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Mapping fire behaviour in a Mediterranean landscape under different future climate change scenarios

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Outline

- Definition of the problem
- Study purpose
- Methodology
- Results
- Concluding remarks

Definition of the problem

- Fire statistics show a significant increase in both the number of wildfires and area burned in Greece. The number of fires doubled and the area burned tripled during the last years due to:

  1) changes in population activities
  2) socioeconomic conditions
  3) land use changes
  4) fuel accumulation
  5) drought frequency and duration

Definition of the problem

- Increase of area burned demonstrates that the last years wild fires occur in a more severe mode in terms of fire behavior parameters, such as fire size, fire rate of spread and fireline intensity, thus creating major difficulties in fire suppression efficiency.

- However, the effects and the possible relationship between climate change and fire behavior parameters has been limited studied due to the difficulties in obtaining high resolution climatic and fuel data as required in spatial fire modeling studies.

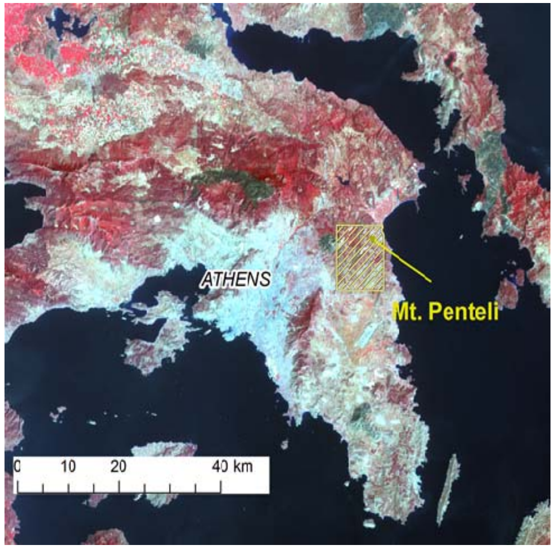
Study Purpose

- The main objective of this study is to investigate the **potential effect** of **different future climate scenarios on fire behaviour** for an area in Eastern Mediterranean by employing fine scale future climate change scenarios and landscape fire behaviour modeling.

Methodology

Study area

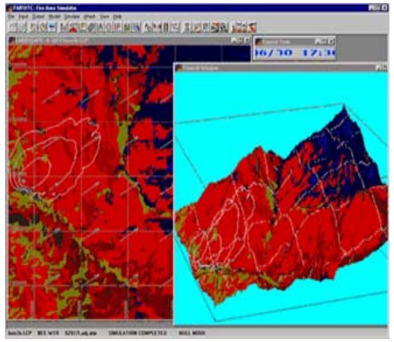
- Mt.Penteli is situated 30 km northeast of Athens and the study area covers 10300 hectares
- Max altitude: 1200 m
- The slope gradient is 15%–30%
- The climate is characterized as Mediterranean type (Csa)
- The annual total amount of rainfall is 413 mm
- The ecosystem is dominated mainly by Aleppo pine (*Pinus halepensis* Mill.) with a shrub understory of maquis species and transitional woodland-shrub followed by sclerophyllous vegetation areas

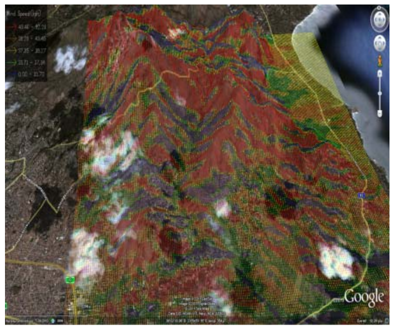


Methodology

Fire Modeling

- Fire behavior simulations were performed using FlamMap software with the Minimum Travel Time (MTT) algorithm.
- A 30 m x 30 m raster input file was created for the fire simulations.
- The duration of all fire simulations was set to 480 minutes (8 hours).
- The ignition point was for all scenarios was set the starting spot of a large fire which burnt large area of the mountain on 21st of August 2009.





