

# Package ‘pems.utils’

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**Title** Portable Emissions (and Other Mobile) Measurement System  
Utilities

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**Description**

Utility functions for the handling, analysis and visualisation of data from portable emissions measurement systems ('PEMS') and other similar mobile activity monitoring devices. The package includes a dedicated 'pems' data class that manages many of the quality control, unit handling and data archiving issues that can hinder efforts to standardise 'PEMS' research.

**Type** Package

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**URL** <http://pems.r-forge.r-project.org/>

**Depends** R (>= 2.10.0)

**Imports** lattice, loa (>= 0.3.1), methods, utils, grid, baseline,  
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pems.utils-package      *pems.utils*

---

## Description

The R package `pems.utils` contains a range of functions for the routine handling and analysis of data collected by portable emissions measurement systems (PEMS) and other similar mobile monitoring systems.

## Details

```

Package:    pems.utils
Type:      Package
Version:   0.3.1.0
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License:   GPL (>= 2)
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```

The `pems.utils` functions have been arranged according to usage, as follows:

- Getting data in and out of `pems.utils`.

- 1.1. Functions for making and importing datasets for use with `pems.utils`: [pems](#), [import2PEMS](#), etc.

- 1.2. Exporting data from pems objects and R: [export.data](#).
2. Data Structure and General Handling
  - 2.1. The pems object structure: [pems.structure](#), [getPEMSElement](#), [pemsData](#), etc.
3. Generic pems handling
  - 3.1. pems objects, [pems.generics](#).
  - 3.2. pems.element objects, [pems.element.generics](#).
4. Structure Handling
  - 4.1. Merging pems objects: [merge.pems](#), [align](#), etc.
  - 4.2. Referencing pems objects: [referencing.pems.data](#), [refRow](#), etc.
  - 4.3. Time handling functions: [regularize](#), etc.
  - 4.4. Unit handler functions: [getUnits](#), [setUnits](#), [convertUnits](#), etc.
5. pems Data Handling
  - 5.1. Plots for pems objects: [pems.plots](#), [latticePlot](#), [pemsPlot](#), etc.
6. Calculations
  - 6.1. Common calculations: [common.calculations](#), [calcDistance](#), [calcAccel](#), etc.
  - 6.2. Common [check...](#) functions for the routine handling of function arguments/user inputs.
  - 6.3. Other correction code
  - 6.4. Analysing data in pems objects: [summary.reports](#)
7. Reference datasets, examples, look-up tables, etc.
  - 7.1. Example datasets: [pems.1](#).
  - 7.2. look-up tables: [ref.unit.conversions](#), etc.
8. Specialist code
  - 8.1. VSP calculations: [calcVSP](#), etc.
  - 8.2. Emissions calculations: [calcEm](#), etc.

### **Author(s)**

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### **References**

Functions in `pems.utils` make extensive use of code developed by others. In particular, I gratefully acknowledge the huge contributions of the R Core Team and numerous contributors in developing and maintaining R:

R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org/>.

### **See Also**

[pems](#), [import2PEMS](#)

---

**1.1.make.import.data** *making and importing data*

---

**Description**

Various pems.utils functions to make and import data as pems objects.

**Usage**

```
#making pems objects

is.pems(x, full.test = TRUE, ...)

pems(x, units = NULL, constants = NULL, history = NULL,
     ...)

pems.element(x, name = NULL, units = NULL,
            ...)

#associated

isPEMS(...)
makePEMS(...)
makePEMSElement(...)
rebuildPEMS(x, ...)

## S3 method for class 'data.frame'
as.pems(x, ...)

#importing data as pems objects

#general

import2PEMS(file.name = file.choose(), ...,
            file.reader = read.delim,
            output="pems")

importTAB2PEMS(..., file.reader = read.delim)

importCSV2PEMS(..., file.reader = read.csv)

#Horiba OBS

importOBS2PEMS(file.name = file.choose(),
               pems = "Horiba OBS",
               constants = NULL, history = NULL,
               analytes = c("co", "co2", "nox", "hc"),
```

```

        fuel = c("petrol", "diesel", "gasoline"), ...)

importOB12PEMS(file.name = file.choose(),
  pems = "Horiba OBS",
  constants = NULL, history = NULL,
  analytes = c("co", "co2", "nox", "hc"),
  fuel = c("petrol", "diesel", "gasoline"), ...)

#3DATX parSYNC

importParSYNC2PEMS(file.name = file.choose(),
  reset.signals = TRUE,
  history = NULL, constants = NULL,
  pm.analyzer = "parSYNC", ... )

#3DATX CAGE
importCAGE2PEMS(..., calibrator = "CAGE")

#Sensors Inc SEMTECH

importSEMTECH2PEMS(file.name = file.choose(),
  history = NULL, constants = NULL,
  pems = "SEMTECH", ...)

#RoyalTek GPS

importRoyalTek2PEMS(file.name = file.choose(),
  file.type = c("special", "txt", "nmea"),
  vbox = "RoyalTEK", history = NULL,
  constants = NULL, ...)

#KML files

importKML2PEMS(file.name = file.choose(), history = NULL,
  constants = NULL, source = "Unknown", ...)

```

## Arguments

- |           |  |
|-----------|--|
| x         | (A required object) For <code>is.pems</code> , any object to be tested as a pems object. For <code>pems</code> , an object to be used as the starting point to make a pems object, so typically a <code>data.frame</code> or another pems object. For <code>pems.element</code> , an object to be used as the starting point to make a <code>pems.element</code> . For <code>rebuildPEMS</code> , a pems object to be rebuilt. |
| full.test | (Logical) For <code>is.pems</code> , should the full pems test be applied and the pems structure confirmed?  |

...	(Optional) Other arguments, handling varies. For <code>is.pems</code> these are ignored. For <code>pems</code> these are added to the <code>pems</code> object unmodified. For <code>import...</code> functions, these are passed on and added to the <code>constants</code> component of the <code>pems</code> object. Note: This different handling is experimental and may be subject to change in future.
<code>units, constants, history</code>	(Default <code>pems</code> arguments) These are arguments that are routinely generated for <code>pems</code> objects. <code>units</code> holds unit ids for unit management, <code>constants</code> holds constants that should be used specifically with data in the <code>pems</code> object, and <code>history</code> holds the <code>pems</code> object modification history.
<code>name</code>	(Default <code>pems.element</code> argument) <code>name</code> (and <code>units</code> ) are arguments that are routinely generated for <code>pems.element</code> objects.
<code>file.name</code>	(file connection, etc.) For <code>import...</code> functions, the file/source to be imported. Note: the default, <code>file.name = file.choose()</code> , automatically opens a file browser if this argument is not supplied.
<code>file.type, file.reader</code>	Data reader parameters for some <code>import...</code> functions. <code>file.type</code> is the type of file to be imported. Note: Some <code>import...</code> functions can handle more than one file type, and <code>file.type = "[option]"</code> should be used to identify these. (Note: <code>file.type</code> options are typically file type identifiers, such as the file extensions, and a default 'special', which leaves the choice to the function. This way this option can typically be ignored unless, e.g. the function does not recognise the file type but the user knows it and wants to force the method.) <code>file.reader</code> identifies the R method/function that should be used to read data from the supplied file. For example, for <code>importTAB2PEMS</code> and <code>importCSV2PEMS</code> , by default, these are the standard R <code>read...</code> functions <code>read.delim</code> and <code>read.csv</code> , respectively.
<code>output</code>	Where included in formal arguments, an option to control function output.
<code>pems, vbox, pm.analyzer, calibrator, source</code>	(Character vectors) For some <code>import...</code> functions, data source descriptions may be automatically added to the <code>pems</code> object. <code>pems</code> and <code>vbox</code> are two examples, but others, such as vehicle and fuel descriptions can also be added in a similar fashion. Note: These are for user-reference, so can say whatever you want.
<code>analytes</code>	(Character vector) For <code>import...</code> functions, the names of any <code>pems</code> elements to be tagged as analyte concentrations. Note: If the PEMS unit reports concentrations rather than emissions it is often useful to identify these at import to avoid confusion, and to simplify later handling. So, if encountered, analyte names are prefixed with the term 'conc. '.
<code>fuel</code>	Some <code>import...</code> functions that handle exhaust monitoring system data may assume fuel types when calibrating inputs or calculating constants. In such cases the <code>fuel</code> argument is also included to identify which fuel was used.
<code>reset.signals</code>	(Logical or Character vector) For <code>importParSYNC2PEMS</code> , should any raw signal be reset? The default (TRUE) reverses the sign of opacity and ionization signals.

## Details

`is.pems` tests if an object is/is not a pems object.

`pems` makes a pems object using supplied data and information.

`pems.element` makes a `pems.element` object using supplied data and information.

`as.pems...` functions attempt to convert a supplied object into a pems object. Currently, there is only a `data.frame` method and (by default) a `pems` method.

`isPEMS`, `makePEMS` and `makePEMSElement` are historical code, retained for backward compatibility.

`rebuildPEMS` rebuilds pems object as a different build version.

Crude `import...` functions import simple file structures, and are useful for getting data quickly into R: `pems.utils.importTAB2PEMS` imports tab delimited files and clipboard content. `importCSV2PEMS` imports comma delimited files. Both assume a simple file structure (i.e. data series in columns with names as headers), but require some time data management by the user. Note: These are wrappers for `import2PEMS`.

Other `import...` import specific file types.

`importOBS2PEMS` imports standard Horiba OBS files and converts them to pems objects. See Notes below.

`importOB12PEMS` imports `.OB1` files and converts them to pems objects. OB1 files are generated by a Visual Basic PEMS data handler used during the RETEMM project. Notes below.

`importParSYNC2PEMS` imports standard `parSYNC` files and converts them to pems objects. See Notes below.

`importCAGE2PEMS` imports standard CAGE files and converts them to pems objects. See `importParSYNC2PEMS` Notes below.

`importSEMTECH2PEMS` imports Sensors Inc. SEMTECH ECOSTAR files and converts them to pems objects. See Notes below.

`importRoyalTek2PEMS` imports `.txt` and `.nmea` format Royal Tek GPS files and converts them to pems objects. See Notes below.

`importKML2PEMS` imports `.kml` format KML files and converts them to pems objects. See Notes below.

## Value

`is.pems` return a logical, TRUE if the supplied object is pems class, otherwise FALSE. If the argument `full.test = TRUE` is also supplied, additional information about the object is returned as `comment(output)`.

`pems` and `pems.element` functions return pems and `pems.element` objects, respectively, made using the supplied file and any additional information also supplied in the same call.

`rebuildPEMS` rebuilds the supplied pems object. The default rebuilds as the latest build structure.

`import...` functions return a pems object, made using the supplied file and any additional information also supplied in the same call.

**Note**

`isPEMS`, `makePEMS` and `makePEMSElement` were earlier functions that performed the same functions as `is.pems`, `pems` and `pems.elements`, respectively. The the current versions of these functions are wrappers for their replacements.

With the crude `import...` functions (`import2PEMS`, `importTAB2PEMS`, `importCSV2PEMS`) modifications are minimal. Unless any additional changes are requested in the `import...(...)` call, the data is simply read in as a `data.frame` and converted to a `pems` object.

With `importOBS2PEMS`, OBS data is also modified as follows: data series names are simplified and converted to lower case to simplify use in R; the data series `time.stamp` and `local.time` are added (generated using the file time stamp, the row counter and the `log.rate` constant); data series `latitude` and `longitude` are resigned according to set N/S and E/W values, if these are present/valid; `latitude` and `longitude` units are also reset to `'d.degLat'` and `'d.degLon'`. Any data series names in `analytes` is renamed `'conc.[analyte name]'`. If not supplied in the `importOBS2PEMS`, typical OBS constants are currently assumed. Several of these are based on emission source fuel. Defaults for these are generated according to `fuel` (default `'petrol'`).

With `importOB12PEMS`, handling is similar to that with `importOBS2PEMS`.

With `importParSYNC2PEMS`, the `parSYNC` data modifications are as follows: `parSYNC` Date and Time data-series are merged and converted into \*POSIX as `time.stamp`; `local.time` is calculated from this; the `parSYNC` data series `Timestamp` is retained as `parsync.timestamp`; by default units are removed from data-series names, but retained as `units(pems)`; (again by default) all names are converted to lower case. The default option `reset.signal = TRUE` reverses the voltage reading of opacity and ionization time-series ( $x = -x$ ), if present. Alternatively, imports can be identified specifically by name, e.g. `reset.signal = "opacity"` to just reset opacity. Typical OBS constants are currently assumed, if not supplied. Several of these are based on emission source fuel. The default assumption is that the fuel is `'petrol'` unless `fuel` has been assigned.

With `importCAGE2PEMS`, handling is similar to that with `importParSYNC2PEMS`.

With `importSEMTECH2PEMS`, SEMTECH data is imported and modified as follows: data series names are simplified and converted to lower case to simplify use in R; the data series `time.stamp` and `local.time` are added (generated using the file time stamp). Defaults constants are assigned according to `fuel` (default `'petrol'`). This function is in-development and has so far only been used with files from two sources, so handle with care, and `time.format` has varied so may need resetting for some files.

With `importRoyalTek2PEMS`, the Royal Tek data modifications are currently being documented.

With `importKML2PEMS`, the function attempts to import and `time.stamp`, `latitude`, `longtiude` and `altitude` data in the supplied KML file. This function is in-development and has so far only been used with KML files from one source, so handle with care.

**Author(s)**

Karl Ropkins

**References**

References in preparation.

**See Also**

See [ref.unit.conversions](#) and [convertUnits](#) for general unit handling; [merge.pems](#) for pems data merging and alignment.

**Examples**

```
#####
##example 1
#####

#make little pems

data <- data.frame(speed=1:10, emissions=1:10)
units <- c("m/s", "g/s")
pems <- pems(x = data, units=units, example="my record")

pems                                #the pems object
summary(pems)                       #summary of held data
pems$speed                          #the speed pems.element

#import data file as pems using import... functions

#For example, to import CSV file as pems object
## Not run:
pems <- importCSV2PEMS()

## End(Not run)
```

---

1.2.export.data

*exporting PEMS data*


---

**Description**

Some functions for exporting data from R and pems.utils.

**Usage**

```
exportPEMS(pems, file = "tempfile", file.writer = write.table,
           sep = "\t", ...)

exportPEMS2TAB(pems, file = "tempfile", file.writer = write.table,
              sep = "\t", ...)

exportPEMS2TAB(pems, file = "tempfile", file.writer = write.table,
              sep = "\t", ...)

