Probabilistic fire spread prediction
The case of the deadly wildfire in Mati, Greece

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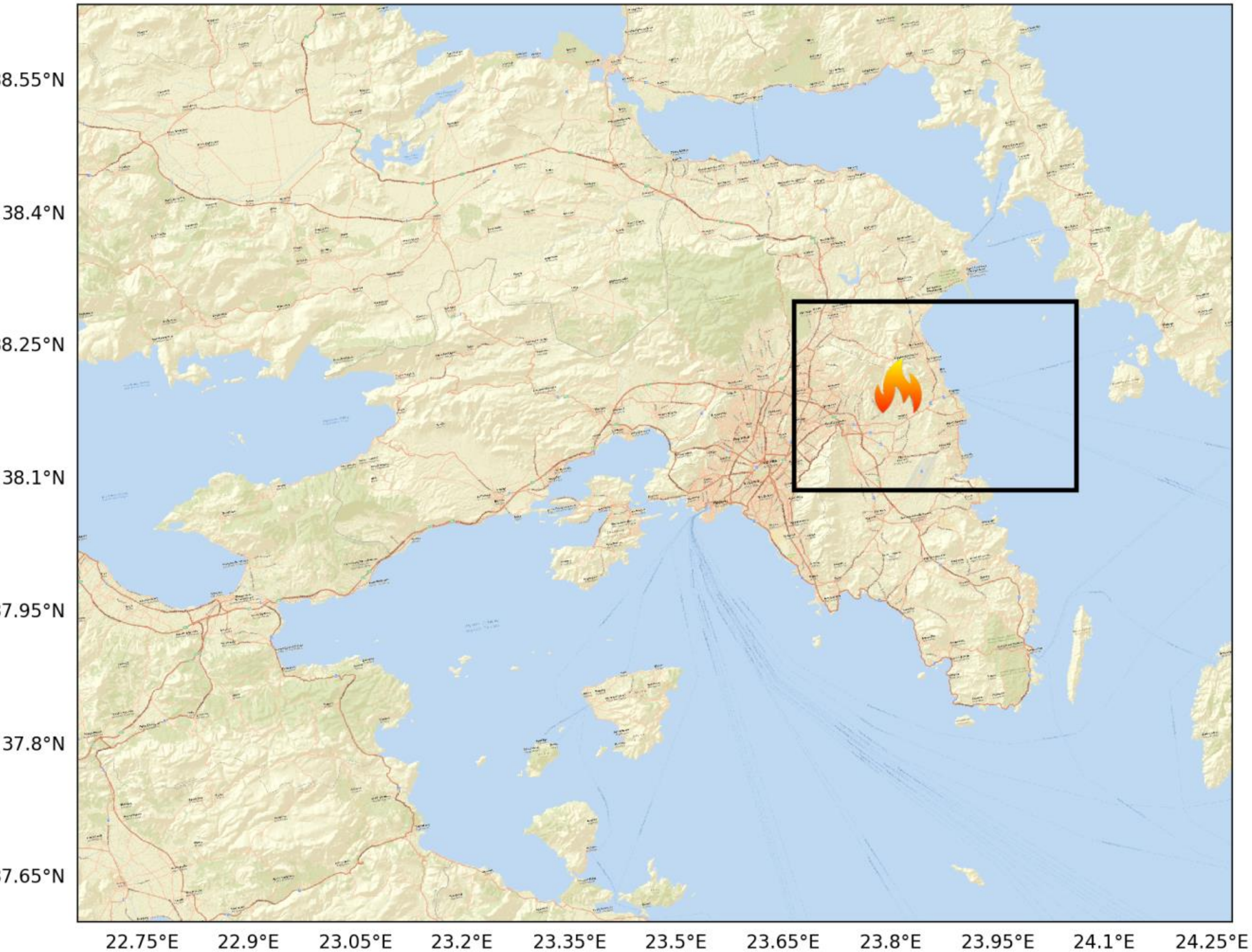
Background

The wildfire broke up in the early afternoon (13:45 UTC) on Monday July 23, 2018, at the foothill of the Penteli Mountain, 20 km NE of the city of Athens and 5 km off the eastern Attica coast.

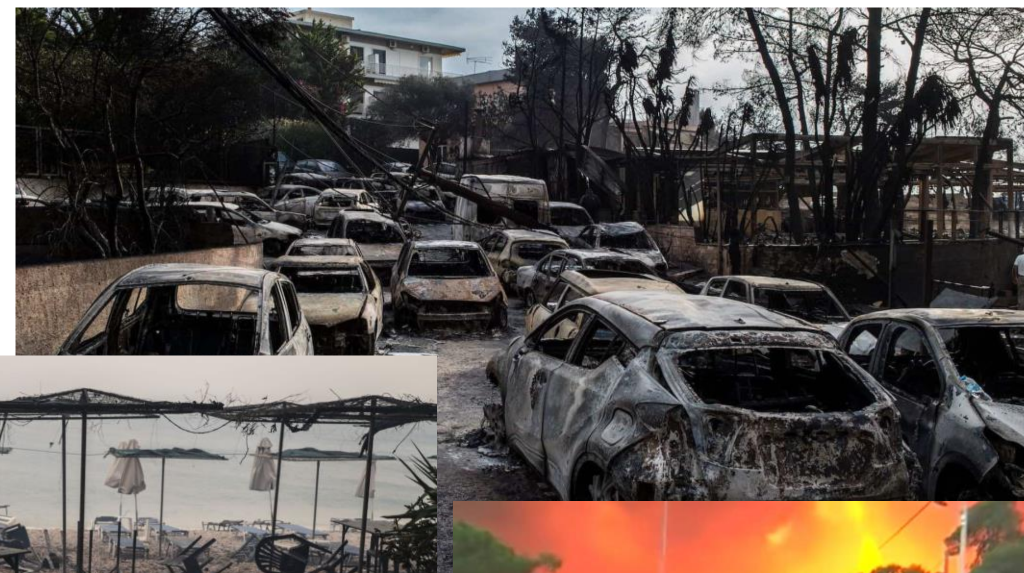
Assisted by the prevailing meteorological conditions, it spread erratically, literally wiping out the residential settlement of Mati in less than 2 h.

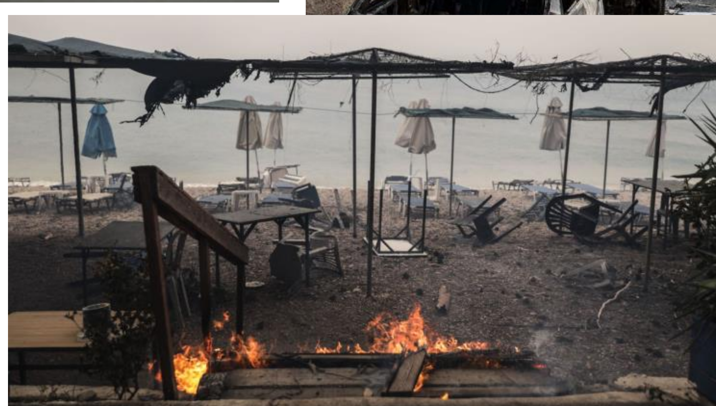


Aftermath

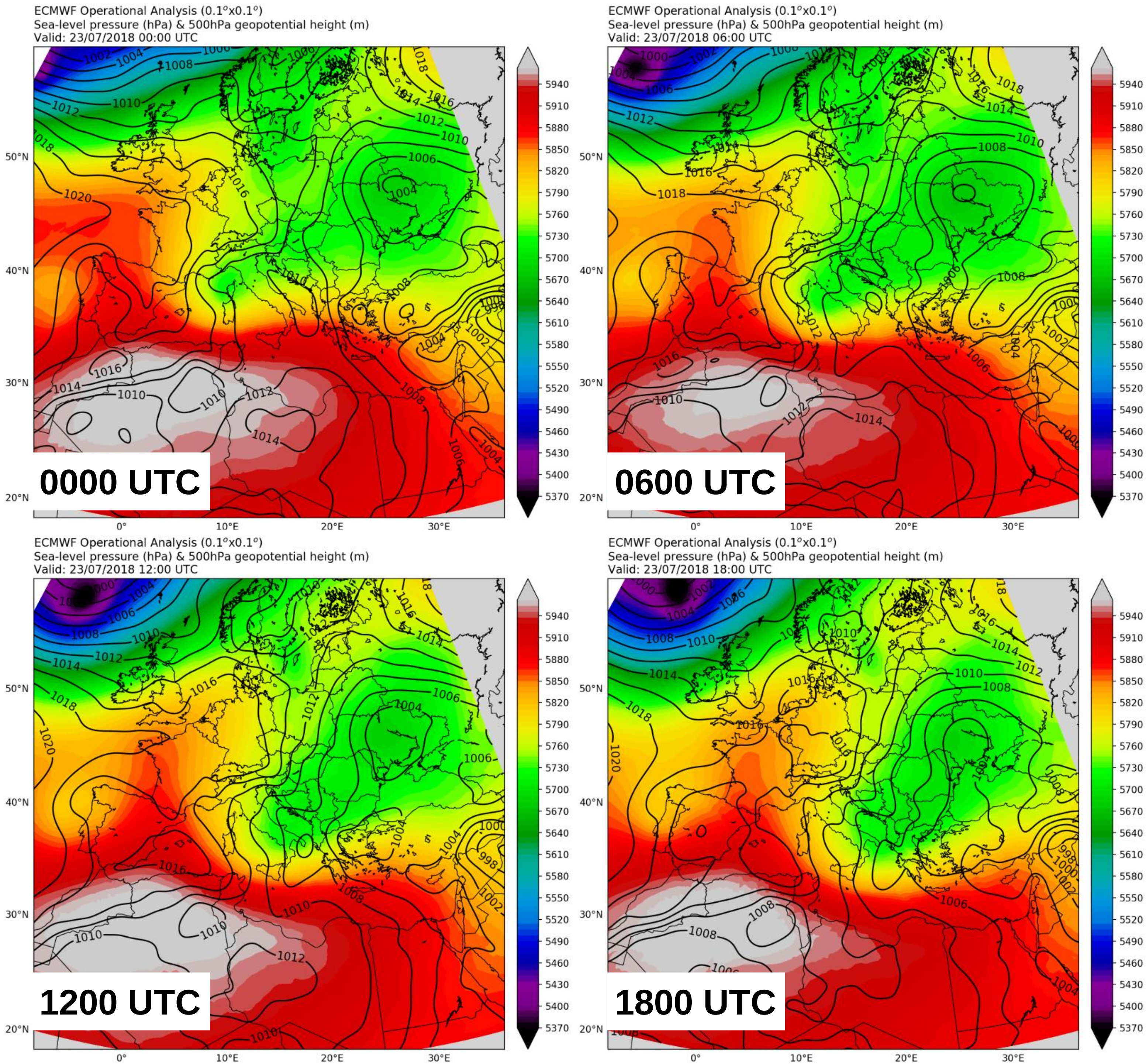
- ~**12.8 km^2** were burnt (1276 ha).
- **>1,000 buildings** were totally destroyed.
- **305 vehicles** were burnt.
- **101 civilian fatalities**.

The Mati wildfire is the 2nd deadliest natural disaster in Greece's modern history.





Overview: Synoptic environment [1]



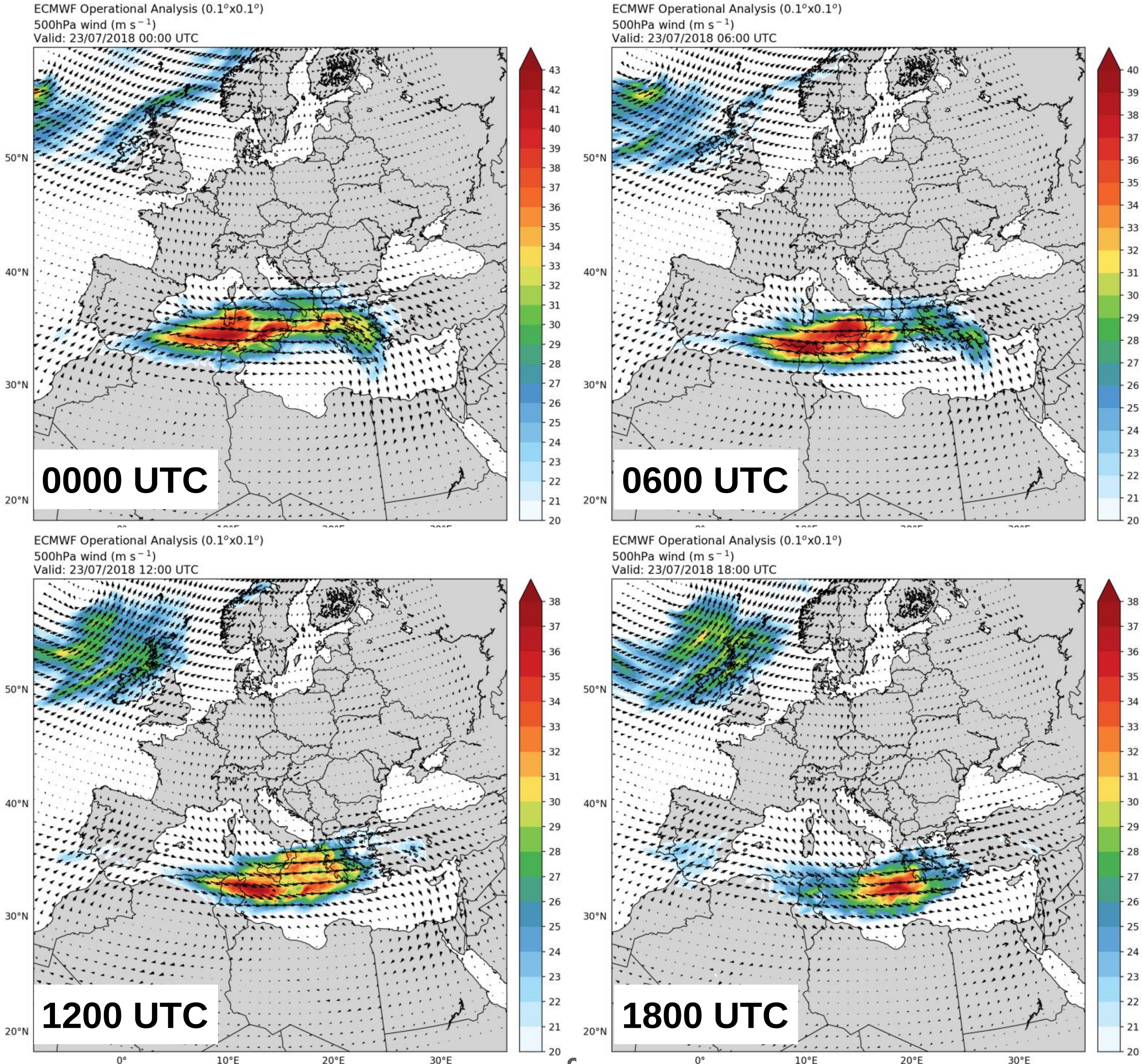
July 23, 2018

Ridge breakdown due to approaching upper-level trough.

