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**TRABAJO FIN DE GRADO**

**TÍTULO DEL TRABAJO**

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# Agradecimientos

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# Resumen

Este proyecto se resume en .....

**Palabras clave:** geometría solar, radiación solar, energía solar, fotovoltaica, métodos de visualización, series temporales, datos espacio-temporales, S4



# Abstract

In this project.....

**Keywords:** solar geometry, solar radiation, solar energy, photovoltaic, visualitation methods, temporal series, space-time data, S4

# Índice general

<b>Agradecimientos</b>	<b>VII</b>
<b>Resumen</b>	<b>IX</b>
<b>Abstract</b>	<b>XI</b>
<b>Índice general</b>	<b>XII</b>
<b>Índice de figuras</b>	<b>XIII</b>
<b>Índice de tablas</b>	<b>XIV</b>
<b>1 Introducción</b>	<b>1</b>
1.1. Objetivos . . . . .	1
1.2. Análisis previo de soluciones . . . . .	2
1.3. Aspectos técnicos . . . . .	3
<b>2 Estado del arte</b>	<b>5</b>
2.1. Situación actual de la generación fotovoltaica . . . . .	5
2.2. Soluciones existentes y sus carencias . . . . .	6
<b>3 Parte teórica y desarrollo del código</b>	<b>7</b>
<b>4 Ejemplo práctico de aplicación</b>	<b>9</b>
4.1. solaR2 . . . . .	9
4.2. solaR . . . . .	9
4.3. PVsyst . . . . .	9
4.4. Comparación entre los tres . . . . .	9
<b>5 Detalles de la programación</b>	<b>11</b>
<b>A Código completo</b>	<b>13</b>
A.1. Constructores . . . . .	13
A.2. Clases . . . . .	37
A.3. Funciones . . . . .	39
A.4. Métodos . . . . .	64
A.5. Conjunto de datos . . . . .	85
<b>Bibliografía</b>	<b>87</b>

# Índice de figuras

# Índice de tablas

# Introducción

## 1.1. Objetivos

El objetivo principal de este proyecto es el desarrollo de un paquete en R[R C23] con el cual poder realizar estimaciones y representaciones gráficas de la posible generación de una instalación fotovoltaica.

Durante el resto del documento, si fuera necesario, se hará referencia al paquete desarrollado en este proyecto con el nombre `solar2` [CITAR SOLAR2].

El usuario podrá colocar los datos que considere convenientes (desde una base de datos oficial, una base de datos propia. . . etc.) en cada una de las funciones que ofrece el paquete pudiendo así obtener resultados de la geometría solar, de la radiación horizontal, de la eficaz y hasta de la producción de diferentes tipos de sistemas fotovoltaicos.

El paquete también incluye una serie de funciones que permiten hacer representaciones gráficas de estas producciones con el fin de poder apreciar con más detalle las diferencias entre sistemas y contemplar cual es la mejor opción para el emplazamiento elegido.

Este proyecto toma su origen en el paquete ya existente `solar`[Per12] el cual desarrolló el tutor de este proyecto en 2012. Por la antigüedad del código se propuso la idea de renovarlo teniendo en cuenta el paquete en el que basa su funcionamiento. El paquete `solar` basó su funcionamiento en el paquete `zoo`[ZG05] el cual proporciona una sólida base para trabajar con series temporales. Sin embargo, como base de `solar2` se optó por el paquete `data.table`[Bar+24]. Este paquete ofrece una extensión de los clásicos `data.frame` de R en los `data.table`, los cuales pueden trabajar rápidamente con enormes cantidades de datos (por ejemplo, 100 GB de RAM).

La clave de ambos proyectos es que al estar alojados en R, cualquier usuario puede acceder a ellos de forma gratuita, tan solo necesitas tener instalado R en tu dispositivo.

Para alojar este proyecto se toman dos vías:

- Github[Wan+23]: Donde se aloja la versión de desarrollo del paquete.
- CRAN: Acrónimo de Comprehensive R Archive Network, es el repositorio donde se alojan las versiones definitivas de los paquetes y desde el cual se descargan a la sesión de R.

El paquete `solar2` permite realizar las siguientes operaciones:

- Cálculo de toda la geometría que caracteriza a la radiación procedente del Sol [CITAR CÓDIGO]

- Tratamiento de datos meteorológicos (en especial de radiación), procedentes de datos ofrecidos del usuario y de la red de estaciones SIAR [Min23] [CITAR CÓDIGO]
- Una vez calculado lo anterior, se pueden hacer estimaciones de:
  - Los componentes de radiación horizontal [CITAR CALCG0].
  - Los componentes de radiación eficaz en el plano inclinado [CITAR CALCGEF].
  - La producción de sistemas fotovoltaicos conectados a red [CITAR PRODGCPV] y sistemas fotovoltaicos de bombeo [CITAR PRODPVPS].

Este proyecto ha tenido a su vez una serie de objetivos secundarios:

- Uso y manejo de GNU Emacs [Sta85] en el que se realizaron todos los archivos que componen este documento (utilizando el modo Org [Dom+03]) y el paquete descrito (empleando ESS [Pro24])
- Dominio de diferentes paquetes de R:
  - `zoo`[ZG05]: Paquete que proporciona un conjunto de clases y métodos en S3 para trabajar con series temporales regulares e irregulares. Usado en el paquete `solaR` como pilar central.
  - `data.table`[Bar+24]: Otorga una extensión a los datos de tipo `data.frame` que permite una alta eficiencia especialmente con conjuntos de datos muy grandes. Se ha utilizado en el paquete `solaR2` en sustitución del paquete `zoo` como tipo de dato principal en el cual se construyen las clases y métodos de este paquete.
  - `microbenchmark`[Mer+23]: Proporciona infraestructura para medir y comparar con precisión el tiempo de ejecución de expresiones en R. Usado para comparar los tiempos de ejecución de ambos paquetes.
  - `profvis`[Wic+24]: Crea una interfaz gráfica donde explorar los datos de rendimiento de una expresión dada. Aplicada junto con `microbenchmark` para detectar y corregir cuellos de botella en el paquete `solaR2`
  - `lattice`[Sar08]: Proporciona diversas funciones con las que representar datos. El paquete `solaR2` utiliza este paquete para representar de forma visual los datos obtenidos en las estimaciones.
- Junto con el modo Org, se ha utilizado el preprocesador de textos  $\text{\LaTeX}$  (partiendo de un archivo `.org`, se puede exportar a un archivo `.tex` para posteriormente exportar un pdf).
- Obtener conocimientos teóricos acerca de la radiación solar y de la producción de energía solar mediante sistemas fotovoltaicos y sus diversos tipos. Para ello se ha usado en mayor medida el libro “Energía Solar Fotovoltaica” [Per23].

## 1.2. Análisis previo de soluciones

Este proyecto, como ya se ha comentado, es el heredero del paquete `solaR` desarrollado por Oscar Perpiñán. La filosofía de ambos paquetes es la misma y los resultados que dan son muy similares. Sin embargo, lo que les diferencia es el paquete sobre el que construyen sus datos. Mientras que `solaR` basa sus clases y métodos en el paquete `zoo`, `solaR2` en el paquete `data.table`. Los dos paquetes pueden trabajar con series temporales, pero, mientras que `zoo` es más eficaz trabajando con series temporales, `data.table` es más



eficiente a la hora de trabajar con una cantidad grande de datos, lo cual a la hora de realizar estimaciones muy precisas es beneficioso. Por otro lado, existen otras soluciones fuera de R:

1. **PVsyst - Photovoltaic Software**

Este software es probablemente el más conocido dentro del ámbito del estudio y la estimación de instalaciones fotovoltaicas. Permite una gran personalización de todos los componentes de la instalación.

2. **SISIFO**

Herramienta web diseñada por el **Grupo de Sistemas Fotovoltaicos del Instituto de Energía Solar de la Universidad Politécnica de Madrid**.

3. **PVGIS**

Aplicación web desarrollada por el **European Commission Joint Research Center** desde 2001.

4. **System Advisor Model**

Desarrollado por el **Laboratorio Nacional de Energías Renovables**, perteneciente al Departamento de energía del gobierno de EE.UU.

En el apartado [ref:sec:ejemplos] se realizará un ejemplo práctico que compare los resultados entre **PVsyst**, **solaR** y **solaR2**

### 1.3. Aspectos técnicos

Para elaborar un paquete en R se deben aportar una serie de ficheros:

- **R**: Fichero que contiene todos los archivos .R que se van a ejecutar en la instalación del paquete. Esto incluye funciones, clases y métodos.
- **data**: Aquí se incluyen los datos externos que el paquete necesita para funcionar.
- **DESCRIPTION**: Contiene metadatos sobre el paquete, como el nombre, la versión, el autor, etc.
- **NAMESPACE**: Especifica qué funciones y datos se exportan y se importan.
- **inst**: Se usa para almacenar archivos importantes pero que no se almacenan en el resto de ficheros.
- **tests**: Se utiliza para almacenar scripts de pruebas que aseguran que el código del paquete funcione correctamente.
- **man**: Donde se alojan los ficheros .Rd relacionados con el manual de uso del paquete. En estos se almacenan la información de funciones, métodos, clases y datos.

Una vez se tienen todos estos ficheros, el paquete se construye y se prueba.



## Estado del arte

### 2.1. Situación actual de la generación fotovoltaica

Según el informe anual de 2023 de la UNEF<sup>1</sup>[UNE23] en 2022 la fotovoltaica se posicionó como la tecnología con más crecimiento a nivel internacional, tanto entre las renovables como entre las no renovables. Se instalaron 240 GWp de nueva capacidad fotovoltaica a nivel mundial, suponiendo esto un incremento del 137 % con respecto a 2021.

A pesar de las diversas crisis internacionales, la energía solar fotovoltaica alcanzó a superar los 1185 GWp instalados. Como otros años, las cifras indican que China continuó siendo el primer actor mundial, superando los 106 GWp de potencia instalada en el año. La Unión Europea se situó en el segundo puesto, duplicando la potencia instalada en 2021, y alcanzando un nuevo record con 41 GWp instalados en 2022.

La producción energía fotovoltaica a nivel mundial representó el 31 % de la capacidad de generación renovable, convirtiéndose así en la segunda fuente de generación, solo por detrás de la energía hidráulica. En 2022 se añadió 3 veces más de energía solar que de energía eólica en todo el mundo.

Por otro lado, la Unión Europea superó a EE.UU. como el segundo mayor actor mundial en desarrollo fotovoltaico, instalando un 47 % más que en 2021 y alcanzando una potencia acumulada de más de 208 GWp. España lideró el mercado europeo con 8,6 GWp instalados en 2022, superando a Alemania.

El año 2022 fue significativo en términos legislativos con el lanzamiento del Plan REPowerEU<sup>2</sup>[Eur22]. Dentro de este plan, se lanzó la Estrategia de Energía Solar con el objetivo de alcanzar 400 GWp (320 GW) para 2030, incluyendo medidas para desarrollar tejados solares, impulsar la industria fotovoltaica y apoyar la formación de profesionales en el sector.

En 2022, España vivió un auge en el desarrollo fotovoltaico, instalando 5.641 MWp en plantas en suelo, un 30 % más que en 2021, y aumentando el autoconsumo en un 108 %, alcanzando 3.008 MWp. El sector industrial de autoconsumo creció notablemente, representando el 47 % del autoconsumo total.

España implementó varias iniciativas legislativas para enfrentar la volatilidad de precios de la energía y la dependencia del gas, destacando el RD-ley 6/2022[BOE22b] y el RD 10/2022[BOE22a], que han modificado mecanismos de precios y estableciendo límites al precio del gas.

---

<sup>1</sup>UNEF: Unión Española Fotovoltaica.

<sup>2</sup>Plan REPowerEU: Proyecto por el cual la Unión Europea quiere poner fin a su dependencia de los combustibles fósiles rusos ahorrando energía, diversificando los suministros y acelerando la transición hacia una energía limpia.

El Plan SE+<sup>3</sup>[dem22] incluye medidas fiscales y administrativas para apoyar las renovables y el autoconsumo. En 2022, se realizaron subastas de energía renovable, asignando 140 MW a solar fotovoltaica en la tercera subasta y 1.800MW en la cuarta, aunque esta última quedó desierta por precios de reserva bajos.

Se adjudicaron 1.200 MW del nudo de transición justa de Andorra a Enel Green Power España, con planes para instalar plantas de hidrógeno verde y agrovoltaica. la actividad en hidrógeno verde y almacenamiento también creció, con fondos adicionales y exenciones de cargos.

El autoconsumo, apoyado por diversas regulaciones y altos precios de la electricidad, registró un crecimiento significativo, alcanzado 2.504 MW de nueva potencia en 2022. Las comunidades energéticas también avanzaron gracias a ayudas específicas, a pesar de la falta de un marco regulatorio definido.

2022 estuvo marcado por los programas financiados por la Unión Europea, especialmente el Mecanismo de Recuperación y Resiliencia[Hac22] que canaliza los fondos Next-GenerationEU[Uni20]. El PERTE<sup>4</sup>, aprobado en diciembre de 2021, espera crear más de 280.000 empleos, con ayudas que se ejecutarán hasta 2026. En 2023 se solicitó a Bruselas una adenda para segunda fase del PERTE, obteniendo 2.700 millones de euros adicionales.

La contribución del sector fotovoltaico a la economía española en 2022 fue significativa, aportando 7.014 millones de euros al PIB<sup>5</sup>, un 51 % más que el año anterior, y generando una huella económica total de 15.656 millones de euros. En términos de empleo, el sector involucró a 197.383 trabajadores, de los cuales 40.683 fueron directos, 97.600 indirectos y 59.100 inducidos.

El sector industrial fotovoltaico nacional tiene una fuerte presencia en España, con hasta un 65 % de los componentes manufacturados localmente. Empresas españolas se encuentran entre los principales fabricantes mundiales de inversores y seguidores solares. Además, España es un importante exportador de estructuras fotovoltaicas y cuenta con iniciativas prometedoras para la fabricación de módulos solares.

UNEF promueve la transformación industrial para que España se convierta en un hub industrial fotovoltaico. Se destaca la necesidad de proteger la industria existente, garantizar un crecimiento constante de la capacidad y ofrecer condiciones de financiamiento favorables. Además se propone implementar una Estrategia Industrial Fotovoltaica para contribuir significativamente a la reindustrialización de la economía, aprovechando las medidas del REPower Plan, la Estrategia Solar y la Alianza de la Industria Solar Fotovoltaica.

En definitiva, la fotovoltaica es una tecnología en auge y con perspectivas para ser el pilar de la transición ecológica. Por ello, surge la necesidad de encontrar herramientas que permitan estimar el desempeño que estos sistemas pueden tener a la hora de realizar estudios de viabilidad económica.

## 2.2. Soluciones existentes y sus carencias

---

<sup>3</sup>Plan + Seguridad Energética: Se trata de un plan con medidas de rápido impacto dirigidas al invierno 2022/2023, junto con medidas que contribuyen a un refuerzo estructural de esa seguridad energética.

<sup>4</sup>PERTE: Proyecto Estratégico para la Recuperación y Transformación Económica.

<sup>5</sup>PIB: Producto Interior Bruto.

# Parte teórica y desarrollo del código

...



# Ejemplo práctico de aplicación

Como demostración se va a realizar un caso práctico...

## 4.1. solaR2

...

## 4.2. solaR

...

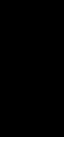
## 4.3. PVsyst

...

## 4.4. Comparación entre los tres







## Detalles de la programación

...



## Código completo

Todo el código que se muestra a continuación está disponible...

### A.1. Constructores

#### calcSol

```

1 calcSol <- function(lat, BTd,
2                     sample = 'hour', BTi,
3                     EoT = TRUE,
4                     keep.night = TRUE,
5                     method = 'michalsky')
6 {
7   if(missing(BTd)) BTd <- truncDay(BTi)
8   sold <- fSold(lat, BTd, method = method) #daily values
9   soli <- fSoli(sold = sold, sample = sample, #intradaily values
10              BTi = BTi, keep.night = keep.night,
11              EoT = EoT, method = method)
12
13   if(!missing(BTi)){
14     sample <- soli$Dates[2]-soli$Dates[1]
15     sample <- format(sample)
16   }
17
18   sold[, lat := NULL]
19   soli[, lat := NULL]
20   result <- new('Sol',
21               lat = lat,
22               sold = sold,
23               soli = soli,
24               sample = sample,
25               method = method)
26   return(result)
27 }
```

#### calcG0

```

1 calcG0 <- function(lat,
```

```

2         modeRad='prom',
3         dataRad,
4         sample='hour',
5         keep.night=TRUE,
6         sunGeometry='michalsky',
7         corr, f, ...)
8     {
9
10        if (missing(lat)) stop('lat missing. You must provide a latitude value.')
11
12        stopifnot(modeRad %in% c('prom', 'aguilar', 'bd', 'bdI'))
13
14
15    ###Datos de Radiacion
16    if (missing(corr)){
17        corr = switch(modeRad,
18            bd = 'CPR', #Correlation between Fd and Kt for daily values
19            aguilar = 'CPR', #Correlation between Fd and Kt for daily
20            values
21            prom = 'Page', #Correlation between Fd and Kt for monthly
22            averages
23            bdI = 'BRL' #Correlation between fd and kt for intraday
24            values
25        )
26    }
27
28    if(is(dataRad, 'Meteo')){BD <- dataRad}
29    else{
30        BD <- switch(modeRad,
31            bd = {
32                if (!is.list(dataRad)) dataRad <- list(file=dataRad)
33                switch(class(dataRad$file)[1],
34                    character={
35                        bd.default=list(file='', lat=lat)
36                        bd=modifyList(bd.default, dataRad)
37                        res <- do.call('readBDd', bd)
38                        res
39                    },
40                    data.table= ,
41                    data.frame={
42                        bd.default=list(file='', lat=lat)
43                        bd=modifyList(bd.default, dataRad)
44                        res <- do.call('dt2Meteo', bd)
45                        res
46                    },
47                    zoo={
48                        bd.default=list(file='', lat=lat, source='')
49                        bd=modifyList(bd.default, dataRad)
50                        res <- do.call('zoo2Meteo', bd)
51                        res
52                    })
53            }, #End of bd
54            prom = {
55                if (!is.list(dataRad)) dataRad <- list(G0dm=dataRad)
56                prom.default <- list(G0dm=numeric(), lat=lat)
57                prom = modifyList(prom.default, dataRad)
58            }
59        )
60    }

```

```

55         res <- do.call('readG0dm', prom)
56     }, #End of prom
57     aguiar = {
58         if (is.list(dataRad)) dataRad <- dataRad$G0dm
59         BTd <- fBTd(mode='serie')
60         solD <- fSolD(lat, BTd)
61         G0d <- markovG0(dataRad, solD)
62         res <- dt2Meteo(G0d, lat=lat, source='aguiar')
63     }, #End of aguiar
64     bdI = {
65         if (!is.list(dataRad)) dataRad <- list(file=dataRad)
66         switch(class(dataRad$file)[1],
67             character = {
68                 bdI.default <- list(file='', lat=lat)
69                 bdI <- modifyList(bdI.default, dataRad)
70                 res <- do.call('readBDi', bdI)
71                 res
72             },
73             data.table = ,
74             data.frame = {
75                 bdI.default <- list(file='', lat=lat)
76                 bdI <- modifyList(bdI.default, dataRad)
77                 res <- do.call('dt2Meteo', bdI)
78                 res
79             },
80             zoo = {
81                 bdI.default <- list(file='', lat=lat, source='')
82                 bdI <- modifyList(bdI.default, dataRad)
83                 res <- do.call('zoo2Meteo', bdI)
84                 res
85             },
86             stop('dataRad$file should be a character, a data.
table, a data.frame or a zoo.')
87         )} #End of btI
88     ) #End of general switch
89 }
90
91
92 ### Angulos solares y componentes de irradiancia
93 if (modeRad=='bdI') {
94     sol <- calcSol(lat, sample = sample,
95     BTi = indexD(BD), keep.night=keep.night, method=
sunGeometry)
96     compI <- fCompI(sol=sol, G0I=BD, corr=corr, f=f, ...)
97     compD <- compI[, lapply(.SD, P2E, sol@sample),
98     .SDcols = c('G0', 'D0', 'B0'),
99     by = truncDay(Dates)]
100     names(compD)[1] <- 'Dates'
101     names(compD)[-1] <- paste(names(compD)[-1], 'd', sep = '')
102     compD$Fd <- compD$D0d/compD$G0d
103     compD$Kt <- compD$G0d/sol@solD$Bo0d
104 } else { ##modeRad!='bdI'
105     sol <- calcSol(lat, indexD(BD), sample = sample,
106     keep.night = keep.night, method = sunGeometry)
107     compD<-fCompD(sol=sol, G0d=BD, corr=corr, f, ...)
108     compI<-fCompI(sol=sol, compD=compD, ...)