#exportPEMS2Excel
#currently disabled
```

**Arguments**

<code>pems</code>	(A required object) The object to export from R, typically a <code>data.frame</code> or <code>pems</code> object.
<code>file</code>	(Character) The name of the file to create when exporting data. This can be 'clipboard', to export to the clipboard assuming the clipboard buffers are not exceeded.
<code>file.writer, sep</code>	(Various arguments) <code>file.writer</code> is the R function used to create the export file. <code>sep</code> is the separator argument passed to <code>file.writer</code> .
<code>...</code>	(Optional) Other arguments, handling varies. For <code>exportPEMS2...</code> functions, these typically passed to <code>exportPEMS</code> or from there to the assigned <code>file.writer</code> .

**Details**

By default, `exportPEMS2TAB` and `exportPEMS2CSV` export the data component of a supplied `pems` object, to tab-delimited `.txt` and comma-delimited `.csv` files, respectively. `file` sets the file name (default `tempfile`).

These are typically used in form:

```
exportPEMS2...(pems, file, ...)
```

By default, they make the following associated modifications:

If file extensions are not included in `file`, they add `.txt` and `.csv` extensions to tab-delimited and comma-delimited files, respectively. The argument `tidy.file=FALSE` can be used to disable this modification.

Time stamps, if identified, are exported in "DD/MM/YYYY HH:MM:SS.x" format. Handling can be altered using `time.stamp`, `time.format` and `tz` arguments like `import2PEMS` or disabled using `tidy.time.stamp=FALSE`.

Data-series units can also be added to exported file column names in form `name(units)` by adding the argument `units="add.to.names"`.

**Value**

`exportPEMS2...()` functions generate export file from `pems` data.

**Warning**

Currently, `exportPEMS...` functions overwrite without warnings.

**Note**

`exportPEMS2Excel` is currently disabled.

These are very crude functions in the most part because they are rarely used. Suggestions for helpful improvements would be very welcome.

**Author(s)**

Karl Ropkins

**References**

References in preparation.

**See Also**

See [import2PEMS](#), etc. for importing data into `pems.utils`.

**Examples**

```
#####
##example 1
#####

#making a comma-delimited copy of pems.1

## Not run:
exportPEMS2CSV(pems.1, "pems.example")
dir()

## End(Not run)
```

---

2.1.pems.structure      *'pems' object structure*

---

**Description**

This pages provides a brief outview description of the 'pems' object structure. It also lists some associated functions

**Usage**

```
getPEMSElement(x, pems = NULL, units = NULL, ...,
               fun.name="getPEMSElement",
               if.missing = "stop", if.null = if.missing,
               track.name = TRUE, .x = enquo(x))

getPEMSData(pems=NULL, ..., fun.name = "getPEMSData",
            if.missing = "stop", .pems = enquo(pems))

getPEMSConstants(pems=NULL, ...,
                 fun.name = "getPEMSConstants",
                 if.missing = "stop", .pems = enquo(pems))

pemsData(pems=NULL, ...,
         fun.name = "pemsData", if.missing = "stop",
         pems.name = deparse(substitute(pems)))
```

```

pemsConstants(pems=NULL, ...,
              fun.name = "pemsConstants", if.missing = "stop",
              pems.name = deparse(substitute(pems)))

pemsHistory(pems=NULL, ...,
            fun.name = "pemsHistory", if.missing = "stop",
            pems.name = deparse(substitute(pems)))

cpe(...)

```

### Arguments

<code>x</code>	(Required vector, typically <code>pems.element</code> ) For <code>getPEMSElement</code> , the required data element.
<code>pems</code>	( <code>pems</code> object) If supplied, the <code>pems</code> object to search for <code>x</code> before checking the parent environments and R workspace.
<code>units</code>	(Optional) The units that <code>x</code> should be supplied in (handled by <code>convertUnits</code> ).
<code>...</code>	(Optional) Other Arguments.
<code>fun.name, if.missing, if.null, track.name, pems.name, .x, .pems</code>	(Various) Other options using for <code>pems.utils</code> house-keeping. See <code>check...</code> for definitions, although generally these can be ignored by users. See Note below.

### Details

The `pems` object is a managed `data.frame`. It has five main components: `data`, `units`, `constants`, `history` and `tags`. `data` is the main `data.frame`. Each element (named `data.frame` column) is a data-series of the original PEMS data. `units` are the associated unit definitions. `constants` is a list of associated constants that are to be used with the `pems` object. (The preference order is arguments given in a call then `constants` declared in the `pems` object then constant defaults held by the `pems.utils` package.) `history` is a log of `pems` object modifications. `tags` are any other components that the user wishes to add to a `pems` object as identifiers.

`getPEMSElement` gets a requested `pems.element` from `pems` if supplied or from the local workspace.

`pemsData` and `getPEMSData` get the data component of a supplied `pems` object.

`pemsConstants` and `getPEMSConstants` get all constants locally defined for the supplied `pems` object.

`pemsHistory` gets the history of supplied `pems` object.

`cpe` combines `pems.elements`. It is intended as an alternative to `c(pems.element, ...)` while that generic is in-development.

### Value

`getPEMSElement` returns the requested element of a supplied `pems` object as a managed vector or `pems.element`, if available. If missing, error handling is by `checkIfMissing`. See `check...` for more details.)

`pemsData` returns the data component of a supplied `pems` object as a `data.frame`.

getPEMSData returns the data component of a supplied pems object as a `data.frame`.  
 pemsConstants returns the constants component of a supplied pems object as a `list`.  
 getPEMSConstants returns the constants component of a supplied pems object as a `list`.  
 pemsHistory returns the history component of a supplied pems object as a `list`.  
 cpe turns the concatenated form of supplied input.

**Note**

`pems...` functions are in development pems object handlers. They are intended for convenient 'front of house' use. As part of this role, their structure will evolve over time, so arguments and operations may change based on user feedback. Those wishing to develop future-proof third party functions should also consider `check...` functions when developing their code. See [common.calculations](#) for some Examples.

`getPEMS...` functions are a revision of earlier `pems...` pems object handlers. They are intended to replace `pems...` code in future package versions.

`rlang` and `dplyr` functions now do the heavy lifting for `getPEMSElement`.

**Author(s)**

Karl Ropkins

**References**

`rlang` and `dplyr` package functions now do the heavy lifting for `getPEMSElement`.

Lionel Henry and Hadley Wickham (2018). `rlang`: Functions for Base Types and Core R and 'Tidyverse' Features. R package version 0.2.0. <https://CRAN.R-project.org/package=rlang>

Hadley Wickham, Romain Francois, Lionel Henry and Kirill Muller (2017). `dplyr`: A Grammar of Data Manipulation. R package version 0.7.4. <https://CRAN.R-project.org/package=dplyr>

**See Also**

See Also: [check...](#) for `check...` function equivalents; [pems.generics](#) for pems object generic functions.

**Examples**

```
#####
##example 1
#####

#basic usage

#using example data pems.1
#(supplied as part of pems.utils package)

#pems structure
pems.1
```

```
# extracting the pems.1 element velocity
getPEMSElement(velocity, pems.1)

## Not run:
#generic (SE) equivalents
pems.1$velocity
pems.1["velocity"]

## End(Not run)
```

---

### 3.1.generic.pems.handlers

#### *Generic handling of pems objects*

---

#### **Description**

pems objects can be manipulated using generic functions like print, plot and summary in a similar fashion to objects of other R classes.

#### **Usage**

```
## S3 method for class 'pems'
as.data.frame(x,...)

## S3 method for class 'pems'
dim(x, ...)

## S3 method for class 'pems'
x$name, ...

## S3 replacement method for class 'pems'
x$name, ... <- value

## S3 method for class 'pems'
x[i, j, ..., force = FALSE, simplify = TRUE]

## S3 replacement method for class 'pems'
x[i, j, ..., force = FALSE] <- value

## S3 method for class 'pems'
x[[k, ...]]

## S3 replacement method for class 'pems'
x[[k, ...]] <- value

## S3 method for class 'pems'
with(data, expr, ...)
```

```

## S3 method for class 'pems'
subset(x, ...)

## S3 method for class 'pems'
names(x, ...)

## S3 replacement method for class 'pems'
names(x, ...) <- value

## S3 method for class 'pems'
print(x,..., rows=NULL, cols=NULL, width=NULL)

## S3 method for class 'pems'
plot(x, id = NULL, ignore = "time.stamp", n = 3, ...)

## S3 method for class 'pems'
head(x, n = 6, ...)

## S3 method for class 'pems'
tail(x, n = 6, ...)

## S3 method for class 'pems'
summary(object, ...)

## S3 method for class 'pems'
na.omit(object, ...)

## S3 method for class 'pems'
units(x)

## S3 replacement method for class 'pems'
units(x) <- value

```

### Arguments

<code>x, object, data</code>	(An Object of pems class). For direct use with <code>print</code> , <code>plot</code> , <code>summary</code> , etc. NOTE: Object naming (i.e., <code>x</code> or <code>object</code> ) is determined in parent or base function in R, so naming can vary by method.
<code>name</code>	Element name, which operates in a similar fashion to <code>data.frame</code> names, e.g. <code>pems\$name</code> extracts the element name from the pems object pems.
<code>i, j</code>	Row and column (elements) indices, which operate as a stricter version of <code>data.frame</code> indices. See Note below.
<code>k</code>	Structural indices. See Note below.
<code>expr</code>	(Expression) For <code>with(pems)</code> , an expression to be evaluated inside the supplied pems object.

value	(vector, data.frame or pems) An object to be inserted into a pems object in e.g. the form <code>pems[i, j] &lt;- value</code> or <code>pems\$name &lt;- value</code> .
...	Addition options, typically passed to associated default method(s).
force	(Logical or character) Data element handling options. <code>force</code> provides various options to forces data to fit it destination. This can either be set as a logical (TRUE/FALSE <code>force</code> /don't <code>force</code> ) or one or more character strings to specify particular types of forcing to try when e.g. fitting value into <code>pems[i, j]</code> : <code>'omit.err.cases'</code> , equivalent to TRUE, remove any unknown/unfound <code>i</code> or <code>j</code> terms; <code>'na.pad.insert'</code> expand the value to fit larger <code>pems[i, j]</code> , placing NAs in any holes generated; <code>'na.pad.target'</code> like previous but expanding <code>pems[i, j]</code> to fit larger value; <code>'fill.insert'</code> like <code>'na.pad.inert'</code> but holes are filled by wrapping the supplied value within elements and then by element.
simplify	(Logical) <code>simplify</code> returns a <code>pems.element</code> rather than a <code>pems</code> object if possible.
id, ignore	(local plot parameters). <code>id</code> identifies which data series to plot; <code>ignore</code> identifies which data series to ignore when leaving the choice of <code>id</code> to the function; and, <code>n</code> gives the maximum number of data series to plot when leaving the choice of <code>id</code> to the function.
rows, cols, width	(numerics, optional). For <code>print</code> , if supplied, these reset the number of rows and columns to table when printing a <code>pems</code> object, and character width to print across.
n	(various). For <code>plot</code> , sets the maximum number of data series to plot when leaving the choice of <code>id</code> to the function. For <code>head</code> or <code>tail</code> , sets the number of rows.

## Value

Generic functions provide appropriate (conventional) handling of objects of 'pems' class:

`as.data.frame(pems)` extracts the `data.frame` component of a `pems` object.

`dim(pems)` extracts the dimensions, row count and column count, respectively, of the `data.frame` component of a `pems` object. The function also allows `nrow(pems)` and `ncol(pems)`.

`pems$name` extracts the named element from a `pems` objects in a similar fashion to `data.frame$name`. Likewise, `pems$name <- value` inserts `value` into a `pems` objects in a similar fashion to `data.frame$name <- value`.

`pems.object[i, j]` extracts the `[i,j]` elements of the data held in a `pems` object. This is returned as either a `pems` or `pems.element` object depending on the dimension of the extracted data and the `simplify` setting.

`pems.object[i, j]<- insert value` into the `[i,j]` region of the supplied `pems` object. By default this action is strict and mismatching `pems[i, j]` and `value` dimension produce an error, although mismatching insertions may be forced using the `force` argument.

`pems.object[[k]]` extracts structural elements of a `pems` object: `data`, the `data.frame`; `units` the unit table, etc.

`with(pems.object, expression)` evaluates the supplied expression using the elements of the supplied `pems.object`.

`subset(pems.object, expression)` behaves like `subset(data.frame, expression)`.

`print(pems.object)` provides a (to console) description of a pems object. This forshortens large datasets in a similar fashion to a tibble.

`plot(pems.object)` generates a standard R plot using selected data series in a pems object.

`names(pems.object)` returns a vector of the names of data series held in a pems object when used in the form `names(pems)` or resets names when used in the form `names(pems) <- new.names`.

`na.omit(pems.object)` returns the supplied pems object with all rows including NAs removed.

`summary(pems.object)` generates a summary report for data series held in a pems object.

`units(pems.object)` extracts the units from a supplied pems object when used in the form `units(pems)` or sets/resets units when used in the form `units(pems) <- new.units`.

### Note

The pems object is intended to be a stricter version of a standard R `data.frame`. Unless the user specifically forces the operation, a `pems[]` or `pems[]<-` call is not allowed unless it fits exactly. So, for example by default the call `pems[,1]<-10` will not place 10 in every row of column one in the same fashion as `data.frame[,1]<-10`.

The logic behind this is that columns (elements) of pems objects are time-series. So, users would want to place these exactly and avoid any unintended wrapping. The `force` argument should be used in cases where data padding or wrapping operations are required.

`pems$name` and `pems$name<-` are not rigorously managed, so behave more like `data.frame$name` and `data.frame$name<-` calls, although even these do wrap by default.

`pems[[]]` provides access to structural components of the pems object, e.g. `pems[["data"]]` extracts the `data.frame` component of the pems object, `pems[["units"]]` extracts the units component, etc. See also [pems.structure](#).

### Author(s)

Karl Ropkins

### References

generics in general:

H. Wickham. Advanced R. CRC Press, 2014.

(Not yet fully implemented within this package.)

### Examples

```
##example 1
##basics pems handling

#extract a subset pems object from pems.1
a <- pems.1[1:4, 1:5]
a

#indices work like data.frame
#a[x] and a[,x] recovers element/column number x
#a[x,] recovers row number x
```

```

#a["name"] and a[, "name"] recovers element/column named "name"
#a[4:5, "name"] recovers rows 4 to 5 of element/column named "name"
#a[x,y] <- z inserts z into a at row x, element y
#etc

#insert 10 in at element 3, row 2
a[2,3] <- 10
a

#replace element conc.co2 with conc.co
a["conc.co2"] <- a$conc.co
a

#Note: by default pems objects subsetting and inserting is
#more rigorous than data.frame subsetting/insertion
#for example, a[1:2, "conc.hc"] <- 8 would generate error
#because the target, a[1:2], and insert, 8, dimensions do not
#match exactly: target 2 x 1; insert 1 x 1

#By default no wrapping is applied.

