Examining environmental drivers on greenhouse gas fluxes in a constructed stormwater wetland (aka 2017 CSW)

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Project Description: Analysis of monthly greenhouse gas fluxes in a constructed stormwater wetland (Greenville, NC, USA).

```
if(Sys.info()[1] == "Darwin"){
  setwd("~/Desktop/ConstructedStormwaterWetland/analyses/")
} else {
  # setwd(choose.dir())
}
rm(list = ls())

library(ggplot2)
library(psych)
```

```
##
## Attaching package: 'psych'
```

```
## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha
```

```
#GHG Flux data
ghg <- read.csv("../data/CSW_GHG_Env.csv", header=T)
```

```
##            vars   n       mean          sd   skew kurtosis        se
## date*         1 180       6.50        3.46   0.00    -1.24      0.26
## month*        2 180       6.50        3.46   0.00    -1.24      0.26
## sampleid*     3 180       8.00        4.33   0.00    -1.23      0.32
## hydrology*    4 180       1.33        0.47   0.70    -1.52      0.04
## placement*    5 180       2.33        1.01   0.07    -1.16      0.08
## hp*           6 180       4.00        1.97   0.00    -1.26      0.15
## season*       7 180       2.50        1.12   0.00    -1.38      0.08
## soiltemp      8 180      