

# A robust scientific workflow for assessing fire danger levels using open-source software



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## Background

The Canadian Fire Weather Index (FWI) danger rating system integrates weather information with an evaluation of the vegetation state in terms of fuel availability and its hygroscopic status to mark favorable conditions for fire ignition, spread and suppression. The FWI is composed of six indices which measure an aspect of fire danger and is expressed as a numeric rating. Rating rise as fire weather becomes more severe. By construction, the relationship between the FWI numerical values and the physical properties of the vegetation is weak and the FWI requires the definition of danger levels (*calibration*) to become a meaningful tool in fire management. The warning levels suggested by the original FWI were derived to describe fires in a standard jack pine stand typical of the Canadian forests. As a consequence, *the definition of local danger classes is a crucial part of the applicability of the FWI in other parts of the world.*

The caliver R package implements a calibration methodology to derive site specific danger classes. The methodology relies on the distribution and range of values from historical simulations which span almost 40 years. We do not intent to replace the local knowledge often available through long established practices and experience at many different national forest fire authorities, but rather to support existing national fire management programs by providing:

- an independent validation based on advanced numerical weather models
- a common international metric during times of cross-boundaries fire disasters.

Having this final aim in mind the algorithm has been implemented as open-source software and made available with an open license. Also, opening the code to the scrutiny of other experts increases the chances to implement more robust solutions and avoids duplication of efforts.

## Proposed approach

In this work we present our contribution to the forest fire modelling community: an open-source tool called "caliver" for the **calibration** and **verification** of forest fire model results. This tool is developed in the R programming language and publicly available under an open license (GPL-2). Below is a typical workflow:

### 1. Install/load the library

The caliver package is available from a public repository (Vitolo and Di Giuseppe and Mirko D'Andrea, 2017). The installation depends on a number of external libraries: the Climate Data Operators (CDO), a large tool set for working on climate and NWP model data), the Geospatial Data Abstraction Library (GDAL, a translator library for raster and vector geospatial data formats), the NetCDF4 library (netcdf4). Once these libraries are available, the package can be installed as follows:

```
> devtools::install_github("ecmwf/caliver")
> library("caliver")
```

### 2. Decompress and merge files over the time dimension

Given a folder containing compressed archives, the code below decompresses the files and merges them along the time dimension:

```
> decompress_gz("/home/forestfire")
> mF <- stack_netcdf_files("/home/forestfire")
```

### 3. Calculate and plot quantiles

Given a netcdf file with 3 dimensions (lat, lon and time), we can calculate quantiles (over time) cell by cell. The command below generates two probability maps corresponding to the 75<sup>th</sup> and 99<sup>th</sup> percentiles.

```
> probsMaps <- get_percentile_raster(mF, probs = c(75, 99))
```

The maps can be plotted over a background as follows (see Figure 1):

```
> plot_percentile_raster(maps = probsMaps)
```

