IMPETUS

Turning climate commitments into action

Upju hidroloģisko procesu modelēšana un plūdu riska kartes

Emīls Rubīns | 20.11.2025 | Rīga

Plūdu risks

- Plūdu risks ir plūdu iestāšanās iespējamība un to radītā varbūtējā nelabvēlīgā ietekme uz cilvēku veselību, vidi, kultūras mantojumu un saimniecisko darbību

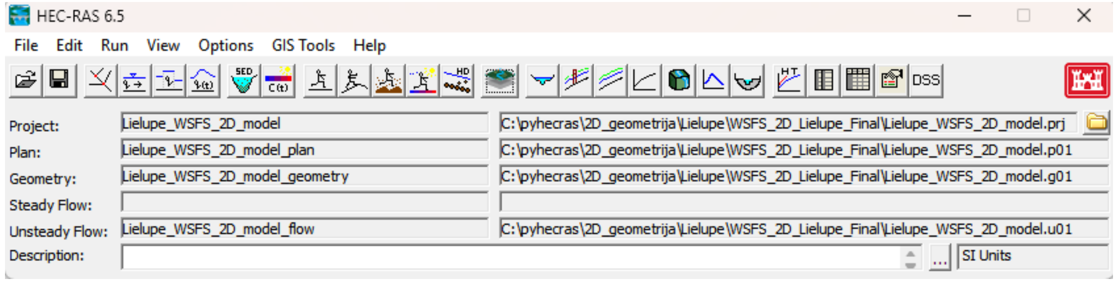
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037084.

HEC-RAS 2D modelis

- Bezmaksas ASV inženieru korpusa izstrādāta programmatūra upju hidraulikas modelēšanai
- Atbalsta 1D, 2D un hibrīda 1D/2D plūsmu aprēķinus
- Piemērota plūdu riska kartēšanai, scenāriju analīzei, dambju pārrāvumu modelēšanai u.c.

https://www.hec.usace.army.mil/software/hec-ras/

- Plūsma tiek aprēķināta divos virzienos (x un y), izmantojot šūnu tīklu (*mesh*)
- Augsta telpiskā precizitāte
- Reālistiska plūsmas dinamika
- Bezmaksas un plaši izmantots industrijā, viegli integrējams ar GIS



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Ievades dati plūdu modelī

- Hidroloģiskie novērojumi (monitorings) un prognozes no LVĢMC prognožu sistēmas (https://videscentrs.lvgmc.lv/iebuvets/hidrologiskas-prognozes)
- Novērojumi līdz 6 reizēm dienā > ūdens līmenis un caurplūdums novērojumu stacijās, prognožu vidējās vērtības
- Uz LiDAR datiem balstīts digitālais reljefa modelis (DTM – 2x2 m)
- Gultnes informācija > gultnes skenēšanas dati, šķērsprofili
- 2D modelēšanas teritorija un ģeometrija
- Zemes lietojums (manninga koeficienta ievadei)
- un citi

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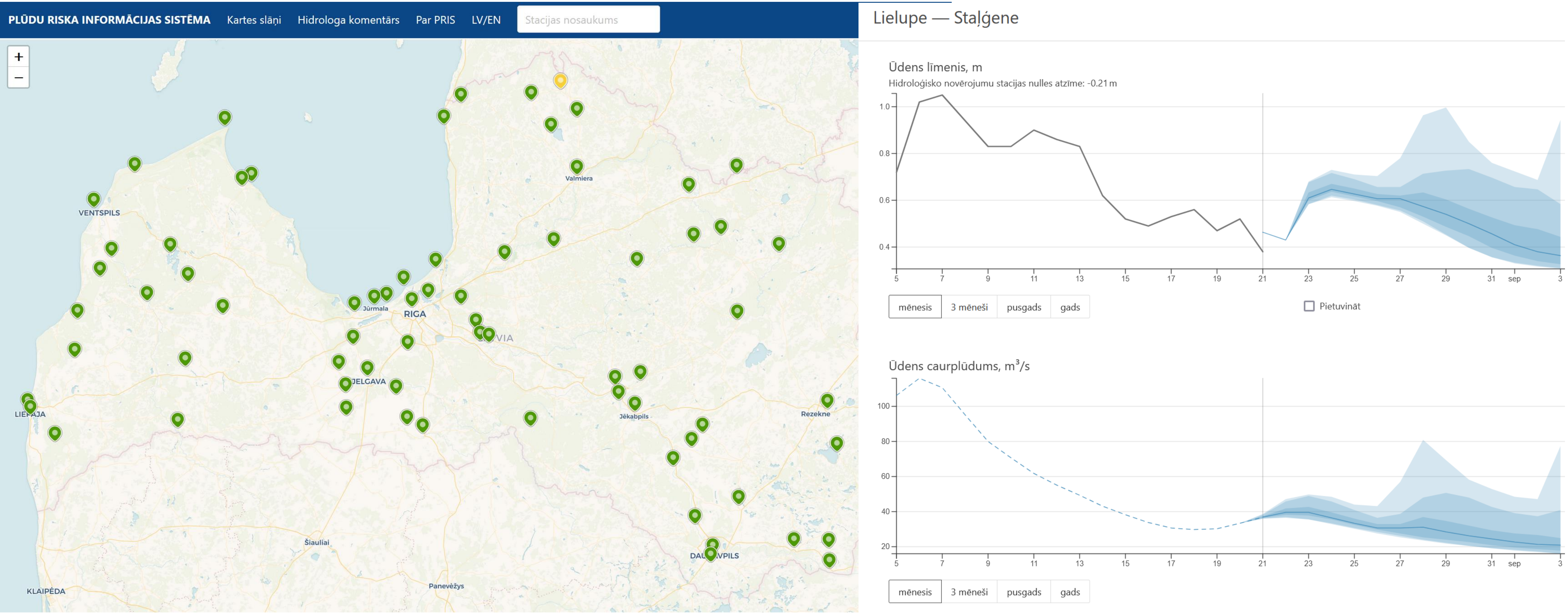
Hidroloģiskie novērojumi un prognozes no Plūdu risku informācijas sistēmas (PRIS) hidro.meteo.lv



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Hidroloģiskie novērojumi un prognozes no Plūdu risku informācijas sistēmas (PRIS) hidro.meteo.lv

Staciju dati Lielupes upju baseinam

Simulētais caurplūdums | Novērotais caurplūdums | Simulētais ŪL | Novērotais ŪL

Nosaukums

- l040021001y_20240725-0903.csv
- l040031001y_20240725-0903.csv
- l040041001y_20240725-0903.csv
- l040051001y_20240725-0903.csv
- q0473422y_20240725-0903.csv
- q0473440y_20240725-0903.csv
- q0473454y_20240725-0903.csv
- q0473461y_20240725-0903.csv
- q0473482y_20240725-0903.csv
- q0473503y_20240725-0903.csv
- q0473506y_20240725-0903.csv
- q0473529y_20240725-0903.csv
- q0473539y_20240725-0903.csv
- q0473548y_20240725-0903.csv
- q0473552y_20240725-0903.csv
- q0473560y_20240725-0903.csv
- q0473702y_20240725-0903.csv

	A	B	C	D	E	F	G	H	I	J	K
1	date	qlask	qhav	wlask	whav	twlask	twhav	qoutlas	qoutha	qinlas	qinhav
2	20240718	17.671	90000	0.444	0.44	22.382	22.17	16.456	90000	17.865	90000
3	20240719	17.202	90000	0.51	0.52	22.661	22.6	15.904	90000	17.437	90000
4	20240720	16.887	90000	0.499	0.5	21.171	21.11	17.239	90000	17.044	90000
5	20240721	16.768	90000	0.47	0.45	21.424	21.23	17.392	90000	16.827	90000
6	20240722	16.517	90000	0.432	0.4	21.191	20.72	17.27	90000	16.643	90000
7	20240723	16.128	90000	0.403	0.4	21.878	21.36	16.438	90000	16.322	90000
8	20240724	15.652	90000	0.392	0.41	21.297	20.94	15.68	90000	15.89	90000
9	20240725	15.202	90000	0.39	0.4	21.536	90000	15.209	90000	15.427	90000
10	20240726	14.769	90000	0.388	90000	21.903	90000	14.793	90000	14.985	90000
11	20240727	14.444	90000	0.302	90000	22.301	90000	15.233	90000	14.607	90000
12	20240728	14.005	90000	0.285	90000	22.308	90000	14.05	90000	14.225	90000
13	20240729	13.623	90000	0.282	90000	22.33	90000	13.63	90000	13.814	90000
14	20240730	13.268	90000	0.283	90000	22.423	90000	13.25	90000	13.446	90000
15	20240731	12.918	90000	0.284	90000	22.455	90000	12.953	90000	13.093	90000
16	20240801	12.597	90000	0.27	90000	22.491	90000	12.759	90000	12.758	90000
17											