```

```

109 }
110
111 ###Temperature
112
113 Ta=switch(modeRad,
114           bd={
115             if (all(c("TempMax","TempMin") %in% names(BD@data))) {
116               fTemp(sol, BD)
117             } else {
118               if ("Ta" %in% names(BD@data)) {
119                 data.table(Dates = indexD(sol),
120                           Ta =BD@data$Ta)
121               } else {
122                 warning('No temperature information available!')
123               }
124             }
125           },
126           bdI={
127             if ("Ta" %in% names(BD@data)) {
128               data.table(Dates = indexI(sol),
129                         Ta = BD@data$Ta)
130             } else {
131               warning('No temperature information available!')
132             }
133           },
134           prom={
135             if ("Ta" %in% names(BD@data)) {
136               data.table(Dates = indexD(sol),
137                         Ta = BD@data$Ta)
138             } else {
139               warning('No temperature information available!')
140             }
141           },
142           aguiar={
143             data.table(Dates = indexI(sol),
144                       Ta = BD@data$Ta)
145           }
146         )
147
148 ###Medias mensuales y anuales
149 nms <- c('G0d', 'D0d', 'B0d')
150 G0dm <- compD[, lapply(.SD/1000, mean, na.rm = TRUE),
151               .SDcols = nms,
152               by = .(month(Dates), year(Dates))]
153
154 if(modeRad == 'prom'){
155   G0dm[, DayOfMonth := DOM(G0dm)]
156   G0y <- G0dm[, lapply(.SD*DayOfMonth, sum, na.rm = TRUE),
157               .SDcols = nms,
158               by = .(Dates = year)]
159   G0dm[, DayOfMonth := NULL]
160 } else{
161   G0y <- compD[, lapply(.SD/1000, sum, na.rm = TRUE),
162               .SDcols = nms,
163               by = .(Dates = year(Dates))]
164 }

```

```

165 G0dm[, Dates := paste(month.abb[month], year, sep = '. ')]
166 G0dm[, c('month', 'year') := NULL]
167 setcolorder(G0dm, 'Dates')
168
169 ###Result
170 result <- new(Class='G0',
171               BD,          #G0 contains "Meteo"
172               sol,         #G0 contains 'Sol'
173               GOD=compD, #results of fCompD
174               G0dm=G0dm, #monthly means
175               G0y=G0y,   #yearly values
176               G0I=compI, #results of fCompD
177               Ta=Ta      #ambient temperature
178               )
179 return(result)
180 }

```

### calcGef

```

1 calcGef<-function(lat,
2                   modeTrk='fixed',      #c('two','horiz','fixed')
3                   modeRad='prom',
4                   dataRad,
5                   sample='hour',
6                   keep.night=TRUE,
7                   sunGeometry='michalsky',
8                   corr, f,
9                   betaLim=90, beta=abs(lat)-10, alfa=0,
10                  iS=2, alb=0.2, horizBright=TRUE, HCPV=FALSE,
11                  modeShd='',           #modeShd=c('area','bt','prom')
12                  struct=list(), #list(W=23.11, L=9.8, Nrow=2, Ncol=8),
13                  distances=data.frame(), #data.table(Lew=40, Lns=30, H=0)){
14    ...){
15
16    stopifnot(is.list(struct), is.data.frame(distances))
17
18    if (('bt' %in% modeShd) & (modeTrk!='horiz')) {
19      modeShd[which(modeShd=='bt')]='area'
20      warning('backtracking is only implemented for modeTrk=horiz')}
21
22    if (modeRad!='prev'){ #not use a prev calculation
23      radHoriz <- calcG0(lat=lat, modeRad=modeRad,
24                        dataRad=dataRad,
25                        sample=sample, keep.night=keep.night,
26                        sunGeometry=sunGeometry,
27                        corr=corr, f=f, ...)
28    } else {                #use a prev calculation
29      radHoriz <- as(dataRad, 'G0')
30    }
31
32    ### Inclined and effective radiation
33    BT=("bt" %in% modeShd)
34    angGen <- fTheta(radHoriz, beta, alfa, modeTrk, betaLim, BT, struct,
35                    distances)
36    inclin <- fInclin(radHoriz, angGen, iS, alb, horizBright, HCPV)

```

```

36
37 ### Daily, monthly and yearly values
38 by <- radHoriz@sample
39 nms <- c('Bo', 'Bn', 'G', 'D', 'B', 'Gef', 'Def', 'Bef')
40 nmsd <- paste(nms, 'd', sep = '')
41
42
43 if(radHoriz@type == 'prom'){
44   Gefdm <- inclin[, lapply(.SD/1000, P2E, by),
45                       .SDcols = nms,
46                       by = .(month(Dates), year(Dates))]
47   names(Gefdm)[-c(1,2)] <- nmsd
48   GefD <- Gefdm[, .SD*1000,
49                 .SDcols = nmsd,
50                 by = .(Dates = indexD(radHoriz))]
51
52   Gefdm[, DayOfMonth := DOM(Gefdm)]
53   Gefy <- Gefdm[, lapply(.SD*DayOfMonth, sum, na.rm = TRUE),
54                 .SDcols = nmsd,
55                 by = .(Dates = year)]
56   Gefdm[, DayOfMonth := NULL]
57 } else{
58   GefD <- inclin[, lapply(.SD, P2E, by),
59                 .SDcols = nms,
60                 by = .(Dates = truncDay(Dates))]
61   names(GefD)[-1] <- nmsd
62
63   Gefdm <- GefD[, lapply(.SD/1000, mean, na.rm = TRUE),
64                 .SDcols = nmsd,
65                 by = .(month(indexD(radHoriz)), year(indexD(radHoriz)))]
66   Gefy <- GefD[, lapply(.SD/1000, sum, na.rm = TRUE),
67                 .SDcols = nmsd,
68                 by = .(Dates = year(indexD(radHoriz)))]
69 }
70
71 Gefdm[, Dates := paste(month.abb[month], year, sep = '. ')]
72 Gefdm[, c('month', 'year') := NULL]
73 setcolorder(Gefdm, 'Dates')
74
75 ###Resultado antes de sombras
76 result0=new('Gef',
77            radHoriz,                #Gef contains 'GO'
78            Theta=angGen,
79            GefD=GefD,
80            Gefdm=Gefdm,
81            Gefy=Gefy,
82            GefI=inclin,
83            iS=iS,
84            alb=alb,
85            modeTrk=modeTrk,
86            modeShd=modeShd,
87            angGen=list(alfa=alfa, beta=beta, betaLim=betaLim),
88            struct=struct,
89            distances=distances
90            )
91 ###Shadows

```



```

92   if (isTRUE(modeShd == "") ||           #If modeShd==' ' there is no shadow
      calculation
93       ('bt' %in% modeShd)) {             #nor if there is backtracking
94       return(result0)
95   } else {
96       result <- calcShd(result0, modeTrk, modeShd, struct, distances)
97       return(result)
98   }
99 }

```

### prodGCPV

```

1  prodGCPV<-function(lat,
2      modeTrk='fixed',
3      modeRad='prom',
4      dataRad,
5      sample='hour',
6      keep.night=TRUE,
7      sunGeometry='michalsky',
8      corr, f,
9      betaLim=90, beta=abs(lat)-10, alfa=0,
10     iS=2, alb=0.2, horizBright=TRUE, HCPV=FALSE,
11     module=list(),
12     generator=list(),
13     inverter=list(),
14     effSys=list(),
15     modeShd='',
16     struct=list(),
17     distances=data.table(),
18     ...){
19
20     stopifnot(is.list(module),
21               is.list(generator),
22               is.list(inverter),
23               is.list(effSys),
24               is.list(struct),
25               is.data.table(distances))
26
27     if (('bt' %in% modeShd) & (modeTrk!='horiz')) {
28         modeShd[which(modeShd=='bt')]='area'
29         warning('backtracking is only implemented for modeTrk=horiz')}
30
31     if (modeRad!='prev'){ #We do not use a previous calculation
32
33         radEf<-calcGef(lat=lat, modeTrk=modeTrk, modeRad=modeRad,
34             dataRad=dataRad,
35             sample=sample, keep.night=keep.night,
36             sunGeometry=sunGeometry,
37             corr=corr, f=f,
38             betaLim=betaLim, beta=beta, alfa=alfa,
39             iS=iS, alb=alb, horizBright=horizBright, HCPV=HCPV,
40             modeShd=modeShd, struct=struct, distances=distances, ...)
41
42     } else { #We use a previous calcG0, calcGef or prodGCPV calculation.
43

```

```

44 stopifnot(class(dataRad) %in% c('GO', 'Gef', 'ProdGCPV'))
45 radEf <- switch(class(dataRad),
46                 GO=calcGef(lat=lat,
47                             modeTrk=modeTrk, modeRad='prev',
48                             dataRad=dataRad,
49                             betaLim=betaLim, beta=beta, alfa=alfa,
50                             iS=iS, alb=alb, horizBright=horizBright, HCPV=
HCPV,
51                             modeShd=modeShd, struct=struct, distances=
distances, ...),
52                 Gef=dataRad,
53                 ProdGCPV=as(dataRad, 'Gef')
54                 )
55 }
56
57
58 ##Production
59 prodI<-fProd(radEf,module,generator,inverter,effSys)
60 module=attr(prodI, 'module')
61 generator=attr(prodI, 'generator')
62 inverter=attr(prodI, 'inverter')
63 effSys=attr(prodI, 'effSys')
64
65 ##Calculation of daily, monthly and annual values
66 Pg=generator$Pg #Wp
67
68 by <- radEf@sample
69 nms1 <- c('Pac', 'Pdc')
70 nms2 <- c('Eac', 'Edc', 'Yf')
71
72
73 if(radEf@type == 'prom'){
74   prodDm <- prodI[, lapply(.SD/1000, P2E, by),
75                       .SDcols = nms1,
76                       by = .(month(Dates), year(Dates))]
77   names(prodDm)[-c(1,2)] <- nms2[-3]
78   prodDm[, Yf := Eac/(Pg/1000)]
79   prodD <- prodDm[, .SD*1000,
80                   .SDcols = nms2,
81                   by = .(Dates = indexD(radEf))]
82   prodD[, Yf := Yf/1000]
83
84   prodDm[, DayOfMonth := DOM(prodDm)]
85   prody <- prodDm[, lapply(.SD*DayOfMonth, sum, na.rm = TRUE),
86                   .SDcols = nms2,
87                   by = .(Dates = year)]
88   prodDm[, DayOfMonth := NULL]
89 } else {
90   prodD <- prodI[, lapply(.SD, P2E, by),
91                   .SDcols = nms1,
92                   by = .(Dates = truncDay(Dates))]
93   names(prodD)[-1] <- nms2[-3]
94   prodD[, Yf := Eac/Pg]
95
96   prodDm <- prodD[, lapply(.SD/1000, mean, na.rm = TRUE),
97                       .SDcols = nms2,

```

```

98         by = .(month(Dates), year(Dates))
99     prodDm[, Yf := Yf * 1000]
100     prody <- prodD[, lapply(.SD/1000, sum, na.rm = TRUE),
101         .SDcols = nms2,
102         by = .(Dates = year(Dates))]
103     prody[, Yf := Yf * 1000]
104 }
105
106 prodDm[, Dates := paste(month.abb[month], year, sep = '. ')]
107 prodDm[, c('month', 'year') := NULL]
108 setcolororder(prodDm, 'Dates')
109
110 result <- new('ProdGCPV',
111     radEf,                #contains 'Gef'
112     prodD=prodD,
113     prodDm=prodDm,
114     prody=prody,
115     prodI=prodI,
116     module=module,
117     generator=generator,
118     inverter=inverter,
119     effSys=effSys
120 )
121 }

```

## prodPVPS

```

1 prodPVPS<-function(lat,
2     modeTrk='fixed',
3     modeRad='prom',
4     dataRad,
5     sample='hour',
6     keep.night=TRUE,
7     sunGeometry='michalsky',
8     corr, f,
9     betaLim=90, beta=abs(lat)-10, alfa=0,
10    iS=2, alb=0.2, horizBright=TRUE, HCPV=FALSE,
11    pump , H,
12    Pg, converter= list(), #Pnom=Pg, Ki=c(0.01,0.025,0.05)),
13    effSys=list(),
14    ...){
15
16    stopifnot(is.list(converter),
17        is.list(effSys))
18
19    if (modeRad!='prev'){ #We do not use a previous calculation
20
21        radEf<-calcGef(lat=lat, modeTrk=modeTrk, modeRad=modeRad,
22            dataRad=dataRad,
23            sample=sample, keep.night=keep.night,
24            sunGeometry=sunGeometry,
25            corr=corr, f=f,
26            betaLim=betaLim, beta=beta, alfa=alfa,
27            iS=iS, alb=alb, horizBright=horizBright, HCPV=HCPV,
28            modeShd='', ...)

```

```

29 } else { #We use a previous calculation of calcG0, calcGef or prodPVPS
30   stopifnot(class(dataRad) %in% c('G0', 'Gef', 'ProdPVPS'))
31   radEf <- switch(class(dataRad),
32     G0=calcGef(lat=lat,
33       modeTrk=modeTrk, modeRad='prev',
34       dataRad=dataRad,
35       betaLim=betaLim, beta=beta, alfa=alfa,
36       iS=iS, alb=alb, horizBright=horizBright, HCPV=HCPV,
37       modeShd='', ...),
38     Gef=dataRad,
39     ProdPVPS=as(dataRad, 'Gef')
40   )
41 }
42
43
44 ###Electric production
45 converter.default=list(Ki = c(0.01,0.025,0.05), Pnom=Pg)
46 converter=modifyList(converter.default, converter)
47
48 effSys.default=list(ModQual=3,ModDisp=2,OhmDC=1.5,OhmAC=1.5,MPP=1,TrafoMT=1,
49   Disp=0.5)
50 effSys=modifyList(effSys.default, effSys)
51
52 TONC=47
53 Ct=(TONC-20)/800
54 lambda=0.0045
55 Gef=radEf@GefI$Gef
56 night=radEf@solI$night
57 Ta=radEf@Ta$Ta
58
59 Tc=Ta+Ct*Gef
60 Pdc=Pg*Gef/1000*(1-lambda*(Tc-25))
61 Pdc[is.na(Pdc)]=0 #Necessary for the functions provided by fPump
62 PdcN=with(effSys,
63   Pdc/converter$Pnom*(1-ModQual/100)*(1-ModDisp/100)*(1-OhmDC/100)
64 )
65 PacN=with(converter,{
66   A=Ki[3]
67   B=Ki[2]+1
68   C=Ki[1]-(PdcN)
69   ##AC power normalized to the inverter
70   result=(-B+sqrt(B^2-4*A*C))/(2*A)
71 })
72 PacN[PacN<0]<-0
73
74 Pac=with(converter,
75   PacN*Pnom*(1-effSys$OhmAC/100))
76 Pdc=PdcN*converter$Pnom*(Pac>0)
77
78 ###Pump
79 fun<-fPump(pump=pump, H=H)
80 ##I limit power to the pump operating range.
81 rango=with(fun,Pac>=lim[1] & Pac<=lim[2])
82 Pac[!rango]<-0
83 Pdc[!rango]<-0

```

```

84 prodI=data.table(Pac=Pac,Pdc=Pdc,Q=0,Pb=0,Ph=0,f=0)
85 prodI=within(prodI,{
86   Q[rango]<-fun$fQ(Pac[rango])
87   Pb[rango]<-fun$fPb(Pac[rango])
88   Ph[rango]<-fun$fPh(Pac[rango])
89   f[rango]<-fun$fFreq(Pac[rango])
90   etam=Pb/Pac
91   etab=Ph/Pb
92 })
93
94 prodI[night,]<-NA
95 prodI[, Dates := indexI(radEf)]
96 setcolorder(prodI, c('Dates', names(prodI)[-length(prodI)]))
97
98 ###daily, monthly and yearly values
99
100 by <- radEf@sample
101
102 if(radEf@type == 'prom'){
103   prodDm <- prodI[, .(Eac = P2E(Pac, by)/1000,
104                      Qd = P2E(Q, by)),
105                    by = .(month(Dates), year(Dates))]
106   prodDm[, Yf := Eac/(Pg/1000)]
107
108   prodD <- prodDm[, .(Eac = Eac*1000,
109                      Qd,
110                      Yf),
111                   by = .(Dates = indexD(radEf))]
112
113   prodDm[, DayOfMonth := DOM(prodDm)]
114
115   prody <- prodDm[, lapply(.SD*DayOfMonth, sum, na.rm = TRUE),
116                      .SDcols = c('Eac', 'Qd', 'Yf'),
117                      by = .(Dates = year)]
118   prodDm[, DayOfMonth := NULL]
119 } else {
120   prodD <- prodI[, .(Eac = P2E(Pac, by)/1000,
121                      Qd = P2E(Q, by)),
122                   by = .(Dates = truncDay(Dates))]
123   prodD[, Yf := Eac/Pg*1000]
124
125   prodDm <- prodD[, lapply(.SD, mean, na.rm = TRUE),
126                      .SDcols = c('Eac', 'Qd', 'Yf'),
127                      by = .(month(Dates), year(Dates))]
128   prody <- prodD[, lapply(.SD, sum, na.rm = TRUE),
129                      .SDcols = c('Eac', 'Qd', 'Yf'),
130                      by = .(Dates = year(Dates))]
131
132 }
133
134 prodDm[, Dates := paste(month.abb[month], year, sep = '. ')]
135 prodDm[, c('month', 'year') := NULL]
136 setcolorder(prodDm, 'Dates')
137
138 result <- new('ProdPVPS',
139              radEf,
              #contains 'Gef'

```

```

140         prodD=prodD,
141         prodDm=prodDm,
142         prody=prody,
143         prodI=prodI,
144         pump=pump,
145         H=H,
146         Pg=Pg,
147         converter=converter,
148         effSys=effSys
149     )
150 }

```

### calcShd

```

1 calcShd<-function(radEf,##class='Gef'
2     modeTrk='fixed',      #c('two','horiz','fixed')
3     modeShd='prom',      #modeShd=c('area','bt','prom')
4     struct=list(), #list(W=23.11, L=9.8, Nrow=2, Ncol=8),
5     distances=data.frame() #data.table(Lew=40, Lns=30, H=0)){
6
7 {
8     stopifnot(is.list(struct), is.data.frame(distances))
9
10    ##For now I only use modeShd = 'area'
11    ##With different modeShd (to be defined) I will be able to calculate Gef in a
12    ##different way
13    ##See macagnan thesis
14    prom=("prom" %in% modeShd)
15    prev <- as.data.tableI(radEf, complete=TRUE)
16    ## shadow calculations
17    sol <- data.table(AzS = prev$AzS,
18                     A1S = prev$A1S)
19    theta <- radEf@Theta
20    AngGen <- data.table(theta, sol)
21    FS <- fSombra(AngGen, distances, struct, modeTrk, prom)
22    ## irradiance calculation
23    gef0 <- radEf@GefI
24    Bef0 <- gef0$Bef
25    Dcef0 <- gef0$Dcef
26    Gef0 <- gef0$Gef
27    Dief0 <- gef0$Dief
28    Ref0 <- gef0$Ref
29    ## calculation
30    Bef <- Bef0*(1-FS)
31    Dcef <- Dcef0*(1-FS)
32    Def <- Dief0+Dcef
33    Gef <- Dief0+Ref0+Bef+Dcef #Including shadows
34    ##Change names
35    nms <- c('Gef', 'Def', 'Dcef', 'Bef')
36    nmsIndex <- which(names(gef0) %in% nms)
37    names(gef0)[nmsIndex]<- paste(names(gef0)[nmsIndex], '0', sep='')
38    GefShd <- gef0
39    GefShd[, c(nms, 'FS') := .(Gef, Def, Dcef, Bef, FS)]
40
41    ## daily, monthly and yearly values

```

```

41 by <- radEf@sample
42 nms <- c('Gef0', 'Def0', 'Bef0', 'G', 'D', 'B', 'Gef', 'Def', 'Bef')
43 nmsd <- paste(nms, 'd', sep = '')
44
45 Gefdm <- GefShd[, lapply(.SD/1000, P2E, by),
46                     by = .(month(truncDay(Dates)), year(truncDay(Dates))),
47                     .SDcols = nms]
48 names(Gefdm)[-c(1, 2)] <- nmsd
49
50 if(radEf@type == 'prom'){
51   GefD <- Gefdm[, .SD[, -c(1, 2)] * 1000,
52                 .SDcols = nmsd,
53                 by = .(Dates = indexD(radEf))]
54
55   Gefdm[, DayOfMonth := DOM(Gefdm)]
56
57   Gefy <- Gefdm[, lapply(.SD*DayOfMonth, sum, na.rm = TRUE),
58                 .SDcols = nmsd,
59                 by = .(Dates = year)]
60   Gefdm[, DayOfMonth := NULL]
61 } else{
62   GefD <- GefShd[, lapply(.SD/1000, P2E, by),
63                 .SDcols = nms,
64                 by = .(Dates = truncDay(Dates))]
65   names(GefD)[-1] <- nmsd
66
67   Gefy <- GefD[, lapply(.SD[, -1], sum, na.rm = TRUE),
68                 .SDcols = nmsd,
69                 by = .(Dates = year(Dates))]
70 }
71
72 Gefdm[, Dates := paste(month.abb[month], year, sep = '. ')]
73 Gefdm[, c('month', 'year') := NULL]
74 setcolorder(Gefdm, c('Dates', names(Gefdm)[-length(Gefdm)]))
75
76 ## Object of class Gef
77 ## modifying the 'modeShd', 'GefI', 'GefD', 'Gefdm', and 'Gefy' slots
78 ## from the original radEf object
79 radEf@modeShd=modeShd
80 radEf@GefI=GefShd
81 radEf@GefD=GefD
82 radEf@Gefdm=Gefdm
83 radEf@Gefy=Gefy
84 return(radEf)
85 }

