Comparison of burned area mapping products and combustion efficiency approaches for estimating GHG and particulate emissions from Italian fires

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OBJECTIVE OF THE STUDY

Forest fires play a crucial role in Earth ecosystems, with both negative and positive impacts on all biosphere components, and with reverberations on different scales, from local to global. One of the main primary effects is the production of a remarkable amount of greenhouse gases and solid particulate matter due to biomass combustion. The large amounts of carbon that fires release into the atmosphere significantly contribute to the atmospheric budgets at local, regional, and even global scale: especially in years of extreme fire activity, it could approach levels of anthropogenic carbon emissions. Simulating emission from forest fires is affected by several errors and uncertainties, due to the different assessment approach to characterize the various parameters involved in the fire emission (FE) equations. Improvements and new advances in remote sensing, experimental measurements of emission factors, fuel consumption models, fuel load evaluation, and spatial and temporal distribution of burning are a valuable help for predicting and quantifying the source and the composition of FE.

The aim of this work is to compare product and approaches of burned area and combustion efficiency evaluating their impact on the GHG and particulate emission estimation.

MATERIALS AND METHODS

1) Integrated approach combining a fire emission model (FOFEM - First Order Fire Effect Model, Reinhardt et al., 1997) with spatially explicit, comprehensive, and accurate fire, vegetation and weather (Bacciu et al. 2012)
2) FUEL TYPES and LOAD - Italian descriptive Database (Ascoli et al. 2019) associated to Corine Land Cover IV level (2012) classes. Crown data derived from literature (Mitsopoulos 2007, Bovio 1996, Leonardi et al. 1996)
3) BURNED AREA – Two products: 1) from the former Corpo Forestale dello Stato (actually Carabinieri C.U.T.F.A.A.); 2) from Copernicus EMS - Rapid Mapping products processing of MODIS satellite imagery
4) FUEL MOISTURE – Two approaches: 1) association of fuel moisture to Fine Fuel Moisture Code classes calculated through weather data from Era-Interim Reanalysis; 2) association of fuel moisture to fire severity classes derived from the Rapid Damage Assessment
5) CROWN CONSUMPTION – Two estimations: 1) fixed value and 2) values related to classes of fire severity

