4th European Regional Conference of IAEG

EUROENGEO 2024

Correlations between JRC and statistical roughness parameters

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Engineering Geology and Geotechnics: Building for the Future

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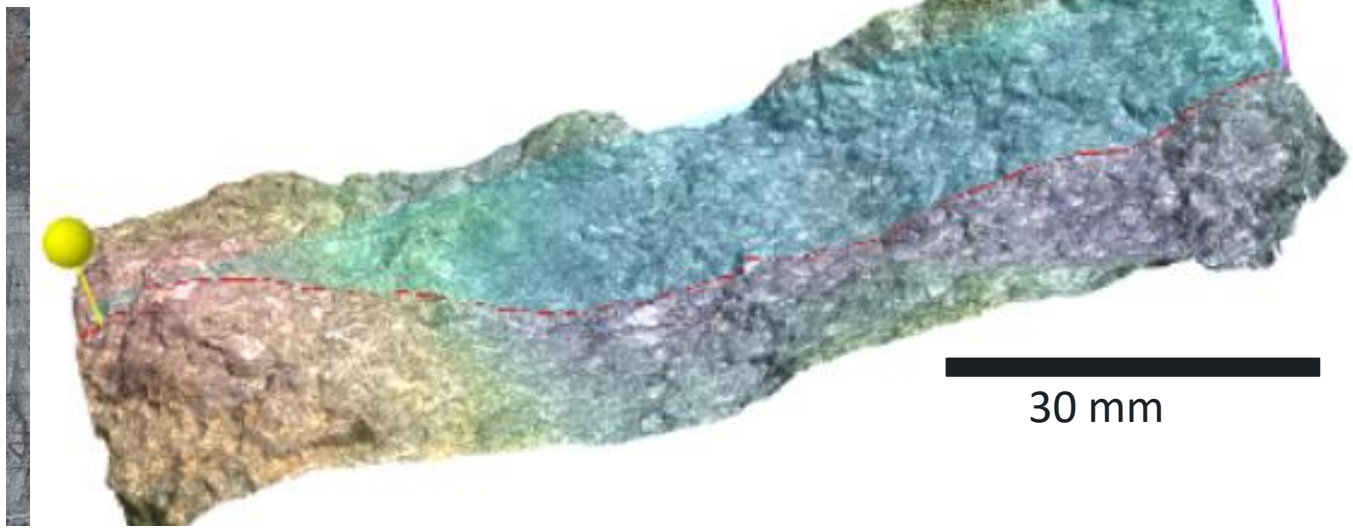
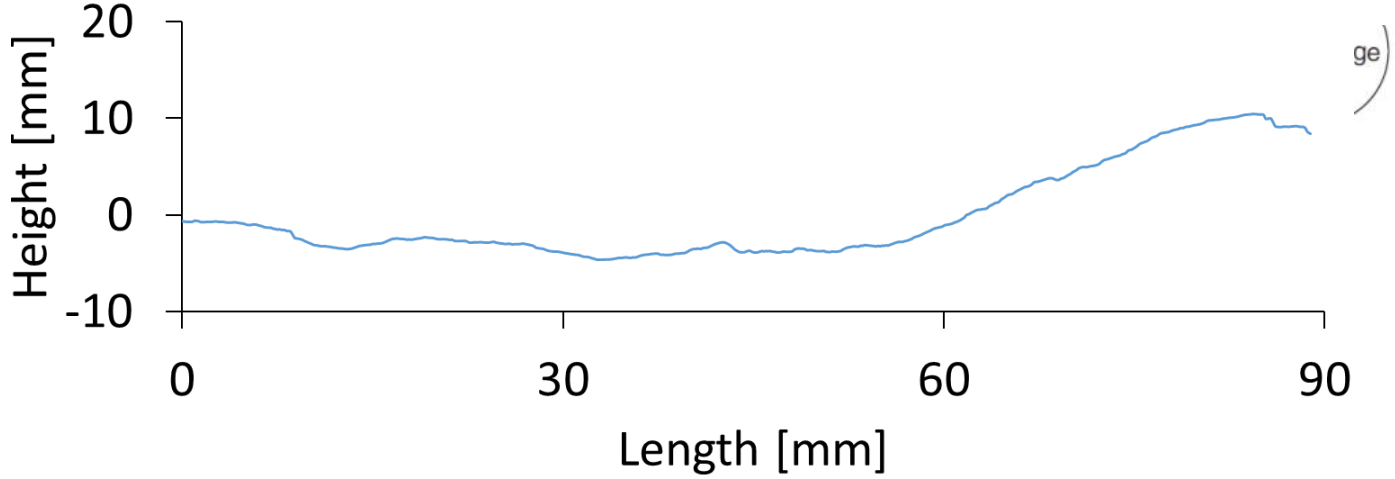
Introduction

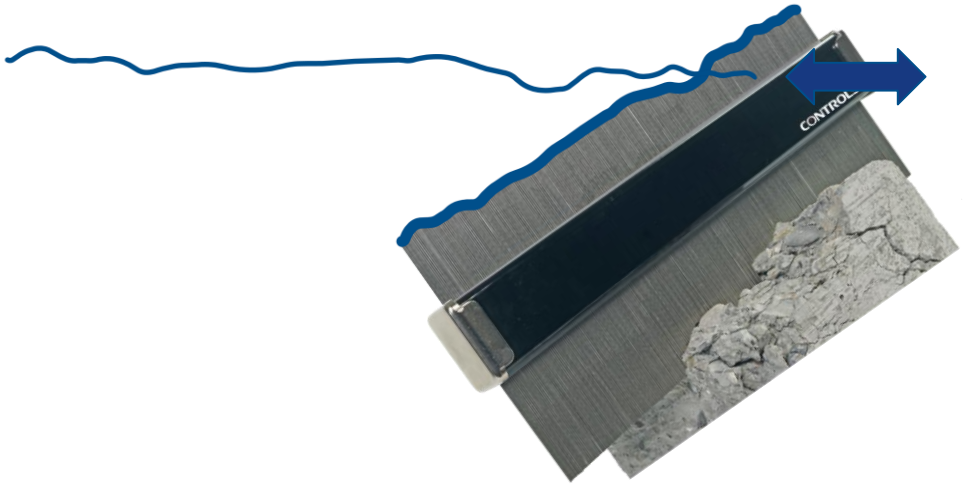
- Heterogeneous & anisotropic media
- Focus on roughness

