

Package ‘NEONiso’

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Type Package

Title Tools to Calibrate and Work with NEON Atmospheric Isotope Data

Version 0.5.3

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Depends R (>= 4.0.0)

Description Functions for downloading, calibrating, and analyzing atmospheric isotope data bundled into the eddy covariance data products of the National Ecological Observatory Network (NEON) <<https://www.neonscience.org>>. In this version, calibration tools are provided for only the carbon isotope products. Tools for calibrating water isotope products are under development. More details are found in Fiorella et al. (2021) <[doi:10.1029/2020JG005862](https://doi.org/10.1029/2020JG005862)>, and the readme file at <<https://github.com/SPATIAL-Lab/NEONiso>>.

License GPL-3

BugReports <https://github.com/SPATIAL-Lab/NEONiso/issues>

URL <https://github.com/SPATIAL-Lab/NEONiso>

Encoding UTF-8

RoxygenNote 7.1.2

Imports dplyr, zoo, httr, lubridate, neonUtilities (>= 2.0.1), magrittr, rhdf5 (>= 2.33.7), R.utils, tidyselect, data.table, rlang, lifecycle

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

VignetteBuilder knitr

Language en-US

Config/testthat/edition 3

NeedsCompilation no

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|-----------------|------------------------|
| calculate_12CO2 | <i>calculate_12CO2</i> |
|-----------------|------------------------|

Description

calculate_12CO2

Usage

calculate_12CO2(total_co2, delta13C, f = 0.00474)

Arguments

| | |
|-----------|--|
| total_co2 | Vector of CO2 mole fractions. |
| delta13C | Vector of d13C values. |
| f | Fraction of CO2 that is not 12CO2 or 13CO2. Assumed fixed at 0.00474 |

Value

Vector of 12CO2 mole fractions.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

calculate_12CO2(total_co2 = 410, delta13C = -8.5)

calculate_13CO2 *calculate_13CO2*

Description

calculate_13CO2

Usage

```
calculate_13CO2(total_co2, delta13C, f = 0.00474)
```

Arguments

| | |
|-----------|--|
| total_co2 | Vector of CO2 mole fractions. |
| delta13C | Vector of d13C values. |
| f | Fraction of CO2 that is not 12CO2 or 13CO2. Assumed fixed at 0.00474 |

Value

Vector of 13CO2 mole fractions.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

```
calculate_13CO2(total_co2 = 410, delta13C = -8.5)
```

calibrate_ambient_carbon_Bowling2003
calibrate_ambient_carbon_Bowling2003

Description

calibrate_ambient_carbon_Bowling2003

Usage

```
calibrate_ambient_carbon_Bowling2003(
  amb_data_list,
  caldf,
  site,
  filter_data = TRUE,
  force_to_end = TRUE,
  force_to_beginning = TRUE,
  gap_fill_parameters = FALSE,
  r2_thres = 0.9
)
```

Arguments

| | |
|---------------------|--|
| amb_data_list | List containing an ambient d13C dataset. Will include all variables in 000_0x0_xxm. (character) |
| caldf | Calibration data frame containing gain and offset values for 12C and 13C isotopologues. |
| site | Four-letter NEON code corresponding to site being processed. |
| filter_data | Apply median absolute deviation filter from Brock 86 to remove impulse spikes? Inherited from calibrate_ambient_carbon_Bowling2003() |
| force_to_end | In given month, calibrate ambient data later than last calibration, using the last calibration? (default true) |
| force_to_beginning | In given month, calibrate ambient data before than first calibration, using the first calibration? (default true) |
| gap_fill_parameters | Should function attempt to 'gap-fill' across a bad calibration by carrying the last known good calibration forward? Implementation is fairly primitive currently, as it only carries the last known good calibration that's available forward rather than interpolating, etc. Default FALSE. |
| r2_thres | Minimum r2 value for calibration to be considered "good" and applied to ambient data. |

Value

Depends on write_to_file argument. If true, returns nothing to environment; but returns calibrated ambient observations to the output file. If false, returns modified version of amb_data_list that include calibrated ambient data.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Function called by calibrate_carbon_bymoth() to apply gain and offset parameters to the ambient datasets (000_0x0_09m and 000_0x0_30m). This function should generally not be used independently, but should be used in coordination with calibrate_carbon_bymonth().

```
calibrate_ambient_carbon_linreg
      calibrate_ambient_carbon_linreg
```

Description

calibrate_ambient_carbon_linreg

Usage

```
calibrate_ambient_carbon_linreg(
  amb_data_list,
  caldf,
  outname,
  site,
  file,
  filter_data = TRUE,
  force_to_end = TRUE,
  force_to_beginning = TRUE,
  gap_fill_parameters = FALSE,
  r2_thres = 0.9
)
```

Arguments

| | |
|---------------------|--|
| amb_data_list | List containing an ambient d13C dataset. Will include all variables in 000_0x0_xxm. (character) |
| caldf | Calibration data frame containing gain and offset values for 12C and 13C isotopologues. |
| outname | Output variable name. Inherited from calibrate_ambient_carbon_linreg |
| site | Four-letter NEON code corresponding to site being processed. |
| file | Output file name. Inherited from calibrate_ambient_carbon_linreg |
| filter_data | Apply median absolute deviation filter from Brock 86 to remove impulse spikes? Inherited from calibrate_ambient_carbon_linreg |
| force_to_end | In given month, calibrate ambient data later than last calibration, using the last calibration? (default true) |
| force_to_beginning | In given month, calibrate ambient data before than first calibration, using the first calibration? (default true) |
| gap_fill_parameters | Should function attempt to 'gap-fill' across a bad calibration by carrying the last known good calibration forward? Implementation is fairly primitive currently, as it only carries the last known good calibration that's available forward rather than interpolating, etc. Default FALSE. |
| r2_thres | Minimum r2 value for calibration to be considered "good" and applied to ambient data. |

Value

Nothing to environment; returns calibrated ambient observations to the output file. This function is not designed to be called on its own, and is not exported to the namespace.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Function called by `calibrate_ambient_carbon_linreg` to apply gain and offset parameters to the ambient datasets (000_0x0_09m and 000_0x0_30m). This function should generally not be used independently, but should be used with `calibrate_ambient_carbon_linreg`.

