Reconstruction of the Ice Thickness Seasonal Evolution in the Northeastern Sea of Azov Using Different Arrays of Meteorological Data

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Purpose. The aim of the paper was to compare the results of numerical experiments on reconstructing seasonal thermal evolution of the sea ice thickness with the data of in situ observations of the ice state in the northeastern part of the Taganrog Bay.
Methods and Results. Characteristics of the ice state in the northeastern part of the Taganrog Bay were studied using the previously developed thermodynamical model of sea ice. The data of the European Center for Medium-Range Weather Forecasts ERA-Interim, regional prognostic model SKIRON and the array of daily eight (with 3-hour intervals) observations of the basic meteorological parameters (All-Russian Research Institute of Hydrometeorological Information – World Data Center (RIHMI – WDC)) obtained at the meteorological station Taganrog, were used in the numerical experiments as the atmospheric forcing. The modeling results were compared with the in situ data for the winter seasons in 2007/2008–2010/2011. It is shown that the characteristics of the snow-ice cover resulted from application of various meteorological data as the external forcing, can be significantly different.
Conclusions. The highest similarity between the modeled ice thickness seasonal variation and the one reconstructed using the observations data was obtained at applying the RIHMI – WDC data array. In this case, both thickness and the basic stages of the snow-ice cover evolution in the Taganrog Bay were adequately reproduced in the model. As compared to the in situ data, the results of the models based on the SKIRON and ERA-Interim data were mainly overestimating and underestimating, respectively. It is related, to a great extent, to determination of the precipitation amount, the prognostic values of which in ERA-Interim are higher than those in SKIRON. However, even in the calculations taking no account of atmospheric precipitation or in those for the ice seasons when the atmospheric precipitation is very insignificant, the SKIRON based model provides the higher values of ice thickness than the values resulted from the ERA-Interim based model. Analysis of the modeling results shows that adequate reconstruction of the ice state characteristics in the Azov Sea requires preliminary setting of the thermodynamic model depending on the chosen data array used as the atmospheric forcing.

Keywords: sea ice, thermodynamics, ice thickness, atmospheric forcing, Sea of Azov, Taganrog Bay.

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Introduction

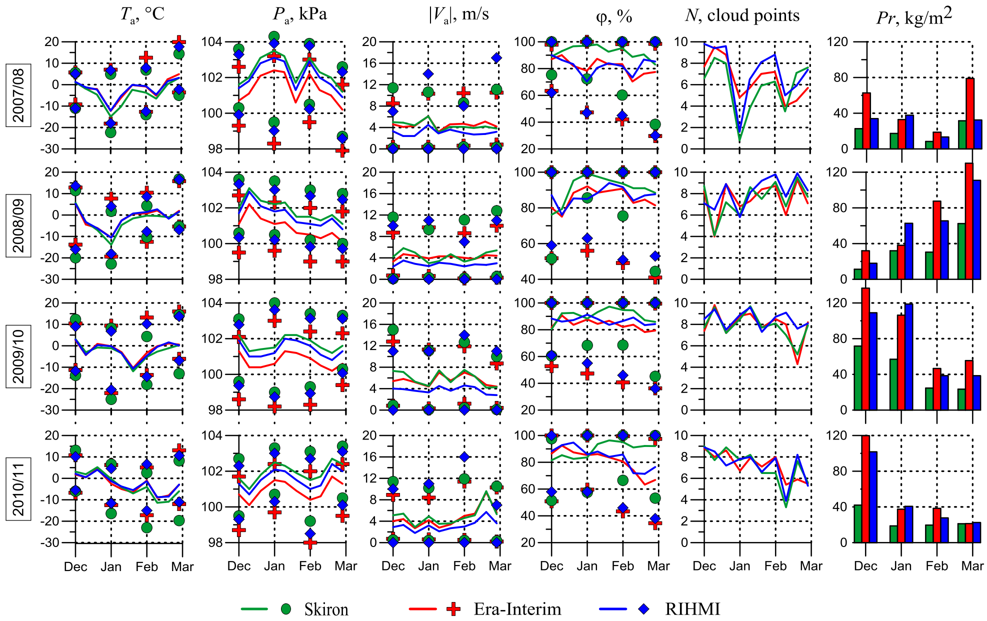
In winter period, the Sea of Azov partially freezes, in severe winters – completely, therefore sea ice is an important component of the sea hydrological regime. The Sea of Azov ice cover is characterized by high variability both in a single season and in a long-term period and depends on the prevailing hydrometeorological conditions. Contrasting weather and ice conditions are formed under effect of high pressure area located in the north and north-east of the Eurasian continent, and cyclonic invasions from the south-west and west [1]. Frequent eastern and northeastern winds bring continental polar and arctic air masses, cause severe frosts and intensive ice formation, and cyclonic activity, on the contrary, leads to the inflow of warm air masses and a rapid decrease in the thickness of snow-ice cover [2].