Shallow (1004 hPa) low-pressure system over NE Aegean Sea.

Subtropical ridge.

Overview: Synoptic environment



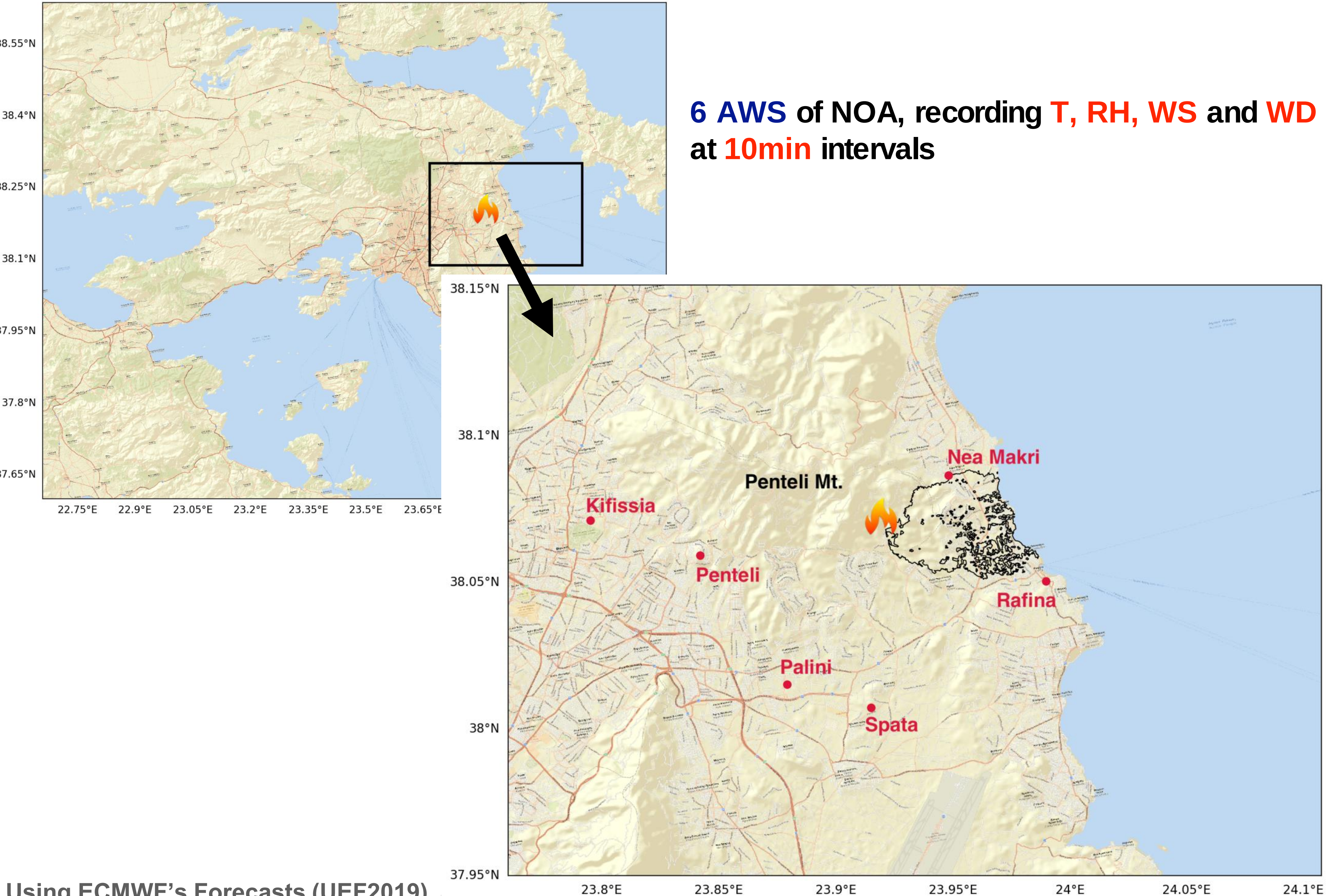
July 23, 2018

Subtropical jet stream extending from S Italy to Greece.

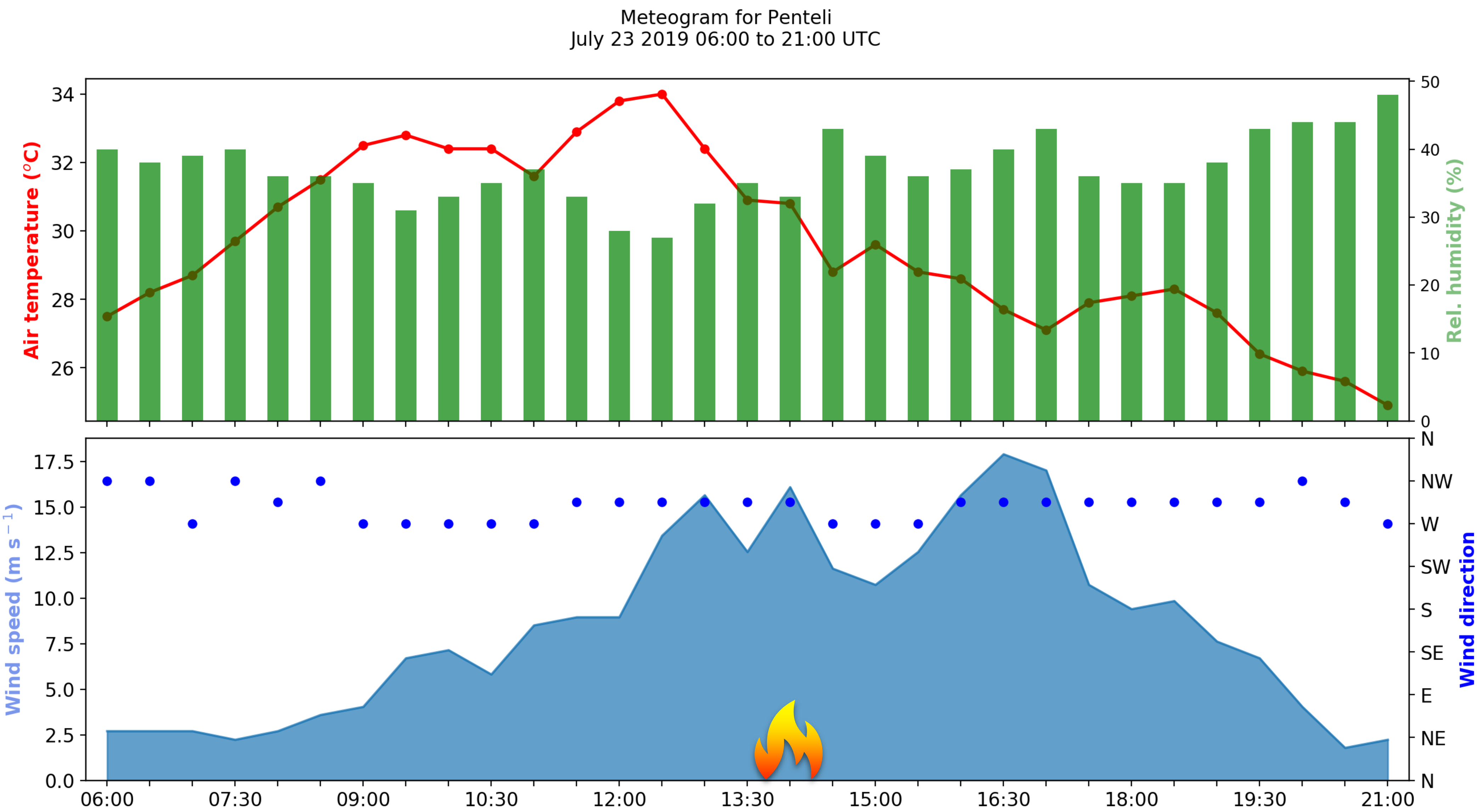
25-30 m s^{-1} peak winds.

