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Average relative humidity from satellite observations

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ABSTRACT. This study describes an attempt to obtain a statistical relationship between the satellite viewed cloudiness and vertically integrated average relative humidity in the lower troposphere over the Indian Seas. For this purpose, the values of average relative humidity for 1000-600 mb layer for the months of April, July and November 1966, were computed for the six radiosonde stations in the Peninsular India with coastal and island locations. Cloud coverage over the small area in the vicinity of these stations were obtained from the Nephanalyses published by U.S.W.B. in the satellite data catalogues and were classified in five categories. A linear relationship was found between the average relative humidity and cloud classification number with a correlation coefficient of 0·71.

1. The qualitative procedures for forecasting clouds and precipitation require the determination of the vertically integrated moisture field. This is readily obtained over the land areas from the available radiosonde observations. In recent years, use of satellite data has been made to infer the mean relative humidities over the sea/ocean areas where data are sparse or non existing. The radiation measurements from the 6·3 micron water vapour channel and 8-12 micron atmospheric window channel, have been used to estimate the relative humidity distribution in the middle and upper troposphere. To determine the average humidity in the lower troposphere in the Gulf of Mexico region, Thompson and West (1966) have made use of satellite pictures. McClain (1966) found a relationship between satellite viewed cloudiness and the vertically integrated moisture filed. He chose saturation deficit as the moisture parameter to measure the relative humidity in the 1000 to 500-mb layer.

2. The purpose of this study is to explore the possibility of using the satellite nephanalysis for obtaining the humidity information of the lower troposphere over the Indian Seas. For the purpose, we selected six radiosonde stations of Peninsular India with coastal and island locations, *viz.*, Bombay, Trivandrum Minicoy, Madras, Vizag and Port Blair. Though the stations selected are not all situated in homogeneous synoptic-climatological region in the months studied, especially in November, it was not considered desirable to group them seperately according to climatological conditions or regions like east and west coast, as this would have considerably reduced the sample sizes in these groups due to the limited number of available radiosonde stations.

The average relative humidity between surface and 600-mb was computed for each station for the months of April, July and November 1966, using the relationship —

$$\overline{H} = \left(\sum_{\text{sfc}}^{600} \overline{h}\, dp/DP \right)$$

where $\overline{h}$ is the relative humidity in each sub-layer, dp is pressure depth of the sub-layer and DP is the pressure depth of the layer between the surface and 600 mb. The upper layer was chosen as 600 mb as the dew point reports were generally not available above 600 mb. The values of $\overline{H}$ were computed from 12 GMT radiosonde observations as most of the satellite passes were in the afternoon during the above months. On occasions of doubtful missing data the values obtained from 00 GMT ascents, were utilised.

3. The cloud coverage over the small area in the vicinity of these stations was then obtained from nephanalyses published by U.S.W.B. in the satellite data catalogues. These nephanalyses depict the cloud cover according to the following classification —

Open	<20%	coverage
Mostly Open (MOP)	20-50%	,,
Mostly Covered (MCO)	50-80%	,,
Covered (C)	>80%	,,

The above classifications are also supplemented by symbols designating the general character of cloudiness. We have made use of the above cloud classification except for the covered cases, where combinations of cumuliform, stratiform and cumulonimbus clouds were grouped separately along with 'covered dense'. We thus made five classifications with 'open' as classification number one and 'covered dense' as classification number

TABLE 1

Relation of satellite nephanalysis cloud cover and relative humidity

Average R.H. (%)	Open	Mostly open	Mostly covered	Covered	Covered dense
31—55	75	22	3	0	0
56—70	23	68	26	3	1
71—80	1	21	72	26	5
81—90	0	3	27	33	8
91—100	0	0	8	11	22
Total : 458 cases					

TABLE 2

Relation of satellite nephanalysis cloud cover and relative humidity

Average R.H. (%)	Open	Mostly open	Mostly covered	Covered	Covered dense	
31—55	59	10	1	0	0	Apr
	0	1	0	0	0	Jul
	16	11	2	0	0	Nov
56—70	15	28	11	0	0	Apr
	0	10	9	1	1	Jul
	8	30	6	2	0	Nov
71—80	0	7	15	6	0	Apr
	0	2	29	9	4	Jul
	1	12	28	11	1	Nov
81—90	0	1	2	4	1	Apr
	0	0	12	16	4	Jul
	0	2	13	13	3	Nov
91—100	0	0	0	0	1	Apr
	0	0	7	11	17	Jul
	0	0	1	0	4	Nov

