Model Comparisons Using seawaveQ

Model Comparisons

This document compares variations on the SEAWAVE-Q for selected sites and pesticides. The first site-pesticide is U.S. Geological Survey (USGS) streamgage 03374100, White River at Hazelton, Indiana, alachlor (parameter code 46342). The second site-pesticide combination is USGS streamgage 02335870, Sope Creek near Marietta, Georgia, deethylatrazine (parameter code 04040). This code produces the plots in figure 3 and provides additional model results. The input data are available in Ryberg and others (2017).

USGS Streamgage 03374100, White River at Hazelton, Indiana, 1992-2012

The drainage basin of the White River at Hazelton, Indiana, is calculated to be 29274.853 square kilometers (km^2). The basin is 8.72-percent developed land and 58.46-percent agricultural land (Falcone, 2017).

Alachlor

SEAWAVE-Q/NoFlow

The following plot represents part the R package output for a linear trend model that does not use streamflow as an explanatory variable. Following the plot is the text file that is produced for the analysis providing a summary of the trend analysis.

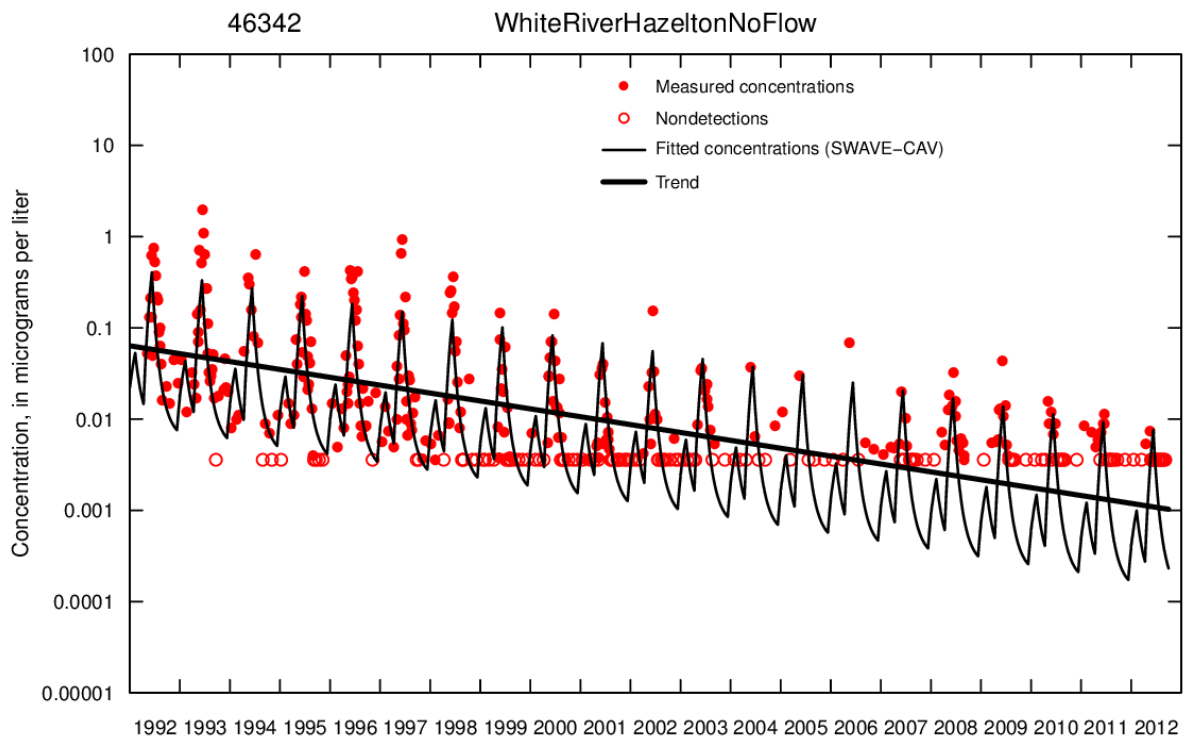
```
site <- "03374100"
siteName <- "WhiteRiverHazelton"
yrs <- 1992
yre <- 2012
trndb <- 1992
trnde <- 2012
onepest <- c("46342")

qw <- subset(input, staid == site)[, 1:70]
contav <- subset(Anoms, staid == site)
combo <- combineData(qwdat = qw, cqwdat = contav)

resname <- paste0(siteName, "NoFlow")

myfitNoFlow <- fitswavecav(cdat = combo, cavdat = contav, tanm = resname,
                      pnames = onepest, yrstart = yrs, yrend = yre, tndbeg = trndb, tndend =
                      trnde, iwcav = c("none"), dcol = "dates", qwcols = c("R","P"))
```

```
ImageProcess(resname)
```




```r
cat(readLines("WhiteRiverHazeltonNoFlow_survregCall.txt"), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:31:34 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 46342
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##               Value Std. Error     z      p
## xmatintcpt -2.06014    0.02807 -73.4 <2e-16
## xmatwavest  1.68558    0.09285  18.1 <2e-16
## xmattndlin -0.08638    0.00467 -18.5 <2e-16
## Log(scale) -0.74245    0.04461 -16.6 <2e-16
##
## Scale= 0.476
##
## Gaussian distribution
## Loglik(model)= -257.9   Loglik(intercept only)= -463.2
##  Chisq= 410.61 on 2 degrees of freedom, p= 6.9e-90
## Number of Newton-Raphson Iterations: 5
## n= 402
##
## Generalized r-squared is:  0.64
## AIC (Akaike's An Information Criterion) is:  523.81
## BIC (Bayesian Information Criterion) is:  539.8
```

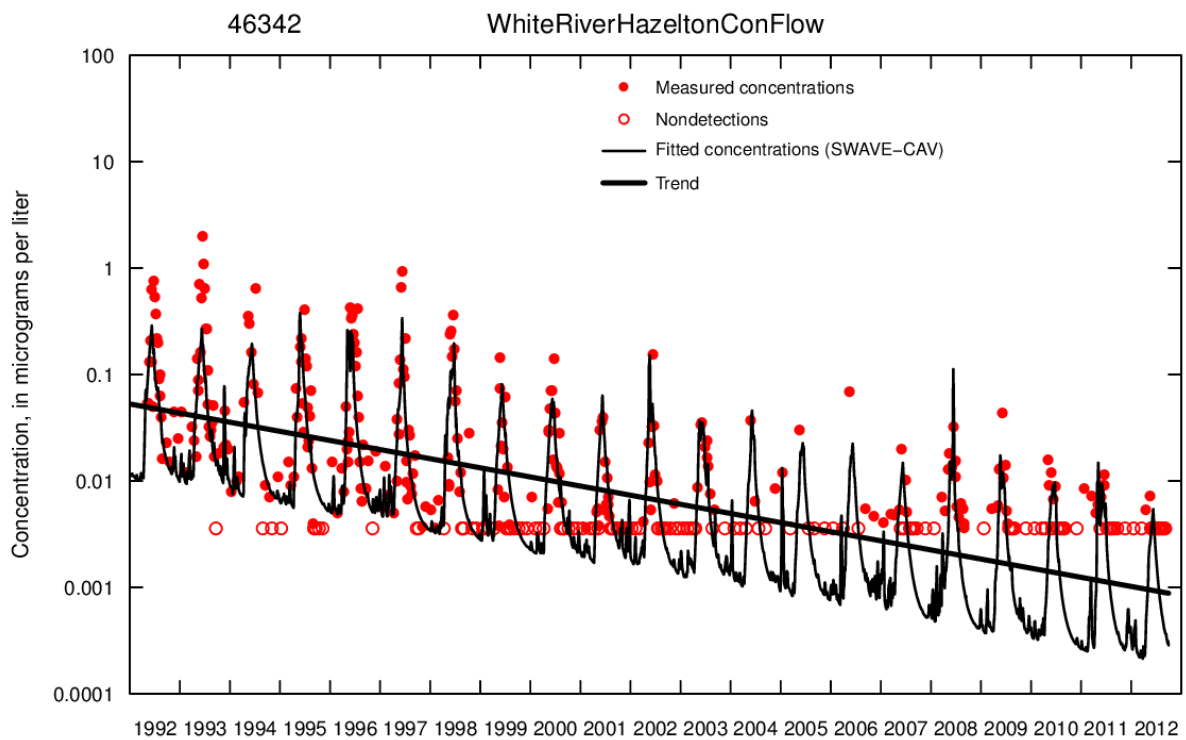
```
## Model class is 1
## Pulse input function is 7
## Half life is 2
## Seasonal value of the maximum concentration is 0.44.
```