```

### optimShd

```

1 optimShd<-function(lat,
2                     modeTrk='fixed',
3                     modeRad='prom',
4                     dataRad,
5                     sample='hour',
6                     keep.night=TRUE,
7                     sunGeometry='michalsky',

```

```

8         betaLim=90, beta=abs(lat)-10, alfa=0,
9         iS=2, alb=0.2, HCPV=FALSE,
10        module=list(),
11        generator=list(),
12        inverter=list(),
13        effSys=list(),
14        modeShd='',
15        struct=list(),
16        distances=data.table(),
17        res=2,      #resolution, distance spacing
18        prog=TRUE){ #Drawing progress bar
19
20    if (('bt' %in% modeShd) & (modeTrk!='horiz')) {
21        modeShd[which(modeShd=='bt')]='area'
22        warning('backtracking is only implemented for modeTrk=horiz')}
23
24    ##I save function arguments for later use
25
26    listArgs<-list(lat=lat, modeTrk=modeTrk, modeRad=modeRad,
27                  dataRad=dataRad,
28                  sample=sample, keep.night=keep.night,
29                  sunGeometry=sunGeometry,
30                  betaLim=betaLim, beta=beta, alfa=alfa,
31                  iS=iS, alb=alb, HCPV=HCPV,
32                  module=module, generator=generator,
33                  inverter=inverter, effSys=effSys,
34                  modeShd=modeShd, struct=struct,
35                  distances=data.table(Lew=NA, Lns=NA, D=NA))
36
37
38    ##I think network on which I will do the calculations
39    Red=switch(modeTrk,
40              horiz=with(distances,
41                          data.table(Lew=seq(Lew[1],Lew[2],by=res),
42                                      H=0)),
43              two=with(distances,
44                        data.table(
45                          expand.grid(Lew=seq(Lew[1],Lew[2],by=res),
46                                      Lns=seq(Lns[1],Lns[2],by=res),
47                                      H=0))),
48              fixed=with(distances,
49                          data.table(D=seq(D[1],D[2],by=res),
50                                      H=0))
51    )
52
53    casos<-dim(Red)[1] #Number of possibilities to study
54
55    ##I prepare the progress bar
56    if (prog) {pb <- txtProgressBar(min = 0, max = casos+1, style = 3)
57              setTxtProgressBar(pb, 0)}
58
59    ###Calculations
60    ##Reference: No shadows
61    listArgs0 <- modifyList(listArgs,
62                           list(modeShd='', struct=NULL, distances=NULL) )
63    Prod0<-do.call(prodGCPV, listArgs0)

```



```

64 YfAnual0=mean(Prod0@prody$Yf) #I use mean in case there are several years
65 if (prog) {setTxtProgressBar(pb, 1)}
66
67 ##The loop begins
68
69 ##I create an empty vector of the same length as the cases to be studied
70 YfAnual<-numeric(casos)
71
72 BT=('bt' %in% modeShd)
73 if (BT) { ##There is backtracking, then I must start from horizontal
radiation.
74   RadBT <- as(Prod0, 'G0')
75   for (i in seq_len(casos)){
76     listArgsBT <- modifyList(listArgs,
77                             list(modeRad='prev', dataRad=RadBT,
78                                 distances=Red[i,]))
79     prod.i <- do.call(prodGCPV, listArgsBT)
80     YfAnual[i]=mean(prod.i@prody$Yf)
81     if (prog) {setTxtProgressBar(pb, i+1)}
82   }
83 } else {
84   prom=('prom' %in% modeShd)
85   for (i in seq_len(casos)){
86     Gef0=as(Prod0, 'Gef')
87     GefShd=calcShd(Gef0, modeTrk=modeTrk, modeShd=modeShd,
88                   struct=struct, distances=Red[i,])
89     listArgsShd <- modifyList(listArgs,
90                              list(modeRad='prev', dataRad=GefShd)
91                              )
92     prod.i <- do.call(prodGCPV, listArgsShd)
93     YfAnual[i]=mean(prod.i@prody$Yf)
94     if (prog) {setTxtProgressBar(pb, i+1)}
95   }
96 }
97 if (prog) {close(pb)}
98
99
100 ###Results
101 FS=1-YfAnual/YfAnual0
102 GRR=switch(modeTrk,
103           two=with(Red,Lew*Lns)/with(struct,L*W),
104           fixed=Red$D/struct$L,
105           horiz=Red$Lew/struct$L)
106 SombraDF=data.table(Red,GRR,FS,Yf=YfAnual)
107 FS.loess=switch(modeTrk,
108               two=loess(FS~Lew*Lns,data=SombraDF),
109               horiz=loess(FS~Lew,data=SombraDF),
110               fixed=loess(FS~D,data=SombraDF))
111 Yf.loess=switch(modeTrk,
112               two=loess(Yf~Lew*Lns,data=SombraDF),
113               horiz=loess(Yf~Lew,data=SombraDF),
114               fixed=loess(Yf~D,data=SombraDF))
115 result <- new('Shade',
116             Prod0, ##contains ProdGCPV
117             FS=FS,
118             GRR=GRR,

```

```

119         Yf=YfAnual,
120         FS.loess=FS.loess,
121         Yf.loess=Yf.loess,
122         modeShd=modeShd,
123         struct=struct,
124         distances=Red,
125         res=res
126     )
127     result
128 }

```

## meteoReaders

```

1  ##### monthly means of irradiation #####
2  readG0dm <- function(G0dm, Ta = 25, lat = 0,
3                      year = as.POSIXlt(Sys.Date())$year + 1900,
4                      promDays = c(17, 14, 15, 15, 15, 10, 18, 18, 18, 19, 18, 13)
5                      ,
6                      source = '')
7  {
8      if(missing(lat)){lat <- 0}
9      Dates <- as.IDate(paste(year, 1:12, promDays, sep = '-'), tz = 'UTC')
10     G0dm.dt <- data.table(Dates = Dates,
11                          G0d = G0dm,
12                          Ta = Ta)
13     setkey(G0dm.dt, 'Dates')
14     results <- new(Class = 'Meteo',
15                   latm = lat,
16                   data = G0dm.dt,
17                   type = 'prom',
18                   source = source)
19 }
20 ##### file to Meteo (daily) #####
21 readBDd <- function(file, lat,
22                     format = "%d/%m/%Y", header = TRUE,
23                     fill = TRUE, dec = '.', sep = ';',
24                     dates.col = 'Dates', ta.col = 'Ta',
25                     g0.col = 'G0', keep.cols = FALSE)
26 {
27     #stops if the arguments are not characters or numerics
28     stopifnot(is.character(dates.col) || is.numeric(dates.col))
29     stopifnot(is.character(ta.col) || is.numeric(ta.col))
30     stopifnot(is.character(g0.col) || is.numeric(g0.col))
31
32     #read from file and set it in a data.table
33     bd <- fread(file, header = header, fill = fill, dec = dec, sep = sep)
34
35     #check the columns
36     if(!(dates.col %in% names(bd))) stop(paste('The column', dates.col, 'is not
37     in the file'))
38     if(!(g0.col %in% names(bd))) stop(paste('The column', g0.col, 'is not in the
39     file'))
40     if(!(ta.col %in% names(bd))) stop(paste('The column', ta.col, 'is not in the
41     file'))

```

```

39
40   #name the dates column by Dates
41   Dates <- bd[[dates.col]]
42   bd[, (dates.col) := NULL]
43   bd[, Dates := as.IDate(Dates, format = format)]
44
45   #name the g0 column by G0
46   G0 <- bd[[g0.col]]
47   bd[, (g0.col) := NULL]
48   bd[, G0 := as.numeric(G0)]
49
50   #name the ta column by Ta
51   Ta <- bd[[ta.col]]
52   bd[, (ta.col) := NULL]
53   bd[, Ta := as.numeric(Ta)]
54
55   names0 <- NULL
56   if(all(c('D0', 'B0') %in% names(bd))){
57     names0 <- c(names0, 'D0', 'B0')
58   }
59
60   names0 <- c(names0, 'Ta')
61
62   if(all(c('TempMin', 'TempMax') %in% names(bd))){
63     names0 <- c(names0, 'TempMin', 'TempMax')
64   }
65   if(keep.cols)
66   {
67     #keep the rest of the columns but reorder the columns
68     setcolorder(bd, c('Dates', 'G0', names0))
69   }
70   else
71   {
72     #erase the rest of the columns
73     cols <- c('Dates', 'G0', names0)
74     bd <- bd[, ..cols]
75   }
76
77   setkey(bd, 'Dates')
78   result <- new(Class = 'Meteo',
79                 latm = lat,
80                 data = bd,
81                 type = 'bd',
82                 source = file)
83 }
84
85 ##### file to Meteo (intradaily) #####
86 readBDi <- function(file, lat,
87                     format = "%d/%m/%Y %H:%M:%S",
88                     header = TRUE, fill = TRUE, dec = '.',
89                     sep = ';', dates.col = 'dates', times.col,
90                     ta.col = 'Ta', g0.col = 'G0', keep.cols = FALSE)
91 {
92   #stops if the arguments are not characters or numerics
93   stopifnot(is.character(dates.col) || is.numeric(dates.col))
94   stopifnot(is.character(ta.col) || is.numeric(ta.col))

```

```

95 stopifnot(is.character(g0.col) || is.numeric(g0.col))
96
97 #read from file and set it in a data.table
98 bd <- fread(file, header = header, fill = fill, dec = dec, sep = sep)
99
100 #check the columns
101 if(!(dates.col %in% names(bd))) stop(paste('The column', dates.col, 'is not
in the file'))
102 if(!(g0.col %in% names(bd))) stop(paste('The column', g0.col, 'is not in the
file'))
103 if(!(ta.col %in% names(bd))) stop(paste('The column', ta.col, 'is not in the
file'))
104
105 if(!missing(times.col)){
106   stopifnot(is.character(times.col) || is.numeric(times.col))
107   if(!(times.col %in% names(bd))) stop(paste('The column', times.col, 'is
not in the file'))
108
109   #name the dates column by Dates
110   format <- strsplit(format, ' ')
111   dd <- as.IDate(bd[[dates.col]], format = format[[1]][1])
112   tt <- as.ITime(bd[[times.col]], format = format[[1]][2])
113   bd[, (dates.col) := NULL]
114   bd[, (times.col) := NULL]
115   bd[, Dates := as.POSIXct(dd, tt, tz = 'UTC')]
116 }
117
118 else
119 {
120   dd <- as.POSIXct(bd[[dates.col]], format = format, tz = 'UTC')
121   bd[, (dates.col) := NULL]
122   bd[, Dates := dd]
123 }
124
125 #name the g0 column by G0
126 G0 <- bd[[g0.col]]
127 bd[, (g0.col) := NULL]
128 bd[, G0 := as.numeric(G0)]
129
130 #name the ta column by Ta
131 Ta <- bd[[ta.col]]
132 bd[, (ta.col) := NULL]
133 bd[, Ta := as.numeric(Ta)]
134
135 names0 <- NULL
136 if(all(c('D0', 'B0') %in% names(bd))){
137   names0 <- c(names0, 'D0', 'B0')
138 }
139
140 names0 <- c(names0, 'Ta')
141
142 if(keep.cols)
143 {
144   #keep the rest of the columns but reorder the columns
145   setcolorder(bd, c('Dates', 'G0', names0))
146 }

```

```

147 else
148 {
149     #erase the rest of the columns
150     cols <- c('Dates', 'G0', names0)
151     bd <- bd[, ..cols]
152 }
153
154 setkey(bd, 'Dates')
155 result <- new(Class = 'Meteo',
156               latm = lat,
157               data = bd,
158               type = 'bdI',
159               source = file)
160 }
161
162
163 dt2Meteo <- function(file, lat, source = '', type){
164     ## Make sure its a data.table
165     bd <- data.table(file)
166
167     ## Dates is an as.POSIX element
168     bd[, Dates := as.POSIXct(Dates, tz = 'UTC')]
169
170     ## type
171     if(missing(type)){
172         sample <- median(diff(file$Dates))
173         IsDaily <- as.numeric(sample, units = 'days')
174         if(is.na(IsDaily)) IsDaily <- ifelse('G0d' %in% names(bd),
175                                           1, 0)
176         if(IsDaily >= 30) type <- 'prom'
177         else{
178             type <- ifelse(IsDaily >= 1, 'bd', 'bdI')
179         }
180     }
181
182     if(!('Ta' %in% names(bd))){
183         if(all(c('Tempmin', 'TempMax') %in% names(bd))){
184             bd[, Ta := mean(c(Tempmin, TempMax))]
185         } else bd[, Ta := 25]
186     }
187
188     ## Columns of the data.table
189     nms0 <- switch(type,
190                   bd = ,
191                   prom = {
192                       nms0 <- 'G0d'
193                       if(all(c('D0d', 'B0d') %in% names(bd))){
194                           nms0 <- c(nms0, 'D0d', 'B0d')
195                       }
196                       nms0 <- c(nms0, 'Ta')
197                       if(all(c('TempMin', 'TempMax') %in% names(bd))){
198                           nms0 <- c(nms0, 'TempMin', 'TempMax')
199                       }
200                       nms0
201                   },
202                   bdI = {

```

```

203         nms0 <- 'G0'
204         if(all(c('D0', 'B0') %in% names(bd))){
205             nms0 <- c(nms0, 'D0', 'B0')
206         }
207         if('Ta' %in% names(bd)){
208             nms0 <- c(nms0, 'Ta')
209         }
210         nms0
211     })
212     ## Columns order and set key
213     setcolorder(bd, c('Dates', nms0))
214     setkey(bd, 'Dates')
215     ## Result
216     result <- new(Class = 'Meteo',
217                   latm = lat,
218                   data = bd,
219                   type = type,
220                   source = source)
221 }
222
223 ##### Liu and Jordan, Collares-Pereira and Rabl proposals #####
224 collper <- function(sol, compD)
225 {
226     Dates <- indexI(sol)
227     x <- as.Date(Dates)
228     ind.rep <- cumsum(c(1, diff(x) != 0))
229     solI <- as.data.tableI(sol, complete = T)
230     ws <- solI$ws
231     w <- solI$w
232
233     a <- 0.409-0.5016*sin(ws+pi/3)
234     b <- 0.6609+0.4767*sin(ws+pi/3)
235
236     rd <- solI[, Bo0/Bo0d]
237     rg <- rd * (a + b * cos(w))
238
239     # Daily irradiation components
240     G0d <- compD$G0d[ind.rep]
241     B0d <- compD$B0d[ind.rep]
242     D0d <- compD$D0d[ind.rep]
243
244     # Daily profile
245     G0 <- G0d * rg
246     D0 <- D0d * rd
247
248     # This method may produce diffuse irradiance higher than
249     # global irradiance
250     G0 <- pmax(G0, D0, na.rm = TRUE)
251     B0 <- G0 - D0
252
253     # Negative values are set to NA
254     neg <- (B0 < 0) | (D0 < 0) | (G0 < 0)
255     is.na(G0) <- neg
256     is.na(B0) <- neg
257     is.na(D0) <- neg
258

```

```

259 # Daily profiles are scaled to keep daily irradiation values
260 day <- truncDay(indexI(sol))
261 sample <- sol@sample
262
263 G0dCP <- ave(G0, day, FUN=function(x) P2E(x, sample))
264 B0dCP <- ave(B0, day, FUN=function(x) P2E(x, sample))
265 D0dCP <- ave(D0, day, FUN=function(x) P2E(x, sample))
266
267 G0 <- G0 * G0d/G0dCP
268 B0 <- B0 * B0d/B0dCP
269 D0 <- D0 * D0d/D0dCP
270
271 res <- data.table(G0, B0, D0)
272 return(res)
273 }
274
275
276 ##### intradaily Meteo to daily Meteo #####
277 MeteoI2MeteoD <- function(G0i)
278 {
279   lat <- G0i@latm
280   source <- G0i@source
281
282   dt0 <- getData(G0i)
283   dt <- dt0[, lapply(.SD, sum),
284               .SDcols = names(dt0)[!names(dt0) %in% c('Dates', 'Ta')],
285               by = .(Dates = as.IDate(Dates))]
286   if('Ta' %in% names(dt0)){
287     Ta <- dt0[, .(Ta = mean(Ta),
288                   TempMin = min(Ta),
289                   TempMax = max(Ta)),
290               by = .(Dates = as.IDate(Dates))]
291     if(all(Ta$Ta == c(Ta$TempMin, Ta$TempMax))) Ta[, c('TempMin', 'TempMax')
292 := NULL]
293     dt <- merge(dt, Ta)
294   }
295   if('G0' %in% names(dt)){
296     names(dt)[names(dt) == 'G0'] <- 'G0d'
297   }
298   if('D0' %in% names(dt)){
299     names(dt)[names(dt) == 'D0'] <- 'D0d'
300   }
301   if('B0' %in% names(dt)){
302     names(dt)[names(dt) == 'B0'] <- 'B0d'
303   }
304   G0d <- dt2Meteo(dt, lat, source, type = 'bd')
305   return(G0d)
306 }
307
308 ##### daily Meteo to monthly Meteo #####
309 MeteoD2MeteoM <- function(G0d)
310 {
311   lat <- G0d@latm
312   source <- G0d@source
313
314   dt <- getData(G0d)

```

```

314 nms <- names(dt)[-1]
315 dt <- dt[, lapply(.SD, mean),
316             .SDcols = nms,
317             by = .(month(Dates), year(Dates))]
318 dt[, Dates := fBTd()]
319 dt <- dt[, c('month', 'year') := NULL]
320
321 setcolororder(dt, 'Dates')
322
323 G0m <- dt2Meteo(dt, lat, source, type = 'prom')
324 return(G0m)
325 }
326
327 zoo2Meteo <- function(file, lat, source = '')
328 {
329   sample <- median(diff(index(file)))
330   IsDaily <- as.numeric(sample, units = 'days')>=1
331   type <- ifelse(IsDaily, 'bd', 'bdI')
332   result <- new(Class = 'Meteo',
333                 latm = lat,
334                 data = file,
335                 type = type,
336                 source = source)
337 }
338
339 siarGET <- function(id, inicio, final, tipo = 'Mensuales', ambito = 'Estacion'){
340   if(!(tipo %in% c('Horarios', 'Diarios', 'Semanales', 'Mensuales'))){
341     stop('argument \'tipo\' must be: Horarios, Diarios, Semanales or
342 Mensuales')
343   }
344   if(!(ambito %in% c('CCAA', 'Provincia', 'Estacion'))){
345     stop('argument \'ambito\' must be: CCAA, Provincia or Estacion')
346   }
347
348   mainURL <- "https://servicio.mapama.gob.es"
349
350   path <- paste('/apisiar/API/v1/Datos', tipo, ambito, sep = '/')
351
352   ## prepare the APIsiar
353   req <- request(mainURL) |>
354     req_url_path(path) |>
355     req_url_query(Id = id,
356                  FechaInicial = inicio,
357                  FechaFinal = final,
358                  ClaveAPI = '_Q8L_niYFBBmBs-
359 vB3UomUqdUYy98FTRX1aYbrZ8n2FXuHYGTV')
360   ## execute it
361   resp <- req_perform(req)
362
363   ##JSON to R
364   respJSON <- resp_body_json(resp, simplifyVector = TRUE)
365
366   if(!is.null(respJSON$MensajeRespuesta)){
367     stop(respJSON$MensajeRespuesta)
368   }
369 }

```



```

368 res0 <- data.table(respJSON$Datos)
369
370 res <- switch(tipo,
371             Horarios = {
372                 res0[, HoraMin := as.ITime(sprintf('%04d', HoraMin),
373                                     format = '%H%M')]
374                 res0[, Fecha := as.IDate(Fecha, format = '%Y-%m-%d')]
375                 res0[, Fecha := as.IDate(ifelse(HoraMin == as.ITime(0),
376                                     Fecha+1, Fecha))]
377                 res0[, Dates := as.POSIXct(HoraMin, Fecha,
378                                     tz = 'Europe/Madrid')]
379                 res0 <- res0[, .(Dates,
380                                 GO = Radiacion,
381                                 Ta = TempMedia)]
382                 return(res0)
383             },
384             Diarios = {
385                 res0[, Dates := as.IDate(Fecha)]
386                 res0 <- res0[, .(Dates,
387                                 GOd = Radiacion * 277.78,
388                                 Ta = TempMedia,
389                                 TempMin,
390                                 TempMax)]
391                 return(res0)
392             },
393             Semanales = res0,
394             Mensuales = {
395                 promDays<-c(17,14,15,15,15,10,18,18,18,19,18,13)
396                 names(res0)[1] <- 'Year'
397                 res0[, Dates := as.IDate(paste(Year, Mes,
398                                     promDays[Mes],
399                                     sep = '-'))]
400                 res0 <- res0[, .(Dates,
401                                 GOd = Radiacion * 277.78,
402                                 Ta = TempMedia,
403                                 TempMin,
404                                 TempMax)]
405             })
406
407 return(res)
408 }
409
410 haversine <- function(lat1, lon1, lat2, lon2) {
411     R <- 6371 # Radius of the Earth in kilometers
412     dLat <- (lat2 - lat1) * pi / 180
413     dLon <- (lon2 - lon1) * pi / 180
414     a <- sin(dLat / 2) * sin(dLat / 2) + cos(lat1 * pi / 180) *
415         cos(lat2 * pi / 180) * sin(dLon / 2) * sin(dLon / 2)
416     c <- 2 * atan2(sqrt(a), sqrt(1 - a))
417     d <- R * c
418     return(d)
419 }
420
421 readSIAR <- function(Lon = 0, Lat = 0,
422                     inicio = paste(year(Sys.Date())-1, '01-01', sep = '-'),
423                     final = paste(year(Sys.Date())-1, '12-31', sep = '-'),

