User Guide

General description

This dataset contains modelled daily data from the European Forest Fire Information System (EFFIS) of fire danger using weather forecast from historical simulations provided by ECMWF ERA5 reanalysis. The fire danger model used to produce the dataset is publicly available Global ECMWF Fire forecast model (GEFF, https://git.ecmwf.int/projects/CEMSF/repos/geff/browse). GEFF implements daily predictions of fire danger conditions based on the U.S. Forest Service National Fire-Danger Rating System (NFDRS), the Canadian Forest Service Fire Weather Index Rating System (FWI), and the Australian McArthur (Mark 5) rating systems. For every one of the three models several variables are provided for the period covered by ERA5. The dataset is continued in time as ERA5 weather forcings become available.

Fire danger variables descriptions

The Canadian Forest Service Fire Weather Index Rating System (FWI)

[Adapted from: INTERPRETING THE CANADIAN FOREST FIRE WEATHER INDEX (FWI) SYSTEM By William J. De Groot av. at http://www.dnr.state.mi.us/WWW/FMD/WEATHER/Reference/FWI_Background.pdf]
The FWI System is comprised of six components (see fig 1): three fuel moisture codes and three fire behavior indexes. Each component has its own scale of relative values. Even though the scales for the six components are different, all are structured so that a high value indicates more severe burning conditions. The FWI System uses temperature, relative humidity, wind speed, and 24-hr precipitation values measured at noon Local Standard Time (LST). These values are used to predict the peak burning conditions, assuming that the measured weather parameters follow a normal diurnal pattern.

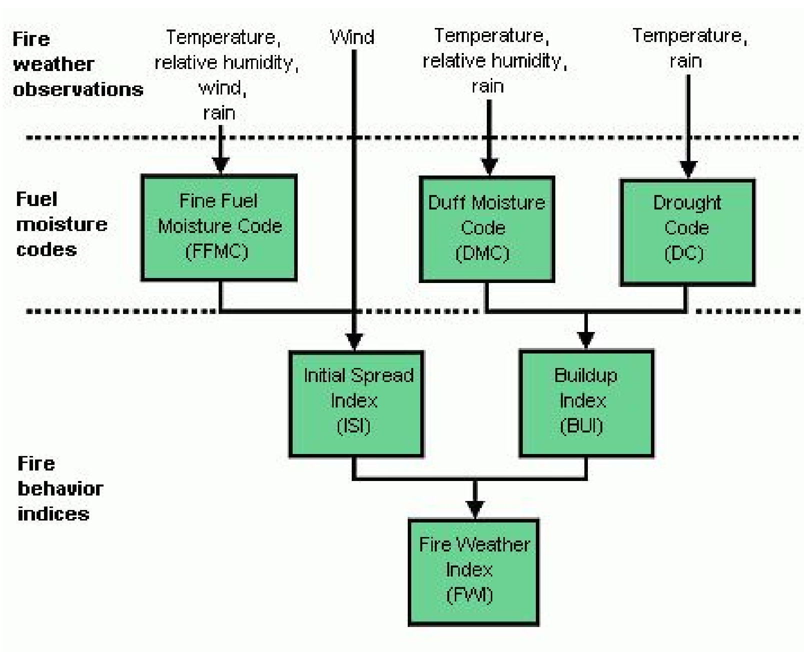
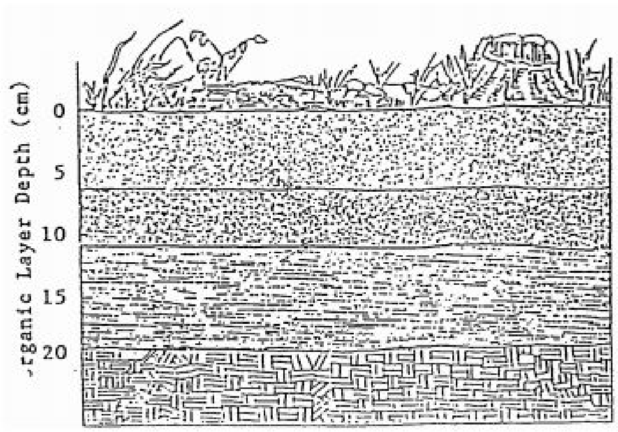


Figure 1 Structure of the Canadian Forest Fire Weather Index (FWI) System

The FWI System evaluates fuel moisture content and relative fire behavior using the past and present effect of weather on forest floor fuels. The three moisture codes represent the fuel moisture content of three classes of forest floor fuels in the "standard" mature pine stand (Fig. 2). The moisture codes calculate the net effect of a daily drying and wetting phase, similar to a bookkeeping system of moisture losses and additions.



