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Dynamic of the gas and aerosol composition in the atmospheric surface layer of Western Siberia during the summer polar intrusion

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ABSTRACT

The paper studies the changes in the gas composition of the atmosphere in the surface layer for the Tomsk region (Akademgorodok) during the periods of sharp change of air masses. Studies were conducted for the summer seasons (June-August 1993-2018) for the periods of change of air masses from warm to cold. Ozone, carbon dioxide, carbon monoxide and sulfur dioxide (O_3, CO_2, CO, SO_2) concentrations were used for the analysis of the change in chemical composition. The concentrations have been derived from TOR station. For the analysis of air mass change, ECMWF Era-Interim data on the potential temperature on the dynamic tropopause (PV-θ) was used. The paper studies the processes air mass change in which the difference of PV-θ anomaly was about 20-30 K. It was found that the concentration of CO_2 is mainly increasing, and concentrations of O_3 and aerosol are decreasing during the polar intrusion. For CO and SO_2, no dependence on a sharp change in the air mass properties was found.

Keywords: atmospheric composition, gas, aerosol, air masses, polar intrusion, PV-θ.

1. INTRODUCTION

A large number of works demonstrate heterogeneity in the chemical composition of air masses of different origin [1-3, 7, 21, 28-32, 34, 35, 28-40]. Areas of mid-latitudes from 50 to 70 ° N. experience the most drastic fluctuations in temperature, humidity and chemical composition due to a sharp change in air masses, especially when passing the fronts. The increase in horizontal geopotential gradients (≥20 dkm/1000 km) on the axis of the dynamically significant high-altitude frontal zone at the counter advection of cold and heat (≥ 4-5 °C/day) to the rear and front of the cyclone, respectively, should be considered as signs of sharp changes and the formation of extreme weather phenomena. In a large number of works, the influence of a sharp change in air masses and the passage of fronts was studied [6, 9, 10, 12, 23, 26, 27, 36, 37]. In some studies [1,2,16] investigated the effect of the passage of fronts on the concentration of ozone and aerosol, it was shown that the atmospheric fronts significantly affect the concentration of ozone and aerosol. Depending on the geographical type of the front and the direction of its movement patterns of ozone distribution are modified. A number of works are devoted to the processes of blocking [11.13], anomalies of concentrations of small gas components [15, 22], modeling and forecasting of atmospheric processes [14, 41, 42]. Also, the influence of synoptic conditions on the aerosol optical thickness is investigated [3, 24, 33]. The authors have shown that different air masses make it possible to distinguish different levels of turbidity, and, consequently, the change in the concentrations of gas components. The changes of CO_2 concentration in the territory of Western Siberia during the passage of atmospheric fronts in the warm and cold period of the year are estimated [4]. The relationship between the distribution of carbon dioxide and the life of plants in the summer is shown. The following works show the influence of air mass transfer directions on the seasonal cycle of concentrations of small gas components of the atmosphere [7, 9, 16, 18-21, 23]. In one of the works, according to the data of long-term monitoring at the TOR station, the average concentrations of gas and aerosol components in different air masses in the Tomsk region were calculated [5].

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It is shown that CO_2 and CH_4 are characterized by a decrease in the concentration from the Arctic to the tropical air mass. For ozone, the reverse is observed: the highest values are recorded in the tropical air mass, the lowest – in the Arctic. In gases such as CO and SO_2, the nature of the distribution is more complex.

In the present work, in contrast to previous studies, we set a more specific task. As the conditions, we will select those under which there is a sharp change of subtropical air, advection of which occurs from the crests of high pressure of large amplitude, from the territory of Central Asia (Mongolia, Kazakhstan, Western China) to the polar. Polar air masses come most often from the territory of the Kara and Barents seas and adjacent areas in systems of deep hollows. We will explore the summer period from June to August as the events described above are best explored for the individual seasons of the year. Our goal is to demonstrate the maximum changes that the gas and aerosol composition is capable of under the influence of changing air masses.

