

# Package ‘DEWSeq’

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**Type** Package

**Title** Differential Expressed Windows Based on Negative Binomial Distribution

**Version** 1.22.0

**Description** DEWSeq is a sliding window approach for the analysis of differentially enriched binding regions eCLIP or iCLIP next generation sequencing data.

**Imports** BiocGenerics, data.table(>= 1.11.8), GenomeInfoDb, GenomicRanges, methods, S4Vectors, SummarizedExperiment, stats, utils

**Depends** R(>= 4.0.0), R.utils, DESeq2, BiocParallel

**Suggests** knitr, tidyverse, rmarkdown, testthat, BiocStyle, IHW

**VignetteBuilder** knitr

**biocViews** Sequencing, GeneRegulation, FunctionalGenomics, DifferentialExpression

**License** LGPL (>= 3)

**URL** <https://github.com/EMBL-Hentze-group/DEWSeq/>

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**LazyData** false

**RoxygenNote** 7.1.2

**BugReports** <https://github.com/EMBL-Hentze-group/DEWSeq/issues>

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Contents

|                                          |           |
|------------------------------------------|-----------|
| .readAnnotation . . . . .                | 2         |
| DESeqDataSetFromSlidingWindows . . . . . | 3         |
| extractRegions . . . . .                 | 5         |
| filterCounts . . . . .                   | 6         |
| resultsDEWSeq . . . . .                  | 7         |
| slbpDds . . . . .                        | 9         |
| slbpRegions . . . . .                    | 9         |
| slbpVst . . . . .                        | 10        |
| slbpWindows . . . . .                    | 10        |
| SLBP_K562_w50s20 . . . . .               | 11        |
| toBED . . . . .                          | 11        |
| topWindowStats . . . . .                 | 12        |
| <b>Index</b>                             | <b>16</b> |

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|                 |                             |
|-----------------|-----------------------------|
| .readAnnotation | <i>read annotation data</i> |
|-----------------|-----------------------------|

---

Description

read annotation data for windows This is an unexported lowlevel function to read annotations from a file. The file MUST be tab separated and MUST have the following columns:

chromosome: chromosome name  
unique\_id: unique id of the window  
begin: window start co-ordinate  
end: window end co-ordinate  
strand: strand  
gene\_id: gene id  
gene\_name: gene name  
gene\_type: gene type annotation  
gene\_region: gene region  
Nr\_of\_region: number of the current region  
Total\_nr\_of\_region: total number of regions  
window\_number: window number

Usage

```
.readAnnotation(  
  fname,  
  uniqIds = NULL,  
  asGRange = TRUE,  
  checkWindowNumber = TRUE,  
  start0based = TRUE,  
  threads = 10  
)
```

**Arguments**

|                   |                                                                                           |
|-------------------|-------------------------------------------------------------------------------------------|
| fname             | character, file name/path                                                                 |
| uniqIds           | character vector, filter stable and keep annotation for these unique ids                  |
| asGRange          | logical, boolean, whether to reaturn a GRange object or a data.frame object               |
| checkWindowNumber | logical, check window number                                                              |
| start0based       | logical, TRUE (default) or FALSE. If TRUE, then the start                                 |
| threads           | numeric, number of threads for fread (default: 10) positions are considered to be 0-based |

**Value**

data.frame or GRanges object

---

DESeqDataSetFromSlidingWindows  
*create DESeq data object*

---

**Description**

create DESeq data object from sliding window counts, phenotype data and annotation data

**Usage**

```
DESeqDataSetFromSlidingWindows(
  countData,
  colData,
  annotObj,
  design,
  tidy = FALSE,
  ignoreRank = FALSE,
  start0based = TRUE
)
```

**Arguments**

|             |                                                                                                                          |
|-------------|--------------------------------------------------------------------------------------------------------------------------|
| countData   | data.frame or matrix, sliding window count data                                                                          |
| colData     | DataFrame or data.frame, phenotype data, see <a href="#">DESeqDataSet</a>                                                |
| annotObj    | data.frame or character, can either be a data.frame or a file name, see details                                          |
| design      | formula or matrix, design of the experiment, see <a href="#">DESeqDataSet</a>                                            |
| tidy        | logical, If TRUE, first column is of countData is treated as rownames (default: FALSE), see <a href="#">DESeqDataSet</a> |
| ignoreRank  | logical, ignore rank, see <a href="#">DESeqDataSet</a>                                                                   |
| start0based | logical, TRUE (default) or FALSE. If TRUE, then the start positions in annotObj is considered to be 0-based              |

## Details

If `annotObj` is a file name, the input file **MUST** be <TAB> separated, and supports reading in .gz files.

