The Hitchhiker's Guide to Successful Wireless Sensor Network Deployments

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ÉCOLE POLYTECHNIQUE
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SensorScope: An Environmental Monitoring System

Today

Tomorrow

Expensive, complex installation, limited storage, no real-time feedback. . .

Low cost, solar powered, flexible, real-time, multidimensional data. . .

# Hardware & Networking Architectures

Hardware:

- ▶ TinyNode sensor mote:
    - ▶ MSP430 (1 MHz, 10 KB RAM, 48 KB ROM).
    - ▶ Xemics 1205 radio (868 MHz, 76 Kbps).
- ▶ Solar panel (1W)
- ▶ Two batteries (150 mAh NiMH + 2 Ah Li-Ion).
- ▶ Seven sensors, nine measures.

Networking (TinyOS 2.x):

- ▶ Overhearing-based neighborhood discovery.
- ▶ Opportunistic gradient routing.
- ▶ Global synchronization.
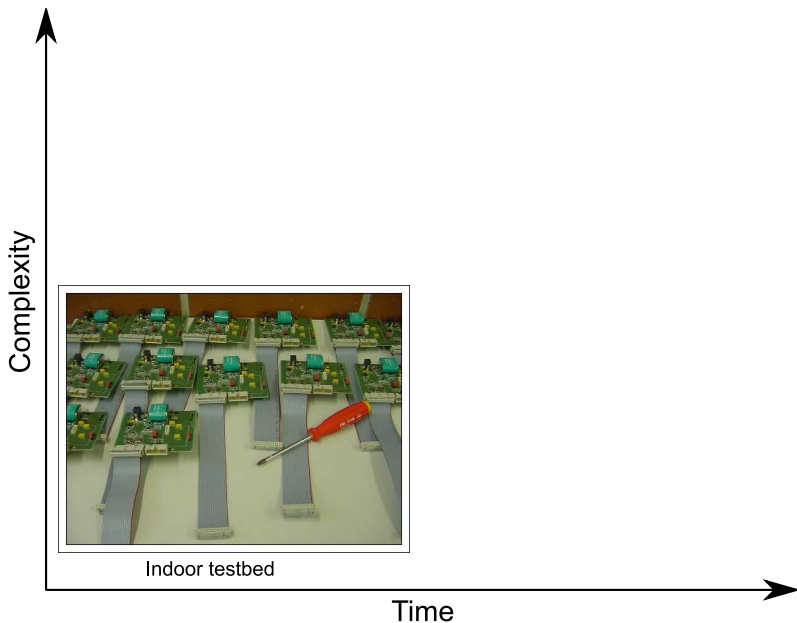- ▶ Synchronous duty-cycling.
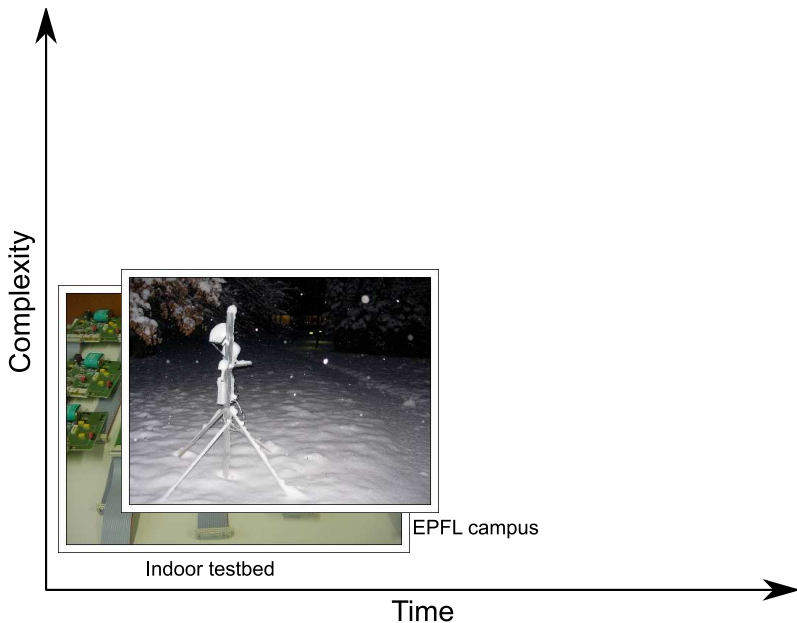- ▶ Open source.

