The origin of the sediment yield of the Ob' and the Yenisei

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Abstract

Abstract Introduction: Nowadays it is nebulous how much matter is delivered by the largest rivers into the Arctic ocean and how much sediments are eroded by bank and watershed erosion. Thus, these investigations were made for the two biggest watersheds of the Arctic Ocean (the Ob' and Yenisei) and their components of the sediment budget estimated. Methods and results: 1.The fieldwork campaign allowed us to obtain characteristic models of the distribution of suspended and bed sediments in the estuaries of the Yenisei and Ob' river 2.The method for estimating the instantaneous sediment yield is developed based on the author's program for extrapolating ADCP measurement data (language R), water velocity and backscatter intensity. The average annual sediment runoff for the Ob' is 63.5 Mt/year, for the Yenisei – 32.5 MT/year; 3.The watershed component of sediment runoff was estimated by the RUSLE, taking into account the trapping of sediments by reservoirs and lakes. For the Ob' potential watershed is 85 MT/year, and 53.6 MT/year for the Yenisei 4.The Bank erosion was calculated based on GSWE, Arctic-DEM, and HYDROATLAS and GRWL databases for the downstream of rivers, which was 35.0 MT/year for the Ob and 21.9 MT/year for the Yenisei. 5.The total deposition of sediments was calculated as a difference between total sediment yield and total erosion in catchments. For the Ob' total deposition was 56.5 MT/year, for the Yenisei is 43 MT/year. Discussion and conclusion The sediments deposited in the catchment area or in the bedforms can be eroded again by snowmelt and rainfall erosion in the catchment area or directly due to the erosion of the banks. The products of erosion gradually move to the end of the river, with the exception of the part of sediment trapped by reservoirs. For instance, for the Ob', it is only 10% of the watershed erosion, and for the Yenisei, it is 17% of eroded soil on the catchment. According to the calculations, bank erosion for both downstream is less than the watershed component of sediment runoff. The fact that these components are comparable and it gives some progress in solving the still unexplored question of the role of the bank and watershed components in the origin of sediment runoff of large rivers. Acknowledgments This work powered by the grant 18-05-60219 of the Russian Foundation for Basic Research(RFBR)

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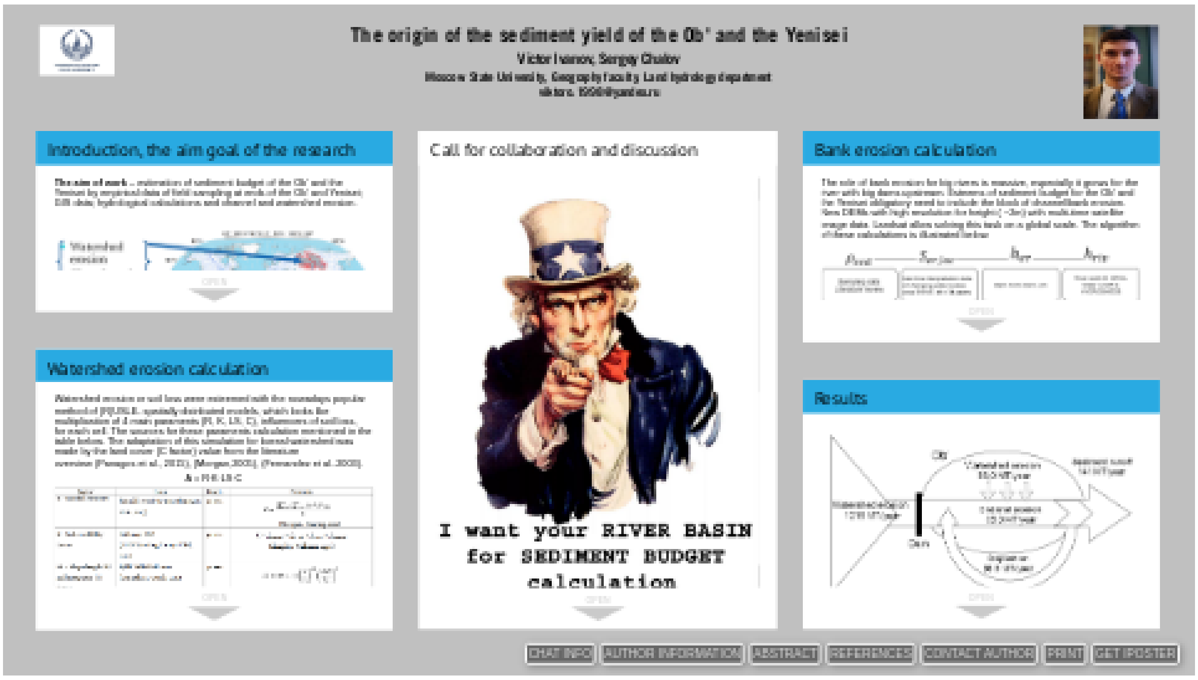

