Spatial variability of the wind field in the area of the Kuril Islands

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Introduction

Examination of time and spatial variability of wind field is important for various applied problems. In particular, the problem of evaluation and development of wind power stations recently became crucial for the region of the Kuril Islands. Climatic characteristics of wind presented in generally used manuals (Climate Guide, 1969; Koshinsky, 1978; Pacific Ocean, 1966) are mainly based on wind data obtained by weather vanes. Since the end of the 1970s more precise instruments have begun to be used to measure wind at meteorological stations of the former USSR. Preliminary analysis of old and modern data showed significant difference of the corresponding estimates. The purpose of the present work is to examine the spatial structure and to obtain some climatic characteristics of the wind field in the vicinity of the Kuril Islands based on the modern wind data.

Observational data

For analysis we used 10-min averaged wind data from stations Shumshu, Matua, Simushir and Shikotan, located on the corresponding islands, and from station Kurilsk, located on Iturup Island, for the period 1966–1984, prepared at the World Data Center at Obninsk, Russia. The location of the meteorological stations is shown in Figure 1. We chose stations Shumshu and Shikotan rather than the nearby stations Severo-Kurilsk on Paramushir Island and Yuzhno-Kurilsk on Kunashir Island, for the reason that the former pair is less influenced by the local orography than the latter. The analysis of the data has revealed their essential heterogeneity, much of the information before 1980 pertaining to measurements executed by weather vanes. For a more detailed examination we used a series for 1980–1984, since these data had no gaps and were obtained by the same type of instrument, an anemorumbometer M-63M.

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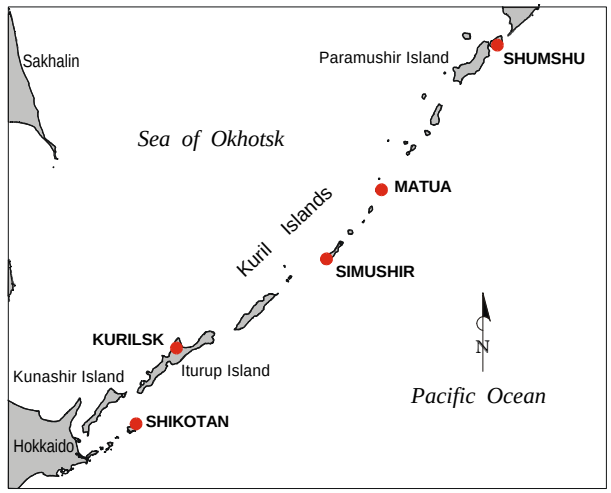

Fig. 1 Location of the meteorological stations in the area of the Kuril Islands.

Recurrence of the wind by directions and speed gradations

Figure 2 presents diagrams illustrating the wind distribution by directions and speed gradations. There are two maxima in the distribution of the wind speed: the main maximum corresponding to the typical wind speed of 2–4 m/s (3–5 m/s at Shumshu), and a secondary maximum at 10–12 m/s. Such character of speed distribution remains