The sea ice evolution is determined by the thermal and dynamic regimes of the atmosphere and the aquatic environment [3], while the ice cover itself significantly affects the heat flux between these media. The limitations of physically based modeling of the thermal evolution of the snow-ice cover thickness are due to the availability of initial information. In order to calculate the seasonal variation of sea-ice thickness, reliable data on temperature, pressure and air humidity, wind velocity, cloudiness, the amount of precipitation and its phase are required. The quality of this data also determines the calculation quality of the snow-ice cover thickness.

A comparative analysis of calculation results of the Arctic Ocean ice and hydrological characteristics using three different data sets as atmospheric effects is presented in [4]. Comparison of *NCEP*/*NCAR* reanalysis data used as atmospheric forcing in a one-dimensional thermodynamic model of sea ice with the observations obtained at drifting stations in the Central Arctic is presented in [5].

The processes of heat and moisture transport in the Sea of Azov snow-ice system significantly differ from the processes occurring in the snow-ice cover of the northern seas. The complexity of the observations and the small number of direct measurements of the Sea of Azov snow-ice cover thickness significantly complicate the study of the winter thermodynamics of this basin. The integration of publicly available data from weather forecast models with a thermodynamic model of seasonal evolution of sea-ice thickness can be considered as a possible element of the forecast of the Sea of Azov ice conditions.

This paper presents the results of modeling the formation and melting processes of snow and ice cover in the Taganrog Bay for the winter seasons from 2007/2008 to 2010/2011. The winter of 2007/2008 in the Sea of Azov region [6] belonged to moderate winters, but its feature was contrasting weather and ice conditions, characterized by both intensive ice formation with short-term low temperatures and significant thaws. Winters of 2008/2009 and 2009/2010 were mild, with cyclonic activity predominating in the atmospheric processes. The effect of anticyclones was insignificant. The minimum air temperatures during the winter period of 2008/2009 were observed in January 2009. During the winter period of 2009/2010, two cold waves, which came from the north in mid-December 2009 and the end of January 2010, were observed. Between them, the sea near the Taganrog weather station was completely clear from the ice. In 2010/2011 ice season, two periods, differing in the general temperature background and ice cover, were clearly visible. The first – from November to December – is warm. At this time, an intensification of cyclonic activity was observed. The second – from January to March – was cold and was characterized by the invasion of the arctic cold masses into the rear of the leaving Atlantic cyclones. In the area under consideration, this winter was classified as mild one [7].



F i g. 1. Average decadal values (solid lines) of the air temperature on height 2 m T_a, the atmospheric pressure on the basin surface P_a, the wind speed on 10 m height $|V_a|$, relative air humidity φ, general cloudiness number, as well as total precipitation for a month *Pr* over the northeastern part of the Taganrog Bay (47° 11'N, 38° 54'E) in December – March, 2007/2008, 2008/2009, 2009/2010 and 2010/2011. Symbols on the graphs denote minimal and maximal monthly values of the meteorological parameters

Three meteorological databases were used as information support: *SKIRON* prognostic atmospheric model [8] of the University of Athens (Greece) with 0.1° × 0.1° spatial resolution and 2 h time step; *ERA-Interim* reanalysis [9] of the European Center for Medium-Range Weather Forecasts (*ECMWF*) with 0.125° × 0.125° resolution and 6 h time step, as well as RIHMI-WDC* array of urgent observations over the main meteorological parameters at the Taganrog weather station (WMO index 34720) with 3 h interval.