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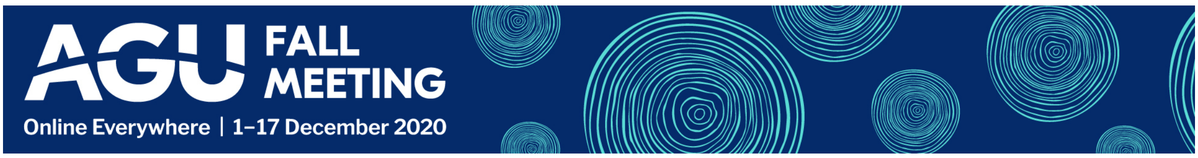
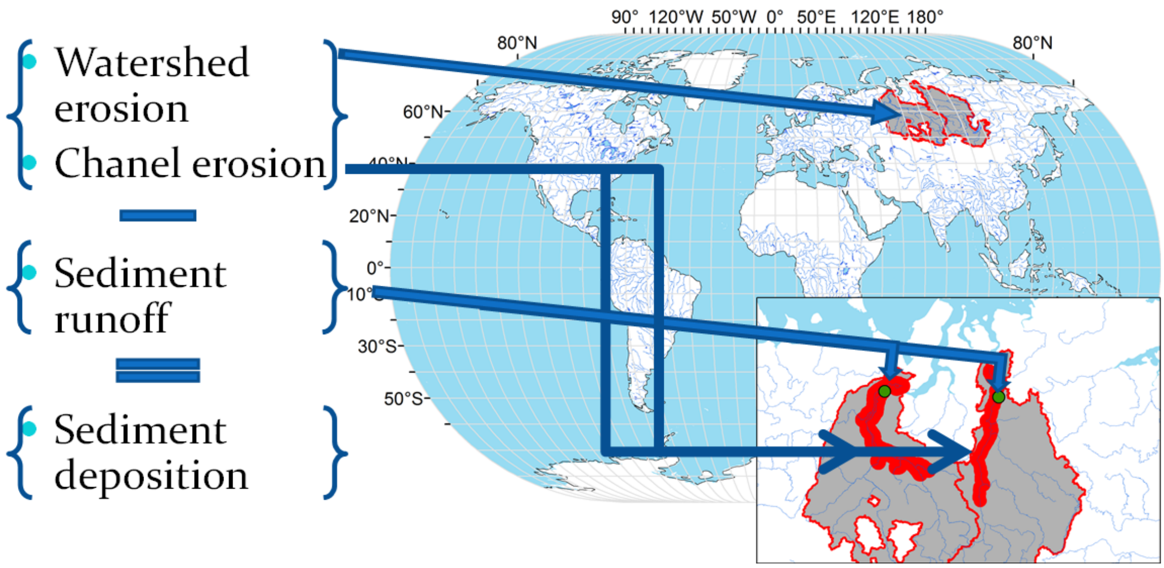


INTRODUCTION, THE AIM GOAL OF THE RESEARCH

The aim of work – estimation of sediment budget of the Ob’ and the Yenisei by empirical data of field sampling at ends of the Ob’ and Yenisei; GIS data; hydrological calculations and channel and watershed erosion.



If watershed erosion and channel/bank erosion can be calculated by modeling and remote sensing data, the sediment yield was measured at the mouths of rivers, the total deposition for all of the watershed can be esteems with normal accuracy only as a difference between sources (erosion) and sinks (sediment yield).