```

```

424         tipo = 'Mensuales', n_est = 3){
425     inicio <- as.Date(inicio)
426     final <- as.Date(final)
427
428     n_reg <- switch(tipo,
429         Horarios = {
430             tt <- difftime(final, inicio, units = 'days')
431             tt <- (as.numeric(tt)+1)*48
432             tt <- tt*n_est
433             tt
434         },
435         Diarios = {
436             tt <- difftime(final, inicio, units = 'days')
437             tt <- as.numeric(tt)+1
438             tt <- tt*n_est
439             tt
440         },
441         Semanales = {
442             tt <- difftime(final, inicio, units = 'weeks')
443             tt <- as.numeric(tt)
444             tt <- tt*n_est
445             tt
446         },
447         Mensuales = {
448             tt <- difftime(final, inicio, units = 'weeks')
449             tt <- as.numeric(tt)/4.34524
450             tt <- ceiling(tt)
451             tt <- tt*n_est
452             tt
453         })
454     if(n_reg > 100) stop(paste('Number of requested records (', n_reg,
455         ') exceeds the maximum allowed (100)', sep = ''))
456     ## Obtain the nearest stations
457     siar <- est_SIAR[
458         Fecha_Instalacion <= final & (is.na(Fecha_Baja) | Fecha_Baja >= inicio)
459     ]
460
461     ## Weights for the interpolation
462     siar[, dist := haversine(Latitud, Longitud, Lat, Lon)]
463     siar <- siar[order(dist)][1:n_est]
464     siar[, peso := 1/dist]
465     siar[, peso := peso/sum(peso)]
466     ## Is the given location within the polygon formed by the stations?
467     siar <- siar[, .(Estacion,Codigo, dist, peso)]
468
469     ## List for the data.tables of siarGET
470     siar_list <- list()
471     for(codigo in siar$Codigo){
472         siar_list[[codigo]] <- siarGET(id = codigo,
473             inicio = as.character(inicio),
474             final = as.character(final),
475             tipo = tipo)
476         siar_list[[codigo]]$peso <- siar[Codigo == codigo, peso]
477     }
478
479     ## Bind the data.tables

```

```

480 s_comb <- rbindlist(siar_list, use.names = TRUE, fill = TRUE)
481
482 nms <- names(s_comb)
483 nms <- nms[-c(1, length(nms))]
484
485 ## Interpole
486 res <- s_comb[, lapply(.SD * peso, sum, na.rm = TRUE),
487                   .SDcols = nms,
488                   by = Dates]
489
490 ## Source
491 mainURL <- "https://servicio.mapama.gob.es"
492 Estaciones <- siar[, paste(Estacion, '(',Codigo, ')', sep = '')]
493 Estaciones <- paste(Estaciones, collapse = ', ')
494 source <- paste(mainURL, '\n -Estaciones:', Estaciones, sep = ' ')
495
496 res <- switch(tipo,
497               Horarios = {dt2Meteo(res, lat = Lat, source = mainURL, type = '
498               bdI')},
499               Diarios = {dt2Meteo(res, lat = Lat, source = mainURL, type = '
500               bd')},
501               Semanales = {res},
502               Mensuales = {dt2Meteo(res, lat = Lat, source = source, type = '
503               prom')})
504 return(res)
505 }

```

## A.2. Clases

### Sol

```

1 setClass(
2   Class='Sol', ##Solar angles
3   slots = c(
4     lat='numeric',#latitud in degrees, >0 if North
5     solD='data.table',#daily angles
6     solI='data.table',#intradaily angles
7     sample='character',#sample of time
8     method='character'#method used for geometry calculations
9   ),
10  validity=function(object) {return(TRUE)}
11 )

```

### Meteo

```

1 setClass(
2   Class = 'Meteo', ##radiation and temperature data
3   slots = c(
4     latm='numeric',#latitud in degrees, >0 if North
5     data='data.table',#data, including G (Wh/m2) and Ta (°C)
6     type='character',#choose between 'prom', 'bd' and 'bdI'
7     source='character'#origin of the data
8   ),
9   validity=function(object) {return(TRUE)}

```

```
10 )
```

## GO

```
1 setClass(  
2   Class = 'GO',  
3   slots = c(  
4     GOD = 'data.table', #result of fCompD  
5     G0dm = 'data.table', #monthly means  
6     G0y = 'data.table', #yearly values  
7     G0I = 'data.table', #result of fCompI  
8     Ta = 'data.table'   #Ambient temperature  
9   ),  
10  contains = c('Sol', 'Meteo'),  
11  validity = function(object) {return(TRUE)}  
12 )  
13
```

## Gef

```
1 setClass(  
2   Class='Gef',  
3   slots = c(  
4     GefD='data.table', #daily values  
5     Gefdm='data.table', #monthly means  
6     Gefy='data.table', #yearly values  
7     GefI='data.table', #result of fInclin  
8     Theta='data.table', #result of fTheta  
9     iS='numeric',      #dirt index  
10    alb='numeric',     #albedo  
11    modeTrk='character', #tracking mode  
12    modeShd='character', #shadow mode  
13    angGen='list',      #includes alpha, beta and betaLim  
14    struct='list',      #structure dimensions  
15    distances='data.frame' #distances between structures  
16  ),  
17  contains='GO',  
18  validity=function(object) {return(TRUE)}  
19 )
```

## ProdGCPV

```
1 setClass(  
2   Class='ProdGCPV',  
3   slots = c(  
4     prodD='data.table', #daily values  
5     prodDm='data.table', #monthly means  
6     prody='data.table', #yearly values  
7     prodI='data.table', #results of fProd  
8     module='list',      #module characteristics  
9     generator='list',   #generator characteristics  
10    inverter='list',     #inverter characteristics  
11    effSys='list'        #efficiency values of the system
```

```

12     ),
13     contains='Gef',
14     validity=function(object) {return(TRUE)}
15 )

```

### ProdPVPS

```

1 setClass(
2   Class='ProdPVPS',
3   slots = c(
4     prodD='data.table', #daily values
5     prodDm='data.table', #monthly means
6     prody='data.table', #yearly values
7     prodI='data.table', #results of fPump
8     Pg='numeric', #generator power
9     H='numeric', #manometric head
10    pump='list', #parameters of the pump
11    converter='list', #inverter characteristics
12    effSys='list' #efficiency values of the system
13  ),
14  contains='Gef',
15  validity=function(object) {return(TRUE)}
16 )

```

### Shade

```

1 setClass(
2   Class='Shade',
3   slots = c(
4     FS='numeric', #shadows factor values
5     GRR='numeric', #Ground Requirement Ratio
6     Yf='numeric', #final productivity
7     FS.loess='loess', #local fitting of FS with loess
8     Yf.loess='loess', #local fitting of Yf with loess
9     modeShd='character', #mode of shadow
10    struct='list', #dimensions of the structures
11    distances='data.frame', #distances between structures
12    res='numeric' #difference between the different steps of the
    calculations
13  ),
14  contains='ProdGCPV', ##Resultado de prodGCPV sin sombras (Prod0)
15  validity=function(object) {return(TRUE)}
16 )

```

## A.3. Funciones

### corrFdKt

```

1 ##### monthly Kt #####
2 Ktm <- function(sol, GOdm){
3   solf <- sol@solD[, .(Dates, BoOd)]
4   solf[, c('month', 'year') := .(month(Dates), year(Dates))]

```

```

5     solf[,Bo0m := mean(Bo0d), by = .(month, year)]
6     G0df <- G0dm@data[, .(Dates, G0d)]
7     G0df[, c('month', 'year') := .(month(Dates), year(Dates))]
8     G0df[, G0d := mean(G0d), by = .(month, year)]
9     Ktm <- G0df$G0d/solf$Bo0m
10    return(Ktm)
11  }
12
13  ##### daily Kt #####
14  Ktd <- function(sol, G0d){
15    Bo0d <- sol@solD$Bo0d
16    G0d <- getG0(G0d)
17    Ktd <- G0d/Bo0d
18    return(Ktd)
19  }
20
21  ### intradaily
22  Kti <- function(sol, G0i){
23    Bo0 <- sol@solI$Bo0
24    G0i <- getG0(G0i)
25    Kti <- G0i/Bo0
26    return(Kti)
27  }
28
29
30  ##### monthly correlations #####
31
32  ### Page ###
33  FdKtPage <- function(sol, G0dm){
34    Kt <- Ktm(sol, G0dm)
35    Fd=1-1.13*Kt
36    return(data.table(Fd, Kt))
37  }
38
39  ### Liu and Jordan ###
40  FdKtLJ <- function(sol, G0dm){
41    Kt <- Ktm(sol, G0dm)
42    Fd=(Kt<0.3)*0.595774 +
43      (Kt>=0.3 & Kt<=0.7)*(1.39-4.027*Kt+5.531*Kt^2-3.108*Kt^3)+
44      (Kt>0.7)*0.215246
45    return(data.table(Fd, Kt))
46  }
47
48
49  ##### daily correlations #####
50
51  ### Collares-Pereira and Rabl
52  FdKtCPR <- function(sol, G0d){
53    Kt <- Ktd(sol, G0d)
54    Fd=(0.99*(Kt<=0.17))+(Kt>0.17 & Kt<0.8)*
55      (1.188-2.272*Kt+9.473*Kt^2-21.856*Kt^3+14.648*Kt^4)+
56      (Kt>=0.8)*0.2426688
57    return(data.table(Fd, Kt))
58  }
59
60  ### Erbs, Klein and Duffie ###

```

```

61 FdKtEKDd <- function(sol, G0d){
62   ws <- sol@solD$ws
63   Kt <- Ktd(sol, G0d)
64
65   WS1=(abs(ws)<1.4208)
66   Fd=WS1*((Kt<0.715)*(1-0.2727*Kt+2.4495*Kt^2-11.9514*Kt^3+9.3879*Kt^4)+
67     (Kt>=0.715)*(0.143))+
68     !WS1*((Kt<0.722)*(1+0.2832*Kt-2.5557*Kt^2+0.8448*Kt^3)+
69     (Kt>=0.722)*(0.175))
70   return(data.table(Fd, Kt))
71 }
72
73 ### CLIMED1 ###
74 FdKtCLIMEDd <- function(sol, G0d){
75   Kt <- Ktd(sol, G0d)
76   Fd=(Kt<=0.13)*(0.952)+
77     (Kt>0.13 & Kt<=0.8)*(0.868+1.335*Kt-5.782*Kt^2+3.721*Kt^3)+
78     (Kt>0.8)*0.141
79   return(data.table(Fd, Kt))
80 }
81
82 ##### intradaily correlations #####
83
84 ### intradaily EKD ###
85 FdKtEKDh <- function(sol, G0i){
86   Kt <- Kti(sol, G0i)
87   Fd=(Kt<=0.22)*(1-0.09*Kt)+
88     (Kt>0.22 & Kt<=0.8)*(0.9511-0.1604*Kt+4.388*Kt^2-16.638*Kt^3+12.336*Kt^4)+
89     (Kt>0.8)*0.165
90   return(data.table(Fd, Kt))
91 }
92
93 ### intradaily CLIMED
94 FdKtCLIMEDh <- function(sol, G0i){
95   Kt <- Kti(sol, G0i)
96   Fd=(Kt<=0.21)*(0.995-0.081*Kt)+
97     (Kt>0.21 & Kt<=0.76)*(0.724+2.738*Kt-8.32*Kt^2+4.967*Kt^3)+
98     (Kt>0.76)*0.180
99   return(data.table(Fd, Kt))
100 }
101
102 ### intradaily Boland, Ridley and Lauret ###
103 FdKtBRL <- function(sol, G0i){
104   Kt <- Kti(sol, G0i)
105   sample <- sol@sample
106
107   solI <- as.data.tableI(sol, complete = TRUE)
108   w <- solI$w
109   night <- solI$night
110   AlS <- solI$AlS
111
112   G0d <- MeteoI2Meteod(G0i)
113   ktd <- Ktd(sol, G0d)
114
115   ##persistence
116   pers <- persistence(sol, ktd)

```

```

117
118   ##indexRep for ktd and pers
119   Dates <- indexI(sol)
120   x <- as.Date(Dates)
121   ind.rep <- cumsum(c(1, diff(x) != 0))
122   ktd <- ktd[ind.rep]
123   pers <- pers[ind.rep]
124
125   ##fd calculation
126   Fd=(1+exp(-5.38+6.63*Kt+0.006*r2h(w)-0.007*r2d(ALS)+1.75*ktd+1.31*pers))^-1)
127
128   return(data.table(Fd, Kt))
129 }
130
131 persistence <- function(sol, Ktd){
132   kt <- data.table(indexD(sol), Ktd)
133   ktNA <- na.omit(kt)
134   iDay <- truncDay(ktNA[[1]])
135
136   x <- rle(as.numeric(iDay))$lengths
137   xLast <- cumsum(x)
138
139   lag1 <- shift(ktNA$Ktd, -1, fill = NA)
140   for (i in xLast){
141     if ((i-1) != 0){lag1[i] <- ktNA$Ktd[i-1]}
142   }
143
144   lag2 <- shift(ktNA$Ktd, 1, fill = NA)
145   for (i in xLast){
146     if ((i+1) <= length(ktNA$Ktd)){lag2[i] <- ktNA$Ktd[i+1]}
147   }
148   pers <- data.table(lag1, lag2)
149   pers[, mean := 1/2 * (lag1+lag2)]
150   pers[, mean]
151 }

```

## fBTd

```

1 fBTd<-function(mode='prom',
2               year= as.POSIXlt(Sys.Date())$year+1900,
3               start=paste('01-01-',year,sep=''),
4               end=paste('31-12-',year,sep=''),
5               format='%d-%m-%Y'){
6   promDays<-c(17,14,15,15,15,10,18,18,18,19,18,13)
7   BTd=switch(mode,
8             serie={
9               start.<-as.POSIXct(start, format=format, tz='UTC')
10              end.<-as.POSIXct(end, format=format, tz='UTC')
11              res<-seq(start., end., by="1 day")
12            },
13             prom=as.POSIXct(paste(year, 1:12, promDays, sep='-'), tz='UTC')
14             )
15   BTd
16 }

```



**fBTi**

```

1 intervalo <- function(day, sample){
2   intervalo <- seq.POSIXt(from = as.POSIXct(paste(day, '00:00:00'), tz = 'UTC')
3   ,
4   to = as.POSIXct(paste(day, '23:59:59'), tz = 'UTC'),
5   by = sample)
6   return(intervalo)
7 }
8 fBTi <- function(d, sample = 'hour'){
9   BTi <- lapply(d, intervalo, sample)
10  BTi <- do.call(c, BTi)
11  return(BTi)
12 }

```

**fCompD**

```

1 fCompD <- function(sol, G0d, corr = 'CPR', f)
2 {
3   if(!(corr %in% c('CPR', 'Page', 'LJ', 'EKDd', 'CLIMEDd', 'user', 'none'))){
4     warning('Wrong descriptor of correlation Fd-Ktd. Set CPR.')
5     corr <- 'CPR'
6   }
7   if(class(sol)[1] != 'Sol'){
8     sol <- sol[, calcSol(lat = unique(lat), BTi = Dates)]
9   }
10  if(class(G0d)[1] != 'Meteo'){
11    dt <- copy(data.table(G0d))
12    if(!('Dates' %in% names(dt))){
13      dt[, Dates := indexD(sol)]
14      setcolorder(dt, 'Dates')
15      setkey(dt, 'Dates')
16    }
17    if('lat' %in% names(dt)){
18      latg <- unique(dt$lat)
19      dt[, lat := NULL]
20    }else{latg <- getLat(sol)}
21    G0d <- dt2Meteo(dt, latg)
22  }
23
24  stopifnot(indexD(sol) == indexD(G0d))
25  Bo0d <- sol@solD$Bo0d
26  G0 <- getData(G0d)$G0
27
28  is.na(G0) <- (G0>Bo0d)
29
30  ### the Direct and Difuse data is not given
31  if(corr != 'none'){
32    Fd <- switch(corr,
33      CPR = FdKtCPR(sol, G0d),
34      Page = FdKtPage(sol, G0d),
35      LJ = FdKtLJ(sol, G0d),
36      CLIMEDd = FdKtCLIMEDd(sol, G0d),
37      user = f(sol, G0d))

```

```

38     Kt <- Fd$Kt
39     Fd <- Fd$Fd
40     D0d <- Fd * G0
41     B0d <- G0 - D0d
42   }
43   ### the Direct and Difuse data is given
44   else {
45     G0 <- getData(G0d)$G0
46     D0d <- getData(G0d)[['D0']]
47     B0d <- getData(G0d)[['B0']]
48     Fd <- D0d/G0
49     Kt <- G0/Bo0d
50   }
51
52   result <- data.table(Dates = indexD(sol), Fd, Kt, G0d = G0, D0d, B0d)
53   setkey(result, 'Dates')
54   result
55 }

```

### fCompI

```

1 fCompI <- function(sol, compD, GOI,
2                       corr = 'EKDh', f,
3                       filterG0 = TRUE){
4   if(!(corr %in% c('EKDh', 'CLIMEDh', 'BRL', 'user', 'none'))){
5     warning('Wrong descriptor of correlation Fd-Ktd. Set EKDh.')
6     corr <- 'EKDh'
7   }
8
9   if(class(sol)[1] != 'Sol'){
10     sol <- sol[, calcSol(lat = unique(lat), BTi = Dates)]
11   }
12
13   lat <- sol@lat
14   sample <- sol@sample
15   night <- sol@solI$night
16   Bo0 <- sol@solI$Bo0
17   Dates <- indexI(sol)
18
19   ## If instantaneous values are not provided, compD is used instead.
20   if (missing(GOI)) {
21
22     GOI <- collper(sol, compD)
23     G0 <- GOI$G0
24     B0 <- GOI$B0
25     D0 <- GOI$D0
26
27     Fd <- D0/G0
28     Kt <- G0/Bo0
29
30   } else { ## Use instantaneous values if provided through GOI
31
32     if(class(GOI)[1] != 'Meteo'){
33       dt <- copy(GOI)
34       if(!('Dates' %in% names(GOI))){

```

```

35         dt[, Dates := indexI(sol)]
36         setcolorder(dt, 'Dates')
37         setkey(dt, 'Dates')
38     }
39     if('lat' %in% names(GOI)){latg <- unique(GOI$lat)}
40     else{latg <- lat}
41     GOI <- dt2Meteo(dt, latg)
42 }
43
44 if (corr!='none'){
45     GO <- getGO(GOI)
46     ## Filter values: surface irradiation must be lower than
47     ## extraterrestrial;
48     if (filterGO) {is.na(GO) <- (GO > Bo0)}
49
50     ## Fd-Kt correlation
51     Fd <- switch(corr,
52                 EKDh = FdKtEKDh(sol, GOI),
53                 CLIMEDh = FdKtCLIMEDh(sol, GOI),
54                 BRL = FdKtBRL(sol, GOI),
55                 user = f(sol, GOI))
56
57     Kt <- Fd$Kt
58     Fd <- Fd$Fd
59     DO <- Fd * GO
60     BO <- GO - DO
61
62 } else {
63     GO <- getGO(GOI)
64     DO <- getData(GOI)[['DO']]
65     BO <- getData(GOI)[['BO']]
66     ## Filter values: surface irradiation must be lower than
67     ## extraterrestrial;
68     if (isTRUE(filterGO)) is.na(GO) <- is.na(DO) <- is.na(BO) <- (GO >
Bo0)
69
70     Fd <- DO/GO
71     Kt <- GO/Bo0
72 }
73 }
74 ## Values outside sunrise-sunset are set to zero
75 GO[night] <- DO[night] <- BO[night] <- Kt[night] <- Fd[night] <- 0
76
77 result <- data.table(Dates, Fd, Kt, GO, DO, BO)
78 setkey(result, 'Dates')
79 result
80 }

```

### fInclin

```

1 fInclin <- function(compI, angGen, iS = 2, alb = 0.2, horizBright = TRUE, HCPV =
FALSE){
2     ##compI es class='GO'
3
4     ##Arguments