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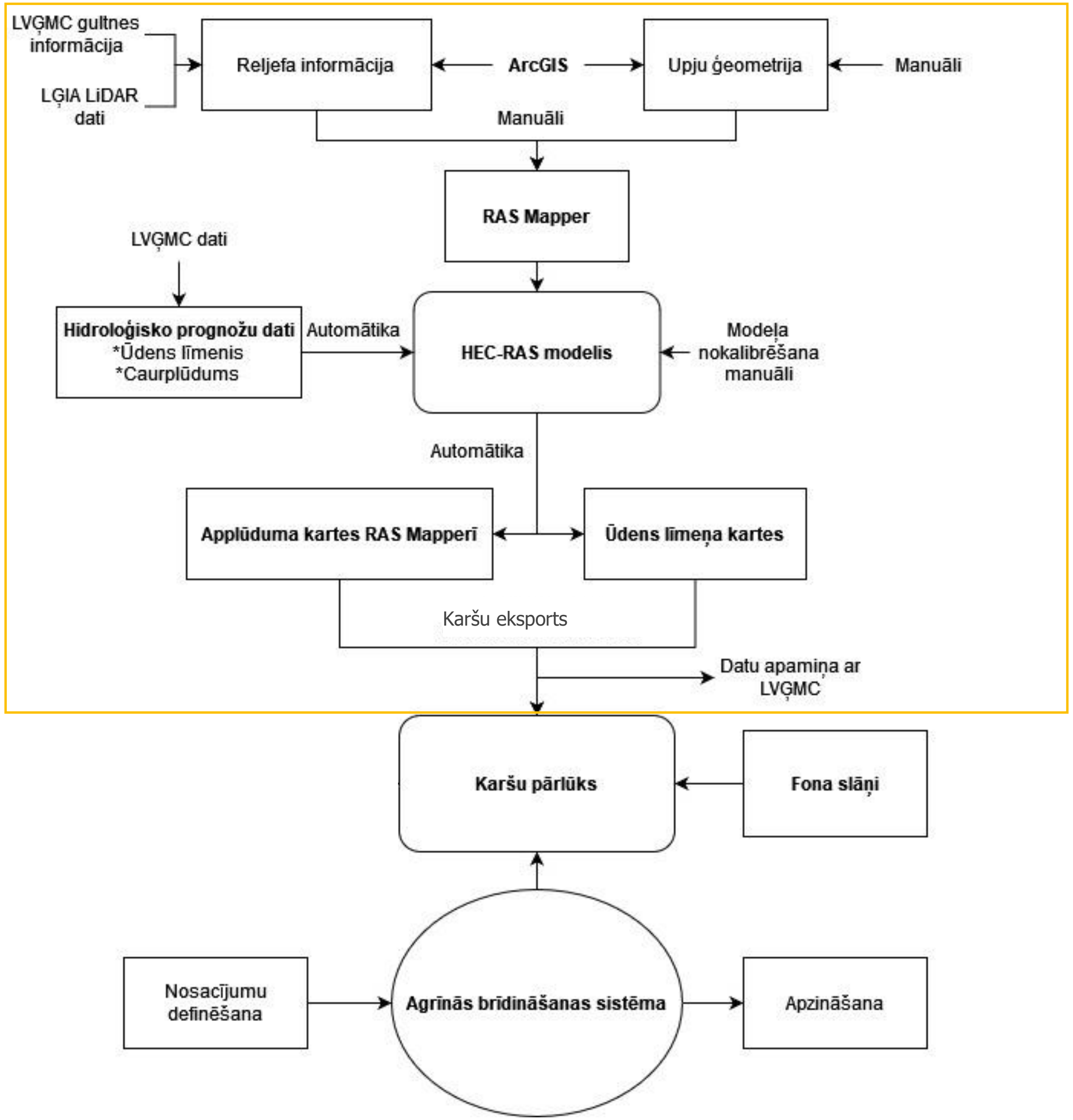
Vienkāršota ZPR agrīnās brīdināšanas sistēmas darbības shēma un plūdu modelis tajā



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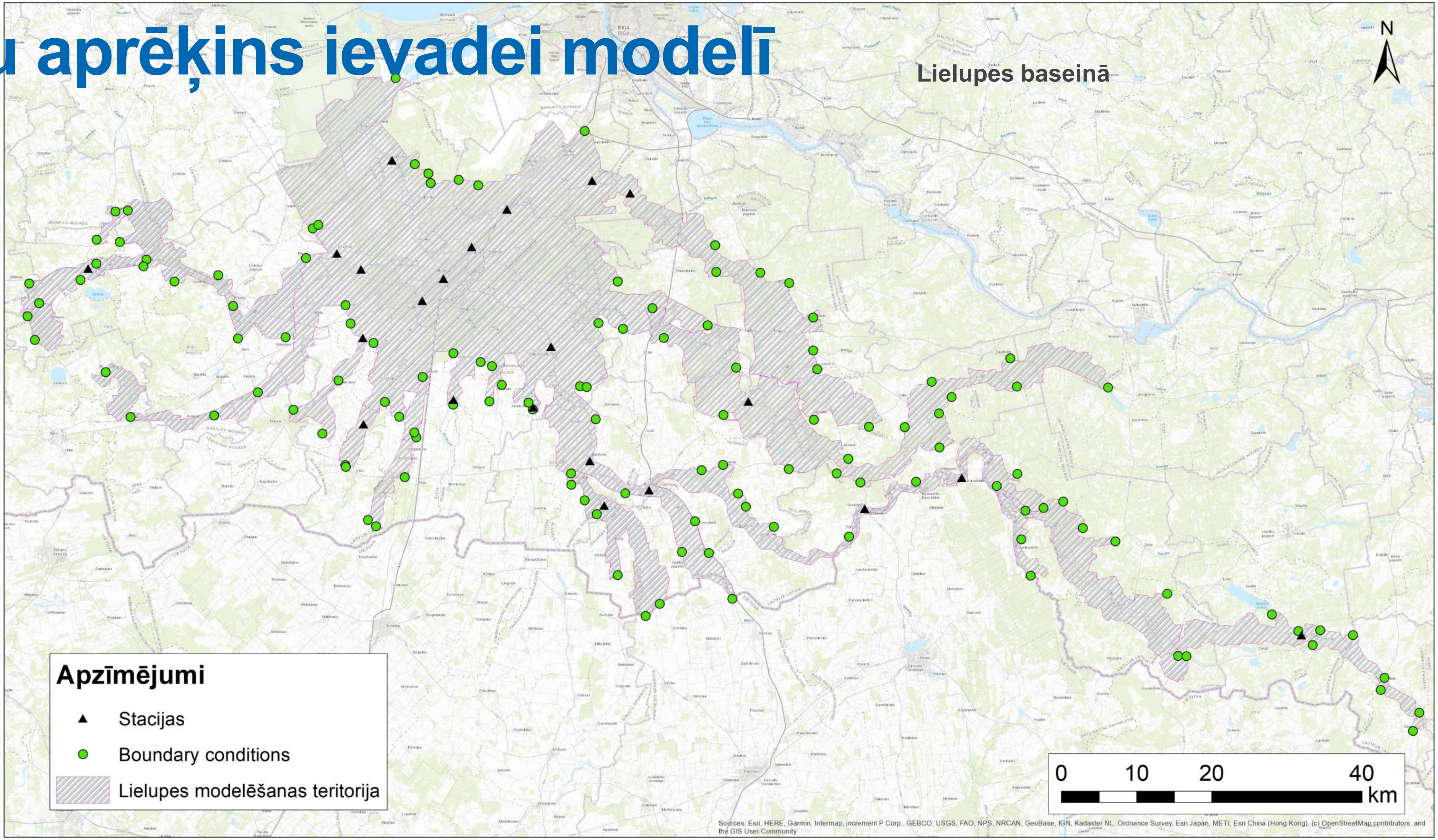
Datu aprēķins ievadei modelī



