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Instituto Sistemas Complejos de Ingeniería (ISCI)
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Cell2Fire+S&B Tutorial

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FIRE-RES

Table of Contents

1.- Requirements

Requirements

Ubuntu libraries

- **g++, write on terminal the following commands:**
  - `sudo apt-get update`
  - `sudo apt-get install g++`
- **Boost (c++), write on terminal the following commands:**
  - `sudo apt-get update`
  - `sudo apt-get install libboost-all-dev`
- **Eigen (c++), write on terminal the following commands**
  - `sudo apt-get update`
  - `sudo apt-get install libeigen3-dev`

Requirements

Python libraries

- **Python 3.6 or higher**
  - numpy
  - pandas
  - matplotlib
  - seaborn
  - tqdm
  - opencv
  - imread
  - networkx
- **It can all be installed after the installation with the instruction: pip install -r requirements.txt (see slide: Installation)**

2.- Installation

Installation

I. **Download Cell2Fire from Github (https://github.com/fire2a/C2FSB)**

II. **From the terminal, navigate to the containing folder of the downloaded file (For this tutorial it will be assumed that said folder is Desktop)**

III. **Write on terminal:**

- `cd Desktop/Cell2FireSB/Cell2FireC`

IV. **Check in the Makefile that the location of Eigen file is corrected entered according to your O.S.**

V. **Write on terminal:**

- `make`
- `cd ..`
- `pip install -r requirements.txt`

makefile on Ubuntu

```
EIGENDIR     = /usr/include/eigen3/
CC = g++
MPCC = g++
OPENMP = -openmp
CFLAGS = -std=c++11 -O3 -I$(EIGENDIR)
LIBS = -m64 -fPIC -fno-strict-aliasing -fexceptions -DNDEBUG -DIL_STD -lm -lpthread -ldl
TARGETS = Cell2Fire
all:	$(TARGETS)
Cell2Fire: Cell2Fire.o CellsFBP.o FuelModelSpain.o SpottingFBP.o ReadCSV.o ReadArgs.o Lightning.o WriteCSV.o Ellipse.o
	$(CC) -o $@ $(LIBS) Cell2Fire.o CellsFBP.o FuelModelSpain.o SpottingFBP.o ReadCSV.o ReadArgs.o Lightning.o WriteCSV.o Ellipse.o
Cell2Fire.o: Cell2Fire.cpp CellsFBP.o FuelModelSpain.o SpottingFBP.o ReadCSV.o ReadArgs.o WriteCSV.o
	$(CC) -c $(CFLAGS) Cell2Fire.cpp
SpottingFBP.o: SpottingFBP.cpp SpottingFBP.h CellsFBP.h
	$(CC) -c $(CFLAGS) SpottingFBP.cpp CellsFBP.h
CellsFBP.o: CellsFBP.cpp CellsFBP.h FuelModelSpain.o
	$(CC) -c $(CFLAGS) CellsFBP.cpp
ReadCSV.o: ReadCSV.cpp ReadCSV.h
	$(CC) -c $(CFLAGS) ReadCSV.cpp
ReadArgs.o: ReadArgs.cpp ReadArgs.h
	$(CC) -c $(CFLAGS) ReadArgs.cpp
Lightning.o: Lightning.cpp Lightning.h
	$(CC) -c $(CFLAGS) Lightning.cpp
Forest.o: Forest.cpp Forest.h
	$(CC) -c $(CFLAGS) Forest.cpp
WriteCSV.o: WriteCSV.cpp WriteCSV.h
	$(CC) -c $(CFLAGS) WriteCSV.cpp
Ellipse.o: Ellipse.cpp Ellipse.h
	$(CC) -c $(LIBS) $(CFLAGS) Ellipse.cpp
FuelModelSpain.o: FuelModelSpain.cpp FuelModelSpain.h
	$(CC) -c $(LIBS) $(CFLAGS) FuelModelSpain.cpp
clean:
	rm Lightning.o ReadArgs.o ReadCSV.o Cell2Fire.o CellsFBP.o Cell2Fire SpottingFBP.o Forest.o WriteCSV.o Ellipse.o FuelModelSpain.o *.gch
```

makefile on Mac

Cell2FireC — vi makefile — 56×29

...C — vi ReadCSV.cpp | ...2/Cell2FireC — -zsh | ...ireC — vi makefile | ...— vi ReadCSV.cpp

```
EIGENDIR = /usr/local/include/eigen3/
CC = g++-8 -I/usr/local/include
MPCC = g++-8 -I/usr/local/include
OPENMP = -openmp
CFLAGS = -std=c++11 -O3 -I$(EIGENDIR)
LIBS = -m64 -fPIC -fno-strict-aliasing -fexceptions -DNDEBUG -DIL_STD -lm -lpthread -ldl

TARGETS = Cell2Fire

all:	$(TARGETS)

Cell2Fire: Cell2Fire.o CellsFBP.o FuelModelSpain.o SpottingFBP.o ReadCSV.o ReadArgs.o Lightning.o WriteCSV.o Ellipse.o
	$(CC) -o $@ $(LIBS) Cell2Fire.o CellsFBP.o FuelModelSpain.o SpottingFBP.o ReadCSV.o ReadArgs.o Lightning.o WriteCSV.o Ellipse.o
```

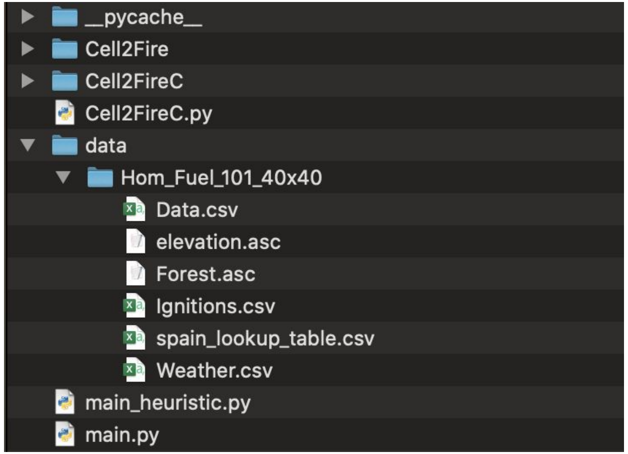
3.- Input Data

Landscape Data

Mandatory data

Landscape Input:

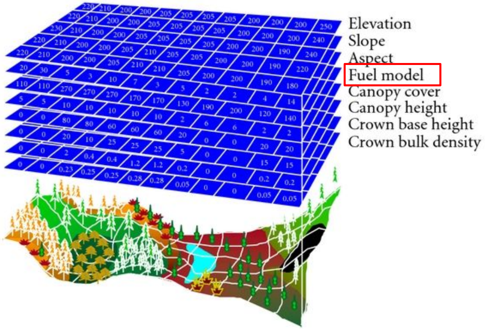
- ❏ fuels.asc
- ❏ elevation.asc
- ❏ Ignitions.csv
- ❏ spain_lookup_table.csv
- ❏ Weather.csv
- ❏ Data.csv



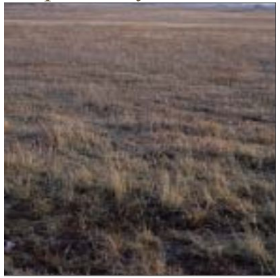
Scott & Burgan Fuel Models

- **fuels.asc**
  - Contains the type of fuel of each cell of the forest

ncols	20																		
nrows	20																		
xllcorner	457900																		
yllcorner	5716800																		
cellsize	100																		
NODATA_value	-9999																		
101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101
101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101
101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101
101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101
101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101
101	101	101	101	101	101	101	101	101	101	101	0	0	0	101	101	101	101	101	101
101	102	102	101	101	101	101	101	101	101	101	0	0	0	101	101	101	101	101	101
101	102	102	101	101	101	101	101	101	101	101	0	0	0	101	101	101	101	101	101
101	102	102	101	101	101	101	101	101	101	101	0	0	0	101	101	101	101	101	101
101	101	102	102	101	101	101	101	101	101	101	101	101	101	101	101	101	103	103	101
101	101	101	102	102	101	101	101	101	101	101	101	101	101	101	103	103	103	103	103
101	101	101	101	102	102	102	102	102	101	101	101	101	101	101	103	103	103	103	103
101	101	101	101	102	102	102	102	102	101	101	101	101	101	101	103	103	103	103	103
101	101	101	101	102	102	102	102	102	101	101	101	101	101	101	103	103	103	103	103
101	101	101	101	101	102	102	102	102	101	101	101	101	101	101	103	103	103	103	103
101	101	101	101	101	101	102	102	102	102	101	101	101	101	101	103	103	103	103	103
101	101	101	101	101	101	101	101	102	102	101	101	101	101	101	103	103	103	103	103
101	101	101	101	101	101	101	101	102	102	101	101	101	101	101	103	103	103	103	103
101	101	101	101	101	101	101	101	102	102	101	101	101	101	101	103	103	103	103	103
101	101	101	101	101	101	101	101	102	102	101	101	101	101	101	103	103	103	103	103



Short, Sparse Dry Climate Grass



Low Load, Dry Climate Grass

Low Load, Very Coarse, Humid Climate Grass

Non-Fuel

Forest Data
Mandatory data

- **spain_lookup_table.csv:**
  - Contains the reference for each type of fuel

grid_value	export_value	descriptive_name	fuel_type	r	g	b	h	s	l
101	101	The primary carrier of fire in GR1 is sparse grass though small amounts of fine dead fuel may be present	GR1	209	255	115	57	255	185
102	102	The primary carrier of fire in GR2 is grass though small amounts of fine dead fuel may be present	GR2	209	255	115	57	255	185
103	103	The primary carrier of fire in GR3 is continuous coarse humid-climate grass. Grass and herb fuel load is relatively light	GR3	34	102	51	95	128	68
104	104	The primary carrier of fire in GR4 is continuous dry climate grass	GR4	131	199	149	96	96	165
105	105	The primary carrier of fire in GR5 is humid climate grass	GR5	112	168	0	57	255	84
106	106	The primary carrier of fire in GR6 is continuous humid-climate grass	GR6	223	184	230	206	122	207
107	107	The primary carrier of fire in GR7 is continuous dry-climate grass	GR7	172	102	237	192	201	170
108	108	The primary carrier of fire in GR8 is continuous very coarse humid climate grass	GR8	112	12	242	188	231	127
121	121	The primary carrier of fire in GS1 is grass and shrubs combined	GS1	196	189	151	35	70	174
122	122	The primary carrier of fire in GS2 is grass and shrubs combined	GS2	137	112	68	27	86	103
123	123	The primary carrier of fire in GS3 is grass and shrubs combined	GS3	196	189	151	35	70	174
124	124	The primary carrier of fire in GS4 is grass and shrubs combined	GS4	251	190	185	3	227	218
142	142	The primary carrier of fire in SH2 is woody shrubs and shrub litter	SH2	247	104	161	-272	229	176
143	143	The primary carrier of fire in SH3 is woody shrubs and shrub litter	SH3	174	1	126	-285	252	88

