Automation and implementation of Dynamic mapping of live fuel moisture estimation in the Valencian Community

Kenneth Pachacama

Data	• AEMET • Sentinel-2 • Statistical models
Spectral	• Google earth engine API JAVA
Meteorological	• Meteoland package R
Unification for processing rasters	• Gdal Library Python

Data – AEMET

Weather stations

- Recovered from AEMET via FTP

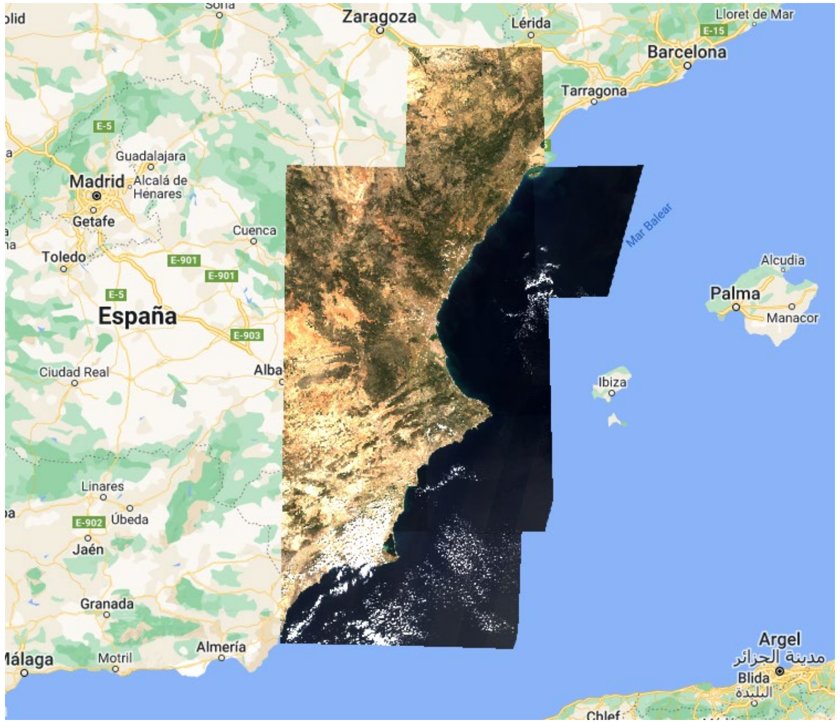
Different files for Wind, Precipitation, Moisture and Temperature

Nombre	Fecha de modificación	Tipo	Tamaño
Descripcionviento0419.txt	16/05/2024 10:59	Documento de te...	2 KB
Descripcionpluvio0419.txt	16/05/2024 10:59	Documento de te...	4 KB
Descripcionhumedad0419.txt	16/05/2024 10:59	Documento de te...	1 KB
Descripcion0419termo.txt	16/05/2024 10:59	Documento de te...	1 KB
viento0419.csv.tmp	16/05/2024 10:59	Archivo TMP	2,383 KB
pluvio0419.csv.tmp	16/05/2024 10:59	Archivo TMP	12,224 KB
humedad0419.csv.tmp	16/05/2024 10:59	Archivo TMP	6,620 KB
Descripcionviento0419.txt.tmp	16/05/2024 10:59	Archivo TMP	2 KB
Descripcionpluvio0419.txt.tmp	16/05/2024 10:59	Archivo TMP	4 KB
Descripcionhumedad0419.txt.tmp	16/05/2024 10:59	Archivo TMP	2 KB
Descripcion0419termo.txt.tmp	16/05/2024 10:59	Archivo TMP	1 KB
0419termo.csv.tmp	16/05/2024 10:59	Archivo TMP	7,198 KB
viento0419.csv	16/05/2024 10:59	Archivo de valores...	170 KB
pluvio0419.csv	16/05/2024 10:59	Archivo de valores...	4,044 KB
humedad0419.csv	16/05/2024 10:59	Archivo de valores...	603 KB
0419termo.csv	16/05/2024 10:59	Archivo de valores...	1,853 KB

