universität innsbruck
Unit of Hydraulic Engineering

Katholische Universität Eichstätt-Ingolstadt

ÖAW IGF

TOPOGRAPHY, BED ROUGHNESS & SURFACE SEDIMENT CHARACTERISTICS OF A PROGLACIAL OUTWASH PLAIN

– A COMBINED APPROACH BASED ON UAV-BORNE PHOTOGRAMMETRY (JAMTAL, AT)

Clemens Hiller, Kay Helfricht, Sebastian Leistner, Florian Haas & Stefan Achleitner

MGM 2021

Munich, 7 November 2021

TOPOGRAPHY, BED ROUGHNESS & SURFACE SEDIMENT CHARACTERISTICS OF A PROGLACIAL OUTWASH PLAIN

RESEARCH FRAMEWORK

- **ESS Project HIDDEN.ICE**

"CHANGING DEBRIS COVER ON EASTERN ALPINE GLACIERS: QUANTIFICATION AND HYDROLOGICAL IMPACTS"

- **THE TEAM**

ÖAW IGF — **Kay Helfricht**

universität innsbruck, Unit of Hydraulic Engineering — **Stefan Achleitner**, **Sebastian Leistner**

Katholische Universität Eichstätt-Ingolstadt — **Florian Haas**

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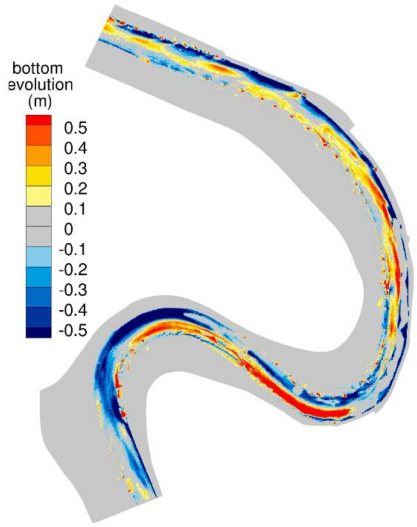
Clemens Hiller

Florian Haas

MOTIVATION

- **Quantification of bedload transport in paraglacial transition zones**
- **Numerical modelling of potential transport capacity**
- **<u>Need for parametrisation of boundary conditions, such as:</u>**

  - Model geometry → topography (i)
  - Bed roughness → friction values for turbulence model (ii)
  - Sediment characteristics → grain size distribution (GSD) (iii)
  - Discharge
  - **…**



Example of sediment transport modul GAIA
Tassi et al., 2019

MOTIVATION

- **Parametrisation of key model inputs challenging due to:**
  - Rapidly changing proglacial topography
  - Highly dynamic (braided) channel network
  - Extensive potential stream bed – where to sample?
  - Remote locations limit volumetric probing of GSD
  - Mostly angular / poorly rounded clasts (hindering spheroid-based photosieving)

- **There is a need for a feasible method to capture these parameters!**

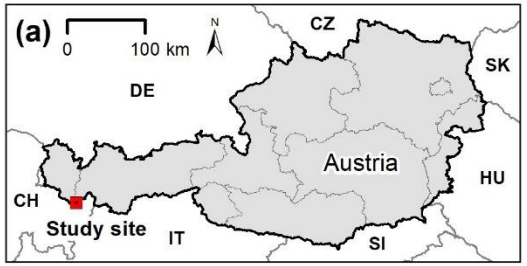
Mostly angular clasts and weakly defined braided channels in an outwash plain, Jamtal valley, AT

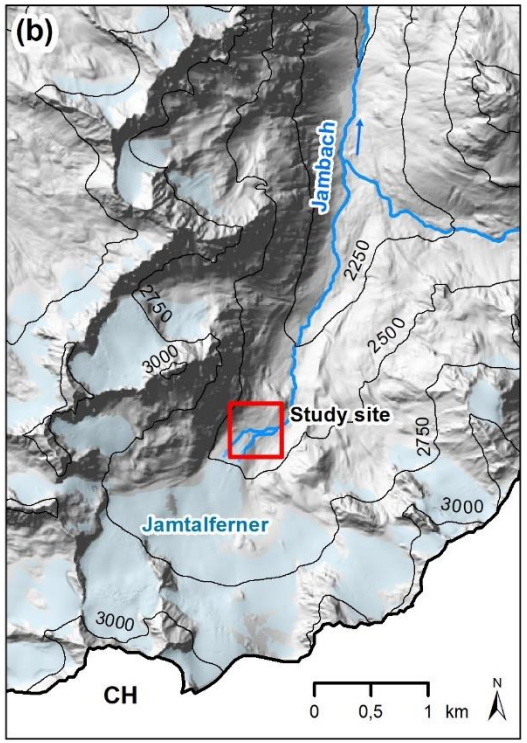
TOPOGRAPHY, BED ROUGHNESS & SURFACE SEDIMENT CHARACTERISTICS OF A PROGLACIAL OUTWASH PLAIN

