OBJECTIVE CLASSIFICATION OF THE ATMOSPHERIC CIRCULATION FORMS, THEIR VARIABILITY AND VARIETY ABOVE THE AREAS OF EAST SIBERIA, FAR EAST AND NORTH WEST PACIFIC

Zhuravleva T.M., Man'ko A.N.

Far Eastern Regional Hydrometeorological Research Institute, Vladivostok, Russia

It is well known that the atmospheric circulation plays an essential role in the formation and change of the climate. For estimation of the atmospheric circulation, in meteorology there exist different methods to make standardization of the atmospheric processes, quantitative indexes and *etc*. Revealing of the typical situations out of different scale movements is a very difficult problem. Therefore, it has mainly been, considered till now, visually (Iliinsky, 1965; Kalachikova & Nikolaeva, 1985; Svinuhova, 1988), in spite of many automatic methods being suggested including the objective criteria of similarity. At present in meteorology of a great interest are the objective standardization and classification of the atmospheric processes related to using in practice statistical and numerical forecasting models as well as up-to-date computer technologies (Kozulin & Reitenbach, 1984; Zhuravleva, 1990).

For the Far Eastern Region in 1965 O.K. Iliinsky (1965) suggested 5 basic forms of circulation and 24 of their variations in the fields of H_{500}. In this case standardization has been produced by means of the visual comparison of the fields taking into account given pictures, however, different intermediate forms of the fields have not been considered. Resulted on the data of 1954-57, it seemed not to be complete for the next off years. O.K. Iliinsky had also some difficulties with insufficient types suggested by him. Later calendar of Iliinsky's forms has been subjectively compiled by different specialists, since 1986 it hasn't been added. In spite of this fact, it has been successfully applied to solve the diagnostic and prognostic problems for the Far Eastern Region. Need to make estimation of the atmospheric circulation state at the level of H_{500} and usage of it in the investigation and prognostic practice takes place not only in the Far East but in the whole second natural synoptic area (2 n.s.a.), that covers Eastern Siberia, Far East and N-W Pacific.

For automated classification in meteorology of the fields different algorithms are being suggested. They allow us to solve problem both by known parameters in advance and unknown ones. The second variant of standardization requires an additional synoptic interpretation and standard statistical analysis.

Prior 1964-84 the authors of the present paper suggested the objective standardization "with a tutor" of daily H_{500} fields for the whole 2 n.s.a. (Zhuravleva & Zhukov, 1989; Zhuravleva & Man'ko, 1990). Iliinsky's circulation forms were used as "tutor" and 2 new forms were suggested by the authors. The objective calendar for 9 types of circulation has been obtained. This type of standardization, taking into account, improved quality of the statistical model to recover data in the fields of H_{500} and P_0 (Zhuravleva, 1990). However, for diagnostic and prognostic purposes the types suggested are insufficient. The fields selected to one type by automated classification, to a forecaster's mind, can be distinguished by a character of the synoptic processes.

The present work has a task to create an objective standardization of H_{500} fields and to obtain calendar that covers the statistical and synoptic approaches. Above all, the calendar should be satisfied and suitable to solve the synoptic problems and include information both on the basic circulation forms and a lot of their variations. As the case may be, a researcher should take information required from the calendar.

The main idea lies in that a large number of fields has to be divided into local types characterized by the field homogeneity and further, on the bases of the field character analysis to group them in larger ones showing the existent understanding of the atmospheric circulation types at the level of H_{500}. The present work, mainly, is a continuation of the studies prior produced by the authors on the standardization.

It should be noted that J. Wangengeim (1935) chose the same way and in 1932-35 he established his own standardization of the synoptic processes near the Earth surface within the limits of the Atlantic-Euroasiatic sector in the northern Hemisphere, all variety of processes observed on the assembly

kinematic maps for 42 years, he presented as 26 types of elementary – synoptic periods. Further, in the early 1940^{s} (Girs, 1974) he generalized them in 3 well known atmospheric circulation types: western, eastern and meridional. With the help of 26 varieties continuously occurring processes over this area firstly to be broken down, then as directed each elementary-synoptic period should be related to one or another type.

