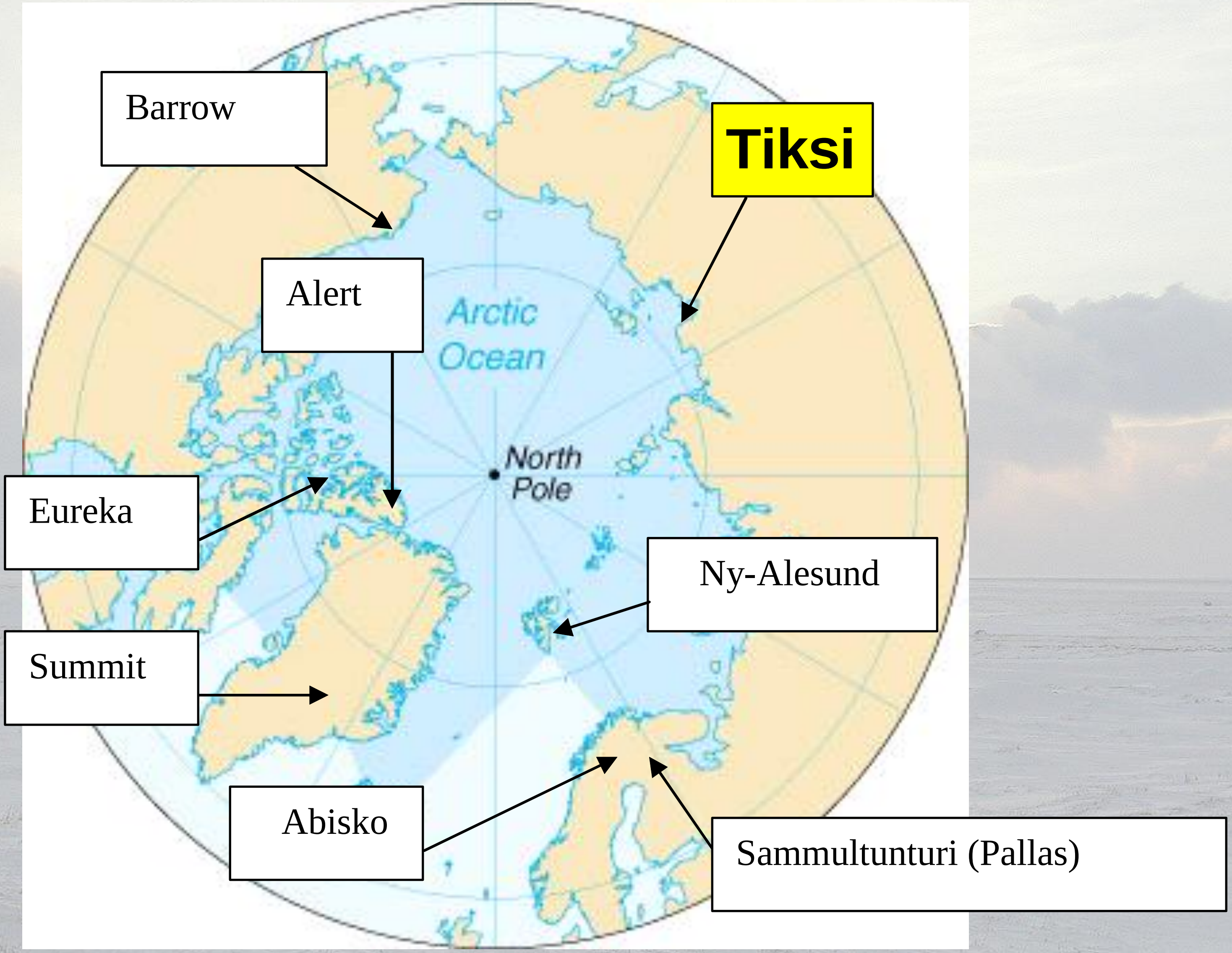
Climate of Tiksi region from the historical instrument records of surface and upper air observations

N. Ivanov, I. Bolshakova, O. Zukova, A. Makshtas



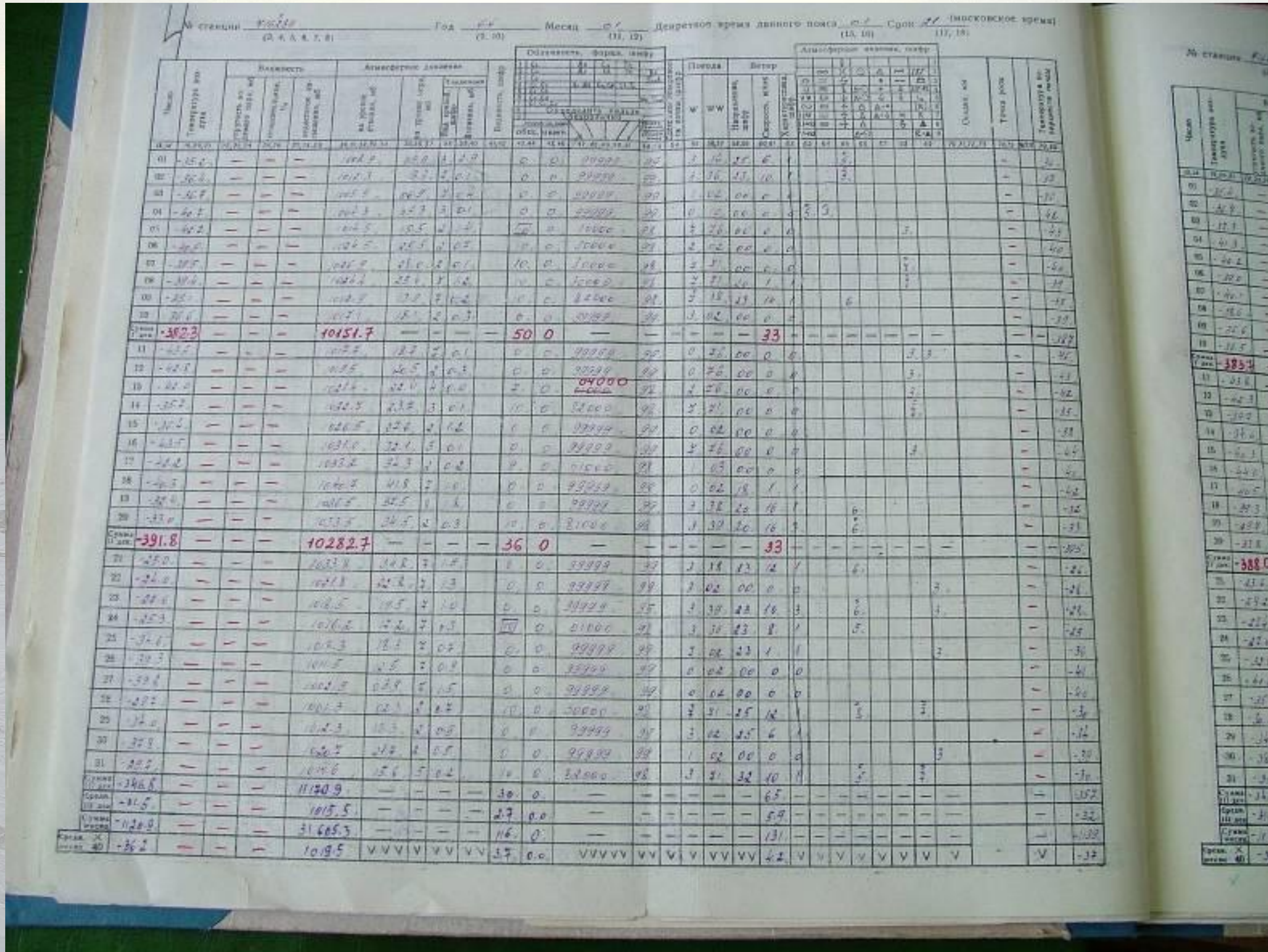
The Tiksi Hydrometeorological Observatory is designed for co-location of observations supporting networks such as BSRN, GAW, UV-NET, CRN, AeroNET, MPLNET and others (including permafrost and other measurements)

Existing positions of meteorological and radiosounding observations

Standard surface meteorological observations have been made with consistent methods since 1934

Radiosoundings in " Polarka" started in 1935 and continue to present

The historical Tiksi data sets have recently been digitized
Example of original table of meteorological data (January 1966)



Data correction

Four steps of Archive corrections had been used for correction of about 1.23 million data prepared from hand written log books, sometimes of low quality, with a lot of improvements. For that EXEL files for each calendar month had been prepared to exclude seasonal variability.

1step. With EXEL graphic presentations of file for each month of each meteorological parameter rough errors had been deleted.

2 step. Mean square deviations of data rows had been calculated to be sure that all rough mistakes had been deleted.

3 step. Graphic analysis of probably wrong information had been done by comparison of dubious data with neighboring data in the same data row.

4 step. After 1-3 steps by number sequence of measured data x_i, i=1,2,…,n the data rows and its sums had been calculated:

$$\delta xi = |xi - xi\text{-}1| , \; i=1,2,\dots,n-1$$

$$\overline{\delta}^* = \frac{1}{n-1}\sum_{k=1}^{n-1}\delta x_k$$

In case $\delta xi > D\delta^*$ the data with numbers i-1, i, i+1are assumed as doubtful and controlled by logbooks. We used D=5 for step 4.

Additional control had been executed by comparison of maximal daily variation of air surface temperature with data of maximal and minimal thermometers. Despite low accuracy of last measurements 72 mistake of air surface temperature had been found. The same procedure with comparison the values of total and low cloudiness had been made.

