FIRE STORM

Extreme Wildfires in Portugal in a changing climate: Driving weather conditions and air quality impacts

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1º Workshop de Projetos de Investigação Científica no âmbito da Prevenção e Combate a Incêndios Florestais

Associação para o Desenvolvimento da Aerodinâmica Industrial

IPMA Instituto Português do Mar e da Atmosfera

cesam universidade de aveiro centro de estudos do ambiente e do mar

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FCT Fundação para a Ciência e a Tecnologia

Roadmap

Work in progress under FIRESTORM

1. **Extreme wildfire definition, data collection and characterization.**
2. Weather and climate drivers of extreme fire events and periods.
3. Interaction between mesoscale atmospheric flows and the fires.
4. Smoke emission and dispersion modelling for air quality impact.

1. Extreme fire definition, data collection and characterization

- Portuguese database of wildfire events (1980-2018, ICNF).
- Only events with a burnt area > 1.0 ha (for consistency).
- Thorough data base compilation & correction, e.g.:
  - Elimination of duplicates (equal time, location and burnt area)
  - Adjustment of outlier fire duration based on reports and media.

Database, 1980-2018

Original data		
Number of fires	**761.508**	**100%**
Burnt area (ha)	**4.691.654**	**100%**
Final data		
Number of fires	**189.734**	**25,8%**
Burnt area (ha)	**4.614.013**	**98,5%**

1. Extreme fire definition, data collection and characterization

Extreme Wildfire Events (EWE)

- Individual fires as recorded in the ICNF database.

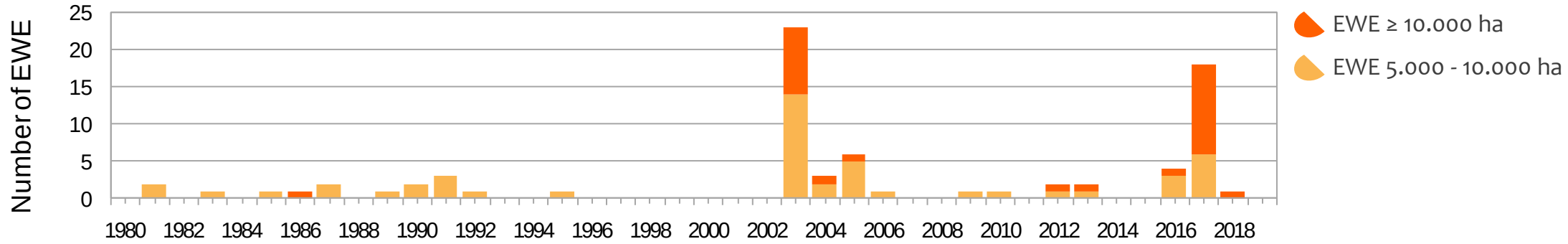
	Number	Proportion of total burnt area
EWE ≥ 1.000 ha	**684**	45 %
EWE ≥ 5.000 ha	**77**	20 %
EWE ≥ 10.000 ha	**28**	12 %
EWE ≥ 30.000 ha	**5**	4 %

Extreme Wildfire Periods (EWP)

- Sequence of days with the largest burnt areas obtained by statistical segmentation (1980-2018):
  - **53 EWP** with a mean daily burnt area ≥ 3.000 ha.
  - Total of **392 days**.
  - **52.1%** of the total burnt area between.

1. Extreme fire definition, data collection and characterization

Extreme Wildfire Events (EWE)



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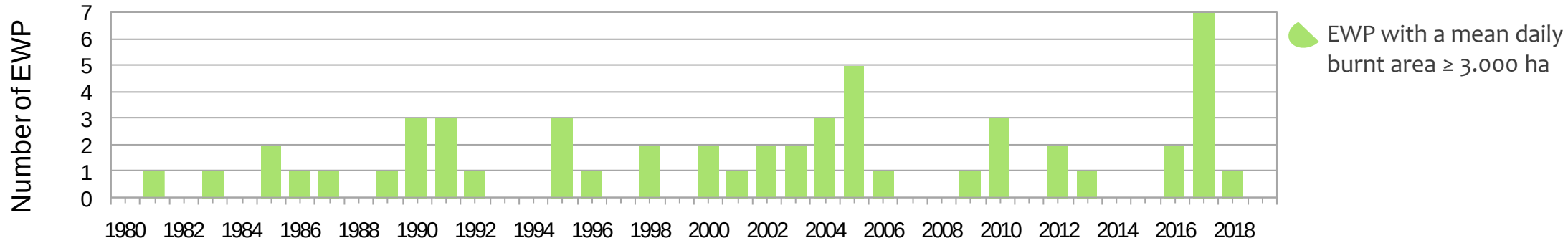
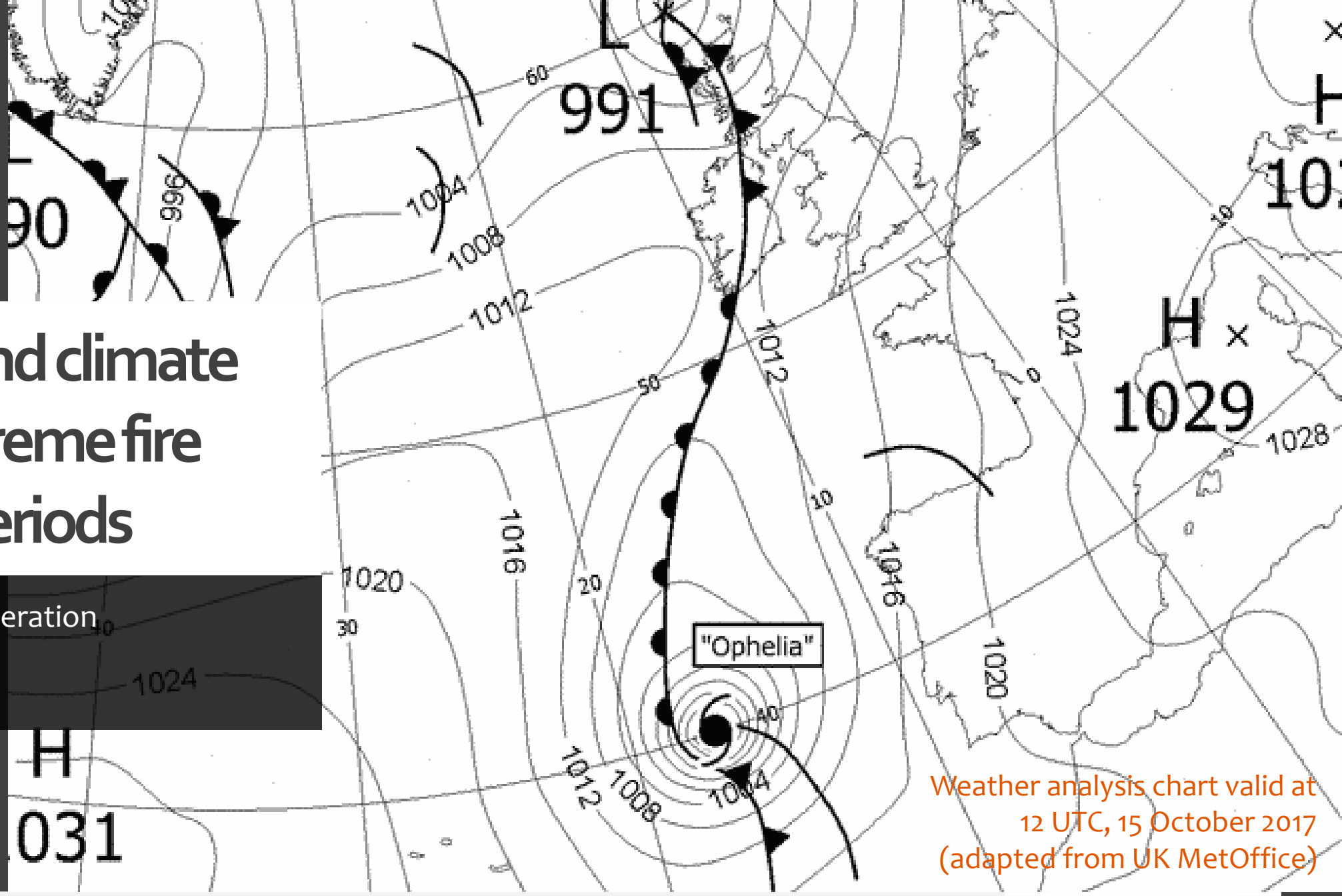