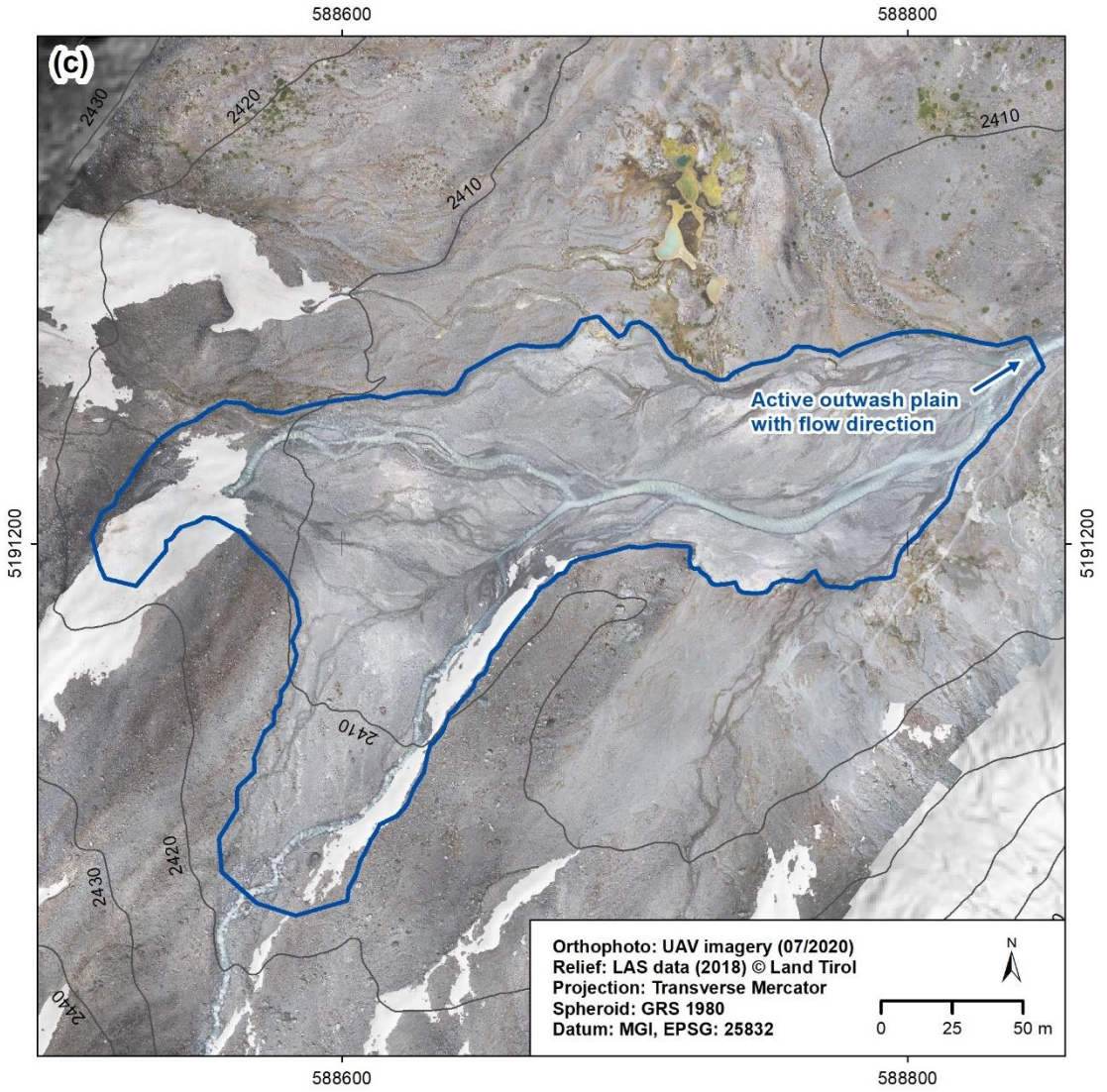
STUDY SITE

- **Jamtal valley, AT**

- Proglacial outwash plain
- Braided channel network
- Retreating debris covered glacier
- Area of re-deposition
- linking subglacial sediment yield with lower stream sections