Example of files, stored in Meteorological Archive

JULday	year	mnnth	day	Ta00	Ta03	Ta06	Ta09	Ta12	Ta15	Ta18	Ta21	Tamax	Tamin
1990	1990	1	1	-24.6	-24.1	-26.1	-25.7	-26.1	-33.3	-32.5	-29.1	-23	-34.7
1990.03	1990	1	2	-28.3	-33.3	-33.9	-33.2	-33.6	-27.3	-30.3	-26.5	-25.9	-34.8

Q00	Q03	Q06	Q09	Q12	Q15	Q18	Q21	Ts00	Ts03	Ts06	Ts09	Ts12	Ts15
0.0006	0.0006	0.0005	0.0005	0.0005	0.0003	0.0003	0.0004	-27	-26	-28	-27	-28	-37
0.0004	0.0003	0.0002	0.0003	0.0003	0.0004	0.0003	0.0004	-32	-36	-36	-37	-38	-30

Ts18	Ts21	Tsmax	Tsmin	NT00	NT03	NT06	NT09	NT12	NT15	NT18	NT21	NL00	NL03
-36	-32	-26	-38	10	10	10	10	6	0	0	0	0	0
-34	-31	-28	-39	0	6	3	4	2	3	0	0	0	0

NL06	NL09	NL12	NL15	NL18	NL21	vi00	vi03	vi06	vi09	vi12	vi15	vi18	vi21
0	0	0	0	0	0	63	97	64	62	80	82	82	82
0	0	0	0	0	0	82	97	83	81	82	80	81	81

RV00	RV12	slp00	slp03	slp06	slp09	slp12	slp15	slp18	slp21	WD00	W00	WD03	W03
0	0.4	1019.9	1019.9	1020.5	1021	1021.9	1020	1019.7	1019.3	0	0	220	8
0	0	1020.2	1019.8	1019.7	1019.9	1019.9	1022	1021.3	1021	40	3	100	2

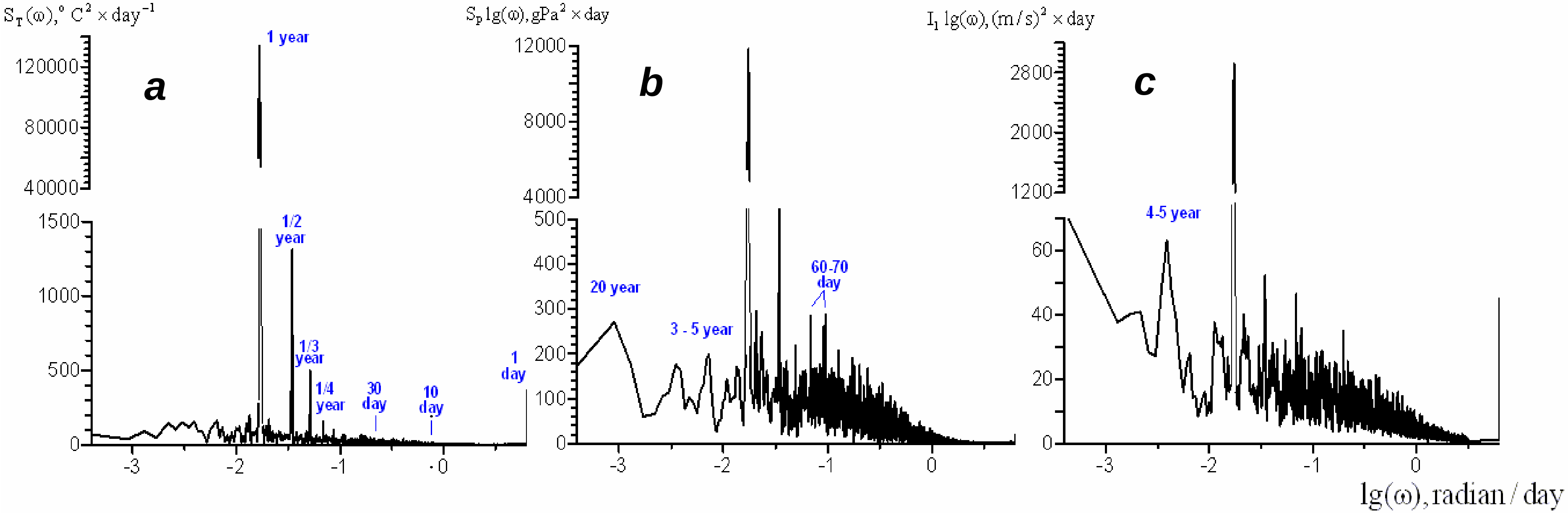
WD06	W06	WD09	W09	WD12	W12	WD15	W15	WD18	W18	WD21	W21	hs	so00
250	6	225	6	225	6	205	2	245	2	220	4	2	8
0	0	0	0	0	0	200	3	0	0	220	4	2	8

The meteorological archive fir Tiksi will be available on WEB in summer 2008

Climate of Tiksi observatory area

Atmospheric surface layer

Spectral density of multi-year variability of air surface temperature (a), surface pressure (b) and wind velocity (c)

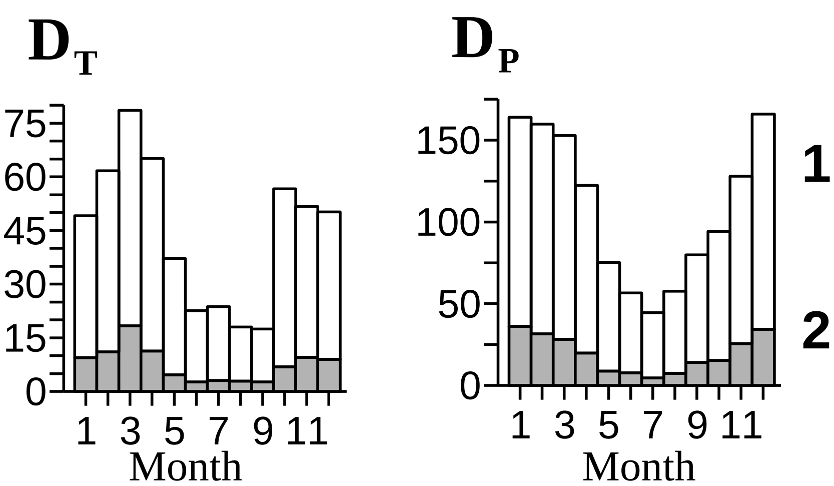


Spectral function

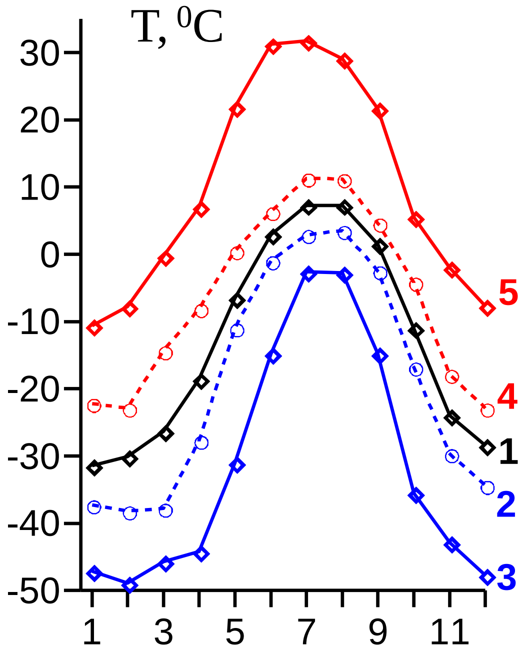
$$F(\omega) = \int_{\omega_1}^{\omega_2} S(\omega)d\omega$$

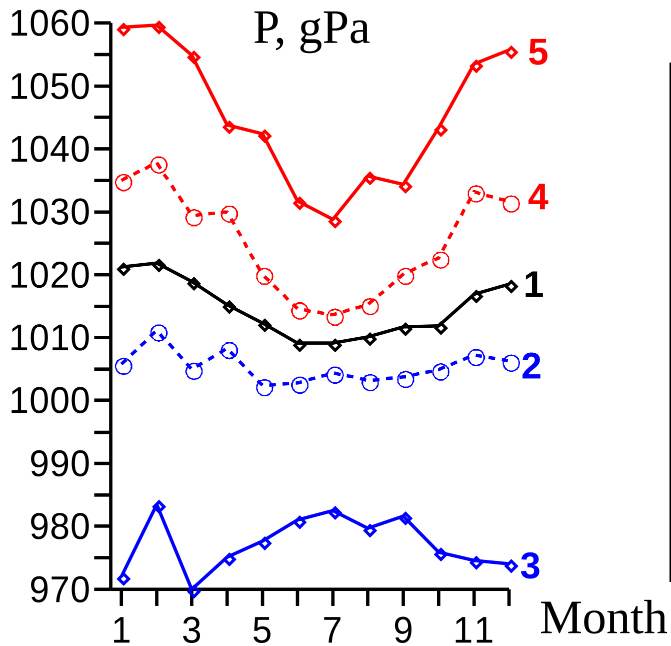
	Multi-year	Seasonal	Synoptip
T	**1%**	**83%**	**10%**
P	**2%**	**22%**	**46%**
$\vec{V}$	**4%**	**15%**	**69%**

Seasonal variability of variance from daily (1) and monthly (2) data



Seasonal variability of monthly means (1) and extremes from daily (3, 5) and monthly (2, 4) averaged data

