

# SEACAR Continuous Water Quality Analysis: SE Region for Water Temperature

Last compiled on 15 May, 2023

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## Important Notes

These scripts were created by [J.E. Panzik](mailto:jepanzik@usf.edu) ([jepanzik@usf.edu](mailto:jepanzik@usf.edu)) for SEACAR.

All scripts and outputs can be found on the SEACAR GitHub repository:

[https://github.com/FloridaSEACAR/SEACAR\\_Trend\\_Analyses](https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses)

This markdown file is designed to be compiled by `SEACAR_WC_Continuous_ReportRender.R` ([https://github.com/FloridaSEACAR/SEACAR\\_Trend\\_Analyses/blob/main/Coral/SEACAR\\_WC\\_Continuous\\_ReportRender.R](https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/blob/main/Coral/SEACAR_WC_Continuous_ReportRender.R)).

## Libraries and Settings

Loads libraries used in the script. The inclusion of `scipen` option limits how frequently R defaults to scientific notation. Sets default settings for displaying warning and messages in created document, and sets figure dpi.

```
library(knitr)
library(data.table)
library(dplyr)
library(lubridate)
library(ggplot2)
library(ggpubr)
library(scales)
library(EnvStats)
library(tidyr)
library(kableExtra)
options(scipen=999)
opts_chunk$set(warning=FALSE, message=FALSE, dpi=200)
```

## File Import

Imports file that is determined in the WC\_Continuous\_parameter\_ReportCompile.R script.

The command `fread` is used because of its improved speed while handling large data files. Only columns that are used by the script are imported from the file, and are designated in the `select` input.

The script then gets the name of the parameter as it appears in the data file and units of the parameter.

The latest version of WC Continuous data is available at: <https://usf.box.com/s/7ocbmndsm5bgfz6535t8btrnj3r73ysch>

The file being used for the analysis is: **Combined\_WQ\_WC\_NUT\_cont\_Water\_Temperature\_SE-2022-Nov-16.txt**

```
data <- fread(file_in, sep="|", header=TRUE, stringsAsFactors=FALSE,
               select=c("ManagedAreaName", "ProgramID", "ProgramName",
                       "ProgramLocationID", "SampleDate", "Year", "Month",
                       "RelativeDepth", "ActivityType", "ParameterName",
                       "ParameterValue", "ParameterUnits", "ValueQualifier",
                       "SEACAR_QAQCFlagCode", "Include"),
               na.strings="")
parameter <- unique(data$ParameterName)
unit <- unique(data$ParameterUnits)
cat(paste("The data file(s) used:", file_short, sep="\n"))

## The data file(s) used:
## Combined_WQ_WC_NUT_cont_Water_Temperature_SE-2022-Nov-16.txt
```

## Data Filtering

Most data filtering is performed on export from the database, and is indicated by the `Include` variable. `Include` values of 1 indicate the data should be used for analysis, values of 0 indicate the data should not

be used for analysis. Documentation on the database filtering is provided here: [SEACAR Documentation-Analysis Filters and Calculations.pdf](#)

The filtering that is performed by the script at this point removes rows that are missing values for **ResultValue** and **RelativeDepth**, and removes any activity type that has “Blank” in the description. Data passes the filtering the process if it is has an **Include** value of 1.

Creates a variable for each **MonitoringID** which is defined as a unique combination of **ManagedAreaName**, **ProgramID**, **ProgramAreaName**, and **ProgramLocationID**.

After the initial filtering, a second filter variable is created to determine whether enough time is represented in the monitoring location, which is that each monitoring location has 5 year or more of unique year entries and have at least 2 consecutive years of observations with at least 2 repeating months for observations that pass the initial filter. If data passes the first set of filtering criteria and the time criteria, they are used in the analysis.

The function that determines whether a monitoring location has at least 2 consecutive years of observations with at least 2 repeating months takes the data, creates a list of the monitoring IDs and cycles through each monitoring ID. For each monitoring ID cycle:

1. List the unique years and put them in ascending order
2. If there are fewer than 2 unique years, skip to the next area
3. If there are 2 or more unique years, start a loop that compares adjacent year entries for the area
  - Start with the first two year entries
4. See if the year entries are subsequent years (1 year apart)
  - If not, skip to next pair of years
5. For the two years being compared, get the list of months for each
6. Compare the two lists of months to see what months are the same
  - If there are two or more months that are the same, the location passes the criteria and is stored in a variable
7. The list of IDs that pass the 2 consecutive years with at least 2 repeating months is returned and used to determine if there is sufficient data for analysis.

A data frame is created that stores summary information for each monitoring location. This information is stored and combined with the results of the Seasonal Kendall Tau analysis and export to a data file once combined.

The sufficient data qualifier is merged with the original data, and a variable **Use\_In\_Analysis** is created to indicate what data should be used.

A variable with the monitoring IDs that pass all criteria is created and stored.

```
# Converts Include to be a logical either TRUE or FALSE
data$Include <- as.logical(data$Include)
# Removes any data rows that do not have Include set to TRUE
data <- data[data$Include==TRUE,]
# Removes rows that have missing ResultValues
data <- data[!is.na(data$ResultValue),]
# Removes rows that have missing RelativeDepth
data <- data[!is.na(data$RelativeDepth),]
# Removes rows that have an ActivityType with Blank
data <- data[!grep("Blank", data$ActivityType),]
```

```

# Removes any data below threshold value of 0, or 5 for Water Temperature
if(param_name=="Water_Temperature"){
  data <- data[data$ResultValue>=-5,]
} else{
  data <- data[data$ResultValue>=0,]
}

# Gets list of managed areas for the specific region being looked at
MA_All_Region <- MA_All[MA_All$Region==region,]

# Gets AreaID for data by merging data with the managed area list for the region
data <- merge.data.frame(MA_All_Region[,c("AreaID", "ManagedAreaName")],
                         data, by="ManagedAreaName", all=TRUE)
# Creates MonitoringID to more easily cycle through monitoring locations
data <- data %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName,
           ProgramLocationID) %>%
  mutate(MonitoringID=cur_group_id())

# Creates function to checks monitoring location for at least 2 years of
# continuous consecutive data
ContinuousConsecutiveCheck <- function(con_data){
  # Gets MonitoringIDs
  IDs <- unique(con_data$MonitoringID[con_data$Include==TRUE &
                                           !is.na(con_data$Include)])
  # Loops through each MonitoringID
  for(i in 1:length(IDs)) {
    # Gets list of Years for MonitoringID
    Years <- unique(con_data$Year[con_data$MonitoringID==IDs[i] &
                                    con_data$Include==TRUE &
                                    !is.na(con_data$Include)])
    # Puts Years in order
    Years <- Years[order(Years)]
    # If there are fewer than 2 years, skip to next MonitoringID
    if(length(Years)<2) {
      next
    }
    # Starts loop to make sure there are at least 2 consecutive years with
    # consecutive months of data
    for(j in 2:length(Years)) {
      # If adjacent year entries are not 1 year apart, skip to the next set
      # of year entries
      if(Years[j]-Years[j-1] !=1) {
        next
      }
      # Gets the list of months from the first year
      Months1 <- unique(con_data$Month[con_data$MonitoringID==IDs[i] &
                                         con_data$Year==Years[j-1] &
                                         con_data$Include==TRUE &
                                         !is.na(con_data$Include)])
      # Gets list of months for the second year
      Months2 <- unique(con_data$Month[con_data$MonitoringID==IDs[i] &
                                         con_data$Year==Years[j] &
                                         con_data$Include==TRUE])
    }
  }
}

```

```

        con_data$Include==TRUE &
        !is.na(con_data$Include)])
# If there are more than 2 months shared between the two years, the
# MonitoringID passes the check and is stored
if(length(intersect(Months1, Months2))>=2) {
  # Creates variable for stored MonitoringID if it doesn't exist
  if(exists("consecutive")==FALSE){
    consecutive <- IDs[i]
    break
  } else{
    # Adds to variable for storing MonitoringID if does exist
    consecutive <- append(consecutive, IDs[i])
    break
  }
}
# After going through all MonitoringID, return variable with list of all
# that pass
return(consecutive)
}

# Stores the MonitoringID that pass the consecutive year check
consMonthIDs <- ContinuousConsecutiveCheck(data)

# Creates data frame with summary for each monitoring location.
Mon_Summ <- data %>%
  group_by(MonitoringID, AreaID, ManagedAreaName, ProgramID, ProgramName,
           ProgramLocationID) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            N_Data=length(ResultValue[Include==TRUE & !is.na(ResultValue)]),
            N_Years=length(unique(Year[Include==TRUE & !is.na(Year)])),
            EarliestYear=min(Year[Include==TRUE]),
            LatestYear=max(Year[Include==TRUE]),
            LastSampleDate=max(SampleDate[Include==TRUE]),
            ConsecutiveMonths=ifelse(unique(MonitoringID) %in%
                                      consMonthIDs==TRUE, TRUE, FALSE),
            # Determines if monitoring location is sufficient for analysis
            # based on having more than 0 data entries, more than the
            #sufficient number of year, and the consecutive month criteria
            SufficientData=ifelse(N_Data>0 & N_Years>=suff_years &
                                     ConsecutiveMonths==TRUE, TRUE, FALSE),
            Median=median(ResultValue, na.rm=TRUE))
Mon_Summ$ConsecutiveMonths <- NULL

# Puts summary data in order based on MonitoringID
Mon_Summ <- as.data.table(Mon_Summ[order(Mon_Summ$MonitoringID), ])

# Creates column in data that determines how many years from the start for each
# Monitoring location
data <- data %>%
  group_by(MonitoringID) %>%

```

```

    mutate(YearFromStart=Year-min(Year))
# Adds SufficientData column to data table based on MonitoringID
data <- merge.data.frame(data, Mon_Summ[,c("MonitoringID", "SufficientData")],
                           by="MonitoringID")
# Creates Use_In_Analysis column for data that is determined if the row has
# Include value of TRUE and SufficientData value of TRUE
data$Use_In_Analysis <- ifelse(data$Include==TRUE & data$SufficientData==TRUE,
                                 TRUE, FALSE)
# Get list of and number of MonitoringID that are to be used in analysis
Mon_IDs <- unique(data$MonitoringID[data$Use_In_Analysis==TRUE])
Mon_IDs <- Mon_IDs[order(Mon_IDs)]
n <- length(Mon_IDs)

```

## Monitoring Location Statistics

Gets summary statistics for each monitoring location. Excluded monitoring locations are not included into whether the data should be used or not. Uses piping from dplyr package to feed into subsequent steps. The following steps are performed:

1. Take the `data` variable and only include rows that have a `Use_In_Analysis` value of TRUE
2. Group data that have the same `ManagedAreaName`, `ProgramID`, `ProgramName`, `ProgramLocationID`, `Year`, and `Month`.
  - Second summary statistics consider the monitoring location grouping and `Year`.
  - Third summary statistics consider the monitoring location grouping and `Month`.
3. For each group, provide the following information: Earliest Sample Date (`EarliestSampleDate`), Latest Sample Date (`LastSampleDate`), Number of Entries (`N`), Lowest Value (`Min`), Largest Value (`Max`), Median, Mean, Standard Deviation, and a list of all Program IDs included in these measurements.
4. Sort the data in ascending (A to Z and 0 to 9) order based on `ManagedAreaName`, `ProgramID`, `ProgramName`, `ProgramLocationID`, `Year`, and `Month` in that order.
5. Write summary stats to a pipe-delimited .txt file in the output directory
  - WC Continuous Output Files in SEACAR GitHub ([https://github.com/FloridaSEACAR/SEACAR\\_Trend\\_Analyses/tree/main/WC\\_Continuous/output](https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/tree/main/WC_Continuous/output))

Because the continuous data is extensive and most measurements are taken every 15 minutes, a daily average is determined and used based on grouping `ManagedAreaName`, `ProgramID`, `ProgramName`, `ProgramLocationID`, and `SampleDate`. The new `ResultValue` is the mean of all values on that date from that specific monitoring location. Sets the `SampleDate` as a date object, and creates various scales of the date to be used by plotting functions.

```

# Create summary statistics for each monitoring location based on Year and Month
# intervals.
Mon_YM_Stats <- data[data$Use_In_Analysis==TRUE, ] %>%
  group_by(MonitoringID, AreaID, ManagedAreaName, ProgramID, ProgramName,
           ProgramLocationID, Year, Month) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            EarliestSampleDate=min(SampleDate),
            LastSampleDate=max(SampleDate), N=length(ResultValue),
            Min=min(ResultValue), Max=max(ResultValue),
            Median=median(ResultValue), Mean=mean(ResultValue),

```

```

    StandardDeviation=sd(ResultValue))
# Puts the data in order based on ManagedAreaName, ProgramID, ProgramName,
# ProgramLocationID, Year, then Month
Mon_YM_Stats <- as.data.table(Mon_YM_Stats[order(Mon_YM_Stats$ManagedAreaName,
                                                 Mon_YM_Stats$ProgramID,
                                                 Mon_YM_Stats$ProgramName,
                                                 Mon_YM_Stats$ProgramLocationID,
                                                 Mon_YM_Stats$Year,
                                                 Mon_YM_Stats$Month), ])
# Writes summary statistics to file without MonitoringID
fwrite(select(Mon_YM_Stats, -MonitoringID),
       paste0(out_dir_param, "/WC_Continuous_", param_abrev, "_", region,
              "_MonLoc_MMYY_Stats.txt"), sep="|")
# Get year from start for each monitoring location
Mon_YM_Stats <- Mon_YM_Stats %>%
  group_by(MonitoringID) %>%
  mutate(YearFromStart=Year-min(Year))
# Create decimal value of year and month values
Mon_YM_Stats$YearMonthDec <- Mon_YM_Stats$Year + ((Mon_YM_Stats$Month-0.5) / 12)

# Create summary statistics for each monitoring location based on Year
# intervals.
Mon_Y_Stats <- data[data$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Year) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            EarliestSampleDate=min(SampleDate),
            LastSampleDate=max(SampleDate), N=length(ResultValue),
            Min=min(ResultValue), Max=max(ResultValue),
            Median=median(ResultValue), Mean=mean(ResultValue),
            StandardDeviation=sd(ResultValue))
# Puts the data in order based on ManagedAreaName, ProgramID, ProgramName,
# ProgramLocationID, then Year
Mon_Y_Stats <- as.data.table(Mon_Y_Stats[order(Mon_Y_Stats$ManagedAreaName,
                                                Mon_Y_Stats$ProgramID,
                                                Mon_Y_Stats$ProgramName,
                                                Mon_Y_Stats$ProgramLocationID,
                                                Mon_Y_Stats$Year), ])
# Writes summary statistics to file
fwrite(Mon_Y_Stats, paste0(out_dir_param, "/WC_Continuous_", param_abrev, "_",
                           region, "_MonLoc_Yr_Stats.txt"), sep="|")

# Create summary statistics for each monitoring location based on Month
# intervals.
Mon_M_Stats <- data[data$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Month) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            EarliestSampleDate=min(SampleDate),
            LastSampleDate=max(SampleDate), N=length(ResultValue),
            Min=min(ResultValue), Max=max(ResultValue),
            StandardDeviation=sd(ResultValue))

```

```

    Median=median(ResultValue), Mean=mean(ResultValue),
    StandardDeviation=sd(ResultValue))
# Puts the data in order based on ManagedAreaName, ProgramID, ProgramName,
# ProgramLocationID, then Month
Mon_M_Stats <- as.data.table(Mon_M_Stats[order(Mon_M_Stats$ManagedAreaName,
                                                 Mon_M_Stats$ProgramID,
                                                 Mon_M_Stats$ProgramName,
                                                 Mon_M_Stats$ProgramLocationID,
                                                 Mon_M_Stats$Month), ])
# Writes summary statistics to file
fwrite(Mon_M_Stats, paste0(out_dir_param, "/WC_Continuous_", param_abrev, "_",
                           region, "_MonLoc_Mo_Stats.txt"), sep="|")
# Reduces size of data by getting a daily average
data <- data %>%
  group_by(MonitoringID, AreaID, ManagedAreaName, ProgramID, ProgramName,
           ProgramLocationID, SampleDate) %>%
  summarise(Year=unique(Year), Month=unique(Month),
            RelativeDepth=unique(RelativeDepth),
            ResultValue=mean(ResultValue), Include=unique(Include),
            Use_In_Analysis=unique(Use_In_Analysis))
# Sets column formats to appropriate types
data$SampleDate <- as.Date(data$SampleDate)
data$YearMonth <- format(data$SampleDate, format = "%m-%Y")
data$YearMonthDec <- data$Year + ((data$Month-0.5) / 12)
data$DecDate <- decimal_date(data$SampleDate)

```

## Seasonal Kendall Tau Analysis

Gets seasonal Kendall Tau statistics using the `kendallSeasonalTrendTest` from the `EnvStats` package. The `Trend` parameter is determined from a user-defined function based on the median, Senn slope, and p values from the data. Analysis modified from that performed at The Water Atlas: <https://sarasota.wateratlas.usf.edu/water-quality-trends/#analysis-overview>

The following steps are performed:

1. Define the trend function.
2. Take the `data` variable and only include rows that have a `Use_In_Analysis` value of TRUE
3. Group data that have the same `ManagedAreaName`, `ProgramID`, `ProgramName`, and `ProgramLocationID`.
4. For each group, provides the following information: Earliest Sample Date (`EarliestSampleDate`), Latest Sample Date (`LastSampleDate`), Number of Entries (`N`), Lowest Value (`Min`), Largest Value (`Max`), Median, Mean, Standard Deviation,
5. For each group, a temporary variable is created to run the `kendallSeasonalTrendTest` function using the `Year` values for year, and `Month` as the seasonal qualifier, and `Trend`.
  - An `independent.obs` value of TRUE indicates that the data should be treated as not being serially auto-correlated. An `independent.obs` value of FALSE indicates that it is treated as being serially auto-correlated, but also requires one observation per season per year for the full time of observation.
  - `tau`, Senn Slope (`SennSlope`), Senn Intercept (`SennIntercept`), and `p` are extracted from the model results.

6. The two stats tables are merged based on similar groups, and then Trend is determined from the user-defined function.
7. Write summary stats to a pipe-delimited .txt file in the output directory
  - WC Continuous Output Files in SEACAR GitHub ([https://github.com/FloridaSEACAR/SEACAR\\_Trend\\_Analyses/tree/main/WC\\_Continuous/output](https://github.com/FloridaSEACAR/SEACAR_Trend_Analyses/tree/main/WC_Continuous/output))

After the analysis is performed, a variable is created that stores the x & y coordinates of the SKT trend line to be used for plotting

```
# Creates function to get the Kendall Tau statistics
tauSeasonal <- function(dat, independent, stats.median, stats.minYear,
                         stats.maxYear) {
  tau <- NULL
  # Stores results from seasonal Kendall Tau
  tryCatch({ken <- kendallSeasonalTrendTest(
    y=dat$Mean,
    season=dat$Month,
    year=dat$YearFromStart,
    independent.obs=independent)
  # Gets the values of interest from the trend fit
  tau <- ken$estimate[1]
  p <- ken$p.value[2]
  slope <- ken$estimate[2]
  intercept <- ken$estimate[3]
  chi_sq <- ken$statistic[1]
  p_chi_sq <- ken$p.value[1]
  trend <- trend_calculator(slope, stats.median, p)
  rm(ken)
  # Prints warnings if a fit does not exist and stores values as NA
  }, warning=function(w) {
    print(w)
  }, error=function(e) {
    print(e)
  }, finally={
    if (!exists("tau")) {
      tau <- NA
    }
    if (!exists("p")) {
      p <- NA
    }
    if (!exists("slope")) {
      slope <- NA
    }
    if (!exists("intercept")) {
      intercept <- NA
    }
    if (!exists("trend")) {
      trend <- NA
    }
  })
  # Puts variables in a vector for the monitoring location currently being
  # analyzed
```

```

KT <- c(unique(dat$MonitoringID),
        independent,
        tau,
        p,
        slope,
        intercept,
        chi_sq,
        p_chi_sq,
        trend)
# Returns the fit parameters
return(KT)
}

# Function that determines statistics from data
runStats <- function(dat, med, minYr, maxYr) {
  #dat$Index <- as.Date(dat$SampleDate) # , "%Y-%m-%d")
  dat$Mean <- as.numeric(dat$Mean)
  # Calculate basic stats
  stats.median <- med
  stats.minYear <- minYr
  stats.maxYear <- maxYr
  # Calculate Kendall Tau and Slope stats assuming they are serially
  # independent, then store in variable
  KT <- tauSeasonal(dat, TRUE, stats.median,
                     stats.minYear, stats.maxYear)
  # If variable returned is empty, run again assuming they are NOT serially
  # independent
  if (is.null(KT[8])) {
    KT <- tauSeasonal(dat, FALSE, stats.median,
                      stats.minYear, stats.maxYear)
  }
  # If KT.Stats does not exist, create it and store values
  if (is.null(KT.Stats)==TRUE) {
    KT.Stats <- KT
    # If KT.Stats does exist, add values to it
  } else{
    KT.Stats <- rbind(KT.Stats, KT)
  }
  return(KT.Stats)
}

# Function to determine trend of Kendal Tau
trend_calculator <- function(slope, median_value, p) {
  # Trend depends on series of conditions
  trend <-
  # If the p value is less than 5% and the slope is greater than 10% of the
  # median value, the trend is large (2).
  if (p < .05 & abs(slope) > abs(median_value) / 10.) {
    if (slope > 0) {
      2
    }
    else {
      -2
    }
  }
}

```

```

# If the p value is less than 5% and the slope is less than 10% of the
# median value, there is a trend (1).
else if (p < .05 & abs(slope) < abs(median_value) / 10.) {
  if (slope > 0) {
    1
  }
  else {
    -1
  }
}
# Otherwise, there is no trend (0)
else
  0
return(trend)
}

KT.Stats <- NULL
# List for column names
c_names <- c("MonitoringID", "Independent", "tau", "p",
            "SennSlope", "SennIntercept", "ChiSquared", "pChiSquared", "Trend")
# Determines if there are any monitoring locations to analyze
if(n==0){
  # Creates data frame to store analysis values in
  KT.Stats <- data.frame(matrix(ncol=length(c_names),
                                 nrow=nrow(Mon_Summ)))
  colnames(KT.Stats) <- c_names
  KT.Stats[, c("MonitoringID")] <- Mon_Summ[, c("MonitoringID")]
} else{
  # Starts cycling through Monitoring locations to determine seasonal
  # Kendall Tau
  for (i in 1:n) {
    # Gets the number of rows of data for the monitoring location
    x <- nrow(Mon_YM_Stats[Mon_YM_Stats$MonitoringID==Mon_IDs[i], ])
    # Perform analysis if there is more than 1 row
    if (x>0) {
      # Store the monitoring location summary statistics to be used in
      # trend analysis
      SKT.med <- Mon_Summ$Median[Mon_Summ$MonitoringID==Mon_IDs[i]]
      SKT.minYr <- Mon_Summ$EarliestYear[Mon_Summ$MonitoringID==Mon_IDs[i]]
      SKT.maxYr <- Mon_Summ$LatestYear[Mon_Summ$MonitoringID==Mon_IDs[i]]

      # Get seasonal Kendall Tau statistics by running data for monitoring
      # location through the functions
      KT.Stats <- runStats(Mon_YM_Stats[Mon_YM_Stats$MonitoringID==
                                              Mon_IDs[i], ],
                            SKT.med, SKT.minYr, SKT.maxYr)
    }
  }

  # Stores as data frame
  KT.Stats <- as.data.frame(KT.Stats)

  # If there was only one location, it is stored as a column vector. Change to

```

```

# row vector
if(dim(KT.Stats)[2]==1){
  KT.Stats <- as.data.frame(t(KT.Stats))
}
# Sets column and row names for KT.Stats
colnames(KT.Stats) <- c_names
rownames(KT.Stats) <- seq(1:nrow(KT.Stats))
# Sets variables to proper format and rounds values if necessary
KT.Stats$tau <- round(as.numeric(KT.Stats$tau), digits=4)
KT.Stats$p <- round(as.numeric(KT.Stats$p), digits=4)
KT.Stats$SennSlope <- as.numeric(KT.Stats$SennSlope)
KT.Stats$SennIntercept <- as.numeric(KT.Stats$SennIntercept)
KT.Stats$ChiSquared <- round(as.numeric(KT.Stats$ChiSquared), digits=4)
KT.Stats$pChiSquared <- round(as.numeric(KT.Stats$pChiSquared), digits=4)
KT.Stats$Trend <- as.integer(KT.Stats$Trend)
}

# Combines the KT.Stats with Mon_Summ
KT.Stats <- merge.data.frame(Mon_Summ, KT.Stats,
                             by=c("MonitoringID"), all=TRUE)

KT.Stats <- as.data.table(KT.Stats[order(KT.Stats$MonitoringID), ])

# Writes combined statistics to file
fwrite(select(KT.Stats, -MonitoringID), paste0(out_dir_param, "/WC_Continuous_",
                                                param_abrev, "_", region,
                                                "_KendallTau_Stats.txt"),
       sep=" | ")

#KT.Stats$MonitoringID <- Mon_Summ$MonitoringID
data <- data[!is.na(data$ResultValue),]

# Gets x and y values for starting point for trendline
KT.Plot <- KT.Stats %>%
  group_by(MonitoringID) %>%
  summarize(x=EarliestYear,
            y=SennIntercept)
# Gets x and y values for ending point for trendline
KT.Plot2 <- KT.Stats %>%
  group_by(MonitoringID) %>%
  summarize(x=decimal_date(LastSampleDate),
            y=(x-EarliestYear)*SennSlope+SennIntercept)
# Combines the starting and endpoints for plotting the trendline
KT.Plot <- bind_rows(KT.Plot, KT.Plot2)
rm(KT.Plot2)
KT.Plot <- as.data.table(KT.Plot[order(KT.Plot$MonitoringID), ])
KT.Plot <- KT.Plot[!is.na(KT.Plot$y), ]

```

## Appendix I: Dataset Summary Box Plots

Box plots are created by using the entire data set and excludes any data that has been previously filtered out. The scripts that create plots follow this format

1. Use the data set that only has `Use_In_Analysis` of TRUE
2. Set what values are to be used for the x-axis, y-axis, and the variable that should determine groups for the box plots
3. Set the plot type as a box plot with the size of the outlier points
4. Create the title, x-axis, y-axis, and color fill labels
5. Set the y and x limits
6. Make the axis labels bold
7. Plot the arrangement as a set of panels

This set of box plots are grouped by year.

```
# Defines standard plot theme: black and white, no major or minor grid lines,
# Arial font. Title is centered, size 12, and blue (hex coded). Subtitle is
# centered, size 10, and blue (hex coded). Legend title is size 10 and the
# legend is left-justified. X-axis title is size 10 and the margins are padded
# at the top and bottom to give more space for angled axis labels. Y-axis title
# is size 10 and margins are padded on the right side to give more space for
# axis labels. Axis labels are size 10 and the x-axis labels are rotated -45
# degrees with a horizontal justification that aligns them with the tick mark
plot_theme <- theme_bw() +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        text=element_text(family="Arial"),
        plot.title=element_text(hjust=0.5, size=12, color="#314963"),
        plot.subtitle=element_text(hjust=0.5, size=10, color="#314963"),
        legend.title=element_text(size=10),
        legend.text.align = 0,
        axis.title.x = element_text(size=10, margin = margin(t = 5, r = 0,
                                                       b = 10, l = 0)),
        axis.title.y = element_text(size=10, margin = margin(t = 0, r = 10,
                                                       b = 0, l = 0)),
        axis.text=element_text(size=10),
        axis.text.x=element_text(angle = -45, hjust = 0))
# Get minimum, mean, and standard deviation of the data
min_RV <- min(data$ResultValue[data$Include==TRUE])
mn_RV <- mean(data$ResultValue[data$Include==TRUE &
                                data$ResultValue <
                                  quantile(data$ResultValue, 0.98)])
sd_RV <- sd(data$ResultValue[data$Include==TRUE &
                                data$ResultValue <
                                  quantile(data$ResultValue, 0.98)])
# Sets y scale based on data
y_scale <- mn_RV + 4 * sd_RV

# Create plot object for auto-scaled y-axis plot
p1 <- ggplot(data=data[data$Include==TRUE], ,
              aes(x=SampleDate, y=ResultValue, group=Year)) +
  geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
               outlier.size=3, outlier.color="#333333",
               outlier.fill="#cccccc", outlier.alpha=0.75) +
  labs(subtitle="Autoscale", x="Year",
       y=paste0("Values (", unit, ")")) +
  plot_theme
# Create plot object for y-axis scaled plot
```

```

p2 <- ggplot(data=data[data$Include==TRUE, ],
             aes(x=SampleDate, y=ResultValue, group=Year)) +
  geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
               outlier.size=3, outlier.color="#333333",
               outlier.fill="#cccccc", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation", x="Year",
       y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  plot_theme

# Create plot object for y-axis scaled plot for past 10 years
p3 <- ggplot(data=data[data$Include==TRUE, ],
             aes(x=Year, y=ResultValue, group=Year)) +
  geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
               outlier.size=3, outlier.color="#333333",
               outlier.fill="#cccccc", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation, Last 10 Years",
       x="Year", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  scale_x_continuous(limits=c(max(data$Year) - 10.5, max(data$Year)+0.5),
                     breaks=seq(max(data$Year) - 10, max(data$Year), 2)) +
  plot_theme

# Arrange plot objects
set <- ggarrange(p1, p2, p3, ncol=1)

# Create title object for plots
p0 <- ggplot() + labs(title="Summary Box Plots for Entire Data",
                       subtitle="By Year") + plot_theme +
  theme(panel.border=element_blank(), panel.grid.major=element_blank(),
        panel.grid.minor=element_blank(), axis.line=element_blank())

# Arrange title on plots
Yset <- ggarrange(p0, set, ncol=1, heights=c(0.07, 1))

```

This set of box plots are grouped by year and month with the color being related to the month.

```

# Create plot object for auto-scaled y-axis plot
p1 <- ggplot(data=data[data$Include==TRUE, ],
             aes(x=YearMonthDec, y=ResultValue,
                 group=YearMonth, color=as.factor(Month))) +
  geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
  labs(subtitle="Autoscale", x="Year",
       y=paste0("Values (", unit, ")"), color="Month") +
  plot_theme +
  theme(legend.position="top", legend.box="horizontal") +
  guides(color=guide_legend(nrow=1))

# Create plot object for y-axis scaled plot
p2 <- ggplot(data=data[data$Include==TRUE, ],
             aes(x=YearMonthDec, y=ResultValue,
                 group=YearMonth, color=as.factor(Month))) +
  geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
  labs(subtitle="Scaled to 5x Standard Deviation",
       x="Year", y=paste0("Values (", unit, ")"))

```

```

    ylim(0, y_scale) +
    plot_theme +
    theme(legend.position="none")
# Create plot object for y-axis scaled plot for past 10 years
p3 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=YearMonthDec, y=ResultValue,
                  group=YearMonth, color=as.factor(Month))) +
  geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
  labs(subtitle="Scaled to 5x Standard Deviation, Last 10 Years",
       x="Year", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  scale_x_continuous(limits=c(max(data$Year) - 10.5, max(data$Year)+0.5),
                     breaks=seq(max(data$Year) - 10, max(data$Year), 2)) +
  plot_theme +
  theme(legend.position="none")
# Create legend item
leg <- get_legend(p1)
# Arrange plots and legend
set <- ggarrange(leg, p1 + theme(legend.position="none"), p2, p3, ncol=1,
                 heights=c(0.1, 1, 1, 1))
# Create plot title object
p0 <- ggplot() + labs(title="Summary Box Plots for Entire Data",
                       subtitle="By Year & Month") + plot_theme +
  theme(panel.border=element_blank(), panel.grid.major=element_blank(),
        panel.grid.minor=element_blank(), axis.line=element_blank())
# Arrange plots and title
YMset <- ggarrange(p0, set, ncol=1, heights=c(0.07, 1))

```

The following box plots are grouped by month with fill color being related to the month. This is designed to view potential seasonal trends.

```

# Create plot object for auto-scaled y-axis plot
p1 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Autoscale", x="Month",
       y=paste0("Values (", unit, ")"), fill="Month") +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="top", legend.box="horizontal") +
  guides(fill=guide_legend(nrow=1))
# Create plot object for y-axis scaled plot
p2 <- ggplot(data=data[data$Include==TRUE, ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 5x Standard Deviation",
       x="Month", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +

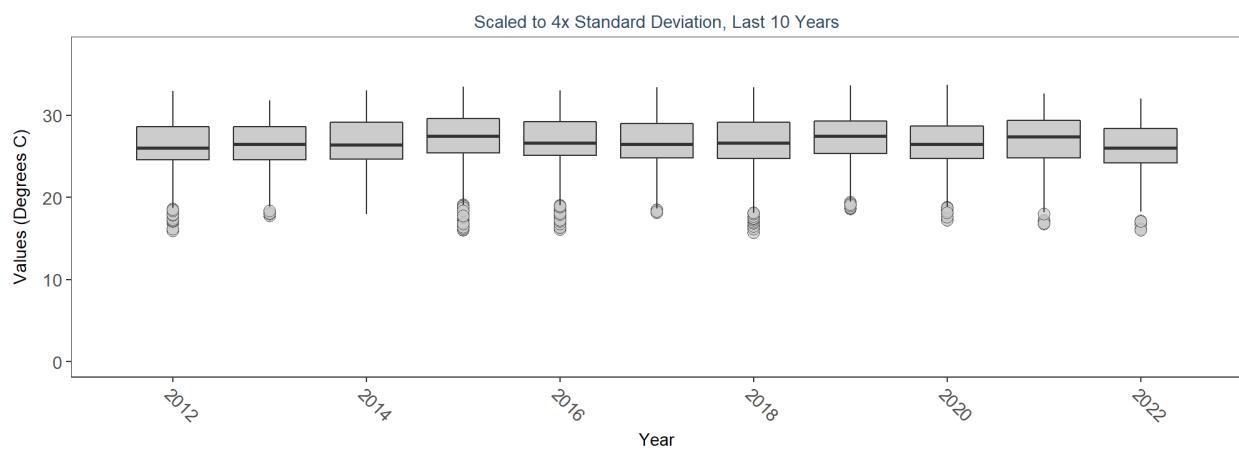
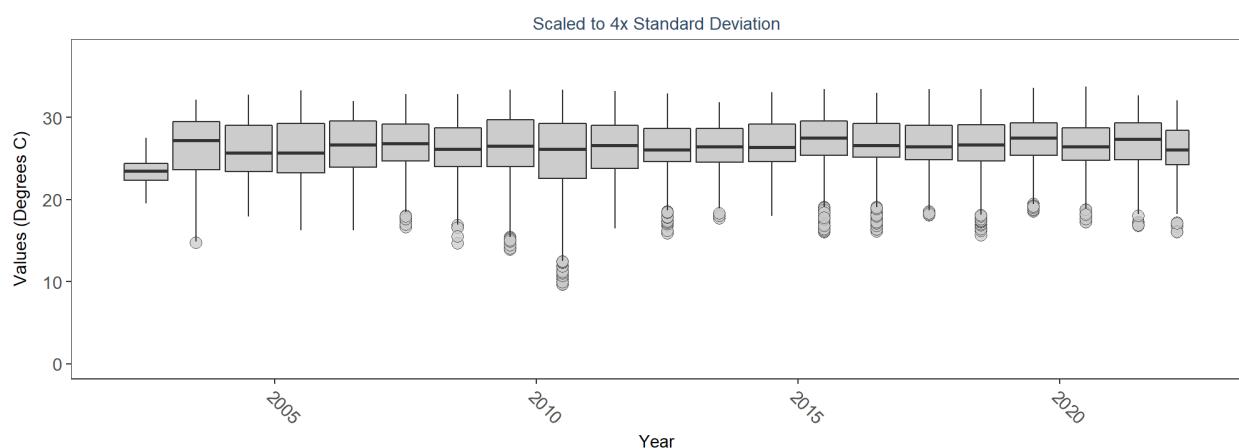
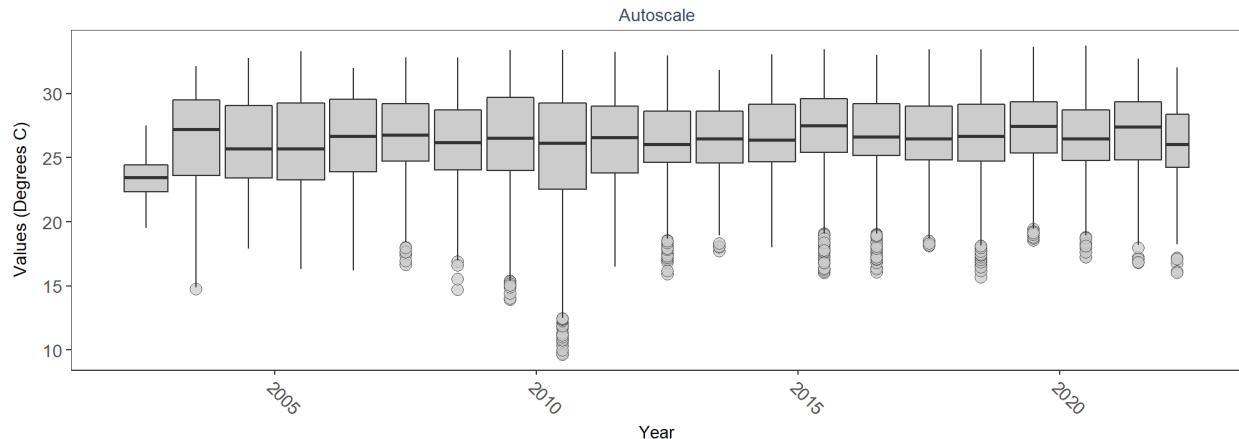
```

```

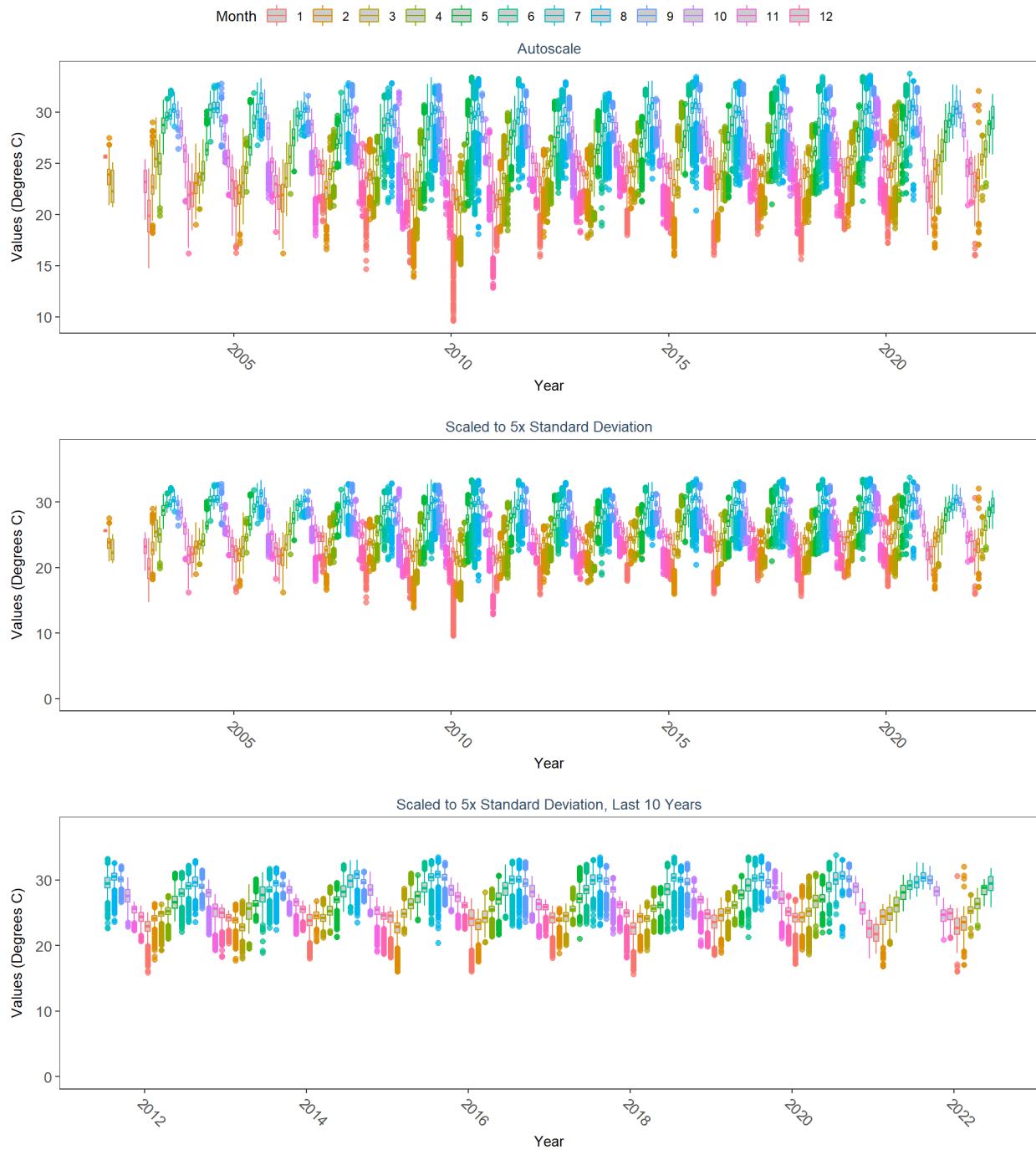
plot_theme +
  theme(legend.position="none")
# Create plot object for y-axis scaled plot for past 10 years
p3 <- ggplot(data=data[data$Include==TRUE &
                        data$Year >= max(data$Year) - 10, ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 5x Standard Deviation, Last 10 Years",
       x="Month", y=paste0("Values (", unit, ")")) +
  ylim(0, y_scale) +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="none")
# Create legend object
leg <- get_legend(p1)
# Arrange plots and legend
set <- ggarrange(leg, p1 + theme(legend.position="none"), p2, p3, ncol=1,
                 heights=c(0.1, 1, 1, 1))
# Create title object for plots
p0 <- ggplot() + labs(title="Summary Box Plots for Entire Data",
                       subtitle="By Month") + plot_theme +
  theme(panel.border=element_blank(), panel.grid.major=element_blank(),
        panel.grid.minor=element_blank(), axis.line=element_blank())
# Arrange plots and title
Mset <- ggarrange(p0, set, ncol=1, heights=c(0.07, 1))

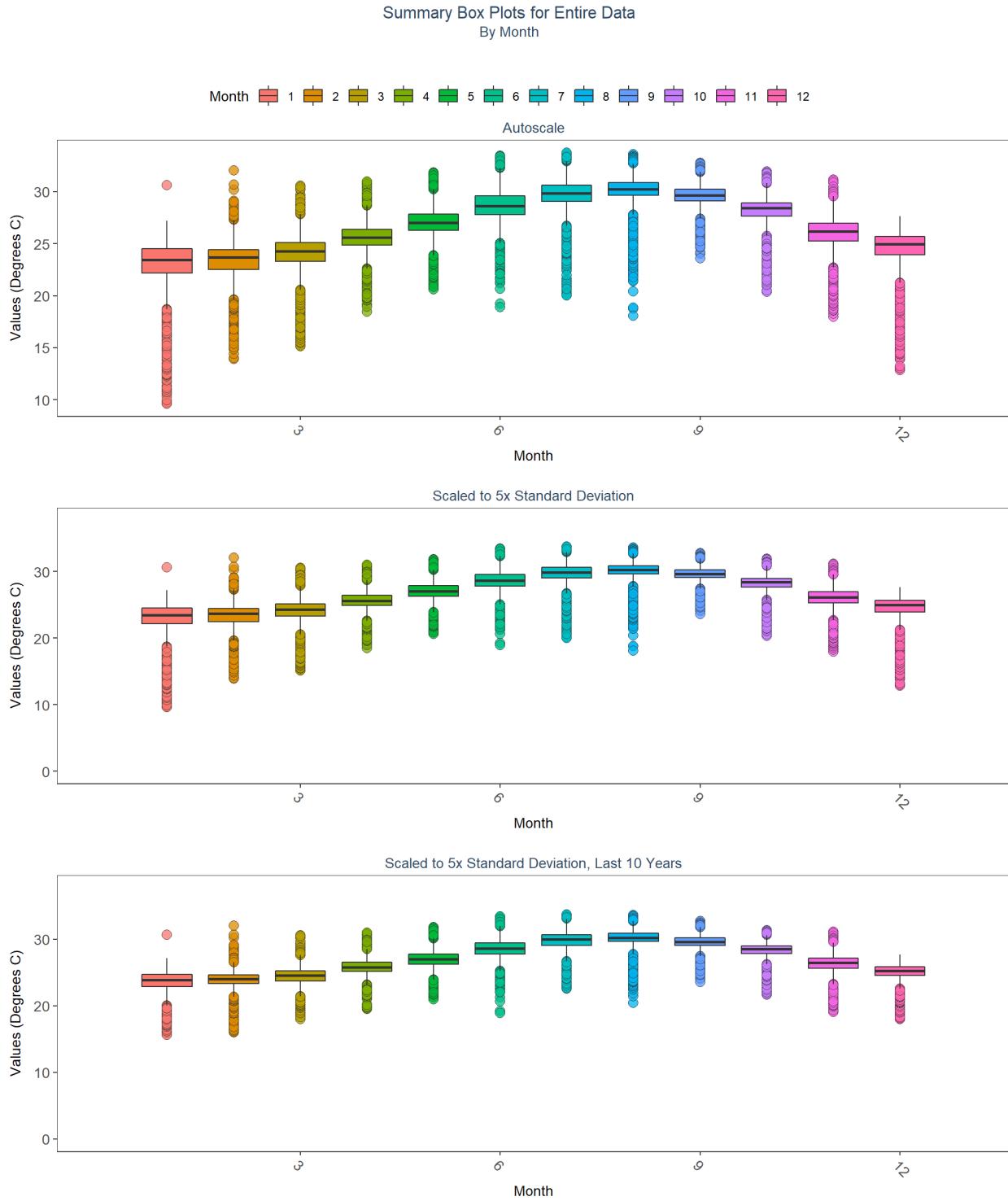
```

Summary Box Plots for Entire Data  
By Year



Summary Box Plots for Entire Data  
By Year & Month





## Appendix II: Monitoring Location Trendlines

The plots created in this section are designed to show the general trend of the data. Data is taken and grouped by **MonitoringID**. The trendlines on the plots are created using the Senn slope and intercept from

the seasonal Kendall Tau analysis. The scripts that create plots follow this format

1. Use the averages that have been aggregated by year and month for the desired monitoring location
2. Determine the earliest and latest year of the data to create x-axis scale and intervals
3. Determine the x-axis scale
4. Set the plot type as a line and point plot with the specifics of each
5. Add the linear trend determined from the seasonal Kendall Tau slope and intercept
6. Create the title, x-axis, y-axis, and labels
7. Set the y and x limits
8. Apply the plot theme
9. Set the SKT analysis results as a table figure
10. Combine the plot and table to be displayed together

```
# Determines whether analyzed monitoring locations exist. If they do, begins
# looping through them
if(n==0){
  print("There are no monitoring locations that qualify.")
} else {
  # Begins looping through each monitoring location
  for (i in 1:n) {
    # Gets data to be used in plot for monitoring location
    plot_data <- Mon_YM_Stats[Mon_YM_Stats$MonitoringID==Mon_IDs[i],]
    # Gets trendline data for monitoring location
    KT.plot_data <- KT.Plot[KT.Plot$MonitoringID==Mon_IDs[i],]
    #Determine max and min time (Year) for plot x-axis
    t_min <- min(plot_data$Year)
    t_max <- max(plot_data$YearMonthDec)
    t_max_brk <- as.integer(round(t_max, 0))
    t <- t_max-t_min
    min_RV <- min(plot_data$Mean)

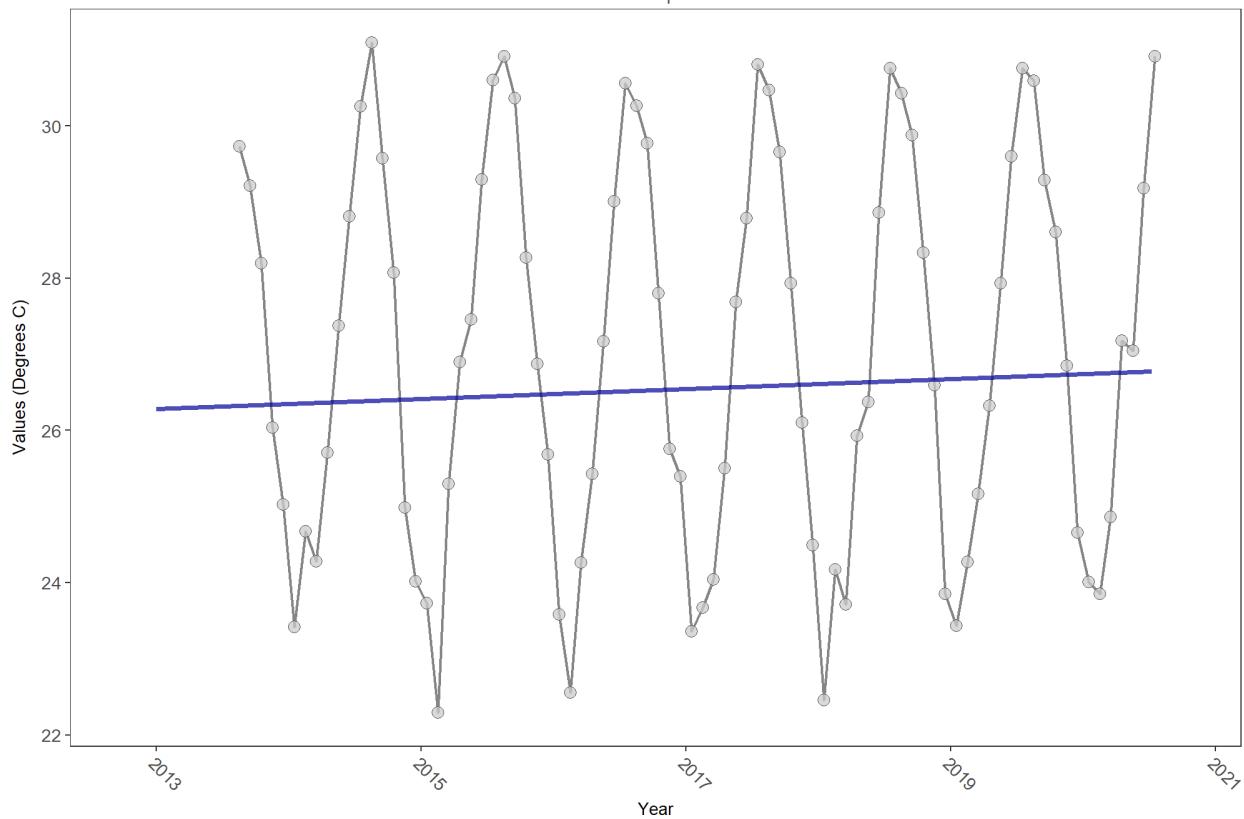
    # Sets break intervals based on the number of years spanned by data
    if(t>=30){
      brk <- -10
    }else if(t<30 & t>=10){
      brk <- -5
    }else if(t<10 & t>=4){
      brk <- -2
    }else if(t<4){
      brk <- -1
    }
    # Get name of managed area
    MA_name <- KT.Stats$ManagedAreaName[KT.Stats$MonitoringID==Mon_IDs[i]]
    # Get program location name
    Mon_name <- paste0(KT.Stats$ProgramID[KT.Stats$MonitoringID==Mon_IDs[i]],
                        "\n",
                        KT.Stats$ProgramName[KT.Stats$MonitoringID==Mon_IDs[i]], "\n",
                        KT.Stats$ProgramLocationID[KT.Stats$MonitoringID==Mon_IDs[i]])
    # Create plot object with data and trendline
    p1 <- ggplot(data=plot_data,
                  aes(x=YearMonthDec, y=Mean)) +
      geom_line(size=0.75, color="#333333", alpha=0.6) +
      geom_point(shape=21, size=3, color="#333333", fill="#cccccc",
                 alpha=0.75) +
      geom_line(data=KT.plot_data, aes(x=x, y=y),
```

```

            color="#000099", size=1.2, alpha=0.7) +
  labs(title=paste0(MA_name, "\n", Mon_name),
       subtitle=parameter,
       x="Year", y=paste0("Values (", unit, ")"))
  scale_x_continuous(limits=c(t_min-0.25, t_max+0.25),
                     breaks=seq(t_max_brk, t_min, brk)) +
  plot_theme

# Creates ResultTable to display statistics below plot
ResultTable <- KT.Stats[KT.Stats$MonitoringID==Mon_IDs[i], ] %>%
  select(RelativeDepth, N_Data, N_Years, Median, Independent, tau, p,
         SennSlope, SennIntercept, ChiSquared, pChiSquared, Trend)
# Create table object
t1 <- ggtexttable(ResultTable, rows=NULL,
                   theme=ttheme(base_size=10)) %>%
  tab_add_footnote(text="p < 0.00005 appear as 0 due to rounding.\n"
                    "SennIntercept is intercept value at beginning of\n"
                    "record for monitoring location",
                    size=10, face="italic")
# Arrange and display plot and statistic table
print(ggarrange(p1, t1, ncol=1, heights=c(0.85, 0.15)))
cat('\n \n \n')
rm(plot_data)
rm(KTset, leg)
rm(plot_data)
rm(KTset, leg)
}
}
}
```

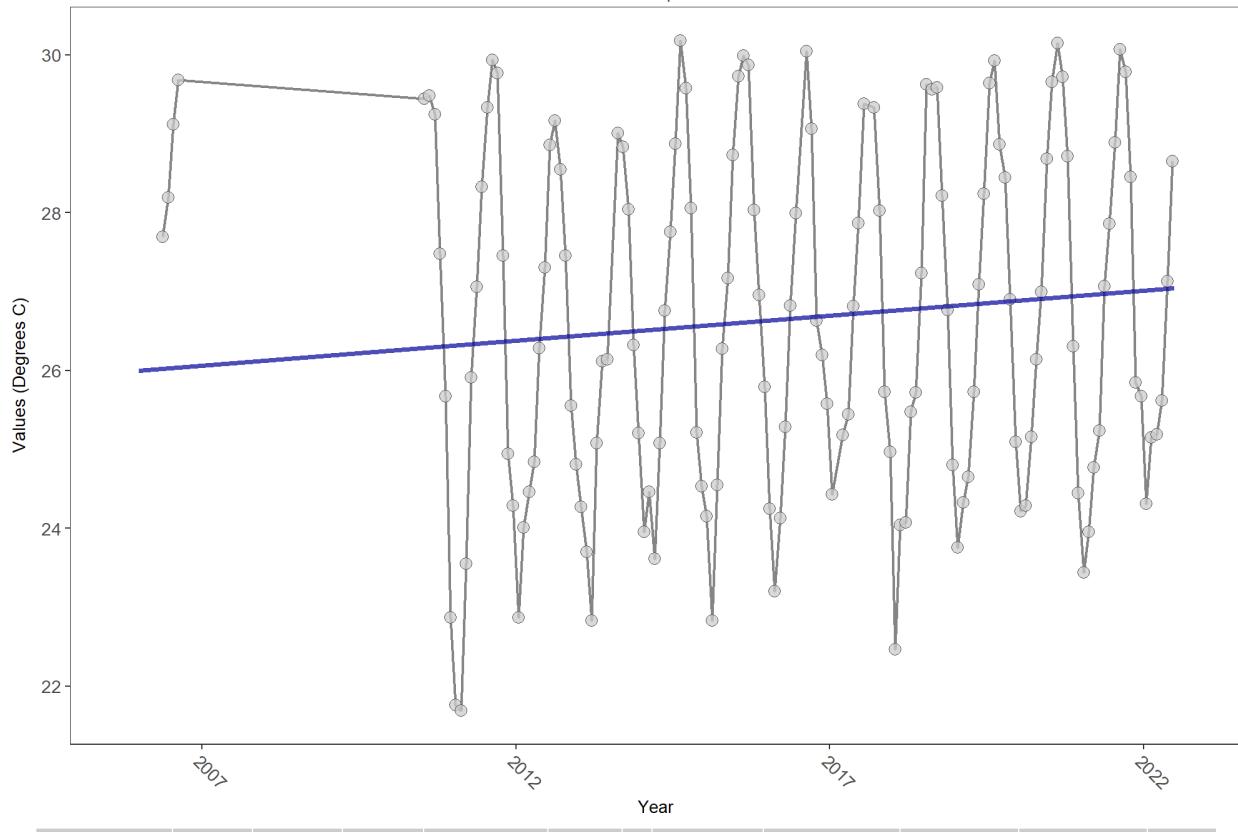
Biscayne Bay-Cape Florida to Monroe County Line Aquatic Preserve  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 6  
 Water Temperature



$p < 0.00005$  appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

Southeast Florida Coral Reef Ecosystem Conservation Area  
 5  
 National Data Buoy Center  
 LKWF1  
 Water Temperature

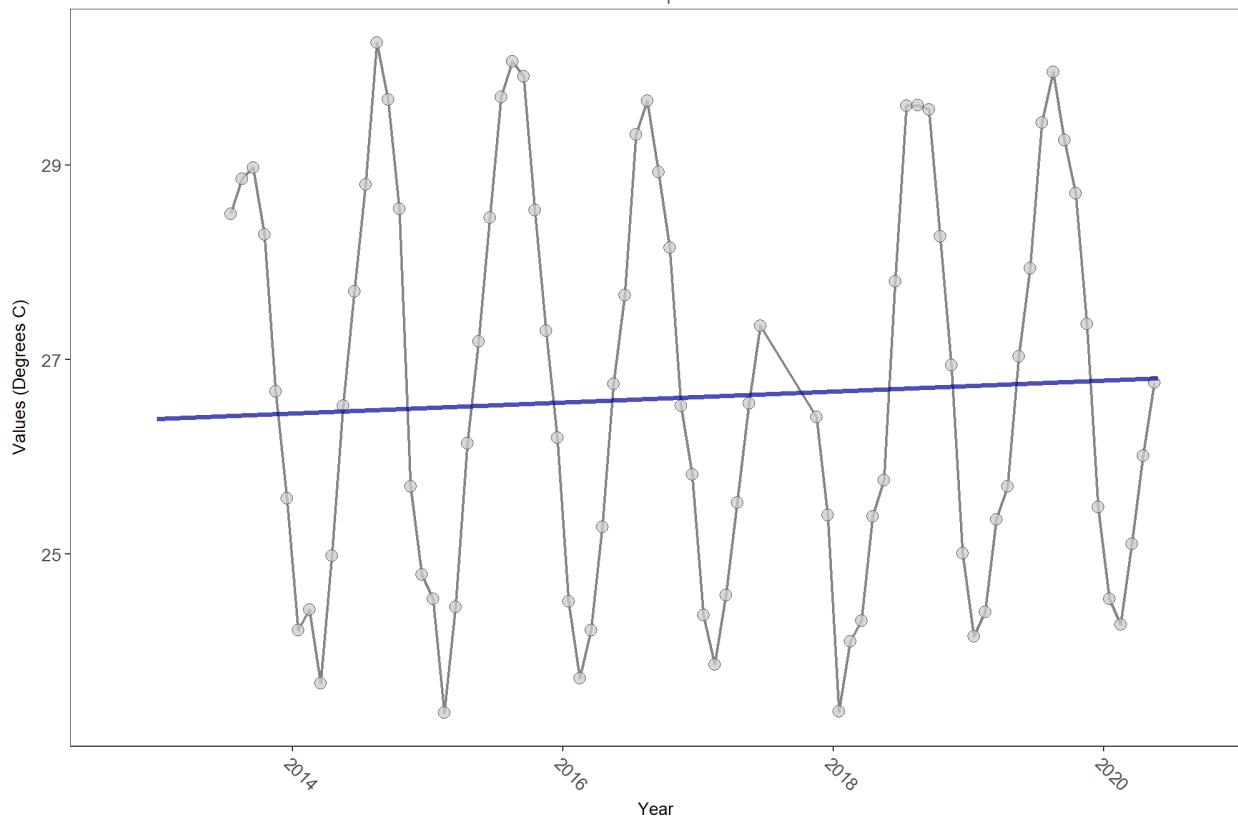


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
surface	932959	14	26.4	1	0.3234	0	0.0632213	26.00088	4.8299	0.9391	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 1  
 Water Temperature

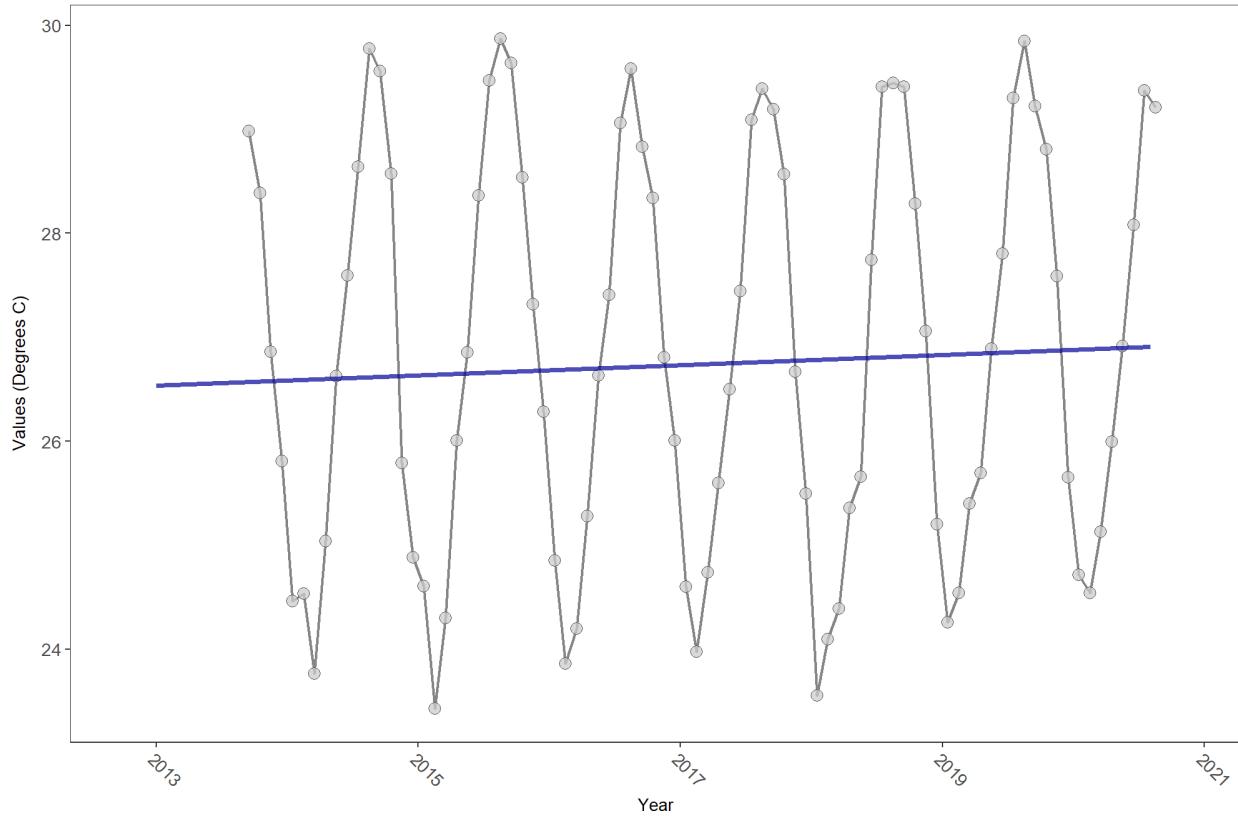


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	50591	8	26.35	1	0.1747	0.0666	0.05683656	26.38857	6.6909	0.8235	0

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 2  
 Water Temperature

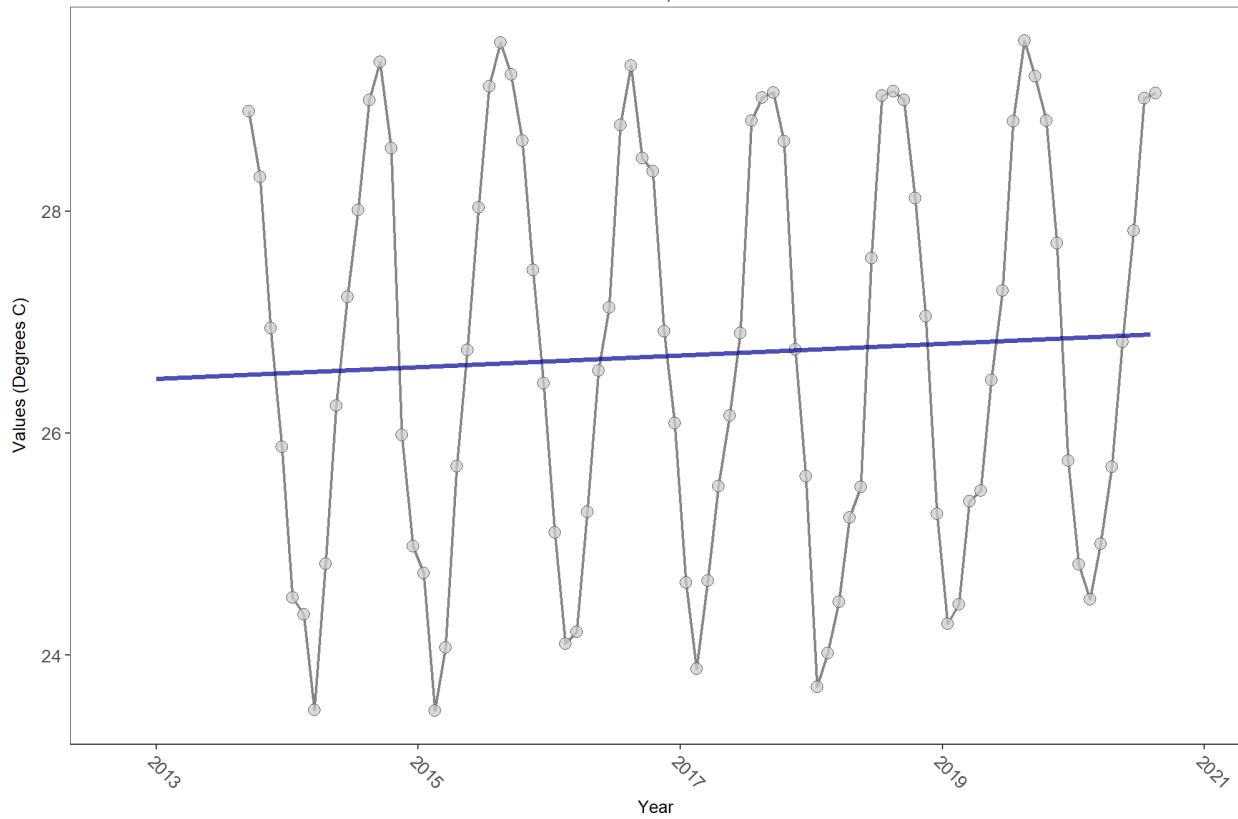


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	46638	8	26.57	1	0.2063	0.027	0.04966833	26.53267	11.609	0.3937	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 3  
 Water Temperature

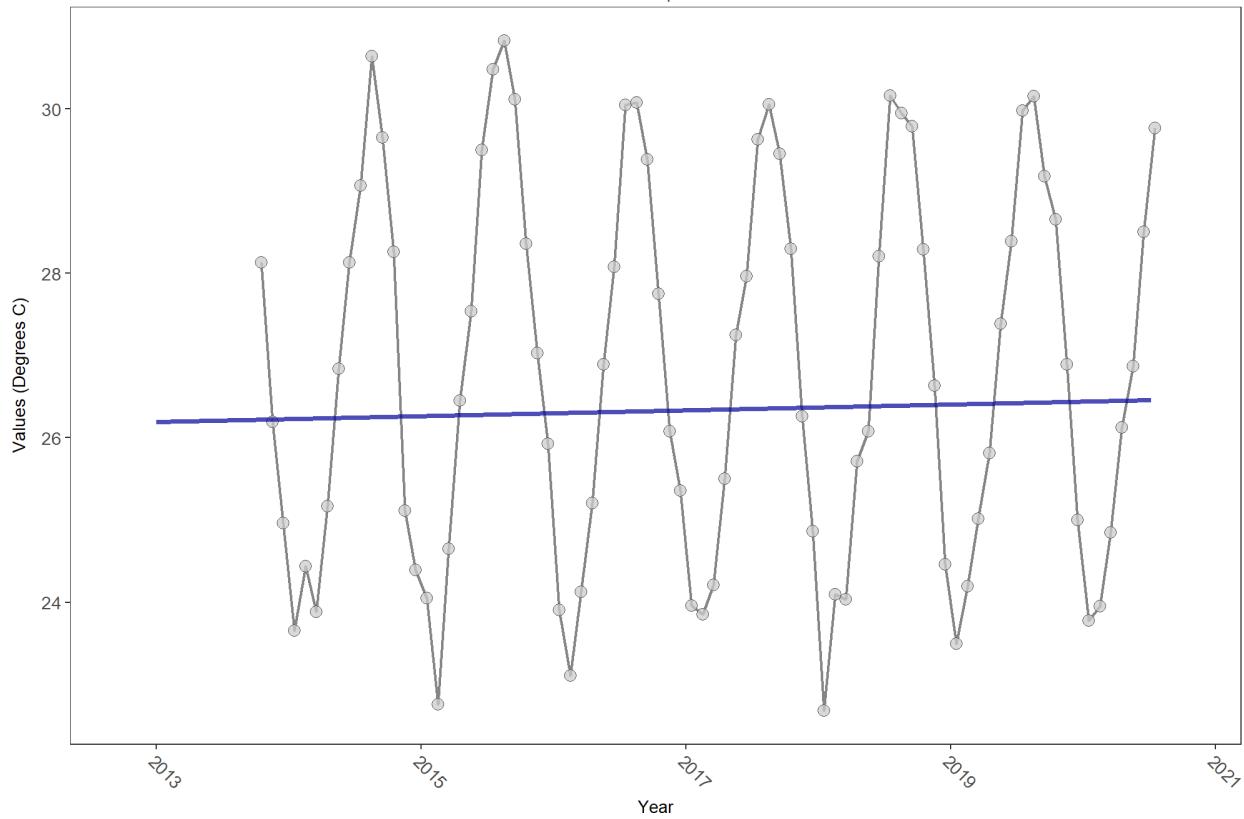


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	50038	8	26.59	1	0.1984	0.0336	0.05316779	26.488	7.1203	0.7893	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 4  
 Water Temperature

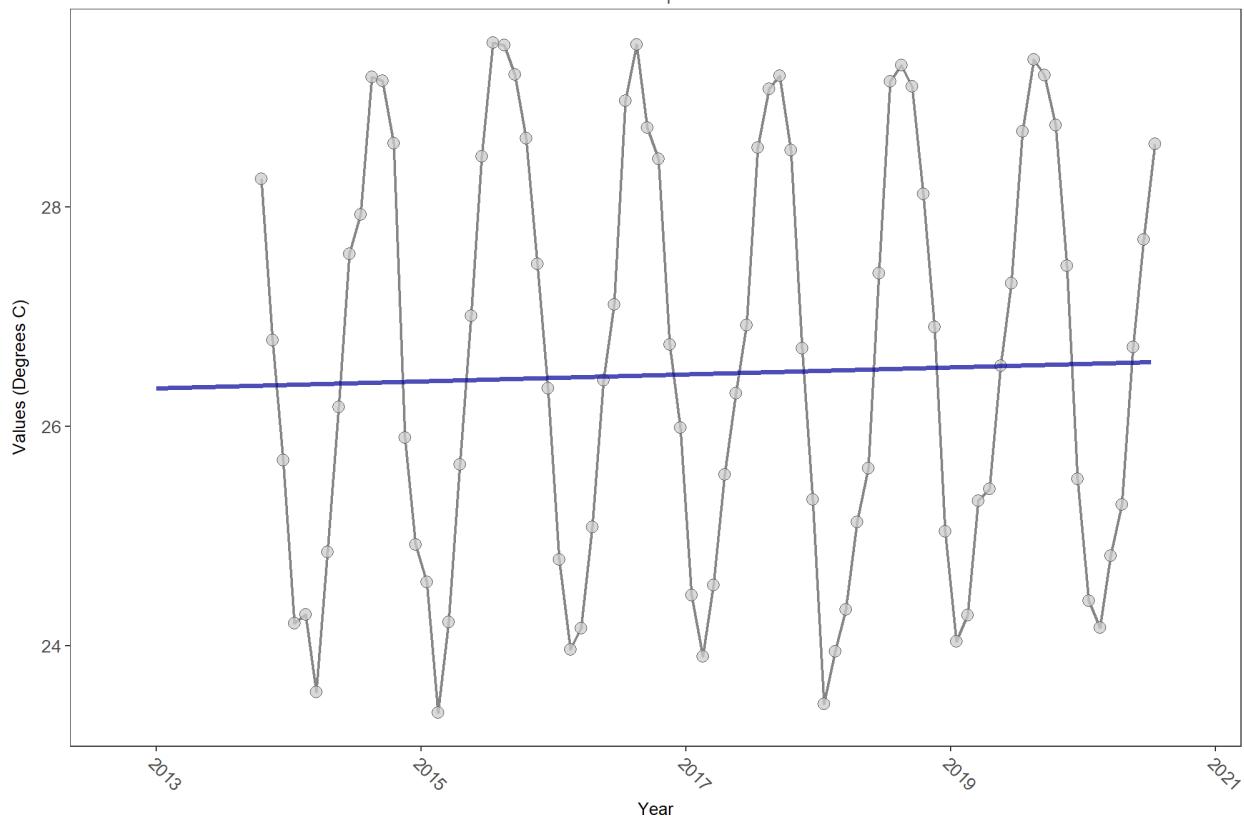


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	53580	8	26.5	1	0.1041	0.2272	0.03593926	26.19177	11.4079	0.4098	0

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 5  
 Water Temperature

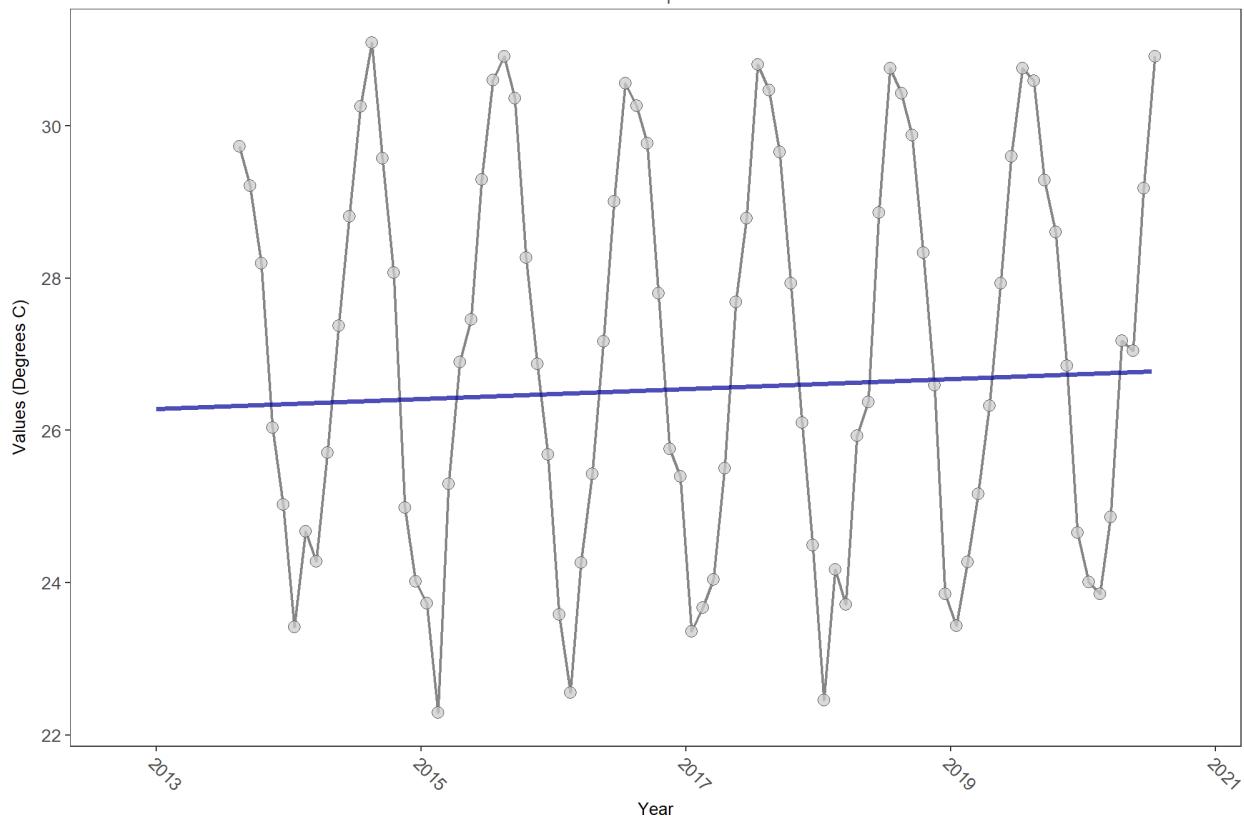


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	40648	8	26.52	1	0.0992	0.3037	0.0323243	26.3447	6.2053	0.8593	0

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 6  
 Water Temperature

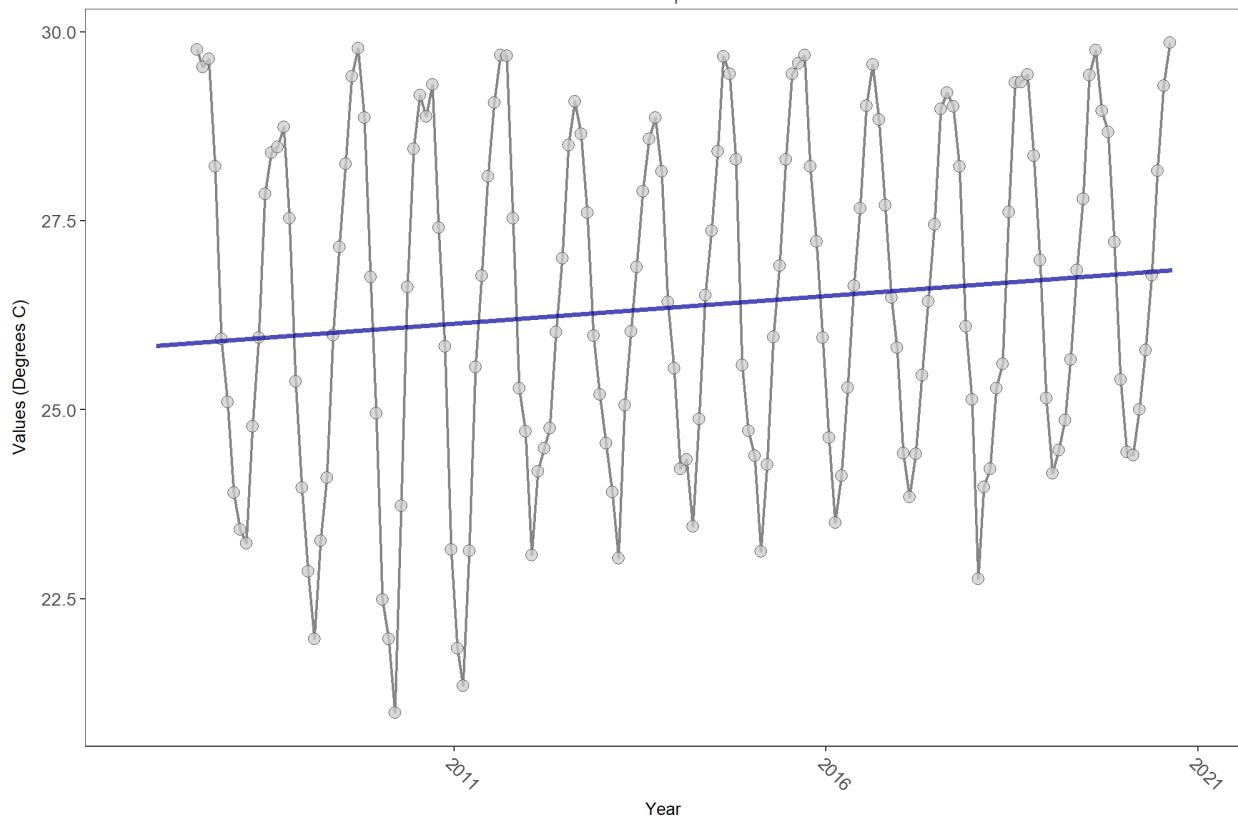


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	47891	8	26.67	1	0.1746	0.0623	0.06578906	26.28368	7.0977	0.7911	0

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 84  
 Water Temperature

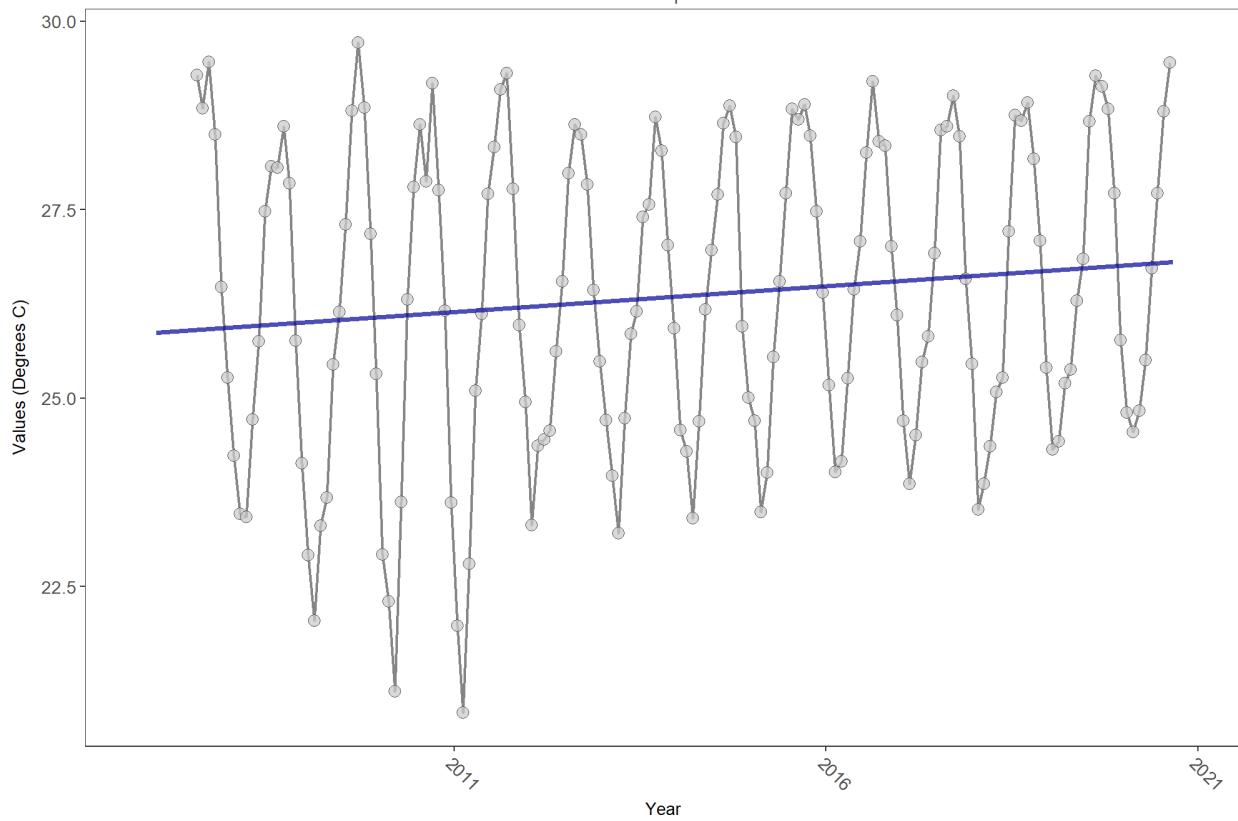


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	98494	14	26.3	1	0.3379	0	0.07320267	25.84432	9.5382	0.5723	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 85  
 Water Temperature

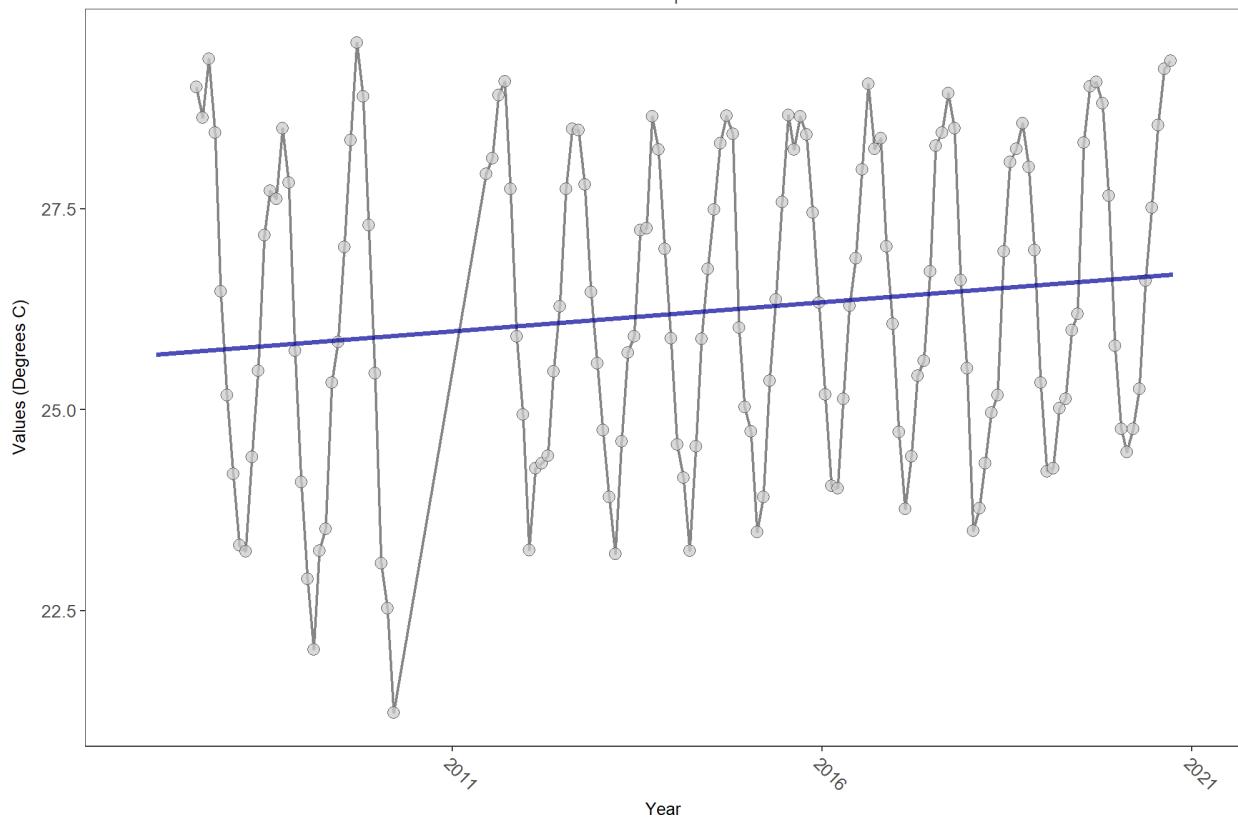


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	98571	14	26.23	1	0.3147	0	0.06864798	25.87104	10.8081	0.4595	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 86  
 Water Temperature

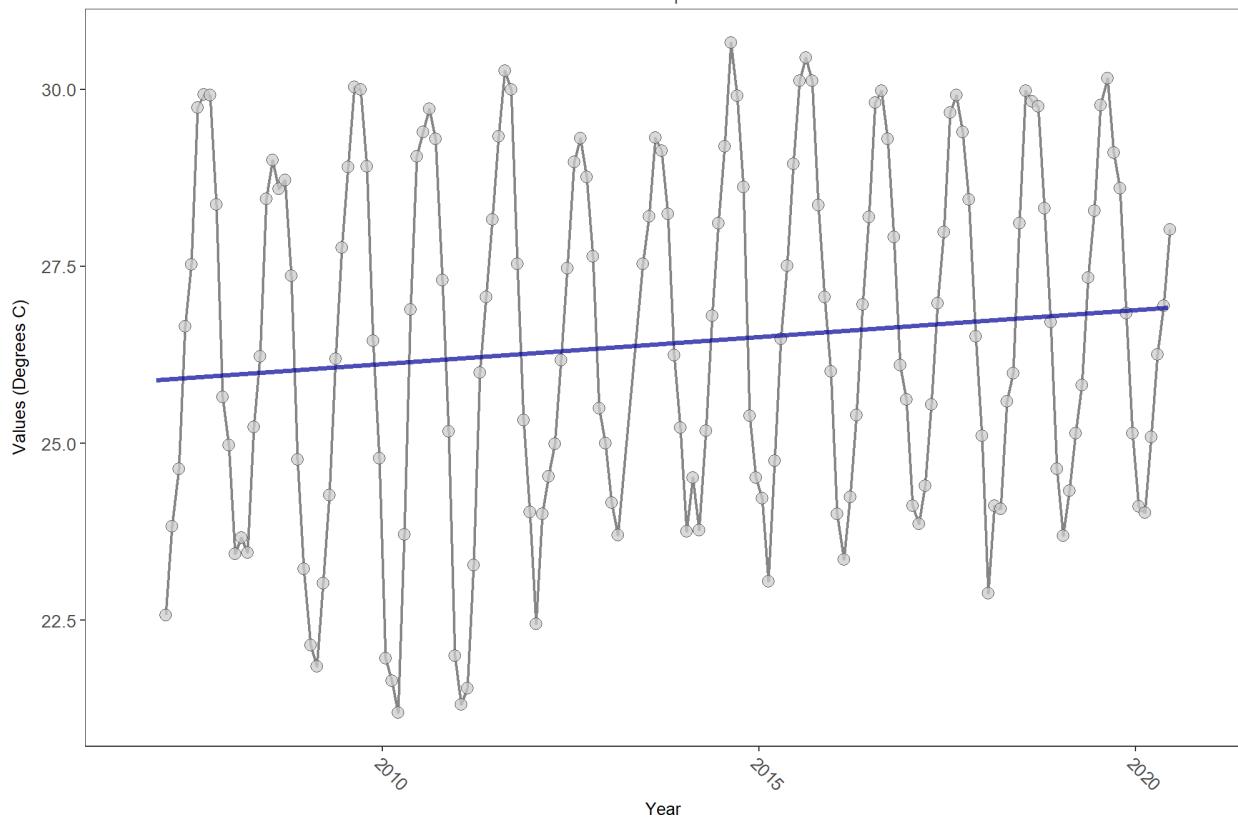


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	89817	14	26.15	1	0.3293	0	0.07212787	25.68906	8.9571	0.6259	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 87  
 Water Temperature

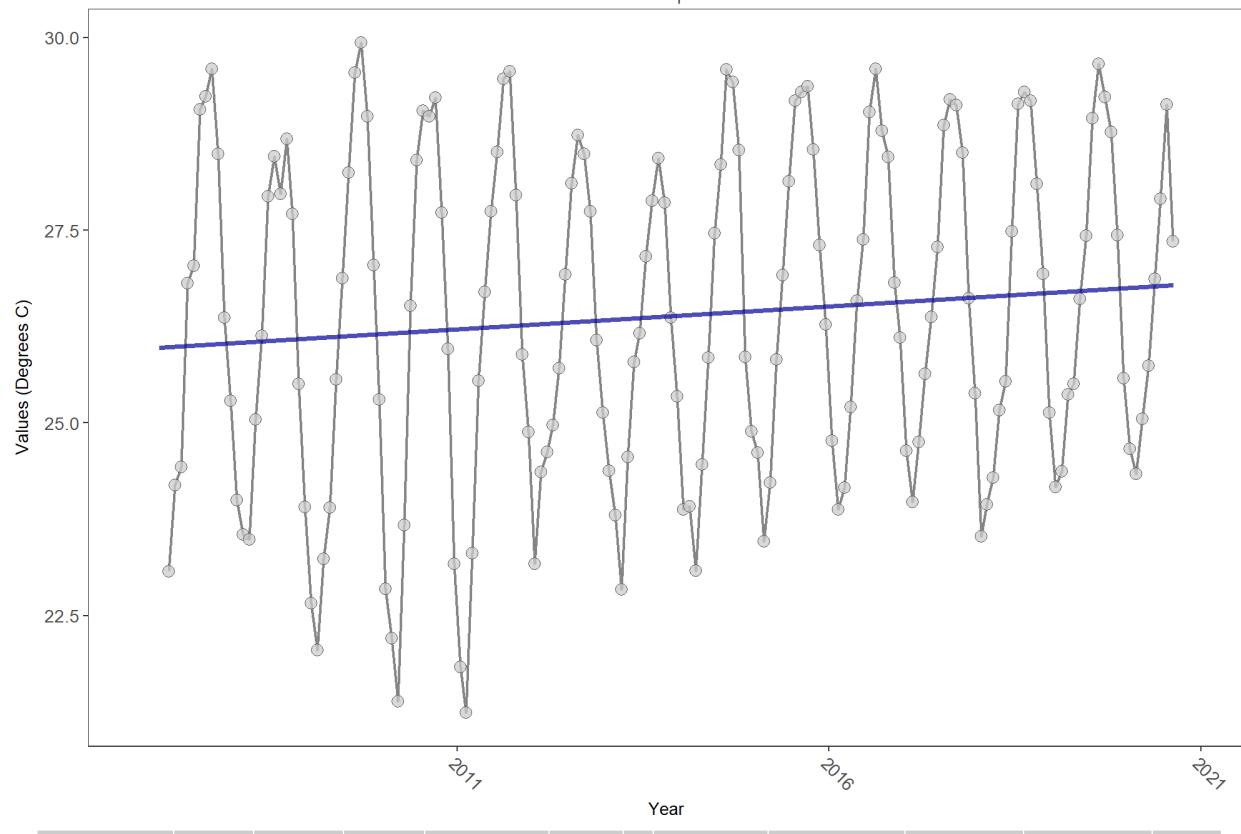


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	95519	14	26.44	1	0.3187	0	0.07613031	25.89366	7.6056	0.7481	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 88  
 Water Temperature

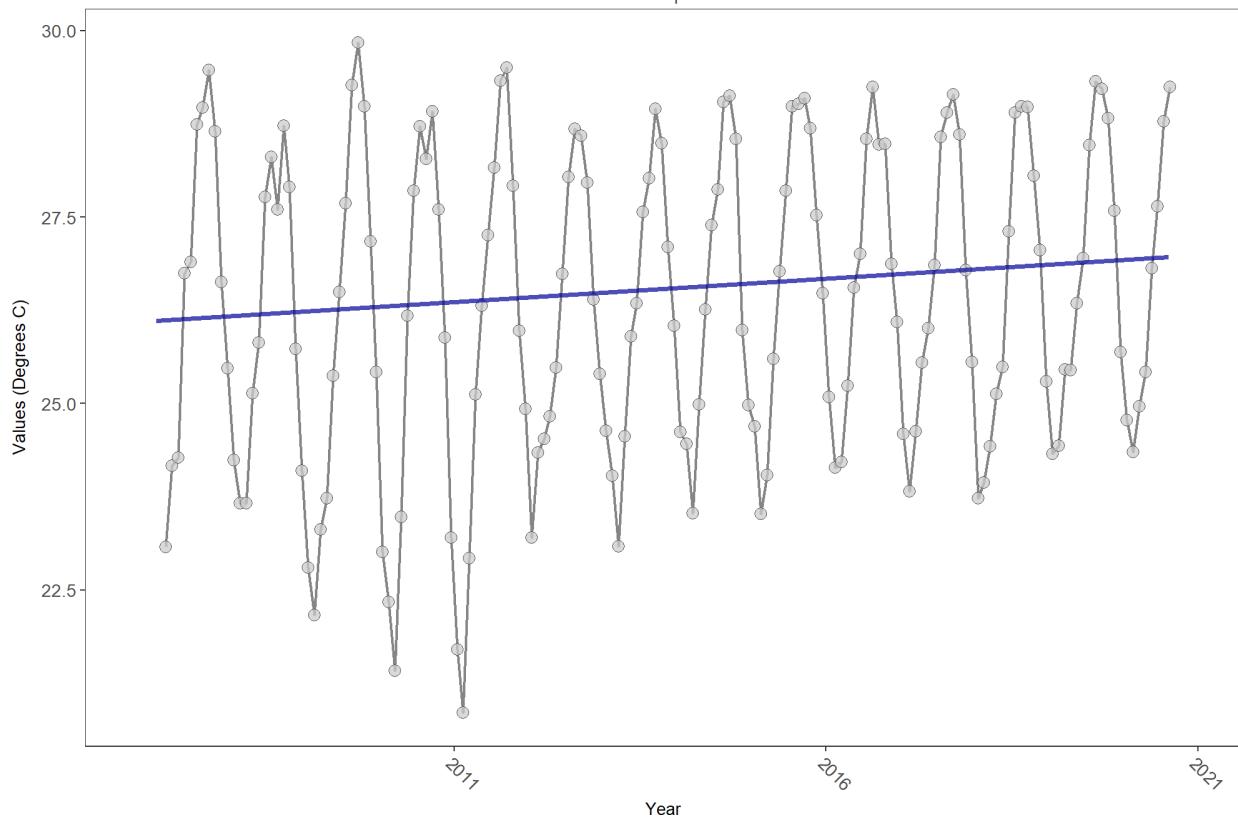


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	103862	14	26.28	1	0.2835	0	0.05922375	25.97923	12.0736	0.3581	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 89  
 Water Temperature

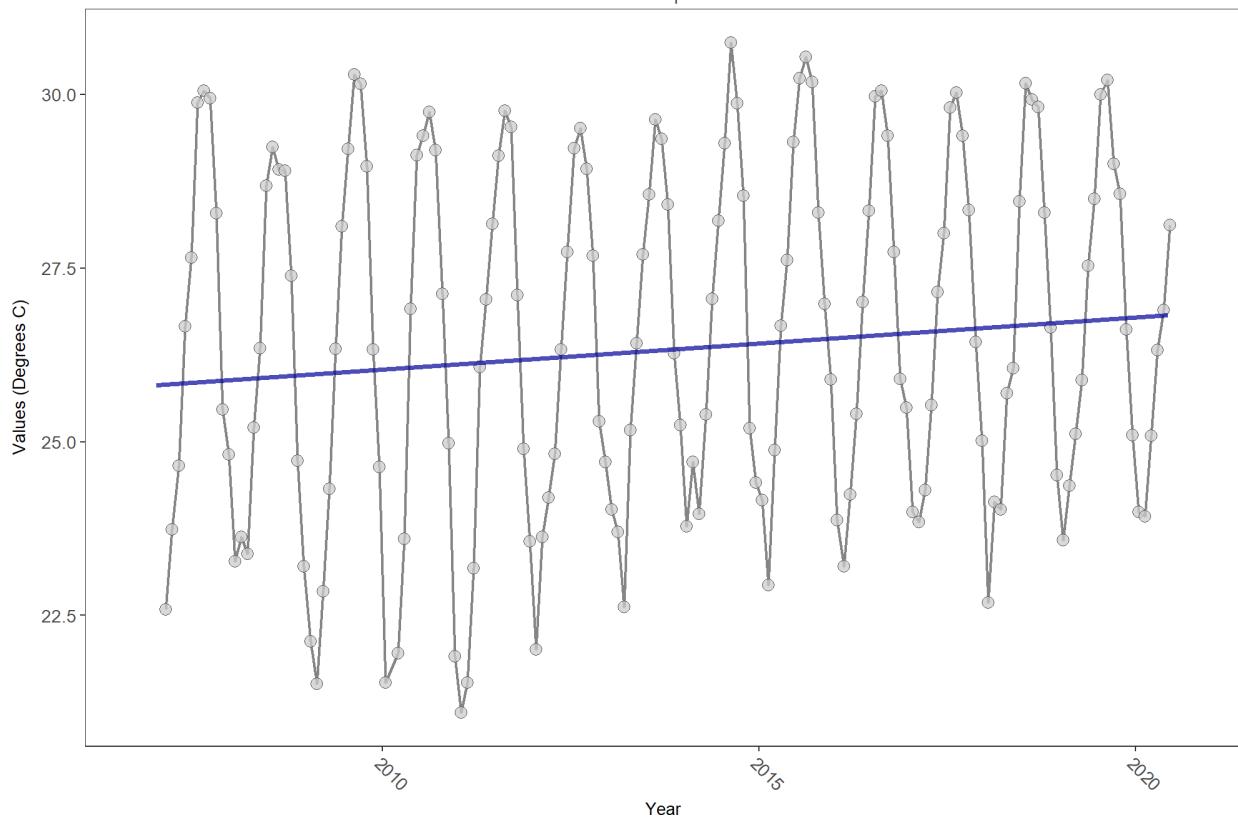


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	101233	14	26.23	1	0.2964	0	0.06271086	26.11009	7.4402	0.7624	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 90  
 Water Temperature

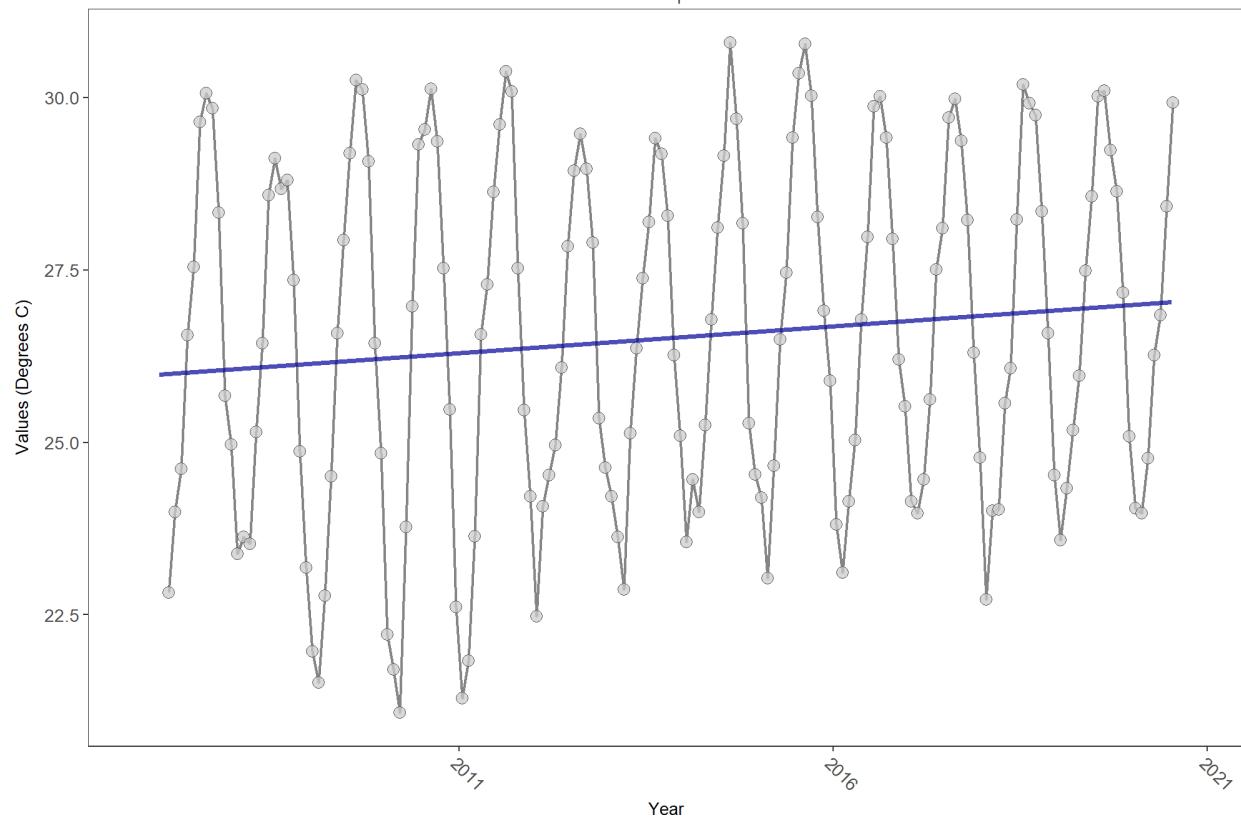


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	84412	14	26.41	1	0.3346	0	0.07519987	25.81181	7.902	0.7221	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 91  
 Water Temperature

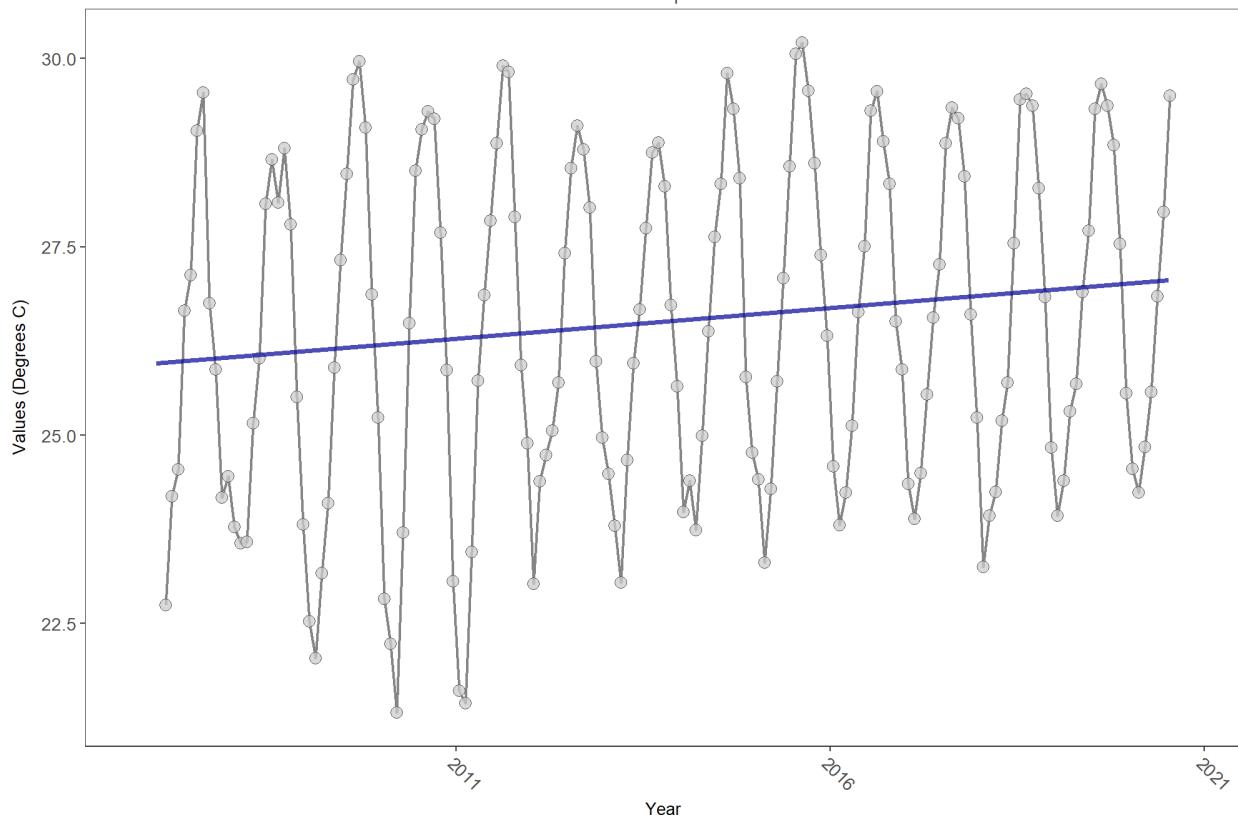


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	84038	14	26.43	1	0.2985	0	0.07740558	25.98815	8.4771	0.67	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 92  
 Water Temperature

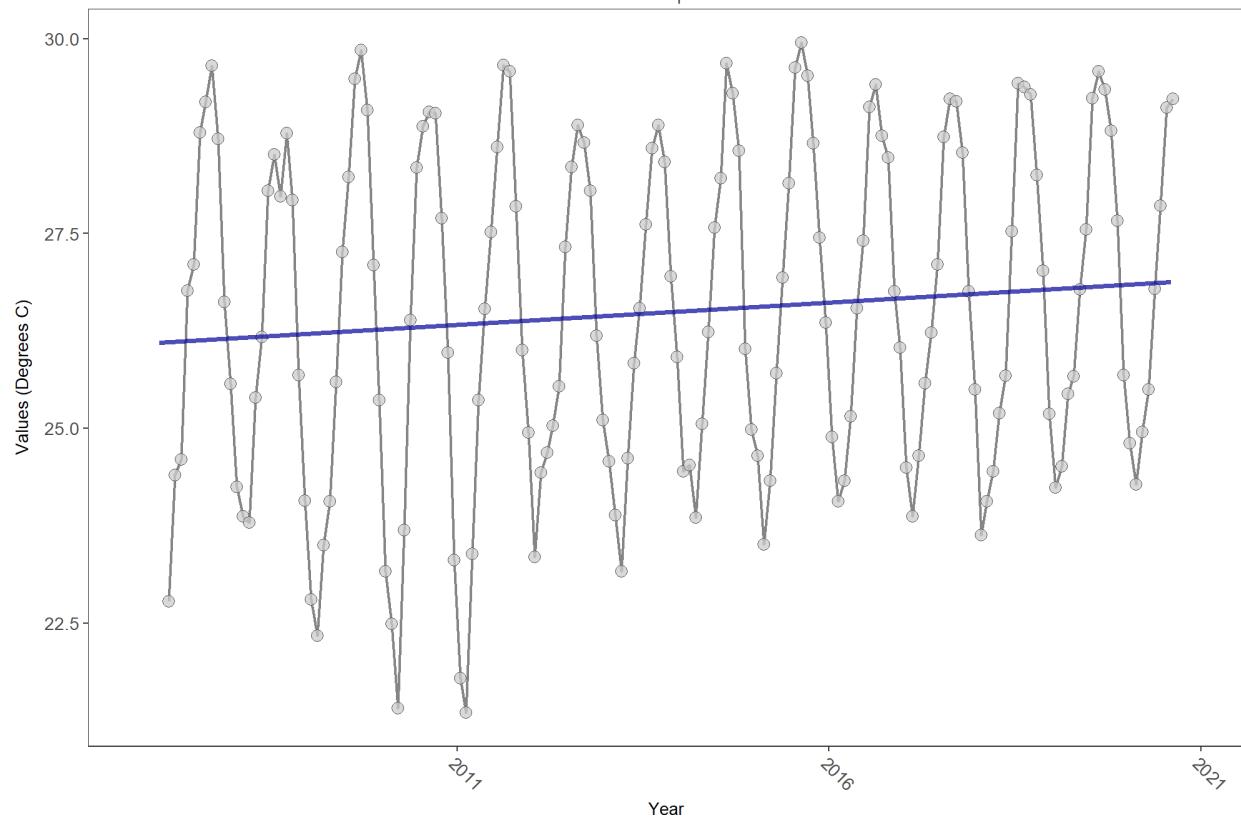


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	97313	14	26.32	1	0.3598	0	0.08187824	25.95257	5.8721	0.8818	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 93  
 Water Temperature

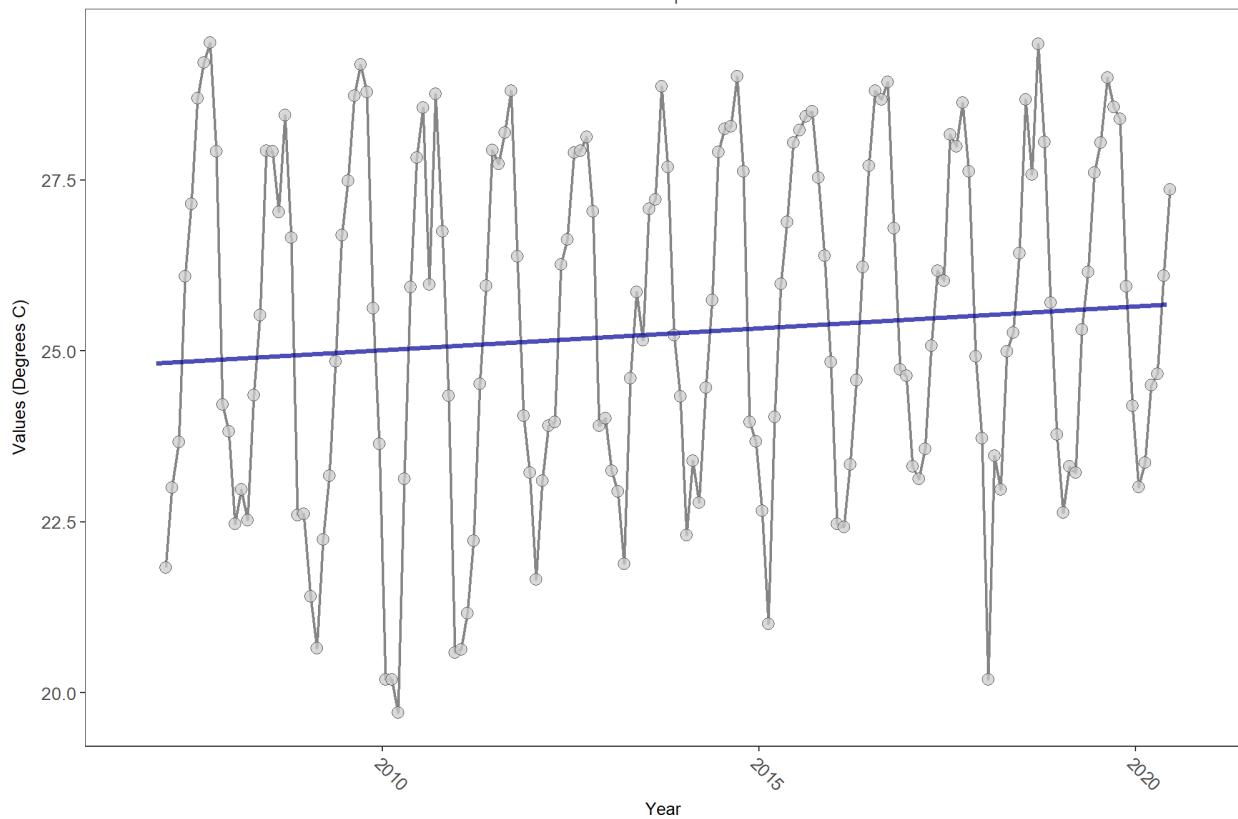


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	89853	14	26.38	1	0.2904	0	0.05767324	26.09549	6.9986	0.7992	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 94  
 Water Temperature

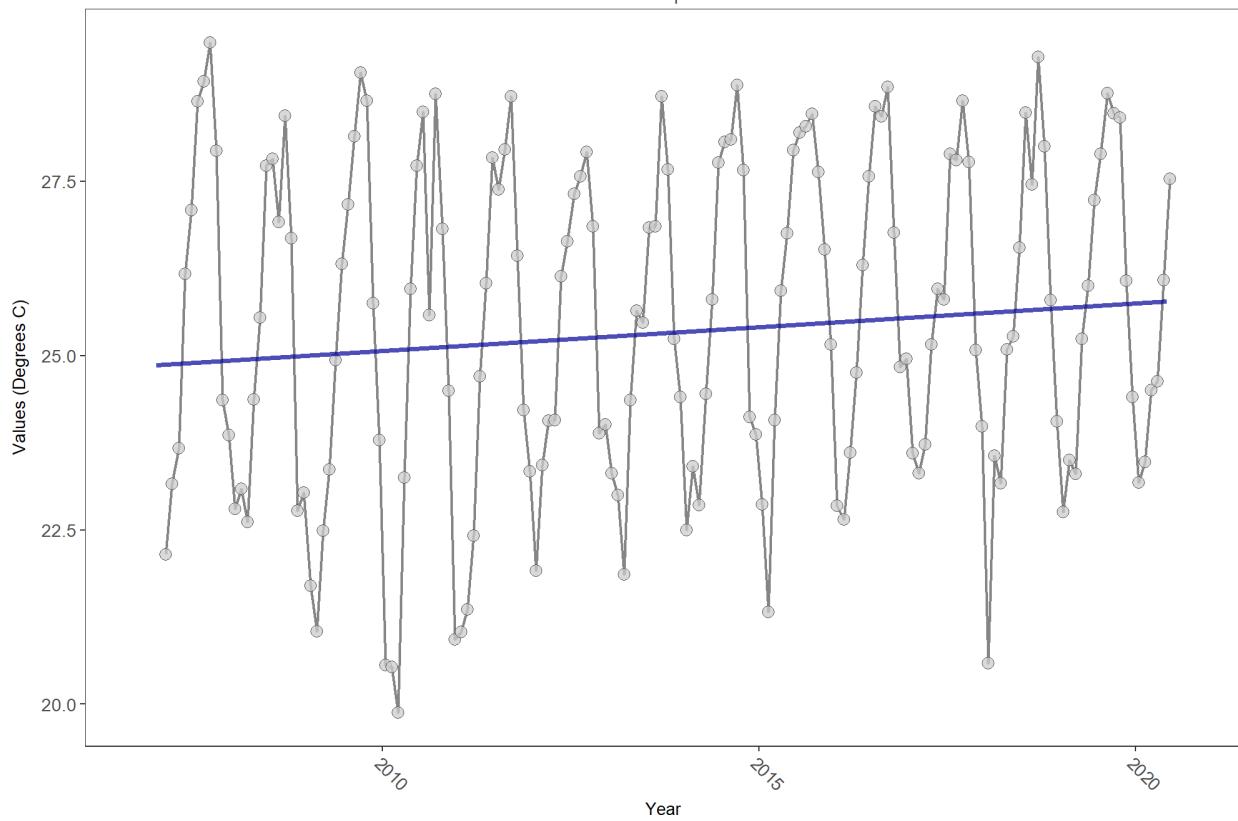


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	77276	14	25.44	1	0.2494	0	0.06389646	24.81559	12.6038	0.32	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 95  
 Water Temperature

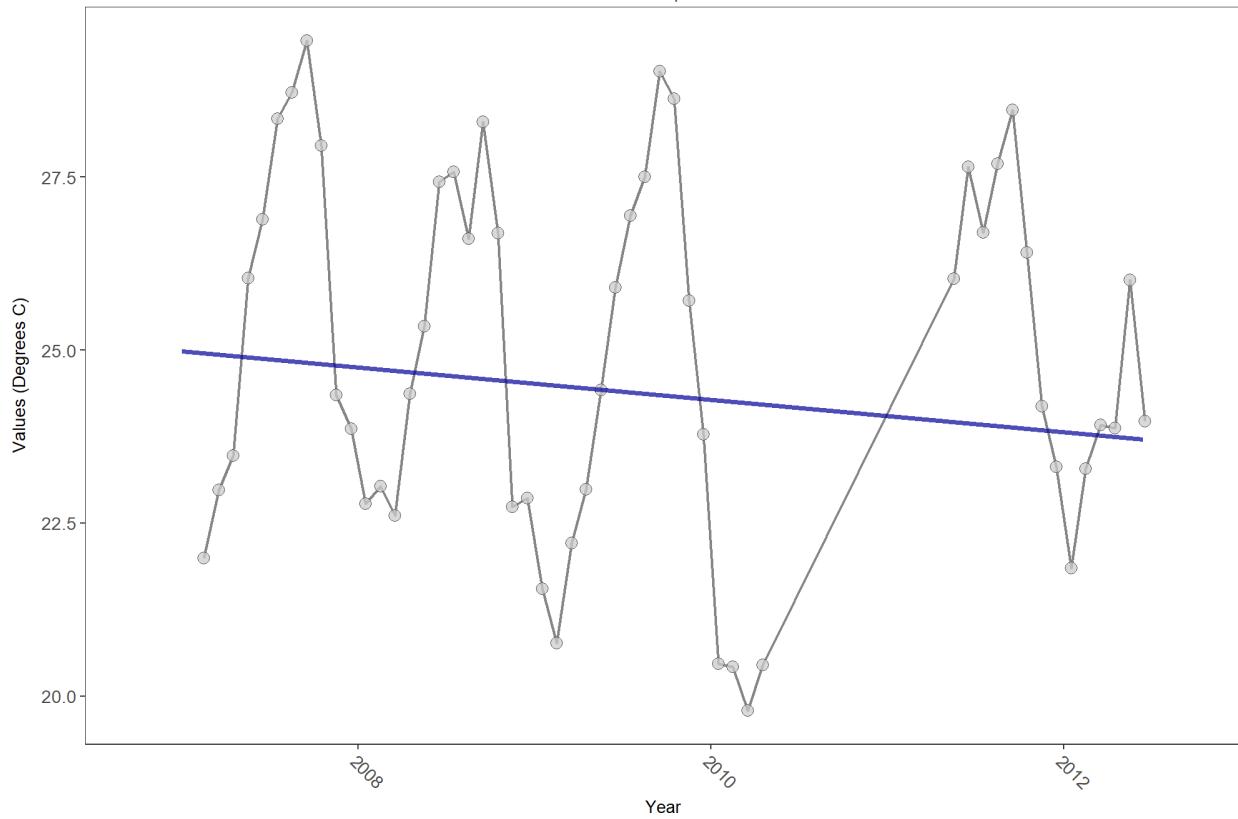


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	89187	14	25.5	1	0.2532	0	0.06827256	24.86634	12.606	0.3199	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

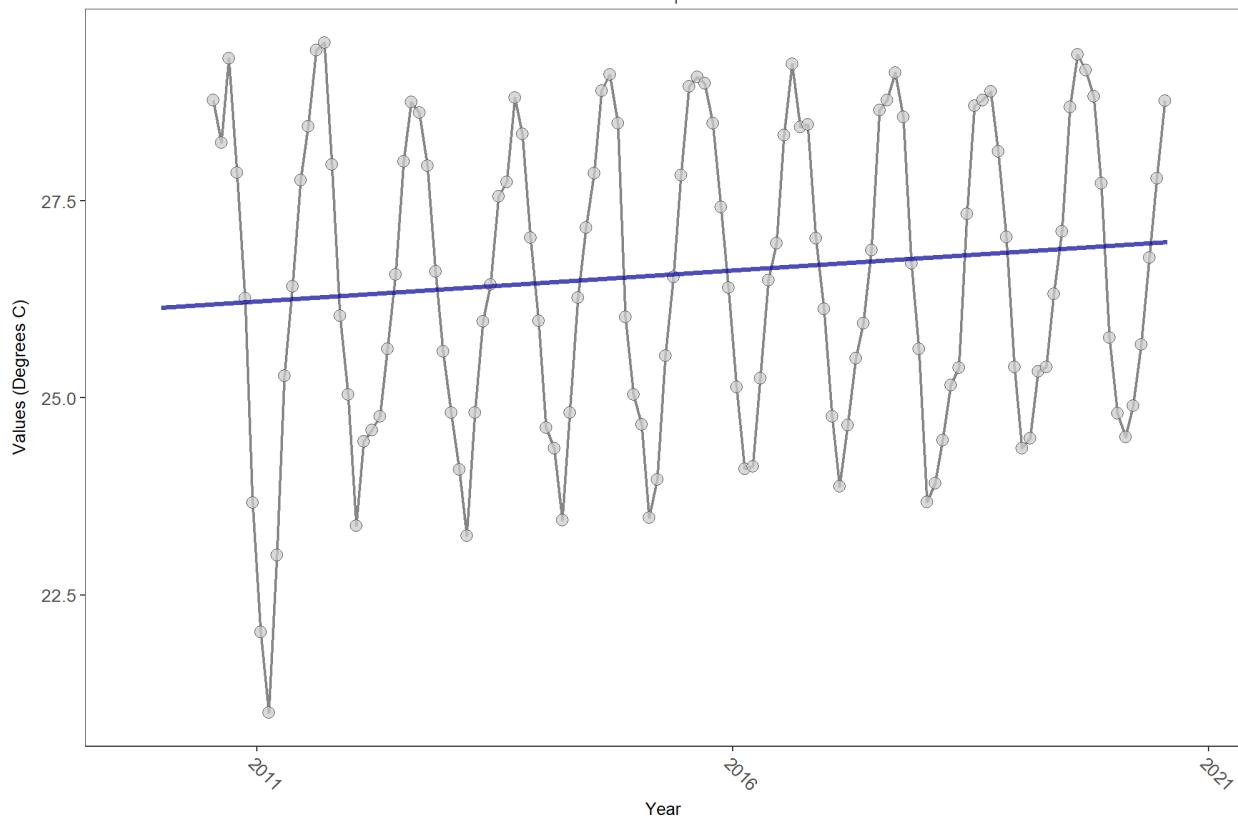
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 96  
 Water Temperature



$p < 0.00005$  appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 97  
 Water Temperature

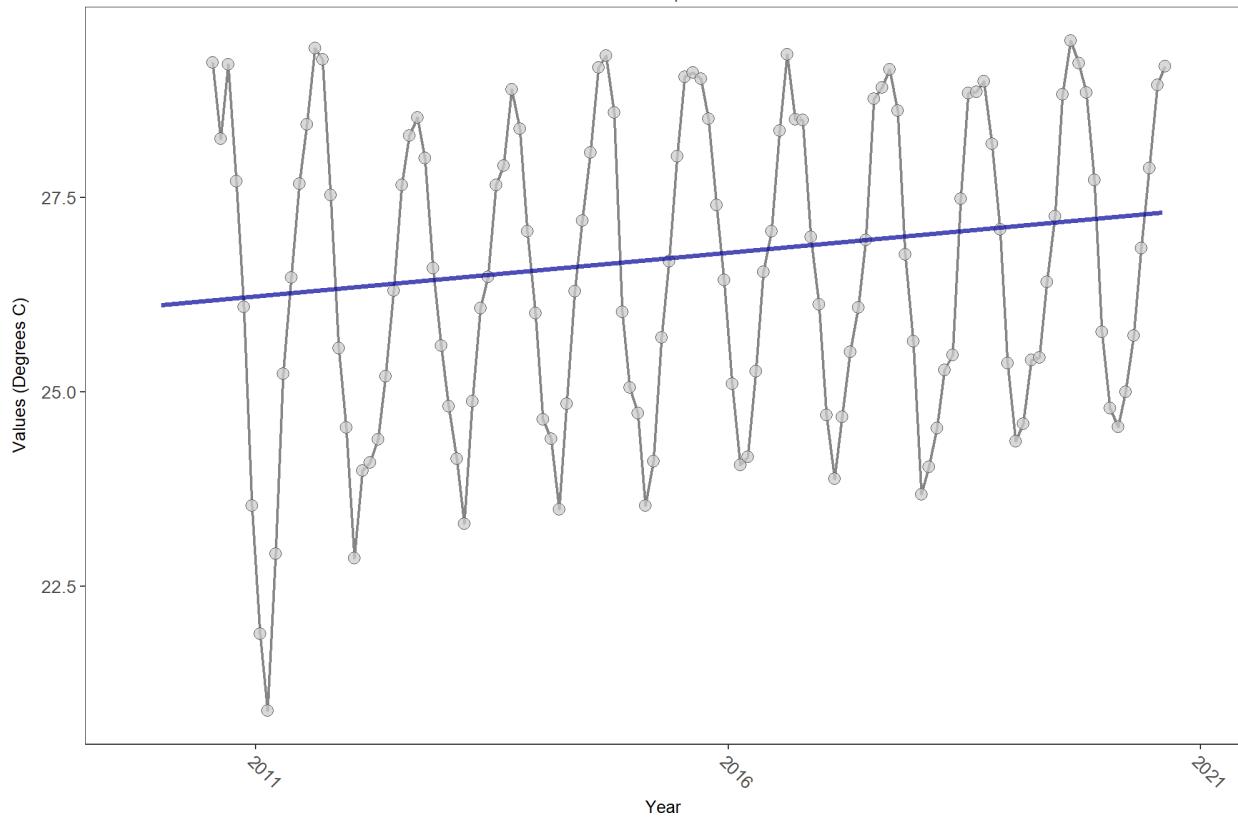


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	82075	11	26.4	1	0.3282	0	0.07857953	26.14659	7.4987	0.7574	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 98  
 Water Temperature

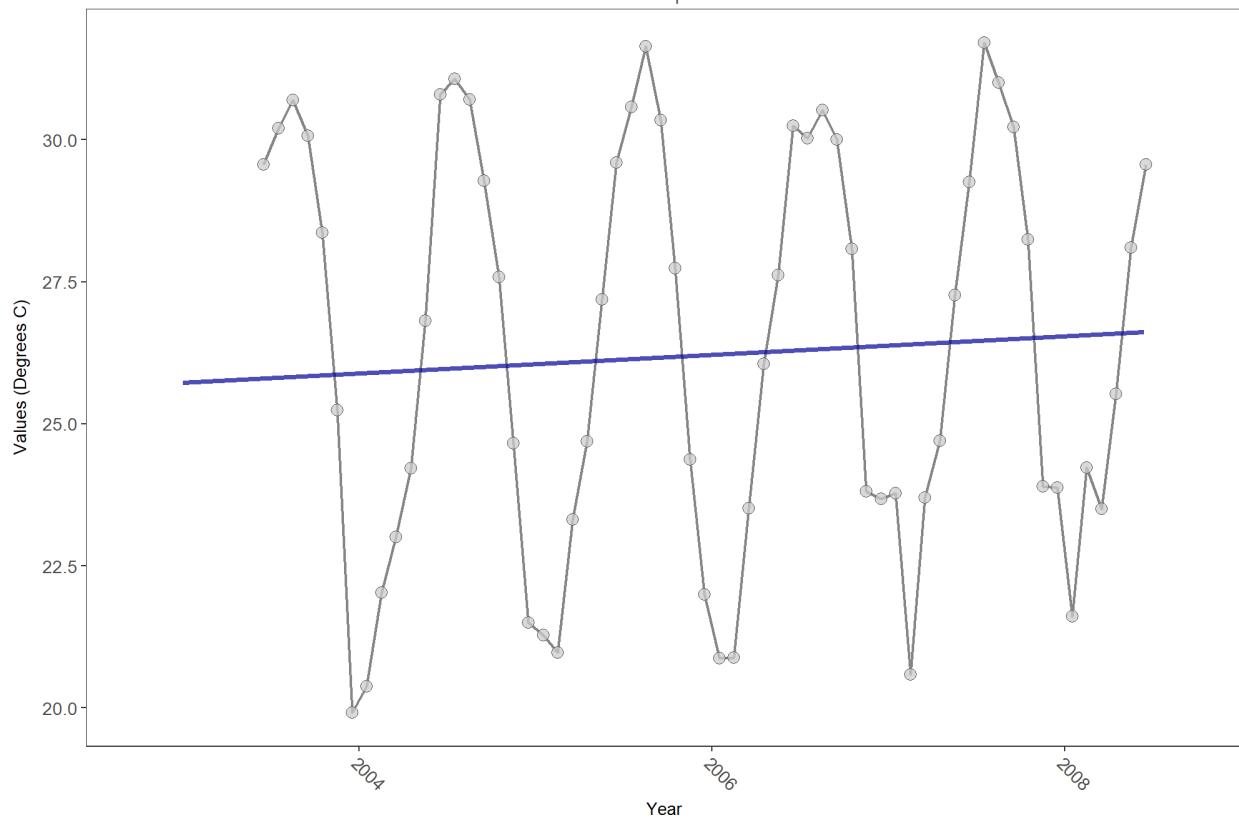


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	73685	11	26.32	1	0.3811	0	0.1124543	26.1169	8.7223	0.6475	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 2  
 Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array  
 1B  
 Water Temperature

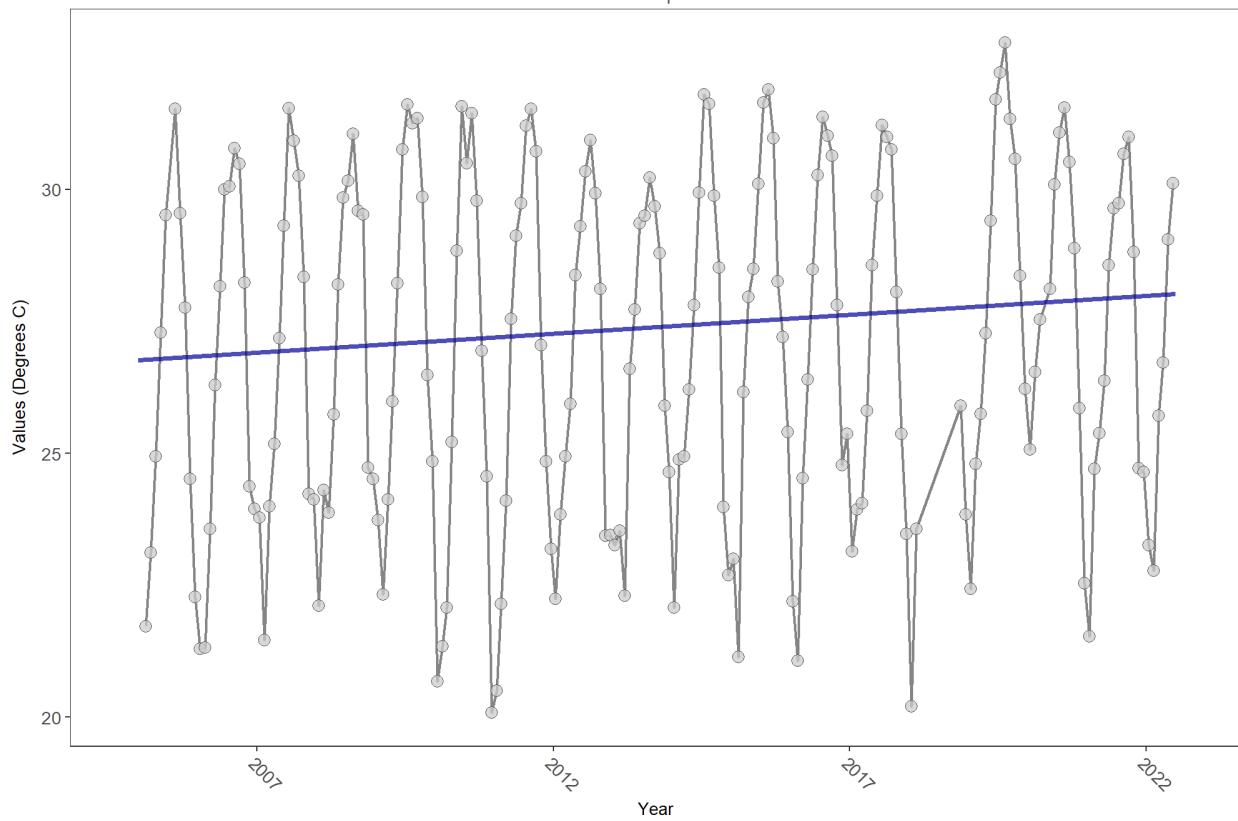


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	86204	6	26.3845	1	0.259	0.0392	0.1627929	25.72826	16.6535	0.1186	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
5  
National Data Buoy Center  
KYWF1  
Water Temperature

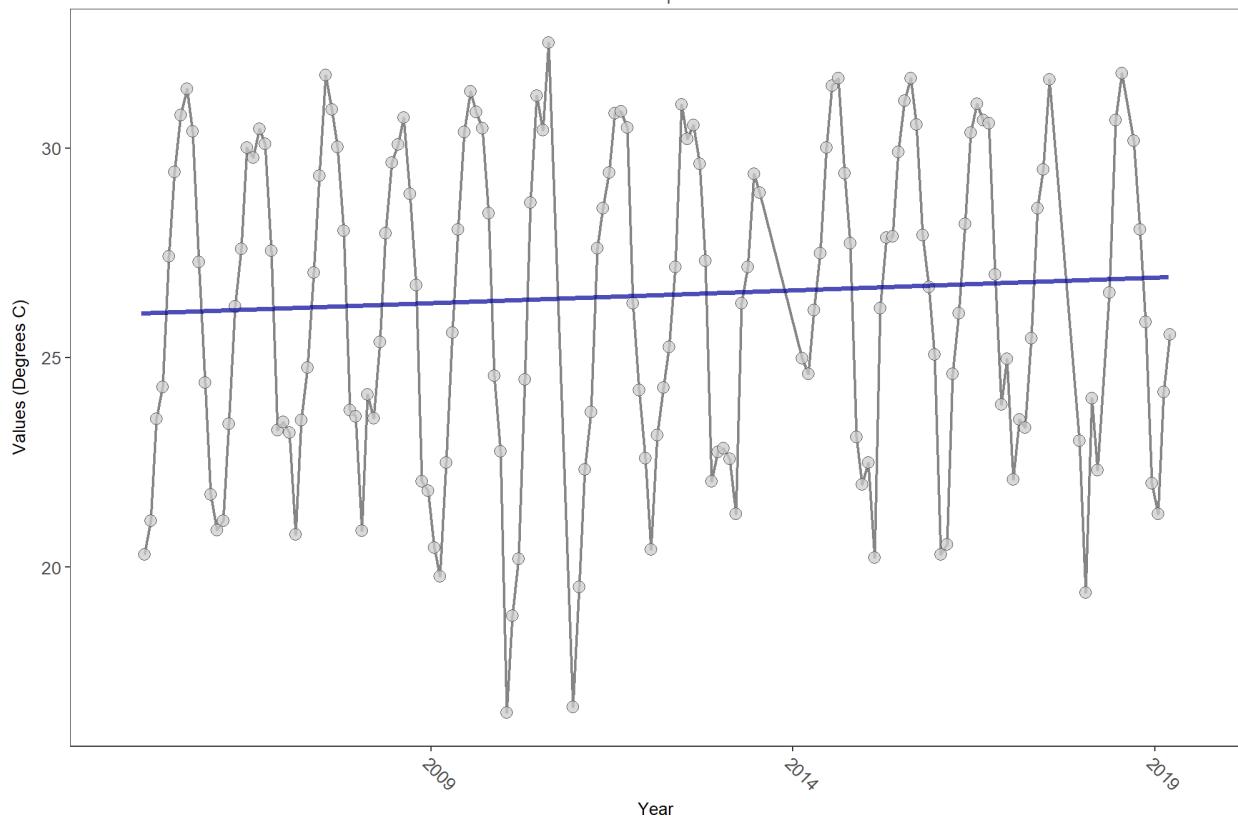


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
surface	1269087	18	27.5	1	0.2853	0	0.07143172	26.76716	7.0403	0.7958	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
5  
National Data Buoy Center  
LONF1  
Water Temperature

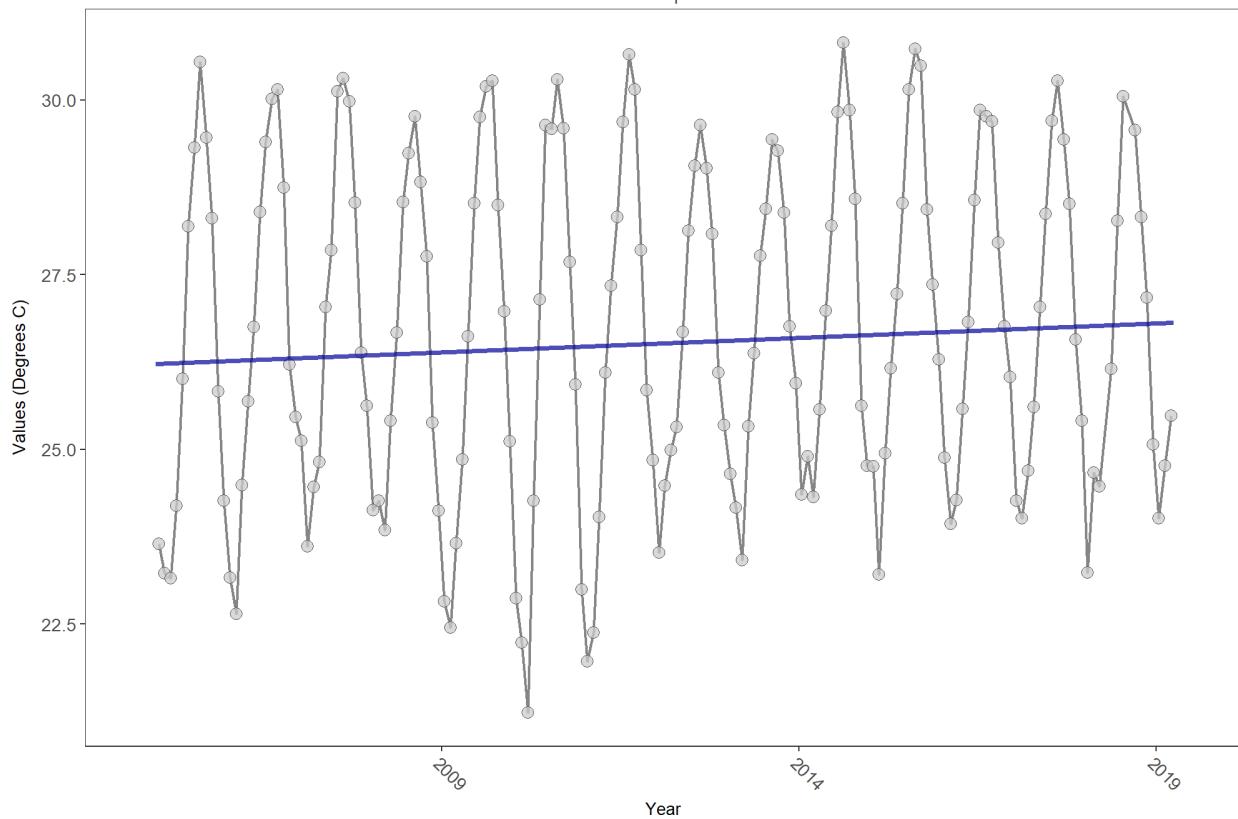


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
surface	107173	15	26.3	1	0.1852	0.0022	0.0606754	26.05832	3.2552	0.9869	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 5  
 National Data Buoy Center  
 MLRF1  
 Water Temperature

