EGU-2020

May long-term historical hydrological data be misleading for flood frequency analysis in current conditions of climate change?

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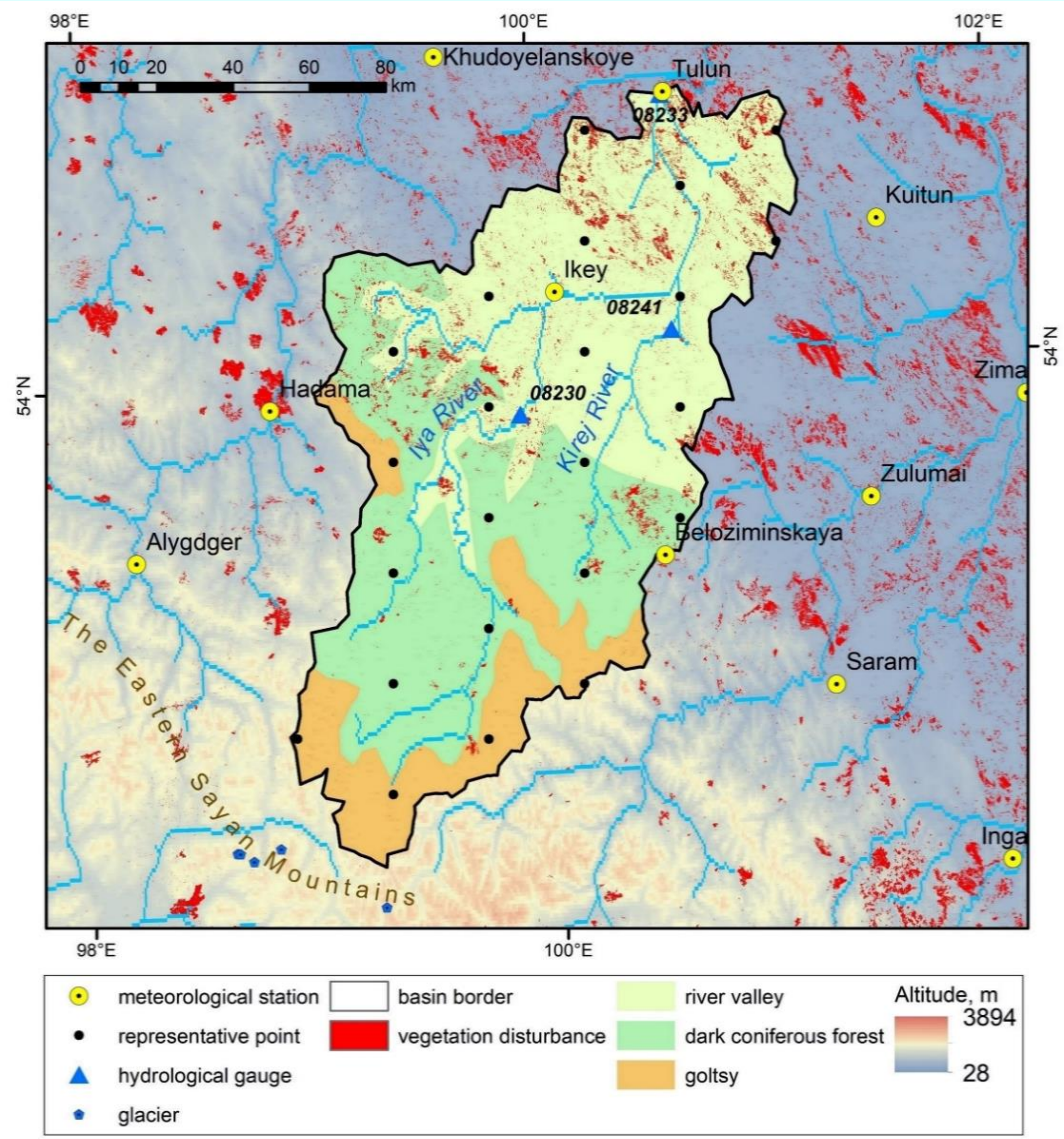
What has happened? – Historical flood

This flood became the most hazardous one in the region in 80 years history of observations.

- 25 people died
- 8 people are missing
- 3.7 thousand homes flooded
- 15 bridges destroyed
- 70 tons of crop washed away
- Economic damage from the flood in 2019 amounted up to half a billion Euro

Where has it happened? – the Iya River



- The South-Eastern part of Siberia, Russia;
- The northern slopes of the Eastern Sayan;
- The Iya River basin (14500 km^2);
- Maximum height (2789 m);
- The climate is sharply continental

What did cause the flood?

- heavy rains as a result of climate change?
- melting of snow and glaciers in the mountains of the East Sayan?
- deforestation of river basins due to clearings and fires?