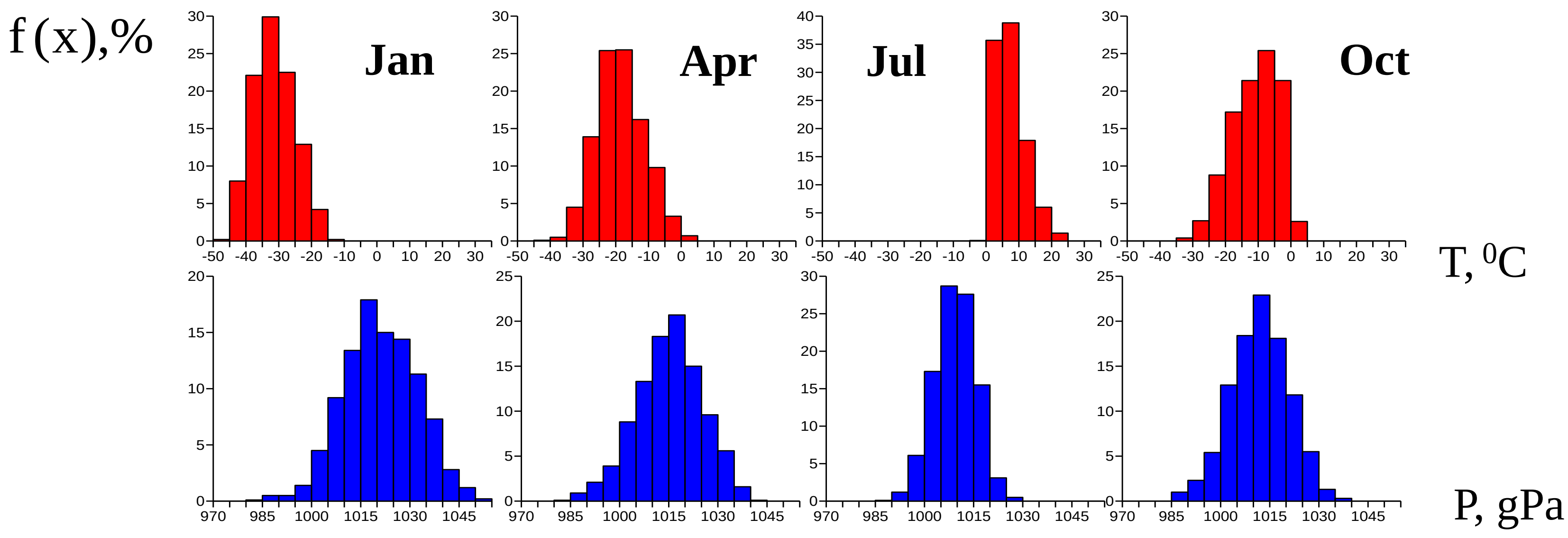




Seasonal A, E coefficients

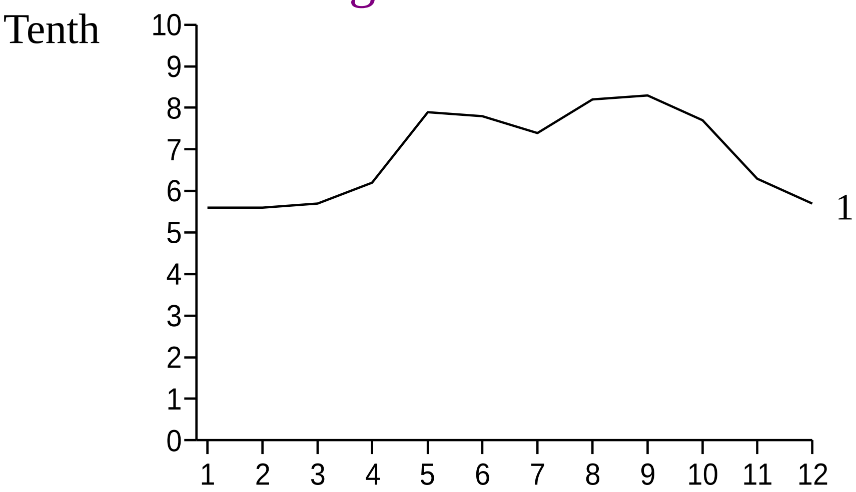
	Jan	Apr	Jul	Oct
Temperature				
A	0.21	0.22	**1.04**	-0.44
E	-0.52	-0.21	**1.95**	-0.47
Pressure				
A	-0.05	-0.22	-0.15	-0.11
E	-0.04	-0.15	-0.12	-0.08

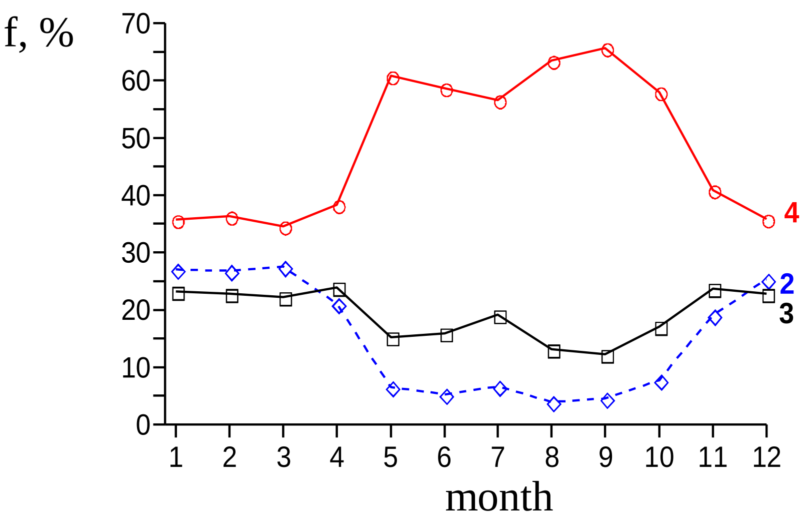
Seasonal variability of probability distribution temperature and pressure