2. DATA AND TECHNIQUE

2.1 Chemical composition data set

Surface ozone (O3), carbon dioxide (CO2), carbon oxide (CO), sulfur dioxide (SO2) concentration, methane (CH4) and air temperature (T) for 1993-2018 have been derived from a TOR-station (Tropospheric Ozone Research). The TOR-station coordinates are 56°28'41"N., 85°03'15" E. This is an automatic station located in the Akademgorodok of Tomsk belongs to the V.E. Zuev Institute of Atmospheric Optics of Siberian Branch of the Russian Academy of Sciences (IAO SB RAS). There are no industrial facilities or motorways near the station, which reduces the influence of local sources of gas and aerosol. The station is located in the zone of boreal forests and surrounded by small woodland of deciduous and coniferous species. When air masses come from the west, the station is influenced by air that passes through Tomsk and contains industrial and transport pollutants. Otherwise, the air comes from areas with numerous forest stands and no large industrial enterprises. The technical equipment of TOR station demonstrates in Table 1. More detailed information about this station and the equipment can be found in [8].

Table 1. Technical characteristics of the equipment TOR station.

Block	Device/sensor	Measured parameter	Range	Error	Time constant, s
Gas analyzer block	LGR	CO_2, ppm	20…10000	0,2 ppm	
	Model 907-0010	CH_4, ppm	0,005…50	0,001 ppm	1
		H_2O, ppm	150…70000	100 ppm	
	OPTEK 3.02 P-A	O_3, μg/m ^{3}	0…500	± 20%	1
	Teledyne API 200E	NO/NO_2, ppm	0…20	± 0,5%	20
	OPTEK K-100	CO, mg/m ^{3}	0…50	± 20%	1
	Teledyne API 100E	SO_2, ppm	0…20	± 0,5%	20
	Brewer 049	T.O.C, DU	-	± 1%	120
Aerosol Block	GRIMM	D_p, micrometer (31			
	Model 1.109	channel)	0,25…32	-	
		N, cm $^{-3}$	0…2000	± 3%	6
	Diffusive	D_p, nm (20 channels)	3…200	-	
	aerosol spectrometer	N, cm $^{-3}$	0…500000	± 10%	80

2.2 Analyzing air masses

We used a new approach to the analysis of changes in air masses (respectively, advection of warm and cold air, the passage of fronts). For the analysis we used maps of the potential temperature at the dynamic tropopause (PV-θ) for 6 UTC. It is known that for a number of reasons [Masato] PV-θ is the best indicator of air masses possessing different properties. Low PV-θ values correspond to Arctic and polar air masses (dark blue in Fig. 1.), high values - tropical and subtropical (red in Fig. 1.).

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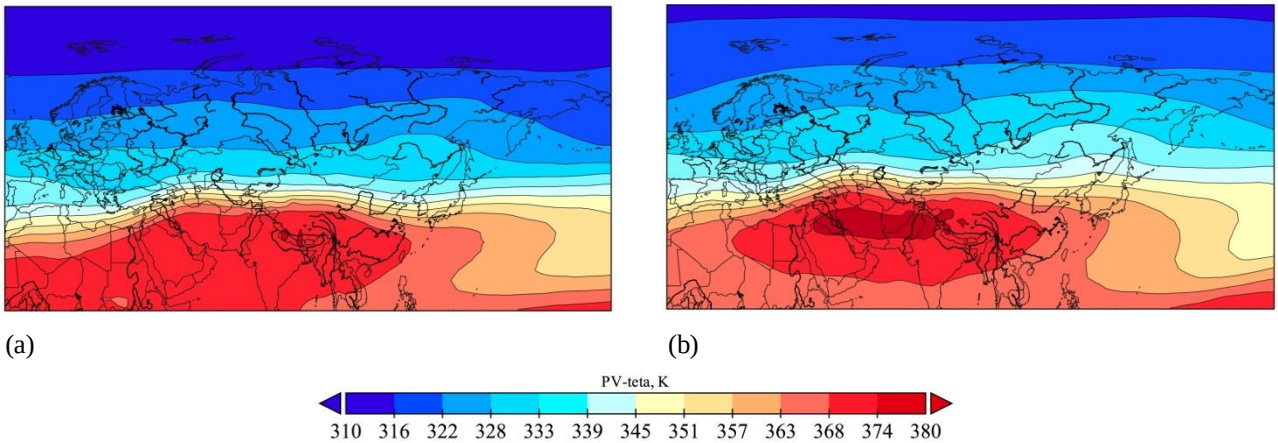

Figure 1. Average monthly PV -θ (K) in June (a) and July (b) (1979-2018).