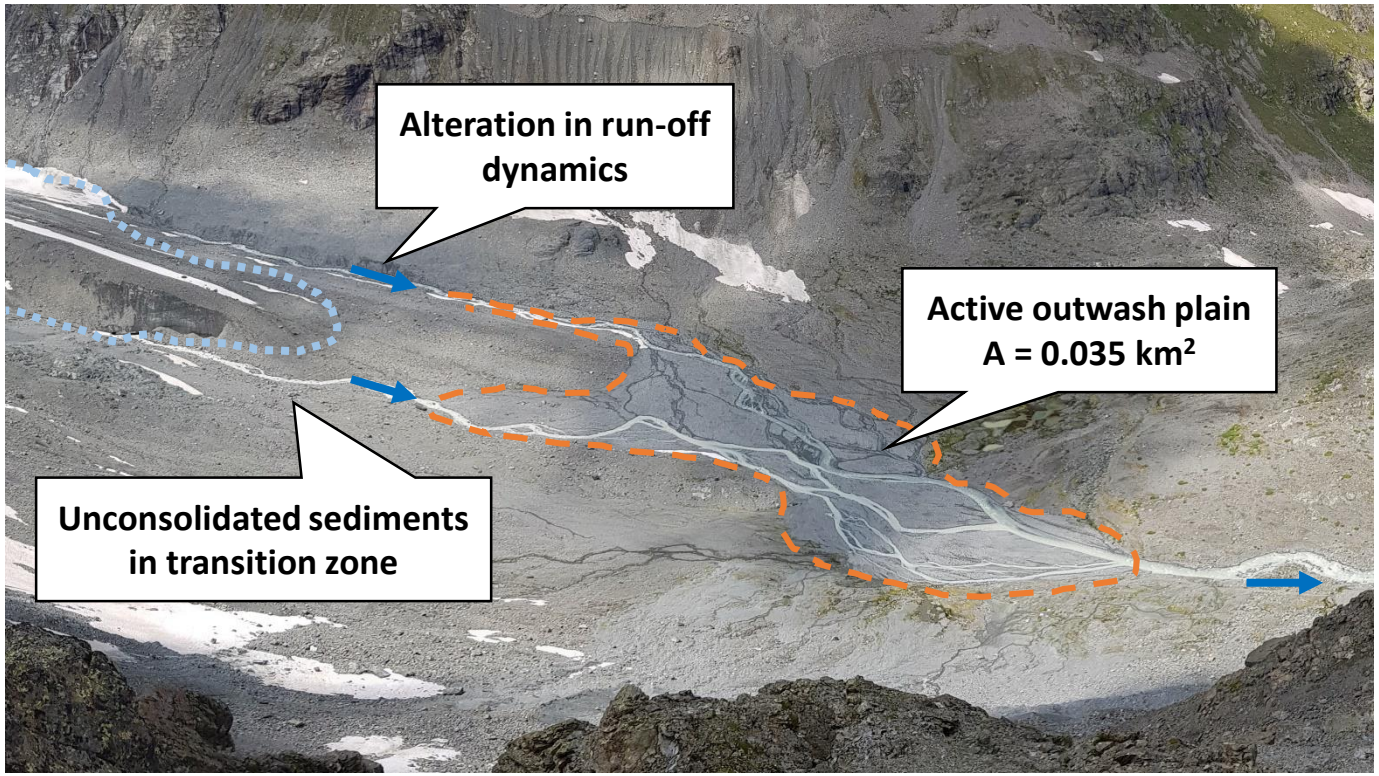






STUDY SITE

- **Jamtal valley, AT**



METHODS

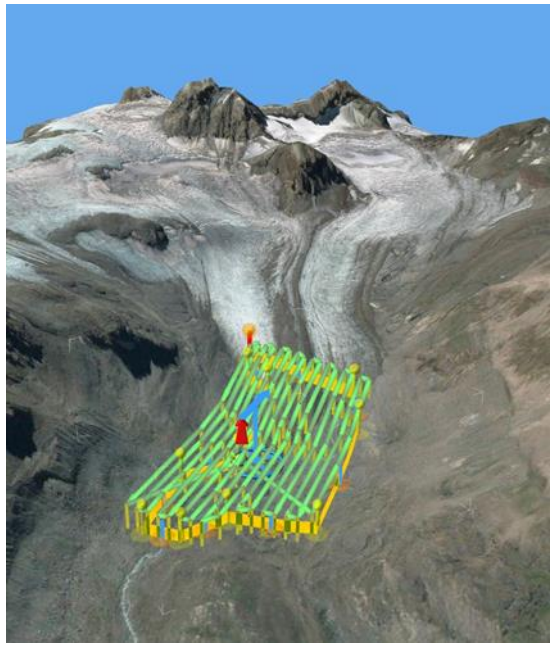
- **Approach based on terrestrial and UAV-based SfM-photogrammetry**
- **High-resolution topographical models are used to determine:**
  - **(i) Geometry of outwash plain** (channel width, inclination,..)
  - **(ii) Topographic surface roughness** (from dense point cloud)
  - **(iii) Surface sediment characteristics** … of the entire active outwash plain.

