Parameterization scheme for operational prediction of large-scale processes

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The current operational forecast models use the different parameterization schemes for horizontal and vertical turbulent exchange because their resolution is larger then the upper limit space scale of the inertial range with minus 5/3 behavior of the spectrum. The three-dimensional parameterization scheme is converted in two-dimensional one which is applied for horizontal turbulence description. The vertical turbulent exchange uses the boundary approximation, which simplifies the all turbulence closure equations and allows to represent the second moments in the characteristics of vertical profiles of the mean variables, turbulence kinetic energy and the length-scale.

The weakest link of turbulence parameterization options in current active models is probably the empirical length scale expression rather than the closure assumptions. The empirical approach to the length scale modeling doesn't allow to fulfill the physical requirements such as to restore the transfer the turbulence kinetic energy to the dissipation subrange through the buoyancy and inertial intervals of the spectrum under different stability conditions. The boundary approximation and the direct relationship from ground distance have no physical reason when the parameterization scheme is applied to atmosphere above the boundary layer.

The effective development of the vertical turbulent parameterization is connected with using the two-equation transport model, which involves the prognostic equations for turbulence kinetic energy and dissipation rate. The boundary layer model (BLM) is included in the large-scale prediction model of Russian Hydrometeorological Center (RHMC) operational prognostic model [Berkovich, L.V., Tarnopolskii, A.G., Shnaydman, V.A.] . The upper and lower boundary conditions for the boundary layer are taken from the large-scale prediction model. The explicit scheme of BLM time integration is applied by using the iteration procedure (3-5 iterations) on each time step.

The main achievements of the improved parameterization in RHMC operational model are the reconstruction of the transition from the nocturnal stable to daily convective boundary layer, increasing the dissipation rate when the stratification changes from stable to unstable, the recognition of the compound vertical profile of the turbulence coefficient in the convective boundary layer. Such features of boundary layer parameters behavior face difficulties when the operational weather prediction is performed by using only prognostic equation for turbulent kinetic energy and empirical formulae for length scale.

The experience of using two-equation parameterization scheme in the Russian Hydrometeorological Center operational prognostic model and confirms that the physical requirements to the turbulence description are fulfilled in this scheme.

As an example, the 24h and 36h forecast of nocturnal and daily vertical profiles of boundary parameters for Moscow at 03h and 15h, 15 July 2003 are given in the tables 1 and 2.

Table 1

z [m]	t [grad C]	dt/dz [grad/100m]	V Vmod	dd	Kt [m2/c]	b*10 [m2/c2]	e*1000 [m2/c3]
0	19.52		0.0	0	0.004	3.000	93.8982
10	19.52	0.00	2.5	45	1.355	3.000	3.0544
20	19.42	-1.00	2.8	45	3.198	3.496	1.7580
30	19.30	-1.20	2.9	45	5.273	3.985	1.3850
50	19.07	-1.15	3.1	52	7.167	3.836	0.9444
100	18.63	-0.88	3.4	52	9.105	3.049	0.4697
150	18.35	-0.56	3.6	52	7.030	1.896	0.2353
200	17.95	-0.80	3.8	52	1.895	0.600	0.0873
250	17.49	-0.92	4.7	57	0.392	0.281	0.0927
300	17.01	-0.96	5.4	66	0.105	0.078	0.0269
350	16.73	-0.56	5.2	74	0.000	0.000	0.0000

Table 2

0	28.90		0.00	0	0.012	5.413	227.5590
10	28.62	-2.80	3.05	41	1.887	5.413	13.4202
20	28.30	-3.20	3.31	41	4.635	7.132	9.1162
30	28.17	-1.31	3.44	41	7.696	8.271	8.0005
50	28.06	-1.22	3.55	48	13.336	9.737	6.3985
100	27.47	-1.16	3.75	53	25.136	10.335	3.8244
150	26.93	-1.08	3.87	53	30.451	9.636	2.7445
200	26.41	-1.04	3.97	53	30.072	8.159	1.9921
250	25.99	-0.82	4.05	53	27.641	6.677	1.4518
300	25.52	-0.94	4.13	53	18.798	4.286	0.8795
350	24.71	-1.62	4.41	54	3.327	1.252	0.4244
400	23.72	-1.98	5.28	62	0.557	0.430	0.3131
450	22.76	-1.92	5.94	72	0.183	0.172	0.1358
500	21.60	-2.32	5.88	82	1.596	0.030	0.0365
550	20.81	-1.59	5.63	84	1.596	0.030	0.0291
600	19.75	-2.11	5.75	85	2.384	0.031	0.0001
650	18.99	-1.52	5.91	85	2.384	0.031	0.0001
700	18.50	-0.99	5.43	85	2.384	0.031	0.0001
750	17.34	-2.31	4.96	85	2.384	0.031	0.0001
800	16.70	-1.29	4.88	85	2.384	0.029	0.0001
900	15.89	-0.81	4.69	84	1.621	0.029	0.0001

Reference:

Berkovich, L.V., Tarnopolskii, A.G., Shnaydman, V.A.: 1997, "A Hydrodynamic Model of the Atmospheric and Oceanic Boundary Layers," Russian Meteorology and Hydrology 7, 30-40.

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