Terabytes on the Lap: Visual Analysis of Massively Large Bathymetric LiDAR Raw Data and Interactive Editing of Derived Big Point Clouds with HydroVISH

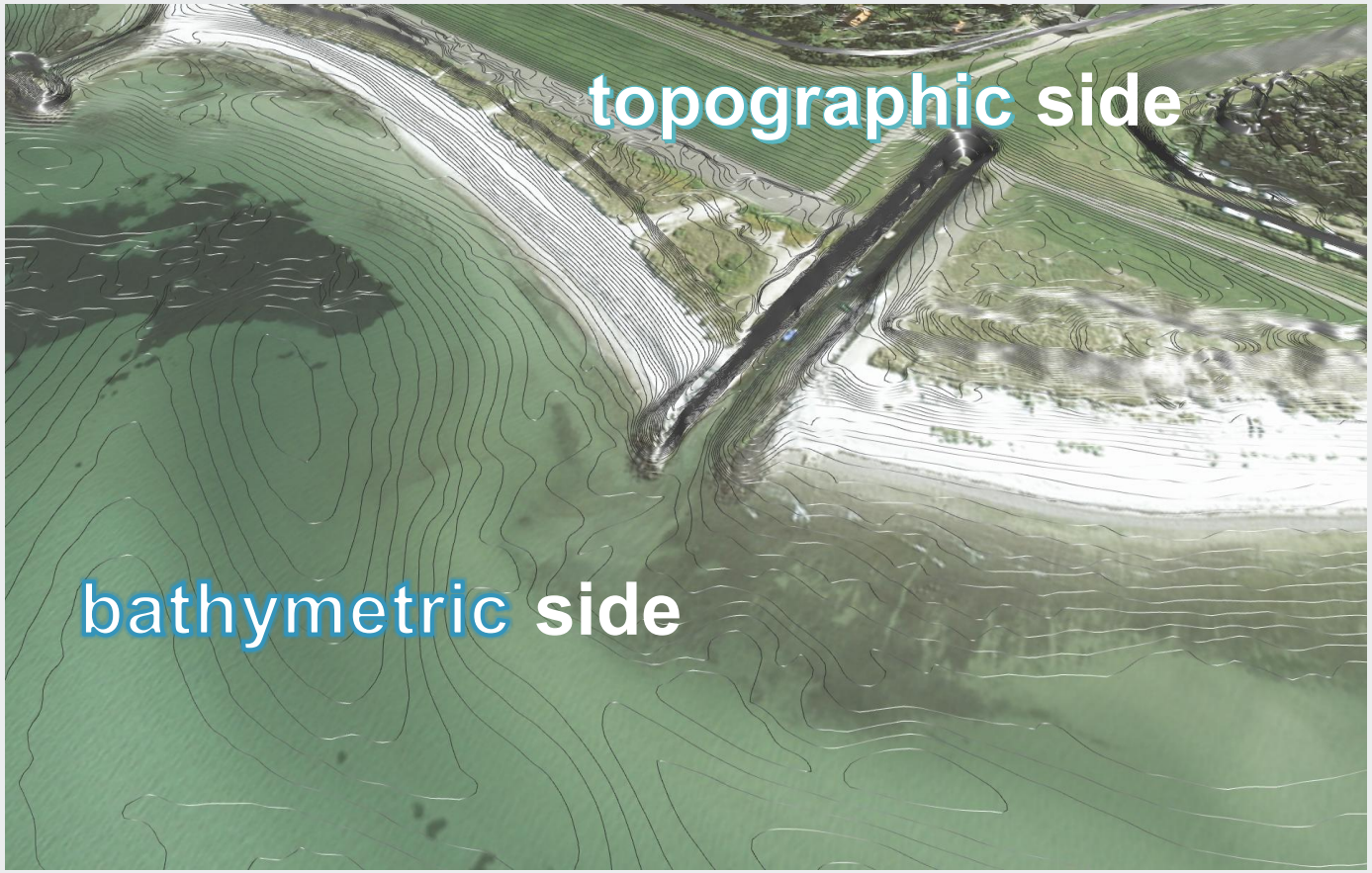
Werner Benger, ***Ramona Baran****,*

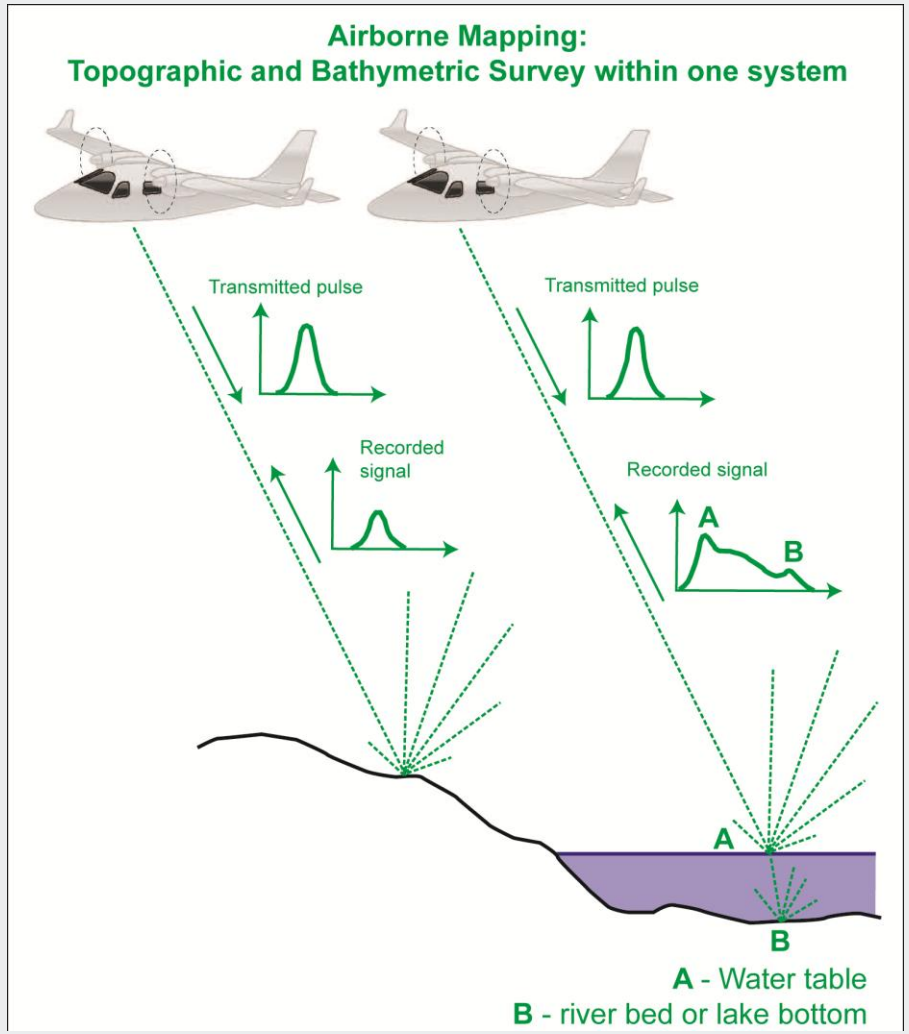
Wolfgang Dobler & Frank Steinbacher

3D Underwater Mapping From Above and Below

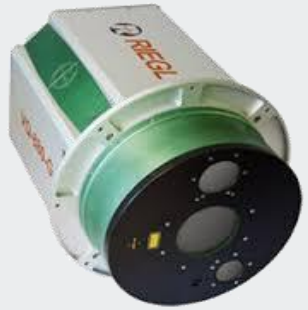
Vienna, 09.07.2025

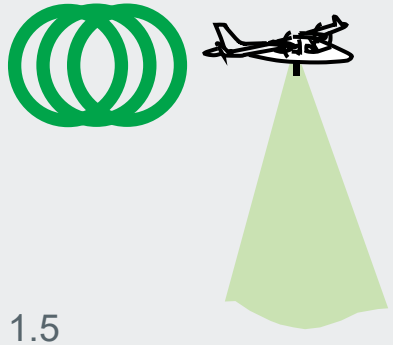
What is topobathymetry?



