

# Package ‘borealis’

December 9, 2025

**Type** Package

**Title** Bisulfite-seq Outlier mEthylation At singLe-sIte reSolution

**Version** 1.15.0

**Depends** R (>= 4.2.0), Biobase

**Imports** doParallel, snow, purrr, plyr, foreach, gamlss, gamlss.dist,  
bsseq, methods, DSS, R.utils, utils, stats, ggplot2, cowplot,  
dplyr, rlang, GenomicRanges

**Description** Borealis is an R library performing outlier analysis for  
count-based bisulfite sequencing data. It detects outlier  
methylated CpG sites from bisulfite sequencing  
(BS-seq). The core of Borealis is modeling Beta-Binomial distributions. This  
can be useful for rare disease diagnoses.

**License** GPL-3

**Encoding** UTF-8

**Suggests** BiocStyle, knitr, rmarkdown, RUnit, BiocGenerics, annotatr,  
tidyr, TxDb.Hsapiens.UCSC.hg19.knownGene, org.Hs.eg.db

**VignetteBuilder** knitr

**biocViews** Sequencing, Coverage, DNAMethylation,  
DifferentialMethylation

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|------------------|--------------------------------------------------------------------|
| borealis-package | <i>Bisulfite-seq Outlier mEthylation At singLe-sIte reSolution</i> |
|------------------|--------------------------------------------------------------------|

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Description

Borealis is an R package performing outlier analysis for count-based bisulfite sequencing data. It detects outlier methylated CpG sites from bisulfite sequencing (BS-seq). The core of Borealis is modeling Beta-Binomial distributions. This can be useful for rare disease diagnoses.

Details

See packageDescription('borealis')

Author(s)

Maintainer: Garrett Jenkinson <gargar934@gmail.com>

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|-------------|---------------------------------------------------------------------------|
| plotCpGsite | <i>Generate a plot of the model and raw data at one or more CpG sites</i> |
|-------------|---------------------------------------------------------------------------|

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Description

Generate plots of model and results. The top panel of the plot will be the beta distribution in the beta-binomial model estimated for the cohort. The bottom panel will be the 95 percent confidence intervals around the percent methylation in each sample at that CpG site.

Usage

```
plotCpGsite(cpgSites, sampleOfInterest=NA, modelFile="CpG_model.csv",
            methCountFile="CpG_model_rawMethCount.tsv",
            totalCountFile="CpG_model_rawTotalCount.tsv")
```

**Arguments**

|                  |                                                                                                                                                                                          |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| cpgSites         | A character vector of CpG sites specified as "chr1:71732" representing the chromosome and start position of the CpG site. A separate plot will be generated for each site specified.     |
| sampleOfInterest | (optional) character(1) Name of sample of interest which will be colored differently than the rest of the samples in the cohort. If NA then all samples will be plotted with same color. |
| modelFile        | character(1) The mode file (including full path if not current working directory) with beta-binomial parameter estimates produced by runBorealis.                                        |
| methCountFile    | character(1) File name (including full path if not current working directory) for the methylated count file produced by runBorealis.                                                     |
| totalCountFile   | character(1) File name (including full path if not current working directory) for the total count file produced by runBorealis.                                                          |

**Value**

Returns a list with each element indexed by the provided cpgSites and storing a ggplot/cowplot object.

**Examples**

```
extdata <- system.file("extdata", package="borealis")
plots <- plotCpGsite("chr14:24780288",
  sampleOfInterest="patient_72",
  modelFile=file.path(extdata,"CpG_model_chr14.csv"),
  methCountFile=file.path(extdata,"CpG_model_rawMethCount_chr14.tsv"),
  totalCountFile=file.path(extdata,"CpG_model_rawTotalCount_chr14.tsv"))
```

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runBorealis

*Run the full borealis pipeline*


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**Description**

Run the full borealis pipeline. It will load in bismark data and save out to disk matrix-based methylation and total count files, then it will build the beta-binomial statistical models for the cohort at each CpG site and save the parameters of this model to disk, and finally provide outlier p-values and summary statistics for each sample in the cohort at each CpG site.

