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The Highest Hill Summits in Latvia Based on LiDAR Data

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Why?

Review of existing datasets when moving statistical data publishing from CSB homepage to Official Statistics Portal in 2020.

Removal of statistical data about geographical features (hills, lakes, rivers) as their source was unable to be determined.

Such data are not part of official statistics program which includes data that changes over time.

Remarks by data users of lack of statistical data about geographical features, nobody responsible.

Normally such data should be calculated by respective institution, e.g., Latvian Geospatial Information Agency (LGIA).

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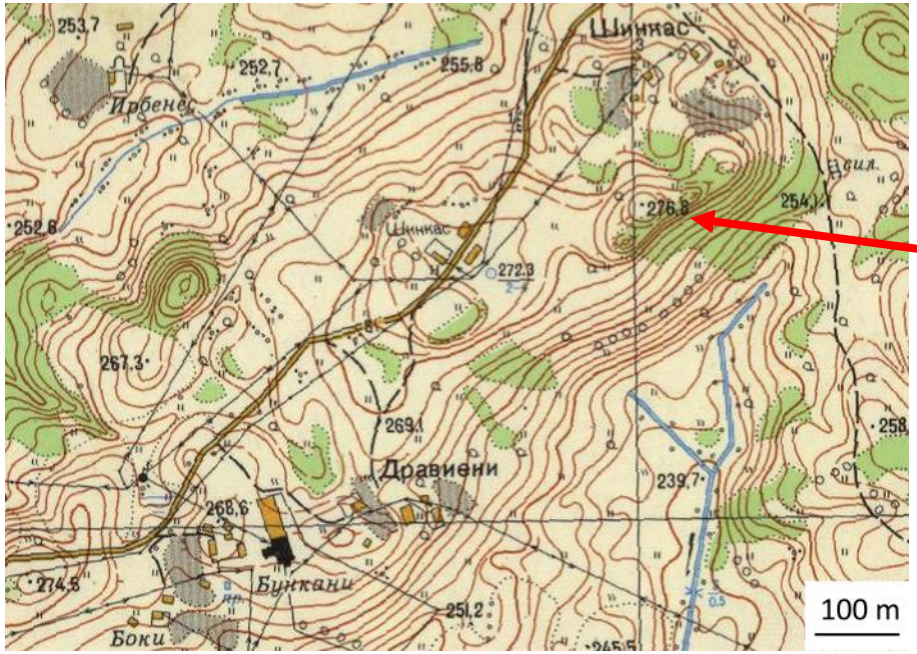
Why?

Heights of hills in existing data sources are primarily based on the topographic maps of the Soviet Army General Staff, names and locations of hills differ.



Topographic map of the Soviet Army General Staff (ĢISnet.lv WMS), LGIA basemap in scale of 1:250 000 (ĢISnet.lv WMS)

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Why?

In 2020, Latvian Geospatial Information Agency finished publishing 2013–2019 LiDAR open data. Data are automatically classified, ground surface level manually corrected. Vertical accuracy of the data up to 12 cm, horizontal – up to 36 cm.

In 2021, the highest hill summits in Latvia were calculated by CSB using DTMs obtained from the LiDAR data. Includes summits higher than 270 m above sea level in the normal height system LAS-2000.5 and highest summits of uplands.