`calibrate_ambient_water_linreg`
calibrate_ambient_water_isotopes

Description

`calibrate_ambient_water_isotopes`

Usage

```
calibrate_ambient_water_linreg(  
  amb_data_list,  
  caldf,  
  outname,  
  site,  
  file,  
  filter_data,  
  force_to_end,  
  force_to_beginning,  
  r2_thres  
)
```

Arguments

| | |
|----------------------------|--|
| <code>amb_data_list</code> | List containing ambient d18O/d2H datasets. Will include all variables in 000_0x0_xxm. (character) |
| <code>caldf</code> | Calibration data frame containing slope and intercept values for d18O and d2H values. |
| <code>outname</code> | Output variable name. Inherited from <code>calibrate_ambient_water_linreg</code> |
| <code>site</code> | Four-letter NEON code corresponding to site being processed. |
| <code>file</code> | Output file name. Inherited from <code>calibrate_ambient_water_linreg</code> |
| <code>filter_data</code> | Apply a median filter to output ambient data? inherited. |
| <code>force_to_end</code> | In given month, calibrate ambient data later than last calibration, using the last calibration? (default true) |

force_to_beginning In given month, calibrate ambient data before than first calibration, using the first calibration? (default true)

r2_thres Minimum r2 value for calibration to be considered "good" and applied to ambient data.

Value

Nothing to environment; returns calibrated ambient observations to the output file. This function is not designed to be called on its own.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Function called by `calibrate_ambient_water_linreg` to apply slope and intercept parameters to the ambient datasets (000_0x0_09m and 000_0x0_30m) to correct to the VSMOW scale. This function should generally not be used independently, but should be used with `calibrate_ambient_water_linreg`. Note that in this version *NO CORRECTION FOR HUMIDITY* is performed. Use with caution.

calibrate_carbon *calibrate_carbon*

Description

[Experimental] This function drives a workflow that reads in NEON carbon isotope data of atmospheric CO₂, calibrates it to the VPDB scale, and (optionally) writes the calibrated data to a new HDF5 file. Two different approaches are possible: a) a calibration on ¹²CO₂ and ¹³CO₂ isotopologues independently, after Bowling et al. 2003 (Agr. For. Met.), or b) a direct calibration of δ¹³C and CO₂ values using linear regression. The vast majority of the time the results generated from either method are extremely similar to each other. Wen et al. 2013 compared several different carbon isotope calibration techniques and found this to be the superior method under most circumstances. We also found this to be the case for NEON data (Fiorella et al. 2021; JGR-Biogeosciences).

Usage

```
calibrate_carbon(
  inname,
  outname,
  site,
  method = "Bowling_2003",
  calibration_half_width = 0.5,
  force_cal_to_beginning = TRUE,
  force_cal_to_end = TRUE,
  gap_fill_parameters = FALSE,
  filter_ambient = TRUE,
  r2_thres = 0.95,
  correct_refData = TRUE,
  write_to_file = TRUE
)
```


Arguments

| | |
|------------------------|---|
| iname | Input file(s) that are to be calibrated. If a single file is given, output will be a single file per site per month. If a list of files corresponding to a timeseries at a given site is provided, will calibrate the whole time series. |
| outname | Name of the output file. (character) |
| site | Four letter NEON site code for site being processed. (character) |
| method | Are we using the Bowling et al. 2003 method ("Bowling_2003") or direct linear regression of d13C and CO2 mole fractions ("linreg")? |
| calibration_half_width | Determines the period (in days) from which reference data are selected (period is 2*calibration_half_width). |
| force_cal_to_beginning | Extend first calibration to the beginning of the file? (default true) |
| force_cal_to_end | Extend last calibration to the end of the file? (default true) |
| gap_fill_parameters | Should function attempt to 'gap-fill' across a bad calibration by carrying the last known good calibration forward? Implementation is fairly primitive currently, as it only carries the last known good calibration that's available forward rather than interpolating, etc. Default FALSE. |
| filter_ambient | Apply the median absolute deviation filter (Brock 86) to remove impulse spikes in output ambient data? (logical; default true) |
| r2_thres | Minimum r2 threshold of an "acceptable" calibration. Acts to remove calibration periods where a measurement error makes relationship nonlinear. Default = 0.95 |
| correct_refData | NEON has indicated there are a few instances where reported d13C or CO2 reference values are wrong. If set to true, correct known incorrect values. This argument will (hopefully, eventually) go away after NEON has fixed the reference database. Users will be warned prior to removal of this argument. |
| write_to_file | Write calibrated ambient data to file? (Mostly used for testing) |

Details

The 'linreg' method simply takes measured and reference d13C and CO2 values and generates a transfer function between them using $lm()$. For the gain-and-offset method, d13C and CO2 values are converted to $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ mole fractions. Gain and offset parameters are calculated for each isotopologue independently, and are analogous to regression slope and intercepts, but jointly correct for CO2 concentration dependence and place d13C values on the VPDB scale. The gain and offset parameters are defined by:

$$G = (X_{2,ref} - X_{1,ref}) / (X_{2,meas} - X_{1,meas})$$

$$O = X_{2,ref} - GX_{2,meas}$$

Calibrated ambient isotopologues are then given as:

$$X_{cal} = X_{meas}G + O$$

Measurements of reference materials were considered "good" if the following conditions were met:

- Measured CO₂ concentrations were within 10 ppm of known "reference" concentrations.
- Variance of the CO₂ concentration in standard peak was < 5 ppm.
- Measured d13C value must be within 5 per mil of known "reference" d13C value.

