Correcting Real Time Automatic Weather Stations Data Through Quality Checks and Analysis

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ABSTRACT

Automatic Weather Stations (AWS) are equipped with various sensors such as Temperature, Humidity, Wind Speed, Wind Direction, Local Pressure, MSLP, Rainfall etc. The weather data from these AWS Stations are received at the APSDPS central servers at any given interval of time. The real-time weather data receives at central server consists of some errors and uneven values, due to sensor problem/some uneven interruptions at AWS sites. For this data, Quality checks are performed to correct erroneous values. These erroneous data are identified and corrected by performing Quality Checks like completeness of data, climatological consistency, Time Consistency, Internal consistency, spatial and range checks. After performing Quality Checks, the accuracy level reached to 95% and during the process of quality checks, the calibration requirements for the AWS is recommended and thereby improving the AWS performance.

Keywords: *Automatic weather stations, Quality check, Real time data, Accurate forecast, Weather parameters.*

1. Introduction

Andhra Pradesh Government established an Early Warning Center (EWC) to forewarn people about cyclones and floods based on mathematical models. The Early Warning Center frame work involves running of weather forecasting models supported by real time acquisition of data on a number of weather related parameters.

Andhra Pradesh Government have established the AP State Disaster Mitigation Society (APSDMS) to take up Disaster Mitigation studies relating to Rainfall, Run-off and Flood Forecasting, Cyclone model for Track, Wind and Storm Surge forecast to improve the early warning capabilities of State during natural disasters. The society in course of its working also started studies on Coastal Zone Management, Delta Water management, Preparation of Disaster Management Plans related to Cyclone, Drought and Earthquakes as part of its long term mitigation measures. After almost 10 years of its existence, APSDMS was restructured and re-named as Andhra Pradesh State Development Planning Society (APSDPS) with effect from 01-04-2012, with modified by-laws and structure.

To facilitate data collection APSDPS has installed following weather sensors in Andhra Pradesh & Telangana State.

Table 1
Weather sensors in Andhra Pradesh of Telengana

Sensors	Andhra Pradesh State	Telangana State
Rainfall	1203	852
Air Temperature	1173	831
Humidity	1173	831
Wind Speed	1173	831
Wind Direction	1173	831
Pressure	713	831
Global Radiation	86	64
Soil Moisture	59	41
River Gauges	93	31
Reservoir Level Sensors	76	1

The AWS measures 6 weather parameters - Rainfall, Wind Speed, Wind Direction, Atmospheric

Pressure, Humidity and Temperature at every one hour interval and transmits it in the form of SMS using GSM technology, the values are logged in the internal memory of the data logger, transmitted via GSM transmitter at assigned time to SMPP (Short Message Peer to Peer) Server and data receives at the central data receiving station established at APSDPS, AP Secretariat Hyderabad. In addition to 6 sensors in AWS, Soil Moisture, Solar Radiation & River Gauge Sensors are Inbuilt in AWS at specific locations duly considering Agro-Climatic regions. The data loggers in AWS are pre-programmed to take measurement of meteorological parameters using interfaced sensors at an interval of an hour.

These data are being used by various government agencies like Agriculture Department, Disaster Management, Irrigation department, Energy Department etc., for proper planning and implementation of varied government programs and schemes. AWS data is also being used by Agriculture Insurance Company of India for implementation of Weather Based Crop Insurance Scheme (WBCIS) for various crops in the districts (Fig 1).

2. AWS Sensor Specifications

AWS in remote areas work on battery backup and solar panels and transmit data on parameters having following ranges and accuracies (Fig 2).

The ideal international norm of one AWS for every 100 sq km has been adopted and thus carries an area of 10KM x 10KM grid, presently at least one AWS for each mandal is installed. The grid spacing for installation of AWS is designed on a scientific basis and the final one adopted is as per the WMO norms.

