Package ‘fwi.fbp’

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Type Package

Title Fire Weather Index System and Fire Behaviour Prediction System Calculations

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Author Xianli Wang, Alan Cantin, Marc-Andre Parisien, Mike Wotton, Kerry Anderson, and Mike Flannigan

Maintainer Alan Cantin <Alan.Cantin@Canada.ca>

Depends R (>= 2.15.1)

Description Provides three functions to calculate the outputs of the two main components of the Canadian Forest Fire Danger Rating System (CFFDRS): the Fire Weather Index (FWI) System and the Fire Behaviour Prediction (FBP) System.

License GPL-2

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fwi.fbp-package *Fire Weather Index and Fire Behavior Prediction Systems*

Description

Allows R users to calculate the outputs of the two main components of the Canadian Forest Fire Danger Rating System (CFFDRS; http://cwfis.cfs.nrcan.gc.ca/background/summary/fdr): the Fire Weather Index (FWI) System (http://cwfis.cfs.nrcan.gc.ca/background/summary/fwi) and the Fire Behaviour Prediction (FBP) System (http://cwfis.cfs.nrcan.gc.ca/background/summary/fbp). These systems are widely used internationally to assess fire danger (FWI System) and quantify fire behavior (FBP System).

The FWI System (Van Wagner, 1987) is based on the moisture content and the effect of wind of three classes of forest fuels on fire behavior. It consists of six components: three fuel moisture codes (Fire Fuel Moisture Code, Duff Moisture Code, Drought Code), and three fire behavior indexes representing rate of spread (Initial Spread Index), fuel consumption (Buildup Index), and fire intensity (Fire Weather Index). The FWI System outputs are determined from daily noon weather observations: temperature, relative humidity, wind speed, and 24-hour rainfall.

The FBP System (Forestry Canada Fire Danger Group. 1992; Hirsch 1996) provides a set of primary and secondary measures of fire behavior. The primary outputs consist of estimates of fire spread rate, fuel consumption, fire intensity, and fire description (i.e., surface, intermittent, or crown fire). The secondary outputs, which are not used nearly as often, gives estimates of fire area, perimeter, perimeter growth rate, and flank and back fire behavior based on a simple elliptical fire growth model. Unlike the FWI System, which is weather based, the FBP System also requires information on vegetation (hereafter, fuel types) and slope (if any) to calculate its outputs. Sixteen fuel types are included in the FBP System, covering mainly major vegetations types in Canada.

Details

Package:	fwi.fbp
Type:	Package
Version:	1.7
Date:	2015-01-07
License:	GPL-2

This package includes three functions. Two functions, fwi and fwiBAT, are used for FWI System calculation, whereas one function, fbp, is used for FBP System calculation. These functions are not fully independent: their inputs overlap greatly and the user will have to provide FWI System outputs to calculate FBP System outputs. The fwi function is a low level function that is used to calculate the outputs of the FWI System for one day based on noon local standard time (LST) weather observations of temperature, relative humidity, wind speed, and 24-hour rainfall, as well as the previous day's weather conditions. The fwiBAT function is similar to fwi, but is at a higher level in that it allows the user to directly calculate FWI System outputs from a list of consecutive daily weather observations. The fbp function calculates the outputs of the FBP System based on given set of fire weather conditions (weather observations and their associated FWI System components), fuel type, and slope (optional).

Author(s)

Xianli Wang, Alan Cantin, Marc-Andre Parisien, Mike Wotton, Kerry Anderson, and Mike Flannigan

Maintainer: Alan Cantin <Alan.Cantin@Canada.ca>

References

1. Van Wagner, C.E. and T.L. Pickett. 1985. Equations and FORTRAN program for the Canadian Forest Fire Weather Index System. Can. For. Serv., Ottawa, Ont. For. Tech. Rep. 33. 18 p.

2. Van Wagner, C.E. 1987. Development and structure of the Canadian forest fire weather index system. Forest Technology Report 35. (Canadian Forestry Service: Ottawa).

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4. Hirsch K.G. 1996. Canadian Forest Fire Behavior Prediction (FBP) System: user's guide. Nat. Resour. Can., Can. For. Serv., Northwest Reg., North. For. Cent., Edmonton, Alberta. Spec. Rep. 7. 122p.

