Analysis of Open data on seasonal roads in a forestry transport GIS-project (Case study: Siberian federal district, Russia)

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Analysis of Open data on seasonal roads in a forestry transport GIS-project
(Case study: Siberian federal district, Russia)

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Abstract
Paper covers the use and features of roads seasonality parameter in the presently publicly available Open datasets. Roads seasonality was considered as a factor of transport accessibility for the forest transport modeling at the regional level of large Siberian federal district, Russia. As analysis of papers shows, roads seasonality is mainly related to the winter conditions and low temperatures, researchers are focused on the winter roads. North big countries like Russia and Canada are the most interested data users in the domain of GIS transport projects. We state a lack of seasonality data, declared in the world databases, but not actually included. Forestry and forest industry need a combination of infrastructural data, and roads seasonality has a role of parameter to be included in the transport accessibility scenarios to reach forest fires and forest resources by ground means. Data on the roads seasonality for the regions of Russian could be found in the form of map view and text description. We have analyzed roads seasonality attributes of four Open datasets available online (Open Street Map, gRoads1, Natural Earth of 1:10 000 000, and Global roads inventory project or GRIP); for Siberian federal district only two of them have an indicator of seasonality (OSM and GRIP). Seasonal use of roads in the forest management depends on the features like relief and rivers, swamps and soils, they would be investigated in the future research. Roads conditions depending on season could be included in the transport scenarios for the regions. Artificial Intelligence and remote sensing materials in combination could lead to the continuation of such research.

Keywords: Open data, road network, seasonality, forestry, GIS

1. Introduction
Forest (timber) industry and forestry largely depend on the development of transport infrastructure. Among the more acute problems of the forest industry in Russia is the underdevelopment of transport infrastructure, which hinders the effective management of logging and forestry work. Forestry transport GIS-project like any other requires up-to-date data with roads attributes. Open data are in quite high demand in a variety of geographical research areas. Forestry in its activities involves a combination of infrastructure objects such as roads, logistic centers like fires stations, and settlements (Podolskaia, 2021a; Podolskaia, 2021b; Podolskaia, 2022).

Season of the year plays a key role in the ground transport modeling then there is a need to make a route to the forest fires (fire season) or forest resources (around the whole year). Seasonality of road use is directly related to the accessibility assessments at regional and country scales. In this regard, forestry transport modeling of ground access for roads of public and special use is becoming a crucial part of regional forestry data management aimed at reducing forest destruction, preventing deterioration of forest lands as well as reducing carbon dioxide emissions.

Specialists in topographic mapping from the Russian geographical scientific school (Alekseenko, Svatkova, 2005; Alekseenko and Svatkova, 2008) noted the significant and still insufficiently studied possibilities of special winter topographic maps like climate and terrain features in a certain period of

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the year. The paper of 2008 contains a list of conventional signs of seasonal changes in the content of winter topographic maps, namely: variability of areal and linear hydrographic features, flood pastures and hayfields, as well as relief features such as ice and passes.

Some papers cover roads seasonality at more than regional (administrative unit of Russia) scale. For instance, a study of seasonal traffic routes on roads aims to create a database to estimate transport accessibility within the territories of Russian Far North. In fact, it is one of the very few works at the extent of federal districts, namely Far Eastern federal district (Kopylov, 2022). Study discusses seasonal highways to form a database for the subsequent improvement of transport accessibility in the Far North in order to establish a stable, uninterrupted transport connection in the transport hub of the Arctic zone of the Far Eastern federal district.

There are some experiences on the roads seasonality from the researchers of Canada, Russia and Japan. Length and opening dates are two main parameters to evaluate operationality of winter roads in the western James Bay region, Ontario, Canada (Hori et al., 2016). Paper (Fu et al., 2009) is dedicated to the winter road maintenance operations and proposes a real-time optimization model which takes into account road network topology, road class, weather forecasts, and contractual service levels for producing a schedule to dispatch vehicles in Canada. For Russia logging roads operations time period and functioning of winter roads were considered in the papers (Shchegelman et al., 2007; Khoroshilov et al., 2019; Mokhirev and Petrova, 2020).

