



**CIVIL PROTECTION  
DISASTER RISK REDUCTION  
BIODIVERSITY**

# **PROPAGATOR - A system for the rapid probability assessment of the evolution of a forest fire**

*Osservare per prevedere, prevedere per prevenire*

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CIMA RESEARCH FOUNDATION

CENTRO INTERNAZIONALE IN MONITORAGGIO AMBIENTALE  
INTERNATIONAL CENTRE ON ENVIRONMENTAL MONITORING



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# no-profit research organization

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Università degli  
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REGIONE LIGURIA



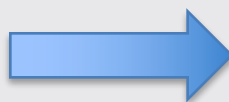
Provincia  
di Savona



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RESEARCH



TRAINING



TECHNOLOGY

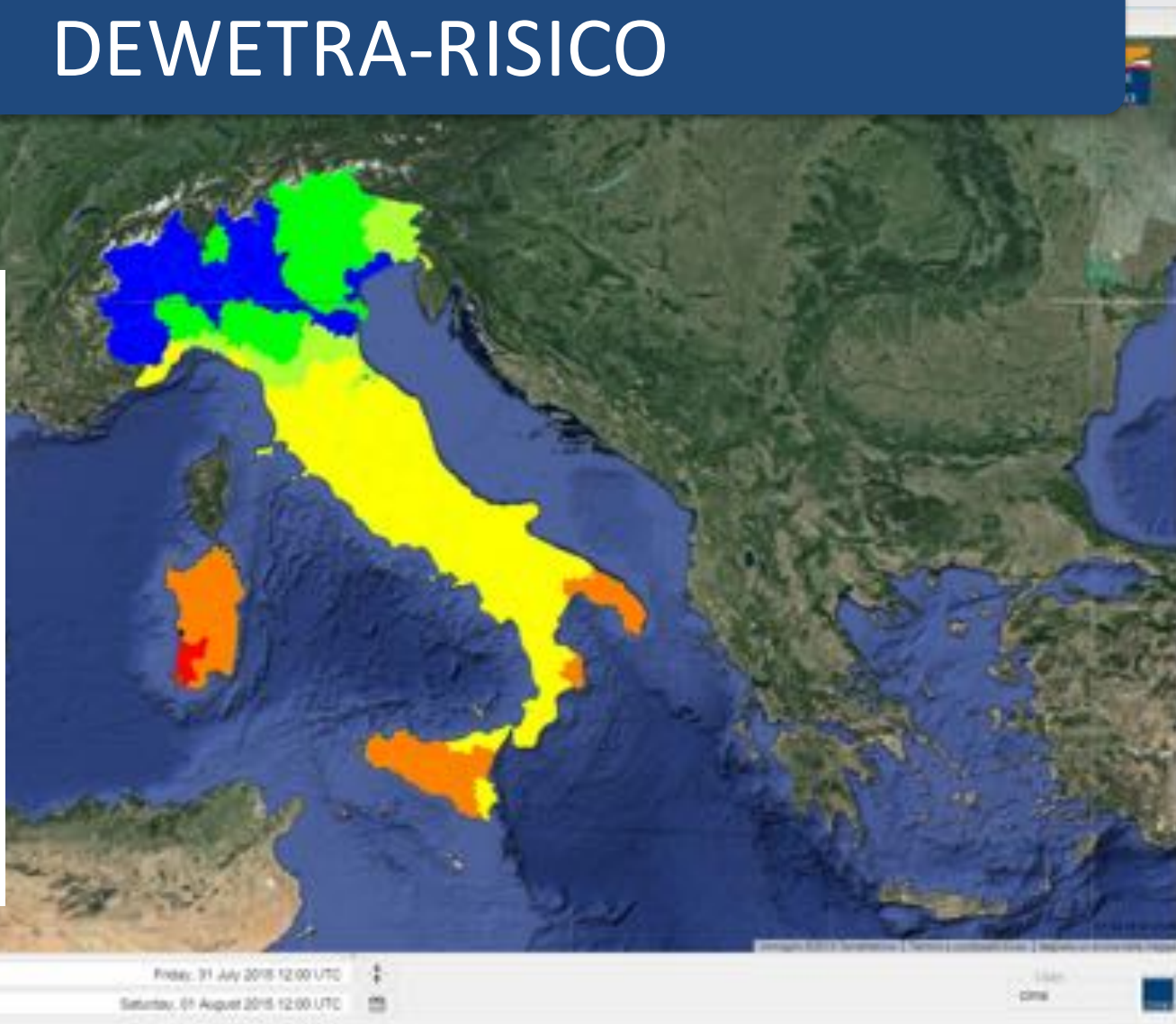


Osservare per prendere, prendere per prendere



Since 2003 CIMA  
support  
**Italian Civil Protection Department**  
**Italian Regions**  
**Other countries**  
provides  
**tools for forest fire risk prevention and  
management**

# DEWETRA-RISICO





After the summer fire season of 2007 a question arise

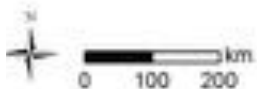
**Is it possible to have a tool able to provide a rapid probability map of fire spreading?**