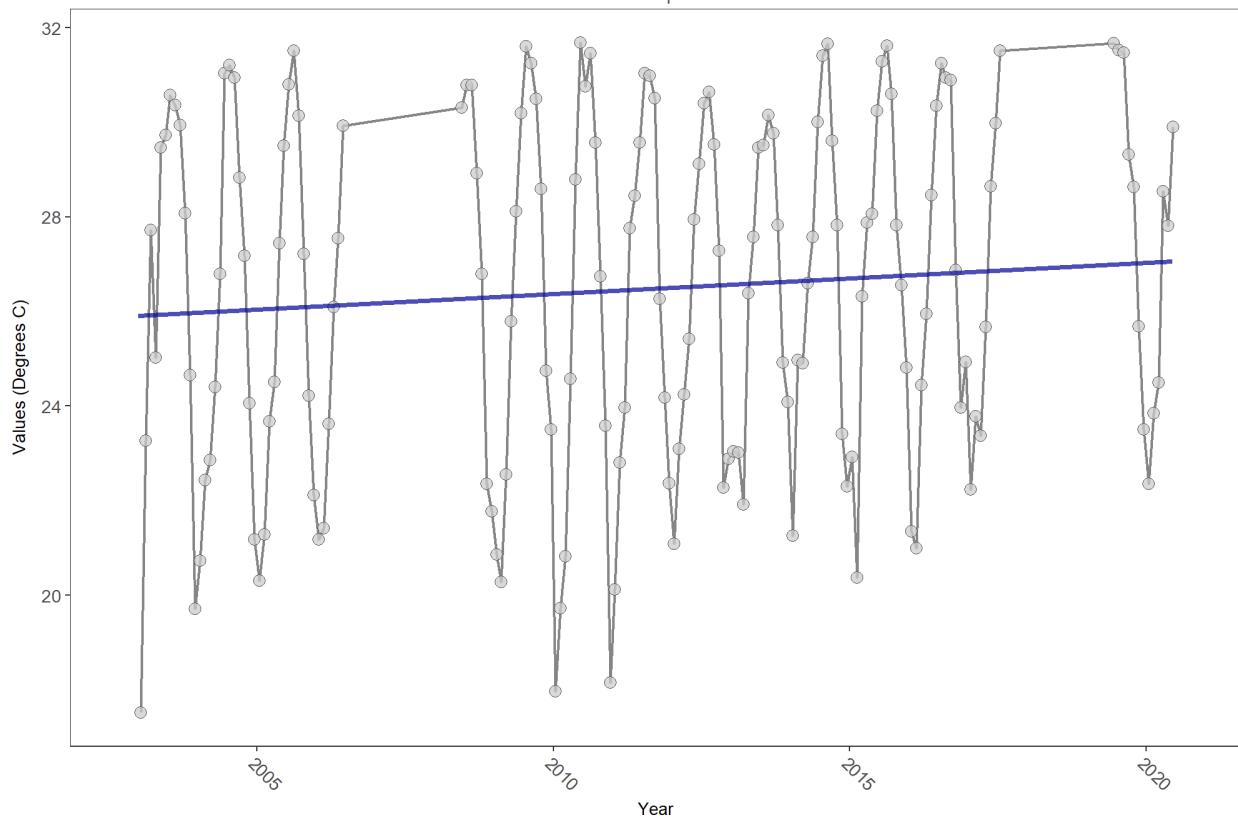


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
surface	111537	15	26.5	1	0.1913	0.0009	0.04159201	26.22273	7.5875	0.7497	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 11  
 Water Temperature

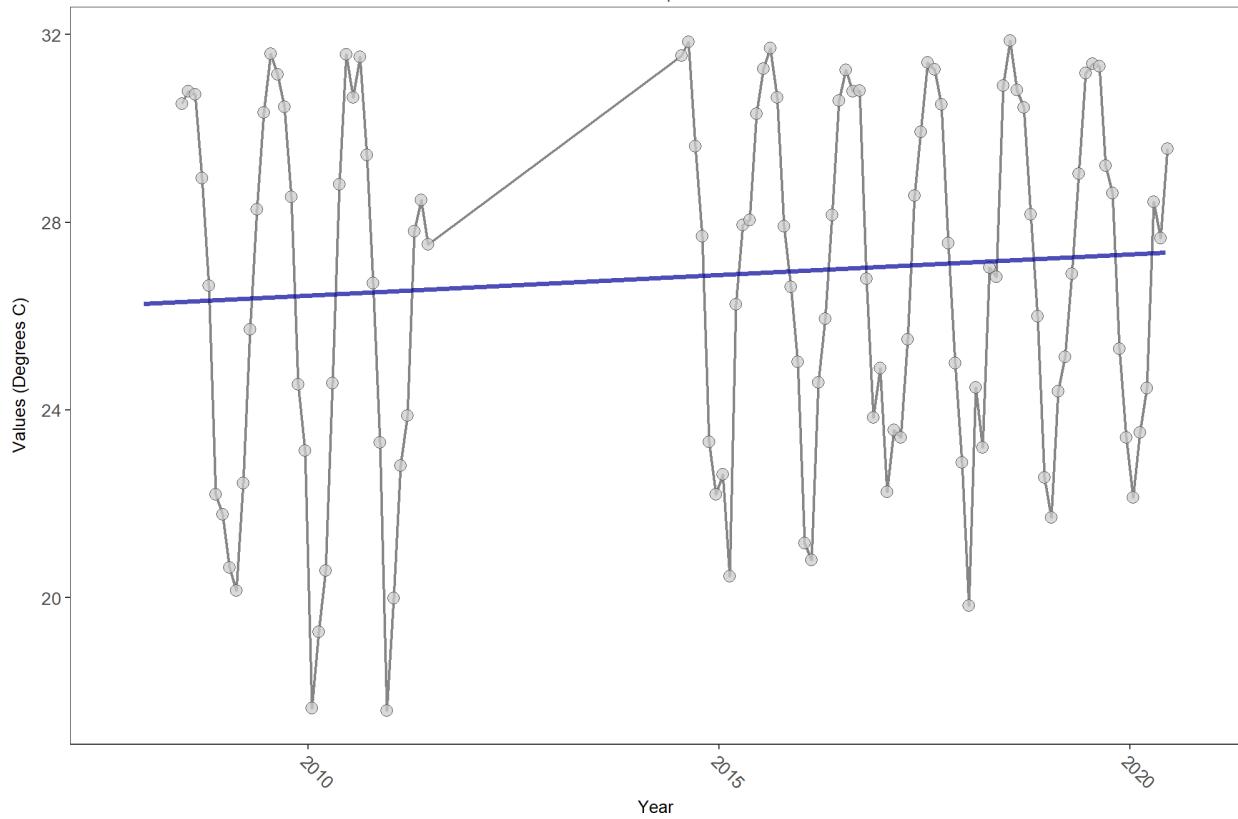


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	210380	16	26.74	1	0.2772	0	0.06628219	25.90438	8.644	0.6547	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 12  
 Water Temperature

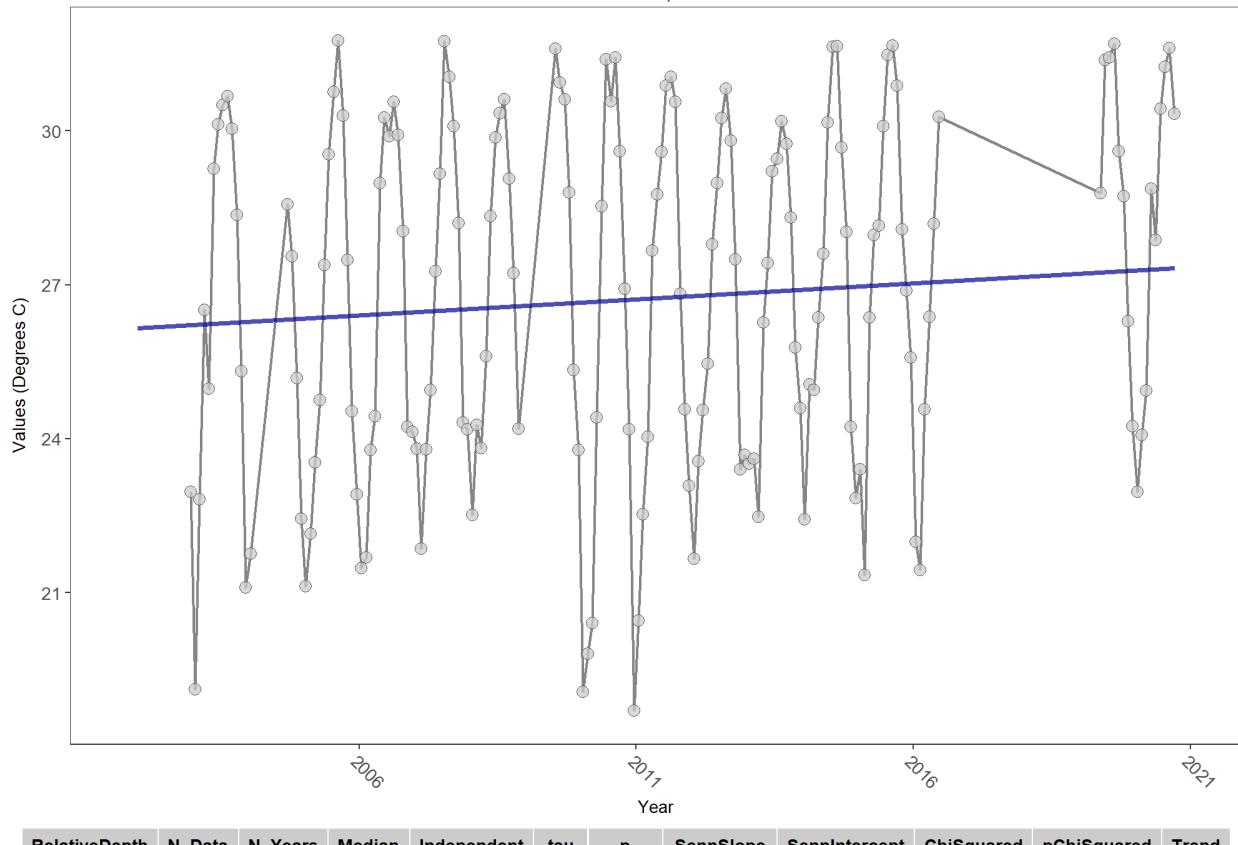


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	119723	11	27.06	1	0.2548	0.0011	0.08755083	26.26602	7.6886	0.7409	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 14  
 Water Temperature

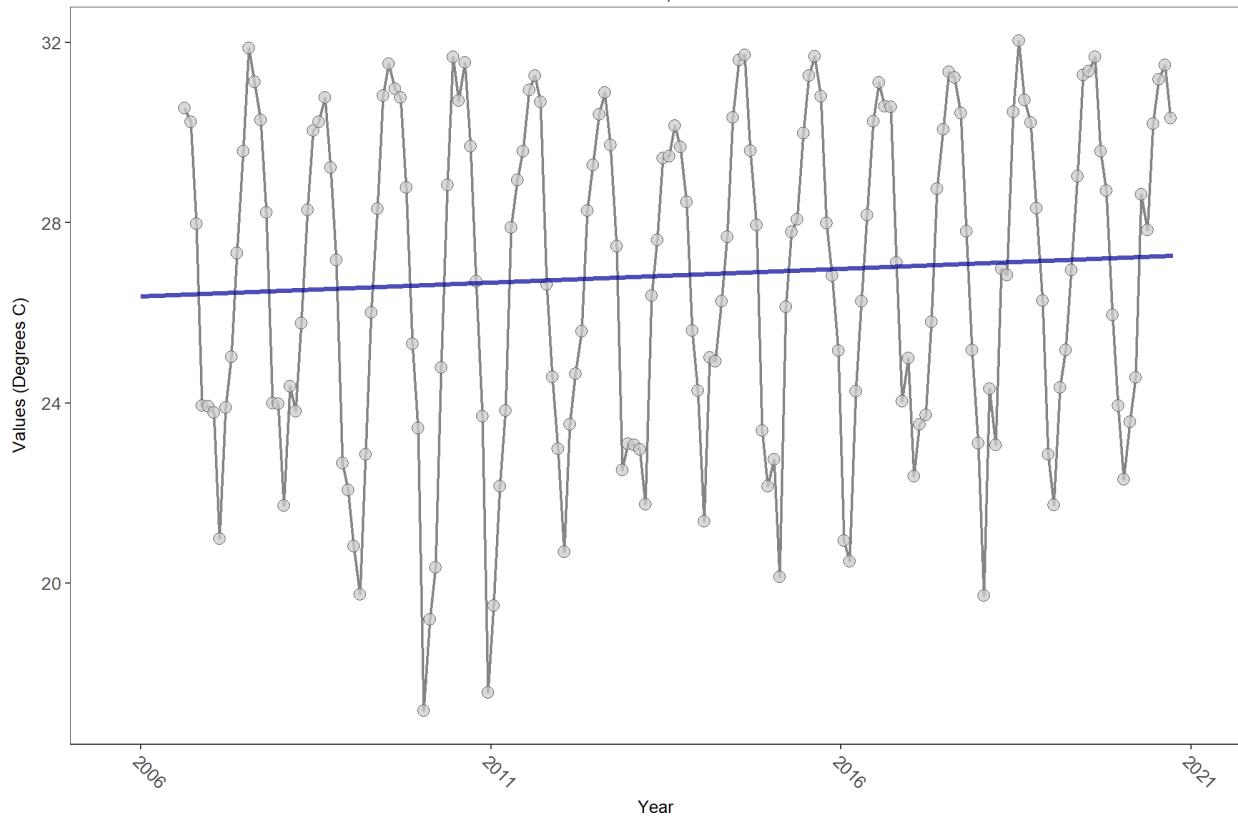


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	209364	17	26.89	1	0.22	0.0002	0.06278126	26.15108	8.384	0.6785	1

$p < 0.00005$  appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 15  
 Water Temperature

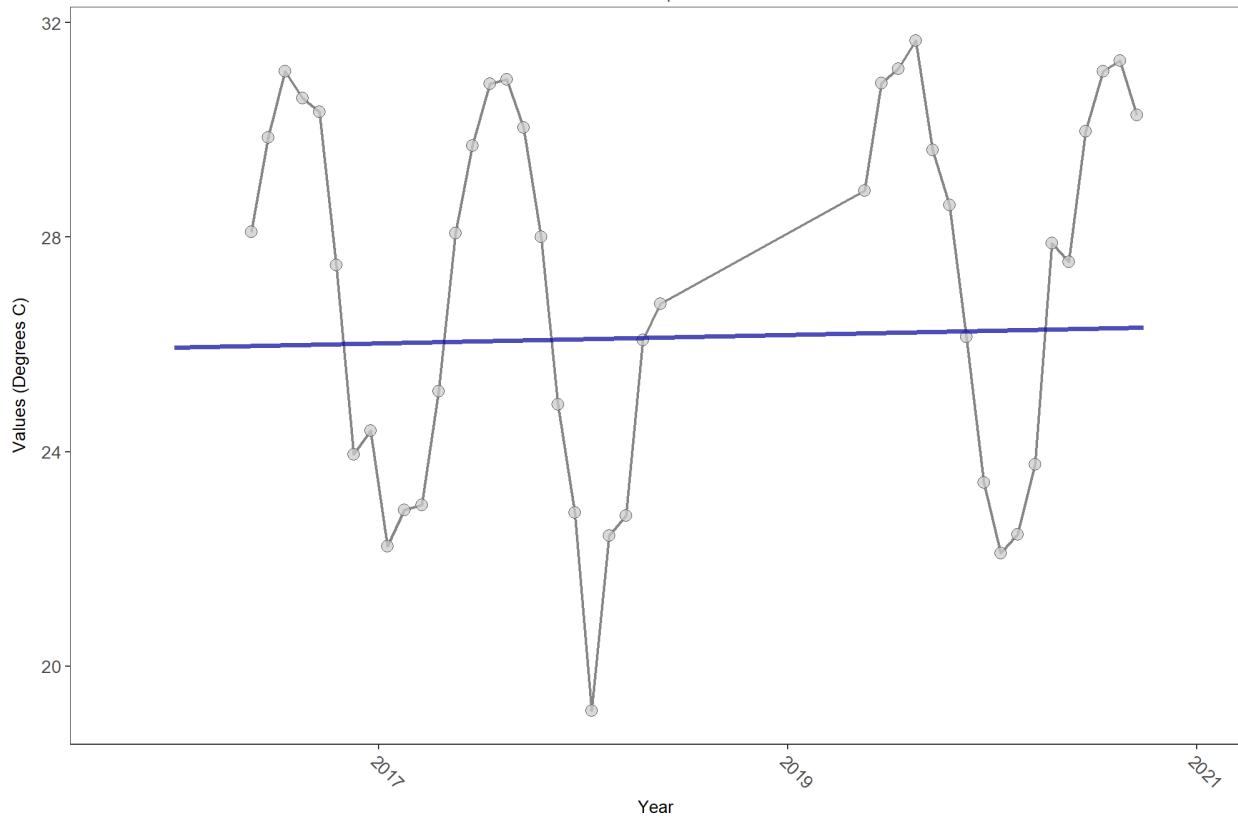


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	203688	15	26.965	1	0.1835	0.0016	0.06102195	26.36201	5.8029	0.8862	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

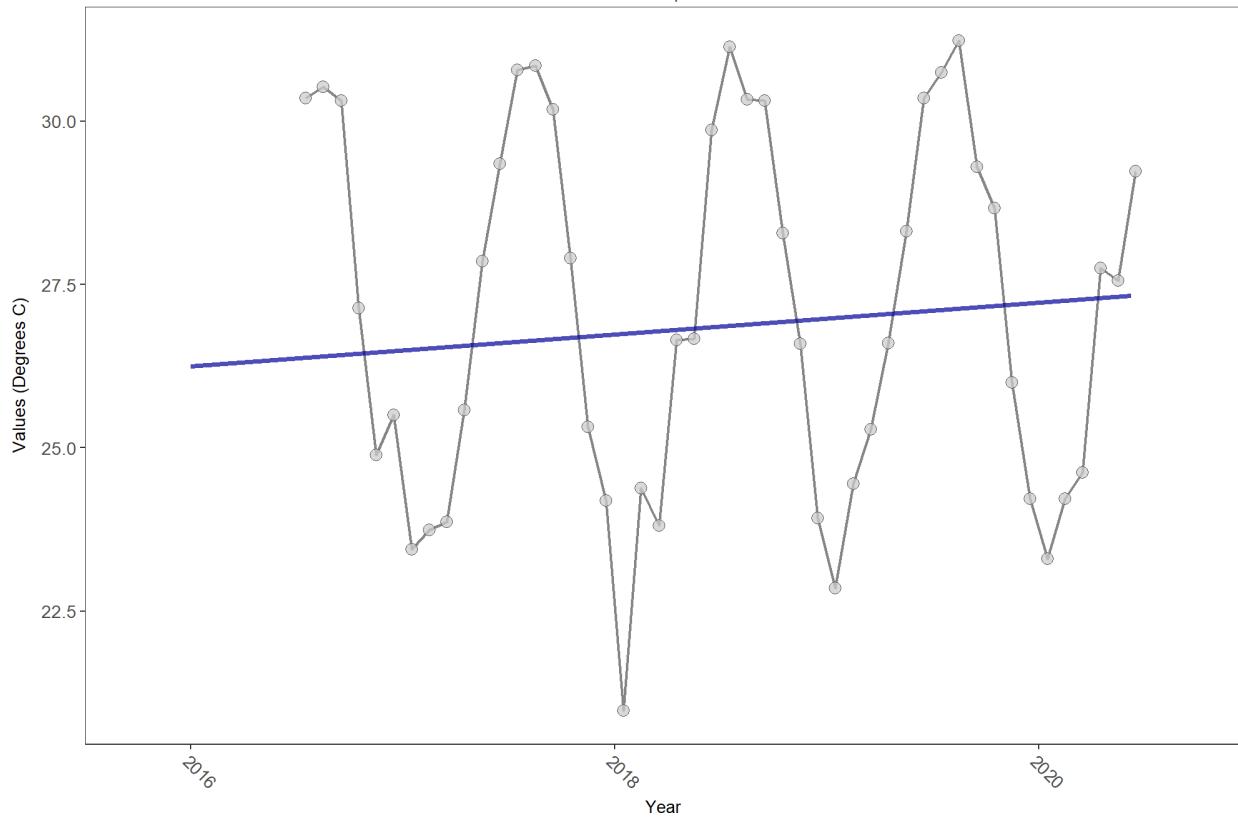
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 18  
 Water Temperature



*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 21  
 Water Temperature

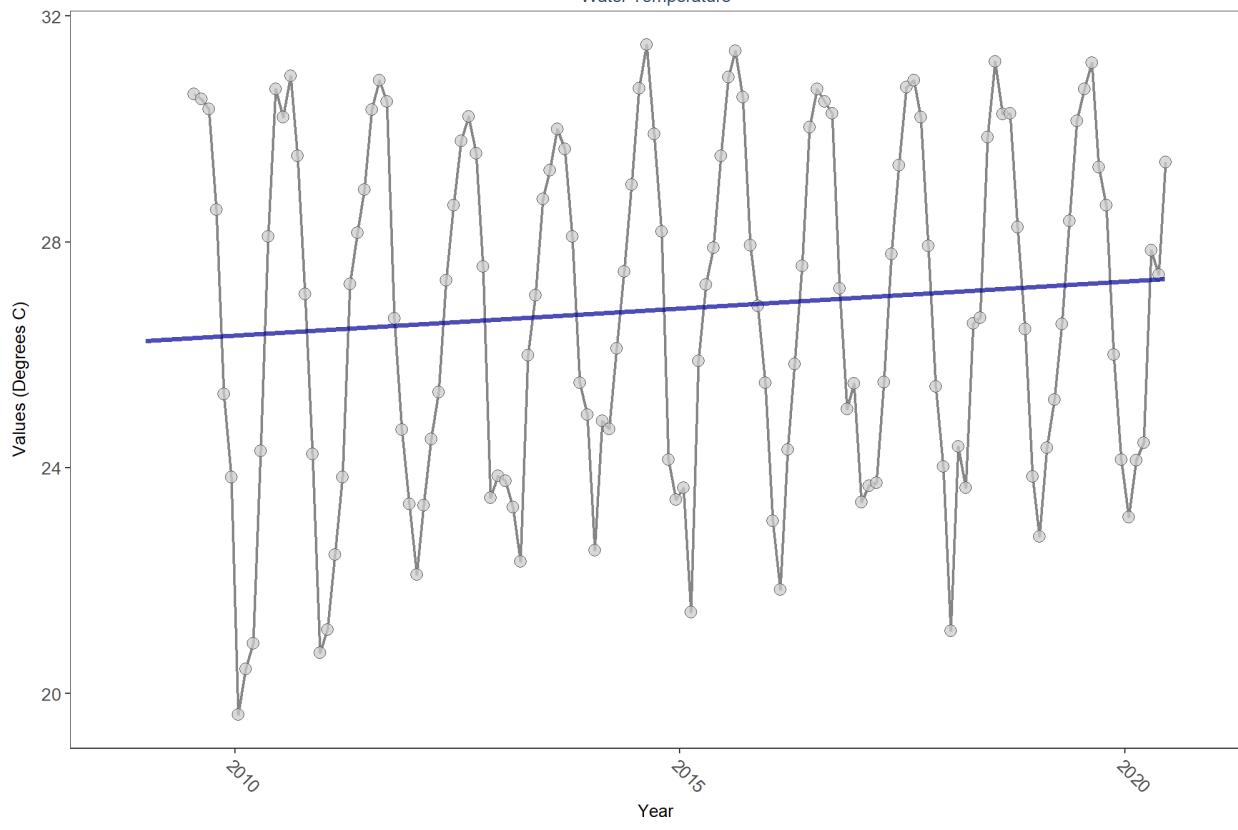


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	37528	5	27.03	1	0.2222	0.1413	0.2439309	26.24477	9.5385	0.5723	0

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 22  
 Water Temperature

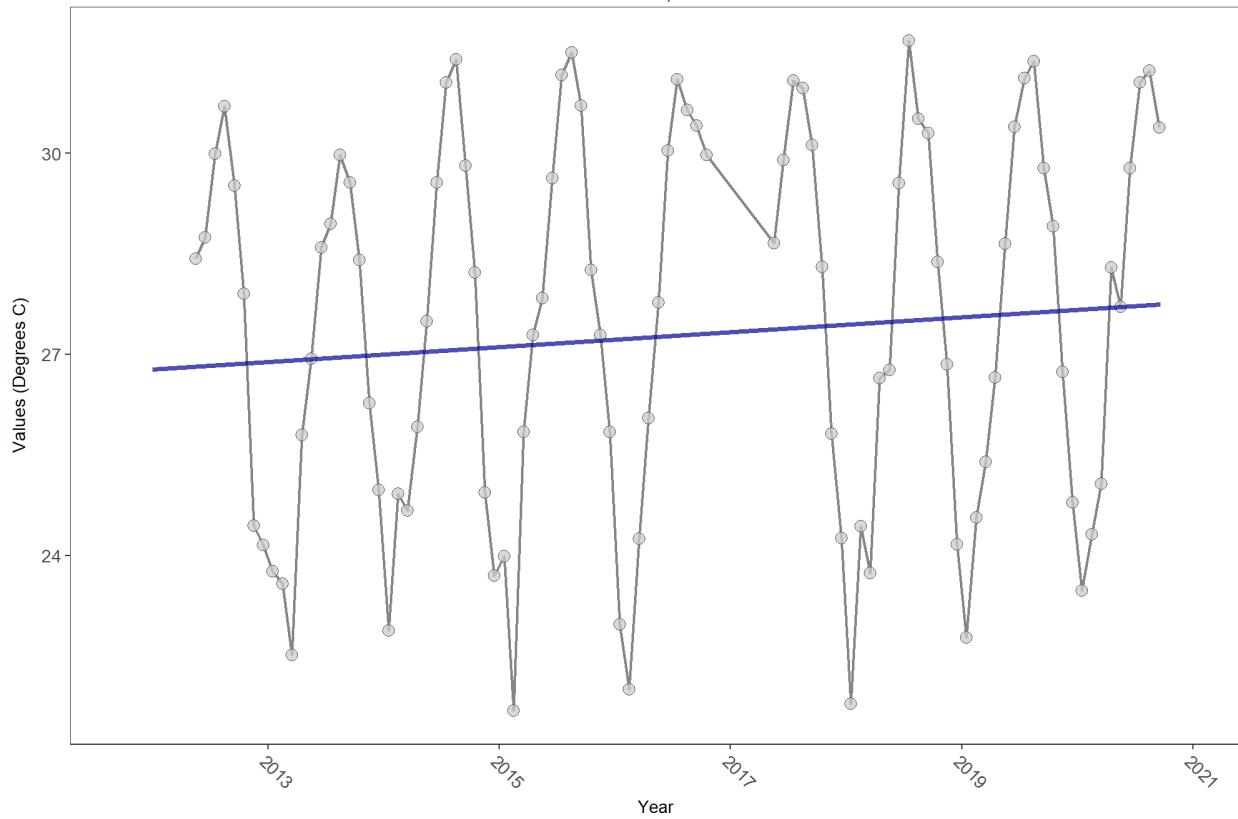


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	153217	12	26.84	1	0.2545	0.0002	0.09575023	26.24964	5.7939	0.8868	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 23  
 Water Temperature

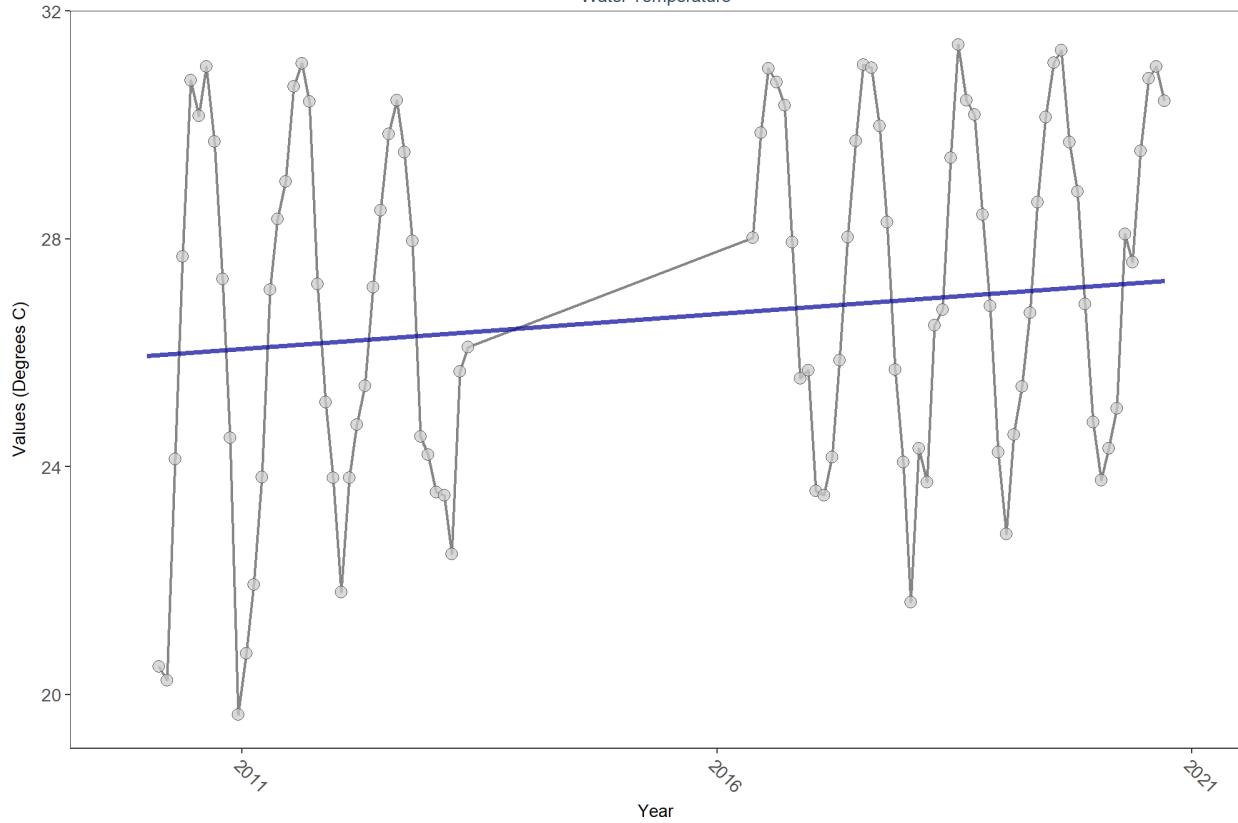


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	98738	9	27.53	1	0.2737	0.0012	0.111081	26.77649	7.7737	0.7334	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 24  
 Water Temperature

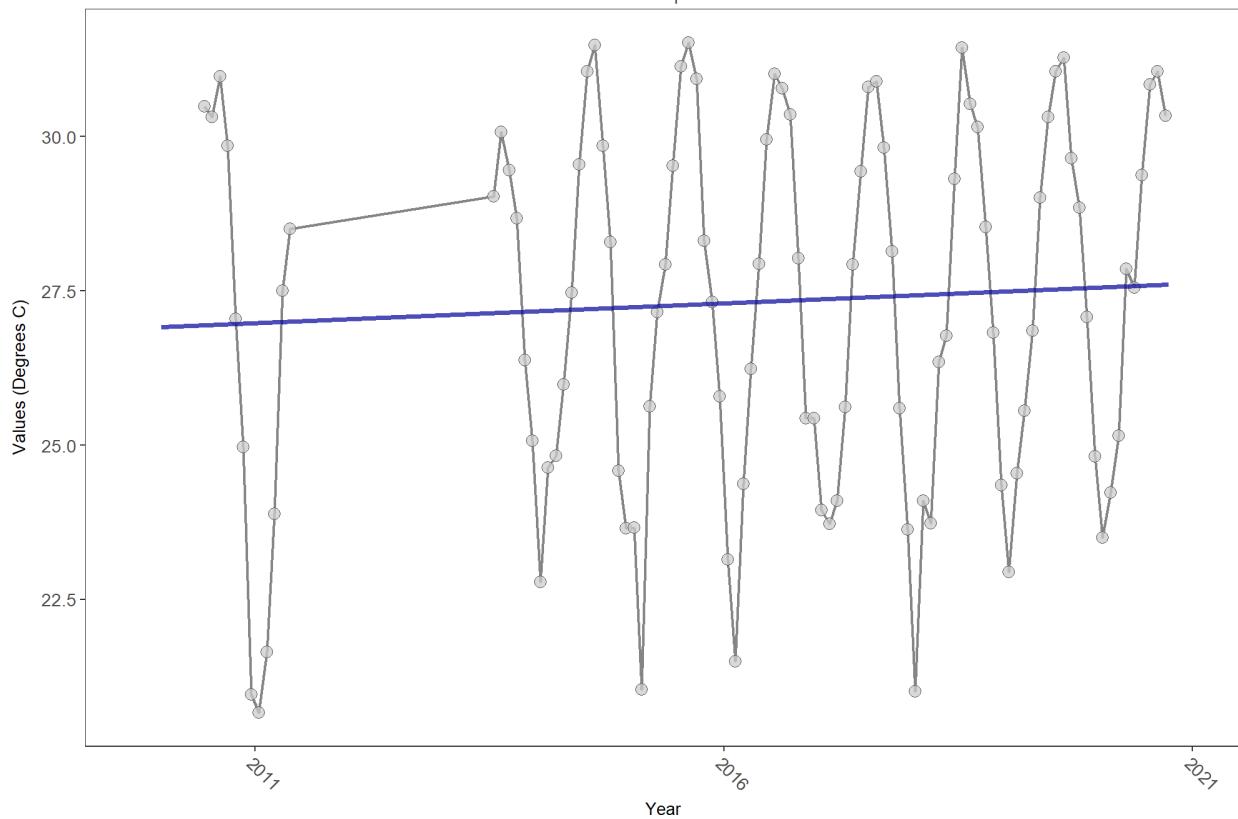


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	96894	9	27.03	1	0.4293	0	0.1227725	25.94573	11.5007	0.4023	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 25  
 Water Temperature

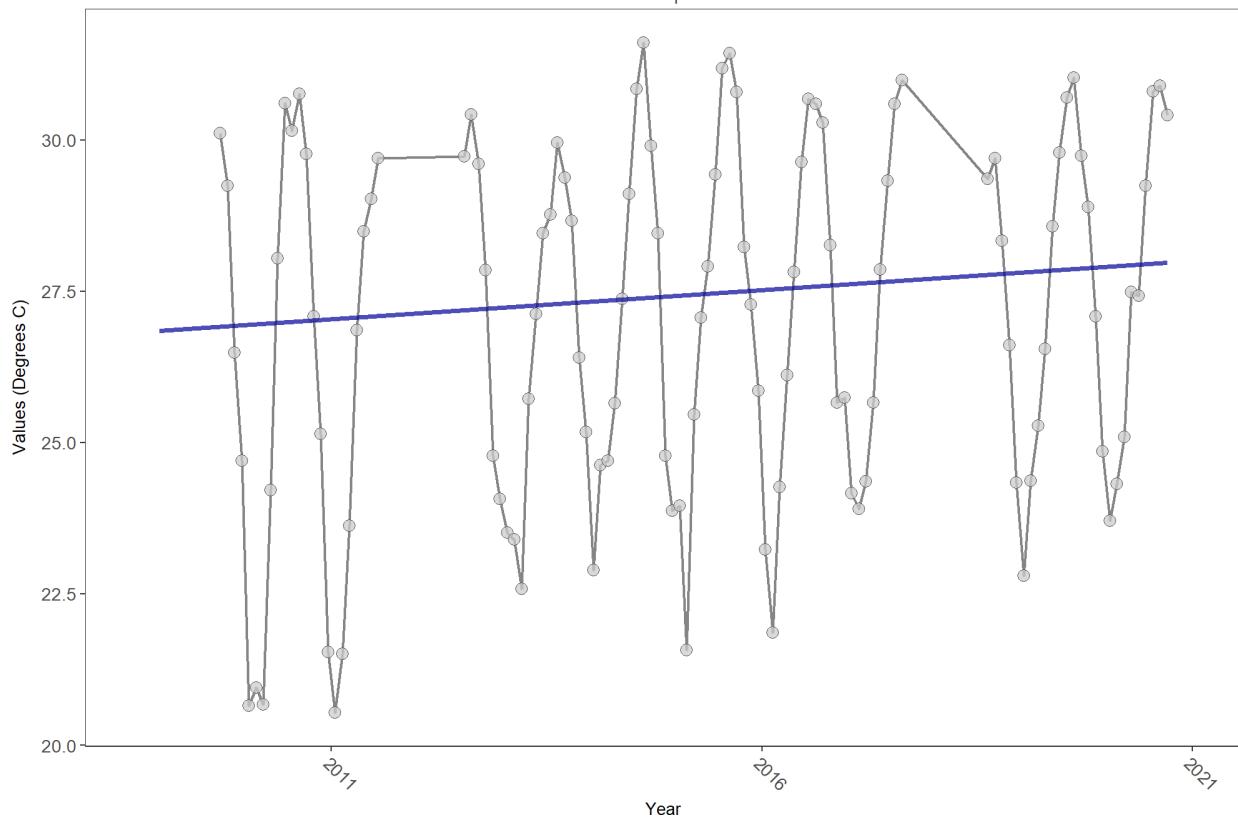


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	102442	10	27.33	1	0.1443	0.0827	0.0640786	26.91524	7.2424	0.7791	0

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 26  
 Water Temperature

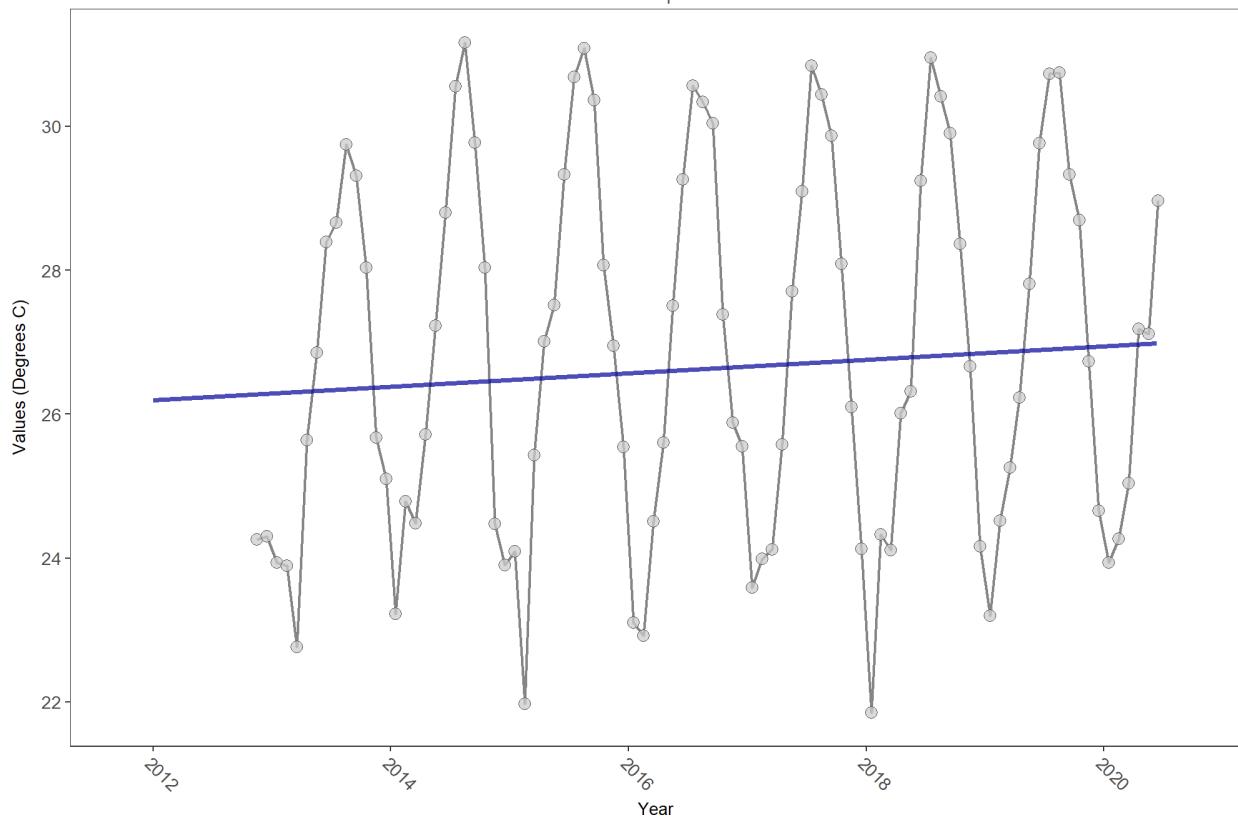


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	126819	12	27.038	1	0.2798	0.0003	0.09620927	26.85033	5.2996	0.9158	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 30  
 Water Temperature

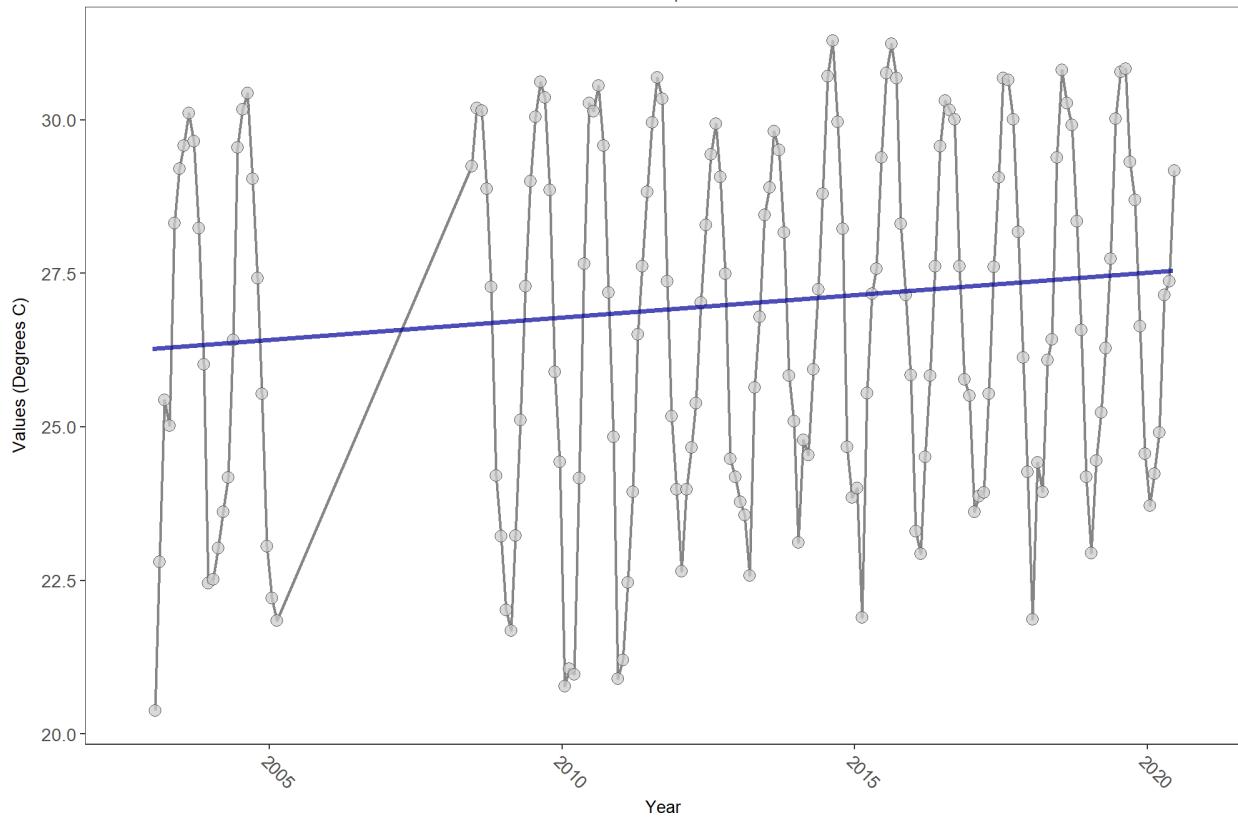


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	98315	9	26.5	1	0.2774	0.0017	0.09363973	26.19655	9.8319	0.5456	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 32  
 Water Temperature

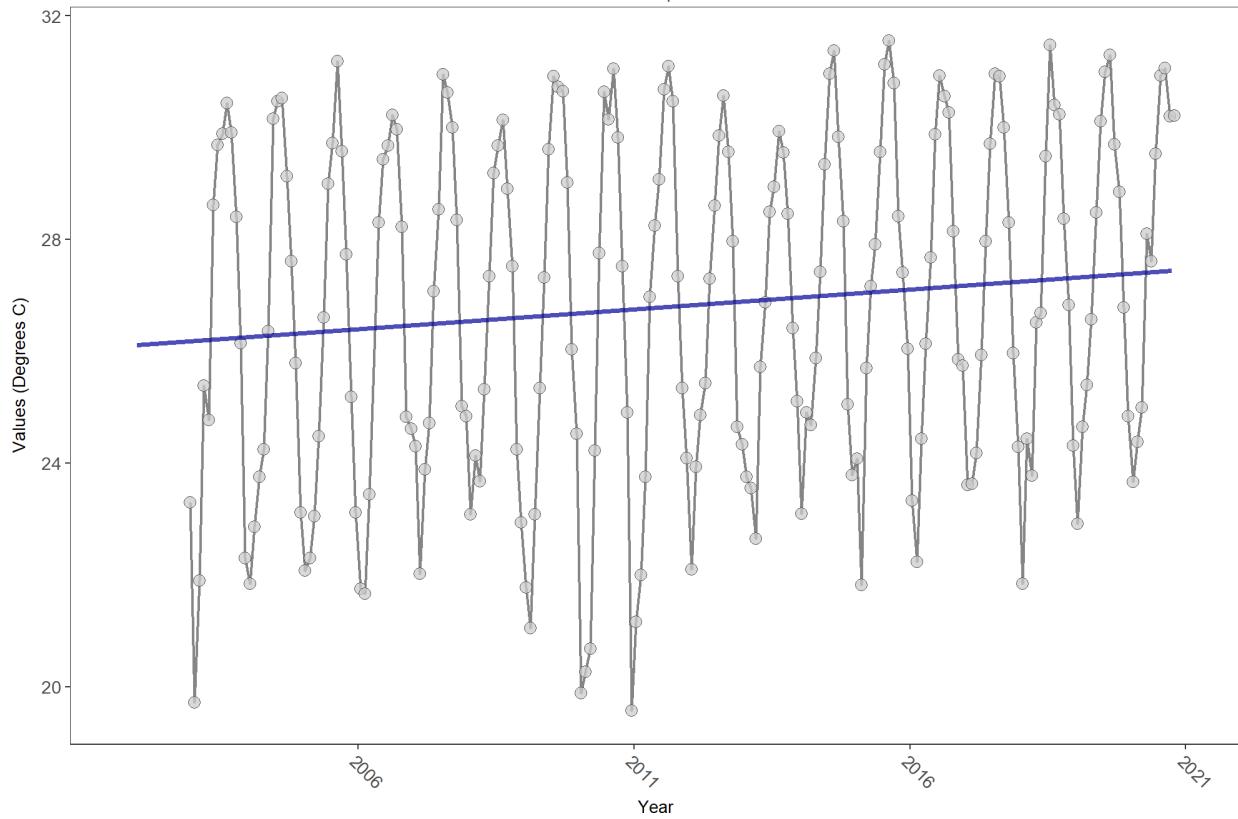


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	204791	16	26.622	1	0.3156	0	0.07297449	26.27038	8.4203	0.6752	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 34  
 Water Temperature

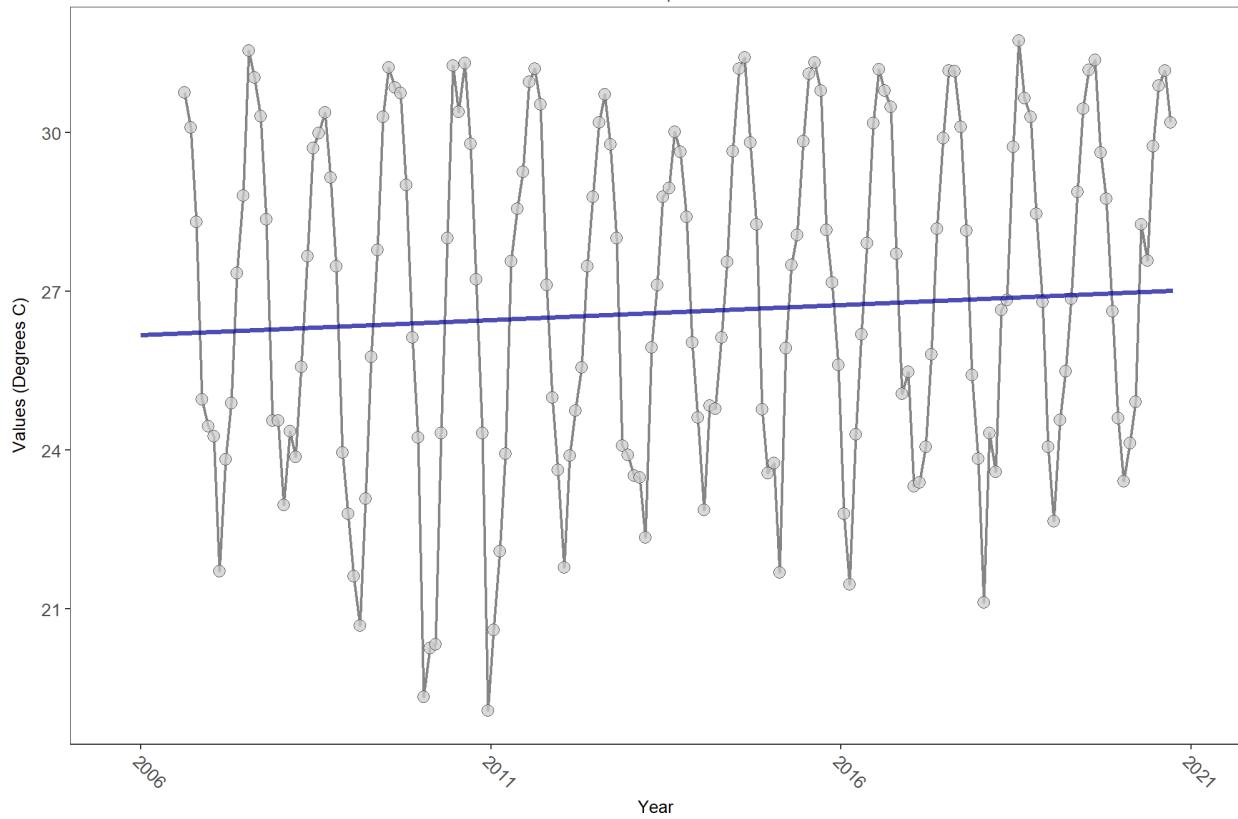


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	259849	19	26.76	1	0.3125	0	0.07057085	26.11442	7.8296	0.7285	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 35  
 Water Temperature

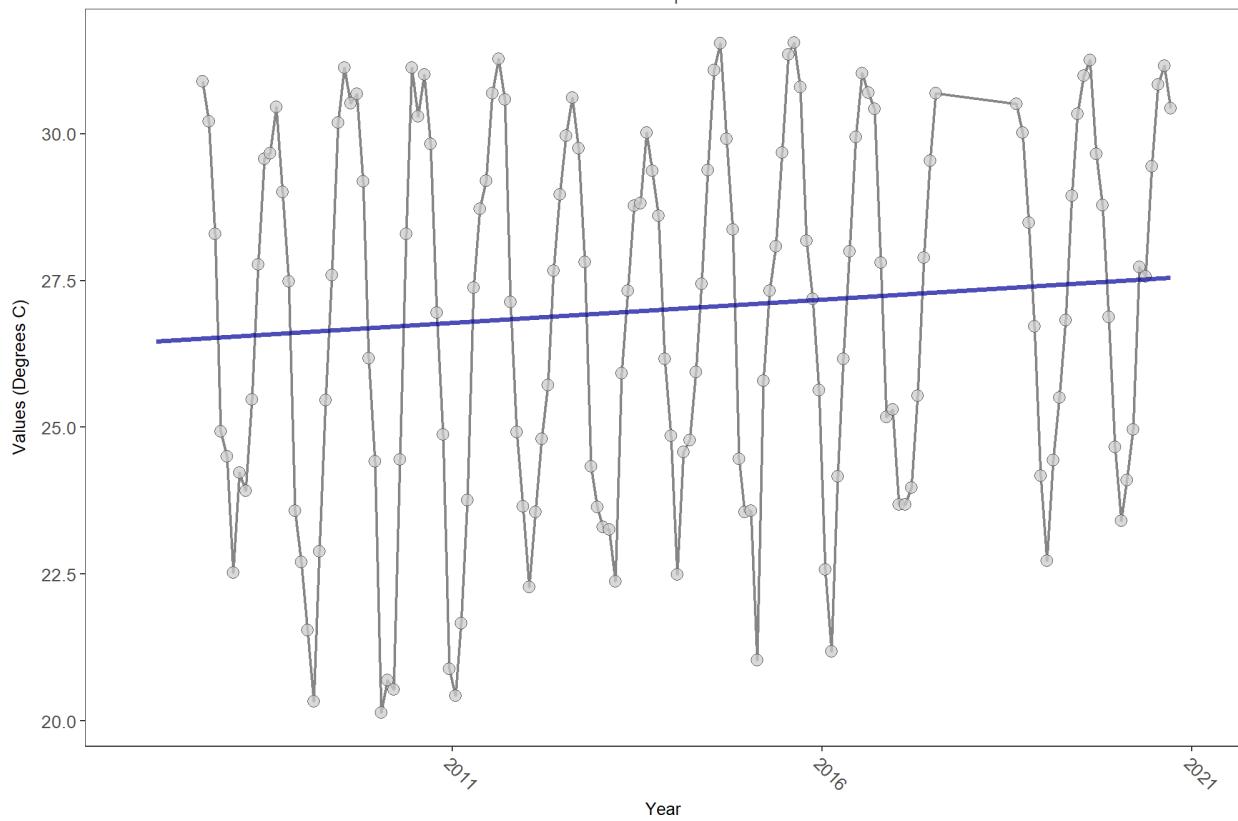


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	203527	15	26.91	1	0.2213	0.0001	0.05687933	26.17344	7.2565	0.7779	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 36  
 Water Temperature

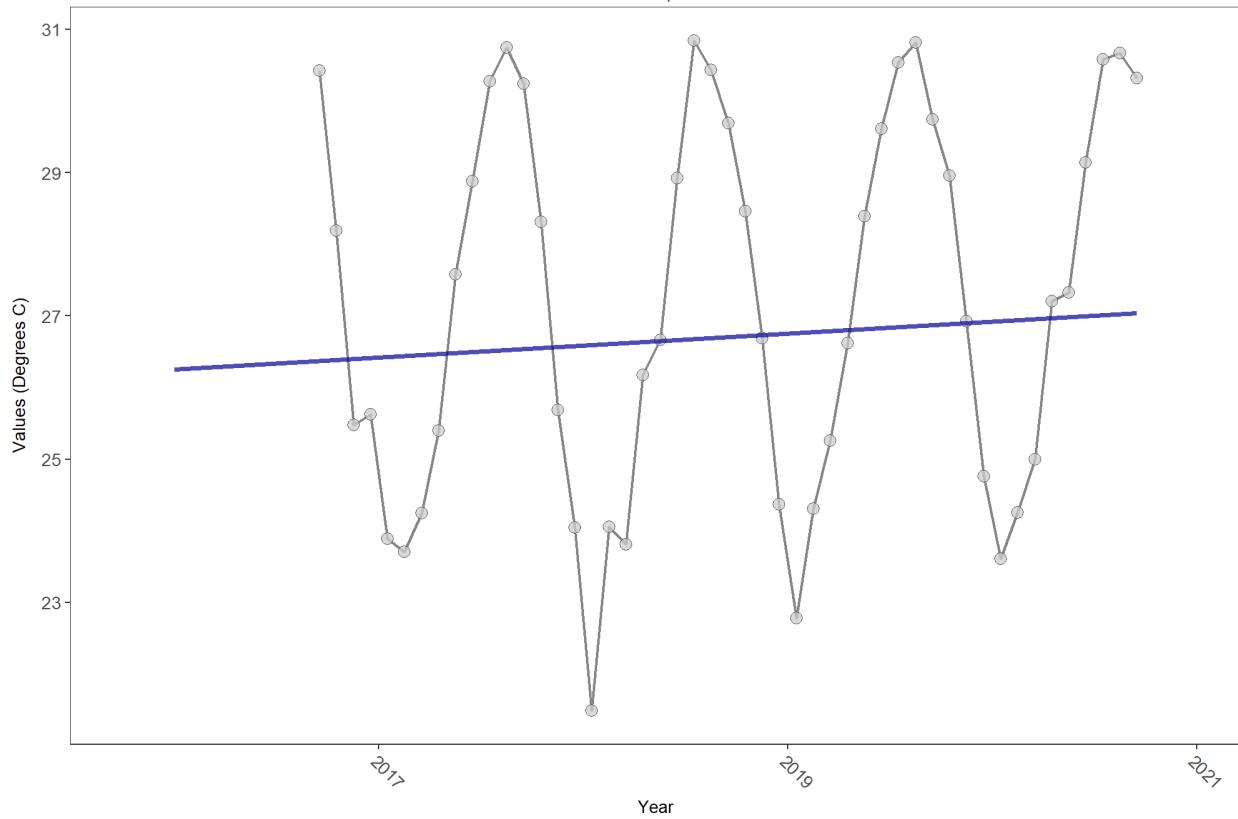


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	177700	14	26.96	1	0.2667	0	0.0793049	26.45765	6.7054	0.8224	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

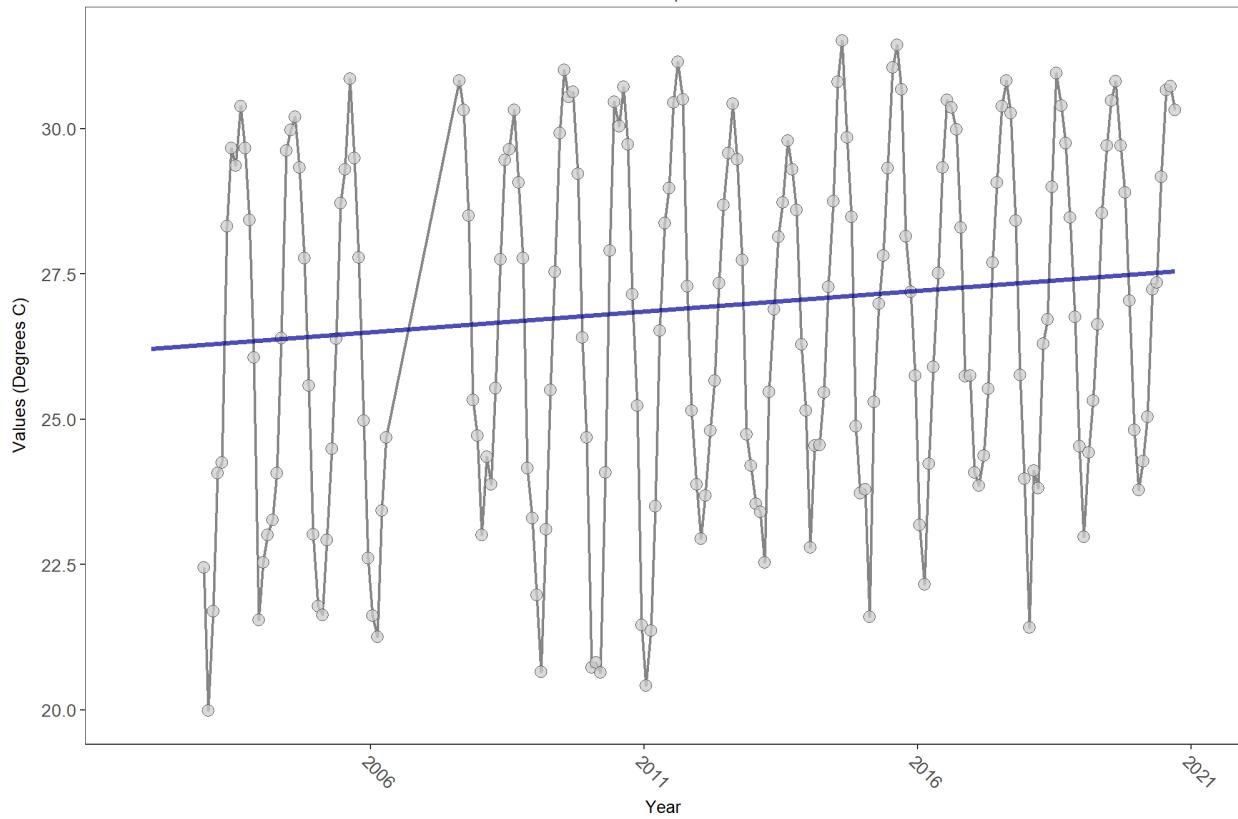
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 37  
 Water Temperature



*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 38  
 Water Temperature

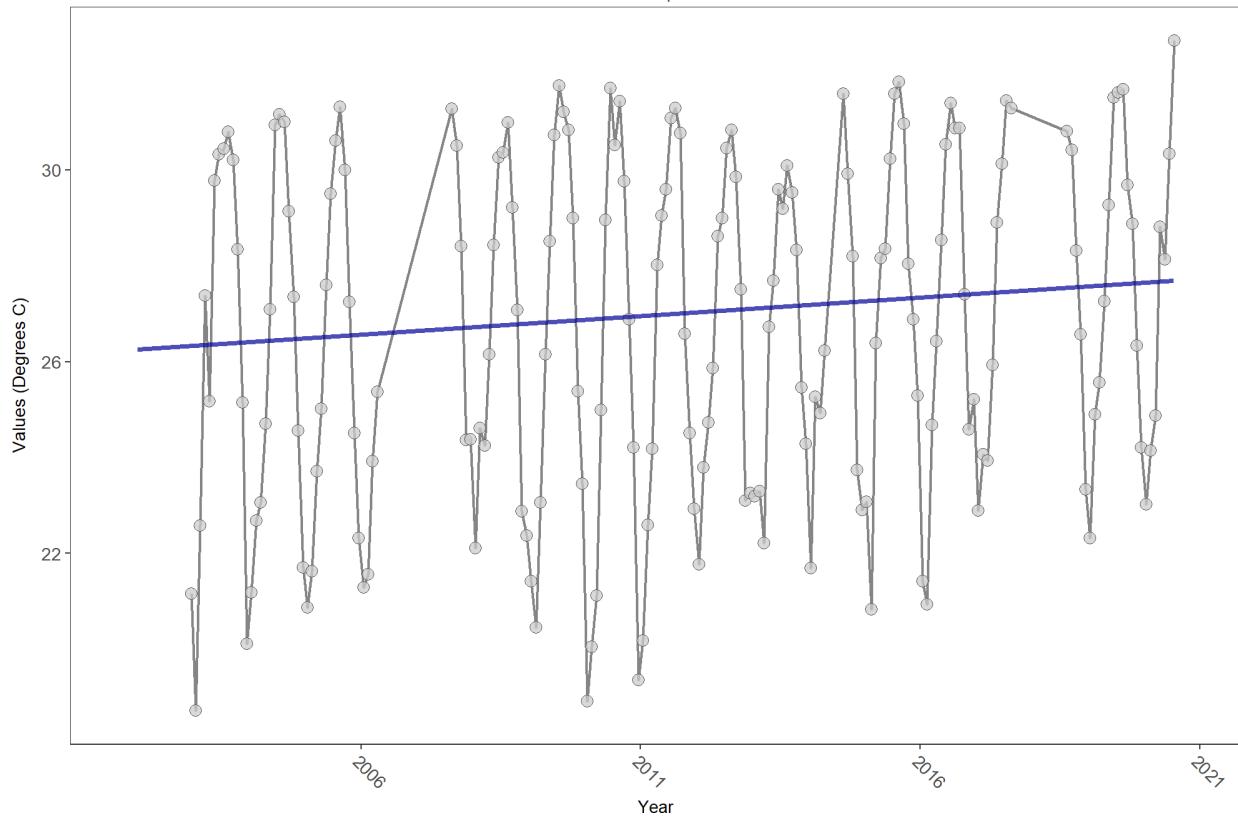


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	241060	19	26.475	1	0.2853	0	0.0713552	26.21232	13.6376	0.2537	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 40  
 Water Temperature

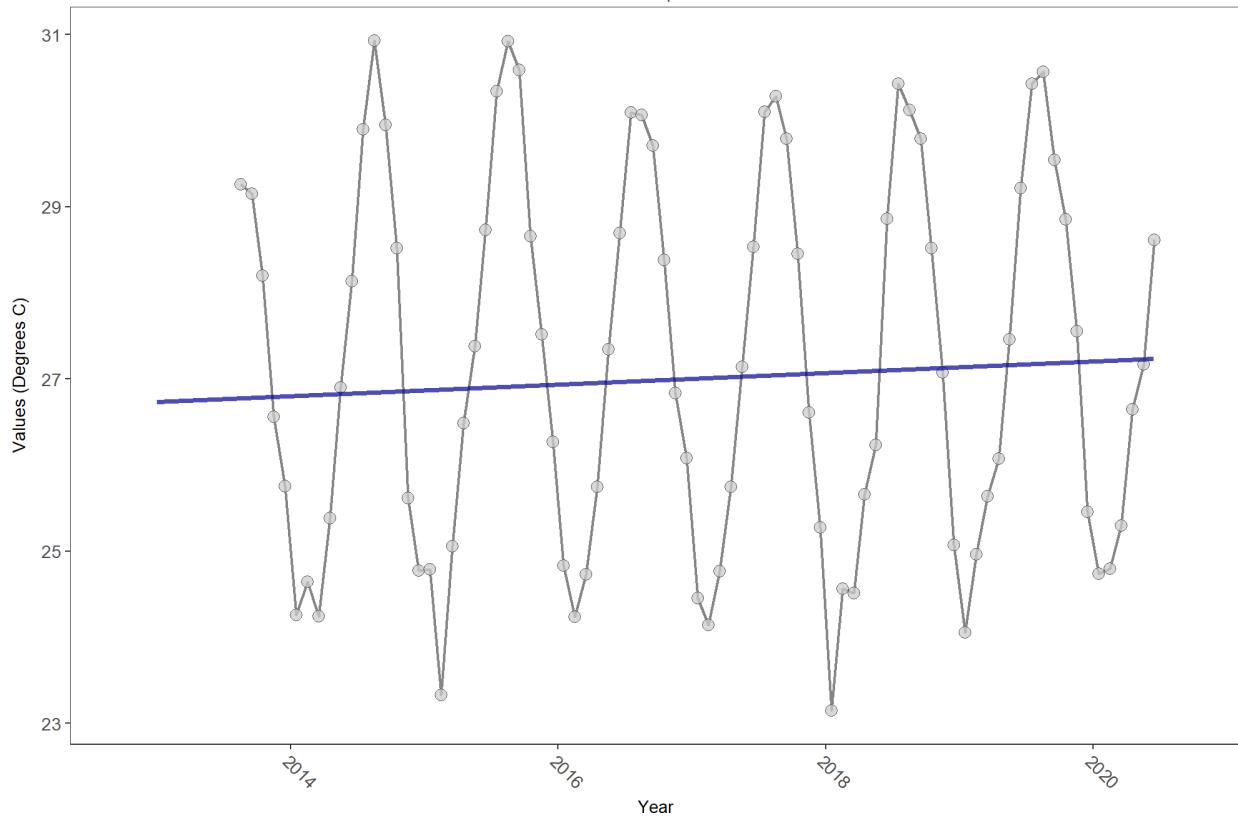


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	227464	19	26.74	1	0.2841	0	0.0772293	26.25809	10.0502	0.5259	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 50  
 Water Temperature

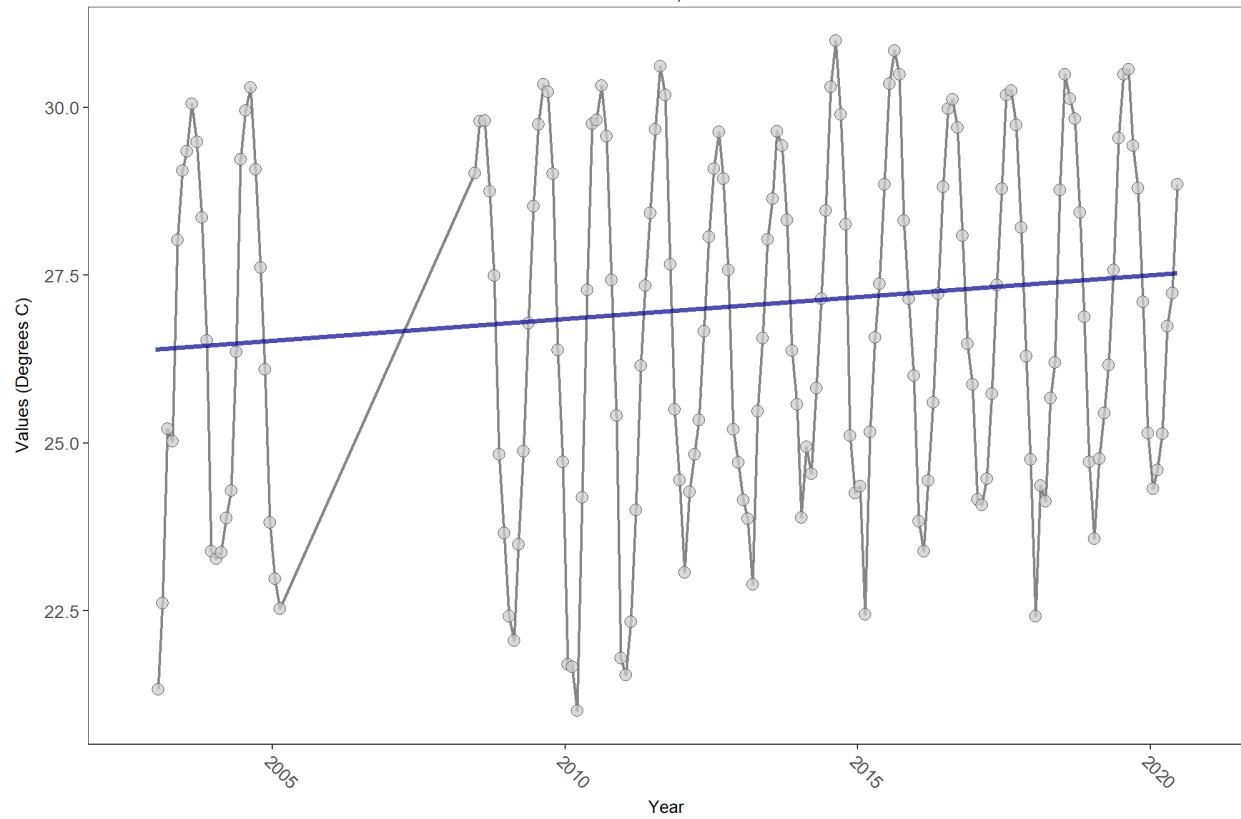


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	85807	8	26.96	1	0.2498	0.0094	0.0666686	26.73252	8.6639	0.6529	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 51  
 Water Temperature

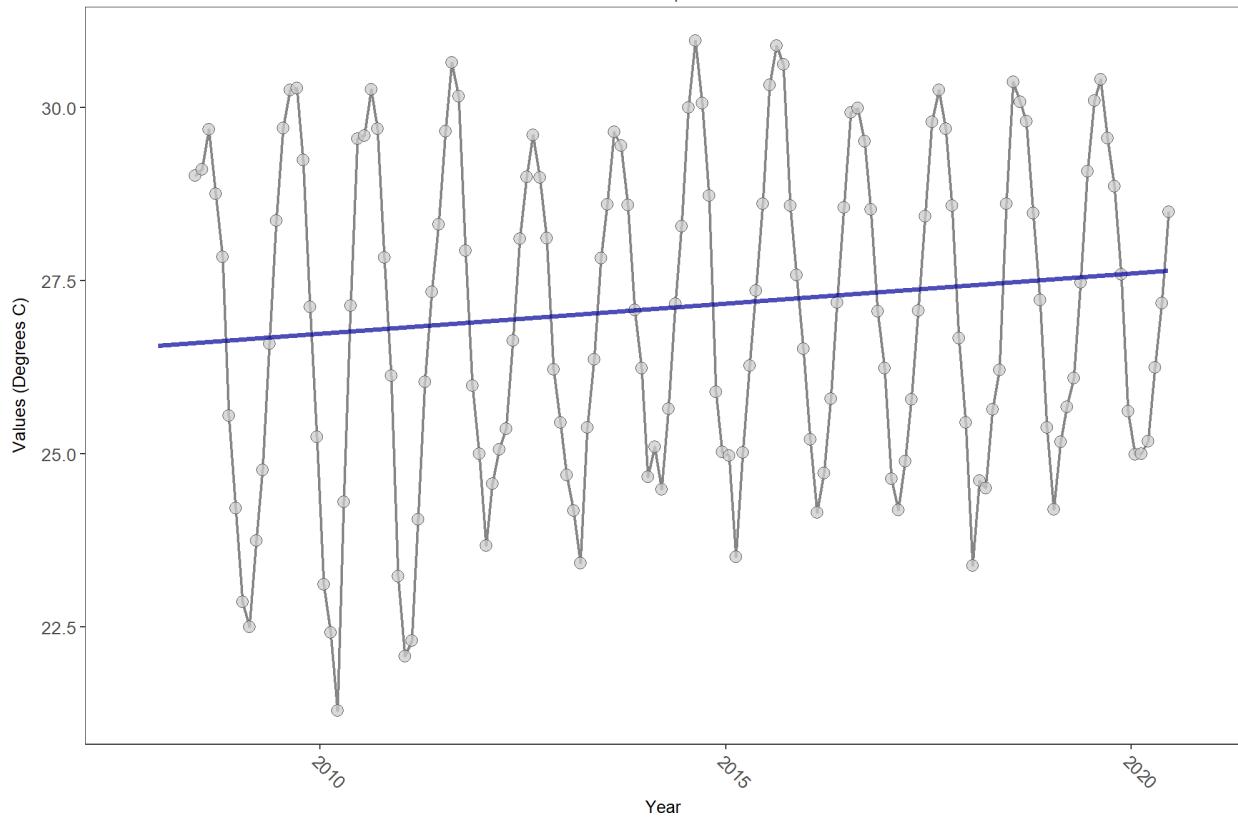


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	204634	16	26.622	1	0.3004	0	0.06535237	26.39176	10.5362	0.4829	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 52  
 Water Temperature

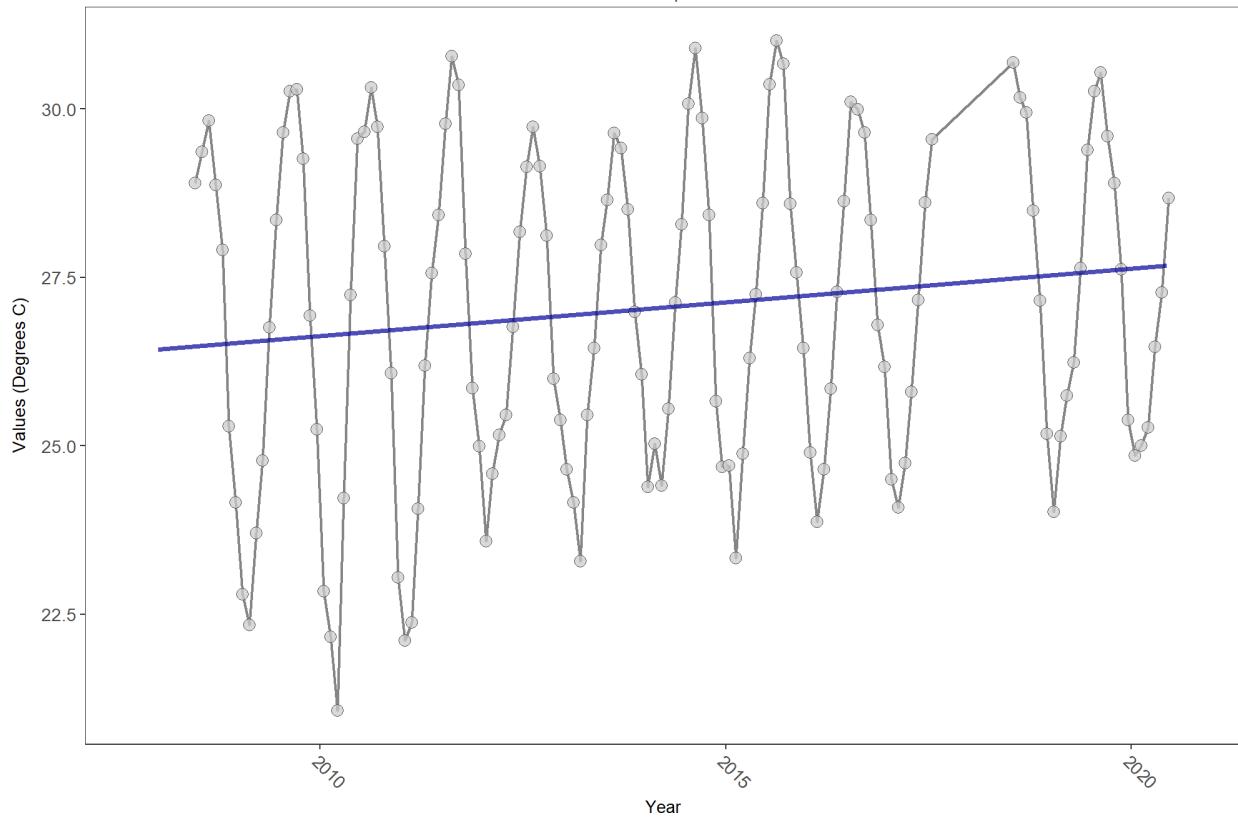


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	169996	13	26.867	1	0.3478	0	0.08700706	26.56397	7.1057	0.7905	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 53  
 Water Temperature

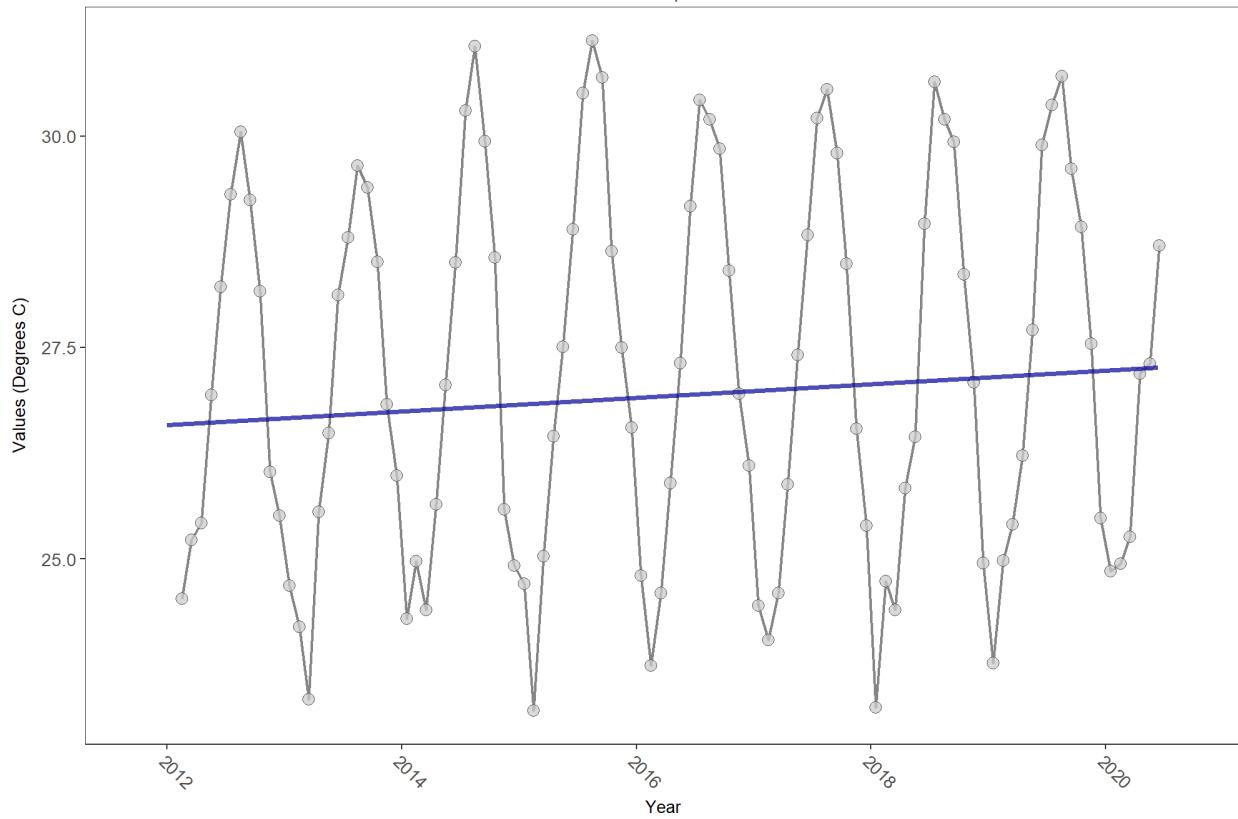


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	161093	13	26.916	1	0.4092	0	0.1001453	26.43179	5.3908	0.9108	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 54  
 Water Temperature

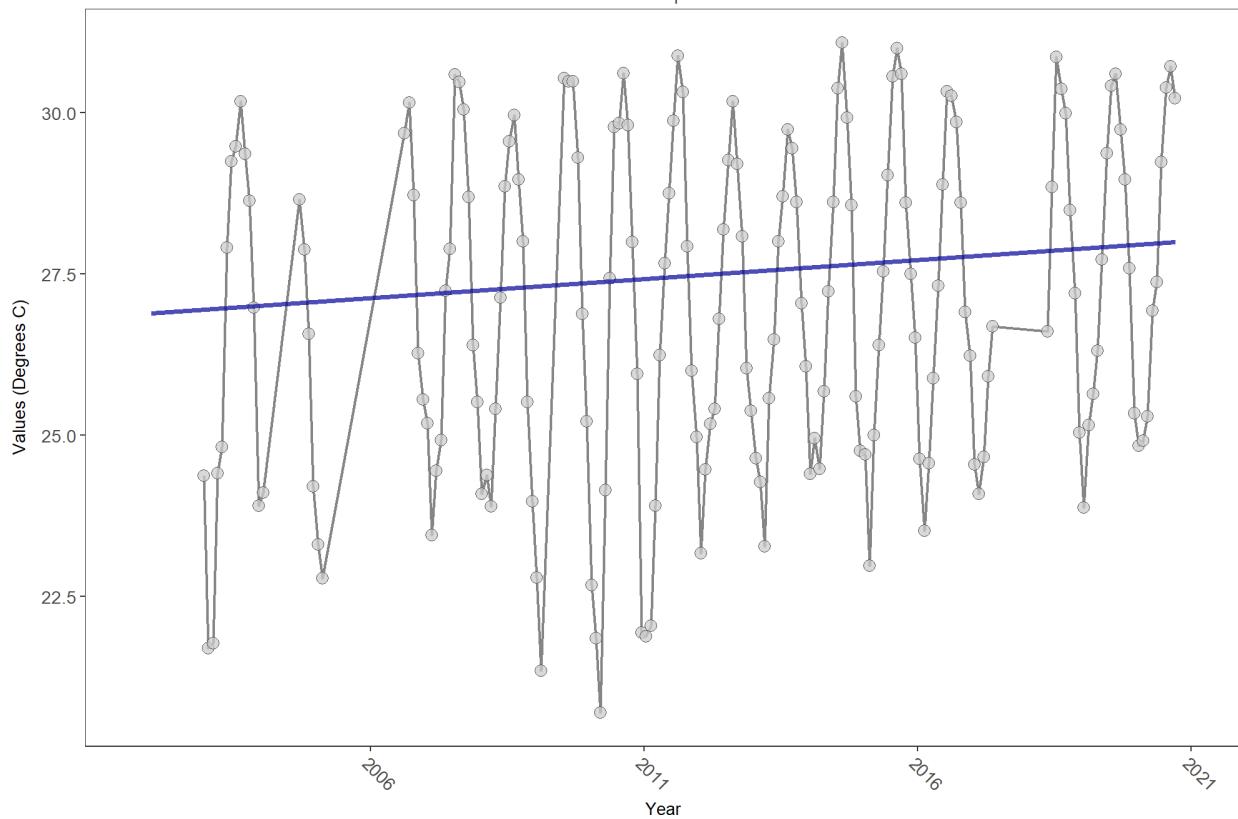


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	110666	9	26.94	1	0.2914	0.0002	0.08076204	26.58215	6.8185	0.8136	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 55  
 Water Temperature

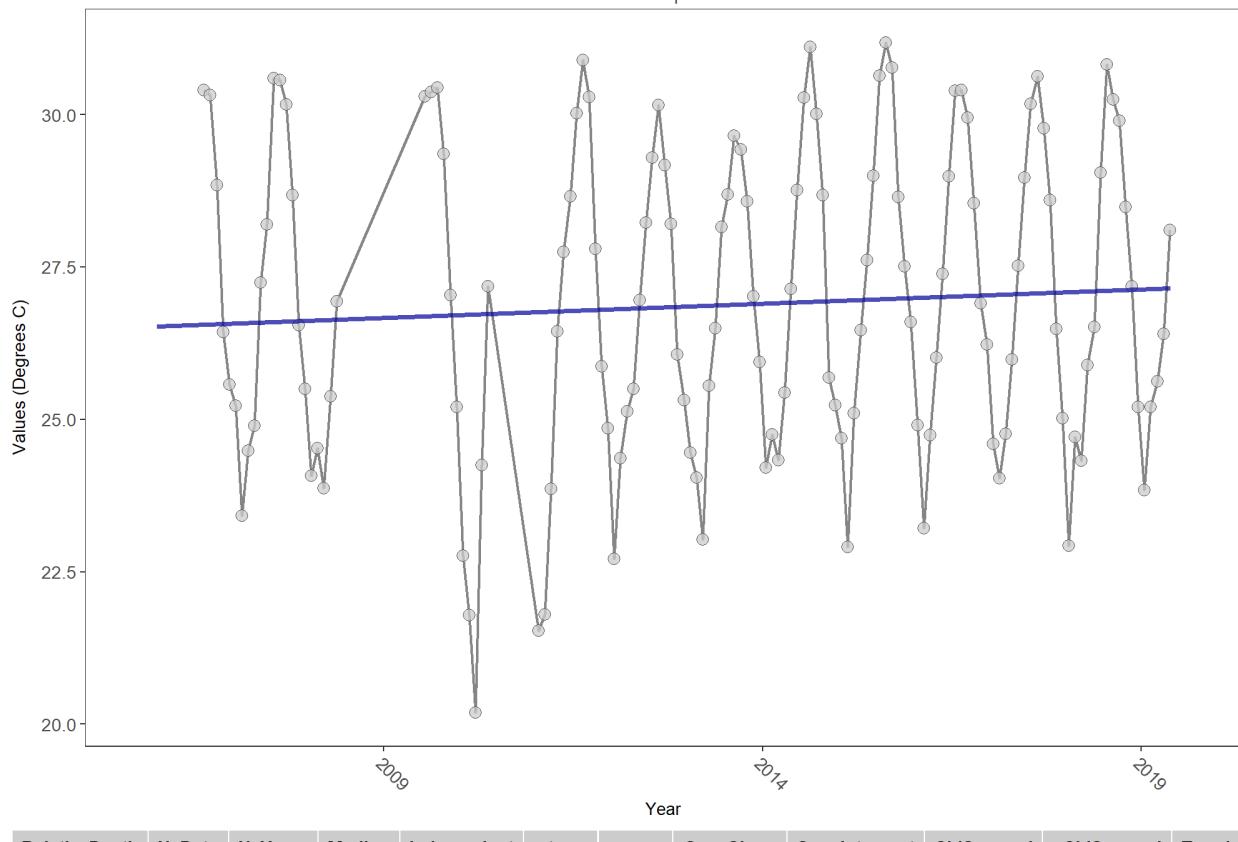


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	211140	19	26.89	1	0.2907	0	0.05894649	26.89647	11.5041	0.4021	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

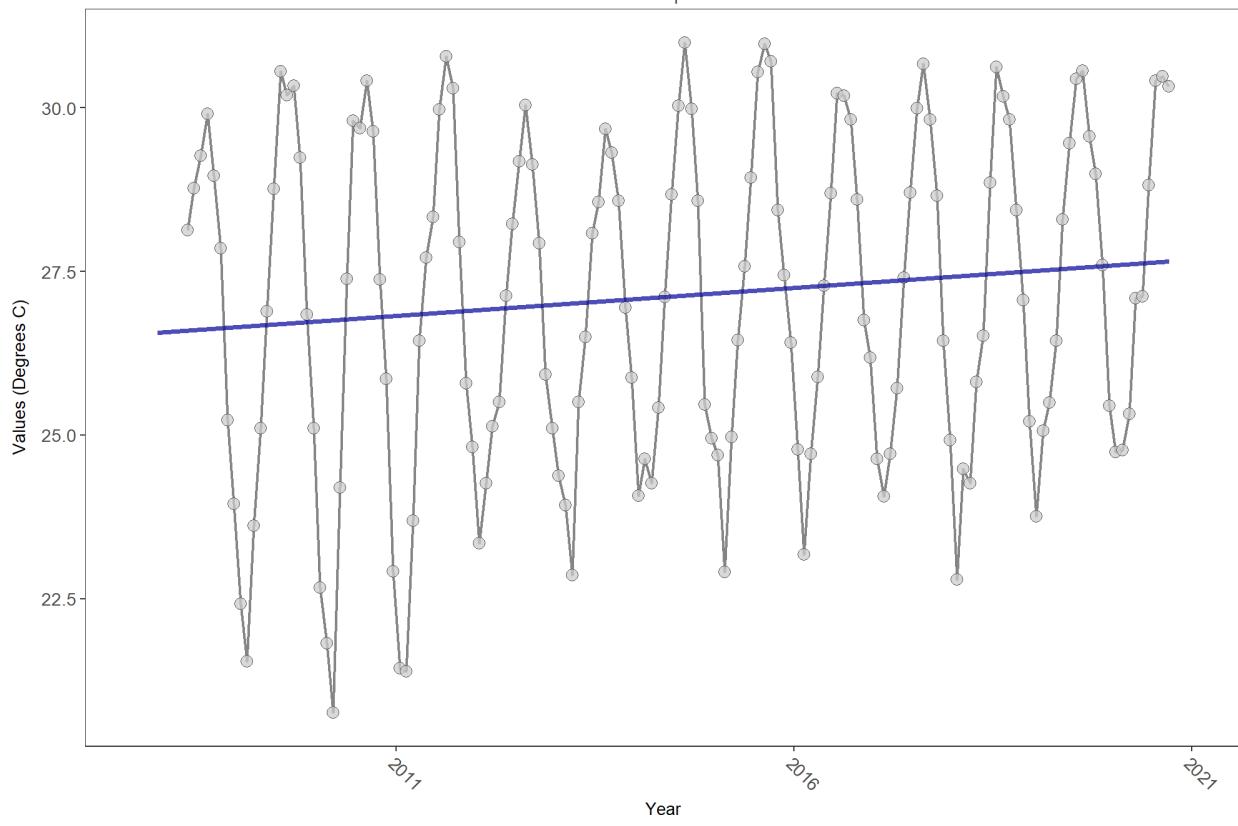
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 56  
 Water Temperature



$p < 0.00005$  appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 57  
 Water Temperature

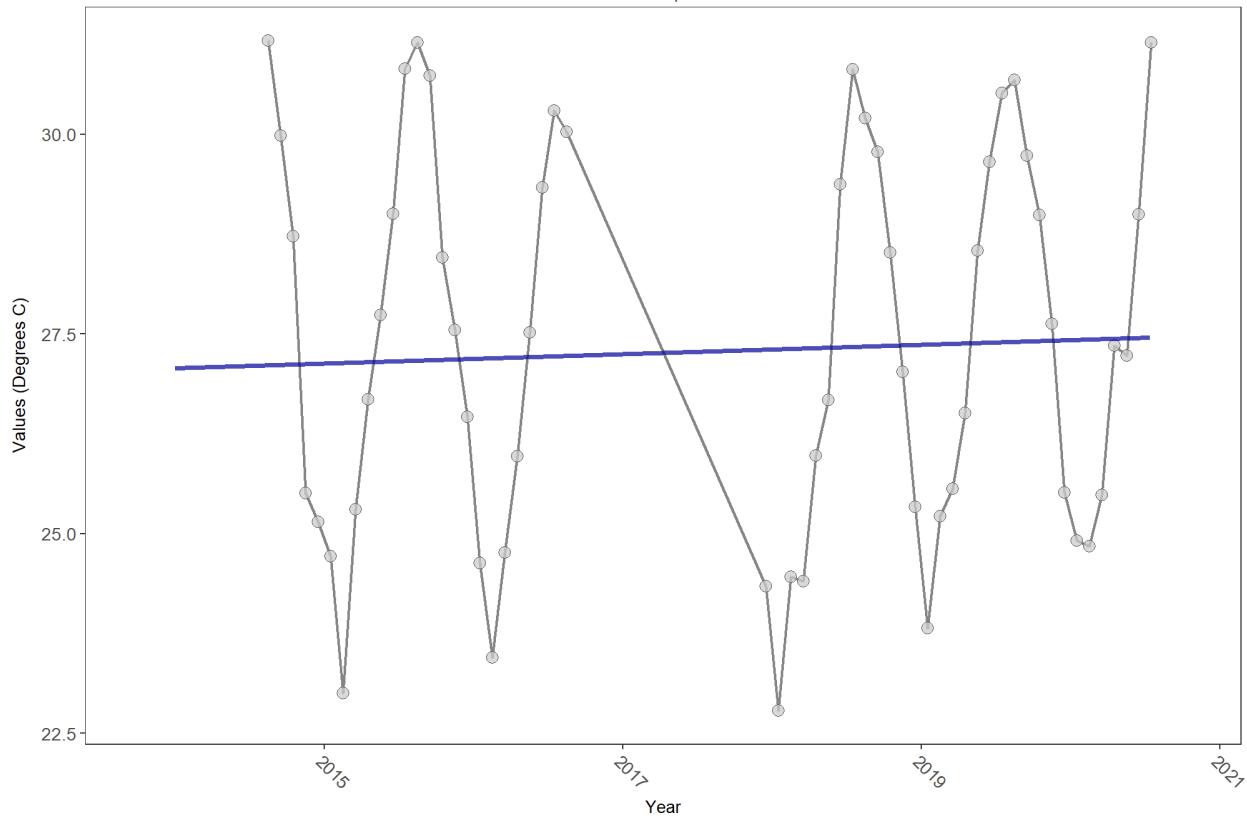


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	173342	13	27.038	1	0.348	0	0.08585187	26.56696	9.2987	0.5943	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 58  
 Water Temperature

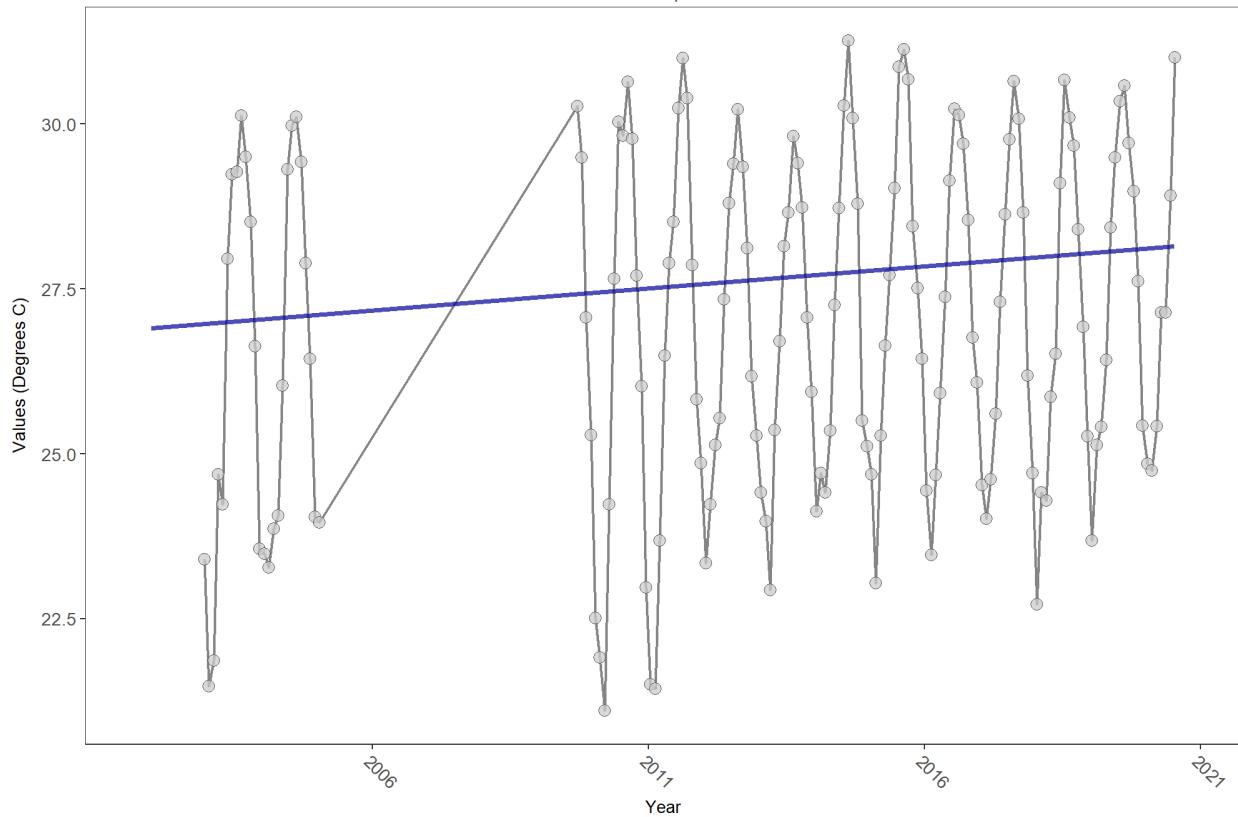


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	55530	7	27.16	1	0.1462	0.2582	0.05875328	27.07077	9.7071	0.5569	0

$p < 0.00005$  appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 59  
 Water Temperature

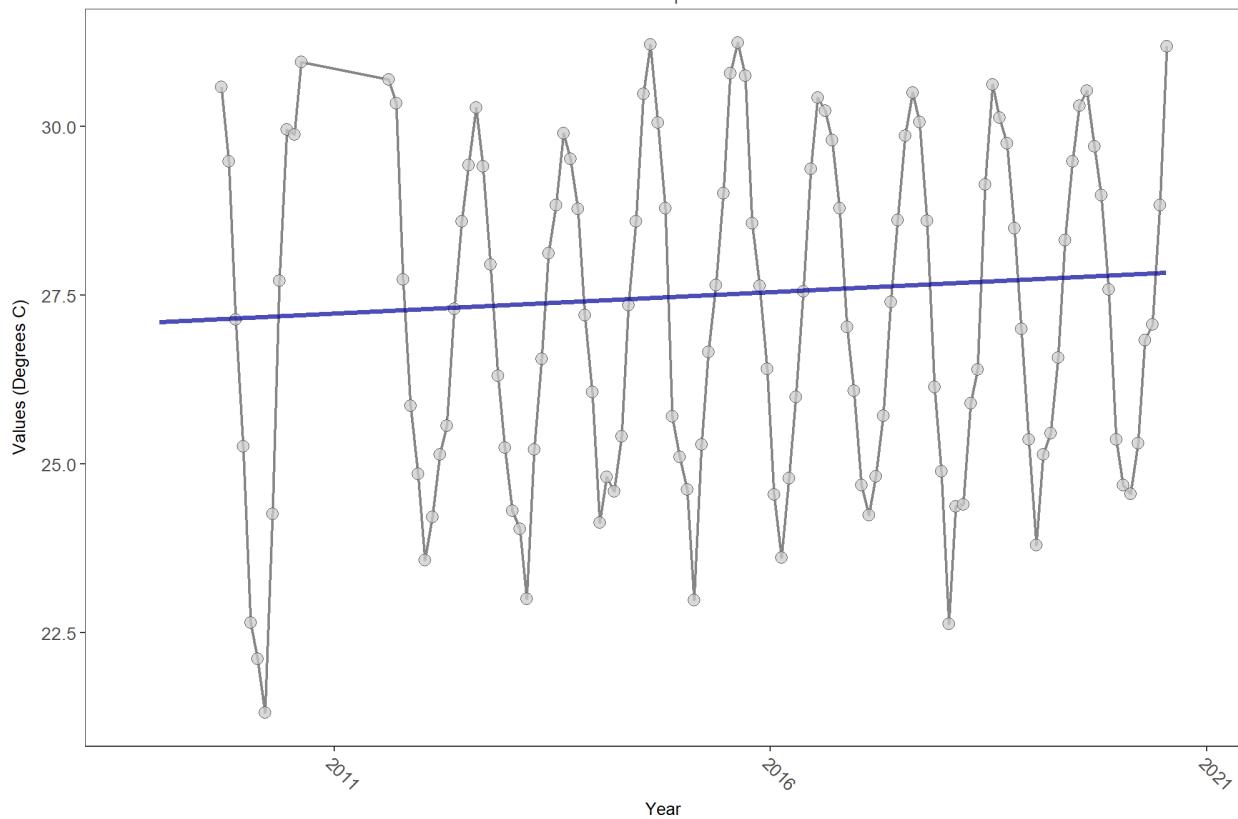


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	174994	16	26.793	1	0.2844	0	0.06708901	26.90262	14.5605	0.2035	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 60  
 Water Temperature

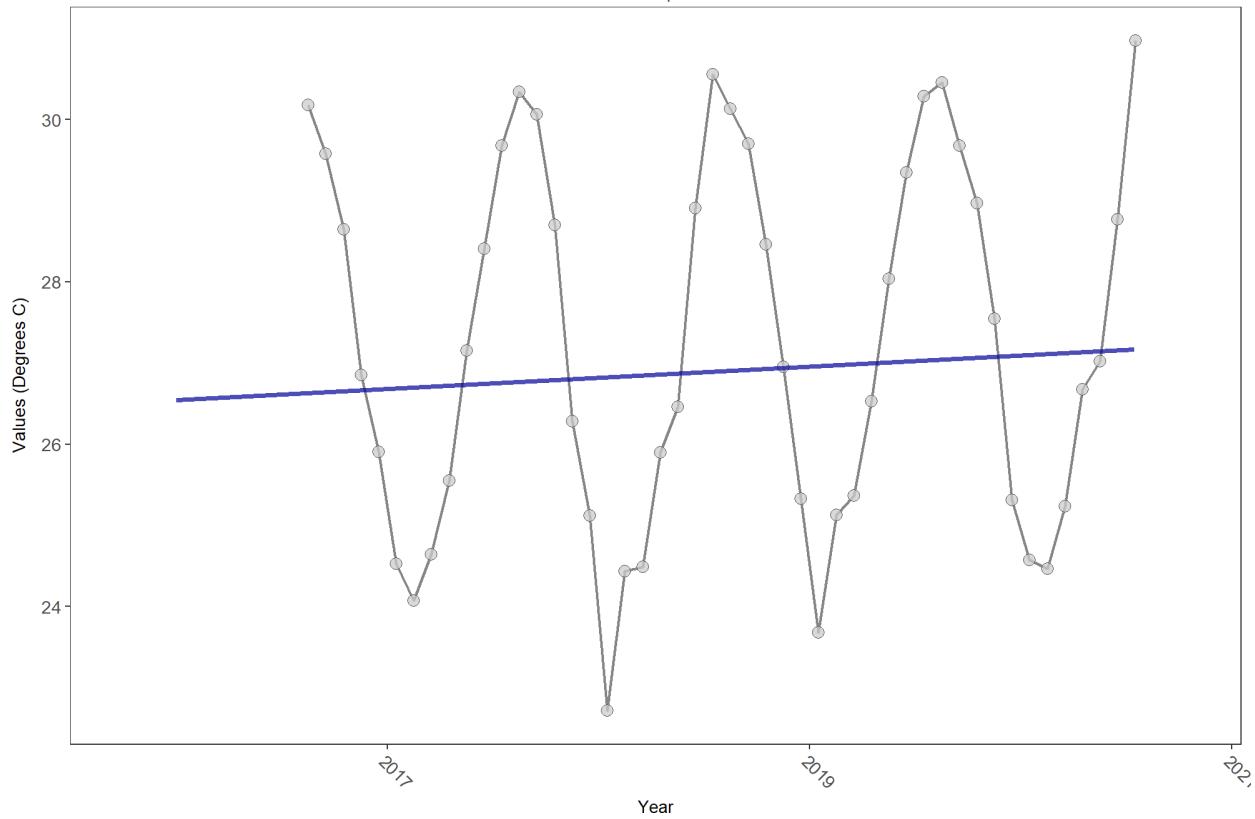


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	133358	12	26.94	1	0.2185	0.0025	0.06331076	27.10515	12.5093	0.3266	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

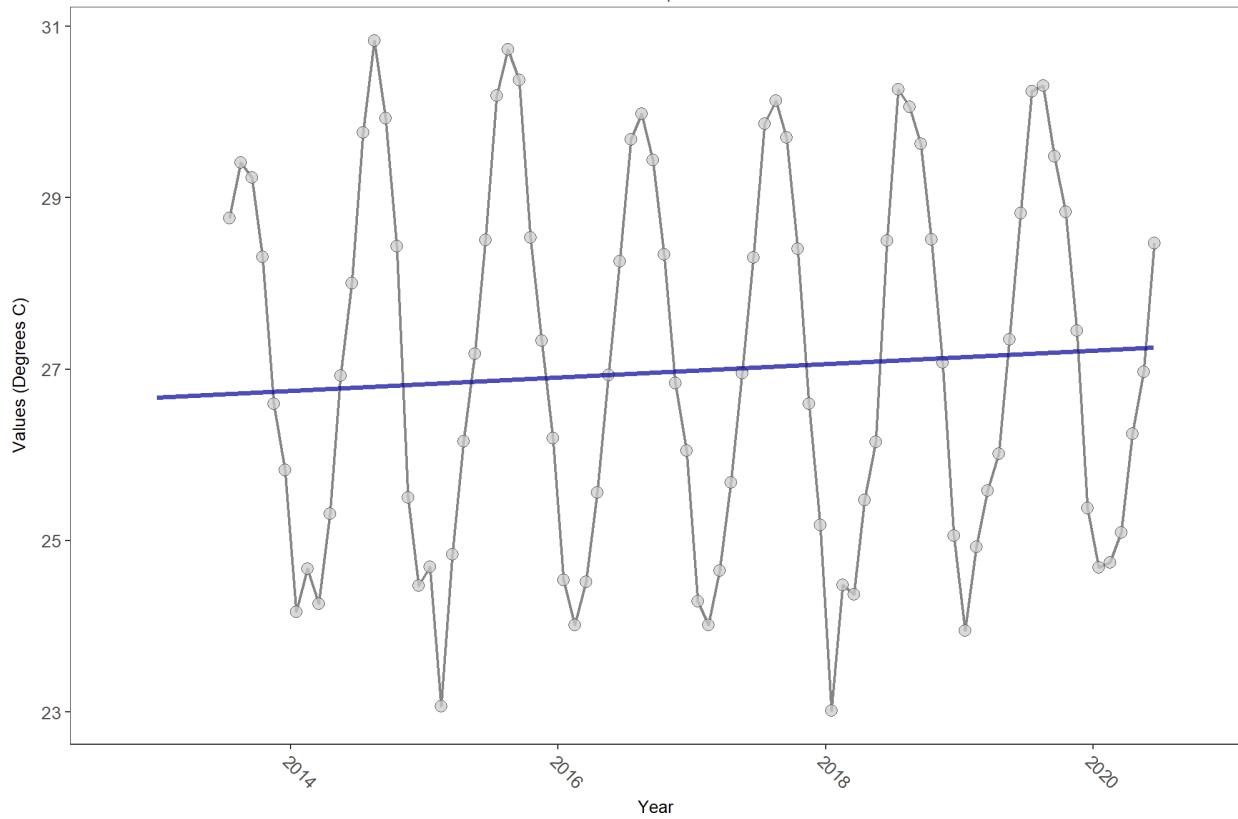
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 61  
 Water Temperature



*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

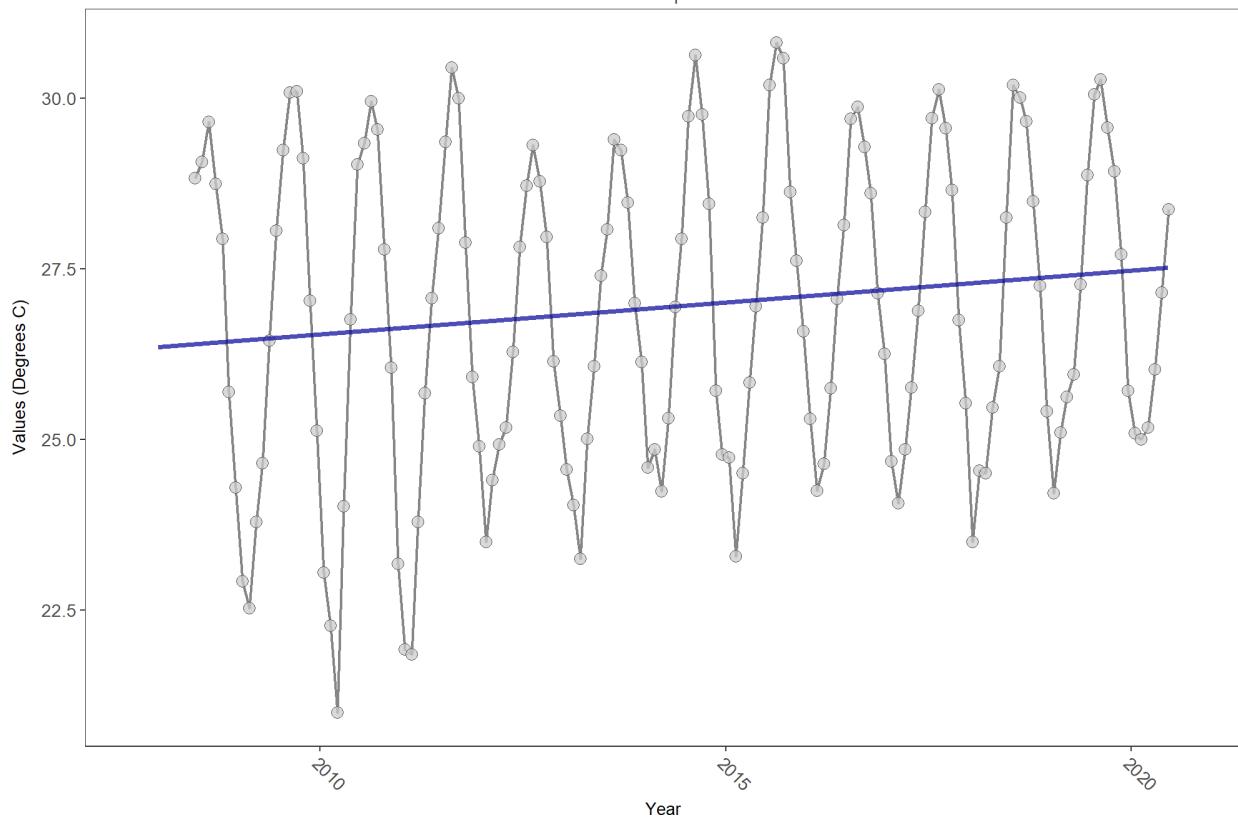
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 70  
 Water Temperature



*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 72  
 Water Temperature

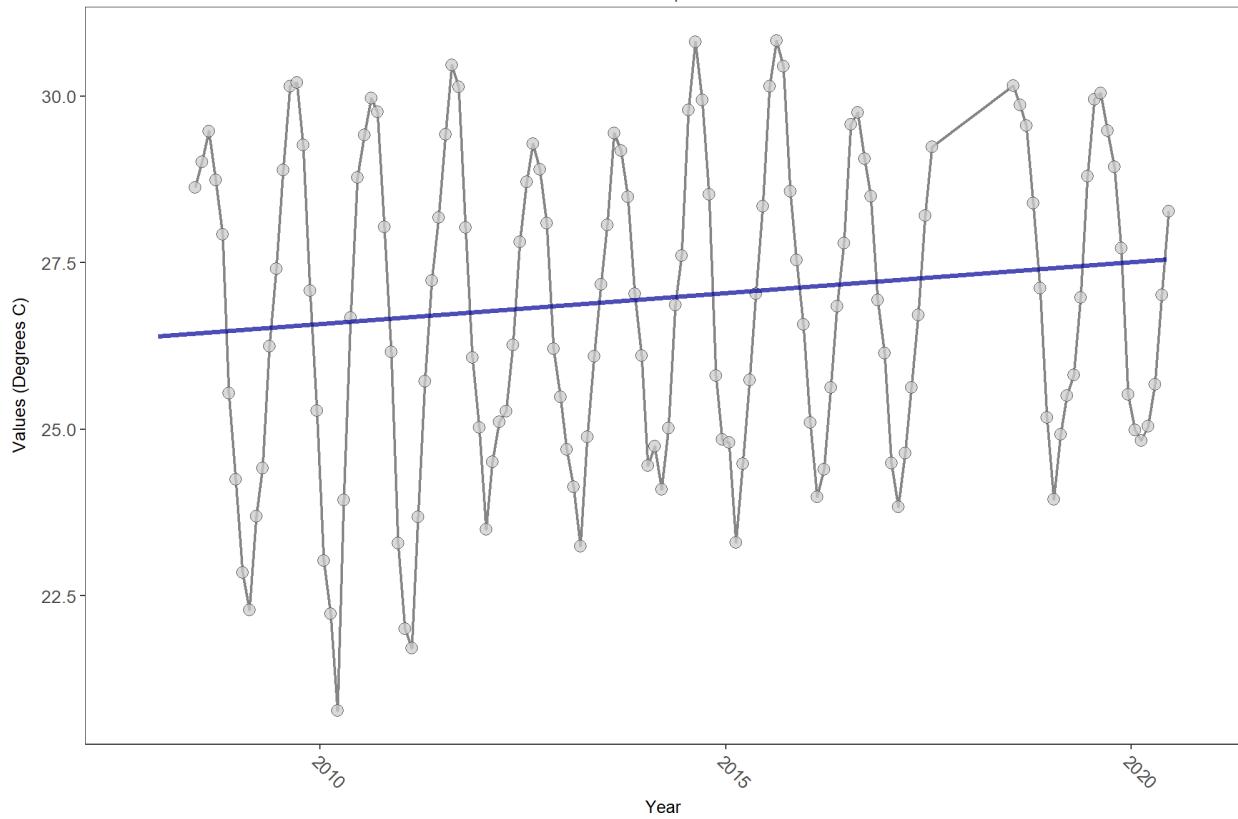


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	169973	13	26.72	1	0.4347	0	0.09338885	26.34968	6.6054	0.8301	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 73  
 Water Temperature

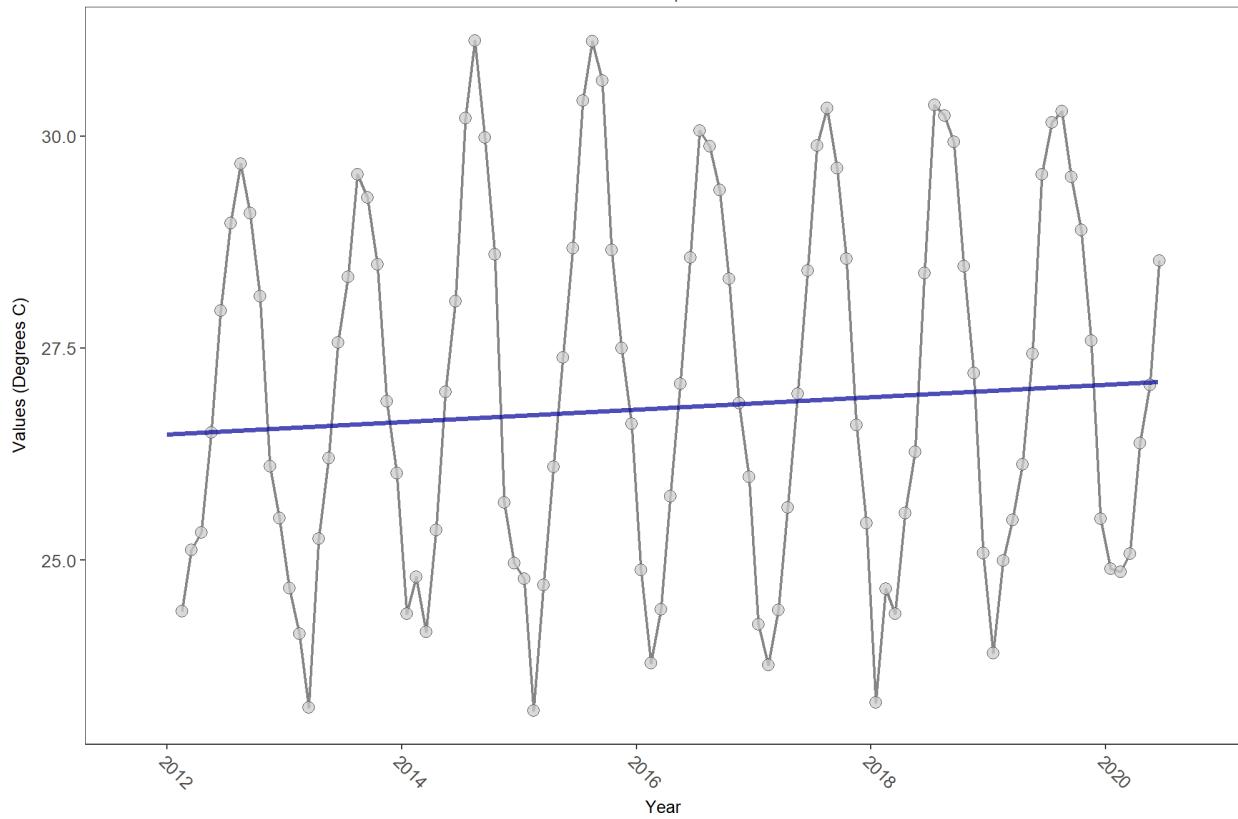


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	161075	13	26.67	1	0.3682	0	0.09312993	26.39139	6.4292	0.8432	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 74  
 Water Temperature

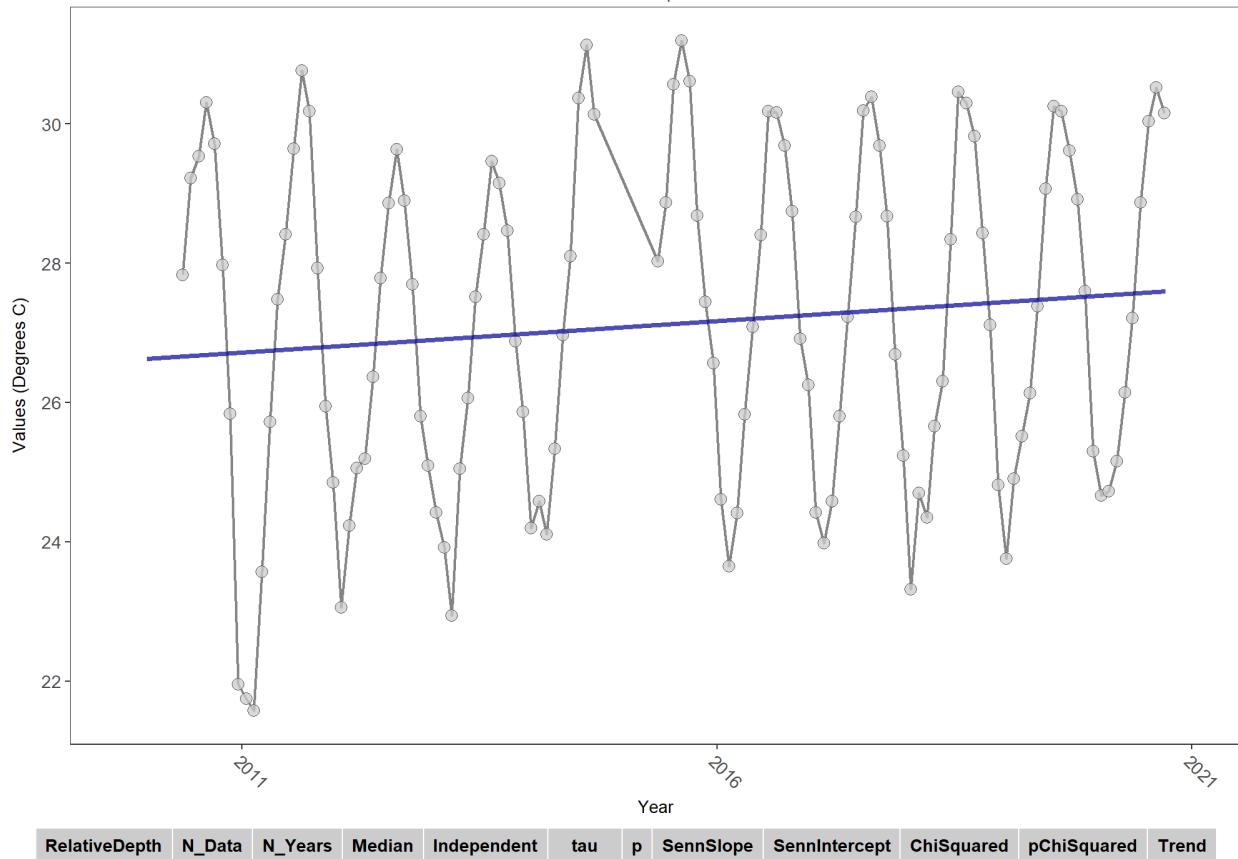


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	110611	9	26.769	1	0.2595	0.0011	0.07394046	26.47977	7.2199	0.781	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

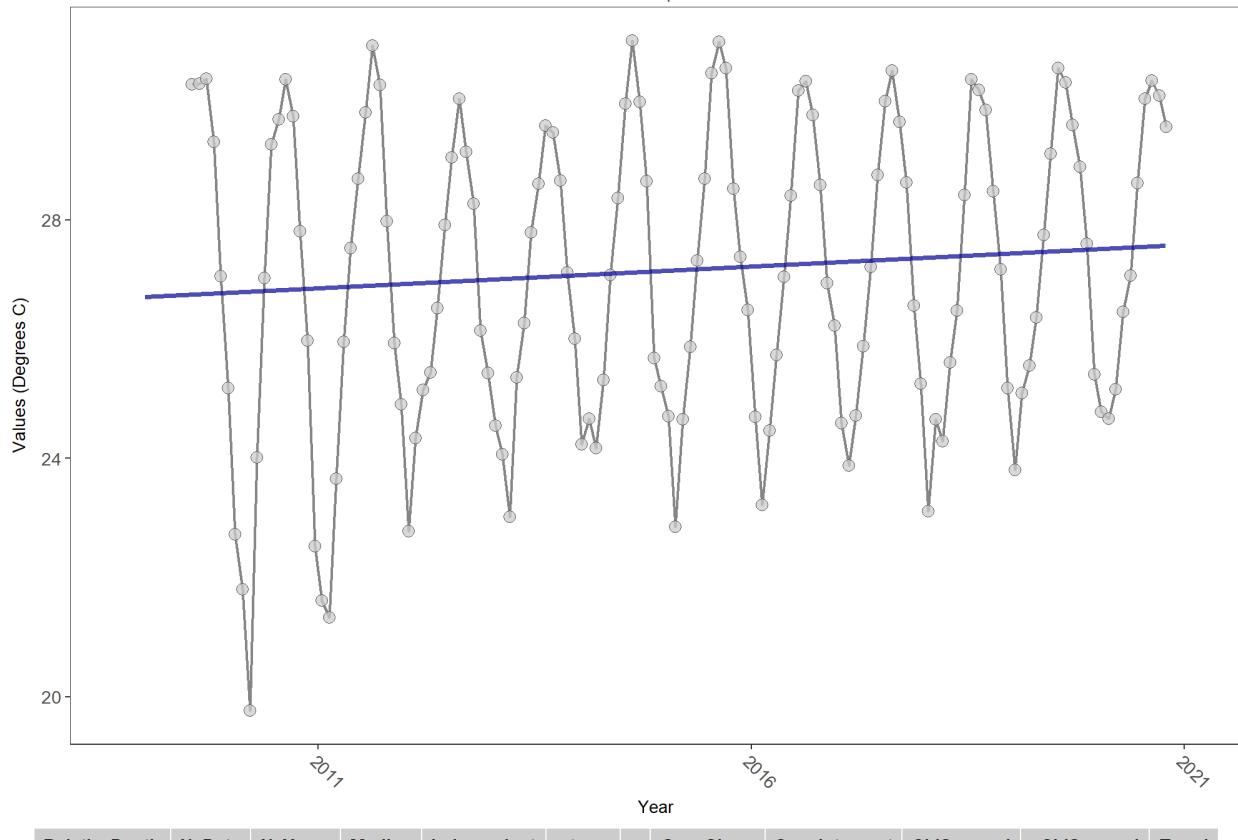
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 75  
 Water Temperature



*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 76  
 Water Temperature

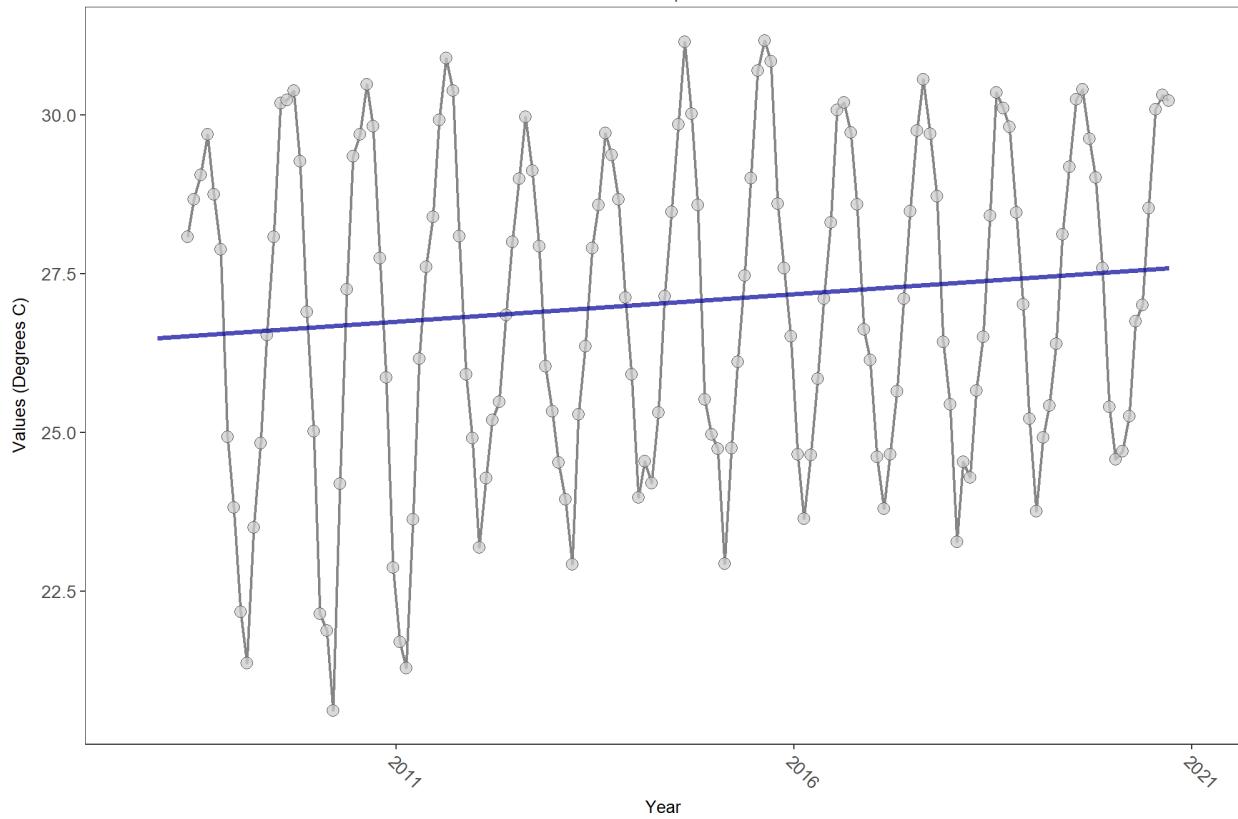


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	155039	12	26.94	1	0.2944	0	0.07351404	26.70301	8.8177	0.6387	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 77  
 Water Temperature

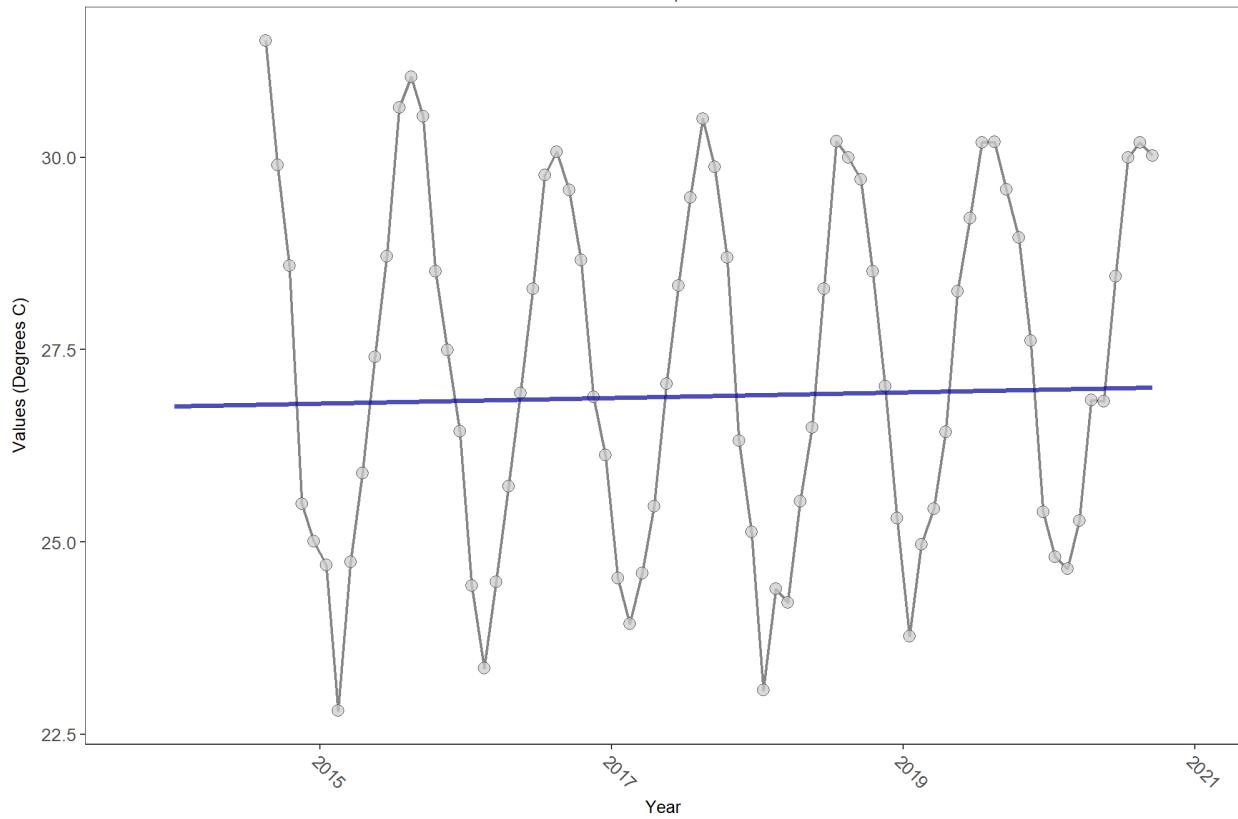


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	173770	13	26.965	1	0.3154	0	0.08631582	26.4857	11.0591	0.4383	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 78  
 Water Temperature

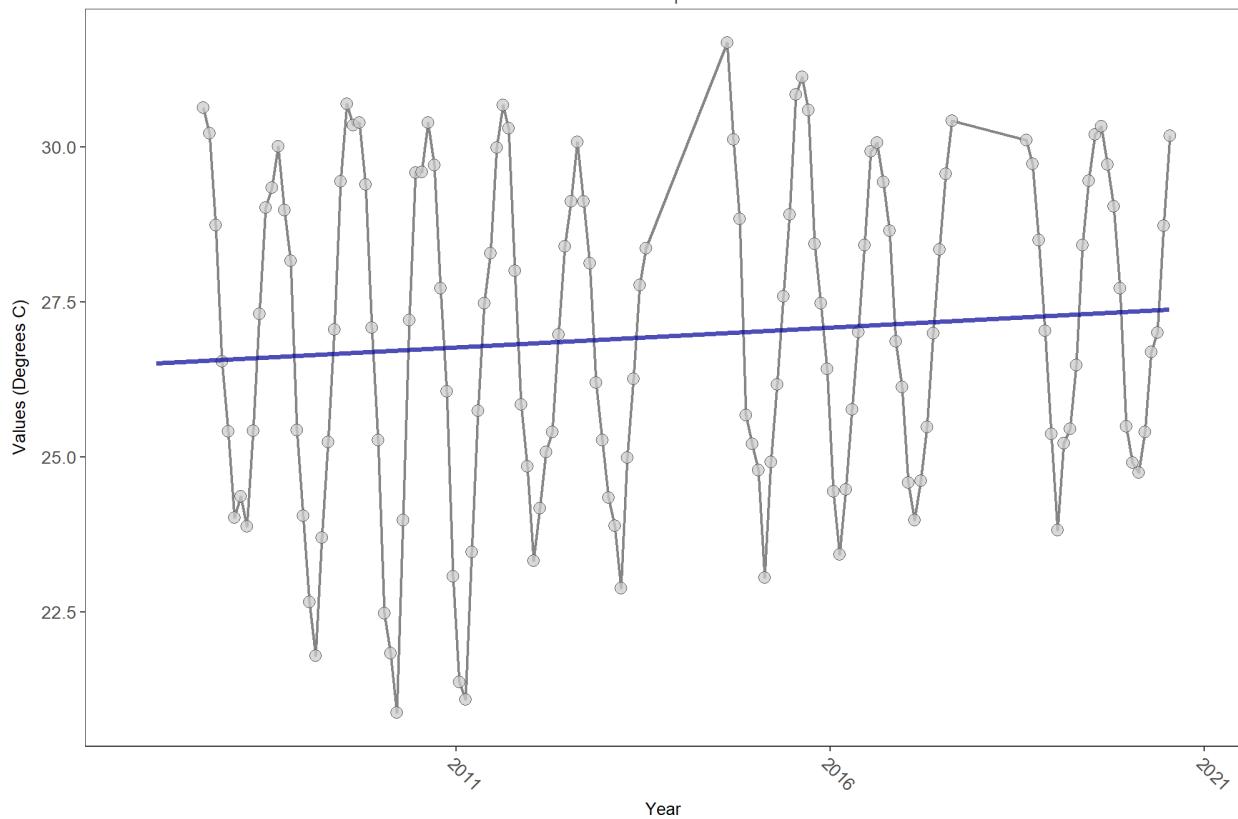


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	72688	7	27.13	1	0.0991	0.4367	0.03572655	26.76449	13.2566	0.2769	0

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 79  
 Water Temperature

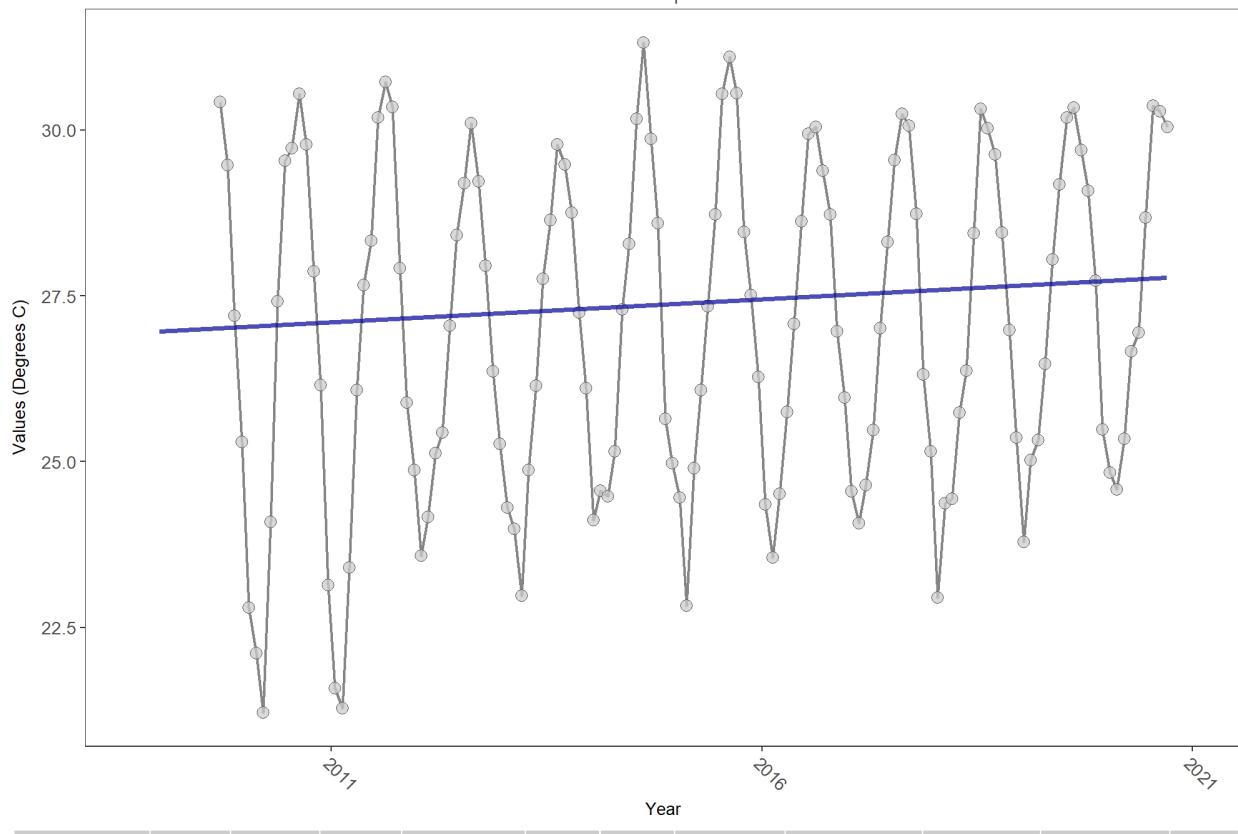


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	158669	14	26.769	1	0.2301	0.0007	0.06391419	26.50617	10.7409	0.4652	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 80  
 Water Temperature

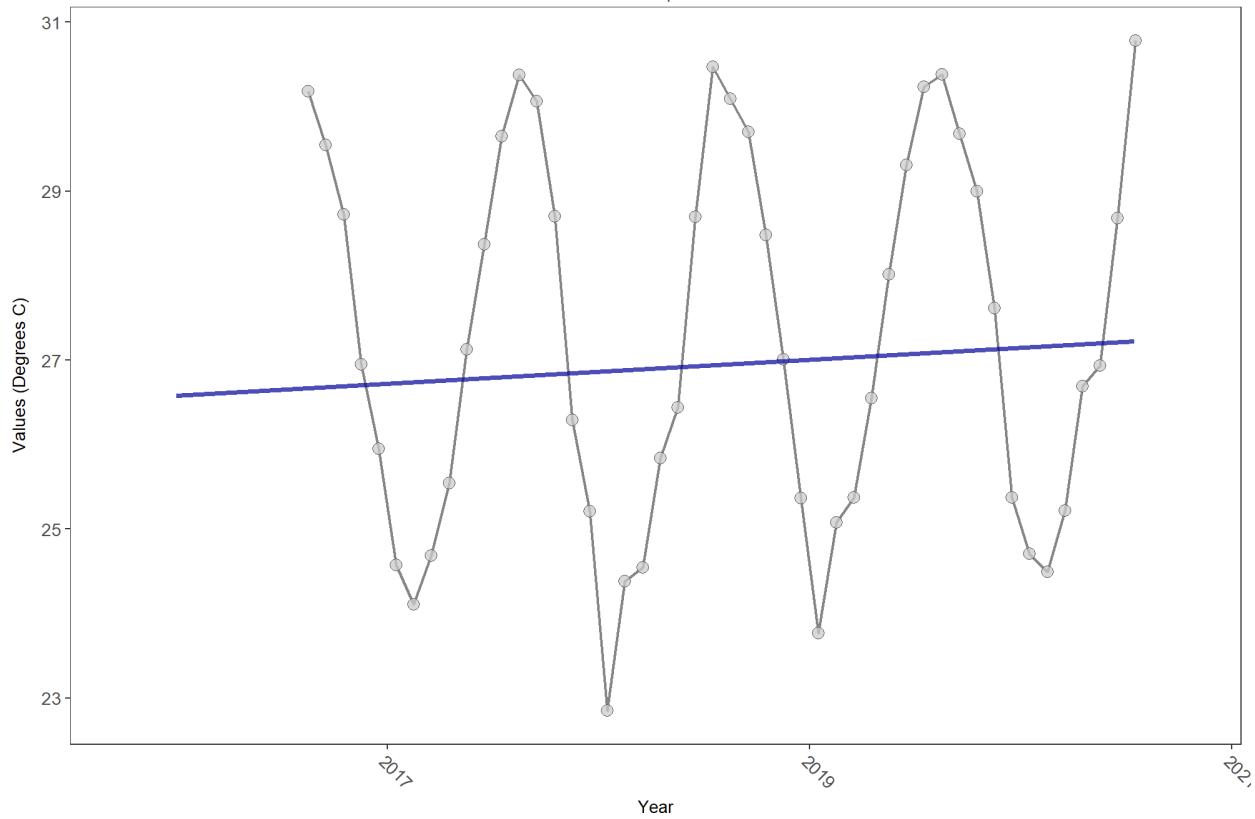


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	152221	12	26.96	1	0.2457	0.0003	0.06925	26.967	14.378	0.2128	1

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

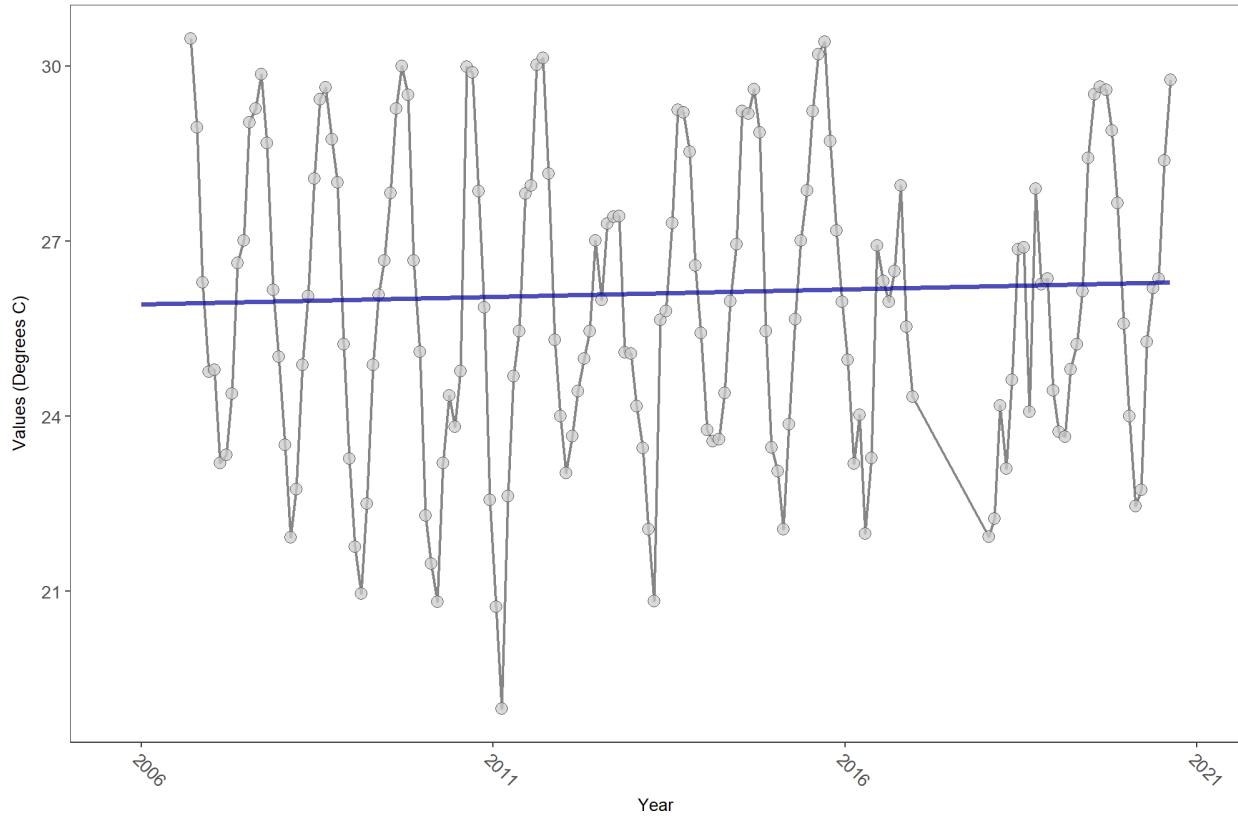
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 81  
 Water Temperature