Different spatial extent and problematic has been discussed in the paper (Tanaka et al., 2014) for the city of Sapporo, Japan. It provides a set of practical GIS-tools for visualization and analysis or roads (streets) in winter then there is a need to deal with snow in a settlement environment. So, seasonality of roads and transport accessibility are very closely linked in the transportation and logistics at various scales and topics associated with management activities and operations.

Research purpose is to study seasonality as a factor of transport accessibility for the forest transport modeling at the regional level. Study includes following tasks:

- to collect papers on the seasonality of road use;
- to search for the Open datasets on roads with seasonality parameter;
- to evaluate presence of seasonality for the territory of Siberian federal district, Russia;
- and to propose some variants to implement roads seasonality into ongoing research activity on the transport modeling.

Research on the roads seasonality is a part of spatial transport modeling project we conduct in collaboration between Center for Forest Ecology and Productivity of the Russian Academy of Sciences (CEPF RAS) and Bursa Technical University (Akay et al., 2021; Akay et al., 2022). Transport modeling of forest fires and resources accessibility has been started as a research direction at CEPF in 2019 with a series of papers (Podolskaia et al., 2019; Podolskaia et al., 2020a; Podolskaia et al., 2020b; Podolskaia et al., 2020c) covering several regions of Russia like Irkutsk and Novosibirsk regions and then has been moved to the size of Russian federal districts.

2. Material and Methods
2.1. Seasonality of Roads
Seasonality of roads includes definition of winter roads. According to the Russian legislation document on the public automobile roads (State standard, 2020), winter road is a seasonal highway consisting of structural elements intended to be used for vehicles move. Its roadway is covered by ice, compacted snow and ice. These roads are being constructed on the frozen rivers of lakes. In Russia there is also an official classification of winter roads (https://base.garant.ru/26727807/b3975f01

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ce8b0eb0c9b11526d9b4c7bf/) built on the land or on the water bodies, varying by operational time (months, season of the year). In the Federal law of Russia "On highways and road activities" (https://rg.ru/documents/2023/03/02/document-dorogi.html) winter roads are described as artificial road structures with no further details. Lack of regulation has a negative impact on the development of Russian North, where these roads are mainly constructed and used.

Planning of the service life of winter public roads (and for forestry and forestry industry tasks) is carried out on the basis of analysis of climate data statistics (Mokhirev and Petrova, 2020). Weather and climatic factors have a significant impact on the reliability and safety of the functioning of roads of all types, with and without pavement. The maximum value of these factors is manifested in winter, when snow drifts, slippery surfaces and negative air temperature are added to meteorological conditions unfavorable for movement in other seasons of the year.

Forest transport modeling of ground access to the forest fires and forest resources is a research field and a forestry practice, which requires up-to-date data sources with the maximum possible set of road attributes to make an access route. Seasonality of road use is among the most crucial ones in the regional transport accessibility for the Russian Federation, especially in winter and summer. Russian geographers pointed out the significance and insufficiently studied special winter topographic maps with the data on climate and terrain.

Figure 1 was generated by the Word Cloud Maker, a free web-tool used to analyze text and make it visual (https://makewordcloud.com/ru/word-cloud-maker) for the papers names from the Reference section. Word cloud is an image made up of text, size of the word image is determined by the frequency of word appearance. All the prepositions in the papers names were removed before running the tool. As we can see on the Figure 1, word 'winter' is dominated, then 'roads', 'logging' as well as 'climate', 'transport' and 'accessibility' are the most frequent in the titles of reviewed papers. So, winter roads are the most common topic in the domain of roads seasonality, there are still very few researches on the off-season (not winter) roads conditions, at least for Russia we can mention the paper (Khoroshilov et al., 2019).
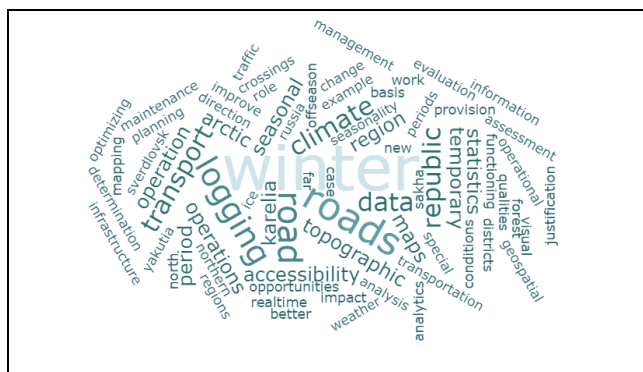