Similarly for river gauges the norm is based on terrain conditions and for plains it is one river gauge per 1875 Sq KM of catchment area. River Gauge sensors will measure the water levels in the rivers/streams at every one hour interval on real time basis with reference to MSL (Mean Sea Level) which stores in the data logger located at remote location and transmits the same to the APSDPS server. Reservoir water level recorders will measure the water level in reservoirs of major (ie.,Srisailam, Nagarjuna Sagar, Somasila and Mylavaram) and medium irrigation projects in the

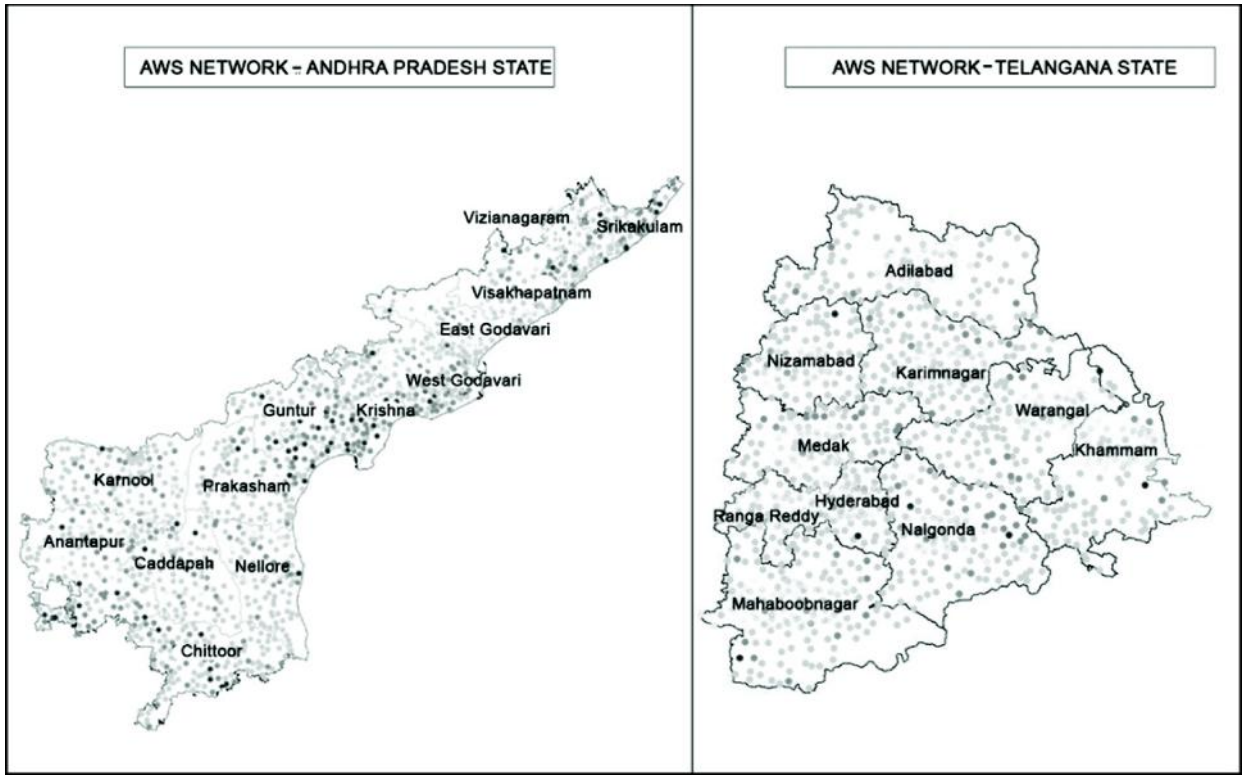

Fig.1: AWS Network

Table 2
Sensor Specifications

Sensors	Range	Accuracy	Resolution
Rainfall (mm)	0 to 600mm/Hr	+/- 2.5 %	0.25mm / tip
Temperature (°C)	-30 to 70°C	+/- 0.2°C	0.01°C
Humidity (%RH)	0% to 100%	+/- 3%	0.10%
Wind speed (kmph)		+ / - 1 Kmph up to 20 kmph	0.1 kmph
		+ / - 2% beyond 20 Kmph	
Wind direction (Degree)	0 to 360°	+/- 3°	1°
Pressure (mbar)	0 to 1100 mbar	+/- 0.15%	0.1 mbar
Global Radiation (w/m2)	0 to 1750 W/m2	5W/m2	
Soil Moisture (%)	0 to 100%	+/- 5%	1%
River Water level Gauges (m)	0 to 30m	0-3m -->3mm;	5mm
		3-30m-->0.1% of the reading	
Reservoir water – All Major and medium	0 to 30m	10mm	10mm

state at every one hour interval on real time basis.

