Combining FOSS4G & Open Hardware for Research & Monitoring in Southern Asia

Yann Chemin

International Water Management Institute

University of Moratuwa, Faculty of Architecture

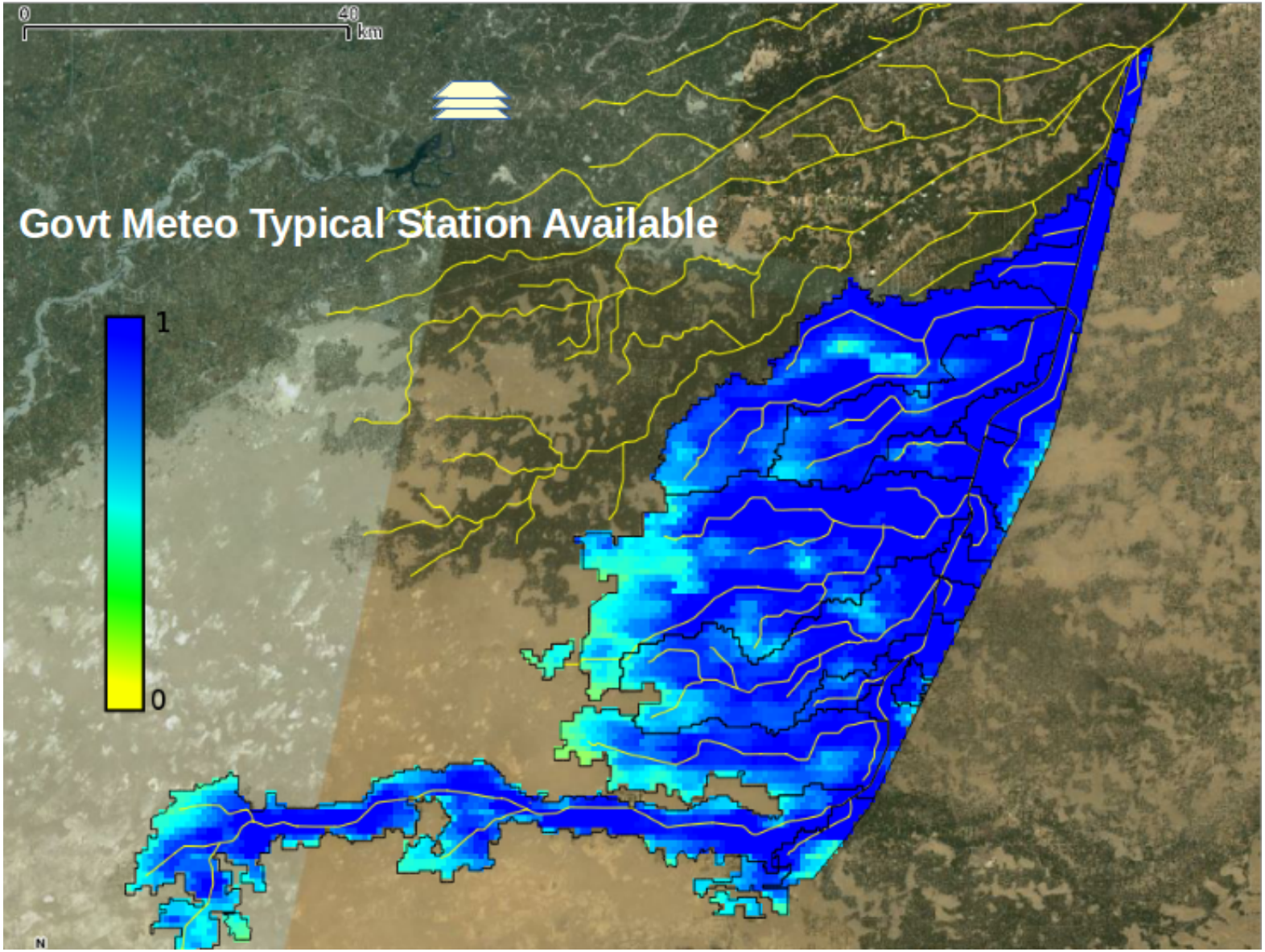
Consultative Group for International Agricultural Research
Ratified on October 2nd, 2013
Full Open Access & Open Source
Research data and publication