Methodology

Fire Modeling

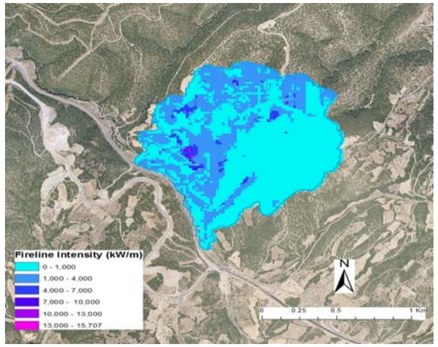
- Wind fields for FlamMap simulations in ASCII grid format were obtained by running the WindNinja model for all scenarios.
- Fuel moistures per fuel category in each fuel type found in the area for each examined future climatic scenario were estimated by using the fuel moisture prediction equations.

Methodology

Fire Modeling

- <u>Input data</u> :
  - ✓ digital terrain model (spatial elevation data of the terrain in a digital format)
  - ✓ climatic input data
  - ✓ fuel type models
  - ✓ spatial extent of fuel models
  - ✓ fuel parameters (e.g. moisture)

- Model Output: **final fire perimeters, time of arrival, rate of spread, and fireline intensity**.
- Statistical significance differences in simulation outputs among the four scenarios were obtained by using the Tukey's significance test.



Methodology- Input data

Fuel Sampling

- Surface fuel load was estimated with standard methods for inventorying surface fuel biomass in **40 plots**. The following fuel parameters were measured in each location:

  1) Dead fuel load per size category,

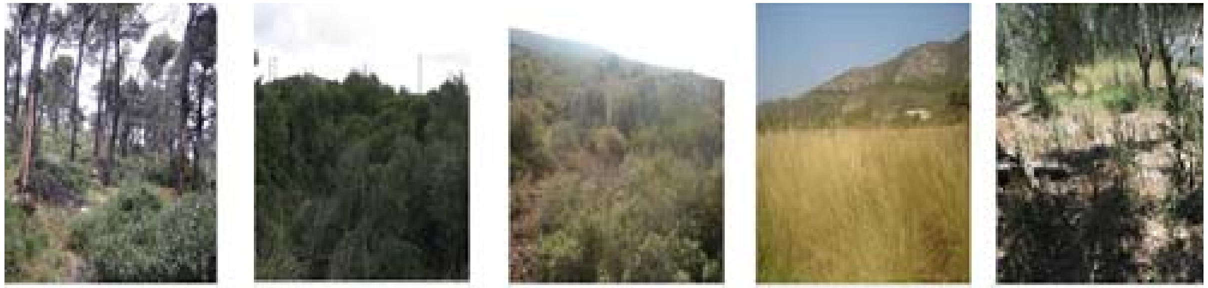
  2) Live foliage load, litter load and depth,

  3) The height of the shrub and herbaceous vegetation layers.

- The percentage of the total area covered by each fuel type were determined with the line intercept method in the fuel transects (30-m long).
- All fuel loads (fuel weight per unit surface area) were expressed on a dry-weight basis.

Methodology- Input data

Fuel types in the study area



FUEL TYPE	TOTAL FUEL LOAD (t/ha)
Understory of pine forests	24.65
Dense shrublands	35.53
Sparse shrublands	15.51
Grasslands	4.31
Agriculture areas	2.28

