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LATVIJAS VIDES, ĢEOLOĢIJAS
UN METEOROLOĢIJAS CENTRS

Latvia – Lithuania

ICEREG

CONCEPTUAL MODEL OF ICE-JAM FLOOD FORMATION, RESULTS AND UNCERTAINTIES

EDUARDS KRIŽICKIS | HYDROMORPHOLOGY EXPERT
PROJECT FINAL CONFERENCE, 21.01.2026

DATA SOURCES AND LIMITATIONS



Historical data for period 1961-2023 from hydro-meteorological monitoring stations of LEGMC

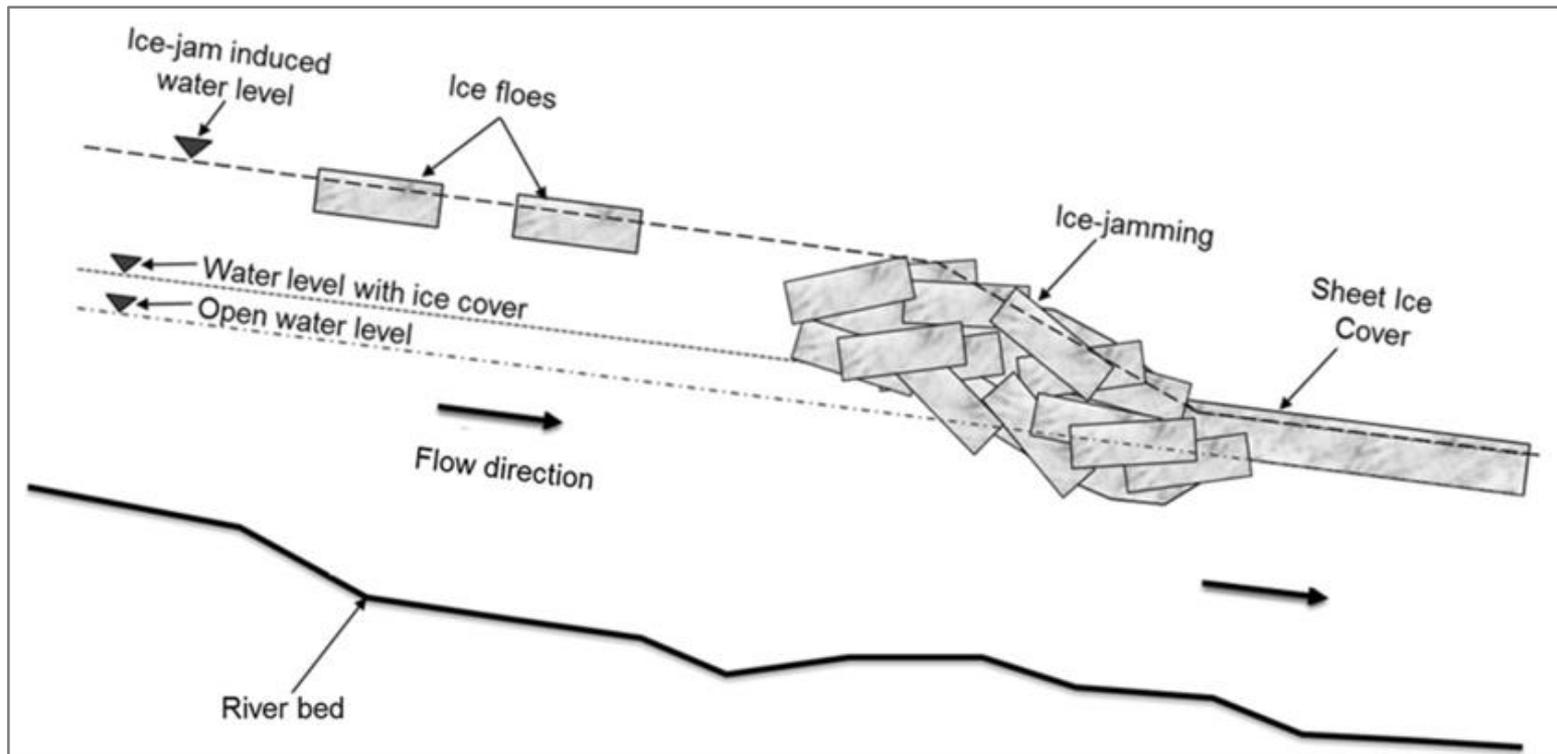
Data	Automatically monitored	Limited available	Calculated
Water level before ice-jam	x		
Maximum water level during ice-jam	x		
Water level rise			x
Stream velocity		x	
Cross-section area under ice		x	
Ice-jam length		x	
Ice-jam volume			x
Water discharge (runoff)		x	x
Ice thickness		x	
Meteorological data	x		