Forest Data

Mandatory data

Fuel Moisture Scenarios

S_1	D1L1
S_2	D2L2
S_3	D3L3
S_4	D4L4

- **Weather.csv**
  - Contains the weather conditions of each hour of the fire event

Instance	datetime	WS	WD	FireScenario
Jaime	16-10-01 13:00	10	15	2
Jaime	16-10-01 14:00	15	20	2
Jaime	16-10-01 15:00	4	45	2
Jaime	16-10-01 16:00	8	30	2
Jaime	16-10-01 16:00	8	35	2

Forest Data

Complementary data

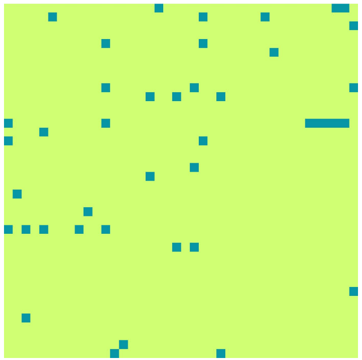
- **HarvestedCells.csv**
  - Contains the cells which will be treated as a firebreak; the format of the file is a column that signals the period of allocation of the firebreak, and another column signaling the firebreaks allocated in that period

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Year Numbei	Cell Numbers													
2	1	18	39	46	63	70	172	231	183	120	372	20	182	15	199
3															

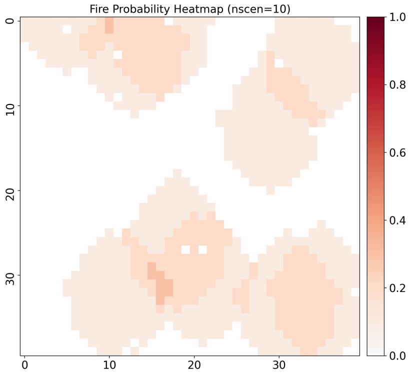
Forest Data

Complementary data

- **HarvestedCells.csv**
  - It is activated with the command –HarvestedCells data/XX/to_harvest_file.csv; the first part of the command activates the use of firebreaks, and the second one indicates the location of the .csv file shown on the previous slide
  - A forest with firebreaks looks like:



Initial forest with firebreaks



Heatmap of fire event in presence of firebreaks

Forest Data

Complementary data

- cur.csv
- elevation.asc
- saz.asc
- slope.asc
- py.asc

Fire Event Data

Ignition

- **Must contain year and cell of ignition:**
  - Ignitions.csv

	A	B
1	Year	Ncell
2	1	66850
3		

For Cell2Fire, a forest consists in a matrix of $n \times m$ cells, each numbered from 1 to N, with N the total number of cells in the forest ($n \times m$). For example, in a forest of dimension 3x3, each cell is identified according to the next figure (lexicographical order):

1	2	3	4
5	6	7	8
9	10	11	12

$n = 3$

$m = 4$

Fire Event Data

Weather

- **If more than one weather scenario is chosen, it is needed to create a folder named Weathers, which contains each one of this scenarios. Weathers must be numbered from 0, as the following image shows:**

> Este equipo > Escritorio > Cell2Fire > data > Sub40x40 > Weathers

Nombre	Estado	Fecha de modificación	Tipo	Tamaño
Weather0		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather1		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather2		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather3		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather4		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather5		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather6		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather7		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather8		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather9		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather10		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather11		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather12		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather13		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather14		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather15		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather16		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather17		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather18		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather19		29-10-2021 22:02	Archivo de valores se...	1 KB
Weather20		29-10-2021 22:02	Archivo de valores se...	1 KB

4.- Functionalities of Cell2Fire+S&B

Execute the simulator

- **Once Cell2Fire is installed and having the forest and fire event information, it is possible to simulate.**
- **For simulate it is needed to open the terminal and navigate to the folder that contains the file main.py**
- **Next, it is exposed an example of a command that generates a simulation scenario:**

```
python main.py -input-instance-folder ../data/Sub40x40/ -output-folder ../results/Sub40x40
-ignitions -sim-years 1 -nsims 5 -finalGrid -weather random -nweathers 1 -Fire-Period-Length
1.0 -output-messages -ROS-CV 0.0 -seed 123 -stats -allPlots -IgnitionRad 5 -grids -combine
```

Execute the simulator

- **Also, it is possible to simulate directly with C++, not using Python**
- **For this purpose, the existence of the Data.csv file is mandatory. If this file does not exists, only simulating via Python is possible, since the file is generated in there**
- **Besides, the use of this method does prohibits the generation of stats of graphs of the fire, since these are generated in Python estos se generan en python**
- **If Data.csv exists and it is wished to simulate via C++, it is needed to navigate through the terminal to the folder Cell2FireC**
- **In there, it is possible to simulate. Next, it is exposed and example of the same simulation shown in the previous slide but executed via C++:**

```
./Cell2Fire -input-instance-folder ../data/Sub40x40/ -output-folder ../results/Sub40x40
-ignitions -sim-years 1 -nsims 5 -finalGrid -weather random -nweathers 1 -Fire-Period-Length
1.0 -output-messages -ROS-CV 0.0 -seed 123 -stats -allPlots -IgnitionRad 5 -grids -combine
```

Execute the Simulator

Inputs details

- **–input-instance-folder ../data/Sub40x40/**
  - Indicates the source folder, which must contains the data required for simulation, in this example it is used the forest called Sub 40x40
- **–output-folder ../results/Sub40x40/**
  - Creates (if it does not exists) and fills a destination folder with the simulations results. In this case, the folder is called Sub 40x40
- **–ignitions**
  - Indicates if the origin of the fire event according to the ignition cell given in the Ignitions.csv. If the instruction is omitted, the fire will start in a random cell
- **–sim years 1**
  - Indicates the number of years to simulate, in this case is only 1 year

Execute the Simulator

Inputs details

- **–nsims 5**
  - Indicates the number of simulations to generate. In this case, 5 scenarios are simulated
- **–finalGrid**
  - Indicates if the user requests the final grid of each simulation. If the instruction is omitted, the final grid is not generated (unless the --grids instruction is entered)
- **–weather random**
  - Indicates how the weather scenario will be chosen. It can be “constant” (always will be selected the same) or random (a random selection will proceed in each simulation)
- **–nweathers 1**
  - Indicates the number of weather scenarios that will be chosen to simulate. It always must be less or equal to the number of Weather.csv files in the Weathers folder

Execute the Simulator

Inputs details

- **–Fire-Period-Lenght 1.0**
  - Signals the time window in which the simulator will go on, in this case, the progress of the fire is shown every 1 simulated hour
- **–output-messages**
  - Indicates if the user requires a file with messages per cell, with the time in which the cell ignites and its corresponding ROS. If it is omitted, the file will not be generated
- **–ROS-CV 0.0**
  - Indicates the variation coefficient for normal random ROS (for example 0..63), in this case 0.0 (deterministic scenario).
- **–seed 123**
  - Signals the random seed that will be used. In this case, the chosen seed is 123

Execute the Simulator

Inputs details

- **–stats**
  - Indicates if the user will require a statistical summary of the simulation results. If it is omitted, the files will not be generated
- **–allPlots**
  - Gives the order for the generation of all the fire event plots. If it is omitted, the plots are not generated
- **–IgnitionRad 5**
  - If the fire does not start randomly but given by the Ignitions.csv file, this instruction signals a radius of cells around said ignition point in which the fire can randomly start. In this case, the fire can start in any point around or inside 5 cells around the ignition cell given in the Ignitions.csv file.

Execute the Simulator

Inputs details

- **–grids**
  - Indicates if the user requires a folder of .csv files that represent the state (Ignition, not Ignition, or firebreak treatment) of each cell of the forest for each simulation period for each simulation (see Output Information Section)
- **–combine**
  - Combines the diagram of fire evolution with the graph that describes the landscape of the forest
- **…more inputs…**
  - Can be studied (and their default values) on …Cell2Fire/cell2fire/utils/ParseInputs.py

Simulation in Python

Subfunctions details

For simulating in Python, it is mandatory the use of the main.py script. Said script calls the Cell2Fire.py class that contains the following subfunctions:

- **init**
  - Initializer function of Cell2FireC object. Defines its characteristics: number of cells, number of columns, type of fuels, among others.
- **run/run_Heur**
  - Assigns the values according to the input entered on the terminal, and calls the simulator with said values
- **generateDataC**
  - Generates the Data.csv file that contains the information of the forest that will be used in the simulation

Simulation in Python

Subfunctions details

- **getData**
  - Reads the file that contains the fuel information of the forest (Forest.asc) and the table that links each fuel with its characteristics (spain_lookup_table.csv) for assign the values of the Cell2FireC object (number of cells, fuel type, etc.)
- **DummyMsg/DummyMsg_Heur**
  - Generates messages files that contain information on the state of the forest in each simulation
- **stats/stats_Heur**
  - Builds the statistics and graphs requested to the simulator

Simulation in Python

Subfunctions details

- **heur**
  - Initializes the heuristic object for the calculation of metrics such as Downstream Protection Value (DPV)

5.- Output Information

Output Information

Grids

❑ Grids folder

- ❑ Indicates the state of the forest in every simulated time window, for each one of the simulation required by the user. This state is shown through the forest grid. In this case, there are 8 time windows and 5 simulations

Este equipo > Escritorio > Cell2Fire > results > Sub40x40 > Grids

Nombre	Estado	Fecha de modificación	Tipo
Grids1	✓	19-11-2021 0:00	Carpeta de archivos
Grids2	✓	19-11-2021 0:00	Carpeta de archivos
Grids3	✓	19-11-2021 0:00	Carpeta de archivos
Grids4	✓	19-11-2021 0:00	Carpeta de archivos
Grids5	✓	19-11-2021 0:00	Carpeta de archivos

Este equipo > Escritorio > Cell2Fire > results > Sub40x40 > Grids > Grids1

Nombre	Estado	Fecha de modificación	Tipo	Tamaño
ForestGrid00	✓	19-11-2021 0:00	Archivo de valores se...	4 KB
ForestGrid01	✓	19-11-2021 0:00	Archivo de valores se...	4 KB
ForestGrid02	✓	19-11-2021 0:00	Archivo de valores se...	4 KB
ForestGrid03	✓	19-11-2021 0:00	Archivo de valores se...	4 KB
ForestGrid04	✓	19-11-2021 0:00	Archivo de valores se...	4 KB
ForestGrid05	✓	19-11-2021 0:00	Archivo de valores se...	4 KB
ForestGrid06	✓	19-11-2021 0:00	Archivo de valores se...	4 KB
ForestGrid07	✓	19-11-2021 0:00	Archivo de valores se...	4 KB