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7. Tymstra, C., Bryce, R.W., Wotton, B.M., Armitage, O.B. 2009. Development and structure of Prometheus: the Canadian wildland fire growth simulation Model. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, AB. Inf. Rep. NOR-X-417.

Examples

```
library(fwi.fbp)

######## fwi function examples ########
# The test data is a standard test
# dataset (Van Wagner and Pickett 1985).

data("test_fwi")
head(test_fwi)
# Using the default initial values
fwi.out1<-fwi(test_fwi)

# Using a different set of initial values
fwi.out2<-fwi(test_fwi,init=c(80,10,16,50))

# fwi system components calculated based on previous day's
```

```
# fwi outputs
fwi.out3<-fwi(test_fwi,fwi.out1)

# Using a suite of initials, assuming variables from fwi.out1
# are the initial values for different records
init_suite<-fwi.out1[,c("ffmc","dmc","dc","lat")]
fwi.out4<-fwi(test_fwi,init=init_suite)

# Using only the required input variables:
fwi.out5<-fwi(test_fwi[,7:10])

# Daylength adjustment:
# Change latitude values where the monthly daylength adjustments
# are different from the standard ones
test_fwi$lat<-22
# With daylength adjustment
fwi(test_fwi)[1:3,]
# Without daylength adjustment
fwi(test_fwi,lat.adjust=FALSE)[1:3,]



######## fwiBAT function examples ########
# The test data is a standard test
# dataset for FWI system(Van Wagner and Pickett 1985).

data("test_fwi")
head(test_fwi)

# using the default initial values
fwi.out<-fwiBAT(test_fwi)

# using a different set of initials
fwi.out<-fwiBAT(test_fwi,init=c(80,10,16,50))

# using only the required input variables:
fwi.out<-fwiBAT(test_fwi[,7:10])



######## fbp function examples ########
# The dataset is the standard test data
# provided by Wotton et al (2009).

data("test_fbp")
head(test_fbp)
#Primary output (default)
fbp(test_fbp)
#or
fbp(test_fbp,output="Primary")
#or
fbp(test_fbp,"P")
```

```
#Secondary output
fbp(test_fbp,"Secondary")
#or
fbp(test_fbp,"S")

#All output
fbp(test_fbp,"All")
#or
fbp(test_fbp,"A")

#For a single record:
fbp(test_fbp[7,])
#For a section of the records:
fbp(test_fbp[8:13,])

#fbp function produces the default values if no data is fed to
#the function:
fbp()
```

---

fbp *Fire Behavior Prediction System function, Deprecated*

Description

fbp calculates the outputs from the Canadian Forest Fire Behavior Prediction (FBP) System (Forestry Canada Fire Danger Group 1992) based on given fire weather and fuel moisture conditions (from the Canadian Forest Fire Weather Index (FWI) System (Van Wagner 1987)), fuel type, date, and slope. Fire weather, for the purpose of FBP System calculation, comprises observations of 10 m wind speed and direction at the time of the fire, and two associated outputs from the Fire Weather Index System, the Fine Fuel Moisture Content (ffmc) and Buildup Index (bui). FWI System components can be calculated with the sister functions `fwi` and `fwiBAT`.

Usage

```
fbp(input, output="Primary")
```

Arguments

`input` The input data, a dataframe containing fuel types, fire weather component, and slope (see below). Each vector of inputs defines a single FBP System prediction for a single fuel type and set of weather conditions. The dataframe can be used to evaluate the FBP System for a single fuel type and instant in time, or multiple records for a single point (e.g., one weather station, either hourly or daily for instance) or multiple points (multiple weather stations or a gridded surface). All input variables have to be named as listed below, but they are case insensitive, and do not have to be in any particular order. Fuel type is of type character; other arguments are numeric. Missing values in numeric variables could either be assigned as NA or leave as blank.