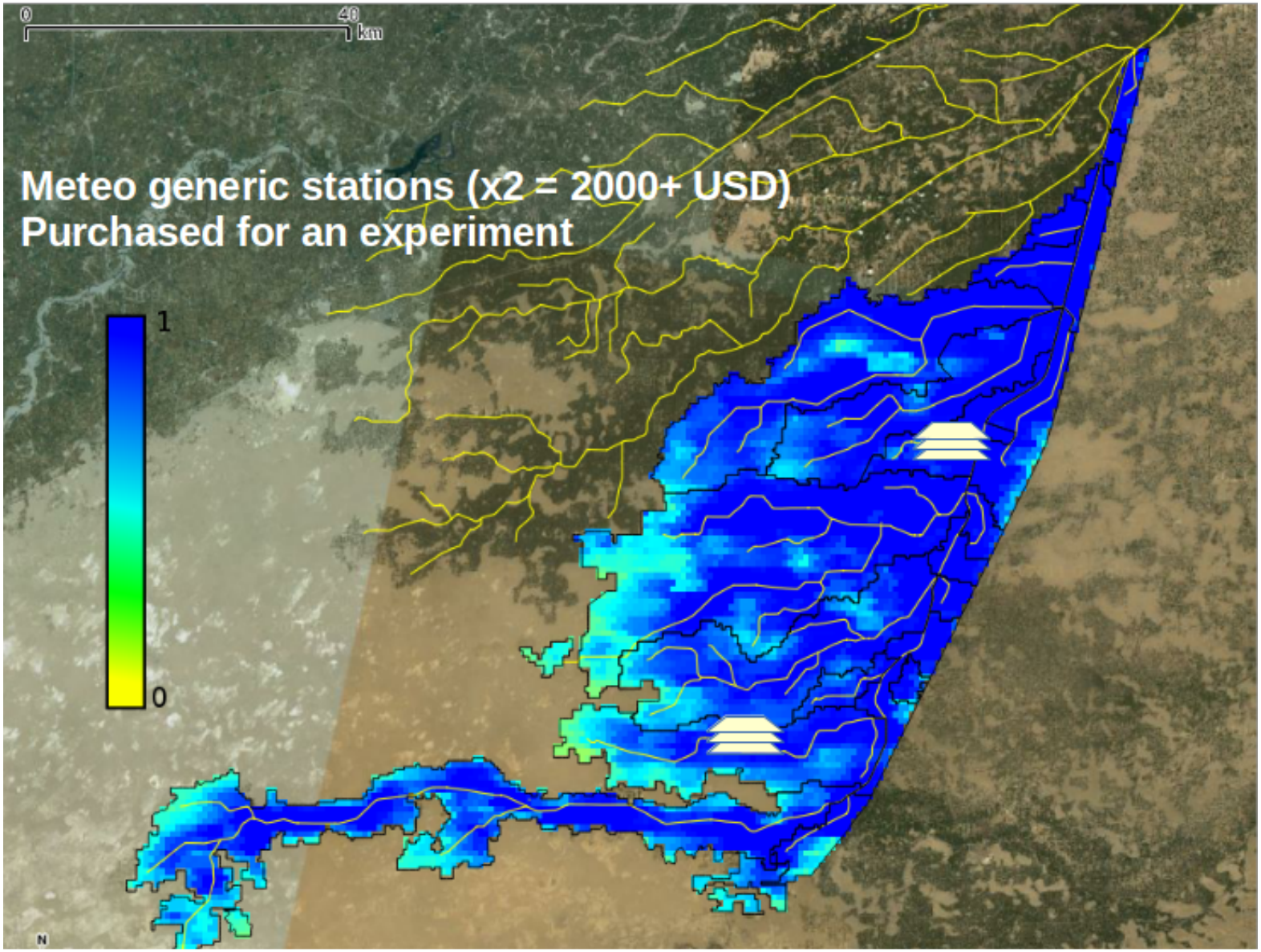
- International Public Goods
- Public Domain
- Publications Open Access
- FOSS models and algorithms

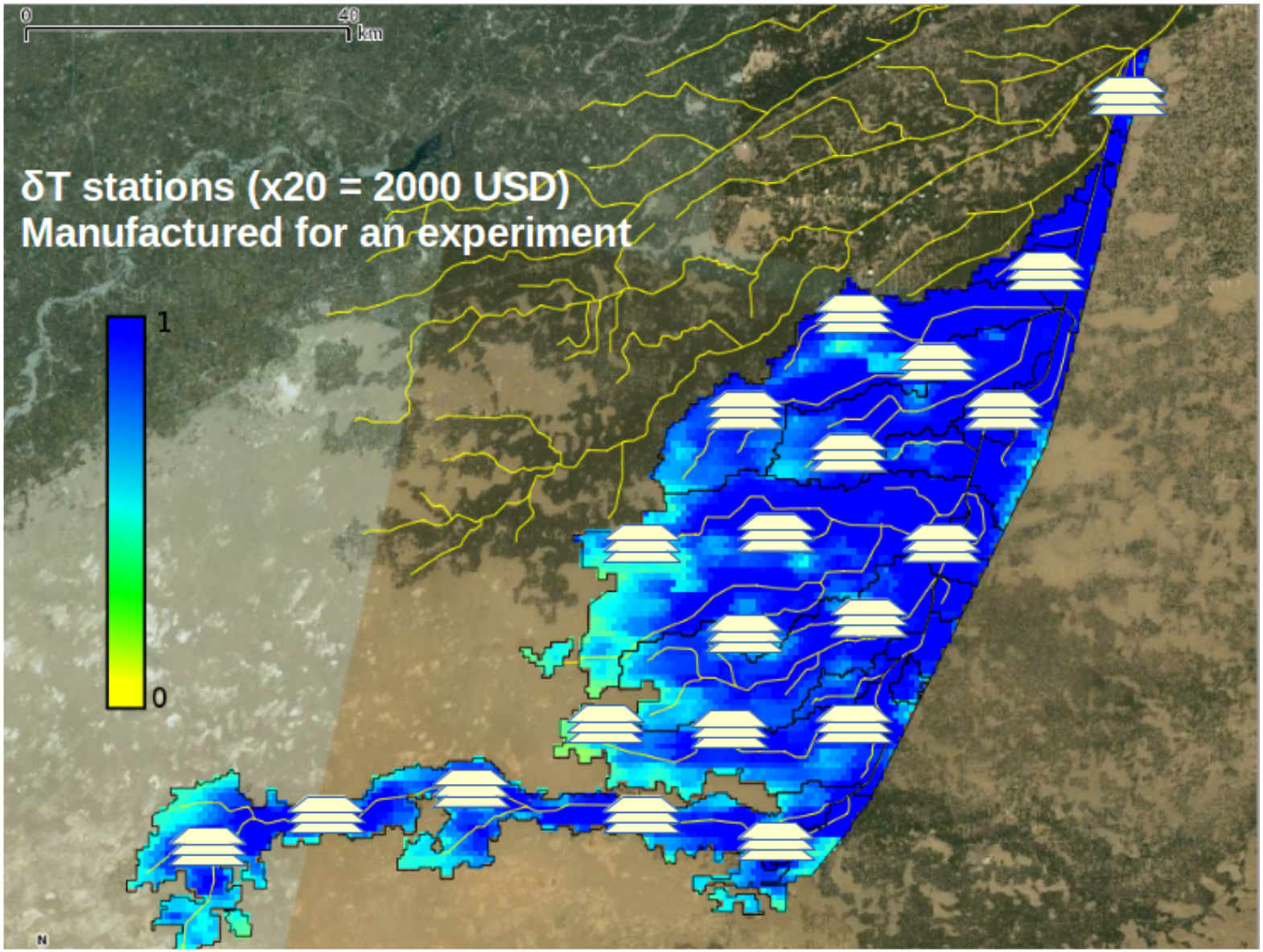
2018: all 15 CG centres, already FOSS4G Lab:
(gsl.worldagroforestry.org)

FOSS4G and Open Hardware
Developed together in new avenues

- Evapotranspiration calibration & modeling
- Road condition monitoring
- Rural tanks evaporation modeling