Figure1. Word cloud with the papers names mentioned seasonality (Russian and international examples)

2.2. Research on the Roads Seasonality in Russia

Winter roads and transportation accessibility in the Arctic were covered in the paper (Kuklina, Osipova, 2018). Winter trucks (winter roads) play an extremely important communication role in the Arctic region of Russia. The increase in the level of motorization has led to an increase in the winter mobility of residents of hard-to-reach settlements. Map of density of all-season motorable roads covering mainly the norrth parts of Russia from the paper (Nokelaynen, 2021) is shown on the Figure 2.
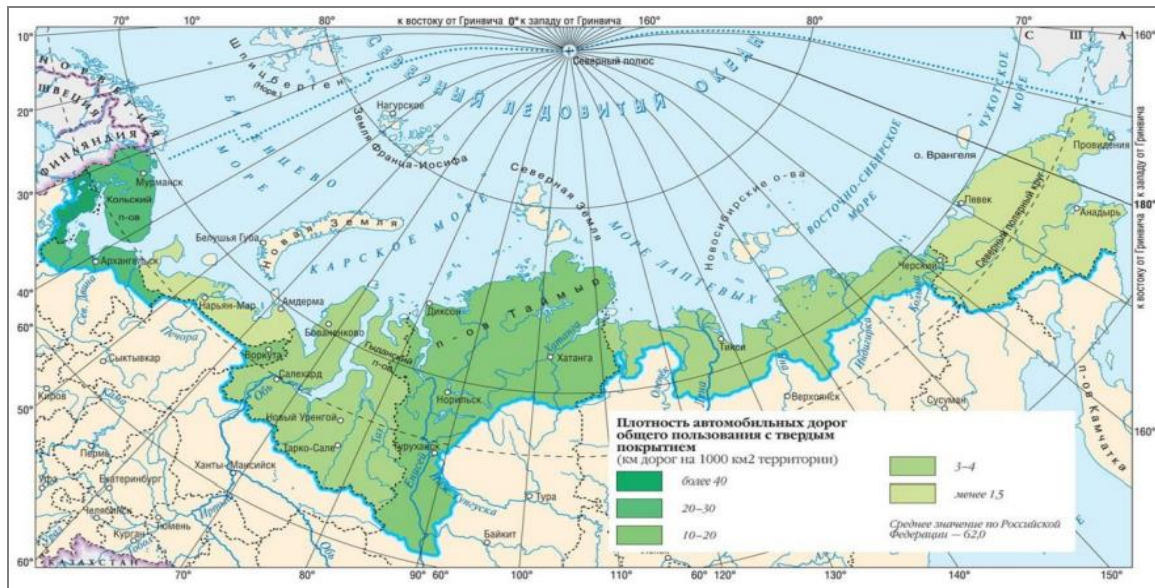
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Figure 2. Density of all-season motorable roads, scale 1:30 000 000 (Nokelaynen, 2021)

