



INDIA METEOROLOGICAL DEPARTMENT

**Forecast Demonstration Project (FDP) for Improving
Track, Intensity and Landfall of
Bay of Bengal Tropical Cyclones**

**Pilot Phase - 2012
Project Implementation Plan**

Background

Currently in India, extensive operational mode activities are in place involving a range of global(GFS-IMD,T-382), regional(QLM), and meso-scale(MM5, ETA, WRF/HWRF) models for generating short(up to 48-72hrs in advance) and medium range(3-7 days in advance) forecast products for use in the prediction of tropical cyclone genesis, intensification, movement and landfall characteristics. Continuous assimilation of all available land based, ocean based and space based observations is carried out at the NCMRWF and regional scale assimilation is carried out at NCMRWF and IMD for generating most representative 3-D atmospheric fields for forcing the regional and meso-scale models.

Extensive performance evaluation and numerical experimentation studies carried out by the operational, R & D and academic groups on tropical cyclone forecasting over the Indian seas of Bay of Bengal and Arabian Sea have concluded that the large tropical cyclone track and intensity forecast errors are due to lack of critical observations from the cyclone core environment. Hence, it is strongly believed that the establishment of necessary aircraft probing of cyclone (APC) facility for generating data from the cyclone core environment can successfully address this critical data gap in cyclone intensity and track forecasting.

The past few years elsewhere in the world have seen huge technological advancements to observe the inner core, both through in situ means, and by remote sensing. During 2005, delegation level meetings from India working in the field of meteorology and atmospheric science to NCAR, USA have identified six themes for Indo-US collaboration. Out of these themes evolution, evolving a programme on prediction of track of tropical cyclones over the Bay of Bengal was marked as the top priority item and the NCMRWF was asked to lead the joint programme from India side. Advanced high resolution global and meso-scale assimilation-forecast systems have been implemented. Capabilities to assimilate data from non-conventional observational platforms (satellite, radar) have been developed.

Recent initiatives for FDP Planning

Follow up meetings between Indo-US groups have culminated to the organizational planning of the FDP over Bay of Bengal on the lines of NOAA-HRD and NCARs experience on cyclone probing over the Atlantic region. A Committee chaired by Shri D R Sikka had addressed this issue and has come out with an overall science plan. This Science Plan has been subsequently modified. Keeping in mind the nature and scale of the programme that needs to be supported with adequate funding, an appropriate project management structure is put in place to ensure the deliverables to get fully integrated with the operational cyclone forecast systems. The Pilot Phase of the programme started in 2008 based upon the available observational, NWP and communication infrastructure. It continued in 2009, 2010 and 2011 with the upgradation observational network and NWP modeling system. Based on the experience of these past pre-pilot phases of FDP, the implementation plan has been modified and presented here for the year 2012.

Key Scientific Objectives and Goals for FDP

- i) To demonstrate the ability of the Numerical Models using enhanced observation over the region including the measurements from the dropsonde's over the periphery of the cyclone and to assess overall accuracy limits in terms of the cyclone track, intensity and landfall for one to two seasons.
- ii) To incorporate modification into the models which could be specific to the Bay of Bengal based on the in-situ measurements and following the actual track through Satellite and Radar observations.

Though the key scientific objective of the programme involves the use of aircraft and dropsondes. The possibility of these tools during 2012 is remote. However, the effort is under the way to have a joint campaign with USA using WC-130 J aircraft and dropsondes.

Programme

The objectives of the programme will be met by conducting a joint observational communication and NWP effort by several institutes in the country during the period 15 Oct.-30 Nov. 2012. There will be Intensive Observational Phases (IOP) within this period tuning actual cyclone events. There will be a National Operational Centre (NOC) and a Field Operational Centre (FOC) at Chennai.

National Operational Centre (NOC):

The overall campaign will be monitored and guided by a Weather Monitoring and Advisory Group (WMAG) at National Weather Forecasting Centre (NWFC), IMD. In addition, communication conferencing and data exchange will be facilitated from this nodal cell. It will be called the NOC. The announcement of IOP will be made by NOC. (Contact: Dr. M. Mohapatra, Cyclone Warning Division, IMD, New Delhi, e-mail mohapatraind@gmail.com & cwdhq2008@gmail.com, Phone no. 011-24652484, 24631913 Mobil: 9868623475, Fax No. 011-24623220).

Field Operational Centre (FOC):

The FOC, Chennai will work in unison with the NOC coordinating all activities of every institution during the IOP (Contact: Dr. Y.E.A. Raj, DDGM, RMC Chennai e-mail: yearaj@gmail.com & Dr. S. Balachandran, Sc. E, Cyclone Warning Research Centre, RMC, Chennai, E-mail: balaimd@gmail.com, Phone No. 044-28276752, Fax No. 044-28276752)

Multi institutional initiative

The institutions involved in the program are as follows:-

- 1) IMD
- 2) NCMRWF
- 3) ISRO
- 4) IAF
- 5) INDIAN NAVY

- 6) IIT KHARAGPUR
- 7) IIT DELHI
- 8) INDIAN INSTITUTE OF SCIENCE
- 9) NIOT
- 10) INCOIS
- 11) NCAOR

**Targeted FDP Requirements for the FDP Campaign of October-November 2012
Observational program:**

(I)AWS:

Operational meso-scale AWS network of IMD along the east coast of India available for pilot phase is shown below.

S. No.	State	Existing No. of AWS Stations
1	West Bengal	17
2	Orissa	30
3	Andhra Pradesh	22
4	Tamilnadu and Puducherry	18
5	Andaman & Nicobar	1
6	Lakshadweep	1
7	Kerala	10
8	Karnataka	21
9	Goa	2
10	Maharashtra	37
11	Gujarat, Daman & Diu and Dadra Nagar & Haveli	27
12	East coast + A&N Islands	88
13	West coast + Lakshadweep	97

The locations of the stations are shown in Fig.1

- DDGM(SI), Pune will ensure the real time transmission of data from AWS stations along east coast of India and additional 14 in the Northeast to DDGM(ISSD) Delhi in GTS mobile synop format. DDGM(SI) will submit

status report by 1st October 2012 to Project Manager on the availability of such data.