2. Weather and climate drivers of extreme fire events and periods

IPMA and ADAI-UC cooperation



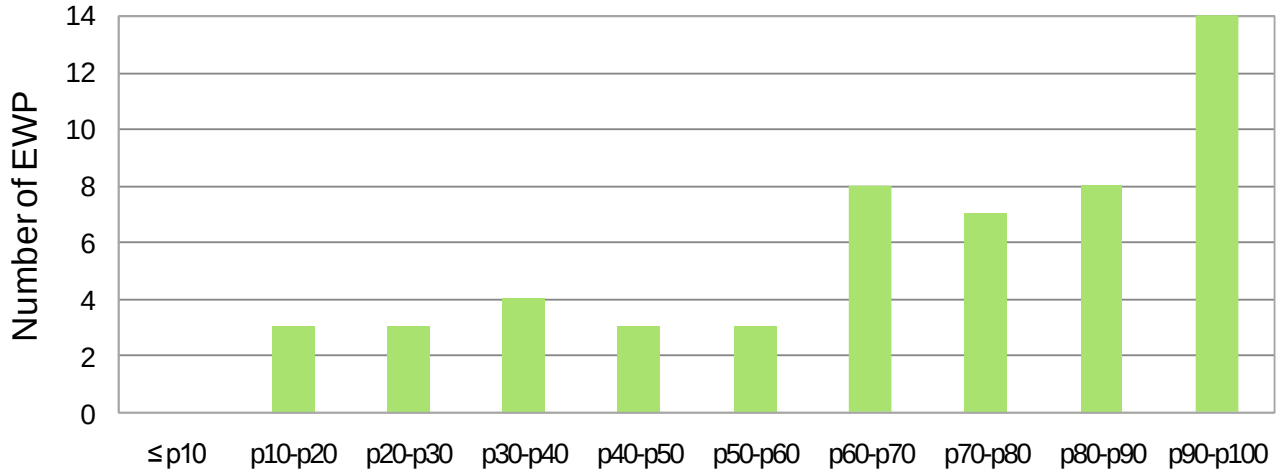
Weather analysis chart valid at
12 UTC, 15 October 2017
(adapted from UK MetOffice)

2. Weather and climate drivers of extreme fire events and periods

2.1 The role of seasonal drought on EWP

- EWP distribution by the Drought Code (FWI) daily percentile of the first day of the period.
- ECMWF / ERA5 reanalysis data

1980 / 2018



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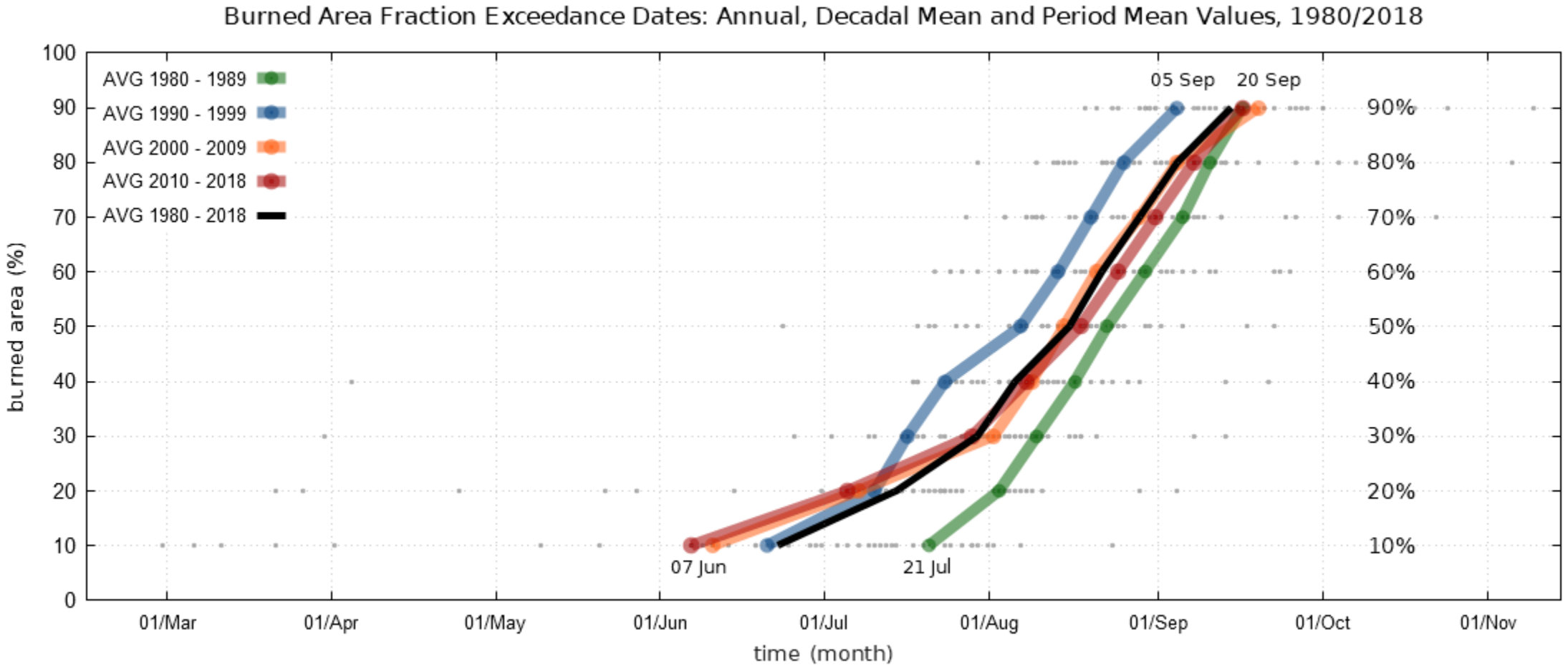
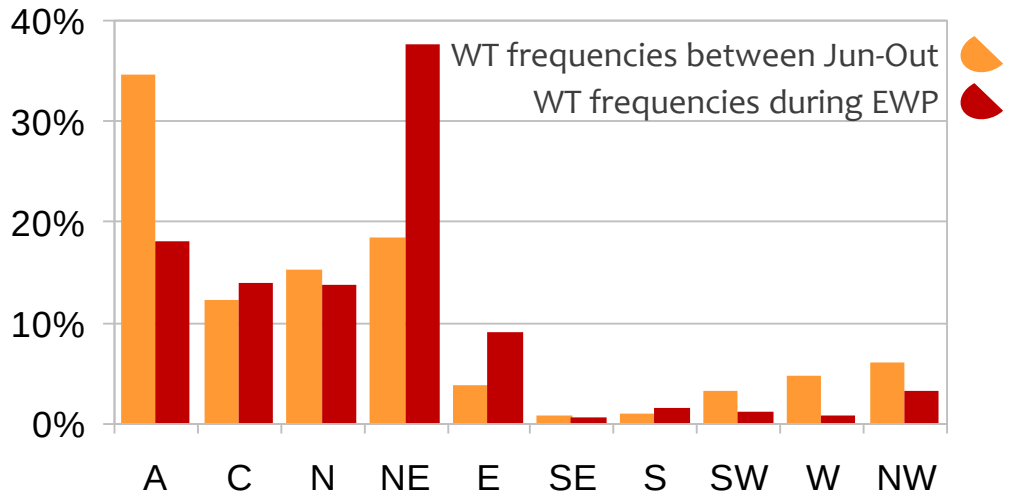