Global radiation sensors are used to measure unobstructed daylight which will be useful for field measurement of global solar radiation in agricultural and meteorological studies. Soil moisture sensors are a resistive device that responds to changes in soil moisture. These sensors are unique in taking the resistive measurement within a defined and consistent internal matrix material, rather than using the surrounding soil as the measurement medium. Soil moisture Sensors are installed at 30 cm,60cm and 1m depth from the soil.

The different sensors and instruments equipped with Automatic Weather Stations such as Rain Gauge (Tipping Bucket), Data logger, Battery (12 V), Solar Panel, GSM Antenna, GSM transmitter , solar charge controller, Temperature, Humidity, Wind Speed ,Wind Direction and Pressure Sensors are certified by IMD. The stations have been installed in the premises of Electrical Substances, Research institutes, Agricultural universities, district collector offices and colleges (Fig 2).

3. AWS Data Flow Model

Data from AWS stations are transmitted through

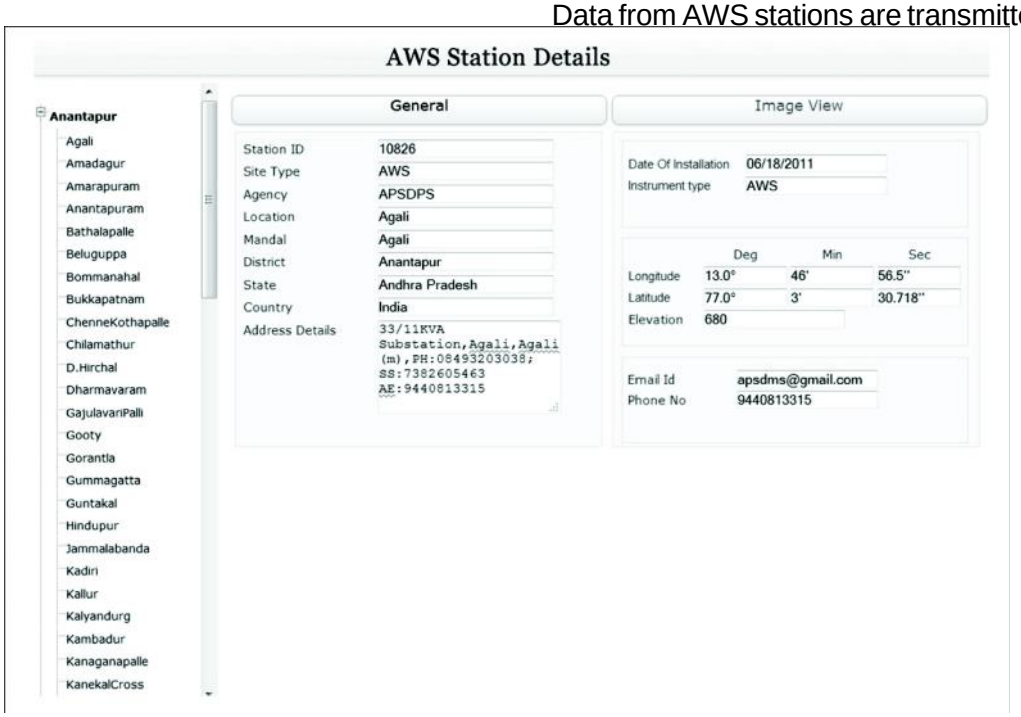

Fig. 2: AWS Station Details

GSM Technology in an encrypted form. The received raw data are decrypted in real time and retrieved at APSDPS central server. Quality checks are performed on this raw data to eliminate error values and disseminate to various technical units as show in Fig.3.

4. AWS Dashboard

AWS dashboard is used to analyze current status of AWS such as total working sites, observing percentage of packets received at server and retrieving pending packets by running queries at database. Front Interface is used to add, delete and modify the AWS stations details. Dashboard is also used to know the quick view of top 5 hottest and raining places in a state in last 12 hours of a day. This is schematically shown in Fig. 4.

5. Quality Control Checks

Step 1: Data Retrieval

✓ Raw Data are retrieved from central server of APSDPS by running query. This is schematically given in Fig.5.

