

Introduction Methods Discussion

Our goal was to provide a platform for gathering hydrologic data in rural and remote watersheds of the United States. The research presented here focuses on the use of microcontrollers and inexpensive GSM radios to collect real-time measurements of stream stage and water temperature.

The sensor we deployed was based on the ubiquitous Arduino microcontroller. It has an on-board voltage regulator, and can be powered from a 12v battery.

We made use of a Chinese built SIM-900 based GSM radio module for the Arduino. The radio is capable of making calls, sending and receiving SMS messages, and accessing the web via GPRS. It is also capable of arbitrary file transfer (FTP). Because carriers tend to offer unlimited text messaging and charge high rates for GPRS data, we used text messages to transmit our data.

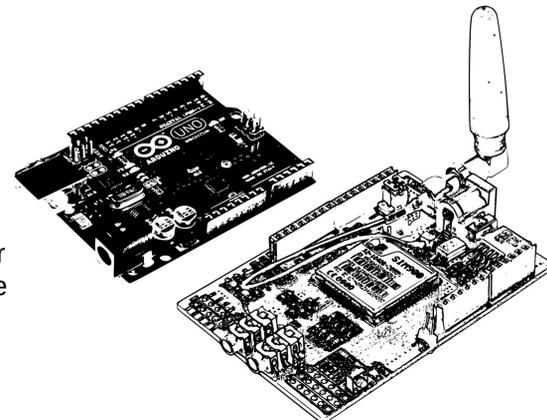
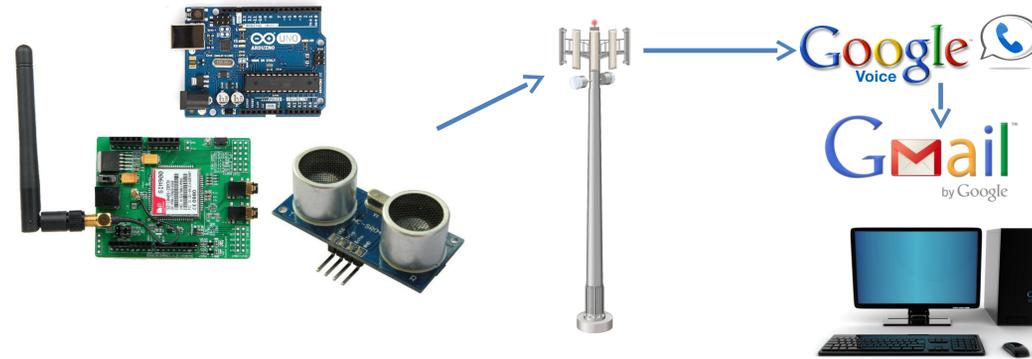


Figure 1. The Arduino Uno and SimCom SIM900 GSM Radio Module



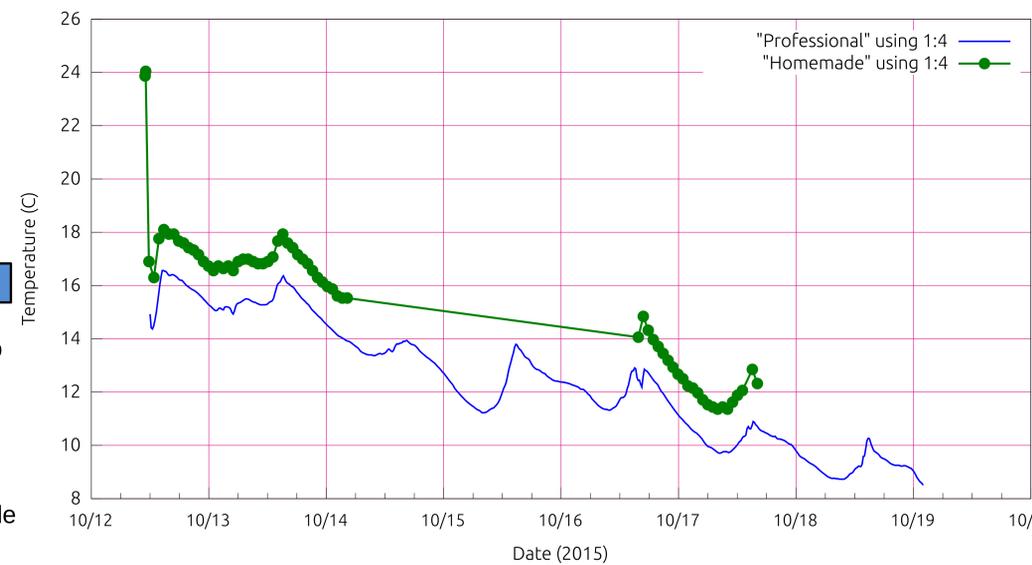
The radio unit uses 2 amps during data transfer. Because of this high power cost, we have written the code to keep the radio off as much as possible. It only needs to remain powered for about 10 seconds to connect to the network and send out an SMS message.

