APEX active layer analysis

Manies

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Needed libraries:

```
library(lubridate)
library(ggplot2)
library(dplyr)   #left_join
```

Importation of data files

The data included in this analysis are from various sources. All data are originally from Excel files where a tab was saved in csv format.

```
guelph <- read.csv("raw_data/Seasonal Thaw Depth Data Dielman.csv",header=TRUE)
usgs1 <- read.csv("raw_data/FINAL End of Season usgs.csv",header=TRUE)
crell <- read.csv("raw_data/douglas APEX ERT lines thaw depths October 2017.csv", header=TRUE)
geo.1819.data <- read.csv("raw_data/APEX_2018_2019_Adjusted_ThawDepth_Data.csv", header=TRUE)
geo.now.data <- read.csv("raw_data/APEX_2020_present_ThawDepth_Data.csv", header=TRUE)
apex.data <- read.csv("raw_data/APEX_non_geophysical_thaw_depths.csv", header=TRUE)
region <- read.csv("APEX_GPS_locations.csv", header=TRUE)
```

Add a column to each dataset so we know where the data is from.

```
usgs1 <- cbind(usgs1, source="USGS")
guelph <- cbind(guelph, source="Guelph")
crell <- cbind(crell, source="CRELL")
geo.1819.data <- cbind(geo.1819.data, source="USGS")
geo.now.data <- cbind(geo.now.data, source="USGS")
apex.data <- cbind(apex.data, source="USGS")
```

Remove bog data

GUELPH:
Names changed throughout the study time. Here old names are converted to current names. Measurements with permafrost are called “Permafrost Plateau” under Site - subset data so only those are chosen.
QUESTION: There are a few sites I assumed were at met_station region. Confirm with Catherine.

USGS:
Measurements with permafrost are labeled “forest” under Treatment

CRELL:
Type of site was assigned by Kristen Manies based on the descriptions.Anything that said it had live spruce was assumed to have permafrost. Anything labeled thermokarst, noted to have standing water, or dead spruce was assumed to be thawed. For the few rows without descriptions the determination was based on adjacent rows and/or the depth measurements.

Once imported each file needed their time stamp converted into strptime so can combine them later.

```
lookup <- read.csv("raw_data/guelph_lookup.csv",header=TRUE)
lookup$Plot <- as.character(lookup$Plot)
guelph <- left_join(guelph, lookup, by = c("Treatment" , "Plot"))
guelph$new_plot <- ifelse(is.na(guelph$new_plot),guelph$Plot,guelph$new_plot)

guelph.gamma <- subset(guelph, Site=="Permafrost Plateau ")

crell.gamma <- subset(crell, Site=="Pfrost")
crell.gamma$date <-substr(crell.gamma$DateTime, 1, 10)
crell.gamma$transect <- substr(crell.gamma$Name, 4,5)
crell.gamma$year <- year(crell.gamma$date)

usgs.gamma <- subset(usgs1, usgs1$Treatment == "forest")
geo.1819.gamma <- subset(geo.1819.data, SiteID != "APEX4" | SiteID != "APEX5")
geo.now.gamma <- subset(geo.now.data, SiteID != "APEX4" | SiteID != "APEX5")

guelph.gamma$Date <- strptime(guelph.gamma$Date, format="%m/%d/%Y", tz="America/Anchorage")
usgs.gamma$date <- strptime(usgs.gamma$date, format="%d-%b-%y", tz="America/Anchorage")
crell.gamma$date <-substr(crell.gamma$DateTime, 1, 10)
crell.gamma$date <- strptime(crell.gamma$date, format="%Y-%m-%d")
geo.1819.gamma$Date <- paste(substr(geo.1819.gamma$Date, 1, 4), substr(geo.1819.gamma$Date, 5, 6
), substr(geo.1819.gamma$Date, 7, 8), sep = '-')
geo.1819.gamma$Date <- strptime(geo.1819.gamma$Date, format="%Y-%m-%d", tz="America/Anchorage")
geo.now.gamma$Date <- strptime(geo.now.gamma$Date, format="%m/%d/%Y", tz="America/Anchorage")
apex.data$Date <- strptime(apex.data$Date, format="%m/%d/%Y", tz="America/Anchorage")
```

Combining all datasets

Combine gamma data from all three data sets and plot over time. Subset larger dataframe to just columns we need. Columns are: site (aka within gamma location), location (more detailed location), Date (%Y-%m-%d format), active layer depth, & source. Using a function, give all dataframes the same names so they can be combined.

```
cg.sub <- data.frame(crell.gamma$transect, crell.gamma$GPSpoint, crell.gamma$date, crell.gamma$D
epth, crell.gamma$source)
gg.sub <- data.frame(guelph.gamma$Treatment, guelph.gamma$new_plot, guelph.gamma$Date, guelph.ga
mma$Ice_Depth_cm, guelph.gamma$source)
usgs.sub <- data.frame(usgs.gamma$Site, usgs.gamma$Chamber, usgs.gamma$date, usgs.gamma$AL_cm, u
sgs.gamma$source)
geo.1819.sub <- data.frame(geo.1819.gamma$SiteID, geo.1819.gamma$Adjacency, geo.1819.gamma$Date,
geo.1819.gamma$ThawDep_cm, geo.1819.gamma$source)
geo.now.sub <- data.frame(geo.now.gamma$SiteID, geo.now.gamma$Adjacency, geo.now.gamma$Date, ge
o.now.data$ThawDep_cm, geo.now.gamma$source)
apex.sub <- data.frame(apex.data$Site, apex.data$Location, apex.data$Date, apex.data$AL_cm, ape
x.data$source)

same.names <- function(df) {
  names(df)[1] <- "site"
  names(df)[2] <- "location"
  names(df)[3] <- "date"
  names(df)[4] <- "depth"
  names(df)[5] <- "source"
  return(df)
}

cg.sub <-same.names(cg.sub)
gg.sub <-same.names(gg.sub)
usgs.sub <- same.names(usgs.sub)
geo.1819.sub <- same.names(geo.1819.sub)
geo.now.sub <- same.names(geo.now.sub)
apex.sub <- same.names(apex.sub)
all.gamma <- rbind(cg.sub, gg.sub, usgs.sub, geo.1819.sub, geo.now.sub, apex.sub)
```