#the force argument allows the user to control how mismatching
#targets and insertions are handled

#na pad target for larger insert
a[1:2, "conc.hc", force="na.pad.target"] <- 1:5
a

#Note here when the target is padded existing enteries are NOT
#overwritten if they are not declared in a[], and the next
#previously unassigned cells are used for any extra cases in
#the insert.

#wrap insert to fill hole made by a[i,j]
a[1:2, "conc.hc", force="fill.insert"] <- 8
a

#pems$name <- value is equivalent to
#pems[name, force=c("na.pad.target", "na.pad.insert")]
a$new <- 1:4
a

```

---

### 3.2.generic.pems.element.handlers

#### *Generic handling of pems.element objects*

---

#### **Description**

pems elements objects can be manipulated using generic functions like print, plot and summary in a similar fashion to objects of other R classes.

**Usage**

```
## S3 method for class 'pems.element'
x[i, ..., force = TRUE, wrap = FALSE]

## S3 replacement method for class 'pems.element'
x[i, ..., force = TRUE, wrap = FALSE] <- value

## S3 method for class 'pems.element'
as.pems(x, ...)

## S3 method for class 'pems.element'
print(x, ..., n = NULL, rows = NULL, width = NULL)

## S3 method for class 'pems.element'
plot(x, y = NULL, xlab = NULL, ylab = NULL, ...)

## S3 method for class 'pems.element'
units(x)

## S3 replacement method for class 'pems.element'
units(x) <- value

## S3 method for class 'pems.element'
summary(object, ...)

## S3 method for class 'pems.element'
round(x, ...)
```

**Arguments**

x, object	(An Object of pems.element class). For direct use with print, plot, summary, etc. NOTE: Object naming (i.e., x or object) is determined in parent or base function in R, so naming varies by method.
i	Element indices, which operate in a similar fashion to vector indices.
...	Addition options, typically passed to associated default method(s).
force, wrap	(Logicals) Data element handling options: force forces data to fit its destination; wrap expands data to fit its destination by wrapping the source pems.element.
value	(Vector) For calls in pems.element[1] <- value or units(pems.element) <- value, the value to be inserted.
n, rows, width	(Numerics) For print(pems), number of elements, rows or screen width to foreshorten print output to.
y, xlab, ylab	(other plot arguments). As with the default plot method, y is an optional second data vector, typically numeric, and xlab and ylab are labels to use on x and y axes.

**Value**

Generic functions provide appropriate (conventional) handling of objects of 'pems.element' class:

`print(pems.element)` provides a (to console) description of the supplied `pems.element` object.

`plot(pems.element)` generates a standard R plot of the supplied `pems.element`.

`units(pems.element)` extracts the units from the supplied `pems.element`.

**Note**

A dedicated `round(pems.element)` is required as a wrapper to `round.Date` and `round.POSIXt` handling.

**Author(s)**

Karl Ropkins

**Examples**

```
#the velocity pems.element in pems.1
pems.1$velocity
```

---

4.1.merge.data.pems    *Merging data and pems objects*

---

**Description**

Various `pems.utils` functions to merge data of different types.

**Usage**

```
#basic alignment
align(data1, data2, n = 0, ...)

#alignment based on correlation
cAlign(form, data1 = NULL, data2 = NULL, ...)

#alignment based on time.stamp
tAlign(form, data1, data2 = NULL, order=TRUE, ...)

#basic stacking
stackPEMS(..., key=key, ordered=TRUE)

#historical
findLinearOffset(x = NULL, y = NULL, ...)
```

**Arguments**

data1, data2	(pems or data.frame; optional for cAlign, required for other alignment functions) pems objects or data.frames to be aligned.
n	(numeric; required) An offset to be applied to data2 when aligning data1 and data2. The default, n = 0, applies no offset and directly aligns the two supplied data sets, first row to first row.
...	(Any other arguments) For stackPEMS this is typically a series of pems objects to be stacked. For other functions, this may be passed on but are typically ignored. See Notes.
form	(formula; required) A formula identifying the elements in the supplied data sets to be used as references for the alignment. This typically takes the form, e.g. cAlign(x~y, d1, d2) where d1\$x and d2\$y are the data series to be used to correlation align the two data sets.
order	(logical; optional) If TRUE the function orders the data.
key	(character or NSE) For stackPEMS the name to key column that identifies the data sources of elements in a stack of pems objects.
ordered	(logical; default TRUE) For stackPEMS, when creating the source key should the order pems objects were supplied be retained.
x, y	(Required objects, various classes) For bindPEMS, two pems, data.frame, pems.elements or vectors to be bound together. For findLinearOffset, two pems.elements or vectors to be aligned.

**Details**

The align function accepts two pems objects, data.frame, etc, and returns a single dataset (as a pems object) of the aligned data. An extra argument, n, may be supplied to offset the starting row of the second data set relative to the first. It is intended to be used in the form:

```
aligned.data <- align(data1, data2) #aligned row 1-to-1
```

```
aligned.data <- align(data1, data2, 3) #row 3-to-1, etc
```

The cAlign function accepts a formula and up to two data sets and returns a single data set (as a pems object) of correlation aligned data. This uses the best fit linear offset correlation for the elements identified in the formula term.

It is intended to be used in the form:

```
aligned.data <- cAlign(name1~name2, data1, data2)
```

The tAlign function accepts a formula and two data sets and returns a single data set (as a pems object) of the time stamp aligned data. This is this done by matching entries in the elements identified in the formula term.

It is intended to be used in the form:

```
aligned.data <- tAlign(name1~name2, data1, data2)
```

The stackPEMS function stacks two or more pems objects and returns a single pems object. stackPEMS stacks using dplyr function bind\_rows so handles pems with column names that do not completely intersect. However it also attempts to units match. It is intended to be used in the form:

```
stacked.data <- stackPEMS(data1, data2)
```

Historical functions:

`findLinearOffset` is historical code.

### Value

`align`, `cAlign`, `tAlign`, etc all return a single object of `pem` class containing the aligned data from `data1` and `data2`.

`findLinearOffset` returns the best fit offset for `y` relative to `x`.

### Note

These functions are under revision and need to be handled with care.

`cAlign`: By default `cAlign` generates an alignment plot and returns a `pems` object of aligned data. But it also allows several hidden arguments to refine outputs, the logicals `plot`, `offset` and `pems`, which turn off/on plot, offset and pems reporting individually, and `output = c("plot", "offset", "pems")` or combinations thereof also provides a single argument alternative.

`bindPEMS`: The historical function `bindPEMS` has been superceded by `align`.

`findLinearOffset`: `findLinearOffset` is currently retained but will most likely be removed from future versions of `pems.utils`.

The call `cAlign(x~y, output = "offset")` is equivalent to `findLinearOffset(x, y)`.

### Author(s)

Karl Ropkins

### References

`align` uses the `dplyr` function `full_join`.

`cAlign` function uses the `stats` function `ccf`.

`tAlign` uses the `dplyr` function `full_join`.

### See Also

See also: [cbind](#) for standard column binding in R; [dplyr](#) for `full_join`.

### Examples

```
#####
##example 1
#####

##data vector alignment

#make two offset ranges
temp <- rnorm(500)
x <- temp[25:300]
y <- temp[10:200]
```

```
#plot pre-alignment data
plot(x, type="l"); lines(y, col="blue", lty=2)

#estimated offset
findLinearOffset(x,y)
#[1] -15

#applying linear offset
ans <- align(x, y, findLinearOffset(x,y))
names(ans) <- c("x", "y")

#plot post-alignment data
plot(ans$x, type="l"); lines(ans$y, col="blue", lty=2)

#shortcut using cAlign
## Not run:
plot(x, type="l"); lines(y, col="blue", lty=2)
ans <- cAlign(x~y)
plot(ans$x, type="l"); lines(ans$y, col="blue", lty=2)

## End(Not run)

#####
##example 2
#####

##aligning data sets
##(pems object example)

#make some offset data
p1 <- pems.1[101:200, 1:5]
p2 <- pems.1[103:350, 1:3]

#correlation alignment using ccf
ans <- cAlign(~conc.co, p1, p2)

#this aligns by comparing p1$conc.co and p2$conc.co
#and aligning at point of best linear regression fit

## Not run:

#compare:

cAlign(~conc.co, p2, p1)
cAlign(conc.co2~conc.co, p1, p2)
#(aligns using p1$conc.co2 and p2$conc.co)
cAlign(conc.co2~conc.co, p1)
#(realigns just conc.co within p1 based on best fit
# with conc.co2 and returns as output ans)

#time stamp alignment
tAlign(~time.stamp, p1, p2)
```

```

#this aligns by pairing elements in p1$time.stamp
#and p2$time.stamp
#(if time stamps have different names
# tAlign(time1~time2, p1, p2), the time stamp name
# from p1 would be retained when merging p1$time1
# and p2$time2, generating [output]$time1)

## End(Not run)

#####
##example 3
#####

##stacking pems

#make some offset data
p1 <- pems.1[1:2, 1:4]
p2 <- pems.1[3, 2:4]
p3 <- pems.1[4:6, 1:3]

#stack
stackPEMS(p1, p2, p3, key=source)

```

---

## 4.2.referencing.pems.data

### *Data Referencing Functions.*

---

#### **Description**

Various functions for grouping, subsetting, filtering and conditioning datasets.

#### **Usage**

```

refRow(ref = NULL, n = 4, breaks = NULL,
       data = NULL, ..., labels = NULL,
       fun.name = "refRow")

refX(ref = NULL, n = 4, breaks = NULL,
     method = "percentile",
     data = NULL, ..., labels = NULL,
     fun.name = "refX")

refEngineOn(rpm = NULL, data = NULL,
            threshold = 200, ..., labels = NULL,
            fun.name = "refEngineOn")

```

```
refDrivingMode(speed = NULL, accel = NULL,
               time = NULL, data = NULL,
               threshold.speed = 0.1,
               threshold.accel = 0.1,
               ..., labels = NULL,
               fun.name = "refDrivingMode")
```

### Arguments

ref	(Data series, typically vector) The reference data-series to consider when making a vector of subset markers/indices. See Details.
n, breaks	(numerics) With refRow and refX, n sets the number of equal intervals to attempt to cut the data into. With refRow, breaks sets the rows at which to cut the data at. With refX, breaks sets the values of ref to cut the data at. In both cases, if both n and breaks are set, breaks is applied.
data	(Optional data.frame or pems object) The data source if ref is supplied in either a data.frame or pems object.
...	(Optional) Other arguments, currently passed on to pems.utils management functions.
labels	(Vector, typically Character) a vector of labels to be assigned to the reference regions.
fun.name	(function management argument) fun.name is the name of the parent function, to be used in error messaging.
method	(Various) For refX, the method to use when cutting data. If character vector, 'percentile' or 'range'. If function, it should be in form function(ref, n), and return breaks.
rpm	For refEngineOn, the input, assumed to be engine speed and expected to have units of rpm.
threshold	For refEngineOn, the signal threshold above which the vehicle engine is assumed to be on.
speed, accel, time	For refDrivingMode, possible inputs. Strictly, refDrivingMode needs speed and accel but can use speed and time to build accel.
threshold.speed, threshold.accel	For refDrivingMode, the speed and acceleration signal thresholds. Below these thresholds the signals are assumed to be noise and the vehicle is not moving or accelerating, respectively.

### Details

ref... functions generate a vector of subset markers or indices based of the referencing method applied and the length of ref. See Value regarding outputs.

refRow assigns reference regions based on row number. Because row depends on the length of the ref element independent of values, this is a unique case where ref can be either a vector or

a data set (`pems`, `data.frame`). It accepts `n` to set the number of cases to make or breaks to set break-points at specific rows.

`refX` assigns reference regions based on the value of a supplied data-series. It accepts `n` to set the number of cases to make or breaks to set the `ref` values to make break-points. If using `n`, method used to assign cut method, e.g. 'percentile' or 'range'.

`refEngineOn` assigns reference regions based on engine operation status. It uses the input, which it assumes is engine speed, and assumes reported engine speeds larger than the supplied threshold, by default 200 rpm, indicate that the engine is on.

`refDrivingMode` assigns reference regions based on vehicle driving mode. It uses inputs, assumed to be speed, `accel` and/or `decel`, and associated threshold to characterize activity as `decel`, `idle`, `cruise` or `accel`.

### Value

By default results are returned as `pems.elements`.

The reference vector generated by `ref...` functions can then be used to group, subset, filter or condition data in `pems` objects.

`refRow` assigns reference according to row number, and, by default, reference labels show start row and end row of the referenced case.

`refX` assigns reference according to value of supplied input, and, by default, reference labels show lower value and higher value of the referenced case.

`refEngineOn` assigns reference according to engine operation status based on engine speed, and, by default, reference labels are 'on' or 'off'.

`refDrivingMode` assigns reference according to vehicle driving mode, based on vehicle speed, acceleration and associated thresholds, and, by default, reference labels are `decel`, `idle`, `cruise` and `accel`.

### Note

With `refRow`, If `n` is applied and the length of `ref` is not exactly divisible by `n` a best attempt is made.

With `refX`, if breaks are at values that are duplicated, all same values are assigned to the same (lower) value case, so e.g. 'percentile' may vary significantly if break-point values are highly duplicated in `ref`

### Author(s)

Karl Ropkins

### References

References in preparation.

### See Also

`cut`, etc. in the main R package.

**Examples**