If `annotObj` is a data.frame, `colnames(annotObj)` **MUST** not be empty.

This function checks for the following columns after reading in the file or on data.frame:

- chromosome: chromosome name
- unique\_id: unique id of the window, `rownames(object)` must match this column
- begin: window start co-ordinate, see parameter `start0based`
- end: window end co-ordinate
- strand: strand
- gene\_id: gene id
- gene\_name: gene name
- gene\_type: gene type annotation
- gene\_region: gene region
- Nr\_of\_region: number of the current region
- Total\_nr\_of\_region: total number of regions
- window\_number: window number

This function creates a [DESeqDataSet](#) using supplied `countData`, phenotype data and annotation data. The chromosomal locations and annotations of the sliding windows (parsed from `annotObj`) can be accessed from the returned object using: `rowRanges(object)`

## Value

DESeq object

## Examples

```
data("SLBP_K562_w50s20")
slbpDat <- counts(SLBP_K562_w50s20)
phenoDat <- DataFrame(conditions=as.factor(c(rep('IP',2),'SMI')),
row.names = colnames(slbpDat))
phenoDat$conditions <- relevel(phenoDat$conditions,ref='SMI')
annotDat <- as.data.frame(rowRanges(SLBP_K562_w50s20))
# by default chromosome column is 'seqnames'
# and begin co-ordinate column is 'start'
# rename these columns
colnames(annotDat)[1:2] <- c('chromosome','begin')
slbpDds <- DESeqDataSetFromSlidingWindows(countData = slbpDat,
colData = phenoDat,annotObj = annotDat,design=~conditions)
```

---

|                |                                    |
|----------------|------------------------------------|
| extractRegions | <i>extract significant regions</i> |
|----------------|------------------------------------|

---

## Description

extract significant windows from output of [resultsDEWSeq](#) using the supplied padj and log2FoldChange cut-offs and merge these significant windows to regions and create the following columns for each significant region:

- padj\_min: min. padj value in the region
- padj\_mean: average padj value in the region
- padj\_max: max. padj value in the region
- log2FoldChange\_min: min. log 2 fold change in the region
- log2FoldChange\_mean: average log 2 fold change in the region
- log2FoldChange\_max: max. log 2 fold change in the region

## Usage

```
extractRegions(  
  windowRes,  
  padjCol = "padj",  
  padjThresh = 0.05,  
  log2FoldChangeCol = "log2FoldChange",  
  log2FoldChangeThresh = 1,  
  start0based = TRUE  
)
```

## Arguments

|                      |                                                                                                              |
|----------------------|--------------------------------------------------------------------------------------------------------------|
| windowRes            | data.frame, output from <a href="#">resultsDEWSeq</a>                                                        |
| padjCol              | character, name of the adjusted pvalue column (default: padj)                                                |
| padjThresh           | numeric, threshold for p-adjusted value (default: 0.05)                                                      |
| log2FoldChangeCol    | character, name of the log2foldchange column (default: log2FoldChange)                                       |
| log2FoldChangeThresh | numeric, threshold for log2foldchange value (default:1)                                                      |
| start0based          | logical, TRUE (default) or FALSE. If TRUE, then the start positions in windowRes is considered to be 0-based |

## Details

The output data.frame from this function will have the following columns:

- chromosome: chromosome name
- regionStartId: unique\_id of the left most window, where an enriched region begins

- region\_begin: starting position of the enriched region
- region\_end: ending position of the enriched region
- strand: strand info
- windows\_in\_region: total number of windows that make up the enriched region
- region\_length: length of the enriched region
- gene\_id: gene id
- gene\_name: gene name
- gene\_type: gene type annotation
- gene\_region: gene region
- Nr\_of\_region: number of the current region
- Total\_nr\_of\_region: total number of regions
- window\_number: window number
- padj\_min: min. padj value in the region
- padj\_mean: average padj value in the region
- padj\_max: max. padj value in the region
- log2FoldChange\_min: min. log 2 fold change in the region
- log2FoldChange\_max: max. log 2 fold change in the region
- log2FoldChange\_mean: average log 2 fold change in the region

### Value

data.frame

### Examples

```
data("slbpWindows")
# using default cut-off thresholds,
# 'pSlidingWindows.adj' padj value columns
slbpRegions <- extractRegions(slbpWindows,
  padjCol = 'pSlidingWindows.adj')
```

---

filterCounts

*filter count data*

---

### Description

In addition to count data matrix, htseq-clip also creates a max count matrix. For each window, this file contains the maximum crosslink site count (height) calculated per nucleotide. This function uses this file to filter the count data file instead of the default prefiltering on rowSums. Windows failing the threshold `rowSums(maxWindowCount>=countThresh)>nSamples` will be removed from the object.