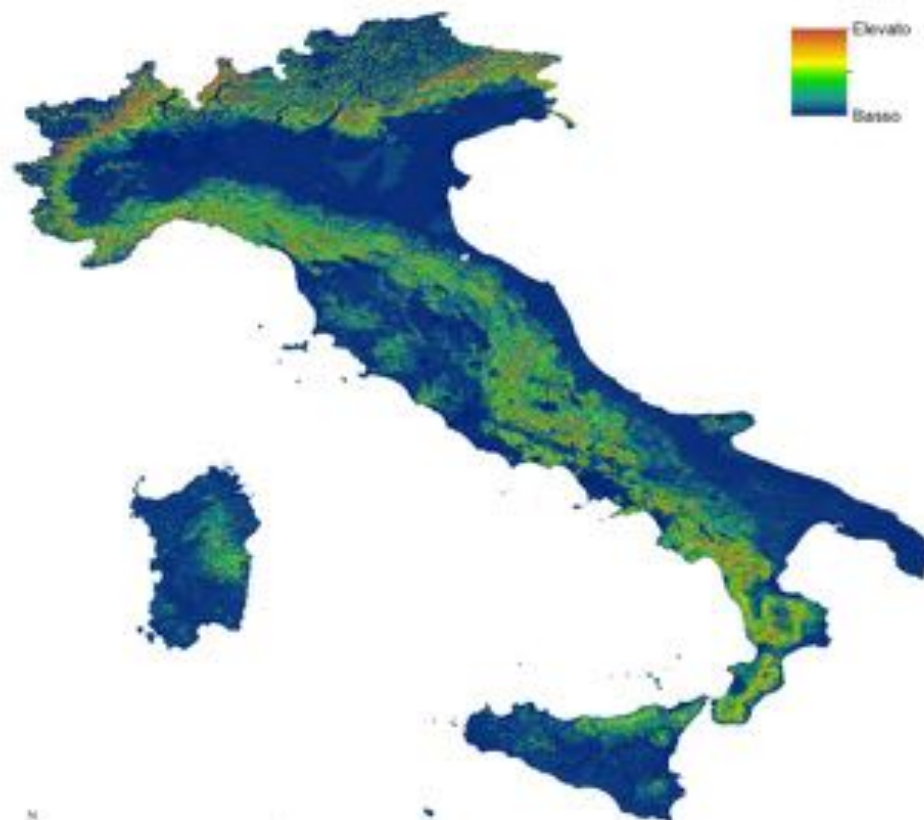
Is the forest fire  
manacing WUI and  
people?

# Fire danger map

Summer



Winter



# PROPAGATOR

PROPAGATOR is a Web application for rapid assessment of active fire risk

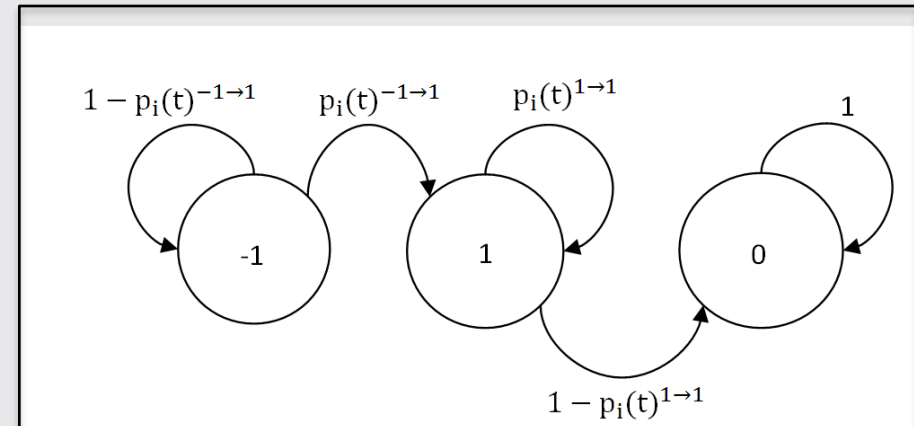
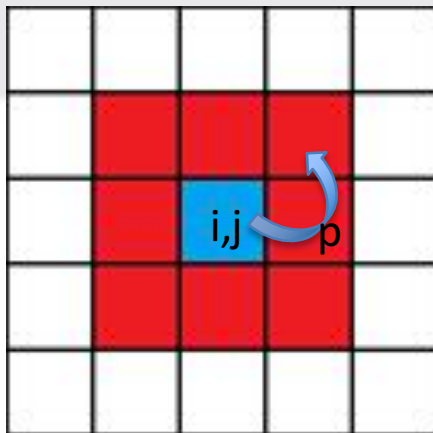
PROPAGATOR considers

- vegetation patterns,
- topography
- wind speed and direction

[http://apps.cimafoundation.org/propagatorapp\\_leaflet](http://apps.cimafoundation.org/propagatorapp_leaflet)



- Stochastic model
- resolution 20x20m
- Vegetation and elevation



Transition probability

$$p_i(t)^{-1 \rightarrow 1} = 1 - \prod_{j \in I_i} \begin{cases} 1 - p_{i,j}(t) & \text{per } y_j(t) = 1 \\ 1 & \text{per } y_j(t) < 1 \end{cases}$$

$$y_i(t) = \begin{cases} 1 & \text{burning} \\ 0 & \text{burned} \\ -1 & \text{unburned} \end{cases}$$