```
#####
##example 1
#####

#basic usage

#working with a temporary pems

temp <- pems.1

#cut into equal subsets

temp$ref <- refRow(velocity, n= 5, data=temp)
pemsPlot(local.time, velocity, cond=ref, data=temp,
          type="l", layout=c(1,5))

#cut at three points

temp <- pems.1
temp$ref <- refRow(velocity, breaks=c(180,410,700),
                  data=temp)

pemsPlot(local.time, velocity, cond=ref, data=temp,
          type="l", layout=c(1,5))
```

---

4.3.time.handlers      *pems Data Time Handlers*

---

**Description**

Time handlers are subset of `pems.utils` functions that work on or with time records (`time.stamp` and `local.time`).

**Usage**

```
regularize(data, Hz=1, method=1, ...)

repairLocalTime(data, local.time, ref, ..., reset.count = TRUE,
                fun.name = "repairLocalTime")
```

**Arguments**

`data`                    (Required, typically `pems`) The dataset to be worked with. For `regularize`, the dataset to regularize (see below).

Hz	(For <code>regularize</code> ) (Required numeric) The time resolution to regularize the data to in Hertz. So, the default, <code>Hz=1</code> is one measurement (or row of data) per second.
method	(For <code>regularize</code> ) (Required numeric) The regularization method to apply. The default, <code>method=1</code> uses <code>approx</code> to linearly interpolate regular time-series for all supplied time-series. The alternative <code>method=2</code> uses a bin-and-average strategy.
...	(Optional) Other arguments, typically passed on.
<code>local.time</code>	(For <code>repairLocalTime</code> ) (Required <code>pems.element</code> ) The <code>local.time</code> <code>pems.element</code> to work been repaired.
<code>ref, reset.count</code>	(For <code>repairLocalTime</code> ) (Other arguments) <code>ref</code> is a second source that <code>local.time</code> can be inferred from in cases where <code>local.time</code> records are missing. If <code>TRUE</code> , <code>reset.count</code> resets <code>local.time</code> so it starts at 0.
<code>fun.name</code>	(character) ( <code>pems handler</code> ) argument used by <code>pems.utils</code> . These can typically be ignored.

### Details

`regularize` attempts to extrapolate a regular series, generated at the time resolution requested, from the supplied data. Both methods can be used for the regularization of irregularly time-logged data, but differ in their data handling. Method 1 estimates measurements at regular intervals by linearly interpolating between the last valid point and the next valid point in supplied time-series. It therefore hole-fills gaps in time-series and is perhaps best suited for use with sparser data-sets. It can also be used to interpolate time-series to higher time-resolutions, but should not be used aggressively, e.g. to convert 1Hz data to 10Hz. By contrast, method 2 uses data binning to aggregate all supplied measurements (e.g. all measurements between -0.5 and +0.5 seconds of requested times when returning 1 Hz data) and (mean) average these. It is better suited for use with higher resolution time-series (e.g. going from about 10Hz to 1Hz) and does not hole-fill empty time intervals. If you want mean binning and hole-filling, apply method 2 then method 1, e.g.:

```
new.data <- regularize(regularize(my.data, method=2), method=1)
```

`repairLocalTime` attempts to repair an incomplete `local.time` record. For example, if you merge two datasets with overlapping but different time ranges, one may not track the time range of the other and this can generate incomplete time records. This function attempts to hole-fill such cases.

### Value

`regularize` returns the supplied dataset (`data`) with time-series (`time.stamp` and `local.time`) are regularized at the requested time resolution, based on `Hz` value. It uses `approx` or data binning to estimate associated changes for other data-series.

`repairLocalTime` returns a repaired `local.time` `pems.element`, typically the supplied `local.time` with any holes (NAs) it can fill filled.

### Note

All time handlers should be used with care.

**Author(s)**

Karl Ropkins

**References**

`regularize(..., method=1)` uses `approx`:

Base R Stats package function based on Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

A lot of leg-work testing `regularize` was done by then Leeds MSc Student Adrian Felipe Ortega Calle.

**See Also**

[approx](#) regarding data regularization methods.

---

4.4.unit.handlers      *data unit handlers*

---

**Description**

Various `pems.utils` functions for the management of data units.

**Usage**

```
getUnits(input = NULL, data = NULL, ...,
         if.missing = c("stop", "warning", "return"))

setUnits(input = NULL, units = NULL, data = NULL, ...,
         if.missing = c("stop", "warning", "return"),
         output = c("input", "data.frame", "pems", "special"),
         force = FALSE, overwrite = FALSE)

convertUnits(input = NULL, to = NULL, from = NULL, data = NULL, ...,
            if.missing = c("stop", "warning", "return"),
            output = c("input", "data.frame", "pems", "special"),
            unit.conversions = NULL, force = FALSE, overwrite = FALSE)

#local unit.conversion method handling

addUnitConversion(to = NULL, from = NULL, conversion = NULL,
                 tag = "undocumented",
                 unit.conversions = ref.unit.conversions, ...,
                 overwrite = FALSE)

addUnitAlias(ref = NULL, alias = NULL,
             unit.conversions = ref.unit.conversions, ...)
```

```
listUnitConversions(unit.conversions = ref.unit.conversions, ...,
                    verbose = FALSE, to = NULL, from = NULL)
```

### Arguments

<code>input</code>	(vector, object or object element) An input, e.g. a vector of speed measurements.
<code>data</code>	( <code>data.frame</code> , <code>pems</code> object) If supplied, the assumed source for an input. This can currently be a standard <code>data.frame</code> or a 'pems' object. Note: if an input is not found in <code>data</code> , the parent environment is then also checked before returning an error message.
<code>units, to, from, ref, alias, tag</code>	(Character vectors). Unit ids. <code>units</code> sets the units of input in <code>setUnits</code> . <code>to</code> sets the units to convert input to when using <code>convertUnits</code> . The additional arguments <code>from</code> can be used to apply unit conversions to inputs with un-defined or mismatched units, but requires the extra argument <code>force = TRUE</code> to confirm action. When working with local unit conversions <code>to</code> and <code>from</code> should be used to identify specific conversions, e.g. when using <code>addUnitConversion</code> to add a new unit conversion method, and <code>ref</code> and <code>alias</code> should be used to identify a current unit id and new alias, respectively, when using <code>addUnitAlias</code> . <code>tag</code> is an optional more detailed conversion description, intended for use in method documentation. (See Below for further details.)
<code>...</code>	(Optional) Other arguments, currently ignored.
<code>if.missing</code>	(Optional character vector) What the function should do if things do not go as expected. Current options include: "stop" to stop the function with an error message; "warning" to warn users that expected information was missing but to continue running the parent code; or "return" to continue running the parent code without any warnings.
<code>output</code>	(Character vector) Output mode for function results. Options currently include: <code>special</code> , <code>input</code> , <code>data.frame</code> , and <code>pems</code> . See <code>force</code> , <code>overwrite</code> and Values below for further details.
<code>force</code>	(Logical) Should a unit change to attempted even if checking indicates a mismatch, e.g. an attempt to set the units of an <code>input</code> that already has units assigned.
<code>overwrite</code>	(Logical) If 'same name' cases are encountered when packing/repacking an output into a <code>data.frame</code> or <code>pems</code> object, should the function overwrite the case in the target <code>data.frame</code> or <code>pems</code> object with the modified input? (If <code>FALSE</code> , a new element is generated with a unique name in the form <code>[input.name].number</code> .)
<code>unit.conversions</code>	(Optional list) If supplied, <code>unit.conversions</code> is a 'look up' table for unit conversion methods. By default, functions in <code>pems.utils</code> use the reference <a href="#">ref.unit.conversions</a> , but this can be copied to the workspace and updated to provide the user with a means of updating and expanding the method set.
<code>conversion</code>	(Numeric or function) When adding or updating a conversion method using <code>addUnitConversion</code> , the conversion method. This can be a numeric, in which case it is assumed to be a multiplication factor (and converted to a function in

the form `function(x) x * conversion`) or a function to be applied directly to an input.

`verbose` (Logical) For `listUnitConversions`. Should `unit.conversions` be reported in detail? By default (`verbose = FALSE`) only unit conversion tags are reported.

### Details

`getUnits` returns the units of an input.

`setUnits` sets/resets the units of an input.

`convertUnits` converts the units of an input.

`addUnitConversion` adds a conversion method to a local version of the unit conversion look-up table. Methods should be supplied as `to` and `from` unit ids and an associated conversion. A `tag` can also be supplied to provide a more detailed description of the conversion for use in documentation.

`addUnitAlias` adds an alias for an existing unit id in a local version of the unit conversion look-up table. The existing unit id should be identified using `ref` and the new alias should be assigned using `alias`. The `alias` is added to all `to` and `from` elements containing `ref` to allow users to work with alternative unit abbreviations.

`listUnitConversions` lists the methods a supplied unit conversion look-up table. If `to` and/or `from` arguments are also supplied, these are used to subsample relevant methods.

### Value

`getUnits` returns the units of an input as a character vector if available, else it returns `NULL`.

`setUnits` sets the units of an input to a supplied value, `units`, if they have not already be set or if `force = TRUE`. The result is returned as the modified input alone, the modified input as an element in a `data.frame`, or the modified input as an element in a `pems` object (depending on output setting). If either a `data.frame` or `pems` object is supplied as `data`, this is used as the target when repacking the output. (Note: `output = "special"` is a special case which allows the function to select the output mode based on the type of data supplied.

`convertUnits` converts the units of an input. Typically, this is done by setting the required new units, using `to`, and letting the function select a suitable conversion method. However, conversions can be forced by setting `from` and `force = TRUE` to apply a specific `to/from` method to an input regardless of the actual units of input. As with `setUnits`, results can be output as `input`, `data.frame` or `pems` objects.

`addUnitConversion` returns a supplied unit conversion look-up table (or in its absence the reference `ref.unit.conversions`) subject to the requested addition or update. Note: modifications that change exist information require the extra argument `overwrite = TRUE` as confirmation.

`addUnitAlias` returns a supplied unit conversion look-up table (or in its absence the reference `ref.unit.conversions`) subject to the requested alias addition.

`listUnitConversions` returns summary descriptions of methods in the supplied unit conversion look-up table (or in its absence the reference `ref.unit.conversions`). Additional arguments, `to` and `from`, can be used to select unit conversions of particular relevance.

### Note

This set of functions is intended to provide a flexible framework for the routine handling of data units.

**Author(s)**

Karl Ropkins

**References**

References in preparation

**See Also**[pems.element](#)**Examples**

```
#####
##example 1
#####

#work with data units

#getting units (where assigned)
getUnits(velocity, pems.1) #km/h

#setting units
a <- 1:10
a <- setUnits(a, "km/h") #add unit

#alternaltive
#using pems.element
#a <- pems.element(a, units="km/h", name = "a")

#changing units
convertUnits(a, "mi/h")

# [1] 0.6213712 1.2427424 1.8641136 2.4854848 3.1068560 3.7282272 4.3495983
# [8] 4.9709695 5.5923407 6.2137119
# pems.element; [unnamed] [mi/h] [n = 10]

#####
##example 2
#####

#working with local unit conversions
#adding/updating unit conversion methods

#make a local reference
ref.list <- ref.unit.conversions

#add a miles/hour alias to mi/h
ref.list <- addUnitAlias("mi/h", "miles/hour", ref.list)

#add a new conversion
ref.list <- addUnitConversion(to = "silly", from = "km/h",
```

```

conversion = function(x) 12 + (21 * x),
tag = "kilometers/hour to some silly scale",
unit.conversions = ref.list)

#use these
convertUnits(a, "miles/hour", unit.conversions = ref.list)

# [1] 0.6213712 1.2427424 1.8641136 2.4854848 3.1068560 3.7282272 4.3495983
# [8] 4.9709695 5.5923407 6.2137119
# units: "miles/hour" (as above but using your unit abbreviations)

convertUnits(a, "silly", unit.conversions = ref.list)

# [1] 33 54 75 96 117 138 159 180 201 222
# units: "silly" (well, you get what you ask for)

```

---

5.1.pems.plots

*Various plots for pems.utils*


---

## Description

Various plot functions and visualization tools for use with pems objects.

## Usage

#pemsPlot

```

pemsPlot(x, y = NULL, z = NULL, groups = NULL,
cond = NULL, ..., data = NULL,
units = TRUE, multi.y = "special",
fun.name="pemsPlot")

```

#associated functions

```

pemsXYZCondUnitsHandler(x,y = NULL, z = NULL,
cond = NULL, groups = NULL, data = NULL,
units = TRUE, ...,
fun.name = "pemsXYZCondHandler")

```

```

preprocess.pemsPlot(lattice.like = lattice.like,
units = units, ...)

```

```

panel.pemsPlot(..., loa.settings = FALSE)

```

```

panel.routePath(..., loa.settings = FALSE)

```

#WatsonPlot

```

WatsonPlot(speed, accel = NULL, z = NULL, ...,
            data = NULL, cond = NULL, units = TRUE,
            plot.type = 2, fun.name="WatsonPlot")

#associated functions

preprocess.WatsonPlot(lattice.like = lattice.like, ...)

panel.WatsonBinPlot(..., ref.line = TRUE,
                    process.panel = NULL, plot.panel = NULL,
                    omit.stopped = FALSE, process = TRUE,
                    plot = TRUE, loa.settings = FALSE)

panel.WatsonContourPlot(...,
                        plot.panel=NULL, process = TRUE,
                        plot = TRUE, loa.settings = FALSE)

panel.WatsonSmoothContourPlot(...,
                                plot.panel=NULL, process = TRUE,
                                plot = TRUE, loa.settings = FALSE)