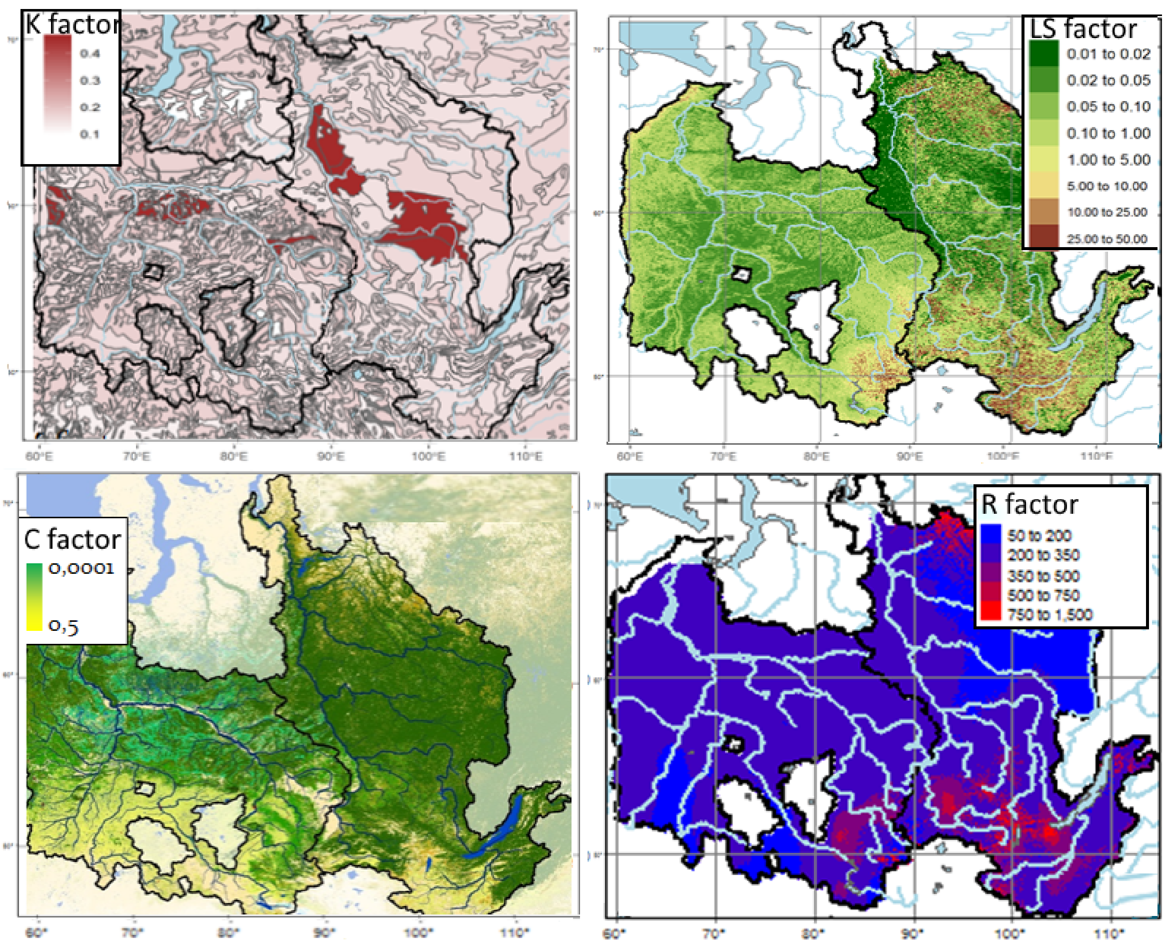
WATERSHED EROSION CALCULATION

Watershed erosion or soil loss were esteemed with the nowadays popular method of (R)USLE- spatially distributed models, which looks like multiplication of 4 main paraments (R, K, LS, C), influencers of soil loss, for each cell. The sources for these paraments calculation mentioned in the table below. The adaptation of this simulation for boreal watershed was made by the land cover (C factor) value from the literature overview (Panagos et al., 2015), (Morgan,2005), (Fernandez et al..2003).

