The stability of the statistical model of the hydrodynamic-statistical forecast of the dangerous summer wind over the territory of Siberia

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INTRODUCTION

The territory of Siberia is more great then territory of European part of Russia. Development of successful method of forecast of storm summer winds, including squalls and tornadoes, that often result in human and material losses, could allow one to take proper measures against destruction of buildings and to protect people. Well-in-advance successful forecast (from 12h to 36h) makes possible to reduce the losses. Prediction of these phenomena involved is a very difficult problem for synoptic of Siberia till now day. The existing graphic and calculation synoptic methods still depend on subjective decision of an operator. At the present time in Russia there is no hydrodynamic model for forecast of the maximal speed of storm wind and heavy rainfalls with Q more 20mm/12h. Hence the main tools of objective forecast are statistical methods using the dependence of the phenomena involved on a number of atmospheric parameters (predictors). We have adapted for the territory of Siberia our hydrodynamic-statistical operative methods of forecast of these phenomena for Europe.

THE STATISTICAL MODEL OF SQUALL AND TORNADO ALTERNATIVE FORECAST

- The meteorological situation involved the dangerous phenomena –the squalls and tornadoes with the velocity V>24m/s-, is submitted as the vector X(A)=(x1(A), x2(A), …xn(A)), where n – the quantity of the empiric potential atmospheric parameters (predictors).
- The values of these predictors for the dates and towns, where these phenomena are observed, were accumulated in the set {X(A)} – the learned simple of the phenomena A presence.
- The learned simple of the phenomena A absence or the phenomena B presence ({X(B)}) was obtained for such towns, where the atmosphere was unstable and the thunderstorms and the rainfalls were frequently observed, but the velocity values were not so great (V<8-10m/s).
- The recognition model of the sets {X(A)} and {X(B)} was constructed by using the Byes approach ([1] and [2]), realized on FORTRAN at the CRAY and XEON:
- $U(X)=\sum a_i x_i + c$, =1,…,n. (1)
- The decisive rule of the forecast of the wind (V>19m/s):
- If U(X)>0, then the phenomenon A is predicting in given point and at its suburb of 150km;
- If U(X)≤0, then the phenomenon B is predicting in given point and its suburb of 150 km. (2)

THE CRITERION OF MAHALANOBIS DISTANCE
AND THE CRITERION OF ENTROPY MINIMUM

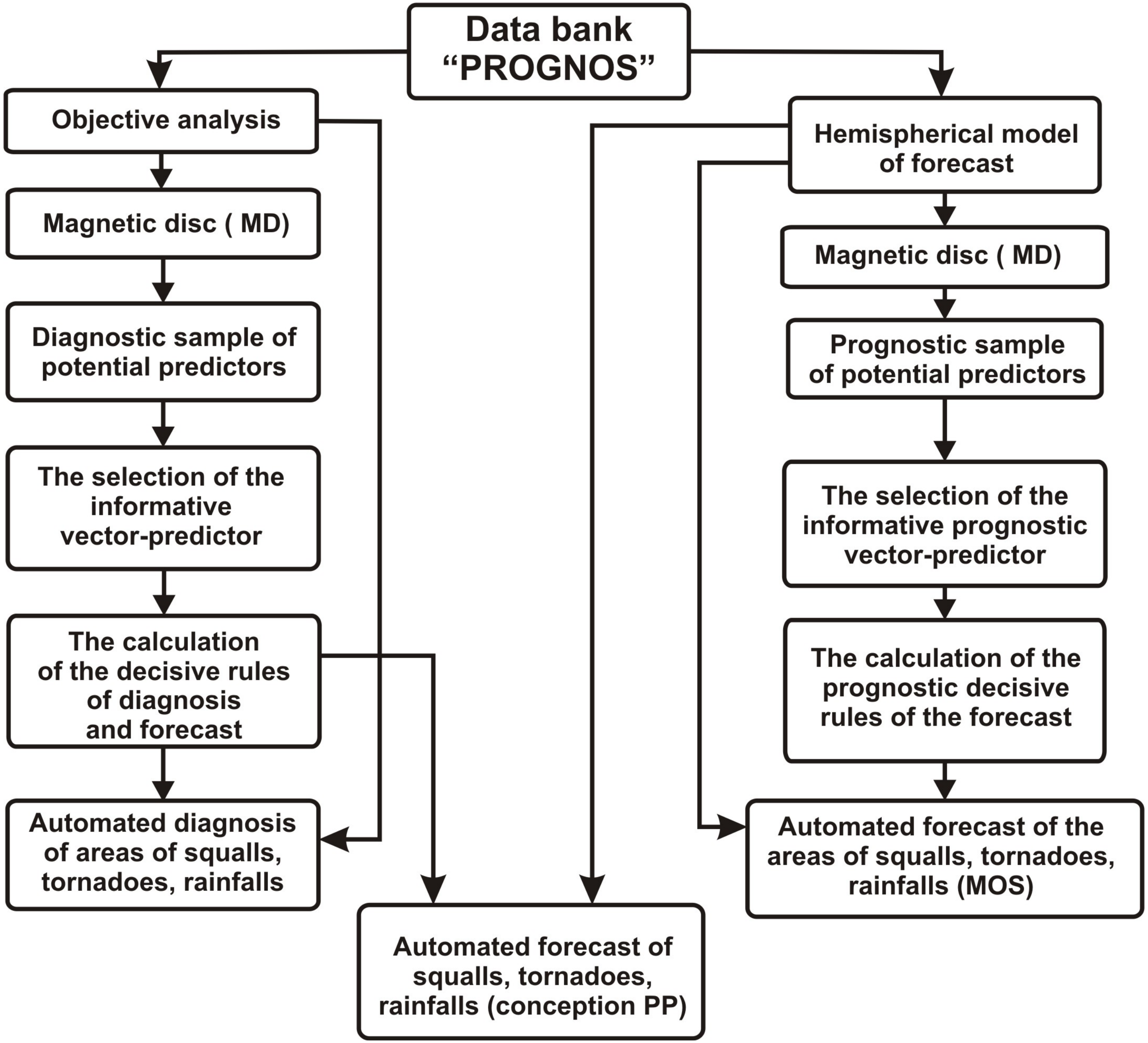
- The most informative predictors in each of the blocks was taken as a representatives from this block. For this purpose we have estimated the informativition of each predictors by using the criterion by Mahalanobis distance Δ^2 [1,2] :
- $$\Delta^2 = (m_i(A)-m_i(B))\uparrow 2/\sigma^2 , \qquad (3)$$
- where $m_i(A)$ and $m_i(B)$ are the components of M(A) and M(B) - of the vectors of empiric expectation of the presence and absence of A respectively, σ^2 – the mean variance.
- Also the criterion of entropy minimum by Vapnik-Chervonenkis H_{min} was used for the assessment of the informativition of predictors [3].
- The criterion Δ^2 is applied for normal distribution as a rule, while the temperature, the pressure, the geopotential, the mean velocity of wind at the different level are distributed close to the normal one, so we have decided to use this criterion as a very sample method.
- The criterion H_{min} of Vapnik-Chervonenkis is nonparametric method, we have got the program for the calculation the values H_{min} for each of the predictors.