2. Weather and climate drivers of extreme fire events and periods

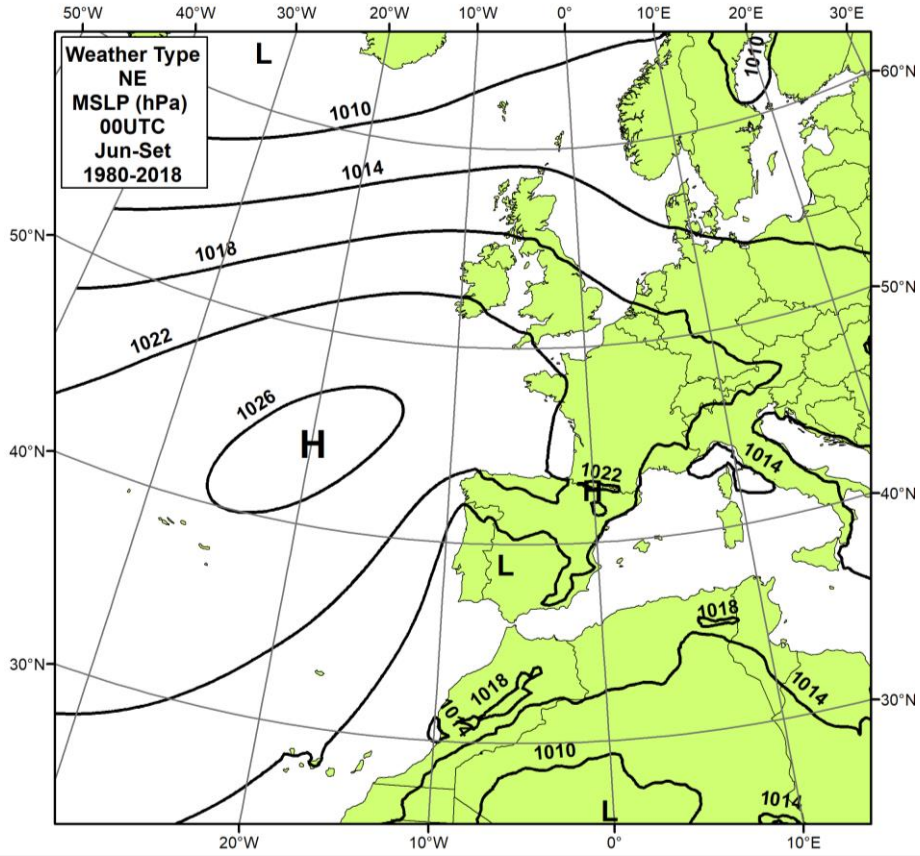
2.2 Weather types (large-scale circulation) frequencies on EWP



Classification of the direction and vorticity of the geostrophic flow: 26 different WT are obtained, which were reduced to the basic 10 WT.

(methodology: Trigo *et al.* 2000)

Jun-Set 1980 / 2018
ECMWF / ERA5 reanalysis data



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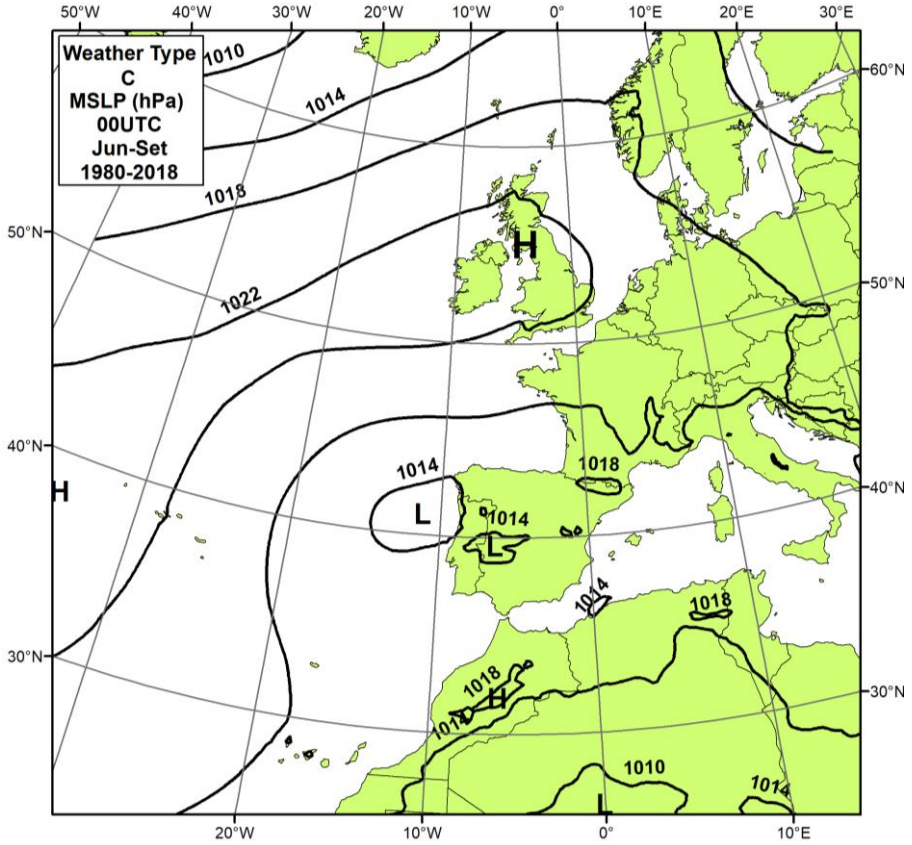