Si solo se indica –finalGrid, solo se genera el último grid. En este caso solo se generaría el archivo ForestGrid07.csv en cada uno de los 5 incendios

Output Information

Grids

- **ForestGridXX.csv Files**
  - Indicates the state of the forest. A 1 represents a burned cell, a 0 represents a non burned cell and a -1 represents a firebreak cell

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
13	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
14	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
15	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
16	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
17	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
18	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
19	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
20	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
21	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

Output Information

Stats

❑ FinalStats.csv

- ❑ Indicates some stats of the simulations, like the percentage of burned cells, non burned cells and firebreak cells

	A	B	C	D	E	F	G
1	ID	NonBurned	Burned	Harvested	%NonBurnec	%Burned	%Harvested
2	1	1288	312	0	0.805	0.195	0
3	2	1156	444	0	0.723	0.278	0
4	3	1130	470	0	0.706	0.294	0
5	4	1336	264	0	0.835	0.165	0
6	5	1054	546	0	0.659	0.341	0
7							

Output Information

Stats

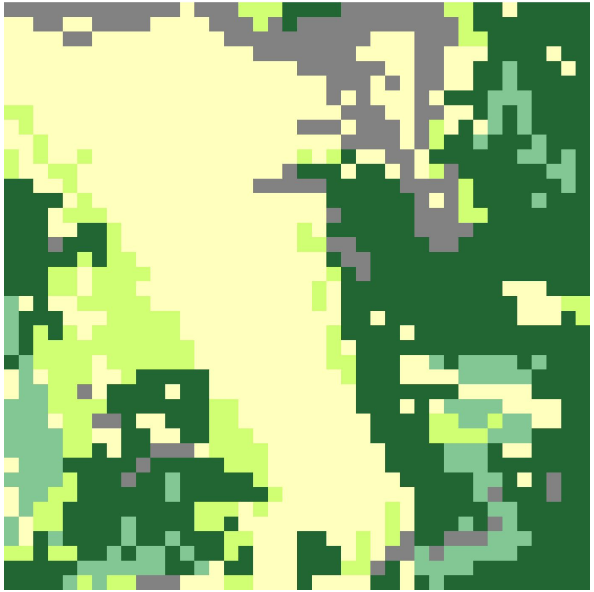
- **GeneralSummary.csv**
  - Gives a statistical summary of some metrics (average, median, maximum, etc) across all the simulations

	A	B	C	D	E	F	G	H
1		ID	NonBurned	Burned	Harvested	%NonBurnec	%Burned	%Harvested
2	count	5	5	5	5	5	5	5
3	mean	3	1192.8	407.2	0	0.746	0.255	0
4	std	1.581	116.332	116.332	0	0.073	0.073	0
5	min	1	1054	264	0	0.659	0.165	0
6	25%	2	1130	312	0	0.706	0.195	0
7	50%	3	1156	444	0	0.723	0.278	0
8	75%	4	1288	470	0	0.805	0.294	0
9	max	5	1336	546	0	0.835	0.341	0

Output Information

Plots

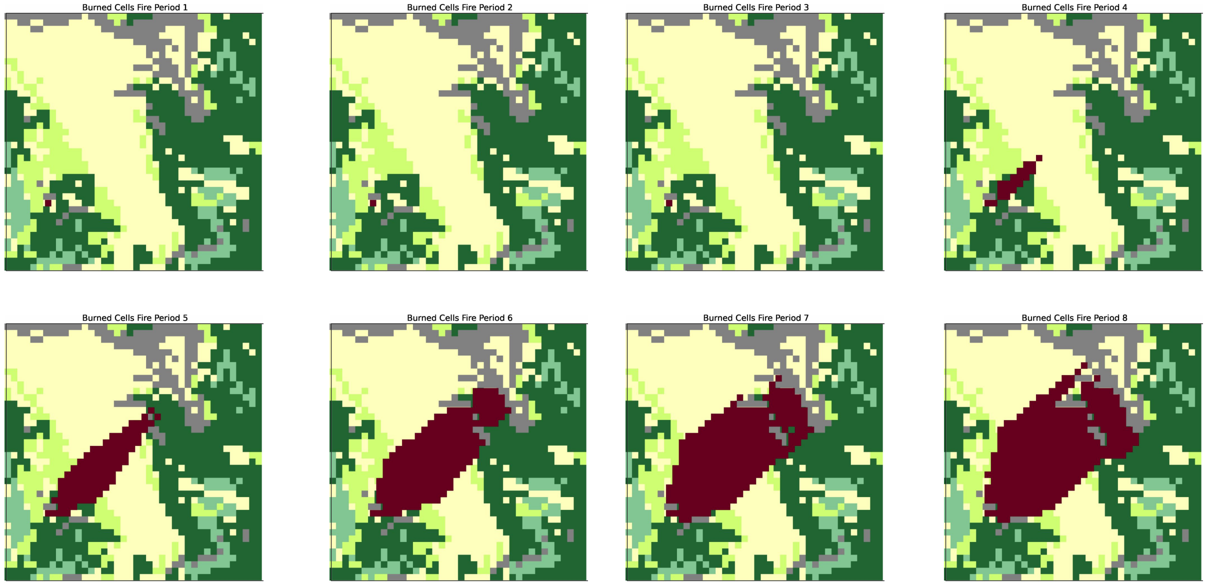
- **InitialForest**
  - Shows the original landscape of the forest



Output Information

Plots

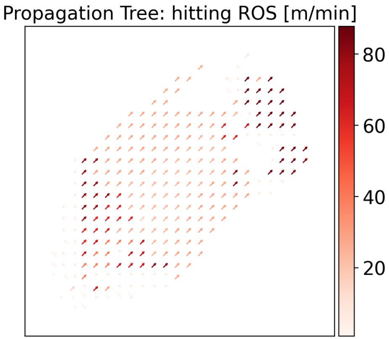
- **Fire evolution on landscape plots**
  - Shows the temporary evolution of the fire in each simulated time window



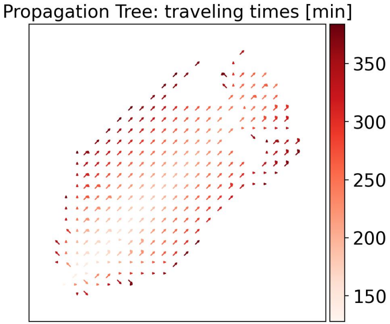
Output Information

Plots

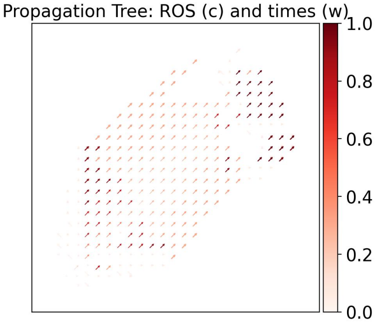
- **Fire Spread Tree**
  - Shows different fire propagation metrics



Hitting Ros



Travelling Times

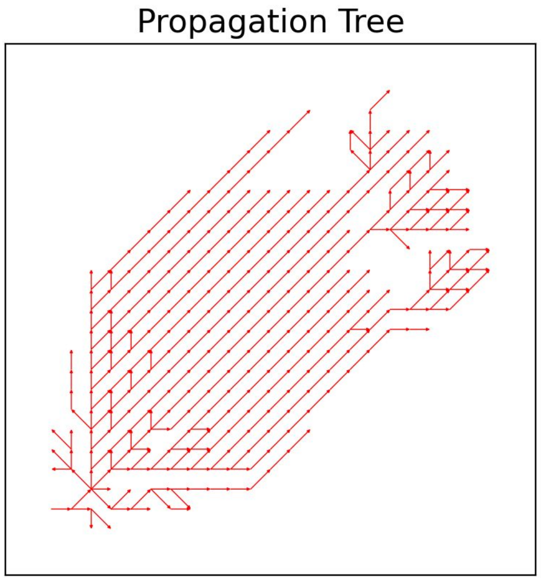


Ros and times

Output Information

Plots

- **Propagation Tree**
  - Shows the fire evolution through a propagation tree

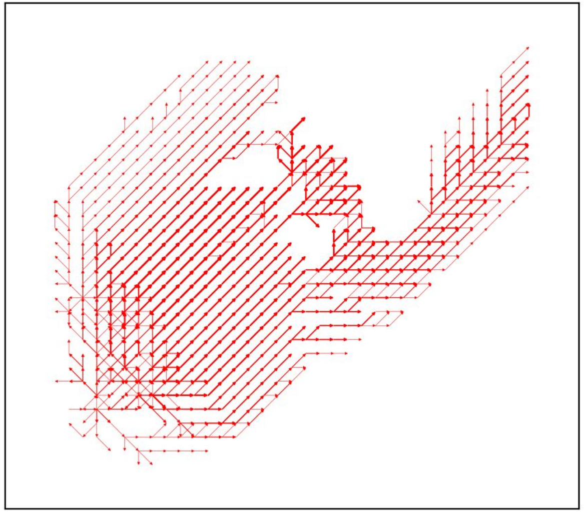


Output Information

Plots

- **Global Propagation Tree**
  - Shows the fire evolution across all simulations through a global propagation tree

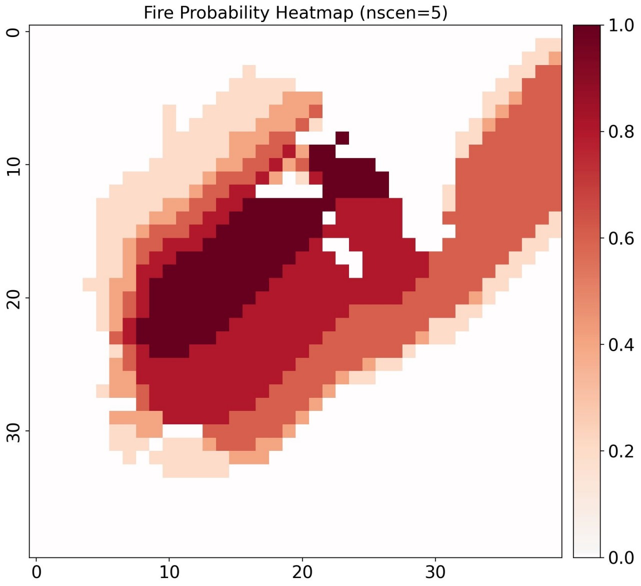
Global Propagation Tree GT ($|R| =$ 5)



Output Information

Plots

- **Burn Probability Map**
  - Shows the ignition probability of each zone of the forest according to the burn frequency across all of the simulations