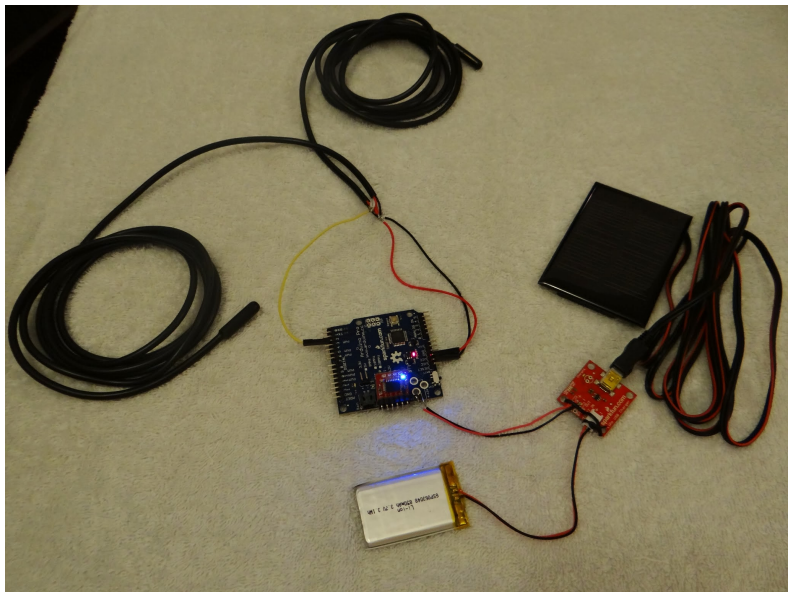




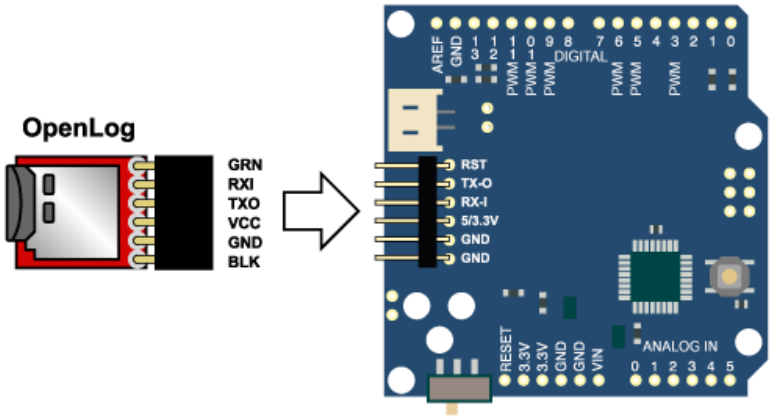


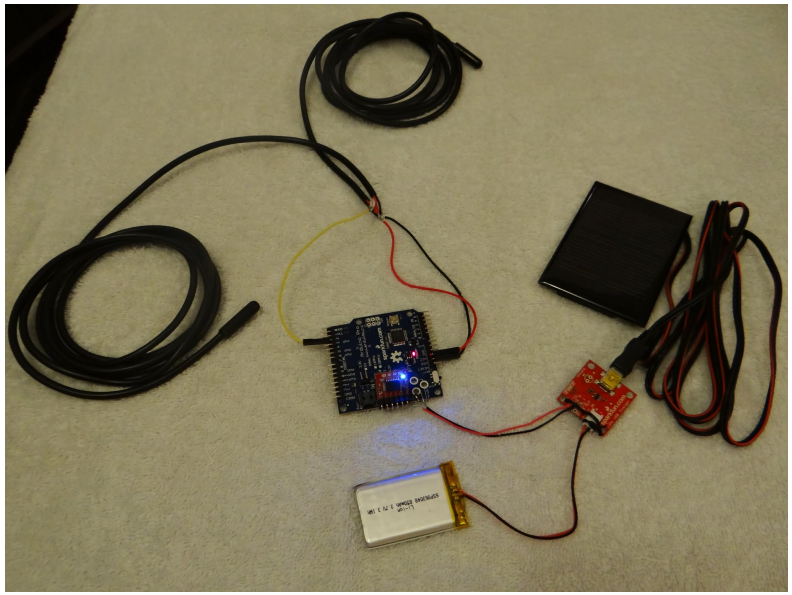
Micro Weather Station v1: Temperature Profiler for ET models calibration