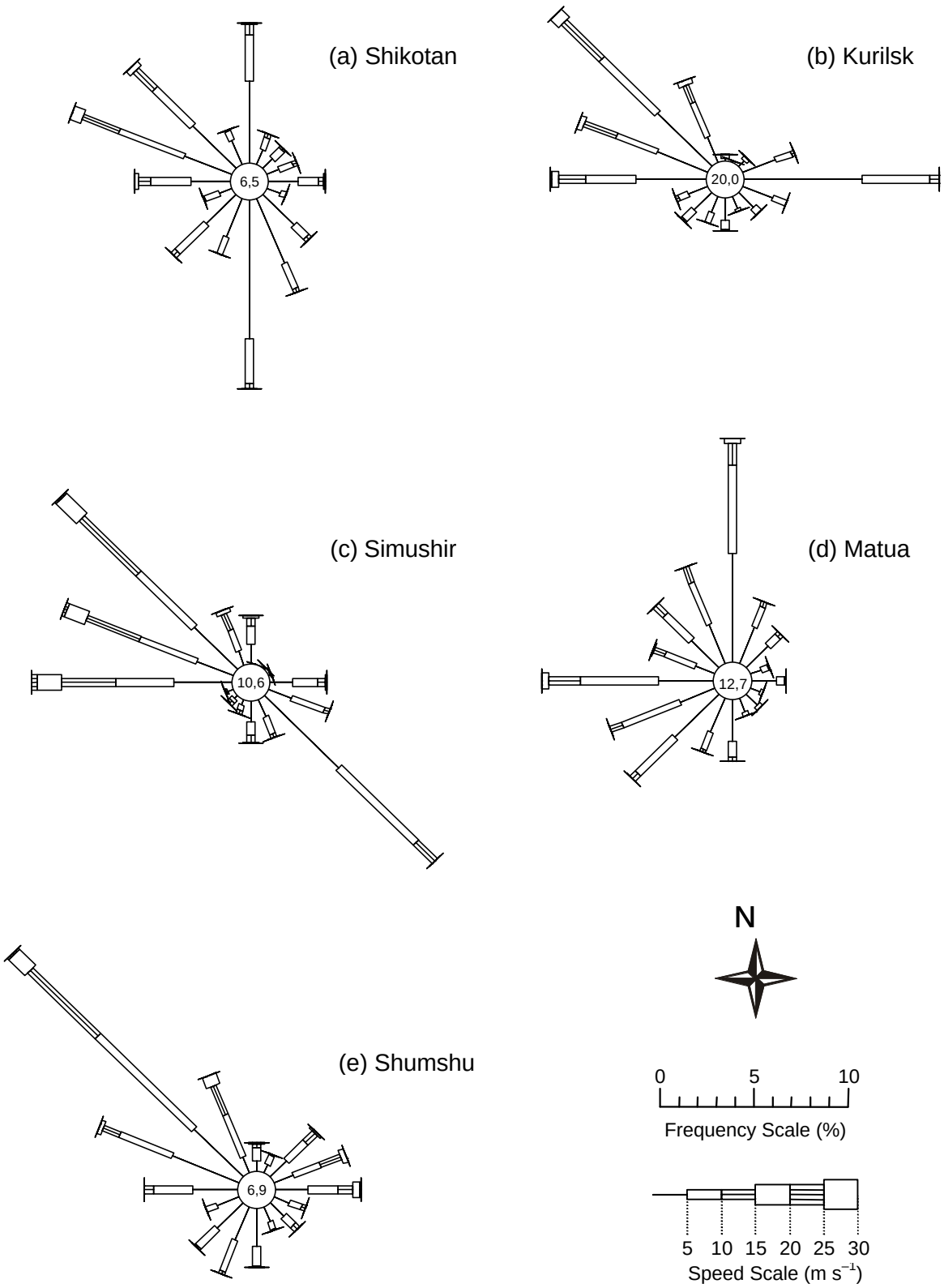

Fig. 2 Diagrams of the direction distribution by the 5-yr averaged wind velocities for various Kuril meteorological stations. Contribution of calm weather (winds weaker than 1 m/s) is presented in the centers of the diagrams (in %).

basically the same for all stations and all seasons. However, in winter, when winds are normally stronger, the second maximum intensifies and the main maximum becomes weaker; the opposite tendency is observed in summer.

The "wind roses" (Fig. 2) demonstrate noticeable spatial variability of wind directions. Northwesterly winds prevail at all stations, however the other features are different for different stations. Thus, in the vicinity of Shumshu Island winds from directions other than northwest are weak and infrequent. In contrast, near Matua Island northerly winds are observed frequently, for Kurilsk easterly winds are rather frequent, for Simushir southeasterly, and for the area of Shikotan Island southerly winds occur quite often.

The dominant northwesterly winds are a typical autumn-winter feature for the whole area of the Sea of Okhotsk (so-called "winter monsoon", related to the influence of the Aleutian Low). The corresponding spatial distribution of the sea surface atmospheric pressure in the area of Okhotsk Sea is shown in the Figure 3a. In the spring-summer period the air streams near the Kuril Islands are apparently not so stable, resulting in the variety of the winds from the other directions observed in this period. (Figure 3b presents a typical distribution of atmospheric pressure in summer.) That means that the wind field in this area cannot be satisfactorily described by a simple layout: The winter monsoon with northwesterly winds is replaced by the summer monsoon with southeasterly winds (Pacific Ocean, 1966).

It is interesting to note that the wind velocities near the Kuril Islands are found to be weaker than is usually assumed: according to Climate Guide (1969) extreme wind velocities in this region are up to 50 m/s. Results of the present examination of wind data for the period 1970–1984 showed that none of the five analyzing stations recorded wind velocities exceeding 30 m/s. The total amount of the cases with wind exceeding 20 m/s is rather insignificant, from 0.4% at Matua up to 2.5% at Simushir. These extreme winds with speed up to 28–30 m/s are mainly observed in March or in October and November (Fig. 4a). The strongest winds have northwesterly direction for the southern and central parts of the Kuril Islands, southwesterly at Matua, and northeasterly at Shumshu. These months correspond to the time of the major cyclonic activity in this area. The distribution of the extreme wind shows that the corresponding cyclones cross the chain of the Kuril Islands just in the center, near Matua Island.