To reveal the typical fields in this paper as an initial data were taken the file of daily H_{500} meanings available at FERHRI in the nodes of regular net with 5° step across latitude and 10° along longitude for the period from 1964 to 1990 (about 10 thousand fields calculations have been carried out for 2 n.s.a), that covers the space from 80°E to 160°W and from 30° to 70°N, in total, 117 nodes.

The estimation comparison of the field H_{500} standardization fulfilled by the authors taking into account the different closeness between the objects showed the better results applying Euclid's distance (Zhuravleva, 1990; Zhuravleva & Man'ko, 1999). Therefore, to solve the task we used that metric.

The temporal H_{500} variability analysis vividly shows in the nodes of the net a presence of the seasonal peculiarities. They are observed both in H_{500} change during the year and in the field character: in summer period the field of H_{500} moves smoothly if compared with the cold period. As we are interested in the typical fields from the point of view of the atmospheric circulation character it was decided in making calculations of the closeness fields to use not H_{500} values but their anomalies. Under the anomalies in this case we understand the difference between the value of H_{500} in a node and an average value for the given estimation field.

It is necessary to remind that the task has been put so that all variety of the field occurred to divide into local types characterized by the field homogeneity. At such statement of the problem there was no any limitation to make selection of a number of the typical H_{500} fields. The calculations have been produced step-by-step, using the following scheme. Making selection of the first types, we have used the fields showing the most vividly the circulation character in accordance with Iliinsky's standardization. Further, the fields were visually selected as standards that were different from having been already chosen. All fields referred to the definite type were ranged by a value of distance (spacing interval) from the standard chosen. Subsequently, visually examining them, the maximal (critical) interval was chosen at which the field character taking into account the atmospheric circulation peculiarities is homogeneous. Standardization has been carried out as long as all fields obtained from the file not to be determined to this or that type.

In total, it was selected 182 varieties of the typical situation of the atmospheric circulation at the level of H_{500} observed in 2 n.s.a. At the next stage they were grouped in 33 subtypes and in 11 macro-types. They cover all basic forms by Iliinsky. Their names were also used the same. The scheme selected can be considered as standardization "with a tutor".

First of all, zonal and meridional circulation state at the average level of troposphere (macro-types) are revealed. In turn, each of macro-types was divided into subtypes. Inside subtypes smaller versions taking into account the local baric field features are also determined.

To meridional processes are referred 8 macro-types: western (W) with three subtypes and 14 varieties, central (C) with three subtypes and 17 varieties, eastern (E) with three subtypes and 24 varieties, mixed (M) with four subtypes and 32 varieties, "running crest" (RC) with two subtypes and 14 varieties, "running trough" (RT) with three subtypes and 9 varieties, combined meridional (CM) with five subtypes and 24 varieties. The zone condition of circulation is characterized by 2 macro-types: combined latitude (CL) with three subtypes and 12 varieties and latitude (L) with five subtypes and 28 varieties. The indefinite condition of circulation are referred to 2 types: type of 1st kind (I1) with 4 varieties and type of 2nd kind (I2) with 4 varieties.

Thus, the aim has been obtained. Now we can select from calendar both the largest forms and their varieties detailed for special areas depending on the aims put by the Researchers.

Unfortunately, we have no possibility to describe each variety selected by us. We are going to show some of them firstly suggested in this paper that are the most complex ones of zonal and meridional macro-types.

Fig. 1 demonstrates the typical fields of H_{500} varieties of meridional type "running crest" (RC) and of meridional type "running through" (RT). Fig. 2 demonstrates the typical fields of H_{500} varieties of complex latitude type (CL) and complex meridional type (CM). These fields are difficult to classify because of some uncertainty in the character of circulation. The first field is more meridional and second - zonal. For this reason they are revealed in special combined macro-types. Such standard situations are

numerous enough, our standardization shows it. In Fig. 3 are shown typical situations in the field of H_{500}, having the same names, as in the previous Iliinsky's work (1965) and the authors Zhuravleva & Man'ko (1990). There are fields of 4 macro-types: western (a), central (b), east (c), mixed (d) and 2 indefinite situations of the 1st (e) and 2nd (f) kinds.