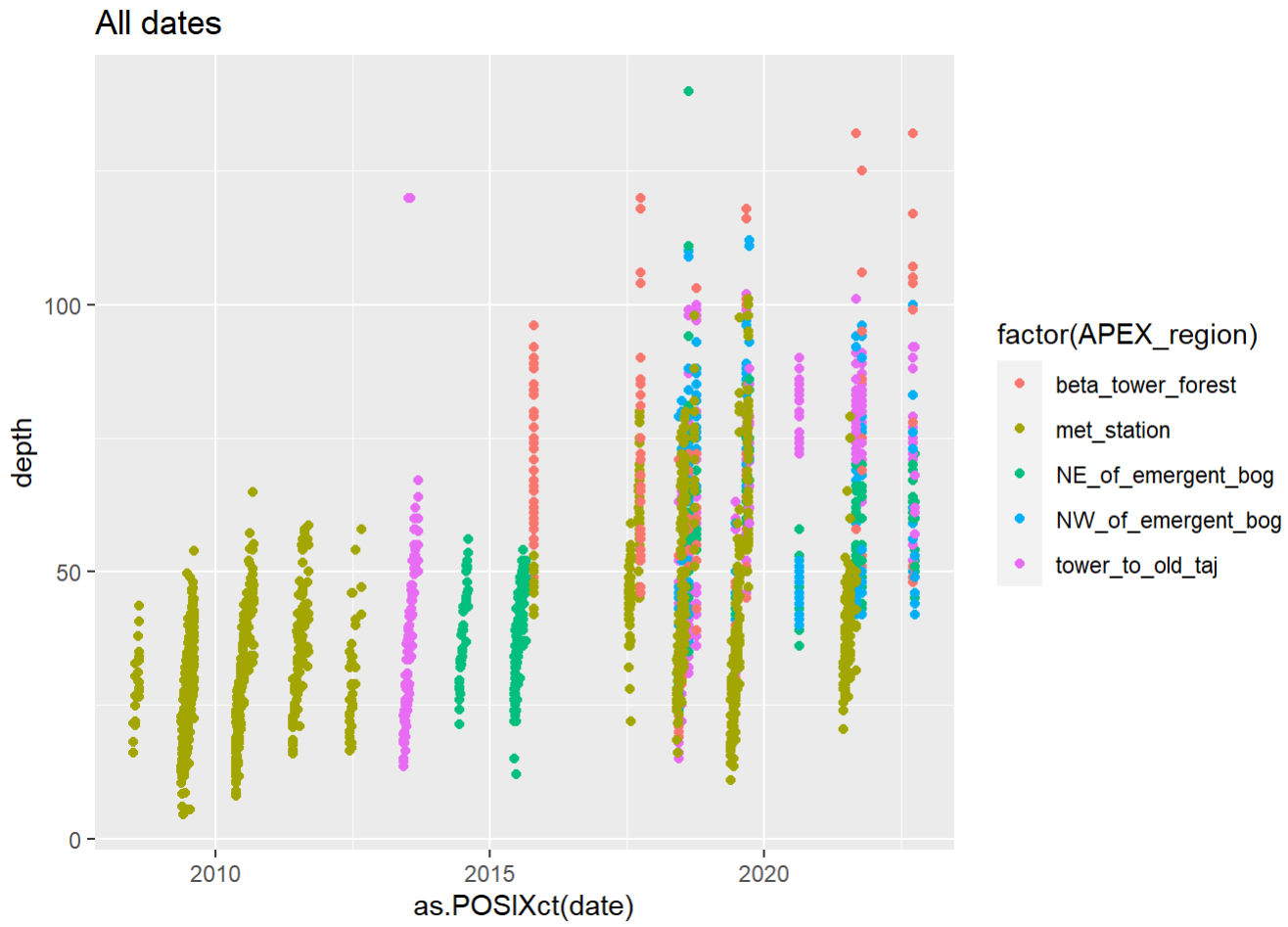
Assign each site-location a region within APEX

So we can look at data by location within APEX to see if there are trends. Choices are: beta_tower_forest, emergent_bog_area, met_station, NE_of_emergent bog (BZFM area), NW_of_emergent_bog (BZFP area), tower_to_old_taj, and towards_alpha. Remove data from the BZBB area (emergent_bog_area) and from the CRELL data where there are only only one or two measurements for that location for that year (too little data to feel secure in) or there is only that year of data (towards_alpha)

```
all.region <- merge(all.gamma, region, by=c("site", "location"))
all.nonbog <- subset(all.region, APEX_region != "emergent_bog_area")
all.nonbog <- subset(all.nonbog, location!="439")
all.nonbog <- subset(all.nonbog, location!="440")
all.nonbog <- subset(all.nonbog, location!="441")
all.nonbog <- subset(all.nonbog, APEX_region != "towards_alpha")

all.plot <- ggplot() +
  geom_point(data=all.nonbog, aes(x=as.POSIXct(date), y=depth, color=factor(APEX_region))) +
  ggtitle("All dates")
print(all.plot)
```

```
## Warning: Removed 3 rows containing missing values (`geom_point()`).
```