17.30        7.38  -0.23    -1.36      0.55
## ch4.ugm2hr    9 180 4235747.26 11396474.10   4.05    19.44 849443.03
## co2.ugm2hr   10 180 3735470.22 10719122.94   4.35    35.19 798956.25
## n2o.ugm2hr   11 180   -7384.84    31276.31  -3.49    16.92   2331.20
## ch4.mgm2hr   12 180    4235.75    11396.47   4.05    19.44    849.44
## co2.mgm2hr   13 180    3735.47    10719.12   4.35    35.19    798.96
## n2o.mgm2hr   14 180      -7.38       31.28  -3.49    16.92      2.33
## ch4.co2e     15 180  105893.68   284911.85   4.05    19.44  21236.08
## n2o.co2e     16 180   -2200.68     9320.34  -3.49    16.92    694.70
## co2.ch4      17 180    -445.21     5748.10 -12.73   164.82    428.44
## co2.n2o      18 180    2388.63    30821.96   7.69   101.71   2297.33
```

```
##
##  Descriptive statistics by group
```

```
## group: t
##            vars   n      mean         sd   skew kurtosis        se
## date*         1 120      6.50       3.47   0.00    -1.25      0.32
## month*        2 120      6.50       3.47   0.00    -1.25      0.32
## sampleid*     3 120     10.50       2.88   0.00    -1.25      0.26
## hydrology*    4 120      1.00       0.00    NaN      NaN      0.00
## placement*    5 120      2.50       1.03   0.00    -1.16      0.09
## hp*           6 