Global Architecture
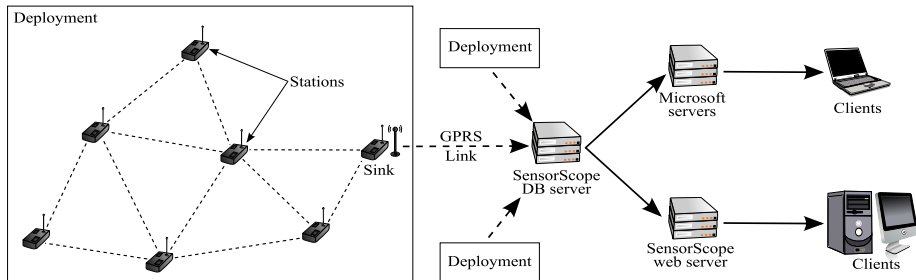
- ▶ Sink is equipped with Ethernet, WiFi, or GPRS connections.
- ▶ Allows for multiple simultaneous deployments.
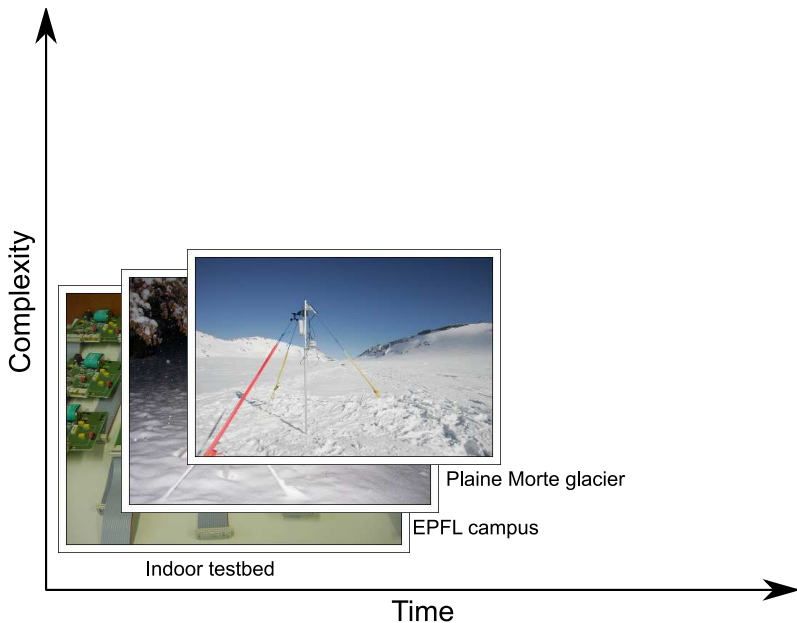- ▶ Data is (currently) publicly available on various servers.
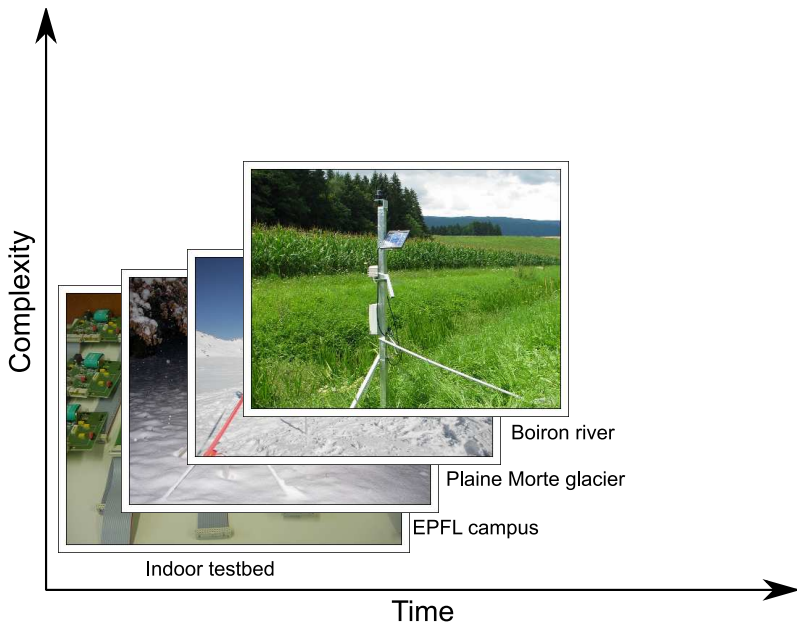
We Learn by Practice

Complexity

Indoor testbed

Time

We Learn by Practice

Complexity

EPFL campus

Indoor testbed

Time

We Learn by Practice

Complexity

Plaine Morte glacier

EPFL campus

Indoor testbed

Time

We Learn by Practice

Complexity (vertical axis)

Time (horizontal axis)

Boiron river

Plaine Morte glacier

EPFL campus

Indoor testbed

We Learn by Practice

Complexity

Grand St Bernard pass

Boiron river

Plaine Morte glacier

EPFL campus

Indoor testbed

Time

We Learn by Practice

Complexity / Time

Génépi mountain

Grand St Bernard pass

Boiron river

Plaine Morte glacier

EPFL campus

Indoor testbed

We Learn by Practice
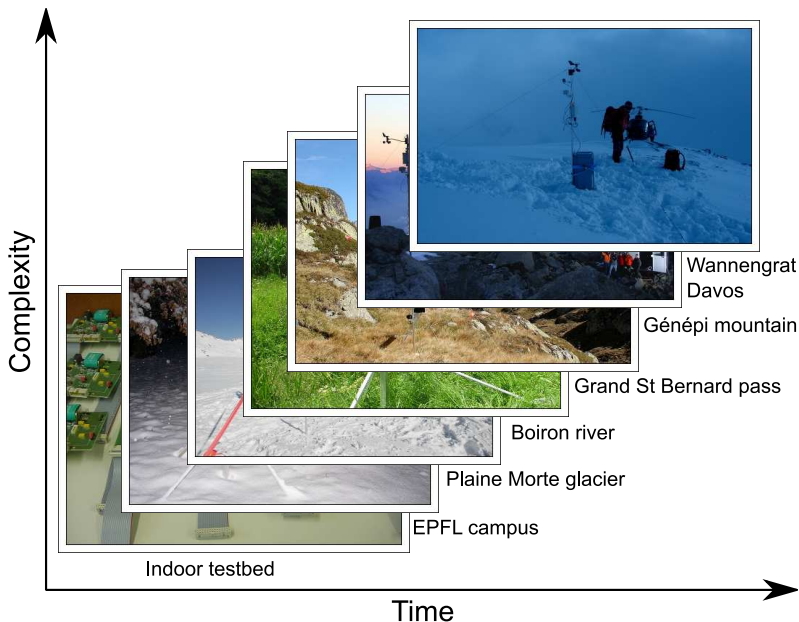
Consider Local Conditions