TABLE 3

Mean relative humidity

Cloud Classification	All months	Apr	Jul	Nov
1	51	49	61	53
2	61	58	69	63
3	73	67	76	72
4	83	76	83	82
5	95	85	91	92

five. The cloud classifications were grouped separately under six ranges of average relative humidity. The results are presented in Table 1.

In Table 1 all the 458 cases of April, July and November months have been included. It will be seen from the table that out of 99 cases of open clouds 75 cases are in the range of R.H. between 31-55 and from total number of 114 'mostly open' cases, 68 fall in the range of 56-70% relative humidity. Similarly, the frequency peak in the 'mostly covered' classification is between 71-80%. In the 'covered' classification the frequency maxima is not so well marked but falls between 81-90%. The peak in the covered dense case is again well defined at 91-100% relative humidity. The break-up of these data in three months, separately, is shown in Table 2.

It will be seen that the frequency peaks are well marked monthwise also except in the case of 'covered cases' and also in certain humidity ranges where number of cases is small. The month of July, however, shows a well marked maxima in the range of 81-90% humidity range.

4. Using these data we have calculated the correlation coefficients (r) between average relative humidity ($\overline{H}$) for air column below 600 mb and cloud classification number (C). The calculated values of r and linear regression equations of $\overline{H}$ on C are given below—

All months

$$\overline{H} = 39{\cdot}5 + 11{\cdot}0\ C \qquad r = 0{\cdot}71$$

April

$$\overline{H} = 40{\cdot}1 + 9{\cdot}0\ C \qquad r = 0{\cdot}67$$

July

$$\overline{H} = 53{\cdot}5 + 7{\cdot}5\ C \qquad r = 0{\cdot}62$$

November

$$\overline{H} = 43{\cdot}0 + 9{\cdot}8\ C \qquad r = 0{\cdot}72$$

It will be seen from the above that the correlation coefficients are fairly high showing good linear relationship between the variables $\overline{H}$ and C. The plotted regression lines are presented in Fig. 1 which shows that the line for the month of November runs very close to that of all months cases. A little difference is however noticeable in the lines for April and July. The mean relative humidity computed from these lines for each cloud classification number is given in Table 3.

5. Though the data sample pertains to one year only the results presented above show that the satellite viewed cloudiness can be utilised to obtain the value of vertically integrated moisture field in the lower troposphere of the Indian Seas. The nephanalysis of cloud pictures can thus enable us to draw isolines of moisture pattern over Indian Seas and incorporate this information into the quantitative forecasting procedures.

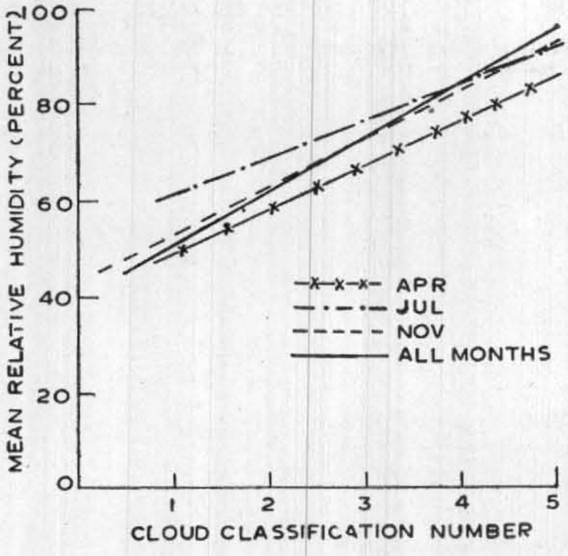

Fig. 1

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DISCUSSION

(Presented by M. G. Gupta)

SHRI V. SRINIVASAN remarked that the hypothesis on which the work is based is that certain clouds (type and amount) are associated with certain integrated humidity in the atmosphere. However in this study cloud cover is taken into account but not the cloud type.