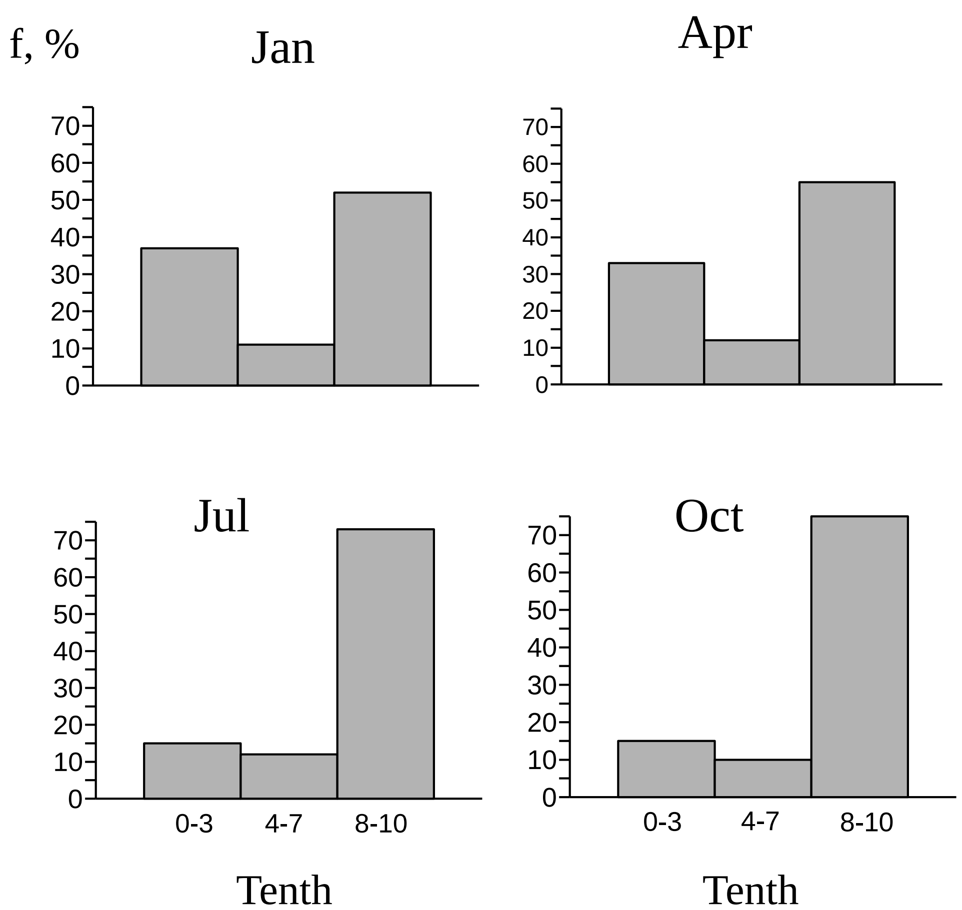
Total cloudiness

Seasonal variability of multi-year averaged characteristics





Seasonal variability of probability distribution

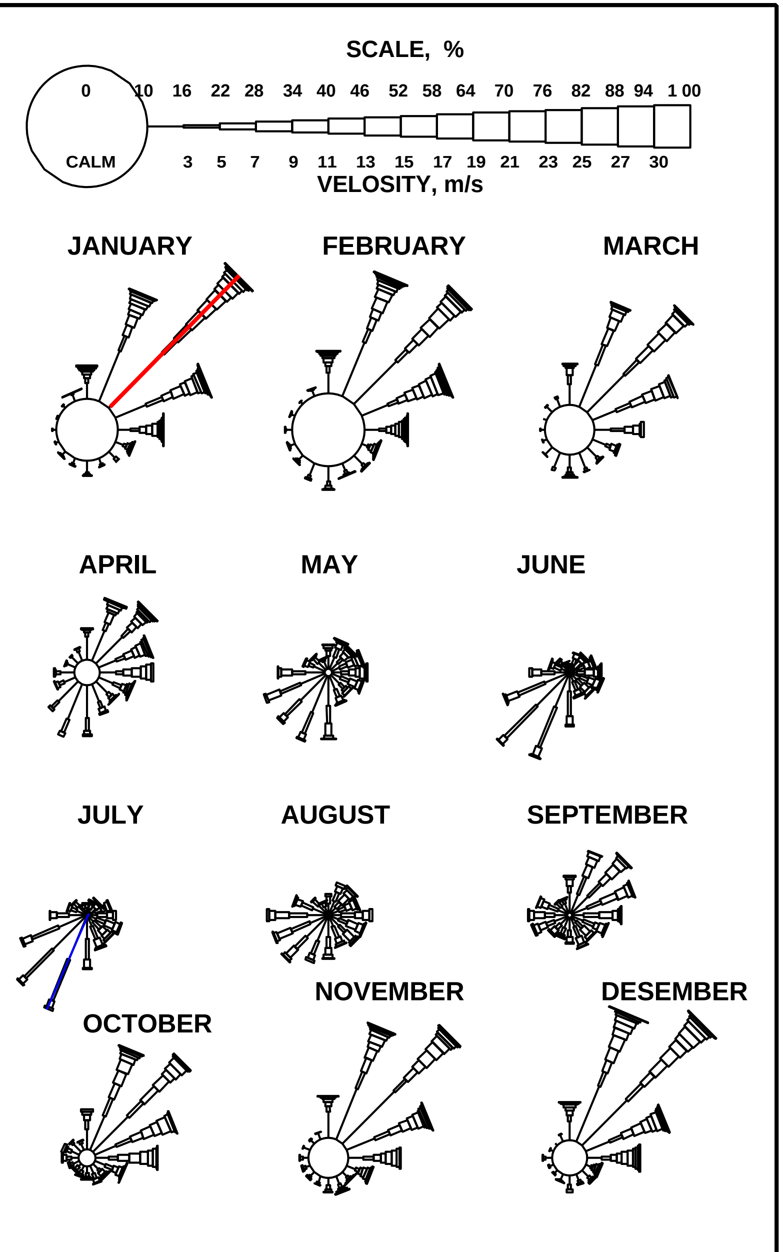


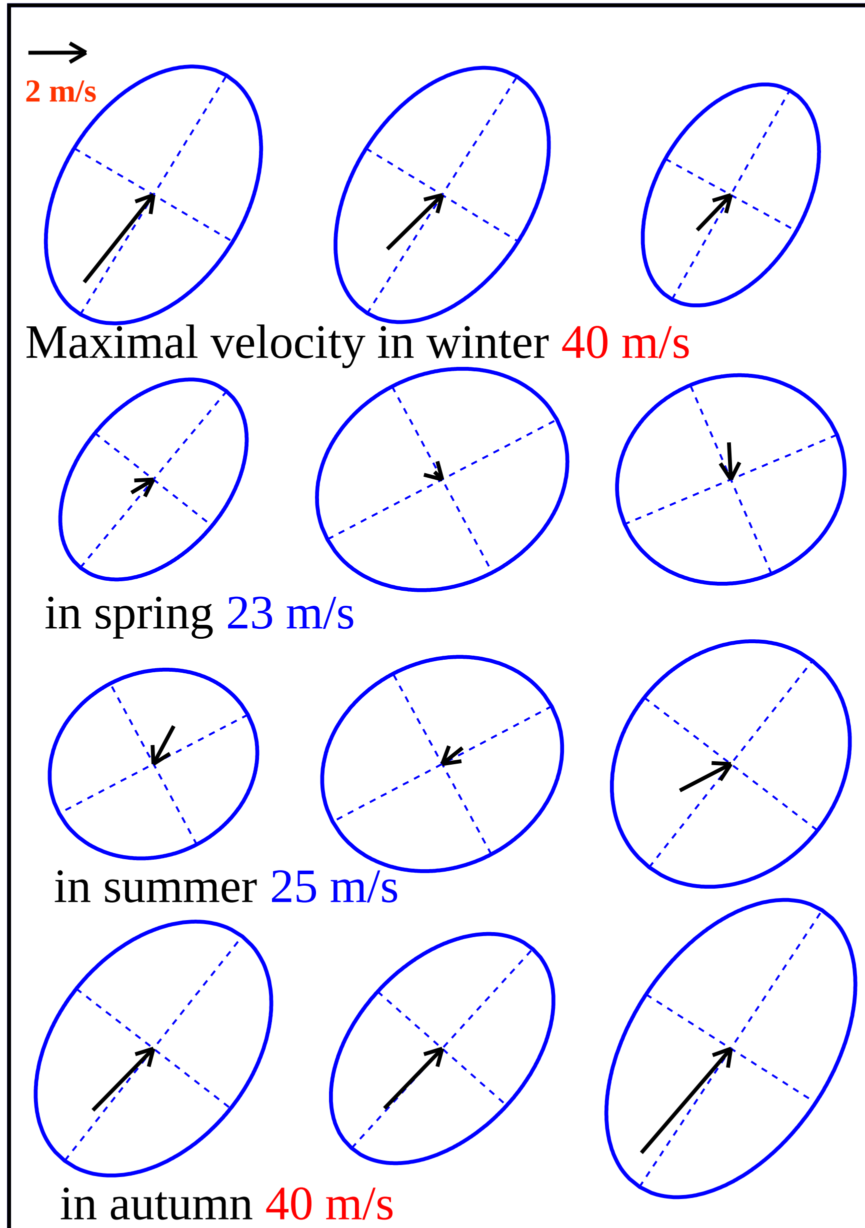
1 – cloudiness;

