Wildland-Urban Interface Virtual Essays Workbench
WUIVIEW
GA number 826522

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Reviewed by	All		

Abstract	This deliverable is written to be distributed as the Proceedings of the First International Workshop of the WUIVIEW Project, entitled “Fire hazard at the WUI microscale”. Being a public deliverable, its contents include an overall view of the project, the consortium and the objectives of the workshop. It also includes the abstracts and printouts of the presentations shown. The wrap-up done at the final of the workshop is also reproduced.

(1) Draft / Final
(2) Public / Restricted / Internal

Disclaimer

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1. Introduction

The 1st International Workshop of Project WUIVIEW (www.wuiview.org), entitled “Fire hazard at the WUI microscale”, took place in Coimbra, Portugal, on January 17th, 2020. The event was organized by ADAI team in the Main Auditorium of the Faculty of Sciences and Technology of the University of Coimbra (black building in Figure 1).

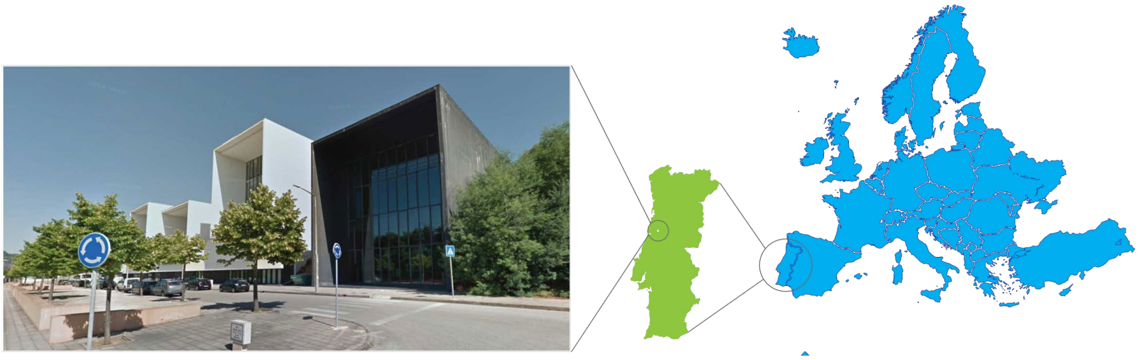


Figure 1 – Venue of the 1st International WUIVIEW Workshop

During the project preparation and submission, we planned this event to have an audience of 60 to 80 people, but we clearly under-estimated the importance that the WUI theme has to the different end-users and actors in the field of land and fire management. There was a total of 298 registered participants (Figure 4).

Figure 2 – Overview of the Auditorium (left) and the opening words by Professor Domingos X. Viegas, Director of ADAI and of CEIF

Most participants came from Portugal (Figure 3). The Portuguese attendees came from all over the country, but approximately one third came from Lisbon municipality (82), followed by Coimbra (36), Porto (17) and Leiria (11). In total, the participants came from 88 different places, from Portugal, Spain, France, Italy and Sweden.

Figure 3 – Geographical distribution of the Workshop attendees

Regarding their occupation, the attendees have different backgrounds. From the 280 registered persons who provided details on their profession, the majority belong to firefighting teams (84), either volunteers or professionals. The municipalities, with their forestry and municipal civil protection offices account for 66 participants. The National Guard (GNR) registered 40 military and there were 33 persons from Research Institutes or Teams. Figure 4 presents all the professional backgrounds.

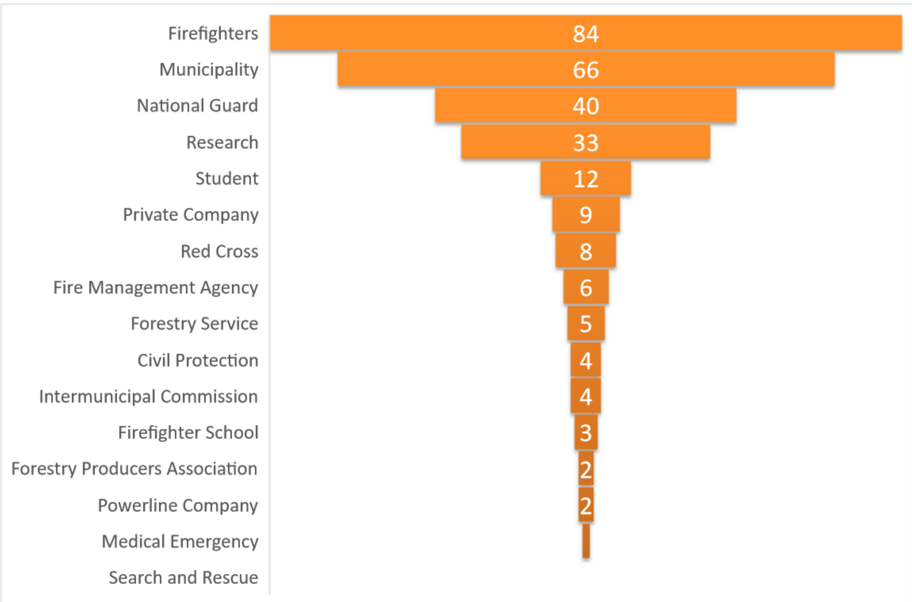


Figure 4 – Attendees occupation

1.1. The WUIVIEW Project

WUIVIEW is a project from the European Union's Civil Protection Mechanism, ECHO, financed under the 2nd priority of the "Prevention Projects in Civil Protection" Call - "Development of disaster risk reduction strategies, taking into account climate change adaptation". It has a duration of 2 years (01/02/2019 – 31/01/2020) and a total budget of around 760K€, distributed among the 6 participant teams.

The main aim of WUIVIEW project is to design, setup, test and operate a virtual workbench service for the performance-based analysis of fire environments in the surroundings of buildings at the wildland-urban interface. In line with the objectives of the Union's Civil Protection Mechanism, the WUIVIEW action is developing an innovative risk management tool that will help WUI communities adapting to face the new generation of forest fires that have already arisen due to climate change. Once implemented, WUIVIEW will become a powerful platform to perform essays and simulation studies dealing with structures survivability, sheltering assessment, building subsystems hazard testing and fire protection systems evaluation. The development of the system will improve knowledge base on microscale fuels fire hazards and on building systems and materials vulnerability, which will be of help to develop better policies and standards to prevent WUI disasters.

WUIVIEW service will cover important needs of current European WUI fire-prone areas (Mediterranean) and of emerging new WUI-fire realities (Northern countries), which are expected to increase in the coming years. In one hand, human pressure in the landscape is continuously growing in Europe and wildfire potential is also increasing associated with housing developments and climate change, leading to new WUI-fire prone regions. On the other hand, innovative design solutions and new materials (e.g. biobased) are certainly appearing from the building and construction sector all over Europe. WUIVIEW will definitely serve as a workbench service to test and develop more resilient emerging WUI-fire scenarios.

The project is also educational oriented. The WUIVIEW outputs and outcomes will finally lead to a higher degree of awareness between fire practitioners and more educated residents at the wildland-urban interface.

For more information please visit the project website at www.wuiview.org.

1.2. The WUIVIEW Consortium

The project consortium is composed of 6 teams, from Spain, Portugal, France, Sweden and Italy:

Barcelona, Spain

UNIVERSITAT POLITÈCNICA DE CATALUNYA (UPC)

UPC is the Coordinator of WUIVIEW Project.

UPC, hosts the CERTEC, which is a research organization with large experience on technological, environmental and natural risks. This mainstreaming grants it unique characteristics to deal with fire hazard characterization, vulnerability analysis and civil protection challenges. CERTEC has engineering background and experience in all types of fire incidents. CERTEC has large computational resources, needed for the project activities.

Coimbra, Portugal

ASSOCIATION FOR THE DEVELOPMENT OF INDUSTRIAL AERODYNAMICS (ADAI)

The Forest Fire Research Center (CEIF) of ADAI, a non-profit Portuguese institution associated to the University of Coimbra, has a worldwide recognized expertise of 30 years of research in forest/WUI fires and hosts the largest laboratory for forest fire experimentation in Europe (LEIF). ADAI members have a wide experience on international research projects.

Alès, France

LABORATORY OF INDUSTRIAL ENVIRONMENT ENGINEERING (ARMINES)

ARMINES, represented by Mines d'Alès, hosts the French "Laboratory of Industrial Environment Engineering" which is a European point of reference of natural-technological risk interactions. They have experimental facilities and proven experience to study burning dynamics of non-natural fuels. They have large computational resources, needed for the project activities.

Barcelona, Spain

PAU COSTA FOUNDATION (PCF)

PCF, is non-profit organization who acts as an international platform devoted to forest fire and fire ecology management, training and dissemination. PCF has a large experience in international projects and cooperation activities. PCF has strong bonds with the fire-fighting community and agencies worldwide.

Borås, Sweden

RESEARCH INSTITUTES OF SWEDEN (RISE)

RISE is a Swedish technical research institution with a broad focus on infrastructure as well as the built and natural environment. RISE has performed many studies on boreal forests fuels characterization, risk assessment and fire behaviour as well as characterisation of fire spread from vegetation to buildings.

Bologna, Italy

UNIVERSITÀ DI BOLOGNA (UNIBO)

UNIBO is an Italian academic institution with specific competence on safety and risk assessment. UNIBO has a worldwide recognized experience in Natech risk assessment, and has a long practice in providing technical support to Italian National and Regional Civil Protection authorities.

2. Objectives and program

The first WUIVIEW Workshop was planned to be held at the end of the tasks performed in Work Packages 2 and 3, respectively, "WUI Natural fuels hazard characterization" and "Artificial fuels hazard characterization", at the end of the first year of the project.

The main objective of the workshop was to present the work done in both WP's, related to the experimental campaigns on natural and artificial fuels hazard and the identification and characterization of WUI microscale scenarios.

Considering the two major themes to be presented, the Workshop title was chosen to address both, and to emphasize its particular focus on the immediate surroundings of house plots: "Fire hazard at the Wildland Urban Interface microscale".

The workshop was held mostly in English with simultaneous translation to Portuguese (and vice versa). The presentations from the Portuguese team, ADAI, were given in Portuguese, for the benefit of the majority of the audience. The interaction with the public, in the questions and answers and in the Round Table was mixed, respecting the understanding and ability to speak English of the attendees.

The bilingual program of the Workshop is presented in Table 1.

Table 1 – Workshop program

Hora/Time	Tema/Subject	Orador/Speaker
08:30 – 09:00	Abertura do secretariado *Secretariat opening (Check-in)*	
09:00 – 09:15	Boas vindas *Welcome*	D.X. Viegas (ADAI) Elsa Pastor (UPC)
09:15 – 09:35	Aspetos gerais dos incêndios na IUF *General overview on WUI fires*	Eulalia Planas (UPC)
09:35 – 10:45	Fogos na IUF na Europa: análise de episódios recentes *WUI fires in Europe: analysis of recent episodes*	David Caballero (PCF) Johan Sjöström (RISE) Luís Mário Ribeiro (ADAI)
10:45 – 11:15	Intervalo para café *Coffee break*	
11:15 – 11:45	A abordagem da investigação do WUIVIEW *The WUIVIEW research approach*	Elsa Pastor (UPC)
11:45 – 12:30	Debate aberto *Open discussion*	
12:30 – 14:00	Almoço *Lunch*	
14:00 – 14:30	Padrões de cenários na IUF: síntese de lições aprendidas *WUI pattern scenarios: synthesizing lessons learnt*	David Caballero (PCF)
14:30 – 15:00	O perigo associado aos combustíveis naturais *Hazard associated to natural fuels*	Miguel Almeida (ADAI)
15:00 – 15:30	O perigo associado aos combustíveis não naturais *Hazard associated to non-natural fuels*	Pascale Vacca (UPC) Giordano Scarponi (UNIBO)
15:30 – 16:30	Mesa redonda *Round table*	
16:30 – 16:45	Conclusões do workshop *Workshop Wrap - up*	Elsa Pastor (UPC) Luís Mário Ribeiro (ADAI)

3. Speakers

A short biographic note of each of the speakers is given here, in order of appearance.

Eulalia Planas (UPC)

Dr. Eulàlia Planas, is Associate Professor at the chemical engineering Department of the Universitat Politècnica de Catalunya (UPC). Head of the Centre for Technological Risk Studies (CERTEC). She has a degree in Industrial Engineering (1993) and a PhD in Chemical Engineering (1996). Her main research lines are the study of hydrocarbon pool-fires; the mathematical modelling of major accidents; risk analysis in the transportation of hazardous materials; and the study of wildfires. In the field of wildfire research, she has developed infrared image processing systems to quantify fire progression (rate of spread, fire intensity, and flame geometry) and aerial fire attack effectiveness. Currently she is working on providing systems to deliver fire behaviour forecasts for decision making, based on data assimilation and inverse modelling. She also develops methodologies based on CFD modelling to study the effects of burning residential fuels on structures, relying on performance-based criteria to assess houses vulnerability and sheltering capacity. Prof. Planas is also extensively involved in experimental fire research.

She has directed 12 PhD thesis and worked on 33 competitive projects. She is author of 6 books and 10 book chapters. She has 65 papers in indexed peer-reviewed journals (26 Q1) and 121 contributions to conferences with a total amount of 2361 citations. Her publishing indexes are h-index of 24 and i10-index of 45 (google scholar metrics).

David Caballero (PCF)

David Caballero is MSc in Forestry Engineering, specializing in forest fires, finishing PhD studies in 2003. David is a freelance consultant on forest fire risk assessment and prevention planning in wildland-urban interface areas in Europe. Currently collaborates with Pau Costa Foundation in the WUIVIEW project. He is the coordinator for the European Observatory of WUI (WUIWATCH) and gathers more than 25 years of experience in international research projects, planning and assessment. He is the author or co-author of more than 60 publications on the subject of forest fires. He accumulates more than 400 hours as instructor on risk assessment and operation, regularly collaborating with the Spanish National School of Civil Protection. He is a member of the NFPA, member of Pau Costa Foundation, Member of the European Union Civil Protection Mechanism and Member of the International Association of Fire Safety Science (IAFSS). He holds the medal to the merit of civil protection of the Ministry of Interior (2017) and the Golden Swatter Award for the best research activity (2011). He is currently working on new technologies for the risk assessment at the micro and mesoscales in the WUI, using drones, 3D models and advanced VR/AR technology.

Johan Sjöström (RISE)

Johan Sjöström and Frida Vermina Plathner are researchers at RISE Research institutes of Sweden, which is a state-owned research institute. They work on fire behaviour, ignition as well as trends and development of fuel characteristics, suppression and fire danger.

Luís Mário Ribeiro (ADAI)

Luís Mário Ribeiro is a senior researcher at ADAI. He has a degree in Forestry from the University of Trás-os-Montes and Alto Douro (1998) in Vila Real (Portugal), where in 2002 finished a post-graduate degree in Forest Resources Engineering. In 2016 he finished his Masters in Social dynamics, natural and technological risks, in the University of Coimbra (Portugal), in which he received a recognition from the Faculty of Economics regarding his outstanding curricular performance.

Since he joined the Forest Fire Research Centre (CEIF) of ADAI, in 1998, he has been actively involved in the realization of various scientific research projects, national and international, in the field of forest fires. He teaches regularly in specialized courses in forest fires promoted by ADAI and is responsible for the lessons related to forest fuels, decision support systems, wildland-urban interface, regulations and safety rules in firefighting and fire behavior prediction systems. Since the beginning of his collaboration with CEIF he has published several papers as author or co-author and presented numerous communications at conferences and seminars, both scientific and operational, in Portugal and abroad.

Elsa Pastor (UPC)

Elsa Pastor, PhD, Associate Professor at the Chemical Engineering Department of Universitat Politècnica de Catalunya · BarcelonaTech and research scientist at the Center for Technological Risk Studies at UPC. She develops teaching and research activities in diverse fields related to wildfire management and technological risk analysis. Over the last 15 years, she has studied several aspects of fire behaviour and dynamics by a multidisciplinary approach, combing both experimental and modelling techniques in a wide range of scenarios. She has profited from diverse fire environments (i.e. wildfires, wildfire research burning campaigns, outdoor large-scale industrial testing fields, compartment fires, laboratory set-ups, etc.) to observe, monitor and analyse flames and their effect to different types of assets and ecosystems. She is currently leading the European Project WUIVIEW (wuiview.org), aimed at designing, setting-up and operating a virtual workbench service for the analysis of fire risk in the surroundings of buildings at the wildland-urban interface.

Miguel Almeida (ADAI)

Miguel Almeida is a senior researcher at ADAI, working since 2003 on fire behaviour and safety in wildland fires and in wildland urban interface fires. He finished his MSc and PhD on wildfires in 2004 and 2011, respectively. In his professional career, he co-supervised several master's and doctoral theses and co-published several papers in this thematic. He participated in more than 20 scientific projects, National and European, many of them in the context of the fire risk in the WUI.

Pascale Vacca (UPC)

Pascale Vacca is PhD student at the Centre for Technological Risk Studies at Universitat Politècnica de Catalunya. As a fire safety engineer with experience in consultancy, she is now studying the interaction between fire, structures, and surrounding elements at the Wildland-Urban Interface microscale, focusing especially on non-natural fuels.

Giordano Scarponi (UNIBO)

Giordano Emrys Scarponi has a PhD in Chemical and Process Engineering and a post-doc at the Department of Civil, Chemical, Environmental and Material Engineering at the University of Bologna (Italy). Over the last 5 years, he has studied several aspects of the behaviour of pressure vessels exposed to fire, combing both experimental and modelling techniques in a wide range of scenarios. In particular, he focused on the development of a CFD modelling approach to predict the response of LPG tanks to fire exposure.

4. Presentations

An abstract of each of the presentations, as well as the printout of the slides shown during the workshop are reproduced here.

4.1. General overview on WUI fires, by Eulalia Planas

4.1.1. Abstract

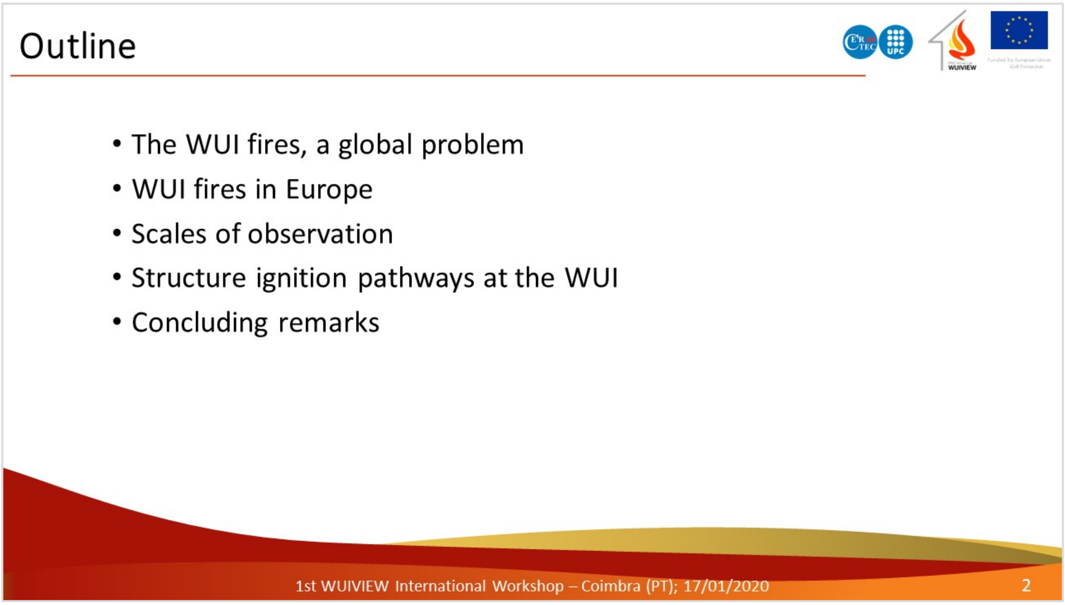
Wildfires are an ecological phenomenon inherent to many ecosystems' dynamics over the globe. They have a key role in ecosystem functioning and ecological evolution. Indeed, it has been recently highlighted that most wildfires are natural processes that provide a wide variety of benefits to humankind when natural ecosystems are functioning properly. However, the problem starts when fire regimes (i.e. fire frequency, intensity, size and duration of fires) are modified by human activities. Human alterations of landscapes and climate have led to strong changes in fire regimes and their socio-ecological impact. Unfortunately, in recent years we have been witnessing theses changes in several regions of the world, which are nowadays facing unprecedented crisis caused by wildfires.

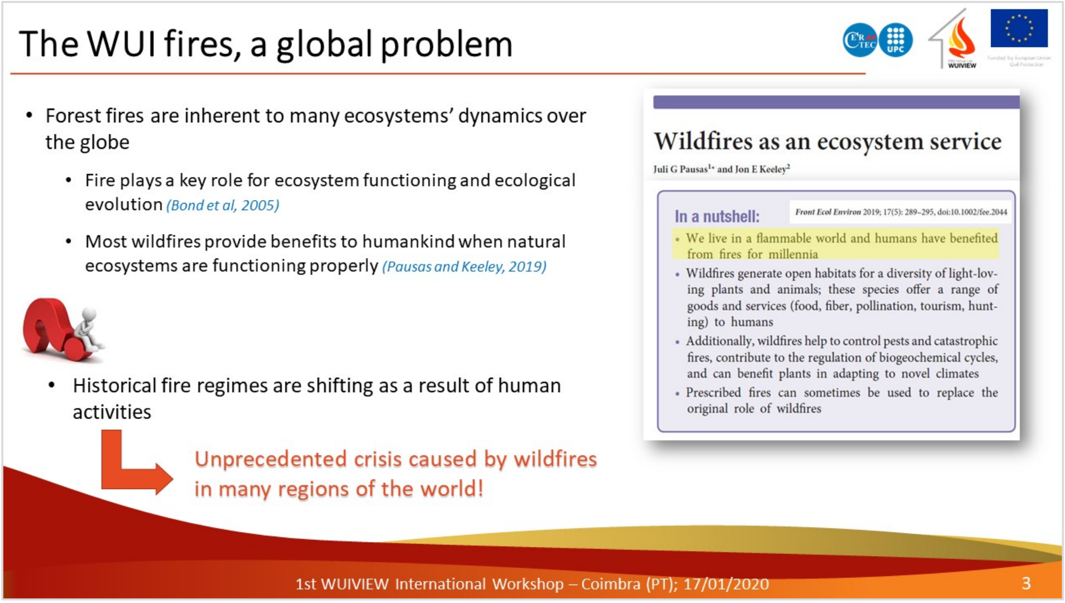
Just to number a few examples of wildfire disasters that we have seen in the last years affecting different areas of the globe: in 2009, Australia suffered what is known as the Black Saturday fires, which are the worst fires in terms of casualties until today. In 2016 the Fort McMurray fire, in Canada, forced the largest wildfire evacuation in Alberta's history with 88,000 people leaving their homes. In California, Tubbs fire (2017), Thomas fire (2017) and Camp fire (2018) are just some of the recent events that have involved catastrophic consequences. We have also dramatic examples in South America too. Chile, with Mediterranean climate, has been struggling with fires at the wildland-urban interface but also fires in the amazon caused a huge impact last summer with 1million ha burned. We can also recall some recent examples in Europe; we saw a devastating fire in Greece last 2018, with over one hundred people dead and the 2017 fires in Portugal, during the summer but also in October. In addition, we have even recently seen the largest fire in Greenland, which in 2019 has been hit with more wildfires than during the whole last decade. Finally, we have to mention the current wildfire crisis in Australia, with record-breaking temperatures and months of severe drought, involving almost 12 million hectares burnt and 2,600 houses destroyed.

Climate change is increasing wildfires intensity and destructive potential in Mediterranean countries. Yet, climate change is also causing emergent WUI-fire prone zones in northern latitudes, which are not adapted to wildfires. In addition, human pressure is continuously growing particularly in Mediterranean forests with an increase of ignitions and housing developments at the WUI. Therefore, every fire season we can see how WUI fires are posing tremendous management challenges in terms of civil protection and fire mitigation. WUI fires quite often exceed fire-fighters capacities who have to respond simultaneously to wildfire suppression, community evacuation and structures protection.

The WUI fire problem is inherently complex, as it is characterized by the interaction of multiple phenomena of diverse nature occurring at different observation scales: the macroscale or landscape scale, the mesoscale or development/settlement scale and the microscale or home/plot scale. All three are interrelated and allow rationalizing and identifying all WUI fire management aspects. It is in all these different scales where scientific-based recommendations have to be developed to drive informed policymaking processes and to help communities, firefighters and civil protection agencies to mitigate WUI fire risk.

4.1.2. Presentation printout




The WUI fires, a global problem
• Forest fires are inherent to many ecosystems' dynamics over the globe
• Fire plays a key role for ecosystem functioning and ecological evolution (Bond et al, 2005)
• Most wildfires provide benefits to humankind when natural ecosystems are functioning properly (Pausas and Keeley, 2019)
• Historical fire regimes are shifting as a result of human activities
Unprecedented crisis caused by wildfires in many regions of the world!
Wildfires as an ecosystem service
Juli G Pausas and Jon E Keeley
In a nutshell:
Front Ecol Environ 2019; 17(5): 289–295, doi:10.1002/fee.2044
• We live in a flammable world and humans have benefited from fires for millennia
• Wildfires generate open habitats for a diversity of light-loving plants and animals; these species offer a range of goods and services (food, fiber, pollination, tourism, hunting) to humans
• Additionally, wildfires help to control pests and catastrophic fires, contribute to the regulation of biogeochemical cycles, and can benefit plants in adapting to novel climates
• Prescribed fires can sometimes be used to replace the original role of wildfires
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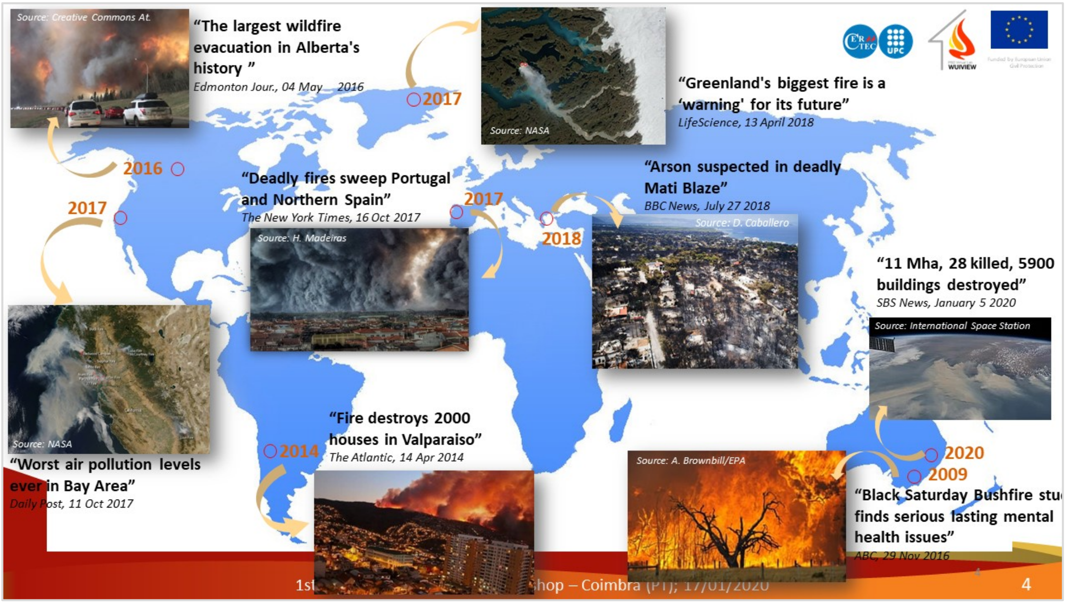
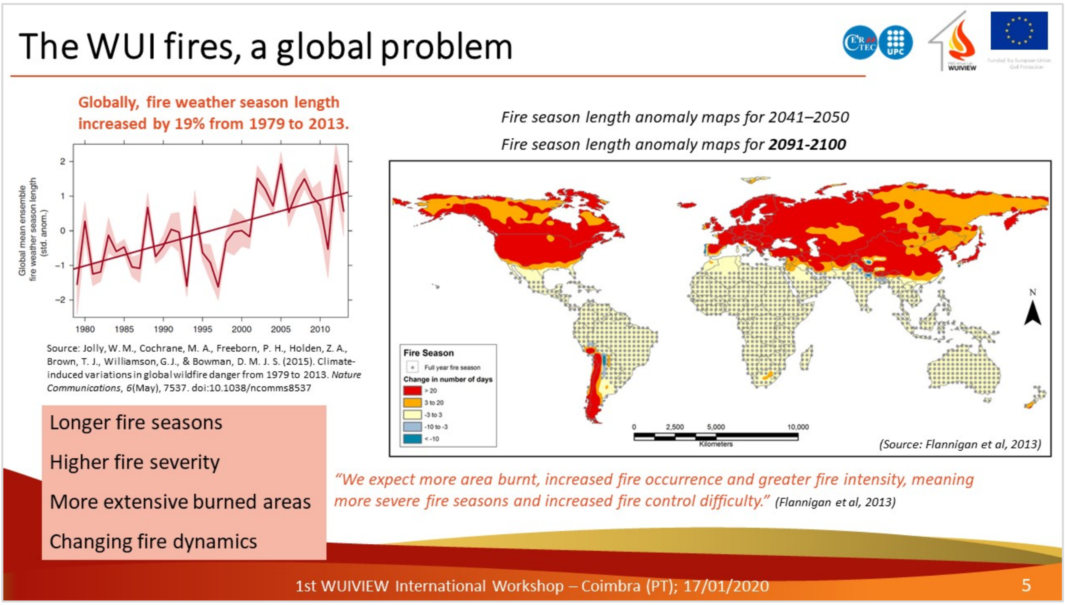

Source: Creative Commons At.
"The largest wildfire evacuation in Alberta's history "
Edmonton Jour., 04 May 2016
2016
2017
Source: NASA
2017
"Greenland's biggest fire is a 'warning' for its future"
LifeScience, 13 April 2018
"Deadly fires sweep Portugal and Northern Spain"
The New York Times, 16 Oct 2017
2017
Source: H. Madeiras
2018
"Arson suspected in deadly Mati Blaze"
BBC News, July 27 2018
Source: D. Caballero
"11 Mha, 28 killed, 5900 buildings destroyed"
SBS News, January 5 2020
Source: International Space Station
Source: NASA
"Worst air pollution levels ever in Bay Area"
Daily Post, 11 Oct 2017
2014
"Fire destroys 2000 houses in Valparaiso"
The Atlantic, 14 Apr 2014
Source: A. Brownbill/EPA
2020
2009
"Black Saturday Bushfire stu finds serious lasting mental health issues"
ABC, 29 Nov 2016
4


The WUI fires, a global problem
Globally, fire weather season length increased by 19% from 1979 to 2013.
Global mean ensemble fire weather season length (std. anom.)
2
1
0
−1
−2
1980 1985 1990 1995 2000 2005 2010
Source: Jolly, W. M., Cochrane, M. A., Freeborn, P. H., Holden, Z. A., Brown, T. J., Williamson, G. J., & Bowman, D. M. J. S. (2015). Climate-induced variations in global wildfire danger from 1979 to 2013. Nature Communications, 6(May), 7537. doi:10.1038/ncomms8537
Fire season length anomaly maps for 2041–2050
Fire season length anomaly maps for 2091-2100
Fire Season
Full year fire season
Change in number of days
> 20
3 to 20
-3 to 3
-10 to -3
< -10
0 2,500 5,000 10,000
Kilometers
N
(Source: Flannigan et al, 2013)
Longer fire seasons
Higher fire severity
More extensive burned areas
Changing fire dynamics
"We expect more area burnt, increased fire occurrence and greater fire intensity, meaning more severe fire seasons and increased fire control difficulty." (Flannigan et al, 2013)
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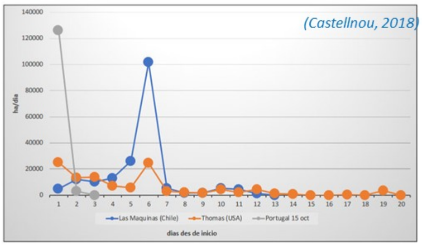
The WUI fires, a global problem

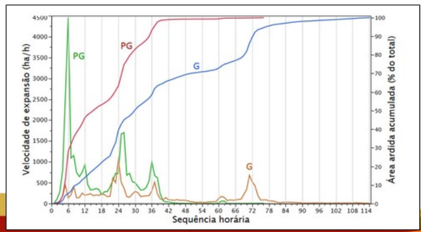
- **Extreme fire events**
  - "Mega-fires" *(Williams, 2013)*
  - Extreme fire behaviour

✓ Burnt area:

- >100,000 ha/day in Portugal and Chile 2017 fire events (mean hourly growth rate: 4,000 – 4500 ha/h)

  Max values > 30,000 ha/h (Black Saturday) *(Cruz et al., 2012)*





(ComissaoTécnica Independente, 2018)

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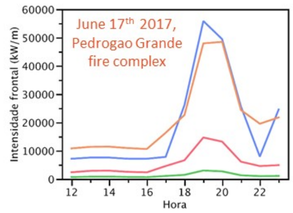
The WUI fires, a global problem

- **Extreme fire events**
  - "Mega-fires" *(Williams, 2013)*
  - Extreme fire behaviour

✓ Fireline intensity:

- Well above fireline intensity threshold (= 10,000 kW/m) for effective suppression
- 90,000 kW/m (Kilmore, AUST, Feb 7th 2009)



(Source: ComissaoTécnica Independente, 2018)

Table 4
Average rate of fire spread, area burned, fireline intensity (Byram, 1959) and heat release for selected burning periods (BP) in the Kilmore East fire.

BP	Main fuel type	Fire perimeter (km)	Average rate of fire spread (m min^{-1})	Hourly area burned (ha)	Average fireline intensity (kW m^{-1})
1	Grass	1.3	–		–
2	Grass	10	71	239	6603
3	Grass, DSFL	21	73	1534	–
4	DSFL	30	68	1311	39,209
5	DSFL	50	153	4286	88,220
6	DSFL, MDWSF	106	–	10,068	–
7	DSFL, MDWSF	143	–	9752	–
8	DSFL	217	127	35,802	73,228
9	MDWSF	311	90	12,626	82,677
10	DSFL	487	–	6129	–

nd, not determined; DSFL, dry sclerophyll forest, low understory, MDWSF, mix dry-wet sclerophyll forest. *(Source: Cruz et al., 2012)*

$$I_B = \Delta H_C \cdot m_c' \cdot V$$ *(Byram, 1959)*

✓ Rate of spread:

- 150 m/min (Kilmore, AUST, 2009)

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The WUI fires, a global problem

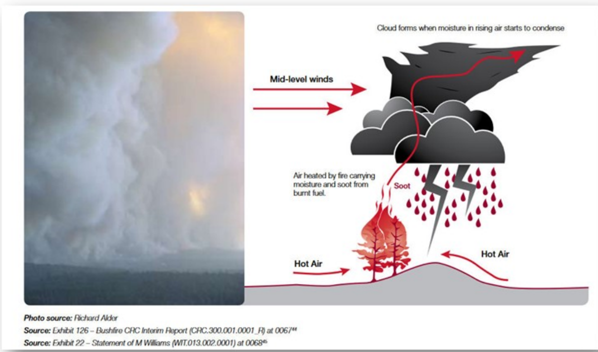
- **Extreme fire events**
  - "Mega-fires" *(Williams, 2013)*
  - Extreme fire behaviour

✓ Complex fire dynamics phenomena:

Massive convective plumes

Pyrocumulonimbus

Downbursts



(Source: Victorian bushfires royal commission, 2009)

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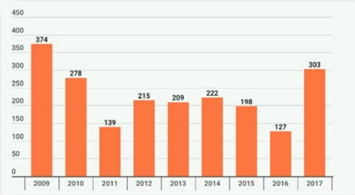
The WUI fires, a global problem

- **Large impact**
  - Ecological impact
  - Loss of human life
  - Health problems
  - Economic damage



Worldwide deaths as a result of wildfires (2009-2017)
(Source: GFMC, 2018)

✓ 2017 figures

- **303 people were killed** (in 33 countries)
- 1,887 people injured (568,244 injuries in 2016 and 74,5871 in 2015)
- **Displacement of 546,768 persons** (in 37 countries)
- **10,498 destroyed and 11,740 damaged homes**; 513,370 other structures (in 50 countries)
- **530,907 ha affected in protected areas** (in 30 countries)
- USD **$22,8 billion of economic impact** (in 18 countries)

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WUI fires in Europe

- **Climate change** worsening the WUI fire problem throughout Europe
  - More intense wildfires
  - Emergent WUI-fire prone zones in northern latitudes
- **Human pressure** increasing in Mediterranean forests
- **Fire-fighters capacities often exceeded** in WUI fires
  - Wildfire suppression, community evacuation, structure protection!