For analysis, we investigated PV-θ anomalies, for each day from June 1 to August 31, 1993-2018 relative to their average seasonal value in these months (separately June, July, August). We selected the events when the difference in the anomalies of PV-θ adjacent days was of the order of 20-30 Kelvin. Maps of anomalies in neighboring days and the date of the change is given in section 3 on the results. The chemical composition was considered three days before and two days after the date of change of air masses. Table 2 is composed for all dates. This table shows the gradients and daily rate of change for temperature, aerosol and gas concentrations. For example, CO_2 concentration mainly increases. It should be noted that abnormally high concentrations of CO_2 in 2010 are associated with a blocking anticyclone, which led to a large number of fires this year. The concentration of carbon monoxide can both increase and decrease. But the number of cases, when CO increases, slightly more than when decreases. The distribution of SO_2 is quite complex. In some cases, the peak concentration of SO_2 occurs at the time of change of air mass. The concentration of O_3 and aerosol decreases in all cases.

Table 2. Gradients and daily rate of changes in T; aerosol, O3, CO2, CO, SO2 concentrations.

dd/mm/y	ΔT °C	V °C/d	ΔO_3,	V O_3	Δa025	V a025	ΔCO_2	V CO_2	ΔCO	V CO	ΔSO_2	V SO_2
1	2	3	4	5	6	7	8	9	10	11	12	13
26-28/07/ 1993	12	-4	100	-33.3	-	-	-	-	0.6412	0.2137	-	-
29-30/08/ 1993	13	-6.5	44	-22	-	-	-	-	1.9775	0.9887	-	-
01-02/07/ 1994	16	-8	54	-27	-	-	-	-	-	-	-	-
07-09/06/ 1994	17	-5.5	42	-14	-	-	-	-	-	-	-	-
14-16/08/ 1994	12	-4	41	-13.6	-	-	-	-	-	-	-	-
10-12/06/ 1996	12	-4	60	-20	-	-	-	-	-	-	-	-
23-26/06/ 1996	11	-5.5	80	-40	-	-	-	-	-	-	-	-
08-09/06/ 1997	18	-9	-	-	-	-	-	-	0.0206	0.0103	-	-
29-30/06/ 1997	11	-5.5	106	-53	-	-	-	-	-	-	-	-
05-07/07/ 1997	13	-4.3	60	-20	-	-	-	-	-	-	-	-
16-19/07/ 1997	14	-4.6	69	-23	-	-	-	-	-	-	-	

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1	2	3	4	5	6	7	8	9	10	11	12	13
08-10/08/ 1997	19	-6.3	95	-31.6	-	-	-	-	-	-	-	-
17-20/08/ 1997	14	-3.5	18	-4.5	-	-	-	-	-	-	-	-
02-03/06/ 1998	18	-9	37	-18.5	-	-	-	-	0.115	-0.0575	-	-
08-10/06/ 1998	11	-3.6	23	-7.6	-	-	-	-	0.0055	0.0018	-	-
16-17/08/ 1998	14	-7	12	-6	-	-	-	-	0.1033	-0.516	-	-
08-10/06/ 1999	19	- 6.33	28	-9.3	-	-	-	-	0.0387	-0.0129	-	-
15-17/06/ 1999	12	-4	39	-13	-	-	-	-	0.0826	-0.0275	-	-
07-08/07/ 2000	14	-7	64	-32	-	-	-	-	-	-	-	-
01-02/06/ 2001	12	-6	126	-63	-	-	-	-	0.0029	-0.0014	-	-
28/06- 01/07/2001	15	-3.7	54	-13.6	-	-	-	-	-	-	-	-
18-21/08/ 2001	10	-2.5	178	-44.5	-	-	-	-	0.0327	-0.0081	-	-
11-12/08/ 2002	14	-7	94	-47	-	-	-	-	0.0254	-0.0127	-	-
20-23/08/ 2002	14	-3.5	29	-7.2	-	-	-	-	0.0618	-0.0154	-	-
07-08/06/ 2003	13	-6.5	39	-19.5	-	-	-	-	0.0123	-0.0061	-	-
16-18/06/ 2003	10	-3.3	9	-3	-	-	-	-	0.0469	0.0156	-	-
08-11/07/ 2003	18	-4.5	100	-25	-	-	-	-	0.0952	-0.0238	-	-
22-23/07/ 2003	12	-6	61	-30.5	-	-	-	-	0.0016	-0.0008	-	-
31/07- 02/08/ 2003	12	-4	35	-11.6	-	-	-	-	0.0637	0.0159	-	-
05-08/06/ 2004	14	-3.5	37	-9.2	-	-	-	-	0.0085	-0.0021	-	-
22-24/08/ 2005	17	-5.6	43	-14.3	-	-	-	-	0.0103	0.0034	-	-
12-14/06/ 2006	14	-4.6	37	-12.3	-	-	-	-	0.099	0.033	-	-
04-06/07/ 2006	17	-5.6	45	-15	-	-	-	-	0.0215	-0.0071	-	-
23-24/07/ 2006	13	-6.5	48	-24	-	-	-	-	0.0044	-0.0022	-	-
14-15/08/ 2006	10	-5	66	-33	-	-	-	-	0.0039	-0.0019	-	-
24-26/06/ 2007	14	-4,6	46	-15.3	-	-	-	-	0.0056	0.0018	-	-
03-06/06/ 2008	13	-3.2	56	-14	-	-	-	-	0.0441	-0.011	-	-
22-24/06/ 2008	10	-2.3	35	-11.6	-	-	-	-	0.0325	0.2006	-	-
22-23/07/ 2008	10	-5	8	-4	-	-	-	-	0.053	0.0265	-	-

