Predictions of extremely low near-surface temperatures over Eastern Siberia in winter with spectral model with different resolutions

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The near-surface temperature forecasts with the two versions of the spectral medium-range forecast model of the Hydrometeorological Center of Russia, T85L31 and T169L31, are compared. Interestingly, the appreciable progress in the model performance due to the increase in its horizontal resolution was found for some events, characterized by large horizontal scales. The simulation of extremely low temperatures in quite a uniform winter Asian anticyclone in Eastern Siberia is an example. A considerable improvement of its predictions with T169L31 is mainly due to the topography effect. The configuration of relatively low but extended relief forms is a factor strongly affecting the near-surface atmospheric cooling (down to -50 -70ºC) over large regions. The orography, used in the model with coarser resolution, is too smoothed in vertical and diffused in horizontal. Low elevations are smoothed in vast regions to a plane pattern thus essentially distorting the atmospheric circulation in the lowermost model layers. And, in turn, the horizontal transfer in the lower atmospheric layers may strongly affect the near-surface temperature regime under highly stable stratification.

Fig. 1 demonstrates the skill of temperature forecasts over Eastern Siberia with T85L31 and T169L31 models for the period of very low temperatures of about -50℃. The T169L31 forecasts are much better because of the improved resolution.

Fig. 2 shows the orography used in two versions of the model. The Verkhoyanskii ridge, the plateau Putorana, and relatively low, but nevertheless important**,** relief forms, which actually prevent the horizontal mixing of the air over inner regions of Yakutia with warmer air masses in the west and east, are too plane in the T85 orography. We managed to catch these morphometric features in the T169 orography. As a result, the spatial distribution of the near-surface air temperature was predicted better with T169L31 (see Fig. 3). The boundary layer parameterization based on the Monin-Obukhov theory (used in both versions of the model) was successful in describing the case of highly stable stratification.

Eastern Siberia is not the only place, where the above-described situation can occur. Similar events were observed in other parts of the polar regions.

Thus, the low-resolution model not only failed to describe small details of the temperature fields, but also introduced large errors in vast regions with badly described relief and was not able to “catch” some important classes of large-scale events (for example, extremely low temperatures over large regions). This conclusion is important for determining the configuration of an ensemble prediction system. The Hydrometcenter of Russia system now operates with T85L31. And the above results show that we should increase both the size of the ensemble and the resolution of the model applied. Otherwise, some large-scale important events may be missed.

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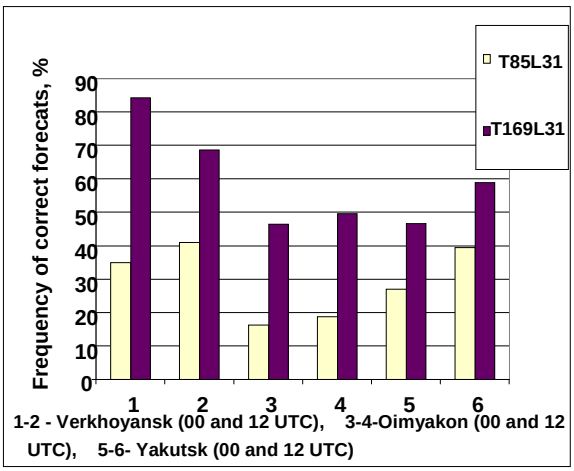

Fig.1. The skill of forecasts of 2-m temperature (the frequency of hitting the interval $T_{observed}$±3ºC, averaged for lead times of 12, 24, 36, and 48 h) in December 2007 at different points in Yakutia for T85L31 and T169L31 models.