In Fig. 1 solid lines denote ten-day mean values of air temperature at 2 m height, atmospheric pressure near the basin surface, wind velocity at 10 m height, relative humidity and general cloudiness number. The bar charts denote total precipitation above the northeastern part of the Taganrog Bay for the month from December to March 2007/2008 – 2010/2011. It can be seen from the figure that the meteorological parameters given in these arrays have a similar nature of temporal variability, and the difference in ten-day values of air temperature, pressure and wind velocity does not exceed 2 °C, 1.5 kPa and 3 m/s, respectively. The greatest differences are manifested in the forecast of precipitation amount, since precipitation is one of the most variable in time and space meteorological phenomena. Uncertainties that arise when modeling the sea ice thickness thermodynamic evolution are largely related both to the estimation of general precipitation amount getting on the sea surface and the lack of reliable information about their structure.

* RIHMI-WDS, 2018. *Hydrometeorological data*. [online] Available at: http://meteo.ru [Accessed: 04 September 2018] (in Russian).

Description of the model

Evolution of the Sea of Azov snow-ice cover, taking into account regional features of its formation, is described by a locally one-dimensional thermodynamic model [10, 11]. Heat distribution in the snow and ice layers is determined by thermal conductivity equations

$$(\rho c)_{\mathrm{i,s}} \frac{\partial T_{\mathrm{i,s}}(z,t)}{\partial t} = \frac{\partial}{\partial z}\left(k_{\mathrm{i,s}} \frac{\partial T_{\mathrm{i,s}}(z,t)}{\partial z} \right) - \frac{\partial I_{\mathrm{i}}(z,t)}{\partial z}, \quad z \in \left[0, h_{\mathrm{i}} + h_{\mathrm{s}}\right]$$

with the boundary conditions at the snow-ice cover upper

$$-k_{\mathrm{i,s}} \frac{\partial T_{\mathrm{i,s}}}{\partial z} = F_{\mathrm{t}}(T_{\mathrm{sfc}}), \qquad z = 0$$

on the surface of snow-ice interface

$$k_{\mathrm{s}} \frac{\partial T_{\mathrm{s}}}{\partial z} = k_{\mathrm{i}} \frac{\partial T_{\mathrm{i}}}{\partial z}, \qquad T_{\mathrm{s}} = T_{\mathrm{i}}, \qquad z = h_{\mathrm{s}}(t)$$

and at the ice cover lower boundary

$$-k_{\mathrm{i}} \frac{\partial T_{i}}{\partial z} = F_{\mathrm{b}}(T_{\mathrm{f}}, T_{\mathrm{w}}), \qquad T_{\mathrm{i}} = T_{\mathrm{f}}, \qquad z = h_{\mathrm{i}}(t).$$

At the moving interfaces of different matter phases the law of energy conservation during phase transitions is fulfilled:

$$-\rho_{\mathrm{i,s}} L_{\mathrm{fi,s}} \frac{\partial h_{\mathrm{i,s}}}{\partial t} = F_{\mathrm{t}}(T_{\mathrm{mi,s}}) + k_{\mathrm{i,s}} \frac{\partial T_{\mathrm{i,s}}}{\partial z}, \quad z = 0,$$

$$-\rho_{\mathrm{i}} L_{\mathrm{fi}} \frac{\partial h_{\mathrm{i}}}{\partial t} = F_{\mathrm{b}}(T_{\mathrm{f}}, T_{\mathrm{w}}) - k_{\mathrm{i}} \frac{\partial T_{\mathrm{i}}}{\partial z}, \qquad z = h_{\mathrm{i}}(t).$$

If the snow-ice cover is absent, the heating or cooling of mixed quasi-homogeneous water layer takes place:

$$\frac{\partial T_{\mathrm{w}}}{\partial t} \rho_{\mathrm{w}} c_{\mathrm{w}} h_{\mathrm{w}} = F_{\mathrm{b}} - F_{\mathrm{t}} - \nu \rho_{\mathrm{s}} L_{\mathrm{fs}}, \qquad z \in \left[0, h_{\mathrm{w}}\right].$$

Here t is time; z is a vertical coordinate directed downward from the snow-ice cover upper surface (z = 0); ρ is a density; h is a thickness; T is a temperature; S a salinity; c is a heat capacity; k is a thermal conductivity; L_{f} is a heat of fusion; I_{i} is a solar radiation penetrating the ice; T_{sfc}, $T_{\mathrm{mi,s}}$,T_{f} are the temperatures on the upper surface of the snow-ice cover, the melting point of ice/snow and the water freezing temperature, respectively; ν is the rate of solid precipitation; F_{t} is a heat flux from the atmosphere through the upper boundary of the snow-ice cover; $F_{\mathrm{b}} = c_{\mathrm{w}} \rho_{\mathrm{w}} C_{\mathrm{tb}} \left(T_{\mathrm{w}} - T_{\mathrm{f}}\right)$ is a heat flux from the water to the lower ice boundary, $C_{\mathrm{tb}} = 10^{-3}$ m/s is a turbulent exchange coefficient. Hereinafter, i, s, w, a indices refer to the parameters of ice, snow, water and the atmosphere, respectively.