- Process to set data in new unify format

Name, date, code, coordinates, variables+

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	INDICATIVO	date	NOMBRE	ALTITUD	C_X	C_Y	P77	TMAX	TMIN	TMED	HU00	HU01	HU02	HU03
2	8486X	02/05/2023	MOSQUERUE	1515	716146	4471104	0	22.2	7.8	15	11	20	15	12
3	8376	02/01/2024	JABALOYAS, I	1430	635114	4455174	0	9	5.5	7.2	26	21	15	16
4	7002Y	15/01/2024	ÃGUILAS	26	625041	4142095	0	24.1	14.9	19.5	25	16	15	17
5	8376	28/12/2023	JABALOYAS, I	1430	635114	4455174	0	12.5	6.4	9.4		14	14	14
6	8376	27/12/2023	JABALOYAS, I	1430	635114	4455174	0	14.5	4	9.2	26	31	24	16
7	9550C	18/07/2023	ANDORRA, H	762	718105	4539158	0	39.8	25.7	32.8	61	25	32	15
8	9563X	18/07/2023	CASTELLFORT	1220	738405	4486905	0.1	34.6	25	29.8	21	23	20	17
9	8486X	28/12/2023	MOSQUERUE	1515	716146	4471104	0	15.1	4.9	10		14	14	14
10	8489X	18/07/2023	VILLAFRANCA	1131	732768	4479473	0	36.2	23.4	29.8	30	24	24	21
11	9563X	29/12/2023	CASTELLFORT	1220	738405	4486905	0	10.8	6.2	8.5	15	18	16	16
12	9563X	13/01/2024	CASTELLFORT	1220	738405	4486905	0	15.8	1.9	8.8	32	43	40	24
13	7067Y	18/07/2023	CAÃ'ADAS DE	1485	551470	4215779	0	35.7	18.5	27.1	19	14	15	15
14	8376	02/05/2023	JABALOYAS, I	1430	635114	4455174	0	22.6	8	15.3	46	53	43	36
15	8486X	26/11/2023	MOSQUERUE	1515	716146	4471104	0	15	2.2	8.6	16	21	17	19
16	9563X	21/02/2024	CASTELLFORT	1220	738405	4486905	0	16.8	8.8	12.8	11	17	16	16
17	8486X	29/12/2023	MOSQUERUE	1515	716146	4471104	0	12.3	4.4	8.4		17	17	17
18	9561X	18/07/2023	CASTELLOTE,	755	726488	4519841	0	41.5	28.5	35	29	23	16	19
19	9563X	06/04/2023	CASTELLFORT	1220	738405	4486905	0	15.2	6.4	10.8		17	17	17
20	0009X	19/12/2023	ALFORJA	406	832278	4570083	0	16.5	5.3	10.9	32	20	29	45
21	3094B	05/04/2023	TARANCÃ“N	808	498175	4429022	0	23.3	6.5	14.9	13	13	14	15
22	7244X	02/04/2023	ORIHUELA DE	26	677074	4215260	0	25.2	12.4	18.8	40	39	41	35
23	9531Y	18/07/2023	MONTALBÃN	895	686094	4522076	0	40.7	24.1	32.4	27	24	22	20
24	9563X	02/05/2023	CASTELLFORT	1220	738405	4486905	0	21.4	8.8	15.1	29	29	25	20
25	9563X	28/12/2023	CASTELLFORT	1220	738405	4486905	0	13.2	6	9.6		18	17	17



Name	Units	Min	Max	Scale	Pixel Size	Wavelength	Description
B1				0.0001	60 meters	443.9nm (S2A) / 442.3nm (S2B)	Aerosols
B2				0.0001	10 meters	496.6nm (S2A) / 492.1nm (S2B)	Blue
B3				0.0001	10 meters	560nm (S2A) / 559nm (S2B)	Green
B4				0.0001	10 meters	664.5nm (S2A) / 665nm (S2B)	Red
B5				0.0001	20 meters	703.9nm (S2A) / 703.8nm (S2B)	Red Edge 1
B6				0.0001	20 meters	740.2nm (S2A) / 739.1nm (S2B)	Red Edge 2
B7				0.0001	20 meters	782.5nm (S2A) / 779.7nm (S2B)	Red Edge 3
B8				0.0001	10 meters	835.1nm (S2A) / 833nm (S2B)	NIR
B8A				0.0001	20 meters	864.8nm (S2A) / 864nm (S2B)	Red Edge 4
B9				0.0001	60 meters	945nm (S2A) / 943.2nm (S2B)	Water vapor
B11				0.0001	20 meters	1613.7nm (S2A) / 1610.4nm (S2B)	SWIR 1
B12				0.0001	20 meters	2202.4nm (S2A) / 2185.7nm (S2B)	SWIR 2

Data – Sentinel-2

Harmonized Sentinel-2 MSI: MultiSpectral Instrument, Level-2A

Data – Statistical models

modelos.txt: Bloc de notas

Archivo Edición Formato Ver Ayuda

```
117.811+86.144*NMDI_10mS-298.158*Mean_EVI_10mS+110.124*Mean_VARI_10mS-11.211* DOY_SIN+0.078* p60+0.033*altitude   MPG1_M

104.962+281.602*OSAVI_10mS-389.16*Mean_EVI_10mS-27.071*DOY_SIN+0.236*p60   ROG1_M

131.7+ 0.03* p60 - 3.2* slope-80.5* Mean_MSI_10mS+847.8* Mean_TCARI_10mS   MPG1_A

28.888+144.968*NMDI_10mS+8.987*DOY_COS+0.052*p60-0.641*t60-0.803*slope   MPG2_M

32.983 + 68.896* Vgreen_10mS+198.154* NMDI_10mS-23.37*DOY_SIN+0.139* p60-1.289* slope   ROG2_M

156.17-5.91* DOY_SIN+0.06*p60-867.76* Mean_TCARI_10mS+43.07* EVI_10mS   MPG2_A
```