SEAWAVE-Q/ConFlow

The following plot represents part the R package output for a linear trend model that uses continuously monitored streamflow as an explanatory variable. Following the plot is the text file that is produced for the analysis providing a summary of the trend analysis.

```
resname <- paste0(siteName, "ConFlow")
myfitFlow <- fitswavecav(cdat = combo, cavdat = contav, tanm = resname,
                         pnames = onepest, yrstart = yrs, yrend = yre,
                         tndbeg = trndb, tndend = trnde, iwcav = c("Q"),
                         dcol = "dates", qwcols = c("R","P"))
```

```
ImageProcess(resname)
```




```
cat(readLines("WhiteRiverHazeltonConFlow_survregCall.txt"), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:31:58 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 46342
## Call:
```

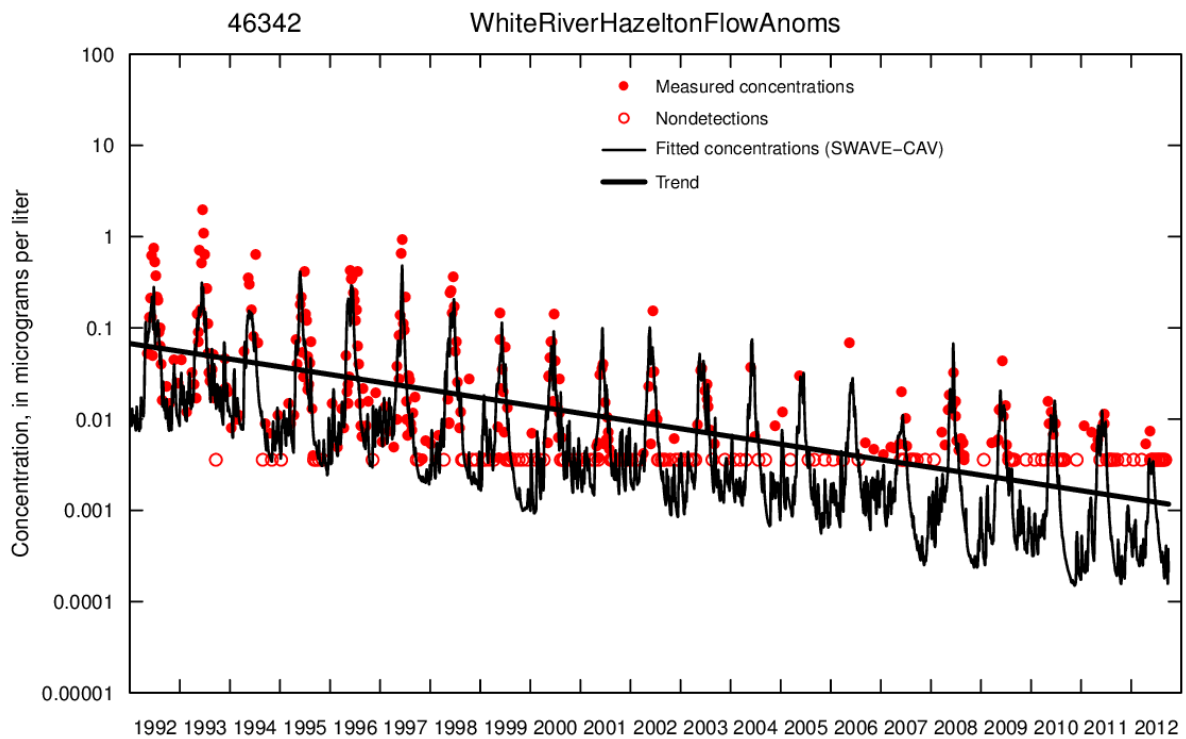
```
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                Value Std. Error      z       p
## xmatintcpt -2.13e+00   3.39e-02 -62.92 < 2e-16
## xmatwavest  1.47e+00   7.88e-02  18.71 < 2e-16
## xmattndlin -8.57e-02   4.43e-03 -19.35 < 2e-16
## xmat        8.12e-06   1.18e-06   6.91 4.9e-12
## Log(scale) -8.04e-01   4.44e-02 -18.09 < 2e-16
##
## Scale= 0.448
##
## Gaussian distribution
## Loglik(model)= -237.2   Loglik(intercept only)= -463.2
##  Chisq= 451.99 on 3 degrees of freedom, p= 1.2e-97
## Number of Newton-Raphson Iterations: 5
## n= 402
##
## Generalized r-squared is:  0.68
## AIC (Akaike's An Information Criterion) is:  484.44
## BIC (Bayesian Information Criterion) is:  504.42
## Model class is 1
## Pulse input function is 2
## Half life is 2
## Seasonal value of the maximum concentration is 0.44.
```

SEAWAVE-Q

The following plot represents part the R package output for a linear trend model that uses streamflow anomalies as explanatory variables. Following the plot is the text file that is produced for the analysis providing a summary of the trend analysis.

```r
resname <- paste0(siteName, "FlowAnoms")
myfitFlowAnoms <- fitswavecav(cdat = combo, cavdat = contav,
                              tanm = resname, pnames = onepest,
                              yrstart = yrs, yrend = yre, tndbeg = trndb,
                              tndend = trnde, iwcav = c("ltfa", "mtfa", "stfa"),
                              dcol = "dates", qwcols = c("R","P"))
```

```r
ImageProcess(resname)
```




```r
cat(readLines("WhiteRiverHazeltonFlowAnoms_survregCall.txt"), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:32:18 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 46342
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##              Value Std. Error      z       p
## xmatintcpt -2.0202     0.0269 -75.19 < 2e-16
## xmatwavest  1.4285     0.0771  18.54 < 2e-16
## xmattndlin -0.0848     0.0042 -20.22 < 2e-16
## xmatltfa    0.6061     0.1461   4.15 3.3e-05
## xmatmtfa    0.5222     0.0701   7.45 9.0e-14
## xmatstfa    0.7322     0.0870   8.42 < 2e-16
## Log(scale) -0.8962     0.0441 -20.31 < 2e-16
##
## Scale= 0.408
##
## Gaussian distribution
## Loglik(model)= -204.4   Loglik(intercept only)= -463.2
##  Chisq= 517.53 on 5 degrees of freedom, p= 1.3e-109
## Number of Newton-Raphson Iterations: 6
## n= 402
##
```

```
## Generalized r-squared is:  0.72
## AIC (Akaike's An Information Criterion) is:  422.9
## BIC (Bayesian Information Criterion) is:  450.87
## Model class is 1
## Pulse input function is 2
## Half life is 2
## Seasonal value of the maximum concentration is 0.44.
```

SEAWAVE-Q/RCS-k

The following plots represent part the R package output for a trend models with 4–7 knots (3–6 cubic splines). Following the each plot the text file that is produced for the analysis providing a summary of the trend analysis.

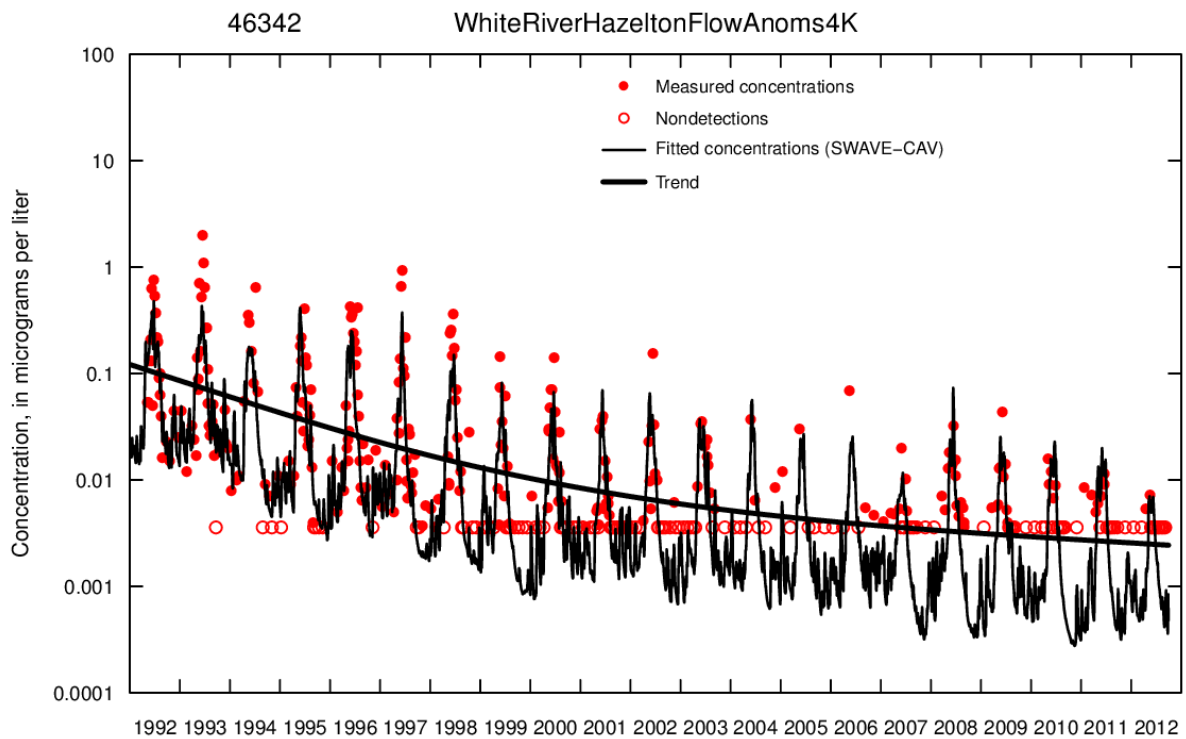
Four Knots

```r
i <- 4
analysisnm <- paste0("FlowAnoms", i, "K")
resname <- paste0(siteName, analysisnm)
txtname <- paste0(resname, "_survregCall.txt")

fit <- fitswavecav(cdat = combo, cavdat = contav,
                   tanm = resname, pnames = onepest, yrstart = yrs,
                   yrend = yre, tndbeg = trndb, tndend = trnde,
                   iwcav = c("ltfa", "mtfa", "stfa"), dcol = "dates",
                   qwcols = c("R","P"), mclass = 2, numk = i)

assign(paste0("myfit", analysisnm), fit)

ImageProcess(resname)
```




```r
cat(readLines(txtname), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:32:38 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 46342
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                Value Std. Error      z       p
## xmatintcpt   -2.4379     0.1470 -16.58 < 2e-16
## xmatwavest    1.4045     0.0730  19.25 < 2e-16
## xmattndlin   -0.1523     0.0203  -7.50 6.2e-14
## xmattndlin'   0.1547     0.1009   1.53 0.12521
## xmattndlin'' -0.1960     0.2517  -0.78 0.43621
## xmatltfa      0.5210     0.1381   3.77 0.00016
## xmatmtfa      0.4746     0.0655   7.24 4.4e-13
## xmatstfa      0.7144     0.0821   8.70 < 2e-16
## Log(scale)   -0.9581     0.0440 -21.80 < 2e-16
##
## Scale= 0.384
##
## Gaussian distribution
## Loglik(model)= -186.7   Loglik(intercept only)= -463.2
##  Chisq= 553.05 on 7 degrees of freedom, p= 3.1e-115
## Number of Newton-Raphson Iterations: 7
```

```
## n= 402
##
## Generalized r-squared is:  0.75
## AIC (Akaike's An Information Criterion) is:  391.38
## BIC (Bayesian Information Criterion) is:  427.35
## Model class is 2
## Pulse input function is 2
## Half life is 2
## Seasonal value of the maximum concentration is 0.44.
```

