

PAPER • OPEN ACCESS

## Landscape-hydrologic systems and erosion processes across the middle Ob region

To cite this article: S E Korkin *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **381** 012047

View the [article online](#) for updates and enhancements.

# Landscape-hydrologic systems and erosion processes across the middle Ob region

S E Korkin, V A Isypov and E A Korkina

Nizhnevartovsk State University, Russia, Nizhnevartovsk

E-mail: egf\_nv@mail.ru

**Abstract.** The present paper considers landscape and hydrological systems and erosion processes in the middle Ob territory. In the monograph by A.N. Antipov and V.N. Fedotov [1], the middle Ob territory belongs to Ob-and-Irtysh forest-boggy, lowland accumulative landscape hydrological system of Western Siberia. In recent years, many significant events of natural character within the middle Ob territory (high level of floodwater in 2002, 2007 and 2015 and unusually warm and low water summer in 2003, 2012 and 2016) bring into focus the role of climatic changes. Variations of meteorological parameters provoke spikes in the development of the leading class of factors related to the complex of natural processes. A map of the key sector of the studied region is drawn to spatially visualize the structure of valley landscapes of the middle Ob region. Erosion processes are observed at the initiative station called "Ust-Vakhsky". Within the sector of the station, the maximum bank recession rate measured by Tymen complex geological survey expedition in 1988 is 25 m/year, and the long-term average is 5.26 m/year (1983-1994). Long-term average annual bank recession rate by monitored cross section over 2002 - 2018 is 2.9 m/year. The maximum bank recession rate measured in 2004 is 17.5 m/year at the fifth cross section.

## 1. Introduction

According to the landscape-hydrological zoning performed by A.N. Antipov and V.N. Fedorov [1], the land of the middle Ob relates to the Ob-Irtysh forest-marsh, a low-accumulative landscape-hydrological system of Western Siberia. Our studies give landscape descriptions and analyze the erosion data at the level of landscape provinces of the Ob River valley: Middle-Ob, Agansk, and Surgut marshy scrub. The landscape-hydrological zoning of the Ob River floodplain within the Middle Ob at the level of provinces is divided by A.N. Antipov and V.N. Fedorov into the Nizhnevartovsk depression long-term flooding and Surgut mid-elevated long-term flooding. Basin characteristics of inflowing rivers determine features of the Ob River floodplain in the latitudinal segment, one of which is the Vakh flowing into the Ob from the right side and forming a massive floodplain area up to 40 km in width. This specific landscape characteristic is subordinated simultaneously to the geological and geomorphic structure of the land, which differentiates the floodplain of the Ob: the Surgut floodplain to the Vatinsky Egan, with absolute heights of 32-34 m, a total area of 245,660 ha; the Nizhnevartovsk floodplain to the mouth reach of the Vakh with absolute heights up to 38 m, an area of 60,900 ha.

The study of erosion processes dynamics based on the analysis of landscape and hydrological indicators includes the characteristics of several important factors: precipitation, air and soil temperatures, the lithological composition of reservoirs, surface slope, water content, and bed-formation flow rates.



The research paper edited by R.S. Chalov, E. M. Pleskevich and V.A. Baula [2] provides data on the Ob river water content, where along with short groups (3-7 years), there are high and low water content cycles of 9, 14 and 26 years. For the Middle Ob, there are three periods of high water content and four periods of low water content. The cyclical nature is obvious in the long-term precipitation trend; they are characterized by cycles of 25-30 years, as well as 4-5 year phases different in water content. The annual precipitation trend relates to the continental type, and the annual amount for the Ob valley varies from 225 to 722 mm. The maximum average annual precipitation is 650 mm. The average precipitation is 510 mm. The average annual runoff varies from 200 to 250 mm. The atmospheric moistening has little effect on the landscape and hydrological organization of the land for hierarchic elements below the provinces.

