Frost: prediction of minimum temperature for frost forecasting in agriculture

Ana Laura Diedrichs[1,3], Facundo Bromberg[1,3] and Diego Dujovne[2]

Ing. Ana Laura Diedrichs

grid Grupo UTN de I&D · Tecnologías de la ICs Información y Comunicaciones

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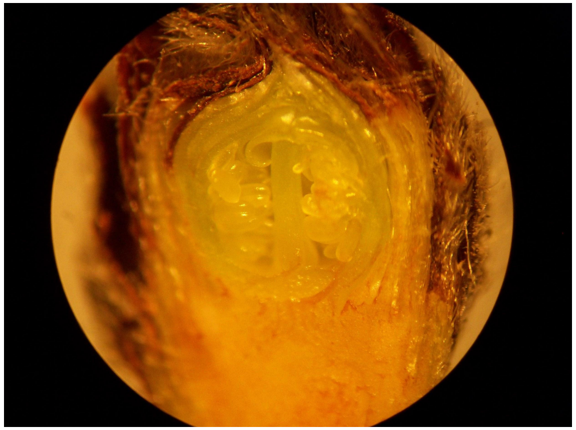
¿De dónde vienen los frutos?

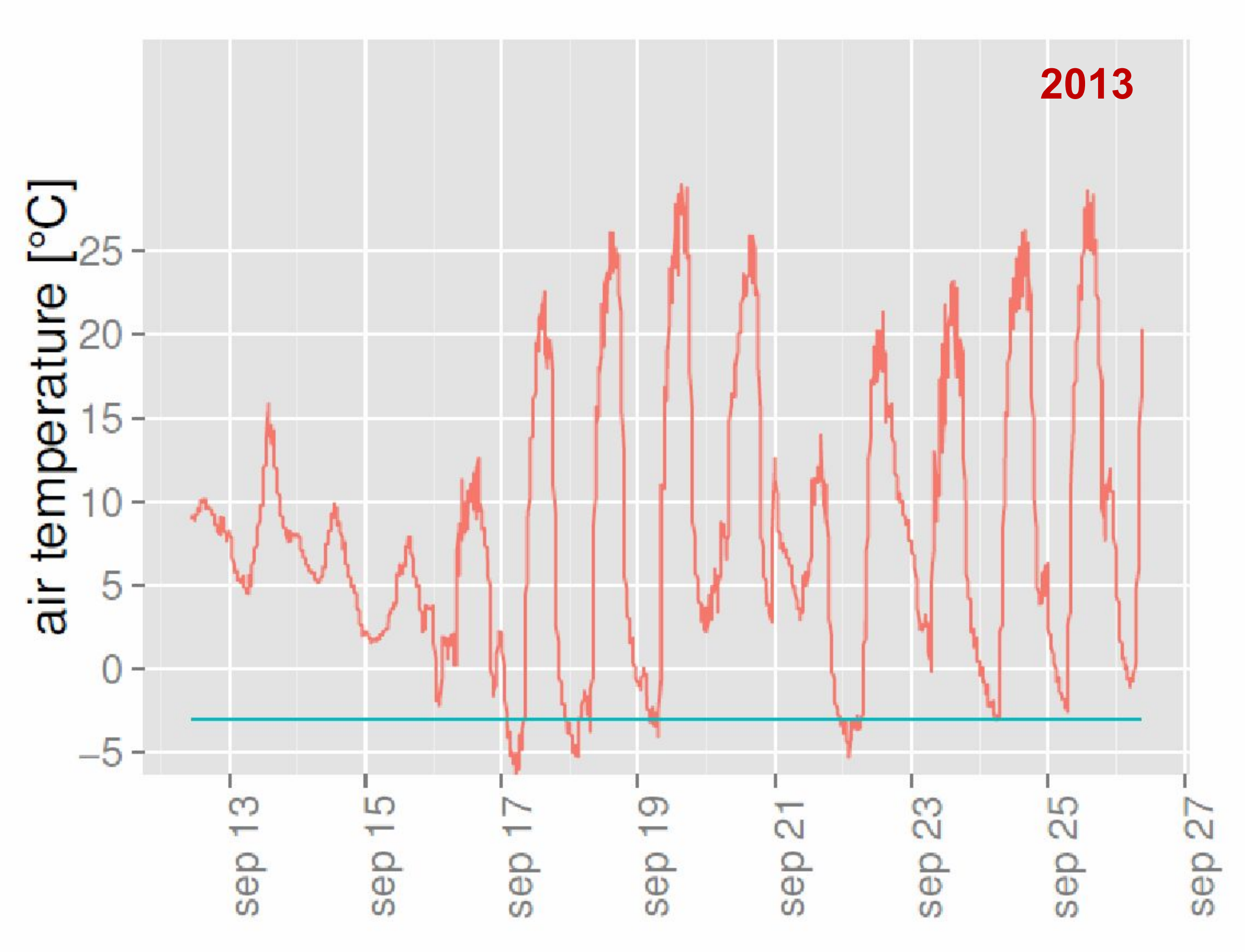


vegetativo

floración

Flor abierta

A los cultivos no les agradan las heladas



2013 - 85% producción durazno perdida · 10,000 puestos de trabajos

Combatir un evento de helada

Sábado, 1 de octubre de 2016 | Edición impresa