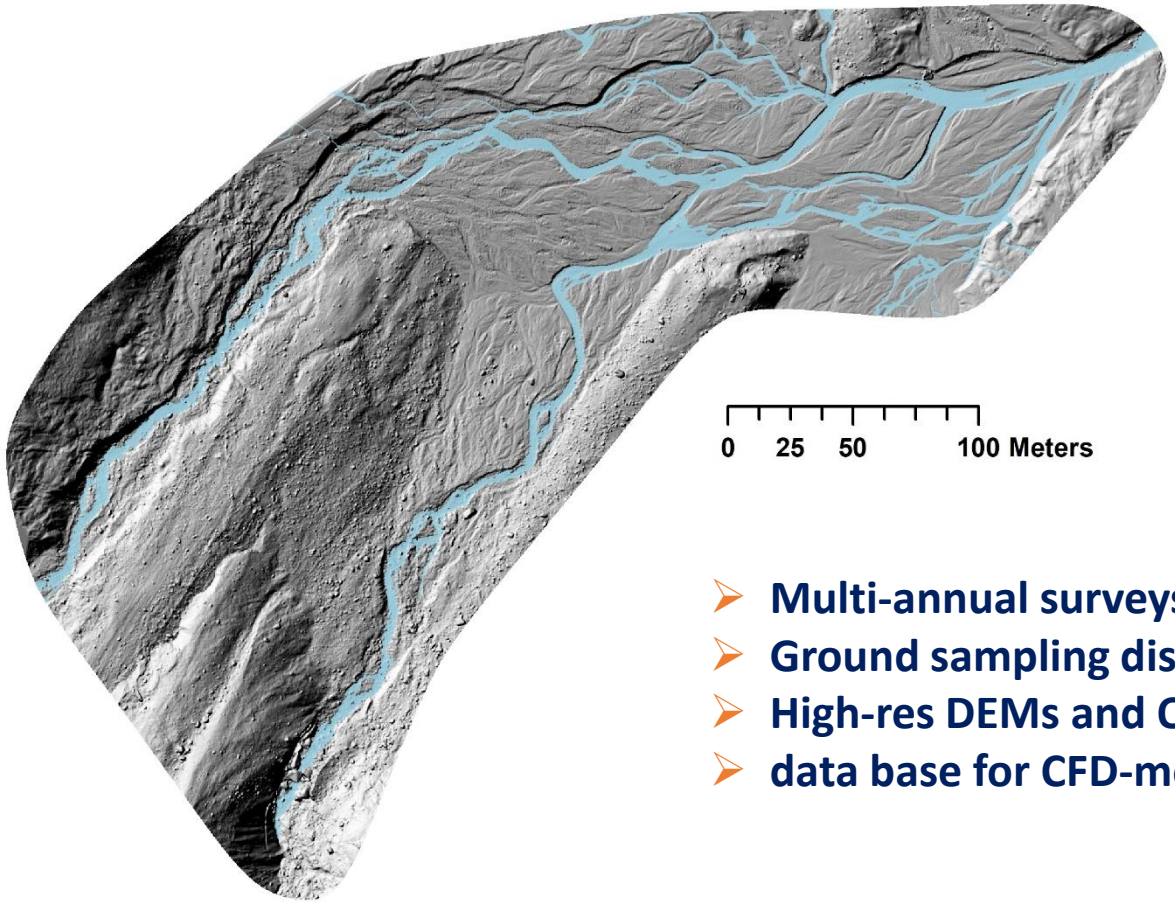
- **Concept builds on** (among others)**:**
  - **Detert et al., 2018**: On the way to airborne gravelometry based on 3D spatial data derived from images
  - **Pearson et al., 2017**: Can high resolution 3D topographic surveys provide reliable grain size estimates in gravel bed rivers?
  - **Vázquez-Tarrío et al., 2016**: Using UAS optical imagery and SfM photogrammetry to characterize the surface grain size of gravel bars in a braided river

