Appendix 2.1A: Example R Package Input and Output

Section 1: Word file report example (1 station/parameter)

General Additive Model Analysis

Date: May 25, 2017 11:31:09 AM

Initialize

```
library(baytrends)
```

```
## Loading required package: lubridate
```

```
##
## Attaching package: 'lubridate'
```

```
## The following object is masked from 'package:base':
##
##     date
```

```
## Loading required package: mgcv
```

```
## Loading required package: nlme
```

```
## This is mgcv 1.8-15. For overview type 'help("mgcv-package")'.
```

```
## Loading required package: smwrQW
```

```
## Loading required package: dataRetrieval
```

```
## Loading required package: smwrBase
```

```
## This information is preliminary or provisional and is subject to revision.
It is being provided to meet the need for timely best science. The
information has not received final approval by the U.S. Geological Survey
(USGS) and is provided on the condition that neither the USGS nor the U.S.
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or the U.S. Government as to the accuracy and functioning of the program and
related program material nor shall the fact of distribution constitute any
such warranty, and no responsibility is assumed by the USGS in connection
therewith.
```

```
## Loading required package: smwrGraphs
```

```
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```

```
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## Loading required package: smwrStats

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therewith.

##
## Attaching package: 'smwrQW'

## The following object is masked from 'package:utils':
##
##     View

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and is subject to revision. This software program is for testing only, no
warranty, expressed or implied, is made as to the accuracy and functioning of
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connection therewith. This software is provided 'AS IS.'
```

```
ProjRoot <- 'C:/Projects/Trends/baytrends/documentationExs'
setwd(ProjRoot)
knitr::opts_chunk$set(dpi=150)
```

Load Station, Parameters and Layer Lookup Lists

```
tidalStations <- loadData(file='StationList_exs.csv', pk='station')
```

Description	Value
1) File Name	StationList_exs.csv
2) Folder Name	.
3) Primary Key	station
4) Rows Read In	145
5) Columns Read In	17
6) Rows After Blank Rows Removed	145
7) Columns After Blank Columns Removed	17
8) Rows After Duplicate Rows Removed	145
9) Rows After Duplicate PK Removed	145

```
parameterList <- loadData(folder='../mySettings', file='parameterList*.csv', pk='parm')
```

Description	Value
1) File Name	parameterList.csv
2) Folder Name	../mySettings
3) Primary Key	parm
4) Rows Read In	81
5) Columns Read In	13
6) Rows After Blank Rows Removed	81
7) Columns After Blank Columns Removed	13
8) Rows After Duplicate Rows Removed	81
9) Rows After Duplicate PK Removed	81

```
layerLukup    <- loadData(folder='../mySettings', file='layerLukup*.csv', pk='layers')
```

Description	Value
1) File Name	layerLukup.csv
2) Folder Name	../mySettings
3) Primary Key	layers
4) Rows Read In	10
5) Columns Read In	3
6) Rows After Blank Rows Removed	10
7) Columns After Blank Columns Removed	3
8) Rows After Duplicate Rows Removed	10
9) Rows After Duplicate PK Removed	10

```
usgsGages     <- loadData(folder='../mySettings', file='usgsGages*.csv', pk='siteNumber')
```

Description	Value
1) File Name	usgsGages.csv
2) Folder Name	../mySettings
3) Primary Key	siteNumber
4) Rows Read In	9
5) Columns Read In	2
6) Rows After Blank Rows Removed	9
7) Columns After Blank Columns Removed	2
8) Rows After Duplicate Rows Removed	9
9) Rows After Duplicate PK Removed	9

```
methodsList   <- loadData(file='MethodChg_TPcb53.csv',
                          pk=c('stationMethodGroup', 'parameter',
'beginDate'))
```

Description	Value
1) File Name	MethodChg_TPcb53.csv
2) Folder Name	.
3) Primary Key	stationMethodGroup + parameter + beginDate
4) Rows Read In	1
5) Columns Read In	7
6) Rows After Blank Rows Removed	1
7) Columns After Blank Columns Removed	6
8) Rows After Duplicate Rows Removed	1
9) Rows After Duplicate PK Removed	1
10) beginDate converted with	%m/%d/%Y format