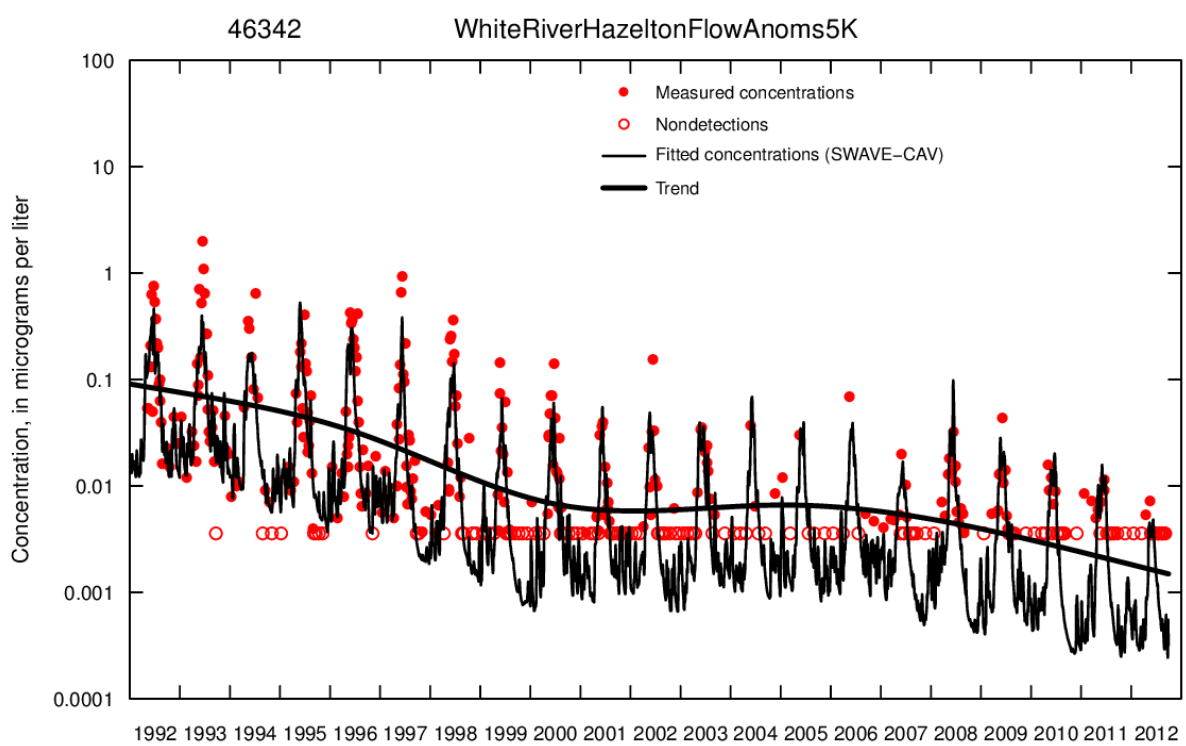
Five Knots

```
i <- 5
analysisnm <- paste0("FlowAnoms", i, "K")
resname <- paste0(siteName, analysisnm)
txtname <- paste0(resname, "_survregCall.txt")

fit <- fitswavecav(cdat = combo, cavdat = contav,
                   tanm = resname, pnames = onepest, yrstart = yrs,
                   yrend = yre, tndbeg = trndb, tndend = trnde,
                   iwcav = c("ltfa", "mtfa", "stfa"), dcol = "dates",
                   qwcols = c("R","P"), mclass = 2, numk = i)

assign(paste0("myfit", analysisnm), fit)

ImageProcess(resname)
```




```
cat(readLines(txtname), sep = "\n")
```

```
##
```

```
##
## Thursday 25 Jun 2020 13:33:04 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 46342
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                 Value Std. Error      z       p
## xmatintcpt    -1.8352     0.2205  -8.32 < 2e-16
## xmatwavest     1.4396     0.0727  19.79 < 2e-16
## xmattndlin    -0.0793     0.0284  -2.79 0.00530
## xmattndlin'   -0.7381     0.2639  -2.80 0.00516
## xmattndlin''   2.6540     0.7478   3.55 0.00039
## xmattndlin''' -3.3925     0.8216  -4.13 3.6e-05
## xmatltfa       0.2725     0.1482   1.84 0.06599
## xmatmtfa       0.4271     0.0653   6.54 6.2e-11
## xmatstfa       0.6929     0.0808   8.57 < 2e-16
## Log(scale)    -0.9784     0.0438 -22.32 < 2e-16
##
## Scale= 0.376
##
## Gaussian distribution
## Loglik(model)= -178.4   Loglik(intercept only)= -463.2
##  Chisq= 569.71 on 8 degrees of freedom, p= 7.6e-118
## Number of Newton-Raphson Iterations: 7
## n= 402
##
## Generalized r-squared is:  0.76
## AIC (Akaike's An Information Criterion) is:  376.72
## BIC (Bayesian Information Criterion) is:  416.68
## Model class is 2
## Pulse input function is 2
## Half life is 2
## Seasonal value of the maximum concentration is 0.44.
```