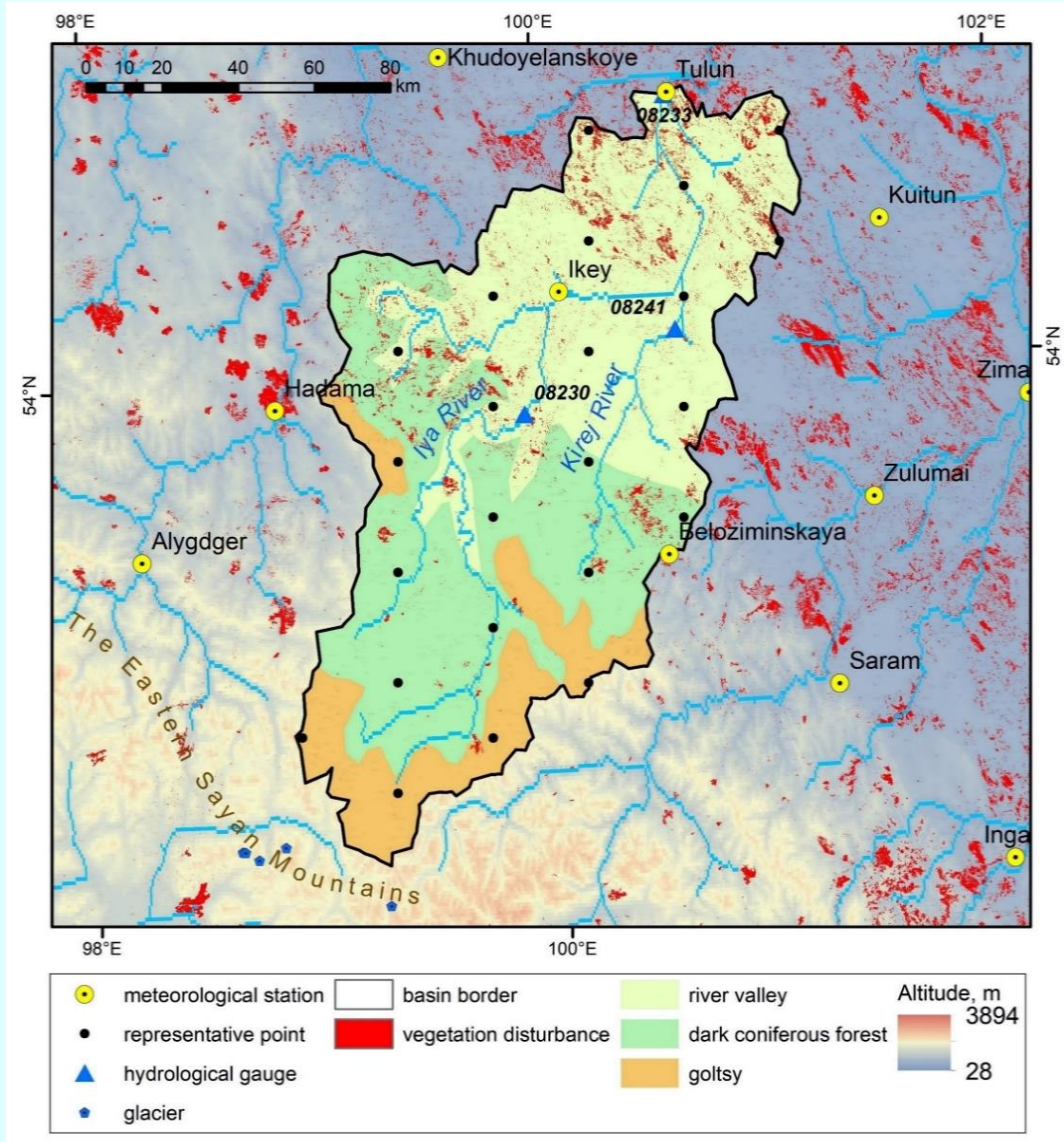
The **aim of the study** was to analyze the factors that led to the formation of a catastrophic flood in June 2019, as well as estimate the maximum discharge at the Iya River.

What did cause the flood? – **heavy rains**

- **Melting of snow and glaciers** in the mountains: **less than 10%** of the area was covered with snow. This **could not cause** flooding of such magnitude

- **Deforestation:** the area of losing forest in the basin consists of **no more than 4%** of the total catchment area.

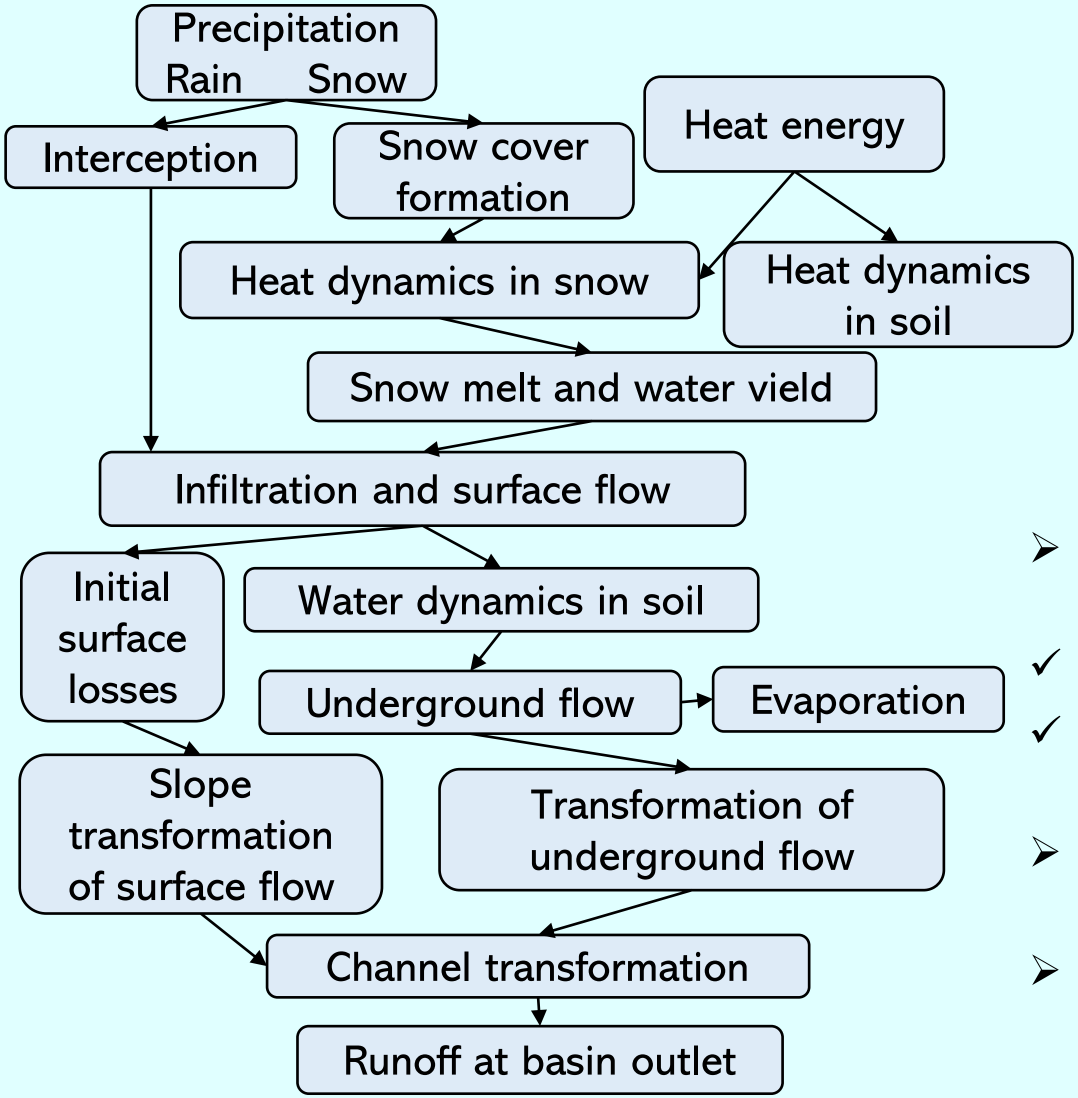
- From June 25 to 27, **from 170 to 250 mm** of precipitation fell. The **main cause of the flood was a heavy rain.**