The first two criteria are intended to filter out periods where there is a clear issue with the gas delivery system (i.e., nearly empty gas tank, problem with a valve in the manifold, etc.); the third criterion was adopted after visual inspection of data timeseries revealed that often the first standard measurement following an instrument issue had higher-than-expected error. This criterion clips clearly poor values. Selection of these criteria will become a function argument, and therefore customizable, in a future release.

The behavior of this function will be a bit different depending on what is supplied as `inname`. If a single file is provided, the output will be monthly. However, a list of files corresponding to a site can also be provided, and then a single output file per site will be generated.

Value

Returns nothing to the environment, but creates a new output HDF5 file containing calibrated carbon isotope values.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

```
## Not run: fin <- system.file('extdata',
  'NEON.D15.ONAQ.DP4.00200.001.nsae.2019-05.basic.20201020T211037Z.packed.h5',
  package = 'NEONiso', mustWork = TRUE)
calibrate_carbon_bymonth(inname = fin, outname = 'out.h5',
  site = 'ONAQ', write_to_file = FALSE)
calibrate_carbon_bymonth(inname = fin, outname = 'out.h5',
  site = 'ONAQ', method = 'linreg', write_to_file = FALSE)
## End(Not run)
```

calibrate_carbon_bymonth

calibrate_carbon_bymonth

Description

[Stable] This function drives a workflow that reads in NEON carbon isotope data of atmospheric CO₂, calibrates it to the VPDB scale, and (optionally) writes the calibrated data to a new HDF5 file. Two different approaches are possible: a) a calibration on ¹²CO₂ and ¹³CO₂ isotopologues independently, after Bowling et al. 2003 (Agr. For. Met.), or b) a direct calibration of d13C and CO₂ values using linear regression. The vast majority of the time the results generated from either

method are extremely similar to each other. Wen et al. 2013 compared several different carbon isotope calibration techniques and found this to be the superior method under most circumstances. We also found this to be the case for NEON data (Fiorella et al. 2021; JGR-Biogeosciences).

Usage

```
calibrate_carbon_bymonth(
  inname,
  outname,
  site,
  method = "Bowling_2003",
  calibration_half_width = 0.5,
  force_cal_to_beginning = TRUE,
  force_cal_to_end = TRUE,
  gap_fill_parameters = FALSE,
  filter_ambient = TRUE,
  r2_thres = 0.95,
  correct_refData = TRUE,
  write_to_file = TRUE
)
```

Arguments

| | |
|------------------------|--|
| inname | Name of the input file. (character) |
| outname | Name of the output file. (character) |
| site | Four letter NEON site code for site being processed. (character) |
| method | Are we using the Bowling et al. 2003 method ("Bowling_2003") or direct linear regression of d13C and CO2 mole fractions ("linreg")? |
| calibration_half_width | Determines the period (in days) from which reference data are selected (period is 2*calibration_half_width). |
| force_cal_to_beginning | Extend first calibration to the beginning of the file? (default true) |
| force_cal_to_end | Extend last calibration to the end of the file? (default true) |
| gap_fill_parameters | Should function attempt to 'gap-fill' across a bad calibration by carrying the last known good calibration forward? Implementation is fairly primitive currently, as it only carries the last known good calibration that's available forward rather than interpolating, etc. Default FALSE. |
| filter_ambient | Apply the median absolute deviation filter (Brock 86) to remove impulse spikes in output ambient data? (logical; default true) |
| r2_thres | Minimum r2 threshold of an "acceptable" calibration. Acts to remove calibration periods where a measurement error makes relationship nonlinear. Default = 0.95 |
| correct_refData | NEON has indicated there are a few instances where reported d13C or CO2 reference values are wrong. If set to true, correct known incorrect values. This |

argument will (hopefully, eventually) go away after NEON has fixed the reference database. Users will be warned prior to removal of this argument.

`write_to_file` Write calibrated ambient data to file? (Mostly used for testing)

Details

The 'linreg' method simply takes measured and reference d13C and CO2 values and generates a transfer function between them using `lm()`. For the gain-and-offset method, d13C and CO2 values are converted to 12CO2 and 13CO2 mole fractions. Gain and offset parameters are calculated for each isotopologue independently, and are analogous to regression slope and intercepts, but jointly correct for CO2 concentration dependence and place d13C values on the VPDB scale. The gain and offset parameters are defined by:

$$G = (X_{2,ref} - X_{1,ref}) / (X_{2,meas} - X_{1,meas})$$

$$O = X_{2,ref} - GX_{2,meas}$$

Calibrated ambient isotopologues are then given as:

$$X_{cal} = X_{meas}G + O$$

Measurements of reference materials were considered "good" if the following conditions were met:

- Measured CO2 concentrations were within 10 ppm of known "reference" concentrations.
- Variance of the CO2 concentration in standard peak was < 5 ppm.
- Measured d13C value must be within 5 per mil of known "reference" d13C value.

The first two criteria are intended to filter out periods where there is a clear issue with the gas delivery system (i.e., nearly empty gas tank, problem with a valve in the manifold, etc.); the third criterion was adopted after visual inspection of data timeseries revealed that often the first standard measurement following an instrument issue had higher-than-expected error. This criterion clips clearly poor values. Selection of these criteria will become a function argument, and therefore customizable, in a future release.

