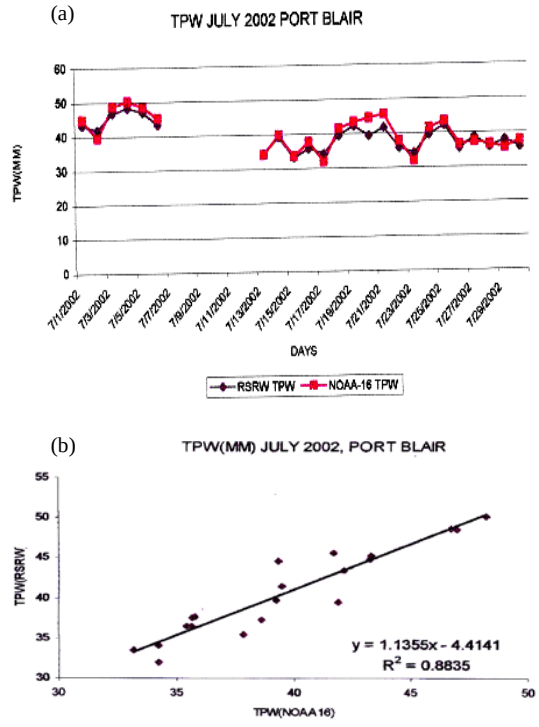
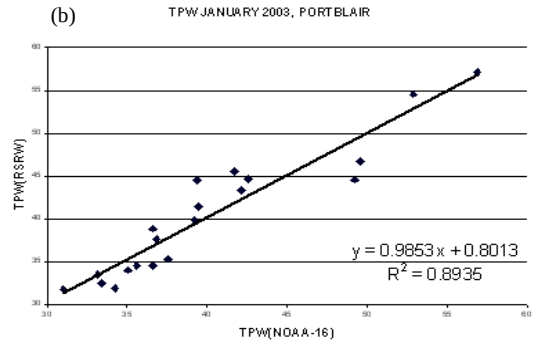
551.508.826 : 556.121

STUDY OF TOTAL PRECIPITABLE WATER (TPW) USING NOAA SATELLITE DATA

1. India Meteorological Department has installed High Resolution Picture Transmission (HRPT) direct readout ground receiving station at Delhi and Chennai to receive HRPT and TOVS data for operational use and research. Recently, the upgraded version of HRPT was installed at IMD, New Delhi to receive the NOAA satellite (K, L and M) ATOVS data in real time. Neural network technique has been used on an operational basis for retrieval of temperature and moisture profiles using