"The economic impact of Greece, Spain, France, Italy and Portugal may increase to over EUR 5 billion /year by 2070-2100"
(Source: European Union, 2018)

Impact of forest fires in the EU (2000-2017 period)
- Environmental losses: 8.5 million ha burnt (**480,000 ha/year**)
- Human losses: 611 people killed (**34 deaths/year**)
- Economic losses: EUR 54 billion (**3 billion /year**)

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WUI fires in Europe

- **Climate change** worsening the WUI fire problem throughout Europe
  - More intense wildfires
  - Emergent WUI-fire prone zones in northern latitudes
- **Human pressure** increasing in Mediterranean forests
- **Fire-fighters capacities often exceeded** in WUI fires
  - Wildfire suppression, community evacuation, structure protection!
- **Self protection needed** → better prepared WUI scenarios

↳ **Actions grounded on solid Regulation and Legislation!**

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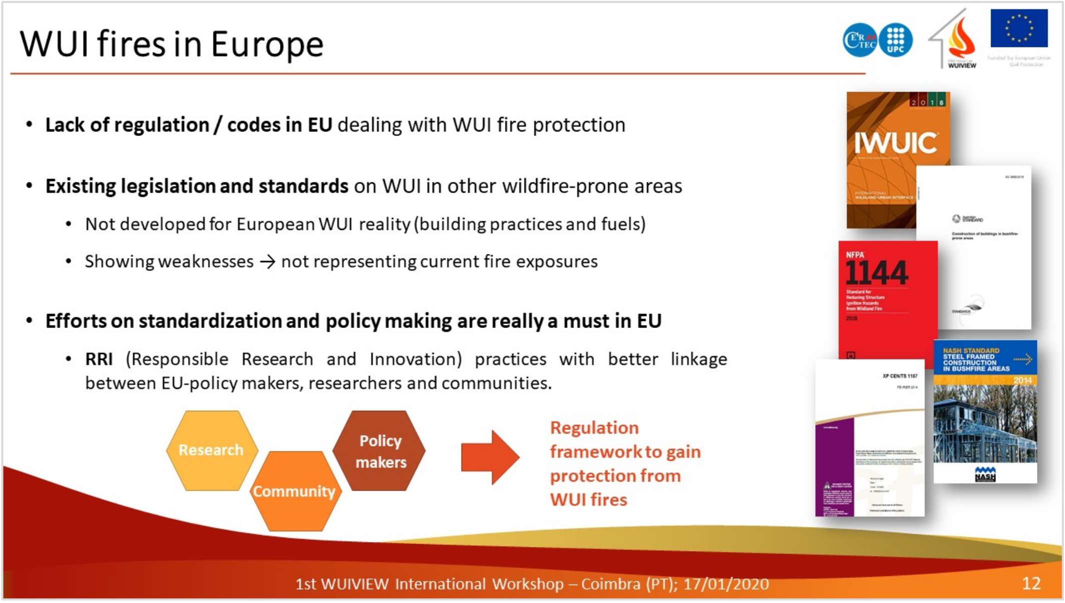
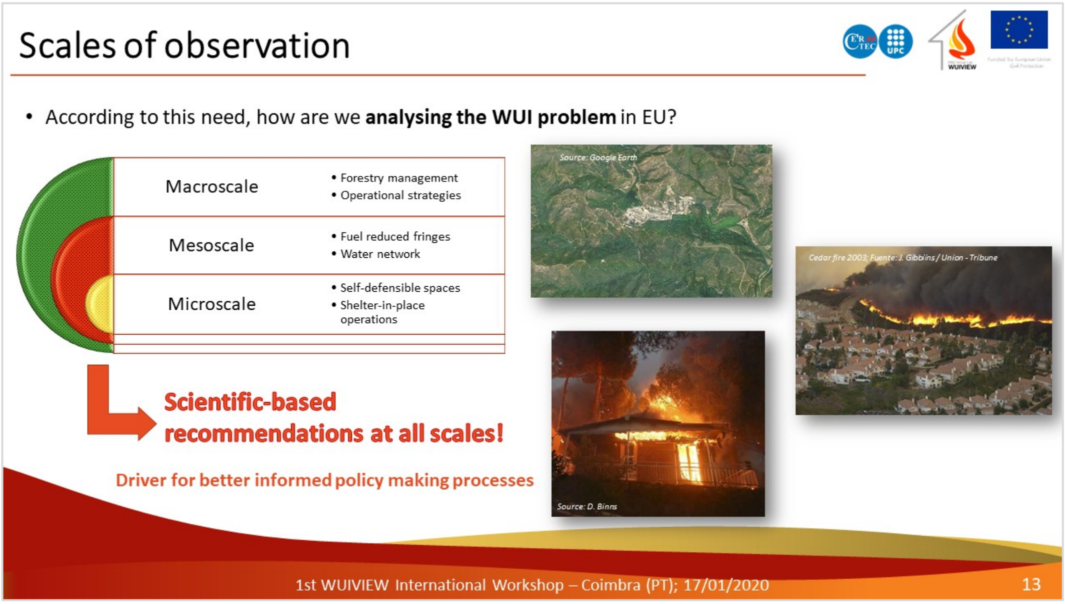
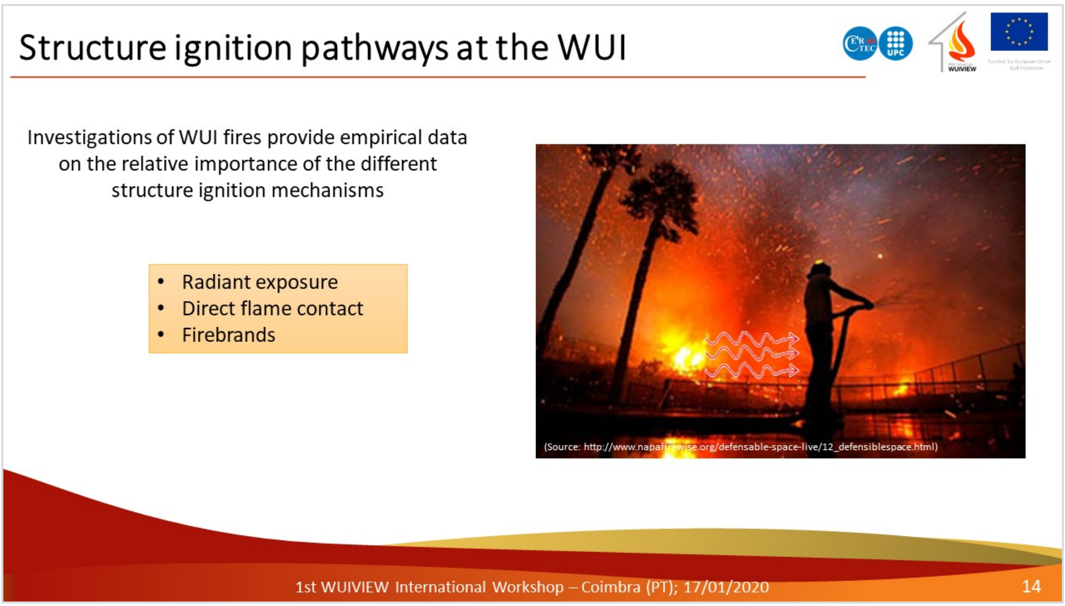
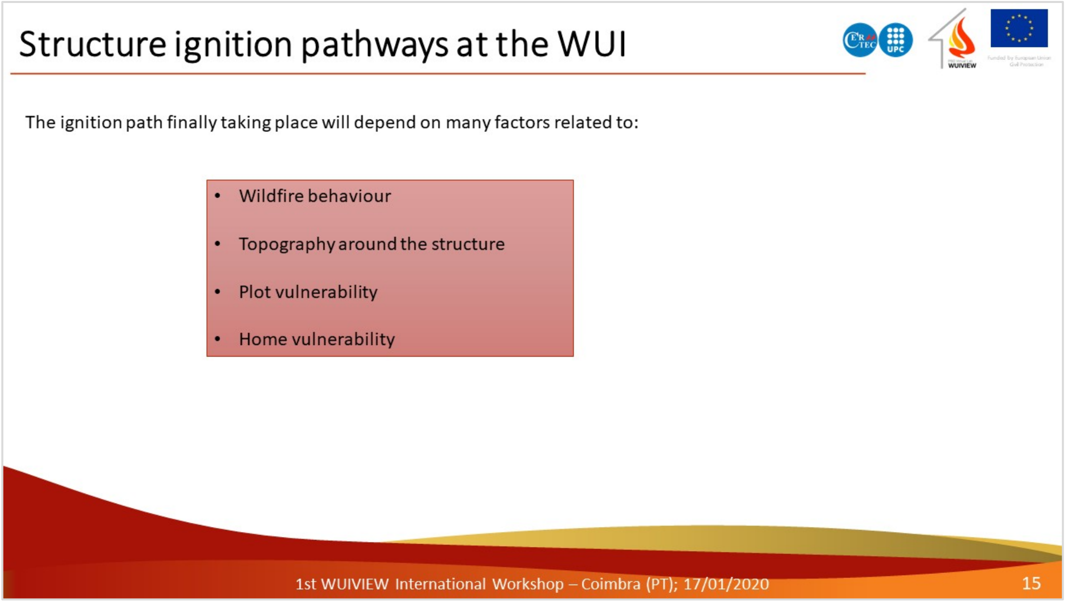

WUI fires in Europe
Lack of regulation / codes in EU dealing with WUI fire protection
Existing legislation and standards on WUI in other wildfire-prone areas
Not developed for European WUI reality (building practices and fuels)
Showing weaknesses → not representing current fire exposures
Efforts on standardization and policy making are really a must in EU
RRI (Responsible Research and Innovation) practices with better linkage between EU-policy makers, researchers and communities.
Research
Community
Policy makers
Regulation framework to gain protection from WUI fires
IWUIC
NFPA
1144
NASH STANDARD STEEL FRAMED CONSTRUCTION IN BUSHFIRE AREAS
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
12


Scales of observation
According to this need, how are we analysing the WUI problem in EU?
Macroscale
Forestry management
Operational strategies
Mesoscale
Fuel reduced fringes
Water network
Microscale
Self-defensible spaces
Shelter-in-place operations
Scientific-based recommendations at all scales!
Driver for better informed policy making processes
Source: Google Earth
Cedar fire 2003; Fuente: J. Gibbins/Union - Tribune
Source: D. Binns
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
13


Structure ignition pathways at the WUI
Investigations of WUI fires provide empirical data on the relative importance of the different structure ignition mechanisms
Radiant exposure
Direct flame contact
Firebrands
(Source: http://www.napafirewise.org/defensable-space-live/12_defensiblespace.html)
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
14


Structure ignition pathways at the WUI
The ignition path finally taking place will depend on many factors related to:
• Wildfire behaviour
• Topography around the structure
• Plot vulnerability
• Home vulnerability
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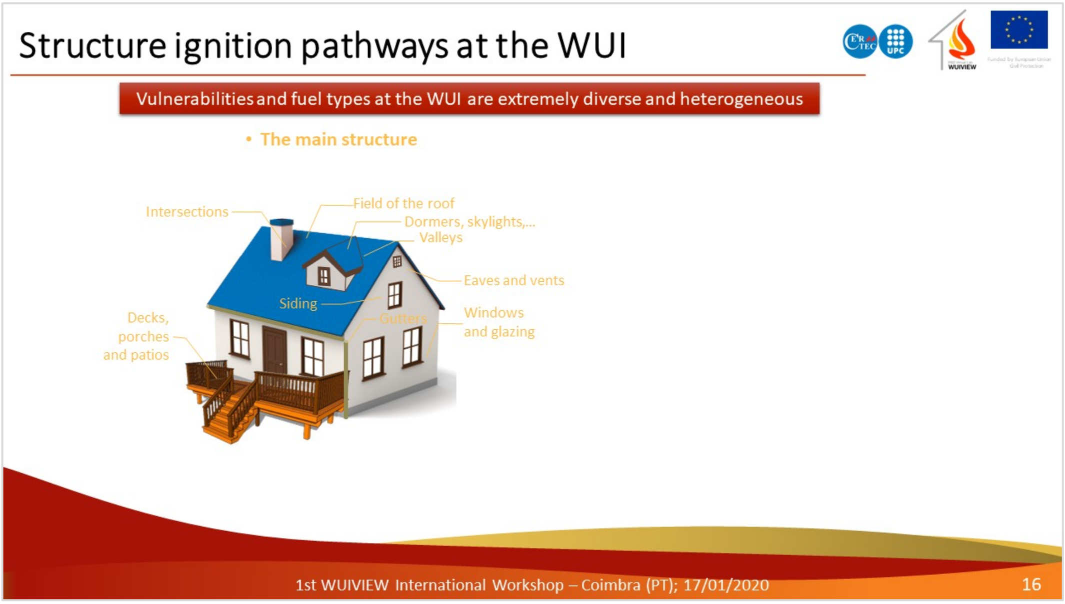
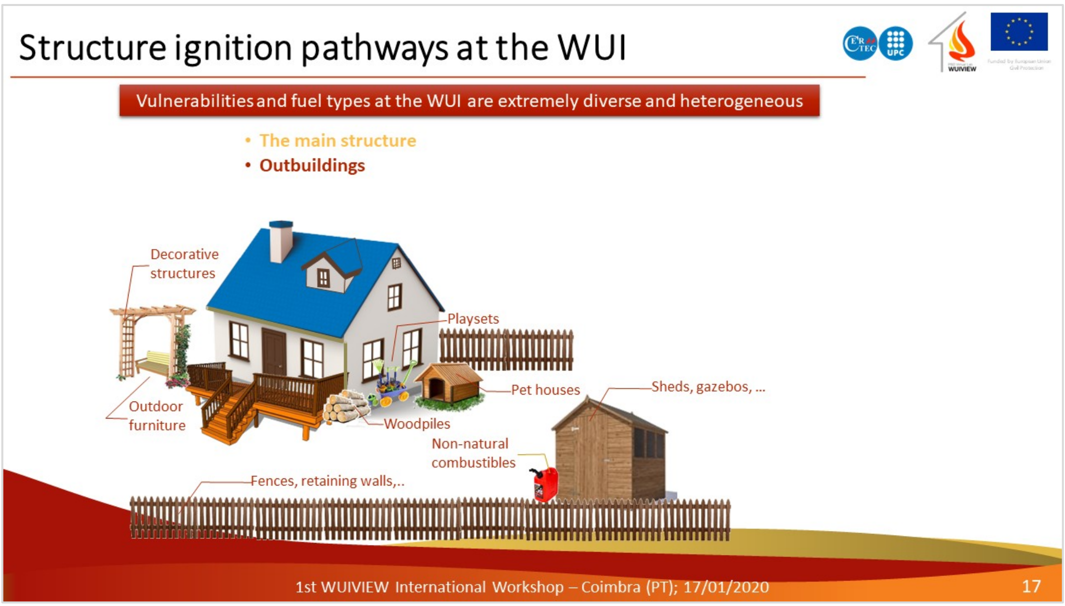
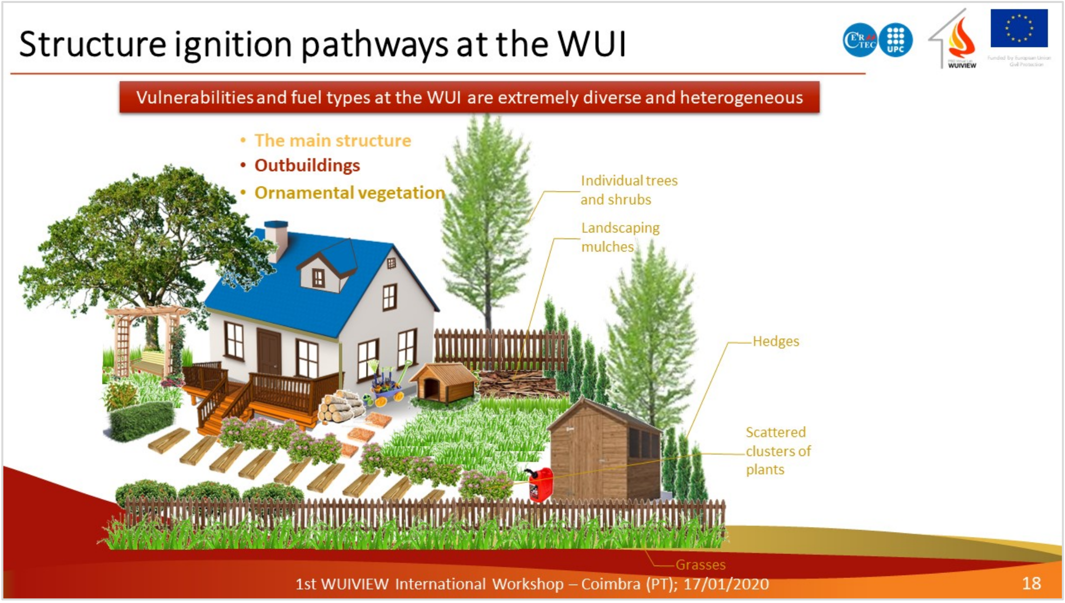
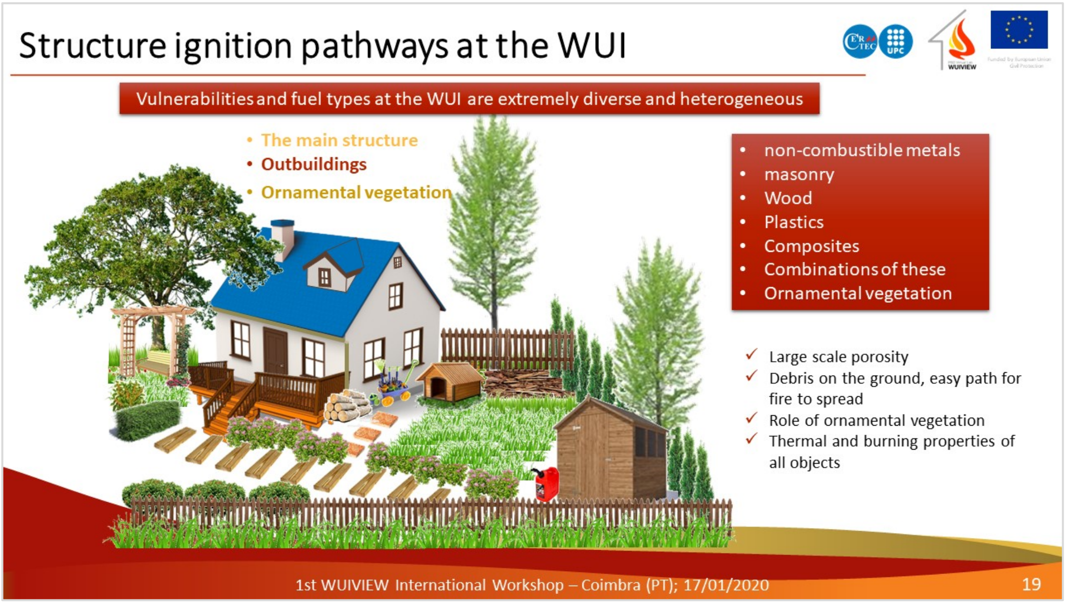
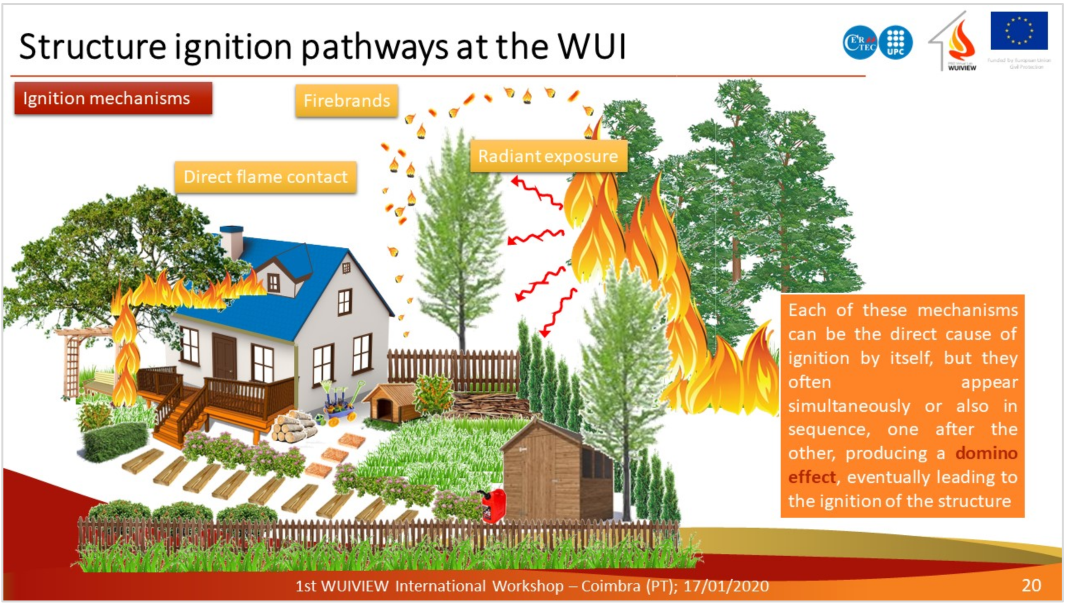
15

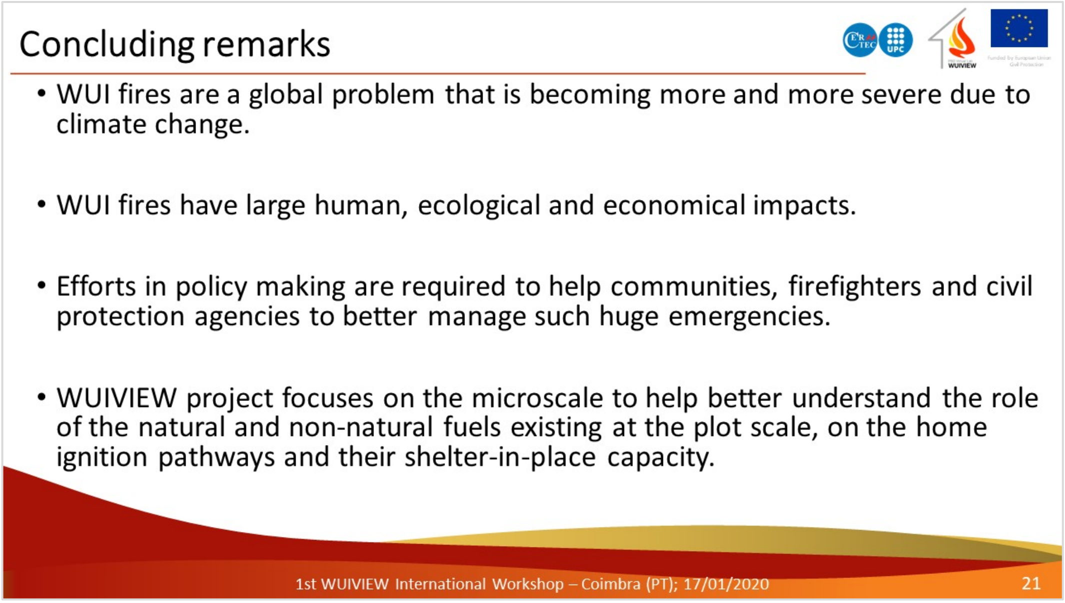

Structure ignition pathways at the WUI
Vulnerabilities and fuel types at the WUI are extremely diverse and heterogeneous
• The main structure
Intersections
Field of the roof
Dormers, skylights,...
Valleys
Eaves and vents
Siding
Gutters
Windows and glazing
Decks, porches and patios
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
16


Structure ignition pathways at the WUI
Vulnerabilities and fuel types at the WUI are extremely diverse and heterogeneous
• The main structure
• Outbuildings
Decorative structures
Playsets
Pet houses
Sheds, gazebos, ...
Outdoor furniture
Woodpiles
Non-natural combustibles
Fences, retaining walls,..
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
17


Structure ignition pathways at the WUI
Vulnerabilities and fuel types at the WUI are extremely diverse and heterogeneous
• The main structure
• Outbuildings
• Ornamental vegetation
Individual trees and shrubs
Landscaping mulches
Hedges
Scattered clusters of plants
Grasses
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
18


Structure ignition pathways at the WUI
Vulnerabilities and fuel types at the WUI are extremely diverse and heterogeneous
• The main structure
• Outbuildings
• Ornamental vegetation
• non-combustible metals
• masonry
• Wood
• Plastics
• Composites
• Combinations of these
• Ornamental vegetation
✓ Large scale porosity
✓ Debris on the ground, easy path for fire to spread
✓ Role of ornamental vegetation
✓ Thermal and burning properties of all objects
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
19


Structure ignition pathways at the WUI
Ignition mechanisms
Firebrands
Radiant exposure
Direct flame contact
Each of these mechanisms can be the direct cause of ignition by itself, but they often appear simultaneously or also in sequence, one after the other, producing a domino effect, eventually leading to the ignition of the structure
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
20


Concluding remarks
• WUI fires are a global problem that is becoming more and more severe due to climate change.
• WUI fires have large human, ecological and economical impacts.
• Efforts in policy making are required to help communities, firefighters and civil protection agencies to better manage such huge emergencies.
• WUIVIEW project focuses on the microscale to help better understand the role of the natural and non-natural fuels existing at the plot scale, on the home ignition pathways and their shelter-in-place capacity.
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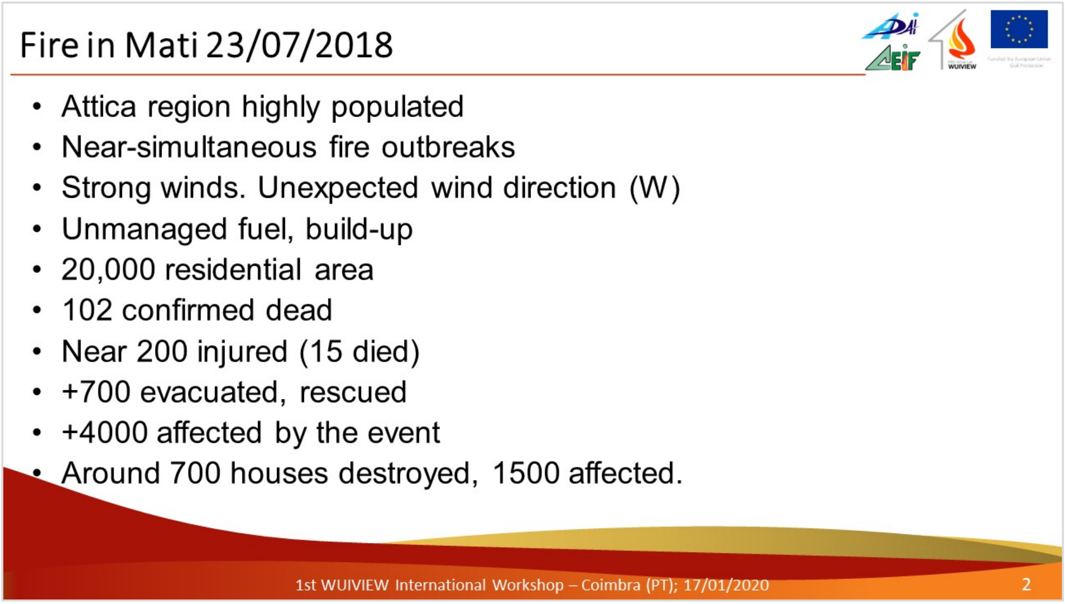
21

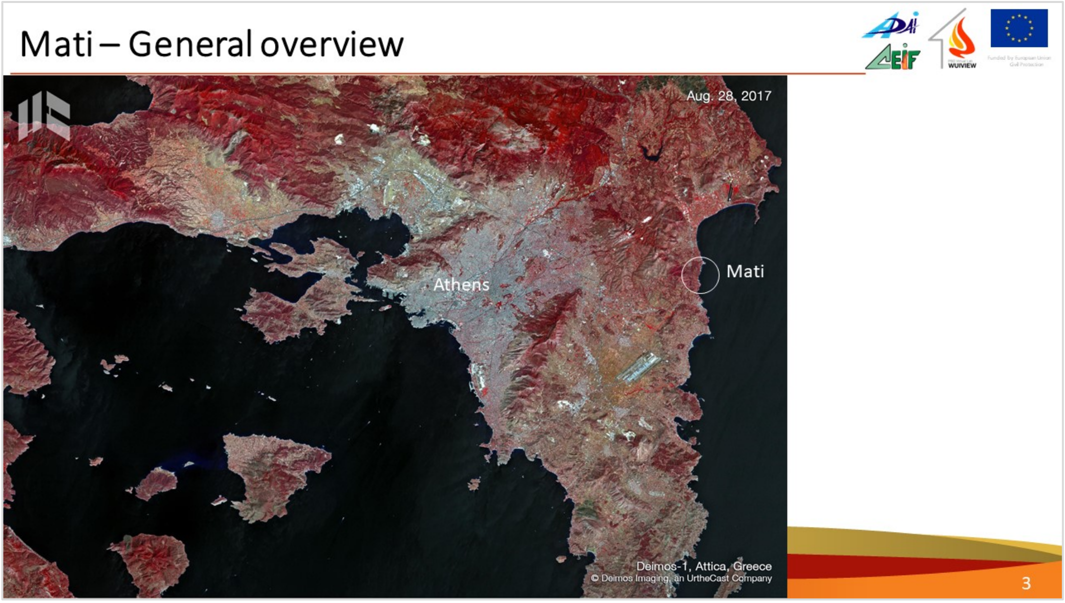
4.2. WUI fires in Europe: analysis of recent episodes – part 1, by David Caballero

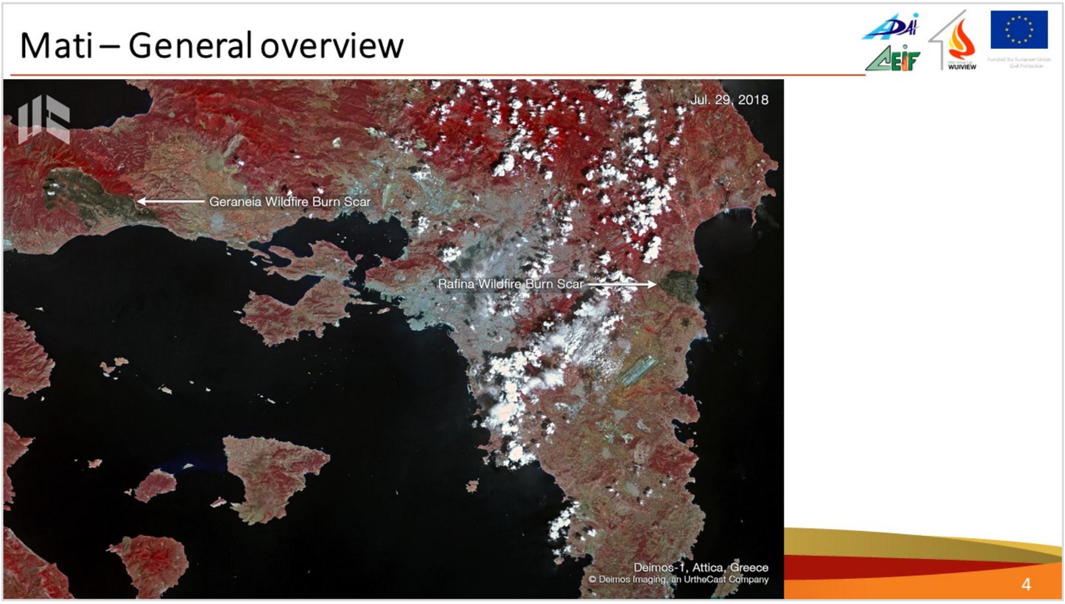
4.2.1. Abstract

On July 23rd 2018 a devastating fire in Mati, Greece, claimed the life of 102 people and severely injuring near 200. A total population of 4000 was affected by a fast-moving wildfire over a large WUI area in Attica region, Greece. In Portugal in 2017, another set of devastating fires burnt across the country, affecting several WUI areas, claiming the lives of 66. The new reality of unexpected weather patterns and fast-moving, highly destructive wildfire is changing the way we look at the WUI, and the way we must design plans for protection of structures and lives. This presentation addresses several facts and lessons observed and suggests some directions to take towards more effective and safer measures based on such experiences. The observed lessons have been a baseline for the definition of WUI pattern scenarios in WUIVIEW project.

4.2.2. Presentation printout

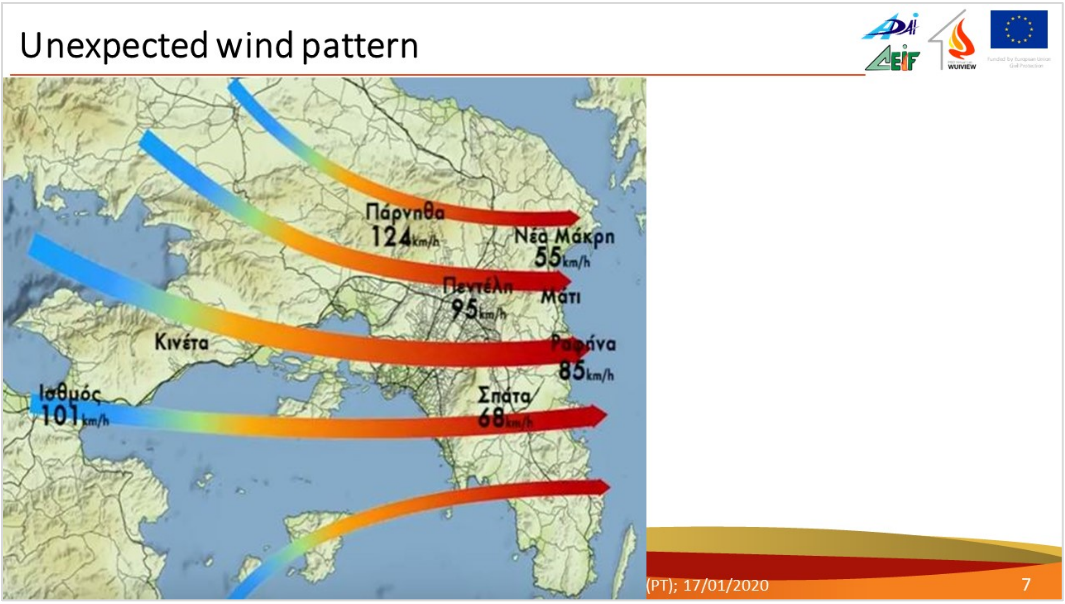


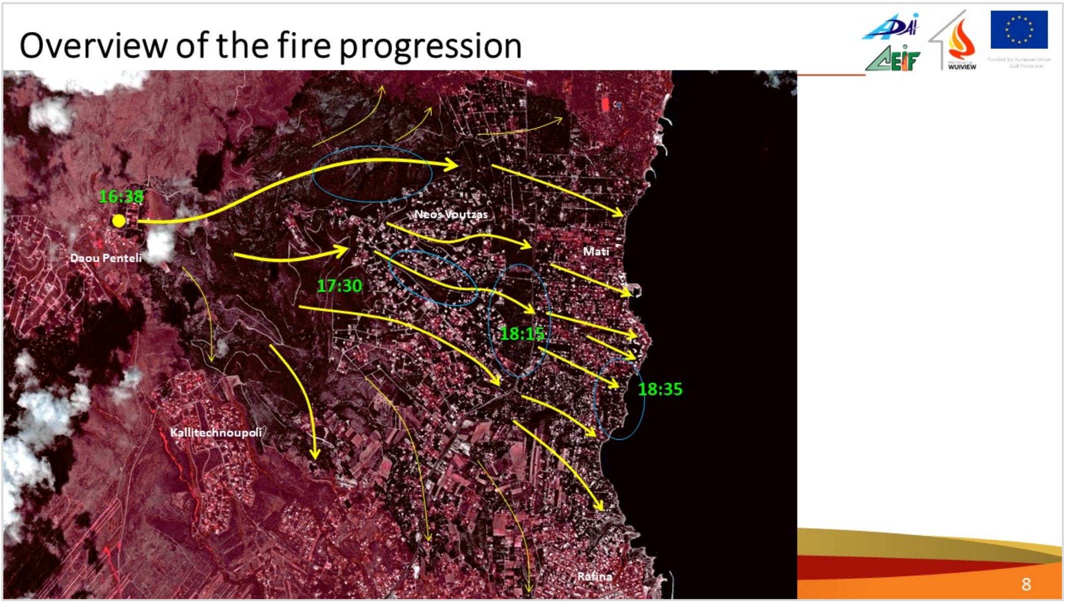

Mati – General overview
Aug. 28, 2017
Athens
Mati
Deimos-1, Attica, Greece
© Deimos Imaging, an UrtheCast Company
3


Mati – General overview
Jul. 29, 2018
Geraneia Wildfire Burn Scar
Rafina Wildfire Burn Scar
Deimos-1, Attica, Greece
© Deimos Imaging, an UrtheCast Company
4


Mati – General overview
Daou Penteli
Neos Voutzas
Mati
Kallitechnoupoli
Rafina
5


Creating the Wildland-Urban Interface. Evolution over the years
2018
1945


Unexpected wind pattern
Πάρνηθα
124km/h
Νέα Μάκρη
55km/h
Πεντέλη
95km/h
Μάτι
Κινέτα
Ραφήνα
85km/h
Ισθμός
101km/h
Σπάτα
68km/h
(PT); 17/01/2020
7


Overview of the fire progression
16:38
Daou Penteli
Neos Voutzas
Mati
17:30
18:15
18:35
Kallitechnoupoli
Rafina
8

Overview of the fire progression

9

Initial point

10

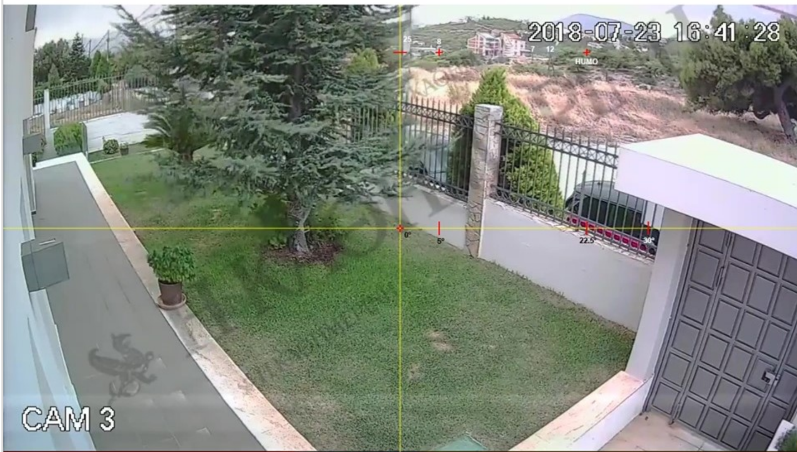
Initial point

11

Initial point

12

Initial point



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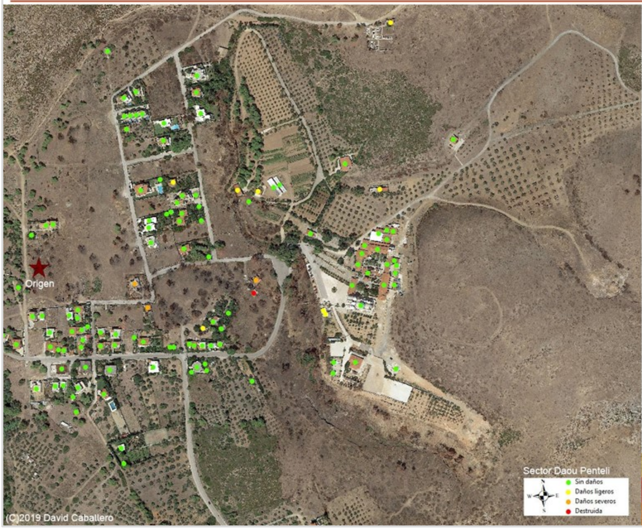
13

Initial point

14

Initial point – Affected houses



(PT); 17/01/2020

15

Initial point – First propagation

16

Initial point – First propagation

17

18

Jump in Pantokrator

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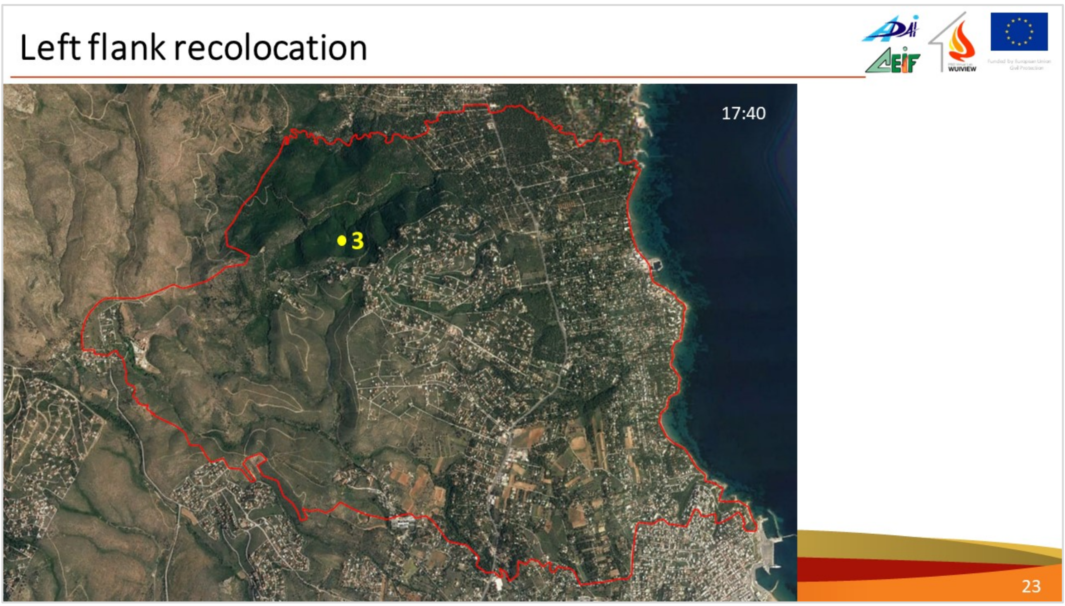
Jump in Pantokrator

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020 20


Spread towards Neos Voutzas
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
21


22


Left flank recolocation
17:40
3
23


Left flank recolocation
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
24


25


Left flank recolocation
26


Left flank recolocation
27


Spread through Neos Voutzas
17:50
4
28


Spread through Neos Voutzas
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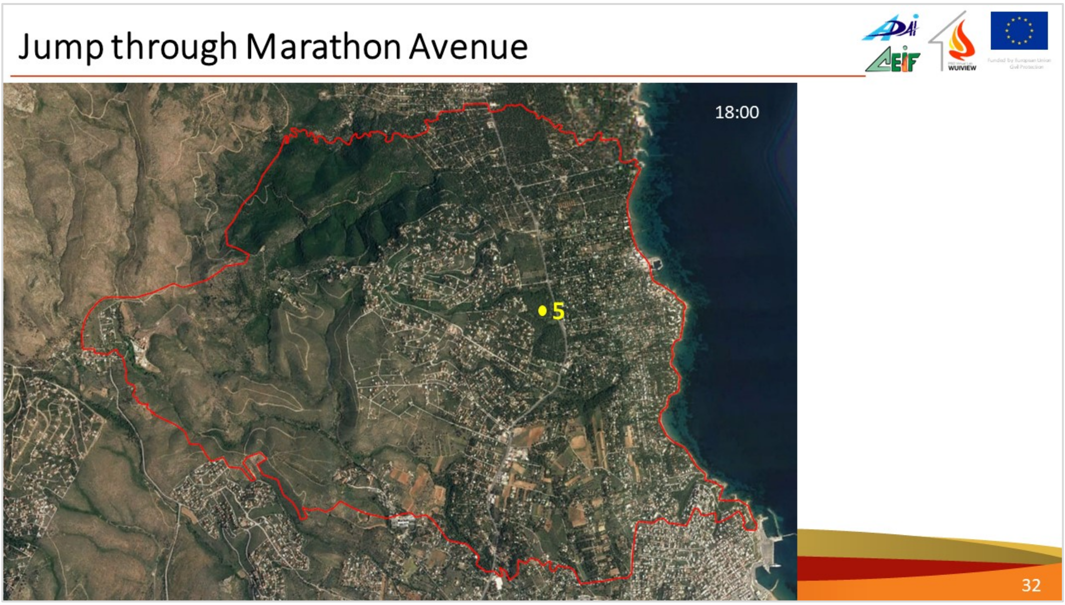
29


Spread through Neos Voutzas
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
30