Casi 30 mil hectáreas afectadas por heladas

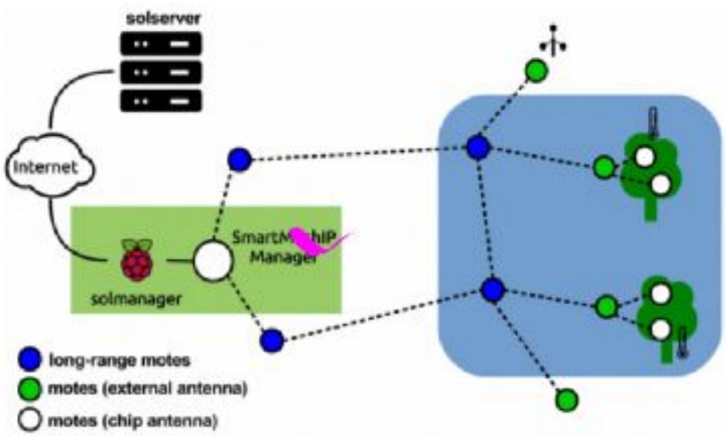
Se trata de un relevamiento estimativo hecho por la Provincia por las heladas que se registraron el mes pasado. La fruta de carozo es la más afectada.

| Archivo Los Andes

Hay muchas formas de combatir la helada, lo que es complicado es predecirla.

PrEcision Agriculture through Climate researcH

- In parallel to sensor measurements, each device produces large amounts of network statistics
- Every 15min, each device produces
  - Packet counters
  - Charge consumed
  - Battery state
  - Neighbors heard
  - Neighbors communicating with
  - Link quality
  - Etc.

