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An objective analysis scheme for relative humidity

Z. N. BEGUM, R. K. BANSAL and R. K. DATTA

Meteorological Office, New Delhi

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सार — वायुमण्डल को 300 मिलीबार से ऊपर शुष्क मानकर वायुमण्डल के छह निम्नतम स्तरों के लिए आपेक्षिक आर्द्रता का वस्तुनिष्ट विश्लेषण किया गया है। उच्च स्तरीय वायु रेडियोसौंडे आँकड़ों की वृद्धि के लिए आपेक्षिक आर्द्रता क्षेत्र के विश्लेषण में प्रेक्षणों के दोनों ही प्रकारों को भिन्न-भिन्न भार देते हुए केन्द्र के भूपृष्ठीय सिनॉप्टिक प्रेक्षणों का उपयोग किया गया है। भूपृष्ठीय प्रेक्षणों, सामयिक मौसम दशाओं और मेघ मात्रा व प्रकार पर आधारित कई आनुभाविक आर्द्रता ऊर्ध्वाधर प्राफिकाएं तैयार की गई हैं। आर्द्रता विश्लेषण के लिए भूपृष्ठीय प्रेक्षणों की उपयोगिता की जांच के उद्देश्य से मानसून प्रयोग (मॉनिक्स) के आँकड़ों का उपयोग करने पर कुछ दिनों के लिए क्रेसमैन विधि का प्रयोग करते हुए वस्तुनिष्ठ विश्लेषण किया गया है।

ABSTRACT. The objective analysis of relative humidity is done for the six lowest layers of the atmosphere assuming the atmosphere to be dry above 300 mb. To augment the upper air radiosonde data, the station surface synoptic observations have been utilized in the analysis of the relative humidity field giving different weights to both the type of observations. A number of empirical humidity vertical profiles have been prepared based on surface observations, current weather conditions and cloud amount and types. Objective analysis using Cressman method has been done for a few days using Monex data to test the utility of surface observations for humidity analysis.

1. Introduction

Relative humidity is of great significance as it furnishes useful information about the moisture conditions prevailing in the atmosphere. For various meteorological studies and NWP work atmospheric moisture field is very essential. Inspite of its great usefulness, this subject has received little attention till very recent times. Atkins (1974) carried out the objective analysis of relative humidity (RH). Mesoscale model for the determination of the effect of the high-resolution moisture analysis on the forecast of precipitation was developed by Warner *et al.* (1978). A moisture analysis procedure utilizing surface and satellite data was given by Stephen and Thomas (1981).

In this paper we present an objective analysis procedure for relative humidity for the levels 1000, 850, 700, 500, 400 and 300 mb utilising upper air data and humidity profiles computed from surface synoptic observations, current weather conditions and cloud amount and types. This analysis is based on weighted correction method (Cressman 1959). As the coverage of surface reports is much denser than the upper air reports, the technique is expected to be very useful in the region of scanty or no radiosonde data. This study also provides an opportunity to make use of the satellite cloud imagery and information on outgoing long-wave radiation (OLR) for improving the humidity analysis.

2. Relative humidity analysis technique

For the Indian region, Datta *et al.* (1970) and Sinha *et al.* (1982) have applied the objective analysis technique for geopotential fields and Ramanathan *et al.* (1972) and Rajamani *et al.* (1983) for the wind fields.

The present study also makes use of the same technique. The analysed value of RH_g, at a discrete point (g) may be expressed as :

$$RH_g = RH_{ges} + a_1 (RH_{obs} - RH_{ges})_1 + a_2 (RH_{obs} - RH_{ges})_2 + \ . \ . \ . + a_n (RH_{obs} - RH_{ges})_n$$

where RH_{ges} is the relative humidity guess, RH_{obs} is the observed value and $a_1, \ . \ . \ ., a_n$ are the coefficients which determine the influence of each observation on the analysed value.

