Low-cost Wireless sensor network system for micro-climate monitoring

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What Syngenta want

- Greenwash?
- Originally:
  - Micro-climate monitoring
  - Bio-diversity
  - Field-margins
- Now:
  - Crop growth monitoring
  - Effect of micro-climate within fields

Parameters

- Air
  - Temperature
  - Humidity
  - Pressure
- Wind
  - Speed and direction
- Soil
  - Temperature
  - Humidity
- Light
  - “Intensity” (ideally PAR)
  - Measure of canopy density
  - Senescence

Carbon Dioxide

Methane

Rainfall

Sensors

- Cheap! (mostly)
- Hobby quality has to be good enough
  - DHT 22 has 0.1C resolution (around 0.4C accuracy)
  - Soil probe similar (slightly more accurate)
- Rowind is lovely but...
  - Expensive
  - Power-hungry

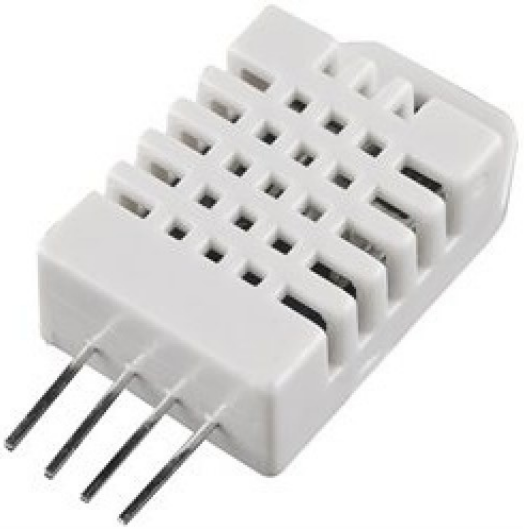
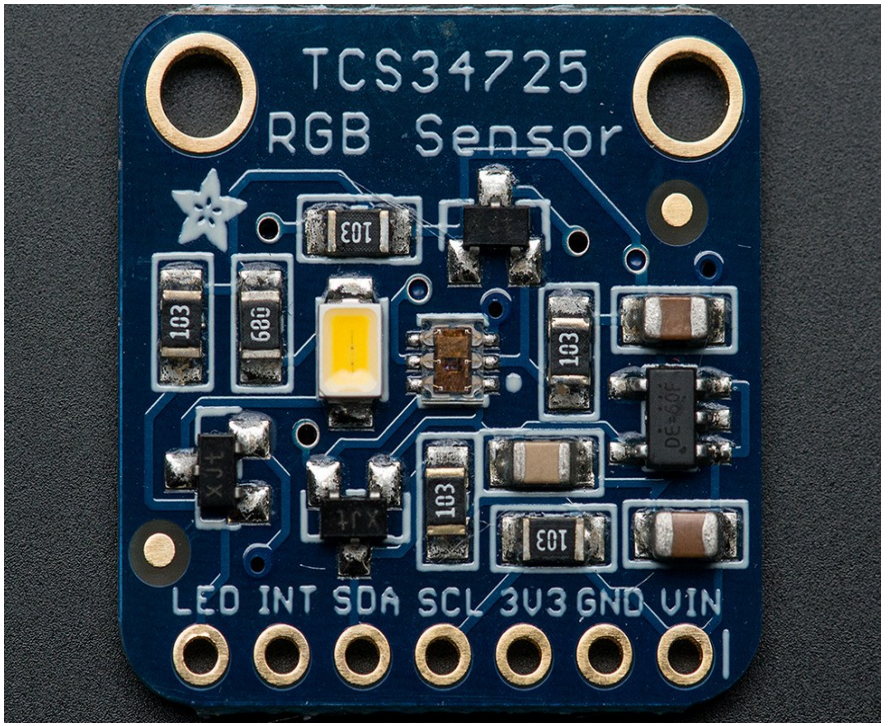


Image from adafruit.com

Light sensors

- Again “hobby” quality
- Two RGB sensors:
  - ISL29125 (intersil)
  - TCS34725 (Texas)
- Just photodiodes with RGB masks
- TCS board has a white LED as well
- Why two types?