120      4.00       2.06   0.00    -1.16      0.19
## season*       7 120      2.50       1.12   0.00    -1.39      0.10
## soiltemp      8 120     17.02       7.16  -0.27    -1.36      0.65
## ch4.ugm2hr    9 120 287212.50 1245852.93   6.76    53.46 113730.29
## co2.ugm2hr   10 120 309343.39 5978531.13  -0.28     3.33 545762.73
## n2o.ugm2hr   11 120  -2956.75   19499.25  -2.58     6.05   1780.03
## ch4.mgm2hr   12 120    287.21    1245.85   6.76    53.46    113.73
## co2.mgm2hr   13 120    309.34    5978.53  -0.28     3.33    545.76
## n2o.mgm2hr   14 120     -2.96      19.50  -2.58     6.05      1.78
## ch4.co2e     15 120   7180.31   31146.32   6.76    53.46   2843.26
## n2o.co2e     16 120   -881.11    5810.78  -2.58     6.05    530.45
## co2.ch4      17 120   -673.53    7038.55 -10.30   107.63    642.53
## co2.n2o      18 120    154.00   17586.36  -7.06    70.89   1605.41
## ------------------------------------------------------------
## group: w
##            vars  n        mean          sd  skew kurtosis         se
## date*         1 60        6.50        3.48  0.00    -1.28       0.45
## month*        2 60        6.50        3.48  0.00    -1.28       0.45
## sampleid*     3 60        3.00        1.43  0.00    -1.36       0.18
## hydrology*    