

Need for development of tethered balloon facility for basic studies of Indian summer monsoon

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Major part of the easily precipitable moisture in the S-W monsoon air mass originates from evaporation over the Arabian Sea and its subsequent upward transport by vertical mixing. It is commonly thought that vertical mixing in the air mass, particularly over the East Arabian Sea, is vitally important for rainfall activity over the west coast. A programme for assessing this vertical mixing should therefore be very valuable for understanding the dynamics of the monsoon circulation and the precipitation over the Indian sub-continent. The vertical mixing can be assessed from measurement of vertical profiles of radon in the air mass. The most practical method for measuring radon in high altitude air, at present, requires bringing about 20 litres sample of this air to the laboratory. This can be best done using tethered balloons which can carry the samplers to the desired altitudes and then bring them back filled with the desired samples of air. In addition to procuring samples of high altitude air for radon measurements, same balloons may be used for obtaining better and more detailed conventional meteorological data than hitherto available.

1 Introduction

During the summer monsoon season, the winds over most of the Arabian Sea and western coast of India are westerly to south-westerly at heights of 0 to 6 km; they constitute the main monsoon current and have been believed to originate from the south-east (S-E) trades which have had a long traverse over the Indian Ocean and get deflected into westerly to south-westerly stream over the Arabian Sea after crossing the equator. The meteorological data collected during the International Indian Ocean Expedition, however, indicated that the moisture in a thick layer of air extending from 1.5 km height to 5-6 km height over most of the Arabian Sea did not come with the S-E trades but was, in fact, introduced over the Arabian Sea itself. Then, there was the question of the origin of the monsoon air mass itself. Further, the origin of even the lower current (0 to 1.5 km thick) of air remains open. This low-level layer can carry comparatively large amounts of water and may be directly (or in some other subtle way) responsible for precipitation observed over the Indian sub-continent. Is this layer constituted of deflected south-east trades all through the monsoon? Or, is it coming from north Africa and during active monsoon period from south of the equator?

One cannot answer such questions from the observations that are usually available from ships. The surface air can soon get saturated irrespective of

whether it is the part of S-E trades or of continental air from East Africa. Further, a south-westerly breeze over the Arabian Sea can be extrapolated backwards to originate from north African Continent or the Indian Ocean according to one's conviction. Therefore, the usual humidity and wind observation results supplied by ships are not of much help in this context. The sea level radon observations, on the other hand, appear to be very useful in this respect¹⁻³. During the monsoon months of June, July, August and September, the radon content of S-E trades over the Indian Ocean just south of equator is 2-4 dpm/m³. If this air crosses the equator and invades the Arabian Sea, its radon content should stay at this low value or fall even lower due to decay. However, the observed radon content of air over the Arabian Sea is often in the range 20-25 dpm/m³, indicating that the low level air is either of continental origin or is strongly contaminated with continental air. It is not yet possible to tell exactly what fraction of it is really continental, since we do not yet know what exactly should be the radon content of continental air coming over the Arabian Sea from East Africa.

The radon content of sea level air near the east coast of Africa has been observed to be in the range 45-160 dpm/m³. If this air moves over the Arabian Sea, its radon content will decrease due to decay, but more important is, perhaps, the decrease caused in the radon content of the sea level air by vertical

mixing with radon-poor air aloft. Until these two factors are assessed accurately (or vertical profiles of radon measured), the answer may remain indeterminate to some extent. A value of 20-35 dpm/m³ for radon content, however, means that the air certainly contains up to about 30% or more of continental air. One can also use an indirect approach. During the winter months, Arabian Sea is invaded by air from Indian sub-continent. The measurements of radon in air over the Arabian Sea during this period yield an average value of about 40 dpm/m³. Taking this as indicative of concentration of radon in the continental air from East Africa as well, we find that the component of continental air in the low level monsoon current exceeds 50%. It is, however, important to measure the radon content of high altitude air. The high altitude measurements are expected to yield information on the vertical mixing of the monsoon air mass and its interaction with other air masses.

It is believed that vertical mixing over the East Arabian Sea is responsible for transport of moisture into the higher levels of the monsoon air mass which is vital for rainfall activity over the west coast. The vertical mixing can be assessed from measurements of vertical profiles of radon in the air mass. At present, the most practical method for measuring radon in high altitude air requires bringing 20 litres sample of air to the laboratory for analysis. This can be done by using aircraft. But it would be far more practical to employ tethered balloons from platforms of research vessels.

2 Experiment

At sea level, the measurements are made using the decay products of radon which are filtered on a glass fibre paper with the help of a pump. The accuracy of such measurements is about 20%. Observations can also be made continuously. This was done by passing atmospheric air through a large (80-litre) chamber at a rate of 21/min and attracting the positively charged decay products of radon onto a thin metallized mylar sheet kept at negative potential. The mylar sheet covers a ZnS(Ag) scintillator viewed by a photomultiplier tube. The alpha scintillations observed by the photomultiplier are recorded electronically every hour. In the case of measurements at high altitudes, most convenient method, as yet, appears to be to bring sealed samples of air in the laboratory for radon analysis.

The sampler, at present, consists of an evacuated 20-litre pyrex flask. This needs to be taken to the desired point by an aircraft (or tethered balloon) and atmospheric air let into it by opening a stopcock and then closing it after two minutes. It should be possible to use a much lighter polythene sampler.

Facilities for analysis of radon in such samples of air are now easily available. There is, however, a great need for development work which can enable high altitude measurements without the use of an aircraft. Ideally, a method may be developed for *in situ* measurements of radon using meteorological balloons. But this is presently not at hand. At present, the best course appears to be the use of tethered balloons for obtaining samples of high altitude air and then extracting radon from them and then measuring it by using laboratory facilities.