**Usage**

```
filterCounts(object, maxCountFile, countThresh, nsamples)
```

**Arguments**

|              |                                                                                |
|--------------|--------------------------------------------------------------------------------|
| object       | DESeqDataSet, see <a href="#">DESeqDataSetFromSlidingWindows</a>               |
| maxCountFile | character file name/path to max count matrix                                   |
| countThresh  | numeric max count threshold                                                    |
| nsamples     | numeric number of samples where the max count value must be $\geq$ countThresh |

**Value**

DESeq object

---

|               |                               |
|---------------|-------------------------------|
| resultsDEWSeq | <i>extract DEWseq results</i> |
|---------------|-------------------------------|

---

**Description**

This is a modified version of the [results](#) function from DESeq2 package.

This function uses chromosomal positions given in the `rowRanges(dds)` to identify overlapping windows in `dds` object. For each window, the number of overlapping windows are counted, and the p-value is adjusted for FWER using bonferroni correction.

For further details, please refer documentation for [results](#) function in DESeq2 package

**Usage**

```
resultsDEWSeq(
  object,
  contrast,
  name,
  listValues = c(1, -1),
  cooksCutoff,
  test,
  addMLE = FALSE,
  tidy = FALSE,
  parallel = FALSE,
  BPPARAM = bpparam(),
  minmu = 0.5,
  start0based = TRUE
)
```

**Arguments**

|             |                                                                                                                                                                                                               |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| object      | DESeqDataSet, on which the following functions has already been called: <a href="#">nbinomWaldTest</a>                                                                                                        |
| contrast    | character vector, list of 2 character vectors or numeric contrast vector<br>contrast this argument specifies what comparison to extract from the object to build a results table, see <a href="#">results</a> |
| name        | character, name the name of the individual effect (coefficient) for building a results table. name argument is ignored if contrast is specified                                                               |
| listValues  | list, check <a href="#">results</a> for details of this parameter                                                                                                                                             |
| cooksCutoff | numeric, threshold on Cook's distance                                                                                                                                                                         |
| test        | character, this is automatically detected internally if not provided.                                                                                                                                         |
| addMLE      | logical, if betaPrior=TRUE was used                                                                                                                                                                           |
| tidy        | logical, whether to output the results table with rownames as a first column 'row'. The table will also be coerced to data.frame                                                                              |
| parallel    | logical, if FALSE, no parallelization. if TRUE, parallel execution using BiocParallel, see next argument BPPARAM                                                                                              |
| BPPARAM     | bpparamClass, an optional parameter object passed internally to <a href="#">bplapply</a> when parallel=TRUE. If not specified, the parameters last registered with <a href="#">register</a> will be used.     |
| minmu       | numeric, lower bound on the estimated count (used when calculating contrasts)                                                                                                                                 |
| start0based | logical, TRUE (default) or FALSE. If TRUE, then the start positions in annotationFile are considered to be 0-based                                                                                            |

**Details**

For a detailed description of the column use `mcols(output)$description`

**Value**

DESeqResults object

**Examples**

```
data("slbpDds")
slbpDds <- estimateSizeFactors(slbpDds)
slbpDds <- estimateDispersions(slbpDds)
slbpDds <- nbinomWaldTest(slbpDds)
slbpWindows <- resultsDEWSeq(slbpDds)

## Not run:
# for a description of the columns in slbpWindows use
mcols(slbpWindows)$description

## End(Not run)
```

---

`slbpDds`*ENCODE eCLIP data SLBP in K562*

---

**Description**

This is a DESeq dataset object for ENCODE eCLIP data: SLBP in K562 cell lines This is used as an example dataset for a runnable example. This dataset is the output from running the example code for the function [DESeqDataSetFromSlidingWindows](#)

**Usage**

```
data(slbpDds)
```

**Format**

An object of class "DESeq";

**Examples**

```
data(slbpDds)
slbpDds
```

---

`slbpRegions`*ENCODE eCLIP data SLBP in K562*

---

**Description**

This is a DESeq results object for ENCODE eCLIP data: SLBP in K562 cell lines This is used as an example dataset for a runnable example. This dataset is the output from running the example code for the function [extractRegions](#)