4 60        2.00        0.00   NaN      NaN       0.00
## placement*    5 60        2.00        0.90  0.00    -1.79       0.12
## hp*           6 60        4.00        1.80  0.00    -1.79       0.23
## season*       7 60        2.50        1.13  0.00    -1.41       0.15
## soiltemp      8 60       17.86        7.83 -0.20    -1.45       1.01
## ch4.ugm2hr    9 60 12132816.78 17198252.24  2.11     4.81 2220284.82
## co2.ugm2hr   10 60 10587723.90 14313574.36  4.28    22.89 1847874.50
## n2o.ugm2hr   11 60   -16241.02    45620.76 -2.50     7.57    5889.62
## ch4.mgm2hr   12 60    12132.82    17198.25  2.11     4.81    2220.28
## co2.mgm2hr   13 60    10587.72    14313.57  4.28    22.89    1847.87
## n2o.mgm2hr   14 60      -16.24       45.62 -2.50     7.57       5.89
## ch4.co2e     15 60   303320.42   429956.31  2.11     4.81   55507.12
## n2o.co2e     16 60    -4839.82    13594.99 -2.50     7.57    1755.11
## co2.ch4      17 60       11.41       43.91  2.60    10.78       5.67
## co2.n2o      18 60     6857.90    47200.76  6.91    48.45    6093.59

##
##  Shapiro-Wilk normality test
##
## data:  ghg$ch4.mgm2hr
## W = 0.43733, p-value < 2.2e-16

##
##  Shapiro-Wilk normality test
##
## data:  ghg$co2.mgm2hr
## W = 0.6896, p-value < 2.2e-16

##
```