Inputs	**Full names of inputs**	**Defaults**
id	Unique identifier of a weather station or spatial point (no restriction on data type). Will use row.names of the Inputs dataset if not specified	N/A
FuelType	FBP System Fuel Types including "C-1", "C-2", "C-3", "C-4", "C-5", "C-6", "C-7", "D-1", "M-1", "M-2", "M-3", "M-4", "S-1", "S-2", "S-3", "O-1a", and "O-1b". "WA" and "NF" stand for "water" and "non-fuel", respectively. The "-" in the Fuel Type names could be omitted, and the Fuel Type names are also case-insensitive.	"C2"
LAT	Latitude [decimal degrees]	55
LON	Longitude [decimal degrees]	-120
*ELV****	Elevation [meters above sea level]	NA
FFMC	Fine fuel moisture code [FWI System component]	90
BUI	Buildup index [FWI System component]	60
WS	Wind speed [km/h]	10
GS	Ground Slope [percent]	0
Dj	Julian day	180
Aspect	Aspect of the slope [decimal degrees]	0
*PC**	Percent Conifer for M1/M2 [percent]	50
*PDF**	Percent Dead Fir for M3/M4 [percent]	35
*cc**	Percent Cured for O1a/O1b [percent]	80
*GFL**	Grass Fuel Load [kg/m^2]	0.35
*CBH***	Crown to Base Height [m]	3
*WD***	Wind direction [decimal degrees]	0
*Accel***	Acceleration: 1 = point, 0 = line	0
*BUIEff***	Buildup Index effect: 1=yes, 0=no	1
*D0***	Julian day of minimum Foliar Moisture Content	0
*hr***	Hours since ignition	1
*ISI***	Initial spread index	0
*CFL***	Crown Fuel Load [kg/m^2]	-1
*FMC***	Foliar Moisture Content if known [percent]	0
*SH***	C-6 Fuel Type Stand Height [m]	0
*SD***	C-6 Fuel Type Stand Density [stems/ha]	0
*theta***	Elliptical direction of calculation [degrees]	0

`output` FBP output offers 3 options (see details in **Values** section):

Outputs	**Number of outputs**
*Primary (**default**)*	7
Secondary	30
All	37

* Variables associated with certain fuel types. These could be skipped if relevant fuel types do not appear in the input data. ** Variables that could be ignored without causing major impacts to the primary outputs. *** Elevation is only used in the calculation of Foliar Moisture Content (FMC). However, FMC can also be calculated without elevation input. The default is to not use elevation in

the calculation of FMC.

Details

The Canadian Forest Fire Behavior Prediction (FBP) System (Forestry Canada Fire Danger Group. 1992) is a subsystem of the Canadian Forest Fire Danger Rating System, which also includes the Canadian Forest Fire Weather Index (FWI) System. The FBP System provides quantitative estimates of head fire spread rate, fuel consumption, fire intensity, and a basic fire description (e.g., surface, crown) for 16 different important forest and rangeland types across Canada. Using a simple conceptual model of the growth of a point ignition as an ellipse through uniform fuels and under uniform weather conditions, the system gives, as a set of secondary outputs, estimates of flank and back fire behavior and consequently fire area perimeter length and growth rate.

The FBP System evolved since the mid-1970s from a series of regionally developed burning indexes to an interim edition of the nationally develop FBP system issued in 1984. Fire behavior models for spread rate and fuel consumption were derived from a database of over 400 experimental, wild and prescribed fire observations. The FBP System, while providing quantitative predictions of expected fire behavior is intended to supplement the experience and judgment of operational fire managers (Hirsch, 1996).

The FBP System was updated with some minor corrections and revisions in 2009 (Wotton et al. 2009) with several additional equations that were initially not included in the system. This fbp function included these updates and corrections to the original equations and provides a complete suite of fire behavior prediction variables.

Default values of optional input variables provide a reasonable mid-range setting.

Latitude, longitude, elevation, and the date are used to calculate foliar moisture content, using a set of models defined in the FBP System; note that this latitude/longitude-based function is only valid for Canada. If the Foliar Moisture Content (FMC) is specified directly as an input, the fbp function will use this value directly rather than calculate it. This is also true of other input variables.

Note that Wind Direction (WD) is the compass direction from which wind is coming. Wind azimuth (not an input) is the direction the wind is blowing to and is 180 degrees from wind direction; in the absence of slope, the wind azimuth is coincident with the direction the head fire will travel (the spread direction azimuth, RAZ). Slope aspect is the main compass direction the slope is facing. Slope azimuth (not an input) is the direction a head fire will spread up slope (in the absence of wind effects) and is 180 from slope aspect (Aspect). Wind direction and slope aspect are the commonly used directional identifiers when specifying wind and slope orientation respectively. The input theta specifies an angle (given as a compass bearing) at which a user is interested in fire behavior predictions; it is typically some angle off of the final spread rate direction since if for instance theta=RAZ (the final spread azimuth of the fire) then the rate of spread at angle theta (TROS) will be equivalent to ROS.