Some recent significant natural events within the middle Ob (high level of floodwaters in 2002, 2007 and 2015 as well as abnormally warm and low-water summer of 2003, 2012 and 2016) emphasized the role of climatic changes. According to F.N. Ryansky [3], among the processes that have a significant impact on geological systems are natural cycles at intervals of 12, 36 and 108 years. A characteristic feature of such processes is the geophysical complex of various natural periodic changes, which include sharp fluctuations in dryness – humidity with economically significant droughts and floods, development of active erosion, long severe and snowy winters (for example, winters of 2014-2015 and 2016-2017) [4]. Fluctuations in meteorological parameters cause spikes in the development of a leading class of factors related to a combination of erosion processes, including channel-forming water flow.

For the spatial reflection of the middle Ob valley landscapes structure, the key section of the study area was mapped. The scientific and methodological basis was the works of V.I. Bulatov [5], E.E. Rodnyanskaya [6] and V.V. Kozin, et al., [7-9]. Landscape group areas singled out by V.V. Kozin and N.N. Moskvina [7] were joined into a landscape area where types of terrain related to the lowland development cycle of the Ob River and its tributaries put in. Within the study area, we have identified 7 landscape areas and 14 sub-districts, which correspond to the localities.

For the level of terraces above floodplains and Holocene for the floodplain level, the landscape-hydrological structure of the river valley depends on erosion-accumulative processes in the upper neo-Pleistocene. Currently, the natural structure of river basins is undergoing an intensive transformation associated with the economic development of the grounds, including agriculture. According to I.B. Petrov [10], in the Nizhnevartovsk floodplain area confined to the middle Ob province, there are 2-2.2 thousand km<sup>2</sup> of reed canarygrass, sedge-reed canarygrass and motley grass-grasses meadows of subdued layer, located in the lithological morphological types of floodplain arrays, having high relevance to an arrangement of grasslands. Indicators of landscape province catchment differ in the structure of landscape-hydrological characteristics given in the table for the right-bank valley landscapes of the middle Ob.

## **2. Objects, data and methods**

In this paper, we used methods of monitoring the dynamics of erosion processes within the middle Ob: a field method using the satellite positioning systems and measurements of bank recession rates by field-established benchmarks and a method of space images interpretation. Extensive experience was obtained in the survey and prediction of river channel deformations in the Tomsk region by researchers of TSU Geography and Hydrology Chairs A.A. Zemtsov and D.A. Burakov; the surveys started at the end of the 1950s and later on were continued by Yu.I. Kamenskov, V.A. Lgotin, N.S. Evseeva, V.S. Khromykh and others. [11]. In 1975, O.I. Bazhenova reported about the development of bends and existing geomorphological processes in the middle Ob by comparison of pilot charts of 1928 and 1968 [12].

Erosion processes are monitored at the proactive station called "Ust-Vakhsky". In 2001, five observation points were arranged on the right bank of the Ob, starting from the mouth of the Vakh, and in autumn 2002 – five more observation points down the river. The deployment of the observation points is subject to the principle of point "location" of the Tyumen complex geological survey

expedition (1983-1993 is the period of TCGSE available data) and the most active parts of the bank slope of the Ob River. The distance between the observation points is 500 m. The peculiarity of this observation station is the intensive manifestation of erosion washing of the bank slope with the connotation of landslide-talus phenomena, peat formation, deflation of sandy beaches, and ravine formation, as well as the development of accumulation on the left bank. The maximum hydrodynamic pressure on the bank of the unbranched channel of the Ob River allows us to identify this area as the most highly exposed to washing (erosion). This type of terrain is central floodplain meadow-sor-affected, where the main surface of the running-sor-affected and central floodplain with sedge-reed canarygrass meadows sometimes turns into open groups of sor-affected vegetation.

