Geomorphometry 2025 Perugia

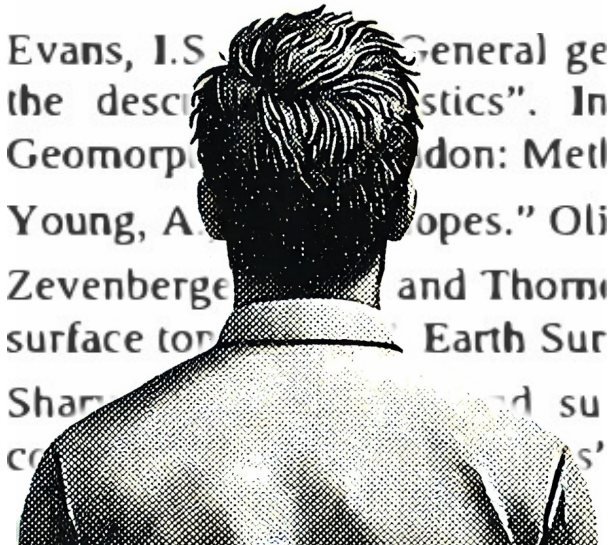
New Tool

for Calculating Land Surface Parameters

Richard Feciskanin

Veronika Hajdúchová

Yet another Land Surface Parameters calculator?



Motivation

- Third-order LSPs are rarely used
  - Lack of tool support
  - High computational complexity
- Most existing methods lack flexibility
  - Moving window size and shape
  - Grid shape (square or rectangular)
  - No-data handling
- Need for an efficient tool to compute advanced LSPs

Third-order LSPs

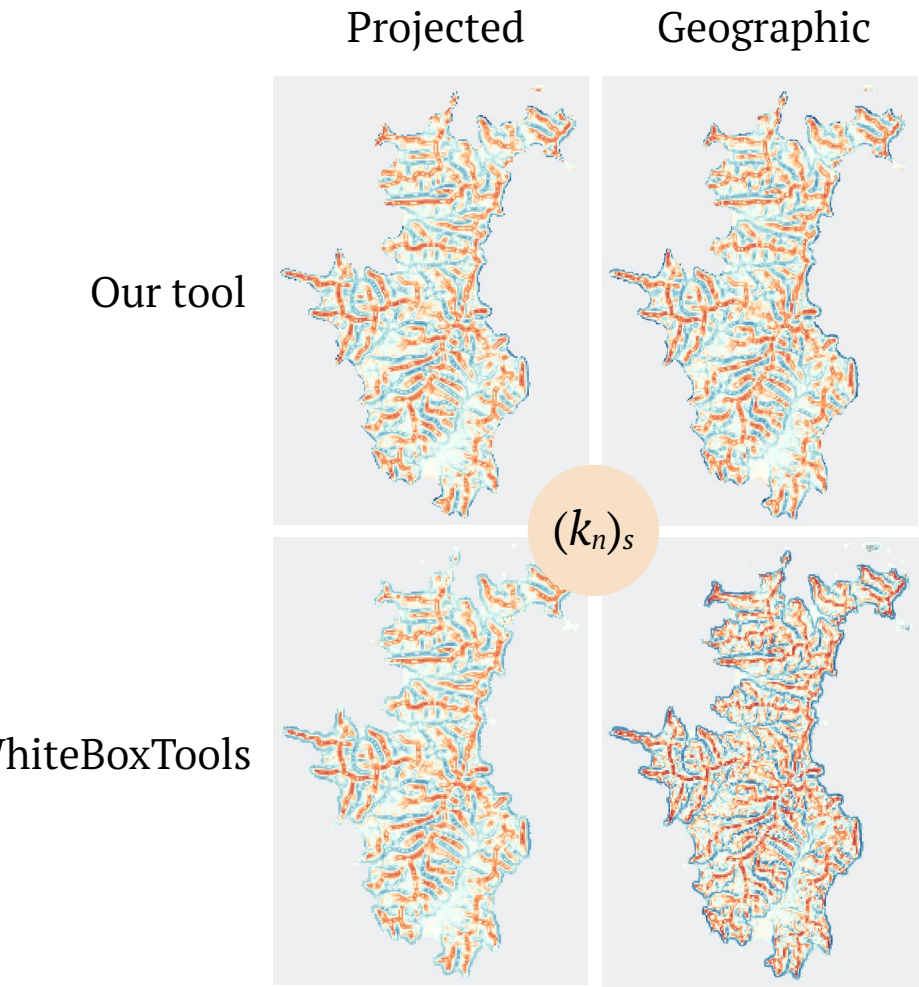
- Changes of curvatures
  - Required for physically based elementary segmentation
  - Physical interpretation
- Partial derivatives up to the third order are needed
  - Minimum required polynomial degree: 3
  - Third-degree bivariate polynomial has 10 coefficients
  - Requires a 5×5 moving window

