Package 'BlackCarbon'

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Type Package

Title Processing Raw Black Carbon Concentration

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Description The functions in this package are designed to be used in the processing of black car-
bon concentration collected by a specific type of a personal monitor. The package includes func-
tions for processing of the data by applying Optimized noise reduction averaging algo-
rithm along with filter loading correction and with an option of filter change adjustment.

License GPL (>= 2)

Encoding UTF-8

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NeedsCompilation no

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R topics documented:

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data_compiled   *Dataset compiled at file level*

Description

This is a hypothetical dataset (compiled at file level) created as an example to faciliate user's learning of the function used in the package while processing the black carbon data with ONA algorithm

Usage

```
data("data_compiled")
```

Format

A data frame with 31118 observations on the following 3 variables.

file_ID a factor with levels AE51-S6-1211_20181114-025500 AE51-S6-1211_20181115-070300 AE51-S6-1211_20181115-201000

ATN a numeric vector

BC a numeric vector

Examples

```
data(data_compiled)
## maybe str(data_compiled)
```

---

data_ONA   *A practise dataset*

Description

This is a hypothetical dataset created as an example to faciliate user's learning of the function used in the package while processing the black carbon data with ONA algorithm

Usage

```
data("data_ONA")
```

Format

A data frame with 31118 observations on the following 2 variables.

ATN a numeric vector

BC a numeric vector

Examples

```
data(data_ONA)
## maybe str(data_ONA)
```

---

filter_adjust_ONA *ONA adjusting filter change*

Description

This function is an extended version of (ONA and filter_loading) which can only work at individual file level, similar to the ONA function. This function has an inbuilt function of filter loading correction as well as has capacity to adjust for filter change or a huge drop in ATN marked as mechanical error.

Usage

```
filter_adjust_ONA(data =data, ATN = "ATN", BC = "BC", dATN = 0.05,
threshold = 5, skip = 15, ignore = 10)
```

Arguments

data	a datafram containing the raw data of black carbon.
ATN	the coloumn having ATN coefficient.
BC	the column having raw black carbon data.
dATN	the difference in ATN coefficient which is used for defining the averaging window of raw black carbon concentration, by default it is 0.05.
threshold	the change in ATN value which indicates the filter change, it is 5 by default.
skip	number of observations before the filter change point that has to be skipped or deleted from analysis. When the AE51 device is about to indicate the need of filter change or when it's about encounters a sudden drop of ATN it either produces maximum negative or positive black carbon concentration which is a mechanical noise and averaging those values also introduces bias. Therefore certain observations before filter change or extreme drop down of ATN should be deleted depending on the data collection interval. By default it is 15 observation for 10s interval data.
ignore	number of observations after the filter change point that has to be ignored or deleted from analysis. After changing the filter or after a while of sudden drop of ATN value, AE51 device either produces maximum negative or positive black carbon concentration which is a mechanical noise and averaging those values also introduces bias. Therefore certain observations after filter change or sudden drop of ATN should be deleted depending on the data collection interval. By default it is 10 observation for 10s interval data.

Details

This method is only applicable when the raw files are not compiled

Value

The default method returns the existing data frame with two additional columns 1) with ONA processed black carbon concentration and 2) filter loading corrected ONA processed black carbon concentration. If there is a filter change or a drop of ATN by more than 5 units within two adjoining observations some observations (25 rows), which is ignore + skip given in the function, will be deleted to correct for the mechanical error

Note

When there is a filter change or a rapid drop of ATN value, as opposed to the assumption that the ATN should gradually increase, the averaging window identified using dATN becomes wider or gets violated as it doesn't/may not get a proper window till the last observation. Therefore, an averaging window should be then identified from the very next point to the rapid drop of ATN, considering it as if an initial point of a new file.

Author(s)

Sanjeev Bista (MPH - Advanced Bio-statistics and Epidemiology)

References

Hagler GSW, Yelverton TLB, Vedantham R, Hansen ADA, Turner JR. Post-processing Method to Reduce Noise while Preserving High Time Resolution in Aethalometer Real-time Black Carbon Data. Aerosol Air Qual Res [Internet]. 2011 Oct [cited 2020 May 3];11(5):539–46. Available from: http://www.aaqr.org/doi/10.4209/aaqr.2011.05.0055

Kirchstetter, T.W., Novakov, T., 2007. Controlled generation of black carbon particles from a diffusion flame and applications in evaluating black carbon measurement methods. Atmospheric Environment 41, 1874-1888 Available from: https://doi.org/10.1016/j.atmosenv.2006.10.067