Value

Returns nothing to the environment, but creates a new output HDF5 file containing calibrated carbon isotope values.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

```
## Not run: fin <- system.file('extdata',
  'NEON.D15.ONAQ.DP4.00200.001.nsae.2019-05.basic.20201020T211037Z.packed.h5',
  package = 'NEONiso', mustWork = TRUE)
calibrate_carbon_bymonth(inname = fin, outname = 'out.h5',
  site = 'ONAQ', write_to_file = FALSE)
```

```
calibrate_carbon_bymonth(inname = fin, outname = 'out.h5',
                        site = 'ONAQ', method = 'linreg', write_to_file = FALSE)
## End(Not run)
```

```
calibrate_carbon_reference_data
      calibrate_carbon_reference_data
```

Description

calibrate_carbon_reference_data

Usage

```
calibrate_carbon_reference_data(inname, outname, standard, site, calDf)
```

Arguments

| | |
|----------|--|
| inname | Input file name. |
| outname | Output file name. |
| standard | Which standard are we working on? Must be "Low", "Med", or "High" |
| site | NEON 4-letter site code. |
| calDf | Calibration data frame - this is the output from fit_carbon_regression |

Value

Nothing to the environment.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

```
calibrate_carbon_reference_data2
      calibrate_carbon_reference_data2
```

Description

calibrate_carbon_reference_data2

Usage

```
calibrate_carbon_reference_data2(outname, standard, site, allData, calParams)
```

Arguments

| | |
|-----------|--|
| outname | Output file name. |
| standard | Which standard are we working on? Must be "Low", "Med", or "High" |
| site | NEON 4-letter site code. |
| allData | Uncalibrated reference data frames. |
| calParams | Calibration data frame - this is the output from fit_carbon_regression |

Value

Nothing to the environment.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

calibrate_standards_carbon
calibrate_standards_carbon

Description

calibrate_standards_carbon

Usage

```
calibrate_standards_carbon(
  cal_df,
  ref_df,
  f = 0.00474,
  r2_thres = 0.95,
  correct_bad_refvals = FALSE,
  site,
  refGas
)
```

Arguments

| | |
|----------|---|
| cal_df | Data.frame containing calibration parameters |
| ref_df | Data.frame containing reference gas measurements |
| f | Fraction of CO ₂ isotopologues that are not ¹² CO ₂ or ¹³ CO ₂ . Inherited from script calling this function. |
| r2_thres | Threshold for calibration regression to be used to calibrate standards data. Default is 0.95. Calibrated reference gas measurements occurring during calibration periods with r ² values less than r2_thres will be marked NA. |

| | |
|---------------------|---|
| correct_bad_refvals | Should we correct known/suspected incorrect reference values in the NEON HDF5 files? (Default = FALSE). |
| site | Four letter NEON site code. Only used if correct_bad_refvals = TRUE. |
| refGas | One of "low", "med", or "high." Only used if correct_bad_refvals = TRUE. |

Value

A data.frame having the same number of rows of cal_df, with additional columns added for calibrated CO2 mole fractions and d13C values.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

calibrate_standards_water
calibrate_standards_water

Description

calibrate_standards_water

Usage

```
calibrate_standards_water(cal_df, ref_df, r2_thres = 0.95)
```

Arguments

| | |
|----------|---|
| cal_df | Data.frame containing calibration parameters |
| ref_df | Data.frame containing reference gas measurements |
| r2_thres | Threshold for calibration regression to be used to calibrate standards data. Default is 0.95. Calibrated reference gas measurements occurring during calibration periods with r2 values less than r2_thres will be marked NA. |

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

| | |
|-----------------|------------------------|
| calibrate_water | <i>calibrate_water</i> |
|-----------------|------------------------|

Description

[Experimental] This function uses NEON validation data to apply drift corrections to measured ambient water isotope ratios. In brief, ambient water isotope ratios are calibrated by generating regressions using reference water measurements bracketing an ambient period. Three reference waters are measured once per day, with several injections per reference water. Due to memory effects, only the last three are used currently to generate calibration equations. Regressions between measured d18O and d2H values and NEON-provisioned known reference values are generated, and used to calibrate the period of ambient measurements between them if the r2 of the regression is greater than a threshold value (by default, this is 0.95). Most of this function deals with selecting the appropriate calibration data and determining calibration quality. This function also contains a wrapper for `calibrate_ambient_water_linreg`, which calibrates the ambient water data using the calibration parameters generated in this function. This function also copies over data in the `qfcm` and `ucrt` hdf5 data groups.

Usage

```
calibrate_water(
    inpath,
    outpath,
    site,
    calibration_half_width = 14,
    filter_data = TRUE,
    force_cal_to_beginning = FALSE,
    force_cal_to_end = FALSE,
    r2_thres = 0.95,
    slope_tolerance = 9999
)
```

Arguments

| | |
|-------------------------------------|--|
| <code>inpath</code> | Directory path to input (monthly) NEON HDF5 files. |
| <code>outpath</code> | Directory path to save output data file. (For now, 1 per site). |
| <code>site</code> | Four-letter NEON code for site being processed. |
| <code>calibration_half_width</code> | Determines the range of standard measurements to use in determining the calibration regression dataset. Creates a moving window that is $2 \times \text{calibration_half_width}$ days wide. Default is set to 14 for a 28 day moving window. |
| <code>filter_data</code> | Apply median absolute deviation filter from Brock 86 to remove impulse spikes? |
| <code>force_cal_to_beginning</code> | Extend first calibration to the beginning of the file? |
| <code>force_cal_to_end</code> | Extend last calibration to the end of the file? |

r2_thres Minimum r2 threshold of an "acceptable" calibration. Acts to remove calibration periods where a measurement error makes relationship nonlinear. Default = 0.95

slope_tolerance How different from 1 should we allow 'passing' regression slopes to be? Experimental parameter, off by default (e.g., default slope parameter = 9999)

Details

IMPORTANT NOTE Currently this function does not apply a correction for humidity dependence of Picarro isotopic measurements. This is because the data to implement these corrections is not yet publicly available. Caution is suggested when analyzing data at low humidities, below ~5000 ppm, with likely higher biases at lower humidity values.

