



UNIVERSIDADE D
COIMBRA

Nuno Pires

**INTELLIGENT SYSTEM FOR LOCALISING AND
MONITORING FOREST FIRES**

Dissertation in the context of the Master in Informatics Engineering, specialization in Information Systems, advised by Professor Alberto Cardoso and Professor Jacinto Estima and presented to the Department of Informatics Engineering of the Faculty of Sciences and Technology of the University of Coimbra.

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SISTEMA INTELIGENTE PARA LOCALIZAÇÃO E MONITORIZAÇÃO DE INCÊNDIOS FLORESTAIS

**Dissertação no âmbito do Mestrado em Engenharia Informática,
especialização em Sistemas de Informação, orientada pelo Professor Alberto
Cardoso e Professor Jacinto Estima e apresentada ao Departamento de
Engenharia Informática da Faculdade de Ciências e Tecnologia da
Universidade de Coimbra.**

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Abstract

Fire can have disastrous consequences. Decision-support systems play a central role in dealing with forest fires. Its early warning capacity and real-world impact help to protect forests, species, and communities from wildfire.

The presented work proposes a system for forecasting and monitoring forest fires using multiple data sources. Data fusion, aggregation, and enhancement techniques are also mentioned.

The main purpose of the system is to provide important information for emergency decision-making, such as the geolocation, severity, and temporal evolution of a wildfire. It will employ statistical and machine learning methodologies to predict and determine fire occurrence, susceptibility, and risk.

Finally, the system, with the help of data visualisation tools, will show findings and insights.

The document also presents current approaches and obstacles to forest fire prediction, as well as the suggested methodology and analysis of risk.

Keywords

Decision support system, Fire management, Fire forecasting, Machine learning, Spatial and temporal prediction

Resumo

Os incêndios podem ter consequências desastrosas. Os sistemas de apoio à decisão desempenham um papel central na luta contra os incêndios florestais. As suas capacidades de alerta e o seu impacto no mundo real ajudam a proteger as florestas, as espécies e as comunidades.

O trabalho apresentado propõe um sistema de previsão e monitorização de incêndios florestais que utiliza fontes diversas de dados. Onde são utilizadas técnicas de fusão, agregação e melhoramento de dados.

O principal objetivo do sistema é fornecer informações importantes para a tomada de decisões de emergência, tais como a geolocalização, a gravidade e a evolução temporal de um incêndio florestal. O sistema empregará metodologias estatísticas e de aprendizagem automática para prever e determinar a ocorrência, a suscetibilidade e o risco de incêndio.

Finalmente, com a ajuda de ferramentas de visualização de dados, o sistema será capaz de apresentar informações e resultados.

No documento também são analisadas as abordagens actuais e os obstáculos à previsão de incêndios florestais, bem como a metodologia sugerida e a análise de risco.

Palavras-Chave

Sistema de apoio à decisão, Gestão de incêndios, Previsão de incêndios, Aprendizagem automática, Previsão espacial e temporal

Contents

1	Experiences	1
1.1	Samples	1
1.2	Uncovering important variables	1
1.2.1	Feature importance and correlation with RandomForestClassifier	1
1.2.2	Sample variables discussion	6
1.2.3	Natural Fires features and correlation	7
	References	29

List of Figures

1.1	Hourly FWI value for the day of wildfire occurrence	4
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List of Tables

1.1	Variable importance for 2015 and 2019	1
1.2	Variable importance for 2022	2
1.3	Variable importance for hourly values	2
1.4	Variable correlation to wildfire	2
1.5	Variable importance with daily mean method	3
1.6	Variable correlation to wildfire daily mean	3
1.7	Variable importance with <i>FWI</i> time frame method	3
1.8	Variable correlation to wildfire time frame method	4
1.9	Variable importance with 3-hours time frame method	4
1.10	Variable correlation to wildfire 3-hours time frame	5
1.11	Variable importance 14-days prior time frame method	5
1.12	Variable correlation to wildfire 3-hours time frame	5
1.13	Variable importance 14-days prior hourly time frame method	6
1.14	Variable correlation 14-days prior hourly time frame method	6
1.15	Entry for previous methods	6
1.16	Correlation of Features with Wildfire	8
1.17	Feature Importances	9
1.18	Correlation of Features with Wildfire	10
1.19	Feature Importances	11
1.20	Correlation of Features with Wildfire	13
1.21	Feature Importances	14
1.22	Correlation of Features with Wildfire	16
1.23	Feature Importances	17
1.24	Correlation of Features with Wildfire	18
1.25	Feature Importances	19
1.26	Correlation of Features with Wildfire	20
1.27	Feature Importances	21
1.28	Correlations	23
1.29	Feature Importances	24
1.30	Correlations	26
1.31	Feature Importances	27
1.32	Variable Ranking	28

Chapter 1

Experiences

1.1 Samples

Sample characterization

1.2 Uncovering important variables

1.2.1 Feature importance and correlation with RandomForestClassifier

The following experiments were designed using the RandomForestClassifier algorithm (Pedregosa et al., 2011). The goal was to obtain important features that would be able to explain the occurrence of wildfires. These tests were conducted on the three samples previously mentioned.

Firstly, for each sample, a wildfire occurrence was set 3 hours before the wildfire occurrence and 1 hour after, and then the most important variables were calculated. Their complete hourly records were used. With a random state of 445621151 for RandomForestClassifier, the tables 1.1 and 1.2 show the results for each year.