DATA ANALYSIS FOR CONCEPTUAL MODEL OF THE ICE-JAM FORMATION

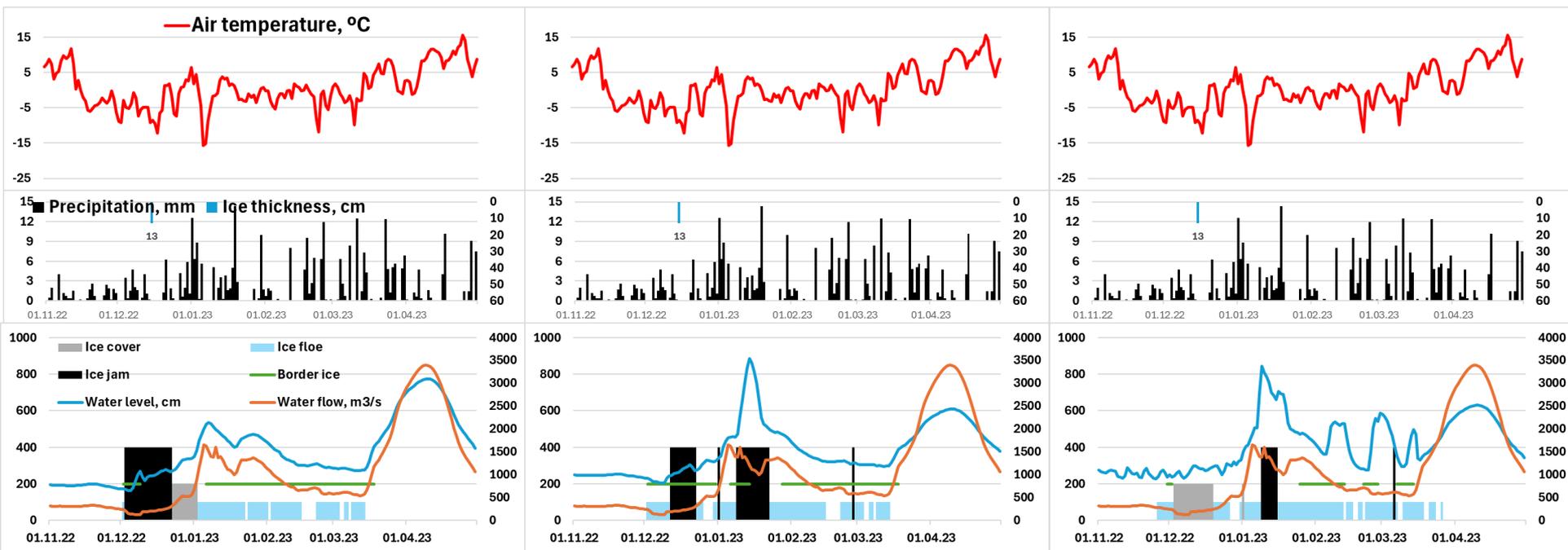


Integrated
graphs
analysis

Correlation
matrix
method

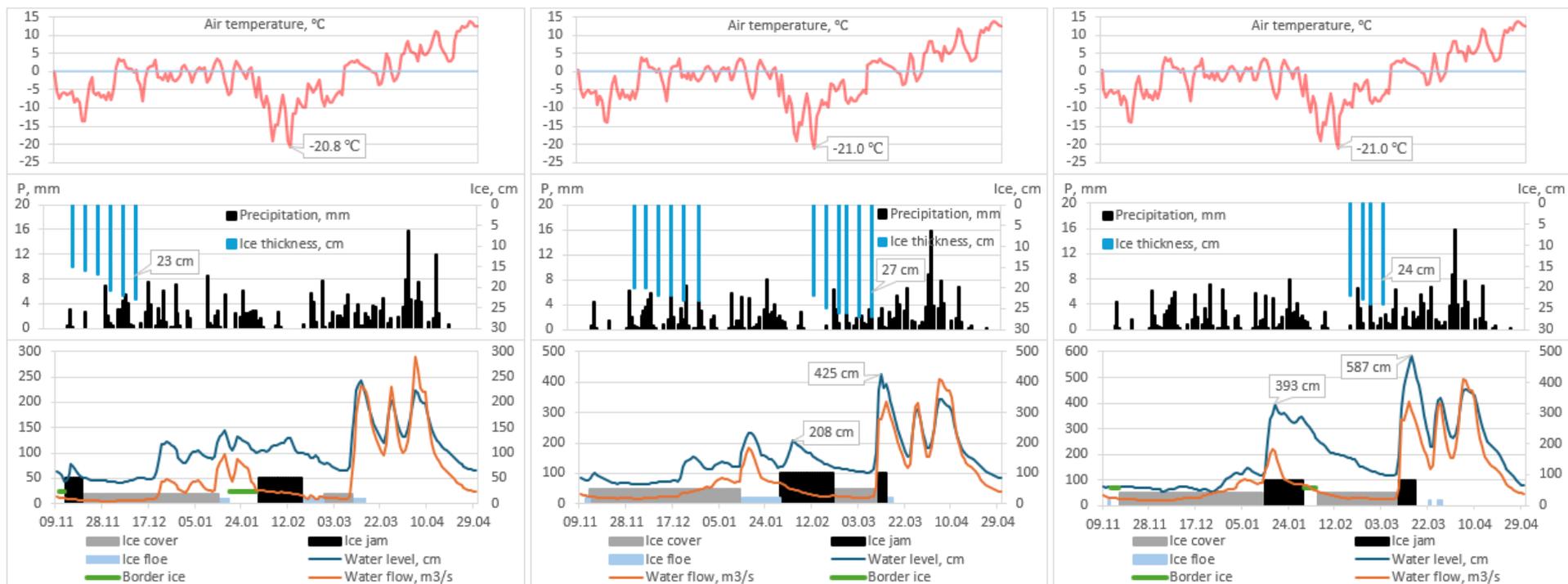


METEOROLOGICAL CONDITIONS - DAUGAVA



Integrated graphs of the meteorological (MS Zīlāni) and hydrological parameters (HS Jersika – left, HS Jēkabpils – centre and HS Zeļķi – right) of the Daugava River, 2023