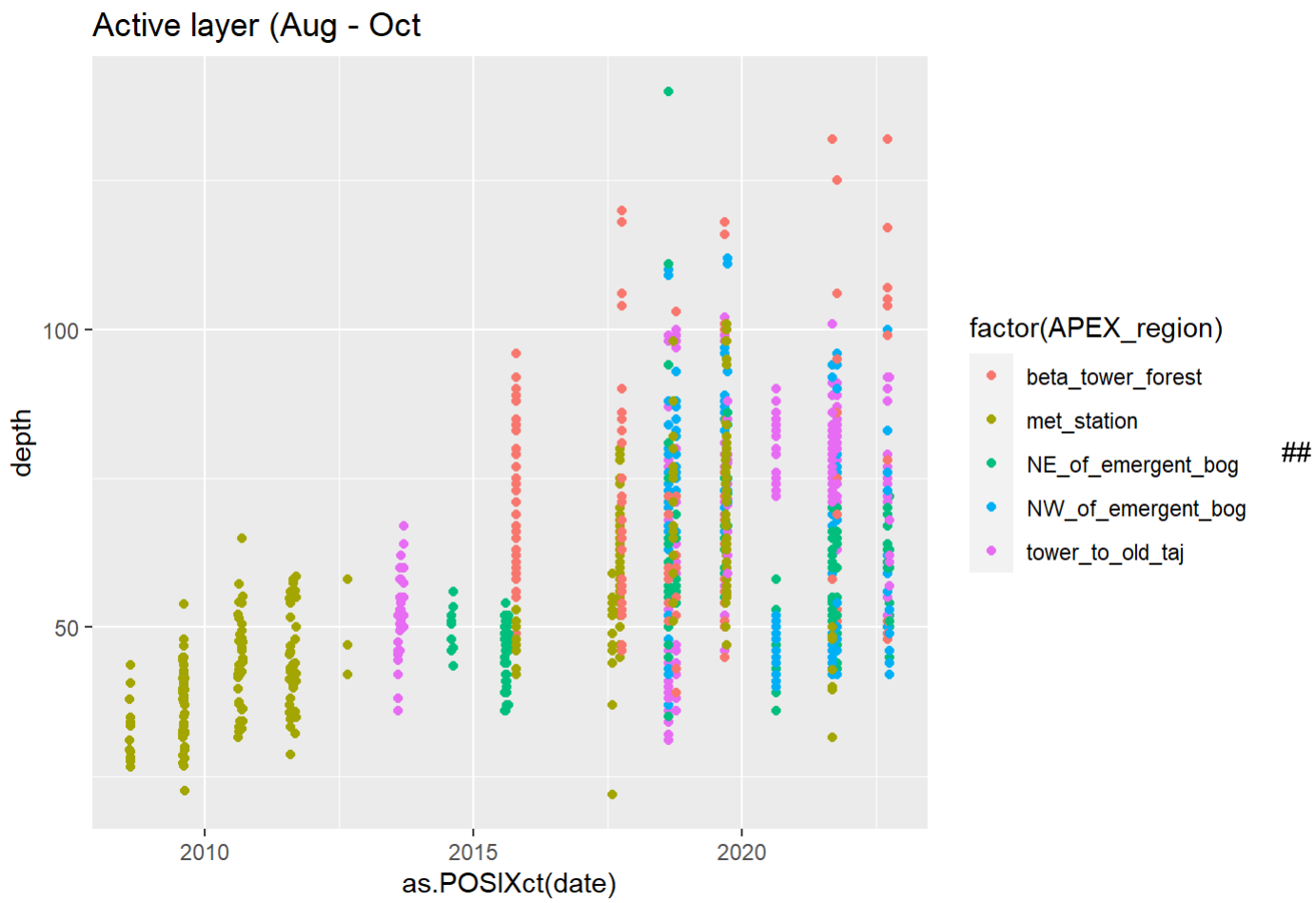
Active layer data

Only looking at data from August through October, so data not impacted by seasonal ice.

```
august.on <- subset(all.nonbog, month(date)>=8)

aug.plot <- ggplot(data=august.on, aes(x=as.POSIXct(date), y=depth)) +
  geom_point(aes(color=factor(APEX_region))) +
  ggtitle("Active layer (Aug - Oct")
print(aug.plot)
```

```
## Warning: Removed 3 rows containing missing values (`geom_point()`).
```