```

```

5  stopifnot(iS %in% 1:4)
6  Beta <- angGen$Beta
7  Alfa <- angGen$Alfa
8  cosTheta <- angGen$cosTheta
9
10 comp <- as.data.tableI(compI, complete=TRUE)
11 night <- comp$night
12 B0 <- comp$B0
13 Bo0 <- comp$Bo0
14 D0 <- comp$D0
15 G0 <- comp$G0
16 cosThzS <- comp$cosThzS
17 is.na(cosThzS) <- night
18
19 ##N.Martin method for dirt and non-perpendicular incidence
20 Suc <- rbind(c(1, 0.17, -0.069),
21             c(0.98,.2,-0.054),
22             c(0.97,0.21,-0.049),
23             c(0.92,0.27,-0.023))
24 FTb <- (exp(-cosTheta/Suc[iS,2]) - exp(-1/Suc[iS,2]))/(1 - exp(-1/Suc[iS,2]))
25 FTd <- exp(-1/Suc[iS,2] * (4/(3*pi) * (sin(Beta) + (pi - Beta - sin(Beta))/(1
26   + cos(Beta)))) +
27   Suc[iS,3] * (sin(Beta) + (pi - Beta - sin(Beta))/(
28   (1 + cos(Beta)))^2))
29   FTr <- exp(-1/Suc[iS,2] * (4/(3*pi) * (sin(Beta) + (Beta - sin(Beta))/(1 -
30   cos(Beta)))) +
31   Suc[iS,3] * (sin(Beta) + (Beta - sin(Beta))/(1 -
32   cos(Beta)))^2))
33
34 ##Hay and Davies method for diffuse treatment
35 B <- B0 * cosTheta/cosThzS * (cosThzS>0.007) #The factor cosThzS>0.007 is
36   needed to eliminate erroneous results near dawn
37 k1 <- B0/(Bo0)
38 Di <- D0 * (1-k1) * (1+cos(Beta))/2
39 if (horizBright) Di <- Di * (1+sqrt(B0/G0) * sin(Beta/2)^3)
40 Dc <- D0 * k1 * cosTheta/cosThzS * (cosThzS>0.007)
41 R <- alb * G0 * (1-cos(Beta))/2
42 D <- (Di + Dc)
43
44 ##Extraterrestrial irradiance on the inclined plane
45 Bo <- Bo0 * cosTheta/cosThzS * (cosThzS>0.007)
46 ##Normal direct irradiance (DNI)
47 Bn <- B0/cosThzS
48 ##Sum of components
49 G <- B + D + R
50 Ref <- R * Suc[iS,1] * (1-FTr) * (!HCPV)
51 Ref[is.nan(FTr)] <- 0 #When cos(Beta)=1, FTr=NaN. Cancel Ref.
52 Dief <- Di * Suc[iS,1] * (1 - FTd) * (!HCPV)
53 Dcef <- Dc * Suc[iS,1] * (1 - FTb) * (!HCPV)
54 Def <- Dief + Dcef
55 Bef <- B * Suc[iS,1] * (1 - FTb)
56 Gef <- Bef + Def + Ref
57
58 result <- data.table(Bo, Bn,
59                     G, D, Di, Dc, B, R,
60                     FTb, FTd, FTr,
61                     Dief, Dcef, Gef, Def, Bef, Ref)

```

```

56
57     ## Use 0 instead of NA for irradiance values
58     result[night] <- 0
59     result[, Dates := indexI(compI)]
60     result[, .SD, by = Dates]
61     setcolorder(result, c('Dates', names(result)[-length(result)]))
62     result
63 }

```

### fProd

```

1  ## voc, isc, vmpp, impp : *cell* values
2  ## Voc, Isc, Vmpp, Impp: *module/generator* values
3
4  ## Compute Current - Voltage characteristic of a solar *cell* with Gef
5  ## and Ta
6  iv <- function(vocn, iscn, vmn, imn,
7                TONC, CoefVT = 2.3e-3,
8                Ta, Gef,
9                vmin = NULL, vmax = NULL)
10 {
11     ##Cell Constants
12     Gstc <- 1000
13     Ct <- (TONC - 20) / 800
14     Vtn <- 0.025 * (273 + 25) / 300
15     m <- 1.3
16
17     ##Cell temperature
18     Tc <- Ta + Ct * Gef
19     Vt <- 0.025 * (Tc + 273)/300
20
21     ## Series resistance
22     Rs <- (vocn - vmn + m * Vtn * log(1 - imn/iscn)) / imn
23
24     ## Voc and Isc at ambient conditions
25     voc <- vocn - CoefVT * (Tc - 25)
26     isc <- iscn * Gef/Gstc
27
28     ## Ruiz method for computing voltage and current characteristic of a *cell*
29     rs <- Rs * isc/voc
30     koc <- voc/(m * Vt)
31
32     ## Maximum Power Point
33     Dm0 <- (koc - 1)/(koc - log(koc))
34     Dm <- Dm0 + 2 * rs * Dm0^2
35
36     impp <- isc * (1 - Dm/koc)
37     vmpp <- voc * (1 - log(koc/Dm)/koc - rs * (1 - Dm/koc))
38
39     vdc <- vmpp
40     idc <- impp
41
42     ## When the MPP is below/above the inverter voltage limits, it
43     ## sets the voltage point at the corresponding limit.
44

```

```

45
46 ## Auxiliary functions for computing the current at a defined
47 ## voltage.
48 ilimit <- function(v, koc, rs)
49 {
50   if (is.na(koc))
51     result <- NA
52   else
53   {
54     ## The IV characteristic is an implicit equation. The starting
55     ## point is the voltage of the cell (imposed by the inverter
56     ## limit).
57
58     izero <- function(i , v, koc, rs)
59     {
60       vp <- v + i * rs
61       Is <- 1/(1 - exp(-koc * (1 - rs)))
62       result <- i - (1 - Is * (exp(-koc * (1 - vp)) - exp(-koc * (1 -
rs))))))
63     }
64
65     result <- uniroot(f = izero,
66                       interval = c(0,1),
67                       v = v,
68                       koc = koc,
69                       rs = rs)$root
70   }
71   result
72 }
73 ## Inverter minimum voltage
74 if (!is.null(vmin))
75 {
76   if (any(vmpp < vmin, na.rm = TRUE))
77   {
78     indMIN <- which(vmpp < vmin)
79     imin <- sapply(indMIN, function(i)
80     {
81       vocMIN <- voc[i]
82       kocMIN <- koc[i]
83       rsMIN <- rs[i]
84       vmin <- vmin/vocMIN
85       ##v debe estar entre 0 y 1
86       vmin[vmin < 0] <- 0
87       vmin[vmin > 1] <- 1
88       ilimit(vmin, kocMIN, rsMIN)
89     })
90     iscMIN <- isc[indMIN]
91     idc[indMIN] <- imin * iscMIN
92     vdc[indMIN] <- vmin
93     warning('Minimum MPP voltage of the inverter has been reached')}
94   }
95
96   if (!is.null(vmax))
97   {
98     if (any(vmpp > vmax, na.rm = TRUE))
99     {

```

```

100     indMAX <- which(vmpp > vmax)
101     imax <- sapply(indMAX, function(i)
102     {
103         vocMAX <- voc[i]
104         kocMAX <- koc[i]
105         rsMAX <- rs[i]
106         vmax <- vmax / vocMAX
107         ##v debe estar entre 0 y 1
108         vmax[vmax < 0] <- 0
109         vmax[vmax > 1] <- 1
110         ilimit(vmax, kocMAX, rsMAX)
111     })
112     iscMAX <- isc[indMAX]
113     idc[indMAX] <- imax * iscMAX
114     vdc[indMAX] <- vmax
115     warning('Maximum MPP voltage of the inverter has been reached')
116 }
117 }
118 data.table(Ta, Tc, Gef, voc, isc, vmpp, impp, vdc, idc)
119 }
120
121 fProd <- function(inclin,
122                   module=list(),
123                   generator=list(),
124                   inverter=list(),
125                   effSys=list()
126                   )
127 {
128
129     stopifnot(is.list(module),
130               is.list(generator),
131               is.list(inverter),
132               is.list(effSys)
133               )
134     ## Extract data from objects
135     if (class(inclin)[1]=='Gef') {
136         indInclin <- indexI(inclin)
137         gefI <- as.data.tableI(inclin, complete = TRUE)
138         Gef <- gefI$Gef
139         Ta <- gefI$Ta
140     } else {
141         Gef <- inclin$Gef
142         Ta <- inclin$Ta
143     }
144
145     ## Module, generator, and inverter parameters
146     module.default <- list(Vocn = 57.6,
147                            Iscn = 4.7,
148                            Vmn = 46.08,
149                            Imn = 4.35,
150                            Ncs = 96,
151                            Ncp = 1,
152                            CoefVT = 0.0023,
153                            TONC = 47)
154     module <- modifyList(module.default, module)
155     ## Make these parameters visible because they will be used often.

```

```

156 Ncs <- module$Ncs
157 Ncp <- module$Ncp
158
159 generator.default <- list(Nms = 12,
160                           Nmp = 11)
161 generator <- modifyList(generator.default, generator)
162 generator$Pg <- (module$Vmn * generator$Nms) *
163               (module$Imn * generator$Nmp)
164 Nms <- generator$Nms
165 Nmp <- generator$Nmp
166
167 inverter.default <- list(Ki = c(0.01,0.025,0.05),
168                           Pinv = 25000,
169                           Vmin = 420,
170                           Vmax = 750,
171                           Gumb = 20)
172 inverter <- modifyList(inverter.default, inverter)
173 Pinv <- inverter$Pinv
174
175 effSys.default <- list(ModQual = 3,
176                       ModDisp = 2,
177                       OhmDC = 1.5,
178                       OhmAC = 1.5,
179                       MPP = 1,
180                       TrafoMT = 1,
181                       Disp = 0.5)
182 effSys <- modifyList(effSys.default, effSys)
183
184 ## Solar Cell i-v
185 vocn <- with(module, Vocn / Ncs)
186 iscn <- with(module, Iscn / Ncp)
187 vmn <- with(module, Vmn / Ncs)
188 imn <- with(module, Imn / Ncp)
189 vmin <- with(inverter, Vmin / (Ncs * Nms))
190 vmax <- with(inverter, Vmax / (Ncs * Nms))
191
192 cell <- iv(vocn, iscn,
193           vmn, imn,
194           module$TONC, module$CoefVT,
195           Ta, Gef,
196           vmin, vmax)
197
198 ## Generator voltage and current
199 Idc <- Nmp * Ncp * cell$idc
200 Isc <- Nmp * Ncp * cell$isc
201 Impp <- Nmp * Ncp * cell$impp
202 Vdc <- Nms * Ncs * cell$vdc
203 Voc <- Nms * Ncs * cell$voc
204 Vmpp <- Nms * Ncs * cell$vmpp
205
206 ##DC power (normalization with nominal power of inverter)
207 ##including losses
208 PdcN <- with(effSys, (Idc * Vdc) / Pinv *
209               (1 - ModQual / 100) *
210               (1 - ModDisp / 100) *
211               (1 - MPP / 100) *

```



```

212         (1 - OhmDC / 100)
213     )
214
215     ##Normalized AC power to the inverter
216     Ki <- inverter$Ki
217     if (is.matrix(Ki)) { #Ki is a matrix of nine coefficients-->dependence with
        tension
218         VP <- cbind(Vdc, PdcN)
219         PacN <- apply(VP, 1, solvePac, Ki)
220     } else { #Ki is a vector of three coefficients-->without dependence on
        voltage
221         A <- Ki[3]
222         B <- Ki[2] + 1
223         C <- Ki[1] - (PdcN)
224         PacN <- (-B + sqrt(B^2 - 4 * A * C))/(2 * A)
225     }
226     EffI <- PacN / PdcN
227     pacNeg <- PacN <= 0
228     PacN[pacNeg] <- PdcN[pacNeg] <- EffI[pacNeg] <- 0
229
230
231     ##AC and DC power without normalization
232     Pac <- with(effSys, PacN * Pinv *
233         (Gef > inverter$Gumb) *
234         (1 - OhmAC / 100) *
235         (1 - TrafoMT / 100) *
236         (1 - Disp / 100))
237     Pdc <- PdcN * Pinv * (Pac > 0)
238
239
240     ## Result
241     resProd <- data.table(Tc = cell$Tc,
242         Voc, Isc,
243         Vmpp, Impp,
244         Vdc, Idc,
245         Pac, Pdc,
246         EffI)
247     if (class(inclin)[1] %in% 'Gef'){
248         result <- resProd[, .SD,
249             by=.(Dates = indInclin)]
250         attr(result, 'generator') <- generator
251         attr(result, 'module') <- module
252         attr(result, 'inverter') <- inverter
253         attr(result, 'effSys') <- effSys
254         return(result)
255     } else {
256         result <- cbind(inclin, resProd)
257         return(result)
258     }
259 }

```

### fPump

```

1 fPump <- function(pump, H){
2

```

```

3      w1=3000 ##synchronous rpm frequency
4      wm=2870 ##rpm frequency with slip when applying voltage at 50 Hz
5      s=(w1-wm)/w1
6      fen=50 ##Nominal electrical frequency
7      fmin=sqrt(H/pump$a)
8      fmax=with(pump, (-b*Qmax+sqrt(b^2*Qmax^2-4*a*(c*Qmax^2-H)))/(2*a))
9      ##fb is rotation frequency (Hz) of the pump,
10     ##fe is the electrical frequency applied to the motor
11     ##which makes it rotate at a frequency fb (and therefore also the pump).
12     fb=seq(fmin,min(60,fmax),length=1000) #The maximum frequency is 60
13     fe=fb/(1-s)
14
15     ###Flow
16     Q=with(pump, (-b*fb-sqrt(b^2*fb^2-4*c*(a*fb^2-H)))/(2*c))
17     Qmin=0.1*pump$Qn*fb/50
18     Q=Q+(Qmin-Q)*(Q<Qmin)
19
20     ###Hydraulic power
21     Ph=2.725*Q*H
22
23     ###Mechanical power
24     Q50=50*Q/fb
25     H50=H*(50/fb)^2
26     etab=with(pump, j*Q50^2+k*Q50+1)
27     Pb50=2.725*H50*Q50/etab
28     Pb=Pb50*(fb/50)^3
29
30     ###Electrical power
31     Pbc=Pb*50/fe
32     etam=with(pump, g*(Pbc/Pmn)^2+h*(Pbc/Pmn)+i)
33     Pmc=Pbc/etam
34     Pm=Pmc*fe/50
35     Pac=Pm
36     ##Pdc=Pm/(etac*(1-cab))
37
38     ###I build functions for flow, frequency and powers
39     ###to adjust the AC power.
40     fQ<-splinefun(Pac,Q)
41     fFreq<-splinefun(Pac,fe)
42     fPb<-splinefun(Pac,Pb)
43     fPh<-splinefun(Pac,Ph)
44     lim=c(min(Pac),max(Pac))
45     ##lim marks the operating range of the pump
46     result<-list(lim = lim,
47                  fQ = fQ,
48                  fPb = fPb,
49                  fPh = fPh,
50                  fFreq = fFreq)
51 }

```

## fSold

```

1 fSold <- function(lat, BTd, method = 'michalsky'){
2   if (abs(lat) > 90){
3     lat <- sign(lat) * 90

```

```

4      warning(paste('Latitude outside acceptable values. Set to', lat))
5    }
6    sun <- data.table(Dates = unique(as.IDate(BTd)),
7                     lat = lat)
8
9    ##### solarAngles #####
10
11    ##Declination
12    sun[, decl := declination(Dates, method = method)]
13    ##Eccentricity
14    sun[, eo := eccentricity(Dates, method = method)]
15    ##Equation of time
16    sun[, EoT := eot(Dates)]
17    ##Solar time
18    sun[, ws := sunrise(Dates, lat, method = method,
19                       decl = decl)]
20    ##Extraterrestrial irradiance
21    sun[, Bo0d := bo0d(Dates, lat, method = method,
22                      decl = decl,
23                      eo = eo,
24                      ws = ws
25                      )]
26    setkey(sun, Dates)
27    return(sun)
28  }

```

### fSolI

```

1 fSolI <- function(sold, sample = 'hour', BTi,
2                   EoT = TRUE, keep.night = TRUE, method = 'michalsky')
3 {
4   #Solar constant
5   Bo <- 1367
6
7   if(missing(BTi)){
8     d <- sold$Dates
9     BTi <- fBTi(d, sample)
10  }
11  sun <- data.table(Dates = as.IDate(BTi),
12                  Times = as.ITime(BTi))
13  sun <- merge(sold, sun, by = 'Dates')
14  sun[, eqtime := EoT]
15  sun[, EoT := NULL]
16
17  #sun hour angle
18  sun[, w := sunHour(Dates, BTi, EoT = EoT, method = method, eqtime = eqtime)]
19
20  #classify night elements
21  sun[, night := abs(w) >= abs(ws)]
22
23  #zenith angle
24  sun[, cosThzS := zenith(Dates, lat, BTi,
25                          method = method,
26                          decl = decl,
27                          w = w

```

```

28         ])
29
30     #solar altitude angle
31     sun[, Als := asin(cosThzS)]
32
33     #azimuth
34     sun[, AzS := azimuth(Dates, lat, BTi, sample,
35                          method = method,
36                          decl = decl,
37                          w = w,
38                          cosThzS = cosThzS)]
39
40     #Extraterrestrial irradiance
41     sun[, Bo0 := Bo * eo * cosThzS]
42
43     #When it is night there is no irradiance
44     sun[night == TRUE, Bo0 := 0]
45
46     #Erase columns that are in sold
47     sun[, decl := NULL]
48     sun[, eo := NULL]
49     sun[, eqtime := NULL]
50     sun[, ws := NULL]
51     sun[, Bo0d := NULL]
52
53     #Column Dates with Times
54     sun[, Dates := as.POSIXct(Dates, Times, tz = 'UTC')]
55     sun[, Times := NULL]
56
57     #keep night
58     if(!keep.night){
59         sun <- sun[night == FALSE]
60     }
61
62     return(sun)
63 }

```

## fSombra

```

1 fSombra<-function(angGen, distances, struct, modeTrk='fixed',prom=TRUE){
2
3     stopifnot(modeTrk %in% c('two','horiz','fixed'))
4     res=switch(modeTrk,
5                two={fSombra6(angGen, distances, struct, prom)},
6                horiz={fSombraHoriz(angGen, distances, struct)},
7                fixed= {fSombraEst(angGen, distances, struct)}
8                )
9     return(res)
10 }

```

```

1 fSombra2X<-function(angGen,distances,struct)
2 {
3     stopifnot(is.list(struct),is.data.frame(distances))
4     ##I prepare starting data
5     P=with(struct,distances/W)

```

```

6      b=with(struct,L/W)
7      AzS=angGen$AzS
8      Beta=angGen$Beta
9      AlS=angGen$AlS
10
11     d1=abs(P$Lew*cos(AzS)-P$Lns*sin(AzS))
12     d2=abs(P$Lew*sin(AzS)+P$Lns*cos(AzS))
13     FC=sin(AlS)/sin(Beta+AlS)
14     s=b*cos(Beta)+(b*sin(Beta)+P$H)/tan(AlS)
15     FS1=1-d1
16     FS2=s-d2
17     SombraCond=(FS1>0)*(FS2>0)*(P$Lew*AzS>=0)
18     SombraCond[is.na(SombraCond)]<-FALSE #NAs are of no use to me in a logical
19     vector. I replace them with FALSE
20     ## Result
21     FS=SombraCond*(FS1*FS2*FC)/b
22     FS[FS>1]<-1
23     return(FS)
24 }

```

```

1  fSombra6<-function(angGen, distances, struct, prom=TRUE)
2  {
3      stopifnot(is.list(struct),
4                is.data.frame(distances))
5      ##distances only has three distances, so I generate a grid
6      if (dim(distances)[1]==1){
7          Red <- distances[, .(Lew = c(-Lew, 0, Lew, -Lew, Lew),
8                                     Lns = c(Lns, Lns, Lns, 0, 0),
9                                     H=H)]
10     } else { #distances is an array, so there is no need to generate the grid
11         Red<-distances[1:5,] #I only need the first 5 rows...necessary in case a
12         wrong data.frame is delivered
13
14     ## I calculate the shadow due to each of the 5 followers
15     SombraGrupo<-matrix(ncol=5,nrow=dim(angGen)[1]) ###VECTORIZE
16     for (i in 1:5) {SombraGrupo[,i]<-fSombra2X(angGen,Red[i,],struct)}
17     ##To calculate the Average Shadow, I need the number of followers in each
18     position (distrib)
19     distrib=with(struct,c(1,Ncol-2,1,Nrow-1,(Ncol-2)*(Nrow-1),Nrow-1))
20     vProm=c(sum(distrib[c(5,6)]),
21             sum(distrib[c(4,5,6)]),
22             sum(distrib[c(4,5)]),
23             sum(distrib[c(2,3,5,6)]),
24             sum(distrib[c(1,2,4,5)]))
25     Nseg=sum(distrib) ##Total number of followers
26     ##With the SWEEP function I multiply the Shadow Factor of each type (
27     ShadowGroup columns) by the vProm result
28
29     if (prom==TRUE){
30         ## Average Shadow Factor in the group of SIX followers taking into
31         account distribution
32         FS=rowSums(sweep(SombraGrupo,2,vProm,'*'))/Nseg
33         FS[FS>1]<-1
34     } else {
35         ## Shadow factor on follower #5 due to the other 5 followers
36         FS=rowSums(SombraGrupo)
37     }
38 }