METEOROLOGICAL CONDITIONS - LIELUPE

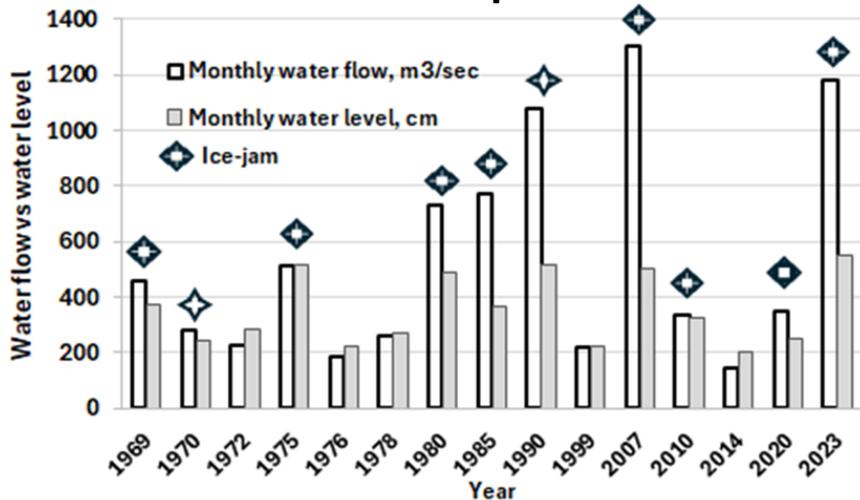


Integrated graphs of the meteorological (MS Bauska) and hydrological parameters (HS Bauska – left, HS Mežotne – centre and HS Staļģene – right) of the Lielupe River, 1980

