Data and tools to forecast wildfire danger - Copernicus Emergency Management Service (CEMS-Fire)

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Copernicus
The European Earth Observation Programme

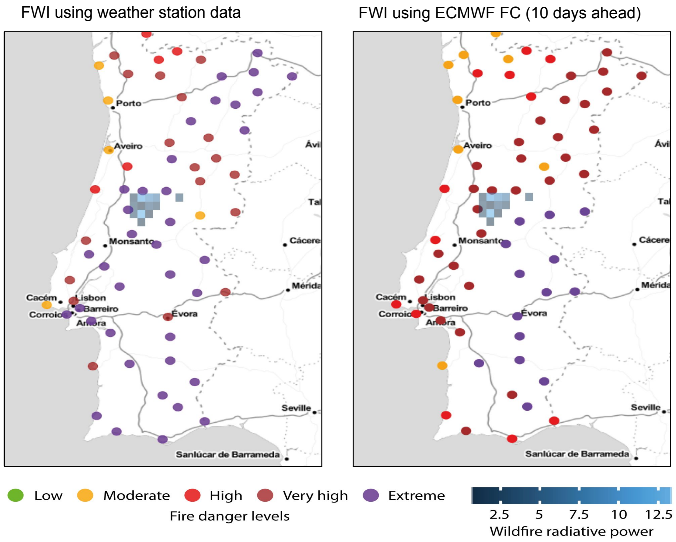
CEMS-Fire activities for proactive fire management practices

Monitoring and forecasting **fire weather**.

Monitoring fire weather can be done using weather station data, but the information is:

- Only available at discrete locations → CEMS provides homogeneous global coverage
- Only available for the current day → CEMS makes use of **ECMWF**'s IFS to forecast fire weather days/months in advanced

Fire weather:
weather conditions conducive of a dangerous fire, typically this includes high temperature, low humidity and strong winds, but other variables can play a role.



CEMS-Fire products are useful for:

- Early Warning Systems
- Decision makers
- Scientists/Researchers

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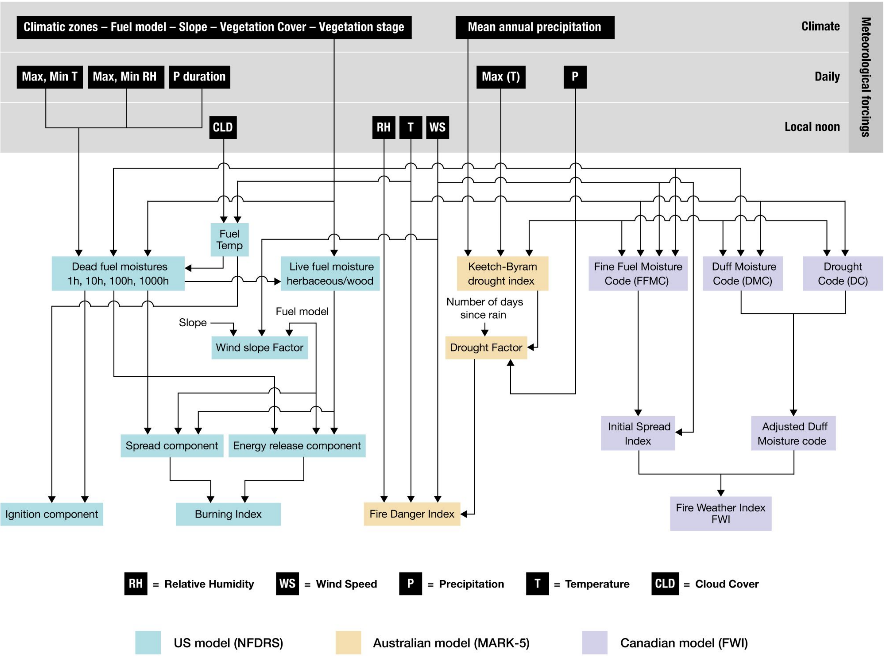
How do we measure danger related to fire weather?