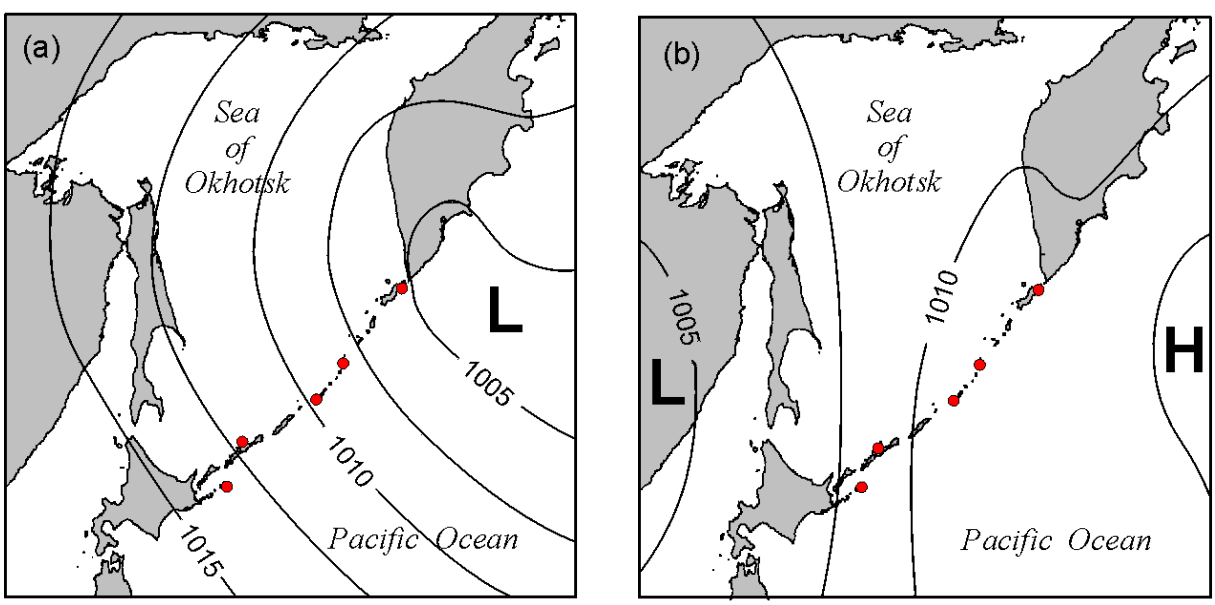

Fig. 3 Typical spatial distribution of sea surface pressure in the area of the Kuril Islands for (a) January and (b) July according to Pacific Ocean (1966).