Weather conditions, especially the temperature and humidity, greatly affect the hardware.
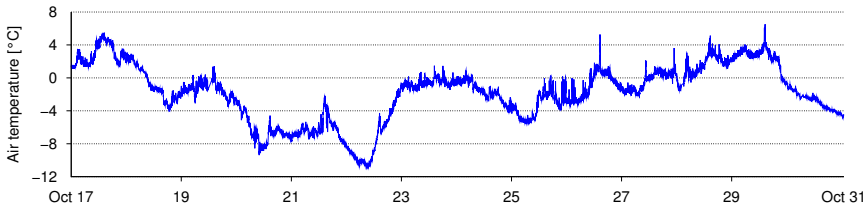

Test your equipment under similar conditions

- ▶ Packaging is crucial:
    - ▶ Outdoor sensors are susceptible to corrosion.
    - ▶ *Ingress Protection* (IP) 67 is needed for full protection.
- ▶ Li-Ion batteries can explode, when charged at sub-freezing temperatures!
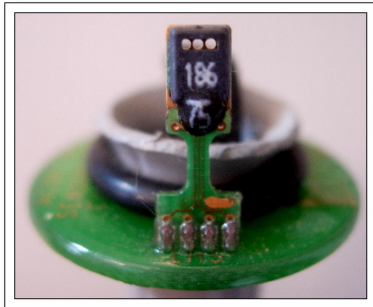- ▶ Crystal oscillators are highly impacted by the temperature.

Impact of Air Temperature on Crystal Oscillators
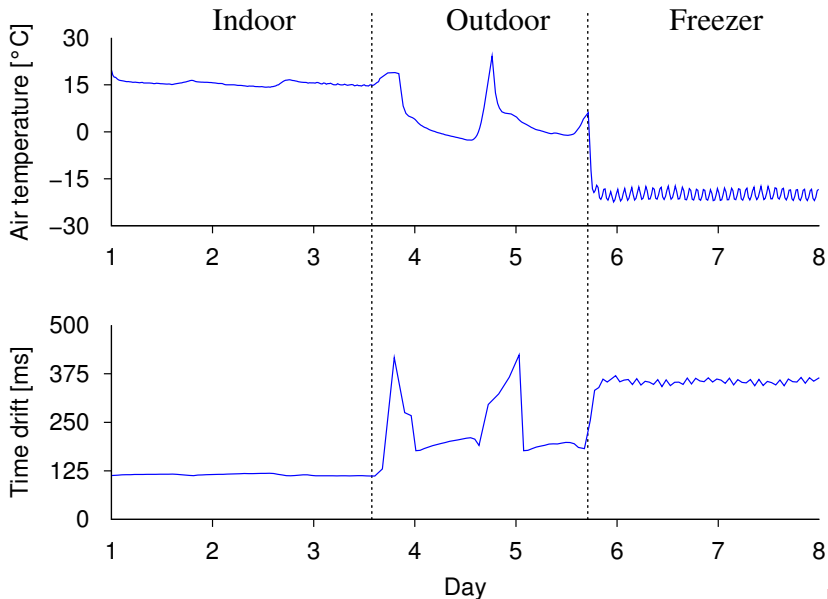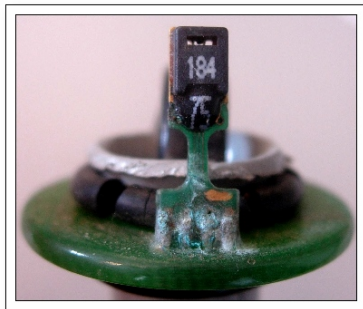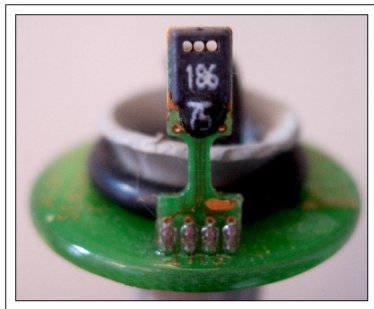
Humidity Measurements: Sensirion SHT75 (Génépi)
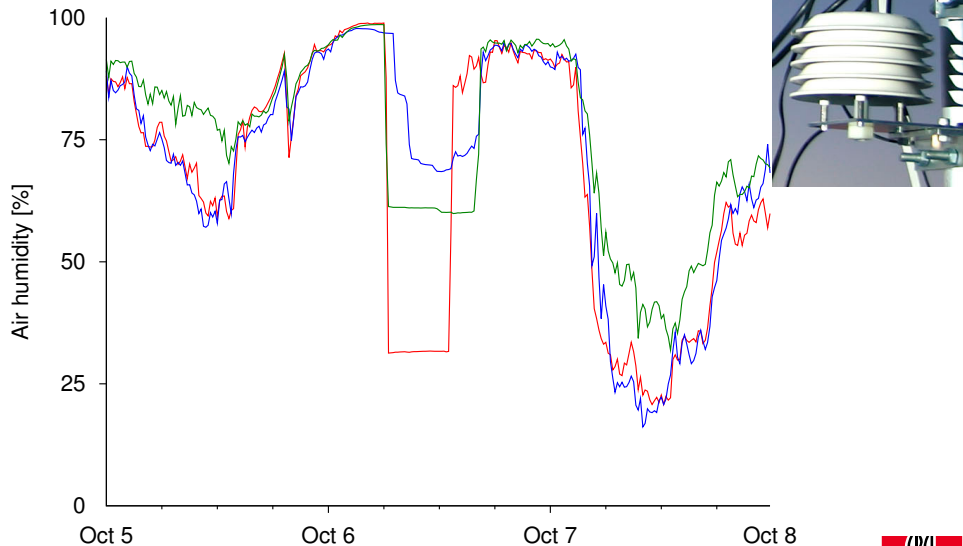
Corrosion Kills