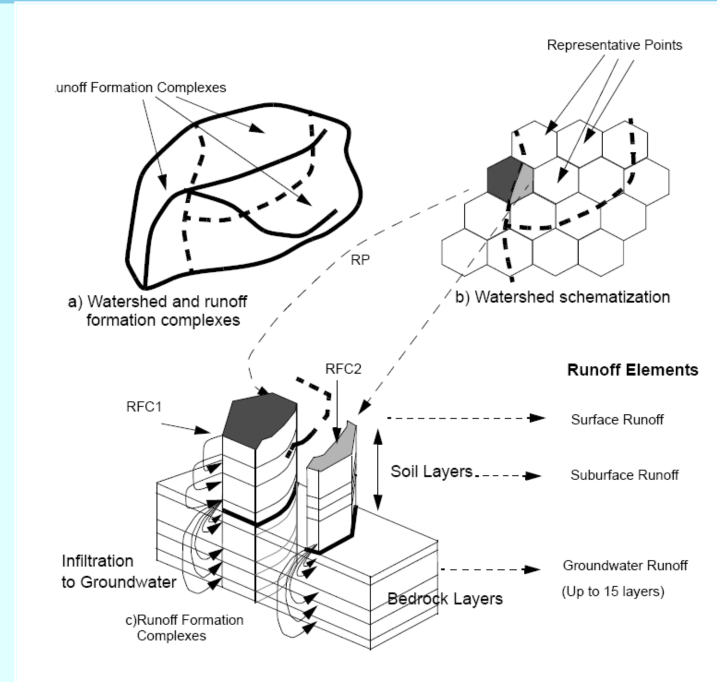


Hydrograph model

Developed by prof. Yu.B. Vinogradov
(SHI, Saint Petersburg)

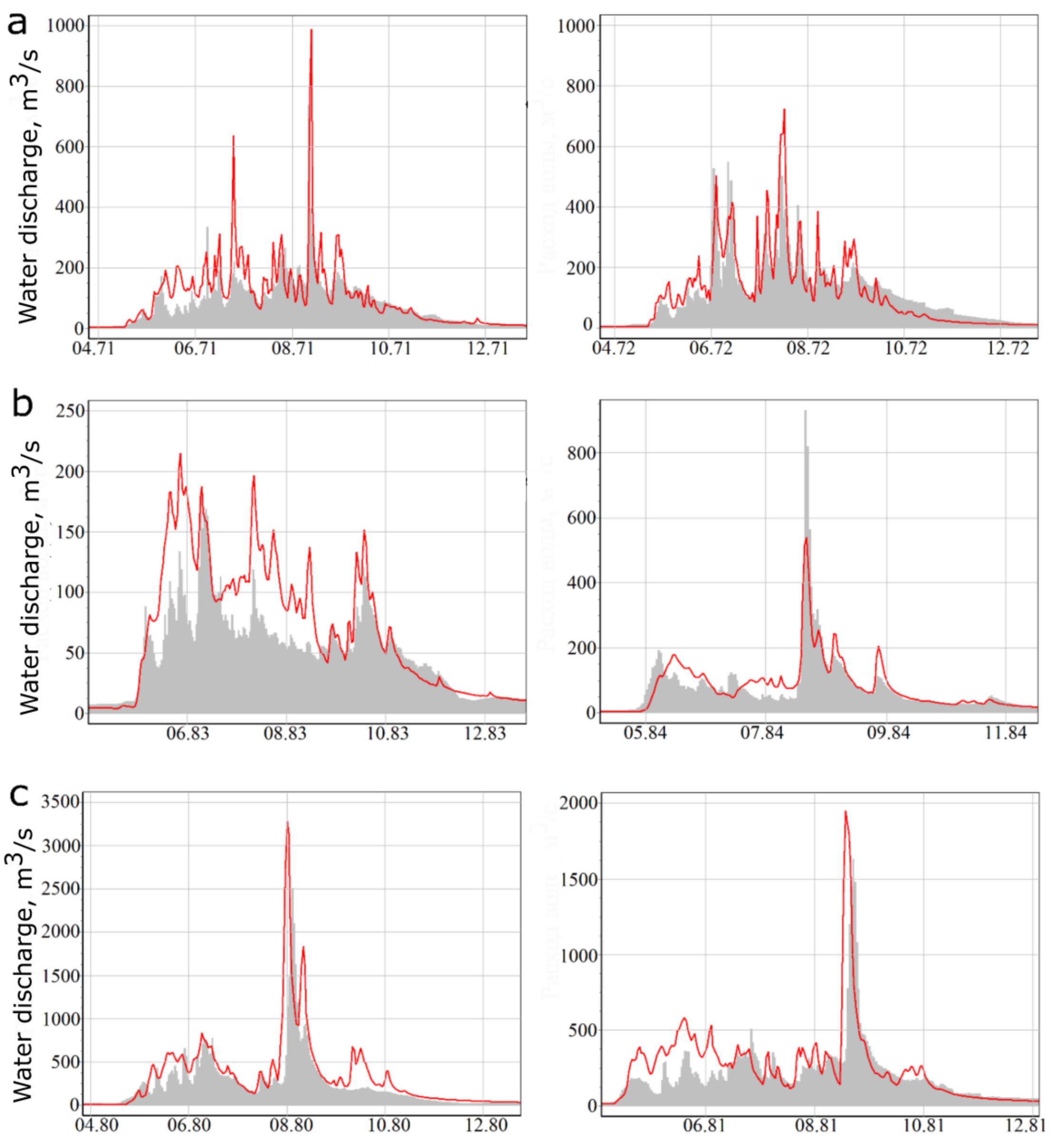
Distributed deterministic model of hydrological processes





