

# Swedish Lidar Metrics

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## Introduction

To produce the Swedish forest variables (published via the Swedish Forest Agency) we use models with specific metrics as independent data and data from the Swedish NFI as dependent data. Thus, we calculate metrics in raster form as well as for the NFI plots. As such metrics may be useful also in other situations, we make a set of metrics available through “Skogsdata-labbet” (where .to.download).

This document contains information on the available metrics.

### WHAT THE METRICS MAY BE USED FOR

The metrics are published as open data under the Simplified BSD License<sup>1</sup> and may be used for any non-criminal purpose as long as the following is clearly stated: “Data is produced by the Swedish University of Agriculture (SLU), for more information see [www.slu.se](http://www.slu.se).”

### WHAT THE METRICS CAN BE USED FOR

We use a subset of the metrics to produce the Swedish forest variables published through the Swedish Forest Agency.<sup>2</sup>

### FILES

To define a metric you combine a statistic and a filter, the naming convention is `year_statistic_filter` as detailed in “Available statistics”, “Definitions”, and “Filtering”, below.

### Rasters

All the available metrics are saved as geotiff raster files (suffix .tif) using lossless compression and the SWEREF99 TM projected georeference system. The resolution is  $10 \times 10 \text{ m}^2$ .

## Metrics

### Available statistics

- The number of points: count. You probably do not want to use count directly, but rather divide two counts with different filtering to get a proportion.
- Summary statistics: mean, mean2, variance, skewness, and kurtosis.

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<sup>1</sup> [https://en.wikipedia.org/wiki/BSD\\_licenses](https://en.wikipedia.org/wiki/BSD_licenses)

<sup>2</sup> <https://skogsstyrelsen.se/skogligagrunddata> (in Swedish)

- Percentiles: p10, p20, p30, p40, p50, p60, p70, p80, p90, and p95.
- L-moments: L2 (L-scale), L3 (L-skewness), and L4 (L-kurtosis).
- Median absolute deviation: mad.

### Filtering

You choose if you want all points (all) or only the first returns (1ret). Optionally you also choose a boundary (\_geHcm).

- all (all points) or all\_geHcm (all points greater than or equal to  $H$  cm).
- 1ret (all first returns) or 1ret\_geHcm (all first returns greater than or equal to  $H$  cm).

All the statistics come with at least the following filters (count has a few extra):  
\_1ret, \_1ret\_ge150cm, \_all, and \_all\_ge150cm.

### Examples

- 2022\_variance\_all (sample variance of all points),
- 2022\_variance\_1ret (sample variance of first returns), and
- 2022\_count\_1ret\_ge150cm (number of first returns greater than or equal to 1.5 m).

### DEFINITIONS

- $n$ , the number of values.
- $z_i$ , value  $i$ , where  $1 \leq i \leq n$ .
- $z_{(i)}$ , ordered value  $i$ , where  $1 \leq i \leq n$  and  $z_{(i)} \leq z_{(i+1)}$ .
- $\bar{z}$ , the mean.

### Number of points

TAG: count

DESCRIPTION: The number of  $z$ -values.

### Mean value

TAG: mean and mean2

DESCRIPTION: The mean and the mean of the squares, respectively.

$$\frac{1}{n} \sum_{i=1}^n z_i \quad \text{and} \quad \frac{1}{n} \sum_{i=1}^n z_i^2$$

### Standard deviation

TAG: –

DESCRIPTION: The standard deviation is the same as the square root of the variance and is not included – use  $\sqrt{\text{variance}}$  instead.