### 3. Results and discussion

Within the observation station "Ust-Vakhsky", the maximum rate of bank edge retreat recorded by the Tyumen complex geological survey expedition (TCGSE) in 1988 is 25 m/year. Over 11 years, the long-term average annual rate was 5.26 m/year. The Ob bank edge shifting rate from 2002 thru 2018 was as follows: in 2002 – 7.8 m/year; 2003 – 2.35 m/year; 2004 – 3.46 m/year; 2005 – 2.89 m/year; 2006 – 4.19 m/year; 2007 – 3.25 m/year; 2008 – 1.93 m/year; 2009 – 2.36 m/year; 2010 – 1.57 m/year; 2011 – 1.51 m/year; 2012 – 0.68 m/year; 2013 – 2.36 m/year; 2014 – 2.45 m/year; 2015 – 5.0 m/year, in 2016 – 1.69 m/year, in 2017 – 2.57 m/year, and in 2018 – 2.58 m/year. Long-term average annual bank recession rate by monitored cross section over 17 years is 2.9 m/year. The maximum rate of shoreline retreat recorded in 2004 is 17.5 m/year at the fifth observation point. The satellite positioning result is that the outwash area in 2015 was 29,472 m<sup>2</sup>, in 2016 – 11,403 m<sup>2</sup>, in 2017 – 15,400 m<sup>2</sup>, and in 2018 – 17,841 m<sup>2</sup>. The volume of washed-out soil in 2015, with the average bank height of 4.9 m, was 144,412.8 m<sup>3</sup>, in 2016, with the average bank height of 4.8 m, – 54,734 m<sup>3</sup>, and in 2017, with the average bank height of 5.3 m, – 81,620 m<sup>3</sup>, and in 2018, with the average bank height of 5.5 m, – 98,125 m<sup>3</sup>. The results are associated with the water content of the river, namely the channel-forming water flow. R.S. Chalov, S.N. Ruleva and N.M. Mikhailova [13] divided the Ob River into sections, where the considered key section falls within the middle Ob (the mouth of the Ket River, conflux with the Irtysh). In this section of the Ob, there are three intervals of bed-formation flow rates. The lower interval  $Q_{\phi}$  occurs at low water content corresponding to the flooding of micro- and mesoforms of the river bottom (ridges, spillovers and midstream sandbanks). The impact works on the bottom and comes to the movement of these forms, as well as the conversion of one form into another. The average interval of the channel-forming water flow is associated with the water flow corresponding to the channel filling level flush with the edges. This interval should include the range of water flows from levels just below the channel edges to levels exceeding them by 1 m. In this case, the flow works on the channel, contributing to the reformation of large forms (individual bends and branch points). To the upper range of channel-forming water flow rates are flows occurring at levels significantly higher than the level of channel edges. The flows of this interval can have a significant impact on entire sections of the channel network, up to the complete change of the channel operation type [14]. An important point in considering the channel-forming flow issue is the analysis of sediment transport. Sediment runoff results from lithogenic material that enters the river with the waters of tributaries and temporary streams brought by the wind as well as enters the channel during landslides, scree and rockslides on the banks. At the same time, sediments enter the stream due to the erosion of the beds and banks. Some material transferred by the river forms and ridge accumulative forms of the channel relief moving along the river is one of the sediment flow types [15]. The paper of Ya.A. Melnikova and D.A. Vershinin [16] duly considers this issue and gives the combined analysis of the two observation stations at the Prokhorkino and Aleksandrovskoe villages since from 1960 to 1997, observations of suspended sediments were carried out at the station of the Prokhorkino village, and after its closure, the observations moved to Aleksandrovskoe. In high-water years, the maximum flow rates reach almost 20,000 m<sup>3</sup>/s. In April, the average monthly flows increase along with the average monthly flows of suspended sediment and turbidity. In the other months of the flood (May, June), the average monthly water and suspended sediment flows are much lower. In summer with low

water, the flow rate less decreases, but the flow of suspended sediment is low due to reducing turbidity. Peculiarities of average monthly suspended sediment flow distribution within a year and during many years generally correlate with the distribution of average monthly water flow rates. Comparison of the two periods of available observations of the bank erosion activity from 1983 to 1993 and from 2002 to 2018, allows us to assume that high erosion rates in the first period are associated with a cycle of increasing sediment flow from 1987 to 1997 [16], and a low erosion in the second period is associated with a decrease until 2012.