Figs. 1(a&b). Scatter plot of AMSU TPW – RAOB TPW



Figs. 2(a&b). Line plot of AMSU TPW – RAOB TPW

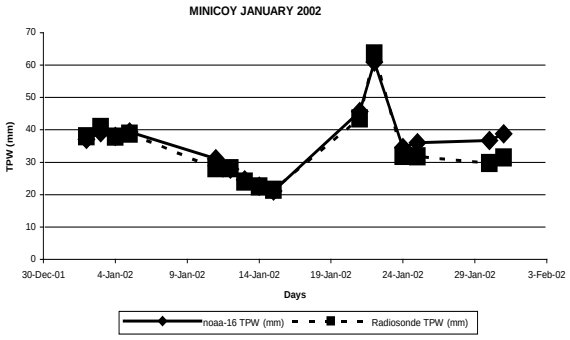


Fig. 3. Minicoy January 2002

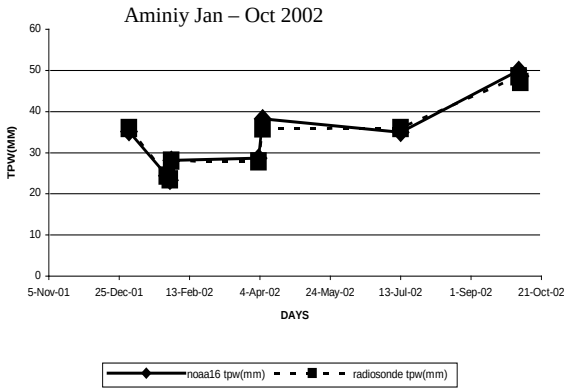


Fig. 4. Aminiy January - October 2002

AMSU data over Indian region (Singh, *et al.*, 2002, 2003a and 2003b). It has been found very useful for assessing the intensity of tropical cyclone by observation of the warm core temperature anomaly (Singh, *et al.*, 2004). The present paper describe the TPW derived from the Advanced Microwave Sounding Unit (AMSU). The 12-channels within 50-60 GHz portion of oxygen band of AMSU-A are used for temperature profiles. The AMSU also contains window channels at 23, 31 and 89 GHz to derive several of hydrological parameter such as total precipitable water (TPW), cloud liquid water (CLW), rain rate (RR), snow cover (SC) and sea ice concentration (SI). In this study these parameters also have been derived using the special sensor microwave/imager of DMSP. An attempt has also been made to compare TPW derived from AMSU to that of derived from SSM/I and TMI sensors, besides validation with radiosonde data over oceanic region.

2. The TPW from Advanced Microwave Sounding Units (AMSU) onboard NOAA-15 and NOAA-

16 orbital satellite have been retrieval on an experimental basis by India Meteorological Department, New Delhi. Using the theoretical algorithms (Grody *et al*., 1999). This uses the two AMSU-A window channel (23.8 GHz and 31.4 GHz) brightness temperature *T* (23), *T* (31) and is given as :

$$TPW = \cos(\theta)\ [c_0 + c_1 \log(285 - T(23.8)) + c_2 \log(285 - T(31.4)]$$

Where

$c_0 = 247.92 - [69.235 - 44.177 \cos(\theta)] \cos(\theta)$,

$c_1 = 116.27$, $c_2 = 73.409$

θ is the local zenith angle.

3. The AMSU TPW is validated against RAOB data. The TPW has been derived from Radiosonde data over Port Blair, Amini and Minicoy. The match-up data (within ~1 degree of latitude – longitude in space and within +/- 3.0 hour in time) has been accumulated. Since the AMSU TPW is an ocean product, only RAOB data over ocean have been used for validation in order to avoid land contamination in the AMSU observations. This has reduced the number of match-up data set and limited the geographical distribution of the match up sites. However, it provides a more reliable validation data set. The validation of against RAOB data has been made at three different island stations located in Bay of Bengal (Port Blair) and Arabian Sea (Minicoy and Amini). The scatter plot and time series diagram given in Figs. 1 (a&b) and Figs. 2 (a&b) are depicted for Port Blair. For the matched points, AMSU TPW has about ~2 mm bias and ~6 mm rms for July 2002 and about 2 mm bias and 4 mm rms error in January 2003 for the Port Blair station. The similar exercise has been done for Minicoy and Amini stations also. The Fig. 3 and Fig. 4 show the time series plots of TPW derived from RAOB and satellite. The Fig. 5 shows the scatter plot of TPW derived from satellite and RAOB for all the stations. This diagram shows very good fitting. The match-up data points are also provided in tabular form. It may be clearly seen that these two data sets are in good agreements. However, the match data points are very small due to constraint of low temporal and spatial resolution taken while making match up data. The validation work against the ground-based observations has shown very good agreements.

The spatial and temporal evaluation of moisture over Indian Ocean and adjacent seas are very important factors for the forecast of monsoon onset over India. TPW has potential to be used in weather forecasting, since it provides high quality monitoring of tropical weather