- As a result, the groups of the most informative predictors calculating by Δ^2 and by H_{min} are coincided, and the informative vector-predictor has been composed from six atmospheric parameters after this selection:
- (V_{700}, H_0, $(T\text{-}T')_{500}$, dt/dn_{ea} , T_{ea} , T_d), where
- -V_{700} – the value of the mean velocity of the wind on the level 700 hPa, м/s;
- - H_0 – the level of the isotherm of 0°C , hPa;
- -$(T'\text{-}T)_{500}$ – the difference between the values of the stratification curve and the moist adiabat on the level 500 hPa, °C
- - dt/dn_{ea} –the maximal difference between temperatures over the front on the earth level in the vicinity of 500 km from the forecast point.
- - T_{ea} – the maximal temperature on the earth level, °C;
- - Td – the maximal temperature of the dew point on the earth level, °C.
- The validation assessments of this statistical model of objective physical-statistical forecast of dangerous wind (V>19m/s) in accordance with (2) over the European territory of Russia were very high (the criterion by Pirsy-Obukhov is $T = 1 - \alpha - \beta = 0{,}63$, where α – the error of first kind, β – the error of second kind [4].

THE MODEL OF AUTOMATED HYDRODYNAMIC-STATISTICAL FORECAST AND THE VALIDATION OF THIS METHOD OVER THE NORTH-WEST TERRITORY OF RUSSIA

- **The values of atmospheric parameters used at the new objective statistical method of squalls and storm wind were calculated by synoptic. The development of the hydrodynamic models of the short-term weather forecast allowed us to develop the automated statistical forecast of the weather phenomenon – squalls and dangerous wind. We have made the new selection of atmospheric parameters informative vector-predictor from new set of forty potential predictors. The selection was made by same method [2] of diagonalization of new mean correlation matrixes R1 and R2. The two new discriminant functions were calculated for two classes: U1 (X) - for the recognition of the wind (V>19m/s) and U2(X) - for the recognition of the wind (V>24m/s) respectively.**
- **These functions and the probabilities of forecast (V>19m/s)**
  - **P1(X)=1/(1+exp(-U1(X))** **(4)**
- **and the probabilities of wind forecast (V>24m/s)**
  - **P2(X)=1/(1+exp(-U2(X))** **(5)**
- **were calculated in the nodes of the grid 150x150km of hemispheric hydrodynamic model for the European part of Russia. The assessments of dangerous wind forecast at the 2003-2005 years were the best (T=0,62-0,75) (Tabl. 1).**

The scheme of diagnosis and forecast of dangerous convective phenomena like squalls, tornadoes, rainfalls.



Результаты независимых испытаний гидродинамико-статистического метода прогноза летних опасных ветров скоростью не менее 25 м/с по территории ВВУГМС, СЗУГМС и УГМС Республики Татарстан за 2003-2005гг.