6.- Anexxes

Types of Fires

ground fire

surface fire

More intense

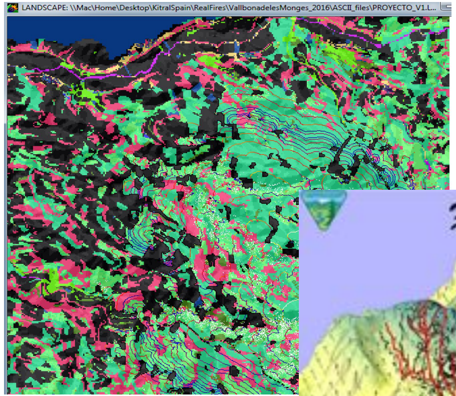
crown fire

More dangerous

- ❑ We are interested in surface and crown fires.
- ❑ Missing studies of the behavior of fire in the crown (we are studying this problem)

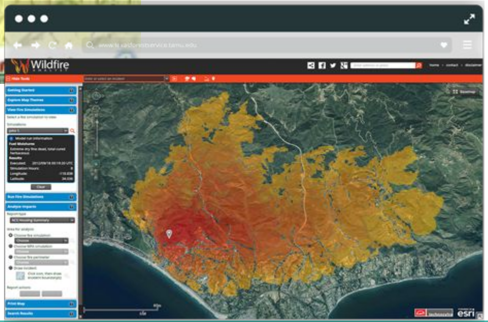
State-of-the-art simulators

FARSITE

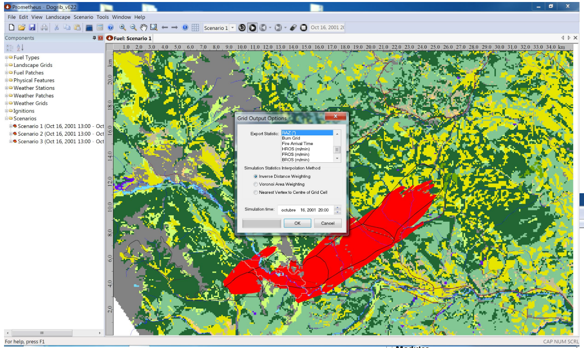


FlamMap

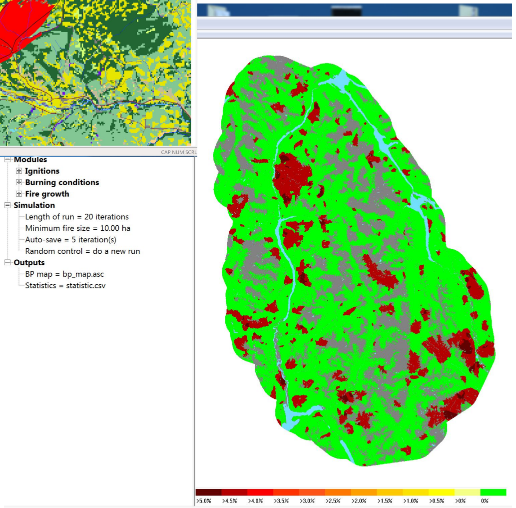
Wildfire Analyst



Prometheus

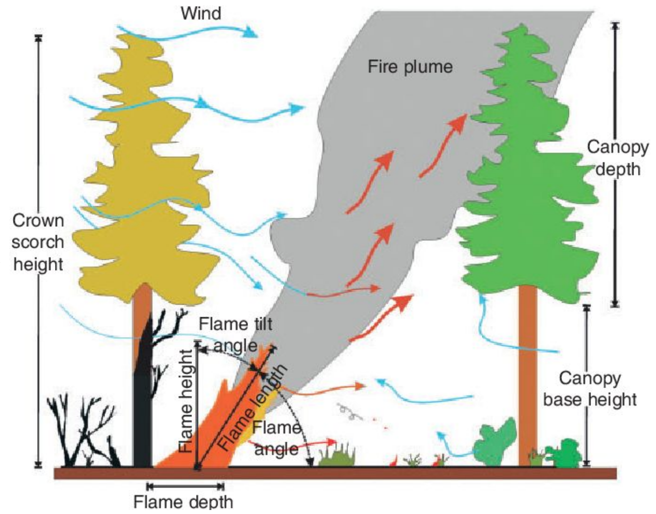


Burn-P3

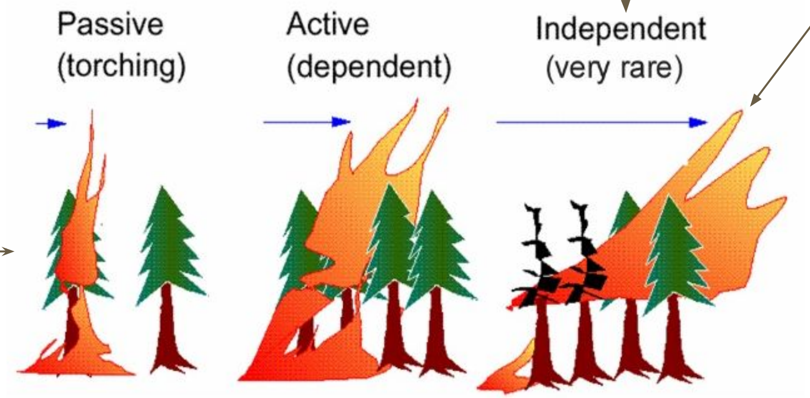


Crown Fire Models
Stages

1. Crown fire Initiation
2. Crown fire behavior
3. Spread of crown fire



$ROS_{active} = ?$



Scott and Burgan Fuels Models

Group	Code	Nombre descriptivo
Nearly pure grass and/or forb type	Gr1 Gr2 Gr3 Gr4 Gr5 Gr6 Gr7 Gr8 Gr9	• Short Grass, patchy, and possibly heavily grazed. Arid or semiarid climate, Spread rate moderate, flame lenght low • Moderately coarse continuous grass, average depth about 1 foot. Arid o semiarid climate, Spread rate high, flame length moderate. • Very coarse grass, average depth about 2 feet. Subhumid to humid climate, Spread rate high; flame length moderate. • Moderately coarse continuous grass, average depth about 2 foot. Arid o semiarid climate, Spread rate high, flame length high. • Dense, coarse grass, average depth about 1 to 2 feet. Subhumid to humid climate, Spread rate very high; flame length high. • Dryland grass about 1 to 2 feet tall. Subhumid to humid climate, Spread rate very high; flame length very high. • Moderately coarse continuous grass, average depth about 3 feet. Arid o semiarid climate, Spread rate very high, flame length very high. • Heavy, coarse, continuous grass 3 to 5 feet tall. Subhumid to humid climate, Spread rate very high; flame length very high • Very heavy, coarse, continuous grass 5 to 8 feet tall. Subhumid to humid climate, Spread rate extreme; flame length extreme.

Group	Code	Nombre descriptivo
Mixture of grass and shrub, up to about 50 percent shrub coverage (GrassShrub)	Gs1 Gs2 Gs3 Gs4	• Shrubs are about 1 foot high, low grass load. Arid or semiarid climate, Spread rate moderate; flame length low. • Shrubs are 1 to 3 feet high, moderate grass load. Arid or semiarid climate, Spread rate high; flame length moderate. • Moderate grass/shrub load, average grass/shrub depth less than 2 feet. Subhumid to humid climate. Spread rate high; flame length moderate. • Heavy grass/shrub load, depth greater than 2 feet. Subhumid to humid climate, Spread rate high; flame length very high.

Group	Code	Nombre descriptivo
Shrubs cover at least 50 percent of the site; grass sparse to nonexistent (Shrub)	Sh1 Sh2 Sh3 Sh4 Sh5 Sh6 Sh7 Sh8 Sh9	• Low shrub fuel load, fuelbed depth about 1 foot; some grass may be present. Spread rate very low; flame length very low. • Moderate fuel load (higher than SH1), depth about 1 foot, no grass fuel present. Spread rate low; flame length low. • Moderate shrub load, possibly with pine overstory or herbaceous fuel, fuel bed depth 2 to 3 feet. Spread rate low; flame length low. • Low to moderate shrub and litter load, possibly with pine overstory, fuel bed depth about 3 feet. Spread rate high; flame length moderate. • Heavy shrub load, depth 4 to 6 feet. Spread rate very high; flame length very high. • Dense shrubs, little or no herb fuel, depth about 2 feet. Spread rate high; flame length high. • Very heavy shrub load, depth 4 to 6 feet. Spread rate lower than SH5, but flame length similar. Spread rate high; flame length very high. • Dense shrubs, little or no herb fuel, depth about 3 feet. Spread rates high; flame length high. • Dense, finely branched shrubs with significant fine dead fuel, about 4 to 6 feet tall; some herbaceous fuel may be present. Spread rate high, flame length very high.

Group	Code	Nombre descriptivo
Grass or shrubs mixed with litter from forest canopy (Timber-Understory)	TU1 TU2 TU3 TU4 TU5	● Fuelbed is low load of grass and/or shrub with litter. Spread rate low; flame length low. ● Fuelbed is moderate litter load with shrub component. Spread rate moderate; flame length low. ● Fuelbed is moderate litter load with grass and shrub components. Spread rate high; flame length moderate. ● Fuelbed is short conifer trees with grass or moss understory. Spread rate moderate; flame length moderate. ● Fuelbed is high load conifer litter with shrub understory. Spread rate moderate; flame length moderate.

Group	Code	Nombre descriptivo
Dead and down woody fuel (litter) beneath a forest canopy (Timber Litter)	TL1 TL2 TL3 TL4 TL5 TL6 TL7 TL8 TL9	● Light to moderate load, fuels 1 to 2 inches deep. Spread rate very low; flame length very low. ● Low load, compact. Spread rate very low; flame length very low. ● Moderate load conifer litter. Spread rate very low; flame length low. ● Moderate load, includes small diameter downed logs. Spread rate low; flame length low ● High load conifer litter; light slash or mortality fuel. Spread rate low; flame length low. ● Moderate load, less compact. Spread rate moderate; flame length low. ● Heavy load, includes larger diameter downed logs. Spread rate low; flame length low. ● Moderate load and compactness may include small amount of herbaceous load. Spread rate moderate; flame length low. ● Very high load broadleaf litter; heavy needle-drape in otherwise sparse shrub layer. Spread rate moderate; flame length moderate.