Table 1.1: Variable importance for 2015 and 2019

2015		2019	
Variable	Importance	Variable	Importance
soil_moisture_100_to_255cm	0.122	wind_speed_100m	0.072
DMC	0.057	soil_temperature_100_to_255cm	0.065
ISI	0.053	BUI	0.062
BUI	0.051	soil_temperature_7_to_28cm	0.056
wind_speed_100m	0.042	soil_moisture_100_to_255cm	0.053

Table 1.2: Variable importance for 2022

2022	
Variable	Importance
DMC	0.127
BUI	0.111
DC	0.087
ISI	0.054
FWI	0.052

For the following experiments, the three samples were concatenated into one. The last 24 rows of each sample were assigned as 1 in the boolean scale of wildfire occurrence, while the rest were assigned as 0. With the RandomForestClassifier algorithm, it was possible to obtain the data shown in Table 1.3 depicting the five most important features according to this method. The two least important features are *rain* and *precipitation*. Although *rain* was considered one of the least important features, it cannot be discarded because it is a variable in *FWI* component analysis, and three components from *FWI* are among the most important features that appear in table 1.3. In relation to wildfire correlation, wind and soil moisture are the most prevalent variables present with a negative correlation in table 1.4. Different depths of soil moisture appear in the positive and negative spectrum of correlation.

Table 1.3: Variable importance for hourly values

Variable	Importance
soil_moisture_100_to_255cm	0.096
soil_moisture_7_to_28cm	0.081
DMC	0.081
DC	0.077
BUI	0.070

Table 1.4: Variable correlation to wildfire

Variable	correlation
surface_pressure	0.105
soil_temperature_100_to_255cm	0.060
soil_moisture_0_to_7cm	0.0602
dew_point_2m	0.026
soil_moisture_7_to_28cm	0.023
soil_moisture_100_to_255cm	-0.155
soil_moisture_28_to_100cm	-0.131
wind_speed_100m	-0.097
wind_speed_10m	-0.095
wind_gusts_10m	-0.080

Table 1.5 displays the five most important features, according to a daily average value. For each variable, a mean value was calculated, and it was assigned to the

last day as a boolean value for wildfire 1, depicting an occurrence of a wildfire. This method showed little difference in relation to the values shown in table 1.3. The two least important features considered were *precipitation* and *dew_point_2m*. Both table 1.4 and table 1.6 do not show the most common variables associated with wildfires (temperature and humidity) as the ones with the most correlation to a wildfire occurrence.

Table 1.5: Variable importance with daily mean method

Variable	Importance
wind_speed_100m	0.115
soil_moisture_100_to_255cm	0.093
wind_speed_10m	0.066
terrestrial_radiation_instant	0.058
soil_moisture_7_to_28cm	0.056

Table 1.6: Variable correlation to wildfire daily mean

Variable	correlation
surface_pressure	0.110
soil_moisture_0_to_7cm	0.061
soil_temperature_100_to_255cm	0.060
dew_point_2m	0.035
cloud_cover_mid	0.028
soil_moisture_100_to_255cm	-0.155
wind_speed_10m	-0.151
wind_speed_100m	-0.149
soil_moisture_28_to_100cm	-0.131
wind_gusts_10m	-0.122

Another experiment was conducted by selecting a time frame between 9:00 and 20:00 hours. Taking a glance at figure 1.1, the value of *FWI* starts to increase around 8 or 9 in the morning, has its highest value around 15, and then it starts to decrease. After around 20 hours, it reaches its lowest point in the samples from the years 2015 and 2019.

Table 1.7 shows soil moisture as the most important feature, like in Table 1.3. There was also another experiment where the time frame was selected according to the hour of the wildfire.

Table 1.7: Variable importance with *FWI* time frame method

Variable	Importance
soil_moisture_100_to_255cm	0.073
DMC	0.072
soil_moisture_7_to_28cm	0.072
DC	0.057
soil_moisture_28_to_100cm	0.049