31


Jump through Marathon Avenue
18:00
5
32

Jump through Marathon Avenue

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020 33

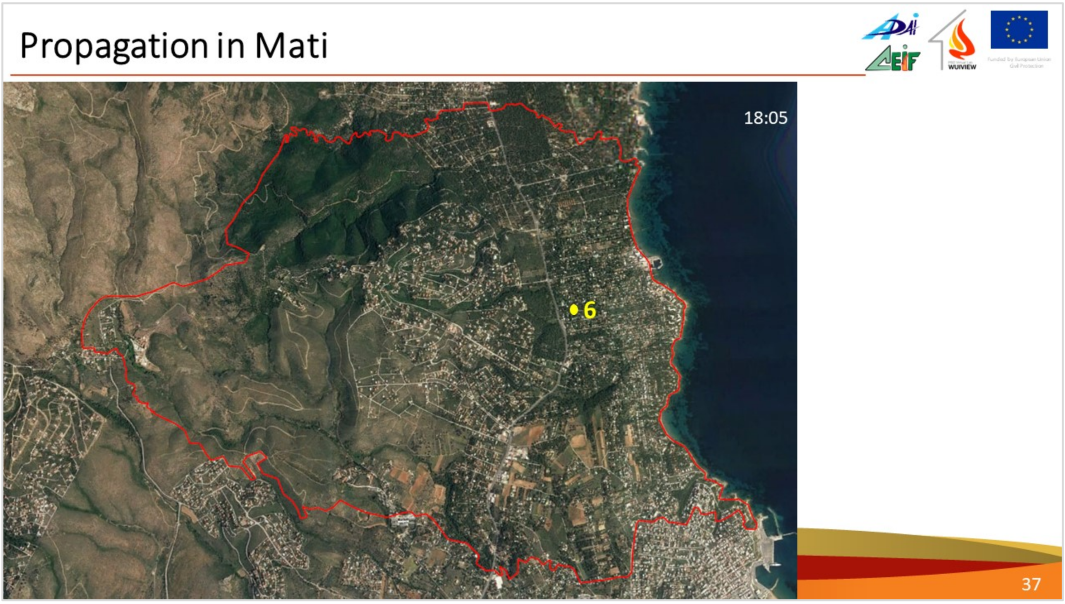
Jump through Marathon Avenue

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020 34

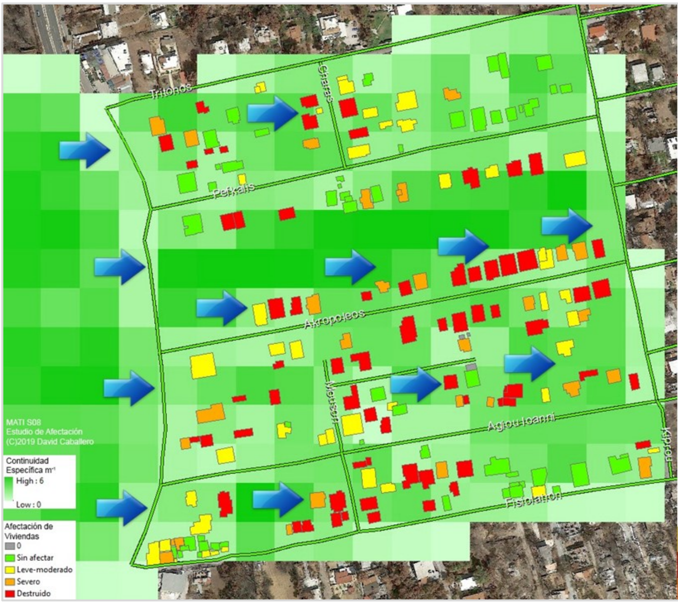
Jump through Marathon Avenue

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020 35

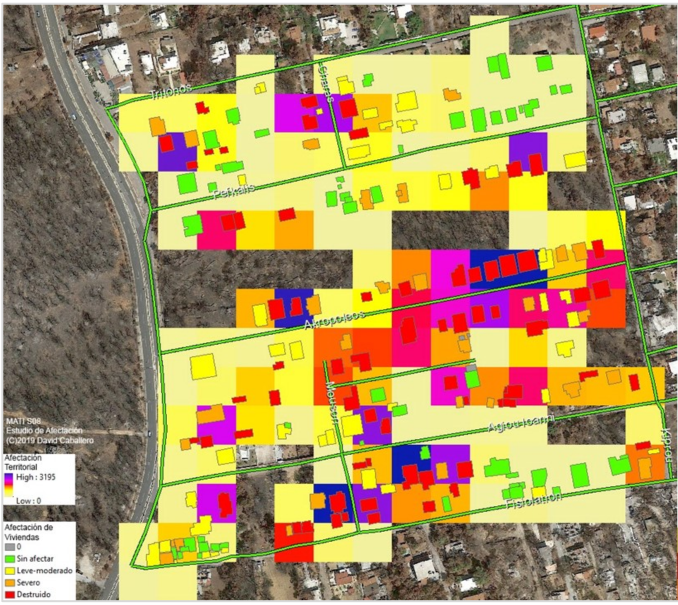

Propagation in Mati
36


Propagation in Mati
18:05
6
37


Propagation in Mati
Mati 2018
38



17/01/2020 39



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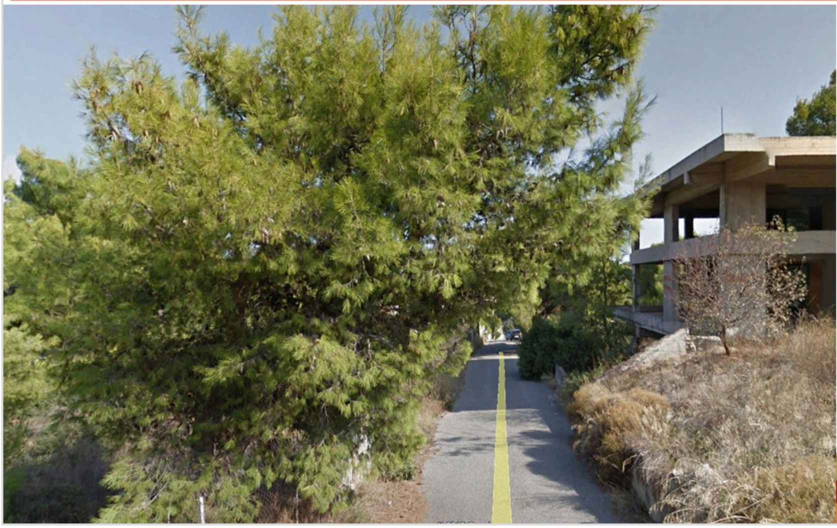
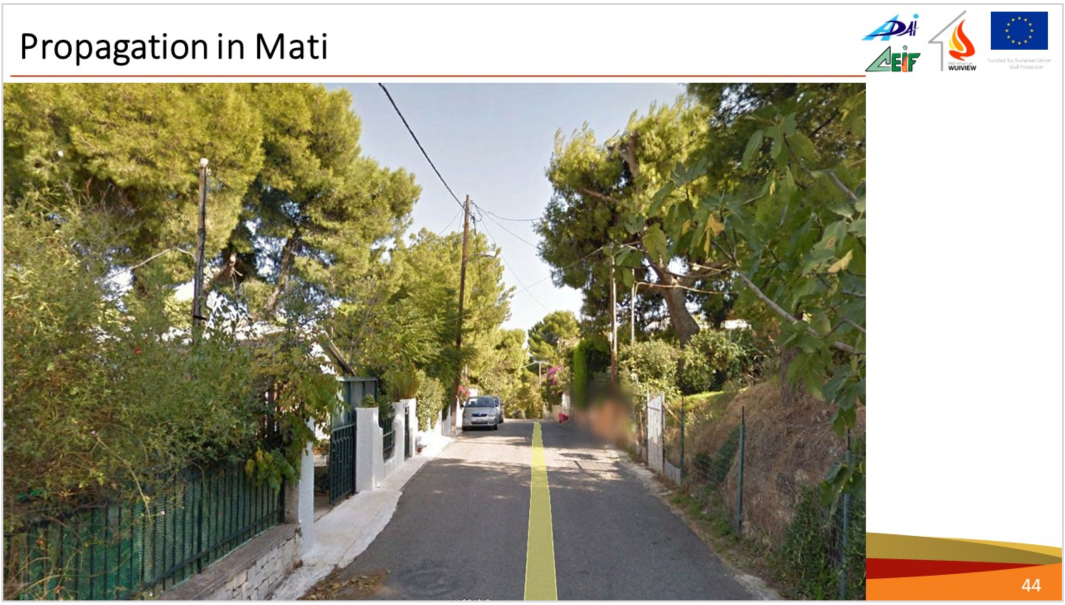
Propagation in Mati



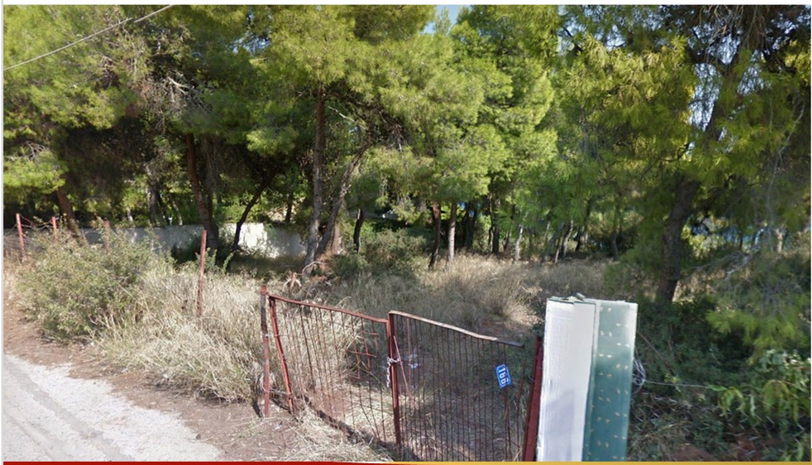
41


CAFETERIA
RESTAURANT
PIZZA
42


43


Propagation in Mati
44

Propagation in Mati



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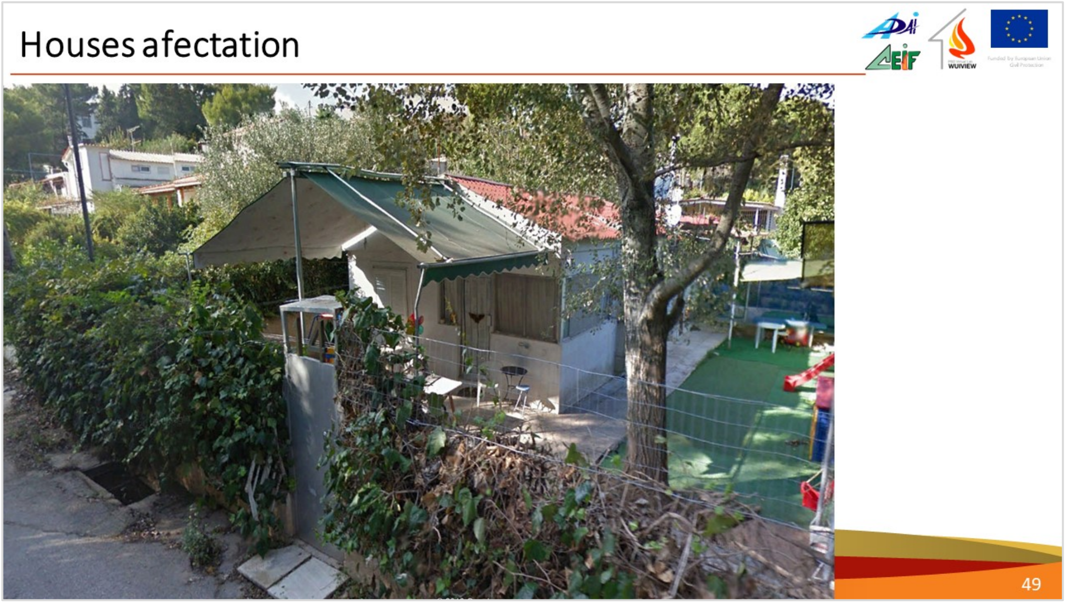
Propagation in Mati

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020 46

Houses afectation

47


Houses afectation
48


Houses afectation
49


Houses afectation
50


Houses afectation
P15
P17
51


Houses afectation
P15
P17
1
2
3
4
5
52


Houses afectation
P17
1
2
3
4
5
53

Houses afectation

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Houses afectation

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Houses afectation

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Houses afectation

57

Houses afectation – Post frontal combustion

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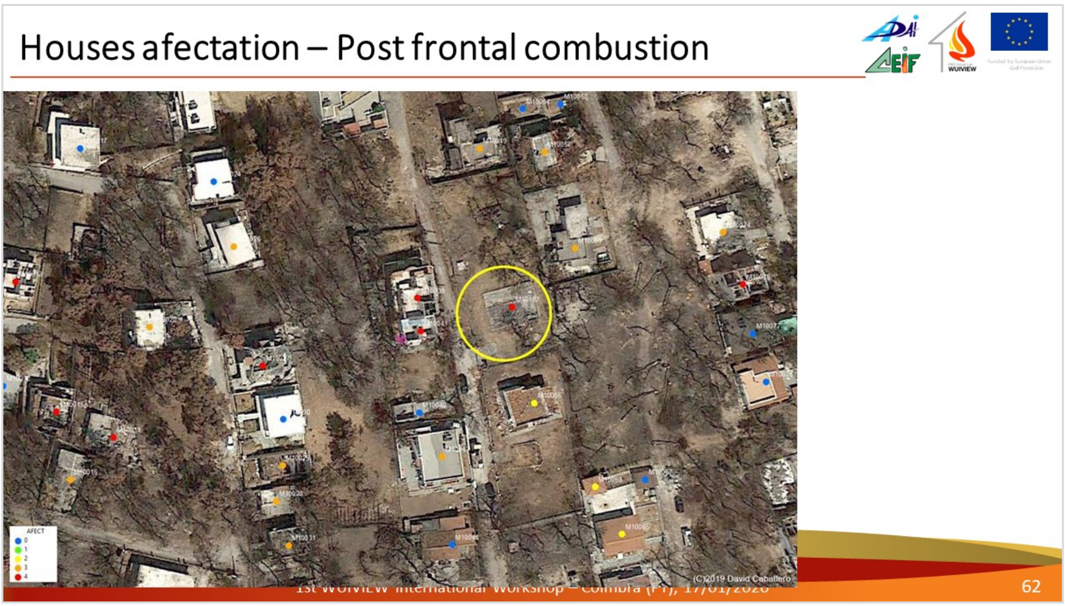
Houses afectation – Post frontal combustion

59


Houses afectation – Post frontal combustion
60

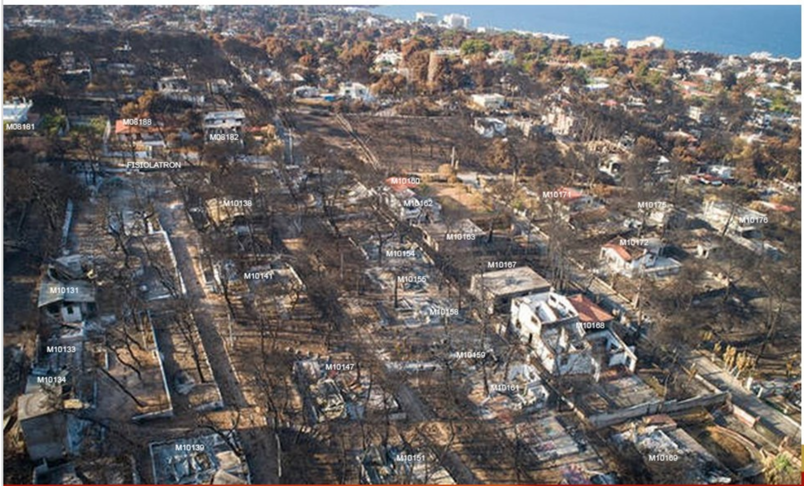

Houses afectation – Post frontal combustion
M10182
Google Earth
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
61


Houses afectation – Post frontal combustion
AFECT
(C)2019 David Caballero
62

Propagation patterns

Propagation patterns

Propagation patterns



Propagation patterns

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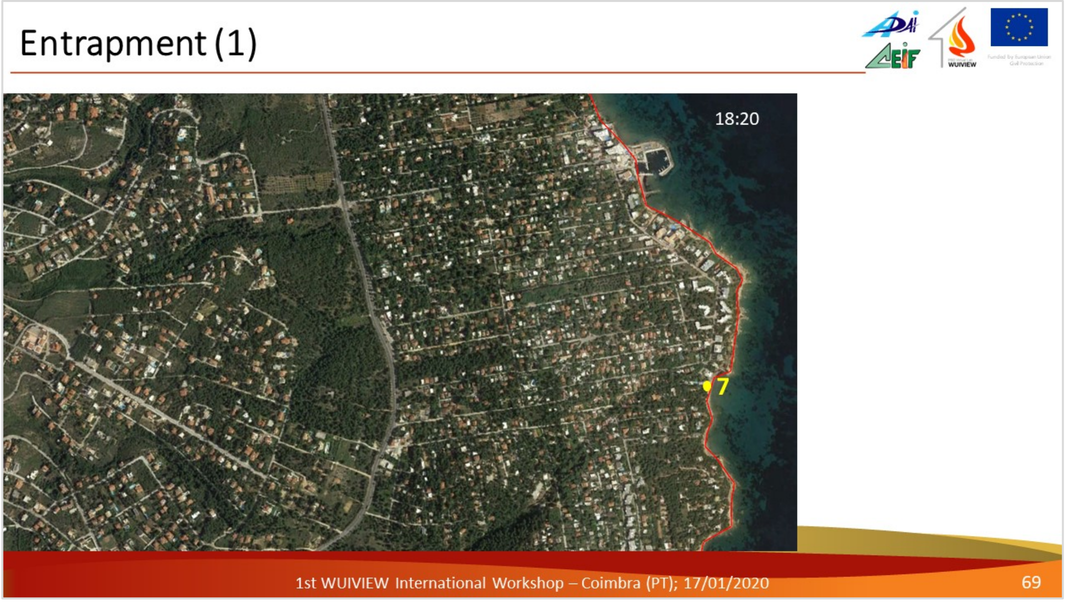
66

Propagation patterns

67

68


Entrapment (1)
18:20
7
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
69


Entrapment (1)
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
70


Entrapment (1)
EPA
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
71

Entrapment (1)

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020

72

Entrapment (1)

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73

Entrapment (1)

74


Entrapment (1)
75


Entrapment (1)
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
76

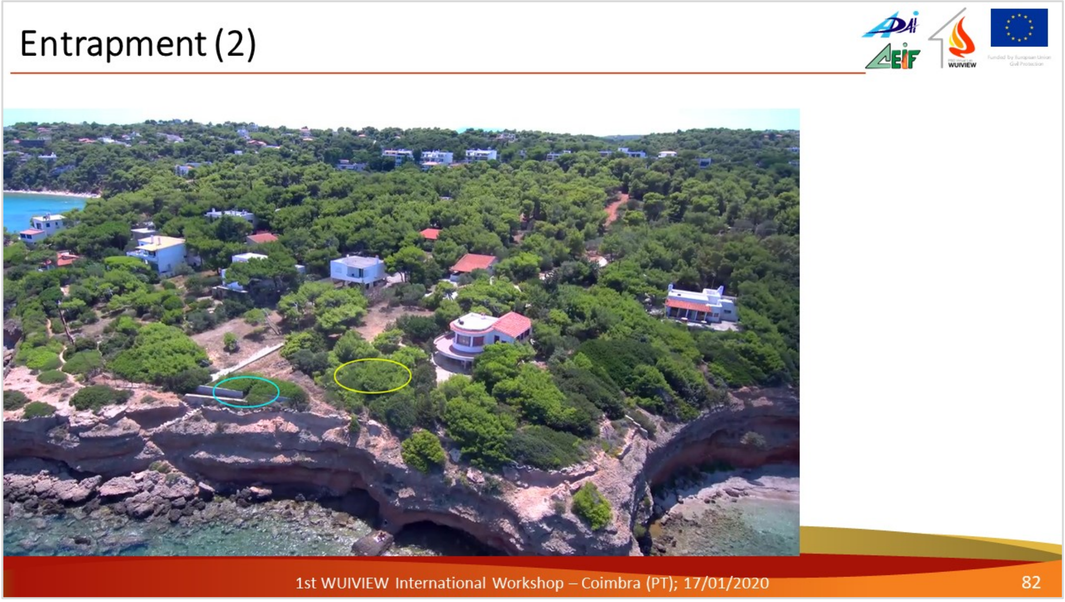

Harbour operation
Google Earth
77


78


Entrapment (2)
18:25
8
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
79


Entrapment (2)
80


Entrapment (2)
81


Entrapment (2)
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
82


Entrapment (2)
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
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Conclusions

- Houses endure flame front impact
- Roofing very vulnerable, maintenance!
- Open windows = vulnerability
- Nearby residential fuel
- Horizontal elements accumulate heat
- Fuel lineations and corridors, fires interaction
- Endangered last-minute evacuation, DMZ in the WUI
- Endangered shelter-in place, unprepared buildings
- Population with limited mobility (elders with children)

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Thank you

dcaballero@paucostafoundation.org

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4.3. WUI fires in Europe: analysis of recent episodes – part 2, by Johan Sjöström

4.3.1. Abstract

The large forest fire regime in Scandinavia has changed dramatically from an average area of 1 – 2 % of the total land area to one of near exclusion. This was a consequence of highly effective fire suppression technique and mobilization of rural population to protect the valuable production forest. In the latter half of the 20th century, fire suppression efforts were instead directed to a complete responsibility of the municipal fire fighters.

The pan-European urbanisation is strong also in Scandinavia, leaving rural municipalities with decreasing tax revenues and increased costs per inhabitant for maintaining fire protection. In recent years, a number of high-intensity wildfires suggest a change in the fire load/suppression balance. In particular the large Västmanland wildfire (summer 2004), the Norwegian heather WUI-fires (winter 2014) and the multiple large forest fires during the dry summer of 2018 were all considered unique and unexpected.

Together, these fires burned 200 structures and resulted in 1 casualty and one severe burn injury. We analyse causes to why these fires grew large and the key factors for structures within the fire area to either exhibit large damage or survive the raging fires. Our findings are as follows:

- A large part of the Scandinavia building stock is within the WUI. Many buildings have combustible facades.
- The risk perception of homeowners regarding ignition from wildfires is low.
- The large fires occur in rural areas where distances to reach the fires is large.
- Insufficient mop-up is a key for many of the large fires.
- Risks are reduced by long distances to highly flammable fuel and the low intensity of most wildfires.
- Ignition of structures most often seem to occur through direct flame impingement to the façade. Thus, the flame from must reach the façade for ignition to occur.
- Relatively few occurrences of ignition through spotting or thermal breakage of windows can be identified.
- The most important factor for survivability of building, apart from active fire suppression, is a managed lawn around the whole perimeter followed by inclusion of broadleaves in the near vicinity.

4.3.2. Presentation printout

WUIVIEW International Workshop

Perigo de incêndio na microescala da Interface Urbano Florestal

Fire hazard at the Wildland Urban Interface microscale

Funded by European Union Civil Protection

Fogos na IUF na Europa: análise de episódios recentes

WUI fires in Sweden/Norway: analysis of recent episodes

Frida Vermina Plathner
Johan Sjöström
frida.vermina.plathner@ri.se
johan.sjostrom@ri.se
RISE- Sweden

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Recent WUI events in Sweden (& Norway)

- Västmanland 2014
- Ljusdal 2018
- Lærdal and Flatanger 2014

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Historical fire occurence in Sweden

- Historically fire frequencies in Sweden were high
  - Reoccurence every 30-80 years
- ~1850s, large scale forestry and arrangements of fire fighting resources in villages. Occurences reduced significantly.
- 1930s, modern techniques were deployed, pumps, fire trucks
- Today fire areas are reduced by 99 % compared to before 1850s

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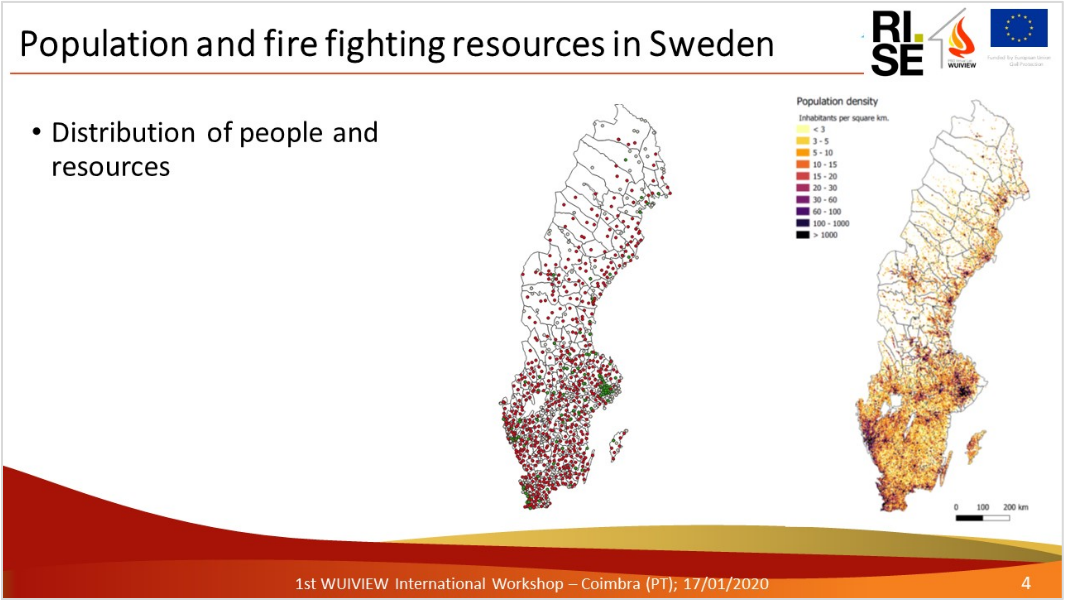
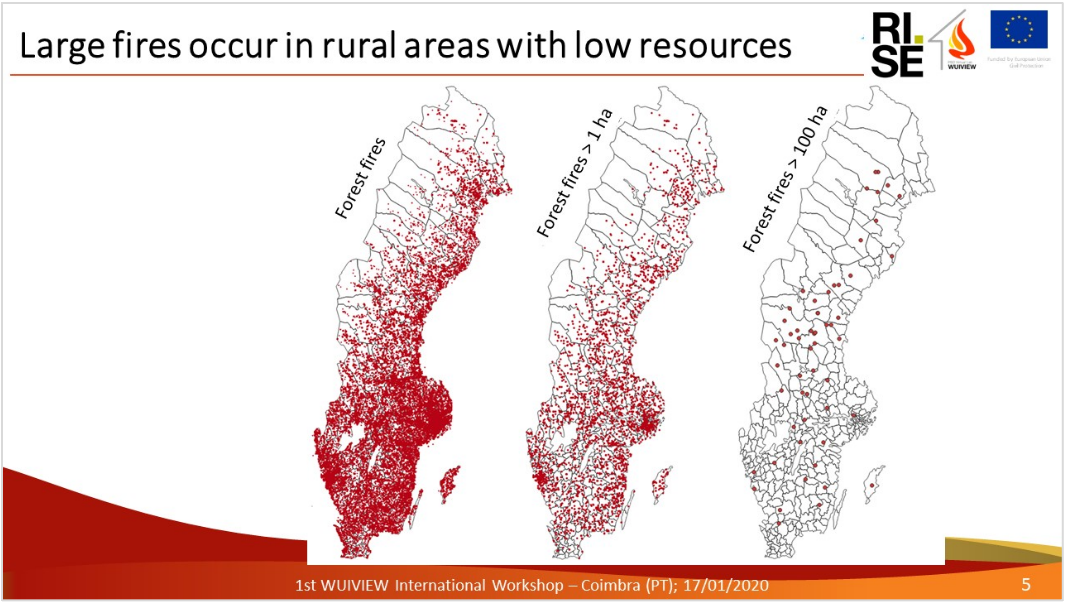

Population and fire fighting resources in Sweden
• Distribution of people and resources
Population density
Inhabitants per square km.
< 3
3 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 60
60 - 100
100 - 1000
> 1000
0 100 200 km
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
4


Large fires occur in rural areas with low resources
Forest fires
Forest fires > 1 ha
Forest fires > 100 ha
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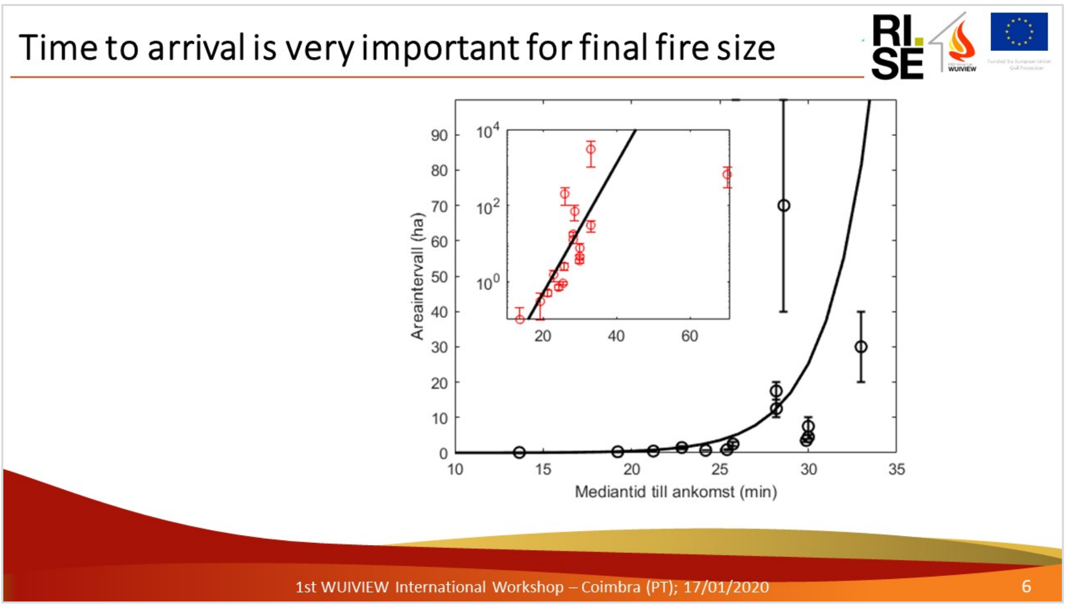
5


Time to arrival is very important for final fire size
Areaintervall (ha)
Mediantid till ankomst (min)
0
10
20
30
40
50
60
70
80
90
10
15
20
25
30
35
10^4
10^2
10^0
20
40
60
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6


Västmanland Fire 2014
RI. SE
WUIVIEW
• No other major fire in the country at the same time
• Started by a forestry machine
• 13 000 ha – much of it burnt in 4 hrs.
• 71 buildings burnt
• 1 casualty, 1 severely injured
• High fire danger but not extreme
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7


Västmanland Fire 2014
RI. SE
WUIVIEW
• Fire fighters arrived to the site after 1h 10 min!
• Already then the fire was large and difficult to reach the flanks.
After two hours
When Fire fighters arrived – 1h 10min
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Västmanland Fire 2014
RI. SE
WUIVIEW
• Fire fighters arrived to the site after 1h 10 min!
• Already then the fire was large and difficult to reach the flanks.
20140731, klockan 22.26.
20140731, klockan 22.31.
20140731, klockan 22.36.
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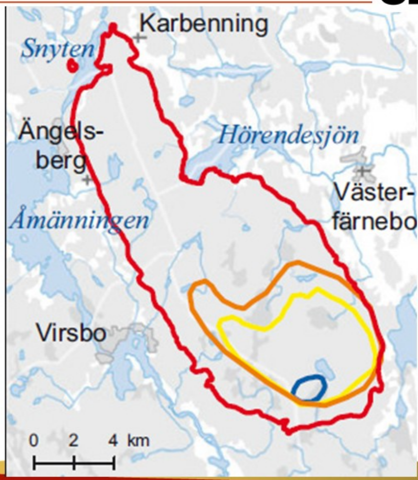
Västmanland Fire 2014

- On the 4th day FWI~35 Most of the area burned in 4 hours
- 71 buildings burnt, not protected by fire fighters
- 1 casualty, 1 severely injured
- 80 m/min in the worst afternoon



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Västmanland Fire 2014

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Västmanland Fire 2014

- A study on the buildings within the fire area was conducted based on aereal photography
- Data was collected on
  - Fire intensity
  - Tree types
  - Building material
  - Cleaned gutters
  - Presence of a managed lawn
  - Mitigation actions before evacuation

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Västmanland Fire 2014

- 71 buildings destroyed – many of them were in direct contact to wildland.

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Västmanland Fire 2014

- Many buildings also survived
- Low intensity fire

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Västmanland Fire 2014

- Many buildings also survived
- Managed lawn

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Västmanland Fire 2014

- Many buildings also survived
- Managed lawn

Västmanland Fire 2014

- Take home mesage from the Västmanland fire
- 1. The potential for large fires in Sweden is large IF weather allows
- 2. Very poor resources to deal with large fires
- 3. Long time to initially reach the fire was key to it growing so fast
- 4. Underestimating the fires the first day(s) lead to the (4th) day of rapid spread
- ... and

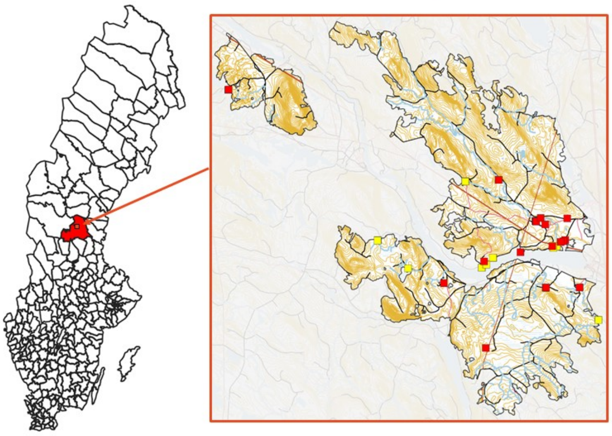
Västmanland Fire 2014

- 5. A managed lawn around the house was the most important factor for survivability
  - This was more important than
    - Cleaned gutters
    - Open windows or doors
    - Fire intensity
    - Building material
  - Other important aspects were portion of broadleaved trees and if mitigation measures were taken by homeowners (watering around the building)
  - Thus, spotting into gutters or other cavities was not very common
  - Breakage of windows due to thermal exposure was not common

Ljusdal fires 2018

- July 2018
- Severe drought in the whole country – resources low
- Fires started by lightning – two were put down but reignited the next day
- Of the 12 largest fires, 9 were reignited
- 30 % of the fighting resources came from other countries

Ljusdal municipality



Ljusdal fires 2018

- July 2018
- Severe drought in the whole country – resources low
- Fires started by lightning – two were put down but reignited the next day
- 30 % of the fighting resources came from other countries

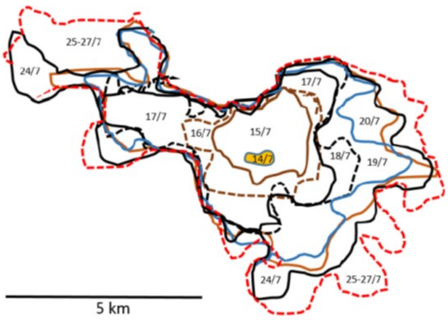
Ljusdal fires 2018

- July 2018
- Luckily, few houses within the area. 50 % of the houses survived

Fire (name)	Area (ha)	Structures (total)	Damaged structures
Enskogen	4326	33	14
Nötberget	872	2	2
Ängra	3797	14	7
Total	8995	49	23

Ljusdal fires 2018

- July 2018
- The fires had an erradicate behaviour, no clear propagation direction
- Some areas burned with crown fires but medium and low intensity fires also burned large areas



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Ljusdal fires 2018

- Many buildings survived
- In this case a barrier of broadleaved trees rescued the building

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Ljusdal fires 2018

- Many buildings survived
- The village in the lower part was saved with a huge effort from helicopters.

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Ljusdal fires 2018

- Many buildings survived
- The village in the lower part was saved with a huge effort from helicopters.

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Ljusdal fires 2018

- ... and some were destroyed
- Often when wildland is very close to facade.

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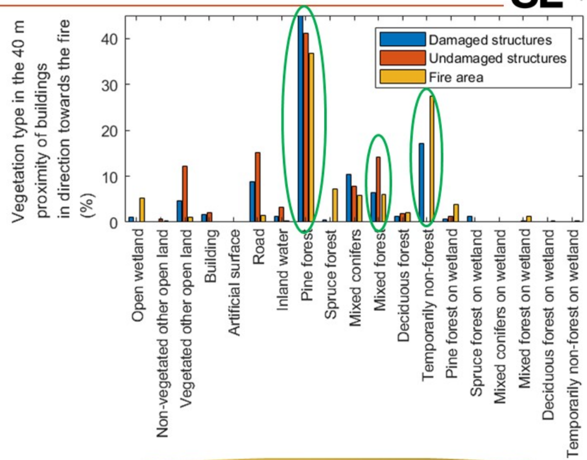
Ljusdal fires 2018

- Vegetation type was important



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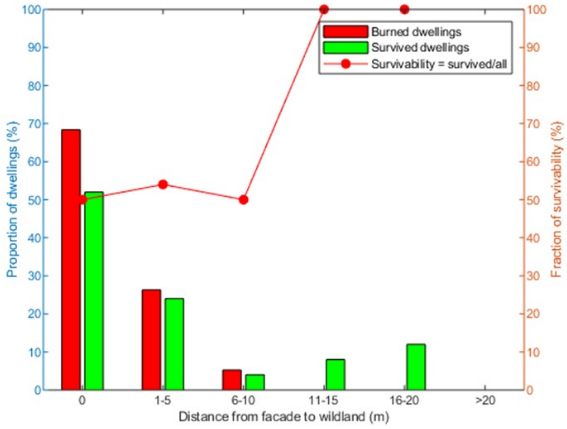
Ljusdal fires 2018

- Distance from facade to wildland was important



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Ljusdal fires 2018

- Take home message from Ljusdal 2018:
- 1. Poor mop-up was the major factor leading to the severity
- 2. Many buildings were burned in low intensity fires because evacuation of people and resources focused elsewhere.
- 3. Just a small distance to the wildland significantly increased survivability

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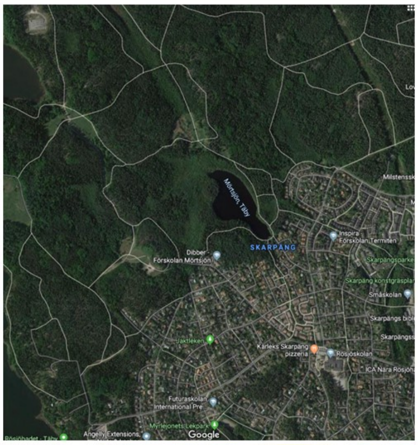
Potentially worse area for a rapidly spreading fire

- One day a rapidly spreading fire reaches a place lie this:
- Skarpäng Stockholm county – The region with the highest fire danger in Sweden



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Potentially worse area for a rapidly spreading fire

- A large part of the Swedish building stock is within the WUI
- The risk perception of homeowners regarding ignition from wildfires is low. In addition, many buildings have combustible facades
- Risk are reduced by the low intensity of most wildfires

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Norwegian fires JANUARY 2014

- Coasta heather landscape in west Norway
- Traditionally, this land was burned by farmers
- Same type of vegetation found in Portugal, France & Scotland.

Calluna vulgaris

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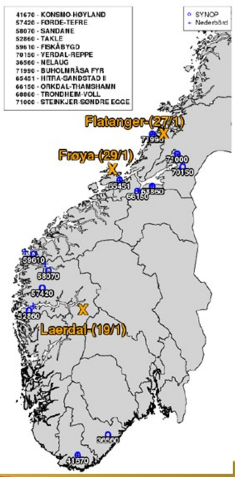
Norwegian fires JANUARY 2014

- Winter of 2014 North Atlantic jet stream took a more east-westerly direction than usual
- Extreme cold in the USA
- Flooding in France and Britain
- Very dry in Norway



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Lærdal fire 18/1 2014 – UNESCO heritage site

- 23.00 18th January
- Fire in a building
- 25% of normal precipitation

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Lærdal fire 18/1 2014 – UNESCO heritage site

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Lærdal fire 18/1 2014 – UNESCO heritage site

- Very strong winds
- 10 ha and 40 buildings
- Structure-to-structure ignition

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Flatanger fire 27/1 2014

- One week later, 22.00, 27th January
- Sparks from unisulated power lines
- 5.5 mm precipitation in January

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Flatanger fire 27/1 2014

- <u>Very</u> strong wind (20-28 m/s)
- **1500 ha, mostly heather**
- 63 buildings

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Flatanger fire 27/1 2014

- 22.00 27th January
- Sparks from unisulated power lines
- 5.5 mm precipitation in January
- <u>Very</u> strong wind (20-28 m/s)
- **1500 ha, also forest**
- 63 buildings

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Flatanger fire 27/1 2014

- 22.00 27th January
- Sparks from unisulated power lines
- 5.5 mm precipitation in January
- Very strong wind (20-28 m/s)
- **1500 ha, also forest**
- 63 buildings

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Norwegian fires JANUARY 2014

Take home message from the Norwegian fires:

1. Very dry weather can occur in places and seasons we are not used to
2. Fire spread in heather is completely different from forest fires
3. Timber buildings also become dry when the fuel becomes dry
4. Operations during winter suffer from DARKNESS and SUB-ZERO temperatures.

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Conclusions

High potential for large consequence WUI fires in Scandinavia

Scandinavian countries are not prepared for large WUI fires

A managed lawn and 10 m distance to wildland is the best insurance

Fire danger in parts of Scandinavia are not well described by CFFWI

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4.4. WUI fires in Europe: analysis of recent episodes – part 3, by Luís Mário Ribeiro

4.4.1. Abstract

The term Wildland Urban Interface can simply be defined as the physical space where vegetation, structures and people coexist, in a fire-prone environment. It is a worldwide matter of concern, that gets an overwhelming importance when the fire risk conditions are extreme, conditioning all combat strategies.

This presentation brings to the audience a selection of 3 of the most infamous WUI fires that happened in Portugal in the more recent years, each one of them with its particularities. The cases selected are:

i) The wildfire of Funchal (Madeira Island), in August 2016. This fire started on August 8th, and burned more than 2000ha, killing 3 persons, destroying 154 houses and damaging more than 250. The fire started on the north outskirts of Funchal and pushed by northerly wind entered the city perimeter in different paths. The 3 fatalities occurred far from the forested area, in an entirely urban area of the city. The continuity in fuels from the outskirts to the city centre (either natural or ornamental vegetation) made it possible for the fire to reach these areas. Even in the historical city centre, an area without any vegetation, there were houses being burned, due to the deposition of firebrands that were transported by wind from the main fire front. We present here a summary of the fire spread and impacts.

ii) The fire complex of Pedrógão Grande, in June 2017. This complex of fires started in June 17th, being the most tragic event ever recorded in Portugal. The total area burned was around 45,000ha and the death toll reached 66 persons. More than 250 persons got injured and more than 1000 structures were destroyed or damaged. This tremendously intense fire burned around 98% of the final area in the first two days, and in approximately 3 hours of the first (17th) almost 9,000ha. Based on a very detailed report produced by ADAI, a summary of the impact of this fire on the structures is presented.

iii) The fires of the Centre Region of Portugal, in October 2017. The multiple fires that started on October 15th devastated the Central Region of Portugal in a very short time. More than 220,000ha were burned in approximately one day, killing 51 persons and causing countless damages to all kinds of infrastructures. These fires were also the subject of an exhaustive study and detailed report. The approach used to analyse the affected structures was different from Pedrógão, as the degree of destruction was too high to be able to inventory all the damage. We analysed the impact in the industrial facilities, choosing one municipality per each of 6 of the larger fires. We present here a summary of the findings.

4.4.2. Presentation printout (*in Portuguese*)

WUIVIEW International Workshop

Perigo de incêndio na microescala da Interface Urbano Florestal

Fire hazard at the Wildland Urban Interface microscale

Fogos na IUF na Europa: análise de episódios recentes

WUI fires in Europe: analysis of recent episodes

PORTUGAL

Luís Mário Ribeiro
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ADAI/CEIF - Portugal

Funded by European Union Civil Protection

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Enquadramento

A IUF é o espaço onde a vegetação, as estruturas [e as pessoas (Ribeiro, 2016)] coexistem, num ambiente propício aos incêndios.

