Tracking mountain geohazards in Uzbekistan with application of remote sensing and advances in data analysis.

PhD at National University of Uzbekistan

Sabitov Timur, et. al.

Overview

Retreating glaciers in some parts of the region are the reason of increasing number of mountain lakes and geological processes. Often lakes located in the mountain areas (hard to reach). Sometimes lakes outburst and create (GLOF'S) glacial lake outburst floods

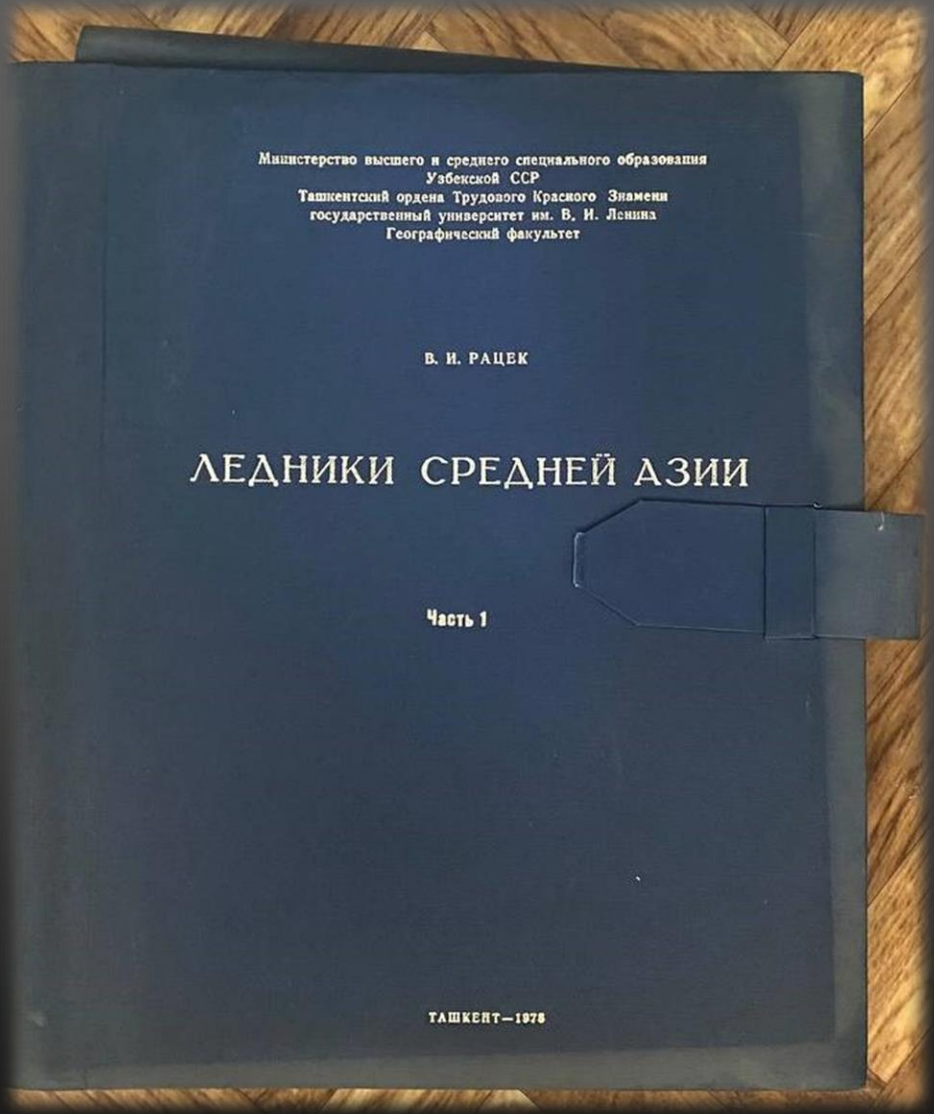
- Past studies of mountain lakes in CA(Ratsek expedition, A.M. Nikitin, G.E. Glazirin, Shamsutdinov, Y.Tarasov and others)
- Current studies(Inventory of the lake)
- Future (RS and GIS integrated)
- Cases
- Problems (lack of data? Lack of expertise ?)
- Discussion (What is happening with data ?)

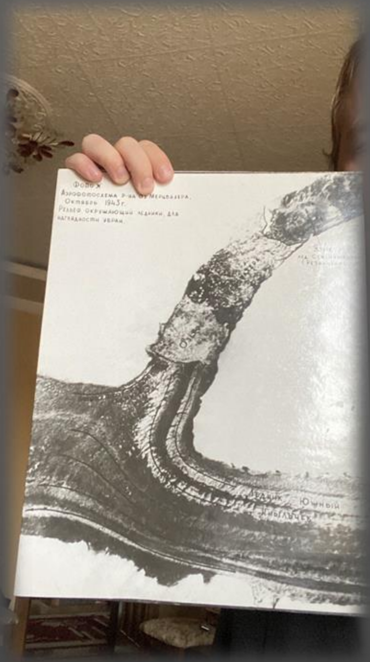
History of studies and sources

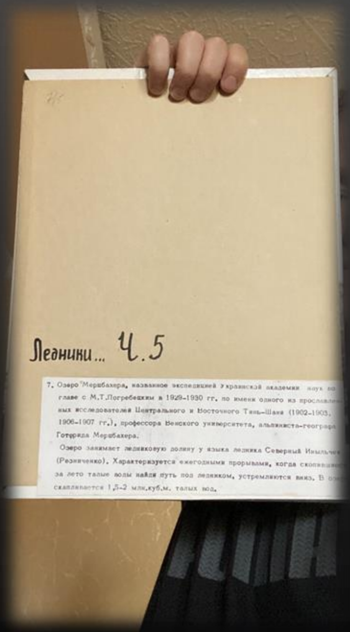
Lack of sources, lack of knowledge where to get information

Published expedition photos and notes from Pamir and Tien Shan expeditions In early and mid 20th century, about 20 books, size A3 each with at least 30 to 50 photos with descriptions. Some examples are shown here as well.

