Study of Statistical Structure of Surface Wind Speed Vector in Western Antarctica

Ivanov N.E.,[1] *Lagun V.E.*[2]

[1] Saint-Petersbug Branch of State Oceanographic Institute, 23 Line, V.O. 2a, St.-Petersburg, Russia
[2] Arctic and Antarctic Research Institute, Bering str. 38, St. Petersburg, 199397, Russia, lagun@aari.nw.ru

The unique synoptic conditions of West Antarctic station Russkaya (74° 46' S, 136° 52' W) characterized frequent hurricane surface wind. Here the regional vector statistical structure of the wind speed is described.

The wind speed mathematical expectation $\vec{\mathbf{V}}(t)$ with cartesian projections {Vx,Vy(t)} is the vector $\vec{\mathbf{V}}(t)$ $\vec{\mathbf{m}}_{\vec{V}} = M\{V_x\vec{\mathbf{e}}_x + V_y\vec{\mathbf{e}}_y\}$, where $\vec{\mathbf{e}}_x$, $\vec{\mathbf{e}}_y$ are unit orts of ÎX and OY axes. Wind speed dispersion $\mathbf{D}_{\vec{V}}$ is symmetric second range tensor $\mathbf{D}_{\vec{V}} = \begin{pmatrix} D_{Vx} & K_{VxVy} \\ K_{VyVx} & D_{Vy} \end{pmatrix} = \begin{pmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{pmatrix}$, where $D_{Vx,y}$, K_{VxVy} is dispersion and co-variations of projections, $\lambda_{1,2}$ are eigenvalues. Geometric image of $\mathbf{D}_{\vec{V}}$ is ellipse with semi-axes $\lambda_{1,2}$, oriented in direction of maximal variability α in initial coordinate system [2]. Numbers $\lambda_{1,2}$ are invariants relative to rotation of coordinate system. Linear invariant $I_1=\lambda_1+\lambda_2$ characterizes the module of total speed variability, it is independent on changes of module $|\vec{\mathbf{V}}|$ or direction φ. Invariant $\chi=\lambda_2/\lambda_1$ characterizes ellipse $\mathbf{D}_{\vec{V}}$. Spectral density $\mathbf{S}_{\vec{V}}(\omega)$ is asymmetric second range tensor $\mathbf{S}_{\vec{V}}(\omega) = \begin{pmatrix} \lambda\ (\omega) & 0 \\ 0 & \lambda_2(\omega) \end{pmatrix} + 0.5D\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$. Rotation indicator of different sign $D(\omega)$ shows the prevailing rotation direction: right for $D(\omega)>0$ or left for $D(\omega)<0$. Indicator of the absence of rotation is $\lambda_2(\omega)=0$. The general peculiarities or Russkaya station wind regime are presented as probability distribution in wind rose (Fig.1), spectrum (Fig. 2) and estimates of $\vec{m}_{\vec{V}}$ and $\mathbf{D}_{\vec{V}}$ values (Tables 1, 2). Wind speed time-series trend $\vec{\mathbf{a}}$ is determined as [1] $\vec{\mathbf{V}}(t) = \vec{\mathbf{m}}_{\vec{V}} + \vec{\mathbf{a}}t + \vec{\mathbf{\varepsilon}}(t)$, where $\vec{\mathbf{a}}$ $\{a_x,a_y\}$ is the vector with cartesian components a_x, a_y, the last are declines of trend projections $V_{x,y}(t) = m_{Vx,y} + a_{x,y}t + \varepsilon_{x,y}(t)$. Trend parameters are module and direction of vector $\vec{\mathbf{a}}$ and they are invariants of anomalies tensor $\mathbf{D}_{\vec{\varepsilon}}$ relative to trend. Regular annual rythmic is presented as hodograph $\vec{\mathbf{m}}_{\vec{V}}(t) - \vec{\mathbf{m}}_{\mathbf{o}}$ and ellipses of annual $\vec{\mathbf{m}}_{\mathbf{1}}(t)$ and semiannual $\vec{\mathbf{m}}_{\mathbf{2}}(t)$ harmonics (Fig. 6), which are commensurable, oblíng and of left rotation. Thus, spectral pikes on annual and semi-annual frequency are determined. Parameterization ranging from interannual (including vector process trend) to daily variations with account of low-frequency modulation provides uniform presentation for all scales of variability characteristics in climate regime Handbooks. Russkaya station data analysis demonstrates (Fig. 3-5), that the main input in dispersion is formed by annual rhythmic and synoptic scale processes, while their low-frequency modulation increases multiply from intensity of the additive component (the mean annual values time series).

Table 1. Mean wind speed $\vec{\mathbf{m}}_{\vec{V}}$ and estimates of wind speed dispersion tensor $\mathbf{D}_{\vec{V}}$ invariants and wind dispersion module D_V for different averaging time scales of initial data.

Averaging scale			6-hourly	Daily	Monthly	Annual
$\vec{\mathbf{m}}_{\vec{V}}$	m	m/s	10.1			
	D	degrees	86			
D_V		m^2/s^2	111.1	93.3	13.1	1.3
$\mathbf{D}_{\vec{V}}$	I_1	m^2/s^2	176.9	138.1	18.9	4.5
	γ	-	0.15	0.12	0.35	0.51
	α	degrees	79	79	75	175

References

1. Bokov, V.N. et all. 2001. Space-time variability of wind field in Norherm Hemisphere extra-tropical latitudes. Atmosphere and ocean physics, 2001, 37, p. 170-181.

2. Rozhkov, V.A.1997. Probabilities theory of stochastic events, values and functions with hydrometeorologicla examples. SPb., Progress-Pogoda, 1997, 559 pp. (in Russian).