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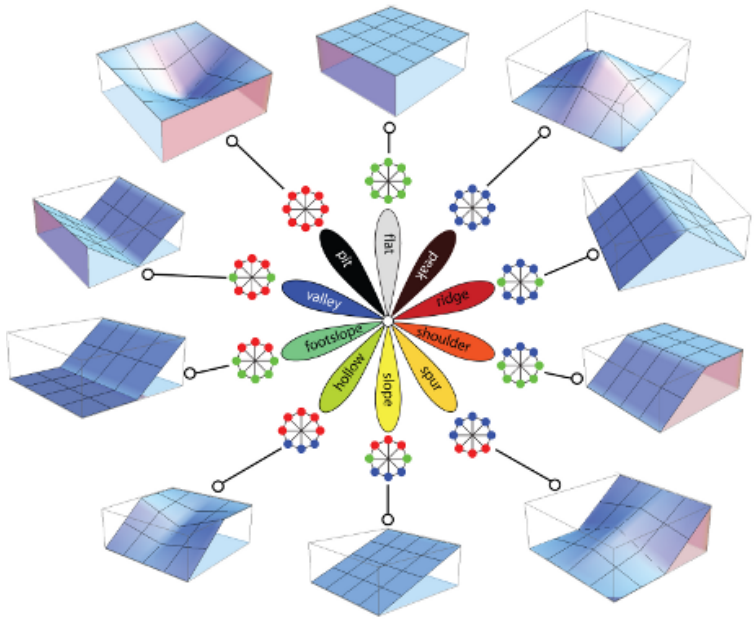
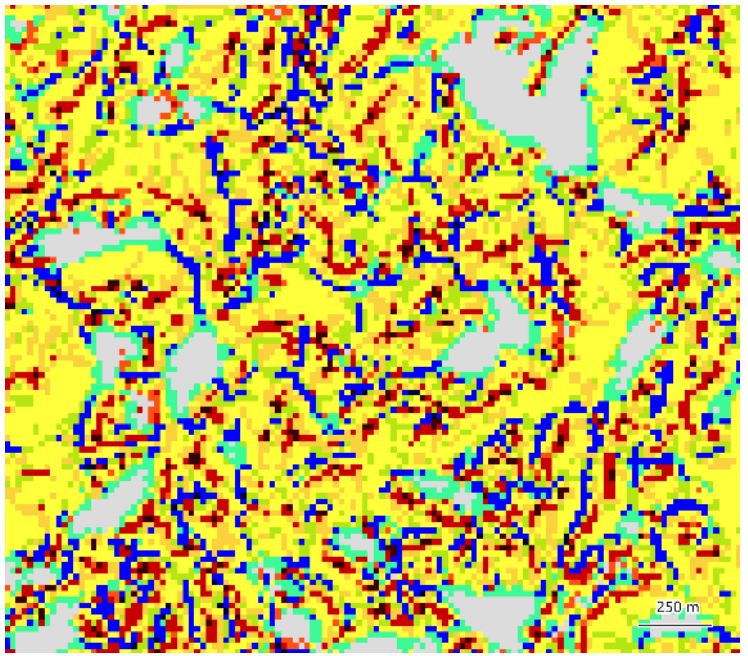
Steps to identify summits and their heights (simplified)

1. Identification of summits from the LGIA 20 m DTM with the GRASS GIS tool r.geomorphon (default parameters were used).



+	0	1	2	3	4	5	6	7	8
0	FL	FL	FL	FS	FS	VL	VL	VL	PT
1	FL	FL	FS	FS	FS	VL	VL	VL	—
2	FL	SH	SL	SL	HL	HL	VL	—	—
3	SH	SH	SL	SL	SL	HL	—	—	—
4	SH	SH	SP	SL	SL	—	—	—	—
5	RI	RI	SP	SP	—	—	—	—	—
6	RI	RI	RI	—	—	—	—	—	—
7	RI	RI	—	—	—	—	—	—	—
8	PK	—	—	—	—	—	—	—	—



https://grass.osgeo.org/grass82/manuals/r.geomorphon.html and example of Abriena hummocky terrain

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Steps to identify summits and their heights (simplified)

2. Manual review of points higher than 268 m using LVM GEO WMS terrain model (ZemeLKS layer) and contour lines (Contours layer) as auxiliary material.

3. ~~Creation of 1 m DTM from LiDAR data using PDAL (calculates not only mean, but also min, max, stdev and count).~~ Used LGIA 1 m DTM instead (free of charge for state and local government institutions) to achieve uniform results.

4. Determine exact height and location of summits from the 1 m DTM. DTM clipped by bbox of 30 m buffer around each summit from the 20 m DTM.

5. Leave only the highest summit of hummocky terrains.

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Steps to identify summits and their heights (simplified)

Identification of highest summits of uplands without already determined highest summits similar to steps before, but in r.geomorphon output, leave only the highest summit and summits up to 2 m below it for each upland.

Consultations with the academic staff of the Department of Geomorphology and Geomatics of the University of Latvia have been performed on the geomorphological interpretation of landforms.