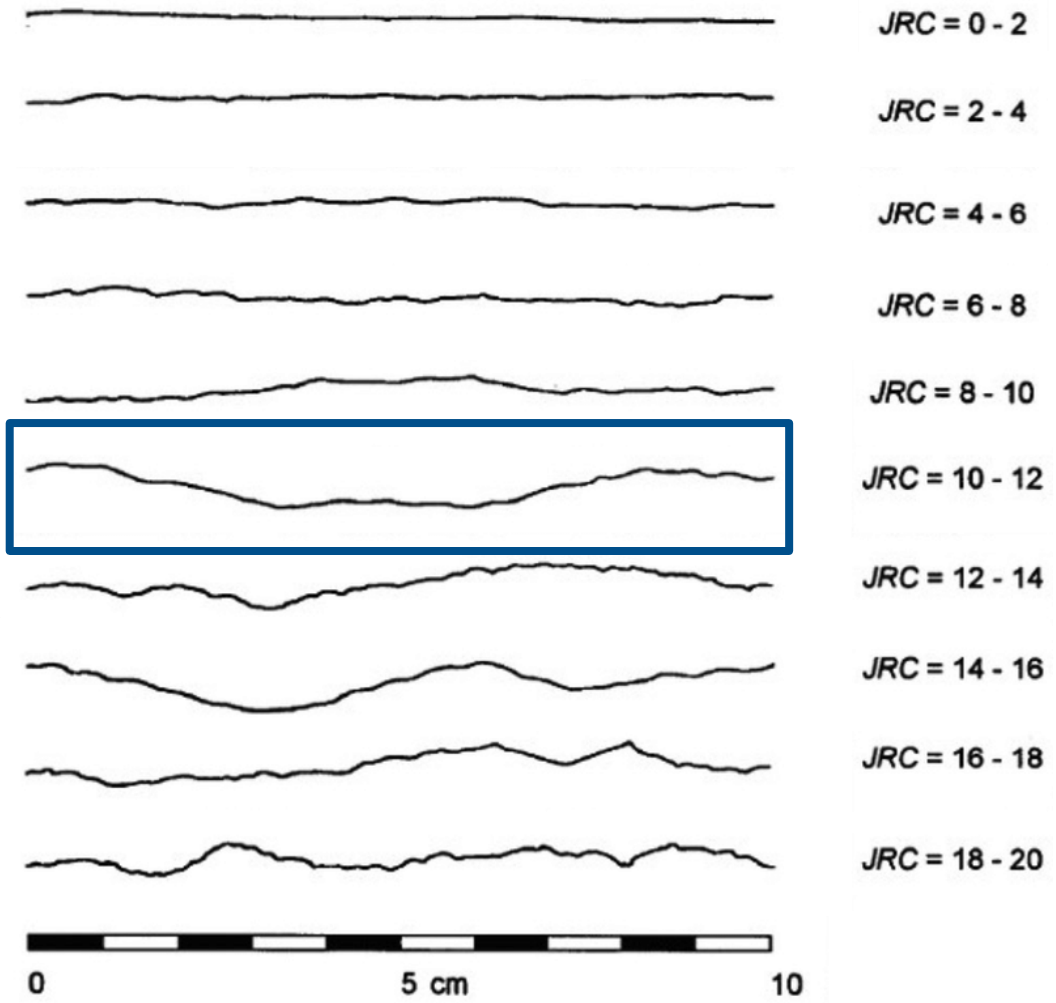




Issues of roughness estimation

- **Barton & Choubey (1977) methodology**
  - Use of profile comb
  - Visual assessment





The most common statistical estimators

- **Root mean square slope**

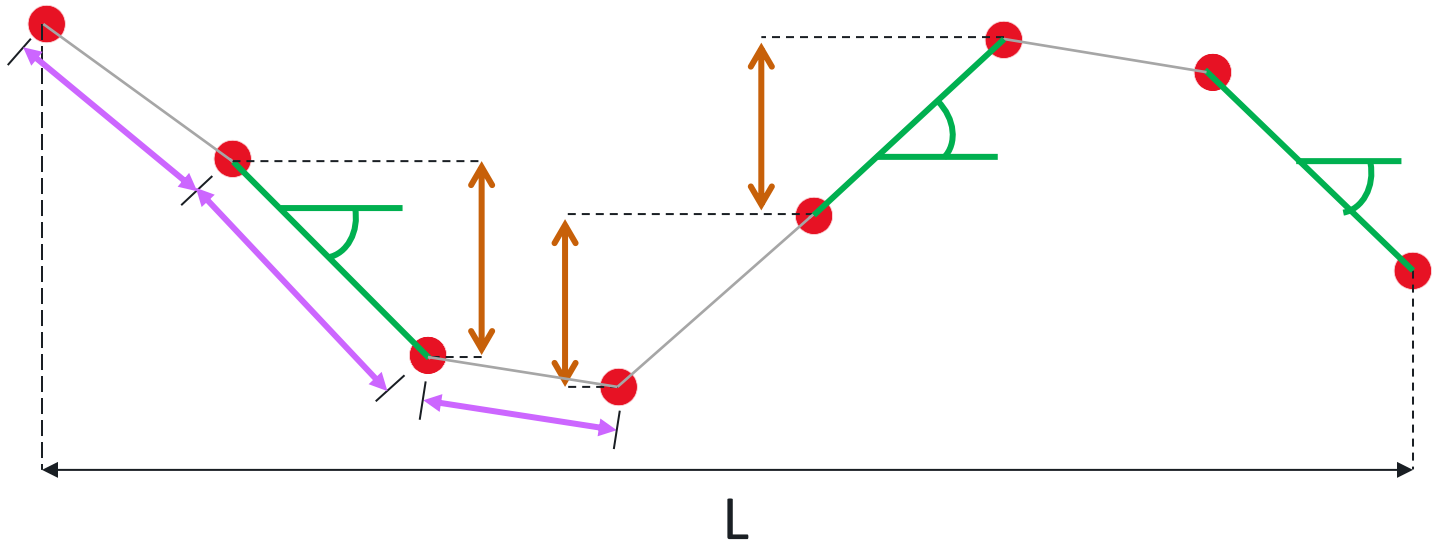
$$Z_2 = \left[\frac{1}{L}\int_0^L \left(\frac{dz}{dx}\right)^2 dx\right]^{1/2}$$

- **Structure function**

$$SF = \frac{1}{L}\int_0^L [z(x_{i+1}) - z(x_i)]^2 dx$$

- **Roughness profile index**

$$R_P = \frac{\sum_{i=1}^{N-1}\left[(z_{i+1} - z_i)^2 - (x_{i+1} - x_i)^2\right]^{1/2}}{L}$$



Some authors tried to digitize standard profiles

Autors	Digitizing method	Sampling interval [mm]
Tse & Cruden (1979)	Profile enlarged 2.5 x	1.27
Maerz and al. (1990)	Shadow profilometry	**0.50**
Yu & Vayssade (1991)	Philips digital A3 plotter Profile enlarged 2.4 x	0.25 – **0.50** – 1.00
Tatone & Grasselli (2010)	AutoCAD (1 200 dpi)	**0.50** – 1.00
Jang et al. (2014)	Origine software (1 200 dpi)	**0.50**