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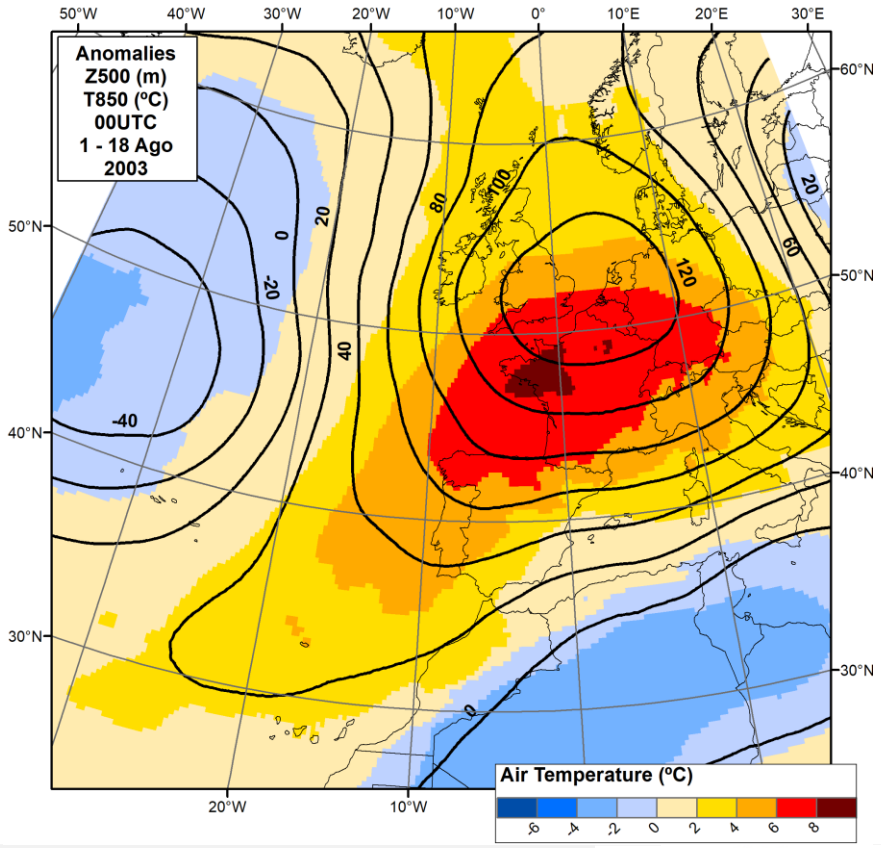


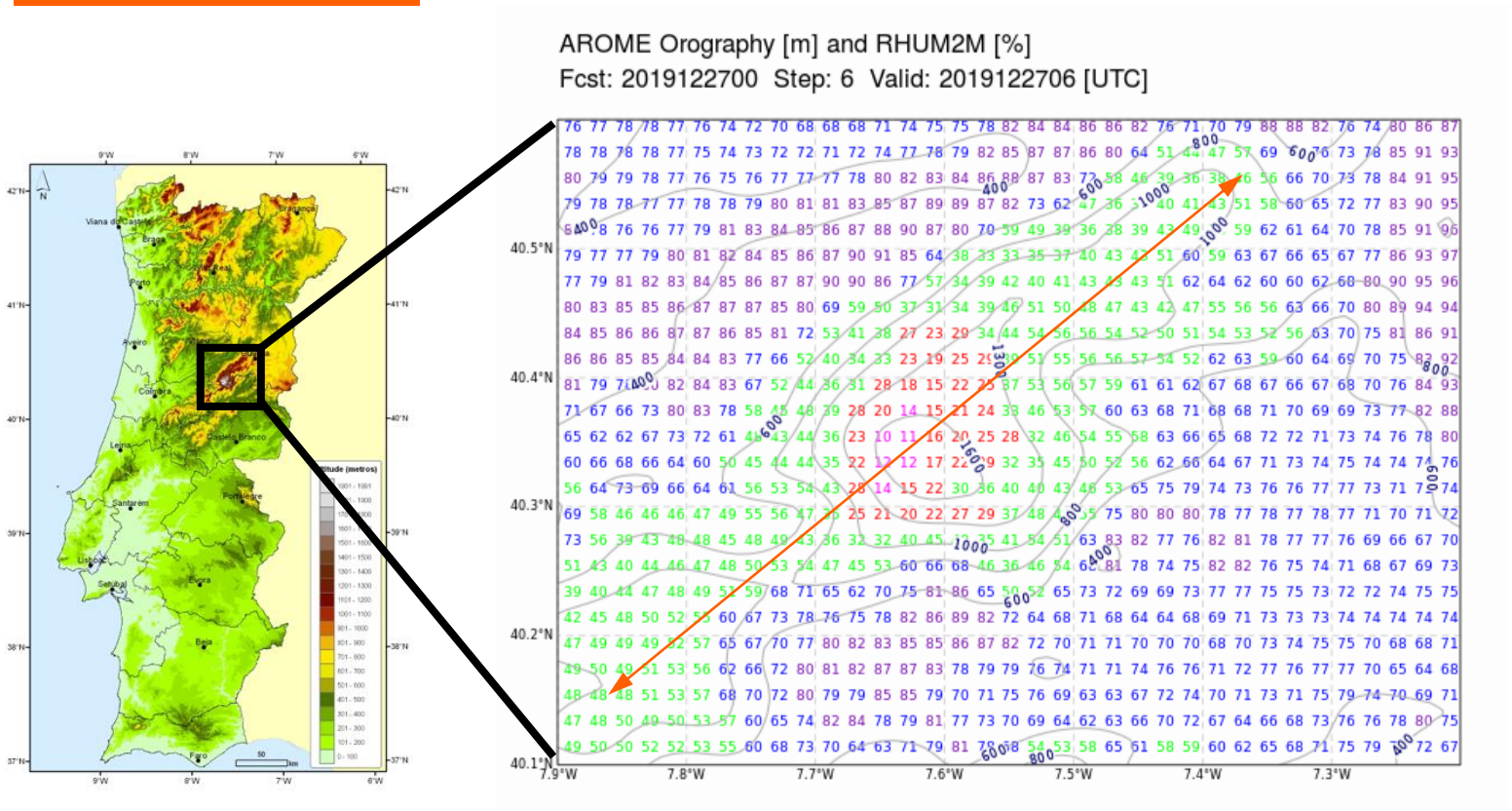
3. Interaction between mesoscale atmospheric flows and the fires

IPMA and ADAI-UC cooperation

Site selection for mobile weather station at the top of the Serra da Lousã (Trevim, Nov. 21, 2019)

3. Interaction between mesoscale atmospheric flows and the fires

3.1 Thermal inversion in the vertical profile in the lower troposphere (Lousã-Estrela system)



AROME forecasts:

- Stable Conditions, with strong inversion
- Warmer and much drier above 800/1000m than in the valleys