Количество прогнозируемых случаев.	Количество фактических случаев		Сумма	Оправдываемость прогноза, %	Предупр. прогноза, %	Общая оправд. прогноза, %	Критерий Пирси-Обухова
	С явлением	Без явления					
Верхне-Волжское УГМС							
С явлением Без явления Сумма	n_{11} **11** n_{21} **5** n_{01} **16**	n_{12} **157** n_{22} **1662** n_{02} **1819**	n_{10} **168** n_{20} **1667** n_{00} **1835**	Ия=**6,5** Ибя=**98**	Пя=**68,8** Пб.я=**91**	F=**91,2**	Т=**0,60**
Северо-Западное УГМС							
С явлением Без явления Сумма	n_{11} **14** n_{21} **1** n_{01} **15**	n_{12} **23** n_{22} **829** n_{02} **852**	n_{10} **37** n_{20} **830** n_{00} **867**	Ия=**38** Ибя=**99**	Пя=**93,3** Пб.я=**97**	F=**97**	Т=**0,90**
УГМС Республики Татарстан							
С явлением Без явления Сумма	n_{11} **7** n_{21} **1** n_{01} **8**	n_{12} **49** n_{22} **344** n_{02} **393**	n_{10} **56** n_{20} **345** n_{00} **401**	Ия=**12** Ибя=**99,7**	Пя=**87,5** Пб.я=**87**	F=**87,5**	Т=**0,75**

F – общая оправдываемость прогноза;
Ия – оправдываемость прогноза явления;
Ибя – оправдываемость прогноза без явления;
Пя – предупрежденность прогноза явления;
Пбя –предупрежденность прогноза без явления;
Т- значение критерия Пирси-Обухова

THE STABILITY AND VALIDATION OF THE HYDRODYNAMIC – STATISTICAL FORECAST OF DANGEROUS WIND AT THE TERRITORY OF SIBERIA

1. For the forecast of the phenomenon of the dangerous wind with the given earliness 12, 24, 36h the values of the discriminant functions and the probabilities of these phenomena were calculated using the prognostic values of operative hemispherical model of Hydrometeorological Center of Russia in the nodes of the rectangular mesh 150x150km over the territory of Siberia. The author proposes the empirical threshold of the probability Pth for the dangerous wind categorical forecast for each earliness 12, 24, 36h. The prediction in the period 2004-2005 with the earliness 36h of the summer wind (V>24m/s) was so exact. In Novosibirsk and Altay on 24.06.05 (V=37m/s!), at the territory of Buryatia on 8-9.08.05, in Tyumen and Omsk areal on 18.06.05 and other (fig. 1 - 5).

The value of estimate of the warning is W=86% and T=0,78 [7,8].

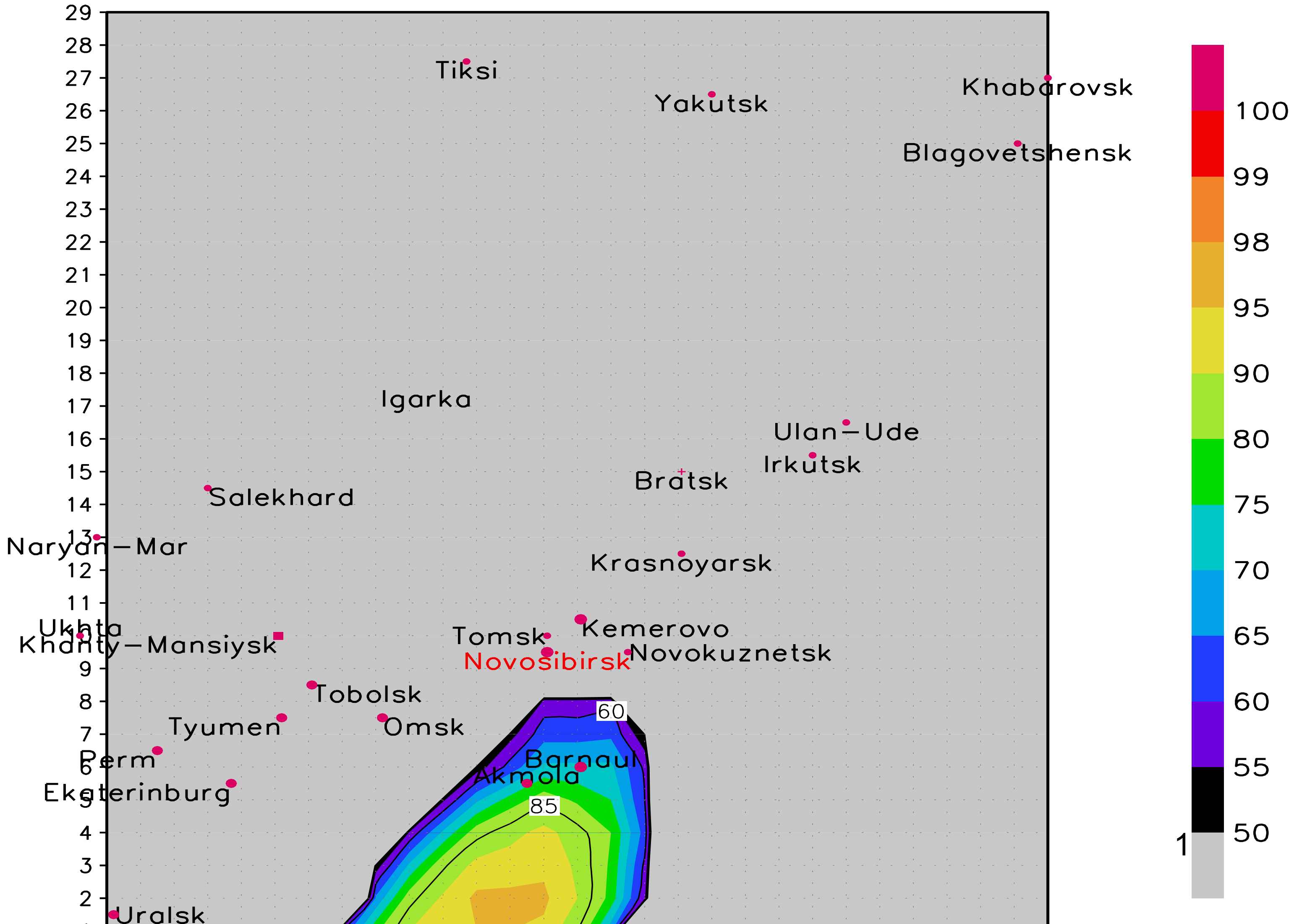
2. The new hydrodynamic-statistical forecast of squalls and wind (V>24m/s) based on the same statistical model and using the output fields of regional model (the author – Losev V.M.) was developed during 2007-08 years for the European part of Russia. Now it is operative automated forecast in Hydrometcenter of Russia for the European part of Russia .