- Data from PRWONAM and northeast India Meso-scale AWS network will be made available by ISRO from the MOSDAC server of SAC, Ahmedabad on real time (Fig.2).
- SAC Ahmedabad to intimate DDGM(Sat. Met) to make arrangements to download ISRO AWS data and relay it to NOC for operational and NWP application.
- Data formatting issues associated with ISRO AWS data are to be sorted out through joint effort of Shri A.K. Sharma DDGM (Satmet) and Dr S.K. Roy Bhowmik, DDGM (NWP) of IMD by first 30th September 2012. On finalisation the process of converting ISRO AWS data into mobile synop (GTS) format need to be automated in liaison with DDGM(ISSD) prior to the FDP-2012 period.
- AWS data from 10 stations commissioned (under STORM Project) by Kolkata University and Guwahati university will also be communicated to NOC. DDGM, RMC, Kolkata and Guwahati will coordinate and intimate the status to NOC and FOC by 1ST October 2012.
- RMCs at Kolkata and Guwahati will work out modalities to collect and transmit data on real time basis from AWS network established under the storm programme by Kolkata University, Jadavpur University and Guwahati University by 1st October. Formatting issues as described above shall also be addressed. The data will be transmitted through AMSS of respective RMC. FOC shall coordinate the exercise.

IMD AWS network data over NE India is given below.

S. No.	State	Existing No. of AWS Stations
1	Assam	26
2	Meghalaya	7
3	Nagaland	7
4	Arunachal Pradesh	7
5	Tripura	4
6	Manipur	10
7	Mizoram	8
8	Sikkim	3

(II) Synop

- Synoptic observatories of IMD network (Fig.3 and Fig.4) over the peninsular/east India under the RMCs of Chennai and Kolkata shall report data on hourly basis, during IOP. During normal period of FDP, 3 hrly. SYNOP will be collected.
- RMC Kolkata and Chennai will ensure hourly observation and transmission through telephone/fax/e-mail of all synops of coastal stations during IOP to NOC and FOC. In addition, RMC Chennai shall organize transmission of such data through AMSS.
- RSMC, New Delhi will write to concerned WMO/ESCAP Panel member countries to ensure the availability of synoptic data from there respective region for the FDP period.
- FOC will also intimate the status of Cyclone Distress Mitigation Committee (CDMC) stations along east coast to NOC and ensure their functioning during FDP period.

(III) Buoys:

Real-time collection of hourly data from deep ocean and met-ocean buoy network over the Bay of Bengal from INCOIS Server will be ensured by DDGM(ISSD).

- NOC & FOC will utilize these data received through GTS/E-mail.
- INCOIS will ensure availability of additional marine surface pressure observation through E-mail to NOC & FOC

(iv) High wind speed recorder(HWSR)

There are twelve HWSRs along the coast of India in the operational conditions as mentioned below.

Digha	: West Bengal
Visakhapatnam	: Andhra Pradesh
Machilipatnam	: Andhra Pradesh
Nellore	: Andhra Pradesh
Chennai	: Tamil Nadu
Karaikal	: Puducherry
Mumbai	: Maharashtra
Puri	: Orissa
Paradip	: Orissa
Gopalpur	: Orissa
Veraval	: Gujarat
Dwarka	: Gujarat

FOC, Chennai will ascertain the functioning of the HWSRs along the east coast. It will make arrangement for collection and dissemination of HWSR data on real time basis to NOC and NWP Division of IMD. It will also make arrangement for archival of this data. NWP Division of IMD and NCMRWF will try to ingest these data in NWP models. The performance of HWSRs during IOP period will be evaluated.

(v) Upper air:

Augmentation of coastal/peninsular upper air measurements (Fig.5)

- Upper air RS/RW data from IMD stations (Guwahati, Kolkata, Port Blair, Bhubaneswar, Visakhapatnam, Machilipatnam, Hyderabad, Chennai, Karaikal, Minicoy/Amini Divi, Trivendrum) will be collected at least once(based on 0000 UTC) for normal days of FDP period. However, during the IOP phase of FDP, 12 hrly. data shall be collected. The flights terminating below 250 hPa are to be repeated.

- DDGM(UI), RMCs Kolkata, Chennai and Guwahati will take all necessary steps in support of FDP observational requirements. The readiness report should be sent to NOC by 1st October 2012.
- Additional GPS Sonde soundings will be taken at Balasore, Gopalpur, Kalingapatnam, Ongole/Bapatla and Pamban with the support of ISRO.
- DDGM, Chennai and DDGM(UI) shall liaise with VSSC, Trivendrum to ensure commissioning of equipment along with training to IMD staff to operate during the IOP phase of FDP. DDGM, Kolkata will depute suitable staff for Balasore and Gopalpur and remain in touch with RMC Chennai.
- Upper air GPS Sonde data from Indian Navy stations shall be made available by the DNOM HQs, Delhi through e-mail. DDGM(UI) shall liaise with DNOM and ensure real time data transfer for the FDP period.
- FOC may explore the availability of Upper air data from GPS Sonde network of ISRO at Gadanki, SHAR, Arakkonam, Kochi etc. for the IOP Phase of FDP. DDGM, Chennai shall liaise with VSSC, Trivendrum to ensure commissioning of equipment along with training to IMD staff to operate at these station if agreed by ISRO during the IOP phase.
- Due arrangements are to be made by DDGM (UI) to receive all available Pilot Balloon data sets for the FDP 2012 period.
- Arrangements have to be made by DDGM(UI) to collect pilot balloon data from IAF. In case of becoming dark by 12UTC, IAF be advised to take the Pilot ascent by 11UTC. Daily flight level winds as collected by IAF flights between Carnicobar and Tambaram are also to be received for FDP 2012 period. Project Director (Instrumentation) shall liaison with IAF to receive GTS coded data.
- DDGM(NWP) of IMD shall ensure the synchronization of data formats and collection at the NWP/NWFC of data received from outside IMD institutions in order to facilitate for the Data Processing and quality control systems at IMD and NCMRWF.
- Wind profiler support from the existing Gadanki and SHAR is to be activated so as to receive hourly profiles in the lower troposphere. FOC,

Chennai will request ISRO (Principal Scientist) for organizing necessary observational support during FDP campaign. ISSD, IMD, New Delhi will identify nodal officers to workout real time data reception modalities in this regard.