	Weight	Fuel Moisture Code
Duff Layer	5 t/ha	FFMC
Upper	50 t/ha	DMC
Middle		
Lower	440 t/ha	DC
Mineral Soil		

Figure 2 Representation of forest floor fuels by Fuel Moisture Codes of the FWI System

Fine Fuel Moisture Codes (FFMC): is a numerical rating of the moisture content of litter and other cured fine fuels (needles, mosses, twigs less than I cm in diameter). The FFMC is representative of the top litter layer less than 1-2 cm deep. FFMC values change rapidly because of a high surface area to volume ratio, and direct exposure to changing environmental conditions. The FFMC scale ranges from 0-99 and is the only component of the FWI System which does not have an open-ended scale. **Generally, fires begin to ignite at FFMC values near 70, and the maximum probable value that will ever be achieved is 96**.

Duff Moisture Code (**DMC):** indicates the moisture content of loosely-compacted organic layers of moderate depth. It is representative of the duff layer that is 5-10 cm deep. DMC fuels are affected by rain, temperature and relative humidity. Because these fuels are below the forest floor surface, wind speed does not affect the fuel moisture content. The DMC fuels have a slower drying rate than the FFMC fuels, with a time lag of 12 days. **Although the DMC has an open-ended scale, the highest probable value is in the range of 150**.

Drought Code (DC): is an indicator of moisture content of deep, compact organic layers. This code represents a fuel layer approximately 10-20 cm deep. The DC fuels have a very slow drying rate, with a time lag of 52 days. The DC scale is open-ended, although the maximum probable value is about **800.**

Initial Spread Index (ISI): combines the FFMC and wind speed to indicate the expected rate of fire spread. Generally, a 13 km/h increase in wind speed will double the ISI value. **The ISI is accepted as a good indicator of fire spread** in open light fuel stands with wind speeds up to 40 km/h.

Build Up Index (**BUI):** is a weighted combination of the DMC and DC to indicate the total amount of fuel available for combustion by a moving flame front. The DMC has the most influence on the BUI value. For example, a DMC value of zero always results in a BUI value of zero regardless of what the DC value is. The DC has the strongest influence on the BUI at high DMC values, and the greatest effect that the DC can have is to make the BUI value equal to twice the DMC value. **The BUI is often used for pre-suppression planning purposes.**

Fire Weather Index (FWI): is a combination of ISI and BUI, and is a numerical rating of the potential frontal fire intensity. In effect, it indicates fire intensity by combining the rate of fire spread with the amount of fuel being consumed. Frontal fire intensity is useful for determining fire suppression requirements, **the FWI is used for general public information about fire danger conditions.**

Danger Rating (DR): FWI classified in 6 classes of danger accordingly to EFFIS danger class levels definition. Fire danger is mapped in 6 classes (very low, low, medium, high, very high and extreme). The fire danger classes are the same for all countries and maps show a harmonized picture of the spatial distribution of fire danger level. The following are the FWI values used as thresholds of the fire danger classes in the map:

Fire Danger Classes	FWI ranges (upper bound excluded)
Very low	< 5.2
Low	5.2 - 11.2
Moderate	11.2 - 21.3
High	21.3 - 38.0
Very high	38.0 - 50.0
Extreme	>= 50.0

More information on how this classification was derived can be find in the EFFIS website http://effis.jrc.ec.europa.eu/about-effis/technical-background/fire-danger-forecast/

The U.S. Forest Service National Fire-Danger Rating System (NFDRS)

[*Adapted from: Gaining an Understanding of the National Fire Danger Rating System available at https://www.nwcg.gov/sites/default/files/products/pms932.pdf*]

In the NFDRS, the characteristics of fire danger are functions of fuel type, topography, and weather. The model explicitly calculates the moisture content of dead and living vegetation.
Dead fuel is divided into classes according to its fast or slow response to changes in atmospheric temperature and humidity forcing, while live fuel is divided into herbaceous and woody shrubs. The numbers generated by NFDRS are relative in the sense that as the value of a component or index doubles, the activity measured by that component or index doubles. (An Ignition Component of 60 has twice the ignition probability of an Ignition Component of 30.) This helps the users of the NFDRS interpret the meaning of the numbers produced for their protection area.