The rate of snow-ice cover thermal evolution depends on the difference between the heat flux from the atmosphere through its upper boundary and the heat flux from the water to its lower boundary. At the upper boundary, the heat flux F_t consists of turbulent fluxes of sensible (F_s) and latent (F_l) heat, which are determined by the integral aerodynamic formulas

$$F_s = c_{pa}\rho_a \mathrm{St} V_a (T_{sfc} - T_a); \quad F_l = L\rho_a \mathrm{Da} V_a (q_0(T_{sfc}) - q_a(T_a))$$

long-wave (R)

$$R = 4\lambda\sigma T_{sfc} T_a^3 - \lambda\sigma T_a^4 (3.765 + 0.22N^3),$$

short-wave (F) radiation fluxes

$$F = F_0(1 - cN)(1 - \alpha)(1 - i_0),$$

as well as heat fluxes (F_m) related to the cooling processes and the subsequent possible crystallization of liquid precipitation:

$$F_m = c_w Pr_r (T_a - 273.15) + Pr_r L_{fi}.$$

Here e is the water vapor pressure; P_a is the atmospheric air pressure; V_a is wind velocity; Pr_r is the amount of precipitation in liquid phase; St = Da = = $1.7 \cdot 10^{-3}$; $q_a = (0.622 f / P_a) \cdot 10^{a_1 T_a/(b_1 + T_a)}$, $q_0 = (0.622 e_0 / P_a) \cdot 10^{a_1 T_{sfc}/(b_1 + T_{sfc})}$ is specific air humidity at 2 m height and at the snow-ice cover upper boundary, respectively; a_1 = 9.5; b_1 = 265.5 K; e_0 = 611 hPa is the pressure of saturated water vapor at 0 °C; $c_{pa} = 10^3$ J/(kg·K) is the heat capacity of air at constant pressure; f is relative humidity; L is the specific heat of sublimation; σ is Stefan-Boltzmann constant; λ, α is an emissivity and albedo of the underlying surface; N is the general cloudiness number; i_0 is a coefficient that determining which part of the short-wave radiation penetrates deep into the snow-ice layer and is evenly distributed throughout the entire thickness; $F_0 = S\cos^2 z_\Theta \left((\cos z_\Theta + 2.7)e \cdot 10^{-5} + 1.085\cos z_\Theta + 0.1\right)^{-1}$ is the incoming short-wave solar radiation for a cloudless sky; S is the solar constant; z_Θ is solar zenith angle. Assuming that the vertical profiles of ice and snow temperature can be described by a linear function, and considering the heat flux through ice and snow to be the same (according to the study of A.P. Makshtas * and [12, 13]), the thermal conductivity equations can be solved analytically. The nonlinear equation for determining the temperature of the snow-ice cover upper surface, obtained from the heat balance equation assuming the continuity of the heat flux at the snow-ice interface, is solved numerically. The parameters used in the model for physical, thermal and optical characteristics of sea water and ice are given in [14].

The basis of the model of snow cover, accumulating on the sea ice surface, is the schematization of the processes making the greatest contribution to the formation of physical and thermal snow characteristics. Due to the intermittent nature of precipitation accumulation, wind effect and changes in air temperature, snow cover is composed of separate layers that differ from each other at least in thickness, density and water content. Considering the regional features of precipitation in the winter period on the Sea of Azov coast, we take the layers of fresh and existing snow as the main structural model units.

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* *Makshtas, A.P.*, Thermal Balance of Arctic Ice in the Winter: Gidrometeoizdat, 1984. 67 p.

