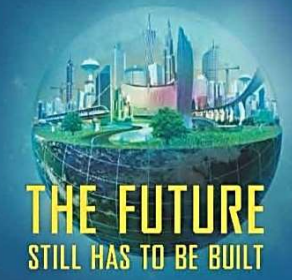


University of Ljubljana Faculty of Civil and Geodetic Engineering

Flash floods and related erosion processes at the Gradaščica River catchment

Simon RUSJAN, Nejc BEZAK, Mitja BRILLY, Klaudija SAPAČ, Matej SEČNIK, Andrej VIDMAR, Matjaž MIKOŠ

University of Ljubljana, Faculty of Civil and Geodetic Engineering (Slovenia) - FGG

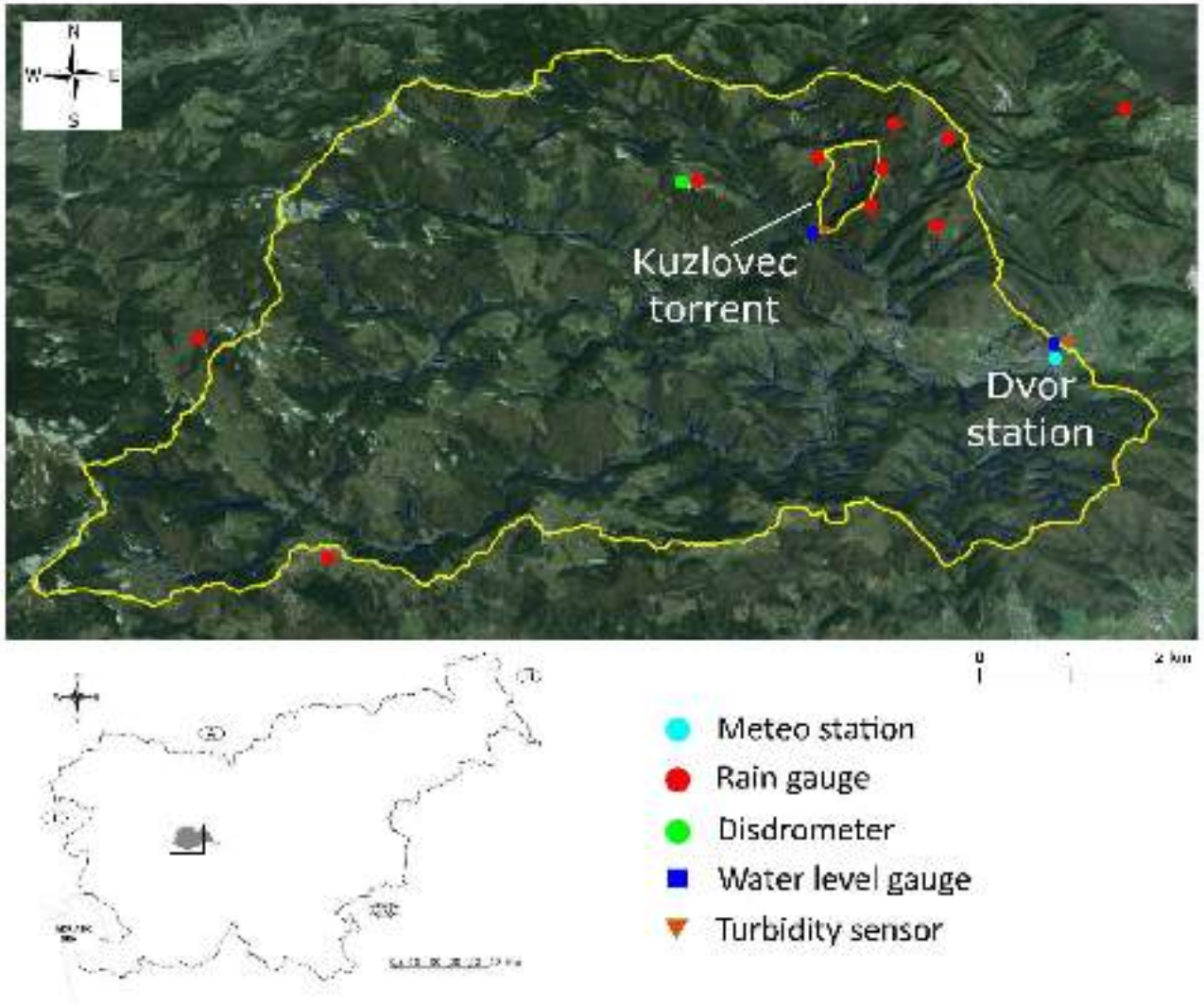
Overview

- **Repeated Terrestrial Laser Scanning (TLS) was combined with hydrological monitoring (rainfall, runoff, sediment transport) in order to identify geomorphic changes and sediment transport processes in the headwater Gradaščica River catchment and Kuzlovec torrent subcatchment.**

- **One specific extreme rainfall event caused intense soil erosion and sediment transport processes.**

- **These kind of extreme events can cause large economic loss and endanger human lives.**

Location


N
W
E
S
Kuzlovec torrent
Dvor station
0
2 km
Meteo station
Rain gauge
Disdrometer