*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 83  
 Water Temperature



RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	113109	14	25.69	1	0.0662	0.2827	0.02597339	25.91354	8.9764	0.6241	0

*p < 0.00005 appear as 0 due to rounding.*

*SennIntercept is intercept value at beginning of record for monitoring location*

### Appendix III: Monitoring Location Summary Box Plots

Data is taken and grouped by MonitoringID. The scripts that create plots follow this format

1. Use the data set that only has `Use_In_Analysis` of TRUE for the desired monitoring location
2. Determine the earliest and latest year of the data to create x-axis scale and intervals
3. Determine the minimum, mean, and standard deviation for the data to be used for y-axis scales
  - Excludes the top 2% of values to reduce the impact of extreme outliers on the y-axis scale
4. Set what values are to be used for the x-axis, y-axis, and the variable that should determine groups for the box plots
5. Set the plot type as a box plot with the size of the outlier points
6. Create the title, x-axis, y-axis, and color fill labels
7. Set the y and x limits
8. Make the axis labels bold
9. Plot the arrangement as a set of panels

The following plots are arranged by MonitoringID with data grouped by Year, then Year and Month, then finally Month only. Each program area will have 3 sets of plots, each with 3 panels in them. Each panel goes as follows:

1. Y-axis autoscaled
2. Y-axis set to be mean + 4 times the standard deviation
3. Y-axis set to be mean + 4 times the standard deviation for most recent 10 years of data

```
# Determines whether analyzed monitoring locations exist. If they do, begins
# looping through them
if(n==0){
  print("There are no monitoring locations that qualify.")
} else {
  for (i in 1:n) {
    # Determine upper and lower bounds of time for x-axis
    year_lower <- min(data$Year[data$Use_In_Analysis==TRUE &
      data$MonitoringID==Mon_IDs[i]])
    year_upper <- max(data$Year[data$Use_In_Analysis==TRUE &
      data$MonitoringID==Mon_IDs[i]])
    # Determine upper and lower bounds of ResultValue for y-axis
    min_RV <- min(data$ResultValue[data$Use_In_Analysis==TRUE &
      data$MonitoringID==Mon_IDs[i]])
    mn_RV <- mean(data$ResultValue[data$Use_In_Analysis==TRUE &
      data$MonitoringID==Mon_IDs[i] &
      data$ResultValue <
      quantile(data$ResultValue, 0.98)])
    sd_RV <- sd(data$ResultValue[data$Use_In_Analysis==TRUE &
      data$MonitoringID==Mon_IDs[i] &
      data$ResultValue <
      quantile(data$ResultValue, 0.98)])
    # Sets x- and y-axis scale
    x_scale <- ifelse(year_upper - year_lower > 30, 10, 5)
    y_scale <- mn_RV + 4 * sd_RV
    # Gets managed area name for title
    MA_name <- KT.Stats$ManagedAreaName[KT.Stats$MonitoringID==Mon_IDs[i]]
    # Gets program location name for title
    Mon_name <- paste0(KT.Stats$ProgramID[KT.Stats$MonitoringID==Mon_IDs[i]],
      "\n", KT.Stats$ProgramName[KT.Stats$MonitoringID==Mon_IDs[i]], "\n",
      KT.Stats$ProgramLocationID[KT.Stats$MonitoringID==Mon_IDs[i]])

    ##Year plots
    # Create plot object for auto-scaled y-axis plot
    p1 <- ggplot(data[data$Use_In_Analysis==TRUE &
      data$MonitoringID==Mon_IDs[i], ],
      aes(x=Year, y=ResultValue, group=Year)) +
      geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
        outlier.size=3, outlier.color="#333333",
        outlier.fill="#cccccc", outlier.alpha=0.75) +
      labs(subtitle="Autoscale",
        x="Year", y=paste0("Values (", unit, ")")) +
      scale_x_continuous(limits=c(year_lower - 1, year_upper + 1),
        breaks=rev(seq(year_upper,
          year_lower, -x_scale))) +
      plot_theme
  }
}
```

```

# Create plot object for y-axis scaled plot
p2 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i], ],
              aes(x=Year, y=ResultValue, group=Year)) +
  geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
               outlier.size=3, outlier.color="#333333",
               outlier.fill="#cccccc", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation",
       x="Year", y=paste0("Values (", unit, ")")) +
  ylim(min_RV, y_scale) +
  scale_x_continuous(limits=c(year_lower - 1, year_upper + 1),
                     breaks=rev(seq(year_upper,
                                   year_lower, -x_scale))) +
  plot_theme

# Create plot object for y-axis scaled plot for past 10 years
p3 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i] &
                        data$Year>=year_upper-10, ],
              aes(x=Year, y=ResultValue, group=Year)) +
  geom_boxplot(color="#333333", fill="#cccccc", outlier.shape=21,
               outlier.size=3, outlier.color="#333333",
               outlier.fill="#cccccc", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation, Last 10 Years",
       x="Year", y=paste0("Values (", unit, ")")) +
  ylim(min_RV, y_scale) +
  scale_x_continuous(limits=c(year_upper - 10.5, year_upper + 1),
                     breaks=rev(seq(year_upper, year_upper - 10,-2))) +
  plot_theme

# Arrange plot objects
Yset <- ggarrange(p1, p2, p3, ncol=1)

# Create plot title object
p0 <- ggplot() + labs(title=paste0(MA_name, "\n", Mon_name),
                       subtitle="By Year") +
  plot_theme + theme(panel.border=element_blank(),
                     panel.grid.major=element_blank(),
                     panel.grid.minor=element_blank(),
                     axis.line=element_blank())

## Year & Month Plots
# Create plot object for auto-scaled y-axis plot
p4 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i], ],
              aes(x=YearMonthDec, y=ResultValue,
                  group=YearMonth, color=as.factor(Month))) +
  geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
  labs(subtitle="Autoscale",
       x="Year", y=paste0("Values (", unit, ")"), color="Month") +
  scale_x_continuous(limits=c(year_lower - 1, year_upper + 1),
                     breaks=rev(seq(year_upper,
                                   year_lower, -x_scale))) +
  plot_theme +
  theme(legend.position="none")

```

```

# Create plot object for y-axis scaled plot
p5 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i], ],
              aes(x=YearMonthDec, y=ResultValue,
                  group=YearMonth, color=as.factor(Month))) +
  geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation",
       x="Year", y=paste0("Values (", unit, ")"), color="Month") +
  ylim(min_RV, y_scale) +
  scale_x_continuous(limits=c(year_lower - 1, year_upper + 1),
                     breaks=rev(seq(year_upper,
                                    year_lower, -x_scale))) +
  plot_theme +
  theme(legend.position="top", legend.box="horizontal") +
  guides(color=guide_legend(nrow=1))
# Create plot object for y-axis scaled plot for past 10 years
p6 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i], ],
              aes(x=YearMonthDec, y=ResultValue,
                  group=YearMonth, color=as.factor(Month))) +
  geom_boxplot(fill="#cccccc", outlier.size=1.5, outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation, Last 10 Years",
       x="Year", y=paste0("Values (", unit, ")"), color="Month") +
  ylim(min_RV, y_scale) +
  scale_x_continuous(limits=c(year_upper - 10.5, year_upper + 1),
                     breaks=rev(seq(year_upper, year_upper - 10,-2))) +
  plot_theme +
  theme(legend.position="none")
# Create legend object
# Arrange plots and legend
leg1 <- get_legend(p5)
YMset <- ggarrange(leg1, p4, p5 + theme(legend.position="none"), p6,
                   ncol=1, heights=c(0.1, 1, 1, 1))
# Create plot title object
p00 <- ggplot() + labs(title=paste0(MA_name, "\n", Mon_name),
                        subtitle="By Year & Month") + plot_theme +
  theme(panel.border=element_blank(),
        panel.grid.major=element_blank(),
        panel.grid.minor=element_blank(), axis.line=element_blank())

## Month Plots
# Create plot object for auto-scaled y-axis plot
p7 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i], ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Autoscale",
       x="Month", y=paste0("Values (", unit, ")"), fill="Month") +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="none")

```

```

# Create plot object for y-axis scaled plot
p8 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i], ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation",
       x="Month", y=paste0("Values (", unit, ")"), fill="Month") +
  ylim(min_RV, y_scale) +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="top", legend.box="horizontal") +
  guides(fill=guide_legend(nrow=1))

# Create plot object for y-axis scaled plot for past 10 years
p9 <- ggplot(data=data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i] &
                        data$Year >= year_upper - 10, ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  geom_boxplot(color="#333333", outlier.shape=21, outlier.size=3,
               outlier.color="#333333", outlier.alpha=0.75) +
  labs(subtitle="Scaled to 4x Standard Deviation, Last 10 Years",
       x="Month", y=paste0("Values (", unit, ")"), fill="Month") +
  ylim(min_RV, y_scale) +
  scale_x_continuous(limits=c(0, 13), breaks=seq(3, 12, 3)) +
  plot_theme +
  theme(legend.position="none")

# Create legend object
leg2 <- get_legend(p8)

# Arrange plots and legend
Mset <- ggarrange(leg2, p7, p8 + theme(legend.position="none"), p9,
                  ncol=1, heights=c(0.1, 1, 1, 1))

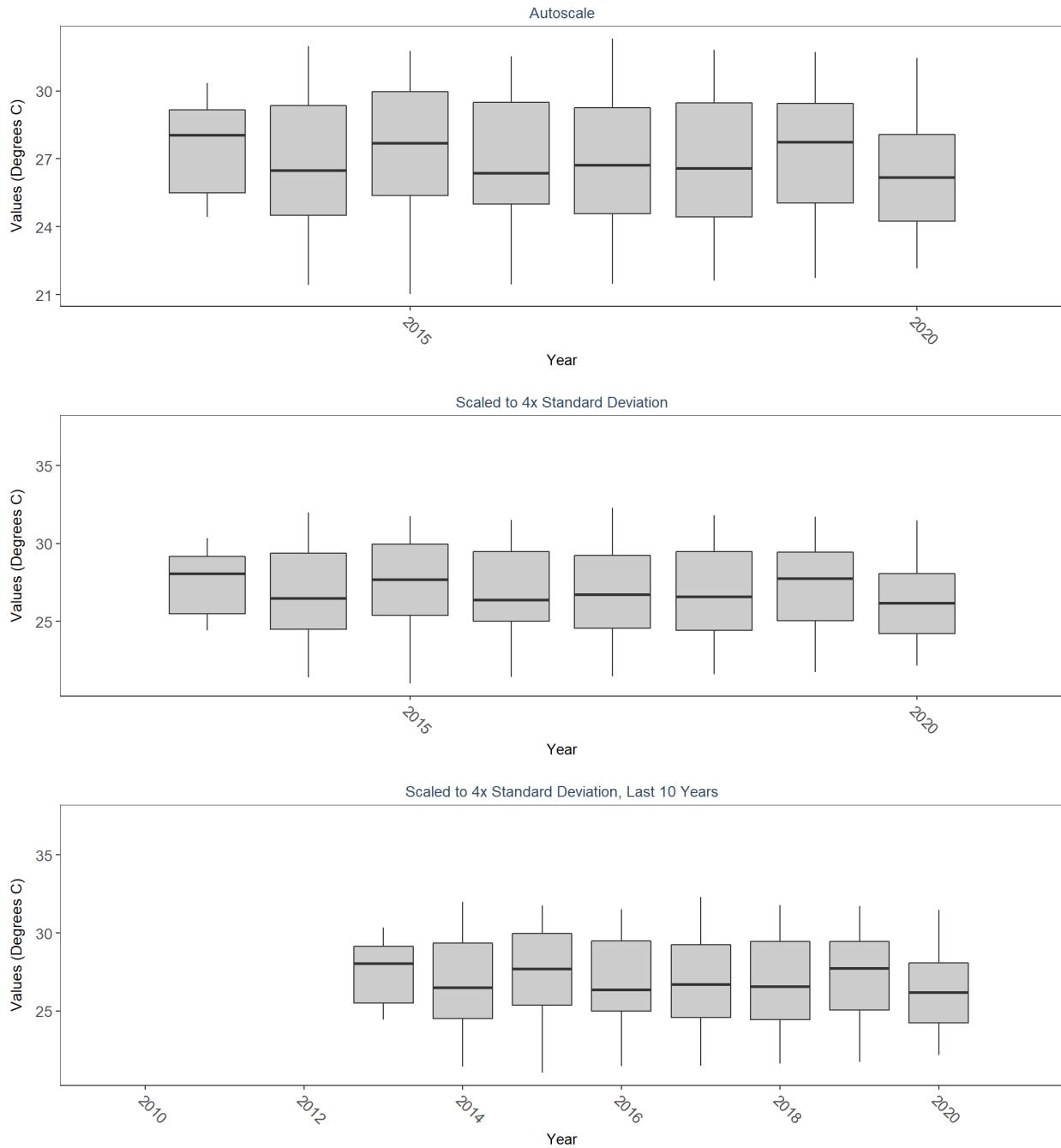
# Create title object
p000 <- ggplot() + labs(title=paste0(MA_name, "\n", Mon_name),
                         subtitle="By Month") + plot_theme +
  theme(panel.border=element_blank(),
        panel.grid.major=element_blank(),
        panel.grid.minor=element_blank(), axis.line=element_blank())

# Arrange and display plots with titles for all combinations
print(ggarrange(p0, Yset, ncol=1, heights=c(0.1, 1)))
print(ggarrange(p00, YMset, ncol=1, heights=c(0.1, 1)))
print(ggarrange(p000, Mset, ncol=1, heights=c(0.1, 1)))

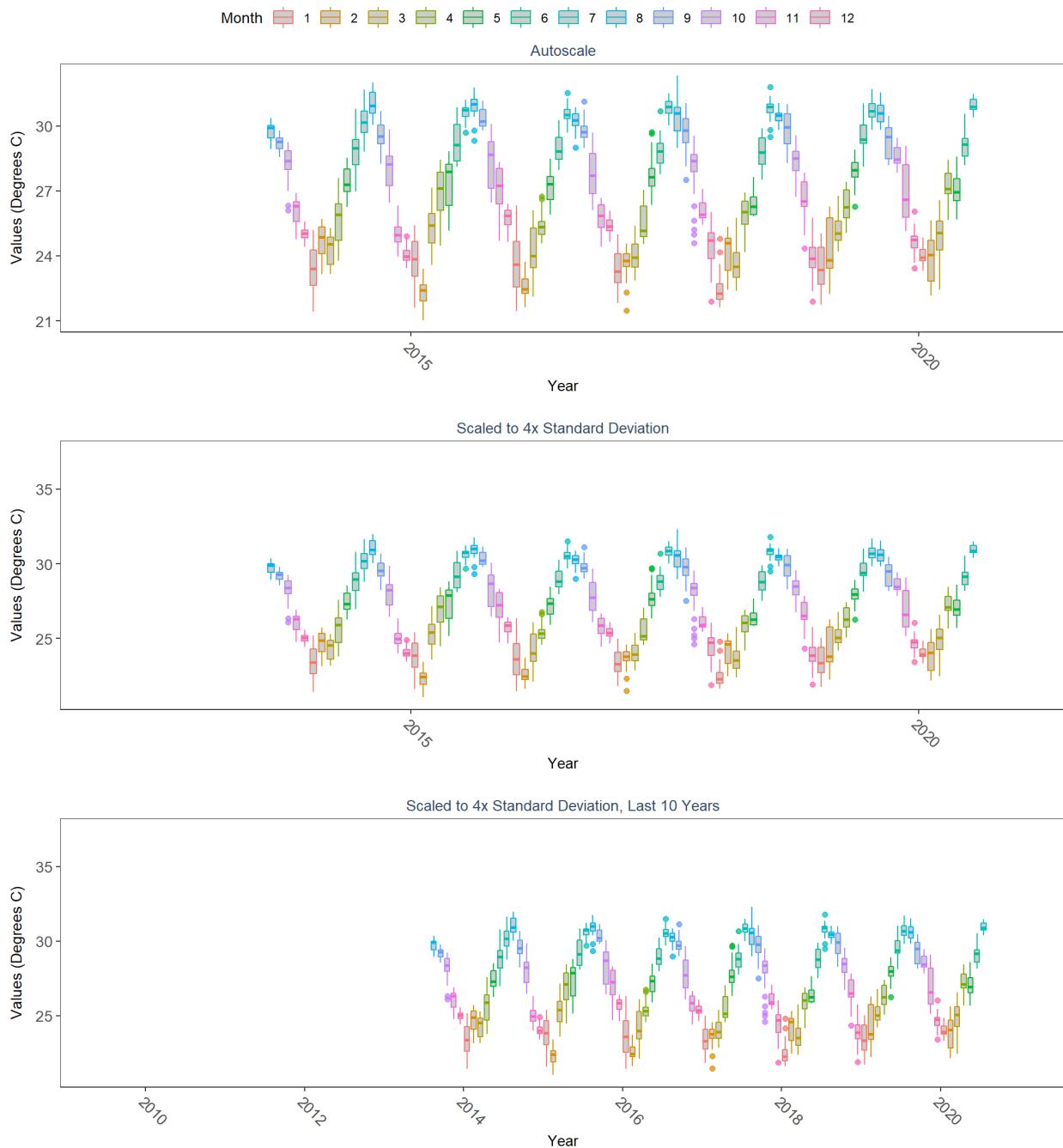
rm(plot_data)
rm(p1, p2, p3, p4, p5, p6, p7, p8, p9, p0, p00, p000, leg1, leg2,
    Yset, YMset, Mset)
}
}

```

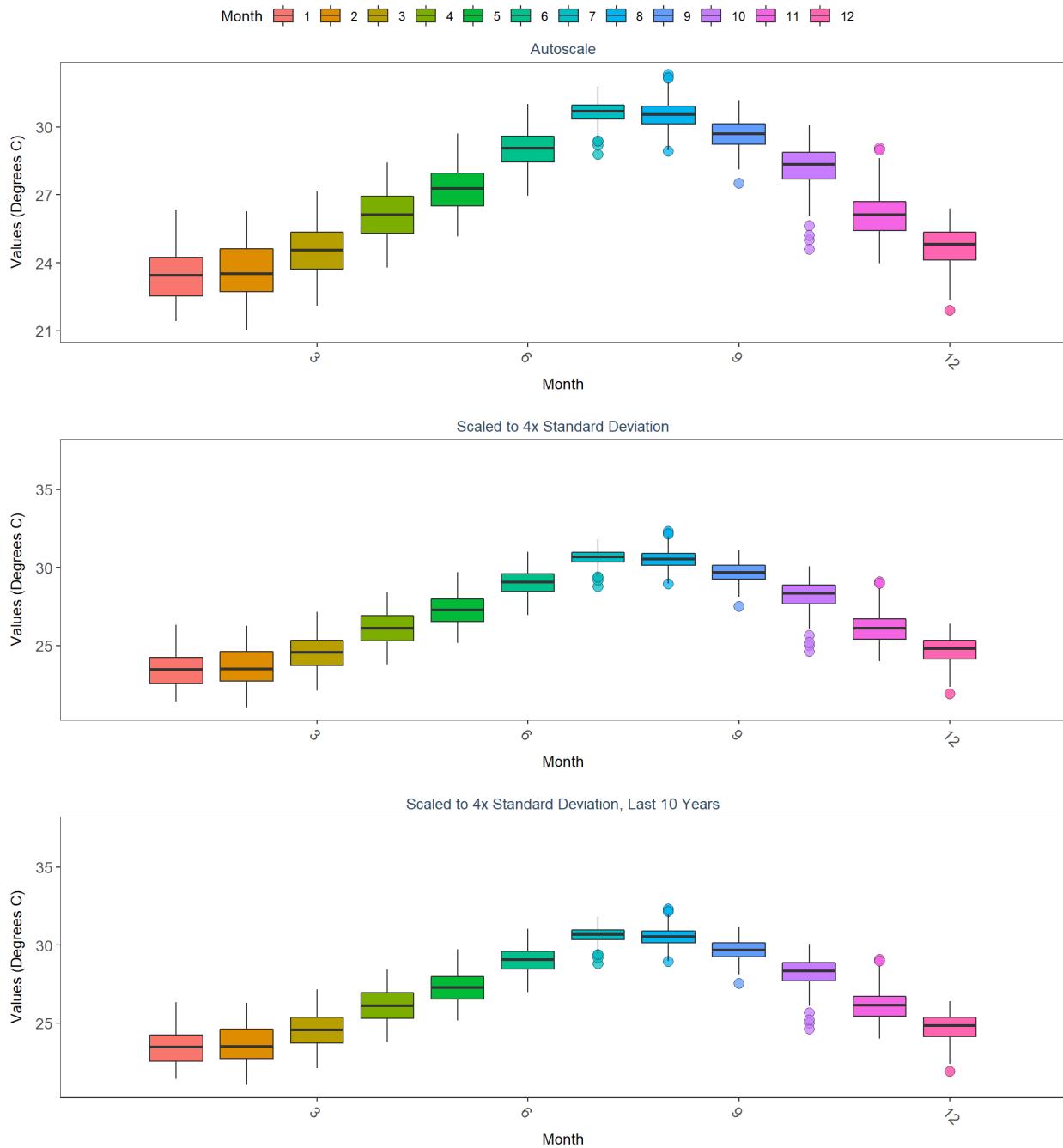
Biscayne Bay-Cape Florida to Monroe County Line Aquatic Preserve  
986  
Water Temperature on Coral Reefs in the Florida Keys  
6  
By Year



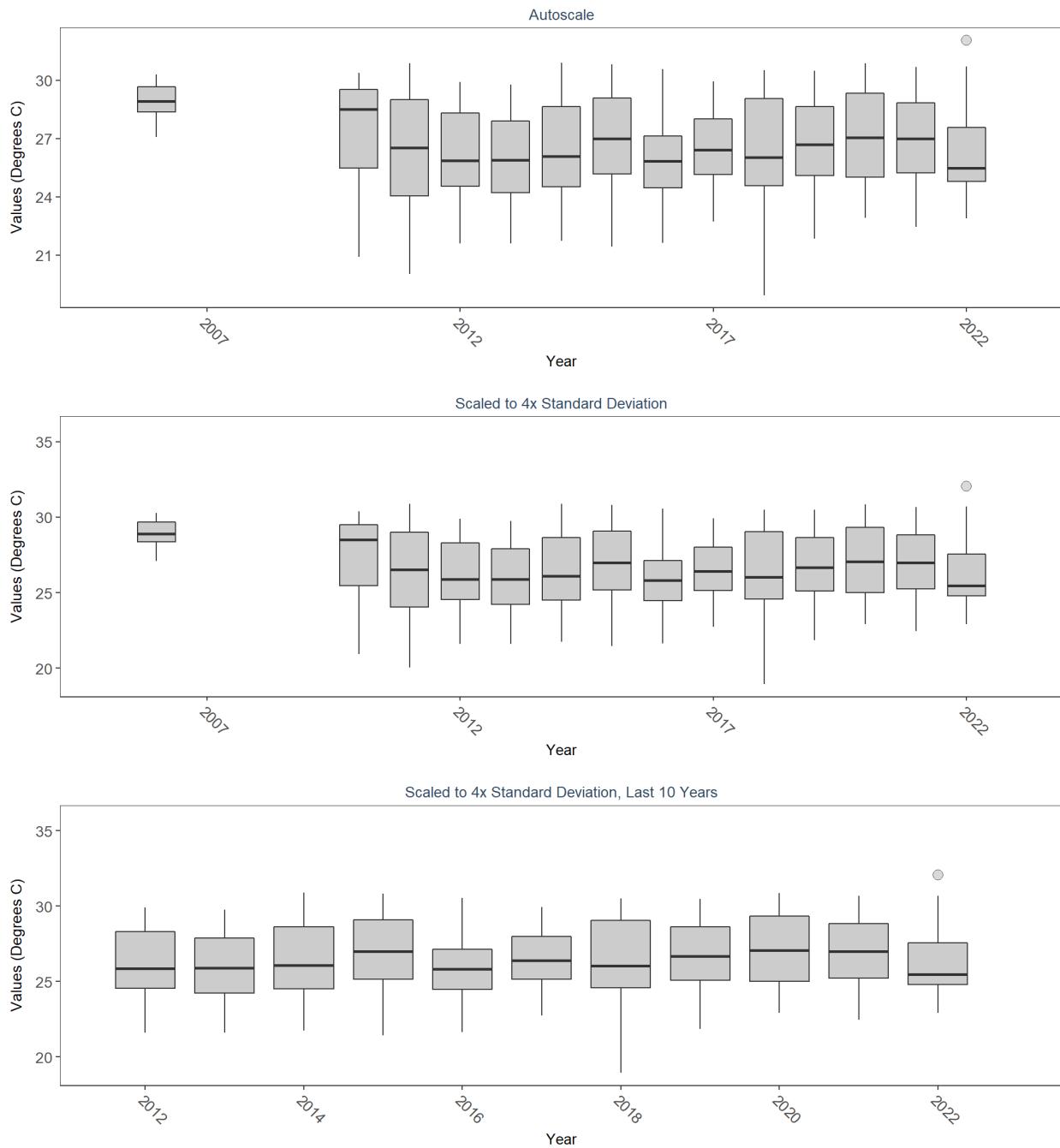
Biscayne Bay-Cape Florida to Monroe County Line Aquatic Preserve  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 6  
 By Year & Month



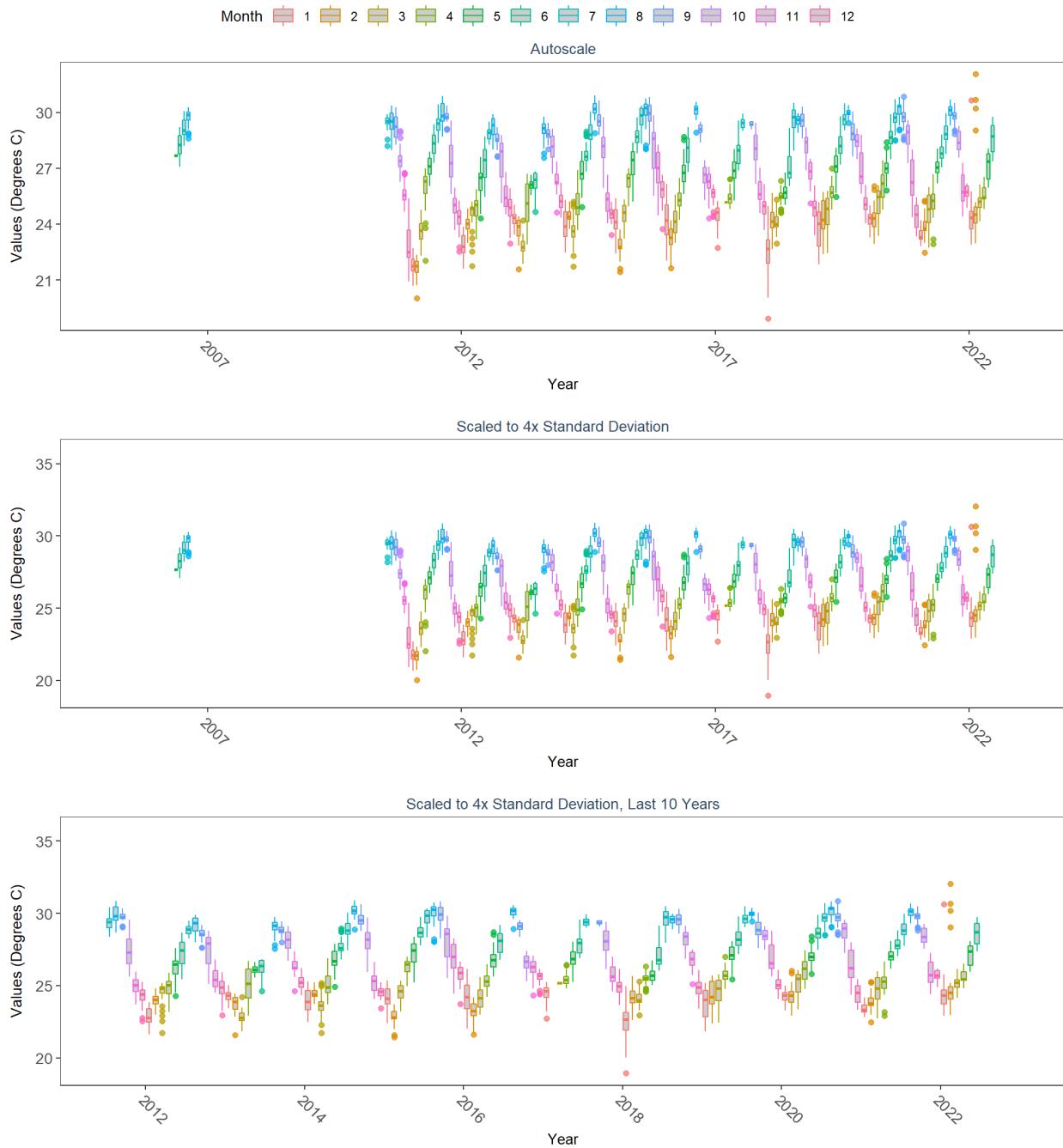
Biscayne Bay-Cape Florida to Monroe County Line Aquatic Preserve  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 6  
 By Month



Southeast Florida Coral Reef Ecosystem Conservation Area  
5  
National Data Buoy Center  
LKWF1  
By Year



Southeast Florida Coral Reef Ecosystem Conservation Area  
 5  
 National Data Buoy Center  
 LKWF1  
 By Year & Month



Southeast Florida Coral Reef Ecosystem Conservation Area

5

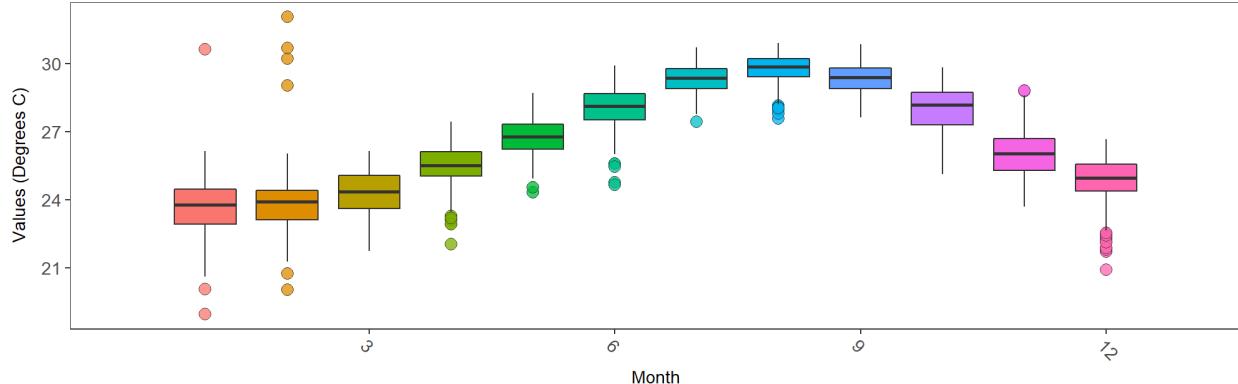
National Data Buoy Center

LKWF1

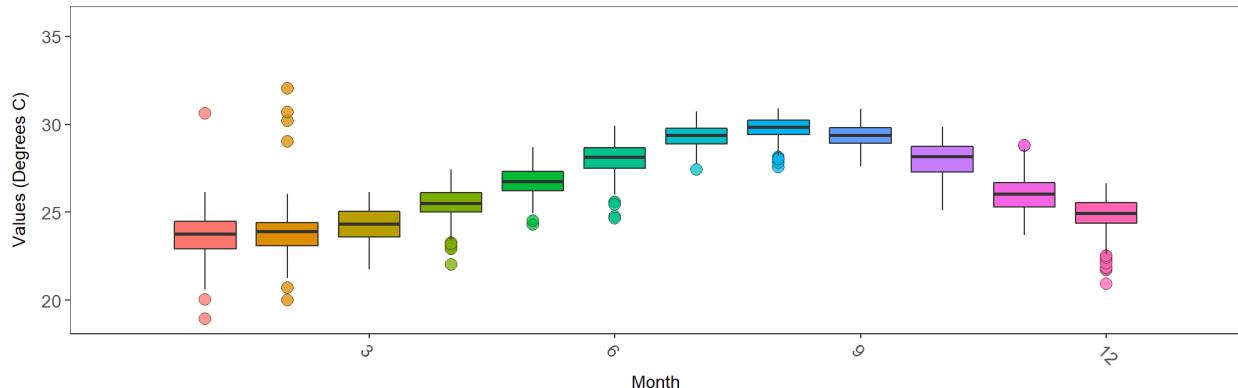
By Month

Month 1 2 3 4 5 6 7 8 9 10 11 12

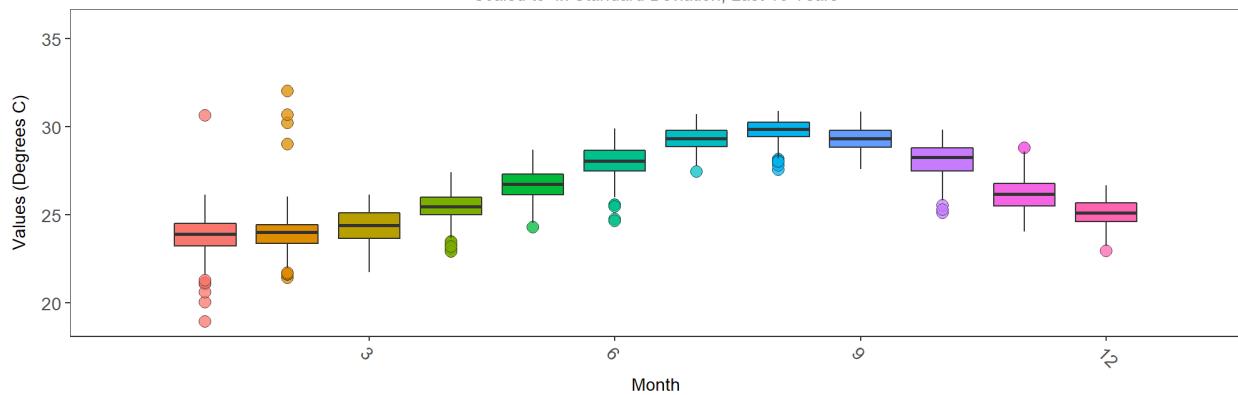
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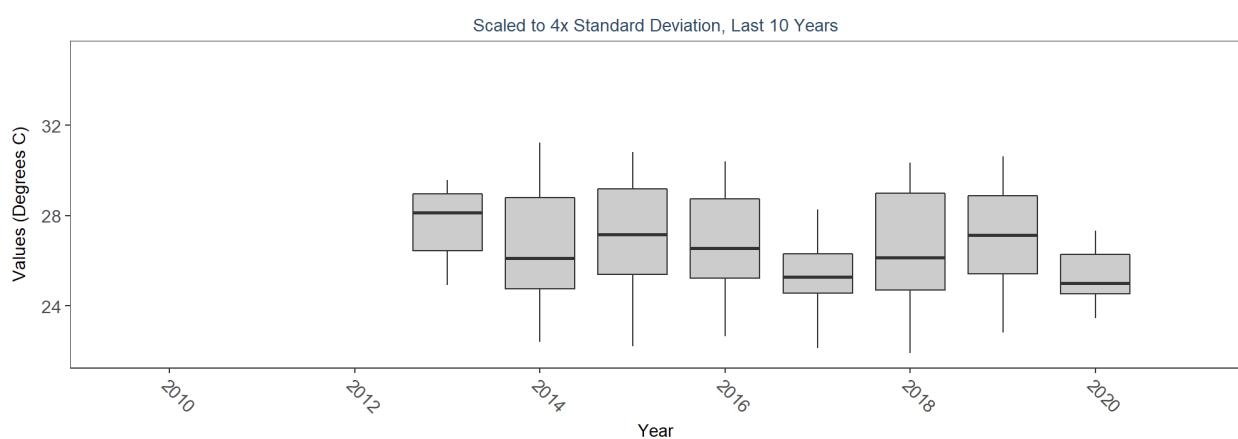
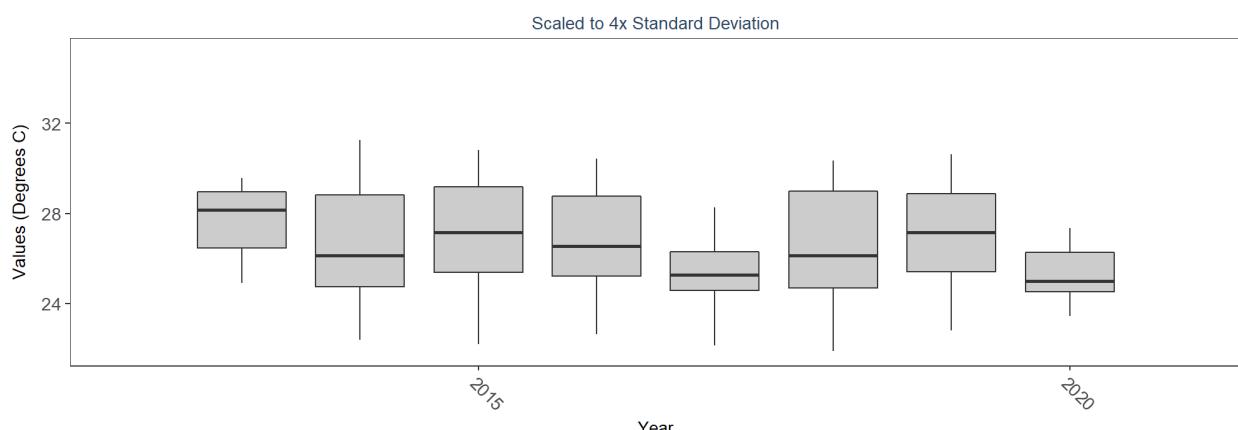
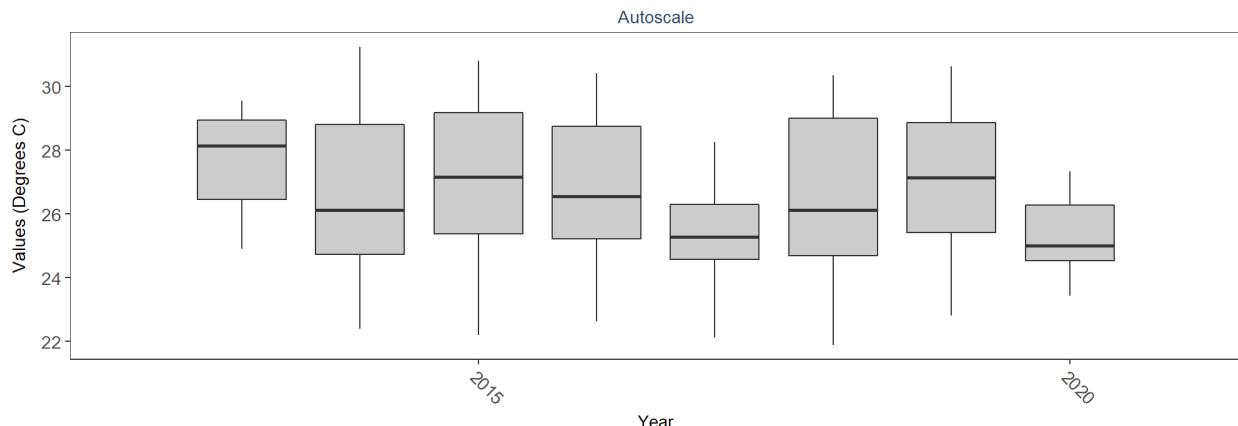
Scaled to 4x Standard Deviation



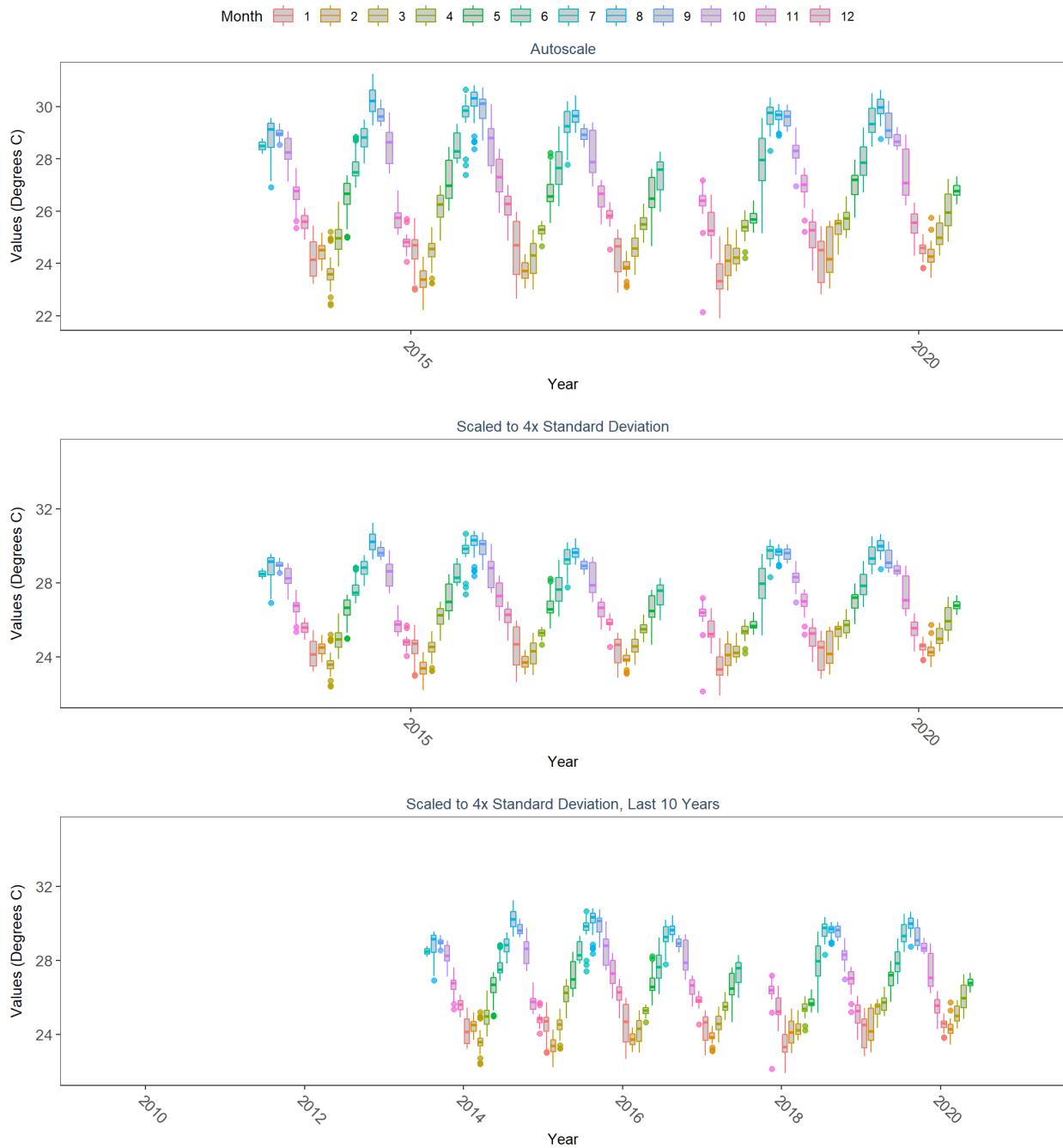
Scaled to 4x Standard Deviation, Last 10 Years



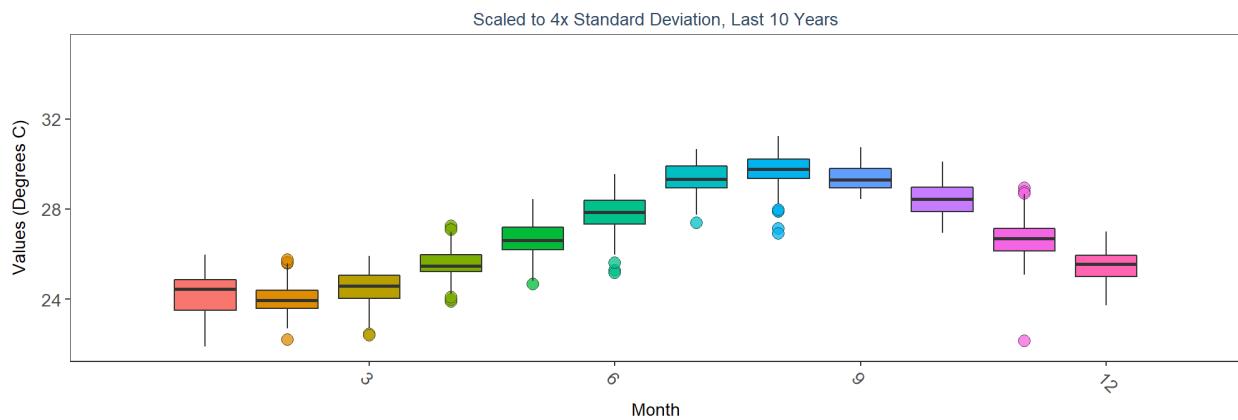
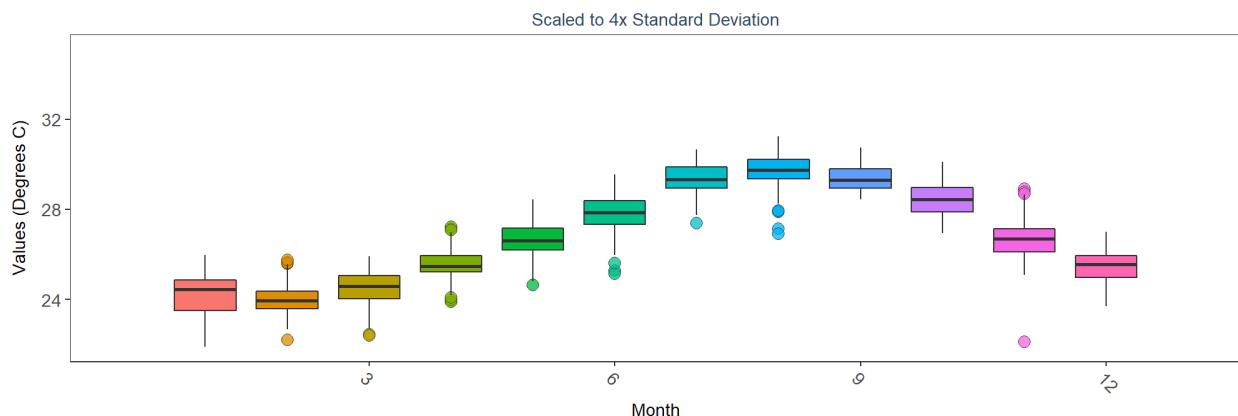
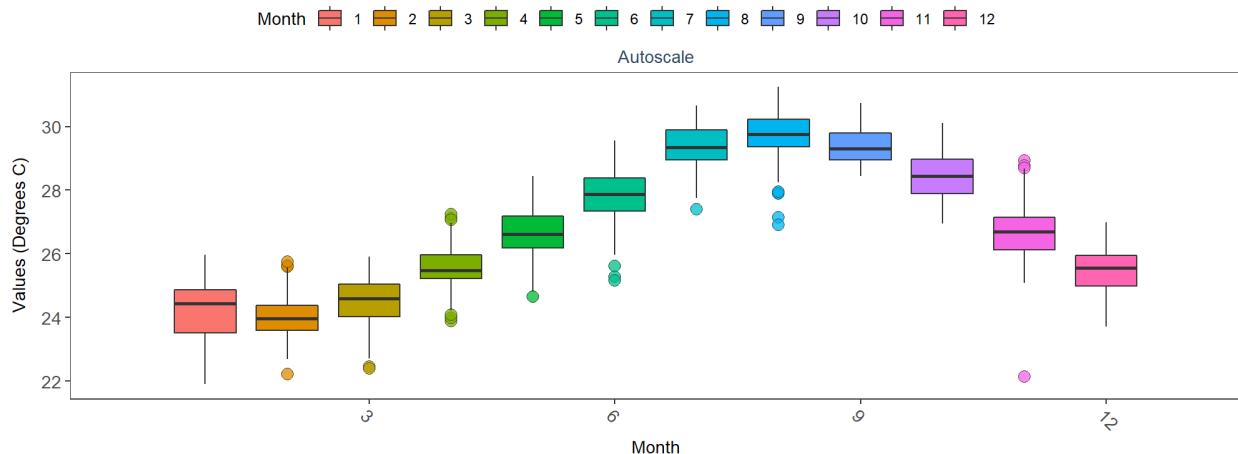
Southeast Florida Coral Reef Ecosystem Conservation Area  
986  
Water Temperature on Coral Reefs in the Florida Keys  
1  
By Year



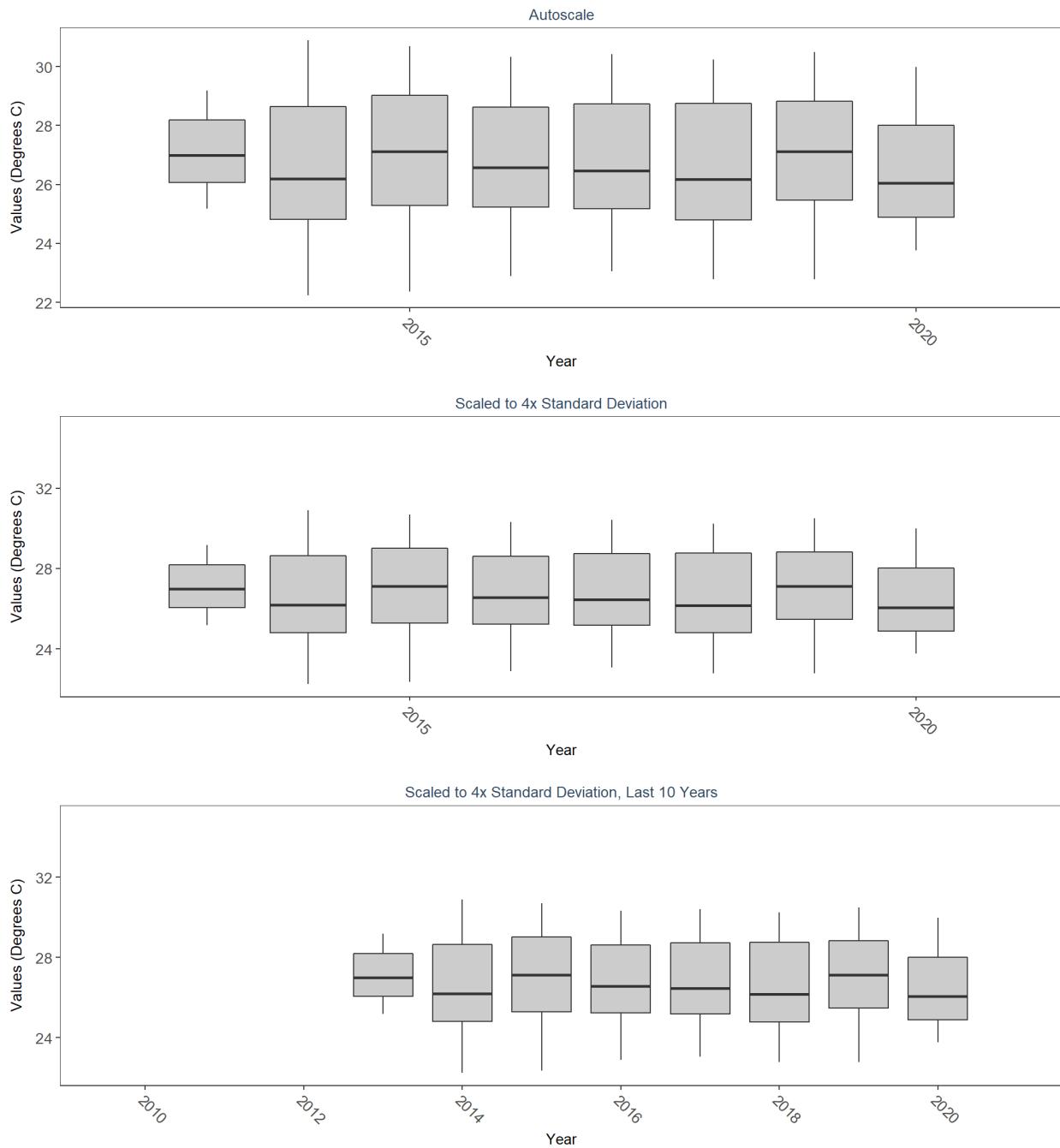
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 1  
 By Year & Month



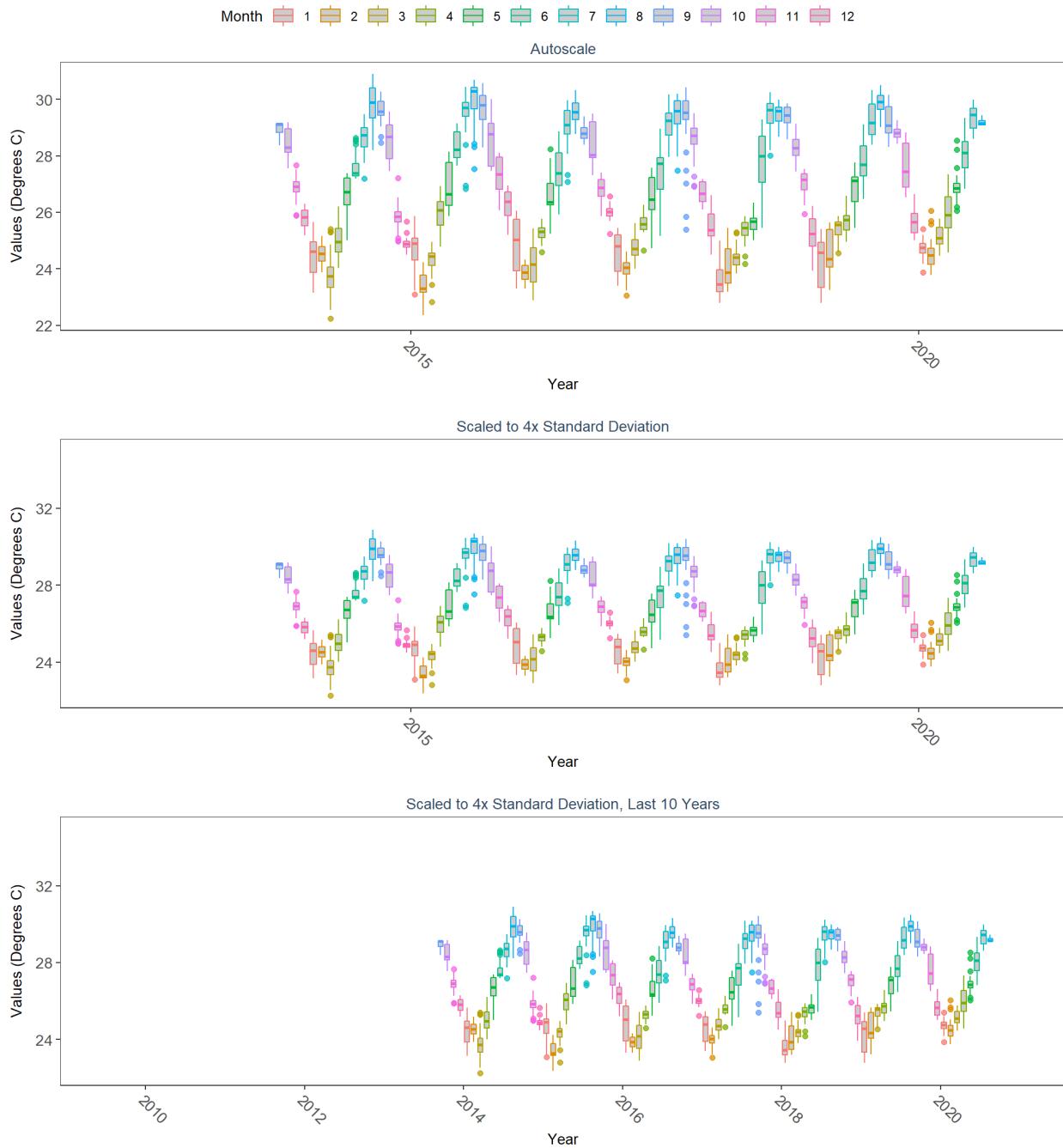
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 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 1  
 By Month



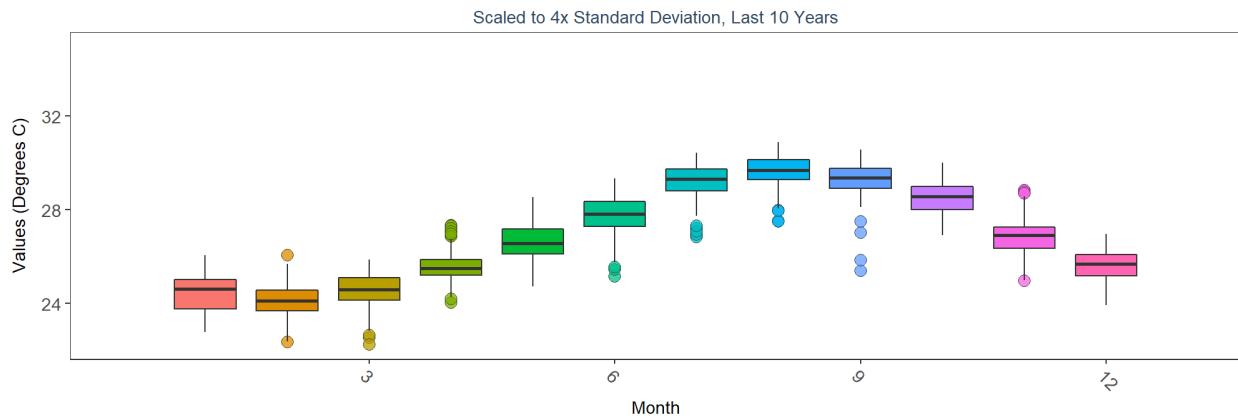
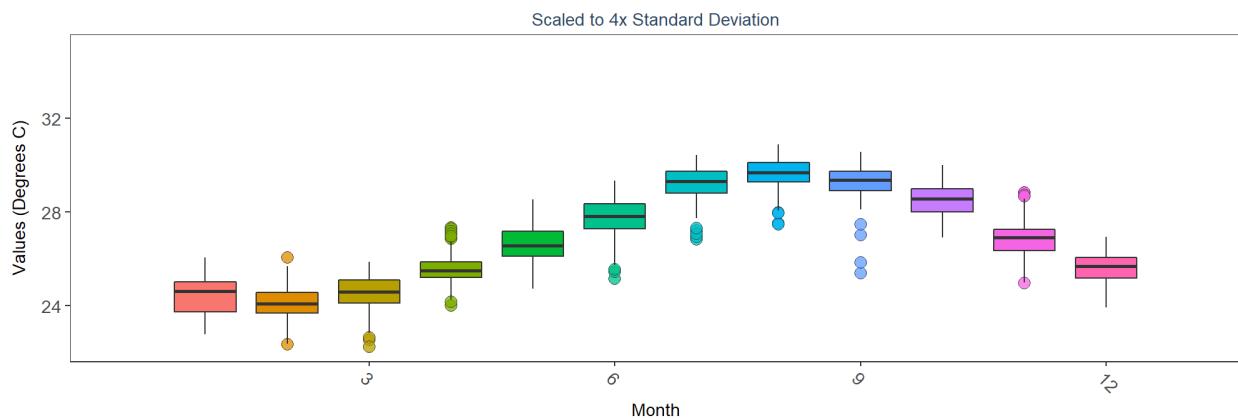
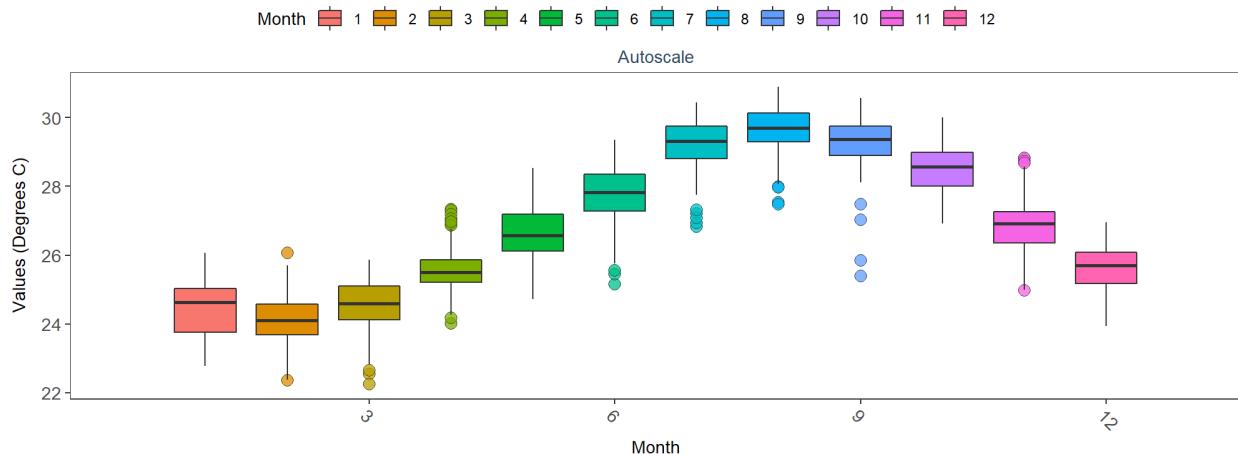
Southeast Florida Coral Reef Ecosystem Conservation Area  
986  
Water Temperature on Coral Reefs in the Florida Keys  
2  
By Year



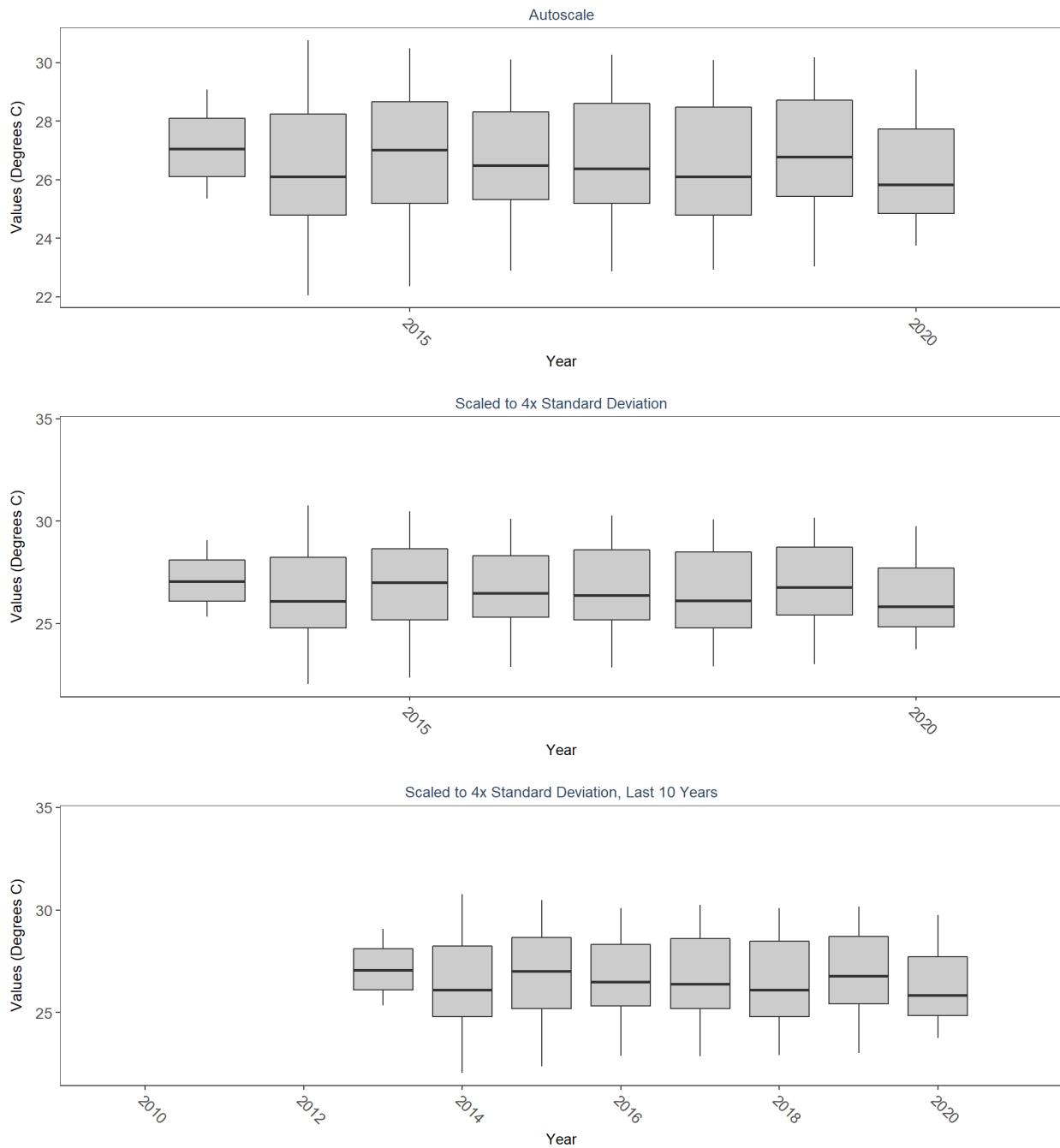
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 2  
 By Year & Month



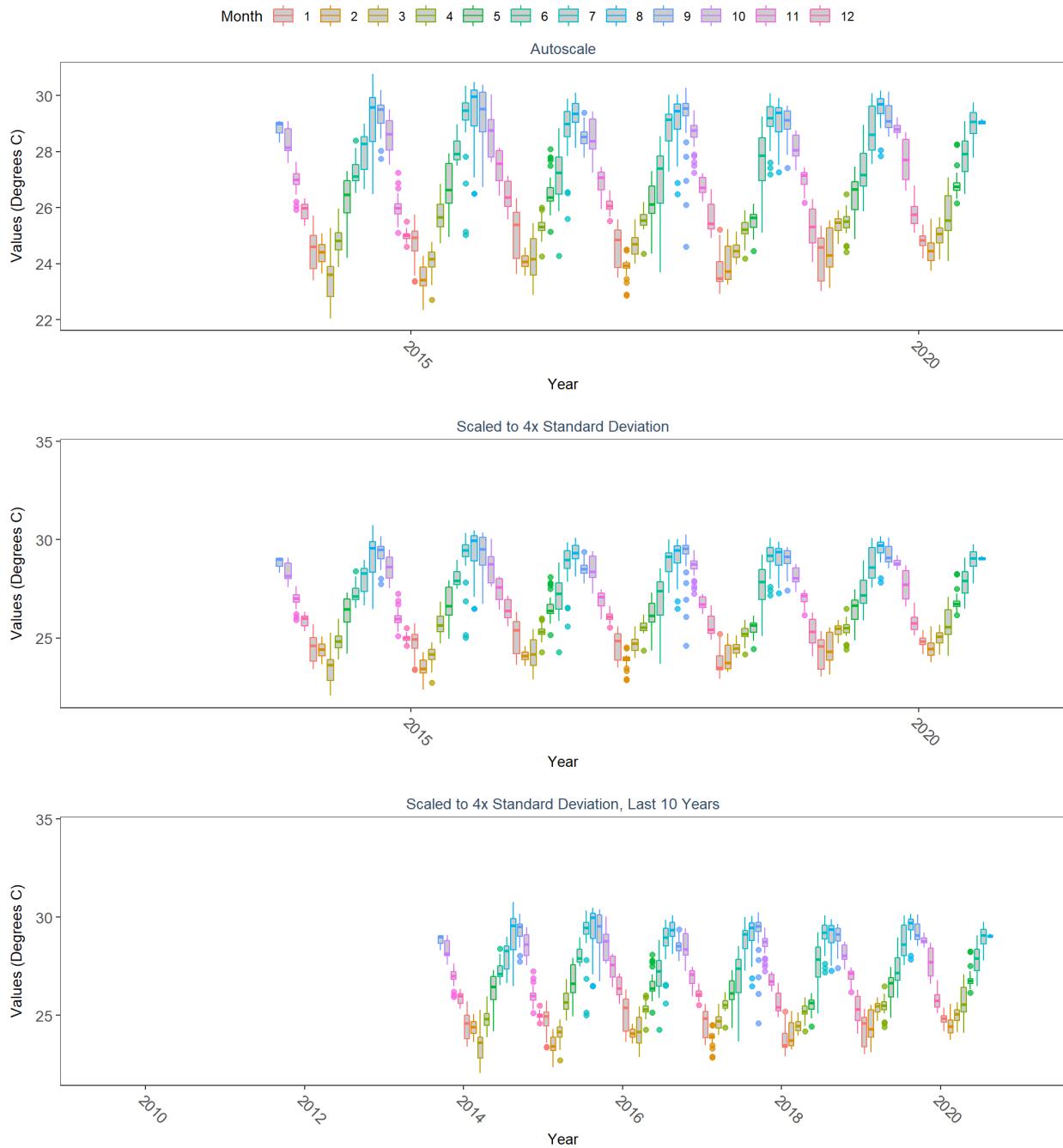
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 2  
 By Month



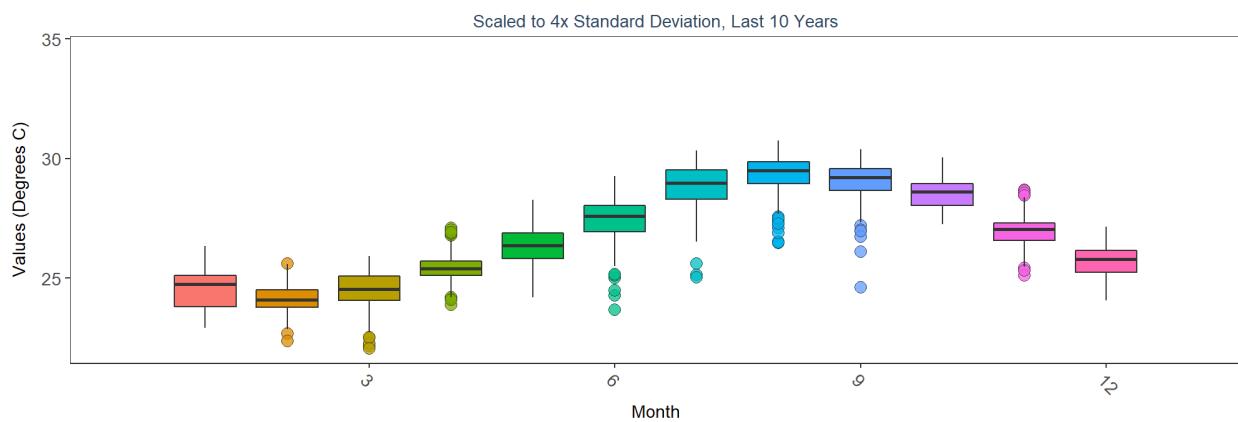
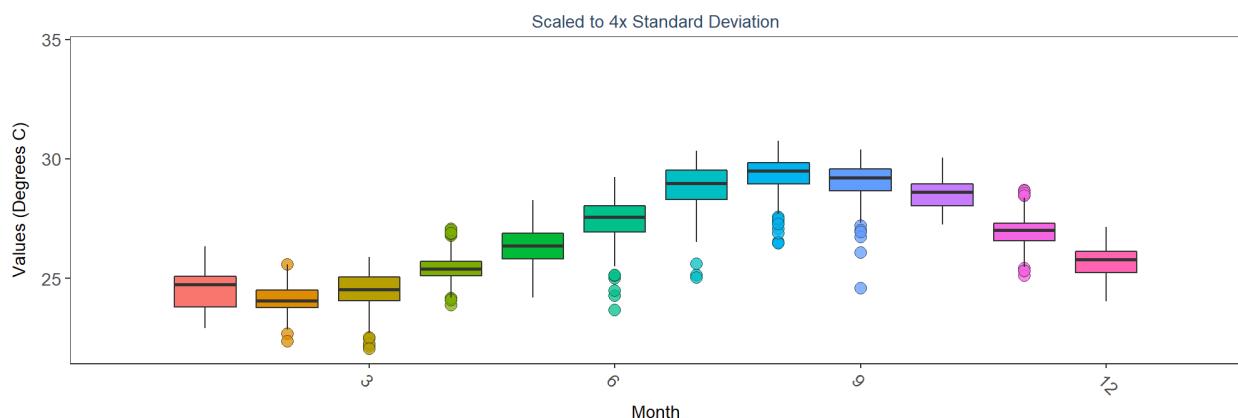
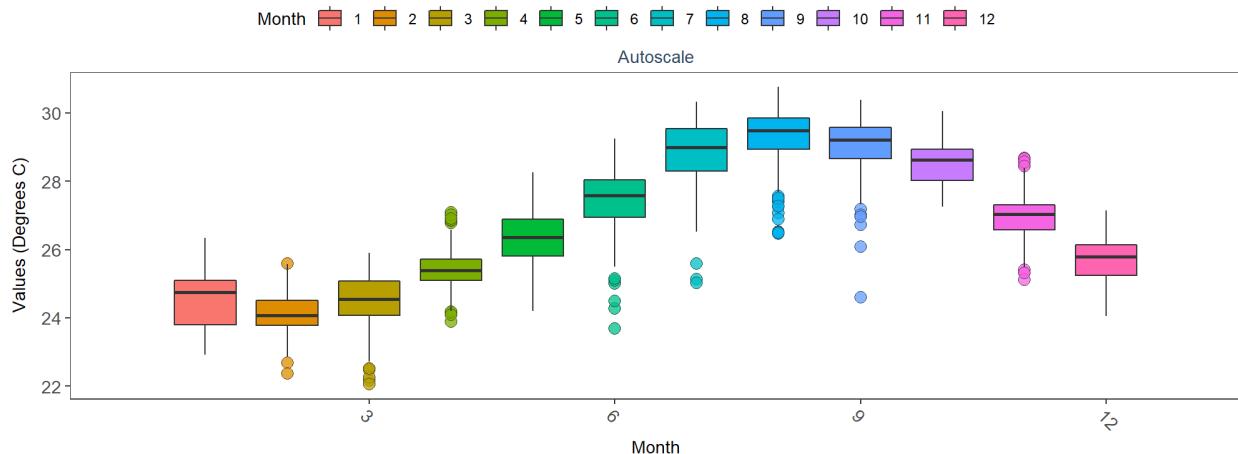
Southeast Florida Coral Reef Ecosystem Conservation Area  
986  
Water Temperature on Coral Reefs in the Florida Keys  
3  
By Year



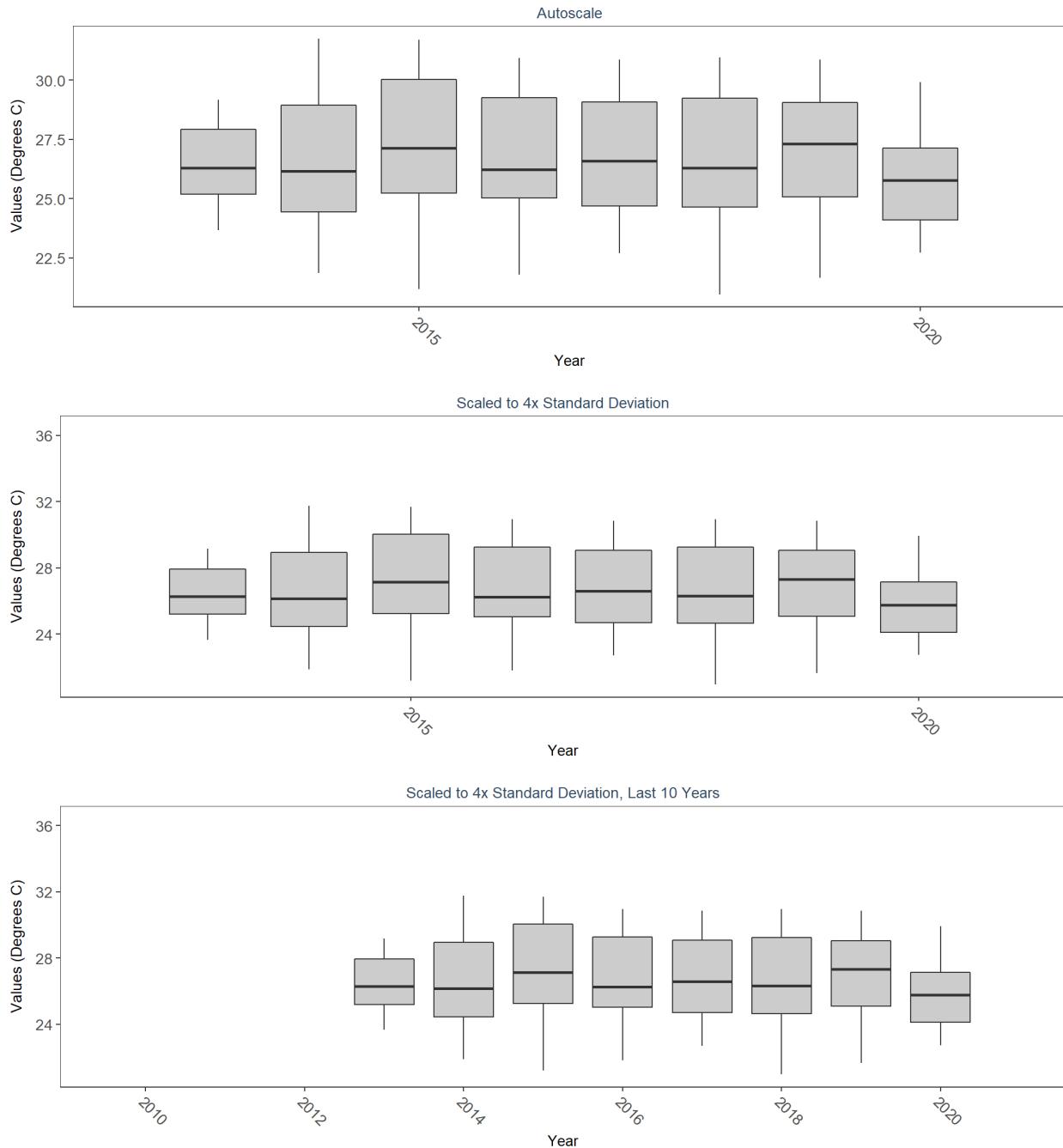
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 3  
 By Year & Month



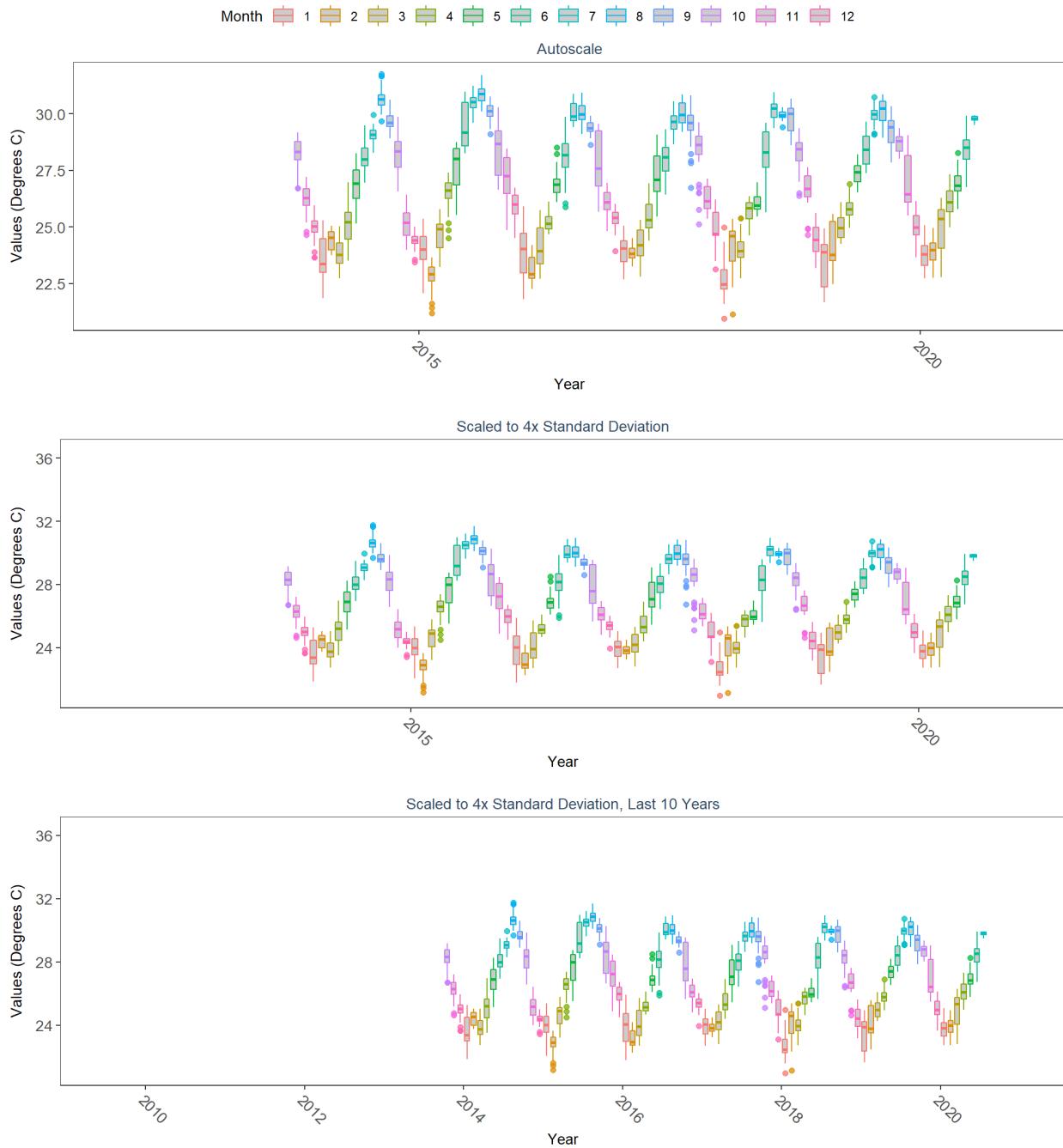
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 3  
 By Month



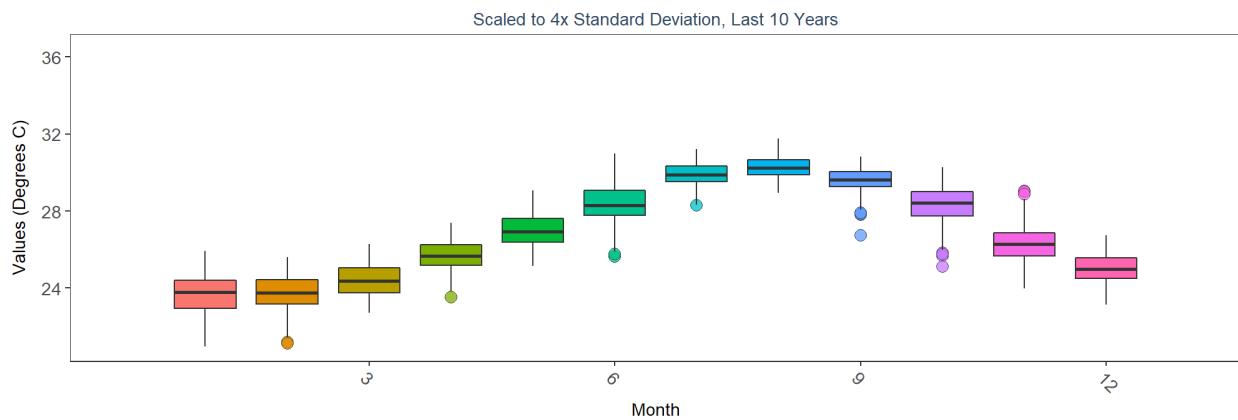
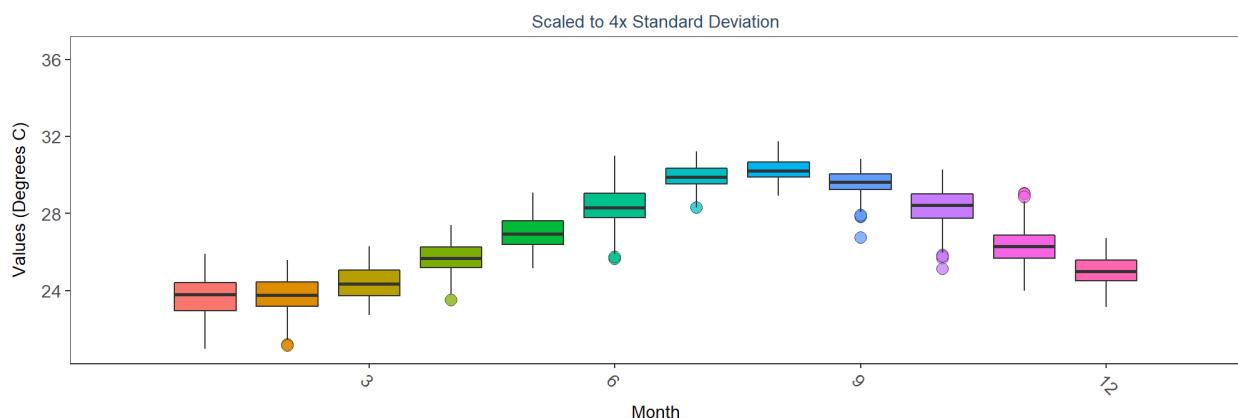
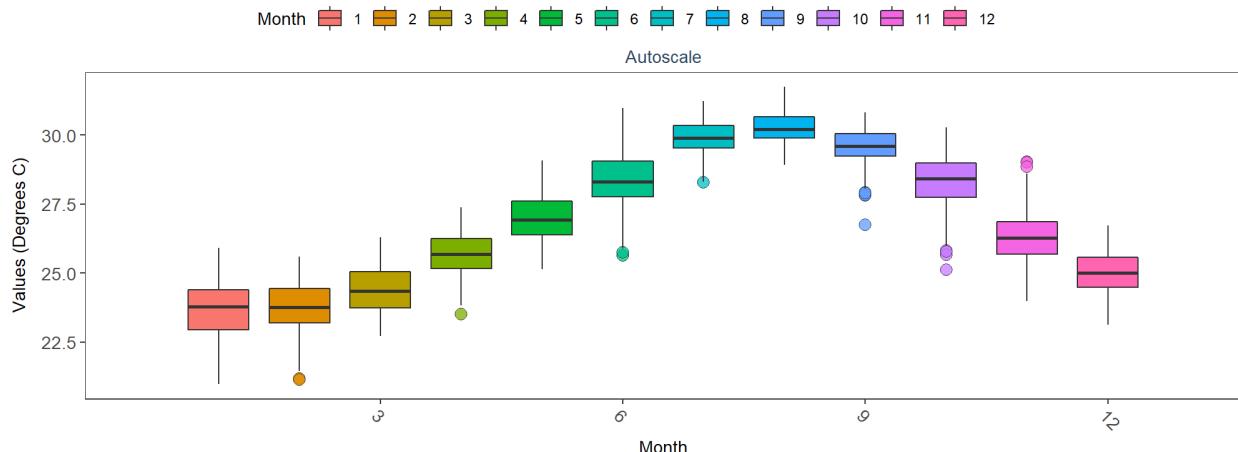
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 4  
 By Year



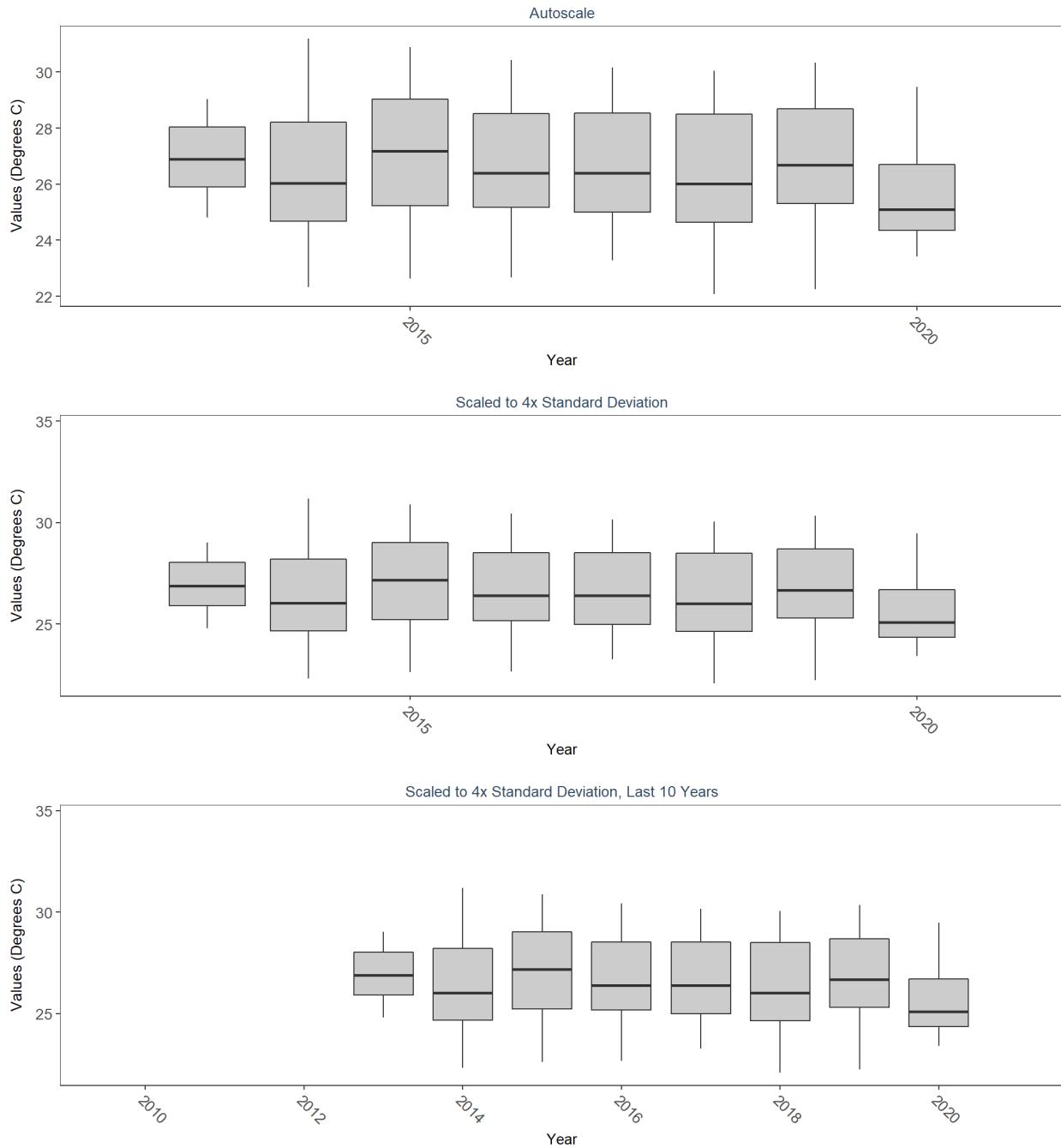
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 4  
 By Year & Month



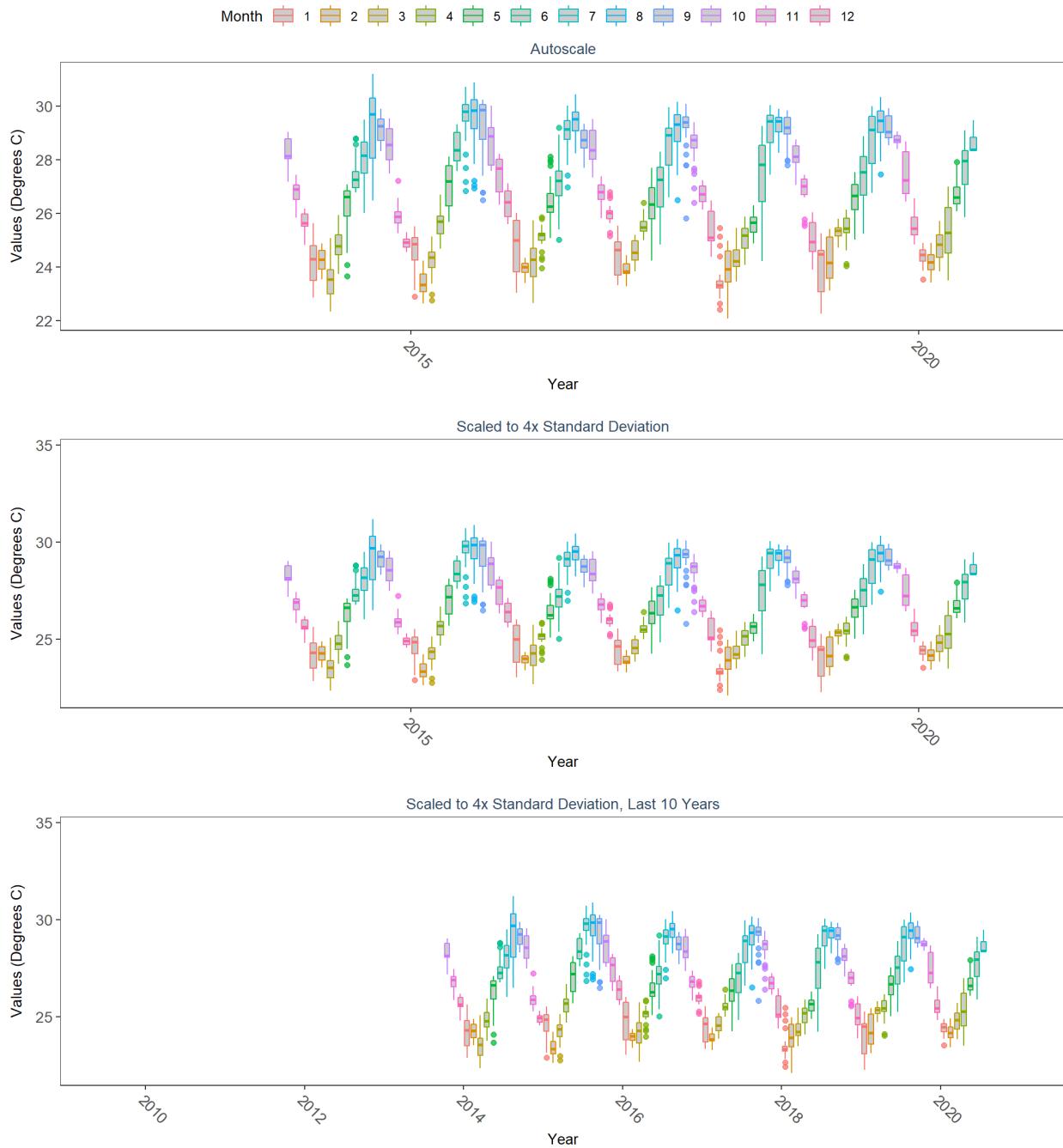
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 4  
 By Month



Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 5  
 By Year



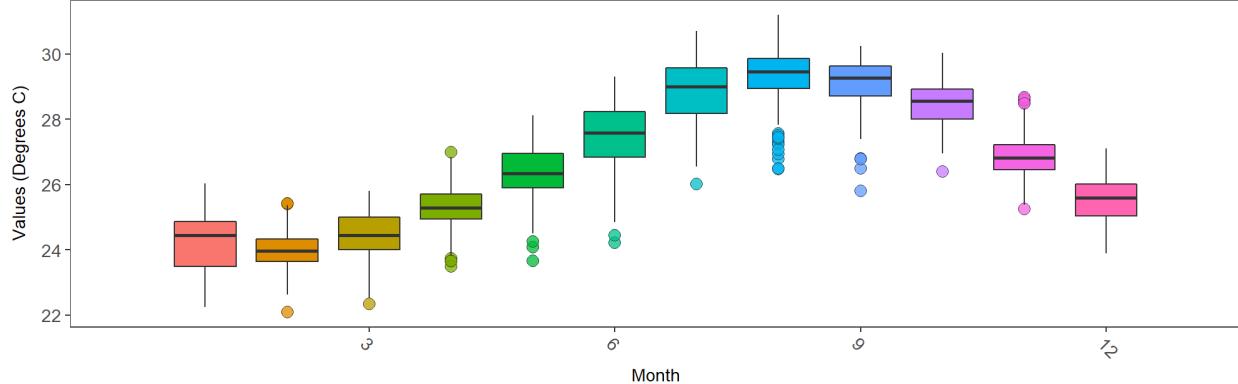
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 5  
 By Year & Month



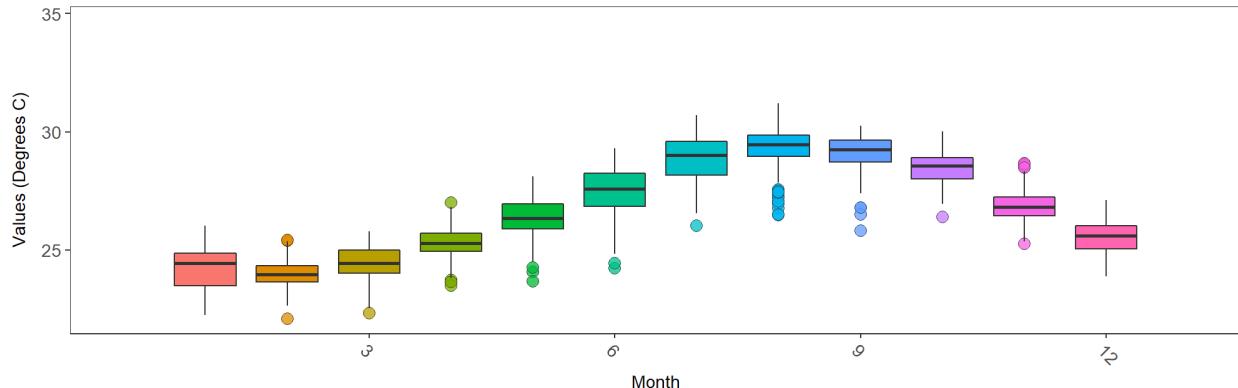
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 5  
 By Month

Month 1 2 3 4 5 6 7 8 9 10 11 12

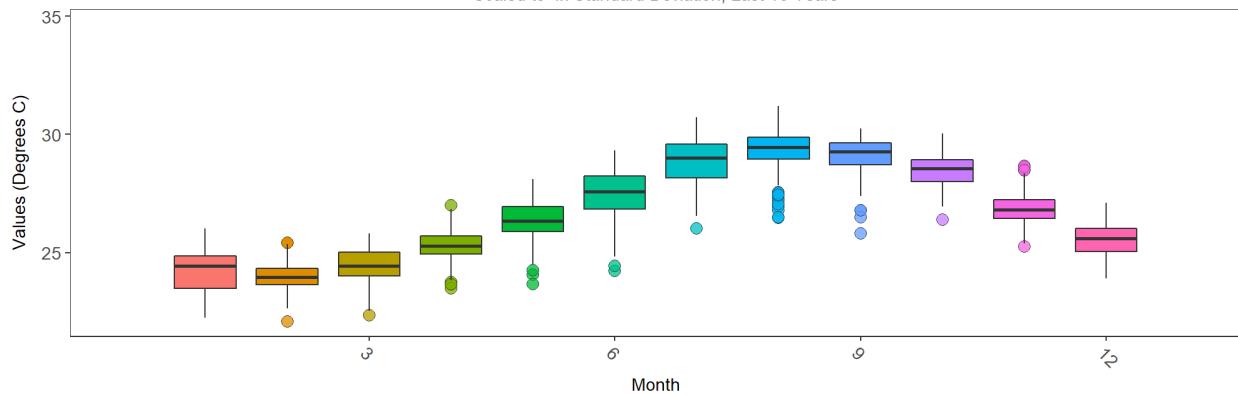
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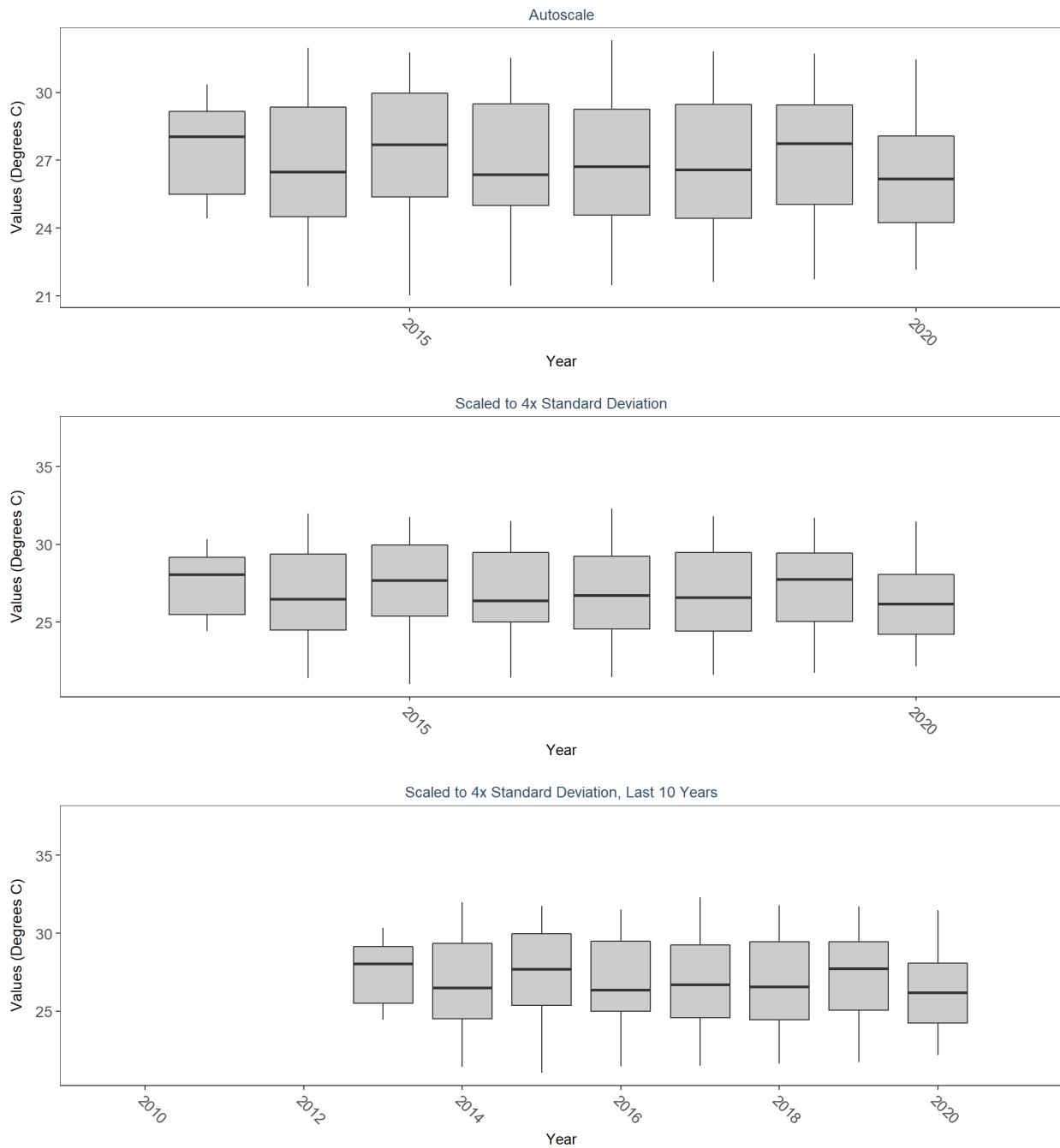
Scaled to 4x Standard Deviation



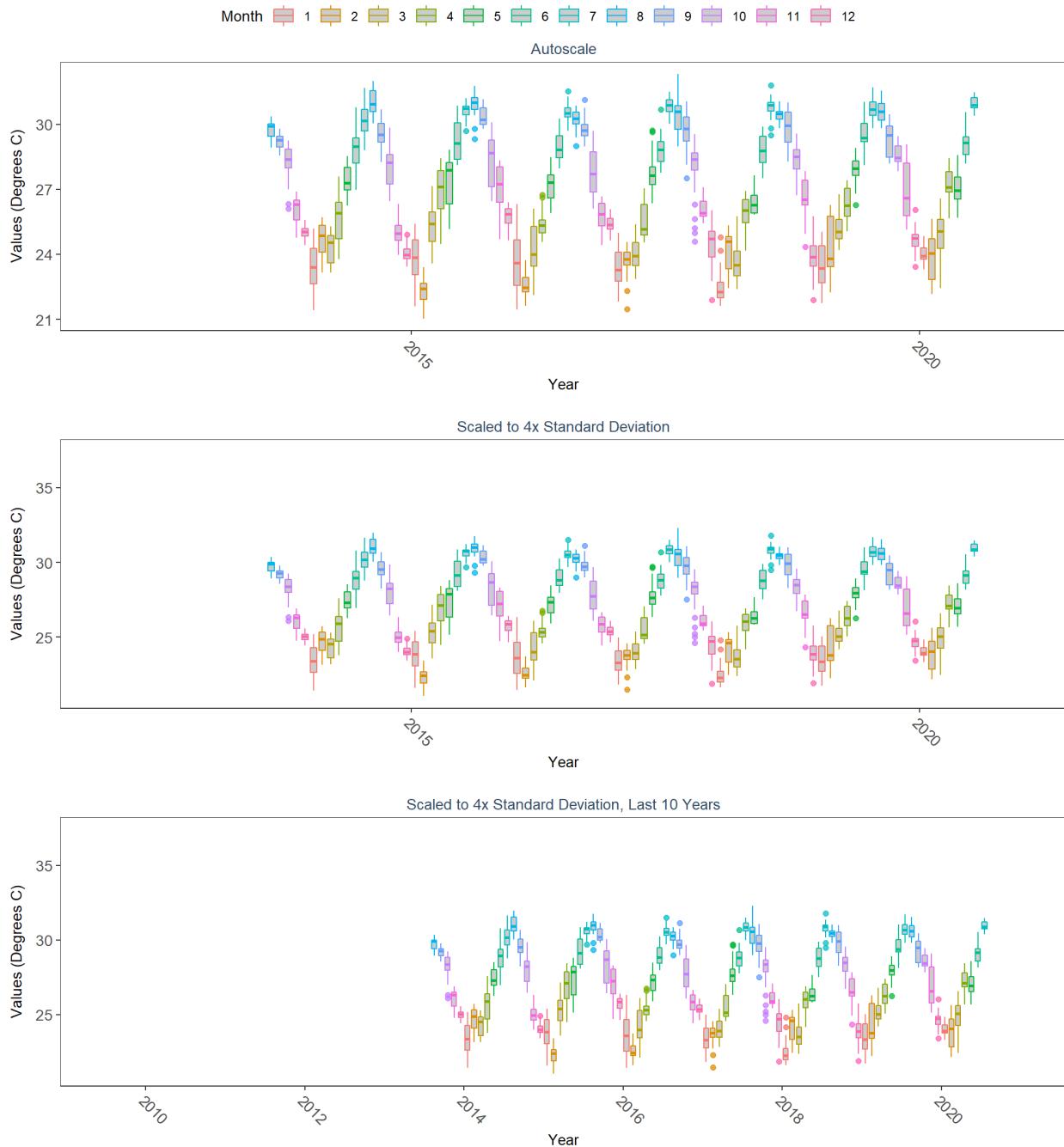
Scaled to 4x Standard Deviation, Last 10 Years



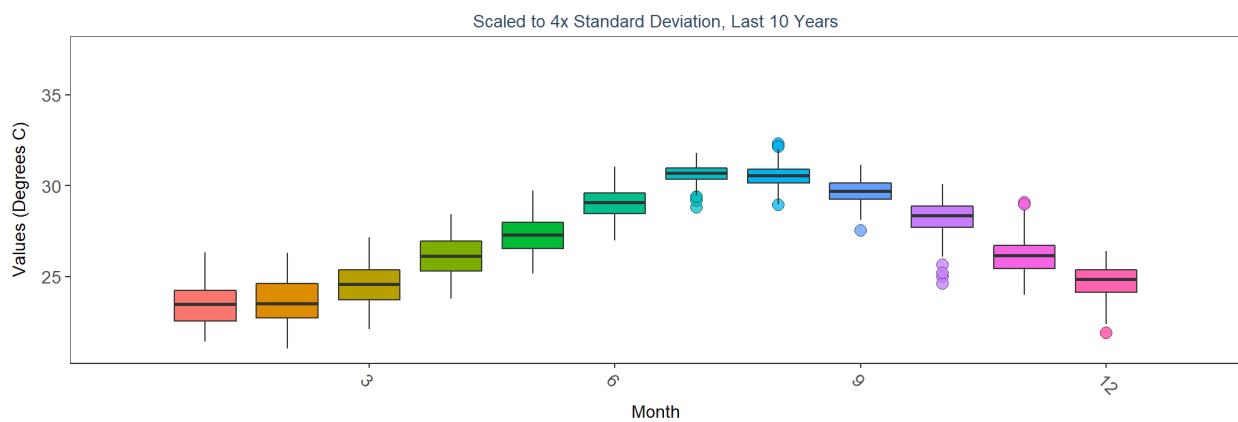
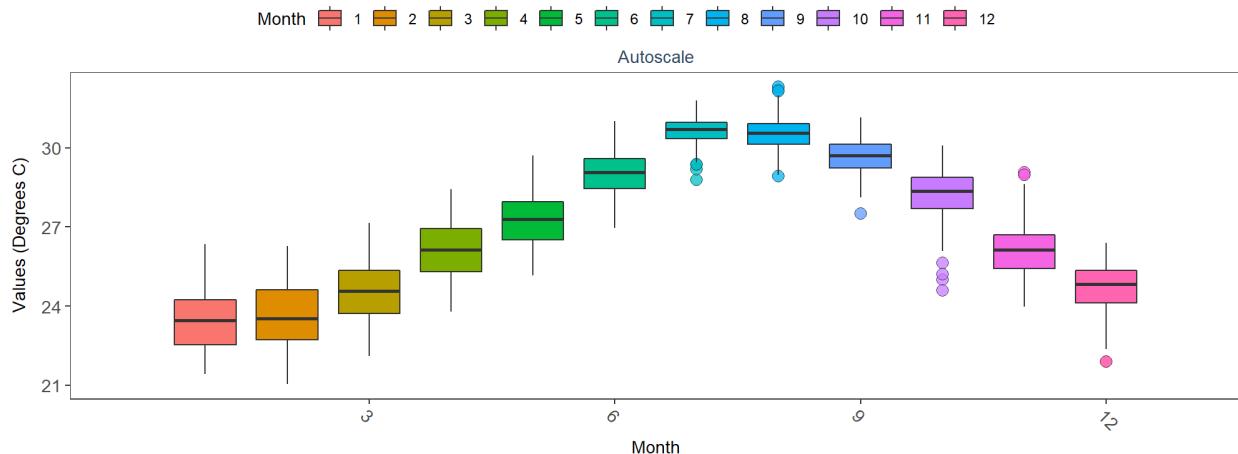
Southeast Florida Coral Reef Ecosystem Conservation Area  
986  
Water Temperature on Coral Reefs in the Florida Keys  
6  
By Year



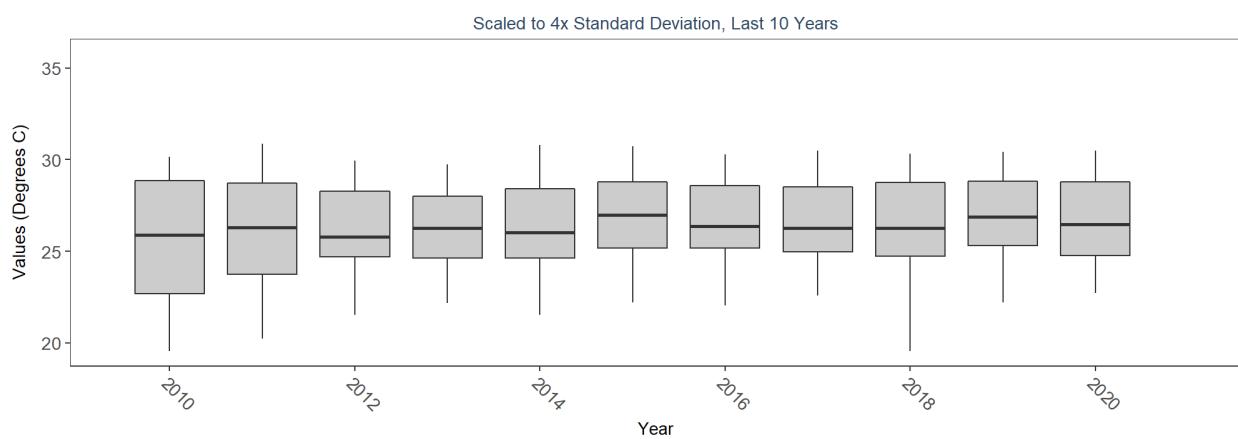
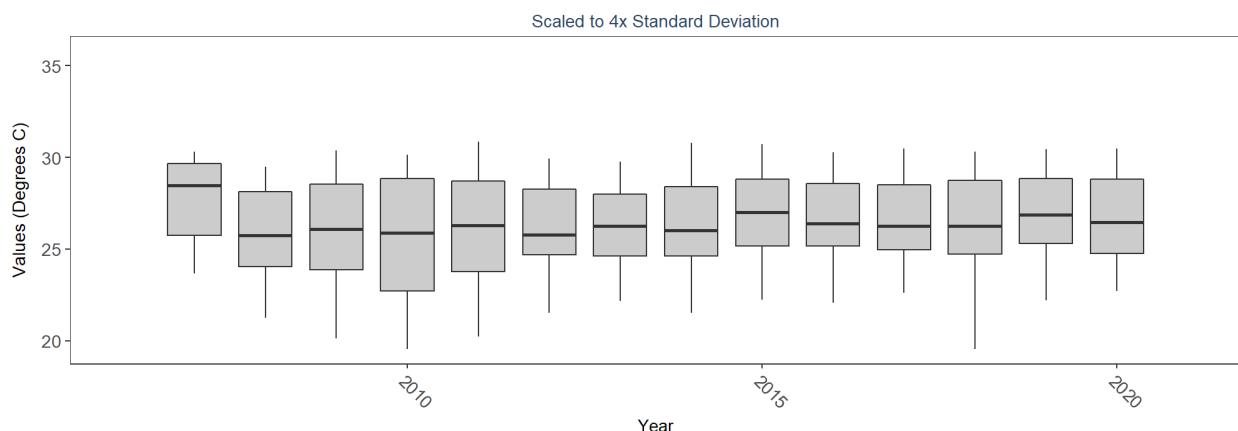
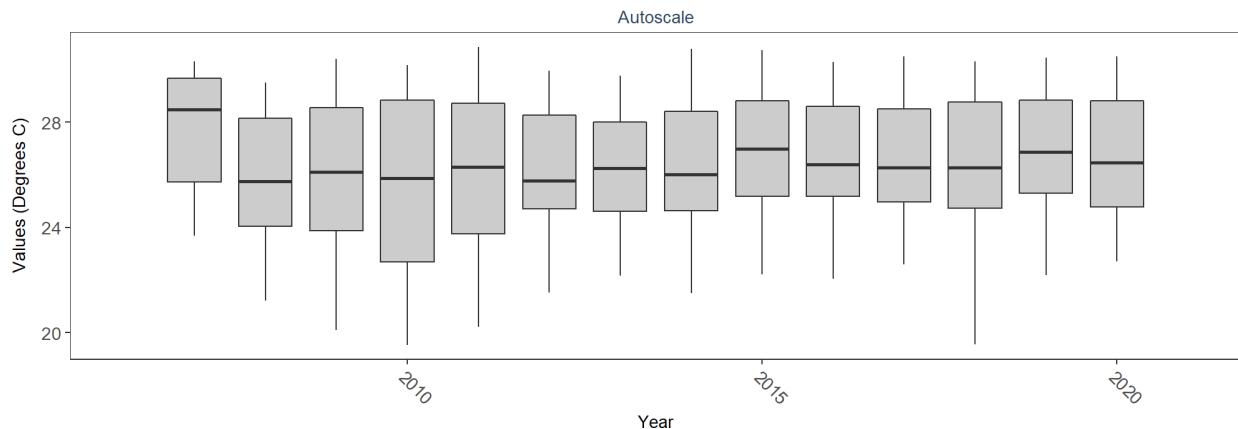
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 6  
 By Year & Month



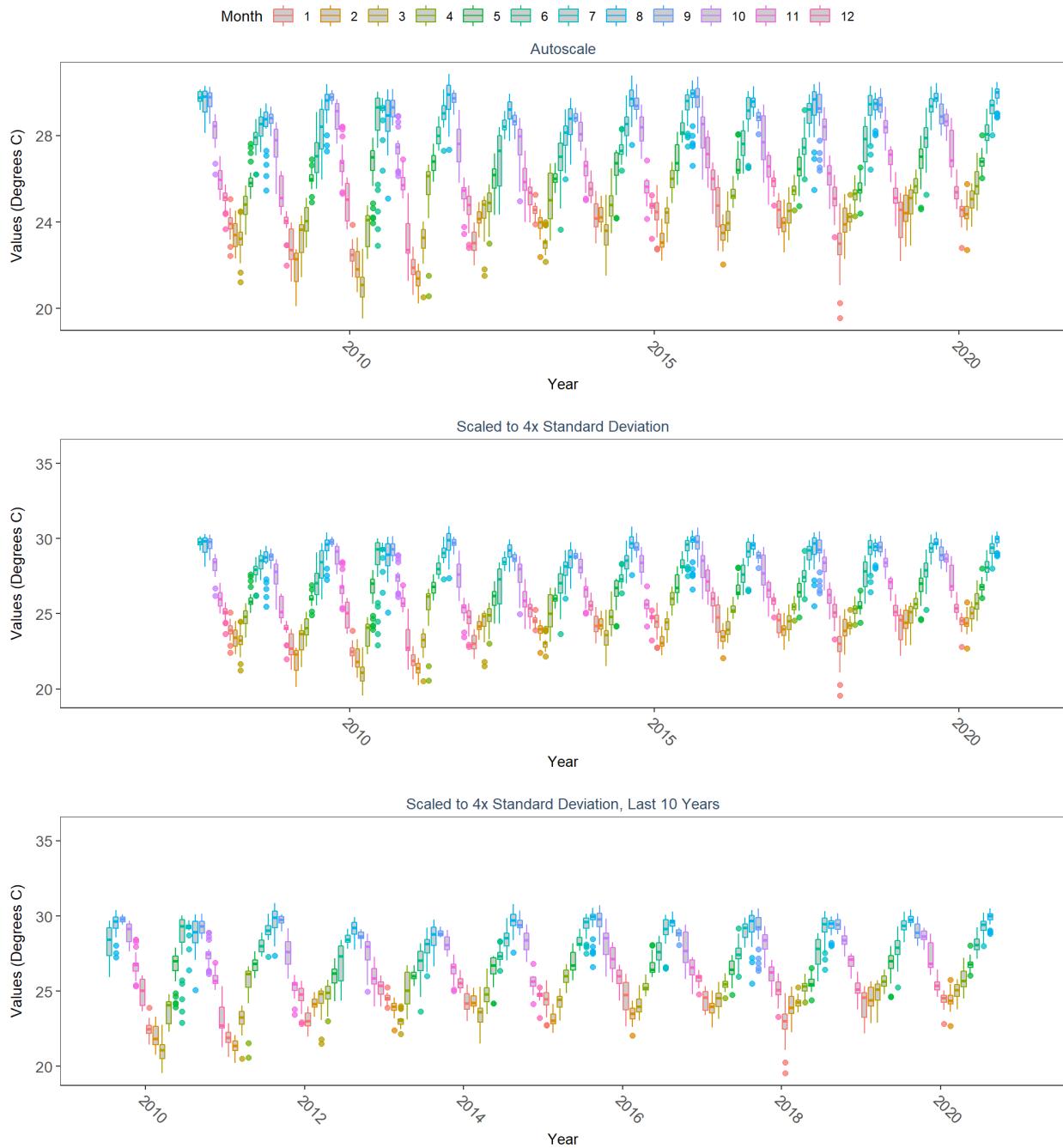
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 6  
 By Month



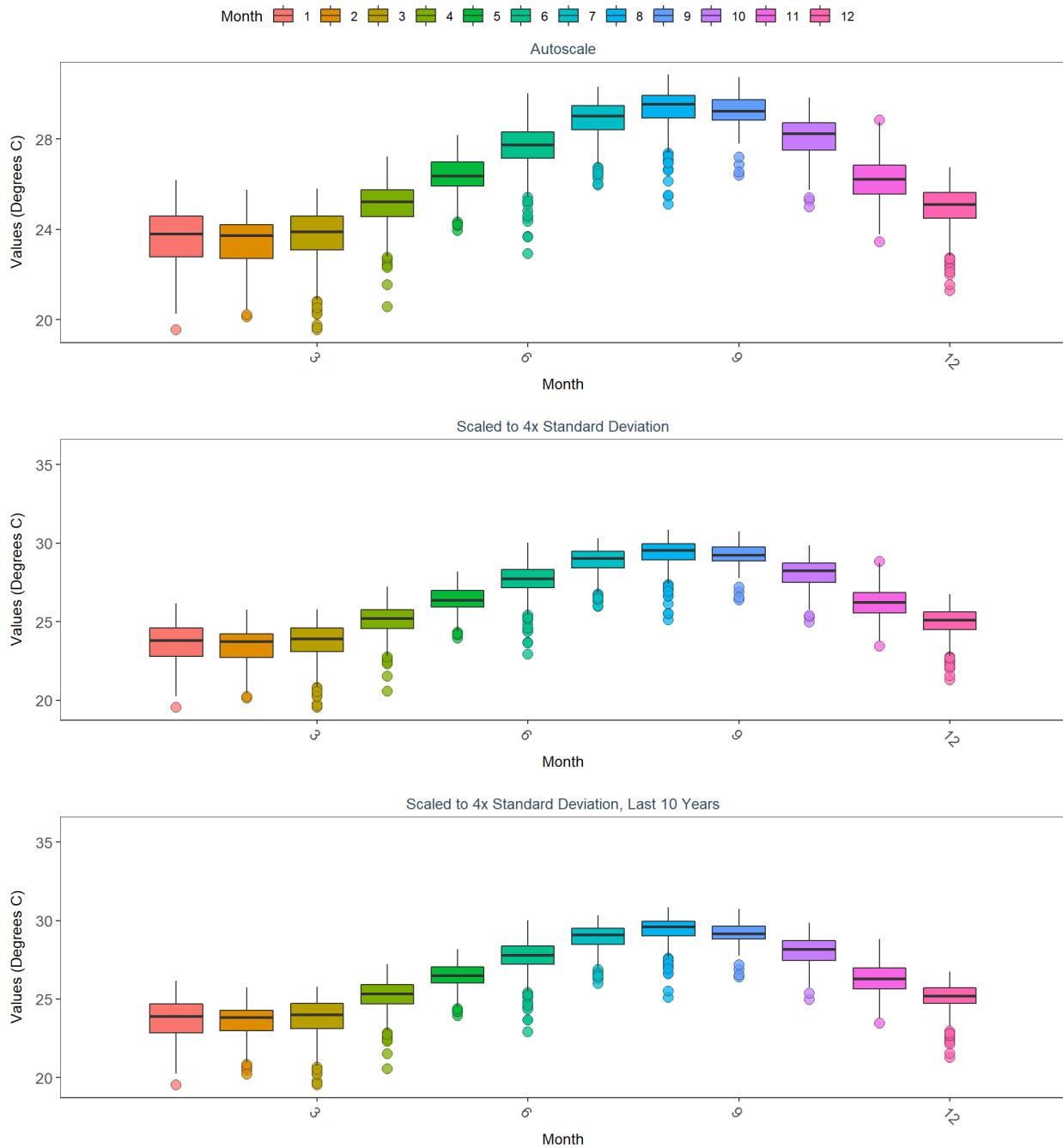
Southeast Florida Coral Reef Ecosystem Conservation Area  
986  
Water Temperature on Coral Reefs in the Florida Keys  
84  
By Year



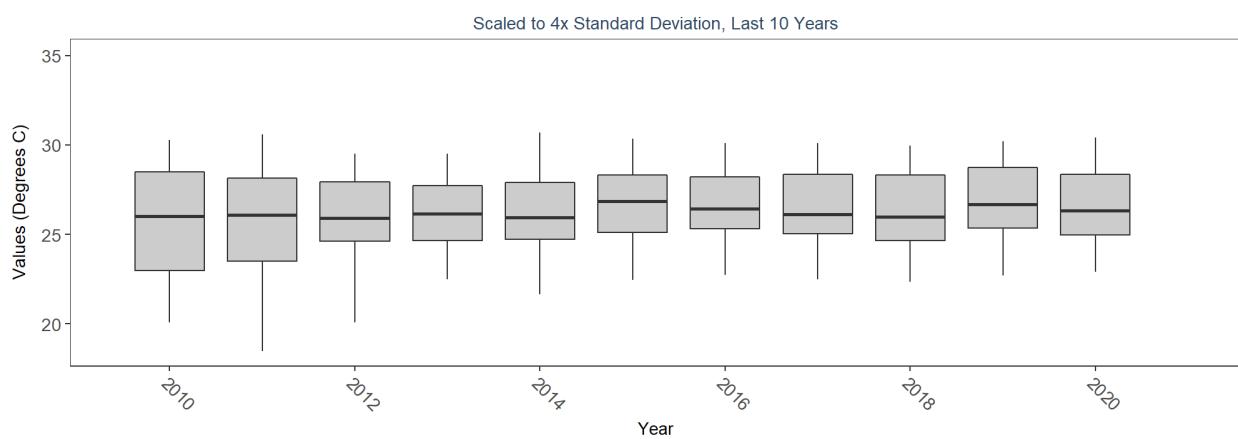
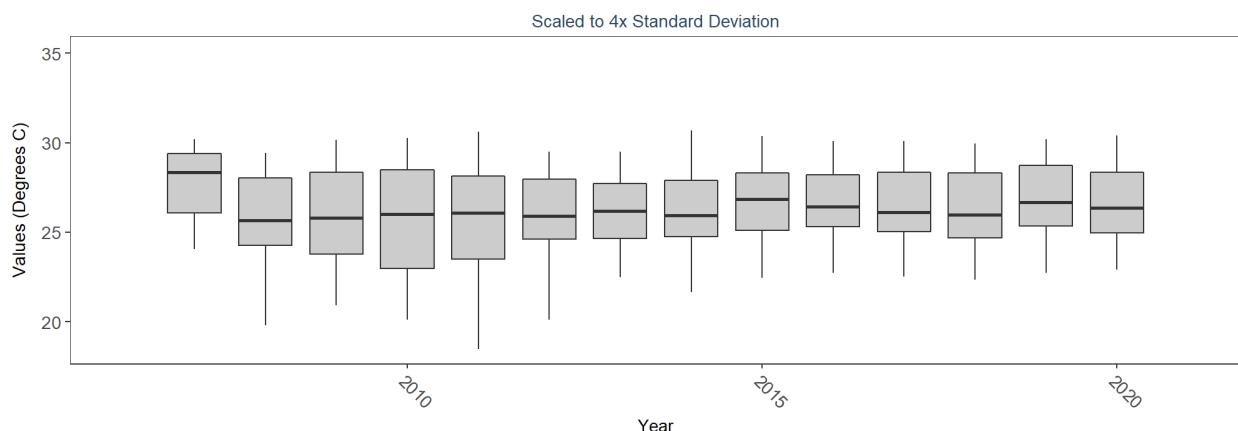
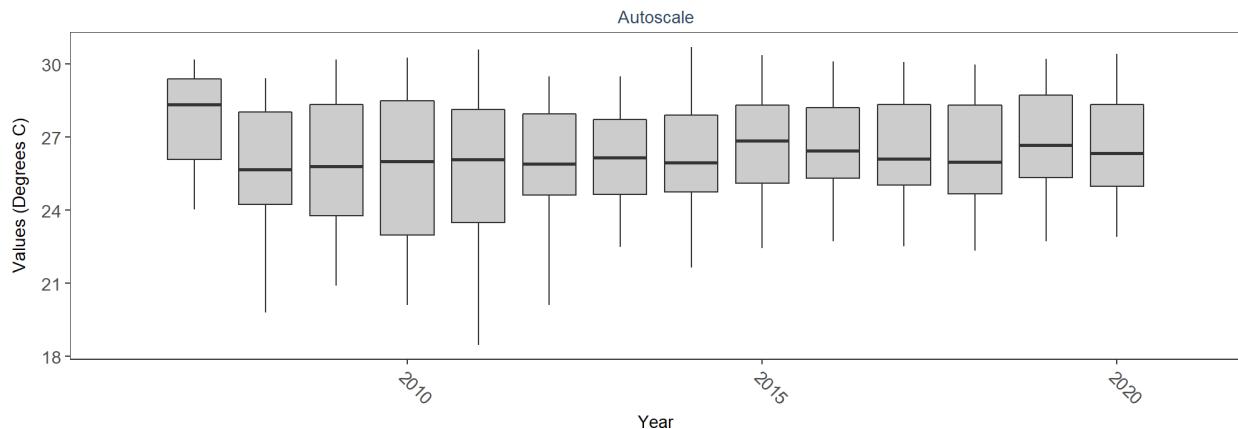
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 84  
 By Year & Month



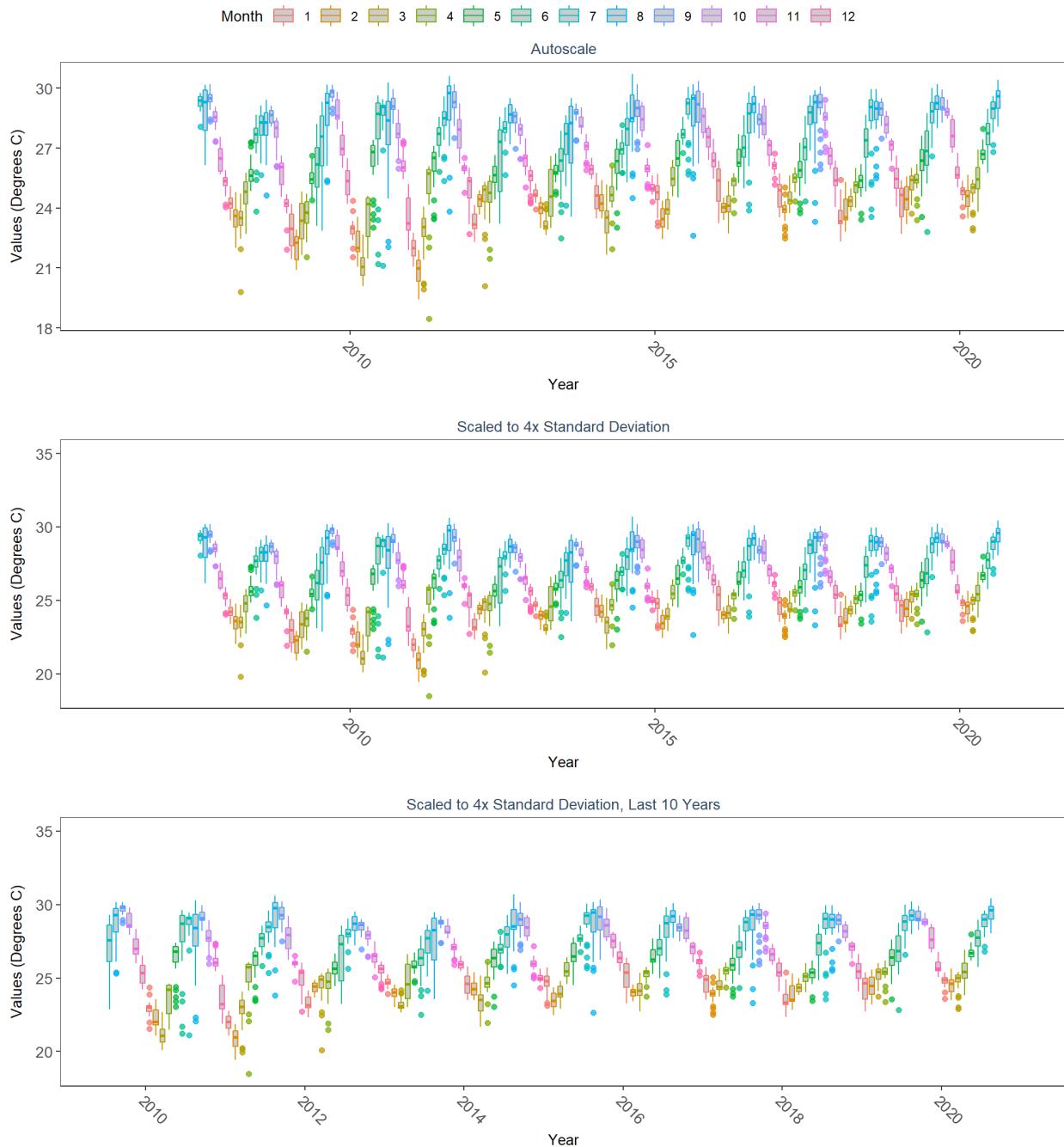
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 84  
 By Month



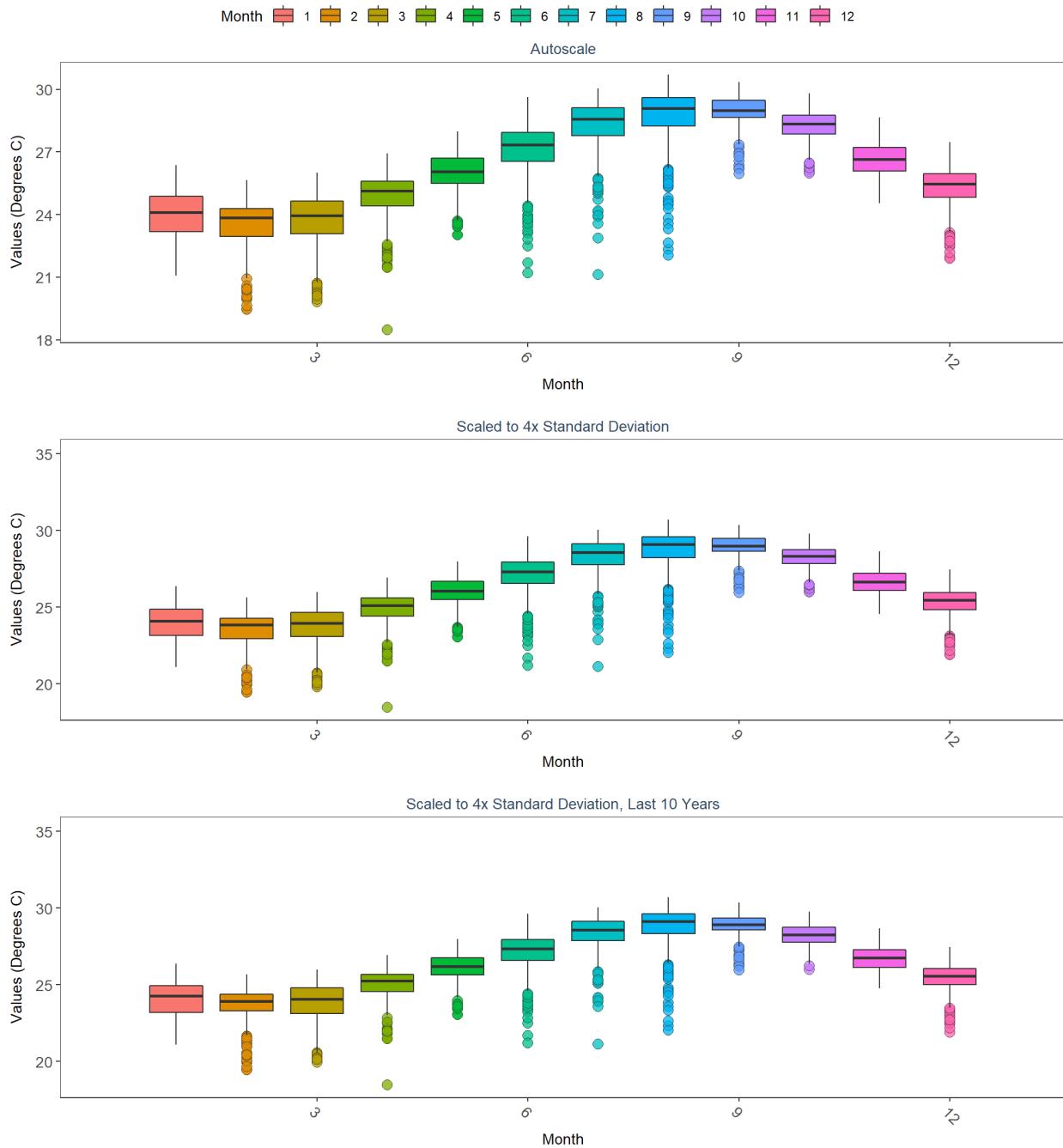
Southeast Florida Coral Reef Ecosystem Conservation Area  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 85  
 By Year



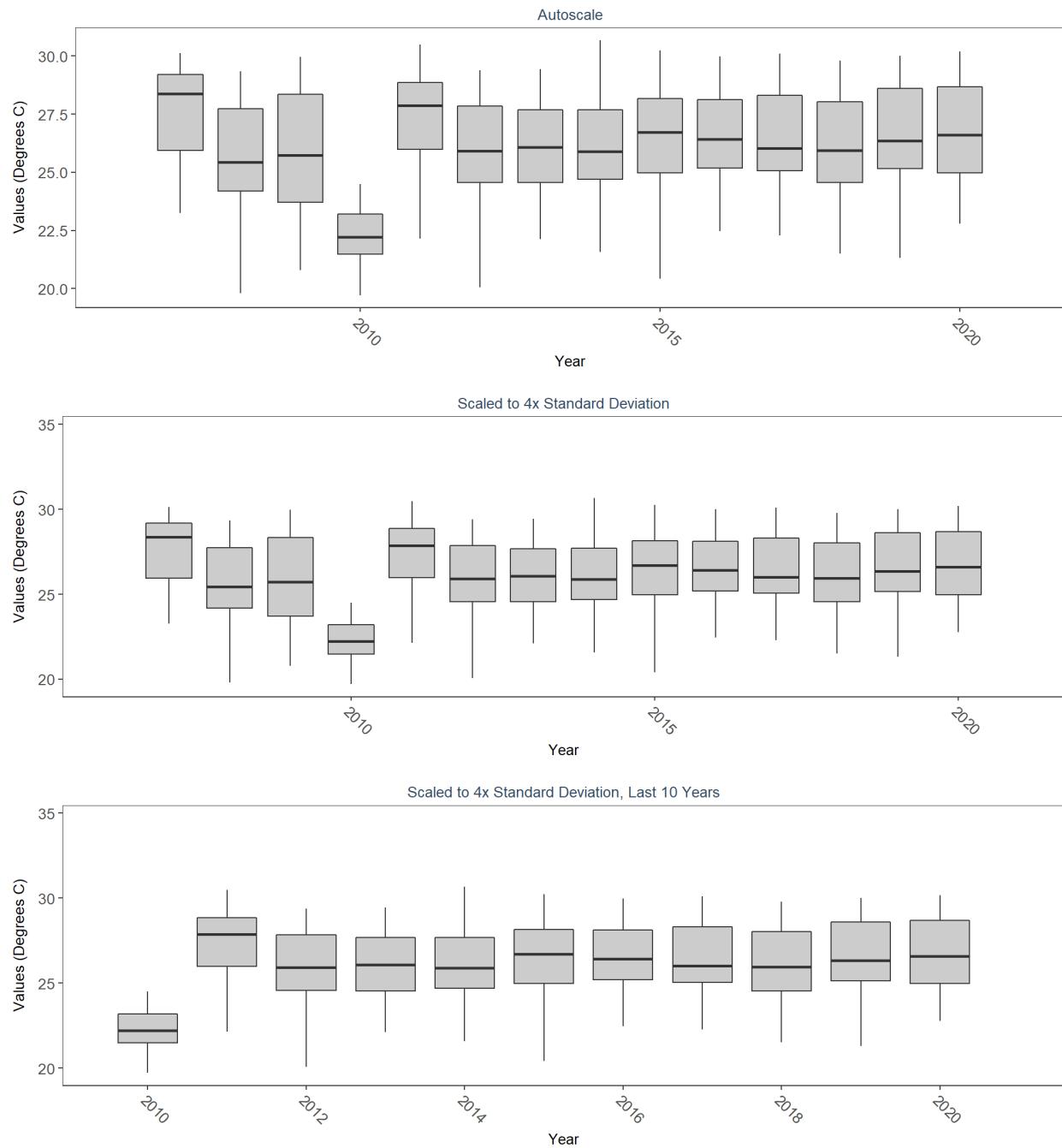
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 85  
 By Year & Month



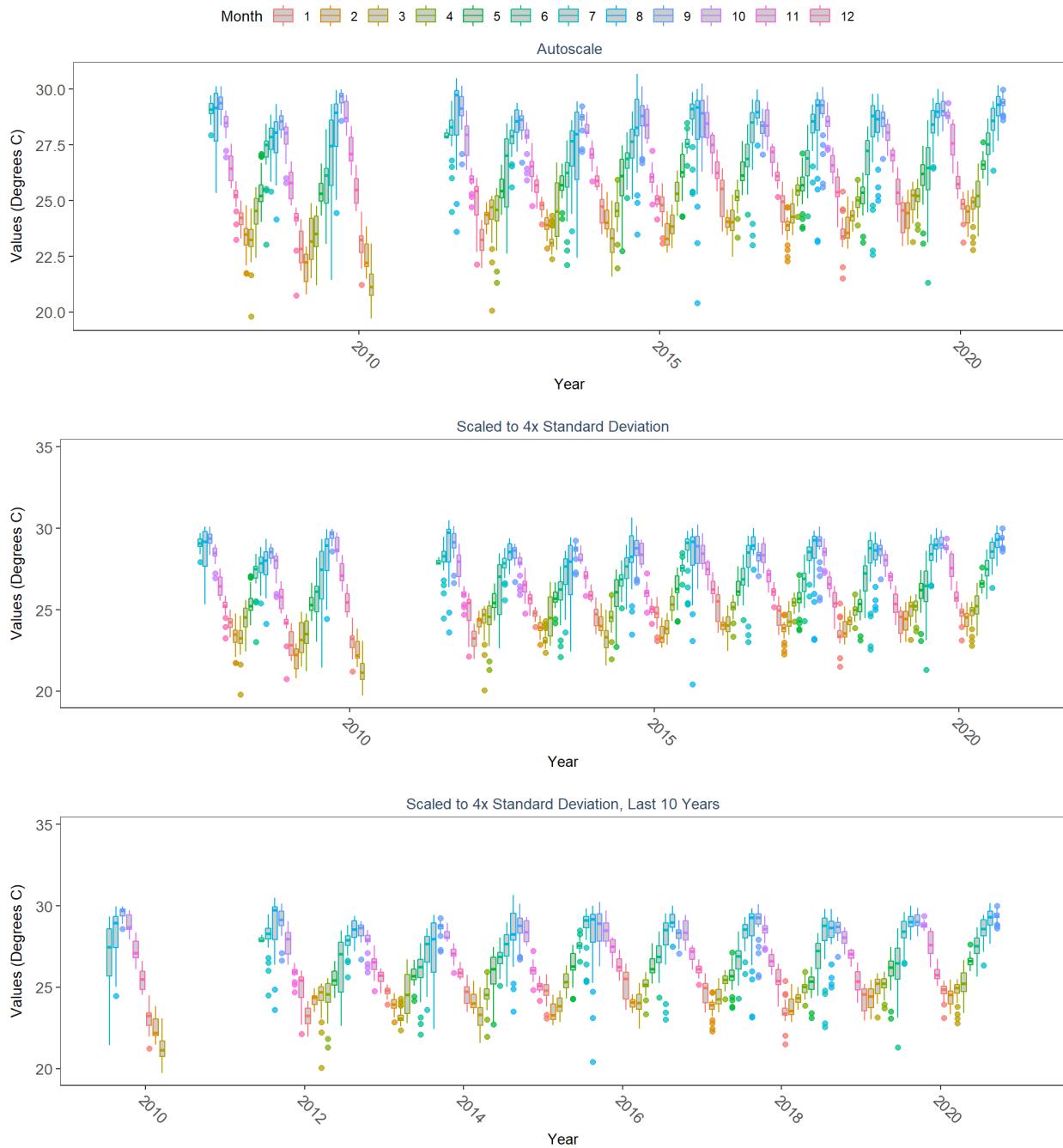
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 85  
 By Month