Occurrence per grid cell, probability per grid cell

# Transition probability

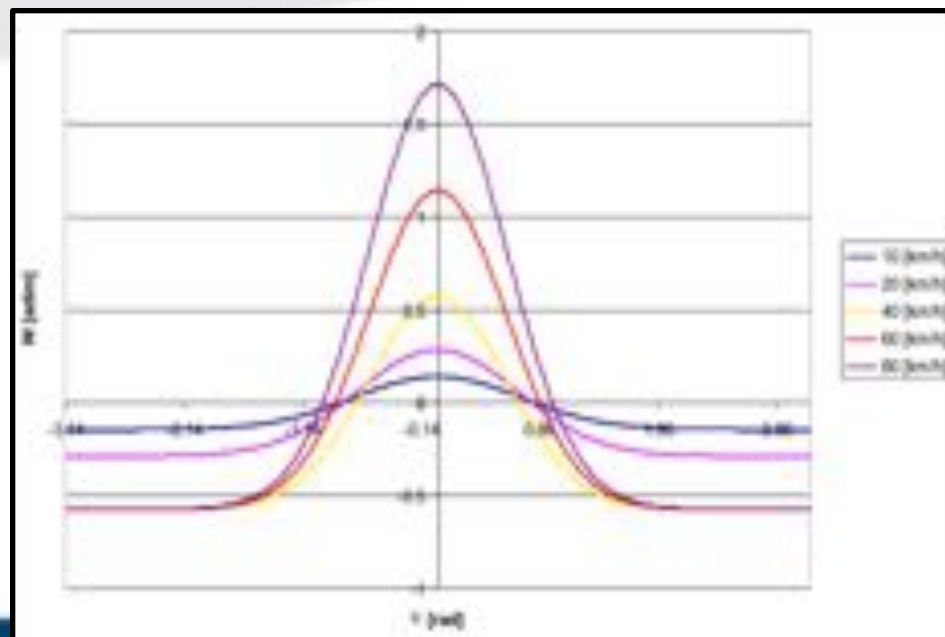
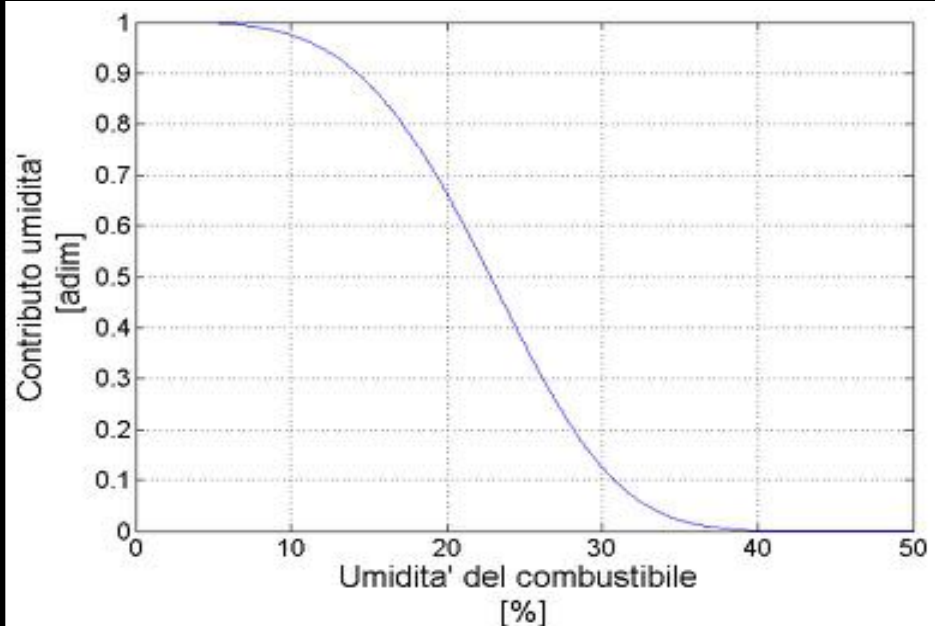
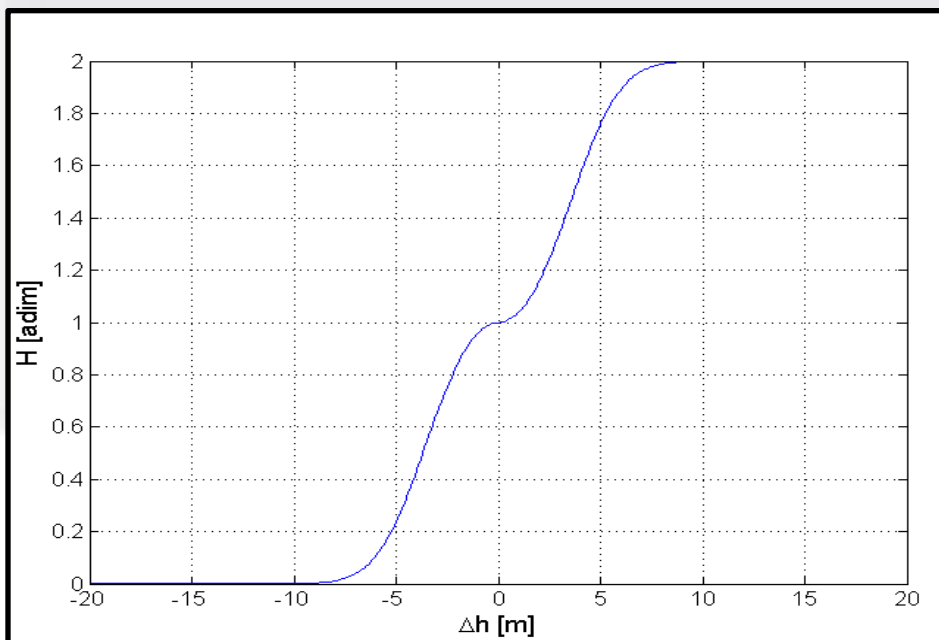
| $p^*_{ij}$         |                       | Burning cell |        |                     |           |                       |                  |       |
|--------------------|-----------------------|--------------|--------|---------------------|-----------|-----------------------|------------------|-------|
|                    |                       | Broadleaves  | Shrubs | Non vegetated areas | Grassland | Mediterranean conifer | Cultivated areas | Fagus |
| Neighbourhood cell | Broadleaves           | 0.2          | 0.25   | 0.005               | 0.15      | 0.275                 | 0.15             | 0.25  |
|                    | Shrubs                | 0.375        | 0.375  | 0.005               | 0.35      | 0.4                   | 0.3              | 0.375 |
|                    | Non vegetated areas   | 0.005        | 0.05   | 0.005               | 0.005     | 0.05                  | 0.005            | 0.005 |
|                    | Grassland             | 0.45         | 0.475  | 0.005               | 0.475     | 0.475                 | 0.375            | 0.475 |
|                    | Mediterranean conifer | 0.325        | 0.325  | 0.005               | 0.1       | 0.35                  | 0.2              | 0.325 |
|                    | Cultivated areas      | 0.25         | 0.25   | 0.005               | 0.25      | 0.475                 | 0.25             | 0.25  |
|                    | Fagus                 | 0.075        | 0.1    | 0.005               | 0.075     | 0.275                 | 0.075            | 0.075 |

