ing that is seen in these insects[7]. As the insects were fed with sucrose mixed with mass-multiplied fungus on the natural medium, there is every chance for the spore to be carried inside the insect body by ingestion. Spread of infection might be via proctodeal trophallaxis and faeces to other members of the population[13]. Twenty-four hours after treatment, the spores were found to invade the haemocoel and the fungus was re-isolated from the hindgut[6]. The mechanism for killing the termites in the present study, appears to be initiated by cuticular infection and further spread of inoculum by ingestion. The isolates used in the present study were collected from the agricultural fields of different districts in Andhra Pradesh during the 35 ± 2°C temperature periods. Mass production on cheap agricultural wastes can easily be undertaken by the enthusiastic farmers themselves, if they are provided with inoculum. Fungal pathogens offer great promise for biological control of soil-inhabiting insects[14], because desiccation of fungal spore and their destruction by UV irradiation and temperature extremes are mitigated in the soil matrix. Mortality rate of 65% and 52% recorded in 4-23 and 4-10 isolates of *B. bassiana* respectively, is an emphatic indication for their effective use as bioinsecticide in a termite control programme. The warm, humid and densely populated termite nests are ideal for growth and persistence of the biocontrol agent for a longer time after application.

1. Khan, H. K., Jayaraj, S. and Gopalan, M., *Insect–Science and its Application*, 1993, vol. 14, pp. 529–535.
2. Jones, W. E., Grace, J. K. and Tamashiro, M., *Environ. Entomol.*, 1996, **25**, 481–487.
3. Almeida, J. E. M., Alves, S. B., Moino, A. Jr. and Lopes, R. B., *An. Soc. Entomol. Bras.*, 1998, **27**, 639–644.
4. Rath, A., *Pest Control*, February 1995, 42–43.
5. Zoberi, M. H. and Grace, J. K., *Sociobiology*, 1990, **16**, 289–296.
6. Kramm, K. R. and West, D. F., 1982, **40**, 7–11.
7. Milner Richard, J. and Staples Judith, A., *Biocontrol Sci. Technol.*, 1996, **6**, 3–9.
8. Fernandes, P. M. and Alves, S. B., *An. Soc. Entomol. Bras.*, 1992, **21**, 319–328.
9. Delate, K. M., Grace, J. K. and Tome, C. H. M., *J. Appl. Entomol.*, 1995, **119**, 429–433.
10. Finney, D. J., *Probit Analysis: A Statistical Treatment of the Sigmoid Response Curve*, University Press, Cambridge, 1964.
11. Grace, J. K. and Zoberi, M. H., *Sociobiology*, 1992, **20**, 23–28.
12. Grace, J. K. and Wildey, K. B. and Robinson, W. H. (eds), Proceedings of the 1st International Conference on Insect Pests in the Urban Environment, 1993, p. 474.
13. Keast, D. and Walsh, L. W., *Appl. Environ. Microbiol.*, 1979, **37**, 661–664.
14. Storey, G. K. and McCoy, C. W., *Fla. Entomol.*, 1992, **75**, 533–539.

ACKNOWLEDGEMENTS. We thank Mr K. Ramesh, a progressive farmer for help in field work and Navayuga Engineering Company for financial support. We thank Prof. Vivekananda Murthy, Population Research Centre, Andhra University, for help with statistical analysis.

Received 6 June 2001; revised accepted 24 July 2001

V. PADMAJA*
GURVINDER KAUR

Department of Botany,
Andhra University,
Visakhapatnam 530 003, India
**For correspondence.*
(e-mail: aulibra@md2.vsnl.net.in)

Monsoon onset-2000 monitored using multi-frequency microwave radiometer on-board Oceansat-1

The south-west monsoon is an important atmospheric circulation which affects the Indian subcontinent. The ocean interacts with the atmosphere through exchange of moisture, momentum and heat, which in turn drives the ocean current and modifies the atmospheric circulation. These exchanges play an important role in the organization of various tropical systems like depressions, cyclones, etc. and their precise knowledge in tropical areas is an extremely important input to ocean and atmospheric models. The atmospheric water vapour profile is the most significant manifestation of these exchanges.