Additionally, please note that this function is meant to work on *all* files for a given site at the same time. A more flexible version that can handle all files or monthly files will be added to a future release.

Value

nothing to the workspace, but creates a new output file of calibrated water isotope data.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

calibrate_water_linreg_bymonth
calibrate_water_linreg

Description

[Deprecated] This function uses NEON validation data to apply drift corrections to measured ambient water isotope ratios. In brief, ambient water isotope ratios are calibrated by generating regressions using reference water measurements bracketing an ambient period. Three reference waters are measured once per day, with several injections per reference water. Due to memory effects, only the last three are used currently to generate calibration equations. Regressions between measured d18O and d2H values and NEON-provisioned known reference values are generated, and used to calibrate the period of ambient measurements between them if the r2 of the regression is greater than a threshold value (by default, this is 0.95). Most of this function deals with selecting the appropriate calibration data and determining calibration quality. This function also contains a wrapper for `calibrate_ambient_water_linreg`, which calibrates the ambient water data using the calibration parameters generated in this function. This function also copies over data in the `qfqm` and `ucrt hdf5` data groups.

Usage

```
calibrate_water_linreg_bymonth(  
  inname,  
  outname,  
  site,  
  time_diff_between_standards = 1800,  
  filter_data = TRUE,  
  force_cal_to_beginning = TRUE,  
  force_cal_to_end = TRUE,  
  r2_thres = 0.95  
)
```

Arguments

| | |
|-----------------------------|--|
| inname | Name of the input file. |
| outname | Name of the output file. |
| site | Four-letter NEON code for site being processed. |
| time_diff_between_standards | Time (in seconds) required between consecutive standard measurements. |
| filter_data | Apply median absolute deviation filter from Brock 86 to remove impulse spikes? |
| force_cal_to_beginning | Extend first calibration to the beginning of the file? |
| force_cal_to_end | Extend last calibration to the end of the file? |
| r2_thres | Minimum r2 threshold of an "acceptable" calibration. Acts to remove calibration periods where a measurement error makes relationship nonlinear. Default = 0.95 |

Details

IMPORTANT NOTE Currently this function does not apply a correction for humidity dependence of Picarro isotopic measurements. This is because the data to implement these corrections is not yet publicly available. Caution is suggested when analyzing data at low humidities, below ~5000 ppm, with likely higher biases at lower humidity values.

Value

nothing to the workspace, but creates a new output file of calibrated carbon isotope data.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

calibrate_water_reference_data
calibrate_water_reference_data

Description

calibrate_water_reference_data

Usage

calibrate_water_reference_data(outname, standard, site, stdDf, calDf)

Arguments

| | |
|----------|---|
| outname | Output file name. |
| standard | Which reference material is being 'calibrated'? (Low, med, or high) |
| site | NEON 4-letter site code. |
| stdDf | Data frame of reference material measurements. |
| calDf | Calibration data frame - this is the output from fit_water_regression |

Value

Nothing to the environment.

convert_NEONhdf5_to_POSIXct_time
convert_NEONhdf5_to_POSIXct_time

Description

convert_NEONhdf5_to_POSIXct_time

Usage

convert_NEONhdf5_to_POSIXct_time(intime)

Arguments

| | |
|--------|--|
| intime | Vector of datetimes in NEON data files (as string) to convert to POSIXct class |
|--------|--|

Value

Vector of datetimes from NEON data file now in POSIXct format.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

```
convert_NEONhdf5_to_POSIXct_time("2019-06-01T12:00:00.000Z")
```

```
convert_POSIXct_to_NEONhdf5_time  
    convert_POSIXct_to_NEONhdf5_time
```

Description

Converts a POSIXct object back to the character format used by NEON in their HDF eddy covariance files. Output format, using strftime syntax, is %Y-%m-%dT%H:%M:%OSZ.

Usage

```
convert_POSIXct_to_NEONhdf5_time(intime)
```

Arguments

intime POSIXct vector to convert to NEON time format.

Value

Returns character version of POSIXct object matching NEON time variable format.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

```
convert_POSIXct_to_NEONhdf5_time(Sys.time())
```

| | |
|-----------------|------------------------|
| copy_qfqm_group | <i>copy_qfqm_group</i> |
|-----------------|------------------------|

Description

copy_qfqm_group

Usage

```
copy_qfqm_group(data_list, outname, site, file, species)
```

Arguments

| | |
|-----------|---|
| data_list | List of groups to retrieve qfqm data from. |
| outname | Output filename. |
| site | Four-letter NEON site code. |
| file | Input filename. |
| species | CO2 or H2O? Same function used for both CO2 and H2O isotopes. |

Value

Nothing to the workspace, but copies qfqm group from input file to output file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

| | |
|-----------------|------------------------|
| copy_ucrt_group | <i>copy_ucrt_group</i> |
|-----------------|------------------------|

Description

copy_ucrt_group

Usage

```
copy_ucrt_group(data_list, outname, site, file, species)
```

Arguments

| | |
|-----------|--|
| data_list | List of groups to retrieve ucrt data from. |
| outname | Output file name. |
| site | NEON 4-letter site code. |
| file | Input file name. |
| species | H2O or CO2. |

Value

Nothing to the workspace, but copies ucr group from input file to output file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

correct_carbon_ref_cval

correct_carbon_ref_cval

Description

This ugly function is present out of necessity, and will only exist for as long as it is necessary. It is an internal correction within the NEONiso calibration routines that is required as there are some mismatches between the 'true' isotope reference values and those in the NEON HDF5 files. NEON is working on correcting this, and after it has been corrected, this function has no need to exist and will be immediately deprecated. As a result, this function is fairly messy but there is little incentive to improve it.