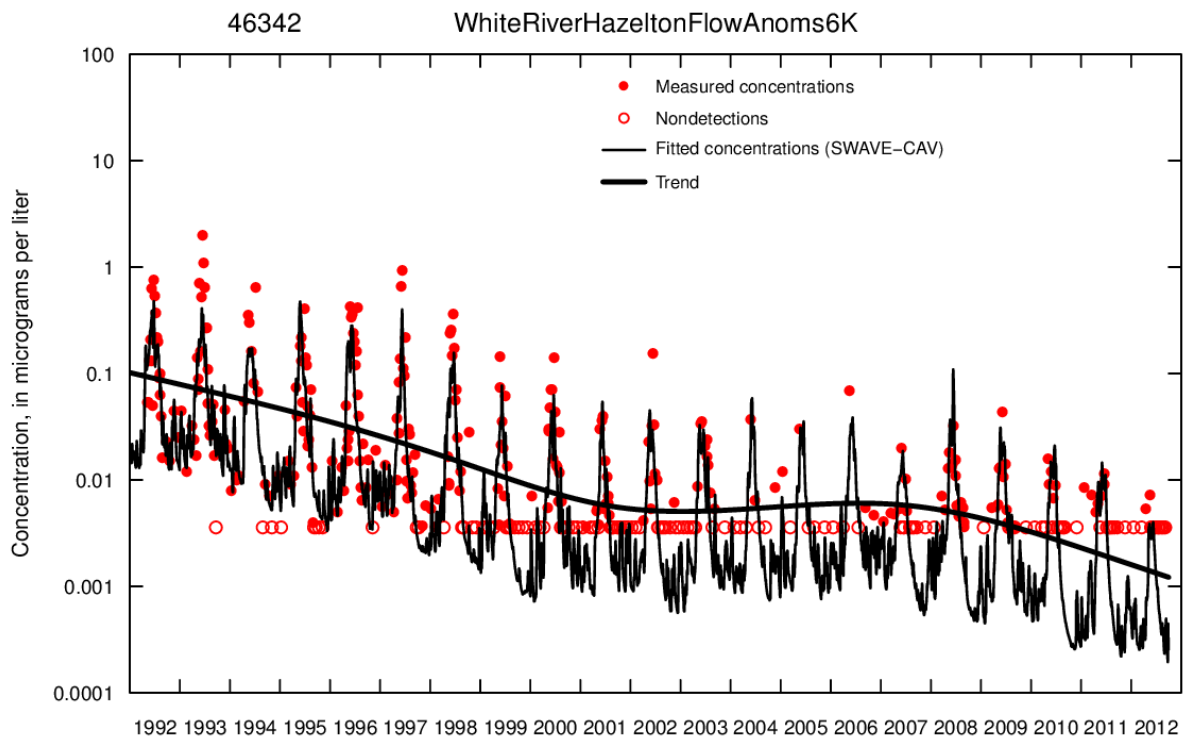
Six Knots

```r
i <- 6
analysisnm <- paste0("FlowAnoms", i, "K")
resname <- paste0(siteName, analysisnm)
txtname <- paste0(resname, "_survregCall.txt")

fit <- fitswavecav(cdat = combo, cavdat = contav,
                   tanm = resname, pnames = onepest, yrstart = yrs,
                   yrend = yre, tndbeg = trndb, tndend = trnde,
                   iwcav = c("ltfa", "mtfa", "stfa"), dcol = "dates",
                   qwcols = c("R","P"), mclass = 2, numk = i)

assign(paste0("myfit", analysisnm), fit)

ImageProcess(resname)
```




```r
cat(readLines(txtname), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:33:25 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 46342
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                  Value Std. Error      z       p
## xmatintcpt     -2.0996     0.3113  -6.74 1.5e-11
## xmatwavest      1.4330     0.0728  19.67 < 2e-16
## xmattndlin     -0.1108     0.0384  -2.89  0.0039
## xmattndlin'    -0.2344     0.5667  -0.41  0.6792
## xmattndlin''    0.2886     2.0655   0.14  0.8889
## xmattndlin'''   1.4829     2.5221   0.59  0.5566
## xmattndlin'''' -2.7712     1.3568  -2.04  0.0411
## xmatltfa        0.3479     0.1470   2.37  0.0180
## xmatmtfa        0.4332     0.0654   6.62 3.5e-11
## xmatstfa        0.7016     0.0810   8.66 < 2e-16
## Log(scale)     -0.9778     0.0438 -22.31 < 2e-16
##
## Scale= 0.376
##
## Gaussian distribution
## Loglik(model)= -177.6   Loglik(intercept only)= -463.2
```

```
##  Chisq= 571.24 on 9 degrees of freedom, p= 3.1e-117
## Number of Newton-Raphson Iterations: 7
## n= 402
##
## Generalized r-squared is:  0.76
## AIC (Akaike's An Information Criterion) is:  377.19
## BIC (Bayesian Information Criterion) is:  421.15
## Model class is 2
## Pulse input function is 2
## Half life is 2
## Seasonal value of the maximum concentration is 0.44.
```

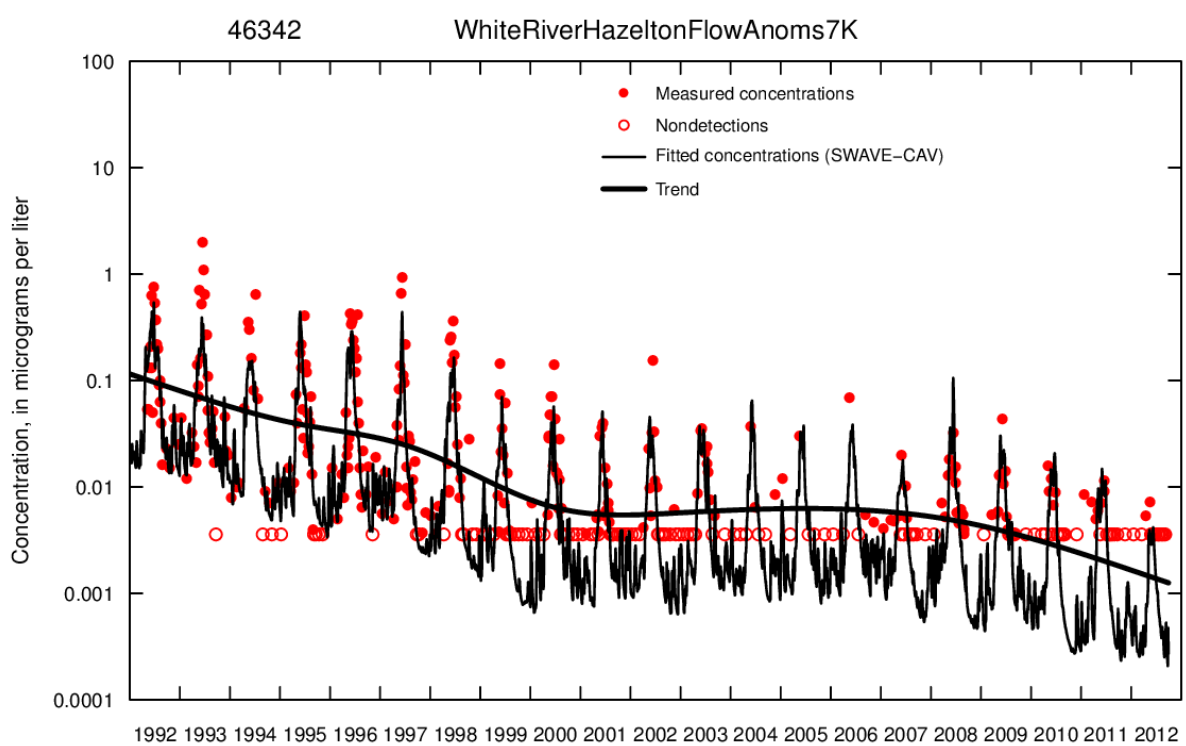
Seven Knots Knots

```
i <- 7
analysisnm <- paste0("FlowAnoms", i, "K")
resname <- paste0(siteName, analysisnm)
txtname <- paste0(resname, "_survregCall.txt")

fit <- fitswavecav(cdat = combo, cavdat = contav,
                   tanm = resname, pnames = onepest, yrstart = yrs,
                   yrend = yre, tndbeg = trndb, tndend = trnde,
                   iwcav = c("ltfa", "mtfa", "stfa"), dcol = "dates",
                   qwcols = c("R","P"), mclass = 2, numk = i)

assign(paste0("myfit", analysisnm), fit)

ImageProcess(resname)
```



```r
cat(readLines(txtname), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:33:45 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 46342
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                   Value Std. Error      z       p
## xmatintcpt      -2.5150     0.4571  -5.50 3.7e-08
## xmatwavest       1.4347     0.0726  19.77 < 2e-16
## xmattndlin      -0.1576     0.0540  -2.92  0.0035
## xmattndlin'      1.0672     1.0368   1.03  0.3033
## xmattndlin''    -5.7769     3.8811  -1.49  0.1366
## xmattndlin'''   10.2215     5.0950   2.01  0.0448
## xmattndlin''''  -9.0155     4.4396  -2.03  0.0423
## xmattndlin'''''  3.0728     2.6878   1.14  0.2529
## xmatltfa         0.2720     0.1559   1.75  0.0810
## xmatmtfa         0.4180     0.0654   6.39 1.7e-10
## xmatstfa         0.6974     0.0806   8.65 < 2e-16
## Log(scale)      -0.9832     0.0439 -22.42 < 2e-16
##
## Scale= 0.374
##
## Gaussian distribution
## Loglik(model)= -176.3   Loglik(intercept only)= -463.2
##  Chisq= 573.92 on 10 degrees of freedom, p= 6.8e-117
## Number of Newton-Raphson Iterations: 7
## n= 402
##
## Generalized r-squared is:  0.76
## AIC (Akaike's An Information Criterion) is:  376.51
## BIC (Bayesian Information Criterion) is:  424.47
## Model class is 2
## Pulse input function is 2
## Half life is 2
## Seasonal value of the maximum concentration is 0.44.
```

USGS streamgage 02335870, Sope Creek near Marietta, Georgia

The drainage basin of the Sope Creek near Marietta, Georgia, is calculated to be 79.597 km^2. The basin is 77.95-percent developed land and 0.34-percent agricultural land (Falcone, 2017).