In the past, several studies have been made to explain different aspects of monsoon circulation. The observational[1] and theoretical attempts[2,3] to understand the advancement of monsoon from the equatorial Indian Ocean to the main continent, deserve special mention.

The onset of monsoon in meteorological parlance has been associated with the heralding of monsoonal rains over the Kerala coast of the Indian mainland[4]. The onset dates varied from 11 May in 1918 to 18 June in 1972. The average onset date is 1 June, with a standard deviation of eight days. Monsoon affects not only rainfall but also tropospheric wind, humidity and temperature fields. Satellite images also show signatures of monsoon onset. There have been earlier attempts to correlate the onset date with antecedent upper air circulation[5] and thermal features[6].

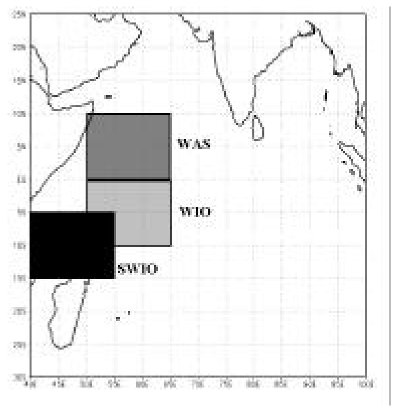

Figure 1. Various segments over the Indian Ocean – Monsoon onset.