occurrence: 2 – 0-3 tenths, 3 – 4-7 tenths, 4 – 8-10 tenths

Wind roses in Tiksi

Vector of mean wind velocity and MSD ellipse in Tiksi





Cold season

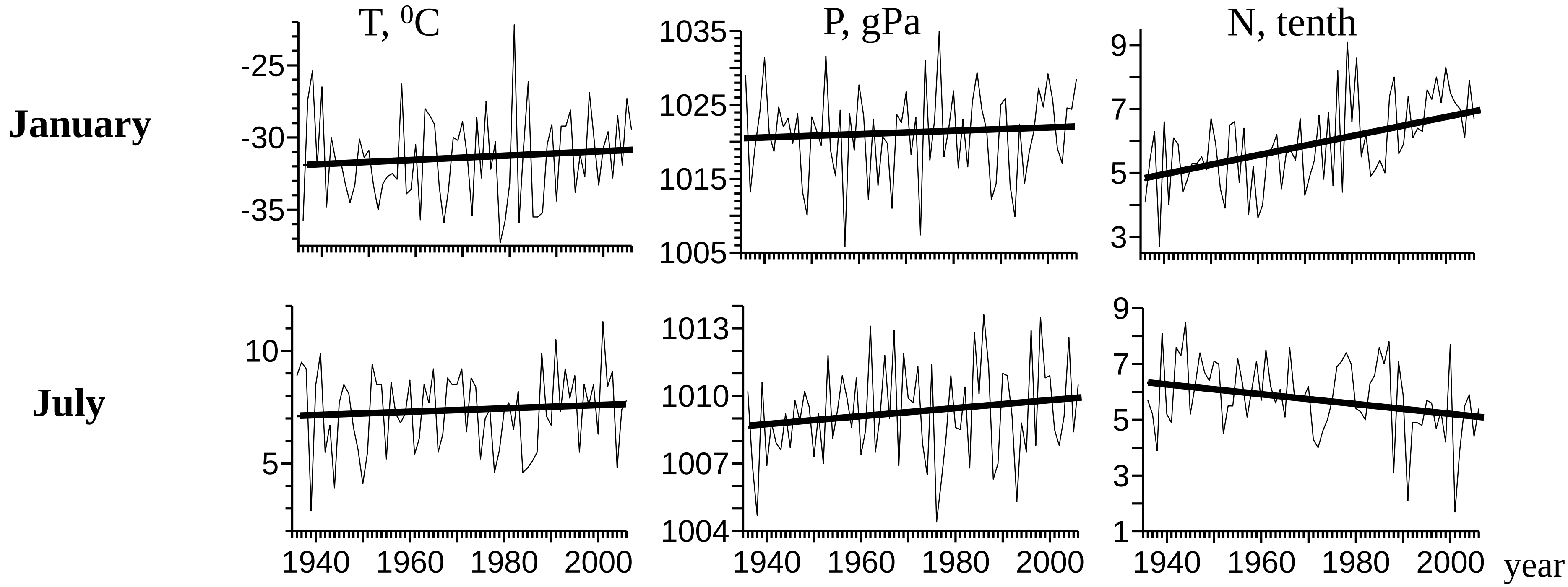
Oct-Mar

Hot season

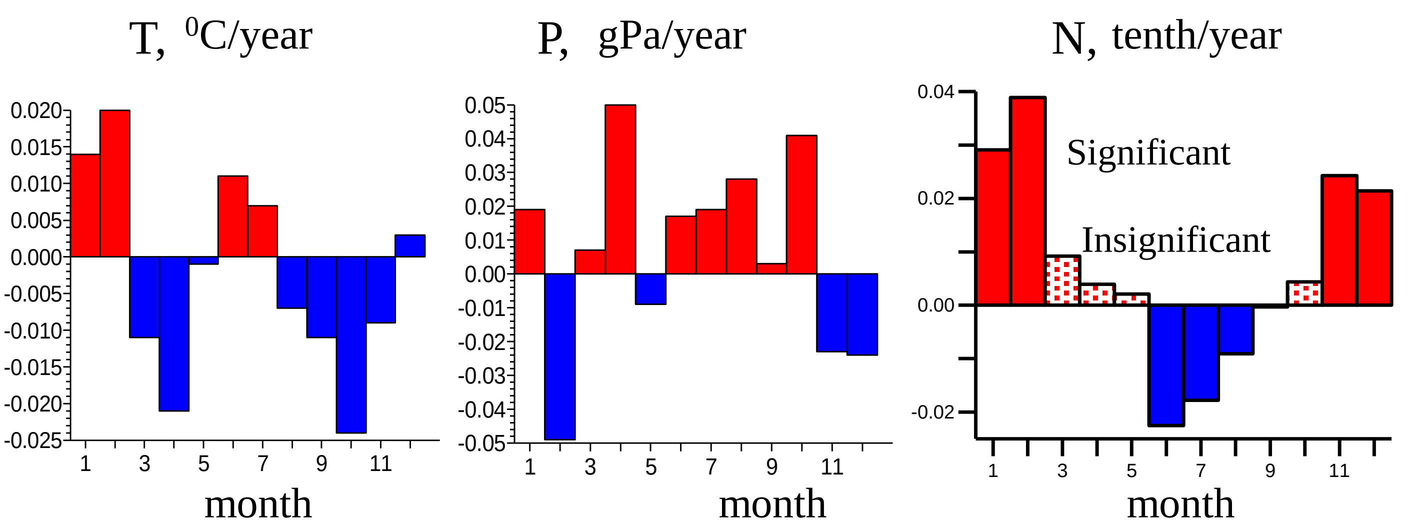
May-Aug

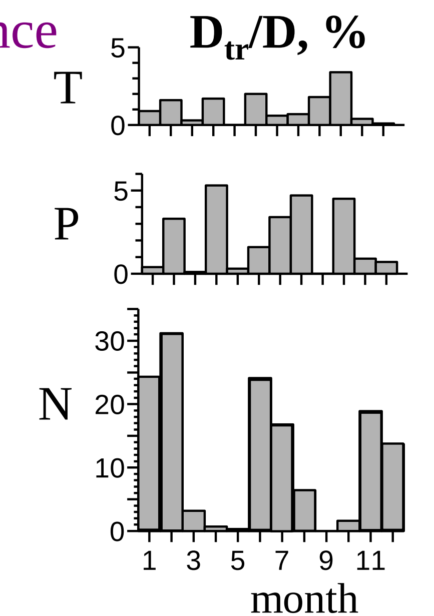
Time series and trend

Interannual variability of temperature, pressure and total cloudiness



Seasonal variability of trend coefficient and relative input to variance



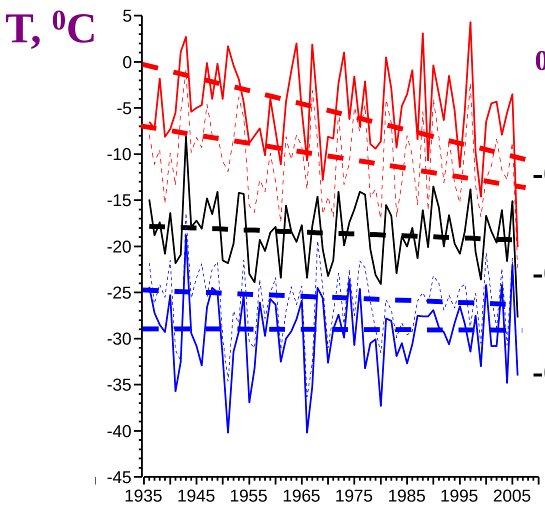


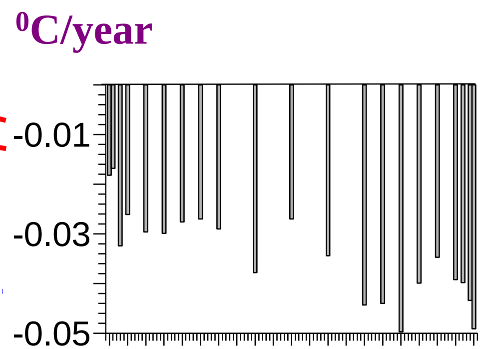
Trends of monthly quantile values of air surface temperature and surface pressure

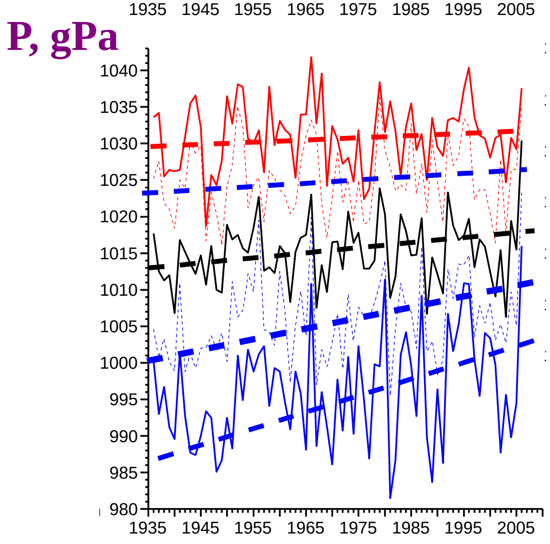
$$X_p(t) = a_p t + b_p, \quad p = \min,\ 0.1, \ldots, 0.9,\ \max$$

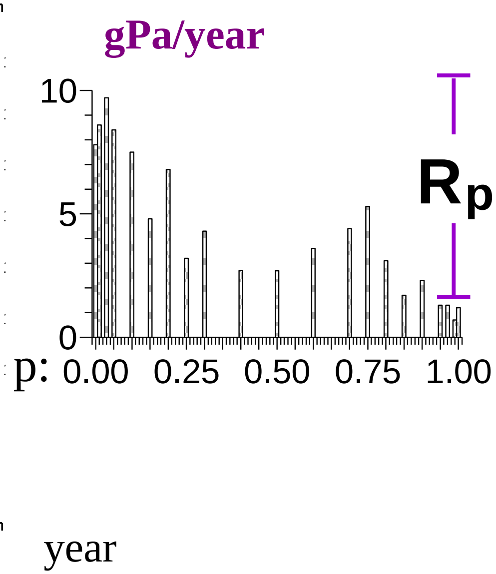
$$\text{Effect of synoptic sistems is significant} \Rightarrow \mathbf{a_p \neq const}$$

Temperature and pressure, April

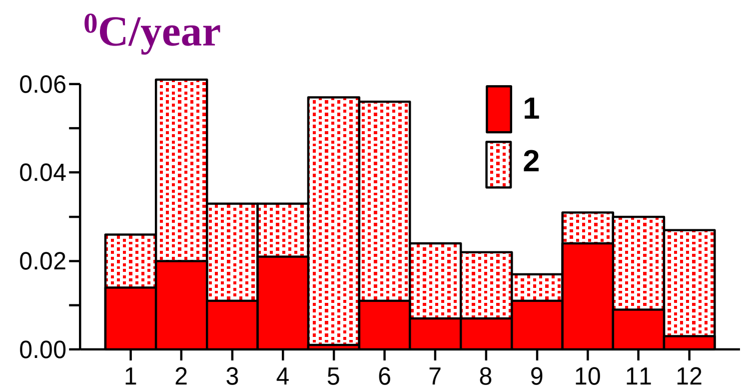


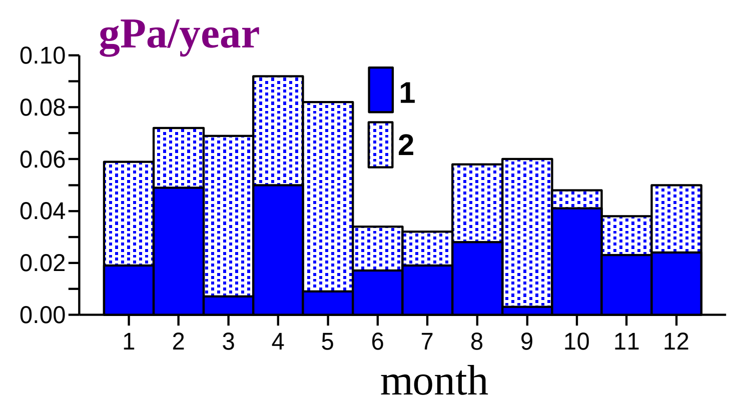




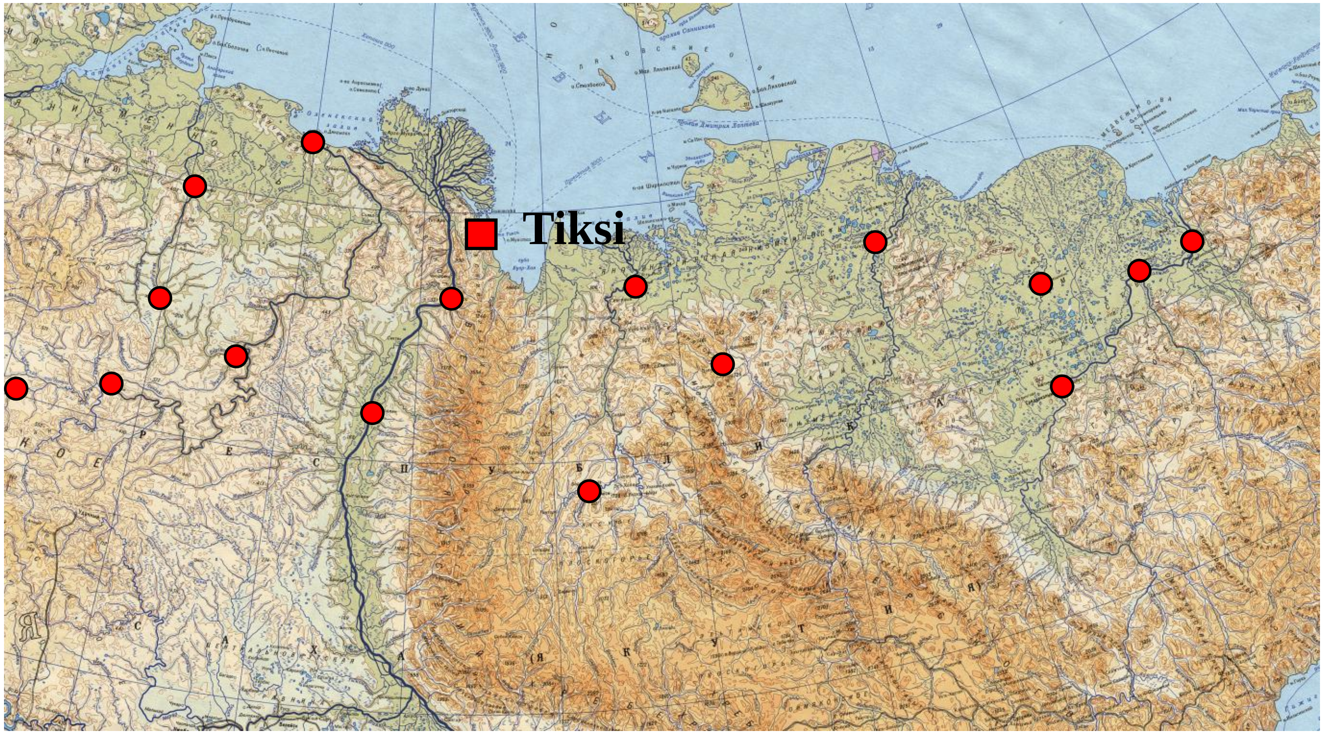


Annual variations of monthly mean absolute values pressure trends (1) and corresponding trends of ranges of deviation $R_p = a_{max} - a_{min}$ (2)





Created archive of data of meteorological stations in the Nothern Yakutia, 1978-2010