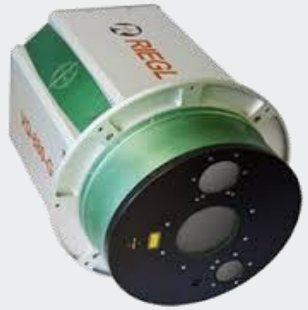


KomVISH HYDROVISH



	VQ820-G	**VQ880-G**
Altitude	600 m (eye safety)	600 m (eye safety)
Wavelength	532 nm	532 nm
Beam divergence	fix (1 mrad)	variable (0.7-1.1 mrad)
Pulse repetition rate	256 kHz	up to 550 kHz
Scan angle	20° backward	20° forward & backward
Scan pattern		
Secchi depth	1	1.5
Online waveform	yes	yes
Full waveform	(yes)	yes

KomVISH HYDROVISH



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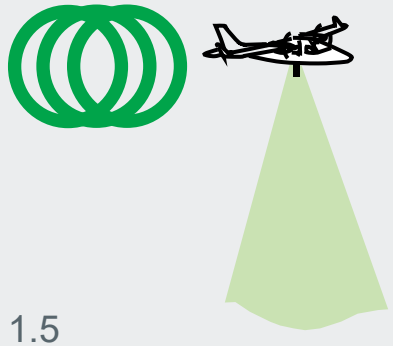
Scan pattern		
Secchi depth	1	1.5
Online waveform	yes	yes
Full waveform	(yes)	yes

Trigger for FWF processing pipeline in HydroVISH

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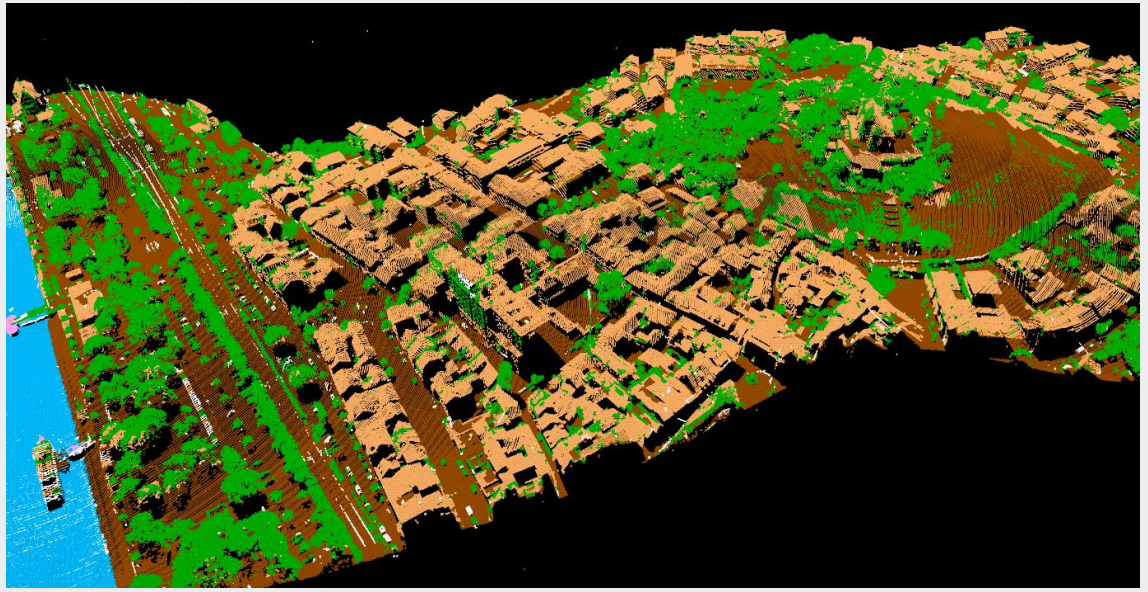
In-house software HydroVISH

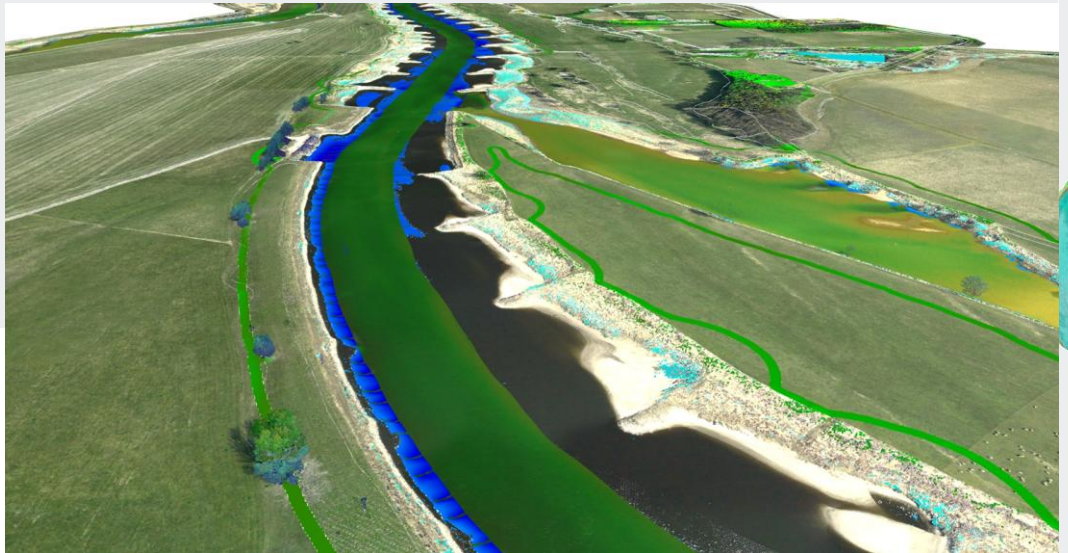
Data visualisation, -processing & -modelling
(FWF analysis, filtering, strip adjustment, classification, refraction, DTM, profiles, contour lines, hydraulic meshes …)

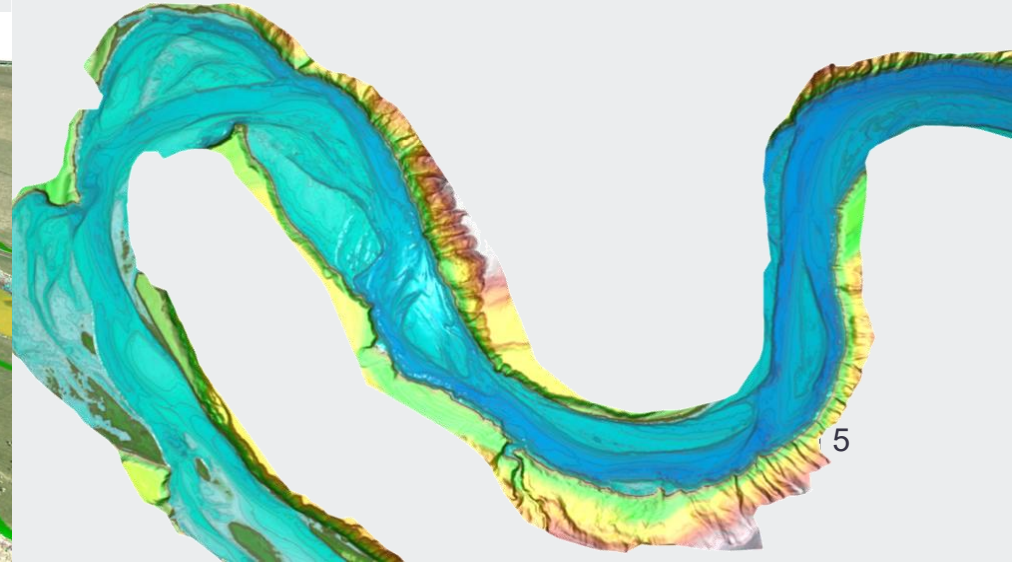
Data merging (LiDAR, MBES, RGB, hydraulics, LoD ...)