(vi) DWR Support

DWR Support from 5 locations (Fig.6) at Kolkata, Visakhapatnam, Machillipatnam SHAR, and Chennai with uniform storm scanning strategy will be ensured prior to the FDP-2012. DDGM(UI) shall make due arrangements to receive the DWR data in real time to DDGM (ISSD) for the FDP 2012.

(vii) Satellite observations

DDG(Sat Met) shall make all available satellite derived products (high resolution AMVs; rapid scan winds; OLR; OceanSat and WINDSAT winds; local HRPT Temperature and moisture profiles from INCOIS; GPS occultation data; MODIS moisture data; TMI; SSMI and AMSU data sets etc.) for its utilization by the global and regional data assimilation-forecast systems of IMD and NCMRWF during the FDP 2012 period.

Satmet. Division will issue special bulletin every three hourly about the cyclonic disturbance.

Telecommunication

- (a) DDG(ISSD) shall take all necessary steps so as to receive the observational data at the NOC and FOC from all identified sources both from FDP partners and the regional countries (Bangladesh, Myanmar, Malaysia, Thailand and Indonesia, Srilanka) in real time. ISSD and NWP division shall continuously monitor the data reception at NWP/Telecom and ensure the timely data reception and onward transmission of data to NWP Division and NCMRWF throughout the FDP 2012 period.
- (b) IMD shall update FDP Web Page on IMD (linked at NCMRWF as well). The existing FDP e-mail group will be updated with full contact details).An FDP discussion group for the exchange of FDP related information among the FDP partners may be created. DDGM(ISSD), IT cell will take necessary action in this regard.

NWP analysis and prediction

- (a) NWP Division shall make all necessary arrangements for the generation of global and regional analyses fields by using special FDP 2012 data at 4 analysis times (00, 06,12,18 UTC) for the whole of FDP 2012 period. Arrangements are also to be made to keep FDP 2012 analyses fields and forecast boundary fields upto 72hrs on ftp servers of NCMRWF and IMD for their utilization by FDP partners in India. Efforts will be made to bring out the Regional Model forecast within three hours of the observation time.
- (b) NWP Division, IMD shall workout arrangements to provide analyses fields of ECMWF and UKMO as well on the ftp servers at NCMRWF and IMD for the FDP 2012 period.

International Cooperation

Director RSMC, New Delhi shall request the ESCAP Panel, SAARC and BIMSTEC countries about the FDP over the Bay of Bengal programme of India and solicit their cooperation in the real time exchange of data (surface, upper air and special observations) for their utilization in the generation of most representative meso-scale analysis fields over the Bay of Bengal and its neighbourhood for generating improved quality of track, intensity and landfall of tropical cyclones.

FDP Operation Centre

Project Director will be assisted by a National FDP Operations Centre (NOC) at NWFC and a FDP Weather Monitoring and Advisory Group will be constituted to identify the IOP phases during FDP 2012 period.

FDP Weather Monitoring and Advisory Group (WMAG)

- 1. DGM Chairman
- 2. Shri D.R. Sikka
- 3. Prof. U.C. Mohanty
- 4. Head ,NCMRWF
- 5. DDGM(S), Scientist-E (S)

6. All members of FDP Project Team
7. Representatives from IAF, Indian Navy.

The WMAG shall meet thrice a week (Monday, Wednesday & Friday) at 1530 hrs. (including holidays) during the period 15 Oct.- 30 Nov., 2012 at NWFC Meeting Room IInd floor to review the FDP activity regularly and decide on IOP declaration. Weather summaries and current information will be presented by Project Scientist, FDP. The weather summaries and information will be prepared daily and uploaded in the website along with circulation through e-mail like previous years.

Implementation Strategy

- Preparatory Phase for the
FDP Pilot 2012: 1-30 September 2012
(Actions to be completed as mentioned above)
- FDP-2012 Field Phase: 15 October to 30 November
(Actions to be completed as mentioned above)
- IOP Phase: Identified by the NOC at NWFC in consultation with the Weather Monitoring and Advisory Group
- NOC: The NOC will be established at NWFC, New Delhi which will be responsible for entire co-ordination and declaration of IOP. The center will function independently. The usual operational activity of RSMC will be separate.
- FOC: Cyclone Warning Research Center at RMC, Chennai shall function as the FOC and establish links with all FDP partners, notify all IOP phases to FDP partners, coordinate and update the status of observation collection and transmission from FDP partners from

time to time. The RMCs at Kolkata and Guwahati; ACWCs at Kolkata and CWCs at Visakhapatnam and Bhubaneswar shall work in close liaison with FDP FOC and NOC, NWFC, Delhi for smooth and efficient organization of FDP 2012 pilot observational campaign.

- FDP Data Centre:

All special observations collected by the FDP project partners shall be archived along with meso-scale analysis and forecast fields at IMD and NCMRWF computing centers.

- Post Experiment Phase:

1. Preparation of weather summery data CD will be carried out by the project management team and NWP group of IMD.

2. Project management team shall Plan and coordinate necessary R&D work involving not only FDP partners but also other academic and research groups in the country to maximize the utilization of FDP data for accomplishing the envisaged targets of the project.

- 3 An article on implementation report will be prepared at the end of FDP-2012. It will highlight societal issues along with the programme implementation, out come and lessons learnt.

- 4.The daily rainfall data along the coast during landfall of a cyclone will be

analysed to find out the diurnal variation of rainfall.

