COMPUTER INFORMATION BASE OF REGIONAL CLIMATIC MODELS OF THE TEMPERATURE AND WIND VELOCITY FOR THE ATMOSPHERIC BOUNDARY LAYER

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The concepts of creation of a computer information base of regional climatic models of the temperature and wind velocity in the atmospheric boundary layer are formulated. Some results of computer base testing are presented by the example of the data on the temperature and wind velocity.

Climatic (statistical) data on the vertical structure of atmospheric meteorological fields are one of the most important elements of information software for solving various problems of hydrometeorology, ecology, and atmospheric optics (e.g., for modeling and prediction of global and regional climates, estimation of pollutant transport, interpretation of lidar sensing data, and so on). However, because of a large body of these data, they are not quite suitable for use in real time. That is why they are spatially averaged and various climatic models are used in practice. Statistical models of vertical distribution of meteorological parameters (e.g., pressure, temperature, wind velocity, and air humidity) in the atmospheric boundary layer are of special interest because they have not yet been developed in contrast with those for the free atmosphere widely used in solving a lot of applied problems (see, e.g., Refs. 1 and 2).

Taking into account this circumstance, we have started construction of regional climatic models of vertical distribution of the pressure, temperature, air humidity, and wind velocity vector components in the atmospheric boundary layer (for brevity, they will be further referred to as regional climatic models of the atmospheric boundary layer). By now the first version of these models was constructed describing the vertical distribution of the temperature as well as the zonal and meridional components of the wind velocity vector above one of the quasihomogeneous regions of the northern hemisphere found earlier during the objective classification of regional climates.[3] Our models describe vertical profiles of the mean values ($\bar{\xi}$) and their standard deviations (σ_ξ) and autocorrelation matrices $\|R_{ij}\|$ of the above meteorological parameters. The models of the atmospheric boundary layer complement the regional climatic models of the free atmosphere constructed earlier at the Institute of Atmospheric Optics under the supervision of V.S. Komarov.[2–4]

To provide real-time application of the regional climatic models of the atmospheric boundary layer, the computer version of information base of these models was developed to achieve the following purposes:

– systematization and optimal organization of storage and access to the models of the atmospheric boundary layer;

– search for the model by user's inquiry;

– tabular representation of the model characteristics;

– export of the required model parameters to computer-aided systems of various application (e.g., to systems designed for the objective analysis of mesometeorological fields and numerical regional weather forecast).

The present paper briefly describes a methodology of construction of a computer information base of regional climatic models of the atmospheric boundary layer and the results of its tests by the example of data on the temperature and wind velocity.

In designing the base of these models, we first developed, as in Ref. 5, a glossary of design instructions that consists of a data glossary and an operation glossary containing specifications of data and applied problems, respectively. Then we developed a conceptual model of the base of the regional climatic models of the atmospheric boundary layer that provided a basis for its further logical and physical design. The conceptual model is commonly considered as a formal specification of statistical (data) and dynamic (operations and events) information base requirements related to one subject area.[6] The formal specification of conceptual representation is commonly based on a model. In our case we selected a semantic model allowing us to represent the subject area as an entity-relationship (ER) diagram first proposed by Chen.[7] In doing so, the notion "entity" was specified as a certain object belonging to this subject area and "relationship" was considered as a joint between two or more entities with the order of relationship that shows the way

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of connection of occurrences of one entity with those of another entity. The order of relationship can take three different values: "one to one" (1:1), "one to set" (1:n), and "set to set" (n:m).

Figure 1 shows the entity-relationship model of the subject area "Regional climatic models of the atmospheric boundary layer." In this figure, the entities of the examined subject area are framed with a single line and relationships – with two lines. The corresponding orders of relationships are also indicated.

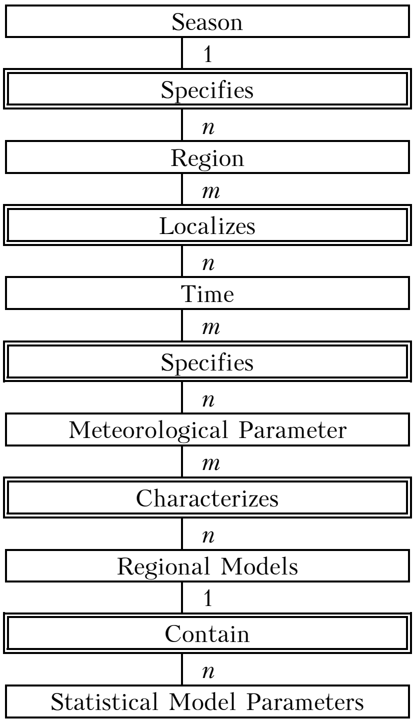

FIG. 1. The entity–relationship model of the subject area "Regional climatic models of the atmospheric boundary layer."

Let us also dwell on the salient features of spatial organization of the data base of regional models of the atmospheric boundary layer. As noted above, each model incorporated into the information base is a set of statistical characteristics of vertical distribution of the fundamental meteorological parameters corresponding to one of the quasihomogeneous regions of the northern hemisphere. In this approach, each quasihomogeneous region is a spatial object (polygon) of irregular form and corresponding regional climatic model of the atmospheric boundary layer is considered as a set of semantically significant descriptors. The description of these objects including descriptions of the polygon and the regional climatic model is provided by two sets of relationship schemes $R_p \subseteq R$ and $R_d \subseteq R$ forming non-intersecting subsets of the scheme of the data base R. In so doing, the subset of relationship schemes R contains the information on spatial localization of polygons, which is represented by ordered values of their geographical coordinates (accurate to 2.5) of their nodes. At the same time, the relation scheme subset R_d contains descriptive information and bears the basic semantic load.