3D-geodata Viewer KomVISH as interface to 2D-GIS (ArcGIS Pro & Kominfo)

Handling 3D-geomass data (e.g. LiDAR data Bavaria)







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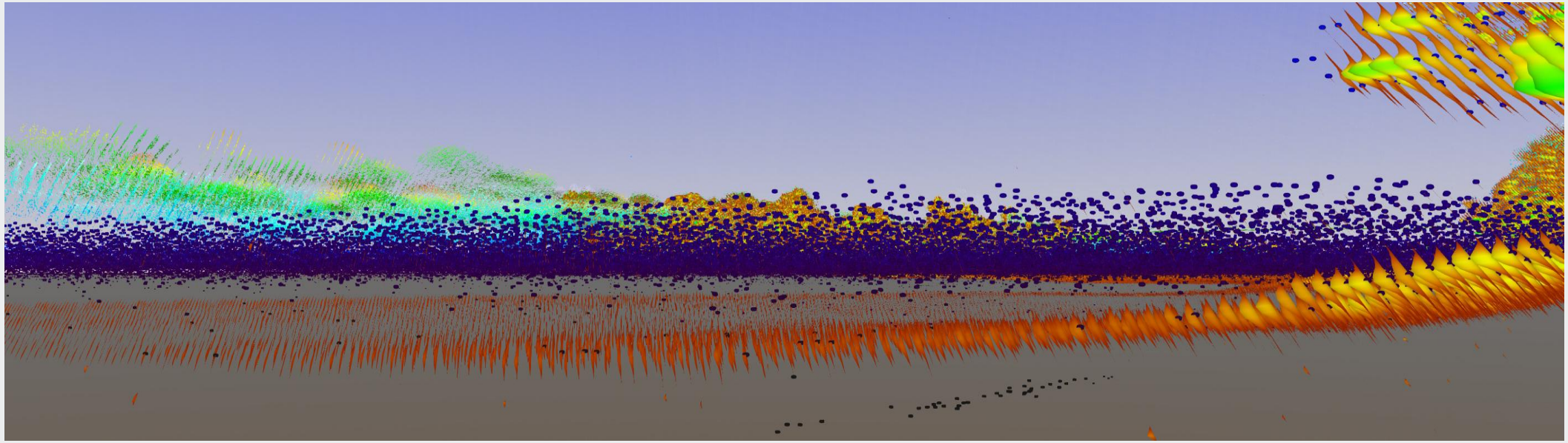
HydroVISH tools

F. Steinbacher, W. Dobler, W. Benger, R. Baran, M. Niederwieser, and W. Leimer, Integrated Full-Waveform Analysis and Classification Approaches for Topo-Bathymetric Data Processing and Visualization in HydroVISH, PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science, vol. 89, 2021, pp. 159–175



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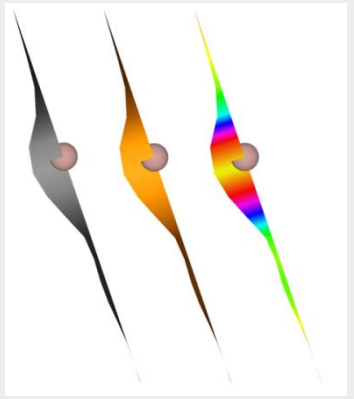
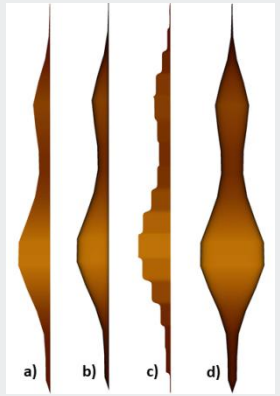
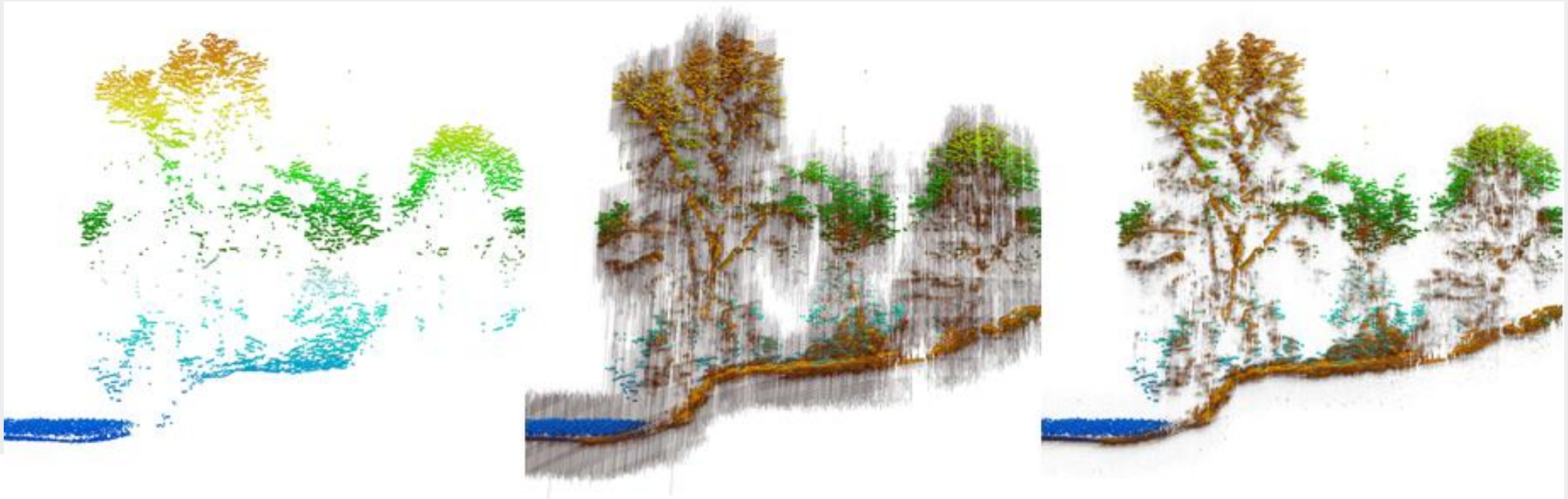
HydroVISH tools

Support of FWF analysis

Flexible real-time visualization of full waveform & point data for evaluation of data quality related penetration depth and aerial waterground coverage







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HydroVISH tools

Flexible FWF analysis related

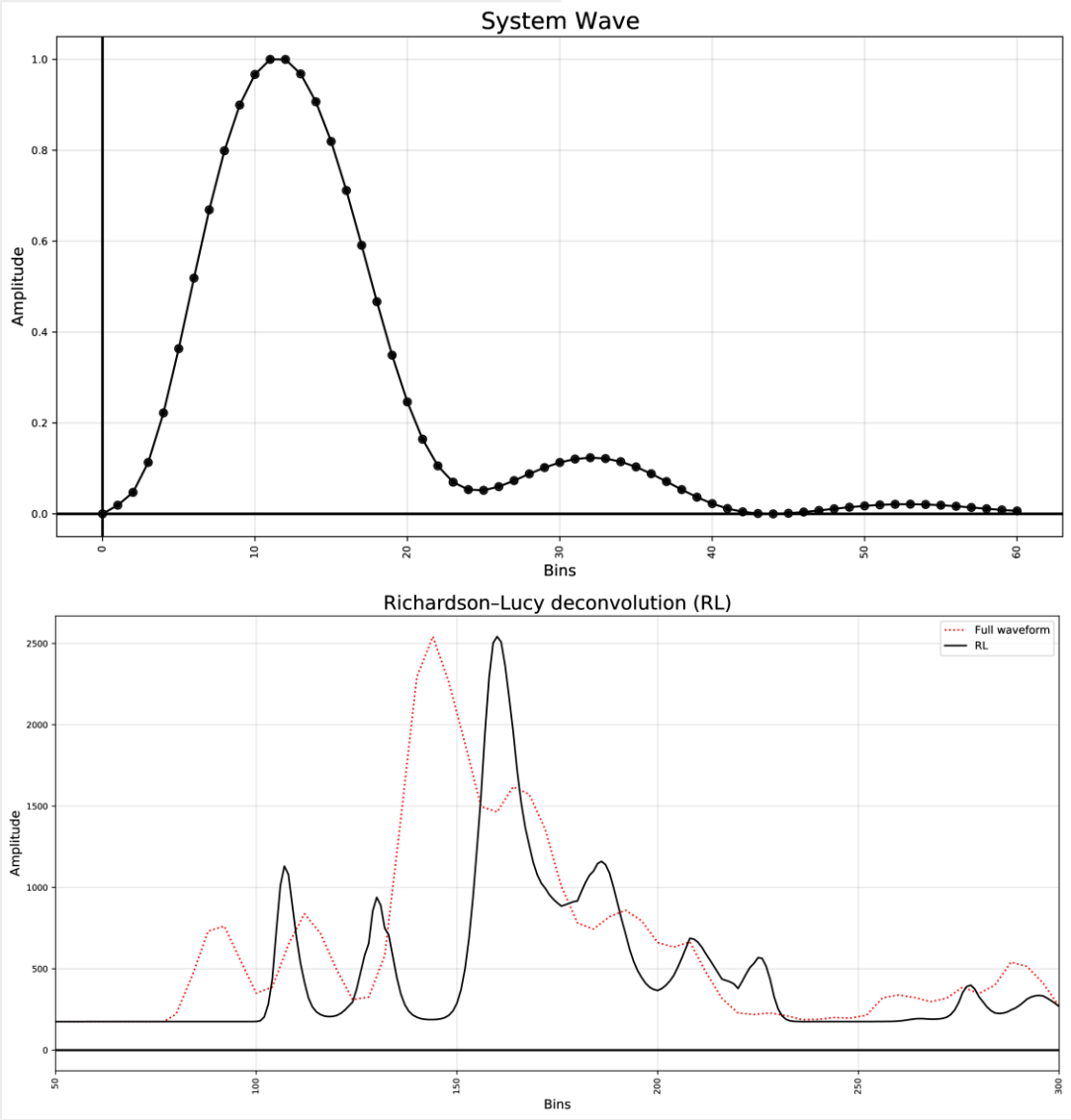
Signal decomposition:

Implemented: Gaussian decomposition
→ linear
→ non-linear

Deconvolution

Using known system wave

Implemented: Richardson-Lucy



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Flexible FWF analysis related

Signal decomposition:

Implemented: Gaussian decomposition
→ linear
→ non-linear

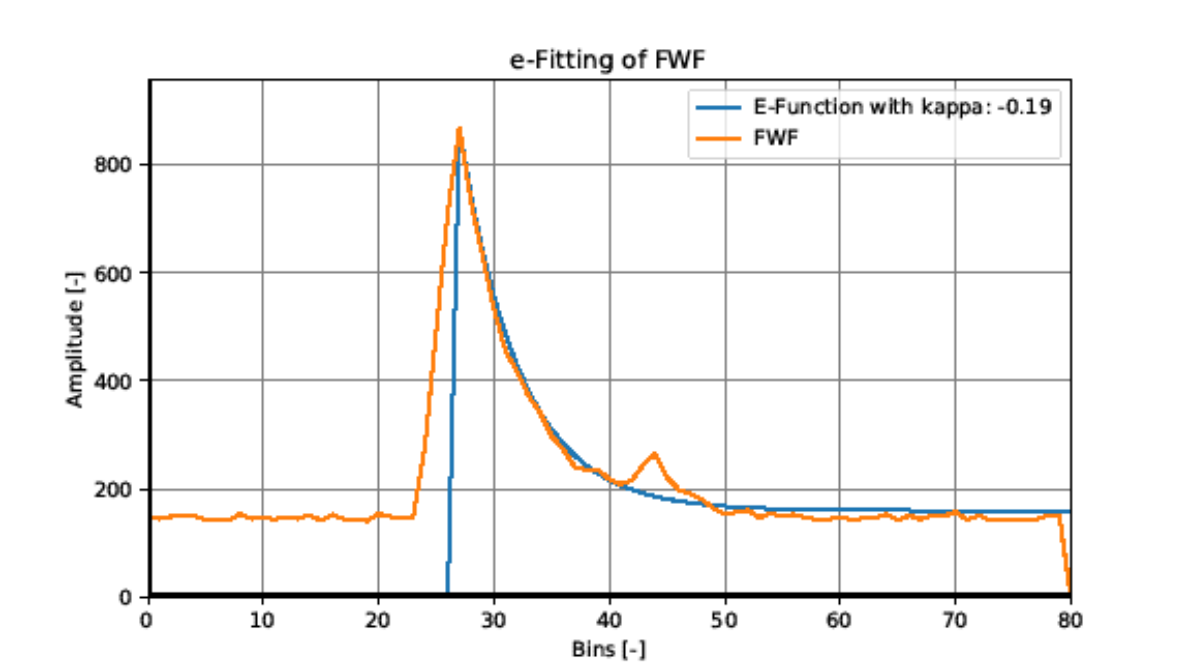
Deconvolution

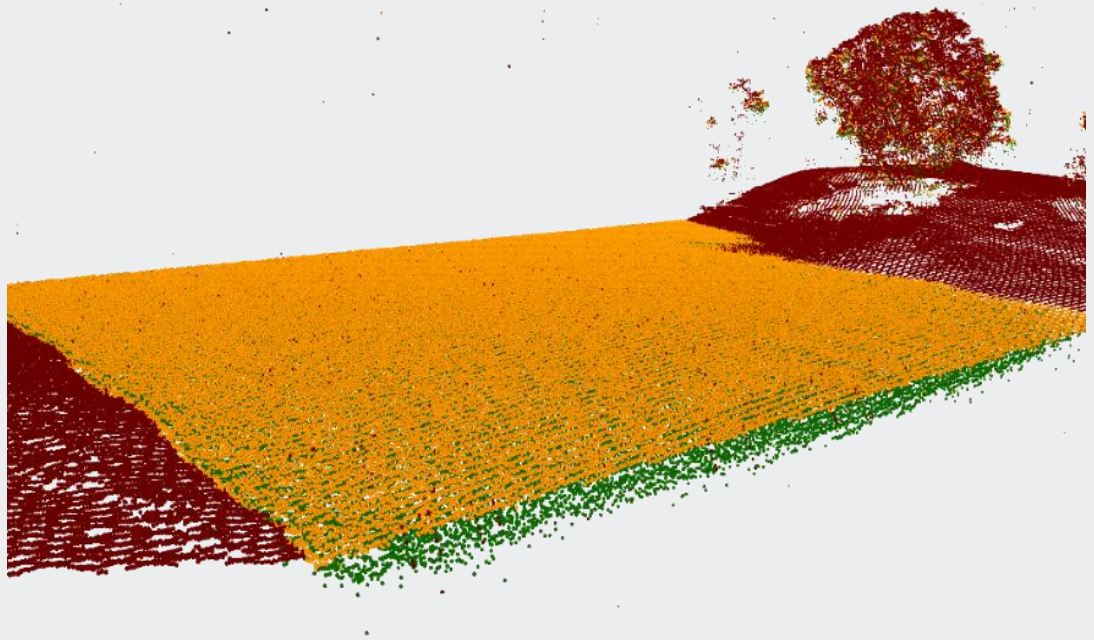
Using known system wave

Implemented: Richardson-Lucy

Support of automatic point classification

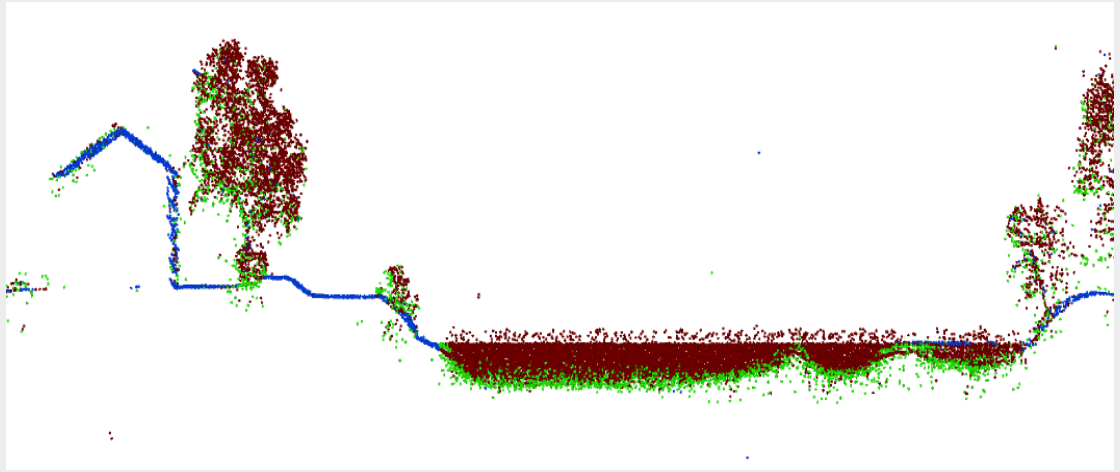
Pre-classification of waterbody based on FWF by e-function fitting