Value

fbp returns a dataframe with primary, secondary, or all output variables, a combination of the primary and secondary outputs.

Primary FBP output includes the following 7 variables:

`CFB` Crown Fraction Burned by the head fire

`CFC` Crown Fuel Consumption [kg/m^2]

FD	Fire description (S=Surface, I=Intermittent, C=Crown)
HFI	Head Fire Intensity [kW/m]
RAZ	Spread direction azimuth [degrees]
ROS	Equilibrium Head Fire Rate of Spread [m/min]
SFC	Surface Fuel Consumption [kg/m^2]
TFC	Total Fuel Consumption [kg/m^2]

Secondary FBP System outputs include the following 34 variables. In order to calculate the reliable secondary outputs, depending on the outputs, optional inputs may have to be provided.

BE	BUI effect on spread rate
SF	Slope Factor (multiplier for ROS increase upslope)
ISI	Initial Spread Index
FFMC	Fine fuel moisture code [FWI System component]
FMC	Foliar Moisture Content [percent]
Do	Julian Date of minimum FMC
RSO	Critical spread rate for crowning [m/min]
CSI	Critical Surface Intensity for crowning [kW/m]
FROS	Equilibrium Flank Fire Rate of Spread [m/min]
BROS	Equilibrium Back Fire Rate of Spread [m/min]
HROSt	Head Fire Rate of Spread at time hr [m/min]
FROSt	Flank Fire Rate of Spread at time hr [m/min]
BROSt	Back Fire Rate of Spread at time hr [m/min]
FCFB	Flank Fire Crown Fraction Burned
BCFB	Back Fire Crown Fraction Burned
FFI	Equilibrium Spread Flank Fire Intensity [kW/m]
BFI	Equilibrium Spread Back Fire Intensity [kW/m]
FTFC	Flank Fire Total Fuel Consumption [kg/m^2]
BTFC	Back Fire Total Fuel Consumption [kg/m^2]
DH	Head Fire Spread Distance after time hr [m]
DB	Back Fire Spread Distance after time hr [m]
DF	Flank Fire Spread Distance after time hr [m]
TI	Time to Crown Fire Initiation [hrs since ignition]
FTI	Time to Flank Fire Crown initiation [hrs since ignition]
BTI	Time to Back Fire Crown initiation [hrs since ignition]
LB	Length to Breadth ratio
LBt	Length to Breadth ratio after elapsed time hr
WSV	Net vectored wind speed [km/hr]
TROS*	Equilibrium Rate of Spread at bearing theta [m/min]

TROSt*	Rate of Spread at bearing theta at time t [m/min]
TCFB*	Crown Fraction Burned at bearing theta
TFI*	Fire Intensity at bearing theta [kW/m]
TTFC*	Total Fuel Consumption at bearing theta [kg/m^2]
TTI*	Time to Crown Fire initiation at bearing theta [hrs since ignition]

* These outputs represent fire behaviour at a point on the perimeter of an elliptical fire defined by a user input angle theta. theta represents the bearing of a line running between the fire ignition point and a point on the perimeter of the fire. It is important to note that in this formulation the theta is a bearing and does not represent the angle from the semi-major axis (spread direction) of the ellipse. This formulation is similar but not identical to methods presented in Wotton et al (2009) and Tymstra et al (2009).

Author(s)

Xianli Wang, Alan Cantin, Marc-Andre Parisien, Mike Wotton, Kerry Anderson, and Mike Flannigan

References

1. Hirsch K.G. 1996. Canadian Forest Fire Behavior Prediction (FBP) System: user's guide. Nat. Resour. Can., Can. For. Serv., Northwest Reg., North. For. Cent., Edmonton, Alberta. Spec. Rep. 7. 122p.

2. Forestry Canada Fire Danger Group. 1992. Development and structure of the Canadian Forest Fire Behavior Prediction System. Forestry Canada, Ottawa, Ontario Information Report ST-X-3. 63 p. http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/10068.pdf

3. Wotton, B.M., Alexander, M.E., Taylor, S.W. 2009. Updates and revisions to the 1992 Canadian forest fire behavior prediction system. Nat. Resour. Can., Can. For. Serv., Great Lakes For. Cent., Sault Ste. Marie, Ontario, Canada. Information Report GLC-X-10, 45p. http://publications.gc.ca/collections/collection_2010/nrcan/Fo123-2-10-2009-eng.pdf

4. Tymstra, C., Bryce, R.W., Wotton, B.M., Armitage, O.B. 2009. Development and structure of Prometheus: the Canadian wildland fire growth simulation Model. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, AB. Inf. Rep. NOR-X-417.