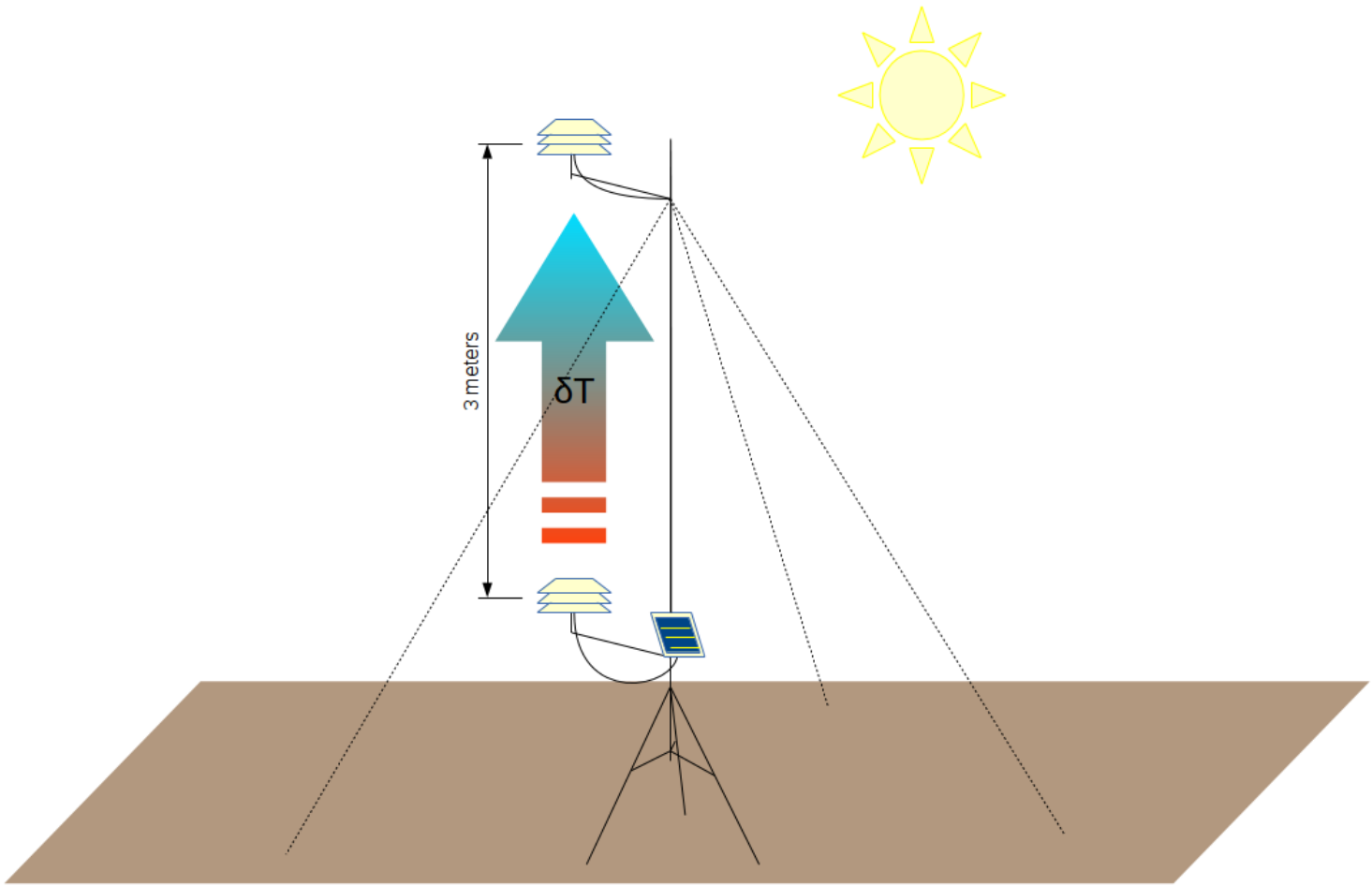
- Arduino Pro 3.3V
- Water-proof Digital Temperature Sensors
- Li-ion Battery + Solar Panel
- OpenLog data logger with SD card
- Cost $<$ 100 USD