The above design method provided a basis for the development of algorithms and computer codes for the information base of regional climatic models of the atmospheric boundary layer. We notice at once that a special menu was made to select the required model (see Fig. 2).

1. Input the season:
Winter = 1
Spring = 2
Summer = 3
Fall = 4

2. Input the coordinates of the required point (latitude and longitude) accurate to within an integer such that:
North latitude = "+B 56
South latitude = "−B
East longitude = "+B 83
West longitude = "−B

3. Input the time (local):
Time-independent = 1
Morning ($6 < t \le 12$) = 2
Day ($12 < t \le 18$) = 3
Evening ($18 < t \le 24$) = 4
Night ($0 < t \le 6$) = 5

4. Input the meteorological parameter:
Pressure (P, hPa) = P
Temperature (T, °C) = T
Humidity (G, g/kg) = G
Zonal wind velocity (U, m/s) = U
Meridional wind velocity (V, m/s) = V

FIG. 2. Menu of the system for the selection of regional climatic model.

As seen from Fig. 2, to select one or another model, a user should input into a computer an instruction set to search for it containing the specifications describing the required model, namely, the season, the coordinates (to search for the corresponding quasihomogeneous region), the time, and the name of the meteorological parameter. An example of the program output of the desired regional climatic model (for input model characteristics: winter = 1; 56° N, 83° E; time independent = 1; temperature = T; zonal wind velocity = U and meridional wind velocity = V) is shown in Fig. 3.

In conclusion, it should be noted that in our further investigations the constructed computer base will be improved through the increase of the number of meteorological parameters and insertion of the regional models of the atmospheric boundary layer being created now for other quasihomogeneous regions of the northern hemisphere.

Regional statistical model of vertical distribution of the temperature (T, °q)
(time-independent. Winter. 56° N, 83° E)

Altitude	0	100	200	300	400	600	800	1200	1600	2000
Mean Value	−17.2	−16.9	−16.6	−16.3	−15.9	−15.1	−14.6	−14.0	−14.5	−15.7
Standard deviation	9.2	8.7	8.4	8.1	7.9	7.5	7.1	6.5	6.3	6.2
Correlation Matrix										
0	1.000	0.969	0.935	0.895	0.864	0.803	0.742	0.613	0.568	0.565
100		1.000	0.985	0.957	0.932	0.877	0.820	0.698	0.648	0.639
200			1.000	0.988	0.970	0.922	0.869	0.749	0.696	0.684
300				1.000	0.992	0.955	0.905	0.785	0.730	0.718
400					1.000	0.978	0.936	0.819	0.764	0.750
600						1.000	0.980	0.878	0.822	0.804
800							1.000	0.932	0.876	0.853
1200								1.000	0.954	0.921
1600									1.000	0.975
2000										1.000

Regional statistical model of vertical distribution of the zonal wind velocity component
(U, m/s) (time-independent. Winter. 56° N, 83° E)

Altitude	0	100	200	300	400	600	800	1200	1600	2000
Mean Value	0.5	1.0	2.3	3.5	4.7	6.0	6.6	7.7	8.3	9.0
Standard deviation	2.2	4.5	5.6	6.1	6.7	7.4	7.5	7.9	8.2	8.5
Correlation matrix										
0	1.000	0.779	0.660	0.626	0.579	0.531	0.527	0.498	0.499	0.492
100		1.000	0.868	0.834	0.781	0.721	0.710	0.660	0.652	0.623
200			1.000	0.964	0.907	0.837	0.816	0.745	0.731	0.701
300				1.000	0.977	0.928	0.902	0.815	0.797	0.767
400					1.000	0.976	0.946	0.851	0.831	0.800
600						1.000	0.982	0.896	0.871	0.840
800							1.000	0.948	0.919	0.885
1200								1.000	0.963	0.924
1600									1.000	0.975
2000										1.000

Regional statistical model of vertical distribution of the meridional wind velocity
component (V, m/s) (time-independent. Winter. 56° N, 83° E)

Altitude	0	100	200	300	400	600	800	1200	1600	2000
Mean Value	2.0	3.7	4.9	4.9	4.7	4.4	4.2	3.8	3.4	3.0
Standard deviation	2.7	4.4	5.6	5.6	5.8	6.0	6.0	6.1	6.4	6.7
Correlation matrix										
0	1.000	0.787	0.703	0.687	0.656	0.607	0.578	0.490	0.467	0.445
100		1.000	0.906	0.874	0.819	0.738	0.702	0.603	0.567	0.525
200			1.000	0.966	0.907	0.813	0.764	0.654	0.615	0.572
300				1.000	0.976	0.908	0.858	0.740	0.700	0.657
400					1.000	0.962	0.914	0.790	0.750	0.707
600						1.000	0.974	0.862	0.820	0.779
800							1.000	0.927	0.881	0.836
1200								1.000	0.950	0.898
1600									1.000	0.970
2000										1.000

FIG. 3. Example of the program output of the desired regional models.

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