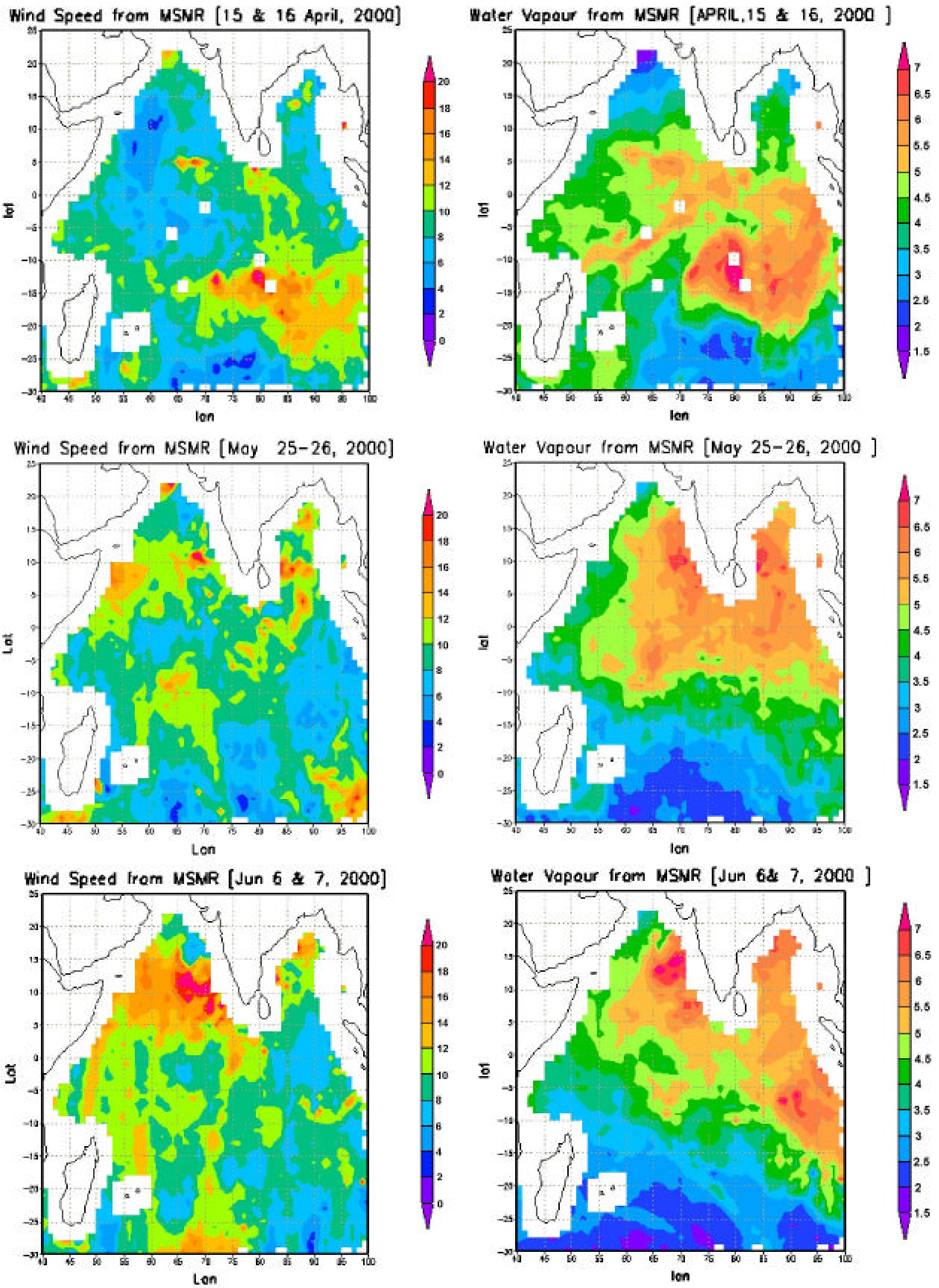

Figure 2. MSMR-derived wind speed and water vapour for three different stages, viz. Pre-monsoon, just prior to monsoon onset and after monsoon onset.

Table 1. Operational parameters from MSMR

Parameter	Channel (GHz)	Grid size (km)	Range	Expected accuracy
Total water vapour	21 + 18, 10	50	0.2–7.5 g/cm^2	0.3 g/cm^2
Sea surface wind speed	10 + 6, 18, 21	75	2–24 m/s	1.5 m/s
Sea surface temperature	6 + 10, 18, 21	150	273–303 K	1.5 K
Cloud liquid water	21 + 18, 10	50	0–80 mg/cm^2	–