Fire weather/danger => weather conditions conducive of a dangerous fire but conditional to an ignition to occur (only a potential danger!).

Three main systems:

- **Canadian Forest Fire Weather Index** (most widely used around the world)
- The U.S. Forest Service National Fire-Danger Rating System
- The Australian McArthur's Forest Fire Danger Meter

The **Global ECMWF Fire Forecasting (GEFF) system** implements the three systems.



*Di Giuseppe, F., Vitolo, C., Krzeminski, B., Barnard, C., Maciel, P., and San-Miguel, J.: "**Fire Weather Index: the skill provided by the European Centre for Medium-Range Weather Forecasts ensemble prediction system**", Nat. Hazards Earth Syst. Sci., 20, 2365–2378, https://doi.org/10.5194/nhess-20-2365-2020, 2020.*

*Di Giuseppe, Francesca, et al. "**The potential predictability of fire danger provided by numerical weather prediction**." Journal of Applied Meteorology and Climatology 55.11 (2016): 2469-2491.*

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Global ECMWF Fire Forecasting (GEFF) system - data offering

Climatological data sets, ~40 years of daily reanalysis**

- ERA5, ~28 Km resolution, 5 days behind real-time, using IFS cycle 41r2 (2016), ~50GB/index
  Vitolo, C., Di Giuseppe, F., Barnard, C. et al. ERA5-based global meteorological wildfire danger maps. Sci Data 7, 216 (2020). https://doi.org/10.1038/s41597-020-0554-z
- ERA-Interim, ~80 Km resolution, 2 months behind real-time, using IFS cycle 31r2 (2006), ~7.5GB/index
  Vitolo, C., Di Giuseppe, F., Krzeminski, B. et al. A 1980–2018 global fire danger re-analysis dataset for the Canadian Fire Weather Indices. Sci Data 6, 190032 (2019). https://doi.org/10.1038/sdata.2019.32

Medium-range forecasts, issued daily for 12 local noon, using IFS cycle 47r2 (May 2021)

Di Giuseppe, F., Vitolo, C., Krzeminski, B., Barnard, C., Maciel, P., and San-Miguel, J.: Fire Weather Index: the skill provided by the European Centre for Medium-Range Weather Forecasts ensemble prediction system, Nat. Hazards Earth Syst. Sci., 20, 2365–2378, https://doi.org/10.5194/nhess-20-2365-2020, 2020.

- High resolution* ~9 Km (1 realisation, 10 days lead time, ~3.6 GB/day)
- ENS prediction* ~18 Km (51 ensemble members, 15 days lead time, ~20 GB/day).
- Statistical indicators*: anomaly, ranking, Extreme Forecast Index (EFI) and Shift Of Tail (SOT)
- Experimental products**:
  - Hourly FWI (up to 3 days)
  - Probability of ignition from lightning

Seasonal forecast, to be issued monthly, 6 months lead time (work in progress)**

- Test development using ECMWF seasonal forecast S5
- Validation in collaboration with NASA

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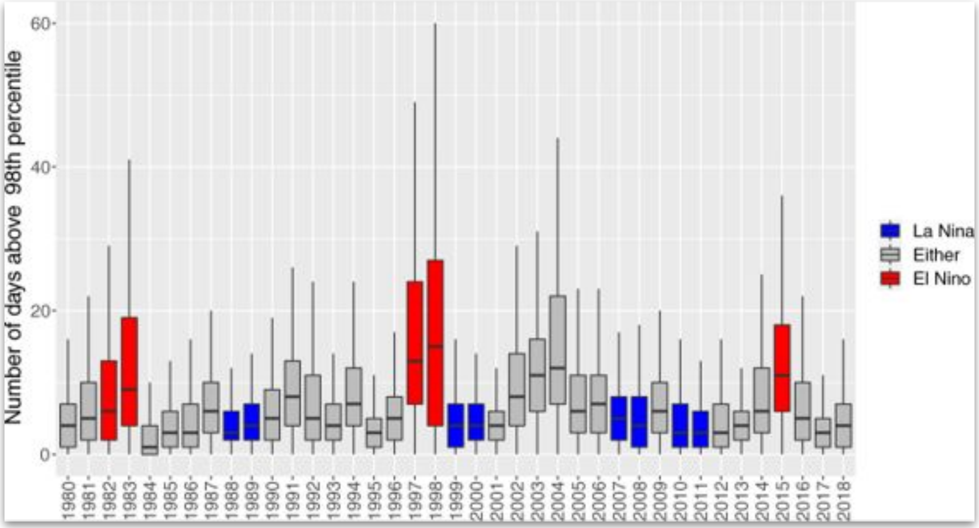
* EC-JRC products available under request from EFFIS/GWIS: https://effis.jrc.ec.europa.eu/apps/data.request.form/
Data also available in ECFS and from 2021 also in MARS (under JRC license)