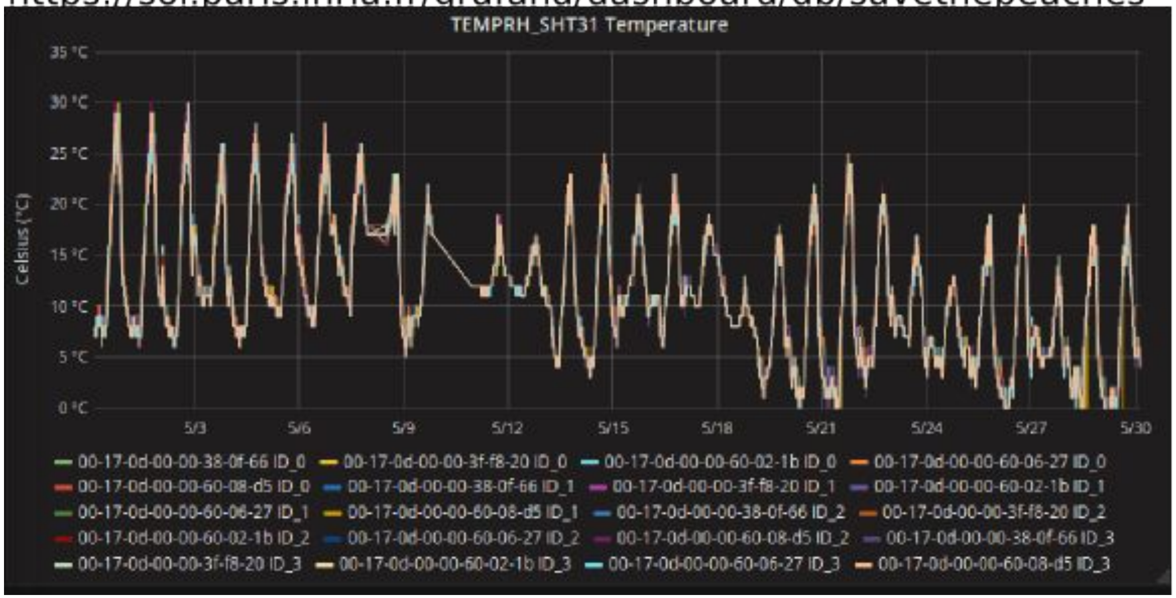


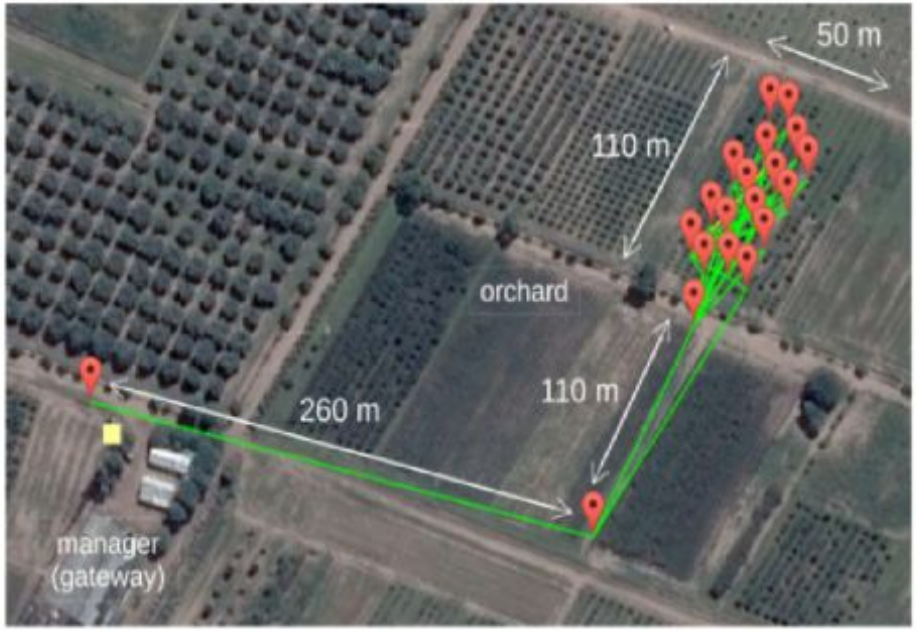
The deployment architecture

SAVETHEPEACHES.COM


SHT31-D sensor

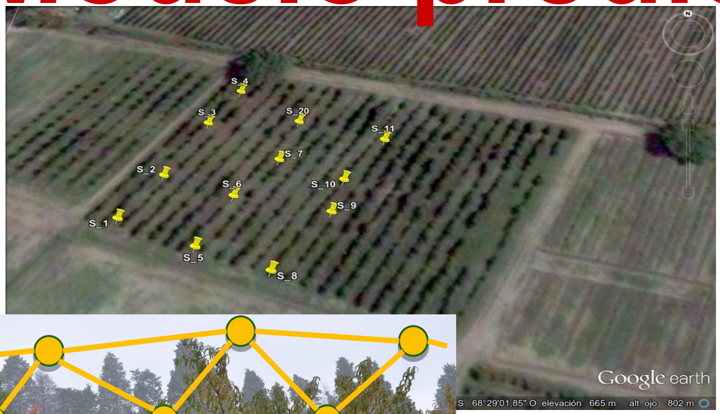
https://sol.paris.inria.fr/grafana/dashboard/db/savethepeaches