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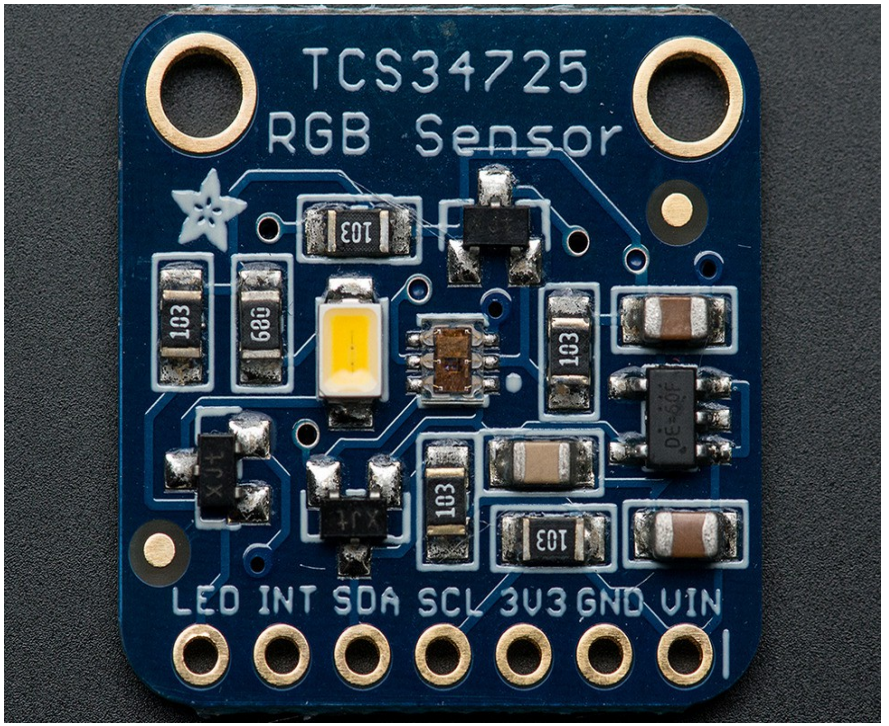

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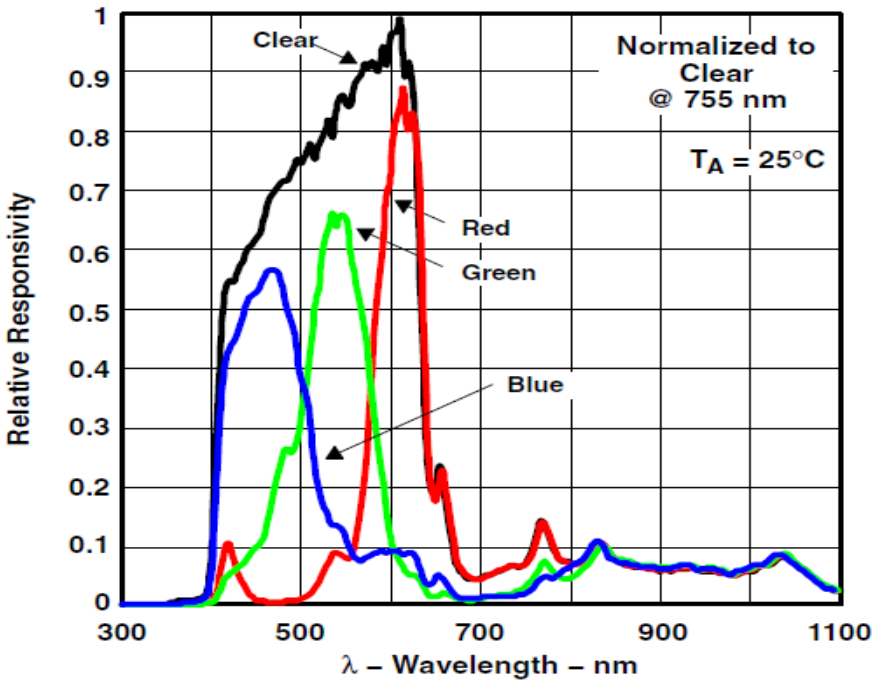
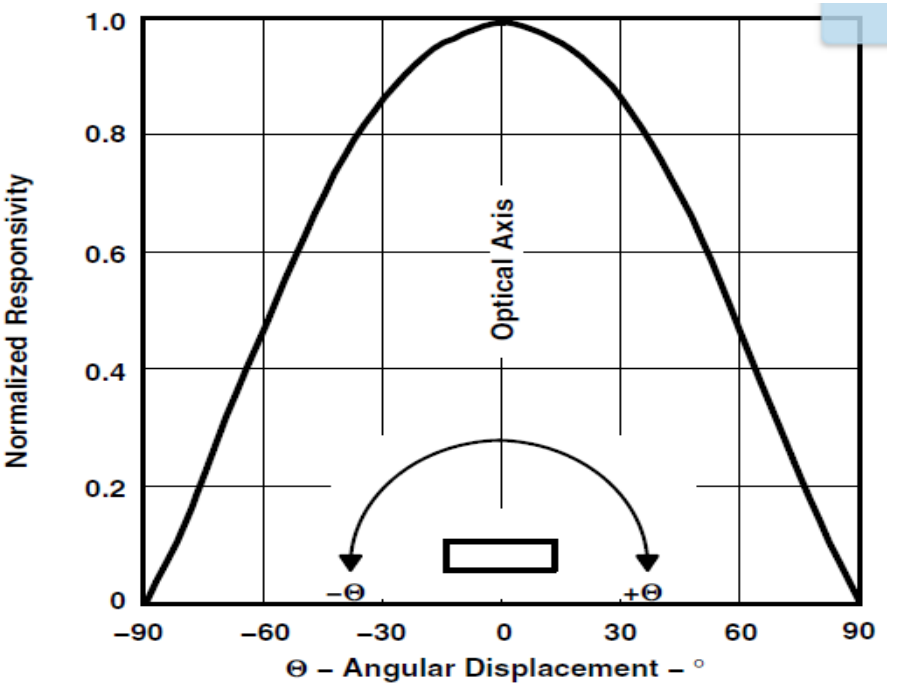