Deethylatrazine

SEAWAVE-Q/NoFlow

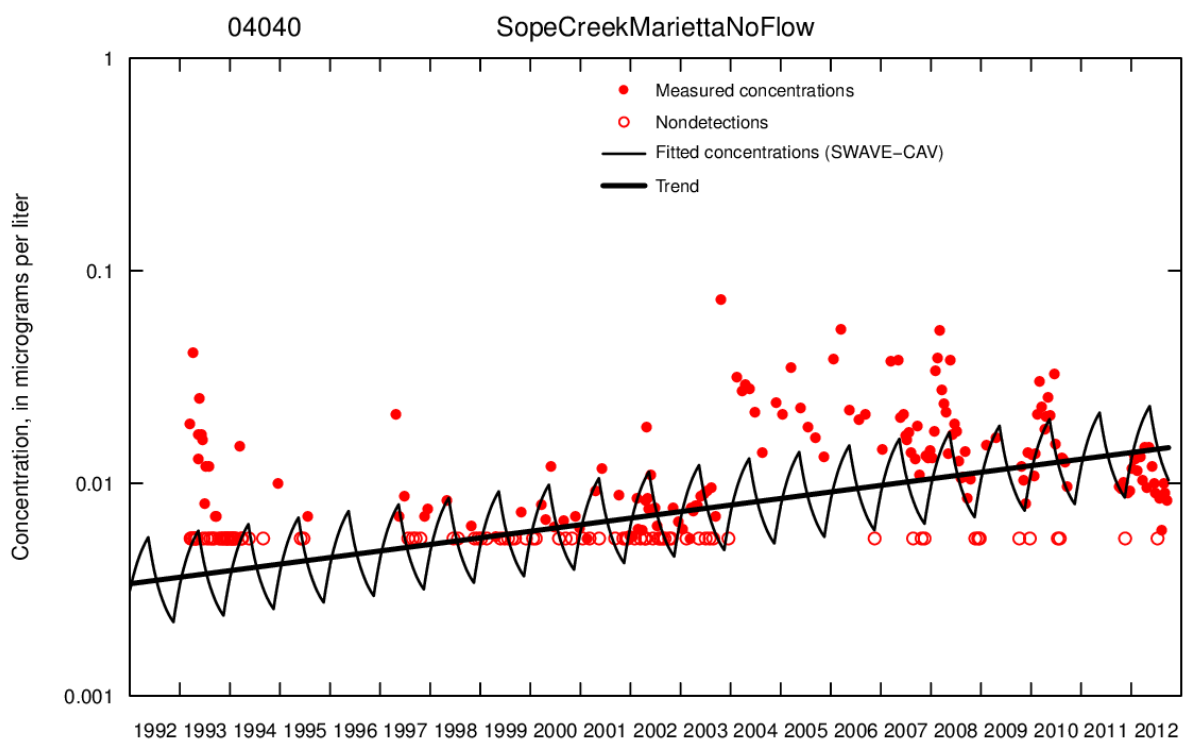
The following plot represents part the R package output for a linear trend model that does not use streamflow as an explanatory variable. Following the plot is the text file that is produced for the analysis providing a summary of the trend analysis.

```
site <- "02335870"
siteName <- "SopeCreekMarietta"
yrs <- 1992
yre <- 2012
trndb <- 1992
trnde <- 2012
onepest <- c("04040")

qw <- subset(input, staid == site)[, 1:70]
contav <- subset(Anoms, staid == site)
combo <- combineData(qwdat = qw, cqwdat = contav)

resname <- paste0(siteName, "NoFlow")
myfitNoFlow <- fitswavecav(cdat = combo, cavdat = contav, tanm = resname,
                      pnames = onepest, yrstart = yrs, yrend = yre, tndbeg = trndb, tndend =
                      trnde, iwcav = c("none"), dcol = "dates", qwcols = c("R","P"))
```

```
ImageProcess(resname)
```




```
cat(readLines("SopeCreekMariettaNoFlow_survregCall.txt"), sep = "\n")
```

```
##
##
```

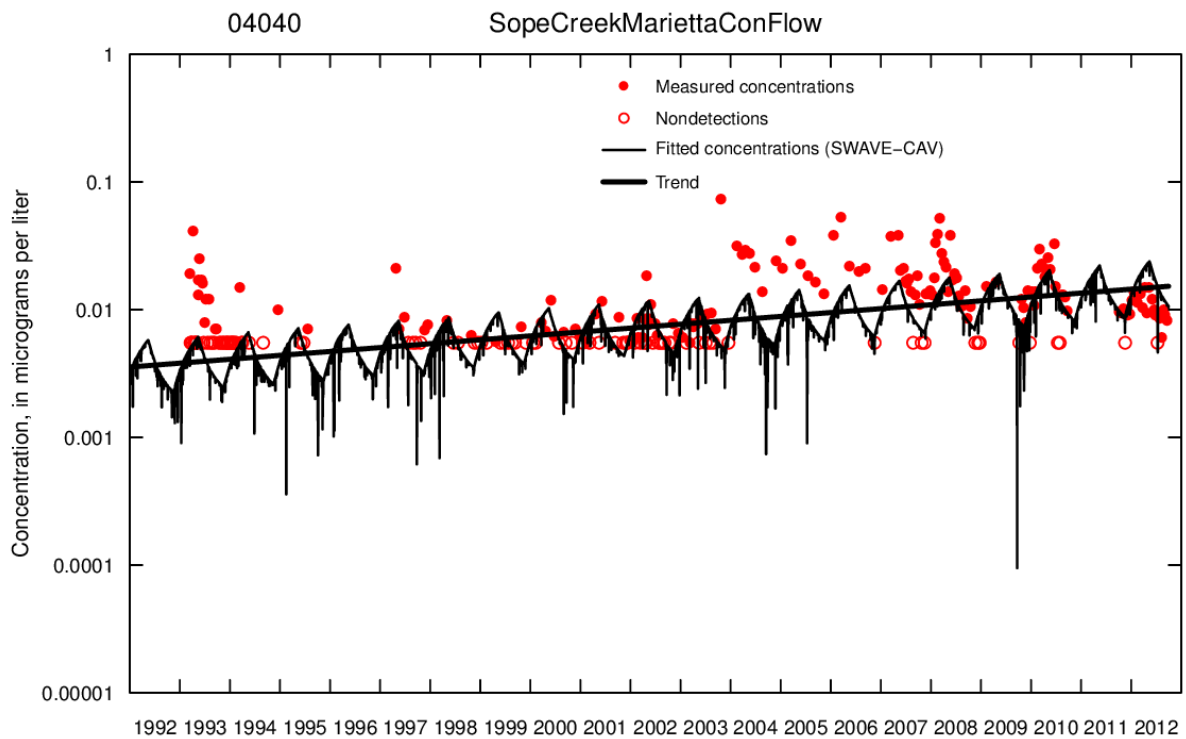
```
## Thursday 25 Jun 2020 13:34:11 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 04040
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##              Value Std. Error      z       p
## xmatintcpt -2.1642     0.0240 -90.23 < 2e-16
## xmatwavest  0.4144     0.0696   5.96 2.6e-09
## xmattndlin  0.0309     0.0037   8.35 < 2e-16
## Log(scale) -1.1814     0.0603 -19.61 < 2e-16
##
## Scale= 0.307
##
## Gaussian distribution
## Loglik(model)= -99.7   Loglik(intercept only)= -145.2
##  Chisq= 91.11 on 2 degrees of freedom, p= 1.6e-20
## Number of Newton-Raphson Iterations: 4
## n= 247
##
## Generalized r-squared is:  0.31
## AIC (Akaike's An Information Criterion) is:  207.34
## BIC (Bayesian Information Criterion) is:  221.38
## Model class is 1
## Pulse input function is 5
## Half life is 4
## Seasonal value of the maximum concentration is 0.37.
```

SEAWAVE-Q/ConFlow

The following plot represents part the R package output for a linear trend model that uses continuously monitored streamflow as an explanatory variable. Following the plot is the text file that is produced for the analysis providing a summary of the trend analysis.

```r
resname <- paste0(siteName, "ConFlow")
myfitFlow <- fitswavecav(cdat = combo, cavdat = contav, tanm = resname,
                         pnames = onepest, yrstart = yrs, yrend = yre,
                         tndbeg = trndb, tndend = trnde, iwcav = c("Q"),
                         dcol = "dates", qwcols = c("R","P"))
```

```r
ImageProcess(resname)
```




```r
cat(readLines("SopeCreekMariettaConFlow_survregCall.txt"), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:34:24 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 04040
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                Value Std. Error      z       p
## xmatintcpt -2.144720   0.026511 -80.90 < 2e-16
## xmatwavest  0.421605   0.069541   6.06 1.3e-09
## xmattndlin  0.030490   0.003686   8.27 < 2e-16
## xmat       -0.000463   0.000311  -1.49    0.14
## Log(scale) -1.184885   0.060228 -19.67 < 2e-16
##
## Scale= 0.306
##
## Gaussian distribution
## Loglik(model)= -98.2   Loglik(intercept only)= -145.2
##  Chisq= 93.96 on 3 degrees of freedom, p= 3.1e-20
## Number of Newton-Raphson Iterations: 4
## n= 247
##
## Generalized r-squared is:  0.32
## AIC (Akaike's An Information Criterion) is:  206.48
```