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1	2	3	4	5	6	7	8	9	10	11	12	13
10-11/08/ 2008	11	-5.6	32	-16	-	-	-	-	0.0615	-0.0307	-	-
15-18/08/ 2008	12	-3	62	-15.5	-	-	-	-	0.0933	0.233	-	-
10-13/06/ 2009	16	-4	88	-22	-	-	-	-	0.0188	-0.0047	-	-
11-12/06/ 2010	12	-6	35	-11.6	90307	30102.5	5.754	2.877	0.0872	0.0436	-	-
20-22/06/ 2010	21	-7	91	-30.3	66268	22089.5	15.062	5.020	0.0766	0.0255	-	-
17-20/07/ 2010	12	-3	110	-27.5	163001	40750.3	22.985	7.661	0.0501	-0.0125	-	-
22-24/08/ 2010	13	-4.3	56	-18.6	-	-	13.737	4.579	0.0422	0.0140	-	-
01-02/07/ 2011	12	-6	57	-28.5	189692	94846	-	-	0.0229	0.0114	0.8943	-0.4471
03-05/08/ 2011	12	-4	41	-13.6	125557	41852.3	5.813	1.937	0.016	-0.0053	10.7569	-3.5856
31/07- 03/08/ 2012	13	-3.25	58	-19.3	327641	81910.2	-	-	1.1389	0.2847	-	-
15-16/06/ 2013	15	-7.5	21	-10.5	74983	37491.6	-	-	0.1111	0.0111	0.0555	0.1315
07-08/07/ 2013	12	-6	30	-15	221943	110971.8	0.638	-0.319	0.0889	0.0444	0.9706	-0.4853
30-31/08/ 2013	12	-6	29	-14,5	90418	30139.3	1.293	-0.646	0.0843	0.0421	2.2961	1.1480
25-27/08/ 2014	17	-5.6	56	-18.6	88316	29438.7	-	-	0.0175	0.058	1.1746	-0.3915
7-10 /06/ 2015	16	-4	18	-4.5	110290	27572.6	4.518	1.129	0.2862	0.0715	1.404	±0.351
03-05/07/ 2015	21	-4.2	43	-14.3	274345	91448	-	-	0.2385	-0.0795	2.9954	±0.9984
19-22/08/ 2015	18	-4.5	53	-13.25	25805	6451.3	6.778	1.694	0.0918	0.0226	2.8989	±0.7247
05-08/08/ 2017	12	-3	44	-11	136943	34235.7	-	-	0.0261	0.0652	11.6154	-2.9038
2-4/07/2018	14	-4.6	43	-14.3	74734	24911.3	-	-	0.0346	0.0115	0.5463	±0.1821