Step 2: Check for completeness of data reception

✓ Raw data received on hourly basis is checked for time of recording. Data with time-tags matching with top of the hours are segregated to eliminate erroneous data

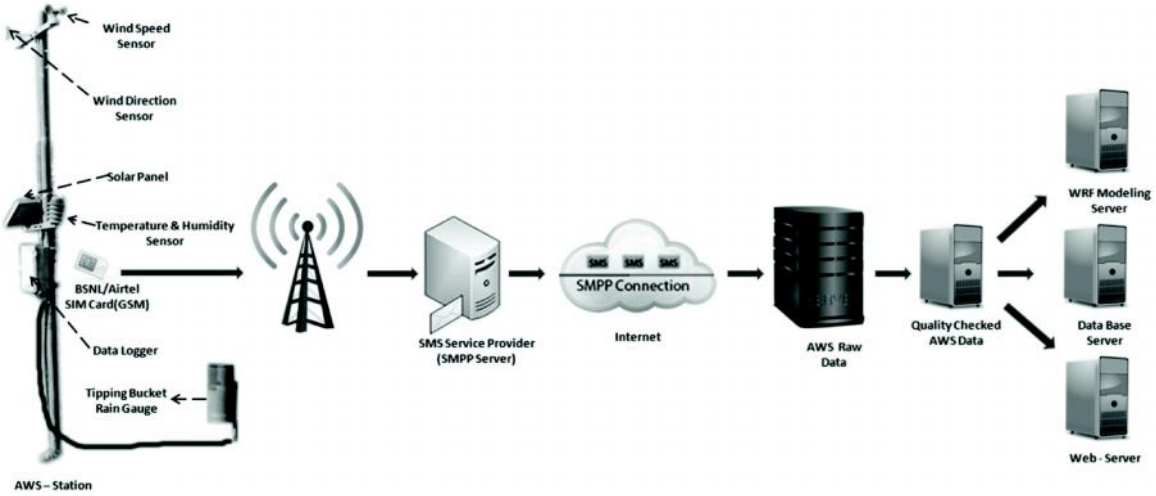

Fig. 3: AWS Data Flow Model.

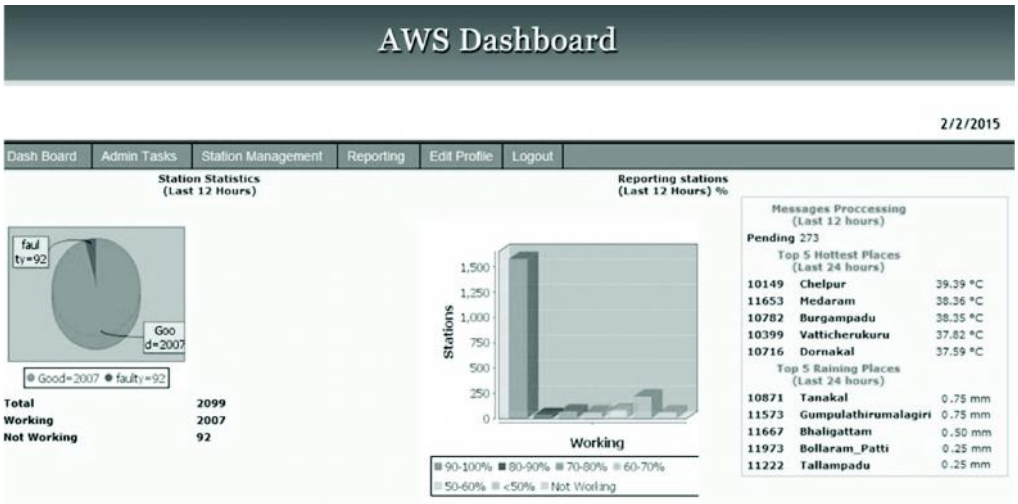

Fig. 4: AWS Dashboard.

Fig. 5: AWS Data Analysis Process.

coming intermittently

- ✓ From the above segregated data, number of packets received from each station/ sensor is counted. Normally functioned station shall send 24 hourly packets one each for every hour.
- ✓ Data received from stations that sent 24 hourly records are separated.