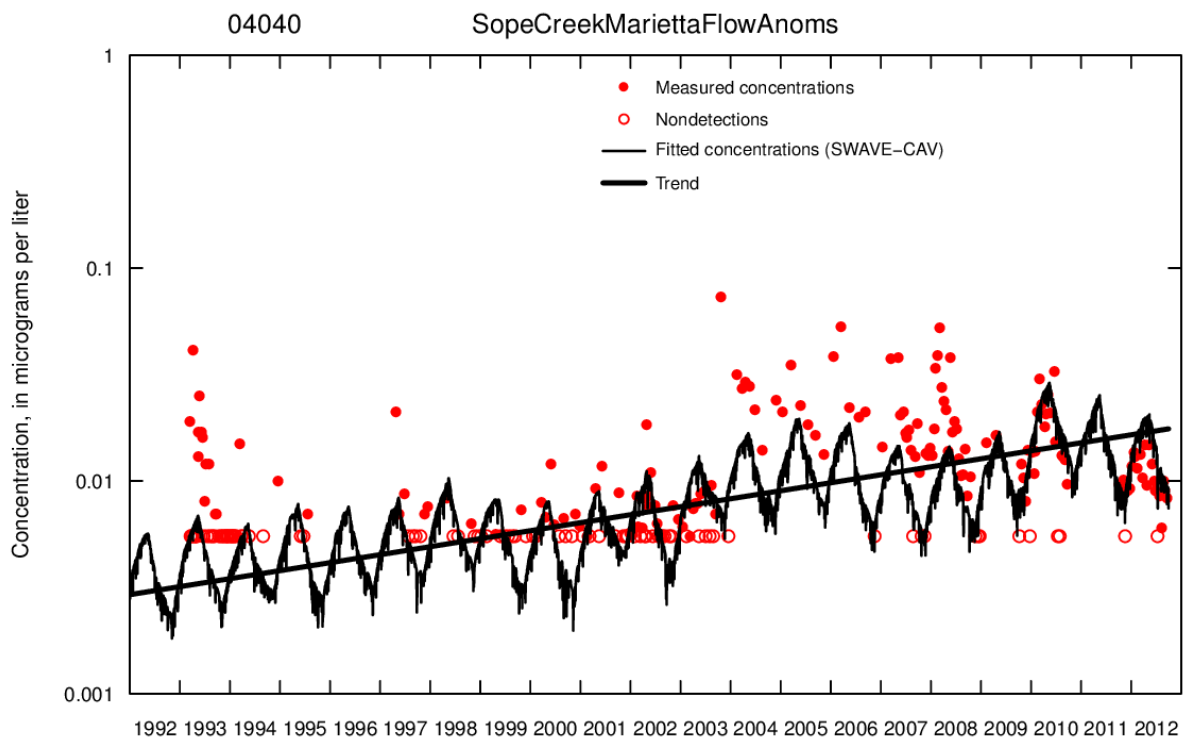
```
## BIC (Bayesian Information Criterion) is:  224.03
## Model class is 1
## Pulse input function is 5
## Half life is 4
## Seasonal value of the maximum concentration is 0.37.
```

SEAWAVE-Q

The following plot represents part the R package output for a linear trend model that uses streamflow anomalies as explanatory variables. Following the plot is the text file that is produced for the analysis providing a summary of the trend analysis.

```
resname <- paste0(siteName, "FlowAnoms")
myfitFlowAnoms <- fitswavecav(cdat = combo, cavdat = contav,
                              tanm = resname, pnames = onepest,
                              yrstart = yrs, yrend = yre, tndbeg = trndb,
                              tndend = trnde, iwcav = c("ltfa", "mtfa", "stfa"),
                              dcol = "dates", qwcols = c("R","P"))
```

```
ImageProcess(resname)
```




```
cat(readLines("SopeCreekMariettaFlowAnoms_survregCall.txt"), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:34:44 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
```

```
## Final model survreg results for 04040
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##               Value Std. Error      z       p
## xmatintcpt -2.15886    0.02304 -93.72 < 2e-16
## xmatwavest  0.39550    0.07640   5.18 2.3e-07
## xmattndlin  0.03754    0.00398   9.43 < 2e-16
## xmatltfa    0.46839    0.11783   3.97 7.0e-05
## xmatmtfa    0.00476    0.08621   0.06    0.96
## xmatstfa   -0.08685    0.06059  -1.43    0.15
## Log(scale) -1.23119    0.06018 -20.46 < 2e-16
##
## Scale= 0.292
##
## Gaussian distribution
## Loglik(model)= -90.5   Loglik(intercept only)= -145.2
##  Chisq= 109.38 on 5 degrees of freedom, p= 5.5e-22
## Number of Newton-Raphson Iterations: 5
## n= 247
##
## Generalized r-squared is:  0.36
## AIC (Akaike's An Information Criterion) is:  195.06
## BIC (Bayesian Information Criterion) is:  219.63
## Model class is 1
## Pulse input function is 5
## Half life is 4
## Seasonal value of the maximum concentration is 0.37.
```

SEAWAVE-Q/RCS-k

The following plots represent part the R package output for a trend models with 4–7 knots (3–6 cubic splines). Following the each plot the text file that is produced for the analysis providing a summary of the trend analysis.

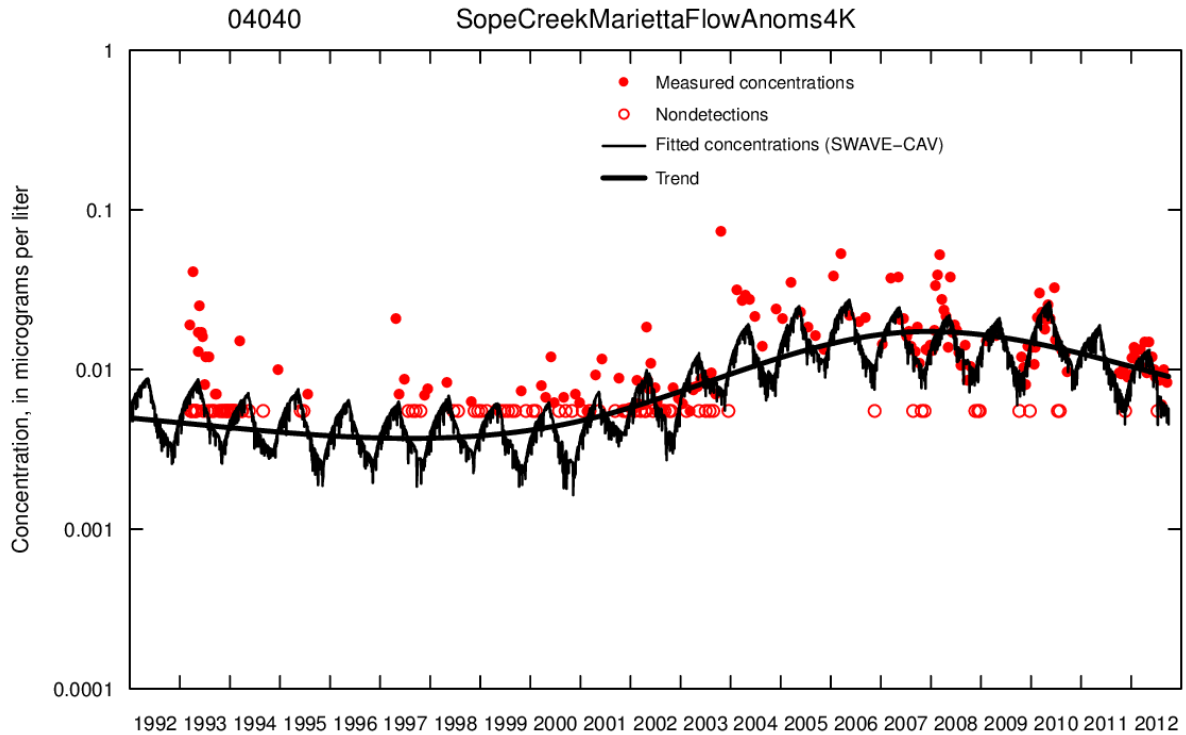
Four Knots

```r
i <- 4
analysisnm <- paste0("FlowAnoms", i, "K")
resname <- paste0(siteName, analysisnm)
txtname <- paste0(resname, "_survregCall.txt")

fit <- fitswavecav(cdat = combo, cavdat = contav,
                   tanm = resname, pnames = onepest, yrstart = yrs,
                   yrend = yre, tndbeg = trndb, tndend = trnde,
                   iwcav = c("ltfa", "mtfa", "stfa"), dcol = "dates",
                   qwcols = c("R","P"), mclass = 2, numk = i)

assign(paste0("myfit", analysisnm), fit)

ImageProcess(resname)
```




```r
cat(readLines(txtname), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:35:01 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 04040
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                Value Std. Error      z       p
## xmatintcpt   -2.6085     0.0803 -32.47 < 2e-16
## xmatwavest    0.3950     0.0654   6.04 1.5e-09
## xmattndlin   -0.0305     0.0129  -2.37  0.0176
## xmattndlin'   0.2082     0.0310   6.71 1.9e-11
## xmattndlin'' -0.8904     0.1226  -7.26 3.8e-13
## xmatltfa      0.3133     0.1044   3.00  0.0027
## xmatmtfa     -0.0643     0.0776  -0.83  0.4080
## xmatstfa     -0.0921     0.0524  -1.76  0.0788
## Log(scale)   -1.3851     0.0601 -23.03 < 2e-16
##
## Scale= 0.25
##
## Gaussian distribution
## Loglik(model)= -66.4   Loglik(intercept only)= -145.2
##  Chisq= 157.64 on 7 degrees of freedom, p= 1e-30
## Number of Newton-Raphson Iterations: 5
```

```
## n= 247
##
## Generalized r-squared is:  0.47
## AIC (Akaike's An Information Criterion) is:  150.81
## BIC (Bayesian Information Criterion) is:  182.39
## Model class is 2
## Pulse input function is 5
## Half life is 3
## Seasonal value of the maximum concentration is 0.37.
```