The nominal transition probability is modified by wind (W), slope (H) and moisture content (U)

$$p_{ij} = 1 - (1 - p^*_{ij})^{(H+W)U}$$



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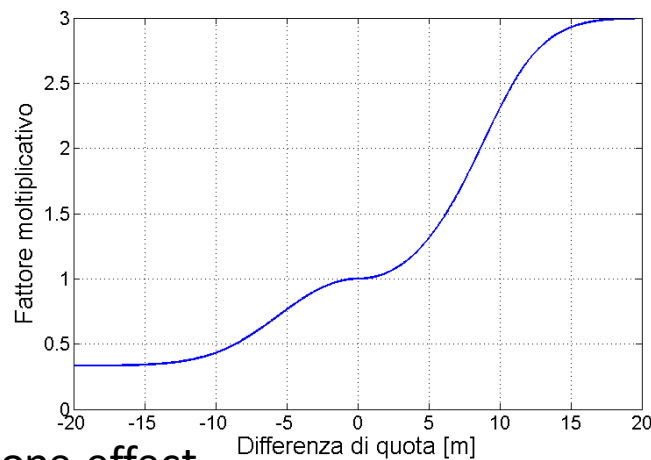


# Timing

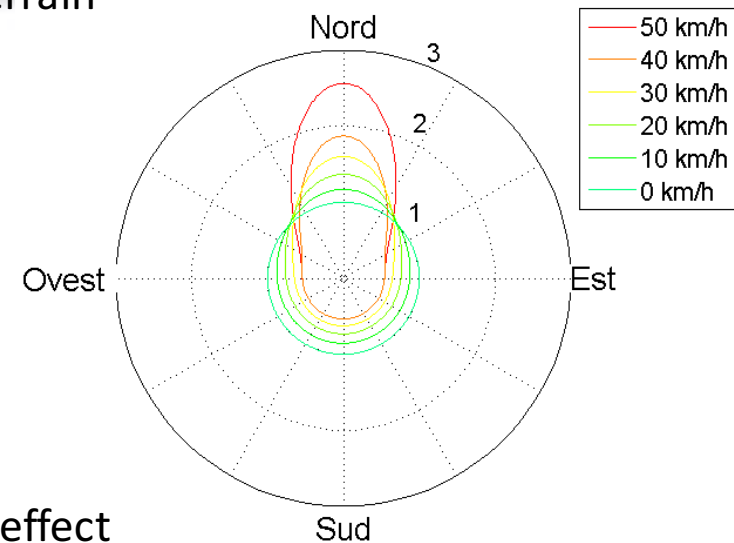
$$T_{prop} = T_{base} / wh$$

| Latifoglie | Arbusti   | Aree nude | Praterie  | Conifere  | Coltivi   | Faggete   |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|
| 30 minuti  | 15 minuti | 60 minuti | 10 minuti | 20 minuti | 10 minuti | 40 minuti |

$T_{base}$ : transition time in absence of wind on flat terrain

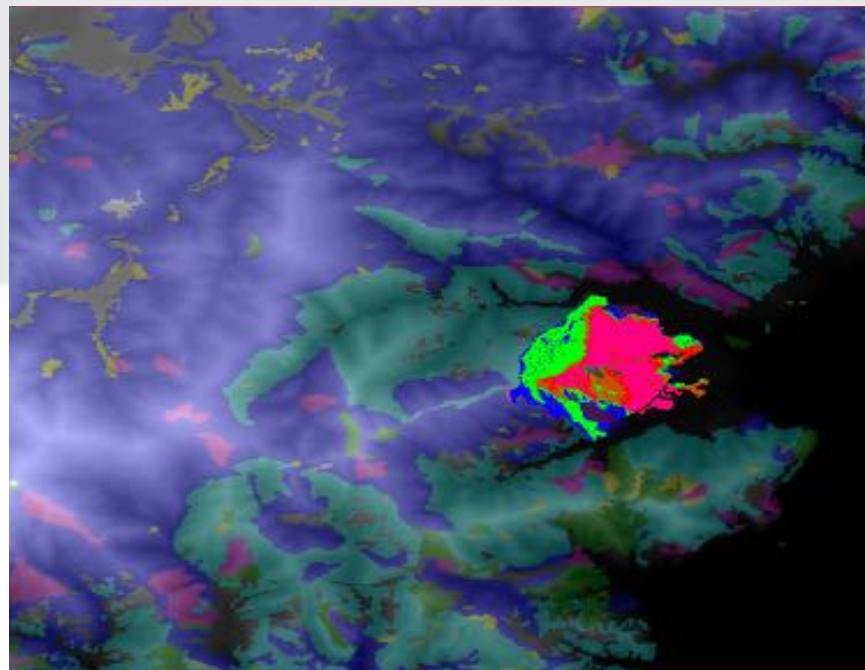
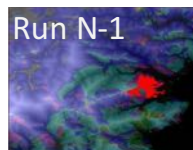
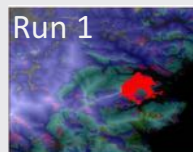


h: slope effect



w: wind effect

# OUTPUT



>90%

>80%

>70%

>50%

>30%

>10%





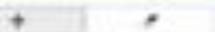
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PROPAGATOR

Forest Fire Propagation Model



Name:

Wind Direction:

Wind Speed:

# Thresholds:

Grid Dimension:

Date: 6/3/2017

File Set: Default File Set

Run

Clear

Close



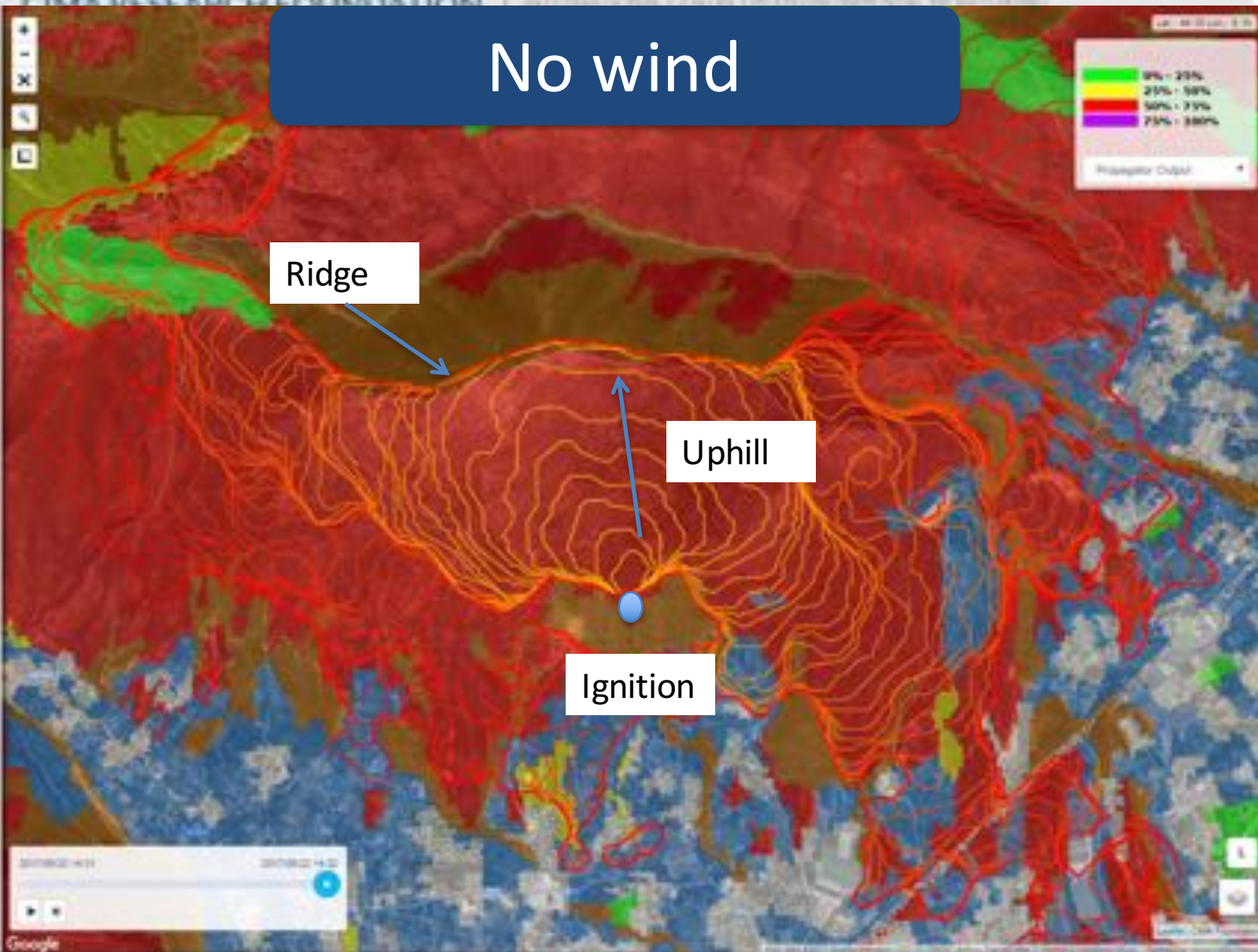


No wind

Ridge

Uphill

Ignition







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PROPAGATOR

Forest Fire Propagation Model



Name: Spumetol

Wind Direction:



Wind Speed: 30 km/h

# Thresholds: 10

Grid Dimension: 10 m

Date: 10/03/2017

Tile Set: Ignition Point Map

Start

Clear

Download

Active: 2010, 10/20/2010 - 10/20/2010

2010/10/20 10:20

2010/10/20 10:20



Google

Legend  
0% - 25%  
25% - 50%  
50% - 75%  
75% - 100%

Propagator Output



  
**PROPAGATOR**  
Forest Fire Propagation Model

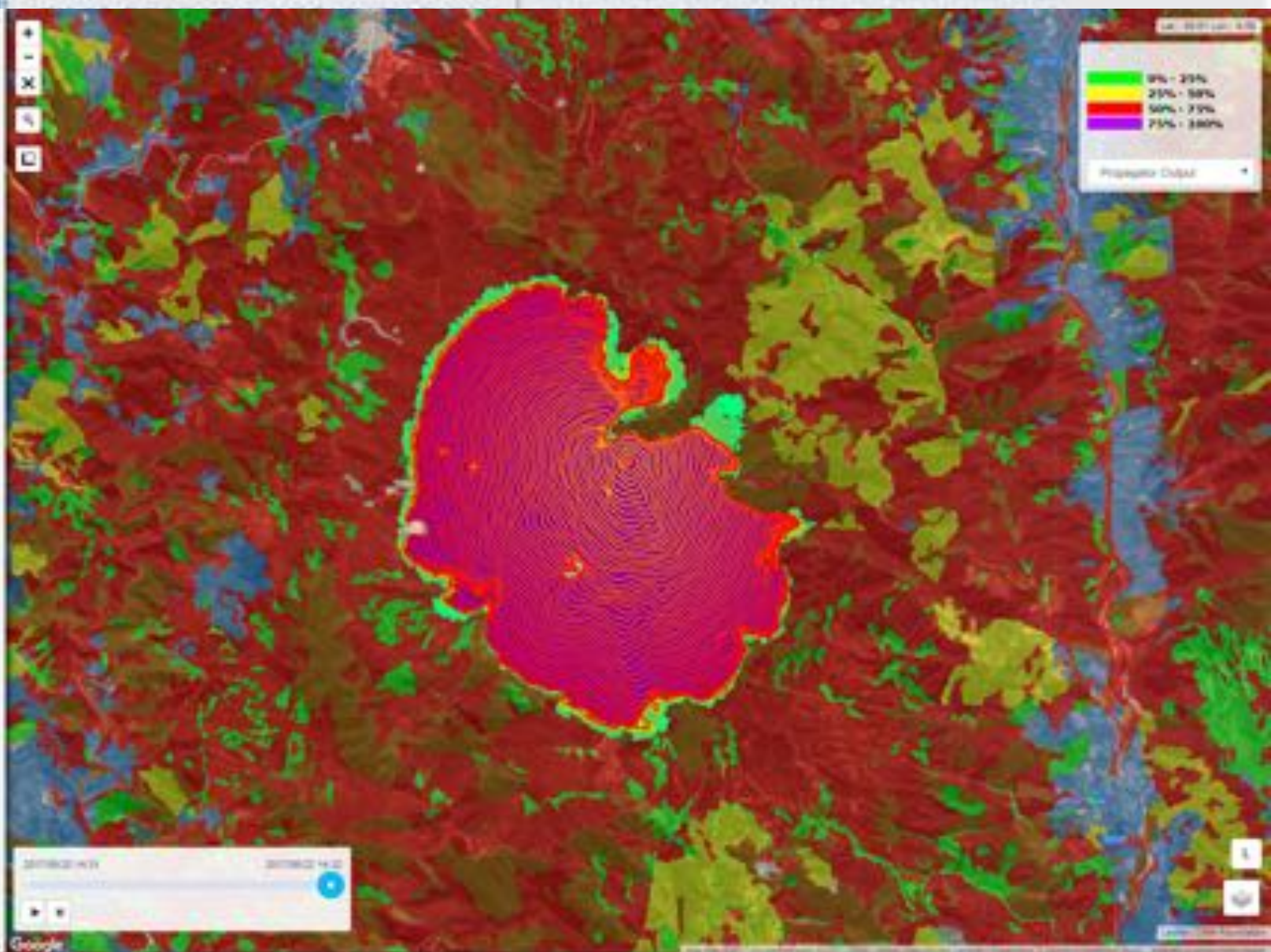
Map navigation controls: zoom in (+), zoom out (-), reset (X), pan (arrow), and a location pin icon.