2.3. Data on the Roads Seasonality for the Regions of Russian

There are few example of roads seasonality projects publicly available for the Russian regions, mainly located on the north of the country. As examples we can describe a geoportal of Yamalo-Nenets Autonomous region (okrug) which is available depending on the season (https://map.yanao.ru/eks/zimnik). It has a section of seasonal geoservices indicating name, status of the winter road, and a forecast of its opening. Another example is a web-page showing driving conditions on winter roads of Krasnoyarsk region (https://krudor.ru/actual/winter/) with their length and operational time frame. In that case there is only textual description of winter road with no map view. Their screenshots are shown on the Figure 3 and 4 successively, both views are as of 9th of May, 2023. Both examples show the data within the administrative unit's extent. So, we can note that for the present time data on the roads seasonality in Russia are being maintained and cartographically represented by administrative unite.
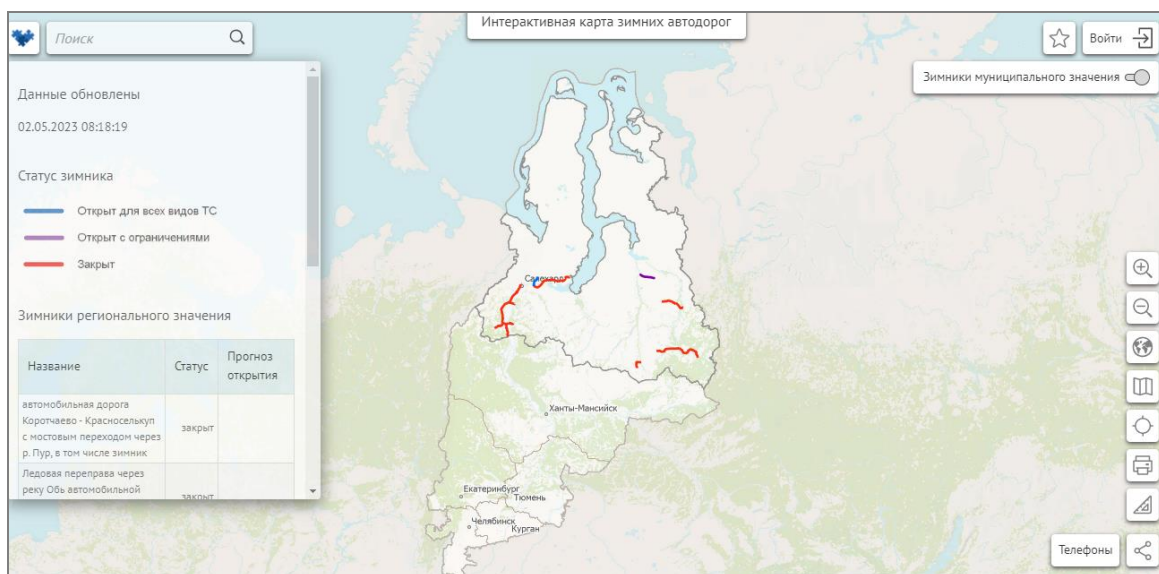

Figure 3. Interactive map of winter autoroads. Geoportal of Yamalo-Nenets Autonomous region (okrug)

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Figure 4. Driving conditions on winter roads of Krasnoyarsk region (road geoportal)

2.4. Forest Roads, Seasonality and Climate Change

It is well known that climate significantly affects condition and transport qualities of roads. Forestry and forest industry have specific features related to the definition of forest roads. Forest roads are roads located on the lands of forest fund (according to the Russian terminology). They are designed to serve the needs of forestry, to ensure access of forest users to the forest management units. Forest roads are adjacent to the public roads, railway stations and to the lower warehouses of logging enterprises (Buldakov, 2016).

Roads seasonality is being studied for the practical cases of roads construction. For the case of Sverdlovsk region (Russia) paper (Kruchinin et al., 2018) highlights the influence of seasonality on the physical mechanical characteristics of road. It has been established that an increase in the bearing capacity of the false-concrete coatings and an increase in the strength characteristics of subgrade soils is possible only during the winter. Based on the data obtained, researchers recommended to improve the transport and performance indicators of logging roads.

North of Russia is the most vulnerable zone in terms of climate change as it was noted in the work from Karelian Research Centre of Russian Academy of Sciences (Prokopyev et al., 2018). Climate warming will definitely reduce the operation life of winter roads. For the stable operation in the forestry it is important to invest in the development of year-round road infrastructure. The issue of quality and length of logging roads is very relevant for the heavily forested regions of the Krasnoyarsk region. Planning the timing of certain logging operations and timing of winter road construction is directly linked to the weather conditions. The main goal of the work (Mokhirev et al., 2018) is to determine the operational period of a winter logging road based on a probabilistic assessment of winter duration on the example of the Yenisei district of the Krasnoyarsk region. Roads seasonality factor, as the analysis of papers shows, has not still been considered widely enough due to the luck of data, and leaves the room to develop transport movement seasonal scenarios in the forest transport modeling projects.