(Blue Ribbon Panel, 2008)

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Enquadramento

O problema dos incêndios florestais na Interface Urbano Florestal (IUF) constitui um assunto preocupante em todos os países que sofrem incêndios florestais, e manifesta-se especialmente em condições de risco extremo, condicionando as estratégias de combate

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Exemplos recentes em Portugal

2016 Funchal
2017 Pedrógão
2017 Região Centro

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Funchal, 8-10 Agosto 2016

- 2.000Ha ardidos
- 251 casas danificadas
- 154 destruídas
- 3 Mortos
- 157M€ danos estimados (todos os IF)

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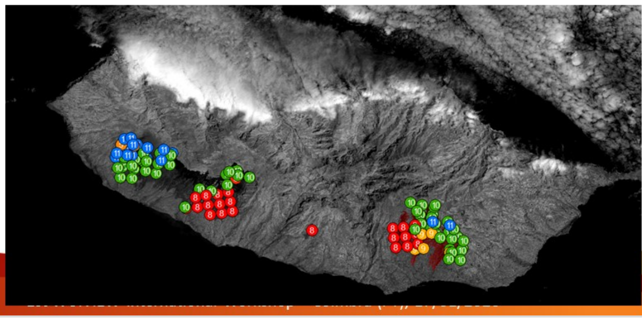
Funchal, 8-10 Agosto 2016

- Temperatura sempre superior a 28ºC (>32ºC em 92% do tempo)
- Humidade relativa inferior a 30% (cerca de 10% a 9 de Agosto)
- Vento com rajadas de 50 a 80 km/h
- Multiplos incêndios simultâneos



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Funchal, 8-10 Agosto 2016

Ignição 8 Agosto
15h30

- Propagação muito intensa
- Várias casas em risco
- Vento Norte

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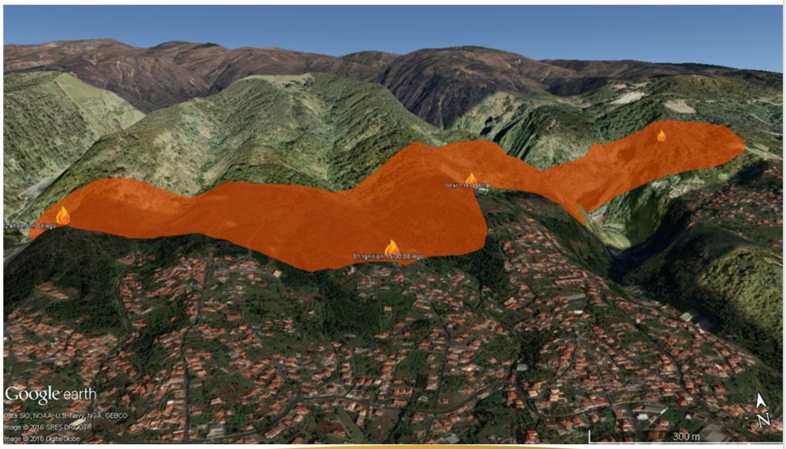
Funchal, 8-10 Agosto 2016

Propagação inicial



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Funchal, 8-10 Agosto 2016

Noite 8/9 Agosto

- 234 pacientes deslocados do Hospital dos Marmeleiros
- 200 pessoas abrigadas em Instalações Militares

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Funchal, 8-10 Agosto 2016
Tarde 9 Agosto
O fogo entrou no perímetro urbano descendo as encostas, através da
• "Ribeira João Gomes"
e
• "Ribeira de Santa Luzia"
04 afternoon 09/Ago
04 Hospital João de Almada Evacuation afternoon 9/Ago
Google earth
1 km
N
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Funchal, 8-10 Agosto 2016
Tarde 9 Agosto
•600 pessoas desalojadas
•300 pessoas abrigadas no Estádio dos Barreiros (Marítimo SC)
•36 casas ardidas
•Hospital João de Almada evacuado
•Hotel Choupana Hills evacuado (cerca das 16:00)
05 Choupana Hills 19:00 9/Ago
04 Hospital João de Almada Evacuation afternoon 9/Ago
04 afternoon 09/Ago
04 Afternoon 09/Ago Burned houses (3 deaths)
04 Burned houses due to massive spotting (ember shower) 20:00 09/Aug
Google earth
1 km
N
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Funchal, 8-10 Agosto 2016

Tarde 9 Agosto

- 3 mortes dentro de casas
- Casas queimadas no centro da cidade do Funchal

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Funchal, 8-10 Agosto 2016

Tarde 9 Agosto

- 3 mortes dentro de casas
- Casas queimadas no centro da cidade do Funchal

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Funchal, 8-10 Agosto 2016

Tarde 9 Agosto

- 3 mortes dentro de casas
- Casas queimadas no centro da cidade do Funchal

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Funchal, 8-10 Agosto 2016

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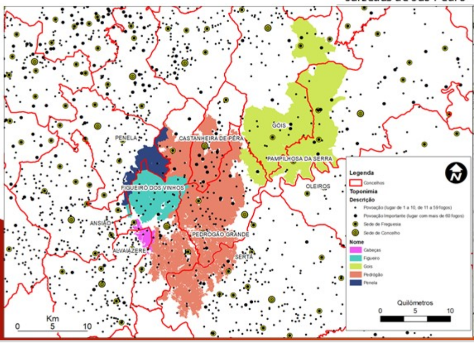
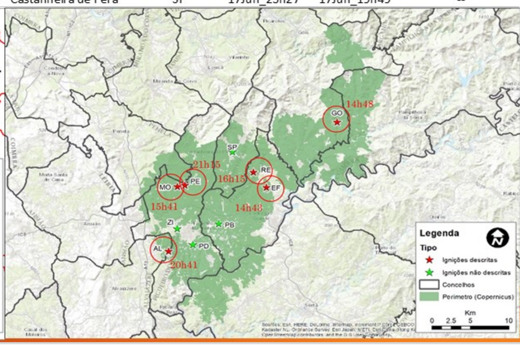
Pedrógão Grande, 17 Junho 2017

Complexo de vários grandes incêndios

Local	Acrónimos	Alerta	Conclusão	Área ardida (hA)
Escalos Fundeiros+Regadas – Pedrógão Grande	EF	17Jun_14h43	22Jun_23h49	24165
Fonte Limpa – Góis (e Pampilhosa)	GO	17Jun_14h48	22Jun_19h30	16119
Moninhos – Figueiró dos Vinhos	MO	17Jun_15h41	17Jun_18h38	7,2
Pinheiro do Bordalo – Figueiró dos Vinhos	PB	17Jun_16h26	170617/16h57	~0
Pedreira – Figueiró dos Vinhos	PD	17Jun_17h04	17Jun_17h32	~0,02
Zona Industrial – Figueiró dos Vinhos	ZI	17Jun_20h28	17Jun_23h30	--
Cabeças – Alvaiázere	AL	17Jun_20h41	20Jun_10h35	638
Pardieiros – Penela	PE	17Jun_21h15	21Jun_00h48	4400
Sarzedas de São Pedro – Castanheira de Pera	SP	17Jun_23h27	17Jun_19h49	--





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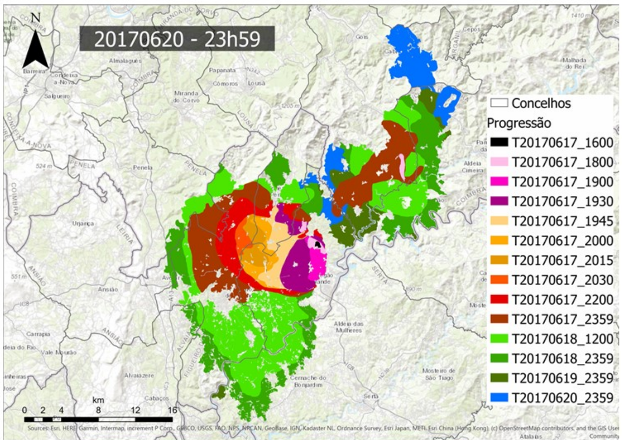
Pedrógão Grande, 17 Junho 2017

- Cerca de 45kHa ardidos
- 66 vítimas mortais
- Mais de 250 feridos
- Mais de 1000 estruturas danificadas ou destruídas
- 97,6% da área ardida foi registada nos dias 17 e 18/Jun

19h00-22h00 ~8700 ha ardidos (quase 3000ha por hora)



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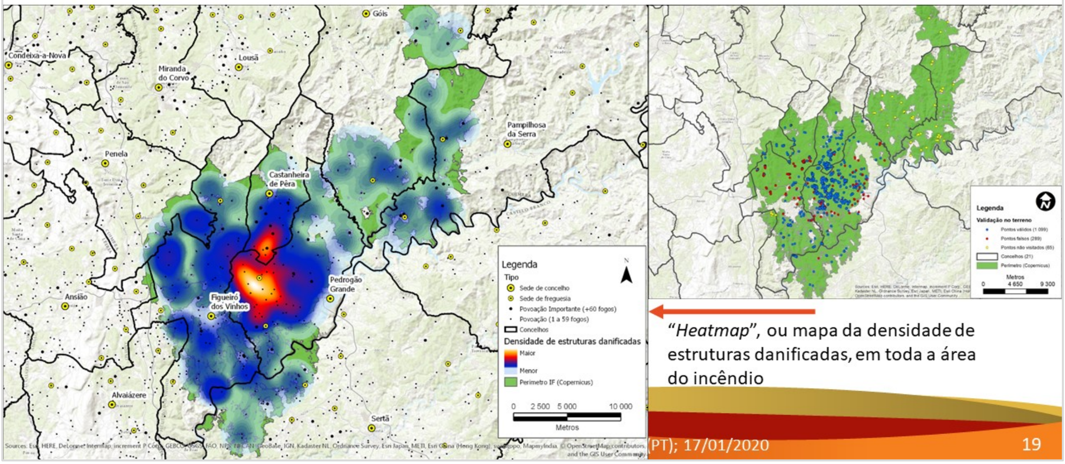
Pedrógão Grande, 17 Junho 2017

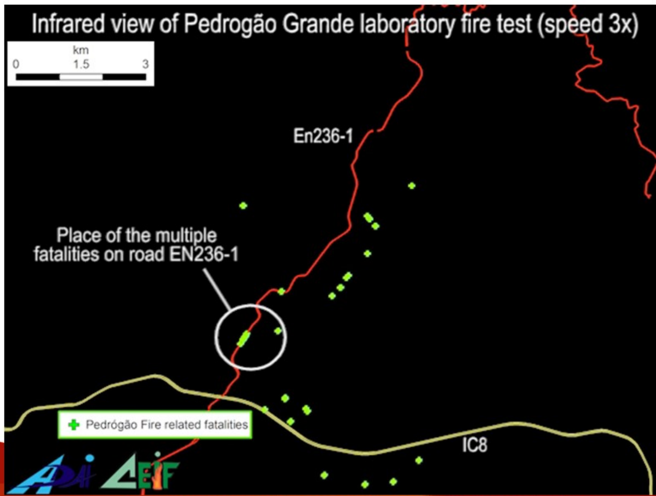
O impacto nas estruturas



"*Heatmap*", ou mapa da densidade de estruturas danificadas, em toda a área do incêndio

PT); 17/01/2020 19

Pedrógão Grande, 17 Junho 2017



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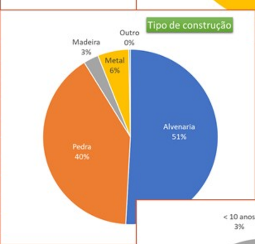
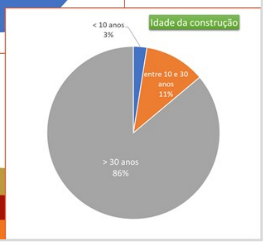
Pedrógão Grande, 17 Junho 2017

O impacto nas estruturas

Variável		Condição da estrutura após o incêndio				
		Pouco danificada	Moderadamente danificada	Muito danificada	Totalmente destruída	Total (%)
Tipo de estrutura	Habitação permanente	35	17	46	41	139
	Habitação secundária	19	9	46	50	124
	Armazém agrícola	1	5	28	40	74
	Barracão/Armazenamento	12	20	179	192	403
	Garagem	5	9	22	24	60
	Casa de comércio	0	1	0	0	1
	Indústria	0	2	5	8	15
	Casa desabitada	2	4	36	16	58
	Estrutura devoluta	1	3	56	72	132
	Estábulo	2	1	8	9	20
	Cozinha exterior	0	2	2	2	6
	Outros	2	1	4	4	11
Tipo de construção	Cimento	71	57	195	207	530
	Pedra	7	14	222	177	420
	Madeira	0	0	0	29	29
	Metal	1	2	14	43	60
	Outros	0	1	1	1	3
Idade da construção	< 10 anos	6	5	2	13	26
	10 a 30 anos	17	11	26	64	118
	> 30 anos	56	58	399	380	893



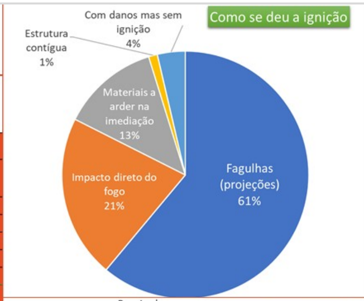


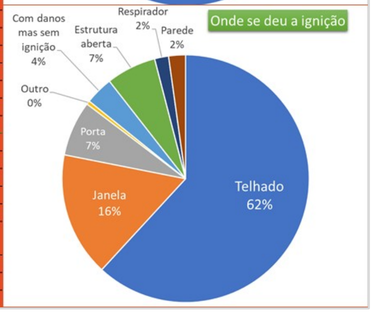
; 17/01/2020

Pedrógão Grande, 17 Junho 2017

O impacto nas estruturas

Variável		Condição da estrutura após o incêndio: Pouco danificada	Moderadamente danificada	Muito danificada	Totalmente destruída	Total
Como se deu a ignição	Fagulhas (projeções)	27	54	294	261	636
	Impacto direto do fogo	7	8	91	116	222
	Materiais a arder na imediação	7	9	43	74	133
	Estrutura contígua	2	1	3	6	12
	Com danos, mas sem ignição	35	2	1	0	38
Onde se deu a ignição	Telhado	16	36	299	293	644
	Janela	14	17	70	68	169
	Porta	4	7	36	28	75
	Estrutura aberta	2	6	13	47	68
	Parede	5	4	0	14	23
	Respirador	0	1	12	6	19
	Outro	3	1	1	0	5
	Com danos, mas sem ignição	35	2	1	0	38
Danos sem ignição	Telhado	16	1	1	0	18
	Persianas	8	1	0	0	9
	Vidros das janelas	4	0	0	0	4
	Janelas	2	0	0	0	1
	Chaminé, telhado	1	0	0	0	1
	Paredes, persianas e vidros das janelas	1	0	0	0	1
	Persianas e vidros das janelas	1	0	0	0	1
	Porta e elementos plásticos	1	0	0	0	1
	Telhado e persianas	1	0	0	0	1





Pedrógão Grande, 17 Junho 2017

- Pelo conhecimento que temos, de casos estudados por todo o mundo, especialmente em Portugal e na Europa, podemos, de um modo geral, considerar as habitações como um local seguro, desde que elas próprias e a sua envolvente sejam mantidas em boas condições.

Vítimas mortais

Género	Tipo de acidente: A fugir a pé	A fugir de carro	Em casa	Encurralamento acidental	Total
Feminino	12	17	2	-	31
Masculino	18	14	2	1	35
Total	30	31	4	1	66

- Evacuações devem ser planeadas e executadas com antecedência. Não pode haver evacuações quando o fogo está a chegar, pois elas transformam-se facilmente em fuga descontrolada.

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Região Centro, 15 Outubro 2017

- 51 vítimas mortais
- Mais de 220Kha de área ardida
- Milhares de estruturas danificadas ou destruídas

Almeida, 2019

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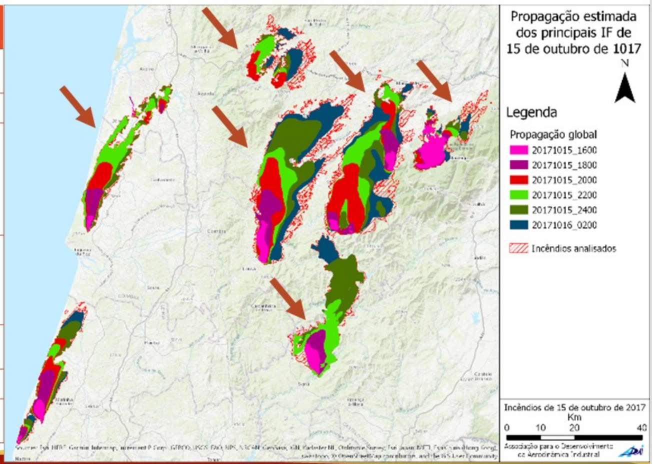
Região Centro, 15 Outubro 2017

Ref.	Complex of fire events	Main ignitions	Hour of alert	Burnt area (ha)
1	Seia	Sabugueiro Casal da Boavista	06.03h 22.30h	17003
2	Lousã	Prilhão	08.41h	54407
3	Oliveira do Hospital	Sandomil Esculca Monte Frio / Relva Velha Casas Figueiras	10.26h 12.28h 14.00h 23.00h	51429
4	Sertã	Ponte das Portelinhas Nespereira Maria Gomes	12.02h 18.41h 21.35h	30977
5	Leiria	Praia da Légua Burinhosa	13.51h 14.33h	20014
6	Quiaios	Cova da Serpe	14.36h	23844
7	Vouzela	Albitelhe Varzielas	17.21h 18.50h	15959



*M. Almeida, 2019

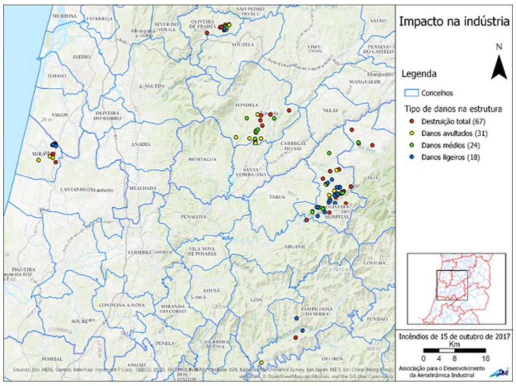
Região Centro, 15 Outubro 2017

O impacto nas indústrias*

140 indústrias analisadas

<10 funcionários	10-50 funcionários	50-250 funcionários
90	39	11

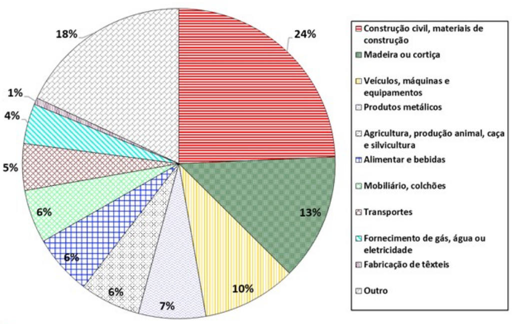
CIF	Município	Instalações industriais	
		CCDR	Visitadas
Seia	Seia	8	4
Lousã	Tondela	29	22
Ol. do Hospital	Ol. do Hospital	75	65
Sertã	P. da Serra	7	5
Quiaios	Mira	15	18
Vouzela	Ol. De Frades	20	26

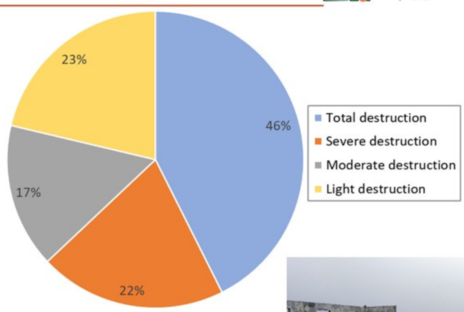


*M. Almeida, 2019

Região Centro, 15 Outubro 2017

O impacto nas indústrias*





*M. Almeida, 2019

Região Centro, 15 Outubro 2017

O impacto nas indústrias*

Mecanismo de ignição	Proximidade dos combustíveis à estrutura				Total
	0-2	2-10	10-50	>50	
Chamas provenientes de estruturas adjacentes	4	2	6	4	16 (11%)
Chamas provenientes de espaços florestais perto da estrutura	19	11	7	1	38 (27%)
Chamas provenientes de resíduos na envolvente à estrutura	3	2	3	1	9 (6%)
Chamas provenientes de matérias primas, subprodutos ou equipamento na envolvente	0	0	1	0	1 (1%)
Projeções de partículas incandescentes	10	19	26	19	74 (53%)
Outros	1	0	1	0	2 (1)
Total	37	34	44	25	140

*M. Almeida, 2019

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O impacto nas indústrias*

Mecanismo de ignição	First ignited component of the structure						
	Aberturas	Janela	Parede	Porta	Ventilado res	Telhado	Outras
Chamas de estruturas adjacentes	1	3	5	2	2	2	0
Chamas provenientes de espaços florestais perto da estrutura	14	2	9	2	3	4	4
Chamas provenientes de resíduos na envolvente à estrutura	1	2	5	0	1	0	9
Chamas provenientes de matérias primas, subprodutos ou equipamento na envolvente	0	0	1	0	0	0	1
Projeções de partículas incandescentes	24	5	7	5	5	15	13
Outros	0	0	0	1	0	1	2
Total	40	12	27	10	10	23	18

*M. Almeida, 2019

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O impacto nas indústrias

Muitas indústrias estão preparadas para incêndios industriais com origem interna, mas são poucas aquelas que têm precauções quanto aos incêndios florestais.

Proteção contra a projeção de partículas

Gestão de combustíveis na envolvente da instalação
- combustíveis florestais
- matérias primas, resíduos, subprodutos, equipamentos, ….

A existência de sistemas de autoproteção é essencial

*M. Almeida, 2019

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4.5. The WUIVIEW research approach, by Elsa Pastor

4.5.1. Abstract

Europe has many areas in which forest fires seriously affect urban and rural communities, the so-called Wildland-Urban Interface (WUI). Climate change is dramatically worsening the WUI fire problem throughout Europe by i) exacerbating highly intense wildfires (firestorms) in Mediterranean countries and ii) causing emergent WUI-fire prone zones in northern latitudes not adapted to wildfires. The main aim of WUIVIEW project is to reinforce WUI fires risk reduction strategies by designing, setting up, testing and operating a virtual workbench service for the performance-based analysis of fire environments in the surroundings of buildings at the wildland-urban interface. In line with the objectives of the Union's Civil Protection Mechanism, the WUIVIEW action is nowadays developing an innovative risk management tool that will help WUI communities adapting to face the new generation of forest fires that have already arisen due to climate change. Once implemented, WUIVIEW will become a powerful platform to perform essays and simulation studies dealing with structures' survivability, sheltering assessment, hazard testing of building subsystems and the evaluation of fire protection systems. To set up our workbench, fire hazard of natural and artificial fuels are being characterized by real fire experiments and modelling. Special focus is being devoted to ornamental highly-flammable vegetation and gas infrastructures typically present at the WUI plot-scale. We are relying on a well-established fire protection engineering methodology (Performance-Based Design, PBD), which is based on cutting-edge fire simulations techniques, to get insights on the response to fire of typical building systems and materials. The WUIVIEW workbench operation will help residents and fire risk managers to assess vulnerability in WUI communities, will assist engineers and architects in their designs and will provide scientifically-based information to fire services and regulatory bodies. The sustainability of the project is envisaged at the end of the Action through exploiting a consultancy service to manage WUI fire risk in vulnerable communities.

4.5.1. Presentation printout


The WUIVIEW Project – Basic information
• Duration: 2 years (01/02/2019 – 31/01/2020)
• Funding agency: DG- ECHO (European Civil Protection and Humanitarian Aid Operations)
• Consortium:
• UPC (Coord.) – Spain
• ADAI – Portugal
• PCF – Spain
• ARMINES – France
• UNIBO – Italy
• RISE – Sweden
• Final users:
• Bombers
• Corpo Nazionale de Vigili del Fuoco
• MSB (Swedish Civil Contingency Agency)
• ANEPC Autoridade Nacional Emergência e Proteção Civil
• Dirección General de Protección Civil y Emergencias
• Instituto da Conservação da Natureza e das Florestas
• Tecnifuego
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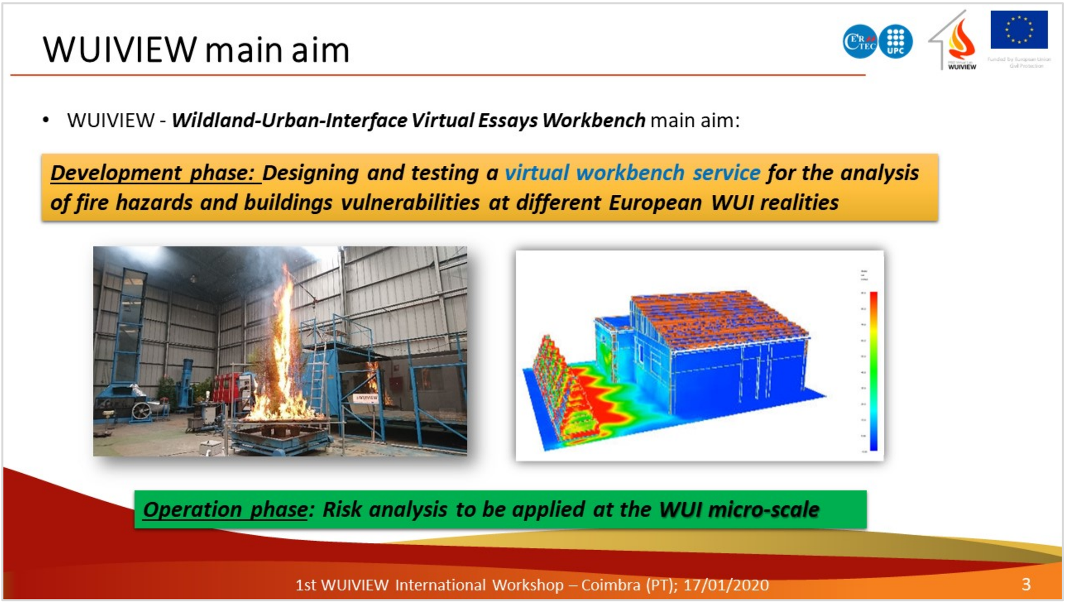
2


WUIVIEW main aim
• WUIVIEW - Wildland-Urban-Interface Virtual Essays Workbench main aim:
Development phase: Designing and testing a virtual workbench service for the analysis of fire hazards and buildings vulnerabilities at different European WUI realities
Operation phase: Risk analysis to be applied at the WUI micro-scale
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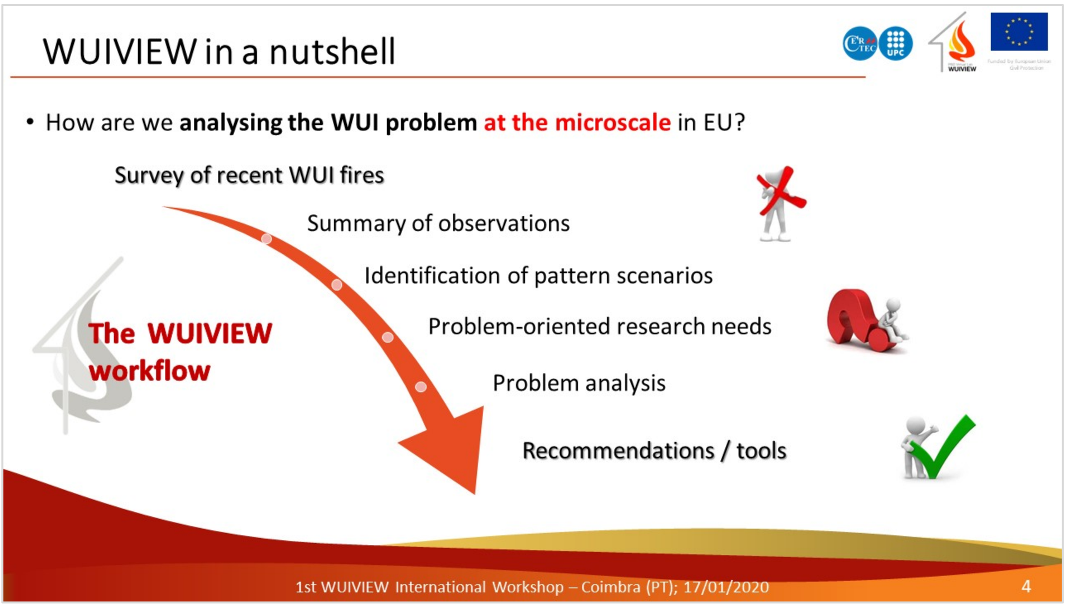
3


WUIVIEW in a nutshell
• How are we analysing the WUI problem at the microscale in EU?
Survey of recent WUI fires
Summary of observations
Identification of pattern scenarios
Problem-oriented research needs
Problem analysis
Recommendations / tools
The WUIVIEW workflow
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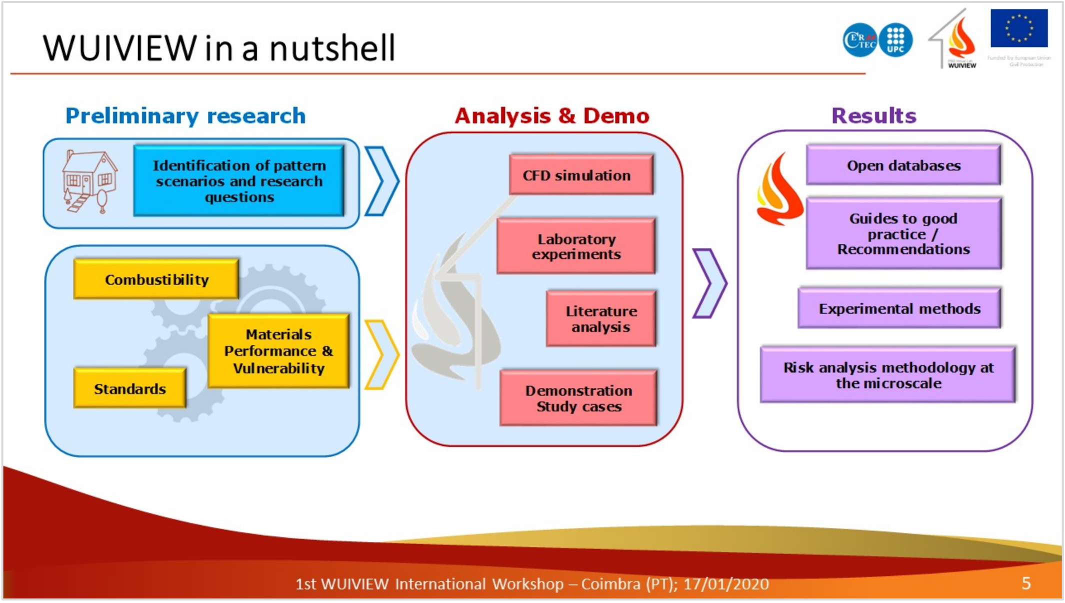
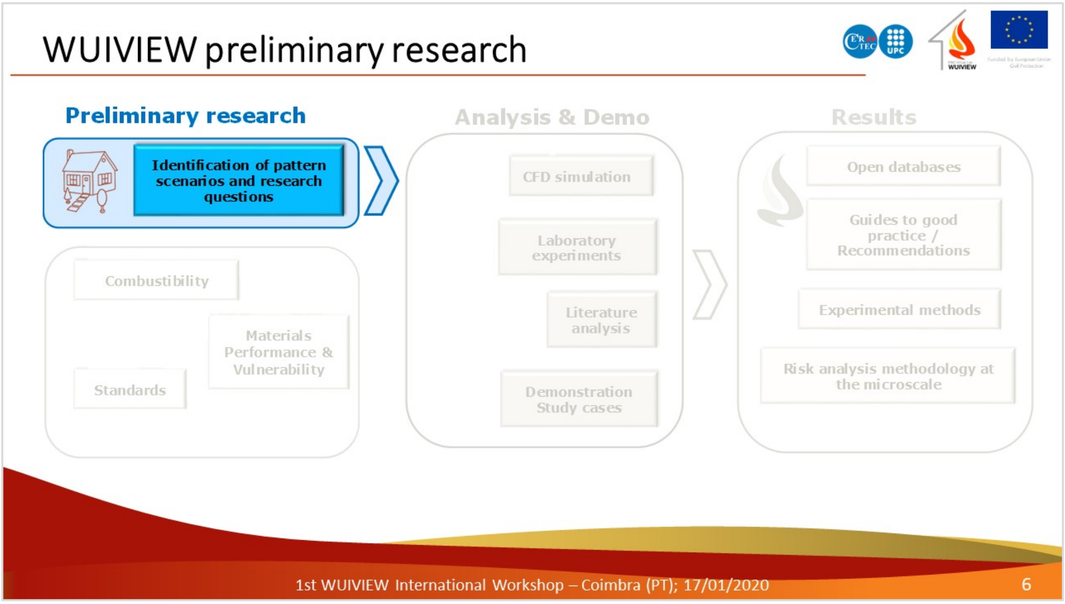
4


WUIVIEW in a nutshell
Preliminary research
Identification of pattern scenarios and research questions
Combustibility
Materials Performance & Vulnerability
Standards
Analysis & Demo
CFD simulation
Laboratory experiments
Literature analysis
Demonstration Study cases
Results
Open databases
Guides to good practice / Recommendations
Experimental methods
Risk analysis methodology at the microscale
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
5


WUIVIEW preliminary research
Preliminary research
Identification of pattern scenarios and research questions
Combustibility
Materials Performance & Vulnerability
Standards
Analysis & Demo
CFD simulation
Laboratory experiments
Literature analysis
Demonstration Study cases
Results
Open databases
Guides to good practice / Recommendations
Experimental methods
Risk analysis methodology at the microscale
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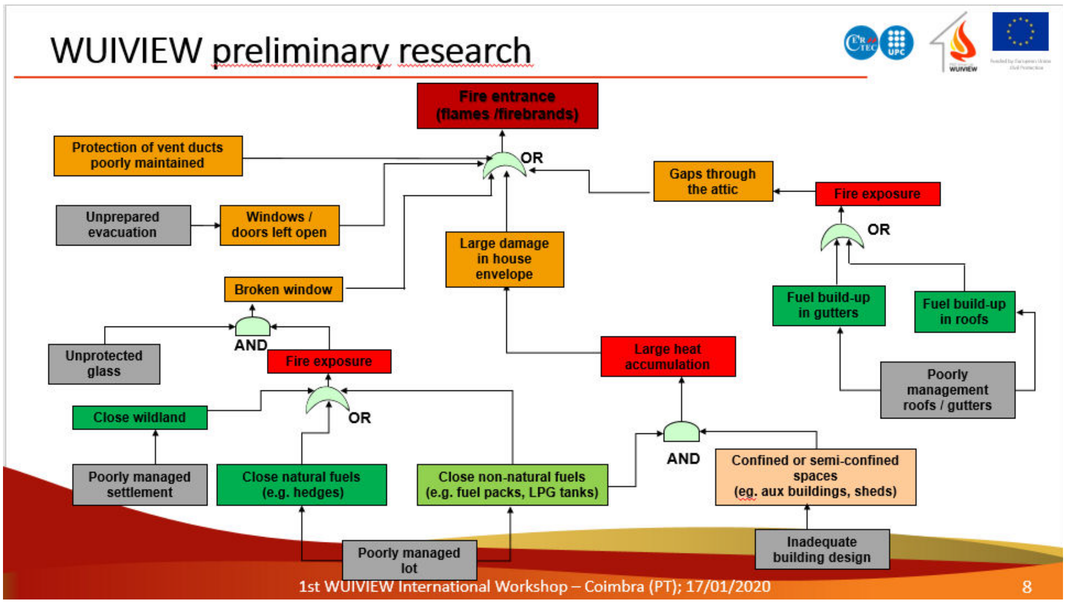
WUIVIEW preliminary research
➢Why do actually our houses burn if they are generally made of non combustible materials?
Source: D. Caballero
Source: D. Caballero
Source: D. Caballero
Source: D. Caballero
Little details matter!
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
7


WUIVIEW preliminary research
Fire entrance (flames /firebrands)
Protection of vent ducts poorly maintained
OR
Gaps through the attic
Fire exposure
Unprepared evacuation
Windows / doors left open
Large damage in house envelope
OR
Broken window
Fuel build-up in gutters
Fuel build-up in roofs
AND
Unprotected glass
Fire exposure
Large heat accumulation
Poorly management roofs / gutters
Close wildland
OR
AND
Poorly managed settlement
Close natural fuels (e.g. hedges)
Close non-natural fuels (e.g. fuel packs, LPG tanks)
Confined or semi-confined spaces (eg. aux buildings, sheds)
Poorly managed lot
Inadequate building design
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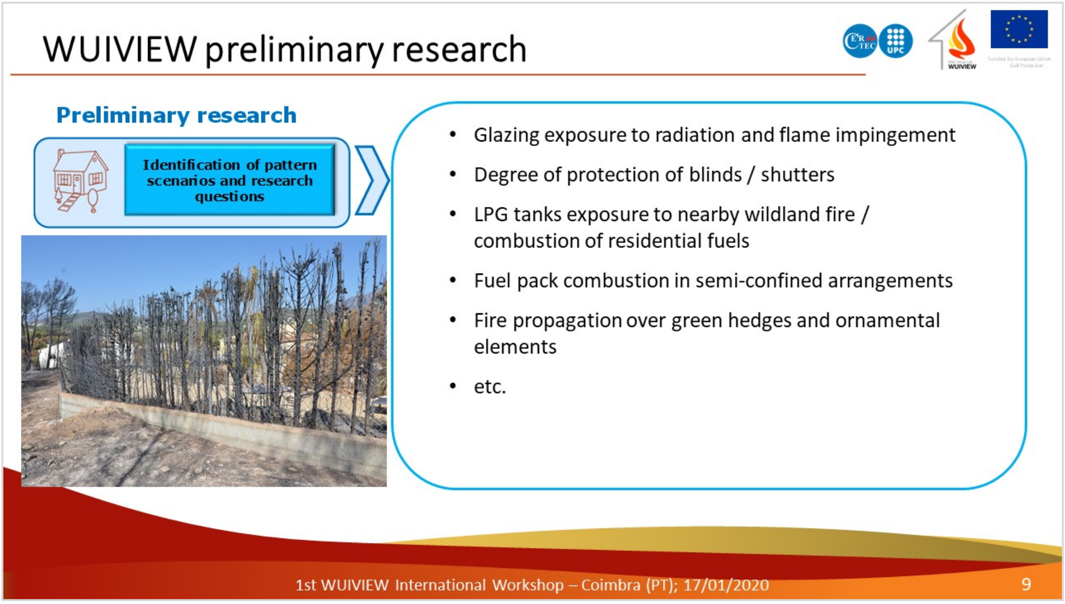
8


WUIVIEW preliminary research
Preliminary research
Identification of pattern scenarios and research questions
Glazing exposure to radiation and flame impingement
Degree of protection of blinds / shutters
LPG tanks exposure to nearby wildland fire / combustion of residential fuels
Fuel pack combustion in semi-confined arrangements
Fire propagation over green hedges and ornamental elements
etc.
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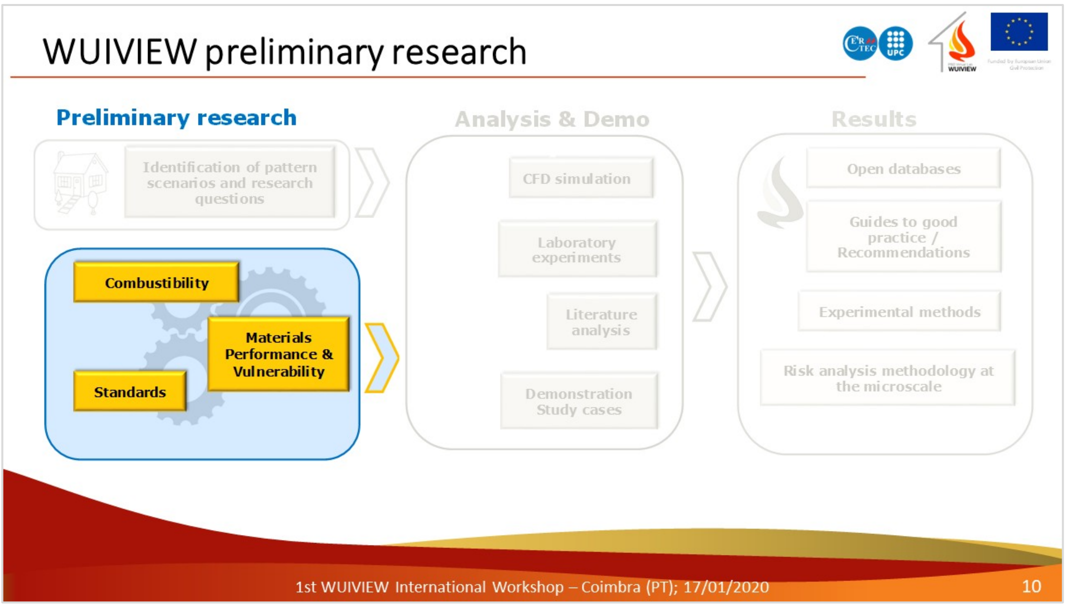
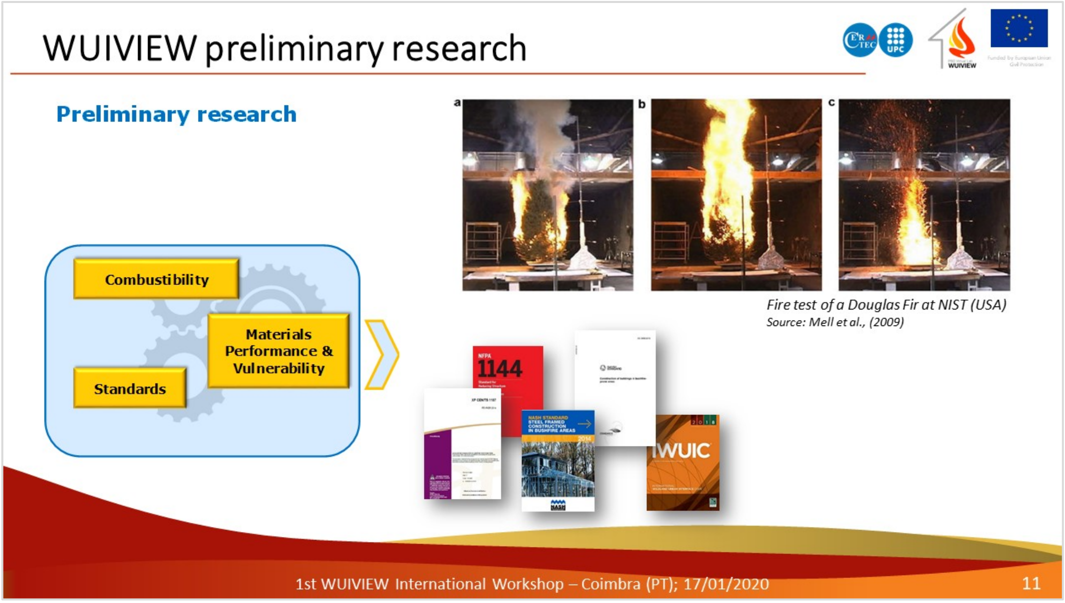
9