3. RESULTS

As a result of this work, on the basis of TOR station data, changes in the concentrations of O_3, CO_2, CO, SO_2 and aerosol during the passage of polar air masses were investigated. The dates presented in Table 2 are selected as the events of a sharp change in air masses. A certain correlation of the concentration of some gases from the temperature was revealed. The higher the rate of daily temperature change, the higher the rate of change in O_3 concentration, while the concentration decreases. For CO_2, the situation is less straightforward, as the summer CO_2 concentration is influenced by vegetation activity and fire conditions. However, it should be noted that carbon dioxide is characterized by a reverse gradient with respect to ozone. For carbon monoxide, as well as for sulfur dioxide, the temperature dependence could not be detected. In 25 cases, out of 46, the concentration of CO increases, and in 21 cases – decreases with the change of air mass. From a number of observations (11 cases) for SO_2, 5 cases were revealed when its concentration decreases, 2 cases when it increases and 4 cases when the concentration has an indefinite course. For a good example, in Figure 2, presents the cases of polar intrusion: June 8-10, 2015 July 3-5, 2015, July 2-4, 2018.

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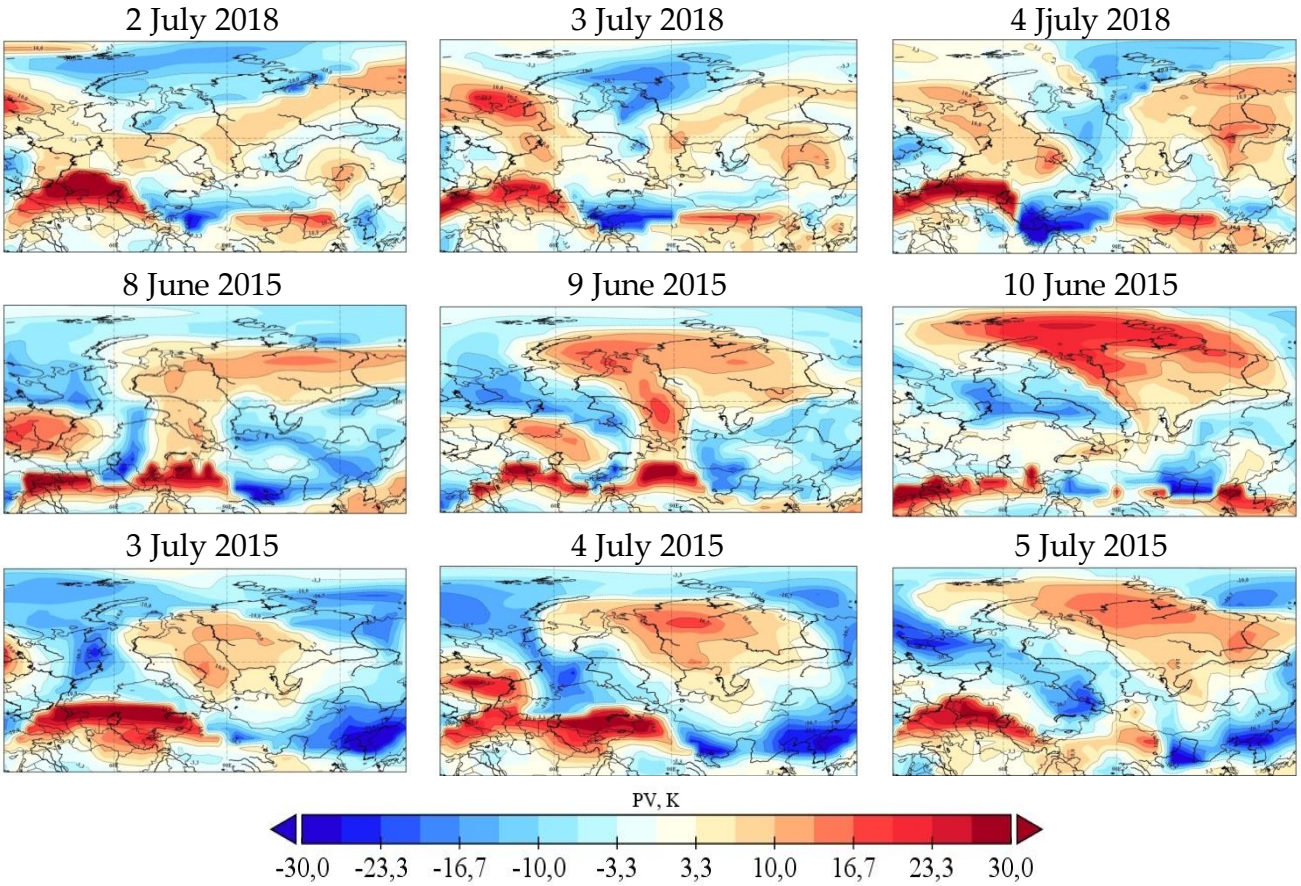