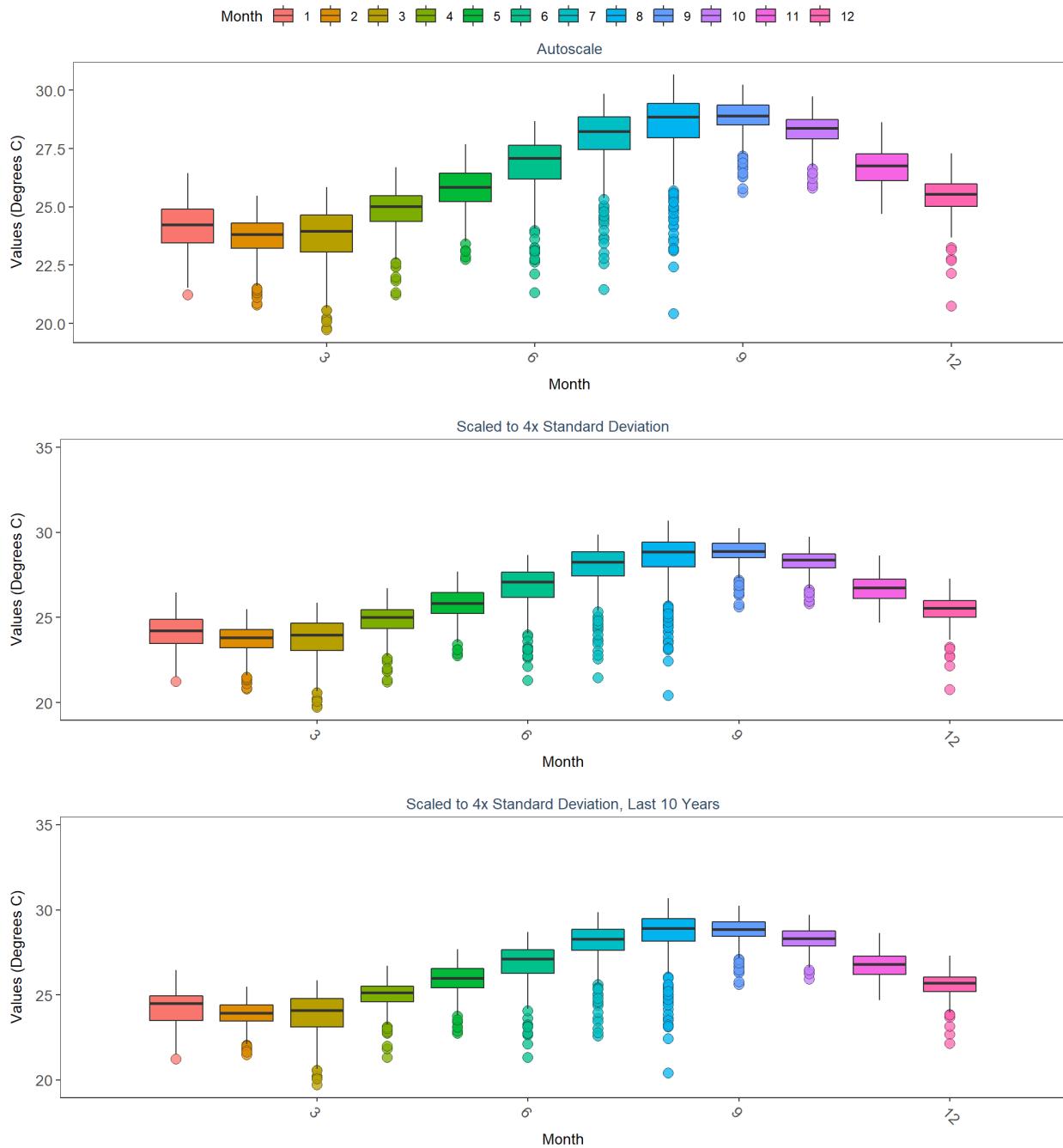
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986  
Water Temperature on Coral Reefs in the Florida Keys  
86  
By Year



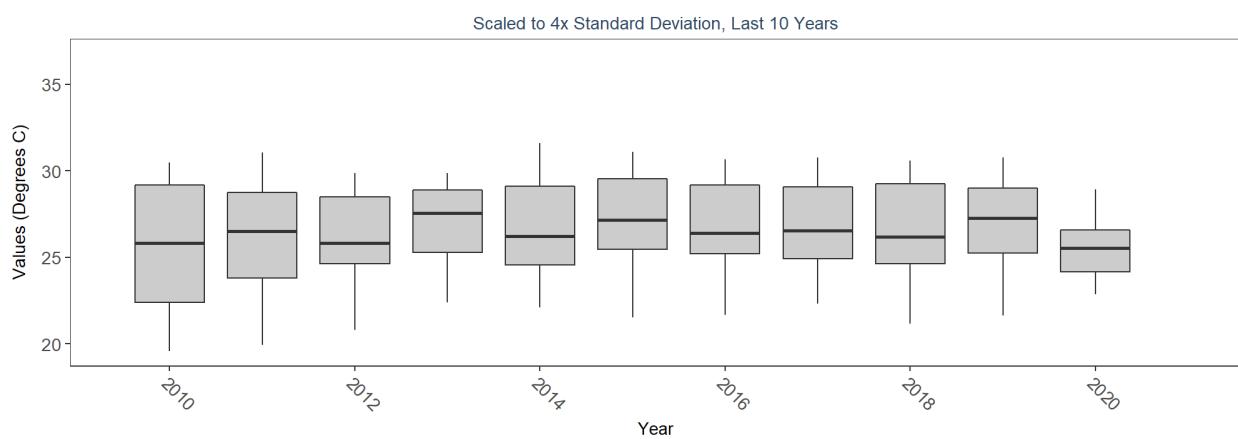
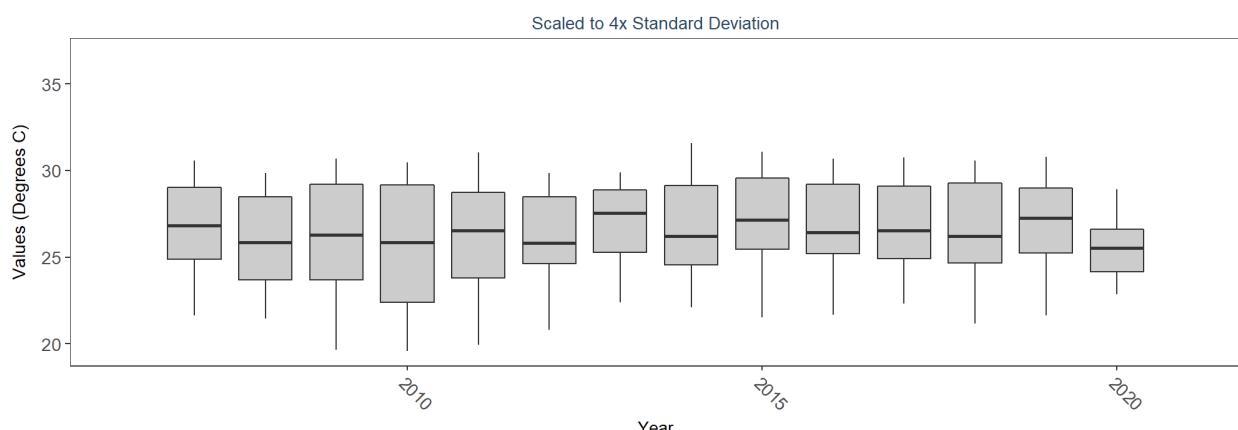
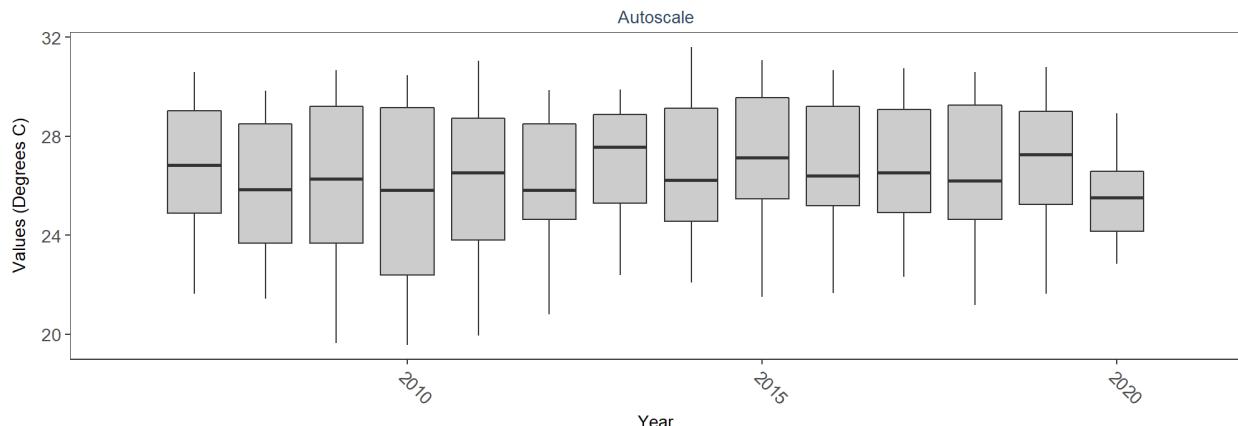
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 86  
 By Year & Month



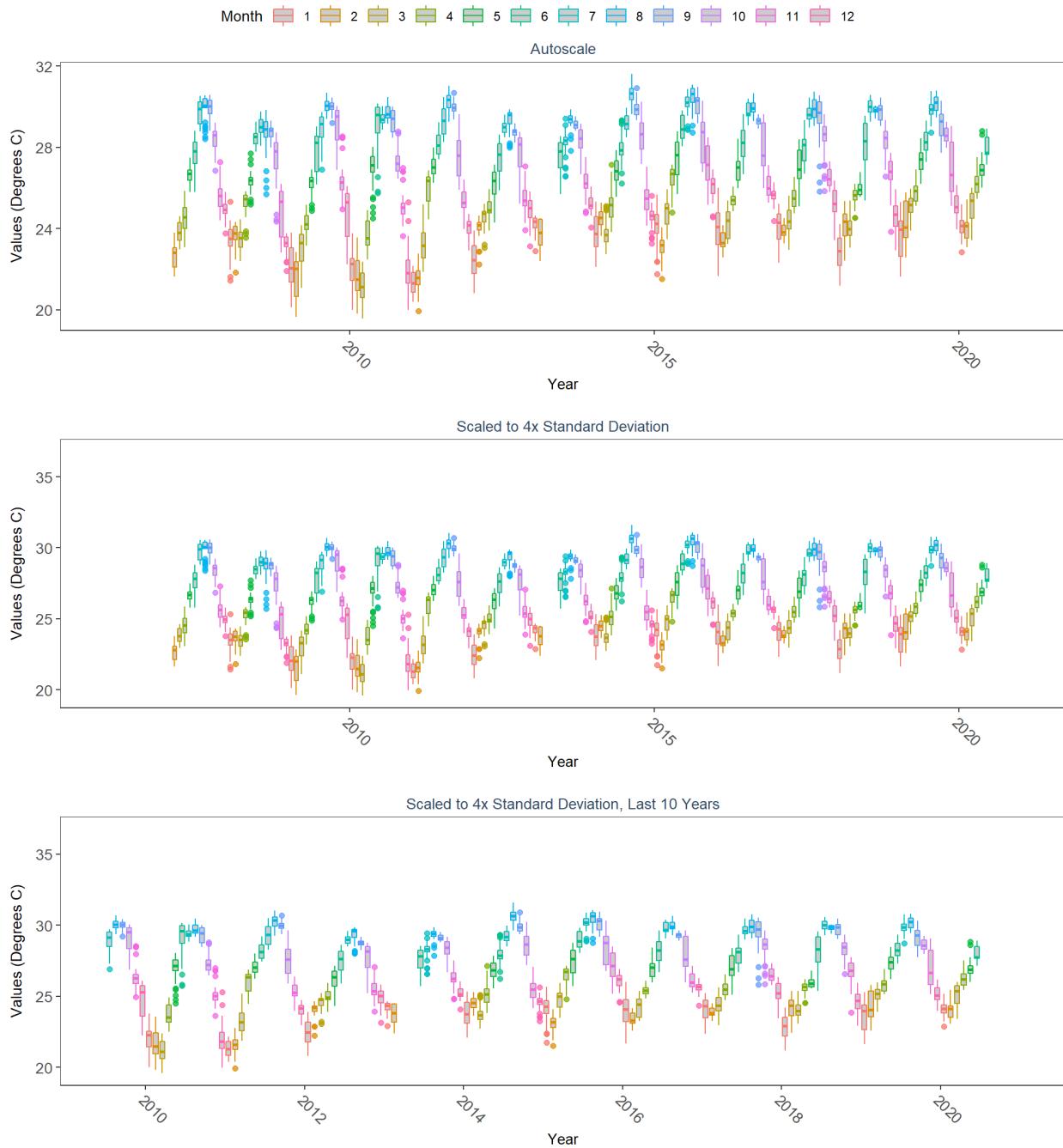
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 86  
 By Month



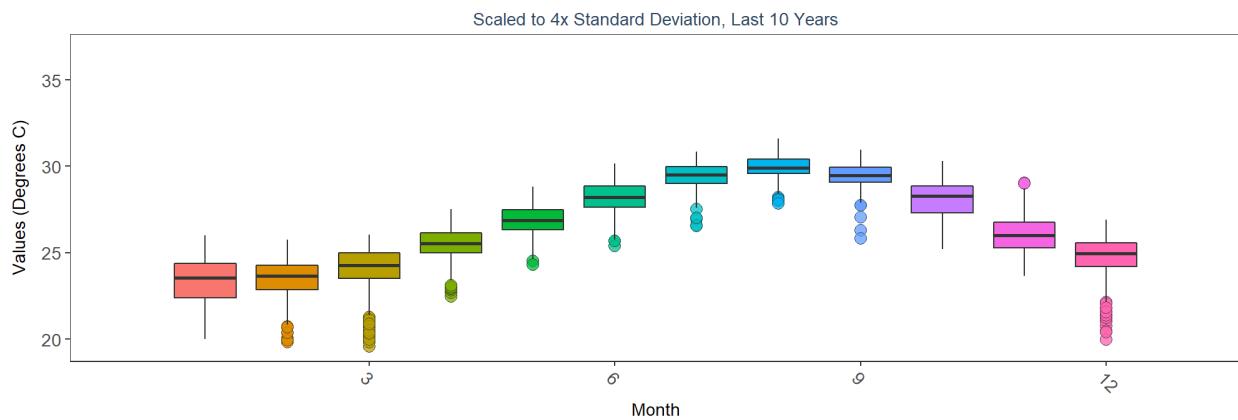
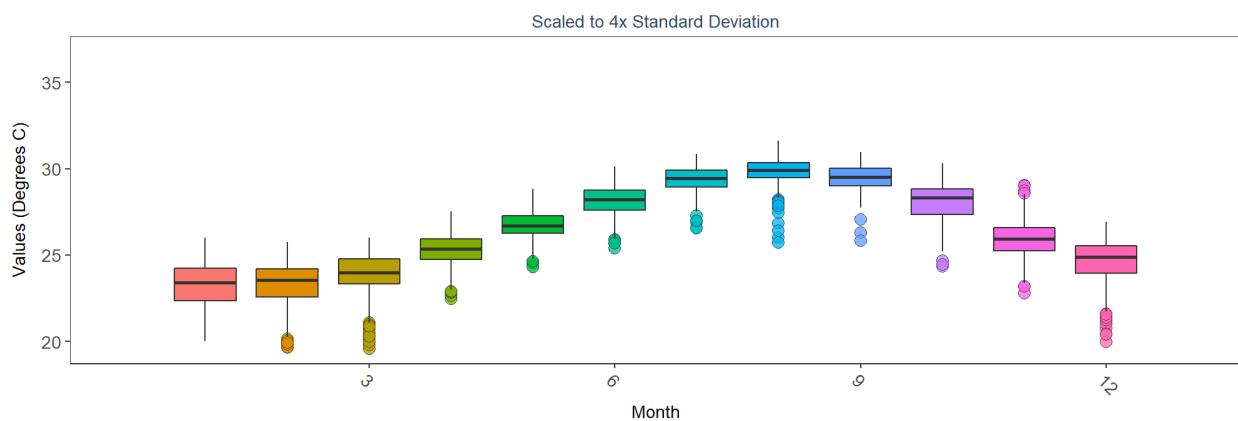
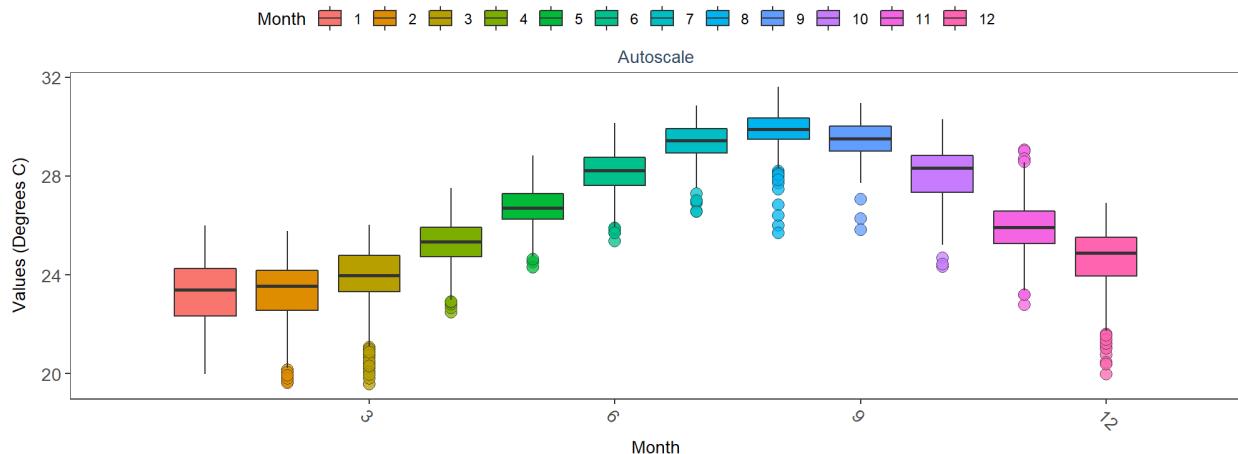
Southeast Florida Coral Reef Ecosystem Conservation Area  
986  
Water Temperature on Coral Reefs in the Florida Keys  
87  
By Year



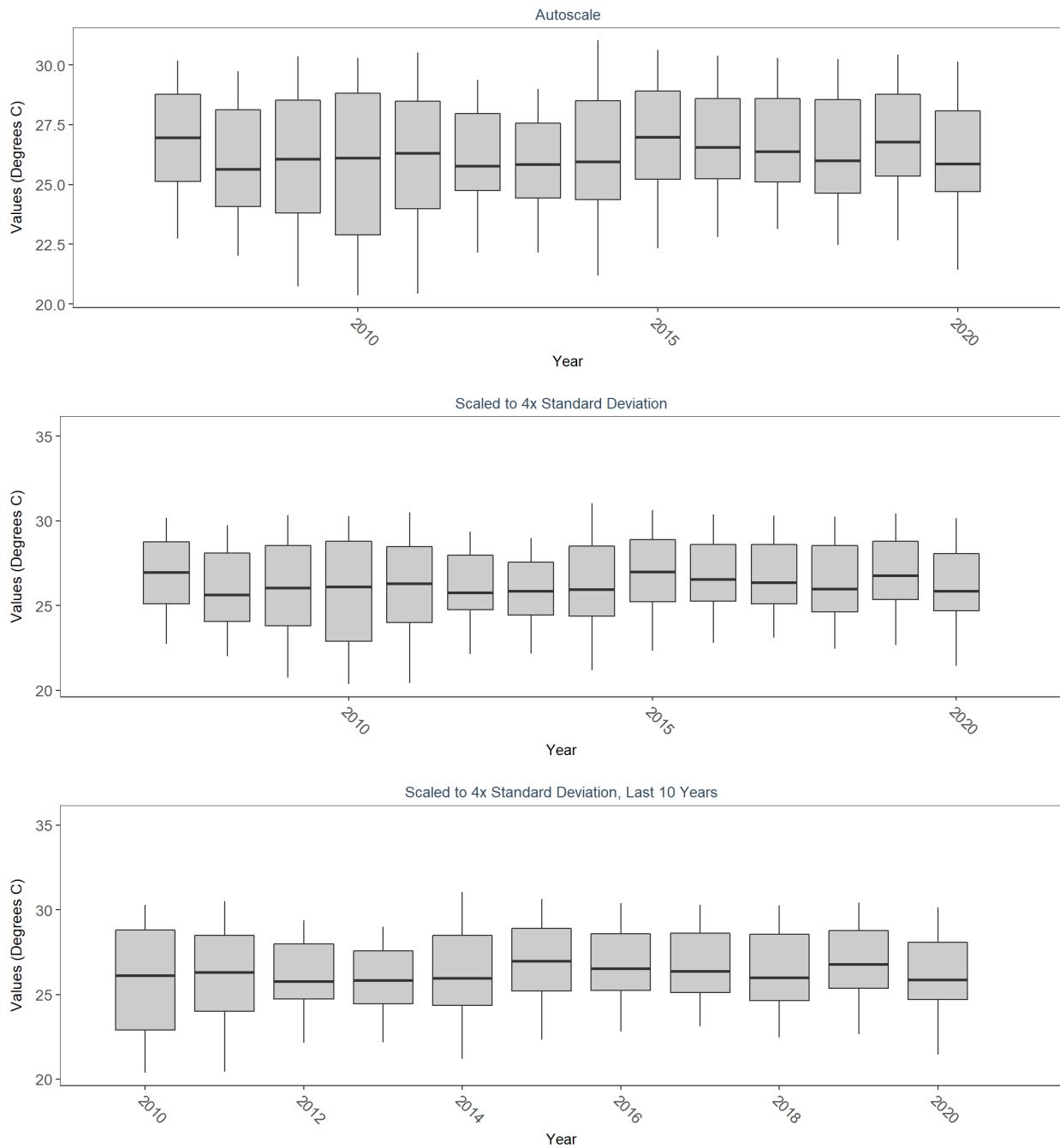
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 87  
 By Year & Month



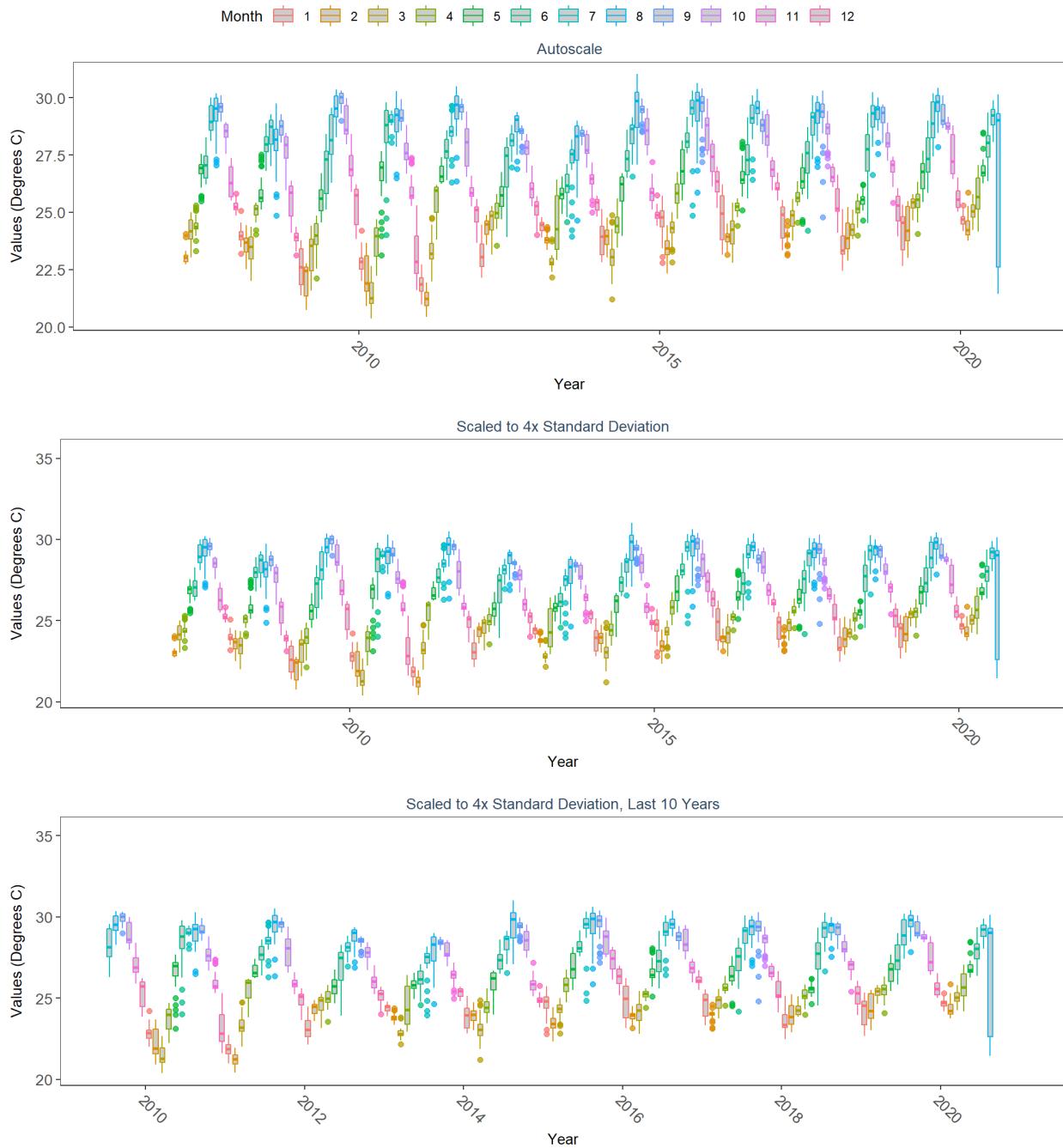
Southeast Florida Coral Reef Ecosystem Conservation Area  
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 Water Temperature on Coral Reefs in the Florida Keys  
 87  
 By Month



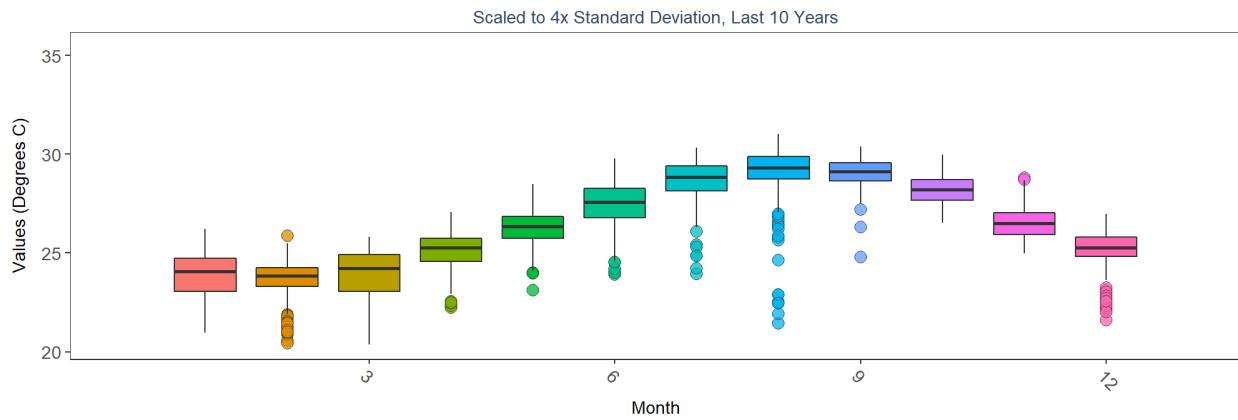
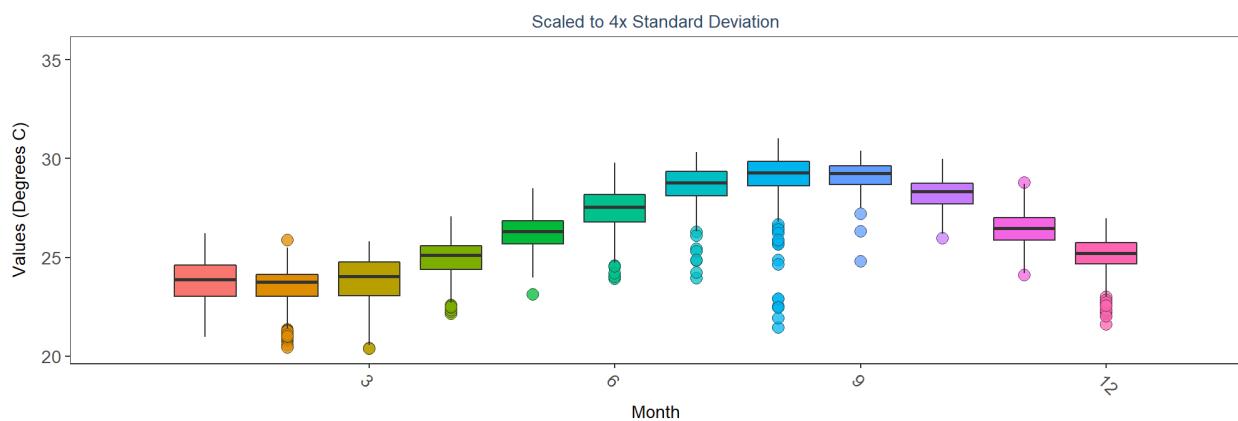
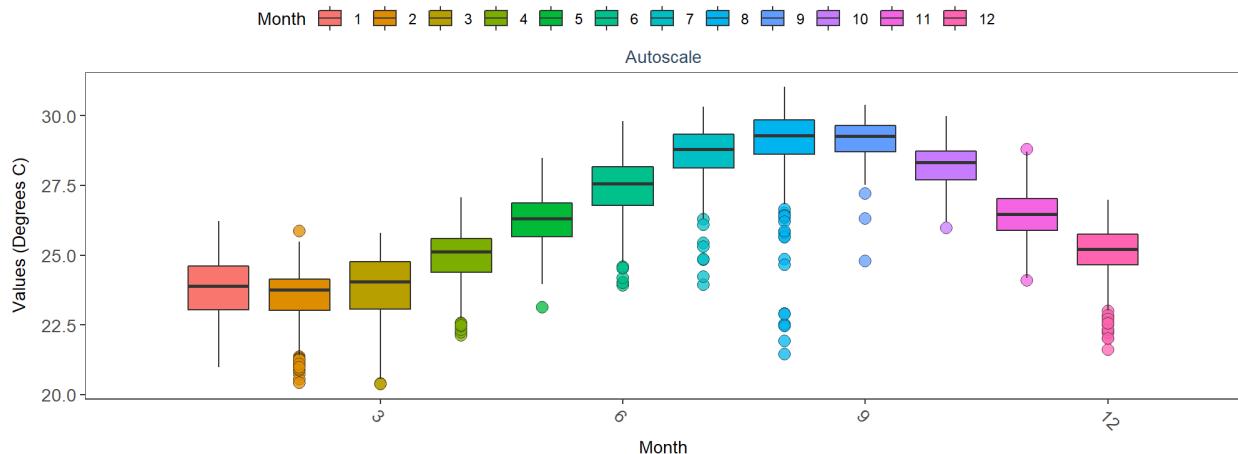
Southeast Florida Coral Reef Ecosystem Conservation Area  
986  
Water Temperature on Coral Reefs in the Florida Keys  
88  
By Year



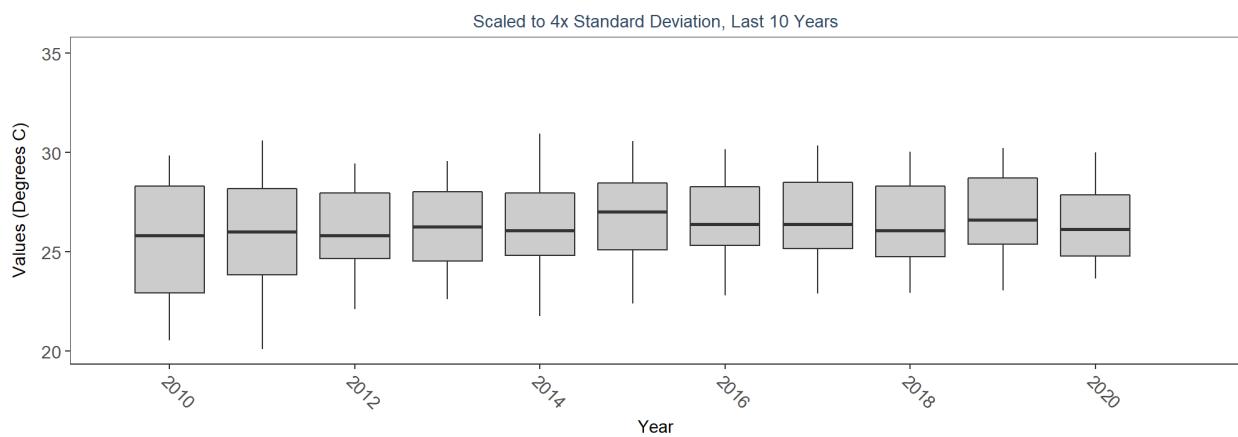
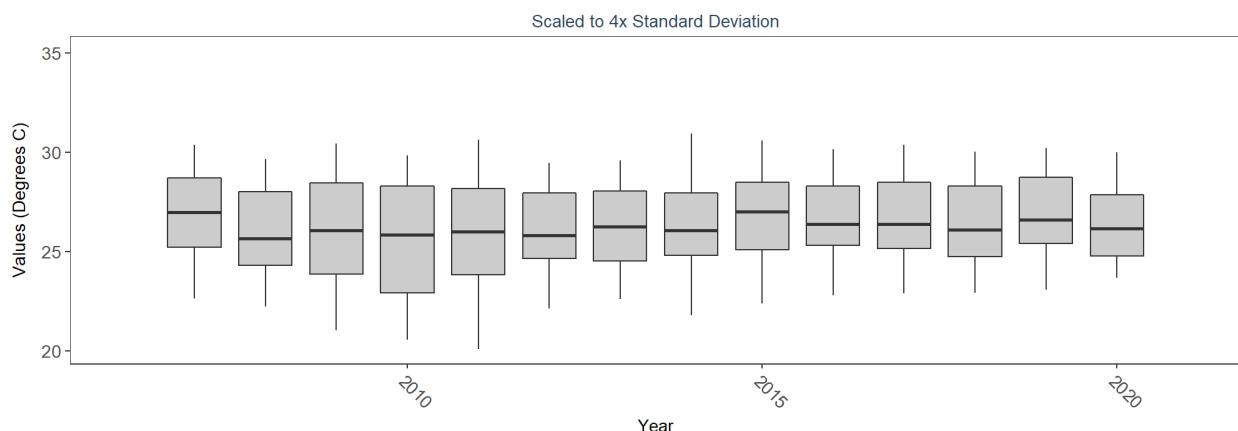
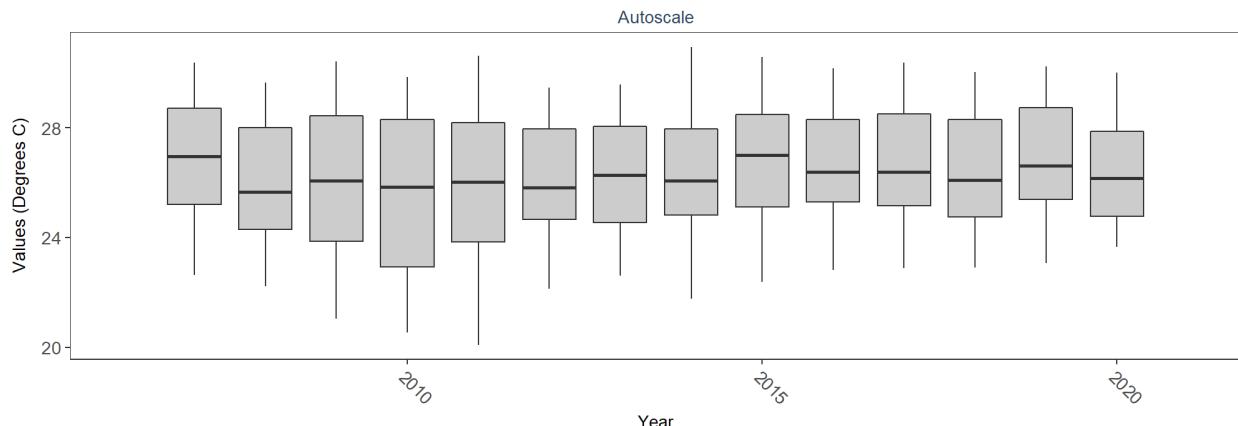
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 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 88  
 By Year & Month



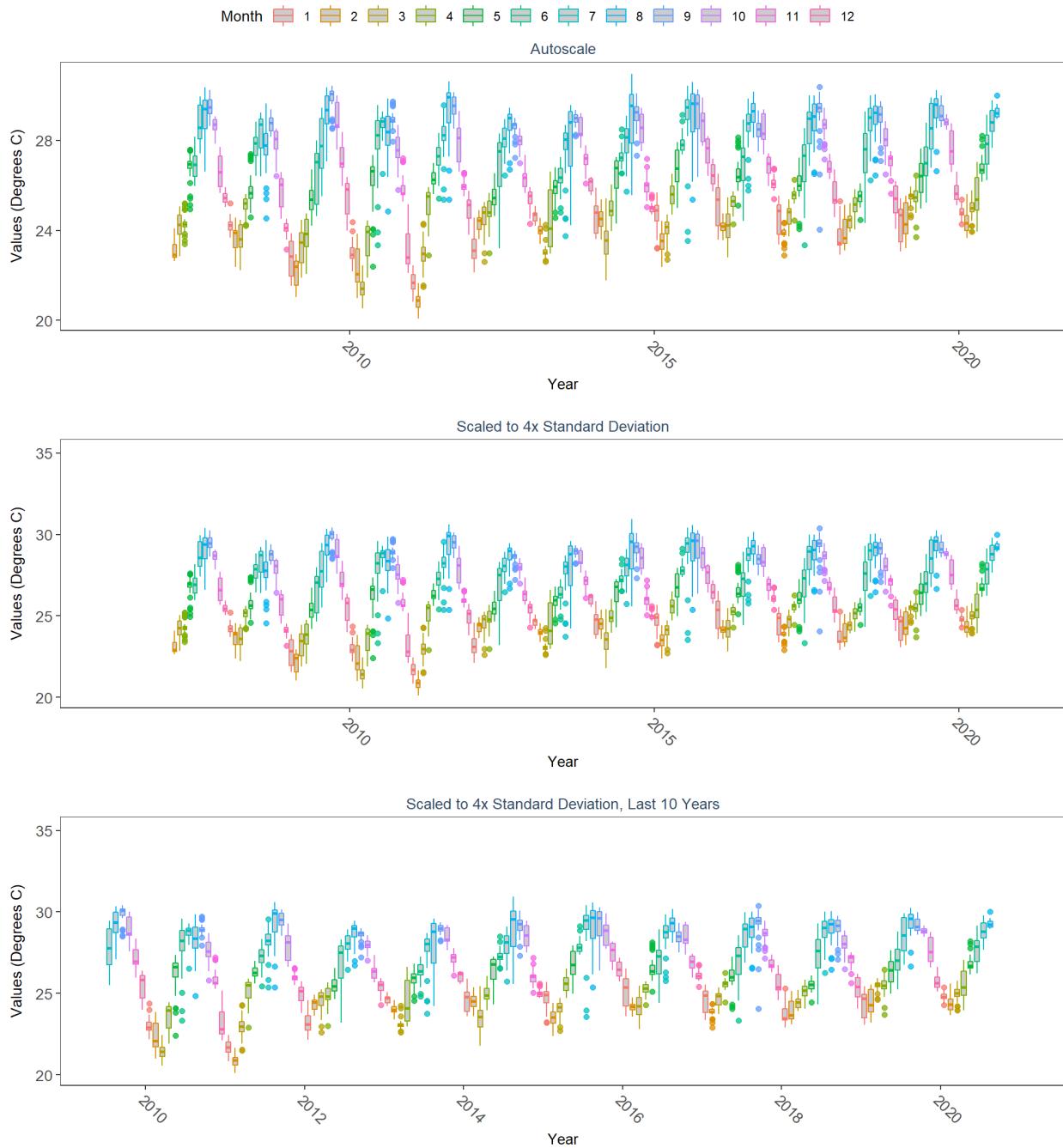
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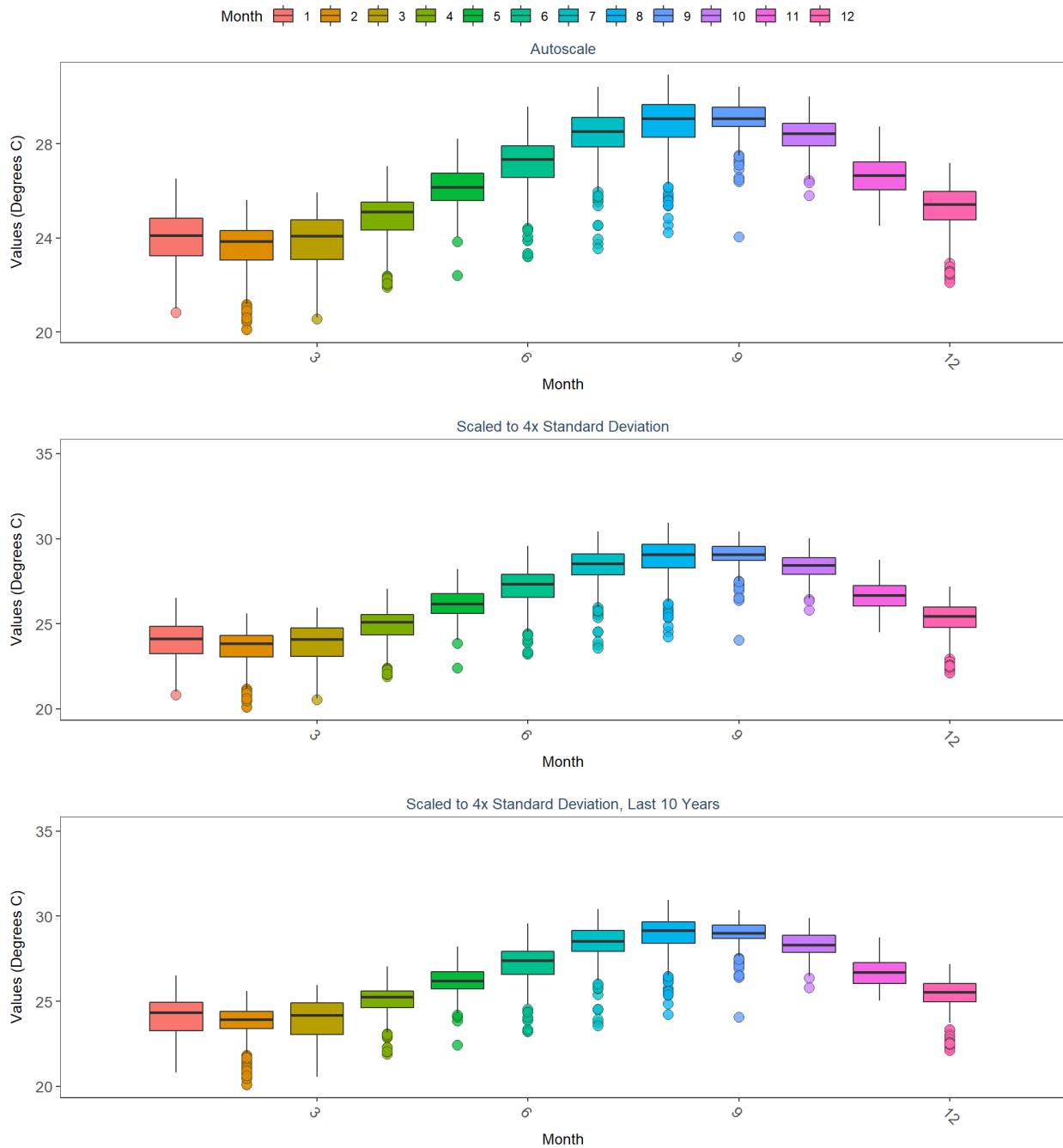
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89  
By Year



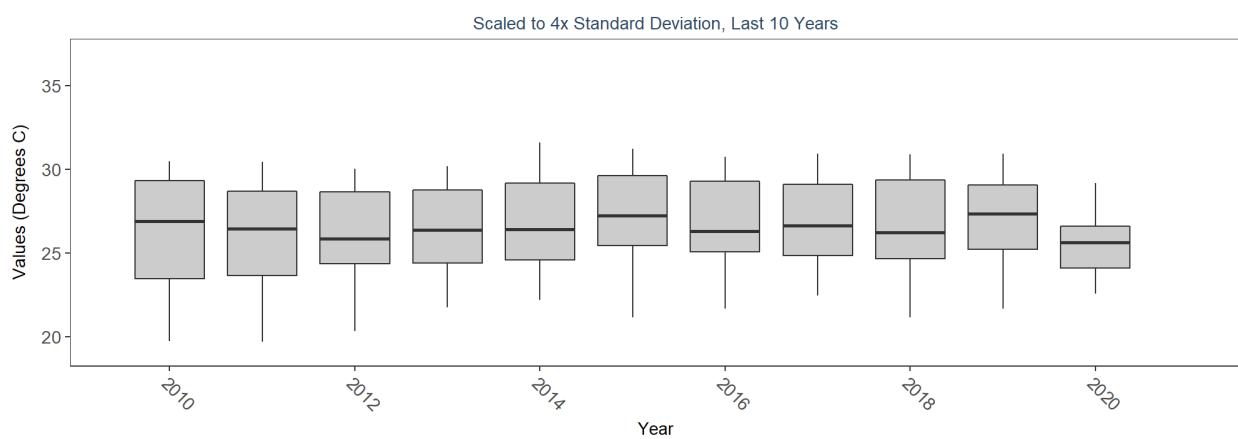
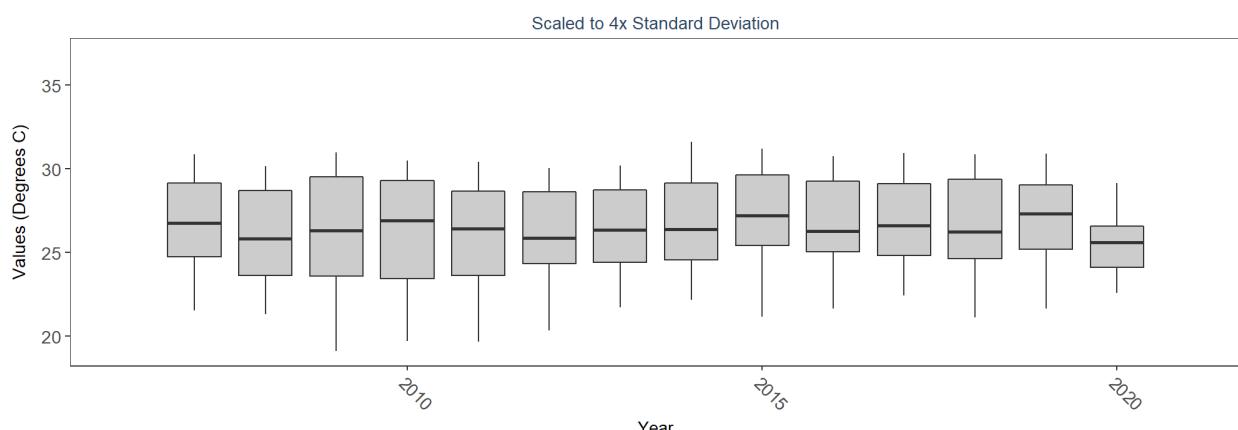
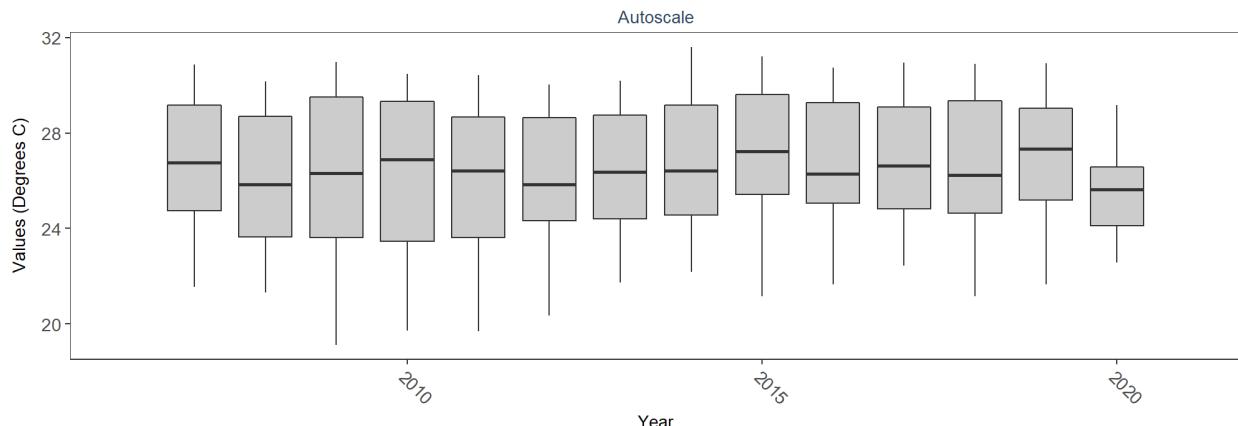
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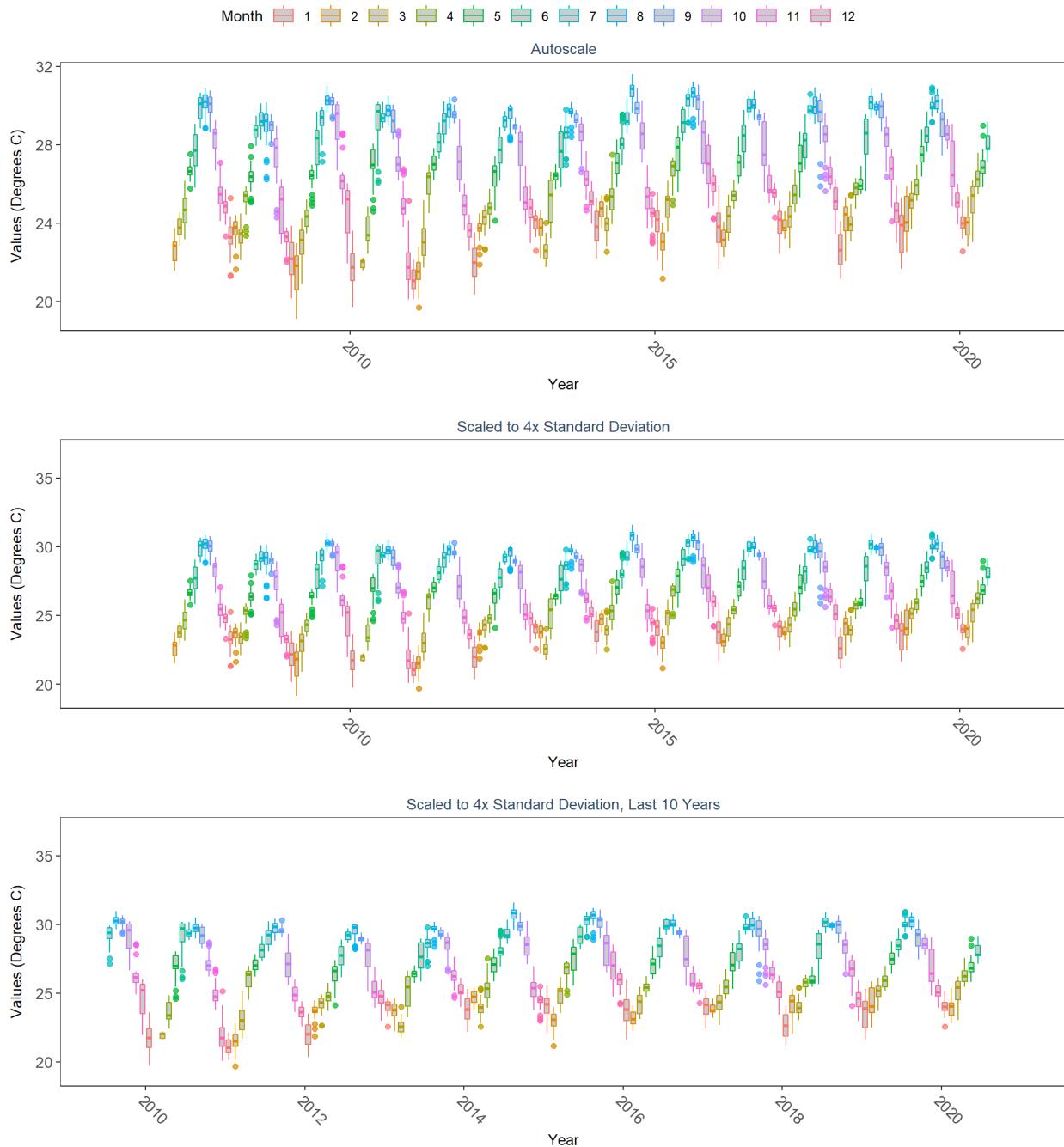
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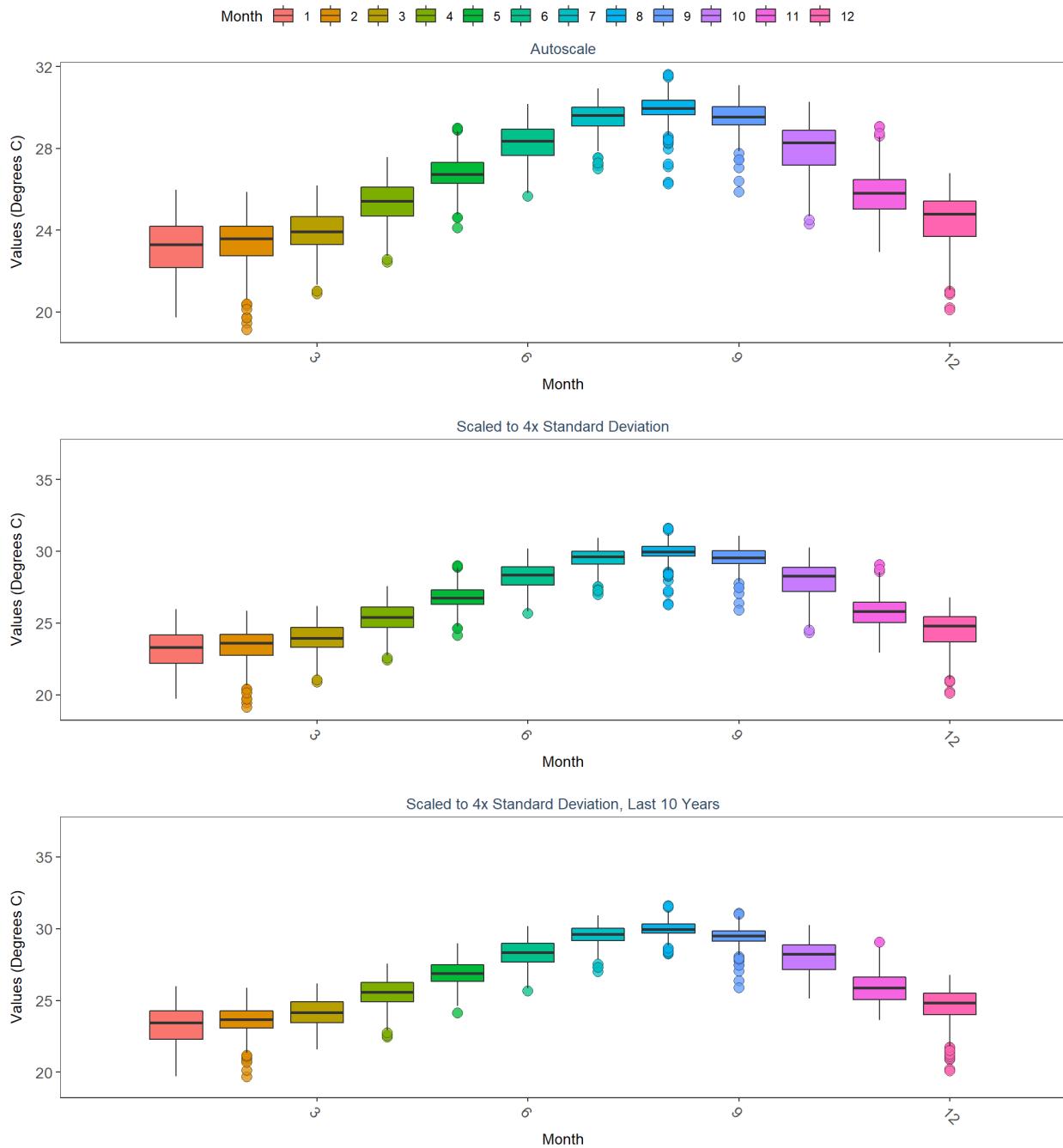
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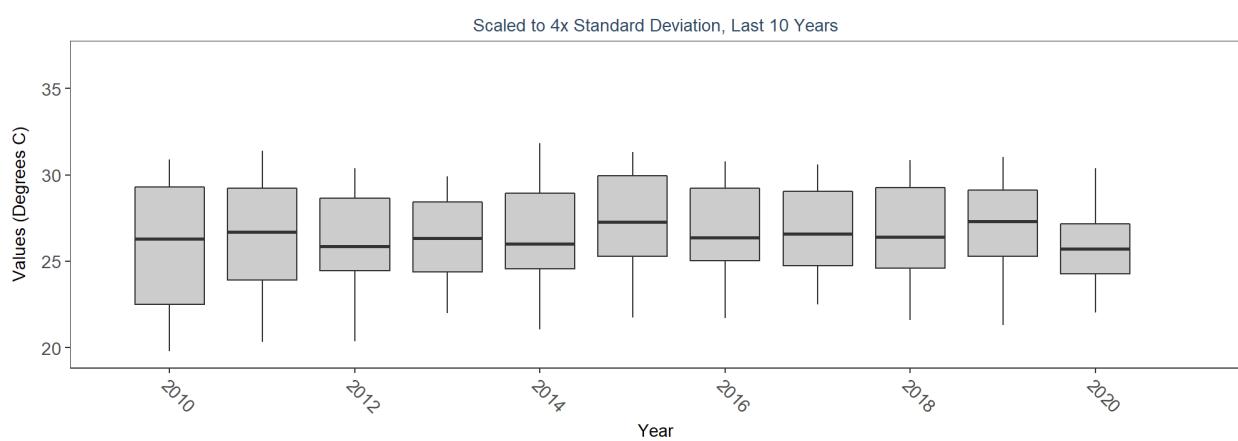
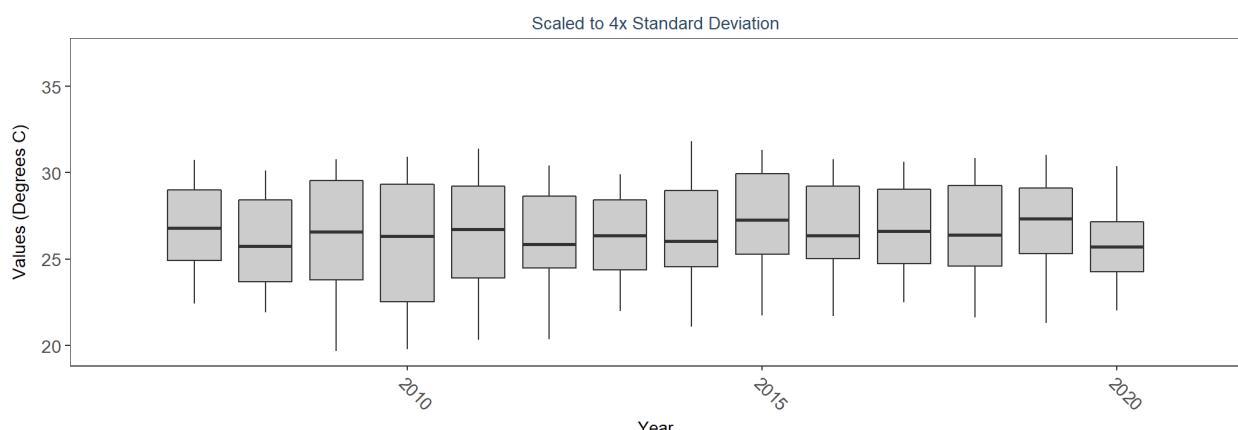
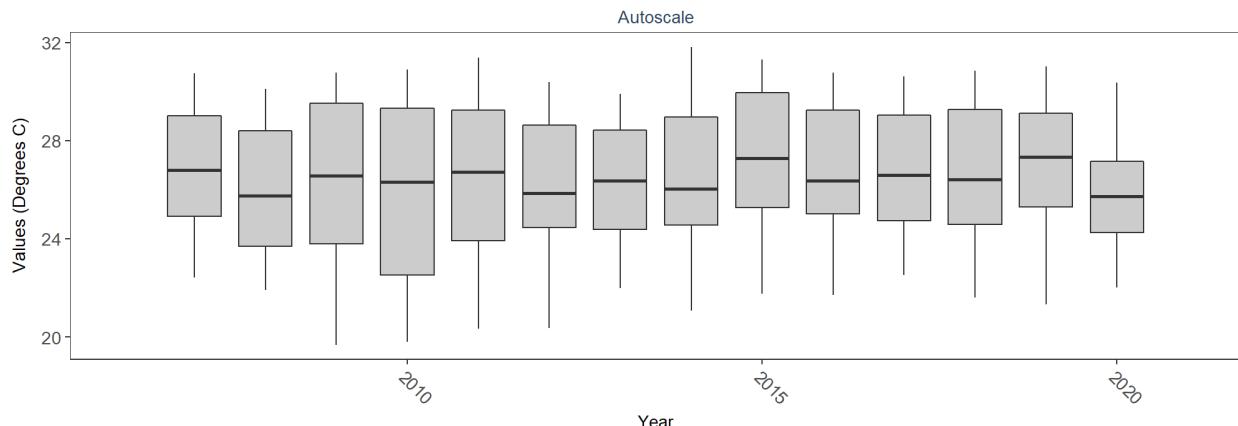
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 By Year & Month



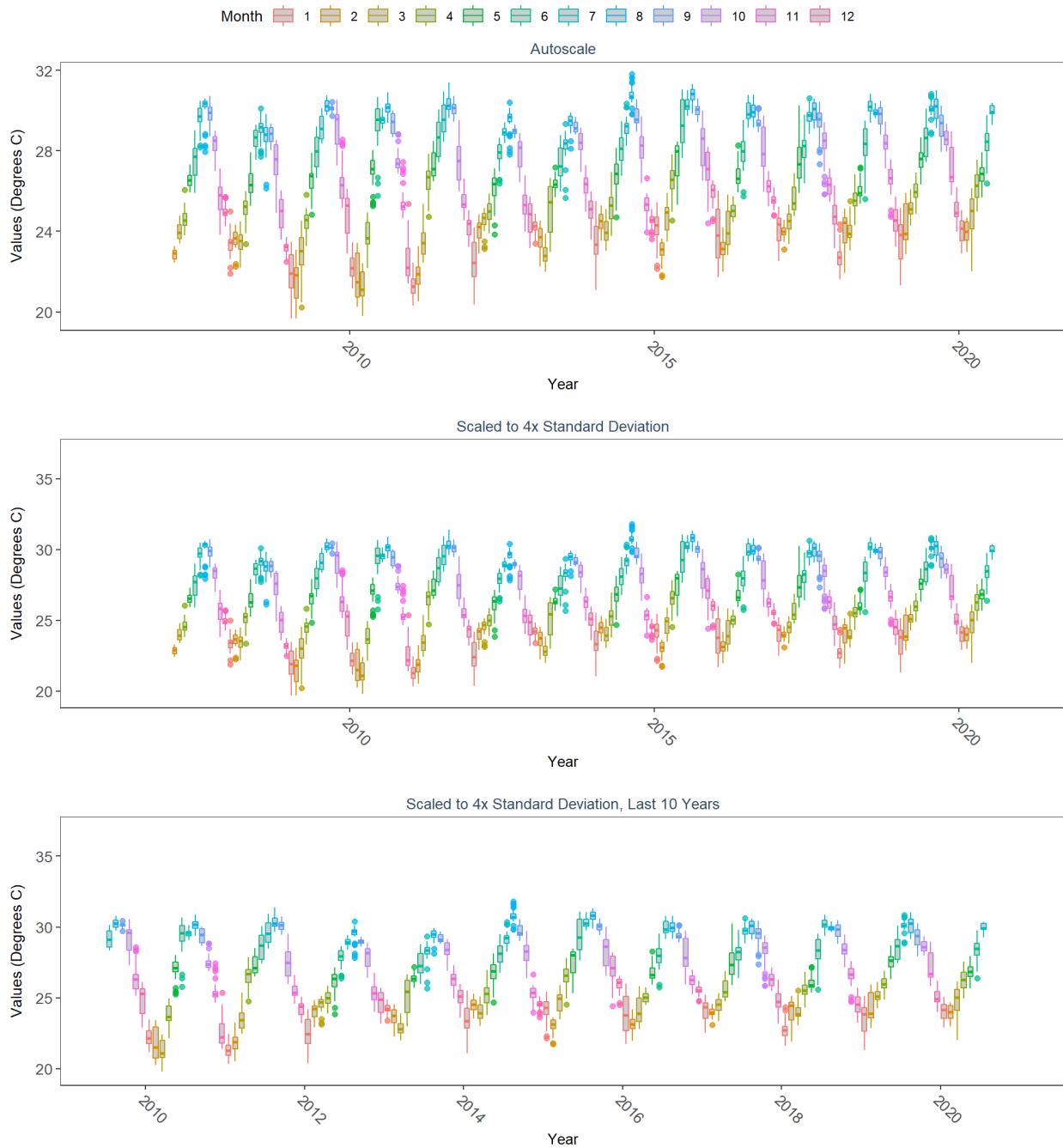
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 By Month



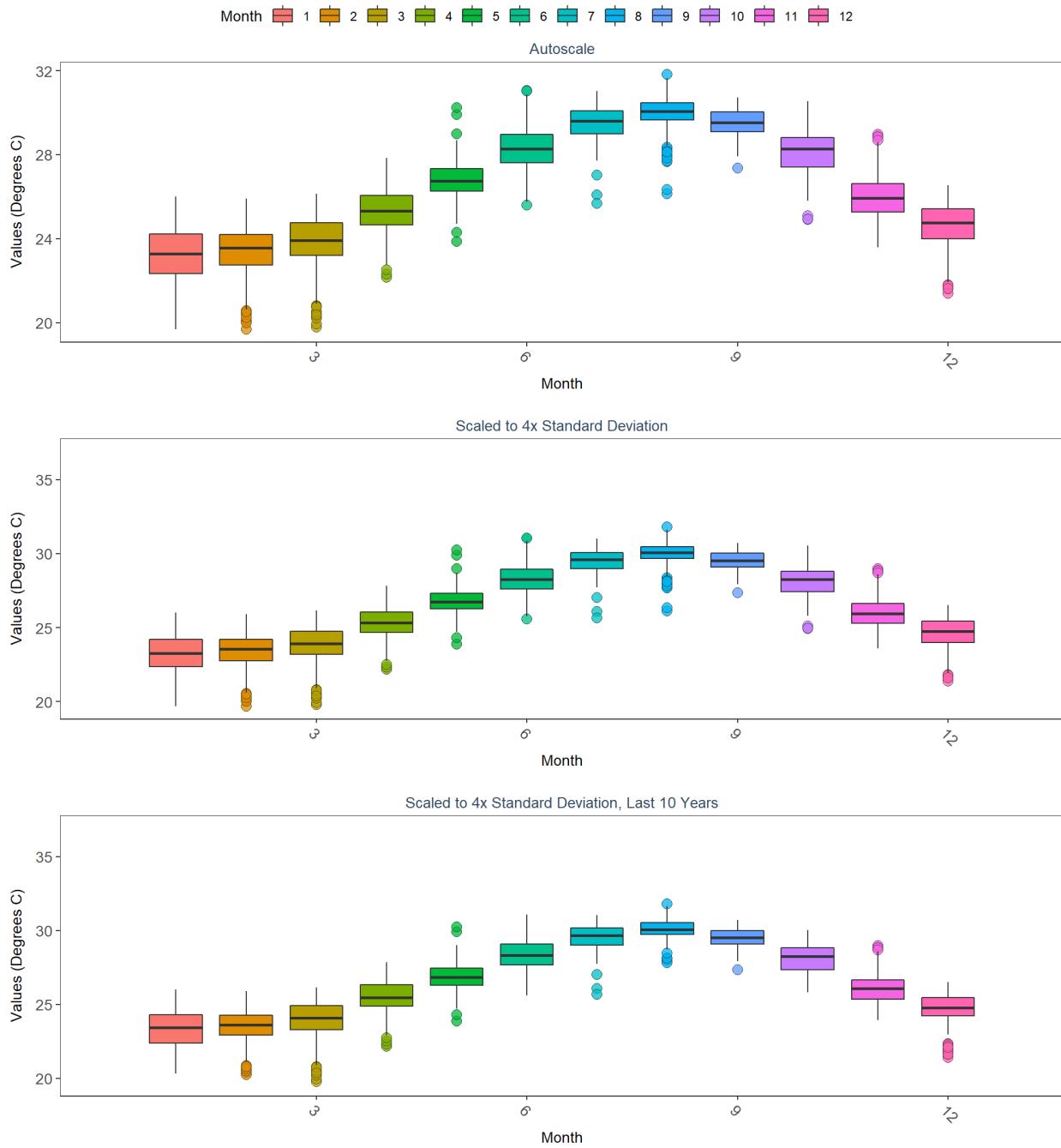
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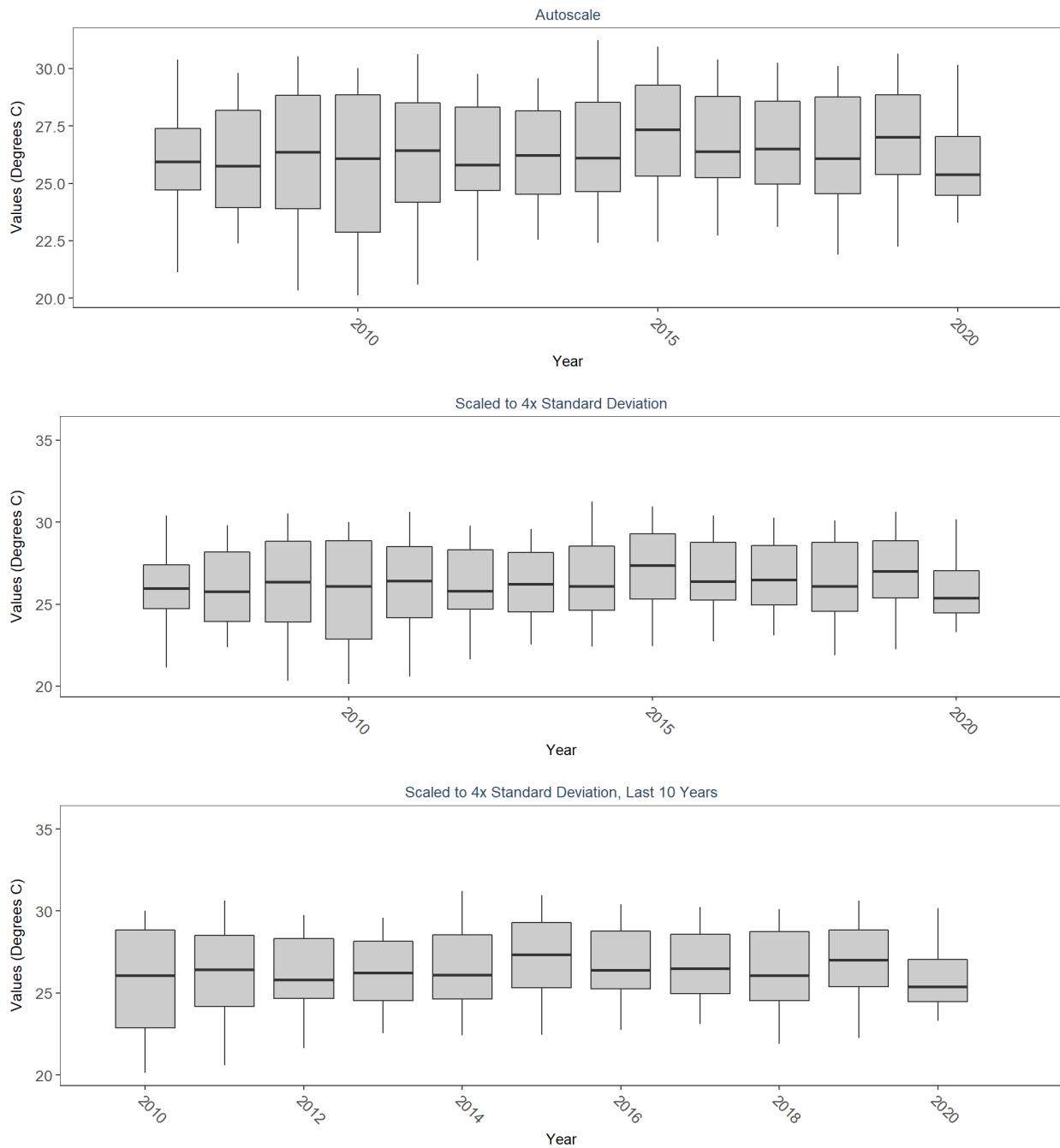
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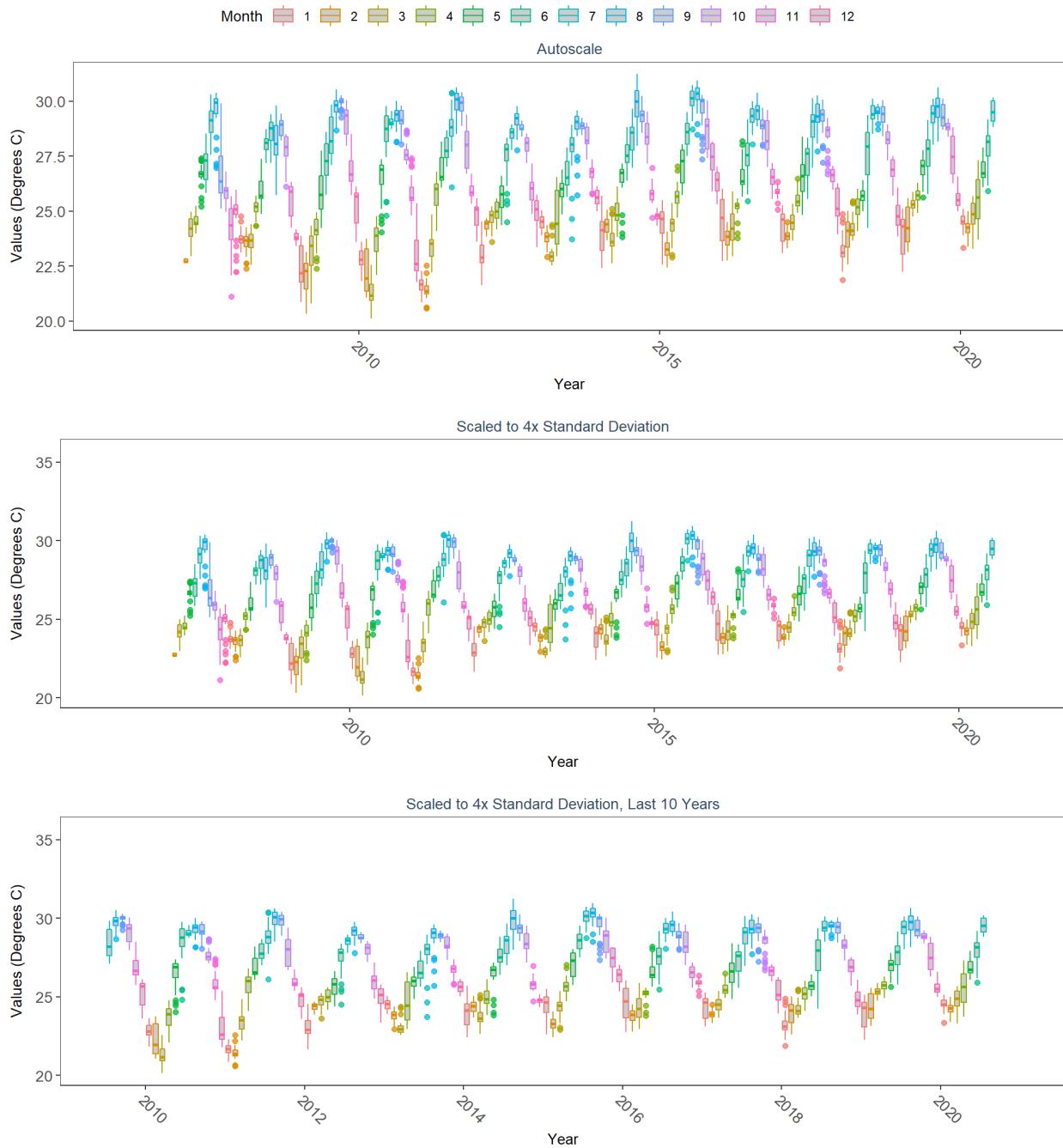
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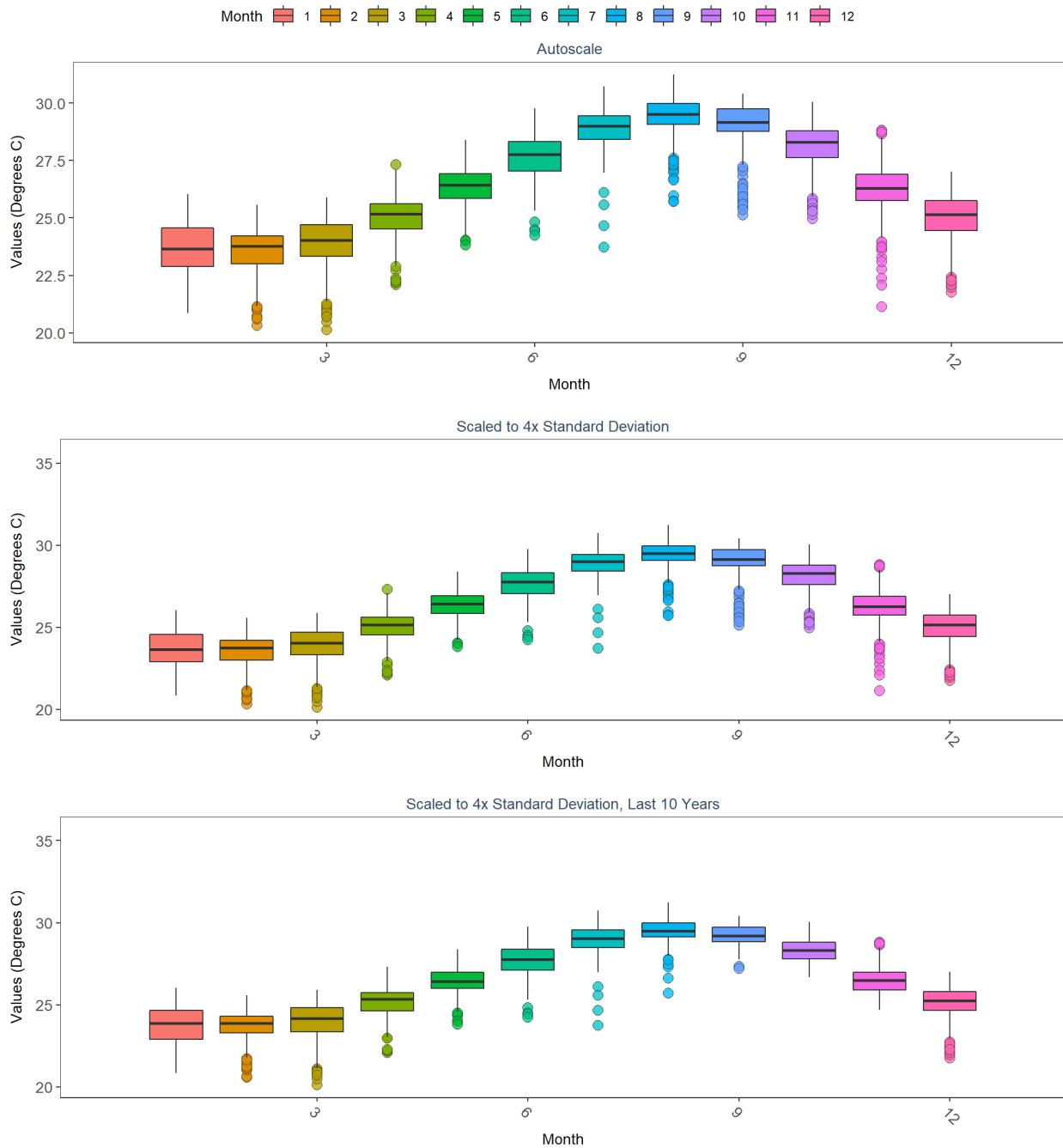
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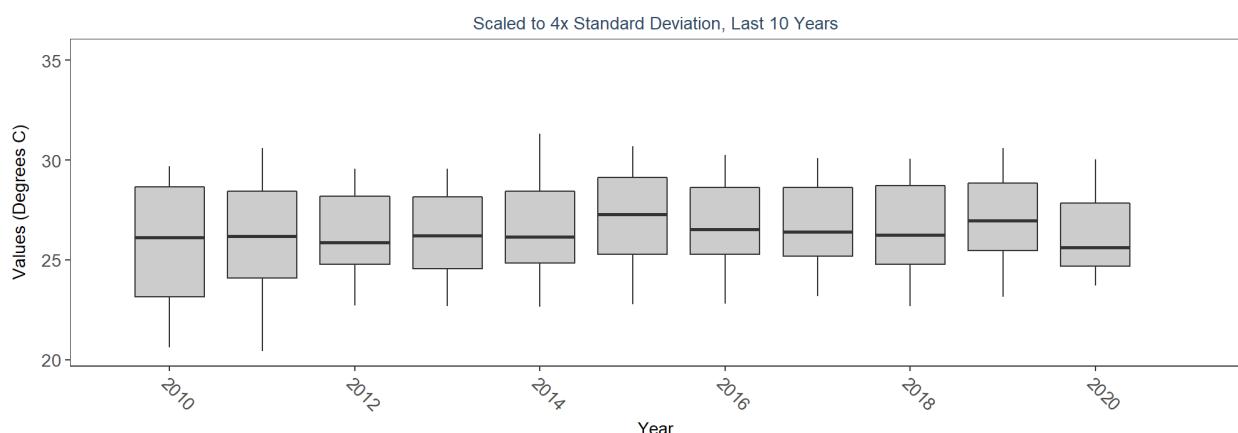
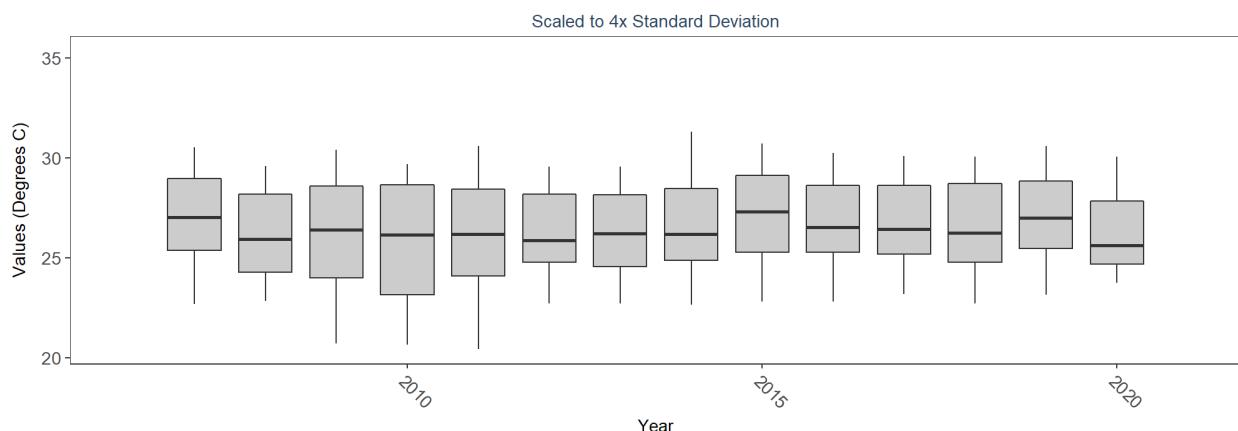
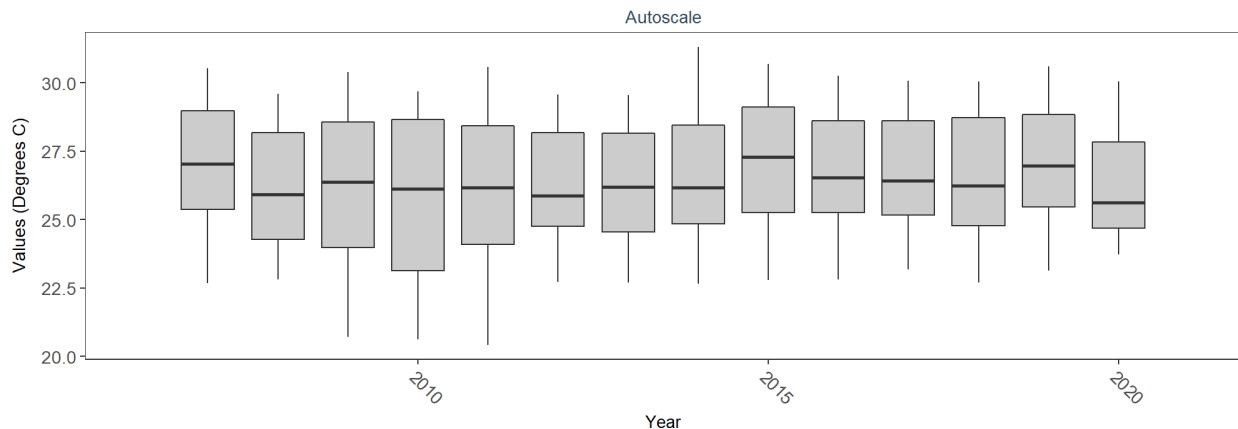
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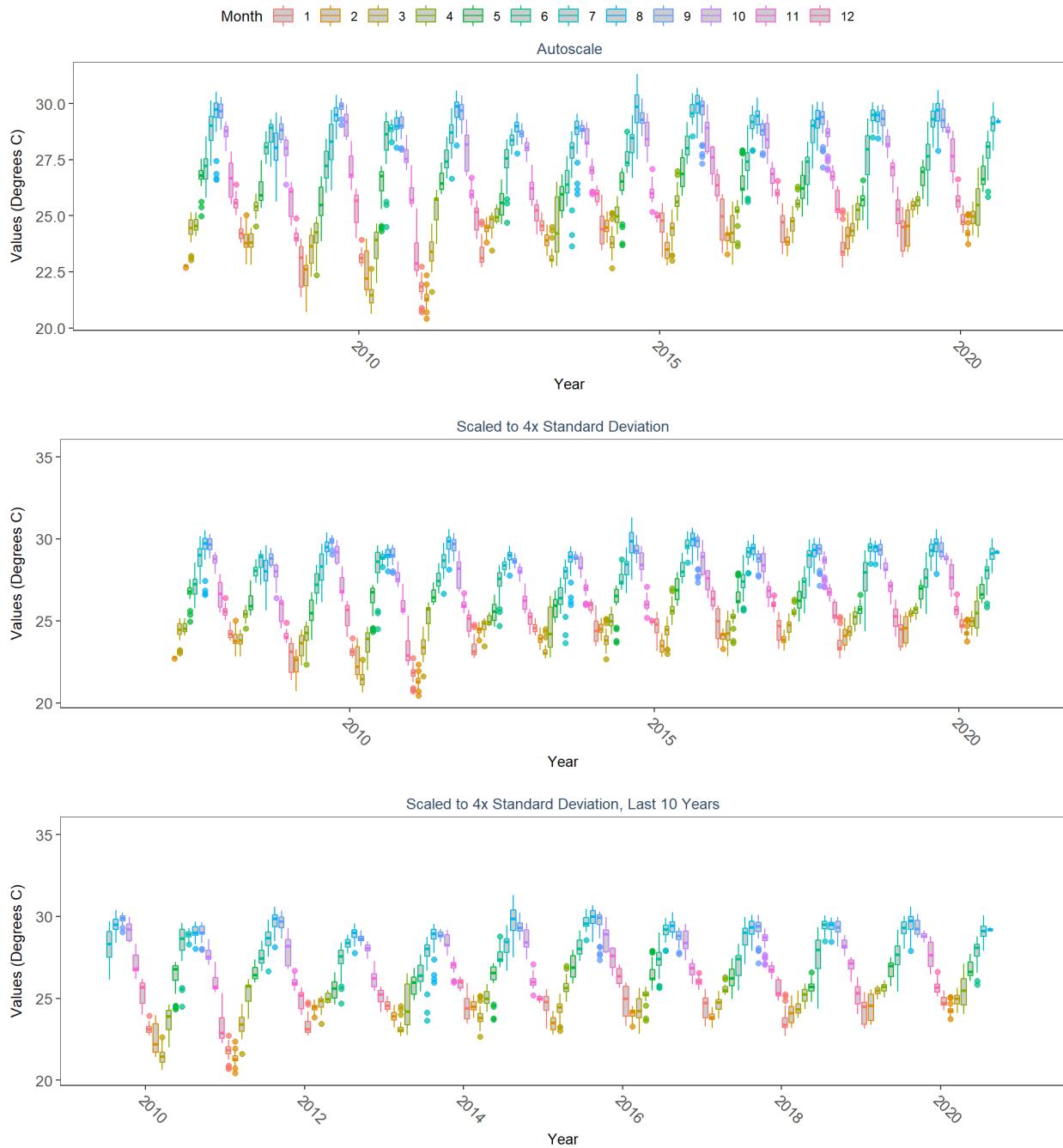
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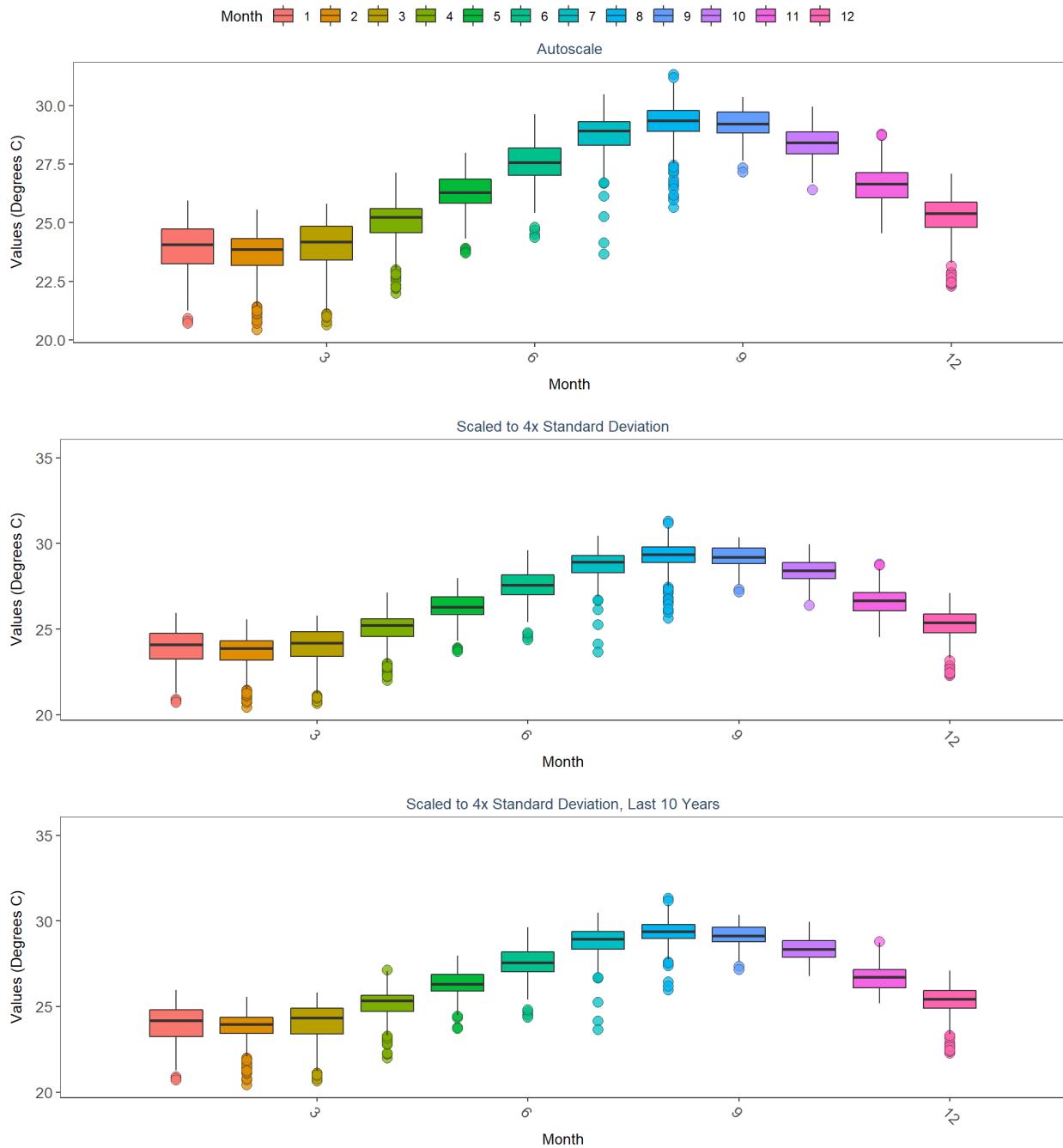
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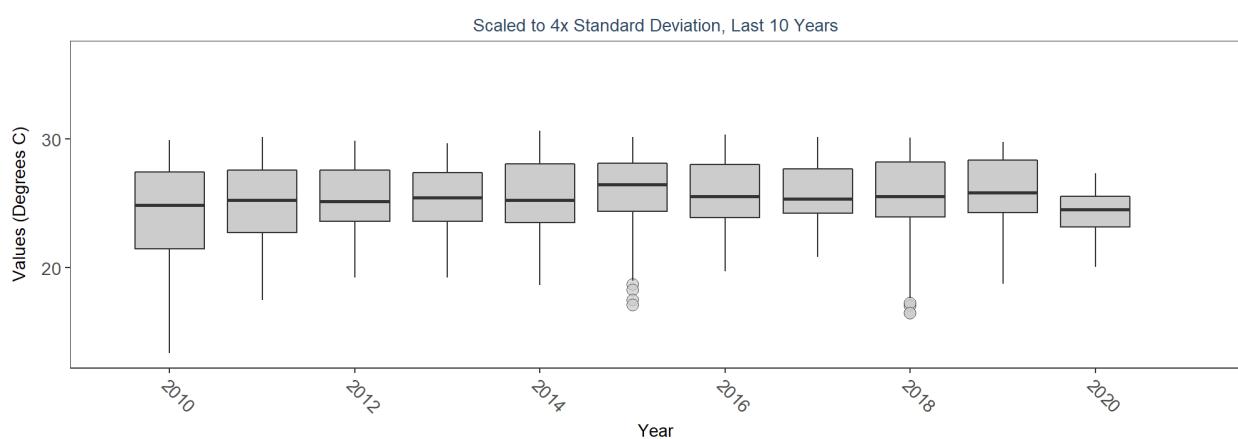
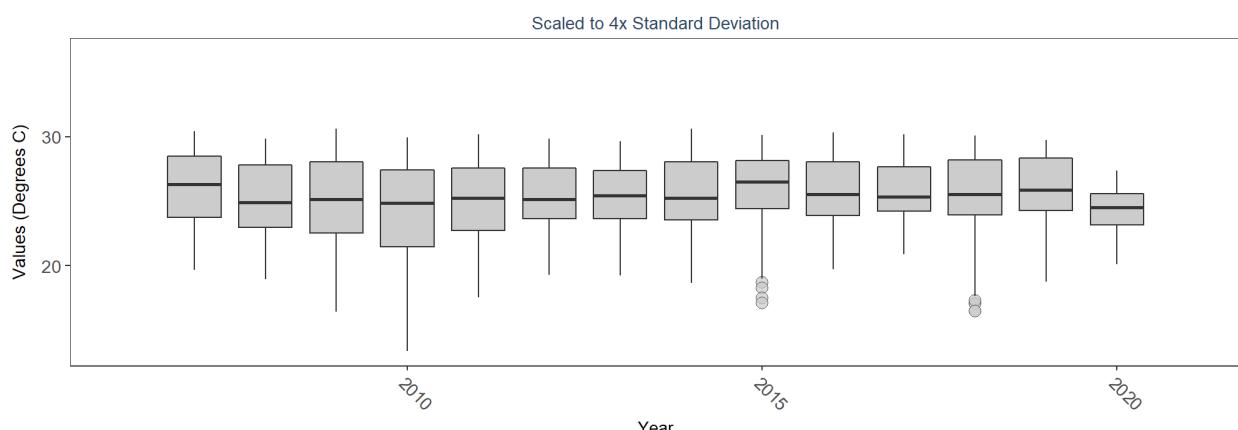
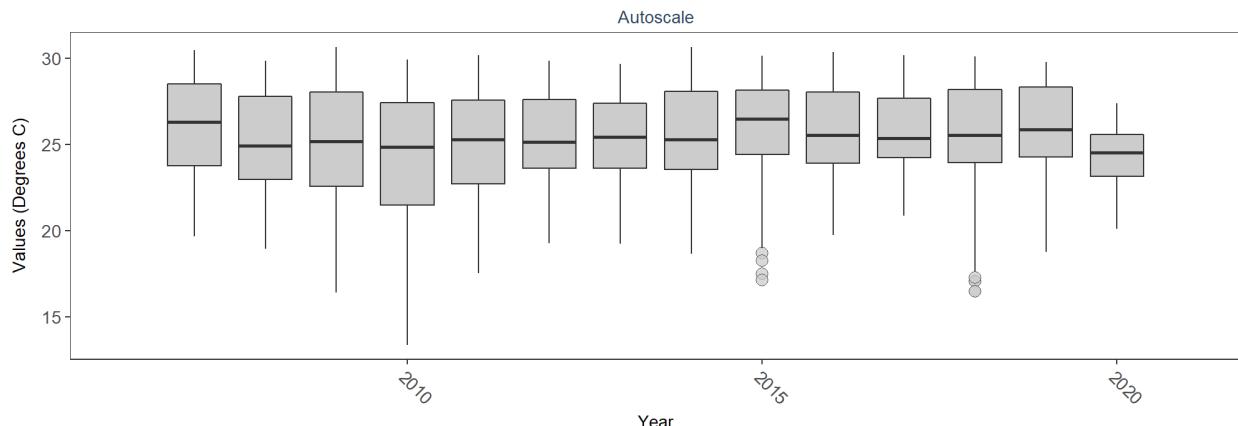
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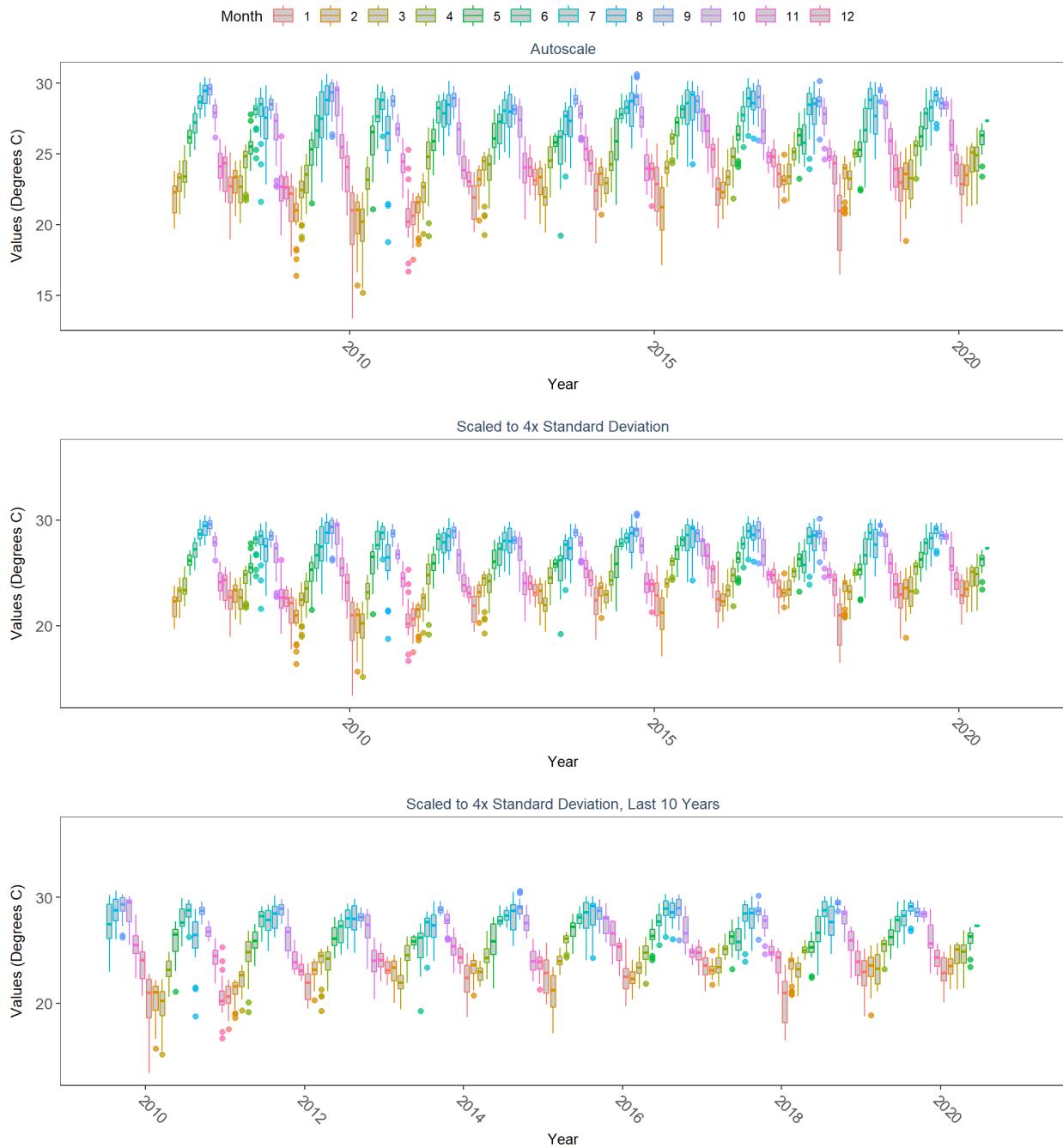
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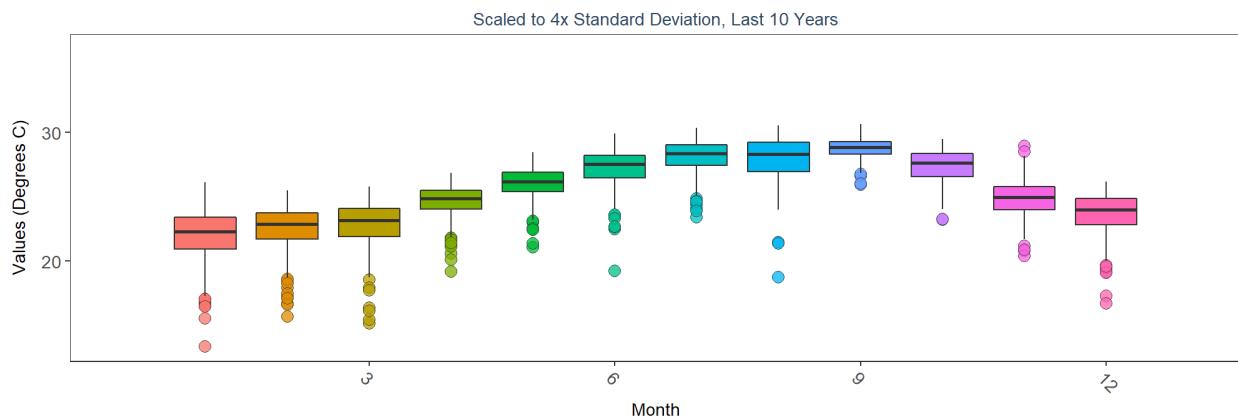
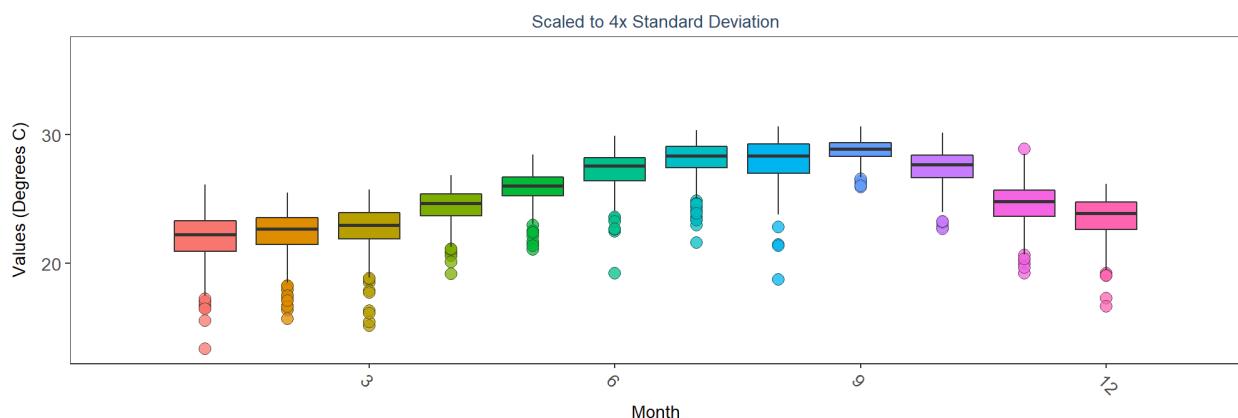
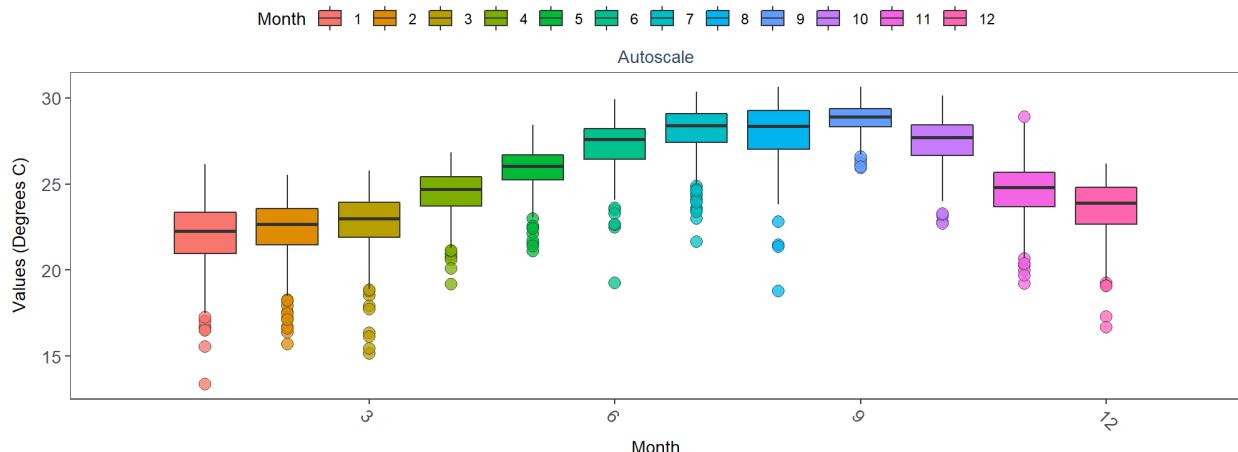
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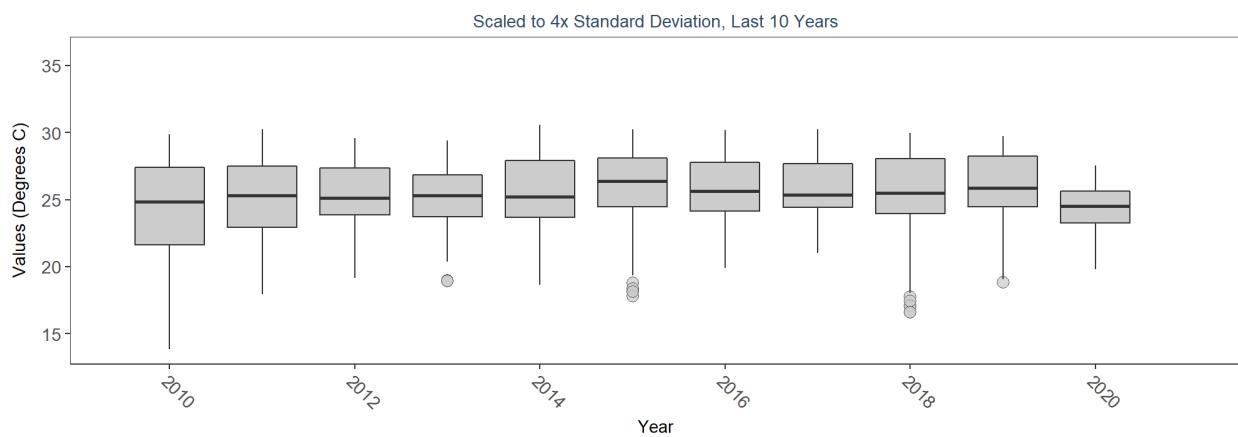
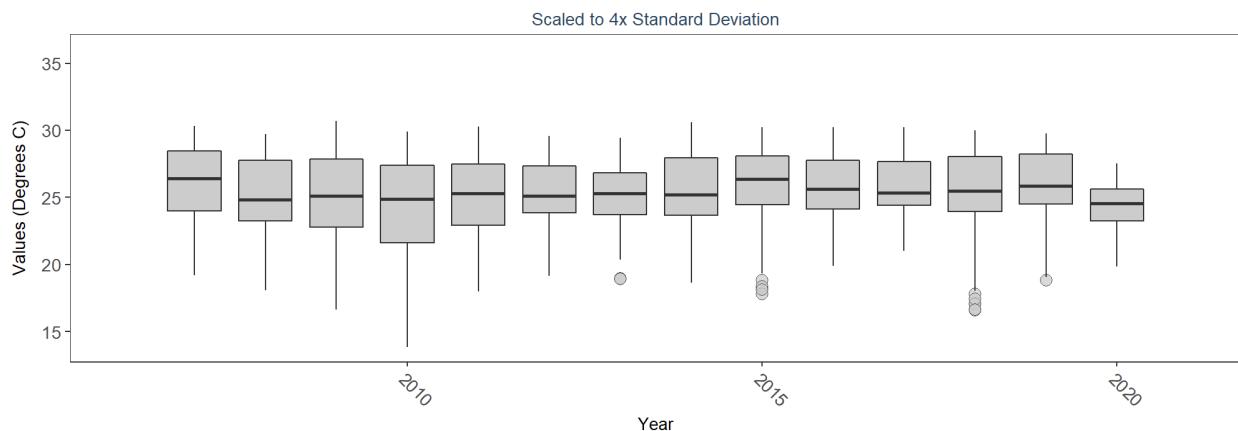
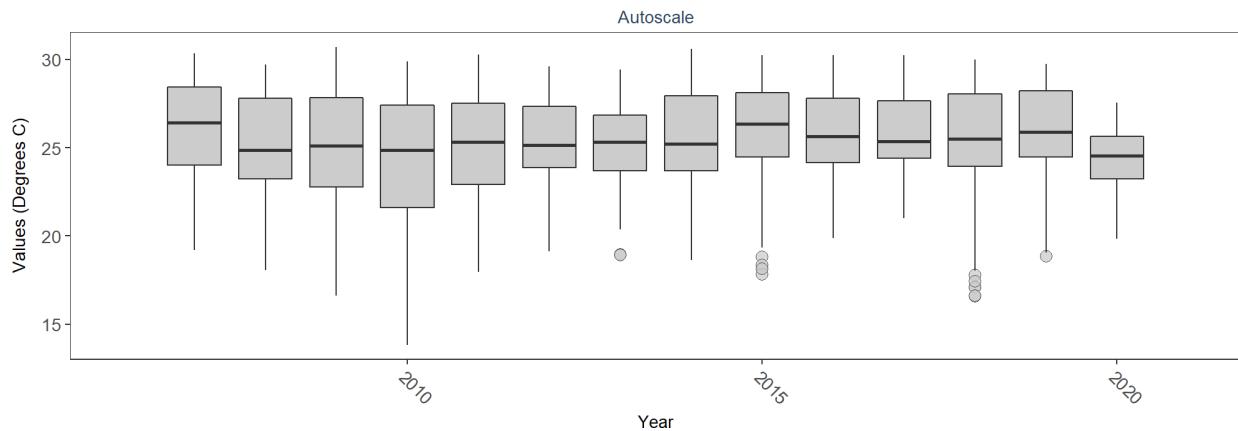
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 By Year & Month