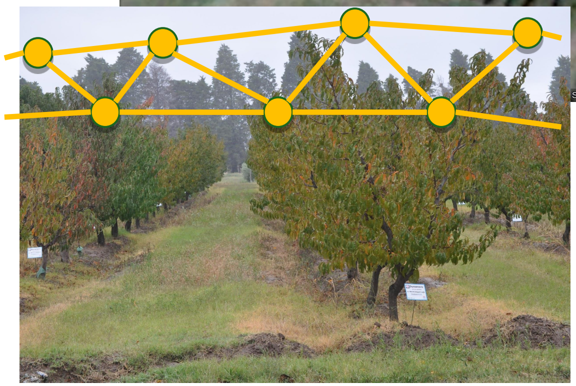


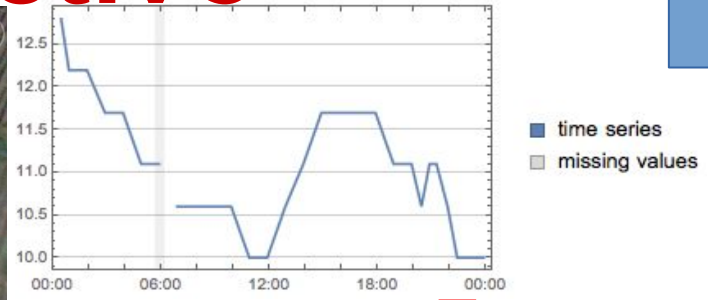


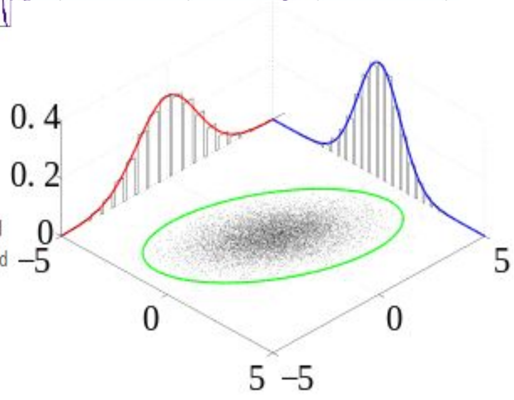
The nodes and wireless links of the PEACH deployment