They cover mountain areas of Pamirs and Tien Shan regions





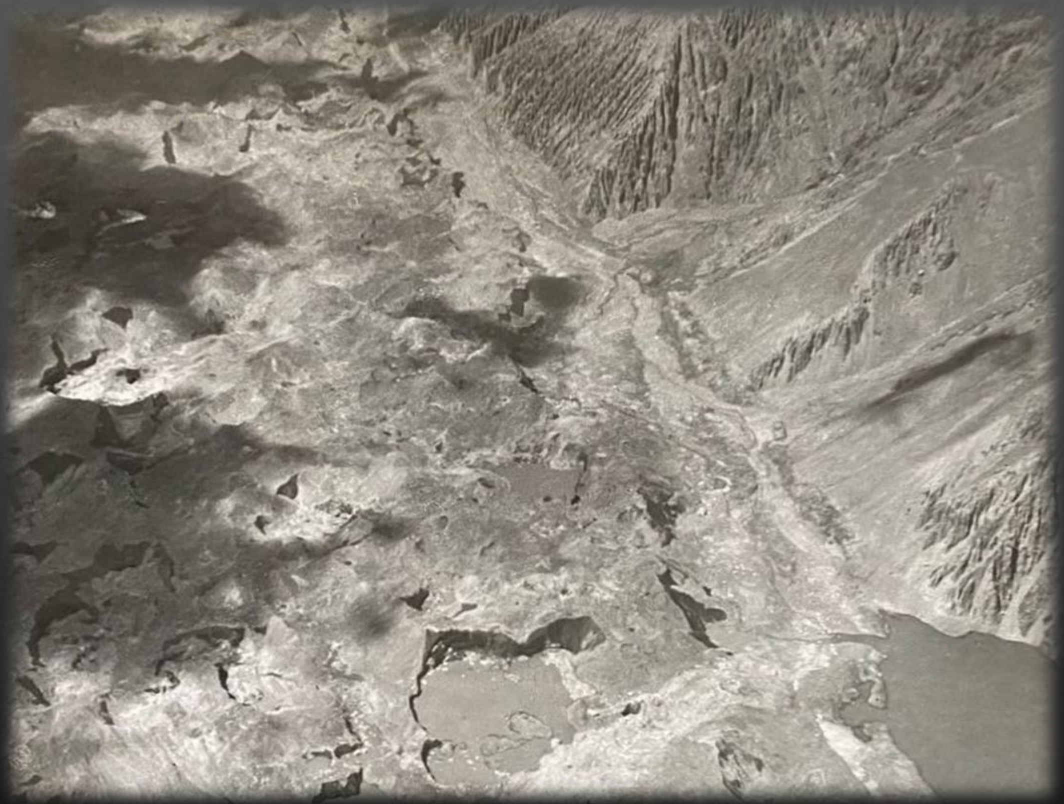


Base on Abramov glacier, Kg

Ratsek expedition to Pamirs, Lenin glacier, TJ

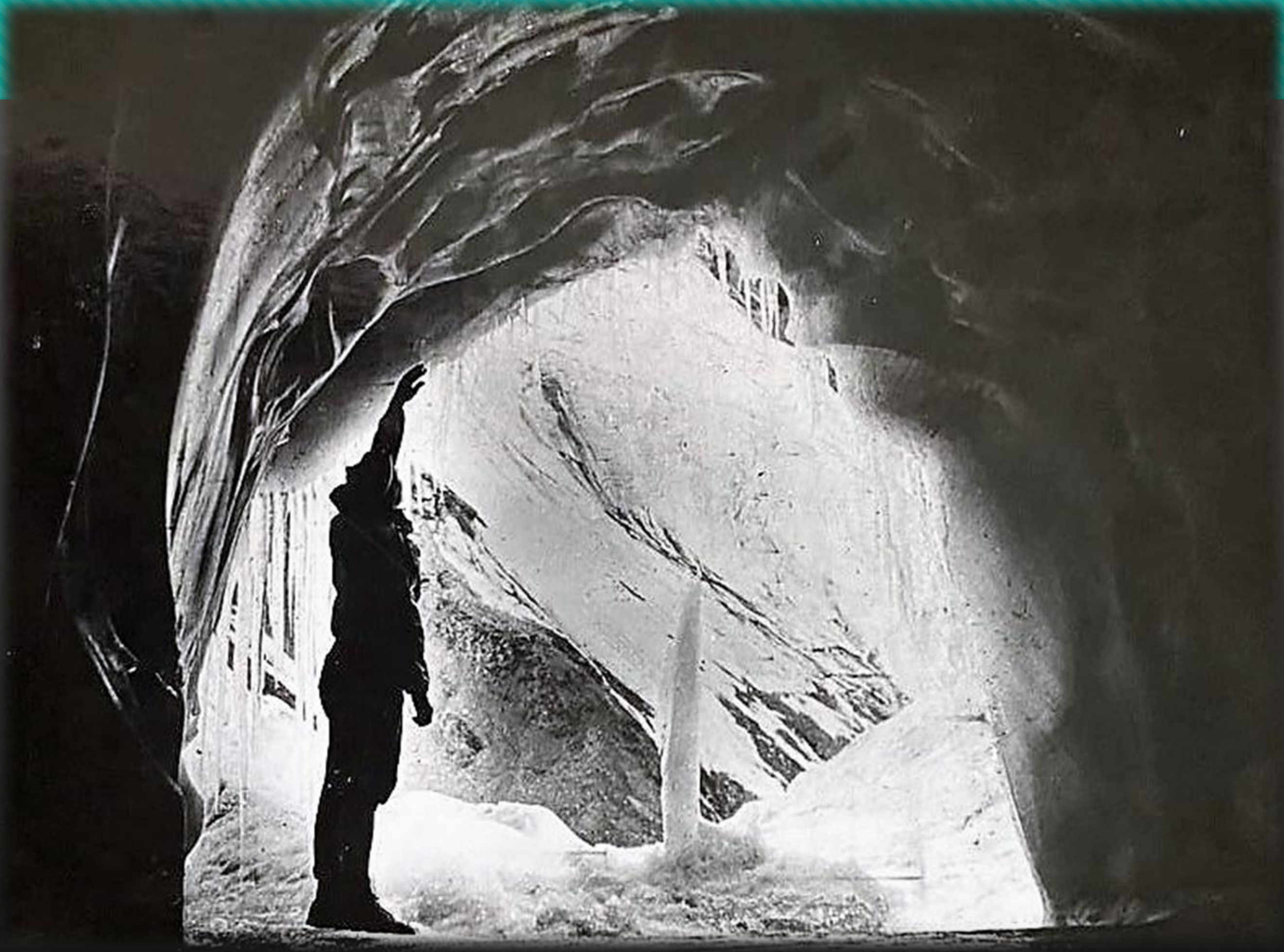
Field visits, aerial observations

Glacial lake, Lenin glacier, Tj



Thermocarst lakes, Bivachniy glacier, Kg

Bathymetric measurements, Sarez lake, Tj



Cave inside of Southern Inylchek glacier, Kg

Aerial view, Merzbaher lake, 1943

Usoy fallout, Sarez lake

A.M. Nikitin, Y.N. Ivanov, G.E. Glazirin and others

- Detailed information about number, area, distribution of lakes in Central Asia
- Distribution by basins
- Distribution by elevation
- By number, 60% of lakes situated in the mountain areas 1500-5500 m, however excluding Issik-Kul lake, 80% of the area of lakes distributed on the plains
- Average proportion of lakes area to the basin 0,56%, in the plains this proportion 0,27% in the mountain regions 2,04%.
- 5 main types of lakes by morphology (tectonic, glacial, hydrogenous, landslide originated, wind originated, thermocarst)
- Mountain group of lakes – glacial, landslide dammed, thermocarst

Lake characteristics

- Morphometrical characteristics (Lake configuration)
  - **Lake elongation** - is the proportion of length of the lake (L) to the average width (b_{av}) L/b
  - **Lake compactness** - proportion of average width to the maximum width b_{av}/b_{max}
  - **Development of water area** - proportion of the area of the circumference with the length of a lake shoreline to the area of the lake ($U1= f_{kr}/f = 0,8L^2/f$)
  - **Development of shoreline** - length of a shoreline to the length of a circumference of an equal-sized circle ($U_2 = 0,28L/f$)

Lake characteristics

- Morphometrical characteristics (vertical development)
  - Max depth
  - Mean depth
  - Relative depth $h_{rel} = h_{av}/\sqrt[3]{f}$ – f surface area of the lake
- Lake capacity indicators:
- $c_1 = h_{av}/h_{max}$
  - cylindric = 1
  - hemisphere = 0,67
  - parabolic = 0,5
- Openness - mirror area to average depth
- Specific catchment ratio k_1– F/f
- Conditional water exchange (Volume per year of incoming water to the volume of water in the lake)

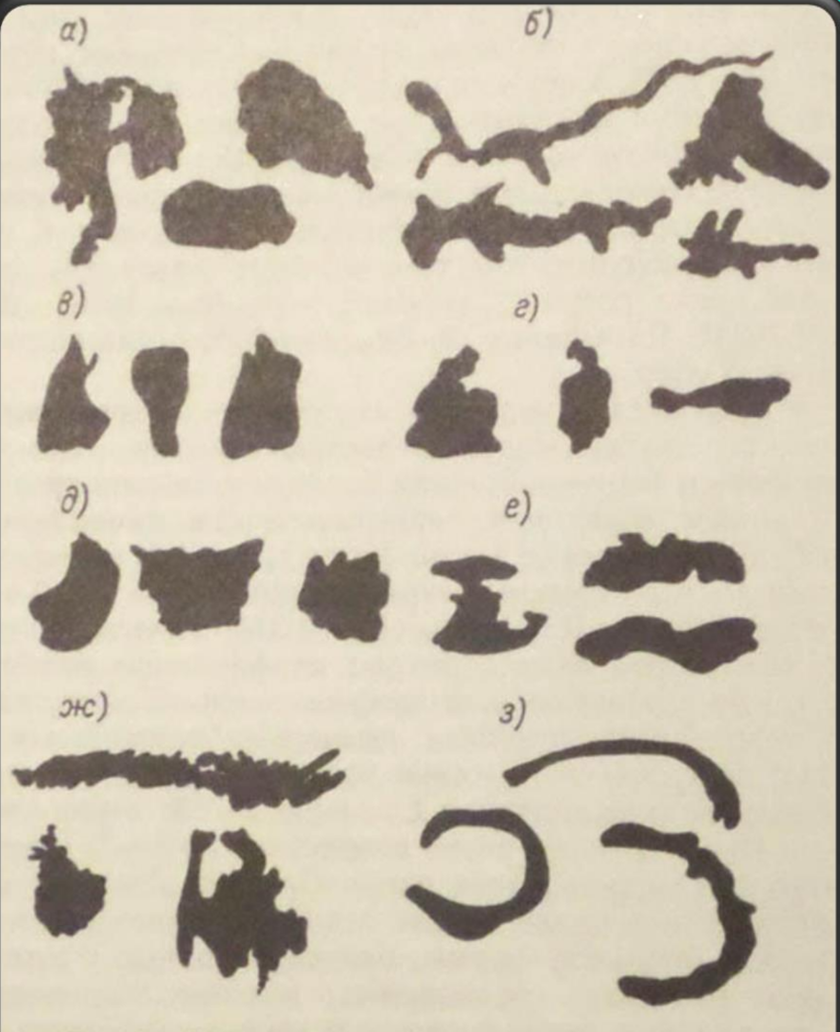
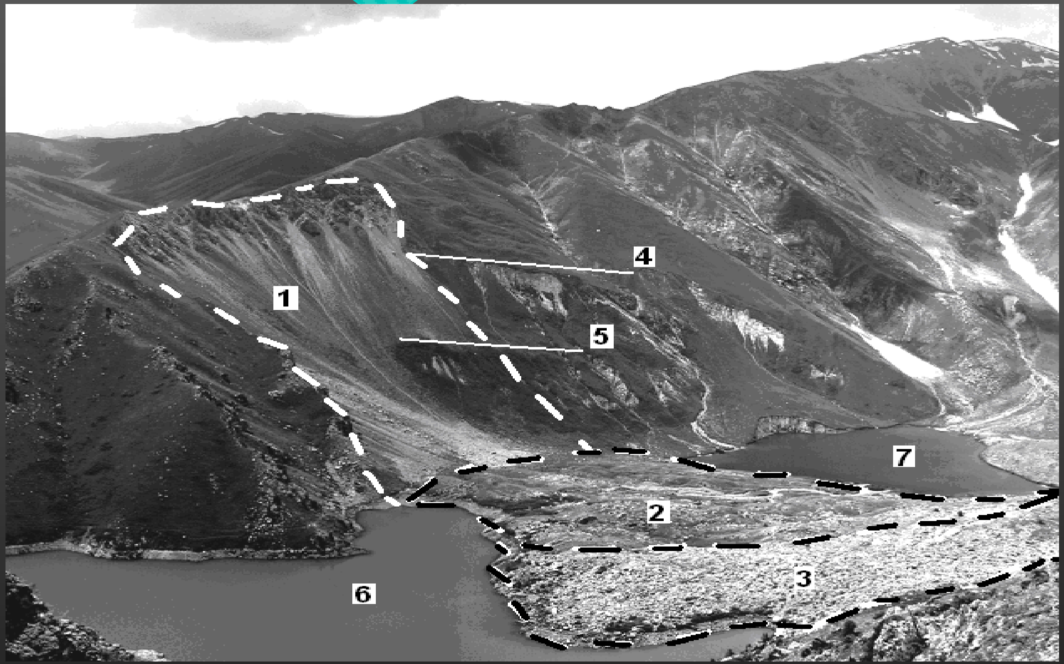


Рис. 1. Сравнительные формы озерных котловин.
а — тектонические, б — завальные, в — каровые, г — моренные, д — провальные, е — дельтовые, ж — конечные, з — старицы.

Early 2000



Sketch of the dam of the Ikhnach Upper lake (view to the South): 1 – part of the valley slope where landslip originated; 2 – the dam; 3 – a surface of the dam covered with boulders; 4 –upper side stage moraine; 5 – lower side stage moraine; the Ikhnach Upper lake; 7 – the Ikhnach Lower lake. Adapted from (Glazirin et al., 2013)

Ozernoe Lower lake. 1 – the stage moraine between the upper and lower lakes; 2 – outflow channel. Adapted from (Glazirin et al., 2013)

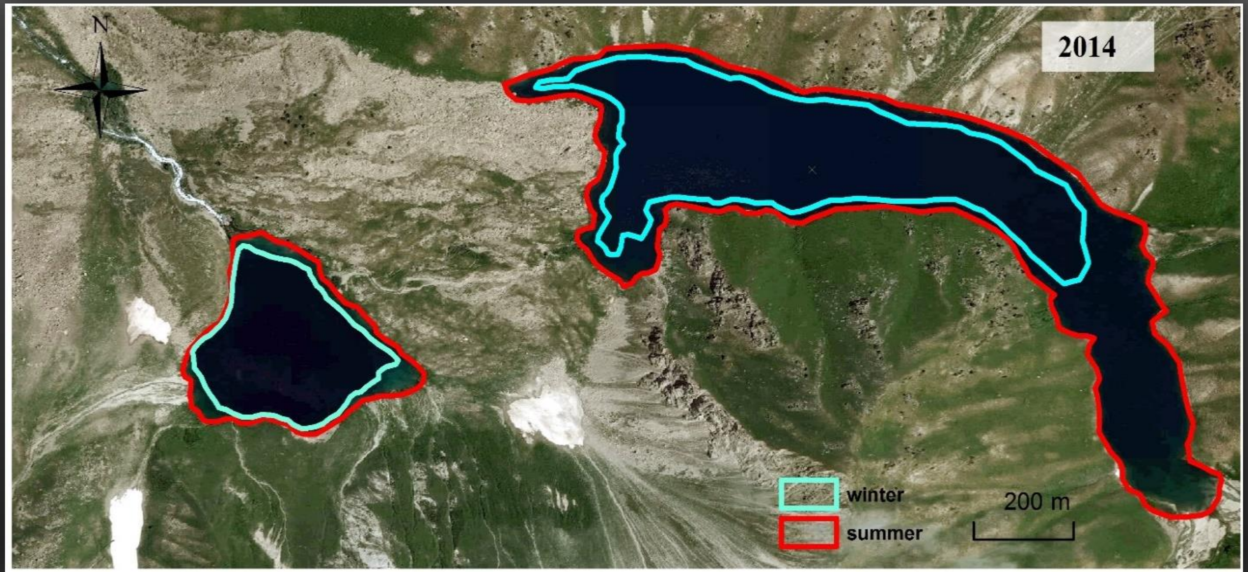
2010

Lake Barkrak (Summer 2012)