3. Interaction between mesoscale atmospheric flows and the fires

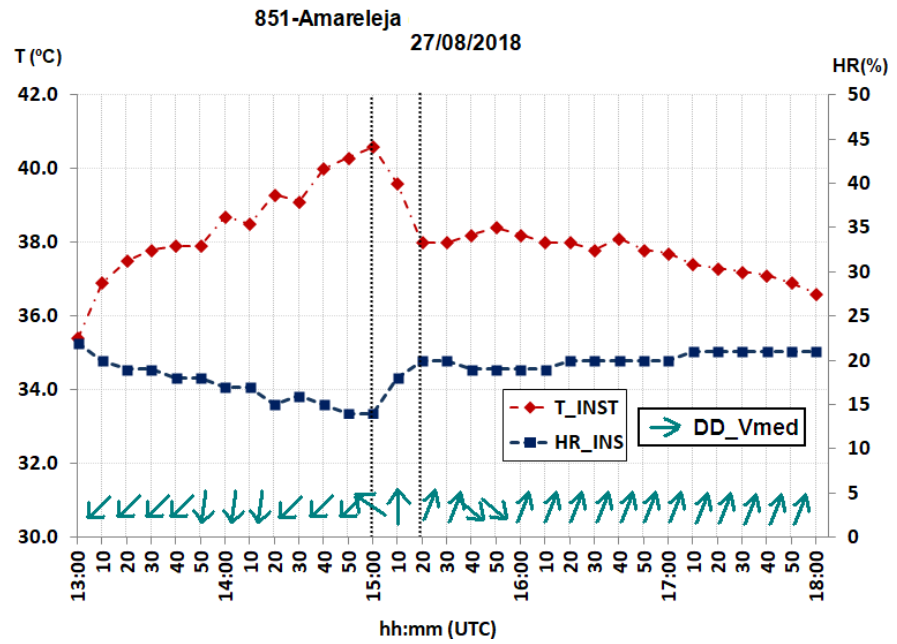
3.1 Thermal inversion in the vertical profile in the lower troposphere (Lousã-Estrela system)

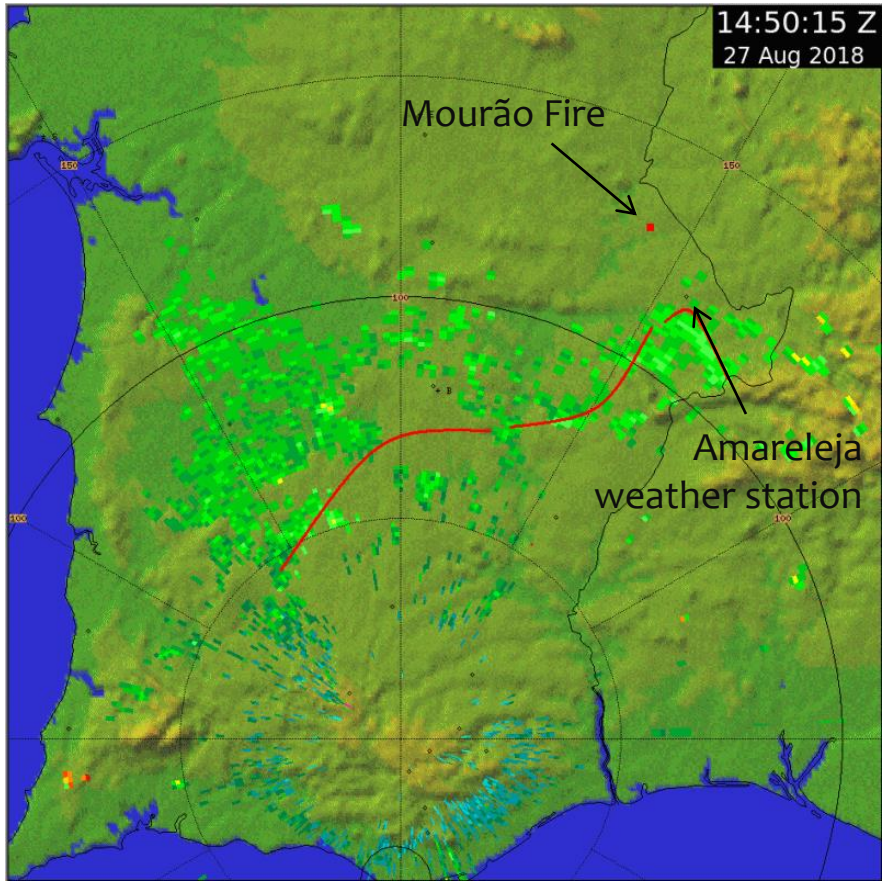
- Monitoring and study of Lousã-Estrela mountain system:
  - SW-NE orientation
  - vertical profile more than 1000 meters deep
- 4 portable meteorological stations (implementation in progress), adding to 2 more from IPMA's network.

Place	Entity	Lat.	Lon.	Alt.
Lousã	IPMA	40.14	-8.24	195
Seia	Firestorm	40.46	-7.69	435
Candal	Firestorm	40.08	-8.21	600
Sabugueiro	Firestorm	40.41	-7.67	990
Trevim	Firestorm	40.09	-8.18	1180
Penhas Douradas	IPMA	40.41	-7.57	1380

3. Interaction between mesoscale atmospheric flows and the fires

3.2 Discontinuity surfaces in the lower troposphere: sea breezes, confluence and convergence zones, and gust fronts





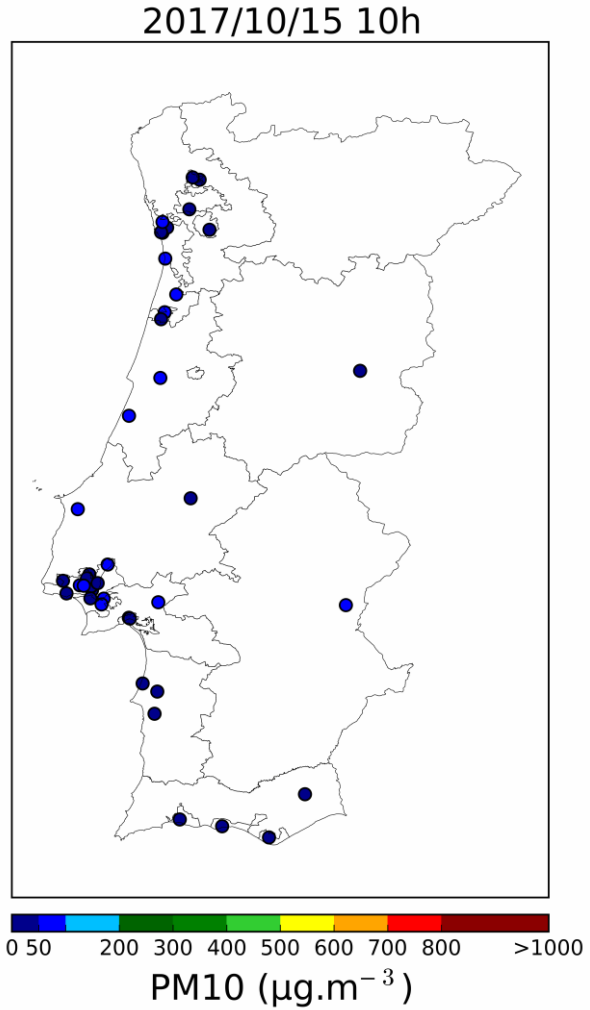
4. Smoke emission and dispersion modelling for air quality impact

