Fire danger: the predictive skill provided by ECMWF Integrated forecasting System (IFS)

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ECMWF involvement in fire forecast

In 2000 the European Forest Fire Information System (EFFIS) became operation. It is a joint effort of the Joint Research Centre (JRC) and the Directorate General for Environment (DG ENV) of the European Commission (EC).

Lately it has been incorporated into the Copernicus Emergency Management Service.

Since the end of 2017 ECMWF is the Computational centre for the Copernicus Emergency Management Service-fire and provides the meteorological input and the forest danger indices for EFFIS and GWIS on a daily base.
ECMWF Fire Forecast system

Climatic zones – Fuel model – Slope – Vegetation Cover – Vegetation stage

Mean annual precipitation

Climate

Meteorological forcings

Local noon

Daily

Max, Min T  Max, Min RH  P duration

Max (T)  P

CLD  RH  T  WS

Dead fuel moistures 1h, 10h, 100h, 1000h

Fuel Temp

Live fuel moisture herbaceous/wood

Fuel model

Slope

Wind slope Factor

Spread component

Energy release component

Ignition component

Burning Index

Fire Danger Index

Keech-Byram drought index

Number of days since rain

Drought Factor

Fine Fuel Moisture Code (FFMC)

Duff Moisture Code (DMC)

Drought Code (DC)

Initial Spread Index

Adjusted Duff Moisture code

Fire Weather Index FWI

RH = Relative Humidity  WS = Wind Speed  P = Precipitation  T = Temperature  CLD = Cloud Cover

US model (NFDRS)  Australian model (MARK-5)  Canadian model (FWI)
Datasets (not-) available from ECMWF fire forecasting system

**Climatological dataset**

38 years of Re-analysis (Available and downloadable)
- 80 Km resolution
- Daily data
- FWI indices only

https://zenodo.org/communities/wildfire

**Realtime - up to 15 days ahead (Available but not openly distributed)**

Daily outputs using latest version of IFS model cycle
1. High resolution ~9km globally
2. ENS prediction (51 ensemble members at 18km).

Only available through ECMWF dissemination service/not publically open. A selection downloadable through the EFFIS website.

**Extended range forecast - up to 7 months ahead (Not available)**

Plan is to develop a system using latest version of ECMWF seasonal forecast S5
ECMWF Fire Forecast model - Open Source

Global ECMWF Fire Forecasting (GEFF) model

Maintainer: Francesco Di Giuseppe, please report any issues or bugs to francesco.digiuseppe@ecmwf.int.

The Global ECMWF Fire Forecasting (GEFF) model is a Fortran-95 program to calculate fire danger indices from atmospheric inputs. It implements the Fire Weather Index, the National Fire Danger Rating System and the Mc-Arthur ratings in one single infrastructure. While it was principally designed for gridded data, it can operate with any kind of inputs.

Content:
- docs/documentation
- src/source code
- tests/script for launching an example run
- data/sample input data (please note, CR404short and other inputs will need to be locally available)

Meta:
- This software and functions herein are part of an experimental open-source project. They are provided as is, without any guarantee.
- Please note that this project is released with a Contributor Code of Conduct. By participating in this project you agree to abide by its terms.
- License: APACHE2
- If you use this software, please cite the following paper:

https://software.ecmwf.int/stash/projects/CEMSF/repos/geff/browse
calive-R package
Calibration and verification package for gridded fire danger input

Table 7. Fire danger levels for selected areas.

