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Long-Range Forecast for the Navigation Season: linking the Northern Sea Route and Maritime Silk Road

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The unprecedented warming in the Arctic opens broad prospects for connecting the Northern Sea Route (NSR) to the Maritime Silk Road. Such a "docking" will significantly impact the global economy. The main problems of the Northern Sea Route are the harsh environmental conditions of the North and, most importantly, the presence of sea ice. While, on average, the ice-free period lasts from June to November, the dates of start and end of ice season vary from year to year within a month or even more. Such variability is impossible to capture by numerical weather prediction, limiting predictability for five days. Therefore, currently, there is no specific timeframe when the waterway is free of ice.

Here I show that a long-range forecast for the navigation season is possible for specific locations in Bering and Okhotsk Seas. The approach is fundamentally different from the numerical weather and climate models; it is based on statistical physics principles and recently discovered spatial-temporal regularities in the Asian-Pacific monsoon system [1]. The regularities appear in the form of spatially organized critical transitions in the near-surface atmosphere over the sea. The specific locations mean critical areas - tipping elements of the spatial-temporal structure of ice formation, which are identified via data analysis. I rely on the distribution of near-surface air temperature and wind data (NCEP/NCAR re-analyses data set) to reveal conditions for ice formation [2]. I show that a transition from open water to ice season begins when the near-surface air temperature crosses a critical threshold, it is a starting point for forecasting the ice season's start date. The approach provides long-term predictions of the ice season's start in critical areas 30 days in advance.

Furthermore, the transition from water to ice in the Bering and Okhotsk Seas is driven by the Asian-Pacific monsoon air movements. It has the following implications. First, there is a linkage between the onset of ice formation in the northern part of the Bering Sea and the western part of the Sea of Okhotsk. Second, Asian Monsoon, including the Indian monsoon [3], is driven by the same Asian-Pacific system [4]. As a result, the timing of the monsoon is linked with the ice season. These findings show that it is essential to consider these connections to overcome regional forecast limitations. The system approach applied on a continental scale will be relevant for improving the long-term monsoon and ice season forecasts, which we desperately need for climate adaptation.

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