Group	Code	Nombre descriptivo
Activity fuel (slash) or debris from wind damage (blowdown) (Slash-Blowdown)	SB1 SB2 (fuelbed is activity fuel) SB2 (fuelbed is blowdown) SB3 (fuelbed is activity fuel) SB3 (fuelbed is blowdown) SB4	• Fine fuel load is 10 to 20 tons/acre, weighted toward fuels 1 to 3 inches diameter class, depth is less than 1 foot. Spread rate moderate; flame length low. • Fine fuel load is 7 to 12 tons/acre, evenly distributed across 0 to 0.25, 0.25 to 1, and 1 to 3 inch diameter classes, depth is about 1 foot. Spread rate moderate; flame length moderate. • Blowdown is scattered, with many trees still standing. Spread rate moderate; flame length moderate. • Fine fuel load is 7 to 12 tons/acre, weighted toward 0 to 0.25 inch diameter class, depth is more than 1 foot. Spread rate high; flame length high. • Blowdown is moderate, trees compacted to near the ground. Spread rate high; flame length high. • Blowdown is total, fuelbed not compacted, foliage still attached. Spread rate very high; flame length very high.

Group	Code	Nombre descriptivo
Insufficient wildland fuel to carry wildland fire under any condition (Nonburnable)	NB1 NB2 NB3 NB8 NB9	• Urban or suburban development; insufficient wildland fuel to carry wildland fire. • Snow/ice. • Agricultural field, maintained in nonburnable condition. • Open water. • Bare ground.

Byram's equation

- The quantity of fuel consumed in a wildland fire varies widely, depending on the fuel or vegetation type (Stocks and Kauffman, 1997).
- Fuel consumption can vary over two orders of magnitude from 0.1 kg/m2 (representing, for example, a gentle surface fire consuming the leaf litter in a hardwood stand in the spring or fall), to more than 10 kg/m2 (associated with the high-intensity burning of a heavy blow-down fuel complex).

Rate of Spread [m/s]

Net low heat of combustion [kJ/kg]

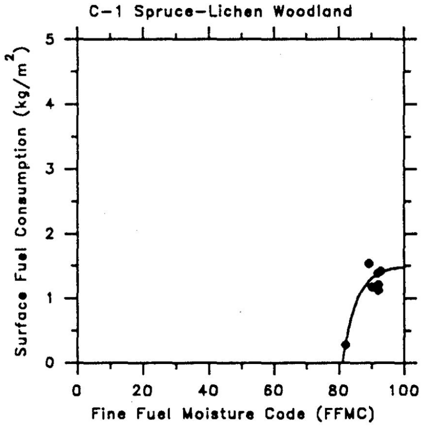
Fireline intensity [kW/m]

$$I_B = H \cdot w_a \cdot ROS$$

Amount of fuel consumed [kg/m2]

- Surface
- Surface + Crown

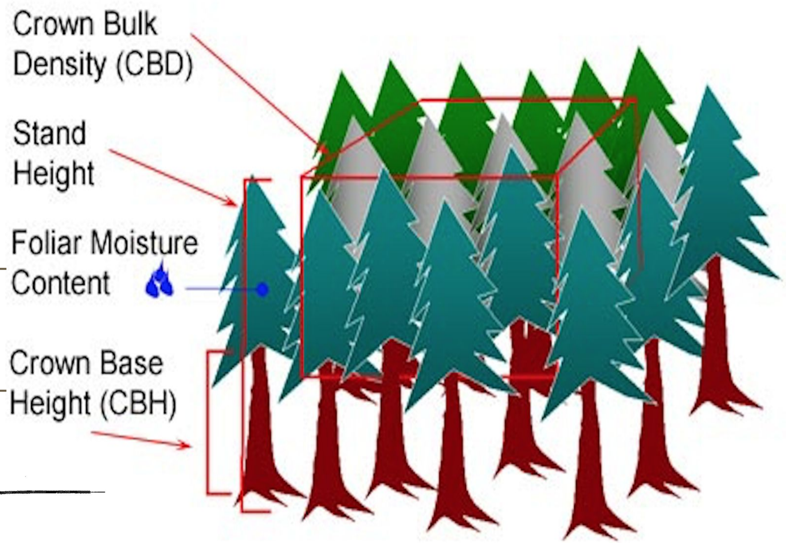
Example (FBP System):



Crown fire initiation

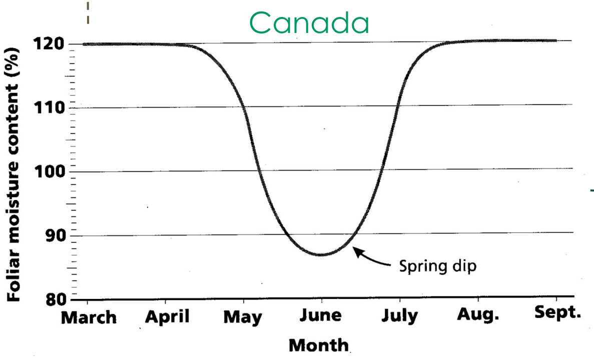
Critical surface fire intensity (CSI) (Van Wagner (1977)):

$$I_0 = 0.001 \cdot CBH^{1.5} \cdot (460.0 + 25.9 \cdot FMC)^{1.5}$$



If $I_B > I_0$ imply crown initiation.

If $I_B \leq I_0$ imply surface fire.



In Spain??

Crown Fire Behavior

Examples

Critical surface rate of spread (RSO)

$$RSO = \frac{I_0}{300 \cdot SFC}$$

FBP System:

Crown fraction burned (CFB):

$$CFB = 1 - e^{0.23 \cdot (ROS - RSO)}$$

$CFB < 0.1$ ⇨ surface fire

$0.1 \leq CFB \leq 0.9$ ⇨ intermittent crown fire

$CFB > 0.9$ ⇨ continuous crown fire

Behave System

$$\left.\begin{array}{l} I > I_0 \\ ROS < RSO \end{array}\right\} \Rightarrow \text{passive crown fire}$$

$$\left.\begin{array}{l} I > I_0 \\ ROS > RSO \end{array}\right\} \Rightarrow \text{active crown fire}$$

Spread of Crown Fire

Crown fraction burned (CFB):

$$CFB = 1 - e^{0.23 \cdot (ROS - RSO)}$$

Van Wagner (1989):

Foliar Moisture Effect (FME):

$$FME = 1000 \cdot \frac{(1.5 - 0.00275 \cdot FMC)^4}{460 + 25.9 \cdot FMC}$$

Crown fire spread rate (RSC):
(Activo)

$$RSC = 77.1208 \cdot (1.0 - e^{-0.0497 \cdot ISI}) \cdot FME$$

Rothermel (1991):

Surface

$$ROS_{active} = 3.34 \cdot (ROS_{FM10})_{40\% \cdot WS}$$

Finney (1993):

$$ROS_{active} = ROS_{surface} + CFB \cdot (\max ROS_{active} - ROS_{surface})$$

1.7 times of Rothermel's ROS-active

Critical horizontal mass-flow rate of fuel into the flaming zone S:

$$S := ROS_{active} \cdot CBD > 0.05$$

Moisture Content Scenarios

Scott & Burgan (2005) (S&P):

	FMS Code	FMS Description	Fuel Moisture Content (%)						
			Herb	Shrub	Crown [1]	1 h	10 h	100 h	
S_1	D1L1	Very low dead FMC, fully cured herb	30	60	60	3	4	5	$HROS_{S_1}$
S_2	D2L2	Low dead FMC, 2/3 cured herb	60	90	60	6	7	8	$HROS_{S_2}$
S_3	D3L3	Moderate dead FMC, 1/3 cured herb	90	120	120	9	10	11	$HROS_{S_3}$
S_4	D4L4	High dead FMC, fully green herb	120	150	150	12	13	14	$HROS_{S_4}$

[1] The Scott and Burgan original FMSs do not include FMCs for Crown. These data were extracted from the description of the variables inside the FCCS software.

Foliar Moisture Content (FMC)

BehavePlus Fire Modeling System

American Behave System

Experiences in Spain (Catalonia), Fuel Moisture Scenarios

BehavePlus 6.0.0 (Build 626 Beta 3)

D1L1

Input Worksheet

Inputs: SURFACE

Input Variables	Units	Input Value(s)
Fuel/Vegetation, Surface/Understory		
Fuel Model		10, 101, 102, 103, 104, 105, 106, 107, 108, 121, 122, 123, 124, 142, 143, 144, 145, 146, 147, 148, 149, 161, 162, 163, 164, 165, 181, 182, 183, 185, 186, 188, 189
Fuel Moisture		
1-h Fuel Moisture	%	3
10-h Fuel Moisture	%	4
100-h Fuel Moisture	%	5
Live Herbaceous Fuel Moisture	%	30
Live Woody Fuel Moisture	%	60
Weather		
Midflame Wind Speed (upslope)	km/h	0,1, 5, 10,15, 20,25, 30,35, 40,45, 50,55, 60
Terrain		
Slope Steepness	%	0
Fire		
Surface Fire Spread Direction (from upslope)	deg	0
Notes		

BehavePlus 6.0.0 (Build 626 Beta 3)

D2L2

Input Worksheet

Inputs: SURFACE

Input Variables	Units	Input Value(s)
Fuel/Vegetation, Surface/Understory		
Fuel Model		10, 101, 102, 103, 104, 105, 106, 107, 108, 121, 122, 123, 124, 142, 143, 144, 145, 146, 147, 148, 149, 161, 162, 163, 164, 165, 181, 182, 183, 185, 186, 188, 189
Fuel Moisture		
1-h Fuel Moisture	%	6
10-h Fuel Moisture	%	7
100-h Fuel Moisture	%	8
Live Herbaceous Fuel Moisture	%	60
Live Woody Fuel Moisture	%	90
Weather		
Midflame Wind Speed (upslope)	km/h	0,1, 5, 10,15, 20,25, 30,35, 40,45, 50,55, 60
Terrain		
Slope Steepness	%	0
Fire		
Surface Fire Spread Direction (from upslope)	deg	0

American Behave System

Experiences in Spain (Catalonia), Fuel Moisture Scenarios

BehavePlus 6.0.0 (Build 626 Beta 3)

D3L3 int 1:23

Input Worksheet

Inputs: SURFACE

Input Variables	Units	Input Value(s)
Fuel/Vegetation, Surface/Understory		
Fuel Model		10, 101, 102, 103, 104, 105, 106, 107, 108, 121, 122, 123, 124, 142, 143, 144, 145, 146, 147, 148, 149, 161, 162, 163, 164, 165, 181, 182, 183, 185, 186, 188, 189
Fuel Moisture		
1-h Fuel Moisture	%	9
10-h Fuel Moisture	%	10
100-h Fuel Moisture	%	11
Live Herbaceous Fuel Moisture	%	90
Live Woody Fuel Moisture	%	120
Weather		
Midflame Wind Speed (upslope)	km/h	0,1, 5, 10,15, 20,25, 30,35, 40,45, 50,55, 60
Terrain		
Slope Steepness	%	0
Fire		
Surface Fire Spread Direction (from upslope)	deg	0