5. A report will be prepared at the end of FDP about the performance of HWSR.

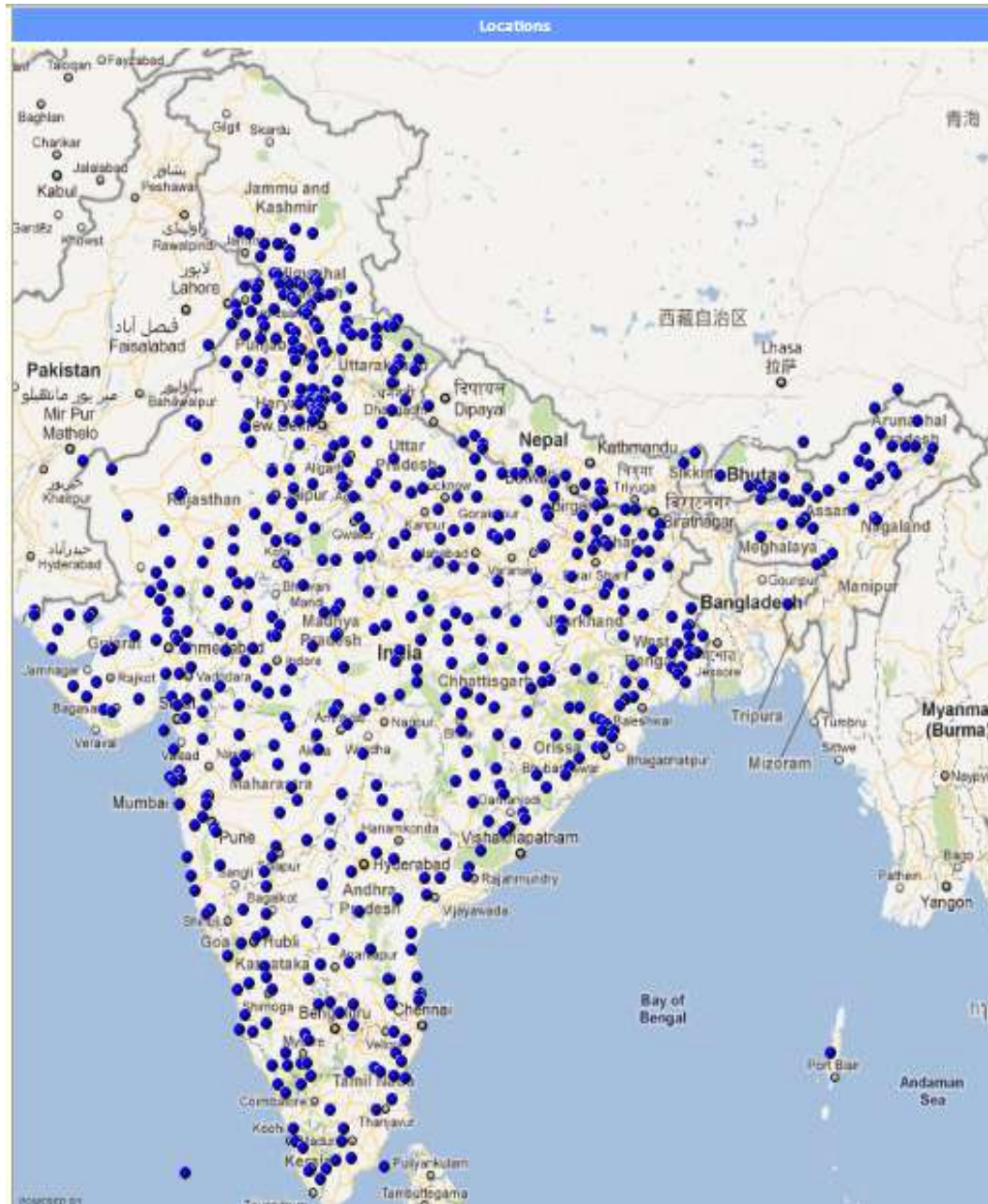


Fig.1(a). IMD's network of 675 (127 Agro+548) AWS