Ignition Component – (IC): is a rating of the probability that a firebrand will cause a fire requiring suppression action. Since it is expressed as a probability, it ranges on a scale of 0 to 100. An IC of 100 means that every firebrand will cause a fire requiring action if it contacts a receptive fuel. Likewise an IC of 0 would mean that no firebrand would cause a fire requiring suppression action under those conditions.

Spread Component – (SC): is a rating of the forward rate of spread of a headfire. The spread component is numerically equal to the theoretical ideal rate of spread expressed in feet-per-minute. The Spread Component is expressed on an open-ended scale; thus it has no upper limit.

Energy Release Component - (ERC): is a number related to the available energy (BTU) per unit area (square foot) within the flaming front at the head of a fire. Daily variations in ERC are due to changes in moisture content of the various fuels present, both live and dead. Since this number represents the potential "heat release" per unit area in the flaming zone, it can provide guidance to several important fire activities. It may also be considered a composite fuel moisture value as it reflects the contribution that all live and dead fuels have to potential fire intensity. The ERC is a cumulative or "build-up" type of index. As live fuels cure and dead fuels dry, the ERC values get higher thus providing a good reflection of drought conditions. The scale is open-ended or unlimited and, as with other NFDRS components, is relative.

Burning Index (BI): is a number related to the contribution of fire behavior to the effort of containing a fire. The BI (difficulty of control) is derived from a combination of Spread Component (how fast it will spread) and Energy Release Component (how much energy will be produced). In this way, it is related to flame length, which, in the Fire Behavior Prediction System, is based on rate of spread and heat per unit area. However, because of differences in the calculations for BI and flame length, they are not the same.

The McArthur's Forest Fire Danger Meter

[Adapted from: Gaining an Understanding of the National Fire Danger Rating System available at https://www.cawcr.gov.au/technical-reports/CTR_010.pdf]

The McArthur Forest Fire Danger Meter (FFDM) first appeared in operational use in 1967 as the Mk 4 FFDM.

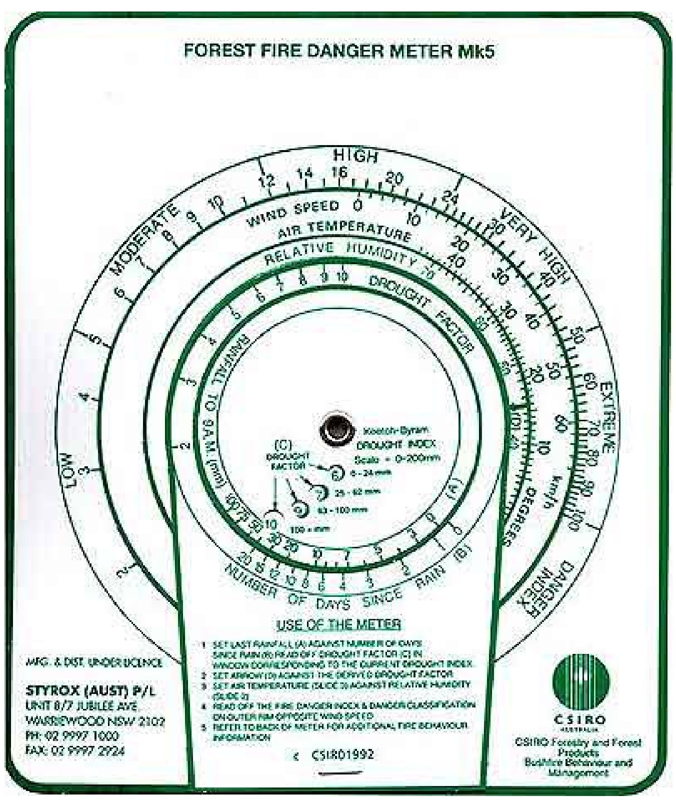


Figure 3 The first MRk4 meter

This meter, for the first time, brought together the results of over 800 experimental fires and wildfire observations into an easy-to-use system to determine the fire danger in forested areas of Australia.It was designed for general forecasting purposes and is based on the expected behaviour of fires burning for an extended period in high eucalypt forest carrying a fine fuel load of 12.5 tonnes/hectare and travelling over level to undulating topography.