Figure 1.1: Hourly FWI value for the day of wildfire occurrence

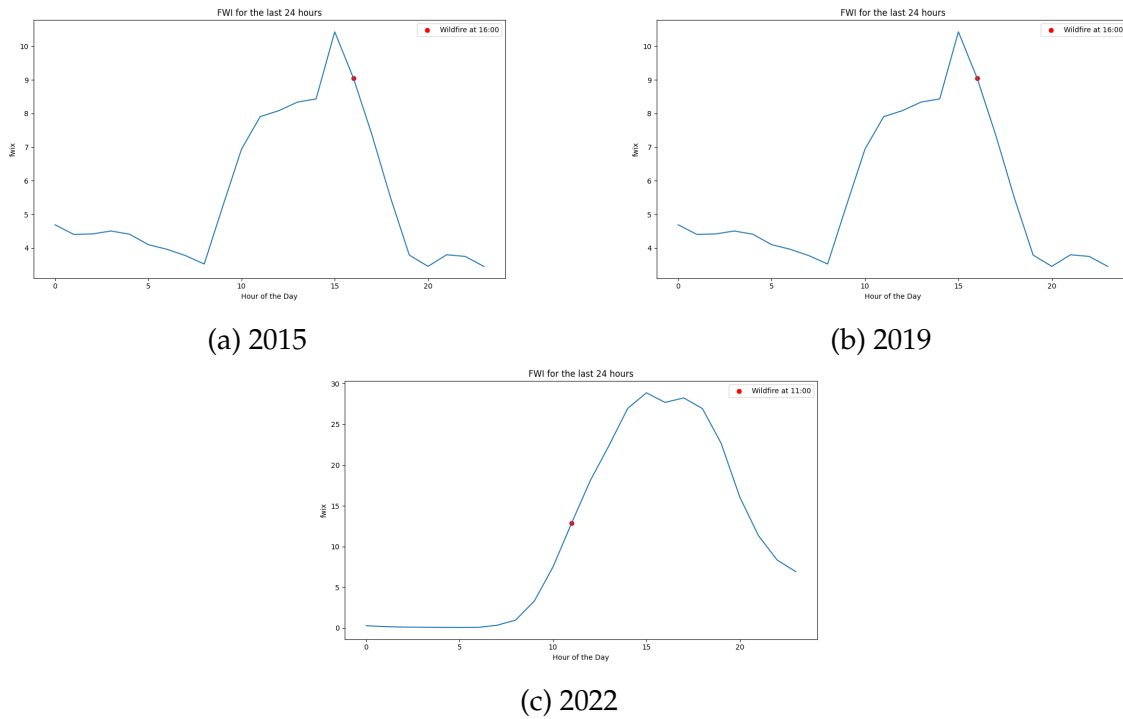


Table 1.8: Variable correlation to wildfire time frame method

Variable	correlation
surface_pressure	0.081
sunshine_duration	0.076
terrestrial_radiation	0.068
et0_fao_evapotranspiration	0.063
terrestrial_radiation_instant	0.063
soil_moisture_100_to_255cm	-0.104
soil_moisture_28_to_100cm	-0.087
relative_humidity_2m	-0.062
wind_speed_100m	-0.054
BUI	-0.047

A time frame three hours after and before the hour of wildfire (table 1.9) was selected. It yielded almost the same variables as table 1.7 in a different order. Those who were in table 1.8 negatively correlated to wildfire maintained themselves in this method.

Table 1.9: Variable importance with 3-hours time frame method

Variable	Importance
BUI	0.060
soil_moisture_100_to_255cm	0.060
DMC	0.051
soil_temperature_7_to_28cm	0.043
DC	0.042

Table 1.10: Variable correlation to wildfire 3-hours time frame

Variable	correlation
sunshine_duration	0.055
surface_pressure	0.055
terrestrial_radiation	0.040
direct_normal_irradiance	0.039
temperature_2m	0.038
soil_moisture_100_to_255cm	-0.077
soil_moisture_28_to_100cm	-0.063
relative_humidity_2m	-0.043
wind_speed_100m	-0.042
BUI	-0.035

The authors from (Wang et al., 2023) set that the maximum time frame for wildfire weather variable analysis is 16 days. Given that the sample from 2022 only contains hourly data for 14 days, the table 1.11 displays the most important features taken 14 days prior to the wildfire occurrence from all three samples. Like the experiment displayed in table 1.5, a daily average was calculated for each day. The wildfire variable was set to 1 in the day the wildfire took place.

The correlation table 1.12 demonstrates that the *FWI* variable itself may be negatively correlated to wildfire occurrence. This is, of course, wrong. The problem may rely on the poor quantity of examples and chosen samples, which may be indicators of anomalies and not of a normal wildfire occurrence paradigm.

Table 1.11: Variable importance 14-days prior time frame method

Variable	Importance
wind_speed_10m	0.129
wind_speed_100m	0.123
soil_temperature_7_to_28cm	0.087
soil_temperature_28_to_100cm	0.060
apparent_temperature	0.053

Table 1.12: Variable correlation to wildfire 3-hours time frame

Variable	correlation
dew_point_2m	0.262
soil_temperature_28_to_100cm	0.206
DC	0.040
apparent_temperature	0.181
temperature_2m	0.113
wind_speed_100m	-0.321
wind_speed_10m	-0.301
wind_gusts_10m	-0.259
FWI	-0.161
ISI	-0.152

A last experiment (table 1.13) was also conducted with an hourly method. The last 360 rows from each sample were selected without taking in averages, it was set as a boolean variable for wildfire occurrence all rows 3 hours prior and 2 hours after the wildfire. With this method all variables from *FWI* were set as the most important to explain the model.

As table 1.14 also demonstrates, it appears that as time gets closer to the day of wildfire occurrence, *FWI* variables become more important to detect a wildfire.

Table 1.13: Variable importance 14-days prior hourly time frame method

Variable	Importance
DMC	0.127
BUI	0.111
DC	0.087
ISI	0.054
FWI	0.052

Table 1.14: Variable correlation 14-days prior hourly time frame method

Variable	correlation
ISI	0.262
FWI	0.206
soil_temperature_28_to_100cm	0.040
DMC	0.181
BUI	0.113
soil_moisture_100_to_255cm	-0.159
relative_humidity_2m	-0.140
soil_moisture_28_to_100cm	-0.089
soil_moisture_7_to_28cm	-0.072
cloud_cover_low	-0.050

1.2.2 Sample variables discussion

Table 1.15: Entry for previous methods

Variable	count
soil_moisture_100_to_255cm	11
BUI	9
soil_moisture_28_to_100cm	7
wind_speed_100m	7
soil_moisture_7_to_28cm	6
DMC	6
DC	5
wind_speed_100m	4