Modelo predictivo

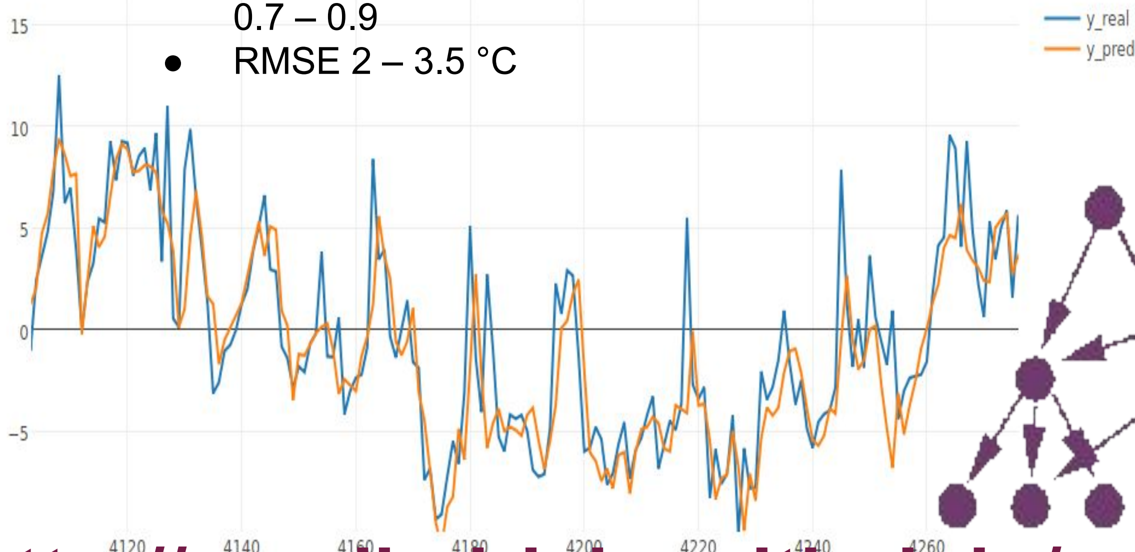


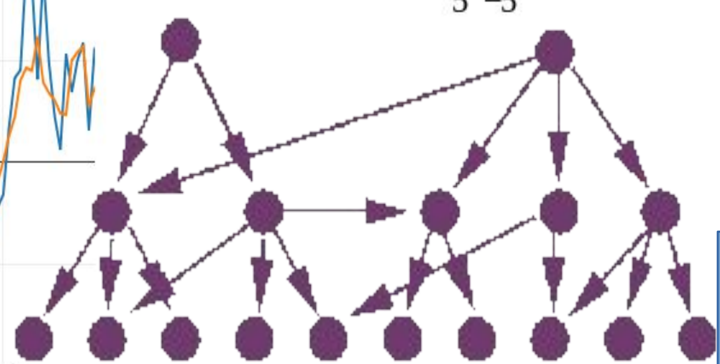






- Resultados preliminares predicción temperatura mínima/heladas
- Probabilidad de detección y precision : 0.7 – 0.9
- RMSE 2 – 3.5 °C





Limpieza de Datos

Configuración Del Entrenamiento

Variables S_(kt-1), k=1..N

Construcción del modelo

Evaluación

Salida: predictor de heladas

http://anadiedrichs.github.io/

frost

Fórmulas empíricas

$T_{min} = T_w(t) - a\,T(t) - b$ Ångström: 1920, 1921, 1923.

$T_{min} = T_w(t) - \frac{1}{4} \times (T_d(t) + a)$ Allen: 1957.

$T_{min} = T_d(t) - a$ Pick: 1928.

$T_{min} = T_d(t) + ae(t) - b$ Ueki: 1950.

$T_{min} = a\,T(t) + b\,T_d(t)$ Peatfield: 1937.

$T_{min} = a\,T(t) + b\,T_d(t) + c$ Flower y Davies: 1934, MacDonald: 1939.

Jefferson: 1951.

máx)] + e Boyden: 1937.

máx)| + f(v, n) McKenzie: (citado por Sutton: 1953).

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$T_{min} = T_d(t) + a + bf(t) + cf^2(t)$ Smith et al.: 1920.

$T_{min} = T_d(t) - \dfrac{f - a}{4}$ Donnel: 1912.

$T_{min} = T_d(t) - \dfrac{f - a}{4} + Vd + Vh$ Young: 1920.

en donde $T_{...}$ significa temperatura mínima ...

Brunt : $$T(t_{\text{sunset}} + \Delta t) = T_{\text{sunset}} - 0.129 \frac{2}{\sqrt{\pi}} R_L \uparrow \frac{\sqrt{K \Delta t}}{k} \qquad (1)$$

where T_{sunset} is the temperature at sunset (°C), t_{sunset} the sunset time, K the soil thermal diffusion coefficient ($m^2\,s^{-1}$), k the soil thermal conductivity coefficient ($W\,m^{-1}\,°C^{-1}$), $R_L\uparrow$ the long-wave radiation balance (positive if outgoing) ($W\,m^{-2}$) and Δt is the time elapsed from sunset (h).

$R_L\uparrow$ in Brunt's equation has been calculated in two different ways (eqs. 2.1 and 2.2):

Brunt : $$R_L \uparrow = \sigma T^4 (a_0 - b_0 \sqrt{e})(1 - ac) \quad (W\,m^{-2}) \qquad (2.1)$$

Swinbank : $$R_L \uparrow = 5.31 \times 10^{-13}\, T^6 \quad (W\,m^{-2}) \qquad (2.2)$$

where σ is the Stefan–Boltzmann constant ($=5.671 \times 10^{-8}\,W\,m^{-2}\,K^{-4}$), T the temperature (K), a_0 and b_0 are the constants, respectively = 0.526 and 0.0065, a the constant depending on cloud type, c the sky cover (in 10ths) and e is the vapour pressure (Pa):

Prediction of minimum temperature for frost forecasting in agriculture

build passing DOI 10.5281/zenodo.1239974

https://github.com/anadiedrichs/frost

Description

This package contains a compilation of empirical methods used by farmers and agronomic engineers to predict the minimum temperature to detect a frost event.