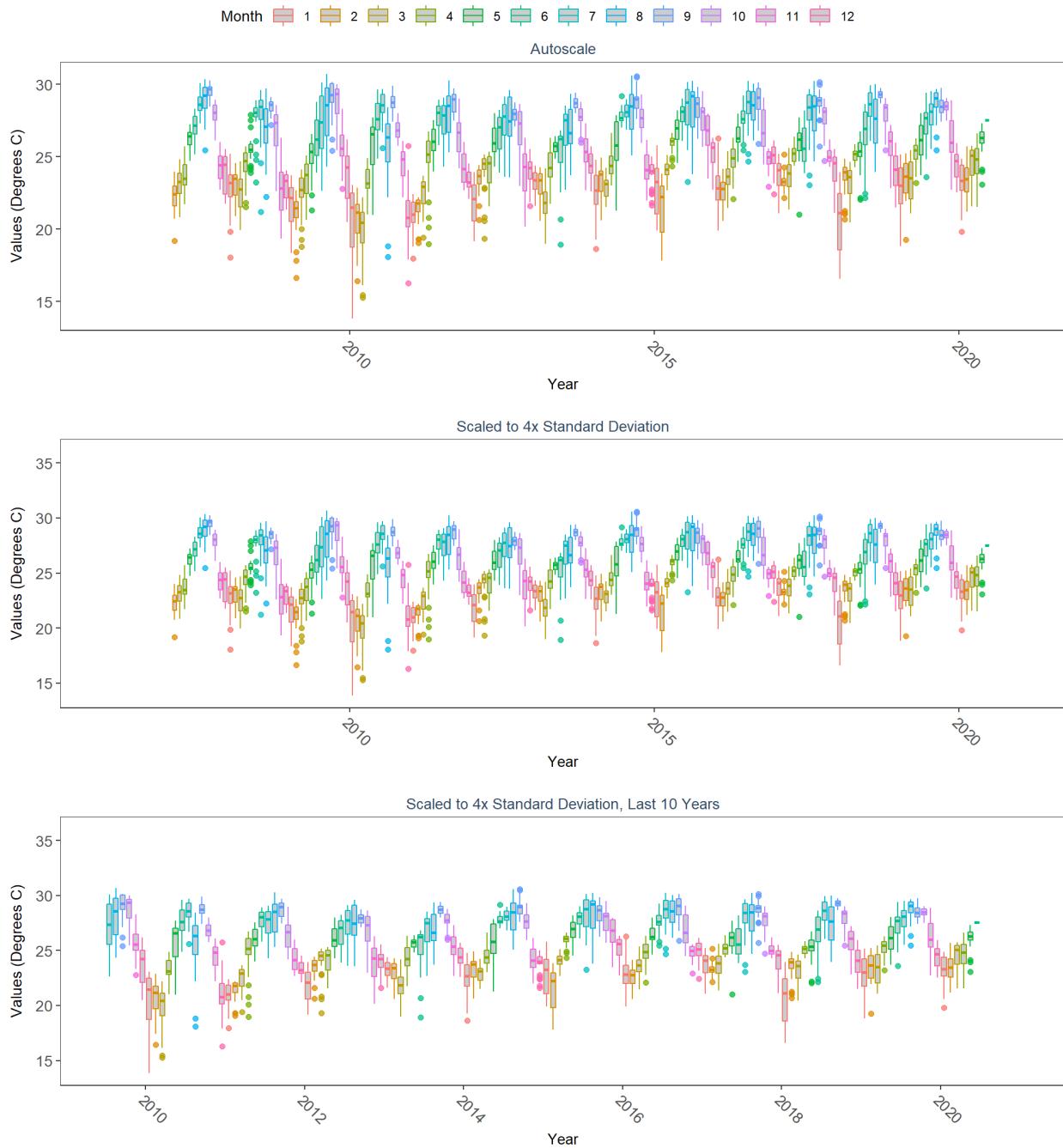
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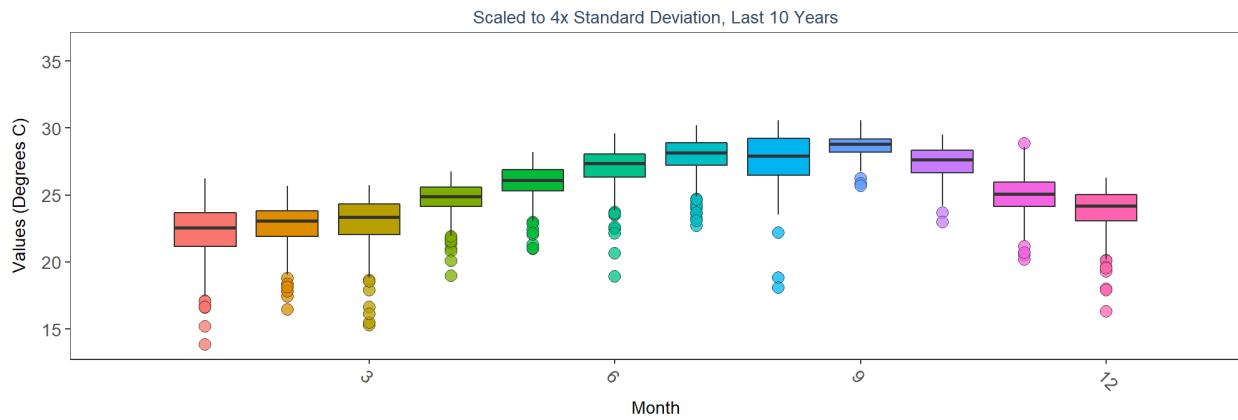
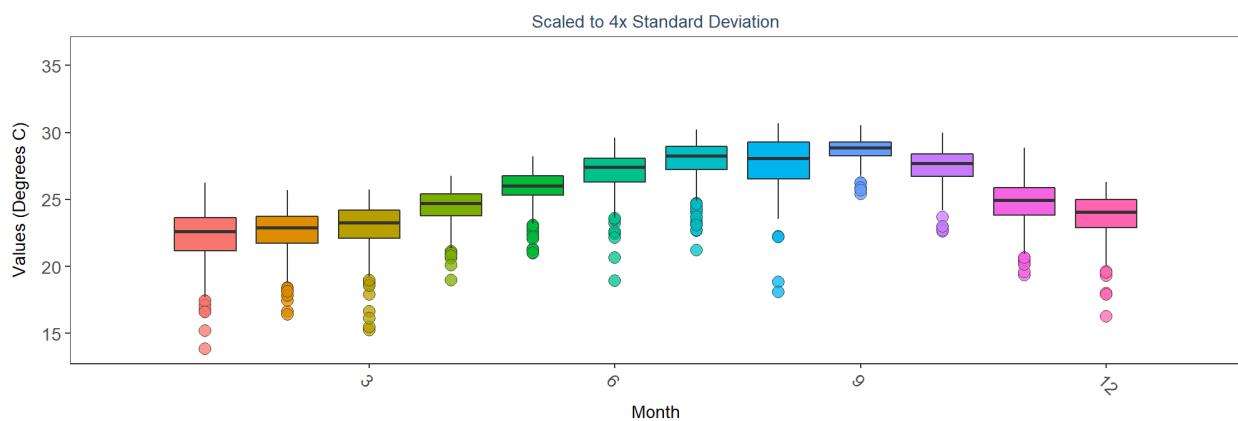
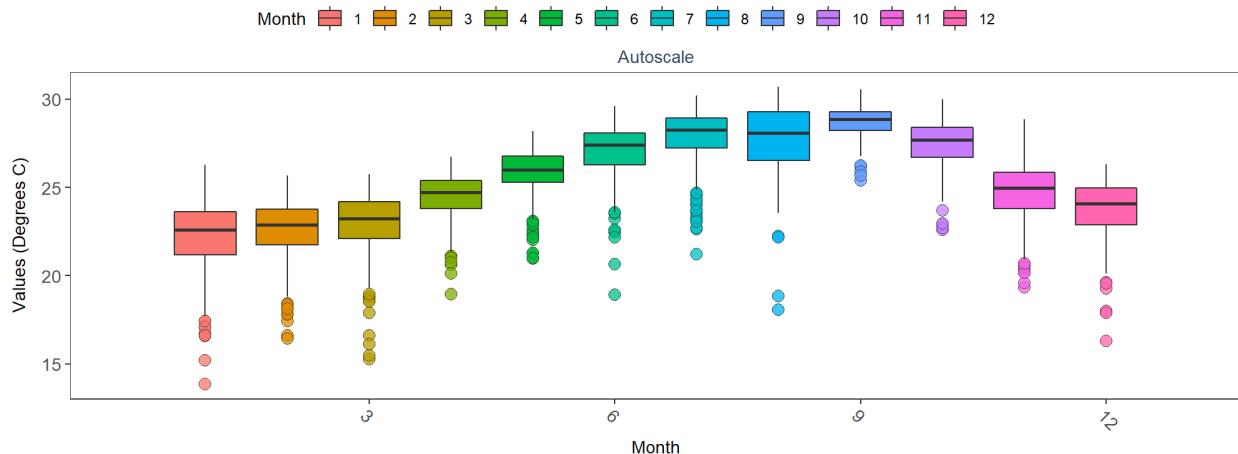
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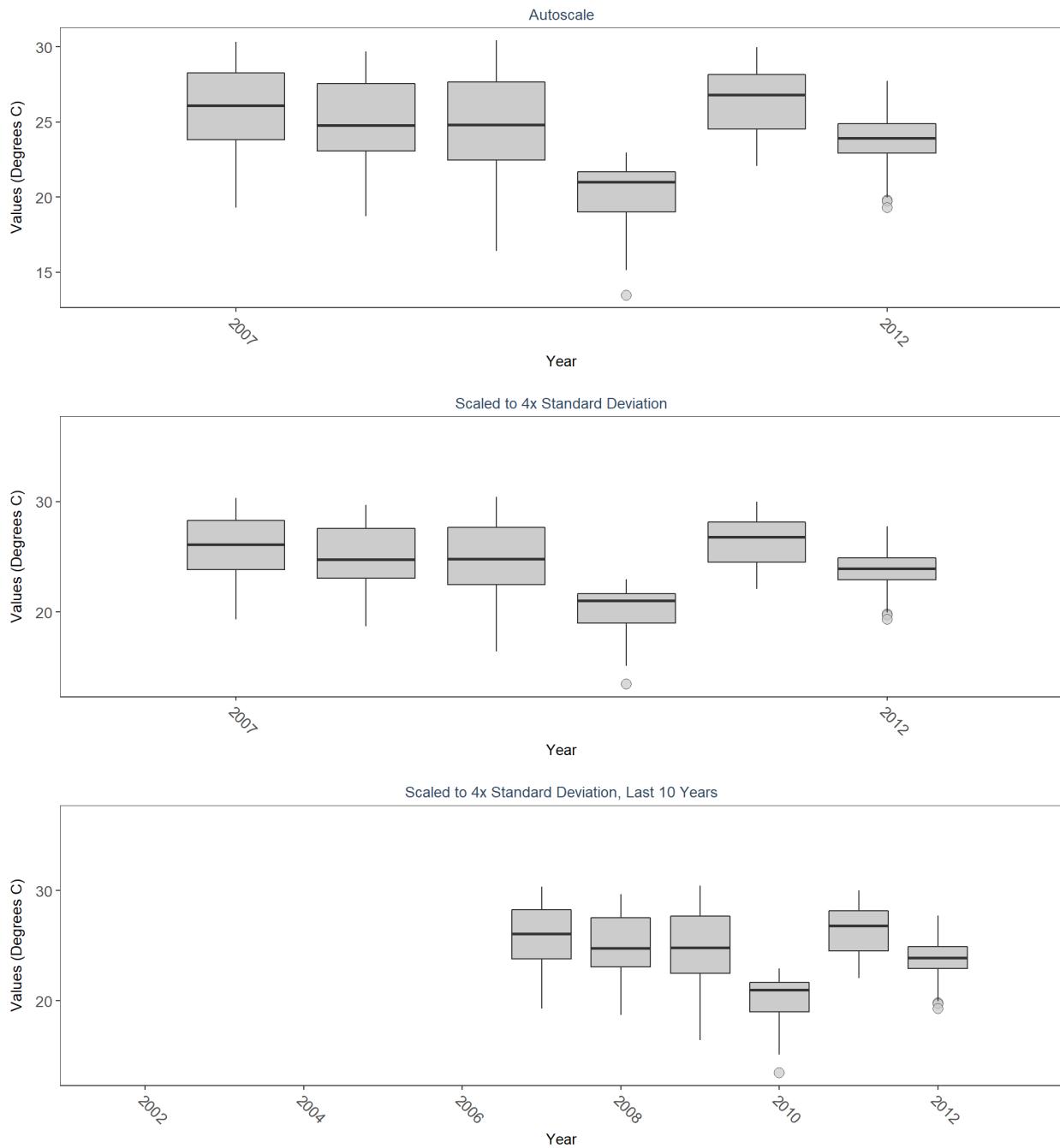
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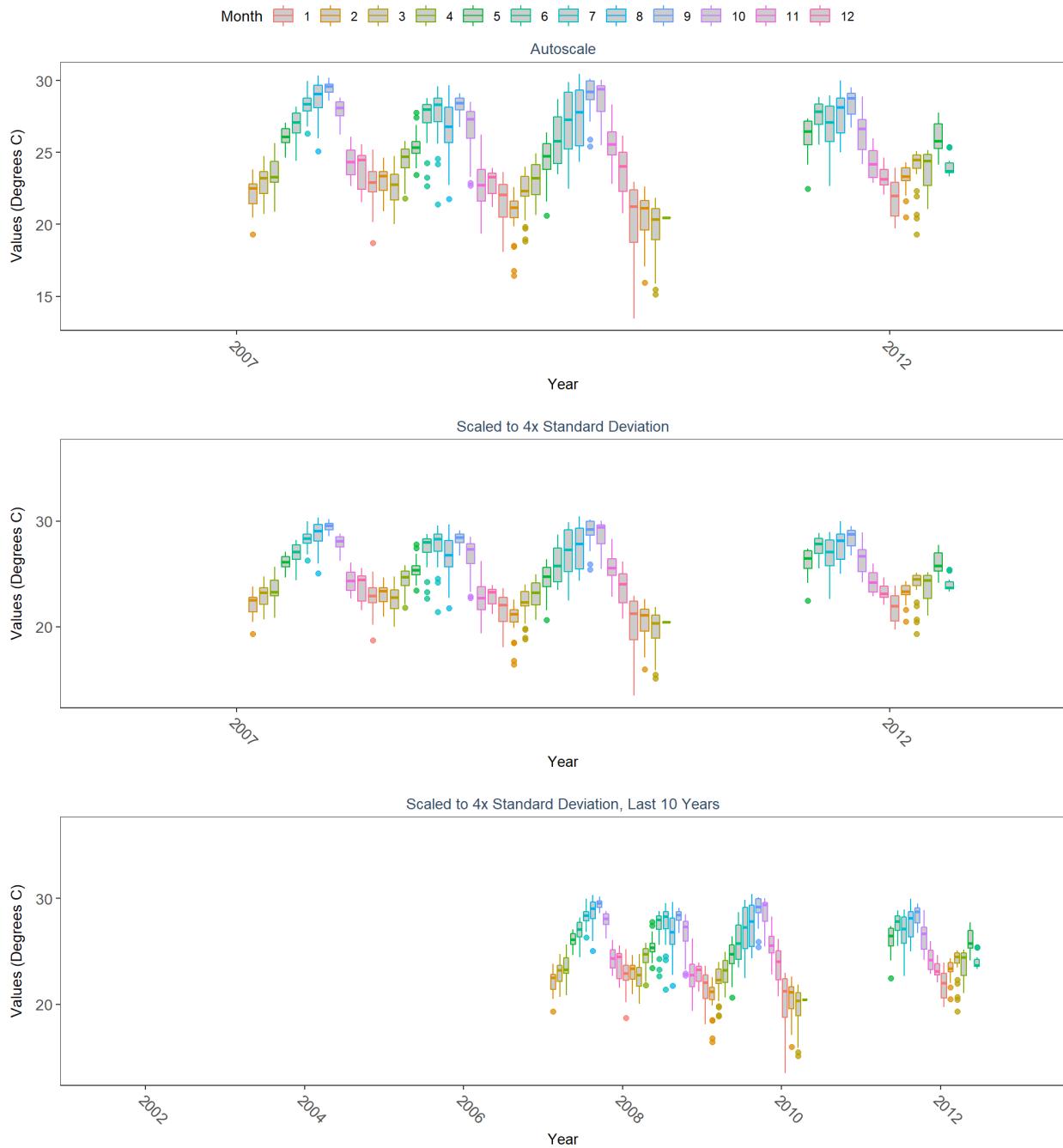
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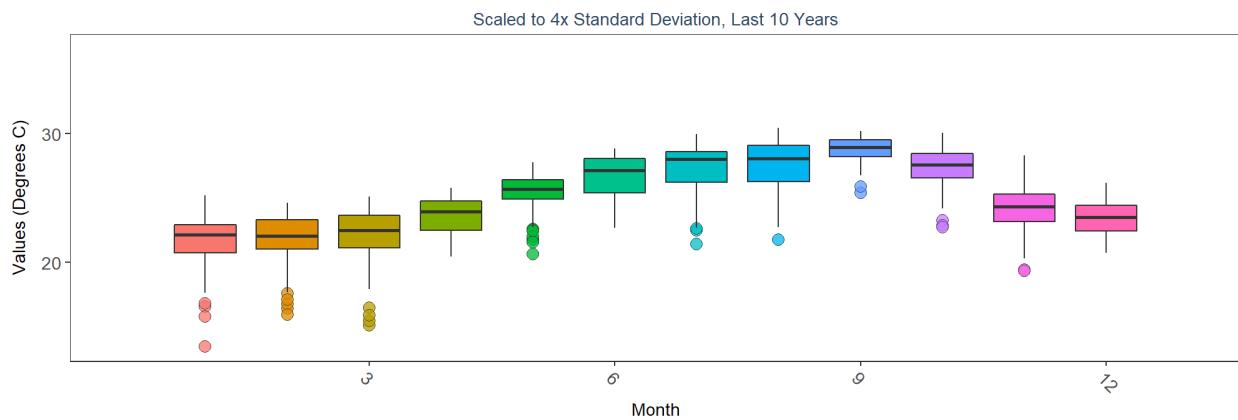
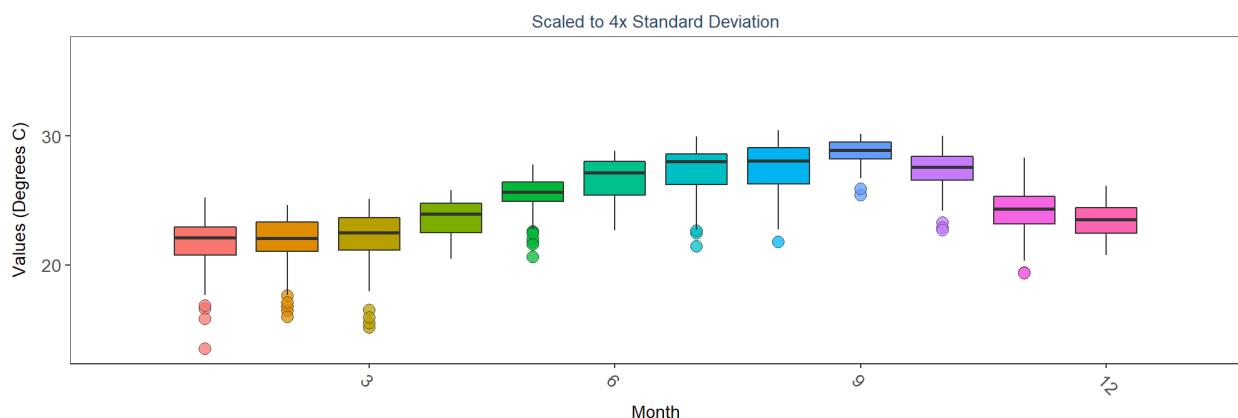
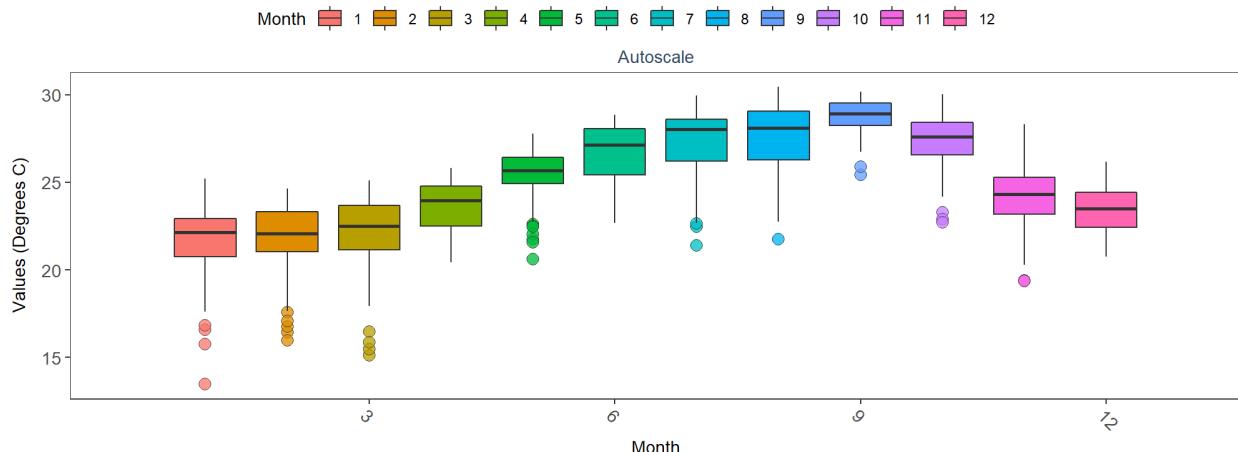
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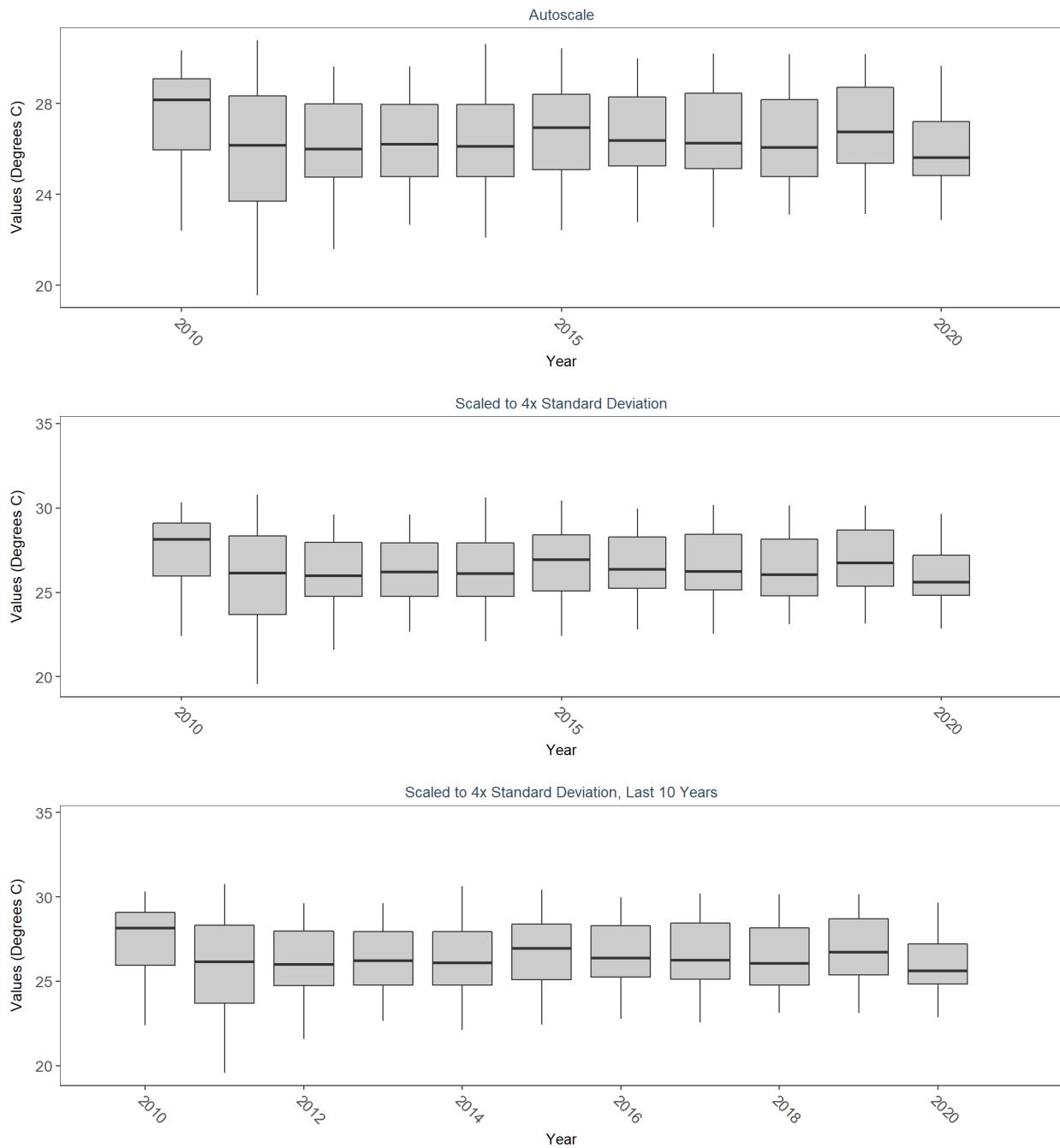
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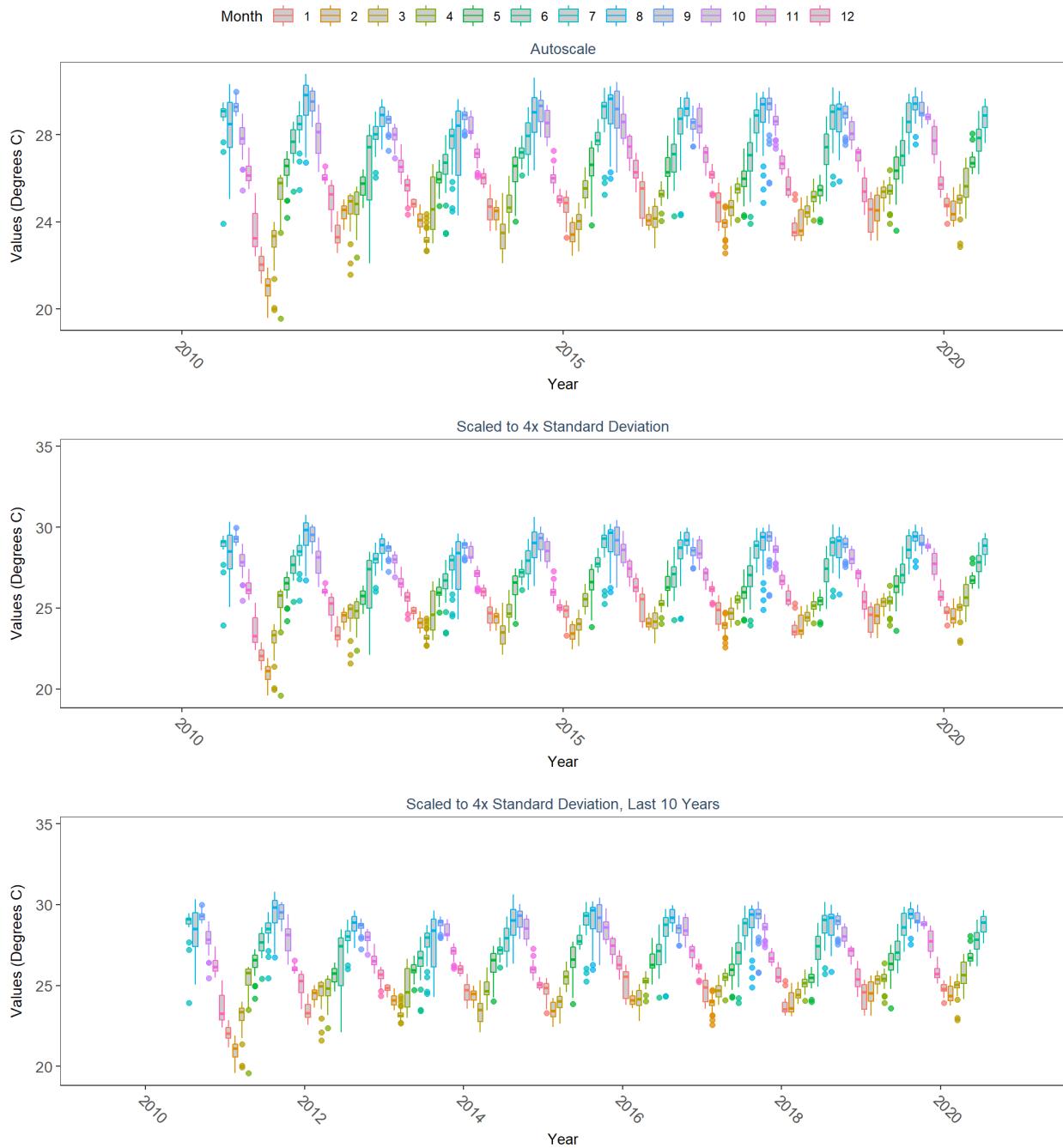
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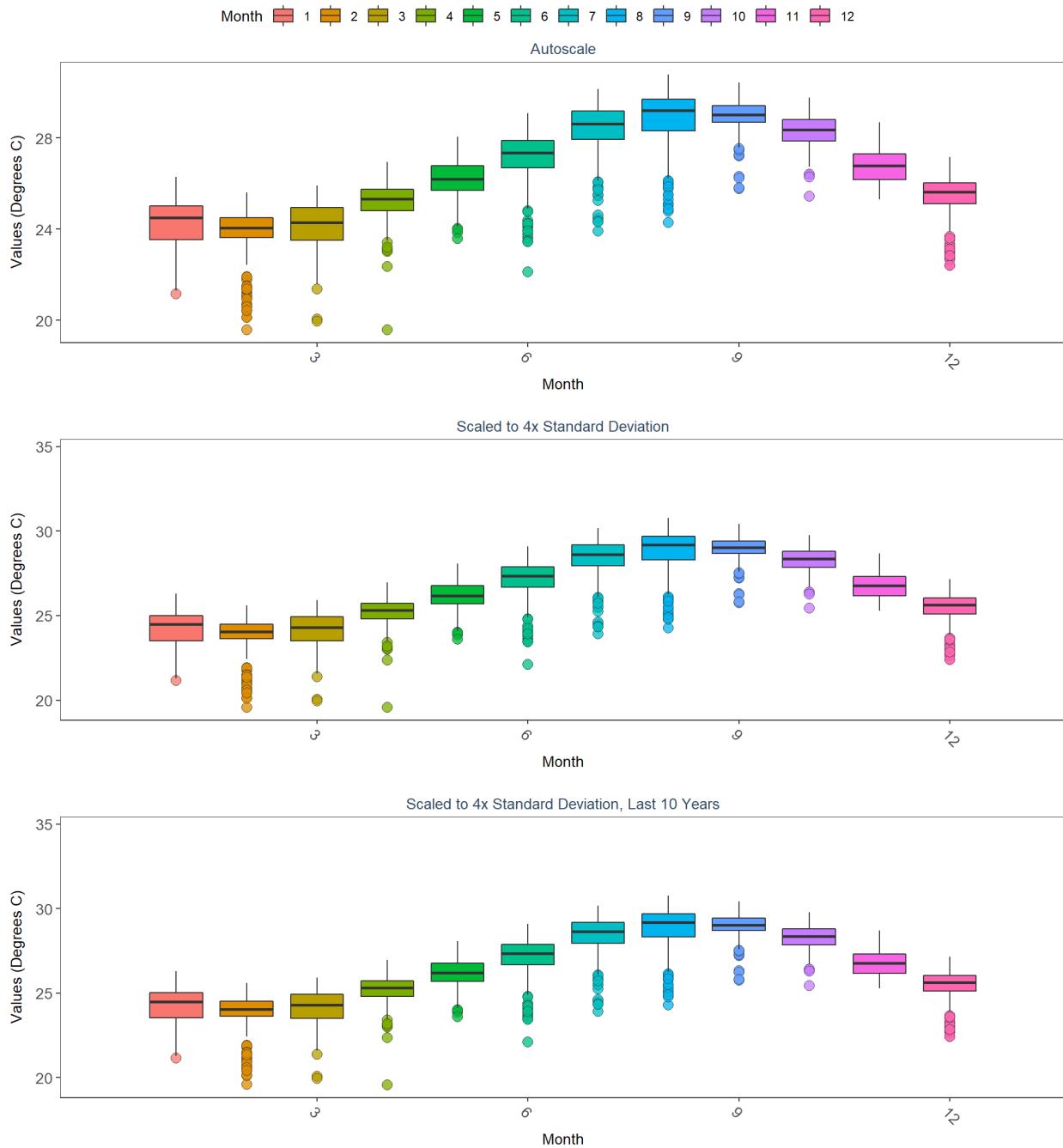
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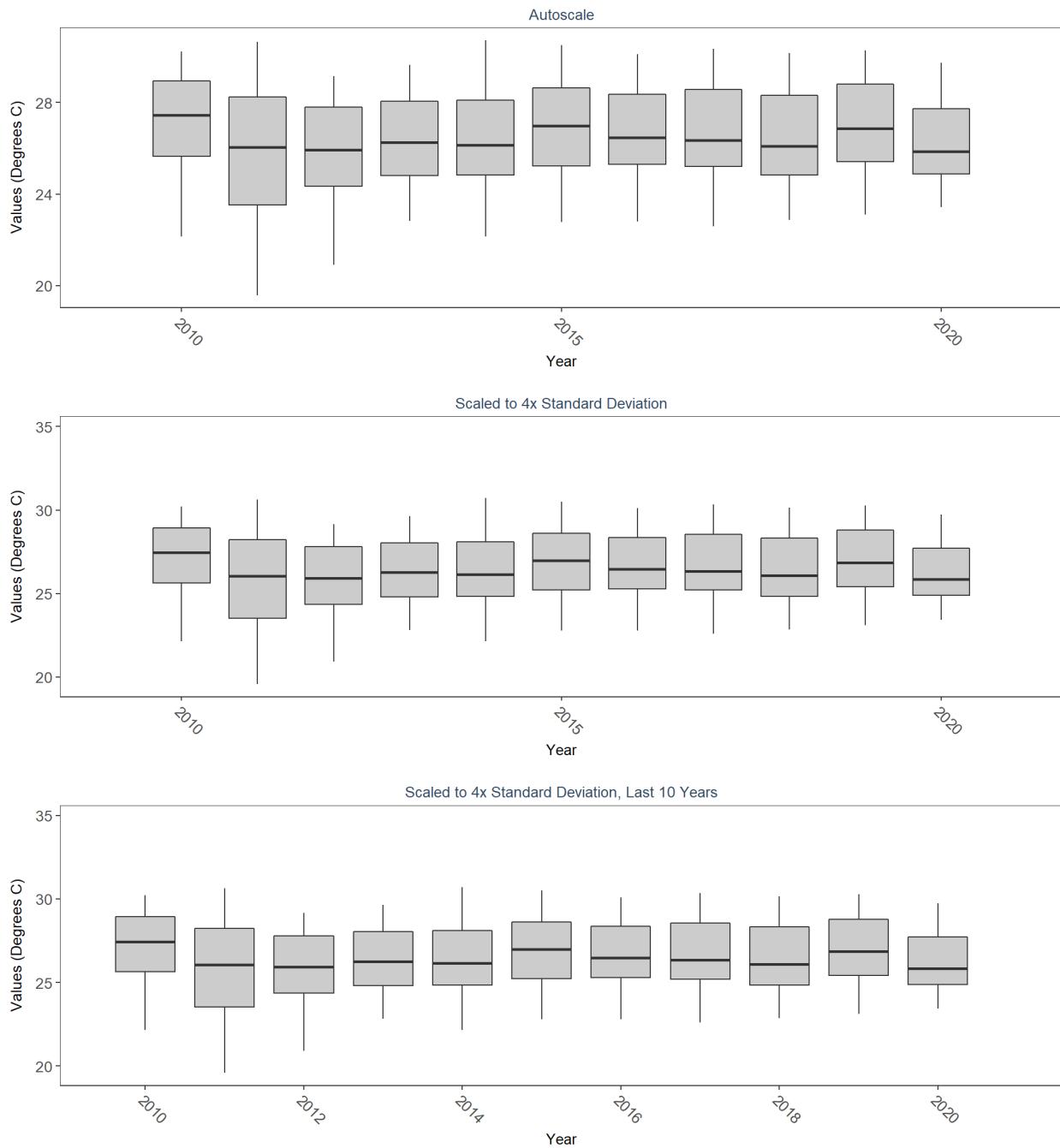
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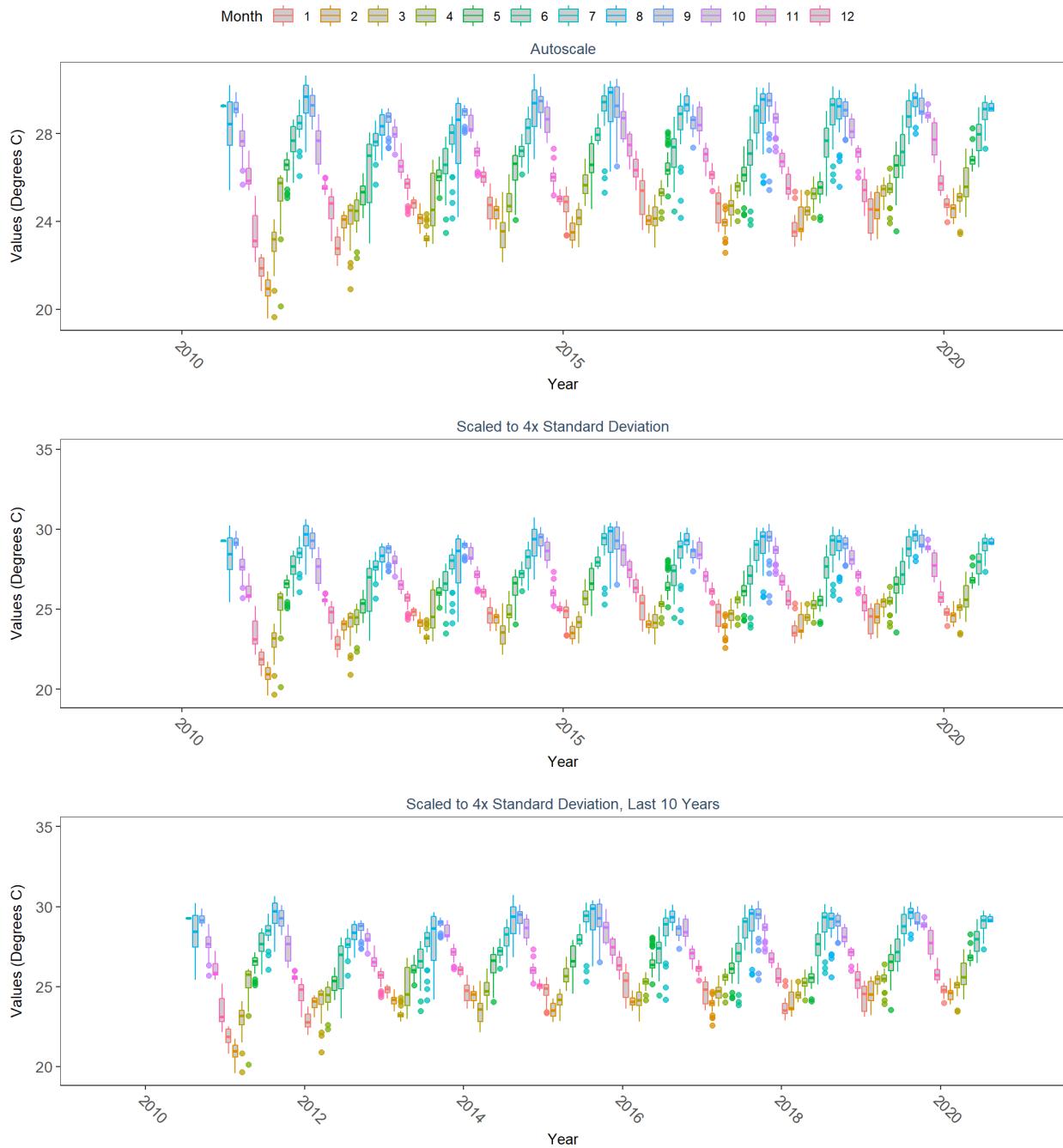
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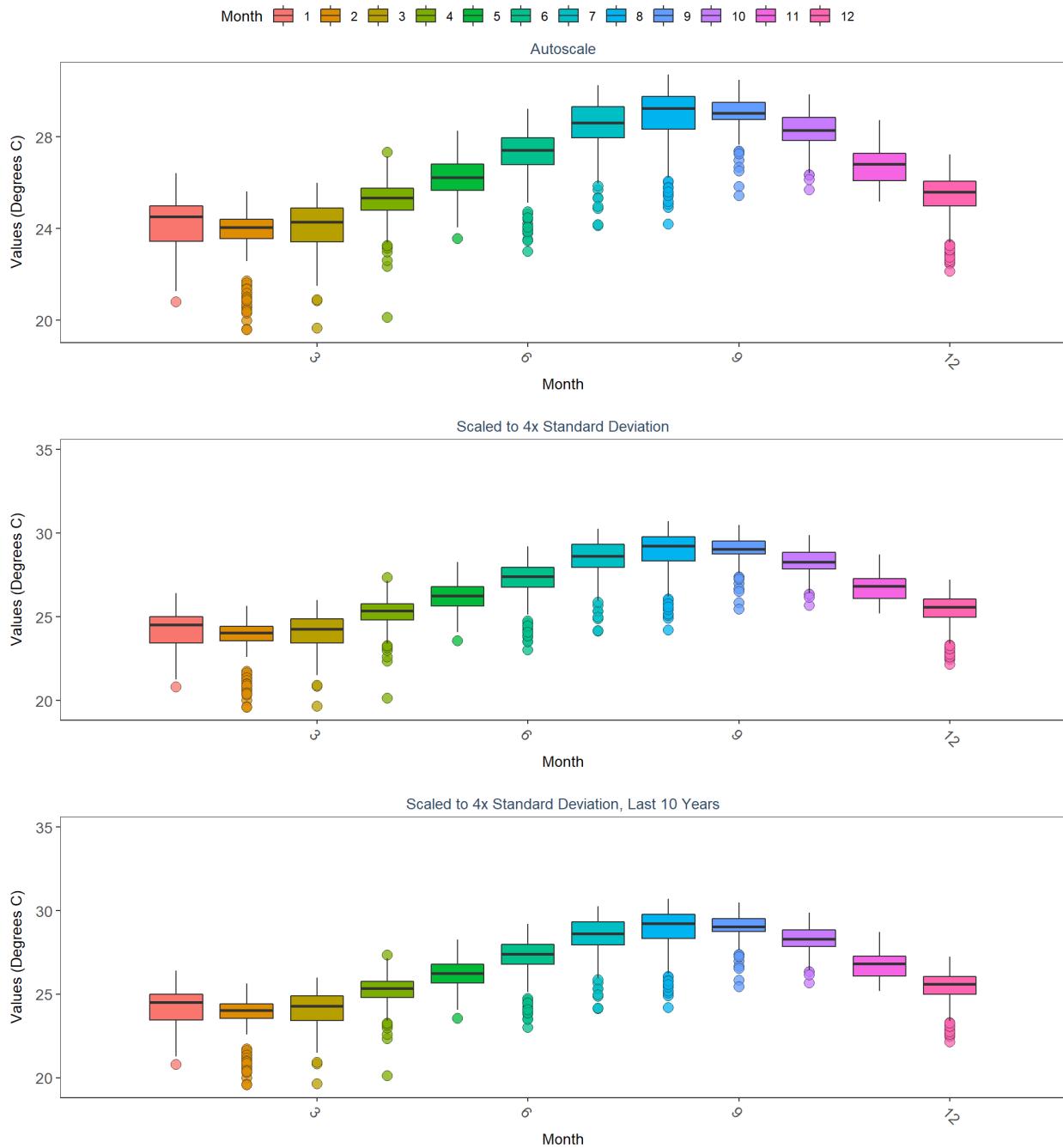
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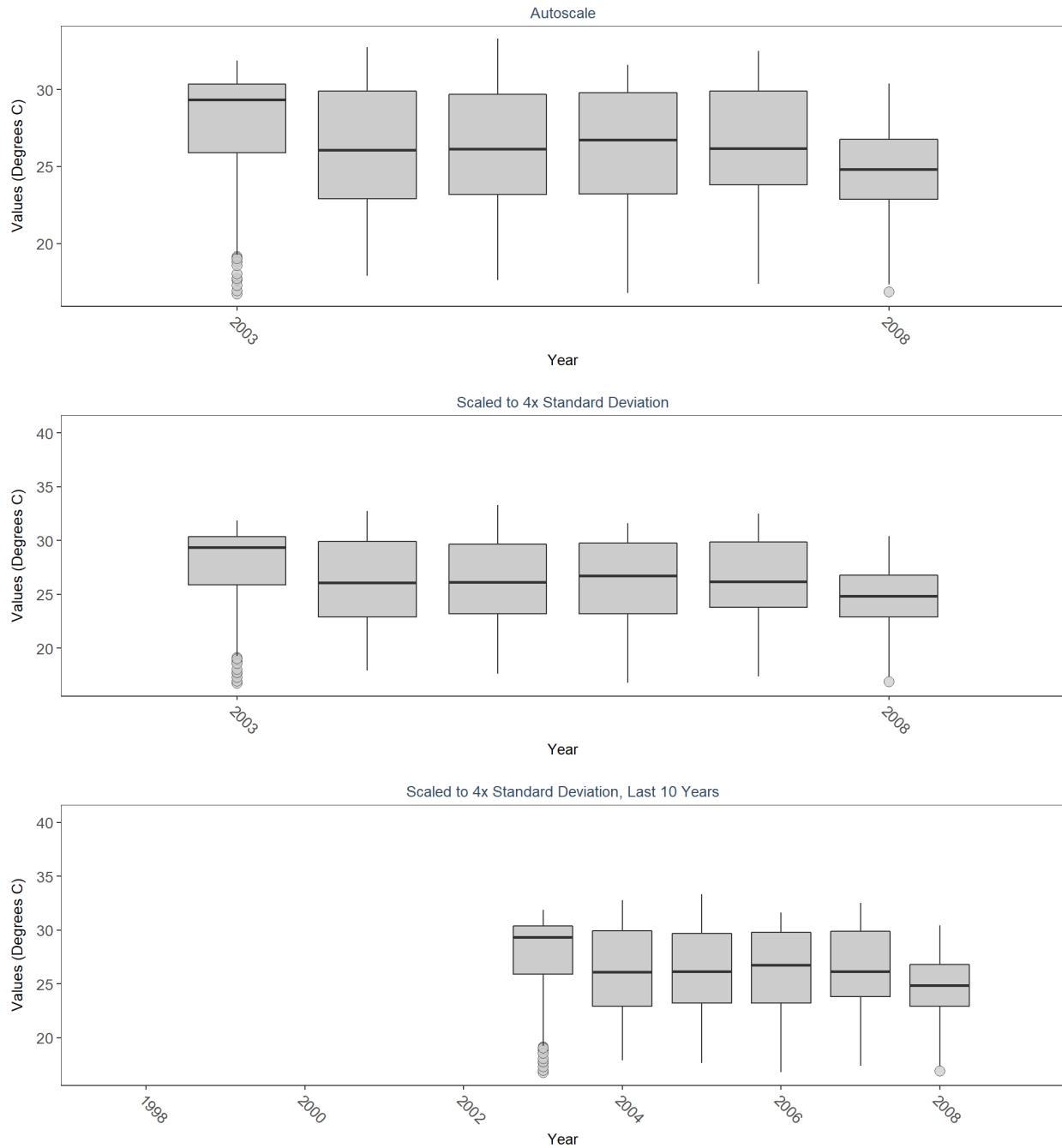
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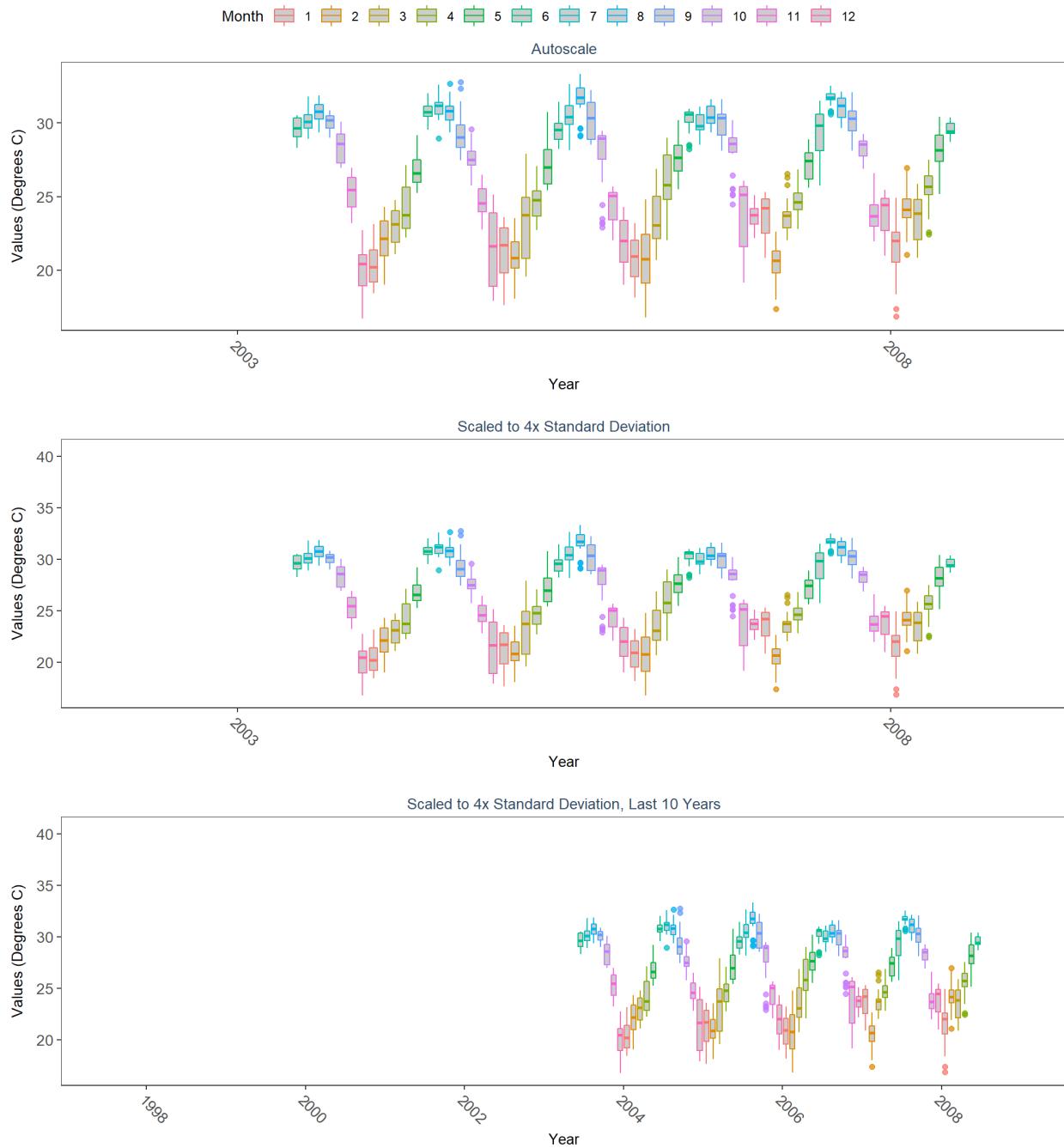
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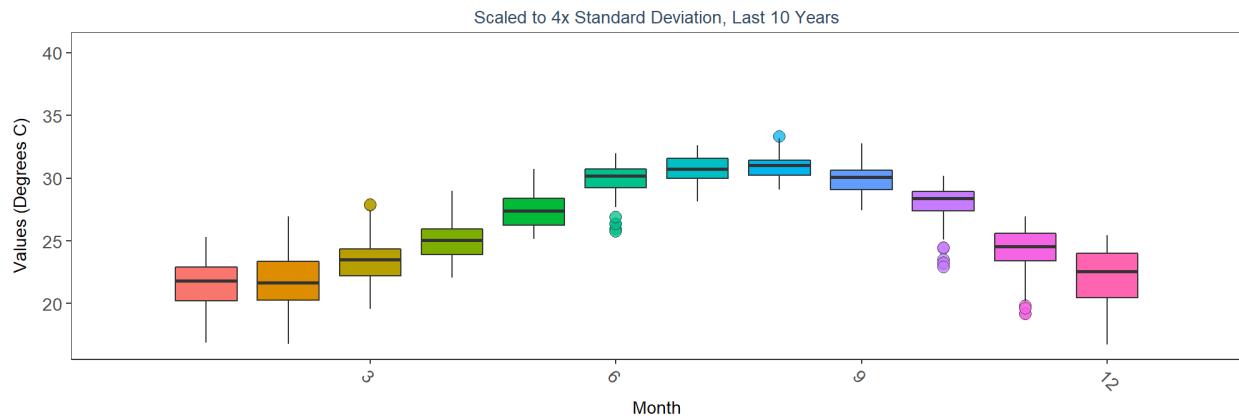
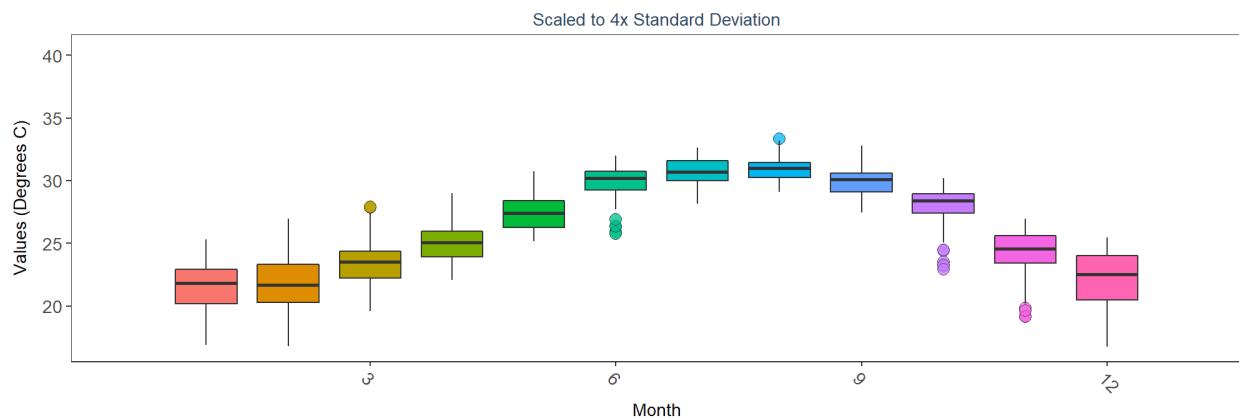
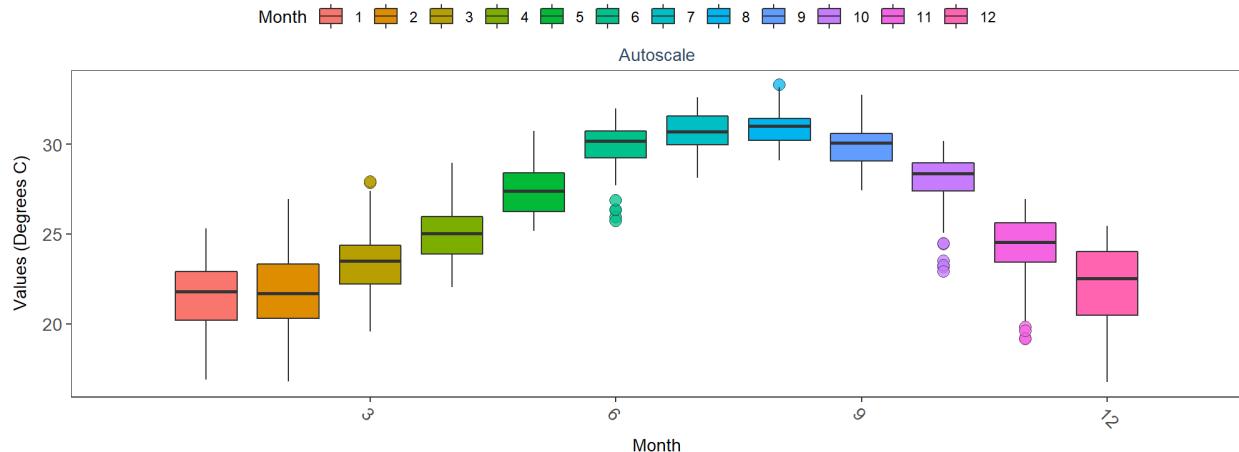
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 Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array  
 1B  
 By Year



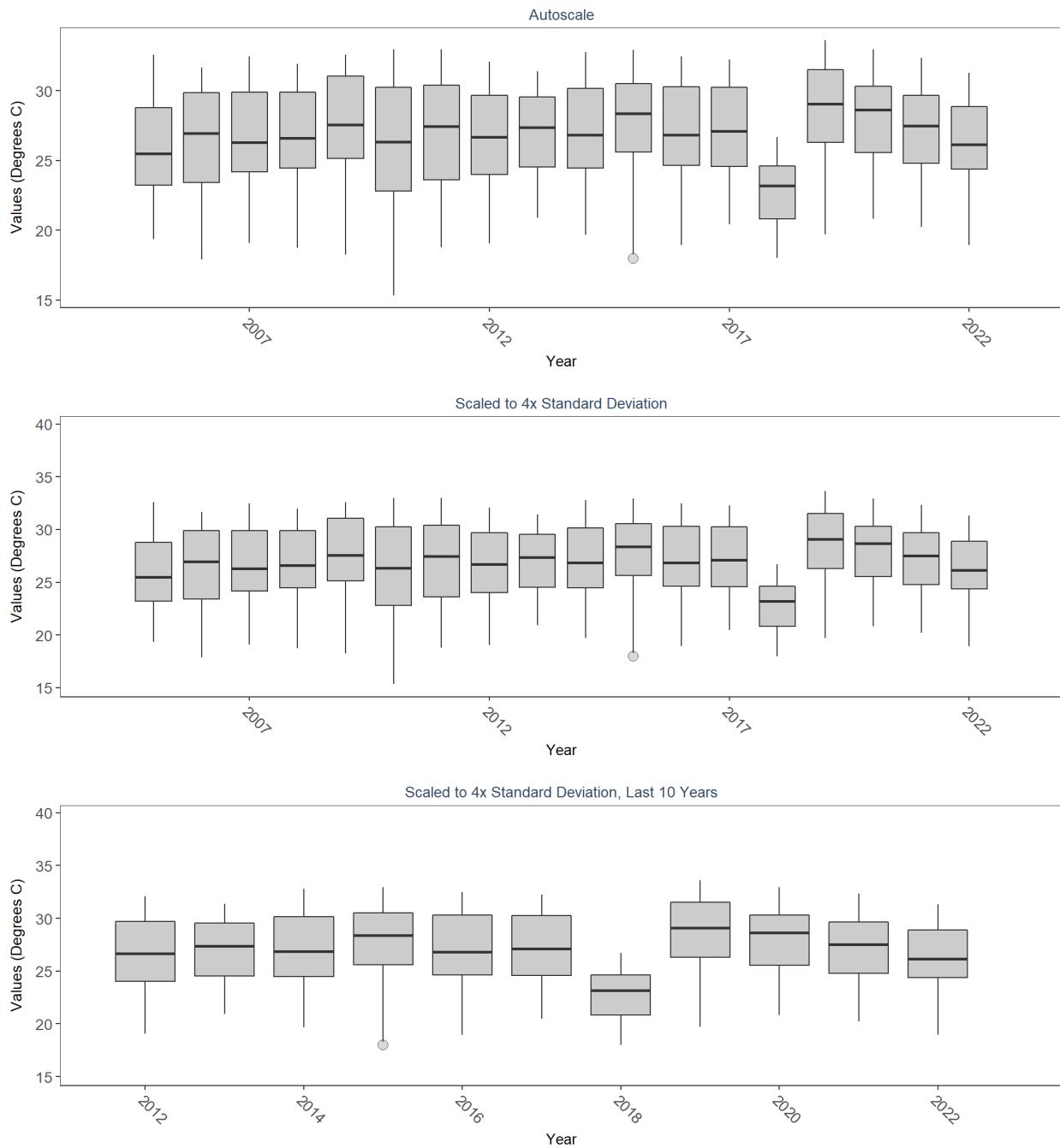
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 By Year & Month



Florida Keys National Marine Sanctuary  
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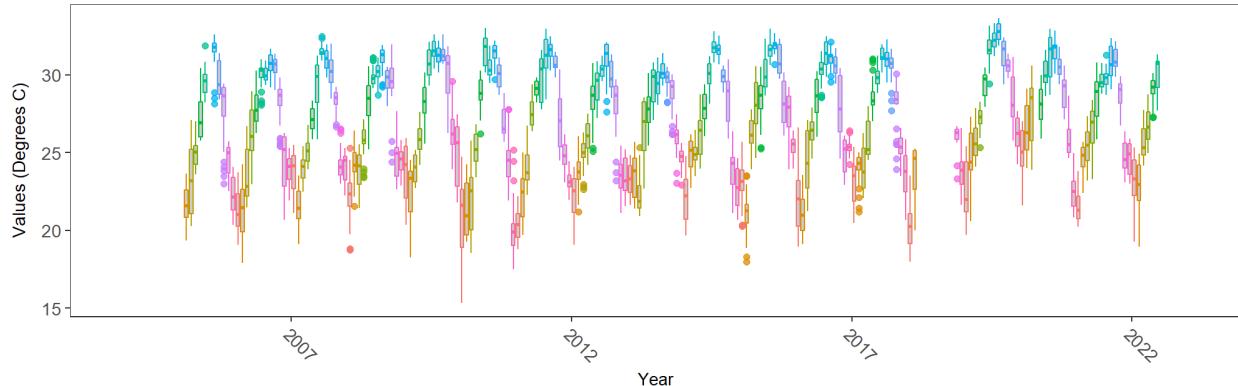
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National Data Buoy Center  
KYWF1  
By Year



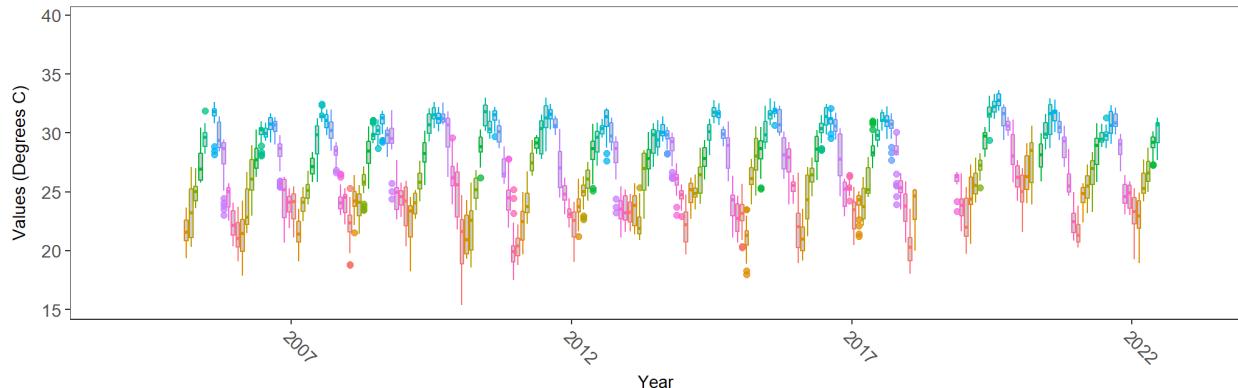
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 National Data Buoy Center  
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 By Year & Month

Month 1 2 3 4 5 6 7 8 9 10 11 12

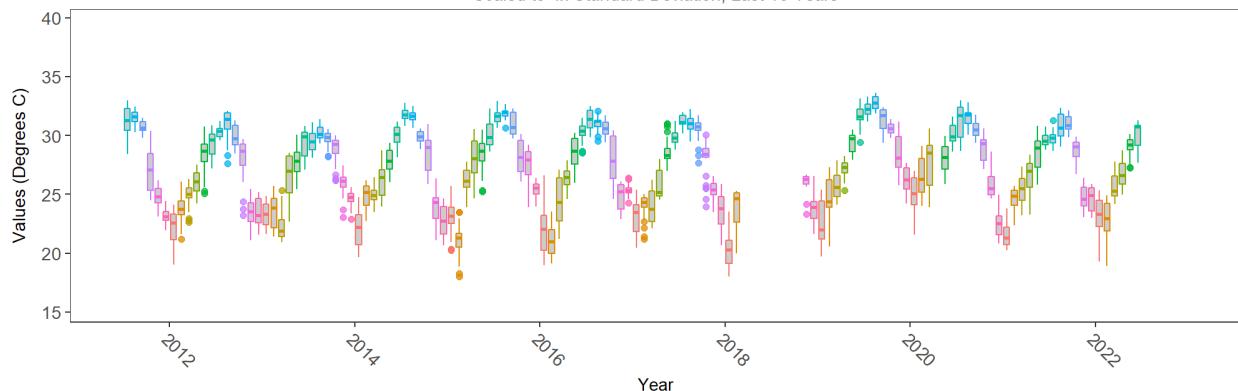
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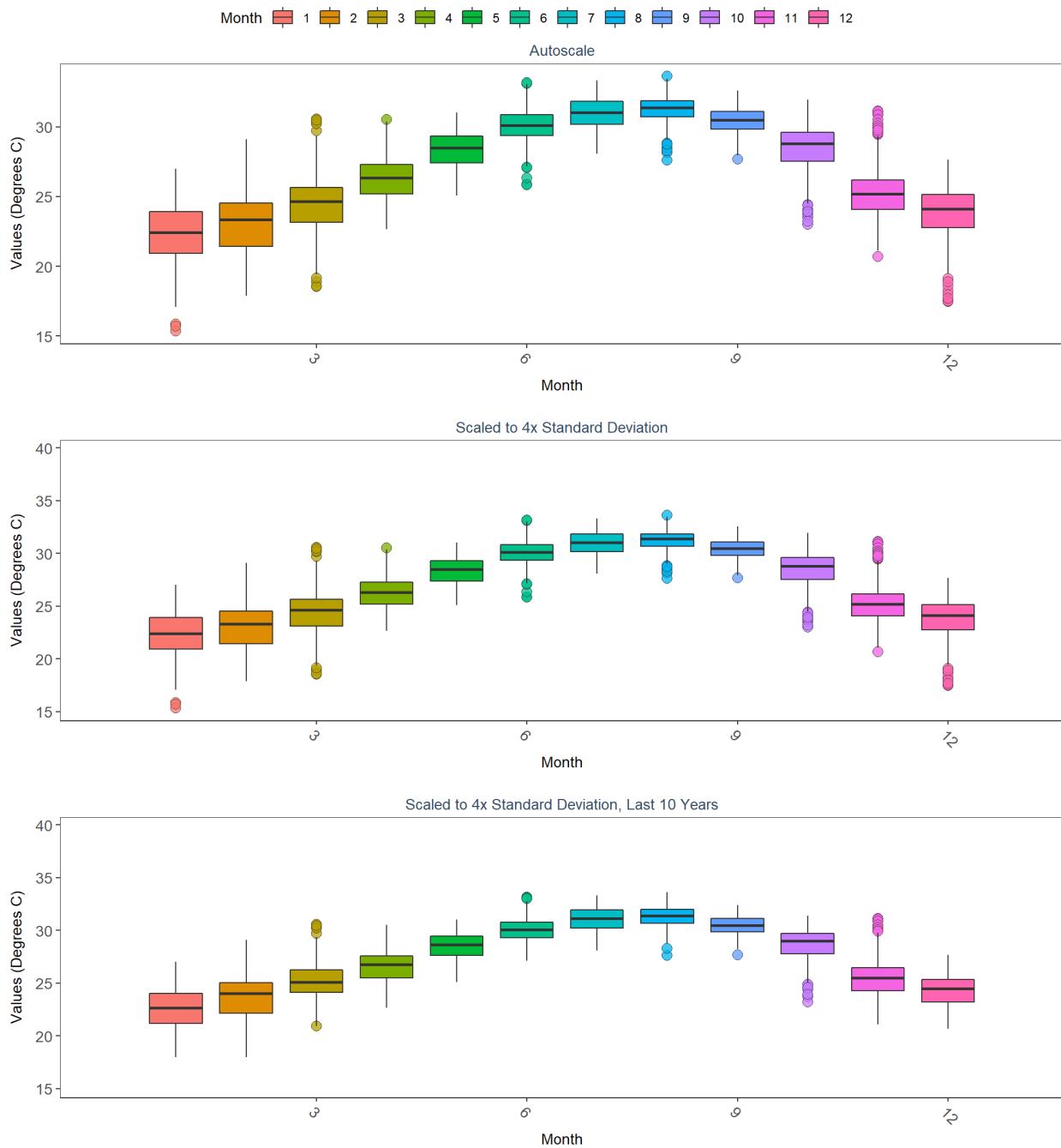
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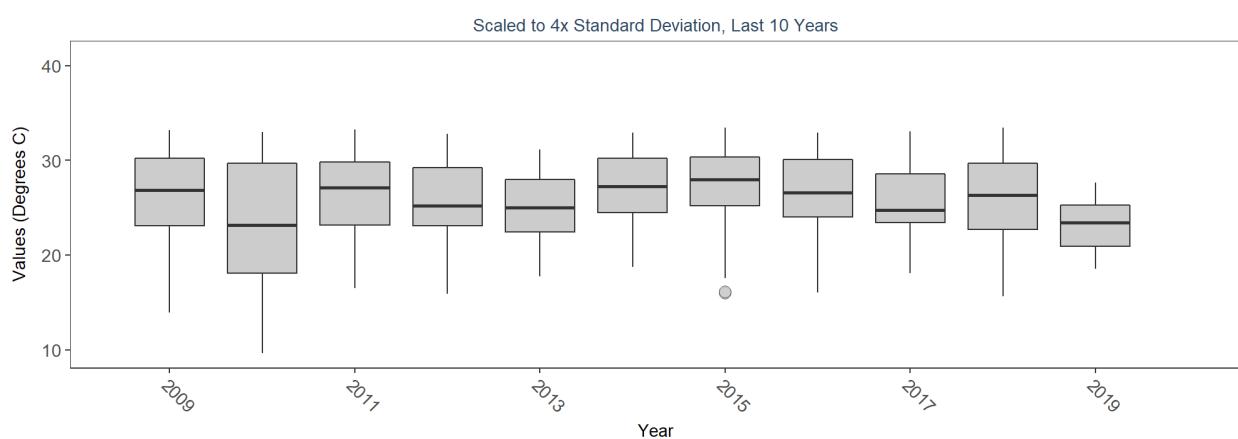
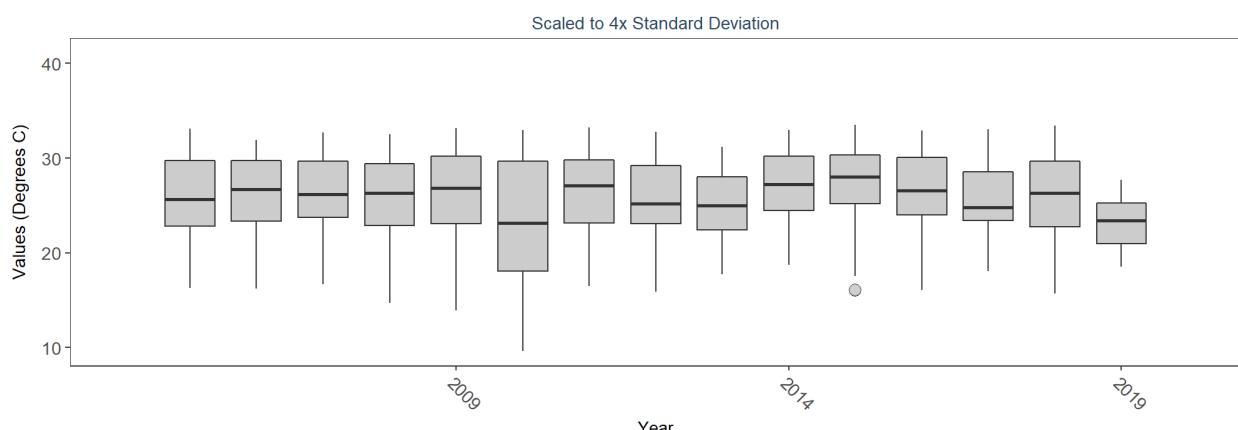
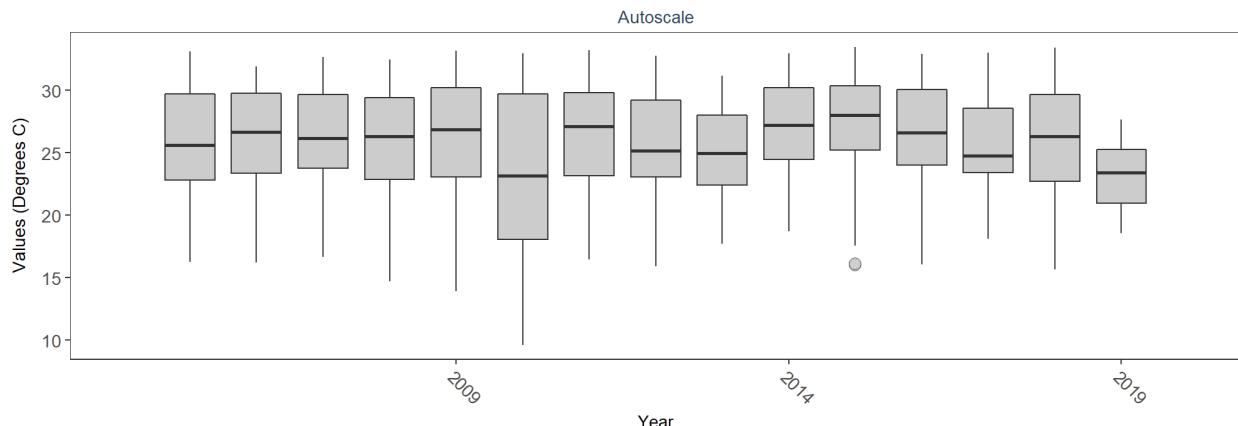
Scaled to 4x Standard Deviation, Last 10 Years



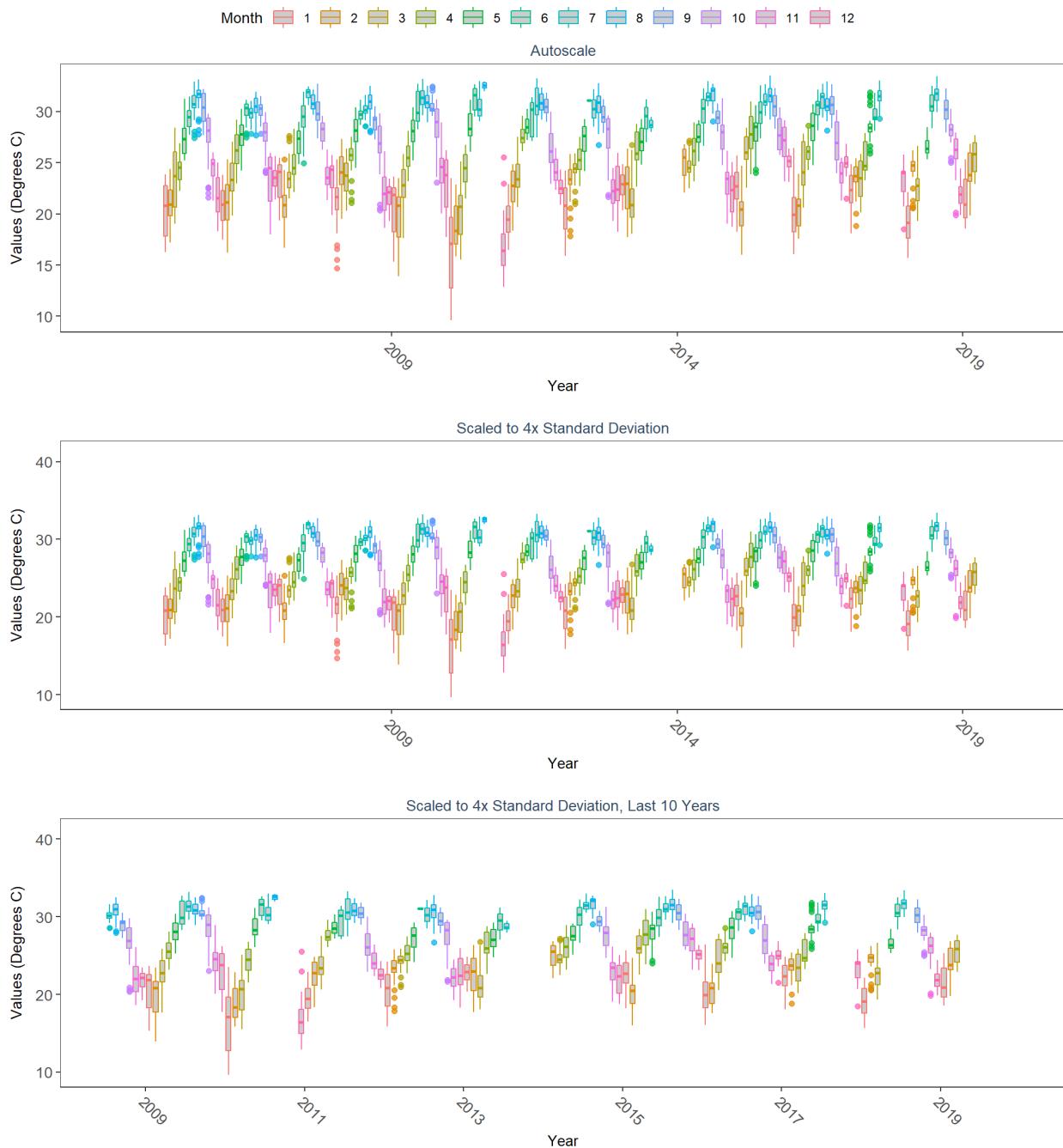
Florida Keys National Marine Sanctuary  
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National Data Buoy Center  
KYWF1  
By Month



Florida Keys National Marine Sanctuary  
5  
National Data Buoy Center  
LONF1  
By Year



Florida Keys National Marine Sanctuary  
 5  
 National Data Buoy Center  
 LONF1  
 By Year & Month



Florida Keys National Marine Sanctuary

5

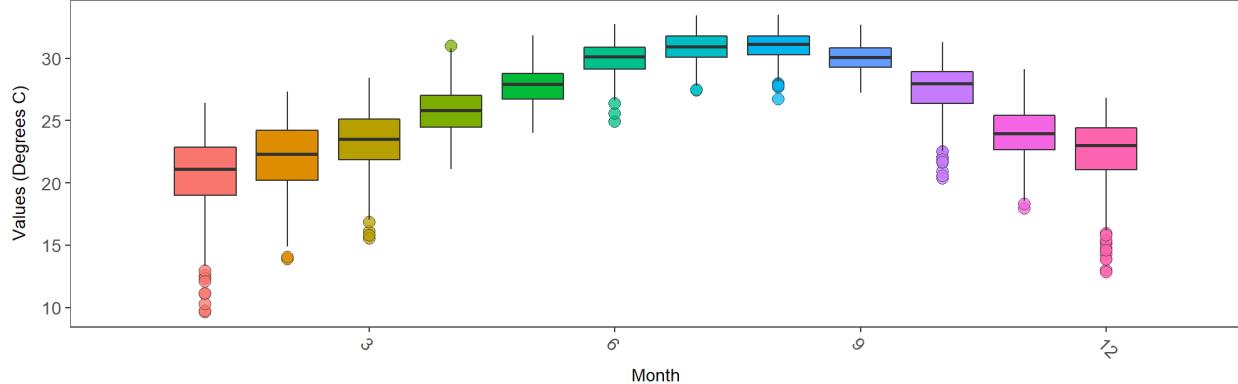
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LONF1

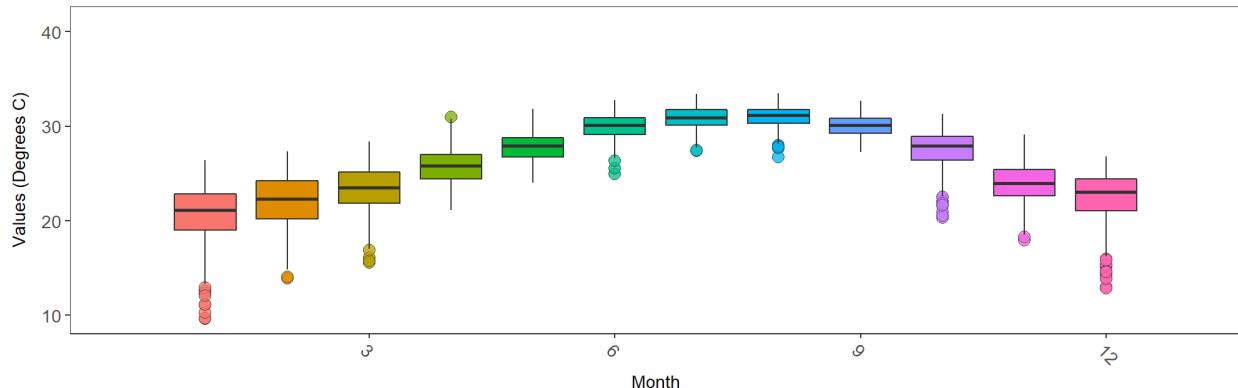
By Month

Month 1 2 3 4 5 6 7 8 9 10 11 12

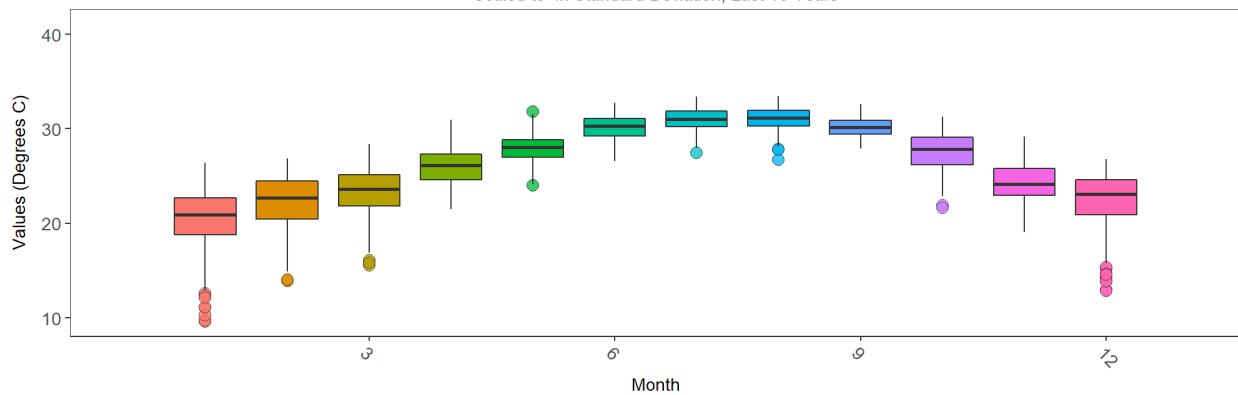
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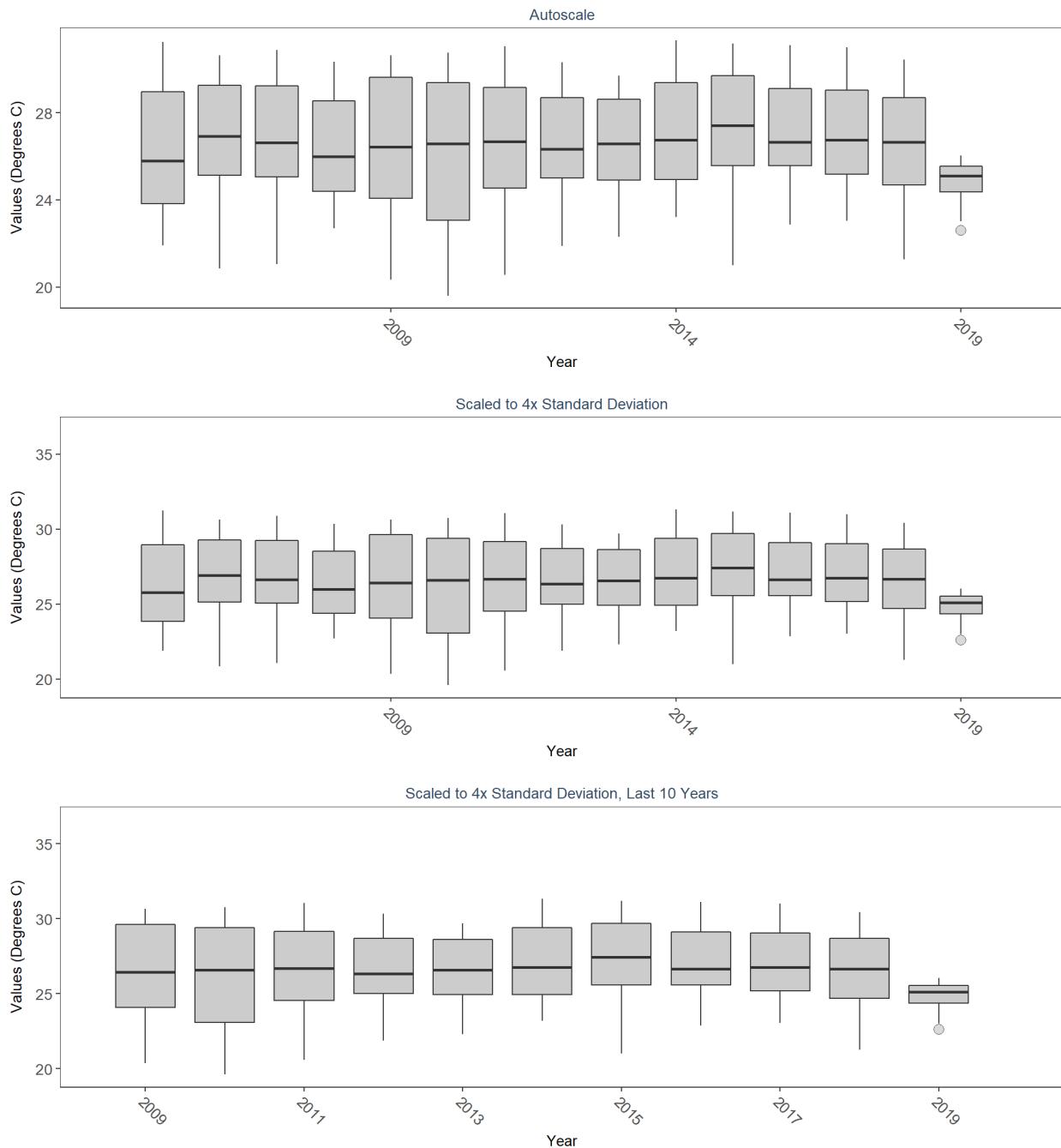
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Scaled to 4x Standard Deviation, Last 10 Years



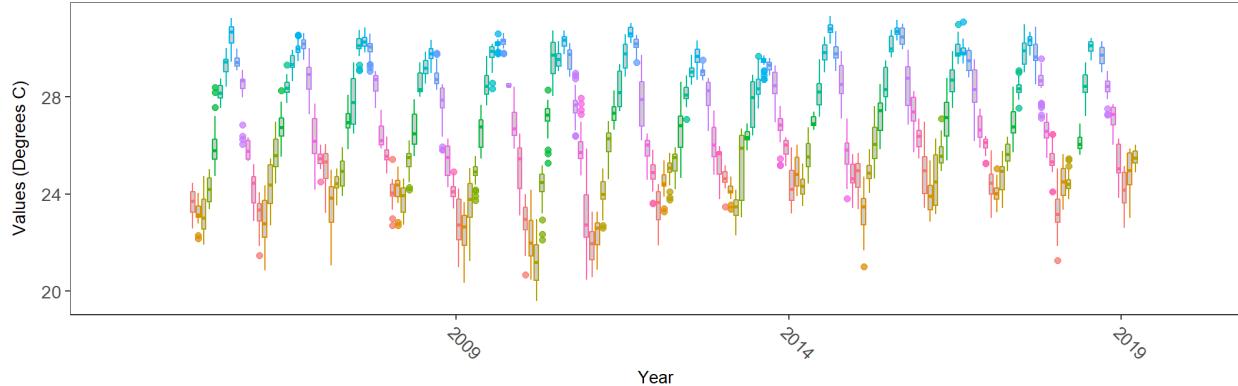
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National Data Buoy Center  
MLRF1  
By Year



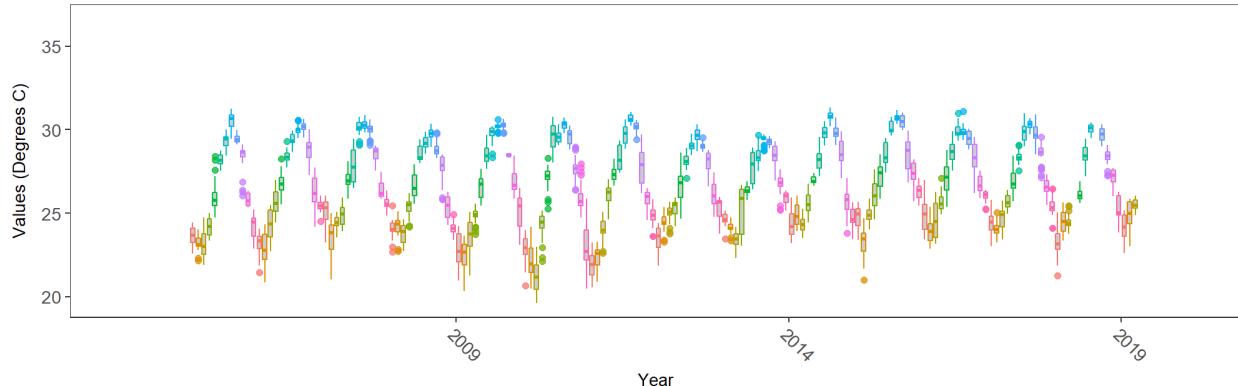
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 National Data Buoy Center  
 MLRF1  
 By Year & Month

Month 1 2 3 4 5 6 7 8 9 10 11 12

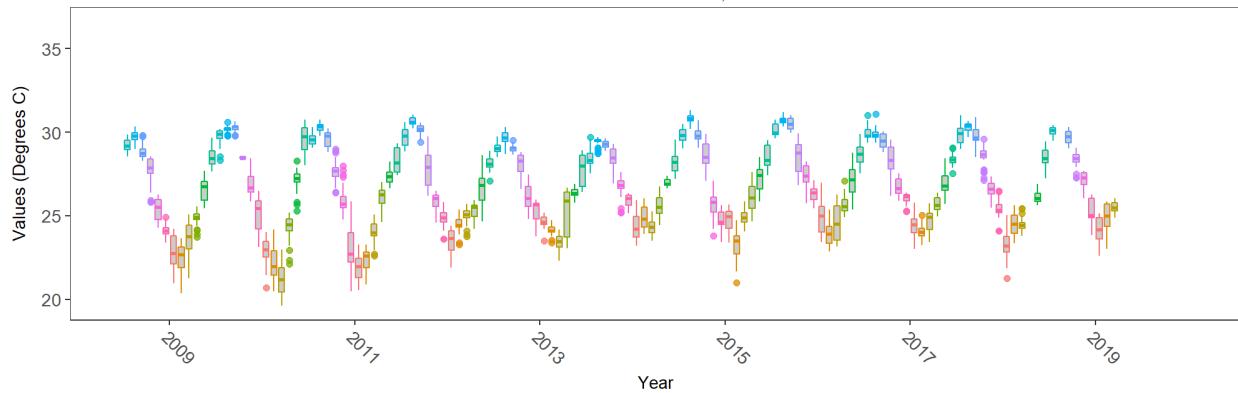
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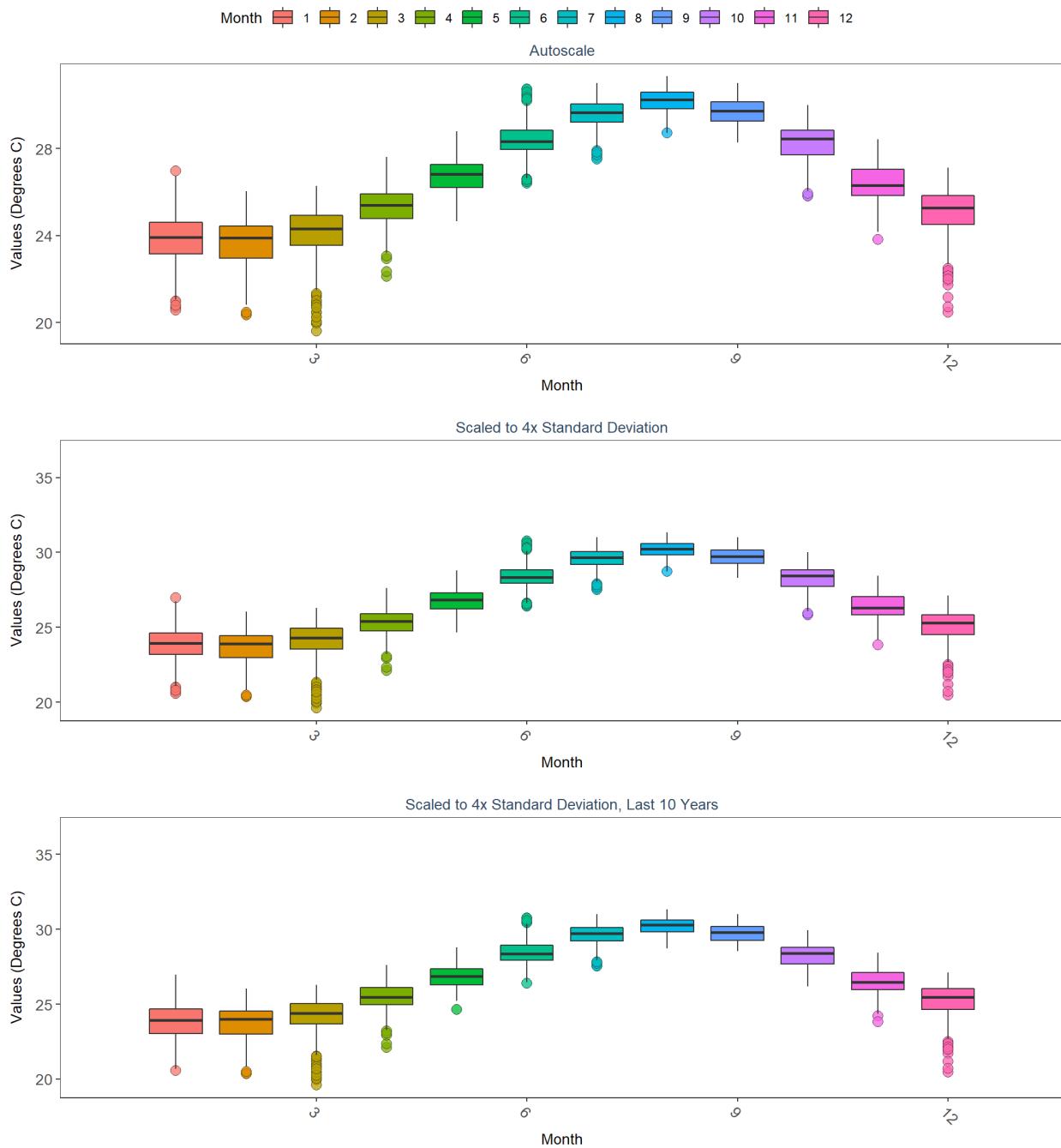
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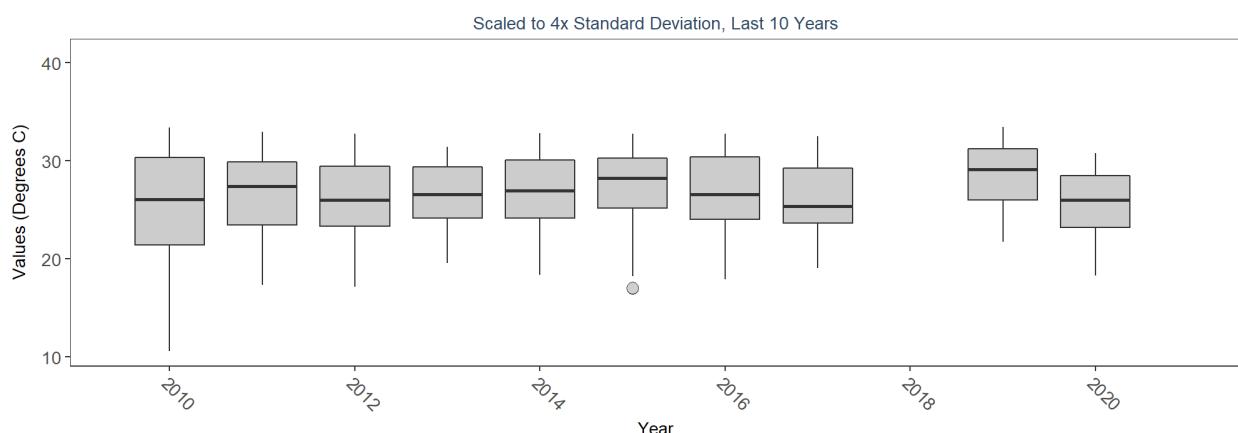
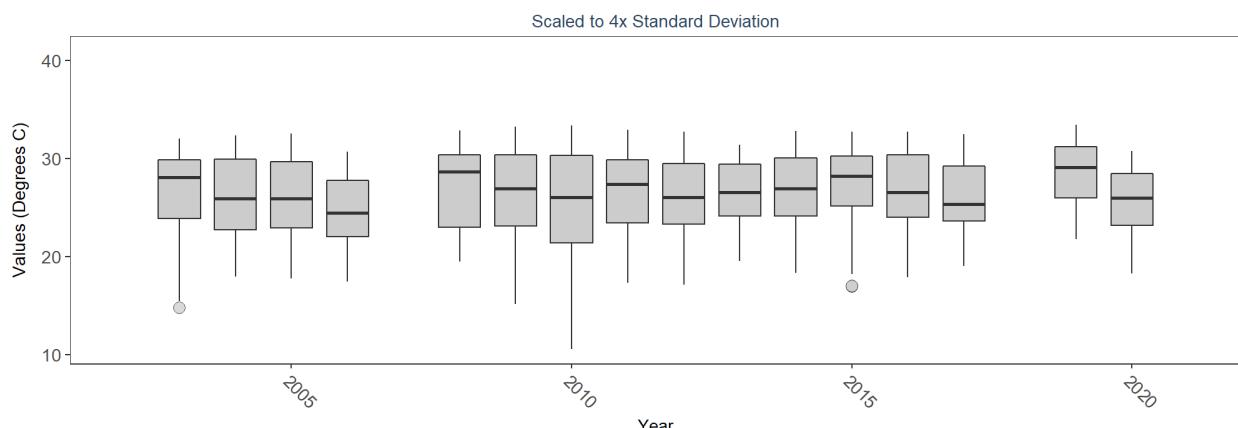
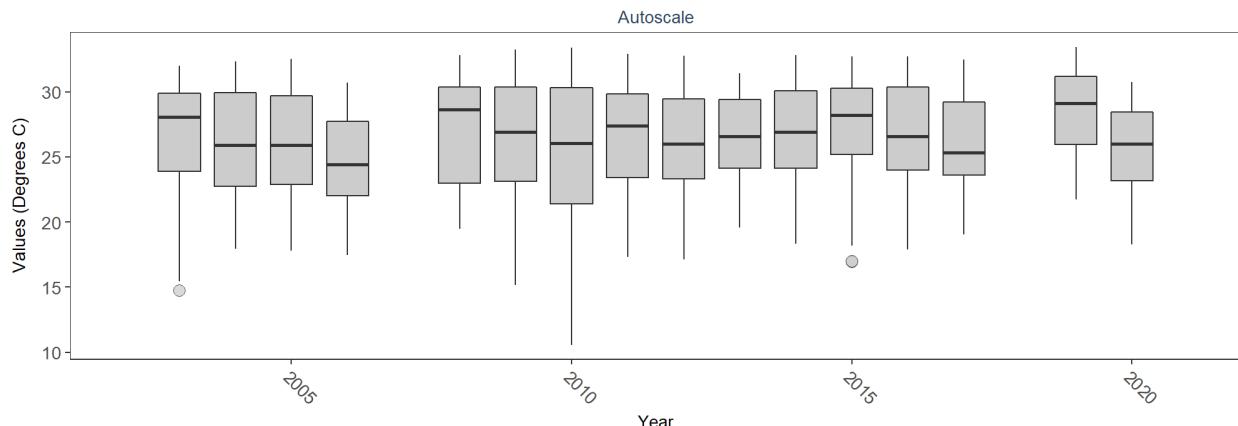
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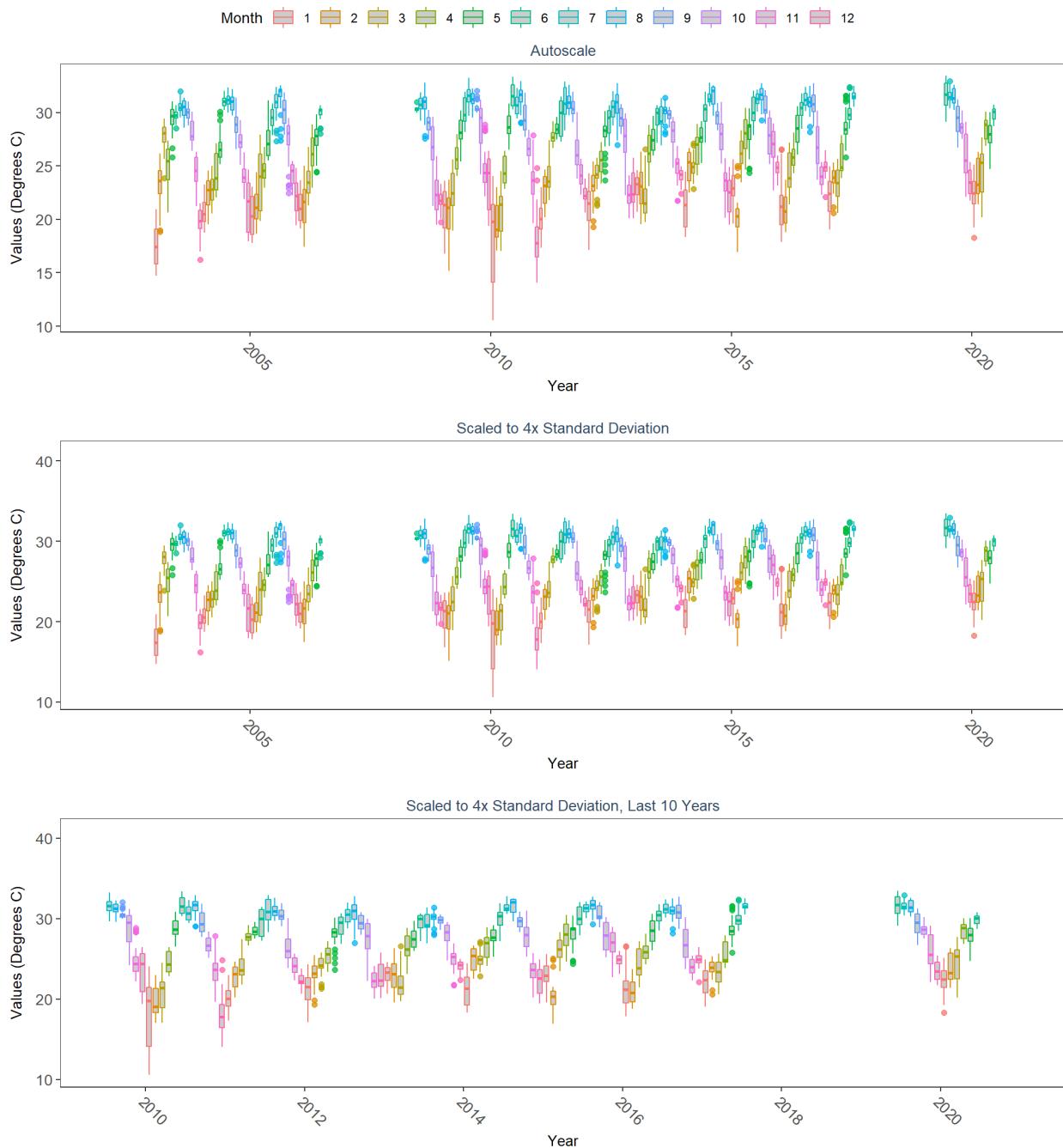
Florida Keys National Marine Sanctuary  
5  
National Data Buoy Center  
MLRF1  
By Month



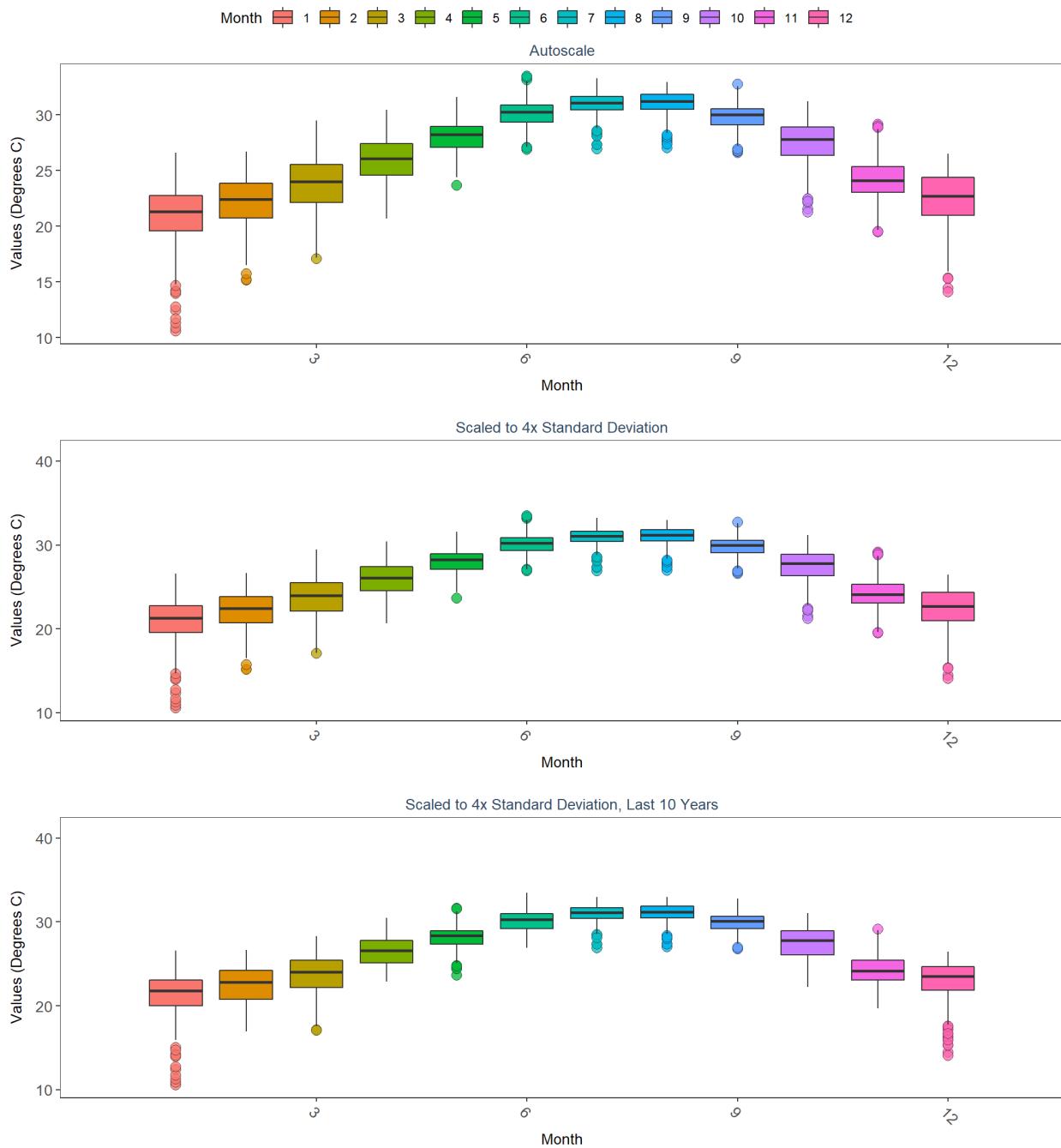
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 Water Temperature on Coral Reefs in the Florida Keys  
 11  
 By Year



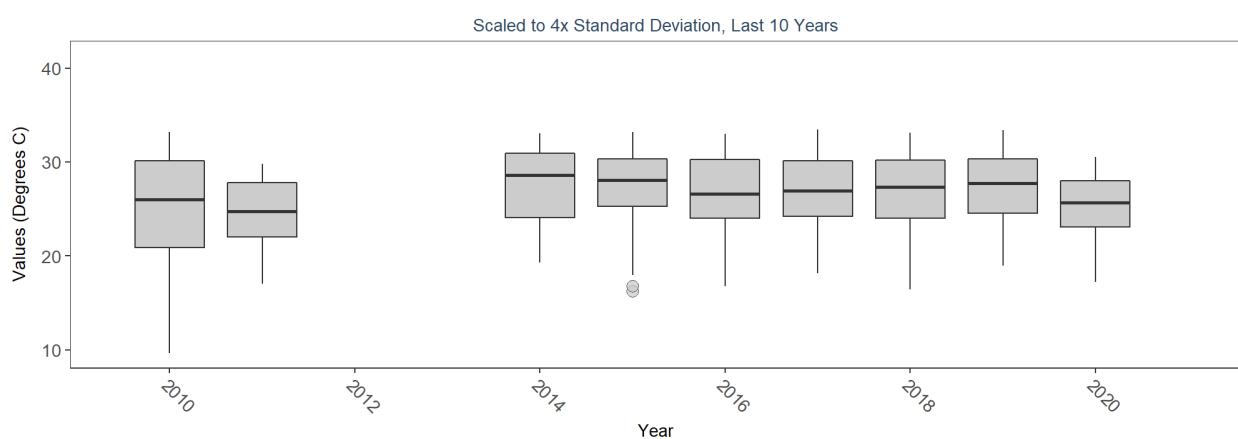
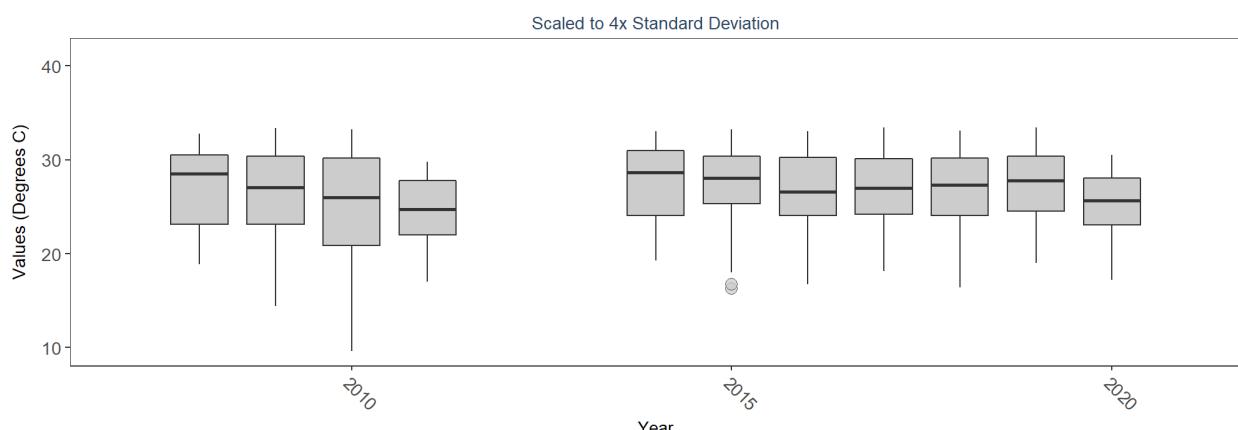
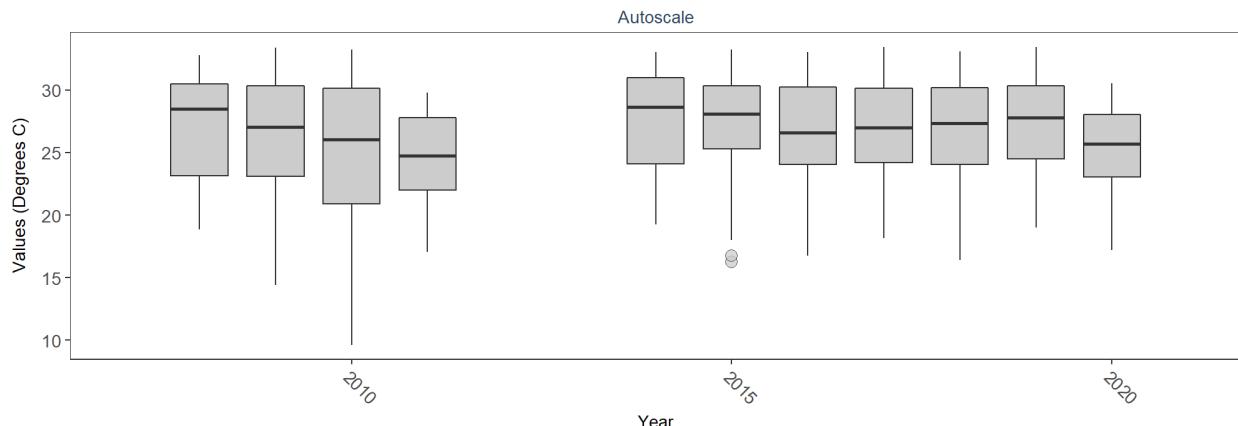
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



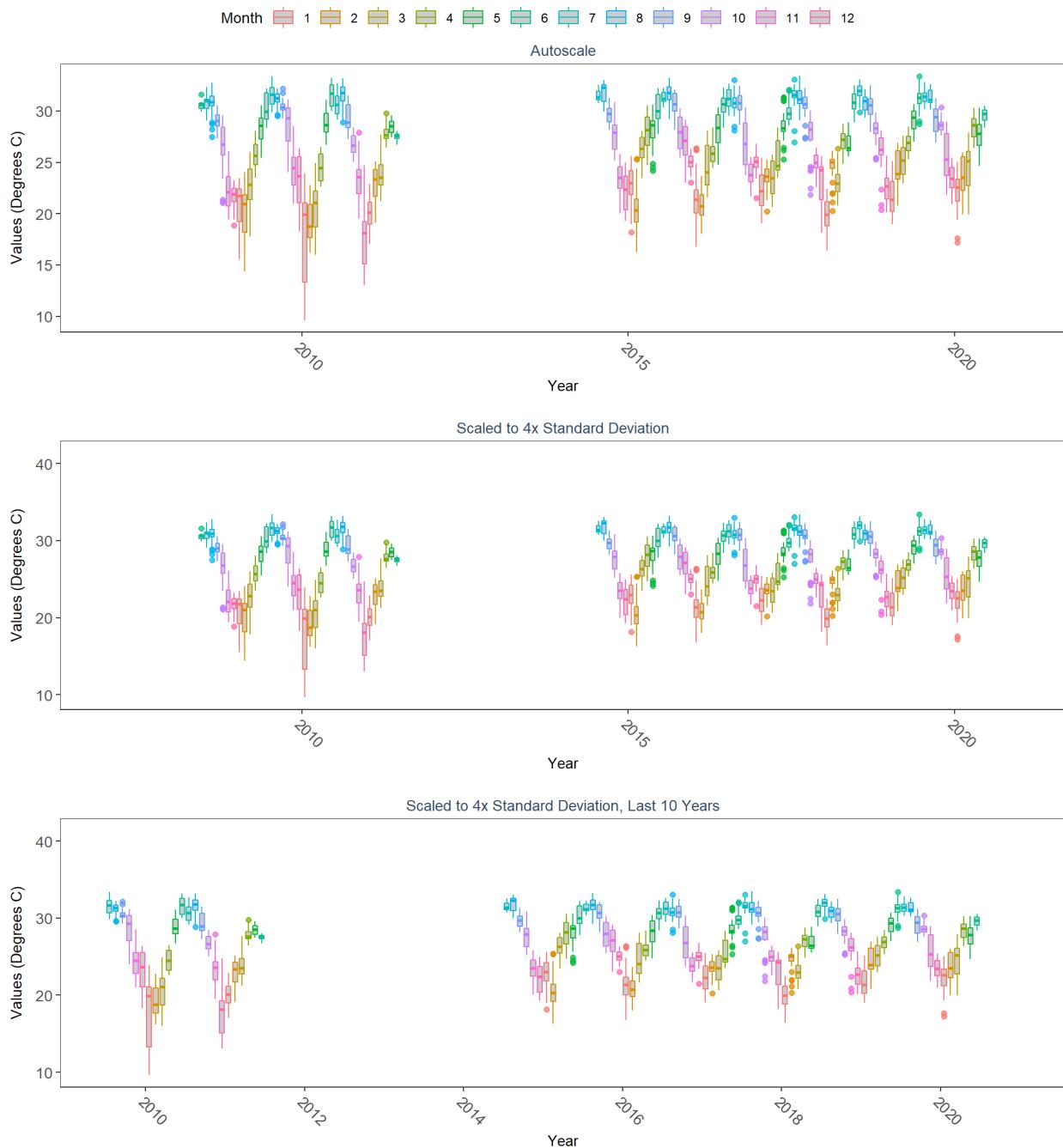
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Month



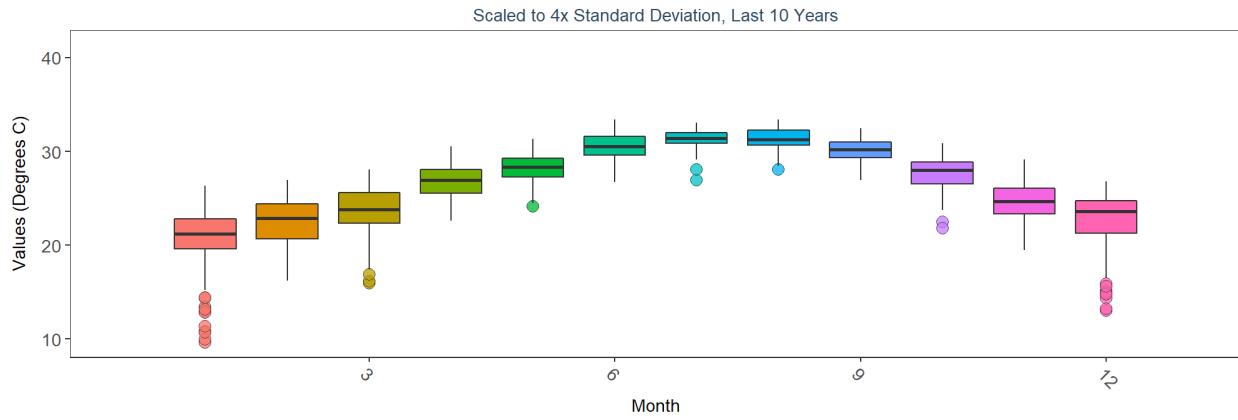
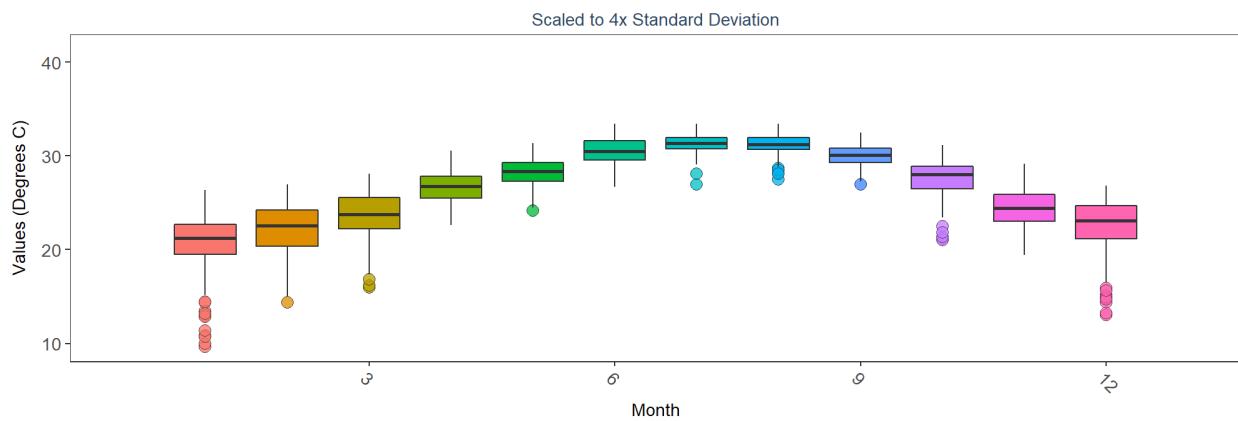
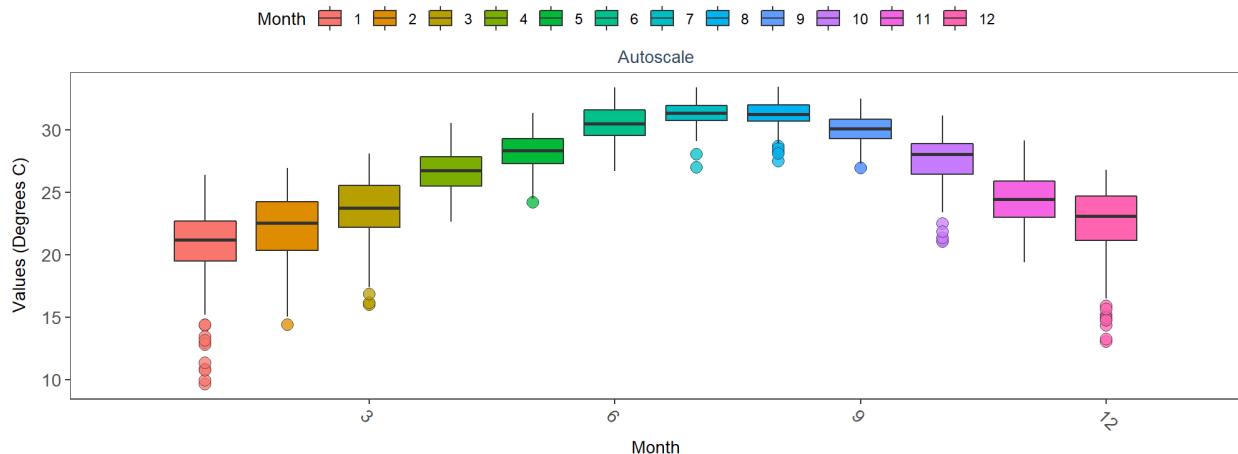
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By Year



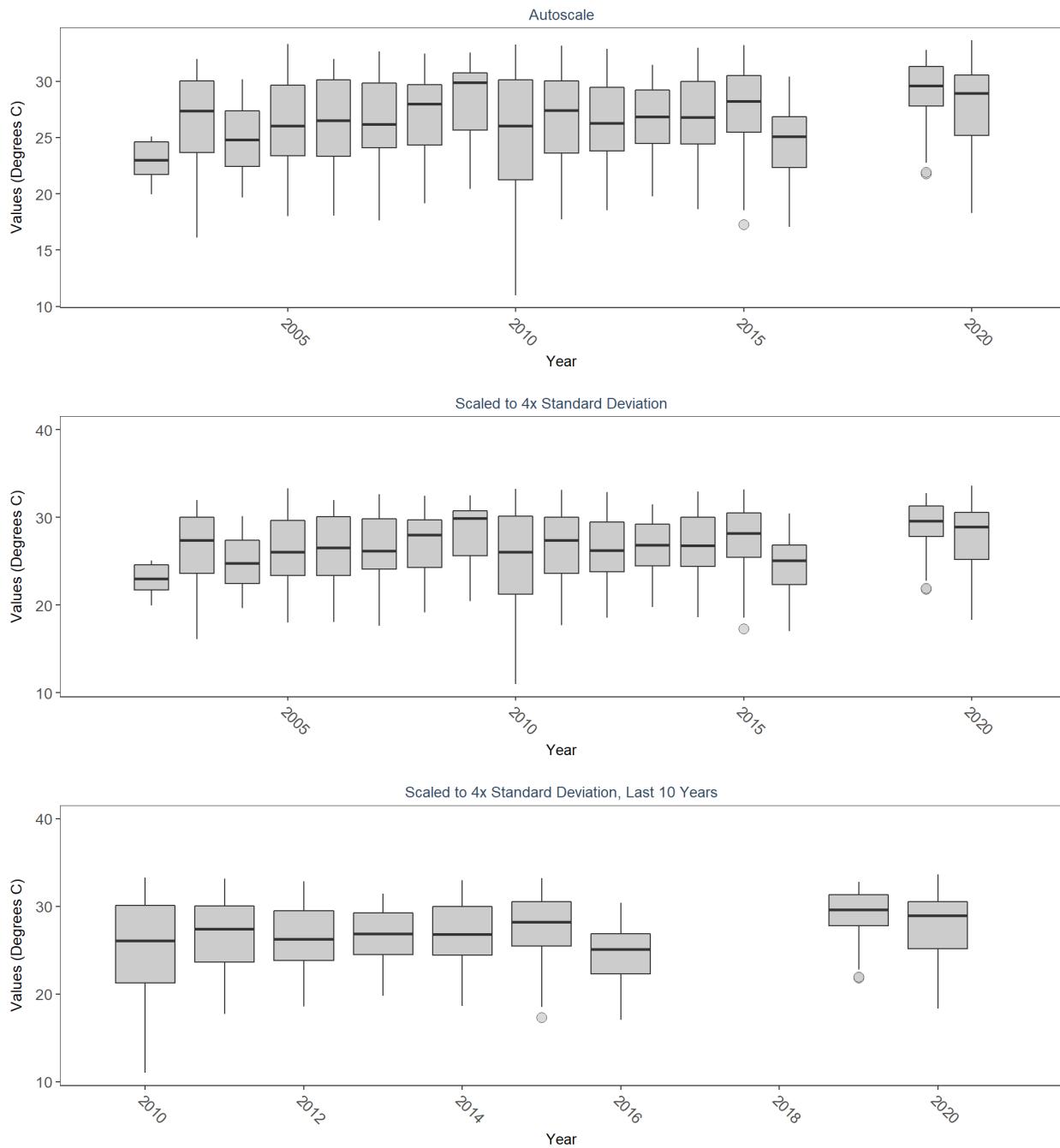
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 By Year & Month



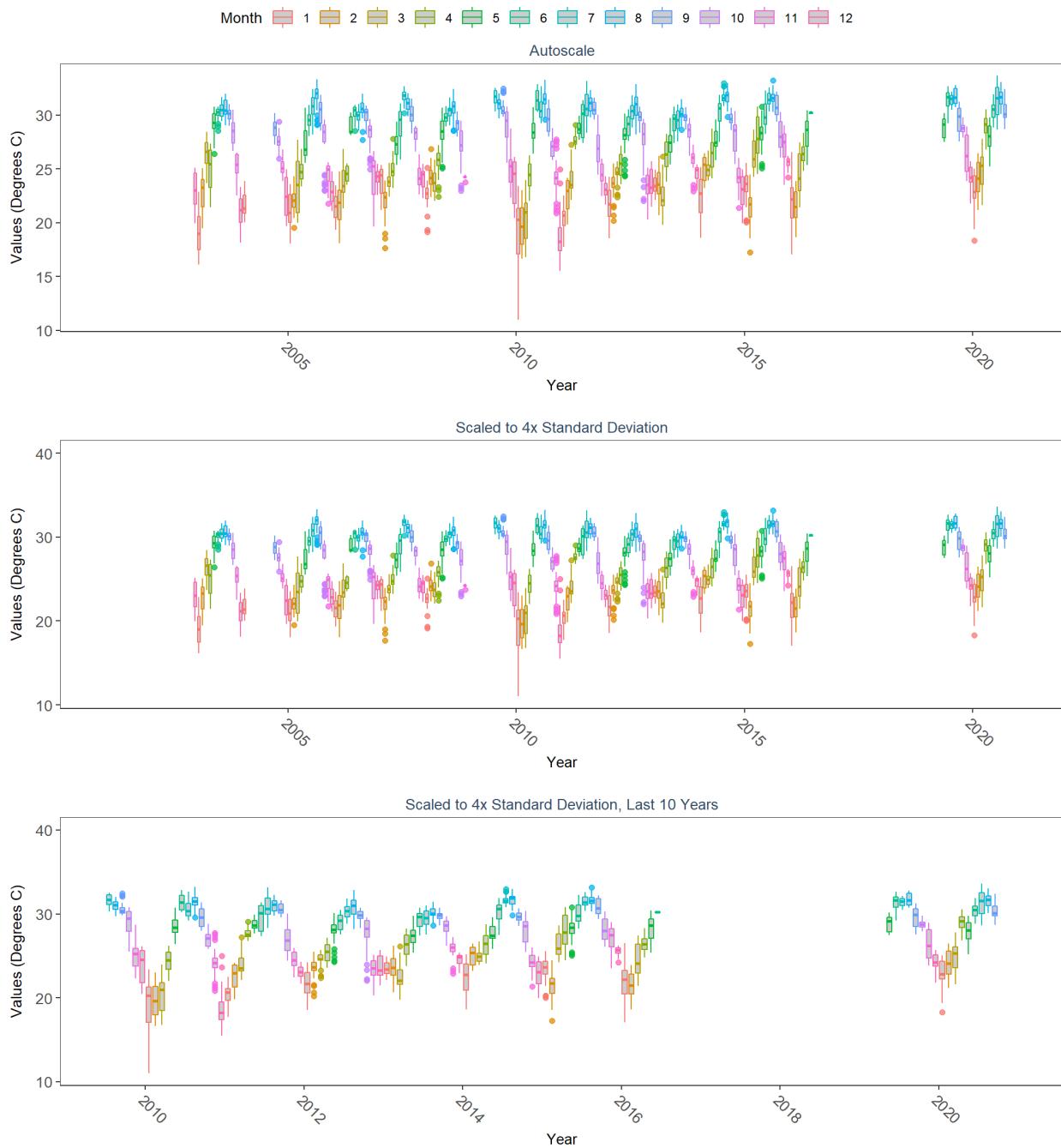
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 By Month



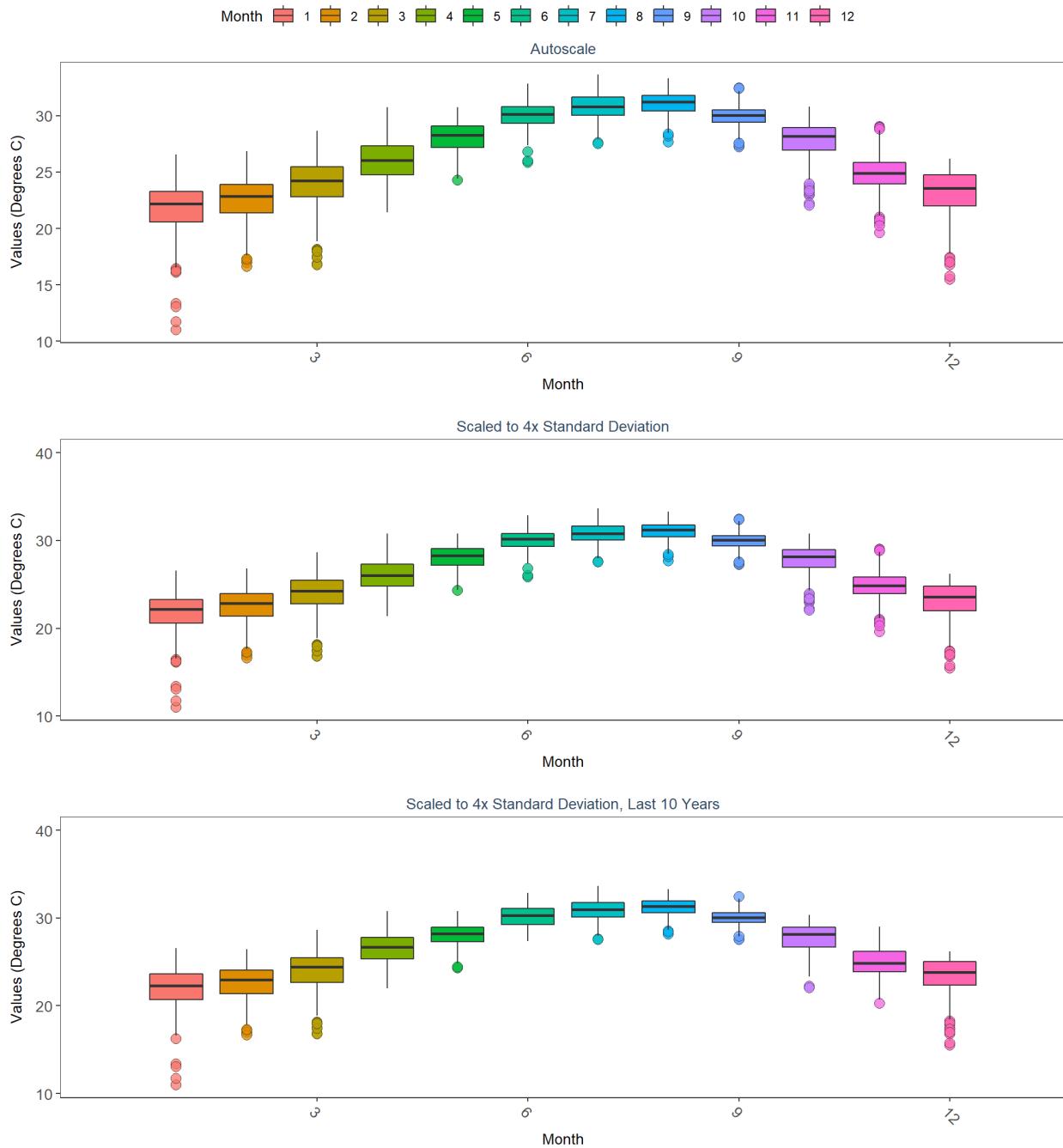
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 By Year



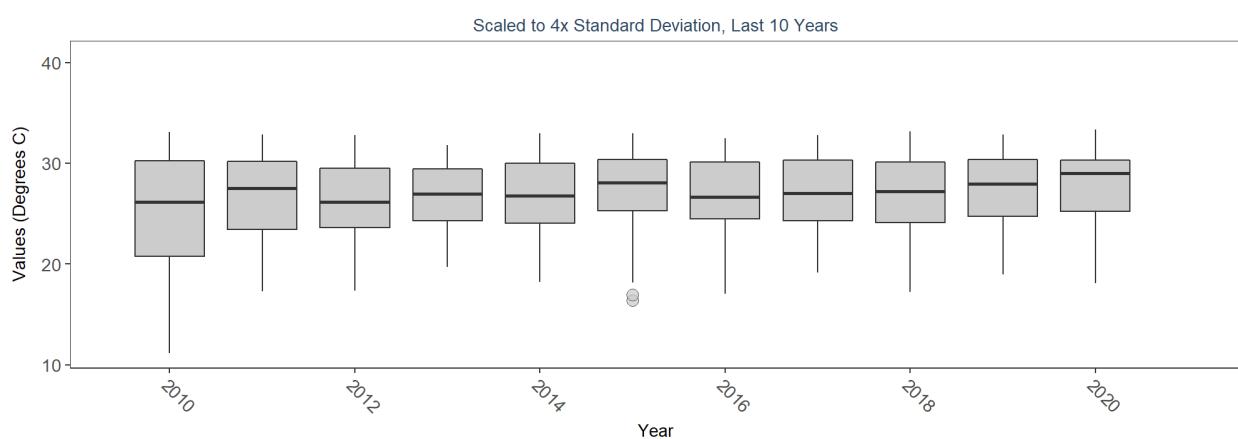
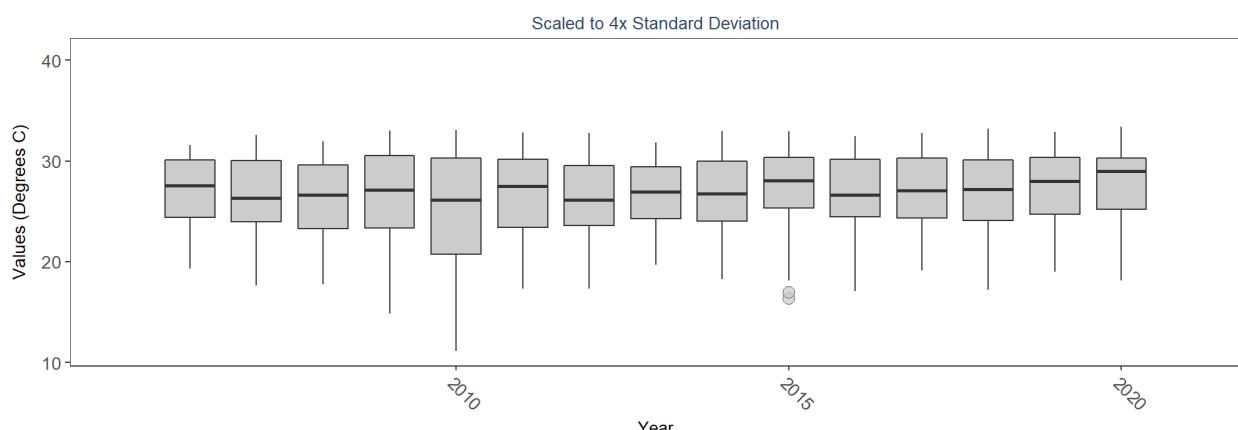
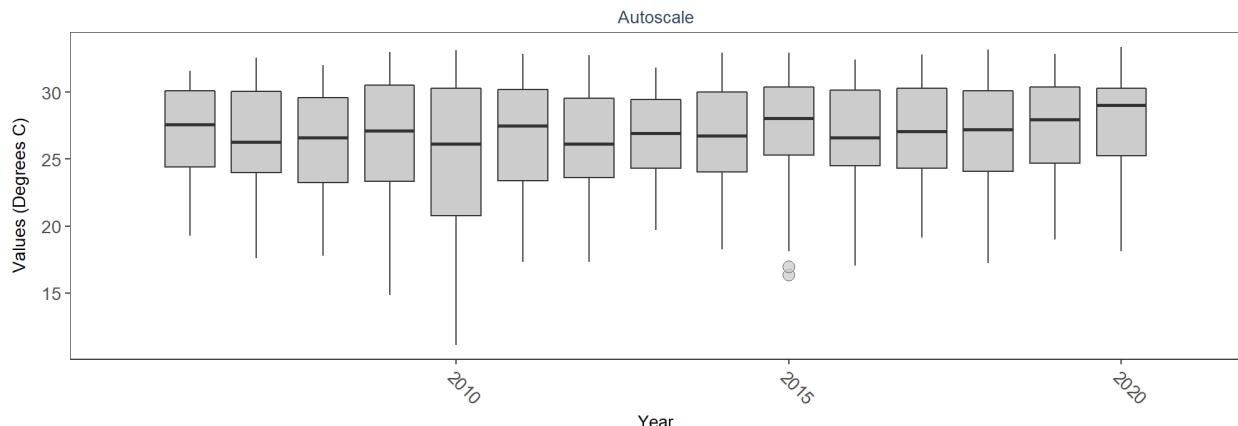
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 By Year & Month



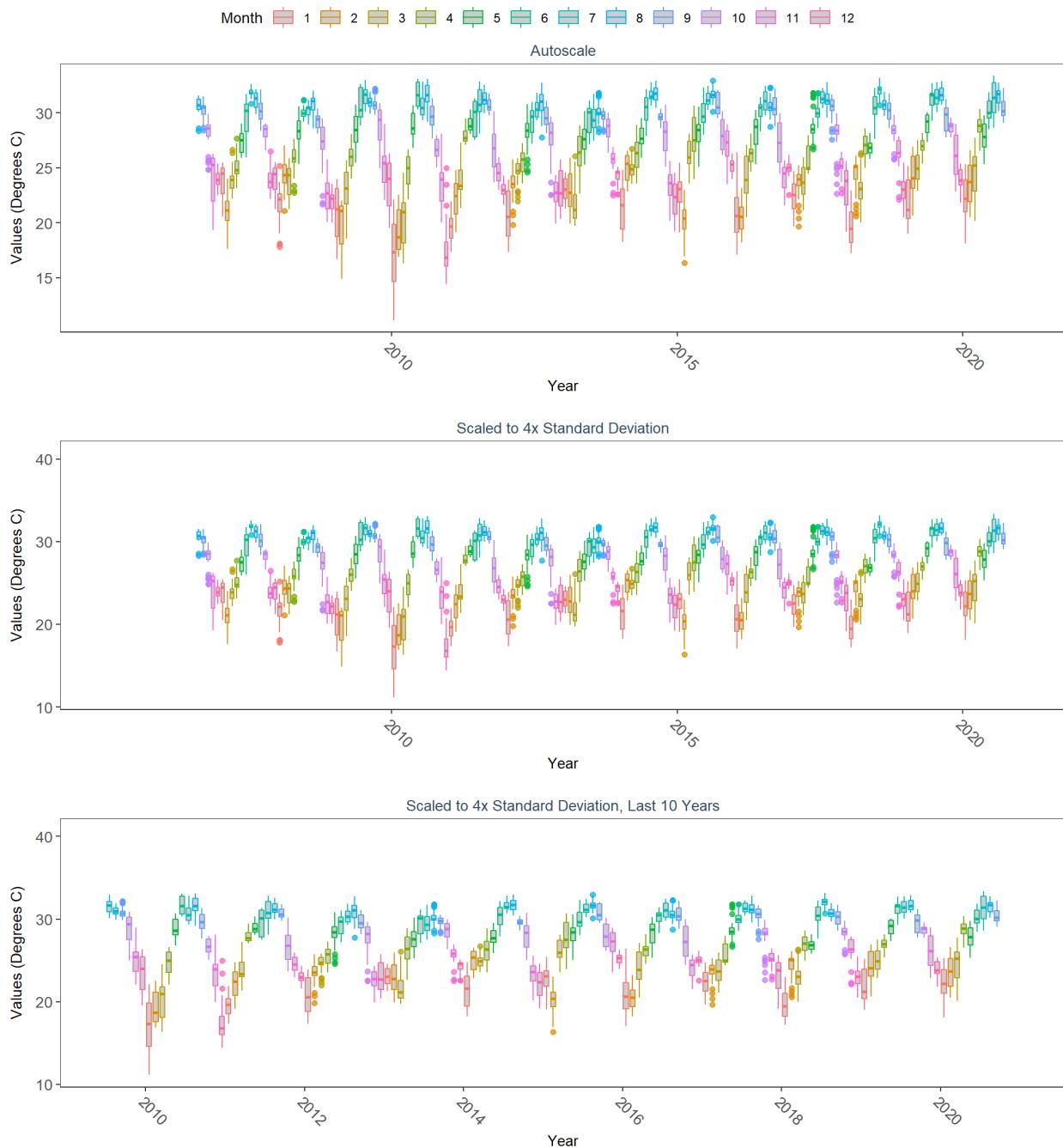
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 By Month



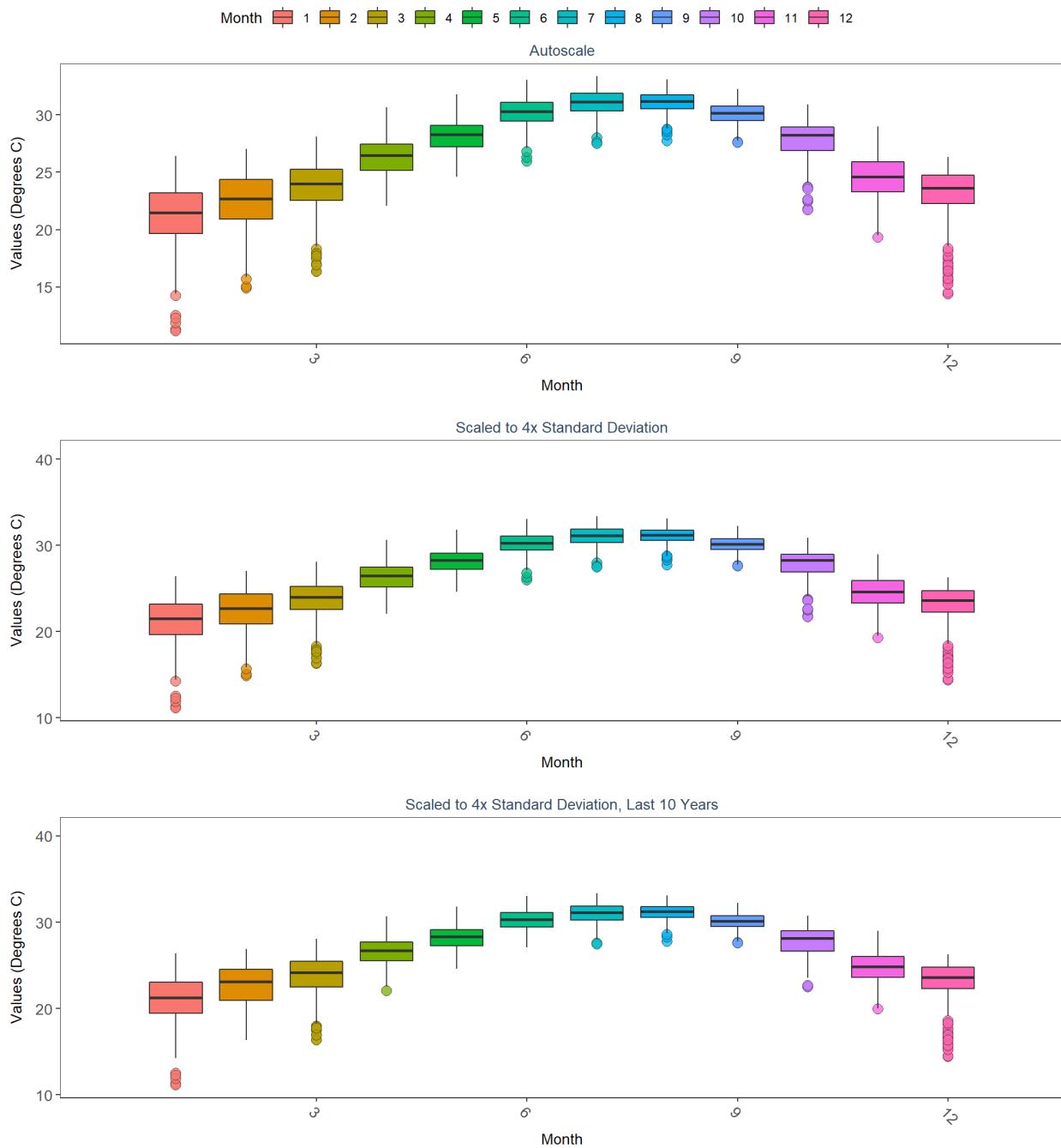
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15  
By Year



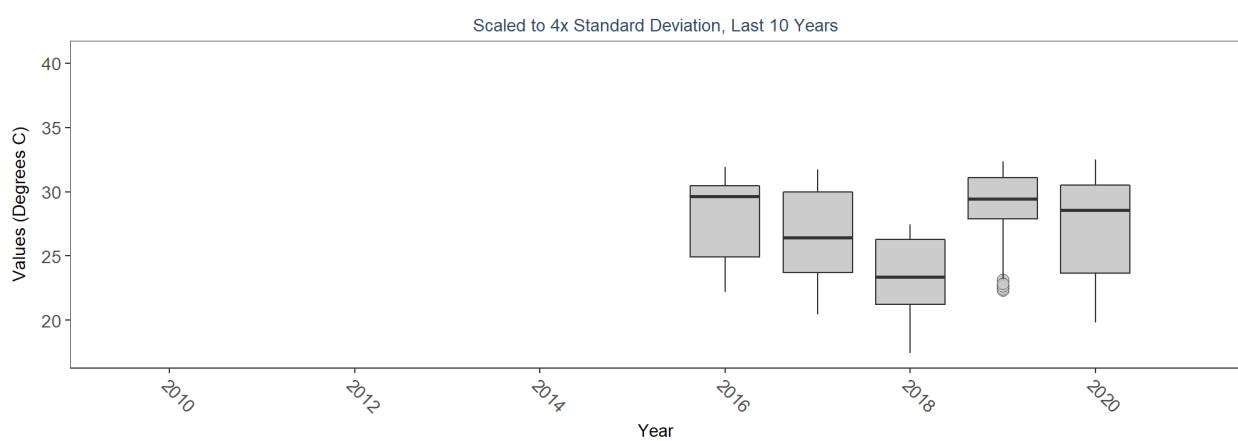
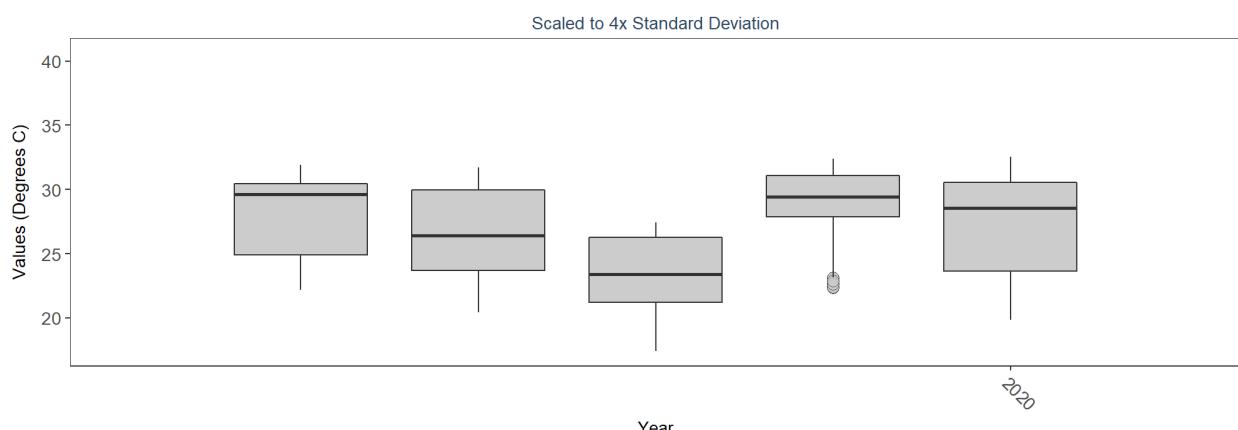
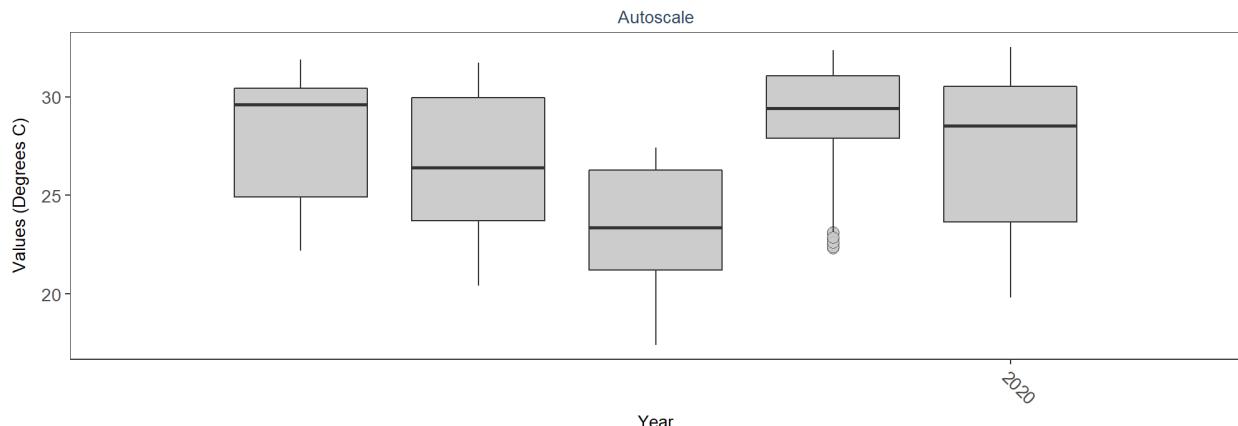
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 By Year & Month



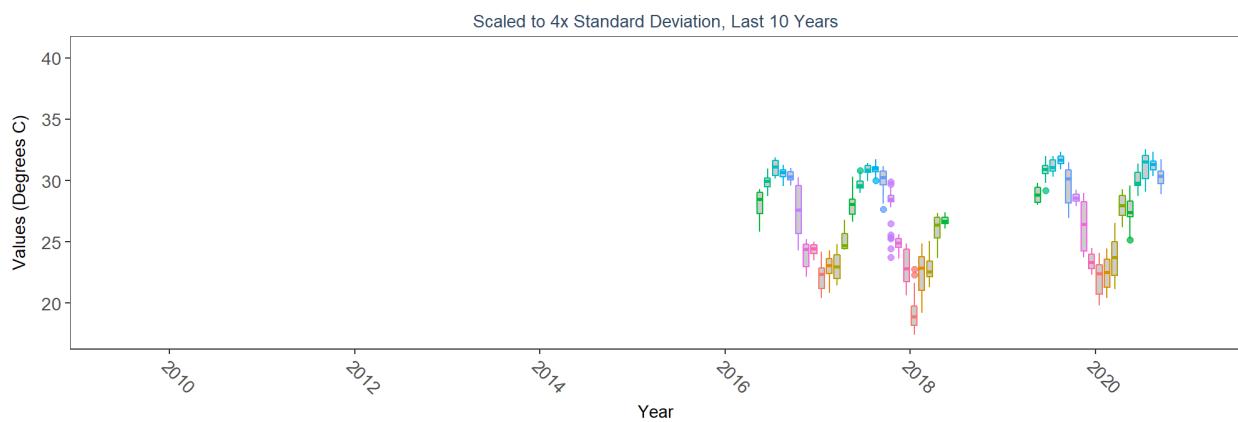
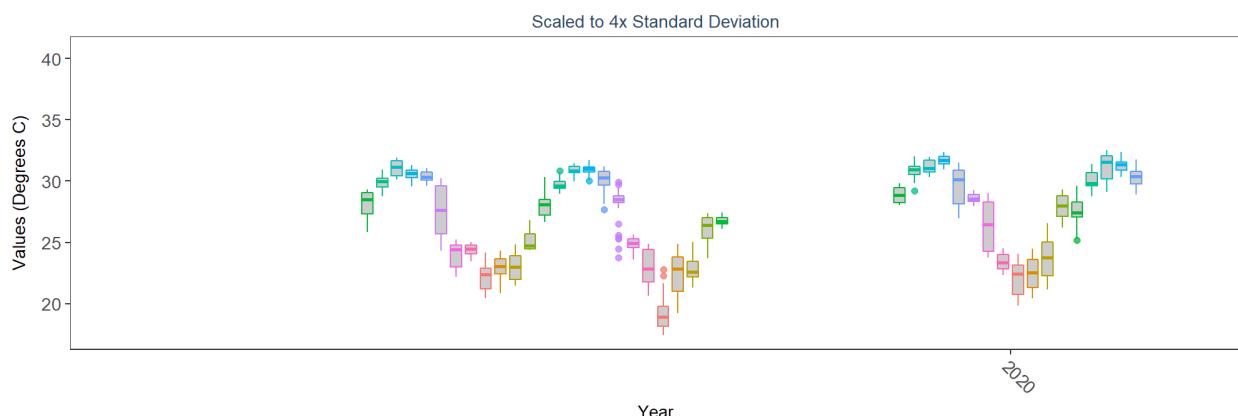
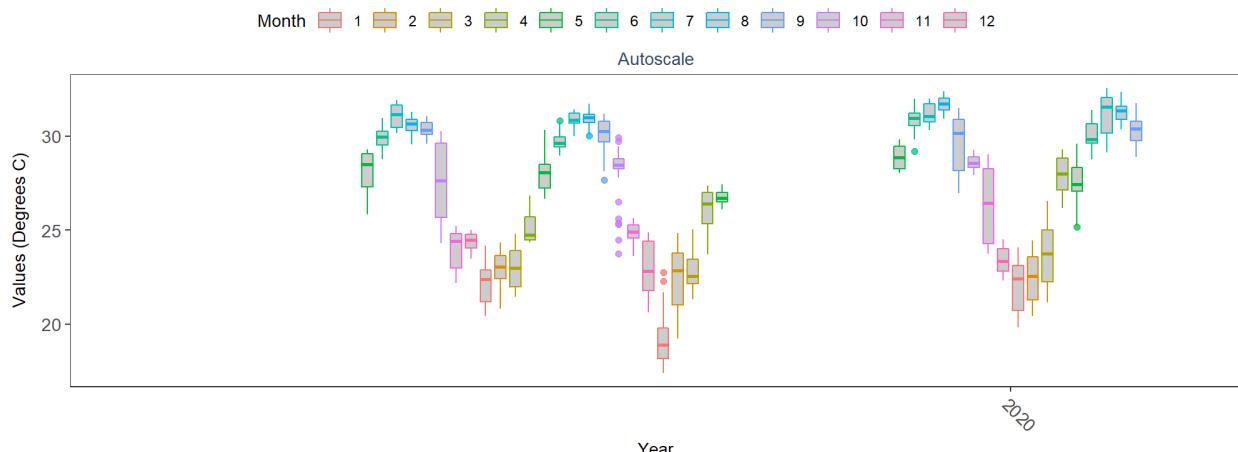
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 By Month



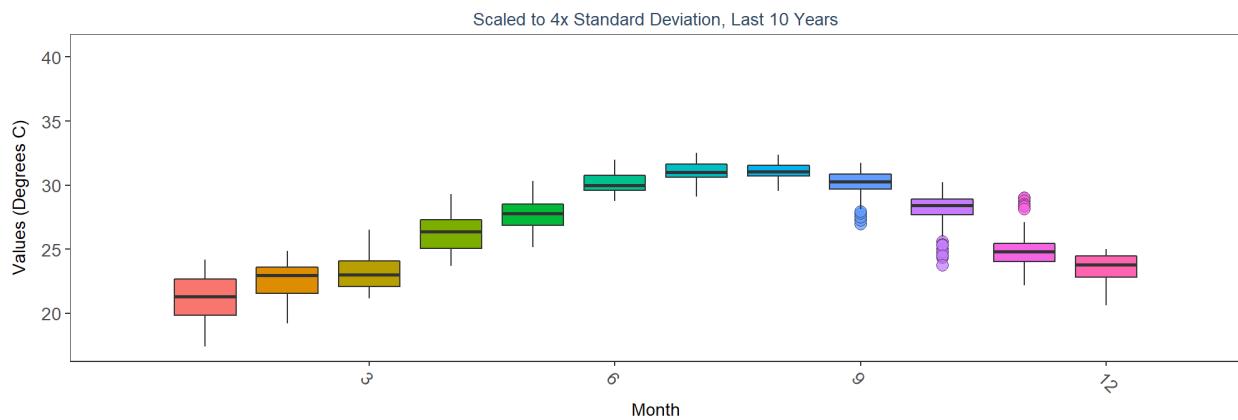
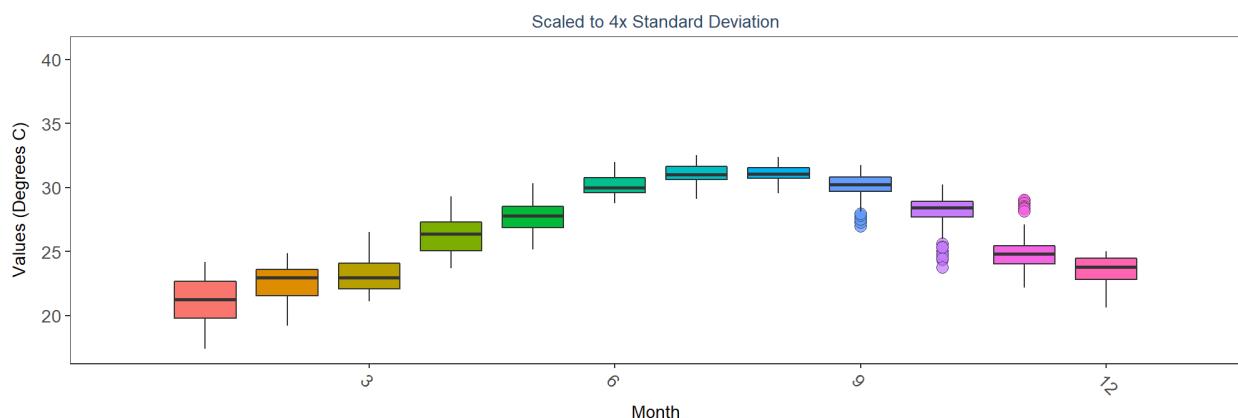
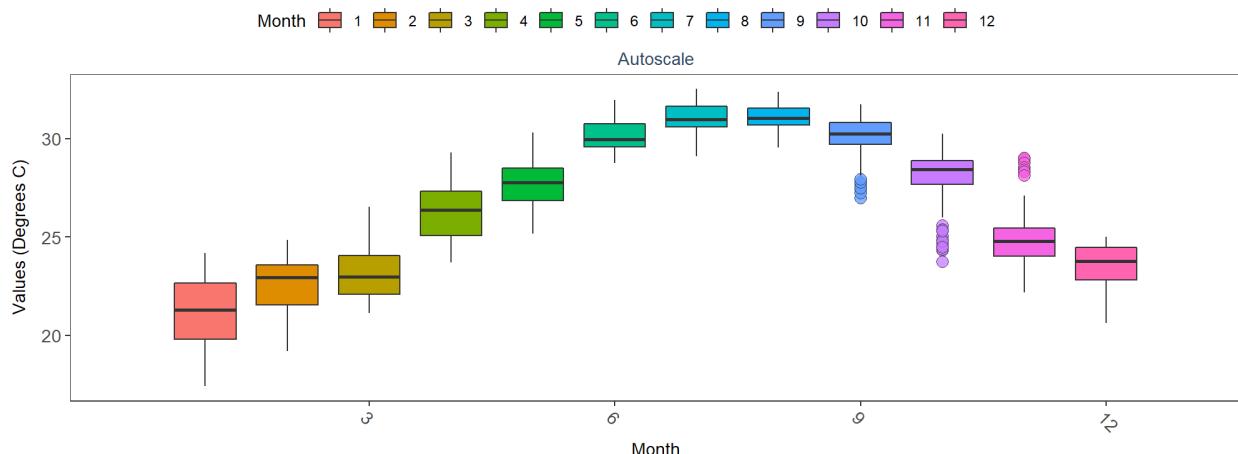
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Water Temperature on Coral Reefs in the Florida Keys  
18  
By Year



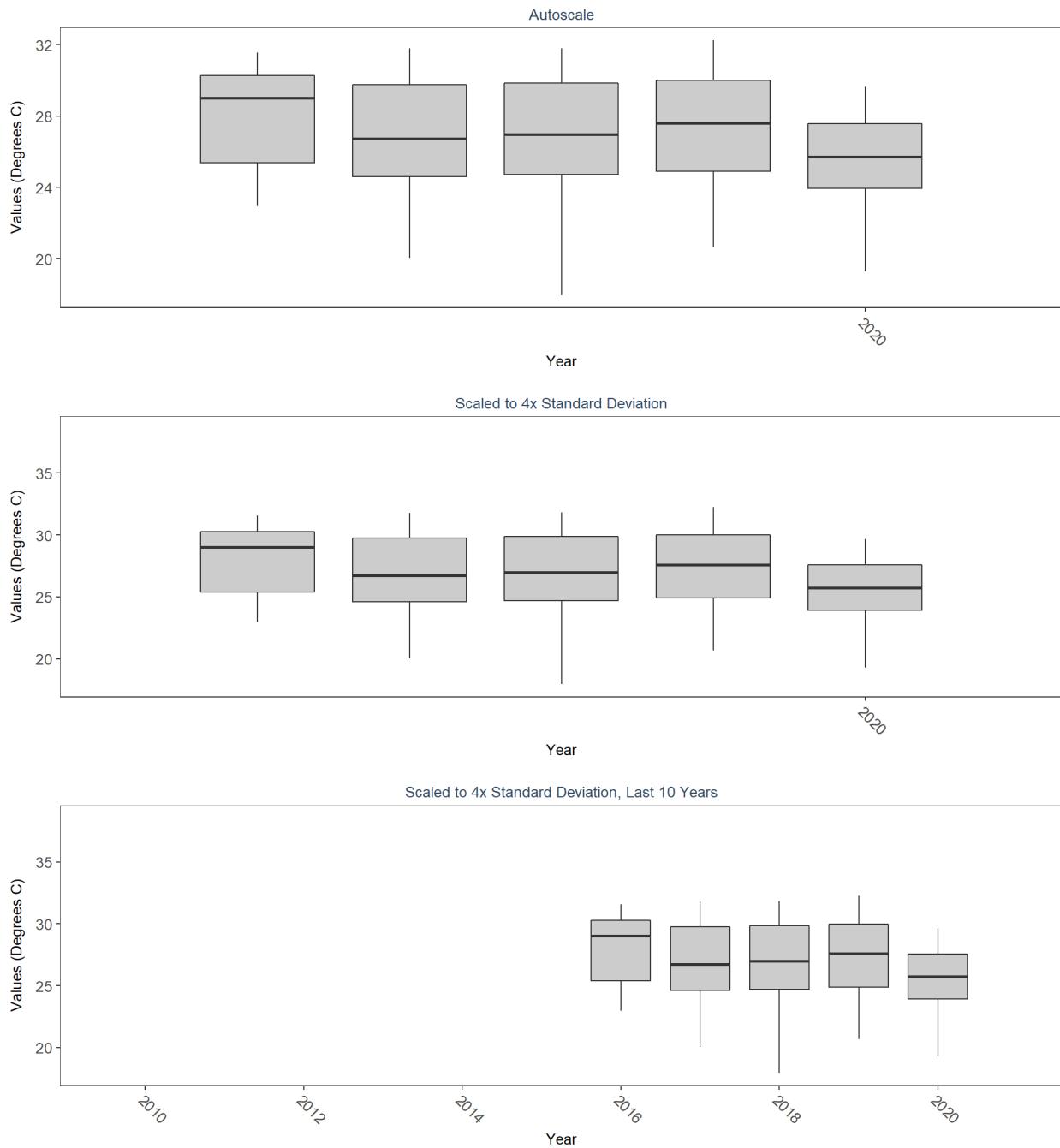
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 By Year & Month



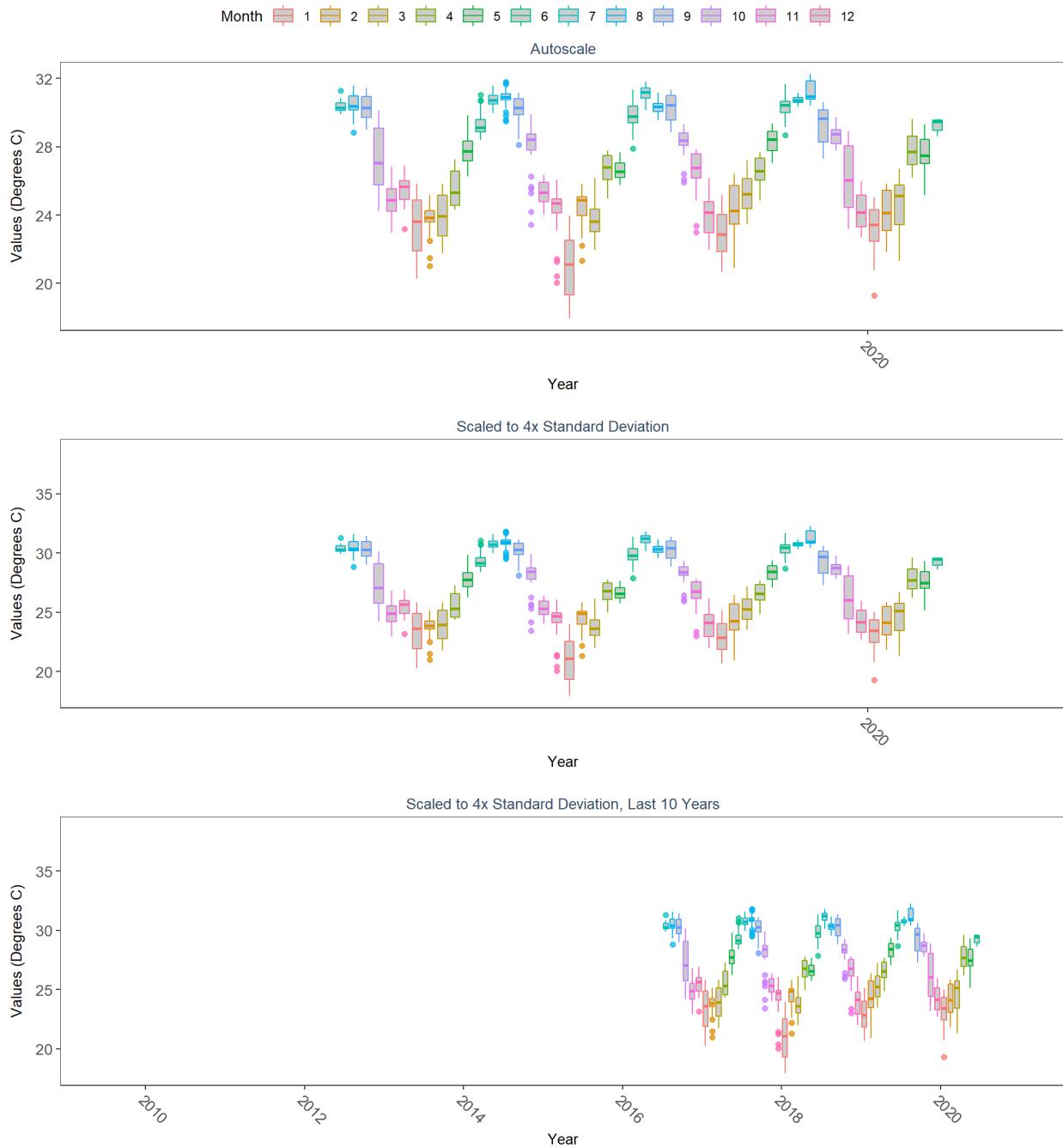
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 Water Temperature on Coral Reefs in the Florida Keys  
 18  
 By Month