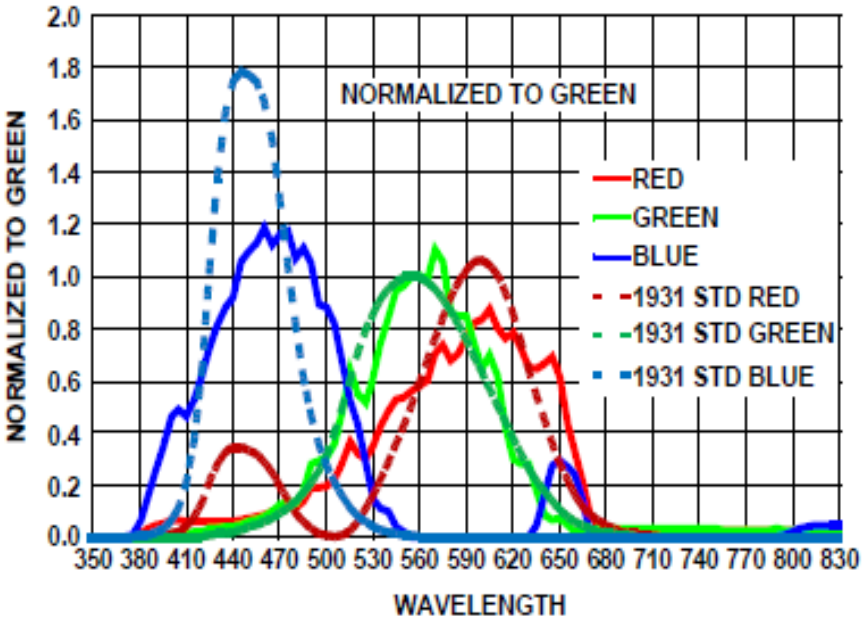


FIGURE 5. NORMALIZED SPECTRAL RESPONSE FOR AMBIENT LIGHT SENSING

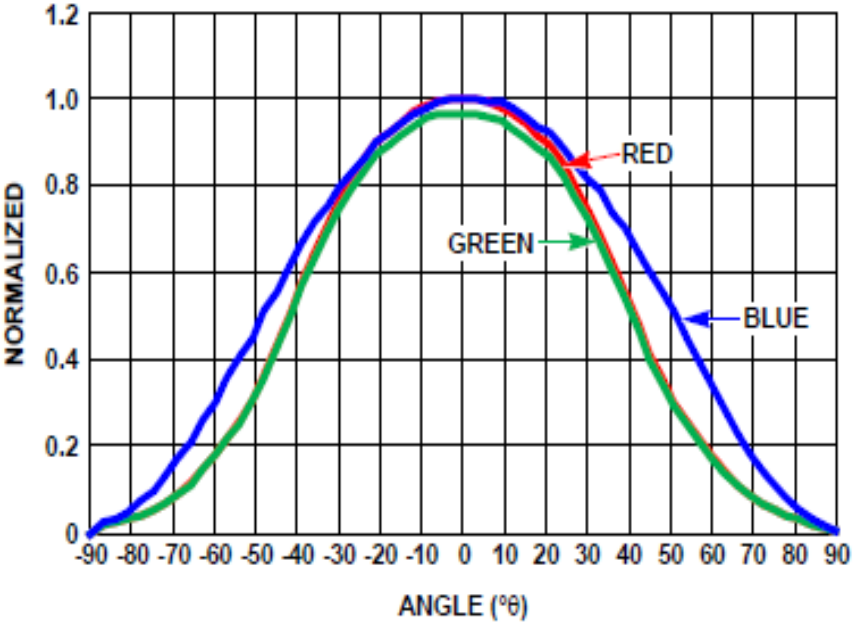


FIGURE 6. RADIATION PATTERN

From intersil (ISL29125, bottom) and Texas datasheets (TCS34725, top)

How to get the most from the light sensors?

- RGB readings at face-value
  - Can separate grossly different colours with single readings
  - Quite noisy, but with multiple reads and taking medians can discriminate more finely
- Calibration?
  - Can I afford the time?
  - What will I gain?
- Exploit variability?
  - Bio-diversity (identical sensors)
  - Crops (heterogeneous sensors?)
- Filtering strategies (open to suggestions!)
  - Add rejection band filter?

