

# Package ‘quantsmooth’

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**Type** Package

**Title** Quantile smoothing and genomic visualization of array data

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**Depends** R(>= 2.10.0), quantreg, grid

**Description** Implements quantile smoothing as introduced in: Quantile smoothing of array CGH data; Eilers PH, de Menezes RX; Bioinformatics. 2005 Apr 1;21(7):1146-53.

**License** GPL-2

**biocViews** Visualization, CopyNumberVariation

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## Contents

|                             |    |
|-----------------------------|----|
| chrom.bands . . . . .       | 2  |
| Chromosome14 . . . . .      | 3  |
| drawSimpleChrom . . . . .   | 3  |
| getChangedRegions . . . . . | 4  |
| getLambdaMin . . . . .      | 5  |
| grid.chromosome . . . . .   | 6  |
| helperFunctions . . . . .   | 7  |
| lengthChromosome . . . . .  | 8  |
| numericCHR . . . . .        | 9  |
| paintCytobands . . . . .    | 9  |
| plotChromosome . . . . .    | 10 |
| plotSmoothed . . . . .      | 11 |
| position2Cytoband . . . . . | 12 |
| prepareGenomePlot . . . . . | 13 |

|                           |    |
|---------------------------|----|
| quantsmooth . . . . .     | 14 |
| quantsmooth.cv . . . . .  | 15 |
| quantsmooth.seg . . . . . | 16 |
| scaletto . . . . .        | 16 |

|              |           |
|--------------|-----------|
| <b>Index</b> | <b>18</b> |
|--------------|-----------|

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|             |                                                                |
|-------------|----------------------------------------------------------------|
| chrom.bands | <i>Dataset of human chromosomes and their banding patterns</i> |
|-------------|----------------------------------------------------------------|

---

## Description

Dataset used to produce human chromosomal ideograms for plotting purposes.

## Usage

```
data(chrom.bands)
```

## Format

A data frame with 4068 observations on the following 12 variables.

```
chr  a character vector
arm  a character vector
band a character vector
ISCN.top  a numeric vector
ISCN.bot  a numeric vector
bases.top a numeric vector
bases.bot a numeric vector
stain  a character vector
cM.top  a numeric vector
cM.bot  a numeric vector
n.markers a numeric vector
p.markers a numeric vector
```

## Details

The original file gives only the physical map positions. The genetic map positions are interpolated from the Rutgers linkage map (Kong et al 2004).

## Source

[ftp://ftp.ncbi.nlm.nih.gov/genomes/H\\_sapiens/maps/mapview/BUILD.35.1/ideogram.gz](ftp://ftp.ncbi.nlm.nih.gov/genomes/H_sapiens/maps/mapview/BUILD.35.1/ideogram.gz).

## References

Kong X, Murphy K, Raj T, He C, White PS, Matise TC. 2004. A Combined Linkage-Physical Map of the Human Genome. *American Journal of Human Genetics*, 75(6):1143-8.

Chromosome14

*Example data from several quantitative genomic methods***Description**

A collection of arrays that contains data of chromosome 14 of 3 colorectal tumors. The first tumor shows 1 region of loss, the second tumor shows no aberration, while the third tumor shows loss of 1 copy of the chromosome.