Lakes Arashan (Summer 2014)

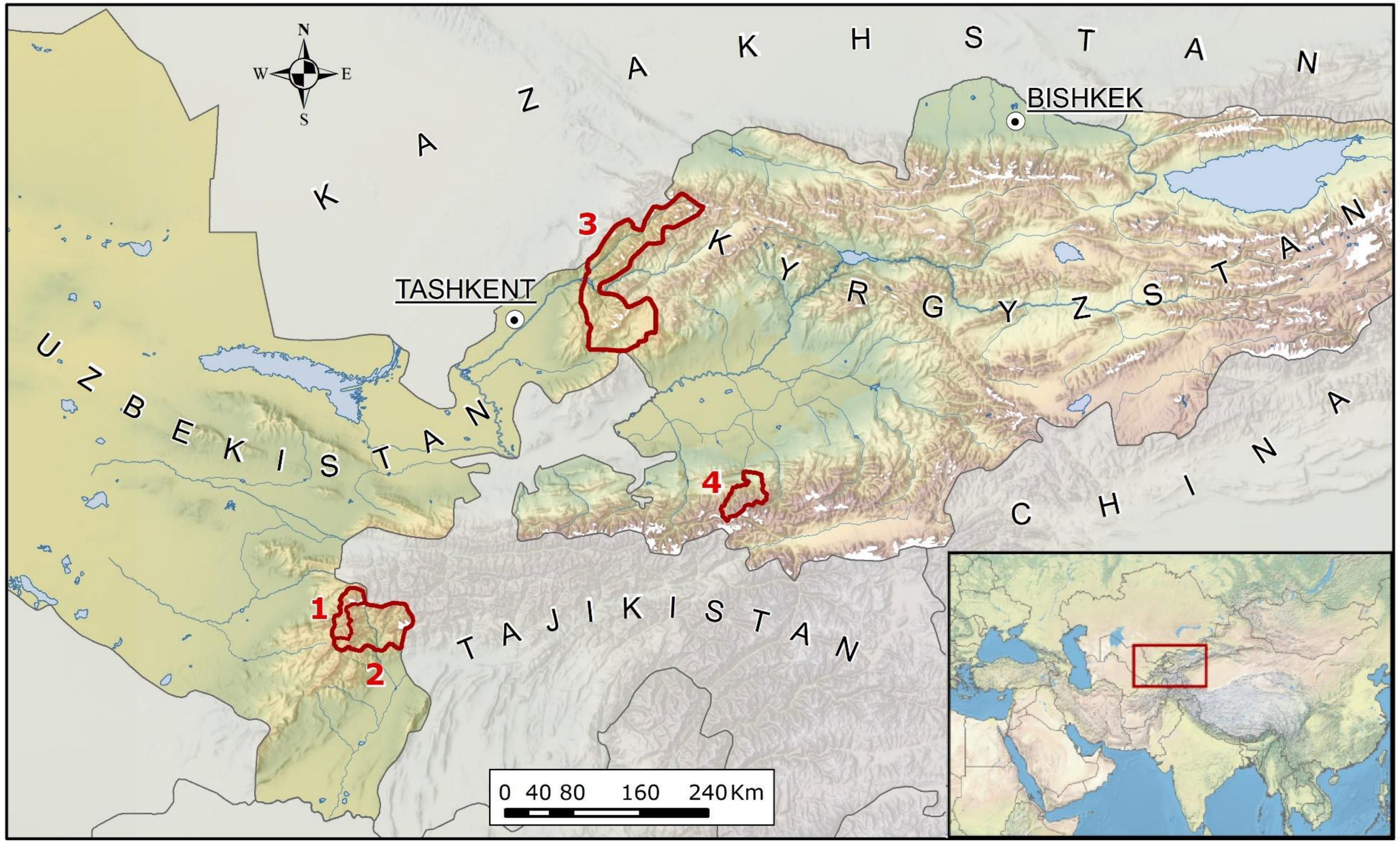
2015

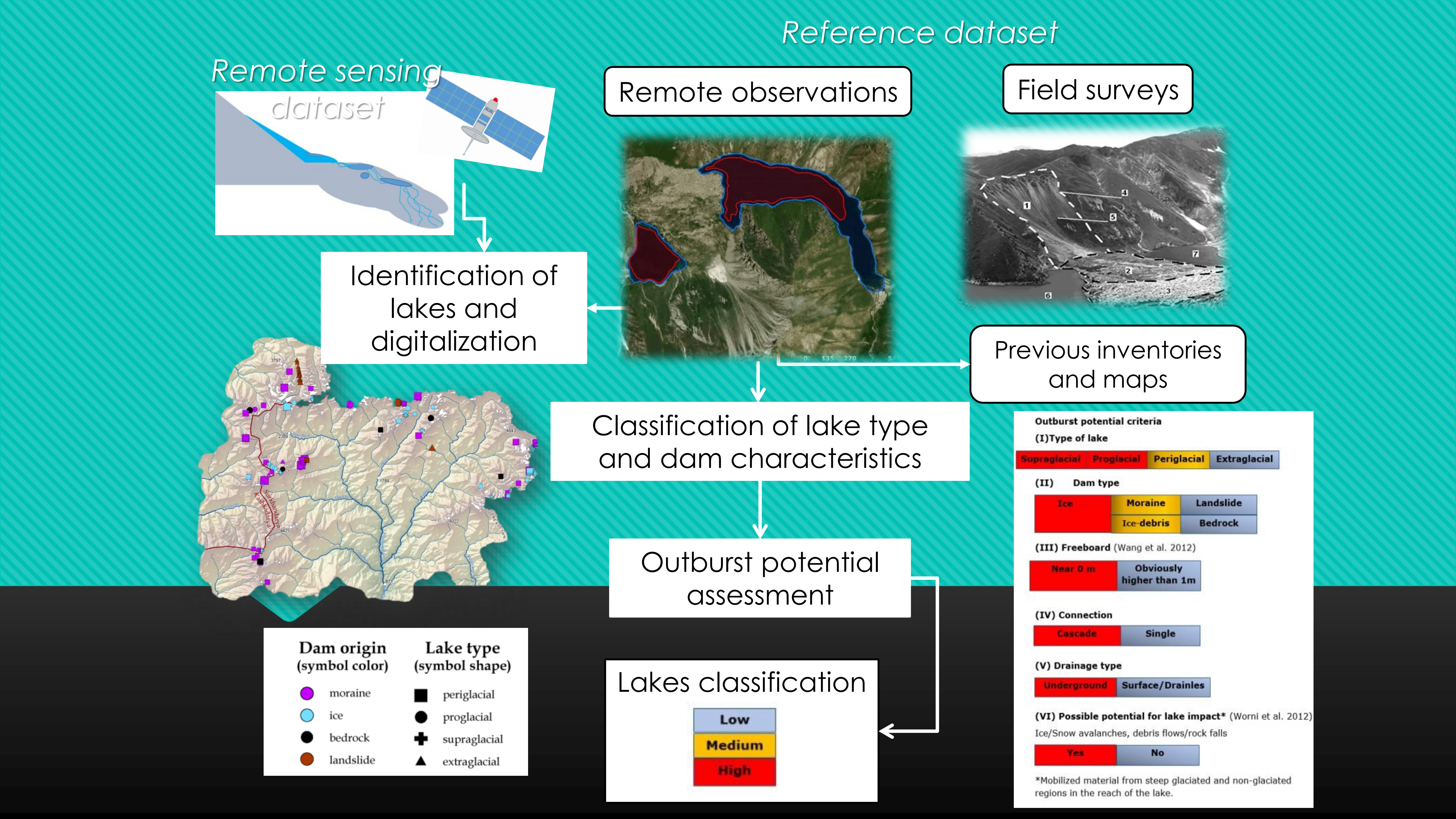
Bathimetric measurements of the lake Kunkermes. 2015, Uz



Examples of the Ikhnach (h>1500 m.a.s.l.) lakes which are highly dynamic in area between individual calendar years and within the same year (depending on the timing of image acquisition).

Regions of Uzbekistan in which mountain lakes have been analyzed: 1 – Kashkadarya, 2 – Surkhandarya, 3 – Tashkent, 4 – Shakhimardan

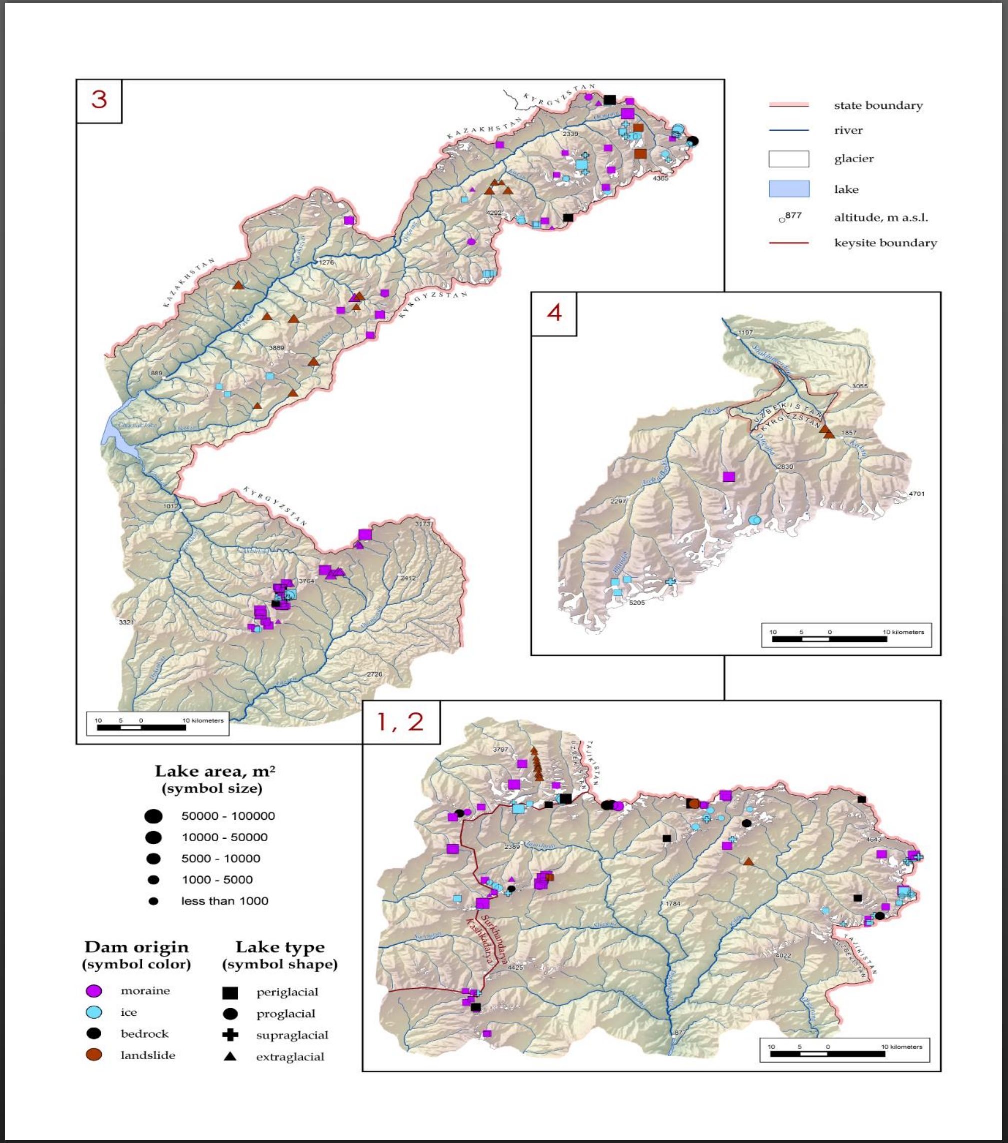




Reference dataset
Remote sensing dataset
Remote observations
Field surveys
Identification of lakes and digitalization
Previous inventories and maps
Classification of lake type and dam characteristics
Outburst potential assessment
Lakes classification
Low
Medium
High
Dam origin (symbol color)
moraine
ice
bedrock
landslide
Lake type (symbol shape)
periglacial
proglacial
supraglacial
extraglacial
Outburst potential criteria
(I)Type of lake
Supraglacial
Proglacial
Periglacial
Extraglacial
(II) Dam type
Ice
Moraine
Landslide
Ice-debris
Bedrock
(III) Freeboard (Wang et al. 2012)
Near 0 m
Obviously higher than 1m
(IV) Connection
Cascade
Single
(V) Drainage type
Underground
Surface/Drainles
(VI) Possible potential for lake impact* (Worni et al. 2012)
Ice/Snow avalanches, debris flows/rock falls
Yes
No
*Mobilized material from steep glaciated and non-glaciated regions in the reach of the lake.