```
##  Shapiro-Wilk normality test
##
## data:  ghg$n2o.mgm2hr
## W = 0.58296, p-value < 2.2e-16
```

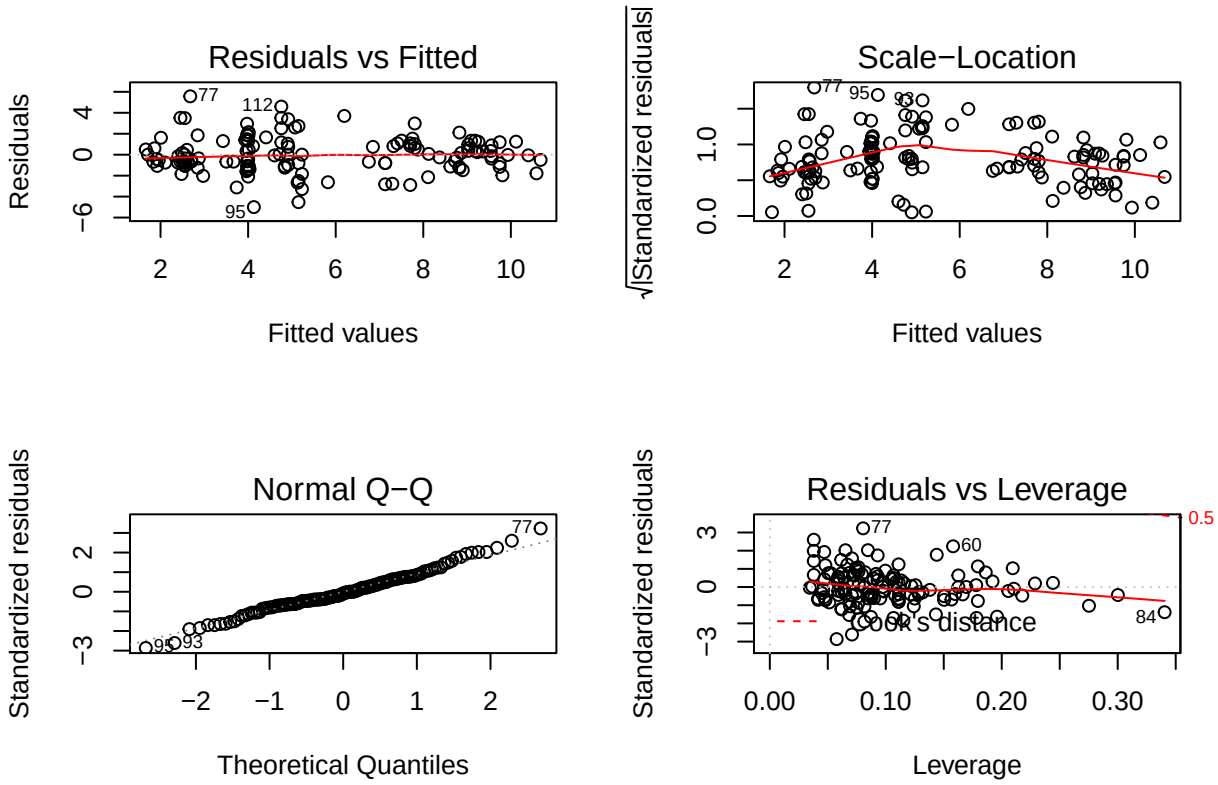
```
#extra info for graphing
library(scales)
```

```
##
## Attaching package: 'scales'
```

```
## The following objects are masked from 'package:psych':
##
##     alpha, rescale
```

```
fancy_scientific <- function(l) {
     # turn in to character string in scientific notation
     l <- format(l, scientific = TRUE)
     # quote the part before the exponent to keep all the digits
     l <- gsub("^(.*)e", "'\\1'e", l)
     # turn the 'e+' into plotmath format
     l <- gsub("e", "%*%10^", l)
     # return this as an expression
     parse(text=l)
} #scale_y_continuous(labels=fancy_scientific)

fmt_decimals <- function(decimals=0){
    function(x) format(x,nsmall = decimals,scientific = FALSE)
} #scale_y_continuous(labels = fmt_decimals(2))
```

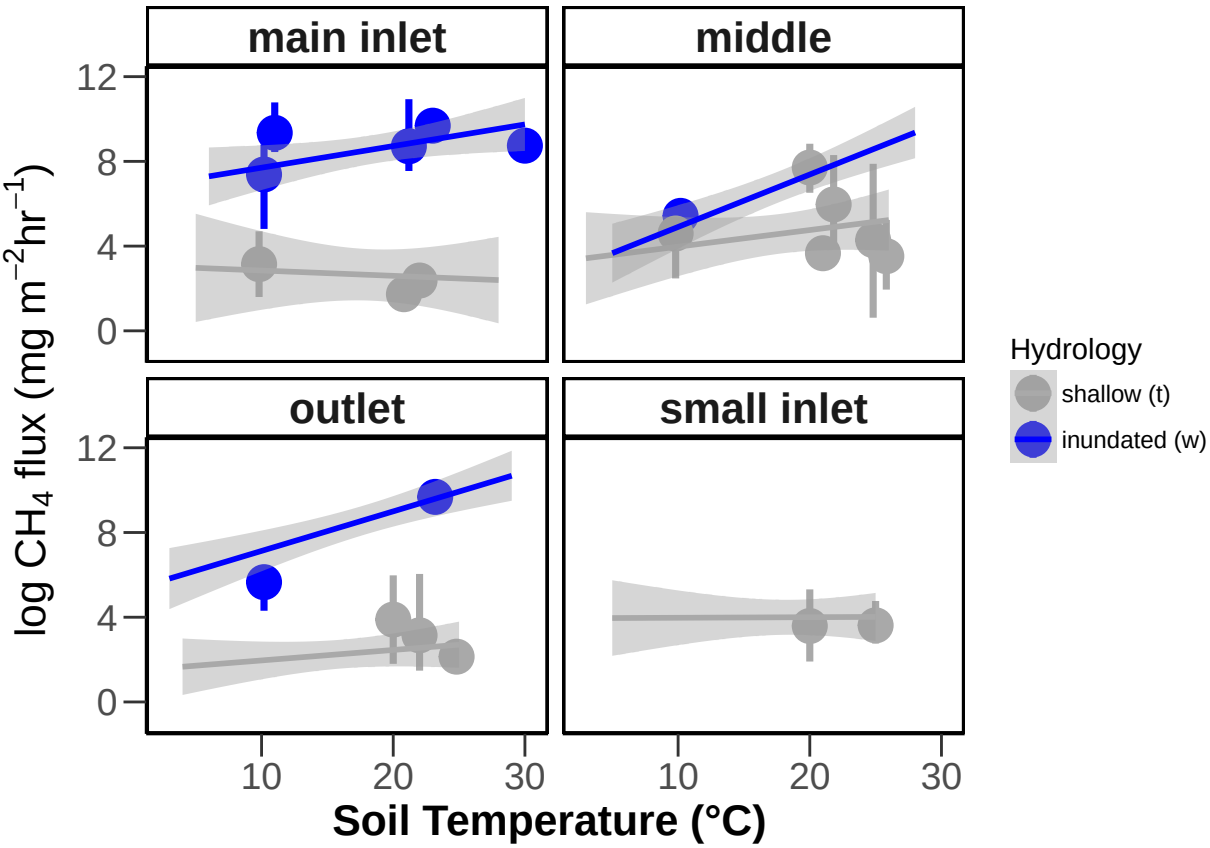
```
#sets plots for 2 rows, 2 columns
par(mfcol=c(2,2))

#linear models for CH4
ch4.lm <- lm(log(ch4.mgm2hr)~soiltemp*hydrology*placement, data=ghg)
plot(ch4.lm)
```




```
anova(ch4.lm)
```

```