#old plots

latticePlot(x = NULL, data = NULL, plot = lattice::xyplot,
            panel = NULL, ..., greyscale = FALSE,
            fun.name = "latticePlot")

panel.PEMSXYPlot(..., grid=NULL)

XYZPlot(x = NULL, ..., data = NULL, statistic = NULL,
        x.res = 10, y.res = 20, plot = lattice::levelplot,
        fun.name = "XYZPlot")

```

### Arguments

`x, y, z, groups, cond`

(Various) The main plot elements. `x` and `y` are typically plot coordinates. `z` is any additional information that could be used, e.g. to modify points plotted at  $(x, y)$  coordinates or generate a third axis for a surface plot. `groups` and `cond` are plot grouping and conditioning terms that can be used to subset the supplied data and/or generate multiple plot panels. See Below.

For new plots, these should be supplied individually, e.g. for `pemsPlot`:

```
pemsPlot(x, y, z, groups, cond)
```

For old plots, these must be formulae.

For `latticePlot` the basic formula structure is  $y \sim x \mid \text{cond}$ .

For `XYZPlot` the basic formula structure is  $z \sim y * x \mid \text{cond}$ . `z` is optional, but

	when it is not supplied <code>z</code> it is treated as the bin count. See Notes and Examples.
<code>data</code>	(Optional <code>data.frame</code> or <code>pems</code> object) For most plots, the data source for plot elements, e.g <code>x</code> , <code>y</code> , <code>z</code> , etc, if these are not supplied directly or accessible from the current workspace.
<code>units</code>	(Optional logical or list) for <code>pemsPlot</code> only, unit handling information. By default, <code>pems.utils</code> adds any known units to plot labels and allows in-plot unit management. Unit management is handled by <code>convertUnits</code> , and requested conversions need to assigned to an axis. So, for example, the call <code>pemsPlot(..., x.to="m/s")</code> would generate a plot with the x-axis in units of m/s (assuming <code>pems.utils</code> knows the unit conversion and the x-axis data series is in units that can be converted). All unit management and associated figure labelling can disabled using <code>units = FALSE</code> , or unit suffixes can be removed but unit management retained using <code>units.add.to.labels = FALSE</code> .
<code>multi.y</code>	(character) <code>pems.plots</code> accepted multiple y data-series if passed using <code>cpe</code> , e.g. <code>y = cpe(a,b)</code> . <code>multi.y</code> sets how these are handled, options include 'groups', 'cond' and 'special' (the default), which selects groups if not used in plot call else <code>cond</code> .
<code>...</code>	(Optional) Other arguments, typically passed on. This includes, <code>scheme</code> which sets the default coloring scheme for the plot. See Note below.
<code>fun.name</code>	(Function management argument) <code>pems.utils</code> management settings, can typically be ignored by most users.
<code>panel</code> , <code>plot.panel</code> , <code>process.panel</code>	(Functions) These functions are used to generate the content of individual plot panels. Typically, all in-panel data processing and plotting is carried out using <code>panel</code> . However, these steps can be handled by separate functions if these are supplied as <code>plot.panel</code> and <code>process.panel</code> .
<code>lattice.like</code> , <code>plot</code> , <code>process</code> , <code>loa.settings</code>	(Various) Plot management elements. These can typically be ignored by most users, but allow plot developers to fine-tune plots. See Details below.
<code>speed</code> , <code>accel</code>	(Various) For <code>WatsonPlot</code> , the x and y terms, speed and acceleration, respectively.
<code>ref.line</code>	(Logical or list) For <code>WatsonPlot</code> . This argument manages the <code>speed = 0</code> reference added to <code>WatsonPlots</code> . It can be either a logical (TRUE/FALSE), to turn the line on or off, or a list of parameters to set the properties of the line.
<code>omit.stopped</code>	(Logical or character) For <code>WatsonPlot</code> , how to handle idling data: FALSE include in plot; TRUE or 'points' removes idle points before plotting; 'cell' or 'cells' removes any cells that include idling points before the data is binned.
<code>plot.type</code>	(numeric) For <code>WatsonPlot</code> , pre-set plot types: 1 scatter plot; 2 bin plot; 3 contour plot of binned data; 4 smoothed surface of binned data. See also <code>statistic</code>
<code>greyscale</code>	(Logical) For older plots only, should the plot be greyscale by default? This option resets the <code>lattice</code> color themes to greyscale while the plot is being generated. So: (1) This only effects the plot itself, not subsequent plots; and, (2) any user resets overwrite this, e.g. <code>latticePlot(..., greyscale=TRUE, col="red")</code> will place red symbols on an otherwise greyscale plot. Newer plots use the alternative <code>plot(..., scheme = "greyscale")</code> .

grid	(List) If supplied, a list of plot parameters to be used to control the appearance of the grid component of the plot. See Below.
statistic	(Function) when binning data with XYZPlot and WatsonPlot, the function to use when evaluating the elements of each data bin. By default, length is used if z is not supplied to generate a frequency plot and mean is used if z is supplied to generate a bin average plot.
x.res, y.res	(Numerics) when binning data with XYZPlot, the number of x- and y-axis bins to generate.

### Details

pems.utils includes conventional (generic) plot methods for pems and pems.element objects. See [plot.pems](#) and [plot.pems.element](#) for further details.

However, it also includes a range of higher-level plotting functions developed for use with pems data.

Early plots, e.g. [latticePlot](#), only allowed plot arguments using the [lattice](#) formula format. While this is flexible and very powerful system, some users preferred the more conventional `plot(x, y, ...)` call format. So, newer plots, e.g. [pemsPlot](#), allow both conventional plot and [lattice](#)-style formula calls.

[pemsXYZCondUnitsHandler](#) handles the pems information associated with the plots. This routine is included as a discrete function within this package and others are welcome to use elsewhere for similar purposes. `edit(pemsPlot)` to see it.

Newer plots use a combination of [lattice](#) and [loa](#) functions to provide a range of additional plotting options, such as integrated panel and key management. See [loa](#) documentation for further details.

`preprocess...` and `panel...` functions handle pre-plot and in-plot elements of plot generation. These use the [loa](#) modification of the [lattice](#) plotting framework.

See Notes, Examples and extra documentation: [pems.plots](#).

### Value

By default, [pemsPlot](#) generates a bubble plot, so it plots  $(x, y)$  points, and by default color-grades and size-scales them according to z if also supplied.

When supplied speed and accel data-series as x and y cases, the [WatsonPlot](#) generates various forms of Watson's classic speed/accel frequency distribution plot.

[latticePlot](#) and [XYZPlot](#) are general purpose 'xy' and 'xyz' data plotting functions.

[fortify](#) is intended for use by [ggplot2](#) functions when users are plotting data in pems objects. See Notes.

### Warning

IMPORTANT: Conditioning is currently disabled on [XYZPlot](#).

[XYZPlot](#) is a short-term replace for previous function [quickPlot](#). It will most likely be replaced when `pems.utils.0.3` is released.

[pemsPlot](#) and [WatsonPlot](#) no longer accept formula x, y, z inputs.

With all these functions I have tried to make the default plotting options as robust as possible. However, it is not always possible to test all the plot combines that users might try. So, please let me know if anything is not working nicely for you. Thanks.

## Note

### General:

Like most other plot functions in R, `lattice` functions use a number of common parameter terms. For example, `xlab` and `ylab` reset the x and y labels of a graph; `xlim` and `ylim` to set the x- and y-scales of a graph; `col` sets the color of a plot element; `type` sets the type ('p' for points, 'l' for lines, etc); `pch` and `cex` set plot symbol type and size, respectively; and, `lty` and `lwd` set plot line type and thickness, respectively; etc. These terms are passed onto and evaluated by all these plot functions to provide standard plot control.

### `latticePlot`:

The default plot option for `latticePlot` is `xyplot`.

`panel` options for `latticePlot`: Default `panel.xyplot`. The alternative panel, `panel.PEMSYPlot` supplied as part of this package, adds a grid layer to a standard xy panel. The extra code just allows you to pass specific plot parameters to the grid panel using the argument `grid`. You can build almost any plot layout using these and other panels in `lattice` and `loa` as building blocks.

### `XYZPlot`:

The default plot option for `latticePlot` is `levelplot`.

### `pemsPlot`:

`pemsPlot` and subsequent plot functions use an alternative convention. Here, plots include separate process and plot steps. This option allows the plot to pass on share the results of in-panel calculations with other panels and keys. The handling mechanism is part of the `loa` package.

The reason for `latticePlot`, etc:

`latticePlot` combines a number of `lattice` and `latticeExtra` function modifications I regularly use when plotting data. So, it is basically a short cut to save having to write out a lot of code I regularly use. I would encourage anyone to at the very least have a look at `lattice`.

I also hope those learning `lattice`, find these functions a helpful introduction and handy 'stop gap' while they are getting to grips with the code behind `trellis` and `panel` structures.

## Author(s)

Karl Ropkins

## References

### `lattice`:

Sarkar, Deepayan (2008) *Lattice: Multivariate Data Visualization with R*. Springer, New York. ISBN 978-0-387-75968-5

### `latticeExtra`:

Deepayan Sarkar and Felix Andrews (2011). *latticeExtra: Extra Graphical Utilities Based on Lattice*. R package version 0.6-18. <http://CRAN.R-project.org/package=latticeExtra>

`lattice` is one of number of really nice graphical tools in R. Others, like `ggplot2` and `iplot`, help you to very quickly explore your data. But, for me the trellis framework of `lattice` has always felt the most flexible.

### See Also

See `lattice`, `latticeExtra`, `loa`.

### Examples

```
#####
##example 1
#####

## Not run:
#plotting pems with other packages

#base
plot(pems.1)
plot(pems.1$velocity)

#with lattice
require(lattice)
xyplot(velocity~local.time, data = pems.1, type = "l")

#with ggplot2
require(ggplot2)
qplot(time.stamp, velocity, data=pems.1)
ggplot(pems.1, aes(x = time.stamp, y = velocity)) + geom_line()
#etc

## End(Not run)

#####
##example 2
#####

#basic usage of latticePlot

latticePlot(velocity~local.time, data = pems.1, type = "l")

latticePlot(velocity~local.time, data = pems.1, col = "red",
            pch = 20, panel = panel.PEMSXYPlot,
            grid = list(col = "black", lty=2))

#####
##example 3
#####

#basic usage of XYZPlot
```

```

a <- calcAccel(velocity, local.time, data = pems.1, output="pems")

XYZPlot(~accel*velocity, data=a)

XYZPlot(~accel*velocity, data=a, plot = lattice::wireframe, shade=TRUE)

#####
##example 4
#####

#basic usage of pemsPlot

pemsPlot(local.time, velocity, data=pems.1, type="l")

#####
##example 5
#####

#basic usage of WatsonPlot

#Note: using 'a' generated in example 3
WatsonPlot(velocity, accel, data=a)

## Not run:
#omit.stopped for different handling of idling data
WatsonPlot(velocity, accel, data=a, omit.stopped="points")
WatsonPlot(velocity, accel, data=a, omit.stopped="cells")

#plot.type for different plot methods
WatsonPlot(velocity, accel, data=a, plot.type=1)
WatsonPlot(velocity, accel, data=a, plot.type=2)
WatsonPlot(velocity, accel, data=a, plot.type=3)
WatsonPlot(velocity, accel, data=a, plot.type=4)

## End(Not run)

```

---

6.1.common.calculations

*Common calculations*

---

## **Description**

Various common calculations associated with PEMS data.

## **Usage**

```
calcDistance(speed = NULL, time = NULL, data = NULL,
```

```

    ..., fun.name = "calcDistance")

calcSpeed(distance = NULL, time = NULL, data = NULL,
  ..., fun.name = "calcSpeed")

calcAccel(speed = NULL, time = NULL, data = NULL,
  ..., method = 2, fun.name = "calcAccel")

calcAcceleration(speed = NULL, time = NULL, data = NULL,
  ..., method = 2, fun.name = "calcAccel")

calcJerk(accel = NULL, time = NULL, data = NULL,
  ..., fun.name = "calcJerk")

#associated

calcChecks(fun.name = "calcChecks", ..., data = NULL,
  if.missing = c("stop", "warning", "return"),
  output = c("input", "data.frame", "pems", "special"),
  unit.conversions = NULL, overwrite = FALSE)

calcPack(output = NULL, data = NULL, settings = NULL,
  fun.name = "calcPack", this.call = NULL)

```

### Arguments

speed, time, distance, accel	(Required data series typically vectors) The inputs to use when doing a calculation. These can typically be vectors or elements in either a <code>data.frame</code> or <code>pems</code> object.
data	(Optional <code>data.frame</code> or <code>pems</code> object) The data source if either a <code>data.frame</code> or <code>pems</code> object is being used.
...	(Optional) Other arguments, currently passed on to <code>calcChecks</code> .
fun.name	(Optional character) The name of the parent function, to be used in error messaging.
if.missing, output, unit.conversions, overwrite, settings, this.call	(Various) Along with <code>data</code> and <code>fun.name</code> , arguments used by <code>calcCheck</code> and <code>calcPack</code> to manage error and unit handling and workhorse <code>calc...</code> operations. These are typically passed to the appropriate <code>check...</code> or <code>...</code> Units function for evaluation. See <code>Details</code> , <code>Note</code> and <code>Examples</code> below.
method	(Character) Currently for <code>calcAccel</code> only. The method to use if options exist.

### Details

With the exception of `calcChecks` and `calcPack`, `calc...` functions are common calculations. `calcDistance` calculates distance (in m) using speed and time.

`calcSpeed` calculates speed (in m/s) using distance and time.

`calcAccel` calculates acceleration (in m/s/s) using speed and time.

`calcJerk` calculates jerk (rate of change of acceleration in m/s/s/s) using acceleration and time.

By default results are returned as `pems.elements`. Other options include returning as the supplied data plus the results as either a `data.frame` or a `pems` object. See Note below.

Unit management is by `convertUnits`. See Note below.

The extra functions `calcChecks` and `calcPack` are add-ins that anyone can use to develop other similar functions. They are added at the start and end of standard `calc...` functions to provide an option to use with third-party code. See Note.

### Value

With the exception of `calcChecks` and `calcPack`, all `calc...` functions return either a `pems.element` vector, `data.frame` or `pems` object, depending on output setting and data supplied.

### Note

Unit handling in `pems.utils` is via `checkUnits`, `getUnits`, `setUnits` and `convertUnits`. Allowed unit conversion methods have to be defined in `ref.unit.conversions` or a locally defined alternative supplied by the user. See `convertUnits` for an example of how to locally work with unit conversions.

`calc.dist` and `calc.accel` are alternatives to `calcDistance` and `calcAccel`.

The functions `calcChecks` and `calcPack` are currently under revision and likely to be replaced in future versions of `pems.utils`.

### Author(s)

Karl Ropkins

### References

References in preparation.

### See Also

`calcVSP` for VSP calculations. `calcEm` for emissions calculations.

### Examples

```
#####
##example 1
#####

#basic usage

#calculated accel as pems.element

calcAccel(velocity, local.time, pems.1)
```

```

#answer returned as supplied pems + calculated accel

calcAccel(velocity, local.time, pems.1, output = "pems")

#or, if you would rather...
## Not run:
pems.1$accel <- calcAccel(velocity, local.time, pems.1)

## End(Not run)

#####
#example 2
#####

#making wrappers for routine data processing

my.pems <- list(pems.1, pems.1)

sapply(my.pems, function(x)
      calcAccel(velocity, local.time, data=x))

#ans = accel data series for each pems in my.pems list

#           [,1]      [,2]
# [1,]      NA       NA
# [2,] 0.00000000 0.00000000
# [3,] 0.05555556 0.05555556
# [4,] 0.00000000 0.00000000
# [5,] -0.02777778 -0.02777778
# [6,] 0.05555556 0.05555556
#      ....