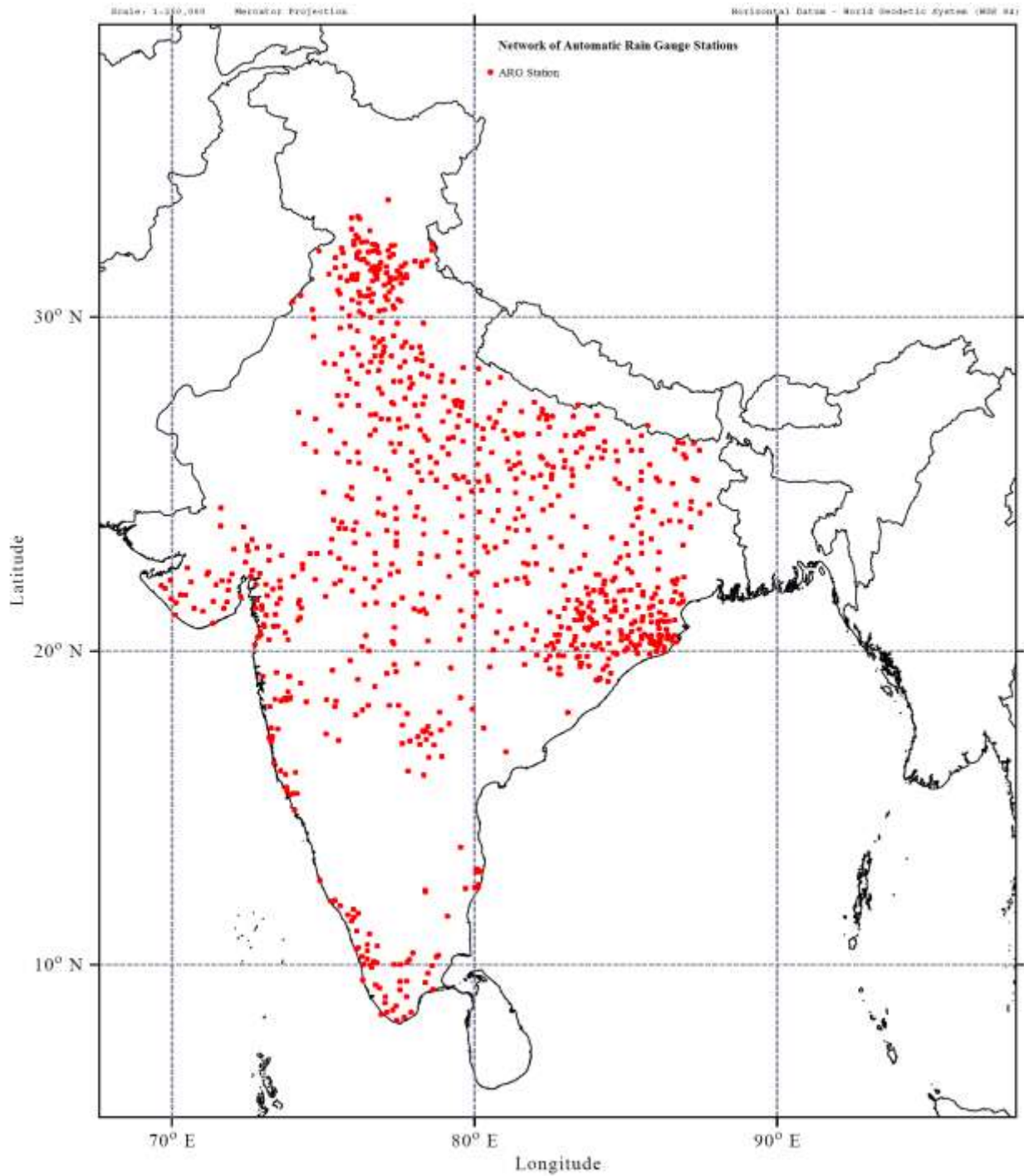


Fig.1(b). IMD's network of 900 Automatic Rain Gauge (ARG)

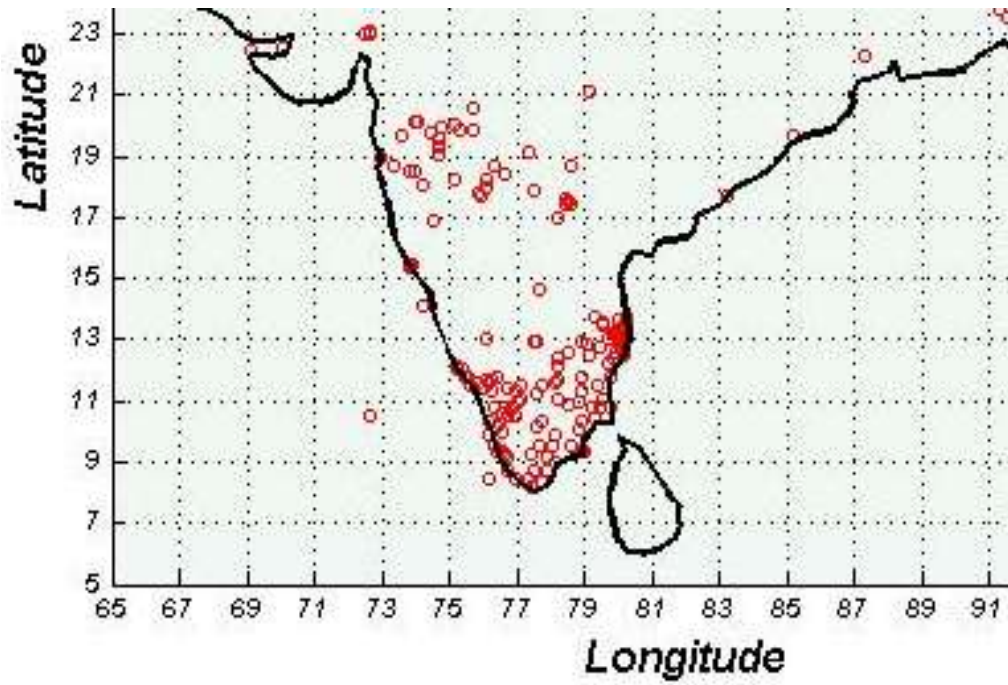


Fig.2. ISRO AWS stations under PRWONAM project.