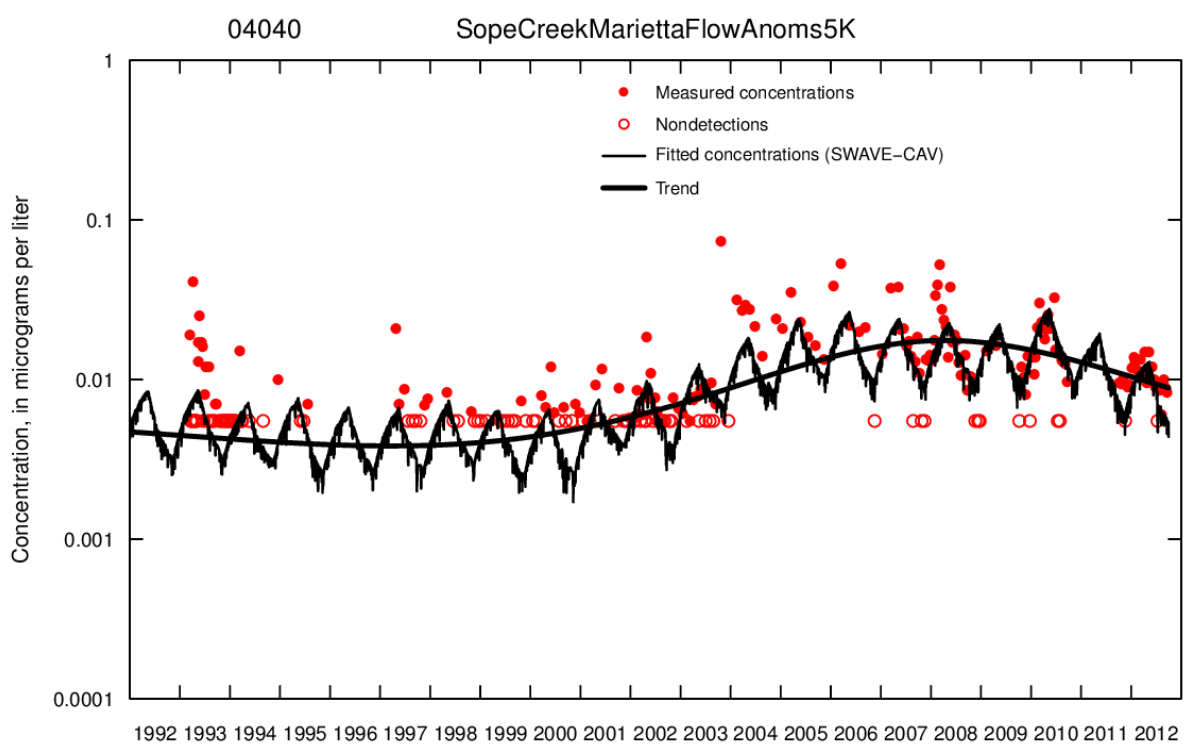
Five Knots

```
i <- 5
analysisnm <- paste0("FlowAnoms", i, "K")
resname <- paste0(siteName, analysisnm)
txtname <- paste0(resname, "_survregCall.txt")

fit <- fitswavecav(cdat = combo, cavdat = contav,
                   tanm = resname, pnames = onepest, yrstart = yrs,
                   yrend = yre, tndbeg = trndb, tndend = trnde,
                   iwcav = c("ltfa", "mtfa", "stfa"), dcol = "dates",
                   qwcols = c("R","P"), mclass = 2, numk = i)

assign(paste0("myfit", analysisnm), fit)

ImageProcess(resname)
```




```
cat(readLines(txtname), sep = "\n")
```

```
##
```

```
##
## Thursday 25 Jun 2020 13:35:19 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 04040
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                 Value Std. Error      z       p
## xmatintcpt    -2.5512     0.1619 -15.76 < 2e-16
## xmatwavest     0.4021     0.0665   6.05 1.5e-09
## xmattndlin    -0.0223     0.0225  -0.99  0.3217
## xmattndlin'    0.1833     0.0993   1.84  0.0650
## xmattndlin''  -0.2867     0.4671  -0.61  0.5394
## xmattndlin''' -0.6337     0.6183  -1.02  0.3054
## xmatltfa       0.3355     0.1075   3.12  0.0018
## xmatmtfa      -0.0381     0.0757  -0.50  0.6147
## xmatstfa      -0.0845     0.0525  -1.61  0.1076
## Log(scale)    -1.3789     0.0602 -22.92 < 2e-16
##
## Scale= 0.252
##
## Gaussian distribution
## Loglik(model)= -67.4   Loglik(intercept only)= -145.2
##  Chisq= 155.67 on 8 degrees of freedom, p= 1.3e-29
## Number of Newton-Raphson Iterations: 5
## n= 247
##
## Generalized r-squared is:  0.47
## AIC (Akaike's An Information Criterion) is:  154.77
## BIC (Bayesian Information Criterion) is:  189.87
## Model class is 2
## Pulse input function is 5
## Half life is 4
## Seasonal value of the maximum concentration is 0.37.
```