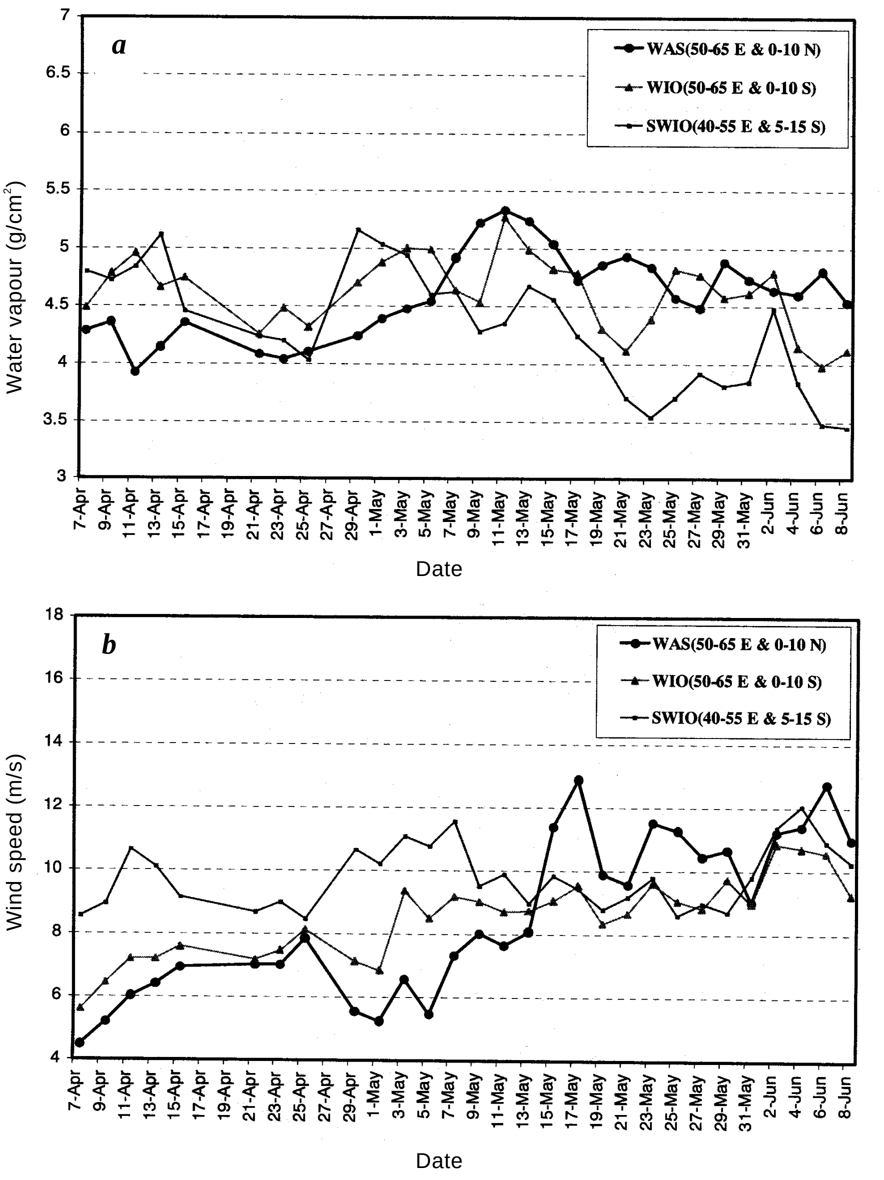

Figure 3. Time series of MSMR-derived ***a***, water vapour; and ***b***, see surface wind speed, over various segments in Indian Ocean.

In bringing the monsoonal rains over India, the cross equatorial flow of moisture and wind as well as the evaporation over the north Indian Ocean and adjoining seas are known to be equally important[7,8]. The kinetic energy shows an increase by an order of magnitude just prior to the onset of monsoon rains over India[9].

The total water vapour (TWV) plays an important role in the summer monsoon circulation/activity over the Indian Ocean, as its availability and transport into the Arabian Sea affects the summer monsoon rainfall, which is generally 60–80% of the annual rainfall in most of the meteorological subdivisions. Simon *et al.*[10,11] have studied the moisture variation and evaporation over the seas adjoining India as available from NOAA/TOVS, satellite data. The study by Joshi *et al.*[6] using data from the NOAA polar orbiting satellites showed that prior to onset of monsoon, tropospheric temperature increases, the maximum change being around 300 hPa, over the Tibetan Plateau region. Simon and Joshi[12] studied the changes in mid-tropospheric water vapour from NOAA/TOVS for seven years over various regions of the Indian Ocean, Bay of Bengal and Arabian Sea. It was found that the mid-tropospheric water vapour content (700–500 hPa) increased by 25% over western Arabian Sea, eight to ten days before the onset of monsoon. The middle level moisture reaches its peak about 8–10 days before the onset of monsoon. In an earlier study of the TWV variation over western Arabian Sea measured using Special Sensor Imager (SSM/I), it was found to increase significantly about 3 weeks before the onset of monsoon. This was a limited study for only two years and data of a few more years have to be analysed for a more precise understanding.

The TWV content and surface wind speeds over the Indian Ocean, which are important parameters related to monsoon onset, were monitored from 15 April 2000 onwards, using Oceansat-1. Maps for these parameters were prepared covering the geographical domain of 40°E to 100°E and 25°N to 30°S. Water vapour and wind speed were also averaged over selected regions covering the Indian Ocean and Arabian Sea (Figure 1). They are marked as western Arabian Sea (WAS), western Indian Ocean (WIO) and south-west Indian Ocean (SWIO). Since multi-frequency scanning microwave radiometer (MSMR) on-board Oceansat-1 can cover the whole of the Indian Ocean region in 2 days, a moving average of two days was adopted.

