Decision Aid Digital Instrument Within Arctic Maritime Logistics During Polar Night

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Abstract. In the article, there are considered decision aid digital instrument development results for arctic maritime logistics during polar night under climate change and COVID-19 pandemic within Industry 4.0 era. In research, there are used risk management, situational analysis, web technologies and building database methods in distributed networks. As the research result, it is proposed the using of geodata from the active remote sensing and supercomputer modelling to increase the efficiency and reliability of arctic maritime logistics during polar night within the global environmental economics. As the decision aid digital instrument, it is proposed to use modular decision aid system, which integrate the heterogeneous hardware and the software resources in distributed networks. As the research results, there are demonstrated examples for arctic maritime logistics in central and eastern Russian Arctic during polar night. Presented in this paper study results have scientific novelty and can be used by the different players, including energy export sector, insurance business and institutional investors.

Keywords: Maritime logistics · Arctic · Polar night · Digitalization · Decision aid · Climate change

1 Introduction

Currently, arctic maritime logistics (AML) is year round activity within global environmental economics and part of year it is going during polar night (PN). Now, there is a need to digitalize AML during PN under climate change (CC) and COVID-19 pandemic in accordance with the concept of Industry 4.0. Last time, a lot of organizations plan and implement whole range of information technologies [1–5] that leads to information technological changes in their activity [6, 7], including decision support [8–10], natural risks management (NRM) [11–14], and learning [15].

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This research purpose is to develop decision aid digital instrument (DADI) for AML during PN under CC and COVID-19 pandemic within Industry 4.0 concept. In paper, we present the DADI development results for AML during PN within geo-information management (GIM) paradigm [16–21], in large environmental projects ([22–25] within environmental economics [26, 27]. We give attention to aspects of climate change [5, 11] and COVID-19 pandemic [2, 14], including the issues of information collection and processing with big data [28–30].

2 Materials and Methods

In research, we used risk management, situational analysis, web-technologies and building database methods. Also, we used Internet of things, machine learning and big data technologies [3, 28–30] for remote sensing and supercomputer modelling geodata processing. For study, we used geodata from different geoinformation digital online platforms (GIDOPs) with open access.

3 Results

We conducted situational analysis and, as its result, we believe that AML during PN is the high-risk and tough business, especially in severe icy area of central and eastern Russian Arctic with very low temperature and strong winds. Sometimes and maybe too often, such activity is going with very slight rescue support and without insurance. As a significant result of research we developed DADI for AML during PN under CC and COVID-19 pandemic in the form of the modular decision aid system (MDAS). As modules within MDAS for AML during PN we proposed to use different geoinformation digital online platforms (GIDOPs) with open access.

The developed MDAS for AML during PN allows to track ships in icy arctic waters and dangerous weather risk factors, as well as to implement business investigation functions in the event of major incidents and disasters related to natural risk factors, including ice risks. Within MDAS for AML during PN, we use as the active remote sensing geodata from Sentinel-1 satellite with synthesized aperture radar (SAR) and supercomputer modelling data.

Let's go to research result, to illustrate the work of developed MDAS for AML during PN in the icy waters of the central and eastern Russian Arctic.

For AML during PN, it is very important to know different weather fields, including their mutual viewing. In Fig. 1, we present wind and air temperature fields for Russian Arctic modelled with supercomputers and visualized with GIDOP Earth on November 16, 2021, when PN of 2021 began in this area.

When PN begin, the ice covers huge area, as a rule. In Fig. 2, we show wind and ice fields for Russian Arctic modelled with supercomputers and visualized with GIDOP Earth on November 16, 2021.

In Fig. 3, we show the screen with the transit and cabotage ships within the central and eastern Russian Arctic, including ships in Ob Gulf and Yenisei river, visualized with GIDOP Marine Traffic on November 16, 2021.