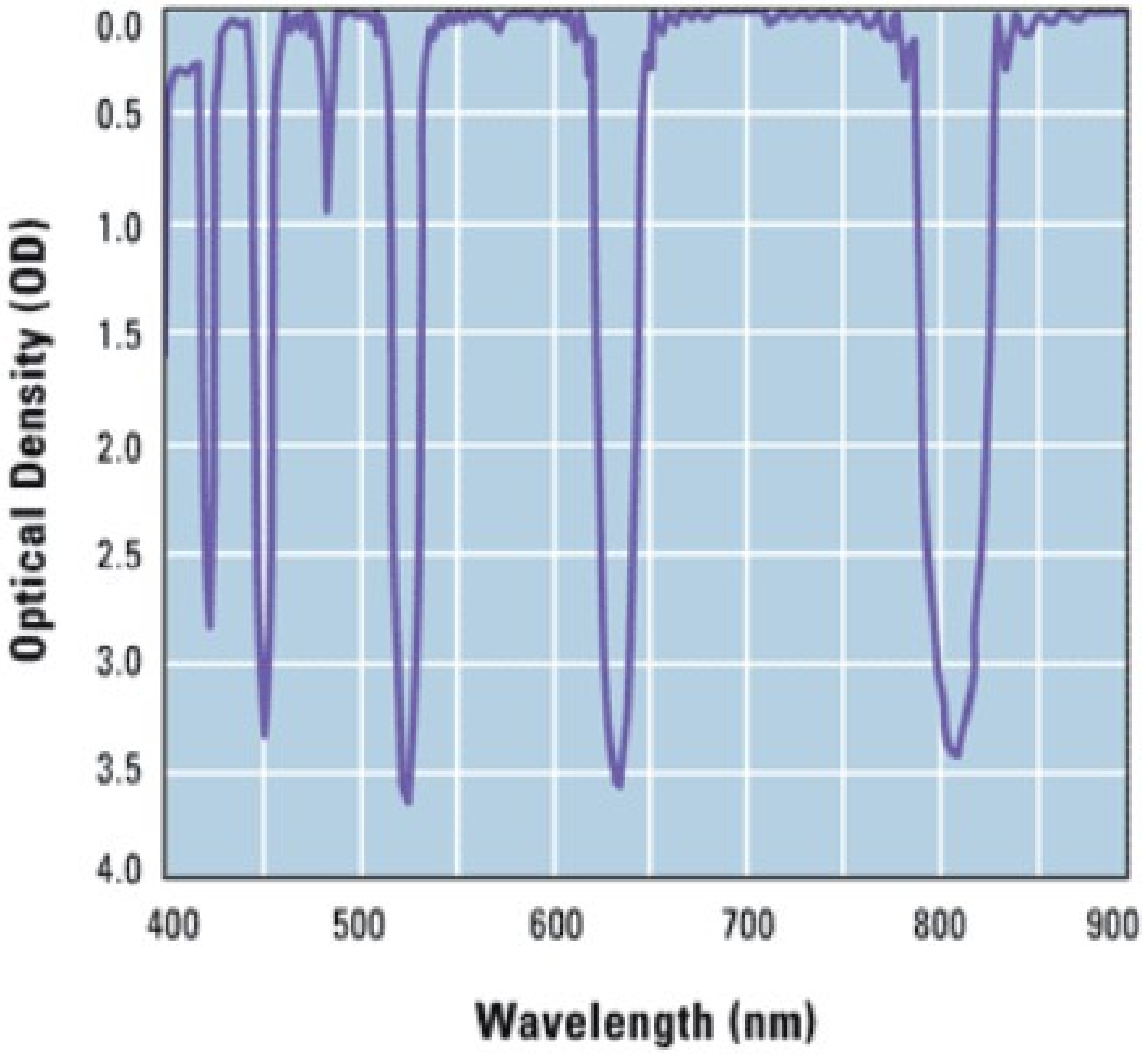


Image from omegafilters.com

Data transmission

- Pretty low bandwidth
  - Expecting ~100 bytes per station per minute
- Encoded as plain ASCII
  - Much easier to debug
  - Simple to store and process