**Usage**

```
data(slbpRegions)
```

**Format**

```
data.frame;
```

**Examples**

```
data(slbpRegions)
head(slbpRegions)
```

---

`slbpVst`*ENCODE eCLIP data SLBP in K562*

---

**Description**

This is a DESeq normalized sliding window count matrix ENCODE eCLIP data: SLBP in K562 cell lines This is used as an example dataset for a runnable example. This dataset is the output from running the example code for the function [vst](#)

**Usage**

```
data(slbpVst)
```

**Format**

```
matrix;
```

**Examples**

```
data(slbpVst)
head(slbpVst)
```

---

`slbpWindows`*ENCODE eCLIP data SLBP in K562*

---

**Description**

This is a DESeq results object for ENCODE eCLIP data: SLBP in K562 cell lines This is used as an example dataset for a runnable example. This dataset is the output from running the example code for the function [resultsDEWSeq](#)

**Usage**

```
data(slbpWindows)
```

**Format**

```
data.frame;
```

**Examples**

```
data(slbpWindows)
head(slbpWindows)
```

SLBP\_K562\_w50s20

*ENCODE eCLIP data for SLBP in K562, low count filtered***Description**

This is ENCODE eCLIP data which was quantified by htseq-clip in sliding-windows of max. length 50nt, the step size was 20. This is not ideal data for DEWSeq since it is lacking replicates, however was small enough for the inclusion of the package.

**Usage**

```
data(SLBP_K562_w50s20)
```

**Format**

An object of class "DESeq";

**Examples**

```
data(SLBP_K562_w50s20)
SLBP_K562_w50s20
```

toBED

*windows/regions to BED***Description**

given output of [extractRegions](#), [resultsDEWSeq](#) and significance thresholds, extract significant windows, create regions by merging adjacent significant windows. Finally, write the output as a BED file for visualization.

**Usage**

```
toBED(
  windowRes,
  regionRes,
  fileName,
  padjCol = "padj",
  padjThresh = 0.05,
  log2FoldChangeCol = "log2FoldChange",
  log2FoldChangeThresh = 1,
  trackName = "sliding windows",
  description = "sliding windows"
)
```

**Arguments**

|                      |                                                                        |
|----------------------|------------------------------------------------------------------------|
| windowRes            | data.frame, output from <a href="#">resultsDEWSeq</a>                  |
| regionRes            | data.frame, output from <a href="#">extractRegions</a>                 |
| fileName             | character, filename to save BED output                                 |
| padjCol              | character, name of the adjusted pvalue column (default: padj)          |
| padjThresh           | numeric, threshold for p-adjusted value (default: 0.05)                |
| log2FoldChangeCol    | character, name of the log2foldchange column (default: log2FoldChange) |
| log2FoldChangeThresh | numeric, threshold for log2foldchange value (default:1)                |
| trackName            | character, name of this track, for visualization                       |
| description          | character, description of this track, for visualization                |

**Value**

write to file

**Examples**

```
data(slbpRegions)
data(slbpWindows)
outFile <- tempfile('SLBP_visualization.bed')
# the results are written to a temp file in this example
toBED(slbpWindows,slbpRegions,outFile,padjCol='pSlidingWindows.adj')
```

---

|                |                                                 |
|----------------|-------------------------------------------------|
| topWindowStats | <i>stats for the top windows in each region</i> |
|----------------|-------------------------------------------------|

---

**Description**

given window results and normalized counts, combine significant overlapping windows into regions and for each region, pick two candidate windows:

1. with highest log2FoldChange and
2. with highest normalized mean in treatment samples (see parameter treatmentCols)

Return a data.frame with region information and stats, and for the selected windows, the following information:

- unique\_id of the window
- start and end co-ordinates
- log2FoldChange
- normalized mean expression in treatment and control samples and
- individual normalized expression in replicates

**Usage**

```
topWindowStats(
  windowRes,
  padjCol = "padj",
  padjThresh = 0.05,
  log2FoldChangeCol = "log2FoldChange",
  log2FoldChangeThresh = 1,
  start0based = TRUE,
  normalizedCounts,
  treatmentCols,
  treatmentName = "treatment",
  controlName = "control",
  op = "max"
)
```