```
print(knitr::kable(methodsList[methodsList$intervention,c(1:3)]))
```

stationMethodGroup	parameter	beginDate
MD-Main	tp	1987-10-01

I/O

```
load('../myData/cbpDataAll_05_QW.rda'); df<-cbpDataAll_05_QW
statFile     <- file.path(ProjRoot,'statGAM_exTP53.csv')
chngFile     <- file.path(ProjRoot,'chngGAM_exTP53.csv')
```

Data Inclusion Filter & Analysis Parameters

```
analySpec <-list()

analySpec$parameterFilt   <- c("tp")
analySpec$stationFilt     <- c("CB5.3")
analySpec$layerFilt       <- c('S')
analySpec$dateFilt        <- as.POSIXct(c('1985-01-01', '2015-12-31'))
analySpec$gamPenalty      <- TRUE          # TRUE to emulate v0.2.3; NA for
default)
analySpec$gamK_CritSel    <- c(10,0.001)   # (10,0.001) to emulate v0.2.3;
(10,2/3) for default)

analySpec$gamModels       <- list(
  list(option=0, name= "Linear Trend with Seasonality",
       model= "~ cyear + s(doy,bs='cc')", deriv=TRUE),
  list(option=1, name= "Non-linear Trend with Seasonality",
       model= "~ cyear + s(cyear, k=gamK) + s(doy,bs='cc')", deriv=TRUE),
  list(option=2, name= "Non-linear trend with Seas+Int",
       model= "~ cyear + s(cyear, k=gamK) + s(doy,bs='cc')+
ti(cyear,doy,bs=c('tp','cc'))", deriv=TRUE),
  list(option=3, name= "Non-linear trend with Seas+Int. & Intervention",
       model= "~ intervention + cyear + s(cyear, k=gamK) + s(doy,bs='cc') +
```

```
ti(cyear,doy,bs=c('tp','cc'))", deriv=TRUE))


analySpec$gamDiffPeriods   <- list(
  list( periodName = "Full Record",     periodStart = c(NA),        periodEnd
= c(NA)))

analySpec$gamDiffSeasons   <- list(
  list ( seasonName = "All",     seasonMonths = c(1:12)))
```

Data Preparation

This section trims down the data as per user specifications. Please review any warning messages.

Warning Messages

Record Count