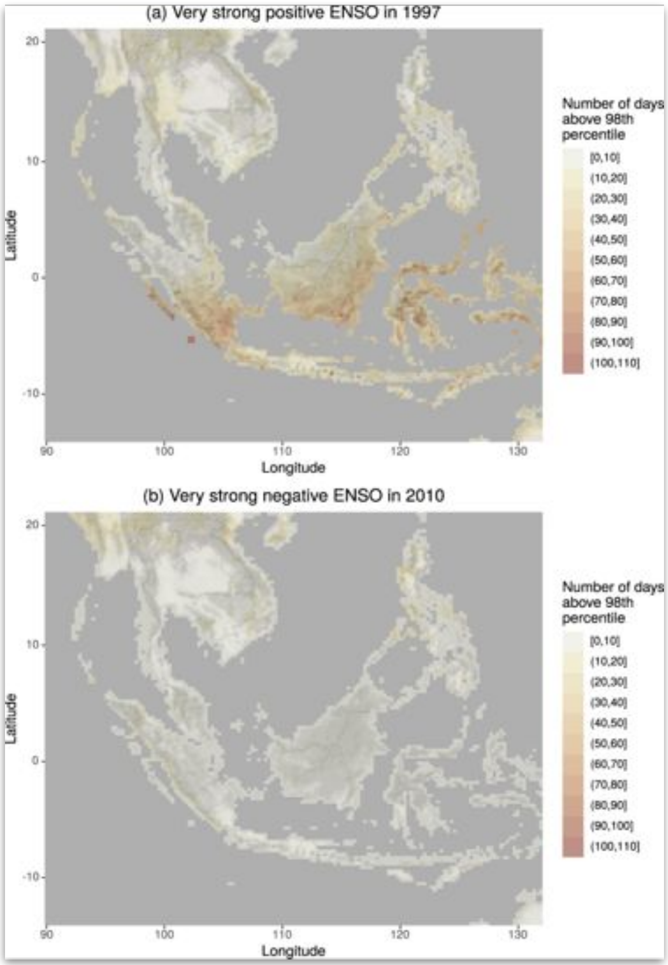
** Copernicus products available on the Climate Data Store: https://cds.climate.copernicus.eu/

Fire danger reanalysis

Used for:

- Fire regime changes
- Fire season modifications
- Identification of fire prone areas
- Climate teleconnection
- … and more