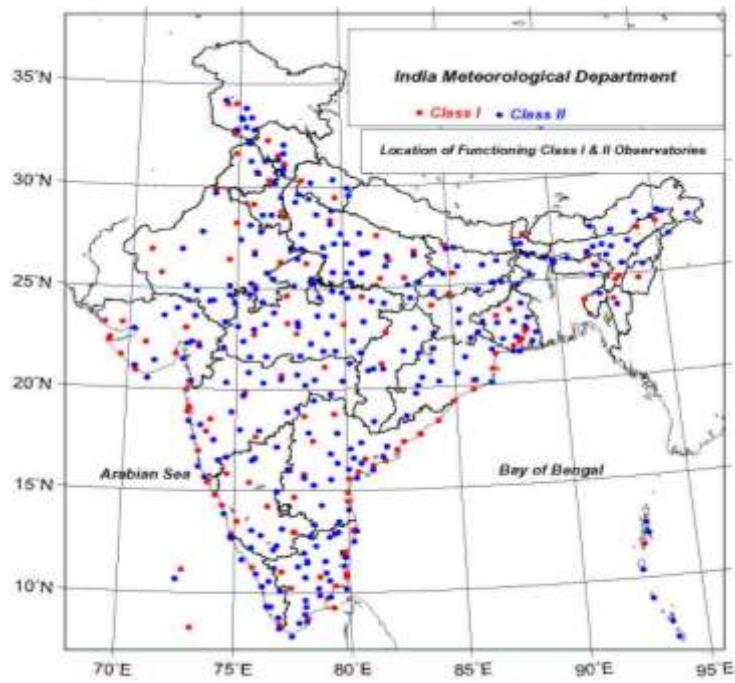


Fig.3. Synoptic stations of IMD

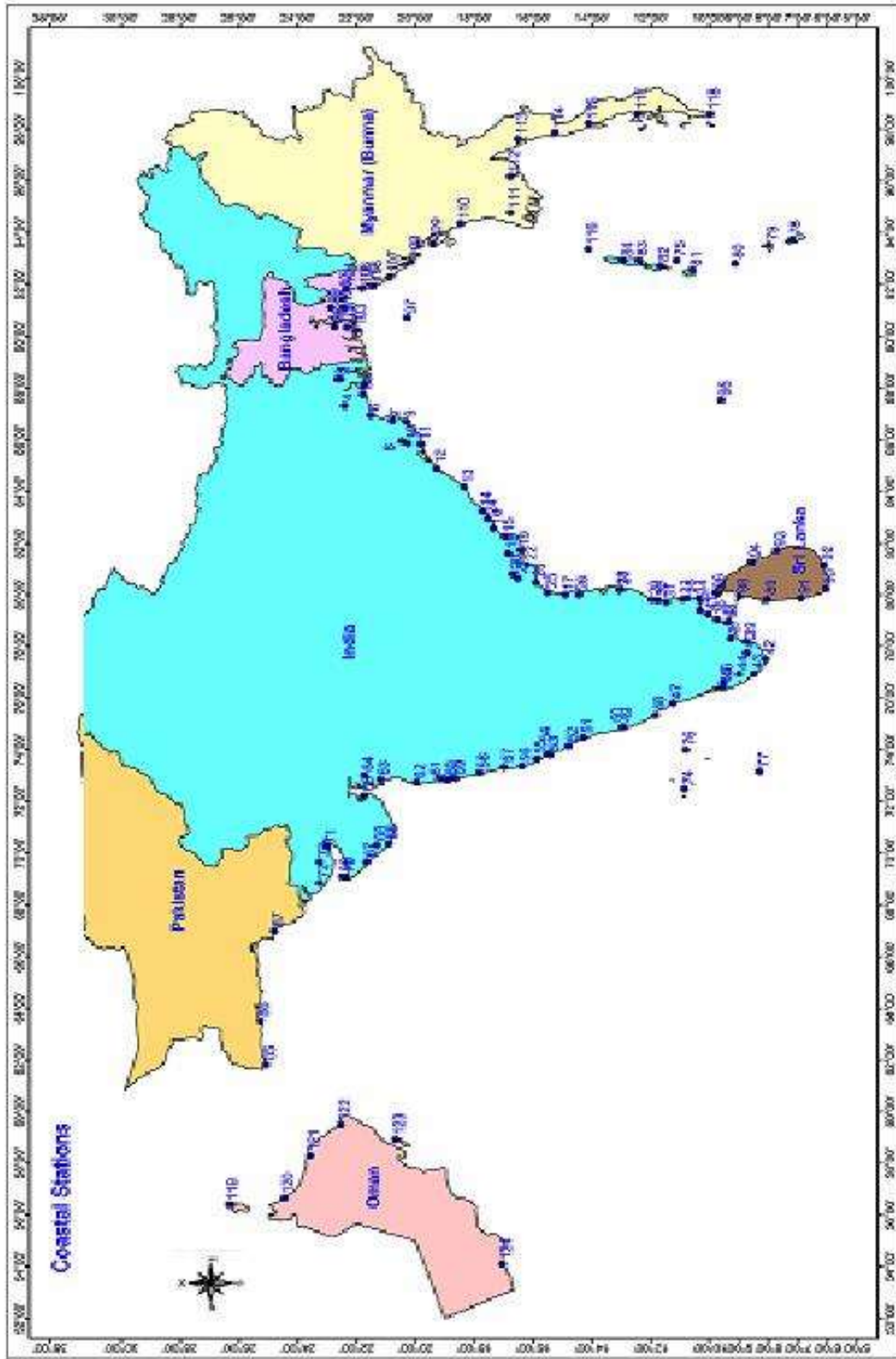


Fig.4. Coastal synoptic stations

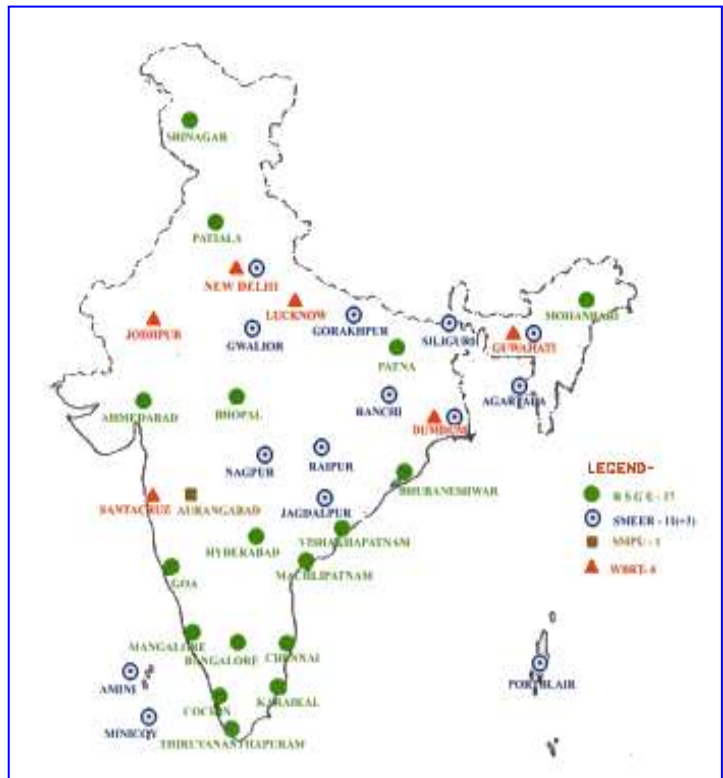
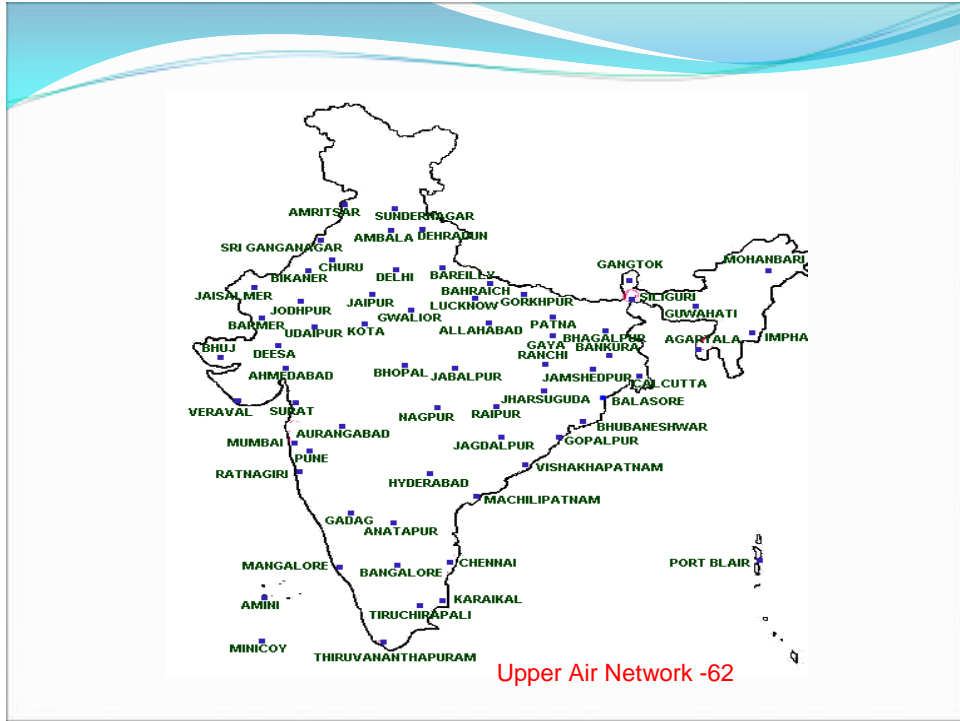