Step 3: Time consistency check

- ✓ The aim of this check is to verify the rate of change of instantaneous data (detection of unrealistic spikes or jumps in values). If the current instantaneous value differs from the prior one by more than a specific limit or step, the current instantaneous value does not pass the check and it should be flagged as doubtful or suspect. The possible limits for maximum variability and the absolute value of the difference between the successive values, are provided below:

Step 4: Internal consistency check

- ✓ The basic algorithms for checking internal consistency of data are based on the relation between two parameters e.g. when there is rainfall, the temperature will fall and humidity will rise.

Step 5: Spatial check

- ✓ The rainfall values are compared with reference to Directorate of Economic & Statistics (DES) manual gauge data [ref 4,ref 5] Indian Meteorological Department

Table 3
Parameters with limits of suspect and error

Parameter	Limit for suspect	Limit for Error
Air Temperature	3° C	10° C
Ground (surface) Temperature	5° C	10° C
Soil Temperature 5 cm	0.5° C	1° C
Soil Temperature 10 cm	0.5° C	1° C
Soil Temperature 20 cm	0.5° C	1° C
Soil Temperature 50 cm	0.3° C	0.5° C
Soil Temperature 100 cm	0.1° C	0.2° C
Relative Humidity	10%	15%
Atmospheric Pressure	0.5 hPa	2 hPa
Wind Speed (2- minute average)	10 ms-1	20 ms-1
Solar Radiation (irradiance)	800 Wm-2	1000 Wm-2
Rainfall	4.5 cm	10 cm

Source: Final Report, CBS/OPAG-IOS ET-AWS-5 (Geneva, Switzerland, 5-9 May 2008), (http://www.wmo.int/pages/prog/www/OSY/Reports/ET-AWS-5_Geneva_2008.pdf) [ref6]

(IMD) manual gauge data and IMD AWS data [ref 1,ref2, ref3].

Step 6: Range check

- ✓ Every weather parameter is checked with its upper and lower limits.

Step 7: Climatological consistency check

- ✓ Temperature values are verified with reference to normal temperature ranges i.e., with maximum of maximum for the day and minimum of minimum for the day.
- ✓ When there is any deviation, the anomaley with respect to normal is calculated.
- ✓ The stations with anomalies are checked with other weather guidance provided.

6. Maintenance of AWS Stations

Preventive Maintenance:

It is a routine maintenance that the field engineer does in regular intervals i.e., once in every 3 months. Especially, it is scheduled before Monsoon i.e. May to June.

Breakdown Maintenance:

Whenever fault is observed or reported in the data received at the server, the station health is communicated to the field engineers, which need to be fixed within 3 working days failing which the service provider will be penalized. In case of breakdown or non- functioning of sensors, the replacement of breakdown material is done.

7. Performance of AWS Network during Hud-Hud Cyclone

Andhra Pradesh experienced a very severe cyclonic storm “HUDHUD”. The cyclone made a landfall on 12th October, 2014 near Visakhapatnam. Four districts namely Visakhapatnam, Vizianagaram, Srikakulam and East Godavari were majorly affected.

The actual rainfall recorded by AWS of APSDPS was rather heavy to very heavy rains in the Visakhapatnam district, about 527mm in Atchutapuram mandal at 0830am of 12th to 0830am of 13th October 2014.

Atchutapuram mandal (Visakhapatnam district) AWS hourly recorded rainfall, local pressure, wind speed and wind direction from 0830am of 11Oct,