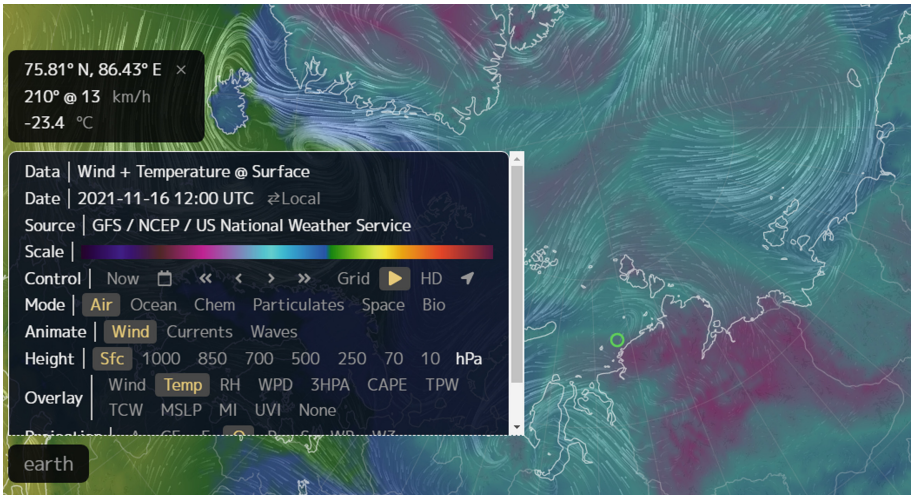

Fig. 1. Modelled with supercomputers wind and air temperature fields for Russian Arctic visualized with GIDOP Earth on November 16, 2021.

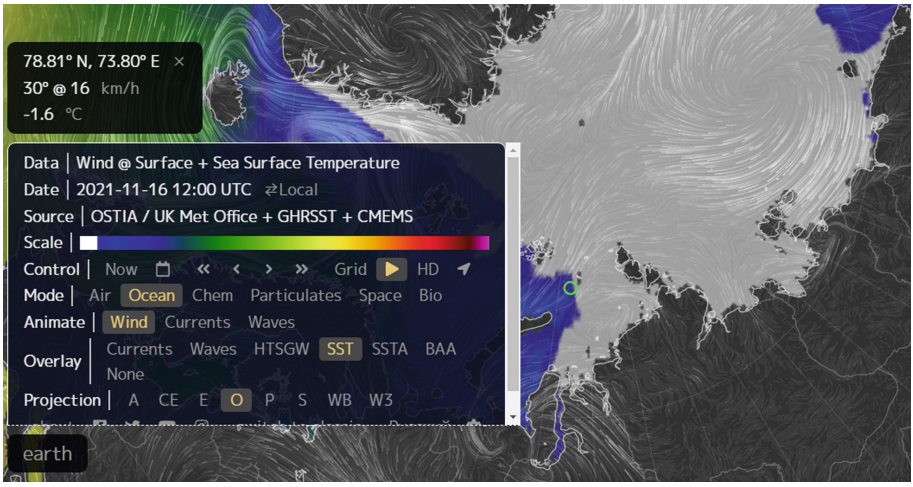

Fig. 2. Modelled with supercomputers wind and ice fields for Russian Arctic visualized with GIDOP Earth on November 16, 2021.

From comparison of Figs. 1, 2 and 3, it is obvious, that a lot of different unmoving ships are in icy trap in central and eastern Russian Arctic. It is very dangerous situation and the ships badly need rescue with icebreaker support. But in Fig. 3, there is no icebreaker and ships will have to wait it in severe weather conditions only to begin rescue operation of great scale. In Fig. 4, we present Sentinel-1 space image of ice field with spot signatures from trapped ships the ice channels in central Russian Arctic on December 13, 2021, scale 3 km.

Fig. 3. Screen with the transit and cabotage ships within the central and eastern Russian Arctic, visualized with GIDOP Marine Traffic on November 16, 2021, 14:12 UTC.

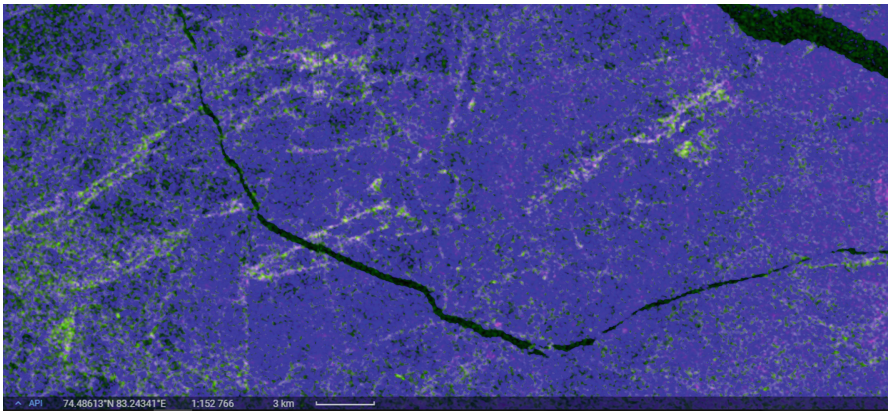

Fig. 4. Sentinel-1 radar space image of ice field with spot signatures of ships inside the ice channels in the central Russian Arctic on December 13, 2021, visualized with GIDOP EOS (LV product), Ratio Application, scale 3 km.

In Fig. 5, we present radar space image of ice field with long main icebreaker channel in the central Russian Arctic on December 13, 2021, visualized with GIDOP EOS (LV product), Band Combination Application, scale 3 km. There are spot signatures from ships in the channel.