The Fire danger Index (FDI): is related to the chances of a fire starting, its rate of spread, its intensity, and its difficulty of suppression, according to various combinations of air temperature, relative humidity, wind speed and both the long and short-term drought effects. An index of 1 means that a fire will not burn, or will burn so slowly that control presents little difficulty. An index of 100 means that fires will burn so fast and hot that control is virtually impossible.

Drought Factor (DF): is given as a number between 0 and 10 and represents the influence of recent temperatures and rainfall events on fuel availability. The Drought Factor is partly based on the soil moisture deficit which is commonly calculated in using the Keetch-Byram Drought Index (KBDI)

Keetch-Byram drought index (KBDI): It is a number representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff and upper soil layers. It is a continuous index, relating to the flammability of organic material in the ground.The KBDI attempts to measure the amount of precipitation necessary to return the soil to full field capacity. It is a closed system ranging from 0 to 200 units and represents a moisture regime from 0 to 20 cm of water through the soil layer. At 20 cm of water, the KBDI assumes saturation. Zero is the point of no moisture deficiency and 200 is the maximum drought that is possible. At any point along the scale, the index number indicates the amount of net rainfall that is required to reduce the index to zero, or saturation.

The inputs for KBDI are weather station latitude, mean annual precipitation, maximum dry bulb temperature, and the last 24 hours of rainfall. Reduction in drought occurs only when rainfall exceeds 0.20 inch (called net rainfall). The computational steps involve reducing the drought index by the net rain amount and increasing the drought index by a drought factor.

KBDI = 0 - 50: Soil moisture and large class fuel moistures are high and do not contribute much to fire intensity. Typical of spring dormant season following winter precipitation.

KBDI = 50 - 100: Typical of late spring, early growing season. Lower litter and duff layers are drying and beginning to contribute to fire intensity.

KBDI = 100 - 150: Typical of late summer, early fall. Lower litter and duff layers actively contribute to fire intensity and will burn actively.

KBDI = 150 - 200: Often associated with more severe drought with increased wildfire occurrence. Intense, deep burning fires with significant downwind spotting can be expected. Live fuels can also be expected to burn actively at these levels.

Rate of spread Expected rate of spread of the fire front in km /hr for the fire in undulating ground

Summary variable table

Variable	Description	UNIT
FWI		
Fire weather index	Numerical rating of fire intensity. It is suitable as a general index of fire danger	Numerical rating
Fire Daily Severity Index	Numeric rating of the difficulty of controlling fires. It is based on the Fire Weather Index but more accurately reflects the expected efforts required for fire suppression.	Numerical rating
Initial Spread Index	Numerical rating of the expected rate of fire spread	Numerical rating
Build-up Index	Numerical rating of the total amount of fuel available for combustion	Numerical rating
Drought Code	Numerical rating of the average moisture content of deep, compact organic layers	Numerical rating
Duff Moisture Code	Numerical rating of the average moisture content of loosely compacted organic layers of moderate depth	Numerical rating
Fine Fuel Moisture Code	Numerical rating of the moisture content of litter and other cured fine fuels.	Numerical rating
Danger Rating	FWI classified in 6 classes of danger accordingly to EFFIS danger class levels definition. http://effis.jrc.ec.europa.eu/about-effis/technical-background/fire-danger-forecast/	Numerical Rating
McArthur-5		
Keetch-Byram Drought Index	Metric of the soil moisture below saturation up to a	mm equivalents

	maximum field capacity of 203.2 mm (i.e. 8 in.) and a minimum of 0 mm	
Drought Factor	Metric of fuel availability as determined by seasonal severity and recent rain effects	Numerical rating (0-10)
Fire danger index	Numeric rating related to the chances of a fire starting, its rate of spread, its intensity, and its difficulty of suppression	Numerical rating
Rate of Spread-MARK5	Rate of forward spread of fire on level to undulating ground	km/hr
NFDRS		
Spread Component	Forward rate of spread at the head of the fire in feet per minute. Truncated value of the Rate of Spread	ft/min
Energy Release Component	Potential available energy at the head of the fire	25Btu/ft^2 (Btu- British thermal unit)
Ignition Component	Numerical rating of the probability that a fire that requires suppression action will result if a firebrand is introduced into a fine fuel complex	%
Burning Index	Metric of flame length in feet at the head of a fire	10ft

The McArthur's Forest Fire Danger Meter (Mark 5) was developed to monitor fire danger throughout eastern Australia. The formulation in implemented in GEFF follows *Noble et al. (1980)* and uses atmospheric conditions to evaluate a generic component representing fuel availability called the drought factor (DF). The DF is used to then calculate the Fire Danger Index (FDI), which provides an assessment of fire danger due to the combined effect of drought conditions and fuel availability.