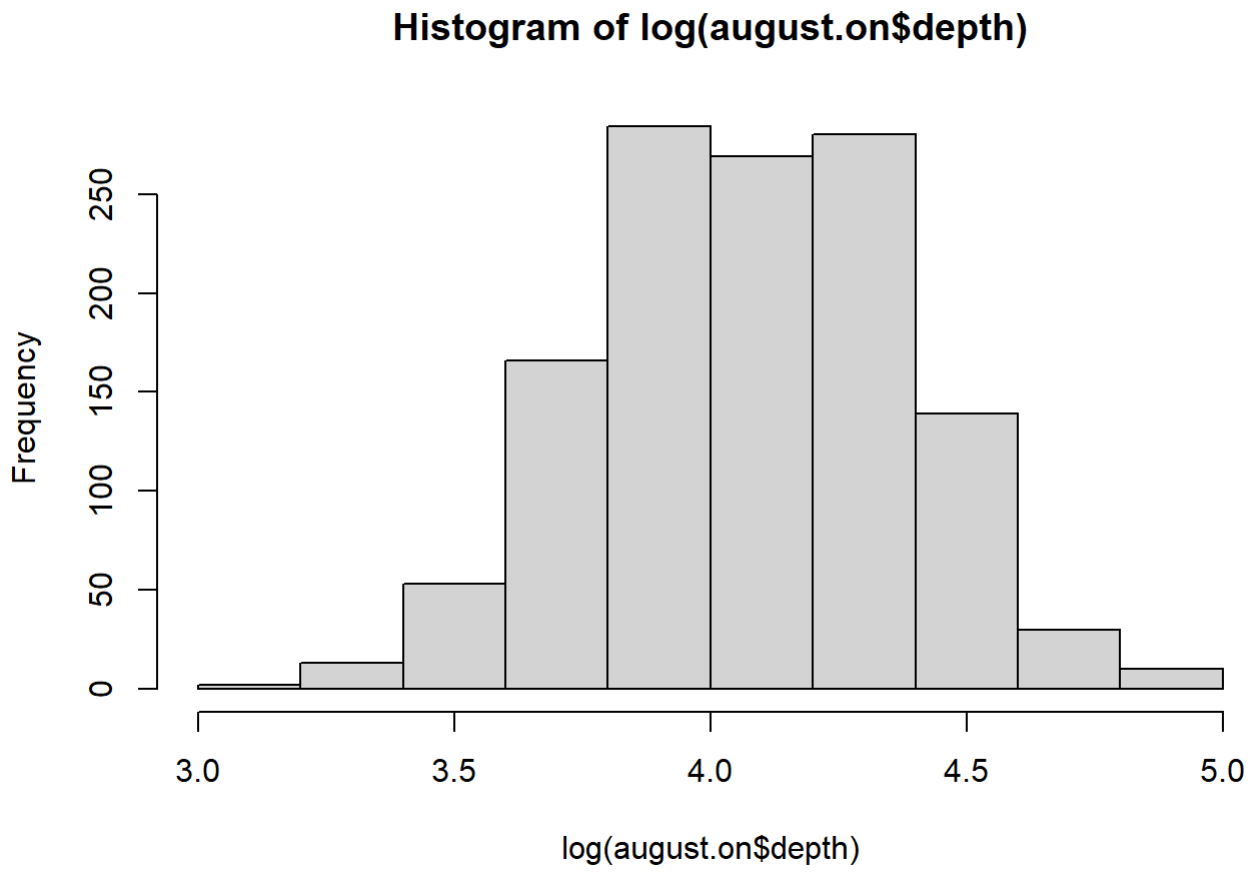
##

Statistics on the data

ADD POST-HOC TEST?

```
august.on$year <- year(as.POSIXct(august.on$date, format="%Y-%m-%d", tz="America/Anchorage"))

#What's the distribution of the data?
#Log helps normality
hist(log(august.on$depth))
```




```
AL.region.stats <- glm(data=august.on, log(depth) ~ factor(year) * APEX_region)
summary(AL.region.stats)
```

```
##
## Call:
## glm(formula = log(depth) ~ factor(year) * APEX_region, data = august.on)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -0.95575  -0.13581   0.00986   0.12907   0.86736
##
## Coefficients: (36 not defined because of singularities)
##                                              Estimate Std. Error t value
## (Intercept)                                   4.12536    0.10400  39.666
## factor(year)2009                              0.12252    0.05898   2.077
## factor(year)2010                              0.27255    0.06073   4.488
## factor(year)2011                              0.25819    0.06148   4.200
## factor(year)2012                              0.38199    0.13165   2.902
## factor(year)2013                             -0.08101    0.13139  -0.617
## factor(year)2014                              0.09614    0.14334   0.671
## factor(year)2015                              0.08045    0.10770   0.747
## factor(year)2017                              0.11780    0.10879   1.083
## factor(year)2018                             -0.03629    0.11211  -0.324
## factor(year)2019                              0.10428    0.11720   0.890
## factor(year)2020                              0.38267    0.13478   2.839
## factor(year)2021                              0.24764    0.09483   2.612
## factor(year)2022                              0.27045    0.12027   2.249
## APEX_regionmet_station                       -0.62460    0.08989  -6.949
## APEX_regionNE_of_emergent_bog                -0.33040    0.07798  -4.237
## APEX_regionNW_of_emergent_bog                -0.31327    0.07890  -3.971
## APEX_regiontower_to_old_taj                  -0.11331    0.07183  -1.578
## factor(year)2009:APEX_regionmet_station            NA         NA      NA
## factor(year)2010:APEX_regionmet_station            NA         NA      NA
## factor(year)2011:APEX_regionmet_station            NA         NA      NA
## factor(year)2012:APEX_regionmet_station            NA         NA      NA
## factor(year)2013:APEX_regionmet_station            NA         NA      NA
## factor(year)2014:APEX_regionmet_station            NA         NA      NA
## factor(year)2015:APEX_regionmet_station       0.27006    0.11507   2.347
## factor(year)2017:APEX_regionmet_station       0.42823    0.09902   4.325
## factor(year)2018:APEX_regionmet_station       0.79452    0.11211   7.087
## factor(year)2019:APEX_regionmet_station       0.64778    0.10649   6.083
## factor(year)2020:APEX_regionmet_station            NA         NA      NA
## factor(year)2021:APEX_regionmet_station            NA         NA      NA
## factor(year)2022:APEX_regionmet_station            NA         NA      NA
## factor(year)2009:APEX_regionNE_of_emergent_bog     NA         NA      NA
## factor(year)2010:APEX_regionNE_of_emergent_bog     NA         NA      NA
## factor(year)2011:APEX_regionNE_of_emergent_bog     NA         NA      NA
## factor(year)2012:APEX_regionNE_of_emergent_bog     NA         NA      NA
## factor(year)2013:APEX_regionNE_of_emergent_bog     NA         NA      NA
## factor(year)2014:APEX_regionNE_of_emergent_bog     NA         NA      NA
## factor(year)2015:APEX_regionNE_of_emergent_bog -0.05181    0.08778  -0.590
## factor(year)2017:APEX_regionNE_of_emergent_bog     NA         NA      NA
## factor(year)2018:APEX_regionNE_of_emergent_bog  0.31561    0.09615   3.282
## factor(year)2019:APEX_regionNE_of_emergent_bog  0.30838    0.10918   2.825
## factor(year)2020:APEX_regionNE_of_emergent_bog -0.36136    0.09122  -3.961
```