BehavePlus 6.0.0 (Build 626 Beta 3)

D4L4 nt :00

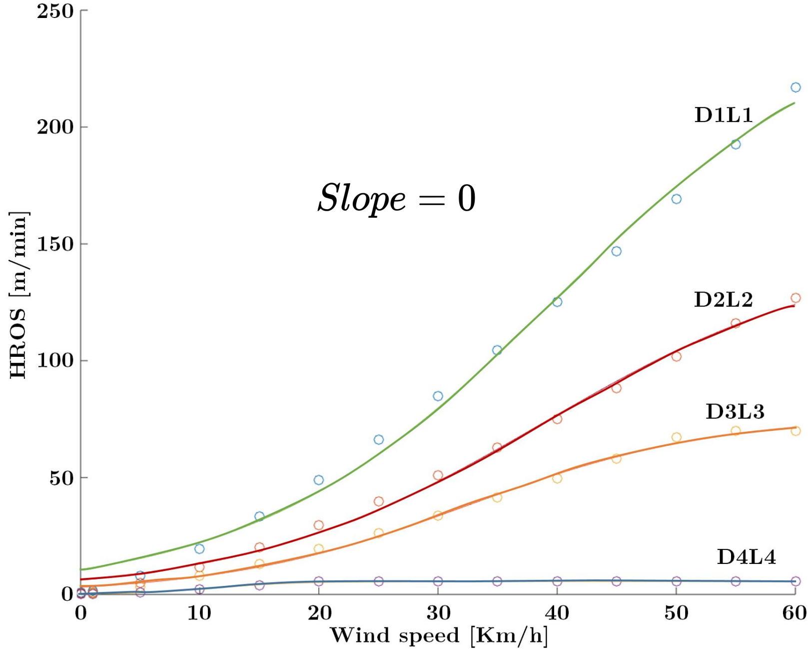
Input Worksheet

Inputs: SURFACE

Input Variables	Units	Input Value(s)
Fuel/Vegetation, Surface/Understory		
Fuel Model		10, 101, 102, 103, 104, 105, 106, 107, 108, 121, 122, 123, 124, 142, 143, 144, 145, 146, 147, 148, 149, 161, 162, 163, 164, 165, 181, 182, 183, 185, 186, 188, 189
Fuel Moisture		
1-h Fuel Moisture	%	12
10-h Fuel Moisture	%	13
100-h Fuel Moisture	%	14
Live Herbaceous Fuel Moisture	%	120
Live Woody Fuel Moisture	%	150
Weather		
Midflame Wind Speed (upslope)	km/h	0,1, 5, 10,15, 20,25, 30,35, 40,45, 50,55, 60
Terrain		
Slope Steepness	%	0
Fire		
Surface Fire Spread Direction (from upslope)	deg	0

Moisture Content Scenarios

HROS Fuel Model 163



Fuel Moisture Scenarios

- D1L1
- D2L2
- D3L3
- D4L4

$$\vec{p} = (p_1, p_2, p_3)$$

$$\boxed{HROS\,(WS, \vec{p}) = \frac{1}{p_1 exp(-p_2 WS) + p_3}}$$

Fuel Model

$$\vec{p} = f(FM, S_x)$$

Scenario

Moisture Content Scenarios (Cell2Fire+S&P)

```
jaimecarrasco2@iMac-de-Jaime Cell2FireC % ls
Cell2Fire.cpp        Forest.h              ReadArgs.h
Cell2Fire.h          FuelModelSpain.cpp    ReadCSV.cpp
CellsFBP.cpp         FuelModelSpain.h      ReadCSV.h
CellsFBP.h           Icon?                 SpottingFBP.cpp
DataGeneratorC.py    Lightning.cpp         SpottingFBP.h
Ellipse.cpp          Lightning.h           WriteCSV.cpp
Ellipse.h            Makefile              WriteCSV.h
Forest.cpp           ReadArgs.cpp
```

Cell2Fire+S&P

```
void initialize_coeff(int scenario)
{
        if (scenario == 1){
                // Populate them
                // FM101
                int F101 = 101;
                std::vector<float> p_101;
                p_101.push_back(2.575);
                p_101.push_back(0.6665);
                p_101.push_back(0.1096);
```

S_1

Fuel model	p_1	p_2	p_3	R-square
10	0.2802	0.07786	0.01123	0.99
101	2.575	0.6665	0.1096	0.99
102	0.4218	0.2915	0.01212	0.99
103	0.1638	0.2095	0.007809	0.99
104	0.07138	0.1417	0.002243	0.99
105	0.03548	0.07829	0.001524	0.99
106	0.02469	0.08049	0.0008245	0.99
107	0.02329	0.09086	0.0009262	0.99
108	0.02111	0.07793	0.001174	0.99
121	0.613	0.2139	0.0187	0.99
122	0.195	0.1243	0.006478	0.99
123	0.06515	0.07833	0.002831	0.99
124	0.07867	0.07788	0.003431	0.99
142	0.3505	0.07768	0.01498	0.99
143	1.748	0.1589	0.08249	0.99

• • •

S_3

Fuel model	p_1	p_2	p_3	R-square
10	0.5731	0.07802	0.02293	0.99
101	10.54	0.9248	0.6665	0.99
102	9.046	0.6935	0.6243	0.99
103	1.101	0.2945	0.05263	0.99
104	2.828	0.4191	0.1083	0.9982
105	0.2066	0.09646	0.008649	0.99
106	0.1252	0.07909	0.004167	0.99
107	0.2693	0.1079	0.009412	0.99
108	0.09611	0.07795	0.005342	0.99
121	25.52	0.7635	1.428	0.99
122	8.922	0.4899	0.3328	0.99
123	5.884	0.3888	0.2259	0.99
124	0.6756	0.07785	0.02949	0.99
142	10.39	0.2182	0.3807	0.99
143	5.59	0.2107	0.254	0.99

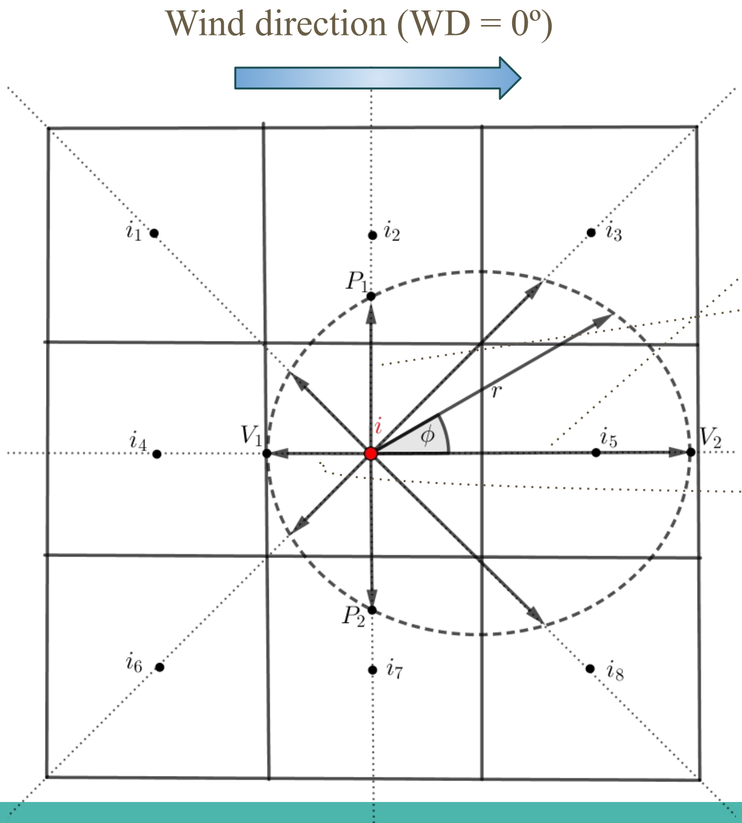
• • •

Cell2Fire+S&P

```
        if (scenario == 3){

                // Populate them
        // FM 101
                int F101 = 101;
                std::vector<float> p_101;
                p_101.push_back(10.54);
                p_101.push_back(0.9248);
                p_101.push_back(0.6665);
```

Elliptical Propagation



- Head ROS (HROS): ROS in the wind direction.

  HROS = ROS(0º)

- Flank ROS (FROS): 90º ROS w.r.t. wind direction.

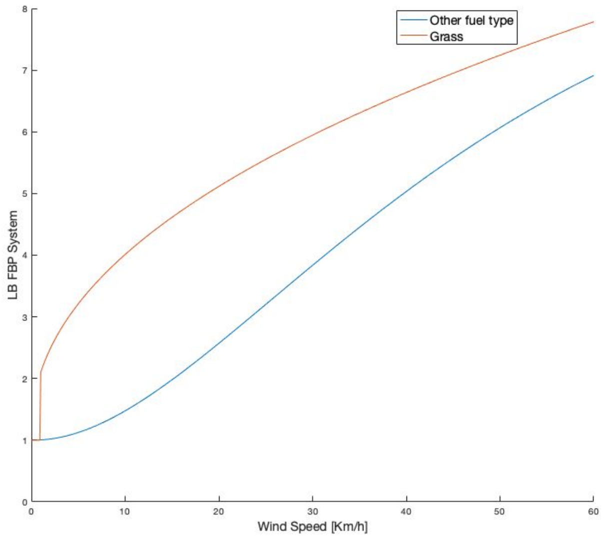
  FROS = ROS(90º)

- Back ROS (BROS): 180º ROS w.r.t. wind direction.