In Fig. 4 are shown the typical fields for five subtypes of latitudinal macro-type distinguished by a quantity and location of altitude frontal zones (AFZ) within the 2 n.s.a.: a – one AFZ in moderate latitudes; b – two AFZ two in moderate and southern; c – two AFZ in northern and southern; d – two AFZ in moderate and northern; e – tree AFZ in northern, moderate and southern. In spite of the fact that in all shown cases the zonal condition of circulation takes place, the weather over the territory of them will essentially to different. It is necessary to note, that latitudinal subtype of Iliinsky, when only one AFZ takes place to the south 40°N by the data of the present work for the period 1964-90 has never been observed. However, in the future, using the given objective technology in the operative practice on conducting a calendar of the types circulation mention subtype should be taken into account.

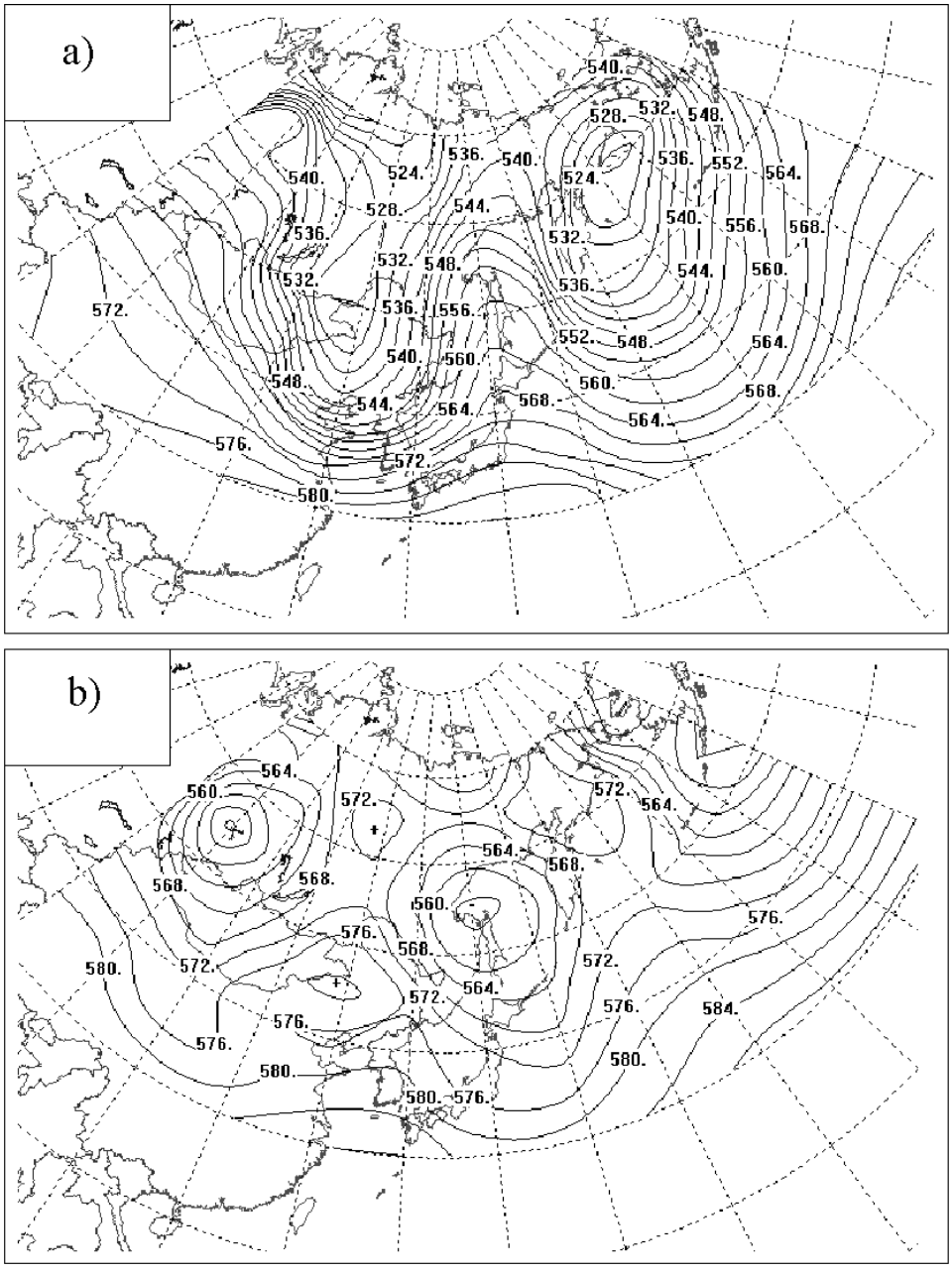

Fig. 1. Example of the subtype of the macro-type "running crest" (RC) – (a) and the subtype of the macro-type "running through" (RT) – (b)