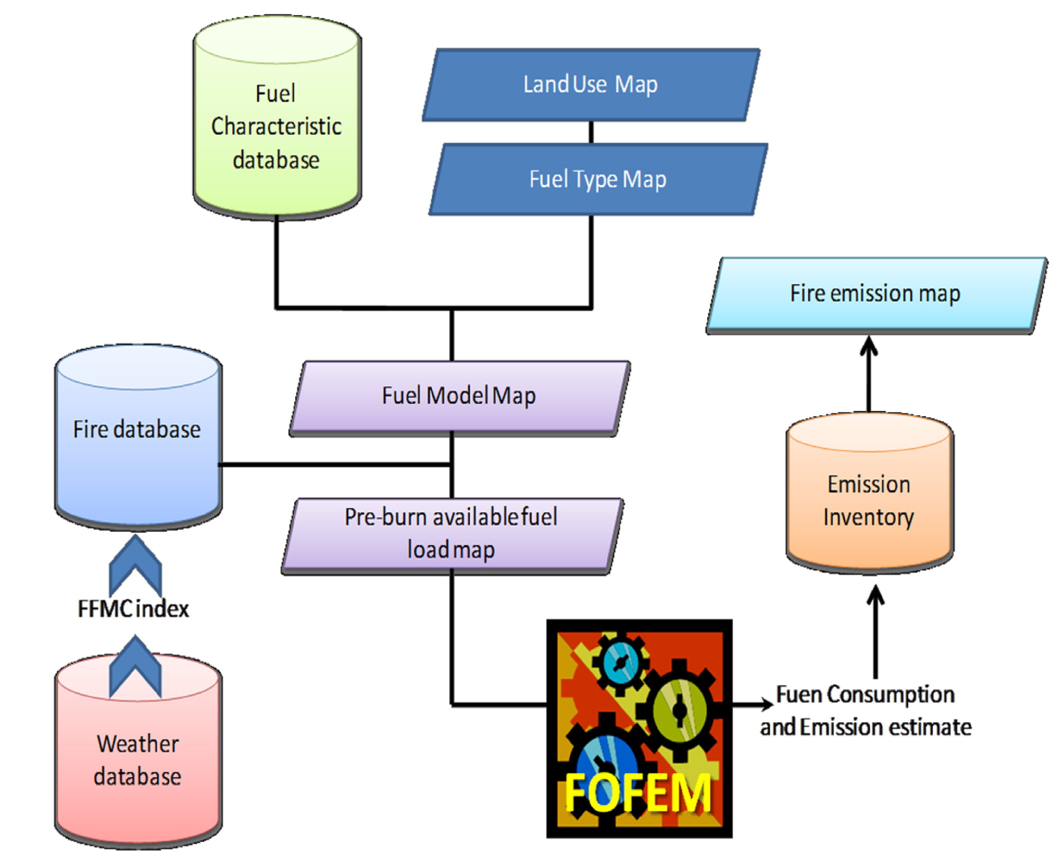


Fig. 1 – Methodological scheme of the integrated approach (Bacciu et al. 2012)

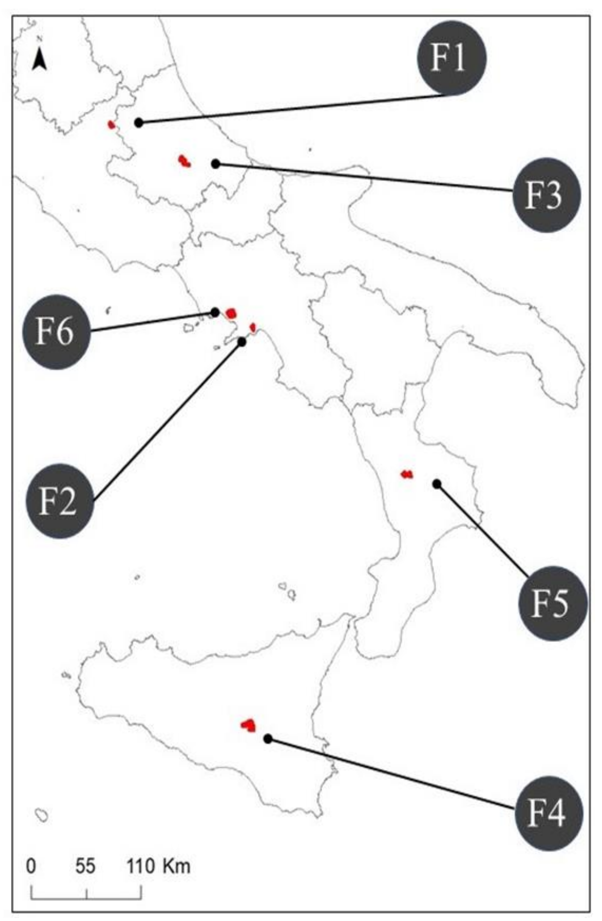
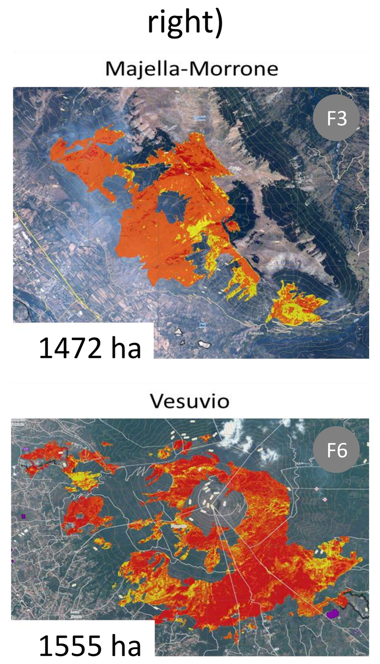


Fig. 2 – Location of fire case studies (on the left) and two examples of fire severity data derived from Rapid Damage Assessment (on the bottom right)



Tab. 1 – Fire study cases, date of ignition, burned areas from Copernicus Rapid Mapping and C.U.T.F.A.A dataset

Fire event	Fire code	Data	Copernicus BA (ha)	C.U.T.F.A.A. BA (ha)
Antrodoco borgo-velino	F1	22/08/2017	696	997
Cava de' tirreni	F2	08-09/08/2017	660	739
Majella Morrone	F3	19-20/08/2017	1472	2544
Piazza armerina	F4	03/08/2017	3200	3213
Rose	F5	02/08/2017	1689	2112
Vesuvio	F6	12/06/2017 05-08/07/2017 10-11-12/07/2017	1555	3176

Tab. 2 – Simulation performed to compare product and approaches and to evaluate their impact on fire emissions