Figure 2. Maps of anomalies of PV-θ (K) for 8-10 June 2015, 3-5 July 2015, 2-4 July 2018.

4. CONCLUSION

Based on the results obtained, it can be concluded that in the summer, polar intrusion have a significant impact not only on the change in the concentrations of aerosol and gas components, but also on the rate of its change. The distribution of SO_2 and CO requires further investigation. Also, sudden changes in temperature can, including cause the rate of transformation of the studied gases into other compounds, which can often have more aggressive chemical properties.

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REFERENCES

[1] Arshinova, V. G., Belan, B. D., Rasskazchikova, T. M., Rogov, A. N. and Tolmachev, G. N., "Variation of the ozone concentration in the ground atmospheric layer by the passage of atmospheric fronts," Atmospheric and oceanic optics 8 (4), 326-328 (1995).

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[2] Arshinova, V. G., Belan, B. D., Vorontsova, E. V., Zadde, G. O., Rasskazchikova, T. M., Sem'yanova O.I. and Sklyadneva, T. K., "Dynamics of aerosol variations during passage of atmospheric fronts," Atmospheric and oceanic optics 10 (7), 507-511 (1997).

[3] Kabanov, D. M., Kurbangaliev, T. R., Rasskazchikova, T. M., Sakerin, S. M. and Khutorova, O. G., "The Influence of Synoptic Factors on Variations of Atmospheric Aerosol Optical Depth under Siberian Conditions," Atmospheric and oceanic optics 24 (6), 543–553 (2011).

[4] Antokhin, P. N., Arshinov, M. Yu., Arshinova, V. G., Belan, B. D., Davydov, D. K., Rasskazchikova, T. M., Fofanov, V. A., Inoue, G., Machida, T., Shimoyama, Ko. and Maksutov, Sh. Sh., "CO_2 concentration variation above the West Siberia area in different seasons during passes of atmospheric fronts," Optika Atmosfery i Okeana 26(1), 24-31 (2013).

[5] Antokhina, O. Yu., Antokhina, P. N., Arshinova, V. G., Arshinov, M. Yu., Belan, B. D., Belan, S. B., Davydov, D. K., Dudorova, N. V., Ivlev, G. A., Kozlov, A. V., Rasskazchikova, T. M., Savkin, E. D., Simonenkov, D. V., Sklyadneva, T. K., Tolmachev, G. N. and Fofonov, A.V., "Study of the composition of air masses of different types," Atmospheric and oceanic optics 32 (1), 72-79 (2019).

[6] Isakov, A. A. and Tikhonov, A. V., "Relationship between aerosol parameters in Central Russia with air masses," Optika Atmosfery i Okeana 27 (3), 192-196 (2014).

[7] Methven, J., Evans, M., Simmonds, P. and Spain, G., "Estimating relationships between air mass origin and chemical composition," Journal of Geophysical Research: Atmospheres 106(D5), 5005–5019 (2001).

[8] Davydov, D. K., Belan, B. D., Antokhin, P. N., Antokhina O. Yu., Antonovich, V. V., Arshinova, V. G., Arshinov, M. Yu., Ahlestin, A. Yu., Belan, S. B., Dudorova, N. V., Ivlev, G. A., Kozlov, A.V., Pestunov, D. A., Rasskazchikova, T. M., Savkin, E. D., Simonenkov, D. V., Sklyadneva, T. K., Tolmachev, G. N., Fazliev, A. Z. and Fofonov, A.V., "Monitoring of Atmospheric Parameters: 25 Years of the Tropospheric Ozone Research Station of the Institute of Atmospheric Optics, Siberian Branch, Russian Academy of Sciences," Atmospheric and Oceanic Optics 32 (2), 180-192 (2019).