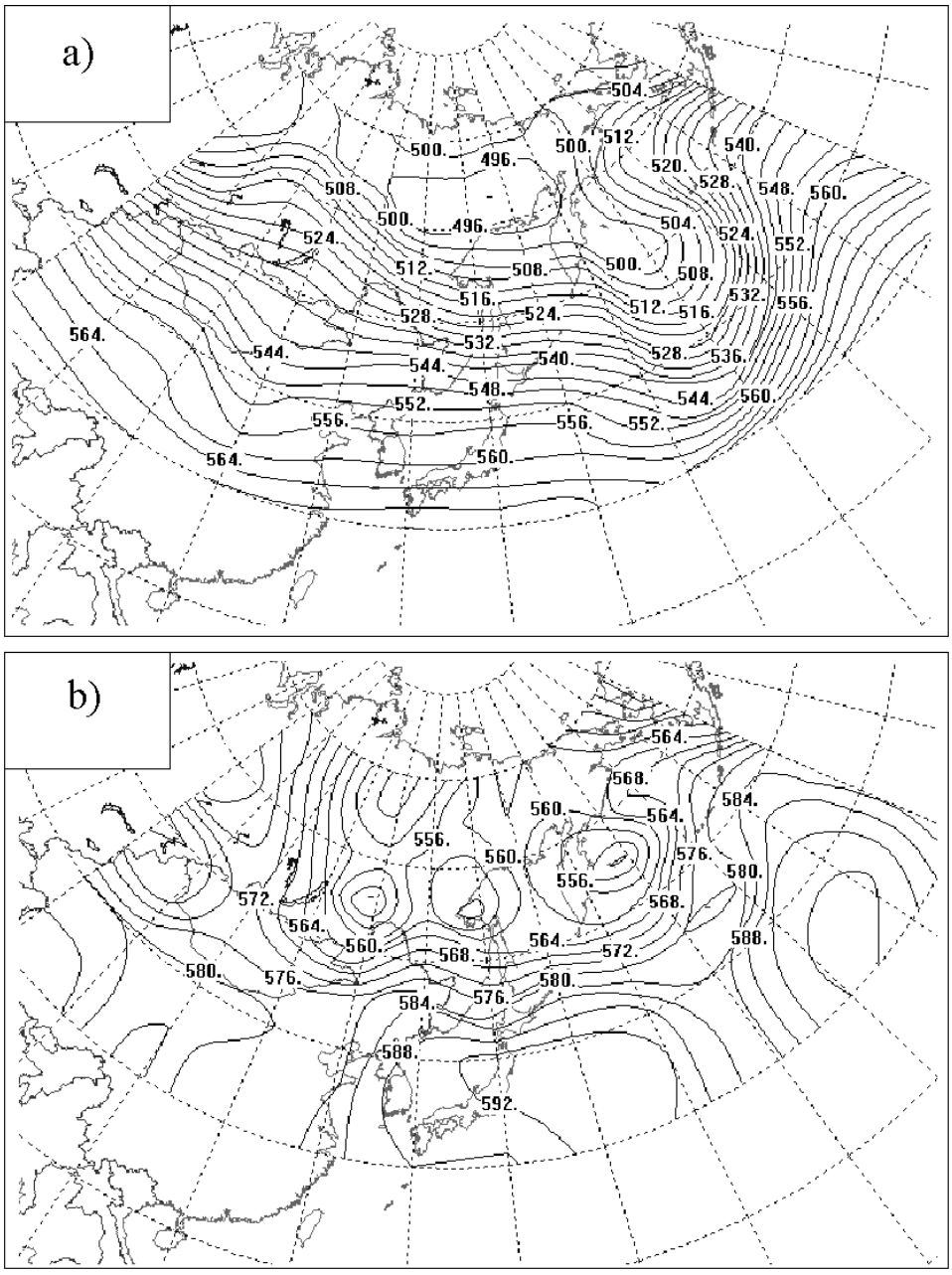

Fig. 2. Example of the subtype of the macro-type "complex latitude" (CL) – (a) and the subtype of the macro-type "complex meridional" (CM) – (b)

By the data of the calendar compiled we can make some conclusions regarding the frequency of the types, their duration, succession and so on. Here only briefly we shall tell about some.

The analysis of Table 1 showed that in the multi-year average (1964-90) over 2 n.s.a. the meridional processes (W, C, E, M, RC, RT, CM) prevailed (69.3%). The forms C, E and M are very often met (respectively, 12.8, 12.5, 12.6%). It is very frequent situations with the fast waves RC and RT. In total they are 12.3% frequency (8.0 and 4.3% respectively). Variety of the meridional forms collected in so called combined meridional macro-type CM is observed in 10.8% examples.

The only latitude processes L happen in 21.1% examples and together with the combined latitude forms their CL their frequency is 27.0%. If we refer the form I1 to this case, then the frequency of zonal but not pronounced the atmosphere state at the level of H_{500} will be 30.5%. It should be noted that in A. Kalendov's paper (1988) we found the identical conclusions made by him in the period from 1954 to 1981 regarding the meridional forms prevailing if compared with the latitude ones on same proportions, though the sampling used by us has been shifted by one decade and covers the whole 2 n.s.a.

