Information retrieval for Northern Sea Route (NSR) navigation: a statistical approach using the TOPAZ4 data

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The Northern Sea Route (NSR), especially the passage along Russia's northern coast reaching the Bering Sea, is becoming mostly ice-free during the warm season due to rapidly declining Arctic sea ice. This passage has an advantage for freight transport from northern Russia to Asian countries: the navigation distance via the NSR is considerably shorter compared to the route via the Suez Canal, and it is immune from piracy and potential political instability along the conventional route. The economic effect is apparent for LNG producers such as Yamal LNG, which is targeting the Asian market. On the other hand, ocean shipping lines need to ensure navigational safety in the Arctic Ocean where sudden weather and sea ice coverage changes are expected. Vessels that navigate the NSR are not necessarily well equipped and/or having enough propulsion for the hazardous Arctic Ocean. A vessel's ice-breaking ability to navigate ice sea is given by the classification "ice class". The Russian NSR Administration (NSRA) manages vessel traffic along the route and issue the permissions based on the ice class, and the passage is sometimes permitted only in the presence of an ice pilot aboard the ship (Attard et al. 2014). Ice pilots have Russian nationality and are trained and experienced in navigation in ice-covered waters. Accordingly, it is possible that the directed course by an ice pilot may reflect the ongoing political overtones from Russian elites. In this research, we study the relationship between the selected courses and ice parameters corresponding to the individual passages and explore the possibility of devising a decision-making algorithm. Ice parameters are from TOPAZ4, which is a coupled ocean-sea ice data assimilation system for the North Atlantic Ocean and Arctic (Sakov et al., 2012). Since its forecast data is daily updated, it can be utilized for the development of the decision-making algorithm.

The Automatic Identification System (AIS) is a vessel tracking system that automatically provides a vessel's location and other relevant information, and the device has been mandated for every ship since July 2008. Thus, the AIS signals acquired via satellites allow us to monitor the traffic over the NSR. It is known that there are three main routes around the New Siberian Islands located between the Laptev Sea and the East Siberian Sea north of the Sakha (Yakutia) Republic (Figure 1). As a preliminary study, we focus on this region and classify the routes, "Northern", "Middle", and "Southern" routes for convenience. As for the study period, we define the warm season as June through December and analyze the recent four-year data, i.e., from 2014 through 2017.

Figure 1. The Northern Route Sea (from Brubaker and Ragner, 2010).

Figure 2 shows the distribution of draft ordered by three routes around the New Siberian Islands. The Southern route has shallow depth as we can see in the boxplot. Thus, ships with large drafts cannot navigate through it even if the route seems suitable for less equipped vessels, i.e., less sea ice along the course. While the distance of the Northern route is the shortest among the three, more sea ice is expected there, and the transit time becomes longer when the route is covered by thicker sea ice. Consequently, the Northern route loses the economic advantage due to increased running cost for ice-breaking operations.

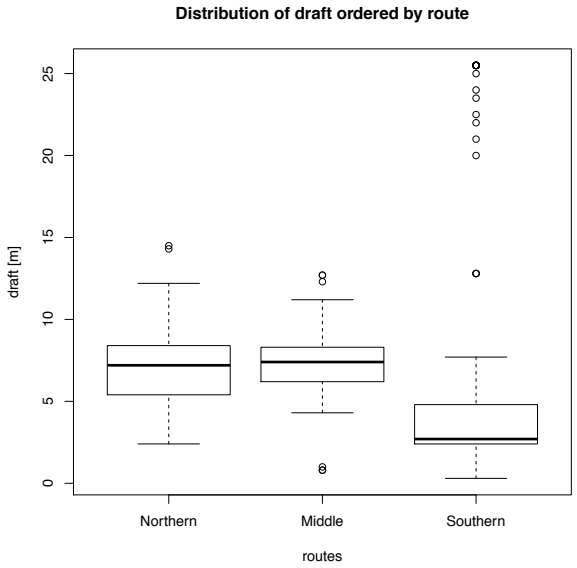

Figure 2. Distribution of draft ordered by three routes around the New Siberian Islands.

After defining the subdivision distance of each route, which is approximately the width of New Siberian Island, we estimate individual ships' transit time through it using the AIS data. Accordingly, assuming that the transit time depends on sea ice condition and ship's capability to navigate through the ice-covered ocean, a statistical relationship can be determined. As a preliminary study, the simple linear regression is applied for the relationship. The coefficient of determination of the model is 0.57, meaning that 57 % of the data is following the regression line. This implies that it is likely to create a statistical model for the prediction of the transit time through each subdivision.

References

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