Our methodology

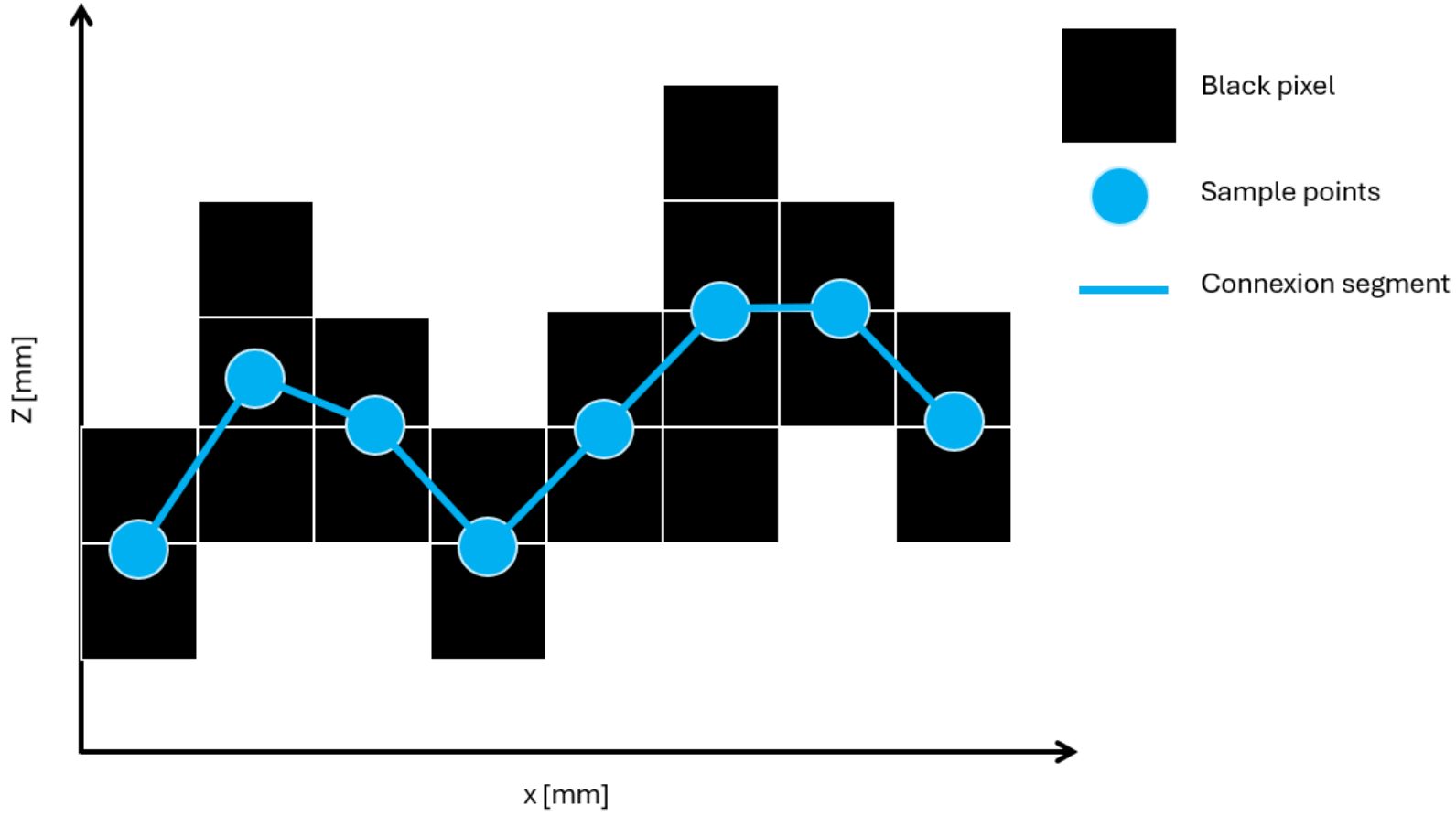
First

- **Profiles scanning**
  - **pixel size of 0.227 mm**

Our methodology

First

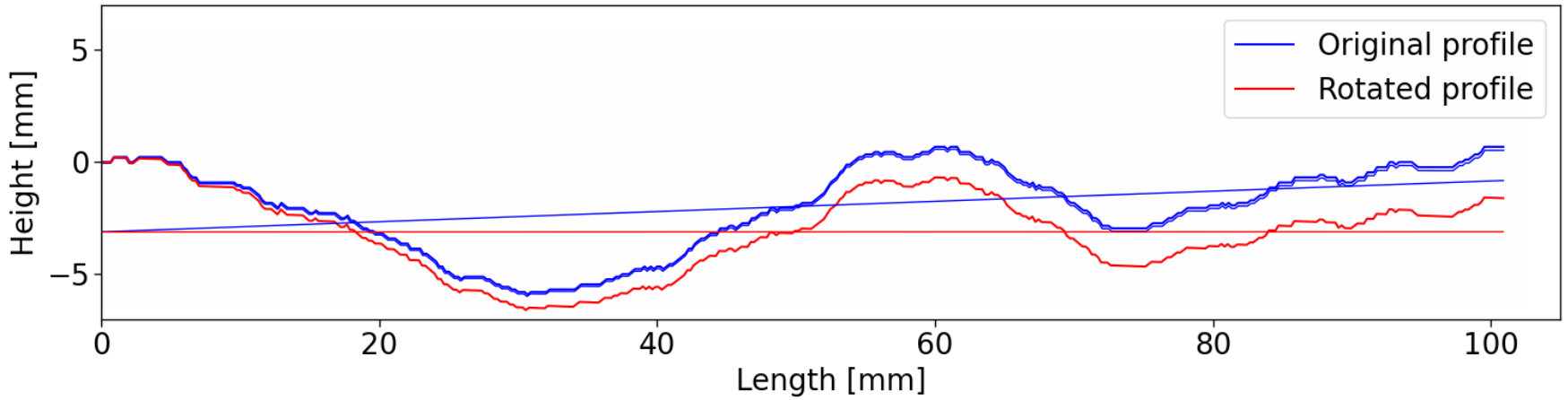
- Profiles scanning
- Digitization on Python
  - X → black pixel center
  - Z → median of black pixels for x position
  - Hypothesis of linear link



Our methodology

First

- Profiles scanning
- Digitization on Python
  - X → black pixel center
  - Z → median of black pixels for x position
  - Hypothesis of linear link
  - Profile rotation