With this setup and a 12A/H battery, we were able to run the unit for 2.5 days. This could be extended by adding a solar panel. This would allow the self-contained unit to remain deployed indefinitely in the field, and would increase the cost per unit about 25-100 dollars depending on the type of panel.

Dr. Benzing's deployment near Albany did not experience these power issues, though it used a similar GSM radio and battery system. This unit collected depth data for two months in 2014.

Results

We deployed our sensor alongside a Solinst Levelogger (\$400.00) and compared the results. Deployment measuring water temperature at University at Buffalo October 12-18th



Methodology

The microcontroller can process digital signals, has 32-bit internal registers, and an analog to digital converter with 10 bits of resolution. We deployed a version with an ultrasonic range finder and resistance based temperature probe. (each costing about \$3.00-\$4.00 depending on the supplier).

The SMS messages are sent to a Google Voice account, and the Social.Water toolkit is used for converting the raw messages into comma separated values files, which are made available through the Crowd Hydrology website (www.crowdhydrology.org).

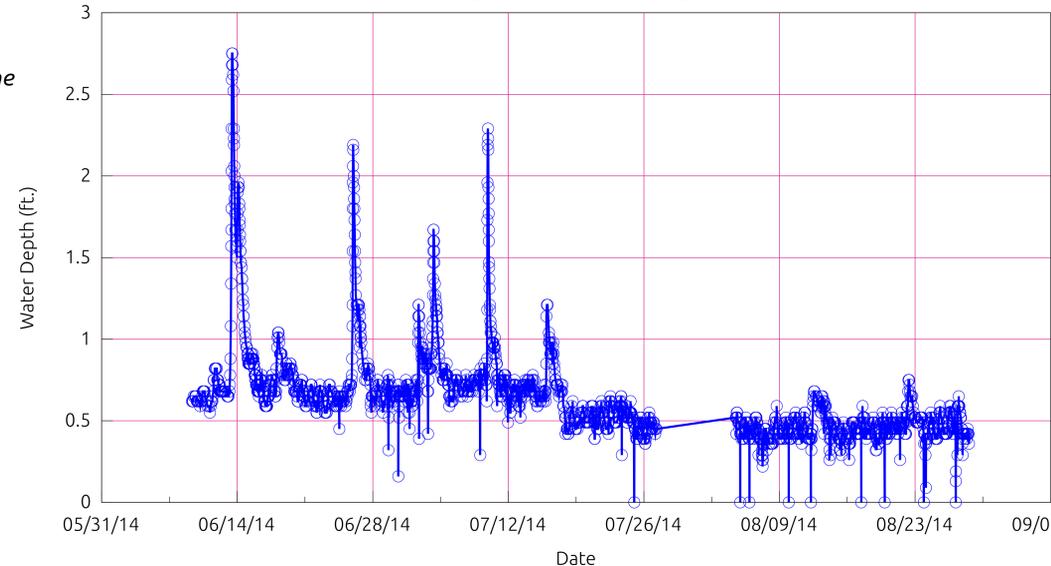
```
void loop()
{
  //first, we collect a round of measurements.
  //just a note, if the radio is on while you read these, it will throw off the accuracy!

  float temp = get_calculated_temperature_from_thermistor();
  long latestMeasurement = read_distance_from_ping_sensor();
  double foot_conversion = convert_inches_to_feet( latestMeasurement );

  //after that, turn on the phone (which sucks up a lot of power!)
  //and send off the text with the data to the base station.
  phoneCom.begin(SIM900_SERIAL_BAUD_RATE);
  press_sim900_power_button();
  send_sms(foot_conversion,temp); //send our text, 2A
  press_sim900_power_button();

  delay(3600000); //wait an hour. 1.5mA
}
}
```

Depth measurements from June- August 2014, Dr. Benzing's deployment near Albany, NY.



Conclusions

Our two stations recorded water temperature and water depth, but the code can be modified to collect data from any sensor that is compatible with the microprocessor. Since the chip is able to handle 32 bit data internally, a much wider range of sensors could be used with this set up. We relied on cheap and easily available sensors and hope to develop a system for measuring other types of data such as turbidity and salinity. Future work will include testing the drift and specific accuracy of our device, as well as developing probes for other types of measurements.

It should be noted that with the appropriate data plan, it would be possible to post arbitrary data to a server via FTP. This is a much more flexible option for data transmission that we overlooked simply due to the cost. Given a reduced cost for GPRS data, this would be the ideal option for data transmission.

Acknowledgements

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