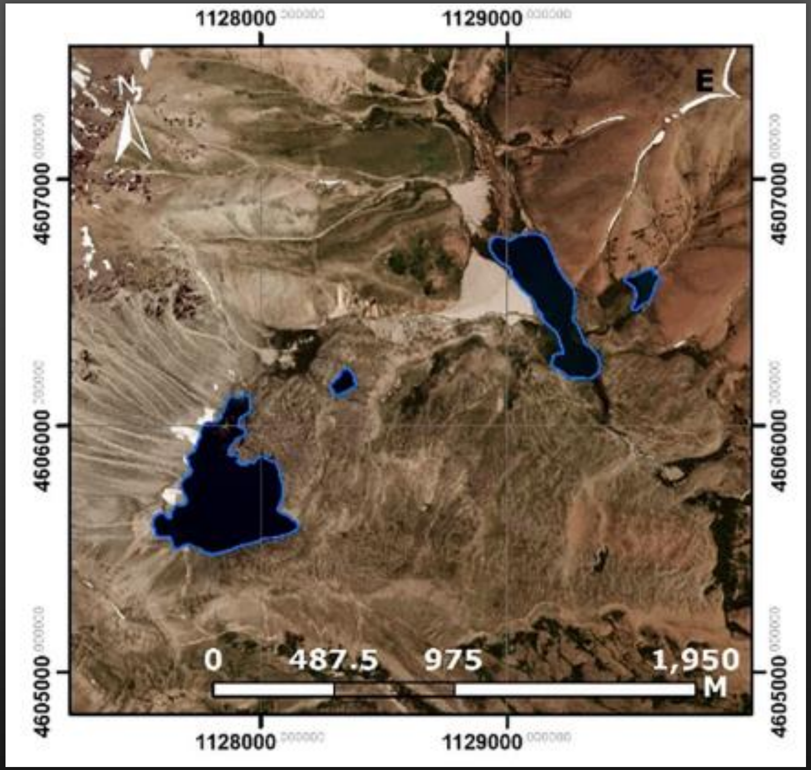
Lakes distribution in Uzbekistan

Most of the lakes are within Tashkent, Kashkadarya and Surkhandarya regions of Uzbekistan. Regions are part of Tien Shan, Pamir mountains. They serve as water sources to the Chirchik, Aksu, Kashkadarya and Surkhandarya rivers. Total population living downstream around 7-10 mln people, with Tashkent city and metro area of 5 mln.

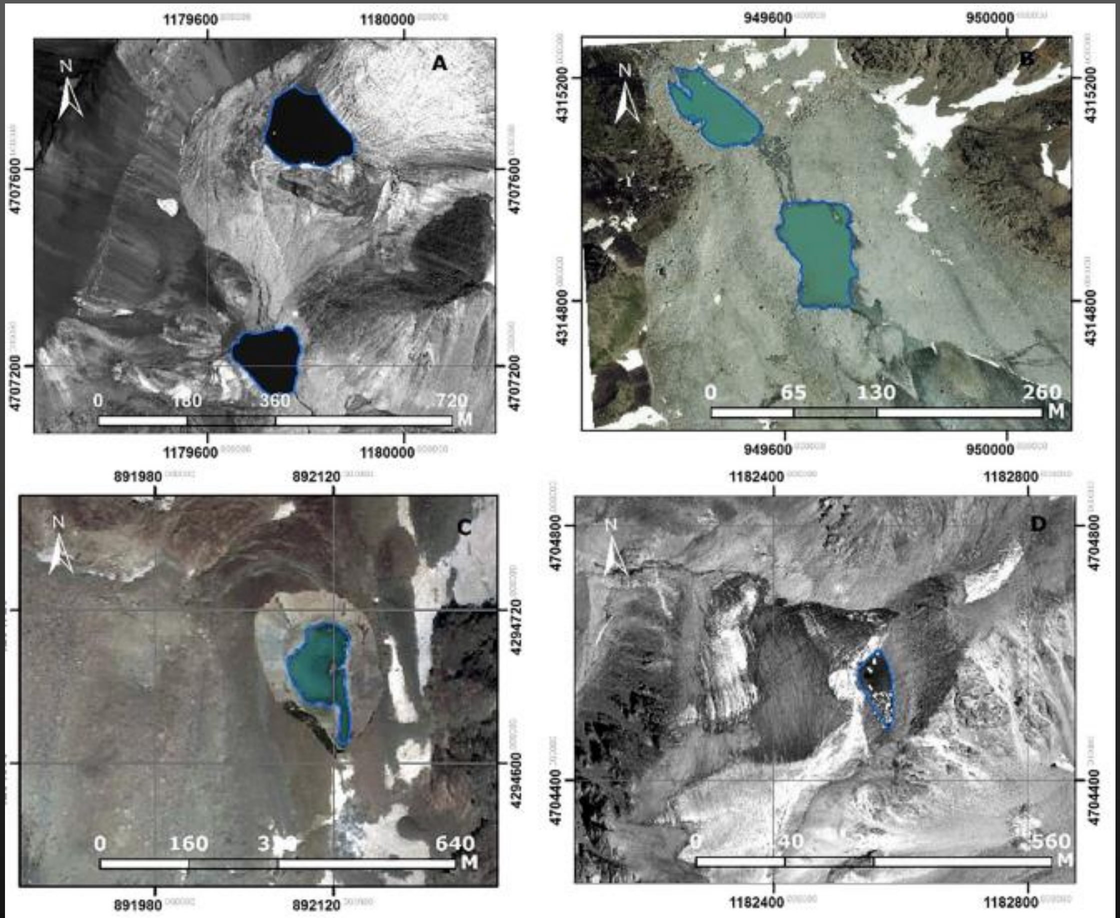


Distribution of mountain lakes by regions in the Republic of Uzbekistan: 1-Kashkadarya, 2-Tashkent, 3-Surkhandarya, 4-Shakhimardan.

Lakes



Arashan lakes



Some lakes in mountain regions of Uzbekistan

Current studies

Inventory of lakes:

- Location
- Type
- Outburst hazard

We lack of:

- Volume
- Bathymetric data
- Upstream and downstream landcover properties
- Existing studies of outburst modeling

We propose:

- Extract volume of the lakes from existing relation F to V
- Integrate Remote sensing (RS) to analyze satellite data of surrounding area
- Reach specific modeling and generate hydrologic database (stream network and stream connection)
- Integrate past RS observations to analyze trends of changes occurring upstream

Volume estimation: Data

- Using different data sources (Bolch et al., 2011; Glazirin, 2013; Huggel et al., 2004; Loriaux and Casassa, 2013; Nikitin, 1987; Petrov et al., 2017; Sakai et al., 2000; Yao et al., 2012) as well as field measurements (Petrov et al., 2017), we were able to extract **172** of lakes with bathymetry observations after pre-processing.
- Most of these studies provided with some sort of equation explaining relationships between lakes volume and lakes area
- Most of these lakes are mountain lakes and located in pere glacial or glacial zones