### Variance

TAG: variance

DESCRIPTION: The sample variance.

$$\frac{1}{n-1} \sum_{i=1}^n (z_i - \bar{z})^2$$

### Skewness

TAG: skewness

DESCRIPTION: The sample ( $G_1$ ) skewness.

$$\frac{\sqrt{n(n-1)}}{n-2} \cdot \sqrt{n} \cdot \frac{\sum_{i=1}^n (z_i - \bar{z})^3}{[\sum_{i=1}^n (z_i - \bar{z})^2]^{1.5}}$$

### Kurtosis

TAG: kurtosis

DESCRIPTION: The sample kurtosis.

$$\frac{(n+1)(n-1)}{(n-2)(n-3)} \cdot n \cdot \frac{\sum_{i=1}^n (z_i - \bar{z})^4}{[\sum_{i=1}^n (z_i - \bar{z})^2]^2} - \frac{3n^2}{(n-2)(n-3)}$$

### Percentile $k$

TAG:  $pk$

DESCRIPTION: The value  $z_{(p)}$  for which  $k$  % of all values are smaller:  $p = \frac{k}{100} \cdot n$ .  
When  $p$  is not an integer value,  $z_{(p)}$  is the linear interpolation of the two adjacent values.

### Median absolute deviation

TAG: mad

DESCRIPTION: Median absolute deviation:  $\text{median}(|z_i - \bar{z}|)$

### L-mean

TAG: -

DESCRIPTION: The mean has the same value in ordered statistics as in unordered, so L1 is not included – use mean instead.

### L-scale

TAG: L2

$$\frac{1}{2} \binom{n}{2}^{-1} \sum_{i=1}^n \left[ \binom{i-1}{1} - \binom{n-i}{1} \right] \cdot z_{(i)}$$

### L-scewness

TAG: L3

$$\frac{1}{3} \binom{n}{3}^{-1} \sum_{i=1}^n \left[ \binom{i-1}{2} - 2 \binom{i-1}{1} \binom{n-i}{1} + \binom{n-i}{2} \right] \cdot z_{(i)}$$

### L-kurtosis

TAG: L4

$$\frac{1}{4} \binom{n}{4}^{-1} \sum_{i=1}^n \left[ \binom{i-1}{3} - 3 \binom{i-1}{2} \binom{n-i}{1} + 3 \binom{i-1}{1} \binom{n-i}{2} - \binom{n-i}{3} \right] \cdot z_{(i)}$$

## List of all the metrics

count_1ret	count_1ret_ge150cm	count_all	count_all_ge150cm
kurtosis_1ret	kurtosis_1ret_ge150cm	kurtosis_all	kurtosis_all_ge150cm
L1_1ret	L1_1ret_ge150cm	L1_all	L1_all_ge150cm
L2_1ret	L2_1ret_ge150cm	L2_all	L2_all_ge150cm
L3_1ret	L3_1ret_ge150cm	L3_all	L3_all_ge150cm
L4_1ret	L4_1ret_ge150cm	L4_all	L4_all_ge150cm
mad_1ret	mad_1ret_ge150cm	mad_all	mad_all_ge150cm
mean_1ret	mean_1ret_ge150cm	mean_all	mean_all_ge150cm
mean2_1ret	mean2_1ret_ge150cm	mean2_all	mean2_all_ge150cm
p10_1ret	p10_1ret_ge150cm	p10_all	p10_all_ge150cm
p20_1ret	p20_1ret_ge150cm	p20_all	p20_all_ge150cm
p30_1ret	p30_1ret_ge150cm	p30_all	p30_all_ge150cm
p40_1ret	p40_1ret_ge150cm	p40_all	p40_all_ge150cm
p50_1ret	p50_1ret_ge150cm	p50_all	p50_all_ge150cm
p60_1ret	p60_1ret_ge150cm	p60_all	p60_all_ge150cm
p70_1ret	p70_1ret_ge150cm	p70_all	p70_all_ge150cm
p80_1ret	p80_1ret_ge150cm	p80_all	p80_all_ge150cm
p90_1ret	p90_1ret_ge150cm	p90_all	p90_all_ge150cm
p95_1ret	p95_1ret_ge150cm	p95_all	p95_all_ge150cm
skewness_1ret	skewness_1ret_ge150cm	skewness_all	skewness_all_ge150cm
stddev_1ret	stddev_1ret_ge150cm	stddev_all	stddev_all_ge150cm
count_1ret_ge500cm	count_1ret_ge1000cm	count_1ret_ge1500cm	
count_all_ge500cm	count_all_ge1000cm	count_all_ge1500cm	