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Names of summits

Names according to:

- LGIA Place Names Database,
- map browser BalticMaps.eu maintained by Jana Seta Map Publishers (Ltd.),
- Department of Geomorphology and Geomatics of the Faculty of Geography and Earth Sciences of the University of Latvia,
- data obtained from the Madona Local History and Art Museum.

Lācu Hill is named after the name of the nearest farmstead.

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Height differences (m) of the highest hill summits: LGIA 1 m DTM vs. topographic map of the Soviet Army General Staff

Name	LGIA 1 m DTM (LAS-2000.5)	USSR topo (BAS 77)	Diffe-rence	Name	LGIA 1 m DTM (LAS-2000.5)	USSR topo (BAS 77)	Diffe-rence
Riekstu (Viešūra) kalns	286.7	260.8	25.9	Klētskalns	270.6	269.3	1.3
Ķelēnu kalns	294.5	283.4	11.1	Lazdiešu kalns	271.4	270.1	1.3
Augstumkalns	282	272.2	9.8	Dubuļu kalns	275	273.8	1.2
Abrienas kalns	295.8	287.3	8.5	Gožu kalns	270.5	269.3	1.2
Āriņu kalns	287	278.9	8.1	Mazais Gaiziņkalns	284.5	283.6	0.9
Bākūžu kalns	279.5	272.4	7.1	Nesaules kalns	285	284.3	0.7
Zlaugotņu kalns	275.8	268.8	7	Gaiziņkalns	312.01	311.6	0.41
Kromonu kalns	276.1	271.1	5	Dravēnu kalns	283.1	282.7	0.4
Ozoliņkalns	271.4	267.3	4.1	Boķu kalns	277.2	276.8	0.4
Dravnieku kalns	277.1	273.2	3.9	Karaļu kalns	273	272.7	0.3
Leišu kalns	281.6	277.8	3.8	Dzerkaļu kalns	286.5	286.3	0.2
Vilkātes kalns	270.2	266.5	3.7	Dēliņkalns	271.6	271.5	0.1
Lācu kalns	271	268.9	2.1	Lielais Liepukalns	289.2	289.3	-0.1
Dēklaiņu kalns	277.2	275.8	1.4	Bolēnu kalns	283.9		
Sirdskalns	298.1	296.8	1.3	Mestrēnu kalns	277		

In grey, named lower summits of hummocky terrains.

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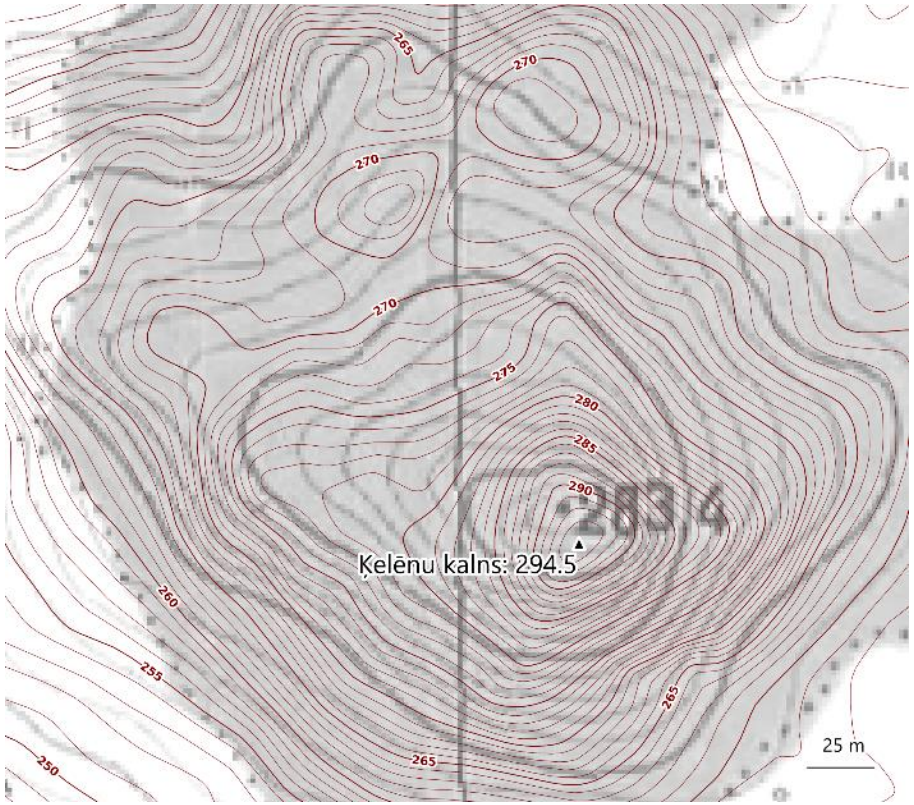
Height difference of Ķelēni Hill

In the topographic maps of the Soviet Army General Staff, terrain recognition from the stereopairs of aerial photos in the areas covered with forests was performed inaccurately.