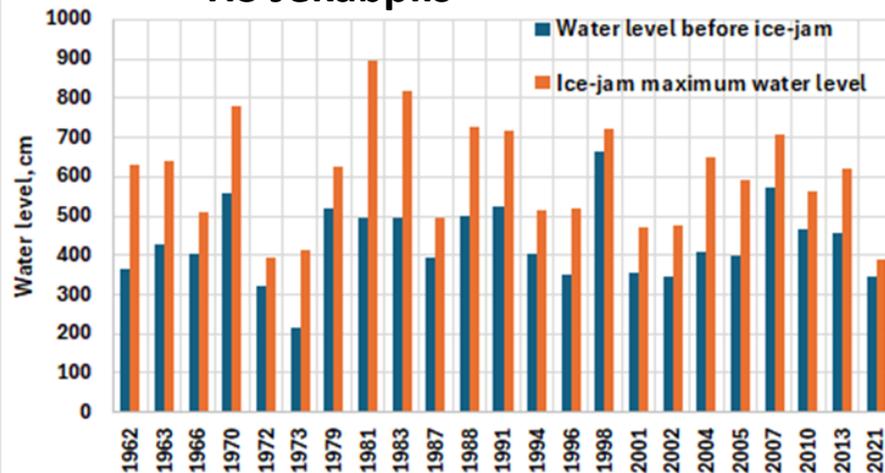
HYDROLOGICAL CONDITIONS - DAUGAVA



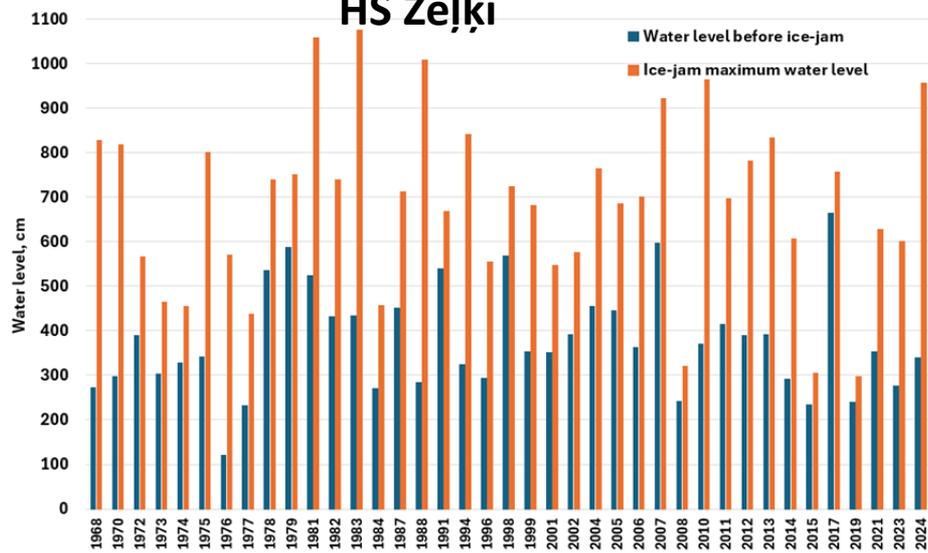
HS Jēkabpils



HS Jēkabpils



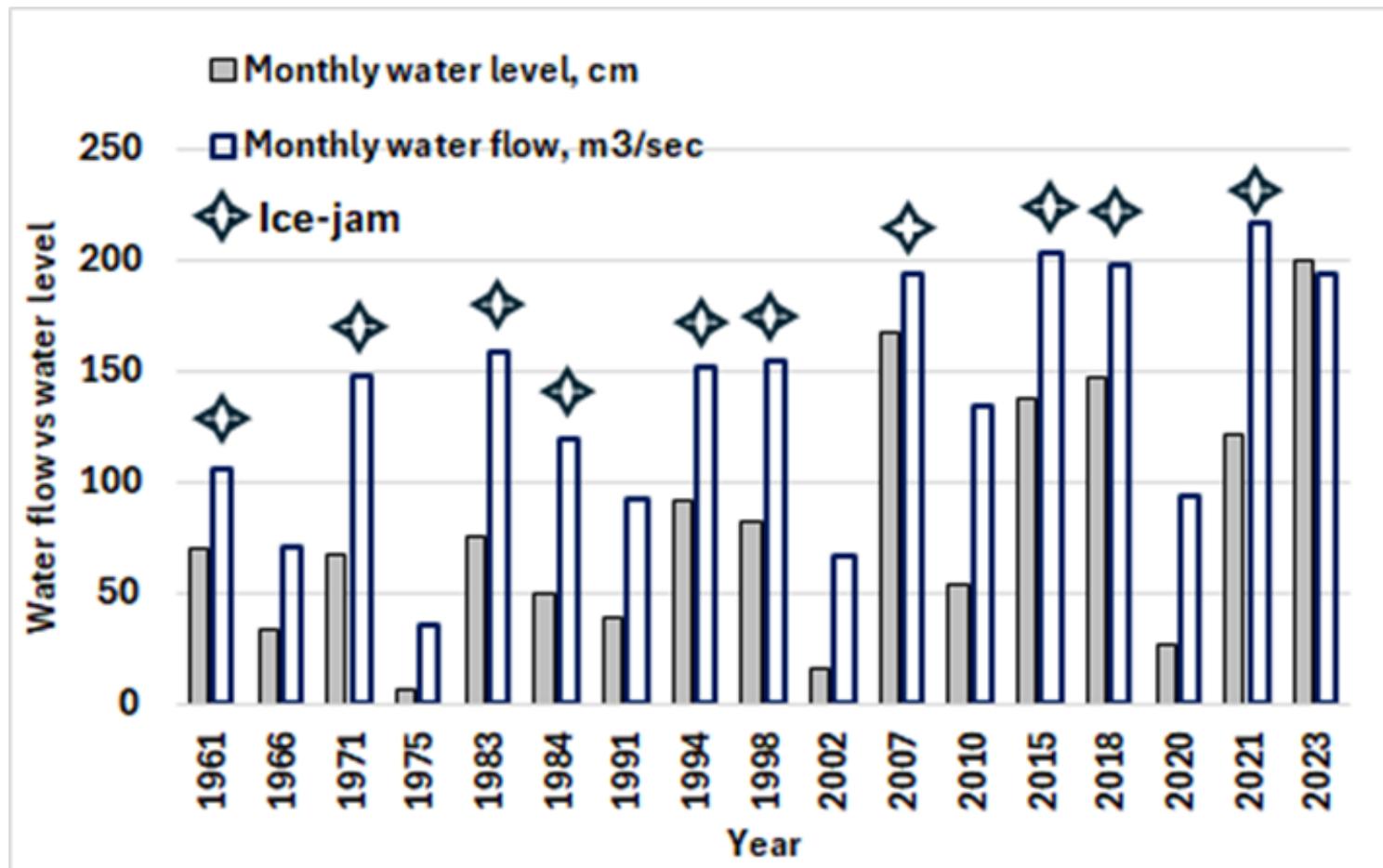
HS Zeļķi



HYDROLOGICAL CONDITIONS - LIELUPE



HS Mežotne



CORRELATION ANALYSIS



Correlation Analysis Results for HS 'Lielupe – Staļģene' (Winter Ice-Jams)

Date of ice-jam beginning	WL max, cm	NDD sum before ice-jam	Ice-jam volume, mil m ³	XS area under ice, m ²
15.01.1971.	448	-152.6	1.50	107
16.12.1979.	220	-74	0.66	127
16.12.1986.	147	-10.4	1.41	129
15.01.1992.	259	-62.1	0.57	177
26.12.1997.	271	-132.8	1.28	166
23.12.2021.	405	-104.5	2.63	322

	WL max	NDD sum	Ice-jam volume	XS area under ice
WL max	1			
NDD sum	-0.82039	1		
Ice-jam volume	0.559409	-0.27706	1	
XS area under ice	0.363863	-0.09129	0.714233017	1

Correlation Analysis Results for HS 'Lielupe – Staļģene' (Spring Ice-Jams)

Date of ice-jam beginning	WL rise, m	PDD sum before ice-jam	Ice-jam volume, mil m ³	Stream velocity (V avr.), m/s
10.04.1963.	302	5.2	5.25	0.24
02.04.1980.	314	10.3	4.17	0.12
25.02.2000.	28	124.5	0.49	0.72
28.02.2017.	164	143.2	1.43	0.22

	WL rise	PDD sum	Ice-jam volume	Stream velocity
WL rise	1			
PDD sum	-0.86068	1		
Ice-jam volume	0.94254	-0.94738	1	
Stream velocity	-0.88795	0.535462	-0.697129205	1