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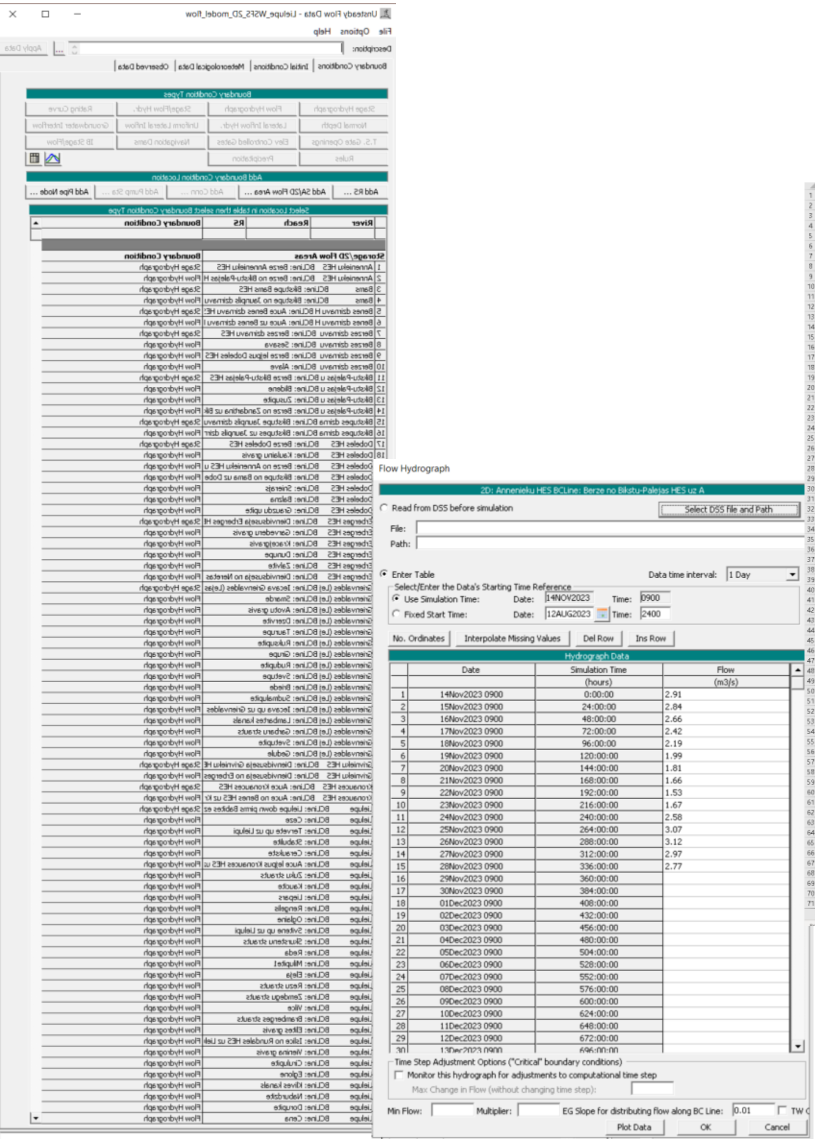
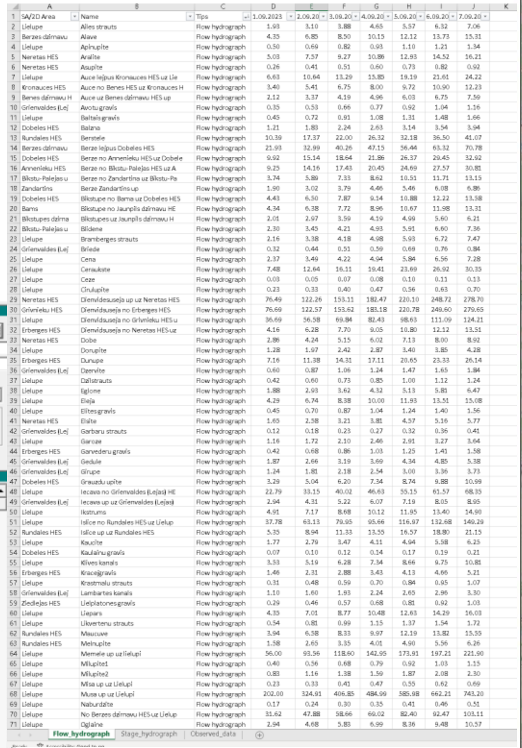
Datu aprēķins ievadei modelī