#note:
#sapply if you can/want to simplify outputs
#lapply if you want to keep output as a list of answers

```

---

## 6.2.common.check.functions

### *common check... functions*

---

#### **Description**

Various pems.utils workhorse functions for input checking and routine data handling.

#### **Usage**

```

checkOption(option=NULL, allowed.options=NULL,
            option.name = "option", allowed.options.name = "allowed.options",

```

```

partial.match=TRUE, fun.name = "checkOption",
if.missing = c("stop", "warning", "return"),
output = c("option", "test.result"), ...)

checkPEMS(data = NULL, fun.name = "checkPEMS",
if.missing = c("return", "warning", "stop"),
output = c("pems", "data.frame", "test.result"),
...)

checkUnits(input = NULL, units = NULL, data = NULL,
input.name = NULL, fun.name = "checkUnits",
if.missing = c("stop", "warning", "return"),
output = c("special", "units", "input", "test.result"),
..., unit.conversions = NULL)

checkOutput(input = NULL, data = NULL,
input.name = NULL, fun.name = "checkOutput",
if.missing = c("stop", "warning", "return"),
output = c("pems", "data.frame", "input", "test.result"),
overwrite = FALSE, ...)

checkIfMissing(..., if.missing = c("stop", "warning", "return"),
reply = NULL, suggest = NULL, if.warning = NULL,
fun.name = NULL)

```

### Arguments

<code>input</code>	(vector, object or object element) An input to be tested or recovered for subsequent use by another function, e.g. a speed measurement from a pems object.
<code>data</code>	(data.frame, pems object) If supplied, the assumed source for an input. This can currently be a standard data.frame or a 'pems' object. Note: if an input is not found in data, the parent environment is then also checked before returning an error message.
<code>input.name, option.name</code>	(Optional character vectors) If a check... function is used as a workhorse by another function, the name it is given in any associated error messaging. See Note below.
<code>fun.name</code>	(Optional character vector) If a check... function is used as a workhorse routine within another function, the name of that other function to be used in any associated error messaging. See Note below.
<code>if.missing</code>	(Optional character vector) How to handle an input, option, etc, if missing, not supplied or NULL. Current options include: "stop" to stop the check... function and any parent function using it with an error message; "warning" to warn users that expected information was missing but to continue running the parent code; or "return" to continue running the parent code without any warnings.
<code>output</code>	(Character vector) Output mode for check... function results. Options typically include the check type and "test.results". See Value below.

...	(Optional) Other arguments, currently ignored by all <code>check...</code> functions expect <code>checkIfMissing</code> .
<code>option, allowed.options, allowed.options.name</code>	(Character vectors) For <code>checkOption</code> , <code>option</code> and <code>allowed.options</code> are the supplied option, and the allowed options it should be one of, respectively, and <code>allowed.options.name</code> if way these allowed options should be identified in any associated error messaging. See Note below.
<code>partial.match</code>	(Logical) For <code>checkOption</code> , should partial matching be used when comparing <code>option</code> and <code>allowed.options</code> .
<code>units</code>	(Character vector) For <code>checkUnits</code> , the units to return input in, if requested ( <code>output = "input"</code> ). Note: The default, <code>output = "special"</code> , is a special case which allows <code>checkUnits</code> to return either the units if they are not set in the call (equivalent to <code>output = "units"</code> ) or the input in the requested units if they are set in the call (equivalent to <code>output = "input"</code> ).
<code>unit.conversions</code>	(List) For <code>checkUnits</code> , the conversion method source. See <a href="#">ref.unit.conversions</a> and <a href="#">convertUnits</a> for further details.
<code>overwrite</code>	(Logical) For <code>checkOutput</code> , when packing/repacking a <code>data.frame</code> or <code>pems</code> object, should 'same name' cases be overwritten? If <code>FALSE</code> and 'same names' are encountered, e.g. when modifying an existing <code>data.frame</code> or <code>pems</code> element, a new element if generated with a unique name in the form <code>[name].[number]</code> .
<code>reply, suggest, if.warning</code>	(Character vectors) For <code>checkIfMissing</code> , when generating error or warning messages, the main reply/problem description, any suggestions what users can try to fix this, and the action taken by the function if just warning (e.g. setting the missing value to <code>NULL</code> ), respectively. All are options.

## Details

The `check...` functions are intended as a means of future-proofing `pems.utils` data handling. They provide routine error/warning messaging and consistent 'front-of-house' handling of function arguments regardless of any underlying changes in the structure of the `pems` objects and/or `pems.utils` code. This means third-party function developed using these functions should be highly stable.

`checkOption` checks a supplied option against a set of allowed options, and then if present or matchable returns the assigned option. It is intended as a workhorse for handling optional function arguments.

`checkPEMS` checks a supplied data source and provides a short-cut for converting this to and from `data.frames` and `pems` object classes. It is intended as a 'best-of-both-worlds' mechanism, so users can supply data in various different formats, but function developers only have to work with that data in one (known) format.

`checkUnits` checks the units of a previously recovered input, and then, depending on the output setting, returns either the units of the input or the input in the required units (assuming the associated conversion is known).

`checkOutput` packs/repacks a previously recovered input. Depending on the output setting, this can be as the (standalone) input, an element of a `data.frame` or an element of a `pems` object.

checkIfMissing if a workhorse function for the `if.missing` argument. If any of the supplied additional arguments are NULL, it stops, warns and continues or continues a parent function according to the `if.missing` argument. If supplied, `reply`, `suggest` and `if.warning` arguments are used to generate the associated error or warning message.

### Value

All `check...` functions return a logical if `output = "test.result"`, TRUE if the input, option, etc., is suitable for use in that fashion or FALSE if not.

Otherwise,

`checkOption` return the option argument if valid (on the basis of `if.missing`) or an error, warning and/or NULL (on the basis of `if.missing`) if not. If `partial.match = TRUE` and partial matching is possible this is in the full form given in `allowed.options` regardless of the degree of abbreviation used by the user.

`checkPEMS` returns the data argument if valid or an error, warning and/or NULL (on the basis of `if.missing`) if not. Depending on output setting, the valid return is either a `data.frame` or `pems` object.

`checkUnits` returns the units of the input argument if no other information is supplied and units have previously been assigned to that input. If units are assigned in the call or output is forced (`output = "input"`), the input is returned in the requested units. If this action is not possible (e.g. `pems.utils` does not know the conversion), the function returns an error, a warning and the unchanged input or the unchanged input alone depending on `if.missing` setting.

Depening on `if.missing` argument, `checkIfMissing` either stops all parent functions with an error message, warns of a problem but allows parent functions to continue running, or allows parent functions to continue without informing the user.

### Note

The `...name` arguments allow the `check...` functions to be used silently. If a parent function is identified as `fun.name` and the check case (input, option, etc.) is identified with the associated `...name` argument these are used in any associated error messaging.

### Author(s)

Karl Ropkins

### References

[TO DO]

### See Also

See [ref.unit.conversions](#) and [convertUnits](#) for general unit handling.

**Description**

Corrections are a special subset of functions which by default write over the elements that they recalculate.

**Usage**

```
correctInput(input = NULL, ..., data = NULL,
             correction = NULL)
```

```
zeroNegatives(input = NULL, ..., data = NULL,
              screen = FALSE)
```

```
correctBaseline(x, ..., data = NULL, output = "ans")
```

```
#associated
```

```
calcPack2(input, ..., settings = NULL, data = NULL)
```

**Arguments**

input	(Required data series typically vectors) The input to use when makin a correction. This is typically a vector or element in either a <code>data.frame</code> or <code>pems</code> object.
x	(For <code>correctBaseline</code> ) (Required data series typically vectors) The input to use when makin a correction. This is typically a vector or element in either a <code>data.frame</code> or <code>pems</code> object.
...	(Optional) Other arguments, typically passed on.
data	(Optional <code>data.frame</code> or <code>pems</code> object) The data source if either a <code>data.frame</code> or <code>pems</code> object is being used.
correction	(For <code>correctInput</code> , required function) The correction operation to apply to input. This is typically a function or function name (as character string).
screen	(For <code>zeroNegatives</code> , logical) If the user intends screening the correction before applying it, this should be set to <code>TRUE</code> .
output	(character) Where options exists for the function output, the required output. For <code>correctBaseline</code> , current options: <code>'ans'</code> (the default) and <code>'diagnostic'</code> .
settings	(For <code>calcPack2</code> , list) Any arguments to be used as settings when handling <code>pems.elements</code> . Unless developing functions, this can typically be ignored.

## Details

`correctInput` is a general correction handlers. It accepts an input and a function, `correction`, which it applies to input.

`zeroNegatives` resets any negative values in an input to zero.

`correctBaseline` attempts to correct the baseline of a supplied data (`pems.element` vector) time-series. Baseline corrections are carried out using methods from the [baseline](#) package. See Below.

`calcPack2` is an alternative version of [calcPack](#). See associated help for details.

## Value

With the exception of `calcPack2`, all the above functions generate input corrections.

`correctBaseline` returns the supplied data time-series (`x`) after applying the requested baseline correction (see below).

## Note

By default, corrections return results in the format of the input. So: If inputs are supplied as vectors, the answer is returned as a vector; If inputs are supplied in a `pems` object, that `pems` object is returned with the answer added in. This behaviour is enabled by the default `output = "special"`. Output type can be forced by declaring `output` in the function call. Options `"input"`, `"data.frame"` and `"pems"` return vectors, `data.frames` and `pems` objects, respectively.

Unlike other calculations, corrections automatically replace the associated input, unless prevented (using `overwrite = FALSE`).

This function management is handled by [calcChecks](#) and [calcPack](#). These are front and back end `calc...` function add-ins that anyone can use as a 'minimal code' means of integrating third-party and `pems.utils` functions.

See [calcChecks](#) documentation for details.

`correctBaseline` is a recent transfer from `sleeperservice`. It uses [baseline](#) functions to provide 'best guess' baseline corrections.

By default, it applies:

```
baseline(..., method="rollingBall", wm=50, ws=50)
```

Please Note the 'best guess': As baseline corrections are based statistical estimates of likely baselines rather than actual measures of drift these should be treated as estimates.

Unit management is by [convertUnits](#). See associated help documentation for details.

## Author(s)

Karl Ropkins

## References

baseline:

Kristian Hovde Liland and Bjorn-Helge Mevik (2015). baseline: Baseline Correction of Spectra. R package version 1.2-1. <https://CRAN.R-project.org/package=baseline>

**See Also**

[baseline](#) regarding baseline corrections.

[common.calculations](#), [calcVSP](#) or [calcEm](#) for calculation functions.

[getElement](#) ([checkUnits](#), etc and [convertUnits](#) for data management.

**Examples**

```
#####
##example 1
#####

#basic usage

zeroNegatives(-10:10) #etc
```

---

6.4.analysis.summary.reports

*Generating summary reports*

---

**Description**

Various functions for generating summary reports for pems objects.

**Usage**