CORRELATION ANALYSIS



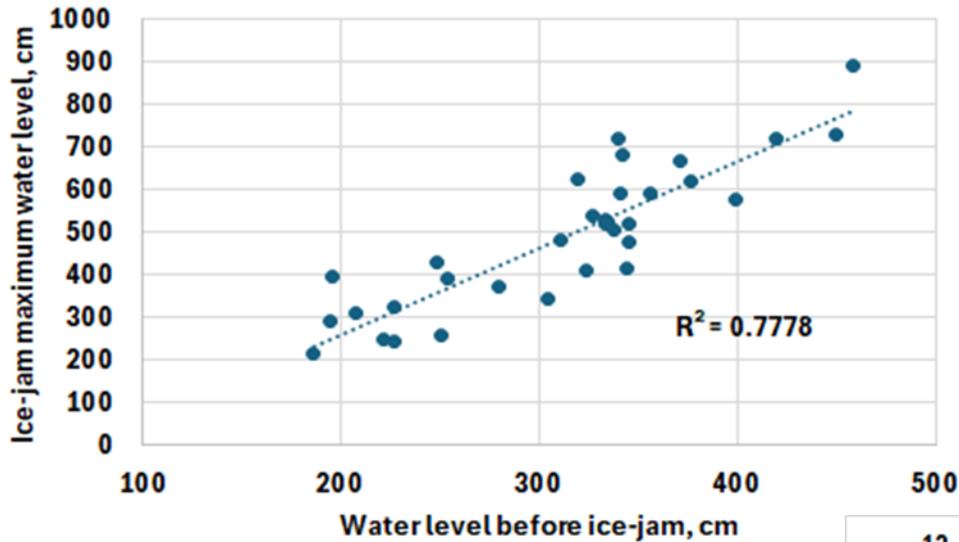
Correlation Analysis Results for HS 'Daugava - Jēkabpils' (Winter & Spring Ice-Jams)

Date of ice-jam beginning	WL rise, m	NDD sum before ice-jam	PDD sum before ice-jam	Ice-jam volume, mil m ³	Stream velocity (V avr.), m/s
09.04.1962.	306	-607.9	37.9	21.8	0.77
16.04.1963.	303	-1182.7	15.2	25.2	0.95
13.03.1966.	120	-792.4	28.7	25.8	0.2
10.12.1969.	172	-38.2	0	6.2	0.84
05.04.1970.	426	-733.8	19.3	29.6	1.15
04.04.1972.	72	-635.8	67.1	16.0	1.05
25.03.1973.	196	-331.9	30.5	4.8	0.59
12.01.1975.	380	-44.9	36.8	10.4	0.54
03.04.1979.	106	-973.9	31	40.8	1.79
18.12.1980.	280	-163.3	44.1	9.4	1.41
22.03.1981.	403	-380.4	16.2	21.8	0.52
25.03.1983.	322	-321.8	66	10.5	0.47
26.11.1985.	188	-56.6	0	16.96	1.09
06.04.1987.	101	-1023.2	28	15.14	0.23
24.01.1988.	186	-198.7	72.2	10.29	0.35
26.03.1988.	396	-199.3	10.5	21.08	0.55
21.01.1989.	72	-263.1	44.8	3.61	0.98
05.01.1990.	299	-247.4	24	2.84	0.87
15.12.1990.	339	-20.2	9.8	2.89	0.91
...
18.01.2021.	91	-94.2	18.4	11.2	0.41
01.03.2021.	42	0	15.9	12.2	0.51
10.12.2021.	305	-78.2	0	10.1	0.42
21.12.2021.	250	-6	4.1	10.1	0.42
10.12.2022.	100	-89	0	4.3	0.16
09.01.2023.	434	-60.4	25.8	8.2	0.63
03.12.2023.	178	-63.4	0.6	6.3	0.21
06.01.2024.	175	-66.8	15.9	6.7	0.65

	WL rise	NDD sum	PDD sum	Ice-jam volume	Stream velocity
WL rise	1				
NDD sum	-0.08318	1			
PDD sum	0.056823	-0.07748	1		
Ice-jam volume	0.175635	-0.67765	0.160337	1	
Stream velocity	0.10773	-0.29569	-0.13563	0.266371924	1

WL max (the maximum water level during an ice jam) and WL rise (difference between the maximum water level during an ice jam and the water level before an ice jam) are dependent variables

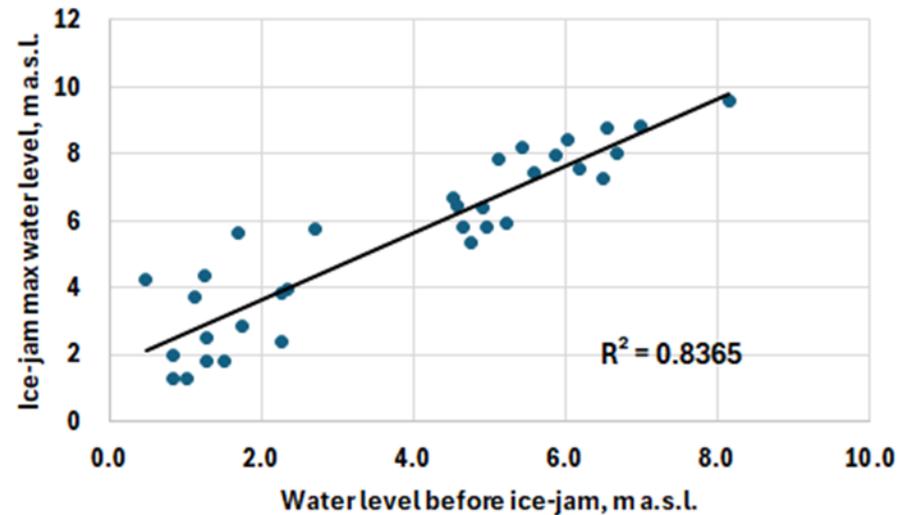
CORRELATION ANALYSIS



HS Daugava - Jēkabpils



HS Lielupe - Mežotne



HOW DOES RIVERBED MORPHOLOGY AFFECT ICE JAM FORMATION?