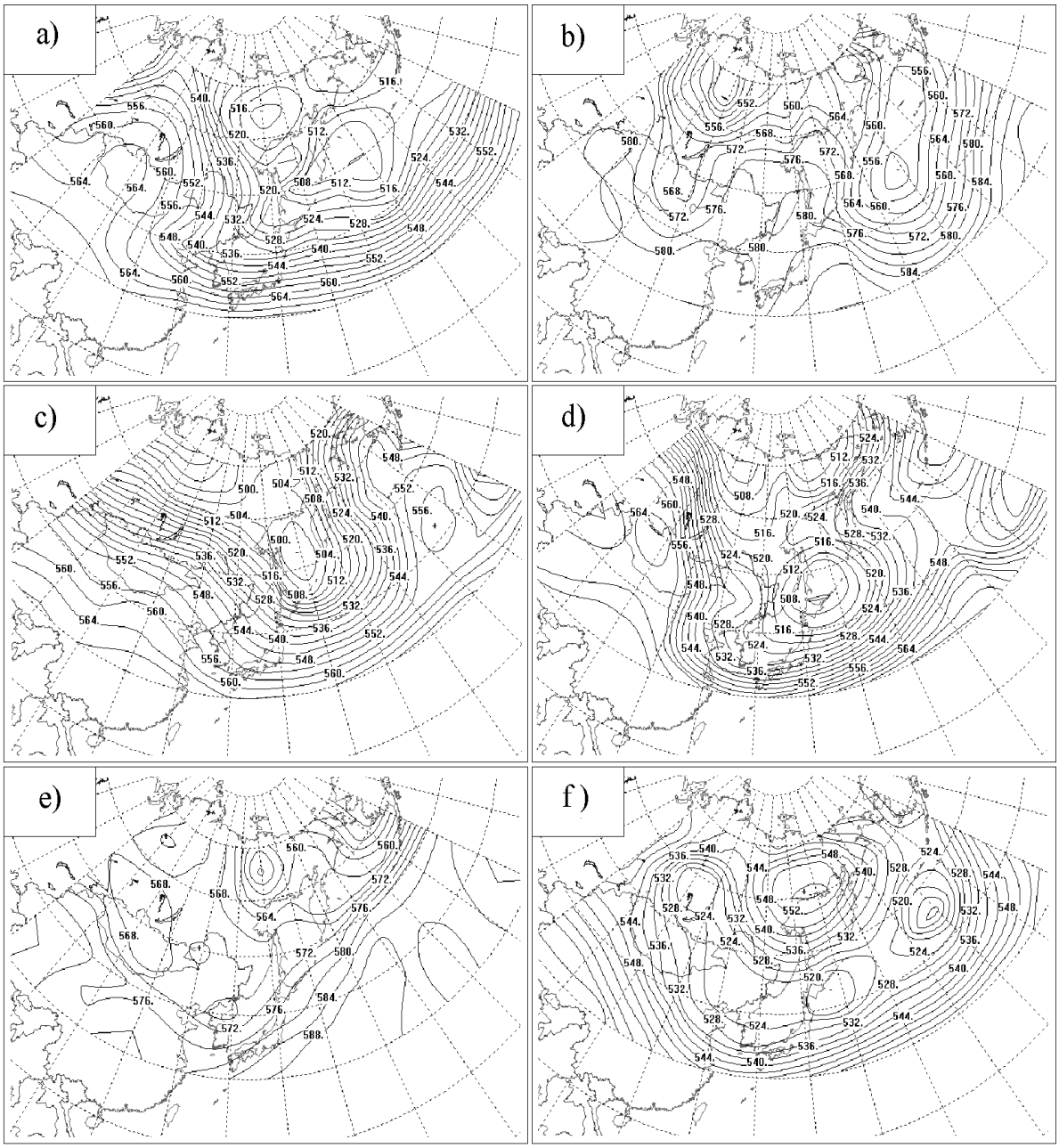

Fig. 3. Example of the subtype of the macro-types "western" (W) – (a), "central" (C) – (b), "eastern" (E) – (c), "mixed" (M) – (d), "1st indefinite type" (I1) – (e) and "2nd indefinite type" (I2) – (f)

In warm period of the year from April to October and even in November the zonal processes (type L) with maximum in April-May (synoptic spring in 2 n.s.a.) and in August-October (autumn and before winter) notably dominate. In the height of a summer (June, July) the central form meridional circulation C dominates.

In cold period of the year the meridional forms showed to be considered the most active in 2 n.s.a. firstly, such as mixed C (12.6%), eastern E (12.5%) and combined CM (10.8%), having maximum of recurrences in the two winter seasons: first half of winter (December-January) and second half of winter (February-March).

It has been revealed that each macro-type has its own subtypes and varieties manifesting in a different way in the definite period of the year. By virtue of limitation of a space we do not stop on these interesting details.