The weights are determined by the function :

$$a_i = \frac{1}{n}\left[\left(R^2 - r_i^2\right) \Big/ \left(R^2 + r_i^2\right)\right]$$

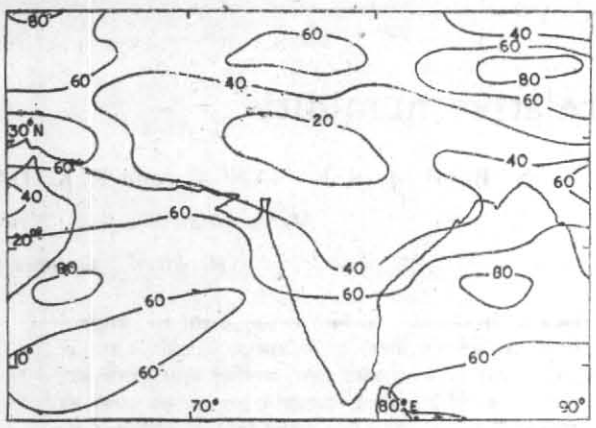

Fig. 1. Analysed 1000 mb relative humidity for India and neighbourhood on 3 May 1979, 00 GMT (with surface observations)

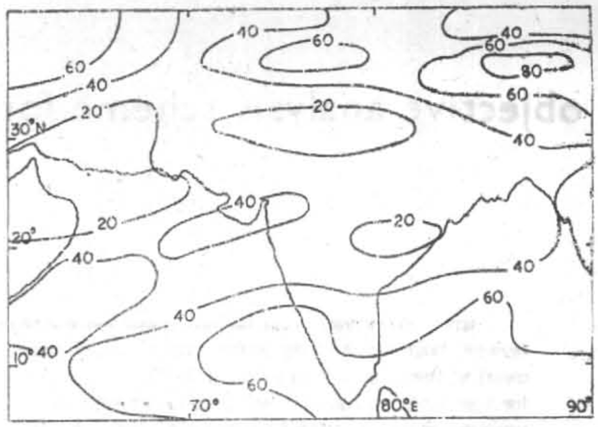

Fig. 2. Analysed 700 mb relative humidity for India and the neighbourhood on 3 May 1979, 00 GMT (with surface observations)

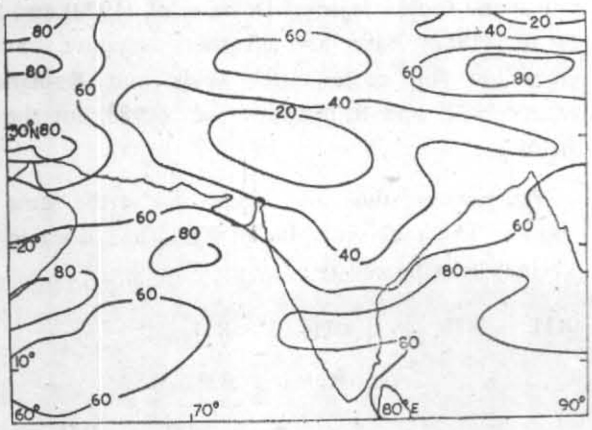

Fig. 3. Same as in Fig. 1 (without surface observations)

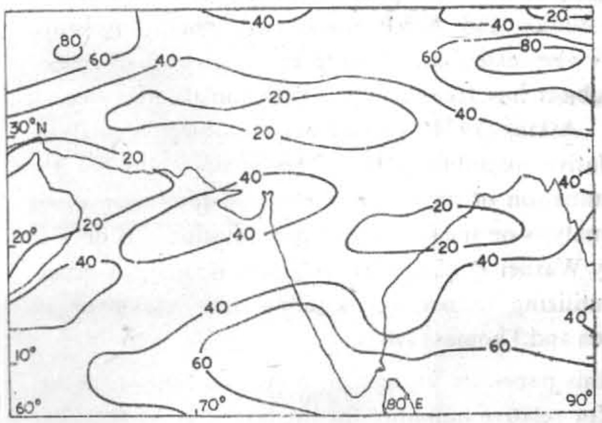

Fig. 4. Same as in Fig. 2 (without surface observations)