Examples

```
library(fwi.fbp)
# The dataset is the standard test data
# provided by Wotton et al (2009).
data("test_fbp")
head(test_fbp)
#Primary output (default)
fbp(test_fbp)
#or
fbp(test_fbp,output="Primary")
#or
fbp(test_fbp,"P")
```

```
#Secondary output
fbp(test_fbp,"Secondary")
#or
fbp(test_fbp,"S")

#All output
fbp(test_fbp,"All")
#or
fbp(test_fbp,"A")

#For a single record:
fbp(test_fbp[7,])
#For a section of the records:
fbp(test_fbp[8:13,])

#fbp function produces the default values if no data is fed to
#the function:
fbp()
```

---

fwi *Fire Weather Index function, Deprecated*

Description

fwi is used to calculate the outputs of the Fire Weather Index (FWI) System for one day based on noon local standard time (LST) weather observations of temperature, relative humidity, wind speed, and 24-hour rainfall, as well as the previous day's weather conditions. This function could be used for either one weather station or for multiple weather stations or a gridded surface. This is a lower-level function that allows for maximum flexibility in FWI System component calculations. This package also contains a similar high-level function, fwiBAT,to calculate FWI System outputs for an entire fire season at one weather station.

Usage

```
fwi(input,yda.fwi=NULL,init=c(ffmc_yda=85,dmc_yda=6,dc_yda=15, lat=55),
    out="all",lat.adjust="TRUE")
```

Arguments

input A dataframe containing input variables of daily weather observations taken at noon LST. Variable names have to be the same as in the following list, but they are case insensitive. The order in which the input variables are entered is not important.

id	(optional)	Unique identifier of a weather station or spatial point (no restriction on data type)
lat	(recommended)	Latitude (decimal degree, default=55)

long	(optional)	Longitude (decimal degree)
yr	(optional)	Year of observation
mon	(recommended)	Month of the year (integer 1-12, default=7)
day	(optional)	Day of the month (integer)
temp	(required)	Temperature (centigrade)
rh	(required)	Relative humidity (%)
ws	(required)	10-m height wind speed (km/h)
prec	(required)	24-hour rainfall (mm)

`yda.fwi` The FWI values calculated for the previous day that will be used for the current day's calculation. This input should be a dataframe that contains fwi outputs from the previous day. When yda.fwi is fed to the function, the initial (i.e., "startup") values in the function would be ignored.

`init` In some situations, such as the first day of the fire season, there are no previous-day values to calculate the current day's FWI System codes. In such a case, initial ("startup") values have to be provided. If neither initial values nor previous day's values are specified, the function will use default values (see below). The init argument can also accept a dataframe with the same number of rows as that of the input data if the initial values are to be applied to more than one point (e.g. a grid), station, or year.

ffmc_yda	Fine Fuel Moisture Code (FFMC; unitless) of the previous day. Default value is 85.
dmc_yda	Duff Moisture Code (DMC; unitless) of the previous day. Default value is 6.
dc_yda	Drought Code (DC; unitless) of the previous day. Default value is 15.
lat	Latitude of the weather station (optional, default=55). Latitude values are used to make day length adjustments in the function.

`out` The function offers two output options, out="all" will produce an output include both the input and the FWI System outputs; out="fwi" will generate only the FWI system components.

`lat.adjust` The function offers options for whether day length adjustments should be applied to the calculations. The default value is "TRUE".

Details

The Canadian Forest Fire Weather Index (FWI) System is a major subsystem of the Canadian Forest Fire Danger Rating System, which also includes Canadian Forest Fire Behavior Prediction (FBP) System. The modern FWI System was first issued in 1970 and is the result of work by numerous researchers from across Canada. It evolved from field research which began in the 1930's and regional fire hazard and fire danger tables developed from that early research.

The modern System (Van Wagner 1987) provides six output indices which represent fuel moisture and potential fire behavior in a standard pine forest fuel type. Inputs are a daily noon observation of fire weather, which consists of screen-level air temperature and relative humidity, 10 meter open wind speed and 24 accumulated precipitation.