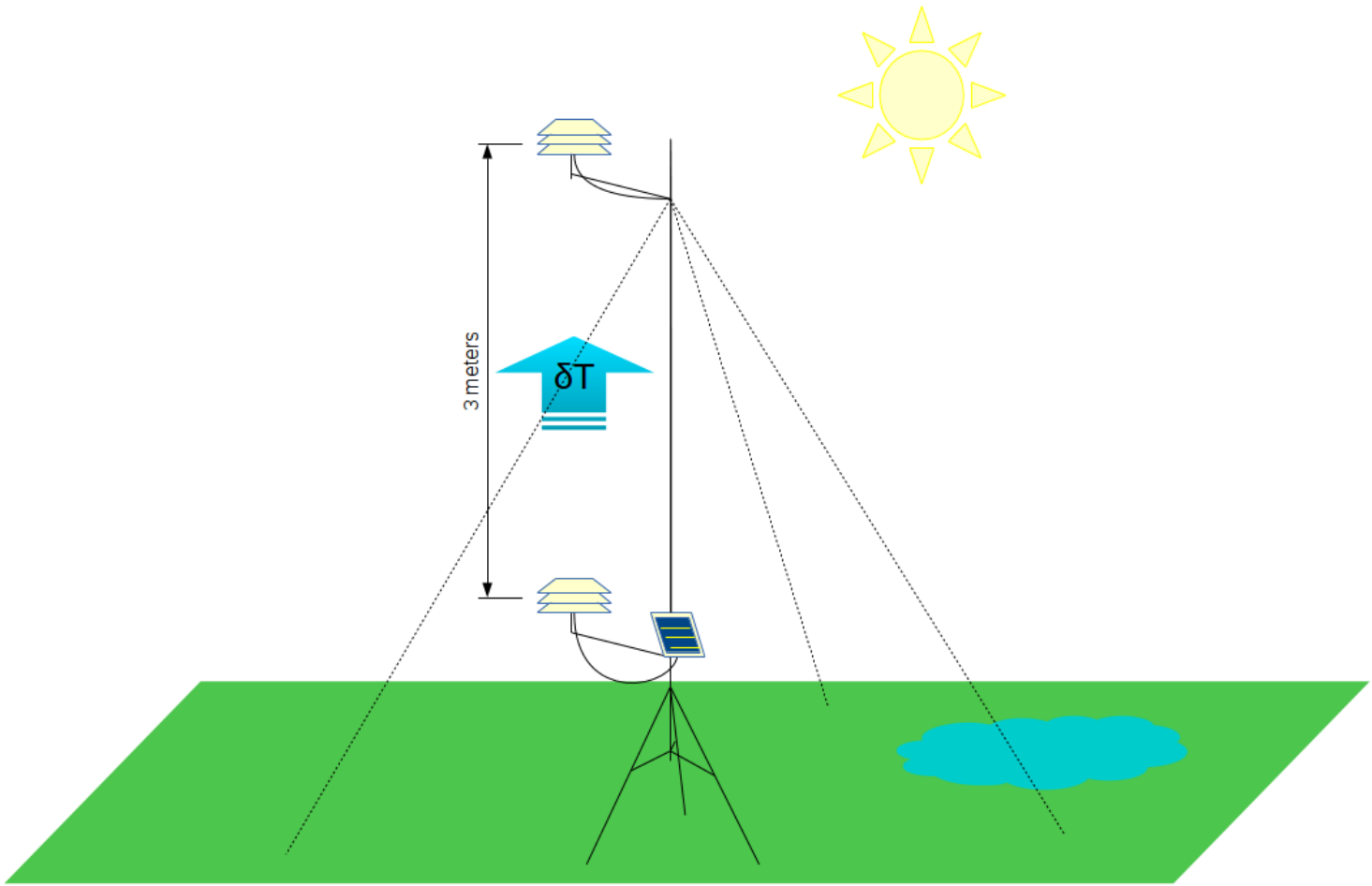


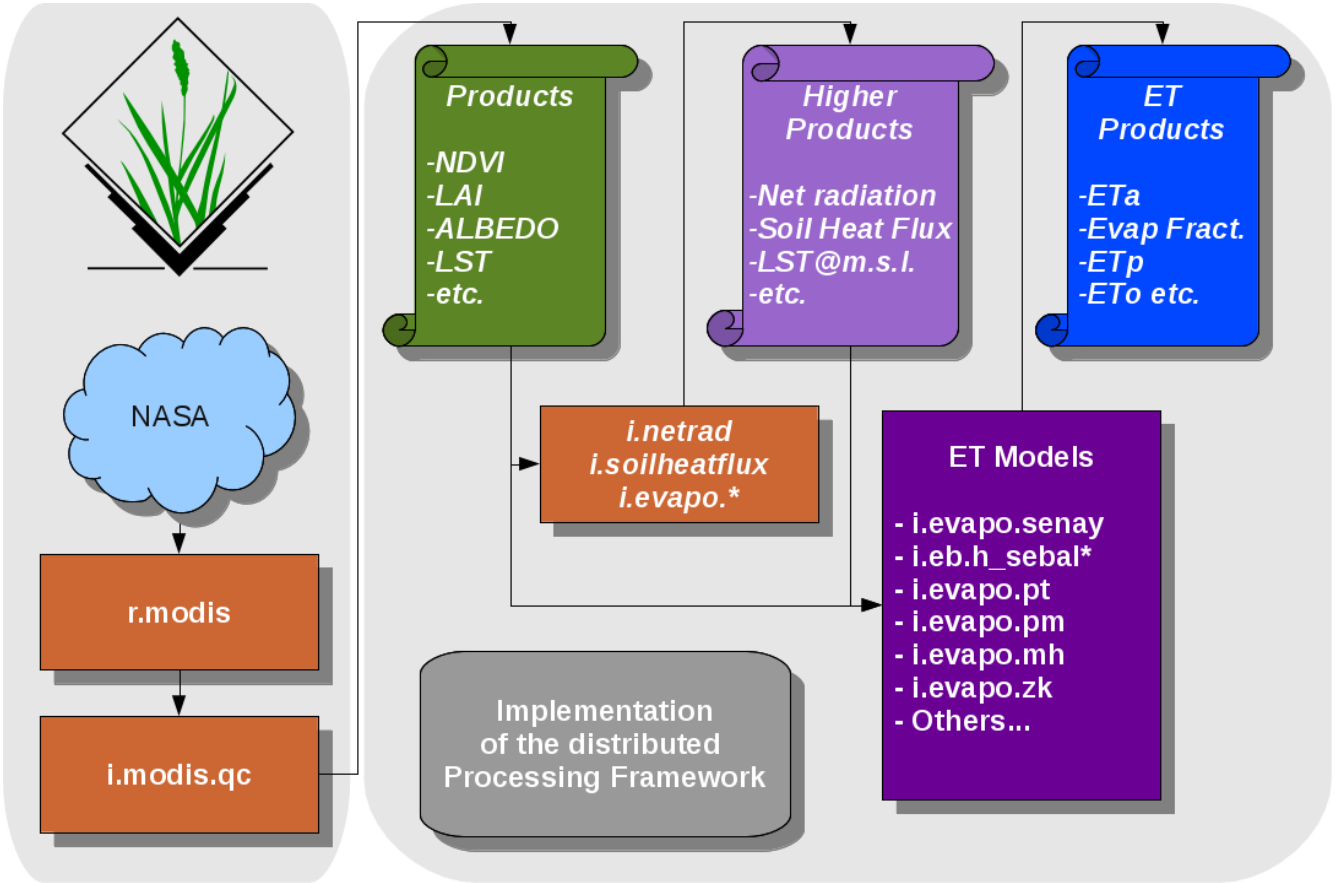
OpenLog + Arduino Pro











Pythonizing GRASS:
From Shell commands to Python functions

metaModule concept

1. **GRASS GIS:** Specific image processing modules
2. **PyWPS:** G modules called by Python
3. **GRASS script:** G mod. called by Python: metaModule
4. **pyGRASS:** G mod. called as Python fun.: metaModule
5. **PyWPS v4:** pyGRASS metaModule used directly **(TODO)**