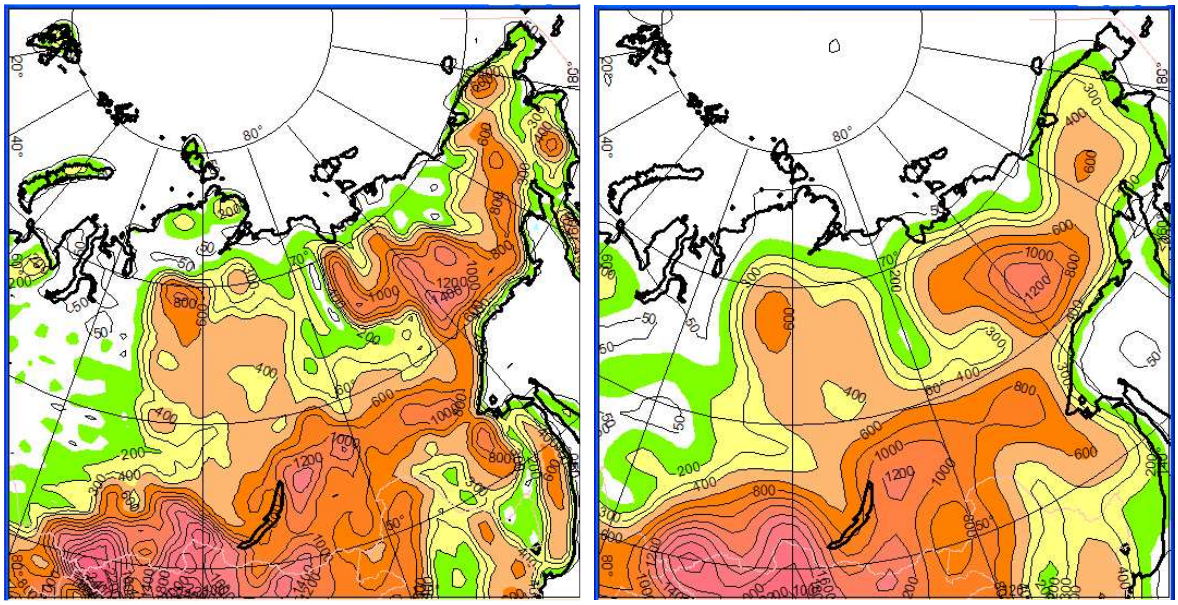

Fig.2. Model orography for T169 (left) and T85 (right). Siberia.

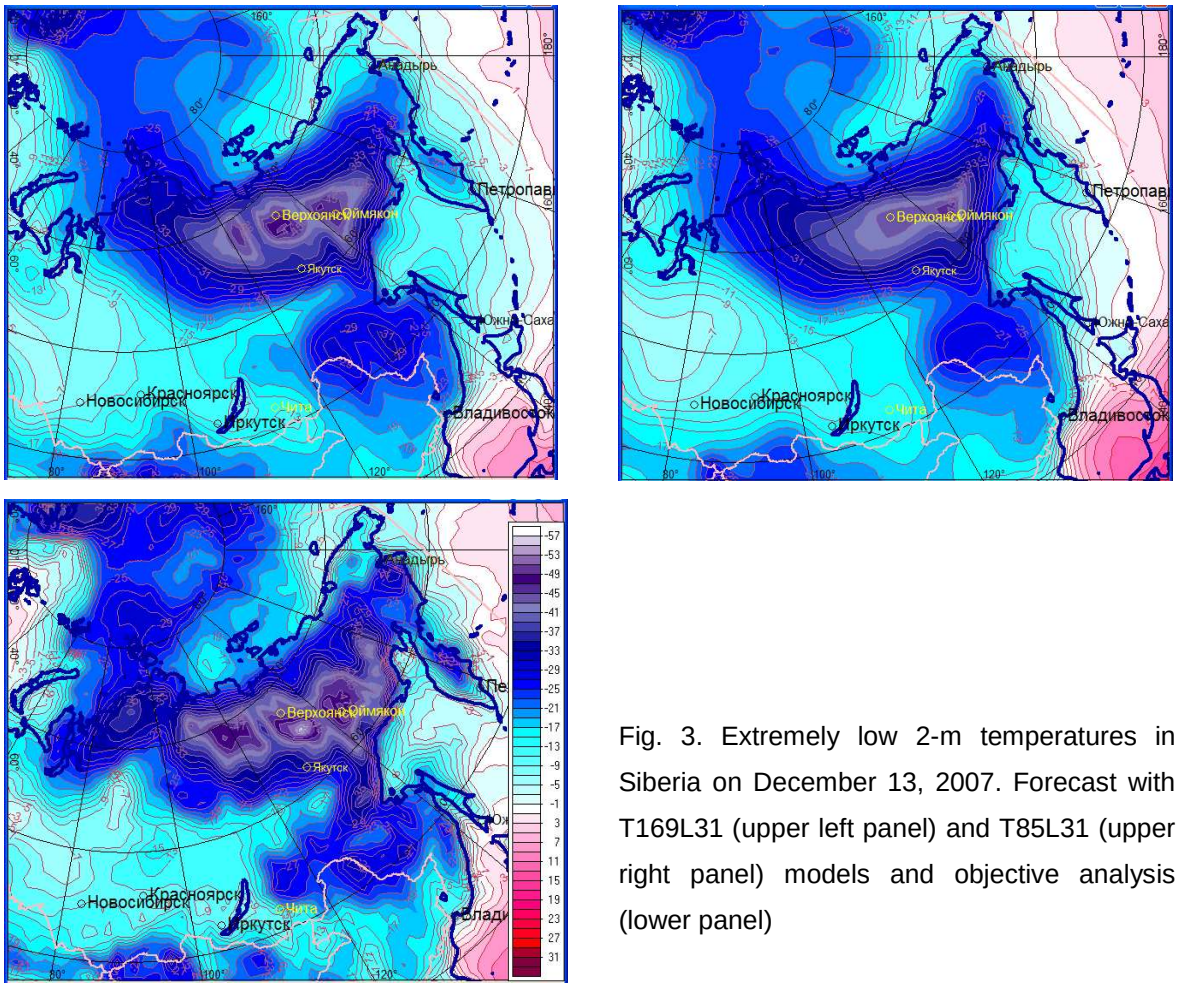

Fig. 3. Extremely low 2-m temperatures in Siberia on December 13, 2007. Forecast with T169L31 (upper left panel) and T85L31 (upper right panel) models and objective analysis (lower panel)