This forecast method was adapted and applied to the territory of Siberia during the period of 2009-2010y. The examples of this forecast of the wind (V>24m/s) with earliness 12, 24, 36 and 48h are submitted at the fig. 6-10. The results of the forecast of these dangerous phenomena are good enough.

CONCLUSION

The results of the application of the first and of the second methods of the forecast of dangerous wind show us that the developed statistical model of the recognition and prediction of dangerous wind at the territory of Siberia is stabile. The more successful estimates of dangerous phenomena forecast could be given by the application of the output field of the new hydrodynamic models.

The forecast of the dangerous wind (V>24m/s) to 24.06.05 with the earliness 36h over the territory of Siberia



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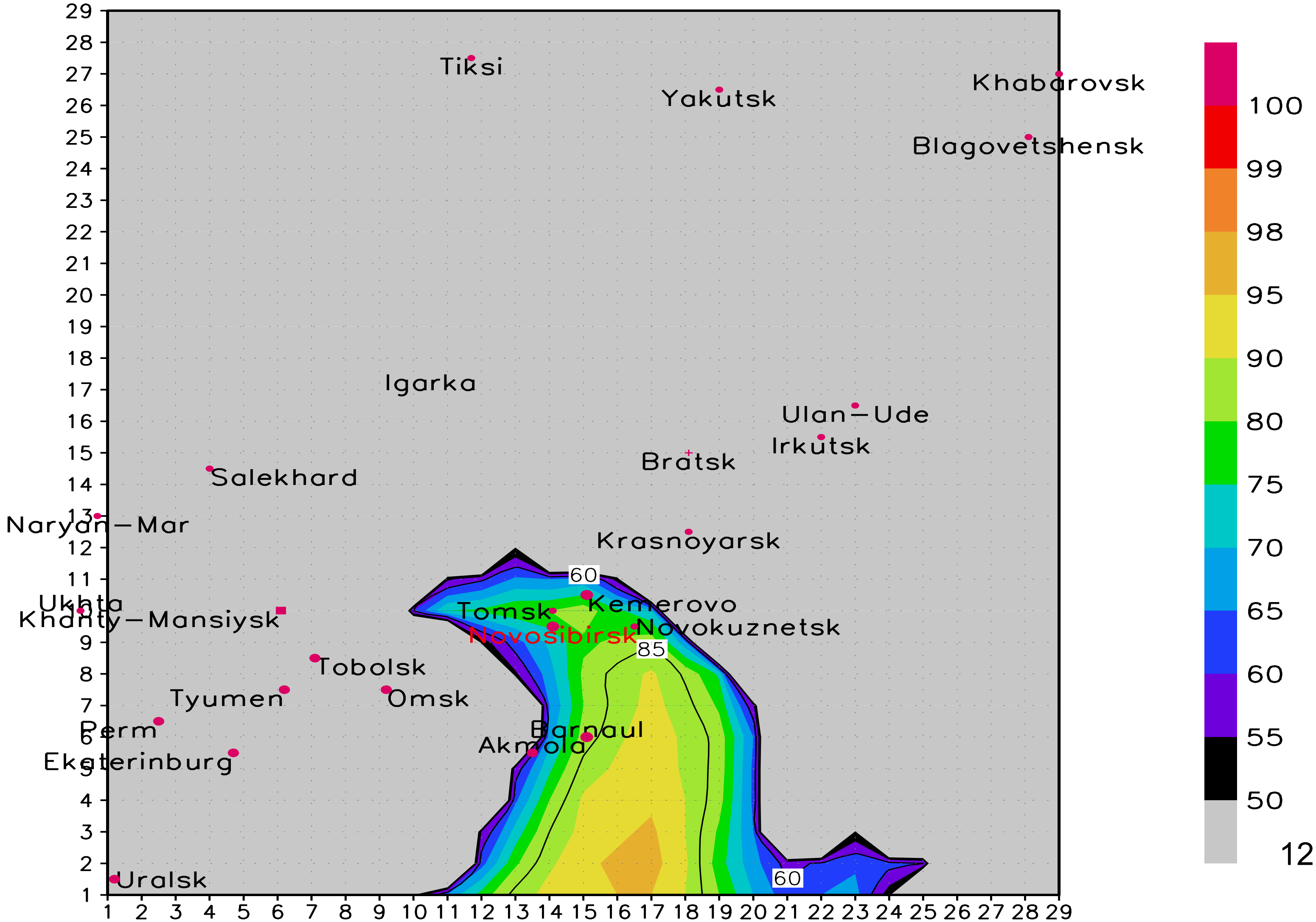
The forecast of the dangerous wind (V>24m/s) to 24.06.05 with the earliness 12h over the territory of Siberia