In Fig. 6, we present radar space image of ice channel generated by moving ice class ship at the moment of rendezvous with standing icebreaker in Russian Arctic. Distance between ships is about 400 m.

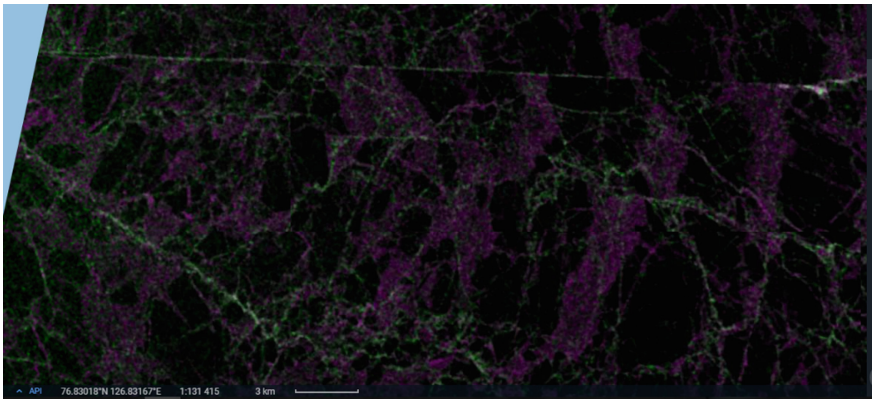

Fig. 5. Radar space image of ice field with long main icebreaker channel in the central Russian Arctic on December 13, 2021, visualized with GIDOP EOS (LV product), Band Combination Application, scale 3 km.

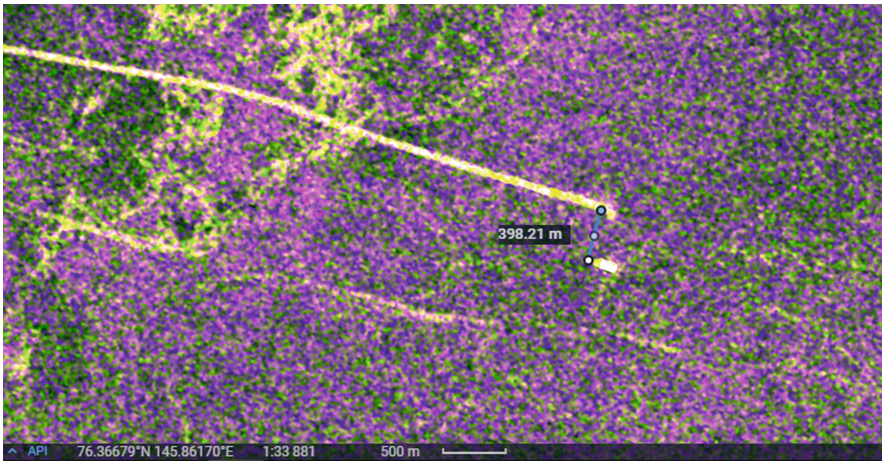

Fig. 6. Radar space image of moving ice class ship at moment of rendezvous with standing icebreaker in Russian Arctic on December 13, 2021, visualized with GIDOP EOS (LV product), Band Combination Application, scale 500 m.

Thus, we developed DADI within global environmental economics under COVID-19 pandemic and climate change in the form of MDAS for AML during PN with free access GIDOPs as modules. The developed DADI allows to track ships during PN in icy arctic waters and to map dangerous weather risk factors, as well as to support the different business investigation functions in the event of major incidents and disasters related to natural risk factors, including ice risks. Within developed DADI in the form of MDAS for AML during PN, we use widely as supercomputer modelling data and the active remote sensing geodata from Sentinel-1 satellite with synthesized aperture

radar (SAR). One more time note, that full decoding of Figs. 1, 2, 3, 4, 5 and 6 and its discussion was not task of this article.

4 Discussion

Developed above-mentioned DADI in the form of MDAS for AML during PN can be used in educational and training purposes. With the help of proposed DADI, students get access to a very large volume of geo-data and learn to work with its for solving practical problems in various areas of AML during PN. Especially useful MDAS for AML during PN will be for Master's programs in global environmental economics.

5 Conclusion

In article, we considered development results of DADI in the form of MDAS for AML during PN within global environmental economics in Industry 4.0 period under conditions of climate change and COVID-19 pandemic. Within study, we used risk management, situational analysis, big data technologies, web-technologies and building database methods. We used as active remote sensing and supercomputer modelling geodata. We demonstrated some using examples of MDAS for AML during PN to the navigation in Russian central and eastern Arctic. Presented in article research results have significant scientific novelty and can be used by different players, including energy export sector, insurance business and institutional investors.

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