A comparison study between fire-spotting models by a wildfire simulator based on a cellular automata approach

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Motivation

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Fire-spotting.

- ➢ **Uncentainty source** → **Starts new fires (spot-fires).**
  → **Accelerate the spread of fire**

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Good fire-spotting model -> Accurate wildfire simulations.

Our work: Fire-spotting comparison models

Fire-spotting models.

- Trucchia A, Egorova V, Butenko A, Kaur I, Pagnini G (2019) RandomFront 2.3: a physical parameterisation of fire spotting for operational fire spread models – implementation in WRF-SFIRE and response analysis with LSFire+. *Geoscientific Model Development* **12**, 69–87. doi:10.5194/gmd-12-69-2019.

- Alexandridis A, Russo L, Vakalis D, Bafas GV, Siettos CI (2011) Wildland fire spread modelling using cellular automata: evolution in large-scale spatially heterogeneous environments under fire suppression tactics. *International Journal of Wildland Fire* **20**, 633. doi:10.1071/WF09119.

- Perryman HA, Dugaw CJ, Varner JM, Johnson DL (2013) A cellular automata model to link surface fires to firebrand lift-off and dispersal. *International Journal of Wildland Fire* **22**, 428. doi:10.1071/WF11045.

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PROPAGATOR

- **Georeferenced map with the burnt probability of each cell.**

The Alexandridis *et al. parametrization*

- **It was developed in CA framework.**

- **Firebrand landing distance:**

$$d_p = r_n \cdot P_w = r_n \, exp\left(U C_2 (Cos\, \varphi - 1)\right) \quad (1)$$

- **r_n is drawn from a normal distribution.**

The Perryman *et al. parametrization*

- **It is based in previously research.**

- **Firebrand landing distance:**

$$d_p = \sqrt{d_{||}^2 + d_{|-}^2} \qquad (2)$$

- **Paralell to wind direction ($d_{||}^2$)-> Lognormal distribution**

- **Perpendicular-to-wind direction($d_{|-}^2$) -> Normal distribution**

RandomFront parametrization

- **Lognormal distribution.**

$$p(d) = \frac{1}{\left(\sqrt{2\pi}\,\sigma\, d\right)}\; exp\left(\frac{-(ln\,(d/\mu\;)^{2}}{\left(2\sigma^{2}\right)}\right) \qquad (3)$$

- **μ , σ -> Parametrizes the physics of the transport.**

RandomFront parametrization

- **Mean:**

$$\mu = H(H_{ABL})\left(\frac{3\rho C_d}{2\,\rho_f}\right)^{1/2} \tag{4}$$

- **Standard deviation:**

$$\sigma = \sigma(\varphi,\omega) = \frac{1}{zp}\, ln\left\{\frac{U\,Cos\,\varphi}{\sqrt{gr\left(1+Tan^2\,\omega\right)}} + \beta_2\sqrt{\frac{2\rho_f}{3\rho C_d}}\,\frac{1.4U\,Cos\,\varphi + \sqrt{gh_0\left(1+\phi_{wind}+\phi_{slope}\right)^{2/3}}\;Tan\,\omega}{\sqrt{gh_0\left(1+\phi_{wind}+\phi_{slope}\right)^{2/3}} - 1.4U\,Cos\,\varphi\;Tan\,\omega}\right\} \tag{5}$$

Study area

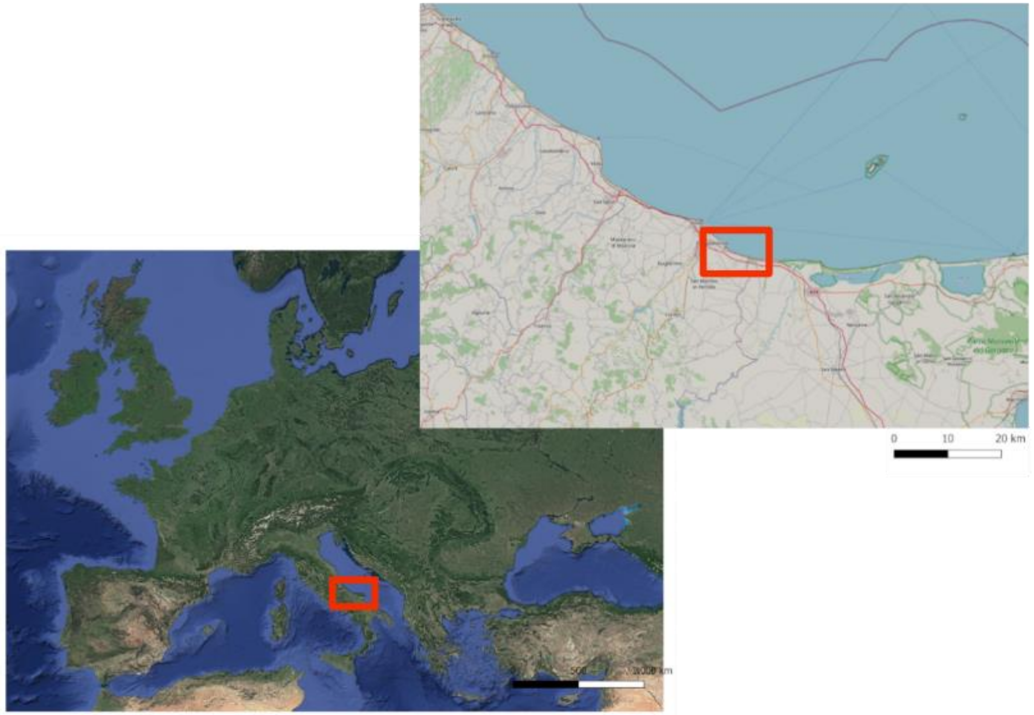


Figure 1

Study area

(a)