Water level gauge
Turbidity sensor

Kuzlovec torrent sub-catchment

Catchment area	0.71 km^2
Elevation range (min, max, average)	394 m; 847 m; 631 m a.s.l
Slope (max, average)	46.5° (105.3%); 27.3° (51.6%)
Exposition	SW
Length of the main stream	
Annual precipitation	1600-1800 mm
Maximum water discharge measured	N/A
Minimum water discharge measured	N/A
Vegetation cover / land cover / land use	broad-leaved forest, mixed forest, land principally occupied by agriculture, with significant areas of natural vegetation
Geology	limestone, dolomite, sandy slate, Groden layers – red sandstone, alevrolite, slate and conglomerate
Soils (FAO type)	Rendzic Leptosol

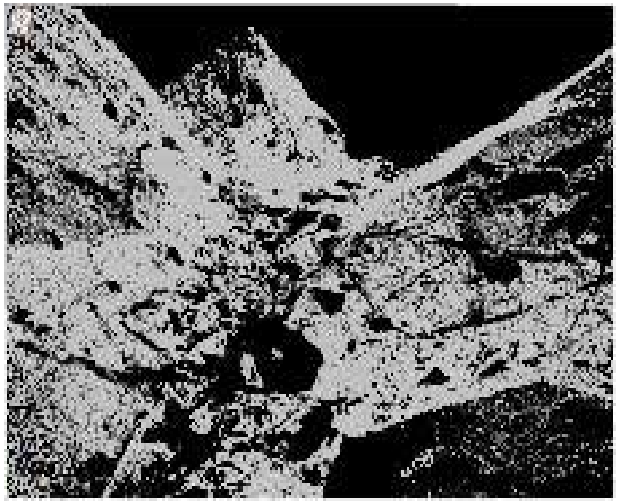
Hydro-meteorological measurements

Terrestrial Laser Scanning (TLS)

- **Based on the points clouds (several million points) the DTMs for years 2013, 2014 and 2015 with 0.05 m grid cell were determined.**
- **An important step of the DTM pre-processing was removal of large wood.**