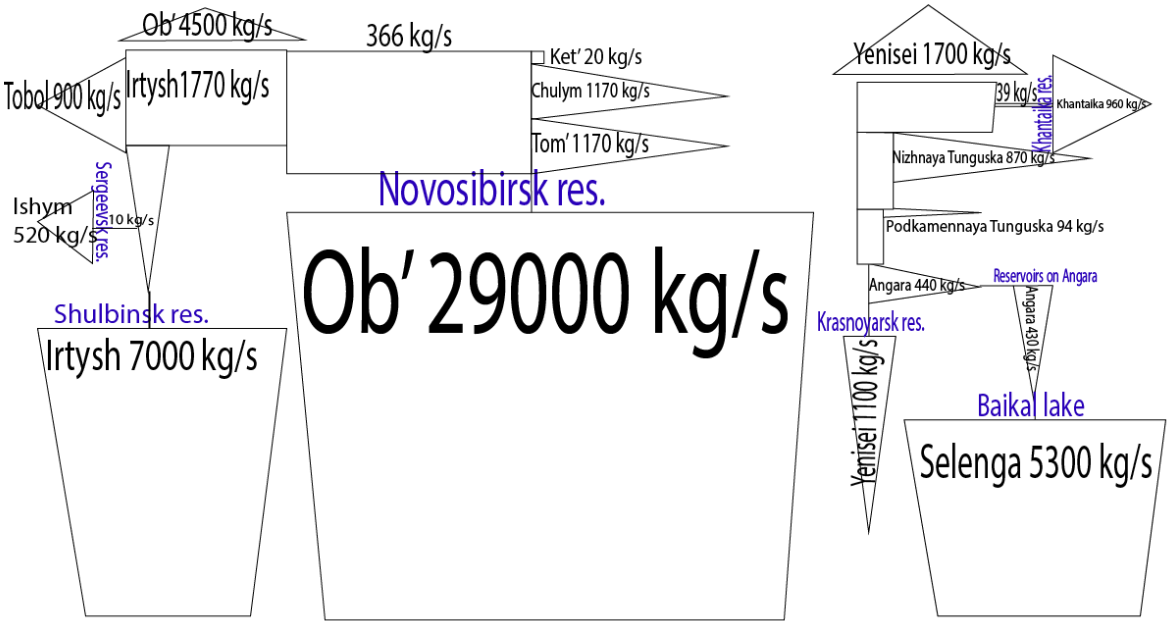
$$A = R \cdot K \cdot LS \cdot C$$

Factor	Issue	Resol.	Formula
R - Rainfall erosivity	Rainfall erosivity map (Panagos et al., 2017)	30 sec.	$R = \frac{(\sum_{i=1}^{n}(\sum_{r=1}^{k}(e_r\vartheta_r)I_{30})}{n}$ (Morgan, Nearing, 2011)
K - Soil erodibility factor	Soil map FAO (IUSS Working Group WRB, 2015)	30 sec.	$K = f_{csand} \times f_{cl-si} \times f_{orgc} \times f_{hisand}$ (Sharpley, Williams, 1990)
LS - Slope length (L) and steepness (S) factor	ЦМР GMETED 2010 (Danielson, Gesch, 2011)	30 sec.	$LS = (m+1)\left(\frac{U}{L_0}\right)^m \left(\frac{sin\beta}{S_0}\right)^n$ (Borrelli et al., 2017)
C - Cover and management factor	GlobCover 2009 Landcover map (Bontemps et al., 2011)	250 m	Empirical coefficients for each vegetation zones (Panagos et al., 2015) (Morgan, Nearing, 2011)

Mapping of RUSLE components:



The fact is that upstream of rivers there are the reservoirs that trap all main sources' large watershed erosion. In other words, more than 70% percents of total eroded material are not potentially accessible to be detected downstream for both rivers because of absence and depositing in reservoirs. It can be illustrated in the figure below. This figure represents the number of sediments which is eroded in each watershed, so its shape suggests that the quantity of matter is growing from upstream to downstream. Furthermore, there are reservoirs in catchments that trap the most part of potential watershed erosion.



Scale:
Mean annual erosion:
100 kg/s
200 kg/s

CALL FOR COLLABORATION AND DISCUSSION

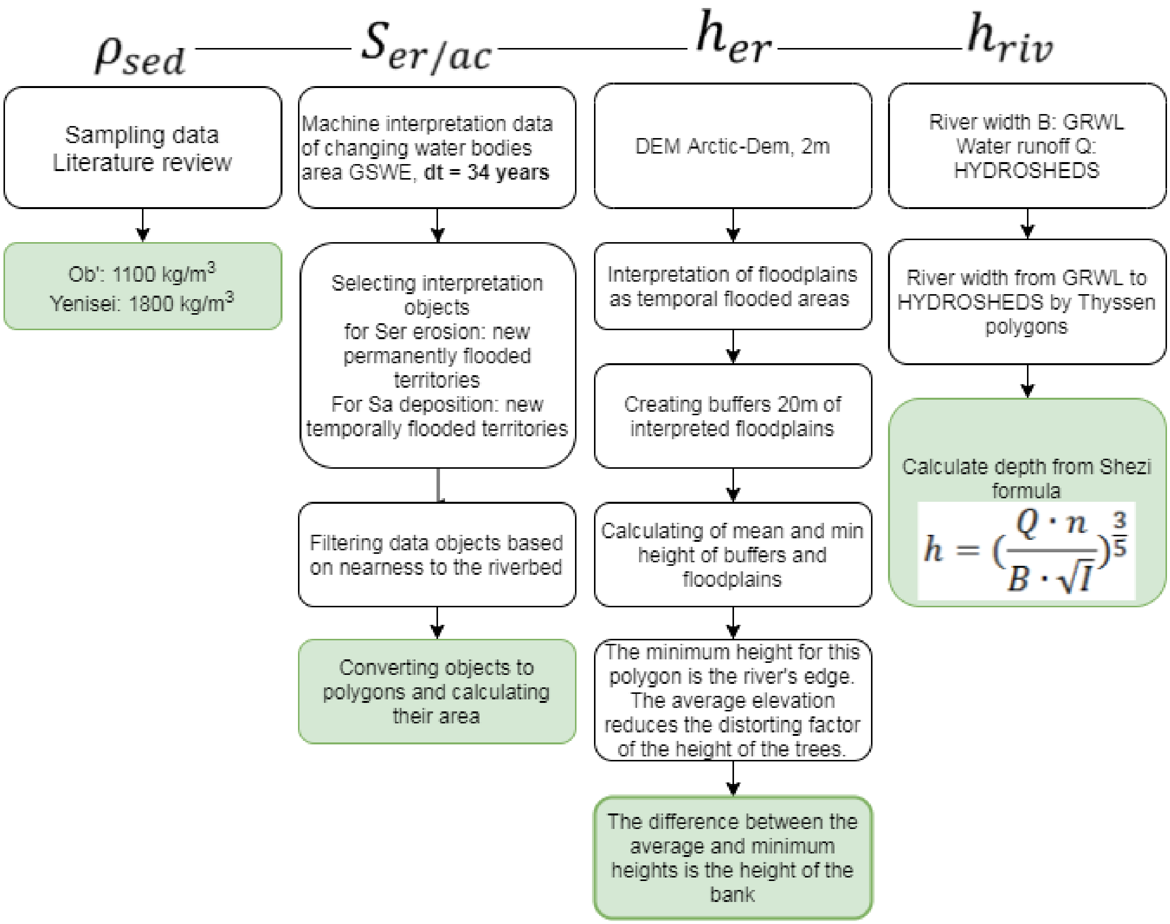
This work is about methods of sediment yield sources calculations for the Ob' and the Yenisei, but if you have ideas of implementing these

calculations for other basins I am full of interest for collaboration!