1.2.3 Natural Fires features and correlation

-3 hours + 1 hour (All time) = Wildfire

Table 1.16: Correlation of Features with Wildfire

Variable	correlation
wildfire	1.000000
vapour_pressure_deficit	0.115521
apparent_temperature	0.105074
soil_temperature_0_to_7cm	0.105006
temperature_2m	0.099187
FWI	0.093873
et0_fao_evapotranspiration	0.091105
ISI	0.090979
direct_radiation_instant	0.083060
direct_radiation	0.081744
soil_temperature_7_to_28cm	0.075246
shortwave_radiation_instant	0.074539
global_tilted_irradiance_instant	0.074513
surface_pressure	0.073711
global_tilted_irradiance	0.073240
shortwave_radiation	0.073240
soil_temperature_100_to_255cm	0.068847
soil_temperature_28_to_100cm	0.067367
direct_normal_irradiance	0.067037
direct_normal_irradiance_instant	0.066927
terrestrial_radiation_instant	0.061423
terrestrial_radiation	0.060433
DC	0.056129
dew_point_2m	0.046324
BUI	0.046308
sunshine_duration	0.043084
ffmc	0.036141
DMC	0.032628
wind_direction_10m	0.021066
diffuse_radiation_instant	0.021033
pressure_msl	0.020358
diffuse_radiation	0.020206
wind_direction_100m	0.019430
cloud_cover_high	0.016310
wind_gusts_10m	0.010233
rain	-0.007193
precipitation	-0.007193
wind_speed_10m	-0.007406
cloud_cover_mid	-0.018288
wind_speed_100m	-0.019549
cloud_cover	-0.028887
cloud_cover_low	-0.031151
soil_moisture_0_to_7cm	-0.049159
soil_moisture_7_to_28cm	-0.055073
soil_moisture_28_to_100cm	-0.055245
relative_humidity_2m	-0.063974
soil_moisture_100_to_255cm	-0.068332

Table 1.17: Feature Importances

Feature	Importance
soil_temperature_0_to_7cm	0.067
soil_temperature_100_to_255cm	0.057
surface_pressure	0.050
soil_moisture_28_to_100cm	0.048
direct_normal_irradiance_instant	0.047
soil_temperature_28_to_100cm	0.045
dc	0.045
dew_point_2m	0.045
direct_radiation	0.045
apparent_temperature	0.042
soil_moisture_100_to_255cm	0.036
shortwave_radiation	0.034
global_tilted_irradiance_instant	0.033
pressure_msl	0.032
soil_temperature_7_to_28cm	0.030
ffmc	0.027
global_tilted_irradiance	0.026
direct_radiation_instant	0.023
terrestrial_radiation	0.022
direct_normal_irradiance	0.020
vapour_pressure_deficit	0.018
soil_moisture_7_to_28cm	0.018
temperature_2m	0.016
relative_humidity_2m	0.016
et0_fao_evapotranspiration	0.014
shortwave_radiation_instant	0.012
cloud_cover_high	0.011
bui	0.008
cloud_cover	0.008
wind_speed_100m	0.006
wind_speed_10m	0.006
dmc	0.005
wind_direction_100m	0.004
wind_direction_10m	0.004
cloud_cover_mid	0.003
soil_moisture_0_to_7cm	0.002
diffuse_radiation_instant	0.002
wind_gusts_10m	0.002
diffuse_radiation	0.000
sunshine_duration	0.000
cloud_cover_low	0.000
rain	0.000
precipitation	0.000

-3 hours + 1 hour (15 days) = Wildfire

Table 1.18: Correlation of Features with Wildfire

Feature	Correlation
wildfire	1.000000
soil_temperature_28_to_100cm	0.218310
apparent_temperature	0.206428
soil_temperature_0_to_7cm	0.205911
et0_fao_evapotranspiration	0.202611
direct_radiation_instant	0.199749
soil_temperature_100_to_255cm	0.198868
direct_radiation	0.195682
shortwave_radiation_instant	0.187064
global_tilted_irradiance_instant	0.186997
global_tilted_irradiance	0.183503
shortwave_radiation	0.183503
vapour_pressure_deficit	0.183090
temperature_2m	0.180857
surface_pressure	0.163178
ISI	0.159240
FWI	0.159159
terrestrial_radiation_instant	0.159120
terrestrial_radiation	0.156705
direct_normal_irradiance	0.155113
direct_normal_irradiance_instant	0.155062
soil_temperature_7_to_28cm	0.139406
sunshine_duration	0.110303
cloud_cover_high	0.086670
FFMC	0.083163
DMC	0.074674
BUI	0.071415
diffuse_radiation_instant	0.068179
diffuse_radiation	0.067139
wind_direction_100m	0.058661
wind_direction_10m	0.058586
dew_point_2m	0.057696
DC	0.056560
wind_gusts_10m	0.040723
pressure_msl	0.023026
wind_speed_10m	-0.015635
precipitation	-0.024298
rain	-0.024298
cloud_cover_mid	-0.033299
cloud_cover	-0.045048
wind_speed_100m	-0.050041
cloud_cover_low	-0.058643
relative_humidity_2m	-0.132352
soil_moisture_0_to_7cm	-0.143583
soil_moisture_100_to_255cm	-0.161813
soil_moisture_7_to_28cm	-0.163834
soil_moisture_28_to_100cm	-0.192249