Usage

```
correct_carbon_ref_cval(std_frame, site)
```

Arguments

| | |
|-----------|---|
| std_frame | Standard data frame to perform swap on. |
| site | NEON four letter site code. |

Value

A data.frame, based on std_frame, where NEON-supplied reference values have been corrected if a mismatch has previously been identified.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

| | |
|------------|-------------------|
| delta_to_R | <i>delta_to_R</i> |
|------------|-------------------|

Description

delta_to_R

Usage

```
delta_to_R(delta_values, element)
```

Arguments

delta_values A vector of isotope ratios in delta notation.
element Which element to return R values - carbon, oxygen, or hydrogen.

Value

Vector of isotope ratios (R values).

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

```
delta_to_R(delta_values = 0, element = 'oxygen') # returns 2005.2e-6 for VSMOW.
```

| | |
|---------------------------------|--|
| extract_carbon_calibration_data | <i>extract_carbon_calibration_data.R</i> |
|---------------------------------|--|

Description

extract_carbon_calibration_data.R

Usage

```
extract_carbon_calibration_data(data_list)
```

Arguments

data_list List containing data, from the `*/dp01/data/` group in NEON HDF5 file.

Value

Returns data frame of required variables.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

```
extract_water_calibration_data
      extract_water_calibration_data
```

Description

extract_water_calibration_data

Usage

```
extract_water_calibration_data(
  data_list,
  ucrt_list = NULL,
  standard,
  ucrt_source = "data",
  method = "by_site"
)
```

Arguments

| | |
|-------------|--|
| data_list | List containing data, from the <code>/*/dp01/data/</code> group in NEON HDF5 file. |
| ucrt_list | List containing uncertainty data, from the <code>/*/dp01/ucrt/</code> group in NEON HDF5 file. (only works if paired with <code>ucrt_source = 'ucrt'</code> and <code>method = 'by_month'</code>) |
| standard | String indicating whether to grab data from the high, medium, or low standard. |
| ucrt_source | Where from HDF5 file should variance be extracted from? (Only "data" works now..."ucrt" will throw an error.) |
| method | Are we calling this function from the <code>calibrate_water_linreg</code> function (use "by_month") or the <code>calibrate_water_linreg_bysite</code> function (use "by_site") |

Value

Returns data frame of required variables.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

filter_median_Brock86 *filter_median_Brock86*

Description

Median absolute deviation filter of Brock 1986.

Usage

```
filter_median_Brock86(data, width = 7, threshold = 5)
```

Arguments

| | |
|-----------|---|
| data | Vector to filter. |
| width | Width of filter, in rows. |
| threshold | Only filter values that are $\text{abs}(\text{threshold})$ away from median |

Value

Returns filtered vector.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

fit_carbon_regression *fit_carbon_regression*

Description

fit_carbon_regression

Usage

```
fit_carbon_regression(ref_data, method, calibration_half_width)
```

Arguments

| | |
|------------------------|---|
| ref_data | Reference data.frame from which to estimate calibration parameters. |
| method | Are we using the Bowling et al. 2003 method ("Bowling_2003") or direct linear regression of d13C and CO2 mole fractions ("linreg")? |
| calibration_half_width | Determines the period (in days) from which reference data are selected (period is $2 * \text{calibration_half_width}$). |

Value

Returns a data.frame of calibration parameters. If method == "Bowling_2003", then data.frame includes gain and offset parameters for 12CO2 and 13CO2, and r^2 values for each regression. If method == "linreg", then data.frame includes slope, intercept, and r^2 values for d13C and CO2 values.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

fit_water_regression *fit_water_regression*

Description

fit_water_regression

Usage

```
fit_water_regression(stds, calibration_half_width, slope_tolerance, r2_thres)
```

Arguments

| | |
|------------------------|--|
| stds | Reference data.frame from which to estimate calibration parameters. |
| calibration_half_width | Determines the period (in days) from which reference data are selected (period is 2*calibration_half_width). |
| slope_tolerance | Allows for filtering of slopes that deviate from 1 by slope_tolerance. |
| r2_thres | What is the minimum r2 value permitted in a 'useful' calibration relationship. |

Value

Returns a data.frame of calibration parameters. Output data.frame includes slope, intercept, and r^2 values for d13C and CO2 values.

`get_Rstd`*get_Rstd*

Description`get_Rstd`**Usage**`get_Rstd(element)`**Arguments**

`element` Which element to return standard ratio - carbon, oxygen, or hydrogen.

Value

Heavy-to-light isotope ratio of most common stable isotope standard. VSMOW for water, VPDB for carbon.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

`ingest_data`*ingest_data*

Description`ingest_data`**Usage**`ingest_data(inname, analyte)`**Arguments**

`inname` A file (or list of files) to extract data from for calibration.

`analyte` Carbon (Co2) or water (H2o)?

Value

List of data frames, taken from files specified in `inname`

```
manage_local_EC_archive  
    manage_local_EC_archive
```

Description

Utility function to help retrieve new EC data and/or prune duplicates, as NEON provisions new data or re-provisions data for an existing site and month.