- Data content
  - 4 x Temp and Humidity
  - 3 x Light

Data transmission

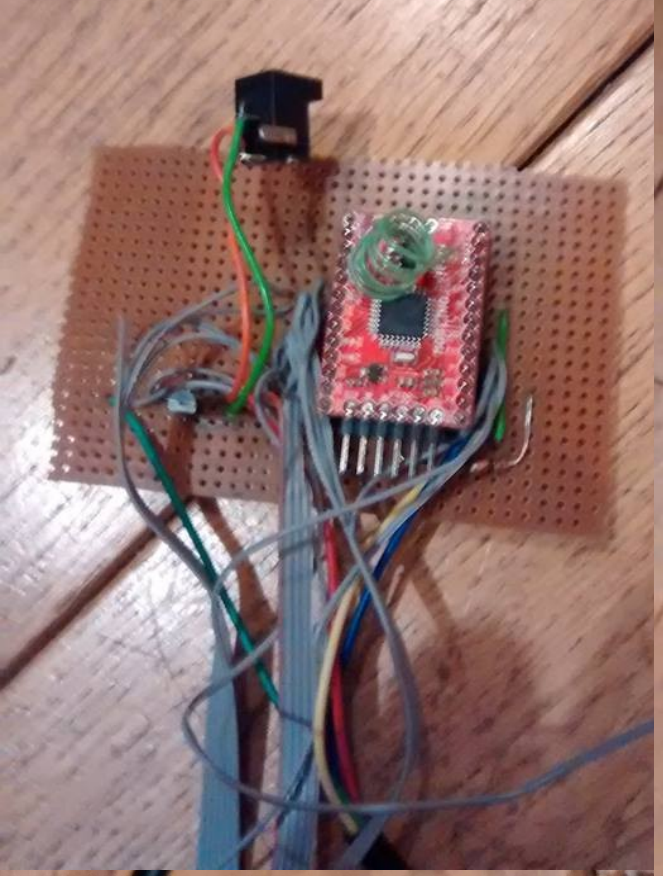
- 433MHz vs 2.4GHz
  - RFM69
  - Xbee
  - 802.11
- Cost
- Range
- Data rates
- Power consumption

