The objective analysis of three-dimensional geometry of atmospheric fronts

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We try to evaluate atmospheric fronts' geometry on standard baric levels according to data of the objective analysis (or of the forecast) on the global regular latitude–longitudinal grid. The algorithm of such evaluation is offered.

Then we evaluate correlation functions (CF) for the principal meteorological fields as functions of a distance between pairs of points. We consider two pairs' ensembles: i) these two points are separated by a frontal line; ii) both points are not separated by any frontal line.

The difference between these CF is significant, that confirms our algorithm's quality.

1. New predictors of the frontal zones were used. Maximal eigen-values of the following matrices: Jacobi matrix of the horizontal wind and Hesse matrix of the geopotential or pressure on the sea level separate frontal zones better than traditional predictors: vertical component of wind's vorticity and Laplacian of the geopotential or pressure on the sea level, respectively. All the predictors are suitable for ideal media models, because they are equal to infinity on tangential discontinuity. However, for real viscous media (were the values are large but limited) new predictors are preferable.

2. To calculate first and second derivatives for the new predictors on a regular discrete two-dimensional grid we use fast Fourier transformation in the spherical case or 4–th order compact schemes in the plane one. The methods are more exact than traditional 2–th order's approaches. Then we "mix" the new predictors.

3. Heuristic methods of thin frontal zones evaluation along "crests" predictor were developed.

4. When the frontal lines are constructed, we evaluate two kinds of CF (fig. 1). Our approach guarantees their positive definiteness. NCEP forecast on 6 hours on latitude–longitudinal grid with the steps $1^\circ \times 1^\circ$ was used as a first guess for the evaluations. Thus, we evaluate covariation for the difference between observations' data and the first guess. The archive of the data as well as forecast fields on territory to the north from 30° for 323 days was used for the evaluation. The evaluation has demonstrated (fig. 1) the essential distinctions between two CF for autocorrelation functions of temperature and a wind and insignificant — for all crosscorrelation and autocorrelations of a geopotential.

5. Methods of a combination of several (three) fields predictors were offered: we maximize L^2 difference between CF for two clusters (two points are separated or not separated by the frontal line).

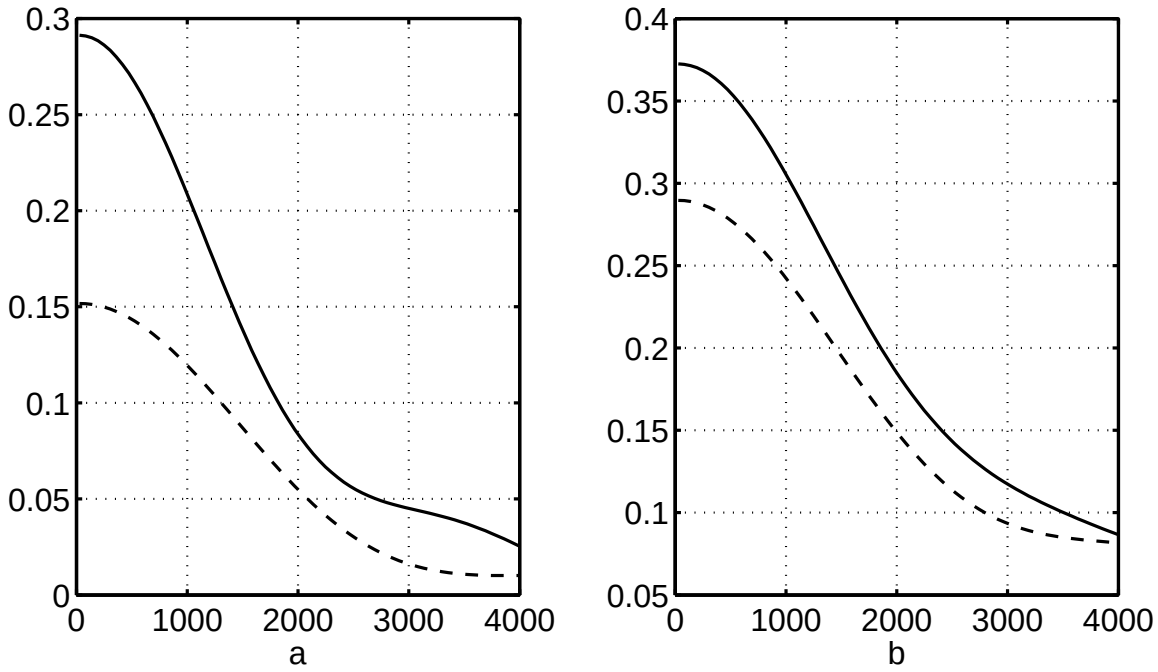

Fig. 1. Regular part of autocorrelation's functions on 300 gPa of difference between measurement and forecast a) temperature and b) geopotential for two clusters: i. two points are separated by the frontal line (dashed line) or ii. not separated (solid line). Horizontal axis — distance in kilometers. The CF may be represented as the sum $a\delta(x) + f(x)$, where $f(x)$ — is continues regular part, and $a + f(0) = 1$. The value $f(0)$ we obtain by an extrapolation from positive distances.

6. Clearness of atmospheric fronts grows with height, and the best quality is obtained at level of 300 gPa. It sharply falls on the levels about tropopause.

References

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