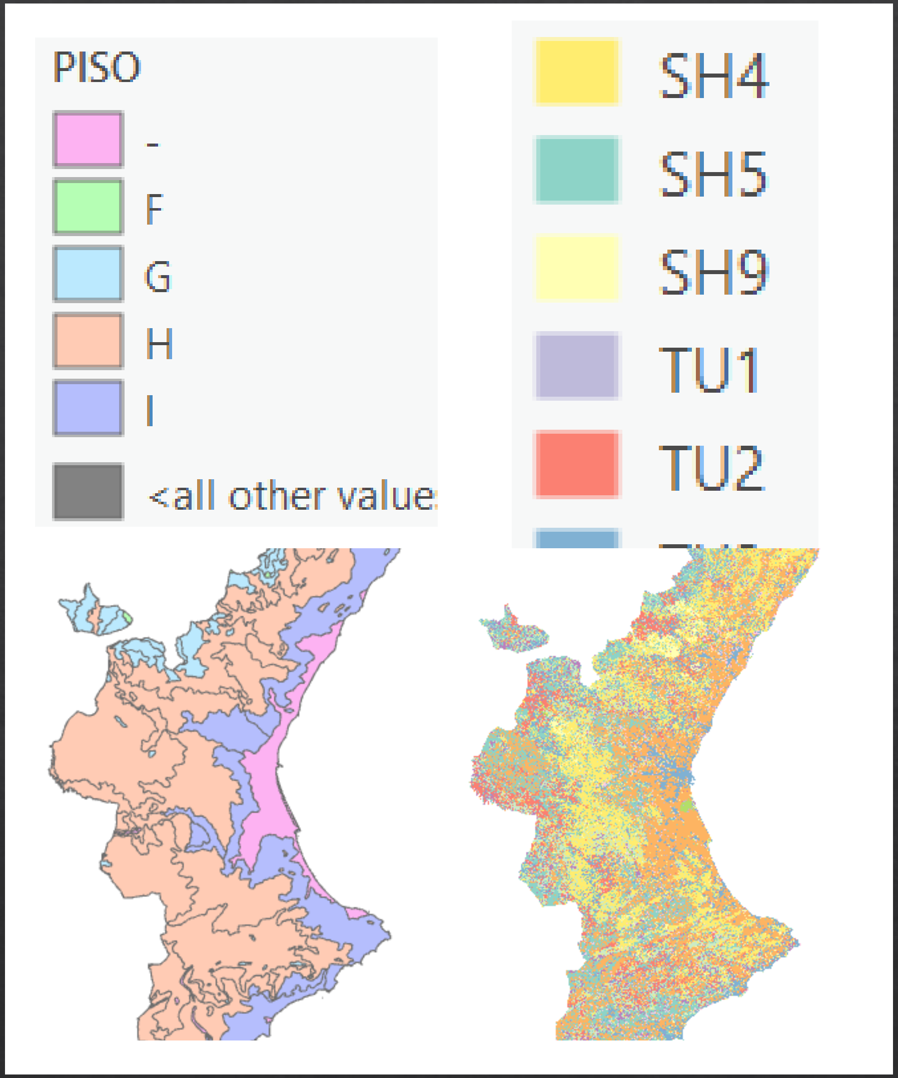
- The classification of the models is carried out based on the following parameters:
  - Weighted average or *Rosmarinus*
  - Bioclimatic floor
  - Fuel model

- Analyzing Independent LFMC Empirical Models in the Mid-Mediterranean Region of Spain Attending to Vegetation Types and Bioclimatic Zones
  - https://doi.org/10.3390/f14071299

GENERALITAT VALENCIANA
Conselleria de Agricultura, Desarrollo Rural, Emergencia Climática y Transición Ecológica