CESAM/DAO-UA and IPMA cooperation

The weather radar of Arouca, 1100 m.
(photo AGA/Avelino Vieira)

4. Smoke emission and dispersion modelling for air quality impact

- Characterization of smoke emission from wildfires and their dispersion
- Modelling the spatial and temporal variability of smoke concentrations
- Smoke effects on safety and human health



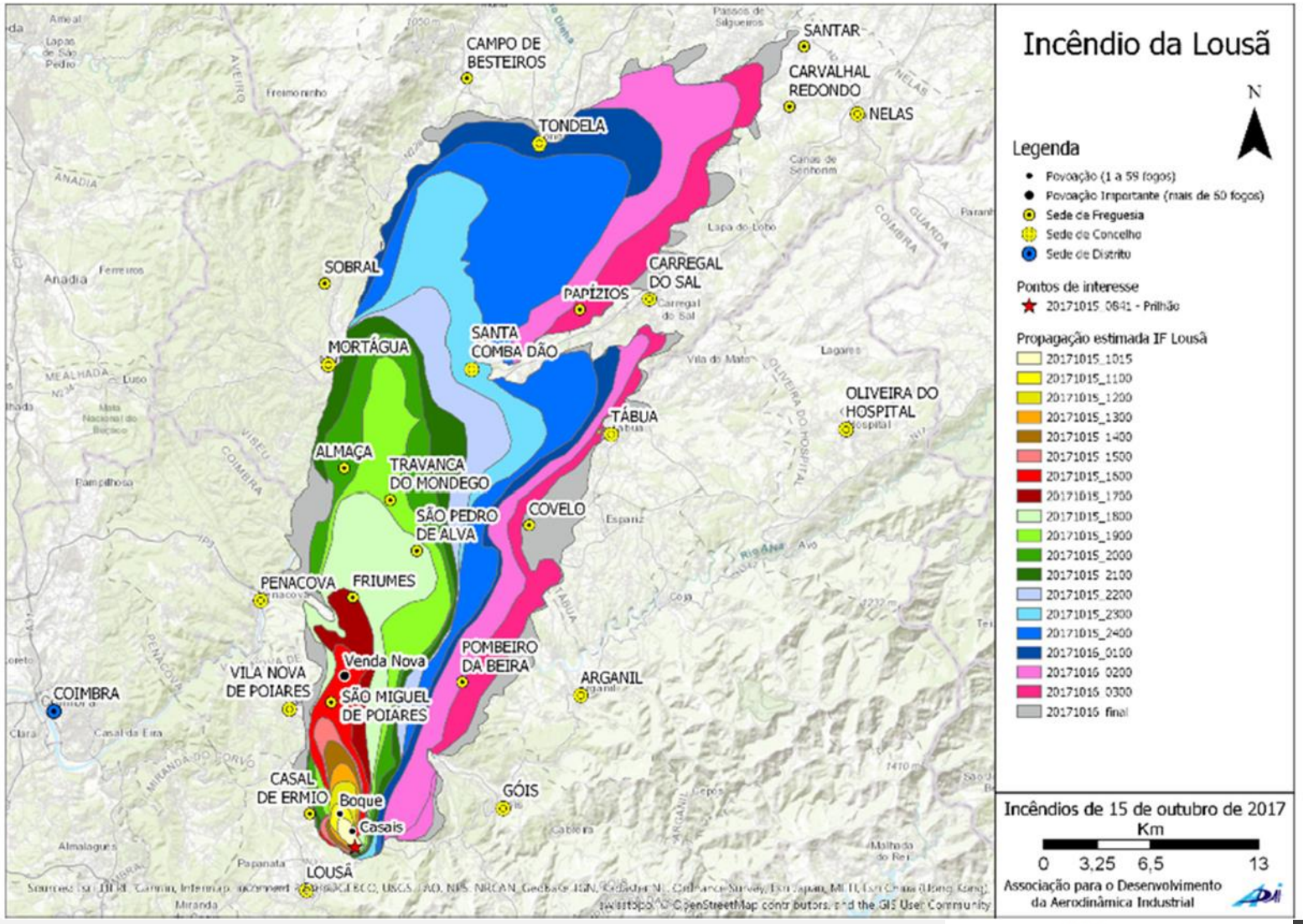
Air quality during EWE

Daily limit value = 50 µg.m^{-3}

4. Smoke emission and dispersion modelling for air quality impact

The Extreme Wildfire Event of CIF Lousã

- Total burned area – 54 407 ha
- Duration – 18 hours
- Start at 10:15 – 15/10/2017
- End at 4:00 – 16/10/2017

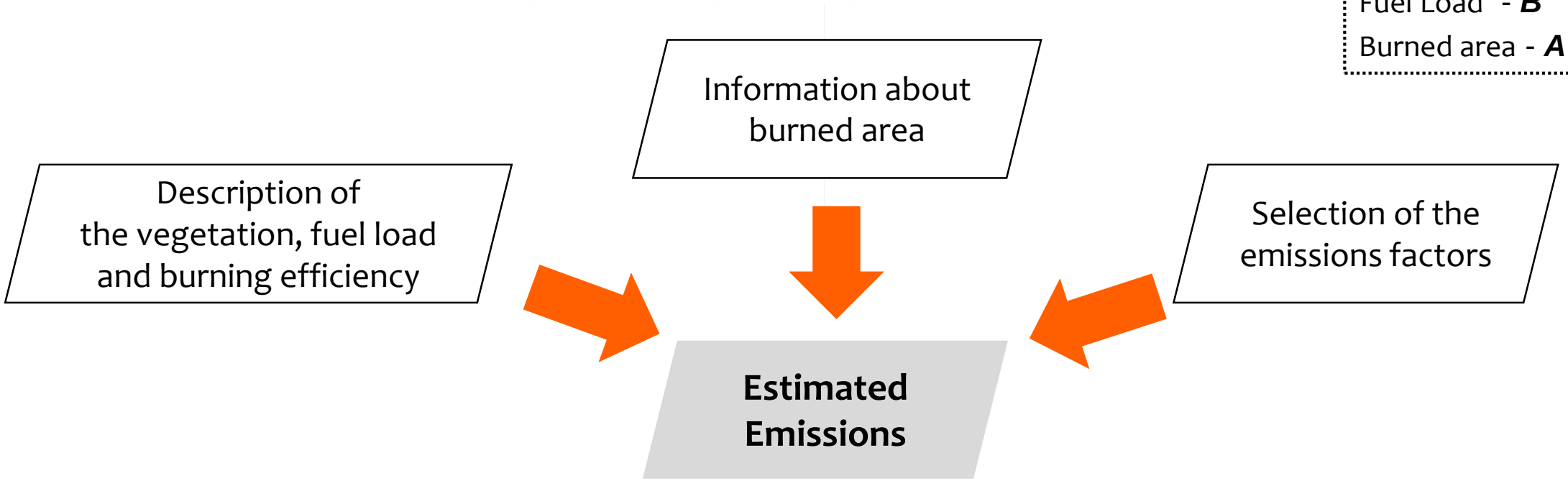


4. Smoke emission and dispersion modelling for air quality impact

Emissions Maps: Metodology

$$E_i = EF_i \times \beta \times B \times A$$

Emission - ***E***
Emission Factor - ***EF***
Burning efficiency- ***β***
Fuel Load - ***B***
Burned area - ***A***