WUIVIEW preliminary research
Preliminary research
Analysis & Demo
Results
Identification of pattern scenarios and research questions
CFD simulation
Open databases
Laboratory experiments
Guides to good practice / Recommendations
Literature analysis
Experimental methods
Combustibility
Materials Performance & Vulnerability
Standards
Demonstration Study cases
Risk analysis methodology at the microscale
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
10


WUIVIEW preliminary research
Preliminary research
Combustibility
Materials Performance & Vulnerability
Standards
a
b
c
Fire test of a Douglas Fir at NIST (USA)
Source: Mell et al., (2009)
1144
IWUIC
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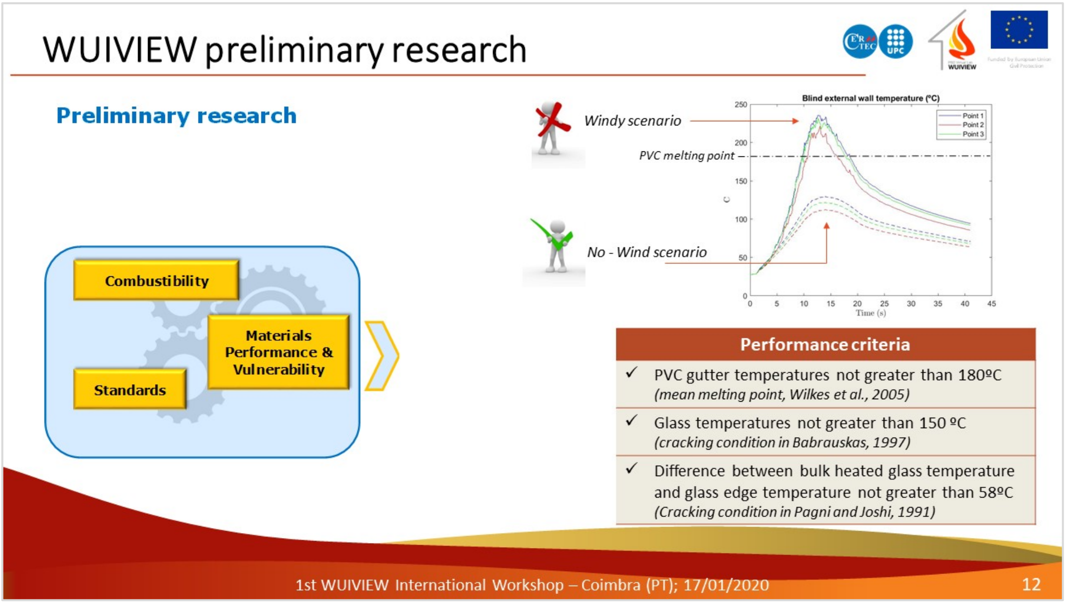
11


WUIVIEW preliminary research
Preliminary research
Combustibility
Materials Performance & Vulnerability
Standards
Windy scenario
PVC melting point
No - Wind scenario
Blind external wall temperature (°C)
Point 1
Point 2
Point 3
Time (s)
Performance criteria
✓ PVC gutter temperatures not greater than 180ºC (mean melting point, Wilkes et al., 2005)
✓ Glass temperatures not greater than 150 ºC (cracking condition in Babrauskas, 1997)
✓ Difference between bulk heated glass temperature and glass edge temperature not greater than 58ºC (Cracking condition in Pagni and Joshi, 1991)
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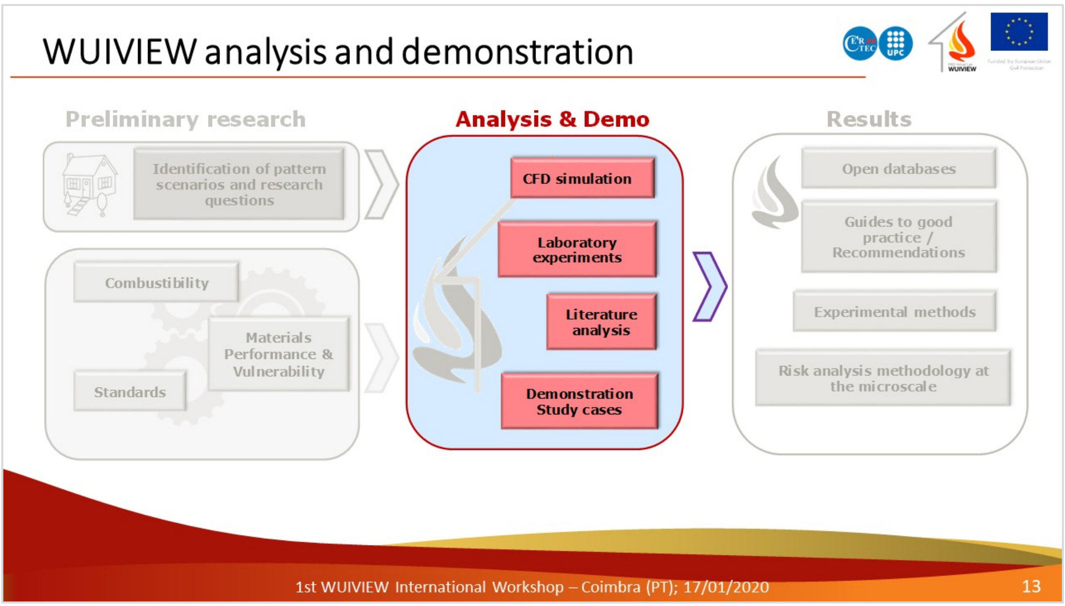
WUIVIEW analysis and demonstration
Preliminary research
Identification of pattern scenarios and research questions
Combustibility
Materials Performance & Vulnerability
Standards
Analysis & Demo
CFD simulation
Laboratory experiments
Literature analysis
Demonstration Study cases
Results
Open databases
Guides to good practice / Recommendations
Experimental methods
Risk analysis methodology at the microscale
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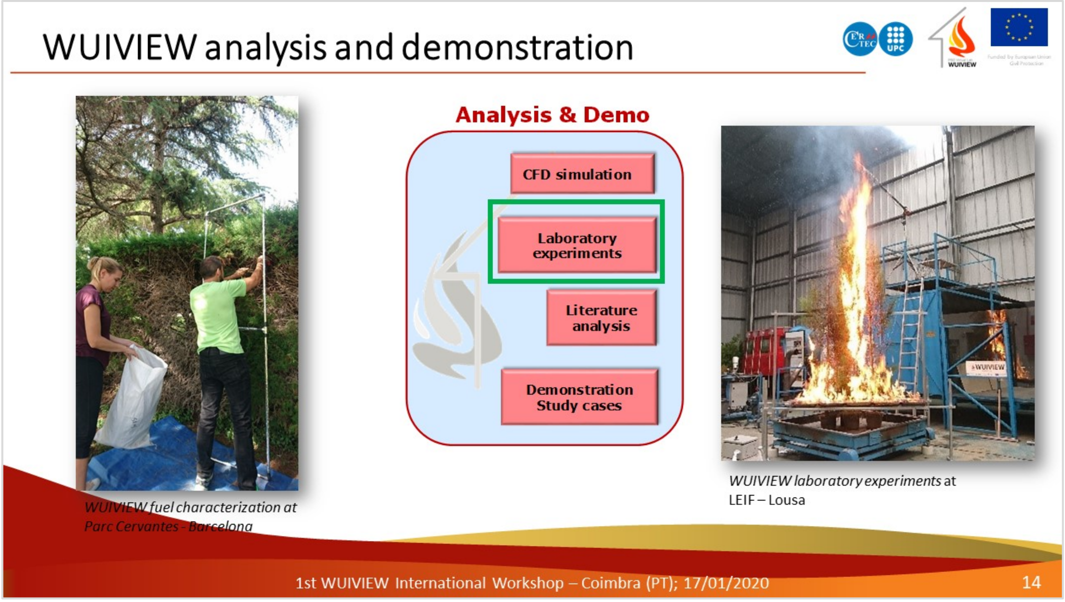
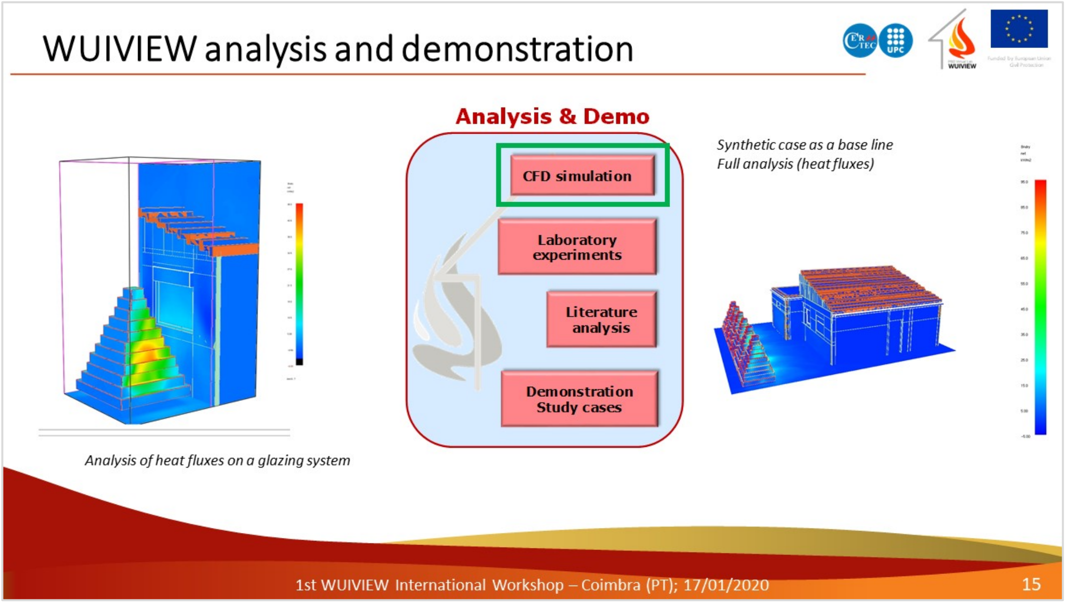
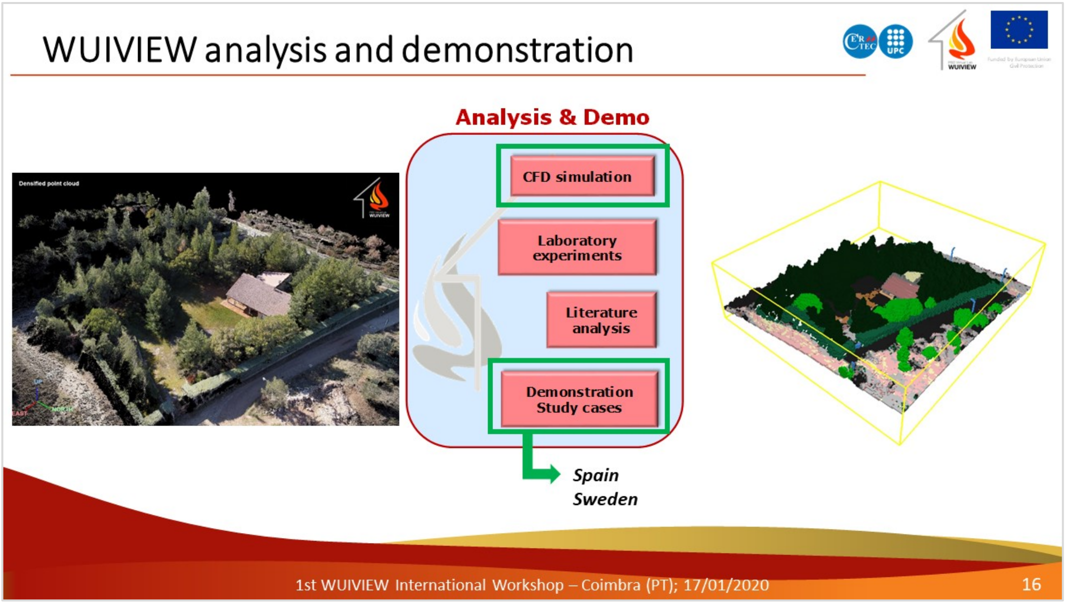
13


WUIVIEW analysis and demonstration
Analysis & Demo
CFD simulation
Laboratory experiments
Literature analysis
Demonstration Study cases
WUIVIEW fuel characterization at Parc Cervantes - Barcelona
WUIVIEW laboratory experiments at LEIF – Lousa
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
14


WUIVIEW analysis and demonstration
Analysis & Demo
CFD simulation
Laboratory experiments
Literature analysis
Demonstration Study cases
Synthetic case as a base line
Full analysis (heat fluxes)
Analysis of heat fluxes on a glazing system
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
15


WUIVIEW analysis and demonstration
Analysis & Demo
CFD simulation
Laboratory experiments
Literature analysis
Demonstration Study cases
Spain
Sweden
Densified point cloud
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
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WUIVIEW results and impact

EXPECTED OUTPUTS

- ✓Data on fuels hazard and buildings vulnerabilities
- ✓Modelling codes and guidelines
- ✓Educational and scientific pubs
- ✓Recommendations for regulation improvement

EXPECTED IMPACT

- ✓Improved knowledge and awareness to all fire actors
- ✓New capability to assist fire safety design

EXPECTED FOLLOW-UP

- ✓Consultancy service to manage WUI fire risk in vulnerable communities

Results

- Open databases
- Guides to good practice / Recommendations
- Experimental methods
- Risk analysis methodology at the microscale

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WUIVIEW results and impact

BENEFICIARIES

- Communities
- Risk managers
- Fire protection industry
- Fire engineers
- Researchers
- Fire services
- Policy makers

Results

- Open databases
- Guides to good practice / Recommendations
- Experimental methods
- Risk analysis methodology at the microscale

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Take-home messages

- **Self-protection** is a real need. Communities have to get **clear messages** of how to prepare their homes to face WUI fires.
- The WUIVIEW project proposes an analytical method to take the most out of the **lessons learnt in past fires**. We have identified **patterns, factors and processes** responsible of homes damages and we are analysing those through **CFD simulations and fire tests.**
- The WUIVIEW approach is **powerful and flexible:** it allows analysing different types of problems with different ranges of **key variables**.
- Outcomes will contribute to the WUI fire community with **scientific-based answers** of how to make **safer microscales** better adapted to incoming **climate change fire scenarios.**

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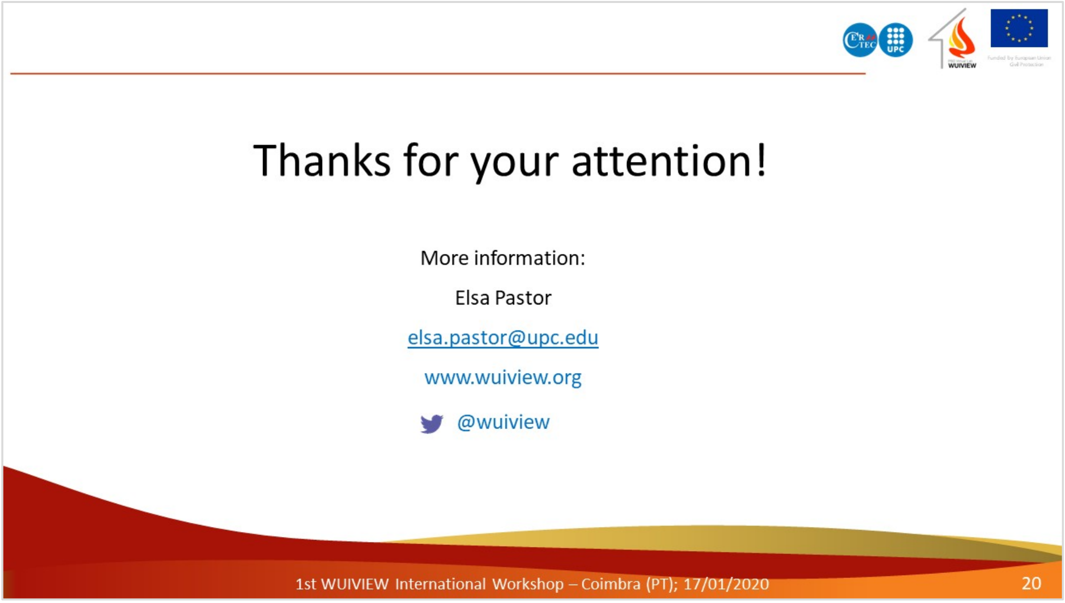
Thanks for your attention!
More information:
Elsa Pastor
elsa.pastor@upc.edu
www.wuiview.org
@wuiview
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4.6. WUI pattern scenarios: synthesizing lessons learnt, by David Caballero

4.6.1. Abstract

As part of the WUIVEW project, the identification and generation of idealised 3D scenarios has been developed during the past 2019 year. Resulting from the lessons observed in the recent devastating fires, a series of WUI microscale patterns have been derived, idealised and parameterised for their modelling in advanced fire dynamics simulations. Besides, particular methodologies have been identified, studied and tested for the generation of realistic and detailed 3D WUI scenarios, such as the use of LIDAR point clouds and models derived from photogrammetry techniques. The use of nano-drones adds a great degree of flexibility for the acquisition of photographs in the micro-scale and the further derivation of densified point clouds. A process of spatial segmentation into cubic elementary volumes (voxels) is then applied, and the custody of colour, as acquired from photos, is detailed. Further assignment of materials according to colour classification by regions is presented as well. This technique ensures full consistency with the geometry used in FDS model while providing a relatively easy, quick and cost-effective procedure for WUI microscale data gathering.

4.6.2. Presentation printout

Inventory of WUI pattern scenarios

Lessons learnt in past fires (Portugal, France, Spain, Greece, Sweden)

Description of components involved in the micro-scale

- Vegetation types (forest, gardens, hedges)
- Description of typified houses (materials, roofing, components)
- Other objects and materials (garden furniture, wood piles,

Description of observed/predicted Typified situations (PROBLEMS)

- Components involved
- Spatial arrangement (distances)
- Phenomena observed
- Effects

It is an OPEN description of observed situations in the mico-scale

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WUIVIEW Typified Situations

- SC1. Glazing exposure to radiation
- SC2. Glazing exposure to flame impingement
- SC3. Fuel build-up and combustion in gutters
- SC4. Fuel build-up and combustion on roofs
- SC5. Firebrands entrance through openings
- SC6. Blinds exposure to radiation and flame impingement
- SC7. LPG tank exposure to nearby forest fire
- SC8. LPG tank exposure to combustion of green hedges and ornamental
- SC9. LPG tank exposure to combustion of other elements
- SC10. Fuel pack combustion in semi-confined arrangements
- SC11. Combustion of materials inside warehouses, garages
- SC12. Smoke entrance and diffusion inside the house
- SC13. Fire propagation over green hedges and ornamental elements

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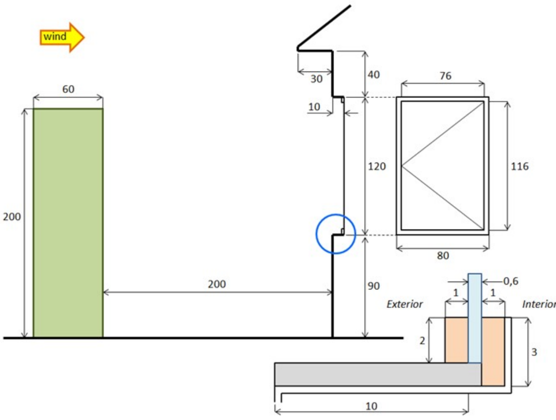
SC1. Glazing exposure to radiation



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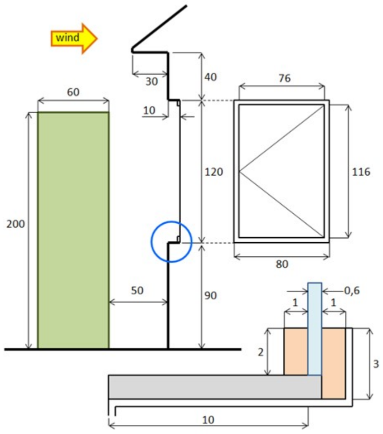
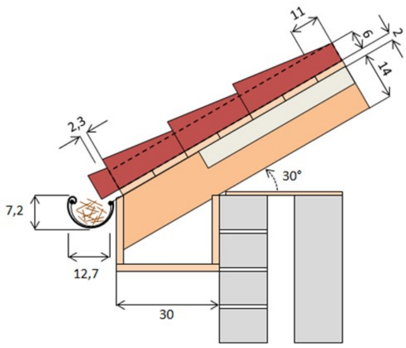
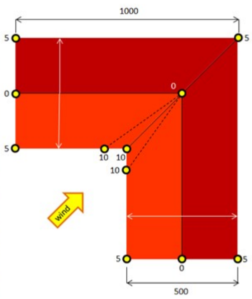
SC2. Glazing exposure to flame impingement

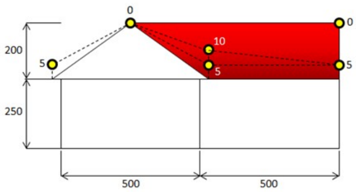


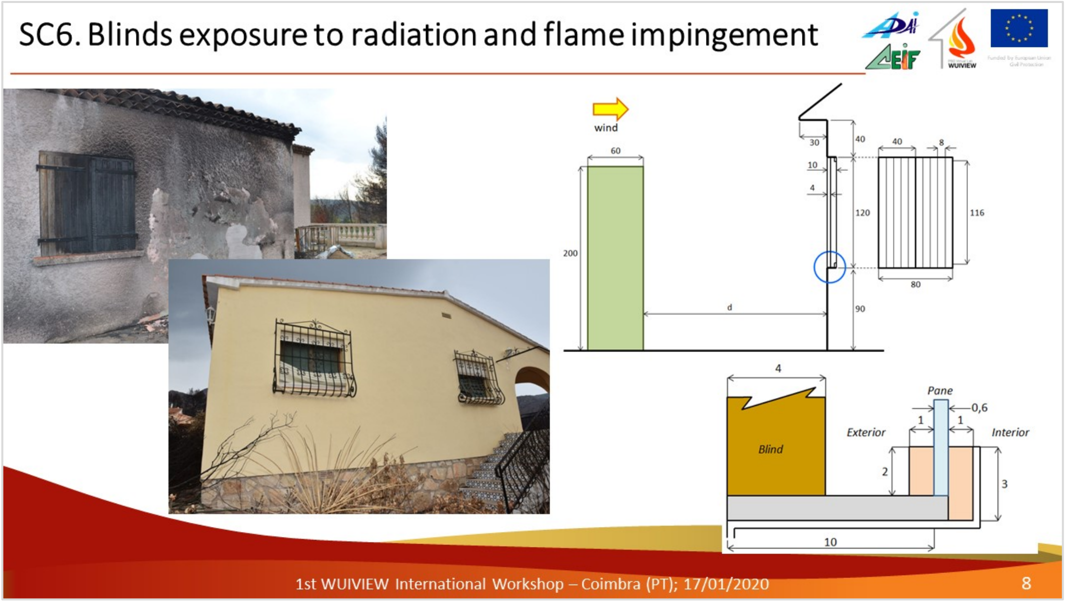
SC3. Fuel build-up and combustion in gutters

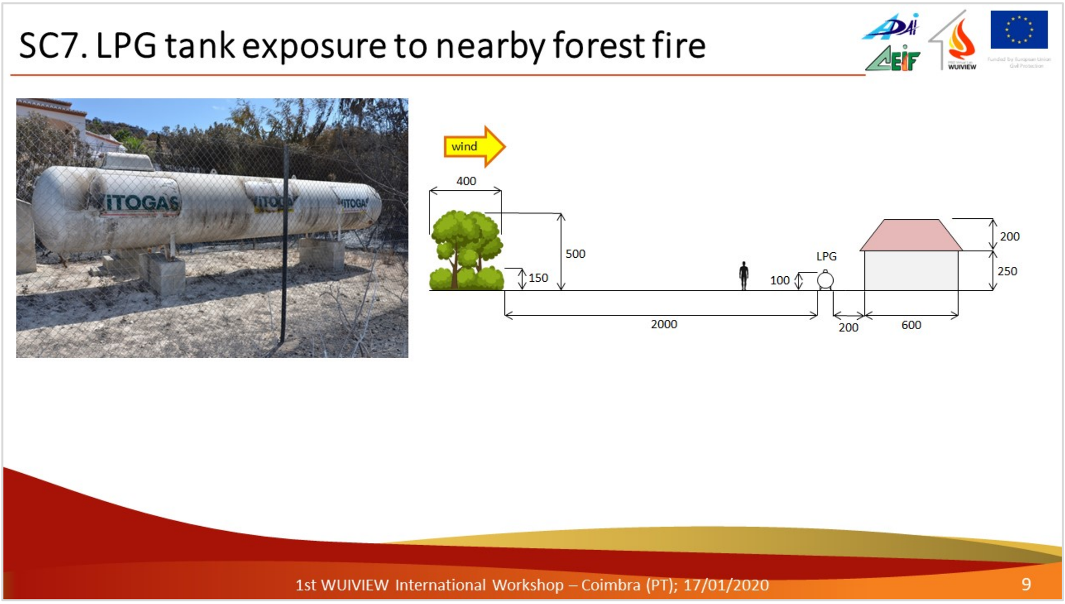


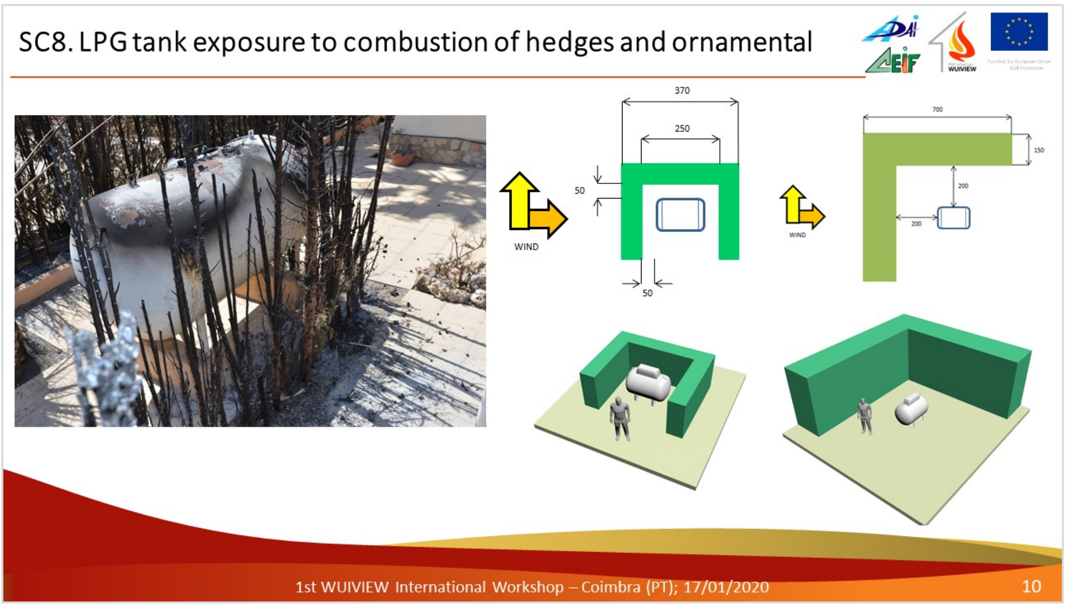
SC4. Fuel build-up and combustion on roofs

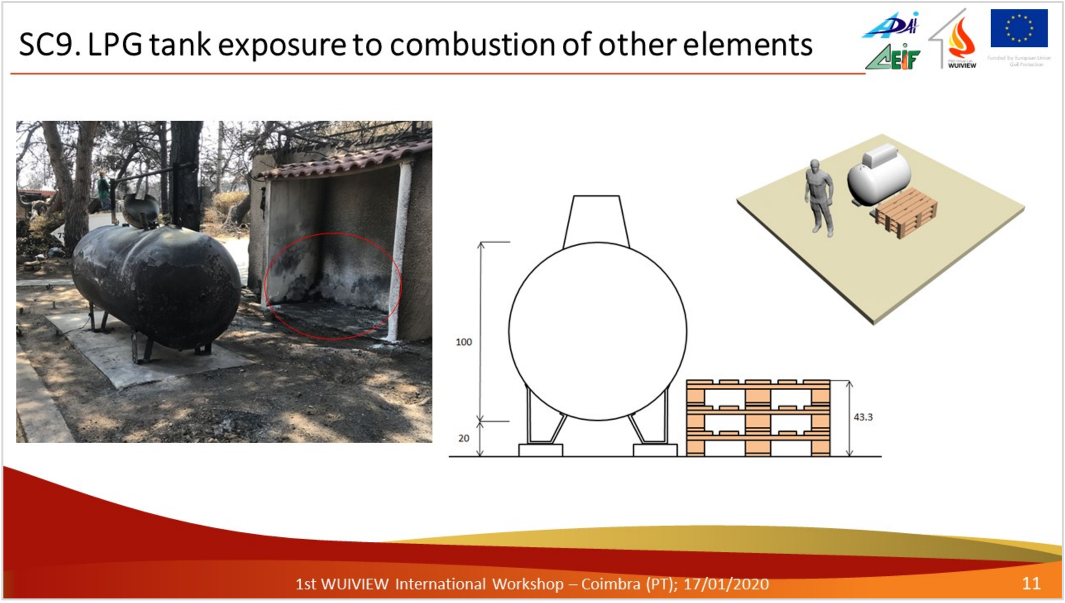


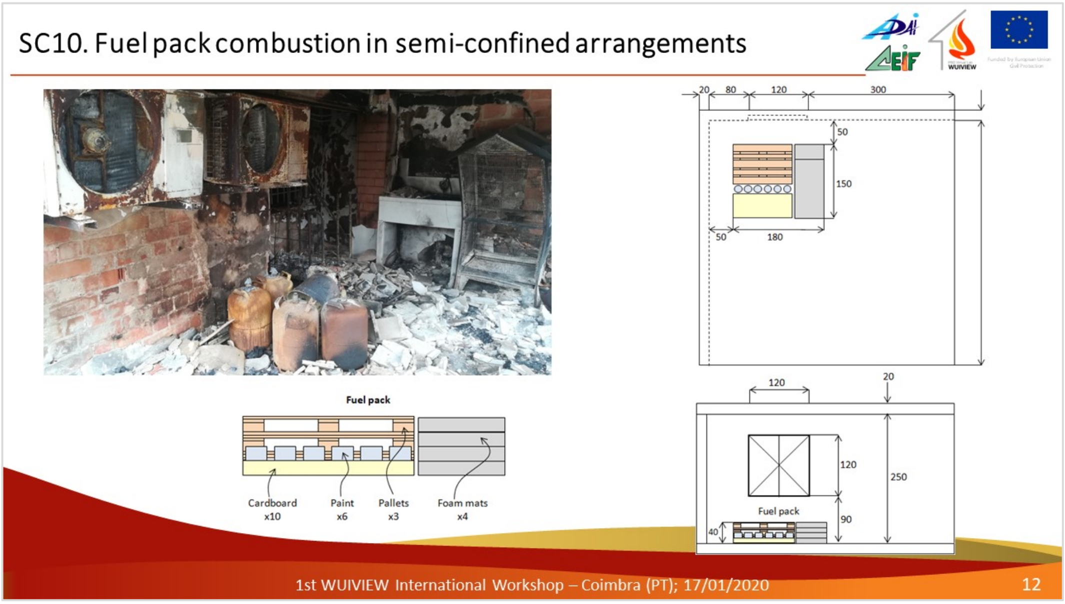



SC6. Blinds exposure to radiation and flame impingement
wind
60
200
d
30
10
4
40
120
90
40
8
116
80
4
Blind
Exterior
Pane
0,6
1
1
Interior
2
3
10
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
8


SC7. LPG tank exposure to nearby forest fire
wind
400
500
150
LPG
100
2000
200
600
200
250
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
9


SC8. LPG tank exposure to combustion of hedges and ornamental
370
250
50
50
WIND
WIND
700
150
200
200
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
10


SC9. LPG tank exposure to combustion of other elements
100
20
43.3
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
11


SC10. Fuel pack combustion in semi-confined arrangements
20
80
120
300
50
150
50
180
120
20
120
250
Fuel pack
90
40
Fuel pack
Cardboard
x10
Paint
x6
Pallets
x3
Foam mats
x4
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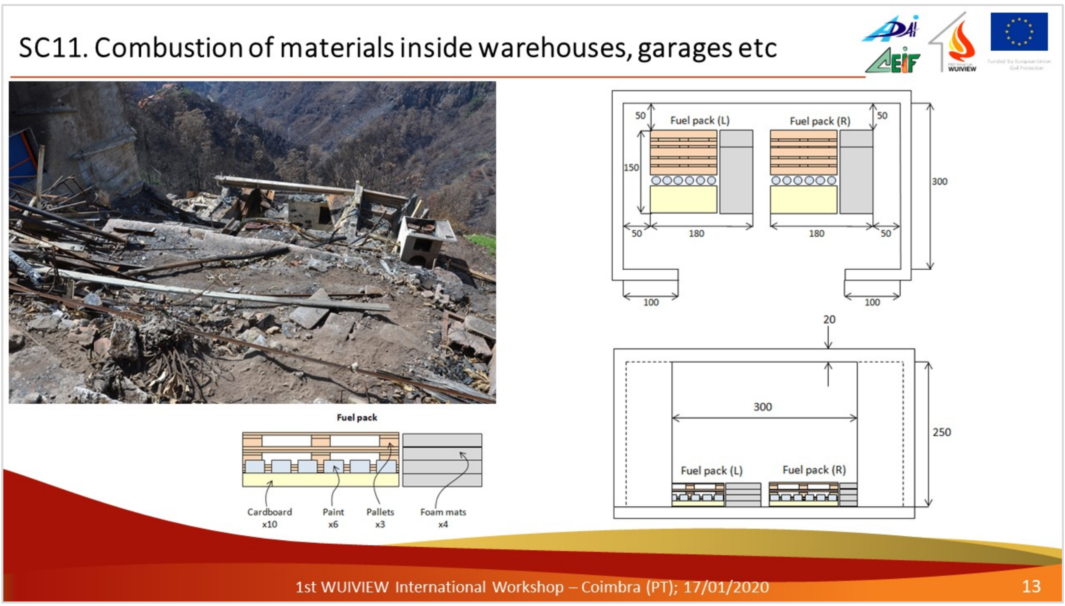
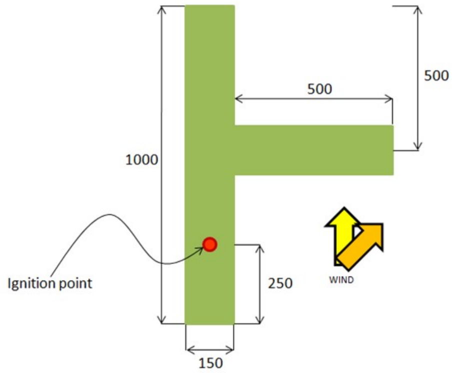

SC11. Combustion of materials inside warehouses, garages etc
Fuel pack (L)
Fuel pack (R)
50
150
50
180
180
50
300
100
100
20
300
250
Fuel pack (L)
Fuel pack (R)
Fuel pack
Cardboard
x10
Paint
x6
Pallets
x3
Foam mats
x4
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
13

SC13. Fire propagation over green hedges and ornamental elements



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Development of 3D scenarios

- Digital copy of geometry and materials in a WUI microscale
- Buildings, components, installations, furniture, vegetation...
- Other materials and objects participating in combustion
- Objects as 3D meshes of triangular facets
- Characteristics (material) as derived from colour

- Objective: obtain the geometry and materials for its simulation in the FDS and Fluent
- Two approaches:
    - Idealised scenarios, objects from catalogue
    - Capture of real world objects and components

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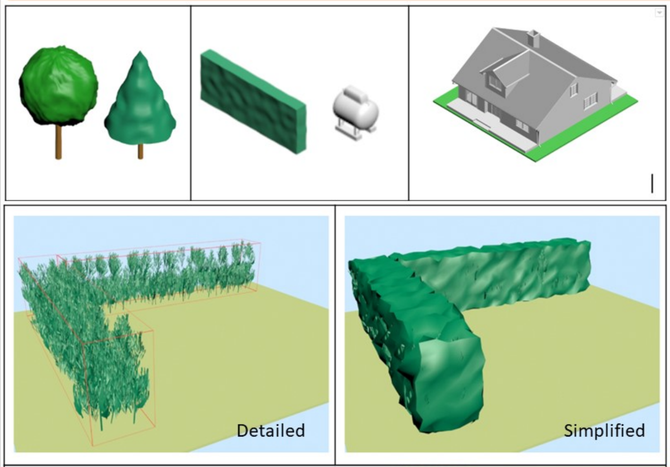
Idealised scenarios



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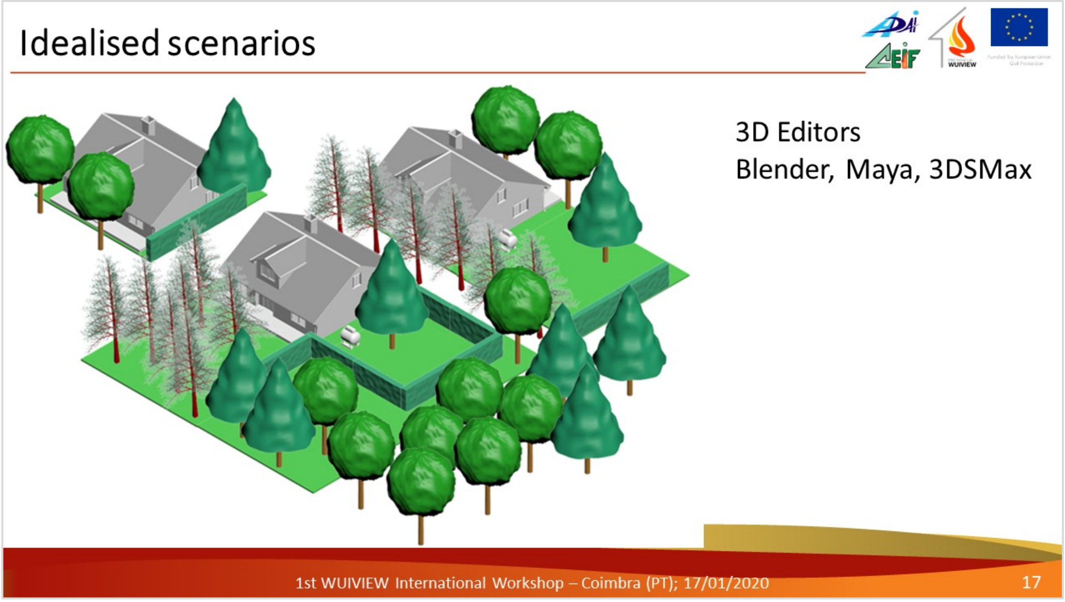
Idealised scenarios
3D Editors
Blender, Maya, 3DSMax
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17


Objects positioning
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18


Objects positioning
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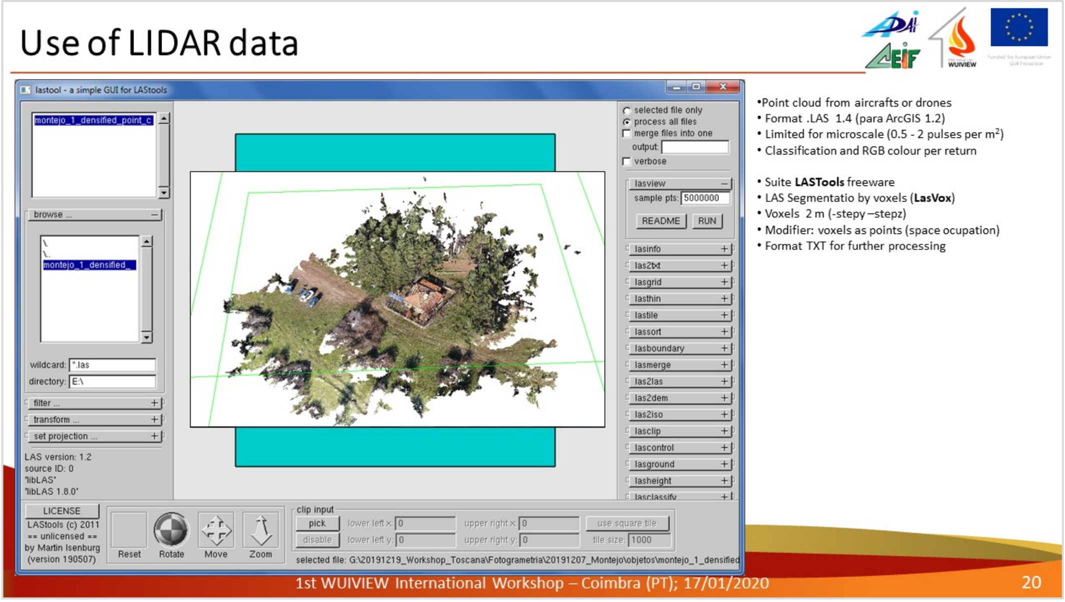
19