Computing Partial Derivatives

- Polynomial least-squares fitting
  - Same approach as common methods (2nd degree Evans, 3rd degree Florinsky)
  - Does not use prepared formulas for direct derivative calculation from the grid
  - Uses a general method based on matrix operations instead
  - Uses a 5×5 moving window
- Various orders of polynomials
  - 3rd and 4th degrees supported
  - Higher orders risk of introducing artifacts (Runge's phenomenon)

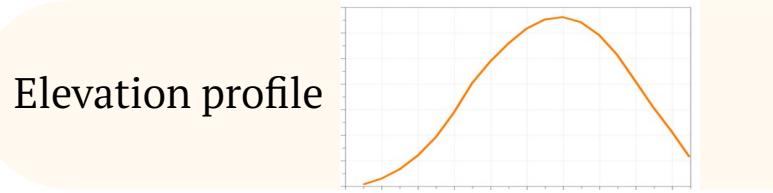
General Method Advantages

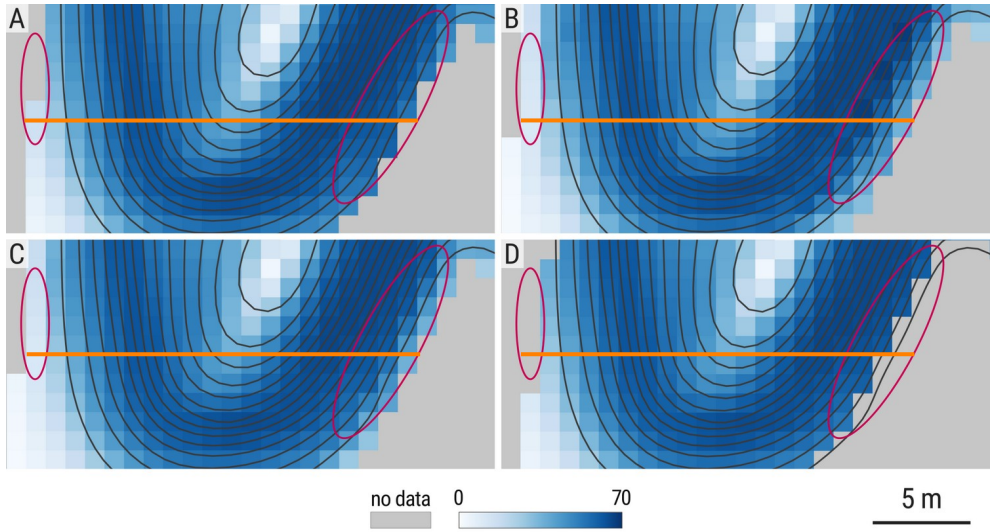
- Easily handles different dx, dy
  - For non-square grid
  - Geographic coordinates
- Same method used for both geographic and projected coordinates



General Method Advantages

- Full neighborhood not required
  - Only enough neighbors needed to fit the polynomial
- Calculations on edge
  - A – calculates correctly
  - B – artifacts, incorrect results
  - C – incorrect results
  - D – does not calculate

