Water Resources Monitoring in Sri Lanka
The Open Source Way

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Abstract

The actual state of the water monitoring network in Sri Lanka is limited in many ways. Few rivers are actually monitored to international standards, raingauge network is expensive to maintain, weather variable are recorded few times a day in weather stations.
A comprehensive water balance monitoring for a river basin needs a dedicated network of weather related sensors, accumulating sufficient temporal information at each location to provide hydrological models with satisfactory spatial and temporal calibration information.
This study explores the use of Open Source Hardware (OSHW) [1] combined with Free & Open Source Software (FOSS), including Open Source Geospatial (Osgeo) software, to setup a cheap, customized, entirely replicable set of generic and specialised water monitoring network in a river basin in Sri Lanka.

GDAL/OGR, Python, QGIS, GRASS GIS, Arduino, RaspberryPI

Water tank evaporation calibration

Sri Lanka has a large number of water tanks. Calibrating remote sensing models of open water evaporation permits a more accurate twice daily monitoring of water volume removed from all the larger tanks. We are in the process of setting up a sailing boat drone to collect conductive (in water) and convective (in atmosphere) upwelling temperature fluxes gradients.
This drone, called Amitomi (`https://sites.google.com/site/amitomiautoboat/`), is powered by a RaspberryPI (`www.raspberrypi.org/`) with a light version of Linux Debian (`www.raspbian.org/`). Its Attitude Control System (ACS) is based on a 3D compass + 3D Accelerometer from the Xloborg extension board for RaspberryPI (`www.piborg.org/xloborg`), and its location and speed is resolved by a standard USB GPS connected to the RaspberryPI.

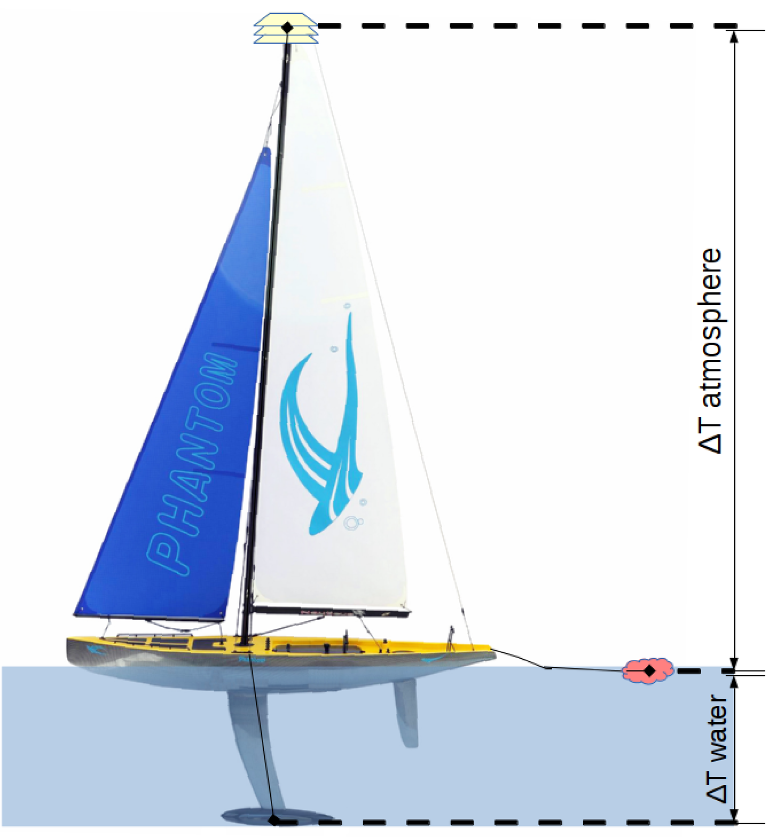

Figure 1: Amitomi autonomous water tank evaporation monitoring

The choice of a sailing boat is essentially one of power efficiency, to increase the distance covered by each survey. The boat analyses the given waypoints by itself using an optimisation algorithm based on OpenOpt (`openopt.org`), sails to the most upwind waypoint and then survey in a downwind manner, to limits energy consumption and risks associated with sailing upwind. Data collected is analysed onboard by GRASS GIS to compute standard maps of evaporation and either transmitted live to WebGIS (if GSM connection or WiFi) or recovered at the end of the survey for further use.

Arduino Weather Stations in Malwatu Oya

The irrigation department in upper reaches of Malwatu Oya is in need of more regular and distributed rainfall information. An Arduino weather sensors shield (`www.sparkfun.com/products/12081`) is being investigated to provide very low cost, tailored solution to spatially distributed, high-temporal weather information. The actual evaluation prototype is under finalization, with 1 year storage of 21 weather parameters and statistics at 5 minutes interval.