A layer of fresh snow is formed as a result of snow accumulation on the surface of the snow-ice cover during the deposition of solid precipitation. The density of freshly fallen snow ρ_{s0} is determined by *COSMO* algorithm [15]. This parametrization is used to calculate the characteristics of fresh snow at a short period of snow accumulation (up to 12 hours) and in the case of small amount of precipitation in the form of snow [16]. Due to the relatively small amount of solid precipitation observed over the water area of the Sea of Azov, as well as extreme instability of snow cover, the process of elastic deformation of fallen snow can be neglected. Wind compaction of snow was parametrized, based on the assumption [12] that its density rises by 20 kg/m^3 at wind velocity increasing for every 1 m/s, as $\rho_s = \max(\rho_{s0}; 20\,V_a)$ (kg/m^3). Due to snow melting or rain falling, the water, which seeps into the snow layer and leads to an increase in its density, is formed. The maximum amount of water a snow layer can contain is determined by its water retention capacity Θ_{max} *. If the liquid water amount Θ_w in the snow layer exceeds Θ_{max}, then its surplus moves to the bottom layer or forms water flow to the snow-ice interface, where it crystallizes if $T_s < T_{mi}$. The density of each layer is calculated based on the amount of water contained in it in the liquid and solid phase. Thermal conductivity of a snow column (a set of snow layers) is determined by the Osokin's formula [17]. The snow surface albedo parameterization is taken from *ECHAM*5 atmosphere model [18].

Ice cover buoyancy is small and its overload occurs when the snow cover height reaches approximately 40% of the ice thickness, so the process of turning snow into ice is possible when the snow − ice section line falls below the water level. The thickness of the flooded part of the snow is calculated from the floating condition of the bodies. According to the change in the snow column height, its mass decreases and the ice mass increases.

Results of calculations

On the basis of the constructed thermodynamic model, numerical experiments for assessing the effect of external forcing choice on the reconstruction of ice thickness seasonal evolution in the north-eastern part of the Sea of Azov were carried out. The modeling results were compared with each other and with the data on the sea ice thickness taken from ice maps published by the Unified State System of Information on the Situation in the World Ocean ** (ESIMO).

In order to assess the adequacy of the forecast of the ice thickness seasonal variation, the following criteria were considered:

– model error $E_t = h_{\text{in situ}} - h_i$;

– root-mean-square deviation of h_i from $h_{\text{in situ}}$ – $\sigma = \sqrt{\sum_l \frac{E_t^{\,2}}{l}}$;

– determination coefficient R^2 (dispersion portion h_i explained by the model), $R^2 = 1 - \frac{\sum_l E_t^{\,2}}{\sum_l (h_i - \bar{h}_i)^2}$;

* Kuzmin, P.P., 1957. *Fizicheskie Svoystva Snezhnogo Pokrova* [Physical Properties of Snow Cover]. Leningrad: Gidrometeoizdat, 179 p. (in Russian).

** NODS, 2018. *The Unified State System of Information on the World Ocean*. [online] Available at: http://esimo.ru/portal/ [Accessed: 04 September 2018] (in Russian).

– Theil's inequality coefficient U (indicates the degree of time series similarity: the closer it is to zero, the closer are the compared series)

$$U = \frac{\sqrt{\sum_l E_t^{\,2}}}{\sqrt{\sum_l h_{\text{in situ}}^{\,2}} + \sqrt{\sum_l h_i^{\,2}}};$$