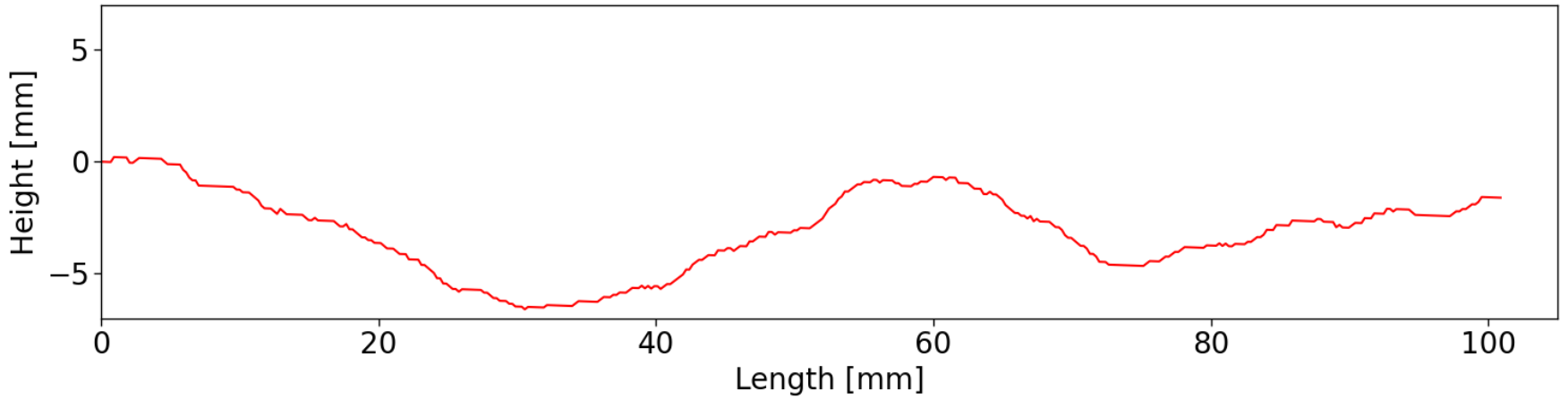
Our methodology

First

- Profiles scanning
- Digitization on Python
  - X → black pixel center
  - Z → median of black pixels for x position
  - Hypothesis of linear link
  - Profile rotation

Scan

Digitized



Our methodology

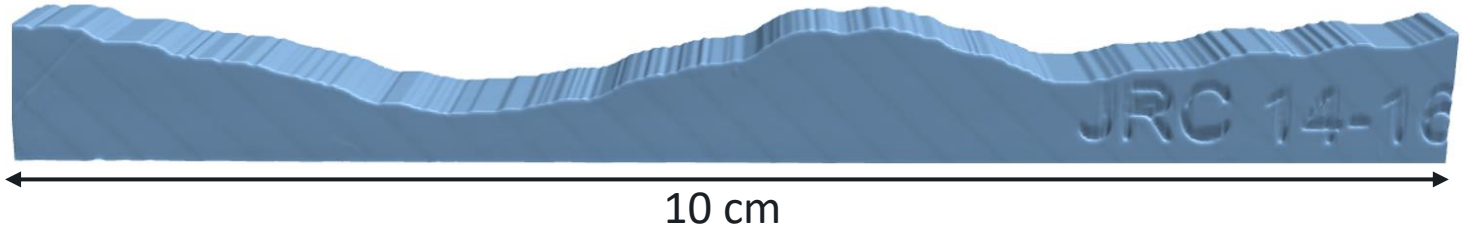
First

- Profiles scanning
- Digitization on Python

Second

- Printing with Elegoo Mars 3
  - Thermoplastic resin
  - Resolution of 10 µm in z,

    0.035 µm in x,y



Our methodology

First

- Profiles scanning
- Digitization on Python

Second

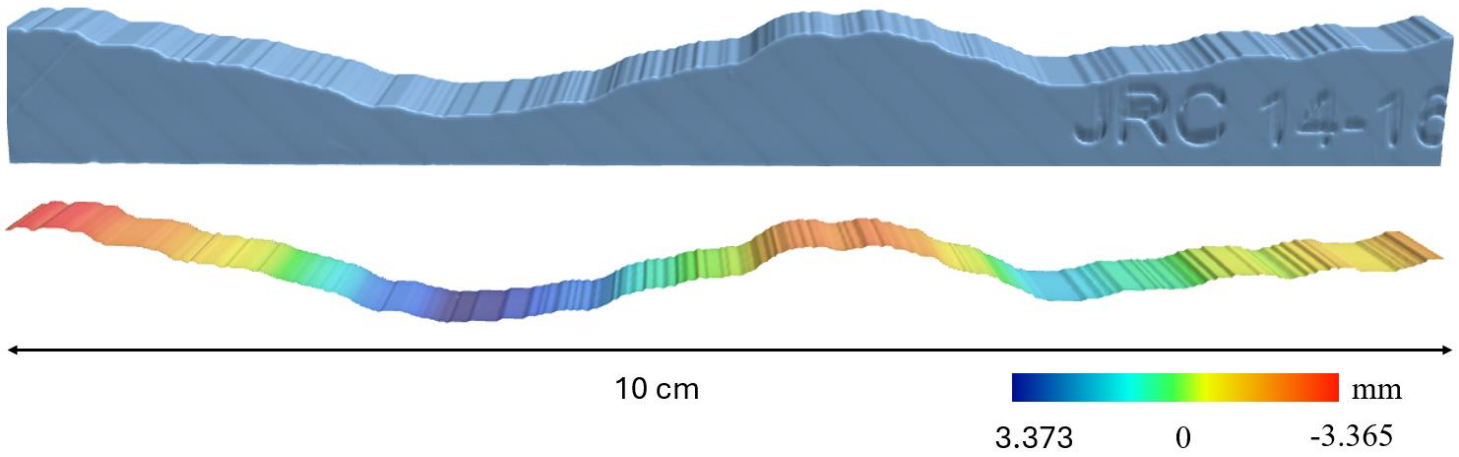
- Printing with Elegoo Mars 3
- Optical profilometry