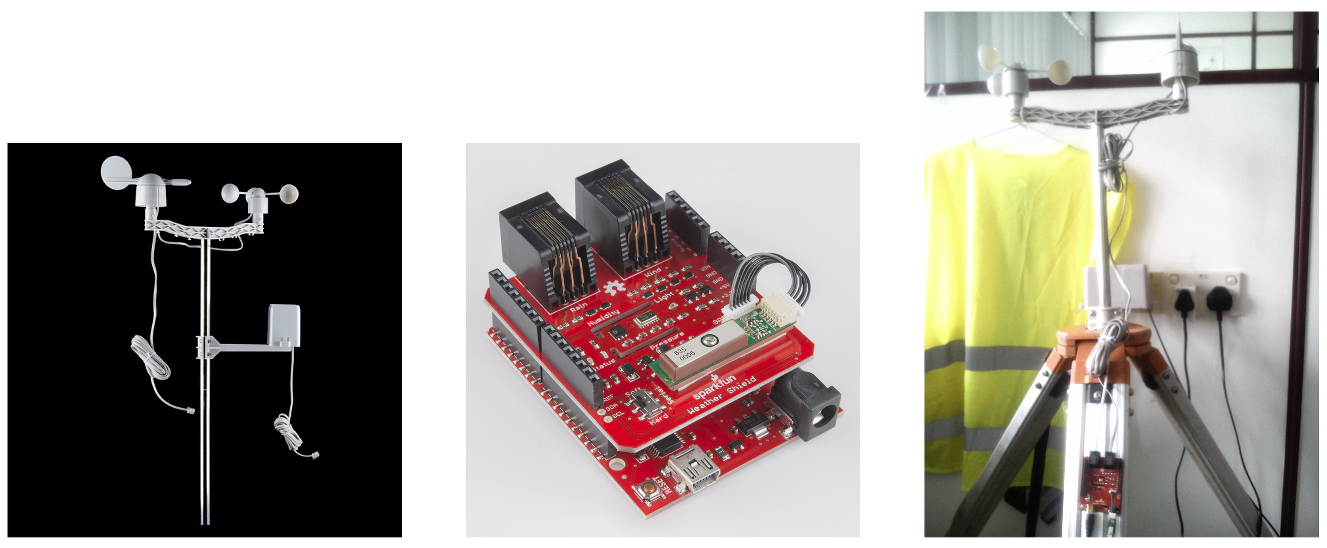

Figure 2: Arduino weather station

Further investigations are starting for the use of a GSM connection, permitting to upload directly to a WebGIS, connected to a hydrological model for cumulative re-analysis of conditions in Malwatu Oya river basin, providing improved calibration/validation procedures in spatial and temporal dimensions. Hydrological modeling will be more robust, and timely to enahnce decision-making on water storage management and risk alleviation.

Evapotranspiration model calibration

Energy partitioning is the most important information required for an accurate estimation of volumes of water evapotranspired. That means the combined evaporation from bare soil and transpiration by plants. Accurately assessing the partitioning of energy fluxes is highly dependent on the vertical gradient of temperature above grounds of various water contents. Sites with less water contents on their surface can naturally be called *dry* and sites with high water content on their surface are *wet*. For each type of site, along a gradient from *dry* to *wet*, the observed vertical gradient of temperature is used to study the partitioning of energy balance and determine parameters of calibration for remote sensing imagery (Figure 3) and used into the image processing chains of GRASS GIS (`grass.osgeo.org` ; [2]) designed to estimate evapotransiration on a daily and temporally integrated basis.