```
## factor(year)2021:APEX_regionNE_of_emergent_bog -0.05176    0.09353  -0.553
## factor(year)2022:APEX_regionNE_of_emergent_bog       NA         NA      NA
## factor(year)2009:APEX_regionNW_of_emergent_bog       NA         NA      NA
## factor(year)2010:APEX_regionNW_of_emergent_bog       NA         NA      NA
## factor(year)2011:APEX_regionNW_of_emergent_bog       NA         NA      NA
## factor(year)2012:APEX_regionNW_of_emergent_bog       NA         NA      NA
## factor(year)2013:APEX_regionNW_of_emergent_bog       NA         NA      NA
## factor(year)2014:APEX_regionNW_of_emergent_bog       NA         NA      NA
## factor(year)2015:APEX_regionNW_of_emergent_bog       NA         NA      NA
## factor(year)2017:APEX_regionNW_of_emergent_bog       NA         NA      NA
## factor(year)2018:APEX_regionNW_of_emergent_bog  0.41161    0.09306   4.423
## factor(year)2019:APEX_regionNW_of_emergent_bog  0.50505    0.10438   4.839
## factor(year)2020:APEX_regionNW_of_emergent_bog -0.36753    0.09200  -3.995
## factor(year)2021:APEX_regionNW_of_emergent_bog -0.01190    0.09351  -0.127
## factor(year)2022:APEX_regionNW_of_emergent_bog       NA         NA      NA
## factor(year)2009:APEX_regiontower_to_old_taj         NA         NA      NA
## factor(year)2010:APEX_regiontower_to_old_taj         NA         NA      NA
## factor(year)2011:APEX_regiontower_to_old_taj         NA         NA      NA
## factor(year)2012:APEX_regiontower_to_old_taj         NA         NA      NA
## factor(year)2013:APEX_regiontower_to_old_taj         NA         NA      NA
## factor(year)2014:APEX_regiontower_to_old_taj         NA         NA      NA
## factor(year)2015:APEX_regiontower_to_old_taj         NA         NA      NA
## factor(year)2017:APEX_regiontower_to_old_taj         NA         NA      NA
## factor(year)2018:APEX_regiontower_to_old_taj    0.06186    0.08588   0.720
## factor(year)2019:APEX_regiontower_to_old_taj    0.13749    0.09514   1.445
## factor(year)2020:APEX_regiontower_to_old_taj         NA         NA      NA
## factor(year)2021:APEX_regiontower_to_old_taj    0.08809    0.08718   1.010
## factor(year)2022:APEX_regiontower_to_old_taj         NA         NA      NA
##                                                Pr(>|t|)
## (Intercept)                                     < 2e-16 ***
## factor(year)2009                                0.03799 *
## factor(year)2010                                7.89e-06 ***
## factor(year)2011                                2.87e-05 ***
## factor(year)2012                                0.00378 **
## factor(year)2013                                0.53765
## factor(year)2014                                0.50254
## factor(year)2015                                0.45520
## factor(year)2017                                0.27911
## factor(year)2018                                0.74619
## factor(year)2019                                0.37377
## factor(year)2020                                0.00460 **
## factor(year)2021                                0.00913 **
## factor(year)2022                                0.02471 *
## APEX_regionmet_station                          6.01e-12 ***
## APEX_regionNE_of_emergent_bog                   2.44e-05 ***
## APEX_regionNW_of_emergent_bog                   7.59e-05 ***
## APEX_regiontower_to_old_taj                     0.11493
## factor(year)2009:APEX_regionmet_station               NA
## factor(year)2010:APEX_regionmet_station               NA
## factor(year)2011:APEX_regionmet_station               NA
## factor(year)2012:APEX_regionmet_station               NA
## factor(year)2013:APEX_regionmet_station               NA
```