Preview of database

Name	Area	Vol	Type	Referer	Year of publication	Year of measurements				Reference to data source	Reference to literature source
Abmachi	0.5600000	0.0190000	moraine-	LIGG/WE	-1988.0000000	1987.0000000	Sakai	NOTE:	VOLUME "Km3, AF	LIGG / WECS / NEA (1988) Report c	Sakai, A., 2012. Glacial Lakes in the Himalayas: A Review on Formation and E
Qangzor	0.7600000	0.0214000	moraine-	LIGG/WE	-1988.0000000	1987.0000000	"	NOTE:	Repetion in HUGGE	LIGG / WECS / NEA (1988) Report on First Expedition toGlaciers and Glacier Lakes in the Pumqu (Arun) and Poiq	
Paqu	0.3100000	0.0060000	moraine-	LIGG/WE	-1988.0000000	1987.0000000	"	NOTE:	Repetion in HUGGE	LIGG / WECS / NEA (1988) Report on First Expedition toGlaciers and Glacier Lakes in the Pumqu (Arun) and Poiq	
Lower	0.6000000	0.0280000	moraine-	Yamada	-1998.0000000	1993.0000000	"			Yamada, T. (1998) Glacier Lake and Its Outburst Flood in theNepal Himalaya. Data Center for Glacier Research,	
Imja	0.6000000	0.0280000	moraine-	Yamada	-1998.0000000	1992.0000000	"			Yamada, T. (1998) Glacier Lake and Its Outburst Flood in theNepal Himalaya. Data Center for Glacier Research,	
Imja	0.9000000	0.0360000	moraine-	Sakai	-2003.0000000	2002.0000000	"			Sakai, A., T. Yamada and K. Fujita (2003) Volume Change of ImjaGlacial Lake in the Nepal Himalayas. Internatio	
Imja	1.0100000	0.0355000	moraine-	ICIMOD	-2011.0000000	2009.0000000	"			International Centre for Integrated Mountain Development(ICIMOD) (2011) Glacial Lakes and Glacial Lake Outbu	
Tsho Rol	1.3900000	0.0766000	moraine-	Yamada	-1998.0000000	1993.0000000	"			Yamada, T. (1998) Glacier Lake and Its Outburst Flood in theNepal Himalaya. Data Center for Glacier Research,	
Tsho Rol	1.5400000	0.0859400	moraine-	ICIMOD	-2011.0000000	2009.0000000	"			International Centre for Integrated Mountain Development(ICIMOD) (2011) Glacial Lakes and Glacial Lake Outbu	
Thulagi	0.7600000	0.0318000	moraine-	Yamada	-1998.0000000	1995.0000000	"			Yamada, T. (1998) Glacier Lake and Its Outburst Flood in theNepal Himalaya. Data Center for Glacier Research,	
Thulagi	0.9400000	0.0353700	moraine-	ICIMOD	-2011.0000000	2009.0000000	"			International Centre for Integrated Mountain Development(ICIMOD) (2011) Glacial Lakes and Glacial Lake Outbu	
Dig	0.5000000	0.0100000	moraine-	Mool	-2001.0000000	N/G	"			Mool, P.K., S.R. Bajracharya and S.P. Joshi (2001) Inventory ofGlaciers, Glacial Lakes and Glacial Lake Outburs	
Tam Pokl	0.4700000	0.0212500	moraine-	Mool	-2001.0000000	1999.0000000	"			Mool, P.K., S.R. Bajracharya and S.P. Joshi (2001) Inventory ofGlaciers, Glacial Lakes and Glacial Lake Outburs	
Ngozump	0.0500000	0.0002400	thermoka	Benn	-2000.0000000	1993.0000000	"			Benn, D.I., S. Wiseman and C.R. Warren (2000) Rapid growth of asupraglacial lake, Ngozumpa Glacier, Khumbu	
Raphsthr	1.3800000	0.0668300	moraine (	Geologic	1995.0000000	1986.0000000	"			Geological Survey of India (1995) Geology, EnvironmentalHazards and Remedial Measures of the Lunana Area,	
Lugge	1.1700000	0.0583000	moraine-	Yamada	-2004.0000000	2002.0000000	"			Yamada, T., N. Naito, S. Kohshima, H. Fushimi, F. Nakazawa, T.Segawa, J. Uetake, R. Suzuki, N. Sato, Karma, I.	
Ripimo	0.0200000	0.0001800	thermoka	Personal	1993.0000000	1993.0000000	"			Personal	
MT'	0.0420000	0.0005000	Ice-damr	Blown an	-1985.0000000	N/G	Thomas Loriaux , Gir	NOTE:	VOLUME "km3, AR	Blown, I., Church, M., 1985. Catast	Loriaux, T., Casassa, G., 2013. Evolution of glacial lakes from the Northern Pa
Nostetuk	0.2620000	0.0075000	Moraine-	Clague a	-1994.0000000	N/G	"	NOTE:	Repetion in HUGGE	Clague, J.J., Evans, S.G., 1994. Formation and failure of natural dams in the CanadianCordillera. Geological Sur	
Between	0.4000000	0.0075000	Ice-damr	Maag	-1963.0000000	N/G	"	NOTE:	Repetion in HUGGE	Maag, H.U., 1963. Marginal drainage and glacier-dammed lakes, Axel Heiberg Island.In: Müller, F. (Ed.), Prelimina	
Cachet	4.0450000	0.2000000	Ice-damr	Casassa	-2010.0000000	N/G	"	NOTE:	Repetion in HUGGE	Casassa, G., Wendt, J., Wendt, A., López, P., Schuler, T., Maas, H.-G., Carrasco, J., Rivera, A.,2010. Outburst fl	
Leones	19.5010000	2.4546100	Moraine-	Harrison	-2008.0000000	N/G	"			Harrison, S., Glasser, N., Winchester, V., Haresign, E., Warren, C., Duller, G.A.T., Bailey, R.,Ivy-Ochs, S., Jansso	
Nef	5.1330000	0.7707100	Moraine-	Warren	-2001.0000000	N/G	"			Warren, C., Benn, D., Winchester, V., Harrison, S., 2001. Buoyancy-driven lacustrinecalving, Glaciar Nef, Chilea	
Lac D'Ar	0.0340000	0.0005300	Moraine-	Vallon	-1989.0000000	N/G	"			Vallon, M., 1989. Evolution water balance potential hazards and control of a pro-glaciallake in the French Alps. A	
Lac D'Ar	0.0590000	0.0008000	Moraine-	Vallon	-1989.0000000	N/G	"	NOTE:	Repetion in HUGGE	Vallon, M., 1989. Evolution water balance potential hazards and control of a pro-glaciallake in the French Alps. A	
Gjanupsv	0.6000000	0.0200000	Ice-damr	Costa an	-1988.0000000	N/G	"	NOTE:	Repetion in HUGGE	Costa, J.E., Schuster, R.L., 1988. The formation and failure of natural dams. GeologicalSociety of America Bulle	
Petrov	3.9000000	0.0639600	Moraine-	Jansky	-2009.0000000	N/G	"			Jansky, B., Engel, Z., Sobr, M., Benes, V., Spacek, K., Yerokhin, S., 2009. The evolution ofPetrov lake and mora	
Petrov	1.6300000	0.0200000	Moraine-	Sevast'ya	-1981.0000000	N/G	"			Sevast'yanov, D.V., Funtikov, A.B., 1981. Novy dannye ob evollucii vysokogornogo ozerau konca lednika Petrov	
Petrov	3.6600000	0.0534000	Moraine-	Engel	-2012.0000000	N/G	"			Engel, Z., Sobr, M., Yerokhin, S.A., 2012. Changes of Petrov glacier and its proglacial lake inthe Akshiirak massif,	
Petrov	3.8000000	0.0592000	Moraine-	Engel	-2012.0000000	N/G	"			Engel, Z., Sobr, M., Yerokhin, S.A., 2012. Changes of Petrov glacier and its proglacial lake inthe Akshiirak massif,	
Petrov	3.8800000	0.0620000	Moraine-	Engel	-2012.0000000	N/G	"			Engel, Z., Sobr, M., Yerokhin, S.A., 2012. Changes of Petrov glacier and its proglacial lake inthe Akshiirak massif,	
Abmachi	0.5650000	0.0194000	Moraine-	Meon an	-1993.0000000	N/G	"			Meon, G., Schwarz, W., 1993. Estimation of glacier lake outburst flood and its impact on ahydro project in Nepal.	
Quangzo	0.7530000	0.0210000	Moraine-	Meon an	-1993.0000000	N/G	"	NOTE:	Repetion in HUGGE	Meon, G., Schwarz, W., 1993. Estimation of glacier lake outburst flood and its impact on ahydro project in Nepal.	
Imja	0.6000000	0.0280000	Moraine-	Yamada	-1992.0000000	N/G	"	NOTE:	Repetion in HUGGE	Yamada, T., 1992. Report for the First Research Expedition to Imja Glacier Lake – 25March to 12 April 1992, WEC	
Imja	0.8640000	0.0358000	Moraine-	Fujita	-2009.0000000	N/G	"	NOTE:	Repetition in SAKA	Fujita, K., Sakai, A., Nuimura, T., Yamaguchi, S., Sharma, R., 2009. Recent changes in Imja Glacial Lake and its	
Imja	1.0100000	0.0355000	Moraine-	Fujita	-2009.0000000	N/G	"	NOTE:	Repetition in SAKA	Fujita, K., Sakai, A., Nuimura, T., Yamaguchi, S., Sharma, R., 2009. Recent changes in Imja Glacial Lake and its	
Thulagi	0.7600000	0.0317500	Moraine-	ICIMOD	-2011.0000000	N/G	"	NOTE:	Repetition in SAKA	International Centre for Integrated Mountain Development(ICIMOD) (2011) Glacial Lakes and Glacial Lake Outbu	
Thulagi	0.9400000	0.0353000	Moraine-	ICIMOD	-2011.0000000	N/G	"	NOTE:	Repetition in SAKA	International Centre for Integrated Mountain Development(ICIMOD) (2011) Glacial Lakes and Glacial Lake Outbu	
Tsho Rol	1.6500000	0.0907500	Moraine-	Yamada	-1992.0000000	N/G	"	NOTE:	Repetition in SAKA	Yamada, T., 1992. Report for the First Research Expedition to Imja Glacier Lake – 25March to 12 April 1992, WEC	
Laguna F	1.6000000	0.0750000	Moraine-	Lliboutry	-1977.0000000	N/G	"	NOTE:	Repetion in HUGGE	Lliboutry, L., Morales Arnao, B., Pautre, A., Schneider, B., 1977. Glaciological problemsset by the control of dan	
Elbrus	0.0890000	0.0005500	Ice-damr	Petrakov	-2007.0000000	N/G	"			Petrakov, D.A., Krylenko, I.V., Chernomorets, S.S., Tutubalina, O.V., Krylenko, I.N.,Shakhmina, M.S., 2007. Deb	
Bashkara	0.0650000	0.0007400	Moraine-	Petrakov	-2007.0000000	N/G	"			Petrakov, D.A., Krylenko, I.V., Chernomorets, S.S., Tutubalina, O.V., Krylenko, I.N.,Shakhmina, M.S., 2007. Deb	
Crusoe-E	0.0170000	0.0000800	Ice-damr	Maag	-1963.0000000	N/G	"	NOTE:	Repetion in HUGGE	Maag, H.U., 1963. Marginal drainage and glacier-dammed lakes, Axel Heiberg Island.In: Müller, F. (Ed.), Prelimina	

Field data

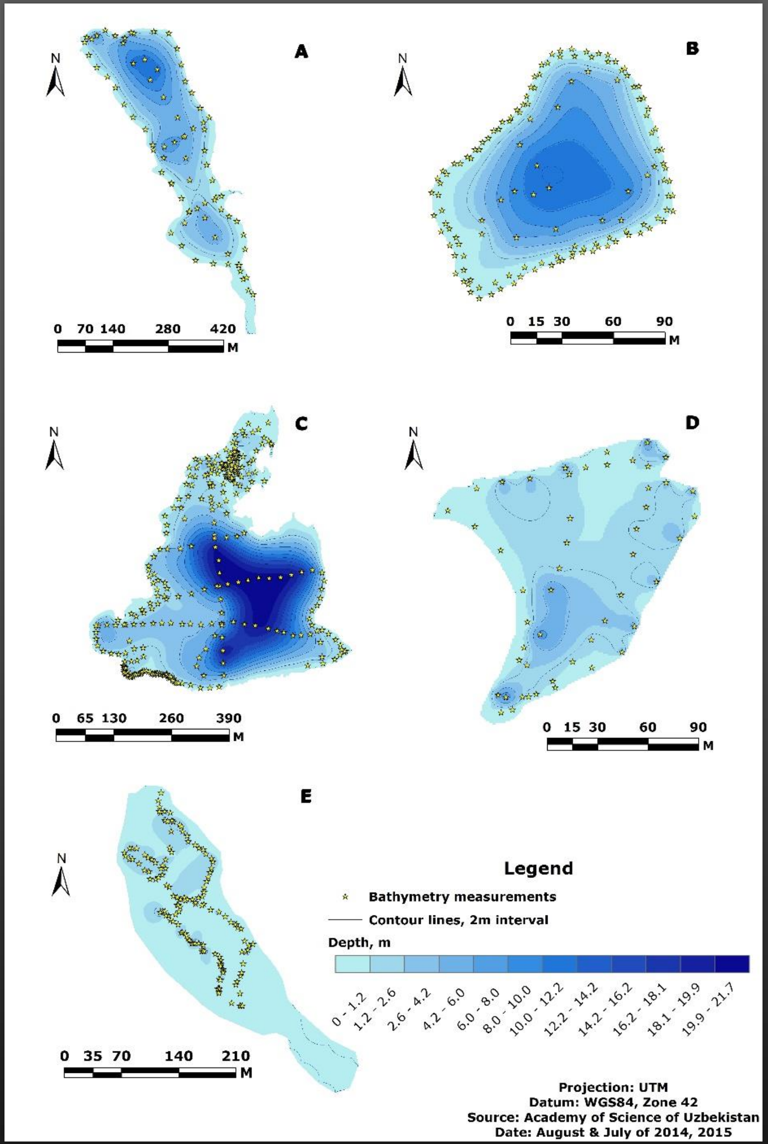
Bathymetric measurements from the field visits to Arashan lakes (2700 m.a.s.l.) and lake Kunkermes (3200 m.a.s.l.)