- **Parameters:** measured properties of soils and vegetation cover
- ✓ Applicable to catchments of all sizes
- ✓ Applicable on basins in the permafrost zone
- **Input:** temperature, humidity, precipitation
- **Output:** hydrographs in the last discharge section line, water balance characteristics, soil and snow conditions

Model verification for 3 basins

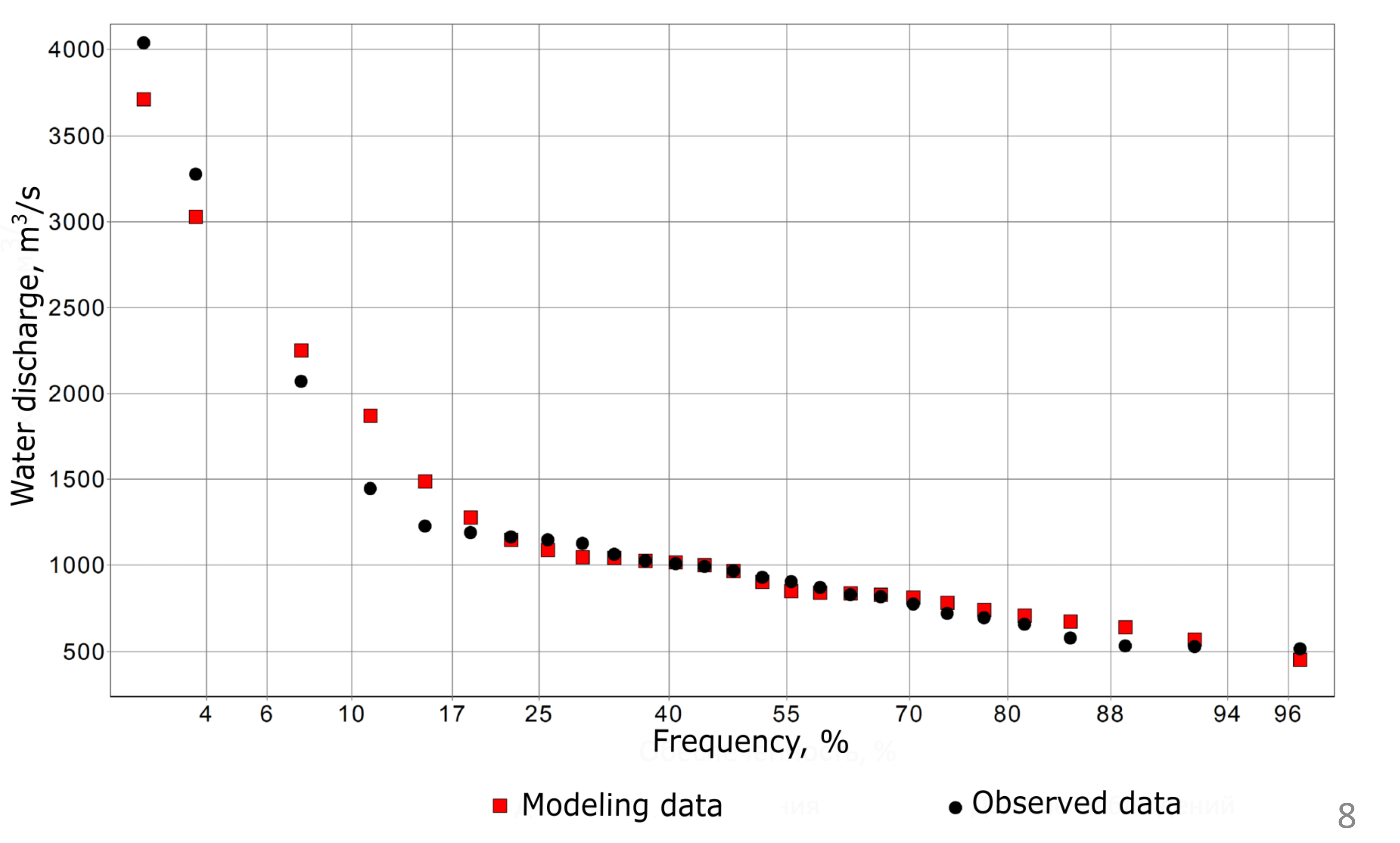


3 basins:
a – the Kirej river, Ujgat
b – the Iya river, Arshan
c – the Iya river, Tulun.