(b)

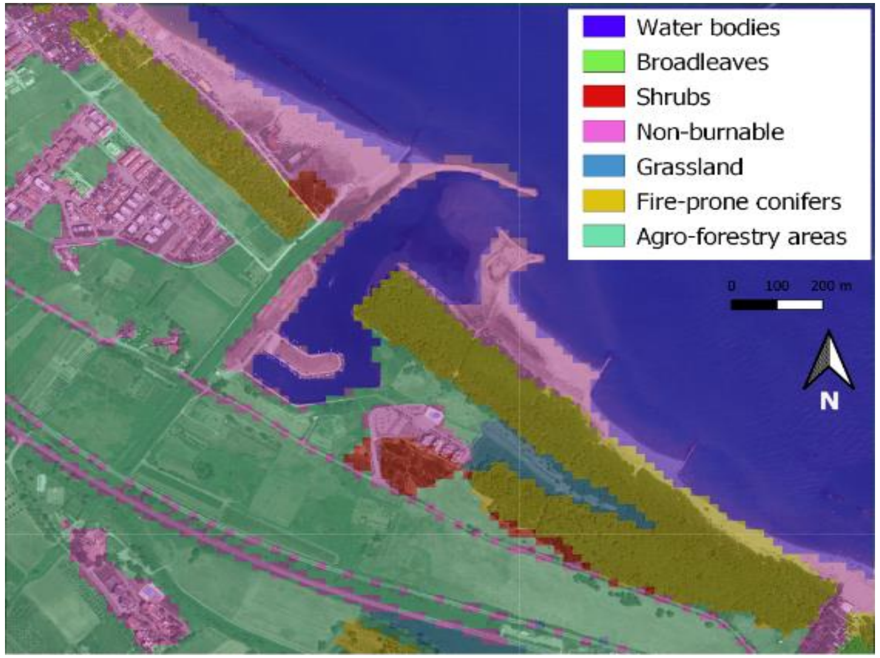
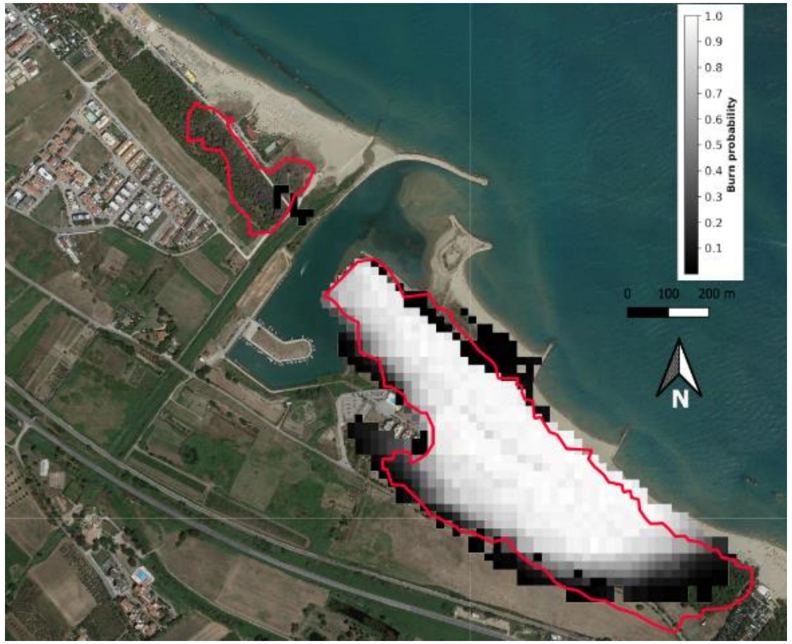


Figure 2

Results of the simulation

➢ **Alexandridis Model**

(a)



(b)

Figure 3.

