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Automatic Weather Station at Dakshin Gangotri, Antarctica

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Abstract

Regular observations of the weather parameters are very important for the understanding of Antarctic meteorology. Main difficulty in the collection of continuous weather data over this ice covered continent is the extremly adverse weather condition experienced. In order to collect continuous weather data, automatic weather stations are established by various countries with the help of satellites. The India Meteorological Department has set up an automatic weather station popularly know as Data Collection Platform (DCP) at Dakshin Gangotri, Antarctica, during the Fifth Indian Scientific Expedition. The weather parameters at each GMT hour are sensed by the system and transmitted to the Meteorological Data Utilisation Centre at New Delhi on real time basis, through Indian National Satellite (INSAT-1B).

In this paper a detailed description of the data collection platform system, the sensors used in the system and the difficulties experienced during installation of this system are highlighted. The. data received from Data Collection Platform is compared with manual observations recorded at permanent observatory, Dakshin Gangotri, Antarctica. The results were found to be encouraging. The difficulties arising in maintaining the system in extreme weather have also been discussed.

Introduction

Current understanding of Antarctic atmospheric processes and dynamics suffers from a shortage of meteorological observations from the southern sea ice-belt and the continent itself. Automatic measurement of surface meteorological parameters is, therefore, of particular importance for increasing sparse data coverage in the vast desolate areas of Antarctica, where a well distributed network of manned meteorological stations does not appear practicable. In the last decade, attempts for automatic weather stations were aimed for on-site recording of the data, which could be retrieved from the station during the subsequent summer season. India made similar efforts in the First Expedition itself, when indigenously designed Automatic Recording Weather Station was installed at the Indian Station (Desa *et al,* 1983).

The deployment of satellites with on-board data collection and relay system and the continuing development of low powered digital electronics has made real time monitoring of weather of the remote areas, where manned observations are not possible, easier. Setting up of Automatic Weather Station at higher latitudes was, however, facilitated by the launching of ARGOS Data Collection and Locating Systems (DCLS) on polar orbiting satellites. First satellite with the above system was TIROS-N which was put in the orbit in October, 1978. According to a report of the Scientific Committee on Antarctica Research, there are now more than thirty Automatic Weather Stations operating year-round in Antarctica which is almost as many as the number of manned stations. Many of these stations contribute to specific research programme and data from stations is exchanged over the World Meteorological Organisation (WMO) and Global Telecommunication Network (GTN).

Indian National Satellite (INSAT-1B) launched in August,1983 is a multipurpose geostationary satellite. It is equipped with facility to interrogate and receive signals from Data Collection Platforms (DCP's) located within its Data Relay Transponder (DRT) range, which extends UD to 70° latitude (Fig, 1).Indian