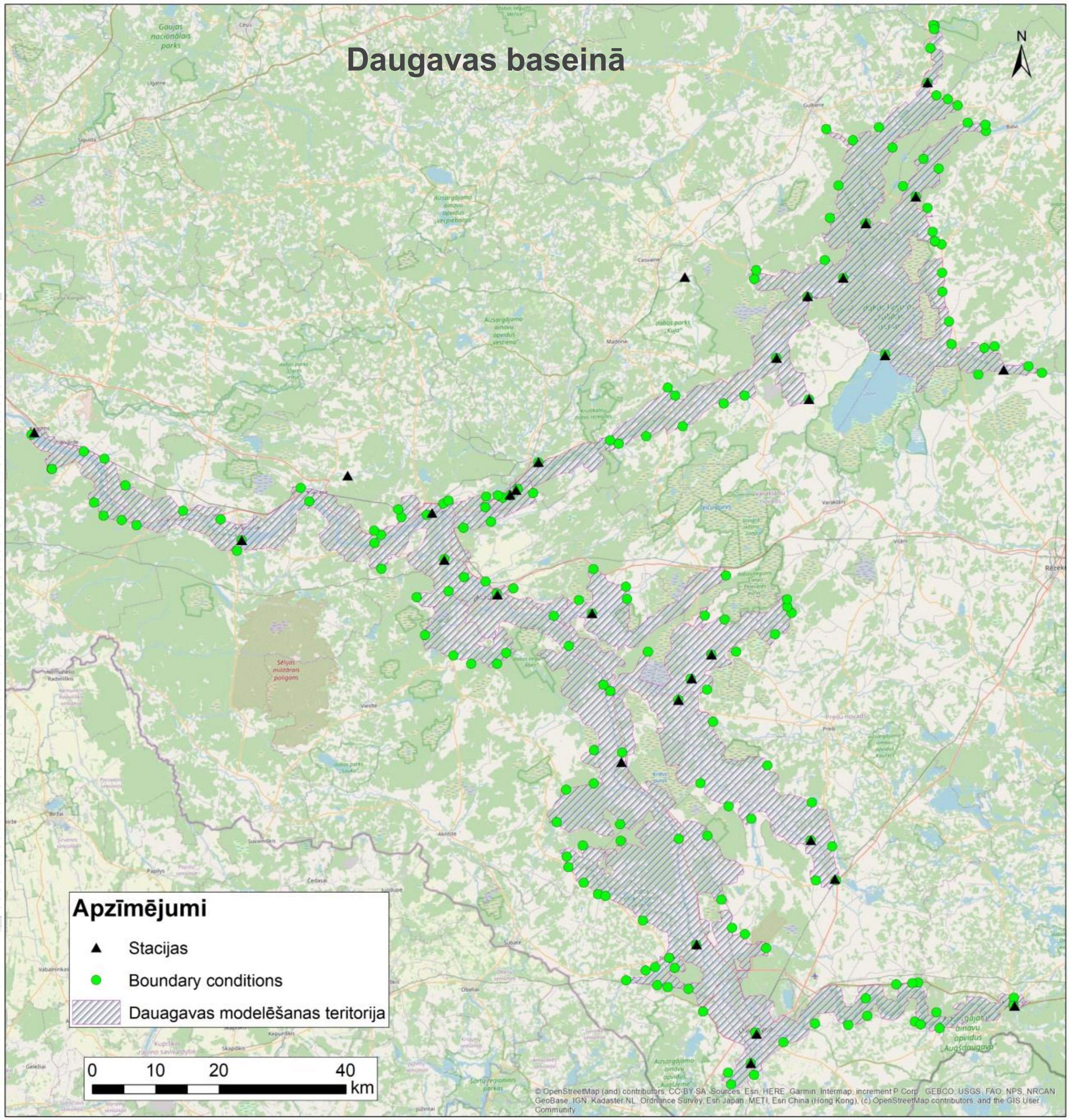


Transformācijas tabulas



	A	B	C	D	E	F	G	H	I	J	K
1	SA/2D Area	Name	Tips	1.09.2023	2.09.20	3.09.20	4.09.20	5.09.20	6.09.20	7.09.20	
2	Lielupe	Alles strauts	Flow hydrograph	1.93	3.10	3.88	4.65	5.57	6.32	7.06	
3	Berzes dzīmavu	Alave	Flow hydrograph	4.35	6.85	8.50	10.15	12.12	13.73	15.31	
4	Lielupe	Apinupīte	Flow hydrograph	0.50	0.69	0.82	0.93	1.10	1.21	1.34	
5	Neretas HES	Aralite	Flow hydrograph	5.03	7.57	9.27	10.86	12.93	14.52	16.21	
6	Neretas HES	Asupīte	Flow hydrograph	0.26	0.41	0.51	0.60	0.73	0.82	0.92	
7	Lielupe	Auce lejpus Kronauces HES uz Lie	Flow hydrograph	6.63	10.64	13.29	15.85	19.19	21.61	24.22	
8	Kronauces HES	Auce no Benes HES uz Kronauces H	Flow hydrograph	3.40	5.41	6.75	8.00	9.72	10.90	12.23	
9	Benes dzīmavu H	Auce uz Benes dzīmavu HES up	Flow hydrograph	2.12	3.37	4.19	4.96	6.03	6.75	7.59	
10	Grienvaldes (Lej	Avotu gravis	Flow hydrograph	0.35	0.53	0.66	0.77	0.92	1.04	1.16	
11	Lielupe	Baltais gravis	Flow hydrograph	0.45	0.72	0.91	1.08	1.31	1.48	1.66	
12	Dobeles HES	Balzna	Flow hydrograph	1.21	1.83	2.24	2.63	3.14	3.54	3.94	
13	Rundales HES	Berstele	Flow hydrograph	10.39	17.37	22.00	26.32	32.18	36.50	41.07	
14	Berzes dzīmavu	Berze lejpus Dobeles HES	Flow hydrograph	21.93	32.99	40.26	47.15	56.44	63.32	70.78	
15	Dobeles HES	Berze no Annenieku HES uz Dobele	Flow hydrograph	9.92	15.14	18.64	21.86	26.37	29.45	32.92	
16	Annenieku HES	Berze no Bikstu-Palejas HES uz A	Flow hydrograph	9.25	14.16	17.43	20.45	24.69	27.57	30.81	
17	Bikstu-Palejas u	Berze no Zandartina uz Bikstu-Pa	Flow hydrograph	3.74	5.89	7.33	8.62	10.51	11.71	13.15	
18	Zandartins	Berze Zandartins up	Flow hydrograph	1.90	3.02	3.79	4.46	5.46	6.08	6.86	
19	Dobeles HES	Bikstupe no Bama uz Dobeles HES	Flow hydrograph	4.43	6.50	7.87	9.14	10.88	12.22	13.58	
20	Bams	Bikstupe no Jaunpils dzīmavu HE	Flow hydrograph	4.34	6.38	7.72	8.96	10.67	11.98	13.31	
21	Bikstupes dzīma	Bikstupes uz Jaunpils dzīmavu H	Flow hydrograph	2.01	2.97	3.59	4.19	4.99	5.60	6.21	
22	Bikstu-Palejas u	Blidene	Flow hydrograph	2.30	3.45	4.21	4.93	5.91	6.60	7.36	
23	Lielupe	Bramberges strauts	Flow hydrograph	2.16	3.38	4.18	4.98	5.93	6.72	7.47	
24	Grienvaldes (Lej	Briede	Flow hydrograph	0.32	0.44	0.51	0.59	0.69	0.76	0.84	
25	Lielupe	Cena	Flow hydrograph	2.37	3.49	4.22	4.94	5.84	6.56	7.28	
26	Lielupe	Ceraukste	Flow hydrograph	7.48	12.64	16.11	19.41	23.69	26.92	30.35	
27	Lielupe	Ceze	Flow hydrograph	0.03	0.05	0.07	0.08	0.10	0.11	0.13	
28	Lielupe	Cirulupīte	Flow hydrograph	0.23	0.33	0.40	0.47	0.56	0.63	0.70	
29	Neretas HES	Dienvidesuseja up uz Neretas HES	Flow hydrograph	76.49	122.26	153.11	182.47	220.10	248.72	278.70	
30	Grivnieku HES	Dienvidsuseja no Erberges HES	Flow hydrograph	76.69	122.57	153.62	183.18	220.78	249.60	279.65	
31	Lielupe	Dienvidsuseja no Grivnieku HES u	Flow hydrograph	36.69	56.58	69.84	82.43	98.63	111.09	124.21	
32	Erberges HES	Dienvidsuseja no Neretas HES uz	Flow hydrograph	4.16	6.28	7.70	9.05	10.80	12.12	13.51	
33	Neretas HES	Dobe	Flow hydrograph	2.86	4.24	5.15	6.02	7.13	8.00	8.92	
34	Lielupe	Dorupite	Flow hydrograph	1.28	1.97	2.42	2.87	3.40	3.85	4.28	
35	Erberges HES	Dunupe	Flow hydrograph	7.16	11.38	14.31	17.11	20.65	23.33	26.14	
36	Grienvaldes (Lej	Dzervite	Flow hydrograph	0.60	0.87	1.06	1.24	1.47	1.65	1.84	
37	Lielupe	Dalstrauts	Flow hydrograph	0.42	0.60	0.73	0.85	1.00	1.12	1.24	
38	Lielupe	Eglone	Flow hydrograph	1.88	2.93	3.62	4.32	5.13	5.81	6.47	
39	Lielupe	Eleja	Flow hydrograph	4.29	6.74	8.38	10.00	11.93	13.51	15.08	
40	Lielupe	Elites gravis	Flow hydrograph	0.45	0.70	0.87	1.04	1.24	1.40	1.56	
41	Neretas HES	Elsite	Flow hydrograph	1.65	2.58	3.21	3.81	4.57	5.16	5.77	
42	Grienvaldes (Lej	Garbaru strauts	Flow hydrograph	0.12	0.18	0.23	0.27	0.32	0.36	0.41	
43	Lielupe	Garoze	Flow hydrograph	1.16	1.72	2.10	2.46	2.91	3.27	3.64	
44	Erberges HES	Garvederu gravis	Flow hydrograph	0.42	0.68	0.86	1.03	1.25	1.41	1.58	
45	Grienvaldes (Lej	Gedule	Flow hydrograph	1.87	2.66	3.19	3.69	4.34	4.85	5.38	
46	Grienvaldes (Lej	Girupe	Flow hydrograph	1.24	1.81	2.18	2.54	3.00	3.36	3.73	
47	Dobeles HES	Grauzdu upite	Flow hydrograph	3.29	5.04	6.20	7.34	8.74	9.88	10.99	
48	Lielupe	Iecava no Grienvaldes (Lejas) HE	Flow hydrograph	22.79	33.15	40.02	46.63	55.15	61.57	68.35	
49	Grienvaldes (Lej	Iecava up uz Grienvaldes (Lejas)	Flow hydrograph	2.94	4.31	5.22	6.07	7.19	8.05	8.95	
50	Lielupe	Ikstrums	Flow hydrograph	4.91	7.17	8.68	10.12	11.95	13.40	14.90	
51	Lielupe	Islice no Rundales HES uz Lielup	Flow hydrograph	37.78	63.13	79.95	95.66	116.97	132.68	149.29	
52	Rundales HES	Islice up uz Rundales HES	Flow hydrograph	5.35	8.94	11.33	13.55	16.57	18.80	21.15	
53	Lielupe	Kaucite	Flow hydrograph	1.77	2.79	3.47	4.11	4.94	5.58	6.25	
54	Dobeles HES	Kaulainu gravis	Flow hydrograph	0.07	0.10	0.12	0.14	0.17	0.19	0.21	
55	Lielupe	Klives kanals	Flow hydrograph	3.53	5.19	6.28	7.34	8.66	9.75	10.81	
56	Erberges HES	Kracejgravis	Flow hydrograph	1.46	2.31	2.88	3.43	4.13	4.66	5.21	
57	Lielupe	Krastmalu strauts	Flow hydrograph	0.31	0.48	0.59	0.70	0.84	0.95	1.07	
58	Grienvaldes (Lej	Lambartes kanals	Flow hydrograph	1.10	1.60	1.93	2.24	2.65	2.96	3.30	
59	Ziedlejas HES	Lielplatones gravis	Flow hydrograph	0.29	0.46	0.57	0.68	0.81	0.92	1.03	
60	Lielupe	Liepars	Flow hydrograph	4.35	7.01	8.77	10.48	12.63	14.29	16.03	
61	Lielupe	Likvertenu strauts	Flow hydrograph	0.54	0.81	0.99	1.15	1.37	1.54	1.72	
62	Rundales HES	Maucuve	Flow hydrograph	3.94	6.58	8.33	9.97	12.19	13.82	15.55	
63	Rundales HES	Melnupite	Flow hydrograph	1.58	2.65	3.35	4.01	4.90	5.56	6.26	
64	Lielupe	Memele up uz lielupi	Flow hydrograph	56.00	93.56	118.60	142.95	173.91	197.21	221.90	
65	Lielupe	Milupite1	Flow hydrograph	0.40	0.56	0.68	0.79	0.92	1.03	1.15	
66	Lielupe	Milupite2	Flow hydrograph	0.83	1.16	1.38	1.59	1.87	2.08	2.30	
67	Lielupe	Misa up uz Lielupi	Flow hydrograph	0.23	0.33	0.41	0.47	0.55	0.62	0.69	
68	Lielupe	Musa up uz Lielupi	Flow hydrograph	202.00	324.91	406.85	484.99	585.98	662.21	743.20	
69	Lielupe	Naburdzite	Flow hydrograph	0.17	0.24	0.30	0.35	0.41	0.46	0.51	
70	Lielupe	No Berzes dzīmavu HES uz Lielup	Flow hydrograph	31.62	47.88	58.66	69.02	82.40	92.47	103.11	
71	Lielupe	Oglaine	Flow hydrograph	2.94	4.68	5.83	6.99	8.36	9.48	10.57	

