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A package for objective analysis of isobaric contours*

M. C. SINHA, V. DAYAL and Z. N. BEGUM

Meteorological Office, New Delhi

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सार – इस शोधपत्र में समदावी पृष्ठों पर भूविभव क्षेत्रों के वस्तुनिष्ठ विश्लेषण के एक संवेष्ट का ब्यौरा दिया गया है। प्रतिदर्श समायोजनीय विभेदनता और अक्षांश-देशान्तर ग्रिड सहित सुवाह्य भी है। इस में समय अविरोध, आन्तरिक अविरोध और निविष्ट आंकड़ों की जांच करने के लिए कुछ गुणात्मक नियंत्रण प्रक्रिया सम्मिलित की गई हैं। अन्तिम निर्गम को आरेख के रूप में मुद्रक निर्गम से प्राप्त किया गया है। 60° उत्तर से भूमध्य रेखा तक के एक चक्रीय विश्व बेल्ट विश्लेषणको भी प्रस्तुत किया गया है। आंकड़ों के दीर्घ अन्तराल तक जांच करने के बाद प्राप्त निम्न मान इस संवेष्ट की अच्छी कार्य कुशलता को सिद्ध करते हैं।

ABSTRACT. The paper gives details of a package for objective analysis of geopotential fields on isobaric surfaces. The model is a portable one with adjustable resolution and latitude-longitude grid. It includes time consistency, internal consistency and some other quality control procedures for checking the input data. The final output is obtained in chart form through printer output. A sample of cyclic global belt analysis from equator to 60 deg. N is also presented. Low values of long term verification statistics (RMSE) prove the good performance of this package.

1. Introduction

This paper describes a package for the objective analysis of geopotential field on the isobaric surfaces. The package uses the Cressman's method for obtaining the analysis of geopotential fields, using reported contours and the observed winds at the observational network.

The model is a perfectly portable one with adjustable gridsize and can be used for any area on the globe. It has also been used for the global belt analysis. It includes horizontal consistency, time consistency and other quality control checks.

One of its versions has been in operational use at the Regional Meteorogological Centre at New Delhi continuously since 1974.

2. Cressman's method

The algorithm for the analysis is based on the method reported by Cressman (1957). In this method a realistic preliminary guess field Z_g is assumed initially at all the grid points. For each grid point all the observational data situated within a symmetric circular area of influence all round are taken into account.

The observed values of geopotential Z_{os} at the stations and the guess field interpolated at the station are compared and the differences for all the stations within area of influence are obtained. The values of the geopotential guess Z_p at the observing stations is obtained from the adjoining grid point guess field by the following expression :

$$Z_p = Z_{g1} + (Z_{g4} - Z_{g1}) \triangle y / GL + [Z_{g2} - Z_{g1} - (Z_{g2} - Z_{g3} + Z_{g4} - Z_{g1}) \triangle y / GL] \triangle x / GL \quad (1)$$

where indices 1, 2, 3 and 4 refer to the points as given in Fig. 1.

Thereafter the following corrections to be applied to the grid point are worked out :

$$C_1 = W (Z_{os} - Z_p) \quad (2)$$

for stations reporting contours only,

$$C_2 = W (Z_p - \frac{kf}{g}(v \triangle x - u \triangle y) - Z_g \quad (3)$$

for stations reporting winds only and

$$C_3 = W (Z_{os} - \frac{kf}{g}(v \triangle x - x \triangle y) - Z_g \quad (4)$$

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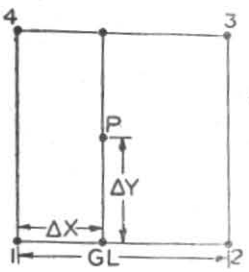

Fig. 1. Grid for interpolation of contours at stations

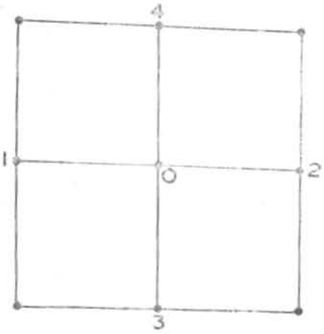

Fig. 2. Grid arrangement as used in smoothing operators

for stations reporting both heights and winds, where the weighting functions W is defined as :

$$W = \frac{(R^2 - D^2)}{(R^2 + D^2)} \tag{5}$$

The total weighted average correction obtained from all the observations within the area of influence which is finally applied to the preliminary grid point guess field is :

$$C = \frac{(A_1 \Sigma C_1 + A_2 \Sigma C_2 + A_3 \Sigma C_3)}{A_1 N_1 + A_2 N_2 + A_3 N_3} \tag{6}$$