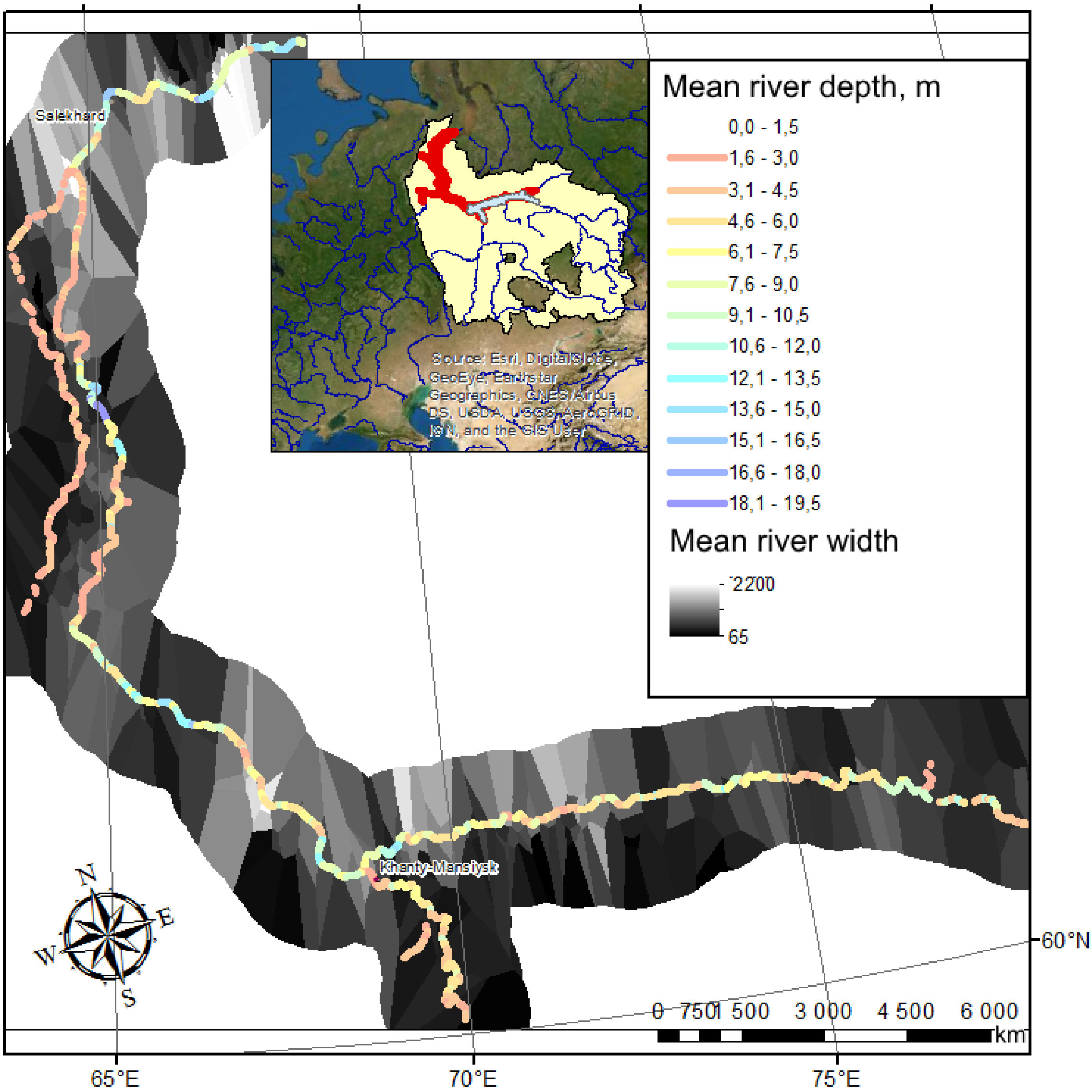
[VIDEO] https://www.youtube.com/embed/o42R1E5L6Ig?rel=0&fs=1&modestbranding=1&rel=0&showinfo=0