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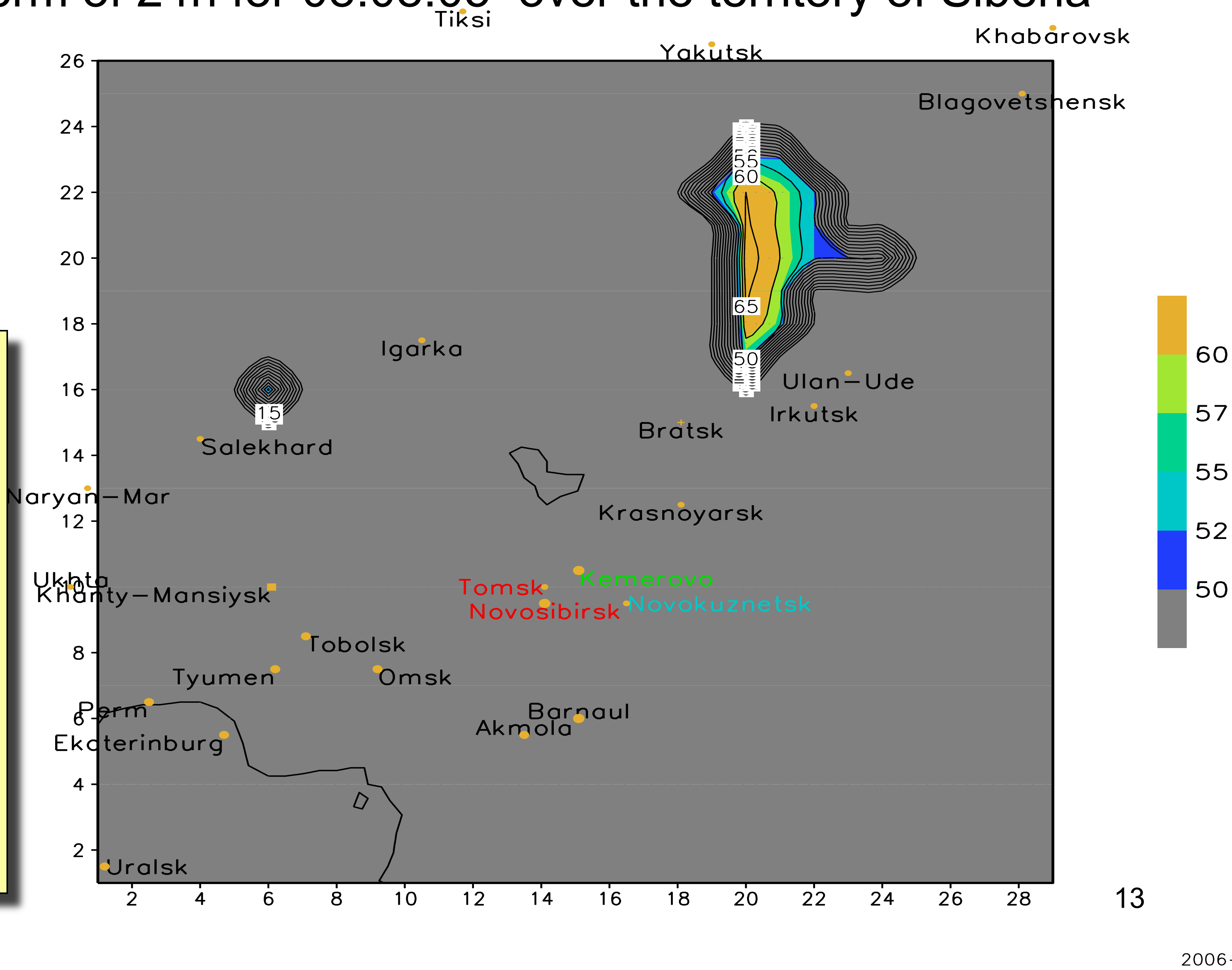
The forecast of day-time storm wind (V>24m/s) to the term of 24h for 08.08.05 over the territory of Siberia