The first three outputs of the system (the Fire Fuel Moisture Code, the Duff Moisture Code, and the Drought Code) track moisture in different layers of the fuel making up the forest floor. Their calculation relies on the daily fire weather observation and also, importantly, the code value from the previous day as they are in essence bookkeeping systems tracking the amount of moisture (water) in to and out of the layer. It is therefore important that when calculating FWI System outputs over an entire fire season, an uninterrupted daily weather stream is provided; one day is the assumed time step in the models and thus missing data must be filled in.

The next three outputs of the System are relative (unitless) indicators of aspects of fire behavior potential: spread rate (the Initial Spread Index), fuel consumption (the Build-up Index) and fire intensity per unit length of fire front (the Fire Weather Index). This final index, the fwi, is the component of the System used to establish the daily fire danger level for a region and communicated to the public. This final index can be transformed to the Daily Severity Rating (dsr) to provide a more reasonably-scaled estimate of fire control difficulty.

Both the Duff Moisture Code (dmc) and Drought Code (dc) are influenced by day length (see Van Wagner, 1987). Day length adjustments for different ranges in latitude can be used (as described in Lawson and Armitage 2008 (`http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/29152.pdf`)) and are included in this R function; latitude must be positive in the northern hemisphere and negative in the southern hemisphere.

At the start of a fire season, or simply the start of a daily weather stream, the FWI System calculation requires an estimate of yesterday's moisture conditions. The default initial (i.e., "start-up") fuel moisture code values (FFMC=85, DMC=6, DC=15) provide a reasonable set of conditions for post-snowmelt springtime conditions in eastern/central Canada, the Northern U.S., and Alaska; physically these spring start-up values represent about 3 days of drying from complete moisture saturation of the fuel layer. In areas or years with particularly dry winters (or parts of the world without significant snow cover) these start-up values for FFMC and DMC may still be appropriate as these two elements respond relatively quickly to changes in the weather. The DC component however, because of its very long response time, can take considerable time to adjust to unrealistic initial values and some effort to estimate over-winter value of the DC may be necessary. Users can look again to Lawson and Armitage (2008) for a more detailed description of code calculation startup issues and the over-winter adjustment process.

Value

fwi returns a dataframe which includes both the input and the FWI System variables as described below:

`Input Variables`
: Including temp, rh, ws, and prec with id, long, lat, yr, mon, or day as optional.

`ffmc`	Fine Fuel Moisture Code
`dmc`	Duff Moisture Code
`dc`	Drought Code
`isi`	Initial Spread Index
`bui`	Buildup Index
`fwi`	Fire Weather Index
`dsr`	Daily Severity Rating

Author(s)

Xianli Wang, Alan Cantin, Marc-Andre Parisien, Mike Wotton, Kerry Anderson, and Mike Flannigan

References

1. Van Wagner, C.E. and T.L. Pickett. 1985. Equations and FORTRAN program for the Canadian Forest Fire Weather Index System. Can. For. Serv., Ottawa, Ont. For. Tech. Rep. 33. 18 p.

2. Van Wagner, C.E. 1987. Development and structure of the Canadian forest fire weather index system. Forest Technology Report 35. (Canadian Forestry Service: Ottawa).

3. Lawson, B.D. and O.B. Armitage. 2008. Weather guide for the Canadian Forest Fire Danger Rating System. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, AB.

Examples

```
library(fwi.fbp)
# The test data is a standard test
# dataset (Van Wagner and Pickett 1985).

data("test_fwi")
head(test_fwi)
# Using the default initial values
fwi.out1<-fwi(test_fwi)

# Using a different set of initial values
fwi.out2<-fwi(test_fwi,init=c(80,10,16,50))

# fwi system components calculated based on previous day's
# fwi outputs
fwi.out3<-fwi(test_fwi,fwi.out1)

# Using a suite of initials, assuming variables from fwi.out1
# are the initial values for different records
init_suite<-fwi.out1[,c("ffmc","dmc","dc","lat")]
fwi.out4<-fwi(test_fwi,init=init_suite)

# Using only the required input variables:
fwi.out5<-fwi(test_fwi[,7:10])

# Daylength adjustment:
# Change latitude values where the monthly daylength adjustments
# are different from the standard ones
test_fwi$lat<-22
# With daylength adjustment
fwi(test_fwi)[1:3,]
# Without daylength adjustment
fwi(test_fwi,lat.adjust=FALSE)[1:3,]
```

---

fwi.fbp-deprecated *Deprecated functions in package 'fwi.fbp'*

Description

These functions are provided for compatibility with older versions of 'fwi.fbp' only, and will be defunct at the next release.