BANK EROSION CALCULATION

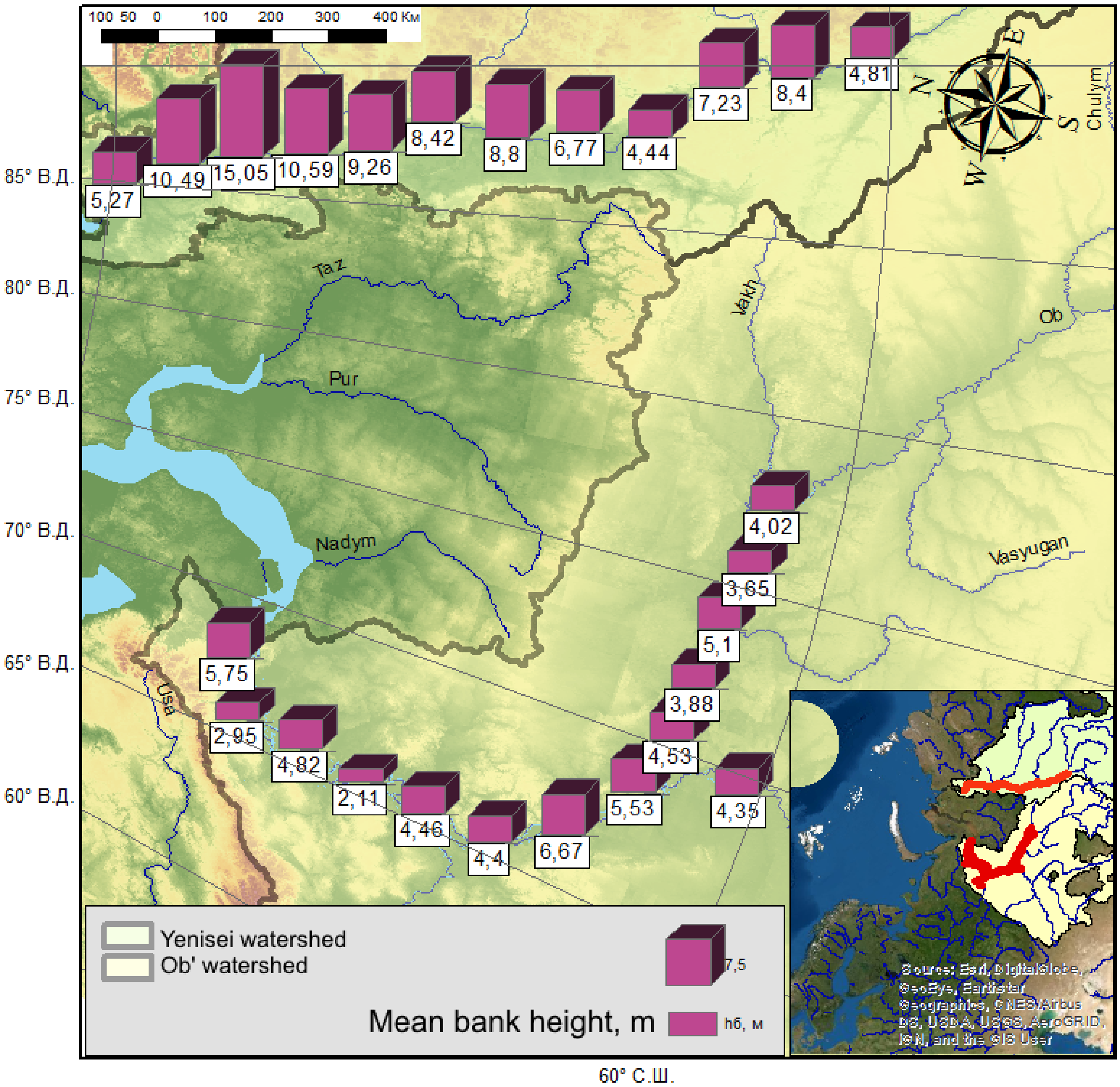
The role of bank erosion for big rivers is massive, especially it grows for the river with big dams upstream. Esteems of sediment budget for the Ob' and the Yenisei obligatory need to include the block of channel/bank erosion. New DEMs with high resolution for height (~2m) with multi-time satellite image data Landsat allow solving this task on a global scale. The algorithm of these calculations is illustrated below.



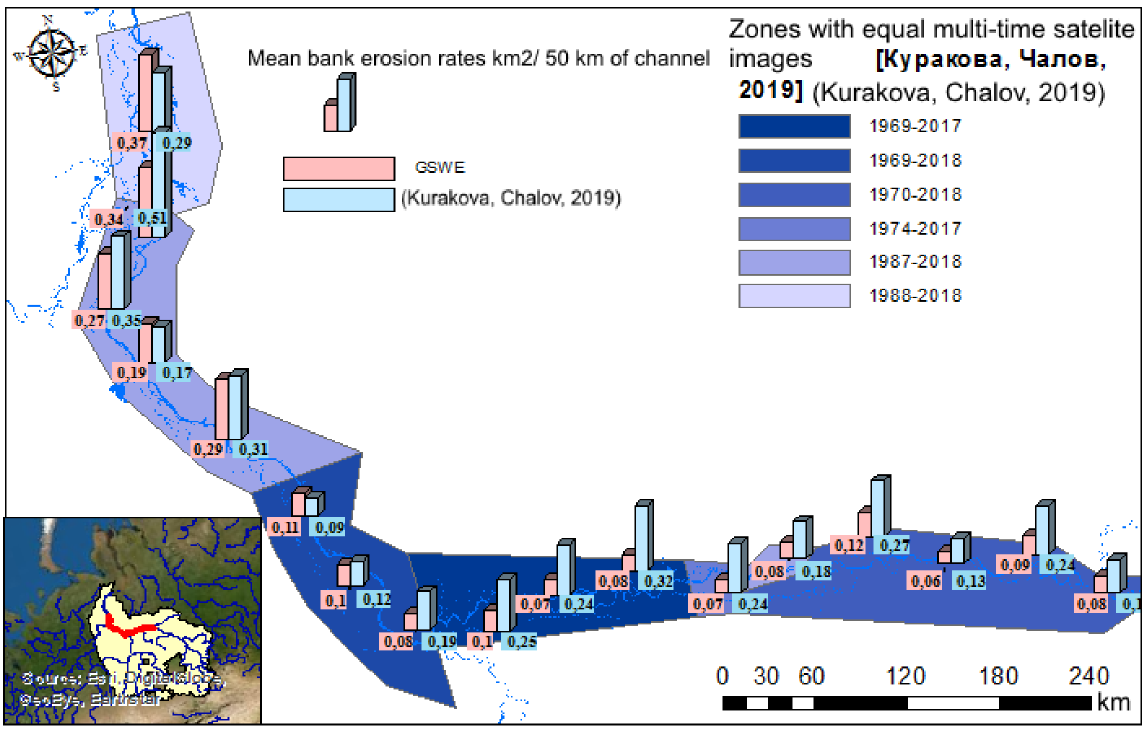
The calculations look like a search of the volume of eroded by rivers polygons with height consisted of mean river depth and mean bank height. These values visualized below