These functions use variables such as environmental temperature, relative humidity, and dew point.

Installation

If you don't have package **devtools** installed, run the following commands.

```
install.packages("devtools")
```

```
library(devtools)
```

To install the package from the GitHub repo, run

```
install_github("anadiedrichs/frost")
```

frost

How to cite this package

```
> citation("frost")
```

To cite package ‘frost’ in publications use:

Ana Laura Diedrichs (2018). frost: Prediction of minimum temperature for frost forecasting in agriculture. R package version 0.0.2. https://github.com/anadiedrichs/frost

A BibTeX entry for LaTeX users is

@Manual{,

title = {frost: Prediction of minimum temperature for frost forecasting in agriculture},

author = {Ana Laura Diedrichs},

year = {2018},

note = {R package version 0.0.2},

url = {https://github.com/anadiedrichs/frost},

}

Temperature conversions

Most of the predictive methods use temperature in degree Celsius, so maybe you want to convert your temperature values to this unit. You can use the method `convert.temperature` to achieve this, and convert from/to Kelvin (K), Fahrenheit (F) or Celcius (C).

```
library(frost)

library(frost)
convert.temperature(from="K", to="C",350)
#> [1] 76.85
cels <- convert.temperature(from="F",to="C",c(120,80,134,110))
k <- convert.temperature(from="C", to="K",cels)
```

Dew point estimation

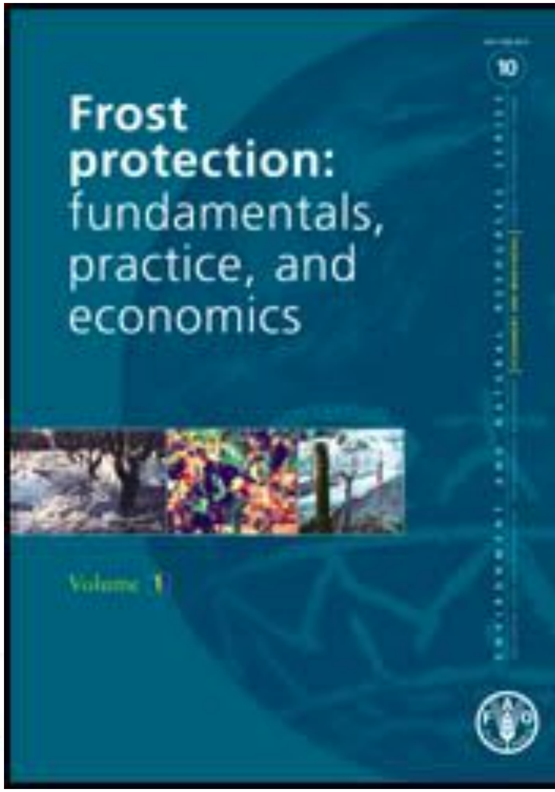
Given that several methods used dew point as an input variable, this package provides methods to estimate the dew point (in Celsius degree) given ambient temperature and relative humidity.

```
library(frost)

temp <- 25
rh <- 54

calcDewPoint(rh,temp,mode="A")
#> [1] 14.99222
calcDewPoint(rh,temp,mode="B")
#> [1] 24.07111
calcDewPoint(rh,temp,mode="C")
#> [1] 15.04884
```

Empirical formula used in Mendoza

The empirical formula for estimating the minimum temperature is $T_{min} = \frac{T_{max} + T_{dew}}{2} - K$. For calculating K, we call `buildMdz` function. Then for prediction we use `predMdz`.

```
# just an example
dw <- c(-2,-5,2,6,8)
tempMax <- c(10,20,30,25,29)
tmin <- c(-1,-2,3,5,10)
out <- buildMdz(dw,tempMax,tmin)
print(out)
#> $model
```