Usage

```
manage_local_EC_archive(  
    file_dir,  
    get = TRUE,  
    unzip_files = TRUE,  
    trim = FALSE,  
    dry_run = TRUE,  
    sites = "all"  
)
```

Arguments

| | |
|--------------------------|---|
| <code>file_dir</code> | Specify the root directory where the local EC store is kept. |
| <code>get</code> | Pull down data from NEON API that does not exist locally? |
| <code>unzip_files</code> | NEON gzips the hdf5 files, should we unzip any gzipped files within <code>file_dir</code> ? (Searches recursively) |
| <code>trim</code> | Search through local holdings, and remove older file where there are duplicates? |
| <code>dry_run</code> | List files identified as duplicates, but do not actually delete them? Default true to prevent unintended data loss. |
| <code>sites</code> | Which sites to retrieve data from? Default will be all sites with available data, but can specify a single site or a vector here. |

Value

Returns nothing to the environment, but will download new NEON HDF5 files for selected sites (if `get = TRUE`), unzip them in the local file directory (if `unzip_files = TRUE`), and identify and remove suspected duplicate files (if `trim = TRUE` and `dry_run = FALSE`).

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

| | |
|---------|--|
| NEONiso | <i>NEONiso: A package for calibrating NEON atmospheric isotope observations.</i> |
|---------|--|

Description

This package provides functions for retrieving, calibrating, and generating diagnostic plots of NEON atmospheric isotope data.

| | |
|--------------------------|---------------------------------|
| restructure_ambient_data | <i>restructure_ambient_data</i> |
|--------------------------|---------------------------------|

Description

restructure_ambient_data

Usage

```
restructure_ambient_data(inpath, analyte)
```

Arguments

| | |
|---------|----------------------------------|
| inpath | Folder containing data to stack. |
| analyte | Carbon (Co2) or water (H2o)? |

Value

List of data extracted from files listed in inpath.

| | |
|---------------------------|----------------------------------|
| restructure_ambient_data2 | <i>restructure_ambient_data2</i> |
|---------------------------|----------------------------------|

Description

restructure_ambient_data2

Usage

```
restructure_ambient_data2(inpath, analyte)
```

Arguments

| | |
|---------|----------------------------------|
| inpath | Folder containing data to stack. |
| analyte | Carbon (Co2) or water (H2o)? |

Value

List of data extracted from files listed in inpath.

restructure_carbon_variables
restructure_carbon_variables

Description

restructure_carbon_variables

Usage

restructure_carbon_variables(dataframe, varname, mode, group)

Arguments

| | |
|-----------|---|
| dataframe | Input data.frame, from neonUtilities::stackEddy |
| varname | Which variable are we applying this function to? There's a list of ~10 common ones to write to the hdf5 file. |
| mode | Are we fixing a reference data frame or an ambient data frame? |
| group | Data, ucrt, or qfqm? |

Value

data.frame formatted for output to hdf5 file.

restructure_water_variables
restructure_water_variables

Description

restructure_water_variables

Usage

restructure_water_variables(dataframe, varname, mode)

Arguments

| | |
|-----------|---|
| dataframe | Input data.frame, from neonUtilities::stackEddy |
| varname | Which variable are we applying this function to? There's a list of ~10 common ones to write to the hdf5 file. |
| mode | Are we fixing a reference data frame or an ambient data frame? |

Value

data.frame formatted for output to hdf5 file.

| | |
|------------|-------------------|
| R_to_delta | <i>R_to_delta</i> |
|------------|-------------------|

Description

R_to_delta

Usage

```
R_to_delta(R_values, element)
```

Arguments

| | |
|----------|---|
| R_values | A vector of isotope ratios (e.g., R values). |
| element | Which element to return delta values - carbon, oxygen, or hydrogen. |

Value

Vector of isotope ratios in delta notation.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

```
R_to_delta(R_values = 2005.20e-6, element = 'oxygen') # returns 0.
```

```
select_daily_reference_data
      select_daily_reference_data
```

Description

select_daily_reference_data

Usage

```
select_daily_reference_data(standard_df, analyte, min_nobs = NA)
```

Arguments

| | |
|-------------|---|
| standard_df | Input reference data.frame. |
| analyte | Are we calibrating CO ₂ and H ₂ O? (Use argument 'co2' or 'h2o', or else function will throw error) |
| min_nobs | Minimum number of high-frequency observations to define a peak. If not supplied, defaults are 200 for analyte = 'co2' or 30 for analyte = 'h2o' |

Value

Smaller data.frame where only the reference data selected to use in the calibration routines is returned. Assumes that we are calibrating on a daily basis, and not on a longer time scale. Data are selected based on two criteria: cannot be missing, and must be at least a certain number of high-frequency observations in order to qualify as a valid measurement. For the water system, this function also keeps only the last three injections for each reference water per day.

```
setup_output_file      setup_output_file
```

Description

Creates a skeleton hdf5 file for the calibrated data.

Usage

```
setup_output_file(inname, outname, site, analyte)
```

Arguments

| | |
|---------|---|
| inname | Input file name. |
| outname | Output file name. |
| site | NEON 4-letter site code. |
| analyte | Carbon ('Co2') or water ('H2o') system? |

Value

Nothing to the environment, but creates a new data file with the most basic output HDF5 structure consistent with NEON's data files.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

swap_standard_isotoperatios
swap_standard_isotoperatios

Description

There are a few suspected instances where the water isotope ratios for oxygen and hydrogen have been flipped in the reference data. This function corrects them until they are corrected in the NEON database using a d-excess filter.