Back from deployment. . .

Corrosion Kills
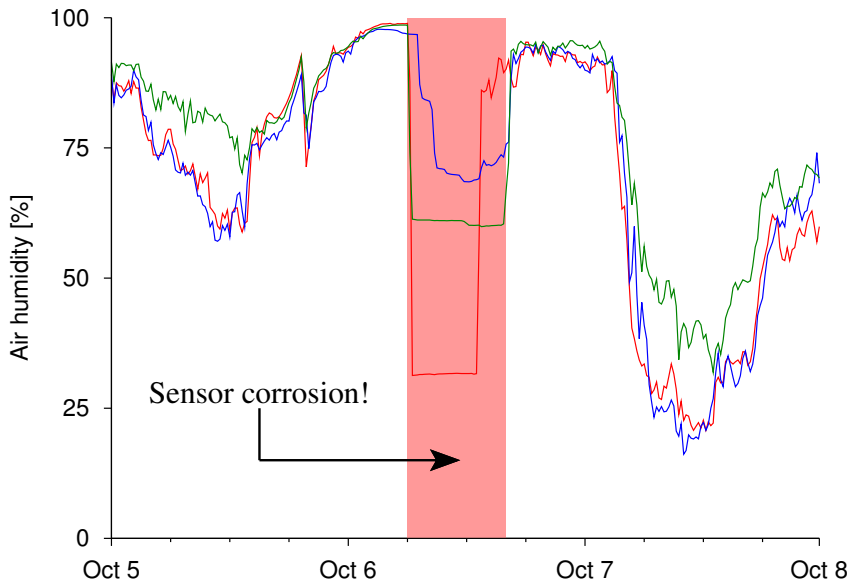
Back from deployment. . .

- ▶ Corrosion causes malfunction of sensors.
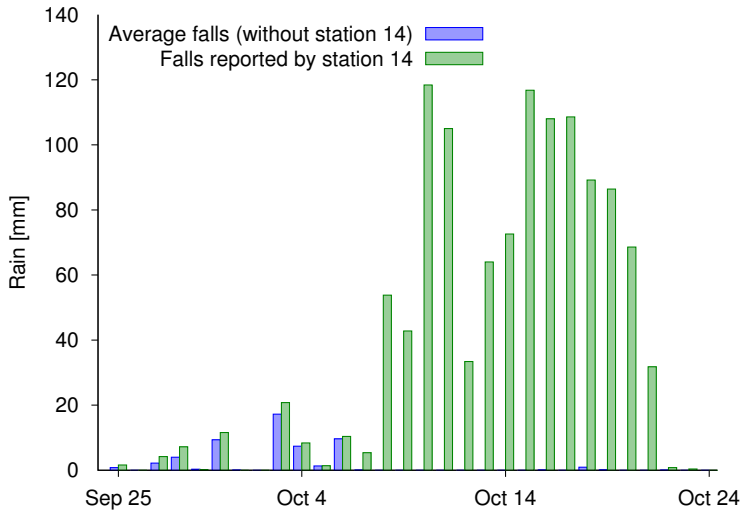- ▶ Corrosion causes nodes reboot.

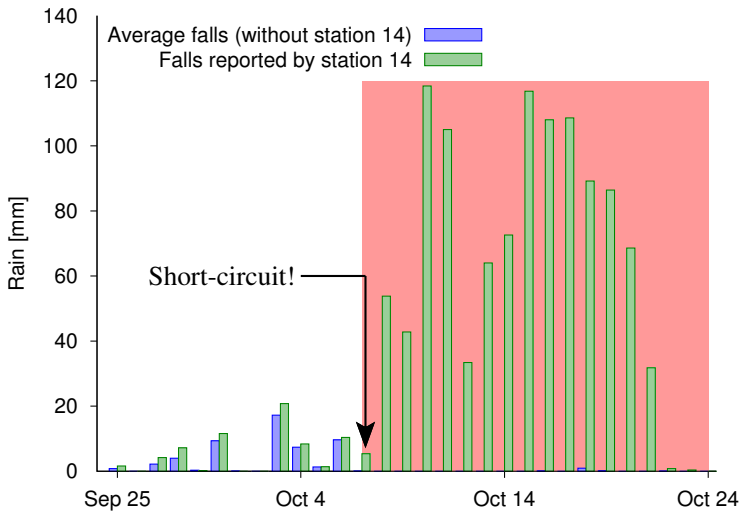**Broken sensors can invalidate an otherwise successful deployment!**

Corrosion Kills — Sensirion SHT75 (Génépi)

Sensor corrosion!