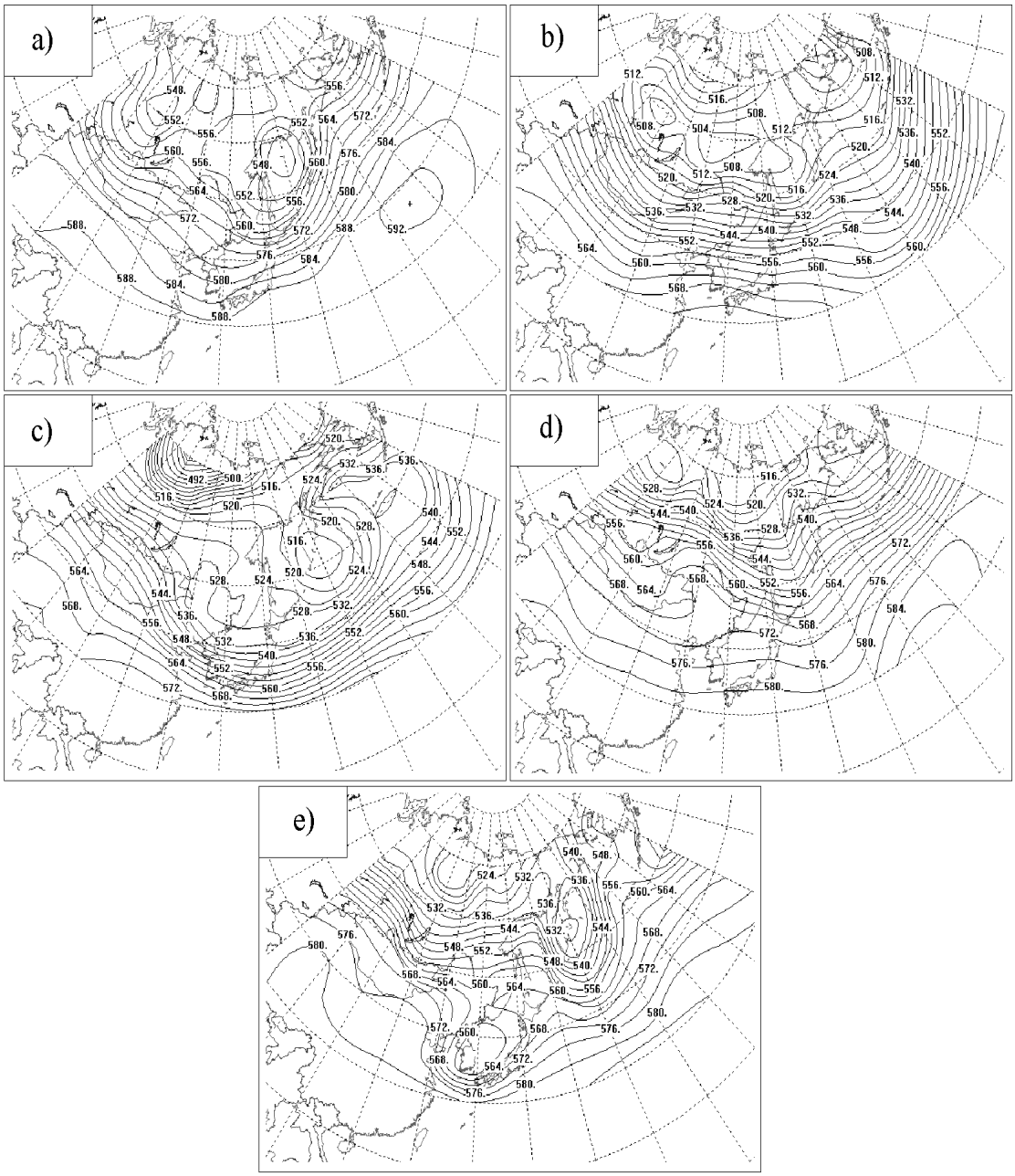

Fig. 4. Example of the subtypes of the macro-type "latitude" (L): (a) – one AFZ in moderate latitudes; (b) – two AFZ two in moderate and southern; (c) – two AFZ in northern and southern; (d) – two AFZ in moderate and northern; (e) – tree AFZ in northern, moderate and southern

Peculiarities of one type transition to another and their stability in a time are of great interest. In accordance with the data from Table 2, it is seen that all macro-types in about half of examples transit to themselves. Macro-types L, C and E preserve themselves best of all on the next day when in 57, 56 and 52% of cases the situation in the field H_{500} do not change. The ability of other macro-types to transit to themselves is within the limits from 31 to 48%. The fields of the most macro-types transform in the latitude form L. Types W, C, E, RC, RT, CL have place in 12, 10, 11, 15, 22, 16% of cases. It happens so called damping of the meridional processes and transition in more calm latitude scale, vivid picture is RC, RT and CL. The types M, I1 and I2 in 13, 18 and 9.3% of cases transit, respectively, to the types CM, C and W, similar to CM. It is interesting that uncertain forms I1 and I2 for 27 years haven't transformed one to another.