Basemap – topographic map of the Soviet Army General Staff (ĢISnet.lv WMS) and LVM GEO WMS layer Contours

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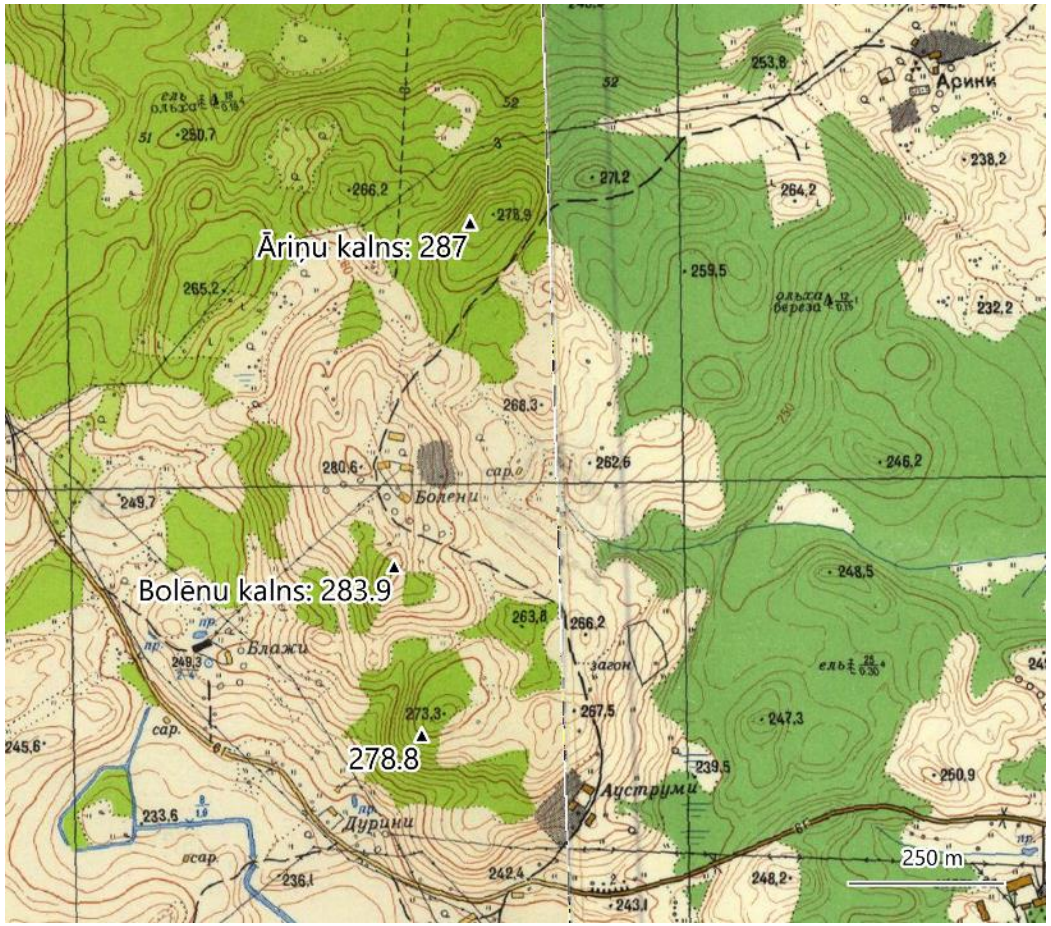
Summits in the Āriņi hummocky terrain



Basemap – topographic map of the Soviet Army General Staff (ĢISnet.lv WMS)