Flow_hydrograph | Stage_hydrograph | Observed_data



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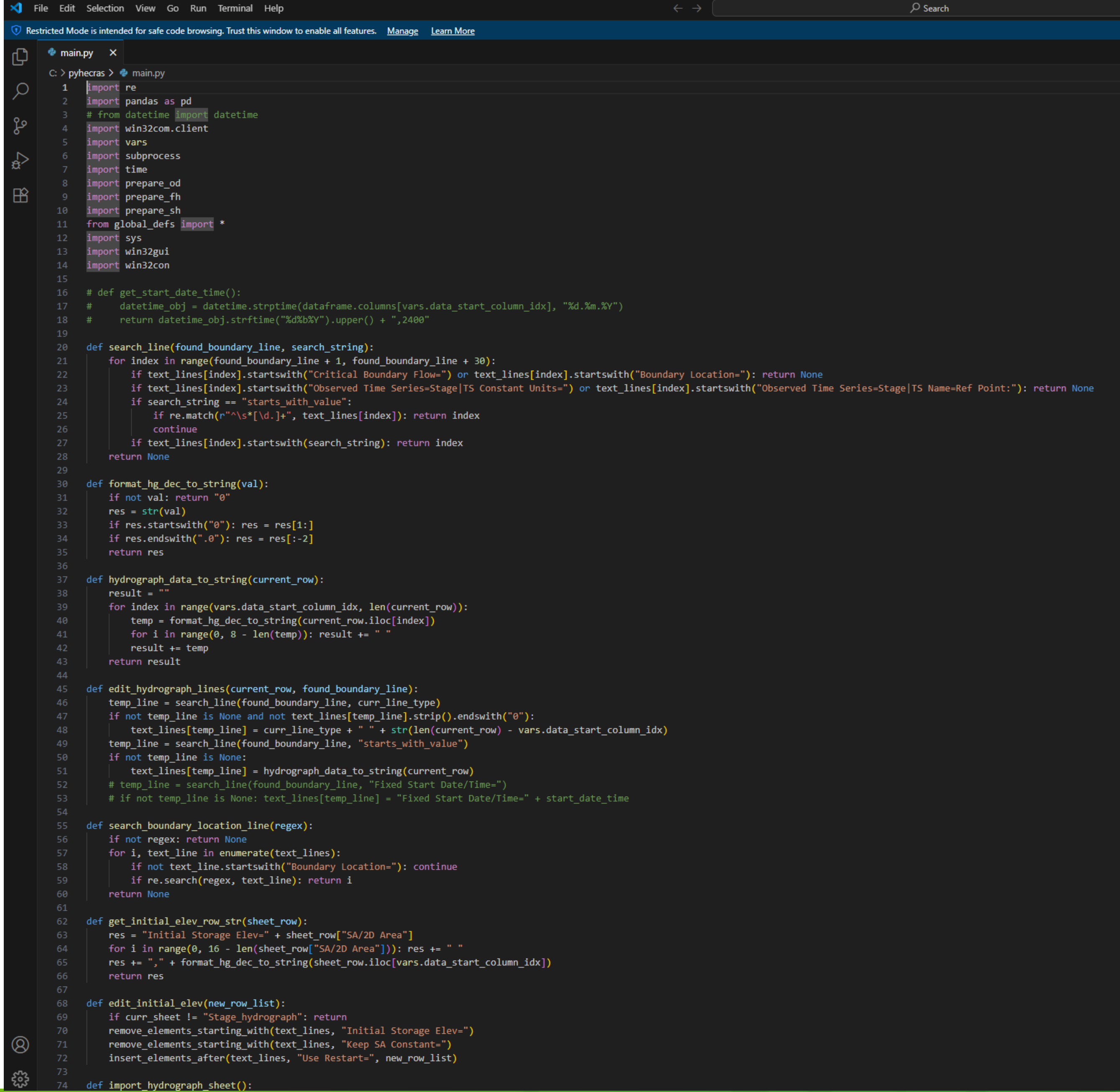
Modeļa automatizācija

- Python programmētājs
- Transformācijas tabulas
- Python scripti, lai darbinātu HEC-RAS controller un ikdienas prognožu datu atjaunošanu un ievadi modelī



```python
import re
import pandas as pd
# from datetime import datetime
import win32com.client
import vars
import subprocess
import time
import prepare_od
import prepare_fh
import prepare_sh
from global_defs import *
import sys
import win32gui
import win32con

# def get_start_date_time():
#     datetime_obj = datetime.strptime(dataframe.columns[vars.data_start_column_idx], "%d.%m.%Y")
#     return datetime_obj.strftime("%d%b%Y").upper() + ",2400"

def search_line(found_boundary_line, search_string):
    for index in range(found_boundary_line + 1, found_boundary_line + 30):
        if text_lines[index].startswith("Critical Boundary Flow=") or text_lines[index].startswith("Boundary Location="): return None
        if text_lines[index].startswith("Observed Time Series=Stage|TS Constant Units=") or text_lines[index].startswith("Observed Time Series=Stage|TS Name=Ref Point:"): return None
        if search_string == "starts_with_value":
            if re.match(r"^\s*[\d.]+", text_lines[index]): return index
            continue
        if text_lines[index].startswith(search_string): return index
    return None

def format_hg_dec_to_string(val):
    if not val: return "0"
    res = str(val)
    if res.startswith("0"): res = res[1:]
    if res.endswith(".0"): res = res[:-2]
    return res

def hydrograph_data_to_string(current_row):
    result = ""
    for index in range(vars.data_start_column_idx, len(current_row)):
        temp = format_hg_dec_to_string(current_row.iloc[index])
        for i in range(0, 8 - len(temp)): result += " "
        result += temp
    return result

def edit_hydrograph_lines(current_row, found_boundary_line):
    temp_line = search_line(found_boundary_line, curr_line_type)
    if not temp_line is None and not text_lines[temp_line].strip().endswith("0"):
        text_lines[temp_line] = curr_line_type + " " + str(len(current_row) - vars.data_start_column_idx)
    temp_line = search_line(found_boundary_line, "starts_with_value")
    if not temp_line is None:
        text_lines[temp_line] = hydrograph_data_to_string(current_row)
    # temp_line = search_line(found_boundary_line, "Fixed Start Date/Time=")
    # if not temp_line is None: text_lines[temp_line] = "Fixed Start Date/Time=" + start_date_time

def search_boundary_location_line(regex):
    if not regex: return None
    for i, text_line in enumerate(text_lines):
        if not text_line.startswith("Boundary Location="): continue
        if re.search(regex, text_line): return i
    return None

def get_initial_elev_row_str(sheet_row):
    res = "Initial Storage Elev=" + sheet_row["SA/2D Area"]
    for i in range(0, 16 - len(sheet_row["SA/2D Area"])): res += " "
    res += "," + format_hg_dec_to_string(sheet_row.iloc[vars.data_start_column_idx])
    return res

def edit_initial_elev(new_row_list):
    if curr_sheet != "Stage_hydrograph": return
    remove_elements_starting_with(text_lines, "Initial Storage Elev=")
    remove_elements_starting_with(text_lines, "Keep SA Constant=")
    insert_elements_after(text_lines, "Use Restart=", new_row_list)

def import_hydrograph_sheet():
```

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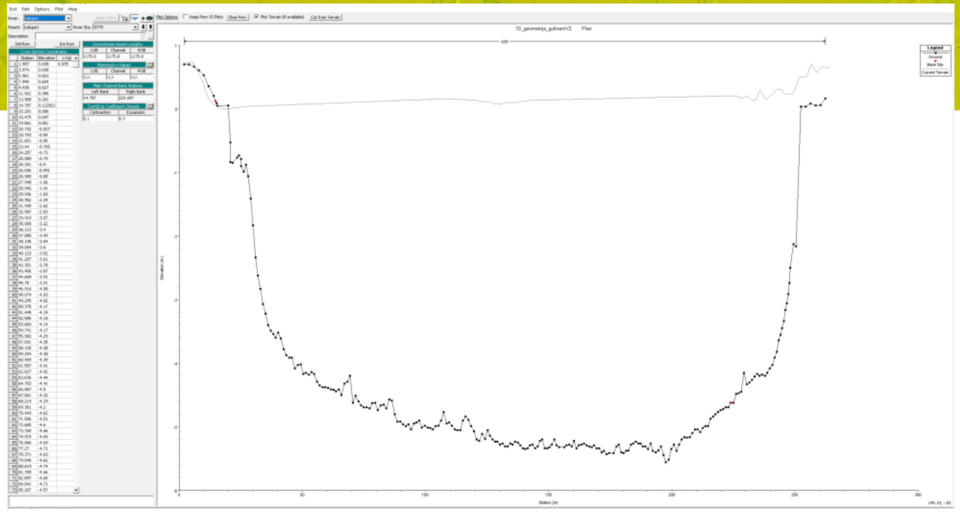
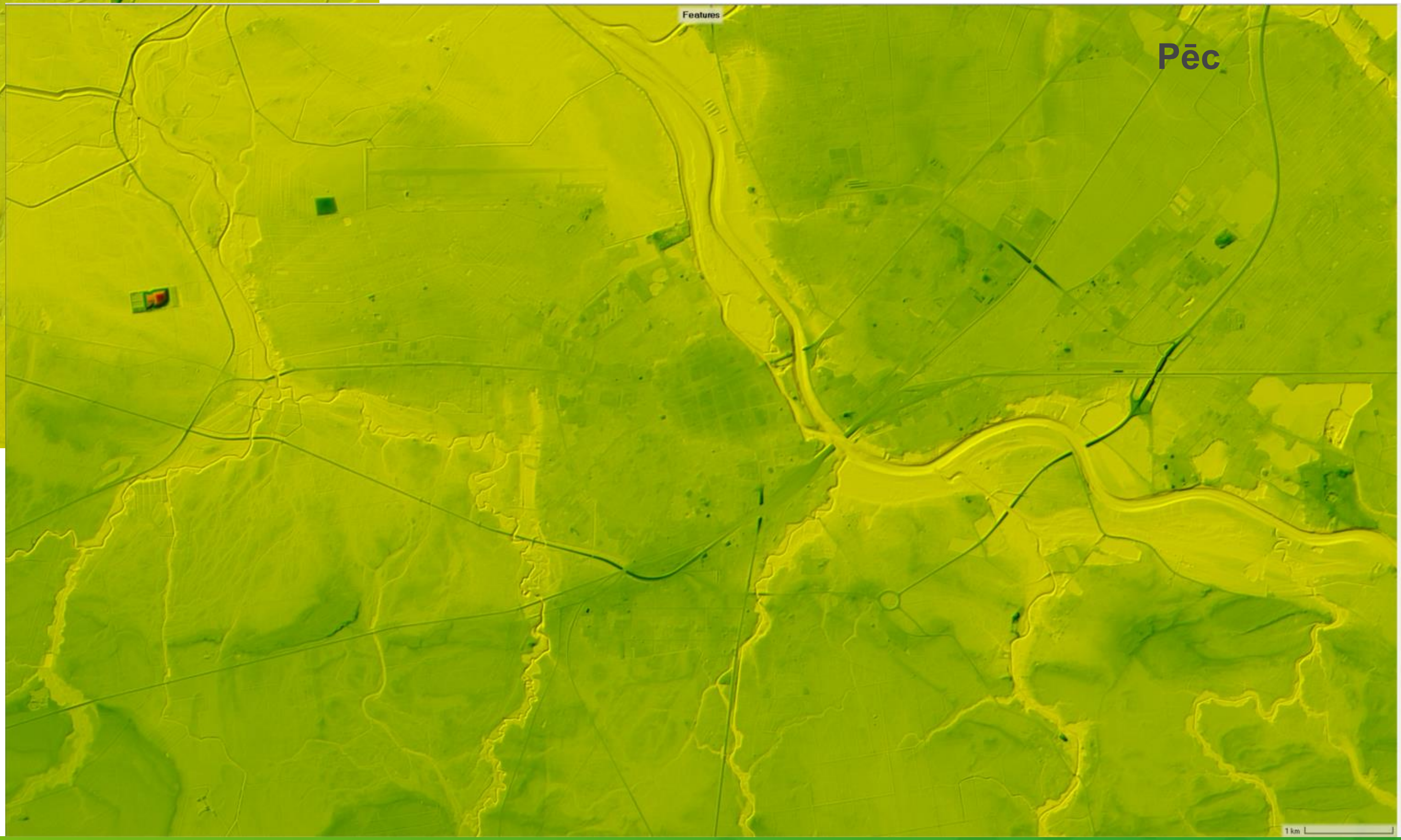
Digitālais augstuma modelis papildināts ar gultņu informāciju