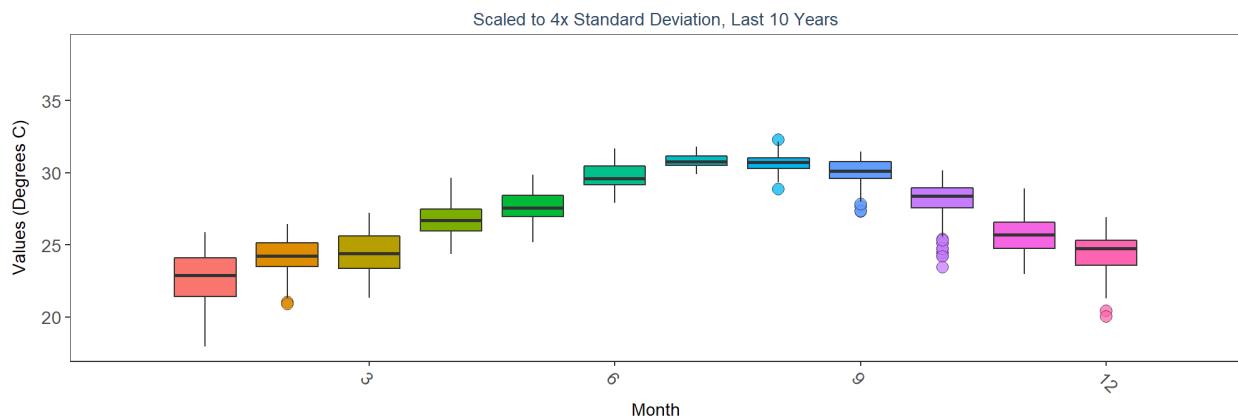
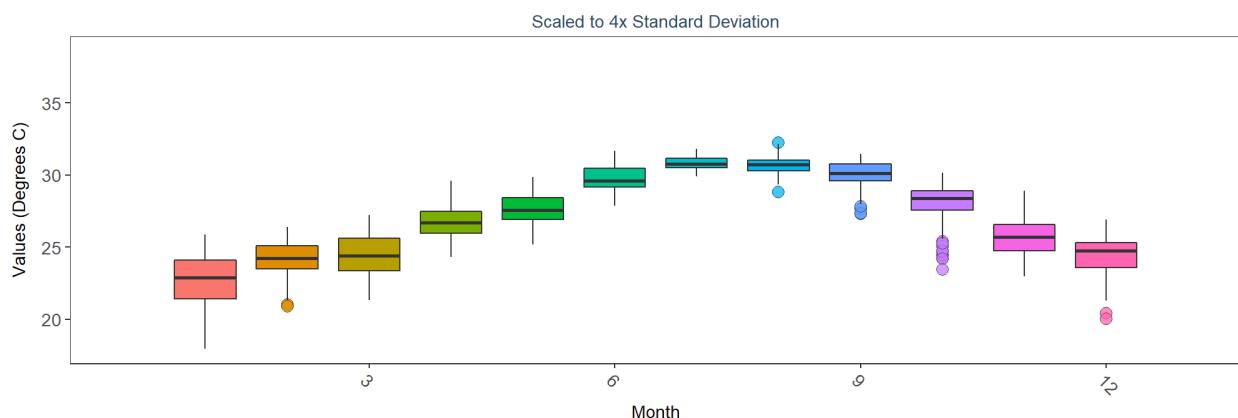
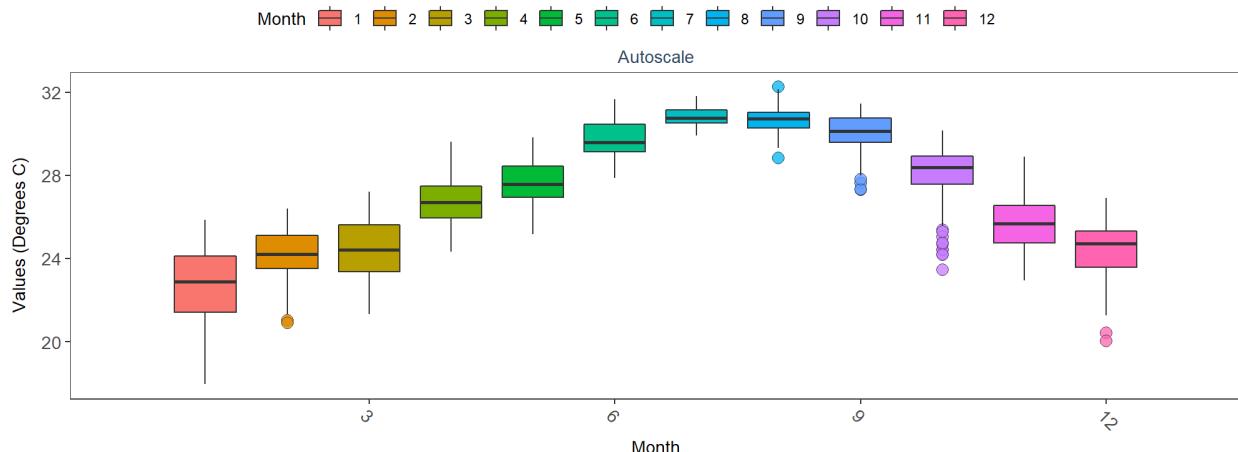
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Water Temperature on Coral Reefs in the Florida Keys  
21  
By Year



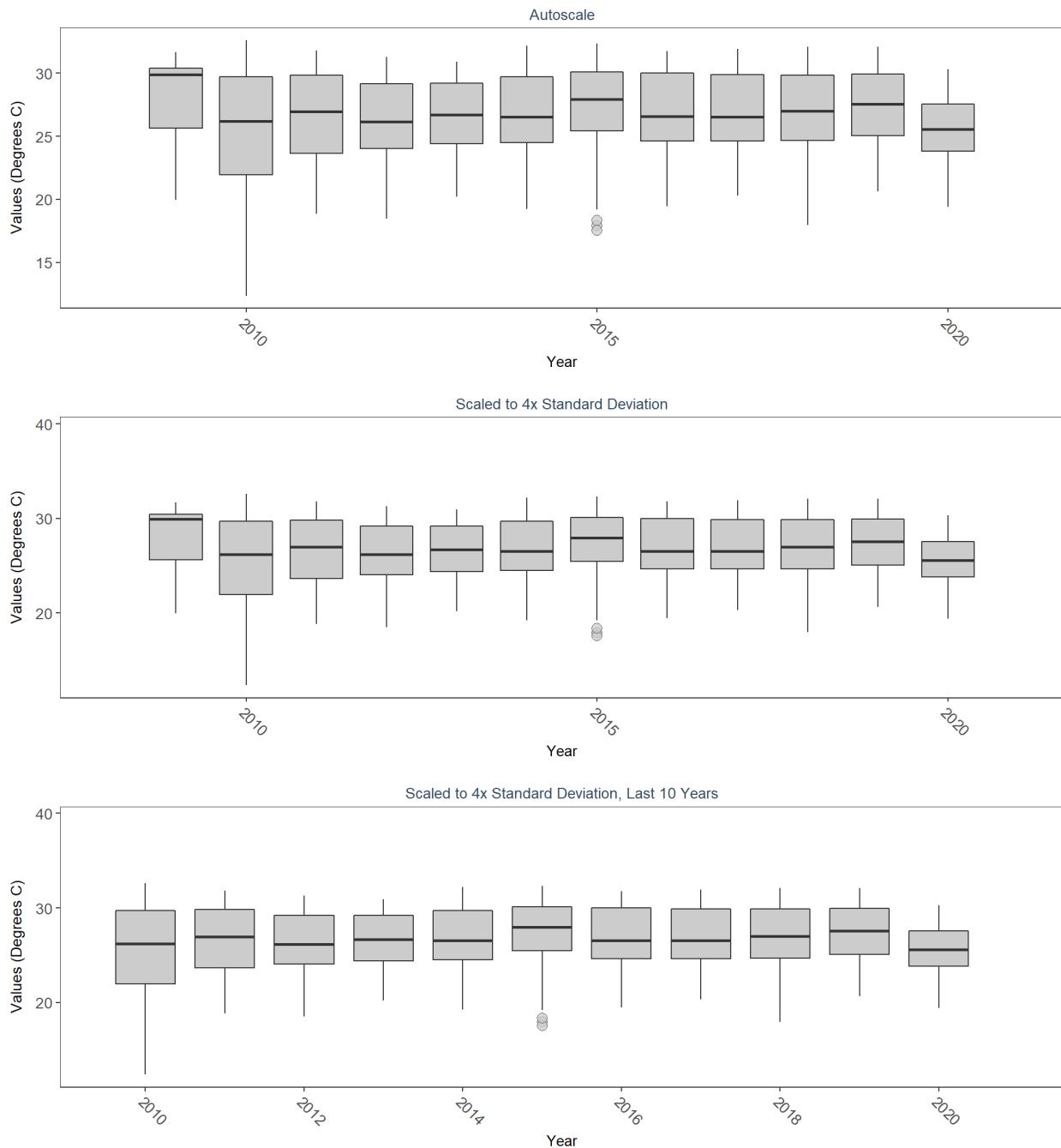
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 By Year & Month



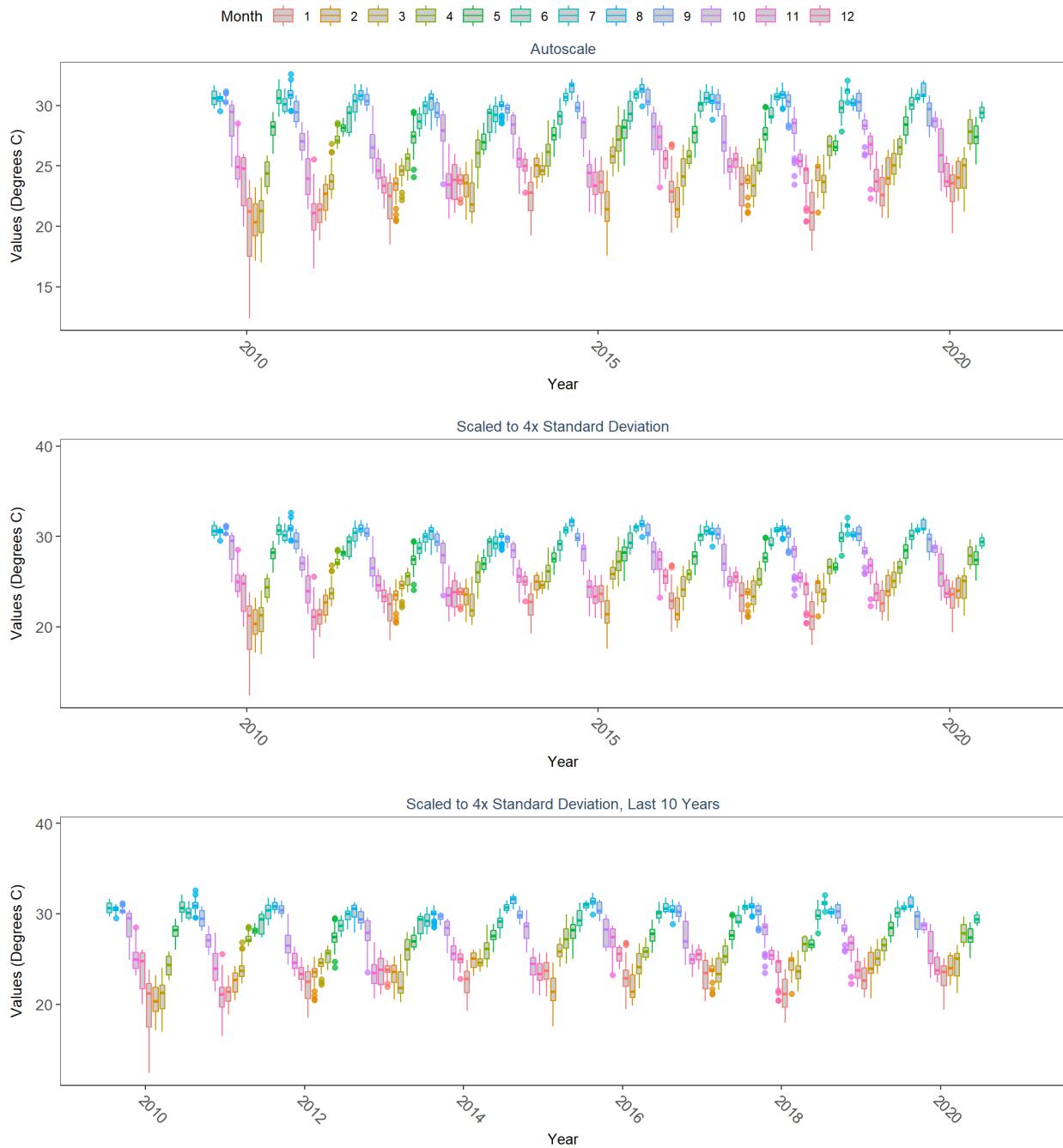
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Month



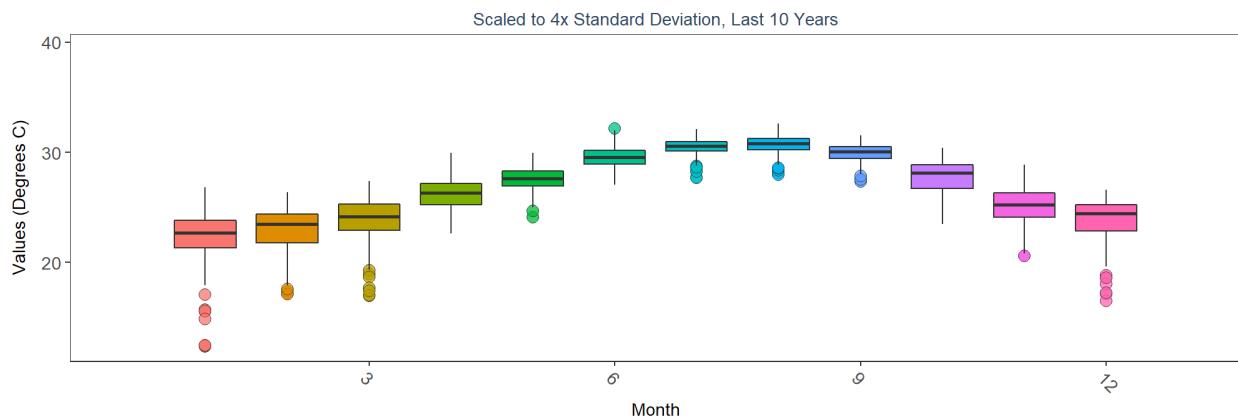
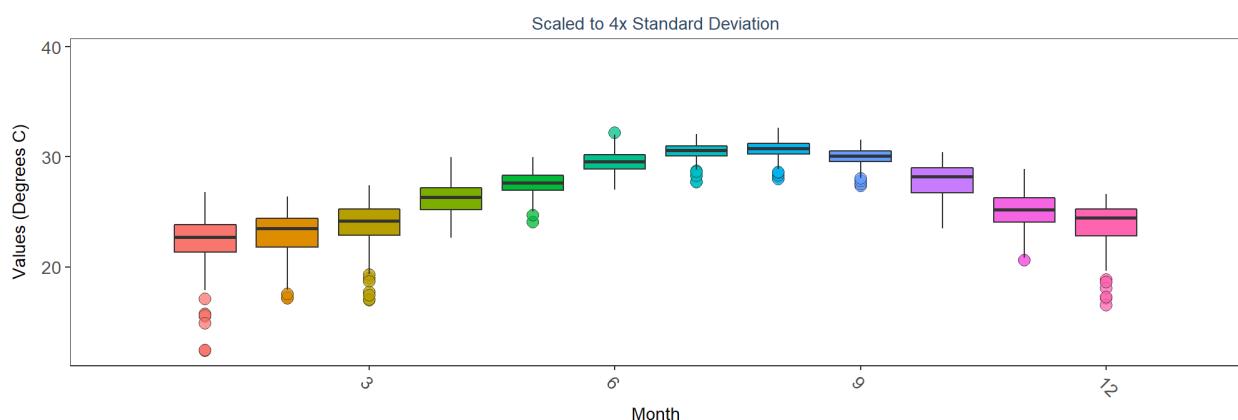
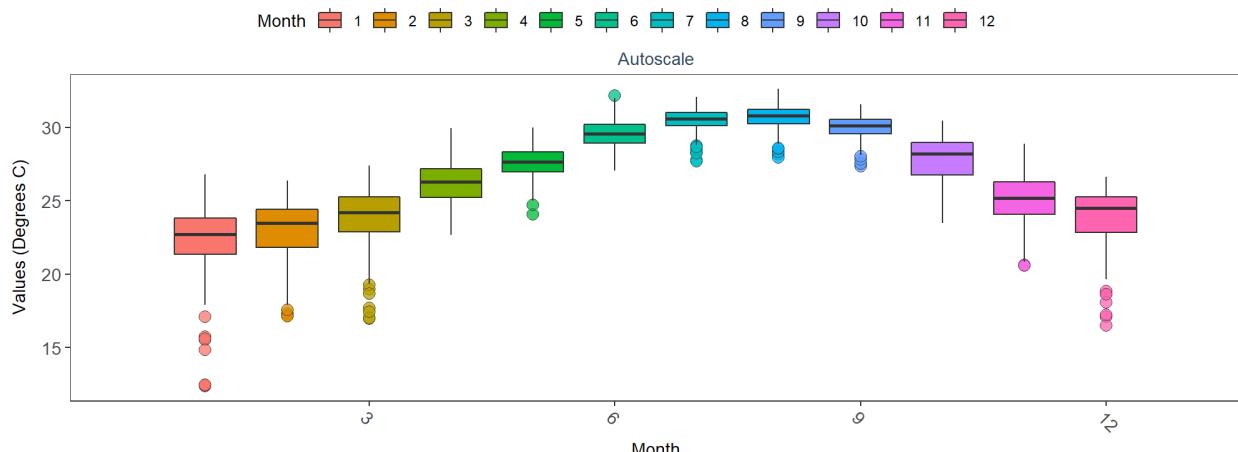
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22  
By Year



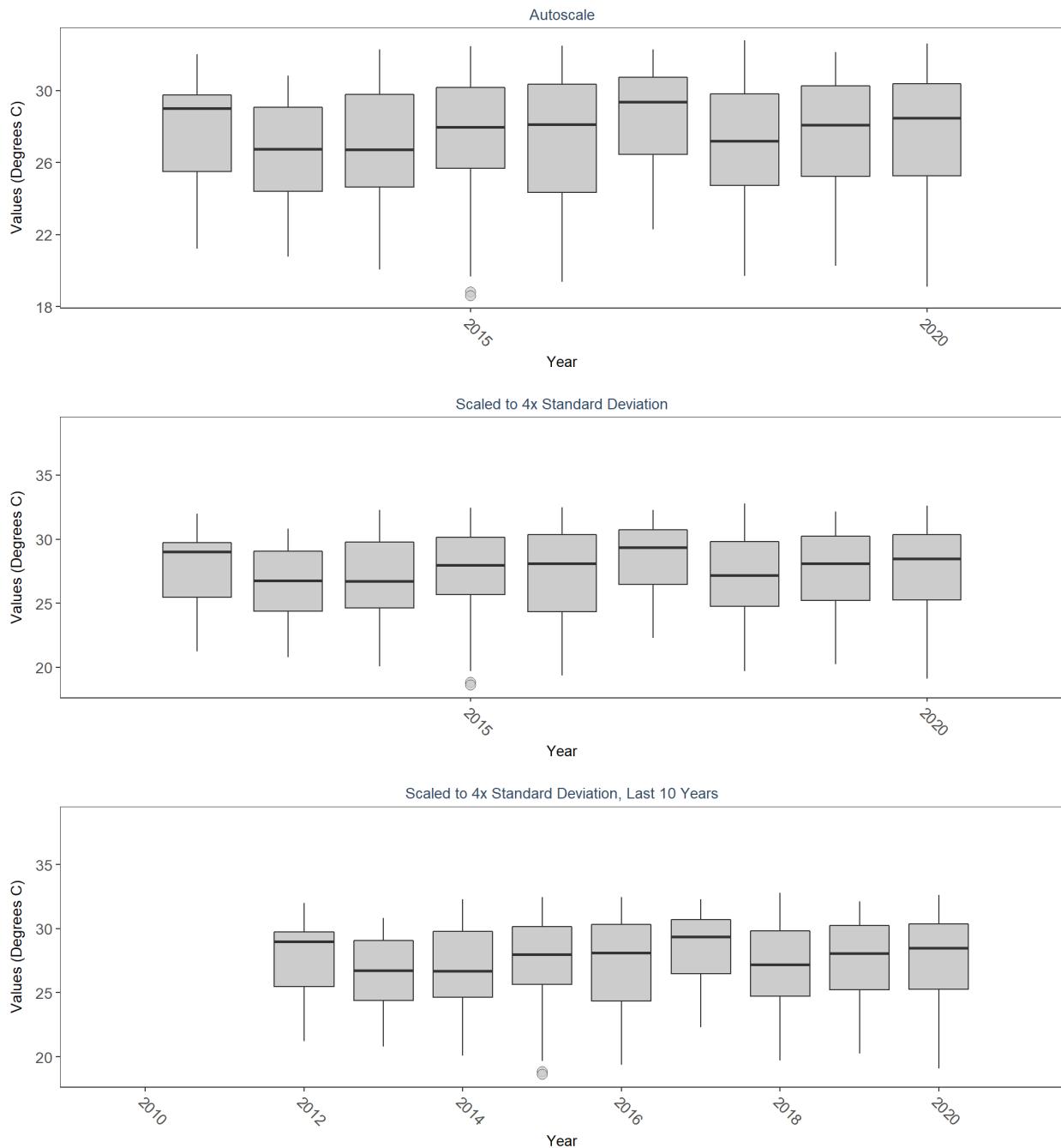
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 By Year & Month



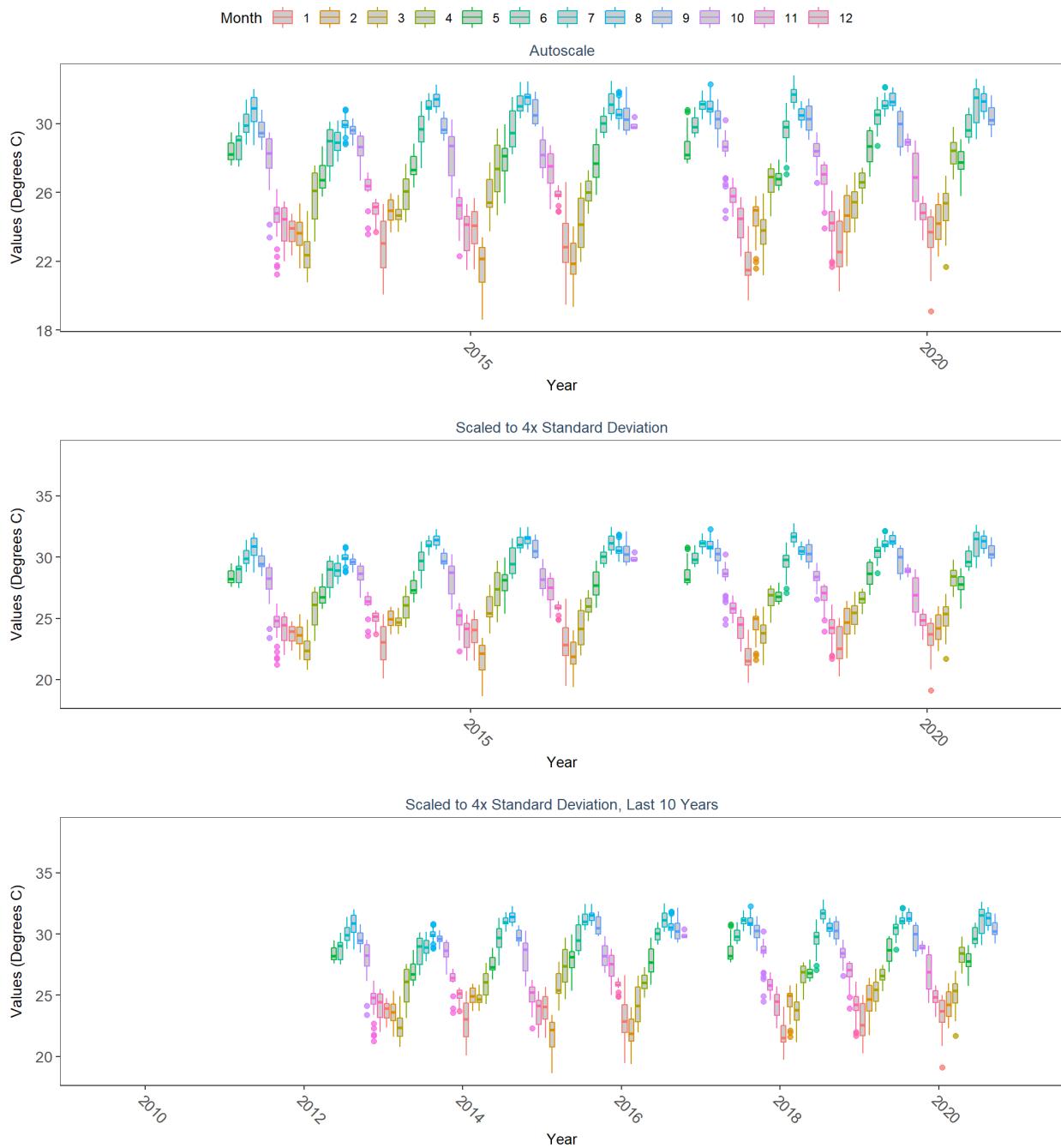
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 By Month



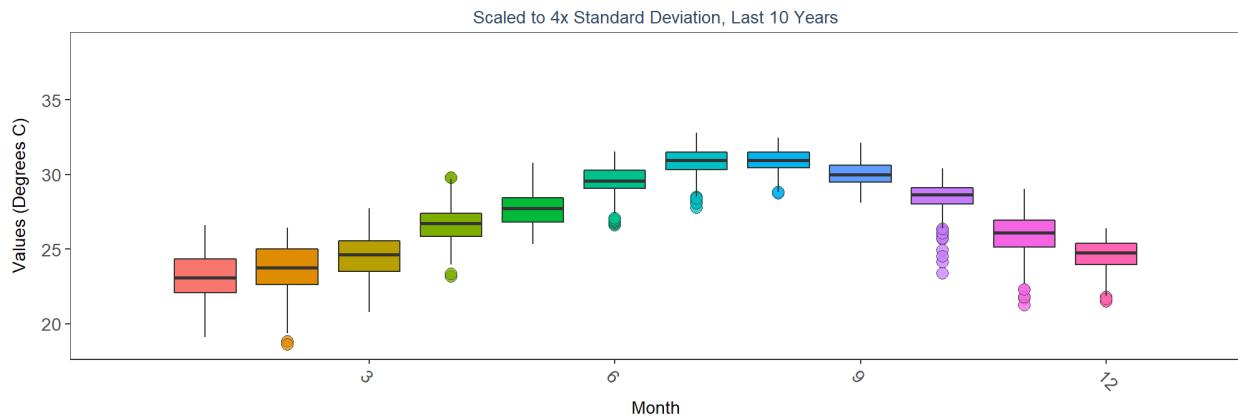
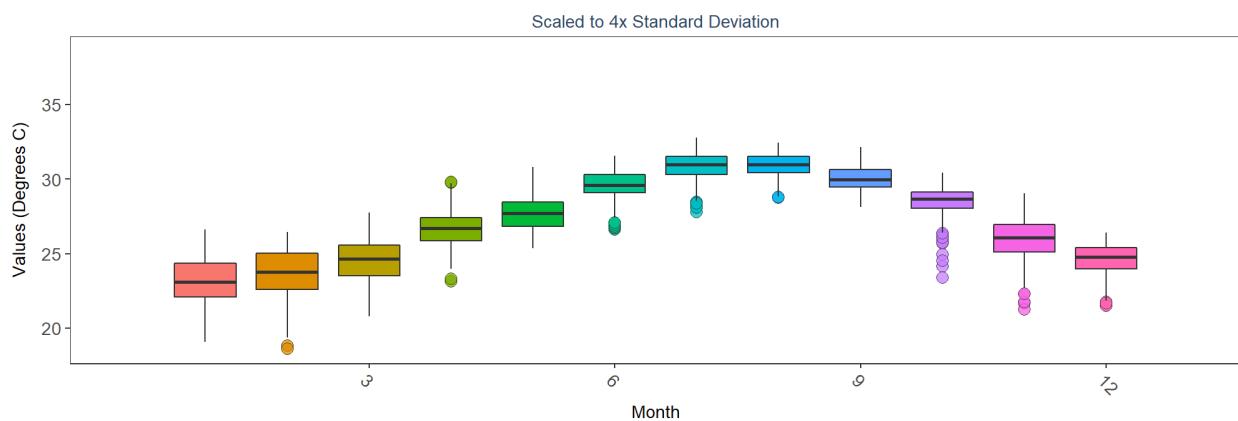
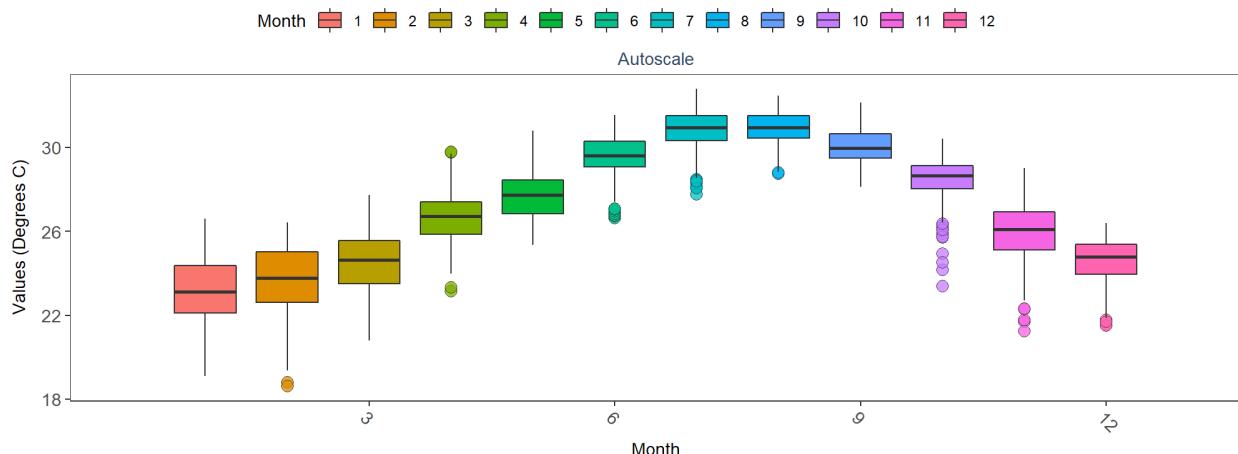
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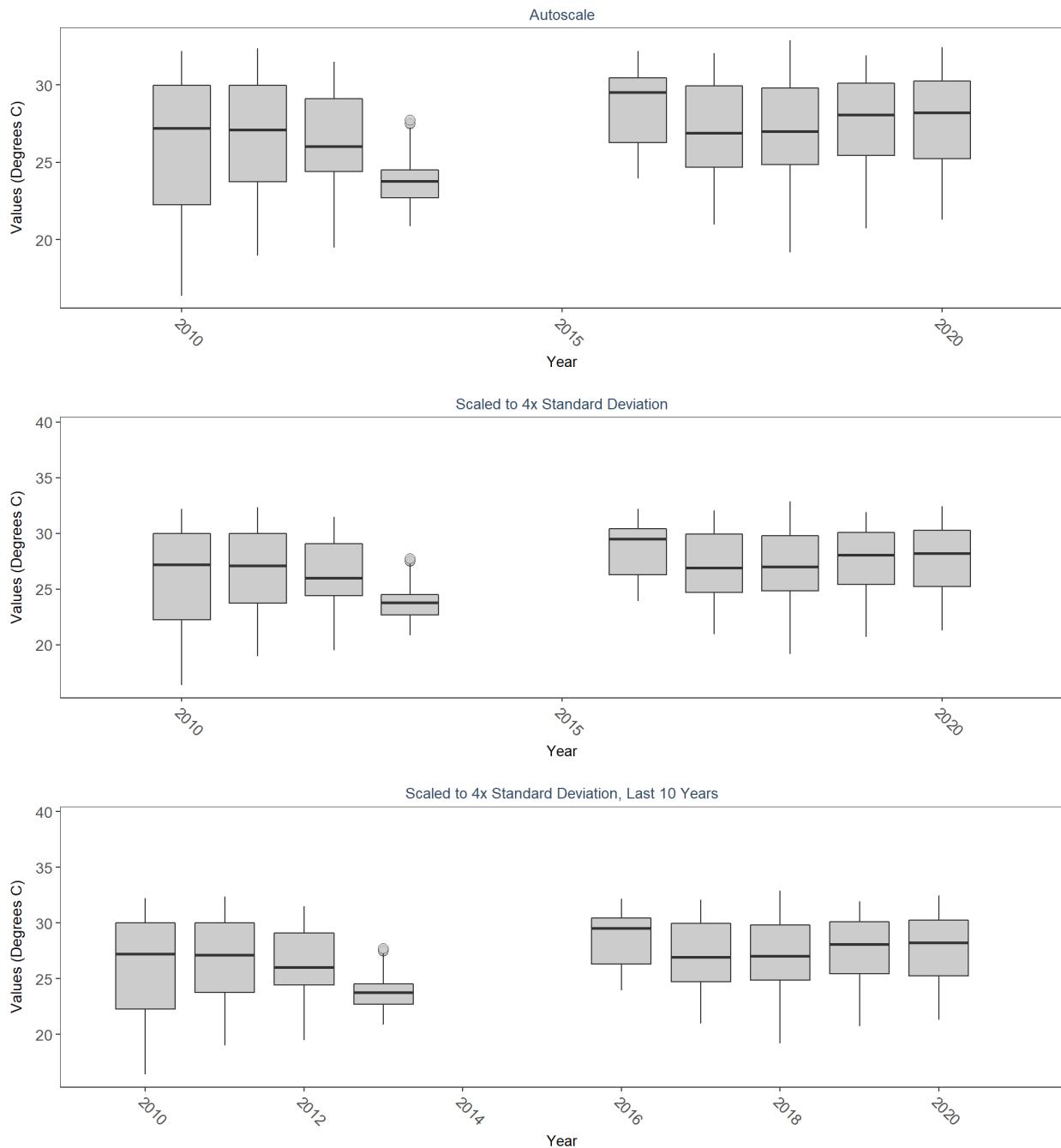
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



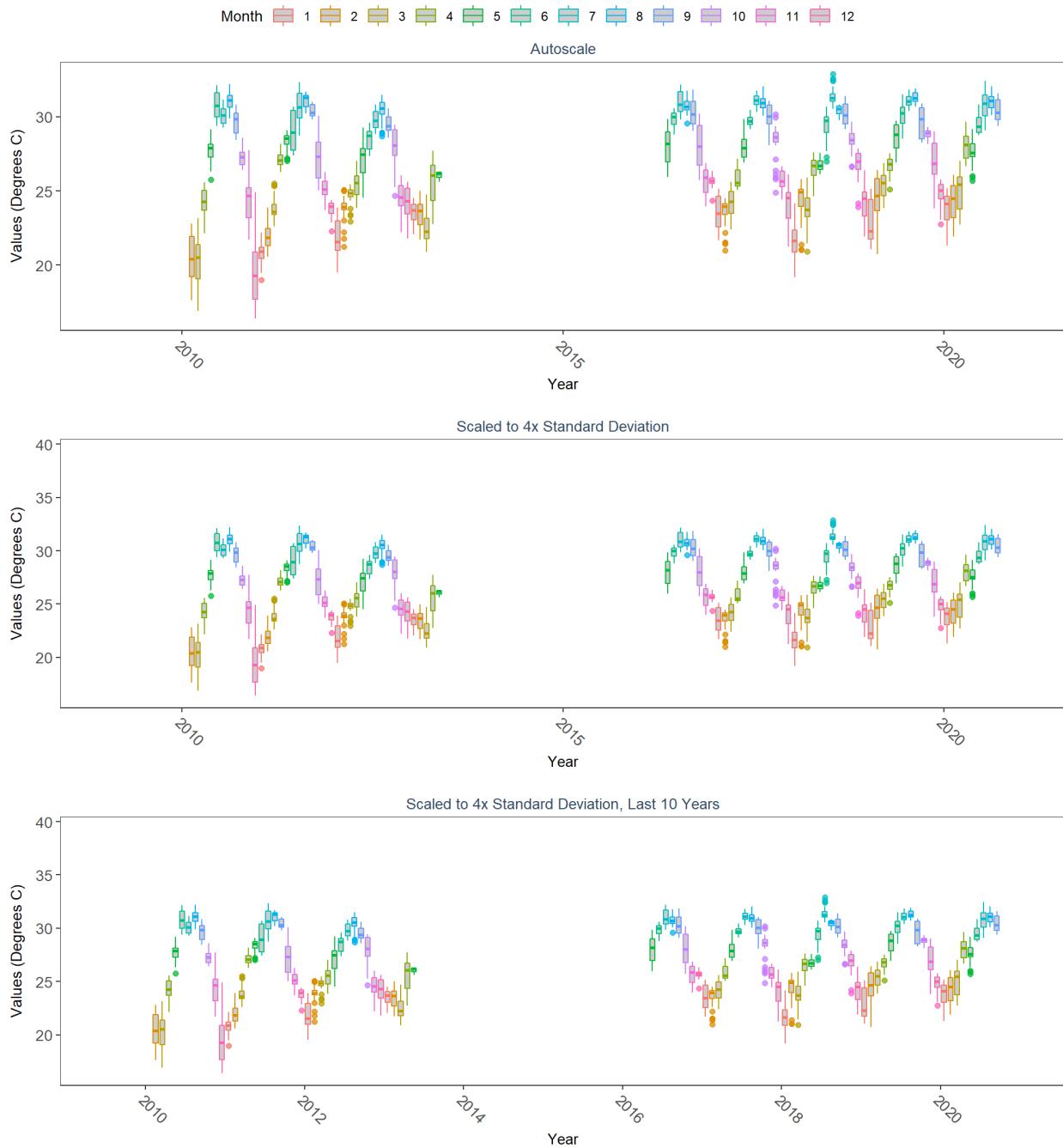
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Month



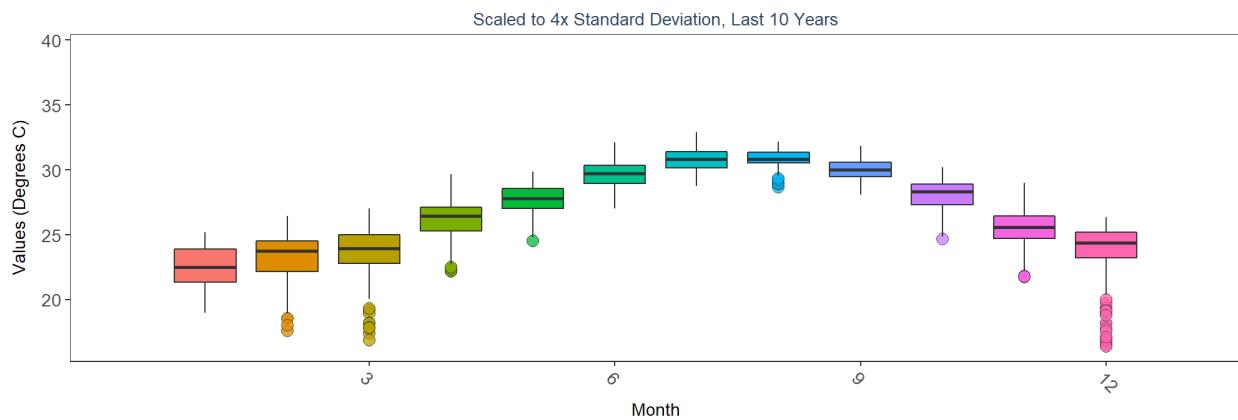
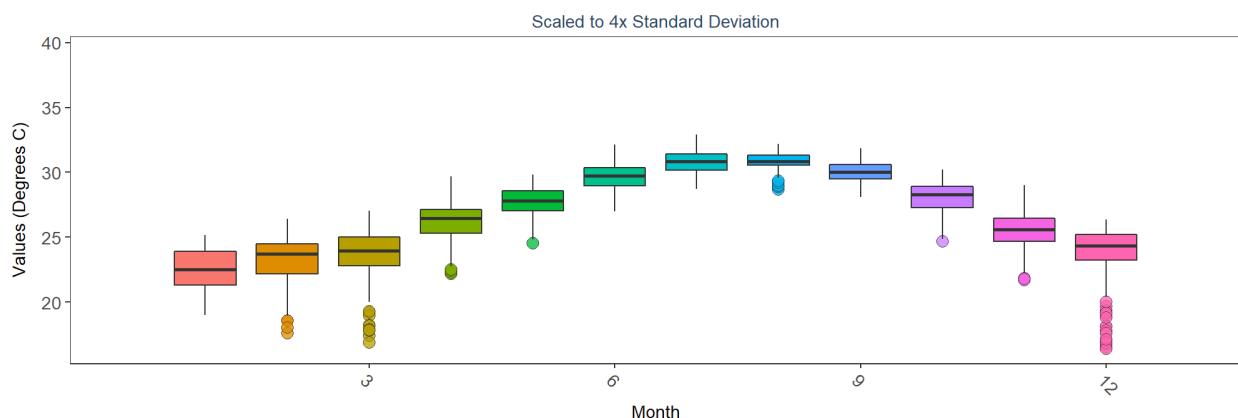
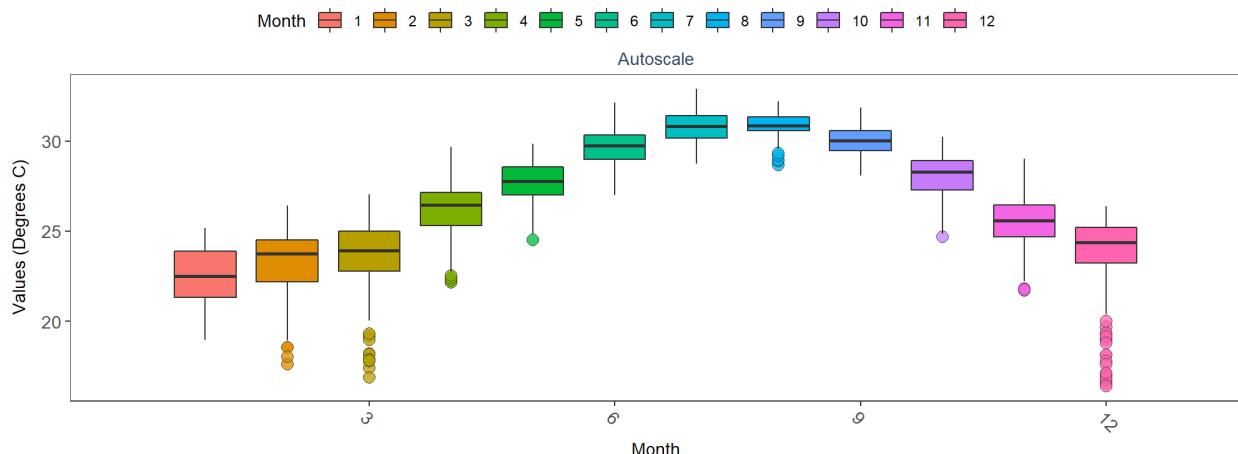
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24  
By Year



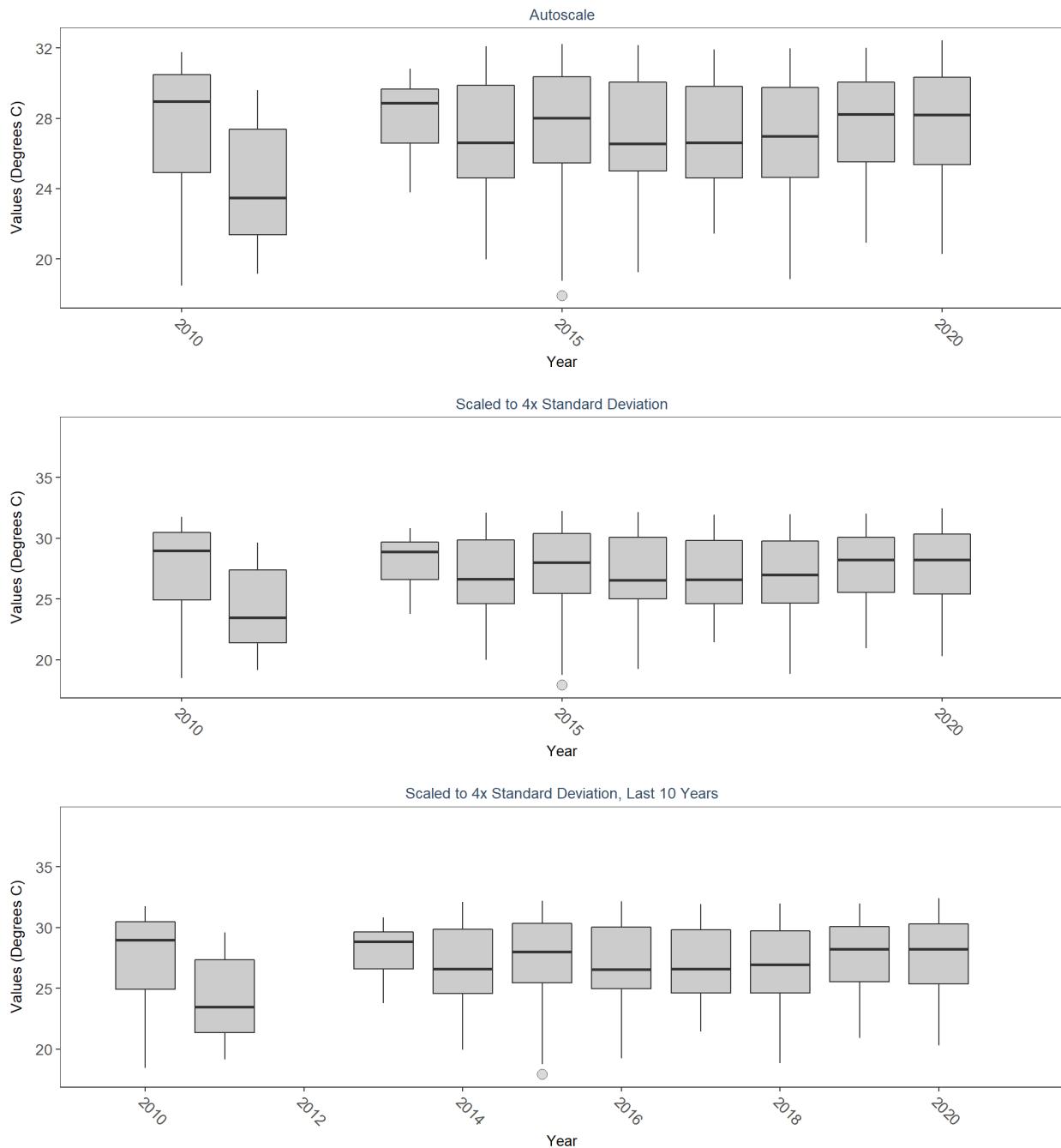
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



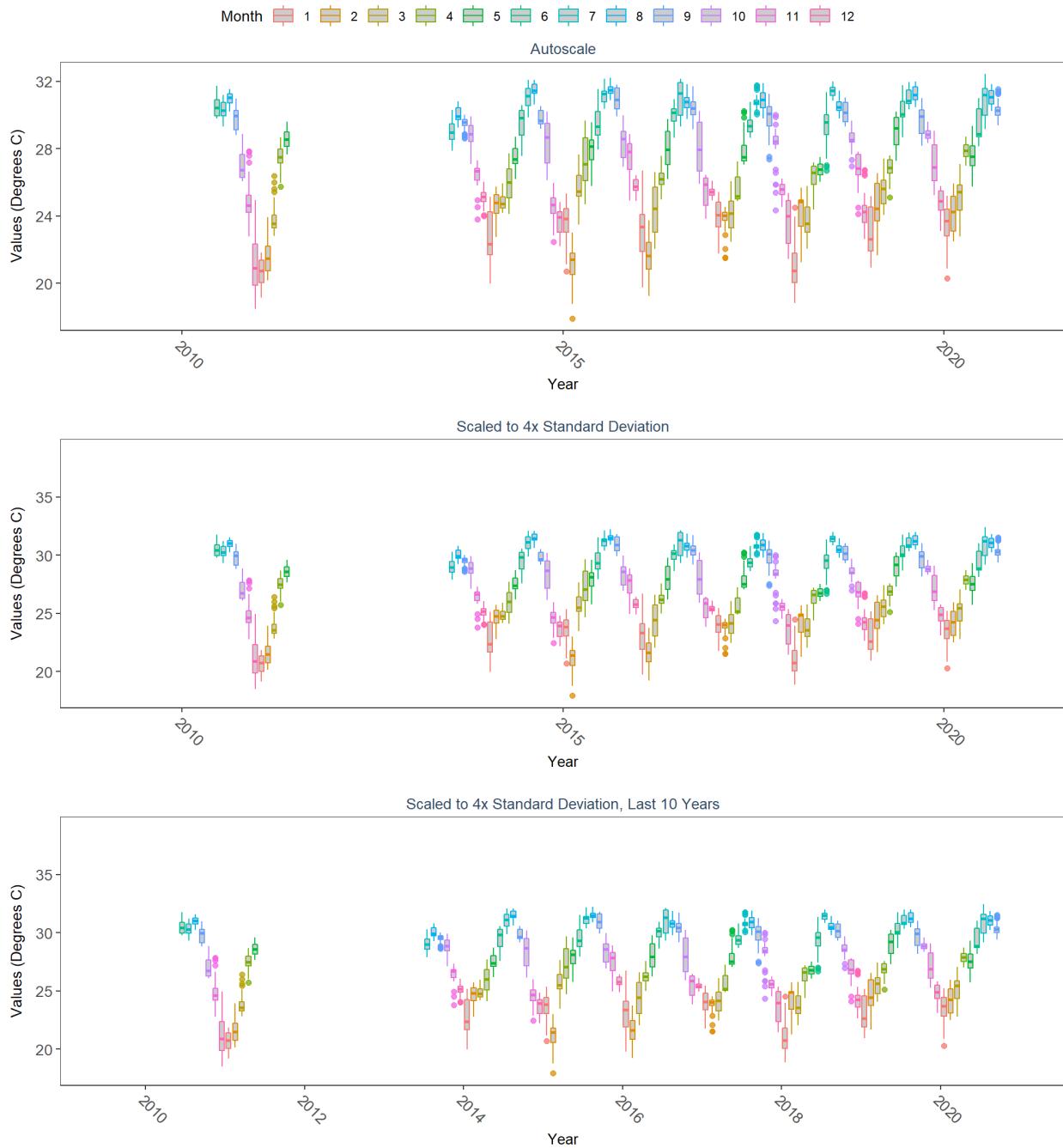
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 By Month



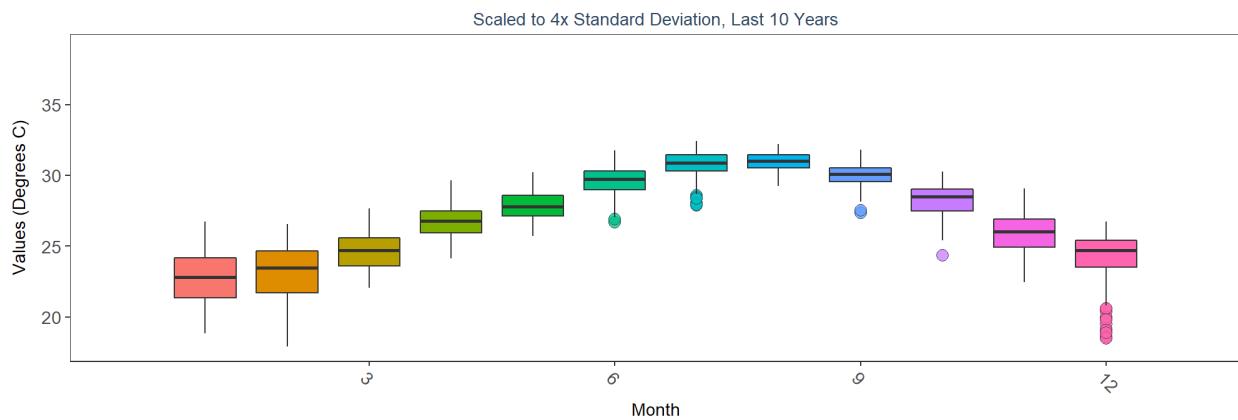
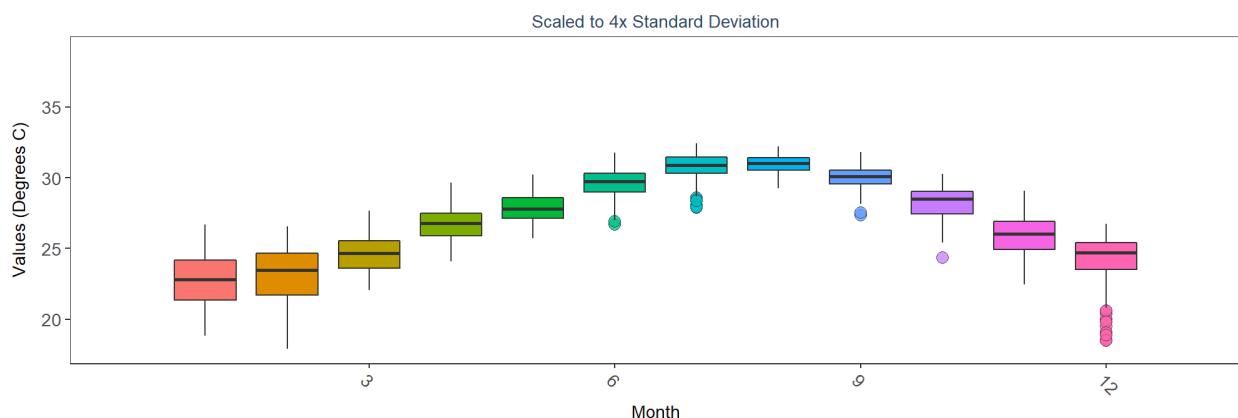
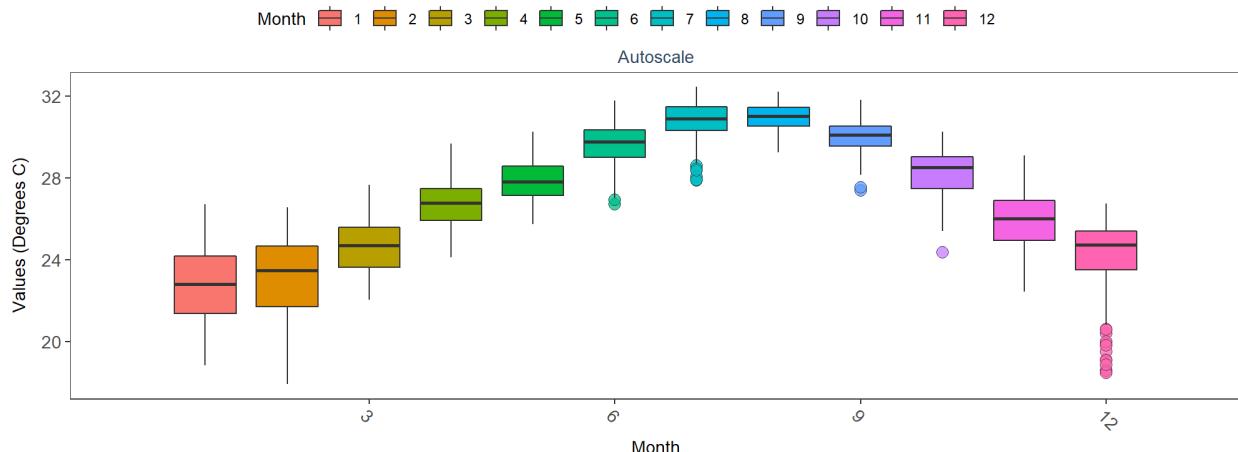
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Water Temperature on Coral Reefs in the Florida Keys  
25  
By Year



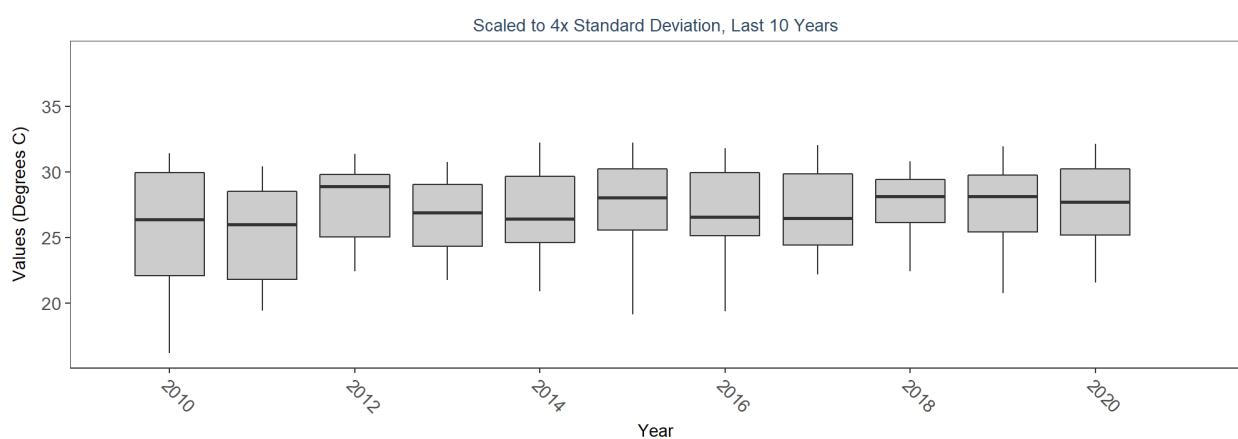
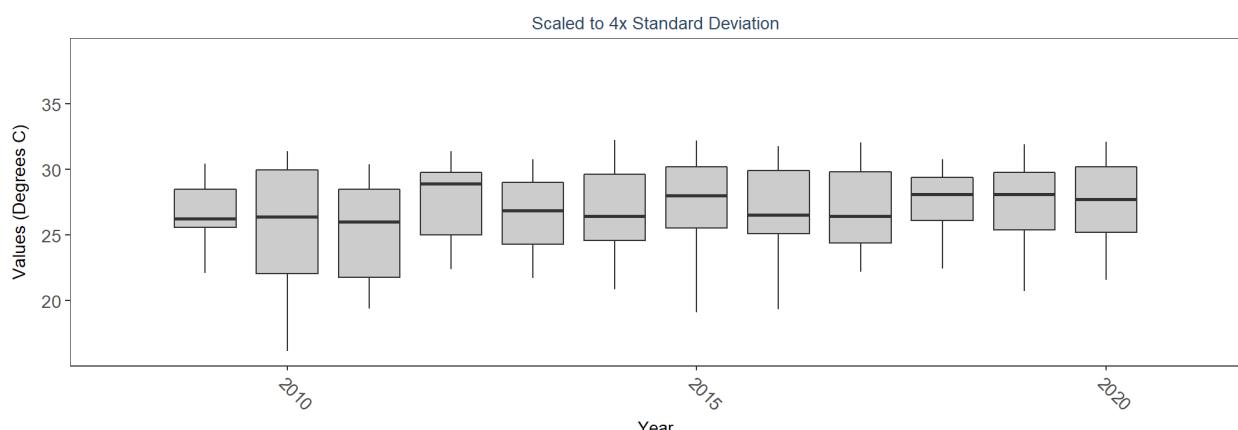
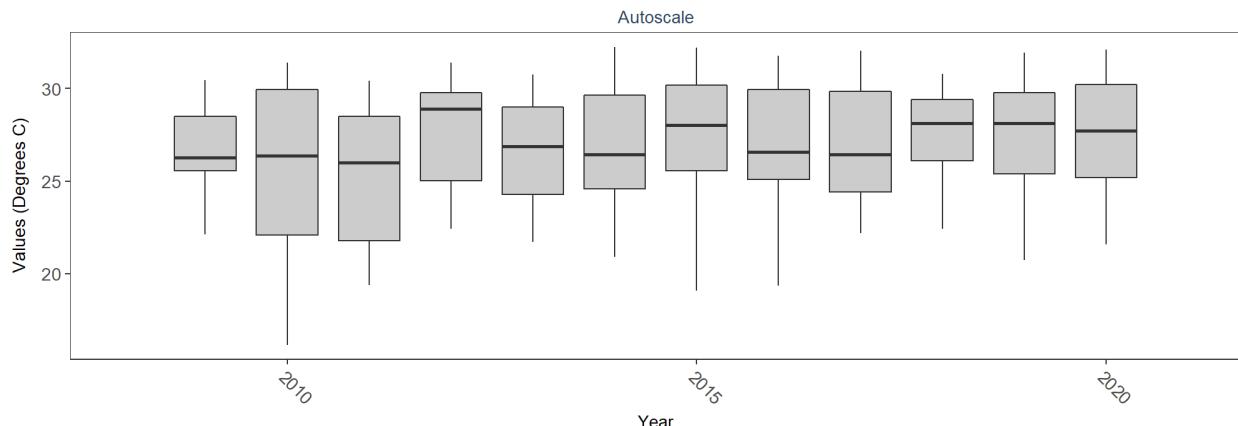
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



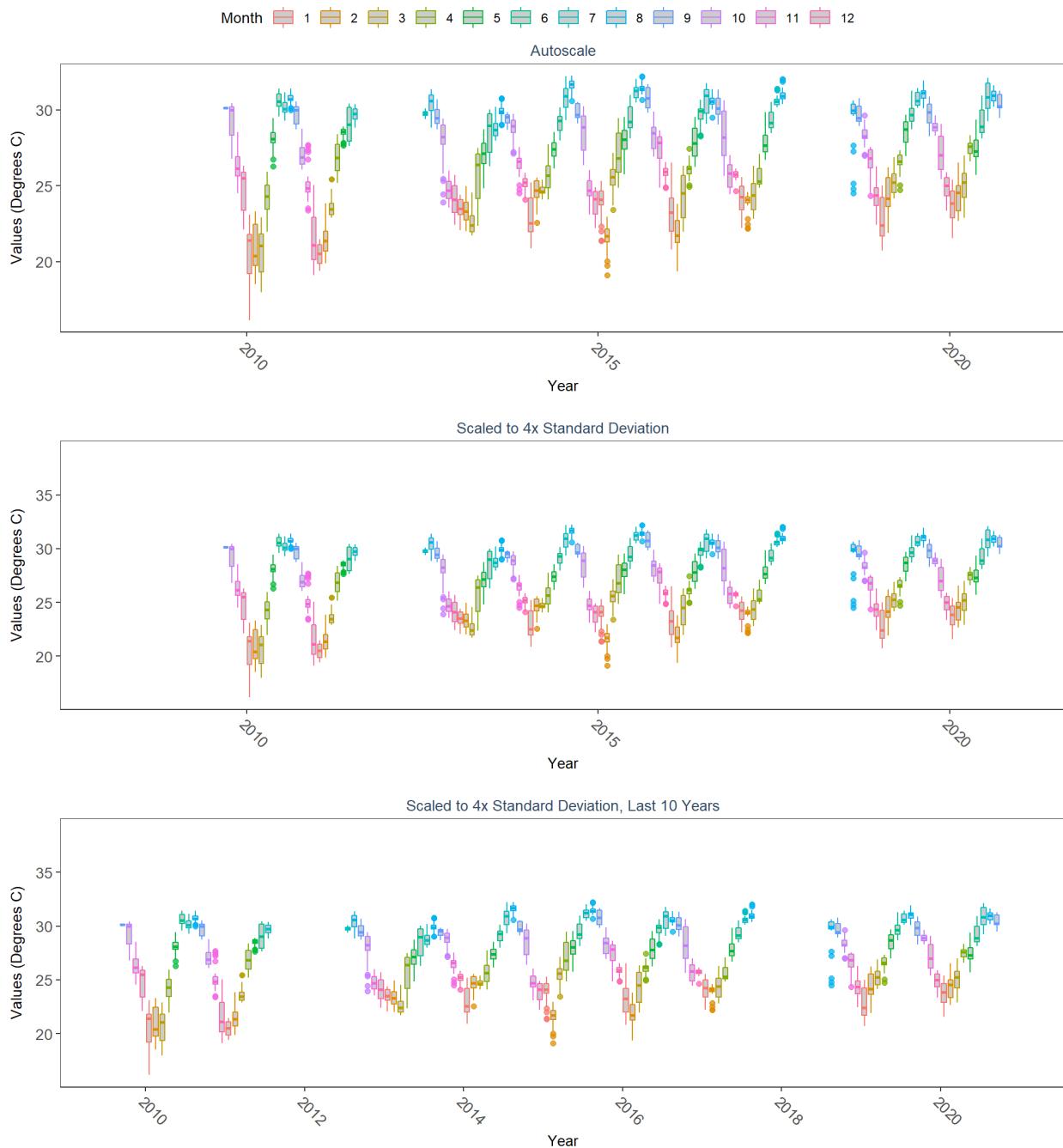
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Month



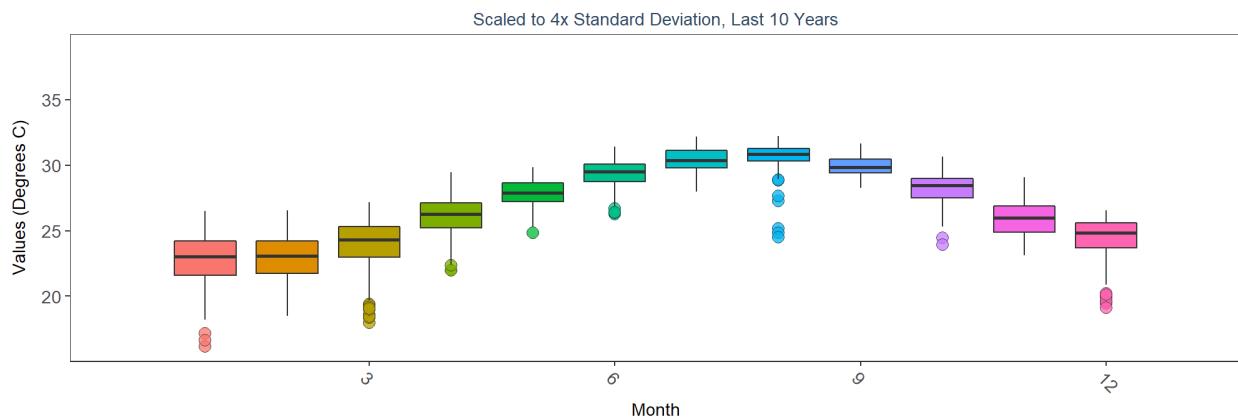
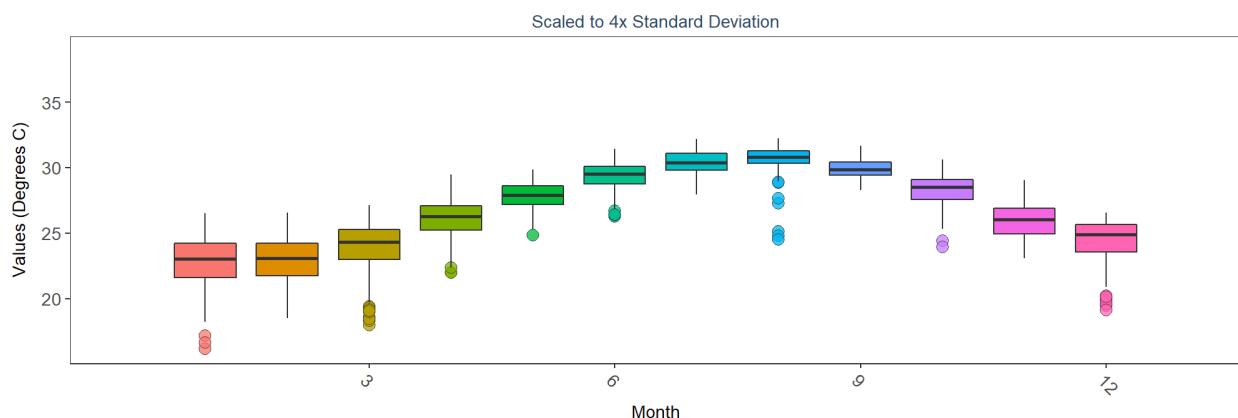
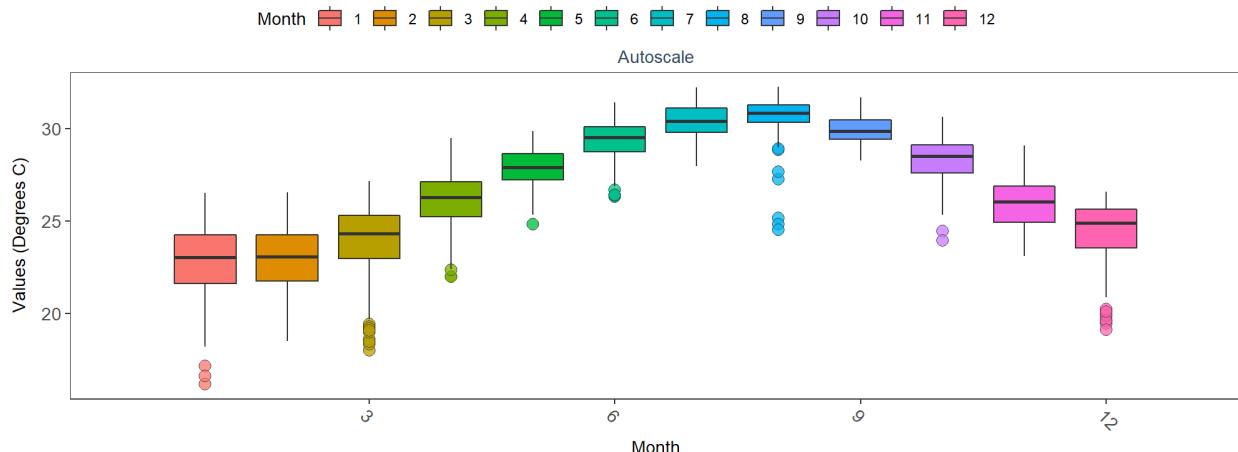
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By Year



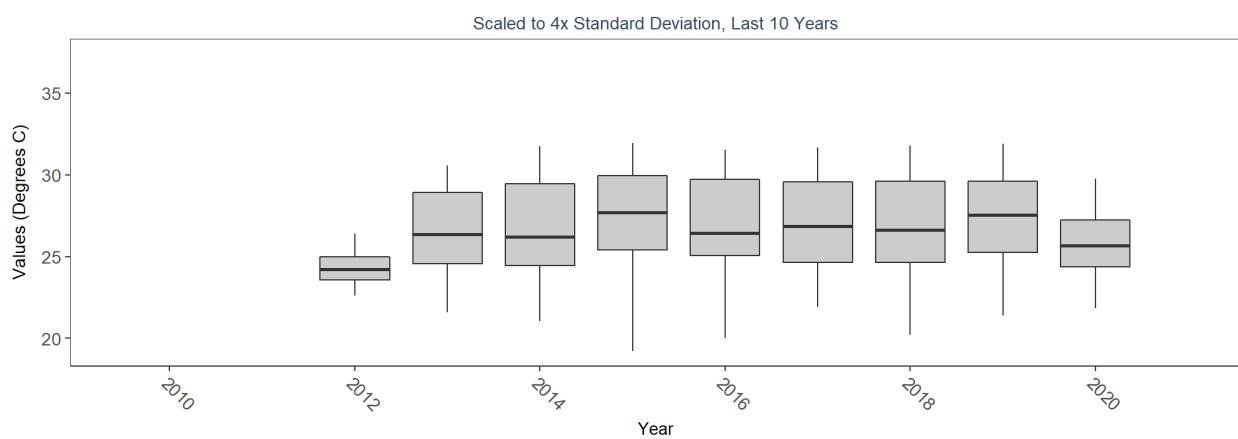
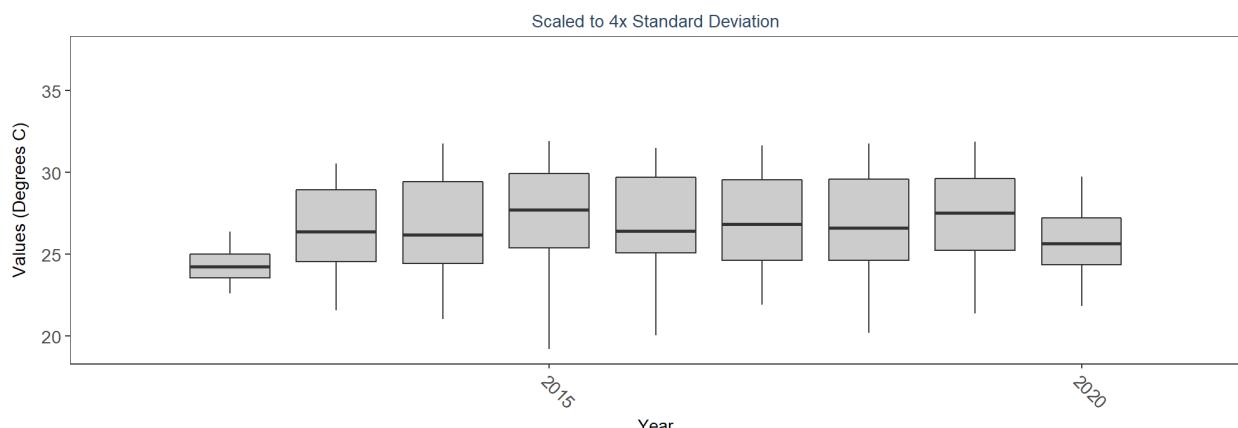
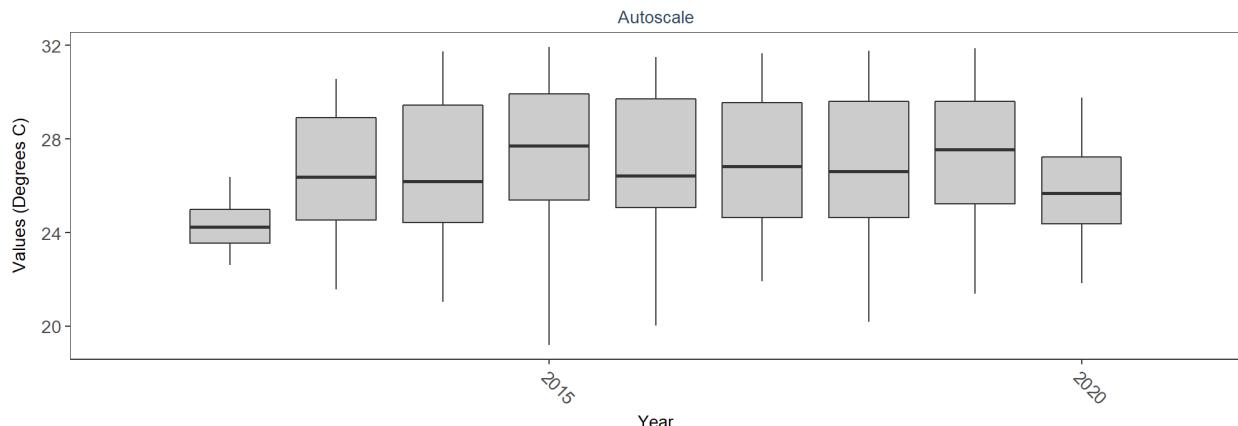
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**Water Temperature on Coral Reefs in the Florida Keys**  
**26**  
**By Year & Month**



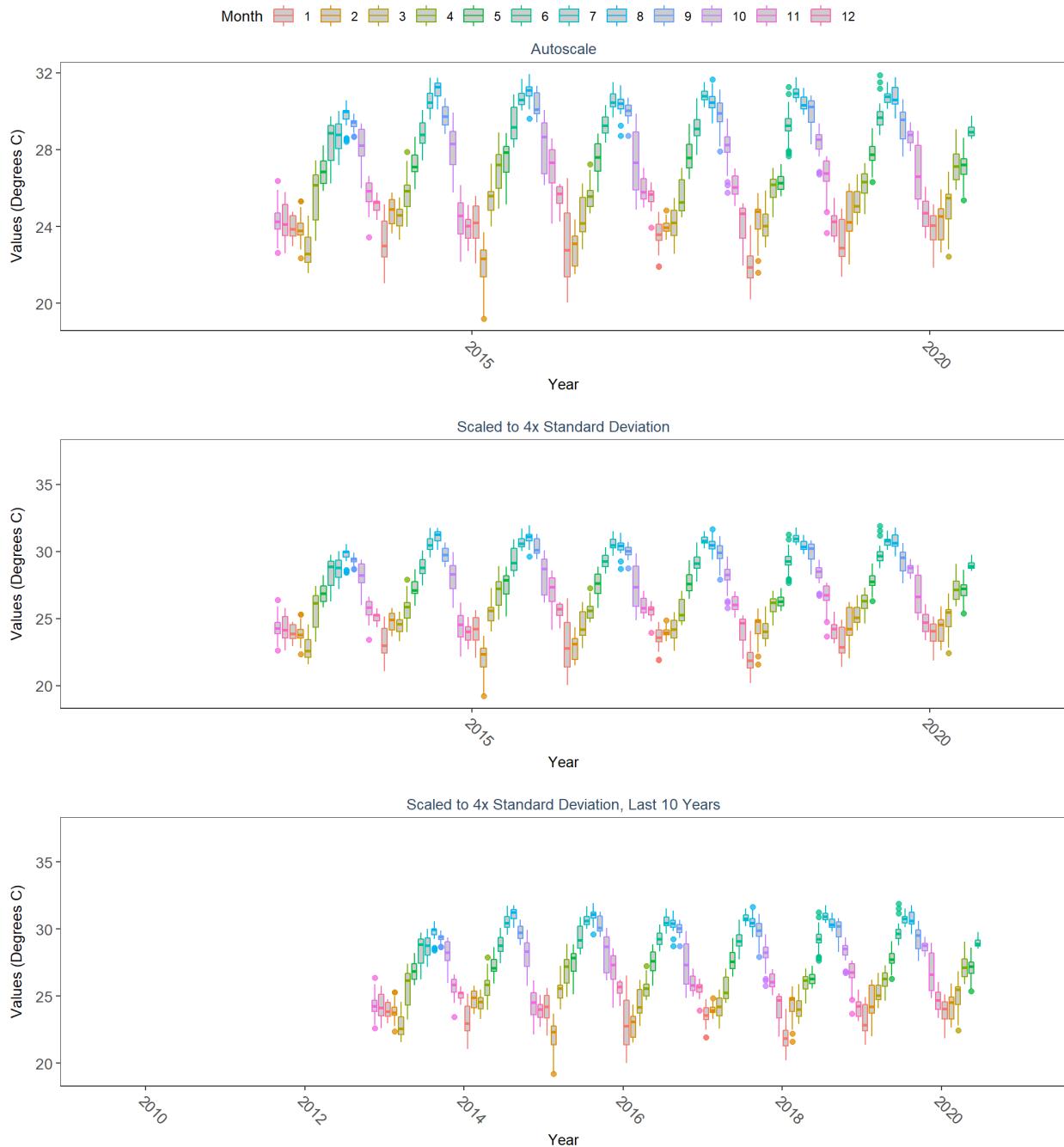
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 Water Temperature on Coral Reefs in the Florida Keys  
 26  
 By Month



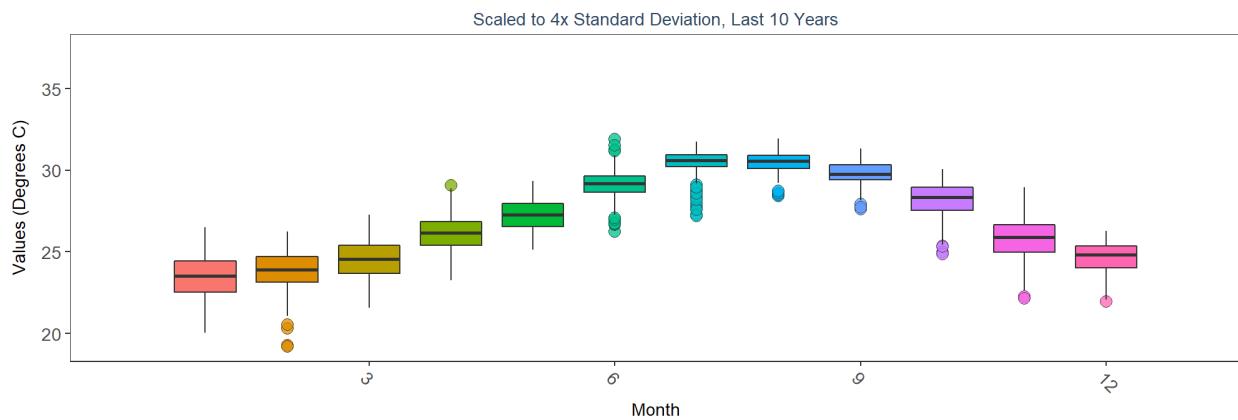
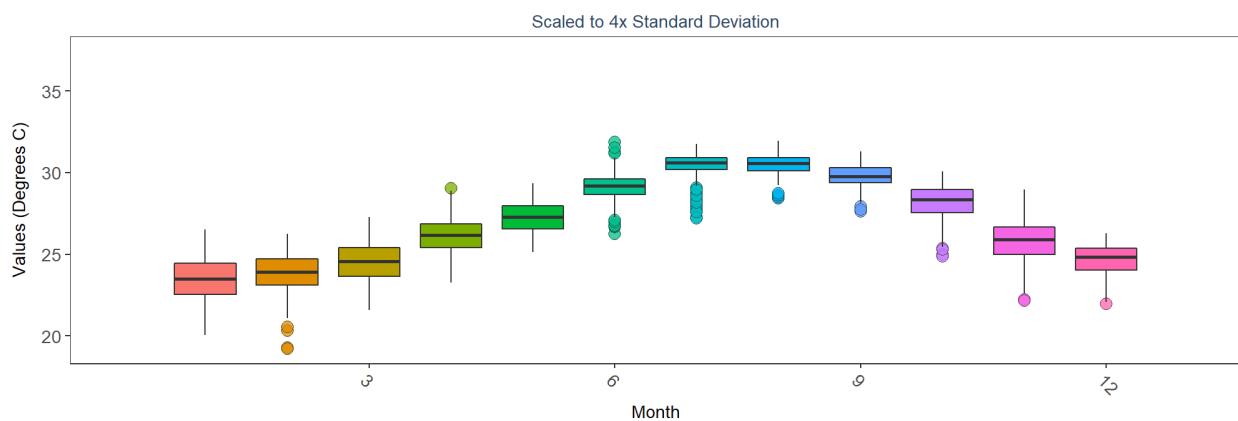
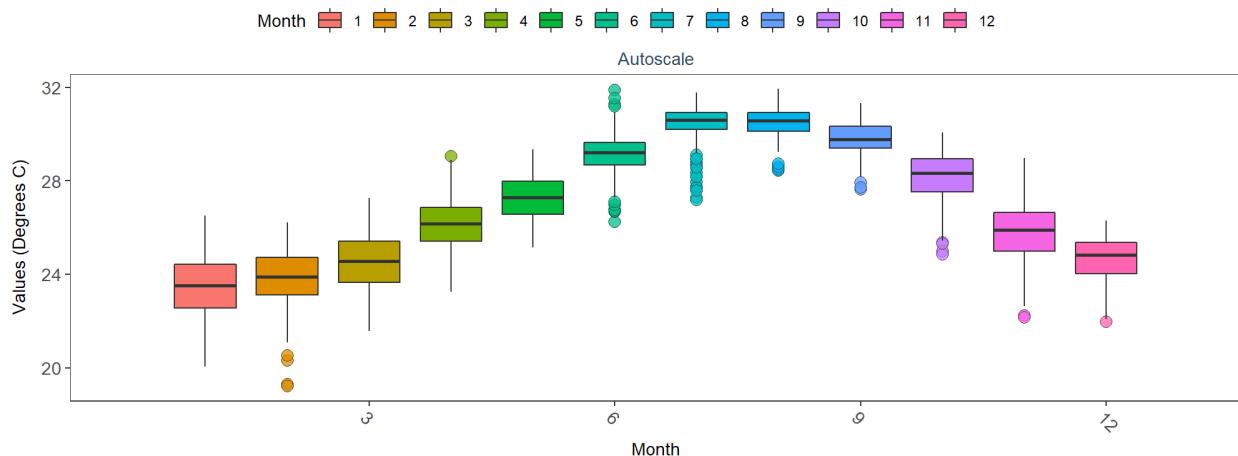
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Water Temperature on Coral Reefs in the Florida Keys  
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By Year



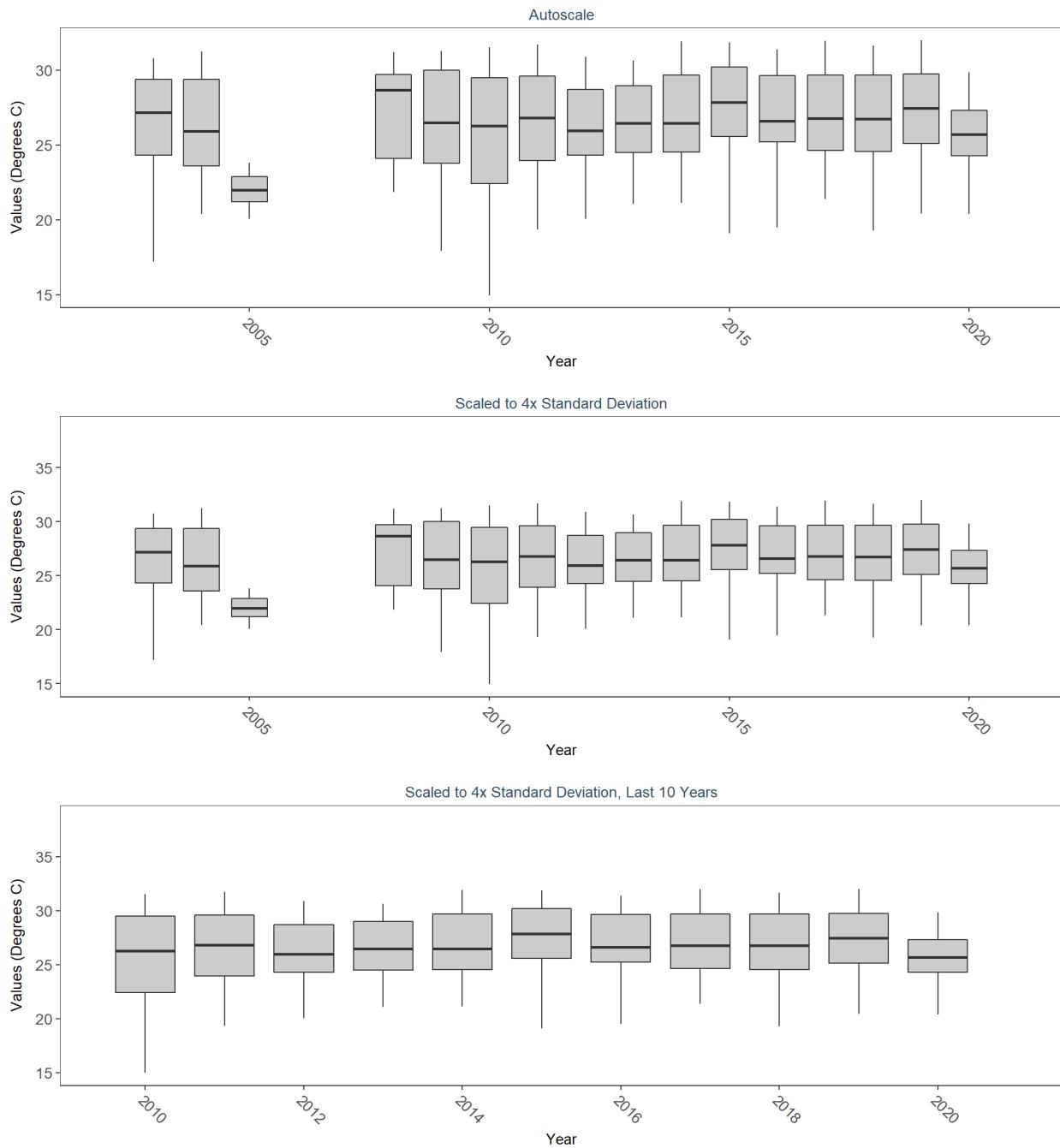
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



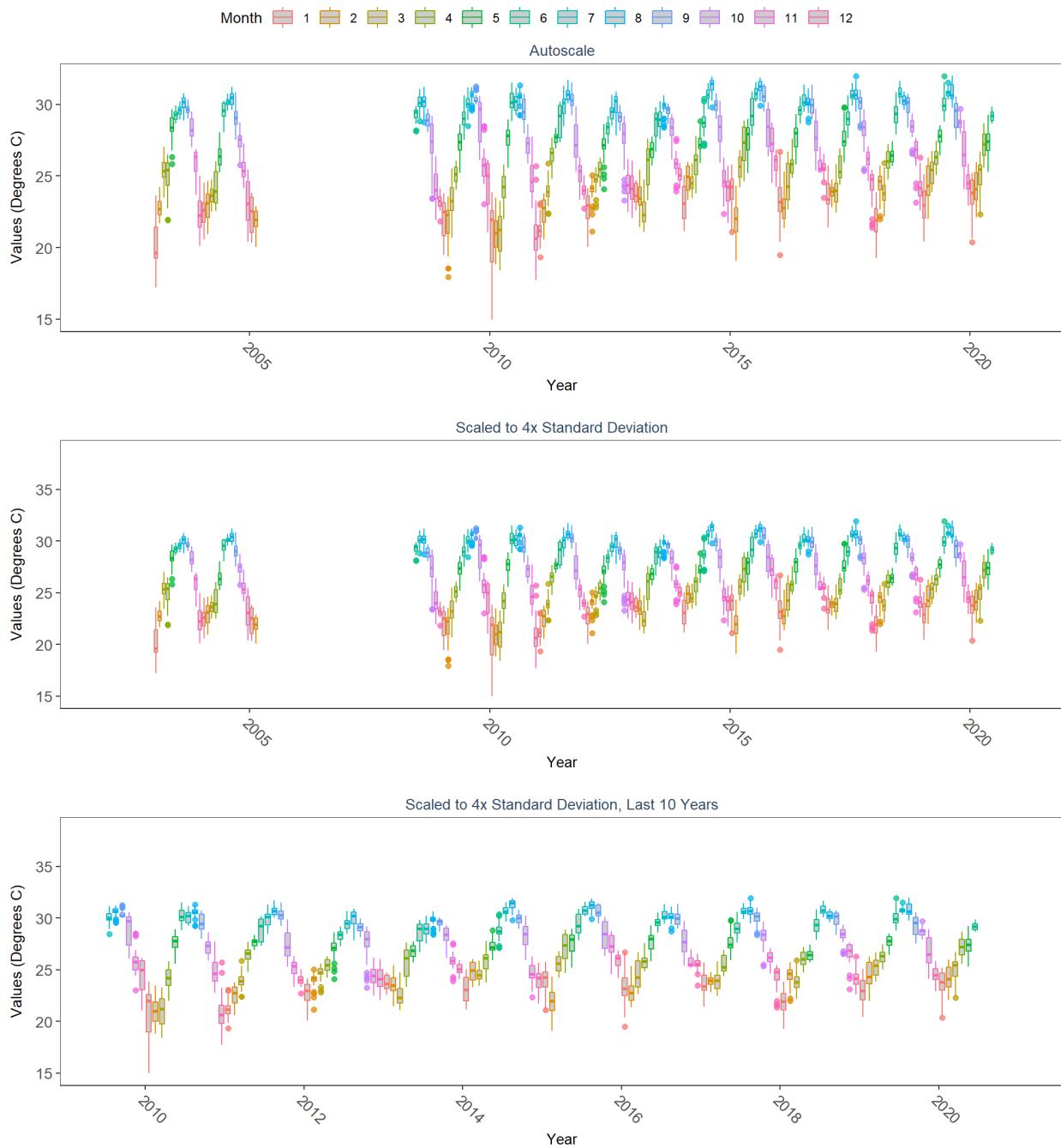
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Month



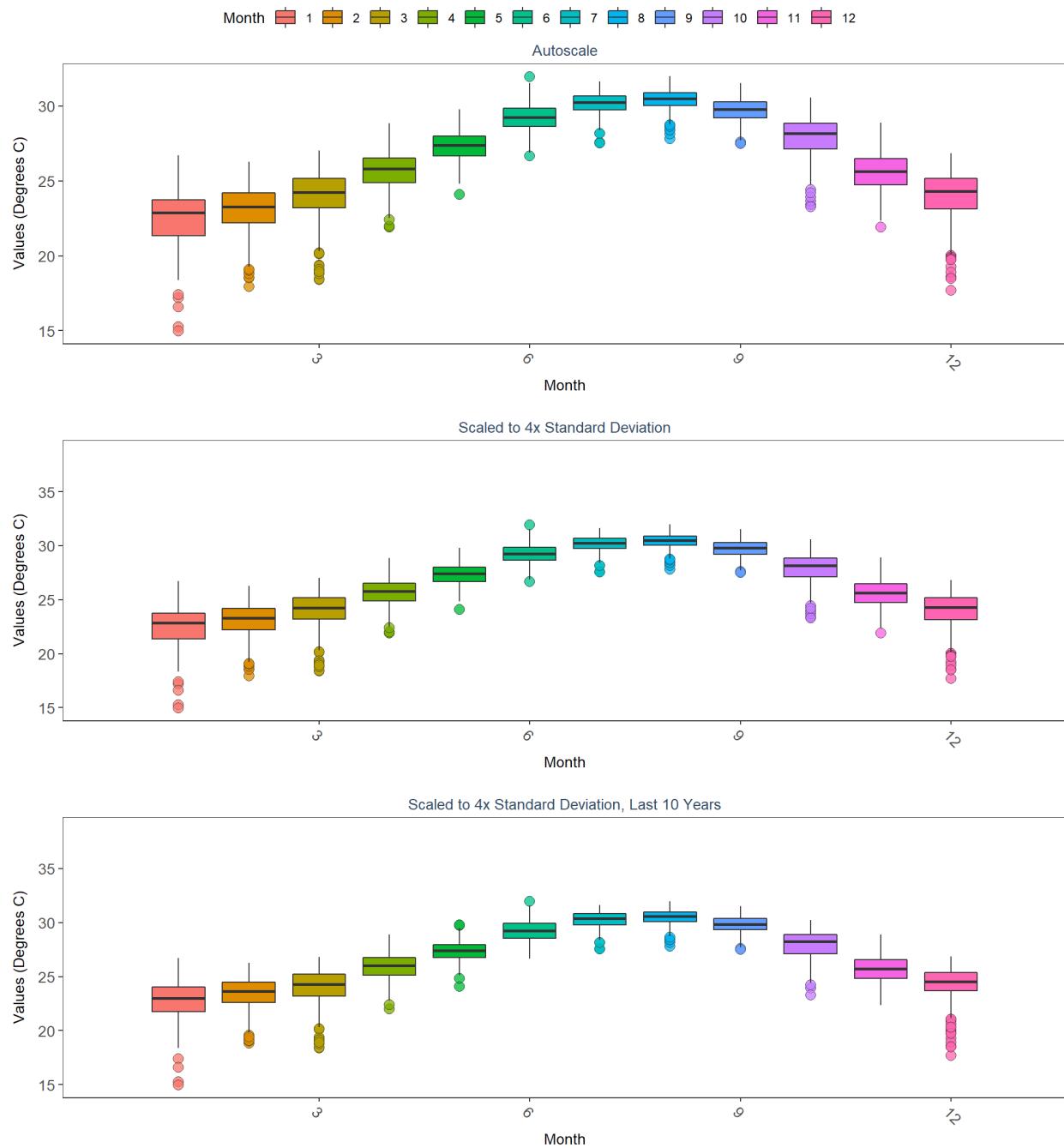
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Water Temperature on Coral Reefs in the Florida Keys  
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By Year



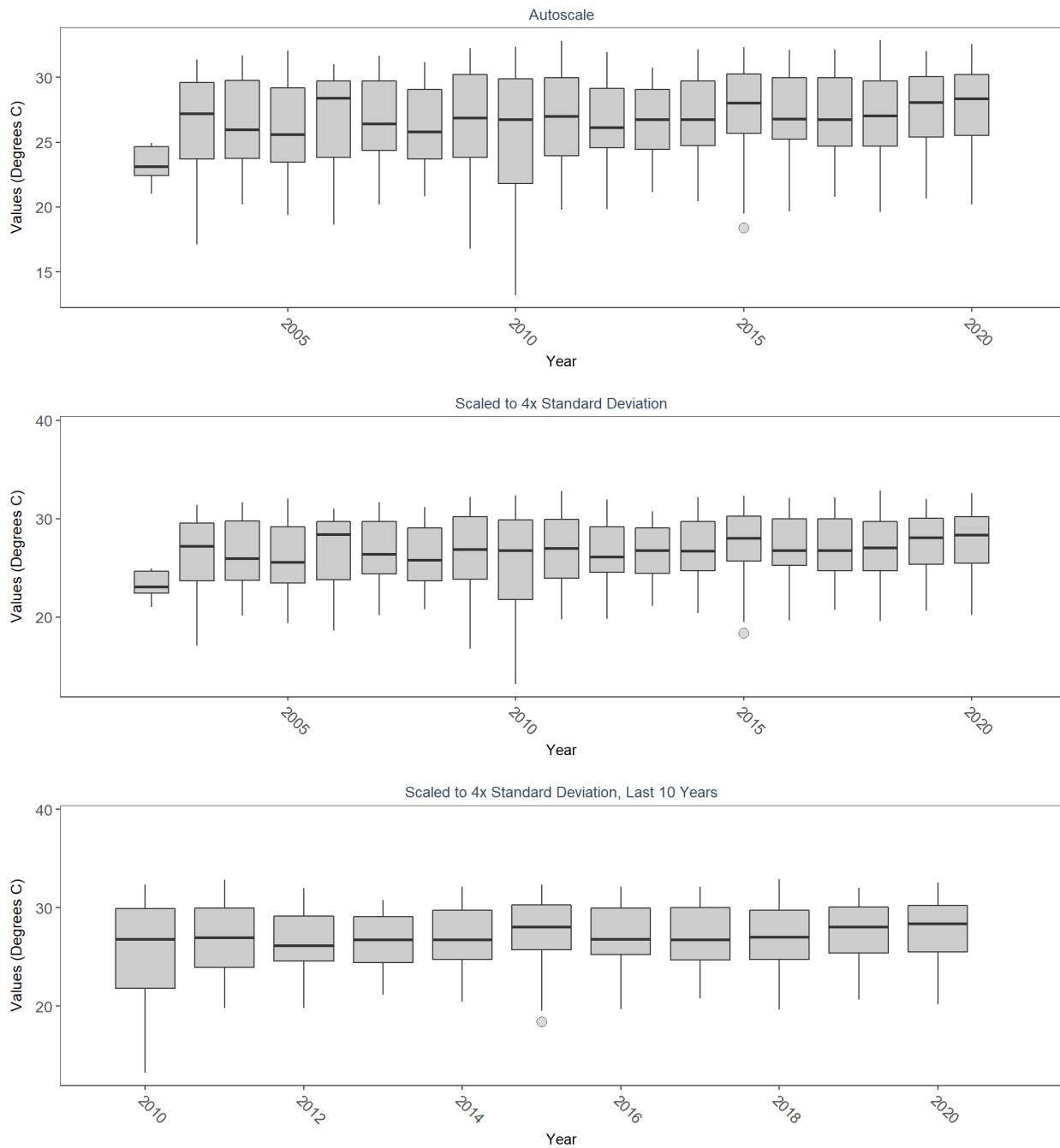
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



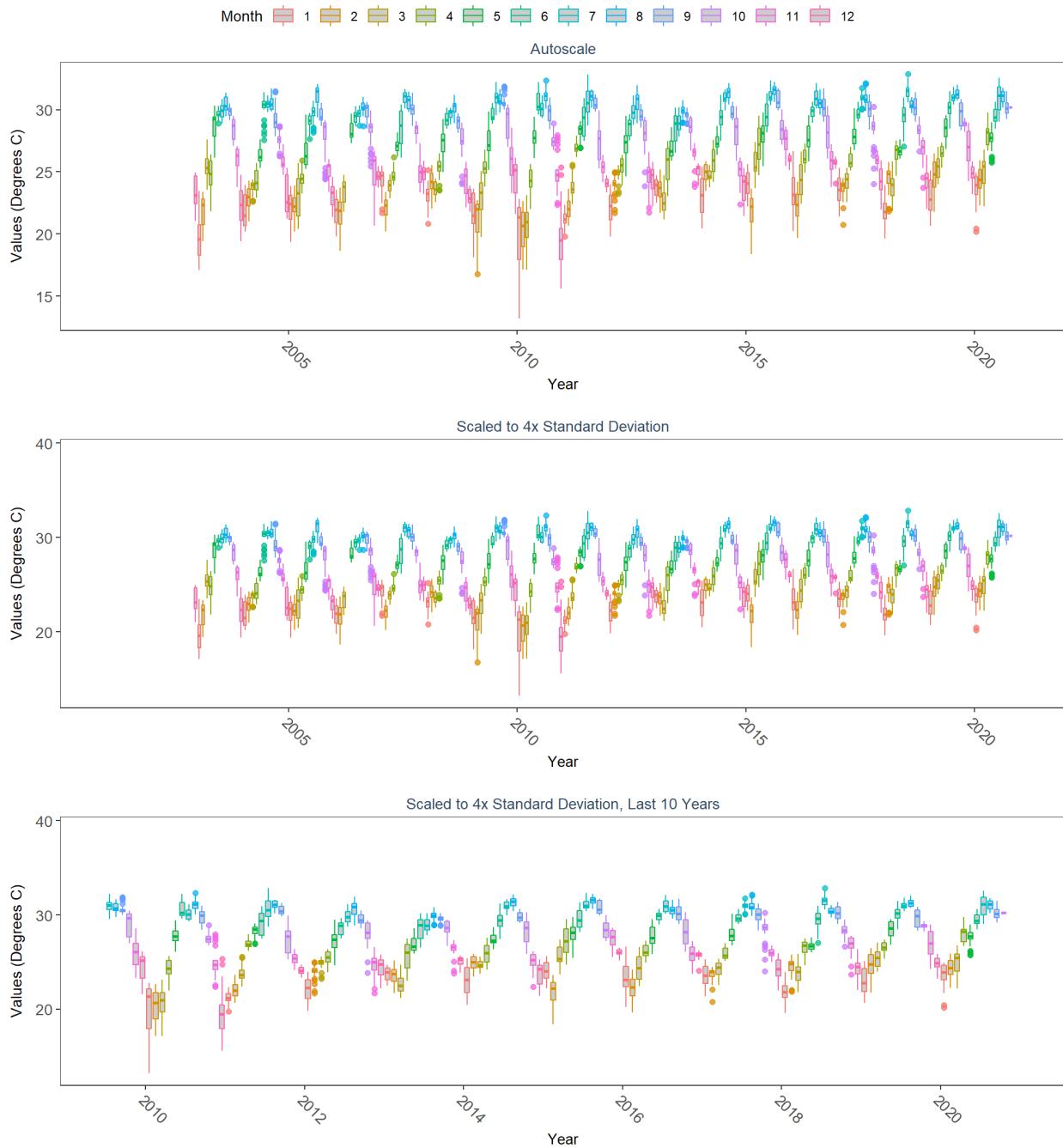
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Month



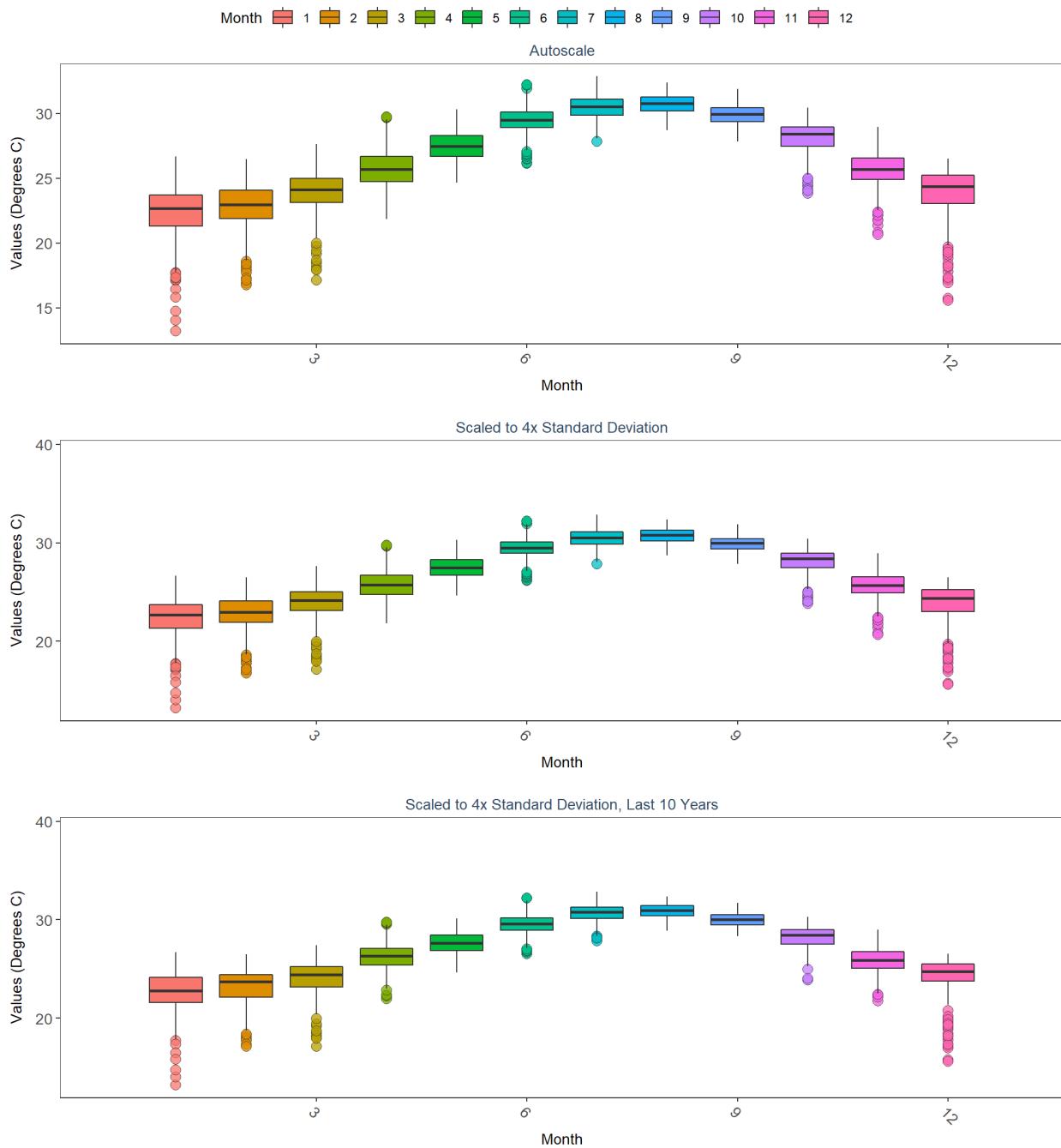
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Water Temperature on Coral Reefs in the Florida Keys  
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By Year



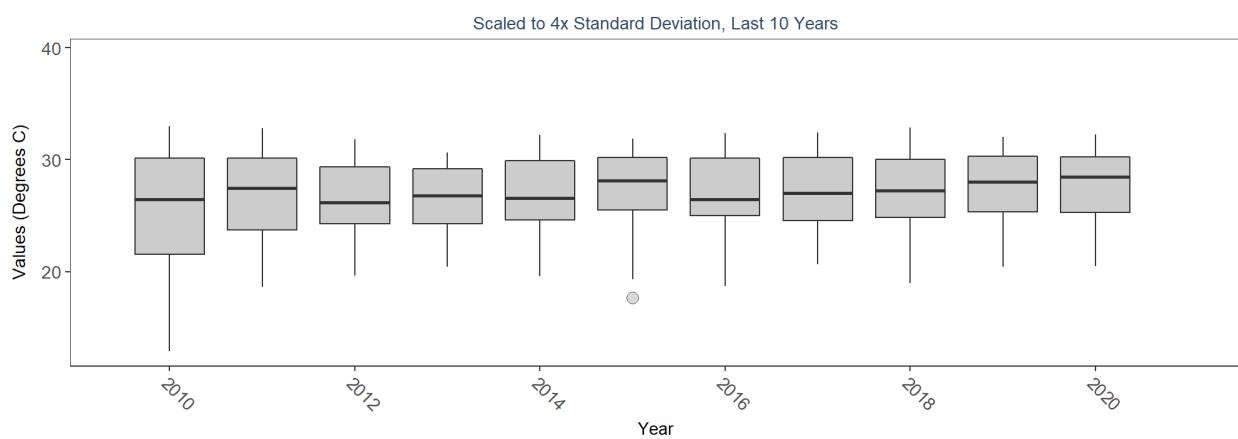
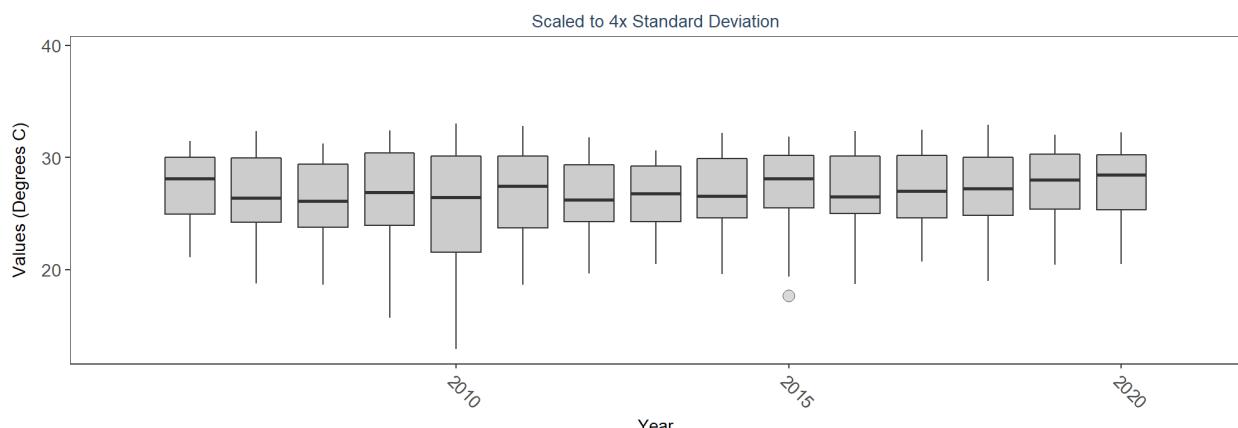
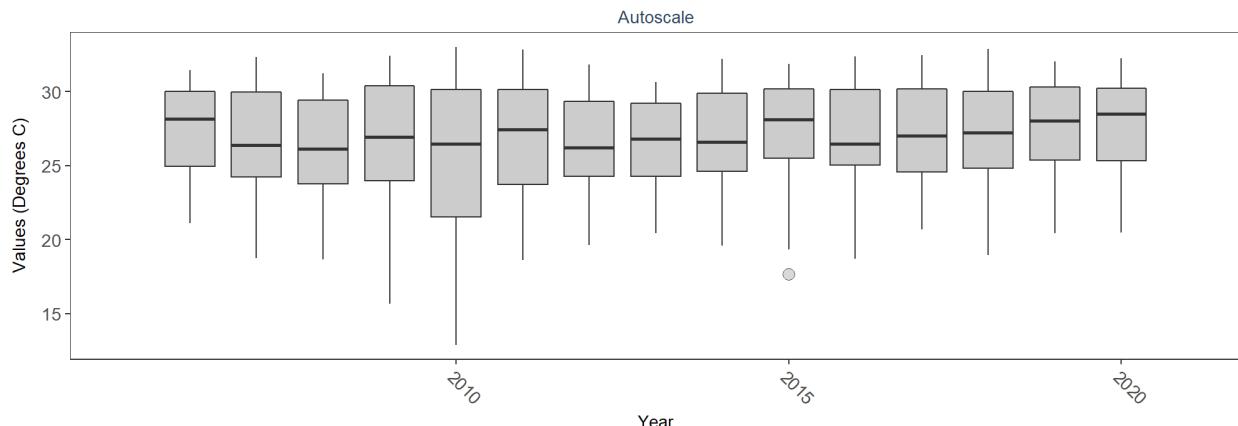
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 Water Temperature on Coral Reefs in the Florida Keys  
 34  
 By Year & Month



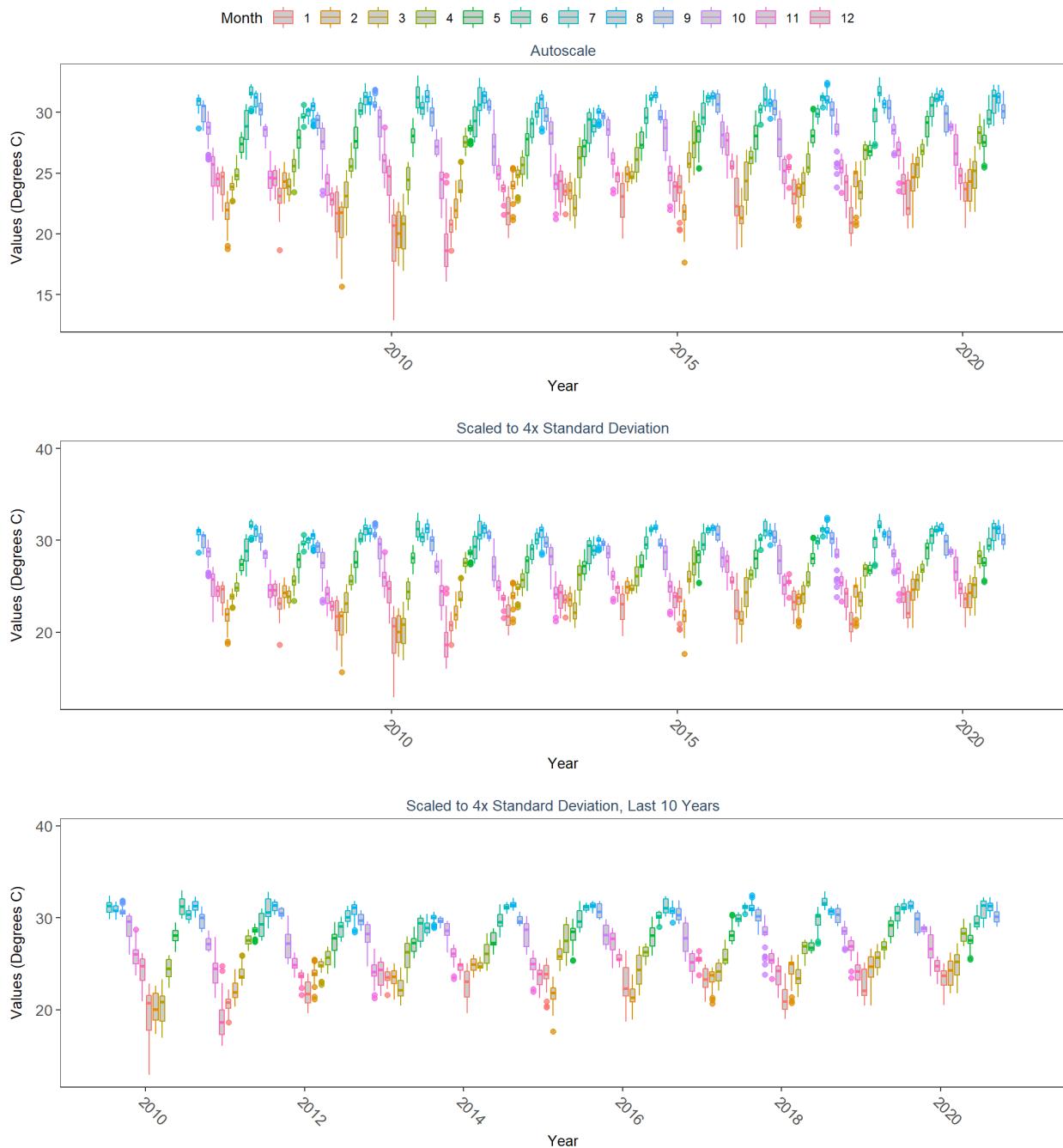
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 By Month



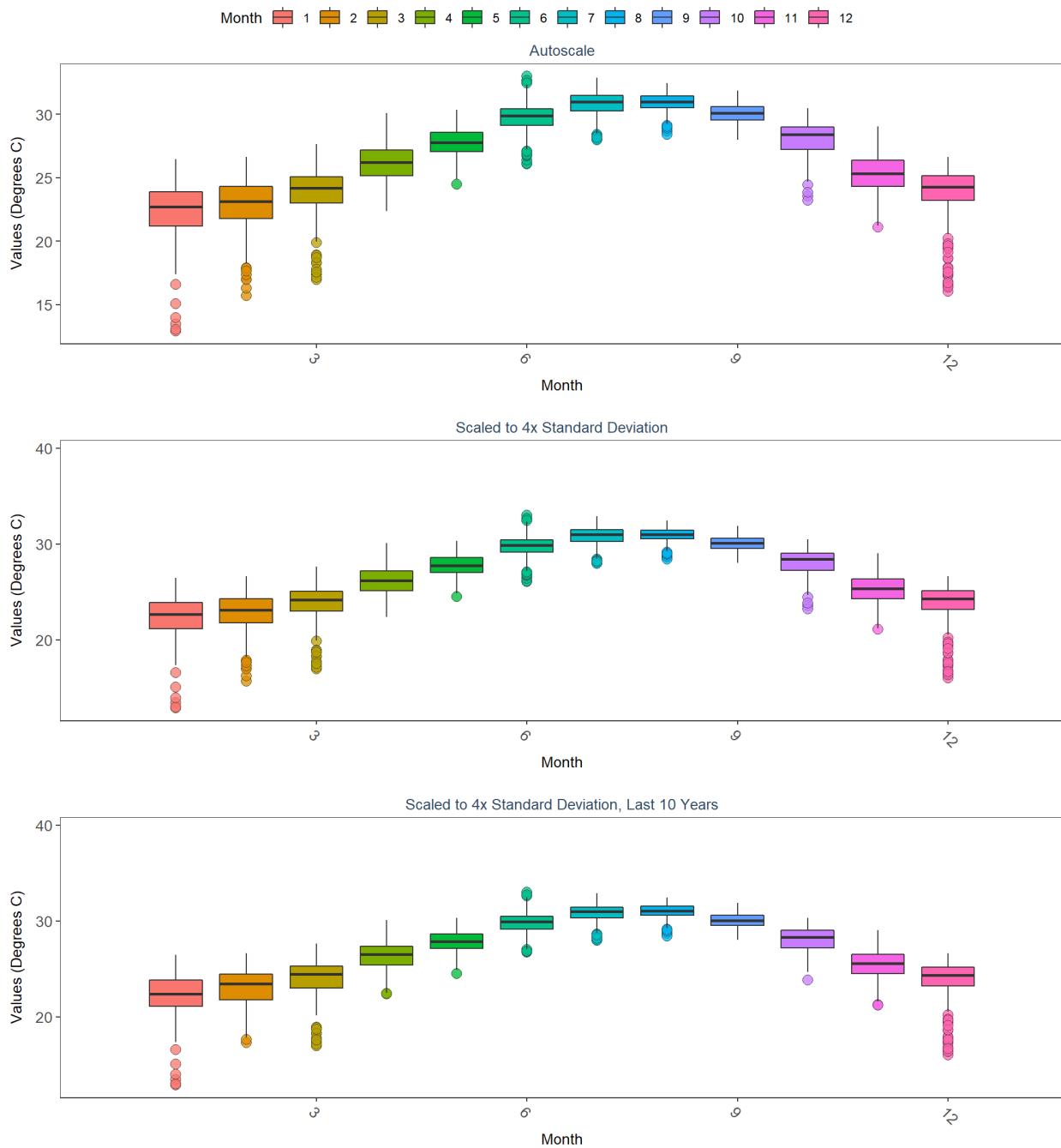
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Water Temperature on Coral Reefs in the Florida Keys  
35  
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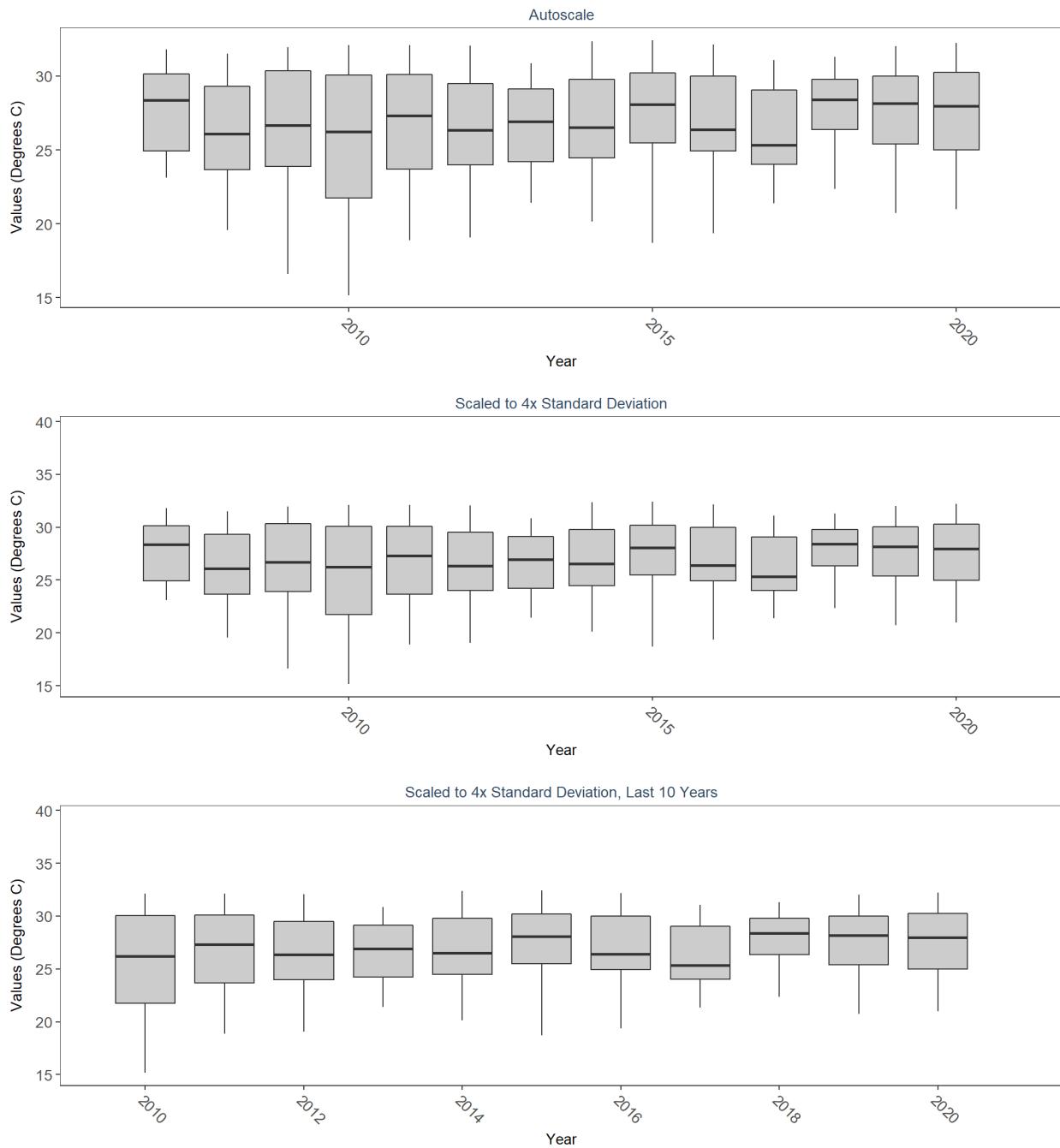
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 35  
 By Year & Month



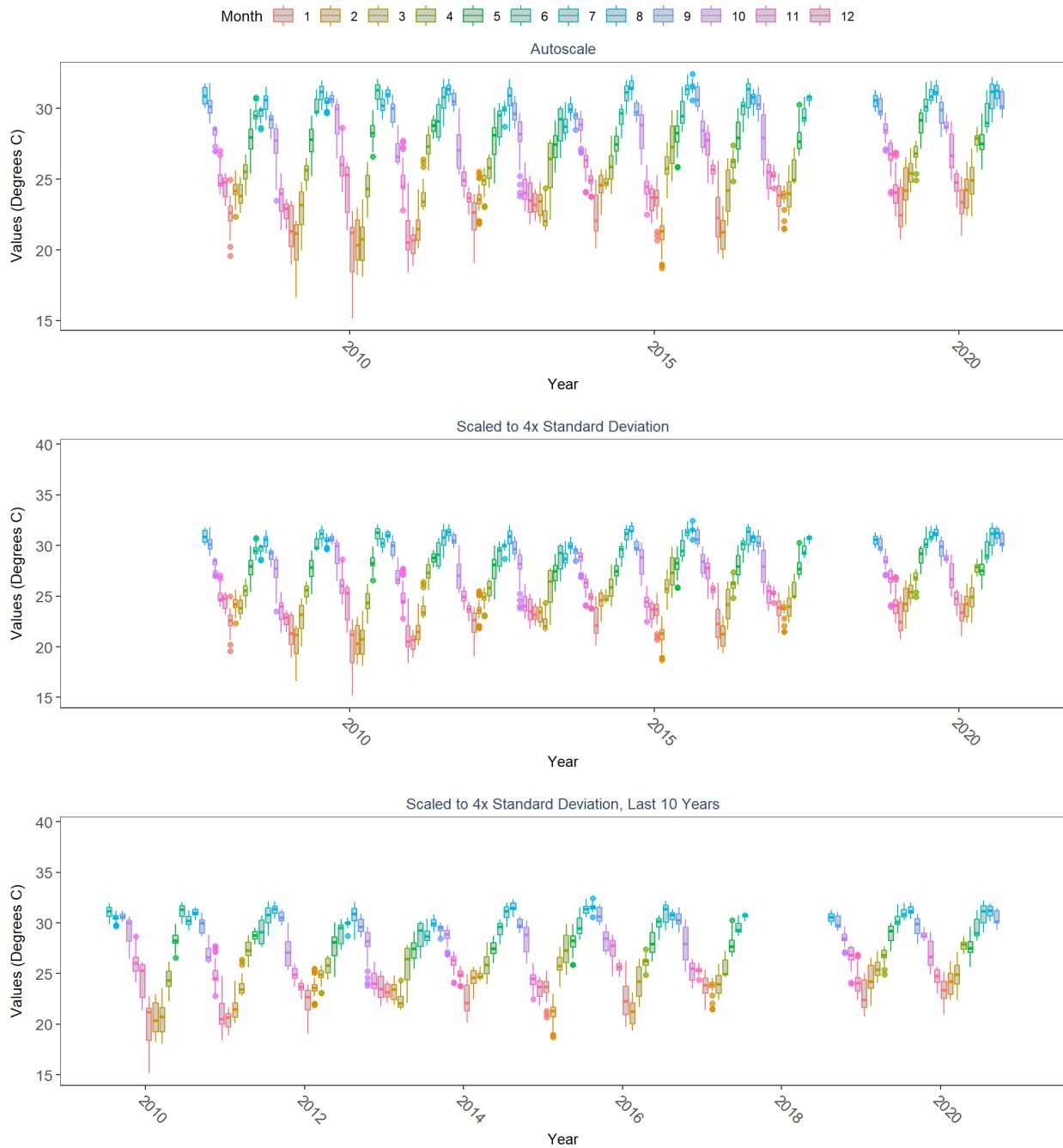
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 Water Temperature on Coral Reefs in the Florida Keys  
 35  
 By Month



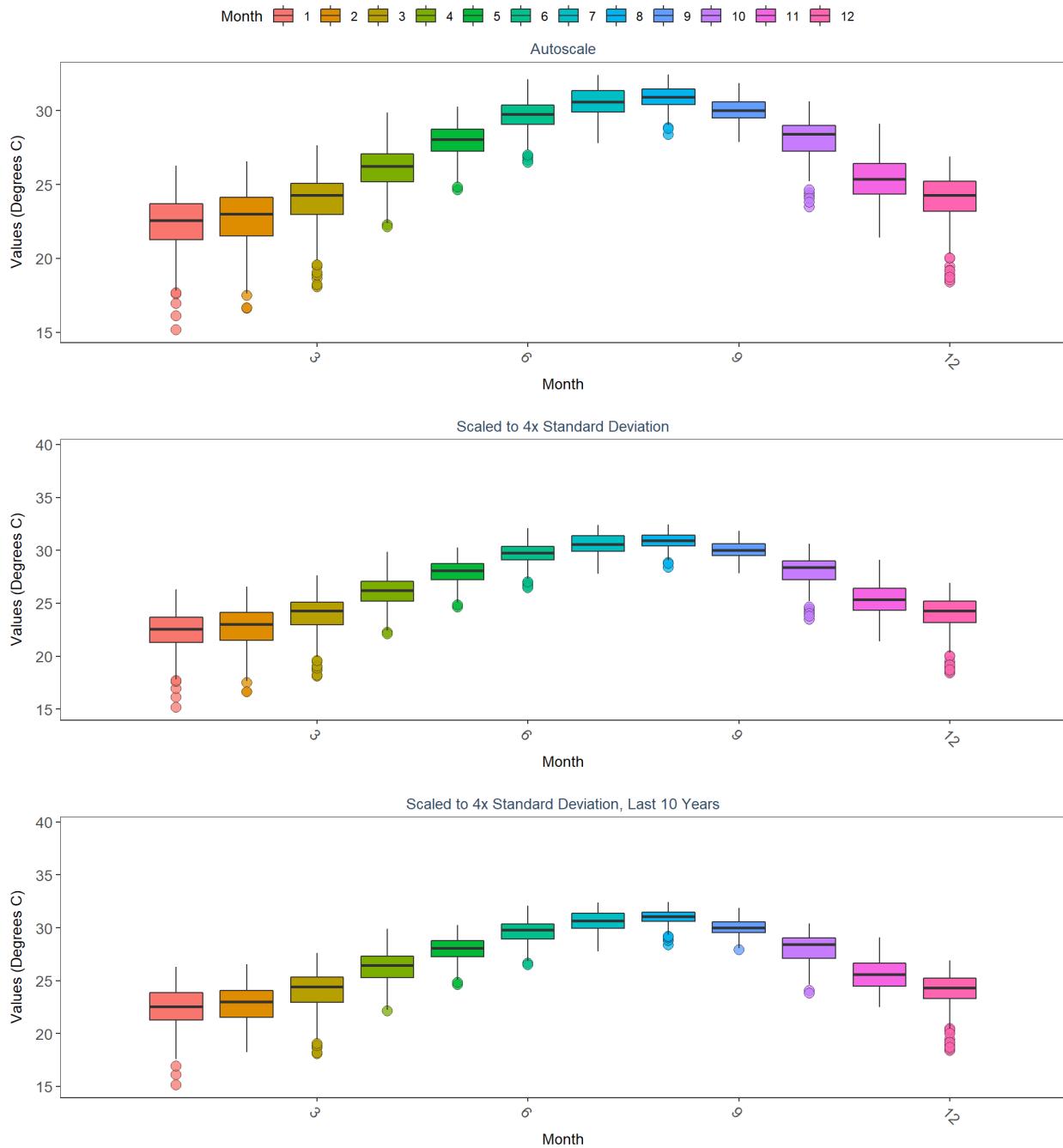
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 Water Temperature on Coral Reefs in the Florida Keys  
 36  
 By Year



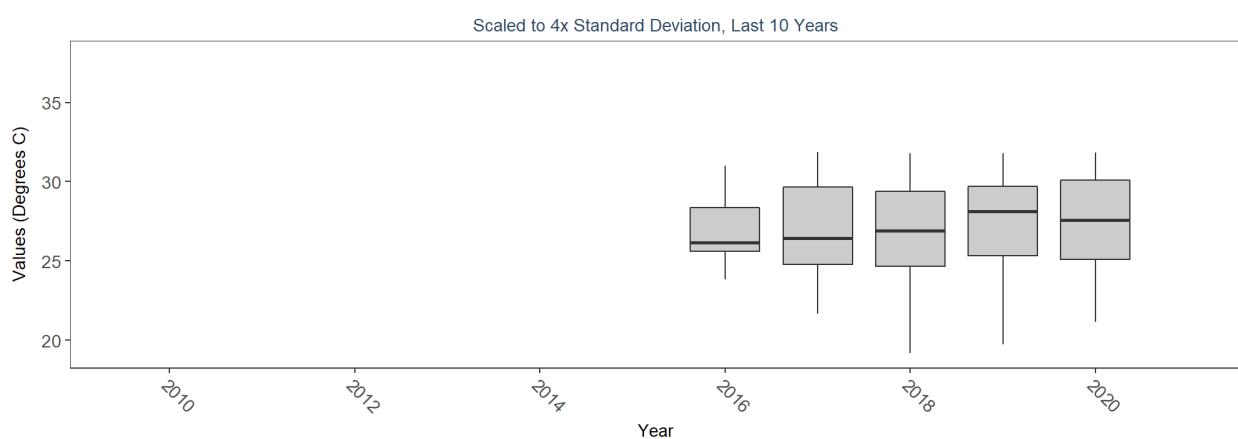
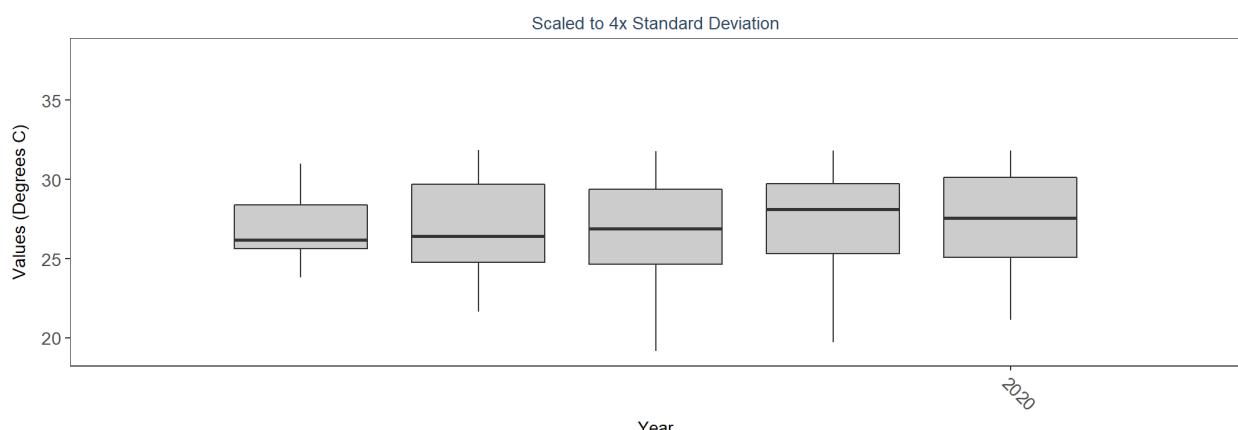
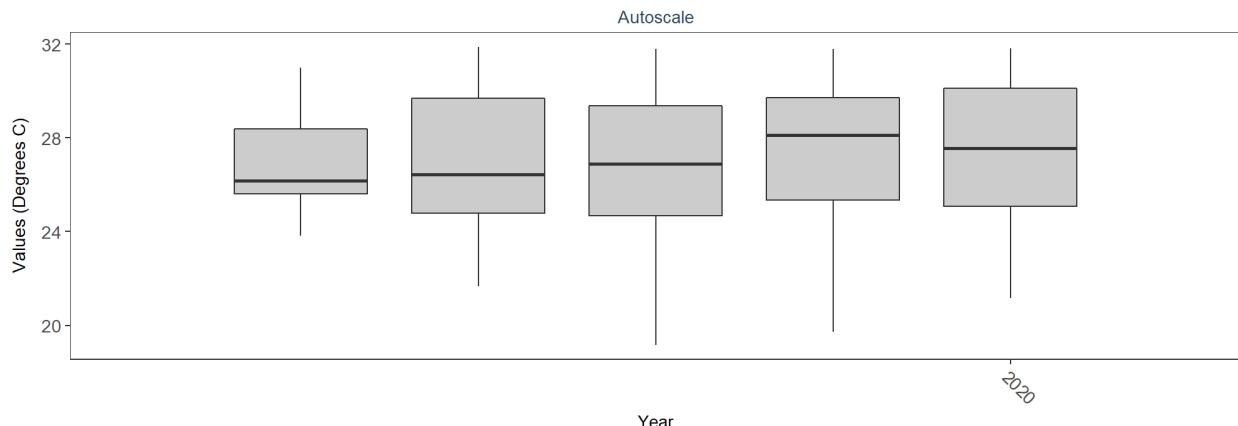
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



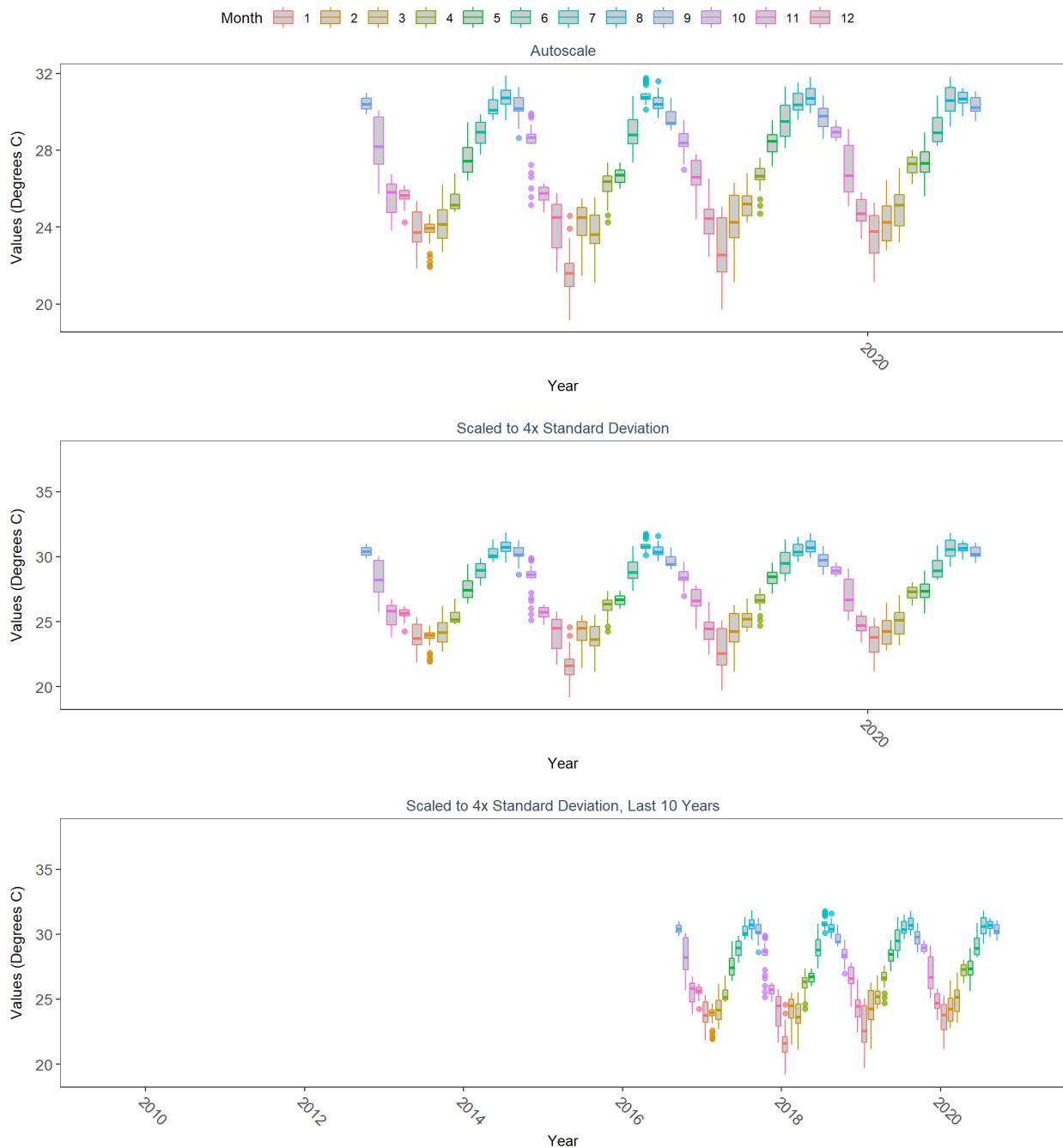
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 By Month



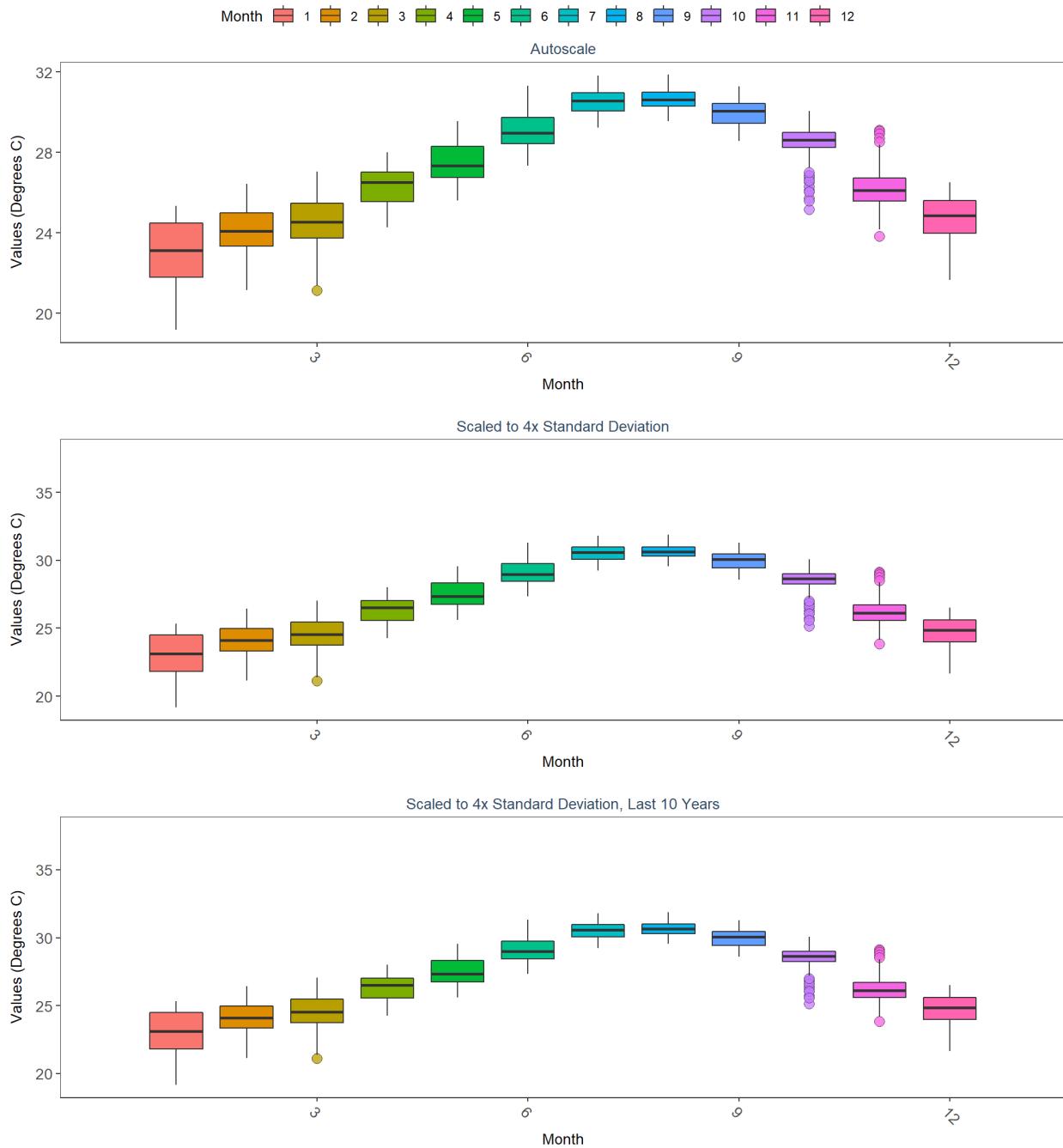
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Water Temperature on Coral Reefs in the Florida Keys  
37  
By Year