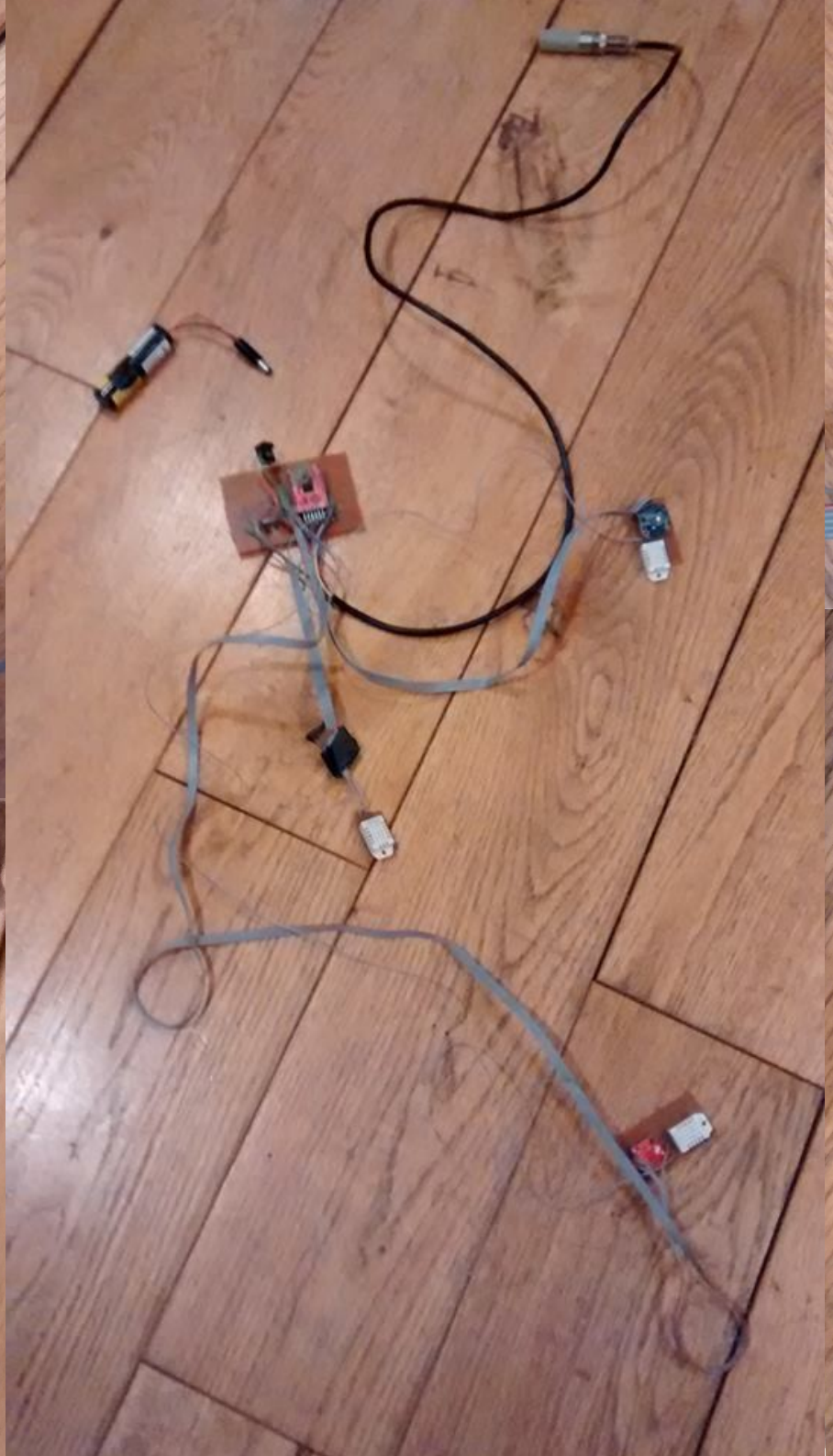
Moteino

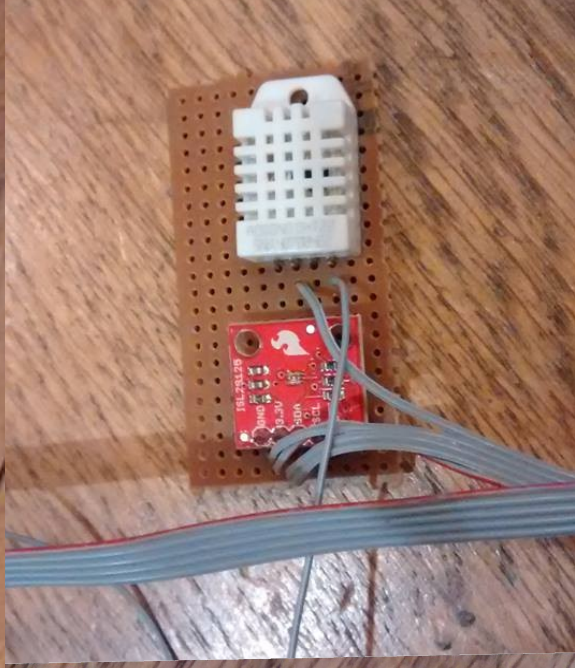
- Arduino compatible with a 433MHz radio module built-in
  - Range reliably ~500m
  - Significantly more with some tweaking
  - Line-of-sight (pretty much)
- Really easy to get going with
  - Nice libraries
- Can do addressing, packet-filtering etc...
- No routing/meshing built-in
- Just used for simple point-to-point at present

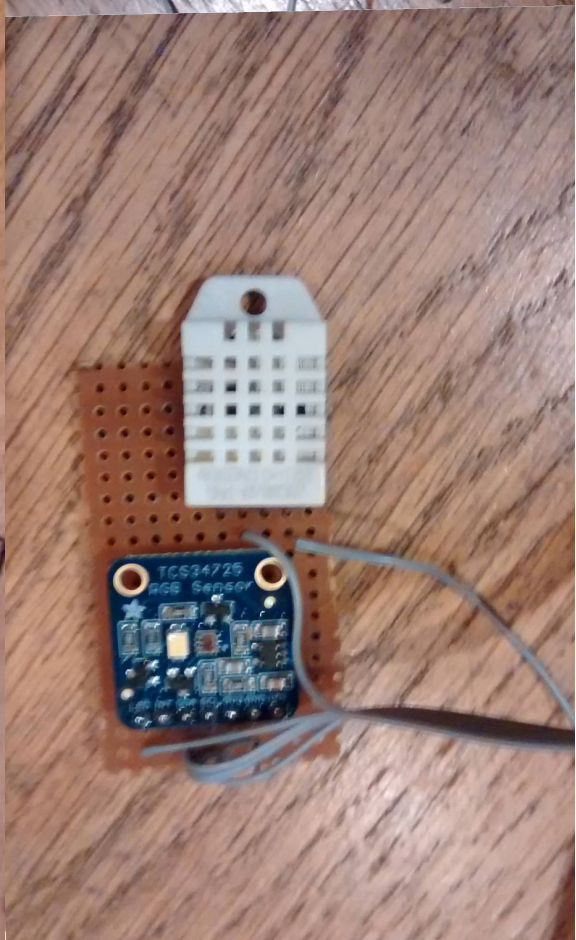
Moteino facilities

- Provides easy IO (just like an Arduino UNO)
- USB programmable
- Nice library provides access to the radio module
- Radio comms is just calling simple functions
- Very quick to get started and generate “cut-and-paste” functionality
- Unregulated frequency (and not in the 2.4GHz band) which is generally very reliable
- Used this on a balloon launch last year and got 2650m using a directional antenna and stock example code








TCS34725
RGB Sensor

Adaptive algorithms for controlling data rate and sampling regime

- Use environment feedback to
  - Increase sampling frequency
  - Decrease sampling frequency
  - Prioritise particular sensors
  - Prioritise particular parts of the network
- Use external input in a similar way
  - Human intervention
  - Weather station data
  - Weather forecast

Conclusion

- Building small, low-power, long-lived systems has never been
  - Easier
  - Cheaper
- What they lack in precision/accuracy/ repeatability they can make up for in other ways
- They offer ways to study things that are genuinely novel
  - But also require a bit of a side-step in the way you think
- Communication technologies can be very cheap, especially for low data rates