**Arguments**

|                      |                                                                                                                                                                                                                                            |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| windowRes            | data.frame, output from <a href="#">resultsDEWSeq</a>                                                                                                                                                                                      |
| padjCol              | character, name of the adjusted pvalue column (default: padj)                                                                                                                                                                              |
| padjThresh           | numeric, threshold for p-adjusted value (default: 0.05)                                                                                                                                                                                    |
| log2FoldChangeCol    | character, name of the log2foldchange column (default: log2FoldChange)                                                                                                                                                                     |
| log2FoldChangeThresh | numeric, threshold for log2foldchange value (default:1)                                                                                                                                                                                    |
| start0based          | logical, TRUE (default) or FALSE. If TRUE, then the start positions in windowRes is considered to be 0-based                                                                                                                               |
| normalizedCounts     | data.frame or matrix, normalized read counts per window. rownames(normalizedCounts) and unique_id column from windowRes must match see <a href="#">counts</a> , <a href="#">vst</a> or <a href="#">rlog</a>                                |
| treatmentCols        | character vector, column names in normalizedCounts for treatment/case samples. The remaining columns in the data.frame will be considered control samples                                                                                  |
| treatmentName        | character, treatment name, see Details (default: treatment)                                                                                                                                                                                |
| controlName          | character, control name, see Details (default: control)                                                                                                                                                                                    |
| op                   | character, can be one of max (default) or min. max returns windows with maximum log2FoldChange and mean normalized expression in the treatmentCols columns, min returns windows with minimum log2FoldChange and mean normalized expression |

**Details**

The output data.frame of this function has the following columns:

- chromosome: chromosome name
- gene\_id: gene id
- gene\_name: gene name

- gene\_region: gene region
- gene\_type: gene type annotation
- regionStartId: unique\_id of the left most window, where a enriched region begins
- region\_begin: start position of the enriched region
- region\_end: end position of the enriched region
- region\_length: length of the enrched region
- strand: strand info
- Nr\_of\_region: number of the current region
- Total\_nr\_of\_region: total number of regions
- log2FoldChange\_min: min. log 2 fold change in the region
- log2FoldChange\_mean: average log 2 fold change in the region
- log2FoldChange\_max: max. log 2 fold change in the region
- unique\_id.log2FCWindow: unique\_id of the window with largest log2FoldChange
- begin.log2FCWindow: start position of the window with largest log2FoldChange
- end.log2FCWindow: end of the window with largest log2FoldChange
- log2FoldChange.log2FCWindow: log2FoldChange of the window with largest log2FoldChange
- treatmentName.mean.log2FCWindow: mean of the normalized expression of the treatment samples for log2FCWindow, names in treatmentCols are used to calculate mean and treatmentName is from the parameter treatmentName
- controlName.mean.log2FCWindow: mean of the normalized expression of the control samples for log2FCWindow, colnames(normalizedCounts) not found in treatmentCols are used to calculate mean and controlName is from the parameter controlName
- the next columns will be normalized expression values of the log2FCWindow from individual treatment and control samples.
- unique\_id.meanWindow: unique\_id of the window with largest mean in all treatment samples from treatmentCols
- begin.meanWindow: start position of the mean window
- end.meanWindow: end position of the mean window
- log2FoldChange.meanWindow:log2FoldChange of the mean window
- treatmentName.mean.meanWindow: mean of the normalized expression of the treatment samples for meanWindow, names in treatmentCols are used to calculate mean and treatmentName is from the parameter treatmentName
- controlName.mean.meanWindow: mean of the normalized expression of the control samples for log2FCWindow, colnames(normalizedCounts) not found in treatmentCols are used to calculate mean and controlName is from the parameter controlName
- the next columns will be normalized expression values of the meanWindow from individual treatment and control samples

## Value

data.frame

**Examples**

```
data(slbpWindows)
data(slbpVst)
slbpList <- topWindowStats(slbpWindows, padjCol = 'pSlidingWindows.adj',
  normalizedCounts = slbpVst, treatmentCols = c('IP1', 'IP2'),
  treatmentName = 'SLBP', controlName = 'SMI')
```

# Index

## \* datasets

SLBP\_K562\_w50s20, 11

slbpDds, 9

slbpRegions, 9

slbpVst, 10

slbpWindows, 10

## \* internal

.readAnnotation, 2

.readAnnotation, 2

bplapply, 8

counts, 13

DESeqDataSet, 3, 4

DESeqDataSetFromSlidingWindows, 3, 7, 9

extractRegions, 5, 9, 11, 12

filterCounts, 6

nbinomWaldTest, 8

register, 8

results, 7, 8

resultsDEWSeq, 5, 7, 10–13

rlog, 13

SLBP\_K562\_w50s20, 11

slbpDds, 9

slbpRegions, 9

slbpVst, 10

slbpWindows, 10

toBED, 11

topWindowStats, 12

vst, 10, 13