Data – Statistical models

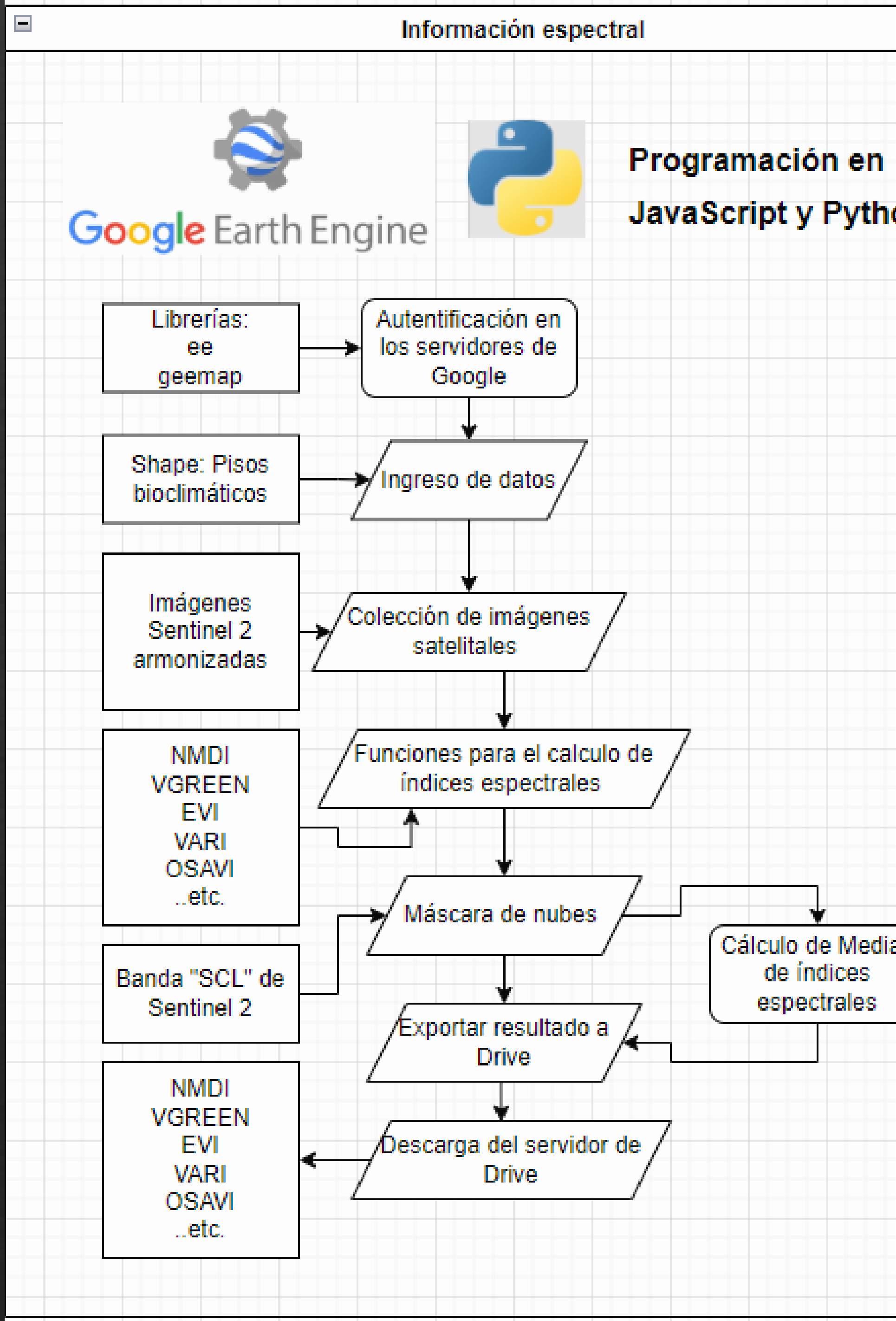
- Information collected from:
- La Conselleria de Agricultura, Desarrollo Rural, Emergencia Climática y Transición Ecológica
- Institut Cartogràfic Valencià - ICV - Generalitat Valenciana



Spectral – GEE API Java

- Download of spectral indices and statistics at different resolution:
- 10 meters aprox 25 minutes (>2 Gb)
- 100 meters aprox 8 minutes (<200 mb)

- Download task called from python Api
- Results stored in google drive account



```
import ee
import geemap
import datetime
import gdown

####activar primera vez para autentificar
ee.Authenticate()
#####siempre activo#######
ee.Initialize()
########################ingresar shape en coordendas
ee_object = geemap.shp_to_ee("D:\Doctorado\shape
##print(ee_object)
polygon=ee_object.geometry()
print("shape correcto")
sent2a=ee.ImageCollection("COPERNICUS/S2_SR_HARM
```

```
##funcion para caluclar ARVI
def CalcularARVI(image):
     arvi=image.expression('(B8-(2*B4)+B2)/(B8
     return image.addBands(arvi);

##funcion para caluclar VARI
def CalcularVARI(image):
    vari=image.expression('float(B3-B4)/float
    return image.addBands(vari);
###funcion para caluclar TCARI
def CalcularTCARI(image):
    tcari=image.expression('3*((B5-B4)/10000-
    return image.addBands(tcari);
#funcion para caluclar OSAVI
def CalcularOSAVI(image):
    osavi=image.expression('(1+0.16)*(B8-B4)/
    return image.addBands(osavi);
#funcion para caluclar TCARI_OSAVI
def CalcularTCARI_OSAVI(image):
    tcariosavi=image.expression('TCARI/OSAVI'
    return image.addBands(tcariosavi);
#funcion para caluclar NMDI
def CalcularNMDI(image) :
    nmdi=image.expression('float(B8A-(B11-B12
    return image.addBands(nmdi);
```

Spectral implemetation

Authenticate, read inputs, launch google tasks and download from the cloud

Libraries: ee, geemap and gdown

https://doi.org/10.1016/j.envsoft.2018.08.003

Meteorological Meteoland R

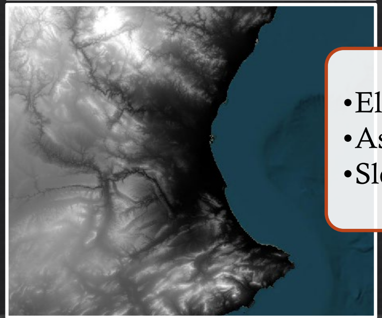
- This approach similar to inverse distance weighting, interpolates weather variables using truncated Gaussian filters, which consist in defining spatial weights W(r), using:

Weather Data

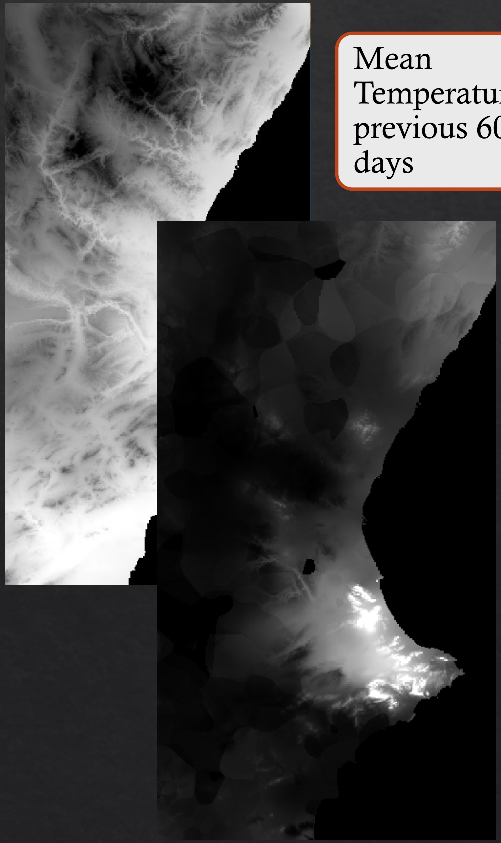
```
:ATIVO;date;NOMBRE;ALTITUD;C_X;C_Y;P77;TMAX;TMIN;TMED;H
;2023-02-01;EL PERELLO;148;812828;4531428;0.0;14.0;1.0;
;2023-02-02;EL PERELLO;148;812828;4531428;0.0;14.
;2023-02-03;EL PERELLO;148;812828;4531428;0.0;16
;2023-02-04;EL PERELLO;148;812828;4531428;0.0;17
;2023-02-05;EL PERELLO;148;812828;4531428;0.0;16
;2023-02-06;EL PERELLO;148;812828;4531428;1.5;11
;2023-02-07;EL PERELLO;148;812828;4531428;57.3;1
;2023-02-08;EL PERELLO;148;812828;4531428;4.3;11
;2023-02-09;EL PERELLO;148;812828;4531428;0.0;12
;2023-02-10;EL PERELLO;148;812828;4531428;0.0;12
;2023-02-11;EL PERELLO;148;812828;4531428;0.0;13
;2023-02-12;EL PERELLO;148;812828;4531428;0.0;13
;2023-02-13;EL PERELLO;148;812828;4531428;0.0;13
;2023-02-14;EL PERELLO;148;812828;4531428;0.0;14.
;2023-02-15;EL PERELLO;148;812828;4531428;0.0;14.0;-1.0
;2023-02-16;EL PERELLO;148;812828;4531428;0.0;15.0;0.0;
;2023-02-17;EL PERELLO;148;812828;4531428;0.0;18.0;0.0;
;2023-02-18;EL PERELLO;148;812828;4531428;0.0;19.0;2.0;
;2023-02-19;EL PERELLO;148;812828;4531428;0.0;20.0;1.0;
```