- **Also considered:**
  - **Marchetti et al., 2021** (using SENTINEL 2 satellite)
  - **Chardon et al., 2020** (using LiDAR)

METHODS

(i) Geometry of outwash plain

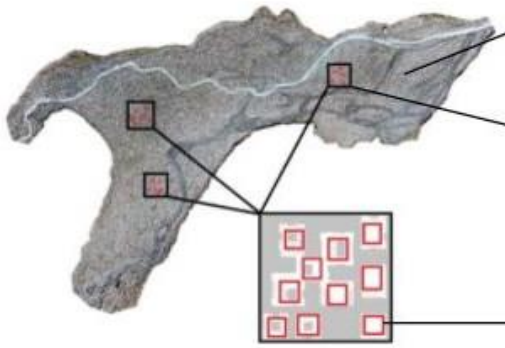




- **Multi-annual surveys**
- **Ground sampling distance < 2.5 cm**
- **High-res DEMs and Orthophotos**
- **data base for CFD-mesh, DoDs …**

METHODS

(ii) Topographic surface roughness
(iii) Surface sediment characteristics



- study area (A = 0.035km²)
  - UAV-flight-height = 50 m
  - approx.: 900 photos
- 3x100m² field
  - UAV-flight-height = 5 m
  - 300-400 photos
- 30x1m² patch
  - Handheld Camera = 1-2 m
  - 30-50 photos

→ Georeferenced SFM point clouds with different densities

Agisoft Metashape

1. Surface Sampling (grid/areal)
2. Orthophoto for photosieving

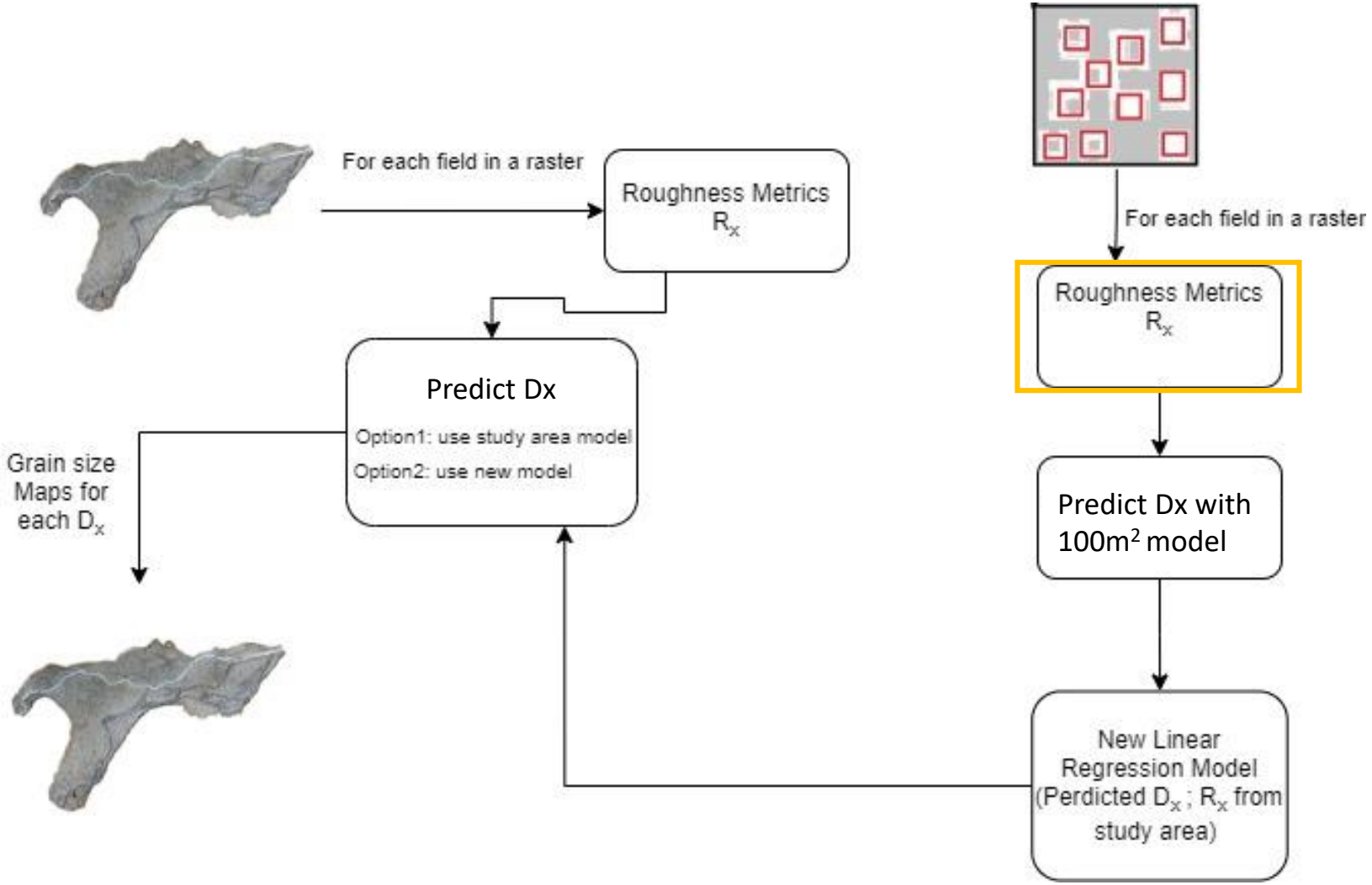
→ 16th, 25th, 30th, 50th, 75th, 84th, 90th, 95th percentile of the cumulative frequency Dx