2.5. Key Area, Open Datasets with Roads Seasonality

Siberian federal district has the following characteristics: low density of transport infrastructure with large extent from north to south of Russia, uneven settlement with low population density, economic

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dependency on the natural and climatic conditions, which determines the seasonality of transport functioning. These factors limit development of region's natural and economic capacity. It is a key area for the forestry research, including regional forestry transport modeling. Region is known by its constant long-term fire activity in the forests and by its seasonal winter roads.

Open Data are widely used in the research projects because of their global and regional coverage and availability; they are of value in the forestry as well. We have analyzed seasonality attributes of several Open datasets available online, namely:

- Open Street Map (OSM, as of October 2022),
- gRoads1 (The Global Roads Open Access Data Set, version 1),
- Natural Earth of 1:10 000 000,
- and Global roads inventory project (GRIP).

Global-scaled Open Street Map (OSM, https://www.openstreetmap.org) is mostly and commonly used source of data within the domain of Volunteered Geographic Information (VGI) for any GIS-projects including roads and transport. Researchers know that the certain number of OSM characteristics like completeness, quality of geometry and attributes, etc. is a subject to check and to combine with other spatial and non-spatial data (Barrington-Leigh and Millard-Ball, 2017). The OSM project is a real example of collective efforts from the interested developers and today it is the only map that can be downloaded for free to almost any device (Anop et al., 2016). It has the attributes for roads seasonality for the Siberian federal district.

Database gRoads1 (The Global Roads Open Access Data Set, version 1, https://data.nasa.gov/dataset/Global-Roads-Open-Access-Data-Set-Version-1-gROADS/bey2-56a2), divided by world regions, has an "IsSeasonal" parameter (affected by season – "depends on the season") of Long Integer type and takes the values "1", "2" or "0" if there is no information about seasonality. As mentioned in its description it contains the best available roads data by country. It has no attributes for seasonality of roads within Siberian federal district.

Project of global scale Natural Earth (https://www.naturalearthdata.com/) has a number of infrastructural features. We have checked the dataset of 1:10 000 000, the most detailed one among others, again no attributes for roads seasonality for key area. Quantitatively (by the number of road segments) and qualitatively (by the set of attributes to them), OSM project data from the studied variants is the most complete and informative one. Three datasets are shown on the Figure 5.