Point cloud

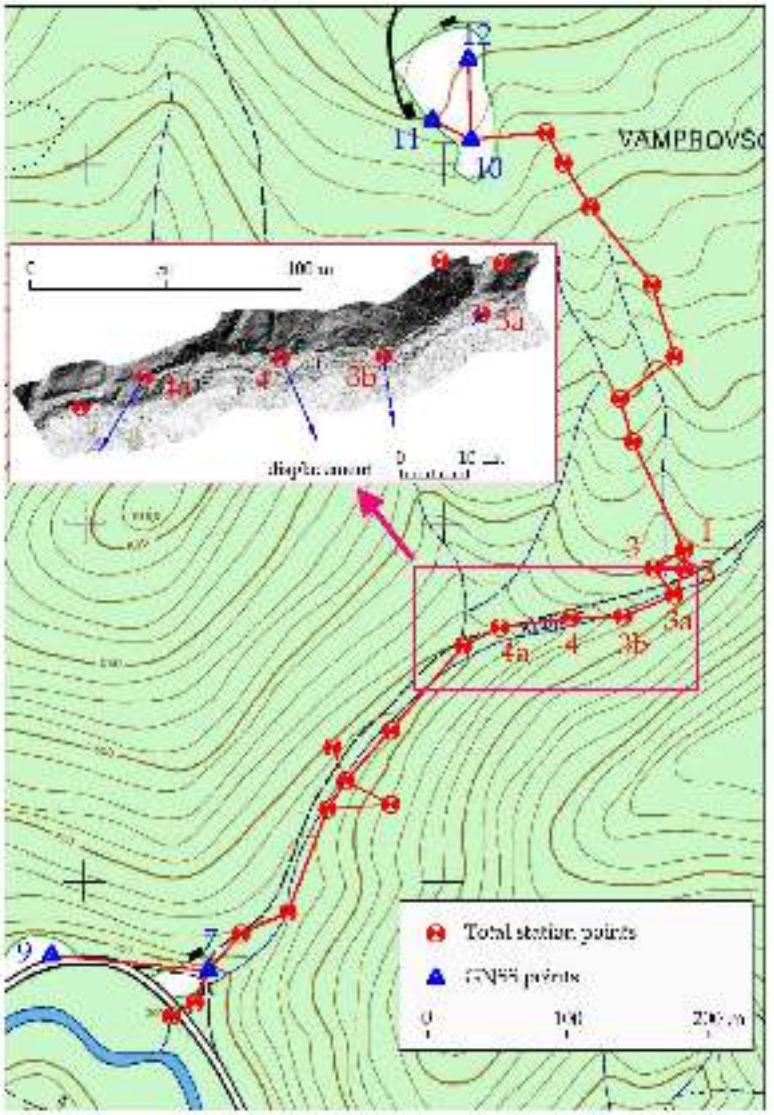
Classified point cloud excluding vegetation