A)Arashan long; B) Arashan small; D) Arashan xodja; II) B) Arashan small; C) Arashan round; III) Arashan xodja; IV) Kunkermes lake

Field data

Name\Par.*	A (m^2)	V (m^3)	Dmax (m)	Davg (m)	Lmax (m)	Havg (m)
Arashan round	189500	1280000	21.7	6.7	527	2875
Arashan long	89000	278745	12.4	6.4	663	2768
Arashan xodja	13864	41800	7.9	1.8	187	2786
Arashan small	12750	61800	12.2	4.9	101	2876
Kunkermes	39900	25100	3.9	0.6	314	3650

*Parameters: A – area of lake; V – volume of lake; Dmax – maximum depth; Davg – average depth; Lmax – maximum length; Havg – average elevation;



Bathymetry measurements of lakes in Central Asia. a) Arashan small; b) Arashan xodja; c) Arashan long; D) Arashan round; E) Turtkuyluk lake;

About dataset of lakes

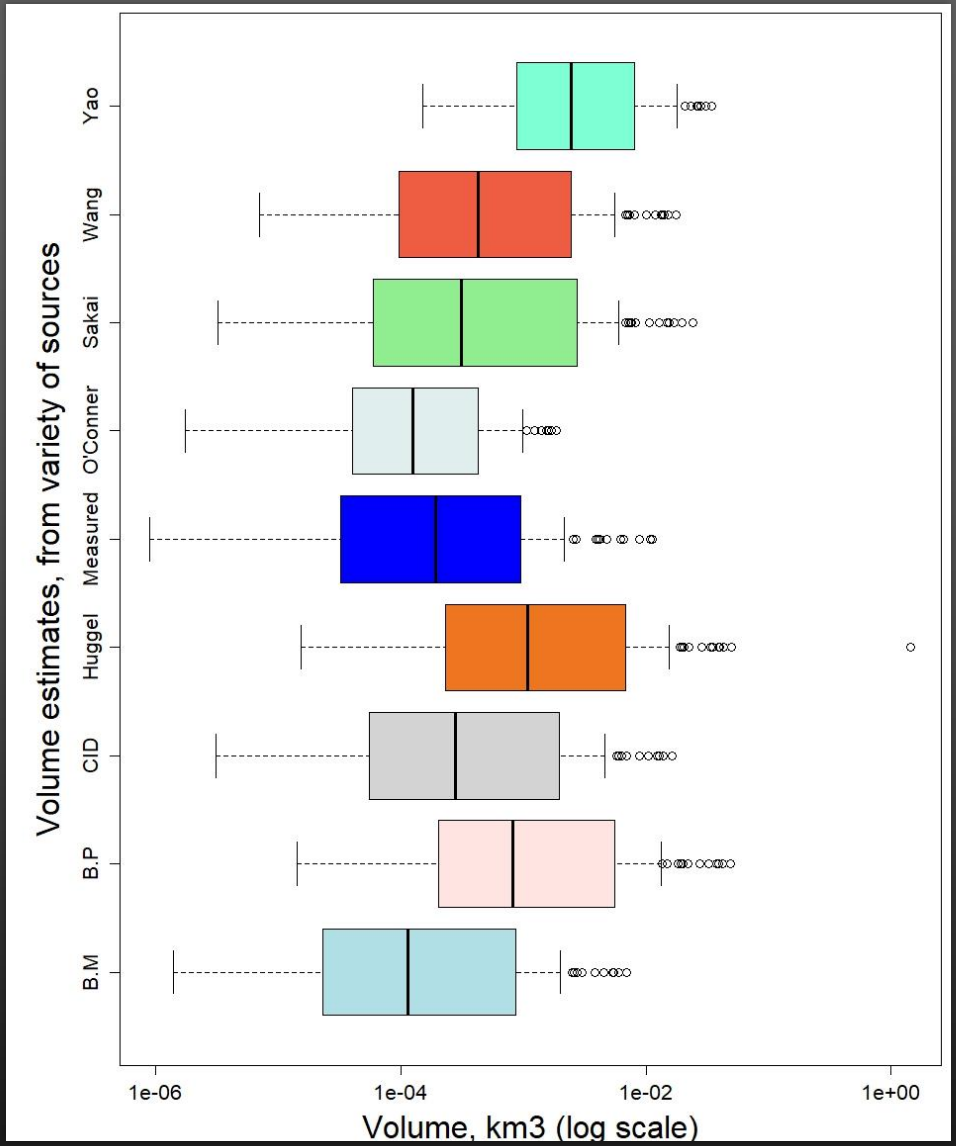
- Data collected all over the world, Asia, South America, North America, Europe

- Described relational equations
  - Sakai 2012, $\mathbf{V=43.74*A^{1.5307}}$ where V is 10^6 m^3 and A is in km^2
  - Huggel in European Alps, $\mathbf{V=0.104*A^{1.42}}$ where V is in m^3 and A is in m^2
  - Canadian Inland Water Directorate (CID) $\mathbf{V=0.035*A^{1.5}}$ where V is in 10^6 $m^{3,}$ and A is in km^2
  - Blagovechshenskiy in Asia for moraine-dammed lakes (B.M) $\mathbf{V=0.636*A^{1.489}}$ **and** $\mathbf{V=0.636*A^{1.489}}$ is for pro-glacial lakes (B.P), where A is in m^2 and V is in m^3
  - O'Connor for Central Oregon Cascade which is following: $\mathbf{V=3.114*A+0.0001685*A^2}$, where V is lake volume in m^3 , and A is the surface area of the lake in m^2
  - Wang for moraine-dammed in Chinese Himalayas and reported the relationship between lakes volume and area $\mathbf{V=0.0354*A^{1.3724}}$ (Wang et al., 2012) where V is in $km^{3,}$ and A is in km^2
  - Yao for Longbasaba (multiple measuremenets) $\mathbf{V=0.0493*A^{0.930}}$, where V is in $km^{3,}$ and A is in km^2

- 4 main types of lakes
  - Thermo carst origin
  - Moraine dammed
  - Ice dammed
  - Landslide dammed

Results

Comparison of equations listed in literature review (estimation of lakes volumes) – entire dataset



Results

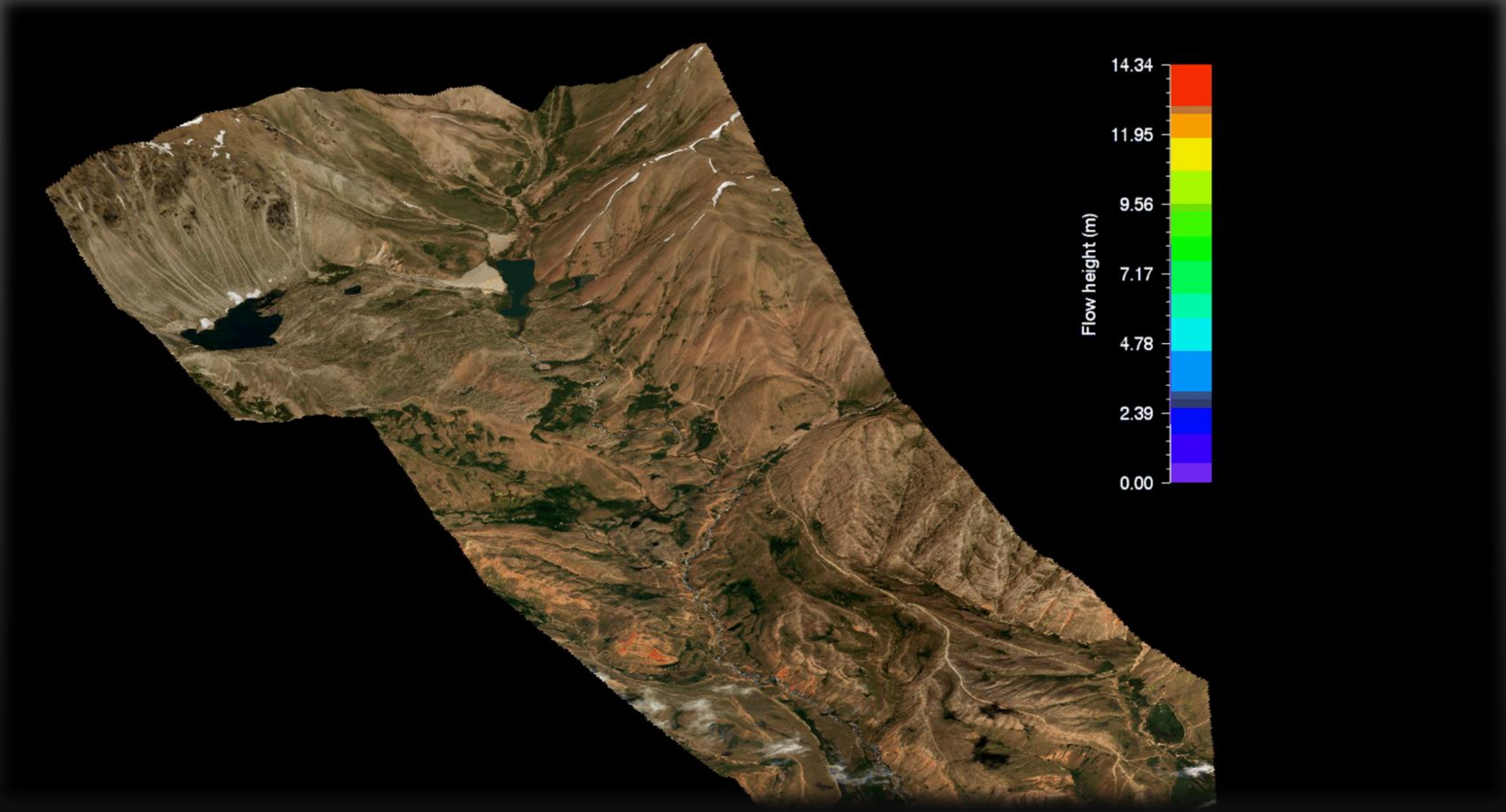
EQ\(%)	Min.	1st	Median	Mean	3rd	Max.	%(Total)
B.M	156†	72	59	71†	91†	62†	85†
B.P	1589	638	423	490	587	436	694
CID	344	173	145	168	210	144	197
Huggel	1700	726	558	1808*	726	12814*	3055
M.Volume (%)	100	100	100	100	100	100	100
O'Conner	193	125†	64†	28	45	17	79
Sakai	356	188	162	218	290	214	238
Wang	778	303	221	196	258	155	319
Yao	16889*	2739*	1276*	513	850*	303	3762*
M.Area (m^2)	2000	17100	50000	116400	157500	600000	-

It is noticeable that among observed lakes, a lake with minimum volume was equal to 900 m^3 and our closest estimate overestimates it by 56 %. The area of the lake is about 2000 m^2.