Parameters:

- Name:
- Wind Direction: 
- Wind Speed:  10 km/h
- # Threads:  10
- Grid Dimension:  100 m
- Date:
- File Set:

Buttons: Run, Clear, Cancel

Active: 10/10 - 24/24 Grids - 3107 Pts







+

-

+

-

+

-

+

-

Name:

Wind Direction:

Wind Speed:

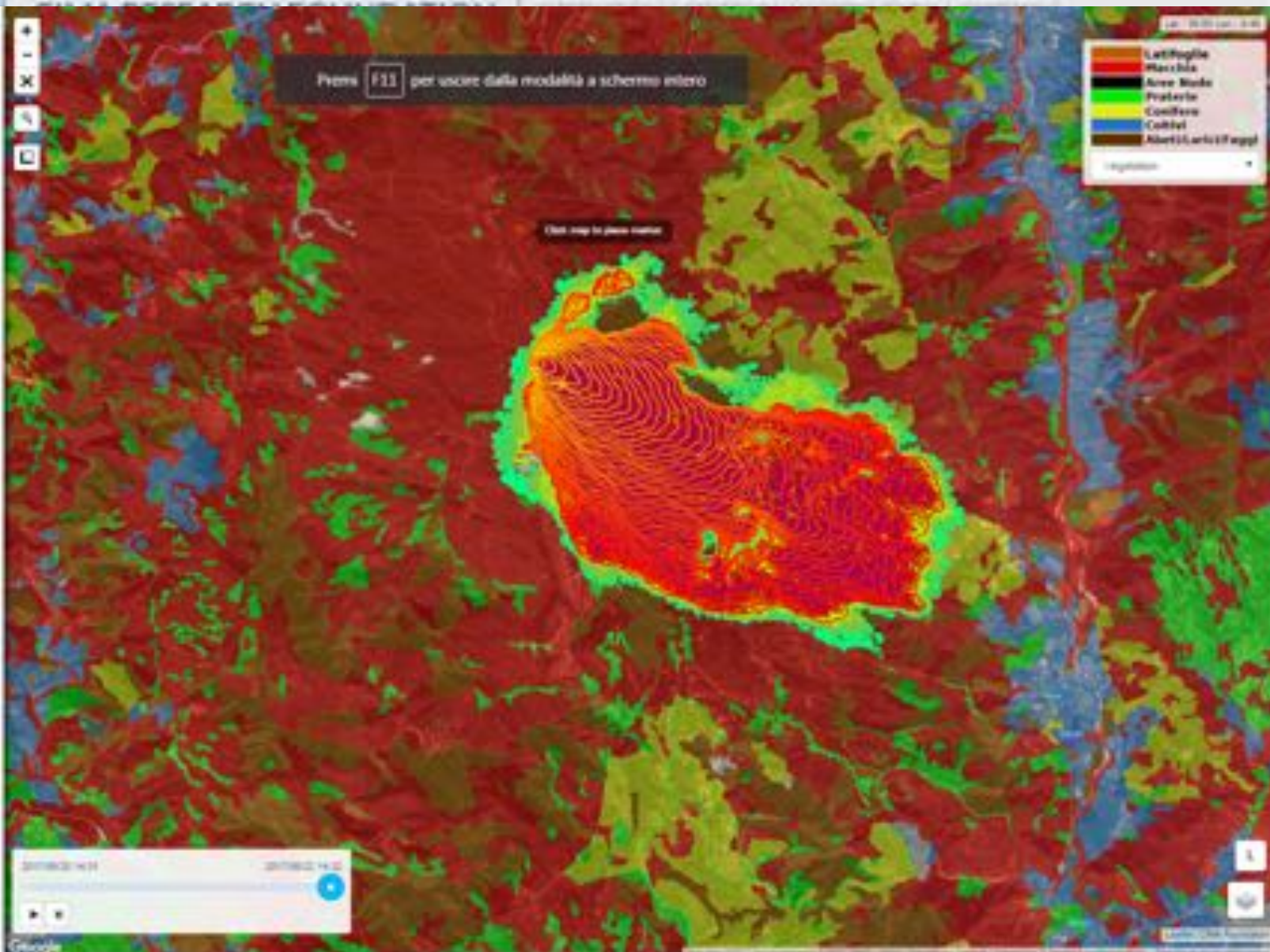
# Thresholds:

Grid Dimension:

Grid:

Tile Set:

Release: 30/03/2012 - 20/04/2014 - 2004 (hr)







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DISSEMINATOR: CIMA Research Foundation