```

```

33     FS[FS>1]<-1}
34     return(FS)
35 }

```

```

1 fSombraEst<-function(angGen, distances, struct)
2 {
3     stopifnot(is.list(struct),is.data.frame(distances))
4     ## I prepare starting data
5     dist <- with(struct, distances/L)
6     Alfa <- angGen$Alfa
7     Beta <- angGen$Beta
8     AlS <- angGen$AlS
9     AzS <- angGen$AzS
10    cosTheta <- angGen$cosTheta
11    h <- dist$H #It must be previously normalized
12    d <- dist$D
13    ## Calculations
14    s=cos(Beta)+cos(Alfa-AzS)*(sin(Beta)+h)/tan(AlS)
15    FC=sin(AlS)/sin(Beta+AlS)
16    SombraCond=(s-d>0)
17    FS=(s-d)*SombraCond*FC*(cosTheta>0)
18    ## Result
19    FS=FS*(FS>0)
20    FS[FS>1]<-1
21    return(FS)
22 }

```

```

1 fSombraHoriz<-function(angGen, distances, struct)
2 {
3     stopifnot(is.list(struct),is.data.frame(distances))
4     ## I prepare starting data
5     d <- with(struct, distances/L)
6     AzS <- angGen$AzS
7     AlS <- angGen$AlS
8     Beta <- angGen$Beta
9     lew <- d$Lew #It must be previously normalized
10    ## Calculations
11    Beta0=atan(abs(sin(AzS)/tan(AlS)))
12    FS=1-lew*cos(Beta0)/cos(Beta-Beta0)
13    SombraCond=(FS>0)
14    ## Result
15    FS=FS*SombraCond
16    FS[FS>1]<-1
17    return(FS)
18 }

```

## fTemp

```

1 fTemp<-function(sol, BD)
2 {
3     ##sol is an object with class='Sol'
4     ##BD is an object with class='Meteo', whose 'data' slot contains two columns
5     called "TempMax" and "TempMin"

```

```

6   stopifnot(class(sol)=='Sol')
7   stopifnot(class(BD)=='Meteo')
8
9   checkIndexD(indexD(sol), indexD(BD))
10
11  Dates<-indexI(sol)
12  x <- as.Date(Dates)
13  ind.rep <- cumsum(c(1, diff(x) != 0))
14
15  TempMax <- BD@data$TempMax[ind.rep]
16  TempMin <- BD@data$TempMin[ind.rep]
17  ws <- sol@solD$ws[ind.rep]
18  w <- sol@solI$w
19
20  ##Generate temperature sequence from database Maxima and Minima
21
22  Tm=(TempMin+TempMax)/2
23  Tr=(TempMax-TempMin)/2
24
25  wp=pi/4
26
27  a1=pi*12*(ws-w)/(21*pi+12*ws)
28  a2=pi*(3*pi-12*w)/(3*pi-12*ws)
29  a3=pi*(24*pi+12*(ws-w))/(21*pi+12*ws)
30
31  T1=Tm-Tr*cos(a1)
32  T2=Tm+Tr*cos(a2)
33  T3=Tm-Tr*cos(a3)
34
35  Ta=T1*(w<=ws)+T2*(w>ws&w<=wp)+T3*(w>wp)
36
37  ##Result
38  result<-data.table(Dates, Ta)
39 }

```

### fTheta

```

1  fTheta<-function(sol, beta, alfa=0, modeTrk='fixed', betaLim=90,
2    BT=FALSE, struct, dist)
3  {
4    stopifnot(modeTrk %in% c('two','horiz','fixed'))
5    if (!missing(struct)) {stopifnot(is.list(struct))}
6    if (!missing(dist)) {stopifnot(is.data.frame(dist))}
7
8    betaLim=d2r(betaLim)
9    lat=getLat(sol, 'rad')
10   signLat=ifelse(sign(lat)==0, 1, sign(lat)) ##When lat=0, sign(lat)=0. I
    change it to sign(lat)=1
11
12   solI<-as.data.tableI(sol, complete=TRUE, day = TRUE)
13   AlS=solI$AlS
14   AzS=solI$AzS
15   decl=solI$decl
16   w<-solI$w
17

```

```

18  night<-solI$night
19
20  Beta<-switch(modeTrk,
21              two = {Beta2x=pi/2-AlS
22                    Beta=Beta2x+(betaLim-Beta2x)*(Beta2x>betaLim)},
23              fixed = rep(d2r(beta), length(w)),
24              horiz={BetaHoriz0=atan(abs(sin(AzS)/tan(AlS)))
25                    if (BT){lew=dist$Lew/struct$L
26                          Longitud=lew*cos(BetaHoriz0)
27                          Cond=(Longitud>=1)
28                          Longitud[Cond]=1
29                          ## When Cond==TRUE Length=1
30                          ## and therefore asin(Length)=pi/2,
31                          ## so that BetaHoriz=BetaHoriz0
32                          BetaHoriz=BetaHoriz0+asin(Longitud)-pi/2
33                    } else {
34                      BetaHoriz=BetaHoriz0
35                      rm(BetaHoriz0)}
36              Beta=ifelse(BetaHoriz>betaLim,betaLim,BetaHoriz)}
37
38  is.na(Beta) <- night
39
40  Alfa<-switch(modeTrk,
41              two = AzS,
42              fixed = rep(d2r(alfa), length(w)),
43              horiz=pi/2*sign(AzS))
44  is.na(Alfa) <- night
45
46  cosTheta<-switch(modeTrk,
47                  two=cos(Beta-(pi/2-AlS)),
48                  horiz={
49                      t1=sin(decl)*sin(lat)*cos(Beta)
50                      t2=cos(decl)*cos(w)*cos(lat)*cos(Beta)
51                      t3=cos(decl)*abs(sin(w))*sin(Beta)
52                      cosTheta=t1+t2+t3
53                      rm(t1,t2,t3)
54                      cosTheta
55                  },
56                  fixed={
57                      t1=sin(decl)*sin(lat)*cos(Beta)
58                      t2=-signLat*sin(decl)*cos(lat)*sin(Beta)*cos(Alfa)
59                      t3=cos(decl)*cos(w)*cos(lat)*cos(Beta)
60                      t4=signLat*cos(decl)*cos(w)*sin(lat)*sin(Beta)*cos(Alfa)
61                      t5=cos(decl)*sin(w)*sin(Alfa)*sin(Beta)
62                      cosTheta=t1+t2+t3+t4+t5
63                      rm(t1,t2,t3,t4,t5)
64                      cosTheta
65                  }
66
67  is.na(cosTheta) <- night
68  cosTheta=cosTheta*(cosTheta>0) #when cosTheta<0, Theta is greater than 90°,
69  and therefore the Sun is behind the panel.
70
71  result <- data.table(Dates = indexI(sol),
72                      Beta, Alfa, cosTheta)
73  return(result)

```



73 }

**HQCurve**

```

1  ## HQCurve: no visible binding for global variable 'fb'
2  ## HQCurve: no visible binding for global variable 'Q'
3  ## HQCurve: no visible binding for global variable 'x'
4  ## HQCurve: no visible binding for global variable 'y'
5  ## HQCurve: no visible binding for global variable 'group.value'
6
7  if(getRversion() >= "2.15.1") globalVariables(c('fb', 'Q', 'x', 'y', 'group.value'
8    '))
9
10 HQCurve<-function(pump){
11   w1=3000 #synchronous rpm frequency
12   wm=2870 #rpm frequency with slip when applying voltage at 50 Hz
13   s=(w1-wm)/w1
14   fen=50 #Nominal electrical frequency
15
16   f=seq(35,50,by=5)
17   Hn=with(pump,a*50^2+b*50*Qn+c*Qn^2) #height corresponding to flow rate and
18     nominal frequency
19   kiso=Hn/pump$Qn^2 #To paint the isoyield curve I take into account the laws of
20     similarity
21   Qiso=with(pump,seq(0.1*Qn,Qmax,l=10))
22   Hiso=kiso*Qiso^2 #Isoperformance curve
23
24   Curva<-expand.grid(fb=f,Q=Qiso)
25
26   Curva<-within(Curva,{
27     fe=fb/(1-s)
28     H=with(pump,a*fb^2+b*fb*Q+c*Q^2)
29
30     is.na(H) <- (H<0)
31     Q50=50*Q/fb
32     H50=H*(50/fb)^2
33     etab=with(pump,j*Q50^2+k*Q50+l)
34     Pb50=2.725*H50*Q50/etab
35     Pb=Pb50*(fb/50)^3
36
37     Pbc=Pb*50/fe
38     etam=with(pump,g*(Pbc/Pmn)^2+h*(Pbc/Pmn)+i)
39     Pmc=Pbc/etam
40     Pm=Pmc*fe/50
41
42     etac=0.95 #Variable frequency drive performance
43     cab=0.05 #Cable losses
44     Pdc=Pm/(etac*(1-cab))
45     rm(etac,cab,Pmc,Pbc,Pb50,Q50,H50)
46   })
47
48   ###H-Q curve at different frequencies
49   ##I check if I have the lattice package available, which should have been
50   loaded in .First.lib

```

```

48 lattice.disp<-"lattice" %in% .packages()
49 latticeExtra.disp<-"latticeExtra" %in% .packages()
50 if (lattice.disp && latticeExtra.disp) {
51   p<-xyplot(H~Q,groups=factor(fb),data=Curva, type='l',
52             par.settings=custom.theme.2(),
53             panel=function(x,y,groups,...){
54               panel.superpose(x,y,groups,...)
55               panel.xyplot(Qiso,Hiso,col='black',...)
56               panel.text(Qiso[1], Hiso[1], 'ISO', pos=3)}
57             )
58   p=p+glayer(panel.text(x[1], y[1], group.value, pos=3))
59   print(p)
60   result<-list(result=Curva, plot=p)
61 } else {
62   warning('lattice and/or latticeExtra packages are not available. Thus, the
63   plot could not be created')
64   result<-Curva}
65 }

```

### local2Solar

```

1 local2Solar <- function(x, lon=NULL){
2   tz=attr(x, 'tzone')
3   if (tz==' ' || is.null(tz)) {tz='UTC'}
4   ##Daylight savings time
5   AO=3600*dst(x)
6   AOneg=(AO<0)
7   if (any(AOneg)) {
8     AO[AOneg]=0
9     warning('Some Daylight Savings Time unknown. Set to zero.')
10  }
11  ##Difference between local longitude and time zone longitude LH
12  LH=lonHH(tz)
13  if (is.null(lon))
14    {deltaL=0
15   } else
16    {deltaL=d2r(lon)-LH
17  }
18  ##Local time corrected to UTC
19  tt <- format(x, tz=tz)
20  result <- as.POSIXct(tt, tz='UTC')-AO+r2sec(deltaL)
21  result
22 }

```

### markovG0

```

1 ## Objects loaded at startup from data/MTM.RData
2 if(getRversion() >= "2.15.1") globalVariables(c(
3   'MTM', ## Markov Transition Matrices
4   'Ktmtm', ## Kt limits to choose a matrix from MTM
5   'Ktlim' ## Daily kt range of each matrix.
6 ))
7
8 markovG0 <- function(G0dm, sold){

```

```

9   sold <- copy(sold)
10  timeIndex <- sold$Dates
11  BoOd <- sold$BoOd
12  BoOdm <- sold[, mean(BoOd), by = .(month(Dates), year(Dates))][[3]]
13  ktm <- G0dm/BoOdm
14
15  ##Calculates which matrix to work with for each month
16  whichMatrix <- findInterval(ktm, Ktmtm, all.inside = TRUE)
17
18  ktd <- state <- numeric(length(timeIndex))
19  state[1] <- 1
20  ktd[1] <- ktm[state[1]]
21  for (i in 2:length(timeIndex)){
22    iMonth <- month(timeIndex[i])
23    colMonth <- whichMatrix[iMonth]
24    rng <- Ktlim[, colMonth]
25    classes <- seq(rng[1], rng[2], length=11)
26    matMonth <- MTM[(10*colMonth-9):(10*colMonth),]
27    ## http://www-rohan.sdsu.edu/~babailey/stat575/mcsim.r
28    state[i] <- sample(1:10, size=1, prob=matMonth[state[i-1],])
29    ktd[i] <- runif(1, min=classes[state[i]], max=classes[state[i]+1])
30  }
31  G0dmMarkov <- data.table(ktd, BoOd)
32  G0dmMarkov <- G0dmMarkov[, mean(ktd*BoOd), by = .(month(timeIndex), year(
timeIndex))][[3]]
33  fix <- G0dm/G0dmMarkov
34  indRep <- month(timeIndex)
35  fix <- fix[indRep]
36  G0d <- data.table(Dates = timeIndex, G0d = ktd * BoOd * fix)
37  G0d
38 }

```

## NmgPVPS

```

1  ## NmgPVPS: no visible binding for global variable 'Pnom'
2  ## NmgPVPS: no visible binding for global variable 'group.value'
3
4  if(getRversion() >= "2.15.1") globalVariables(c('Pnom', 'group.value'))
5
6  NmgPVPS <- function(pump, Pg, H, Gd, Ta=30,
7                      lambda=0.0045, TONC=47,
8                      eta=0.95, Gmax=1200, t0=6, Nm=6,
9                      title='', theme=custom.theme.2()){
10
11    ##I build the type day by IEC procedure
12    t=seq(-t0,t0,l=2*t0*Nm);
13    d=Gd/(Gmax*2*t0)
14    s=(d*pi/2-1)/(1-pi/4)
15    G=Gmax*cos(t/t0*pi/2)*(1+s*(1-cos(t/t0*pi/2)))
16    G[G<0]<-0
17    G=G/(sum(G,na.rm=1)/Nm)*Gd
18    Red<-expand.grid(G=G,Pnom=Pg,H=H,Ta=Ta)
19    Red<-within(Red,{Tcm<-Ta+G*(TONC-20)/800
20                  Pdc=Pnom*G/1000*(1-lambda*(Tcm-25)) #Available DC power
21                  Pac=Pdc*eta}) #Inverter yield

```

```

22
23   res=data.table(Red,Q=0)
24
25   for (i in seq_along(H)){
26     fun=fPump(pump, H[i])
27     Cond=res$H==H[i]
28     x=res$Pac[Cond]
29     z=res$Pdc[Cond]
30     rango=with(fun,x>=lim[1] & x<=lim[2]) #I limit the power to the operating
    range of the pump.
31     x[!rango]<-0
32     z[!rango]<-0
33     y=res$Q[Cond]
34     y[rango]<-fun$fQ(x[rango])
35     res$Q[Cond]=y
36     res$Pac[Cond]=x
37     res$Pdc[Cond]=z
38   }
39
40   resumen <- res[, lapply(.SD, function(x)sum(x, na.rm = 1)/Nm),
41                     by = .(Pnom, H)]
42   param=list(pump=pump, Pg=Pg, H=H, Gd=Gd, Ta=Ta,
43             lambda=lambda, TONC=TONC, eta=eta,
44             Gmax=Gmax, t0=t0, Nm=Nm)
45
46
47   ###Abacus with common X-axes
48
49   ##I check if I have the lattice package available, which should have been
    loaded in .First.lib
50   lattice.disp<-"lattice" %in% .packages()
51   latticeExtra.disp<-"latticeExtra" %in% .packages()
52   if (lattice.disp && latticeExtra.disp){
53     tema<-theme
54     tema1 <- modifyList(tema, list(layout.width = list(panel=1,
55                                                         ylab = 2, axis.left=1.0,
56                                                         left.padding=1, ylab.axis.padding=1,
57                                                         axis.panel=1)))
58     tema2 <- modifyList(tema, list(layout.width = list(panel=1,
59                                                         ylab = 2, axis.left=1.0, left.padding=1,
60                                                         ylab.axis.padding=1, axis.panel=1)))
61     temaT <- modifyList(tema, list(layout.heights = list(panel = c(1, 1))))
62     p1 <- xyplot(Q~Pdc, groups=H, data=resumen,
63                 ylab="Qd (m\u00b3/d)",type=c('l','g'),
64                 par.settings = tema1)
65
66     p1lab<-p1+glayer(panel.text(x[1], y[1], group.value, pos=2, cex=0.7))
67
68     ##I paint the linear regression because Pnom~Pdc depends on the height.
69     p2 <- xyplot(Pnom~Pdc, groups=H, data=resumen,
70                 ylab="Pg",type=c('l','g'), #type=c('smooth','g'),
71                 par.settings = tema2)
72     p2lab<-p2+glayer(panel.text(x[1], y[1], group.value, pos=2, cex=0.7))
73
74     p<-update(c(p1lab, p2lab, x.same = TRUE),
75              main=paste(title, '\nSP', pump$Qn, 'A', pump$stages, ' '),

```

```

76         'Gd ', Gd/1000," kWh/m\u00b2",sep=''),
77         layout = c(1, 2),
78         scales=list(x=list(draw=FALSE)),
79         xlab='',
80         ylab = list(c("Qd (m\u00b3/d)", "Pg (Wp)"), y = c(1/4, 3/4)),
81         par.settings = temaT
82     )
83     print(p)
84     result<-list(I=res,D=resumen, plot=p, param=param)
85 } else {
86     warning('lattice, latticeExtra packages are not all available. Thus, the
87     plot could not be created')
88     result<-list(I=res,D=resumen, param=param)
89 }

```

### utils-angle

```

1 #degrees to radians
2 d2r<-function(x){x*pi/180}
3
4 #radians to degrees
5 r2d<-function(x){x*180/pi}
6
7 #hours to radians
8 h2r<-function(x){x*pi/12}
9
10 #hours to degrees
11 h2d<-function(x){x*180/12}
12
13 #radians to hours
14 r2h<-function(x){x*12/pi}
15
16 #degrees to hours
17 d2h<-function(x){x*12/180}
18
19 #radians to seconds
20 r2sec<-function(x){x*12/pi*3600}
21
22 #radians to minutes
23 r2min<-function(x){x*12/pi*60}

```

### utils-time

```

1 #complete time to hours
2 t2h <- function(x)
3 {
4     hour(x)+minute(x)/60+second(x)/3600
5 }
6
7 #hours minutes and seconds to hours
8 hms <- function(x)
9 {
10     hour(x)+minute(x)/60+second(x)/3600

```

```

11 }
12
13 #day of the year
14 doy <- function(x){
15   as.numeric(format(x, '%j'))
16 }
17
18 #day of the month
19 dom <- function(x){
20   as.numeric(format(x, '%d'))
21 }
22
23 #trunc days
24 truncDay <- function(x){as.POSIXct(trunc(x, units='days'))}

```

## A.4. Métodos

**as.data.tableI**

**as.data.tableD**

```

1  setGeneric('as.data.tableD', function(object, complete=FALSE, day=FALSE){
2    standardGeneric('as.data.tableD')})
3
4  setMethod('as.data.tableD',
5    signature=(object='Sol'),
6    definition=function(object, complete=FALSE, day=FALSE){
7      sol <- copy(object)
8      sold <- sol@sold
9      data <- sold
10     if(day){
11       ind <- indexD(object)
12       data[, day := doy(ind)]
13       data[, month := month(ind)]
14       data[, year := year(ind)]
15     }
16     return(data)
17   })
18
19  setMethod('as.data.tableD',
20    signature = (object='GO'),
21    definition = function(object, complete=FALSE, day=FALSE){
22     g0 <- copy(object)
23     GOD <- g0@GOD
24     sold <- g0@sold
25     if(complete){
26       data <- data.table(GOD, sold[, Dates := NULL])
27     } else {
28       GOD[, Fd := NULL]
29       GOD[, Kt := NULL]
30       data <- GOD
31     }
32     if(day){
33       ind <- indexD(object)

```

```

34         data[, day := doy(ind)]
35         data[, month := month(ind)]
36         data[, year := year(ind)]
37     }
38     return(data)
39 })
40
41 setMethod('as.data.tableD',
42     signature = (object='Gef'),
43     definition = function(object, complete=FALSE, day=FALSE){
44         gef <- copy(object)
45         GefD <- gef@GefD
46         GOD <- gef@GOD
47         sold <- gef@sold
48         if(complete){
49             data <- data.table(GefD,
50                               GOD[, Dates := NULL],
51                               sold[, Dates := NULL])
52         } else {data <- GefD[, c('Dates', 'Gefd',
53                                'Defd', 'Befd')]}
54         if(day){
55             ind <- indexD(object)
56             data[, day := doy(ind)]
57             data[, month := month(ind)]
58             data[, year := year(ind)]
59         }
60         return(data)
61     }
62 )
63
64 setMethod('as.data.tableD',
65     signature = (object='ProdGCPV'),
66     definition = function(object, complete=FALSE, day=FALSE){
67         prodgcpv <- copy(object)
68         prodD <- prodgcpv@prodD
69         GefD <- prodgcpv@GefD
70         GOD <- prodgcpv@GOD
71         sold <- prodgcpv@sold
72         if(complete){
73             data <- data.table(prodD,
74                               GefD[, Dates := NULL],
75                               GOD[, Dates := NULL],
76                               sold[, Dates := NULL]
77             )
78         } else { data <- prodD[, c('Dates', 'Eac',
79                                  'Edc', 'Yf')]}
80         if(day){
81             ind <- indexD(object)
82             data[, day := doy(ind)]
83             data[, month := month(ind)]
84             data[, year := year(ind)]
85         }
86         return(data)
87     }
88 )
89