River	a	b	c
Period	1959-2017	1963-2017	1941-2017
S (km^2)	2950	5140	14500
H (m)	873	1483	979
Flow.obs.	374	540	326
Flow.sim.	402	528	338
Precip.	688	771	586
Evap.	286	243	247
NS (m/av)	0,66/0,57	0,69/0,62	0,72/0,67

Model verification

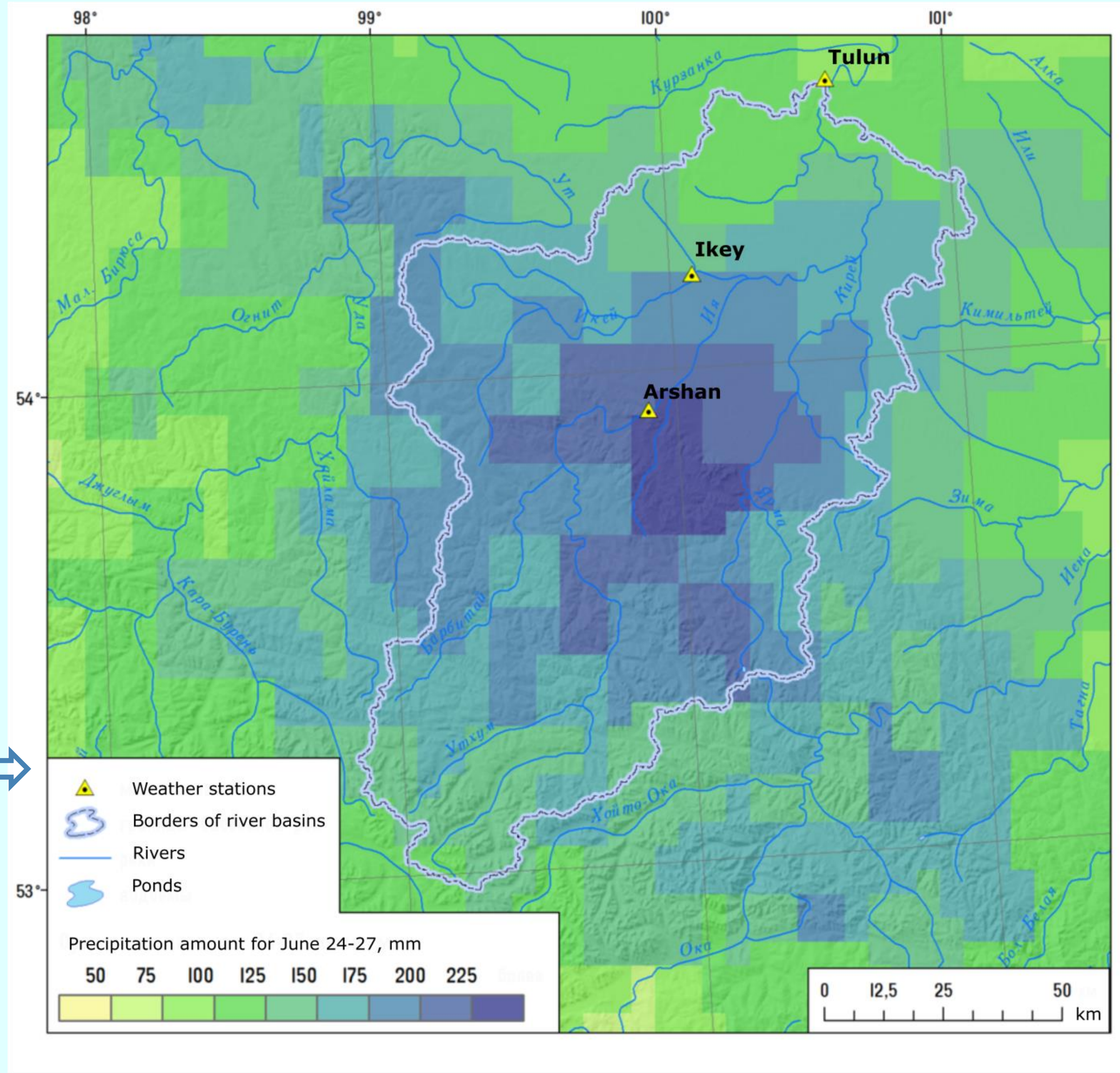
For annual **maximum** water discharge;
Period: 1970-1996;
The difference in values does not exceed 300 m^3s^{-1} (8%).