## Analysis of Variance Table
##
## Response: log(ch4.mgm2hr)
##                              Df Sum Sq Mean Sq  F value    Pr(>F)
## soiltemp                      1 101.03  101.03  31.2149 1.429e-07 ***
## hydrology                     1 700.42  700.42 216.4130 < 2.2e-16 ***
## placement                     3  13.29    4.43   1.3691  0.255476
## soiltemp:hydrology            1  31.26   31.26   9.6585  0.002345 **
## soiltemp:placement            3  16.68    5.56   1.7182  0.166808
## hydrology:placement           2  85.75   42.88  13.2480 6.214e-06 ***
## soiltemp:hydrology:placement  2   0.46    0.23   0.0705  0.931928
## Residuals                   122 394.85    3.24
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

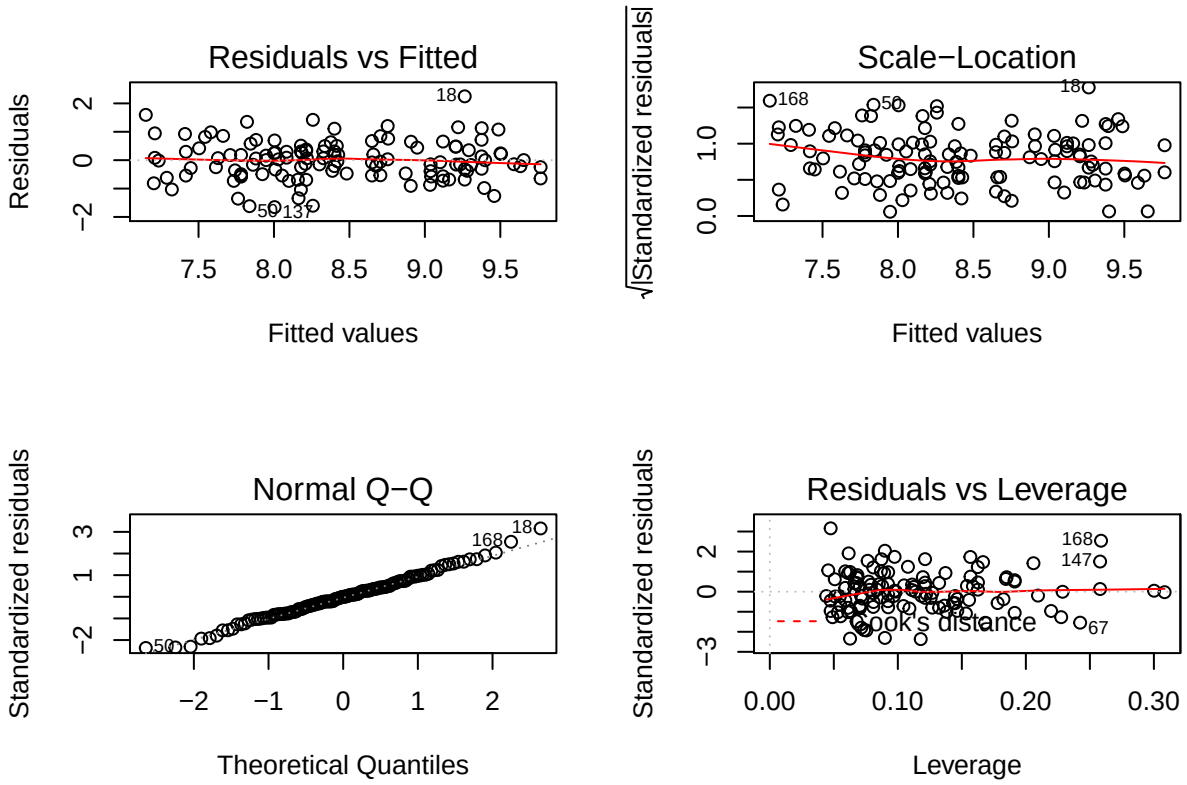
```
p <- ggplot(ghg, aes(x=soiltemp, y=log(ch4.mgm2hr), color=as.factor(hydrology))) + theme_bw() + theme(pa
p1=p+geom_smooth(method="lm")+facet_wrap(~placement)
p1 + theme_bw() + theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.lin
```




```
ggsave("../figures/methane.pdf", plot=last_plot(), device=NULL, path=NULL, scale=1, width=NA, height=NA
```

```
## Saving 6.5 x 4.5 in image
```

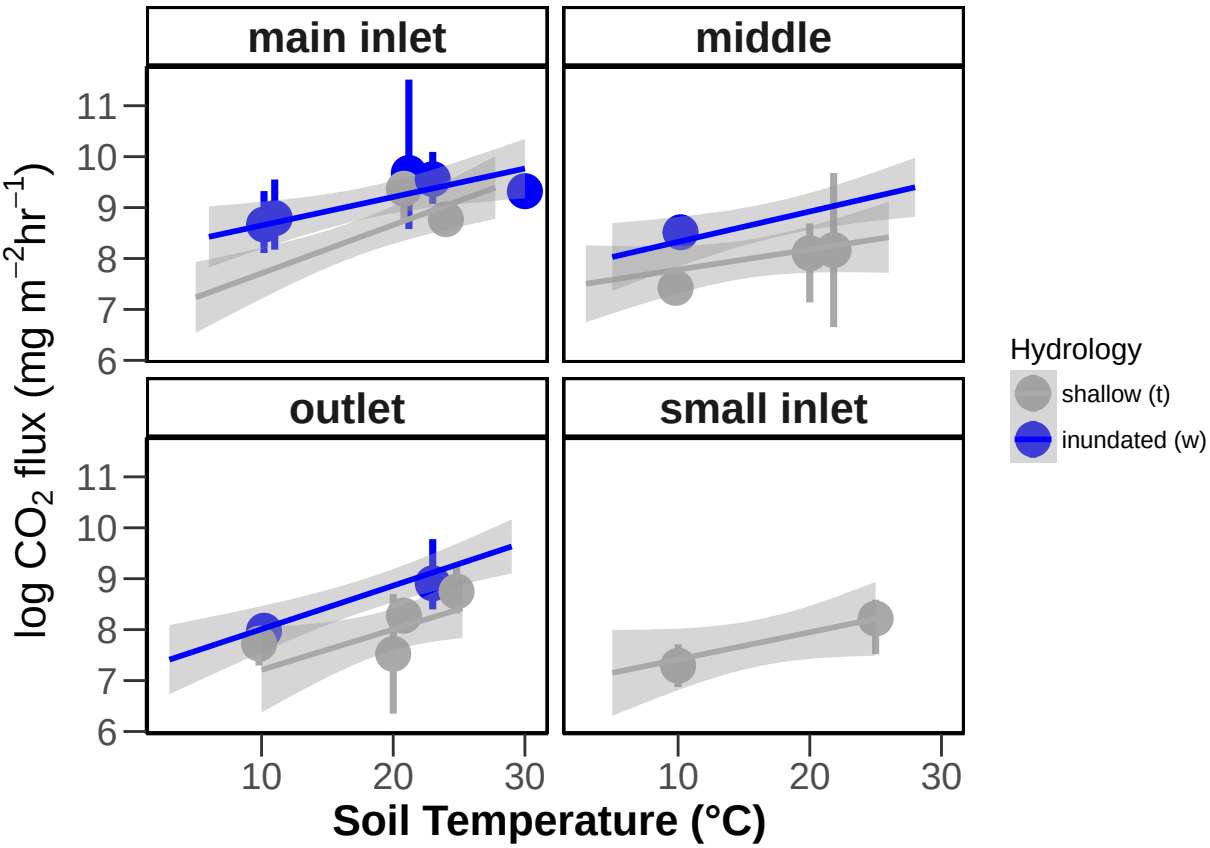
```
#sets plots for 2 rows, 2 columns
par(mfcol=c(2,2))

#linear models for CH4
co2.lm <- lm(log(co2.mgm2hr)~soiltemp*hydrology*placement, data=ghg)
plot(co2.lm)
```




```