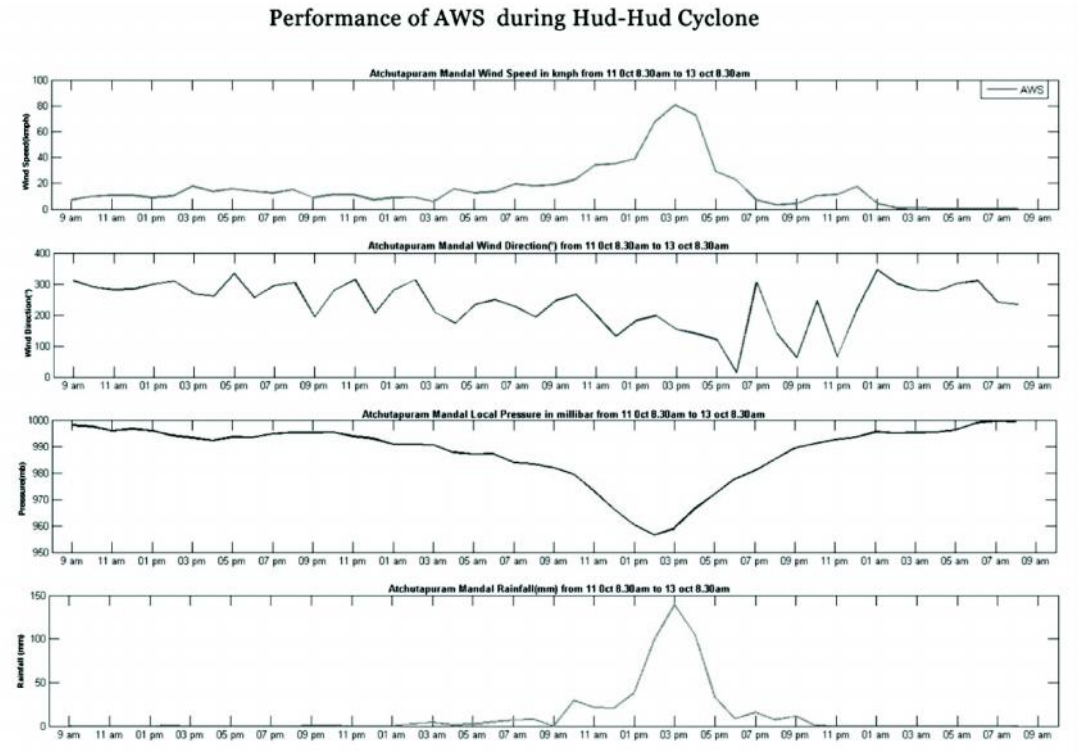

Fig. 6: Performance of AWS during Hud-Hud Cyclone.

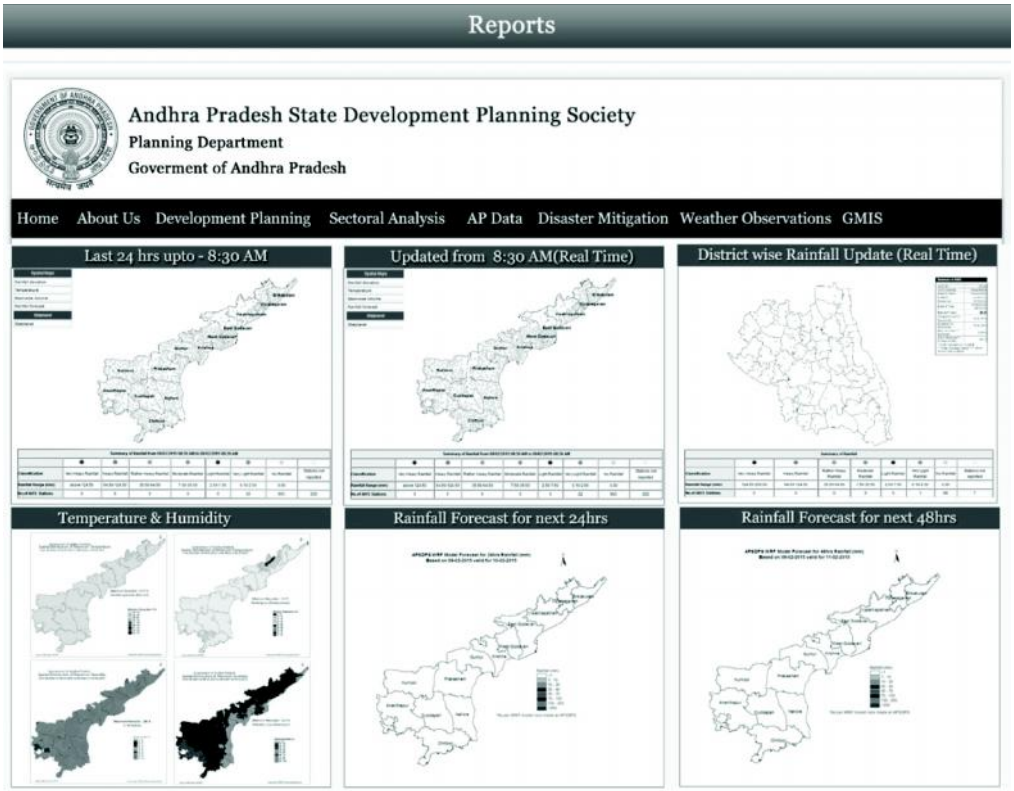

Fig. 7: APSDPS Reports.