Data for modelling catastrophic flood

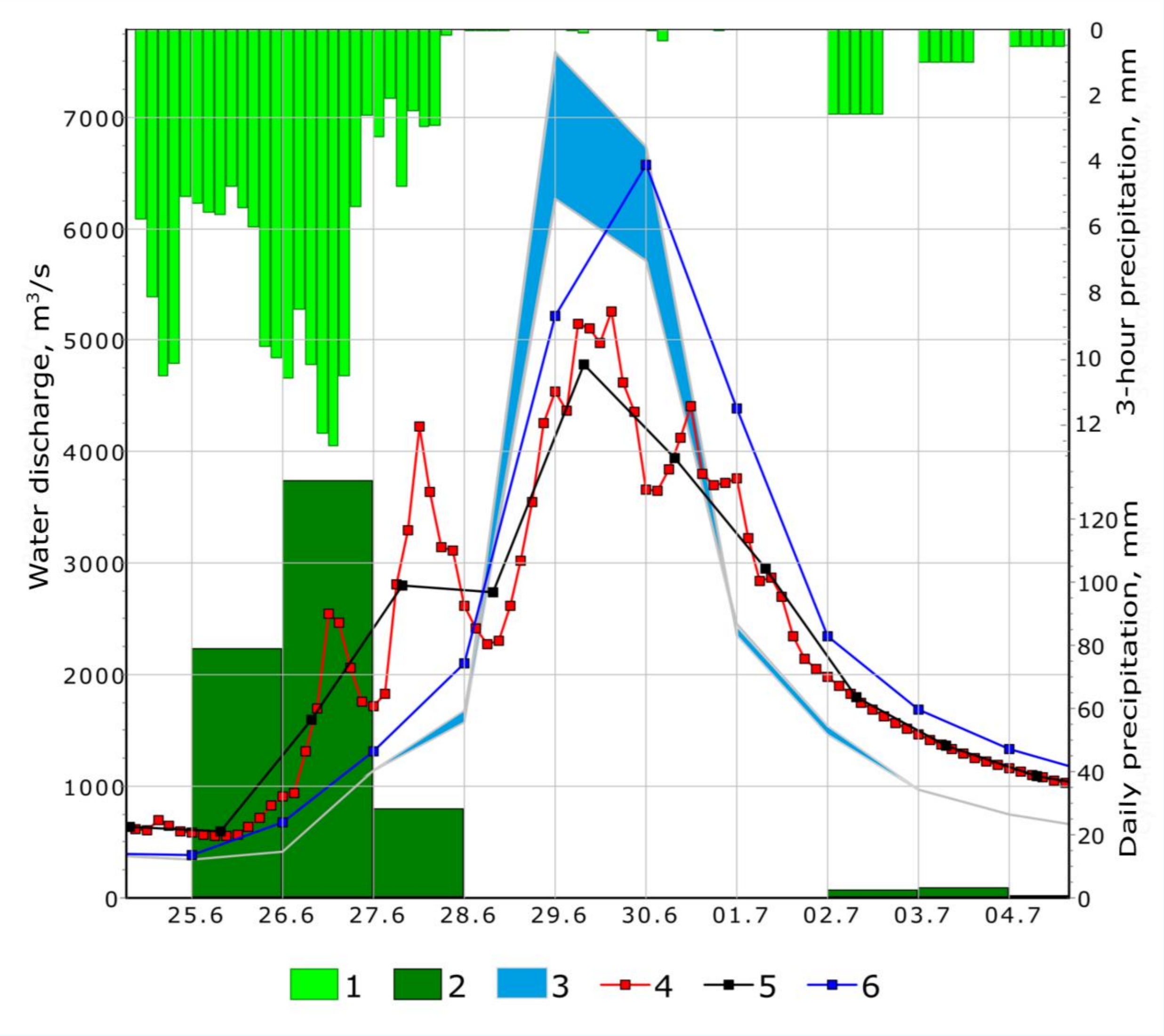
The assessment of the maximum water discharge in June 2019 based on two types of input:

- Observed weather stations' data (Arshan, Ikey, Tulun);
- ICON climate model data



Results

The results of flood modeling at the Iya River – Tulun in June 2019:



1, 2 – the amount of precipitation for the catchment - 3-hour precipitation according to the ICON weather model and daily precipitation based on data from weather stations;

3 – the observed flow hydrograph (based on extrapolation of the dependence of water flow on the level);

4, 5 – calculated 3-hour and averaged daily flow hydrograph according to the ICON weather model;

6 – calculated daily runoff hydrograph based on data from weather stations.

Results of modeling

- **Qmax. based on ICON:** 4780 m3s-1 (daily) and 5260 m3s-1 (3-hour)

- **Qmax. weather station data:** 6570 m3s-1 (daily)

- The maximum discharge based on **ICON data is 1400 m3s-1 lower than the observed**, however, its **formation coincides in the term**. According to **weather station data**, the maximum discharge **coincides in dimension**, but its formation is **delayed by 1 day;**

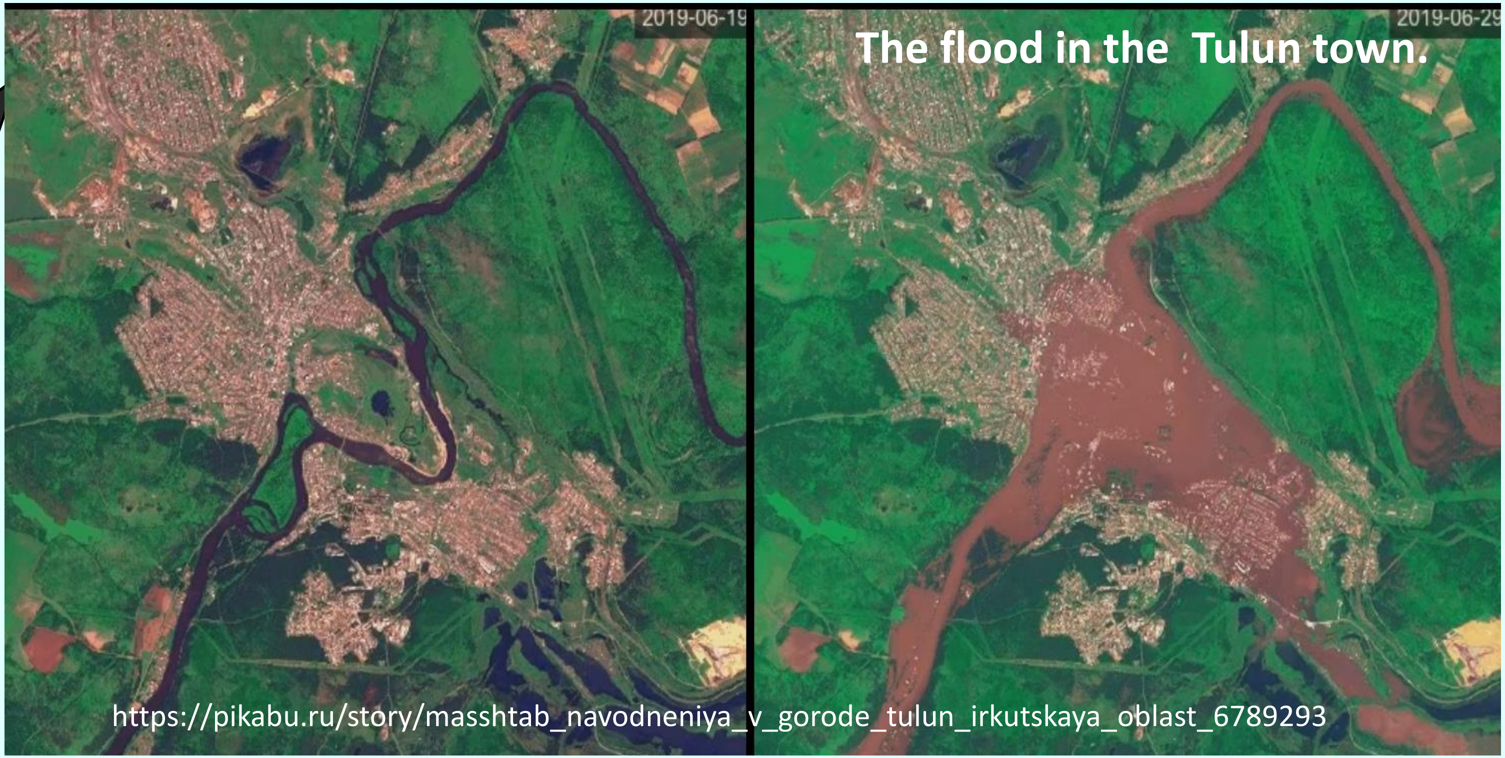
- We attempt to show the need to expand the meteorological and hydrological network. We also demonstrate the capabilities of the modern calculation methods and forecasts in case of insufficient observed data;