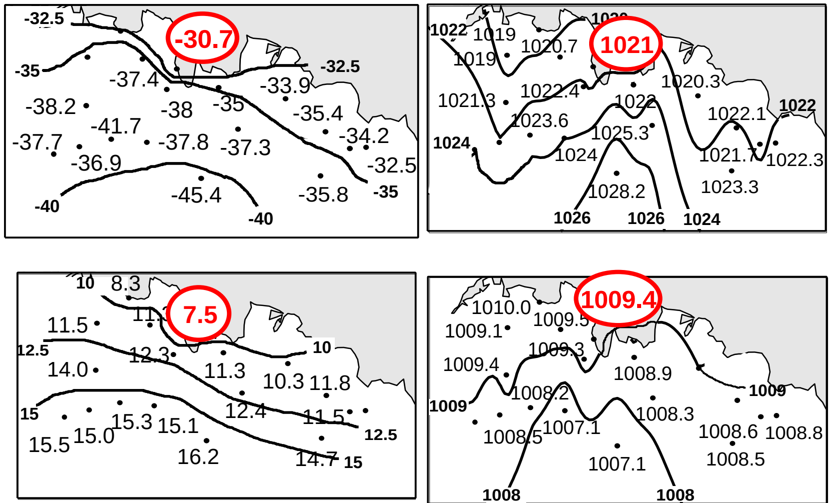
	Station	Latitude	Longitude	H, m		Station	Latitude	Longitude	H, m
1	Андрюшкино	69.1	154.3	16	11	Джалинда	70.1	113.8	62
2	Верхоянск	67.3	133.2	138	12	Оленёк	68.5	112.6	217
3	Депутатский	69.2	139.5	284	13	Саскылах	72.0	114.1	16
4	Колымская	68.4	158.4	12	14	Сухана	68.8	118.0	77
5	Среднеколымская	67.37	153.4	21	15	Тюмяти	71.9	123.4	28
6	Тикси	71.3	128.5	8	16	Усть-Оленёк	73.0	119.5	14
7	Черский	68.5	161.2	25	17	Ярольин	68.2	108.5	236
8	Чокурдах	70.4	147.5	61	18	Д追ржан	68.7	124.0	14
9	Юбилейное	70.8	136.2	22		Кюсюр	70.7	127.4	36

Multi-year averaged, 1978 - 2010

Temperature, ^{0}C **Pressure, gPa**

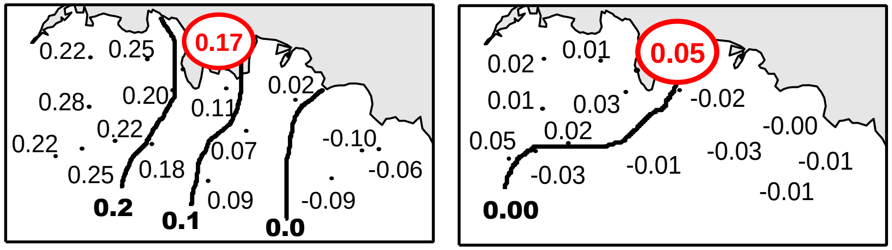
Jan

Jul

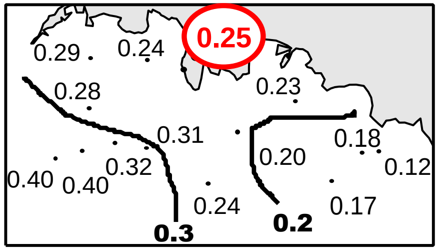


Time series and trend coefficient 1978 – 2010, January

Temperature, ^{0}C/10 year **Pressure, gPa/10 year**



Total cloud., tenth/10 year

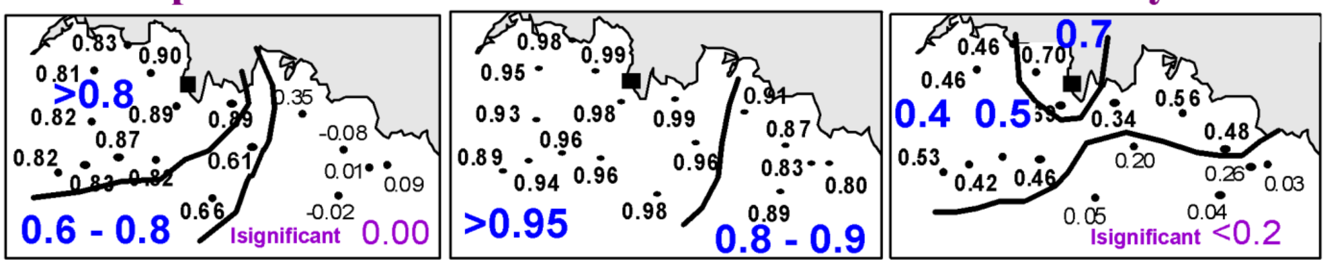


Correlation of monthly means values

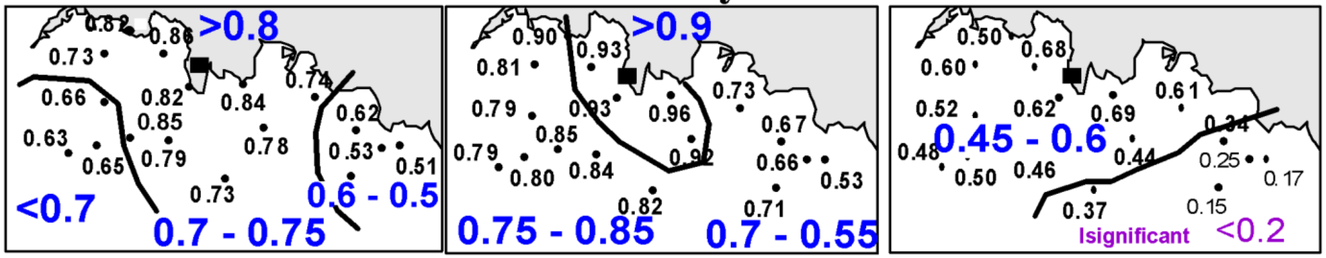
r: **0.90** – Significant, 0.05 - Insignificant

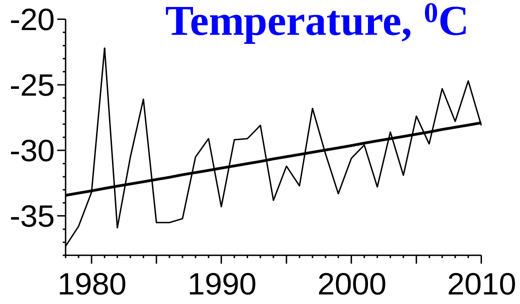
January

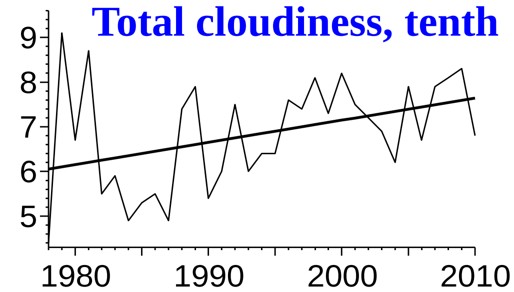
Temperature **Pressure** **Wind velocity vector**



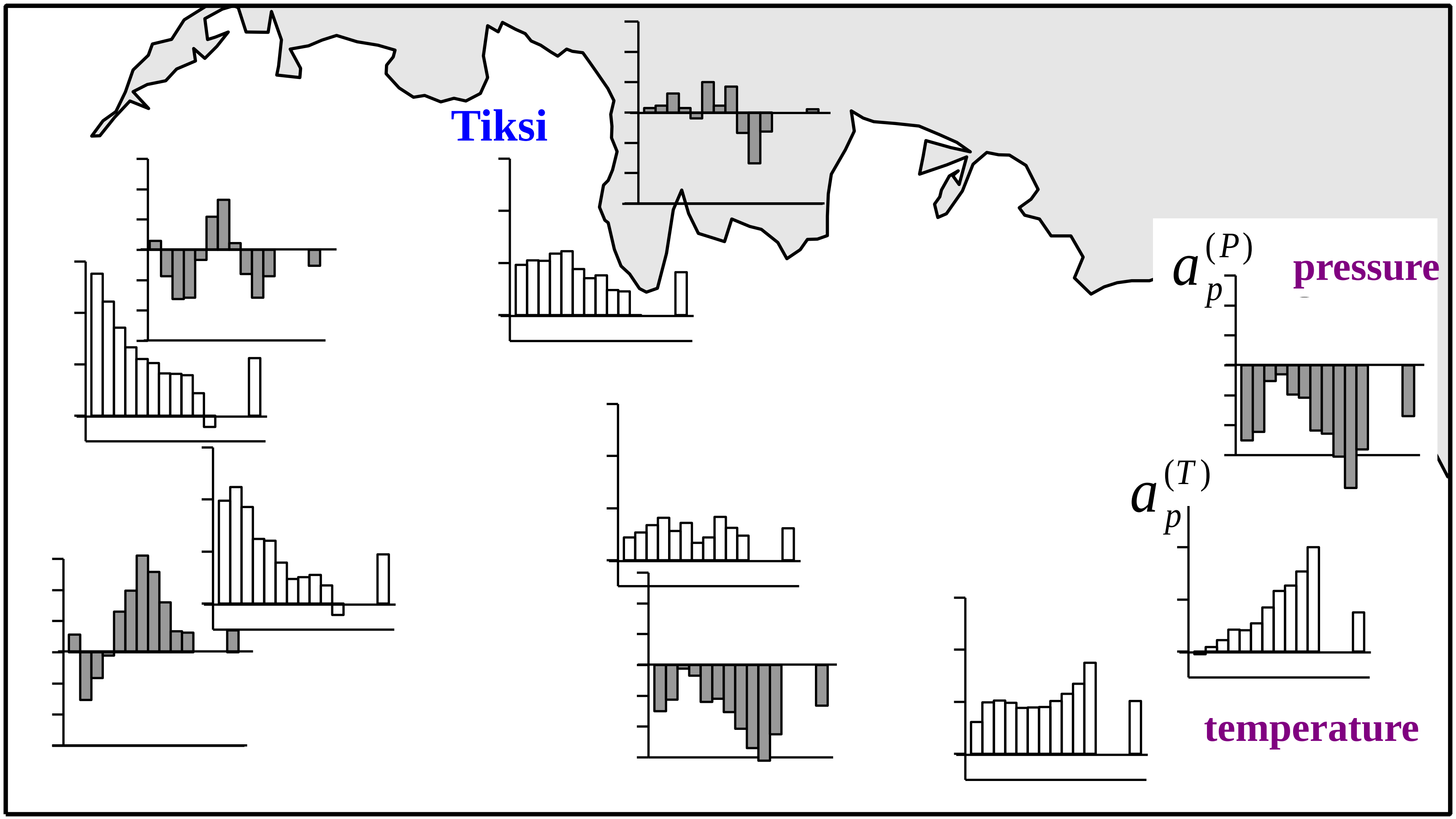
July







1978 – 2010. Trends of monthly quantile values of air surface temperature (transparent) and surface pressure (black)