Fig.5. Pilot balloon and RS/RW (including 10 GPS stations) network of IMD

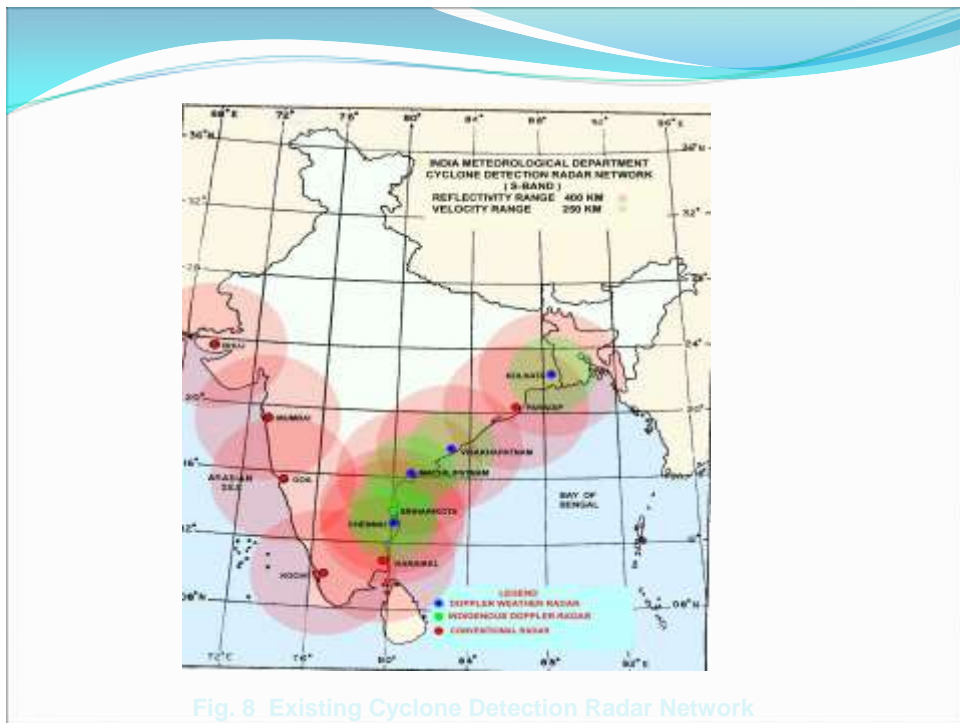
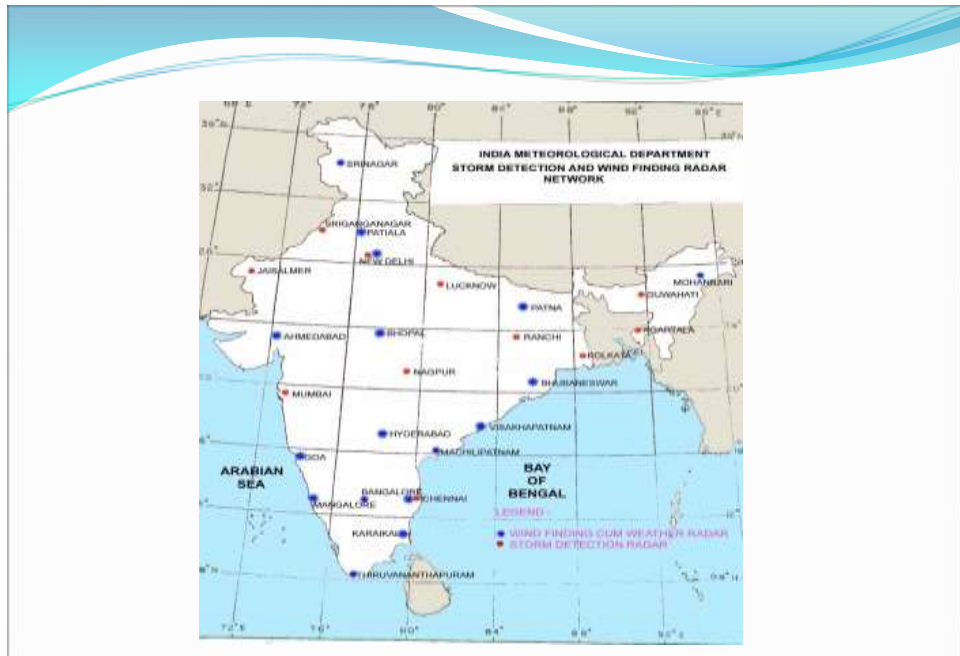