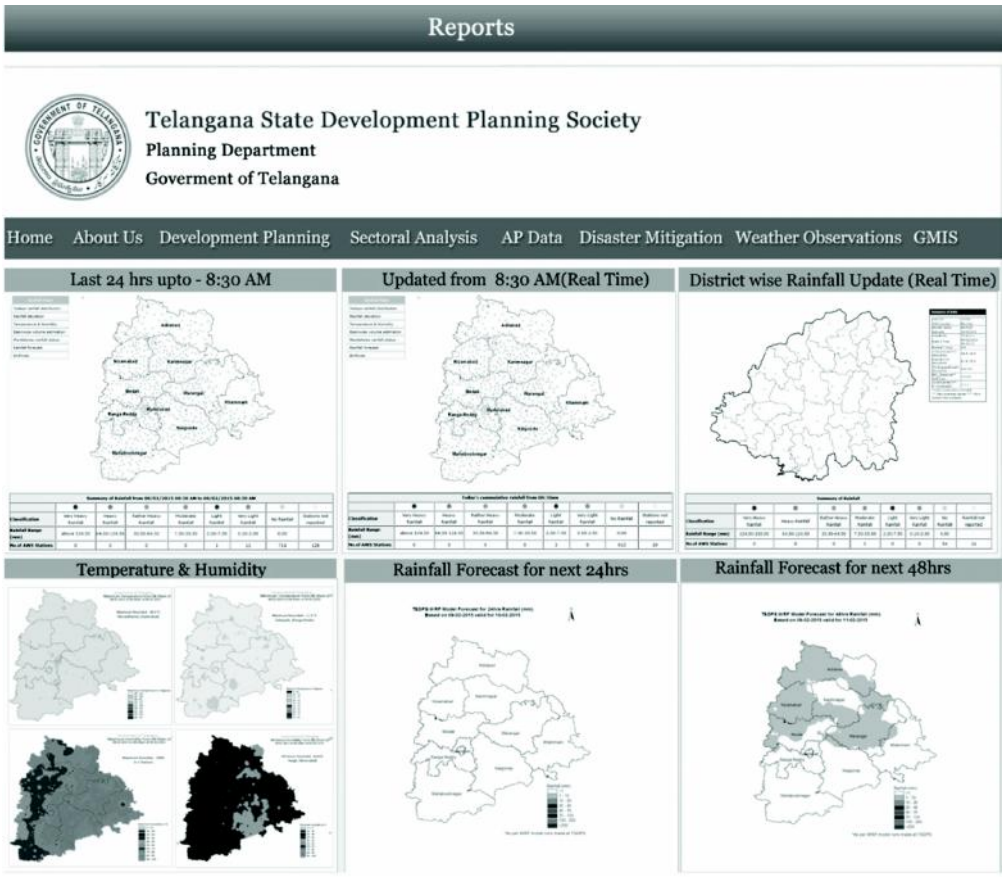

Fig. 8: APSDPS Reports.

2014 to 0830am of 13thOct, 2014 (Fig 6).

8. Results and Discussion

The quality checked summary report (8.30am of previous day to 08.30am of present day) is updated every day in website ie.,www.apsdps.com and real-time data is dynamically updated in APSDPS website for every 1 hour interval (http://www.apsdps.gov.in/aws.jsp).

Various reports are generated using AWS data such as rainfall deviation report, temperature & humidity maps, rainfall maps and forecast maps of entire state with mandal wise status (Fig 7 & Fig 8).

9. Conclusion

AWS data are very crucial for real time observations and forecasting. After performing Data Quality Checks (DQC), the accuracy level reached 95% and AWS performance was also improved. Thus DQC are very important in order to use the data for real time and decision making purpose. Quality checked AWS data are used by WRF models to get nearly accurate forecasts. These high resolution AWS observed data are being archived in a systematic database for future analysis.

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