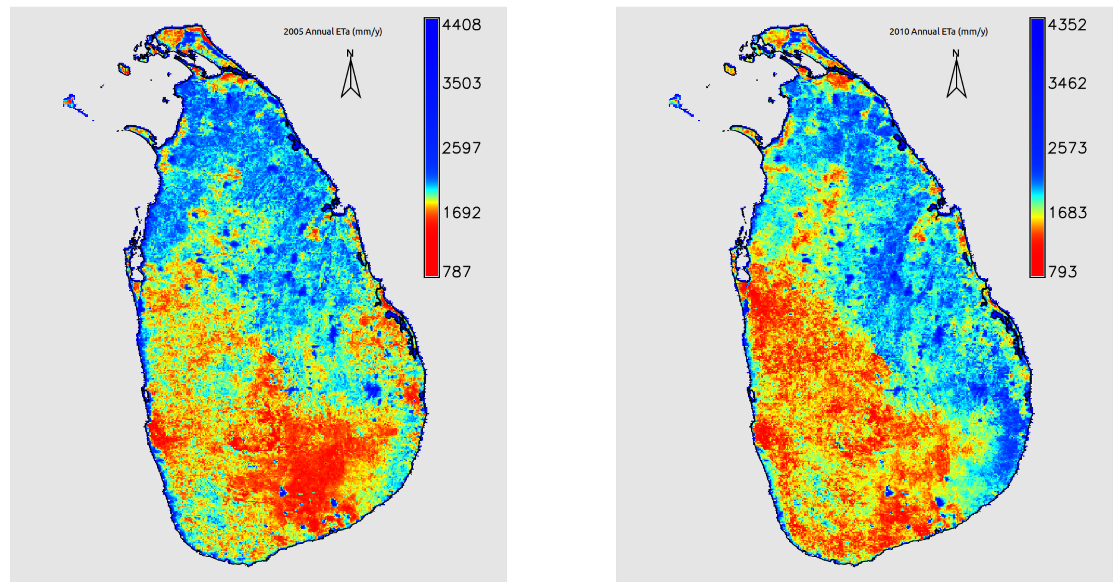

Figure 3: Actual evapotranspiration (mm/y ; GRASS GIS i.eb.*/i.evapo.* modules) for water monitoring and management [3]

In order to provide such calibration information to energy balance modules of GRASS GIS, an Arduino-based instrument has been designed (Figure 4), called a δT tower. It has two temperature sensors (`www.sparkfun.com/products/11050`) separated by a vertical height of 3-4m depending on the support availability. Radiation shields are made locally and an OpenLog (`github.com/sparkfun/OpenLog/`) is collecting 5 minutes interval weather parameters and statistics computed onboard the Arduino (`www.arduino.cc`). A Real TIme Clock (RTC) is in the process to be added to all towers to keep date and time independently of power supply quality.