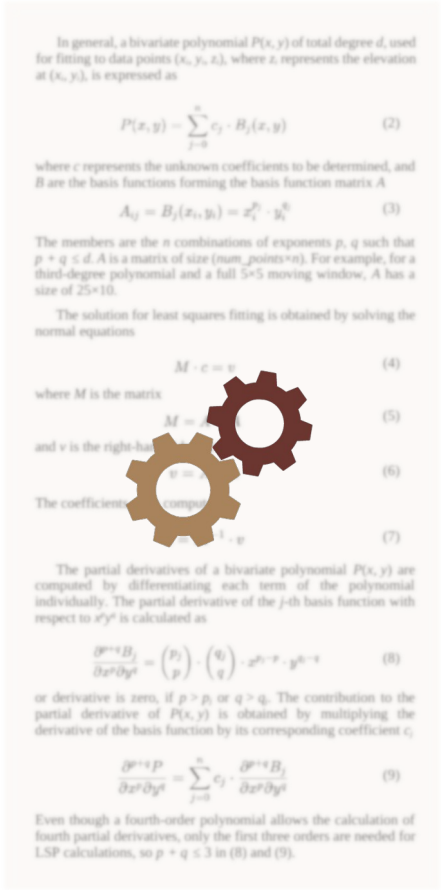




Slope: A – our tool, B – WhiteBoxTools,
C – GRASS GIS (-e), D – GRASS GIS

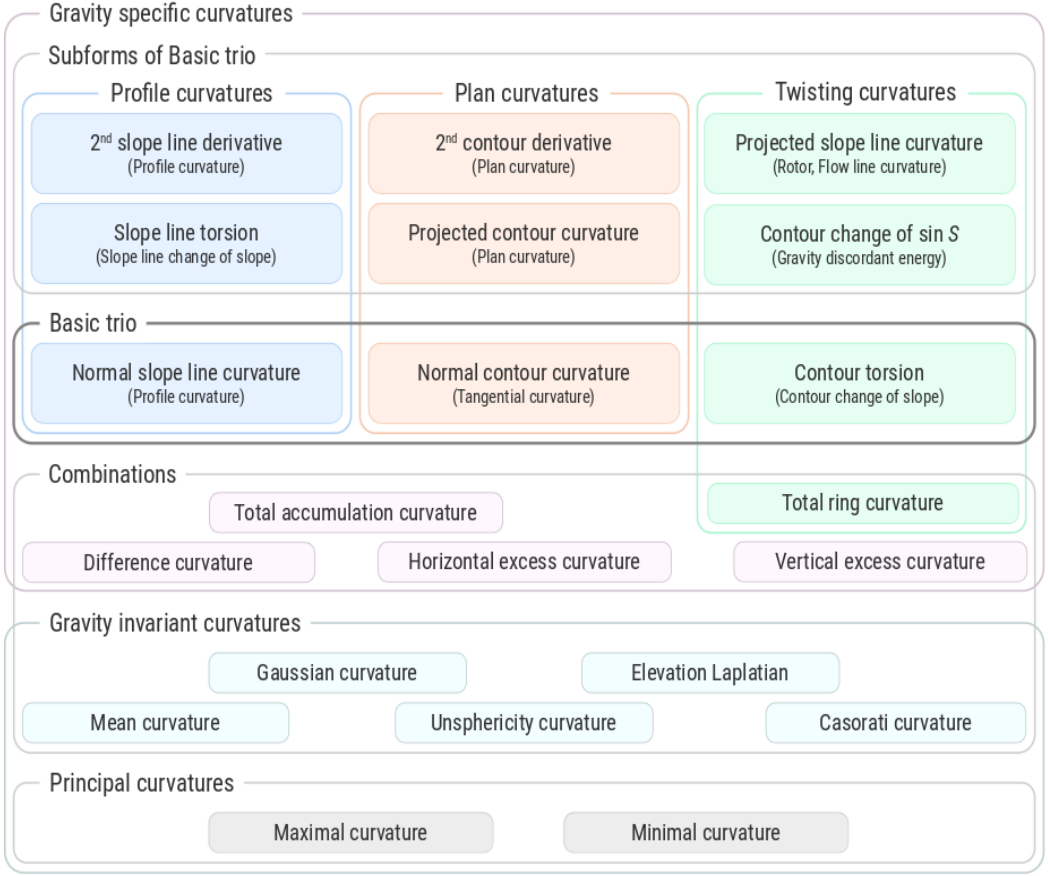
General Method Disadvantages

- Computational complexity
  - Coordinate powers
  - Matrix dot products
- Optimization is possible
  - Precalculation of matrices
  - Projected: once per grid, Geographic: once per row
  - Missing neighbors reduce its effectiveness



Land Surface Parameters

- Slope S, Aspect A
  - sin S, sin A, cos A
- Comprehensive set of curvatures:
- Changes of curvatures
  - contour change of normal contour curvature $(k_n)_{cc}$
  - slope line change of normal contour curvature $(k_n)_{cs}$
  - slope line change of normal slope line curvature $(k_n)_{ss}$