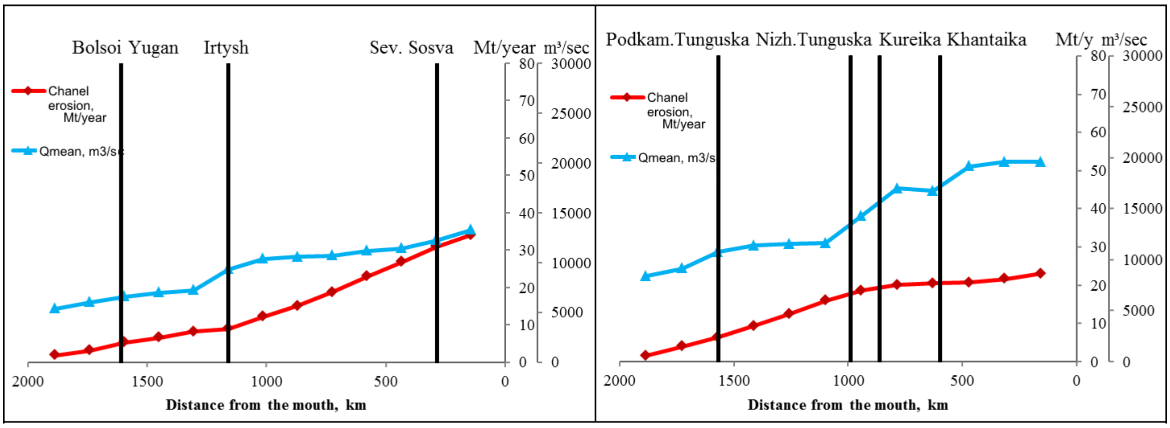
Salekhard
Khanty-Mansiysk
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User
Mean river depth, m
0,0 - 1,5
1,6 - 3,0
3,1 - 4,5
4,6 - 6,0
6,1 - 7,5
7,6 - 9,0
9,1 - 10,5
10,6 - 12,0
12,1 - 13,5
13,6 - 15,0
15,1 - 16,5
16,6 - 18,0
18,1 - 19,5
Mean river width
2200
65
N
E
W
S
60°N
0 750 1 500 3 000 4 500 6 000
km
65°E
70°E
75°E



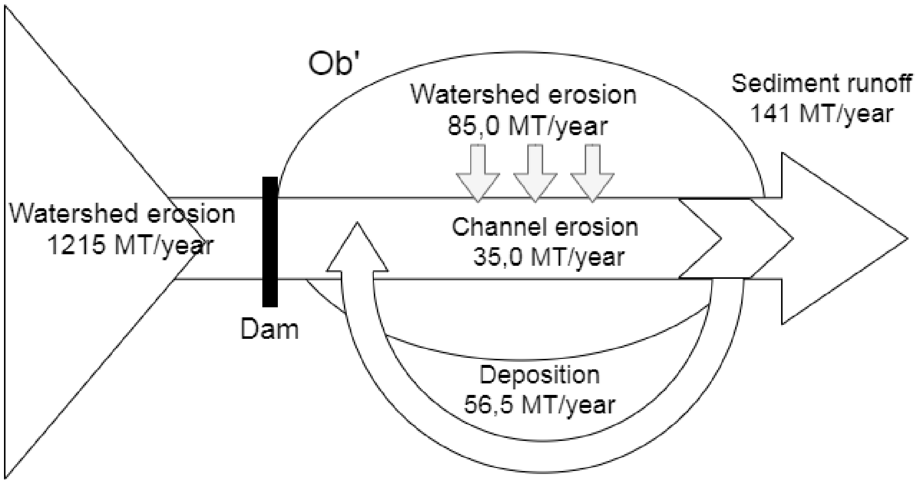
The source for bank erosion areas was the GWSE database that specializes in the water bodies traditions search by Landsat data. The areas of the absence of water near the current channel can be identified as channel erosion areas. This theory was validated with the manual search of channel erosion areas from (Kurakova, Chalov, 2019) and appears a good correlation between GSWE and (Kurakova, Chalov, 2019) data. The difference between areas at least 11%.