```
## factor(year)2014:APEX_regionmet_station             NA
## factor(year)2015:APEX_regionmet_station        0.01909 *
## factor(year)2017:APEX_regionmet_station       1.65e-05 ***
## factor(year)2018:APEX_regionmet_station       2.32e-12 ***
## factor(year)2019:APEX_regionmet_station       1.58e-09 ***
## factor(year)2020:APEX_regionmet_station             NA
## factor(year)2021:APEX_regionmet_station             NA
## factor(year)2022:APEX_regionmet_station             NA
## factor(year)2009:APEX_regionNE_of_emergent_bog      NA
## factor(year)2010:APEX_regionNE_of_emergent_bog      NA
## factor(year)2011:APEX_regionNE_of_emergent_bog      NA
## factor(year)2012:APEX_regionNE_of_emergent_bog      NA
## factor(year)2013:APEX_regionNE_of_emergent_bog      NA
## factor(year)2014:APEX_regionNE_of_emergent_bog      NA
## factor(year)2015:APEX_regionNE_of_emergent_bog  0.55512
## factor(year)2017:APEX_regionNE_of_emergent_bog      NA
## factor(year)2018:APEX_regionNE_of_emergent_bog  0.00106 **
## factor(year)2019:APEX_regionNE_of_emergent_bog  0.00481 **
## factor(year)2020:APEX_regionNE_of_emergent_bog 7.89e-05 ***
## factor(year)2021:APEX_regionNE_of_emergent_bog  0.58012
## factor(year)2022:APEX_regionNE_of_emergent_bog      NA
## factor(year)2009:APEX_regionNW_of_emergent_bog      NA
## factor(year)2010:APEX_regionNW_of_emergent_bog      NA
## factor(year)2011:APEX_regionNW_of_emergent_bog      NA
## factor(year)2012:APEX_regionNW_of_emergent_bog      NA
## factor(year)2013:APEX_regionNW_of_emergent_bog      NA
## factor(year)2014:APEX_regionNW_of_emergent_bog      NA
## factor(year)2015:APEX_regionNW_of_emergent_bog      NA
## factor(year)2017:APEX_regionNW_of_emergent_bog      NA
## factor(year)2018:APEX_regionNW_of_emergent_bog 1.06e-05 ***
## factor(year)2019:APEX_regionNW_of_emergent_bog 1.48e-06 ***
## factor(year)2020:APEX_regionNW_of_emergent_bog 6.87e-05 ***
## factor(year)2021:APEX_regionNW_of_emergent_bog  0.89876
## factor(year)2022:APEX_regionNW_of_emergent_bog      NA
## factor(year)2009:APEX_regiontower_to_old_taj        NA
## factor(year)2010:APEX_regiontower_to_old_taj        NA
## factor(year)2011:APEX_regiontower_to_old_taj        NA
## factor(year)2012:APEX_regiontower_to_old_taj        NA
## factor(year)2013:APEX_regiontower_to_old_taj        NA
## factor(year)2014:APEX_regiontower_to_old_taj        NA
## factor(year)2015:APEX_regiontower_to_old_taj        NA
## factor(year)2017:APEX_regiontower_to_old_taj        NA
## factor(year)2018:APEX_regiontower_to_old_taj   0.47147
## factor(year)2019:APEX_regiontower_to_old_taj   0.14866
## factor(year)2020:APEX_regiontower_to_old_taj        NA
## factor(year)2021:APEX_regiontower_to_old_taj   0.31246
## factor(year)2022:APEX_regiontower_to_old_taj        NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.04378771)
##
```

```
##     Null deviance: 112.266  on 1245  degrees of freedom
## Residual deviance:  53.071  on 1212  degrees of freedom
##   (3 observations deleted due to missingness)
## AIC: -326.47
##
## Number of Fisher Scoring iterations: 2
```

```
source("summarystats.R")
#For all regions and years
year.region.stats <- summarystats(august.on, measurevar="depth", groupvars=c("APEX_region", "yea
r"), na.rm=TRUE)
```

```
## ------------------------------------------------------------------------------
```

```
## You have loaded plyr after dplyr - this is likely to cause problems.
## If you need functions from both plyr and dplyr, please load plyr first, then dplyr:
## library(plyr); library(dplyr)
```

```
## ------------------------------------------------------------------------------
```

```
##
## Attaching package: 'plyr'
```

