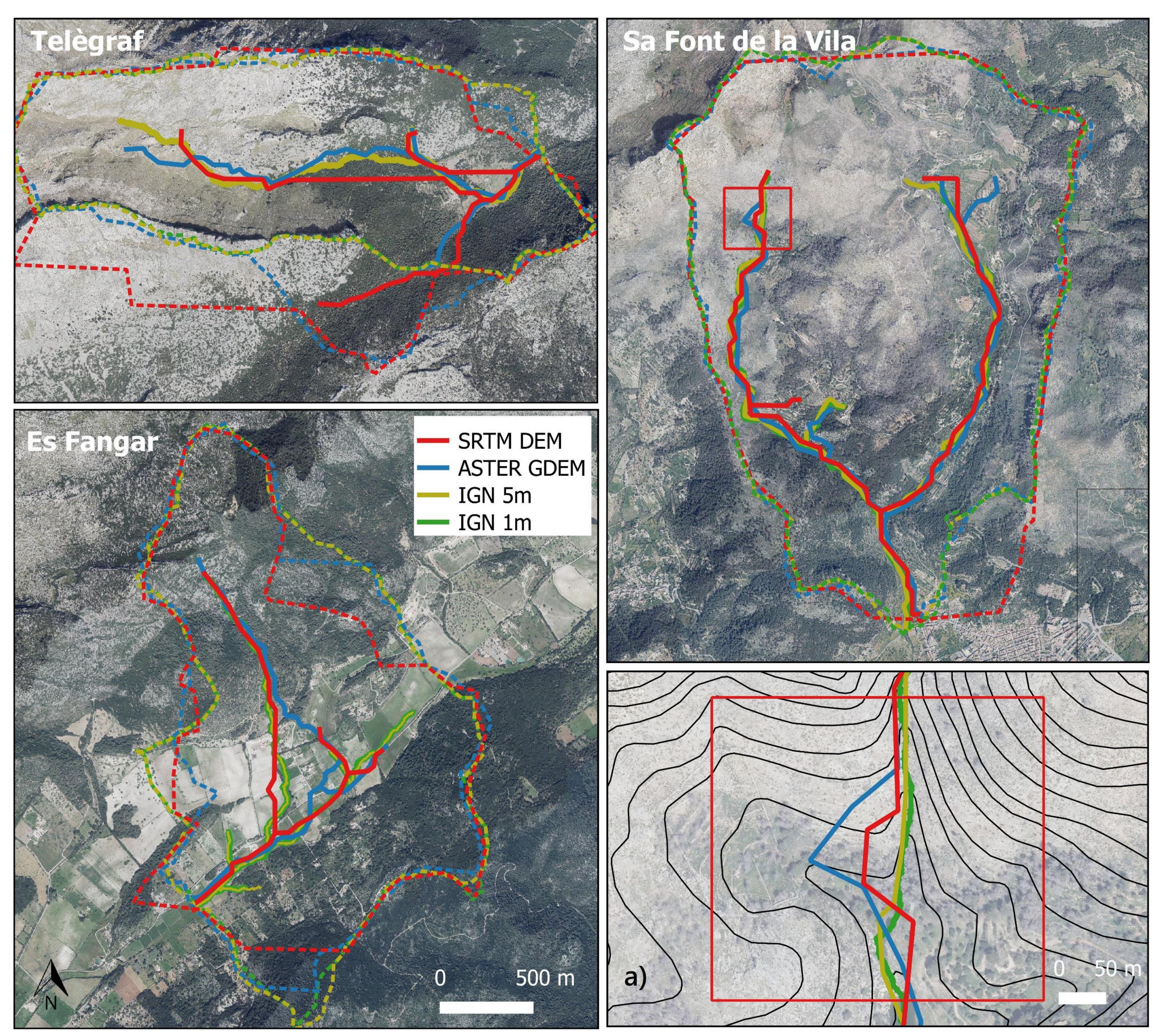

Figure 2 (UP). Stream network patterns (solid lines) and catchment boundaries (dashed lines) derived from the DTM datasets showing the studied catchments. (a) Area of interest selected in Sa Font de la Vila (solid black lines indicate height contours with Δh= 10 m).