MSMR is an eight-band (four frequency in dual polarizations), passive microwave radiometer with a conical scan mechanism. The frequency combinations of MSMR, i.e. 6.6, 10.6, 18 and

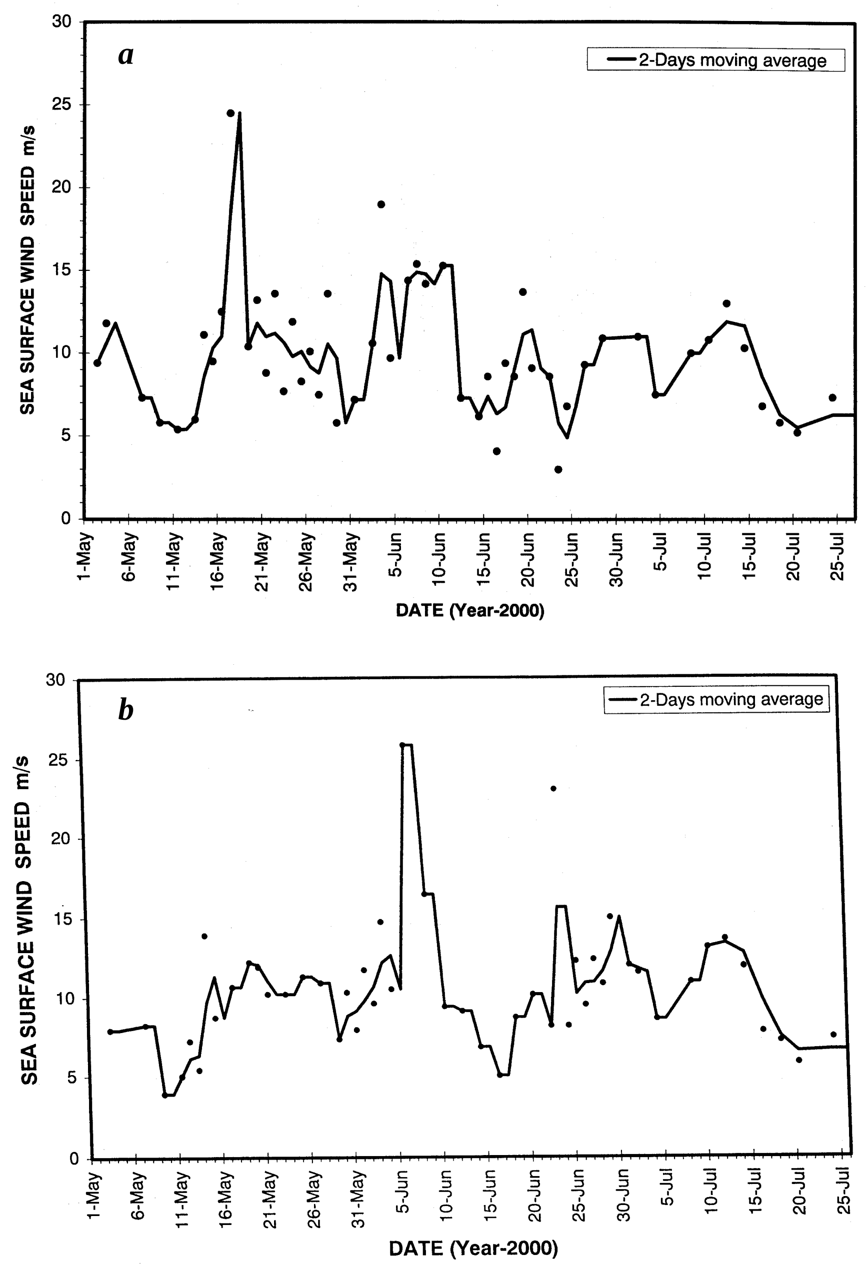

Figure 4. Time series of MSMR-derived sea surface wind speed over ***a***, 7°N, 69°E and ***b***, 9°N, 67°E.

21 GHz, facilitated generation of geophysical parameters – TWV in the marine atmosphere, sea surface wind speed, sea surface temperature and total cloud liquid water, as shown in Table 1. The first version of data product software for both the brightness temperature data as well as the geophysical parameters mentioned above, were developed by the Oceansat-1 Data Products Project team at the Space Applications Centre (SAC), Indian Space Research Organization (ISRO), Ahmedabad, including the geophysical retrieval algorithm software[13]. The MSMR data are available in three grid sizes as shown in Table 1.

