THE OPERATIONAL 254 KM GRID ANALYSIS SCHEME
AND THE EXPERIMENTAL 127 KM GRID SCHEME AT DWD

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The present operational DWD analysis scheme was designed to provide the initial data for the forecasting model BKF(9 level, 254 km grid, moisture and radiation included). A nested model, having half the mesh width but the same physics and vertical resolution, is being developed along with a corresponding 127 km resolution analysis scheme which is based on the operational scheme. Therefore the description of the 254 km analysis scheme given below will also be valid for the fine mesh analysis.

The analysed variables are the surface pressure P_s, geopotential ϕ and temperature T. The reason for this double description of the mass field is that some kinds of upper observations seem to be more suitable to describe only one of these fields. The wind field is not analysed at present. The domain of the analysis is an octagon north of about 8^o north, vertical levels are the surface and 950, 850, 700, 500, 300, 200, 100 mb (by a 381 km SCM-program also 70 and 50 mb are analysed). The grid is rectangular on a stereographic projection map. An intermittent insertion is performed every 6 hours using multivariate statistical interpolation.

The analysis consists of 3 steps: 1.) 3-dimensional interpolation of observations using climate as norm. 2.) Mixing of interpolated and forecasted fields. 3.) Vertical adjustment of the independently determined height and temperature fields.

The interpolation of observations to grid points is made by using the well known optimum interpolation method, i.e. analysed grid point values f_g^A are computed from observations f_i^o according to

$$f_g^A = f_g^N + \sum_i w_i \left(f_i^o - f_i^N \right)$$

where f^N is a climatological mean value and w_i are the weights assigned to the observations. The common requirement of minimizing the interpolation error

$$E = \overline{\left(f_g^A - f_g^T \right)^2} = \text{Min}$$

leads to the following set of linear equations

$$\sum_{i=1}^{n} w_i \left(\overline{f_i' f_j'} + \overline{f_i' \delta_j} + \overline{f_j \delta_i} + \overline{\delta_i \delta_j} \right) = \overline{f_g' f_j'} + \overline{f_g' \delta_j'}$$

$j = 1 \ldots n$ equations

where $f' = f^T - f^N$ and $\delta = f^0 - f^T$

This set of equations is solved at each grid point both for height and temperature. The computation of height values is performed in a multivariate manner using observations of height, wind components u and v and also height data derived from thickness observations by using P_s analysis as a reference level. The maximum number of equations is 12. The temperature analysis is performed in a univariate manner where temperature data derived from thickness observations are also taken into account. A maximum number of 6 equations is used. The selection of observations is made according to distance which proved to yield better results than selection according to correlation. The correlations for deviations from climate norm were derived from climatological data and an exponential function was fitted

$$\mu_{ij} = \frac{\overline{f_i' f_j'}}{\overline{f_i'^2} \cdot \overline{f_j'^2}} = e^{-cx^2}$$

where c depends on latitude, month, level and variable.

The error correlations $\overline{f'\delta}$ are all set to 0, as are the error correlations $\overline{\delta_i \delta_j}$ for $i \neq j$. The observational errors depend on observation type and level. Considering the fact that errors in wind speed are higher than errors in wind direction, the wind error in cross wind direction is set to $\frac{1}{2}$ of that valid for down stream direction.

The cross-correlations $\overline{\phi' u'}$ etc are derived from the height-height-correlation by making the geostrophic assumption (see Schlatter (1975)).

At present the interpolation scheme is not fully 3-dimensional, as only an upward directed stream of information is allowed. When computing a grid point value at any upper level, the already computed value for the level beyond is used like an observation. This results in only one additional linear equation when computing the weights. The vertical correlations between neighboured pressure levels have been derived from climatological data.

The information about the forecast is inserted into the analysis by optimal mixing. Let f^I be an interpolated grid point value with associated error δ, and let f^P be the forecast value with error ε. Then the mixed value

$$f^M = \xi \cdot f^I + (1 - \xi) \cdot f^P$$

has a minimum error

$$\overline{(f^M - f^T)^2} = \text{Minimum},$$

if

$$\xi = \frac{\overline{\varepsilon^2}}{\overline{\delta^2} + \overline{\varepsilon^2}}$$

where the bar denotes a mean value with respect to time. The main advantage of this mixing is that the correlation function for deviation from climate is independent of model performance, so it can be derived once for ever from climatological data. But unlike this, the prediction error has to be actualized. Since the field of forecast errors represents a smaller scale, the usage of the forecast as norm may probably better resolve smaller scales. Therefore as soon as a proper correlation function is made available, we will change our procedure.

Since height and temperature are analysed independently they have to be adjusted. This is done in a variational manner:

$$\sum_k \left[\left(\frac{\delta \phi_k}{\varepsilon \phi_k} \right)^2 + \left(\frac{\delta T_k}{\varepsilon T_k} \right)^2 \right] = \text{Minimum}$$

here $\delta \phi_k$ and δT_k are the variations applied at ϕ_k respective T_k, $\varepsilon \phi_k$ and εT_k the associated errors of mixed grid point values, and summation is over levels k.

Because the analysis program should be able to run without manual intervention, special care was taken upon the checking procedure. The main arguments taken into account are: time consistence, comparison with neighboured observations, comparison with forecast, quality indicators set by the decoding program, time consistence of ship positions. Radiosonde data as well as surface pressure data from ships are corrected for systematic errors.

The operational DWD forecast model is used as the driving model within the analysis scheme. All p-levels of the model with exception of 550 mb are analysed, so that only a small amount of vertical interpolation is needed. The initial wind field is derived from the analysed height field and the 6 hours forecasts by geostrophic adjustment

$$\underline{v_0} = \underline{v}^P + \frac{1}{f}\underline{K} \times \nabla(\phi^A - \phi^P)$$

At present the 127 km version is a purely formal extension of the coarse mesh program with results which are not adequate. For that reason the initial data to start the nested model are derived from the initialized 254 km model by interpolation. There are several weaknesses of the present program version: 1. Low level fields seem to be too rough. 2. An improved checking procedure is needed to maintain high gradient small scale features. 3. Smaller observational errors should be applied. 4. A problem which seems to be most difficult to overcome will probably be the initial wind field.