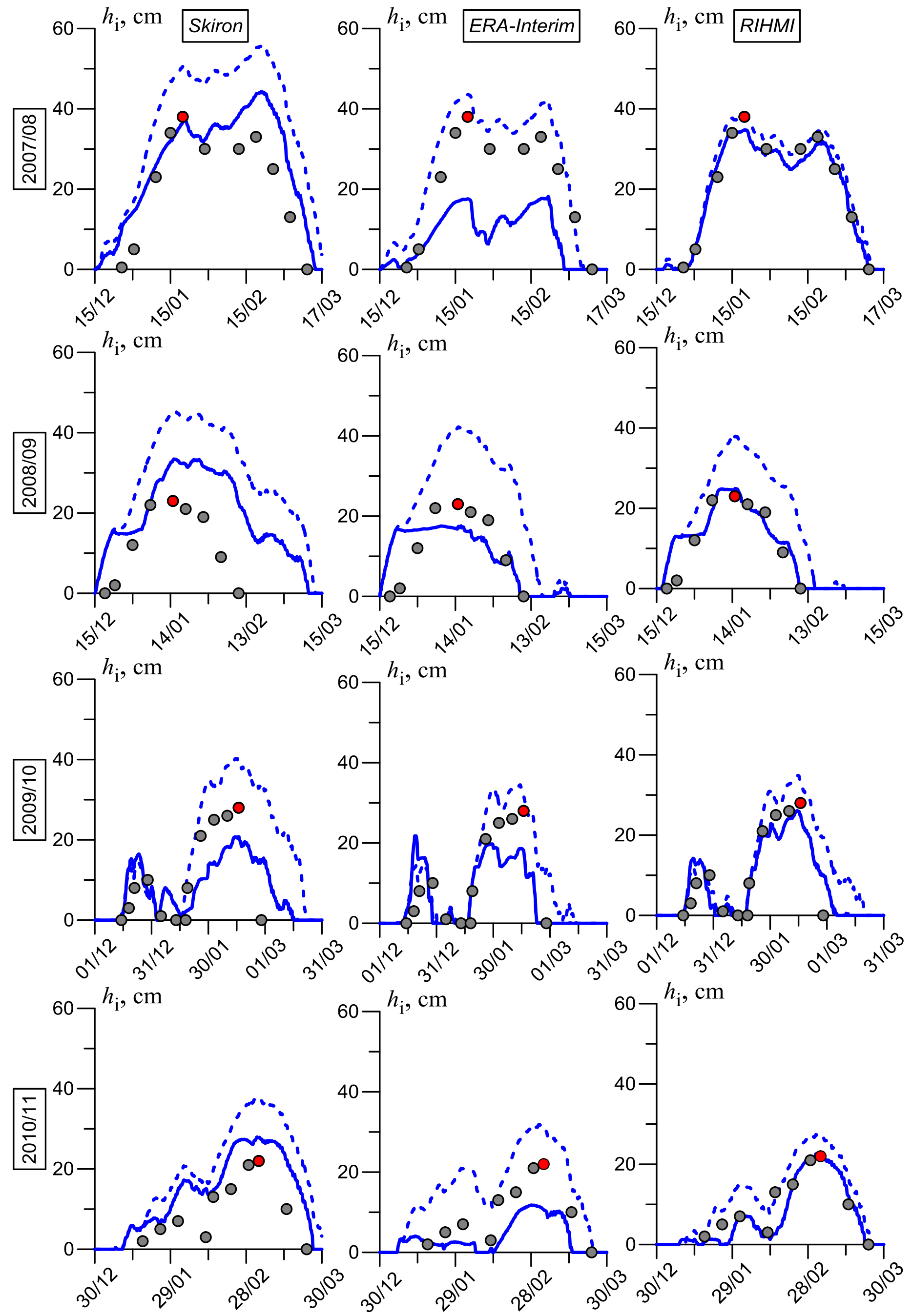
– correlation coefficient $K = \dfrac{\sum_l \left(h_{\text{in situ}} - \bar{h}_{\text{in situ}}\right)\left(h_i - \bar{h}_i\right)}{\sqrt{\sum_l \left(h_{\text{in situ}} - \bar{h}_{\text{in situ}}\right)^2}\sqrt{\sum_l \left(h_i - \bar{h}_i\right)^2}}$,

where l is a number of steps in which the measured ice thickness, corresponding to the computational time step, differed from zero.

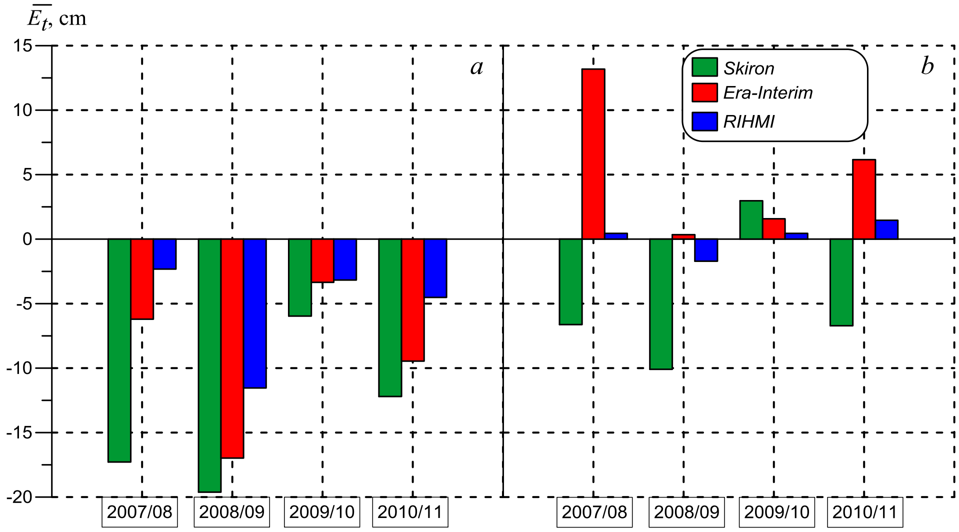
The modeling results of ice thickness thermodynamic evolution in ice seasons from 2007/2008 to 2010/2011 are represented in Fig. 2. Since, as noted earlier, the most noticeable differences between the meteorological data of the considered arrays are manifested in the amount of precipitation, for a comparative analysis of atmospheric forcing effect on the ice thickness seasonal variation, a series of calculations were carried out both with regard to precipitation and without it [1].