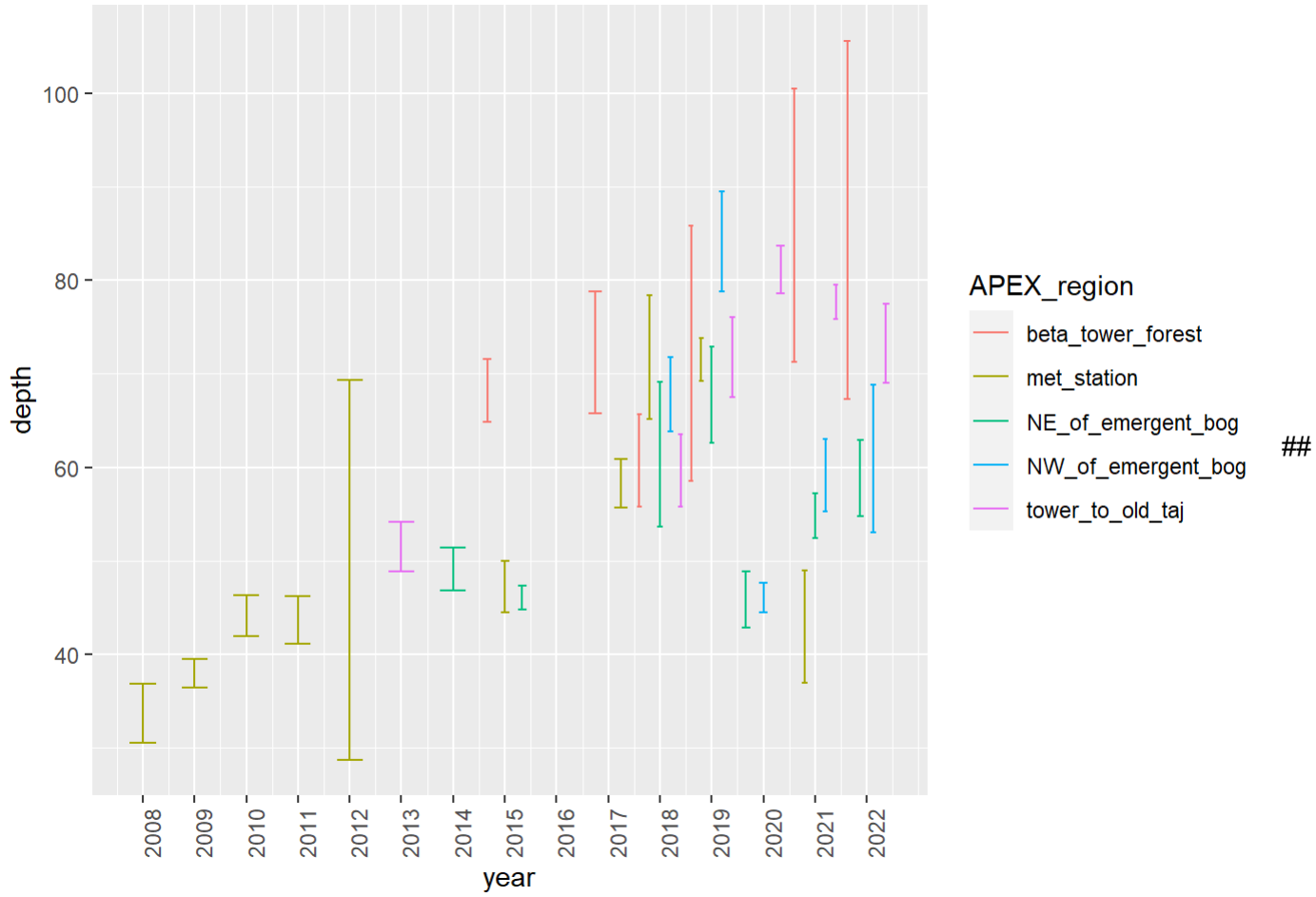
```
## The following objects are masked from 'package:dplyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize
```

```
print(year.region.stats)
```

```
##           APEX_region year   N    depth        sd        se        ci
## 1   beta_tower_forest 2015  56 68.19643 12.674125 1.6936512  3.394153
## 2   beta_tower_forest 2017  43 72.32558 21.211768 3.2347643  6.528019
## 3   beta_tower_forest 2018  25 60.72000 12.077941 2.4155883  4.985529
## 4   beta_tower_forest 2019  15 72.20000 24.678504 6.3719624 13.666500
## 5   beta_tower_forest 2021  24 85.87500 34.689069 7.0808766 14.647909
## 6   beta_tower_forest 2022  12 86.50000 30.164699 8.7077987 19.165736
## 7         met_station 2008  16 33.61250  5.941478 1.4853696  3.165990
## 8         met_station 2009  59 37.91186  5.729990 0.7459812  1.493244
## 9         met_station 2010  46 44.12609  7.389495 1.0895216  2.194409
## 10        met_station 2011  42 43.62381  8.047112 1.2416963  2.507656
## 11        met_station 2012   3 49.00000  8.185353 4.7258156 20.333544
## 12        met_station 2015  10 47.20000  3.910101 1.2364825  2.797118
## 13        met_station 2017  62 58.26613 10.431556 1.3248089  2.649119
## 14        met_station 2018  16 71.75000 12.423097 3.1057742  6.619801
## 15        met_station 2019 128 71.48438 13.152338 1.1625135  2.300404
## 16        met_station 2021   7 42.91429  6.553734 2.4770786  6.061193
## 17 NE_of_emergent_bog 2014  12 49.08333  3.591868 1.0368830  2.282164
## 18 NE_of_emergent_bog 2015  52 46.00000  4.537426 0.6292278  1.263227
## 19 NE_of_emergent_bog 2018  31 61.38710 21.024870 3.7761781  7.711985
## 20 NE_of_emergent_bog 2019  15 67.76667  9.263729 2.3918844  5.130082
## 21 NE_of_emergent_bog 2020  20 45.85000  6.425893 1.4368734  3.007411
## 22 NE_of_emergent_bog 2021  52 54.75962  8.606023 1.1934407  2.395932
## 23 NE_of_emergent_bog 2022  18 58.83333  8.161963 1.9237932  4.058849
## 24 NW_of_emergent_bog 2018  64 67.78125 15.845954 1.9807442  3.958201
## 25 NW_of_emergent_bog 2019  25 84.20000 13.038405 2.6076810  5.381989
## 26 NW_of_emergent_bog 2020  20 46.05000  3.332061 0.7450715  1.559453
## 27 NW_of_emergent_bog 2021  63 59.09524 15.356741 1.9347675  3.867545
## 28 NW_of_emergent_bog 2022  17 60.94118 15.364206 3.7263673  7.899546
## 29   tower_to_old_taj 2013  34 51.52941  7.596791 1.3028389  2.650646
## 30   tower_to_old_taj 2018  94 59.64894 18.908215 1.9502335  3.872777
## 31   tower_to_old_taj 2019  45 71.76667 14.283096 2.1291982  4.291117
## 32   tower_to_old_taj 2020  20 81.20000  5.463756 1.2217330  2.557117
## 33   tower_to_old_taj 2021  71 77.67606  7.671421 0.9104302  1.815796
## 34   tower_to_old_taj 2022  29 73.27586 11.218278 2.0831819  4.267205
```

```
write.csv(year.region.stats, "year.region.stats.csv")

plot.by.year <- ggplot(year.region.stats, aes(x=year, y=depth, color=APEX_region)) +
  geom_errorbar(aes(ymin=depth-ci, ymax=depth+ci), width=0.5, position=position_dodge(width=1))
 +
  scale_x_continuous(breaks=seq(2008, 2022, 1)) +
  theme(axis.text.x = element_text(angle = 90))
print(plot.by.year)
```