with Keyence VR-6200

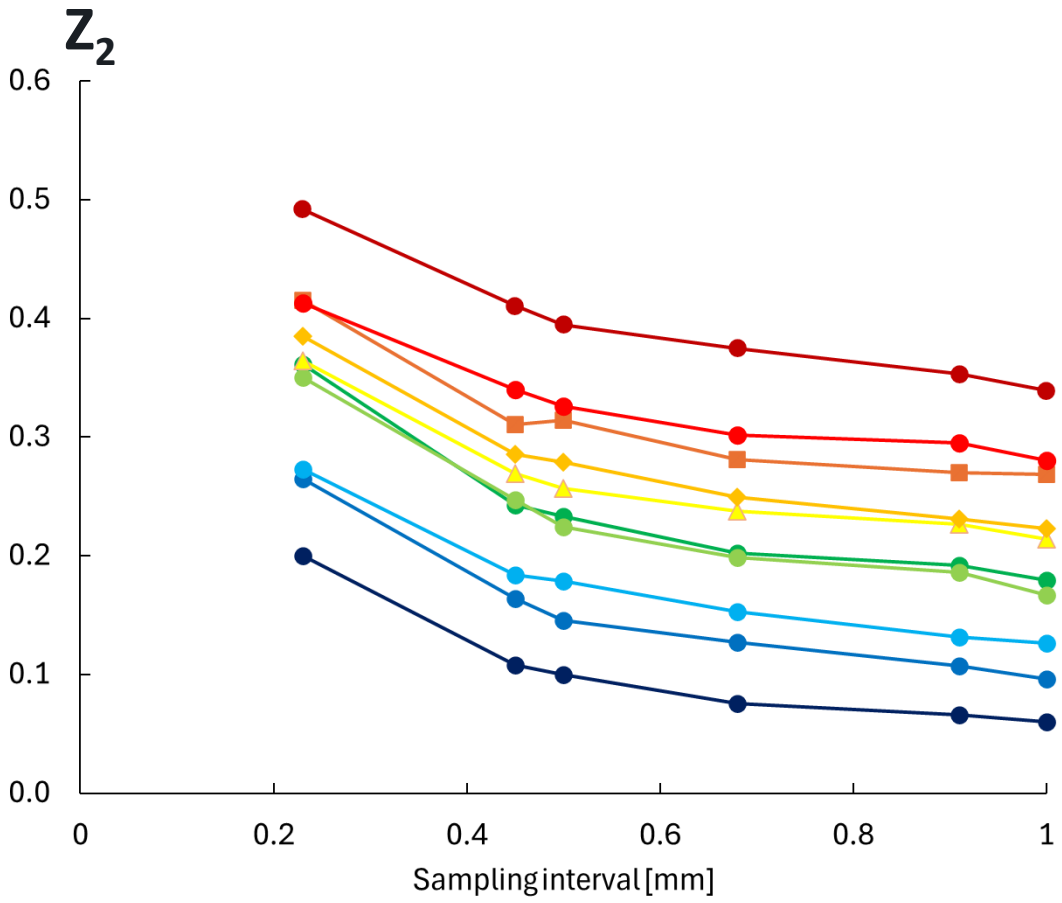
- Resolution of ± 4 µm in z

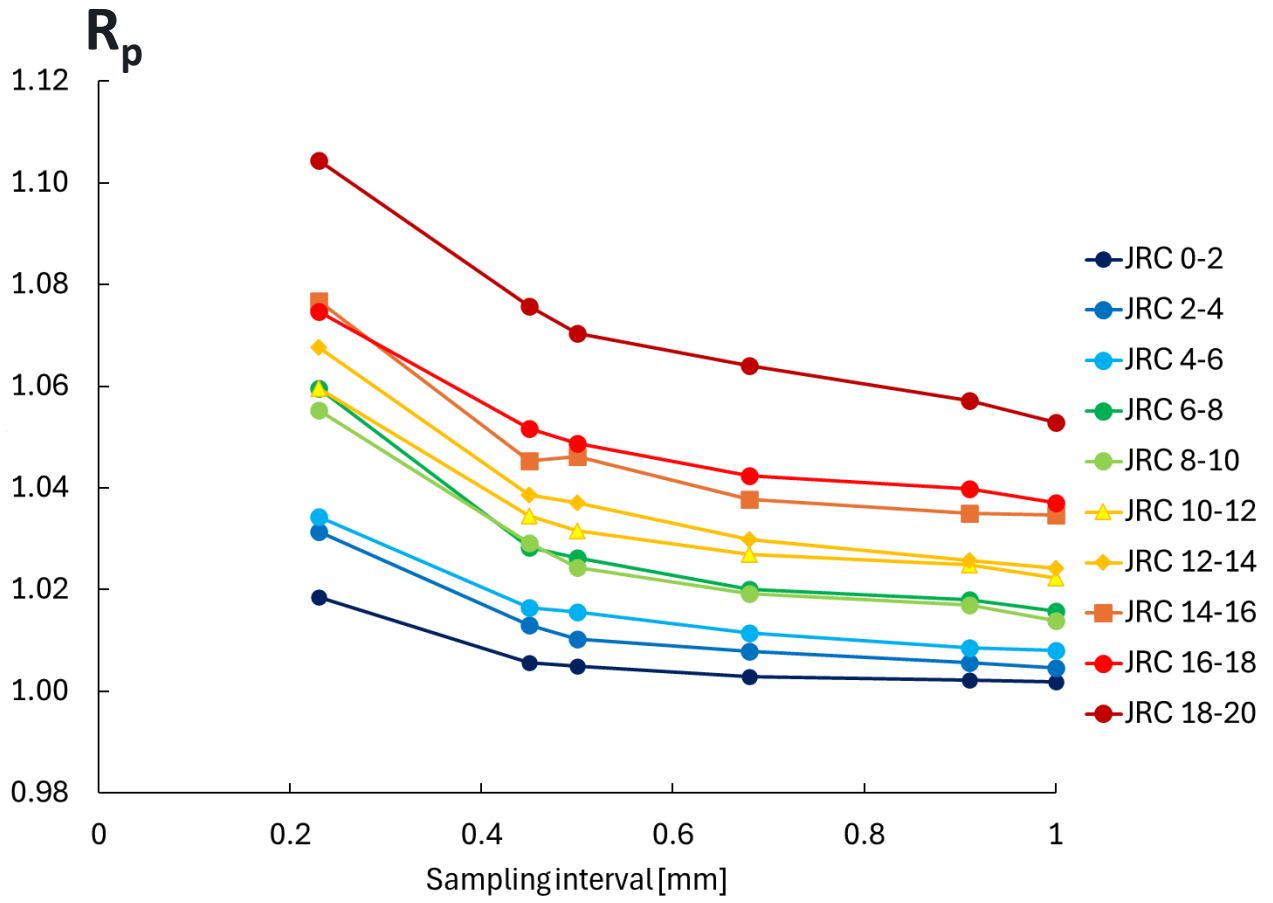
and ±5 µm in x, y

- Stylus simulation

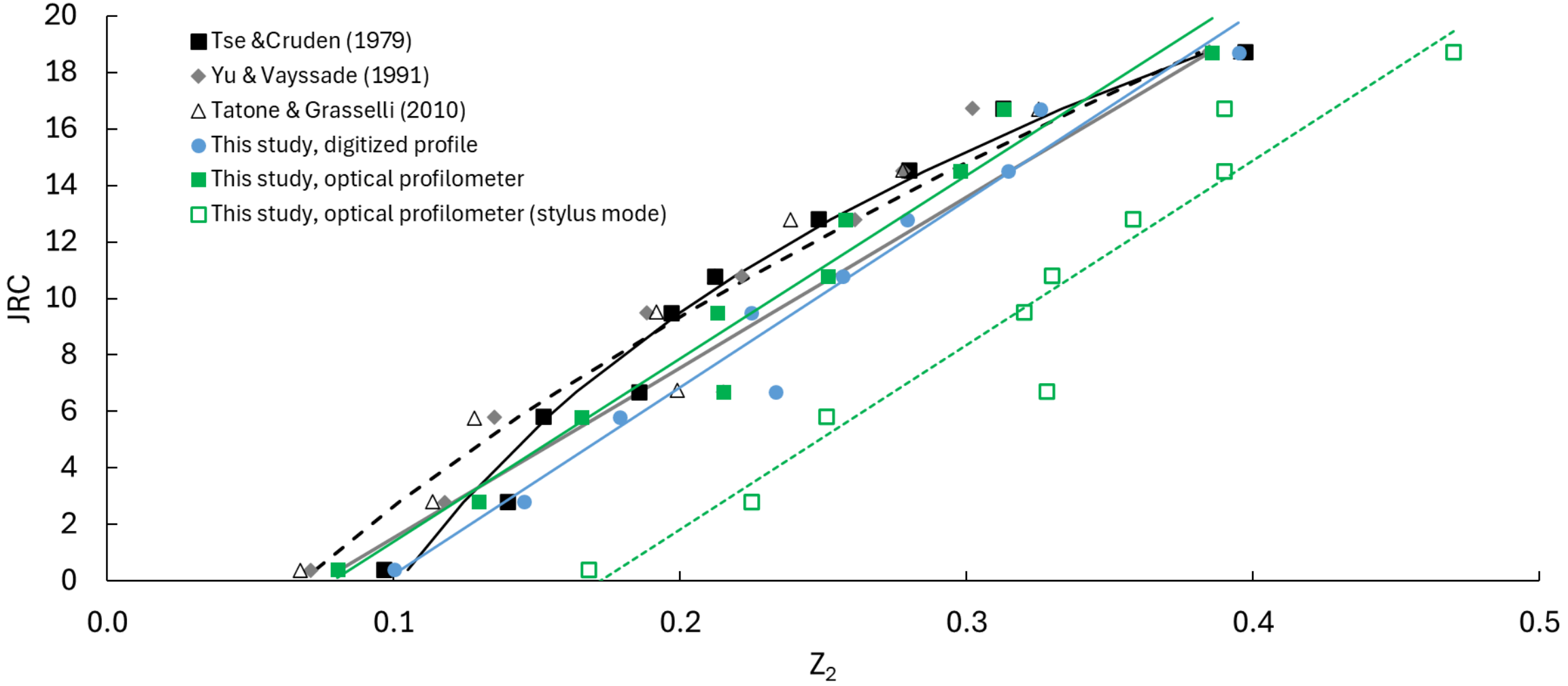


Roughness estimators depend on sampling intervals

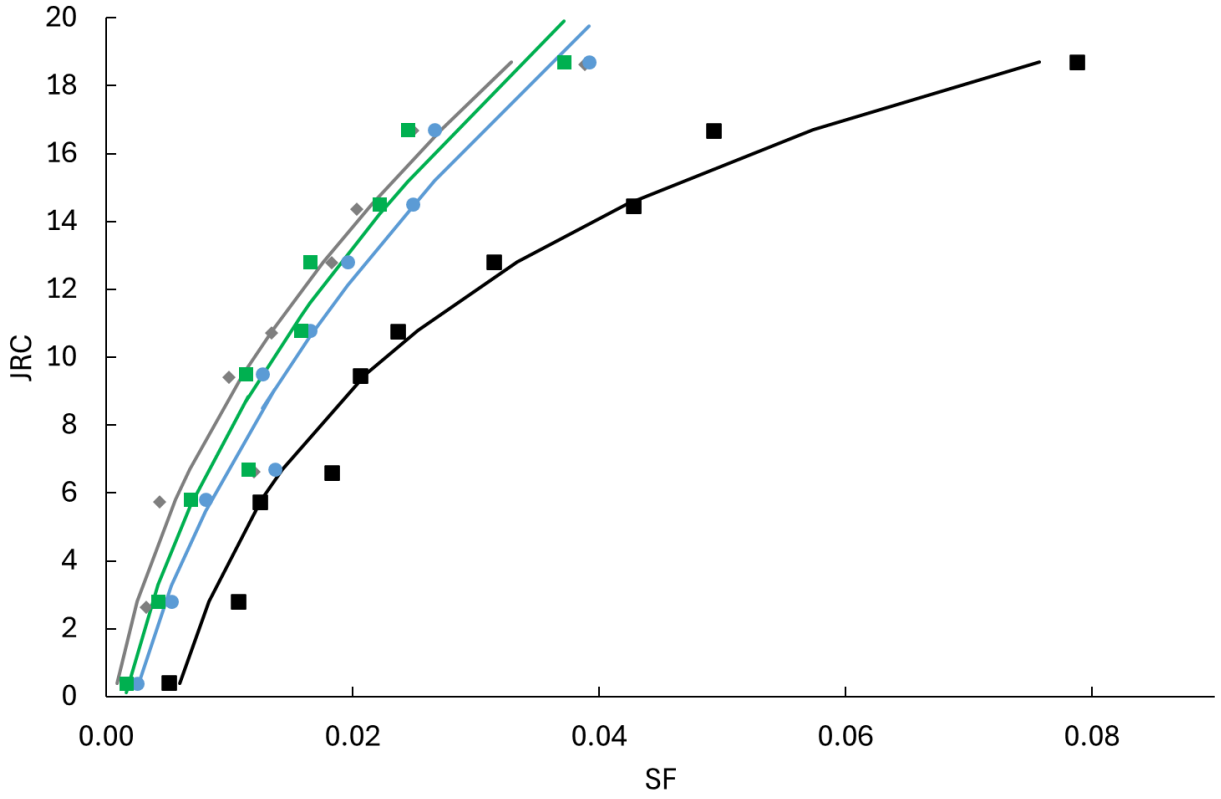