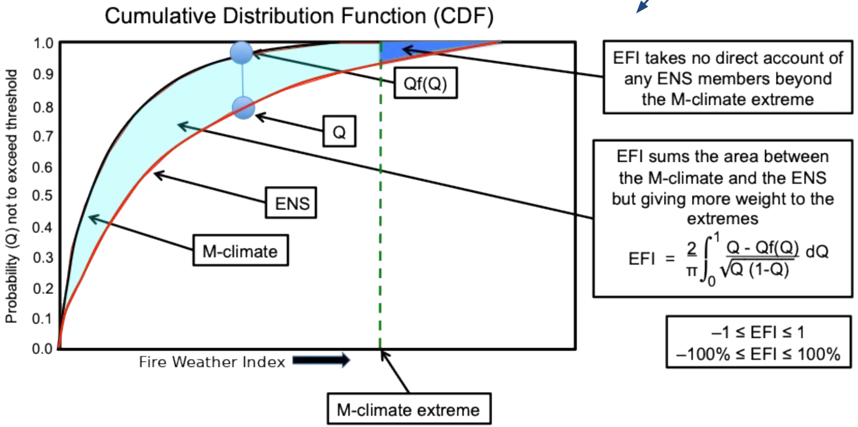


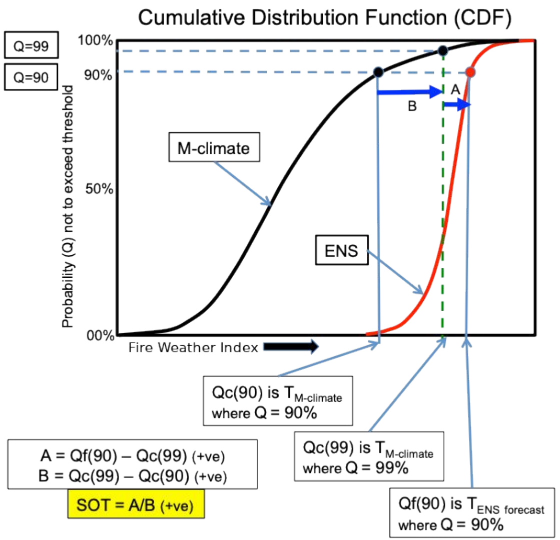


Vitolo, C., Di Giuseppe, F., Barnard, C. et al. **ERA5-based global meteorological wildfire danger maps.** Sci Data 7, 216 (2020). https://doi.org/10.1038/s41597-020-0554-z

Probabilistic products: anomaly, EFI and SOT

FWI is classified into 6 danger levels (from very low to extreme), however the thresholds that define these levels are often pre-defined, while different ecosystems would require a local calibration. When assessing extreme events, it is not advisable to rely on the raw FWI but refer to statistical indicators such as anomalies, Extreme Forecast Index (EFI) and the Shift Of Tail (SOT).





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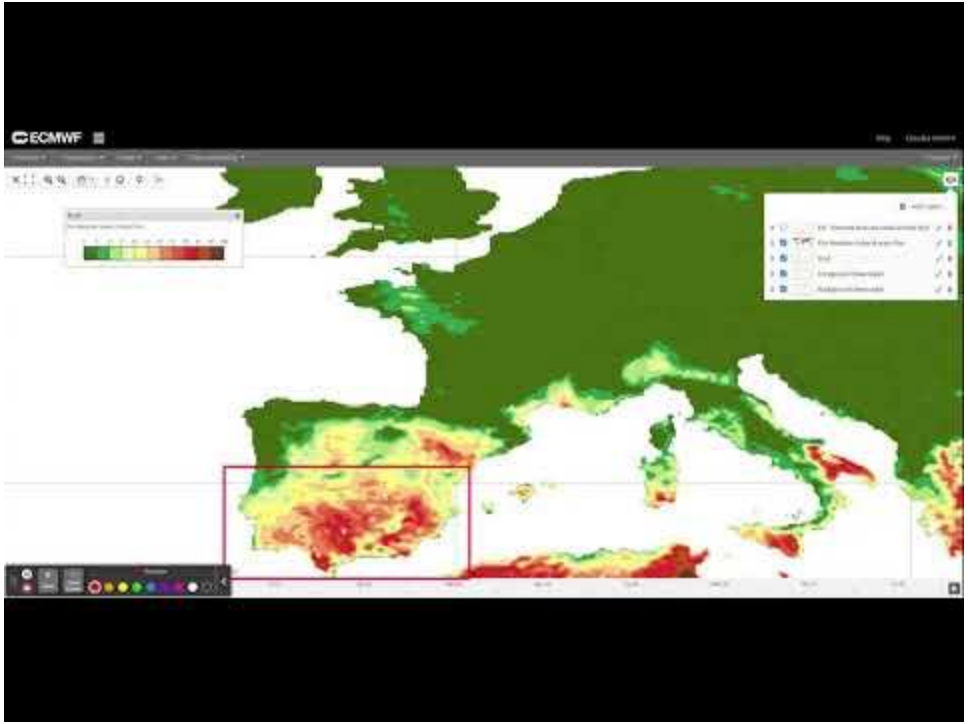
FWI vs EFI for identifying extreme events: an example