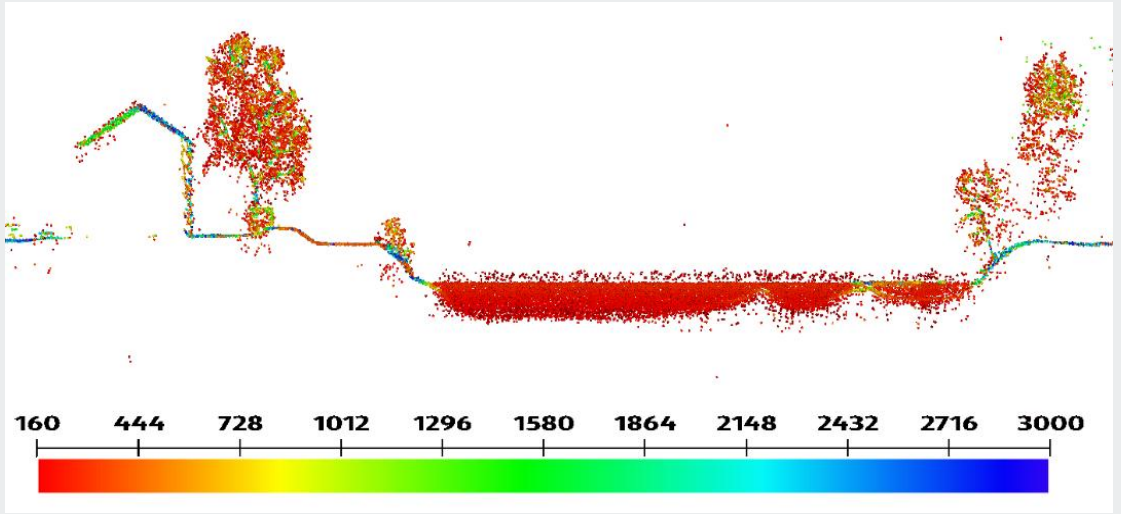


Automatic point classification

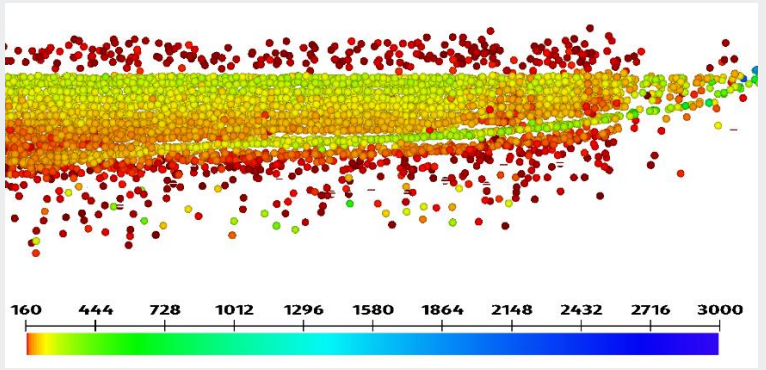
Usage of recorded and calculated point attributes

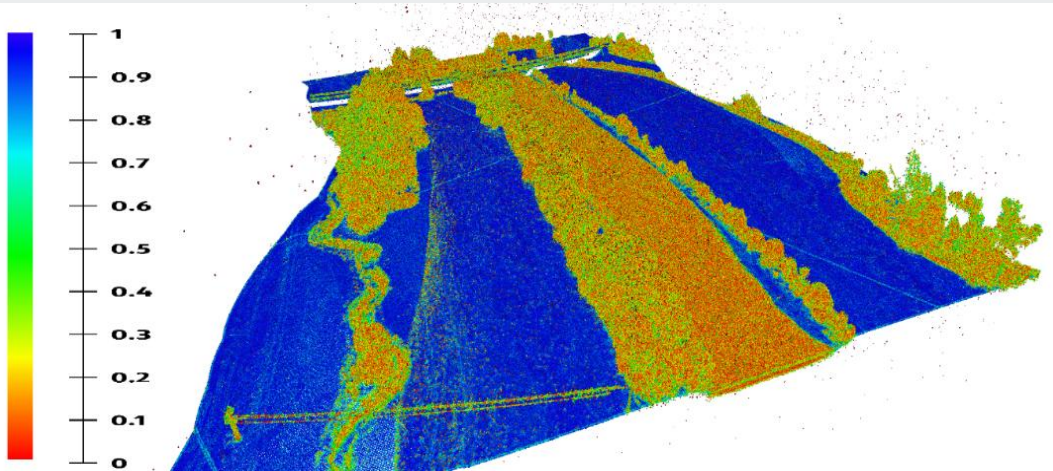


Last return / Single Return



Amplitude





Planarity
planar
non planar

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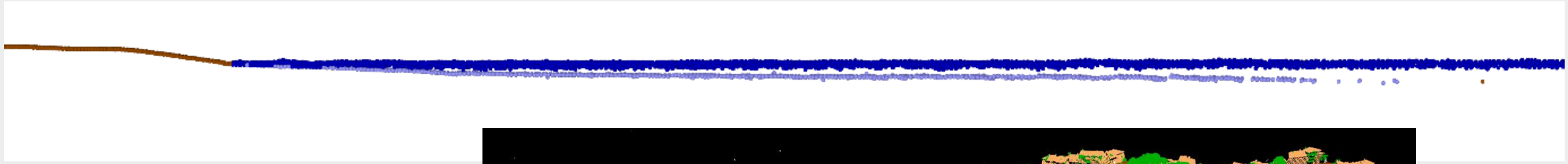
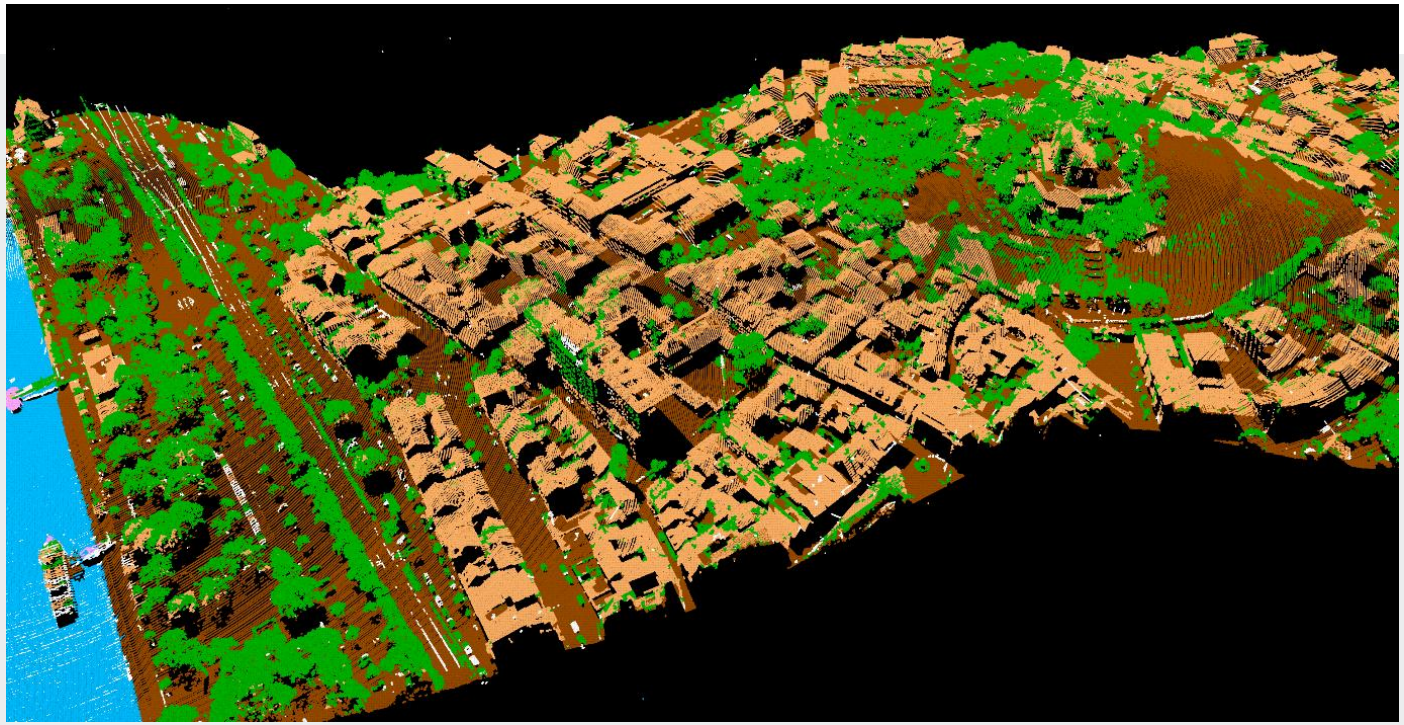
Automatic point classification with Random Forest