The first seventy days (viz. 15 June to 23 August 1999) of MSMR, geophysical parameters underwent validation through comparison exercises with *in situ*, concurrent satellite and numerical model analyses. The results revealed that total atmospheric water vapour and surface wind speed as derived by MSMR are fairly accurate[14] and acceptable for the use in applications. It was therefore recommended that MSMR-derived parameters be used in monitoring monsoon onset of the year 2000 in real time.

As the monsoon progresses towards the Indian subcontinent, the area of maximum moisture content and wind speed moves northwards as revealed by images seen on a weekly basis (Figure 2). There was a sharp increase in water vapour over western Indian Ocean, about 3 weeks before the onset of monsoon (Figure 3 *a*). The MSMR-derived TWV increased by 20% (4.5 g/cm^2 to 5.6 g/cm^2) from 5 May 2000 over WAS region within a span of four days (Figure 3 *a*). Though the monsoon onset was on 1 June 2000, pre-monsoonal showers began from 27 May 2000 onwards. Along with the onset of monsoon over the Kerala coast, an increase in moisture was observed over the Bay of Bengal and Arabian Sea for a considerable period of time, during which there was good rainfall activity over peninsular India.

The wind speed increased to 10–13 m/s over the WAS region from 6 to 8 m/s (Figure 3 *b*) prior to the onset of monsoon. This parameter is useful for characterizing onset, but seems to have less predictive value. The wind speed increase over WIO and SWIO was not as strong as that over WAS.

Bhatia *et al.*[15], in their study with SSM/I data for the period 17 June 1999 to 14 July 1999 noticed that when TWV over the Arabian Sea, off the west coast of India, was 7 g/cm^2 or more and was accompanied by strong surface wind gradients, it led to the convergence of moisture near the west coast and heavy to very heavy rainfall occurred over the west coast and its neighbourhood during the next 24 h or so. When TWV was less then 6 g/cm^2 and was also accompanied by weak low-level wind gradients, the chances of heavy rainfall were less.

A time series plot of wind speed at two specific locations in the Arabian Sea, i.e. 7°N, 69°E (Figure 4 *a*) and 9°N, 67°E (Figure 4 *b*) has shown that two distinct surges of high wind speed have come on 15 May 2000 and 1 June 2000, after which there was increase in rainfall activity, particularly over the west coast of India. The first surge was of a short duration, since high wind speeds were not sustained for a long time after that, though there were daily fluctuations. However, the second surge on 1 June 2000 was of prolonged duration and high wind speeds were sustained for a longer time. Two heavy rainfall events, one over Mumbai on 17–18 May 2000 and the other over Karnataka coast on 6–7 June 2000 were observed. In both these events strong moisture convergence was observed, 1–2 days before heavy rainfall.

1. Sikka, D. R. and Gadgil. S., *Mon. Weather Rev*., 1980, **108**, 1840–1853.
2. Krishnamurti, T. N., Philip, A., Ramananathan, Y. and Richard, P., *Mon. Weather Rev*., 1981, **109**, 344–363.
3. Pearce, R. P. and Mohanty, U. C., *J. Atmos. Sci*., 1984, **41**, 1620–1639.
4. Ananthkrishnan, R., *J. Climate*, 1988, **8**, 283–296.
5. Kung, E. C. and Sharif, T. A., *J. Appl. Meteorol*., 1980, **19**, 370–380.
6. Joshi, P. C., Simon, B. and Desai, P. S., *Int. J. Climatol*., 1990, **10**, 49–56.
7. Cadet, D. and Reverdin, G., *Mon. Weather Rev*., 1981, **109**, 148–158.
8. Cadet, D. and Reverdin, G., *Tellus*, 1981, **33**, 476–487.
9. Krishnamurti, T. N., Pan, H., Chang, C. B., Polsney, J. and Oodally, W., *Q. J. R. Meteorol. Soc*., 1979, **105**, 979–1010.
10. Simon, B. and Desai, P. S., *Boundary Layer Meteorol*., 1986, **37**, 37–52.
11. Simon, B., Joshi, P. C. and Desai, P. S., *J. Geophys. Res*., 1995, **100**, 1439–1443.
12. Simon, B. and Joshi, P. C., *Meteorol. Atmos. Phys*., 1994, **53**, 223–231.
13. Gohil, B. S., Mathur, A. K. and Varma, A. K., PORSEC Proceedings, Goa, 2000, vol. 1, pp. 207–211.
14. Ali, M. M. *et. al*., PORSEC Proceedings, Goa, 2000, vol. 1, p. 182.
15. Bhatia, R. C., Meena, L. R. and Jain, R. K., *Proc. of Tropmet-2000, Ocean and Atmosphere* (eds Joseph, P. V. *et al*.), Pai & Co., Cochin, pp. 281–285.