Overview: AWS observations

6 AWS of NOA, recording T, RH, WS and WD at 10min intervals

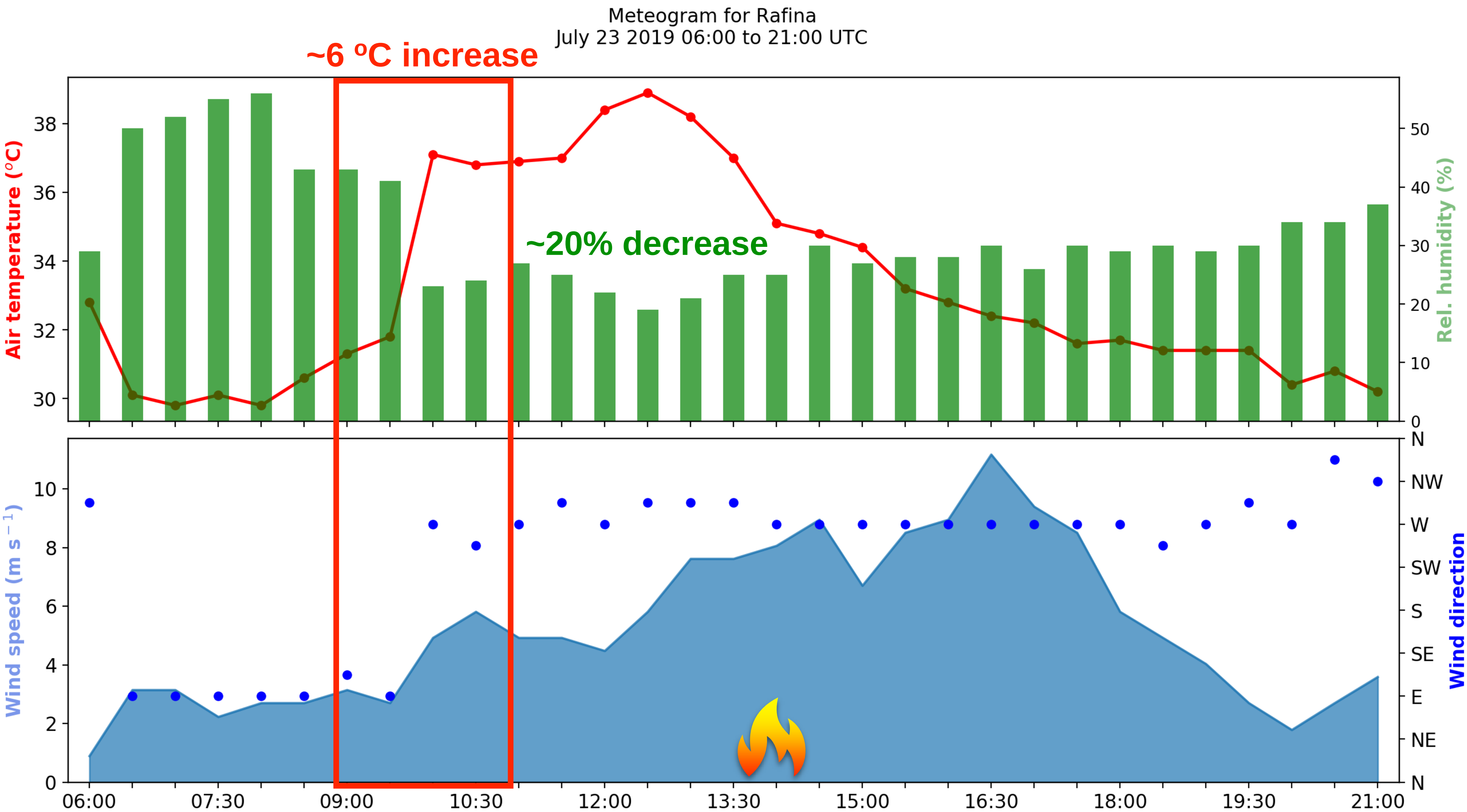


Overview: AWS observations



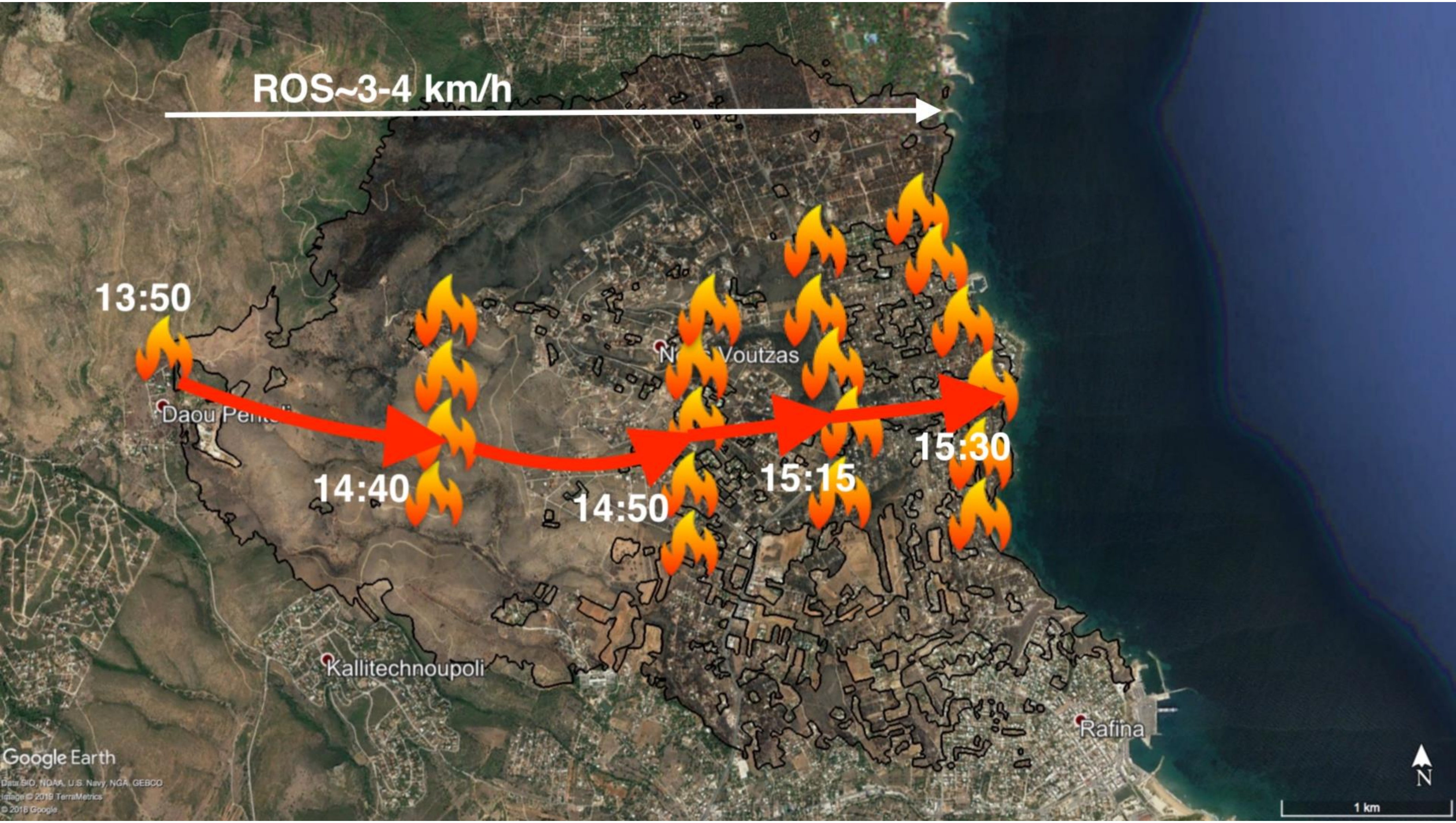
W/NW winds >15 m s^{-1} prior to fire ignition, peaking at ~18 m s^{-1} (~65 km h^{-1}) during active fire spread.

Overview: AWS observations [3]



Rapid dry-out of fine fuels **prior** to fire ignition. **W** winds **8-10 m s^{-1} during** active fire spread.

Overview: Fire spread



Based on evidence collected by the National and Kapodistrian University of Athens (https://edcm.edu.gr/images/docs/2018/Newsletter_Attica_Fires_2018_v11.pdf)

Objectives

IRIS
Weather ready
Powered by Meteo

IRIS: rapId Response fIre Spread forecasting system for Greece, based on the coupled fire-atmosphere WRF-Fire modelling system (Munoz-Esparza et al., 2018) and supported by a prototype fuel models' map derived from products of the Copernicus Land Monitoring Service.

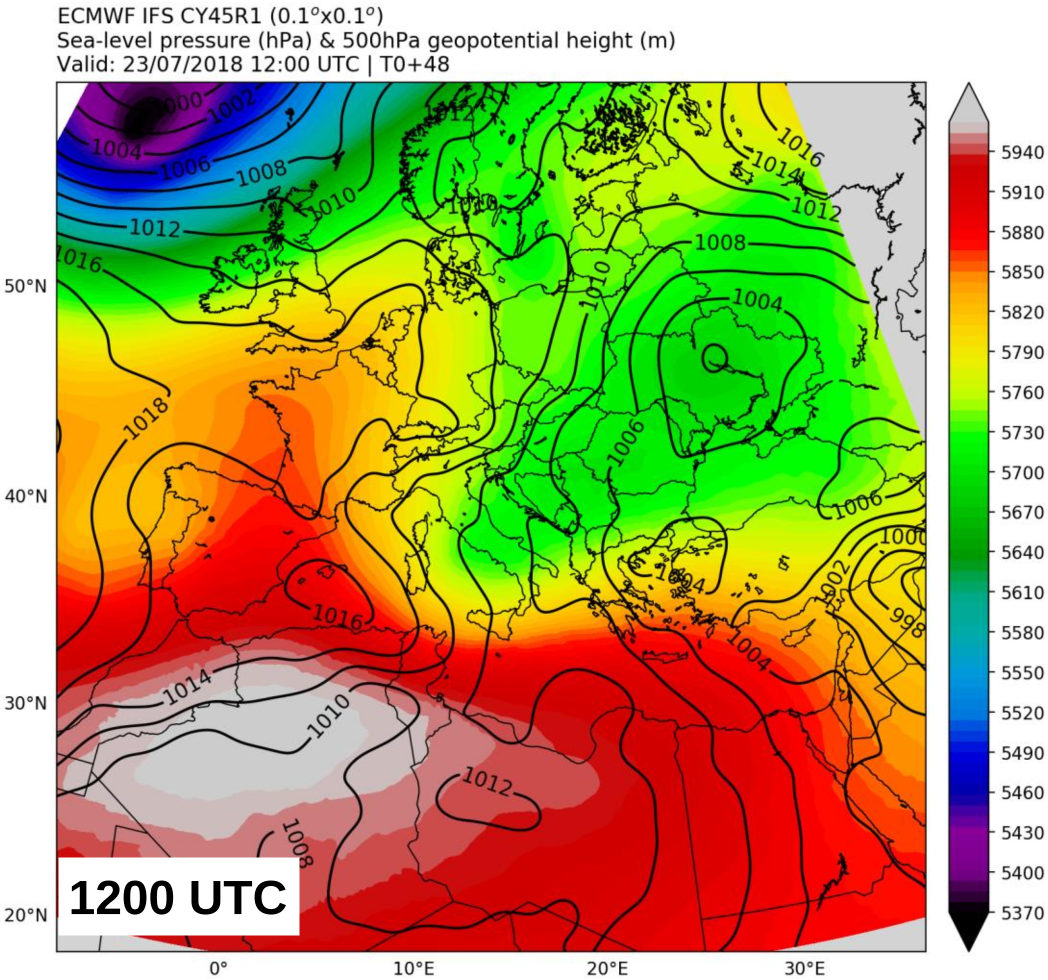
Pre-operational implementation during 2018 fire season; Fully operational during 2019 fire seaso

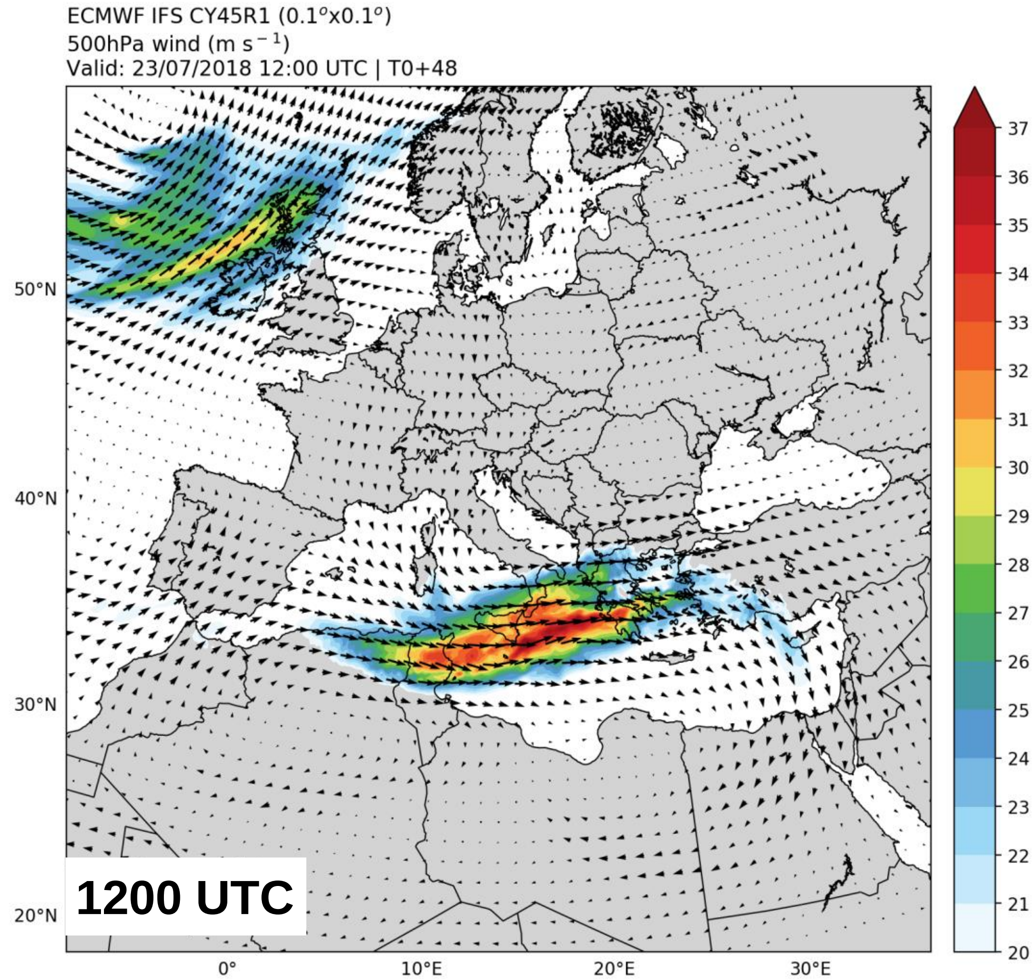
Two-way coupling between the fire and the atmosphere (via heat/vapour fluxes); Rapid-respons

Could *ECMWF's* EPS be used (and how?) for providing an early warning?

Does driving IRIS with *ECMWF's* EPS provide added-value for fire spread forecasting?