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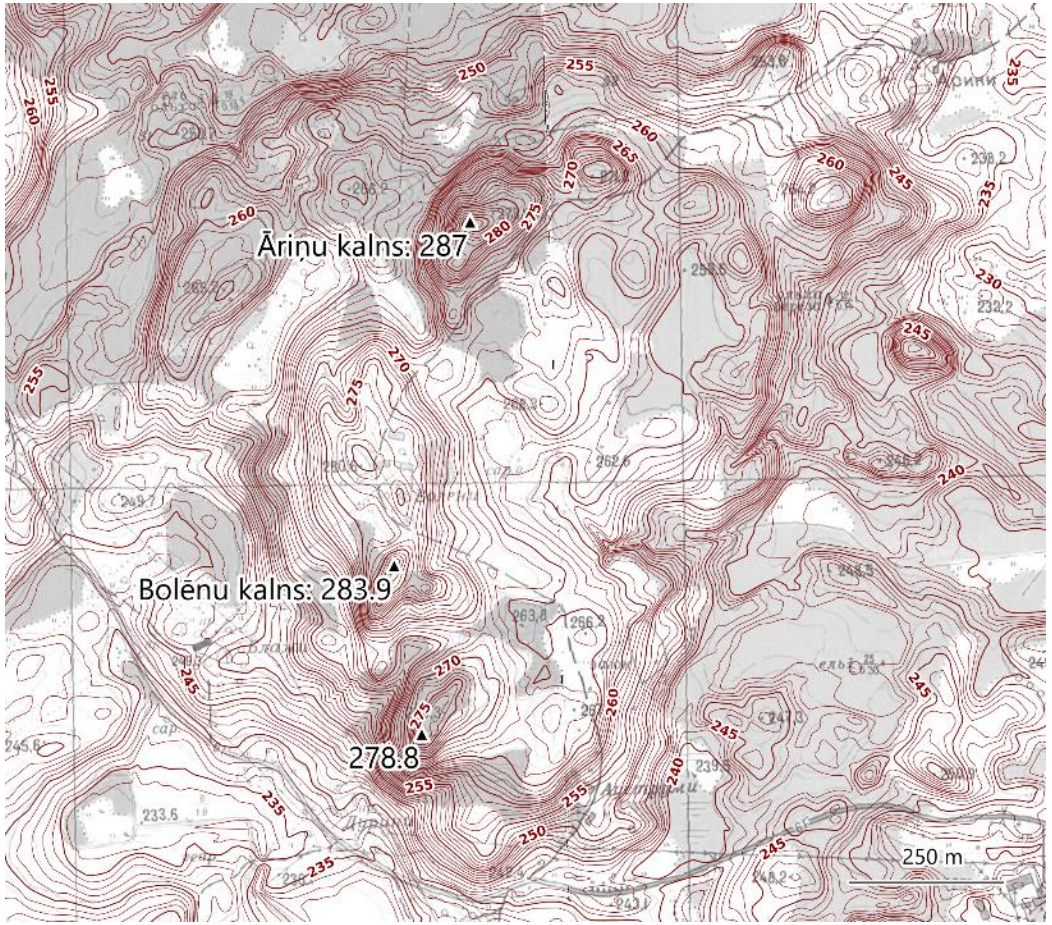

Basemap – topographic map of the Soviet Army General Staff (ĢISnet.lv WMS) and LVM GEO WMS layer Contours