➤ Natural river characteristics:

- Sharp meander bends
- Shallow reaches
- Channel narrowing
- Islands & bottom bars
- River mouths & confluence of rivers
- Changes in flow velocity

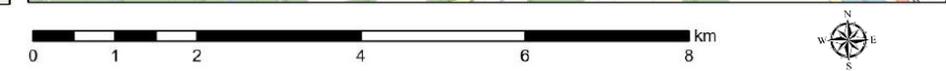
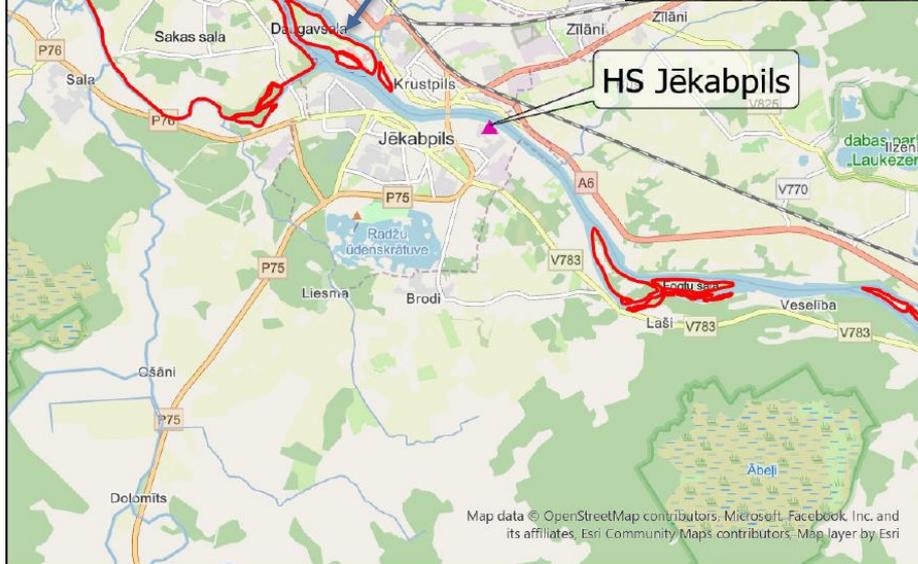
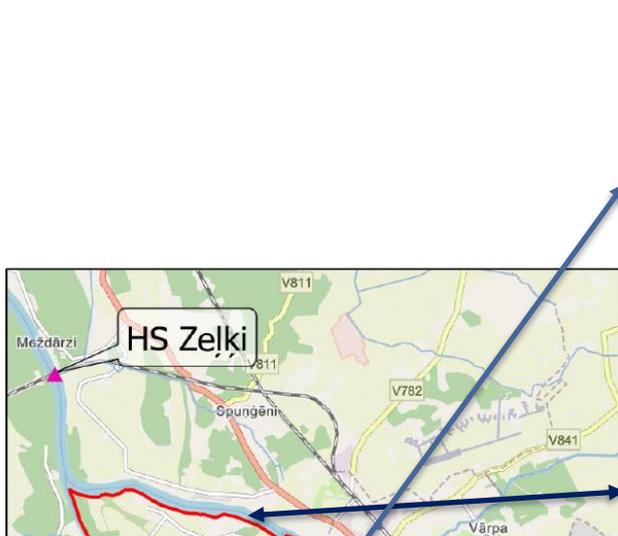


➤ Artificial structures:

- Bridges (bridge piers)
- Culverts
- Dams, etc.