CSV Format

Study area

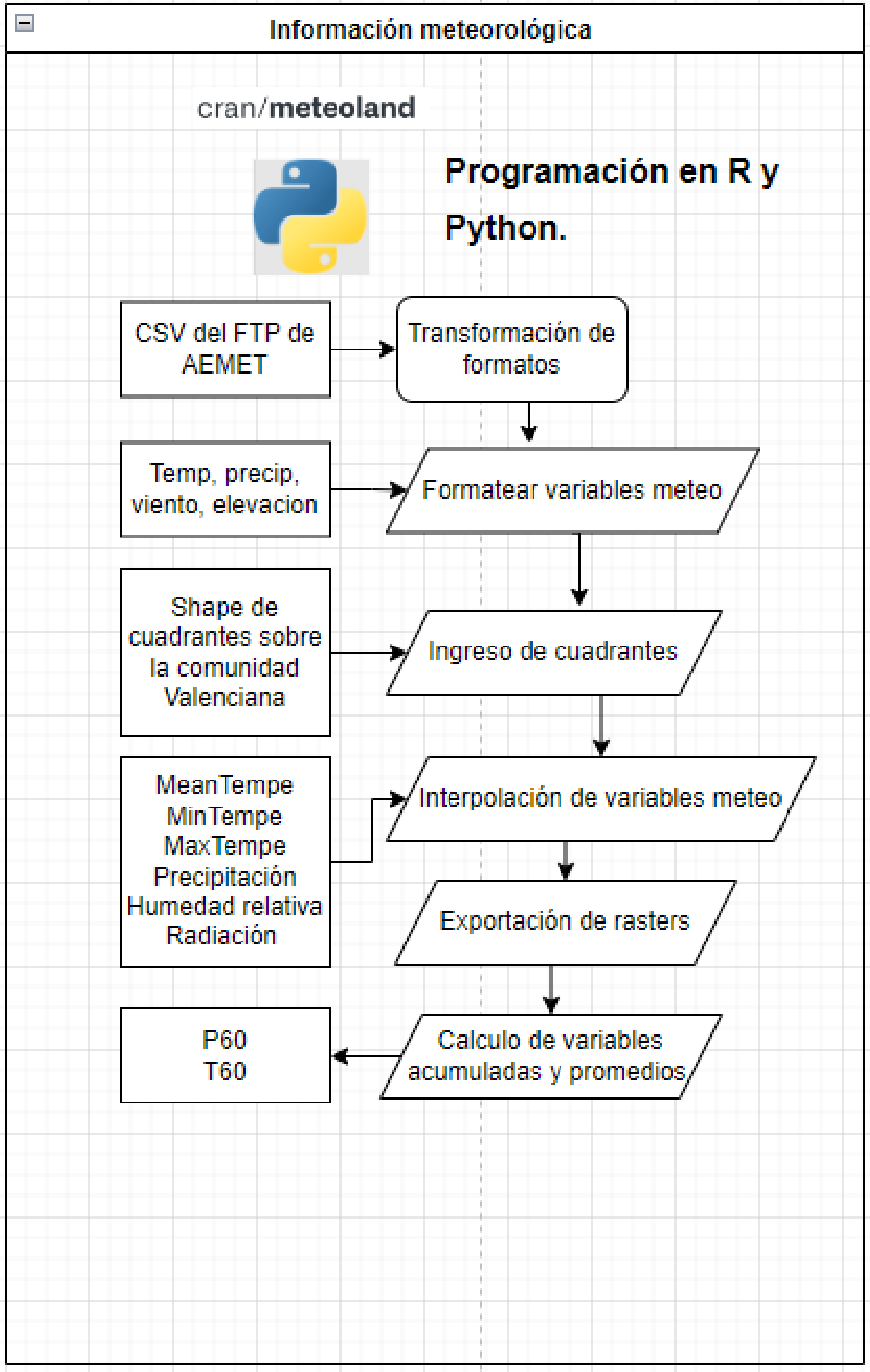


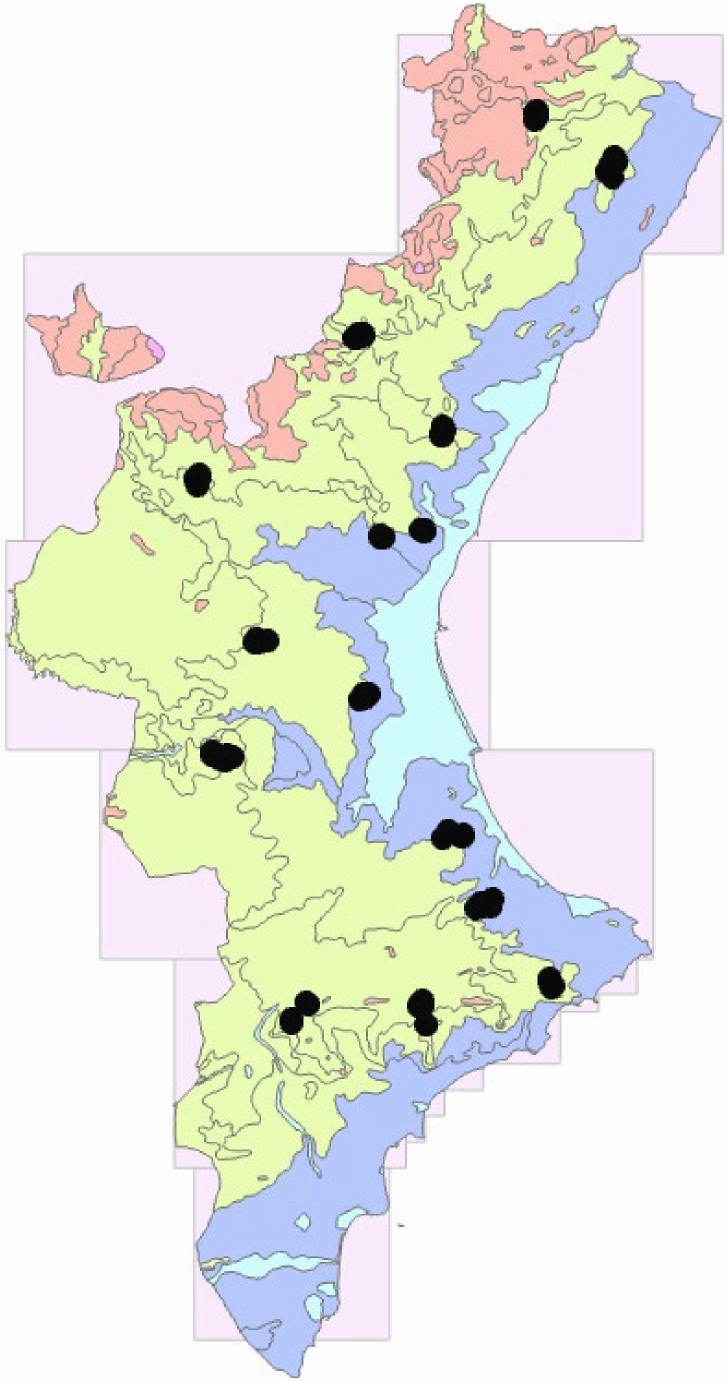
- Elevation
- Aspect
- Slope



Mean Temperatura in previous 60 days

Average precipitation in 60 previous days





Meteorological
Meteoland package R

- Due to information provided by Aemet was necessary implement 12 quadrants to fit de interpolation
- Meteoland just allow to do interpolation, its not possible to make an extrapolation to far areas
- Since 2024 the bordering stations were increased so quadrant were no necessary

```r
library(meteoland)
library(stars)
library(dplyr)
unformatted_meteo=read.csv("C:\\Users\\kpachac\\Desktop\\Modelo_05032024\\aemet\\aemet
unformatted_meteo$date <- as.Date(unformatted_meteo$date,format="%Y-%m-%d")
unformatted_meteo = filter(unformatted_meteo,between(unformatted_meteo$date,as.Date('

ready_meteo <- unformatted_meteo |>
  # convert names to correct ones
  dplyr::mutate(
    MinTemperature = TMIN,
    MaxTemperature = TMAX,
    MeanRelativeHumidity = HU,
    Precipitation = P77,
    stationID = INDICATIVO,
    WindSpeed = R_MAX_VEL,
    WindDirection = R_MAX_DIR,
    elevation = ALTITUD,
    dates = as.Date(date,"%Y-%m-%d")
  ) |>
  # transform to sf (25830)
  sf::st_as_sf(
    coords = c("C_X", "C_Y"),
    crs = sf::st_crs(25830)
  )
```

```r
for (m in 1:length(MF2)) {
  raster_example=read_stars(c(elevation,slope,aspect))
  plot(raster_example[1])