Implementation

LSP Calculator

- Command-line tool
- Rust programming language
- Parallelized calculations

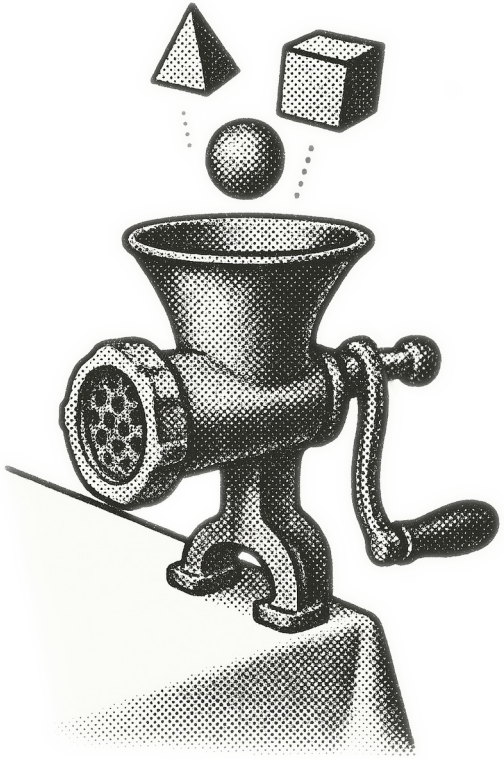
```
$ lsp_calculator --input-file dem.tif --output-prefix dem --degree 3 --all
```

- Github repository

  🔗 `https://github.com/xiceph/physical-geomorphometry-tools/tree/main/lsp-calculator`

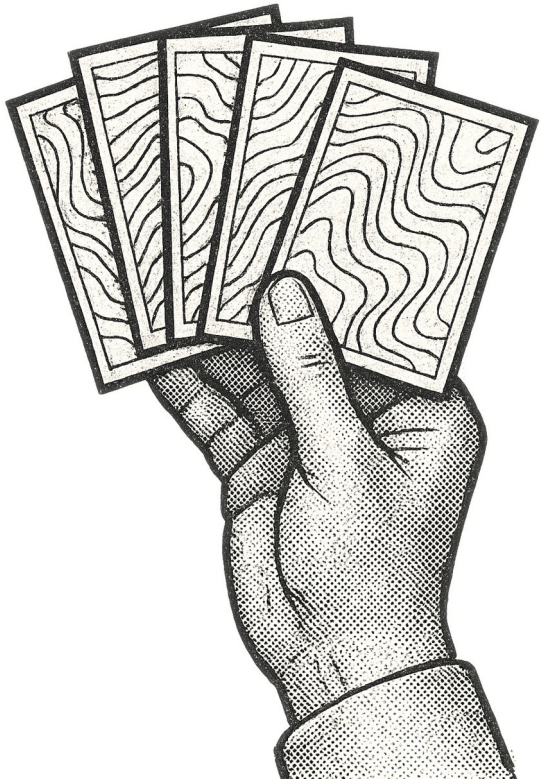
Inputs

- DEM Grid (GeoTIFF)
- Polynomial degree (3 or 4)
- Parameters selection
  - Individual selection
  - Batch selection
- Output name prefix
- Output only partial derivatives
  - Up to 3rd order
  - Fitted elevation output (0th order derivative)

