# Numerical simulation of the reaction of surface thermobaric field to temperature anomalies on the ocean surface

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The results on the surface thermobaric field calculated using the ICM MG SB RAS global circulation model with the allowance made for real changes in the sea surface temperature (SST) during the 19 years from 1982 through 2000 are compared with the NCEP / NCAR Reanalysis data. The model calculations underestimate the level of the eddy activity, which results in the systematic deviations of the surface pressure from the NCEP / NCAR Reanalysis data in the middle and high latitudes. The degree of SST effect on the continental areas decreases quickly with the distance from the shore. The exclusions are the regions affected by the North Atlantic, North Pacific, and Southern Oscillations. Quite high amplitude of the surface pressure oscillations not connected with the SST-induced oscillations in the interior Asia suggests the existence of an independent source of interannual oscillations of the atmospheric circulation in this region.

Variations of the ocean surface temperature (OST) are among the major factors of long-term variability of the climatic characteristics of the atmosphere.[1] The effect of OST on the thermal and circulation conditions of the atmosphere over oceans is especially important. The correlation between the near-surface pressure and OST achieves $\sim -0.7$ in the tropics and $\sim 0.7$ in the mid-latitudes. Therefore, to reveal other factors of climatic variability, for example, heliogeophysical ones, it is necessary to exclude the OST-induced variations from the time series of observations.

For analysis of variations of the meteorological quantities due to OST variations, we used the ICM MG SB RAS global circulation model[2] with the OST observations interpolated to the nodes of a regular grid (SST Reynolds) as boundary conditions. The calculations have been carried out for the period since 1982 through 2000. The results on the thermobaric field calculated for the level closest to the ground ($\sigma = 0.992$, where $\sigma = p / p_s$, $p_s$ is the near-surface pressure), were then compared with the NCEP / NCAR Reanalysis data.

Figure 1*a* shows the differences between 19-year averaged diurnally mean values of the near-surface temperature obtained from the NCEP / NCAR Reanalysis data and by the model calculations at the nodes of the $10 \times 10°$ grid. As would be expected, the temperature differences over oceans are close to zero, while over continents the differences are more significant, especially, in the high and midlatitude regions of the Northern Hemisphere and high latitudes of the Southern Hemisphere. In these zones, the observations give much more lower temperatures than model calculations do. In the midlatitudes over continents, the differences between the mean temperatures are much smaller, and the calculated temperatures prove to be lower than the observed ones. The difference in the zonal temperature contrasts is possibly caused by an incorrect parameterization of the radiation budget in the global circulation model or the effect of orography, which is hard to be taken into account in simulation.

To estimate the effect of the OST variations on the thermal conditions of continental regions, the correlation coefficients of variations of the annual mean temperatures were determined by the model calculations and by the NCEP / NCAR Reanalysis data (Fig. 1*b*). The correlation achieves 90% and higher over oceans and decreases inland. The correlation coefficients of temperature variations over Europe, Alaska, central parts of Africa, and South America are higher. This is likely caused by the effect of the North Atlantic, North Pacific, and Southern Oscillations. In contrast to observations, the model calculations made for the continental regions give practically no significant variations and trends of the annual mean temperature.

For analysis of the features in simulation of atmospheric circulation, Fig. 2*a* shows the differences between the mean values of the calculated near-surface baric field and the field reduced to the sea level by the NCEP / NCAR Reanalysis data. If we exclude from consideration high mountains and ice shield of the Antarctic, where the calculated results not reduced to the sea level are much lower than the Reanalysis data, the widest deviations prove to be concentrated in the middle and high latitudes over the oceans. These differences are probably caused by a relatively low spatial resolution of the model ($4 \times 5°$), which significantly decreases the level of eddy activity, characteristic for the latitudinal zones analyzed, especially, in the region of circumantarctic depression. However, it should be noted that the observation network in the region of depression is too widely spaced, and the level of eddy activity in this region should be discussed with care.