**affy.cn** Copy number values of 358 probes from Affymetrix 10K genechip. Data was obtained from DChip

**affy.pos** corresponding probe positions

**bac.cn** Copy number values of 112 probes from a 1 mb spaced BAC array-CGH

**bac.pos** corresponding probe positions

**ill.cn** Copy number values of 207 probes from Illumina GoldenGate Linkage IV data

**ill.pos** corresponding probe positions

**Usage**

```
data(chr14)
```

**Format**

Matrices of copy number values and vectors of chromosomal probe positions

**Author(s)**

Jan Oosting

drawSimpleChrom

*Draw chromosome-like icons***Description**

This function paints chromosomal icons on an existing plot

**Usage**

```
drawSimpleChrom(x, y, len = 3, width = 1, fill, col, orientation = c("h", "v"), centromere.size = 0.6
```

**Arguments**

|                              |                                                                                                                                                                               |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>               | start x-position                                                                                                                                                              |
| <code>y</code>               | start y-position                                                                                                                                                              |
| <code>len</code>             | total length of the chromosome                                                                                                                                                |
| <code>width</code>           | width of the chromosome                                                                                                                                                       |
| <code>fill</code>            | character, {"a","p","q","q[1-3]","p[1-3]"}. Events to a chromosome can be depicted by coloring "a"ll of the chromosome, the complete p or q-arm, or a sub-segment of the arms |
| <code>col</code>             | color(s) of fill                                                                                                                                                              |
| <code>orientation</code>     | either "h"orizontal or "v"ertical                                                                                                                                             |
| <code>centromere.size</code> | The size of the centromere as fraction of the width                                                                                                                           |

**Value**

This function is executed for its side effects

**Author(s)**

Jan Oosting

**Examples**

```
plot(c(0,4),c(0,3),type="n",xaxt="n",yaxt="n",xlab="",ylab="")
drawSimpleChrom(2,3,fill=c("p","q3"),col=c("red","blue"),orientation="v")
```

---

|                   |                          |
|-------------------|--------------------------|
| getChangedRegions | <i>getChangedRegions</i> |
|-------------------|--------------------------|

---

**Description**

retrieve regions of interest in a vector of intensities using quantile smoothing

**Usage**

```
getChangedRegions(intensities, positions, normalized.to=1, interval, threshold, minlength=2, ...)
```

**Arguments**

|                            |                                                                                                                                                                                                                                                                                            |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>intensities</code>   | numeric vector                                                                                                                                                                                                                                                                             |
| <code>positions</code>     | numeric vector of the same length as <code>intensities</code> . If this argument is not given the results contain the indexes of the <code>intensities</code> vector, else the values in <code>positions</code> are used. Both vectors are sorted in the order of <code>positions</code> . |
| <code>normalized.to</code> | numeric, reference value. Changes are compared to this value                                                                                                                                                                                                                               |
| <code>interval</code>      | numeric [0,1], bandwidth around reference. If the smoothed line at the higher quantile drops below the <code>normalized.to</code> value, a deleted region is recognized, and vice versa.                                                                                                   |
| <code>threshold</code>     | numeric, if the median smoothed value drops below <code>normalized.to</code> - <code>threshold</code> , or above <code>normalized.to</code> + <code>threshold</code> a changed region is called                                                                                            |
| <code>minlength</code>     | integer, not used currently                                                                                                                                                                                                                                                                |
| <code>...</code>           | extra arguments for <code>quantsmooth</code> function                                                                                                                                                                                                                                      |

**Details**

This function uses `quantsmooth` to detect regions in the genome that are abnormal. If `interval` is set then a smoothed line is calculated for  $\tau = 0.5 - \text{interval}/2$ , and a region is determined as upregulated if this line is above the reference. Down regulation is determined when the smoothed line for  $\tau = 0.5 + \text{interval}/2$  is below the reference value. If `threshold` is set then a smoothed line is calculated for  $\tau = 0.5$  and up- or down regulation are determined when this line is outside the range `[normalized.t - threshold:normalized.to + threshold]`

**Value**

A data.frame with 3 columns is returned. Each row contains a region with columns `up`, `start` and `end`. `start` and `end` indicate positions in the vector of the first and last position that were up- or downregulated

**Author(s)**

Jan Oosting

**Examples**

```
data(chr14)
getChangedRegions(ill.cn[,1],ill.pos,normalized.to=2,interval=0.5)
```

---

getLambdaMin

*getLambdaMin*


---

**Description**

Test a set of smoothing parameters to find best fit to data

**Usage**

```
getLambdaMin(intensities,lambdas,...)
```

**Arguments**

|                          |                                                                                            |
|--------------------------|--------------------------------------------------------------------------------------------|
| <code>intensities</code> | numeric vector                                                                             |
| <code>lambdas</code>     | numeric vector; see <a href="#">quantsmooth</a>                                            |
| <code>...</code>         | extra parameters for <code>quantsmooth.cv</code> ; currently only <code>ridge.kappa</code> |

**Details**

Cross validation is performed using a set of lambda values in order to find the lambda value that shows the best fit to the data.

