Personalizing a Low cost weather forecasting system

Muditha Dantanarayana[1], Srikantha Herath[2] and Dilum Bandara[3]
[1]Centre for Urban Water, Ministry of Megapolis and Western Development, Sri Lanka (muditha.danta@eng.pdn.ac.lk)
[2]Centre for Urban Water, Ministry of Megapolis and Western Development, Sri Lanka (srikantha.herath@gmail.com)
[3]Department of Computer Science and Engineering, University of Moratuwa, Sri Lanka (dilumb@cse.mrt.ac.lk)

SUMMARY

A low cost observation system that can be used to customize rainfall forecast was tested. System includes a low cost IOT based real time rainfall observing station. Weather Research and Forecasting (WRF) model with freely available Global Forecasting System (GFS) data, is used to forecast a set of possible rain systems and real time observations are used to select the most suitable forecast.

Keywords: Weather observation, IOT, Weather forecast

INTRODUCTION

The uncertainty imposed by the climate change leads to difficulty in making timely decisions on future activities which will be otherwise effectively made based on historical patterns (Iizumi et al. 2015). Increase in Disaster risk due to increased occurrence of severe weather conditions in unsuspected times makes the current manner of resource utilization for disaster response much ineffective.

This paper discusses a system that could be individually implemented to assess the forecast weather in local area so that the near future activities could be planned effectively.

METHODOLOGY

Center for Urban Water (CurW), the organisation working on flood early warning and water management in the Kelani River Basin, Sri Lanka is involved in deploying different types of weather stations systems covering the entire catchment and use these data to select a reliable weather forecast (Herath 2017).

The study was conducted to assess the performance of a variety of rain monitoring devices based on accuracy. Five tipping bucket rain gauges namely TR-525M and TR-525USW from Texas Electronics Inc., Vantage Pro2 from Davis Instruments, WS-601SS2 from Beijing Guoxinhuayuan and Technology and WS-2600-1 from Misol International were tested in field. The configuration of the rain gauges are as in Table 1.

The resolution of rain gauge was checked by measured water volume recorded at each tip using Equation 1.

$$Rain\_Depth(mm) = \frac{Consumed\_Volume(ml) \times 10^3}{\frac{1}{4}\pi \times Funnel\_Diameter(mm)^2} \quad (1)$$

Table 1. Rain gauge configuration

Rain Gauge Model	Resolution (mm)	Funnel diameter (mm)
TR-525M	0.1	245
TR-525USW	0.2	203
Vantage Pro2	0.2	200
WS-601SS2	0.2	200
WS-2600-1	0.3	120

Four data transmission systems described in Table 2, used with the rain gauges to detect the tips and transmit to the local server. The reliability and and cost of the complete systems were tested for the performance assessment.

Table 2. Transmission module configuration

Communication method	Rate (sec)	Power
Wired + GSM	360	Solar
Wired + GSM	360	Solar
Radio + Wifi	2.5	AC
Radio + Ethernet	16	AC

Data transmitted in different rates were processed and recorded in a common database at interval of 5 minutes, Reliability of data were assessed from the percentage of successfully transmitted records of each system.

Currently CUrW use Weather Research and Forecasting (WRF) model instances calibrated for different types of weather patterns to produce rainfall in 3km spatial resolution and 1-hour time resolution, downscaled from 0.5□ resolution 3-hour time step Global Forecast System (GFS) produced by National Centers for Environmental Prediction (NCEP). These WRF model outputs differ from each other with the different schemes used for downscaling parameters. Suitable parameters for four weather types namely Anti-Cyclonic, Cyclonic, East and South East prominent wind direction (Vuillaume et al. 2017) were used for the comparison. Such forecast for 3 days completes processing within 5 hours in a workstation with Intel® Xeon® E5-2650 v4 @ 2.20GHz *24 processor and 16GB RAM run on Ubuntu 16.04 LTS.

Suitable configuration for the Kelani basin is to be selected based on the temporal distribution and magnitude of rain events in the forecasts compared with observed data obtained from the field observation stations shown in Figure 1. As the first step a scoring criteria will be developed to rank the WRF models with respect to the timing of rain events. Observed and forecast time series of hourly resolution were used and a mark was given if rain or no-rain condition is matching in each hour. Ranking was the percentage of matching hours.

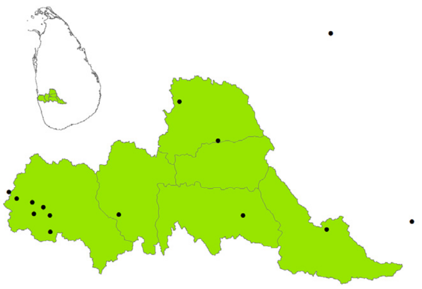

Figure 1. Rain gauge locations

RESULTS & DISCUSSION

As stated in Table3, all weather stations perform with over 90% accuracy which means only less than 10% of rain volume will be missed from the rain gauge. Such errors might be due to high winds and changes in funnel design. GSM transmission system shows the highest reliability as it is independently powered with solar and not effected by the power shortages, as in the case of Wifi and Ethernet transmission systems which are powered by AC supply.

Table 3. System Accuracy, Reliability and Cost

Rain Gauge Model	Trans. Sys.	Accur -acy (%)	Relia-bility (%)	Cost (USD)
TR-525M	GSM	94.1	91.5	846
TR-525USW	GSM	96.6	91.5	835
Vantage Pro2	Wifi	95.6	94.0	1655
WS-601SS2	GSM	92.7	99.2	1100
WS-2600-1	Ethernet	91.7	92.2	200

WRF models configured for weather types of Anti-Cyclonic and East Wind direction shows the best performance in the entire catchment being over 70% matching in terms of the temporal distribution of rain events as shown in Figure 2.

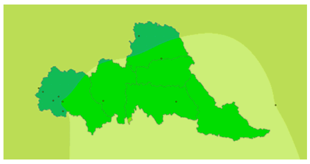

Figure2a. Anti-Cyclonic

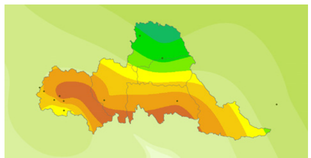

Figure2b. Cyclonic

Figure2c. East Wind

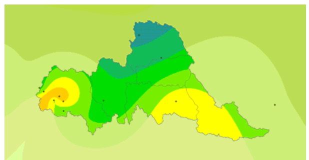

Figure2d. South East Wind

Figure 2. Temporal performance of WRF models

CONCLUSION

AC powered weather stations with radio and wifi transmission proved to deliver reliable weather data at low cost and convenient installation facility. Data gathered from such weather stations can be used to identify suitable forecasting models for specific regions and produce an effective forecast to be incorporated in decision support systems for regional disaster response.

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