```

```

90 setMethod('as.data.tableD',
91   signature = (object='ProdPVPS'),
92   definition = function(object, complete=FALSE, day=FALSE){
93     prodpvps <- copy(object)
94     prodD <- prodpvps@prodD
95     GefD <- prodpvps@GefD
96     GOD <- prodpvps@GOD
97     sold <- prodpvps@sold
98     if(complete){
99       data <- data.table(prodD,
100         GefD[, Dates := NULL],
101         GOD[, Dates := NULL],
102         sold[, Dates := NULL]
103       )
104     } else { data <- prodD[, c('Dates', 'Eac',
105       'Qd', 'Yf')]}
106     if(day){
107       ind <- indexD(object)
108       data[, day := doy(ind)]
109       data[, month := month(ind)]
110       data[, year := year(ind)]
111     }
112     return(data)
113   }
114 )

```

### as.data.tableM

```

1  setGeneric('as.data.tableM', function(object, complete = FALSE, day=FALSE){
2    standardGeneric('as.data.tableM')})
3
4  setMethod('as.data.tableM',
5    signature=(object='GO'),
6    definition=function(object, complete=FALSE, day=FALSE){
7      g0 <- copy(object)
8      GOdm <- g0@GOdm
9      data <- GOdm
10     if(day){
11       ind <- indexD(object)
12       data[, month := month(ind)]
13       data[, year := year(ind)]
14     }
15     return(data)
16   }
17 )
18
19 setMethod('as.data.tableM',
20   signature=(object='Gef'),
21   definition = function(object, complete=FALSE, day=FALSE){
22     gef <- copy(object)
23     Gefdm <- gef@Gefdm
24     GOdm <- gef@GOdm
25     if(complete){
26       data <- data.table(Gefdm, GOdm[, Dates := NULL])
27     } else {data <- Gefdm}

```



```

27         if(day){
28             ind <- indexD(object)
29             data[, month := month(ind)]
30             data[, year := year(ind)]
31         }
32         return(data)
33     }
34 )
35
36 setMethod('as.data.tableM',
37     signature = (object='ProdGCPV'),
38     definition = function(object, complete=FALSE, day=FALSE){
39         prodgcpv <- copy(object)
40         prodDm <- prodgcpv@prodDm
41         Gefdm <- prodgcpv@Gefdm
42         G0dm <- prodgcpv@G0dm
43         if(complete){
44             data <- data.table(prodDm,
45                               Gefdm[, Dates := NULL],
46                               G0dm[, Dates := NULL])
47         } else {data <- prodDm}
48         if(day){
49             ind <- indexD(object)
50             data[, month := month(ind)]
51             data[, year := year(ind)]
52         }
53         return(data)
54     }
55 )
56
57 setMethod('as.data.tableM',
58     signature = (object='ProdPVPS'),
59     definition = function(object, complete=FALSE, day=FALSE){
60         prodpvps <- copy(object)
61         prodDm <- prodpvps@prodDm
62         Gefdm <- prodpvps@Gefdm
63         G0dm <- prodpvps@G0dm
64         if(complete){
65             data <- data.table(prodDm,
66                               Gefdm[, Dates := NULL],
67                               G0dm[, Dates := NULL])
68         } else {data <- prodDm}
69         if(day){
70             ind <- indexD(object)
71             data[, month := month(ind)]
72             data[, year := year(ind)]
73         }
74         return(data)
75     }
76 )

```

### as.data.tableY

```

1 setGeneric('as.data.tableY', function(object, complete=FALSE, day=FALSE){
    standardGeneric('as.data.tableY')})

```

```

2
3 setMethod('as.data.tableY',
4   signature=(object='G0'),
5   definition=function(object, complete=FALSE, day=FALSE){
6     g0 <- copy(object)
7     G0y <- g0@G0y
8     data <- G0y
9     if(day){data[, year := Dates]}
10    return(data)
11  }
12 )
13
14 setMethod('as.data.tableY',
15   signature = (object='Gef'),
16   definition = function(object, complete=FALSE, day=FALSE){
17     gef <- copy(object)
18     Gefy <- gef@Gefy
19     G0y <- gef@G0y
20     if(complete){
21       data <- data.table(Gefy, G0y[, Dates := NULL])
22     } else {data <- Gefy}
23     if(day){data[, year := Dates]}
24     return(data)
25   }
26 )
27
28 setMethod('as.data.tableY',
29   signature = (object='ProdGCPV'),
30   definition = function(object, complete=FALSE, day=FALSE){
31     prodgcpv <- copy(object)
32     prody <- prodgcpv@prody
33     Gefy <- prodgcpv@Gefy
34     G0y <- prodgcpv@G0y
35     if(complete){
36       data <- data.table(prody,
37                           Gefy[, Dates := NULL],
38                           G0y[, Dates := NULL])
39     } else {data <- prody}
40     if(day){data[, year := Dates]}
41     return(data)
42   }
43 )
44
45 setMethod('as.data.tableY',
46   signature = (object='ProdPVPS'),
47   definition = function(object, complete=FALSE, day=FALSE){
48     prodpvps <- copy(object)
49     prody <- prodpvps@prody
50     Gefy <- prodpvps@Gefy
51     G0y <- prodpvps@G0y
52     if(complete){
53       data <- data.table(prody,
54                           Gefy[, Dates := NULL],
55                           G0y[, Dates := NULL])
56     } else {data <- prody}
57     if(day){data[, year := Dates]}

```

```

58         return(data)
59     }
60 )

```

### compare

```

1  ## compareFunction: no visible binding for global variable 'name'
2  ## compareFunction: no visible binding for global variable 'x'
3  ## compareFunction: no visible binding for global variable 'y'
4  ## compareFunction: no visible binding for global variable 'group.value'
5
6  if(getRversion() >= "2.15.1") globalVariables(c('name', 'x', 'y', 'group.value'))
7
8  setGeneric('compare', signature='...', function(...){standardGeneric('compare')})
9
10 compareFunction <- function(..., vars){
11     dots <- list(...)
12     nms0 <- substitute(list(...))
13     if (!is.null(names(nms0))) { ##in do.call
14         nms <- names(nms0[-1])
15     } else {
16         nms <- as.character(nms0[-1])
17     }
18     foo <- function(object, label){
19         yY <- colMeans(as.data.tableY(object, complete = TRUE)[, ..vars])
20         yY <- cbind(stack(yY), name=label)
21         yY
22     }
23     cdata <- mapply(FUN=foo, dots, nms, SIMPLIFY=FALSE)
24     z <- do.call(rbind, cdata)
25     z$ind <- ordered(z$ind, levels=vars)
26     p <- dotplot(ind~values, groups=name, data=z, type='b',
27                 par.settings=solaR.theme)
28     print(p+glayer(panel.text(x[length(x)], y[length(x)],
29                               label=group.value, cex=0.7, pos=3, srt=45)))
30     return(z)
31 }
32
33
34 setMethod('compare',
35           signature='GO',
36           definition=function(...){
37             vars <- c('D0d', 'B0d', 'G0d')
38             res <- compareFunction(..., vars=vars)
39             return(res)
40           }
41 )
42
43 setMethod('compare',
44           signature='Gef',
45           definition=function(...){
46             vars <- c('Defd', 'Befd', 'Gefd')
47             res <- compareFunction(..., vars=vars)
48             return(res)
49           }

```



```

15         deg = object@latm)
16     return(result)
17 })

```

### indexD

```

1  ## extract the index of the daily data ##
2  setGeneric('indexD', function(object){standardGeneric('indexD')})
3  ### indexD ###
4  setMethod('indexD',
5            signature = (object = 'Sol'),
6            definition = function(object){as.POSIXct(object@sold$Dates)
7            })
8
9  setMethod('indexD',
10           signature = (object = 'Meteo'),
11           definition = function(object){as.POSIXct(getData(object)$Dates)})

```

### indexI

```

1  ## extract the index of the intradaily data ##
2  setGeneric('indexI', function(object){standardGeneric('indexI')})
3  ### indexI ###
4  setMethod('indexI',
5            signature = (object = 'Sol'),
6            definition = function(object){as.POSIXct(object@solI$Dates)
7            })

```

### levelplot

```

1  setGeneric('levelplot')
2
3  setMethod('levelplot',
4            signature=c(x='formula', data='Meteo'),
5            definition=function(x, data,
6                               par.settings = solaR.theme,
7                               panel = panel.levelplot.raster, interpolate = TRUE,
8                               xscale.components = xscale.solar,
9                               yscale.components = yscale.solar,
10                               ...){
11                data0=getData(data)
12                ind=data0$Dates
13                data0$day=doy(ind)
14                data0$month=month(ind)
15                data0$year=year(ind)
16                data0$h=h2r(hms(ind)-12)
17                levelplot(x, data0,
18                          par.settings = par.settings,
19                          xscale.components = xscale.components,
20                          yscale.components = yscale.components,
21                          panel = panel, interpolate = interpolate,
22                          ...)
23            })

```

```

24     )
25
26   setMethod('levelplot',
27     signature=c(x='formula', data='Sol'),
28     definition=function(x, data,
29       par.settings = solaR.theme,
30       panel = panel.levelplot.raster, interpolate = TRUE,
31       xscale.components = xscale.solar,
32       yscale.components = yscale.solar,
33       ...){
34     data0=as.data.tableI(data, complete=TRUE, day=TRUE)
35     ind=data0$Dates
36     data0$day=doy(ind)
37     data0$month=month(ind)
38     data0$year=year(ind)
39     levelplot(x, data0,
40       par.settings = par.settings,
41       xscale.components = xscale.components,
42       yscale.components = yscale.components,
43       panel = panel, interpolate = interpolate,
44       ...)
45   }
46 )
47
48   setMethod('levelplot',
49     signature=c(x='formula', data='G0'),
50     definition=function(x, data,
51       par.settings = solaR.theme,
52       panel = panel.levelplot.raster, interpolate = TRUE,
53       xscale.components = xscale.solar,
54       yscale.components = yscale.solar,
55       ...){
56     data0=as.data.tableI(data, complete=TRUE, day=TRUE)
57     ind=data0$Dates
58     data0$day=doy(ind)
59     data0$month=month(ind)
60     data0$year=year(ind)
61     levelplot(x, data0,
62       par.settings = par.settings,
63       xscale.components = xscale.components,
64       yscale.components = yscale.components,
65       panel = panel, interpolate = interpolate,
66       ...)
67   }
68 )

```

## losses

```

1   setGeneric('losses', function(object){standardGeneric('losses')})
2
3   setMethod('losses',
4     signature=(object='Gef'),
5     definition=function(object){
6       dat <- as.data.tableY(object, complete=TRUE)
7       isShd=('Gef0d' %in% names(dat)) ##is there shadows?

```

```

8       if (isShd) {
9         shd <- with(dat, mean(1-Gefd/Gef0d))
10        eff <- with(dat, mean(1-Gef0d/Gd))
11      } else {
12        shd <- 0
13        eff <- with(dat, mean(1-Gefd/Gd))
14      }
15      result <- data.table(Shadows = shd, AoI = eff)
16      result
17    }
18  )
19
20  setMethod('losses',
21    signature=(object='ProdGCPV'),
22    definition=function(object){
23      datY <- as.data.tableY(object, complete=TRUE)
24      module0=object@module
25      module0$CoefVT=0 ##No losses with temperature
26      Pg=object@generator$Pg
27      Nm=1/sample2Hours(object@sample)
28      datI <- as.data.tableI(object, complete=TRUE)
29      if (object@type=='prom'){
30        datI[, DayOfMonth := DOM(datI)]
31        YfDC0 <- datI[, sum(Vmpp*Imppp/Pg*DayOfMonth, na.rm = TRUE),
32                        by = month(Dates)][[2]]
33        YfDC0 <- sum(YfDC0, na.rm = TRUE)
34        YfACO <- datI[, sum(Pdc*EffI/Pg*DayOfMonth, na.rm = TRUE),
35                        by = month(Dates)][[2]]
36        YfACO <- sum(YfACO, na.rm = TRUE)
37      } else {
38        datI[, DayOfMonth := DOM(datI)]
39        YfDC0 <- datI[, sum(Vmpp*Imppp/Pg*DayOfMonth, na.rm = TRUE),
40                        by = year(Dates)][[2]]
41        YfACO <- datI[, sum(Pdc*EffI/Pg*DayOfMonth, na.rm = TRUE),
42                        by = year(Dates)][[2]]
43      }
44      gen <- mean(1-YfDC0/datY$Gefd)
45      YfDC <- datY$Edc/Pg*1000
46      DC=mean(1-YfDC/YfDC0)
47      inv=mean(1-YfACO/YfDC)
48      AC=mean(1-datY$Yf/YfACO)
49      result0 <- losses(as(object, 'Gef'))
50      result1 <- data.table(Generator = gen,
51                            DC = DC,
52                            Inverter = inv,
53                            AC = AC)
54      result <- data.table(result0, result1)
55      result
56    }
57  )
58
59  ###compareLosses
60
61  ## compareLosses,ProdGCPV: no visible binding for global variable 'name'
62  if(getRversion() >= "2.15.1") globalVariables(c('name'))
63

```

```

64 setGeneric('compareLosses', signature='...', function(...){standardGeneric('
    compareLosses'})})
65
66 setMethod('compareLosses', 'ProdGCPV',
67   definition=function(...){
68     dots <- list(...)
69     nms0 <- substitute(list(...))
70     if (!is.null(names(nms0))) { ##do.call
71       nms <- names(nms0[-1])
72     } else {
73       nms <- as.character(nms0[-1])
74     }
75     foo <- function(object, label){
76       yY <- losses(object)
77       yY <- cbind(yY, name=label)
78       yY
79     }
80     cdata <- mapply(FUN=foo, dots, nms, SIMPLIFY=FALSE)
81     z <- do.call(rbind, cdata)
82     z <- melt(z, id.vars = 'name')
83     p <- dotplot(variable~value*100, groups=name, data=z,
84       par.settings=solaR.theme, type='b',
85       auto.key=list(corner=c(0.95,0.2), cex=0.7), xlab='Losses
    (%)')
86     print(p)
87     return(z)
88   }
89 )

```

### mergeSolar

```

1  setGeneric('mergesolaR', signature='...', function(...){standardGeneric('
    mergesolaR'})})
2
3  fooMeteo <- function(object, var){yY <- getData(object)[, .SD,
4                                     by = Dates,
5                                     .SDcols = var]}
6
7  fooGO <- function(object, var){yY <- as.data.tableD(object)[, .SD,
8                                     by = Dates,
9                                     .SDcols = var]}
10
11 mergeFunction <- function(..., foo, var){
12   dots <- list(...)
13   dots <- lapply(dots, as, class(dots[[1]])) ##the first element is the one
14   that dictates the class to everyone
15   nms0 <- substitute(list(...))
16   if (!is.null(names(nms0))) { ##do.call
17     nms <- names(nms0[-1])
18   } else {
19     nms <- as.character(nms0[-1])
20   }
21   cdata <- sapply(dots, FUN=foo, var, simplify=FALSE)
22   z <- cdata[[1]]
23   for (i in 2:length(cdata)){

```



```

23     z <- merge(z, cdata[[i]], by = 'Dates', suffixes = c("", paste0('.', i)))
24   }
25   names(z)[-1] <- nms
26   z
27 }
28
29 setMethod('mergesolaR',
30   signature='Meteo',
31   definition=function(...){
32     res <- mergeFunction(..., foo=fooMeteo, var='G0')
33     res
34   }
35 )
36
37 setMethod('mergesolaR',
38   signature='G0',
39   definition=function(...){
40     res <- mergeFunction(..., foo=fooG0, var='G0d')
41     res
42   }
43 )
44
45 setMethod('mergesolaR',
46   signature='Gef',
47   definition=function(...){
48     res <- mergeFunction(..., foo=fooG0, var='Gefd')
49     res
50   }
51 )
52
53 setMethod('mergesolaR',
54   signature='ProdGCPV',
55   definition=function(...){
56     res <- mergeFunction(..., foo=fooG0, var='Yf')
57     res
58   }
59 )
60
61 setMethod('mergesolaR',
62   signature='ProdPVPS',
63   definition=function(...){
64     res <- mergeFunction(..., foo=fooG0, var='Yf')
65     res
66   }
67 )

```

### shadeplot

```

1 setGeneric('shadeplot', function(x, ...)standardGeneric('shadeplot'))
2
3 setMethod('shadeplot', signature(x='Shade'),
4   function(x,
5     main='',
6     xlab=expression(L[ew]),
7     ylab=expression(L[ns]),

```

```

8         n=9, ...){
9         red=x@distances
10        FS.loess=x@FS.loess
11        Yf.loess=x@Yf.loess
12        struct=x@struct
13        mode=x@modeTrk
14        if (mode=='two'){
15            Lew=seq(min(red$Lew),max(red$Lew),length=100)
16            Lns=seq(min(red$Lns),max(red$Lns),length=100)
17            Red=expand.grid(Lew=Lew,Lns=Lns)
18            FS=predict(FS.loess,Red)
19            Red$FS=as.numeric(FS)
20            AreaG=with(struct,L*W)
21            GRR=Red$Lew*Red$Lns/AreaG
22            Red$GRR=GRR
23            FS.m<-matrix(1-FS,
24                          nrow=length(Lew),
25                          ncol=length(Lns))
26            GRR.m<-matrix(GRR,
27                          nrow=length(Lew),
28                          ncol=length(Lns))
29            niveles=signif(seq(min(FS.m),max(FS.m),l=n+1),3)
30            pruebaCB<-("RColorBrewer" %in% .packages())
31            if (pruebaCB) {
32                paleta=rev(brewer.pal(n, 'YlOrRd'))
33            } else {
34                paleta=rev(heat.colors(n))}
35            par(mar=c(4.1,4.1,2.1,2.1))
36            filled.contour(x=Lew,y=Lns,z=FS.m,#...,
37                          col=paleta, #levels=niveles,
38                          nlevels=n,
39                          plot.title=title(xlab=xlab,
40                                           ylab=ylab, main=main),
41                          plot.axes={
42                              axis(1);axis(2);
43                              contour(Lew, Lns, FS.m,
44                                      nlevels=n, #levels=niveles,
45                                      col="black", labcex=.8, add=TRUE)
46                              contour(Lew, Lns, GRR.m,
47                                      col="black", lty=3, labcex=.8, add=
48 TRUE)
49                              grid(col="white",lty=3)},
50                              key.title=title("1-FS",cex.main=.8))
51        }
52        if (mode=='horiz') {
53            Lew=seq(min(red$Lew),max(red$Lew),length=100)
54            FS=predict(FS.loess,Lew)
55            GRR=Lew/struct$L
56            plot(GRR,1-FS,main=main,type='l',...)
57            grid()
58        }
59        if (mode=='fixed'){
60            D=seq(min(red$D),max(red$D),length=100)
61            FS=predict(FS.loess,D)
62            GRR=D/struct$L
63            plot(GRR,1-FS,main=main,type='l',...)
64            grid()

```

```

63     }
64     )

```

## window

```

1  setMethod('[',
2      signature='Meteo',
3      definition=function(x, i, j,...){
4          if (!missing(i)) {
5              i <- truncDay(i)
6          } else {
7              i <- indexD(x)[1]
8          }
9          if (!missing(j)) {
10             j <- truncDay(j)+86400-1 ##The end is the last second of the day
11         } else {
12             nDays <- length(indexD(x))
13             j <- indexD(x)[nDays]+86400-1
14         }
15         stopifnot(j>i)
16         if (!is.null(i)) i <- truncDay(i)
17         if (!is.null(j)) j <- truncDay(j)+86400-1
18         d <- indexD(x)
19         x@data <- x@data[(d >= i & d <= j)]
20         x
21     }
22     )
23
24
25 setMethod('[',
26     signature='Sol',
27     definition=function(x, i, j, ...){
28         if (!missing(i)) {
29             i <- truncDay(i)
30         } else {
31             i <- indexD(x)[1]
32         }
33         if (!missing(j)) {
34             j <- truncDay(j)+86400-1##The end is the last second of the day
35         } else {
36             nDays <- length(indexD(x))
37             j <- indexD(x)[nDays]+86400-1
38         }
39         stopifnot(j>i)
40         if(!is.null(i)) i <- truncDay(i)
41         if(!is.null(j)) j <- truncDay(j)
42         d1 <- indexD(x)
43         d2 <- indexI(x)
44         x@solD <- x@solD[(d1 >= i & d1 <= j)]
45         x@solI <- x@solI[(d2 >= i & d2 <= j)]
46         x
47     }
48     )
49
50 setMethod('[',