Breiman, Leo (2001) Random forests; Machine learning 45.1: p. 5-32

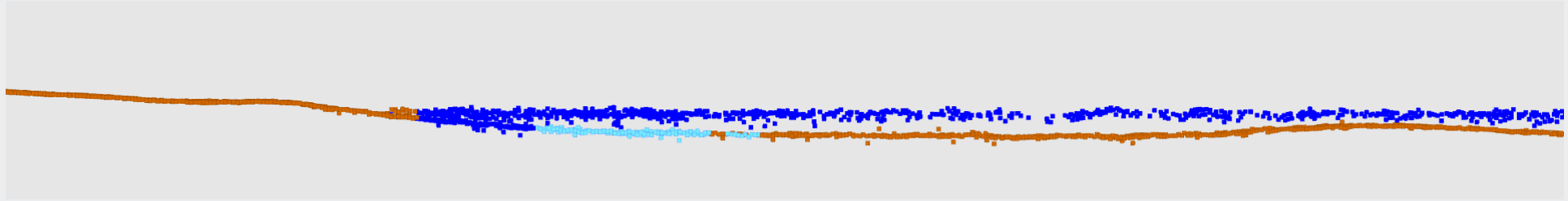
Wenzhong, Li & Yue, Shiyong (2017) Point cloud classification with random forest. International Journal of Remote Sensing 38.16: p. 4578-4592

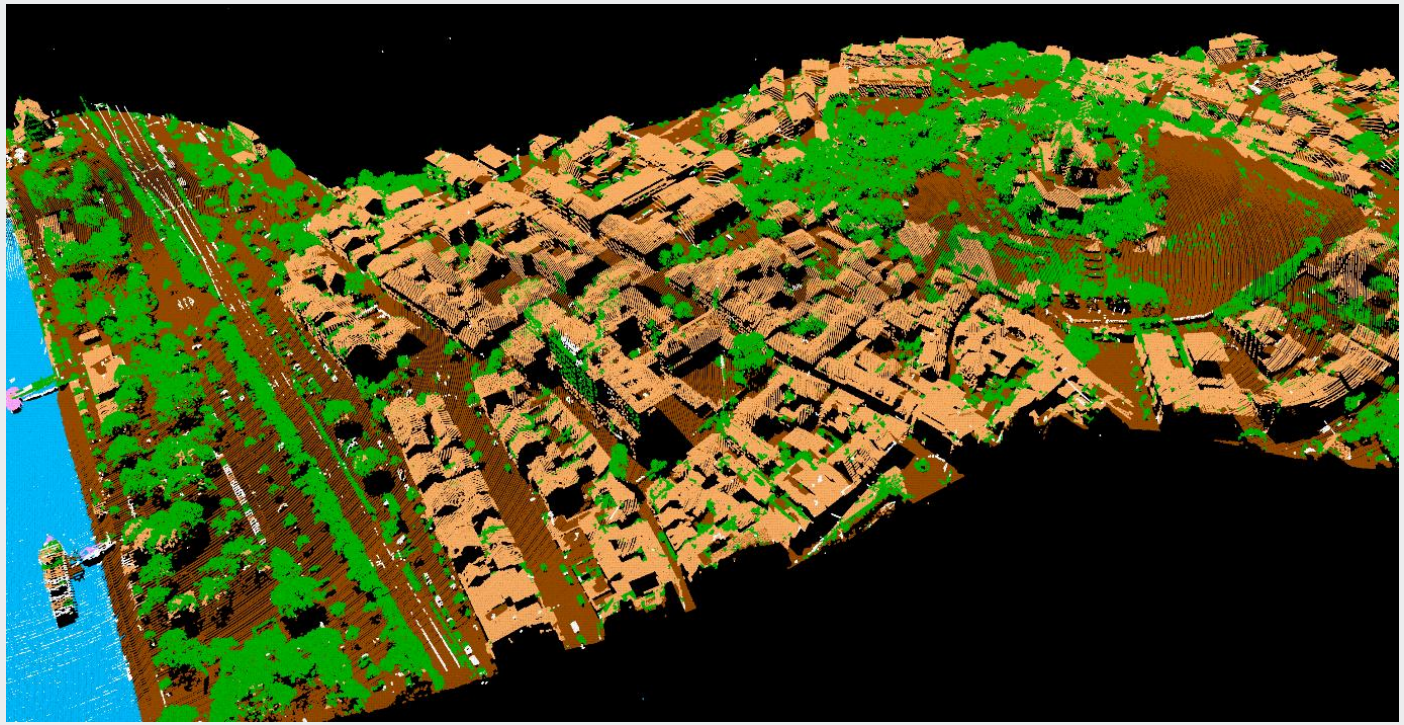




Automatic point classification with Random Forest

Perfect results?





Automatic point classification with Random Forest

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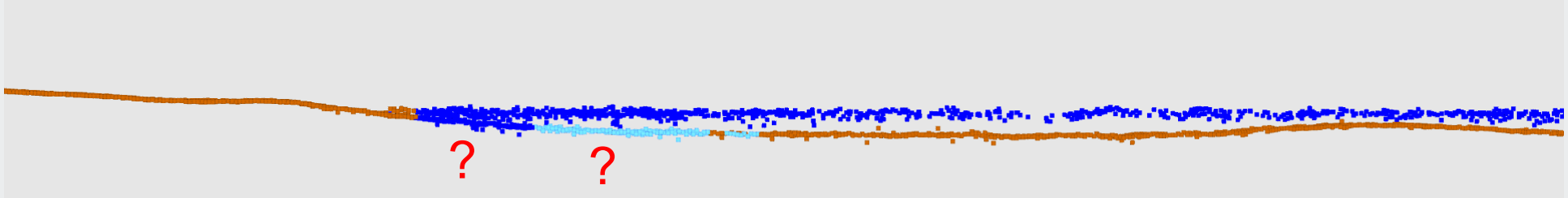
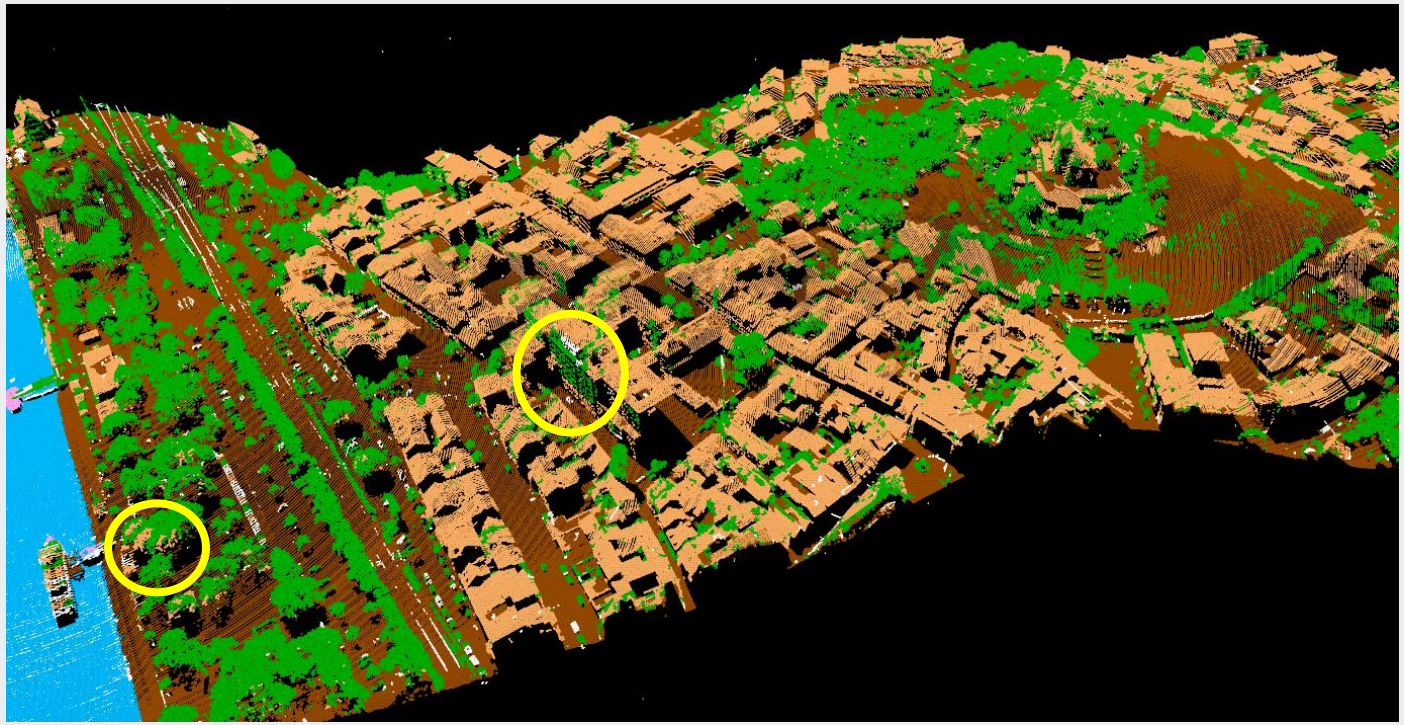