Prediction of minimum temperature

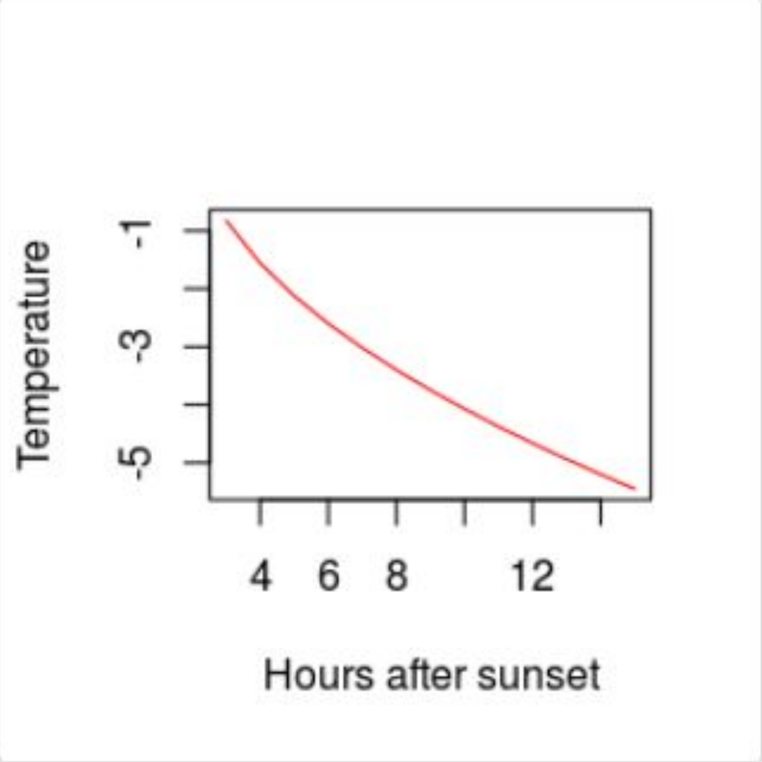
FAO approach

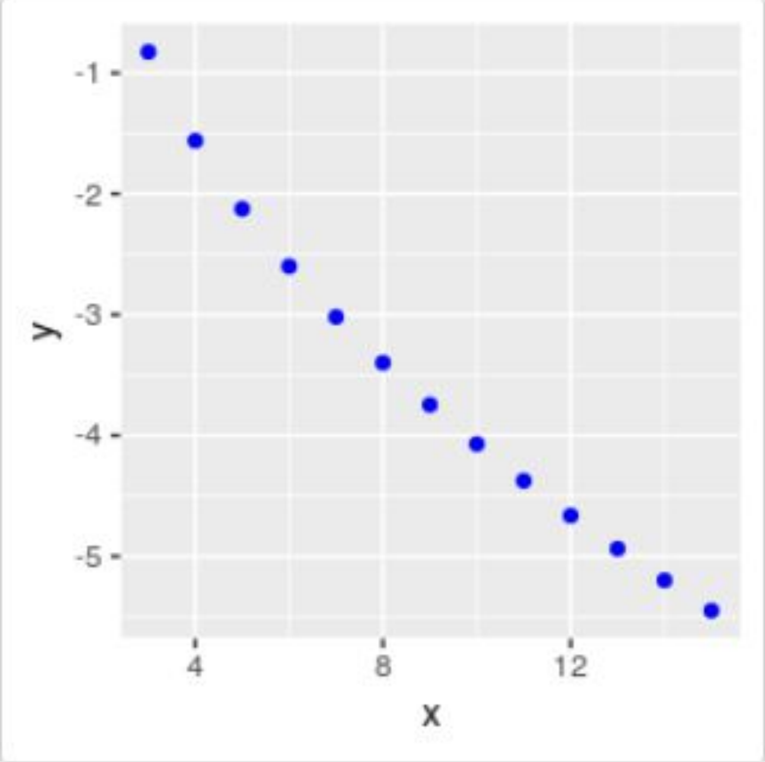
The empirical formula for estimating the minimum temperature is $T_{min} = a * T + b * T_{dew} + c$. coefficientes a, b and c we call `buildFAO(dw,temp,tmin)`.

```
library(frost)
# We create random data
x1 <- rnorm(100,mean=2,sd=5)
x2 <- rnorm(100,mean=1,sd=3)
y <- rnorm(100,mean=0,sd=2)
buildFAO(dw = x2,temp=x1,tmin=y)
#> $a
#> [1] -0.01026935
#>
#> $b
```