```
summaryReport(speed = NULL, time = NULL, accel = NULL,
              distance = NULL, data = NULL, ...,
              lod.speed = 0.1, lod.accel = 0.1,
              fun.name = "summaryReport")
```

**Arguments**

speed, accel, time, distance	(Data series typically vectors) The inputs to use when doing a calculation. These can typically be vectors or elements in either a <code>data.frame</code> or <code>pems</code> object if supplied as data. See Details below regarding requirements.
data	(Optional <code>data.frame</code> or <code>pems</code> object) The data source if either a <code>data.frame</code> or <code>pems</code> object is being used.
...	(Optional) Other arguments, currently passed on to <a href="#">calcChecks</a> which in turn provides access to <code>pems.utils</code> management arguments such as <code>if.missing</code> and unit handlers such as <code>unit.conversions</code> .

<code>lod.speed</code> , <code>lod.accel</code>	(numerics) The limits of detection for speed and accel measurements, respectively. [Note: if only one value is given for accel, the accel limits are assumed to be $c(-lod.accel, +lod.accel)$ ].
<code>fun.name</code>	(Optional character) The name of the parent function, to be used in error messaging.

### Details

`summaryReport` does not strictly require all the arguments `speed`, `accel`, `time` and `distance` as inputs. It calculates as many of the missing cases as it can using the [common.calculations](#) before halting an analysis or warning the user of any problems.

Unit management is by [convertUnits](#). See Note below.

### Value

`summaryReport` returns a one-row data.frame with twelve elements:

`distance.travelled.km` this total distance travelled (in km)

`time.total.s` the total time taken (in s)

`avg.speed.km.h` the mean speed as averaged across the total journey/dataset (in km/h)

`avg.running.speed.km.h` the mean speed while the vehicle was in motion (in km/h), assuming a 0.01 km/h accuracy for speed measurements.

`time.idle.s` and `time.idle.pc`, the time the vehicle was idling (in s and as a percentage, respectively), also assuming a 0.01 km/h cutoff for speed measurements.

`avg.accel.m.s.s` the mean (positive component of) acceleration (in m/s/s), assuming a 0.1 m/s/s cutoff for accel measurements.

`time.accel.s` and `time.accel.pc`, the time the vehicle was accelerating (in s and as a percentage, respectively), also assuming a 0.1 m/s/s cutoff for accel measurements.

`avg.decel.m.s.s` the mean deceleration (negative component of acceleration in m/s/s), assuming a -0.1 m/s/s cutoff for accel measurements.

`time.decel.s` and `time.decel.pc`, the time the vehicle was decelerating (in s and as a percentage, respectively), also assuming a -0.1 m/s/s cutoff for accel measurements.

### Warning

Currently, `summaryReport` outputs have units incorporated into their names because the outputs themselves are unitless data.frames.

### Note

Unit handling in `pems.utils` is via [checkUnits](#), [getUnits](#), [setUnits](#) and [convertUnits](#). Allowed unit conversion methods have to be defined in [ref.unit.conversions](#) or a locally defined alternative supplied by the user. See [convertUnits](#) for an example of how to locally work with unit conversions.

**Author(s)**

Karl Ropkins

**References**

References in preparation.

**See Also**[checkUnits](#) and [convertUnits](#) for data management.**Examples**

```
#####
##example 1
#####

#basic usage

summaryReport(velocity, local.time, data=pems.1)

# distance.travelled.km time.total.s avg.speed.km.h avg.running.speed.km.h
# 1 6.186056 1000 22.2698 28.78538
# time.idle.s time.idle.pc avg.accel.m.s.s time.accel.s time.accel.pc
# 1 40 4 0.7921279 271 27.1
# avg.decel.m.s.s time.decel.s time.decel.pc
# 1 -0.9039449 238 23.8

#apply to multiple cases

my.pems <- list(pems.1, pems.1)

sapply(my.pems, function(x)
  summaryReport(velocity, local.time, data = x))

#           [,1]      [,2]
# distance.travelled.km 6.186056 6.186056
# time.total.s          1000    1000
# avg.speed.km.h        22.2698  22.2698
# avg.running.speed.km.h 28.78538 28.78538
# time.idle.s           40      40
# time.idle.pc          4       4
# avg.accel.m.s.s       0.7921279 0.7921279
# time.accel.s          271     271
# time.accel.pc         27.1    27.1
# avg.decel.m.s.s       -0.9039449 -0.9039449
# time.decel.s          238     238
# time.decel.pc         23.8    23.8
```

---

7.1.vsp.code

*Vehicle Specific Power (VSP) related code*

---

## Description

Functions associated with VSP calculations.

## Usage

#calculation

```
calcVSP(speed = NULL, accel = NULL, slope = NULL,  
        time = NULL, distance = NULL, data = NULL,  
        calc.method = calcVSP_JimenezPalacios,  
        ..., fun.name = "calcVSP", this.call = NULL)
```

```
calcVSP_JimenezPalacios(speed = NULL, accel = NULL,  
                        slope = NULL, vehicle.weight = NULL, vsp.a = NULL,  
                        vsp.b = NULL, vsp.c = NULL, vsp.g = NULL, ...,  
                        data = NULL,  
                        fun.name = "calcVSP_JimenezPalacios",  
                        this.call = NULL)
```

#VSP binning

```
refVSPBin(..., bin.method="ncsu.14")
```

```
refVSPBin_NCSU.14(vsp = NULL, data = NULL,  
                 ..., fun.name="refVSPBin_NCSU.14")
```

```
refVSPBin_MOVES.23(vsp = NULL, speed = NULL, data = NULL,  
                  ..., fun.name="refVSPBin_MOVES.23")
```

#vsp plotting

```
VSPPlot(vsp, em = NULL, ..., data = NULL, plot.type = 1,  
        fun.name="VSPPlot")
```

```
VSPBinPlot(vspbin, em = NULL, ..., data = NULL,  
           plot.type = 1, stat = NULL, fun.name="VSPBinPlot")
```

**Arguments**

<code>speed, accel, slope, time, distance, vsp, vspbin, em</code>	(Typically <code>pems.element</code> vectors) <code>speed, accel, slope, time</code> and <code>distance</code> are possible inputs for VSP calculation. <code>vsp</code> and <code>speed</code> are possible inputs for VSP binning methods. <code>vsp, vspbin</code> and <code>em</code> are x and y inputs for associated plots. (See Notes about inputs and methods.)
<code>data</code>	(Optional, typically <code>pems</code> ) The data source for inputs.
<code>calc.method, bin.method</code>	(Required functions) <code>calc.method</code> is the function used to calculate VSP (default <code>calcVSP_JimenezPalaciosCMEM</code> ). <code>bin.method</code> is the methods used when binning VSP measurements. (See Notes.)
<code>...</code>	(Optional) Other arguments, currently passed on as supplied to associated calculation or binning method, or back to <code>pemsPlot</code> .
<code>fun.name</code>	(Optional character) The name of the parent function, to be used in error messaging.
<code>this.call</code>	(Optional) Initial call, should generally be ignored. See <a href="#">common.calculations</a> for further details.
<code>vehicle.weight, vsp.a, vsp.b, vsp.c, vsp.g</code>	(Numerics) VSP constants. If not supplied, defaults are applied. See Below.
<code>plot.type</code>	(Optional numeric) For <code>VSPPlot</code> and <code>VSPBinPlot</code> , the type of plot to generate. For <code>VSPPlot</code> , 1 a conventional scatter plot; or 2 a box-and-whisker plot. For <code>VSPBinPlot</code> , 1 a bar plot; or 2 a box-and-whisker plot.
<code>stat</code>	(Function) For <code>VSPBinPlot</code> , the statistic to use when calculating bar scales for <code>plot.type</code> 1. By default this is <code>mean</code> if <code>em</code> is supplied or <code>count</code> if not. NOTE: <code>stat</code> is ignore when <code>plot.type</code> is used

**Details**

`calcVSP...` functions calculate VSP:

`calcVSP` is a wrapper function which allows users to supply different combinations of inputs. VSP calculations typically require speed, acceleration and slope inputs. However, This wrapper allows different input combinations, e.g.:

time and distance (time and distance -> speed, time and speed -> accel)

time and speed (time and speed -> accel)

speed and accel

This then passes on `speed, accel` and (if supplied) `slope` to the method defined by `calc.method`. (This means other VSP functions run via `calcVSP(..., calc.method = function)` share this option without needed dedicated code.)

`calcVSP_JimenezPalacios` calculates VSP according to Jimenez Palacios methods. See References and Note below.

`refVSPBin...` functions generate a reference list of VSP bins:

`refVSPBin` is a wrapper that generates VSP Mode bins depending on method applied.

`binVSP_NCSU`. 14 bins supplied `vsp` using the 14 bin method described in Frey et al 2002.

`binVSP_MOVES`. 23 bins supplied vsp using that and speed and the 23 bin MOVES method (See Note).

`VSPPlot` generates various plots of VSP (x-axis) and emission (y-axis) data.

`VSPBinPlot` generates various plots of VSP binned data.

### Value

`calcVSP` by default uses the Jimenez Palacios method to calculate VSP in kW/metric ton.

`refVSPBin` generates a `pems.element` factor vector of VSP Mode bin assignments.

`VSPPlot` and `VSPBinPlot` generate plots as lattice objects.

### Note

`calcVSP...` constants can be set/modified in the calculation call, e.g. `calcVSP(..., vsp.a = [new.value])`. If not supplied, defaults are used. (See References.)

`binVSP_MOVES`. 23 is in-development. Do not use without independent confirmation of values.

Unit handling in `pems.utils` is via [checkUnits](#), [getUnits](#), [setUnits](#) and [convertUnits](#). See [common.calculations](#) for details.

### Author(s)

Karl Ropkins

### References

`calcVSP_JimenezPalacios` uses methods described in:

Jimenez-Palacios, J.L. (1999) Understanding and Quantifying Motor Vehicle Emissions with Vehicle Specific Power and TILDAS Remote Sensing. PhD Thesis, Massachusetts Institute of Technology, Cambridge, MA.

`vehicle.weight` is the vehicle mass (in metric tons), and `vsp.a`, `vsp.b`, `vsp.c` and `vsp.g` are the calculations constants for:

$$\text{vsp} = \text{speed} * (\text{a} * \text{accel} + (\text{g} * \text{slope}) + \text{b}) + (\text{c} * \text{speed}^3)$$

By default: `a = 1.1`, `b = 0.132`, `c = 0.000302` and `g = 0.132` (as of Jimenez-Palacios, 1999).

Method ONLY INTENDED FOR vehicles < 3.855 metric tons.

`refVSPBin_NCSU`. 14 VSP binning as described in:

Frey, H.C., Unal, A., Chen, J., Li, S. and Xuan, C., 2002. Methodology for developing modal emission rates for EPA's multi-scale motor vehicle & equipment emission system. Ann Arbor, Michigan: US Environmental Protection Agency. (EPA420-R-02-027)

### See Also

See [common.calculations](#) (and [checkUnits](#) and [convertUnits](#)) for details of data management.

**Examples**

```
#####
##example 1
#####

#basic usage

vsp <- calcVSP(velocity, time = local.time, data = pems.1)
#where the returned object, vsp, is vsp values as pems.element

ncsu.14 <- refVSPBin(vsp)
#where the returned object, ncsu.14, is the associated modal bin
# assignments based on the Frey et al (2002) 14 bin method.
```

---

7.2.emissions.calculations

*Emission calculations*


---

**Description**

Functions associated with emissions calculations.

**Usage**

```
calcEm(conc = NULL, calc.method = calcEm_HoribaPitot,
        analyte = NULL, ..., data = NULL, fun.name = "calcEm",
        force = FALSE, this.call = NULL)

calcEm_HoribaPitot(conc = NULL, time = local.time, exflow = exh.flow.rate,
                   extemp = exh.temp, express = exh.press, analyte = NULL,
                   delay = NULL, mm = NULL, ..., force = force, data = NULL,
                   fun.name = "calcEm_HoribaPitot", this.call = NULL)
```

**Arguments**

conc	(Data series, typically pems.element vector) Analyte/species concentrations, the main input for calculating emissions. If conc is a concentration data series from a standard pems source it should be named conc.[analyte] and pems.utils will manage it accordingly. See below for further details.
time, exflow, extemp, express	(Data series, typically pems.element vectors) Other inputs used when calculating emissions. The combination depending on the calculation method used (and set by calc.method).
calc.method	(Required function) The function to use to calculate emissions. (Default calcEm_HoribaPitot). See below for further details.

analyte	(Optional character vector) The analyte emissions are to be calculated for. If supplied, this is used as a reference when assigning molecule weight and other analyte properties if these are not provided as part of calculate call. If not supplied, <code>pems.utils</code> attempts to recover these from available sources, e.g. <code>data</code> if supplied as part of the calculation call or package references such as <a href="#">ref.chem</a> .
...	(Optional) Other arguments, currently passed on to function provided as <code>calc.method</code> (default <code>calcEm_HoribaPitot</code> ) and appropriate <code>pems.utils</code> functions.
data	(Optional <code>pems</code> object) The data source for inputs.
<code>fun.name</code> , <code>this.call</code> , <code>force</code>	(Various <code>pems</code> management functions) <code>fun.name</code> (character vector) the name of the parent function, to be used in error messaging. <code>this.call</code> the initial call (can generally be ignored). <code>force</code> (Logical) Should <code>calcEm</code> and <code>calc.method</code> ignore any error checking, e.g. units assignments, and do calculations anyway?
delay, mm	(Optional numerics) Emissions calculation constants. <code>delay</code> is the time delay between conc measurements and other timeseries. <code>mm</code> is the molecular mass of the analyte. If supplied, these in-call values supercede any preset in e.g. package look-up tables.

### Details

`calcEm...` functions calculate emissions.

`calcEm` is a wrapper function which is intended to provide a convenient front for emissions calculation methods. It accepts an input `conc` which it checks and passes on to `calc.method`, along with other supplied arguments.

`calcEm_HoribaPitot` calculates emissions using methods described in the Horiba OBS Operators Manual. In addition to `conc`, the function requires the time, and exhaust flow data series (measured by the OBS Pitot flow meter). By default, the function assumes that these are default names that are generated for these when standard OBS files are imported into R using the `pems.utils` import function [importOBS2PEMS](#). See References and Note below.

### Value

`calcEm_HoribaPitot` (and `calcEm` by default) use Horiba Manual methods to calculate emissions (in g/s).

### Note

`calcEm...` constants can be set/modified in the calculation call, e.g. `calcEm(..., delay = [new.value])`. If not supplied, these are first checked for in the associated `pems` object (if supplied), or set to default values. See References. If analyte-related constants are to be added to a `pems` object, these should be named in the format `'[type].[analyte]'`, e.g. `delay.co` for the `delay` constant to be used for the analyte CO.

Unit handling in `pems.utils` is via [checkUnits](#), [getUnits](#), [setUnits](#) and [convertUnits](#). See [common.calculations](#) for details.

### Author(s)

Karl Ropkins

**References**

calcEm\_HoribaPitot uses methods described in:  
The Horiba Operators Manual.

**See Also**

See [common.calculations](#).

**Examples**

```
#####
##example 1
#####

#basic usage

em.co <- calcEm(conc.co, data = pems.1)