  BROS = ROS(180º)

$$\boxed{r(\phi) = ROS(\phi)}$$

Elliptical Propagation

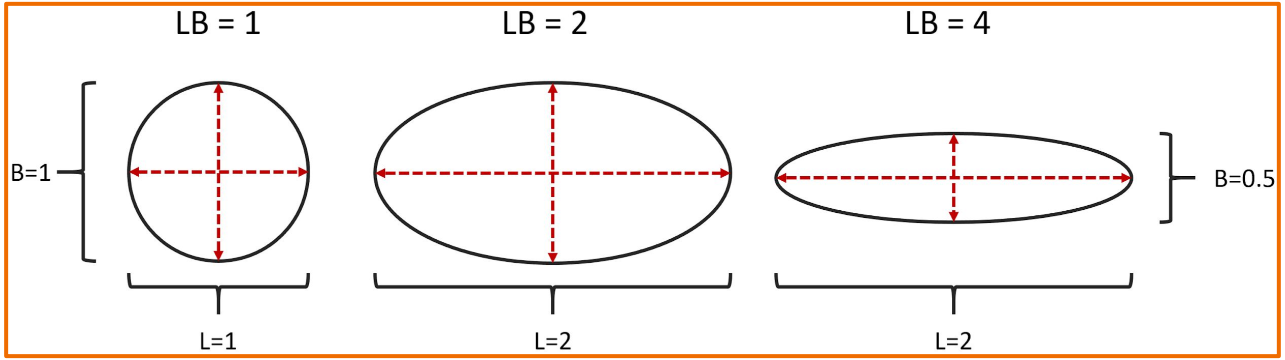


- Length-to-breadth (LB) ratio represents the ellipse deformation as a function of wind speed (WS) and depends of fuel type.
- In FBP System, for almost forest fuels, except for those of grass fuel types denoted by O-1a and O-1b, it is used the eq.:

$$LB(WS) = 1 + 8.729[1 - exp(-0.03WS)]^{2.155}$$

- For grass fuel types O-1a and O-1b, it is used the eq.:

$$LB(WS) = \begin{cases} 1.1 + WS^{0.464}, & WS \geq 1.0, \\ 1.0, & WS < 1.0. \end{cases}$$



Elliptical Propagation

Step 2

Step 1

$$BROS\,(WS) = HROS\,(WS)/HB\,(WS)$$

$$HB\,(WS) = \frac{LB(WS)+\left(LB(WS)^2-1\right)^{0.5}}{LB(WS)-\left(LB(WS)^2-1\right)^{0.5}}$$

$$FROS\,(WS) = \frac{HROS(WS)+BROS(WS)}{2LB}$$

Step 3

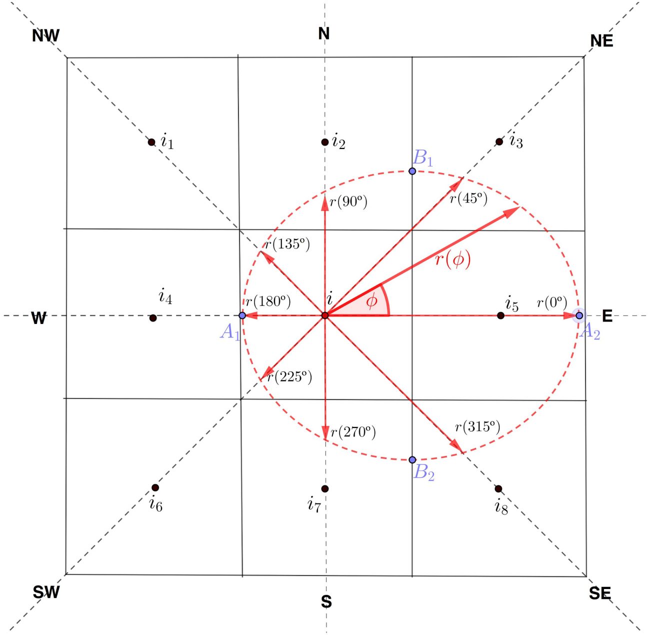
Elliptical Propagation

Cell2Fire calculates the ROS towards the 8 directions where the neighboring cells are located. We denote by ROS_{ij} the fire that travels from cell i to cell j and let *Adj(i)* the set of adjacent cells to i. Each adjacent cell to i corresponds to an angle $\phi \in \{0^o, \ldots, 315^o\}$ by a step of 45^o.

$$a(WS,t) = \frac{HROS(WS) + BROS(WS)}{2} \cdot t \qquad b(WS,t) = FROS(WS) \cdot t$$

$$c(WS,t) = \frac{HROS(WS) - BROS(WS)}{2} \cdot t \qquad e(WS,t) = c(WS,t)/a(WS,t)$$

$$r(\phi) = \frac{a(1-e^2)}{(1-e \cdot \cos\phi)}$$



$$\begin{aligned}
ROS_{i,i_5} &= r(0^o),\\
ROS_{i,i_3} &= r(45^o),\\
ROS_{i,i_2} &= r(90^o),\\
ROS_{i,i_1} &= r(135^o),\\
ROS_{i,i_4} &= r(180^o),\\
ROS_{i,i_6} &= r(225^o),\\
ROS_{i,i_7} &= r(270^o),\\
ROS_{i,i_8} &= r(315^o)
\end{aligned}$$

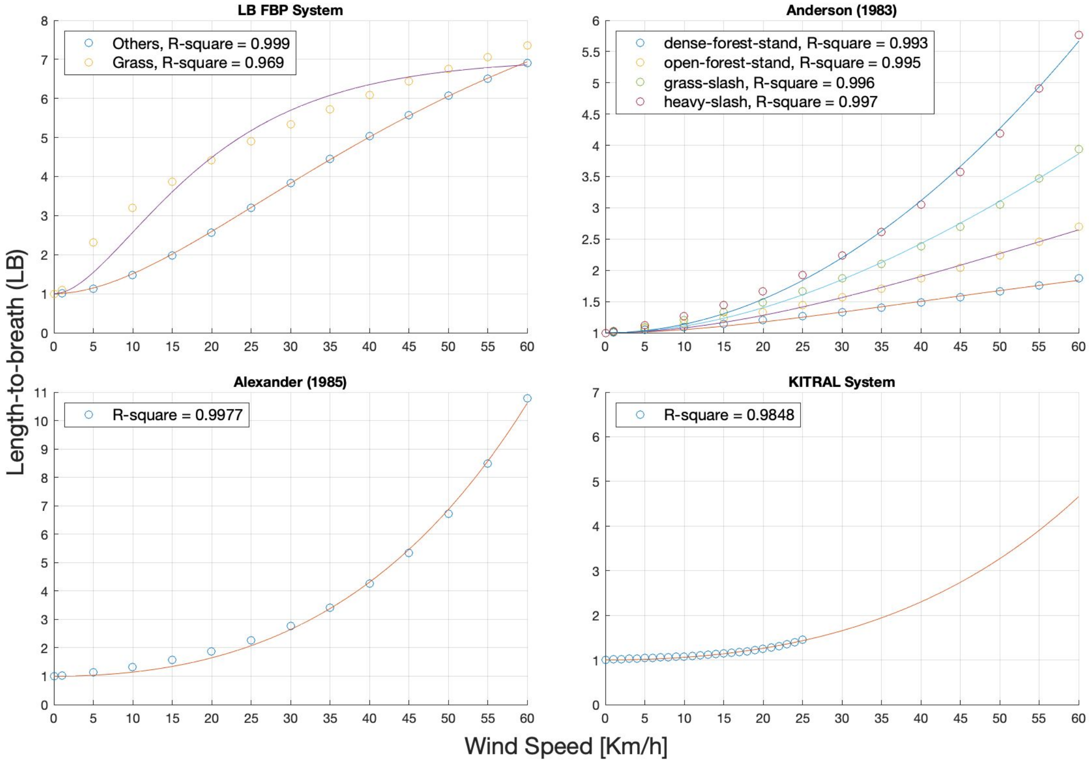
Elliptical Propagation

$$LB\left(WS, \vec{lb}\right) = 1.0 + \left[l_1\left(1 - exp(-l_2 \cdot WS)\right)\right]^2$$

Cell2Fire+KITRAL

```
/* ----------------- Length-to-Breadth -------------------------*/
float l_to_b(float ws, fuel_coefs *ptr)
  {
    float l1, l2, lb ;
            l1 = 2.233 ; // ptr->l1 ;
            l2 = -0.01031; // ptr->l2 ;
            lb = 1.0 + pow(l1 * exp(-l2 * ws) - l1, 2.0) ;
    return lb;
  }
```

System \Param.	l_1	l_2	R^2
FBP System (Others)	3.053	0.02667	0.999
FBP System (Grass)	2.454	0.07154	0.969
Anderson (1983) - dense forest stand	1.411	0.01745	0.993
Anderson (1983) - open forest stand	2.587	0.01142	0.995
Anderson (1983) - grass/slash	5.578	0.006023	0.996
Anderson (1983) - heavy slash	37.49	0.0009885	0.997
Alexander (1985)	3.063	-0.01165	0.997
KITRAL System	2.233	-0.01031	0.984



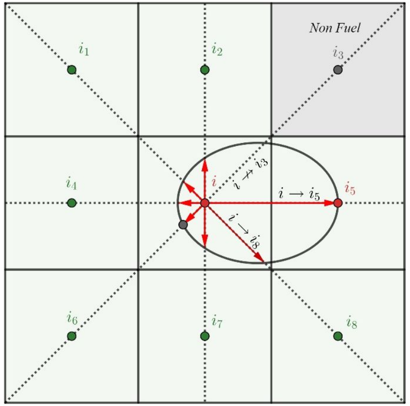
Cell2Fire+S&B

“Cellular Huygens Principle”

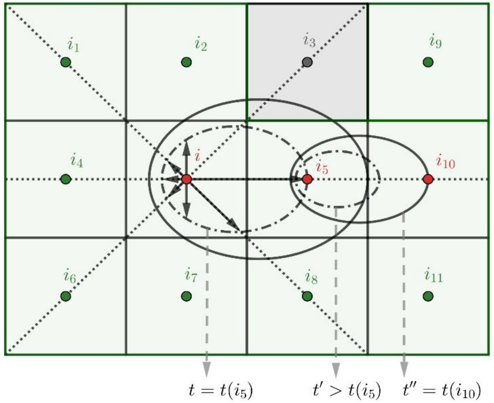
Instance	datetime	WS	WD	FireScenario
Jaime	16-10-01 13:00	10	0	2
Jaime	16-10-01 14:00	25	12	2
Jaime	16-10-01 15:00	16	16	2
Jaime	16-10-01 16:00	31	90	2

Extract of an hourly weather stream file.

- Average precipitation (APCP), temperature (TMP), relative humidity (RH), wind speed (WS) and wind direction (WD).