The values of the weighting factors A, A_2 and A_3 are given below :

Scan	I	II	III	IV	V
A_1	1.0	1.0	1.0	0.125	0.125
A^2	0.0	0.0	0.0	0.50	0.50
A_3	0.0	0.0	0.0	1.0	1.0

These corrections are computed and applied to each grid point simultaneously after each scan. The process isrrepeated iteratively five times with gradual reduction of the area of influence in successive scans. The radii of influence taken are :

Scan	I	II	III	IV	V
Radius of influences	12.6°	10.6°	7.8°	4.8°	3.5°

The adjustment of analysis to the reported wind observations is included only in the last two scans.

The analysis sometimes develops some ripples on account of non-uniformity of data and therefore a mild nine point smoother (Shuman 1957) is applied to the analysis obtained after the third scan onwards. The smoother is broken into two three-point component smoothers, one applied along x axis and the other applied along y axis. These are given below :

$$\begin{aligned} \overline{Z}^{x}_{g0} &= Z_{g0} + 0.5 \times G \times (Z_{g2} - 2\,Z_{g0} + Z_{g1}) \\ \overline{Z}^{y}_{g0} &= Z_{g0} + 0.5 \times G \times (Z_{g3} - 2\,Z_{g0} + Z_{g4}) \end{aligned} \tag{7}$$

The values of the smoothing indices used for various levels in atmosphere are :

Level (mb)	850	700	500	300	200
Smoothing index 'G'	0.2	0.2	0.2	0.4	0.5

The grid point numbering used for smoothing are given in Fig. 2.

3. Quality control procedure

All the observations used for the analysis are first subjected to time consistency and climatological checks. Thereafter these observations are checked for internal consistency through mean gradients which are not allowed to exceed a certain fixed values for each level. This is done in the following way. For each station weighted average contours height of all the neighbouring observatories within a circle of radius 9.2 is obtained.

$$\overline{Z}^{9.2°}_{os} = \frac{\Sigma\, w_i\, Z_{osi}}{\Sigma\, w_i} \quad \text{where } w_i = 1/(1+1.4\, d_i^2) \tag{8}$$

Similarly the mean distance of these observatories is obtained by :

$$\overline{d}^{9.2°} = \frac{\Sigma\, d_i}{N} \tag{9}$$

The observations are rejected if :

$$|\, \overline{Z}^{9.2°}_{os} - Z_{osi}\,| > \overline{d}^{9.2°} \times \text{constant} \tag{10}$$

where the constant may be taken as analogous to the mean gradient, the values of the constant used in this package are :

Level (mb)	850	700	500	300	200
Constant	25	30	33	50	55

This is similar to work reported by Masuda and Arakawa (Masuda and Arakawa 1962).

Time consistency checks are also applied. All observations which give value of C_1, C_2 and C_3 greater than a specified value in any scan are suspected and flagged for intervention if required. The specified values of C_1, C_2 and C_3 are