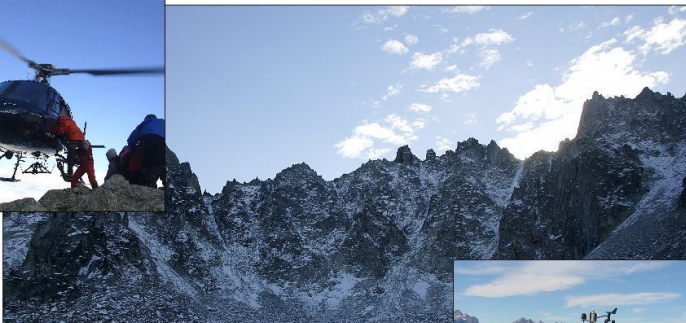# Corrosion Kills — Rain Meter (Grand Saint Bernard)

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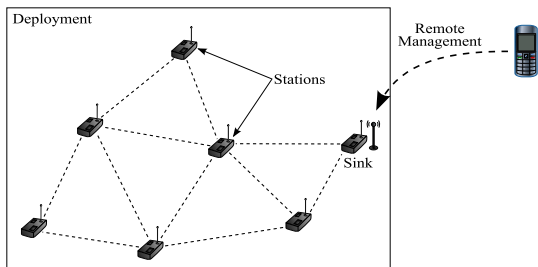

Advice: *Packaging is of prime importance.*

The Génépi Deployment

Remote & Local Control

- ▶ We can control the sink with GSM text messages.
- ▶ We can monitor stations in the field.

Don't Be a Black Box

Programming for embedded devices is very specific!

► Debugging with LEDs is exhausting. . .

► . . . And LEDs consume a lot of energy (*i.e.*, around 3 mA each).

► Embedded software is often subject to hardware failures.

► You must know what happens *inside* the network.

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- ▶ You must know what happens *inside* the network.

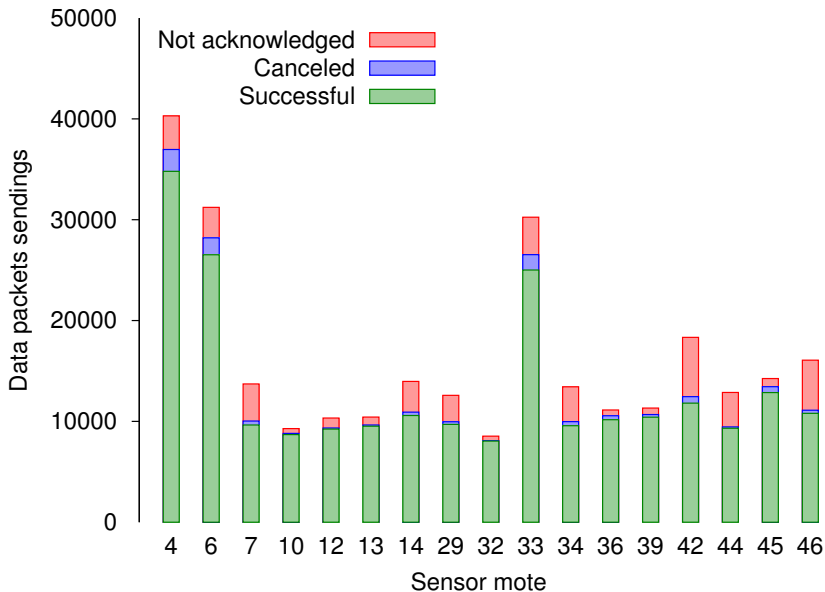In SensorScope, we use specific *status packets*:

- ▶ *Energy* — Level of batteries, incoming solar power...
- ▶ *Network* — Most recent activity of the transport layer.
- ▶ *Neighborhood* — Neighborhood table and link qualities.
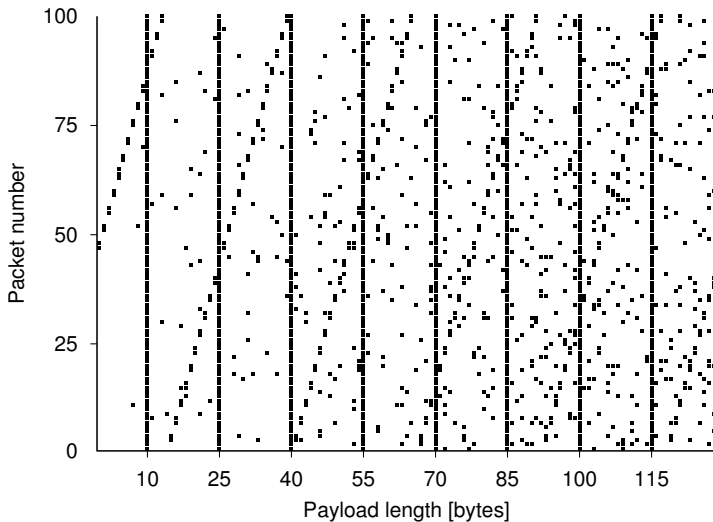
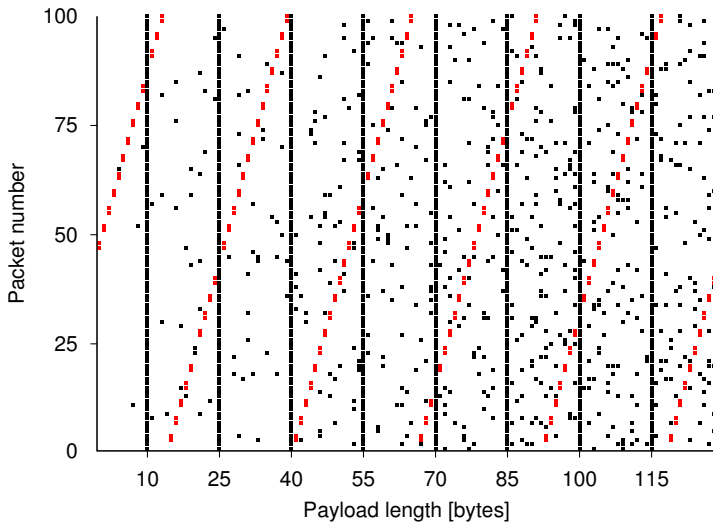# **Don't Be a Black Box — Energy Level (Génépi)**
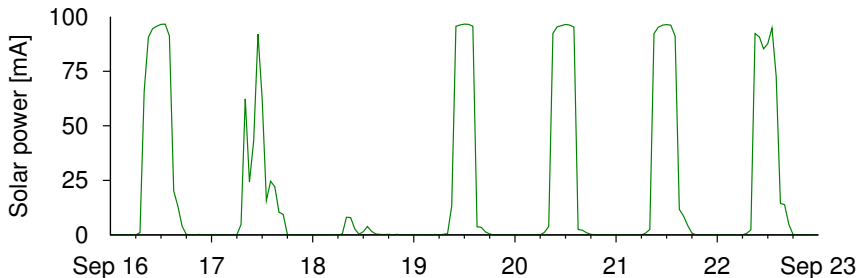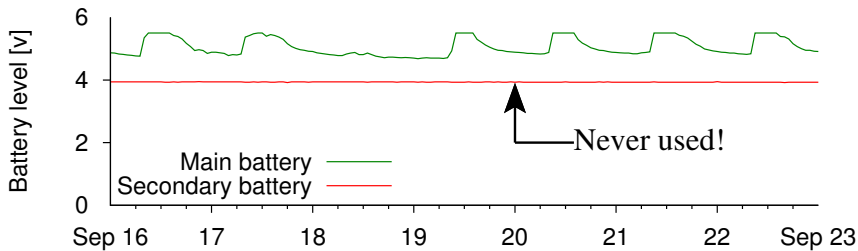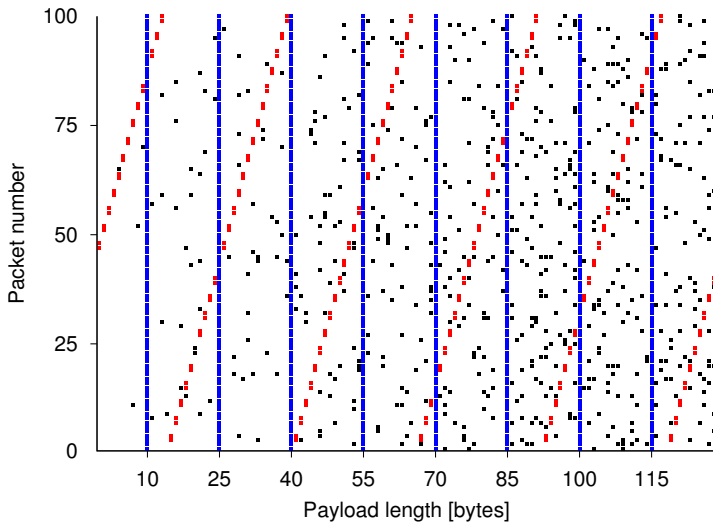
Don't Be a Black Box — Network Load
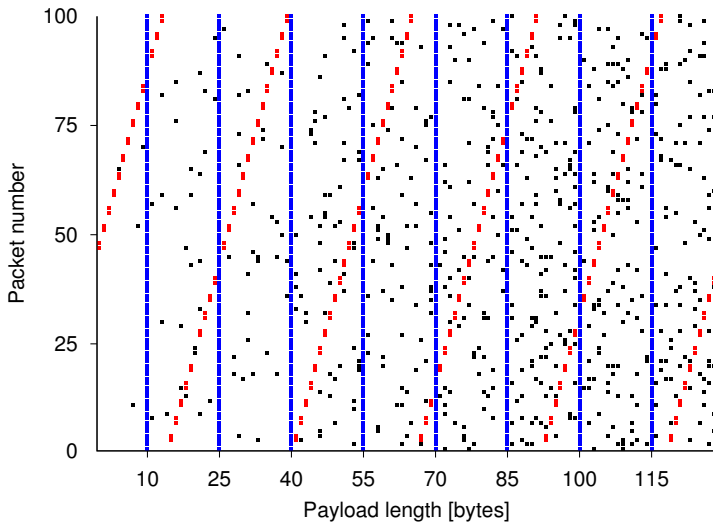
Know Your Enemy