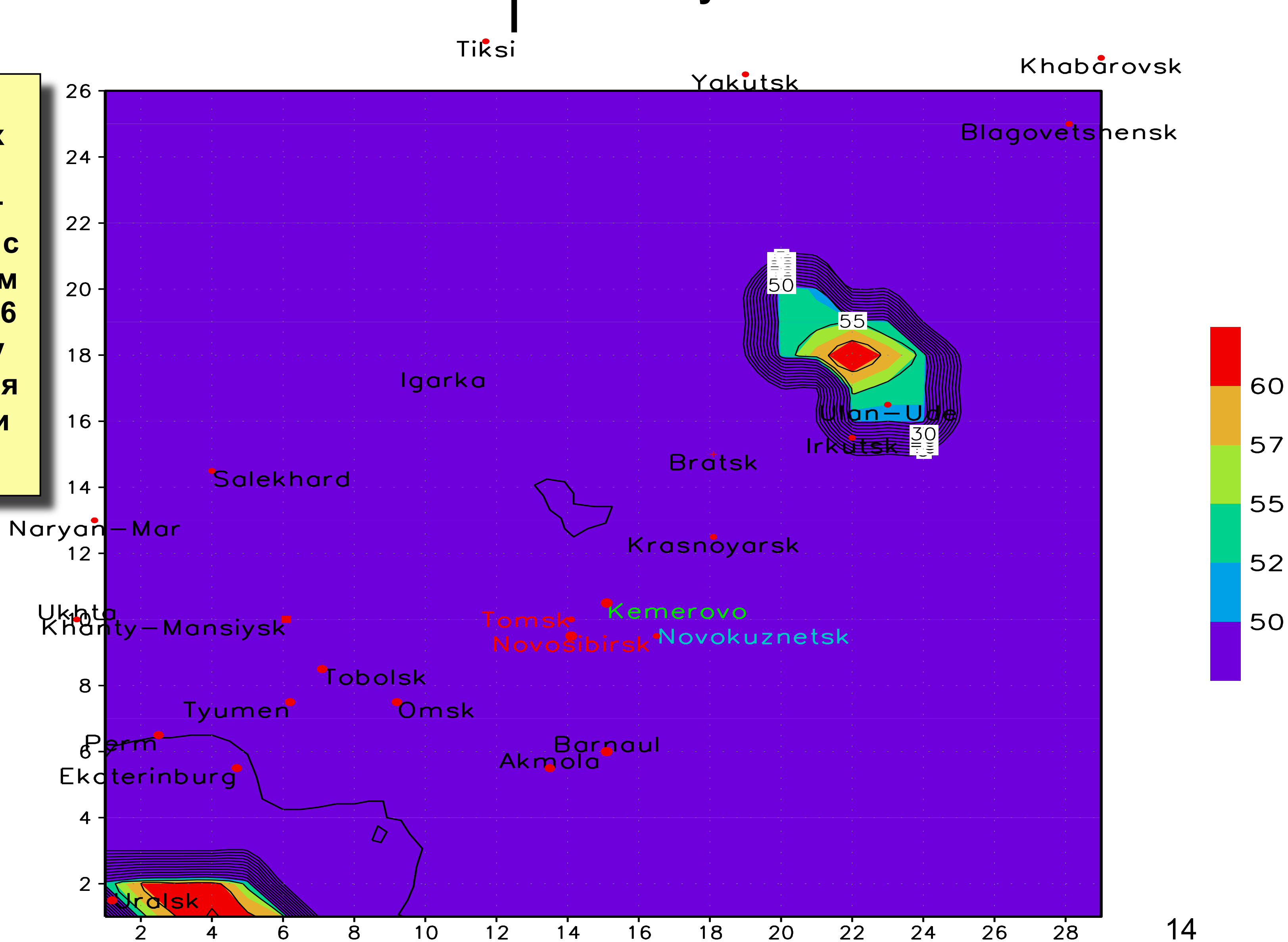


Прогноз стихийных дневных ветров по данным от 06.08.2005г. с заблаговременностью 24 ч. по сроку 12 ч. СГВ для территории Сибири

25.01.11

The forecast of day-time storm wind (V>24m/s) to the term of 36h for 09.08.05 over the territory of Siberia

Прогноз стихийных ветров по данным от 08.08.2005г. с заблаговременностью 36 ч. по сроку 00ч. СГВ для территории Сибири.