Simulation Code	Fuel Moisture Condition Approach	Burned Area product	% Canopy Fuel Consumption)
S4-COP	2 - Copernicus	2 - Copernicus Grading Map	25; 55; 85; 100
S5-COP	1 - FFMC	2 - Copernicus Grading Map	25; 55; 85; 100
S5-CUTFAA	1 - FFMC	1 - C.U.T.F.A.A. Database	25; 55; 85; 100
S6-COP	1 - FFMC	2 - Copernicus Grading Map	25
S6-CUTFAA	1 - FFMC	1 -C.U.T.F.A.A. Database	25

Range = 415 Gg – 688 Gg of total emissions

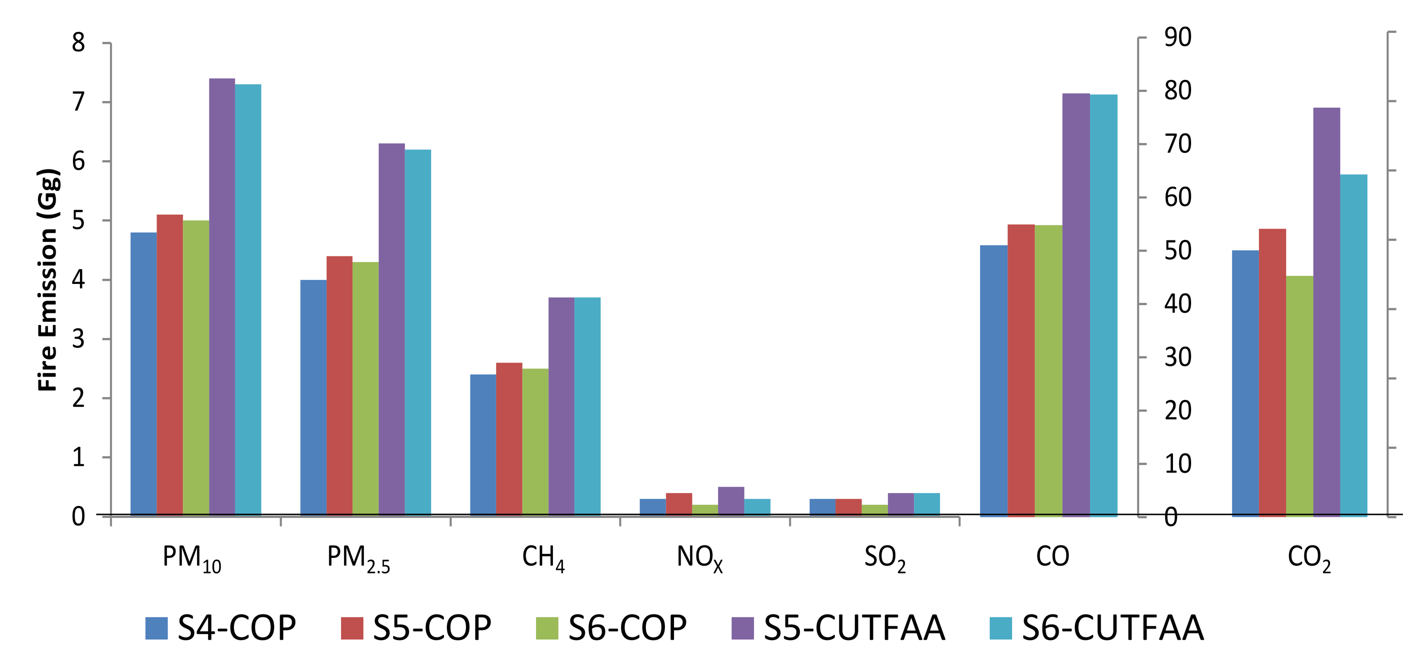


Fig. 3 – Fire emission results for GHG and particulate from the different simulation described in Tab. 2

RESULTS AND DISCUSSIONS

- ❑ Using the same BA product, different Fuel Moisture Scenario and different crown consumption approaches, the percentage difference in fire emission is about 8% (S5-COP vs S4-COP)
- ❑ Using the same BA product, same Fuel Moisture Scenario and different crown consumption approaches, the percentage difference in fire emission is about 14% (S6-COP vs S5-COP and S6-CUTFAA vs S5-CUTFAA)
- ❑ Using different BA products, different crown consumption approaches, and same Fuel Moisture Scenario the percentage difference in fire emission is about 42% (S5-COP vs S5-CUTFAA)

PRELIMINARY CONCLUSIONS

- ➢ The estimated total emissions clearly changed at the modification of each input
- ➢ Largest emission estimate variation are linked to differences in Burned Area;
  - ➢ secondly, accurate evaluation of Fuel Moisture conditions appears important in estimating surface Fuel Consumption;
  - ➢ lastly, definition of Canopy Consumption contributed only for a small percentage

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