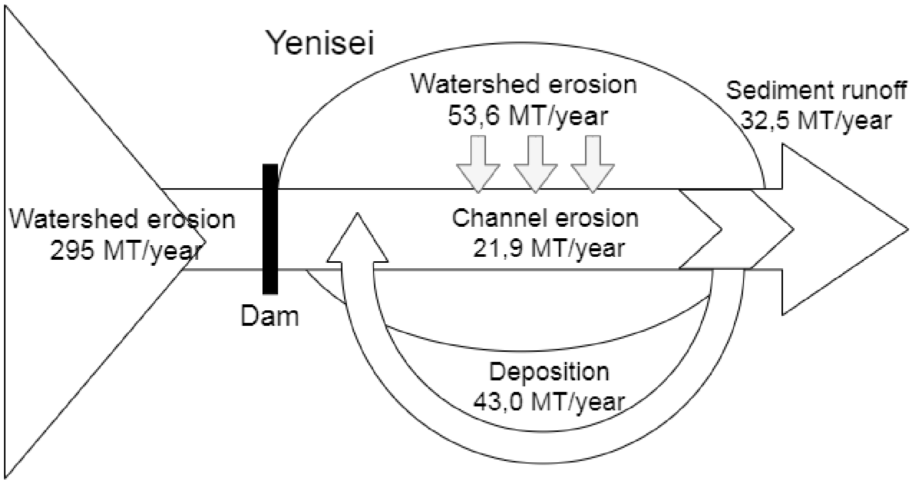


The result of watershed erosion can be visualized as line figures, where lines are summarised values of total channel erosion. With black lines bolded the intersection of main rivers with the biggest tributaries. These places confirm the slowing of erosion rates due to the slowing of mean river velocity and the incoming of new material from tributary catchments, most clear it is for the intersection of the Ob' and the Irtysh.



RESULTS





1. Based on the use of modern databases and DEM with a resolution of 250 m, the watershed component of sediment runoff was esteemed by RUSLE, taking into account the trapping of sediment runoff by reservoirs and lakes. For the Ob catchment area, potential soil loss is estimated as 142 MT/year (11% of the total catchment erosion), for the Yenisei 53.6 MT/year (17%)
2. The calculation of bank erosion was esteemed based on automatic interpretation data: GSWE, Arctic-DEM, HYDROATLAS, and GRWL for the downstream. It was 35.0 MT/year for the Ob and 21.9 MT/year for the Yenisei, which was 20% and 29% for rivers of the full erosion in the studied areas
3. The samplings made it possible to obtain characteristic models of the distribution of suspended sediments downstream of the Yenisei and the Ob' according to the developed methodology for estimating the instantaneous flow of sediments in the cross-section based on the program created by the author for extrapolating ADCP measurement data (R language), as well as by Roshydromet net data. The average annual sediment runoff for the Ob' was 63.5 MT/year, for the Yenisei – 32.5 MT/year (by MSU measurements); for the Ob' 16.4 MT/year, for the Yenisei – 2.38 MT/year for Roshydromet;
4. Based on the assessment of the average annual sediment discharge, the deposition of sediment in the basins of these rivers was esteemed. For the Ob', it was 85.5 MT/year (67,8% of the expenditure components), for the Yenisei 43 M/year (57%), and the sediment delivery coefficients were 0,43 and 0,56, respectively for MSU data for not trapped by reservoirs area.

This information can be also presented as the tables:

Sediment budget								
MT/year	Erosion: Channel	Erosion: Watershed, Not trapped	Erosion: Watershed, Total (100%)	Sediment runoff	Σ Deposition: Not trapped	Σ Deposition: Total	SDR: Not Trapped	SDR: Total
Ob'	35	142 (11%)	1250	63,5	85,5	11186	0,44	0,05
Yenisei	21,9	53,6 (17%)	315	32,5	43,0	304	0,43	0,10

Sediment budget								
%	Erosion, % of full erosion: Channel for not trapped area	Erosion, % of full erosion: Channel from **total**	Erosion, % of full erosion: Watershed, Not trapped	Erosion, % of full erosion: Watershed, Total	Sediment runoff, % full erosion: Not trapped	Sediment runoff, % full erosion: Total	Deposition, % full erosion: Not trapped	Deposition, % full erosion: Total
Ob'	20%	2,7%	80%	97,3%	32,2%	5,0%	67,8%	95,0%
Yenisei	29%	6,5%	53,6	93,5%	43,0%	9,6%	57%	90,4%

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hh.ru: https://hh.ru/applicant/resumes/view?resume=3a3bbe1fff087ad2380039ed1f65664b385971 (https://hh.ru/applicant/resumes/view?resume=3a3bbe1fff087ad2380039ed1f65664b385971)

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ABSTRACT

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