See Also

ONA filter_loading

Examples

```
data(data_ONA)#loading the example dataset
#saving a processed dataset with the same name
data_ONA<-filter_adjust_ONA(data =data_ONA, ATN = "ATN", BC = "BC", dATN = 0.05, threshold = 5,
                 skip = 15, ignore = 10)


## The function is currently defined as
function (data =data, ATN = "ATN", BC = "BC", dATN = 0.05, threshold = 5,
    skip = 15, ignore = 10)
{
    if (nrow(data) < (skip + ignore)) {
        print("not enough observations to correct for filter loading")
    }
    else {
        for (j in skip:(nrow(data) - ignore)) {
```

```
            if ((data[, ATN][j] - data[, ATN][j - 1]) < (-threshold)) {
                f <- j
                k1 <- data[1:(f - skip), ]
                k2 <- data[(f + ignore):nrow(data), ]
                k1[, "BC_ONA"] <- ONA(data = k1, ATN = "ATN",
                  BC = "BC", dATN = dATN)
                k1[, "BC_ONA_Cor"] <- k1[, "BC_ONA"] * (0.88 *
                  exp(-(k1[, ATN])/100) + 0.12)^(-1)
                k2[, "BC_ONA"] <- ONA(data = k2, ATN = "ATN",
                  BC = "BC", dATN = dATN)
                k2[, "BC_ONA_Cor"] <- k2[, "BC_ONA"] * (0.88 *
                  exp(-(k2[, ATN])/100) + 0.12)^(-1)
            }
        }
    }
    if (exists("k1") == T) {
        data <- rbind(k1, k2)
        rm(k1, k2)
    }
    else {
        data[, "BC_ONA"] <- ONA(data, ATN = "ATN", BC = "BC",
            dATN = 0.1)
        data[, "BC_ONA_Cor"] <- data[, "BC_ONA"] * (0.88 * exp(-(data[,
            ATN])/100) + 0.12)^(-1)
    }
    return(data)
}
```

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filter_loading	*Filter loading correction*

Description

This function is applied when we already have black carbon concentration processed by ONA algorithm. Since Black carbon concentration measured by AE51 substantially decreases when the filter loading goes up, we can apply filter correction function to adjust for that.

Usage

```
filter_loading(data, ONA_BC = "BC_ONA", ATN = "ATN")
```

Arguments

data	a datafram containing the raw data of black carbon.
ONA_BC	the column having black carbon concentration processed by ONA algorithm.
ATN	the column having ATN coefficient.

Details

This method is applicable even when the raw files are compiled as it uses the corresponding ATN values to correct for filter loading of black carbon concentration

Value

The default mthod returns a vector with equal length as the dataframe.

Note

Higly recommend to read the reference before using the function

Author(s)

Sanjeev Bista (MPH - Advanced Bio-statistics and Epidemiology)

References

Kirchstetter, T.W., Novakov, T., 2007. Controlled generation of black carbon particles from a diffusion flame and applications in evaluating black carbon measurement methods. Atmospheric Environment 41, 1874-1888 Available from: https://doi.org/10.1016/j.atmosenv.2006.10.067

See Also

ONA

Examples

```
data(data_ONA)#loading the example dataset
#calculating ONA processed black carbon first
data_ONA$ONA_BC<-ONA(data=data_ONA, ATN = "ATN", BC ="BC", dATN =0.05)
filter_loading(data =data_ONA, ATN = "ATN", ONA_BC="BC")

## The function is currently defined as
function (data, ONA_BC = "BC_ONA", ATN = "ATN")
{
    data[, ONA_BC] * (0.88 * exp(-(data[, ATN])/100) + 0.12)^(-1)
  }
```

ONA   *Optimized Noise Reduction Averaging (ONA) algorithm*

Description

The function uses the Optimized Noise Reduction Averaging (ONA) algorithm to process the raw black carbon data collected by Aethalometers (MicroAeth AE51, AethLabs, CA, USA).The algorithm smooths the black carbon concentration over a varying smoothing window identified by change in coefficient of light attenuation (ATN).

Usage

```
ONA(data=data, ATN = "ATN", BC ="BC", dATN =0.05)
```

Arguments

data	it is a datafram generated by the AE51 device at the file level and not compiled with other files, however, a little pre-processing has to be done such as naming the columns and formatting it as a data frame.
ATN	the column having ATN coefficient.
BC	the column having raw black carbon data.
dATN	the difference in ATN coefficient which is used for defining the averaging window of raw black carbon concentration, by default it is 0.05.