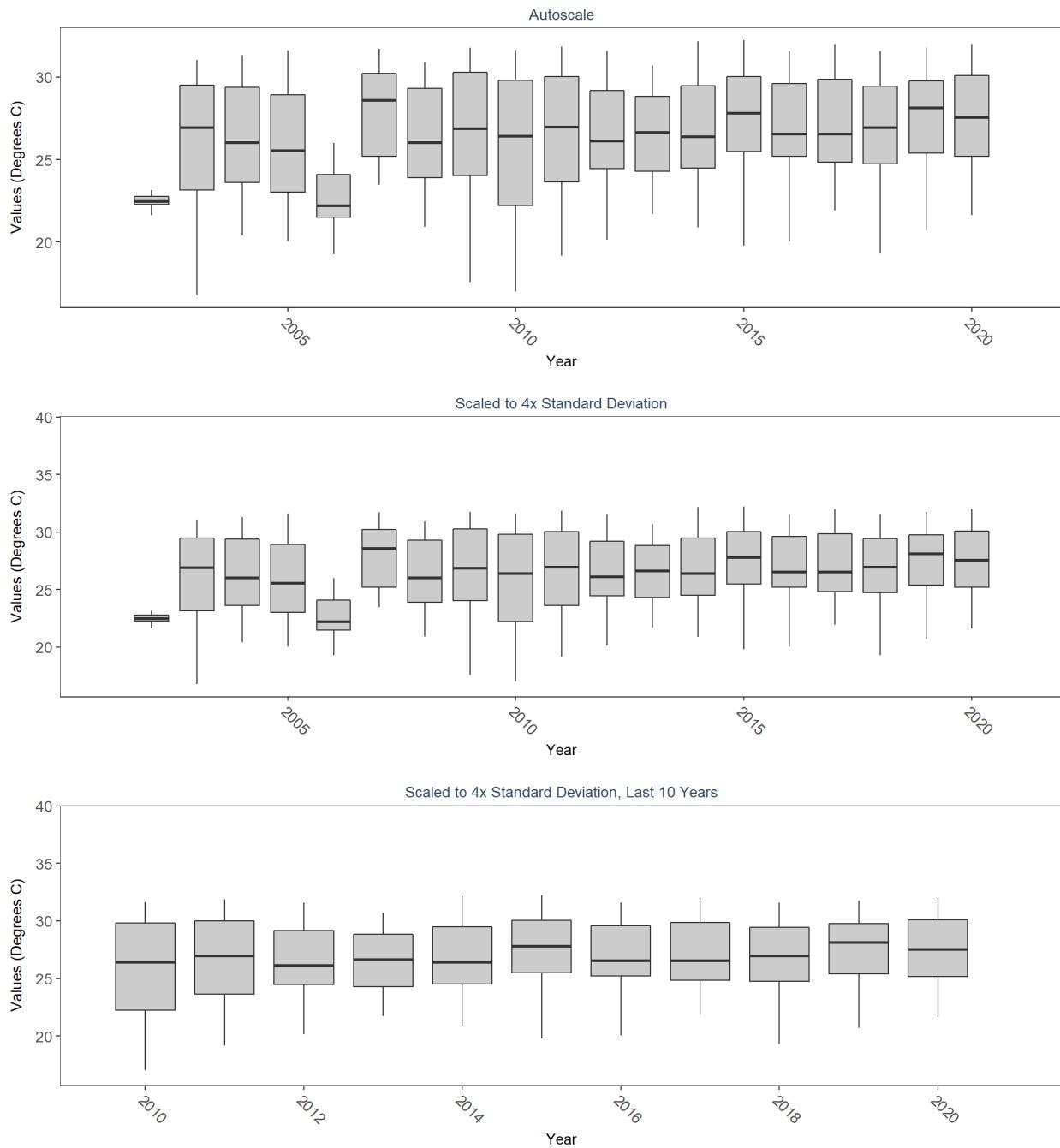
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



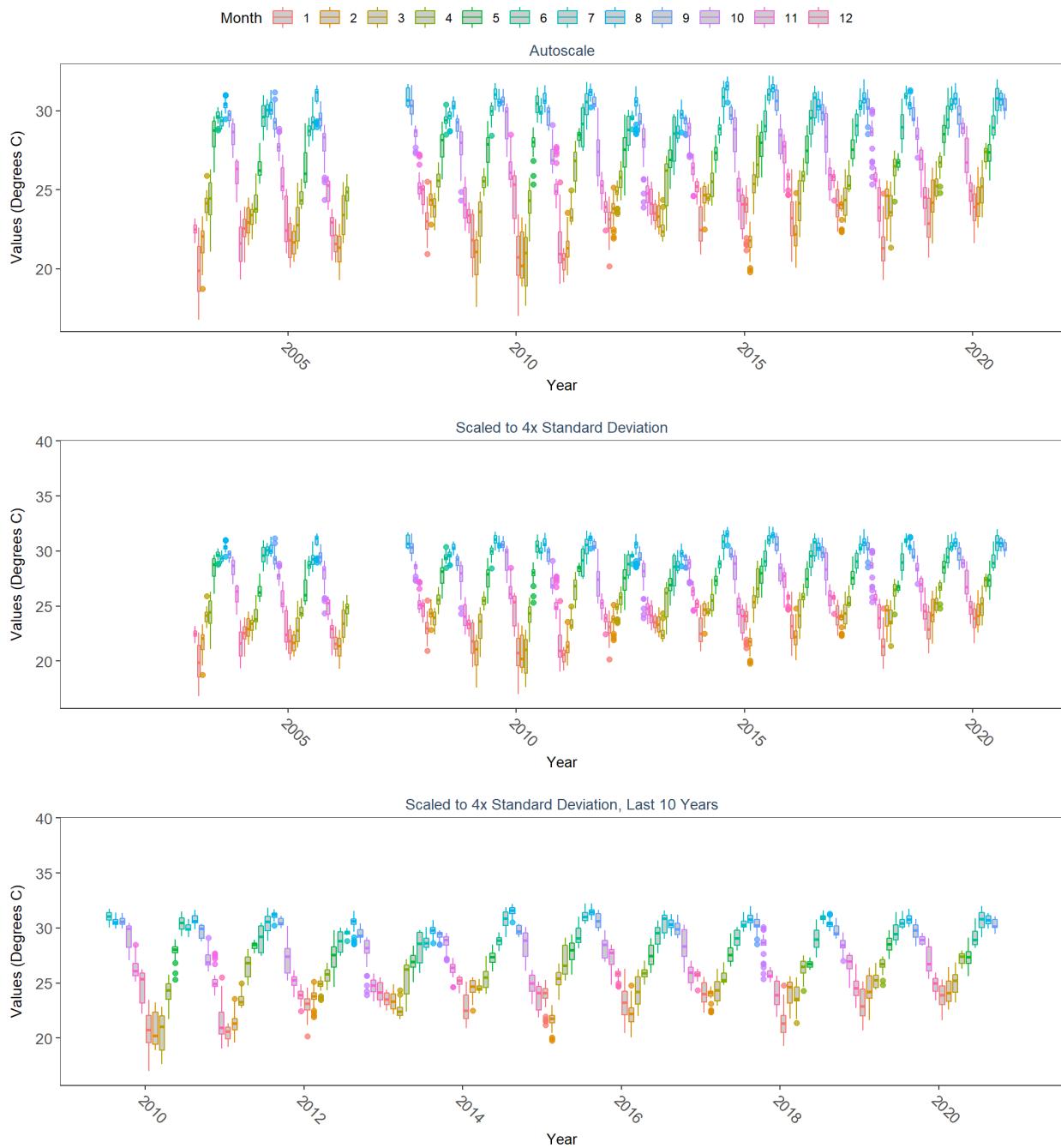
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 By Month



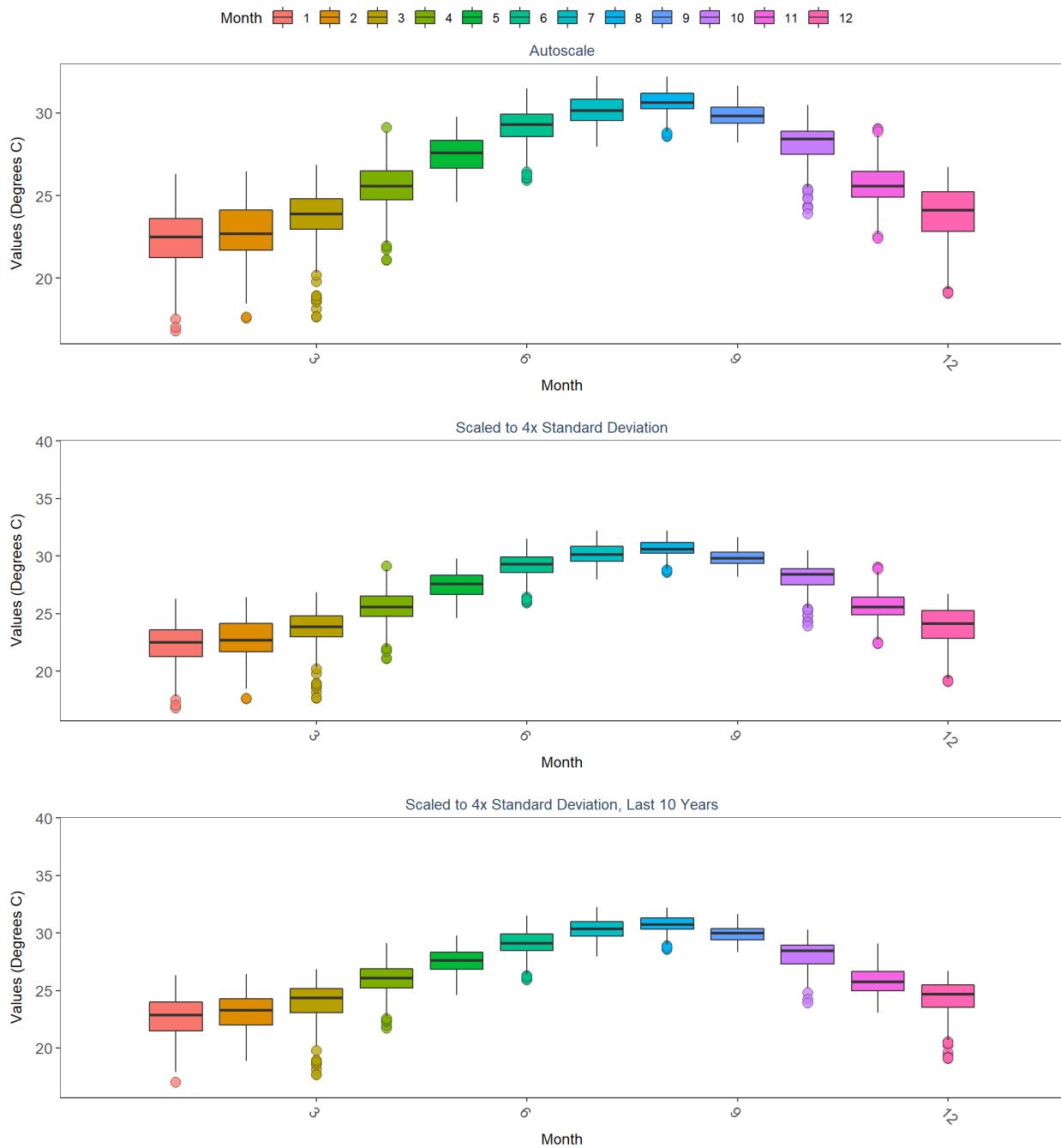
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Water Temperature on Coral Reefs in the Florida Keys  
38  
By Year



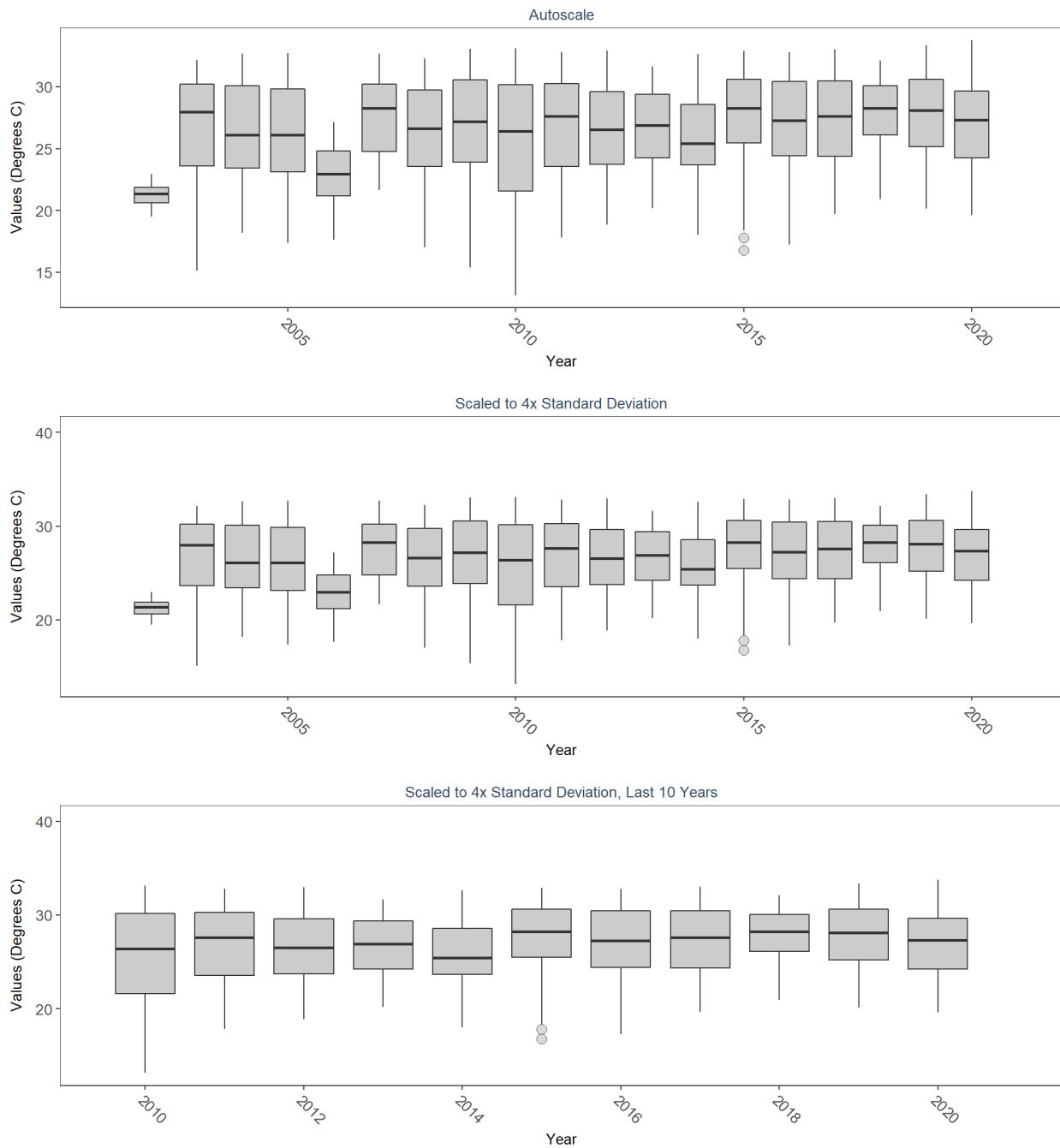
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



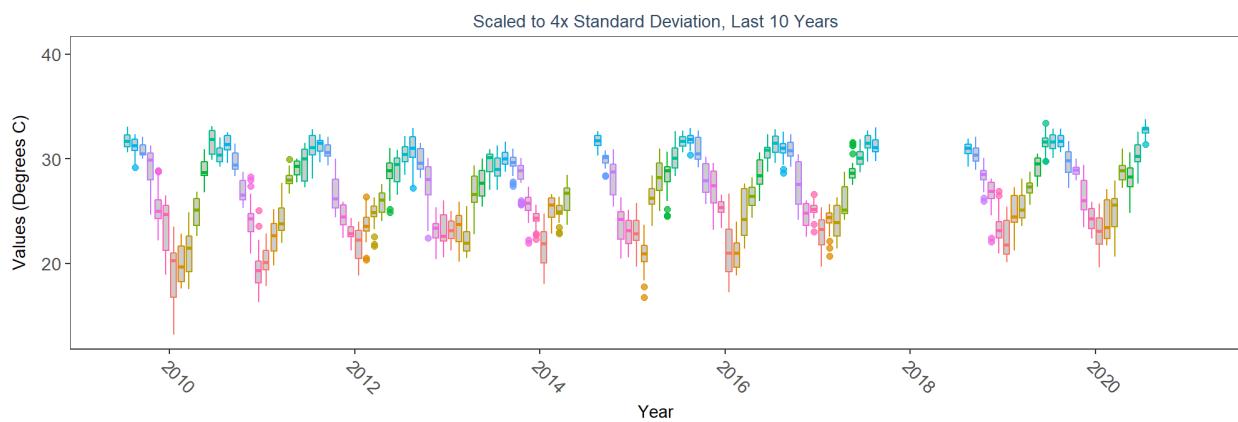
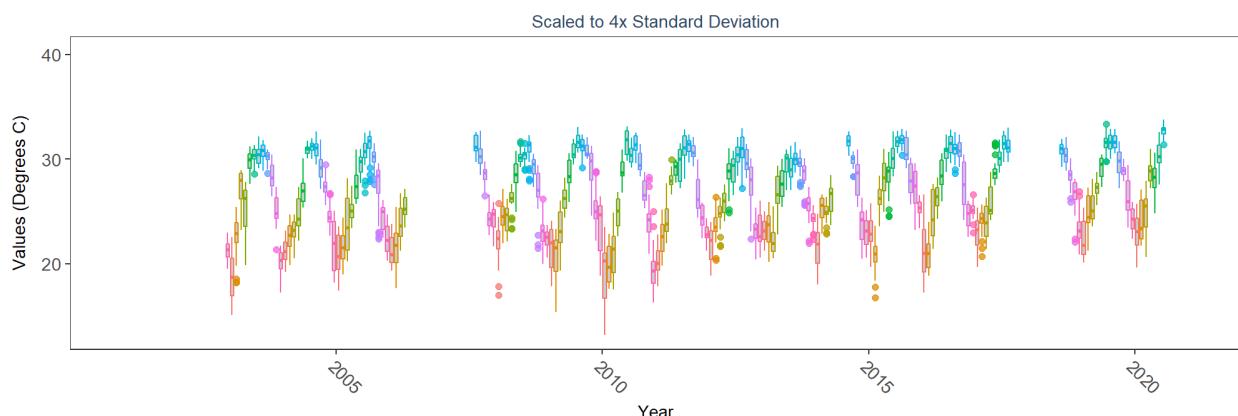
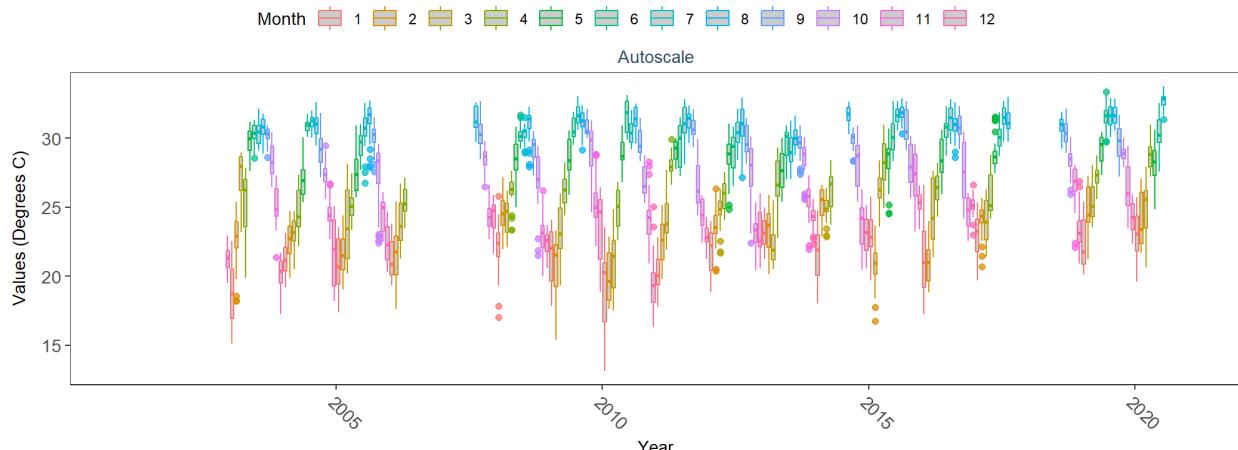
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 Water Temperature on Coral Reefs in the Florida Keys  
 38  
 By Month



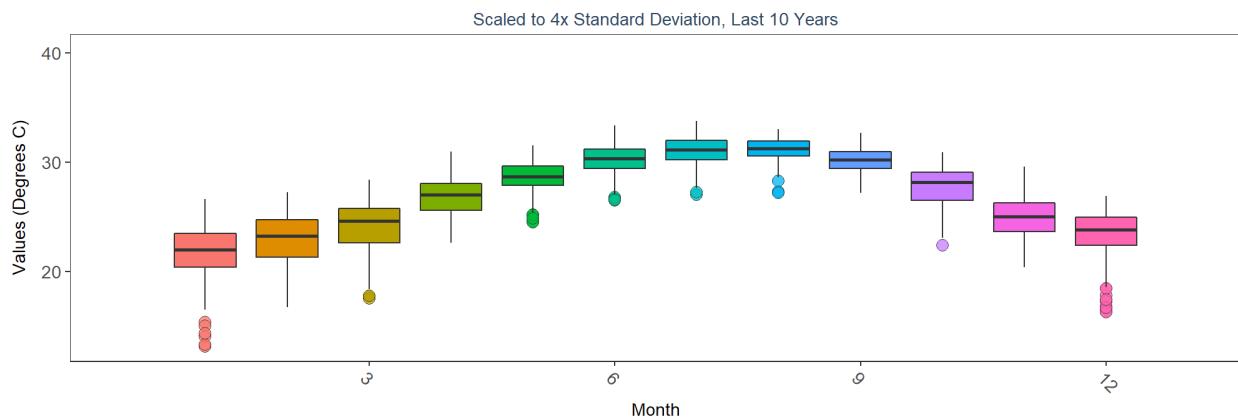
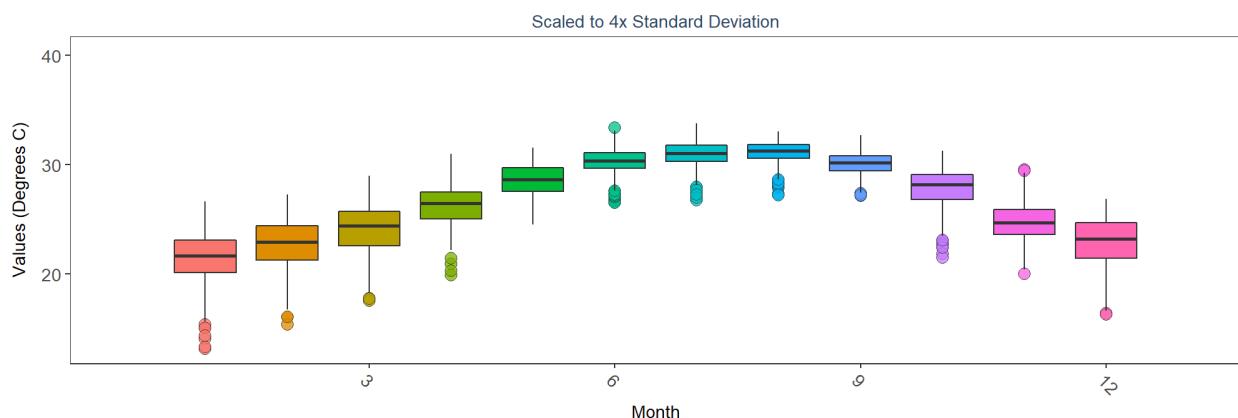
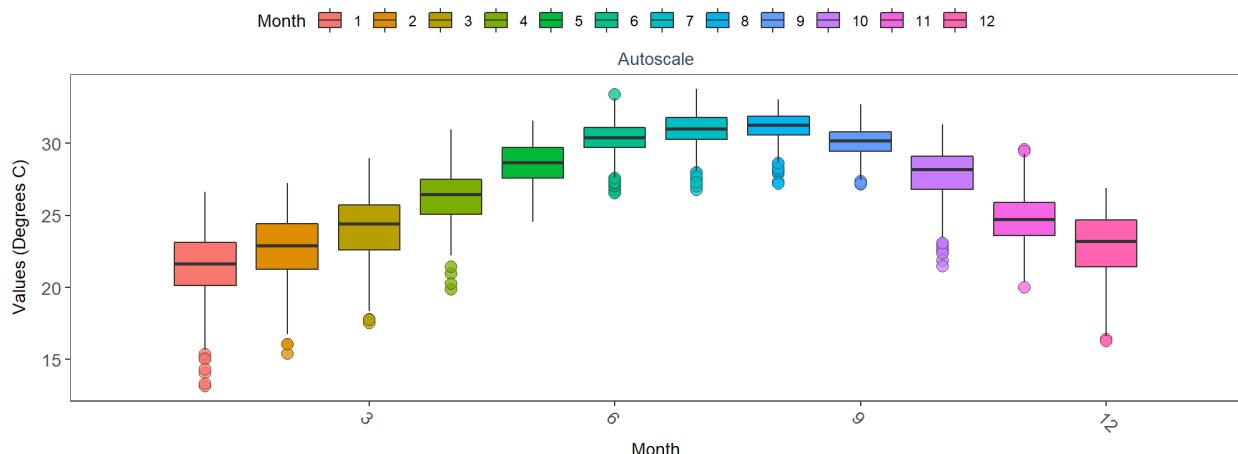
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year



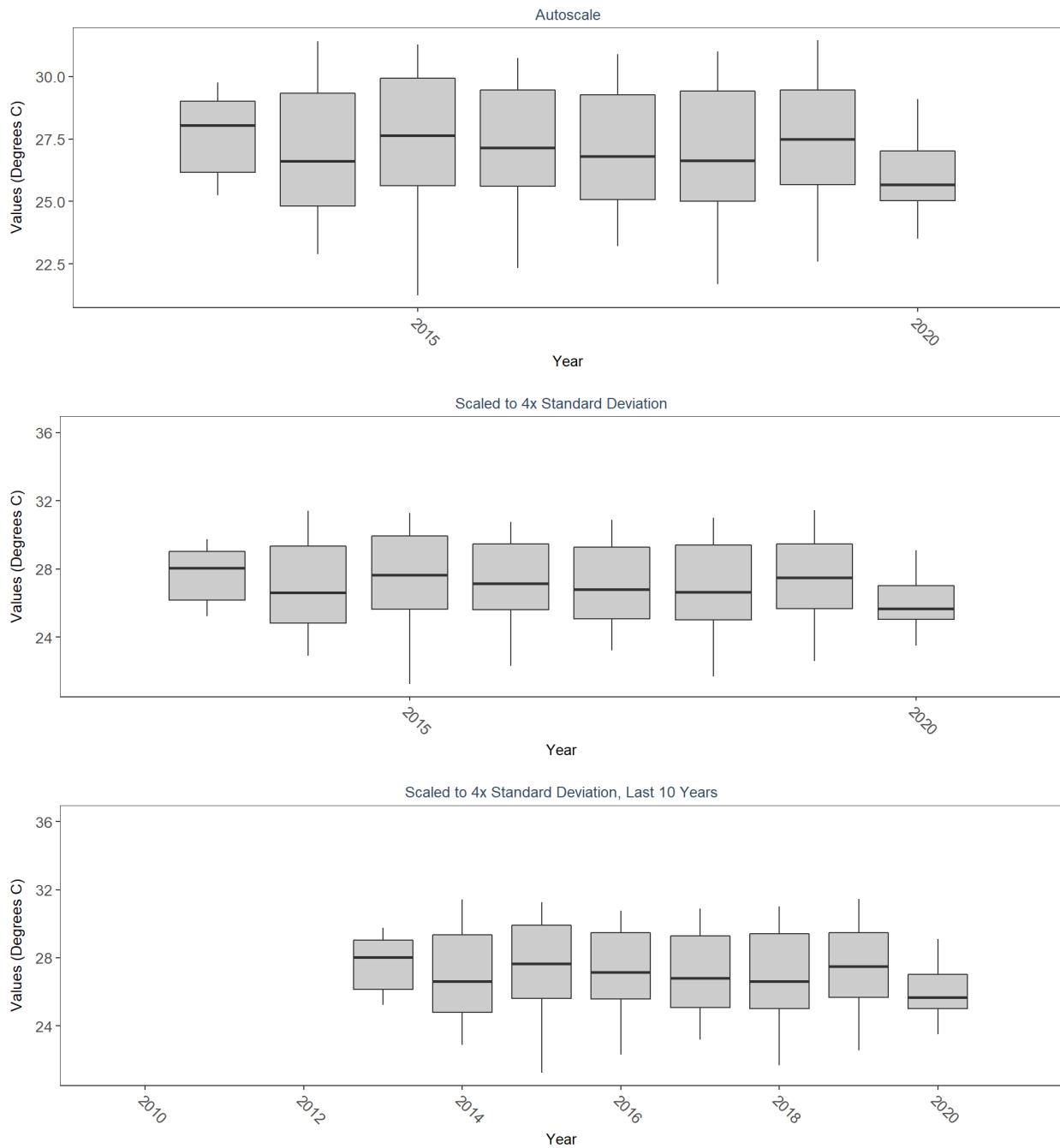
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 By Year & Month



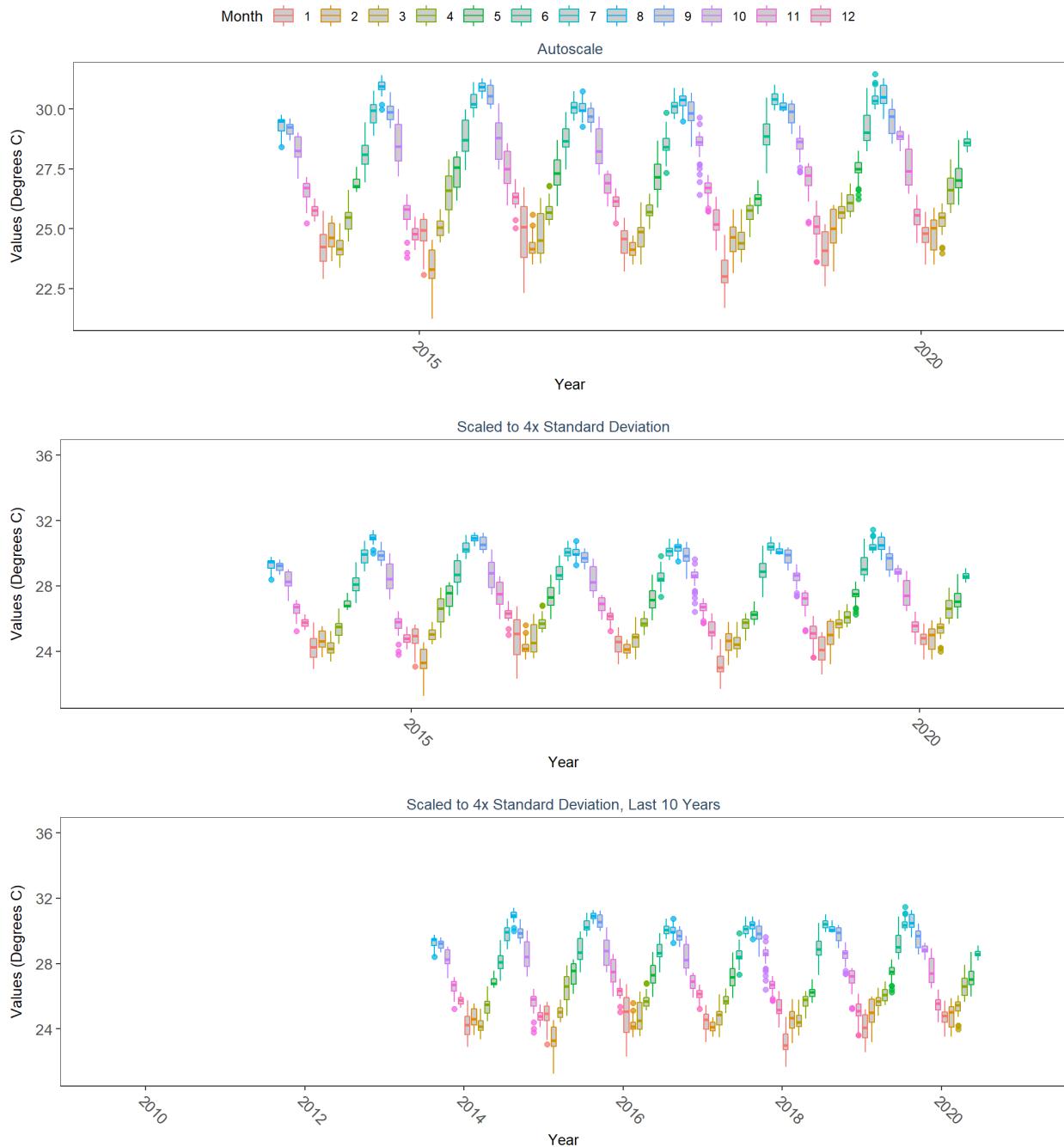
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 By Month



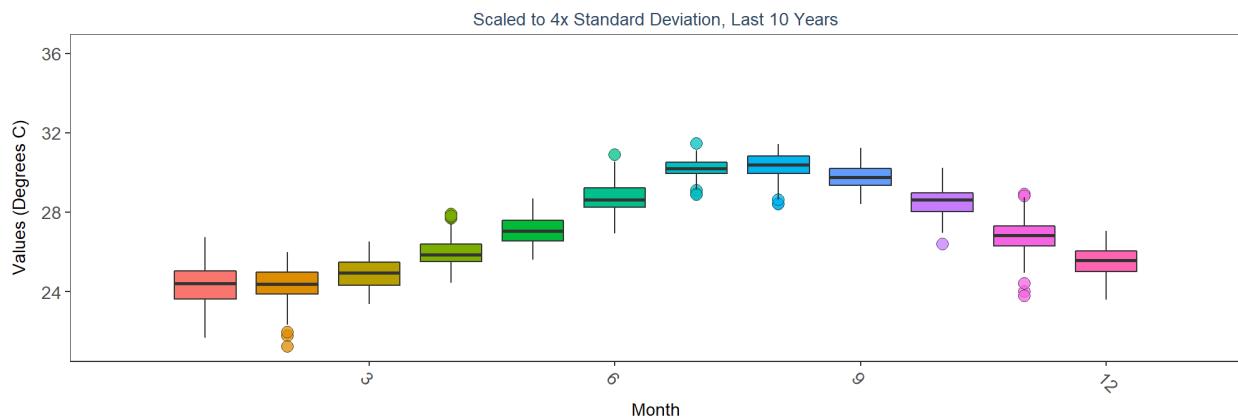
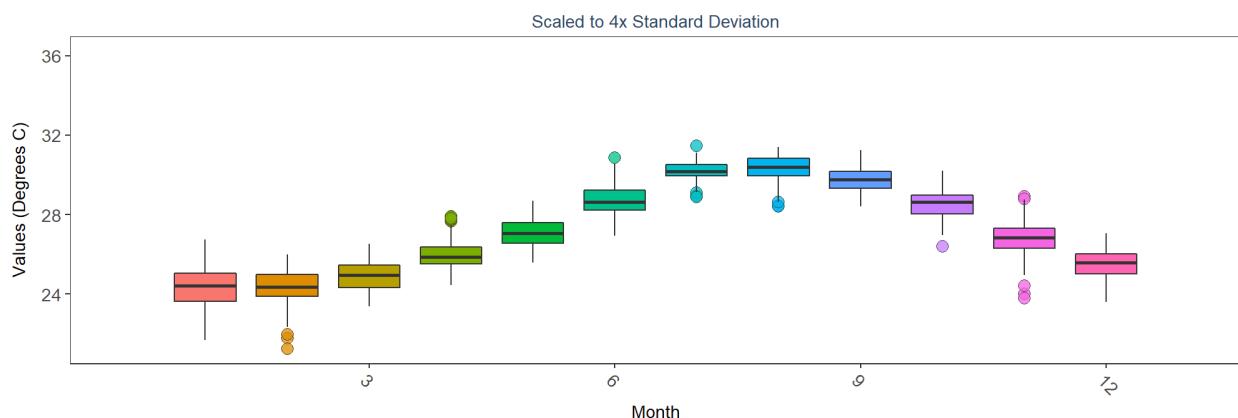
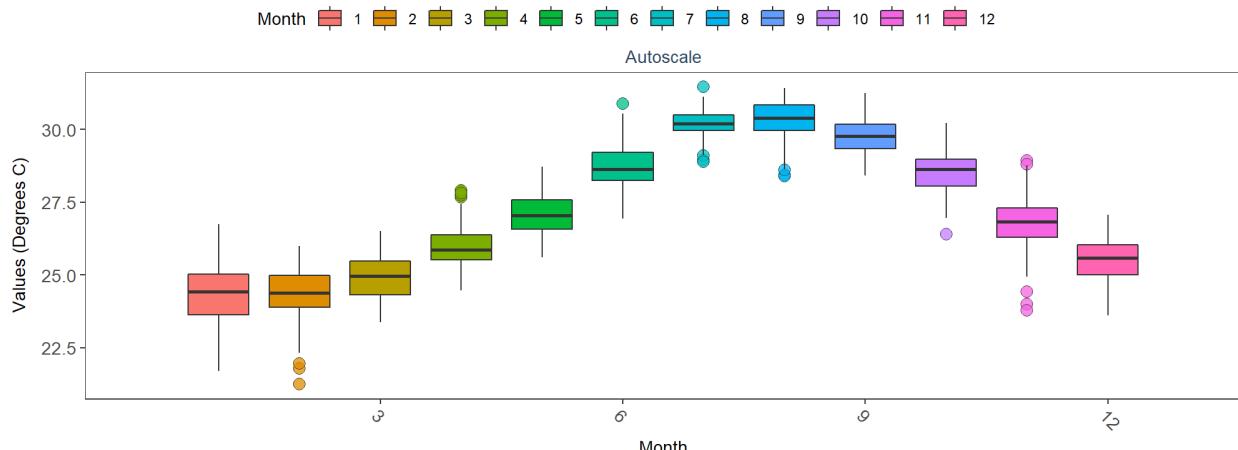
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 Water Temperature on Coral Reefs in the Florida Keys  
 50  
 By Year



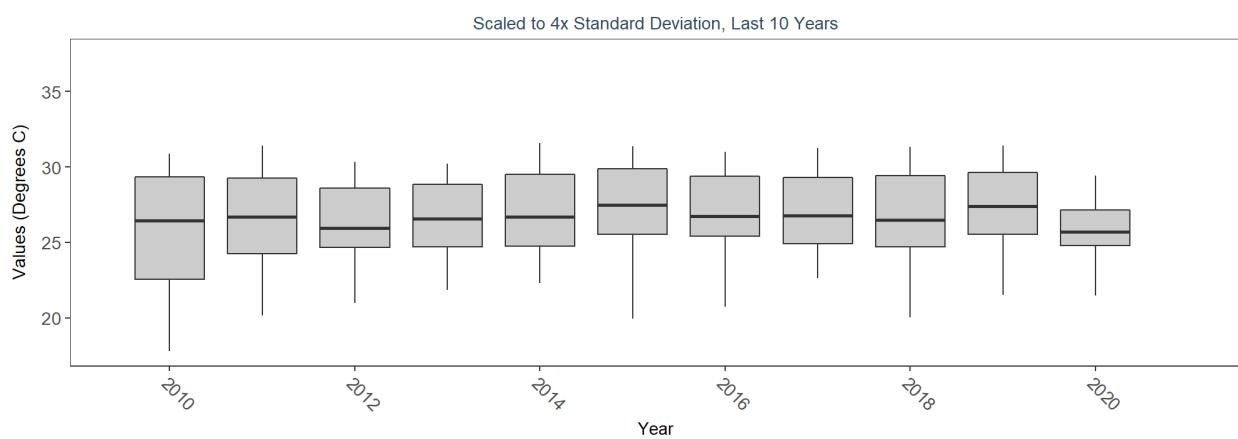
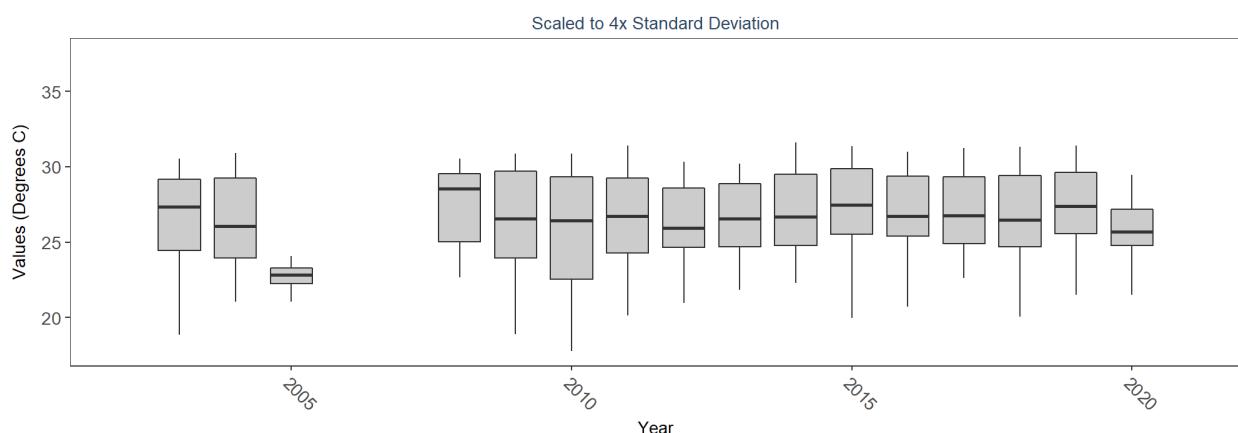
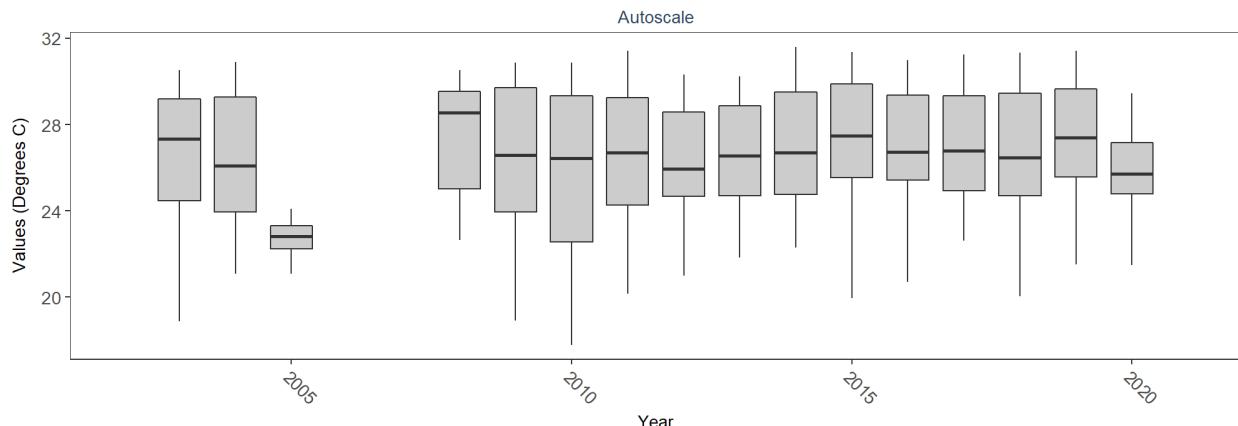
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



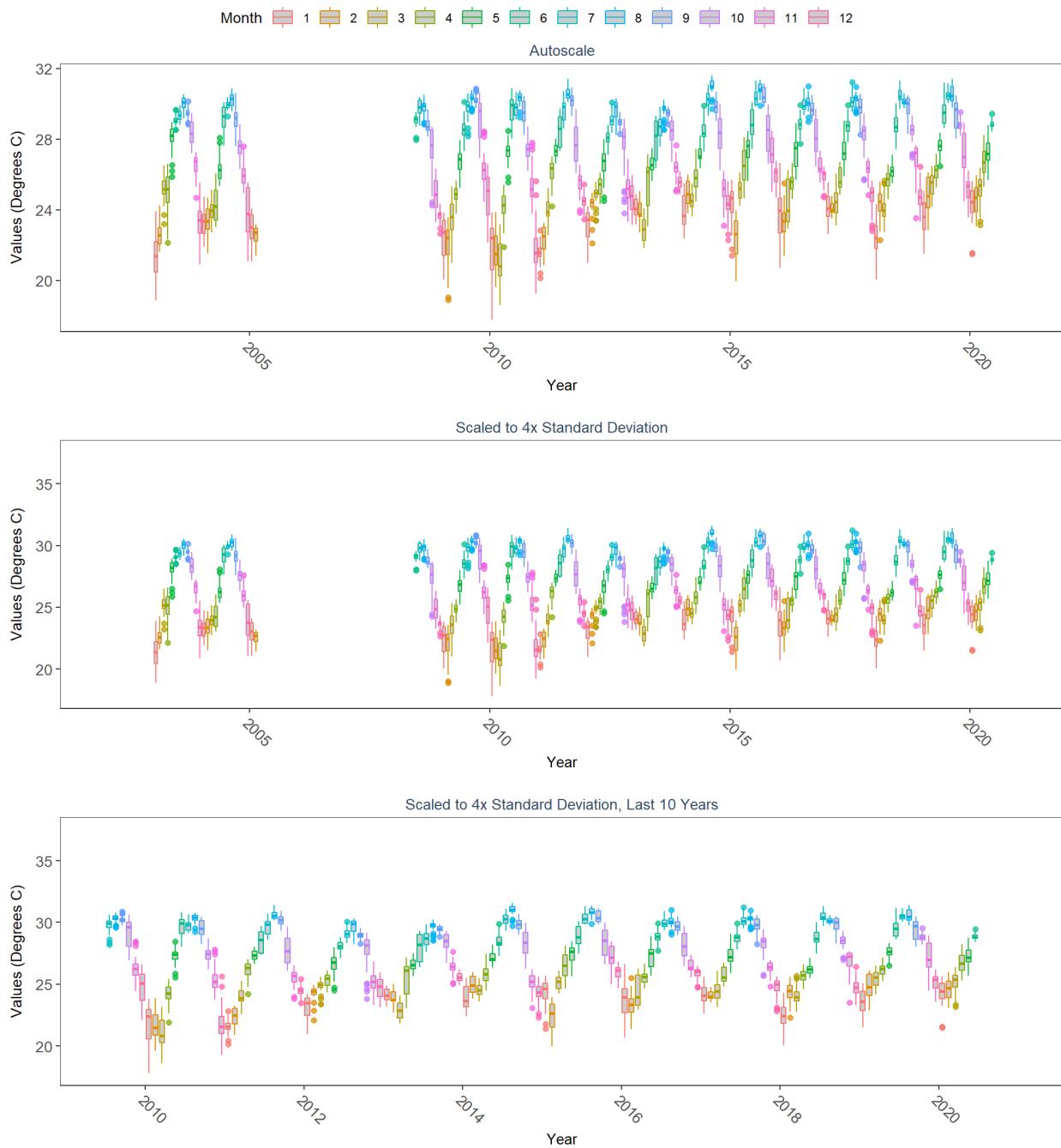
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 By Month



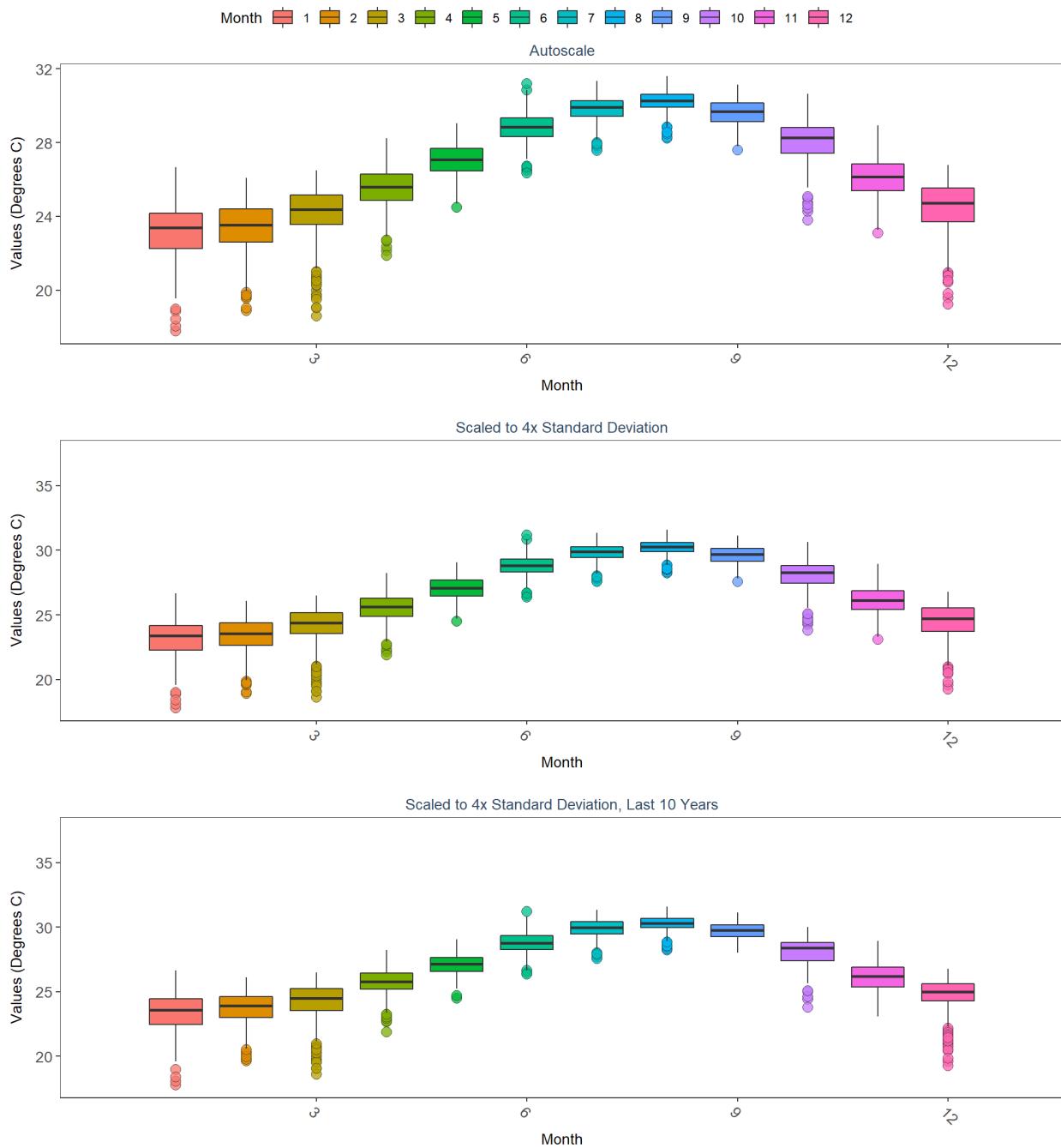
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Water Temperature on Coral Reefs in the Florida Keys  
51  
By Year



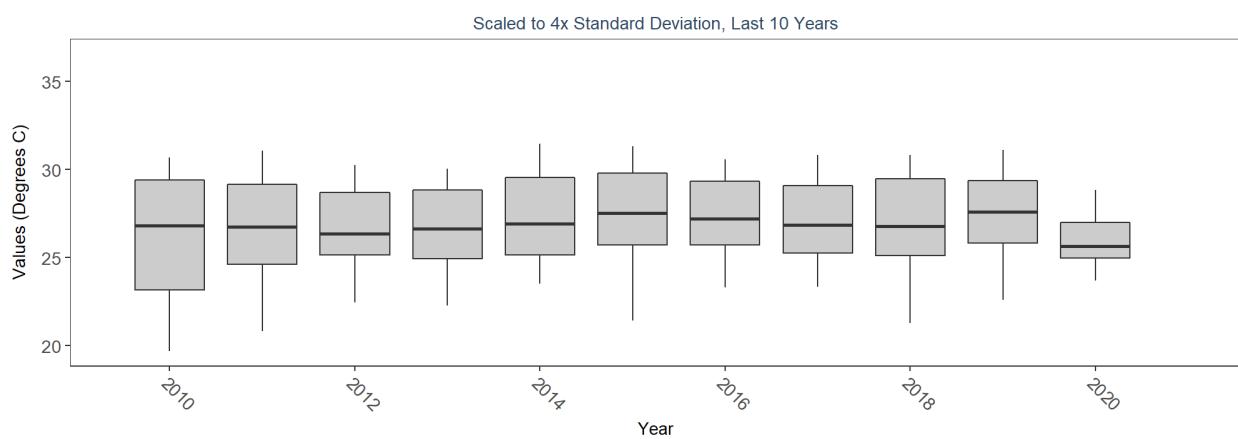
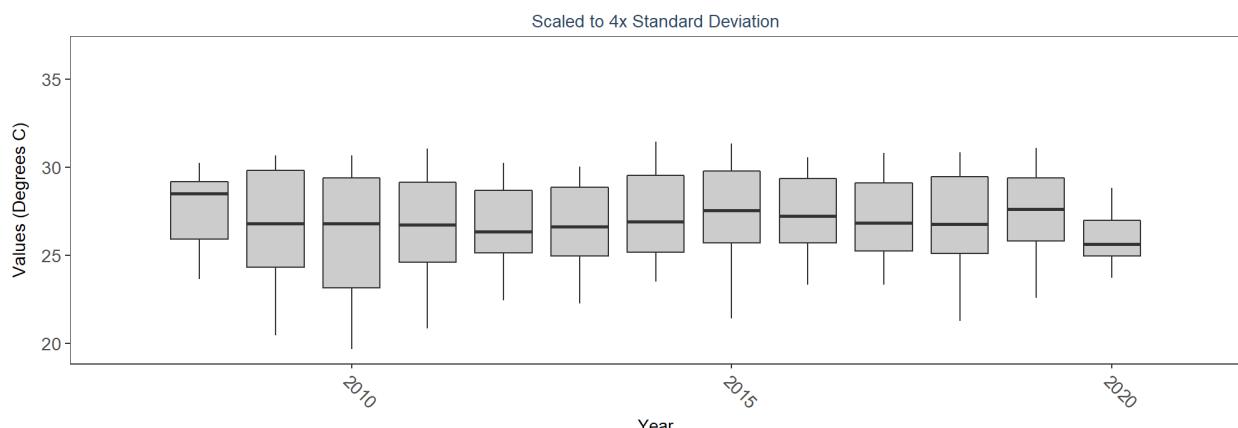
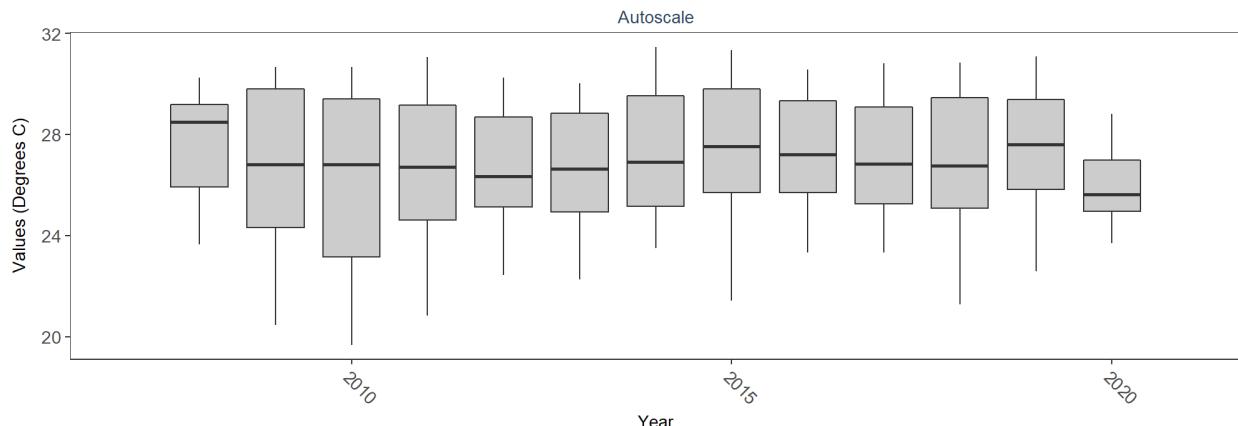
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



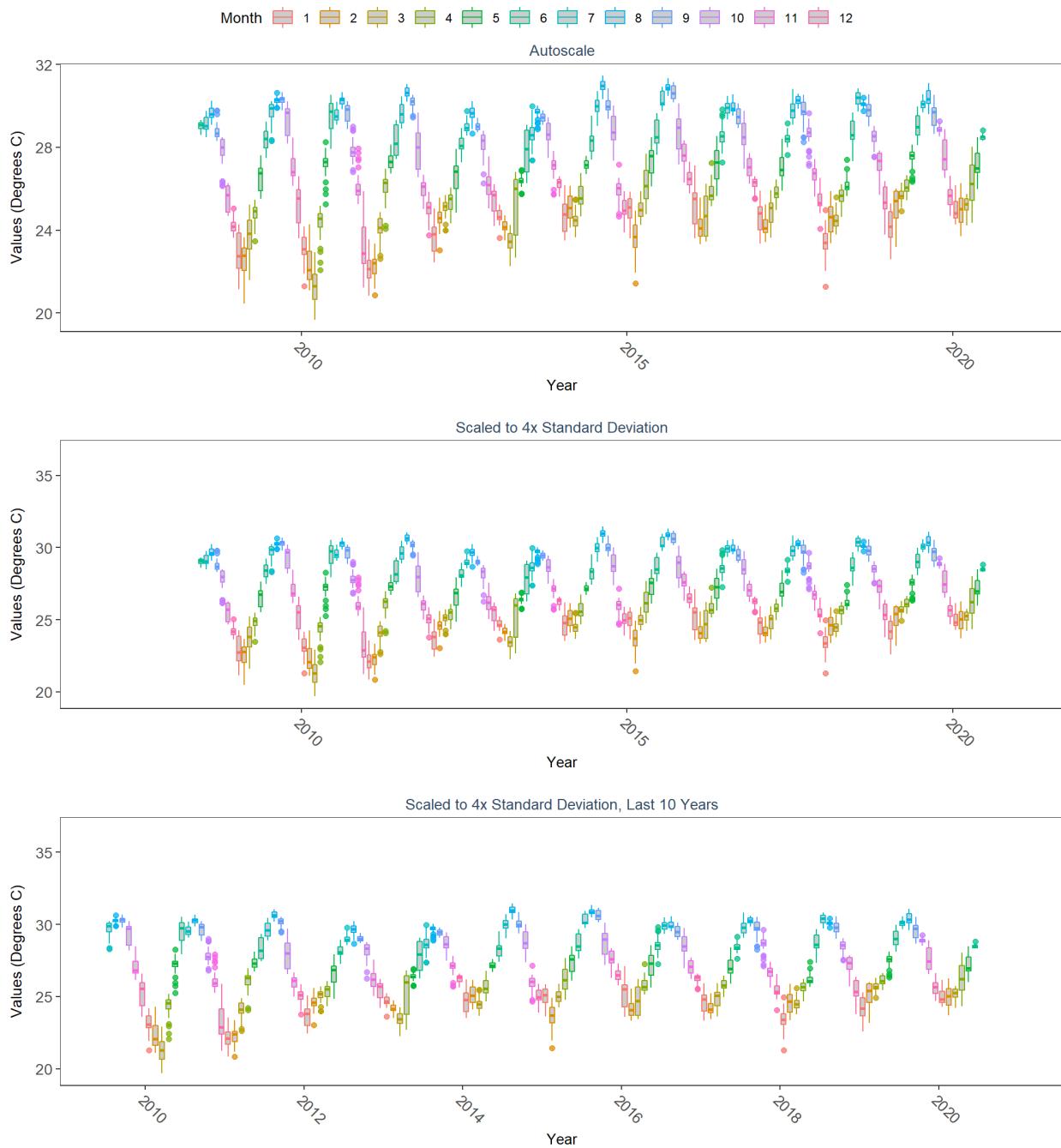
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Month



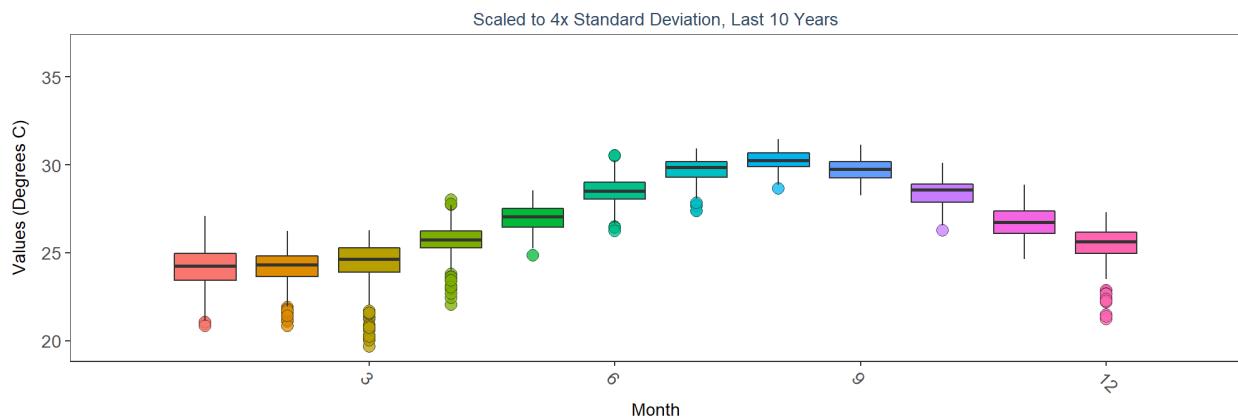
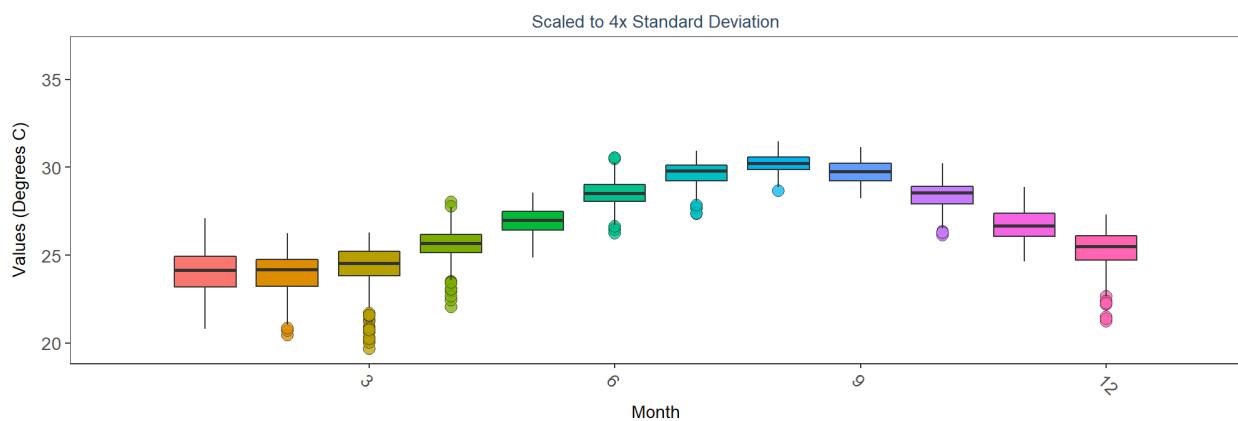
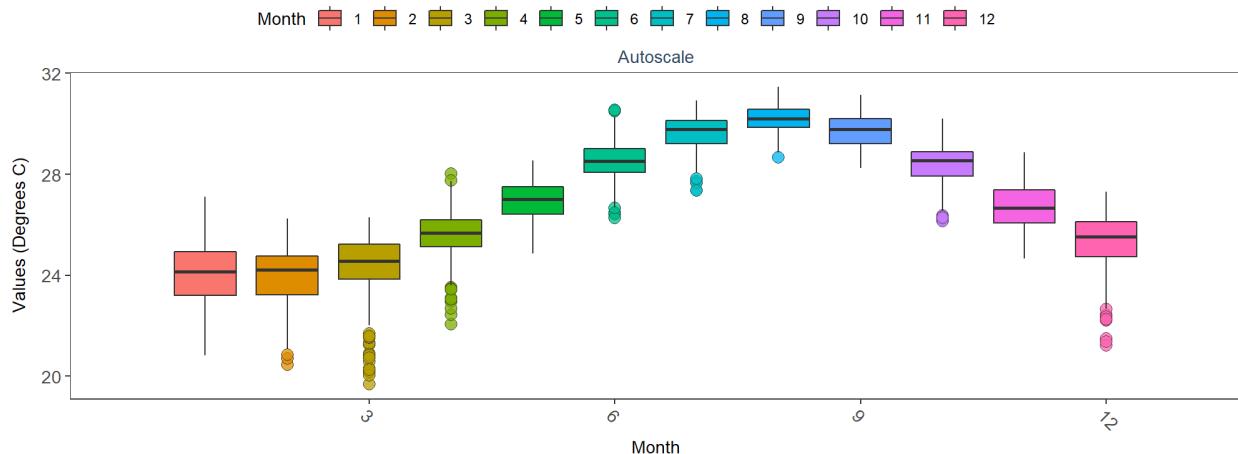
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 By Year



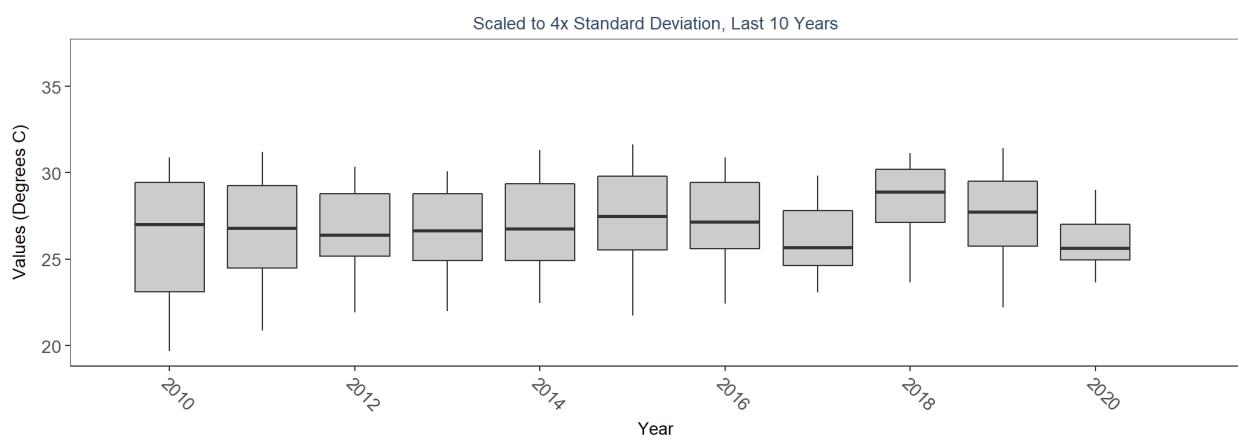
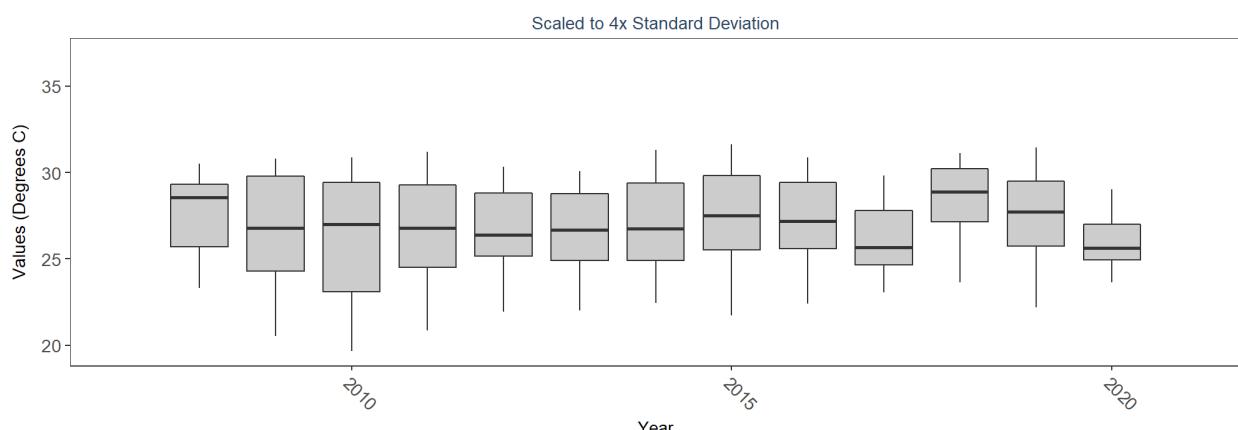
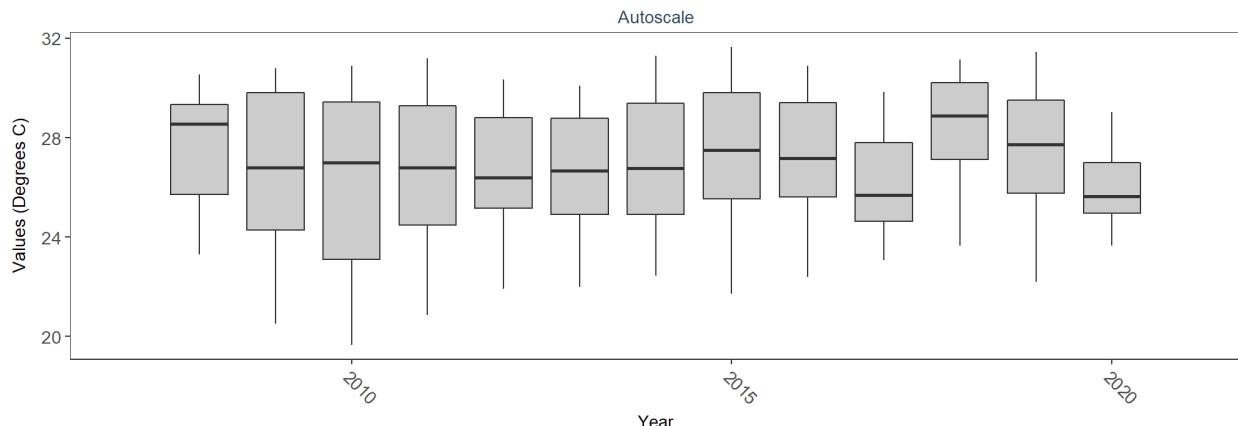
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



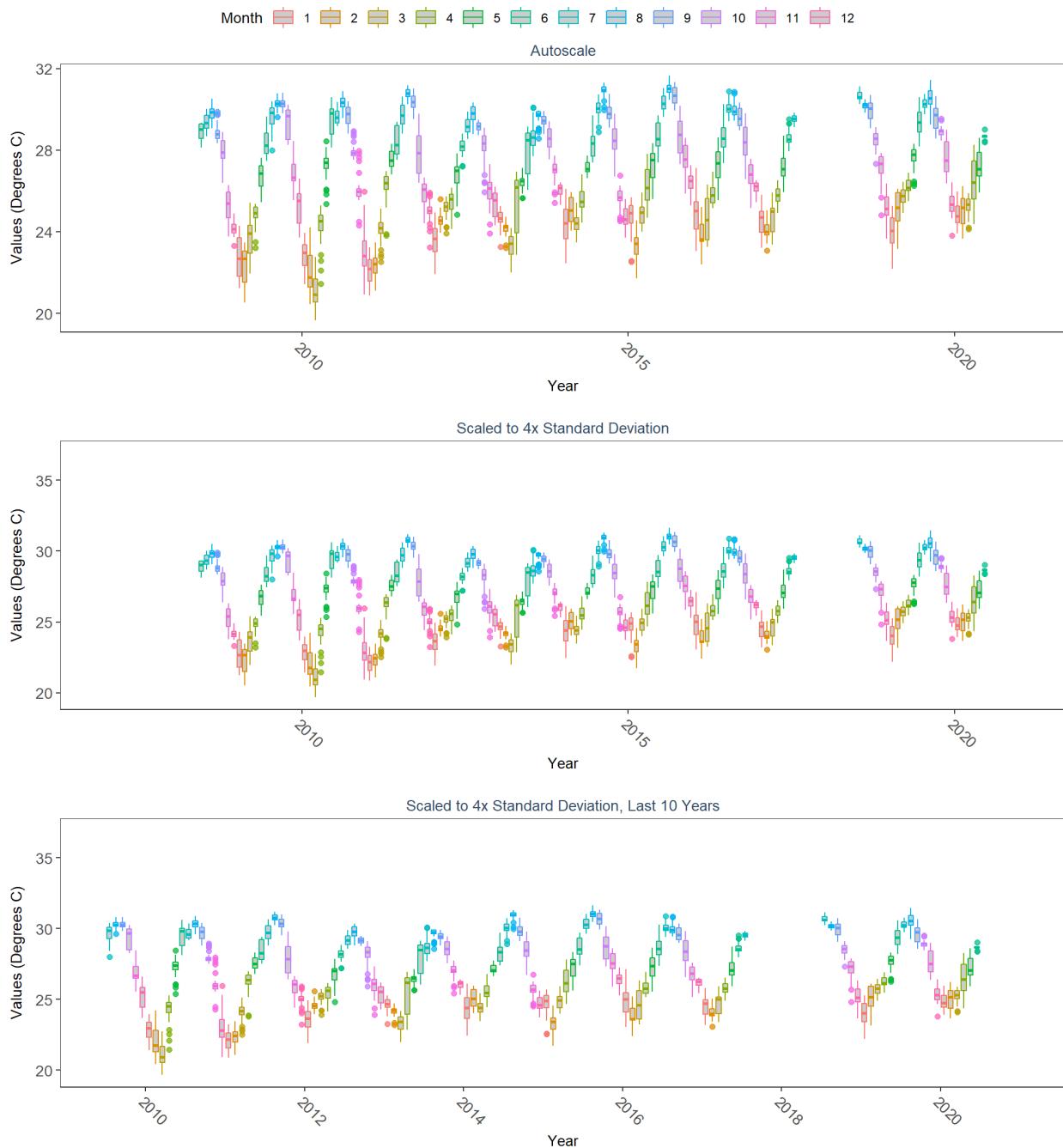
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Month



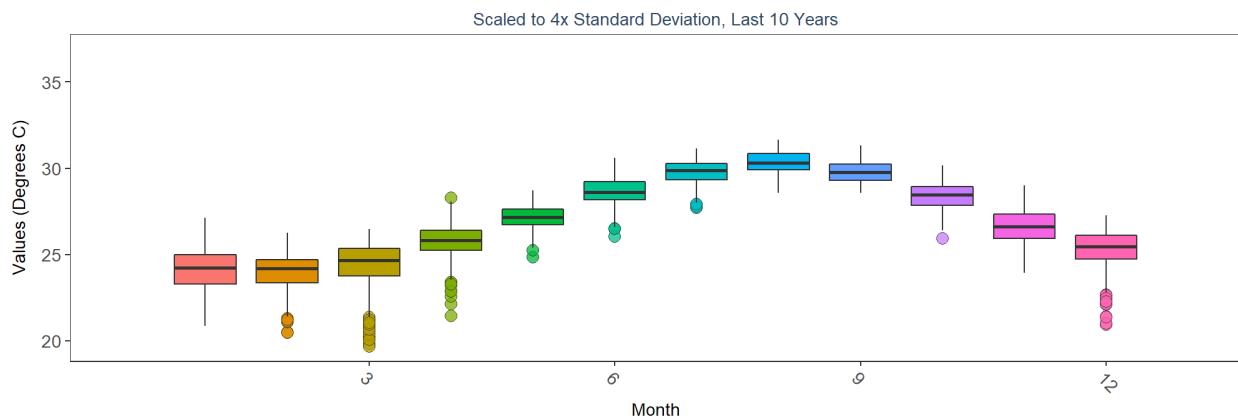
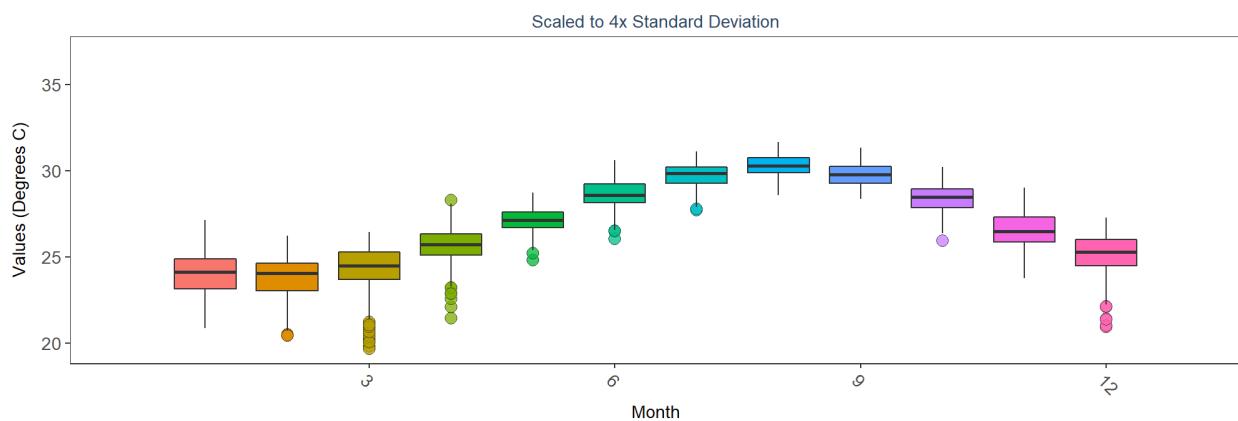
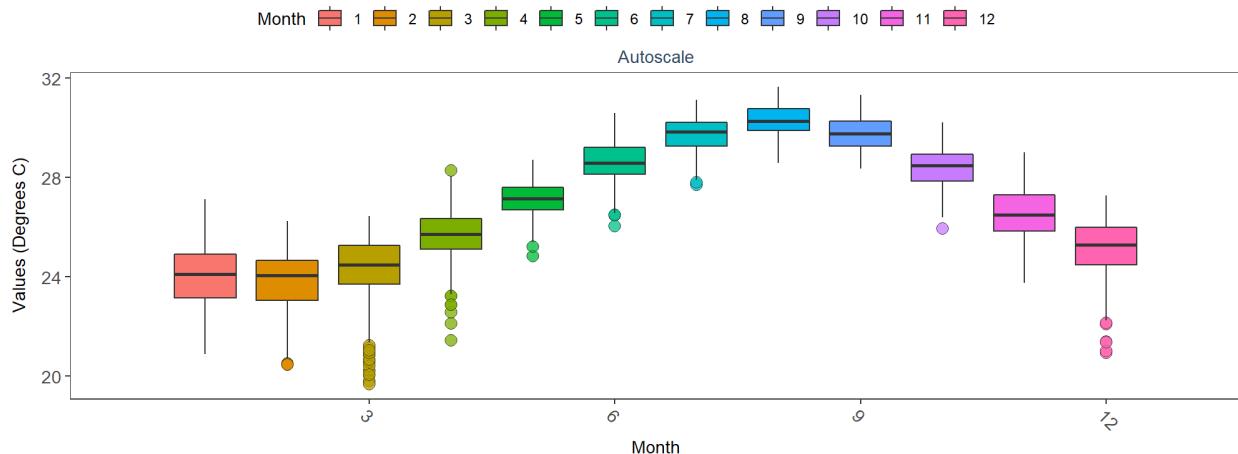
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53  
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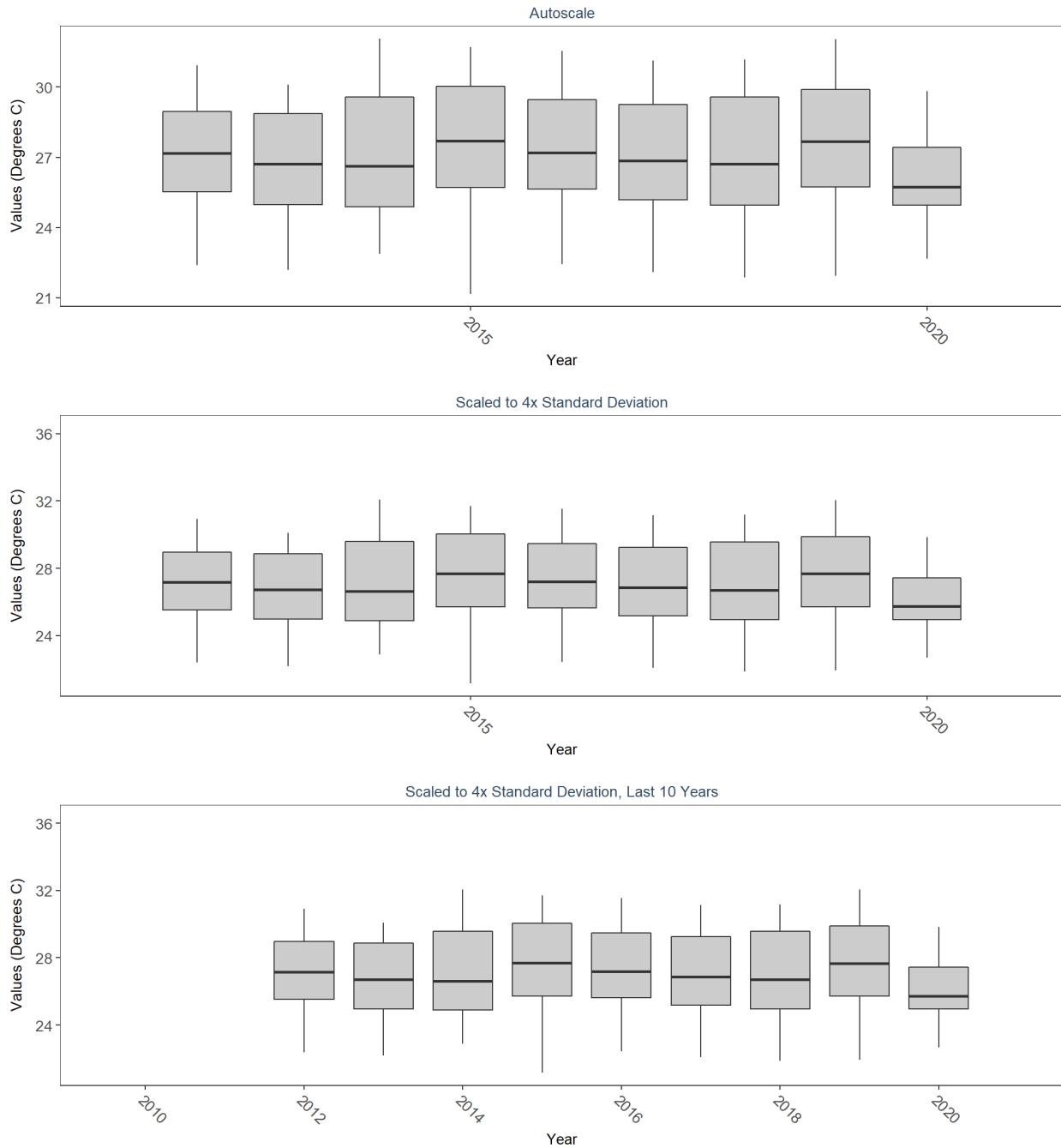
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



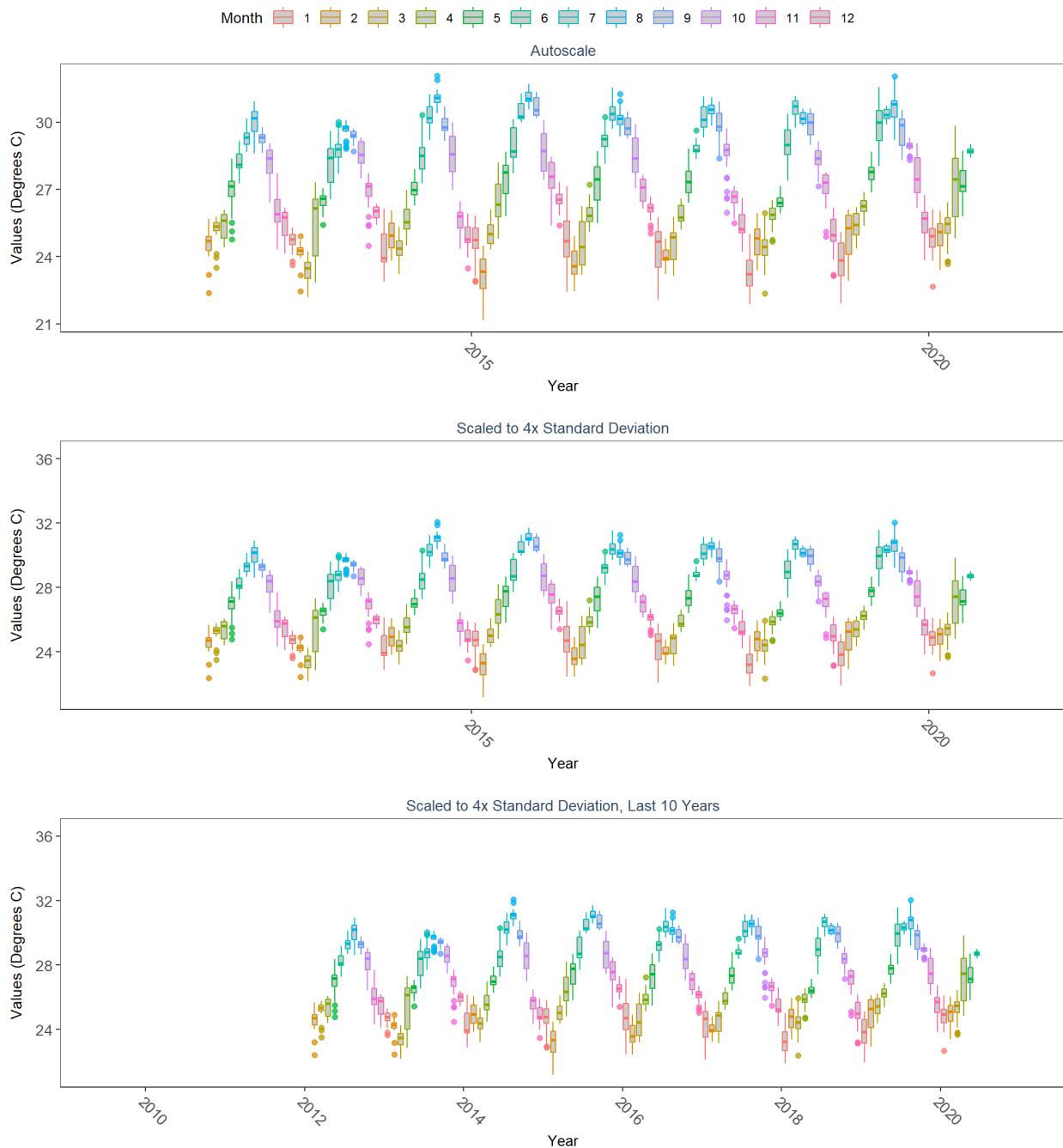
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 By Month



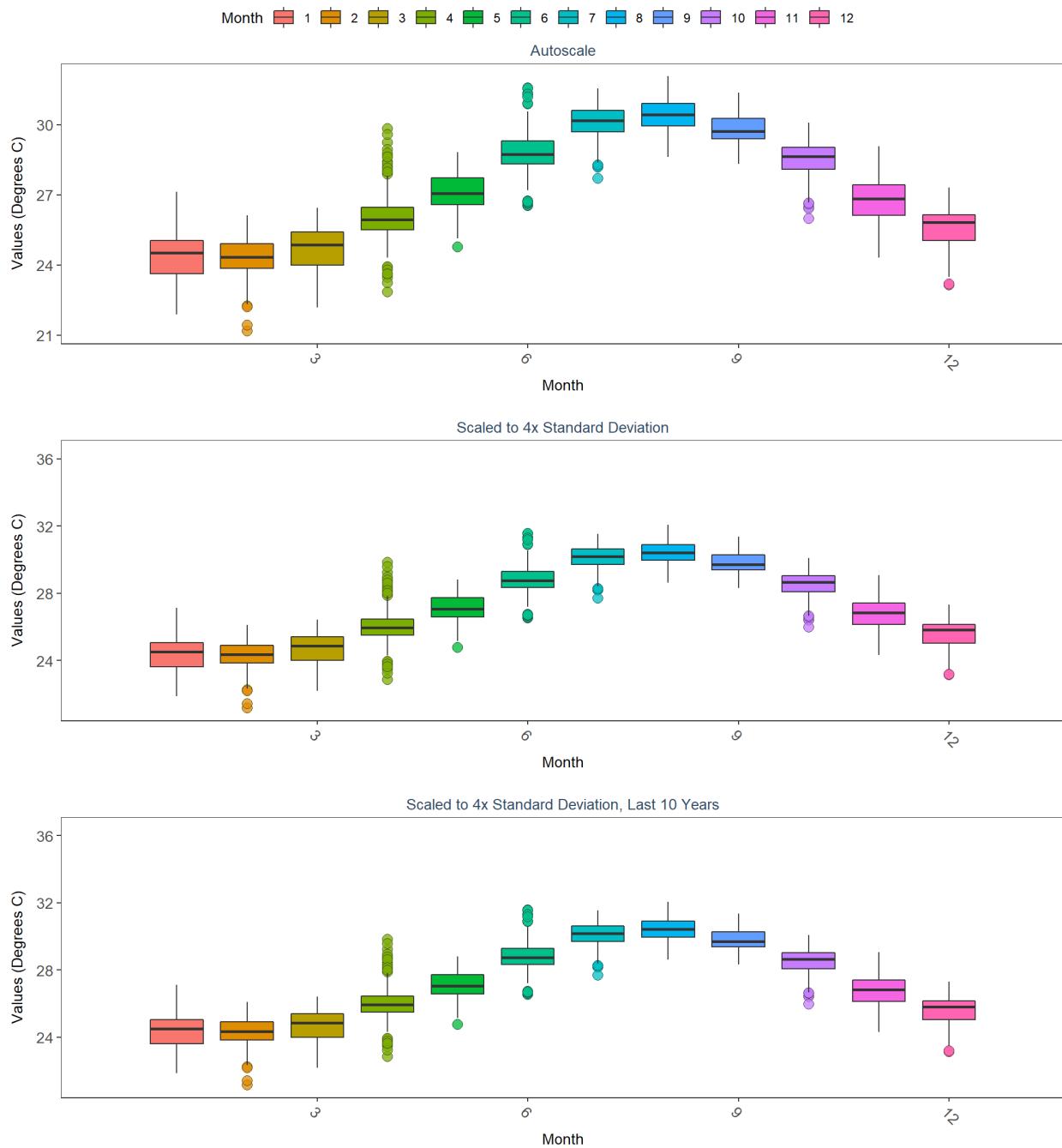
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Water Temperature on Coral Reefs in the Florida Keys  
54  
By Year



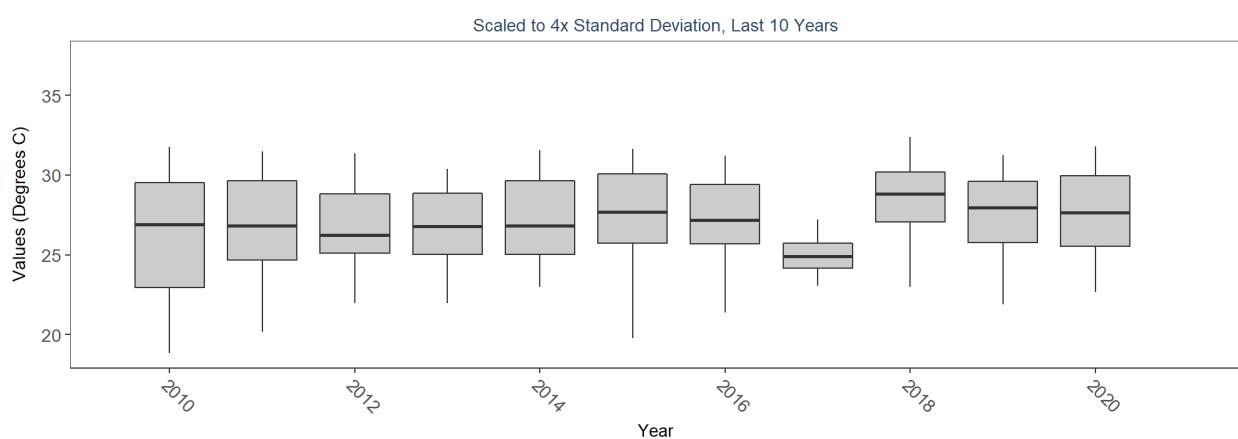
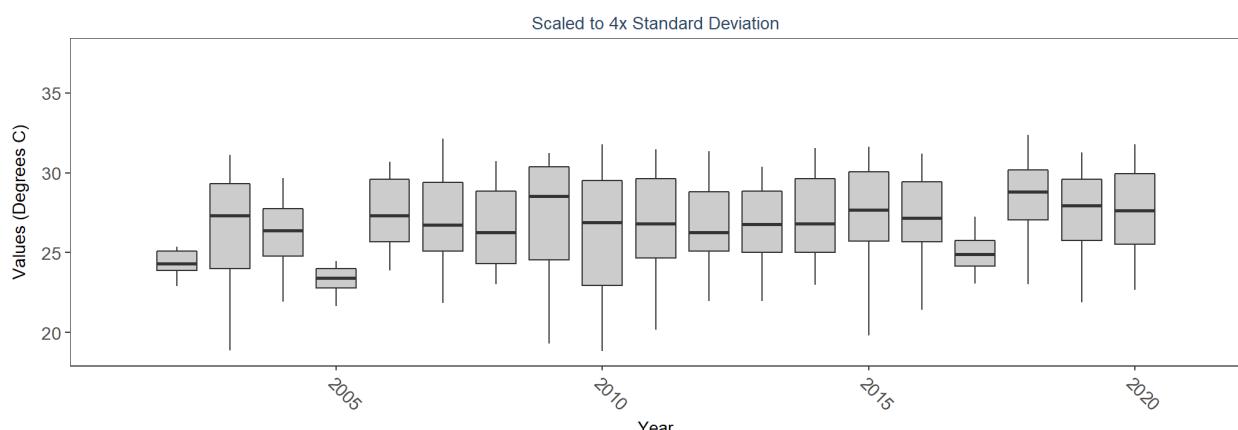
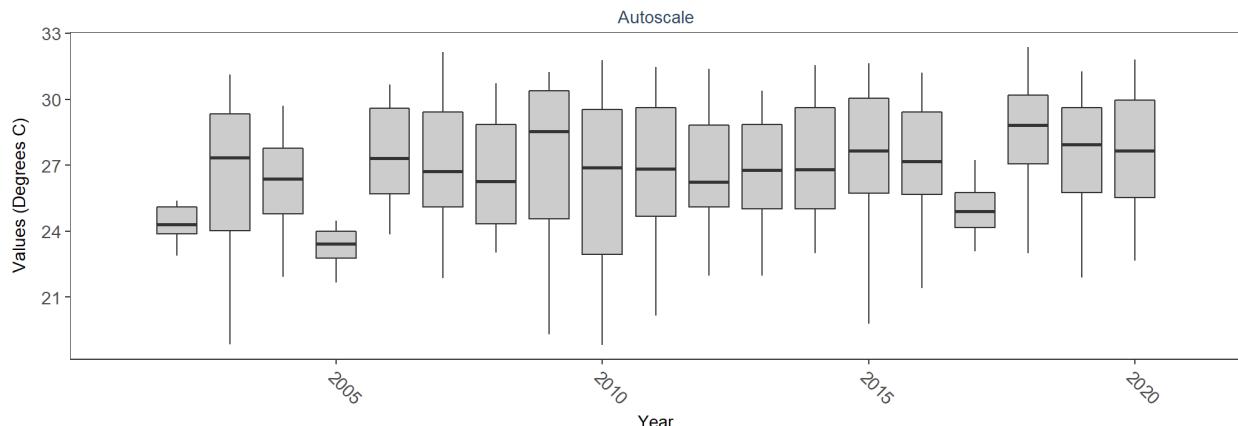
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



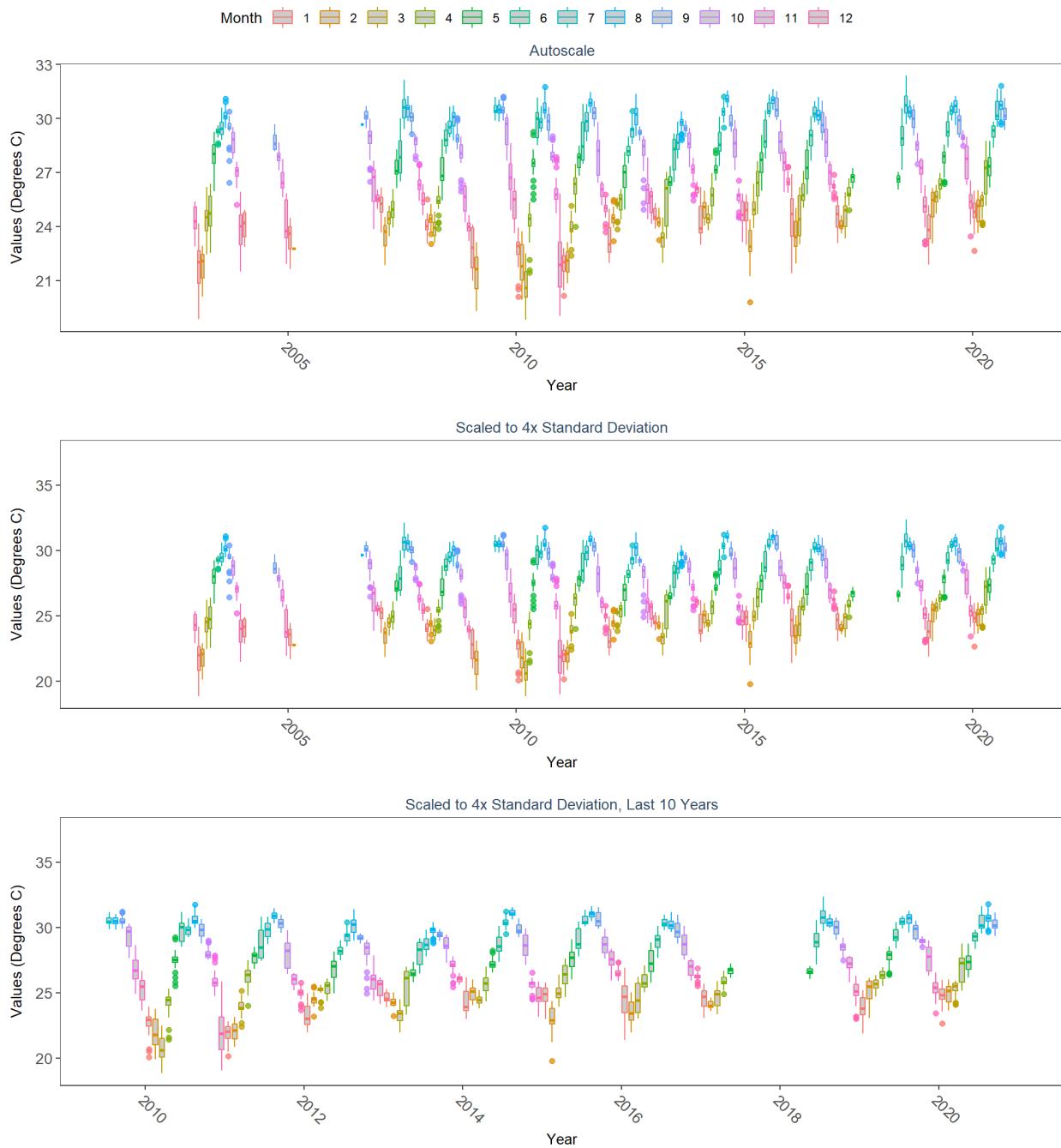
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 By Month



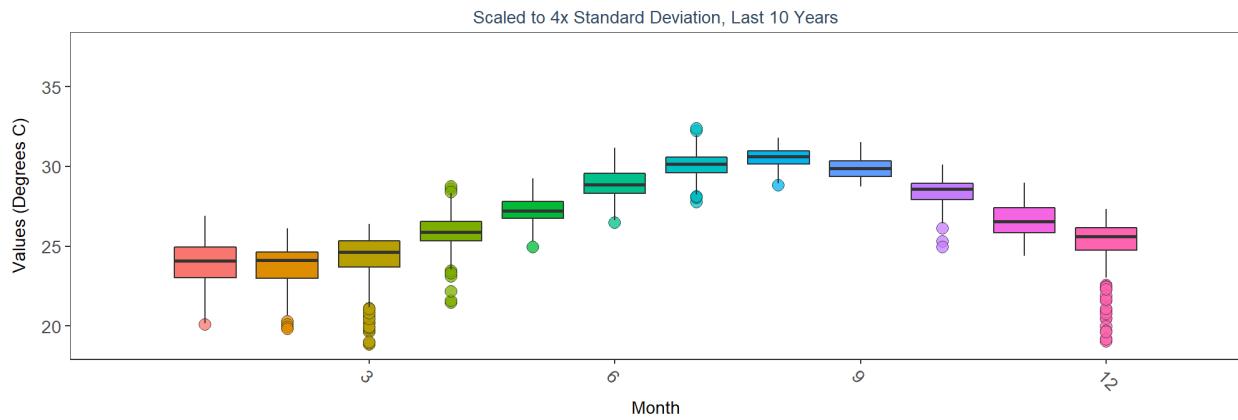
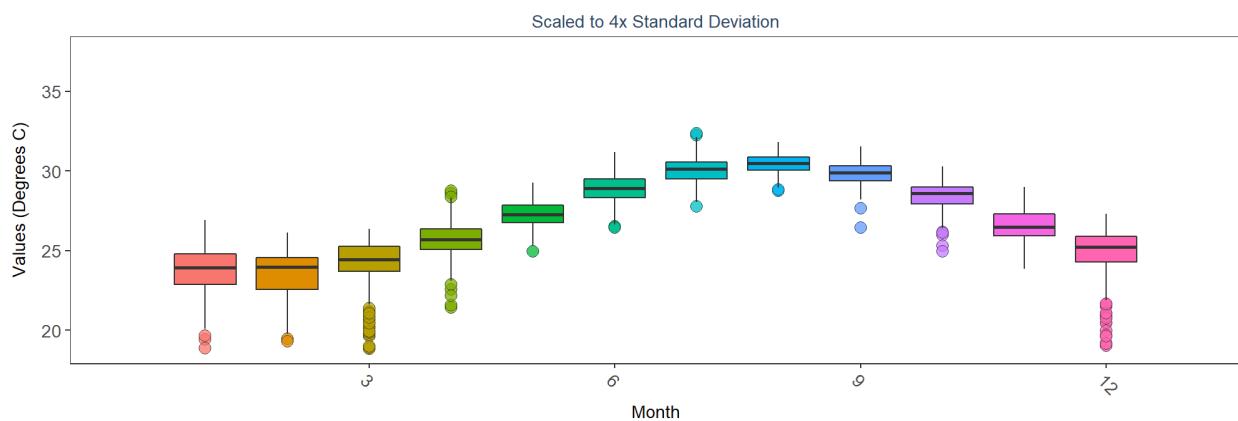
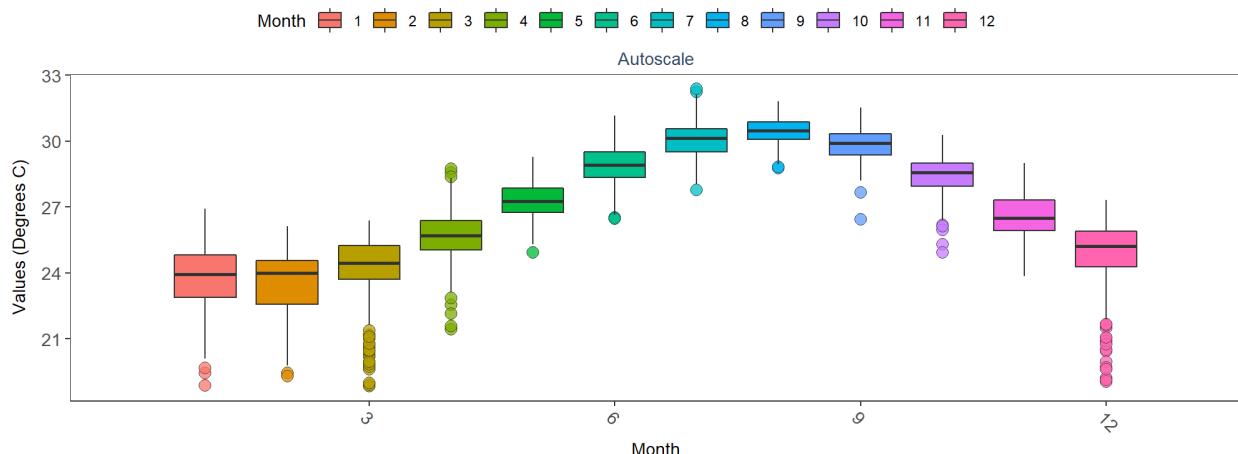
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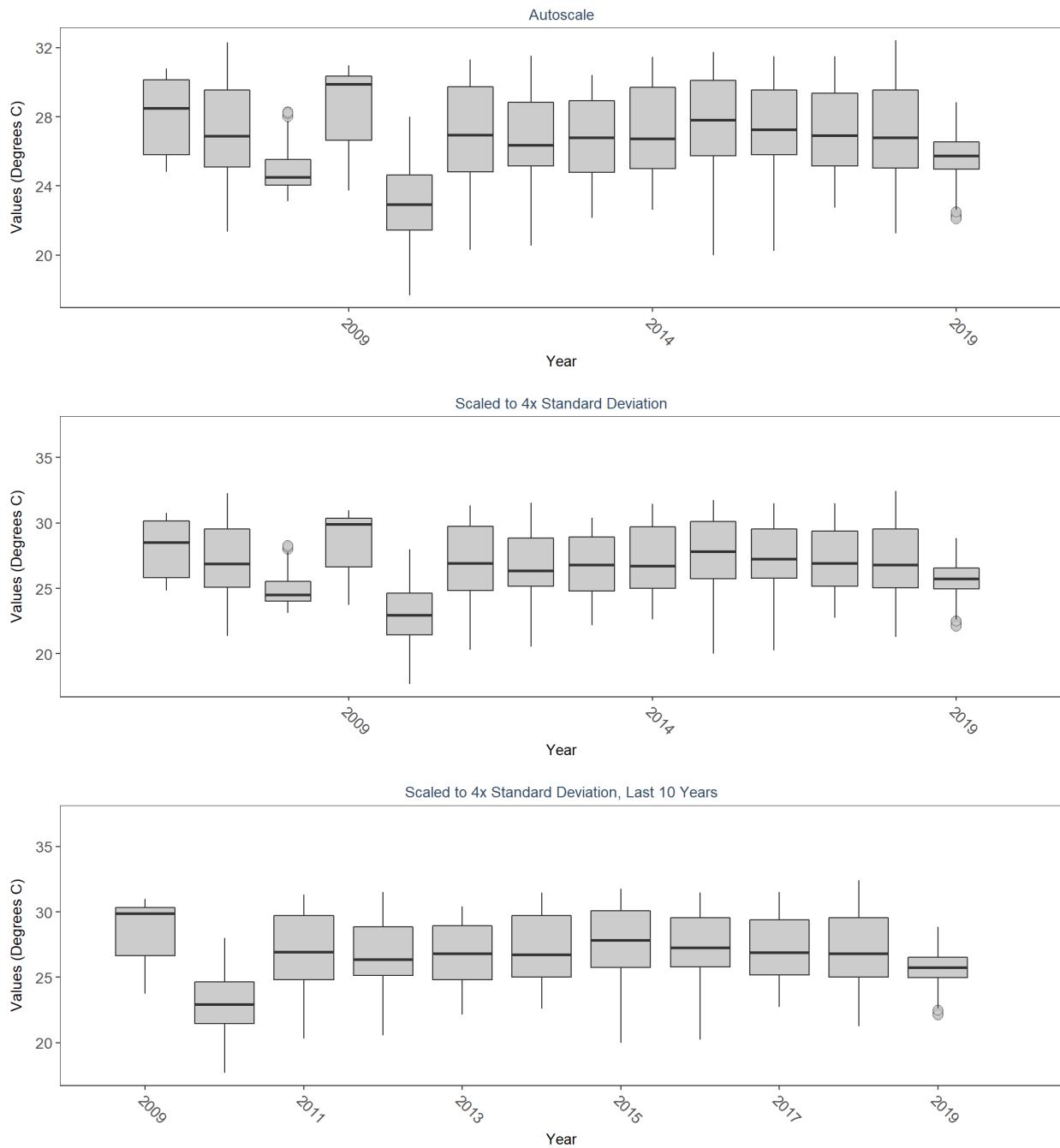
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



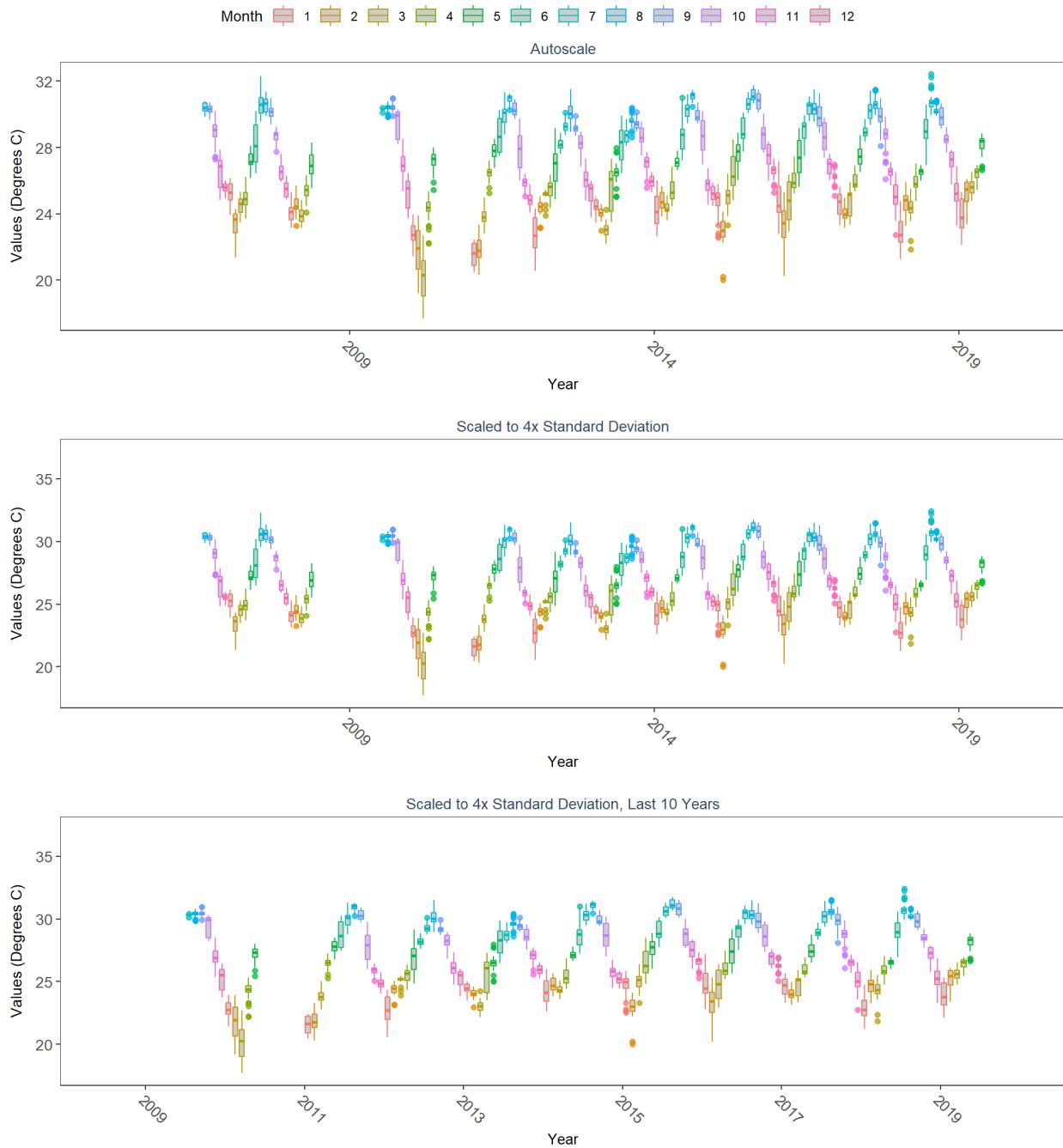
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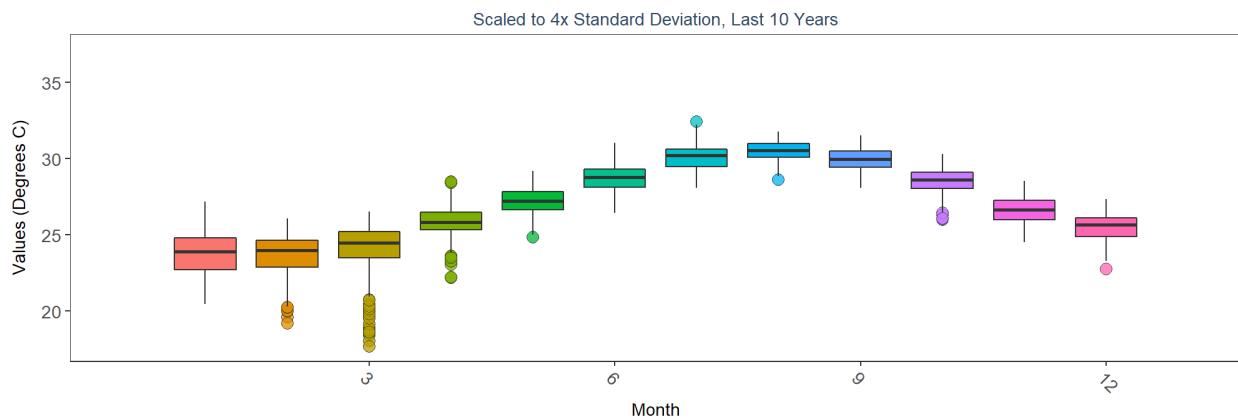
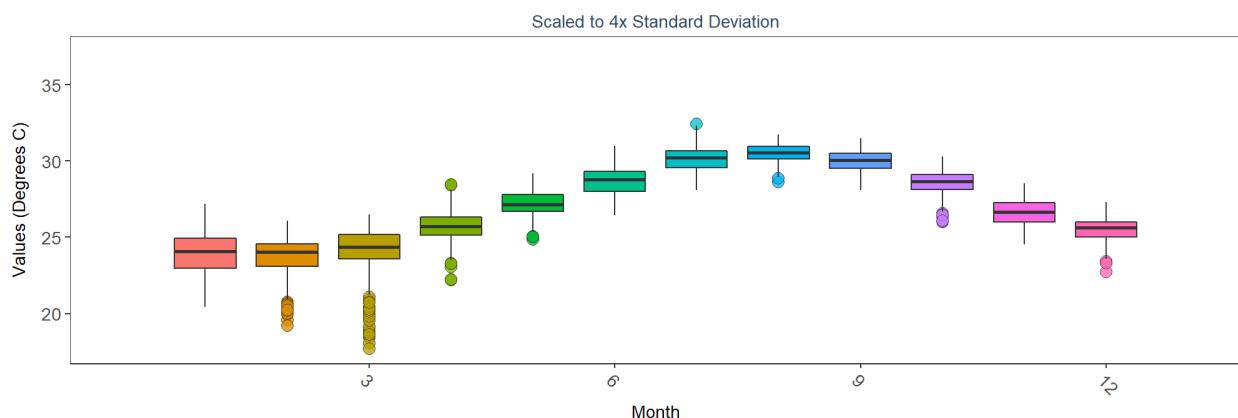
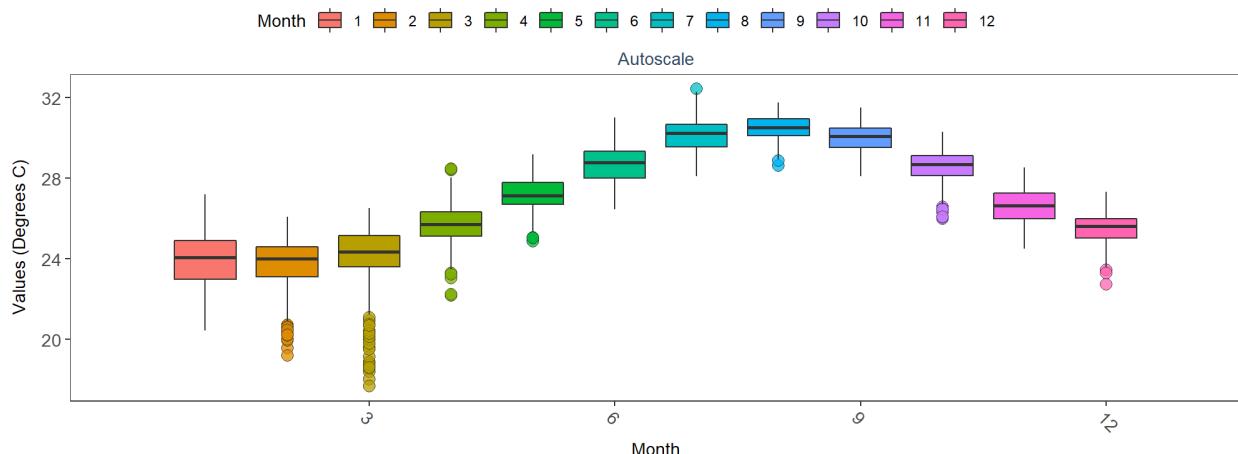
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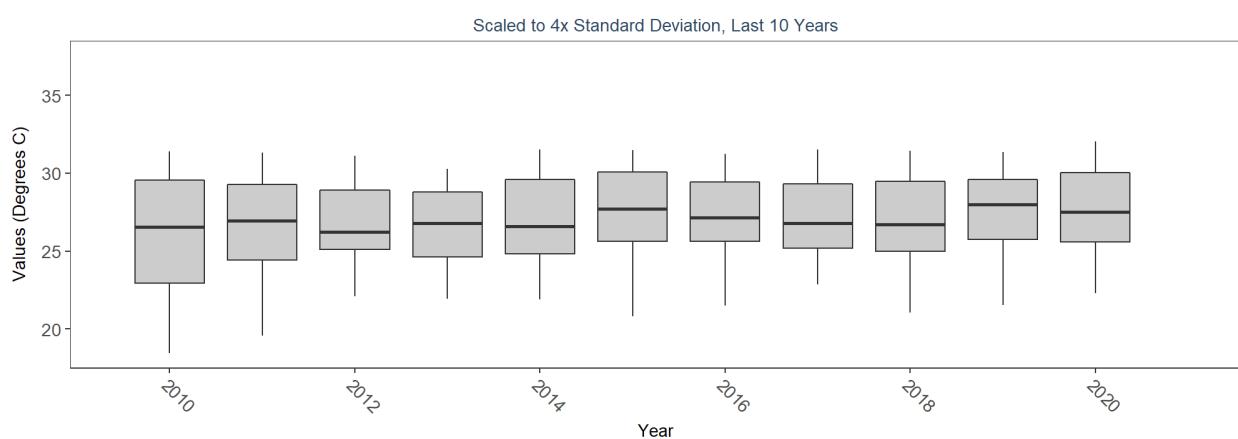
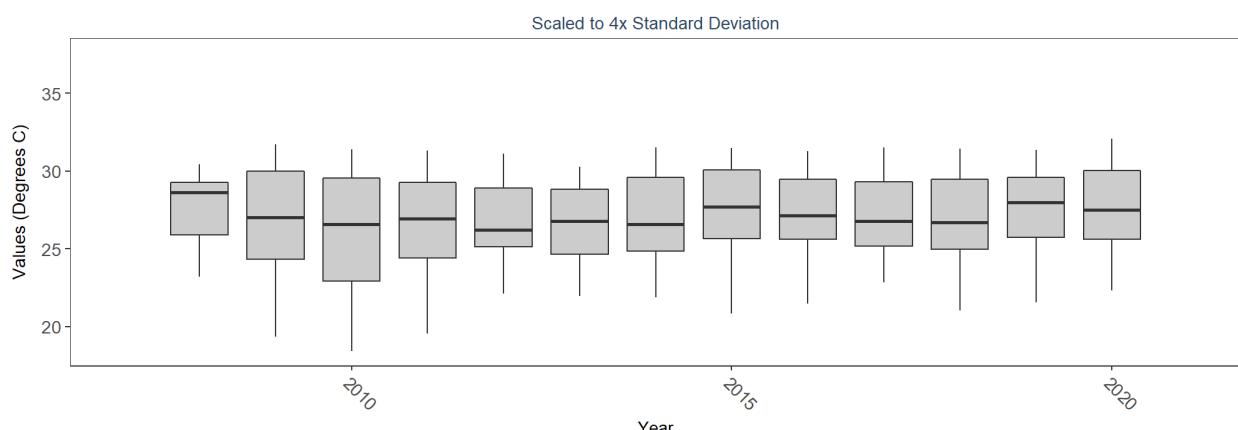
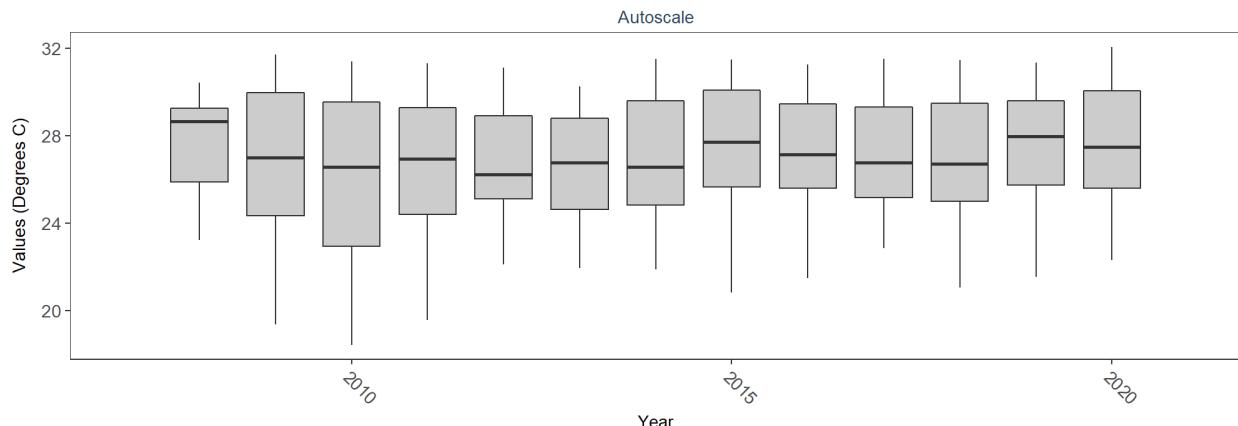
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 By Year & Month



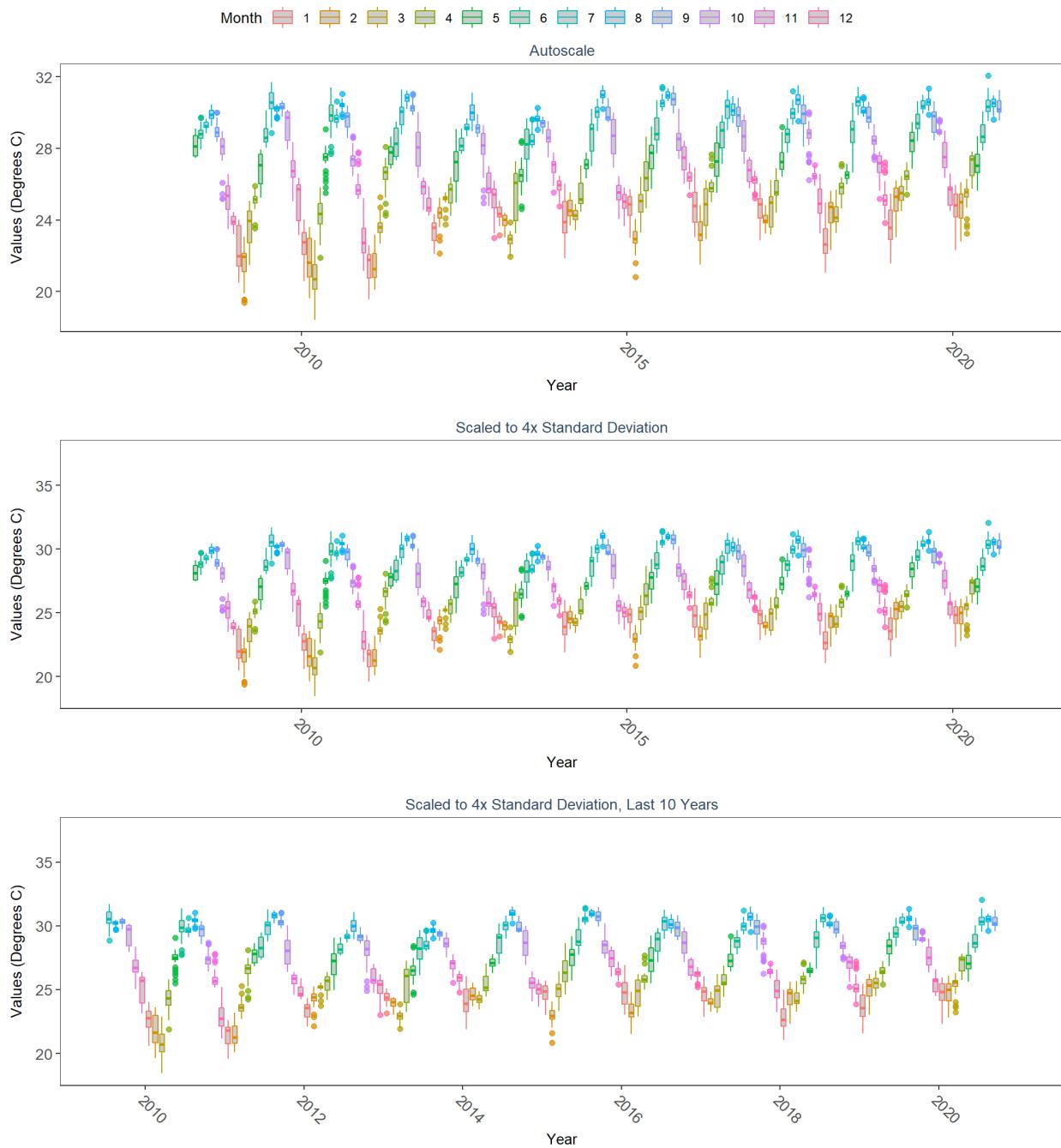
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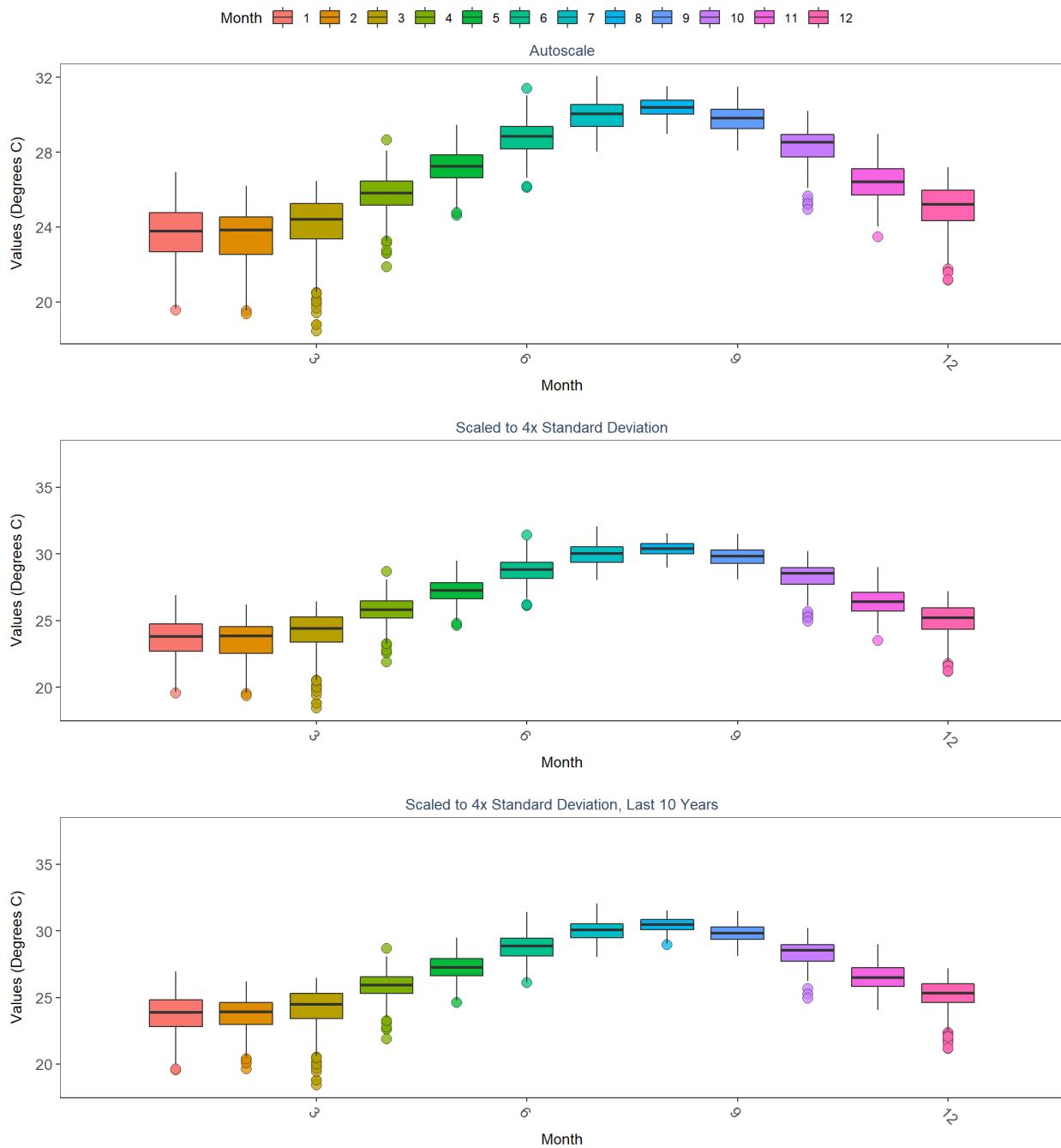
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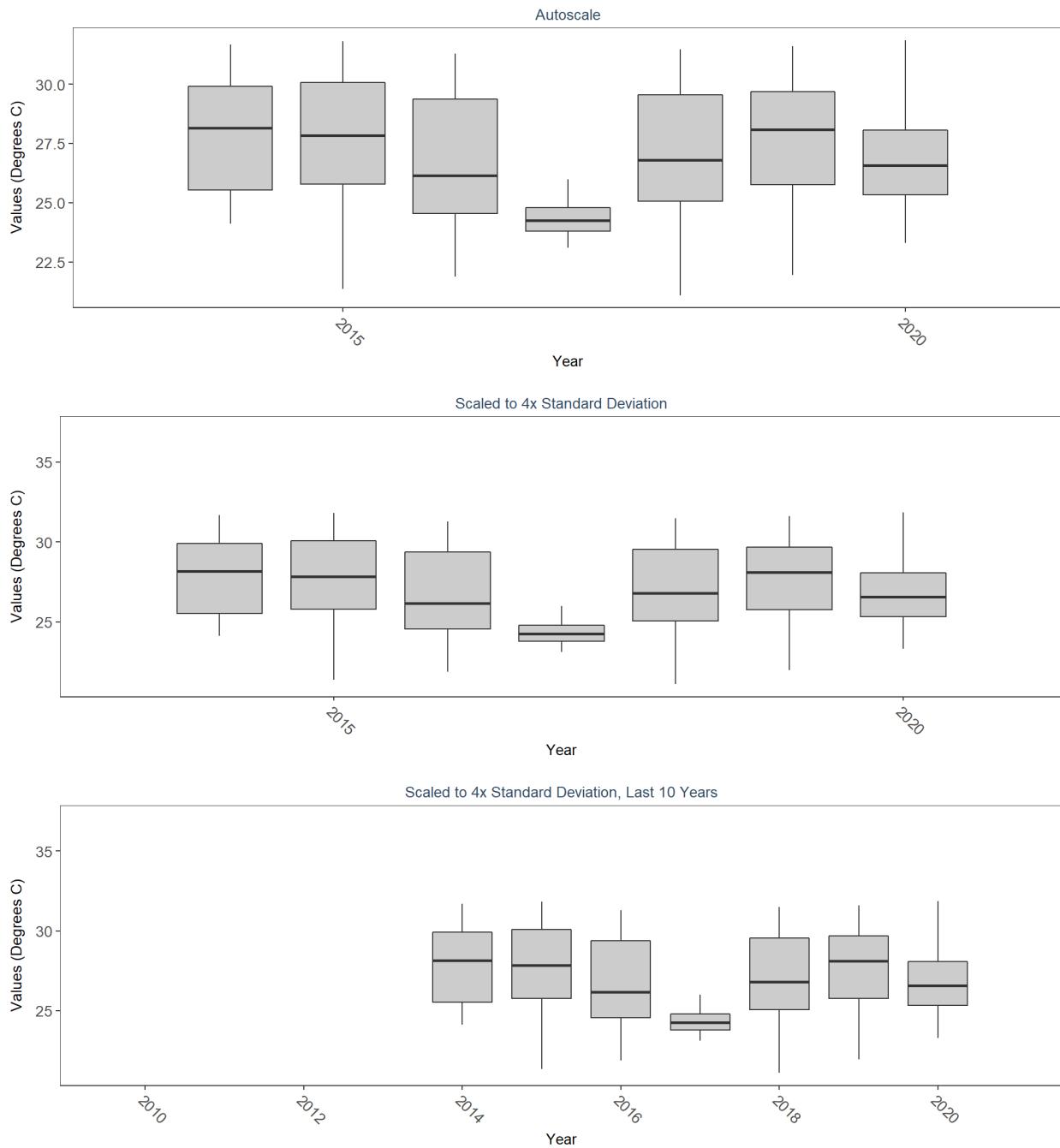
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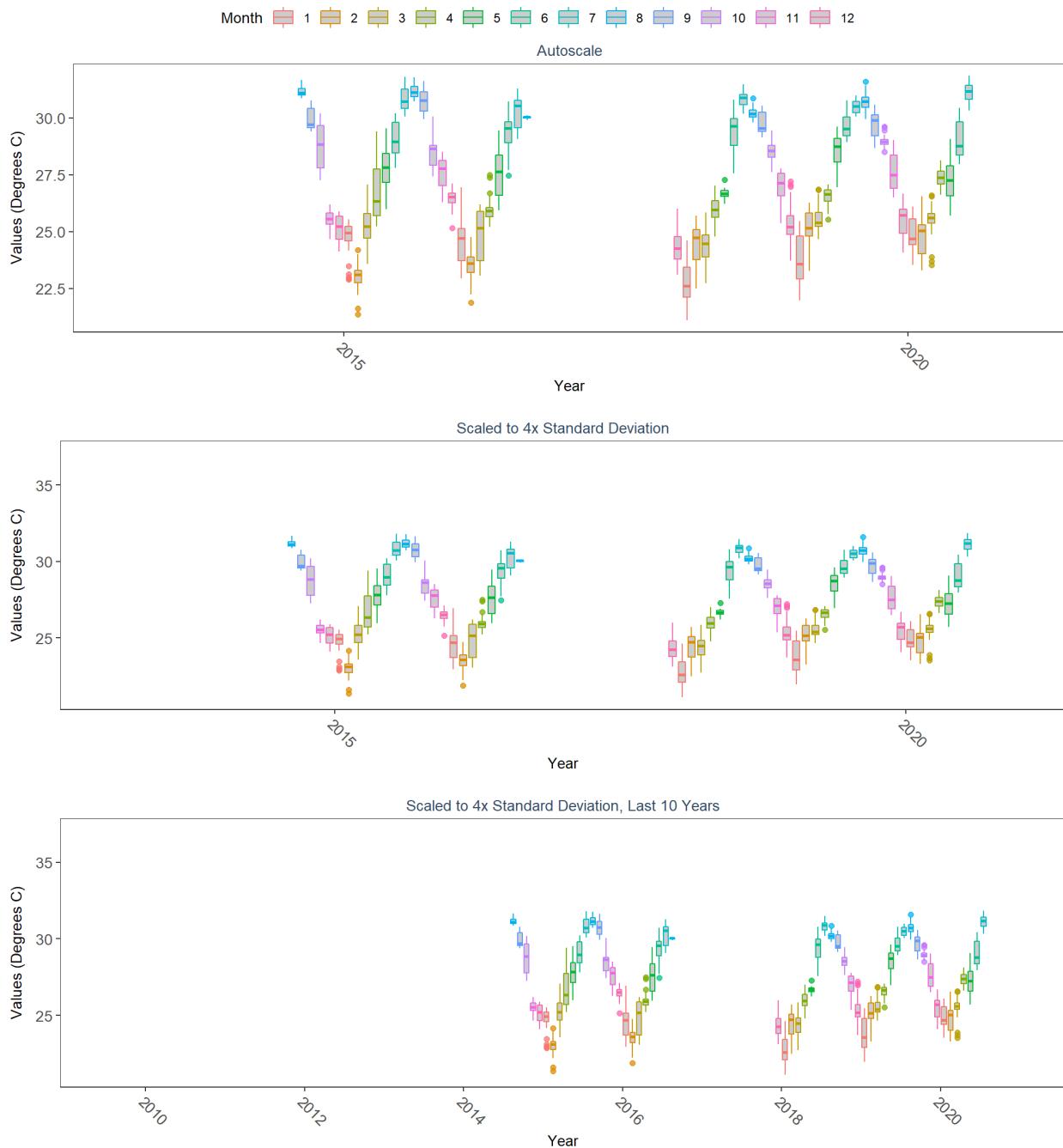
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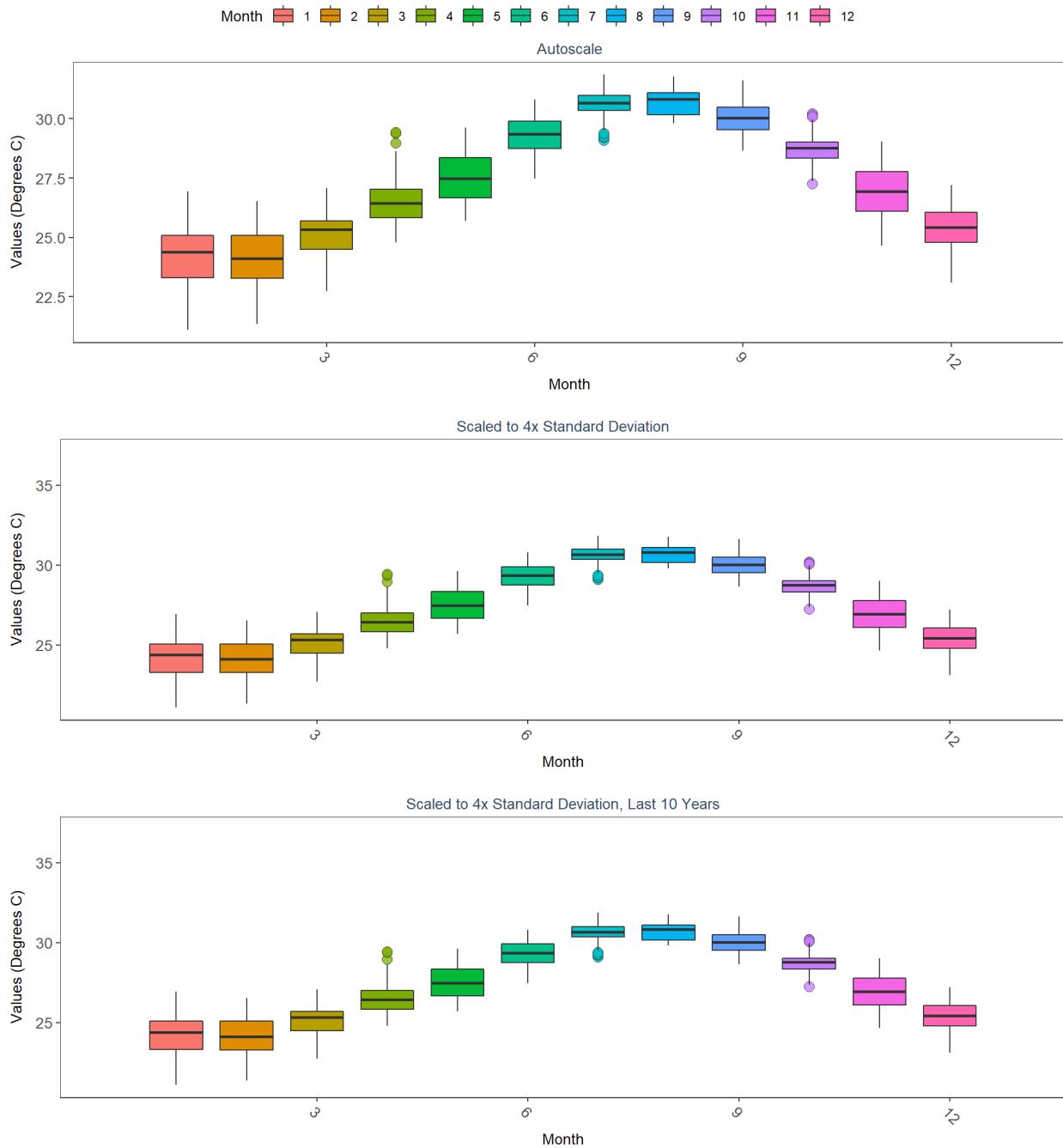
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By Year



