

## COMPARISON OF SEA SURFACE WIND SPEEDS DERIVED FROM BHASKARA-II SAMIR DATA WITH SEATRUTH MEASUREMENTS

N.K. VISWAMBHARAN, M. VENKATESWARA RAO AND  
L.V. GANGADHARA RAO

*National Institute of Oceanography, Dona Ponda, Goa - 403 004.*

### ABSTRACT

The values of wind speed retrieved from *Bhaskara-II* SAMIR data are compared with those obtained from sea-truth measurements from 3 to 10 June, 1982. The retrieved values, in general, are found to be slightly higher than the sea-truth values. They matched fairly well with the sea-truth when the wind speed is higher and it is felt that an improved prediction of satellite orbits and operation of SAMIR in alternate mode would yield better results from sea-truth campaigns.

*Key-words* : *Bhaskara-II*, SAMIR, sea surface wind speed.

India's second satellite for Earth Observations (SEO-II) named as *Bhaskara-II* was launched into a near circular orbit on 20 Nov. 1981 at an altitude of about 530 km with inclination of about 51° and period of about 95 minutes. The two primary payloads on board *Bhaskara* are a TV Camera system and a Satellite Microwave Radiometer (SAMIR) system.

The SAMIR payload on board *Bhaskara-II* consists of three Dicke type microwave radiometers which measure the microwave radiations received from the earth's surface at 31.4, 19.35 and 22.235 GHz. The radiations measured by SAMIR are finally expressed in terms of equivalent brightness temperatures. The SAMIR system has a spatial resolution of 125 km and a brightness temperature resolution of about 1°K. It can be operated in two modes, viz., normal mode and alternate mode. In the normal mode of operation, the space craft spin axis is maintained perpendicular to the orbit plane so that the radiometers scan along the satellite orbital track. In the alternate mode of operation, the space craft spin axis is maintained tangential to the orbit plane at a certain latitude so that the radiometers scan across the orbital track (*Bhaskara-II* SAMIR Data Users Guide, 1982).

To start with, the SAMIR system is being operated in the normal mode. During each spin of the satellite, each of the three radiometers measures brightness temperature at four different angular positions (look angles) with respect to the local vertical direction (nadir). These look angles off nadir and towards the earth are +5.6°, +2.8°, -2.8°, -5.6°.

From the earlier studies, the data from *Bhaskara-I* SAMIR at 19 and 22 GHz was found to be useful for deriving information on sea surface winds (Pandey, Gohil and Sharma, 1980) and atmospheric moisture contents (Gohil

and Sarkar, 1982). It was considered that the data from *Bhaskara-II* SAMIR which has an additional channel at 31 GHz would be more useful. In order to validate the *Bhaskara-II* SAMIR data, sea-truth data was collected on board RV *Gaveshani* during 3-10 June, 1982 (Anon., 1982 and Bhandari, Pathak, Rana, Desai, Raju and Sarkar, 1982). The cruise track was so planned that it facilitated the observations along three predicted orbits (viz. orbit nos. 2967, 3006 and 3021) in the Arabian Sea. In this paper a comparison of the sea-truth measurements carried out during this cruise with the sea surface wind speeds derived from *Bhaskara-II* SAMIR data is presented.