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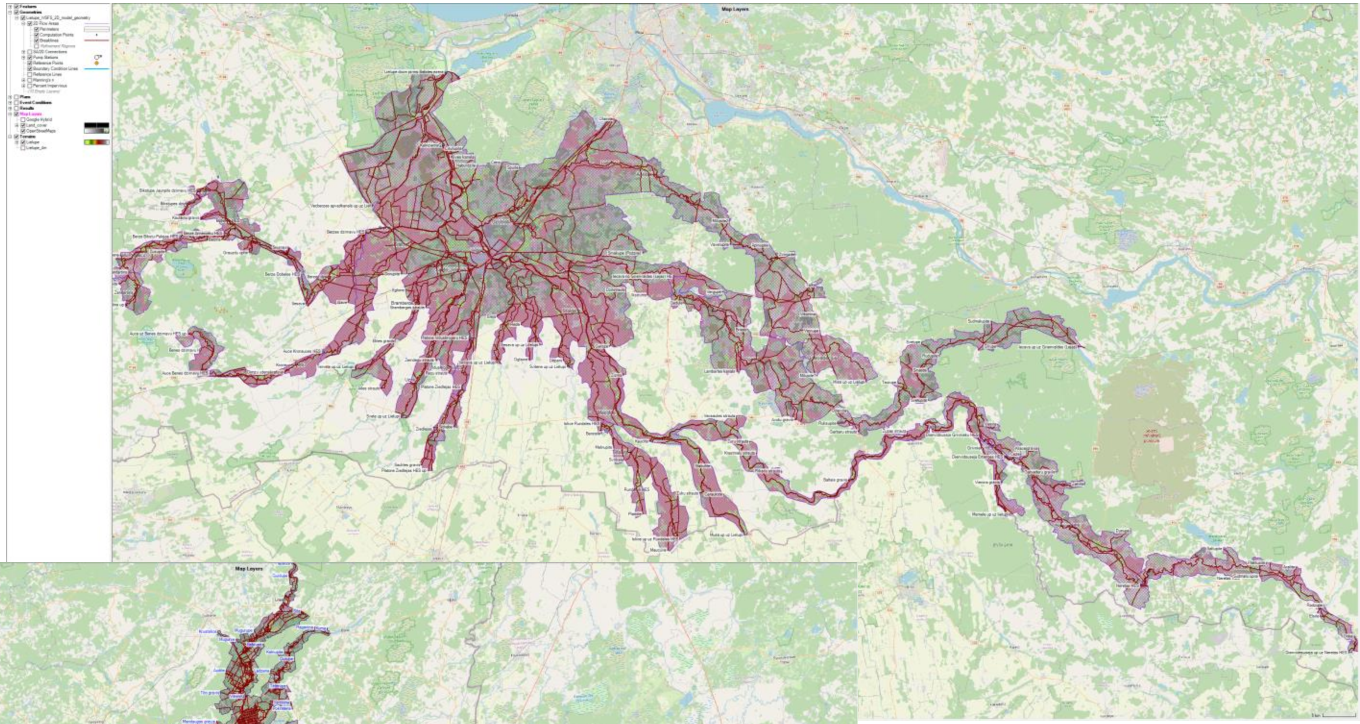
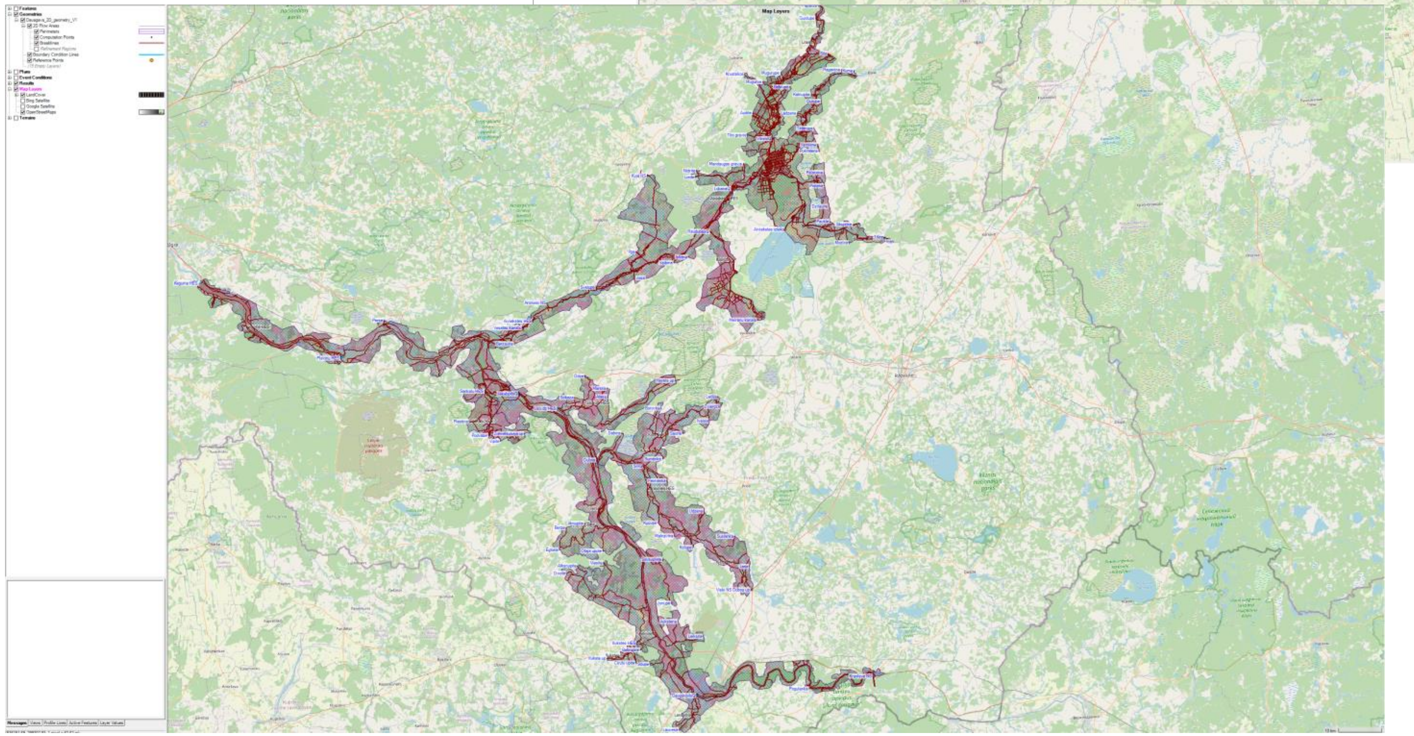
2D ģeometrija