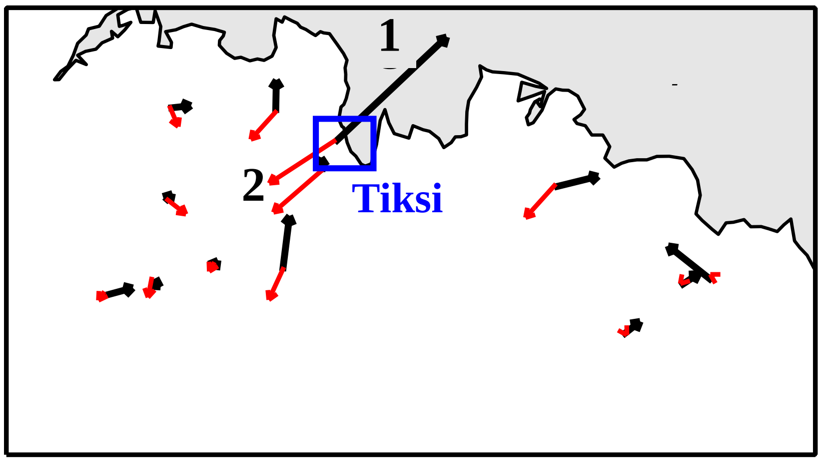


Monthly mean wind velocity (1) and vector trend (2), 1978 - 2010

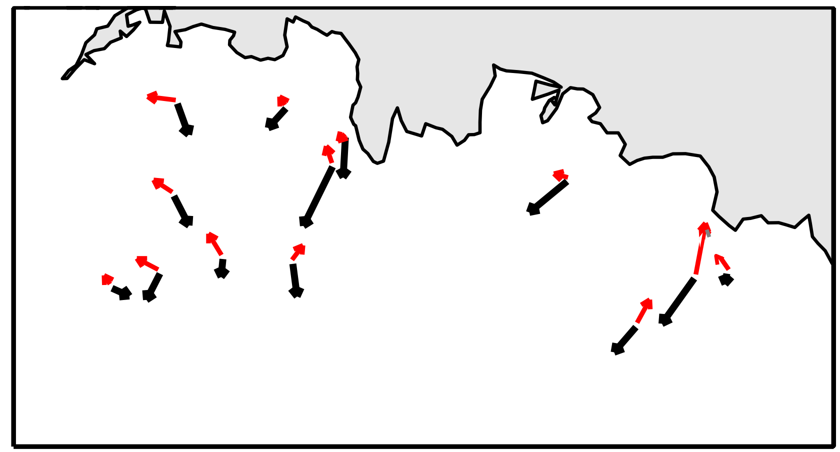
$$\vec{V}(t) = \hat{\vec{V}}(t) + \vec{\varepsilon}$$

$$\text{Trend}: \quad \hat{\vec{V}}(t) = \vec{a}(t) + \vec{b}, \quad \text{anomal} \quad \vec{\varepsilon}(t) = \vec{V}(t) - \hat{\vec{V}}(t)$$

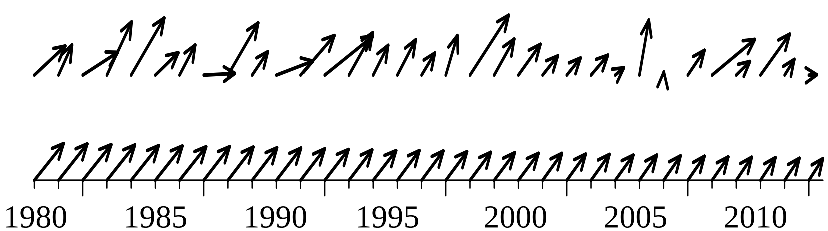
Winter

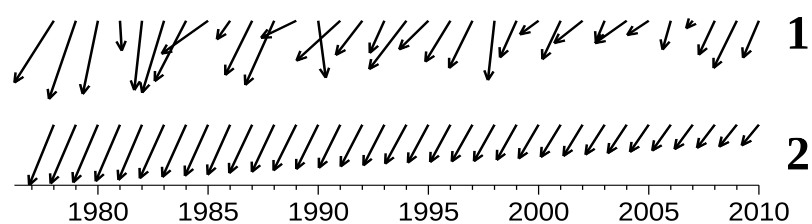


Summer



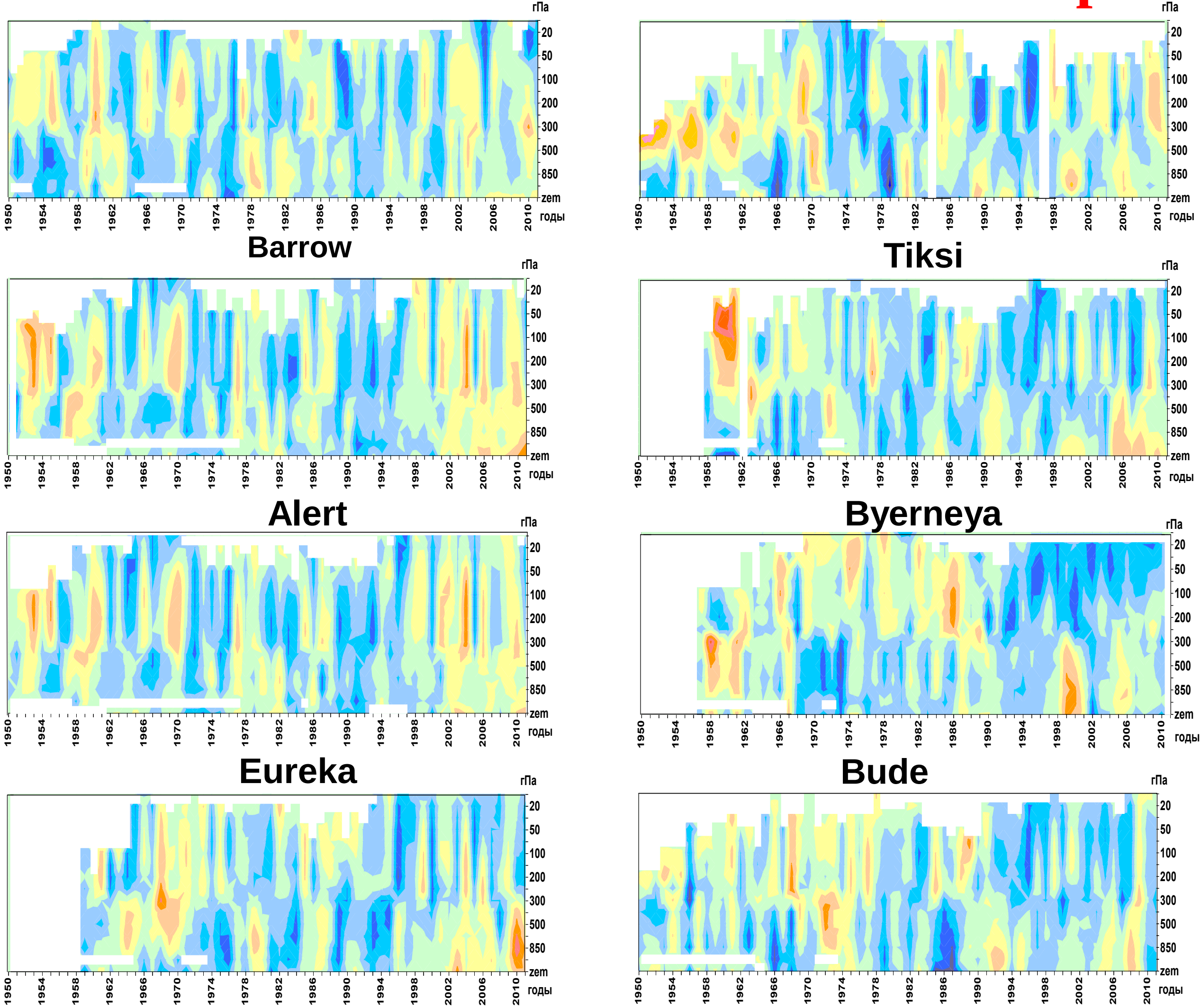
Attention on $\varphi_{\vec{V}} \Leftrightarrow \varphi_{\vec{a}}$: $\uparrow\uparrow$ – increase, $\uparrow\downarrow$ – decrease, $\uparrow\rightarrow$ rotation

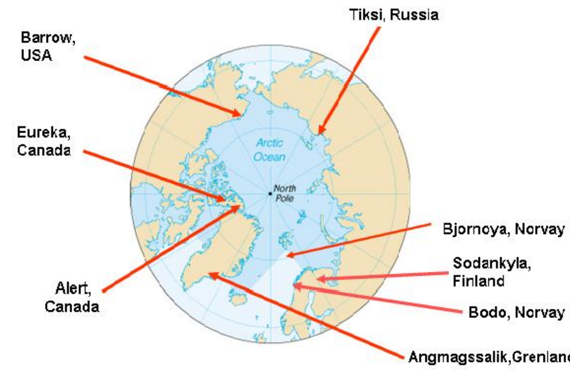




Climate of free atmosphere

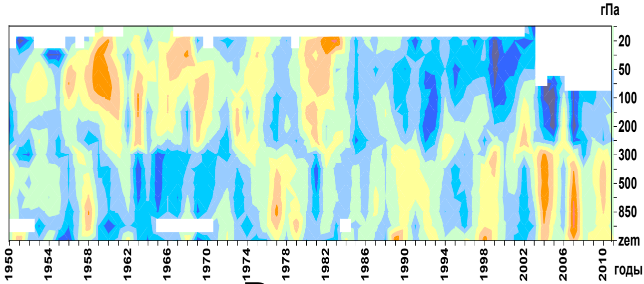
1950 – 2010
Normalized anomalies of air temperature, winter