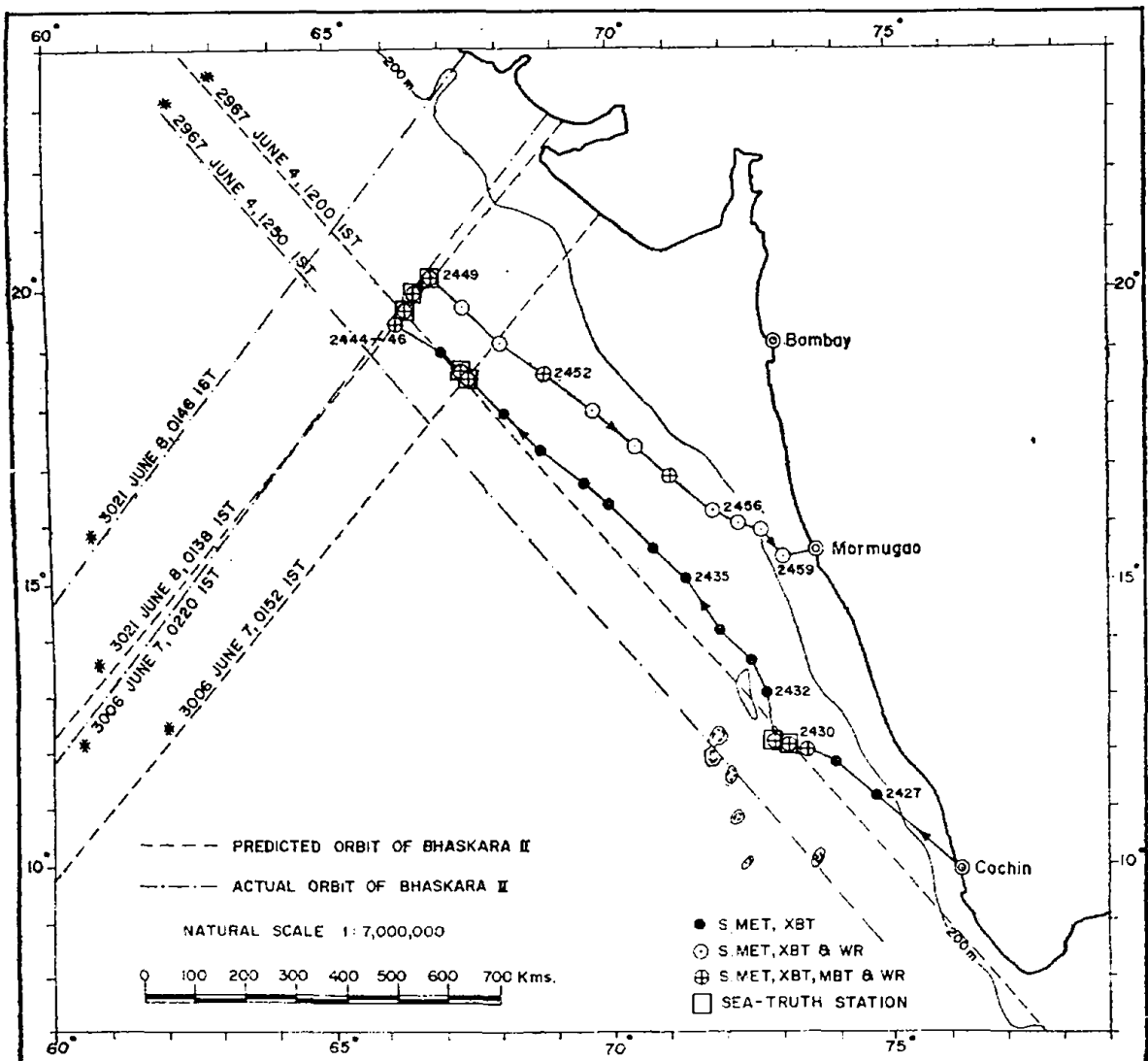


Fig. 1. Cruise track of RV *Gaveshani*, 3-10 June, 1982. (Abbreviations — S. MET.: Surface meteorological observations, XBT: XBT observations, WR: Wave recorder observations, MBT: MBT observations).

The SAMIR data for the normal mode operation after processing and recalibration was obtained from Space Applications Centre in the form of brightness temperatures at 19, 22 and 31 GHz frequencies for  $\pm 2.8^\circ$  and  $\pm 5.6^\circ$  look angles. From these data sea surface wind speeds are computed using the following regression relations developed by Sarkar and Gohil (1982) viz.

$$SW = -14.429 - 0.11872 T_{B19} + 0.18331 T_{B22} \quad (1)$$

$$SW = -26.218 + 0.15966 T_{B19} + 0.1624 T_{B22} - 0.16842 T_{B31} \quad (2)$$

where SW is the surface wind speed in m/s and  $T_{B19}$ ,  $T_{B22}$  and  $T_{B31}$  are the brightness temperatures at 19, 22 and 31 GHz respectively.