Table 1.19: Feature Importances

Feature	Importance
soil_moisture_0_to_7cm	0.125
DC	0.065
soil_moisture_28_to_100cm	0.064
direct_normal_irradiance	0.052
soil_temperature_28_to_100cm	0.052
apparent_temperature	0.049
dew_point_2m	0.048
soil_moisture_7_to_28cm	0.037
soil_moisture_0_to_7cm	0.037
soil_temperature_7_to_28cm	0.034
shortwave_radiation	0.033
global_tilted_irradiance	0.033
global_tilted_irradiance_instant	0.031
direct_normal_irradiance_instant	0.029
soil_temperature_100_to_255cm	0.028
cloud_cover_high	0.025
DMC	0.024
soil_moisture_100_to_255cm	0.020
BUI	0.019
terrestrial_radiation	0.017
cloud_cover	0.016
terrestrial_radiation_instant	0.015
surface_pressure	0.014
ISI	0.014
et0_fao_evapotranspiration	0.013
pressure_msl	0.013
diffuse_radiation	0.012
direct_radiation_instant	0.012
wind_speed_10m	0.010
shortwave_radiation_instant	0.010
FFMC	0.009
vapour_pressure_deficit	0.009
direct_radiation	0.007
wind_direction_100m	0.006
wind_gusts_10m	0.006
FWI	0.004
temperature_2m	0.003
cloud_cover_mid	0.002
diffuse_radiation_instant	0.001
sunshine_duration	0.000
relative_humidity_2m	0.000
wind_direction_10m	0.000
cloud_cover_low	0.000
rain	0.000
precipitation	0.000

(24 hours = 1) Hourly Method

Table 1.20: Correlation of Features with Wildfire

Feature	Correlation
wildfire	1.000000
soil_temperature_7_to_28cm	0.195028
soil_temperature_100_to_255cm	0.168080
soil_temperature_28_to_100cm	0.165931
DC	0.163708
dew_point_2m	0.155349
apparent_temperature	0.153682
bui	0.144392
soil_temperature_0_to_7cm	0.139286
temperature_2m	0.137257
surface_pressure	0.119224
DMC	0.110123
vapour_pressure_deficit	0.100018
FWI	0.093907
ISI	0.062057
FFMC	0.058507
pressure_msl	0.044965
direct_normal_irradiance_instant	0.023391
direct_normal_irradiance	0.023292
et0_fao_evapotranspiration	0.019237
direct_radiation_instant	0.015533
direct_radiation	0.015213
sunshine_duration	0.007154
global_tilted_irradiance_instant	0.006062
shortwave_radiation_instant	0.005950
global_tilted_irradiance	0.005651
shortwave_radiation	0.005651
wind_direction_100m	-0.002203
cloud_cover_high	-0.002437
terrestrial_radiation_instant	-0.006101
terrestrial_radiation	-0.006217
rain	-0.017701
precipitation	-0.017701
wind_direction_10m	-0.019207
diffuse_radiation_instant	-0.027817
diffuse_radiation	-0.027948
cloud_cover_mid	-0.038474
relative_humidity_2m	-0.040506
wind_gusts_10m	-0.071675
wind_speed_10m	-0.073636
cloud_cover_low	-0.076654
cloud_cover	-0.079753
wind_speed_100m	-0.089582
soil_moisture_0_to_7cm	-0.119617
soil_moisture_7_to_28cm	-0.135793
soil_moisture_28_to_100cm	-0.135850
soil_moisture_100_to_255cm	-0.170354

Table 1.21: Feature Importances

Feature	Importance
soil_temperature_28_to_100cm	0.220
soil_temperature_100_to_255cm	0.147
soil_moisture_28_to_100cm	0.138
soil_moisture_100_to_255cm	0.098
soil_temperature_7_to_28cm	0.058
soil_moisture_7_to_28cm	0.057
dc	0.033
soil_moisture_0_to_7cm	0.027
pressure_msl	0.027
dew_point_2m	0.026
surface_pressure	0.015
wind_gusts_10m	0.014
soil_temperature_0_to_7cm	0.014
dmc	0.013
bui	0.013
wind_direction_10m	0.013
wind_direction_100m	0.011
wind_speed_100m	0.011
cloud_cover	0.007
fwix	0.006
apparent_temperature	0.006
wind_speed_10m	0.005
ISI	0.005
ffmc	0.005
vapour_pressure_deficit	0.005
temperature_2m	0.004
cloud_cover_high	0.003
direct_radiation	0.003
terrestrial_radiation	0.003
diffuse_radiation	0.002
global_tilted_irradiance	0.001
shortwave_radiation_instant	0.001
direct_radiation_instant	0.001
shortwave_radiation	0.001
global_tilted_irradiance_instant	0.001
cloud_cover_low	0.001
cloud_cover_mid	0.001
sunshine_duration	0.000
precipitation	0.000
rain	0.000
direct_normal_irradiance_instant	0.000
et0_fao_evapotranspiration	0.000
terrestrial_radiation_instant	0.000
diffuse_radiation_instant	0.000
direct_normal_irradiance	0.000

Daily Average (All time)