#### 4. Conclusion

These surveys allow for short-range prediction of the Ob bank stream erosion dynamics in the Nizhnevartovsk province, low long-term-flooding, when wide floodplain river channel types are formed, bends are free, reaches are developed with islands in the near-to-summit part, and the floodplain is dissected into multiple arms. Channel-forming water flow rates largely depend on the water content and are indicators of the river channel operation stability.

#### Acknowledgments

The survey was carried out within the framework of pilot scientific project No. 5.7590.2017/8.9 of the Ministry of Education and Science of the Russian Federation and under the sponsorship of RFBR and the Government of the Khanty-Mansiysk Autonomous Area – Yugra research project No. 18-45-860001.

#### References

- [1] Antipov A N and Fedorov V N 2000 *Landscape-Hydrological Planning* (Novosibirsk: Publishing house SB RAS) p 254
- [2] Chalov R S, Pleskevich E M and Baula V A 2001 *Riverbed Evolution and Waterways of the Ob Basin* (Novosibirsk: RIPEL Plus) p 300
- [3] Ryansky F N 2001 Landscape approaches and methods of geo-ecologic regional prediction *II Regional Meeting Issues of Ecological Safety of oil and Gas Complex of Middle Ob and Ecological and Economic Sustainable Development of Khanty-Mansiysk Autonomous Area* pp 77-80
- [4] Korkin S E, Talyneva O Yu, Kail E K, Korkina E A and Isupov V A 2017 Exogenous geodynamic processes of the central part West Siberia *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM* pp 329-35
- [5] Bulatov V I 1968 Types of terrain and natural areas *Nature and Economy of the Aleksandrov Oil-Bearing Area* (Tomsk: Tomsk University) pp 278-88
- [6] Rodnyanskaya E E 1993 *Floodplain Landscapes of Taiga Zone* (St. Petersburg: Editorial and Publishing Unit of St. Petersburg University) p 112
- [7] Kozin V V and Moskvina N N 1998 Fractional landscape zoning of Khanty-Mansiysk Autonomous Area *Issues of Geography and Ecology of Western Siberia: Collection* (Tyumen: Publishing house of the Tyumen State University) vol. 3 pp 3-39
- [8] Kozin V V 2000 *Types of Localities Yugoria: Encyclopedia of Khanty-Mansiysk Area*. (Khanty-Mansiysk: PH Socrates) vol. 3 pp 188-96
- [9] Moskvina N N and Kozin N N 2001 *Landscape Zoning of Khanty-Mansiysk Autonomous Area* (Khanty-Mansiysk: GUIPP Poligrafist) p 40
- [10] Petrov I B 1979 *Ob-Irtysh Floodplain (Typing and Qualitative Assessment of Lands)* (Novosibirsk: Nauka, Sib. branch) p 136
- [11] Zemtsov A A and Khromykh V S 1999 Issues of West Siberia geography *Issues of Siberian Geography* **23** 5-10
- [12] Bazhenova O I 1976 Development of bends and existing geomorphic processes in the mid-Ob *Report Institute of Geography of Siberia and Far East* **50** 64-71

- [13] Chalov R S, Ruleva S N and Mikhailova N M 2016 Assessment of the morpho-dynamic complexity of a large river bed in the planning of water management activities (as exemplified by the Ob) *Geography and natural resources* **1** 29-37
- [14] Kiselev D V and Zemtsov V A 2011 Determination of characteristic water flow rates intensively affecting the riverbed formation process (as exemplified by rivers of the Tomsk region) *Bulletin of Tomsk State University* **351** 169-74
- [15] Chalov R S and Liu Shuguang 2005 sediment Load and its components as a factor of channel processes (as exemplified by rivers of Russia and China) *Soil Erosion and Riverbed Evolution* **15** 253-82
- [16] Melnikova Ya A and Vershinin D A 2018 Long-term changes in the average monthly flows of suspended sediments of the Ob within the Tomsk region *Bulletin of the Udmurt State University* **28**(4) 419-26