[9] Li, J. and Ruan, C., "The North Atlantic–Eurasian teleconnection in summer and its effects on Eurasian climates," Environmental Research Letters 13 (2), 024007 (2018).

[10] Coumou, D., Capua, G. D., Vavrus, S., Wang, L. and Wang, S., "The influence of Arctic amplification on mid-latitude summer circulation," Nature Communications 9(1) (2018).

[11] Masato, G., Hoskins, B. J. and Woollings, T. J., "Wave-breaking characteristics of midlatitude blocking," Quarterly Journal of the Royal Meteorological Society 138(666), 1285–1296 (2011).

[12] Palmén, E. H. and Newton, C. W., "Atmospheric circulation systems: their structure and physical interpretation," Acad. Press (1991).

[13] Pelly, J. L. and Hoskins, B. J., "A New Perspective on Blocking," Journal of the Atmospheric Sciences 60(5), 743–755 (2003).

[14] Dee, D. P., Uppala, S. M., Simmons, A. J., Berrisford, P., Poli, P., Kobayashi, S., Andrae, U., Balmaseda, M. A., Balsamo, G., etc., "The ERA-Interim reanalysis: configuration and performance of the data assimilation system," Quarterly Journal of the Royal Meteorological Society 137(656), 553–597 (2011).

[15] Hoskins, B. J., "Towards a PV-θ view of the general circulation," Tellus B: Chemical and Physical Meteorology 43(4), 27–35 (1991).

[16] Andronova, A.V., Granberg, I. G., Gubanova, D. P., etc., "The results of measurements of surface ozone on the Spitsbergen Archipelago in 2005-2006 are presented. The seasonal ozone variation shows a pronounced maximum of monthly mean values in late spring (April-May) and a minimum in summer (July-August). T.," Atmospheric and oceanic optics 20(10), 831-836 (2007).

[17] Vinogradova, A. A. and Ponomareva, T. Ya., "Cleaning of the Arctic atmosphere by air transport of pollutants into the midlatitudes.," Atmospheric and oceanic optics 14 (6-7), 458-462 (2001).

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[18] Vinogradova, A. A. and Ponomareva, T. Ta., "Sources and sinks of anthropogenic microelements in the Arctic atmosphere: tendencies in variations from 1981 to 2005," Atmospheric and oceanic optics 20 (6), 433-441 (2007).

[19] Vinogradova, A. A., Shevchenko, V. P., Ponomareva, T. Ta. and Kluvitkin, A. A., "Contribution of atmospheric aerosol to water pollution of the Laptev Sea," Atmospheric and oceanic optics 15 (5-6), 391-396 (2002).

[20] Vinogradova, A. A., Shevchenko, V. P., Ponomareva, T. Ta. and Kluvitkin, A. A., "Anomalies of trace gases in air of the European part of Russia and Ukraine in summer, 2010," Atmospheric and oceanic optics 16 (5-6), 391-395 (2003).

[21] Elansky, N. F., Mokhov, I. I., Belikov, I. B., etc., "Gas impurities in the atmosphere over Moscow in the summer of 2010,"Physics of atmosphere and ocean 47 (6), 729-738 (2011).

[22] Zvyagintsev, A. M., Blyum, O. B., Glazkov, A. A., etc., "The anomalies of concentrations of minor gas constituents in the air of the European part of Russia and Ukraine in the summer of 2010," Optika Atmosfery i Okeana 24 (7), 582-588 (2011).

[23] Zvyagintsev, A. M., Kachaganova, G. and Tarasova, O. A., "The influence of the directions of transport of air masses on the seasonal cycle of the concentrations of minor gas atmospheric components in Europe," Russian Meteorology and hydrology 7, 18-28 (2010).

[24] Shevchenko, V. P., Lisitsin, A. P., Vinogradova, A. A., Smirnov, V. V., Serova, V. V. and Stein, R., "Arctic aerosols. Results of ten-year investigations," Atmospheric and oceanic optics 13 (6-7), 510-533 (2000).

[25] Agel, L., Lopez, V., Barlow, M. and Colby, F., "Regional and Large-scale Influences on Summer Ozone Levels in Southern California," J. Appl. Meteor. Climatol. 50, 800–805 (2011).