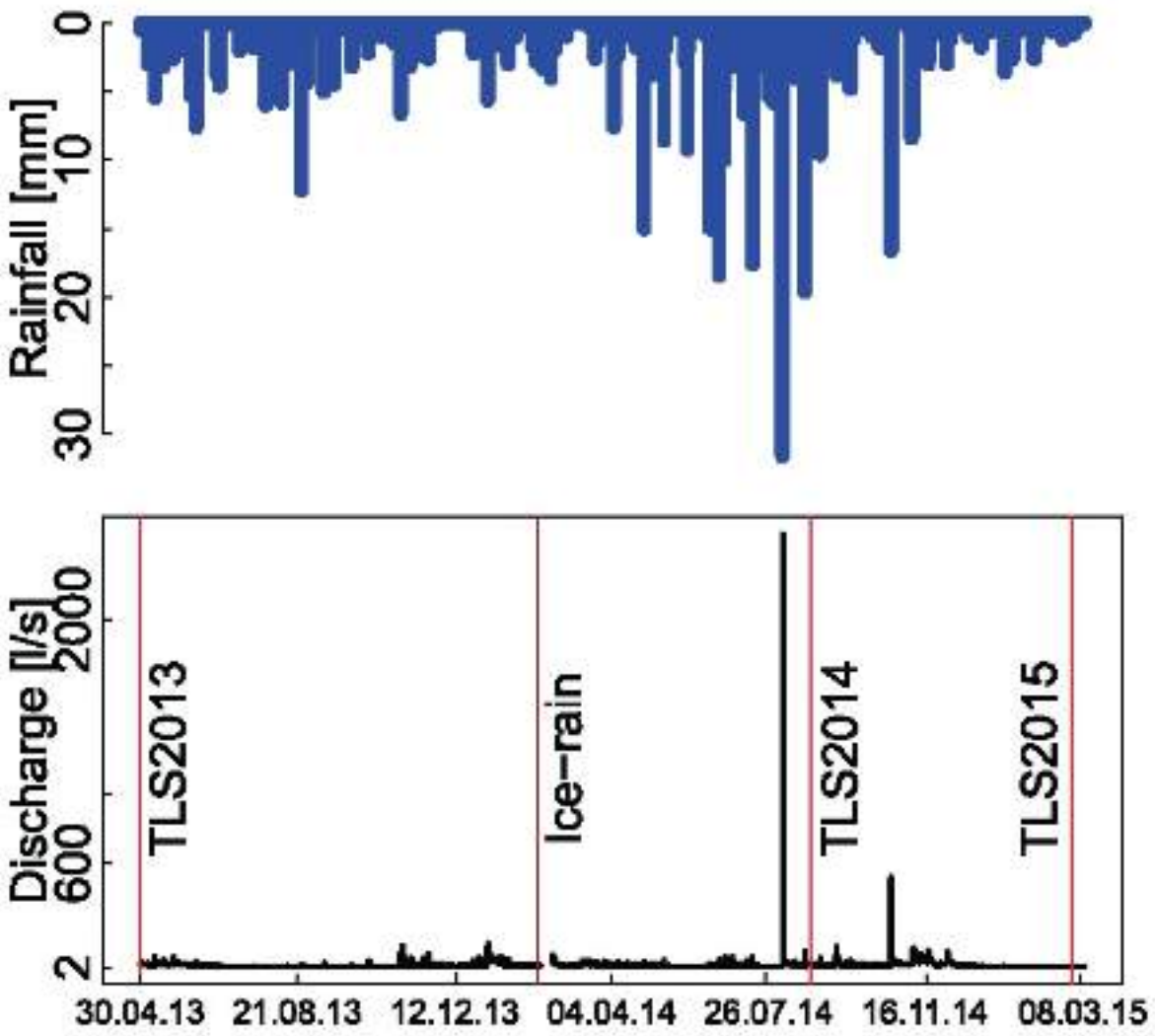
Ground points

TLS

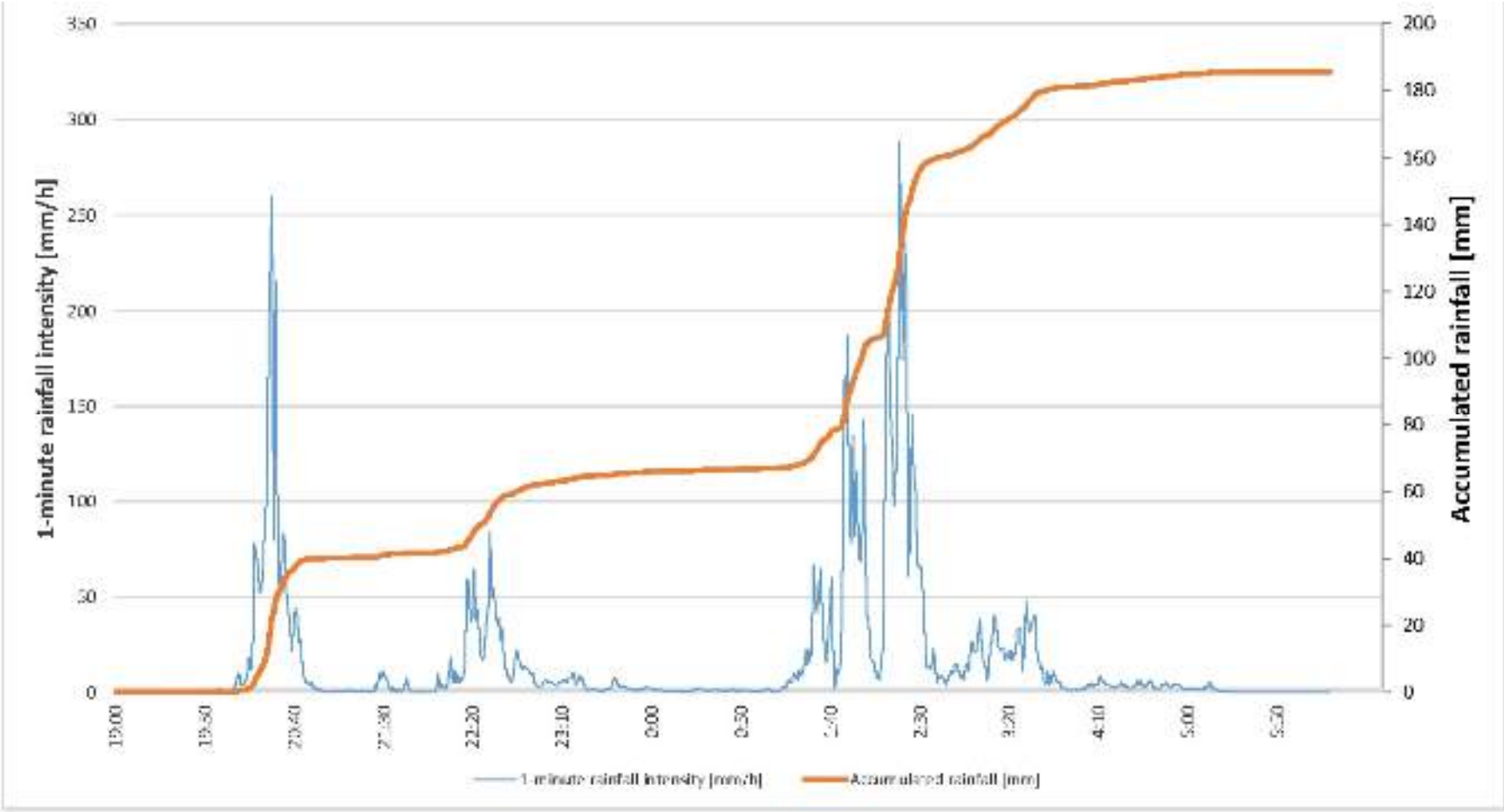
- **DTM comparison was performed on a smaller section of the Kuzlovec torrent.**