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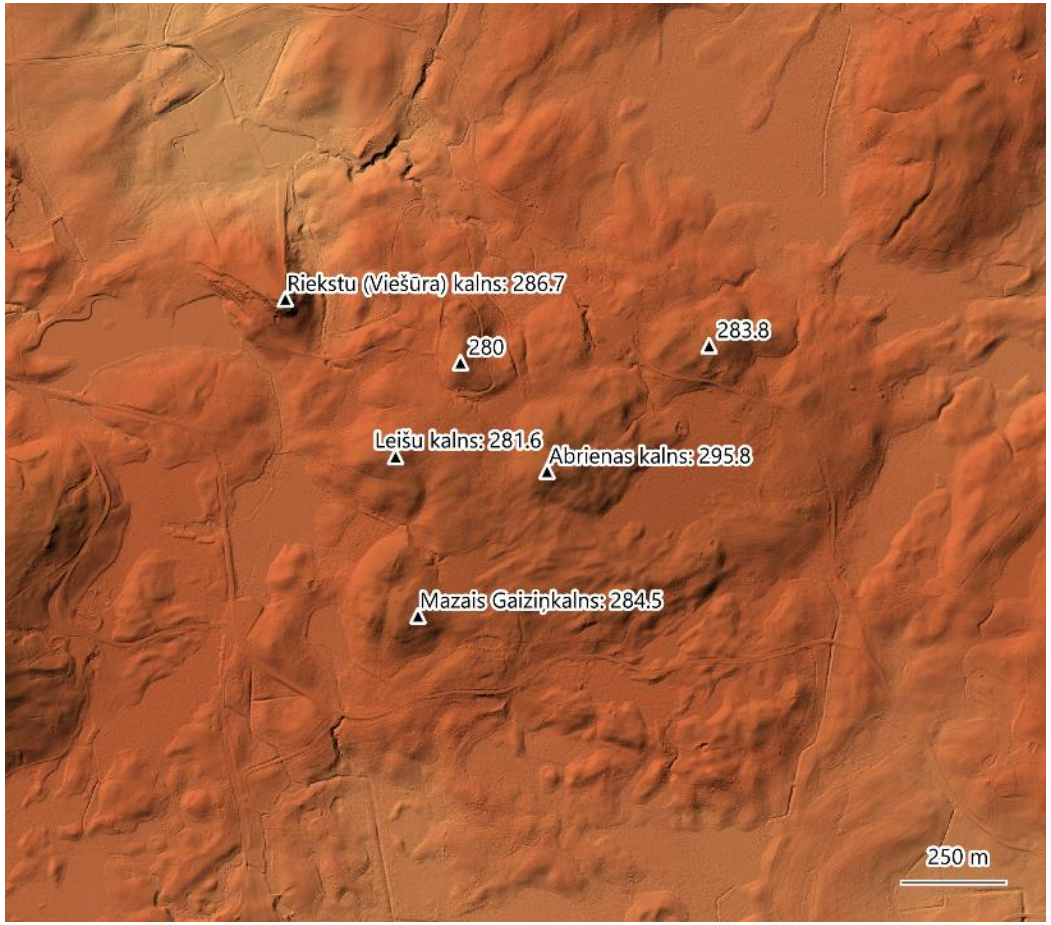
Summits in the Abriena hummocky terrain



Basemap – LVM GEO WMS layer ZemeLKS

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Height differences (m) of the highest hill summits: LGIA 1 m DTM (after) vs. book Latvija. Zeme, daba, tauta, valsts (before)

Name		Book Latvija. Zeme, daba, tauta, valsts (before)		LGIA 1 m DTM (after), ±0.1 m	Difference
Gaiziņkalns	1	311.9	**1**	**311.94***	0
Sirdskalns	2	297	**2**	**298.1**	1.1
Abrienas kalns	4	287.5	**3**	**295.8**	8.3
Ķelēnu kalns	8	283.6	**4**	**294.5**	10.9
Lielais Liepukalns	3	289.5	**5**	**289.2**	-0.3
Āriņu kalns			**6**	**287**	
Dzerkaļu kalns	5	286.5	**7**	**286.5**	0
Nesaules kalns	6	284.4	**8**	**285**	0.6
Mazais Gaiziņkalns	7	283.8		284.5	0.7
Bolēnu kalns	9	282.9		283.9	1
Dravēnu kalns	9	282.9	**9**	**283.1**	0.2
Bākūžu kalns			**10**	**279.5**	
Boķu kalns	10	277	**11**	**277.2**	0.2
Dēklaiņu kalns	11	276	**11**	**277.2**	1.2

*According to https://www.mod.gov.lv/en/node/6107.

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Published data

Official Statistics Portal: https://stat.gov.lv/en/statistics-themes/environment/nature-resources/other/8249-highest-hill-summits-latvia, available also as GeoPackage.

Metadata: https://stat.gov.lv/en/metadata/8250-highest-hill-summits-latvia.

Data included in the Latvian National Encyclopaedia, Wikipedia, Wikidata and OpenStreetMap, but still missing in any other web maps. Missing also in the Place Names Database by LGIA.