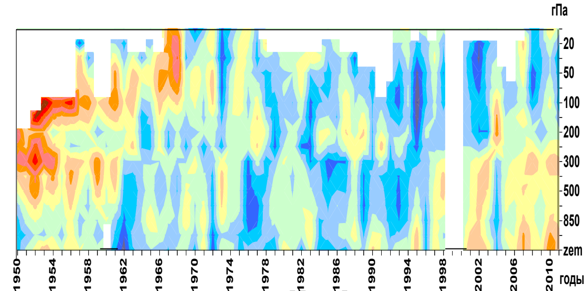


-4,00--3,50 -3,50--3,00 -3,00--2,50 -2,50--2,00 -2,00--1,50 -1,50--1,00 -1,00--0,50 -0,50-0,00 0,00-0,50
0,50-1,00 1,00-1,50 1,50-2,00 2,00-2,50 2,50-3,00 3,00-3,50 3,50-4,00 отутствие

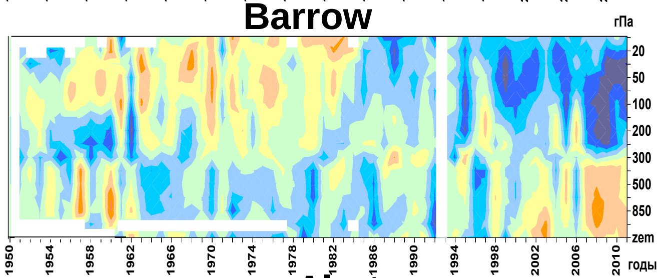
1950 – 2010
Normalized anomalies of air temperature, summer



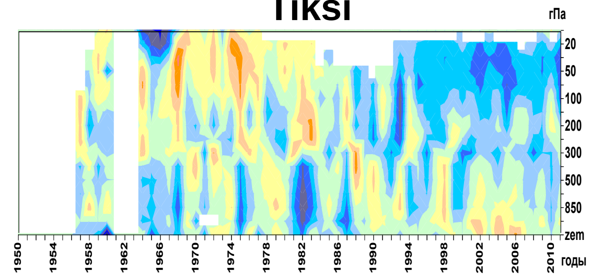
Barrow



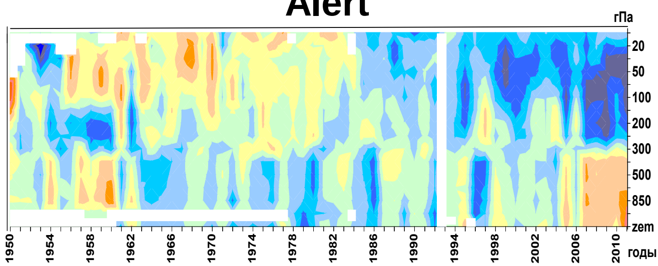
Tiksi



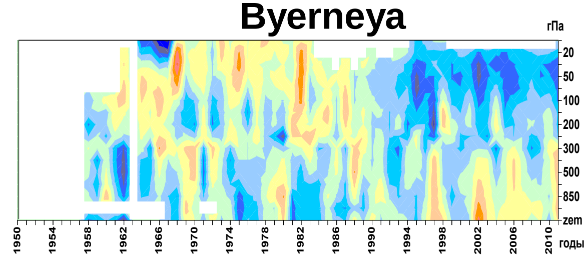
Alert



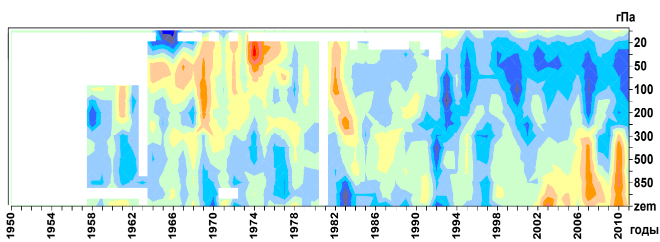
Byerneya



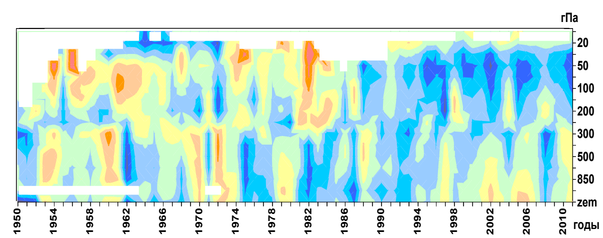
Eureka



Bude



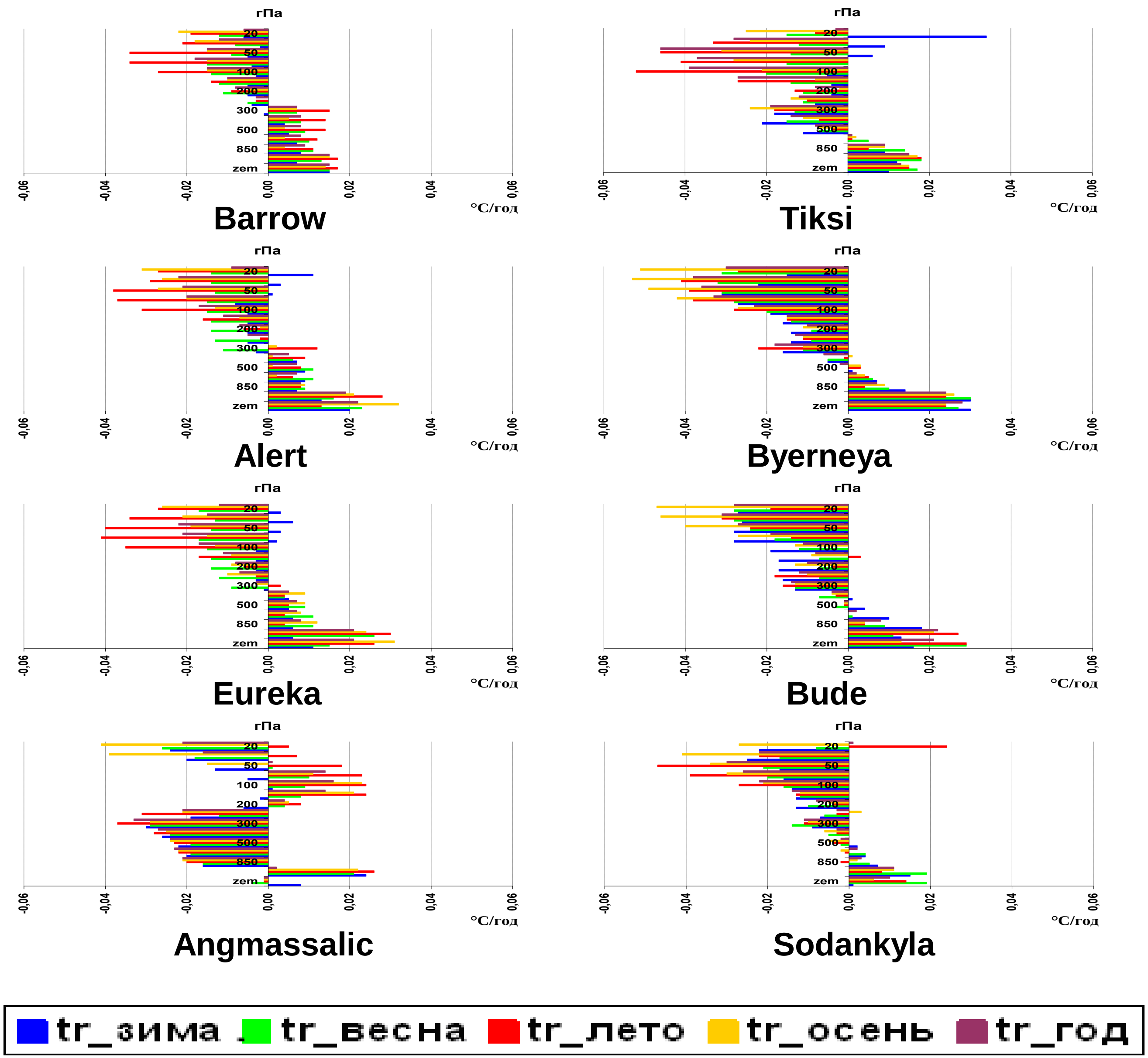
Angmassalic



Sodankyla

-4,00--3,50 | -3,50--3,00 | -3,00--2,50 | -2,50--2,00 | -2,00--1,50 | -1,50--1,00 | -1,00--0,50 | -0,50-0,00 | 0,00-0,50
0,50-1,00 | 1,00-1,50 | 1,50-2,00 | 2,00-2,50 | 2,50-3,00 | 3,00-3,50 | 3,50-4,00 | отутствие

Trends of air temperature on the standard meteorological surfaces for 1950-2011



SUMMARY

- digital archives of historical Tiksi meteorological data (1934 to present) and 18 other stations of the Nothern Yakutia from 1978 to present has been created.
- the main input in variability of meteorological parameters is determined by seasonal cycle of monthly mean values and synoptic processes.
- trends of air temperature and surface pressure are not significant in Tiksi, its variances below 5%.
- strong trends in cloudiness (up to 20-30% increasing in winter and decreasing in summer) have been detected. It could be the reason of small positive trends of surface air temperature during winter and summer.
- quantile analysis supports conclusion about significant influence of synoptic systems on temperature trends.
- wind regime in Tiksi region is of monsoon type (in winter wind direction from south-west, in summer – from north-east). Wind velocity in Tiksi is maximal among all 18 station - 40 m/s.
- the analysis, based on data of all meteorological stations in the Northern Yakutia, shows that mean values and MSD of air temperature and surface pressure are characterized by variability in meridian direction. Same time spatial variability of its trends has latitudinal direction.
- strong positive air temperature trends are revealed in low troposphere and negative – in low stratosphere, except Tiksi region and Eurika in winter.