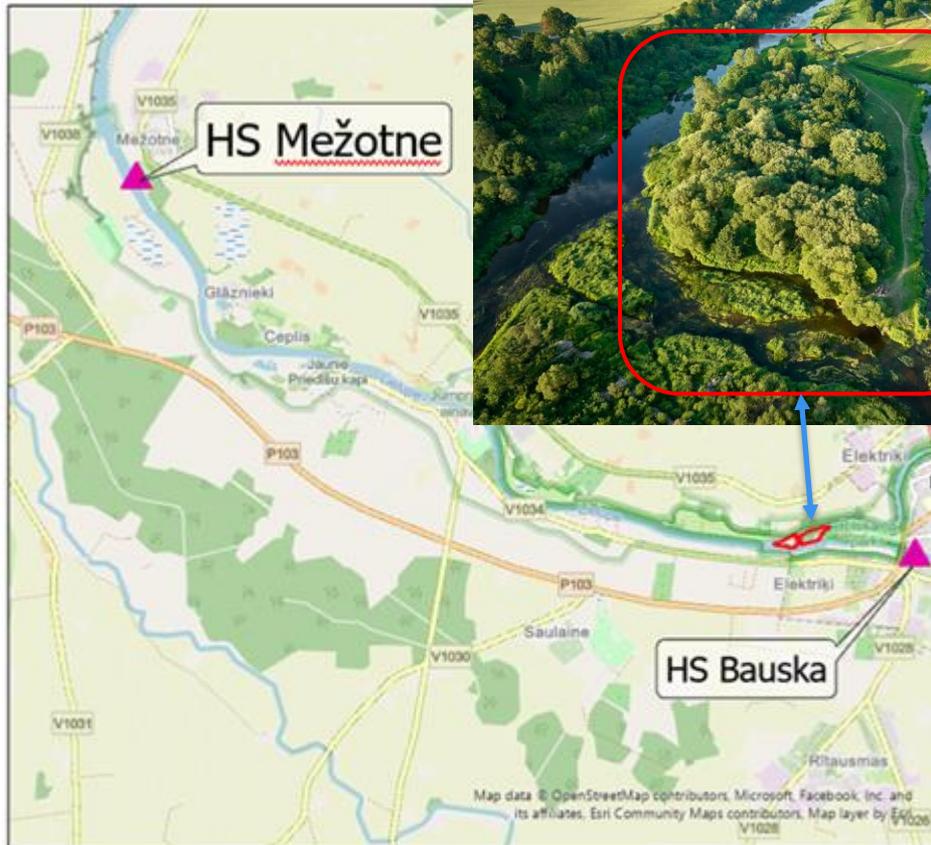
HYDROMORPHOLOGICAL CONDITIONS - DAUGAVA



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HYDROMORPHOLOGICAL CONDITIONS - LIELUPE



Legend

 Islands

Legend

 Islands

MAIN FACTORS FOR ICE-JAM FORMATION - DAUGAVA



➤ *River morphology:*

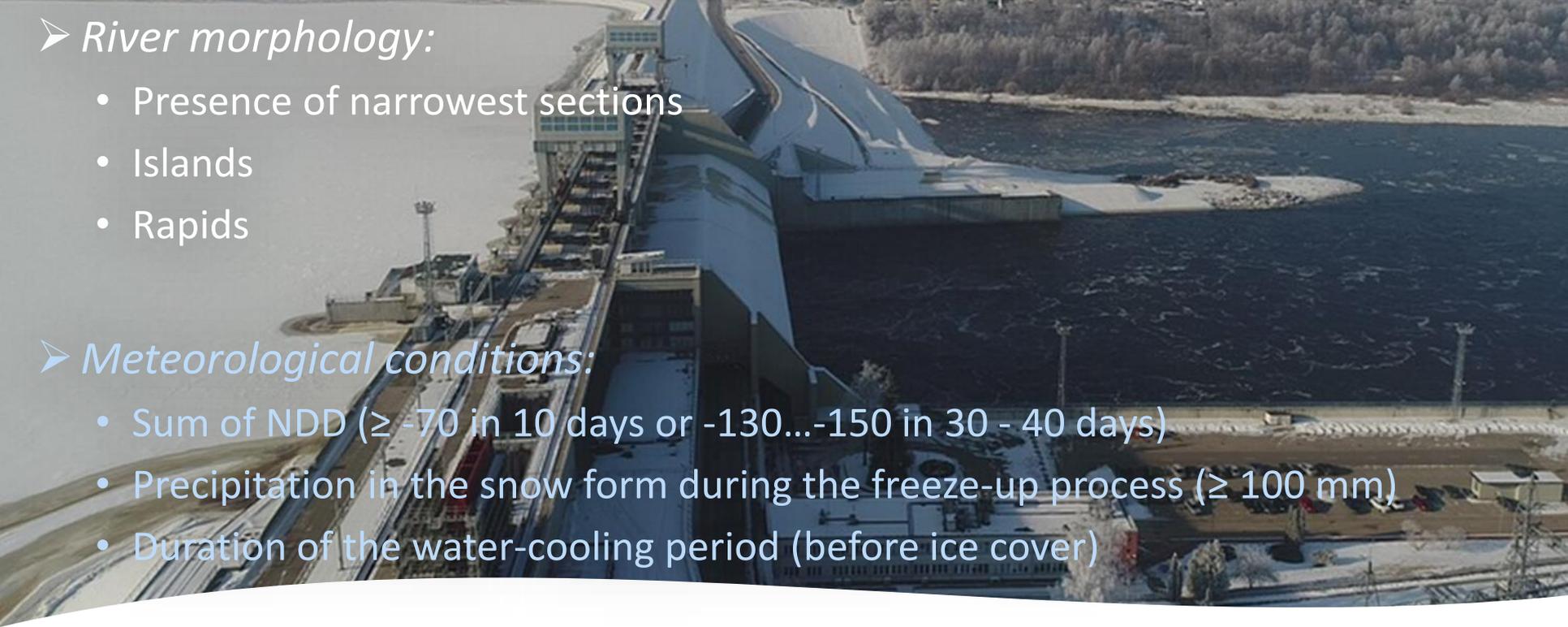
- Presence of narrowest sections
- Islands
- Rapids

➤ *Meteorological conditions:*

- Sum of NDD (≥ -70 in 10 days or $-130 \dots -150$ in 30 - 40 days)
- Precipitation in the snow form during the freeze-up process (≥ 100 mm)
- Duration of the water-cooling period (before ice cover)

➤ *Hydrological conditions:*

- Water discharge before an ice jam (≥ 330 m³/s)
- Water level before an ice jam (≥ 400 cm at Jēkabpils HS; ≥ 300 cm at Zeļķi HS)
- Changes of surface water gradient after construction of the Pļaviņas HPP Reservoir