Table 1

Number of cases with the macro-types for the period from 1964 to 1990

Macro types	Month												Year	%
	1	2	3	4	5	6	7	8	9	10	11	12		
W	69	64	68	56	75	85	16	20	64	87	59	58	721	7.3
C	21	36	53	71	125	267	273	225	114	35	17	25	1262	12.8
E	132	166	110	71	55	86	102	120	93	41	129	130	1235	12.5
M	181	129	132	127	76	35	20	16	65	123	150	189	1243	12.6
RC	52	41	62	83	82	74	52	53	91	95	51	54	790	8.0
RT	18	24	37	67	69	30	19	30	45	37	28	22	426	4.3
CM	198	161	196	85	31	34	23	18	25	36	89	169	1065	10.8
CL	55	31	40	36	24	26	78	47	19	56	108	67	587	5.9
L	80	70	123	206	228	102	173	250	245	322	178	112	2089	21.1
I1	2	6	1	6	71	69	80	58	49	5	0	0	347	3.5
I2	29	35	15	2	1	2	1	0	0	0	1	11	97	1.0

Table 2

Transition probability of base type to the subsequent type, %

Macro-type	Subsequent type										
	W	C	E	M	RC	RT	CM	CL	L	I1	I2
W	44.2	4.7	4.0	9.6	6.1	3.3	8.7	5.5	11.9	1.7	0.1
C	3.6	56.0	6.3	1.8	6.9	3.7	3.3	3.5	10.4	3.6	0.7
E	2.3	7.4	51.6	8.8	4.0	1.6	8.2	2.0	11.4	1.7	1.0
M	4.9	2.5	10.7	48.4	3.9	2.6	13.0	4.3	8.7	0.4	0.7
RC	5.8	7.5	8.9	8.7	37.2	14.1	6.6	3.3	15.3	2.4	0.3
RT	5.2	12.9	6.3	4.0	8.9	30.8	5.2	2.1	21.6	2.8	0.2
CM	7.2	3.6	8.6	15.4	4.3	2.3	44.3	4.4	7.2	1.1	1.5
CL	4.9	5.3	5.6	8.7	7.0	1.9	9.4	38.2	15.8	3.2	0.0
L	3.4	6.9	5.9	6.2	5.6	4.0	3.8	4.9	57.0	2.2	0.1
I1	3.7	17.9	1.4	2.0	6.6	4.9	2.6	4.3	12.1	44.4	0.0
I2	9.3	8.2	6.2	4.1	4.1	5.2	9.3	0.0	7.2	0.0	46.4

An average duration of the form circulation existence for all sampling is not long, it is only two days. It is not surprising because the atmosphere is in a constant motion. The periods of 2 days have been marked in 21% out of the total number of cases, 3 days in 10.5%, 4 days in 4.5%. Further, the cases decrease. For example, the field preserved 7 days only in 1.2% (62 cases). Basically, they are the types C, E, M and L. The forms C and L have an ability to exist up to 14 days. There is one example when macro-type E preserved 19 days! The running ridges and troughs as well as indifferent and combined latitude types are of the shortest duration: maximal 4-5 days.

Conclusion

The fact that the studied file of the fields of H_{500} can be divided into 182 varieties shows us that the processes over 2 n.s.a. are more variable and have less duration if compared to the Atlantic-European Region. It is due to the orography complex of the Asian Continent and a great contrast between the Continent and the N-W Pacific. The results obtained are well correspondent with the modern thoughts on the circulation character in the middle troposphere over the 2 n.s.a. Thus, it is possible to conclude that the objective detailed division of the circulation processes at the level of the H_{500} into 182 varieties as well as there union in the larger subtypes (33) and macro-types (11) proposed in the present paper have been carried out successfully enough.

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