anova(co2.lm)
```

```
## Analysis of Variance Table
##
## Response: log(co2.mgm2hr)
##                              Df Sum Sq Mean Sq F value    Pr(>F)
## soiltemp                      1 31.395 31.3952 59.0439 7.501e-12 ***
## hydrology                     1 19.106 19.1060 35.9321 2.746e-08 ***
## placement                     3  4.959  1.6530  3.1087   0.02948 *
## soiltemp:hydrology            1  0.105  0.1052  0.1979   0.65734
## soiltemp:placement            3  1.231  0.4105  0.7719   0.51217
## hydrology:placement           2  0.250  0.1249  0.2350   0.79100
## soiltemp:hydrology:placement  2  0.820  0.4102  0.7714   0.46490
## Residuals                   108 57.426  0.5317
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

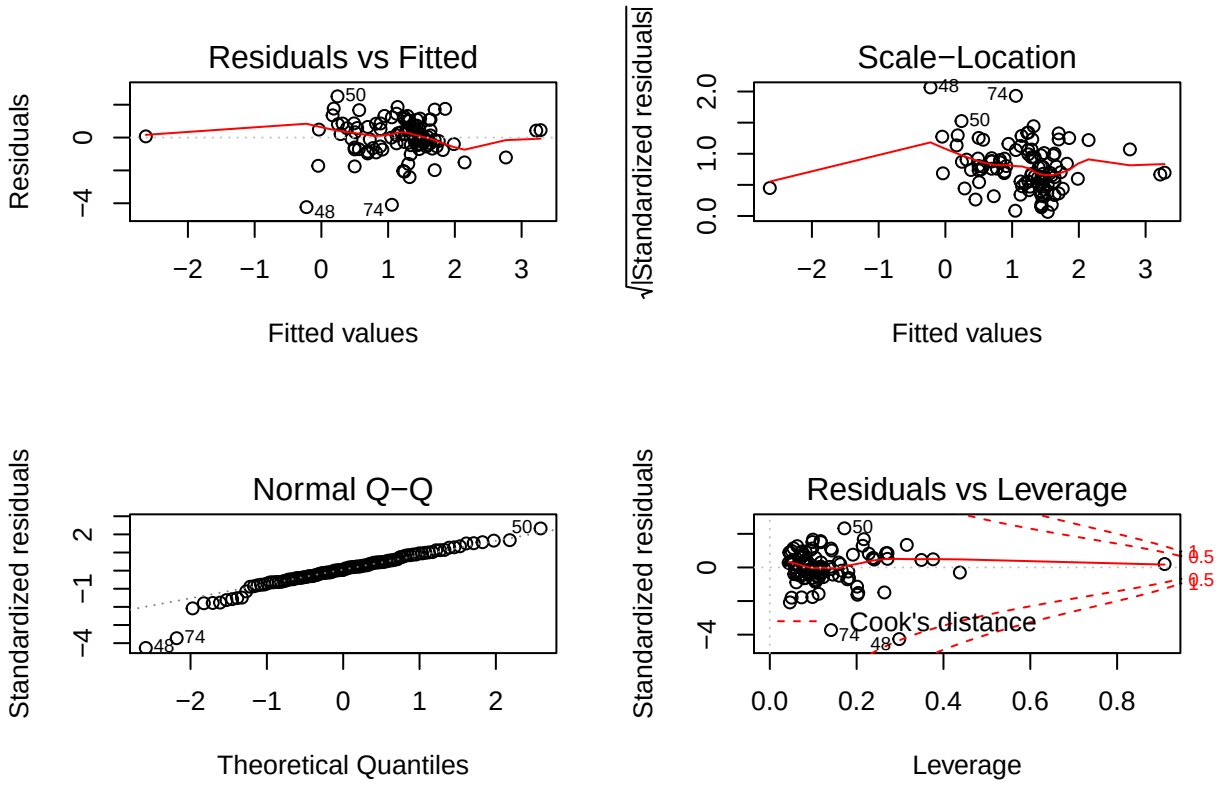
```
p <- ggplot(ghg, aes(x=soiltemp, y=log(co2.mgm2hr), color=as.factor(hydrology))) + theme_bw() + theme(pa
p1=p+geom_smooth(method="lm")+facet_wrap(~placement)
p1 + theme_bw() + theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.lin
```




```
ggsave("../figures/carbondioxide.pdf", plot=last_plot(), device=NULL, path=NULL, scale=1, width=NA, hei
```

```
## Saving 6.5 x 4.5 in image
```

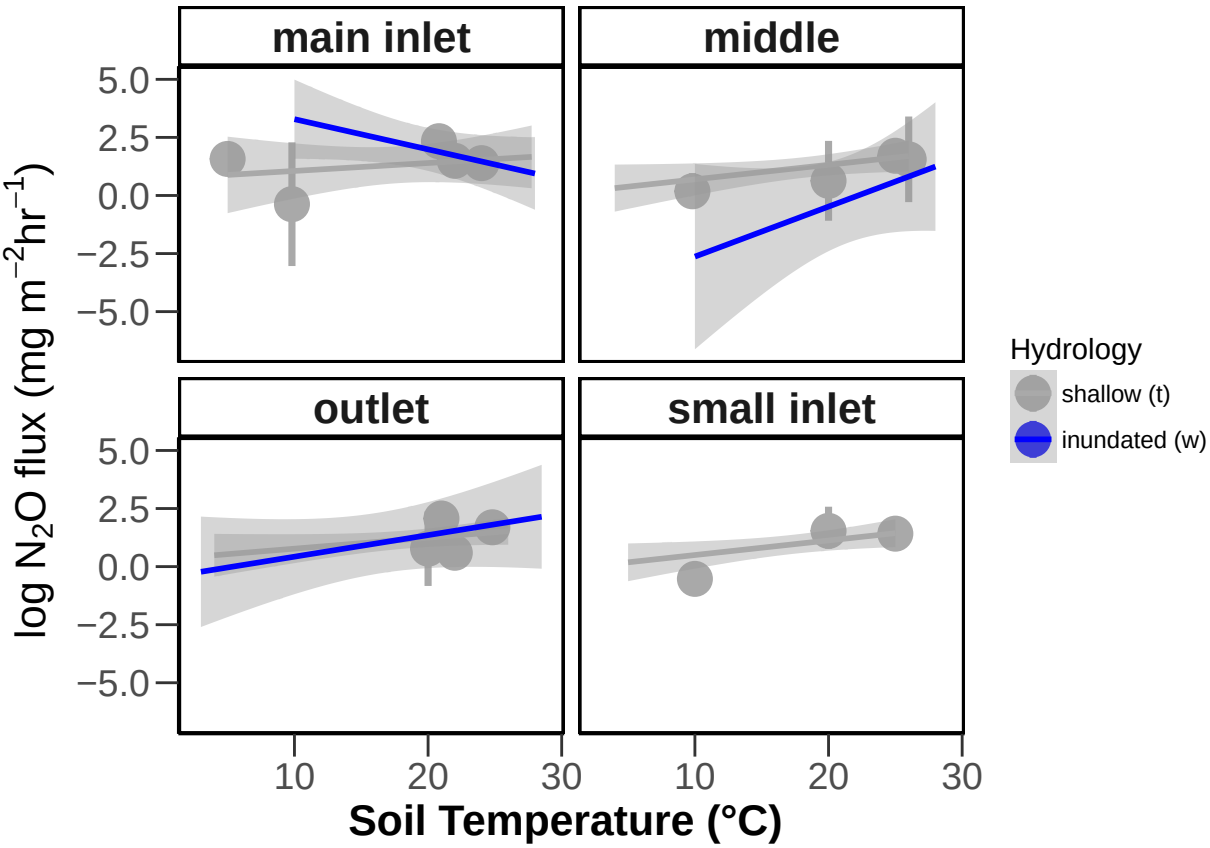
```
#sets plots for 2 rows, 2 columns
par(mfcol=c(2,2))