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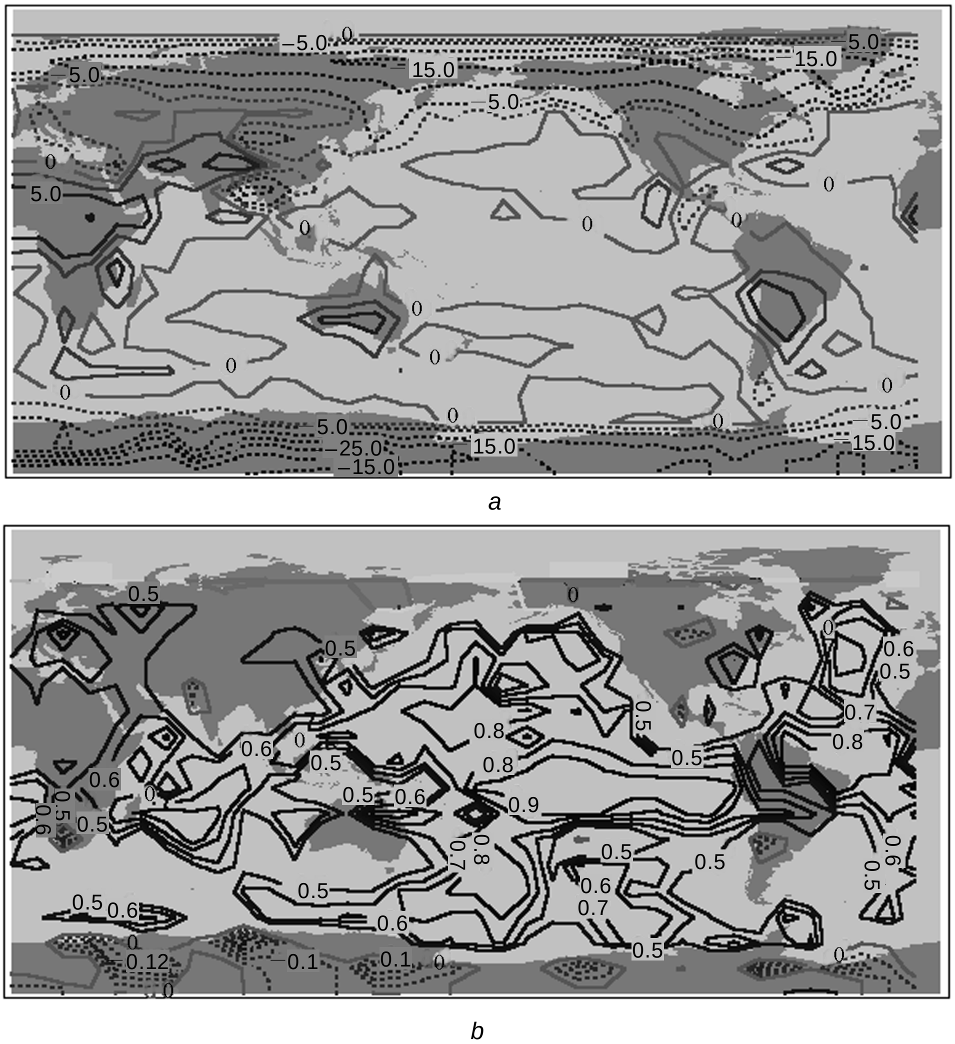


**Fig. 1.** Difference between the mean values of the near-surface temperature for 19 years according to the NCEP / NCAR Reanalysis data and model calculations. Solid lines show regions of positive difference and dashed lines show regions of negative difference (*a*); the correlation coefficients between variations of the annual mean temperatures obtained by the model calculations and the NCEP / NCAR Reanalysis data. Solid lines show regions of positive correlation and dashed lines show regions of negative correlation (*b*).

For a comparison between the interannual variations, Figs. 2*b*, and *c* show the distributions of the correlation coefficients of variations of the near-surface pressure according to the model results and observations separately for summer and winter months. The model results for baric anomalies are the best in the winter months. The zone of high positive correlation covers almost all the Pacific Ocean (except for the far north-west), eastern Africa, western Indian Ocean, Australia, and Northern Atlantic. The zones of negative correlation cover Europe, northeastern Asia, eastern North America, Southern Atlantic, eastern Indian Ocean, and South America. In summer, the zone of negative correlation occupies significant part of the Northern Hemisphere. The values of the correlation coefficient in this zone are relatively low and, as can be seen from the direct comparison of the figures, are likely caused by random fluctuations than by the opposing pressure variations. To explain the features in variations of the baric fields, it is necessary to pay more attention to the relation of two factors, namely the OST-dependence of the eddy activity and the quasistationary centers of action. The model accounts for the latter more adequately than for the former one. Possibly, this explains partly the spatial structure of the correlation fields.