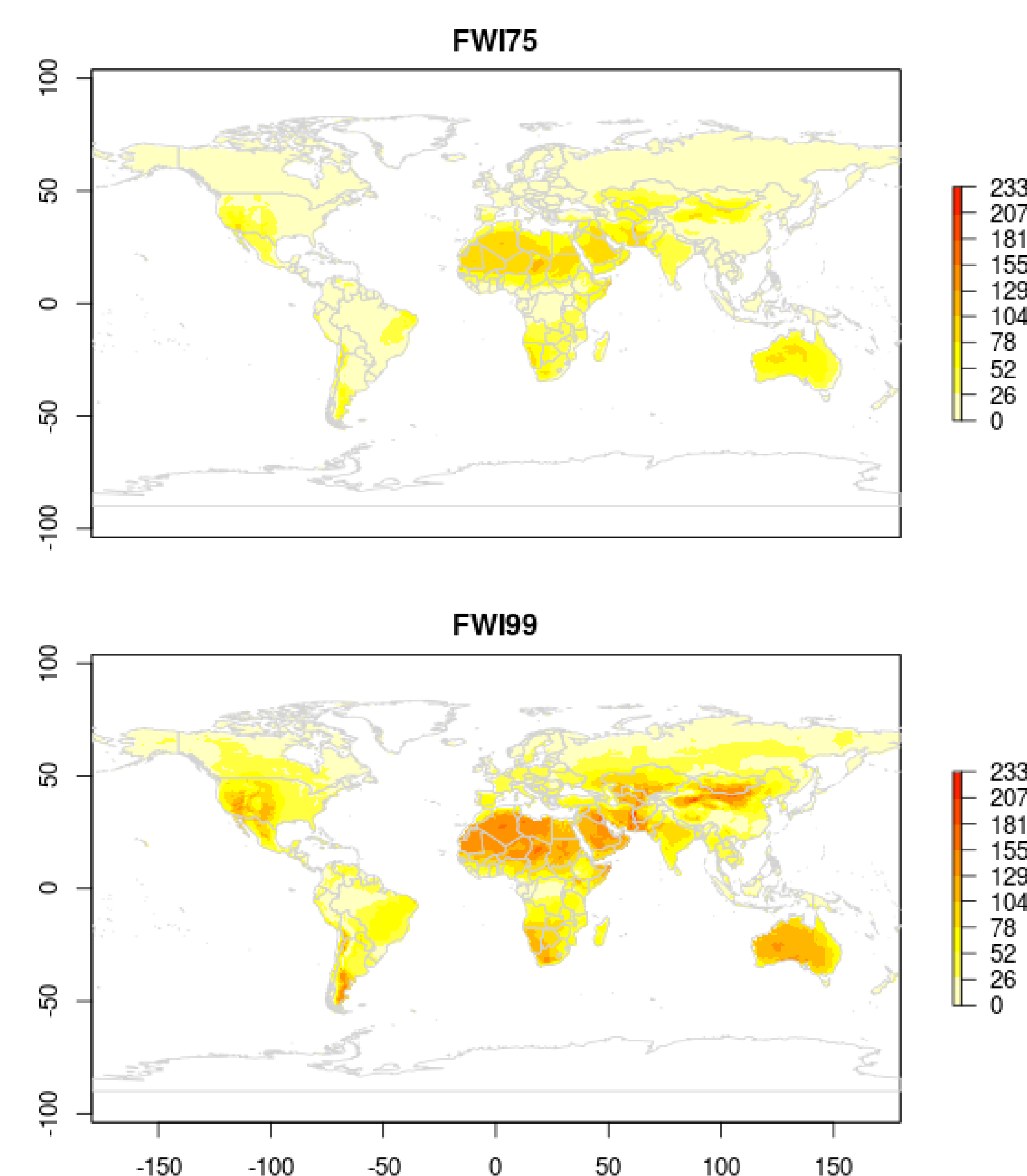


Figure 1: Maps of percentiles

### 4. Danger classes by country

Based on the mean number of days with extreme conditions and the length of the fire season, a methodology has been implemented to identify fire danger classes (Di Giuseppe and Vitolo, 2017). These classes can be calculated by country or based on custom regions (e.g. the regions defined by the Global Fire Emission Database, see [www.globalfiredata.org](http://www.globalfiredata.org)).

As an example, Table 1 lists danger classes for Italy.

Table 1: Danger classes by country.

Country	Very low	Low	Moderate	High	Very high	Extreme
Italy	0-2	3-6	7-12	13-23	24-42	>42

## Conclusions and next steps

The caliver R package is designed to facilitate the post-processing of fire model outputs. In this poster we only demonstrate the main functionalities with regards to GEFF outputs. For a more in-depth description of caliver we refer the reader to Vitolo et al. (2017) in which we also compare country-specific thresholds with the existing global ones to demonstrate how this methodology can lead to improved calibration of fire forecast models in an operational setting. Next step will be to validate the fire danger classes using satellite observations of fire radiative power. More details will be soon available from Di Giuseppe and Vitolo (2017).

### Wish to contribute?

Scan the QR code or visit the project's repository:



caliver on GitHub:  
<https://github.com/ecmwf/caliver>



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## References

- Di Giuseppe, F., and C. Vitolo, 2017: **Danger class definition in a global fire early warning system**, (in preparation).
- Vitolo, C., F. Di Giuseppe, and M. D'Andrea, 2017: **caliver: an R package for CALibration and VERification of Forest Fire gridded model outputs**, (under review).
- Vitolo, C., and F. Di Giuseppe and Mirko D'Andrea, 2017: **caliver: CALibration and VERification of gridded model outputs**. URL <https://github.com/ecmwf/caliver>, R package version 0.1, DOI: <https://doi.org/10.5281/zenodo.376613>.