Additionally to OSM, we have to described the Global Roads Inventory Project (GRIP, https://www.globio.info/download-grip-dataset) includes vector data on roads and aimed for the global research environmental projects and biodiversity. Country-based GRIP delivers presently about 21 million km of road. It includes the data from OSM and can be named the best publicly available country-based global roads dataset. These dataset has been already used for the project of combining road infrastructural data (Meijer et al., 2018).
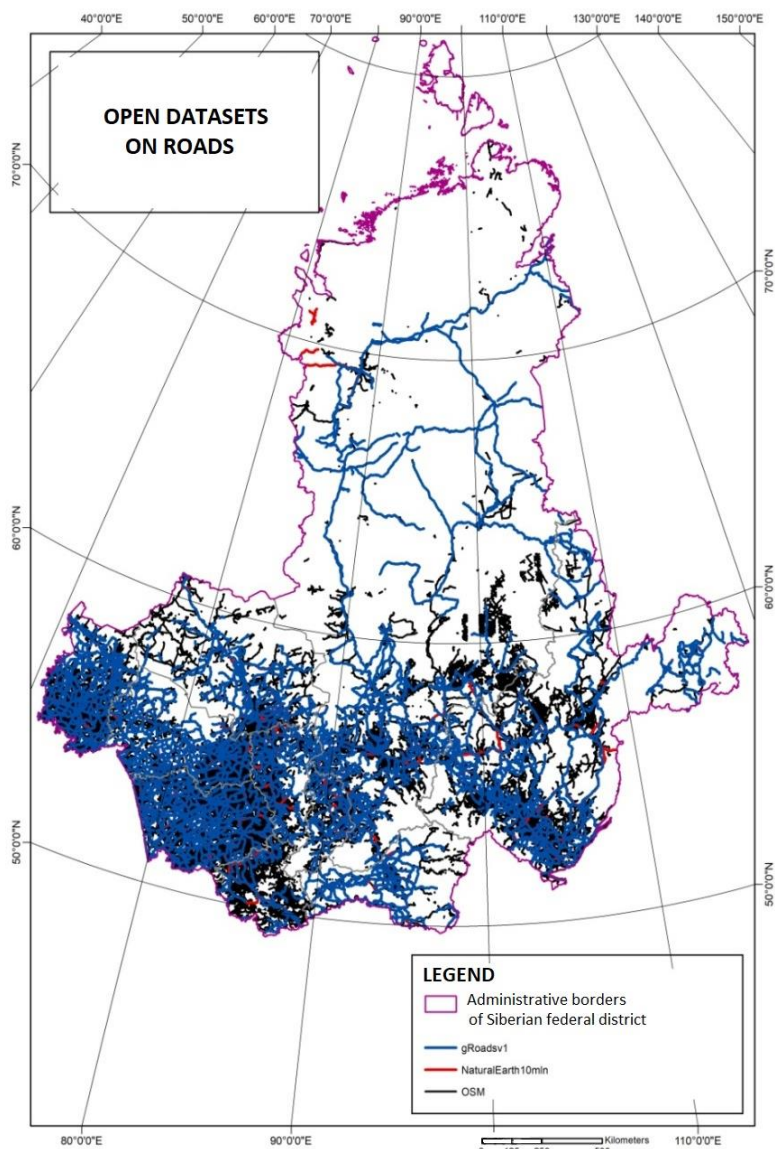
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Figure 5. Open roads datasets for the territory of the Siberian federal district

3. Results and Discussion

As we can see from the Figure 5, OSM dataset, even taking into account its specificity and uncertainty, could be a source for a roads seasonality assessment. Data on roads indicating their operational period for a number of years can be systematized and then used as the most likely interval of roads operation. Type of road could be a parameter to investigate as well. In this regard, a certain comparison of roads classification between OSM-dataset and country official classification should be done before starting a forestry GIS-project.

As we can state from the papers and Open data analysis, roads conditions in summer, autumn and spring are the less studied ones, but they have a big influence on the all-the-year regional transport accessibility in the forestry for the forest fires and resources. Thus, roads seasonality could be a part of transport seasonal scenarios for the regions. Practically seasonality could be an input parameter for the technology of access routes creation developed at the Laboratory of forest ecosystems monitoring, Center for Forest Ecology and Productivity of the Russian Academy of Sciences (CEPF RAS). Relief

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and hydrographic features, swamps and soils are the key features that influence seasonal use of roads in the forest management. Factors of their influence could be investigated in further research.

4. Conclusion

Open Data have a value for the transport projects requested seasonality parameter. Open datasets of large scale covering the world, even declaring roads seasonality, have in fact very few and simply attributed roads. Two Open datasets have chosen (OSM and GRIP) for the Siberian federal region as they have a parameter of roads seasonality. They both may be used as a data source to create seasonal ground access routes to access forest resources and fires. Regional Open data (for instance: Federal Road Agency of Russia, Rosavtodor, https://rosavtodor.gov.ru/) should be monitored and studied in addition. Their non-spatial files could be converted to the GIS-layers. Quality and relevance of Open data should be investigated further in depth. Seasonality of roads as qualitative characteristic should be given more importance and it has the certain value for the forestry. Infrastructure, economics, sustainable development could certainly benefit from available data on the seasonal road use. Seasonality of roads could be studied on the space images of different nature; other the past several decades there is dynamically developing research area of Artificial Intelligence that could be used to detect roads seasonality.

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