**Value**

This function returns the lambda value that has the lowest cross validation value on this dataset

**Author(s)**

Jan Oosting

**See Also**

[quantsmooth.cv](#)

**Examples**

```
data(chr14)
lambdas<-2^seq(from=-2,to=5,by=0.25)
getLambdaMin(bac.cn[,1],lambdas)
```

---

grid.chromosome

*Draw a chromosome using the grid package*


---

**Description**

A chromosome is drawn including the cytobands

**Usage**

```
grid.chromosome(chrom, side = 1, units = "hg19", chrom.width = 0.5, length.out,
  bands = "major", legend = c("chrom", "band", "none"), cex.leg = 0.7, bleach = 0, ...)
```

**Arguments**

|             |                                                                                                                                       |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------|
| chrom       | numeric or character, id of chromosome to plot                                                                                        |
| side        | numeric [1:4], side of rectangle to draw, 4 sides, side 2 and 4 are vertical                                                          |
| units       | character or data.frame, type of units for genomic data, or a dataframe with UCSC cytoband data, see <a href="#">lengthChromosome</a> |
| chrom.width | numeric [0,1], The width relative to the width (sides 2 and 4) or height(sides 1 and 3) of the viewport                               |
| length.out  | numeric, size of native units of viewport                                                                                             |
| bands       | character, draw either major or minor bands                                                                                           |
| legend      | character, type of legend                                                                                                             |
| cex.leg     | numeric, relative size of legend text                                                                                                 |
| bleach      | numeric [0,1], proportion by which to bleach the chromosome                                                                           |
| ...         | arguments for viewport(), especially x,y, width, and height                                                                           |

**Details**

The chromosome is drawn within a rectangle defined by x, y, width, and height, which is pushed as a viewport. The legend is drawn within the same rectangle in the space left over by chrom.width.

**Value**

This function is executed for its side effects

**Author(s)**

David L Duffy ,Jan Oosting

## References

lodplot package

## See Also

[paintCytobands](#)

## Examples

```
grid.newpage()  
grid.chromosome(1,units="bases",height=0.15)
```

---

helperFunctions

*arraysmooth Helper functions*

---

## Description

quantsmooth Helper functions

## Usage

```
getChangedIdx(changed,up)
```

## Arguments

changed

up

## Details

Should not be called directly

## Value

A data.frame with 3 columns is returned. Each row contains a region with columns up, start and end. start and end indicate positions in the vector of the first and last position that were up- or downregulated

## Author(s)

Jan Oosting

---

|                  |                                    |
|------------------|------------------------------------|
| lengthChromosome | <i>Retrieve chromosomal length</i> |
|------------------|------------------------------------|

---

## Description

Retrieve human chromosomal length from NCBI data

## Usage

```
lengthChromosome(chrom, units = "hg19")
```

## Arguments

|       |                                       |
|-------|---------------------------------------|
| chrom | vector of chromosomal id, 1:22,X,Y    |
| units | character, or data.frame, see details |

## Details

The cytoband data was originally obtained from the lodplot package by David Duffy, which contained basepair data from genome version hg17, but also the linkage related positions in cM. These datasets have units "bases" and "cM" respectively. Cytoband data for genome versions "hg18", "hg19", "hg38" and "mm10" has been included, and can be referenced by these strings. It is also possible to use cytoband data as obtained from the UCSC site, by downloading the cytoBand.txt.gz or cytoBandIdeo.txt.gz annotation file for a species (see example below). Note however that this information is not available for most species.