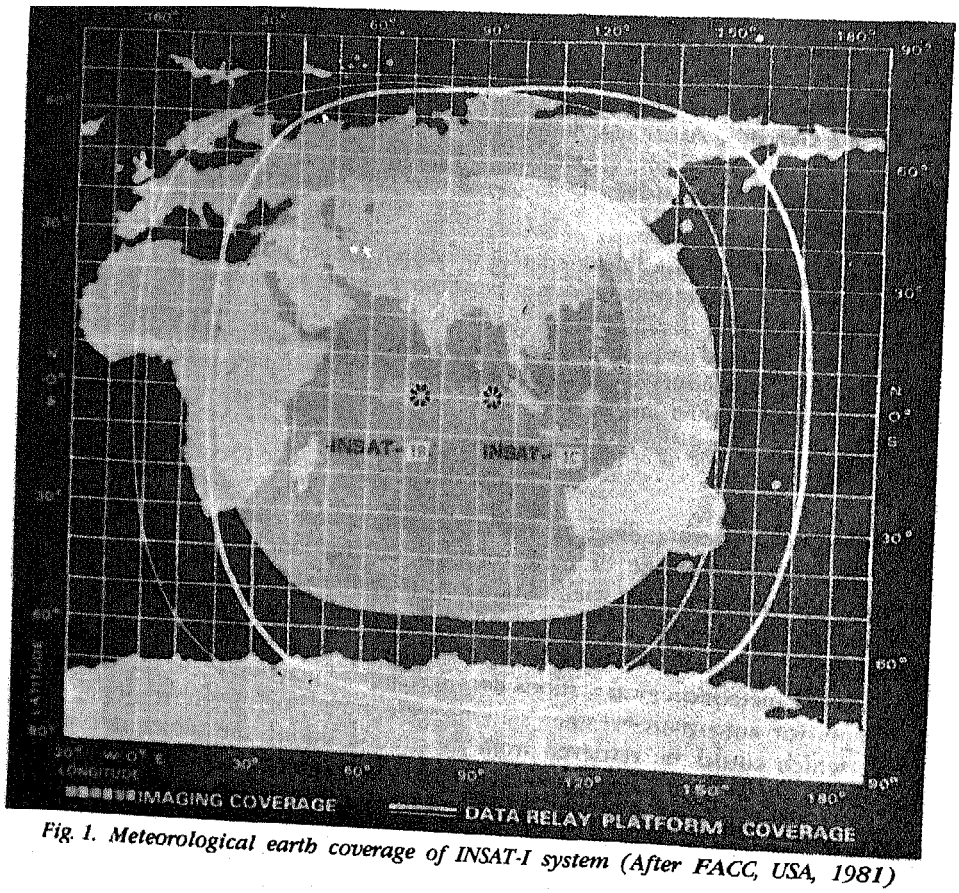

Fig. 1. Meteorological earth coverage of INSAT-I system (After FACC, USA, 1981)

Station at Antarctica being at the fringe of the above limit, initial trials to explore the feasibility of real time reception of surface meteorological observations from Antarctica through INSAT-1B were made by installing a DCP on-board the ship which carried the Fourth Indian Scientific Expedition Team to Antarctica. During the anchorage of the ship off-Antarctic coast, the DCP data signals were successfully received at the Meteorological Data Utilisation Center (MDUC) at New Delhi., Consequently, during the Fifth Expedition, a DCP was installed at Dakshin Gangotri by the India Meteorological Department (IMD) team.

Brief Description of DCP System

The Data Collection Platform System of INSAT-lB comprises of three components; viz,

(a) Data Collection Platform (DCP) consisting of environmental sensors, sensor electronics, data conversion, storage and transmitting system and a tapered helical antenna.

(b) Data Relay Transponder (DRT) on-board INSAT-1B Satellite.

(c) Ground receiving and data processing system.

The DCP transmits data to the satellite at a frequency of 402.75 MHz within the frequency band of 402.65 to 402.85 MHz (Band width 200 KHz). Each DCP automatically records the environmental observations once every full hour GMT, converts it to digital form, stores in the memory and transmits at a pre-set time slot within the next sixty minutes. The message transmitted thus is a serial bit stream consisting of 422 bits, and is sequentially arranged in a specific format. The signal is pulse code modulated (PCM) and transmitted in Bi-Phase shift keying mode. The overall design of the DCP and its sub-system is such that the DCP installation should function satisfactorily unattended for a period of at least up to three months. The characteristics of DCP are given in Table I.

Table I. Technical Characteristics of DCP at Dakshin Gangotri.

Carrier Frequency	402.75 MHz
Frequency Tolerance	±lkHz.
RF Power output	3 Watt nominal/10 watt(max)
Antenna type	Tapered helix:
Antenna gain	12 dB
EIRP	16.5 dBWMIN
BIT Rate	4.8 KBPS
Modulation	PCM-BPSK (0-180)
Message Duration	87.9 m sec
Number of sensors	Four (ten max.)
Transmission mode	Random RF Burs.

The satellite-borne Data Relay Transponder (DRT) relays the data received by individual DCPs to Delhi Earth Station (Sikanderabad) at 4038.1 MHz. This data is transmitted from Delhi Earth Station to Meteorological Data Uulisation Centre (MDUC) at New Delhi over a microwave link. At MDUC, the incoming signal is demodulated in to a digital data stream and buffered on a storage device for checking the quality of data as well as performance of each individual DCP.

DCPs are designed to measure ten different meteorological parameters, out of which eight are functional and two are spare. These are as follows:

1 Air temperature,
2 Wet bulb temperature/relative humidity
3 Wind speed,
4 Wind direction,
5 Station level pressure,
6 Rainfall,
7 Duration of sunshine,
8 DCP housing temperature and
9 and 10 Spare.

In the DCP installed at Dakshin Gangotri only four sensors have been provided, viz., air temperature, wind speed, wind direction and station level pressure. The technical details of these sensors are given in Table II.