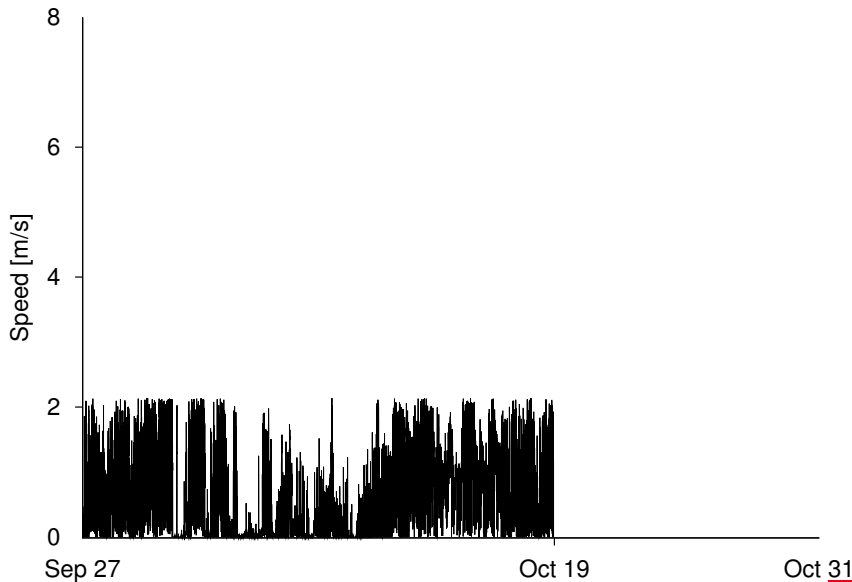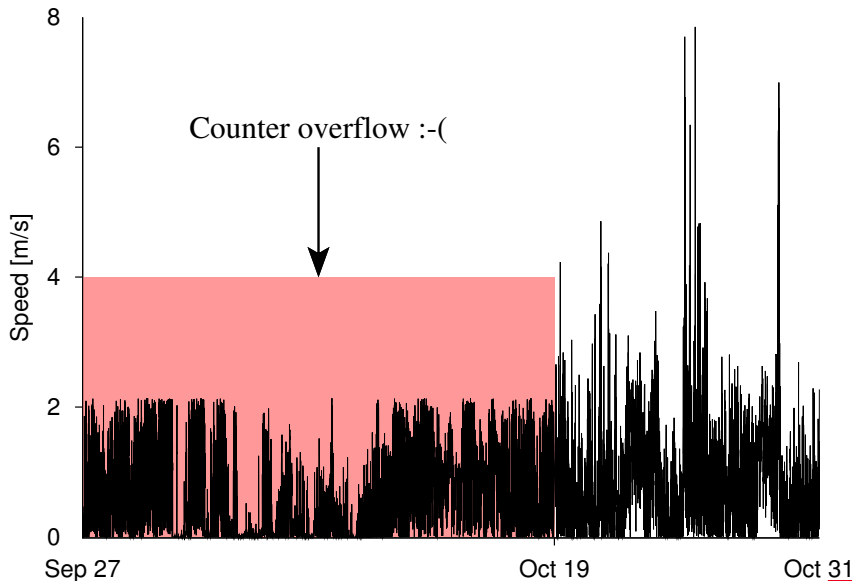# Know Your Enemy

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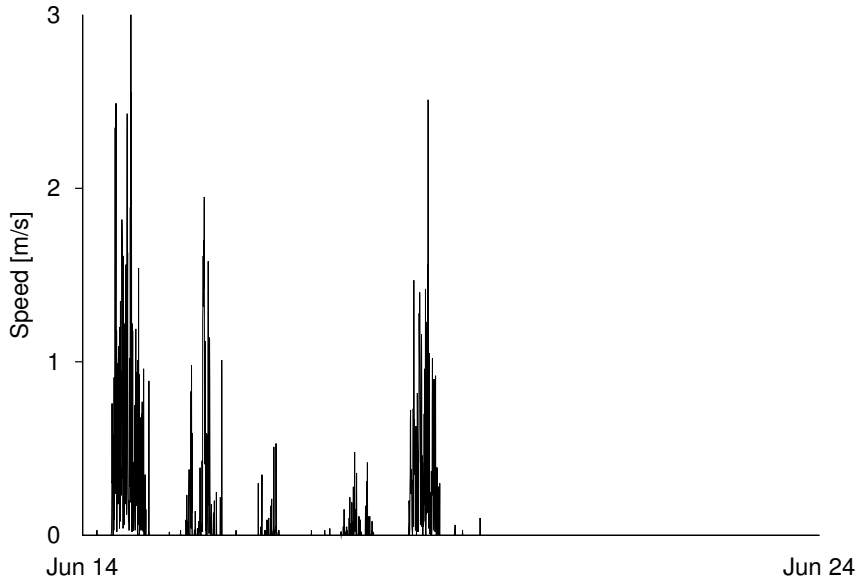Advice: *Make sure the radio frequency is not already in use.*