Deterministic outlook: T0+48



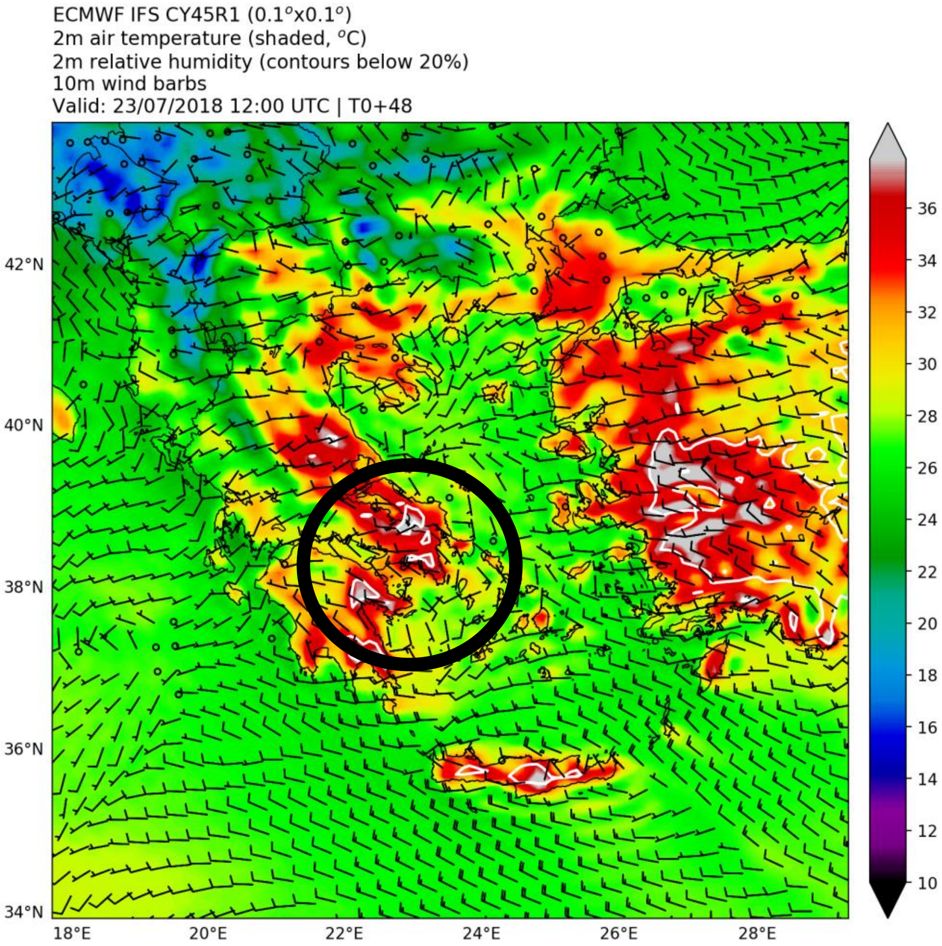


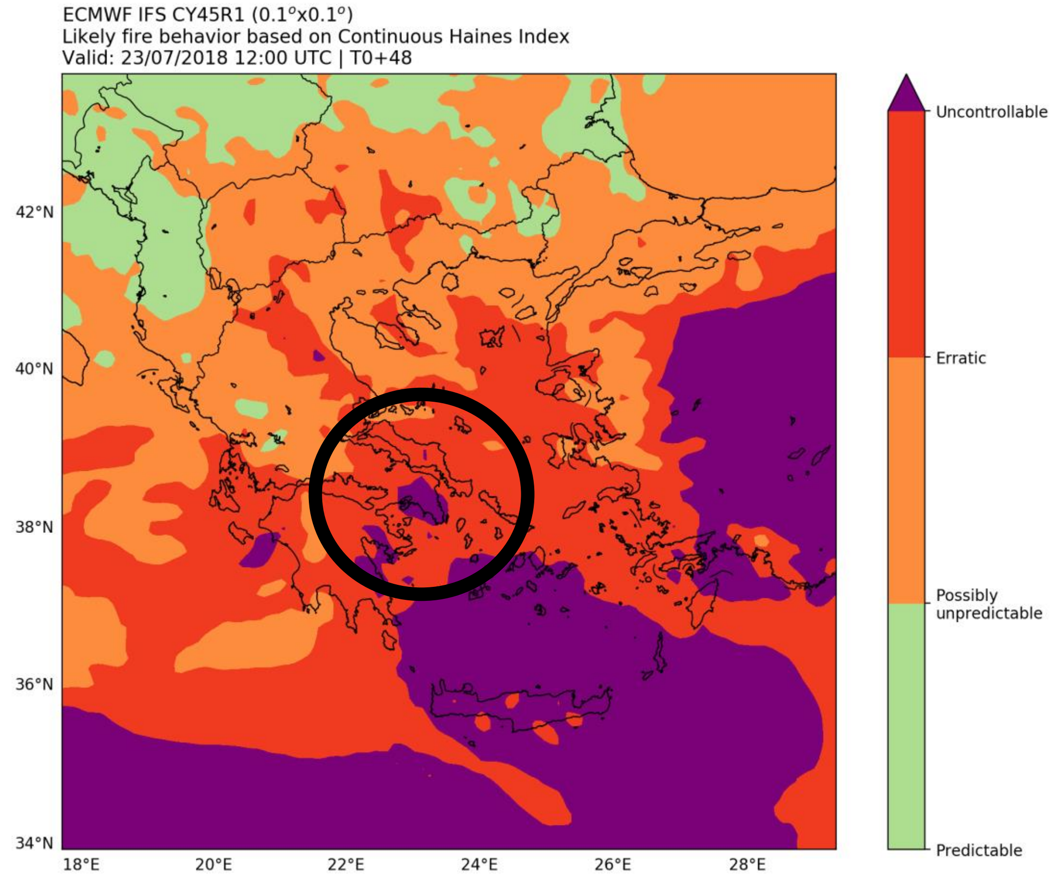
The key ingredients for potentially extreme fire behaviour are present in the deterministic forecast:

- **Ridge break-down.**
- **Approaching upper-level trough.**
- **Mid-level subtropical jet stream (~30 m s^{-1}) over S Greece.**

Critical fire weather pattern

Deterministic outlook: T0+48 [2]



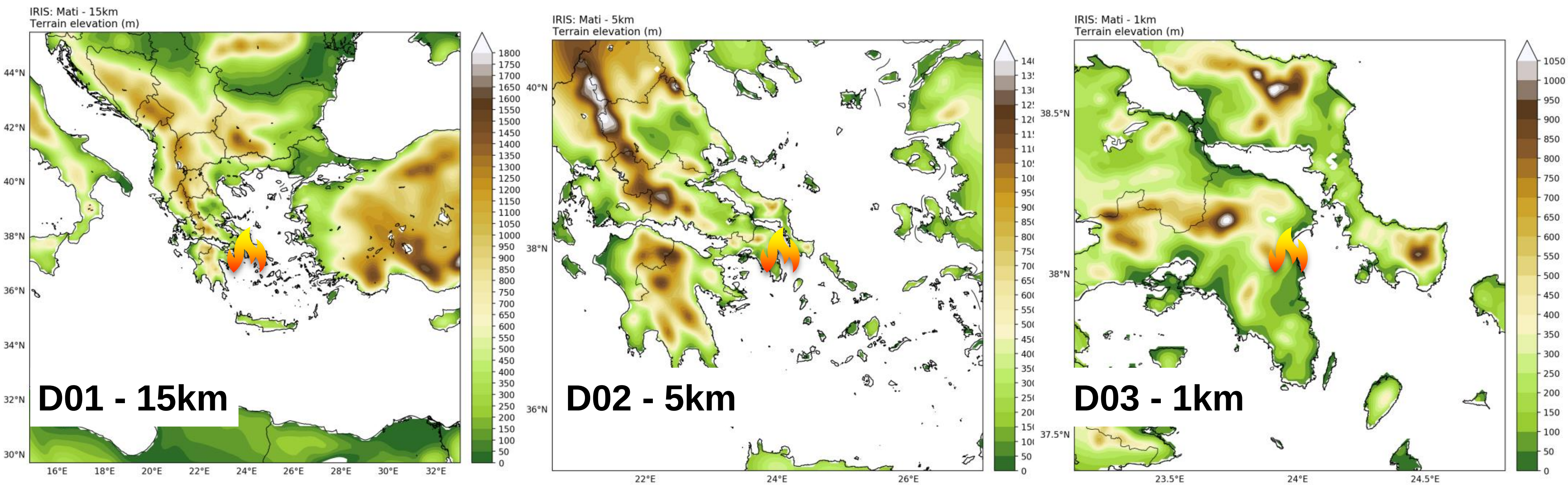


Deterministic forecast guidance for conditions highly conducive for extreme fire behaviour in Attica.

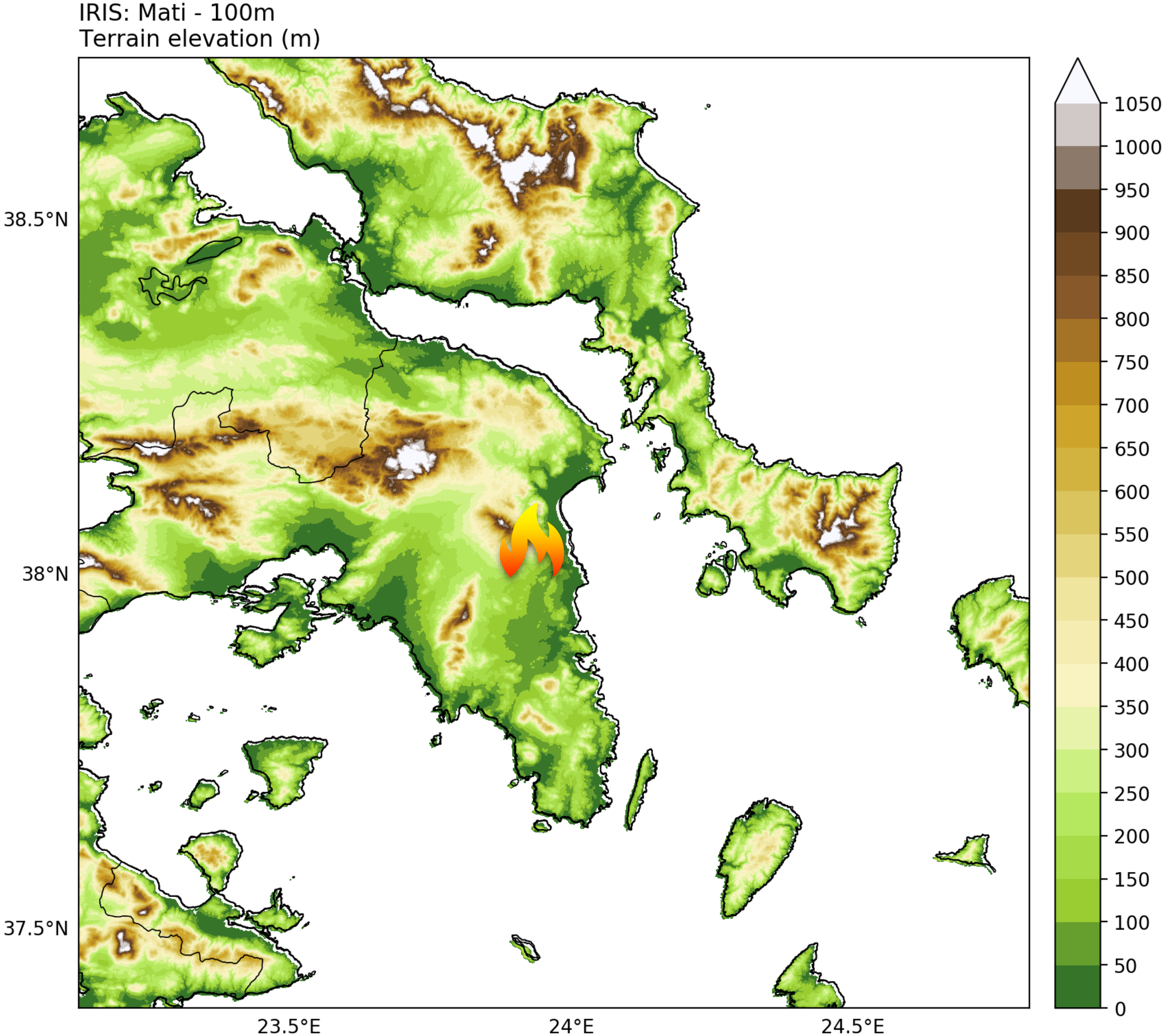
Trigger alarm for potentially dangerous conditions in Attica; Employ ECMWF EPS for gaining further insight.

IRIS: Configuration - Atmospheric model (WRF)

Three 2-way nested modelling domains, centred around fire ignition: 15 - 5 - 1 km.
Initialisation: ECMWF EPS of 21/07/2018, ~16km resolution (T0+48).
Simulations: 50 (EPS members) + 1 (EPS control) + 1 (IFS CY45R1)



IRIS: Configuration - Fire spread model (Fire)



Ultra-high-resolution domain (100m) embedded as sub-grid within the 1km atmospheric domain:

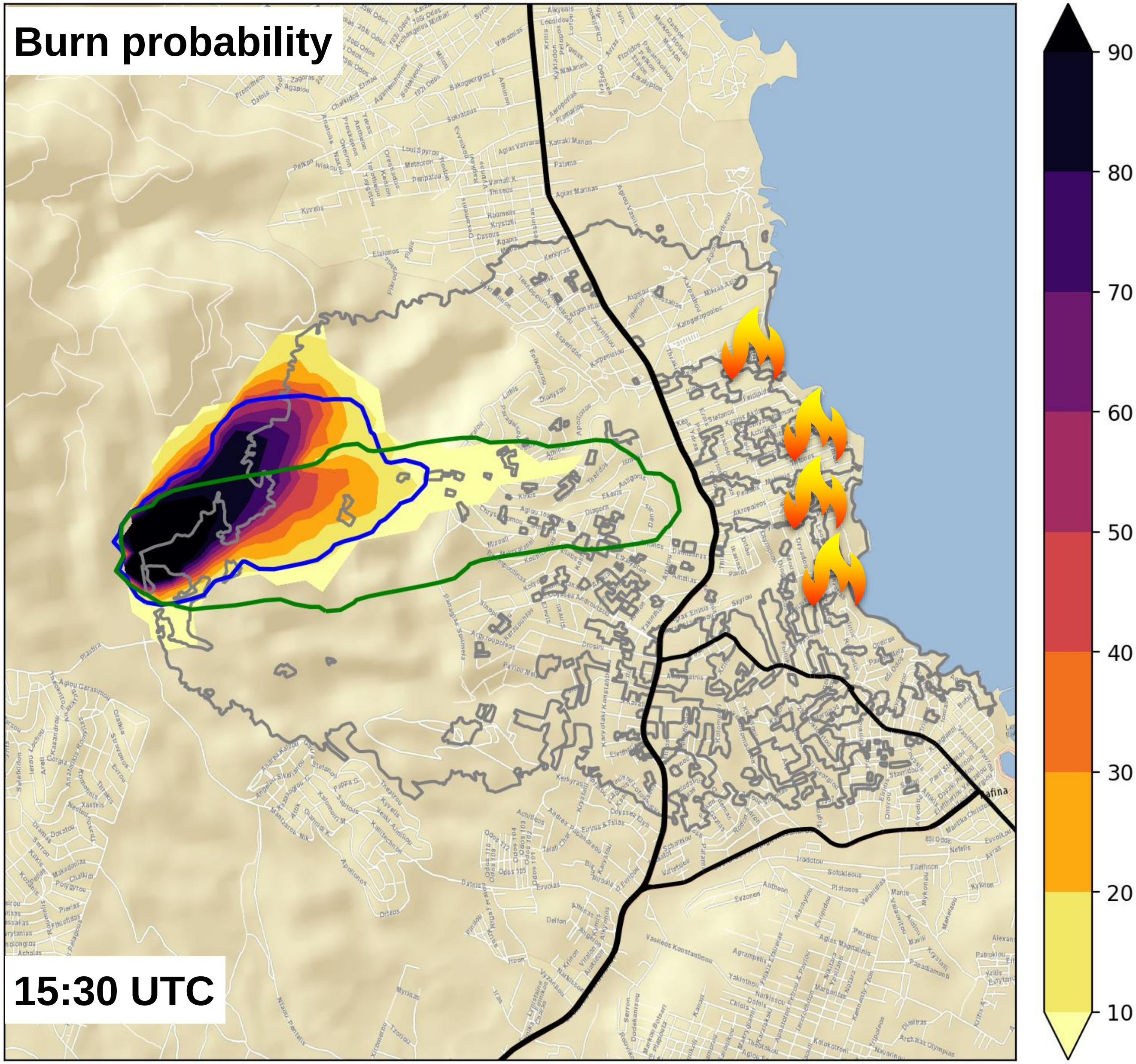
- **90m SRTM topography.**
- **100m fuel models (based on Copernicus Land Monitoring Service products).**

Fire spread simulated with the level-set method (Munoz-Esparza et al., 2018).