To illustrate the temporal variations of the near-surface temperature and the baric field, Fig. 3 shows the plots of variations of these parameters drawn based on the calculated results and the observations. The baric fields in the central part of the Pacific Ocean demonstrate very high level of correlation (Fig. 3*a*). Near the shores, the correlation decreases, and inland the calculated and observed pressure variations, having roughly equal amplitudes, do not correlate (Fig. 3*b*). The higher correlation is inherent in inland areas in the zone of Southern Oscillation (Fig. 3*c*). Temperature variations correlate in Europe (Fig. 3*d*), which, as was noted above, is likely caused by the North Atlantic Oscillation.

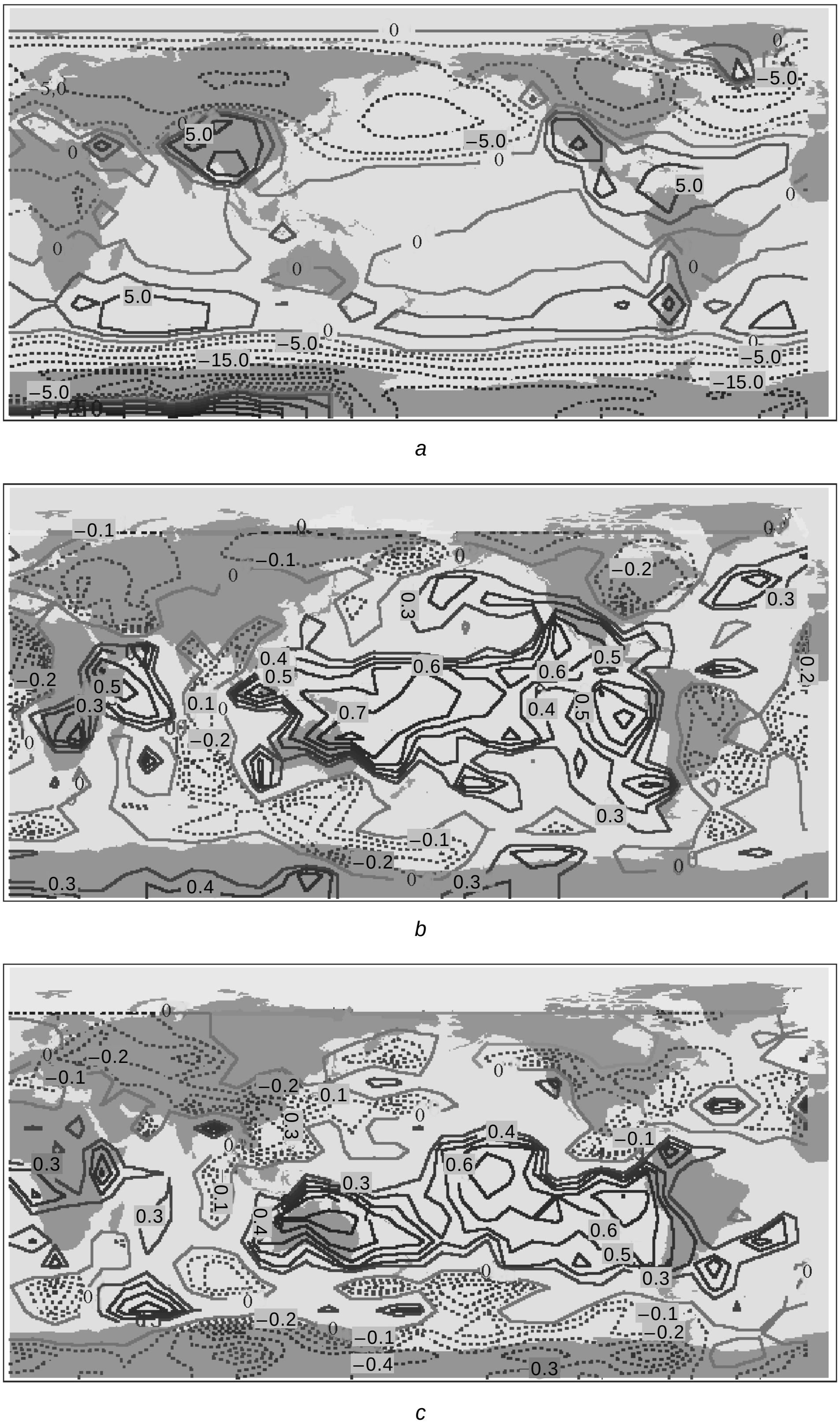


**Fig. 2.** Differences between the mean values of the model near-surface baric field and the baric field according to the NCEP/NCAR Reanalysis data reduced to the sea level. Solid lines show regions of positive difference, dashed lines show regions of negative difference (*a*); distribution of the correlation coefficients of near-surface pressure variations by the model results and observations in winter months (*b*); distribution of the correlation coefficients in summer months (*c*). Solid lines show regions of positive correlation, dashed lines show regions of negative correlation.

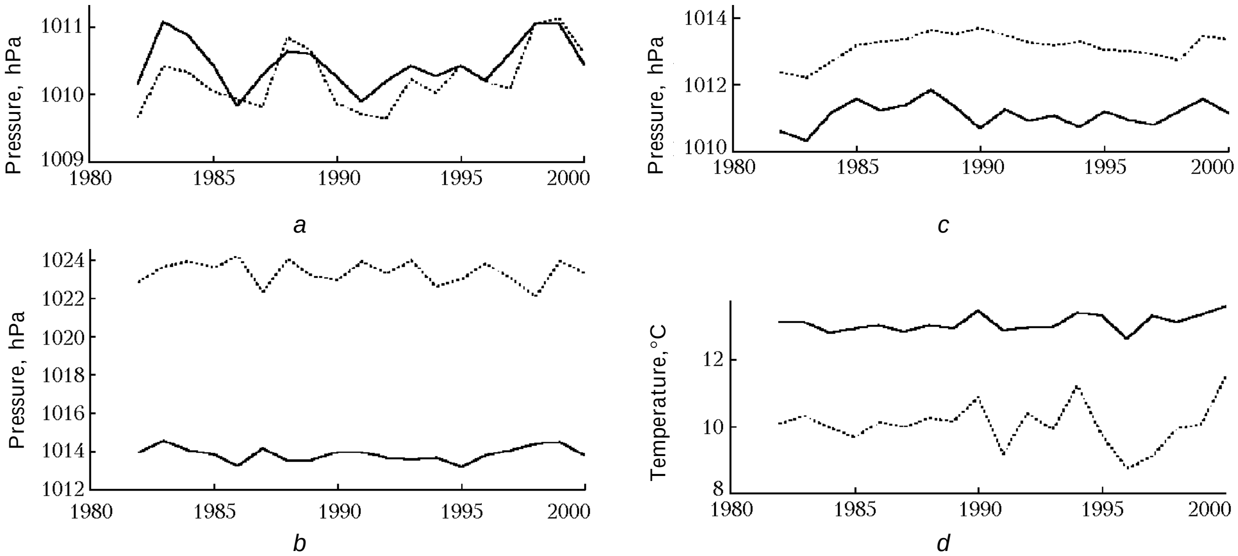


**Fig. 3.** Calculated (dashed curves) and observed (solid curves) variations of near-surface temperature and baric field at the points with the coordinates: 150°W, 0°N (*a*); 100°E, 50°N (*b*); 110°W, 30°N (*c*); 20°E, 45°N (*d*).

## Conclusions

The results of modeling the near-surface thermobaric field with regard for real variations of the ocean surface temperature for 19 years since 1982 through 2000 have been compared to the NCEP / NCAR Reanalysis data. The differences are small over oceans and increase inland, where the calculations practically fail to reveal significant variations and trends of the annual mean temperature. The correlation coefficients between the interannual variations of the calculated and observed near-surface pressure also decrease quickly with the distance from a shore. Exceptions are the zones of influence of the North Atlantic, North Pacific, and Southern Oscillations. This fact is indicative of the existence of a different (than OST) source of interannual variations in the atmospheric circulation.

## Acknowledgments

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## References

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