Average model errors $\bar{E}_t$ calculated for each of four ice seasons are shown in Fig. 3; the season-average values of the measured $\bar{h}_{\text{in situ}}$ and computational $\bar{h}_{\text{i}}$ ice thickness, root-mean-square deviations σ, determination coefficients R^2, Theil's inequality coefficient U and correlation coefficients K are listed in the table. It can be seen that for the considered periods the forecast of ice thickness seasonal variation, performed without taking into account the precipitation, is overestimated. This conclusion applies to all three atmospheric forcing. The largest negative values of the model errors were obtained for the *SKIRON* data, and the smallest - for the RIHMI-WDC data (Fig. 3, *a*). However, despite the consistent ice thickness h_{i} reassessment by the models constructed with no regard to precipitation, they adequately reconstruct (except for *SKIRON*, 2007/2008) the dates of the maximum ice thickness formation (see. Fig. 2). In addition, sufficiently high correlation coefficients indicate a similar nature of temporal dependences of the measured $h_{\text{in situ}}(t)$ and computational $h_{\text{i}}(t)$ ice thickness values.

It should be noted that although the ten-day values of meteorological parameters (see Fig. 1) in the given arrays are quite close to each other (except for precipitation, which were not taken into account in this series of calculations), the differences in the maximum ice thickness forecast for the same season can reach 40–70 % of the average ice thickness per season $\bar{h}_{\text{in situ}}$, depending on the atmospheric forcing type.



F i g. 2. Results of modeling the ice thickness thermodynamic evolution in the 2007–2011 in the ice seasons obtained due to application of the meteorological data arrays SKIRON, ERA-Interim and RIHMI – WDC as the external forcing with the regard for precipitation (solid lines) and with no regard for precipitation (hatch lines). Grey circles correspond to the sea ice thickness data from the ESIMO ice charts, red ones – to the maximum ice thicknesses measured at the meteorological station Taganrog [1]



F i g. 3. Season-average model errors $\bar{E}_t$ resulted from determining the ice thickness seasonal variation using meteorological data from the SKIRON, ERA-Interim and RIHMI – WDC arrays with no regard to atmospheric precipitation (*a*) and with regard to atmospheric precipitation (*b*)

In order to carry out numerical experiments taking into account the snow accumulation on the sea ice surface, it is necessary to choose a criterion by which the phase of precipitation is determined. As one of these criteria, air temperature near the sea surface can be used. The criterion for dividing precipitation into liquid and solid can be the threshold air temperature [19], below which all precipitation is classified as snow, and higher as rain. In some studies [20], the empirical dependences of rain and snow percentage on the surface temperature are given and it is assumed that there is a range of temperature values at which mixed precipitation is observed. Such dependencies are not universal and have pronounced regional in nature. The condition for dividing the total amount of prognostic precipitation into liquid and solid is to a certain extent a setup one. In this work, it was assumed that when the air temperature is below –0.5 °C, all precipitation is in the solid phase, and at air temperature above 0.3 °C, it is only in the liquid one. Within the air temperature range $-0.5\ °C \leq T_a \leq 0.3\ °C$ the snow content in precipitation was determined as follows: within −0.5 … −0.2 °C temperature interval the snow content percentage was measured linearly from 100 to 95 %, within −0.2 … 0 °C – from 95 to 60 % and within 0 … 0.3 °C – from 60 to 0 %.