**Usage**

```
runBorealis(inDir,
  suffix = "_merged.cov.gz.CpG_report.merged_CpG_evidence.cov.gz",
  nThreads = 8, minDepth = 4, minSamps = 5, timeout = 10,
  laplaceSmooth = TRUE,
  chrs = c(paste0("chr",seq_len(22)), "chrX", "chrY"),
  outprefix = "borealis_", modelOutPrefix = "CpG_model")
```

**Arguments**

|                             |                                                                                                                                                                                                    |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>inDir</code>          | character(1) Directory path to bismark results. NOTE: this assumes following pattern for full paths to bismark coverage gz files: <code>\${inDir}/\${sampleName}/\${sampleName}\${suffix}</code> . |
| <code>suffix</code>         | (optional) character(1) File suffix for the bismark coverage files.                                                                                                                                |
| <code>nThreads</code>       | (optional) numeric(1) Number of compute threads to be used in multithreading computations.                                                                                                         |
| <code>minDepth</code>       | (optional) numeric(1) The minimum depth of coverage for sample to go into modeling.                                                                                                                |
| <code>minSamps</code>       | (optional) numeric(1) The minimum number of samples with <code>minDepth</code> coverage required to build a model at a given CpG site.                                                             |
| <code>timeout</code>        | (optional) numeric(1) The maximum time in seconds to spend trying to build a model at a given CpG site (if it takes longer, we skip the site).                                                     |
| <code>laplaceSmooth</code>  | (optional) logical(1) Whether or not to do Laplace (i.e., add one) smoothing on the counts.                                                                                                        |
| <code>chrs</code>           | (optional) A character vector listing the chromosomes to be loaded.                                                                                                                                |
| <code>outprefix</code>      | (optional) character(1) The sample output file prefix (can include a full file path if current working directory is not desired output location).                                                  |
| <code>modelOutPrefix</code> | (optional) character(1) The cohort modeling output file prefix (can include a full file path if current working directory is not desired output location).                                         |

**Value**

Returns an object of "BSseq" class with raw dataset loaded and used for modeling purposes.

**Examples**

```
extdata <- system.file("extdata", "bismark", package="borealis")
outdir <- tempdir()
results <- runBorealis(extdata, nThreads=2, chrs="chr14", suffix=".gz",
                      outprefix = file.path(outdir, "borealis_"),
                      modelOutPrefix = file.path(outdir, "CpG_model"))
```

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|                                 |                                                        |
|---------------------------------|--------------------------------------------------------|
| <code>runSingleNewSample</code> | <i>Run a single new sample after modeling complete</i> |
|---------------------------------|--------------------------------------------------------|

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**Description**

Run a single new sample after modeling using `runBorealis` has already been completed in a cohort of samples. It will not rebuild the models and only predict using previously estimated model specified by `modelFile`.

**Usage**

```
runSingleNewSample(inFile, outFile, minObsDepth=10, modelFile="CpG_model.csv")
```

**Arguments**

|                          |                                                                                                                                                                           |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>inFile</code>      | character(1) File name (including full path if not current working directory) to the bismark coverage file.                                                               |
| <code>outFile</code>     | character(1) File name (including full path if not current working directory) for the sample's modeling outputs. If NULL is provided, no outputs will be written to disk. |
| <code>minObsDepth</code> | (optional) numeric(1) Minimum depth of coverage in this sample for a modeling output/p-value to be produced at a given CpG.                                               |
| <code>modelFile</code>   | (optional) character(1) File name (including full path if not current working directory) for the model files (built by running <code>runBorealis</code> function).        |

**Value**

Returns a `GRanges` object with modeling results.

**Examples**

```
extdata <- system.file("extdata", package="borealis")
outdir <- tempdir()
gr <- runSingleNewSample(file.path(extdata, 'bismark', 'patient_72',
                                   'patient_72.gz'), file.path(outdir, 'output.txt'),
                        modelFile=file.path(extdata, 'CpG_model_chr14.csv'))
```

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