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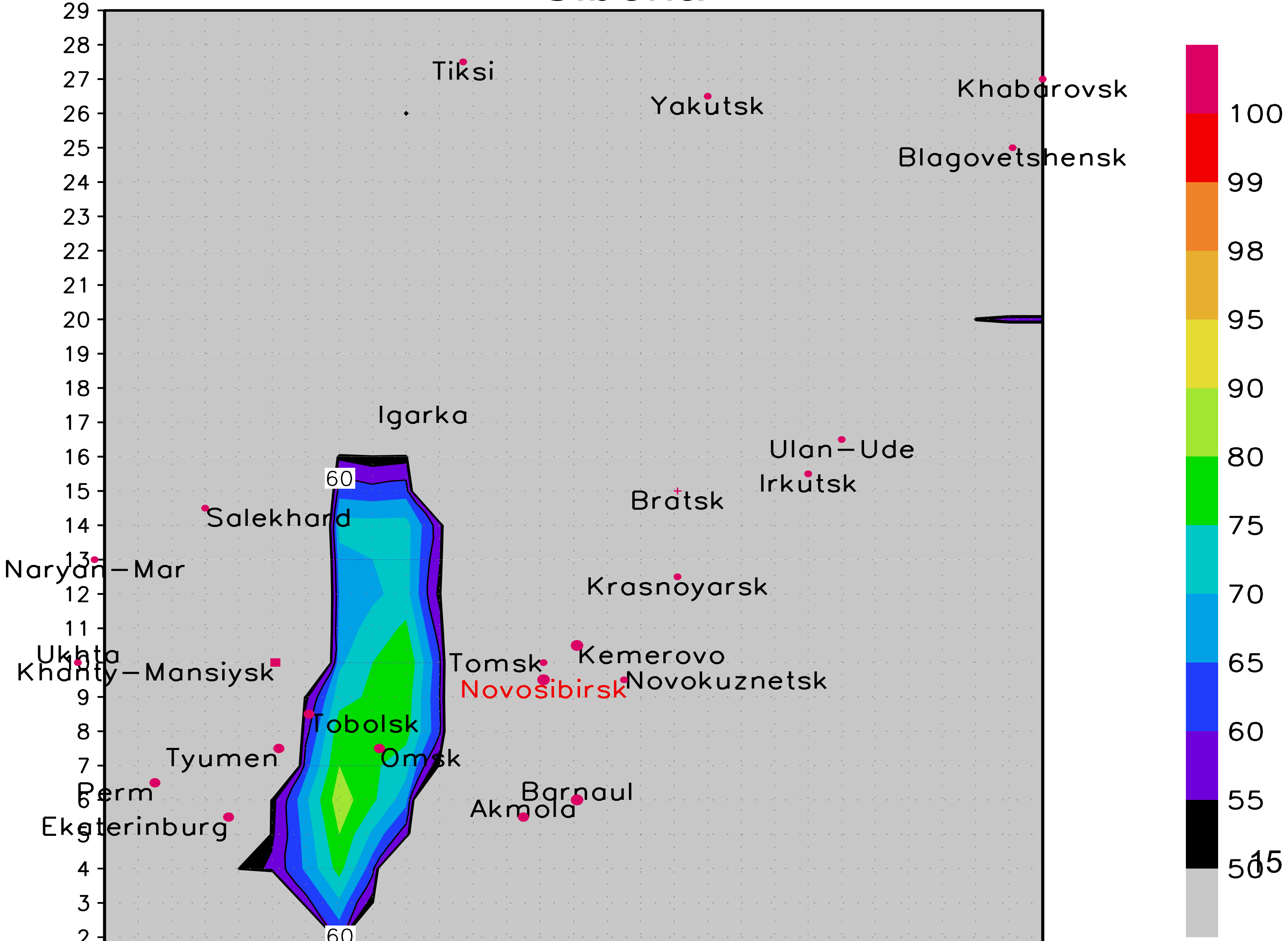
The forecast of the dangerous wind (V>24m/s) to 04.07.05 with the earliness 12h over the territory of Siberia



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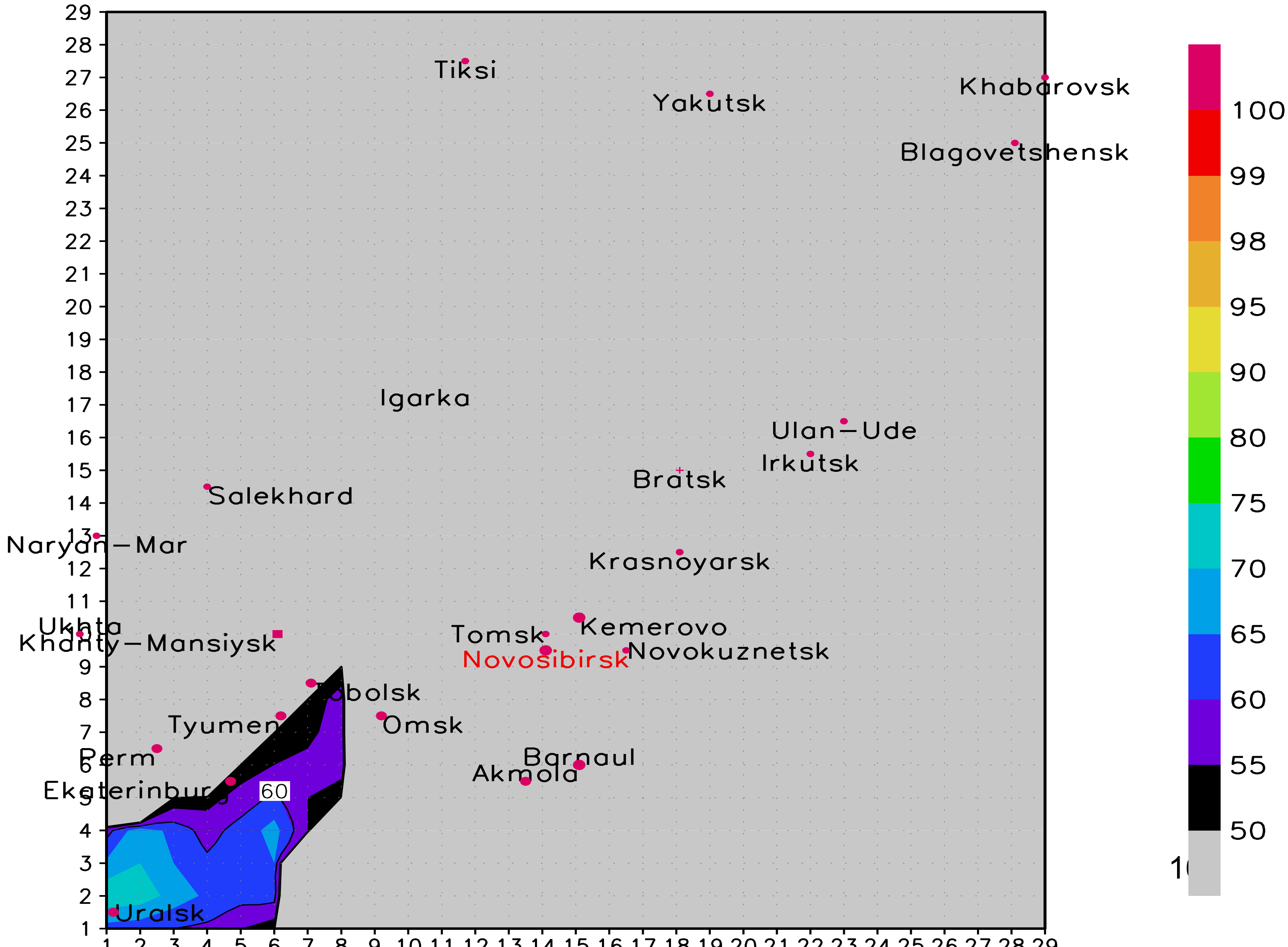
The forecast of the wind (V>24m/s) to 04.07.2005 with the earliness 36h over the territory of Siberia