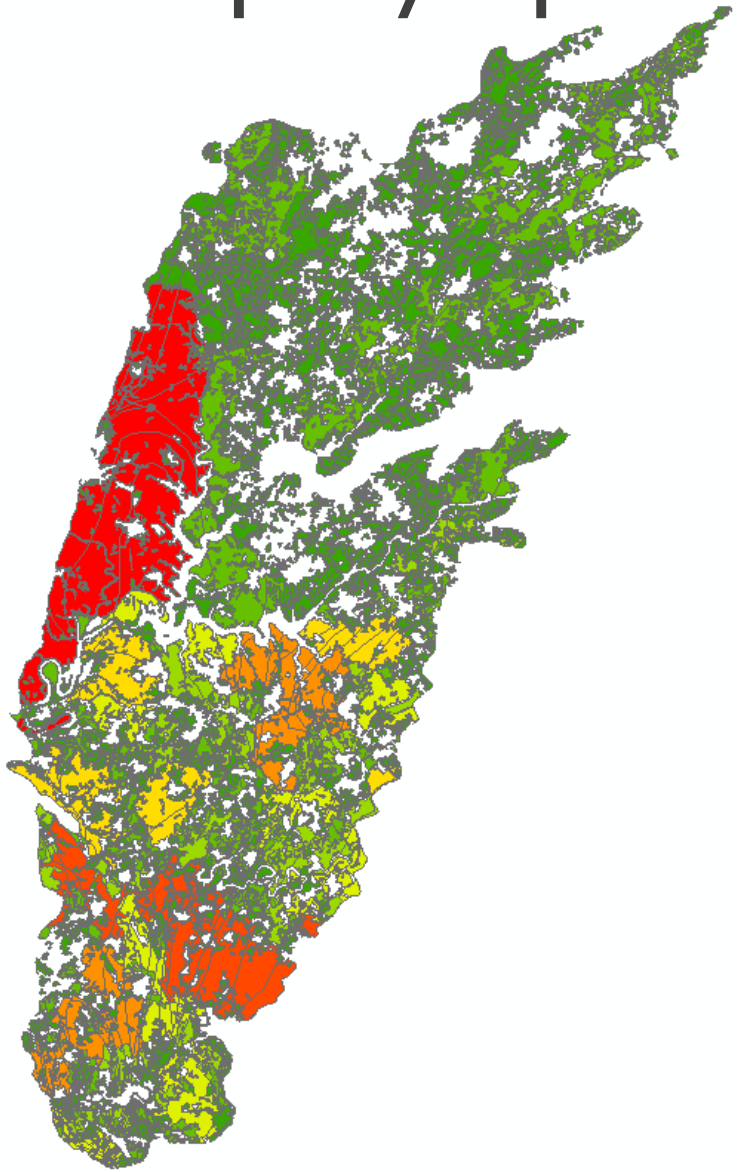


4. Smoke emission and dispersion modelling for air quality impact

Emissions Maps:
Spatial distribution of the PM10 Emissions (CIF Lousã)

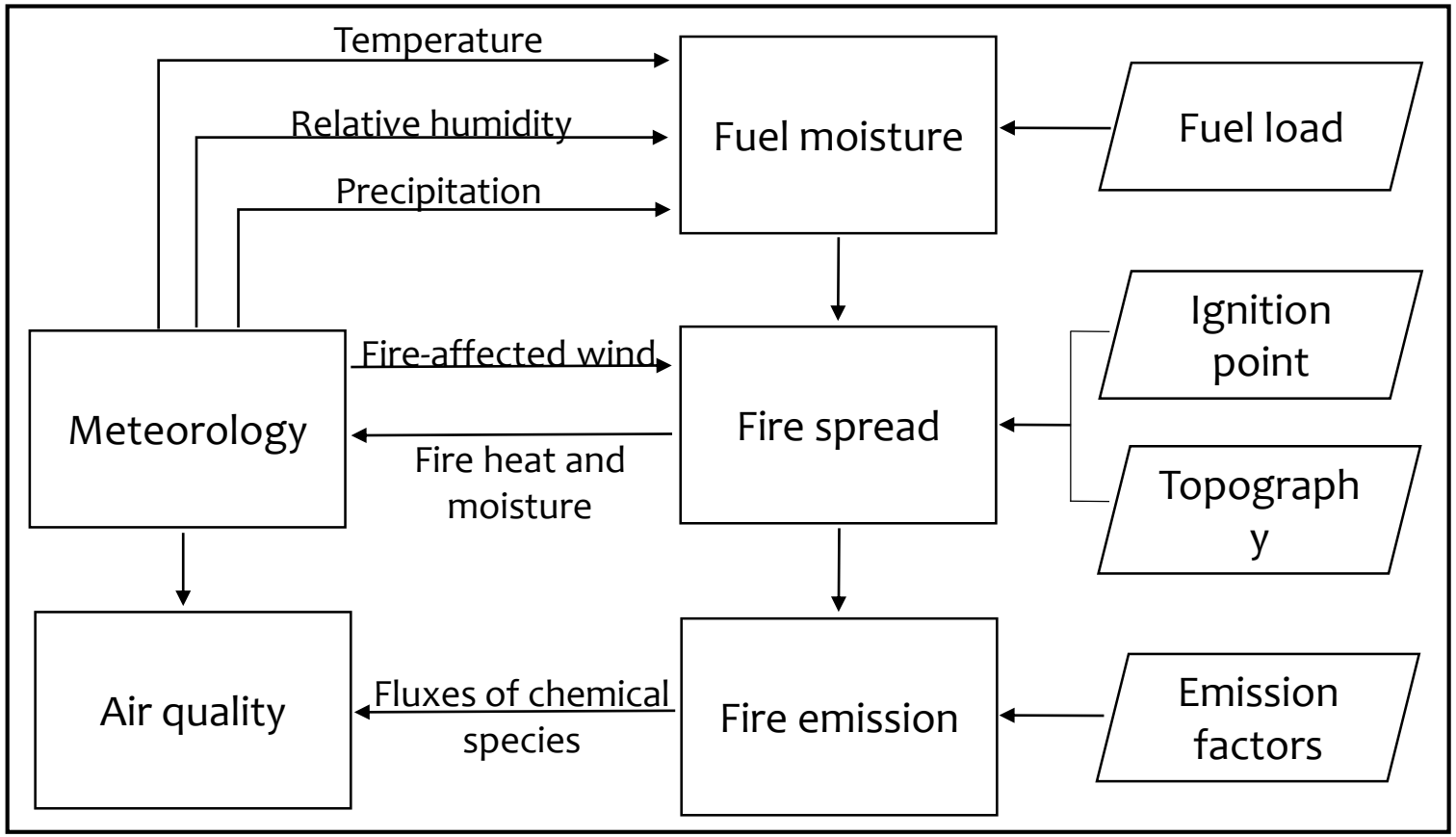
PM10 emissions ($kg.m^{-2}$)