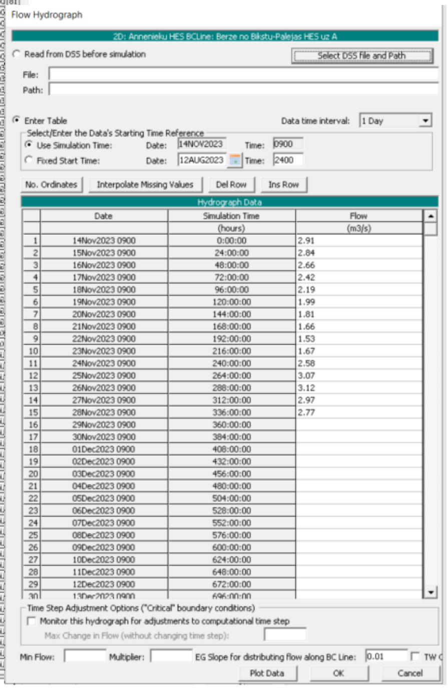
- 2D Modelēšanas teritorija
- *Boundary condition* vietas
- *Breaklines*
- *Zemes lietojuma veids (manninga koef. vērtības)*
- *Reljefa modelis*
- *un citi*

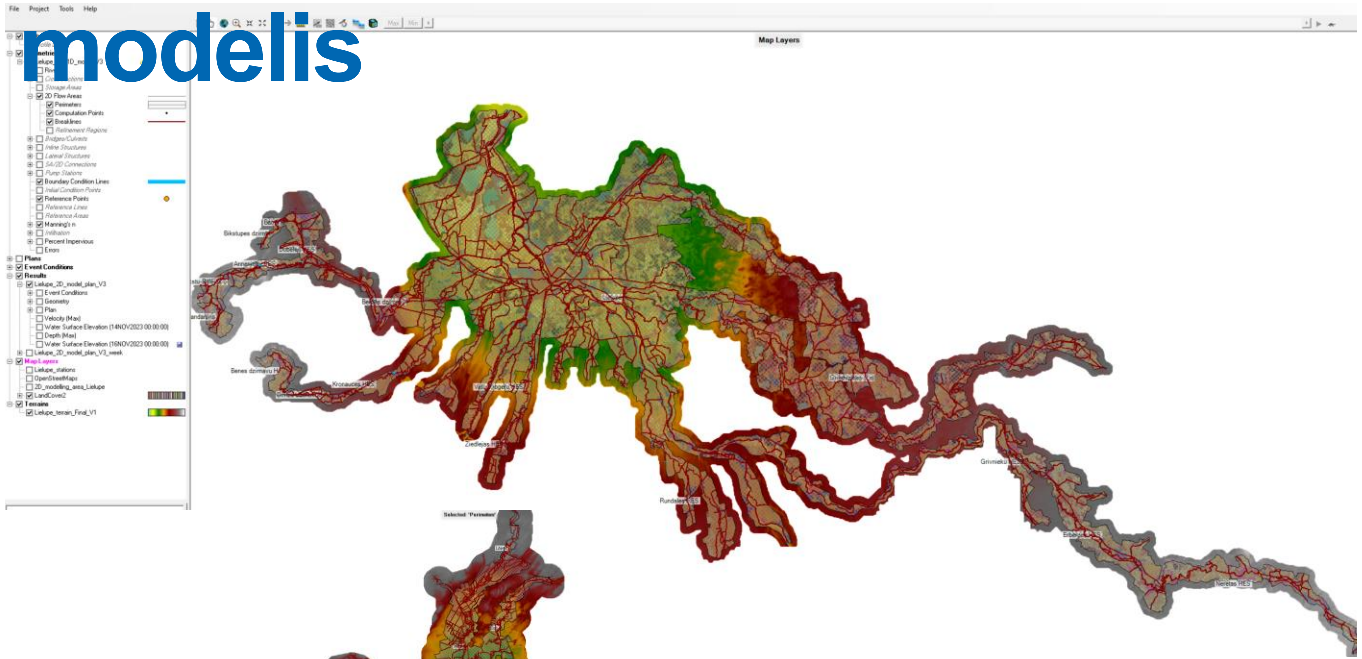


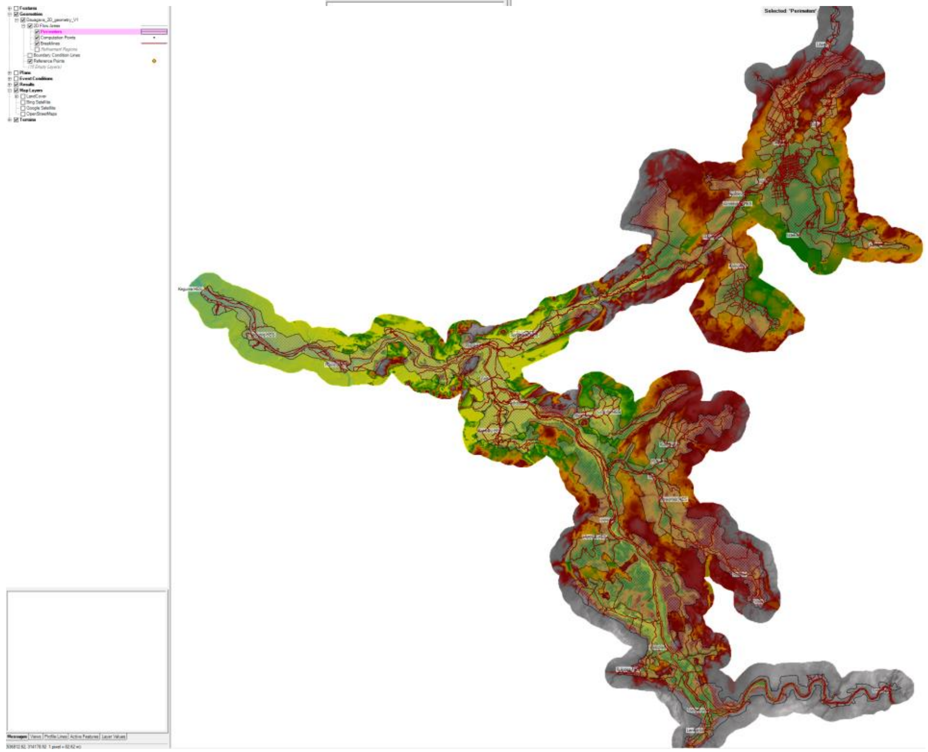


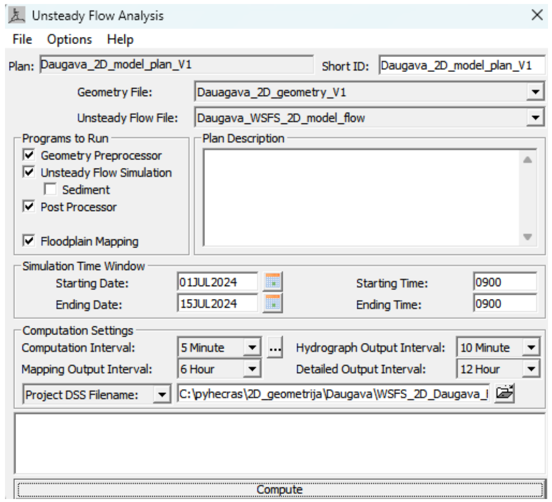
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037084.

Automatizēts 2D modelis









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Prognožu karšu vizualizācija…