  print(m)
  xmin=min(MF2@polygons[[m]]@Polygons[[1]]@coords[,1])
  xmax=max(MF2@polygons[[m]]@Polygons[[1]]@coords[,1])
  ymin=min(MF2@polygons[[m]]@Polygons[[1]]@coords[,2])
  ymax=max(MF2@polygons[[m]]@Polygons[[1]]@coords[,2])
  bb = st_bbox(c(xmin = xmin,
                 ymin = ymin,
                 xmax = xmax,
                 ymax = ymax), crs = st_crs(raster_example))

  raster_example=st_crop(raster_example,bb)
  plot(raster_example[1])

  fechas = seq(as.Date("2023-02-01"),as.Date( "2023-04-05"),by="days")
  #varia <- c("Temperature","Precipitation","RelativeHumidity")
  varia <- c("Temperature","Precipitation")
  raster_interpolated = interpolate_data(raster_example,interpolator,dates=fechas,variables=varia)

  plot(raster_interpolated[1,,,])

  #variables <- c("MeanTemperature", "MinTemperature", "MaxTemperature", "Precipitation", "MeanRelativeHumi
  variables <- c("MeanTemperature","Precipitation", "MinRelativeHumidity")
  for(i in variables){
    for(j  in seq_along(fechas)){
      file.tiff <- sprintf('C:\\Users\\kpachac\\Desktop\\Modelo_05032024\\meteo\\%s-%s_%s.tiff',i,fechas[j]
      write_stars(raster_interpolated[i,,,j],file.tiff)
    }
```

Meteorological implementation

- Libraries necesary: Meteoland, Stars and dplyr
- Read data from weather stations
- Create de interpolator object
- Interpolate variables (Temperature, Precipitation and RelativeHumidity) on the study área