Grid sampling after **Bunte & Abt, 2001**

METHODS

(ii) Topographic surface roughness
(iii) Surface sediment characteristics

- **Surface roughness**
- Best fit plane
- Method of least squares
- Scale dependent kernel size

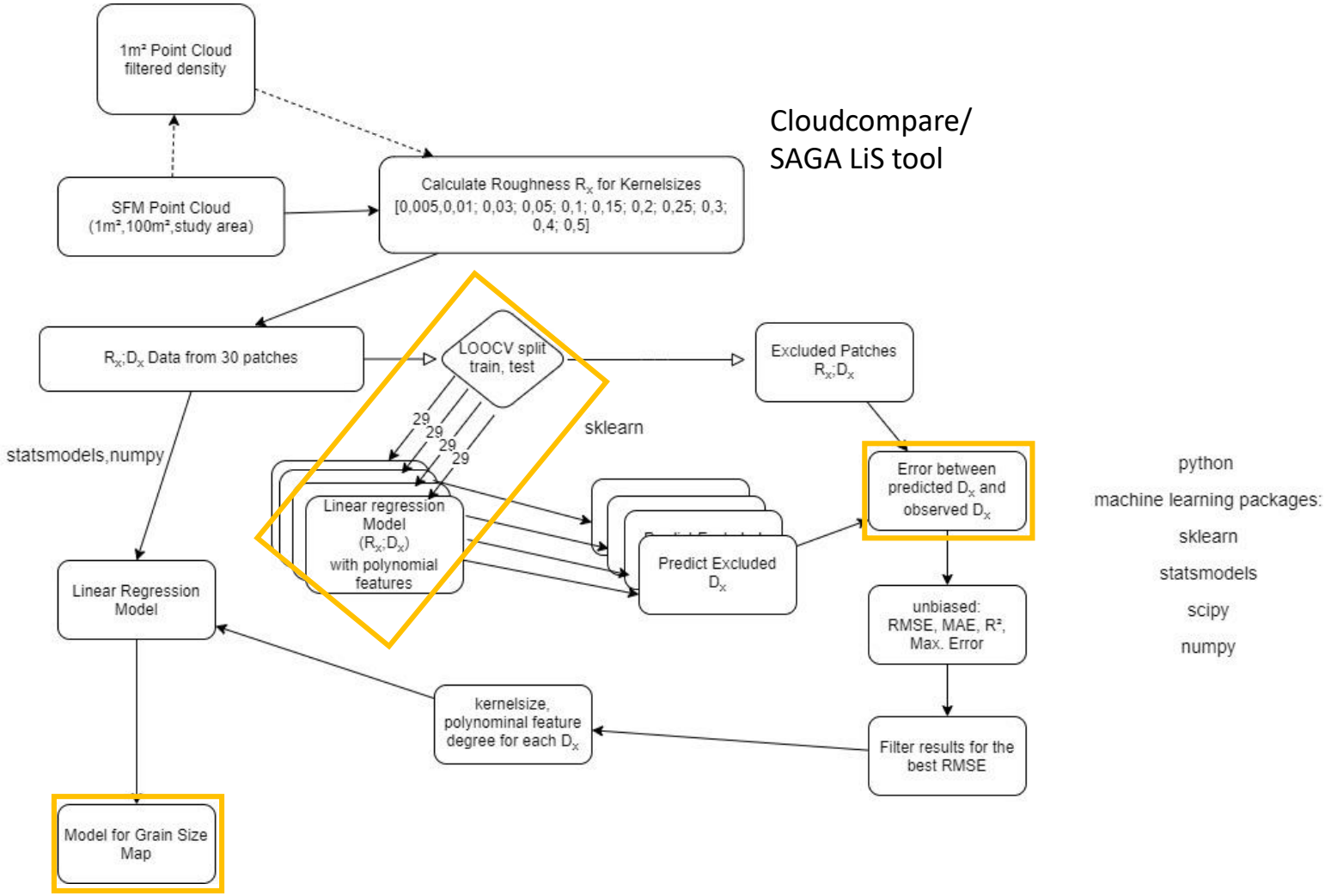


METHODS

(ii) Topographic surface roughness
(iii) Surface sediment characteristics

- **Model training**
- Leave-one-out cross validation
- Linear regression Model
- Error estimation
  predicted Dx vs. observed Dx

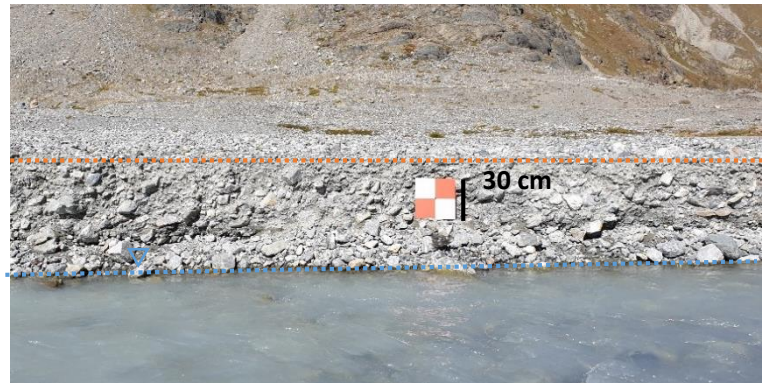
- **Goal: Grain size map**



DISCUSSION

- **Methodological approach in trial / work in progress**

- First results from training python machine learning tools and statistal analysis are promising
- Smallest grain size classes are likely to be underestimated – correlation problematic due to small sampling size
- GSD percentile estimates **>D50 show robust correlations**
- **Sub**surface GSD remains unknown – estimation needed



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THANK YOU FOR YOUR INTEREST!

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DISCUSSION

Dx	Kernelsize	Number of Patches	Polyn. feature degree	Mean diameter	RMSE	mean absolute error	Max. error	Unbiased R^2(test vs. perdicted)	R^2 (Final Model)	P-Value
16	0,20	5	1	21,58	5,56	5,14	7,24	-24,07	49,61	0,184
25	0,10	16	1	21,10	6,20	4,63	14,45	29,33	44,85	0,005
30	0,10	22	2	21,98	4,96	3,39	16,85	60,06	62,62	0,000
50	0,10	27	1	33,66	12,01	7,03	49,94	54,30	65,11	0,000
75	0,10	30	2	53,20	16,34	9,75	60,62	67,31	81,28	0,000
84	0,15	30	2	67,40	17,10	12,45	49,86	75,78	84,73	0,000
90	0,15	30	2	80,46	19,85	14,57	55,58	75,50	83,16	0,000
95	0,25	30	2	101,04	21,57	17,12	53,19	80,95	82,96	0,000
median	0,15	30	1	37,31	7,40	5,03	24,55	73,40	82,72	0,000