Details

The 'fwi.fbp' package has been deprecated, and all functions have replacements within the cffdrs package.https://cran.r-project.org/package=cffdrs
The following functions are deprecated and will be made defunct. Use the replacements from the 'cffdrs' package indicated below (links will not work without the 'cffdrs' package installed):

- fwi: `fwi`
- fwiBAT: `fwi`
- fbp: `fbp`

Author(s)

Alan Cantin <Alan.Cantin@Canada.ca>

See Also

`Deprecated`

`fwiBAT` *Fire Weather Index batch function, Deprecated*

Description

fwiBAT generates Fire Weather Index (FWI) System outputs for one weather station during a continuous period of time. This is a high-level function in which FWI System components are calculated from a list of consecutive (e.g., all days of a fire season). For maximum flexibility, the low-level function fwi should be used.

Usage

```
fwiBAT(input,init=c(ffmc_yda=85,dmc_yda=6,dc_yda=15,lat=55),out="all",
       lat.adjust="TRUE")
```

Arguments

`input` A dataframe containing input variables of daily weather observations taken at noon LST. Variable names have to be the same as in the following list, but they are case insensitive. The order in which the input variables are entered is not important.

id (optional) Unique identifier of a weather station or spatial point (no restriction on data type)

lat	(recommended)	Latitude (decimal degree, default=55)
long	(optional)	Longitude (decimal degree)
yr	(optional)	Year of observation
mon	(recommended)	Month of the year (integer 1-12, default=7)
day	(optional)	Day of the month (integer)
temp	(required)	Temperature (centigrade)
rh	(required)	Relative humidity (%)
ws	(required)	10-m height wind speed (km/h)
prec	(required)	24-hour rainfall (mm)

`init` Initial ("startup") values are provided for the calculation of the first day of a multi-day dataframe. In this case, except for the first day, the function assumed the previous day's conditions to be contained in the previous line of the dataframe (i.e., the previous day).

ffmc_yda	Fine Fuel Moisture Code (FFMC; unitless) of the previous day. Default value is 85.
dmc_yda	Duff Moisture Code (DMC; unitless) of the previous day. Default value is 6.
dc_yda	Drought Code (DC; unitless) of the previous day. Default value is 15.
lat	Latitude of the weather station (optional, default=55). Latitude values are used to make day length adjustments in the function.

`out` The function offers two output options, out="all" will produce an output include both the input and the FWI System outputs; out="fwi" will generate only the FWI system components.

`lat.adjust` The function offers options for whether day length adjustments should be applied to the calculations. The default value is "TRUE".

Details

The Canadian Forest Fire Weather Index (FWI) System is a major subsystem of the Canadian Forest Fire Danger Rating System, which also includes Canadian Forest Fire Behavior Prediction (FBP) System. The modern FWI System was first issued in 1970 and is the result of work by numerous researchers from across Canada. It evolved from field research which began in the 1930's and regional fire hazard and fire danger tables developed from that early research.

The modern System (Van Wagner 1987) provides six output indices which represent fuel moisture and potential fire behavior in a standard pine forest fuel type. Inputs are a daily noon observation of fire weather, which consists of screen-level air temperature and relative humidity, 10 meter open wind speed and 24 accumulated precipitation.

The first three outputs of the system (the Fire Fuel Moisture Code, the Duff Moisture Code, and the Drought Code) track moisture in different layers of the fuel making up the forest floor. Their calculation relies on the daily fire weather observation and also, importantly, the code value from the previous day as they are in essence bookkeeping systems tracking the amount of moisture (water) in to and out of the layer. It is therefore important that when calculating FWI System outputs over an entire fire season, an uninterrupted daily weather stream is provided; one day is the assumed time step in the models and thus missing data must be filled in.