REPOLARICE (RANK 1) 100

|  |                     |   |   |   |   |
|--|---------------------|---|---|---|---|
| +  | -                   | + | - | + | - |
| Name   | joshua2             |   |   |   |   |
| Water Depth  | 210                 |   |   |   |   |
| Water Speed  | 10                  |   |   |   |   |
| W. Thickness   | 10                  |   |   |   |   |
| Sea Direction  | 10                  |   |   |   |   |
| Date   | 11/23/2019 08:21 PM |   |   |   |   |
| <input type="button" value="Close"/> <input type="button" value="Close"/> <input type="button" value="Close"/> |                     |   |   |   |   |



2019/11/23 17:21



Observing per procedure, providing per procedure



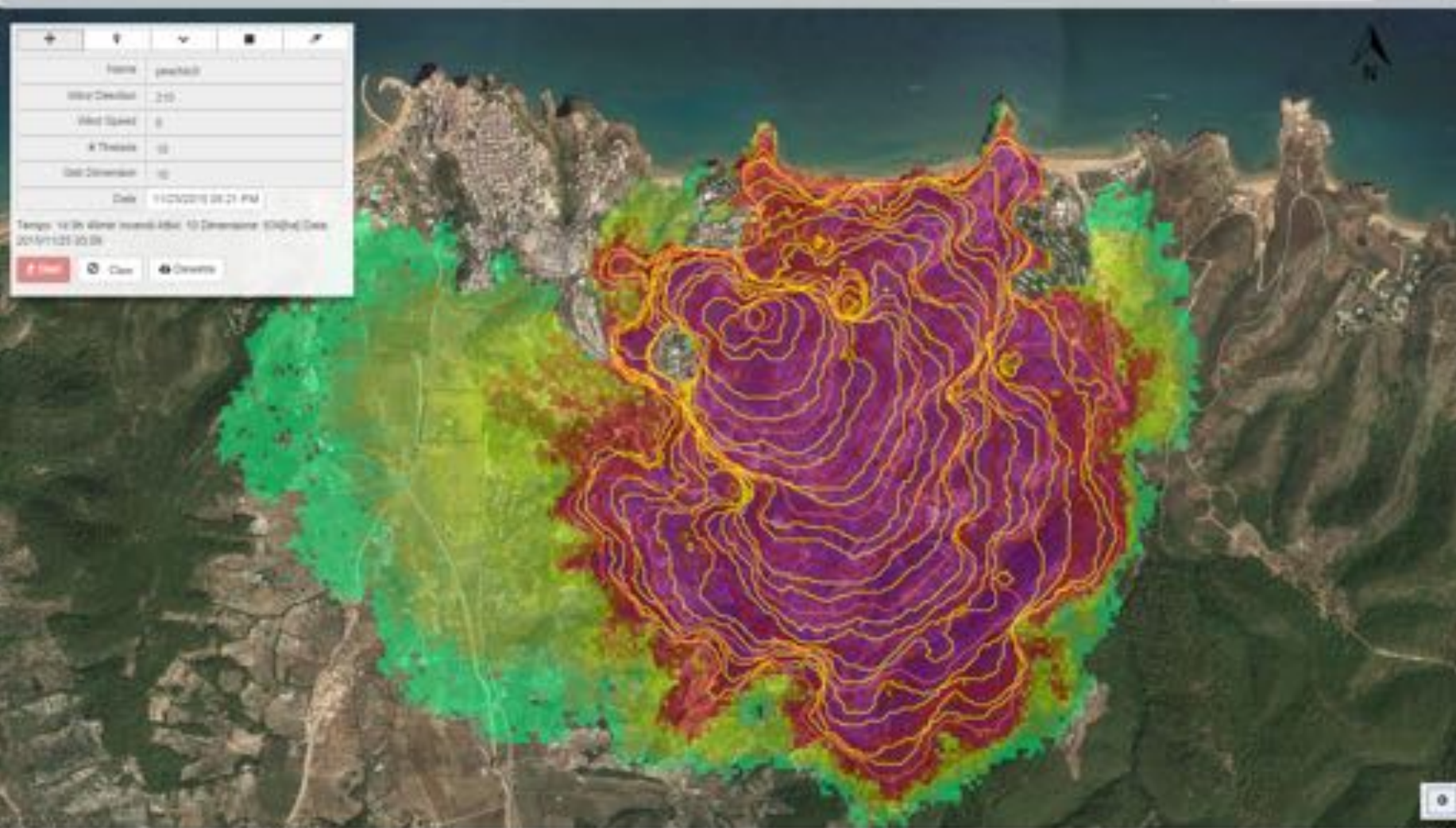
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PROPAGATOR

REPORTING RESULTS

|  |                     |   |   |   |   |
|--|---------------------|---|---|---|---|
| +  | -                   | + | - | + | - |
| Name   | propagator          |   |   |   |   |
| Water Depth  | 2.00                |   |   |   |   |
| Water Speed  | 0                   |   |   |   |   |
| Water Temperature  | 10                  |   |   |   |   |
| Water Density  | 10                  |   |   |   |   |
| Date   | 11/25/2018 08:21 PM |   |   |   |   |
| Target: 10.00 Water Depth: 2.00 Water Temperature: 10.00 Water Density: 10.00 Date: 2018/11/25 08:21 PM        |                     |   |   |   |   |
| <input type="button" value="Save"/> <input type="button" value="Clear"/> <input type="button" value="Create"/> |                     |   |   |   |   |