Sea-truth data on surface winds were collected on board RV *Gaveshani* using a calibrated cup anemometer. Calibrated cup anemometers are typically accurate to within  $\pm 1\%$  of the actual reading above 5 m/s and to  $\pm 5$  cm/s below (Busch, Christensen, Kristensen, Lading and Larsen, 1980). Data on actual orbits of *Bhaskara-II* indicated a spatial difference of about 100 to 150 km and time difference of 8 to 50 minutes between the predicted and actual orbits (Fig. 1). Assuming that the sea surface winds do not change significantly within 250 km and remain fairly constant upto 3 hours, a comparison between the surface wind speeds derived from SAMIR data and those

Table I. Comparison of retrieved results with sea-truth for *Bhaskara-II* Orbit No. 2967 (Date : 4.6.1982; Time : 1249-1250 hrs.)

| S. No. | Sat. Pass Location |                 | View angle | Brightness Temp. ( $^\circ$ K) |        |        | surface wind speed (m/s) |         |
|--------|--------------------|-----------------|------------|--------------------------------|--------|--------|--------------------------|---------|
|        | Lat. (N)           | Long. (E)       |            | 19 GHz                         | 22 GHz | 31 GHz | Eqn (1)                  | Eqn (2) |
| 1      | 12 $^\circ$ 49'    | 71 $^\circ$ 10' | + 5.6      | 171                            | 226    | 174    | 6.70                     | 8.50    |
| 2      | 12 $^\circ$ 49'    | 71 $^\circ$ 10' | + 2.8      | 170                            | 225    | 174    | 6.63                     | 8.17    |
| 3      | 12 $^\circ$ 49'    | 71 $^\circ$ 10' | - 2.8      | 169                            | 224    | 176    | 6.57                     | 7.52    |
| 4      | 12 $^\circ$ 49'    | 71 $^\circ$ 10' | - 5.6      | 170                            | 224    | 171    | 6.45                     | 8.50    |
| 5      | 12 $^\circ$ 20'    | 71 $^\circ$ 33' | + 5.6      | 173                            | 231    | 170    | 7.38                     | 10.30   |
| 6      | 12 $^\circ$ 20'    | 71 $^\circ$ 33' | + 2.8      | 173                            | 230    | 180    | 7.19                     | 8.46    |
| 7      | 12 $^\circ$ 20'    | 71 $^\circ$ 33' | - 2.8      | 174                            | 227    | 180    | 6.53                     | 8.13    |
| 8      | 12 $^\circ$ 20'    | 71 $^\circ$ 33' | - 5.6      | 172                            | 227    | 182    | 6.76                     | 7.47    |
| 9      | 11 $^\circ$ 21'    | 72 $^\circ$ 41' | + 5.6      | 178                            | 235    | 186    | 7.52                     | 9.06    |
| 10     | 11 $^\circ$ 21'    | 72 $^\circ$ 41' | + 2.8      | 177                            | 235    | 186    | 7.64                     | 8.89    |
| 11     | 11 $^\circ$ 21'    | 72 $^\circ$ 41' | - 2.8      | 174                            | 234    | 184    | 7.81                     | 8.59    |
| 12     | 11 $^\circ$ 21'    | 72 $^\circ$ 41' | - 5.6      | 174                            | 233    | 181    | 7.62                     | 8.93    |
| 13     | 10 $^\circ$ 51'    | 72 $^\circ$ 41' | + 5.6      | 178                            | 235    | 186    | 7.52                     | 9.06    |
| 14     | 10 $^\circ$ 51'    | 72 $^\circ$ 41' | + 2.8      | 176                            | 235    | 186    | 7.75                     | 8.74    |
| 15     | 10 $^\circ$ 51'    | 72 $^\circ$ 41' | - 2.8      | 174                            | 234    | 185    | 7.81                     | 8.42    |
| 16     | 10 $^\circ$ 51'    | 72 $^\circ$ 41' | - 5.6      | 174                            | 233    | 182    | 7.62                     | 8.77    |
| 17     | 10 $^\circ$ 22'    | 73 $^\circ$ 04' | + 5.6      | 180                            | 238    | 190    | 7.82                     | 9.19    |
| 18     | 10 $^\circ$ 22'    | 73 $^\circ$ 04' | + 2.8      | 178                            | 237    | 191    | 7.88                     | 8.54    |
| 19     | 10 $^\circ$ 22'    | 73 $^\circ$ 04' | - 2.8      | 179                            | 237    | 184    | 7.76                     | 9.88    |
| 20     | 10 $^\circ$ 22'    | 73 $^\circ$ 04' | - 5.6      | 178                            | 235    | 172    | 7.52                     | 11.41   |

Sea-truth — 8.35 m/s (1240 hrs. at station 2430, Lat. 12 $^\circ$ 11'N Long. 73 $^\circ$ 22'E)  
 — 5.22 m/s (1420 hrs. at station 2431, Lat. 12 $^\circ$ 19'N Long. 73 $^\circ$ 15'E)

obtained from sea-truth measurements is made. The atmospheric stability conditions were not considered in the present wind speed comparison.