```
Beginning Number of Records:  122825
```

```
Number of Records After Processing:  505
```

Parameters

Table: List of Parameters.

Dep. Var.	Parameter Name	Units	Log Tran.	Inc. Conc.	GAM Dep. Var.
tp	Total Phosphorus	mg/L	TRUE	Degrading	lntp

Layers

Table: List of Layers.

Layer ID	Layer Name
S	Surface

Stations

Table: List of Stations.

Station ID	Latitude	Longitude	CB 92 Seg.	Flow Adj. Gage	Mth. Group
CB5.3	37.9101	-76.1714	CB5MH_MD	01578310	MD-Main

GAM Analysis

This analysis implements a preliminary GAM analysis in R.

Appendix 2.1A

Total Phosphorus -- Surface

CB5.3

Total Phosphorus - Linear Trend with Seasonality

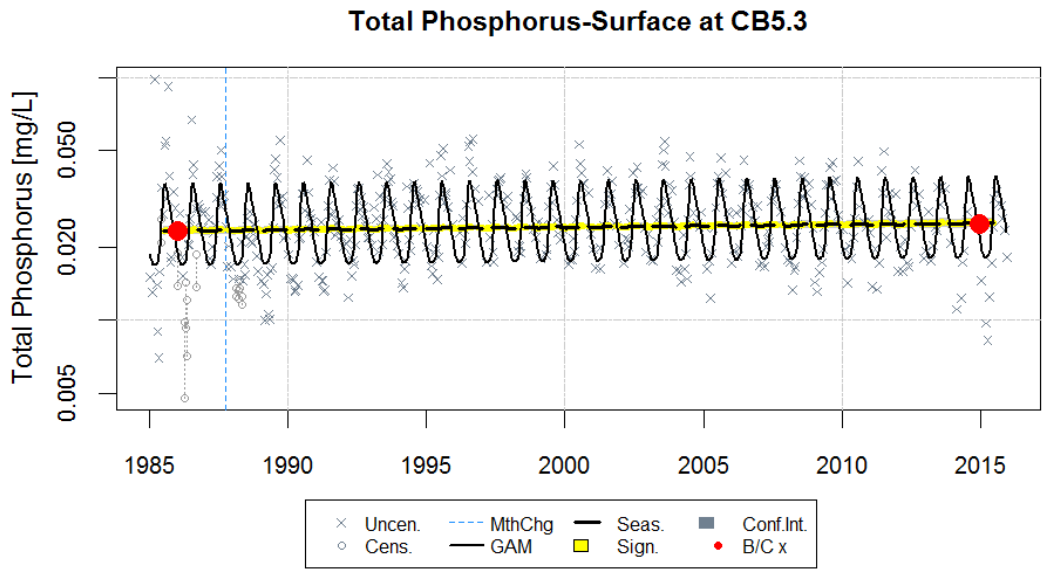

Table: GAM Analysis of Variance.

Type	Source	edf	F-stat	p-value
parametric terms	cyear	1.00	3.4293	0.0647
smoothed terms	s(doy)	6.26	71.6260	<0.0001

Table: GAM Parameter Coefficients.

Parameter	Estimate	Std. Err.	t value	p-value
(Intercept)	-3.690153	0.011879	-310.6359	<0.0001
cyear	0.002482	0.001340	1.8518	0.0647

Table: GAM Diagnostics.

AIC	RMSE	Adj. R-squared
82.46	0.2603	0.5386

Table: Estimates of Change from 1985-2015.

Calculation	Estimate
Baseline log mean (geometric mean)	-3.7601 (0.0233)
Current log mean (geometric mean)	-3.6882 (0.025)
Estimated log difference	0.072
Std. Err. log difference	0.0389
95% Confidence interval for log difference	(-0.0042 , 0.1481)
Difference p-value	0.0646
Period of Record Percent Change Estimate (%)	7.46%

Appendix 2.1A

Total Phosphorus - Non-linear Trend with Seasonality