Table 1.22: Correlation of Features with Wildfire

Feature	Correlation
wildfire	1.000000
apparent_temperature	0.212990
soil_temperature_0_to_7cm	0.207830
temperature_2m	0.204283
soil_temperature_7_to_28cm	0.203788
vapour_pressure_deficit	0.180951
dc	0.177241
dew_point_2m	0.175252
soil_temperature_100_to_255cm	0.168341
soil_temperature_28_to_100cm	0.166894
bui	0.158333
surface_pressure	0.130914
fwix	0.129210
dmc	0.120350
isi	0.103540
et0_fao_evapotranspiration	0.082286
ffmc	0.072982
direct_normal_irradiance_instant	0.068857
direct_normal_irradiance	0.067806
direct_radiation_instant	0.054054
direct_radiation	0.052884
pressure_msl	0.047901
sunshine_duration	0.032468
global_tilted_irradiance_instant	0.030325
shortwave_radiation_instant	0.029607
shortwave_radiation	0.028376
global_tilted_irradiance	0.028376
cloud_cover_high	-0.003827
wind_direction_100m	-0.004891
rain	-0.030804
precipitation	-0.030804
wind_direction_10m	-0.032895
cloud_cover_mid	-0.055702
relative_humidity_2m	-0.086702
cloud_cover_low	-0.098828
wind_gusts_10m	-0.101219
cloud_cover	-0.103068
diffuse_radiation	-0.111690
diffuse_radiation_instant	-0.112992
wind_speed_10m	-0.117575
soil_moisture_0_to_7cm	-0.123955
wind_speed_100m	-0.125507
soil_moisture_28_to_100cm	-0.136487
soil_moisture_7_to_28cm	-0.137500
soil_moisture_100_to_255cm	-0.170715
terrestrial_radiation	-0.242384
terrestrial_radiation_instant	-0.243558

Table 1.23: Feature Importances

Feature	Importance
apparent_temperature	0.110
soil_temperature_0_to_7cm	0.110
soil_temperature_7_to_28cm	0.105
soil_moisture_100_to_255cm	0.100
soil_temperature_100_to_255cm	0.098
soil_temperature_28_to_100cm	0.078
soil_moisture_28_to_100cm	0.076
dc	0.060
terrestrial_radiation	0.060
terrestrial_radiation_instant	0.039
soil_moisture_7_to_28cm	0.034
wind_speed_10m	0.021
wind_speed_100m	0.020
soil_moisture_0_to_7cm	0.017
sunshine_duration	0.015
temperature_2m	0.014
cloud_cover_low	0.014
diffuse_radiation_instant	0.009
surface_pressure	0.008
wind_gusts_10m	0.005
bui	0.002
dew_point_2m	0.002
vapour_pressure_deficit	0.001
dmc	0.001
precipitation	0.000
direct_normal_irradiance_instant	0.000
global_tilted_irradiance_instant	0.000
wind_direction_10m	0.000
fwix	0.000
ffmc	0.000
shortwave_radiation_instant	0.000
isi	0.000
direct_radiation_instant	0.000
direct_normal_irradiance	0.000
rain	0.000
global_tilted_irradiance	0.000
cloud_cover	0.000
relative_humidity_2m	0.000
cloud_cover_mid	0.000
cloud_cover_high	0.000
et0_fao_evapotranspiration	0.000

Daily Average (30 Days)

Table 1.24: Correlation of Features with Wildfire

Feature	Correlation
wildfire	1.000000
soil_temperature_28_to_100cm	0.459369
soil_temperature_7_to_28cm	0.334023
soil_temperature_100_to_255cm	0.307733
soil_temperature_0_to_7cm	0.305549
dmc	0.287481
apparent_temperature	0.286605
temperature_2m	0.269204
bui	0.267538
dc	0.247237
dew_point_2m	0.241486
vapour_pressure_deficit	0.234861
surface_pressure	0.209579
fwix	0.194527
isi	0.159801
et0_fao_evapotranspiration	0.113612
ffmc	0.111992
direct_normal_irradiance_instant	0.111116
cloud_cover_high	0.108811
direct_normal_irradiance	0.107701
direct_radiation_instant	0.087220
direct_radiation	0.083642
pressure_msl	0.079537
sunshine_duration	0.063280
global_tilted_irradiance_instant	0.057106
shortwave_radiation_instant	0.056407
shortwave_radiation	0.052975
global_tilted_irradiance	0.052975
wind_direction_100m	-0.044598
precipitation	-0.046771
rain	-0.046771
cloud_cover_mid	-0.067303
wind_direction_10m	-0.099506
cloud_cover	-0.152059
diffuse_radiation	-0.158267
diffuse_radiation_instant	-0.161205
relative_humidity_2m	-0.166397
cloud_cover_low	-0.171404
wind_gusts_10m	-0.177690
soil_moisture_0_to_7cm	-0.195395
wind_speed_100m	-0.221394
wind_speed_10m	-0.223371
soil_moisture_7_to_28cm	-0.309296
soil_moisture_100_to_255cm	-0.318663
terrestrial_radiation	-0.353063
terrestrial_radiation_instant	-0.355169
soil_moisture_28_to_100cm	-0.366748

Table 1.25: Feature Importances

Feature	Importance
bui	0.130
soil_moisture_7_to_28cm	0.118
soil_moisture_0_to_7cm	0.090
soil_temperature_28_to_100cm	0.090
soil_moisture_100_to_255cm	0.070
dc	0.070
terrestrial_radiation_instant	0.058
soil_temperature_7_to_28cm	0.055
soil_temperature_0_to_7cm	0.050
wind_speed_100m	0.040
soil_moisture_28_to_100cm	0.040
apparent_temperature	0.035
soil_temperature_100_to_255cm	0.030
terrestrial_radiation	0.030
dmc	0.015
precipitation	0.012
sunshine_duration	0.010
isi	0.010
cloud_cover_mid	0.008
wind_direction_10m	0.008
wind_direction_100m	0.008
ffmc	0.007
dew_point_2m	0.007
wind_speed_10m	0.005
temperature_2m	0.003
surface_pressure	0.003
relative_humidity_2m	0.000
wind_gusts_10m	0.000
rain	0.000
pressure_msl	0.000
cloud_cover	0.000
cloud_cover_low	0.000
fwix	0.000
cloud_cover_high	0.000
global_tilted_irradiance_instant	0.000
direct_normal_irradiance_instant	0.000
diffuse_radiation_instant	0.000
direct_radiation_instant	0.000
shortwave_radiation_instant	0.000
shortwave_radiation	0.000
direct_normal_irradiance	0.000
et0_fao_evapotranspiration	0.000