#where the returned object, em.co, is a pems.element
```

---

7.3.coldstart.code      *Cold Start Emissions related code*

---

**Description**

Functions associated with Cold Start Emissions calculations.

**Usage**

```
#calculations

fitColdStart(em, time, engine.on = NULL,
              data = NULL, method = 2, ...,
              fun.name="fitColdStart")

#Cold Start Plots

coldStartPlot(time, em = NULL,
              ..., data = NULL, engine.on = NULL,
              plot.type = 1, method = 2,
              fun.name="coldStartPlot")

panel.coldStartPlot1(..., loa.settings = FALSE)
panel.coldStartPlot2(..., loa.settings = FALSE)
```

**Arguments**

<code>em, time</code>	(Typically <code>pems.element</code> vectors) <code>em</code> is the emissions data-series that the cold start contribution should be estimated for; <code>time</code> is the associated time-series, typically a local time measurement in seconds.
<code>engine.on</code>	(Optimal, single Numeric) The time the emission source, e.g. monitored vehicle engine, was started. If not supplied, this is assumed to be start of the supplied <code>em</code> and <code>time</code> data-series. See also Notes.
<code>data</code>	(Optional, typically <code>pems</code> ) The data source for <code>em</code> and <code>time</code> .
<code>method</code>	(Optimal, Numeric) The method to use when fitting and calculating the cold start contribution: method 1 Single break point fit of accumulated emissions; method 2 modified break-point. If not supplied, method 2 is used by default. See also Notes and References.
<code>...</code>	(Optional) Other arguments, currently passed on as supplied to associated calculation or plotting function, or passed back to <code>pemsPlot</code> .
<code>fun.name</code>	(Optional character) The name of the parent function, to be used in error messaging.
<code>plot.type</code>	(Optional numeric) For <code>coldStartPlot</code> , the type of cold start plot to generate: 1 a conventional accumulation profile; or 2 an emission time-series. If not supplied, plot type 1 is selected by default.
<code>loa.settings</code>	(Logical) For <code>coldStartPlot</code> panel functions, a <code>loa</code> plot argument that can typically be ignored by plot users.

**Details**

`fitColdStart` fits a cold start model to the supplied emissions and time-series data.

`coldStartPlot` generates a plot of the cold start model.

`panel.coldStartPlot1` and `panel.coldStartPlot2` are plot panels used by `coldStartPlot` when generating `plot.types` 1 and 2, respectively.

**Value**

`fitColdStart` generates a cold start contribution report as a `pems` dataset.

`coldStartPlot` generates a cold start contribution report as a `lattice` plot.

**Note**

Regarding `engine.on`: This is specifically the time the engine is turned on rather than the row of data set where this happens. In some cases, they are same, e.g. when the data is logged at a regular 1-Hz and data capture is complete.

Regarding `method`: Method 1 (break-point) and method 2 (modified break-point) are based on the identification of a change point in the accumulated emissions profile.

[Doc further]

(See References.)

**Author(s)**

Karl Ropkins

**References**

fitColdStart uses methods described in:

[Heeb]

[Ropkins cold start]

**See Also**See [common.calculations](#) (and [checkUnits](#) and [convertUnits](#)) for details of data management.**Examples**

```
#####
##example 1
#####

#basic usage

#to do/maybe not run... time to compile...
```

---

7.4.speed.em.code      *Speed Emissions related code*

---

**Description**

Functions associated with Speed/Emissions terms.

**Usage**

```
#calculations

fitSpeedEm(em, time, speed, engine.on = NULL,
           data = NULL, method = 1, min.speed = 5,
           bin.size = NULL, ...,
           fun.name="fitEmSpeed")

#speed/emissions Plots

speedEmPlot(speed, em = NULL, time = NULL,
            ..., data = NULL, engine.on = NULL,
            min.speed = 5, bin.size = NULL,
            plot.type = 1, method = 1,
            fun.name="speedEmPlot")
```

**Arguments**

<code>em, time, speed</code>	(Typically <code>pems.element</code> vectors) <code>em</code> is the (g/s) emissions data-series; <code>speed</code> and <code>time</code> are the associated speed profile and time-series.
<code>engine.on</code>	(Optimal, single Numeric) The time the emission source, e.g. monitored vehicle engine, was started. If not supplied, this is assumed to be start of the supplied <code>em</code> and <code>time</code> data-series. See also Notes.
<code>data</code>	(Optional, typically <code>pems</code> ) The data source for <code>em</code> , <code>speed</code> and <code>time</code> .
<code>method</code>	(Optimal, Numeric) The method to use when calculating and binning data: <code>method 1</code> calculate g/km emissions and bin by row. See also <code>bin.size</code> , Notes and References.
<code>min.speed</code>	(Optimal, Numeric) measurements when speeds were less than this value are excluded, default value 5. See also Notes.
<code>bin.size</code>	(Optimal, Numeric) The data binning scale to use. For <code>method 1</code> , this is the number of rows of measurements to merge.
<code>...</code>	(Optional) Other arguments, currently passed on as supplied to associated calculation or plotting function, or back to <code>pemsPlot</code> .
<code>fun.name</code>	(Optional character) The name of the parent function, to be used in error messaging.
<code>plot.type</code>	(Optional numeric) For <code>speedEmPlot</code> , the type of speed/emission plot to generate: <code>1</code> a conventional scatter plot; or <code>2</code> a box-and-whisker plot. If not supplied, plot type <code>1</code> is selected by default.

**Details**

`fitSpeedEm` builds a speed and g/km emissions data sets for the supplied emissions, speed and time-series data.

`speedEmPlot` generates a plot of one or more data set generated by `fitSpeedEm`.

**Value**

`fitSpeedEm` generates a speed/emissions contribution report as a `pems` dataset.

`speedEmPlot` generates a speed/emissions contribution report as a `lattice` plot.

**Note**

Regarding `engine.on`: This is specifically the time the engine is turned on rather than the row of data set where this happens. In some cases, they are same, e.g. when the data is logged at a regular 1-Hz and data capture is complete.

Regarding `method`: Method 1 [Doc further].

[Doc further]

(See References.)

**Author(s)**

Karl Ropkins

## References

fitColdStart uses methods described in:

[COPERT on speed/emission terms]

[Ropkins speed/emissions]

## See Also

See [common.calculations](#) (and [checkUnits](#) and [convertUnits](#)) for details of data management.

## Examples

```
#####  
##example 1  
#####  
  
#basic usage  
  
#to do/maybe not run... time to compile...
```

---

8.1.example.data

*example data for use with pems.utils*

---

## Description

Example data intended for use with functions in `pems.utils`.

## Usage

```
pems.1
```

## Format

`pems.1` is a example pems object.

## Details

`pems.1` is supplied as part of the `pems.utils` package.

## Note

None at present

## Source

Reference in preparation

**References**

None at present

**See Also**

See examples in [pems.structure](#).

---

8.2.look-up.tables      *reference data for use with pems.utils*

---

**Description**

Various reference and example datasets intended for use with functions in `pems.utils`.

**Usage**

`ref.unit.conversions`

`ref.chem`

`ref.petrol`

`ref.diesel`

`pems.scheme`

**Format**

`ref.unit.conversions`: Unit conversion methods stored as a list of lists. See Details.

`ref.chem`, `ref.petrol`, `ref.diesel`: Common chemical and fuel constants stored as lists.

`pems.scheme`: Default scheme for `pems.utils` plots.

**Details**

`unit.conversions` is basically a 'look-up' for unit conversion methods. Each element of the list is another list. These lists are each individual conversion methods comprising four elements: `to` and `from`, character vectors given the unit ids and alias of the unit types that can be converted using the method; `conversion`, a function for the associated conversion method; and (possibly) `tag`, a more detailed description of the conversion intended for use in documentation.

Other `ref...` are sets of constants or reference information stored as lists. `ref.chem` contains atomic weights of some elements and molecular weights of some species. `ref.petrol` and `ref.diesel` contain default properties for typical fuels.

**Note**

`ref.unit.conversions` can be updated locally. See [convertUnits](#), [addUnitConversion](#), etc.

## Examples

```
#basic structure  
ref.unit.conversions[[1]]
```

---

### 9.1.pems.tidyverse.tools

*Functions to use tidyverse code with pems.utils outputs*

---

## Description

Various codes and methods.

## Usage

```
#ggplot2  
  
## S3 method for class 'pems'  
fortify(model, data, ...)  
  
#dplyr (1) standard methods  
  
## S3 method for class 'pems'  
filter(.data, ...)  
## S3 method for class 'pems'  
arrange(.data, ...)  
## S3 method for class 'pems'  
slice(.data, ...)  
## S3 method for class 'pems'  
mutate(.data, ..., units=NULL, warn=TRUE)  
## S3 method for class 'pems'  
group_by(.data, ..., .add=FALSE)  
## S3 method for class 'pems'  
groups(x)  
## S3 method for class 'pems'  
ungroup(x, ...)  
## S3 method for class 'pems'  
group_size(x)  
## S3 method for class 'pems'  
n_groups(x)  
## S3 method for class 'pems'  
pull(.data, ...)  
  
#dplyr (2) related underscore methods  
  
## S3 method for class 'pems'  
filter_(.data, ..., warn=TRUE)
```

```

## S3 method for class 'pems'
arrange_(.data, ..., warn=TRUE)
## S3 method for class 'pems'
slice_(.data, ..., warn=TRUE)
## S3 method for class 'pems'
mutate_(.data, ..., units=NULL, warn=TRUE)
## S3 method for class 'pems'
group_by_(.data, ..., .add=FALSE, warn=TRUE)

#dplyr (3) joining methods
## S3 method for class 'pems'
inner_join(x, y, by = NULL, copy = FALSE, ...)
## S3 method for class 'pems'
left_join(x, y, by = NULL, copy = FALSE, ...)
## S3 method for class 'pems'
right_join(x, y, by = NULL, copy = FALSE, ...)
## S3 method for class 'pems'
full_join(x, y, by = NULL, copy = FALSE, ...)
## S3 method for class 'pems'
semi_join(x, y, by = NULL, copy = FALSE, ...)
## S3 method for class 'pems'
anti_join(x, y, by = NULL, copy = FALSE, ...)

```

## Arguments

model, data	(pems.object) In fortify, the pems object to be used as a data source when plotting using ggplot2 code. The method is routinely applied by ggplot2, so users can typically ignore this. See below.
...	(Optional) Other arguments, typically passed on to equivalent tidyverse function or method.
.data	(pems.object) For dplyr functions, the pems object to be used with, e.g. dplyr code.
warn	(Optional) Give warnings? For an underscore methods: a warning that an underscore method was used (See Below). For mutate: if new elements are generated without unit assignments.
units	(Character) In mutate, the units to assign to new elements created by call. See Below.
x, y	(Various) For group... functions, x is the pems dataset to be grouped. For ...join functions, x and y are the two datasets (pems, data.frame, etc) to be joined together.
.add	(Optional) Argument used by group_by and related dplyr grouping functions.
by, copy	(Various) For ...join functions, consistent with dplyr, by and copy are optional arguments. See Below.

**Details**

`fortify` is used by `ggplot2` functions when these are used to plot data in a `pems` dataset. Most users will never have to use this directly.

The `pems` object methods `select`, `filter`, `arrange`, `slice`, `mutate`, and `group_by` are similar to `data.frame` methods of the same names in `dplyr`, but (hopefully) they also track units, etc, like a `pems` object. Work in progress. See below, especially Note.

Equivalent underscore methods (`select_`, etc) are also provided, although it should be noted that they are probably going when `dplyr` drops these.

Data joining methods include `inner_join`, `left_join`, `right_join`, `full_join`, `semi_join` and `anti_join`. Like above these are similar `data.frame` equivalents in `dplyr`, but (hopefully) also track units, etc, like a `pems` object. Same 'work in progress' caveat. See Note.

**Value**

`filter` returns the supplied `pems` object after the requested filter operation has been applied, e.g.: `filter(pems.1, velocity>0.5)` returns `pems.1` after excluding all rows where the velocity value was less than or equal to 0.5.

`arrange` returns the supplied `pems` object reordered based on order of values in an identified element, e.g.: `arrange(pems.1, velocity)` returns `pems.1` with its row reordered lowest to highest velocity entry.

`slice` returns requested rows of the supplied `pems` object, e.g.: `slice(pems.1, 1:10)` returns rows 1 to 10 of `pems.1` as a new `pems` object.

`mutate` returns the supplied `pems` object with extra elements calculated as requested, e.g.: `mutate(pems.1, new=velocity*2)` returns the `pems` object with additional column, called `new`, which is twice the values in the velocity column. The units of the new column can be set using the additional argument `units`, e.g. `mutate(pems.1, new=velocity*2, units="ick")`.

`group_by` returns a `grouped_df` object, which allowed by-group handling in subsequent `dplyr` code.

The `..._join` joining methods, join two supplied datasets. The first, `x`, must be a `pems` to employ `..._join.pems` but the second, `y` can be e.g. a `data.frame`, etc.

**Warning**

Currently removing `select`, `rename` and `summarise` while deciding how to respond to changes to tidyverse code...

**Note**

Currently not sure what I think about tidyverse, but it is always interesting, and ideas like `fortify` are nice.

The `fortify` method was developed by Hadley Wickham to simplify the integration of `ggplot2` functions and special object classes.

It is a really nice idea for multiple reasons, the main one being that package users will probably never have to worry about it. However, packaging it means you can use a `pems` object directly as the data argument with `ggplot2` code.

**Author(s)**

Karl Ropkins

**References**

Generics in general:

H. Wickham. *Advanced R*. CRC Press, 2014.

(Not yet fully implemented within this package.)

ggplot2:

H. Wickham. *ggplot2: elegant graphics for data analysis*. Springer New York, 2009.

(See Chapter 9, section 9.3, pages 169-175, for discussion of fortify)

dplyr:

Hadley Wickham, Romain Francois, Lionel Henry and Kirill Muller (2020). *dplyr: A Grammar of Data Manipulation*. R package version 1.0.2. <https://CRAN.R-project.org/package=dplyr>

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