*Worst estimates between models; † Best estimates between models; CID – Canadian Inland directorate; B.M – Blagoveshenskiy for moraine dammed lakes from (Bolch et al., 2011); B.P – Blagoveshenskiy for progralacial lakes from (Bolch et al., 2011) ; Measured from (Glazirin, 2013; Nikitin, 1987; Petrov et al., 2017); Huggel from (Huggel et al., 2004) ; O'Conner from ; Sakai from (Sakai et al., 2000) ; Wang from (Wang et al., 2012) ; Yao from (Zhang et al., 2015);

History of outburst: Arashan lakes

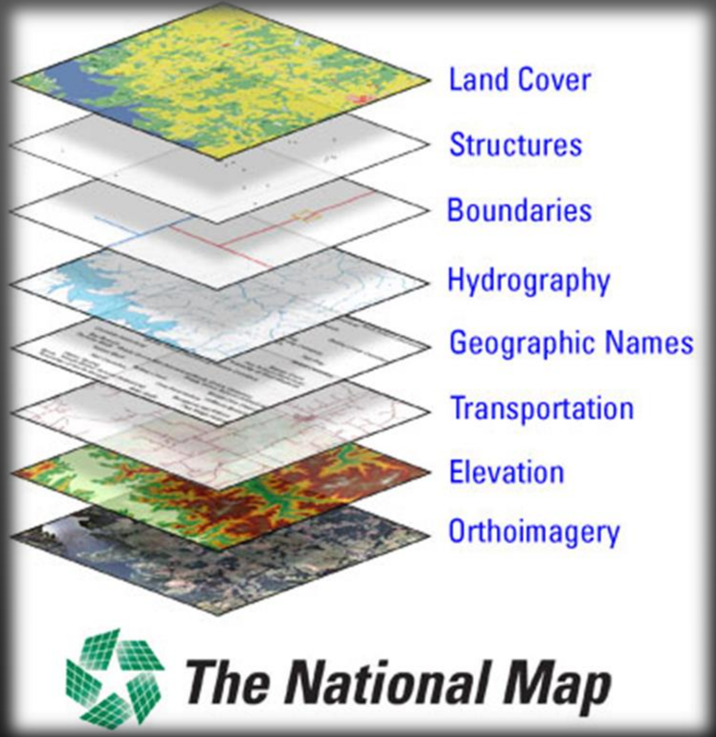
Volume => Hydrograph => Peak discharge & modeling



Seamless GIS modeling, can we do it ?

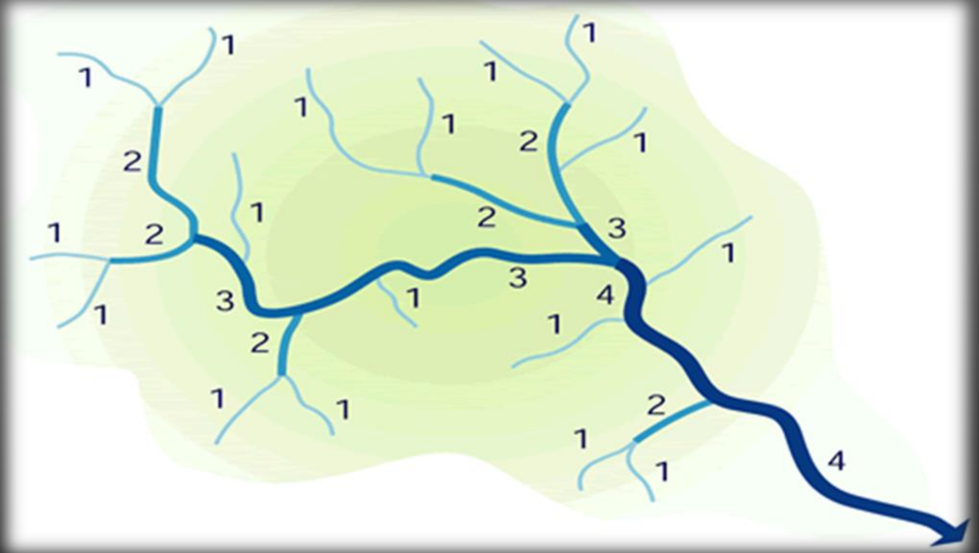
1. Rasterized format of information
2. Elevation accumulation layer
3. River network, from unique flowline to unique flowline ordered downstream
4. Database with flowlines, and related properties of basins upstream, accumulated (Impervious surfaces, soil water capacity, slopes, roughness, proportion of a discharge, land cover types, number of lakes)

    1. Large scale, multidimensional modeling of an event
    2. Assessment of not only lakes, but the entire basin
    3. With integration of RS this process can be dynamic



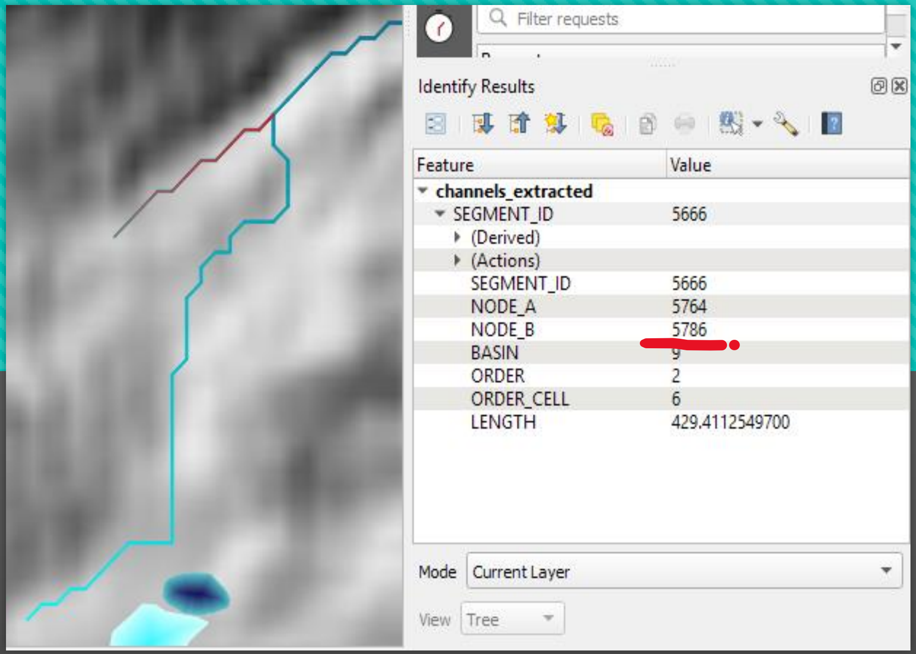
https://en.wikipedia.org/wiki/The_National_Map

River network, Strahler order



1. Unique Reach ID
2. To Node ID
3. From Node ID

Vector features faster to compute and manage, easy access to watershed delination, raindrop trace tools
Extract rasterized information for a flowline vector (Upstream area, soil and landcover properties, surface temperatures other.)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(Derived)
(Actions)
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BASIN 9
ORDER 2
ORDER_CELL 6
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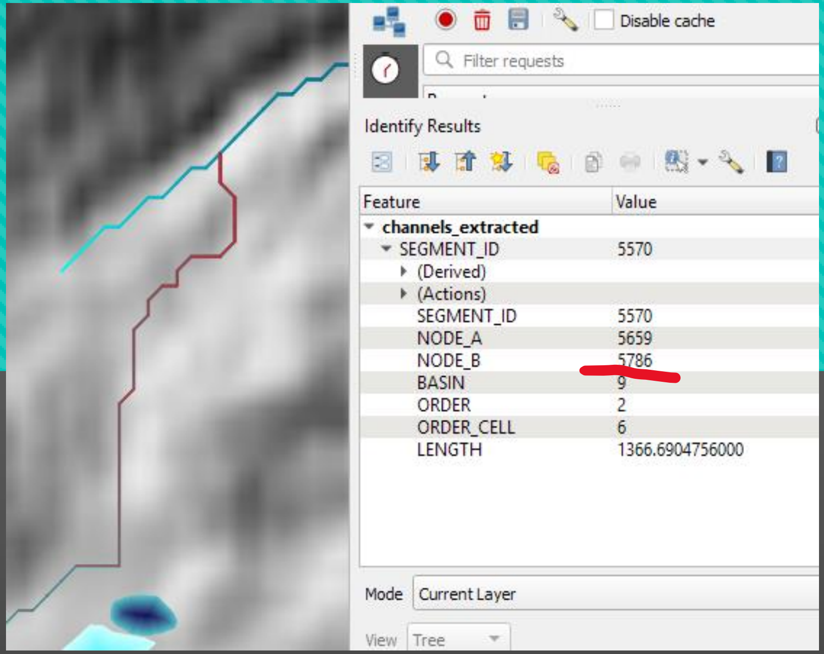
Mode
Current Layer
View
Tree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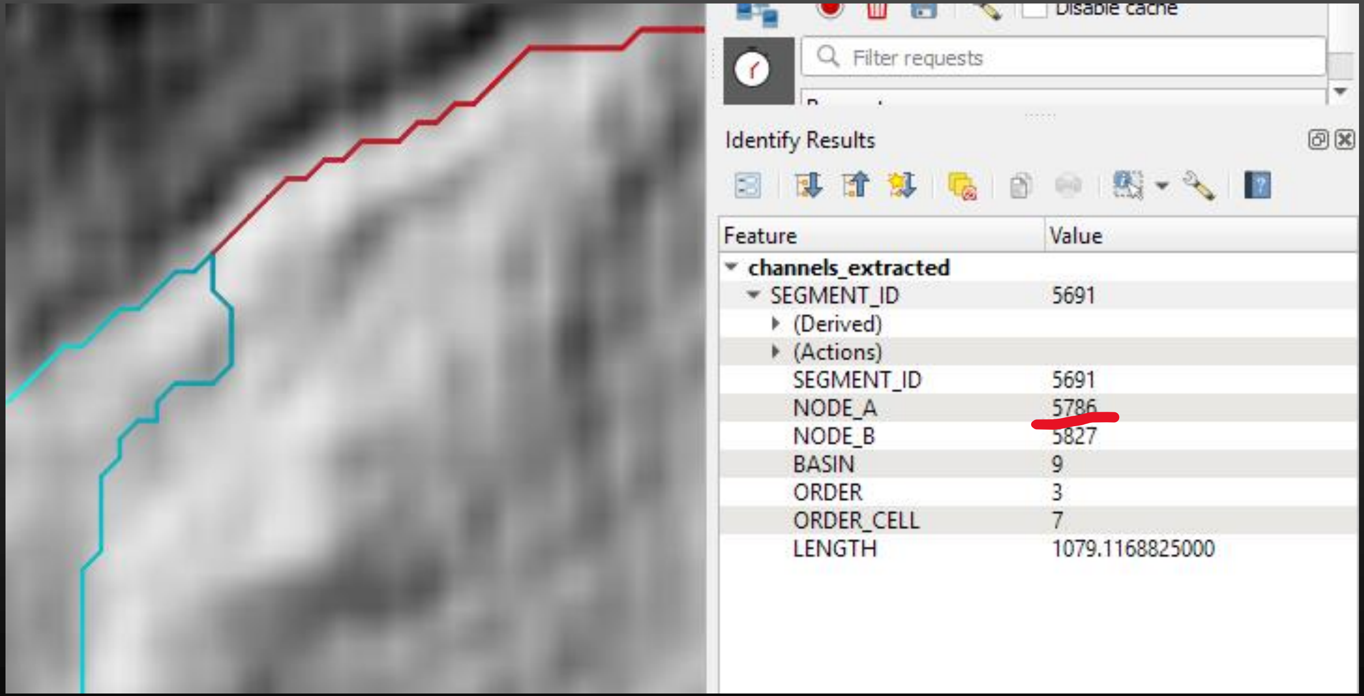
Tree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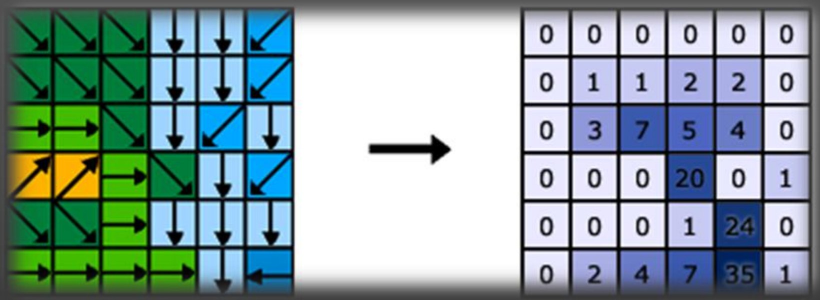
Flow accumulation