Link: https://youtu.be/cminxYStUGM

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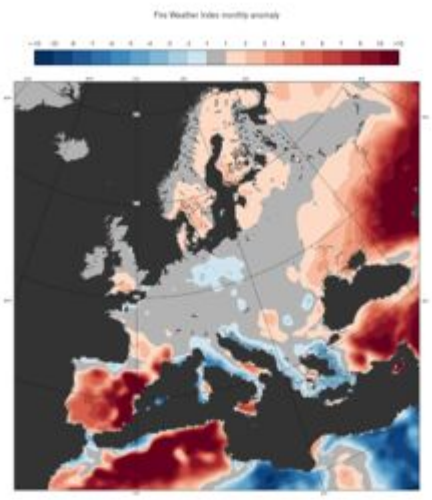
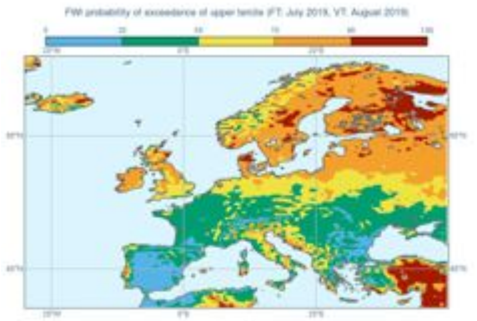
Seasonal forecast

- Forecast of monthly anomaly for the FWI are generated for up to 6 months ahead to provide an outlook of the likely fire danger conditions in the incoming period.
- The forecast is now produced in real time once a month.
- The anomalies are evaluated with respect to the climate defined in 1993-2016.