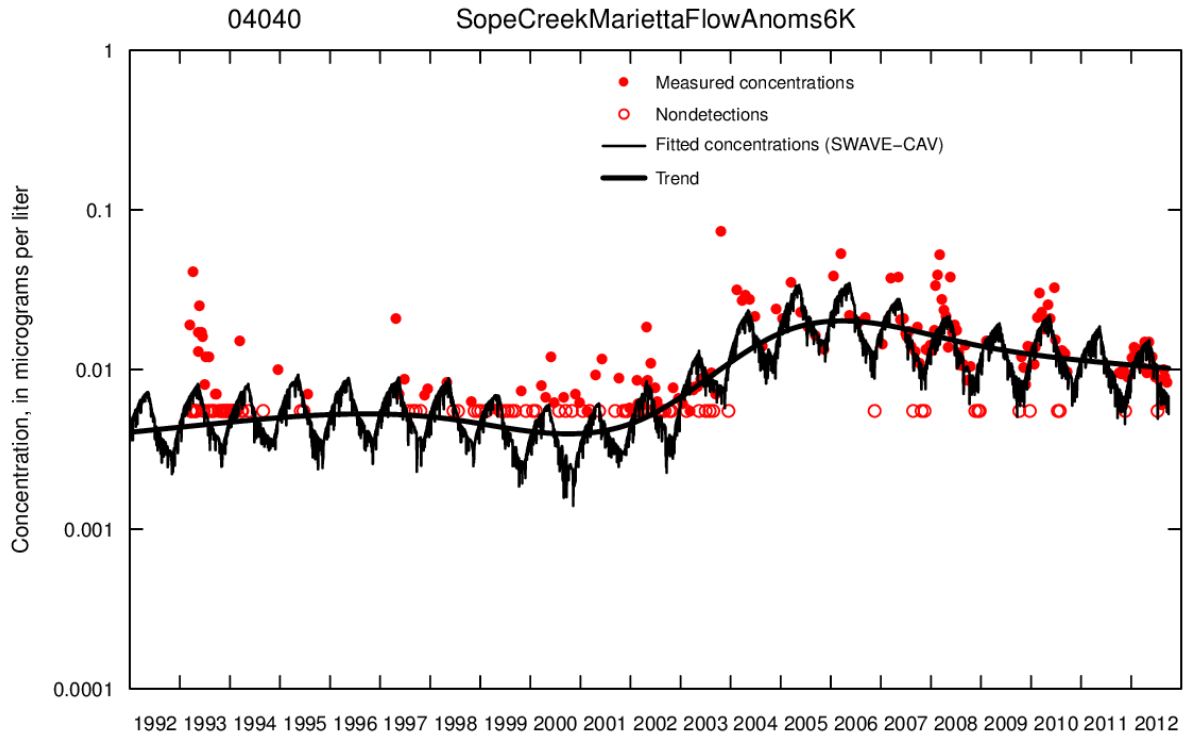
Six Knots

```r
i <- 6
analysisnm <- paste0("FlowAnoms", i, "K")
resname <- paste0(siteName, analysisnm)
txtname <- paste0(resname, "_survregCall.txt")

fit <- fitswavecav(cdat = combo, cavdat = contav,
                   tanm = resname, pnames = onepest, yrstart = yrs,
                   yrend = yre, tndbeg = trndb, tndend = trnde,
                   iwcav = c("ltfa", "mtfa", "stfa"), dcol = "dates",
                   qwcols = c("R","P"), mclass = 2, numk = i)

assign(paste0("myfit", analysisnm), fit)

ImageProcess(resname)
```




```r
cat(readLines(txtname), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:35:37 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 04040
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                  Value Std. Error      z       p
## xmatintcpt     -2.0748     0.2070 -10.02 < 2e-16
## xmatwavest      0.3933     0.0628   6.27 3.7e-10
## xmattndlin      0.0319     0.0271   1.18 0.23939
## xmattndlin'    -0.3488     0.1797  -1.94 0.05220
## xmattndlin''    2.7117     0.7807   3.47 0.00051
## xmattndlin'''  -7.7273     1.6749  -4.61 4.0e-06
## xmattndlin''''  7.9623     1.8429   4.32 1.6e-05
## xmatltfa        0.2014     0.1051   1.92 0.05542
## xmatmtfa       -0.0318     0.0749  -0.42 0.67147
## xmatstfa       -0.1037     0.0499  -2.08 0.03778
## Log(scale)     -1.4312     0.0601 -23.80 < 2e-16
##
## Scale= 0.239
##
## Gaussian distribution
## Loglik(model)= -58.8   Loglik(intercept only)= -145.2
```

```
##  Chisq= 172.94 on 9 degrees of freedom, p= 1.5e-32
## Number of Newton-Raphson Iterations: 6
## n= 247
##
## Generalized r-squared is:  0.5
## AIC (Akaike's An Information Criterion) is:  139.51
## BIC (Bayesian Information Criterion) is:  178.11
## Model class is 2
## Pulse input function is 5
## Half life is 3
## Seasonal value of the maximum concentration is 0.37.
```

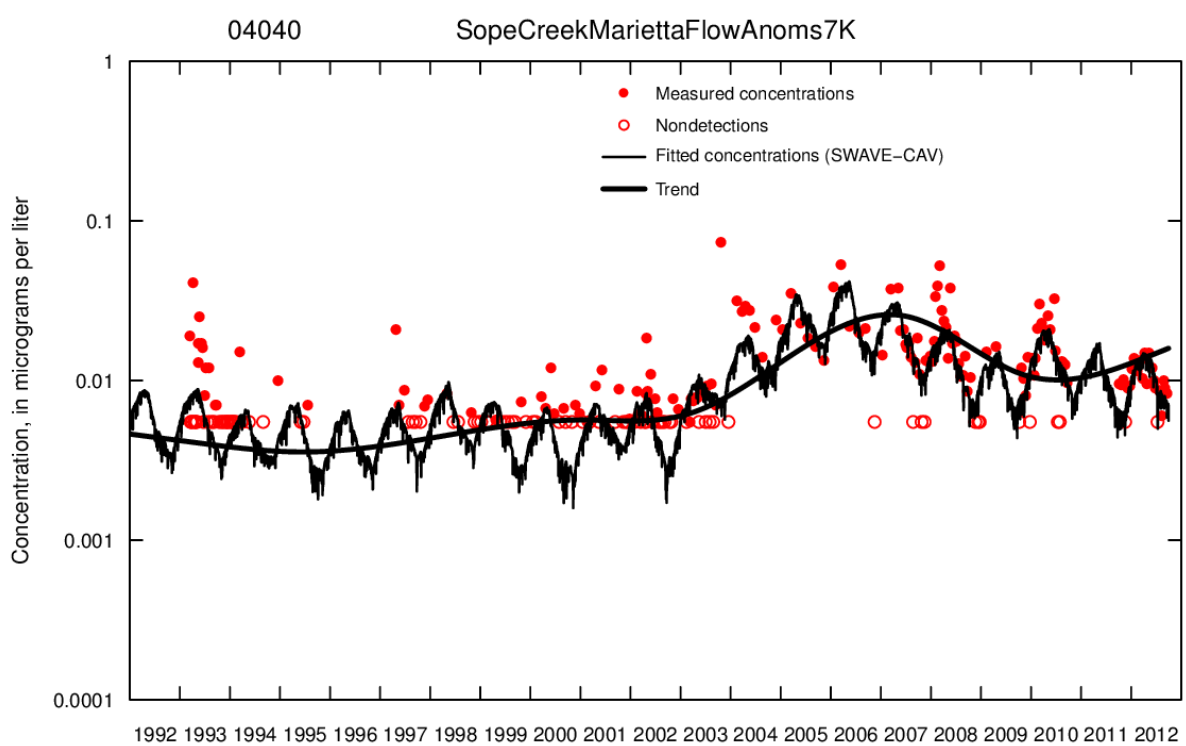
Seven Knots Knots

```
i <- 7
analysisnm <- paste0("FlowAnoms", i, "K")
resname <- paste0(siteName, analysisnm)
txtname <- paste0(resname, "_survregCall.txt")

fit <- fitswavecav(cdat = combo, cavdat = contav,
                   tanm = resname, pnames = onepest, yrstart = yrs,
                   yrend = yre, tndbeg = trndb, tndend = trnde,
                   iwcav = c("ltfa", "mtfa", "stfa"), dcol = "dates",
                   qwcols = c("R","P"), mclass = 2, numk = i)

assign(paste0("myfit", analysisnm), fit)

ImageProcess(resname)
```



```r
cat(readLines(txtname), sep = "\n")
```

```
##
##
## Thursday 25 Jun 2020 13:35:56 PM CDT
## R version 3.5.1 (2018-07-02)
## seawaveQ version 2.0.0
## x86_64-apple-darwin15.6.0 (64-bit)
##
## Final model survreg results for 04040
## Call:
## survreg(formula = Surv(time = clogtmp, time2 = indcen, type = "left") ~
##     xmat - 1, dist = "gaussian", control = list(maxiter = 100))
##                   Value Std. Error      z       p
## xmatintcpt      -2.7445     0.4591  -5.98 2.3e-09
## xmatwavest       0.3489     0.0626   5.58 2.5e-08
## xmattndlin      -0.0409     0.0556  -0.74   0.462
## xmattndlin'      1.0794     0.9861   1.09   0.274
## xmattndlin''    -1.9225     1.7356  -1.11   0.268
## xmattndlin'''    5.6770     2.6927   2.11   0.035
## xmattndlin''''  -9.7042     2.9498  -3.29   0.001
## xmattndlin''''' 14.7258     2.9495   4.99 6.0e-07
## xmatltfa         0.6324     0.1294   4.89 1.0e-06
## xmatmtfa         0.0530     0.0776   0.68   0.494
## xmatstfa        -0.0937     0.0492  -1.90   0.057
## Log(scale)      -1.4507     0.0601 -24.15 < 2e-16
##
## Scale= 0.234
##
## Gaussian distribution
## Loglik(model)= -55.3   Loglik(intercept only)= -145.2
##  Chisq= 179.9 on 10 degrees of freedom, p= 2.5e-33
## Number of Newton-Raphson Iterations: 6
## n= 247
##
## Generalized r-squared is:  0.52
## AIC (Akaike's An Information Criterion) is:  134.54
## BIC (Bayesian Information Criterion) is:  176.65
## Model class is 2
## Pulse input function is 5
## Half life is 3
## Seasonal value of the maximum concentration is 0.37.
```

References Cited

Falcone, J.A., 2017, Watershed characteristics for study sites of the Surface Water Trends project, National Water Quality Program: U.S. Geological Survey data release, https://doi.org/10.5066/F7TX3CKP.

Ryberg, K.R., Murphy, J.C., Falcone, J.A., Riskin, M.L., Wieben, C.M., and Vecchia, A.V., 2017, Pesticide concentration and streamflow datasets used to evaluate pesticide trends in the Nation's rivers and streams, 1992-2012: U.S. Geological Survey data release, http://dx.doi.org/10.5066/F7BC3WPC.