Nothing is perfect …

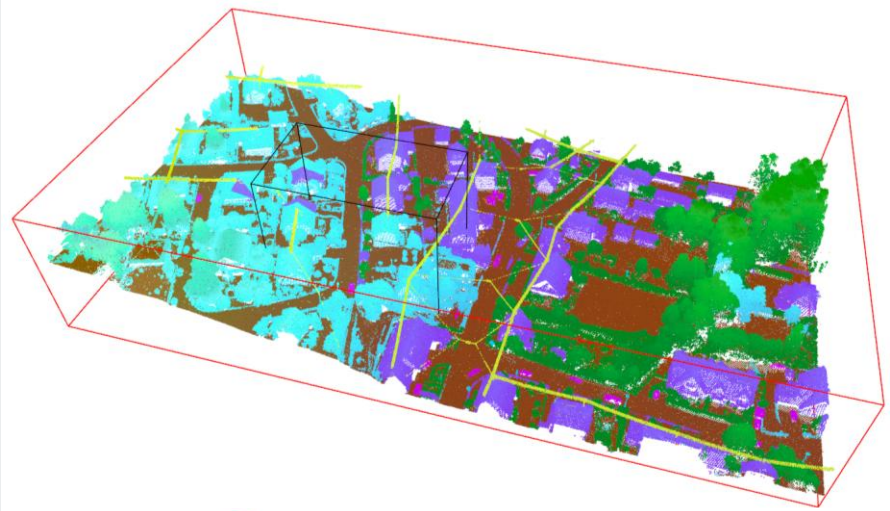


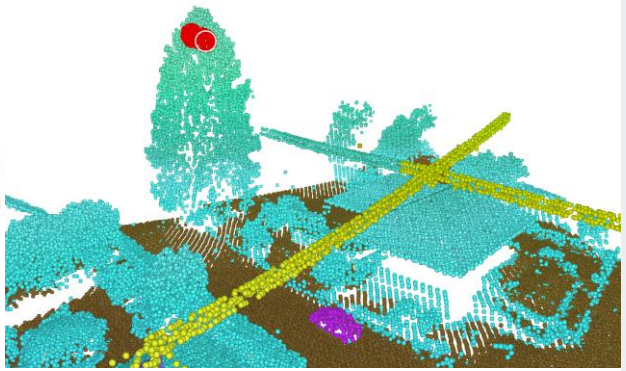
Manual correction

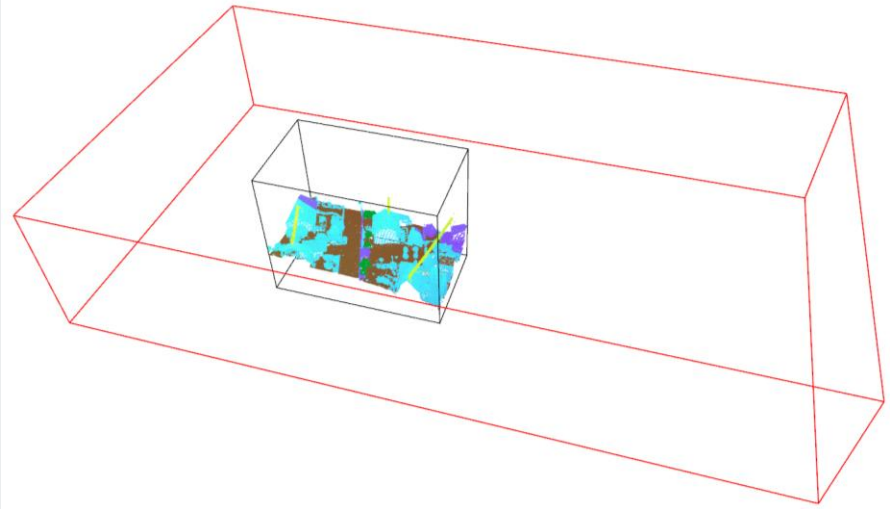
Local interactive visual inspection and manual correction of automatic classification required

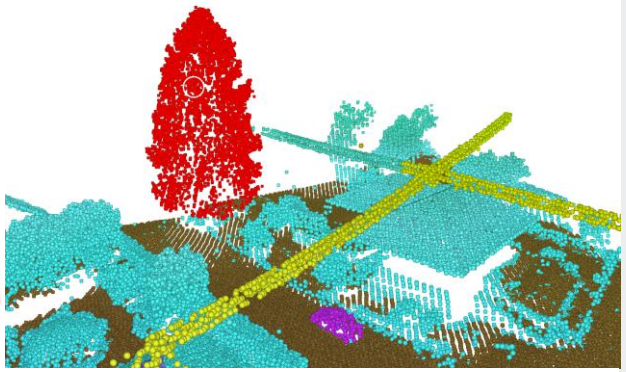
Flexible, user-defined handling of point selection plus persistant storage of point-cloud editing history related undo/redo operations

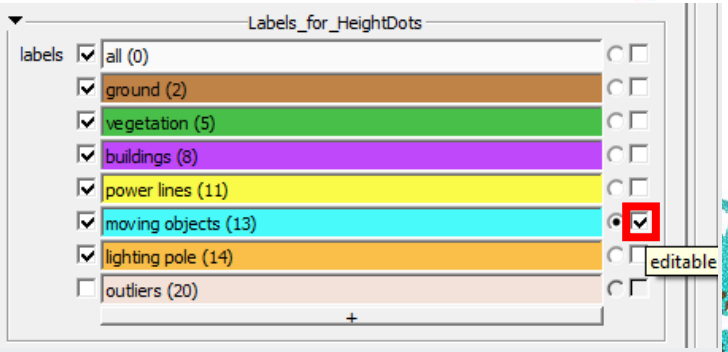
Werner Benger, Anca Voicu, Ramona Baran, Cosmin Barna, Frank Steinbacher, and Loredana Gonciulea, The Method of Mixed States for Interactive Editing of Big Point Clouds, Proceedings of the WSCG 2023 Conference, 2023, pp. 23–34