Hydro-meteorological situation in the torrent



August 2014 extreme event



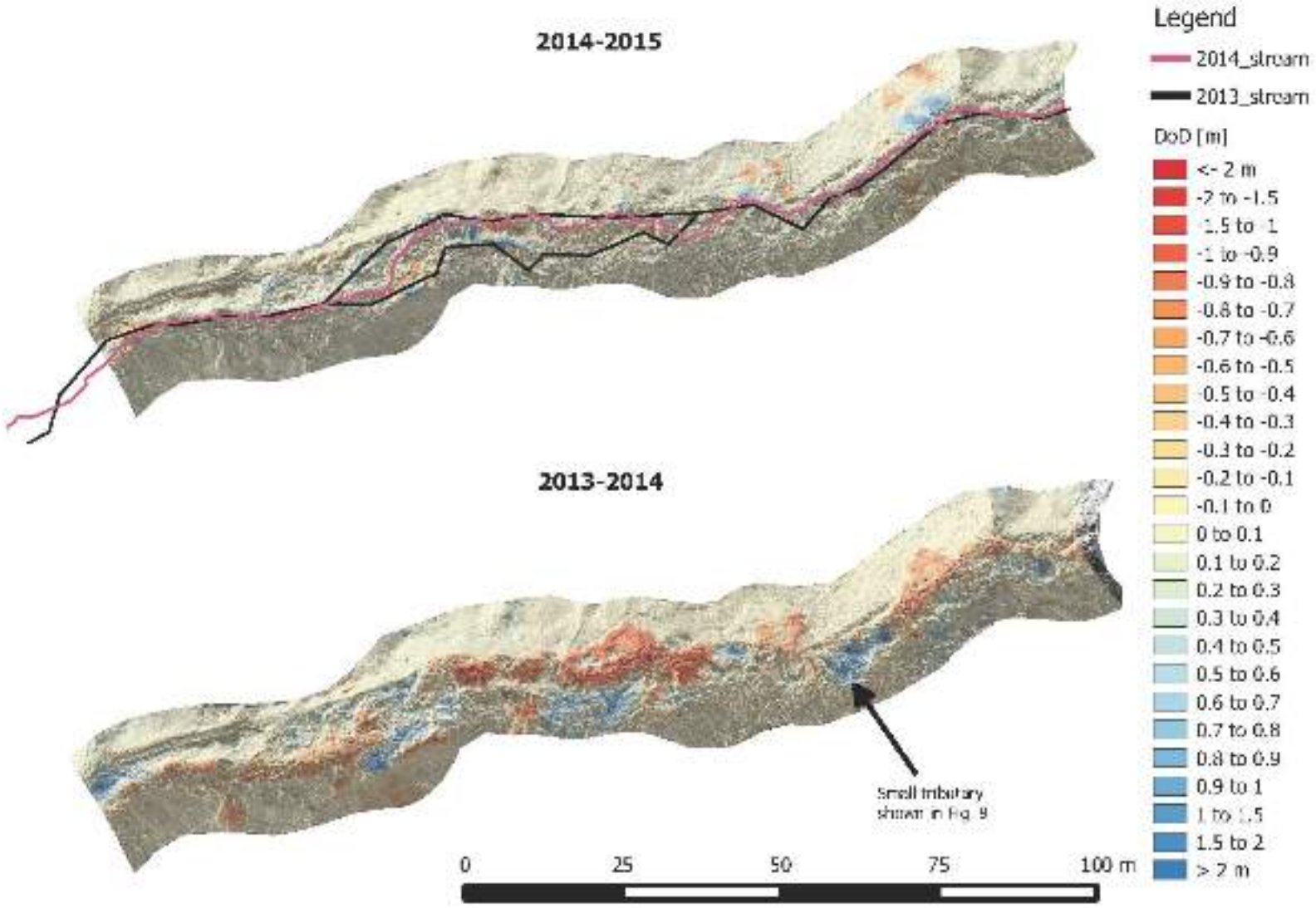
http://ksh.fgg.uni-lj.si/avp/DisCrniVrh/