## Value

A numeric vector in the requested units

## Author(s)

Jan Oosting

## Examples

```
# Show length of chromosome 1 in several types of units
lengthChromosome(1,"cM")
lengthChromosome(1,"bases")
lengthChromosome(1,"hg38")
# mm9 cytoband data
temp <- tempfile(fileext = ".txt.gz")
download.file("http://hgdownload.soe.ucsc.edu/goldenPath/mm9/database/cytoBand.txt.gz", temp)
mm9cytobands <- read.table(temp, sep="\t")
lengthChromosome(1, mm9cytobands)
# remove temp file
unlink(temp)
```

---

|            |                                                                   |
|------------|-------------------------------------------------------------------|
| numericCHR | <i>Conversion of chromosome IDs between numeric and character</i> |
|------------|-------------------------------------------------------------------|

---

**Description**

The function converts chromosomal ids to their numeric form, and the sex chromosomes to values between 98 and 100. This simplifies sorting on chromosome ID

**Usage**

```
numericCHR(CHR, prefix="chr")
characterCHR(CHR, prefix="")
```

**Arguments**

|        |                                                                                                                                                                       |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CHR    | character/numeric vector for both functions the mode of the input is not forced. For numericCHR strings "X","Y" and "XY" are converted to 98,99 and 100 respectively. |
| prefix | character, string is excluded from (numericCHR) or prepended to (characterCHR) all items of the output                                                                |

**Value**

numericCHR returns a numeric vector of same length as CHR characterCHR returns a character vector of same length as CHR

**Author(s)**

Jan Oosting

**Examples**

```
chroms<-c("3","2","8","X","7","Y","5","1","9","10","11","12","4","6")
sort(chroms)
sort(numericCHR(chroms))
characterCHR(sort(numericCHR(chroms)),prefix="chr")
```

---

|                |                                     |
|----------------|-------------------------------------|
| paintCytobands | <i>Paint a chromosomal idiogram</i> |
|----------------|-------------------------------------|

---

**Description**

Paints a human chromosomal idiogram in an existing plot Adapted from the paint.chromosome function in the lodplot package by David L Duffy

**Usage**

```
paintCytobands(chrom, pos = c(0, 0), units = "hg19", width = 0.4,
               length.out, bands = "major", orientation = c("h","v"), legend = TRUE,
               cex.leg = 0.7, bleach = 0, ...)
```

**Arguments**

|             |                                                                                                                                       |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------|
| chrom       | chromosomal id, chromosome to plot 1:22,X,Y                                                                                           |
| pos         | numeric vector of length 2, position in the plot to start the plot                                                                    |
| units       | character or data.frame, type of units for genomic data, or a dataframe with UCSC cytoband data, see <a href="#">lengthChromosome</a> |
| width       | numeric, width of the chromosome, the chromosome is plotted between pos[2] and pos[2]-width                                           |
| length.out  | numeric, if given, the chromosome will have this length in the plot                                                                   |
| bands       | if not equal to "major", then also the minor bands will be plotted                                                                    |
| orientation | chromosome is plotted either <i>Horizontally</i> to the right of the starting point or <i>Vertically</i> down from the starting point |
| legend      | logical, if TRUE then the bandnames are plotted next to the chromosome                                                                |
| cex.leg     | numeric, relative size of legend text                                                                                                 |
| bleach      | numeric [0,1], proportion by which to bleach the chromosome                                                                           |
| ...         | extra parameters for plot                                                                                                             |

**Value**

This function is executed for its side effects

**Author(s)**

David L Duffy , Jan Oosting

**References**

lodplot package

**Examples**

```
plot(c(0,lengthChromosome(14,"bases")),c(-2,2),type="n",xaxt="n",yaxt="n",xlab="",ylab="")
paintCytobands(14,units="bases")
```

---

|                |                                 |
|----------------|---------------------------------|
| plotChromosome | <i>Wrapper for plotSmoothed</i> |
|----------------|---------------------------------|

---

**Description**

This function is a wrapper for plotSmoothed, to make data subsetting easier

**Usage**

```
plotChromosome(gendata, chrompos, chromosome, dataselection = NULL, ylim = NULL, normalized.to = NULL)
```