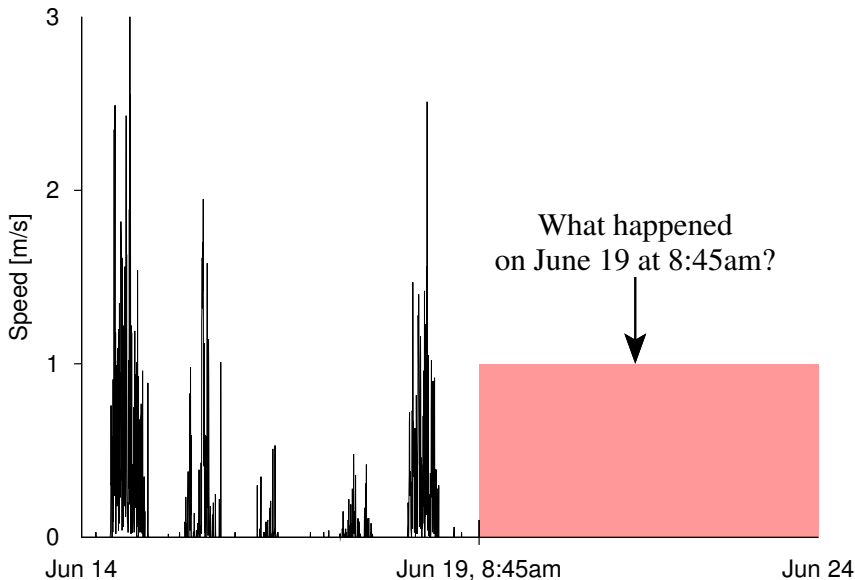# **Bug in the Sensor's Driver**

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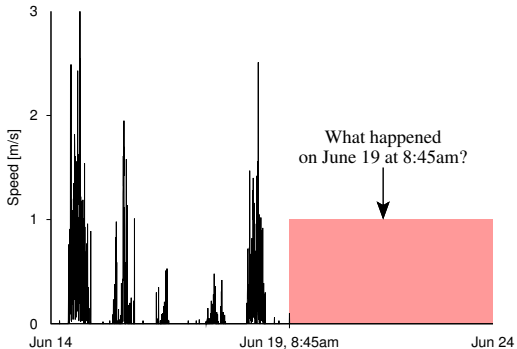
Did You Say Outliers? (ClimatScope)
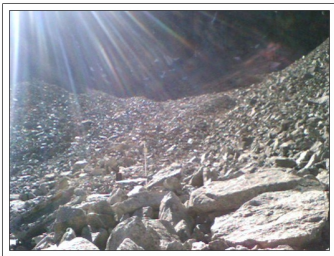
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What happened
on June 19 at 8:45am?
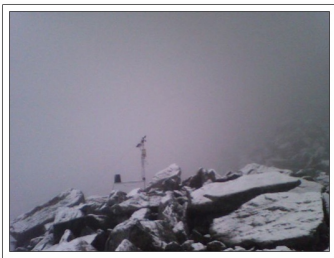
This is what happened. . .

Seeing is Believing

Are you sure to interpret data correctly?

- ▶ High humidity level or fog?
- ▶ Rain or snow?
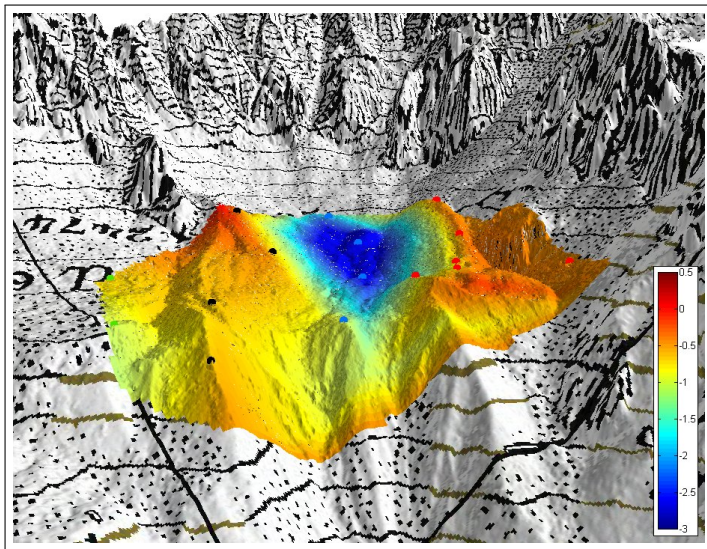- ▶ Clouds or a leaf on the sensor?

Vidicam: 640x480 images every 30'.
First deployment, Génépi.
Unsolved problems:

- ▶ Energy management (2 months)
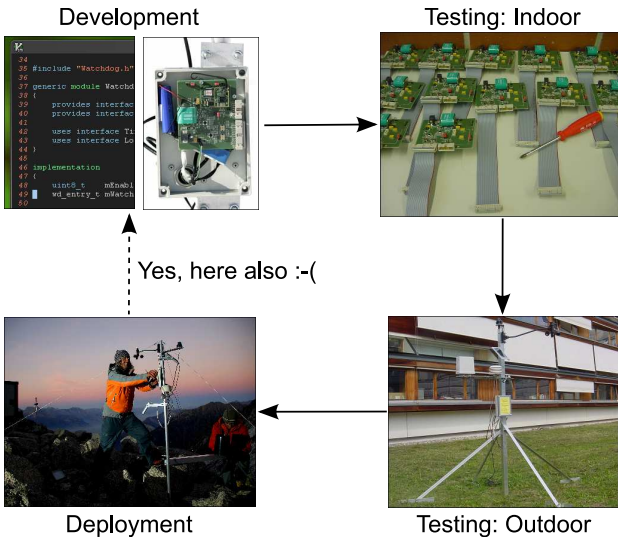- ▶ Bandwidth (dedicated GPRS connection)

Autonomous camera on the Génépi.

Choose Your Partner

The permafrost creates a micro-climate on top of the Génépi mountain.

The Development Cycle

Development

Testing: Indoor

Yes, here also :-(

Deployment

Testing: Outdoor

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