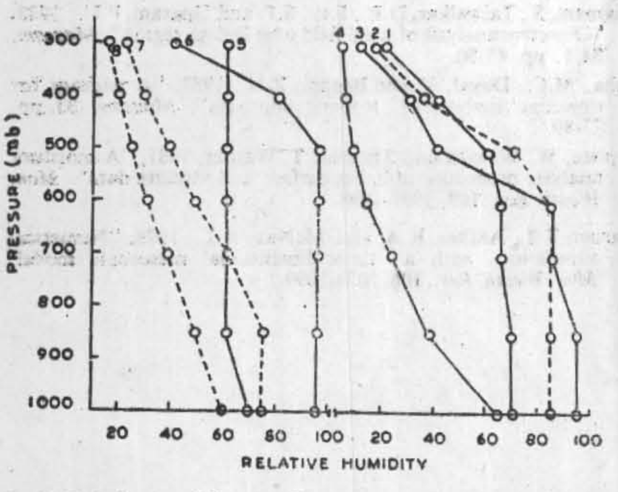

Fig. 5. Relative humidity profiles used in generating subjective humidity estimates from surface synoptic observation, cloud amount and type and current weather conditions

where R is the influence radius, held constant for each iteration, r_i is the distance for the ith observation location to the analysis point and n is the number of observations within the area of influence. The background field for analysis have been taken from the ECMWF analysis.

3. Construction of vertical humidity profiles

Relative humidity for various levels can be deduced from the following formula which has been deduced empirically :

$$RH_i = RH_s - A\cos(\alpha) + B_i$$
$$\text{where, } i = 1, 2, \ldots, 6$$

and RH_i are the values of RH for the levels from 1000 upto 300 mb and A is the low cloud amount and α is the sky cover by low/middle and high clouds in octas. RH_s is the surface relative humidity and is estimated from dry and wet bulb temperature reports for the surface/current weather observations. B_i is a constant which is different for various levels and categories of RH profiles. Thirty-five such profiles in the vertical have been prepared based on surface synoptic observations current weather, cloud amount and types. The RH profiles for eight categories (1, 2, ..., 8) are shown in Fig. 5.

4. Impact of surface synoptic observations on humidity analysis

In order to assess the influence of surface synoptic observations on the RH analysis, the objective analysis has been made with and without the surface synoptic observations for India and the neighbourhood. The observed data used as input for the analysis, should fit in the analysed field. To examine this, the root mean square error (RMSE) was calculated between the original observations and the interpolated value of the analysed field to the observation locations. The RMSE of this analysis for 1000 and 700 mb levels for 00 GMT of 3 May 1979 are found to be 18 and 23% with synoptic surface observations (Figs. 1 and 2) and 21 and 27% without surface observations (Figs. 3 and 4) respectively. This shows that the inclusion of the synoptic observations improves the humidity analysis.

5. Results and discussions

In this study the area covered for the analysis extends from Lat. 24°S to 43°N and Long. 26°E to 153°E with a Lat./Long. grid of 1.875 degrees. The number of iterations is three and the scan lengths for first, second and third iterations are 6.0°, 3.5° and 2.0° respectively. The RH analysis has been done for the pressure levels 1000, 850, 700, 500, 400 and 300 mb for 00 GMT of 1, 2 and 3 May 1979 and also of 19 and 20 May 1979 (not shown in figure).

To study the impact of use of surface observations analysis was performed with and without surface observations for 3 May 1979 (Figs. 1 to 4). From these cases it is seen that the use of surface observations considerably improve the analysis of humidity field. Another advantage of this scheme is that it provides the opportunity to use the information on weather elements reported in the conventional surface observations, which are comparatively much larger in number than the upper air observations. Although the profiles derived for the surface observations are empirical but still these have been found to be very useful for supplementing the upper air data.

For the analysis over oceanic areas, where even surface synoptic observations are limited to a few ship reports, the use of satellite observed cloud imagery and vertical distribution of analysis could be useful for the humidity analysis over oceanic area. The use of satellite information for humidity analyses will be reported in a separate study.

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