- 0 - 4
- 5 - 16
- 17 - 49
- 50 - 108
- 109 - 229
- 230 - 413
- 414 - 1259
- 1260 - 7356



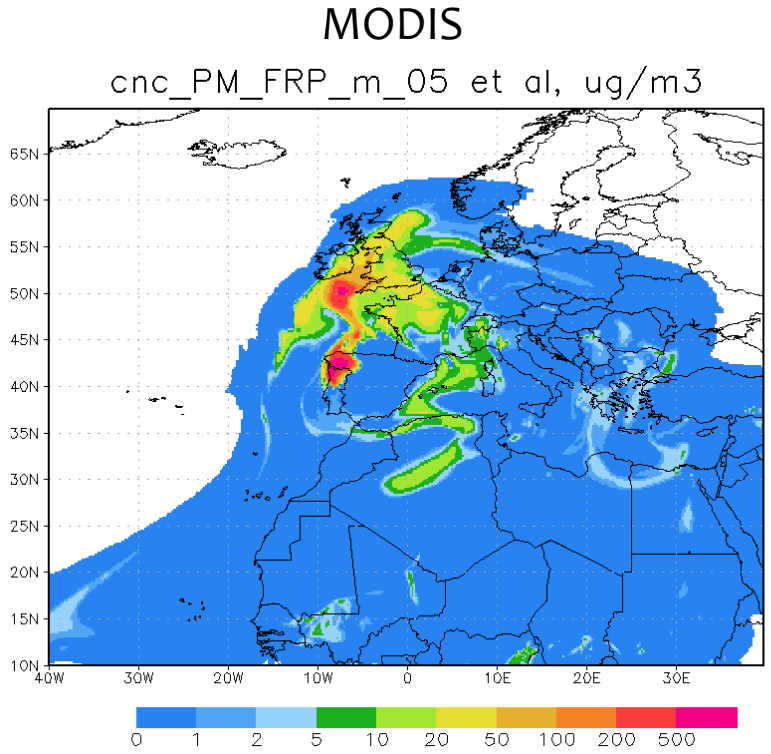
4. Smoke emission and dispersion modelling for air quality impact

Air quality modelling system



4. Smoke emission and dispersion modelling for air quality impact

Air quality modelling: Preliminary results



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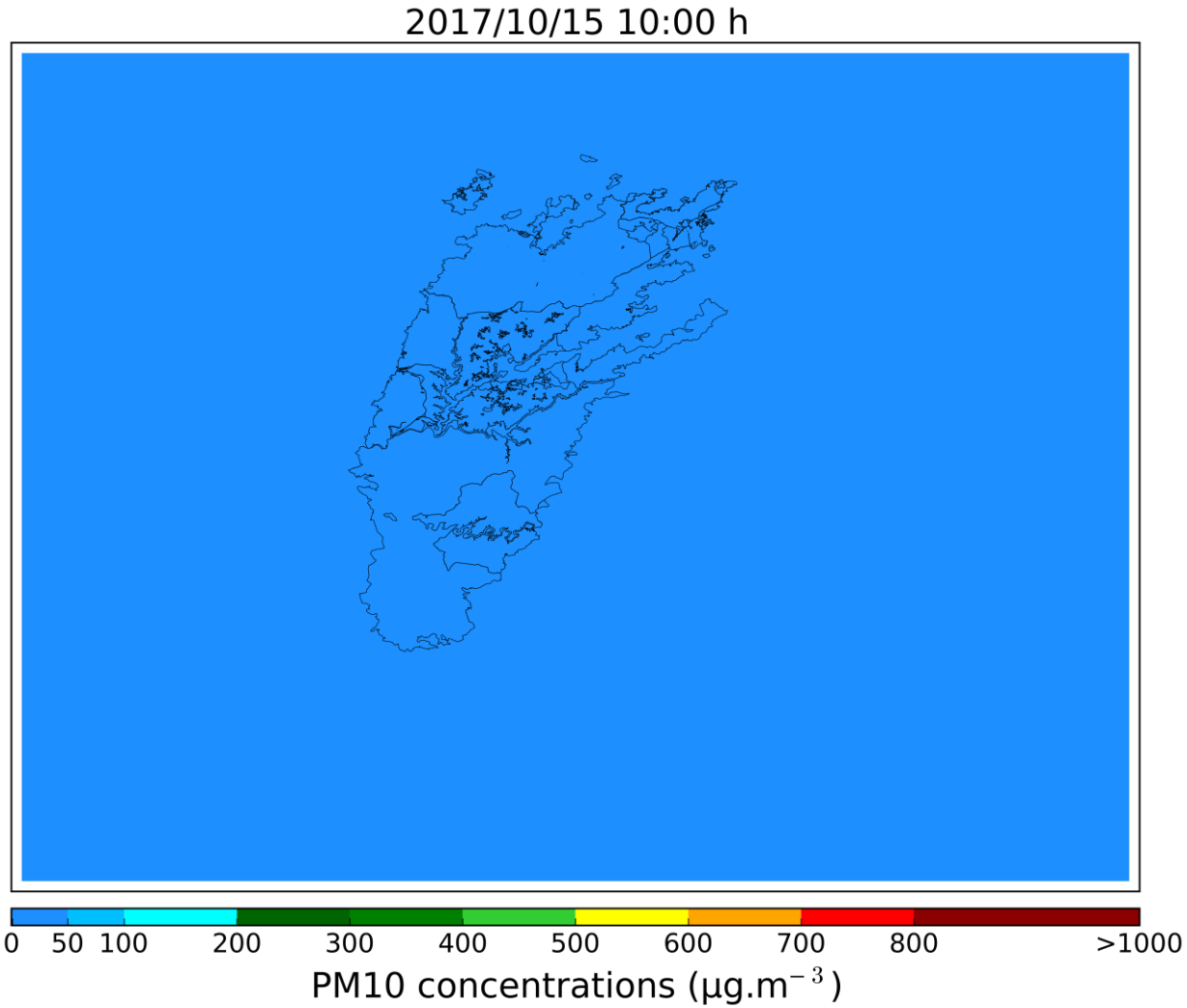

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Health effects

Air pollutants can enter a human body through:

inhalation

ingestion

skin absorption

Dose-response relationship:

For a given air pollutant describes the association between exposure and the observed response (health effect)

Varies with:

- ✓ Air pollutant
- ✓ individual's sensitivity
- ✓ Health effect

Estimate how different levels of exposure to an air pollutant change the intensity of the health effects

Future work

ADAI-UC, CESAM/DAO-UA and IPMA cooperation

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Future work

- Full weather and climate characterization of EWE and EWP at the national level and at NUTS3 level.
- Relationship between cumulative burned area and predicted fine dead fuel moisture content.
- Results from the study of Lousã-Estrela system.
- Diagnosis of discontinuity surfaces associated to EWP.

- Forest fuel and emission maps for the Extreme Wildfire Events of the year 2017.
- Air quality modelling for the EWE.
- Impact assessment on visibility and human health.

Thanks !

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