```

```

51 signature='G0',
52 definition=function(x, i, j, ...){
53   sol <- as(x, 'Sol')[i=i, j=j, ...] ##Sol method
54   meteo <- as(x, 'Meteo')[i=i, j=j, ...] ##Meteo method
55   i <- indexI(sol)[1]
56   j <- indexI(sol)[length(indexI(sol))]
57   d1 <- indexD(x)
58   d2 <- indexI(x)
59   GOIw <- x@GOI[(d2 >= i & d2 <= j)]
60   Taw <- x@Ta[(d2 >= i & d2 <= j)]
61   GODw <- x@GOD[(d1 >= truncDay(i) & d1 <= truncDay(j))]
62   G0dmw <- G0dw[, lapply(.SD/1000, mean, na.rm= TRUE),
63     .SDcols = c('G0d', 'D0d', 'B0d'),
64     by = .(month(Dates), year(Dates))]
65   if (x@type=='prom'){
66     G0dmw[, DayOfMonth := DOM(G0dmw)]
67     G0yw <- G0dmw[, lapply(.SD*DayOfMonth, sum, na.rm = TRUE),
68       .SDcols = c('G0d', 'D0d', 'B0d'),
69       by = .(Dates = year)]
70     G0dmw[, DayOfMonth := NULL]
71   } else {
72     G0yw <- G0dw[, lapply(.SD/1000, sum, na.rm = TRUE),
73       .SDcols = c('G0d', 'D0d', 'B0d'),
74       by = .(Dates = year(unique(truncDay(Dates))))]
75   }
76   G0dmw[, Dates := paste(month.abb[month], year, sep = '. ')]
77   G0dmw[, c('month', 'year') := NULL]
78   setcolorder(G0dmw, 'Dates')
79   result <- new('G0',
80     meteo,
81     sol,
82     GOD=G0dw,
83     G0dm=G0dmw,
84     G0y=G0yw,
85     GOI=GOIw,
86     Ta=Taw)
87   result
88 }
89 )
90
91
92 setMethod('[',
93   signature='Gef',
94   definition=function(x, i, j, ...){
95     g0 <- as(x, 'G0')[i=i, j=j, ...] ##G0 method
96     i <- indexI(g0)[1]
97     j <- indexI(g0)[length(indexI(g0))]
98     d1 <- indexD(x)
99     d2 <- indexI(x)
100    GefIw <- x@GefI[(d2 >= i & d2 <= j)]
101    Thetaw <- x@Theta[(d2 >= i & d2 <= j)]
102    Gefdw <- x@GefD[(d1 >= truncDay(i) & d1 <= truncDay(j))]
103    nms <- c('Bod', 'Bnd', 'Gd', 'Dd',
104      'Bd', 'Gefd', 'Defd', 'Befd')
105    Gefdmw <- Gefdw[, lapply(.SD/1000, mean, na.rm = TRUE),
106      .SDcols = nms,

```

```

107         by = .(month(Dates), year(Dates))]
108     if (x@type=='prom'){
109         Gefdmw[, DayOfMonth:= DOM(Gefdmw)]
110         Gefyw <- Gefdmw[, lapply(.SD*DayOfMonth, sum),
111                               .SDcols = nms,
112                               by = .(Dates = year)]
113         Gefdmw[, DayOfMonth := NULL]
114     } else {
115         Gefyw <- Gefdw[, lapply(.SD/1000, sum, na.rm = TRUE),
116                               .SDcols = nms,
117                               by = .(Dates = year)]
118     }
119     Gefdmw[, Dates := paste(month.abb[month], year, sep = '. ')]
120     Gefdmw[, c('month', 'year') := NULL]
121     setcolorder(Gefdmw, 'Dates')
122     result <- new('Gef',
123                  g0,
124                  GefD=Gefdw,
125                  Gefdm=Gefdmw,
126                  Gefy=Gefyw,
127                  GefI=GefIw,
128                  Theta=Thetaw,
129                  iS=x@iS,
130                  alb=x@alb,
131                  modeTrk=x@modeTrk,
132                  modeShd=x@modeShd,
133                  angGen=x@angGen,
134                  struct=x@struct,
135                  distances=x@distances
136                  )
137     result
138 }
139 )
140
141
142 setMethod('[',
143           signature='ProdGCPV',
144           definition=function(x, i, j, ...){
145             gef <- as(x, 'Gef')[i=i, j=j, ...] ##Gef method
146             i <- indexI(gef)[1]
147             j <- indexI(gef)[length(indexI(gef))]
148             d1 <- indexD(x)
149             d2 <- indexI(x)
150             prodIw <- x@prodI[(d2 >= i & d2 <= j)]
151             prodDw <- x@prodD[(d1 >= truncDay(i) & d1 <= truncDay(j))]
152             prodDmw <- prodDw[, lapply(.SD/1000, mean, na.rm = TRUE),
153                                   .SDcols = c('Eac', 'Edc'),
154                                   by = .(month(Dates), year(Dates))]
155             prodDmw$Yf <- prodDw$Yf
156             if (x@type=='prom'){
157                 prodDmw[, DayOfMonth := DOM(prodDmw)]
158                 prodyw <- prodDmw[, lapply(.SD*DayOfMonth, sum, na.rm = TRUE),
159                                       .SDcols = c('Eac', 'Edc', 'Yf'),
160                                       by = .(Dates = year)]
161                 prodDmw[, DayOfMonth := NULL]
162             } else {

```

```

163     prodyw <- prodDw[, lapply(.SD/1000, sum, na.rm = TRUE),
164                           .SDcols = c('Eac', 'Edc', 'Yf'),
165                           by = .(Dates = year)]
166   }
167   prodDmw[, Dates := paste(month.abb[month], year, sep = '. ')]
168   prodDmw[, c('month', 'year') := NULL]
169   setcolorder(prodDmw, c('Dates', names(prodDmw)[-length(prodDmw)]))
170   result <- new('ProdGCPV',
171               gef,
172               prodD=prodDw,
173               prodDm=prodDmw,
174               prody=prodyw,
175               prodI=prodIw,
176               module=x@module,
177               generator=x@generator,
178               inverter=x@inverter,
179               effSys=x@effSys
180             )
181   result
182 }
183 )
184
185 setMethod('[',
186   signature='ProdPVPS',
187   definition=function(x, i, j, ...){
188     gef <- as(x, 'Gef')[i=i, j=j, ...] ##Gef method
189     i <- indexI(gef)[1]
190     j <- indexI(gef)[length(indexI(gef))]
191     d1 <- indexD(x)
192     d2 <- indexI(x)
193     prodIw <- x@prodI[(d2 >= i & d2 <= j)]
194     prodDw <- x@prodD[(d1 >= truncDay(i) & d1 <= truncDay(j))]
195     prodDmw <- prodDw[, .(Eac = Eac/1000,
196                         Qd = Qd,
197                         Yf = Yf),
198                       by = .(month(Dates), year(Dates))]
199     if (x@type=='prom'){
200       prodDmw[, DayOfMonth := DOM(prodDmw)]
201       prodyw <- prodDmw[, lapply(.SD*DayOfMonth, sum, na.rm = TRUE),
202                             .SDcols = c('Eac', 'Qd', 'Yf'),
203                             by = .(Dates = year)]
204       prodDmw[, DayOfMonth := NULL]
205     } else {
206       prodyw <- prodDw[, .(Eac = sum(Eac, na.rm = TRUE)/1000,
207                           Qd = sum(Qd, na.rm = TRUE),
208                           Yf = sum(Yf, na.rm = TRUE)),
209                         by = .(Dates = year)]
210     }
211     prodDmw[, Dates := paste(month.abb[month], year, sep = '. ')]
212     prodDmw[, c('month', 'year') := NULL]
213     setcolorder(prodDmw, c('Dates', names(prodDmw)[-length(prodDmw)]))
214     result <- new('ProdPVPS',
215                 gef,
216                 prodD=prodDw,
217                 prodDm=prodDmw,
218                 prody=prodyw,

```

```

219         prodI=prodIw,
220         pump=x@pump,
221         H=x@H,
222         Pg=x@Pg,
223         converter=x@converter,
224         effSys=x@effSys
225     )
226     result
227 }
228 )

```

### writeSolar

```

1  setGeneric('writeSolar', function(object, file,
2                                complete=FALSE, day=FALSE,
3                                timeScales=c('i', 'd', 'm', 'y'), sep=',',
4                                ...){
5      standardGeneric('writeSolar')}}
6
7  setMethod('writeSolar', signature=(object='Sol'),
8            definition=function(object, file, complete=FALSE, day=FALSE,
9                                timeScales=c('i', 'd', 'm', 'y'), sep=',', ...){
10      name <- strsplit(file, '\\.')[[1]][1]
11      ext <- strsplit(file, '\\.')[[1]][2]
12      timeScales <- match.arg(timeScales, several.ok=TRUE)
13      if ('i' %in% timeScales) {
14          zI <- as.data.tableI(object, complete=complete, day=day)
15          write.table(zI,
16                     file=file, sep=sep, row.names = FALSE, ...)
17      }
18      if ('d' %in% timeScales) {
19          zD <- as.data.tableD(object, complete=complete, day = day)
20          write.table(zD,
21                     file=paste(name, 'D', ext, sep='.'),
22                     sep=sep, row.names = FALSE, ...)
23      }
24      if ('m' %in% timeScales) {
25          zM <- as.data.tableM(object, complete=complete, day = day)
26          write.table(zM,
27                     file=paste(name, 'M', ext, sep='.'),
28                     sep=sep, row.names = FALSE, ...)
29      }
30      if ('y' %in% timeScales) {
31          zY <- as.data.tableY(object, complete=complete, day = day)
32          write.table(zY,
33                     file=paste(name, 'Y', ext, sep='.'),
34                     sep=sep, row.names = FALSE, ...)
35      }
36  })

```

### xyplot

```

1  #####
2  ## THEMES

```

```

3 #####
4 xscale.solar <- function(...){ans <- xscale.components.default(...); ans$top=
  FALSE; ans}
5 yscale.solar <- function(...){ans <- yscale.components.default(...); ans$right=
  FALSE; ans}
6
7 solaR.theme <- function(pch=19, cex=0.7, region=rev(brewer.pal(9, 'YlOrRd')),
  ...) {
8   theme <- custom.theme.2(pch=pch, cex=cex, region=region, ...)
9   theme$strip.background$col='transparent'
10  theme$strip.shingle$col='transparent'
11  theme$strip.border$col='transparent'
12  theme
13 }
14
15 solaR.theme.2 <- function(pch=19, cex=0.7, region=rev(brewer.pal(9, 'YlOrRd')),
  ...) {
16   theme <- custom.theme.2(pch=pch, cex=cex, region=region, ...)
17   theme$strip.background$col='lightgray'
18   theme$strip.shingle$col='lightgray'
19   theme
20 }
21
22 #####
23 ## XYPLOT
24 #####
25 setGeneric('xyplot')
26
27 setMethod('xyplot',
28   signature = c(x = 'data.frame', data = 'missing'),
29   definition = function(x, data,
30     par.settings = solaR.theme.2,
31     xscale.components=xscale.solar,
32     yscale.components=yscale.solar,
33     scales = list(y = 'free'),
34     ...){
35     N <- length(x)-1
36     x0 <- x[, lapply(.SD, as.numeric), by = Dates]
37     x0 <- melt(x0, id.vars = 'Dates')
38     x0$variable <- factor(x0$variable,
39       levels = rev(levels(factor(x0$variable))))
40     xyplot(value ~ Dates | variable, x0,
41       par.settings = par.settings,
42       xscale.components = xscale.components,
43       yscale.components = yscale.components,
44       scales = scales,
45       type = 'l', layout = c(1,N),
46       ...)
47   })
48
49 setMethod('xyplot',
50   signature=c(x='formula', data='Meteo'),
51   definition=function(x, data,
52     par.settings=solaR.theme,
53     xscale.components=xscale.solar,
54     yscale.components=yscale.solar,

```



```

55         ...){
56         data0=getData(data)
57         xyplot(x, data0,
58             par.settings = par.settings,
59             xscale.components = xscale.components,
60             yscale.components = yscale.components,
61             strip = strip.custom(strip.levels=c(TRUE, TRUE)), ...)
62     }
63 )
64
65 setMethod('xyplot',
66     signature=c(x='formula', data='Sol'),
67     definition=function(x, data,
68         par.settings=solaR.theme,
69         xscale.components=xscale.solar,
70         yscale.components=yscale.solar,
71         ...){
72         data0=as.data.tableI(data, complete=TRUE, day=TRUE)
73         data0[, w := h2r(hms(Dates)-12)]
74         xyplot(x, data0,
75             par.settings = par.settings,
76             xscale.components = xscale.components,
77             yscale.components = yscale.components,
78             strip = strip.custom(strip.levels=c(TRUE, TRUE)), ...)
79     }
80 )
81
82 setMethod('xyplot',
83     signature=c(x='formula', data='G0'),
84     definition=function(x, data,
85         par.settings=solaR.theme,
86         xscale.components=xscale.solar,
87         yscale.components=yscale.solar,
88         ...){
89         data0=as.data.tableI(data, complete=TRUE, day=TRUE)
90         xyplot(x, data0,
91             par.settings = par.settings,
92             xscale.components = xscale.components,
93             yscale.components = yscale.components,
94             strip = strip.custom(strip.levels=c(TRUE, TRUE)), ...)
95     }
96 )
97
98 setMethod('xyplot',
99     signature=c(x='formula', data='Shade'),
100    definition=function(x, data,
101        par.settings=solaR.theme,
102        xscale.components=xscale.solar,
103        yscale.components=yscale.solar,
104        ...){
105        data0=as.data.table(data)
106        xyplot(x, data0,
107            par.settings = par.settings,
108            xscale.components = xscale.components,
109            yscale.components = yscale.components,
110            strip = strip.custom(strip.levels=c(TRUE, TRUE)), ...)

```

```

111     }
112   )
113
114   setMethod('xyplot',
115     signature=c(x='Meteo', data='missing'),
116     definition=function(x, data,
117       ...){
118       x0=getData(x)
119       xyplot(x0,
120         scales=list(cex=0.6, rot=0, y='free'),
121         strip=FALSE, strip.left=TRUE,
122         par.strip.text=list(cex=0.6),
123         ylab = '',
124         ...)
125     }
126   )
127
128   setMethod('xyplot',
129     signature=c(x='G0', data='missing'),
130     definition=function(x, data, ...){
131       x0 <- as.data.tableD(x, complete=FALSE)
132       x0 <- melt(x0, id.vars = 'Dates')
133       xyplot(value~Dates, x0, groups = variable,
134         par.settings=solar.theme.2,
135         xscale.components=xscale.solar,
136         yscale.components=yscale.solar,
137         superpose=TRUE,
138         auto.key=list(space='right'),
139         ylab='Wh/m\u00b2',
140         type = 'l',
141         ...)
142     }
143   )
144
145   setMethod('xyplot',
146     signature=c(x='ProdGCPV', data='missing'),
147     definition=function(x, data, ...){
148       x0 <- as.data.tableD(x, complete=FALSE)
149       xyplot(x0,
150         strip = FALSE, strip.left = TRUE,
151         ylab = '', ...)
152     }
153   )
154
155   setMethod('xyplot',
156     signature=c(x='ProdPVPS', data='missing'),
157     definition=function(x, data, ...){
158       x0 <- as.data.tableD(x, complete=FALSE)
159       xyplot(x0,
160         strip = FALSE, strip.left = TRUE,
161         ylab = '', ...)
162     }
163   )

```

## A.5. Conjunto de datos

### aguiar

```
1 data(MTM)
2 Ktlim
```

```
      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,] 0.031 0.058 0.051 0.052 0.028 0.053 0.044 0.085 0.010 0.319
[2,] 0.705 0.694 0.753 0.753 0.807 0.856 0.818 0.846 0.842 0.865
```

```
1 Ktmtm
```

```
[1] 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 1.00
```

```
1 head(MTM)
```

```
      V1      V2      V3      V4      V5      V6      V7      V8      V9 V10
1 0.229 0.333 0.208 0.042 0.083 0.042 0.042 0.021 0.000 0
2 0.167 0.319 0.194 0.139 0.097 0.028 0.042 0.000 0.014 0
3 0.250 0.250 0.091 0.136 0.091 0.046 0.046 0.023 0.068 0
4 0.158 0.237 0.158 0.263 0.026 0.053 0.079 0.026 0.000 0
5 0.211 0.053 0.211 0.158 0.053 0.053 0.158 0.105 0.000 0
6 0.125 0.125 0.250 0.188 0.063 0.125 0.000 0.125 0.000 0
```

### SIAR

```
1 data(SIAR)
2 head(est_SIAR)
```

```
      Estacion Codigo      Longitud  Latitud  Altitud Fecha_Instalacion Fecha_Baja
1:      Villena   A01 -0.884444444 38.67639      519      1999-11-09 2000-03-19
2: Camp de Mirra A02 -0.772777778 38.67917      589      1999-11-09      <NA>
3: Vila Joiosa  A03 -0.256111111 38.52778      73      1999-11-10      <NA>
4:      Ondara   A04 0.006388889 38.81833      38      1999-11-10      <NA>
5:      Dénia Gata A05 0.082500000 38.79250      86      1999-11-15      <NA>
6:      Pinoso   A06 -1.060555556 38.42722     629      1999-11-14      <NA>
```

### helios

```
1 data(helios)
2 head(helios)
```

```
      yyyy.mm.dd      G.O. TambMax TambMin
1 2009/01/01 980.14      11.77      6.31
2 2009/01/02 1671.80     15.08      7.27
3 2009/01/03 671.02      9.33      6.36
4 2009/01/04 2482.80     11.71      1.11
5 2009/01/05 1178.19      7.33     -1.54
6 2009/01/06 1722.31      7.77     -0.78
```

**prodEx**

```
1 data(prodEx)
2 head(prodEx)
```

	Dates	1	2	3	4	5	6	7	8	9	
	<Date>	<num>	<num>	<num>	<num>	<num>	<num>	<num>	<num>	<num>	
1:	2007-07-02	8.874982	8.847533	7.173181	8.874982	8.920729	8.975626	8.948177	8.948177	8.948177	
2:	2007-07-03	8.710291	8.691992	8.655395	8.710291	8.737740	8.792637	8.774338	8.774338	8.746889	
3:	2007-07-04	8.746889	8.737740	8.865832	8.737740	8.765188	8.838384	8.810935	8.792637	8.801786	
4:	2007-07-05	8.280266	8.271117	8.408359	8.280266	8.344313	8.380911	8.353462	8.362612	8.316864	
5:	2007-07-06	8.399209	8.417508	8.509003	8.435807	8.490704	8.490704	8.499854	8.527302	8.472405	
6:	2007-07-07	8.197921	8.170473	8.335163	8.225370	8.243669	8.307715	8.298565	8.280266	8.243669	
	10	11	12	13	14	15	16	17	18	19	20
	<num>	<num>	<num>	<num>	<num>	<num>	<num>	<num>	<num>	<num>	<num>
1:	8.984775	8.783487	8.865832	8.966476	8.884131	8.774338	8.829234	8.627946	8.911580	8.807886	6.505270
2:	8.801786	8.545601	8.682843	8.774338	8.691992	8.591348	8.646245	8.426658	8.710291	8.563900	3.952569
3:	8.829234	8.545601	8.618797	8.829234	8.719441	8.618797	8.664544	8.426658	8.728590	8.612697	6.331430
4:	8.380911	8.179622	8.271117	8.353462	8.280266	8.207071	8.261968	8.188772	7.950886	8.222320	5.498829
5:	8.509003	8.316864	8.426658	8.490704	8.435807	8.344313	8.408359	8.371761	8.463256	8.332113	6.551017
6:	8.326014	8.152174	8.161323	8.316864	8.234519	8.143024	8.179622	8.170473	8.243669	8.161323	6.669960
	21	22									
	<num>	<num>									
1:	3.742131	3.980018									
2:	4.080662	3.238911									
3:	1.363270	1.043039									
4:	3.998316	2.461206									
5:	5.361587	4.959010									
6:	5.215195	4.922413									

**pumpCoef**

```
1 data(pumpCoef)
2 head(pumpCoef)
```

	Qn	stages	Qmax	Pmn	a	b	c	g	h	i	j	k	l
	<int>	<int>	<num>	<int>	<num>	<num>	<num>	<num>	<num>	<num>	<num>	<num>	<num>
1:	2	6	2.6	370	0.01409736	0.018576	-3.6324	-0.32	0.74	0.22	-0.1614	0.5247	0.0694
2:	2	9	2.6	370	0.02114604	0.027864	-5.4486	-0.32	0.74	0.22	-0.1614	0.5247	0.0694
3:	2	13	2.6	550	0.03054428	0.040248	-7.8702	-0.12	0.49	0.27	-0.1614	0.5247	0.0694
4:	2	18	2.6	750	0.04229208	0.055728	-10.8972	-0.16	0.42	0.47	-0.1614	0.5247	0.0694
5:	2	23	2.6	1100	0.05403988	0.071208	-13.9242	-0.20	0.51	0.42	-0.1614	0.5247	0.0694
6:	2	28	2.6	1500	0.06578768	0.086688	-16.9512	-0.24	0.50	0.49	-0.1614	0.5247	0.0694

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