Table II. Technical Characteristics of Sensors used in DCP system at Dakshin Gangotri.

Sr. No.	Weather parameter	Sensor used	Range of measurement	Accuracy (WMO specification)
1.	Air temperature	YSI linear thermistor	+50.5°C to -50°C	±1°C
2.	Wind speed	Cup generator anemometer	0.0 to 1000 knots	4.0 knots up to 40.0 knots & 10.0 knots above 40.0 knots.
3.	Wind direction	Potentiometric wind-vane	0° to 360°	±20°
4.	Atmospheric pressure	Aneroid pressure transducer	0.0 to 100.0 mb above datum	±1mb

DCP Installation at Dakshin Gangotri

DCPs are normally installed in a fenced plot of land measuring 2.5 m x 6.0 m, having adequate space for proper exposure of sensors. The DCP installations in Antarctica have to face severe blizzards. They are also susceptible to snow accumulation hazards. The electronic components of the system and power supply unit should be well protected from the extremely low temperatures. Hence it was not feasible to install the DCP system at the surface level as generally done in case of DCP at land. The sensors and helical antenna of the system, therefore, have been installed on the top of a three-container assembly structure attached to the vehicle hangar (Fig. 2). This assembly is nearly 300

Fig. 2. Installation of the data collection platform (DCP) atop hangar garage at Dakshin Gangotri station

metres away from the habitat. All the electronic equipment and power supply units are kept in thermally insulated boxes in the middle container. The temperature inside these boxes is maintained within the workable range of the equipment by illuminating high wattage bulbs inside.

Since Dakshin Gangotri is located beyond the extreme end of the coverage area of INS AT-IB Data Relay Transponder (DRT) antenna, and since there was no sufficient space for the helical antenna, whose position (Azimuth 70 degrees and Elevation 3 degrees) had to be accurately adjusted towards INSAT-1B, the tripod' structure of the antenna was modified at site so as to fix it firmly to

the main frame of the container. Moreover, the antenna and sensors have to face severe blizzards associated with strong winds and blowing snow and hence these outside installations were provided with additional supporting guy wires.

Discussions

Installation of DCP system over Antarctica itself was a challenging job since Indian Station Dakshin Gangotri is outside the fringe of INSAT-1B Data Relay Transponder coverage area. Positioning the antenna accurately towards INSAT-1B was also a critical job where sufficient space and foundation base was not available. During the installation period, station experienced nine blizzards/strong wind conditions. However, the installation and commissioning of the system was completed successfully as per the schedule and system became operational from 22 February, 1986. The satellite link is depicted in Fig. 3.

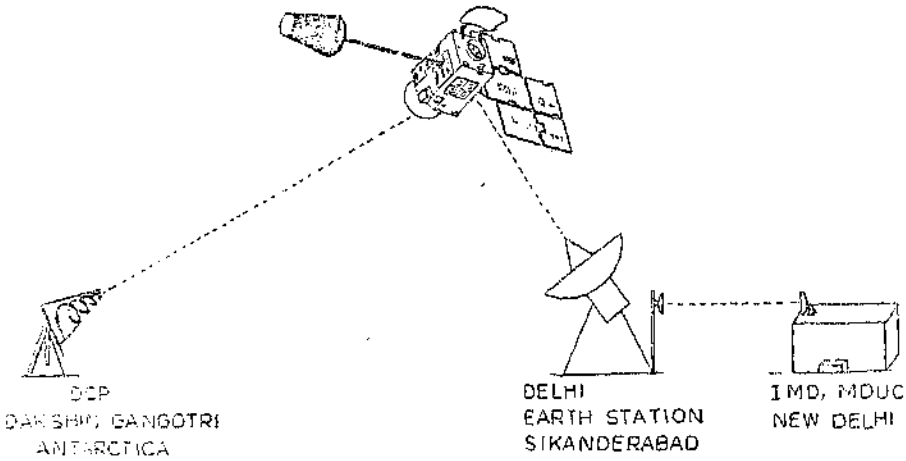

Fig. 3. Transmission of the, meteorological data from Dakshin Gangotri to New Delhi.

Even in adverse weather conditions with very low temperature and severe blizzards, the DCP system at Dakshin Gangotri performed satisfactorily. It is observed that on an average 13 hours of data is received at MDUC, New Delhi for about 25 days per month (Veeraraghavan *et al.*, 1986).