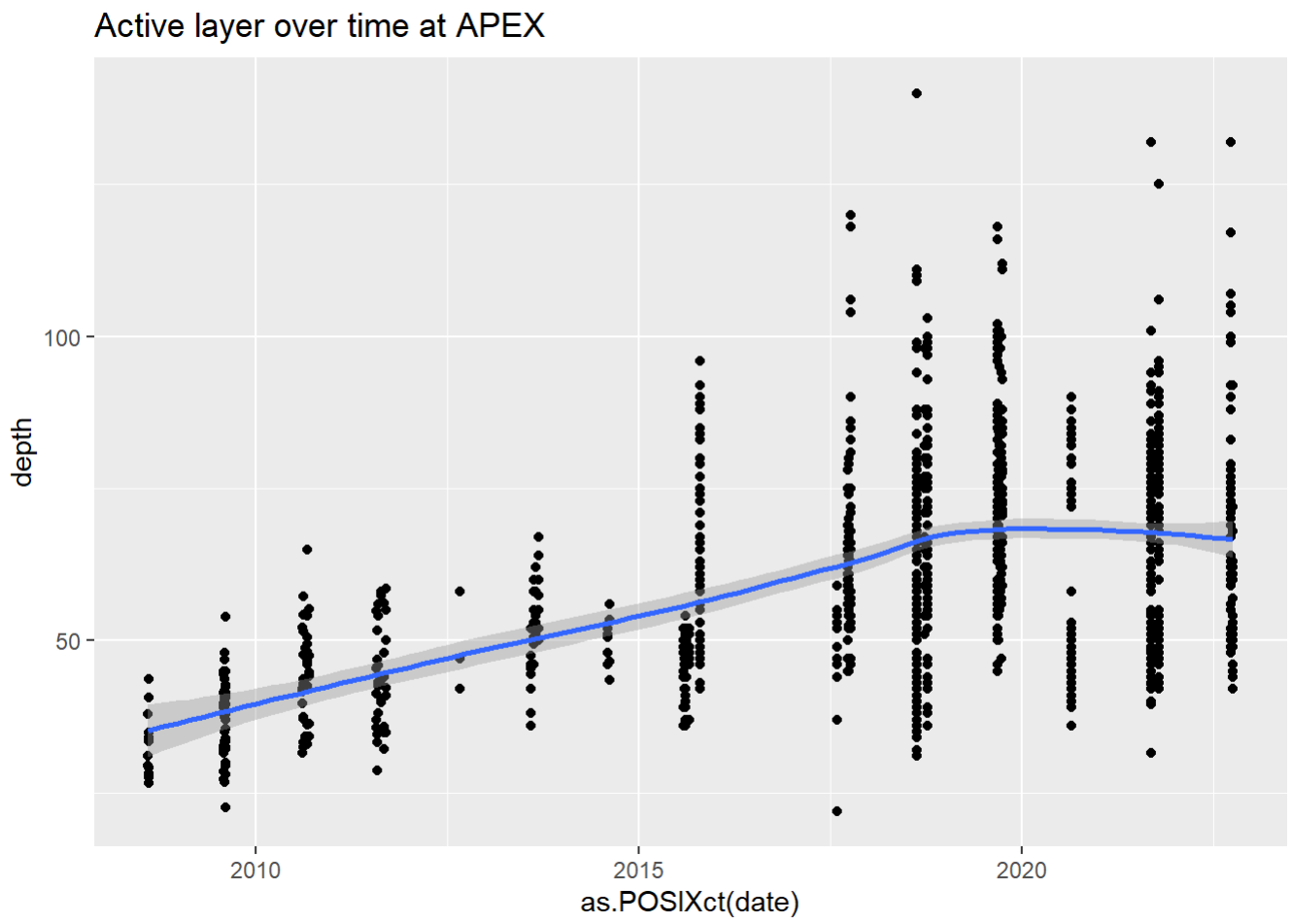


Plot all active lyear data with error

```
error.plot <- ggplot(data=august.on) +
  geom_point(aes(x = as.POSIXct(date), y = depth)) +
  geom_smooth(aes(x = as.POSIXct(date), y = depth), method = "loess", formula = y ~ x) +
  ggtitle("Active layer over time at APEX")
print(error.plot)
```

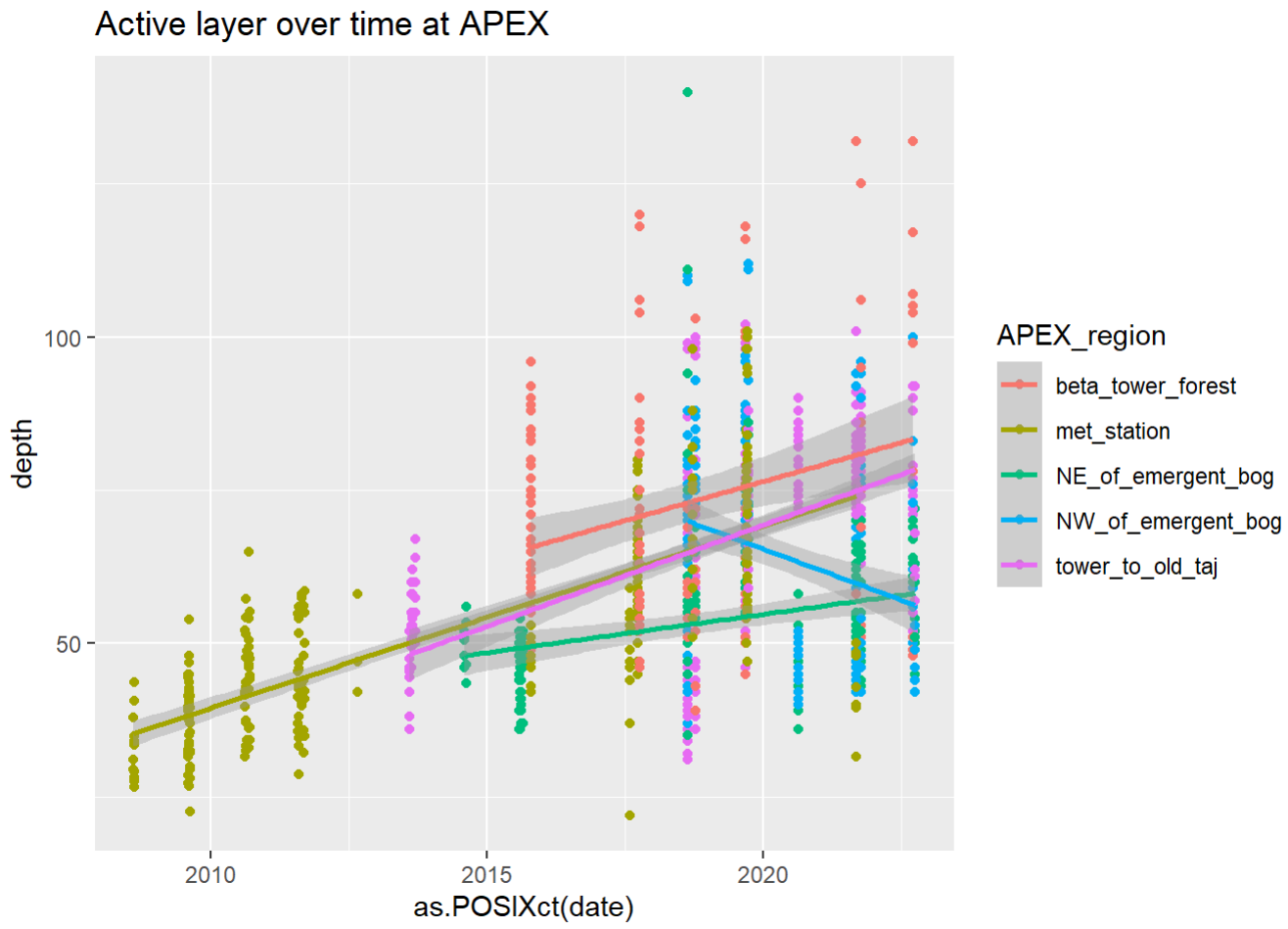
```
## Warning: Removed 3 rows containing non-finite values (`stat_smooth()`).
```

```
## Warning: Removed 3 rows containing missing values (`geom_point()`).
```




```
region.error.plot <- ggplot(data=august.on) +
  geom_point(aes(x = as.POSIXct(date), y = depth, color=APEX_region)) +
  geom_smooth(aes(x = as.POSIXct(date), y = depth, color=APEX_region), method = "lm", formula =
 y ~ x) +
  ggtitle("Active layer over time at APEX")
print(region.error.plot)
```

```
## Warning: Removed 3 rows containing non-finite values (`stat_smooth()`).
## Removed 3 rows containing missing values (`geom_point()`).
```


Active layer over time at APEX
depth
100
50
2010
2015
2020
as.POSIXct(date)
APEX_region
beta_tower_forest
met_station
NE_of_emergent_bog
NW_of_emergent_bog
tower_to_old_taj