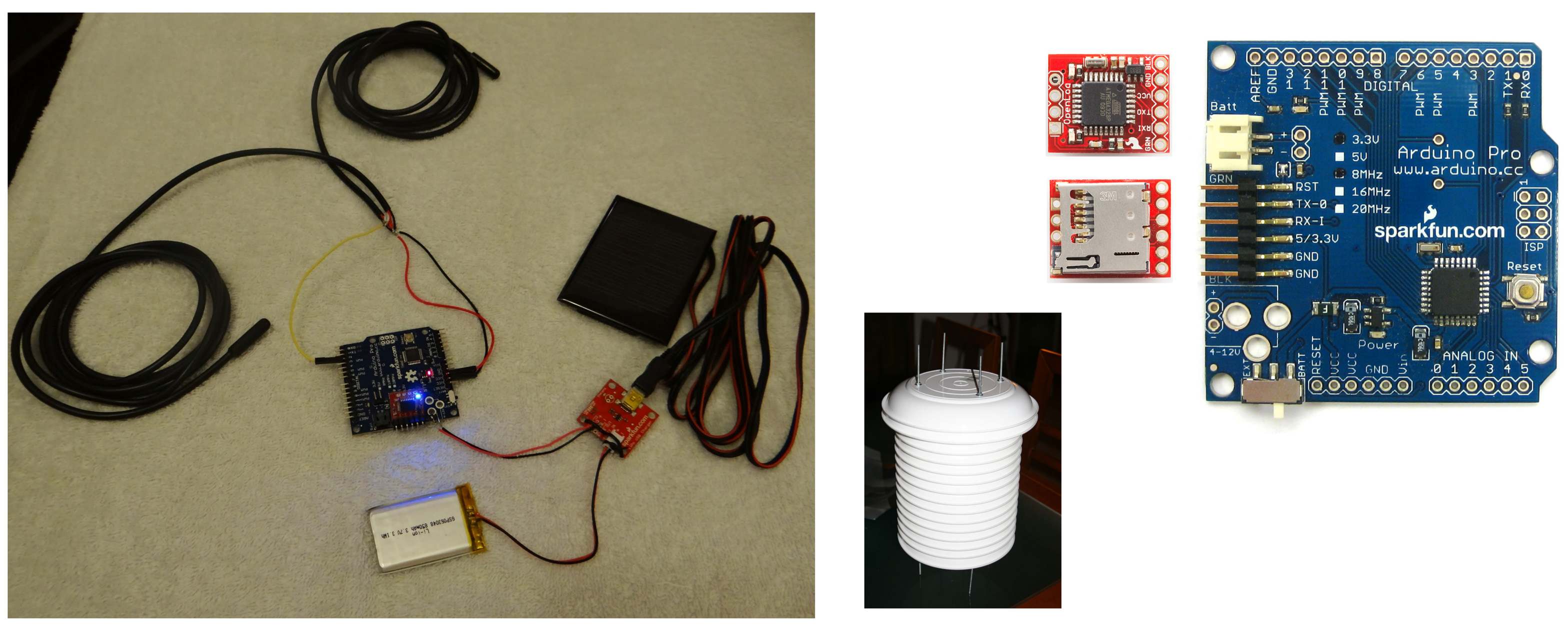

Figure 4: Delta T tower implementation with Arduino, OpenLog and locally made radiation shields (Radiation shield picture courtesy of (www.meteopt.com/forum/mercado/vendo-radiation-shield-2810.html)

The instrumental setup on both extrema (*dry* & *wet*) will require different strategies. The dry conditions can easily be met by a concrete ground with a pole fixed into it, though a dry barren land might be a good option to cover larger spatially homogenous ground. On the other hand, a wet location might need a lot of maintenance for growing vegetation and protection from disturbance by fauna. Homogeneously large wet areas are also a challenge in many cases for their accessibility.

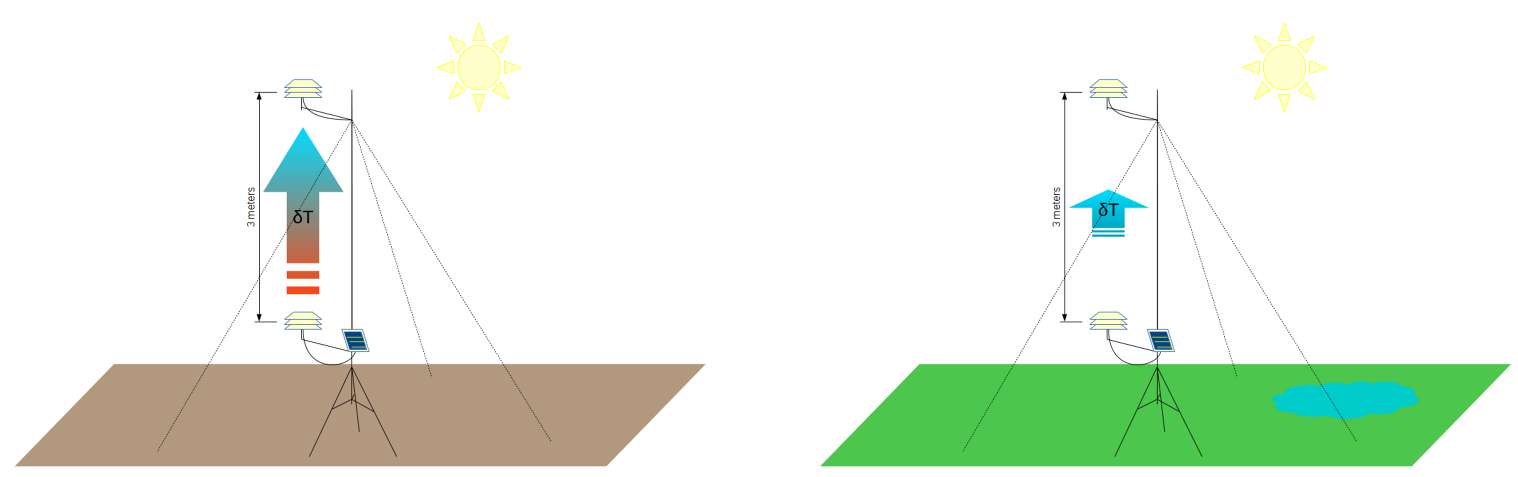

Figure 5: Calibration of upwelling heat flux at dry (left side) & wet (right side) locations

There is on-going discussion to merge the δT tower concept within the Arduino Weather Stations, as it can easily accomodate two additional temperature sensors. However, issues are there of justification of the choice for locations for a weather station being very different than the one made for δT towers, being specific to energy balance pseudo-invariants and land uses of interest.

References

[1] Pearce, 2013. Physics Today, 66(11):8-9
[2] Neteler & Bowman & Landa & Metz, 2012. Environment & Modeling Software, 31:124-130
[3] Chemin, 2012. Chapter 19, DOI: 10.5772/23571 (`http://bit.ly/16qJ0ep`)

www.iwmi.org

www.mrt.ac.lk/tcp/osgeosl.html

OSGeo Your Open Source Compass

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