Fig. 8 Existing Cyclone Detection Radar Network

Fig.6. Cyclone detection radar network of IMD

Table 1. List of East Coast stations in India

Station	Index	Latitude	Longitude	Class	00Z	03Z	06Z	09Z	12Z	15Z	18Z	21Z
Kolkata(Alipore)	42807	22 32N	88 20E	I	X	X	X	X	X	X	X	X
Kolkata(DumDum)	42809	22 39N	88 20E	I	X	X	X	X	X	X	X	X
Diamond Harbour	42811	22 11N	88 12E		X	X	X	X	X	X	X	X
Canning	42812	22 15n	88 40 E		0	X	0	0	X	0	0	0
Midnapore	42803	22 25N	87 19E	IIb	0	X	0	0	X	0	0	0
Digha	42901	21 50N	87 47 E		X	X	X	X	X	X	X	X
Basirhat	42810				0	X	X	X	X	0	0	0
Contai	42900	21 47N	87 45E	IIb	0	X	0	0	X	0	0	0
Balasore	42895	21 31N	86 56E	I	0	X	X	X	X	X	0	0
Chandbali	42973	20 47N	86 44E	I	0	X	X	X	X	X	X	X
Cuttack	42970	20 28N	85 56E	IIb	0	X	0	0	X	0	0	0
Paradip	42976	20 18N	86 41E	IIa	0	X	0	0	X	0	0	0
Bubaneswar	42971	20 15N	85 50E	I	X	X	X	X	X	X	X	X
Puri	43053	19 48N	85 49E	I	X	X	X	X	X	X	X	X
Gopalpur	43049	19 16N	84 53E	I	X	X	X	X	X	X	X	X
Kalingapatnam	43105	18 20N	84 08E	I	X	X	X	X	X	X	X	X
Vishakapatnam	43149	17 43N	83 14E	I	X	X	X	X	X	X	X	X
Kakinada	43189	16 57N	82 14E	I	X	X	X	X	X	X	X	X
Tuni	43147	17 21N	82 33E	I	X	X	X	X	X	X	X	X
Kavali	43243	14 54N	79 59E	I	X	X	X	X	X	X	X	X
Nidadavole	43184	16 50N	81 35E	IIb	0	X	0	X	X	0	0	0
Narsapur	43187	16 26N	81 42E	I	X	X	X	X	X	X	X	X
Gannavaram	43181	16 42N	80 48E	I	X	X	X	X	X	X	X	X
Machlipatnam	43185	16 12N	81 09E	I	X	X	X	X	X	X	X	X
Bapatla	43220	15 54N	80 28E	I	0	X	X	X	X	0	0	0
Ongole	43221	15 30N	80 05E	I	X	X	X	X	X	X	X	X
Nellore	43245	14 27N	79 59E	I	X	X	X	X	X	X	X	X
Minambakkam	43279	13 00N	80 12E	I	X	X	X	X	X	X	X	X
Pondicherry	43331	11 58N	79 49E	I	X	X	X	X	X	X	X	X
Cuddalore	43329	11 46N	79 46E	I	X	X	X	X	X	X	X	X
Karaikal	43346	10 55N	79 50E	I	X	X	X	X	X	X	X	X
Nagapattinam	43347	10 46N	79 51E	I	X	X	X	X	X	X	X	X
Vedaranyam	43349	10 22N	79 51E	IIb	0	X	0	0	X	0	0	0
Adiramapattinam	43348	10 20N	79 23E	I	X	X	X	X	X	X	X	X
Tondi	43361	09 44N	79 02E	I	X	X	X	X	X	X	X	X
Pamban	43363	09 16N	78 18E	I	X	X	X	X	X	X	X	X
Tuticorin	43379	08 45N	78 11E	IO	0	X	X	X	X	0	0	0
Palayamkottai	43376	08 44N	77 45E	IIb	0	X	0	0	X	0	0	0
Kanniyakumari	43377	08 05N	77 30E	IIa	0	X	X	0	X	0	0	0
Kondul	43385	07 13N	93 44E	IIb	0	X	0	0	X	0	0	0
Nancowri	43382	07 59N	93 32E	IIb	0	X	0	0	X	0	0	0
Carnicobar	43367	09 09N	92 49E	IIb	X	X	X	X	X	X	X	X
Hut bay	43364	10 35N	92 33E	IIb0	0	X	0	0	X	0	0	0

**Table 3. List of Co-operative Cyclone Reporting Network of Stations
(Andhra Pradesh & Orissa)**

S. No	Station	District	Nearest Telegraphic Office	Distance From Station
Andhra Pradesh				
	Palasa	Srikakulam	Palasa	2 km
2	Sompeta	Srikakulam	Sompeta	100 meters
3	Anakapalli	Vishakapatnam	Anakapalli	1.5 km
4	Rajamundry	East Godavari	Rajamundry	2.5 km
5	Yanam	East Godavari	Yanam	1.0 km
6	Razaole	East Godavari	Razaole	200 meters
7	Eluru	West Godavari	Eluru	1.0 km
8	Challapalli	Krishna	Challapalli	0.5 km
9	Avani Gadda	Krishna	Avani Gadda	200 meters
10	Nagayalanka	Krishna	Nagayalanka	1.0 km
11	Bantimalli	Krishna	Bantimalli	1.0 km
12	Kothapatnam	Prakasam	Kothapatnam	200 meters
13	Narasapuram	Nellore	Narasapuram	0.5 km
ORISSA				
1	Bhogral	Balasore	Bhogral	2Km
2	Basta	Balasore	Basta	1 Km
3	Bhadrak	Balasore	Bhadrak	2 Km
4	Bansara	Balasore	Bansara	2 Km
5	Rajkanika	Cuttack	Rajkanika	2 Km
6	Aul	Cuttack	Aul	2 Km
7	Rajnagar	Cuttack	Rajnagar	1 Km
8	Kendrapara	Cuttack	Kendrapara	2 Km
9	Mahakalpara	Cuttack	Mahakalpara	2 Km
10	Jagatsingpur	Cuttack	Jagatsingpur	1 Km
11	Ersama	Cuttack	Ersama	2 Km
12	Nimapara	Puri	Nimapara	0.5 Km
13	Brahmagiri	Puri	Brahmagiri	1 Km
14	Krishnaprasad	Puri	Krishnaprasad	0.5 Km
15	Chatrapur	Ganjam	Chatrapur	0.5 Km
16	Berhampur	Ganjam	Berhampur	3 Km