~10min integration time per 6h of forecast

IRIS: Results - T0+48

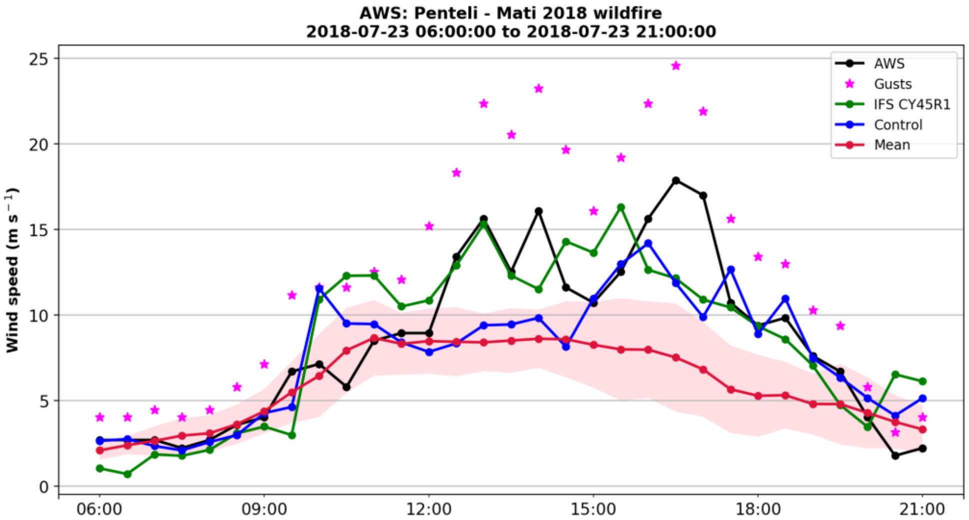
IRIS: Mati Wildfire - 100m
ECMWF EPS init.: 21/07/2018 12Z
Burn probability (shaded, %)
Green (contour): Deterministic | Blue (contour): Control
Valid: 23/07/2018 15:30Z

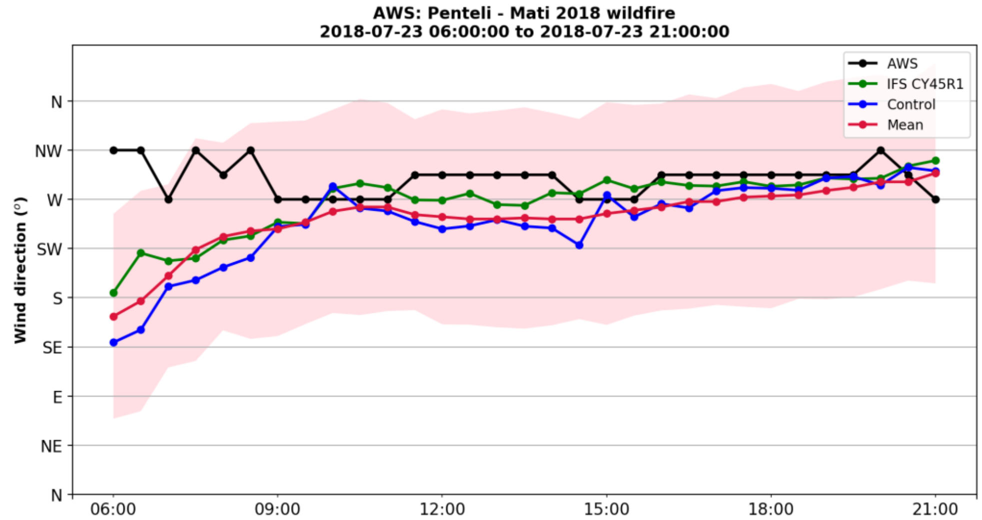


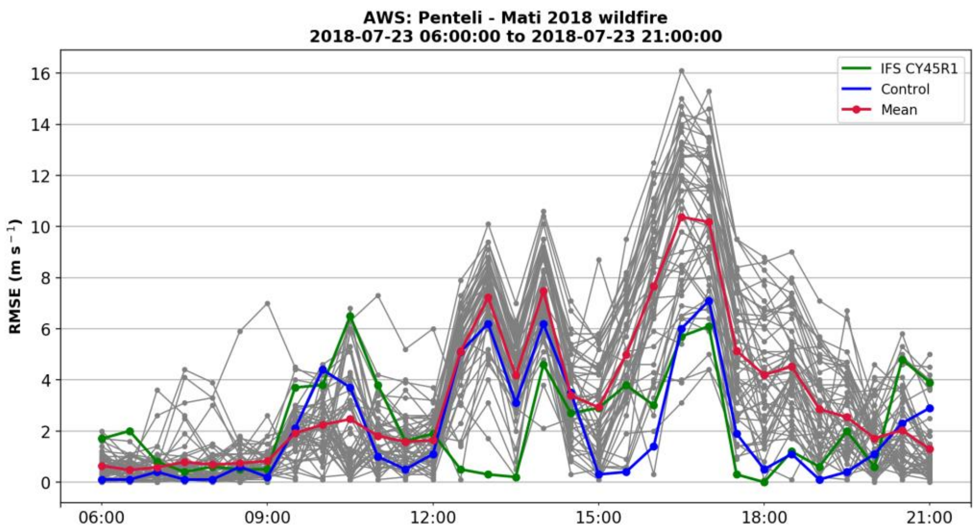
EPS fails to provide added-value guidance.

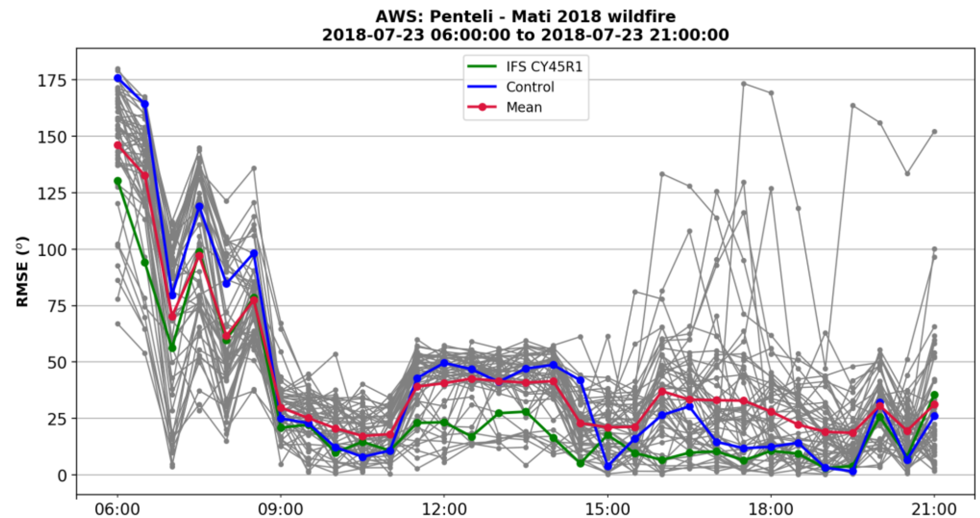
- **Limited fire spread.**
- **NE movement of the fire front.**

IRIS: Results - T0+48



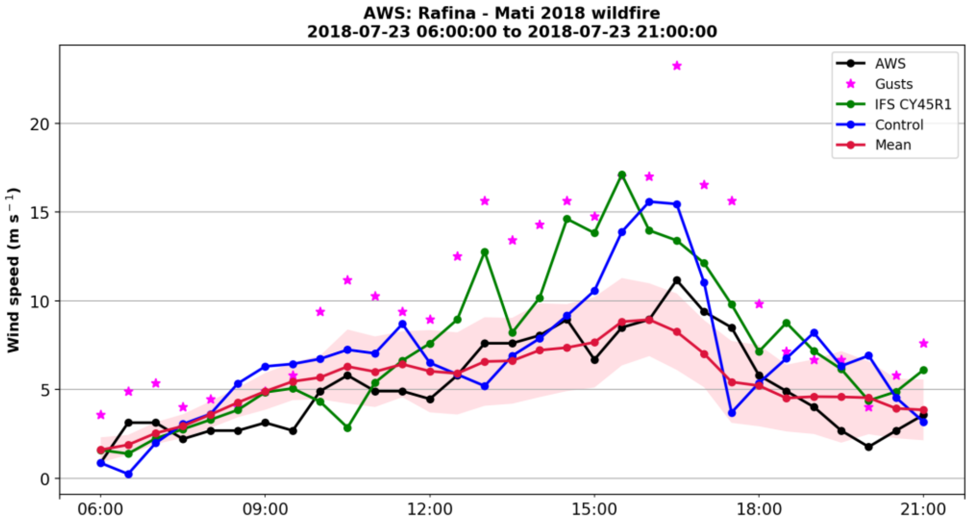


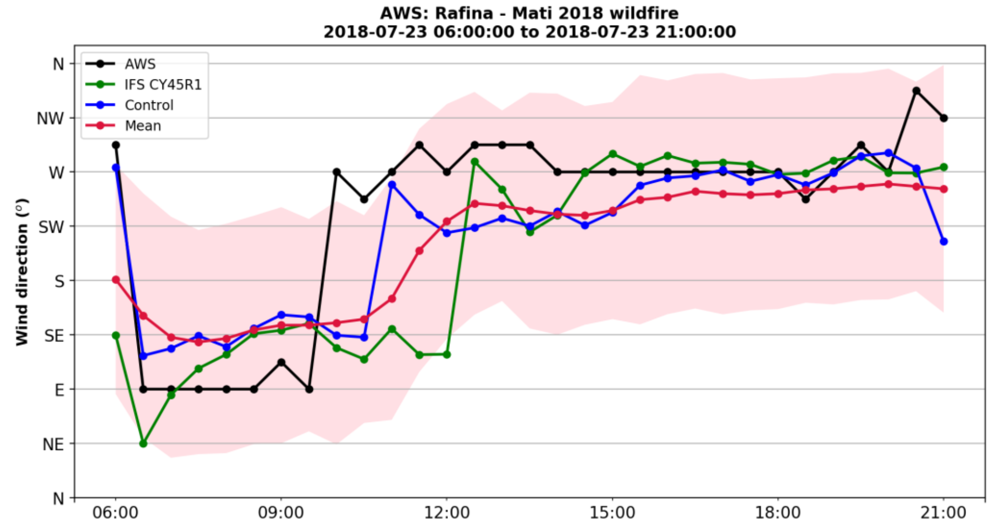


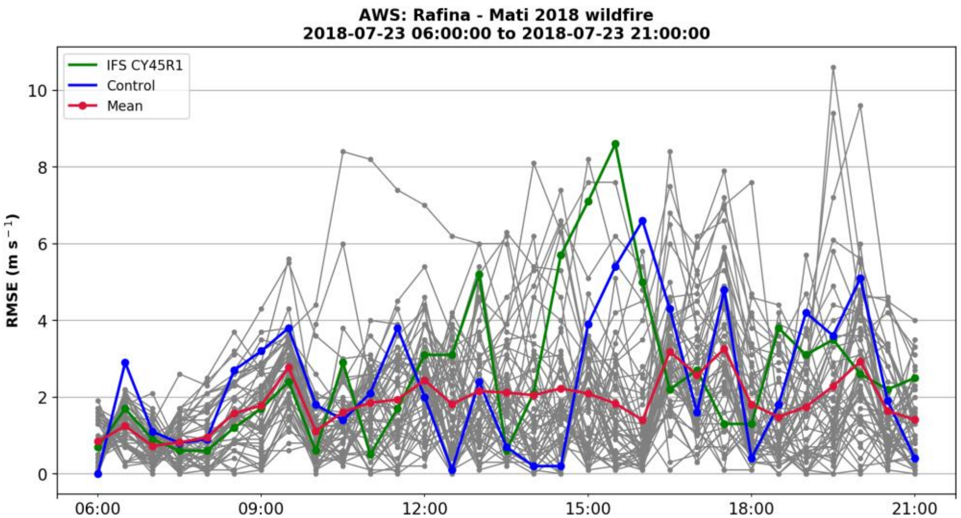


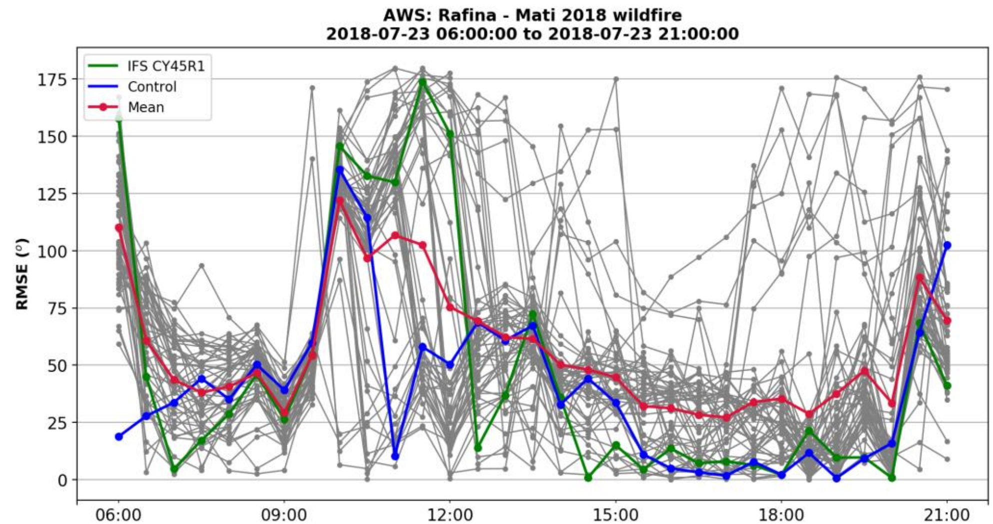
CY45R1: 3 m s^{-1}, 42.5^{o}
EPS: 4.2 m s^{-1}, 50.9^{o}