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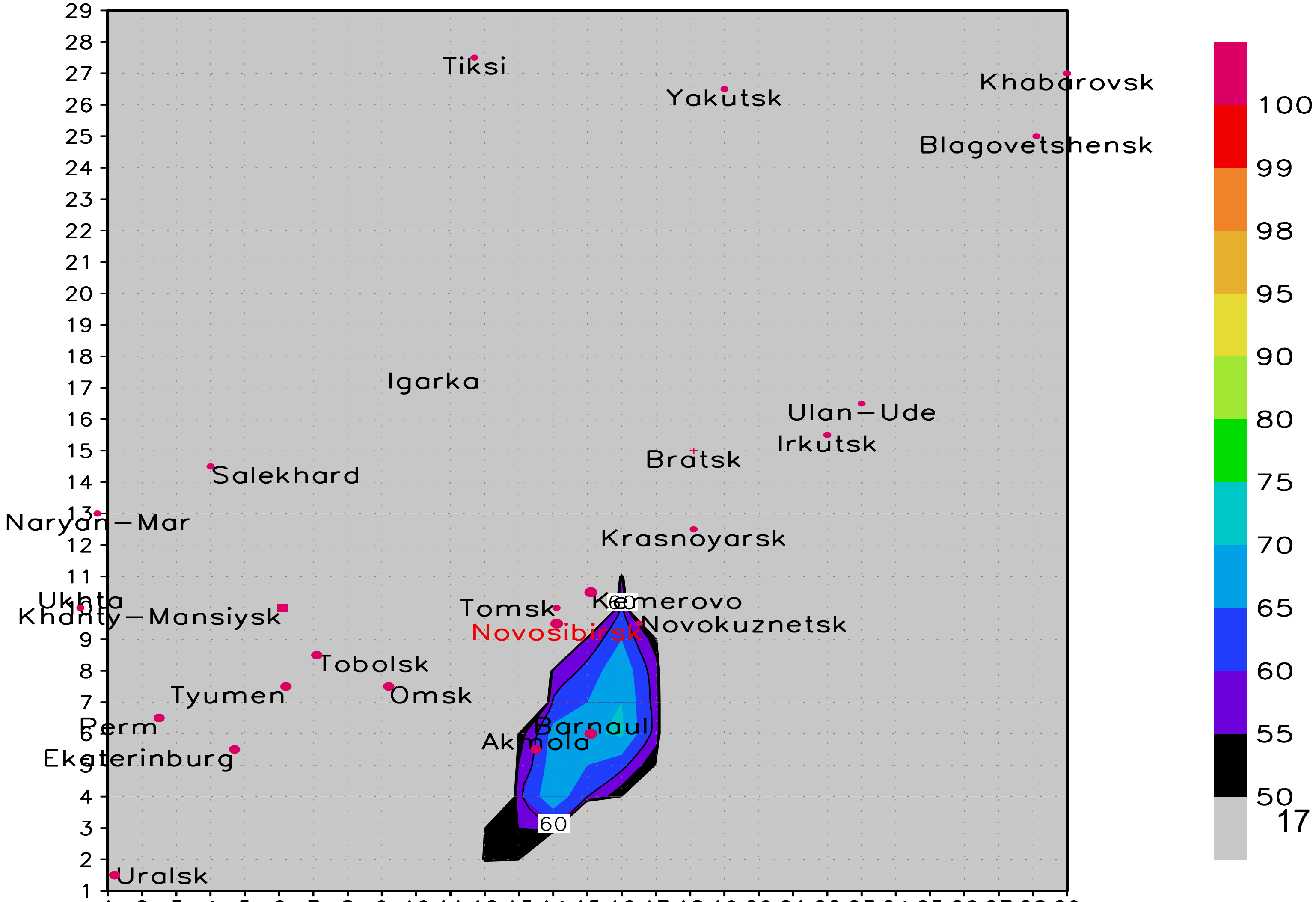
The forecast of the dangerous wind (V>24m/s) to 18.06.05 with the earliness 24h over the territory of Siberia



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Thanks

for your attention