During and after the peak Winter period, difficulties were encountered in maintaining the system due to snow accumulation around installations. Efficiency of the batteries provided with the system was not very satisfactory during severe cold conditions. With all these problems, occasional breakdown of DCP equipment at Dakshin Gangotri was noticed after July, 1986.

The DCP data received at MDUC, New Delhi and the data recorded manually at Dakshim Gangotri were compared for a number of days during

different seasons of the year. Random dates on which DCP peformance was satisfactory were selected. The differences observed were mainly due to different exposure conditions of the sensors.

It was observed that the DCP data compared very well with actual observations during March to May. Temperature, pressure and wind-speed recorded in comparison to the respective values at the time of the synoptic observations on March 27, 1986 are shown in Table III and Figs. 4, 5 and 6. It will be seen that the DCP

Table III. Comparison of DCP data and manual observations on a typical day, 27 March 1986.

Time GMT	Temperature in°C		Wind in knots		Pressure in mb	
	DCP	Manual	DCP	Manual	DCP	Manual
00	-19.0	-20.0	8.0	5.0	974.3	976.7
03	-19.0	-19.0	11.0	12.0	974.4	976.8
06	-19.5	-20.0	12.0	10.0	974.4	976.8
09	-18.4	-18.5	19.0	13.0	974.5	976.5
12	-16.6	-18.0	9.0	10.0	974.0	976.5
15	-20.8	-22.0	11.0	5.0		976.1
18		-22.0		5.0	973.4	976.6
21	-20.4	-21.0	12.0	10.0	973.9	976.4