MAIN FACTORS FOR ICE-JAM FORMATION - LIELUPE



➤ *River morphology:*

- Islands
- Presence of narrowest sections
- Rapid depth variations from one section to another
- Staļģene Bridge

➤ *Meteorological conditions:*

- Sum of NDD (≤ -300 during a freeze-up; ~ -1000 before a break-up)
- Count of PDD ($< 50-55$ days) & Sum of PDD (< 80)
- Positive air temperature during an ice jam

➤ *Hydrological conditions:*

- Water level before an ice-jam (≥ 200 cm at Mežotne HS)
- Water discharge before an ice-jam (≥ 100 m³/s)



UNCERTAINTIES

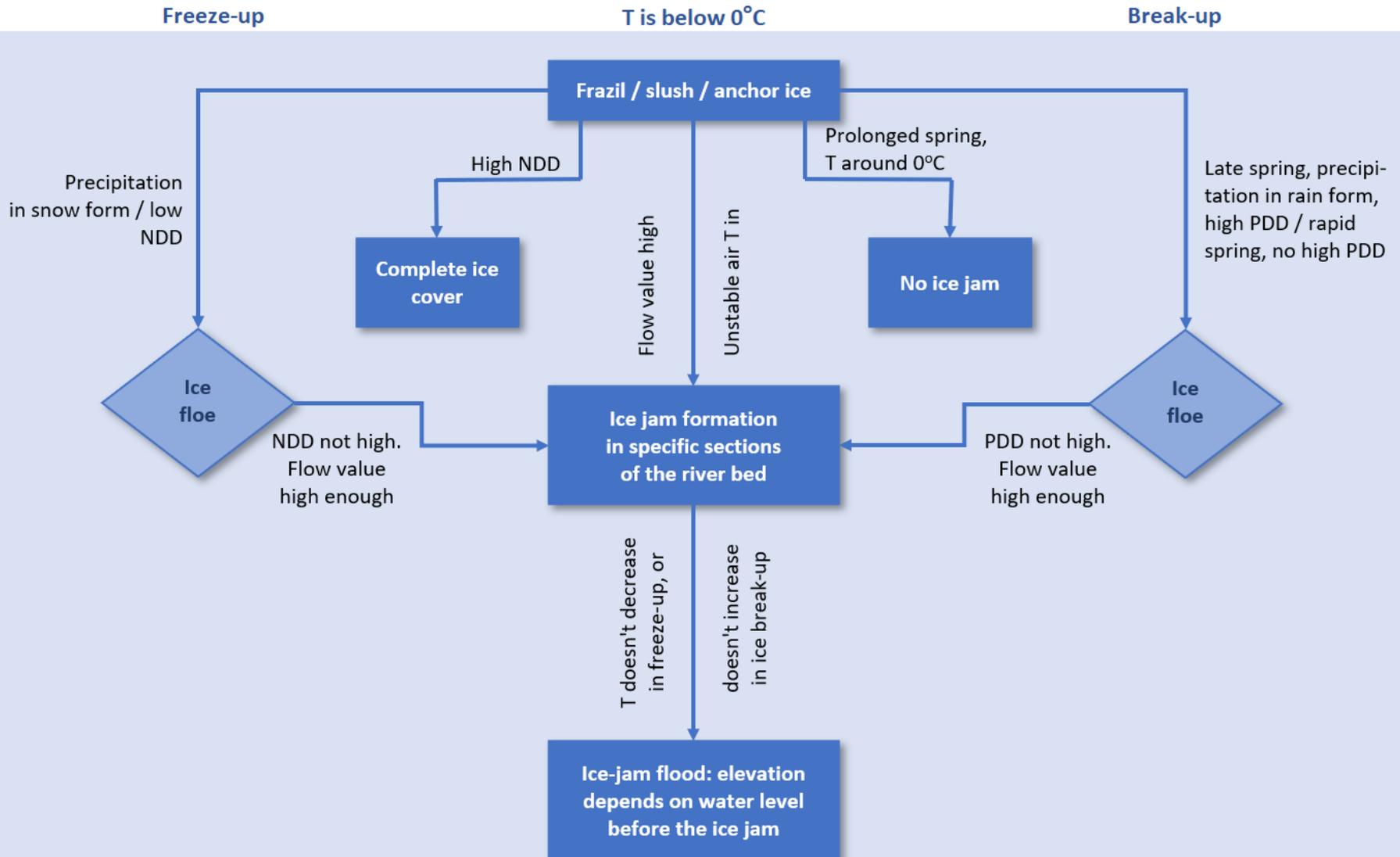


- We don't have exact data along the river, because our HS are located at a long distance from each other.

HS	Distance between HS, km
Jersika - Jēkabpils	40
Jēkabpils - Zeļķi	12
Tabokine - Mežotne	77 (!)
Bauska - Mežotne	10
Mežotne - Staļģene	17
Staļģene - Jelgava	20

- During winter period, when we have incomplete ice cover, the flow and ice measurements aren't carried out.
- We have web cameras for ice phenomena observations, and the results of observations depend on weather conditions and camera resolution.

INTERACTION OF MULTIPLE DRIVERS FOR CREATING CONCEPTUAL MODEL





THANKS FOR YOUR ATTENTION!



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