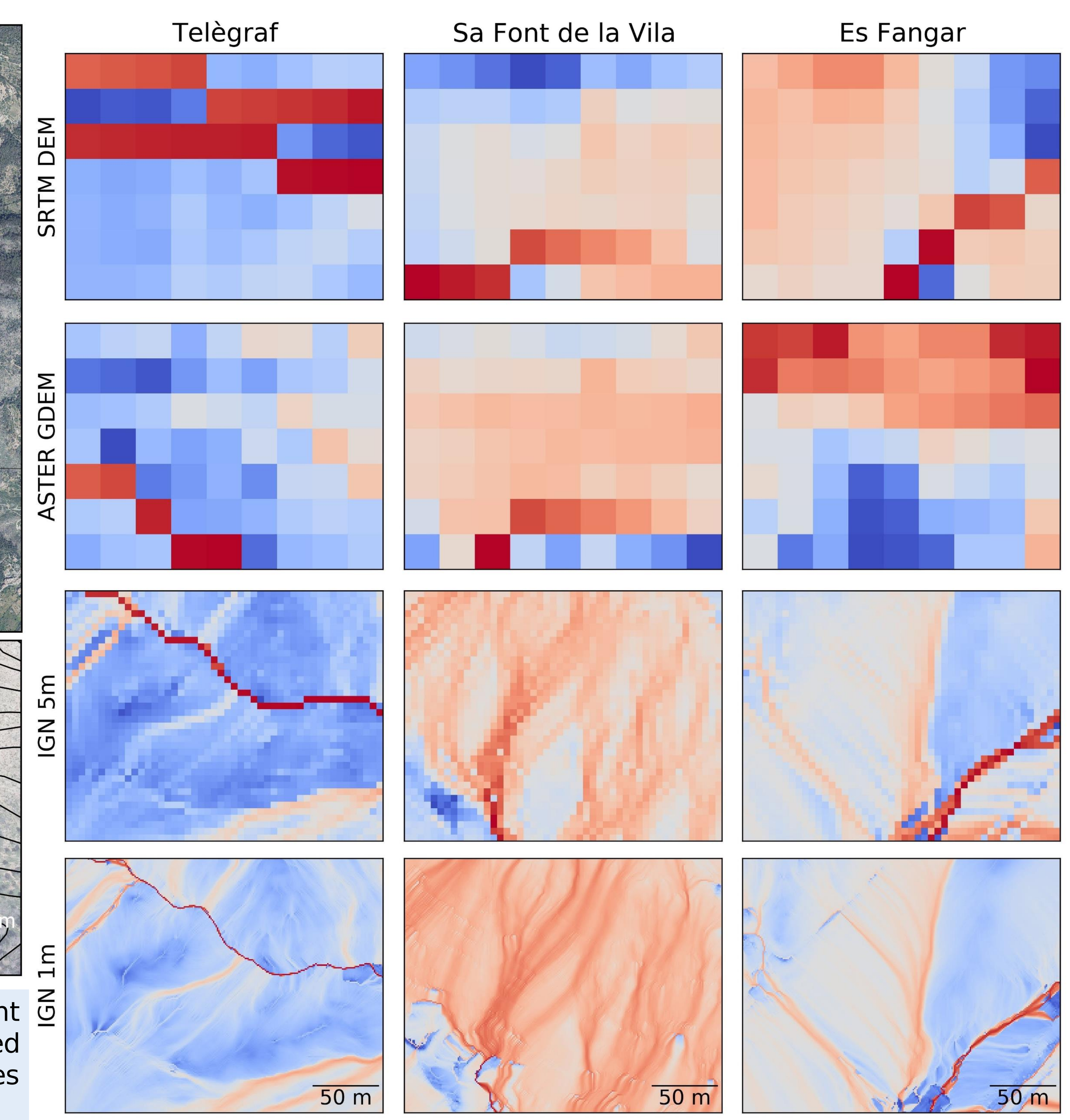

Figure 3 (RIGHT). Selected plots representing the connectivity index (IC) in the three catchments, including high-resolution aerial pictures of the selected plots and contour lines (Δh= 10 m).

- ***4.2.2. Small Detail Water and Sediment Connectivity*** The coarse spatial resolution of the SRTM and ASTER models limited the applicability of the water/sediment connectivity index. The IC showed reliable surface flow patterns using the IGN DTMs, although the 1-m data considerably improved the details provided by the 5-m data (***Figure 3***).

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