The next three outputs of the System are relative (unitless) indicators of aspects of fire behavior potential: spread rate (the Initial Spread Index), fuel consumption (the Build-up Index) and fire intensity per unit length of fire front (the Fire Weather Index). This final index, the fwi, is the component of the System used to establish the daily fire danger level for a region and communicated to the public. This final index can be transformed to the Daily Severity Rating (dsr) to provide a more reasonably-scaled estimate of fire control difficulty.

Both the Duff Moisture Code (dmc) and Drought Code (dc) are influenced by day length (see Van Wagner, 1987). Day length adjustments for different ranges in latitude can be used (as described in Lawson and Armitage 2008 (http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/29152.pdf)) and are included in this R function; latitude must be positive in the northern hemisphere and negative in the southern hemisphere.

At the start of a fire season, or simply the start of a daily weather stream, the FWI System calculation requires an estimate of yesterday's moisture conditions. The default initial (i.e., "start-up") fuel moisture code values (FFMC=85, DMC=6, DC=15) provide a reasonable set of conditions for post-snowmelt springtime conditions in eastern/central Canada, the Northern U.S., and Alaska; physically these spring start-up values represent about 3 days of drying from complete moisture saturation of the fuel layer. In areas or years with particularly dry winters (or parts of the world without significant snow cover) these start-up values for FFMC and DMC may still be appropriate as these two elements respond relatively quickly to changes in the weather. The DC component however, because of its very long response time, can take considerable time to adjust to unrealistic initial values and some effort to estimate over-winter value of the DC may be necessary. Users can look again to Lawson and Armitage (2008) for a more detailed description of code calculation startup issues and the over-winter adjustment process.

Value

fwiBAT returns a data.frame which may include both the input and the FWI System outputs (default) or the FWI System outputs only as described below:

`Input Variables`
: May include id, long, lat, yr, mon, day, temp, rh, ws, and prec when option out='all' (default) is chosen

`ffmc`
: Fine Fuel Moisture Code

`dmc`
: Duff Moisture Code

`dc`
: Drought Code

`isi`
: Initial Spread Index

`bui`
: Buildup Index

`fwi`
: Fire Weather Index

`dsr`
: Daily Severity Rating

Author(s)

Xianli Wang, Alan Cantin, Marc-Andre Parisien, Mike Wotton, Kerry Anderson, and Mike Flannigan

References

1. Van Wagner, C.E. and T.L. Pickett. 1985. Equations and FORTRAN program for the Canadian Forest Fire Weather Index System. Can. For. Serv., Ottawa, Ont. For. Tech. Rep. 33. 18 p.

2. Van Wagner, C.E. 1987. Development and structure of the Canadian forest fire weather index system. Forest Technology Report 35. (Canadian Forestry Service: Ottawa).

3. Lawson, B.D. and O.B. Armitage. 2008. Weather guide for the Canadian Forest Fire Danger Rating System. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, AB.

Examples

```
library(fwi.fbp)
# The test data is a standard test
# dataset for FWI system(Van Wagner and Pickett 1985).

data("test_fwi")
head(test_fwi)

# using the default initial values
fwi.out<-fwiBAT(test_fwi)

# using a different set of initials
fwi.out<-fwiBAT(test_fwi,init=c(80,10,16,50))

# using only the required input variables:
fwi.out<-fwiBAT(test_fwi[,7:10])
```

---

test_fbp — *Fire Behaviour Prediction Sample Data Set*

Description

This data set is a set of input data for each of the test cases in the publication supplied below.

Usage

```
test_fbp
```

Format

A data frame containing 24 columns, 20 rows, and 1 header line

Source

http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/31414.pdf

References

1. Wotton, B.M., Alexander, M.E., Taylor, S.W. 2009. Updates and revisions to the 1992 Canadian forest fire behavior prediction system. Nat. Resour. Can., Can. For. Serv., Great Lakes For. Cent., Sault Ste. Marie, Ontario, Canada. Information Report GLC-X-10, 45p.

`test_fwi` *Fire Weather Index Sample Input Data Set*

Description

This data set is the sample input data that was used in original FWI program calibration.

Usage

```
test_fwi
```

Format

A data frame containing 10 columns and 49 rows, with 1 header line

Source

http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/19973.pdf

References

1. Van Wagner, CE. and T.L. Pickett. 1985. Equations and FORTRAN program for the Canadian Forest Fire Weather Index System. Can. For. Serv., Ottawa, Ont. For. Tech. Rep. 33. 18 p.

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