IRIS: Results - T0+48





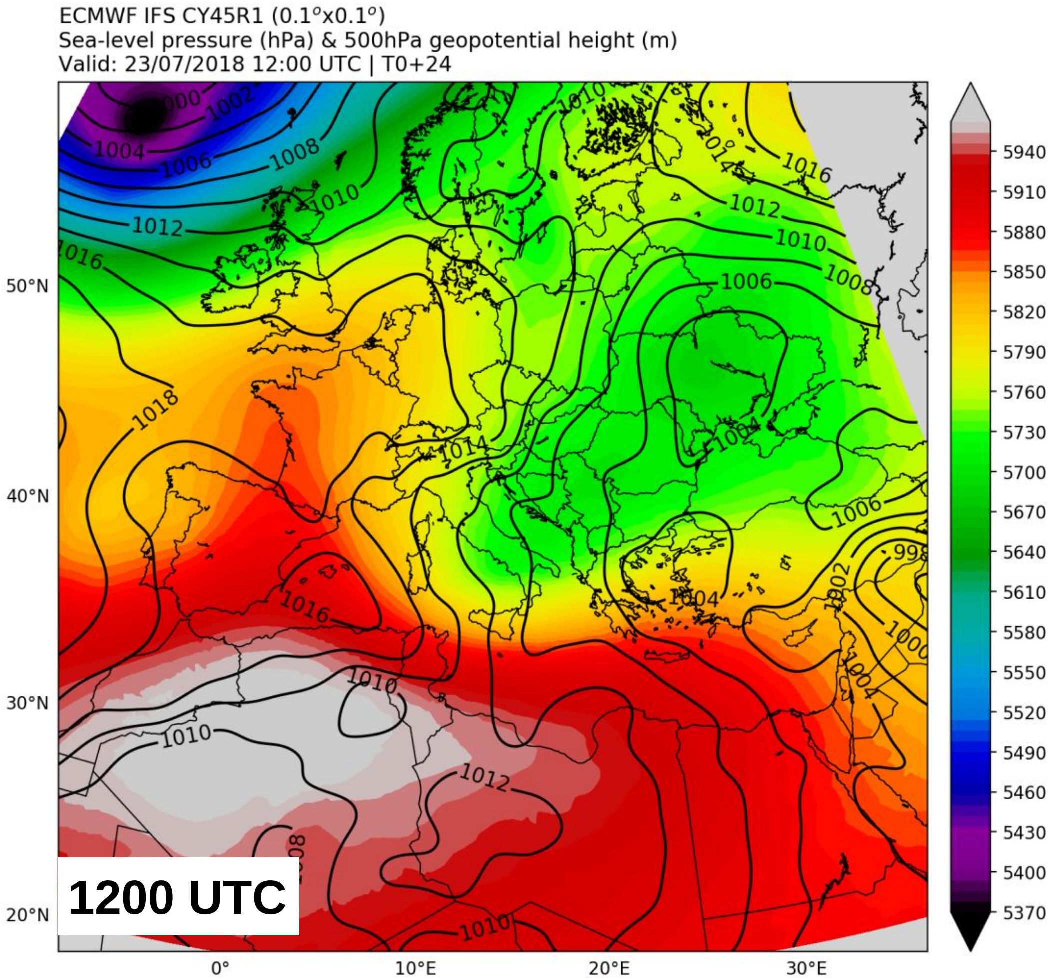


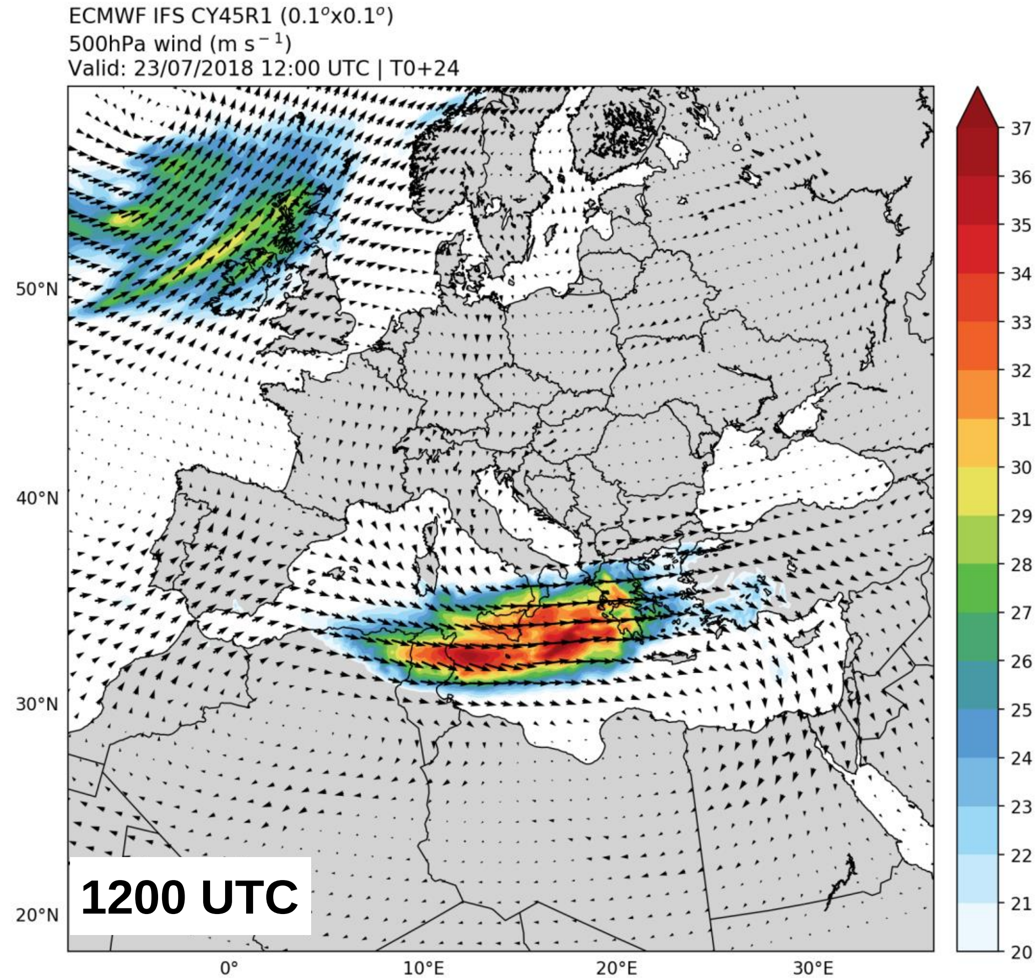


CY45R1: 3.3 m s^{-1}, 71.4^{o}

EPS: 1.5 m s^{-1}, 56.3^{o}

Deterministic outlook: T0+24





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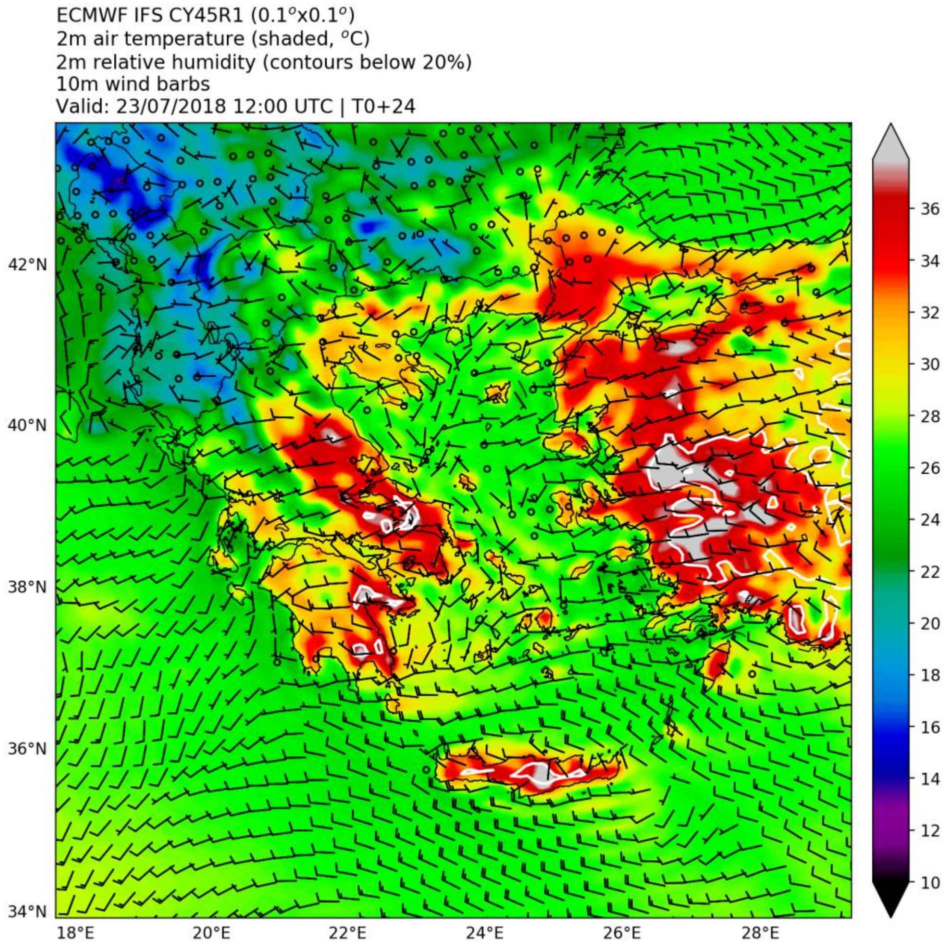
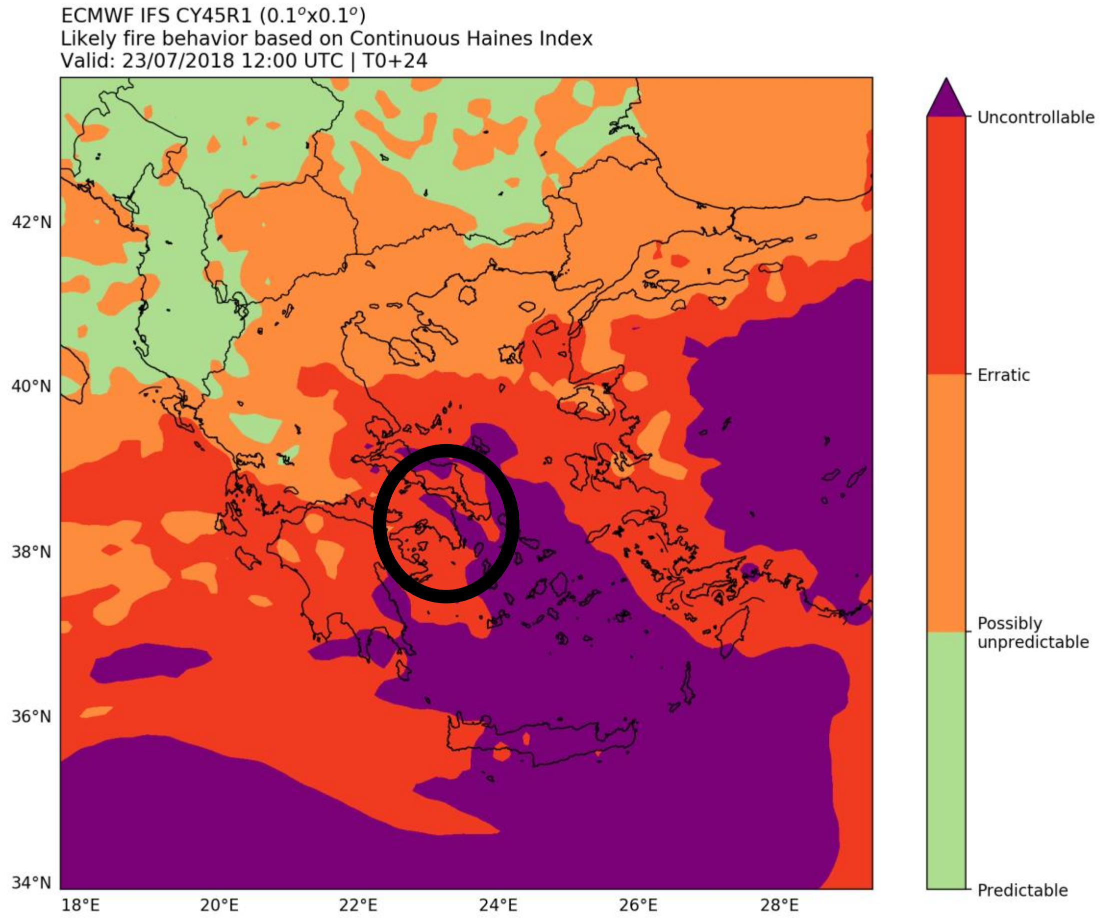