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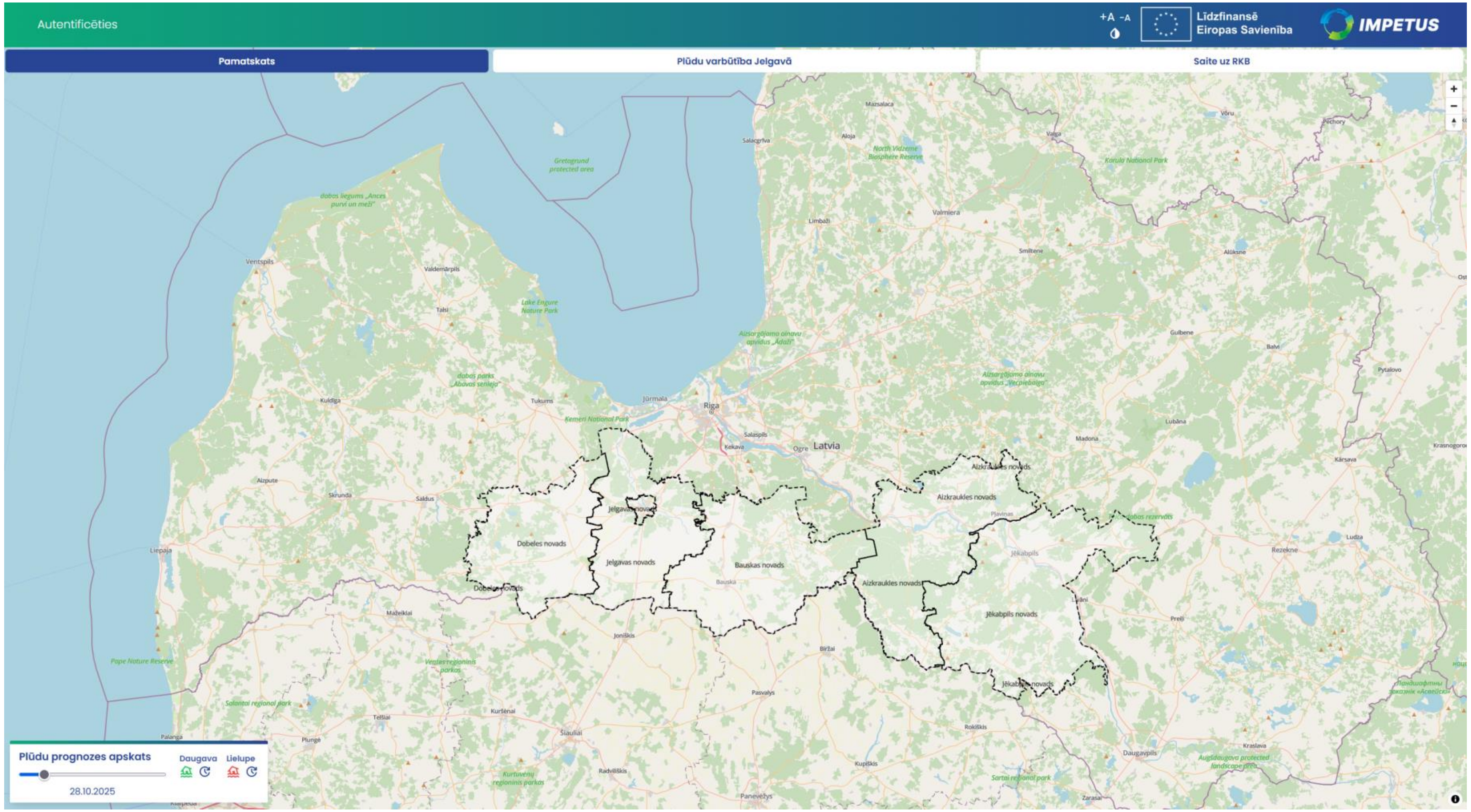
Modeļa rezultāti agrīnās brīdināšanas sistēmā

https://apzinosana.lv/

Par šo nākamajā prezentācijā!



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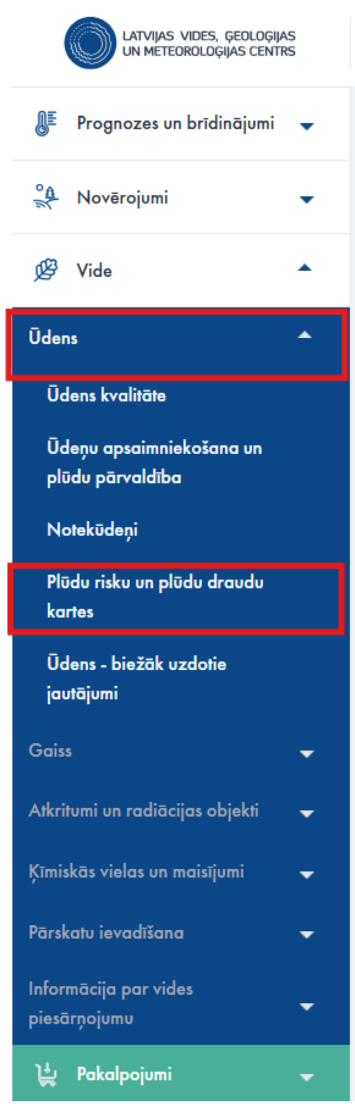
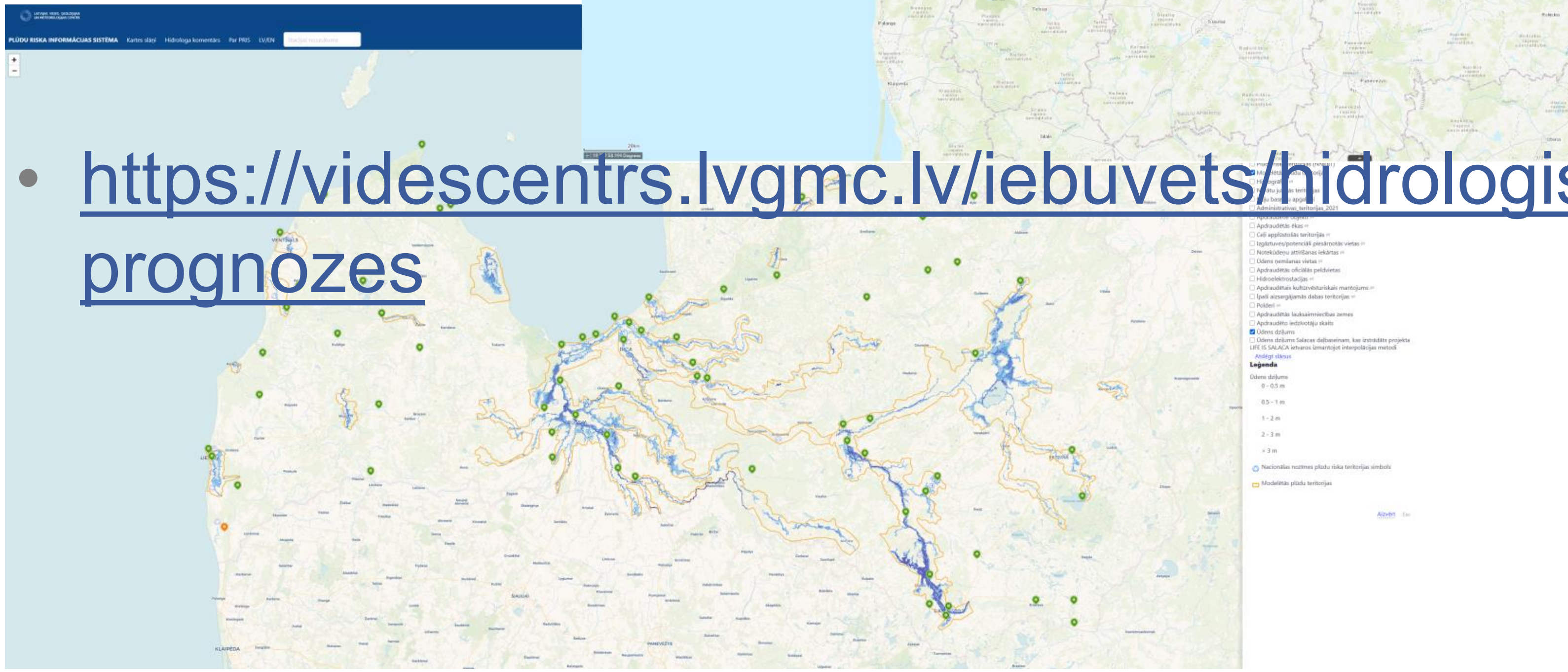
Plūdu draudu un plūdu riska kartes



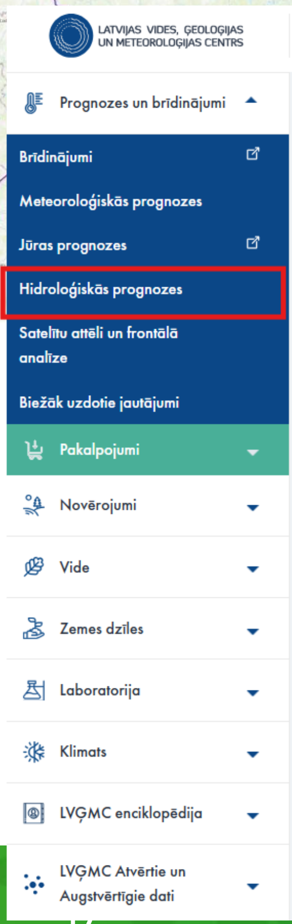
Kur meklēt?

- https://videscentrs.lvgmc.lv/iebuvets/pludu-riska-un-pludu-draudu-kartes

vai



- https://videscentrs.lvgmc.lv/iebuvets/hidrologiskas-prognozes



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Plūdu draudu un plūdu riska kartes

- **Trīs " galvienie" scenāriji** (0.5%, 1% un 10%) **pavasara palu un jūras vējuzplūdu** situācijām
- 4 papildu scenāriji: 2%, 5%,; 20% un 50%
- Nākotnes scenāriji
- Cita veida kartes: Ledus plūdu risks, lietus plūdu risks u.c.
- Kartēs **ietverta informācija** par:
  – plūdu riska teritorijām
  – ūdens dziļumiem applūstošās teritorijās
  – iedzīvotāju blīvumu
  – infrastruktūru (ceļiem, polderiem, zemes lietojumveidu)
  – riska objektiem (dzīvojamās mājas, notekūdeņu attīrīšanas iekārtas u.c.)
  – kultūrvēsturiskā mantojuma pieminekļiem applūstošās teritorijās

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IMPETUS