- We showed that the ensemble of input meteorological data from various sources could potentially be used to satisfactorily predict the magnitude and duration of the catastrophic flood in order **to minimize the consequences;**

Has this flood been observed before?

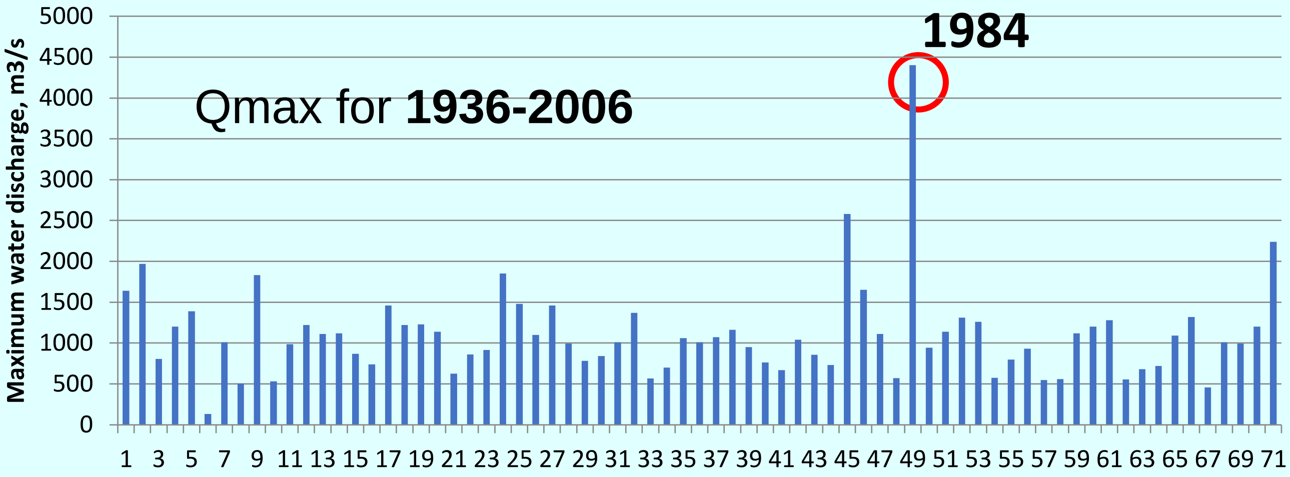
Year	Water level, m	Discharge, м³/с
1937	8.5	1907
1980	9.0	2520
1984	11.0	4400
2019	**13.8**	**6800 (preliminary assessment)**

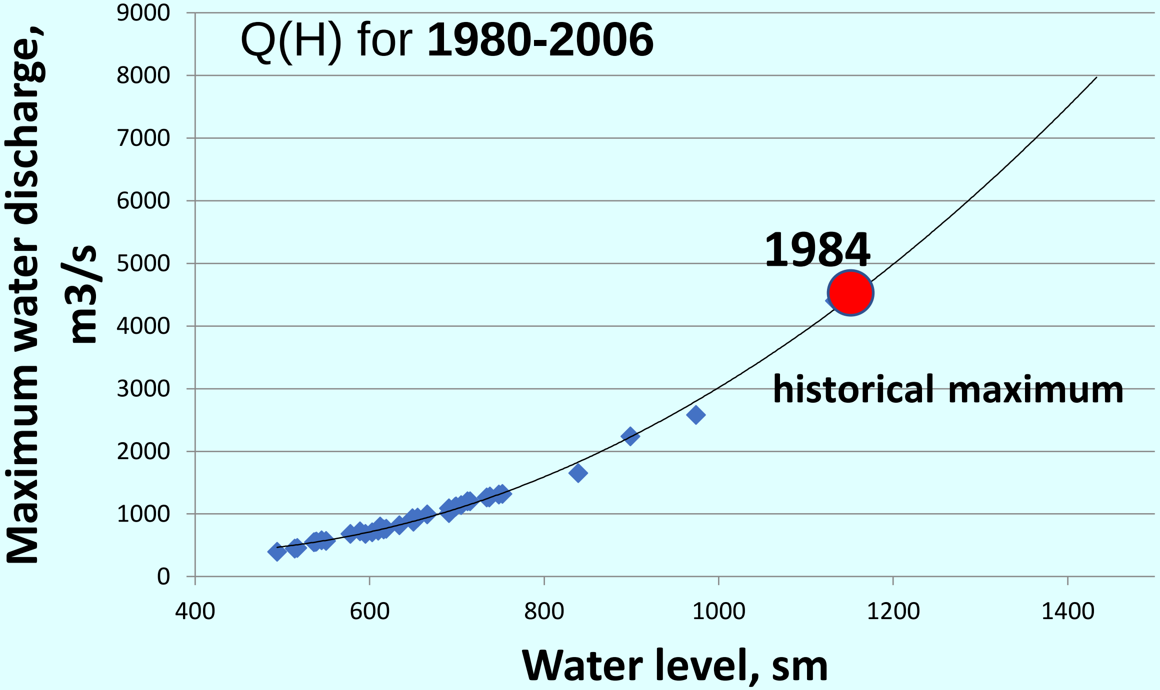
! The level of protective dam is **12 m**. Why?