Usage

```
swap_standard_isotoperatios(std_frame, dxs_thres = 500)
```

Arguments

| | |
|-----------|--|
| std_frame | Standard data frame to perform swap on. |
| dxs_thres | d-excess threshold to indicate when to swap. |

Value

A data.frame based on std_frame, where d18O and d2H values have been swapped from NEON input files if determined to have a reference value mismatch. Mismatch is determined based on the d-excess of the standard ($= d2H - 8 * d18O$), using a value of 500 by default.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

```
terrestrial_core_sites  
    terrestrial_core_sites
```

Description

```
terrestrial_core_sites
```

Usage

```
terrestrial_core_sites()
```

Value

A vector listing NEON core terrestrial sites.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

```
terrestrial_core_sites()
```

```
terrestrial_relocatable_sites  
    terrestrial_relocatable_sites
```

Description

```
terrestrial_relocatable_sites
```

Usage

```
terrestrial_relocatable_sites()
```

Value

A vector listing NEON core terrestrial sites.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

Examples

```
terrestrial_relocatable_sites()
```

validate_analyte *validate_analyte*

Description

validate_analyte

Usage

validate_analyte(analyte)

Arguments

analyte Co2 or H2o?

Value

Standardized string for the water ('H2o') or carbon ('Co2') systems to make sure strings are standardized across package functions.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

water_isotope_sites *water_isotope_sites*

Description

water_isotope_sites

Usage

water_isotope_sites()

Value

A vector listing NEON sites measuring water vapor isotope ratios.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

```
write_carbon_ambient_data  
    write_carbon_ambient_data
```

Description

Write out ambient observations from the NEON EC towers where the isotope data (either H2O or CO2) have been calibrated using this package.

Usage

```
write_carbon_ambient_data(outname, site, amb_data_list)
```

Arguments

| | |
|---------------|---|
| outname | Output file name. |
| site | NEON 4-letter site code. |
| amb_data_list | Calibrated list of ambient data - this is the output from one of the calibrate_ambient_carbon* functions. |

Value

Nothing to the environment, but writes data in amb_data_list to file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

```
write_carbon_calibration_data  
    write_carbon_calibration_data
```

Description

```
write_carbon_calibration_data
```

Usage

```
write_carbon_calibration_data(outname, site, calDf, method)
```

Arguments

| | |
|---------|--|
| outname | Output file name. |
| site | NEON 4-letter site code. |
| calDf | Calibration data frame - this is the output from fit_carbon_regression |
| method | Was the Bowling et al. 2003 or the linear regression method used in fit_carbon_regression? |

Value

Nothing to the environment, but writes out the calibration parameters (e.g., gain and offset or regression slopes and intercepts) to the output hdf5 file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

write_carbon_reference_data
write_carbon_reference_data

Description

write_carbon_reference_data

Usage

```
write_carbon_reference_data(inname, outname, site, calDf)
```

Arguments

| | |
|----------------------|---|
| <code>inname</code> | Input file name. |
| <code>outname</code> | Output file name. |
| <code>site</code> | NEON 4-letter site code. |
| <code>calDf</code> | Calibration data frame - this is the output from <code>fit_carbon_regression</code> |

Value

Nothing to the environment, but writes calibrated reference data to hdf5 file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

```
write_carbon_reference_data2
    write_carbon_reference_data2
```

Description

write_carbon_reference_data2

Usage

```
write_carbon_reference_data2(outname, site, allData, calDf)
```

Arguments

| | |
|---------|--|
| outname | Output file name. |
| site | NEON 4-letter site code. |
| allData | Uncalibrated reference data frames. |
| calDf | Calibration data frame - this is the output from fit_carbon_regression |

Value

Nothing to the environment, but writes calibrated reference data to hdf5 file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

```
write_qfqm    write_qfqm
```

Description

Write NEON's qfqm data for an isotope species to output file. Wraps copy_qfqm_group.

Usage

```
write_qfqm(inname, outname, site, analyte)
```

Arguments

| | |
|---------|---|
| inname | Input file name. |
| outname | Output file name. |
| site | NEON 4-letter site code. |
| analyte | Carbon ('Co2') or water ('H2o') system? |

Value

Nothing to the environment, but writes qfqm data to file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

write_ucrt

write_ucrt

Description

Write NEON's ucrt data for an isotope species to output file. Wraps copy_ucrt_group.

Usage

```
write_ucrt(inname, outname, site, analyte)
```

Arguments

| | |
|---------|---|
| inname | Input file name. |
| outname | Output file name. |
| site | NEON 4-letter site code. |
| analyte | Carbon ('Co2') or water ('H2o') system? |

Value

Nothing to the environment, but writes ucrt data to file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

write_water_calibration_data
write_water_calibration_data

Description

write_water_calibration_data

Usage

```
write_water_calibration_data(outname, site, calDf)
```

Arguments

| | |
|---------|---|
| outname | Output file name. |
| site | NEON 4-letter site code. |
| calDf | Calibration data frame - this is the output from fit_water_regression |

Value

Nothing to the environment, but writes out the calibration parameters (e.g., regression slopes and intercepts) to the output hdf5 file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

write_water_reference_data
write_water_reference_data

Description

write_water_reference_data

Usage

```
write_water_reference_data(inname, outname, site, lowDf, medDf, highDf, calDf)
```


Arguments

| | |
|----------------------|--|
| <code>iname</code> | Input file name. |
| <code>outname</code> | Output file name. |
| <code>site</code> | NEON 4-letter site code. |
| <code>lowDf</code> | Dataframe corresponding to the "low" reference water. |
| <code>medDf</code> | Data frame corresponding to the "med" reference water. |
| <code>highDf</code> | Data frame corresponding to the "high" reference water. |
| <code>calDf</code> | Calibration data frame - this is the output from <code>fit_water_regression</code> |

Value

Nothing to the environment, but writes calibrated reference data to hdf5 file.

Author(s)

Rich Fiorella <rich.fiorella@utah.edu>

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