3 Results and discussion

As discussed earlier even the surface observations have been found to be quite useful. However, the full potential of such measurements needs to be realized yet. Measurements need to be made in concert with conventional meteorological observations at a number of stations in an organized way. Further, the general features of observations over the Bay of Bengal still need to be explored; only some sketchy observations have so far been made.

A few high altitude observations were made near Bombay coast and over East Arabian Sea using samples brought by aircraft. These observations reveal the vertical uniformity of monsoon air mass, arising from intense vertical convection during active monsoon period⁴. Potential usefulness of similar observations over the Thar desert in establishing the nature of low level inversion (which hinders rainfall) was pointed out, but it still remains to be realized. There are several features of the data already obtained from surface observations which still need to be understood. For example, it can be seen from Fig. 1, that there are comparatively low values of radon concentration in air over the mid north Arabian Sea on 15 and 16 Aug. 1966 and again on 6 and 7 Sept. 1966. Are they indicative of intrusions of air from S-E trades? Similarly, we also notice from Fig. 2 that unusually low values are seen near East African coast on 15 and 16 Nov. 1967 and again on 20 and 21 Nov. 1967. It appears as if the air with high radon content coming from Indian sub-continent and pervading over the Arabian Sea is unable to cross the equator. Or, is there some other explanation?

Another general feature of the observations over the Arabian Sea is the rather remarkable constancy of the concentration with time as compared to that over the land. The fluctuations with distance also are comparatively small. These observations indicate large-scale homogeneity of air mass over the oceans. Diurnal variations observed near the Bay of Bengal had small magnitude and were seen to be in anti-phase to that over land, as expected⁵.

If observations are made extensively at the sur-

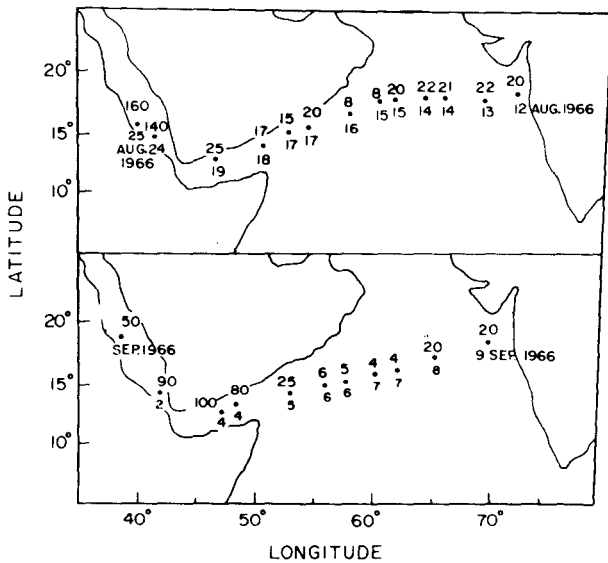


Fig. 1—Concentration of radon in the air mass over the Arabian Sea and the Indian Ocean (unit: dpm/m³) [These are measured during the voyages between coastal North Africa to the west coast of India during August 1966. The upper numbers indicate the radon concentration and the lower one the date of observation.]

face and at high altitude in the air over the Arabian Sea and Bay of Bengal, we can expect many new and interesting features which, presumably, should advance our understanding of the monsoon features. It is, therefore, important to develop facilities for tethered balloons in order to obtain samples of high altitude air. To begin with, samples from altitudes up to 1-2 km may suffice. The same balloons may be used for obtaining better and detailed conventional meteorological data of the monsoon air mass. It is surmised that these balloons are designed such that they become more buoyant at high wind speed, thus making them stand vertically overhead. Hopefully, this behaviour can be extended to high speed turbulent monsoon air mass too.

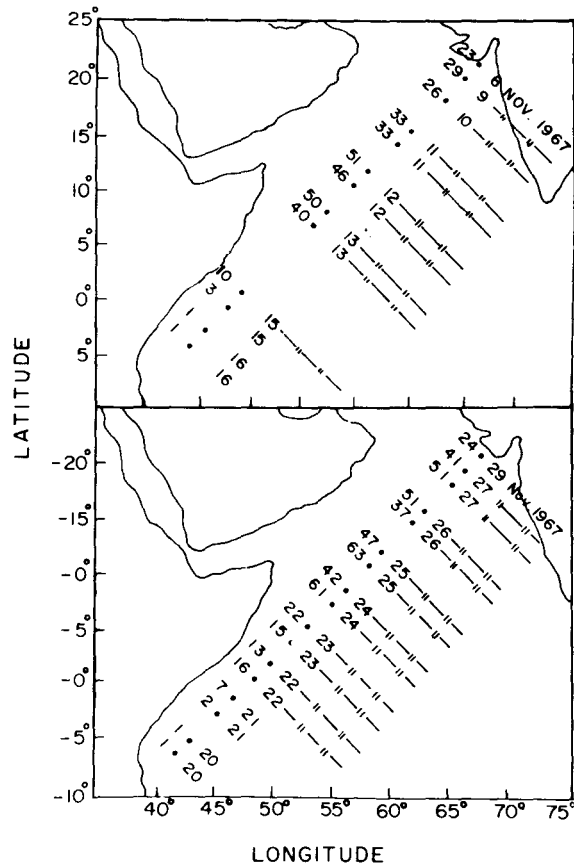


Fig. 2—Concentration of radon in air over the Arabian Sea and the Indian Ocean (Unit: dpm/m³) (The measurements were made during November 1967.)

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