**Arguments**

|               |                                                                          |
|---------------|--------------------------------------------------------------------------|
| gendata       | numeric matrix or data.frame                                             |
| chrompos      | chrompos object with same number of rows as gendata                      |
| chromosome    | numeric, chromosome to show                                              |
| dataselection | optional, subset of samples/columns in gendata                           |
| ylim          | limits for plot                                                          |
| normalized.to | y-value(s) for line                                                      |
| grid          | x-value(s) for line                                                      |
| smooth.lambda | smoothing parameter, see <a href="#">quantsmooth</a>                     |
| interval      | position of extra lines besides median, see <a href="#">plotSmoothed</a> |
| ...           | extra arguments for <a href="#">plotSmoothed</a>                         |

**Value**

The function is used for its side effects

**Author(s)**

Jan Oosting

**See Also**

[plotSmoothed](#), [quantsmooth](#)

---

|              |                     |
|--------------|---------------------|
| plotSmoothed | <i>plotSmoothed</i> |
|--------------|---------------------|

---

**Description**

Plot a smoothed line together with the original data values

**Usage**

```
plotSmoothed(intensities, position, ylim=NULL, ylab="intensity", xlab="position", normalized.to=
```

**Arguments**

|               |                                                                                                                |
|---------------|----------------------------------------------------------------------------------------------------------------|
| intensities   | numeric vector or matrix, data are plotted by column                                                           |
| position      | numeric vector; the length should be the number of rows in intensities                                         |
| ylim          | numeric vector of length 2, limits for plot. If NULL then the minimal and maximal value in intensities is used |
| ylab          | character, label for y-position                                                                                |
| xlab          | character, label for x-position                                                                                |
| normalized.to | numeric, a line(s) is drawn at this horizontal position                                                        |
| grid          | numeric, a line(s) is drawn at this vertical position                                                          |
| smooth.lambda | numeric, smoothing parameter see <a href="#">quantsmooth</a>                                                   |

|          |                                                                                                                                                                                           |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| interval | numeric (0..1), plotting of extra smoothed lines around median. With interval = 0.5 the 0.25 and 0.75 quartiles are plotted, with interval = 0.9 the 0.05 and 0.95 quartiles are plotted, |
| plotnew  | logical, if TRUE a new plot is created, else the data are plotted into an existing plot                                                                                                   |
| cols     | color vector, colors for columns in intensities                                                                                                                                           |
| cex.pts  | size of the dots in the plot. Set to 0 to skip plotting the dots                                                                                                                          |
| ...      | extra parameters for plot                                                                                                                                                                 |

### Details

This function plots the raw data values as dots and the median smoothed values as a continuous line. If interval is supplied these are plotted as lines in different line types. More than 1 interval can be given.

### Value

This function is used for its side effects

### Author(s)

Jan Oosting

### See Also

[quantsmooth](#)

### Examples

```
data(chr14)
plotSmoothed(bac.cn,bac.pos,ylim=c(1,2.5),normalized.to=2,smooth.lambda=2.5)
```

---

|                   |                                                               |
|-------------------|---------------------------------------------------------------|
| position2Cytoband | <i>Determine cytoband position based on location of probe</i> |
|-------------------|---------------------------------------------------------------|

---

### Description

Determine cytoband position based on location of probe

### Usage

```
position2Cytoband(chrom, position, units = "hg19", bands = c("major", "minor"))
```

### Arguments

|          |                                             |
|----------|---------------------------------------------|
| chrom    | chromosomal id, chromosome to plot 1:22,X,Y |
| position | numeric vector                              |
| units    | character, type of positional unit          |
| bands    | character, type of cytoband                 |

**Value**

Character vector with cytobands, if an illegal position was used, the value "-" is returned. All positions within a single function call should be for a single chromosome

**Author(s)**

Jan Oosting

**See Also**

[lengthChromosome](#)

**Examples**

```
position2Cytoband(1,c(50e6,125e6,200e6),units="bases")
position2Cytoband(1,c(50,125,200),units="cM",bands="minor")
```

---

|                   |                                  |
|-------------------|----------------------------------|
| prepareGenomePlot | <i>Set up a full genome plot</i> |
|-------------------|----------------------------------|

---

**Description**

This function starts up a plot consisting of all chromosomes of a genomen, including axes with chromosome names.