#linear models for CH4
n2o.lm <- lm(log(n2o.mgm2hr)~soiltemp*hydrology*placement, data=ghg)
plot(n2o.lm)
```




```
anova(n2o.lm)
```

```
## Analysis of Variance Table
##
## Response: log(n2o.mgm2hr)
##                              Df  Sum Sq Mean Sq F value   Pr(>F)
## soiltemp                      1  13.682 13.6825  9.7448 0.002425 **
## hydrology                     1   0.039  0.0387  0.0276 0.868471
## placement                     3   6.560  2.1866  1.5573 0.205362
## soiltemp:hydrology            1   0.086  0.0857  0.0610 0.805474
## soiltemp:placement            3   5.157  1.7191  1.2244 0.305606
## hydrology:placement           2  13.570  6.7850  4.8324 0.010178 *
## soiltemp:hydrology:placement  2  11.088  5.5439  3.9484 0.022754 *
## Residuals                    89 124.963  1.4041
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
p <- ggplot(ghg, aes(x=soiltemp, y=log(n2o.mgm2hr), color=as.factor(hydrology))) + theme_bw() + theme(pa
p1=p+geom_smooth(method="lm")+facet_wrap(~placement)
p1 + theme_bw() + theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(), axis.lin
```




```
ggsave("../figures/nitrousoxide.pdf", plot=last_plot(), device=NULL, path=NULL, scale=1, width=NA, heig
```

```
## Saving 6.5 x 4.5 in image
```