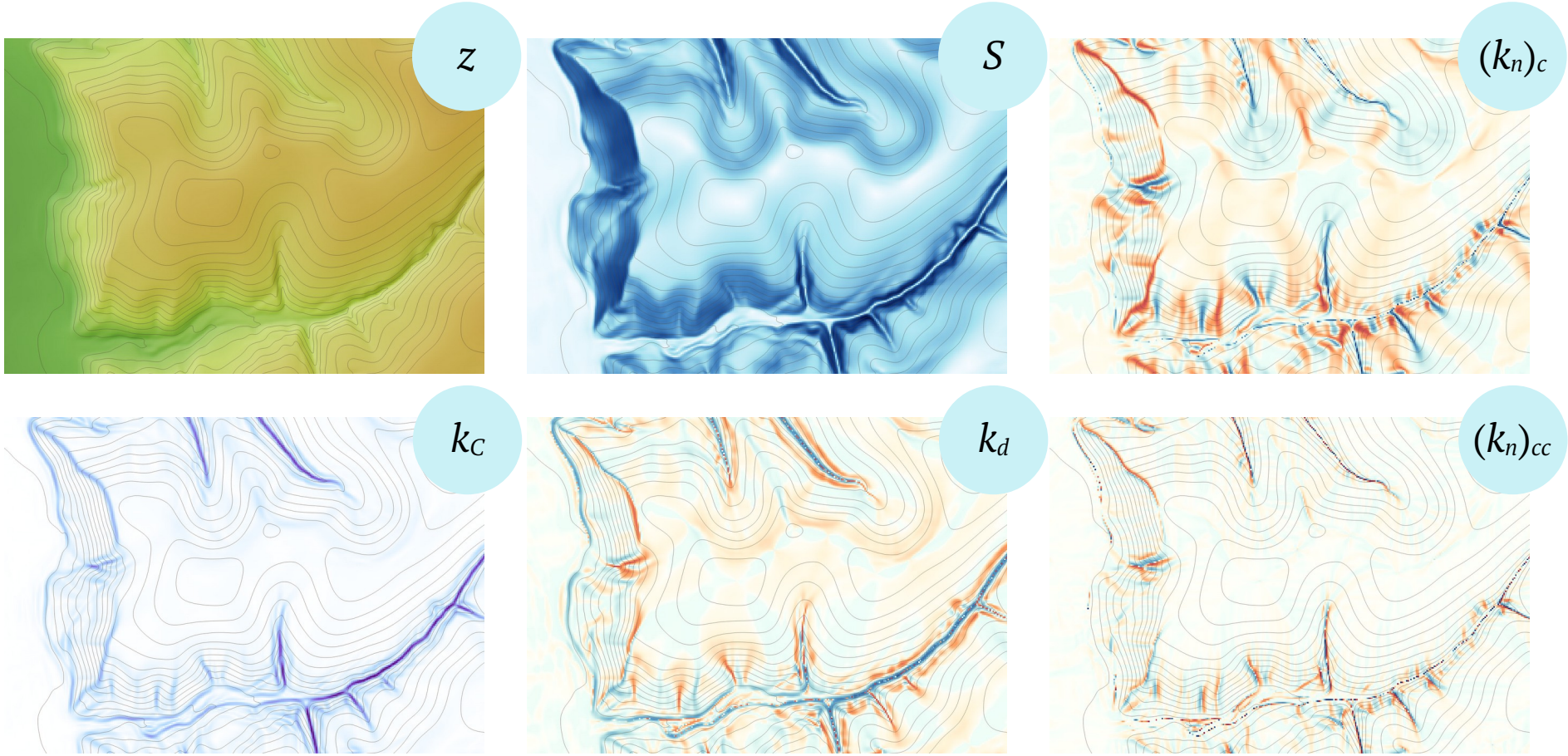


Outputs

- Multiple grids
  - Number depends on selected parameters
  - All outputs calculated at once
  - GeoTIFF format

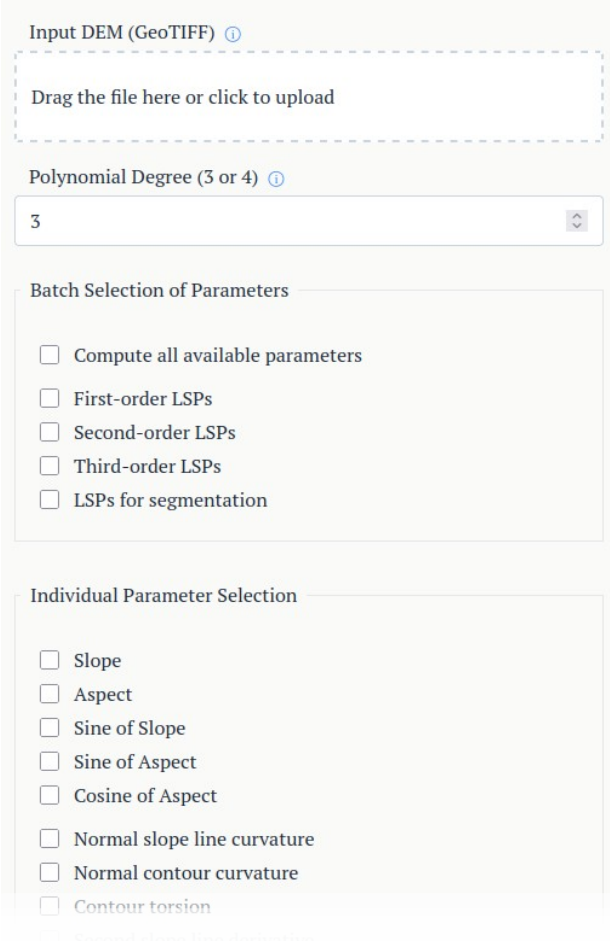


Outputs



Web Service

- We offer web computational service
  - No need to install
  - File size and pixels count restriction
  - Currently in test mode 🆕



🔗 `https://geomorphometry.fns.uniba.sk/calc-service/lsp_calculator`

Contact

Richard Feciskanin
richard.feciskanin@uniba.sk

Veronika Hajdúchová
veronika.hajduchova@uniba.sk

Department of Physical Geography and Geoinformatics

FACULTY
OF NATURAL SCIENCES
Comenius University
Bratislava