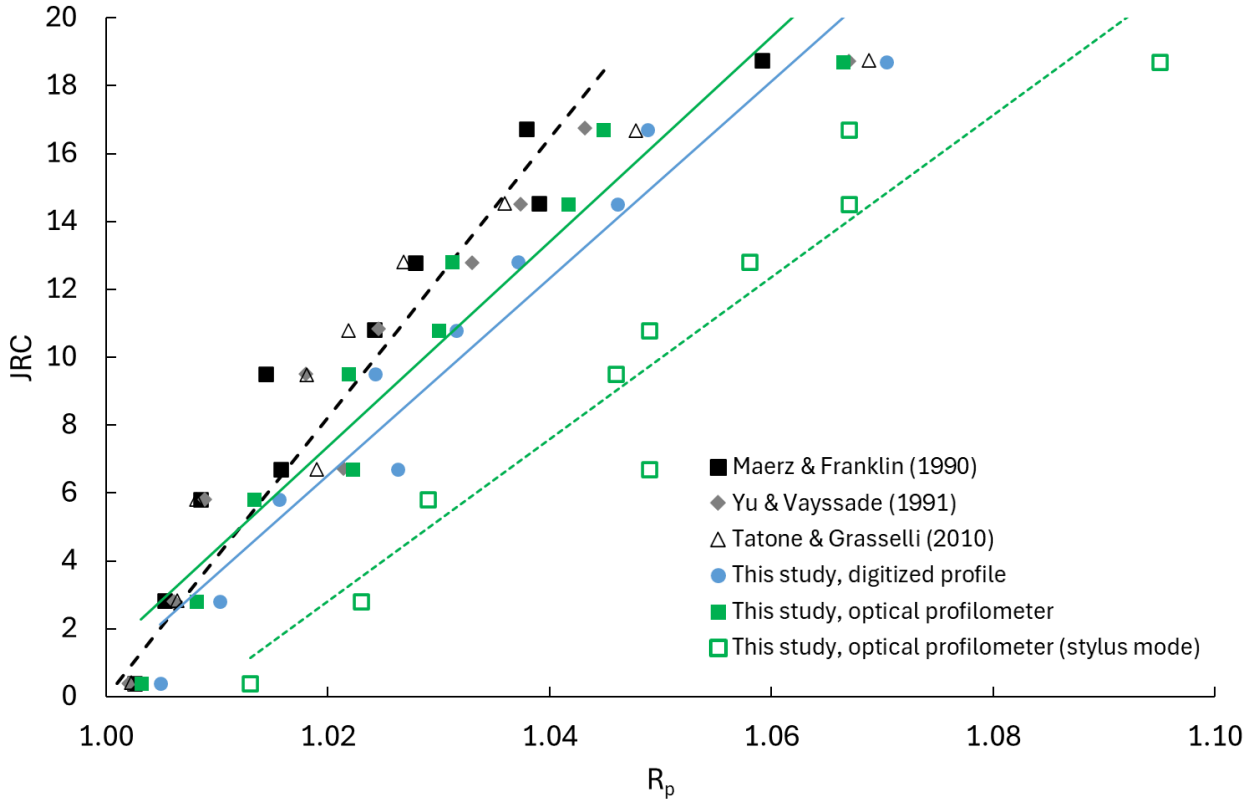


Statistical estimators analysis for SI 0.5mm

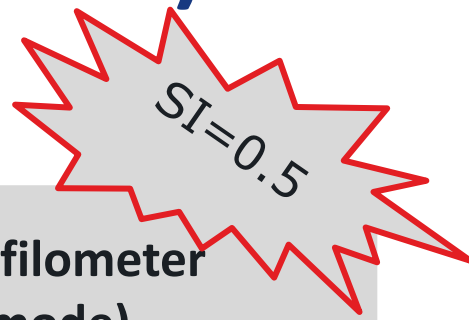


Statistical estimators analysis for SI 0.5mm





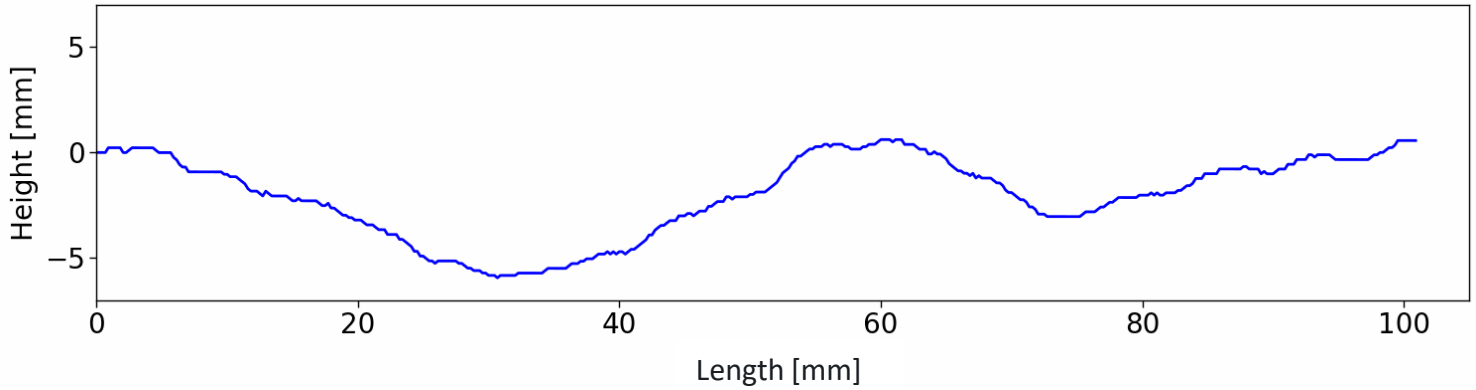
Z_2, SF and R_p correlate well with JRC (R^2 >0.90)

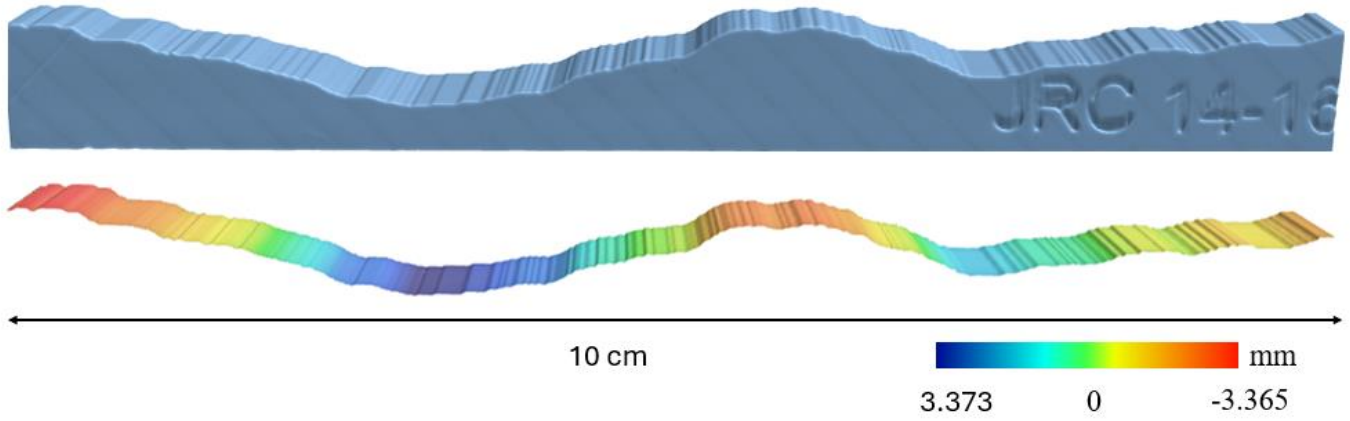


Digitized profiles	Optical profilometer	Optical profilometer (stylus mode)
$JRC = 66.20Z_2 - 6.38$	$JRC = 64.79Z_2 - 5.09$	$JRC = 65.25Z_2 - 11.21$
$JRC = 132.06\sqrt{SF} - 6.376$	$JRC = 129.59\sqrt{SF} - 5.091$	
$JRC = 290.7R_P - 290$	$JRC = 302.18\,R_P - 300.86$	$JRC = 238.6R_P - 240.57$