Calculations showed that the consideration of precipitation reduces $\bar{E}_t$ model error (Fig. 3, *b*). However, in most of the considered cases, when using *SKIRON* array the model remains noticeably overestimating, and when using *ERA-Interim* data – underestimating. From three considered arrays, *ERA-Interim* gives the most, and *SKIRON* – the least amount of predictive precipitation in both the seasonal and inter-annual cycle. It should also be noted that when modeling the thermal evolution of ice thickness for the conditions of winter 2009/2010 (which was most abundant in precipitation: their total monthly amount exceeded climatic norms by 1.5–2 times), all three models turned out to be somewhat underestimating. The most adequate values of ice thickness seasonal variation for the selected parameterizations in the thermodynamic model were obtained using RIHMI – WDC data (Fig. 2, 3, table). In this series of calculations, the duration of the ice period, the observation time of the maximum ice thickness and its value, the error in the determination of which did not exceed 3 cm, were rather reliably reconstructed.

T a b l e

Comparison of the ice thickness model calculations with the data of *in situ* observations

Season	$\bar{h}_{\text{in situ}}$, cm	Taking account of precipitation	Forcing	$\bar{h}_i$, cm	σ, cm	R^2	*U*	*K*
2007/2008	23.1	No	*SKIRON*	40.4	18.1	-	0.26	0.93
			ERA-Interim	29.4	7.1	0.66	0.12	0.97
			RIHMI	25.5	3.1	0.93	0.06	0.98
		Yes	*SKIRON*	29.8	8.6	0.50	0.15	0.89
			ERA-Interim	10.0	15.1	-	0.40	0.86
			RIHMI	**22.7**	**1.9**	**0.98**	**0.04**	**0.98**
2008/2009	15.3	No	*SKIRON*	34.9	20.8	-	0.40	0.74
			ERA-Interim	32.3	17.4	-	0.35	0.88
			RIHMI	26.8	12.1	-	0.30	0.89
		Yes	*SKIRON*	25.4	11.9	-	0.27	0.62
			ERA-Interim	14.9	7.1	0.04	0.22	0.26
			RIHMI	**17.0**	**4.6**	**0.59**	**0.13**	**0.83**
2009/2010	14.4	No	*SKIRON*	20.4	7.9	0.37	0.19	0.95
			ERA-Interim	17.8	6.1	0.62	0.16	0.92
			RIHMI	17.6	4.7	0.78	0.12	0.96
		Yes	*SKIRON*	11.5	7.7	0.40	0.25	0.71
			ERA-Interim	12.9	8.9	0.19	0.28	0.51
			RIHMI	**14.0**	**4.7**	**0.77**	**0.14**	**0.88**
2010/2011	10.9	No	*SKIRON*	23.1	13.2	-	0.35	0.89
			ERA-Interim	20.4	9.9	-	0.29	0.92
			RIHMI	15.4	5.4	0.41	0.18	0.94
		Yes	*SKIRON*	17.6	7.7	-	0.24	0.87
			ERA-Interim	4.7	7.3	-	0.38	0.87
			RIHMI	**9.4**	**3.9**	**0.68**	**0.15**	**0.90**

Conclusion

The results of modeling of the ice thickness thermodynamic evolution in 2007–2011 ice seasons, obtained using different meteorological data as external forcing, showed that at the same parameterization of physical processes in the snow-ice cover thermodynamic model, the computational snow-ice thickness values can vary significantly. The greatest similarity of the reconstructed seasonal variations in ice thickness in the Taganrog Bay northeastern part with the data on the sea ice thickness taken from ESIMO ice maps was obtained using the observations taken 8 times per day of the main meteorological parameters at the Taganrog weather station (RIHMI – WDC) in the array model. The model constructed on the basis of SKIRON data is usually overestimated, and on the ERA-Interim data – is an underestimating one. This is largely due to the determination of precipitation amount, the prognostic values of which in ERA-Interim are greater than in SKIRON. However, even in calculations without taking into account precipitation (or in ice seasons with a small amount of them), the model based on the SKIRON data gives higher ice thickness values than the one based on ERA-Interim data. The analysis of the simulation results showed that for adequate reconstruction of ice regime characteristics in the Sea of Azov, it is necessary to carry out a preliminary adjustment of the thermodynamic model depending on the selected data set used as atmospheric forcing.

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