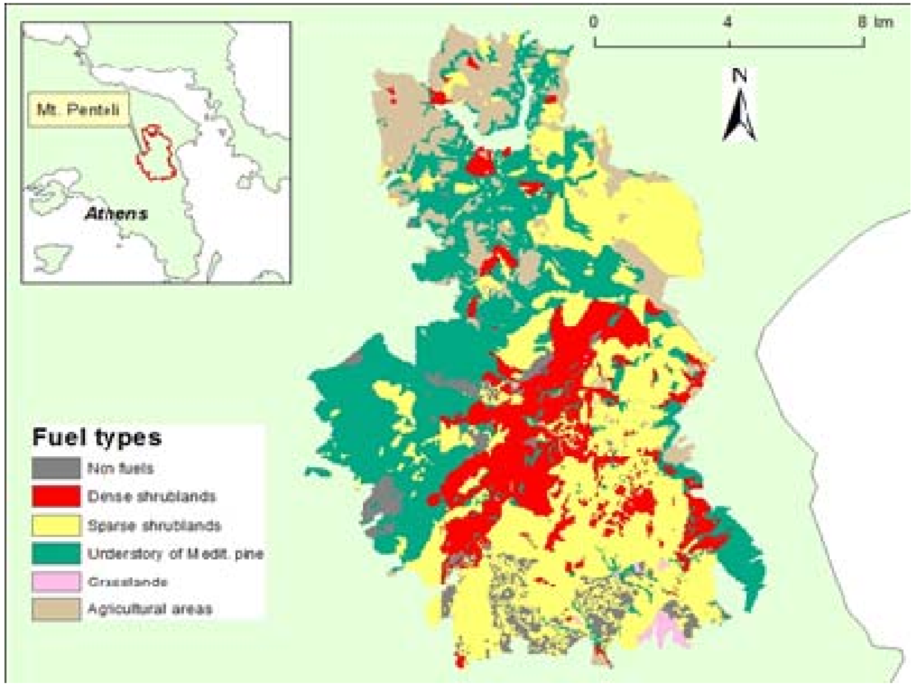
Methodology- Input data

Fuel Mapping

- Fuel type categories were reconstructed based on aerial photographs on a scale of 1:30000 acquired in 2000.
- The images were radiometrically corrected prior to the mosaic process to adjust black and white tonal variation by using an empirical linear spectral normalization technique.
- Fuel type categories were identified based on visual stereoscopic photointerpretation of panchromatic aerial photographs.

Methodology- Input data

Fuel type spatial extent



Methodology- Input data

Climatic input data

- Present and future climatic output from the regional climate model RACMO2.
- The model uses 40 vertical levels on a horizontal 95x85 (lat x lon) grid and has a horizontal resolution of 25km.
- The future period simulations of the model are based on the IPCC SRES A1B scenario.
- The climatic input data used concern **daily values of air maximum temperature, minimum relative humidity, maximum wind speed and the meteorological wind direction**. In order to calculate the meteorological direction of the wind, the horizontal and vertical wind components were used.