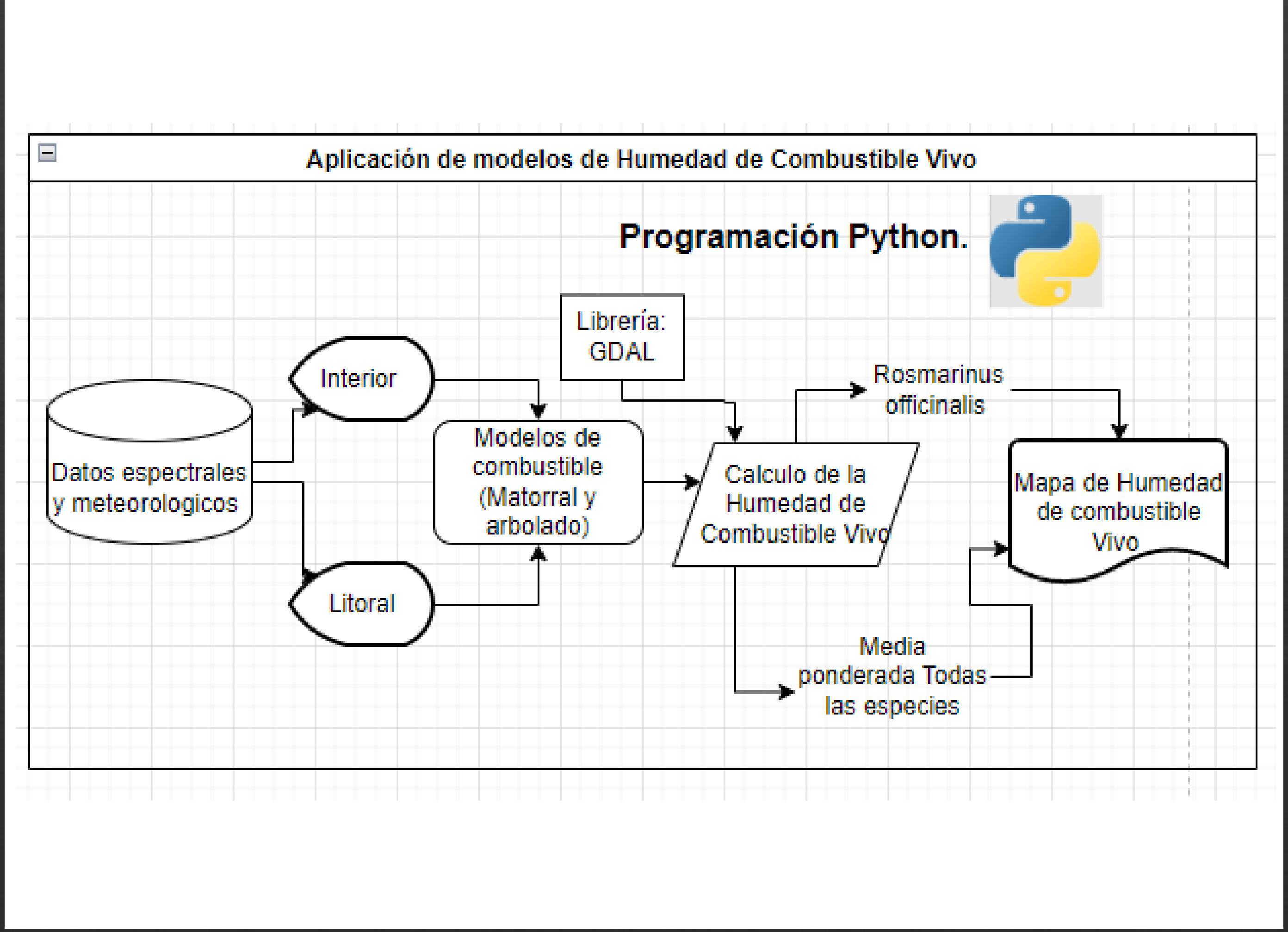
Unification for processing rasters

- Gdal library used to operate rasters and apply the statistical equation

- Parameters to take into account:

Resolution

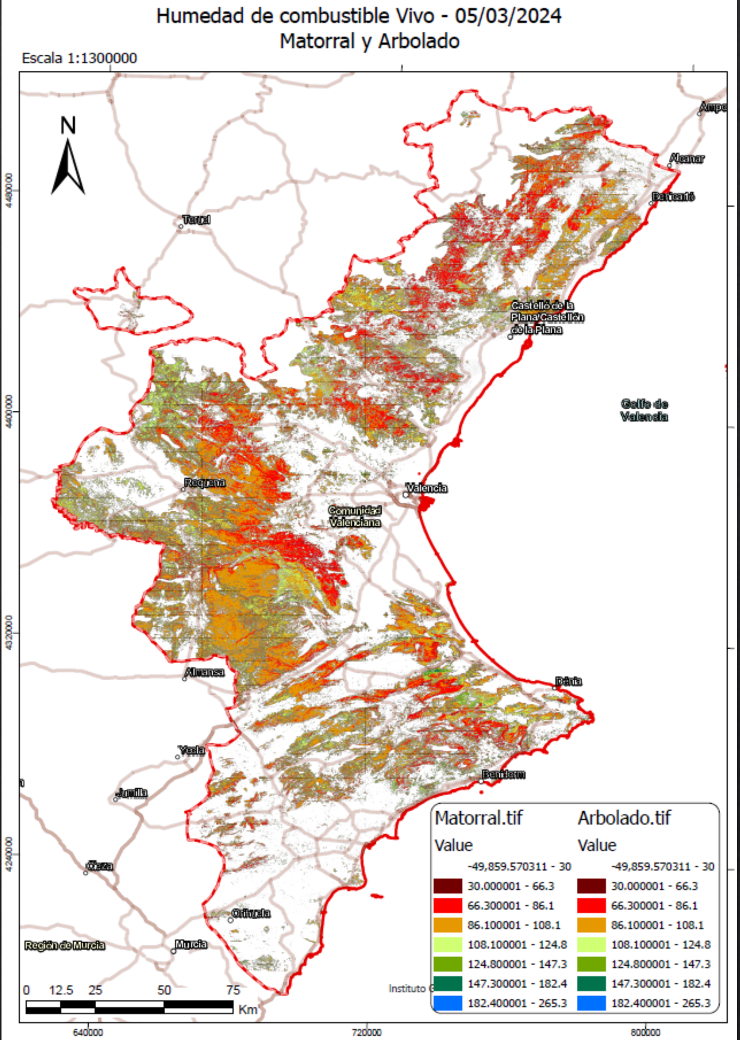
Coordinate system (EPSG)



Implementation of the process in the integrated forest fire management system

- Final product is the creation of thematic fuel moisture mapping, created daily and available for download in different resolutions in a SIGIF geoportal.
- The implementation was carried out entirely in free Python software.
- The project is stored in Azure Devops git https://dev.azure.com/VaersaServicios/_git/HCVivo_UPV

Azure DevOps



Thanks

MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
AGENCIA ESTATAL DE INVESTIGACIÓN
GENERALITAT VALENCIANA
MDPI
CGAT
Grupo de Cartografía GeoAmbiental y Teledetección
AET