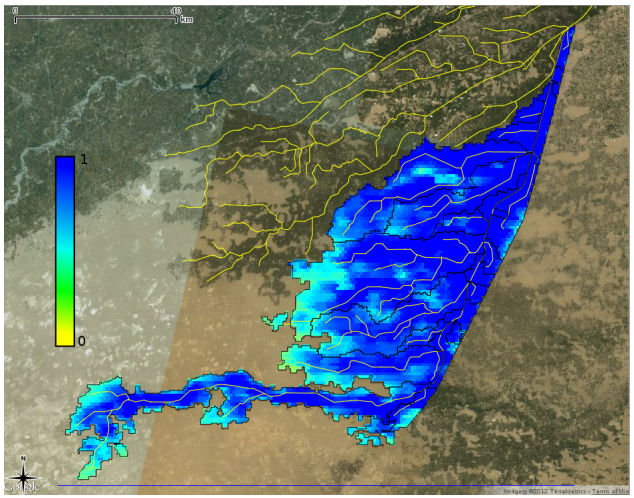
Summary for Landsat pyGRASS metaModule

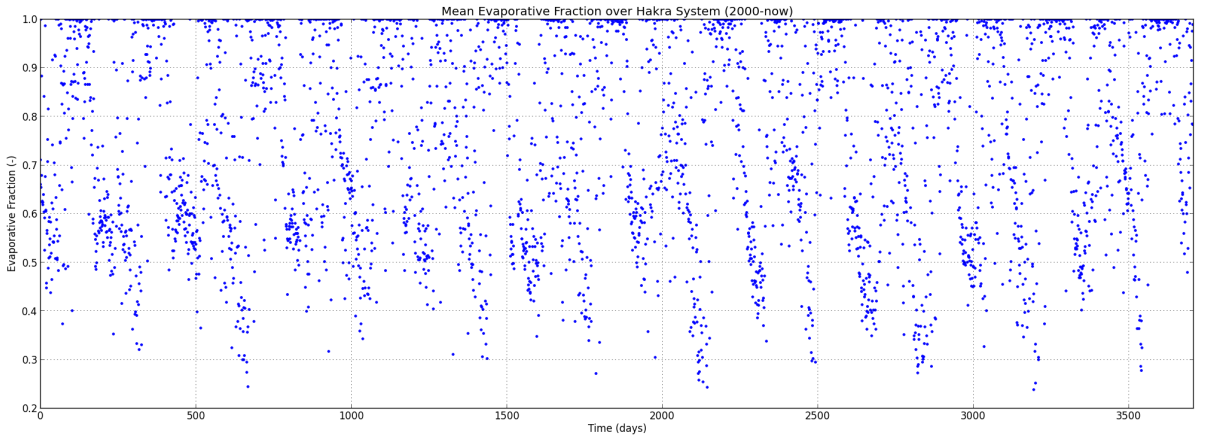
```
from grass import script as g
from grass.script import setup as gsetup
gisbase=os.environ['GISBASE']
gsetup.init(gisbase,gisdb,location,mapset)
from grass.pygrass.modules.shortcuts import raster as r
from grass.pygrass.modules.shortcuts import imagery as i
from grass.pygrass.modules.shortcuts import display as d

r.mapcalc(expression="vis=18",overwrite=OVR)
r.in_gdal(input=L7f,output=L7r,flags="e",overwrite=OVR)
r.proj(input="dem",location="Myanmar",memory=10000,resolution=90.0,overwrite=OVR)

i.landsat_toar(input_prefix=pref,output_prefix=outpref,
        metfile=metadata[0],sensor=LSENSOR,quiet=QIET,overwrite=OVR)

i.atcorr(input=b, elevation="dem", visibility="vis", parameters=prm,
        output=b_out, flags="ra", range=[0,1],quiet=QIET,overwrite=OVR)

i.landsat_acca(input_prefix=b_in,output=b_clouds,overwrite=OVR)
r.mask(raster=b_clouds,flags="i",overwrite=True)

i.vi(red=b3,nir=b4,output=b_ndvi,viname="ndvi",quiet=QIET,overwrite=OVR,finish_=False)
i.albedo(input=b_in,output=b_albedo,flags="lc",quiet=QIET,overwrite=OVR,finish_=False)
i.emissivity(input=b_ndvi, output=b_emissivity,quiet=QIET,overwrite=OVR,finish_=False)
```

http://grasswiki.osgeo.org/wiki/Python/pygrass

Irrigation water monitoring & management

- Map: Uniform colour is equity of water distribution
- Graph: Irrigation system equity (mm/d, daily, 12 years)





Developed by Jachym Cepicky (http://les-ejk.cz/)

- OGC WPS standard
- Server side
- Written in Python Language
- Version 4 in the making
- v4 Low-level API: integration with GRASS GIS
- v4 Possible pyGRASS support

PyWPS v2 style

WPS_hakra_ef.py (~/wps_processes/evapfr) - gedit

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WPS_hakra_ef.py

```
        # EF processing
        if os.system("i.eb.evapfr lst=lst ouput=hakra_ef_%s >&2" % (self.Inputs[0]['value'])):
            return   """Could not process Hakra EF map"""

        #Mask non Hakra Command Area
        if os.system("""r.mapcalc hakra_ef_%s"="if(isnull(MASK),null(),hakra_ef_%s)" >&2""" % (self.Inputs[0]
['value'])):
            return   """Could not clip Hakra Command Area"""

        # export
        if os.system("r.out.gdal in=hakra_ef_%s out=hakra_ef_%s.tif type=Float32 >&2" % (self.Inputs[0]
['value'],self.Inputs[0]['value'])):
            return   """Could not export Hakra EF map"""

        #clean the mess 2
        os.system("rm -f %s" % tmpfilelist)
        del rnd, tmpfilelist, f, lstfiles, wildcard, tmpdir


if __name__ == "__main__":

    p = Process()
    p.Inputs[0]['value'] = "2012-09-01"
```

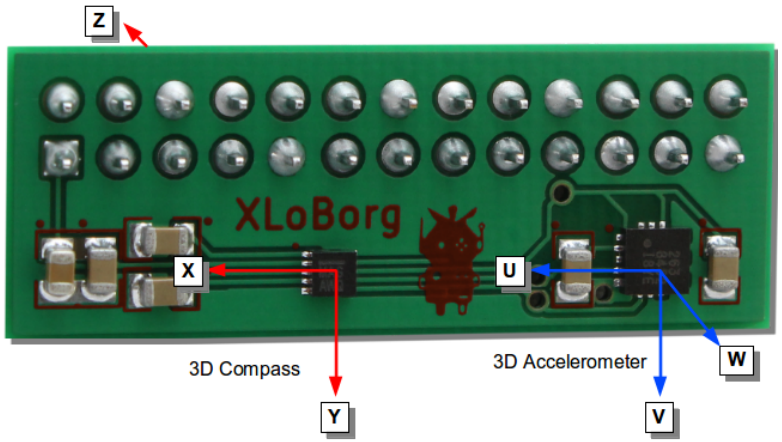
Python Largeur des tabulations: 8 Lig 67, Col 9 INS