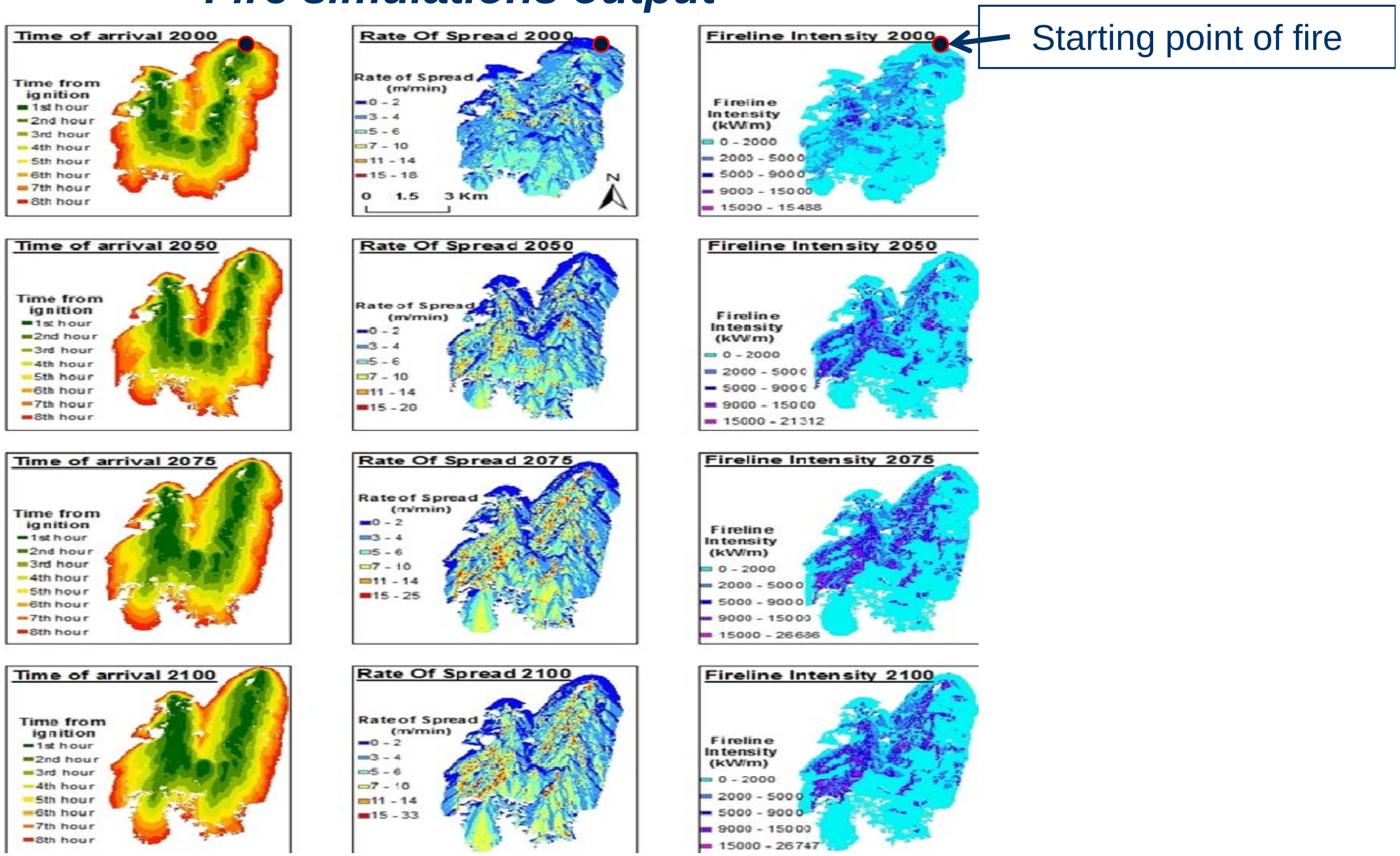
Methodology- Input data

Climatic input data

	Maximum Temperature (°C)	Minimum Relative Humidity (%)	Maximum Wind Speed (km/h)	Wind direction (degrees)
1991-2000 (2000 scenario)	30.1	28	21.7	357
2045-2055 (2050 scenario)	32.0	27	21.7	355
2065-2075 (2070 scenario)	33.5	27	21.7	357
2091-2100 (2100 scenario)	34.2	26	23.0	356

Results

Fire simulations output



Results

Fire behavior parameters for the 4 scenarios

Climate Scenario	Rate of Spread (m/min)	Fireline Intensity (kW/m)	Final fire size (ha)
2000	9	3516	3998
2050	10	5763	4096
2070	12.5	6838	4389
2100	16.1	6671	4512

Concluding remarks

- This study mapped the fire behaviour values and investigated the potential effect under different future climate scenarios for an area in Eastern Mediterranean.

- FlamMap simulations resulted in the most intense fires in the dense shrubland fuel type under the 2100 climate scenario. Furthermore, fireline intensity maps were derived, representing the fire suppression difficulty on a spatial scale under the 4 different climate scenarios.

Concluding remarks

- The proposed methodology presents an integration of fuel mapping, projected future climate change and fire behaviour simulation for fire management planning across the landscape. The final fire behaviour maps are the end product and they can be fully exploited operationally by local fire management authorities without further processing.

- Output created from this study will respond to climate change and can be used as valuable components of judicial long-term wildland fire prevention and management in Greece.

Future Study

- Further studies of actual fire behaviour in the field are necessary in order to validate and calibrate the outcomes of the FlamMap fire behaviour simulators, especially in the Mediterranean vegetation conditions.
- Although the RCM we have used has been proven to be the best performer for our domain of study, there is still a degree of uncertainty as we have use only a single model instead of an ensemble mean of RCMs and only a single emissions scenario.
- Additionally, the potential future change of fuel spatial extent and fuel load values could be further examined in order to allow land managers to address potential future changes to fire severity and regime.

Thank you

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