Use of LIDAR data
•Point cloud from aircrafts or drones
• Format .LAS 1.4 (para ArcGIS 1.2)
• Limited for microscale (0.5 - 2 pulses per m²)
• Classification and RGB colour per return
• Suite LASTools freeware
• LAS Segmentatio by voxels (LasVox)
• Voxels 2 m (-stepy –stepz)
• Modifier: voxels as points (space ocupation)
• Format TXT for further processing
lastool - a simple GUI for LAStools
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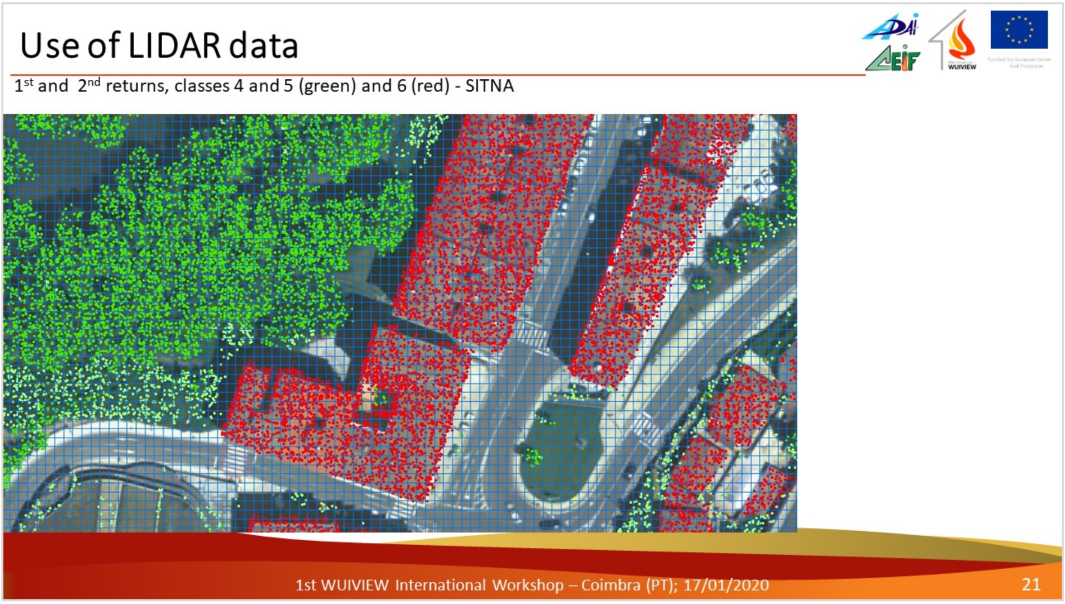
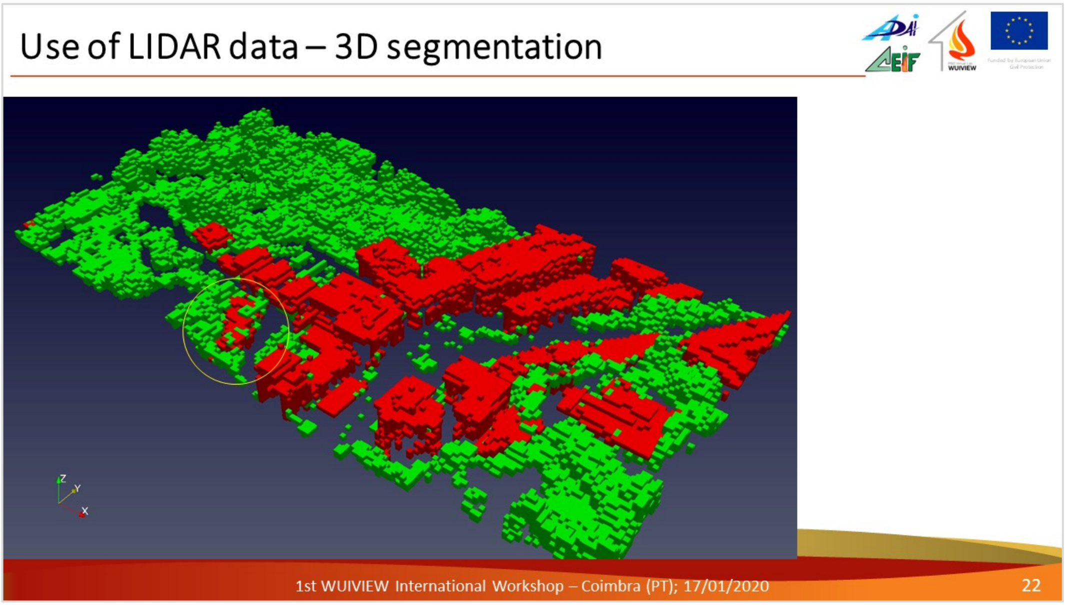
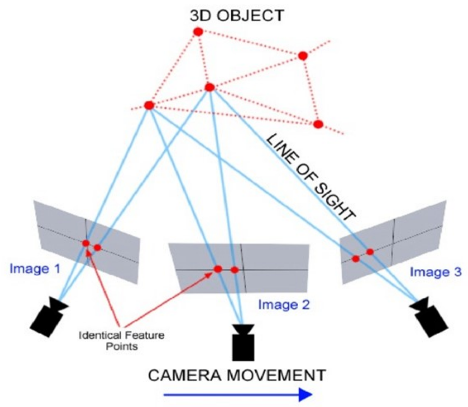
20


Use of LIDAR data
1st and 2nd returns, classes 4 and 5 (green) and 6 (red) - SITNA
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
21


Use of LIDAR data – 3D segmentation
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
22

Photogrammetry



- Generation of 3D objects from photographs
- Used in artificial vision
- Based in camera movement

- Autodesk Recap
- Zephyr
- MeshRoom
- Pix4D Map

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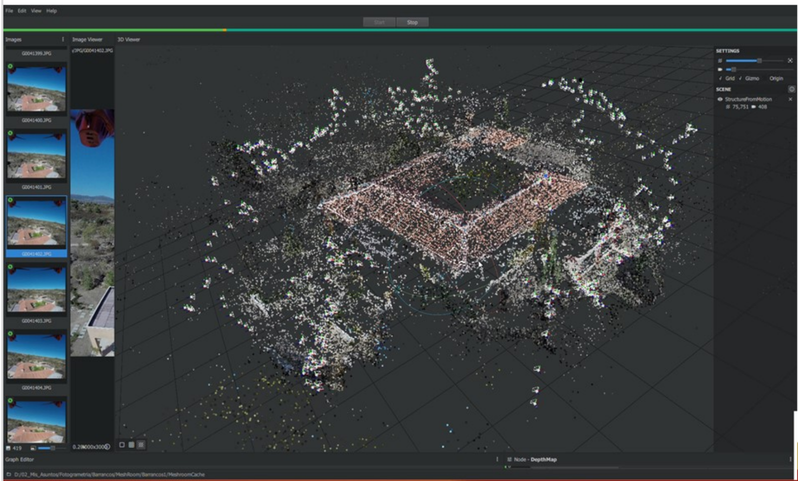
Photogrammetry



- MeshRoom
- Zephyr
- Autodesk Recap
- Pix4D Map

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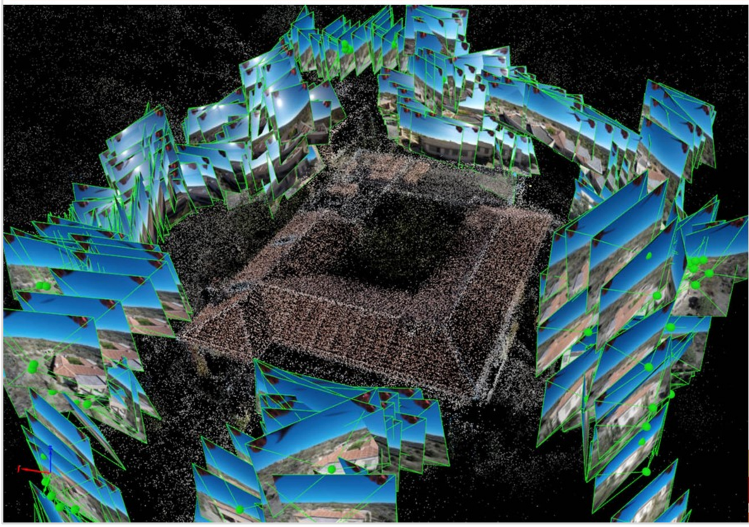
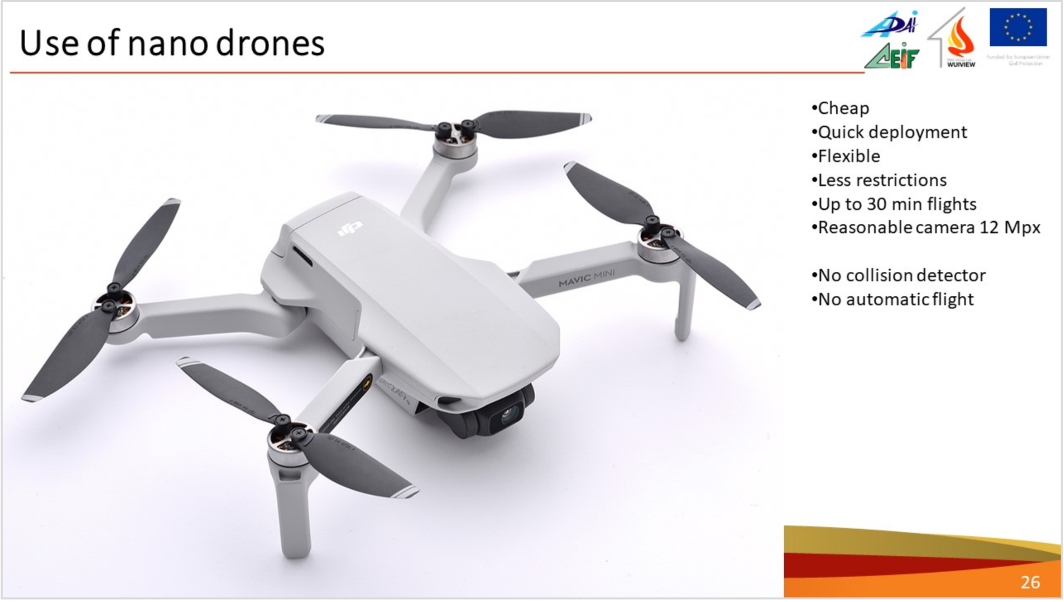
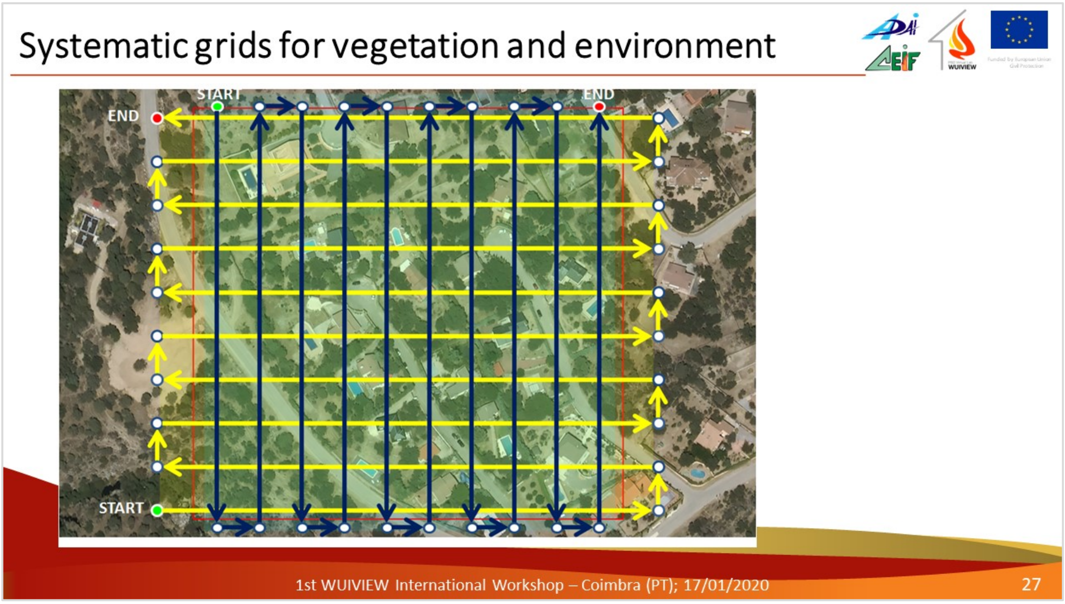
Photogrammetry



20 25


Use of nano drones
•Cheap
•Quick deployment
•Flexible
•Less restrictions
•Up to 30 min flights
•Reasonable camera 12 Mpx
•No collision detector
•No automatic flight
MAVIC MINI
26


Systematic grids for vegetation and environment
START
END
END
START
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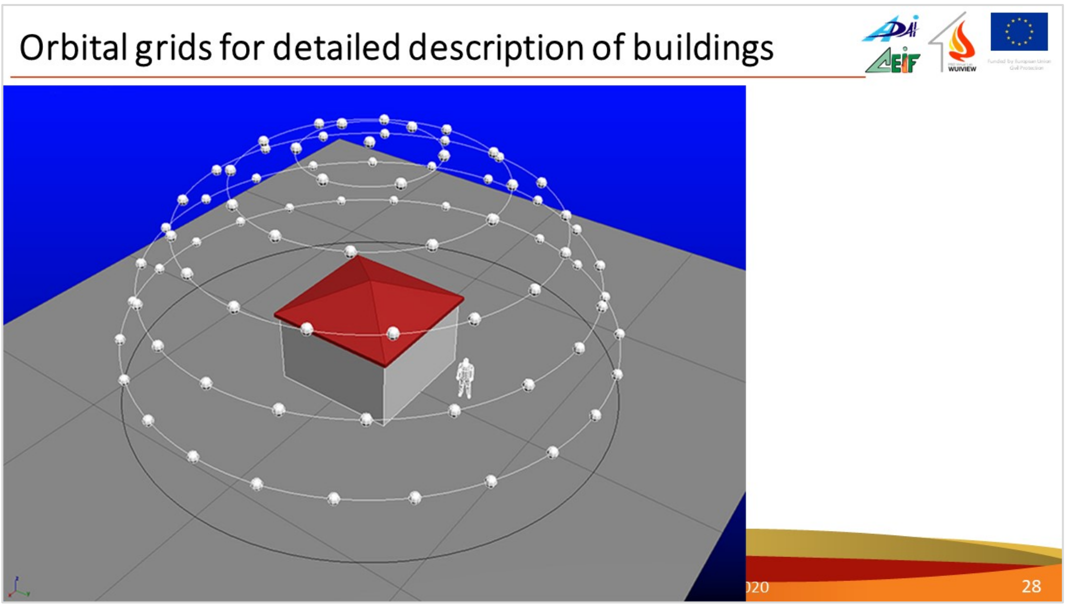
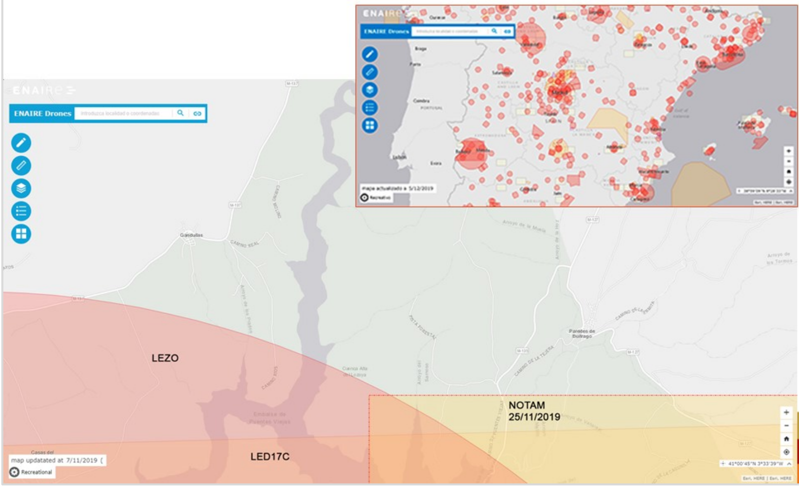
27

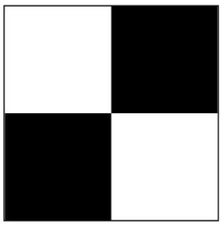

Orbital grids for detailed description of buildings
28

Restricted areas

Enaire Drones (https://drones.enaire.es/)



Geographical references (targets)



1 405155.64 m E 4484401.98 m N
2 405138.04 m E 4484390.77 m N
3 405174.93 m E 4484378.31 m N

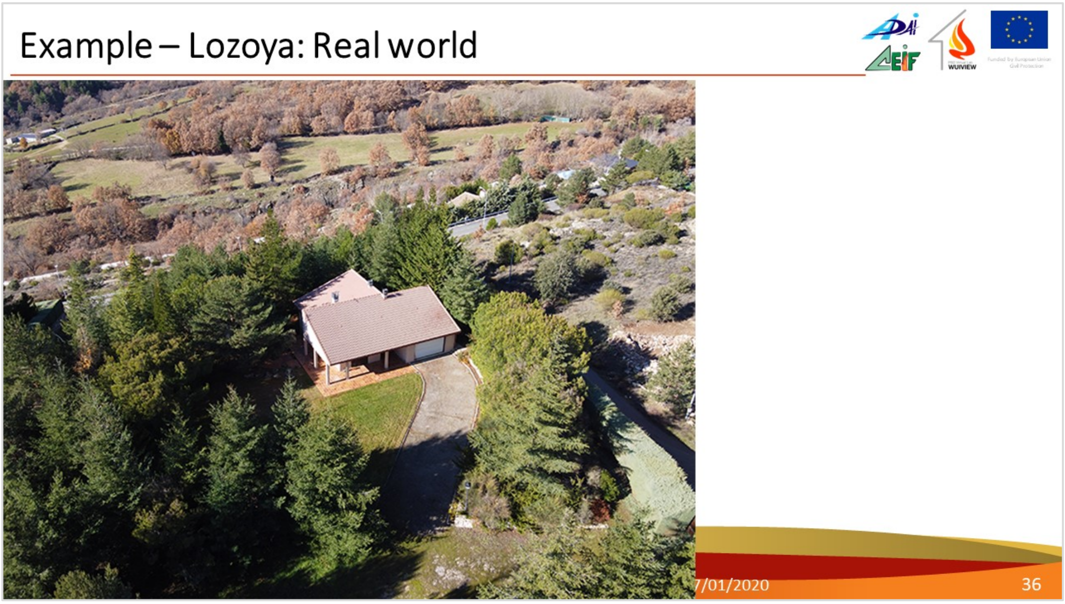
Collection of photos


32


33


34


35


Example – Lozoya: Real world
7/01/2020
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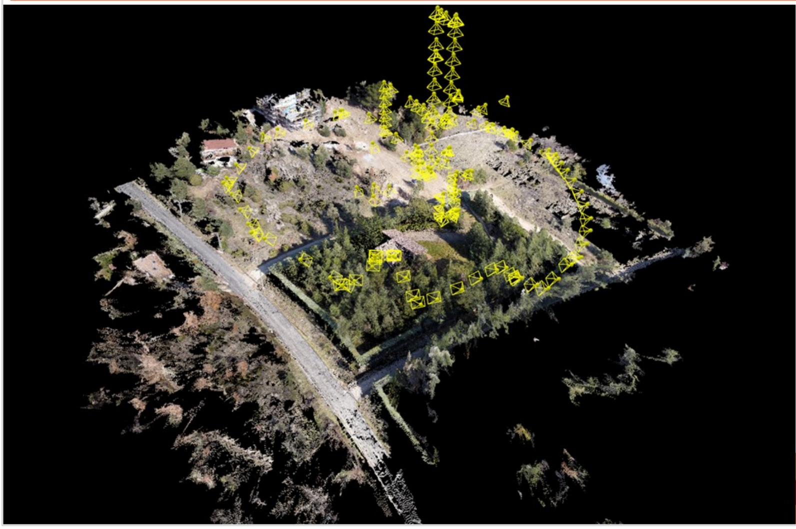
Example – Lozoya: Drone set-up and flight
20
37

Example – Lozoya: Drone set-up and flight

38

Example - Lozoya: Camera positions



39

Example - Lozoya: Densified point cloud

40

Example - Lozoya: Densified point cloud

41

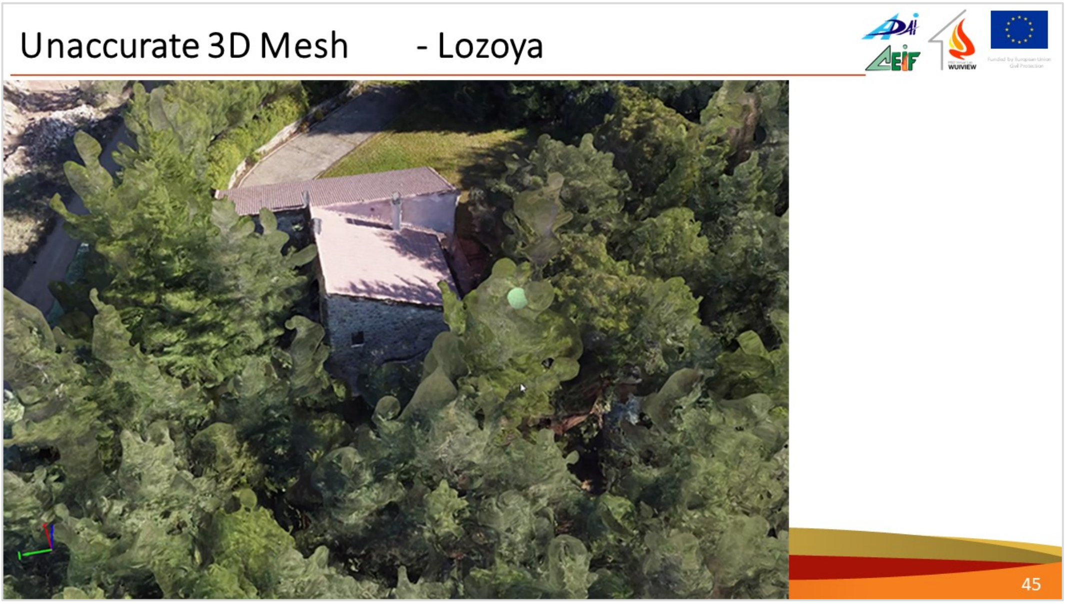
Example - Entrepinos: Densified point cloud

42

Example - Montejo: Densified point cloud

43


Unaccurate 3D Mesh - Lozoya
44


Unaccurate 3D Mesh - Lozoya
45

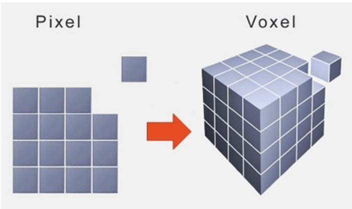

Unaccurate 3D Mesh - Entrepinos
46

Unaccurate 3D Mesh - Los Barrancos

47

Voxelization

- Convert point clouds or 3D objects into volumetric elements (voxels)
- Each voxel represents a space occupation in the calculation mesh
- Each voxel has an associated material based in colour
- Statistical calculation of voxel colour based on points/facets
- Voxels perfectly aligned with FDS calculation mesh
- Voxels as FDS obstructions



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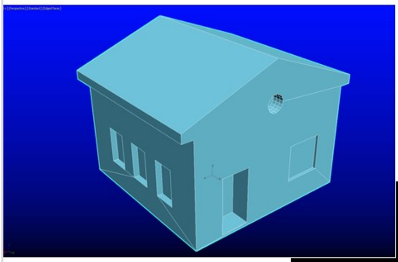
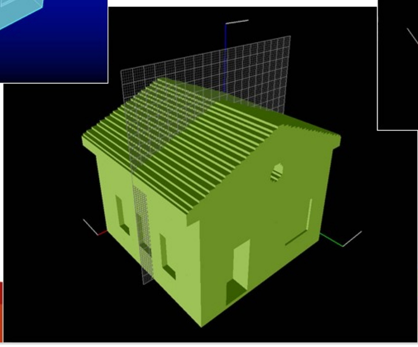
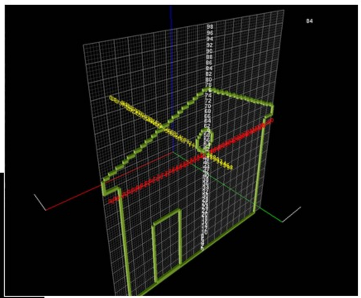
Voxelization – From 3d object mesh

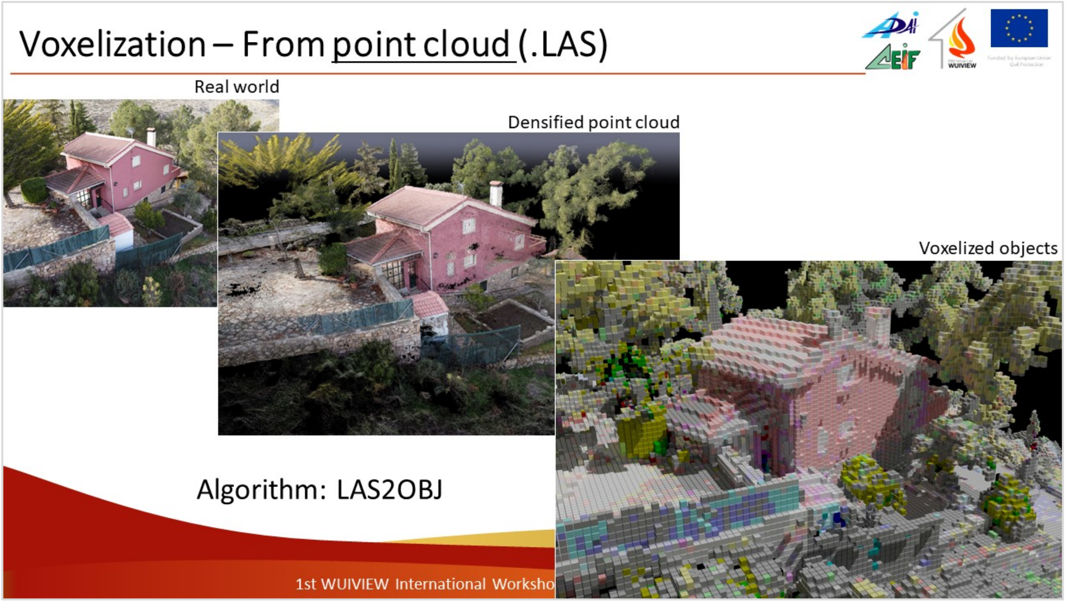


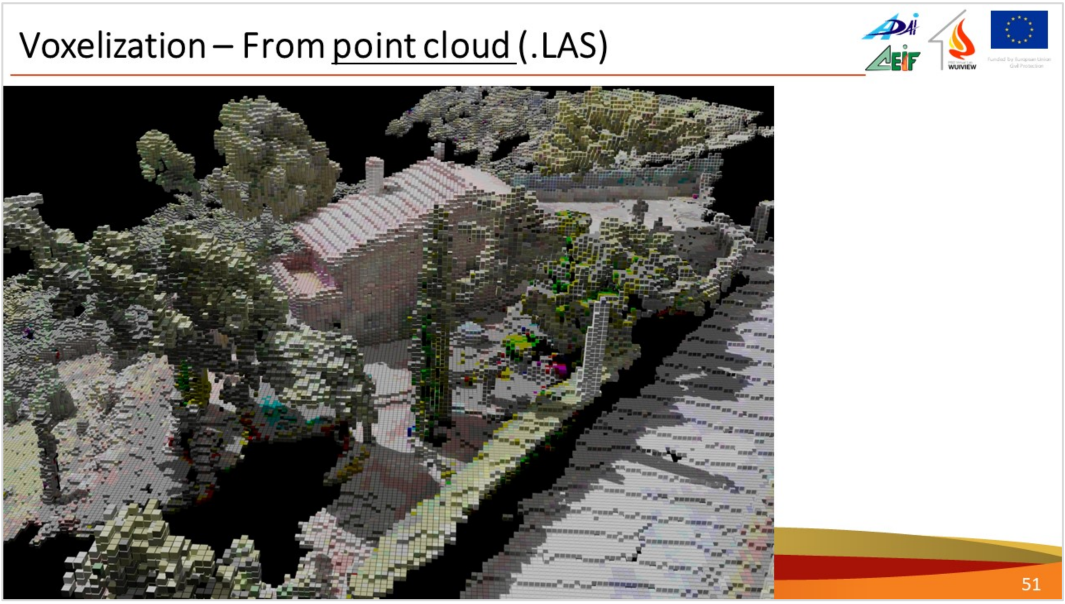


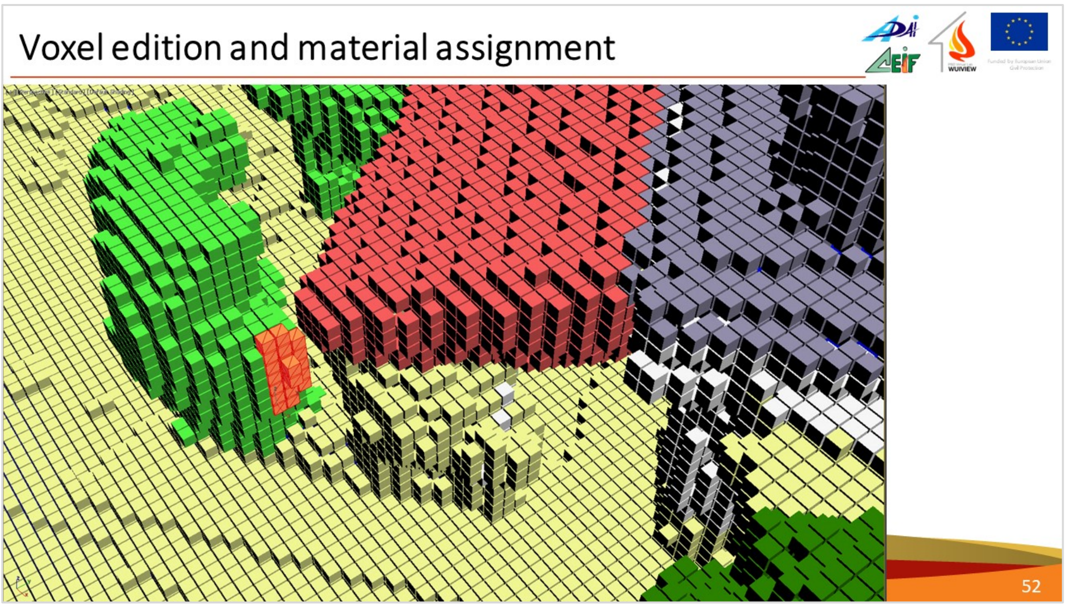


BinVox

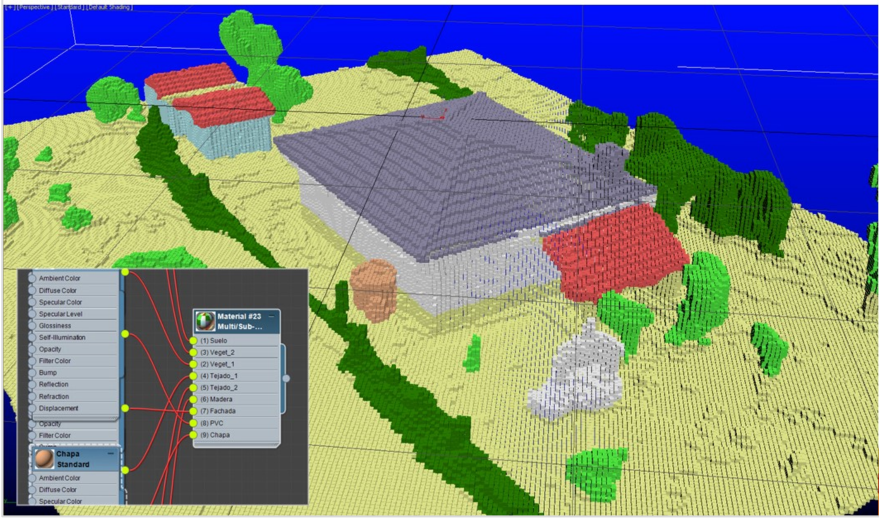
01/2020 49


Voxelization – From point cloud (.LAS)
Real world
Densified point cloud
Voxelized objects
Algorithm: LAS2OBJ
1st WUIVIEW International Worksho


Voxelization – From point cloud (.LAS)
51


Voxel edition and material assignment
52

Voxel edition and material assignment



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Example - Lozoya: Real world

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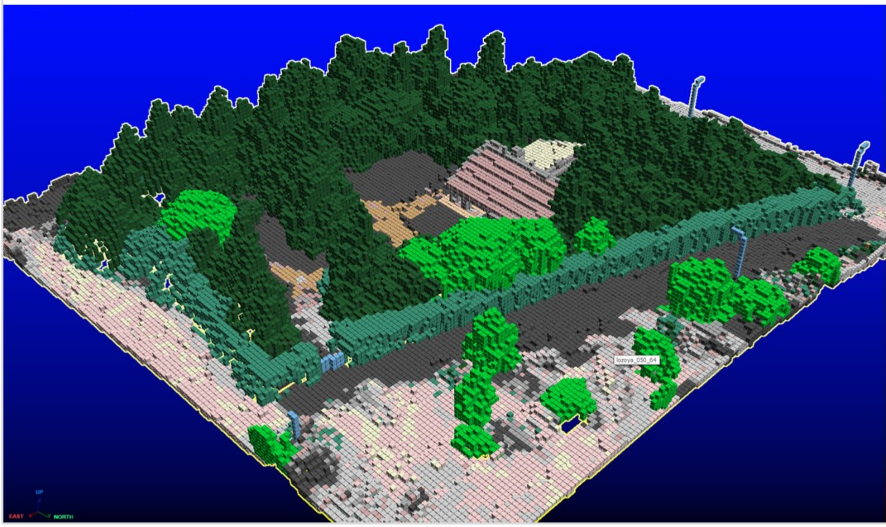
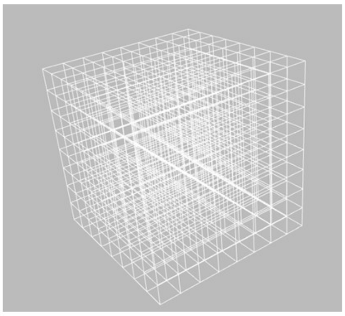
Example – Lozoya: Voxelized objects with materials

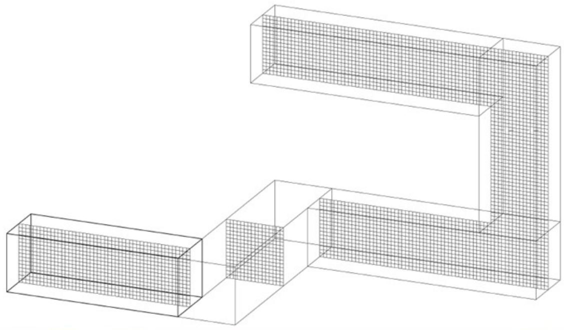


55

Parsing voxels into FDS



- Structured 3D calculation mesh
- Matches perfectly with voxel dimensions
- Establishes extension and boundaries



Parsing voxels into FDS

1. Sets calculation mesh boundaries

$$Nx = (x_f - x_i) / d$$
$$Ny = (y_f - y_i) / d$$
$$Nz = (z_f - z_i) / d$$

```
&MESH IJK=Nx,Ny,Nz, XB=xi,xf,yi,yf,zi,zf /
```

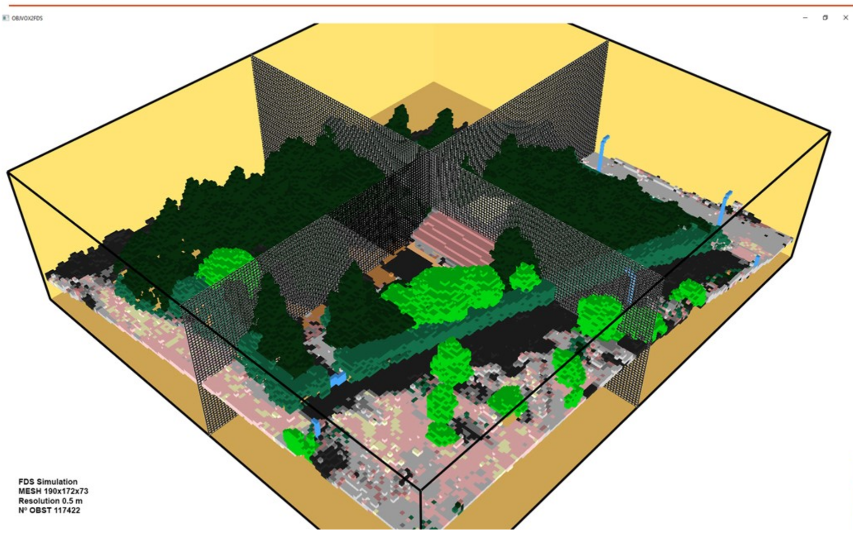
2. Describes voxels geometry

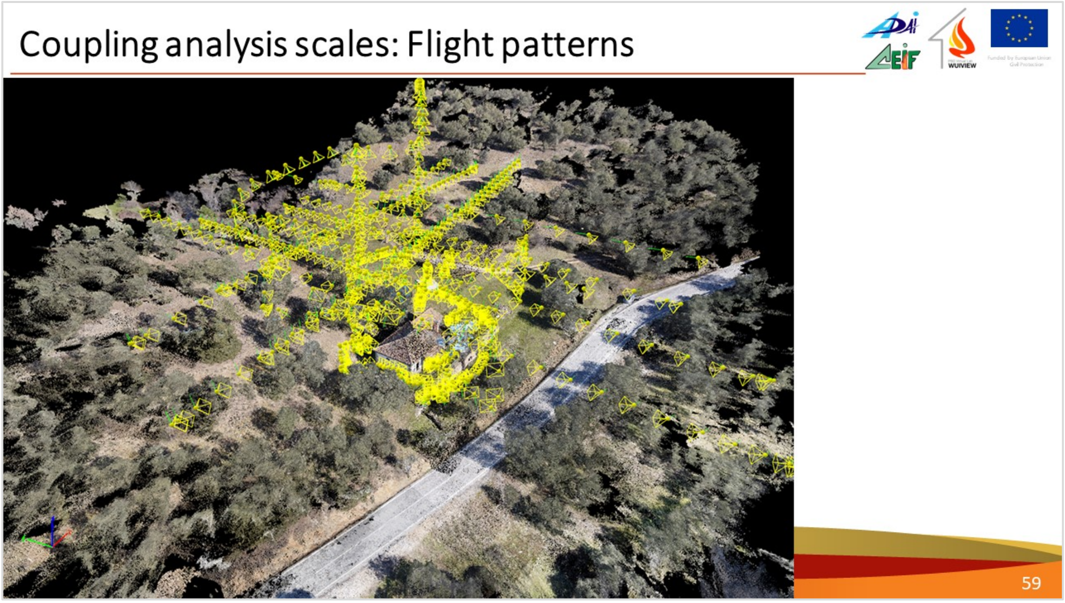
```
&OBST XB=x1,x2,y1,y2,z1,z2, SUF_ID='MATj' /
```

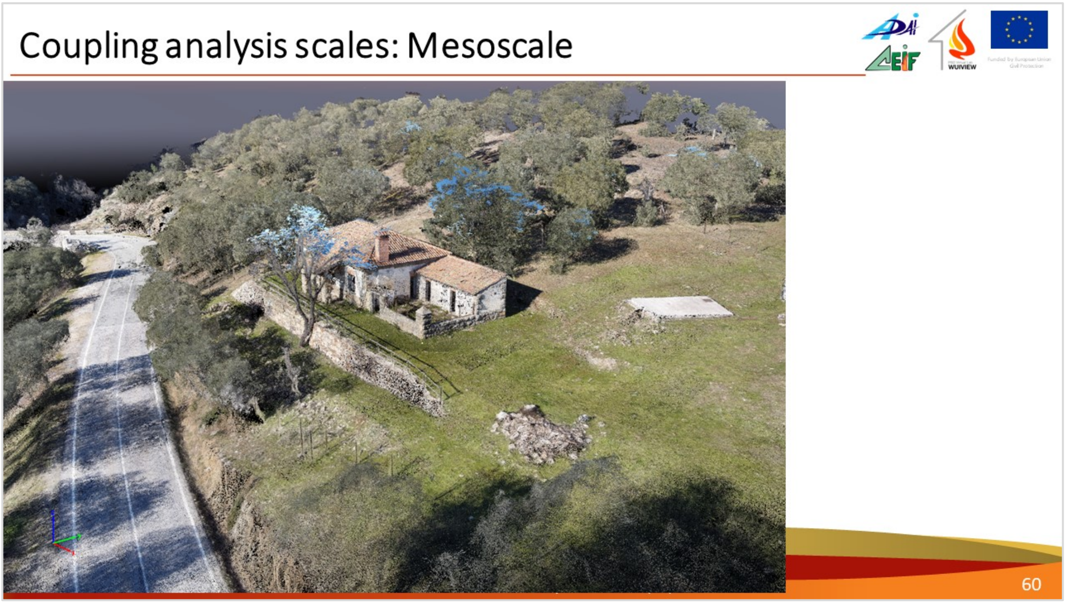
3. Describes materials associated to voxels