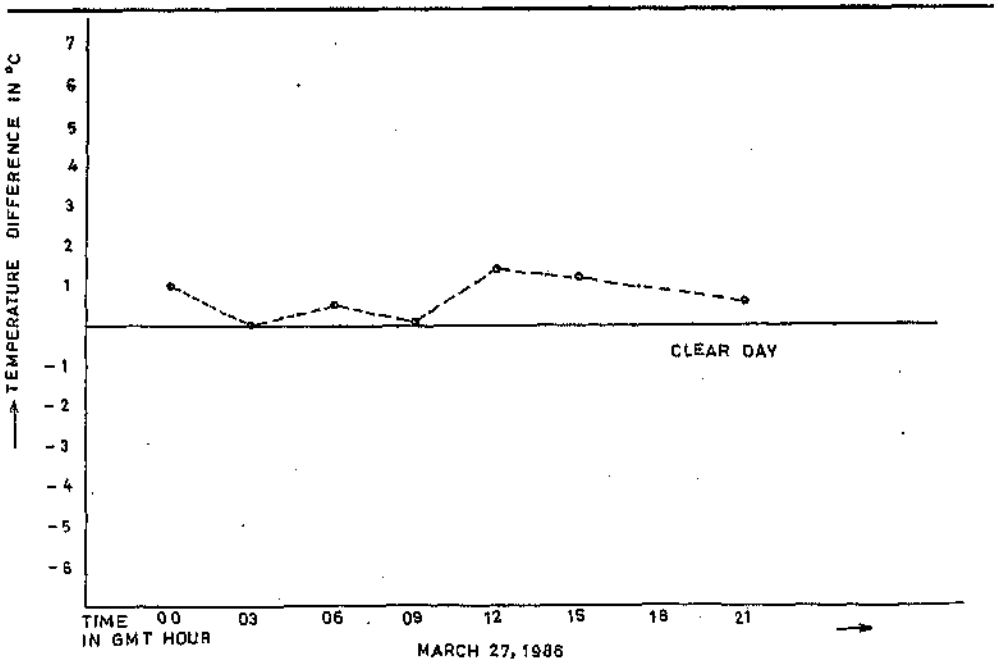

Fig. 4. Temperature difference DCP—Manual

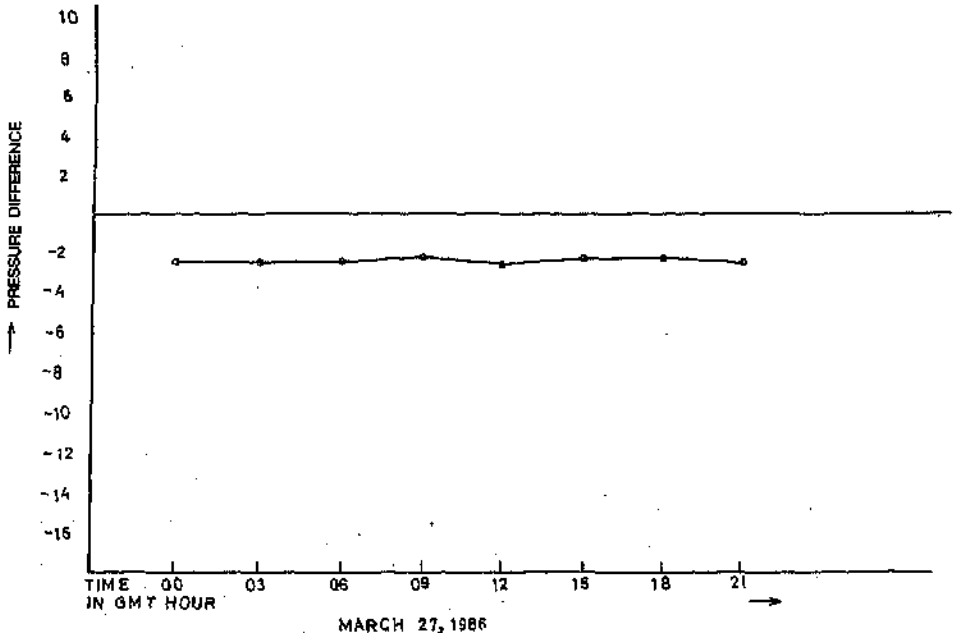

Fig. 5. Pressure difference DCP—Manual

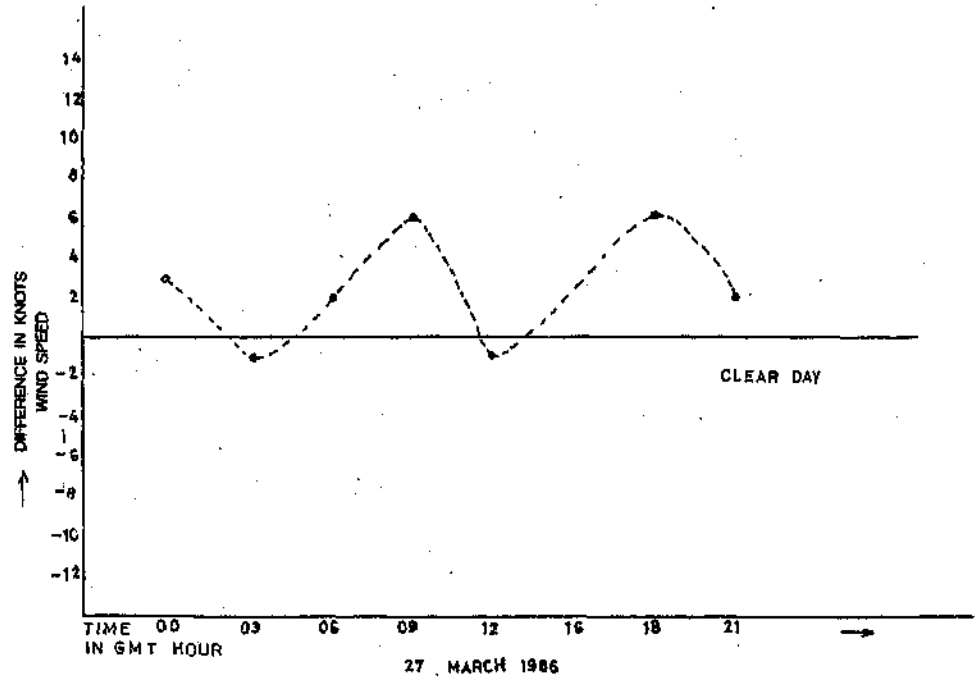

Fig. 6 Wind speed difference DCP—Manual

temperatures were within +0.1°C to +1.4°C compared to the actual observations, and pressure values were 2.0 to 2.5 mb lower than actual observations. These differences were within the sensor limit keeping in view the fact that DCP sensors were at 12 m higher elevation compared to the observatory enclosure which is at the surface level. March 27, 1986 was a clear day with light winds, and thus surface level inversion may account for 1° higher temperature with 1 mb lower pressure value recorded at DCP sensor level. The difference in temperature and pressure values were frequently large in the following months requiring occasional adjustments in voltage of temperature sensor and checking the performance of the batteries. These aspects are being analysed for remedial action.

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