University of Moratuwa, F. of Archit., Urban Planning

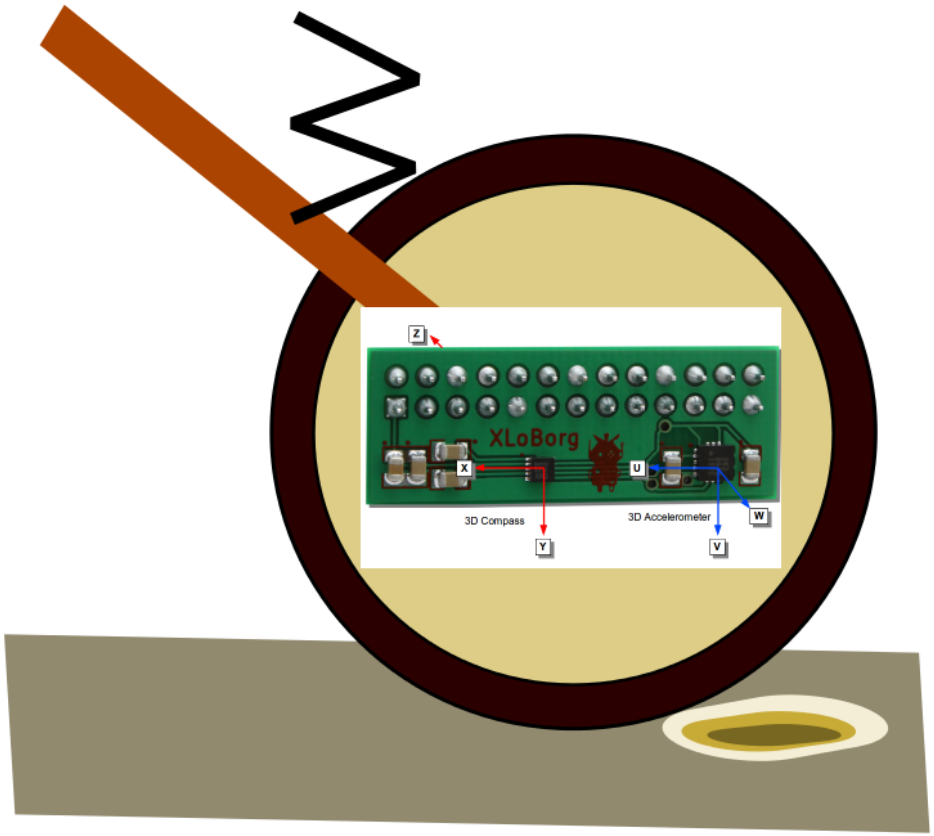
- **Road condition:** chronic issue in Sri Lanka
- **RDA:** few IMU Vehicles (V. Expensive)
- **Challenge:** OSHW+FOSS4G $<$ 100 USD/vehicle
- **Solution:** GDAL/OGR + RaspberryPI

System setup on a vehicle:

- RaspberryPI
- + XloBorg Accelerometer
- + GPS
- + Python-OGR



Python-OGR reporting Z-axis anomalies into road Shapefiles by integrating Xloborg and GPS data




```
pi@raspberrypi: ~/xloborg
X = -0.0156 G, Y = +0.0000 G, Z = -1.0000 G
mX = -00377, mY = -00017, mZ = +00378
X = +0.0000 G, Y = +0.0156 G, Z = -1.0000 G
mX = -00370, mY = -00015, mZ = +00386
X = -0.0156 G, Y = +0.0156 G, Z = -1.0156 G
mX = -00370, mY = -00016, mZ = +00381
X = -0.0156 G, Y = +0.0156 G, Z = -1.0000 G
mX = -00376, mY = -00018, mZ = +00376
X = -0.0156 G, Y = +0.0156 G, Z = -1.0000 G
mX = -00376, mY = -00014, mZ = +00385
X = -0.0156 G, Y = +0.0156 G, Z = -1.0000 G
mX = -00372, mY = -00019, mZ = +00386
X = -0.0156 G, Y = +0.0156 G, Z = -1.0000 G
mX = -00375, mY = -00016, mZ = +00384
X = -0.0156 G, Y = +0.0156 G, Z = -1.0000 G
mX = -00378, mY = -00018, mZ = +00385
X = +0.0000 G, Y = +0.0156 G, Z = -1.0000 G
mX = -00375, mY = -00018, mZ = +00382
X = +0.0000 G, Y = +0.0156 G, Z = -1.0000 G
mX = -00378, mY = -00019, mZ = +00377
X = -0.0156 G, Y = +0.0312 G, Z = -1.0000 G
mX = -00374, mY = -00019, mZ = +00379
X = -0.0156 G, Y = +0.0156 G, Z = -1.0156 G
```

Water Resources Monitoring in Sri Lanka
Trans-basin water, Jaffna city pipeline, etc.

Characteristics

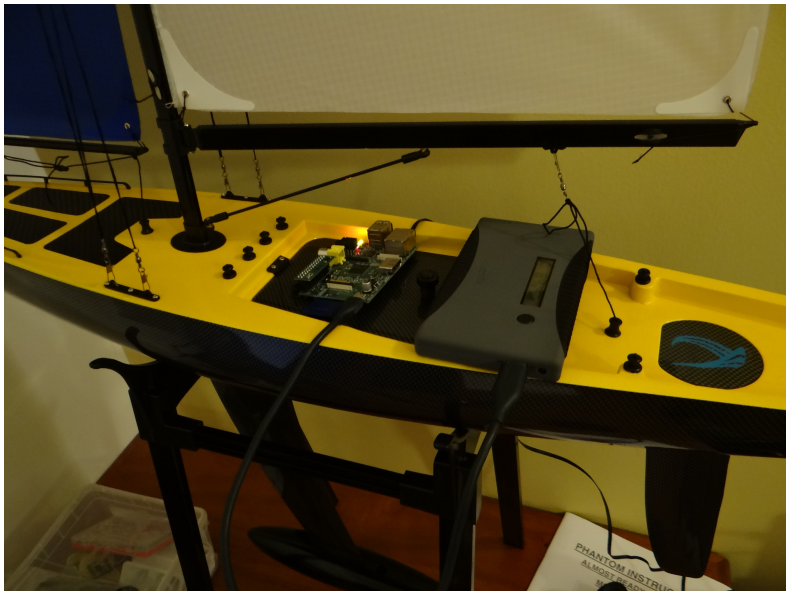
- Rural tanks (several thousands!)
- Cascade systems (interconnected)
- Water Storage capacity changes regularly
- Evaporative losses less known