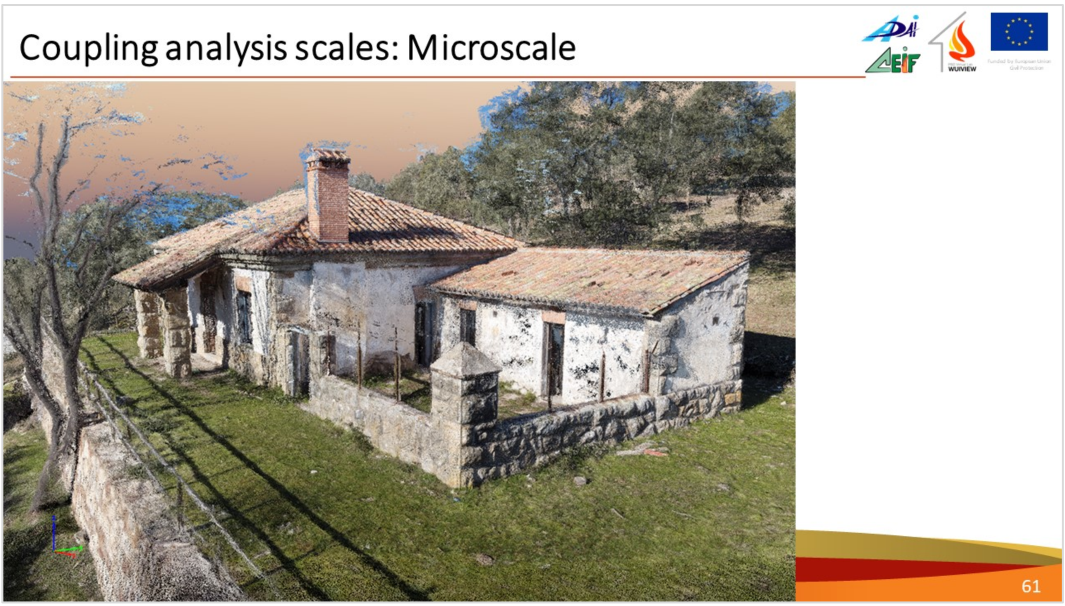
```
&SURF ID='MATj'
```

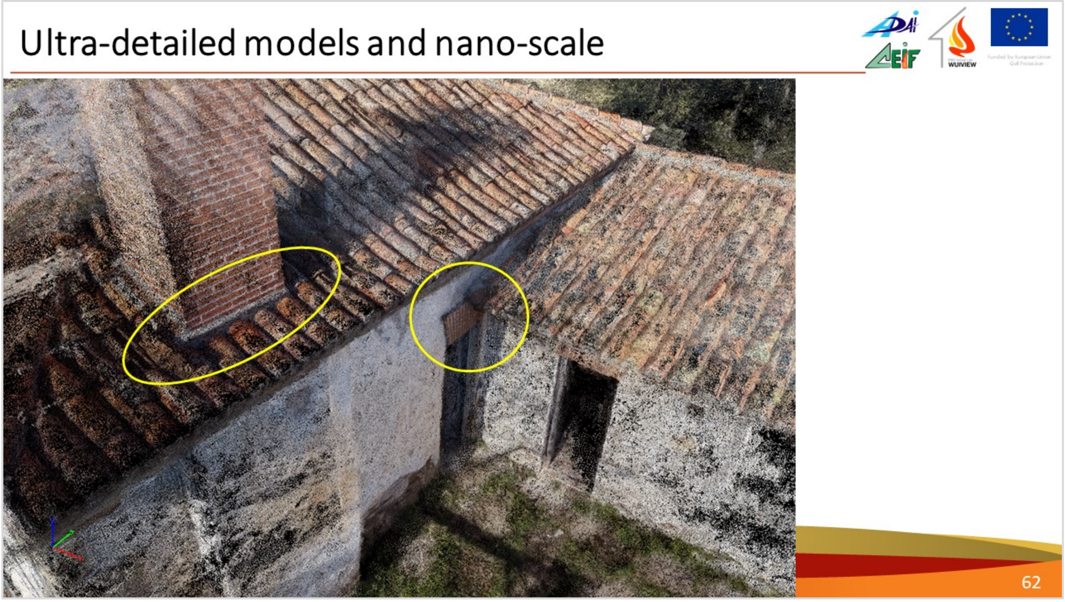

Example – Lozoya: FDS scenario

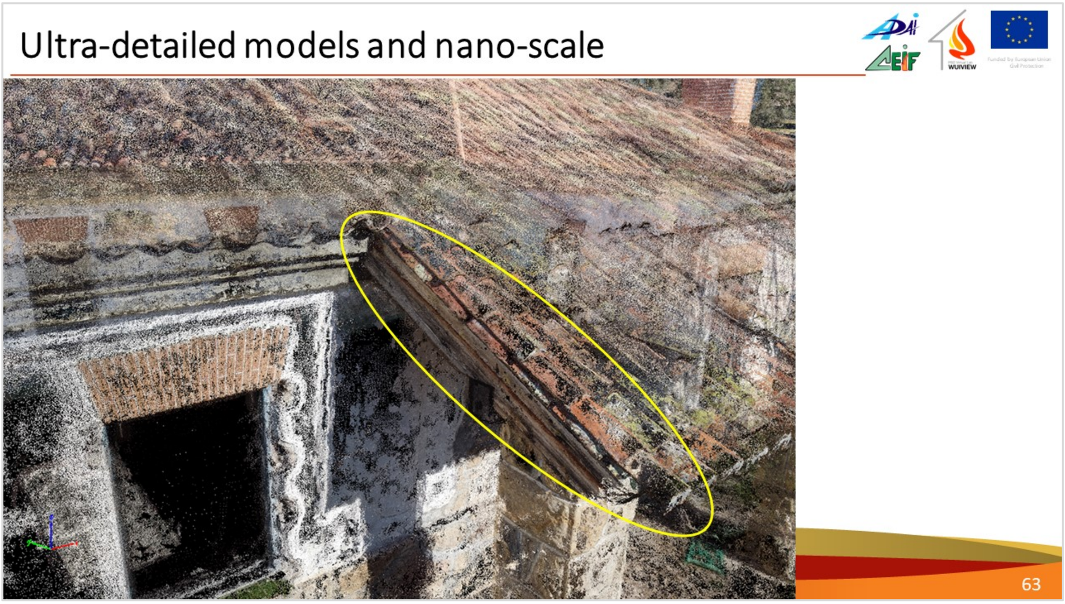


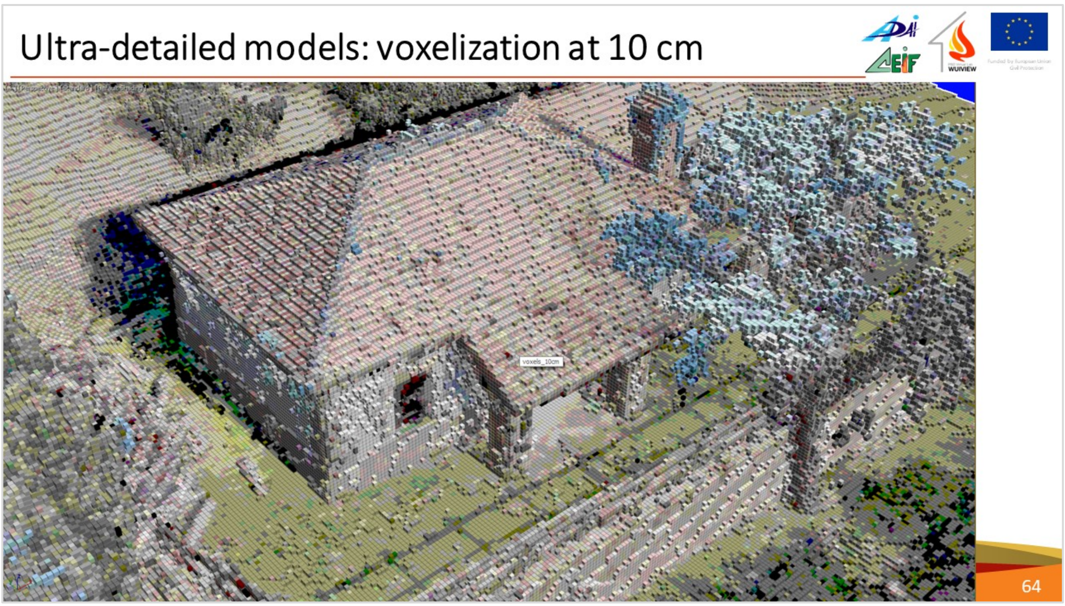

Coupling analysis scales: Flight patterns
59


Coupling analysis scales: Mesoscale
60


Coupling analysis scales: Microscale
61


Ultra-detailed models and nano-scale
62


Ultra-detailed models and nano-scale
63


Ultra-detailed models: voxelization at 10 cm
64


Thanks!
dcaballero@paucostafoundation.org
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4.7. Hazard associated to natural fuels, by Miguel Almeida

4.7.1. Abstract

The importance of an adequate design of gardens, in particular concerning natural fuels, and a proper management of the vegetation aiming at the fire risk mitigation was highlighted in this presentation.

Among several common components of gardens, the vegetation hedges were the main focus of this presentation. The factors that change its combustibility potential, such as the type of vegetation, maintenance (e.g. watering) and pruning were discussed. A greater evidence was given to the pruning, highlighting that the trimming of the branches' ends, stimulates its sprout creating a thick layer of new leaves in the surface of the vegetation hedge that prevent the entrance of light inside the vegetation, increasing the fraction of dead material and consequently the combustibility of the hedge.

Several laboratory tests addressing the burning of four different species – *Cupressus arizonica, Cupressocyparis leylanddi, Thuja occidentalis, Prunus laurocerasus* – typically used in natural hedges, developed within the WUIVIEW Project, were described. The lower combustibility of some species such as the *Prunus laurocerasus* which are indicate as an adequate specie to be used in hedges in order to reduce the fire risk was stated.

The experiments performed also addressed the dehydration degree of the different species used. Three lots of trees with different fuel moisture contents were analysed: 1) no dehydration; 2) 28-32 days of no watering; and 3) 100/101 days of no watering. Once again, the *Prunus laurocerasus* showed to be the most favourable specie aiming at the fire risk reduction since the weakening of the plant caused by de dehydration drives to the release and fall down of the dead leaves before they become dry, while the other species keep the dead/dry leaves and branches attached to the plant increasing the combustibility.

4.7.2. Presentation printout (*in Portuguese*)

Estrutura da apresentação

- Combustíveis naturais na IUF
- Estudo específico – sebes na proximidade do edificado
  - Desenvolvimento do estudo laboratorial desenvolvido
- Conclusão

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Contextualização

Relatório da ADAI sobre "O Complexo dos incêndios de Pedrógão Grande e Concelhos limítrofes, iniciado a 17 de Junho de 2017

Gestão de combustíveis	Estado da estrutura após o IF				
	Pouco danificada	Moderadamente danificada	Muito danificada	Totalmente destruída	Total
Ausente	17	20	183	203	423
Parcial	37	40	198	211	486
Total	7	8	19	20	54
Total	61	68	400	434	963

Como se deu a ignição	Estado da estrutura após o IF				Total
	Pouco danificada	Moderadamente danificada	Muito danificada	Totalmente destruída	
Fagulhas (projeções)	27	54	294	261	636
Impacto direto do fogo	7	8	91	116	222
Materiais a arder na imediação	7	9	43	74	133
Estrutura contígua	2	1	3	6	12
Com danos, mas sem ignição	35	2	1	0	38
Total	78	74	432	457	1041

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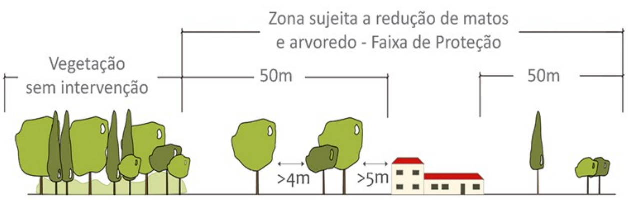
Incêndios provenientes do exterior



Projeto HOUSE-REFUGE
www.adai.pt/houserefuge)

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Risco de incêndio na microescala da IUF
Vários combustíveis na proximidade imediata das construções
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Risco de incêndio na microescala da IUF
Combustíveis na proximidade imediata das construções
1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
6


Fatores de perigo de incêndio na microescala da IUF
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Fatores de perigo de incêndio na microescala da IUF
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8


Fatores de perigo de incêndio na microescala da IUF
Sebes
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Sebes como fator potenciador de risco de IF na IUF
Tipo de vegetação
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Sebes como fator potenciador de risco de IF na IUF
Corte/aparo
Sebe com corte/aparo
Sebe sem corte
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Sebes como fator potenciador de risco de IF na IUF
Manutenção / rega
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Espécies analisadas
Cupressus arizonica
Cupressocyparis leylanddi
Thuja occidentalis
Prunus laurocerasus
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Metodologia dos ensaios realizados

Árvores verdes

Árvores parcialmente secas

Árvores novas

- Caracterização das espécies analisadas
- Ensaios com queima
  - Queima de árvore isolada
  - Queima de uma linha de 3 árvores

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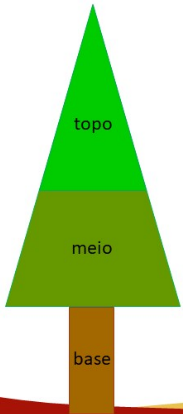
Caracterização das espécies – metodologia

Análise de dimensões e massa

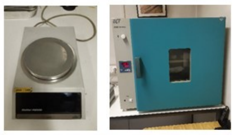
Divisão em altura



Fracionamento e divisão por dimensões

∅<3mm
3<∅<6mm
6<∅<10mm
∅>10mm

Determinação das humidades e da distribuição de massas



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Caracterização das espécies ("verdes")

			Cupressocyparis leylandii (CH=230cm)			*Cupressus arizonica* (CH=270cm)			*Prunus laurocerasus* (CH=168cm)			*Thuja Occidentalis* (CH=204cm)		
			Massa BS (g)	Massa BS (%)	Humidade (%)	Massa BS (g)	Massa BS (%)	Humidade (%)	Massa BS (g)	Massa BS (%)	Humidade (%)	Massa BS (g)	Massa BS (%)	Humidade (%)
Topo	Folhagem		28.7	5.3	160	---	---	---	92.61	9.2	199	197.26	9.7	59
	lenhoso verde	ø<3mm	---	---	---	---	---	---	7.52	0.7	182	---	---	---
		3<ø<6mm	---	---	---	---	---	---	9.25	0.9	151	---	---	---
		6<ø<10mm	---	---	---	---	---	---	13.93	1.4	153	---	---	---
	lenhoso castanho	ø<3mm	2.31	0.4	107	---	---	---	---	---	---	11.47	0.6	57
		3<ø<6mm	4.22	0.8	119	---	---	---	---	---	---	20.41	1.0	64
		6<ø<10mm	7.61	1.4	121	---	---	---	15.8	1.6	136	10.43	0.5	70
		ø>10mm	---	---	---	---	---	---	11.6	1.1	133	---	---	---
	material morto	ø<3mm	---	---	---	191.46	10.3	21	0.70	0.1	7	---	---	---
		3<ø<6mm	---	---	---	11.82	0.6	23	1.14	0.1	30	---	---	---
		6<ø<10mm	---	---	---	---	---	---	---	---	---	---	---	---
		ø>10mm	---	---	---	2.21	0.1	28	97.17	9.6	196	---	---	---
Meio	Folhagem		89.20	16.6	173	---	---	---	17.02	1.7	161	484.26	23.9	48
	lenhoso verde	ø<3mm	---	---	---	---	---	---	24.11	2.4	139	---	---	---
		3<ø<6mm	---	---	---	---	---	---	32.22	3.2	143	---	---	---
	lenhoso castanho	ø<3mm	10.57	2.0	94	---	---	---	29.31	2.9	131	45.77	2.3	51
		3<ø<6mm	9.53	1.8	105	---	---	---	---	---	---	58.53	2.9	63
		6<ø<10mm	6.4	1.2	134	---	---	---	146.61	14.5	116	117.88	5.8	66
		ø>10mm	40.25	7.5	150	---	---	---	4.7	0.5	26	158.07	7.8	67
	material morto	ø<3mm	---	---	---	582.92	31.2	20	10.03	1.0	22	---	---	---
		3<ø<6mm	---	---	---	62.15	3.3	21	---	---	---	---	---	---
		6<ø<10mm	---	---	---	78.33	4.2	22	26.39	2.6	185	---	---	---
		ø>10mm	---	---	---	124.36	6.7	23	4.63	0.5	151	---	---	---
Base	Folhagem		178.83	33.3	160	---	---	---	5.20	0.5	149	194.96	9.6	40
	lenhoso verde	6<ø<10mm	---	---	---	---	---	---	2.33	0.2	36	---	---	---
		ø>10mm	---	---	---	---	---	---	10.67	1.1	90	---	---	---
	lenhoso castanho	ø<3mm	13.13	2.4	78	---	---	---	17.11	1.7	114	9.22	0.5	46
		3<ø<6mm	23.1	4.3	82	---	---	---	431.74	42.7	111	27.27	1.3	52
		6<ø<10mm	1.11	0.2	110	---	---	---	---	---	---	59.05	2.9	70
		ø>10mm	122.12	22.7	141	---	---	---	---	---	---	621.47	30.6	69
	material morto	ø<3mm	---	---	---	369.49	19.8	19	---	---	---	14.33	0.7	21
		3<ø<6mm	---	---	---	41.80	2.2	22	---	---	---	---	---	---
		6<ø<10mm	---	---	---	30.27	1.6	24	---	---	---	---	---	---
		ø>10mm	---	---	---	372.30	19.9	21	---	---	---	---	---	---

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Caracterização das espécies – resultados

			Cupressocyparis leylandii (CH=230cm)			*Cupressus arizonica* (CH=270cm)			*Prunus laurocerasus* (CH=168cm)			*Thuja Occidentalis* (CH=204cm)		
			Massa BS (g)	Massa BS (%)	Humidade (%)	Massa BS (g)	Massa BS (%)	Humidade (%)	Massa BS (g)	Massa BS (%)	Humidade (%)	Massa BS (g)	Massa BS (%)	Humidade (%)
Topo	Folhagem		28.7	5.3	160	---	---	---	92.61	9.2	199	197.26	9.7	59
	lenhoso verde	ø<3mm	---	---	---	---	---	---	7.52	0.7	182	---	---	---
		3<ø<6mm	---	---	---	---	---	---	9.25	0.9	151	---	---	---
		6<ø<10mm	---	---	---	---	---	---	13.93	1.4	153	---	---	---
	lenhoso castanho	ø<3mm	2.31	0.4	107	---	---	---	---	---	---	11.47	0.6	57
		3<ø<6mm	4.22	0.8	119	---	---	---	---	---	---	20.41	1.0	64
		6<ø<10mm	7.61	1.4	121	---	---	---	15.8	1.6	136	10.43	0.5	70
		ø>10mm	---	---	---	---	---	---	11.6	1.1	133	---	---	---
	material morto	ø<3mm	---	---	---	191.46	10.3	21	0.70	0.1	7	---	---	---
		3<ø<6mm	---	---	---	11.82	0.6	23	1.14	0.1	30	---	---	---
		6<ø<10mm	---	---	---	---	---	---	---	---	---	---	---	---
		ø>10mm	---	---	---	2.21	0.1	28	97.17	9.6	196	---	---	---
Meio	Folhagem		89.20	16.6	173	---	---	---	17.02	1.7	161	484.26	23.9	48
	lenhoso verde	ø<3mm	---	---	---	---	---	---	24.11	2.4	139	---	---	---
		3<ø<6mm	---	---	---	---	---	---	32.22	3.2	143	---	---	---
	lenhoso castanho	ø<3mm	10.57	2.0	94	---	---	---	29.31	2.9	131	45.77	2.3	51
		3<ø<6mm	9.53	1.8	105	---	---	---	---	---	---	58.53	2.9	63
		6<ø<10mm	6.4	1.2	134	---	---	---	146.61	14.5	116	117.88	5.8	66
		ø>10mm	40.25	7.5	150	---	---	---	4.7	0.5	26	158.07	7.8	67
	material morto	ø<3mm	---	---	---	582.92	31.2	20	10.03	1.0	22	---	---	---
		3<ø<6mm	---	---	---	62.15	3.3	21	---	---	---	---	---	---
		6<ø<10mm	---	---	---	78.33	4.2	22	26.39	2.6	185	---	---	---
		ø>10mm	---	---	---	124.36	6.7	23	4.63	0.5	151	---	---	---
Base	Folhagem		178.83	33.3	160	---	---	---	5.20	0.5	149	194.96	9.6	40
	lenhoso verde	6<ø<10mm	---	---	---	---	---	---	2.33	0.2	36	---	---	---
		ø>10mm	---	---	---	---	---	---	10.67	1.1	90	---	---	---
	lenhoso castanho	ø<3mm	13.13	2.4	78	---	---	---	17.11	1.7	114	9.22	0.5	46
		3<ø<6mm	23.1	4.3	82	---	---	---	431.74	42.7	111	27.27	1.3	52
		6<ø<10mm	1.11	0.2	110	---	---	---	---	---	---	59.05	2.9	70
		ø>10mm	122.12	22.7	141	---	---	---	---	---	---	621.47	30.6	69
	material morto	ø<3mm	---	---	---	369.49	19.8	19	---	---	---	14.33	0.7	21
		3<ø<6mm	---	---	---	41.80	2.2	22	---	---	---	---	---	---
		6<ø<10mm	---	---	---	30.27	1.6	24	---	---	---	---	---	---
		ø>10mm	---	---	---	372.30	19.9	21	---	---	---	---	---	---

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Ensaios realizados

1 árvore

Teste	Série	Tempo de secagem
CA_01_01	S1	5
CA_02_01	S1	5
CA_03_01	S2	32
CA_04_01	S2	32
CA_05_01	S2	33
PL_01_01	S1	5
PL_02_01	S2	28
PL_03_01	S2	28
PL_04_01	S2	101
PL_05_01	S1	5
CL_01_01	S1	5
CL_02_01	S2	28
CL_03_01	S2	28
CL_04_01	S2	101
TO_01_01	S1	5
TO_02_01	S2	28
TO_03_01	S2	101
TO_04_01	S2	29

3 árvores

Teste	Série	Tempo de secagem
CA_01_03	S1	5
CA_02_03	S1	5
CA_03_03	S2	100
CA_04_03	S2	32
CA_05_03	S2	33
PL_01_03	S1	5
PL_02_03	S1	5
PL_03_03	S2	28
PL_04_03	S2	28
PL_05_03	S2	101
CL_01_03	S1	5
CL_02_03	S2	28
CL_03_03	S2	100
CL_04_03	S2	100
TO_01_03	S1	5
TO_02_03	S2	28
TO_03_03	S2	100
TO_04_03	S2	100

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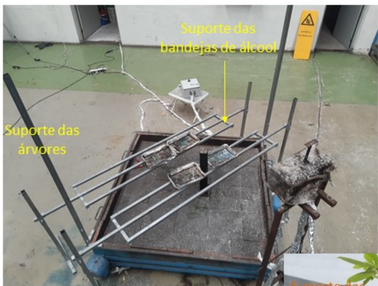
Ensaios laboratoriais – ensaios de queima



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Ensaios laboratoriais – ensaios de queima
Tubo de Pitot + termopar
Radiómetro
Aquisição de massas
Imagens PIV
Vídeo e fotografias
Imagens IV
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Ensaios laboratoriais – ensaios de queima
Medição e pesagem das árvores
Álcool desnaturado
Ignição simultânea
Queima
Fim do ensaio
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Ensaios laboratoriais – ensaios de queima
C. arizonica T04_03 (28 dias)
P. laurocerasus T03_03 (28 dias)
2019_12_10_Arizonica_T04_03
2019_12_10_Prunus_T03_03
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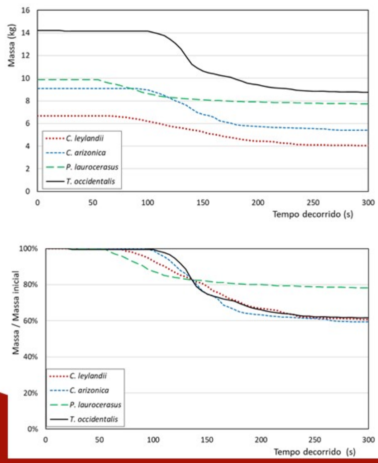
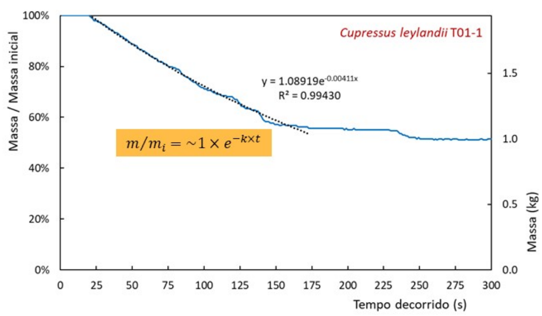
Resultados dos Ensaios – perda de massa



Constante de decaimento de massa k



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Resultados dos Ensaios – perda de massa

Constante de decaimento de massa k

1 árvore	Tempo de secagem	Ensaio	k (s^{-1})	r^2
C. arizonica	5 dias	T01_01	--	--
		T02_01	0,00286	0,68
	28-32 dias	T03_01	0,01755	0,69
		T04_01	0,00809	0,76
		T05_01	0,01307	0,73
	100/101 dias	---	---	---
C. leylandii	5 dias	T01_01	0,00411	0,99
	28-32 dias	T02_01	0,00747	0,95
		T04_01	0,00661	0,94
	100/101 dias	T03_01	0,00482	0,93
P. laurucerasus	5 dias	T01_01	0,00137	0,96
	28-32 dias	T02_01	0,00241	0,92
		T03_01	0,00063	0,94
	100/101 dias	T04_01	0,00085	0,98
T. occidentalis	5 dias	T01_01	0,00210	0,84
	28-32 dias	T02_01	0,00386	0,92
		T03_01	0,00829	0,89
	100/101 dias	T04_01	0,00050	0,98

3 árvores	Tempo de secagem (s)	Ensaio	k (s^{-1})	r^2
C. arizonica	5 dias	T01_03	---	---
		T02_03	0,00284	0,86
	28-32 dias	T03_03	0,01279	0,65
		T04_03	0,00684	0,62
		T05_03	0,01076	0,68
	100/101 dias	---	---	---
C. leylandii	5 dias	T01_03	0,00305	0,99
	28-32 dias	T02_03	0,00498	0,98
		T04_03	0,00831	0,81
	100/101 dias	T03_03	---	---
P. laurucerasus	5 dias	T01_03	0,00157	0,89
	28-32 dias	T02_03	0,00110	0,94
		T03_03	0,00115	0,90
	100/101 dias	T04_03	0,00105	0,90
T. occidentalis	5 dias	T01_03	0,00259	0,86
	28-32 dias	T02_03	0,00307	0,94
		T03_03	0,00963	0,75
	100/101 dias	T04_03	0,01001	0,78

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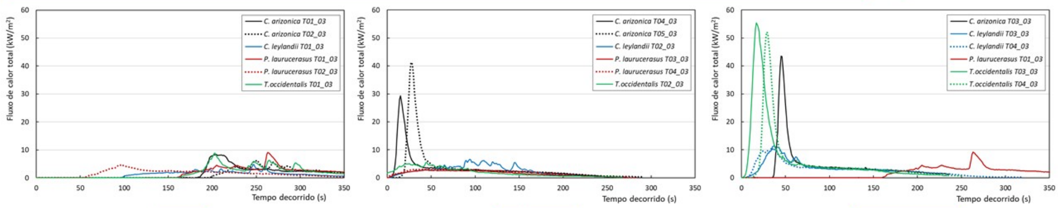
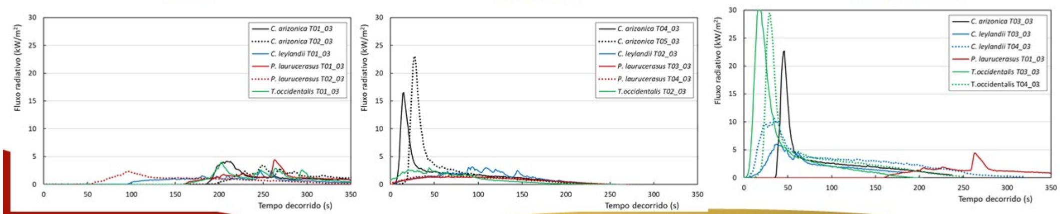
Resultados dos Ensaios – fluxo de calor – 3 árvores



5 dias 28-32 dias 100/101 dias



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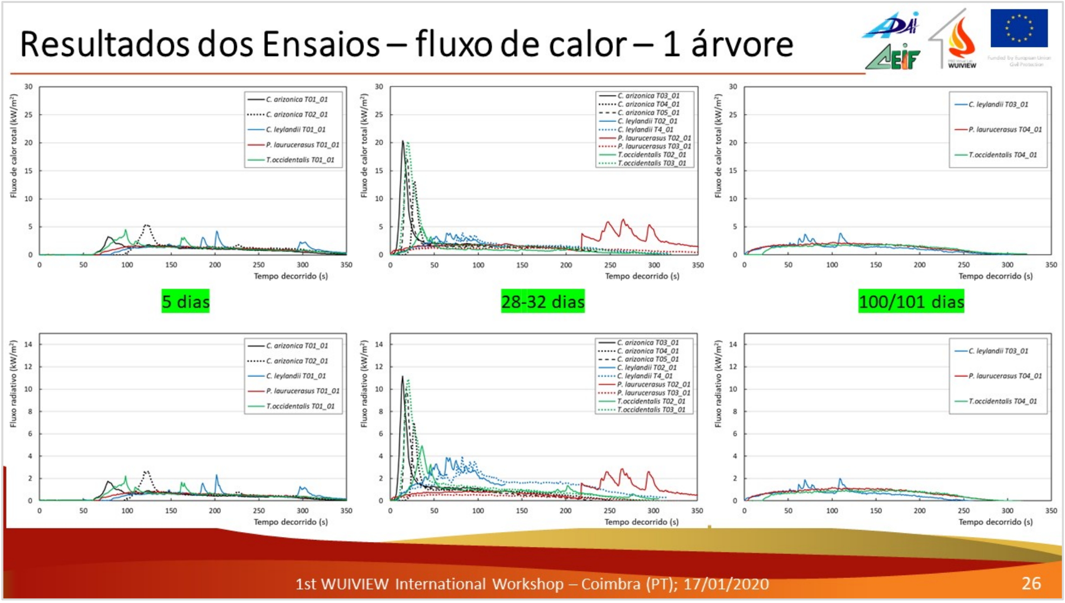
Resultados dos Ensaios – fluxo de calor – 1 árvore
Fluxo de calor total (kW/m²)
Tempo decorrido (s)
5 dias
28-32 dias
100/101 dias
Fluxo radiativo (kW/m²)
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Resultados dos Ensaios – geometria da chama
Imagens IV (2s) – área de chama e altura de chama
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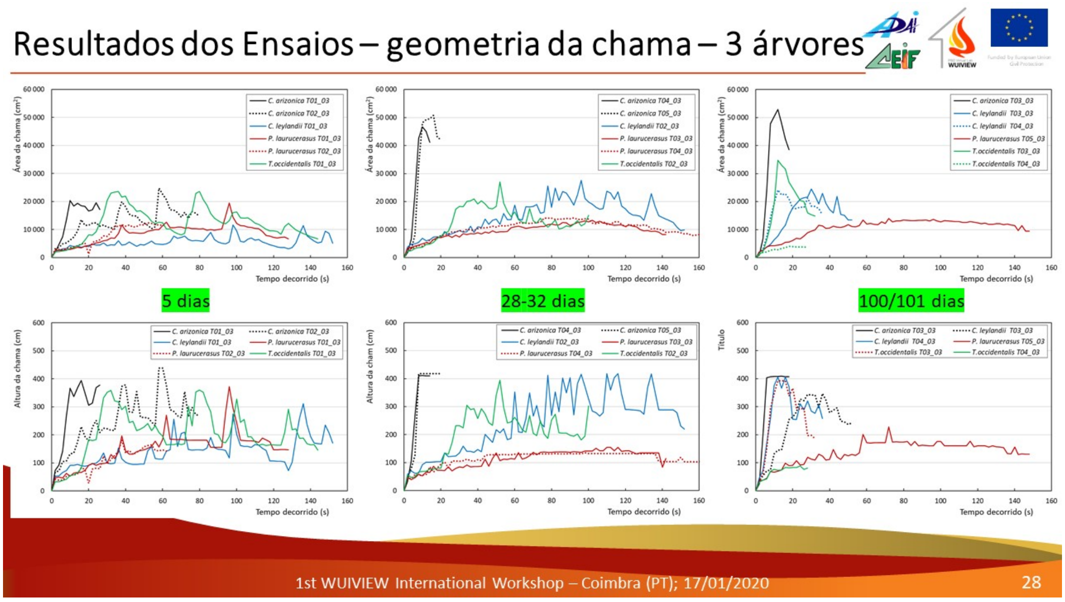
Resultados dos Ensaios – geometria da chama – 3 árvores
Área da chama (cm²)
Tempo decorrido (s)
5 dias
28-32 dias
100/101 dias
Altura da chama (cm)
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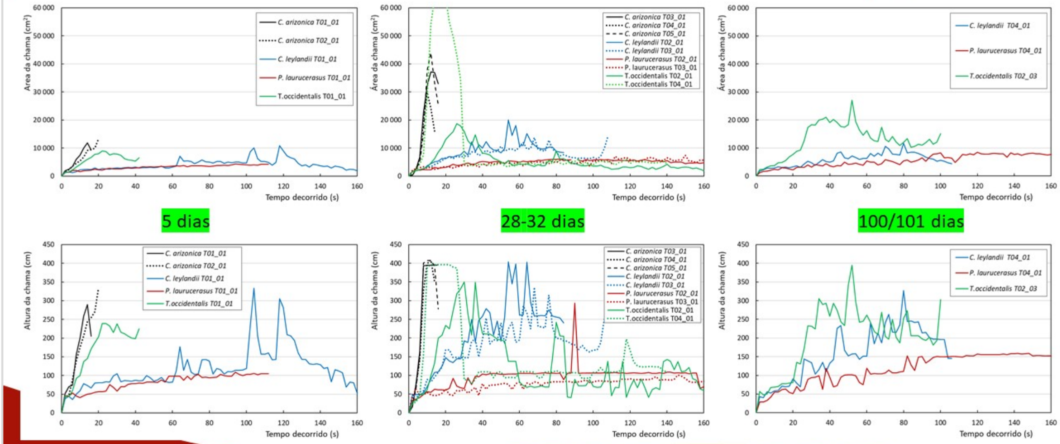
Resultados dos Ensaios – geometria da chama – 1 árvore



Principais conclusões

- A existência próxima de combustíveis naturais a edificações é um fator que faz acrescer de sobremaneira a probabilidade da propagação do fogo;
- A presença frequente de sebes na proximidade das casas aumenta o risco da passagem do fogo;
- A escolha e manutenção das espécies que compõem as sebes permitem mitigar a sua importância enquanto fator de risco de incêndio
- Espécies como a *Prunus laurucerasus* são espécies com um comportamento favorável, mitigando o risco de propagação do fogo, quando comparada com as restantes espécies analisadas, sobretudo a *Cupressus arizonica* que foi aquela que apresentou um comportamento mais desfavorável.

Principais conclusões

- A perda de humidade das plantas (e.g. falta de rega) faz acrescer o risco de propagação do fogo, no entanto, este efeito é mais evidente em espécies como a *Cupressus arizonica* do que em espécies como a *Prunus laurucerasus*;
- A presença de matéria seca no interior da sebe contribui de forma decisiva para a sua propensão para sustentar o fogo;
- A fração de matéria seca varia em função da espécie e cresce com o aumento de ações de corte/aparo/poda e com a ação de agentes meteorológicos como a geada.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International Workshop
Perigo de incêndio na microescala da Interface Urbano Florestal
Fire hazard at the Wildland Urban Interface microscale
Funded by European Union Civil Protection
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1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020

4.8. Hazard associated to non-natural fuels, by Pascale Vacca and Giordano Scarponi

4.8.1. Abstract

Managing Wildland-Urban-Interface (WUI) fires is a challenging task due to the inherent complexity of the interactions between structures, surrounding elements, fire and people. To ensure the success of strategies for the protection of population and structures, safety measures have to be implemented at different scales (landscape, community and homeowner).

At the homeowner scale, artificial fuels present within property limits create an additional hazard due to their prolonged burning time and the toxicity of the pyrolysis gases. A dynamic database was created with the aim of collecting fuel characteristics of typical pattern scenarios at the WUI microscale. The quantitative information on the burning behaviour of the items present in this database (e.g. Heat Release Rate, Mass Loss Rate, etc.) can be used as inputs for Computational Fluid Dynamics simulations. In this way the hazard of such non-natural fuels onto structures and people can be quantified.

The second part of the presentation deals with the threat related to the presence of LPG domestic tanks in a WUI fire scenario. Recent accidents have demonstrated that the risk associated with this type of installation is real, but often disregarded by residents. The survey of regulations detailed in the presentation provides evidence of a lack of harmonization throughout European countries. There is no general agreement in the definition of safety distances. A methodology is presented to be used as a tool to assess whether the response of a LPG tank exposed to WUI fire scenarios falls within acceptable safety limits. This methodology is based on a 3-step process: the fire source characterization, which may be carried out following different options according to the desired level of detail and data availability, the analysis of the tank response, which is performed via CFD simulation, and the consequence assessment, in which it is evaluated whether the scenario under analysis can be considered safe or not. To assist this task, two indicators are proposed: the WSI, that provides a measure of the mechanical weakening of the tank wall due to high temperature, and the PRVI, that indicates if the pressurization induced by the fire may lead to the PRV opening. Threshold values are also proposed (a value of 0.9 of both the WSI and PRVI), against which the two indicators may be compared in order to assess whether the scenario can be deemed safe. The methodology is applicable to a vast range of situations and at a different level of detail according to available data. Some case studies are also presented, showing how the methodology can be applied.

4.8.2. Presentation printout

WUIVIEW International Workshop

Perigo de incêndio na microescala da Interface Urbano Florestal

Fire hazard at the Wildland Urban Interface microscale

O perigo associado aos combustíveis não naturais

Hazards associated to non-natural fuels

Pascale Vacca, Giordano Scarponi
pascale.vacca@upc.edu
giordano.scarponi@unibo.it
CERTEC – UPC, Spain
UNIBO, Italy

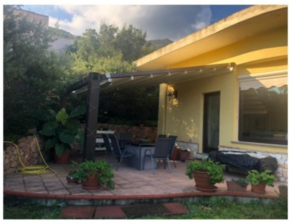
Funded by European Union Civil Protection

Presentation Outline

- Non-natural fuels
- Critical scenarios and fuel characterization
- Needed information on non-natural fuels
  - Non-natural fuels database
- LPG tanks
  - Overview of the issue
  - Regulatory framework
  - Methodology
  - Examples – applications
- Concluding remarks

Non-natural fuels

- Artificial fuels present within property limits
  - Stored materials
  - Outdoor furniture
  - LPG tanks
  - Vehicles
  - …
- Hazard to the structure
- Burning time of these materials is typically longer compared to the one of natural fuels



Critical scenarios

- LPG Tanks
- Accumulation of objects in semi-confined spaces
- Fuel packs

Benitatxell, Spain

Mati, Greece

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Fuel Characterization

- Quantifying hazards:
  - What is the burning behaviour of non-natural fuels?
- Pattern scenarios
- Objective: obtain quantitative information on real-scale fire hazards of artificial fuels
  - Literature
  - Experiments

Mati, Greece

Funchal, Portugal

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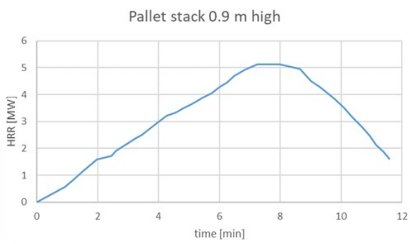
Fuel Characterization

- Needed information:
  - Heat Release Rate: rate at which a fire releases energy (power)
    - Main input in simulations of burning of non-natural fuels
  - Critical heat flux or critical temperature
    - Gives information on the ignition of an item

Critical conditions radiative conditions for a person

- 1 kW/m² for indefinite skin exposure
- 6.4 kW/m² pain after 8 s
- 10.4 kW/m² pain after 3 s

Distance	Radiative heat flux
1 m	13 kW/m²
2 m	10 kW/m²
3 m	7 kW/m²



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Empirical estimation of HRR

$$\dot{Q} = A_f \dot{m}'' \Delta H_{eff} \ [kW]$$

A_f: area of the fire [m^2]

$\dot{m}''$: burning rate per unit area [kg/m^{2}s]

ΔH_{eff}: effective heat of combustion [kJ/kg]

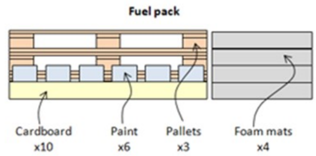
- Information is not always available
- ΔH_{eff} is not constant
- Equation does not take into account the initial transient period
- Objects contain different materials

Empirical estimation of HRR

- Fuel packs

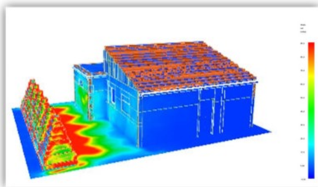
Items	Peak HRR
Cardboard	750 kW
Pallets	1360 kW
Foam mats	2050 kW
Paint	?

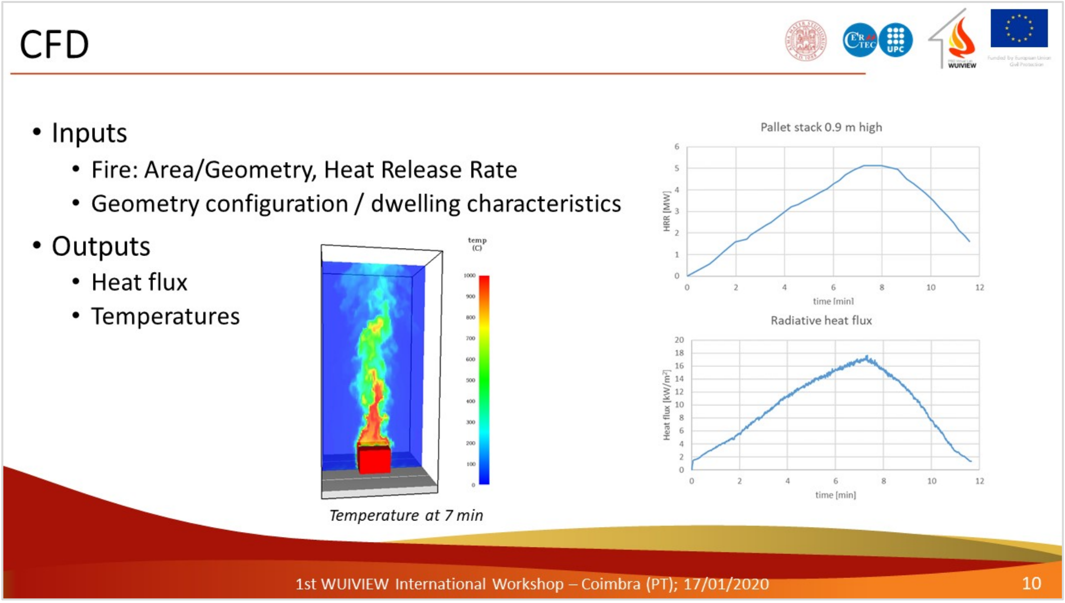
- How can we measure the hazard?