**Usage**

```
prepareGenomePlot(chrompos, cols = "grey50", paintCytobands = FALSE, bleach = 0, topspace = 1, organism = "hg19", sexChromosomes = FALSE, units = "hg19", ...)
```

**Arguments**

|                |                                                                                                                                                   |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| chrompos       | chrompos object, data.frame with CHR column identifying the chromosome of probes, and a MapInfo column identifying the position on the chromosome |
| cols           | color(s) for the chromosome lines                                                                                                                 |
| paintCytobands | logical, use paintCytoband to plot ideograms for all chromosomes                                                                                  |
| bleach         | numeric [0,1], proportion by which to bleach the ideograms                                                                                        |
| topspace       | numerical, extra space on top of plot, i.e. for legends                                                                                           |
| organism       | character, if given a 2 column plot is created with the chromosomes for the given species. Currently "hsa", "mmu", and "rno" are supported        |
| sexChromosomes | logical, if TRUE then also the sex chromosomes X and Y are plotted                                                                                |
| units          | character or data.frame, type of units for genomic data, or a dataframe with UCSC cytoband data, see <a href="#">lengthChromosome</a>             |
| ...            | extra arguments for plot function                                                                                                                 |

**Details**

If organism is not supplied then a single column is plotted of the available chromosomes in chrompos\$CHR. The arguments paintCytobands, bleach, and sexChromosomes are not used in that case. If organism is supplied and chrompos is NULL then a result is generated with the starting Y and X position of each chromosome

**Value**

A matrix with 2 columns that contain the Y and X positions for the probes on the plot

**Author(s)**

Jan Oosting

---

|             |                    |
|-------------|--------------------|
| quantsmooth | <i>quantsmooth</i> |
|-------------|--------------------|

---

**Description**

Quantile smoothing of array data

**Usage**

```
quantsmooth(intensities, smooth.lambda=2, tau=0.5, ridge.kappa=0, smooth.na=TRUE, segment)
```

**Arguments**

|               |                                                                  |
|---------------|------------------------------------------------------------------|
| intensities   | numeric vector                                                   |
| smooth.lambda | numeric                                                          |
| tau           | numeric [0..1], the quantile desired; see <a href="#">rq.fit</a> |
| ridge.kappa   | fudge parameter; see details                                     |
| smooth.na     | logical; handling of NA                                          |
| segment       | integer, length of overlapping segments                          |

**Value**

This function returns a vector of the same length as `intensities`, or a matrix if the length of `tau` is greater than 1.

**Author(s)**

Jan Oosting

**Examples**

```
data(chr14)
plot(quantsmooth(bac.cn[,1], smooth.lambda=2.8), type="l")
```

---

|                |                       |
|----------------|-----------------------|
| quantsmooth.cv | <i>quantsmooth.cv</i> |
|----------------|-----------------------|

---

## Description

Cross validation of smoothing parameters

## Usage

```
quantsmooth.cv(intensities, smooth.lambda=2, ridge.kappa=0)
```

## Arguments

|               |                                                  |
|---------------|--------------------------------------------------|
| intensities   | numeric vector                                   |
| smooth.lambda | numeric; see <a href="#">quantsmooth</a>         |
| ridge.kappa   | fudge parameter; see <a href="#">quantsmooth</a> |

## Details

Cross validation is performed by calculating the fit from the even indices on the odd indices and vice versa.