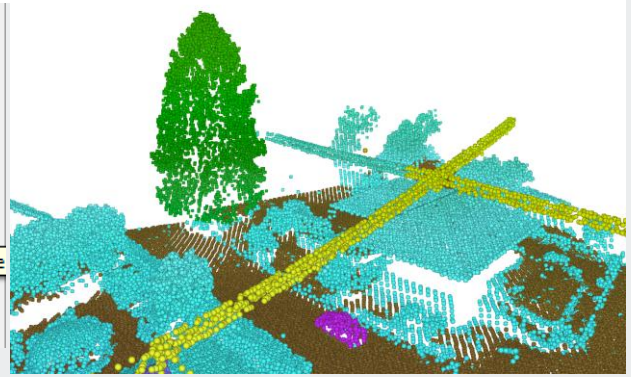






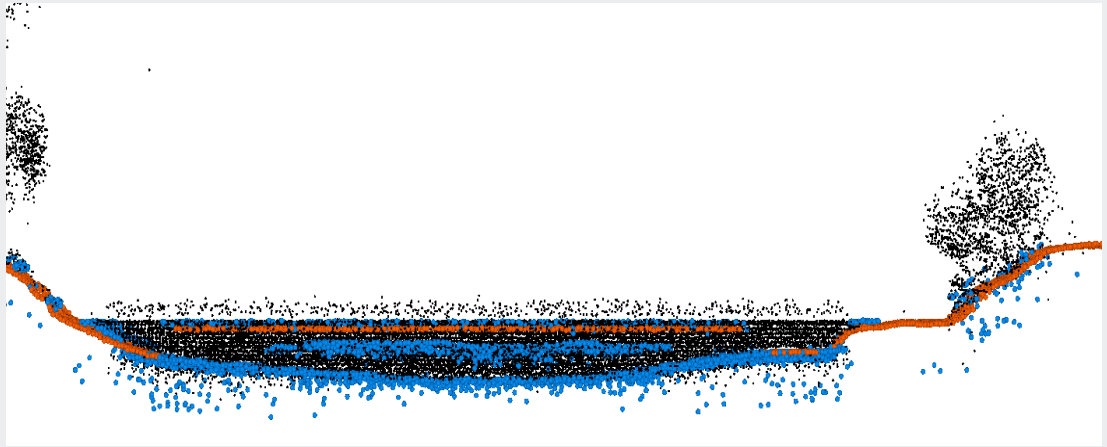




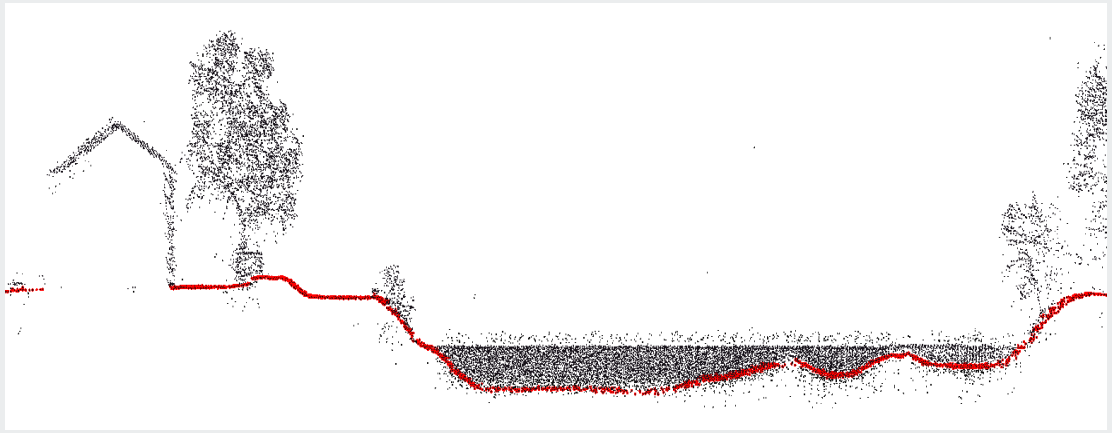


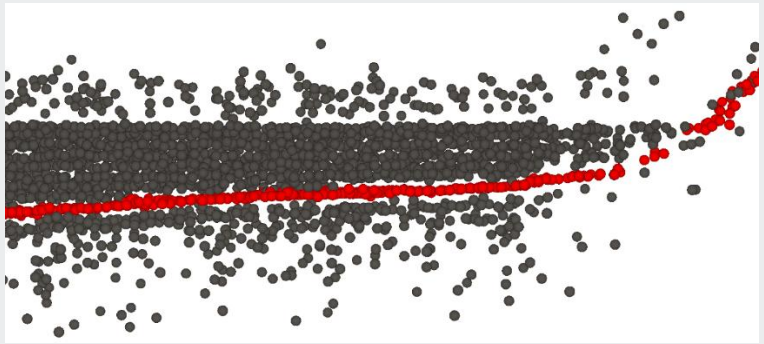
Manual correction

Automatic classification
Terrain & water ground



Manual correction
Terrain above/below water



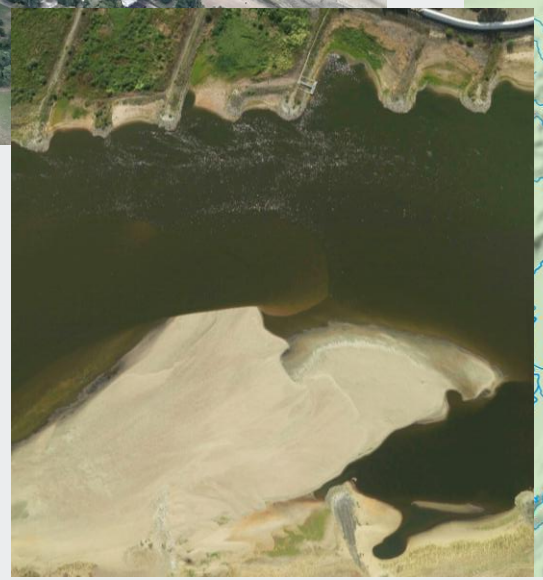


Project example

Elbe – August 2018

600 km river survey at extreme low water stage: 5.2 TB rxp raw data

Secchi depth 1.2-1.5 m → penetration depth down to 2.5 m



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Wasserstraßen- und Schifffahrtsverwaltung des Bundes

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Elbe – August 2018

Scientifically supported FWF analysis and evaluation of results for three ca. 5 km long river section:

Classified waterground point density
Aerial waterground coverage

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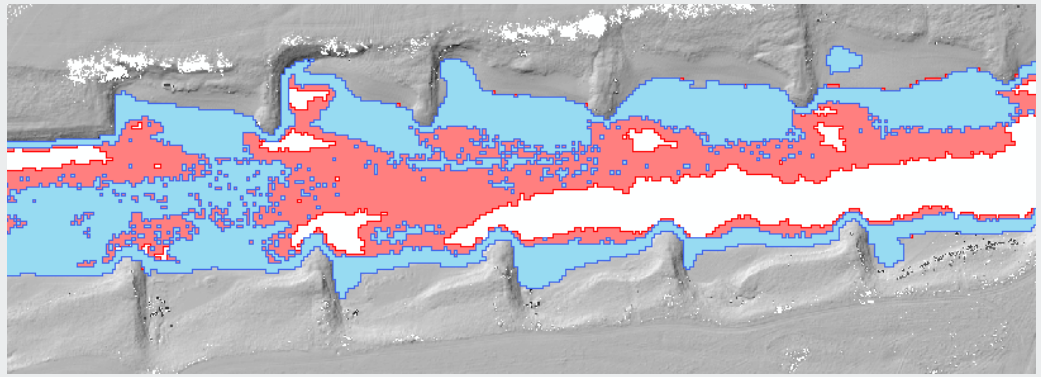
Project example

Elbe – August 2018

Best statistics for Richardson Lucy deconvolution & hybrid approach

Results very similar, as for hybrid approach at low amplitudes of waterbody Richardson Lucy deconvolution is applied

High amplitudes: Gaussian decomposition with one iteration → Suppression of implausible FWF points from implausible FWF peak detection



Perimeter	Method	Mean (points/m²)	Median (points/m²)	Total number water ground points
TS1 Hamburg	FWF - linearGauss	33.383	24	5‘384‘882
	FWF - GaussZerlegung	35.077	25	5‘421‘125
	FWF - RL-Entfaltung	38.087	28	6‘902‘709
	FWF - Hybrid	37.332	28	6‘475‘765
	OWP	35.085	26	5‘088‘627
TS2 Magdeburg	FWF - linearGauss	38.951	30	10‘736‘365
	FWF - GaussZerlegung	35.812	25	9‘660‘734
	FWF - RL-Entfaltung	43.384	34	12‘886‘671
	FWF - Hybrid	42.695	33	12‘301‘374
	OWP	40.102	31	8‘931‘249
TS3 Elster	FWF - linearGauss	54.454	51	25‘214‘902
	FWF - GaussZerlegung	51.382	47	23‘595‘085
	FWF - RL-Entfaltung	61.002	56	28‘646‘848
	FWF - Hybrid	60.853	56	28‘329‘504
	FWF - Stapelung	69.450	65	32‘133‘627
	OWP	46.936	40	12‘642‘703

Perimeter	Method	Number of 2x2 m-raster cells	Water ground area (m²)	Gain in FWF- to OWP-water ground (%)
TS1 Hamburg	FWF - linearGauss	49‘727	198‘908	+10.66
	FWF - GaussZerlegung	48‘337	193‘348	+7.57
	FWF - RL-Entfaltung	53‘616	214‘464	+19.32
	FWF - Hybrid	51‘673	206‘692	+14.99
	OWP	44‘935	179‘740	
TS2 Magdeburg	FWF - linearGauss	82‘061	328‘244	+18.63
	FWF - GaussZerlegung	81‘077	324‘308	+17.21
	FWF - RL-Entfaltung	86‘226	344‘904	+24.65
	FWF - Hybrid	83‘893	335‘572	+21.28
	OWP	69‘175	276‘700	
TS3 Elster	FWF - linearGauss	122‘442	489‘768	+53.19
	FWF - GaussZerlegung	121‘933	487‘732	+52.55
	FWF - RL-Entfaltung	123‘950	495‘800	+55.08
	FWF - Hybrid	122‘911	491‘644	+53.78
	FWF - Stapelung	122‘394	489‘576	+53.13
	OWP	79‘928	319‘712	

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Thank you for your attention!

Any questions?