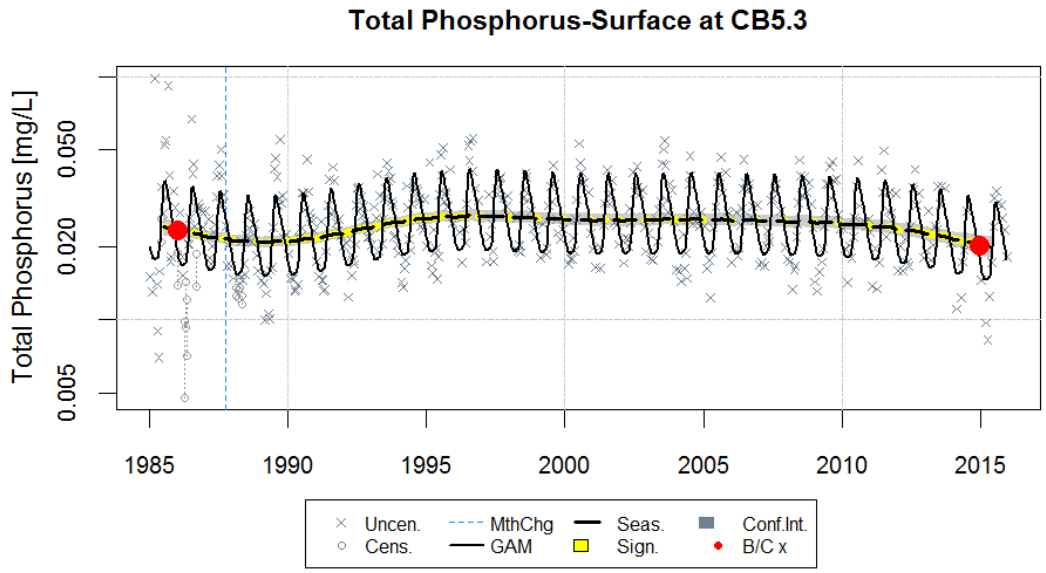

Table: GAM Analysis of Variance.

Type	Source	edf	F-stat	p-value
parametric terms	cyear	1.00	0.7170	0.3975
smoothed terms	s(cyear)	5.63	6.5702	<0.0001
" "	s(doy)	6.48	79.5722	<0.0001

Table: GAM Parameter Coefficients.

Parameter	Estimate	Std. Err.	t value	p-value
(Intercept)	-3.782915	0.105840	-35.7417	<0.0001
cyear	-0.060288	0.071197	-0.8468	0.3975

Table: GAM Diagnostics.

AIC	RMSE	Adj. R-squared
31.74	0.2459	0.5883

Table: Estimates of Change from 1985-2015.

Calculation	Estimate
Baseline log mean (geometric mean)	-3.7573 (0.0233)
Current log mean (geometric mean)	-3.8983 (0.0203)
Estimated log difference	-0.141
Std. Err. log difference	0.0593
95% Confidence interval for log difference	(-0.2572 , -0.0247)
Difference p-value	0.0179
Period of Record Percent Change Estimate (%)	-13.15%

Appendix 2.1A

Total Phosphorus - Non-linear trend with Seas+Int

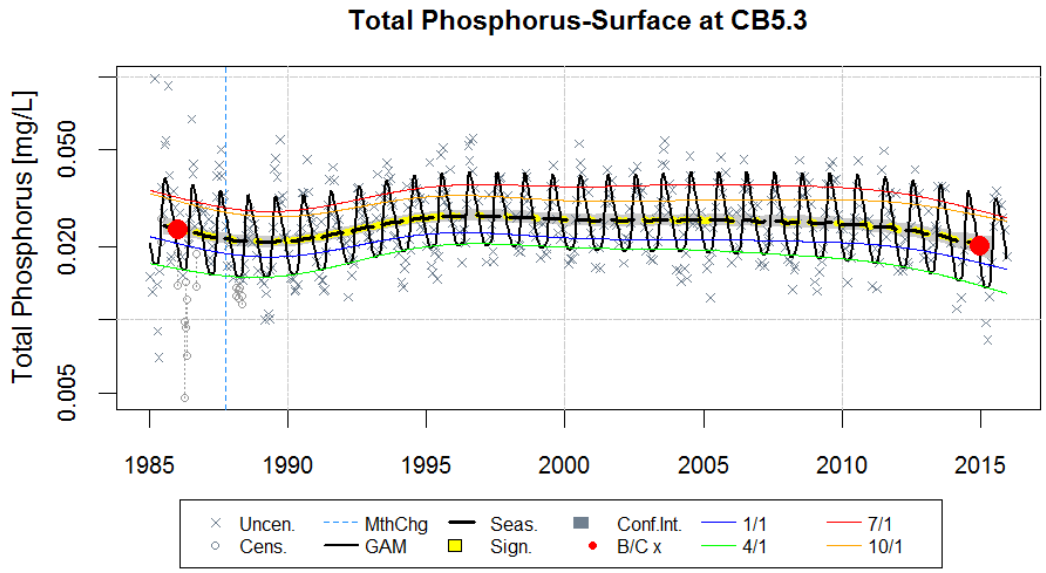

Table: GAM Analysis of Variance.

Type	Source	edf	F-stat	p-value
parametric terms	cyear	1.00	11.8983	0.0006
smoothed terms	s(cyear)	5.80	7.7776	<0.0001
" "	s(doy)	6.49	81.1321	<0.0001
" "	ti(cyear,doy)	4.40	0.8784	0.0198

Table: GAM Parameter Coefficients.

Parameter	Estimate	Std. Err.	t value	p-value
(Intercept)	-3.789626	0.029917	-126.6711	<0.0001
cyear	-0.064949	0.018829	-3.4494	0.0006

Table: GAM Diagnostics.

AIC	RMSE	Adj. R-squared
25.62	0.2433	0.5971

Table: Estimates of Change from 1985-2015.

Calculation	Estimate