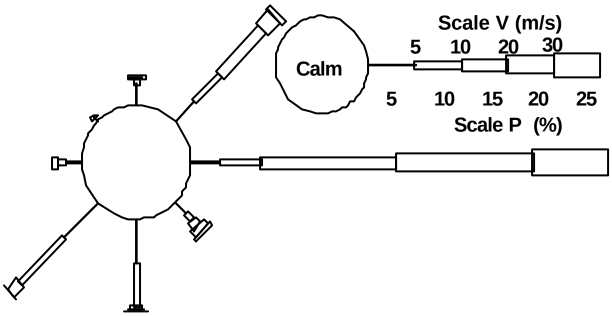

Fig.1 Wind speed rose at Russkaya station

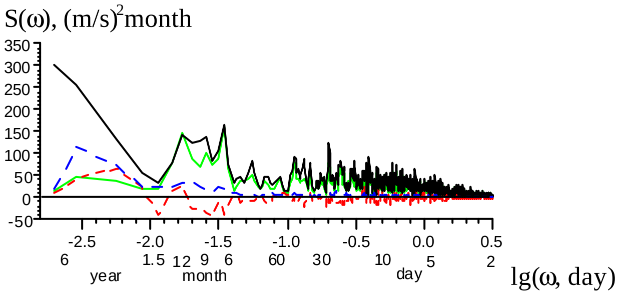

Fig.2 Wind speed Spectrum

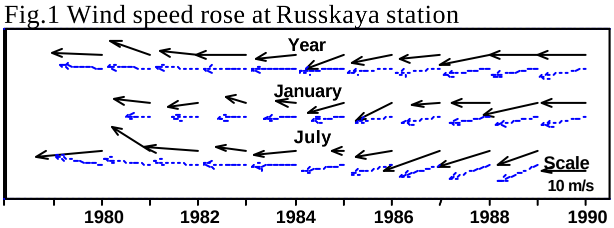

Fig. 3 Time series of mean wind speed (solid) and their linear trend (dashed)

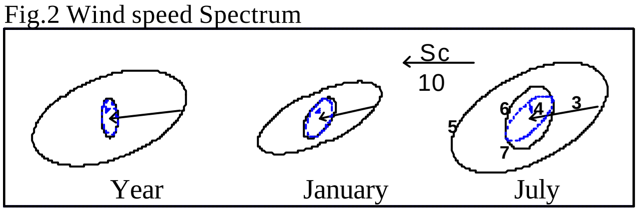

Fig. 4 Mean wind speed, trend coefficients and mean square deviation ellipse of $\mathbf{D}_{\vec{V}}^{0.5}$ (curves 5, 6).

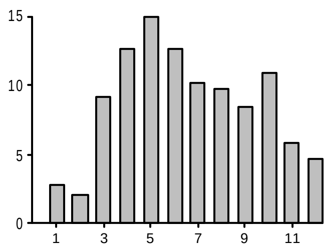

Fig. 5 Annual variation of storm frequency (%)

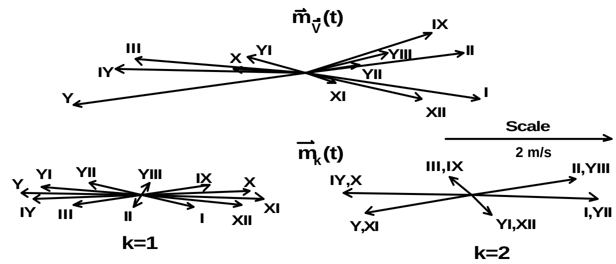

Fig.6 Godograph of $\vec{m}_{\vec{V}}$, annual (k=1) and semiannual (k=2) harmonics

Table 2. Annual variation of mean wind speed $\vec{\mathbf{m}}_{\vec{V}}$, estimates of tensor dispersion $\mathbf{D}_{\vec{V}}$ invariants of monthly mean wind speed, linear tend parameters and maximum wind values (from 6-hourly data).

Month	$\vec{\mathbf{m}}_{\vec{V}}$		$\mathbf{D}_{\vec{V}}$			$\vec{\mathbf{a}}$		$\mathbf{D}_{\vec{a}}$			max($\vec{\mathbf{V}}$)	
	m	D	I_1	φ	χ	|**a**|	d_a	$I_1^{(\varepsilon)}/I_1^{(v)}$	φ	χ	**V**	φ
	m/s	degrees	$(m/s)^2$	degrees	-	m/s	degrees	%	degrees	-	m/s	degrees
I	8.0	83	8.8	59	0.22	0.45	63	70	55	0.33	39	90
II	8.2	86	6.0	63	0.22	0.23	48	90	66	024	38	80
III	11.9	87	25.3	93	0.32	0.99	276	71	88	0.51	60	90
IY	12.6	86	35.4	76	0.17	0.65	38	86	82	0.11	60	90
Y	13.4	84	25.6	43	0.25	0.51	6	88	49	0.20	55	90
YI	10.5	87	17.3	37	0.61	0.66	2	69	69	0.36	52	90
YII	9.8	85	20.1	57	0.44	0.62	343	76	63	0.20	49	80
YIII	9.5	87	23.6	73	0.20	0.38	8	92	75	0.12	52	90
IX	8.2	88	9.5	24	0.42	0.37	33	83	18	0.48	54	110
X	11.1	85	15.7	89	0.81	0.20	323	97	82	0.78	53	85
XI	8.9	85	15.9	87	0.25	0.39	64	88	93	0.21	47	90
XII	8.3	81	8.1	75	0.25	0.33	73	84	76	0.32	49	90