MODIS Land Products
MODIS Surface Reflectance
MODIS Land Surface Temperature and Emissivity (MOD11)
MODIS Land Surface Temperature and Emissivity (MOD21)
MODIS Land Cover Products
MODIS Vegetation Index Products (NDVI and EVI)
MODIS Thermal Anomalies - Active Fires
MODIS Fraction of Photosynthetically Active Radiation (FPAR) / Leaf Area Index (LAI)
MODIS Evapotranspiration
MODIS Gross Primary Productivity (GPP) / Net Primary Productivity (NPP)
MODIS Bidirectional Reflectance Distribution Function (BRDF) / Albedo Parameter
MODIS Vegetation Continuous Fields
MODIS Water Mask
MODIS Burned Area Product

1. One of the best temporal/spatial resolutions for grid products
2. Field data

Methods: pixel to pixel assessment of changes

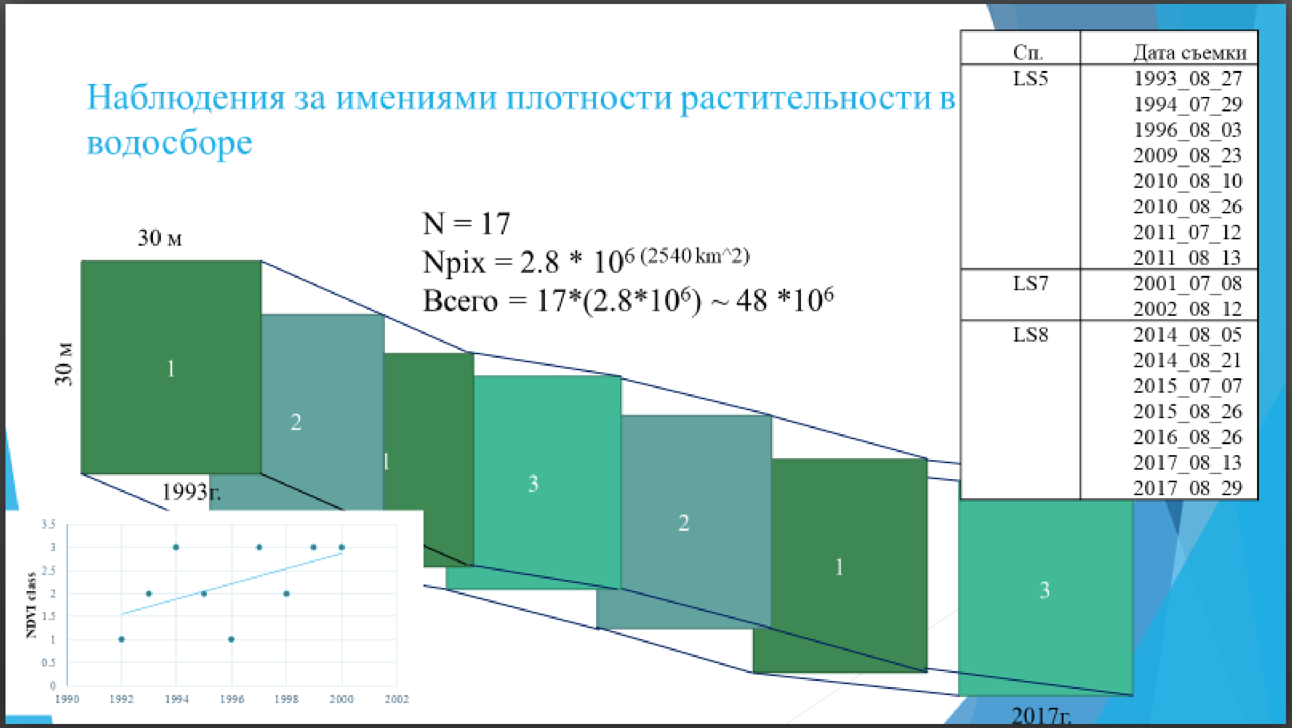
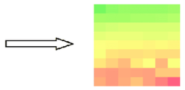
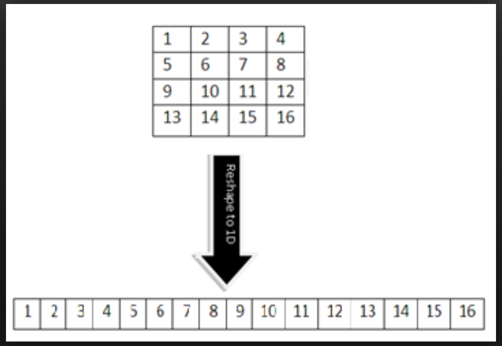


Image – pixel to pixel statistical analysis of changes occurring on the surface of basin

Combination of non-parametric methods of trend detection and remote observations

247	262	267	266	266	266	269
274	272	273	276	277	278	280
289	292	294	295	294	295	294
301	303	303	303	301	301	303
310	312	314	314	315	313	315
309	321	322	322	321	323	323
320	328	336	319	310	338	309
346	350	343	345	346	331	331
342	349	341	333	346	360	376

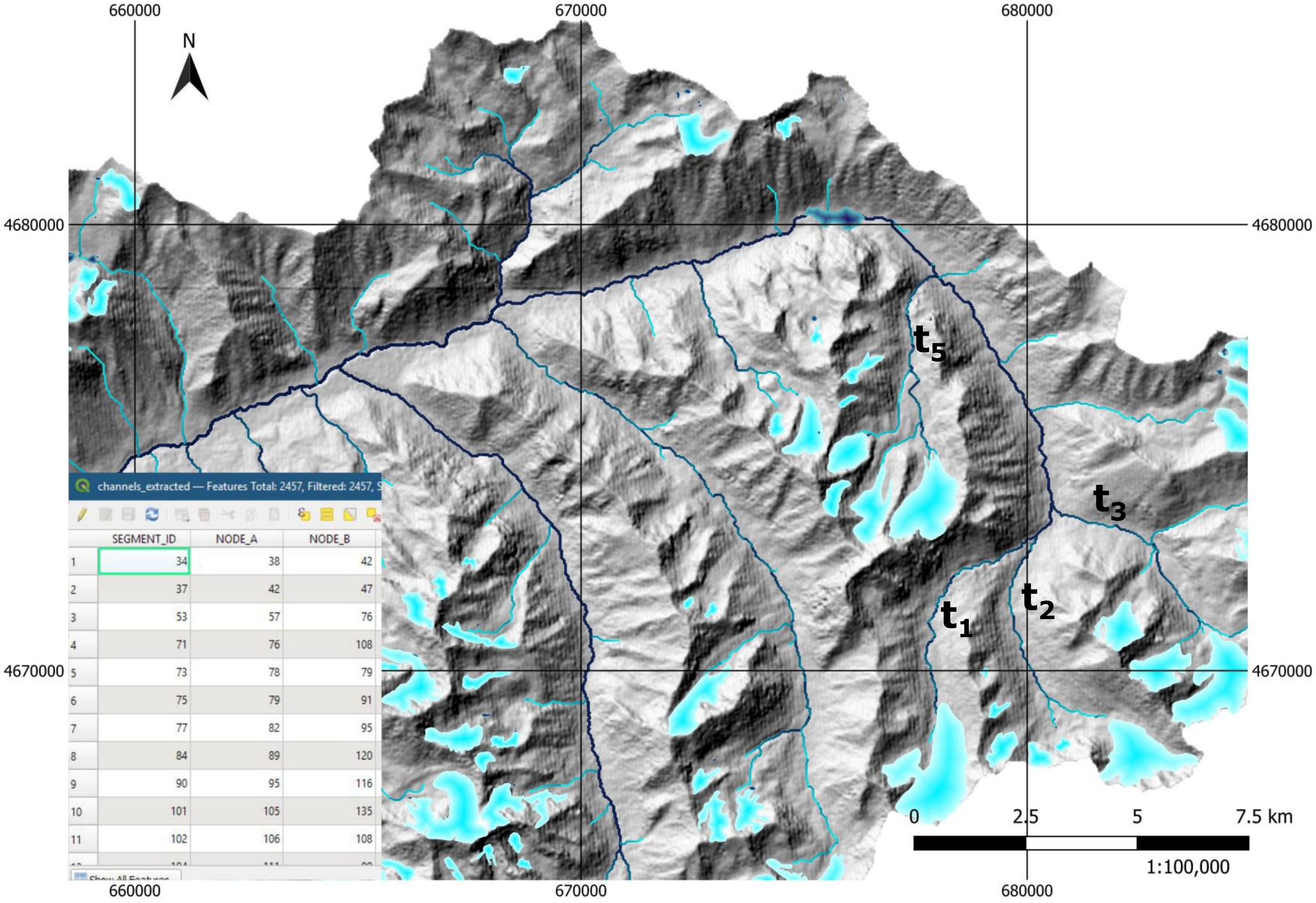




4	8	7	4	4	1	8	3	7	6
1	7	9	3	4	4	8	9	7	9
7	7	2	2	7	7	6	6	7	7
6	9	6	2	3	7	9	8	9	2
3	5	9	5	4	5	8	8	1	3
3	6	8	9	3	8	7	3	9	8
6	8	1	2	1	7	1	1	3	4
4	3	4	8	9	5	3	3	4	3
6	4	4	1	7	7	8	7	2	1
5	1	6	9	1	6	9	9	1	1

Multiple reaches will have various travel times of mudflow (upstream accumulation area, various slopes, various velocity, discharges)

It takes some time before the mudflow or any impact to arrive. We could compute the arrival time after the event. We can model height, velocity, pressure gradients etc.



	SEGMENT_ID	NODE_A	NODE_B
1	34	38	42
2	37	42	47
3	53	57	76
4	71	76	108
5	73	78	79
6	75	79	91
7	77	82	95
8	84	89	120
9	90	95	116
10	101	105	135
11	102	106	108

Live events, April – May, 2022

- Djizakh expiriensed unusualy heavy rains, 10% of annual sum of precipitation in a two hours -> mountain area
- Multiple little slope failures triggered mudflow event
- By the time it reached populated areas, mudflow had at least 90 cms

Djizakh event (April 20th)

Summary

Studies were present from the past that show interest in glacial forms, glaciers and glacial lakes from early 20th century for the region of Central Asia. In the last few decades bigger attention directed towards possible hazard to downstream population, lakes were studied and the bigger one were analyzed in the field. However, there are so many lakes with smaller areas and volume, but the hazard in the events of extreme weather conditions and various impacts is present. Here in Uzbekistan, we are looking to the ways to collect information, not only about lakes but the surround and upstream areas, as well about downstream conditions, cover bigger areas with RS and create seamless GIS database in order to model possible large scale events that would have effect on bigger area and impact number of lakes, watersheds. Such knowledge would help to separate regions with bigger hazard and impact potential and will make it easier to control and direct studies in the future.

Thank you for your attention!
Questions ?

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