

# “HEDA” Package

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**Type** Package

**Title** Hydropeaking Events Detection Algorithm

**Version** 1.0

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**Description** HEDA is designed to identify hydropeaking events from raw time-series flow record, a rapid flow variation induced by the hourly-adjusted electricity market. The novelty of HEDA is to use vector angle instead of the first-order derivative to detect change points which not only largely improves the computing efficiency but also accounts for the rate of change of the flow variation. More details: <https://doi.org/10.1016/j.jhydrol.2021.126392> (<https://doi.org/10.1016/j.jhydrol.2021.126392>)

**License**

**Encoding** UTF-8

**LazyData** true

**RoxygenNote**

**NeedsCompilation** no

**Repository** CRAN

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## User Guide

Prior to using this library, four packages needs to install: **dplyr**, **lubridate**, **zoo**, **ggplot2**.

```
library(dplyr)
library(ggplot2)
library(zoo)
library(lubridate)
library(HEDA)
```

The input files should be .csv files, and are required to only contain 3 columns, which are site id, datetime and parameter value respectively. Site id is the identification number of gauge stations. Datetime is the date and time of the record. Parameter value refers to the discharge of flow record.

```
# import the flow data
HPK_Q <- read.table("D:/Ninalty/UCD_Hydropeaking/HPK_FlowData/HPK_WC/CA/11278400.csv", sep = ",",
,header = TRUE, row.names = NULL)
head(HPK_Q)
```

```
##      site_no      dateTime X_00060_00000
## 1 11278400 10/1/1988 7:02      791
## 2 11278400 10/1/1988 7:17      667
## 3 11278400 10/1/1988 7:32      532
## 4 11278400 10/1/1988 7:47      507
## 5 11278400 10/1/1988 8:02      487
## 6 11278400 10/1/1988 8:17      461
```

# Functions

HEDA\_Tidy      Preprocess the data

## Description

Format flow record into hourly record; Split record by designated season; Interpolate and smoothing the record.

## Usage

HEDA\_Tidy(dataframe, season)

## Arguments

dataframe      Name of the dataframe to be processed.  
season      Subset data by season.

## Outputs

Output dataframe has 4 columns containing location id, datetime, parameter value, ann\_thre. ann\_thre is originally the mean annual discharge. If flow record is subset by season, ann\_thre will be the mean discharge of that period.

## Example

```
# format the time column to time format
HPK_Q$dateTime <- parse_date_time(HPK_Q$dateTime, "mdy HM")

# clean subset data by season
hpk_flow_cln = HEDA_Tidy(HPK_Q, season = c(6,7,8,9))
head(hpk_flow_cln)
```

```
## # A tibble: 6 x 4
##   location_id datetime      parameter_value ann_thre
##       <int> <chr>          <dbl>      <dbl>
## 1   11278400 1989-6-1 0:00:00      1568.      723.
## 2   11278400 1989-6-1 1:00:00      1778.      723.
## 3   11278400 1989-6-1 2:00:00      1768.      723.
## 4   11278400 1989-6-1 3:00:00      1770.      723.
## 5   11278400 1989-6-1 4:00:00      1762.      723.
## 6   11278400 1989-6-1 5:00:00      1768.      723.
```

ReversalCount      Detect hydropeaking events

## Description

Detect change points of hydropeaking events and classified change points into four categories.

## Usage

```
ReversalCount(dataframe, alpha1, theta)
```

## Arguments

dataframe      Name of the dataframe to be processed.  
alpha1          Default value : 0.03  
theta            Default value : 60 degree for m<sup>3</sup>/s, 85 degree for cfs. gamma default value: 1.1 m<sup>3</sup>/s or 40 cfs.

## Outputs

Output dataframe has six columns containing location id, datetime, parameter value, ann\_thre, vt\_degree and dgtag. ann\_thre is originally the mean annual discharge. If flow record is subset by season, ann\_thre will be the mean discharge of that period. vt\_degree is the vector angle between two flow vectors. dgtag is the catogrizied change points.

## Example

```
hpk_flow_cg <- ReversalCount(hpk_flow_cln, alpha1 = 0.03, theta = 85, gamma = 40)  
head(hpk_flow_cg)
```

##	location_id	datetime	parameter_value	ann_thre	vt_degree	dgtag
## 1	11278400	1989-06-01 00:00:00	1567.5	722.5849	NA	NA
## 2	11278400	1989-06-01 01:00:00	1752.5	722.5849	89.6903	2
## 3	11278400	1989-06-01 02:00:00	1752.5	722.5849	0.0000	0
## 4	11278400	1989-06-01 03:00:00	1752.5	722.5849	0.0000	0
## 5	11278400	1989-06-01 04:00:00	1752.5	722.5849	0.0000	0
## 6	11278400	1989-06-01 05:00:00	1752.5	722.5849	0.0000	0

Clean\_position      Exclude change points in wrong position

## Description

Change points are excluded if they are in the wrong position. For example, both point 3 and the peak pair represent the peaking discharge whose value (position) should be close to the daily maximum discharge. If the peaking discharge is close to the daily minimum discharge, change points will be removed since they are in the wrong positions.

## Usage

```
Clean_position(dataframe, alpha2)
```

## Arguments

dataframe      Name of the dataframe to be processed.  
alpha2          Default value : 0.3.

## Outputs

The output is dataframe.

## Example

```
hpk_flow_cg <- Clean_position(hpk_flow_cg, alpha2 = 0.3)
```

Clean_Spt	Clean repeated points
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## Description

Clean continuous points of the same type

## Usage

```
clean_Spt(dataframe, alpha3, alpha4)
```

## Arguments

dataframe	Name of the dataframe to be processed.
alpha3	The default value: 0.7
alpha4	The default value: 0.5

## Outputs

The output file is dataframe.