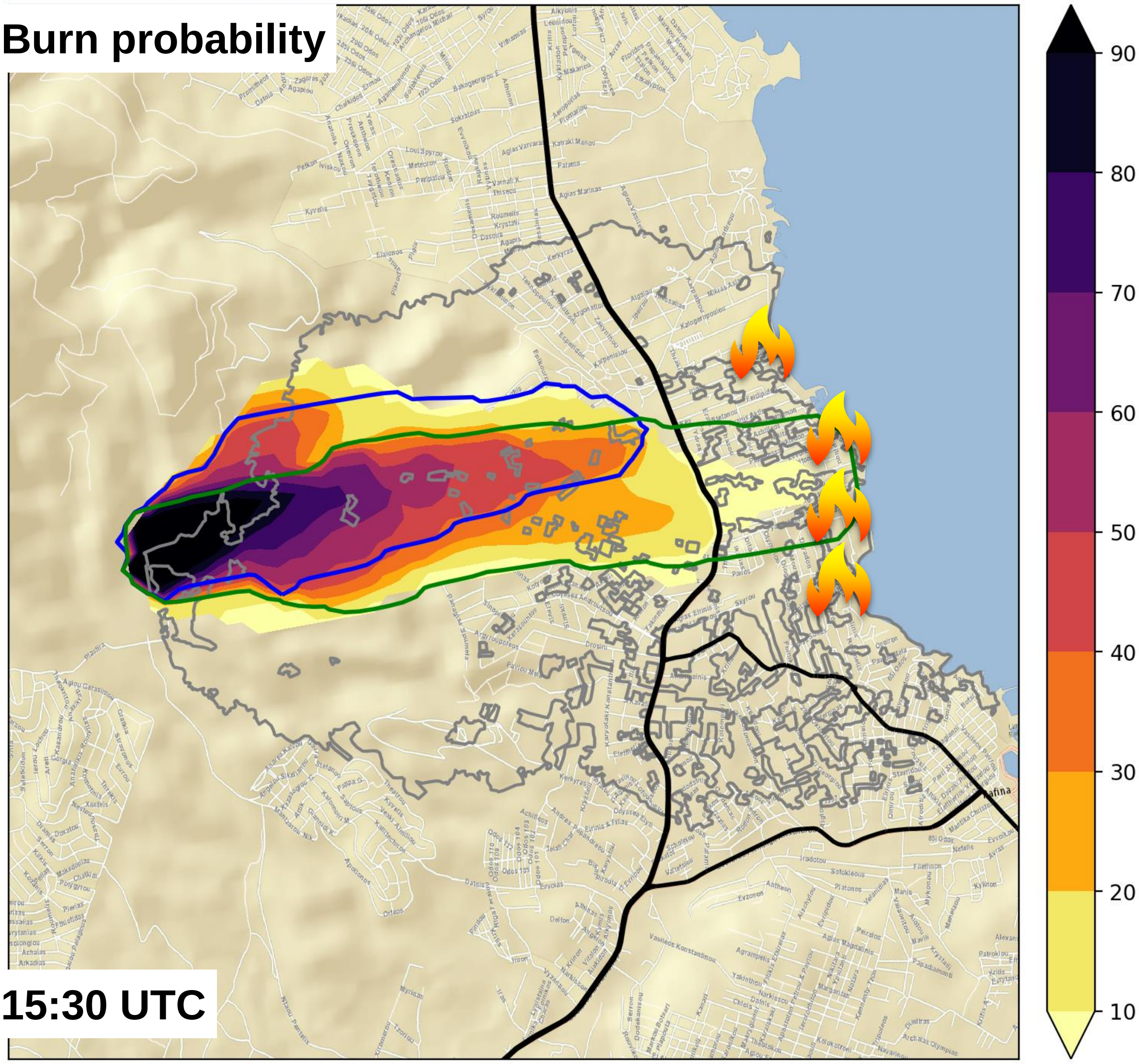


Deterministic forecast guidance for conditions highly conducive for extreme fire behaviour in Eastern Attica.

Trigger alarm for potentially dangerous conditions in Eastern Attica; Employ ECMWF EPS for gaining further insight.

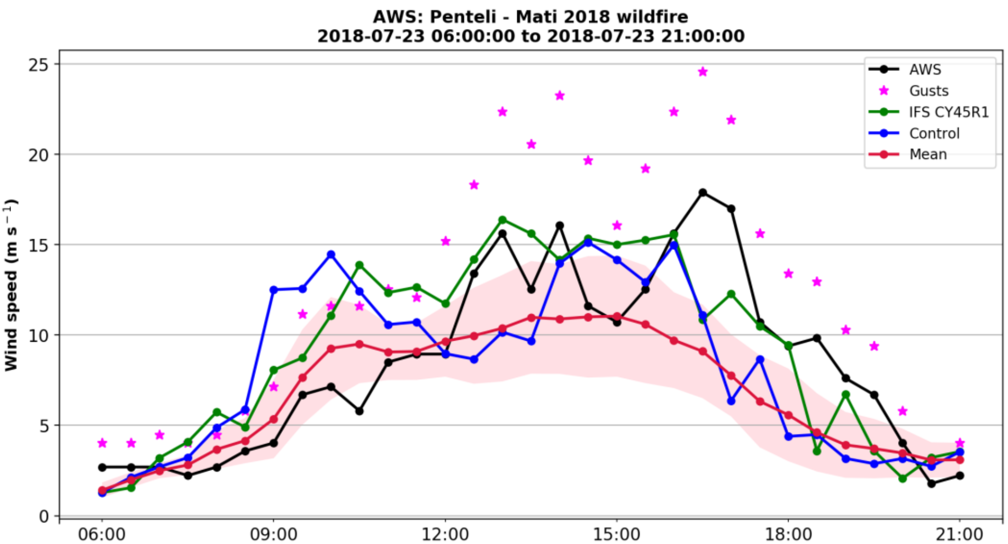
IRIS: Results - T0+24

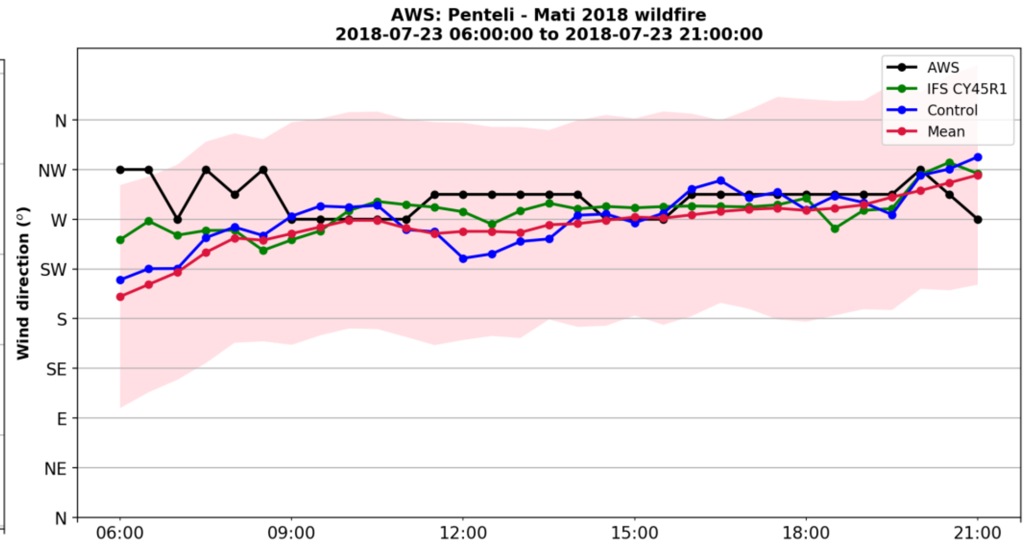
IRIS: Mati Wildfire - 100m
ECMWF EPS init.: 22/07/2018 12Z
Burn probability (shaded, %)
Green (contour): Deterministic | Blue (contour): Control
Valid: 23/07/2018 15:30Z

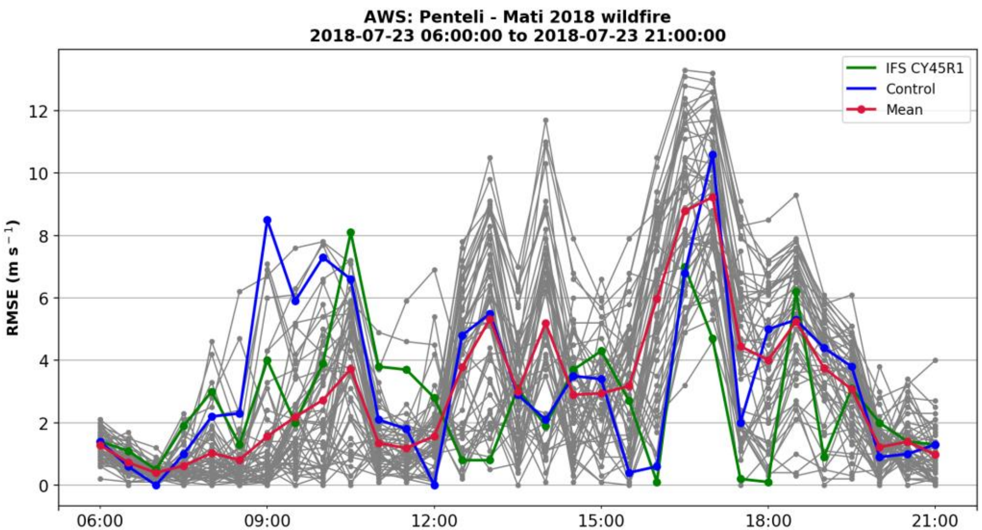


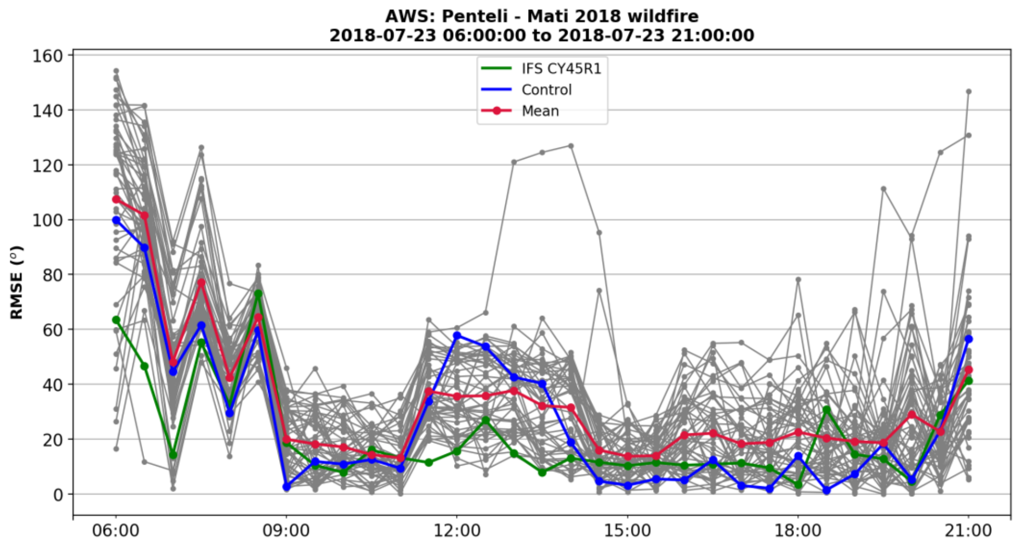
EPS shows larger lateral spread along the north flank of the fire front, while it also enhances the credibility of the deterministic forecast.

IRIS: Results - T0+24 [2]





