Tutorial for merging a WRF output (maximum temperature) with ground observations using VARMER

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05 febrero 2021

1 About

This vignette describes a basic application of the VARMER library, which provides methods to combine satellite-based or model-based gridded images with ground-based observed time-series [1].

2 Installation

Install the latest stable version (from CRAN):

```
install.packages("VARMER")
```

3 Setting up the environment

1. Load other packages that will be used in this analysis and VARMER:

```
library(zoo)
library(sf)
library(raster)
library(tictoc)
library(cluster)
library(parallel)
#library(ggplot2)
library(VARMER)
```

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4 Loading input data

First, daily time series of maximum temperature observations in 34 stations located in Ecuador will be used for this example, from *2004-01-01* to *2004-01-10*, which are available in the **ecuador.tmax.zoo** dataset provided in the `VARMER` package (for your own application, this dataset might be read from a CSV file or a `zoo` file). In addition, the **ecuador.tmax.stations.df** dataset contains information about the IDs and spatial coordinates of each station (for your own application, this dataset might be read from a CSV file).

```
data(ecuador.tmax.zoo)
data(ecuador.tmax.stations.df)
```

Secondly, we need to load the WRF output. For this example, the model-data was obtained from a WRF v3.6.1 simulation at 10Km spatial resolution and at daily temporal resolution.

```
data(ecuador.tmax.wrf.out)
```

5 Basic exploratory data analysis

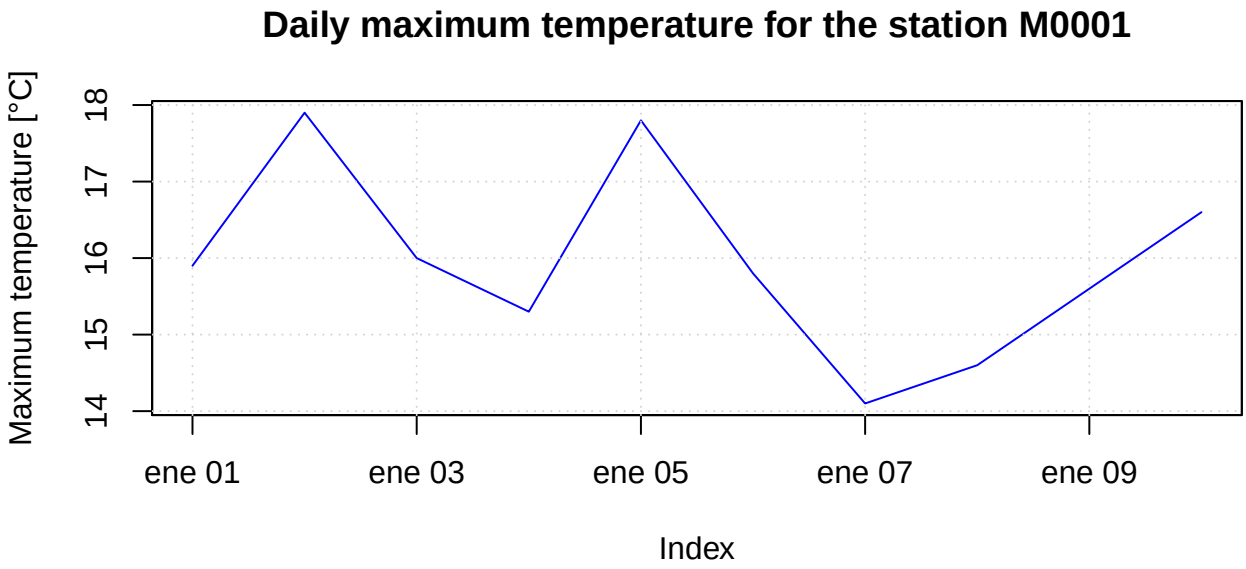
First, we would like to visualize the first six rows of the spatial metadata:

```
head(ecuador.tmax.stations.df)
```

```
##   CODIGO            NOMBRE     CUENCA_INAMHI PROVINCIA     CANTON
## 1  M0001         INGUINCHO 12 Rio Esmeraldas  IMBABURA    OTAVALO
## 2  M0002           LA TOLA 12 Rio Esmeraldas PICHINCHA      QUITO
## 3  M0003          IZOBAMBA 12 Rio Esmeraldas PICHINCHA      MEJIA
## 4  M0004 RUMIPAMBA-SALCEDO    76 Rio Pastaza  COTOPAXI    SALCEDO
## 5  M0005    PORTOVIEJO-UTM                      MANABI PORTOVIEJO
## 6  M0006       PICHILINGUE     52 Rio Guayas  LOS RIOS    MOCACHE
##                PARROQUIA       LAT       LON
## 1 SAN JOSE DE QUICHINCHE  0.258333 -78.40083
## 2                TUMBACO -0.229444 -78.36667
## 3             CUTUGLAHUA -0.366667 -78.55000
## 4             SAN MIGUEL -1.020000 -78.59472
## 5             PORTOVIEJO -1.037500 -80.45953
## 6                MOCACHE -1.074361 -79.49294
```