August 2014 extreme event

- Tipping bucket rain gauges measured between 110 and 140 mm in 9 hours, which correspond to the return period between 100 and 250 years. Minute rainfall intensities measured by disdrometer were up to 300 [mm/h].
- More than 50 shallow landslides were triggered.
- About 50 km of roads were damaged, 4 bridges collapsed.
- Flood peak at the Gradaščica River water station: Q = 69 [m^3/s] (~25-year return period).

August 2014 extreme event

Comparison between the derived DTMs



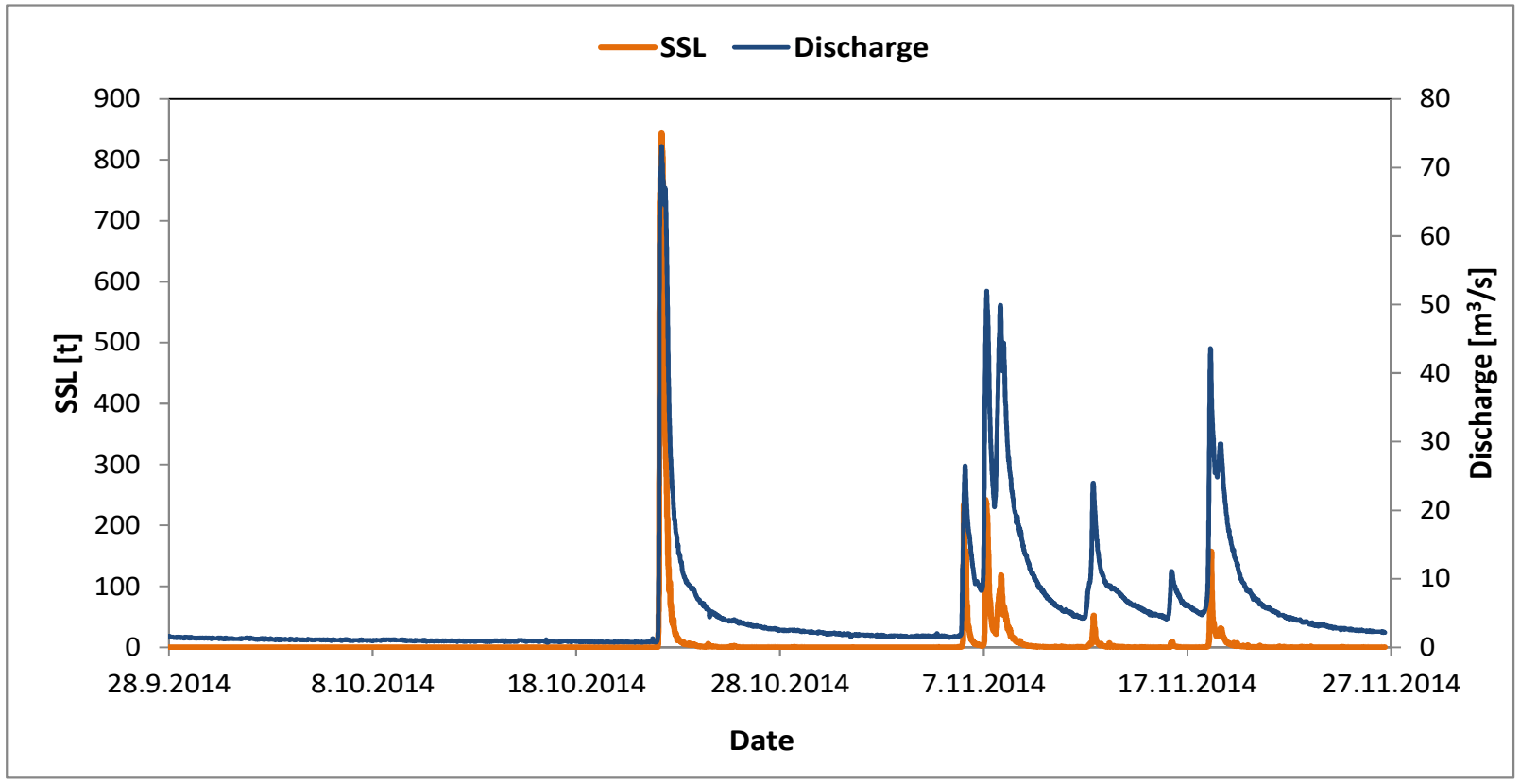
Comparison between the derived DTMs

Comparison between the derived DTMs

Overview of the erosion rates estimated from the DoD maps with and without consideration of uncertainty (uniform threshold and spatially variable FIS approach).

		DoD 13–14	DoD 14–15
Gross DoD budget	Erosion [m^3]	674	202
	Deposition [m^3]	229	161
	Gross change [m^3]	−445	−41
Net DoD budget (uniform threshold)	Erosion [m^3]	601	172
	Deposition [m^3]	204	127
	Net change using uniform uncertainty threshold [m^3]	−397	−45
Net DoD budget (FIS approach)	Erosion [m^3]	609	156
	Deposition [m^3]	192	116
	Net change using the FIS approach [m^3]	−417	−40

Rainfall event in October 2014



Rainfall event in October 2014

Sediment deposits along the Gradaščica River channel after the October 2014 flood event (left-suspended sediment deposition on the floodplain; right – excavation of the deposited material).

Rainfall event in October 2014

- The recurrence interval of the October floodwave (peak Q = 72 $m^3/s \approx Q_{50}$).
- The total amount of the transported suspended sediment material during the October and November 2014 events was about 21,000 t.
- The specific sediment yield of about 2.6 t/ha.
- The estimated total volume of the suspended material transported along the Gradaščica River channel was approximately 8000 m^3.

Sediment deposition in Ljubljanica river channel

Estimation: 40.000 m^3 of deposited sediments.

Conclusions

- The extreme August and October 2014 flash flood triggered by the rainfall event with a return period of over 100 years caused extensive damage of infrastructure and had a great impact on the geomorphic conditions in the rive channels.
- Most of the local deposition areas can be attributed to the sediment delivery from small local side tributaries (gullies) whereas the erosion areas detected near the stream channel or in the channel itself are mostly caused by the water flow drag force.
- A particular torrential channel characteristic is the shifting and degradation of the Kuzlovec torrent channel bed, which is, in some short sub-reaches, eroded to the bedrock.

Conclusions

- **The sediment budget due to an extreme flash flood can be more than a magnitude larger than the mean annual budget during average hydrological years.**

- **The unit stream power for the investigated area of the Kuzlovec torrent was assessed to be approximately 500 W/m^2 during the August 2014 extreme event (the unit stream power was well above the often used threshold where significant geomorphic changes can occur).**

- **High amounts of suspended sediments can be transported along the Gradaščica river channel).**