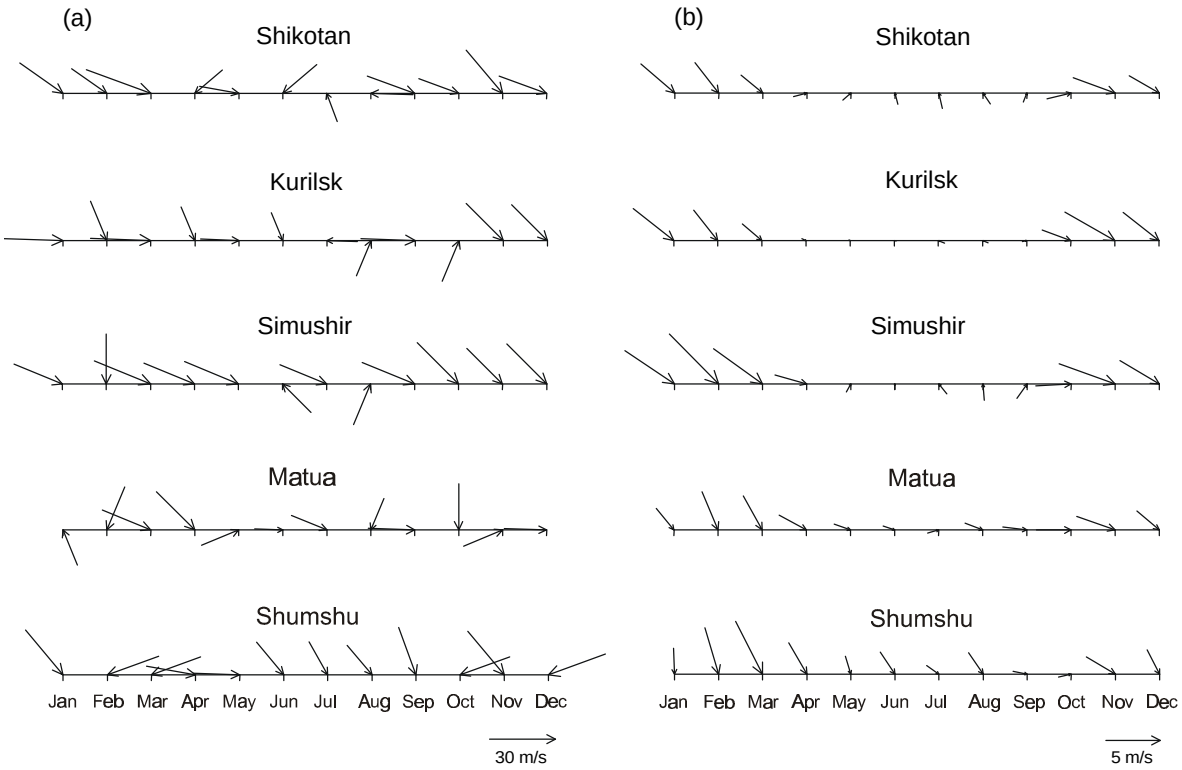

Fig. 4 (a) Maximum monthly and (b) mean monthly winds for the period 1980–1984 for the meteorological stations in the area of the Kuril Islands.

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The complicated picture of maximum winds is observed in summer. Extreme wind speeds are about 17–25 m/s, the direction of maximum winds varies siginicantly from year to year, except at Shumshu where northwesterly winds are dominant, and from station to station. Typhoons which are coming from the tropical Pacific into the area of the Kuril Islands in summer and early fall are probably the reason for destabilizing atmospheric circulation and producing storm winds of various directions.

Monthly mean winds

Spatial and temporal variability of monthly mean winds averaged over 5 years (1980–1984) is clearly seen in Figure 4b. The primary feature of the wind field is the very strong seasonal change of wind velocity. In the cold season (October–March) mean winds are sufficiently strong and steady. For the whole area of the Kuril Islands, they have northwesterly direction; variations from station to station are insignificant. In contrast, in the warm season (April–September), mean winds are much weaker and there is essential difference between the two northernmost stations Shumshu and Matua and the others. At stations Shikotan and Kurilsk in the South Kuril Islands, winds change direction to the southerly and

the southerly and southeasterly, i.e. the wind field takes the character typical for summer monsoon. A similar picture but not so evident is observed also at Simushir. At the same time, monthly mean winds of northwesterly and westerly direction prevail at Matua and Shumshu. The seasonal changes at these stations are manifested mainly in the variations of the velocity magnitude rather than in the direction. This character of seasonal variability of monthly mean wind velocities is in good agreement with the spatial distribution of atmospheric pressure in the area of the Sea of Okhotsk (Fig. 3). Probably, a local area of high atmospheric pressure observed in summer time over the Kamchatka Peninsula influences winds near the North Kuril Islands, causing the difference from the winds in the area of the South Kuril Islands.

We estimated the relation between the variance of the average group values (factorial variance) and the average of the group variances (casual variance), showing the stability of the performance. We found that contribution of the factorial variance is about 70–80% of the total variance except for the east-going (zonal) component of the wind at Matua and Shumshu stations. Seasonal changes of this zonal component of the wind are weak in the area of the Northern Kuril Islands.

Conclusions

The main conclusions of the present analysis are as follows:

- The maximum wind velocities in the area of the Kuril Islands were found to be up to 30 m/s, i.e. significantly smaller than it was assumed according to well-known reference guides mainly based on obsolete weather vane measurements.
- In winter, significant northwesterly winds associated with the Aleutian Low prevail in the area of the Kuril Islands (“winter monsoon”); however there are noticeable differences in distribution of wind directions (“roses of winds”) for various stations.
- In summer, winds are weaker and not stable resulting in the variety of the winds from different directions. A simple model of “summer monsoon” cannot describe summer circulation for the whole area of the Kuril Islands. In fact, there is a boundary between the Simushir and Matua Islands (i.e. in the central part of the Kuril Islands) dividing zones with different character of prevailing winds: northwesterly for the northern stations and southerly to southeasterly for the southern stations.

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