## Example

```
hpk_flow_cg <- Clean_Spt(hpk_flow_cg, alpha3 = 0.7, alpha4 = 0.5)
```

Clean_conectD	Evaluate difference between peaking and off-peaking discharge
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## Description

Evaluate whether the difference in discharge between peaking and off-peaking points is qualified to be identified as hydropeaking events.

## Usage

```
clean_conectD(dataframe, alpha3, alpha4)
```

## Arguments

dataframe	Name of the input dataframe to be processed.
alpha3	The default value: 0.7.
alpha4	The default value: 0.5.

## Outputs

The output will be a dataframe in the same form with the input.

## Example

```
hpk_flow_cg <- Clean_conectD(hpk_flow_cg, alpha3 = 0.7, alpha4 = 0.5)
```

HPK\_plot      Plot hydrograph

## Description

Plot the hydrograph of the processed data with change points marked by different colors.

## Usage

```
HPK_plot(dataframe)
```

## Arguments

dataframe      Name of the input dataframe to be processed.

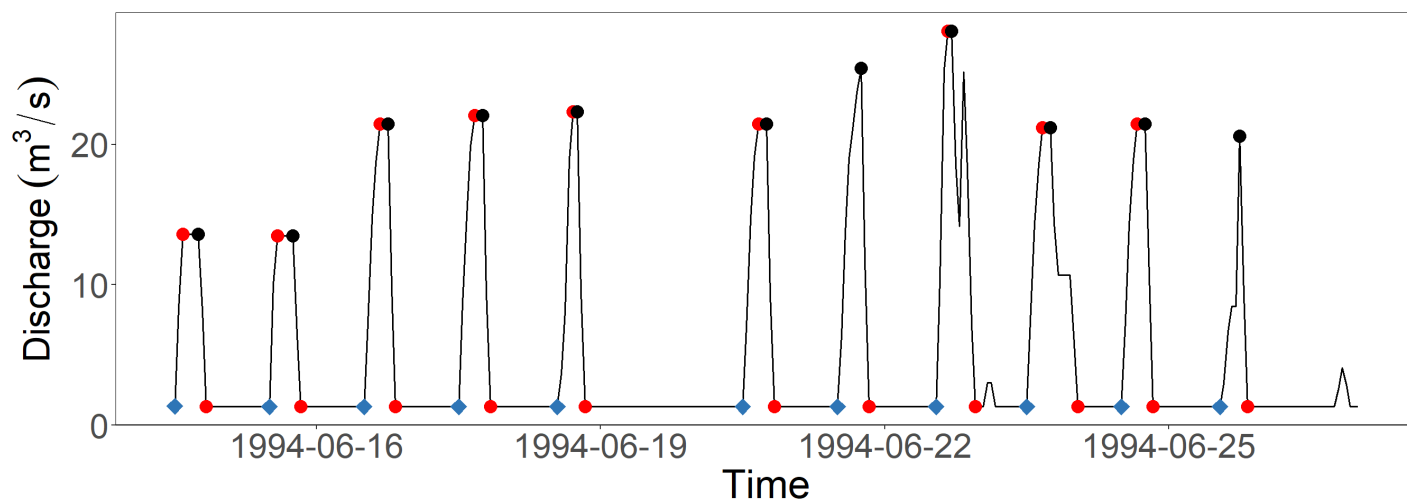
## Outputs

The plot will be presented under the “Plots” tab in RStudio. Users can determine whether to save out the diagram by themselves. The plot shows flow in  $\text{m}^3/\text{s}$ .

## Example

```
## subset the data
tt = hpk_flow_cg[13100:13400,]

# plot the hydrograph of the subset data
HPK_plot(tt)
```



HpkFrqMgt      Extract frequency and magnitude metrics

## Description

Extract Qpeak, offQpeak, pk\_no and pkraio from the identified hydropeaking events.

## Usage

```
HPK_frq_mgt(dataframe)
```

## Arguments

dataframe                      Name of the dataframe to be processed.

## Outputs

Output dataframe includes time-series values of four metrics. Qpeak is the hydropeaking discharge, offQpeak is base flow, pk\_no is the daily number of rise and fall process, pkratio is the ratio of days with hydropeaking to the total number of days analyzed

## Example

```
HpkFrqMgt <- HPK_frq_mgt(hpk_flow_cg)
head(HpkFrqMgt)
```

HpkRtDur                      Extract rate of change and duration related metrics

## Description

Extract rate of change and duration related metrics: pk\_rtn is the retention of peaking process. offpk\_rtn is the retention of base flow. D\_rampup/D\_ramp is the duration of rise/fall process. RB\_Indx\_up/RB\_Index\_dw is the flashness of rise/fall process. Ramp\_up/Ramp\_dw is the rate of change of rise/fall process. Strange\_up/Strange\_dw is the standardized rise/fall amplitude.

## Usage

```
HPK_frq_mgt(dataframe)
```

## Arguments

dataframe                      Name of the dataframe to be processed.

## Outputs

Output dataframe includes time-series values of four metrics. Qpeak is the hydropeaking discharge, offQpeak is base flow, pk\_no is the daily number of rise and fall process, pkratio is the ratio of days with hydropeaking to the total number of days analyzed.

## Example

```
HpkRtDur <- HPK_rt_dur(hpk_flow_cg)

# to extract the time-series of one metric without missing value
pk_rtn <- HpkRtDur[na.omit(HpkRtDur$pk_rtn),c("location_id", "datetime", "pk_rtn")]
```