Conclusion

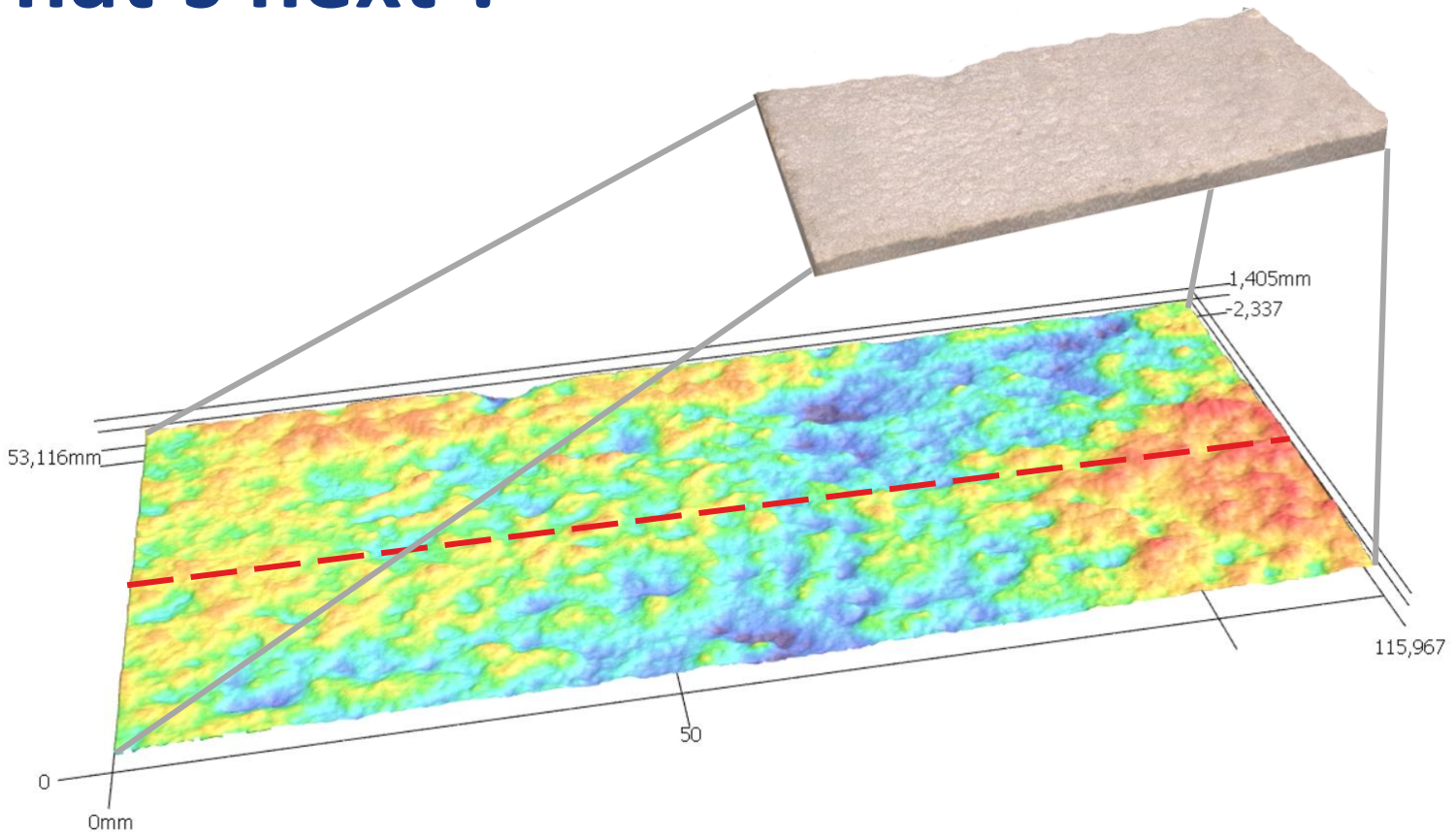
- Correlation between JRC and statistical estimators
- Digitization, printing and profilometry
- Z_2, R_P and SF correlate well with JRC
- Automation of roughness estimation in laboratory

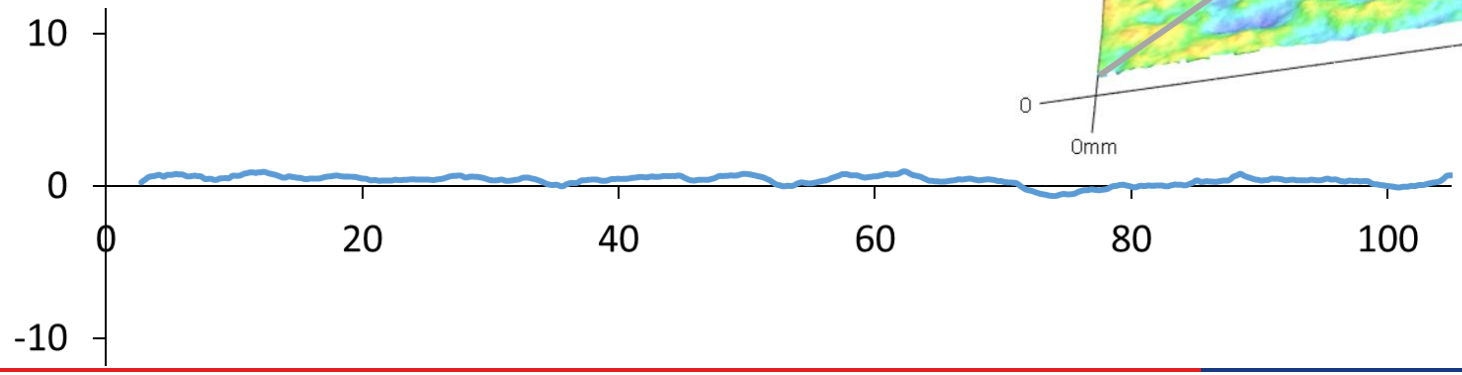




What's next ?

- **Optical profilometry**
  - $Z_2 = 0.2 \rightarrow JRC = 7.9 \approx 8$
  - $R_P = 1.022 \rightarrow JRC = 8$





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