Baseline log mean (geometric mean)	-3.7489 (0.0235)
Current log mean (geometric mean)	-3.9005 (0.0202)
Estimated log difference	-0.1516
Std. Err. log difference	0.0598
95% Confidence interval for log difference	(-0.2687 , -0.0344)
Difference p-value	0.0115
Period of Record Percent Change Estimate (%)	-14.06%

Appendix 2.1A

Total Phosphorus - Non-linear trend with Seas+Int. & Intervention

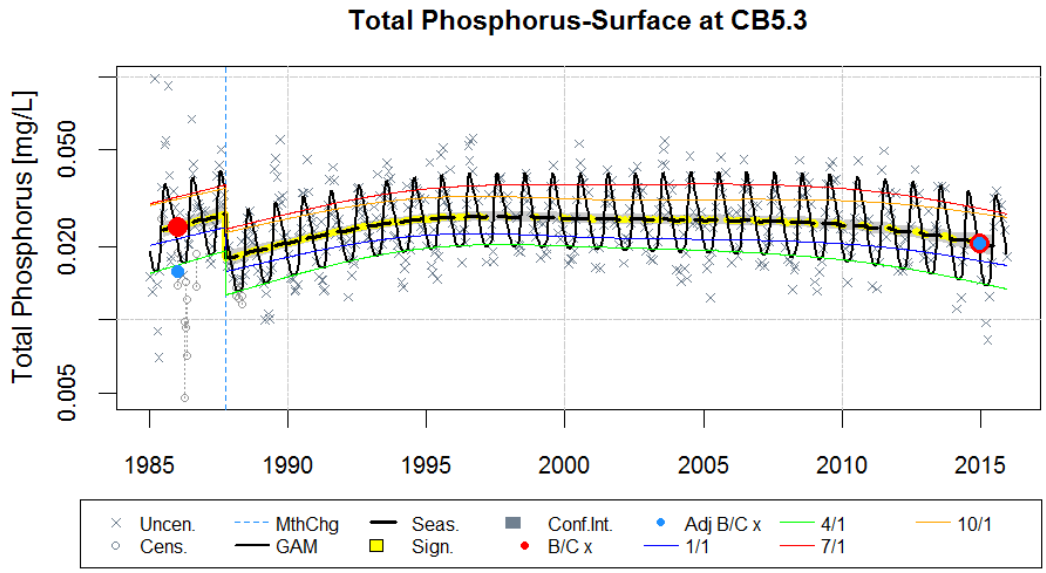

Table: GAM Analysis of Variance.

Type	Source	edf	F-stat	p-value
parametric terms	intervention	1.00	34.0172	<0.0001
" "	cyear	1.00	0.3131	0.5761
smoothed terms	s(cyear)	3.78	10.6593	<0.0001
" "	s(doy)	6.54	83.2624	<0.0001
" "	ti(cyear,doy)	4.28	0.9103	0.0141

Table: GAM Parameter Coefficients.

Parameter	Estimate	Std. Err.	t value	p-value
(Intercept)	-3.306467	0.079876	-41.3952	<0.0001
interventionB	-0.419769	0.071972	-5.8324	<0.0001
cyear	0.008978	0.016046	0.5595	0.5761

Table: GAM Diagnostics.

AIC	RMSE	Adj. R-squared
-0.44	0.2372	0.6166

Table: Estimates of Change from 1985-2015.

Calculation	Estimate	Adj. Estimate
Baseline log mean (geometric mean)	-3.7271 (0.0241)	-4.1469 (0.0158)
Current log mean (geometric mean)	-3.8805 (0.0206)	-3.8805 (0.0206)
Estimated log difference	-0.1534	0.2664
Std. Err. log difference	0.0554	0.0837
95% Confidence interval for log difference	(-0.2619 , -0.0449)	(0.1023 , 0.4304)
Difference p-value	0.0058	0.0016
Period of Record Percent Change Estimate (%)	-14.22%	30.52%

Close Out

Total Processing Time