Results of the simulation

- **Perryman**

(a) *(b)*

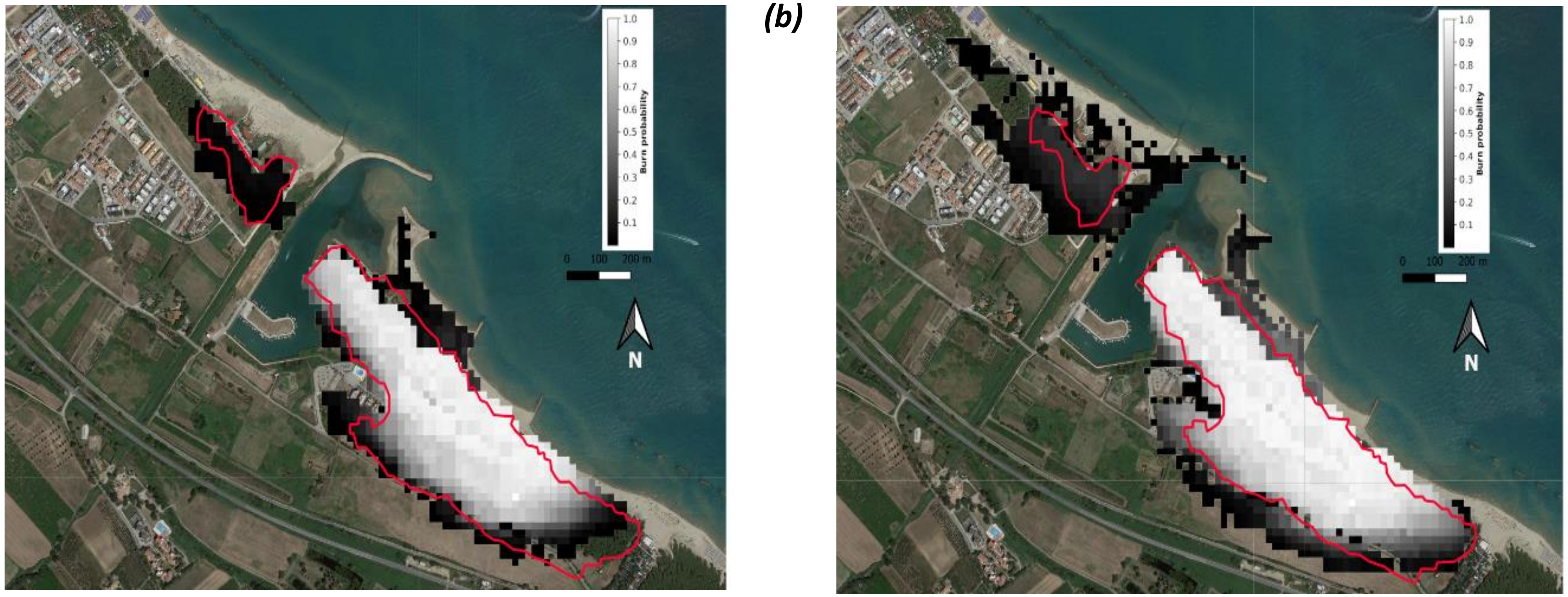


Figure 4

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Results of the simulation

➢ **RandomFront fomulation**

(a)

(b)

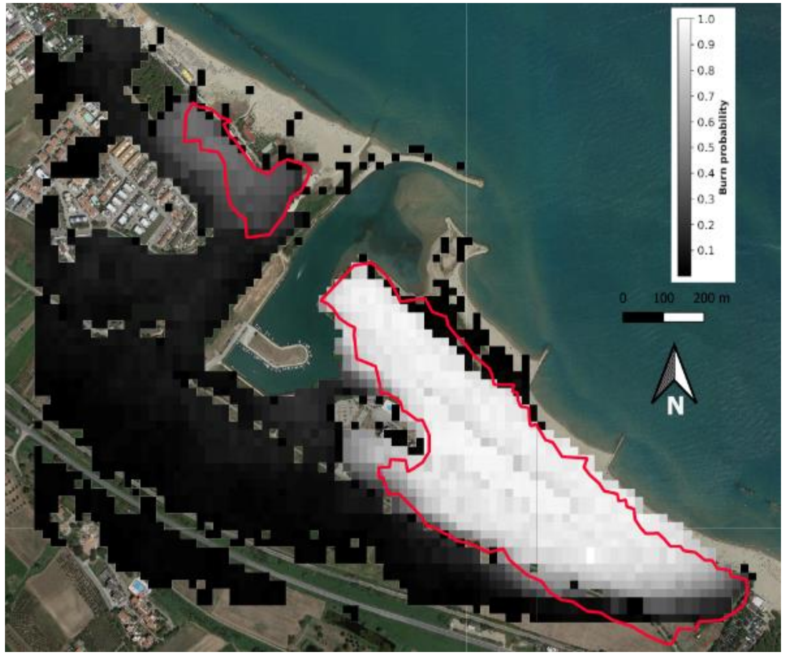

Figure 5

Results of the simulation

➢ **Probability generated**

Sub-model	East	West
Alexandridis	0.7938	0.0358
Perryman	0.7370	0.1330
RandomFront	0.7303	0.2868

***Table* 1** Main probability generated inside the reference Areas.

Results of the simulation

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Conclusions and Further work

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- **Richer spread pattern is observed in physical models.**
- **Higher probability density with RF.**
- **The operational context is conserved.**
- **Further work:**
  - **Analysis of the spread patterns in the ensemble contex.**
  - **Suitable fire-spotting metrics.**
  - **Firebrand generation process.**
  - **Spot ignition probability.**

Thank you for your attendance!!

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