Calibration of evaporative losses
and regular monitoring are much needed

Amitomi is a 1m-class autonomous sailing boat
Designed to survey small tanks temperature gradient for calibrating Evaporation models

https://sites.google.com/site/amitomiautoboat

RaspberryPI as AmiTomi

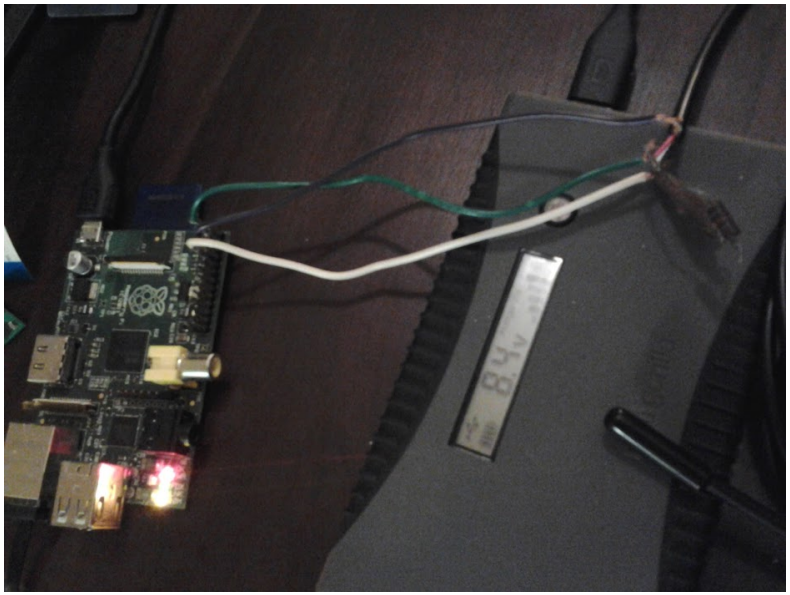


Boat itself

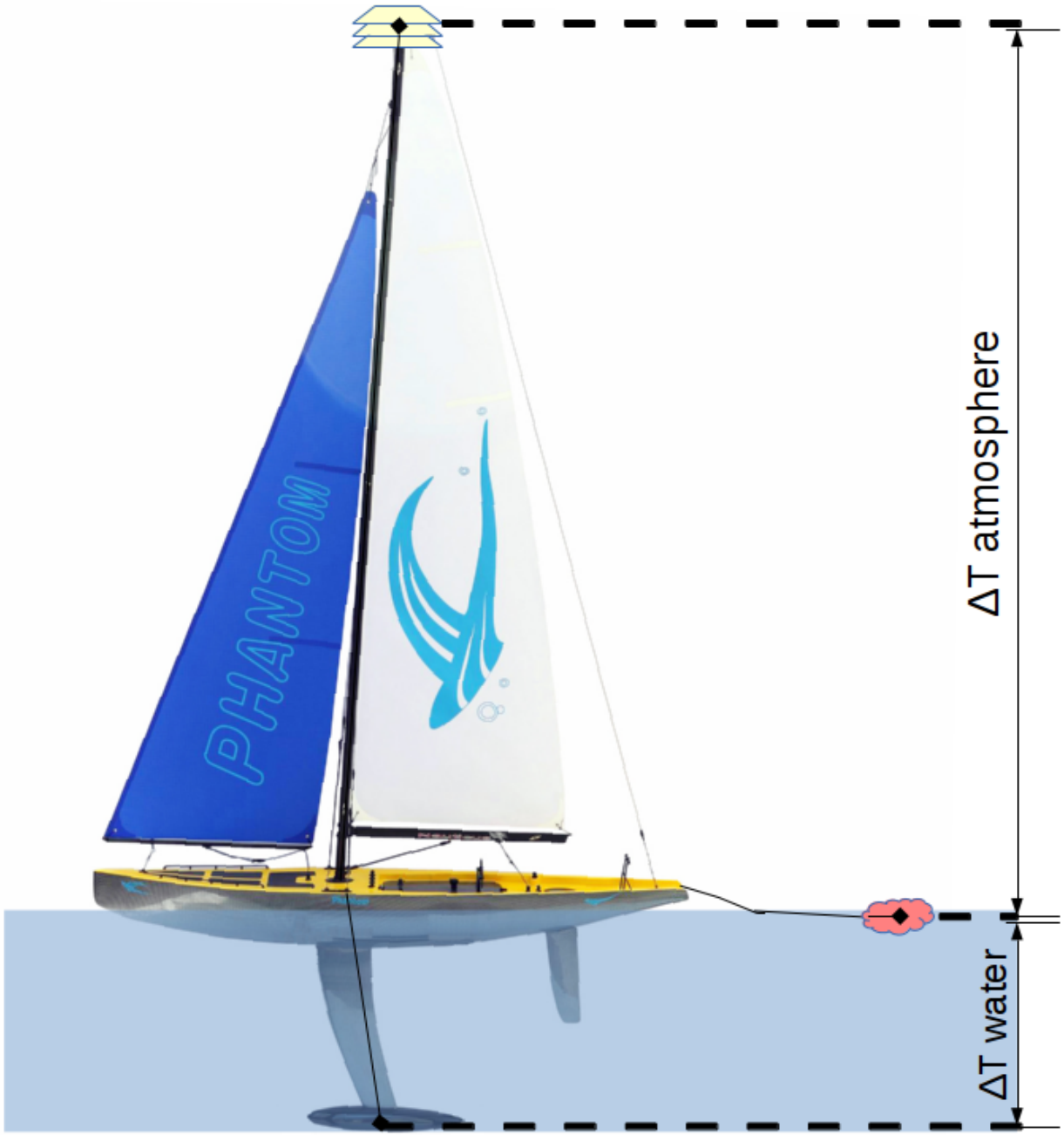
AmiTomi's brain is the RaspberyPI python code:

- Skipper: the captain/navigator software
- Waypoint sorter: optimizer for route
- Sensor datalogger: simultaneous sensing
- Mapper: import data and 3D interpolation

RaspberryPI GPIO connecting to temperature sensor



Temperature digital sensors (2m cables)



- Python-gps (GPS data)
- Python-i2ctools (Compass/Temperature data)
- Python-XIoBorg (Compass data)
- Python-openopt (Waypoints downwind sorting openopt.org)
- Python-MotorPiTX (servo control for sails & rudder)
- (py)GRASS (live processing of 3D GIS data)
- If online: PyWPS, SOS/network reporting.

FOSS4G natural extension is Open Source Hardware

- **RaspberryPI:** Small PC (ARM v8, Linux)
- **Arduino:** Micro-controller
- **OpenLog:** Data Logger
- **GDAL/OGR:** Flexible sensor raw data manipulation
- **GRASS GIS:** Mobile FOSS4G powerhouse
- **PyWPS:** Online GRASS GIS processing
- **Together:** Flexible all-in-one sensor-to-map solutions