Why was the maximum level of the dam 12 m?

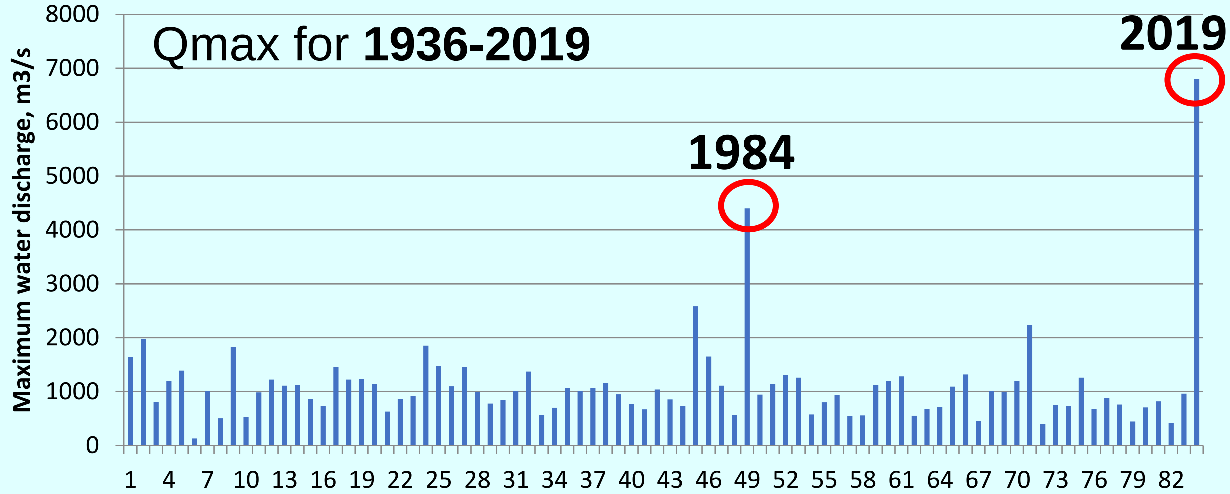
Dam construction:
2006-2009

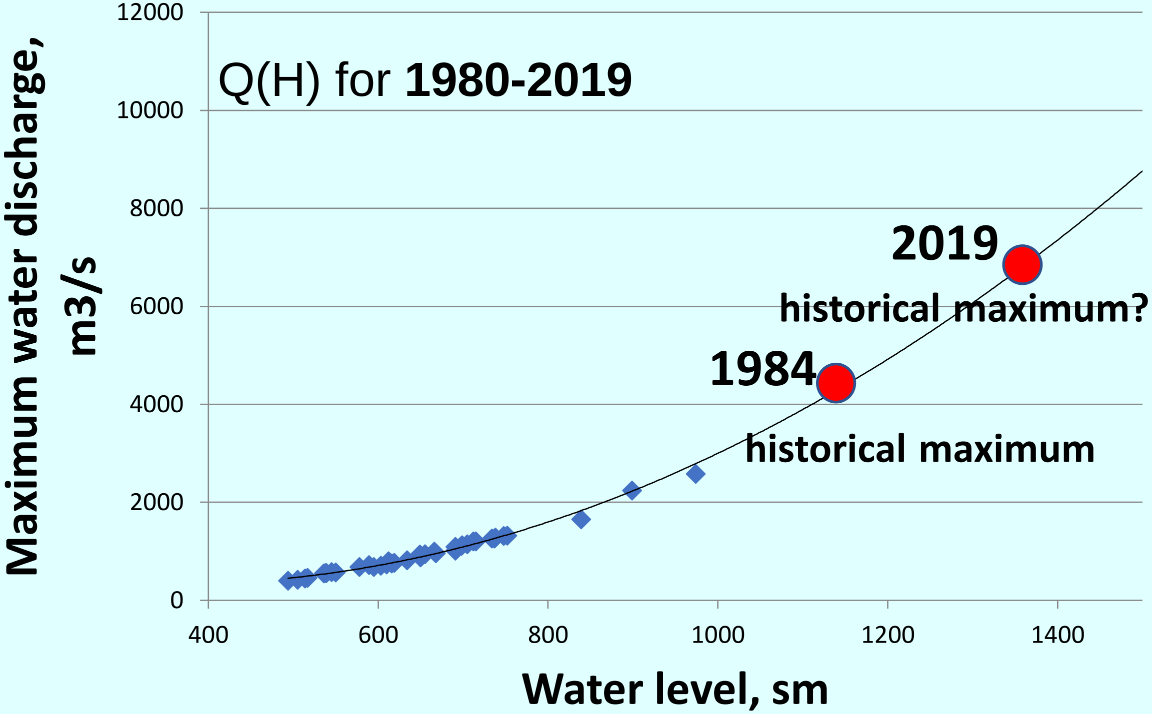




- This series of discharge are not homogeneous;
- Probability of the flood (1984) was underestimated as historical maximum;

What will be the new max level of the dam?





- This series of discharge also are not homogeneous;
- Will the probability of the flood (2019) be underestimated?

Conclusion

- The estimated discharge has exceeded previously observed one by about 50%.
- The results of the study have shown that recent flood damage was caused mainly by unprepared infrastructure.
- The safety dam which was built in the town of Tulun just ten years ago was 2 meters lower than maximum observed water level in 2019.
- This case and many other cases in Russia suggest that the flood frequency analysis of even long-term historical data may mislead design engineers to significantly underestimate the probability and magnitude of flash floods.

Thank you for attention!