The values of brightness temperature from *Bhaskara-II* SAMIR and sea surface wind speeds retrieved therefrom together with the corresponding values of wind speed measured during sea-truth cruise are presented in Tables I, II and III for orbits 2967, 3006 and 3021 respectively. To facilitate comparison, average values of wind speeds derived from eqns. (1) & (2) and sea-truth measurements are given in Table IV. It may be seen that the wind speed retrieved from SAMIR data is, in general, slightly higher than the sea-truth values. The values derived from the brightness temperature at 19 and 22 GHz using eqn. (1) matched fairly well with the sea-truth when the wind speed is higher. However, these inferences need to be verified further, as the sea-truth observations available for this study are very few (in the statistical sense) covering a limited range.

Perhaps, an improved prediction of *Bhaskara-II* orbits with less errors in both space and time would have facilitated collection of more realistic sea-

Table II. Comparison of retrieved results with sea-truth for *Bhaskara-II* Orbit No. 3006 (Date: 7.6.1982; Time: 0200-0201).

| S. No. | Sat. Pass Location |                   | View angle | Brightness Temp. ( $^{\circ}$ K) |        |        | Surface wind speed (m/s) |         |
|--------|--------------------|-------------------|------------|----------------------------------|--------|--------|--------------------------|---------|
|        | Lat. (N)           | Long. (E)         |            | 19 GHz                           | 22 GHz | 31 GHz | Eqn (1)                  | Eqn (2) |
| 1      | 18 $^{\circ}$ 02'  | 64 $^{\circ}$ 54' | + 5.6      | 168                              | 231    | 176    | 7.97                     | 8.49    |
| 2      | 18 $^{\circ}$ 02'  | 64 $^{\circ}$ 54' | + 2.8      | 168                              | 232    | 177    | 8.15                     | 8.49    |
| 3      | 18 $^{\circ}$ 02'  | 64 $^{\circ}$ 54' | - 2.8      | 168                              | 232    | 180    | 8.15                     | 7.98    |
| 4      | 18 $^{\circ}$ 02'  | 64 $^{\circ}$ 54' | - 5.6      | 171                              | 231    | 181    | 7.61                     | 8.13    |
| 5      | 18 $^{\circ}$ 32'  | 65 $^{\circ}$ 19' | + 5.6      | 166                              | 228    | 177    | 7.66                     | 7.52    |
| 6      | 18 $^{\circ}$ 32'  | 65 $^{\circ}$ 19' | + 2.8      | 167                              | 228    | 176    | 7.54                     | 7.85    |
| 7      | 18 $^{\circ}$ 32'  | 65 $^{\circ}$ 19' | - 2.8      | 170                              | 232    | 177    | 7.92                     | 8.81    |
| 8      | 18 $^{\circ}$ 32'  | 65 $^{\circ}$ 19' | - 5.6      | 171                              | 232    | 180    | 7.81                     | 8.46    |
| 9      | 19 $^{\circ}$ 01'  | 65 $^{\circ}$ 44' | + 5.6      | 165                              | 227    | 178    | 7.59                     | 7.03    |
| 10     | 19 $^{\circ}$ 01'  | 65 $^{\circ}$ 44' | + 2.8      | 166                              | 228    | 177    | 7.66                     | 7.52    |
| 11     | 19 $^{\circ}$ 01'  | 65 $^{\circ}$ 4 / | - 2.8      | 168                              | 230    | 177    | 7.79                     | 8.16    |
| 12     | 19 $^{\circ}$ 01'  | 65 $^{\circ}$ 44' | - 5.6      | 168                              | 231    | 179    | 7.97                     | 7.99    |
| 13     | 19 $^{\circ}$ 30'  | 66 $^{\circ}$ 09' | + 5.6      | 164                              | 225    | 175    | 7.35                     | 7.05    |
| 14     | 19 $^{\circ}$ 30'  | 66 $^{\circ}$ 09' | + 2.8      | 163                              | 226    | 175    | 7.65                     | 7.05    |
| 15     | 19 $^{\circ}$ 30'  | 66 $^{\circ}$ 09' | - 2.8      | 165                              | 228    | 176    | 7.78                     | 7.49    |
| 16     | 19 $^{\circ}$ 30'  | 66 $^{\circ}$ 09' | - 5.6      | 167                              | 230    | 179    | 7.91                     | 7.67    |
| 17     | 19 $^{\circ}$ 59'  | 66 $^{\circ}$ 34' | + 5.6      | 164                              | 225    | 176    | 7.35                     | 6.88    |
| 18     | 19 $^{\circ}$ 59'  | 66 $^{\circ}$ 34' | + 2.8      | 165                              | 225    | 178    | 7.23                     | 6.70    |
| 19     | 19 $^{\circ}$ 59'  | 66 $^{\circ}$ 34' | - 2.8      | 165                              | 225    | 178    | 7.23                     | 6.70    |
| 20     | 19 $^{\circ}$ 59'  | 66 $^{\circ}$ 34' | - 5.6      | 166                              | 226    | 178    | 7.29                     | 7.03    |
| 21     | 20 $^{\circ}$ 28'  | 67 $^{\circ}$ 00' | + 5.6      | 164                              | 225    | 175    | 7.35                     | 7.05    |
| 22     | 20 $^{\circ}$ 28'  | 67 $^{\circ}$ 00' | + 2.8      | 165                              | 224    | 177    | 7.04                     | 6.71    |
| 23     | 20 $^{\circ}$ 28'  | 67 $^{\circ}$ 00' | - 2.8      | 165                              | 225    | 178    | 7.23                     | 6.70    |
| 24     | 20 $^{\circ}$ 28'  | 67 $^{\circ}$ 00' | - 5.6      | 166                              | 226    | 177    | 7.29                     | 7.19    |