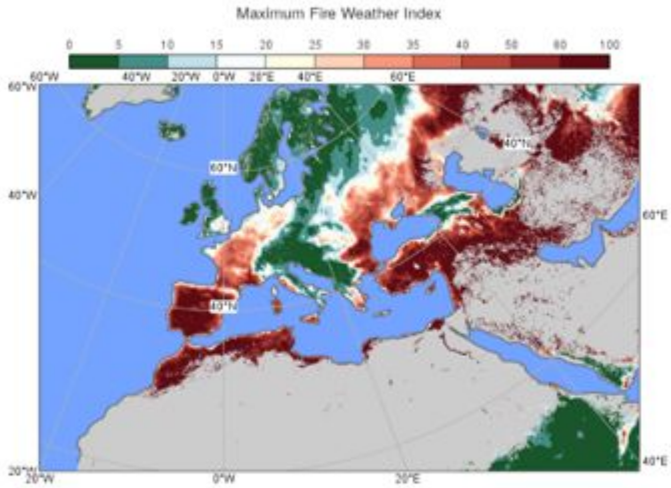


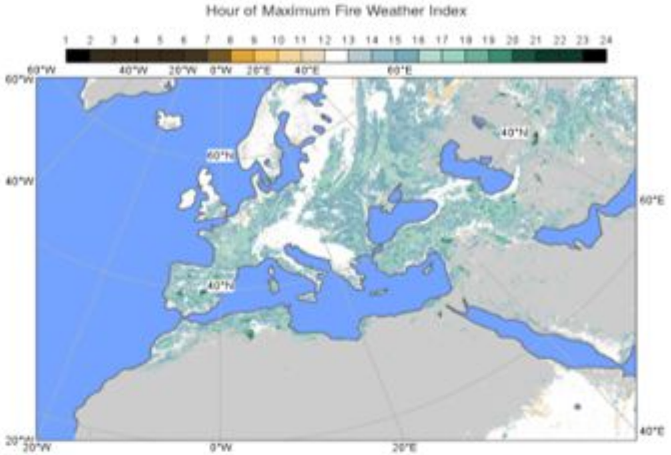


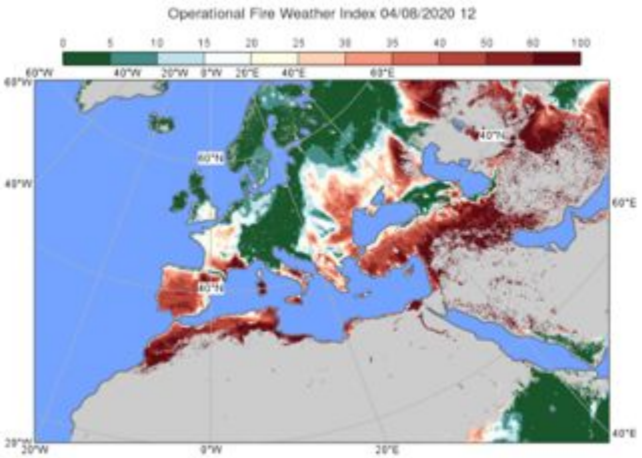
https://effis.jrc.ec.europa.eu/about-effis/technical-background/seasonal-forecast-explained

Experimental: Max hourly FWI for the day

- Maximum fire danger might not occur at 12 local time!
- 24 independent calculations are performed at different local time
- Forecast is re-initialised with the 12 local time forecast
- Maximum fire danger & time at which it occurs







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Experimental: Machine Learning model to predict ignition from lightning

- Dry lightning are more likely to ignite a fire than lightning associated with heavy precipitation
- The key predictors of natural ignitions are lightning, fuel availability and moisture content.

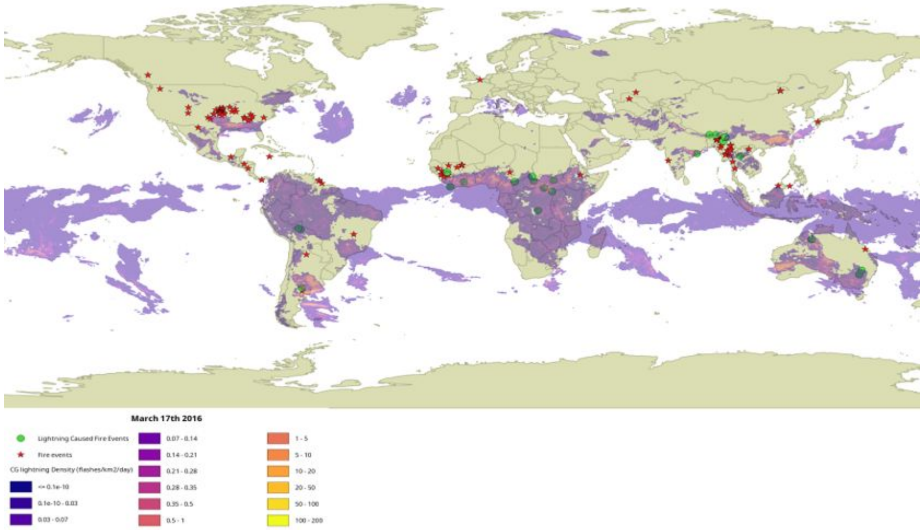

Photo by [Jonathan Bowers]() on [Unsplash]()

ECMWF

Coughlan, R, Di Giuseppe, F, Vitolo, C, Barnard, C, Lopez, P, Drusch, M. **Using machine learning to predict fire-ignition occurrences from lightning forecasts**. Meteorol Appl. 2021; 28:e1973. https://doi.org/10.1002/met.1973

Thank you!