TABLE 1

Mach up data

Date	Satellite TPW (mm)	RAOB TPW (mm)
	Port Blair	
7 Jan 2003	36.82	37.67
8 Jan 2003		
9 Jan 2003		
10Jan 2003		
11 Jan 2003		
12 Jan 2003		
13 Jan 2003		
14 Jan 2003	35.06	34.04
15 Jan 2003	39.23	39.78
16 Jan 2003	33.17	33.53
17-Jan 2003	31.02	31.84
18 Jan 2003	34.23	31.94
19 Jan 2003	39.48	41.47
20 Jan 2003	42.16	43.38
21 Jan 2003	39.34	44.53
22 Jan 2003	41.69	45.59
23 Jan 2003		
24 Jan 2003		
25 Jan 2003		
26 Jan 2003		
27 Jan 2003	37.56	35.34
28 Jan 2003	36.59	34.51
29 Jan 2003	36.58	38.86
30 Jan 2003	35.59	34.56
31 Jan 2003	33.40	32.53
	Minicoy	
2 Jan 2002	37.04	37.95
3 Jan 2002	39.12	40.85
4 Jan 2002	37.98	37.87
5 Jan 2002	39.38	38.74
11 Jan 2002	31.13	28.17
12 Jan 2002	27.85	28.17
13 Jan 2002	24.52	24.01
14 Jan 2002	22.61	22.48
15 Jan 2002	21.11	21.46
21 Jan 2002	45.64	43.45
22 Jan 2002	60.92	63.62
24 Jan 2002	34.59	31.88
25 Jan 2002	35.98	31.74
30 Jan 2002	36.73	29.69
	Amini	
1 Jan 2002	35.11	35.98
28 Jan 2002	24.36	24.43
30 Jan 2002	23.3	23.49
31 Jan 2002	28.09	28.06
3 Apr 2002	28.66	27.89
6 Apr 2002	38.26	35.87
13 Jul 2002	35	36
5 Oct 2002	50	48.57
6 Oct 2002	48.6	47.18

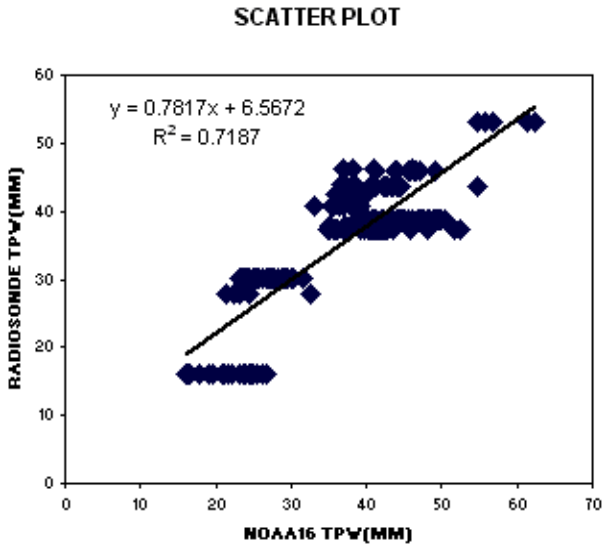


Fig. 5. Scatter plot

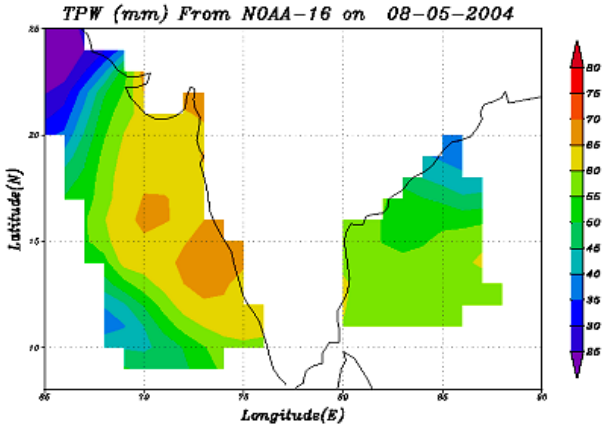


Fig. 6. Scatter plot

systems. Because the AMSU can penetrate most cloud conditions, these retrievals are of particular use in active weather regions. It also presents detailed images of the precipitation pattern for active oceanic storms. The Fig. 6 shows a case of tropical cyclone formed in the Arabian Sea on 8th May 2004. The high values of TPW are clearly shown on the center of tropical cyclone.

4. The quality of geophysical parameters such as total precipitable water derived from microwave data of NOAA satellites were found to be closely matched with radiosonde derived TPW. The bias and rms error are slightly larger in case of July compared to January. This may be due to contamination of precipitating clouds. The advantage of microwave data over infrared data is that microwave data is least affected by the cloud presence and therefore geophysical parameters can be derived in all weather conditions unlike in case of infrared data. Operational availability of TPW could be useful for forecasting possible areas of heavy precipitation.

5. The authors are thankful to Director General of Meteorology, Shri R. C. Bhatia, ADGM (I&T), Dr. Sant Prasad, DDGM (Sat-Met) for their encouragements during course of this study.

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