Sea-truth — 4.10 m/s (0150 hrs. at station 2441, Lat. 18 $^{\circ}$ 25' N Long. 67 $^{\circ}$ 47' E)

— 4.40 m/s (0455 hrs. at station 2442, Lat. 18 $^{\circ}$ 39' N Long. 67 $^{\circ}$ 31' E)

Table III. Comparison of retrieved results with sea-truth for *Bhaskara-II* Orbit No. 3021 (Date : 8.6.1982; Time : 0146-0147 hrs.)

| S. No. | Sat. Pass Location |           | View angle | Brightness Temp. (°K) |        |        | Surface wind speed (m/s) |         |
|--------|--------------------|-----------|------------|-----------------------|--------|--------|--------------------------|---------|
|        | Lat. (N)           | Long. (E) |            | 19 GHz                | 22 GHz | 31 GHz | Eqn (1)                  | Eqn (2) |
| 1      | 20° 04'            | 64° 26'   | + 5.6      | 164                   | 227    | 174    | 7.71                     | 7.54    |
| 2      | 20° 04'            | 64° 26'   | + 2.8      | 165                   | 227    | 178    | 7.59                     | 7.03    |
| 3      | 20° 04'            | 64° 26'   | - 2.8      | 170                   | 229    | 179    | 7.37                     | 8.02    |
| 4      | 20° 04'            | 64° 26'   | - 5.6      | 171                   | 232    | 181    | 7.80                     | 8.29    |
| 5      | 20° 33'            | 64° 52'   | + 5.6      | 163                   | 225    | 176    | 7.46                     | 6.72    |
| 6      | 20° 33'            | 64° 52'   | + 2.8      | 164                   | 225    | 178    | 7.35                     | 6.54    |
| 7      | 20° 33'            | 64° 52'   | - 2.8      | 166                   | 225    | 178    | 7.11                     | 6.86    |
| 8      | 20° 33'            | 64° 52'   | - 5.6      | 167                   | 223    | 179    | 6.62                     | 6.53    |
| 9      | 21° 02'            | 65° 18'   | + 5.6      | 163                   | 220    | 179    | 6.55                     | 5.40    |
| 10     | 21° 02'            | 65° 18'   | + 2.8      | 164                   | 221    | 175    | 6.61                     | 6.40    |
| 11     | 21° 02'            | 65° 18'   | - 2.8      | 166                   | 222    | 179    | 6.56                     | 6.21    |
| 12     | 21° 02'            | 65° 18'   | - 5.6      | 167                   | 223    | 179    | 6.62                     | 6.53    |
| 13     | 21° 31'            | 65° 44'   | + 5.6      | 163                   | 218    | 172    | 6.18                     | 6.26    |
| 14     | 21° 31'            | 65° 44'   | + 2.8      | 167                   | 216    | 176    | 5.33                     | 5.90    |
| 15     | 21° 31'            | 65° 44'   | - 2.8      | 165                   | 217    | 173    | 5.76                     | 6.25    |
| 16     | 21° 31'            | 65° 44'   | - 5.6      | 168                   | 218    | 177    | 5.59                     | 6.21    |
| 17     | 22° 00'            | 66° 11'   | + 5.6      | 165                   | 220    | 177    | 6.31                     | 6.06    |
| 18     | 22° 00'            | 66° 11'   | + 2.8      | 163                   | 221    | 178    | 6.73                     | 5.73    |
| 19     | 22° 00'            | 66° 11'   | - 2.8      | 164                   | 220    | 175    | 6.43                     | 6.24    |
| 20     | 22° 00'            | 66° 11'   | - 5.6      | 164                   | 222    | 177    | 6.80                     | 6.22    |