Data Availability

Data Availability will vary depending on the version of the model.
ERA5 reanalysis is released monthly with a lag of two to three months. ERA5 also produces a near real time dataset that is produced with a time lag of up to 5 days. The near real time data is subject to possible change prior to being officially released.

In this dataset you will find two datasets per model version:

- Consolidated Dataset : Based upon the Officially released ERA5 Reanalysis
- Intermediate Dataset: Based upon the near real time ERA5 Reanalysis dataset and initialized from the Consolidated Dataset at the time of the release of that model.

Once the consolidated dataset has been released, the intermediate dataset will be initialised from the last data available and will produce for all available data in ERA5 near real time. The intermediate dataset will not be replaced when the consolidated dataset is extended.

Version	Release Date	Date of Initialisation of Intermediate Dataset	Start Date (Consolidated)	End Date (Consolidated)
3.0	2019	20190731	19790103	20190731
3.1	2019	20190831	19790103	On going

File naming convention

Files will follow the following naming convention:

ECMWF_FWI_FWI_19790524_1200_spread_v3.1_con.nc

PRODUCER_MODEL_[VARIABLE_VARIABLE]_DATE_TIME_FCTYPE_Version_Dataset.nc

1. Producer :
    a. ECMWF
2. Model:
    a. FWI
    b. MARK5
    c. NFDRS
3. Variable (some variables have _ in name):
    a. FWI Variables : FWI, BUI, DANGER_RISK,DC,DMC,ISI,FFMC.DSR
    b. MARK5 Variables: KBDI,DF,ROS,FDI
    c. NFDRS Variables: SC,ERC,BI,IC
4. Date:
    a. Date of the Reanalysis
5. Time:
    a. Time of the Reanalysis

6. Fctype:
    a. Hr: Reanalysis, ERA5 Reanalysis Short Model at 0.25 Degrees
    b. En: Ensemble Members, ERA5 Reanalysis ensemble at 0.50 Degrees
    c. Spread: Ensemble Spread at 0.50 Degrees
    d. Mean: Ensemble Mean at 0.50 Degrees
7. Version:
    a. 3.0:
    b. 3.1: Updated smoothing of data and Drought Coefficients
8. Dataset:
    a. Con: Consolidated ERA5 Data (2-3 Month Lag behind real time)
    b. Int: Intermediate ERA5 Data (up to 5 days lag behind real time, product could differ when quality checks and consolidation occurs)

ATTENTION

*Some files will have been downloaded without the con or int at the end of the filename. With Version 3.1 it was decided that we would also provide the intermediate dataset in near real time and so the additional name was required to distinguish the files. All files downloaded in version 3.0 ending v3.0.nc are to be considered as part of the Consolidated Dataset.

Useful links

Di Giuseppe, F., F. Pappenberger, F. Wetterhall, B. Krzeminski, A. Camia, G. Libertá, and J. San Miguel, 2016: The Potential Predictability of Fire Danger Provided by Numerical Weather Prediction. *J. Appl. Meteor. Climatol.*, **55**, 2469–2491, https://doi.org/10.1175/JAMC-D-15-0297.1

Bradshaw, L. S., J. E. Deeming, R. E. Burgan, and J. D. Cohen, 1983: The 1978 National Fire-Danger Rating System: Technical documentation. USDA Forest Service Intermountain Forest and Range Experiment Station General Tech. Rep. INT-169, 44 pp. [Available online at http://www.fs.fed.us/rm/pubs_int/int_gtr169.pdf.]

Van Wagner, C. E., 1987: Development and structure of the Canadian Forest Fire Weather Index System. Canadian Forestry Service Tech. Rep. 35, 37 pp. [Available online at http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/19927.pdf.]

Noble, I. R., G. A. V. Bary, and A. M. Gill, 1980: McArthur's fire-danger meters expressed as equations. *Aust. J. Ecol.*, **5**, 201–203, doi:https://doi.org/10.1111/j.1442-9993.1980.tb01243.x.

Keetch, J. J., and G. M. Byram, 1968: A drought index for forest fire control. USDA Forest Service Southeastern Forest Experiment Station Research Paper SE-38, 32 pp. [Available online at http://www.srs.fs.usda.gov/pubs/rp/rp_se038.pdf?.]