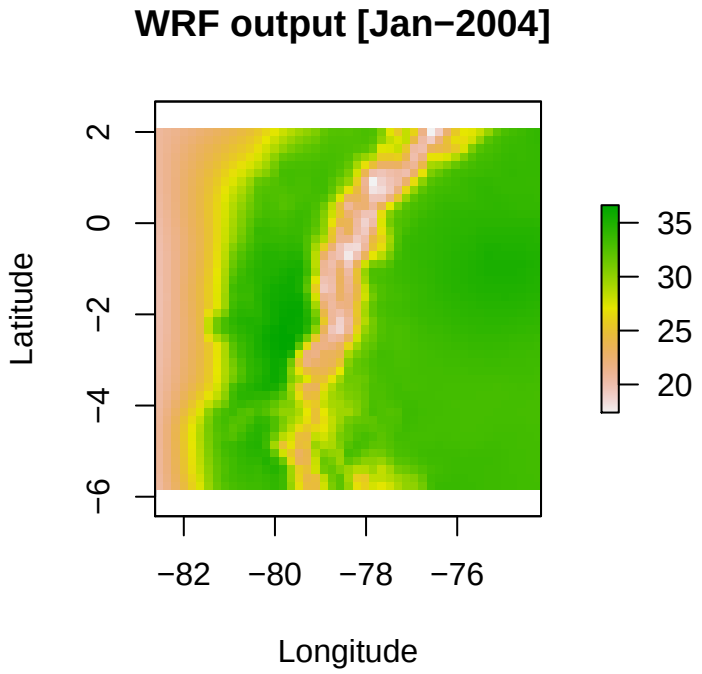
Plotting the daily precipitation time series for the first station (code: *M0001*).

```
main <- paste("Daily maximum temperature for the station", ecuador.tmax.stations.df$CODIGO[1])
ylab <- "Maximum temperature [°C]"
x.ts <- ecuador.tmax.zoo[,1]

plot(x.ts, main=main, ylab= ylab, col="blue")
grid()
```



Plotting the average maximum temperature from WRF output, and overlying the boundaries of the study area (only its first attribute):

```
wrfout.total <- mean(ecuador.tmax.wrf.out, na.rm=FALSE)

plot(wrfout.total, main = "WRF output [Jan-2004] ", xlab = "Longitude", ylab = "Latitude")
```



6 Running `VARMER`

6.1 Setup

Finally, you need to define the output directory (`drty.out`) before running `VARMER`. Then, you can run the `varmer.ts` function as follows:

```
varmer.ts(x=ecuador.tmax.zoo, x.metadata=ecuador.tmax.stations.df,
          v=ecuador.tmax.wrf.out, lat='LAT', lon='LON',
          drty.out="~/Documentos/dataset_ecuador")
```

6.2 Expected outputs

If `VARMER` runs without problems, the final merged product (individual *GeoTiff* files) will be stored in your user-defined `drty.out` directory.

7 Software details

This tutorial was built under:

```
## [1] "x86_64-pc-linux-gnu (64-bit)"
```

```
## [1] "R version 4.0.3 (2020-10-10)"
```

```
## [1] "VARMER 1.0.0"
```

8 References

1. Ulloa, J., Samaniego, E., Campozano, L., & Ballari, D. (2018). A variational merging approach to the spatial description of environmental variables. Journal of Geophysical Research: Atmospheres, 123. https://doi.org/10.1002/2017JD027982.