We can use the output of `plotTrend` to plot using other libraries such as ggplot2.

```
library(frost)
var <- getTrend(Tmin = -5.45,t2 = 0.95,n = 15) # in °C degress
require(ggplot2)
#> Loading required package: ggplot2
# just plotting points
ggplot(var,aes(x=x,y=y)) + geom_point(color="blue")
# add trend line
ggplot(var,aes(x=x,y=y)) + geom_point() + geom_smooth(color="red")
#> `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```





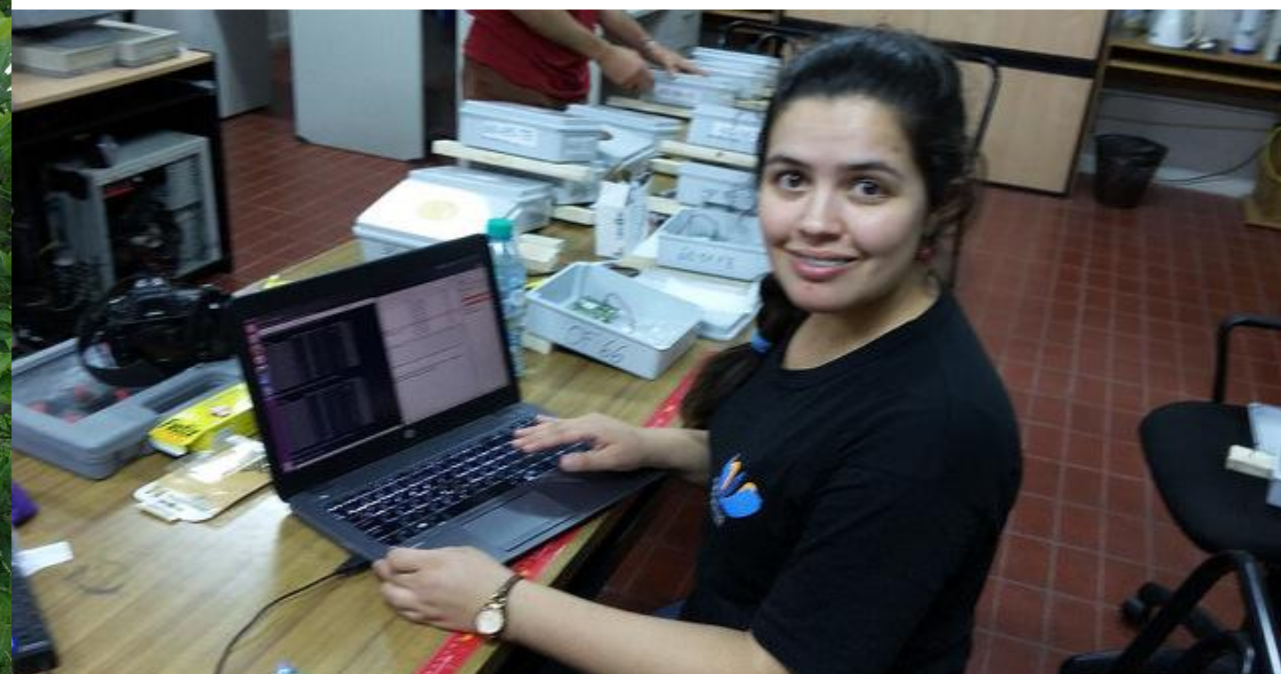
Ana Laura Diedrichs

Telegram / twitter @anadiedrichs

web http://anadiedrichs.github.io/

Frost R package repo
https://github.com/anadiedrichs/frost

- ¡Muchas gracias!
- ana.diedrichs@frm.utn.edu.ar
- @anadiedrichs



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