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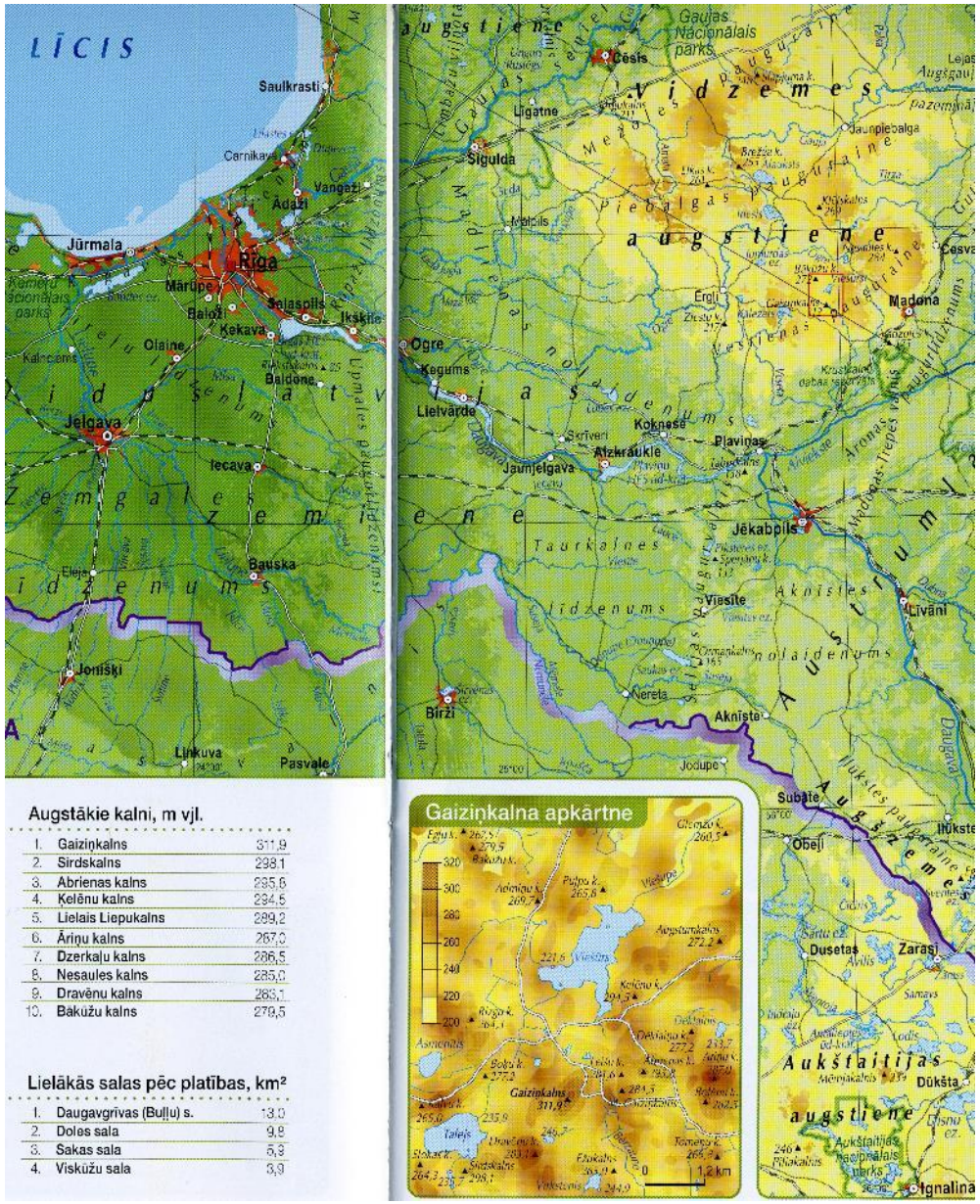
Published data

Data included also in the Geographic Atlas of Latvia by Jāņa sēta LLC.

Some map features still not updated.



J. Turlajs, *Latvijas ģeogrāfijas atlants*. Rīga: SIA «Jāņa sēta», 2023.

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Possible extensions

Relative heights (methodology!), heights of all hills in Latvia.

Other geographical objects – largest lakes, longest rivers etc. Planned to be taken from LGIA topographic map in scale 1:10 000, 4th cycle when finished.

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View from Gaiziņkalns observation tower, 2010