## Value

This function returns the sum of squared differences or NA if the fitting function gave an error

## Author(s)

Jan Oosting

## See Also

[getLambdaMin](#)

## Examples

```
data(chr14)
# A low value is indicative of a better fit to the data
quantsmooth.cv(bac.cn[,1],1)
quantsmooth.cv(bac.cn[,1],2.8)
```

---

|                 |                        |
|-----------------|------------------------|
| quantsmooth.seg | <i>quantsmooth.seg</i> |
|-----------------|------------------------|

---

### Description

segmented Quantile smoothing of array data

### Usage

```
quantsmooth.seg(y, x = 1:length(y), lambda = 2, tau = 0.5, kappa = 0, nb = length(x))
```

### Arguments

|        |                                                                  |
|--------|------------------------------------------------------------------|
| y      | numeric vector                                                   |
| x      | numeric vector of same length as y. Position of values           |
| lambda | numeric                                                          |
| tau    | numeric [0..1], the quantile desired; see <a href="#">rq.fit</a> |
| kappa  | fudge parameter; see details                                     |
| nb     | integer, basis                                                   |

### Value

This function returns a vector of the same length as y

### Author(s)

Jan Oosting

### Examples

```
data(chr14)
plot(quantsmooth.seg(bac.cn[,1], lambda=2.8, nb=50), type="l")
```

---

|         |                                                  |
|---------|--------------------------------------------------|
| scaleto | <i>Scales data within a range to a new range</i> |
|---------|--------------------------------------------------|

---

### Description

This function scales data to a new range while enforcing the boundaries. This can be helpful in preventing overlap between chromosomal plots that display multiple chromosomes in the same plot

### Usage

```
scaleto(x, fromlimits = c(0, 50), tolimits = c(0.5, -0.5), adjust = TRUE)
```

**Arguments**

|                         |                                                                         |
|-------------------------|-------------------------------------------------------------------------|
| <code>x</code>          | numeric                                                                 |
| <code>fromlimits</code> | numeric vector with length 2, original range of data                    |
| <code>tolimits</code>   | numeric vector with length 2, target range of data                      |
| <code>adjust</code>     | logical, if TRUE then the target values are clipped to the target range |

**Value**

numeric of same size as `x`

**Author(s)**

Jan Oosting

# Index

- \* **aplot**
  - drawSimpleChrom, [3](#)
  - grid.chromosome, [6](#)
  - paintCytobands, [9](#)
- \* **attribute**
  - getChangedRegions, [4](#)
- \* **datasets**
  - chrom.bands, [2](#)
  - Chromosome14, [3](#)
- \* **data**
  - lengthChromosome, [8](#)
- \* **hplot**
  - plotChromosome, [10](#)
  - plotSmoothed, [11](#)
  - prepareGenomePlot, [13](#)
- \* **htest**
  - quantsmooth.cv, [15](#)
- \* **internal**
  - helperFunctions, [7](#)
- \* **manip**
  - numericCHR, [9](#)
  - position2Cytoband, [12](#)
  - scaleto, [16](#)
- \* **smooth**
  - getLambdaMin, [5](#)
  - quantsmooth, [14](#)
  - quantsmooth.cv, [15](#)
  - quantsmooth.seg, [16](#)

affy.cn (Chromosome14), [3](#)  
affy.pos (Chromosome14), [3](#)

bac.cn (Chromosome14), [3](#)  
bac.pos (Chromosome14), [3](#)

characterCHR (numericCHR), [9](#)  
chr14 (Chromosome14), [3](#)  
chrom.bands, [2](#)  
Chromosome14, [3](#)

drawSimpleChrom, [3](#)

getChangedIdx (helperFunctions), [7](#)  
getChangedRegions, [4](#)  
getLambdaMin, [5](#), [15](#)

grid.chromosome, [6](#)

helperFunctions, [7](#)

ill.cn (Chromosome14), [3](#)  
ill.pos (Chromosome14), [3](#)

lengthChromosome, [6](#), [8](#), [10](#), [13](#)

numericCHR, [9](#)

paintCytobands, [7](#), [9](#)  
plotChromosome, [10](#)  
plotSmoothed, [11](#), [11](#)  
position2Cytoband, [12](#)  
prepareGenomePlot, [13](#)

quantsmooth, [5](#), [11](#), [12](#), [14](#), [15](#)  
quantsmooth.cv, [6](#), [15](#)  
quantsmooth.seg, [16](#)

rq.fit, [14](#), [16](#)

scaleto, [16](#)