Daily Average (15 Dias)

Table 1.26: Correlation of Features with Wildfire

Feature	Correlation
wildfire	1.000000
soil_temperature_28_to_100cm	0.553636
soil_temperature_100_to_255cm	0.476615
dew_point_2m	0.439009
soil_temperature_7_to_28cm	0.421863
soil_temperature_0_to_7cm	0.390804
apparent_temperature	0.369505
dc	0.312748
temperature_2m	0.306234
dmc	0.300509
bui	0.286209
surface_pressure	0.246773
vapour_pressure_deficit	0.202954
fwix	0.161924
ffmc	0.146147
direct_normal_irradiance_instant	0.137113
direct_normal_irradiance	0.133707
et0_fao_evapotranspiration	0.122184
direct_radiation_instant	0.119018
isi	0.114871
direct_radiation	0.113501
sunshine_duration	0.111183
cloud_cover_high	0.109400
global_tilted_irradiance_instant	0.092729
shortwave_radiation_instant	0.092356
global_tilted_irradiance	0.087512
shortwave_radiation	0.087512
pressure_msl	0.043181
wind_direction_100m	0.040252
wind_direction_10m	-0.046414
precipitation	-0.107160
rain	-0.107160
relative_humidity_2m	-0.119044
cloud_cover_mid	-0.122544
cloud_cover	-0.168215
diffuse_radiation	-0.174104
cloud_cover_low	-0.176382
diffuse_radiation_instant	-0.178686
wind_gusts_10m	-0.288845
wind_speed_10m	-0.352325
soil_moisture_0_to_7cm	-0.357137
wind_speed_100m	-0.363464
soil_moisture_7_to_28cm	-0.416905
soil_moisture_100_to_255cm	-0.451545
terrestrial_radiation	-0.457123
terrestrial_radiation_instant	-0.457290
soil_moisture_28_to_100cm	-0.486671

Table 1.27: Feature Importances

Feature	Importance
bui	0.120
soil_moisture_7_to_28cm	0.115
soil_moisture_0_to_7cm	0.090
soil_temperature_28_to_100cm	0.090
soil_moisture_100_to_255cm	0.070
dc	0.070
soil_temperature_7_to_28cm	0.055
soil_temperature_0_to_7cm	0.050
terrestrial_radiation_instant	0.048
soil_moisture_28_to_100cm	0.040
wind_speed_10m	0.040
wind_speed_100m	0.040
apparent_temperature	0.033
terrestrial_radiation	0.030
soil_temperature_100_to_255cm	0.030
dew_point_2m	0.014
isi	0.010
wind_gusts_10m	0.009
dmc	0.009
cloud_cover_mid	0.008
shortwave_radiation_instant	0.005
wind_direction_10m	0.005
sunshine_duration	0.005
diffuse_radiation_instant	0.005
ffmc	0.004
surface_pressure	0.003
global_tilted_irradiance_instant	0.000
direct_normal_irradiance_instant	0.000
direct_radiation_instant	0.000
global_tilted_irradiance	0.000
fwix	0.000
temperature_2m	0.000
direct_normal_irradiance	0.000
direct_radiation	0.000
shortwave_radiation	0.000
relative_humidity_2m	0.000
wind_direction_100m	0.000
cloud_cover_high	0.000
vapour_pressure_deficit	0.000
et0_fao_evapotranspiration	0.000
cloud_cover_low	0.000
cloud_cover	0.000
rain	0.000
precipitation	0.000

Daily Average (5 Days)

Table 1.28: Correlations

Feature	Correlation
wildfire	1.000
apparent_temperature	0.890
surface_pressure	0.882
pressure_msl	0.869
soil_temperature_0_to_7cm	0.762
soil_temperature_100_to_255cm	0.720
dc	0.714
soil_temperature_28_to_100cm	0.690
soil_temperature_7_to_28cm	0.655
bui	0.502
dew_point_2m	0.472
wind_direction_100m	0.467
dmc	0.387
relative_humidity_2m	0.348
sunshine_duration	0.288
wind_direction_10m	0.281
direct_normal_irradiance_instant	0.272
direct_normal_irradiance	0.268
direct_radiation_instant	0.254
direct_radiation	0.244
global_tilted_irradiance_instant	0.233
shortwave_radiation_instant	0.233
global_tilted_irradiance	0.222
shortwave_radiation	0.222
cloud_cover_high	-0.109
temperature_2m	-0.114
et0_fao_evapotranspiration	-0.186
ffmc	-0.242
cloud_cover_low	-0.250
diffuse_radiation	-0.277
diffuse_radiation_instant	-0.285
rain	-0.323
precipitation	-0.323
vapour_pressure_deficit	-0.367
wind_gusts_10m	-0.398
cloud_cover_mid	-0.405
cloud_cover	-0.437
fwix	-0.543
isi	-0.668
soil_moisture_7_to_28cm	-0.695
soil_moisture_28_to_100cm	-0.700
terrestrial_radiation_instant	-0.714
terrestrial_radiation	-0.714
soil_moisture_100_to_255cm	-0.723
wind_speed_100m	-0.724
wind_speed_10m	-0.751
soil_moisture_0_to_7cm	-0.775