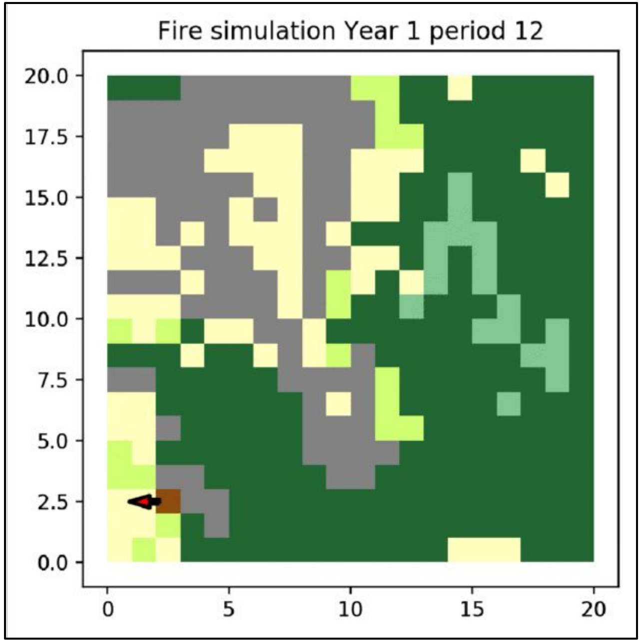


Wind direction (WD)



Cell2Fire

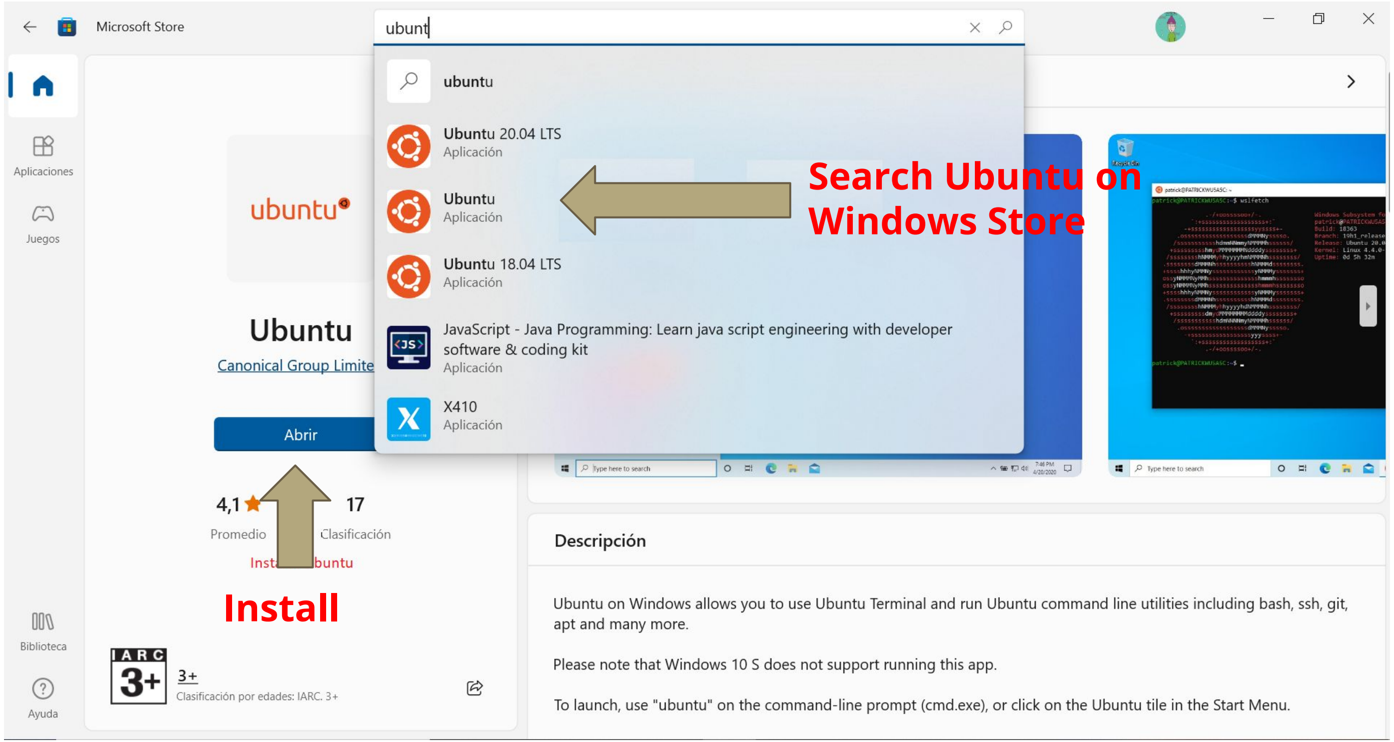
Cell2Fire: Cell Fire Growth minute to minute



Installation and use of Ubuntu on Windows

Step 1

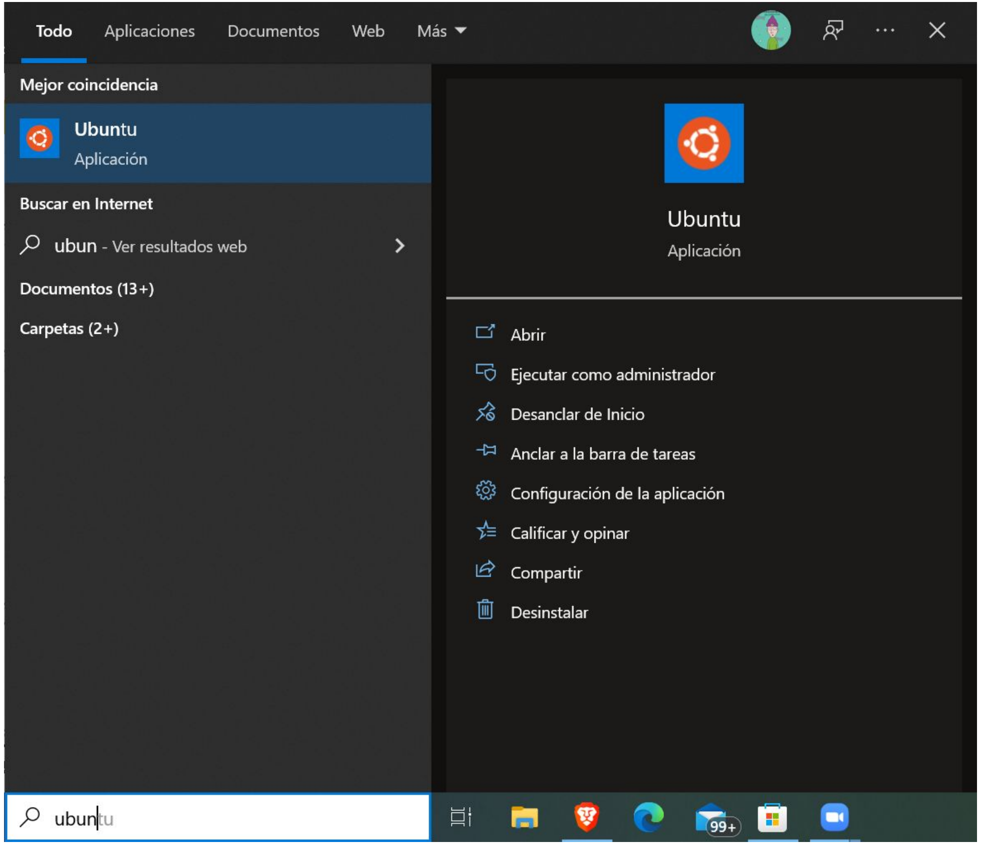
- Installation of Ubuntu terminal through Windows Store



Installation and use of Ubuntu on Windows

Step 2

- ❑ Open the terminal



Search Ubuntu on Windows navigator

Installation and use of Ubuntu on Windows

Step 3

- **Navigation to Cell2Fire**

Ubuntu has a default source folder that is difficult to find

Assuming that Cell2Fire is on the folder C: (that is, directly on the C disk), the navigation until there is according to the shown in the image

Installation and use of Ubuntu on Windows

Step 4

- ❑ **Access to Cell2Fire**

```
davidpalacios@LAPTOP-P59MBE95:/mnt/c/Users/david/Desktop/Cell2Fire$ cd Cell2Fire_Spain
davidpalacios@LAPTOP-P59MBE95:/mnt/c/Users/david/Desktop/Cell2Fire/Cell2Fire_Spain$ ls
Cell2Fire  Cell2FireC  Cell2FireC.py  __pycache__  data  main.py  main_heuristic.py
davidpalacios@LAPTOP-P59MBE95:/mnt/c/Users/david/Desktop/Cell2Fire/Cell2Fire_Spain$
```

Being in the Cell2Fire folder it is already possible to run the simulator

Installation and use of Ubuntu on Windows

Step 5

Just execute the line of code with the desired conditions

- Cell2Fire execution

```
davidpalacios@LAPTOP-P59MBE95:/mnt/c/Users/david/Desktop/Cell2Fire/Cell2Fire_Spain$ python3 main.py --input-instance-folder data/Hom_Fuel_101_40x40/ --output-folder results
/test --ignitions --sim-years 1 --nsims 5 --finalGrid --weather random --nweathers 1 --Fire-Period-Length 1.0 --output-messages --ROS-CV 0.0 --seed 123 --stats --allPlots -
-IgnitionRad 5 --grids --combine
End of Cell2FireC execution...
------ Generating Statistics --------
Hourly stats...
General stats...
Reading data...
Dummy if needed...
Generating global fire spread evolution...
100%|| 3/3 [00:06<00:00,  2.03s/it]
Generating individual Fire Spread plots...
100%|| 5/5 [00:05<00:00,  1.18s/it]
Generating initial forest plot...
Generating fire evolution plots...
100%|| 5/5 [00:06<00:00,  1.34s/it]
Combining Fires with background (initial forest)...
100%|| 5/5 [00:07<00:00,  1.58s/it]
Generating detailed individual propagation trees...
100%|| 5/5 [00:14<00:00,  2.90s/it]
davidpalacios@LAPTOP-P59MBE95:/mnt/c/Users/david/Desktop/Cell2Fire/Cell2Fire_Spain$
```

Installation and use of Ubuntu on Windows

Step 6

- **Results folder**

OS (C:) > Usuarios > david > Escritorio > Cell2Fire > Cell2Fire_Spain

Nombre	Fecha de modificación	Tipo	Tamaño
__pycache__	20-01-2022 14:23	Carpeta de archivos	
Cell2Fire	20-01-2022 14:23	Carpeta de archivos	
Cell2FireC	20-01-2022 14:23	Carpeta de archivos	
data	20-01-2022 14:23	Carpeta de archivos	
results	20-01-2022 14:29	Carpeta de archivos	
.DS_Store	21-12-2021 15:47	Archivo DS_STORE	11 KB
Cell2FireC	21-04-2020 0:59	Python File	30 KB
main	12-05-2019 17:21	Python File	1 KB
main_heuristic	02-05-2019 19:55	Python File	1 KB

The results are generated in the folder indicated as destination folder

Installation and use of Ubuntu on Windows

Step 7

- **Available results**

OS (C:) > Usuarios > david > Escritorio > Cell2Fire > Cell2Fire_Spain > results >

Nombre	Fecha de modificación	Tipo	Tamaño
test	20-01-2022 14:30	Carpeta de archivos	

OS (C:) > Usuarios > david > Escritorio > Cell2Fire > Cell2Fire_Spain > results > test >

Nombre	Fecha de modificación	Tipo	Tamaño
Grids	20-01-2022 14:30	Carpeta de archivos	
Messages	20-01-2022 14:30	Carpeta de archivos	
Plots	20-01-2022 14:30	Carpeta de archivos	
Stats	20-01-2022 14:30	Carpeta de archivos	
InitialForest	20-01-2022 14:30	Archivo PNG	11 KB
LogFile	20-01-2022 14:30	Documento de texto	3 KB