Sea-truth — 4.90 m/s (2300 hrs. at station 2447, Lat. 19°42'N Long. 66°30'E)  
 — 5.90 m/s (0135 hrs. at station 2448, Lat. 19°59'N Long. 66°42'E)  
 — 4.60 m/s (0410 hrs. at station 2449 Lat. 20°14'N Long. 66°53'E)

Table IV. Comparison of retrieved results with sea-truth (average values).

| <i>Bhaskara-II</i><br>Orbit No. | Date     | Average wind speed (m/s) from |          |           |
|---------------------------------|----------|-------------------------------|----------|-----------|
|                                 |          | Eqn. (1)                      | Eqn. (2) | Sea-truth |
| 2967                            | 4.6.1982 | 7.72                          | 8.83     | 6.79      |
| 3006                            | 7.6.1982 | 7.61                          | 7.53     | 4.25      |
| 3021                            | 8.6.1982 | 6.72                          | 6.55     | 5.13      |

truth data and thereby contributed to better results. Further, if SAMIR was operated in alternate mode, by which 500 km on either side of the satellite track could be scanned, its data would have been more useful.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. V.V.R. Varadachari and Dr. J.S. Sastry for the encouragement in taking-up this study. They would also like to thank Drs. T.A. Hariharan, P.S. Desai, A. Sarkar, S.M. Bhandari, G. Raju and Dr. B.S. Gohil of Space Applications Centre (ISRO), Ahmedabad, for the benefit of discussions. The first two authors are thankful to CSIR for awarding fellowship.

## REFERENCES

- Anonymous, 1982. *Data Report of 107th Oceanographic Cruise of RV Gaveshani*, National Institute of Oceanography, Dona Paula, Goa.
- Bhandari, S.M., P.N. Pathak, S.S. Rana, P.S. Desai, G. Raju and A. Sarkar, 1982. Report on SAMIR data validation campaign, *Bhaskara-II SAMIR Technical Report No. 1*, Space Applications Centre (ISRO), Ahmedabad, p. 12-13.
- Bhaskara-II SAMIR Data Users Guide, 1982. *Report No. SAC-RSA-UC-IN-02*, Space Applications Centre (ISRO), Ahmedabad.
- Busch, N.E., O. Christensen, L. Kristensen, L. Lading and S.E. Larsen, 1980. Cups, Vanes, Propellers and Laser Anemometers. In: *Air-Sea Interaction — Instruments and Methods*, edited by F. Dobson, L. Hasse and R. Davis, Plenum Press, London, p. 11-46.
- Gohil, B.S. and A. Sarkar, 1982. Atmospheric water vapour, liquid water and surface wind speed over oceans from passive microwave radiation at *Bhaskara-II* SAMIR frequencies, the retrieval coefficients, *Bhaskara-II SAMIR Technical Note No. 6*, Space Applications Centre (ISRO), Ahmedabad.
- Pandey, P.C., B.S. Gohil and A.K. Sharma, 1980. Determination of ocean surface wind with a Satellite Microwave Radiometer (SAMIR) on board *Bhaskara*. *Mahasagar — Bulletin of the National Institute of Oceanography*, 13(2): 91-98.
- Sarkar, A. and B.S. Gohil, 1982. Estimation of sea surface wind speed from SAMIR data. *Bhaskara-II SAMIR Tech. Note No. 16*, Space Applications Centre (ISRO), Ahmedabad.