ACKNOWLEDGEMENTS. We are grateful to SAC, IMD and NRSA scientists and staff for support during the course of the study.

Received 17 April 2001; revised accepted 29 June 2001

B. SIMON*,#
P. C. JOSHI*
P. K. THAPLIYAL*
P. K. PAL*
ABHIJIT SARKAR*
R. C. BHATIA†
R. K. JAIN†
DEVENDRA SINGH†
S. K. MUKHERJEE†
H. V. GUPTA†

**Meteorology and Oceanography Group,*
Space Applications Centre,
Indian Space Research Organization,
Ahmedabad 380 015, India
†SATMET Division,
India Meteorological Department,
Lodi Road,
New Delhi 110 003, India
#For correspondence.
(e-mail: baby_simon@hotmail.com)

A note on the plankton from Barren Island region, Andamans

Barren Island, located 75 nautical miles north-east of Port Blair in the Andaman Sea, is the only active volcanic island in India (Figure 1). A general description of the Barren Island region by Boden[1], dates back to 1902. Until now, only two scientific investigations have been made in and near this volcanic island. Rao and coworkers[2] gave a preliminary account of the fauna and flora found in the island. A subsequent report by Mustafa[3] dealt with the general physicochemical characteristics of near-shore waters at a time when the volcano last erupted in 1991. During intense volcanic activity, the author noticed regions of low pH and high temperature in some shallow water columns in the immediate vicinity of the land mass.

This paper presents the results of surface-water plankton studies in the Barren Island region. These results relate to the cruise by *MV Bhikaiji Cama* during 11–12 November 2000.

Sampling was performed on 12 November 2000 from a smaller vessel deployed at N 12°17′21″; E 93°59′06″, roughly 0.5 km from the western shoreline of Barren Island. Physicochemical characteristics of surface sea water were measured using standard methods[4]. Plankton samples were taken using Heron-type nets (mouth area 0.197 m^2) that used 65 and 350 μm mesh types for phyto and zoo portions, respectively. Nets were towed for 10 min in a seaward direction. Additionally, three 1-litre water samples were taken and treated with Lugol's solution. These samples were used for the estimation of phytoplankton density in accordance with the settlement procedure. Net plankton samples were preserved in 2 to 5% formalin buffered with borax. Zooplankton was in addition frozen with no formaldehyde treatment.

From 10.05 am until noon, surface water temperature varied between 29.1 and 29.5°C. Water pH was consistently about 8.1, while oxygen and salinity values were 5.7 mg l^{-1} and 34.1×10^{-3}, respectively. Transparency was profoundly high in the region around Barren Island. In three measurements made at water depths 12, 25 and 150 m, Sechi readings were 12, 25 and 42.

Phytoplankton data in Table 1 address numerical abundance as well as per cent composition details. Phytoplankton density was extremely low and cell numbers in the three surface-water samples were fewer than 10^2 l^{-1}. The listing presents 38 species altogether, comprising of 20 diatoms, 17 dinoflagellates and a blue-green alga, *Trichodesmium erythraeum*. Per cent composition data show obvious prevalence of dinoflagellates and *T. erythraeum* over diatoms, consistent with the propensity of Andaman waters[5]. Notably, as many as 12 species of Peridiniales were represented in the present samples, of which 8 belonged to the genus *Ceratium*.

As seen from Table 2, foraminiferans, radiolarians and sponge larvae contributed to a large portion of the zooplankton. This pattern is in good agreement with the observations by Sorokin *et al*.[6], who recorded high to very high percentage of protozoans in zooplankton taken