Computational Fluid Dynamics

- CFD tools numerically solve the conservations equations of mass, energy and momentum in discretized volumes to represent fluid flow
- Fire Dynamics Simulator
  - CFD model of fire-driven fluid flow
  - Emphasis on smoke and heat transport from fires
- Used to calculate the effect of flame impingement and heat exposure on structures and on people
- Performance-Based Design approach for vulnerability assessment




CFD
• Inputs
• Fire: Area/Geometry, Heat Release Rate
• Geometry configuration / dwelling characteristics
• Outputs
• Heat flux
• Temperatures
Temperature at 7 min
Pallet stack 0.9 m high
HRR [MW]
time [min]
Radiative heat flux
Heat flux [kW/m²]
time [min]
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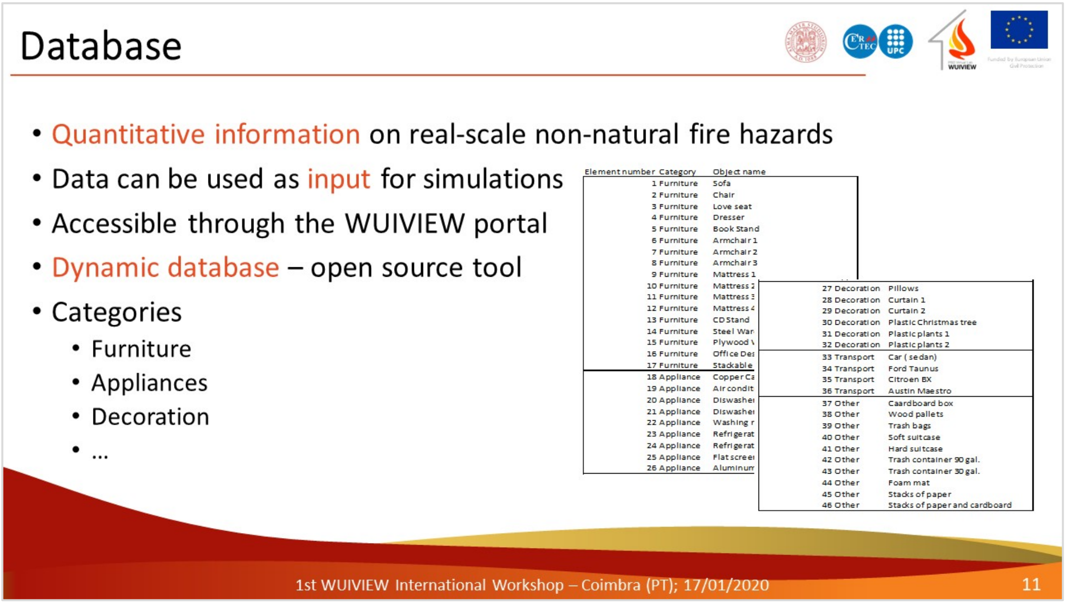
Database
• Quantitative information on real-scale non-natural fire hazards
• Data can be used as input for simulations
• Accessible through the WUIVIEW portal
• Dynamic database – open source tool
• Categories
• Furniture
• Appliances
• Decoration
• …
Element number Category Object name
1 Furniture Sofa
2 Furniture Chair
3 Furniture Love seat
4 Furniture Dresser
5 Furniture Book Stand
6 Furniture Armchair 1
7 Furniture Armchair 2
8 Furniture Armchair 3
9 Furniture Mattress 1
10 Furniture Mattress 2
11 Furniture Mattress 3
12 Furniture Mattress 4
13 Furniture CD Stand
14 Furniture Steel War
15 Furniture Plywood
16 Furniture Office Des
17 Furniture Stackable
18 Appliance Copper Ca
19 Appliance Air condit
20 Appliance Diswasher
21 Appliance Diswasher
22 Appliance Washing r
23 Appliance Refrigerat
24 Appliance Refrigerat
25 Appliance Flat screen
26 Appliance Aluminum
27 Decoration Pillows
28 Decoration Curtain 1
29 Decoration Curtain 2
30 Decoration Plastic Christmas tree
31 Decoration Plastic plants 1
32 Decoration Plastic plants 2
33 Transport Car (sedan)
34 Transport Ford Taunus
35 Transport Citroen BX
36 Transport Austin Maestro
37 Other Caardboard box
38 Other Wood pallets
39 Other Trash bags
40 Other Soft suitcase
41 Other Hard suitcase
42 Other Trash container 90 gal.
43 Other Trash container 30 gal.
44 Other Foam mat
45 Other Stacks of paper
46 Other Stacks of paper and cardboard
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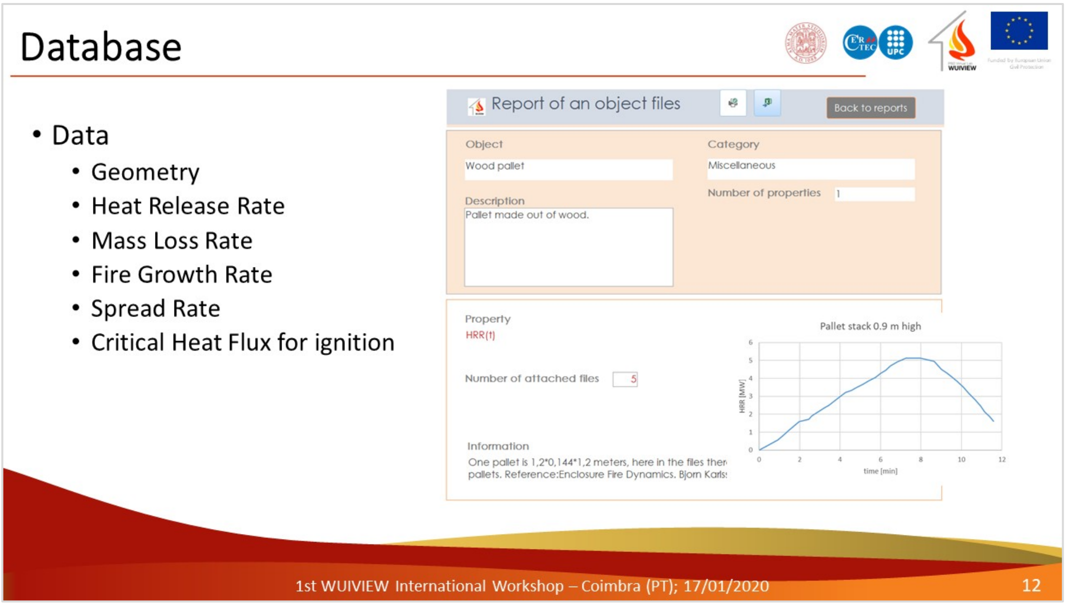
Database
• Data
• Geometry
• Heat Release Rate
• Mass Loss Rate
• Fire Growth Rate
• Spread Rate
• Critical Heat Flux for ignition
Report of an object files
Back to reports
Object
Wood pallet
Category
Miscellaneous
Number of properties 1
Description
Pallet made out of wood.
Property
HRR(t)
Number of attached files 5
Information
One pallet is 1,2*0,144*1,2 meters, here in the files ther
pallets. Reference:Enclosure Fire Dynamics. Bjorn Karls
Pallet stack 0.9 m high
HRR [MW]
time [min]
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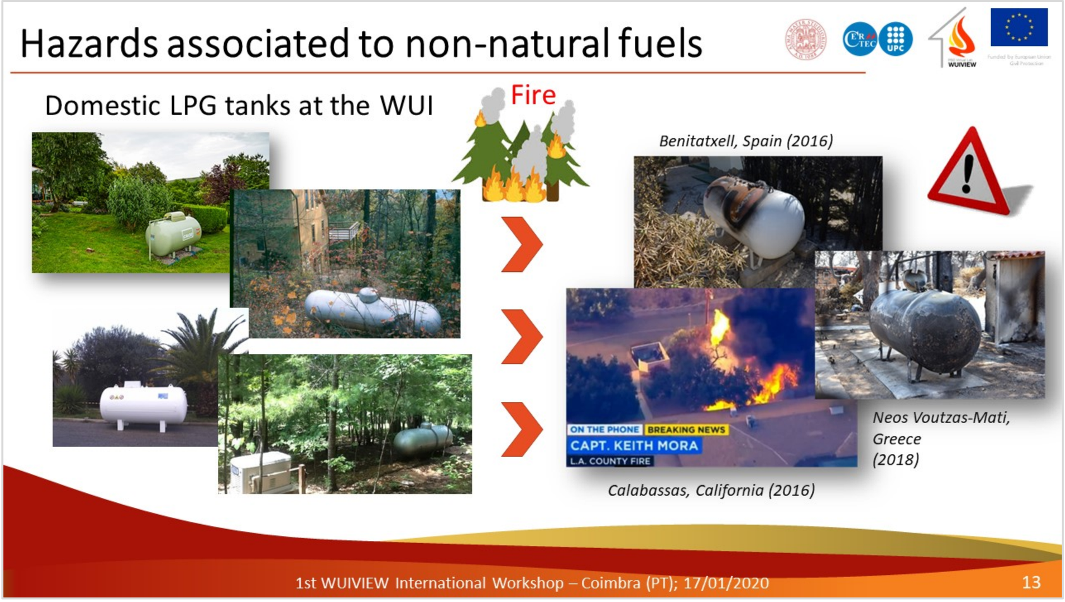
Hazards associated to non-natural fuels
Domestic LPG tanks at the WUI
Fire
Benitatxell, Spain (2016)
ON THE PHONE
BREAKING NEWS
CAPT. KEITH MORA
L.A. COUNTY FIRE
Neos Voutzas-Mati, Greece (2018)
Calabassas, California (2016)
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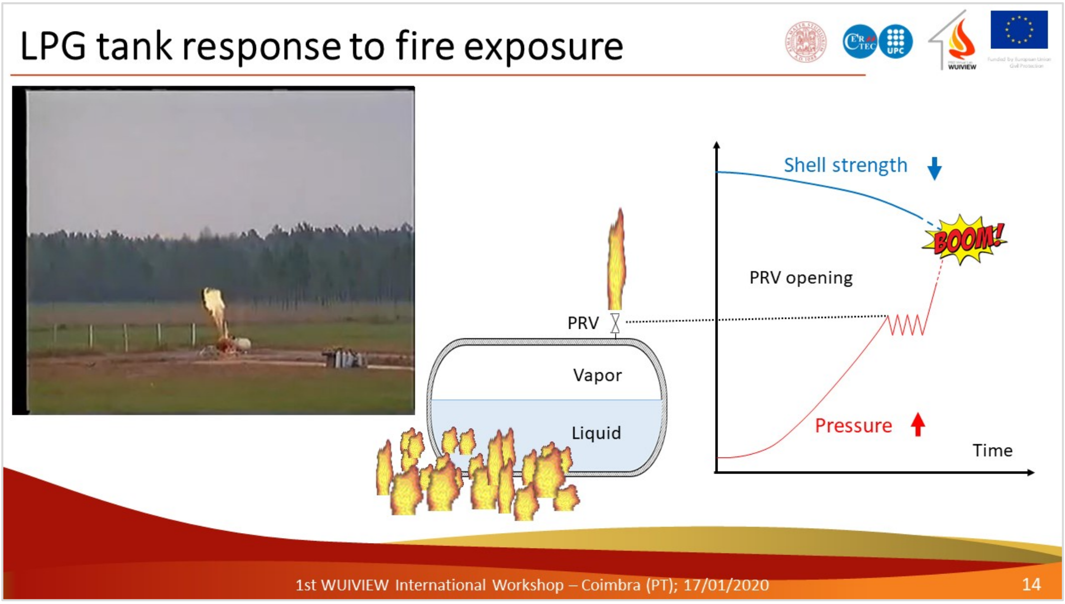
LPG tank response to fire exposure
Shell strength
BOOM!
PRV opening
PRV
Vapor
Liquid
Pressure
Time
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Consequences of tank failure
BLEVE
(Boiling Liquid Expanding Vapor Explosion)
Fireball
Fragments projection
Overpressure
Radiation
Impact
We must prevent tank failure!!!
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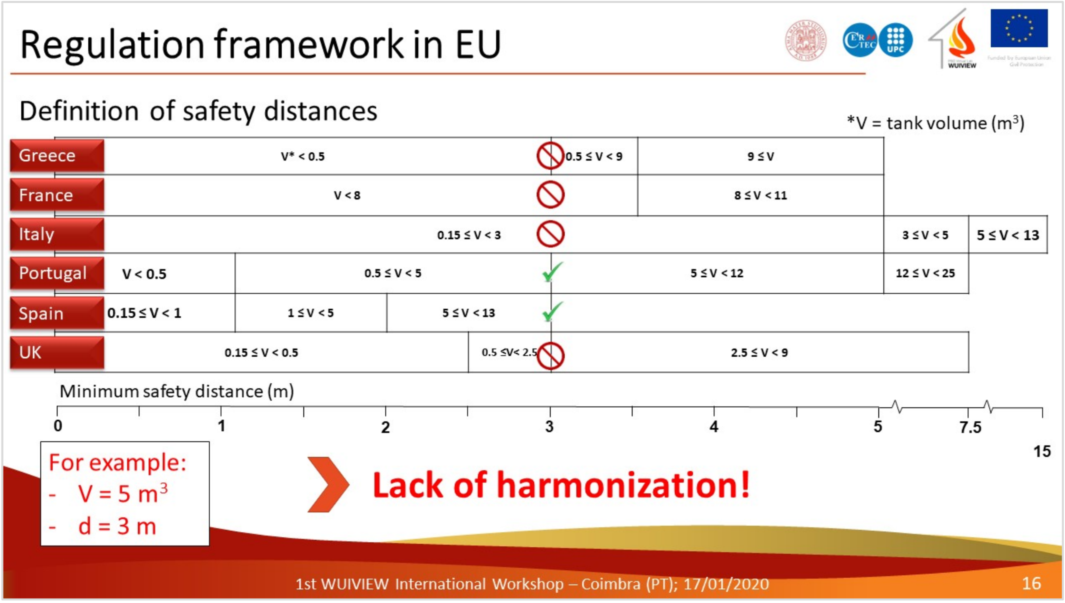
Regulation framework in EU
Definition of safety distances
*V = tank volume (m3)
Greece
V* < 0.5
0.5 ≤ V < 9
9 ≤ V
France
V < 8
8 ≤ V < 11
Italy
0.15 ≤ V < 3
3 ≤ V < 5
5 ≤ V < 13
Portugal
V < 0.5
0.5 ≤ V < 5
5 ≤ V < 12
12 ≤ V < 25
Spain
0.15 ≤ V < 1
1 ≤ V < 5
5 ≤ V < 13
UK
0.15 ≤ V < 0.5
0.5 ≤V< 2.5
2.5 ≤ V < 9
Minimum safety distance (m)
0
1
2
3
4
5
7.5
15
For example:
- V = 5 m3
- d = 3 m
Lack of harmonization!
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Regulation framework in EU
Maintenance is left to the owner, but no control system is in place
Cases like these are not uncommon at all!!
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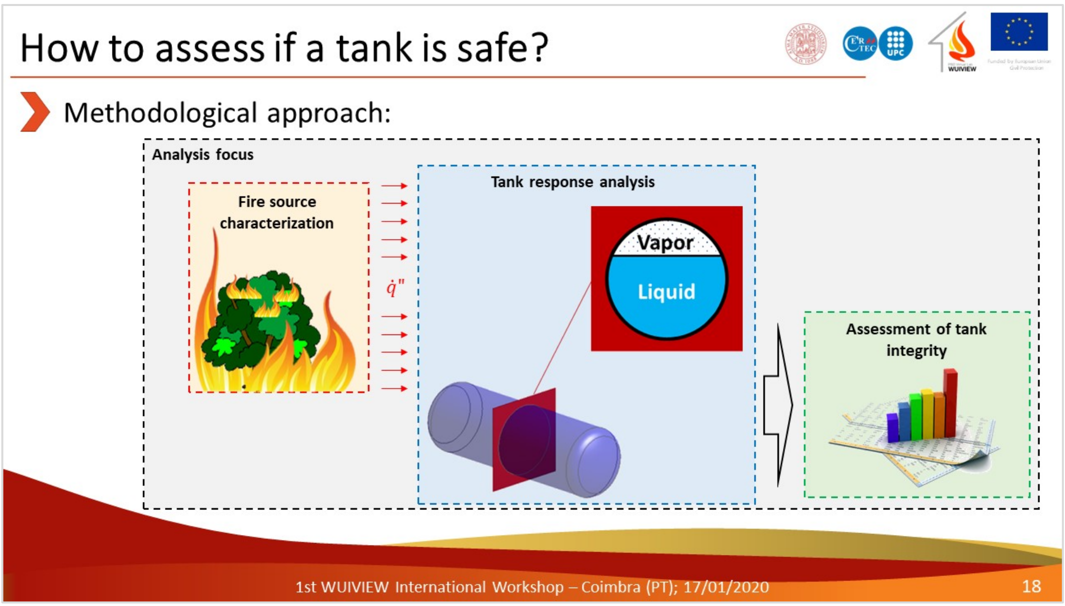
How to assess if a tank is safe?
Methodological approach:
Analysis focus
Fire source characterization
q̇"
Tank response analysis
Vapor
Liquid
Assessment of tank integrity
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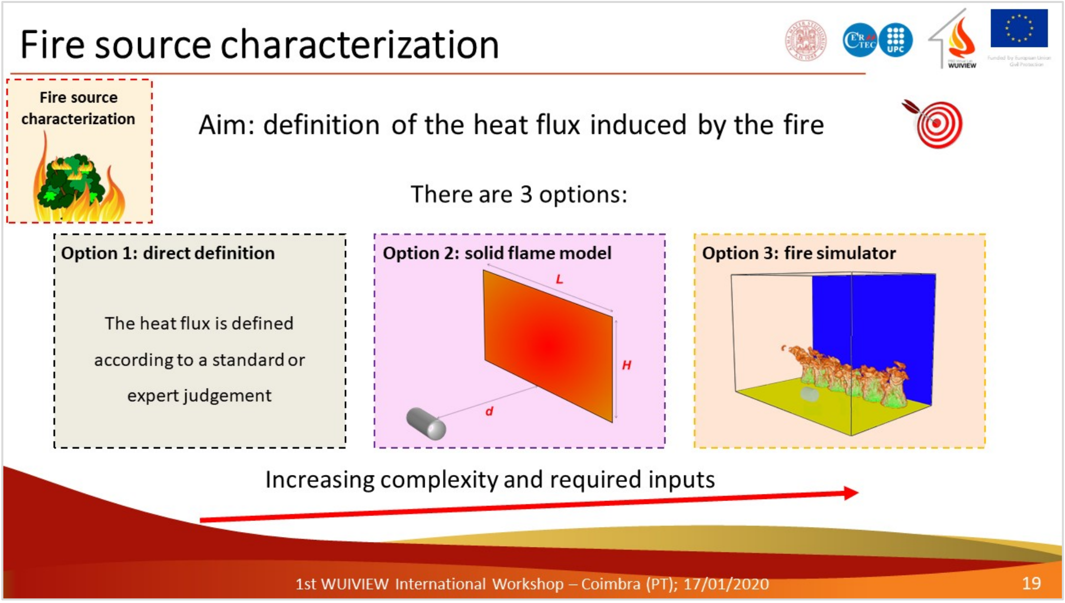
Fire source characterization
Fire source characterization
Aim: definition of the heat flux induced by the fire
There are 3 options:
Option 1: direct definition
The heat flux is defined according to a standard or expert judgement
Option 2: solid flame model
L
H
d
Option 3: fire simulator
Increasing complexity and required inputs
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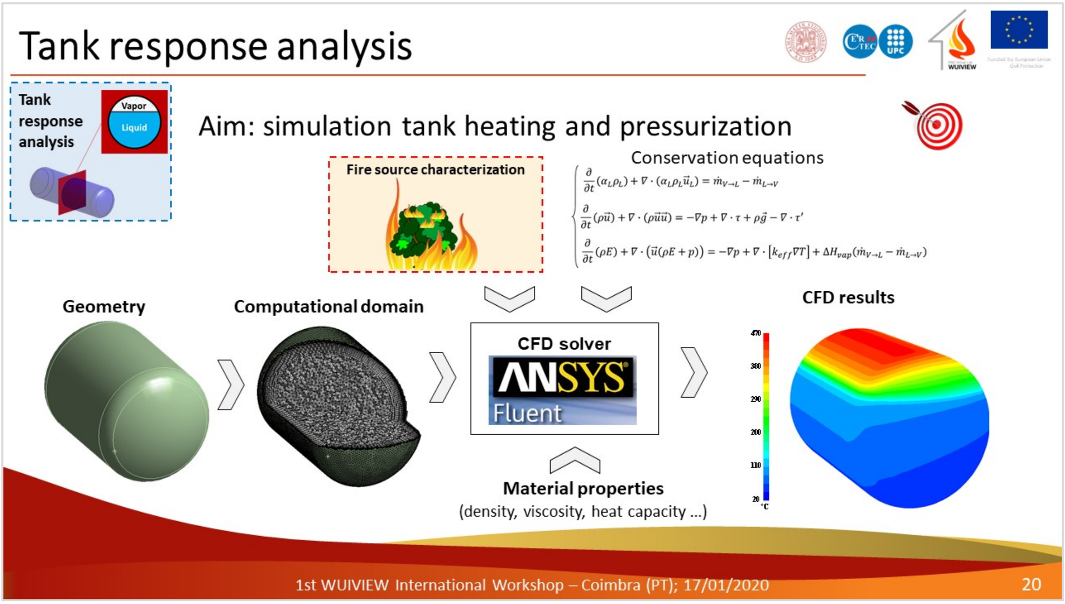
Tank response analysis
Tank response analysis
Vapor
Liquid
Aim: simulation tank heating and pressurization
Fire source characterization
Conservation equations
$\frac{\partial}{\partial t}(\alpha_L\rho_L) + \nabla\cdot(\alpha_L\rho_L\vec{u}_L) = \dot{m}_{V\to L} - \dot{m}_{L\to V}$
$\frac{\partial}{\partial t}(\rho\vec{u}) + \nabla\cdot(\rho\vec{u}\vec{u}) = -\nabla p + \nabla\cdot\tau + \rho\vec{g} - \nabla\cdot\tau'$
$\frac{\partial}{\partial t}(\rho E) + \nabla\cdot(\vec{u}(\rho E + p)) = -\nabla p + \nabla\cdot[k_{eff}\nabla T] + \Delta H_{vap}(\dot{m}_{V\to L} - \dot{m}_{L\to V})$
Geometry
Computational domain
CFD solver
ANSYS Fluent
CFD results
Material properties
(density, viscosity, heat capacity …)
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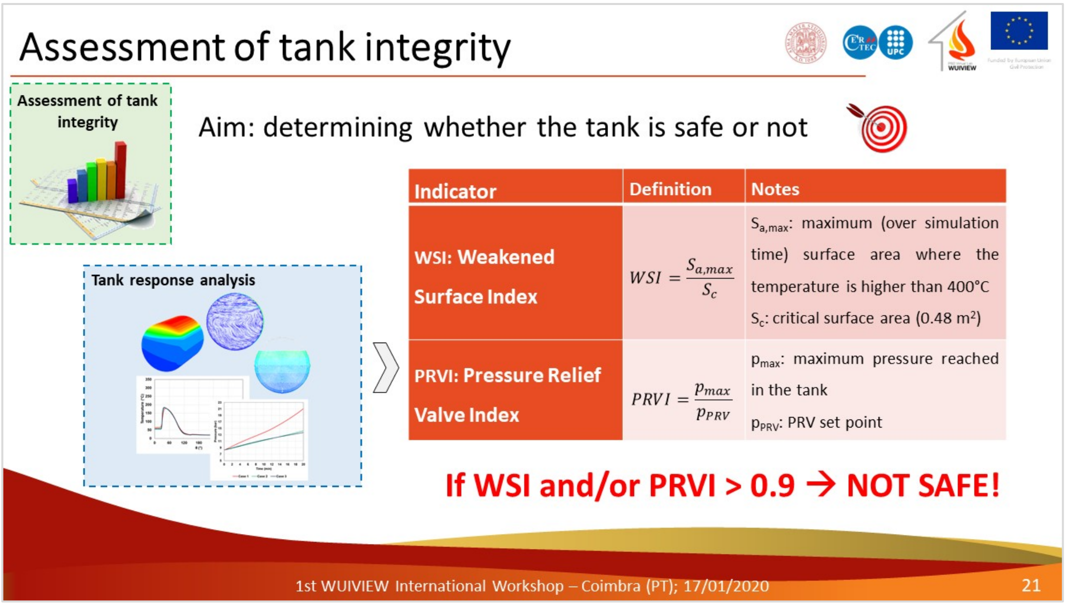
Assessment of tank integrity
Assessment of tank integrity
Aim: determining whether the tank is safe or not
Tank response analysis
Indicator | Definition | Notes
WSI: Weakened Surface Index | $WSI = \frac{S_{a,max}}{S_c}$ | $S_{a,max}$: maximum (over simulation time) surface area where the temperature is higher than 400°C; S_c: critical surface area (0.48 m^2)
PRVI: Pressure Relief Valve Index | $PRVI = \frac{p_{max}}{p_{PRV}}$ | p_{max}: maximum pressure reached in the tank; p_{PRV}: PRV set point
If WSI and/or PRVI > 0.9 → NOT SAFE!
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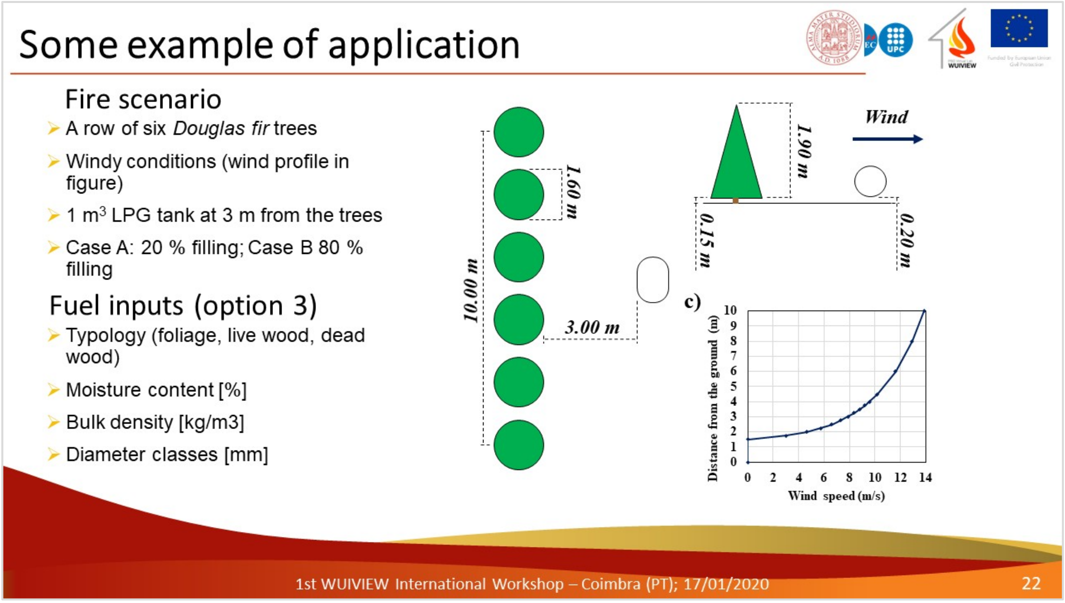
Some example of application
Fire scenario
A row of six Douglas fir trees
Windy conditions (wind profile in figure)
1 m3 LPG tank at 3 m from the trees
Case A: 20 % filling; Case B 80 % filling
Fuel inputs (option 3)
Typology (foliage, live wood, dead wood)
Moisture content [%]
Bulk density [kg/m3]
Diameter classes [mm]
1.60 m
10.00 m
3.00 m
1.90 m
Wind
0.15 m
0.20 m
c)
Distance from the ground (m)
Wind speed (m/s)
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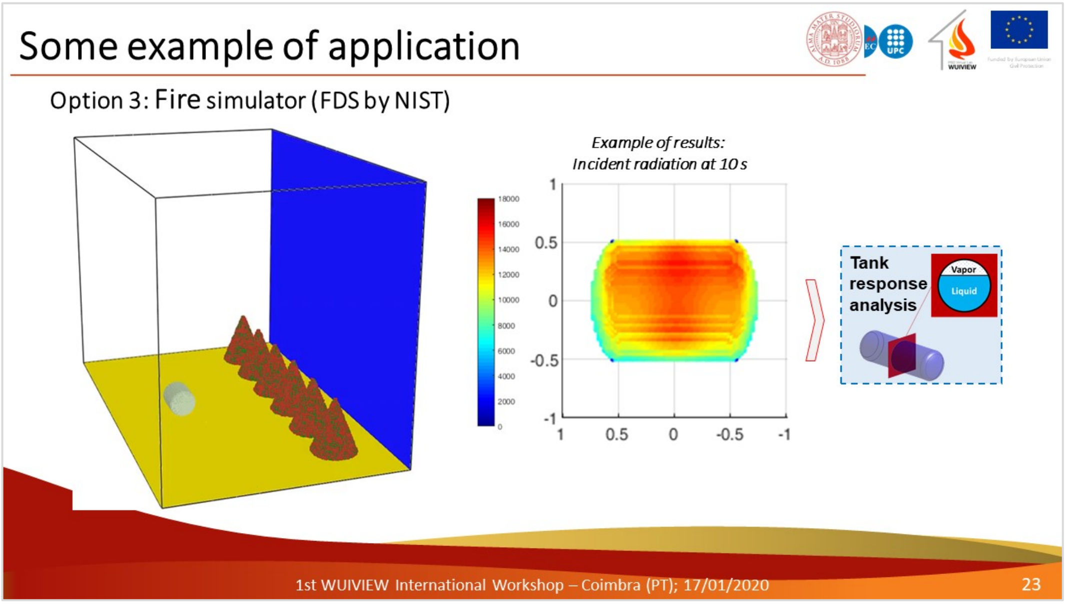
Some example of application
Option 3: Fire simulator (FDS by NIST)
Example of results:
Incident radiation at 10 s
Tank response analysis
Vapor
Liquid
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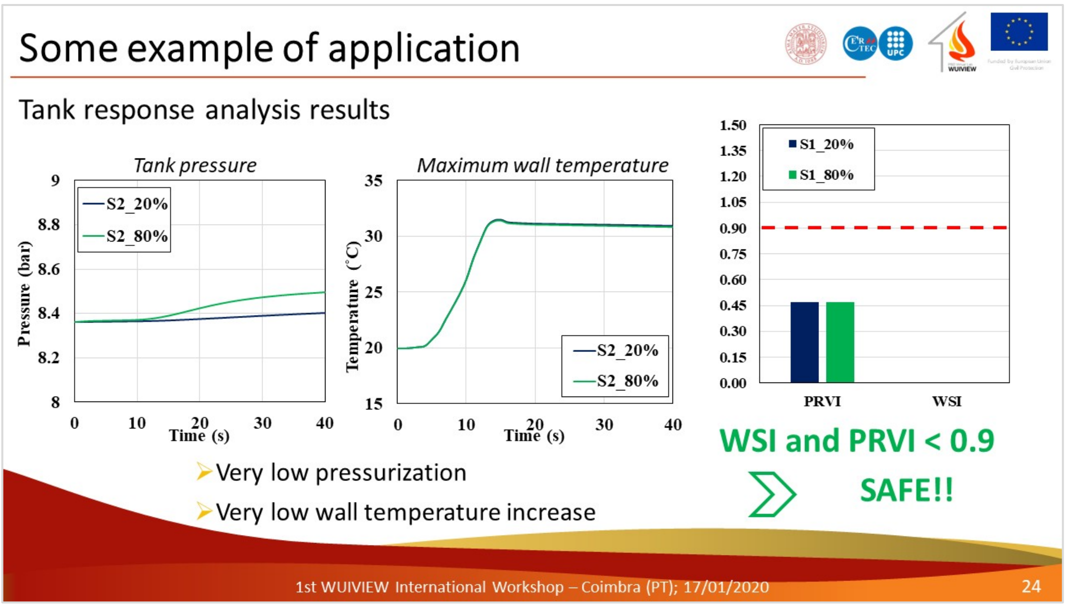
Some example of application
Tank response analysis results
Tank pressure
Pressure (bar)
Time (s)
S2_20%
S2_80%
Maximum wall temperature
Temperature (°C)
Time (s)
S2_20%
S2_80%
S1_20%
S1_80%
PRVI
WSI
Very low pressurization
Very low wall temperature increase
WSI and PRVI < 0.9
SAFE!!
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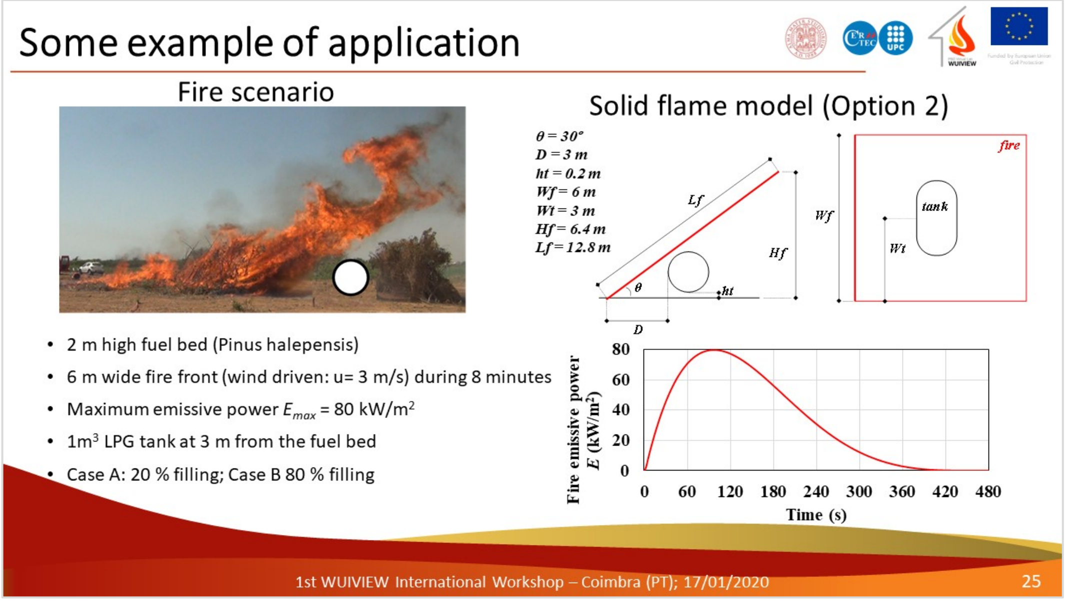
Some example of application
Fire scenario
Solid flame model (Option 2)
θ = 30°
D = 3 m
ht = 0.2 m
Wf = 6 m
Wt = 3 m
Hf = 6.4 m
Lf = 12.8 m
Lf
Wf
Hf
θ
ht
D
fire
tank
Wt
• 2 m high fuel bed (Pinus halepensis)
• 6 m wide fire front (wind driven: u= 3 m/s) during 8 minutes
• Maximum emissive power E_{max} = 80 kW/m²
• 1m³ LPG tank at 3 m from the fuel bed
• Case A: 20 % filling; Case B 80 % filling
Fire emissive power E (kW/m²)
80
60
40
20
0
0 60 120 180 240 300 360 420 480
Time (s)
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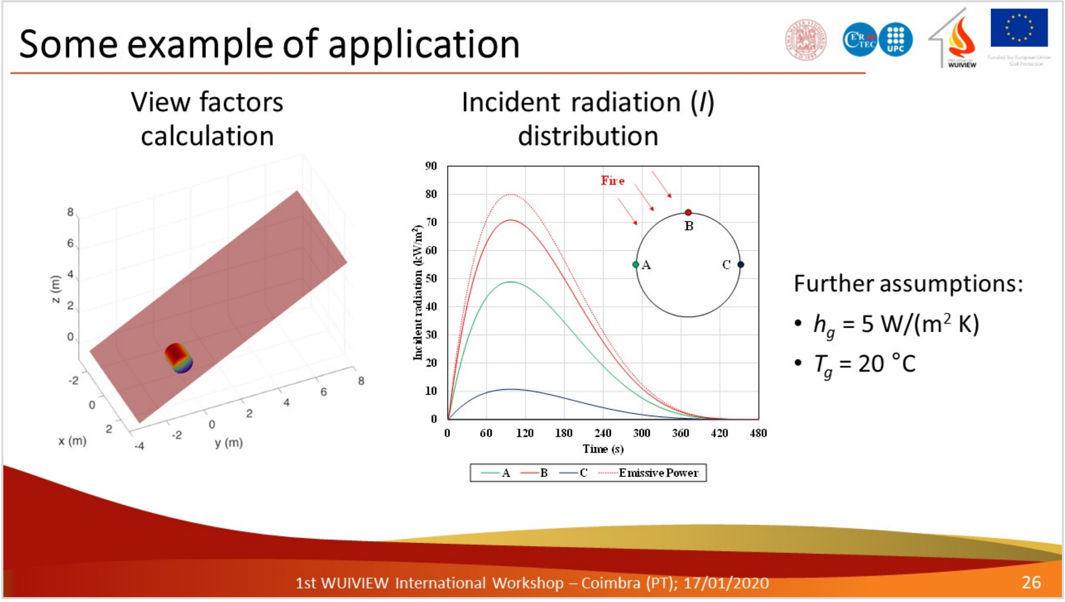
Some example of application
View factors calculation
Incident radiation (I) distribution
z (m)
x (m)
y (m)
Fire
A
B
C
Incident radiation (kW/m²)
Time (s)
A B C Emissive Power
Further assumptions:
• h_g = 5 W/(m² K)
• T_g = 20 °C
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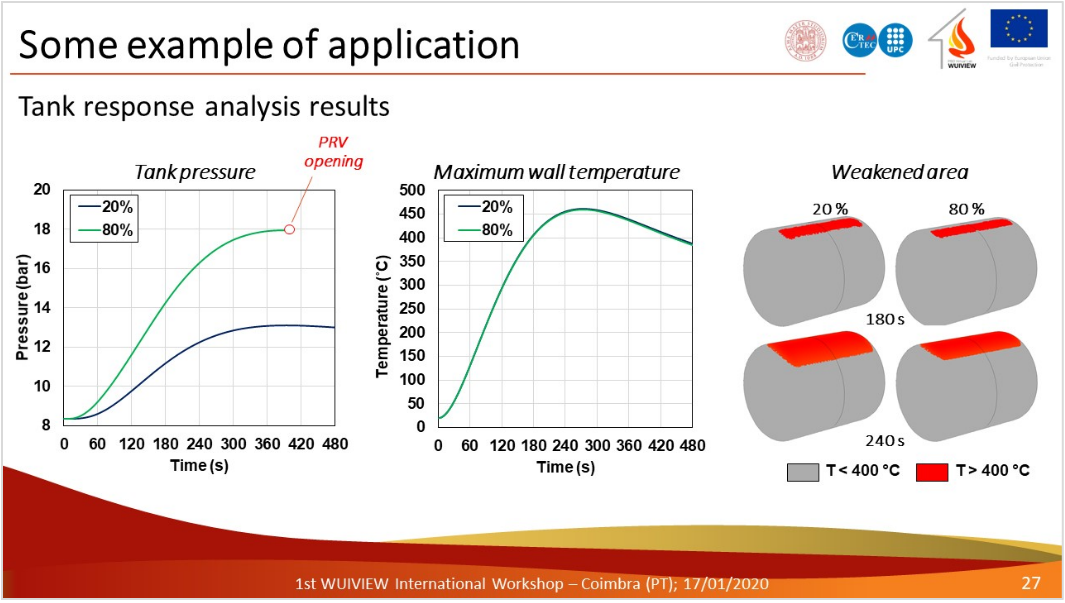
Some example of application
Tank response analysis results
Tank pressure
PRV opening
20%
80%
Pressure (bar)
Time (s)
Maximum wall temperature
Temperature (°C)
Time (s)
Weakened area
20 %
80 %
180 s
240 s
T < 400 °C
T > 400 °C
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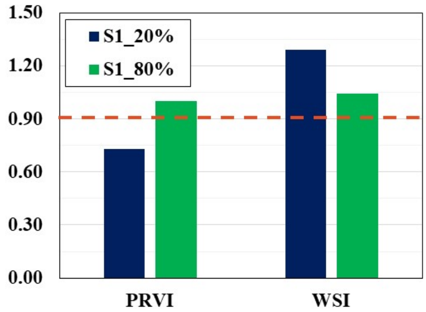
Some example of application

Main results:

- The PRV opens in the 80 % filling degree case only
- The wall temperature exceeds 400 °C in both cases
- The region suffering mechanical weakening is more extended in the 20 % filling case



WSI and/or PRVI > 0.9 ⟩ NOT SAFE!!

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Concluding remarks

- In order to estimate the hazards of non-natural fuels a database containing quantitative information is needed (dynamic tool)
- The hazard of non-natural fuels is often disregarded, even though their burning time is generally longer compared to natural fuels
- Among non-natural fuels, domestic LPG tanks represent a critical safety issue
- The legislation in terms of LPG tanks set-up does not provide enough provisions, nor sufficient safety distances.
- The proposed methodology is a promising tool to assess tank vulnerability in WUI fire scenarios, and it uses the information contained in the database as inputs.

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5. Workshop wrap-up

Forest fires affecting communities represent a rising problem in Europe. As the climate warms, hot and dry seasons are lengthening and wildfires are behaving more often as real firestorms with huge intensities and large destructive potential. In addition, human pressure in Mediterranean forests is continuously growing with an increase of ignitions and housing developments at the WUI. WUI fires are posing huge civil protection and fire suppression challenges, therefore becoming self-protection a growing need.

The WUIVIEW project is one more effort devoted to help communities to self-protect in case of fire. WUI communities have to feel self-empowered to face fire crises and we envisage WUIVIEW providing helpful tools for that. Outcomes from the WUIVIEW project will give guidance on how to manage residential fuels (either natural or non-natural) and prepare properties at the WUI against fires based on scientific research, hence going beyond empirical interpretations and assumptions of what we usually observe in the aftermath of fires.

WUIVIEW is foreseen to be a powerful platform to assess structures survivability, pre-triage of defensible/indefensible houses, sheltering capabilities, building subsystems hazards and fire protection systems performance. Results from our project will be particularly valuable to EU regulatory bodies. Although Spain, Portugal, France and Italy are developing and implementing regulations for the protection of communities in the wildland against forest fires, it is already recognised that EU legislation specifically focusing areas of WUI is still needed. Moreover, the WUIVIEW system will provide fire practitioners with new capabilities for fire risk managing, engineering, research, and fire safety building design. Professionals will have available a new tool for fire risk analysis, based on open-source codes, so that they will have free access to the modelling library and database to undertake performance-based simulations. Fire engineers and architects will have advanced technology available to develop new skills to face emerging WUI fire safety problems.

Consequently, our project is not only about science and research, but also about how scientific results are transferred into i) performance-based regulations and provisions; ii) new fire safety engineering methods and, finally, iii) into good management, maintenance and gardening practices at home owner level. To reach this degree of implementation, the engagement of all fire actors is a key issue: policy makers, fire and civil protection agencies, fire practitioners, fire risk managers and WUI community leaders have to cooperate for the sake of risk mitigation. The Workshop on fire hazards at the WUI microscale has been an ideal platform to foster this engagement and encourage discussions among this vibrant and motivated European wildfire community to which we all belong.