[26] Barkan, J., Alpert, P., Kutiel, H. and Kishcha, P., "Synoptic of dust transportation days from Africa toward Italy and central Europe," J. Geophys. Res.110 (D07208), 10.1029/2004JD005222 (2005).

[27] Benson, D. R., Young, L.-H., Lee, S.-H., et. al., "The effects of air mass history on new particle formation in the free troposphere: case studies," Atmos. Chem. Phys. 8 (12), 3015-3024 (2008).

[28] Chen, Z. H., Cheng, S. Y., Li, J. B. et. al. "Relationship between atmospheric pollution processes and synoptic pressure patterns in northern China," Atmos. Environ. 42 (24), 6078-6087 (2008).

[29] De Reus, M., Fischer, H., Arnold, F,. et.al., "On the relationship between acetone and carbon monoxide in different air masses," Atmos. Chem. Phys.3 (5), 1709-1723 (2003).

[30] Demuzere, M., Trigo, R. M., Vila-Guerau de Arellano, J. and van Lipzig, N. P. M., "The impact of weather and atmospheric circulation on O_3 and PM10 levels at a rural mid-latitude site," Atmos. Chem. Phys. 9, 2695-2714 (2009).

[31] Dharshana, T., Kravtsov, S. and Kahl, J., "Relationship between synoptic weather disturbances and particulate matter air pollution over the United States," J. Geoph. Res. 115, D24 (2010).

[32] Diem, E. J., Hurse,y M. A., Morris, I. R., Murray, A. C. and Rodriguez, R. A., "Upper-Level Atmospheric Circulation Patterns and Ground-Level Ozone in the Atlanta Metropolitan Area," J. Appl. Meteor. Climatol. 49, 2185–2196 (2010).

[33] Estelles, V., Martinez-Lozano, J. A. and Utrillas, M. P., "Influence of air mass history on the columnar aerosol properties at Valencia, Spain," J. Geophys.Res.112 (D15211), 10.1029/2007JD008593 (2007).

[34] Fleming, Z. L., Monks, P. S. and Manning, A. J., "Review: Untangling the influence of air-mass history in interpreting observed atmospheric composition," Atm. Res. 104–105, 1-39 (2012).

[35] Flocas, H., Kelessis, A., Helmis, C., Petrakakis, M., Zoumakis, M. and Pappas, K., "Synoptic and local scale atmospheric circulation associated with air pollution episodes in an urban Mediterranean area," Theor. and Appl. Clim. 95 (3-4), 265-277 (2009).

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[36] Freitag, S., Clarke, A. D., Howell, S. G., Kapustin, V. N., Campos, T., Brekhovskikh, V. L. and Zhou, J., "Combining airborne gas and aerosol measurements with HYSPLIT: a visualization tool for simultaneous evaluation of air mass history and back trajectory consistency," Atmos. Meas. Tech. 7, 107-128 (2014).

[37] Gangoiti, G., et al., "Regional transport of pollutants over the Bay of Biscay: analysis of an ozone episode under a blocking anticyclone in west-central Europe," Atmos. Environ. 36 (8), 1349-1361 (2002).

[38] Greene, J.S., Kalkstein, L.S., Ye, H. and Smoyer, K., "Relationships between synoptic climatology and atmospheric pollution at 4 US cities," Theor. Appl. Climatol. 62 (3-4), 163-174 (1999).

[39] Heinesch, B., Yernaux, Y. and Aubinet, M., "Dependence of CO_2 advection patterns on wind direction on a gentle forested slope," Biogeosciences 5 (3), 657-668 (2008).

[40] Jaegle, L., Jaffe, D.A., Price, H.U., et.al., "Sources and budgets for CO and O_3 in the northeastern Pacific during the spring of 2001: Results from the PHOBEA-11 Experiment,"J. Geophys.Res. 108 (D20), 8802 (2008), doi:10.1029/2002JD003121, 2003.

[41] Kim Oanh, N.T., Chufimon, P., Ekbordin, W. and Supat, W., "Meteorological pattern classification and application for forecasting air pollution episode potential in a mountain-valley area," Atmos. Environ. 39 (7), 1211-1225 (2005).

[42] Lam, K.-C. and Cheng, S., "A synoptic climatological approach to forecast concentrations of sulfur dioxide and nitrogen oxides in Hong Kong," Environ. Pollut.101 (2), 183-191 (1998).

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