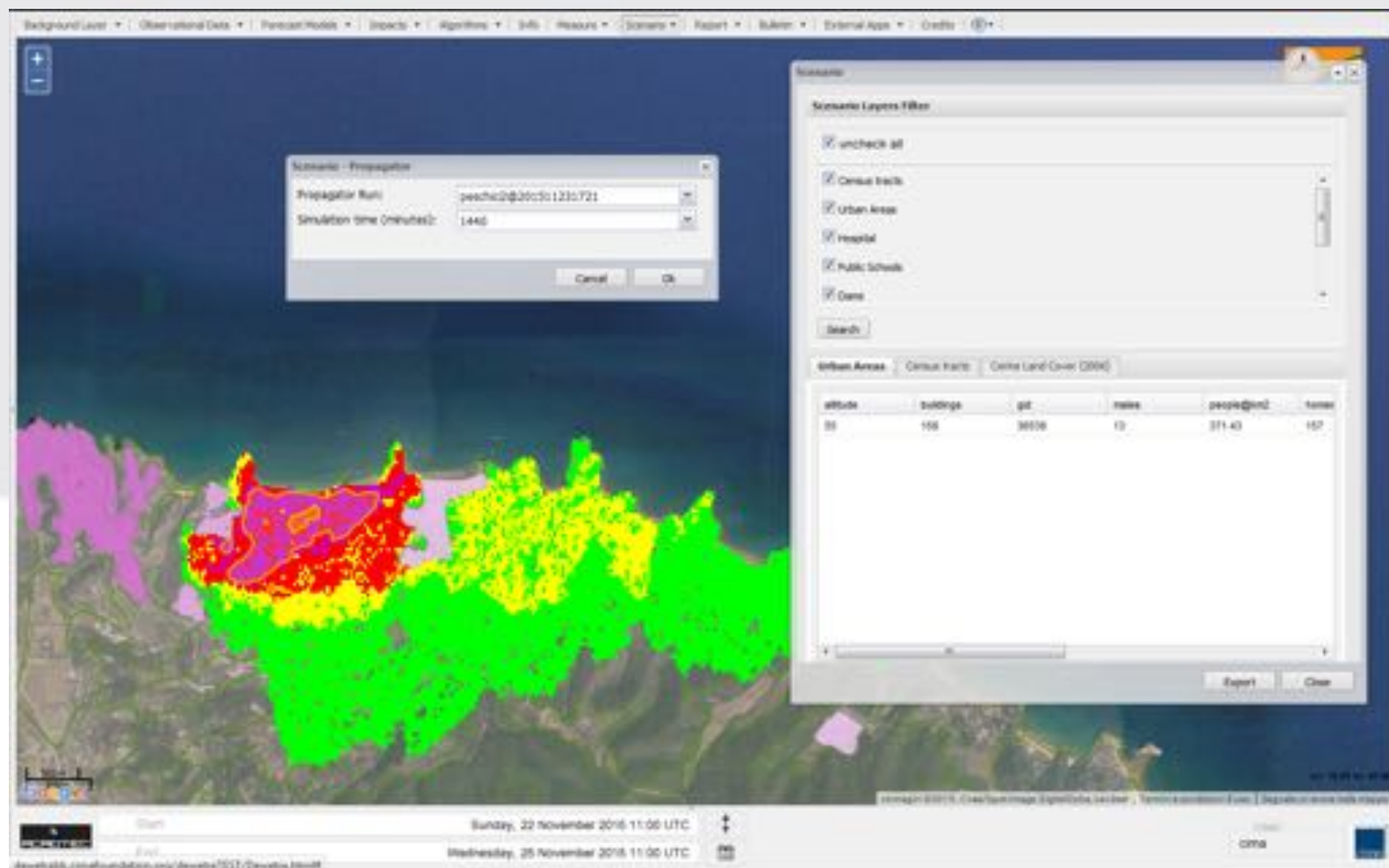


2018/11/25 17:21

2018/11/25

Observing per procedure, providing per procedure





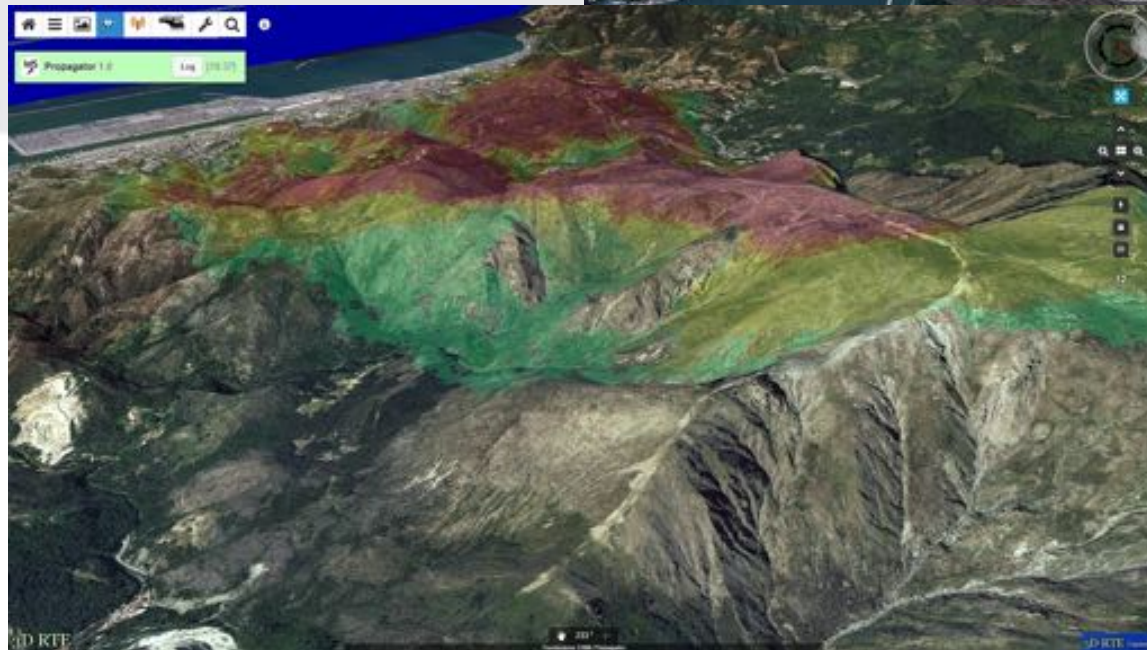
# Next steps

20 m fire danger map (National level)  
Lidar data (20 cm resolution)





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Interoperability with  
commercial 3d analyzer  
3dRTE- PANGEA



# Conclusion

Most of the fires under extreme weather  
became WUI fire

Prevention needs time to be implemented  
Decision makers need tool and technology

# Ulteriori sviluppi

Definizione copertura vegetale

Calibrazione parametrica

Modelli di combustibile