```
Begin processing time 2017-05-25 11:31:09.

End processing time 2017-05-25 11:31:39.

The total processing time was 30.0226640701294.
```

Distribution and Contact Information

Category	Description
Name	Rebecca Murphy, Ph.D.
Organization	Chesapeake Bay Program Office
Address	410 Severn Ave., Suite 112, Annapolis, MD 21403
Voice phone	(410)267-9837
email	rmurphy@chesapeakebay.net

Category	Description
Name	Elgin S. Perry, Ph.D.
Address	377 Resolutions Rd., Colonial Beach, VA 22443
Voice phone	(410)610-1473
email	eperry@chesapeake.net

Category	Description
Name	Jon B. Harcum, Ph.D.
Organization	Tetra Tech, Inc.
Address	313 Kings Way, Clemson, SC 29631
Voice phone	(864)650-5815
email	jon.harcum@tetratech.com

Session Information

Platform

setting value
version R version 3.3.1 (2016-06-21) system x86_64, mingw32
ui RTerm
language (EN)
collate English_United States.1252
tz America/New_York
date 2017-05-25

Appendix 2.1A

Section 2: Tabular output (generated in csv files)

Station	dep	layer	latitude	longitude	cbSeg92	state	stationGrpName	parmName	numObservations
CB5.3	tp	S	37.91011	-76.17137	CB5MH_MD	MD	Chesapeake Bay Mainstem (CB5MHMD)	Total Phosphorus [mg/L]	494
CB5.3	tp	S	37.91011	-76.17137	CB5MH_MD	MD	Chesapeake Bay Mainstem (CB5MHMD)	Total Phosphorus [mg/L]	494
CB5.3	tp	S	37.91011	-76.17137	CB5MH_MD	MD	Chesapeake Bay Mainstem (CB5MHMD)	Total Phosphorus [mg/L]	494
CB5.3	tp	S	37.91011	-76.17137	CB5MH_MD	MD	Chesapeake Bay Mainstem (CB5MHMD)	Total Phosphorus [mg/L]	494

Continued:

yearBegin	yearEnd	numYrs	yearRangeDropped	fracLT	fracUnc	fracInt	fracRecen	recensor	depGAM	logTrans	gamOption
1985	2015	31	NA-NA	0	0.979757085	0.020242915	0	0.0024	lntp	TRUE	0
1985	2015	31	NA-NA	0	0.979757085	0.020242915	0	0.0024	lntp	TRUE	1
1985	2015	31	NA-NA	0	0.979757085	0.020242915	0	0.0024	lntp	TRUE	2
1985	2015	31	NA-NA	0	0.979757085	0.020242915	0	0.0024	lntp	TRUE	3

Continued:

gamName	gamSelect	gamK	cyear.coeff	cyear.pv	interB.label	interB.coeff	interB.pv	
Linear Trend with Seasonality	TRUE	10	0.00248166	0.064655024	10/1/1987	NA	NA	
Non-linear Trend with Seasonality	TRUE	10	-0.060288269	0.397541687	10/1/1987	NA	NA	
Non-linear trend with Seas+Int	TRUE	10	-0.06494942	0.000611875	10/1/1987	NA	NA	
Non-linear trend with Seas+Int. & Intervention	TRUE	10	0.008978402	0.576057678	10/1/1987	-0.419768701	1.00926E-08	

Continued:

p.cyear.pv	s.cyear.pv	s.doy.pv	ti.pv	p.inter.pv	edfMin	edfMinSource	FstatFlag	mn.doy	sa.sig.inc	sa.sig.dec	por.diffType
0.064655	NA	5.12E-117	NA	NA	1	cyear		NA	07/1985-08/1985 02/1986-08/1986 ...	11/1985-01/1986 11/1986-01/1987...	regular
0.397542	6.27E-12	7.71E-129	NA	NA	1	cyear		NA	Many dates, not copied		regular

Appendix 2.1A

									here		
0.000612	1.99E-12	1.91E-131	0.019808	NA	1	cyear		NA			regular
0.576058	7.29E-20	1.10E-134	0.014142	1.01E-08	1	intervention		NA			adjusted

Continued:

por.bl.mn	por.cr.mn	por.bl.mn.obs	por.cr.mn.obs	por.abs.chg	por.abs.chg.obs	por.pct.chg	por.chg.pv	aic	rmse	adjR2
-3.76014	-3.68817	0.023281	0.025018	0.071968	0.001737	7.462109	0.064646	82.46	0.2603	0.5386
-3.75734	-3.8983	0.023346	0.020276	-0.14097	-0.00307	-13.148	0.017875	31.74	0.2459	0.5883
-3.74892	-3.90049	0.023543	0.020232	-0.15157	-0.00331	-14.0644	0.011526	25.62	0.2433	0.5971
-4.14686	-3.88048	0.015814	0.020641	0.266388	0.004827	30.52411	0.001551	-0.44	0.2372	0.6166