Details

This method is only applicable when the raw files are not compiled

Value

The default method returns a vector with equal length as the dataframe

Note

Higly recommend to read the reference before using the function

Author(s)

Sanjeev Bista (MPH - Advanced Bio-statistics and Epidemiology)

References

Hagler GSW, Yelverton TLB, Vedantham R, Hansen ADA, Turner JR. Post-processing Method to Reduce Noise while Preserving High Time Resolution in Aethalometer Real-time Black Carbon Data. Aerosol Air Qual Res [Internet]. 2011 Oct [cited 2020 May 3];11(5):539–46. Available from: http://www.aaqr.org/doi/10.4209/aaqr.2011.05.0055

See Also

mean lapply

Examples

```
data(data_ONA) # loading example dataset
ONA(data=data_ONA, ATN = "ATN", BC ="BC", dATN =0.05)

data(data_compiled) #loading the example dataset compiled at file level
#applying ONA on a compiled file where data come from different files
data_compiled$file_ID<-as.factor(data_compiled$file_ID)
data_compiled$ONA_BC<-unlist(lapply(split(data_compiled, data_compiled$file_ID),
```

```
function(x) ONA(data=x, ATN = "ATN", BC ="BC", dATN =0.05)))
```

ONA_compiled	*ONA at file level*

Description

This function is an extended version of filter_adjust_ONA which can work with the files compiled at person level or at study level, unlike the filter_adjust_ONA function.

Usage

```
ONA_compiled(data = data, ATN = "ATN", BC = "BC", file_id = "file_ID", dATN = 0.05,
threshold = 5, skip = 15, ignore = 10)
```

Arguments

data	a datafram containing the raw data of black carbon.
ATN	
BC	the column having ATN coefficient.
file_id	the column having file id after compiling files produced at different time for a person or of different participants.
dATN	the difference in ATN coefficient which is used for defining the averaging window of raw black carbon concentration, by default it is 0.05.
threshold	the change in ATN value which indicates the filter change or the rapid drop of ATN value that may violate the averaging window which is based on the assumption that the ATN gradually increases.By default the value of 5 is used.
skip	number of observations before the filter change point that has to be skiped or deleted from analysis. When the AE51 device is about to indicate the need of filter change it either produces maximum negative or positive black carbon concentration which is a mechanical noise and averaging those values also introduces bias. Therefore certain observations before filter change should be deleted depending on the data collection interval. By default it is 15 observation for 10s interval data.
ignore	number of observations after the filter change point that has to be ignored or deleted from analysis. After chaning the filter AE51 device either produces maximum negative or positive black carbon concentration which is a mechanical noise and averaging those values also introduces bias. Therefore certain observations after filter change should be deleted depending on the data collection interval. By default it is 10 observation for 10s interval data.

Details

This method also applicable when the raw files are compiled at person level or even at study level

Value

The default method returns the existing data frame with two additional columns 1) with ONA processed black carbon concentration and 2) filter loading corrected ONA processed black carbon concentration.

Note

The file id helps the function to distinguish each separate file created by AE51 device at different point in time or created for different participants and assists in processing the file individually and compile them back to make a single file as it was given to the function.

Author(s)

Sanjeev Bista (MPH - Advanced Bio-statistics and Epidemiology)

References

Hagler GSW, Yelverton TLB, Vedantham R, Hansen ADA, Turner JR. Post-processing Method to Reduce Noise while Preserving High Time Resolution in Aethalometer Real-time Black Carbon Data. Aerosol Air Qual Res [Internet]. 2011 Oct [cited 2020 May 3];11(5):539–46. Available from: http://www.aaqr.org/doi/10.4209/aaqr.2011.05.0055

Kirchstetter, T.W., Novakov, T., 2007. Controlled generation of black carbon particles from a diffusion flame and applications in evaluating black carbon measurement methods. Atmospheric Environment 41, 1874-1888

See Also

ONA filter_loading filter_adjust_ONA

Examples

```
data(data_compiled) #loading the example dataset compiled at file level
#saving a processed dataset (compiled at file level) with the same name
data_compiled<-ONA_compiled(data = data_compiled, ATN = "ATN", BC = "BC", file_id = "file_ID",
         dATN = 0.05, threshold = 5, skip = 15, ignore = 10)

## The function is currently defined as
function (data = data, ATN = "ATN", BC = "BC", file_id = "file_ID",
    dATN = 0.05, threshold = 5, skip = 15, ignore = 10)
{
    data[, "file_ID"] <- as.factor(data[, "file_ID"])
    data1 <- lapply(split(data, data[, file_id]), function(x) {
        filter_adjust_ONA(x, ATN = ATN, BC = BC, dATN = dATN,
            threshold = threshold, skip = skip, ignore = ignore)
    })
    names(data1) <- NULL
    data2 <- do.call("rbind", data1)
    return(data2)
  }
```

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