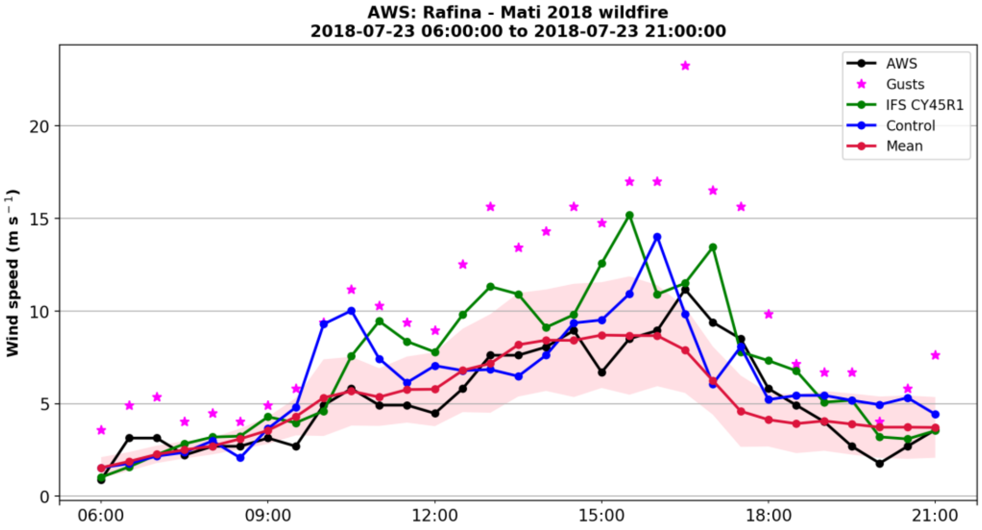


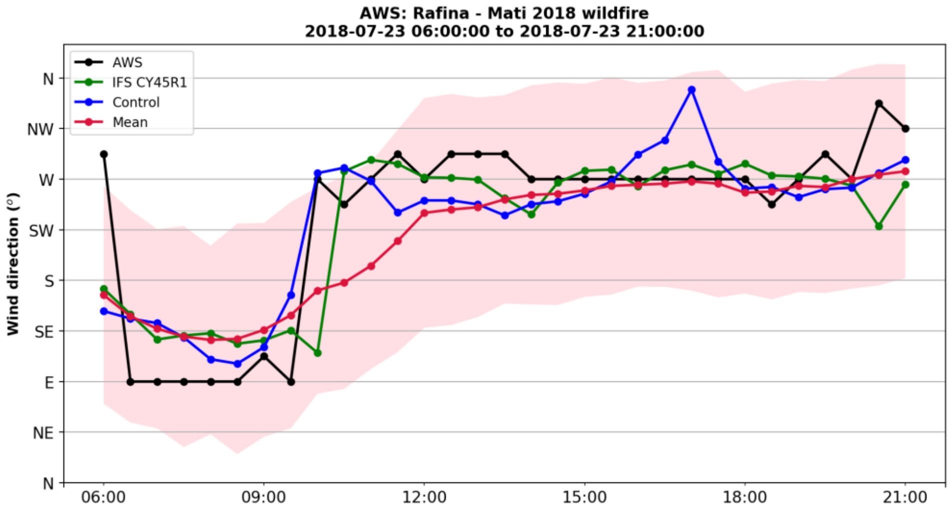


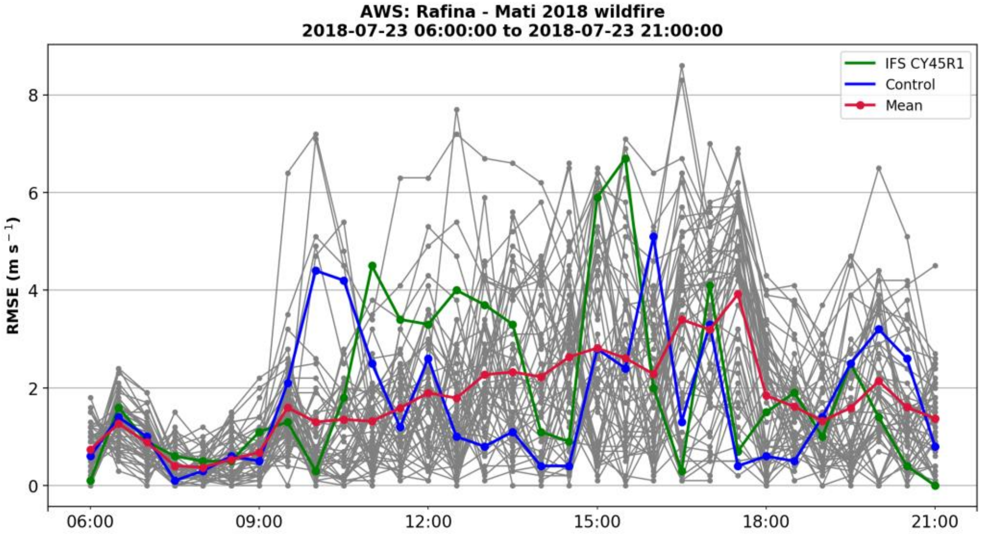
CY45R1: 3.3 m s^{-1}, 27.3^{o}

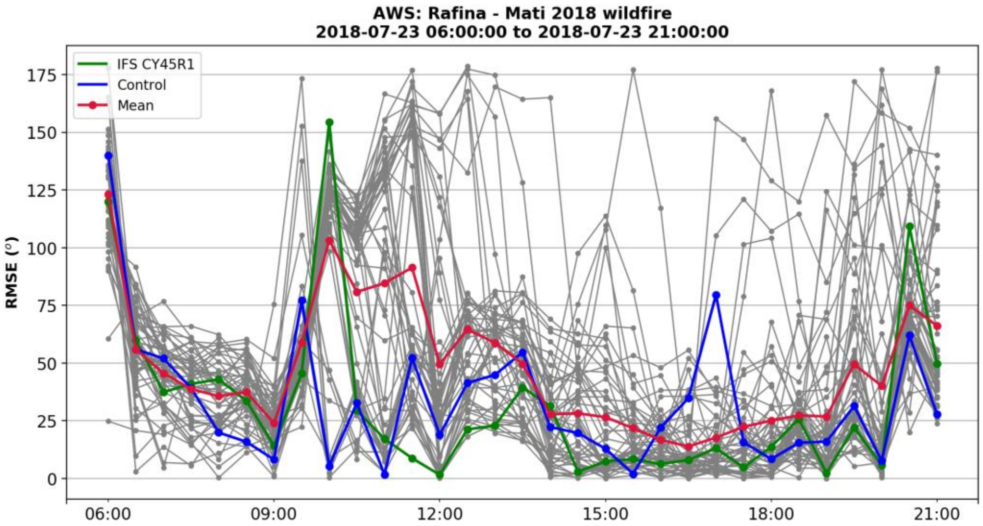
EPS: 3.5 m s^{-1}, 39.2^{o}

IRIS: Results - T0+24





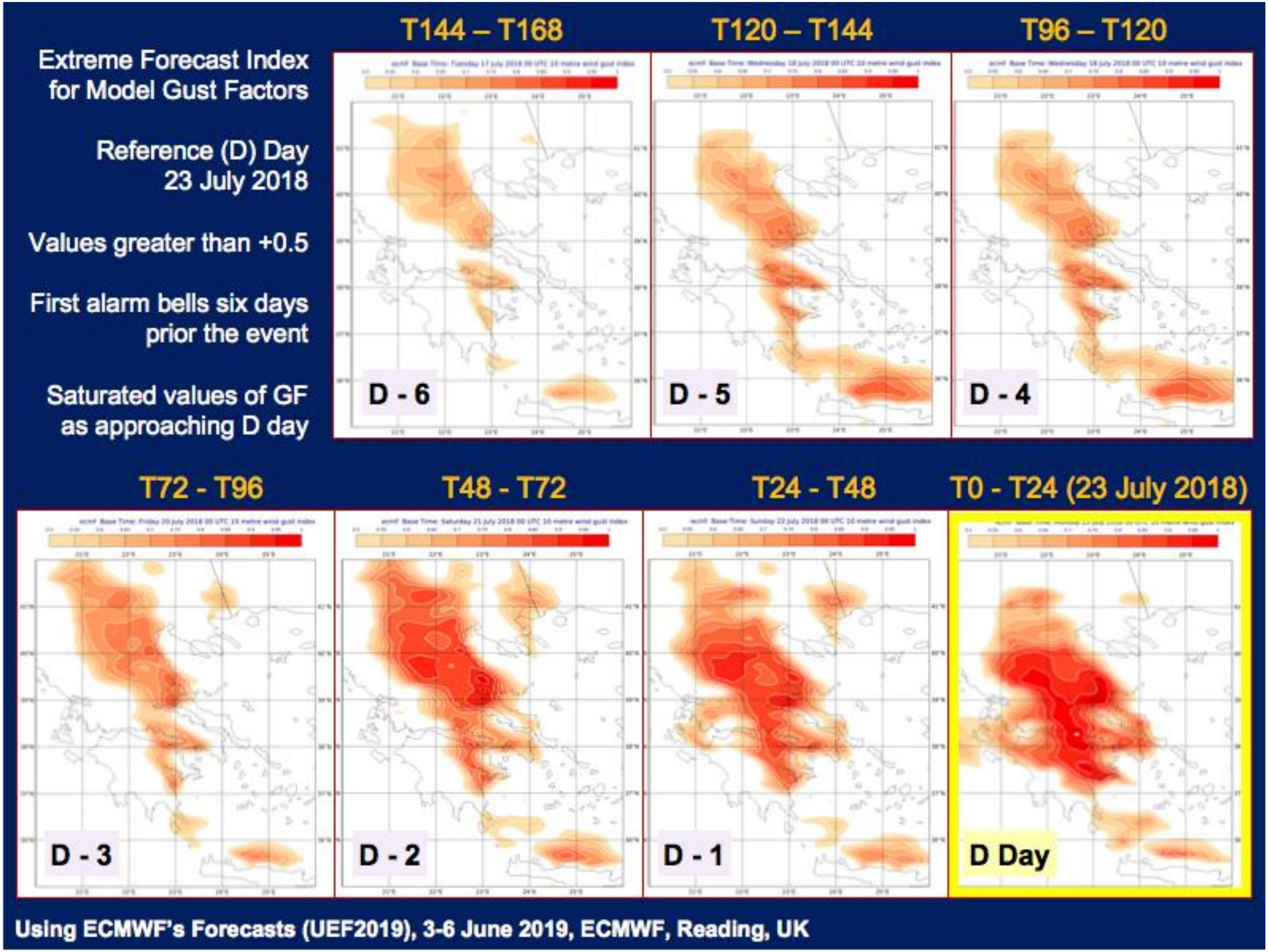




CY45R1: 2.6 m s^{-1}, 47.9^{o}

EPS: 1.4 m s^{-1}, 47.8^{o}

EPS: Alarm bells [1]

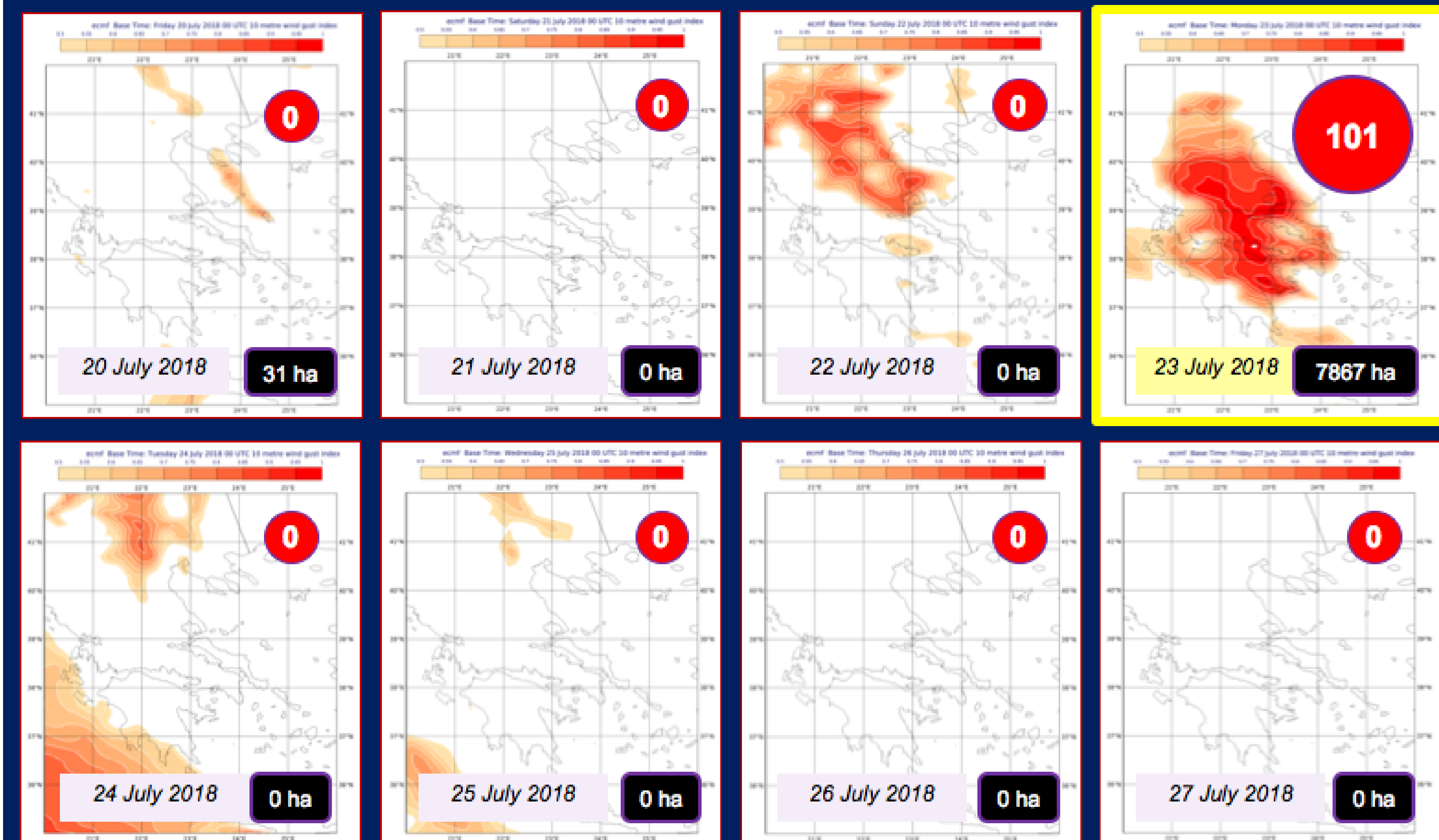


EPS: Alarm bells [2]

Extreme Forecast Index (EFI) T0-T24 Values (based on 00utc model run) of ECMWF EPS for Gust Factors (GF) of winds at 10-meter height that could be available to Fire Managers during morning hours for assessing the anticipated gusty behaviour of atmosphere flow

No. of Fatalities

Burned Area



Using ECMWF's Forecasts (UEF2019), 3-6 June 2019, ECMWF, Reading, UK

Summary - Conclusions - Future work

The coupled fire-atmosphere IRIS forecasting system was used for retrospectively forecasting the deadly Mati wildfire, driven by ECMWF deterministic and EPS data.

Preliminary results show that:

- The deterministic forecast outperformed EPS at both lead times: T0+48, T0+24.
- At T0+48, the EPS guidance is misleading (NE movement of fire front).
- At T0+24, the EPS is in line with the deterministic forecast, enhancing credibility.
- Extreme forecast index for gust factors could be used for early warning.

Overall, the present study shows no significant added-value provided by the use of EPS for driving a fire spread forecasting system. This is particularly true, considering the computational cost for running the probabilistic fire spread forecasts.

Preliminary results should be revisited by expanding the current study:

- More wildfires, covering a wide range of meteorological/fuel conditions.
- Include fire ignition location uncertainty in the ensemble forecasting.

Interreg Balkan-Mediterranean DISARM

EUROPEAN UNION

Meteo All about weather

Thank you for attention!

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