Scan	I	II	III	IV	V
$C_1/C_2/C_3$ (gpm)	180	150	105	60	60

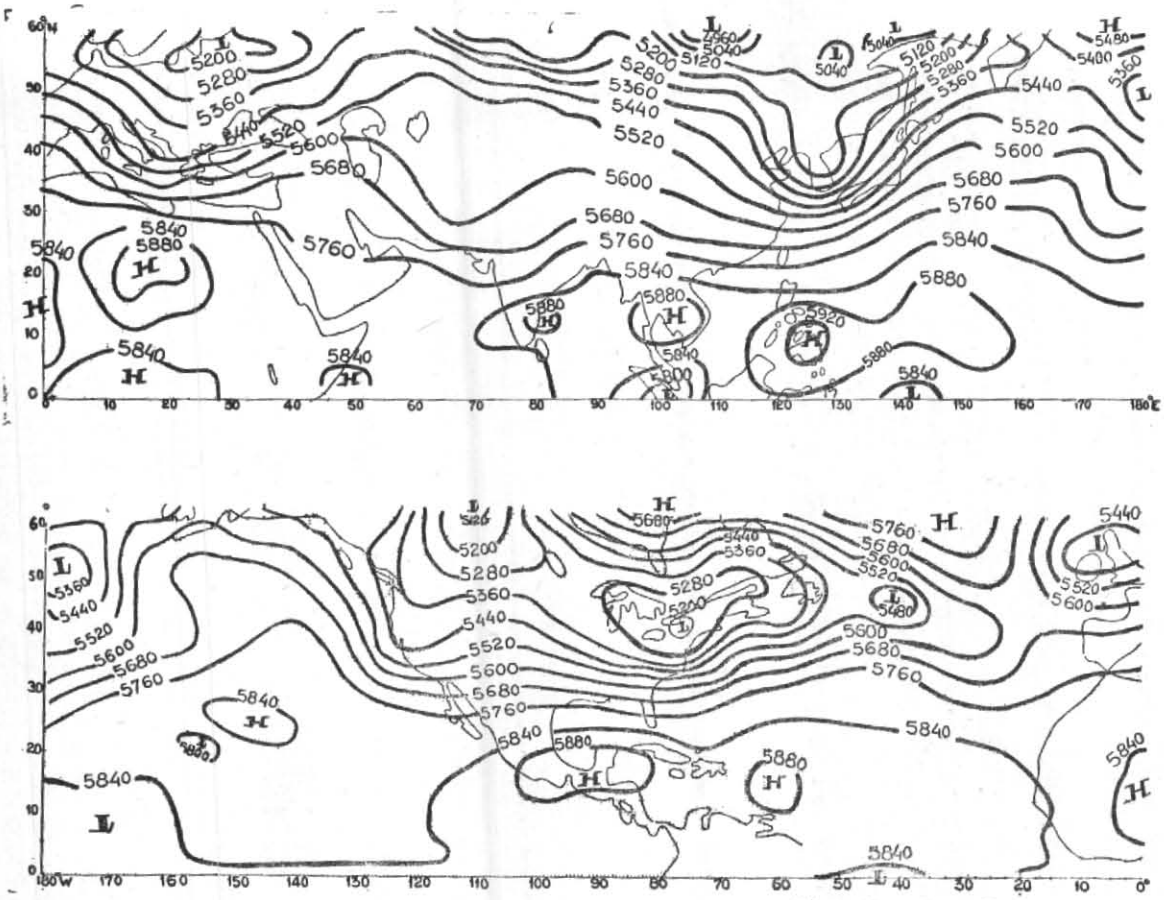

Fig. 3. Cyclic global belt analysis of contours at 500 mb for 0000 GMT of 1 February 1979

Total weighted average correction to any grid point is kept to a maximum of 100 gpm in any scan.

4. General description of model

The model uses natural latitude longitude system and the number of grid point required along east-west and north-south, size of the grid, the position of the grid are prescribed at the object time and are fed as data through cards. The model is perfectly portable and can be used for any part of the earth. The programme can be used for global belt with cyclic continuity. It has provision to take into account for analyses bogussed and other non-conventional data also like satellite winds etc.

It is written in Fortran IV language for IBM 360/-44. It also uses direct access disk storage on IBM 2314.

The final product of isobaric contour analysis is obtained in a chart form of representation through printer output.

It has a built in sub-routine for getting verification statistics. The average RMS errors of the analysis obtained operationally with 2·5 deg. grid length calculated at all reporting stations within the area from equator to 60° N and Greenwhich meridian to 140° E are given below :

Level (mb)	Jan	Apr	Jul	Oct
850	6.5	6.7	7.4	6.5
700	7.1	7.0	7.4	7.0
500	9.9	9.2	10.7	10.0
300	21.6	20.7	20.3	18.3
200	25.5	24.3	24.1	23.1

A sample of the cyclic global belt analysis is given in Fig. 3.

5. List of Symbols used

A_1 Weight function for corrections applied for height observations only

A_2 Weight function for corrections applied for observations of winds only

A_3 Weight function for corrections applied for observations of winds & height both

C_1 Correction from observations reporting height only

C_2 Correction from observations reporting winds only

C_3	Corrections from observations reporting wind and height both
C	Total correction to be applied to a grid point
D	Distance of observation point from Grid point
d	Distance of the neighbouring observation point from the stations subject to internal consistency check
f	Coriolis parameter
g	Gravity
G	Smoothing Index
GL	Grid length
K=1.08	Correction for ageostrophy of actual wind
N_1, N_2, N_3	Number of stations reporting height only, wind only and height and wind both
R	Radius of influence
u	Zonal component of wind
v	Meridional component of wind
w	Weighing function for giving weightage for distance of observation from the grid point for calculating total correction to grid point
w_i	Weight used for checking horizontal consistency of observations
Z	Geopotential height
Z_g	Geopotential height at grid point
Z_{os}	Geopotential height observed at any station
Z_p	Preliminary Guess field of Geopotential height at observing station
$\triangle x$	Distance along east west
$\triangle y$	Distance along north south

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