Table 1.29: Feature Importances

Feature	Importance
bui	0.100
soil_temperature_28_to_100cm	0.090
soil_moisture_0_to_7cm	0.080
soil_moisture_7_to_28cm	0.080
isi	0.070
soil_moisture_100_to_255cm	0.050
pressure_msl	0.050
surface_pressure	0.050
soil_temperature_0_to_7cm	0.050
wind_speed_10m	0.040
soil_moisture_28_to_100cm	0.040
soil_temperature_7_to_28cm	0.040
wind_speed_100m	0.040
fwix	0.040
terrestrial_radiation_instant	0.036
dc	0.030
soil_temperature_100_to_255cm	0.030
terrestrial_radiation	0.020
apparent_temperature	0.016
ffmc	0.008
cloud_cover_mid	0.007
wind_gusts_10m	0.006
diffuse_radiation_instant	0.006
sunshine_duration	0.006
shortwave_radiation_instant	0.006
et0_fao_evapotranspiration	0.004
dmc	0.004
direct_normal_irradiance_instant	0.000
global_tilted_irradiance_instant	0.000
global_tilted_irradiance	0.000
direct_radiation_instant	0.000
temperature_2m	0.000
direct_normal_irradiance	0.000
direct_radiation	0.000
shortwave_radiation	0.000
relative_humidity_2m	0.000
wind_direction_100m	0.000
wind_direction_10m	0.000
vapour_pressure_deficit	0.000
cloud_cover_high	0.000
cloud_cover_low	0.000
cloud_cover	0.000
rain	0.000
precipitation	0.000
location	0.000

-3 hours + 1 hour Hourly (5 days)

Table 1.30: Correlations

Feature	Correlation
wildfire	1.000
ISI	0.271
FWI	0.230
soil_temperature_28_to_100cm	0.215
DMC	0.207
BUI	0.197
vapour_pressure_deficit	0.195
soil_temperature_0_to_7cm	0.195
DC	0.195
soil_temperature_7_to_28cm	0.188
temperature_2m	0.186
soil_temperature_100_to_255cm	0.180
apparent_temperature	0.156
cloud_cover_high	0.143
et0_fao_evapotranspiration	0.124
wind_speed_10m	0.123
diffuse_radiation	0.116
wind_gusts_10m	0.112
sunshine_duration	0.104
FFMC	0.095
diffuse_radiation_instant	0.091
terrestrial_radiation	0.090
wind_speed_100m	0.088
surface_pressure	0.088
global_tilted_irradiance	0.071
shortwave_radiation	0.071
terrestrial_radiation_instant	0.069
direct_normal_irradiance_instant	0.055
direct_normal_irradiance	0.055
global_tilted_irradiance_instant	0.054
shortwave_radiation_instant	0.054
direct_radiation	0.052
wind_direction_100m	0.045
wind_direction_10m	0.044
direct_radiation_instant	0.038
cloud_cover_mid	0.029
cloud_cover	0.015
dew_point_2m	0.006
pressure_msl	-0.017
rain	-0.025
precipitation	-0.025
soil_moisture_0_to_7cm	-0.028
cloud_cover_low	-0.050
soil_moisture_7_to_28cm	-0.072
soil_moisture_28_to_100cm	-0.090
relative_humidity_2m	-0.141
soil_moisture_100_to_255cm	-0.159

Table 1.31: Feature Importances

Feature	Importance
DMC	0.127
BUI	0.111
DC	0.087
ISI	0.054
FWI	0.052
soil_temperature_7_to_28cm	0.047
wind_speed_10m	0.043
soil_temperature_28_to_100cm	0.040
global_tilted_irradiance_instant	0.032
diffuse_radiation	0.028
cloud_cover	0.027
direct_radiation_instant	0.026
temperature_2m	0.025
pressure_msl	0.025
soil_temperature_100_to_255cm	0.021
direct_radiation	0.017
wind_speed_100m	0.017
et0_fao_evapotranspiration	0.017
terrestrial_radiation_instant	0.017
cloud_cover_high	0.016
diffuse_radiation_instant	0.015
surface_pressure	0.015
FFMC	0.014
direct_normal_irradiance_instant	0.014
relative_humidity_2m	0.014
cloud_cover_mid	0.012
wind_direction_100m	0.012
soil_temperature_0_to_7cm	0.010
apparent_temperature	0.010
terrestrial_radiation	0.009
soil_moisture_28_to_100cm	0.009
wind_gusts_10m	0.009
shortwave_radiation	0.006
vapour_pressure_deficit	0.005
global_tilted_irradiance	0.005
soil_moisture_0_to_7cm	0.005
direct_normal_irradiance	0.003
soil_moisture_100_to_255cm	0.003
dew_point_2m	0.002

Table 1.32: Variable Ranking

Variable	Rank
Temperature	-
Relative Humidity	-
Wind Speed	-
Rain	-
Soil Moisture	1
Soil Temperature	2
terrestrial_radiation	3
Pressure	4

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