<table>
<thead>
<tr>
<th>Area of interest</th>
<th>Very low</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Very high</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>&lt;= 2</td>
<td>3 – 4</td>
<td>5 – 9</td>
<td>10 – 16</td>
<td>17 – 28</td>
<td>&gt; 28</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>&lt;= 1</td>
<td>2 – 3</td>
<td>4 – 6</td>
<td>7 – 11</td>
<td>12 – 18</td>
<td>&gt; 18</td>
</tr>
<tr>
<td>Spain</td>
<td>&lt;= 2</td>
<td>3 – 6</td>
<td>7 – 14</td>
<td>15 – 28</td>
<td>29 – 52</td>
<td>&gt; 52</td>
</tr>
<tr>
<td>Italy</td>
<td>&lt;= 2</td>
<td>3 – 5</td>
<td>6 – 11</td>
<td>12 – 21</td>
<td>22 – 38</td>
<td>&gt; 38</td>
</tr>
<tr>
<td>Calabria Region (IT)</td>
<td>&lt;= 2</td>
<td>3 – 5</td>
<td>6 – 12</td>
<td>13 – 22</td>
<td>23 – 40</td>
<td>&gt; 40</td>
</tr>
<tr>
<td>Sicily (IT)</td>
<td>&lt;= 2</td>
<td>3 – 6</td>
<td>7 – 13</td>
<td>14 – 26</td>
<td>27 – 48</td>
<td>&gt; 48</td>
</tr>
<tr>
<td>Liguria Region (IT)</td>
<td>&lt;= 1</td>
<td>2 – 4</td>
<td>5 – 8</td>
<td>9 – 15</td>
<td>16 – 25</td>
<td>&gt; 25</td>
</tr>
<tr>
<td>Province of Genoa, part of Liguria Region</td>
<td>&lt;= 2</td>
<td>3 – 4</td>
<td>5 – 9</td>
<td>10 – 16</td>
<td>17 – 27</td>
<td>&gt; 27</td>
</tr>
</tbody>
</table>

Journal paper:

Repository on GitHub: https://github.com/ecmwf/caliver
Where FWI approach is likely to be more accurate to detect fire danger: reanalysis 2000-2015

Extremal Dependence Index (EDI) for the Fire Weather Index (FWI). The EDI skill score is calculated using the fire mask derived from the burnt areas of the GFED4 dataset.

A fire is considered to have been forecasted when the FWI is above > 75% of its distribution.

EDI = 1 perfect forecasts
EDI = 0 random forecasts.

Probability of detection 2 -6 days forecast in 2017

POD = hits / (hits + misses)

Very rough overview of potential usability of weather forecast for fire danger detection

Di Giuseppe, F et al. "Fire Danger: the skill provided by ECMWF ensemble prediction system." submitted Environment international
Looking into the fire forecasting system - California Fire 2017

The 2017 California wildfire season was the most destructive wildfire season on record, which saw multiple wildfires burning across California. A total of 9,133 fires burned 1,381,405 acres (5,590.35 km²), according to the California Department of Forestry and Fire Protection, including five of the 20 most destructive wildland-urban interface fires in the state's history.

State data showed that the large wildfires killed 43 people – 41 civilians and 2 firefighters - higher than the previous 10 years combined.
The accuracy of a global model compared to local observations

FWI comparison between ERA-I and weather stations data (2017-California)

ACC >0.85 in all stations
Calibration can correct the bias

Credits: Claudia Vitolo
Exploiting the information from the ensemble prediction

California fire (8-11 October 2017)

Five-day EFFIS (GEFF) fire danger forecast for 09/10/2017

Observed fires
“Fire -gram”

The higher resolution did not capture the “Extreme conditions”

Fire Weather Index distribution at one location where fire raged out of control the 8th of October. California Fire 8 October 2017

1 Location @ [38 34'N; 122 34' W]

Di Giuseppe, F et al. "Fire Danger: the skill provided by ECMWF ensemble prediction system." Journal of Applied Meteorology and Climatology (2018); to be submitted
The added skill provided by the ensemble prediction system is, in this case, better than the HRES.

California Fire 8 October 2017
1 Location @ [38 34'N; 122 34' W]

Skills from the distribution of the ENS prediction system is, in this case, better than the HRES.

Links between CAMS and CEMS: from fire forecasts to emissions

10-day forecasts of fire danger, calibrated for central Sweden between 10 July and 9 August 2018.

c/o C. Vitolo, F. di Giuseppe (ECMWF)

Fire danger classes calculated with ECMWF Fire Forecast (GEFF) System.

Featured in Euronews interview with C3S senior scientist Freja Vamborg.

Daily forecasts available via CEMS EFFIS (for Europe) and GWIS (globally).
Conclusions

• ECMWF is producing fire forecast on a daily base.
• Software and datasets are available

• Fire forecasting based on weather predictions can be less accurate than using local observations
  – Mitigation through warning level calibration
  – The advantage of the Information provided by the ensemble in decision making

Improve the distribution of fire products. Best way it to get into the climate data store?

Extended range forecast especially for the global forecast