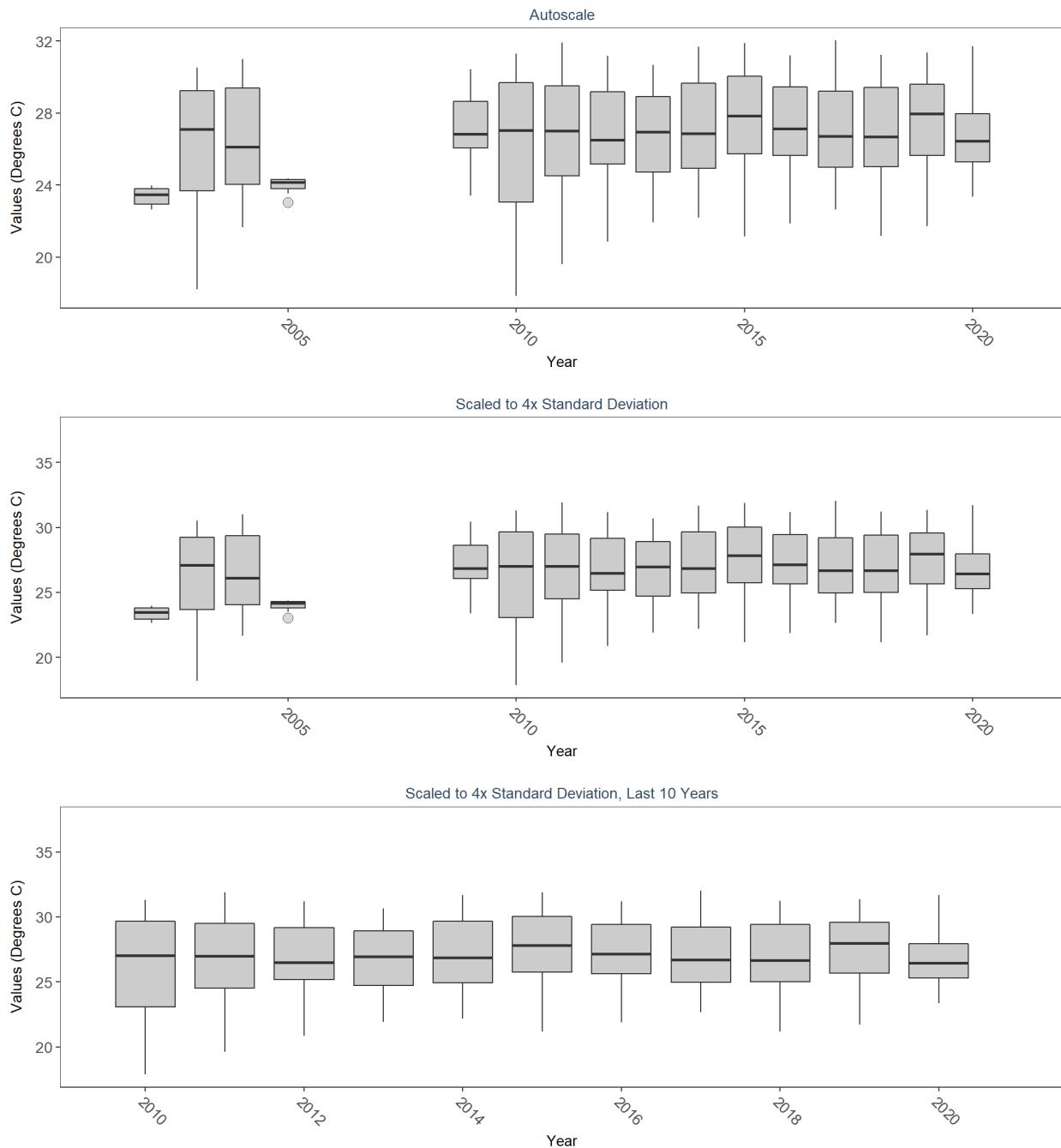
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 By Year & Month



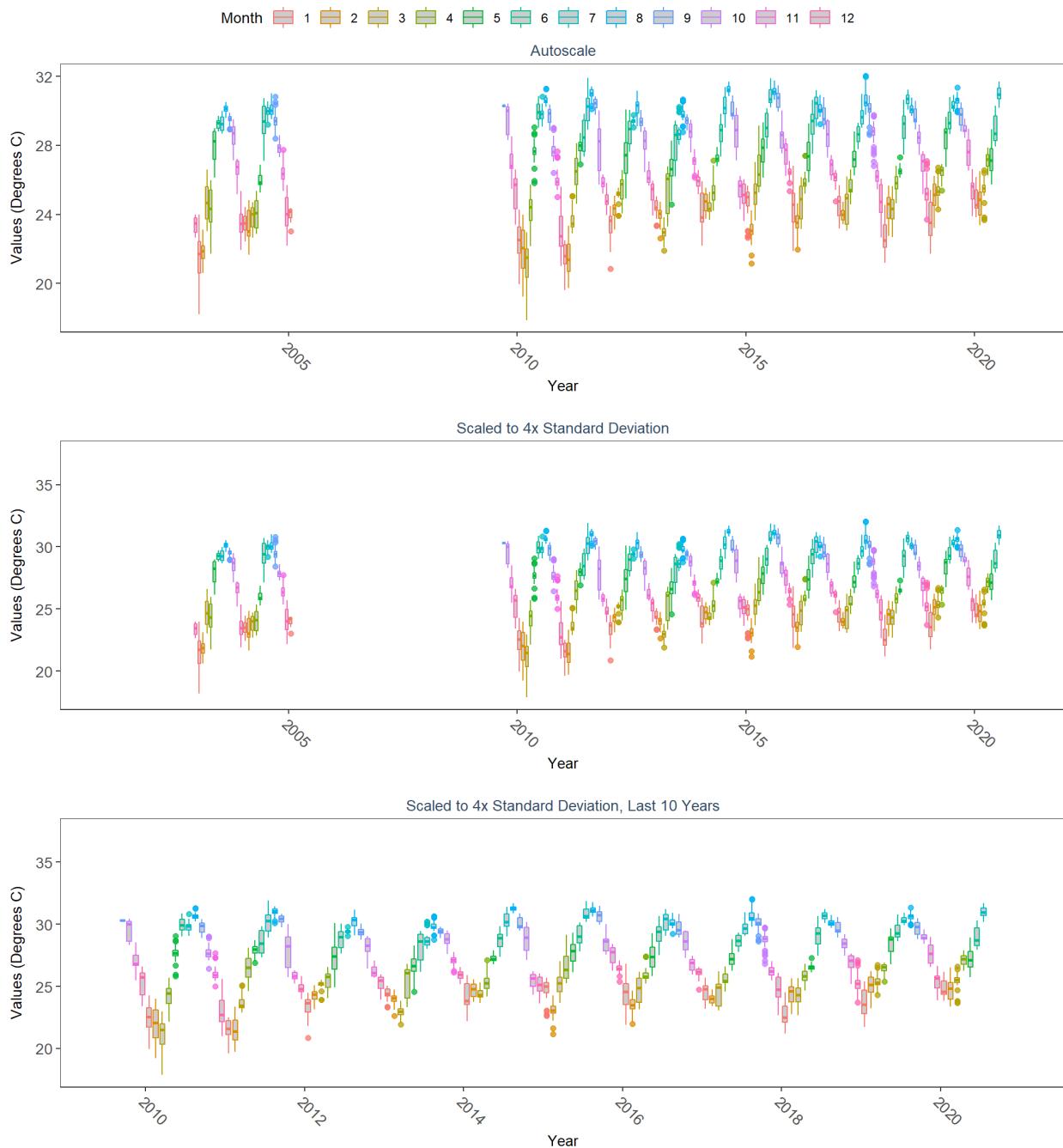
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 By Month



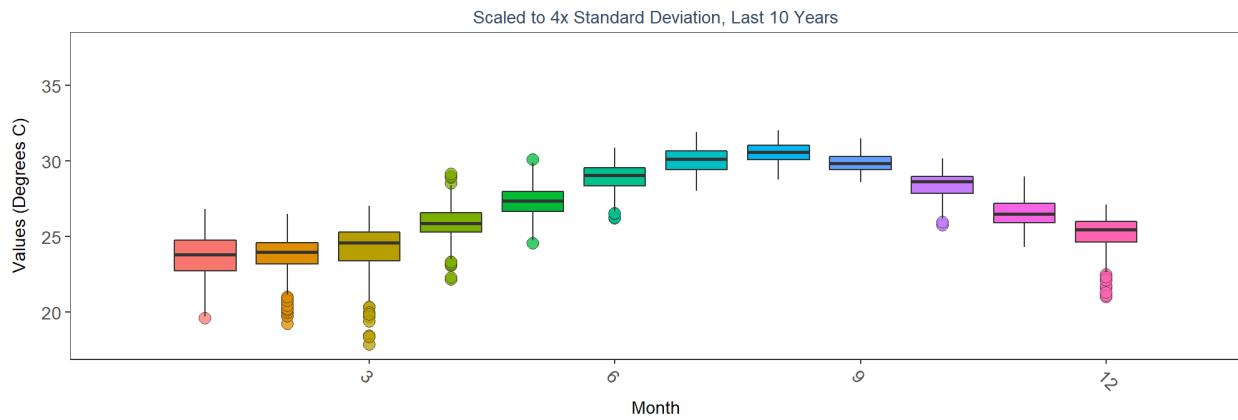
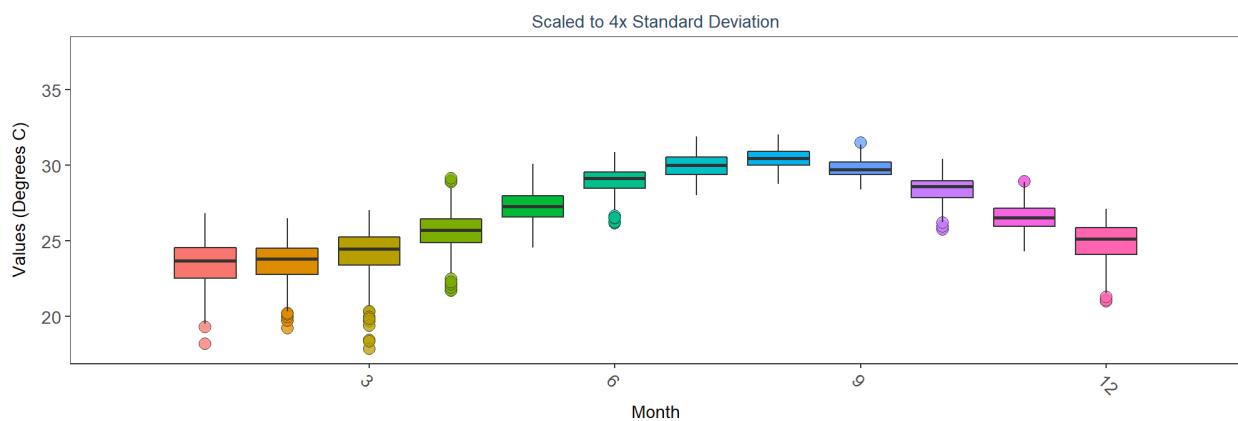
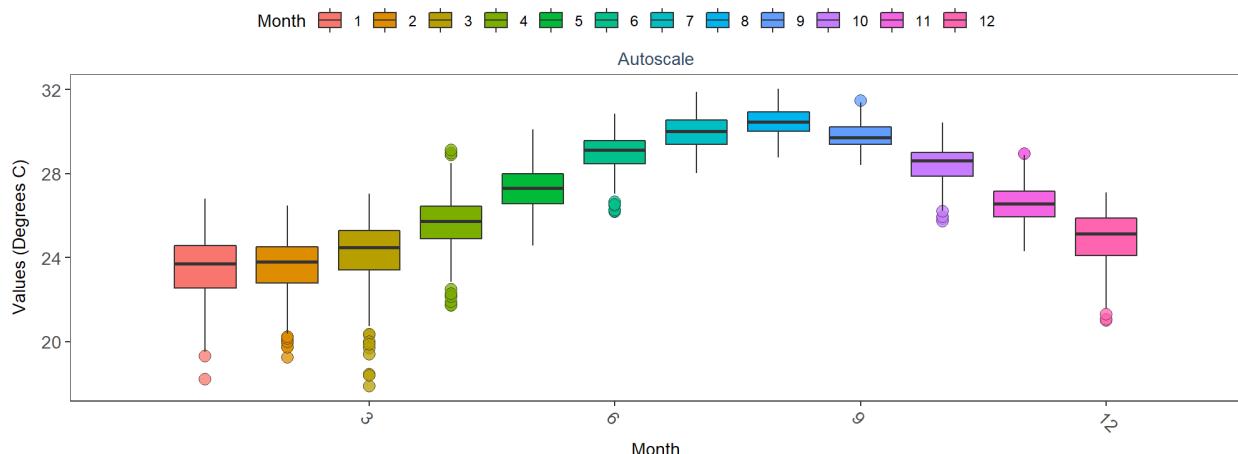
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 By Year



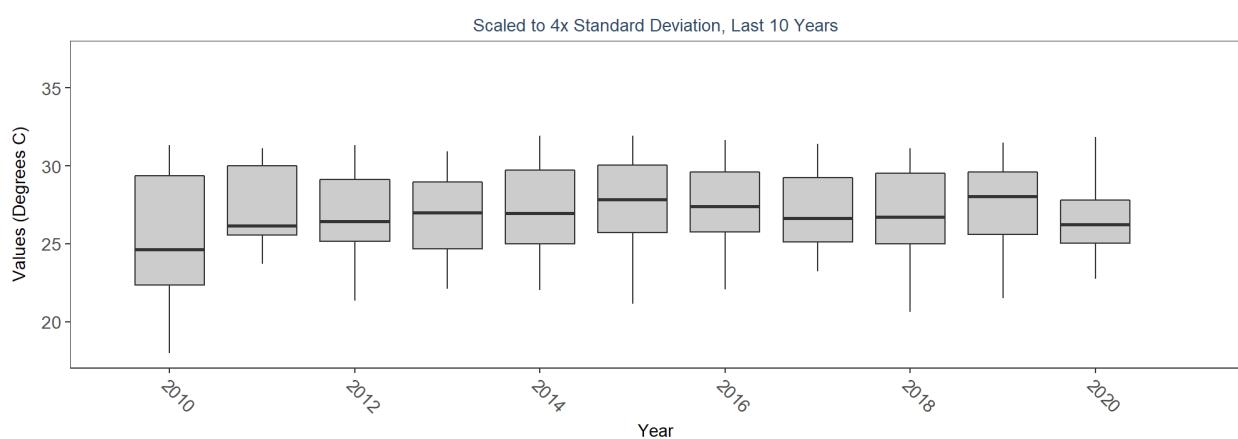
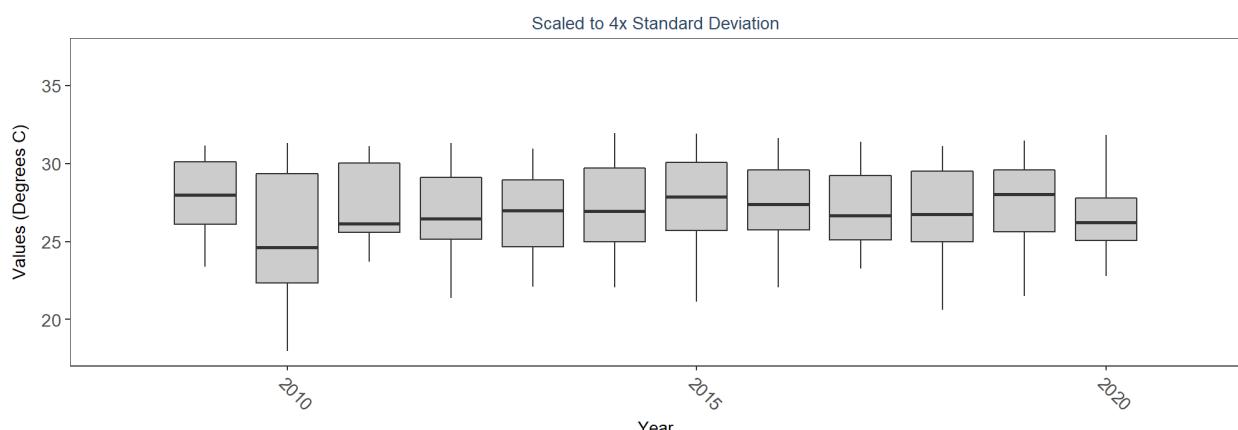
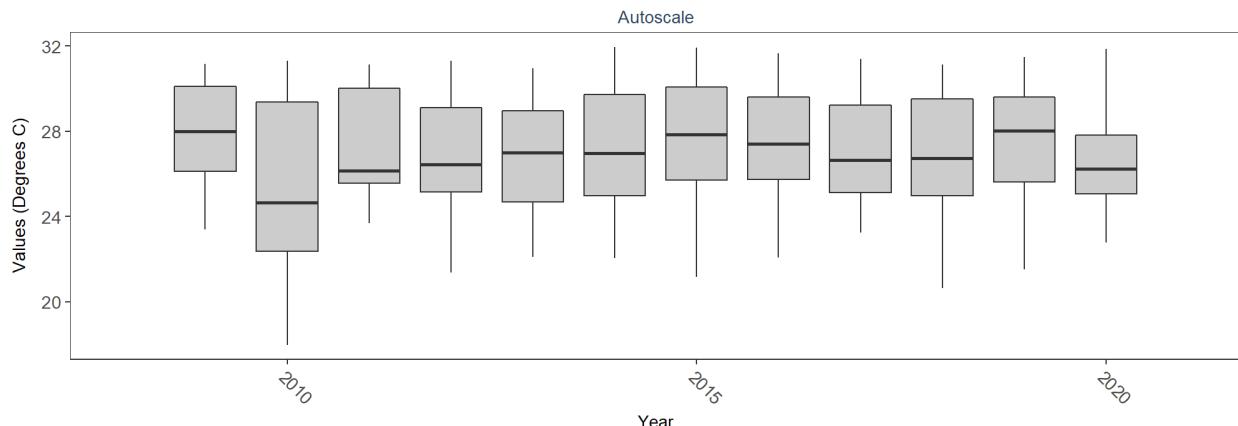
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 Water Temperature on Coral Reefs in the Florida Keys  
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 By Year & Month



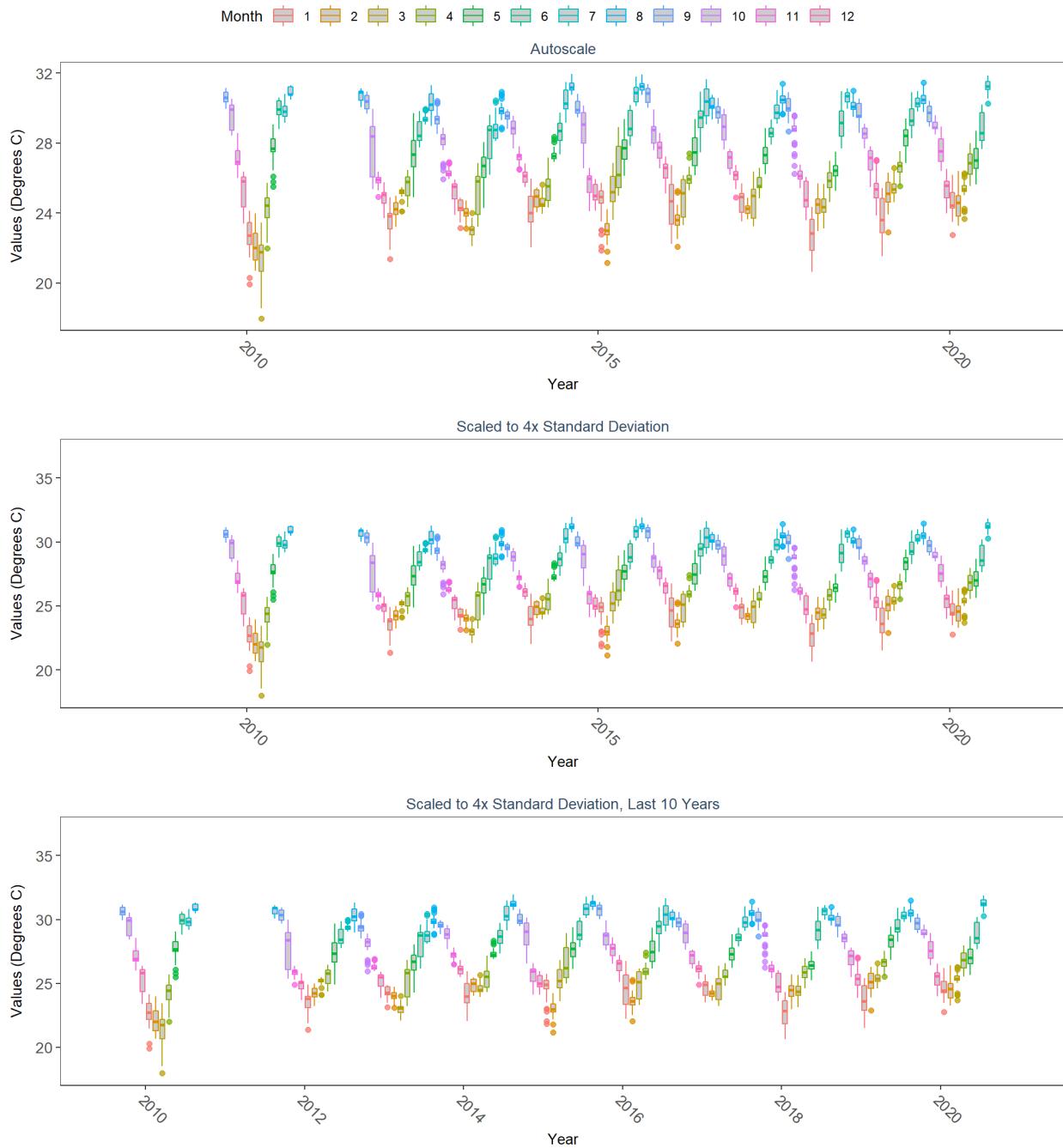
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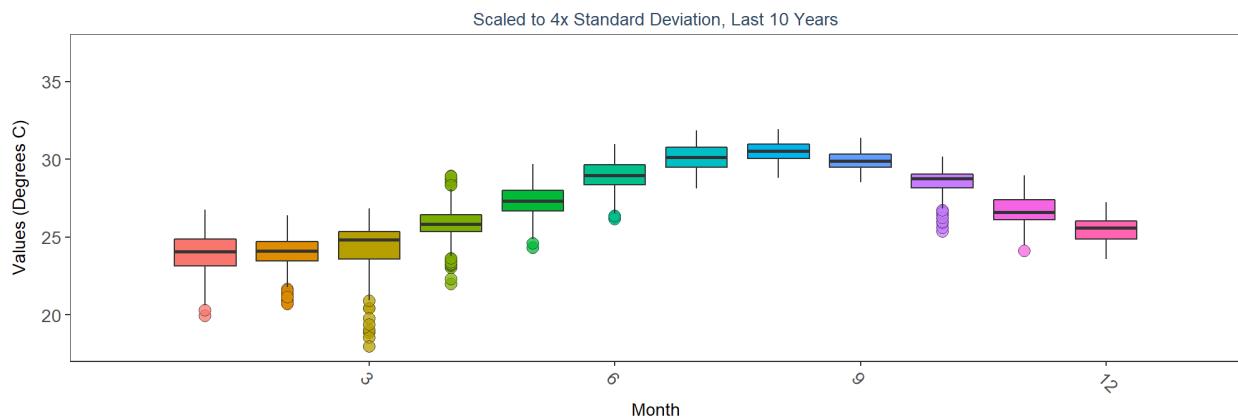
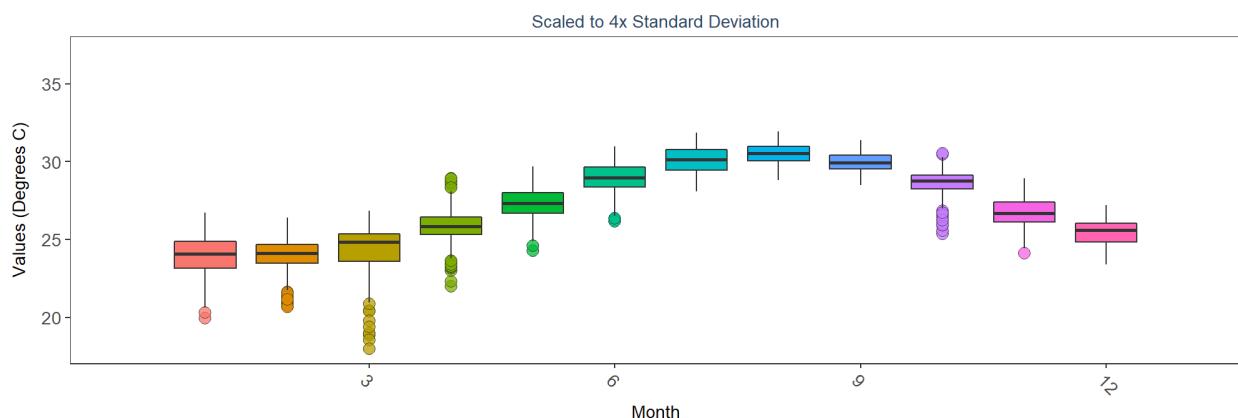
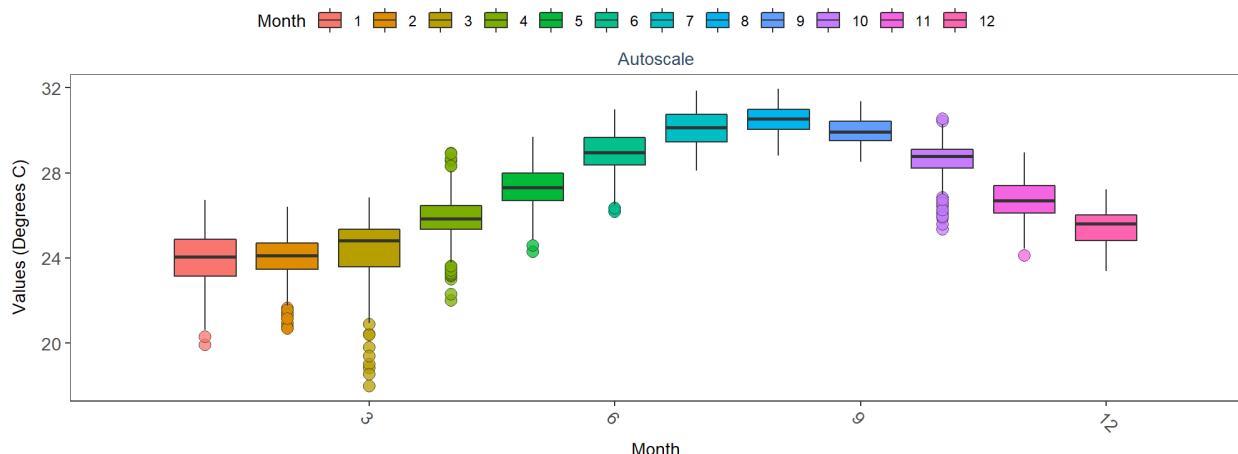
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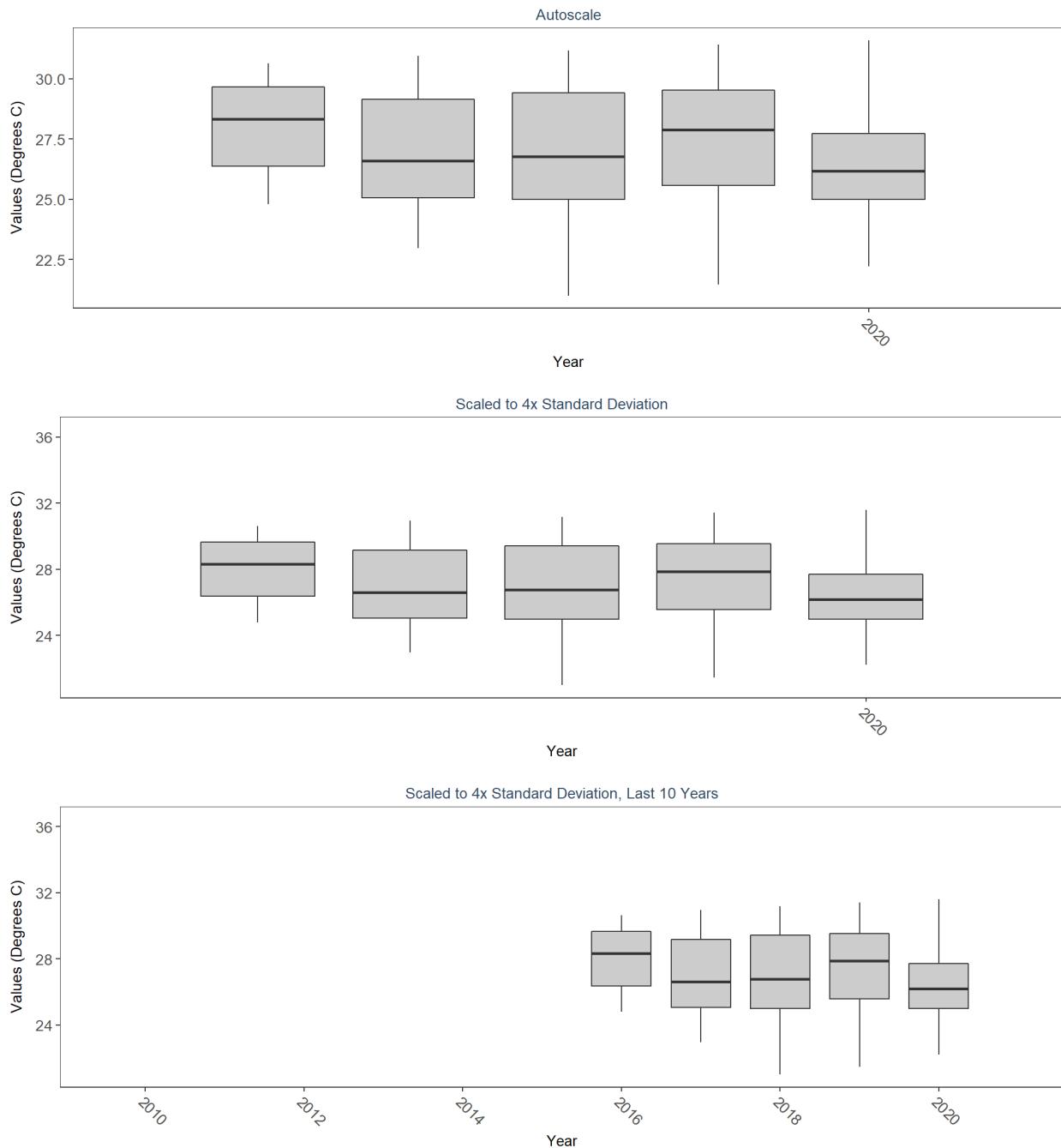
**Florida Keys National Marine Sanctuary**  
**986**  
**Water Temperature on Coral Reefs in the Florida Keys**  
**60**  
**By Year & Month**



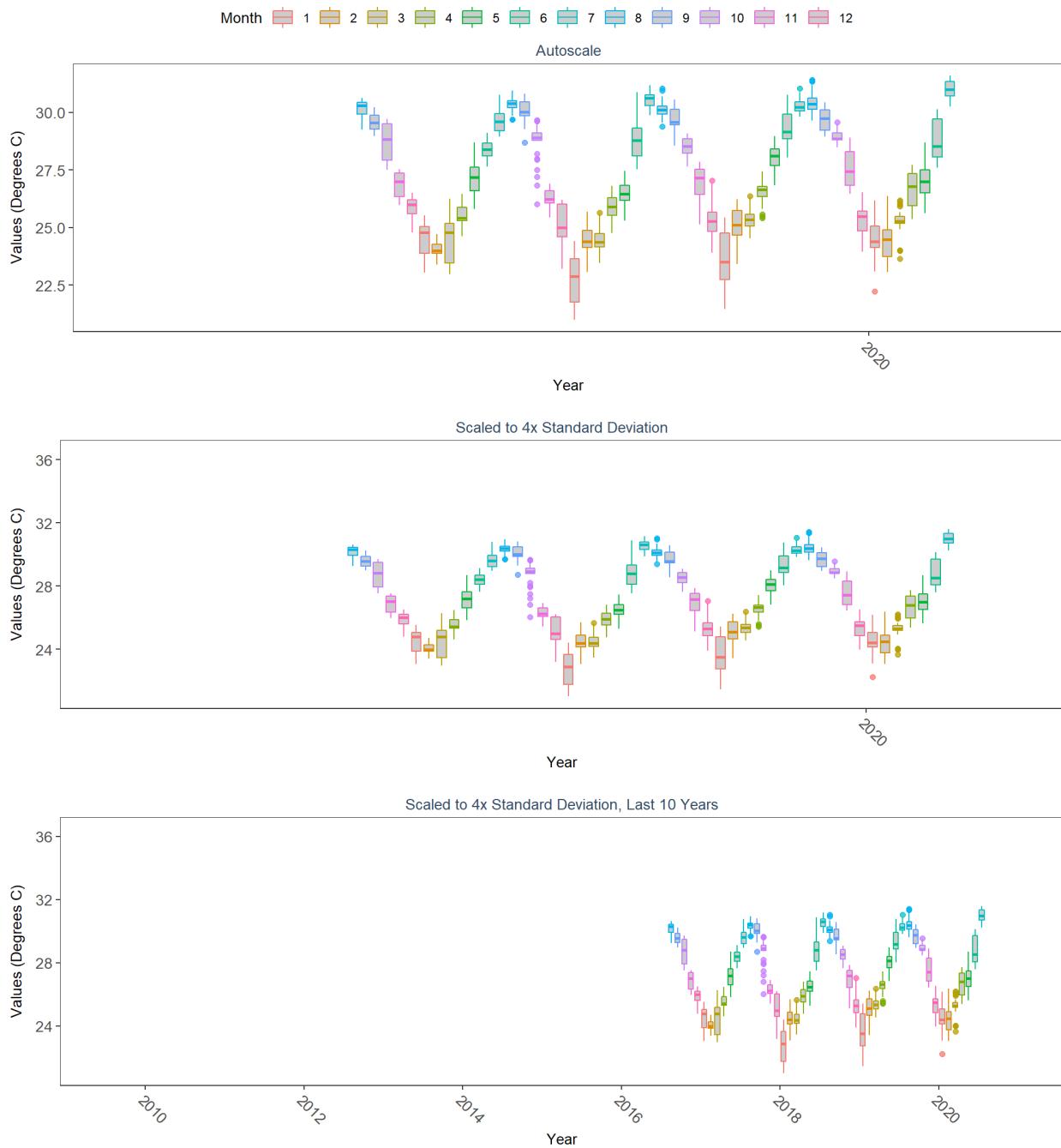
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 60  
 By Month



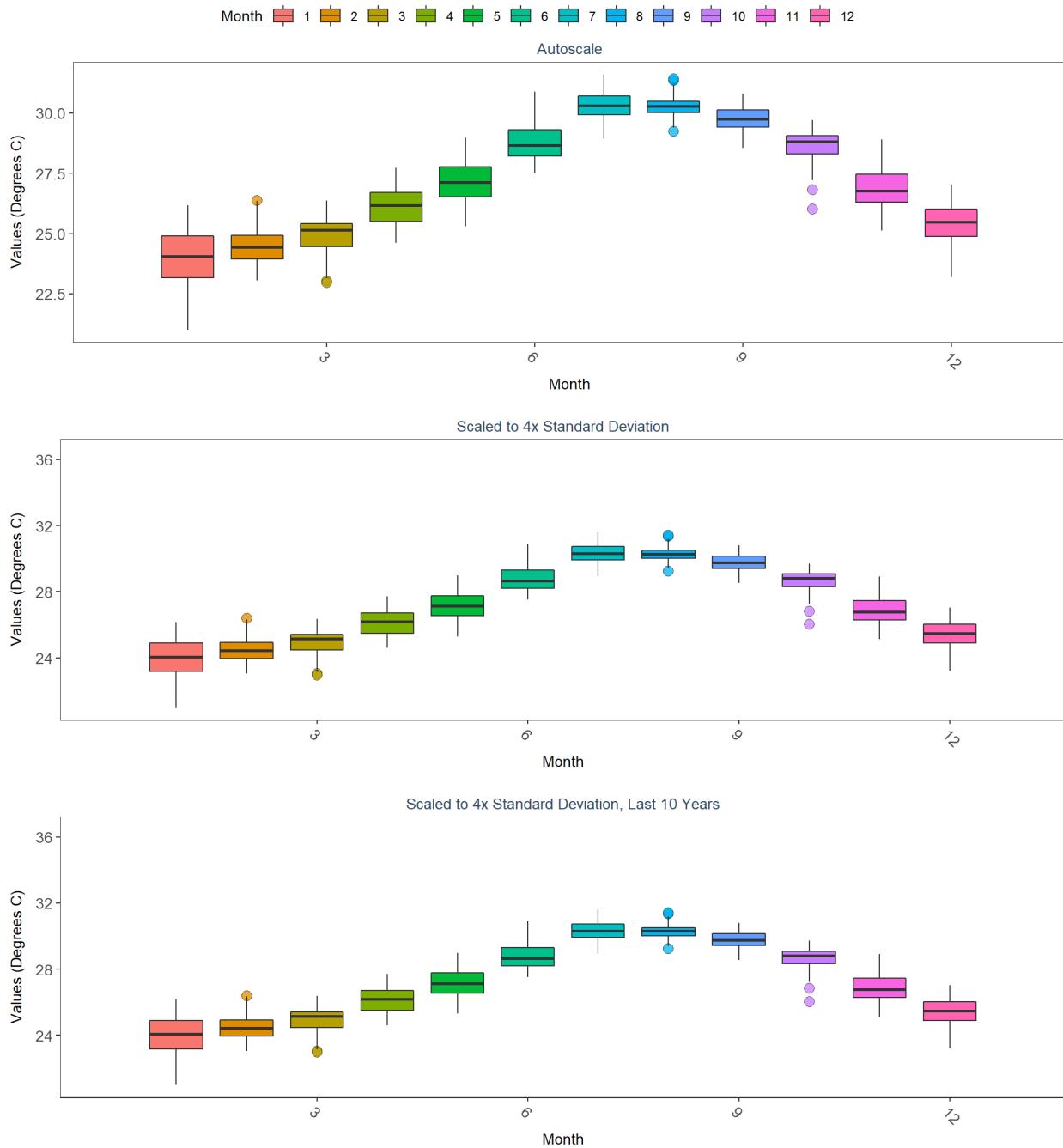
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986  
Water Temperature on Coral Reefs in the Florida Keys  
61  
By Year



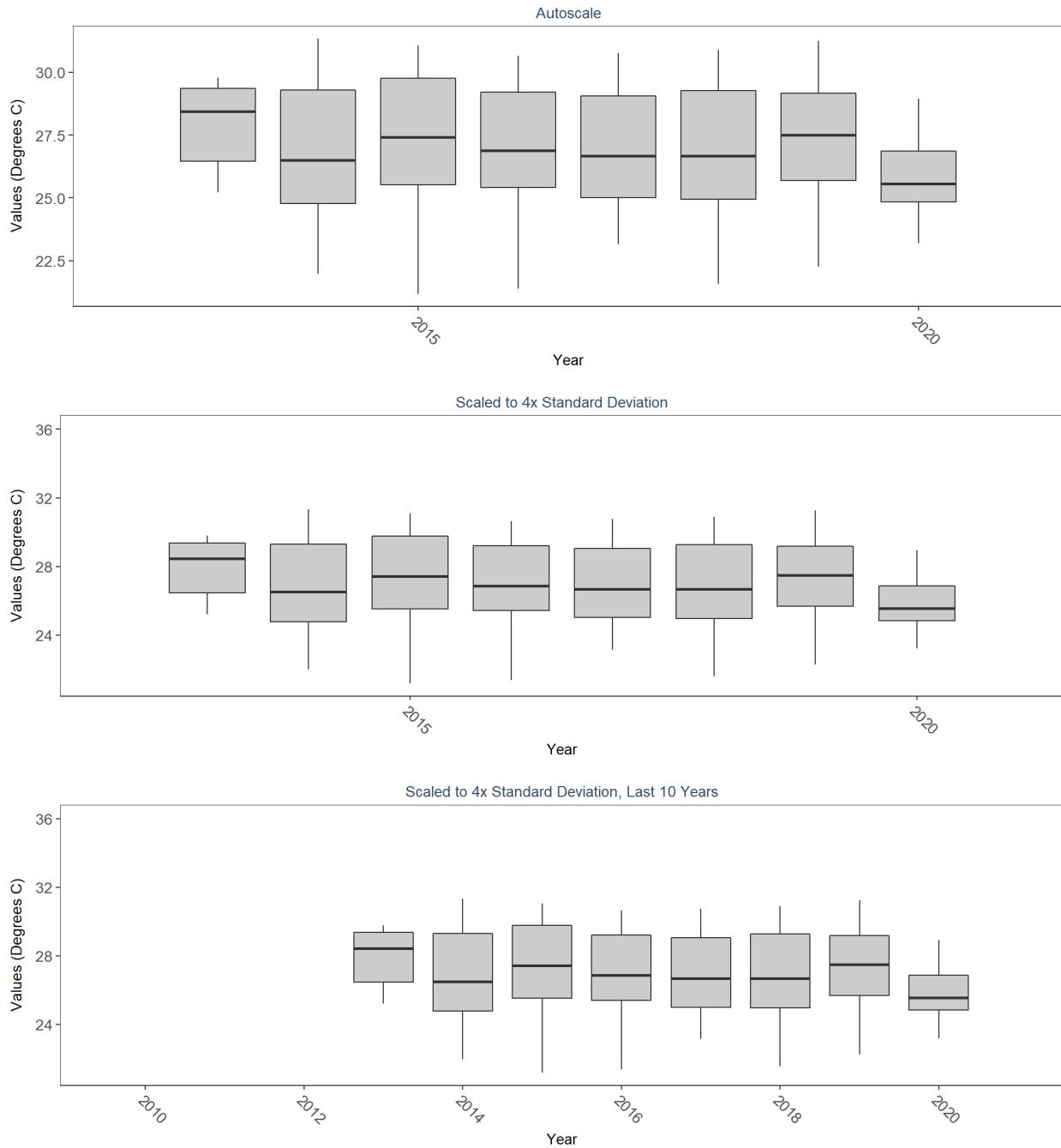
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 61  
 By Year & Month



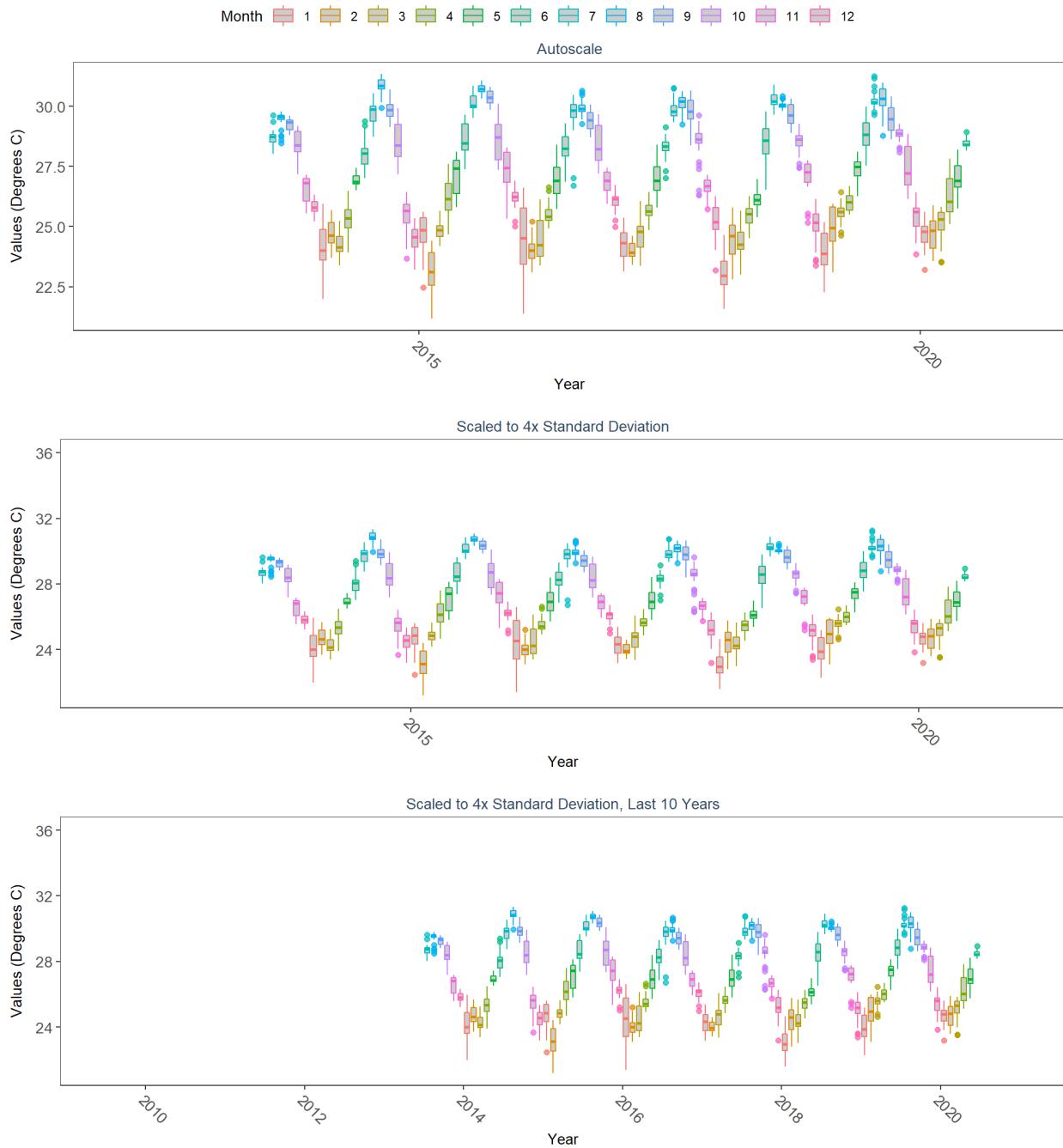
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 Water Temperature on Coral Reefs in the Florida Keys  
 61  
 By Month



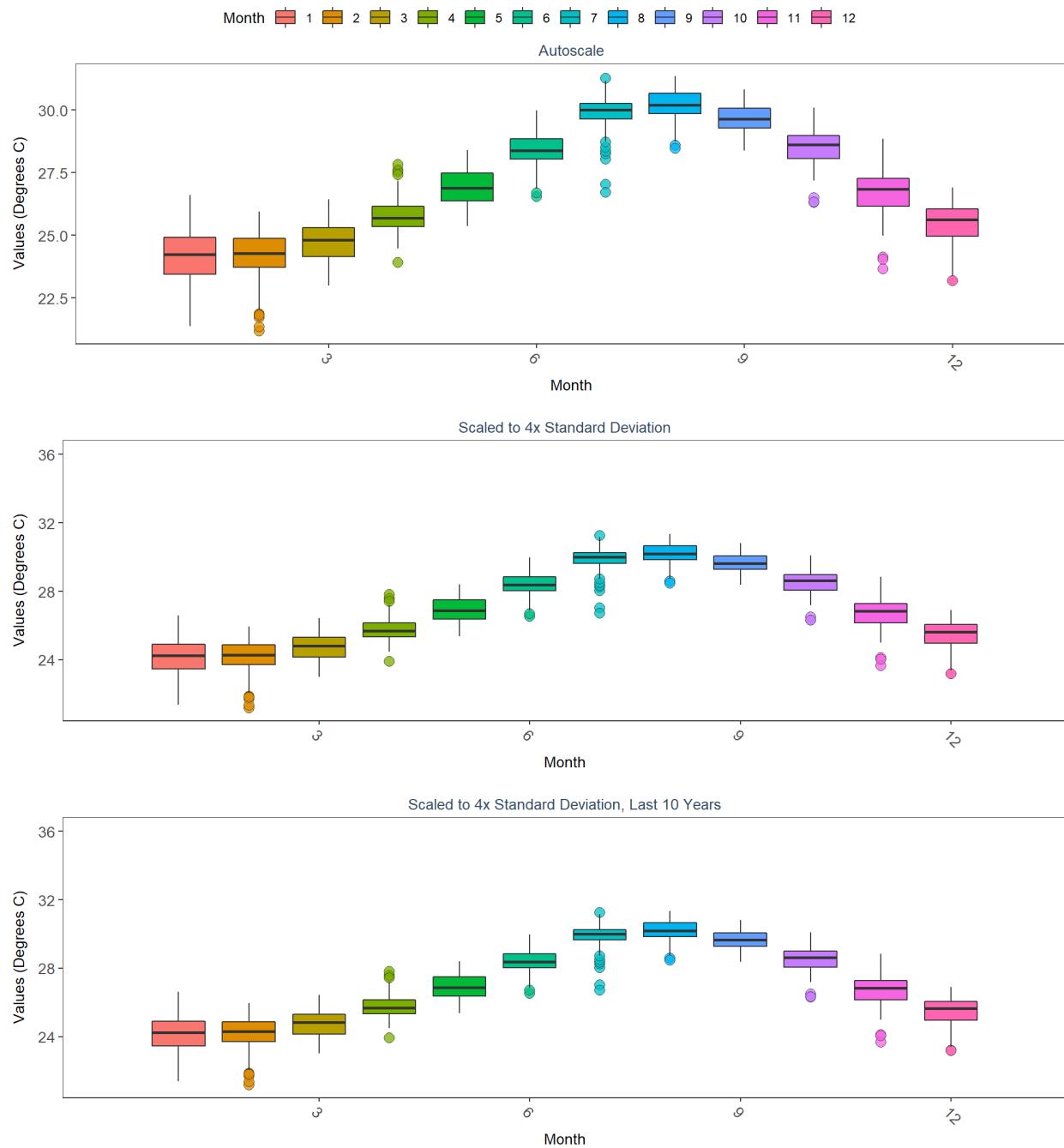
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
70  
By Year



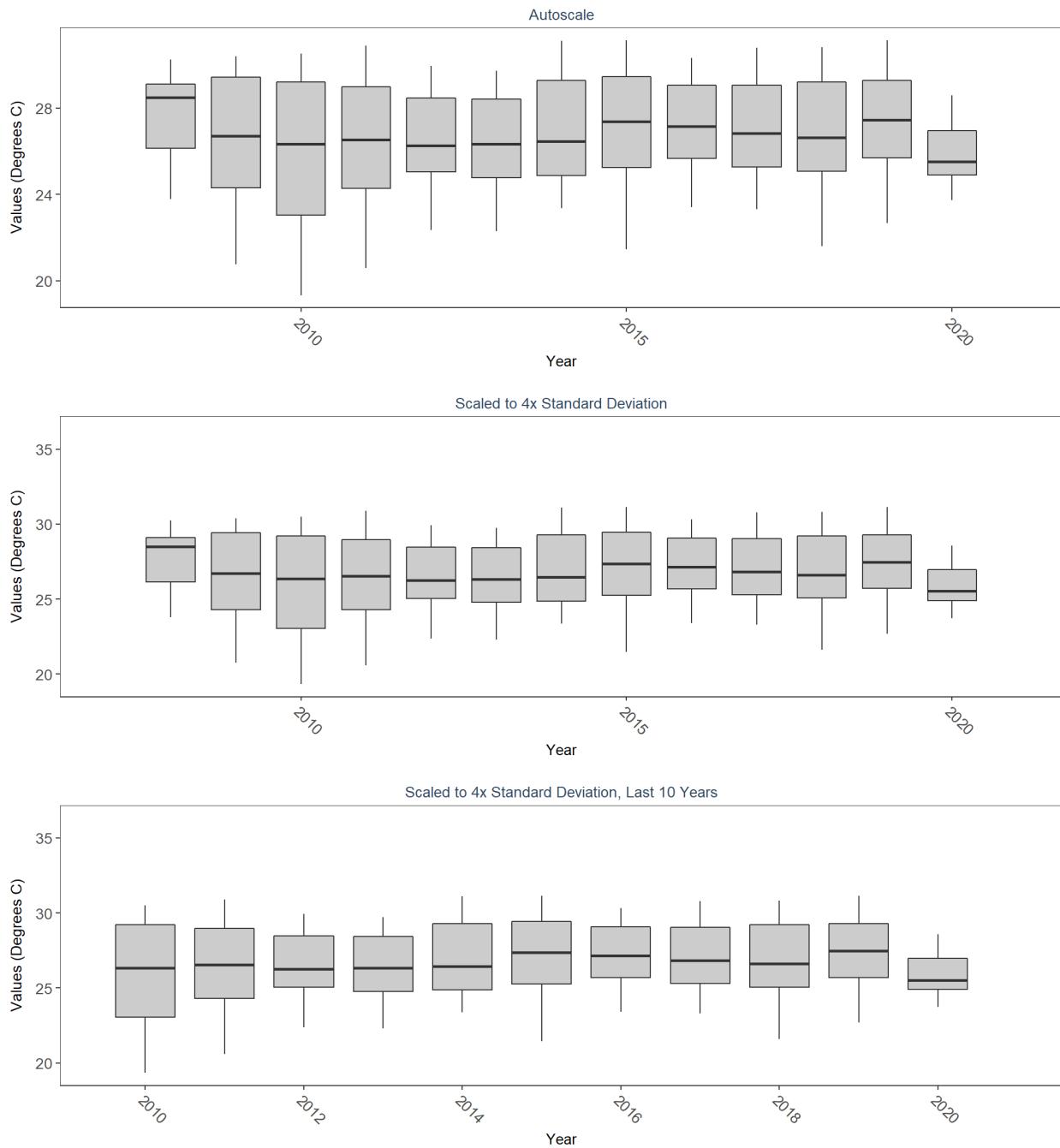
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 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 70  
 By Year & Month



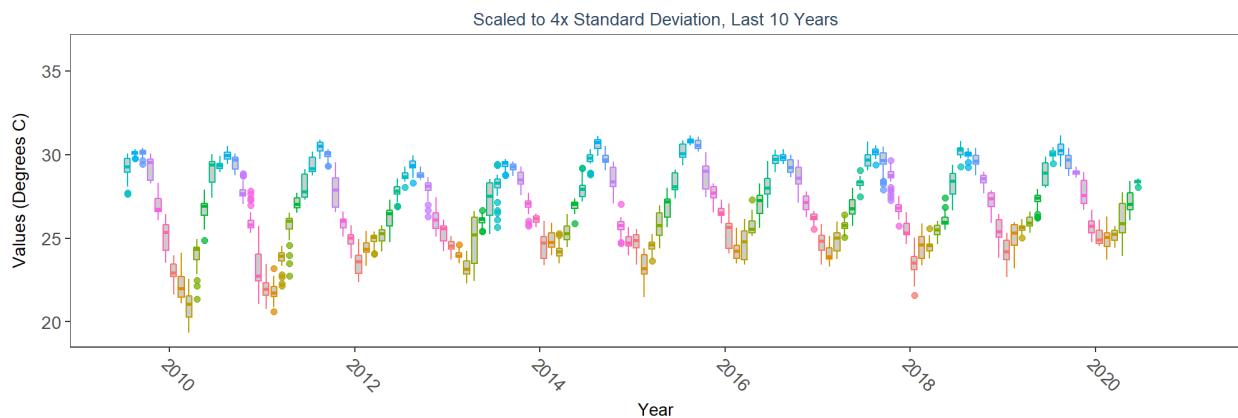
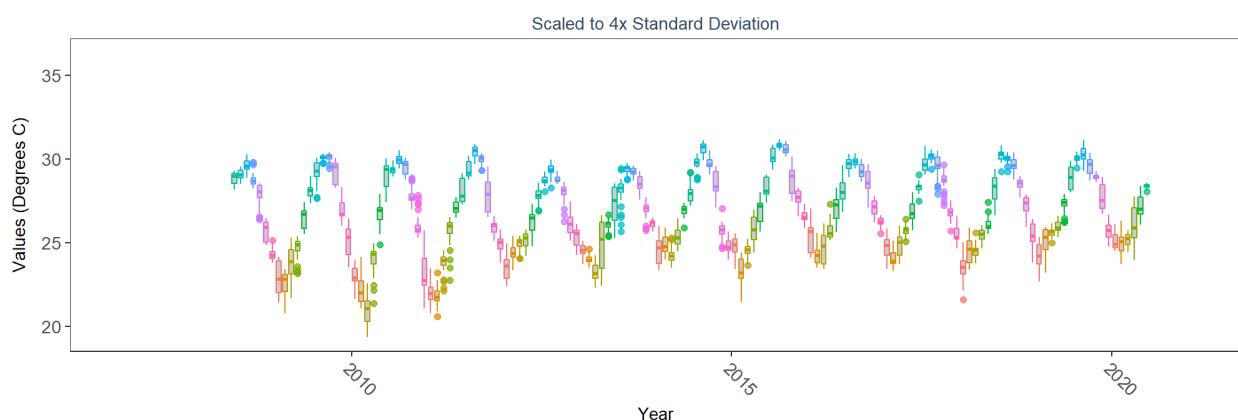
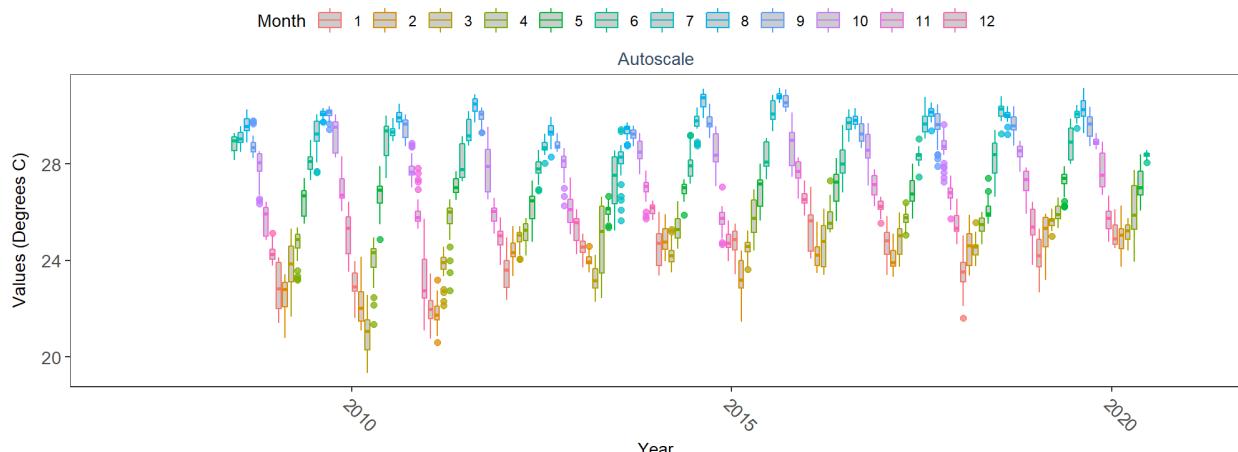
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 70  
 By Month



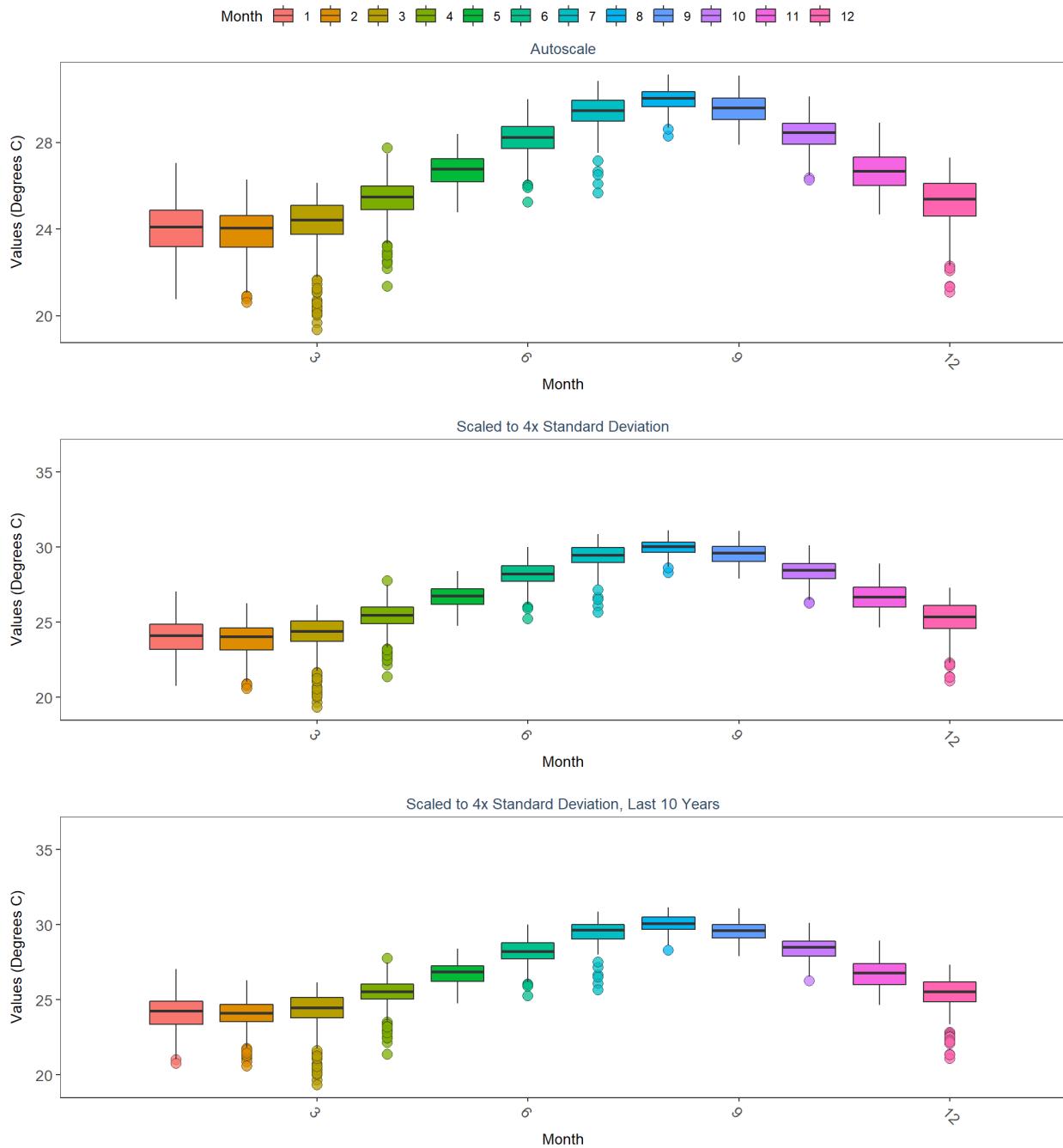
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
72  
By Year



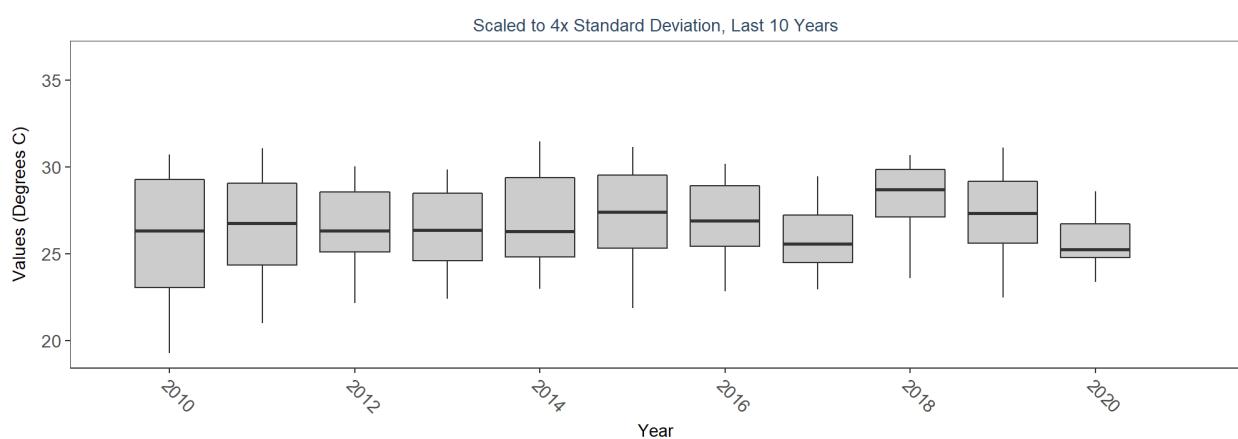
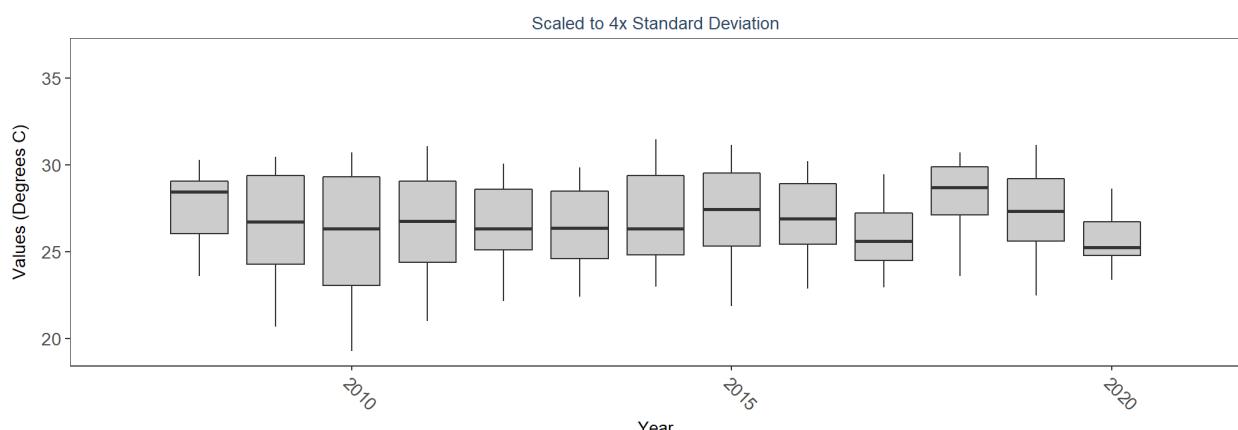
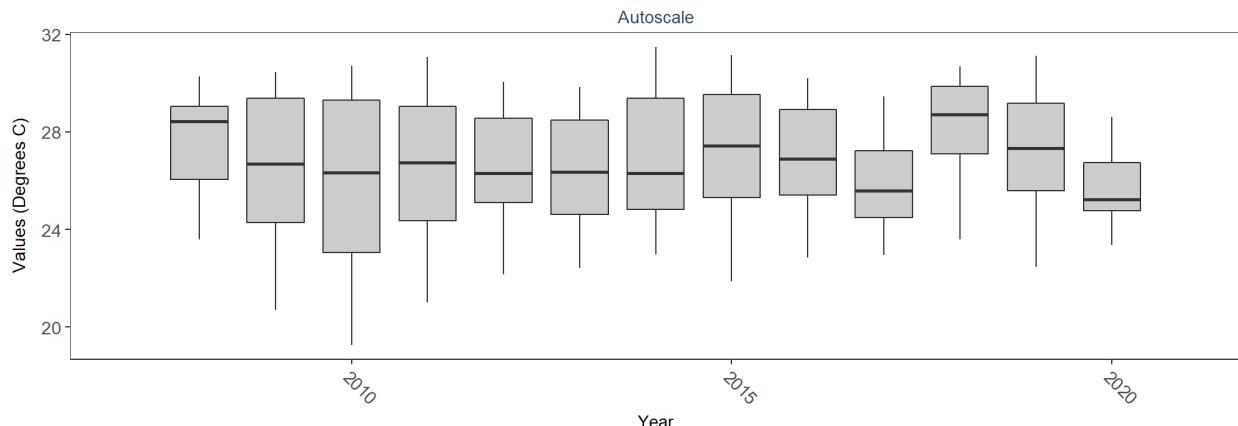
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 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 72  
 By Year & Month



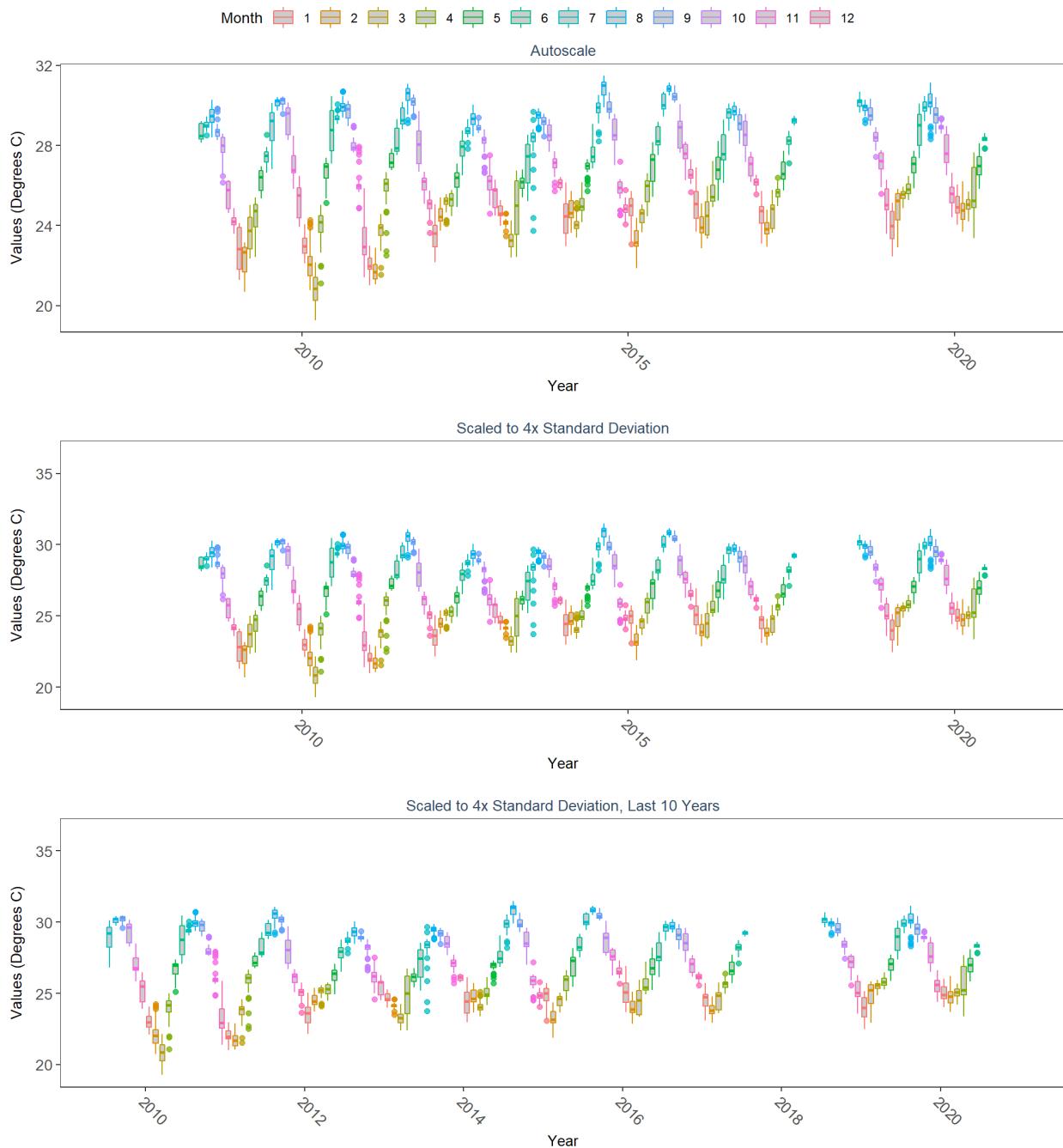
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 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 72  
 By Month



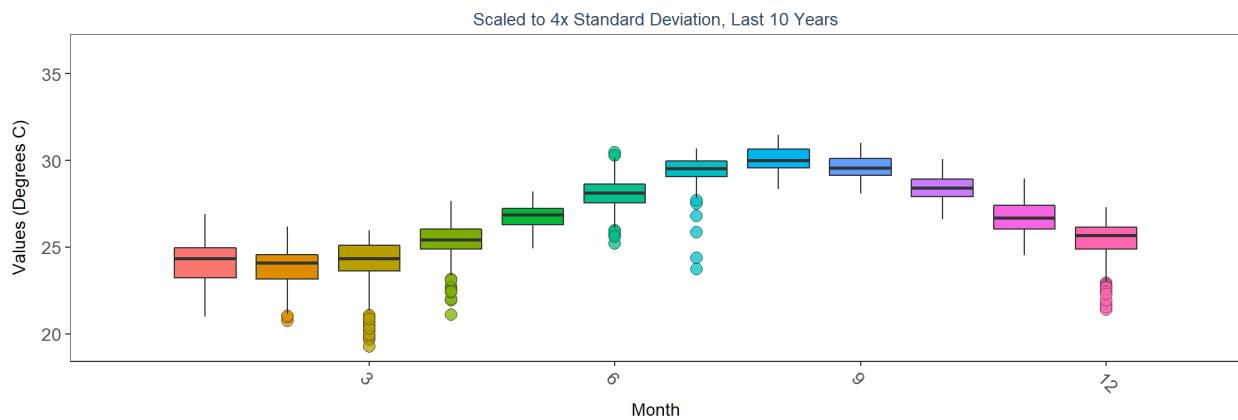
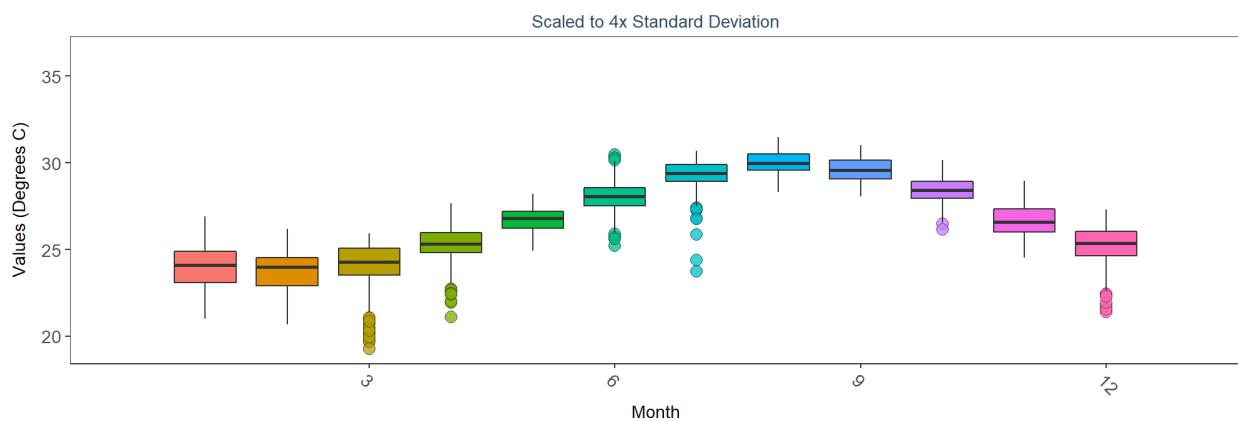
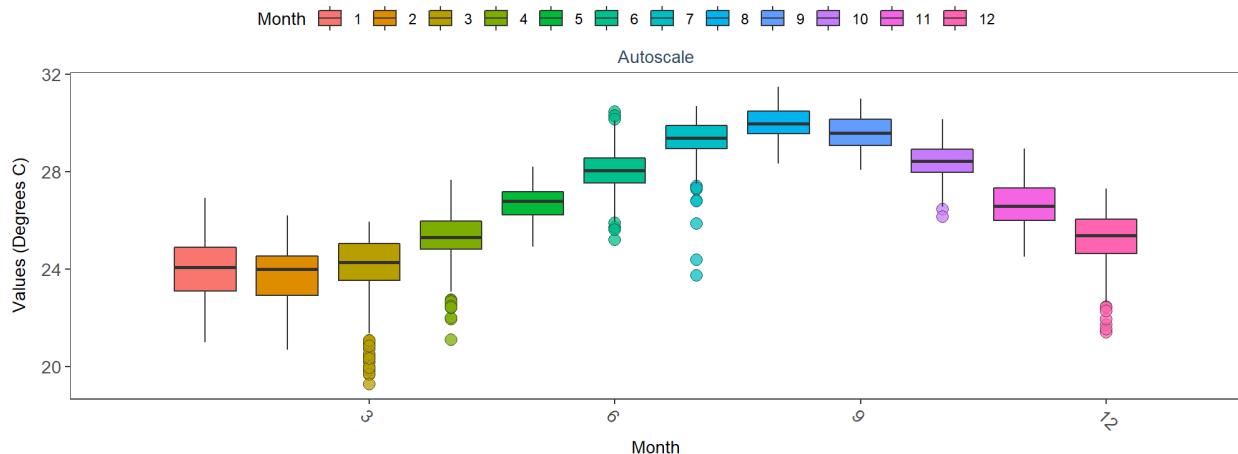
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
73  
By Year



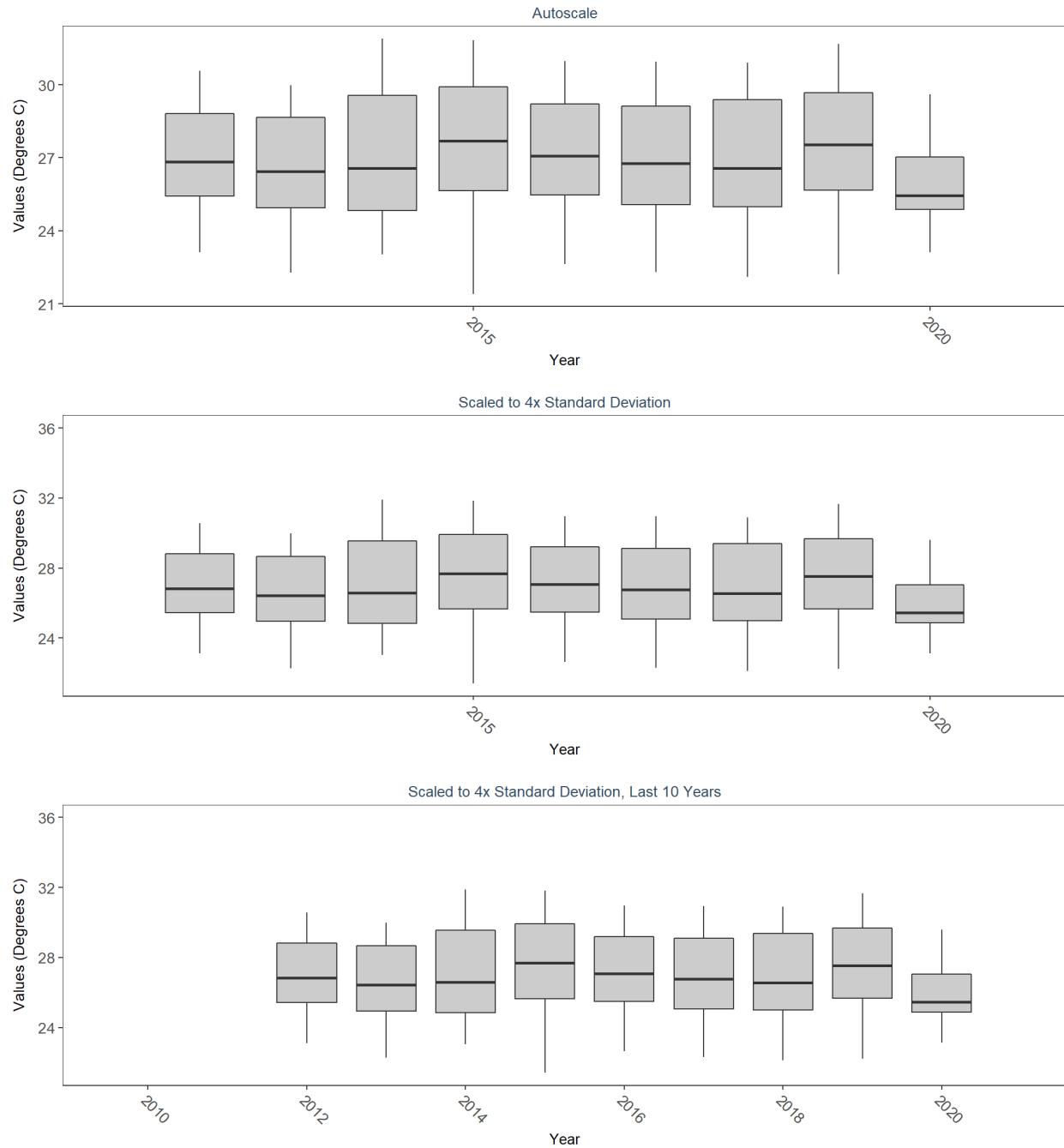
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 73  
 By Year & Month



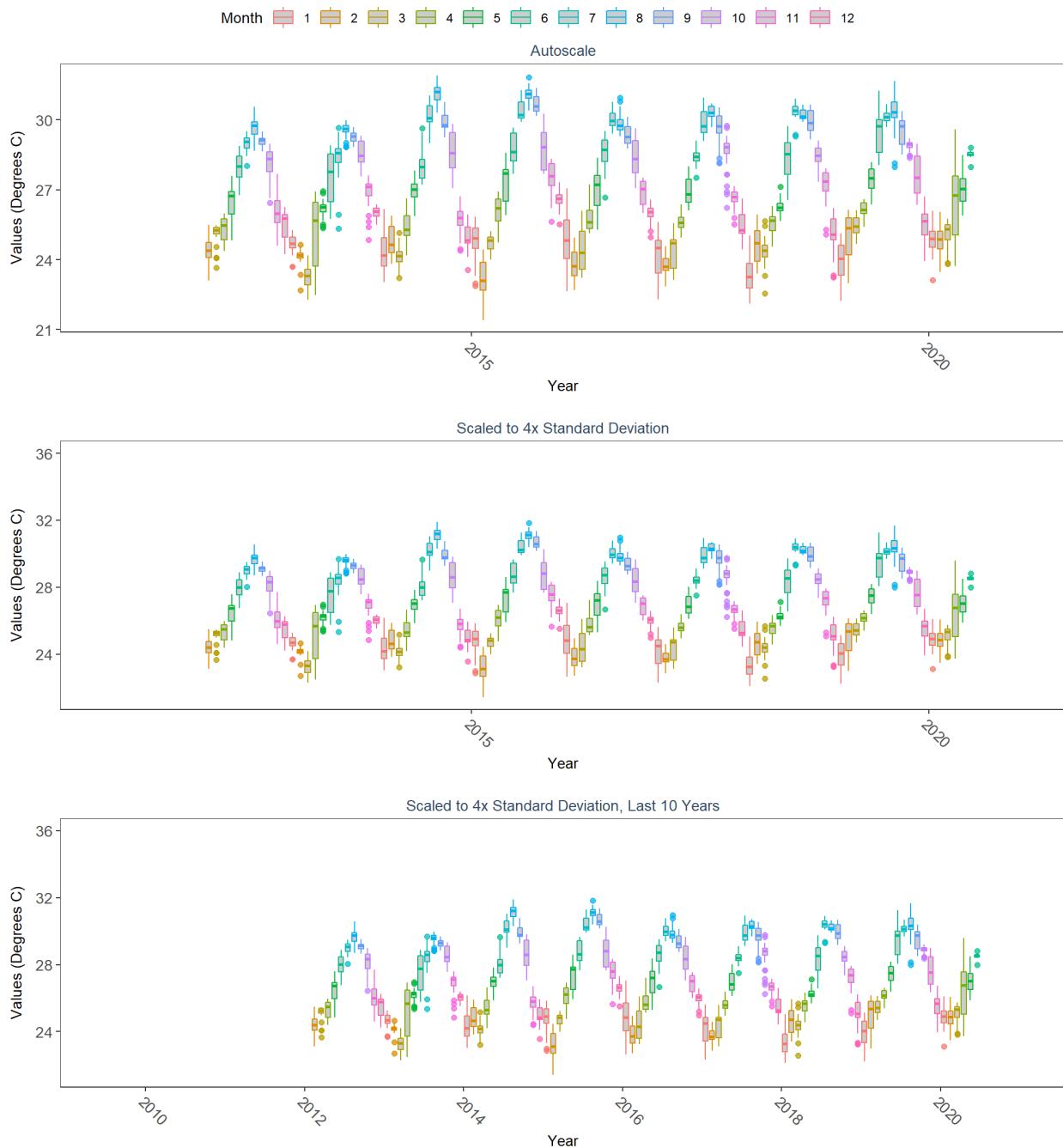
Florida Keys National Marine Sanctuary  
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 Water Temperature on Coral Reefs in the Florida Keys  
 73  
 By Month



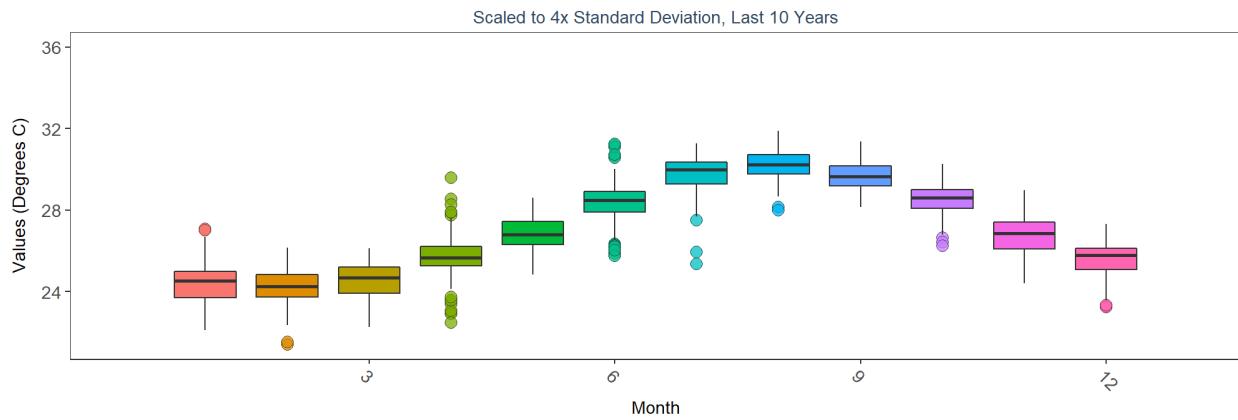
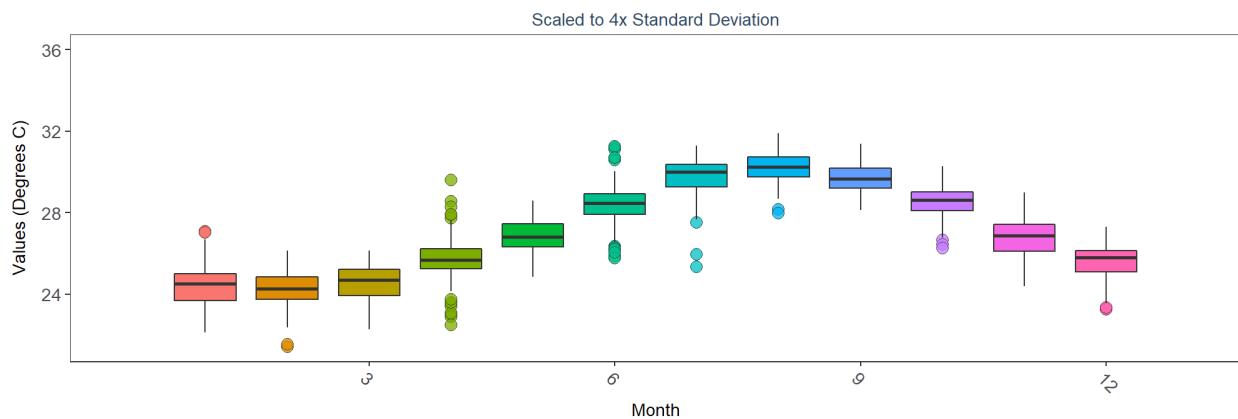
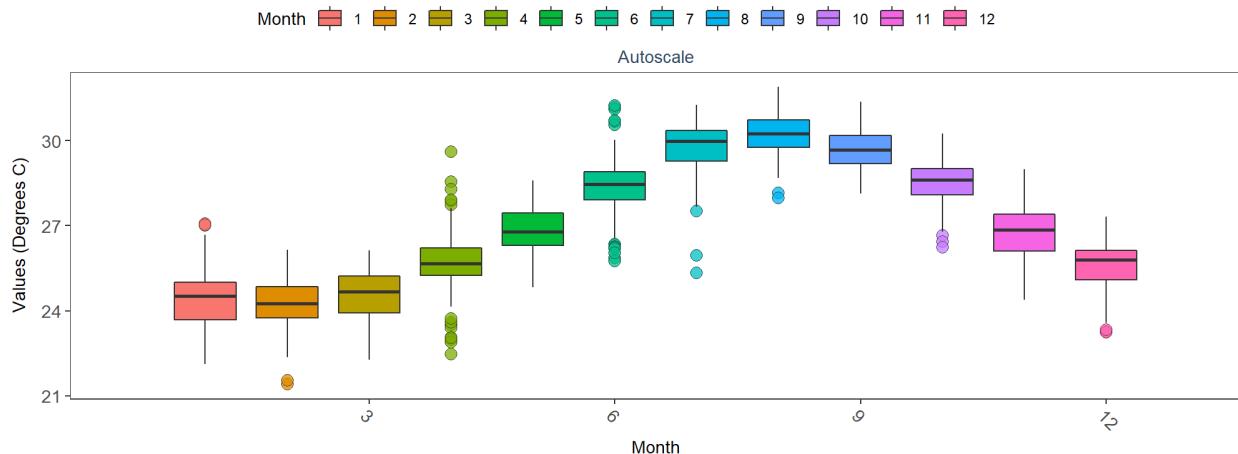
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
74  
By Year



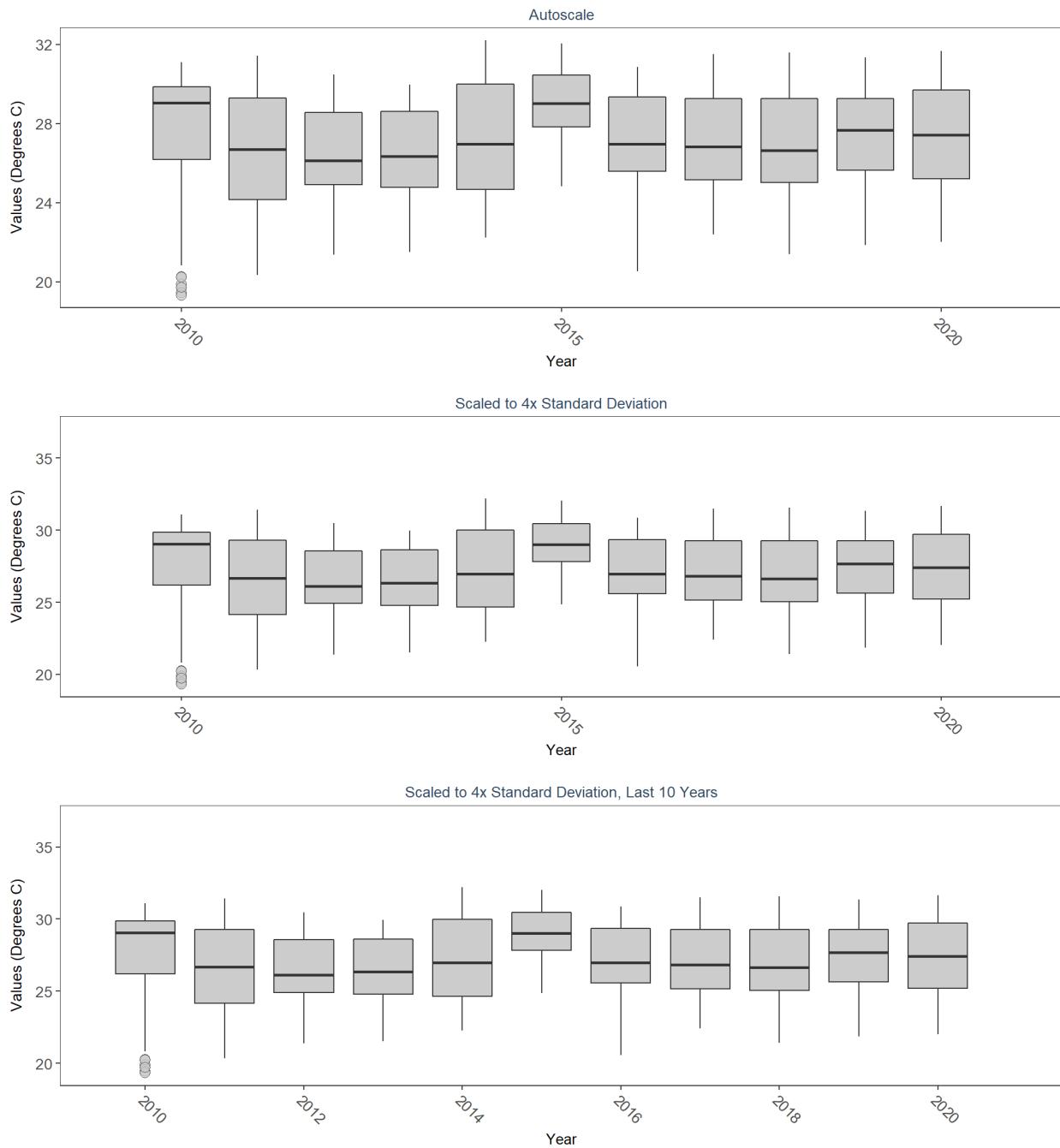
Florida Keys National Marine Sanctuary  
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 Water Temperature on Coral Reefs in the Florida Keys  
 74  
 By Year & Month



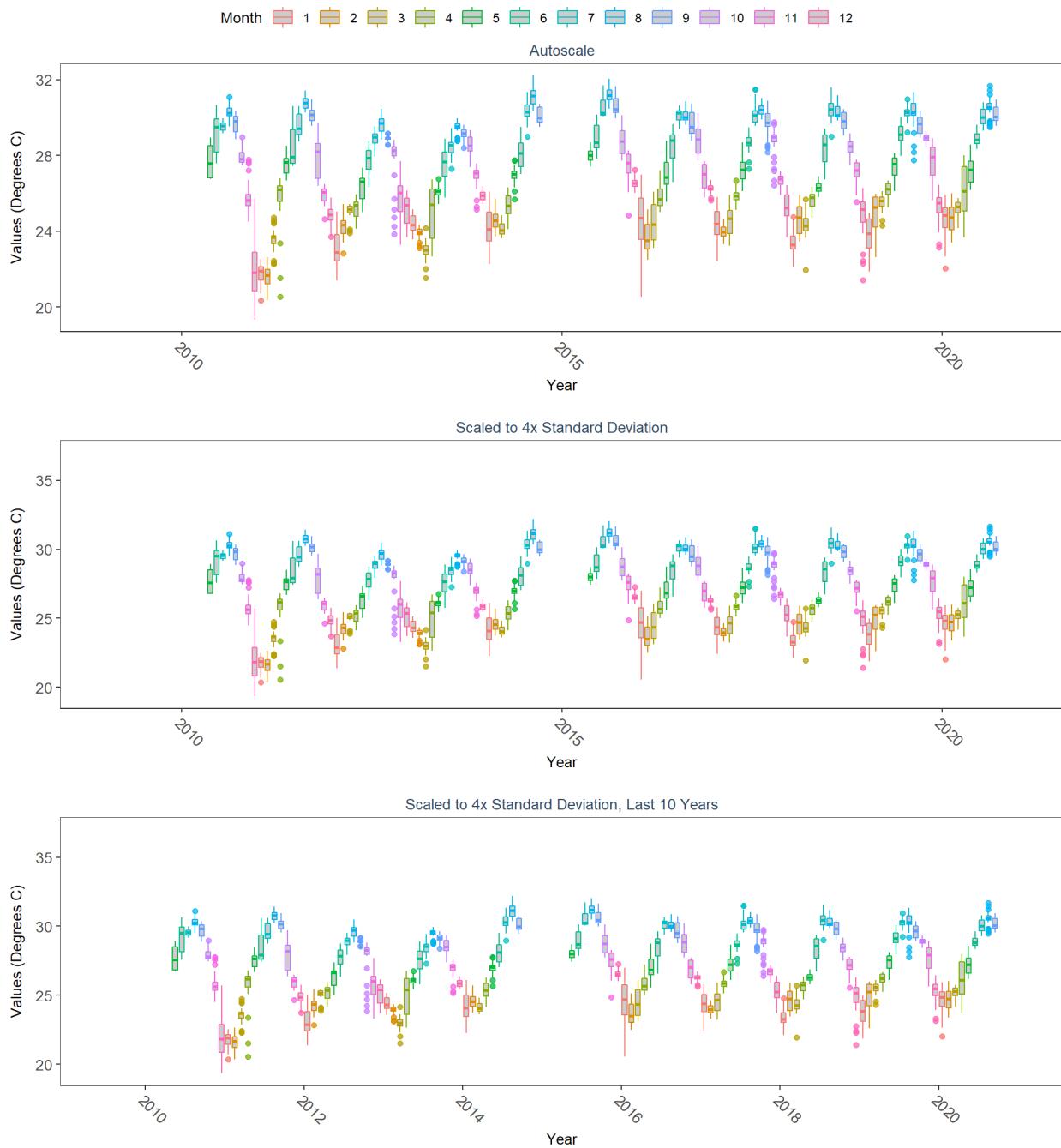
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 74  
 By Month



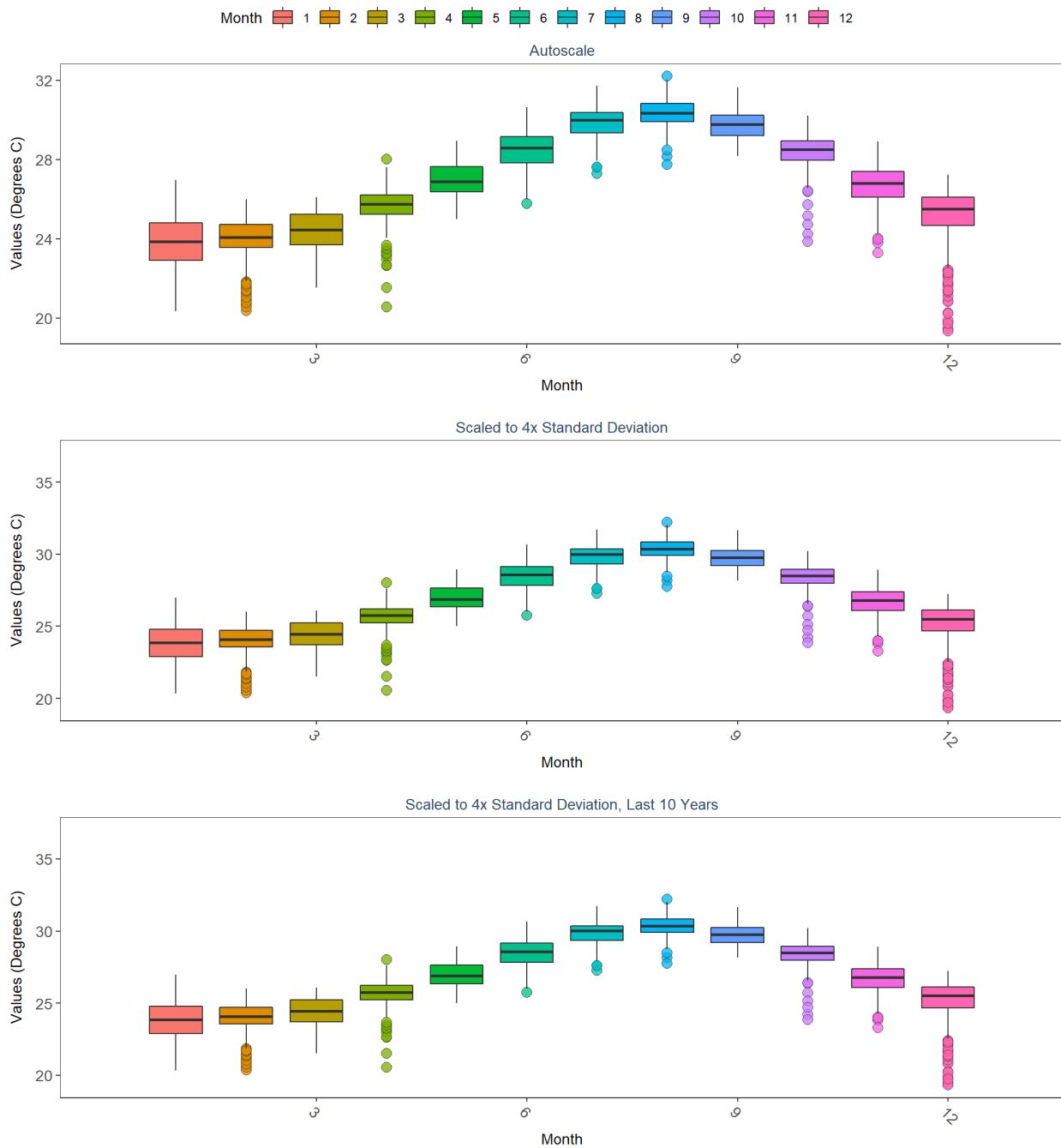
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
75  
By Year



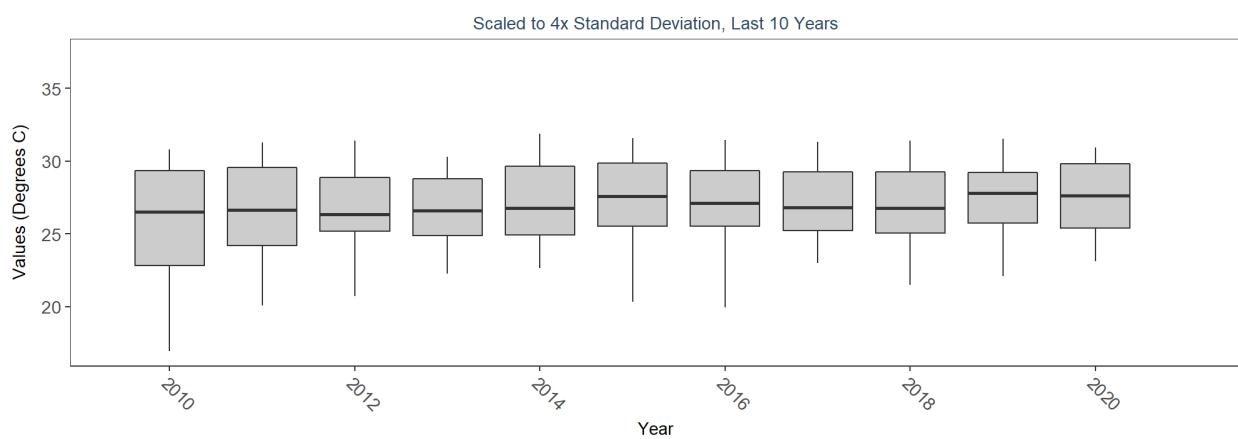
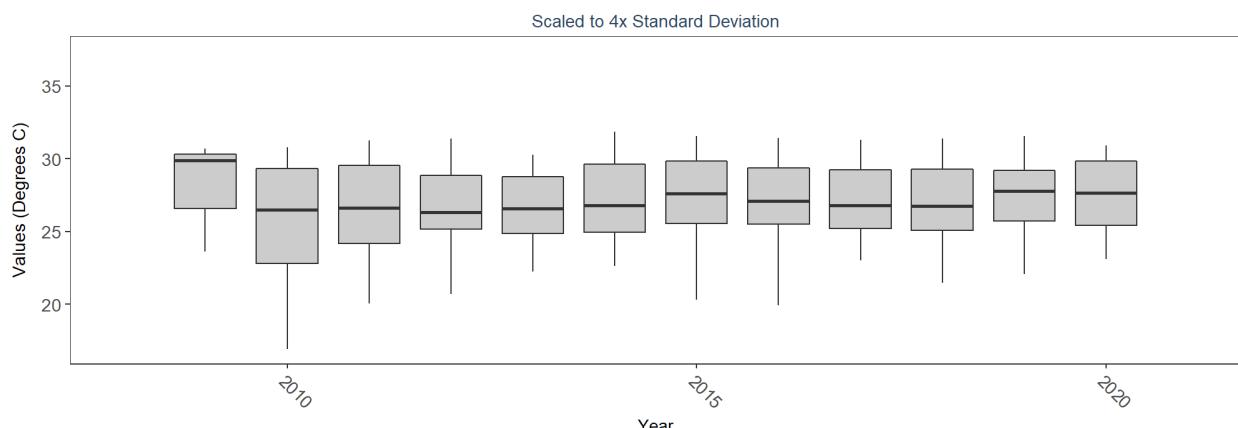
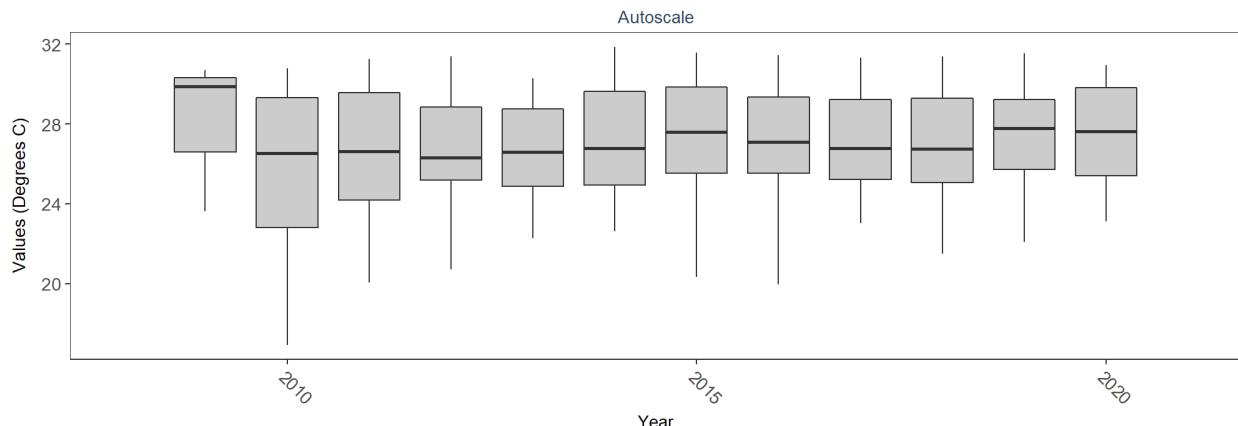
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 75  
 By Year & Month



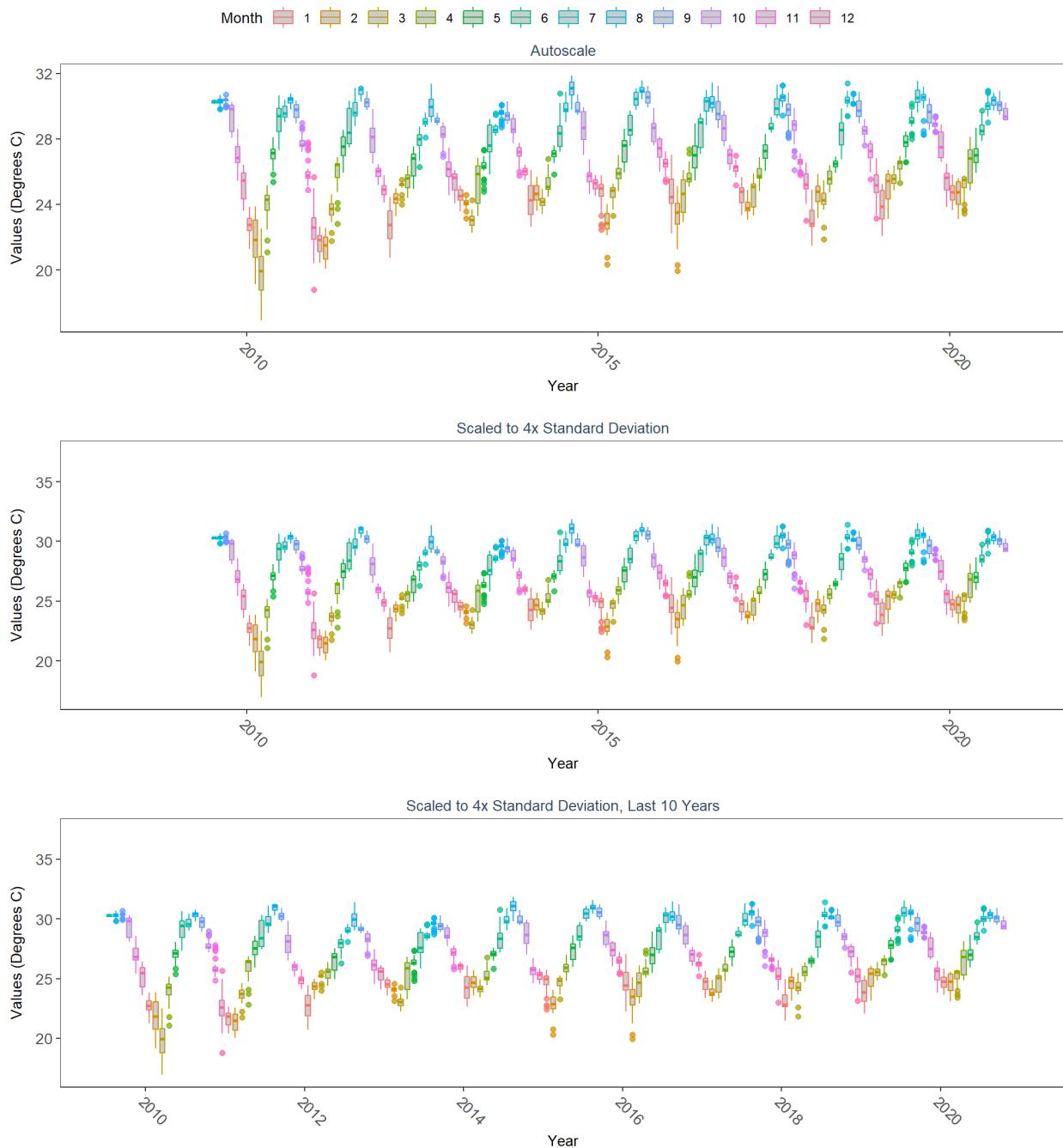
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 75  
 By Month



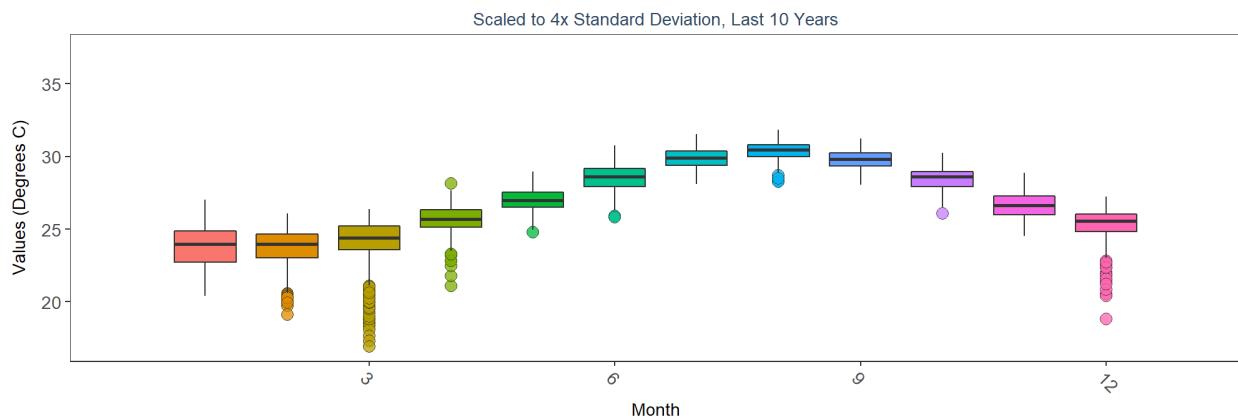
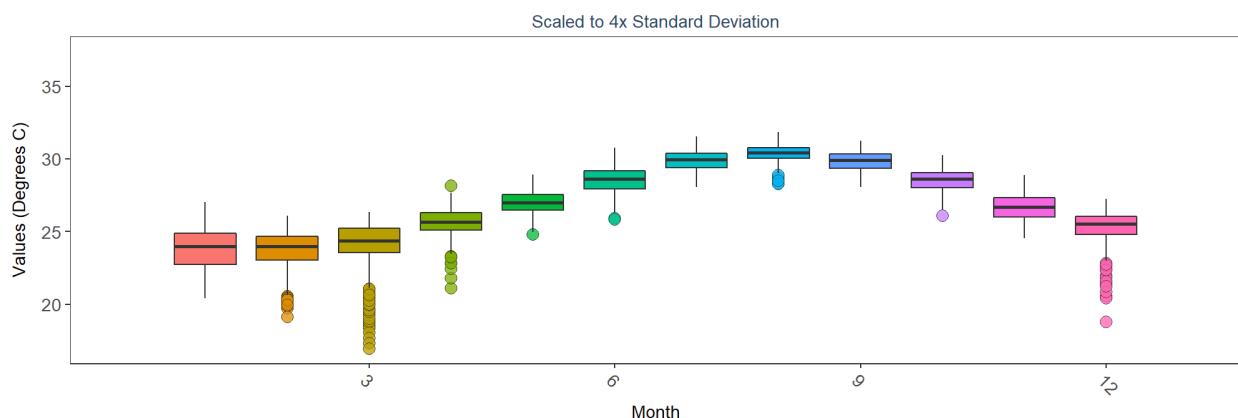
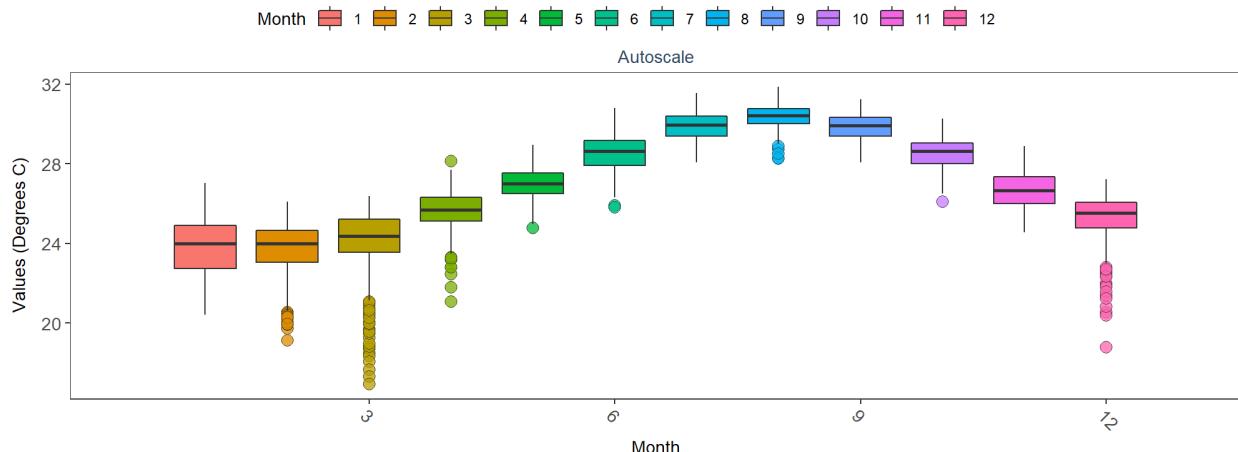
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
76  
By Year



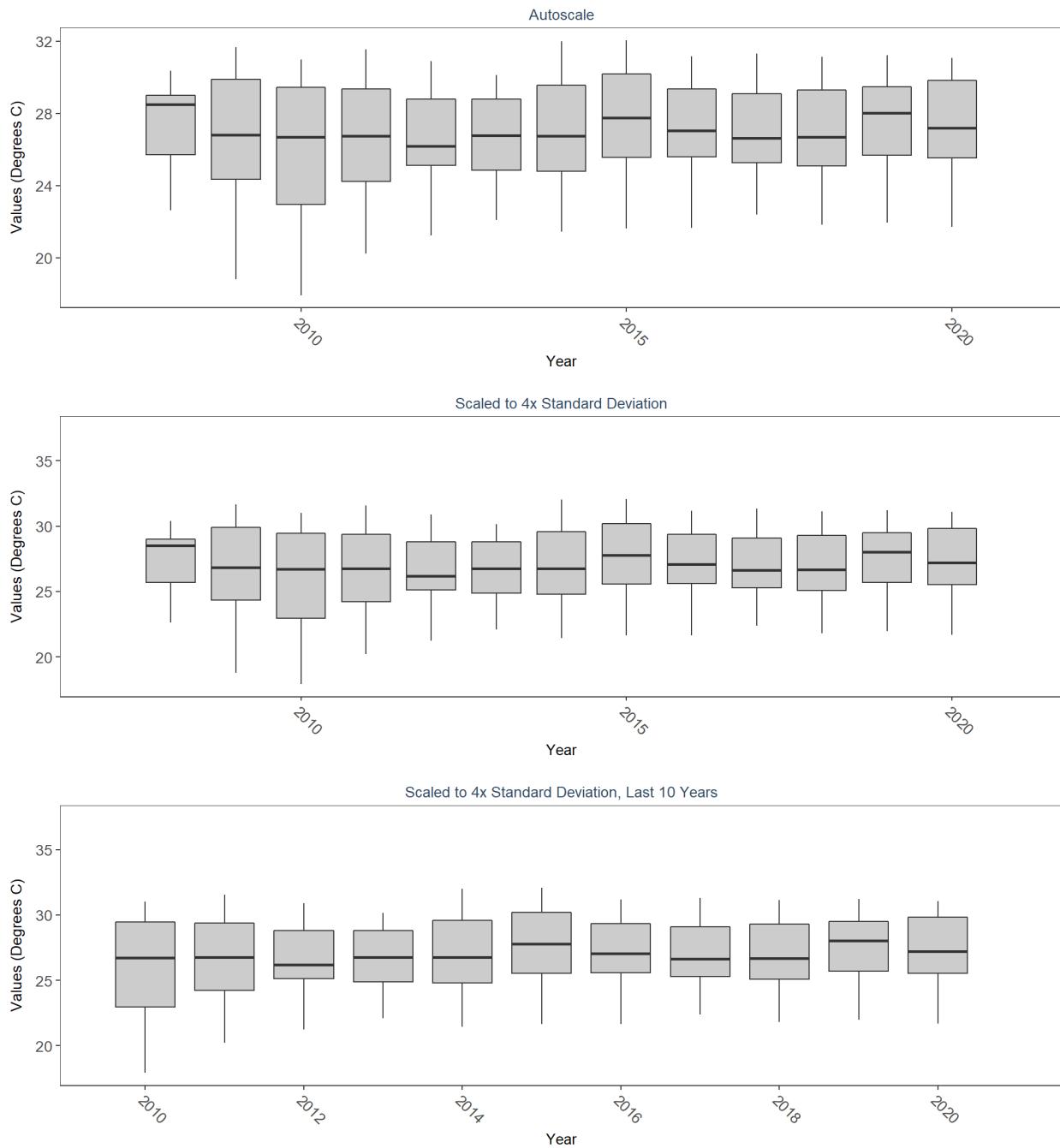
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 76  
 By Year & Month



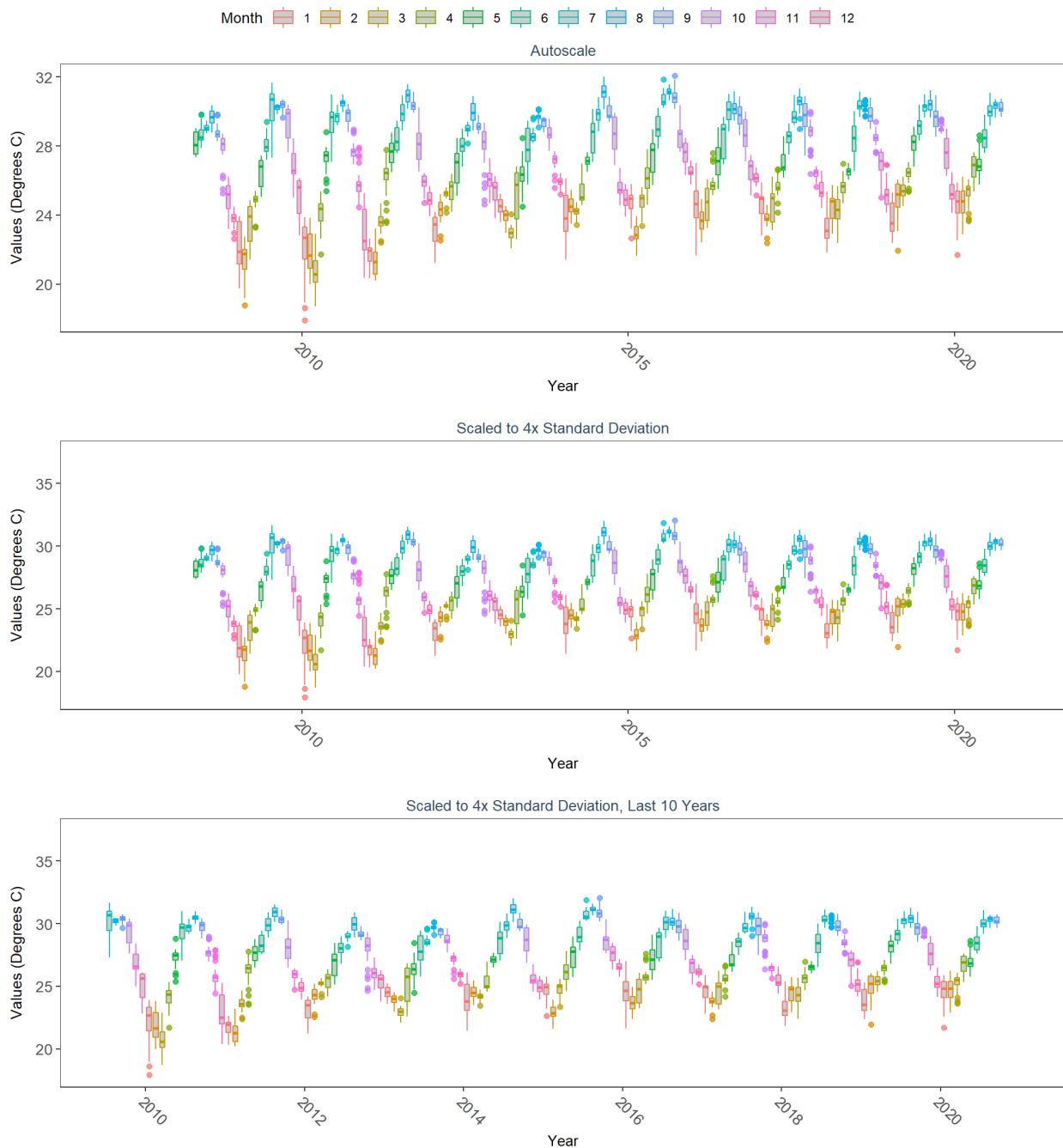
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 76  
 By Month



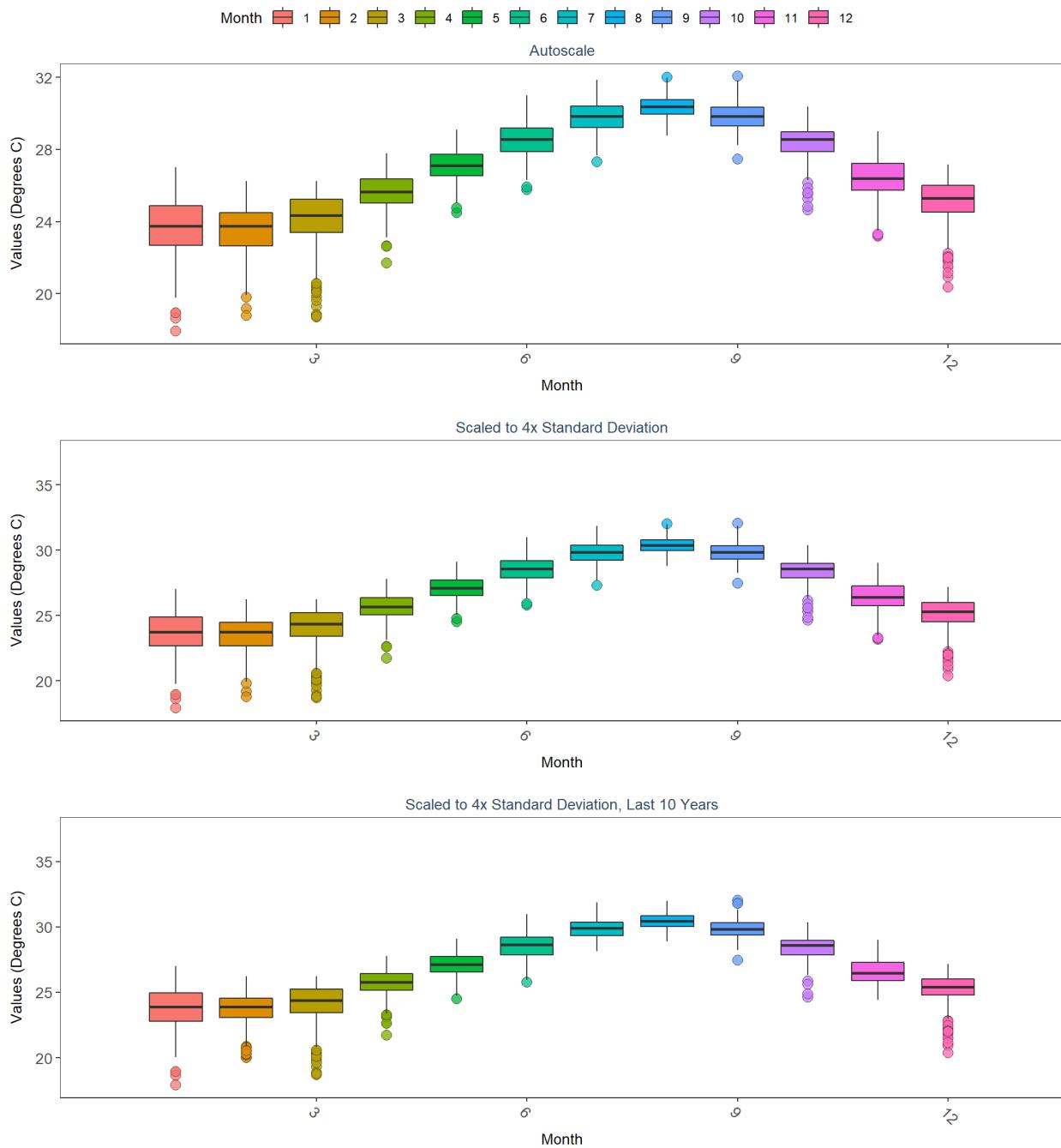
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
77  
By Year



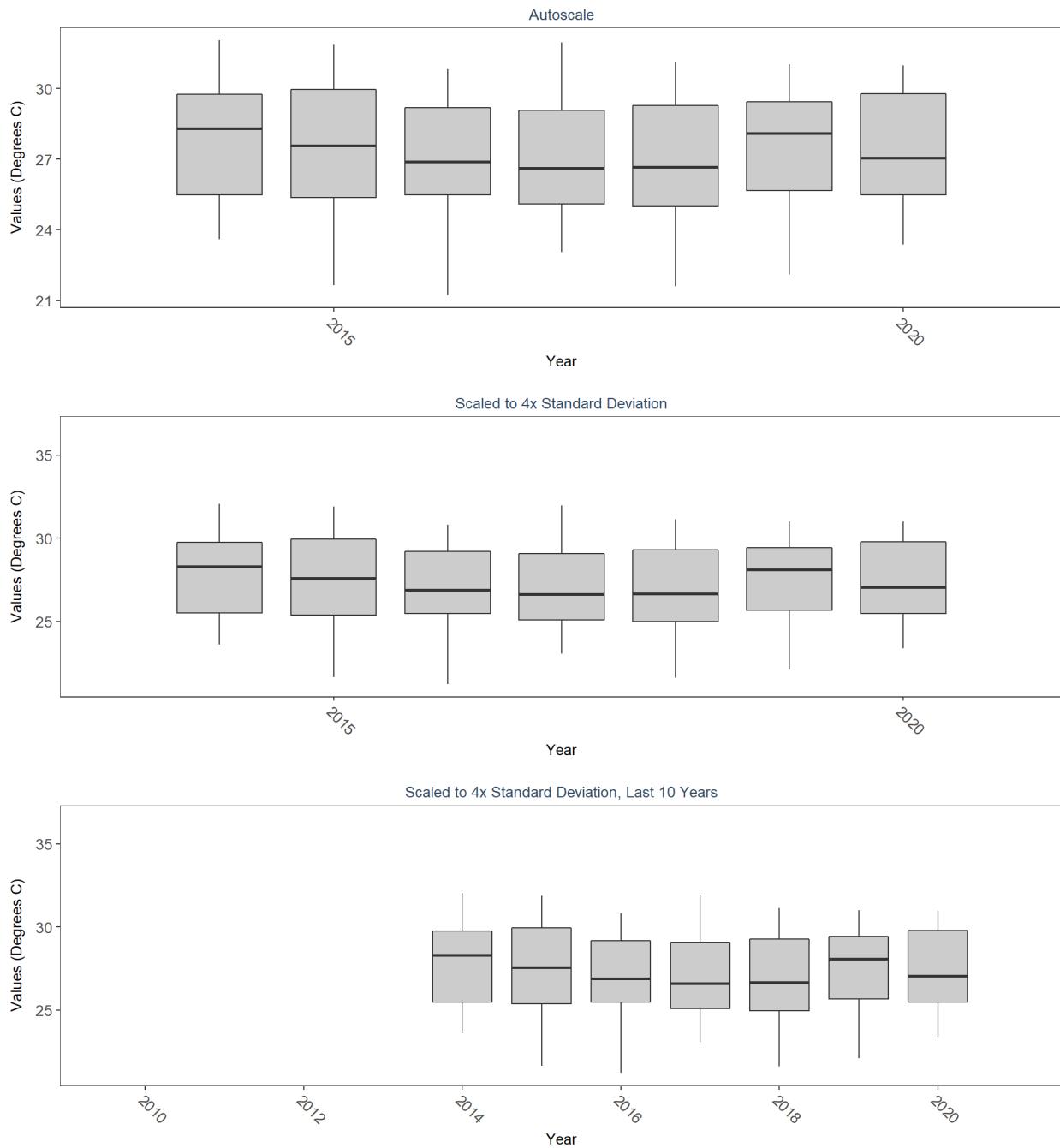
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 77  
 By Year & Month



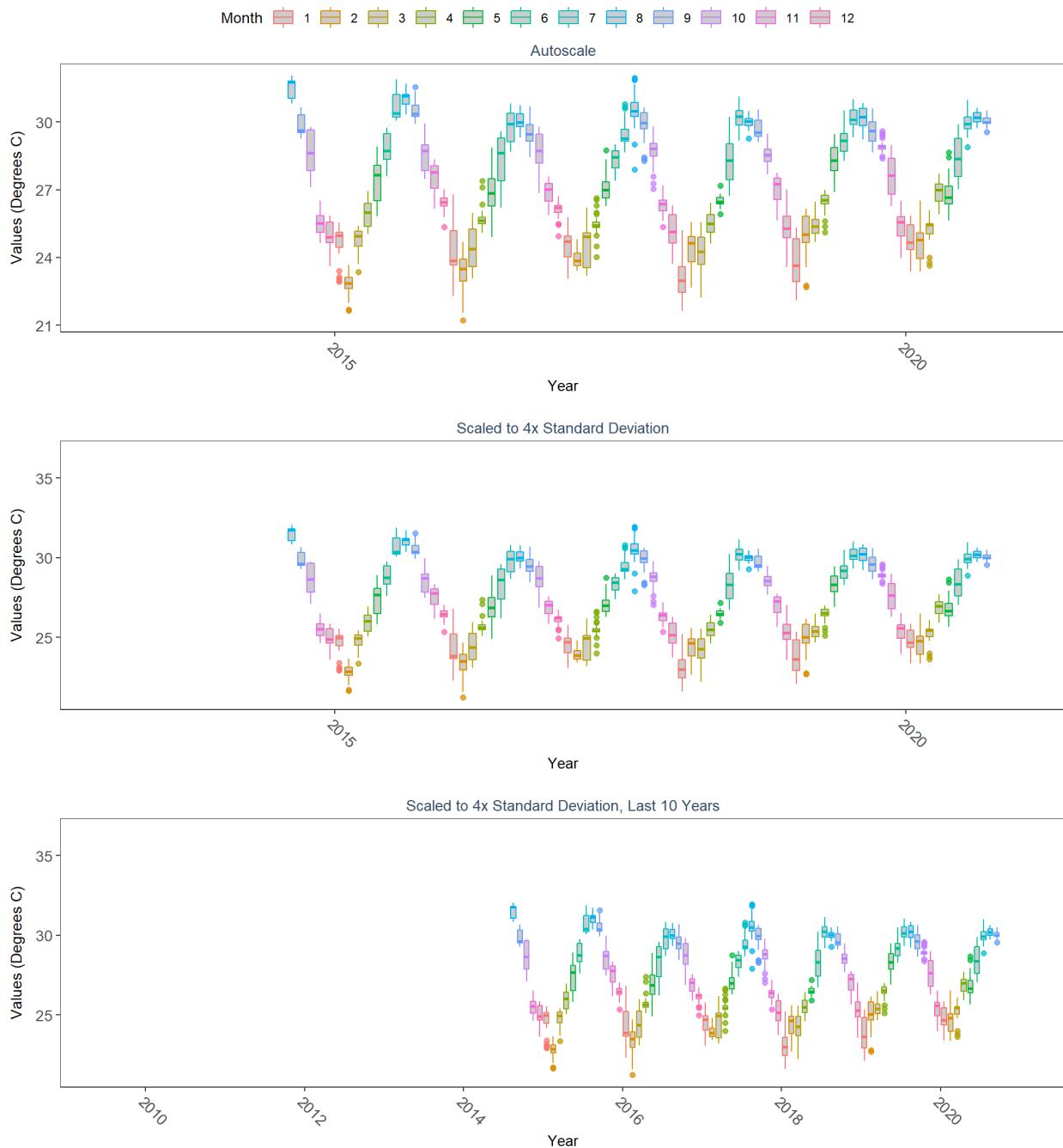
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 77  
 By Month



Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
78  
By Year



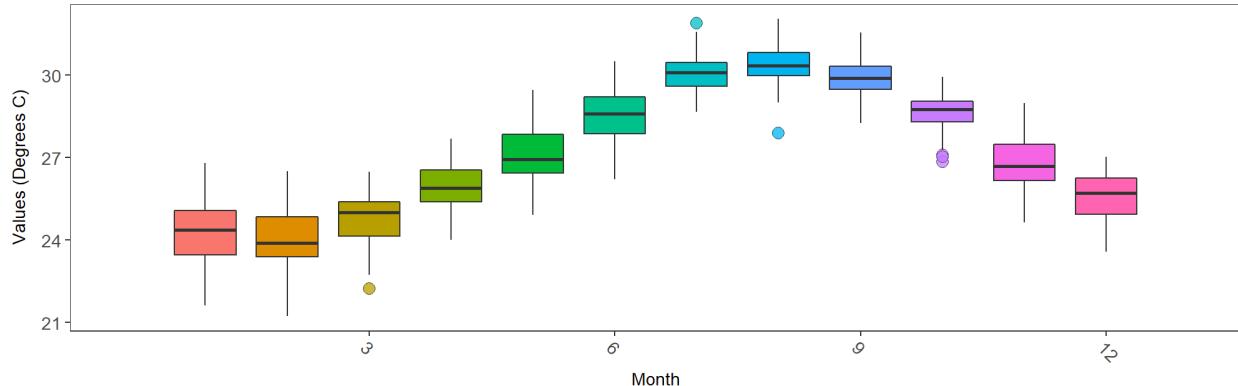
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 78  
 By Year & Month



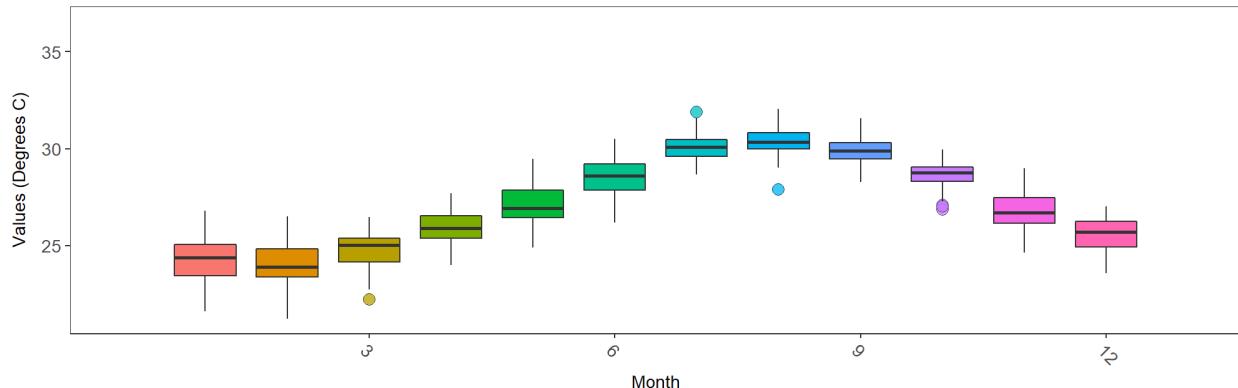
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 78  
 By Month

Month 1 2 3 4 5 6 7 8 9 10 11 12

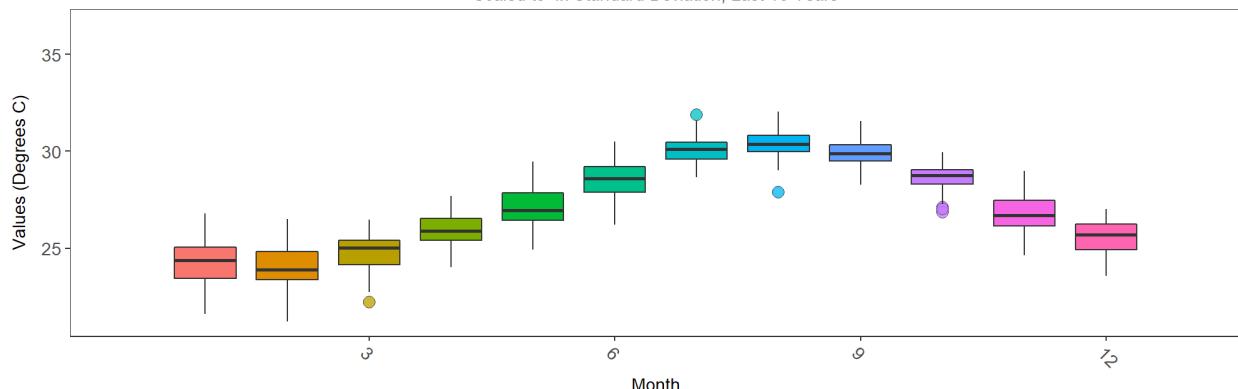
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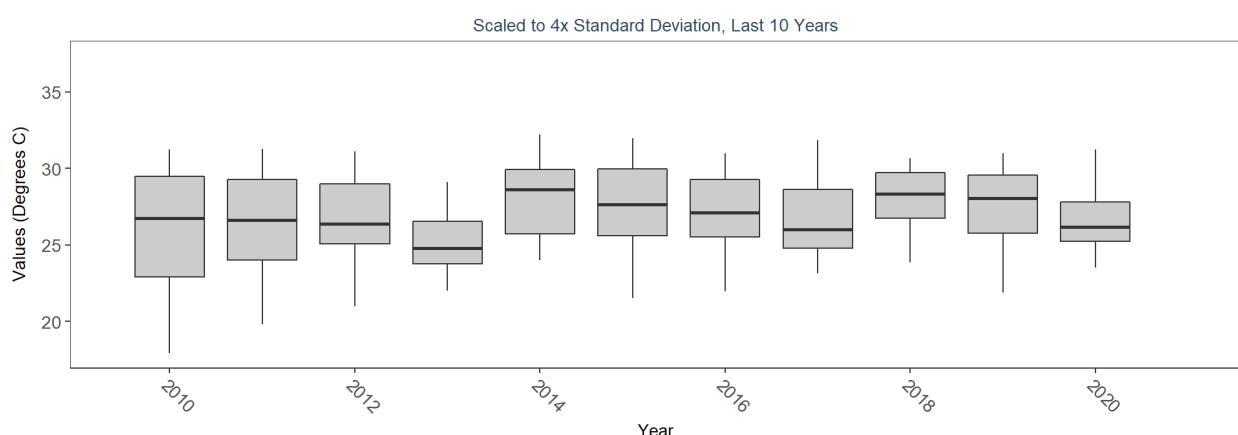
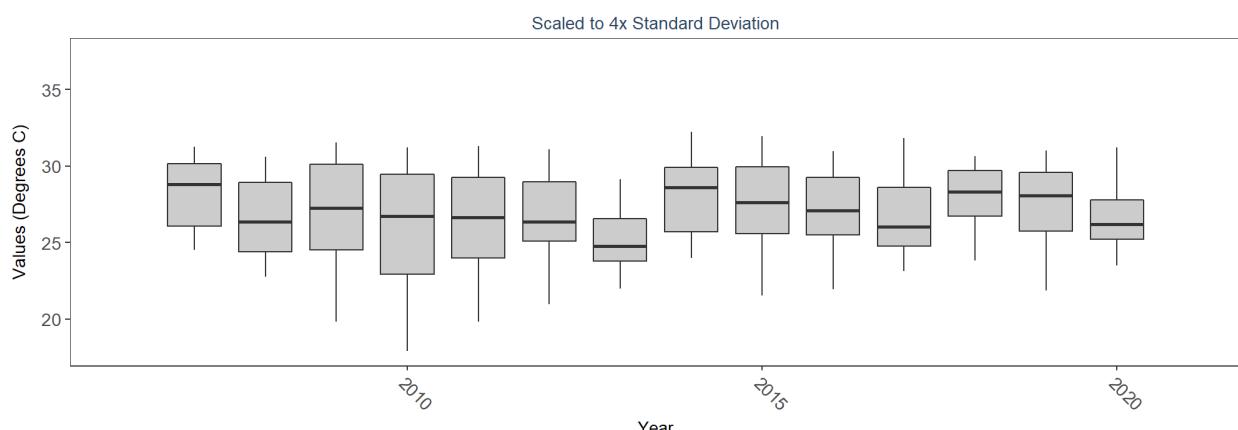
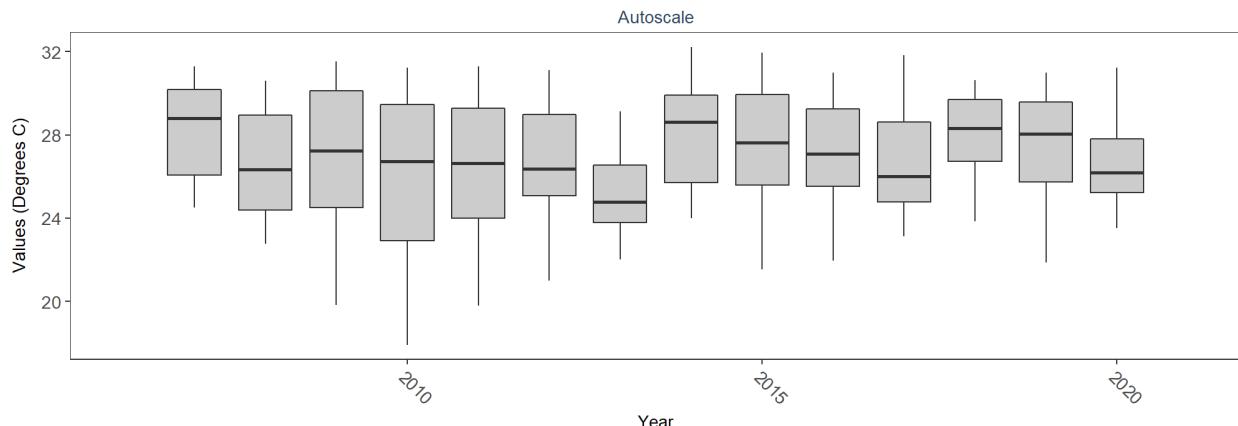
Scaled to 4x Standard Deviation



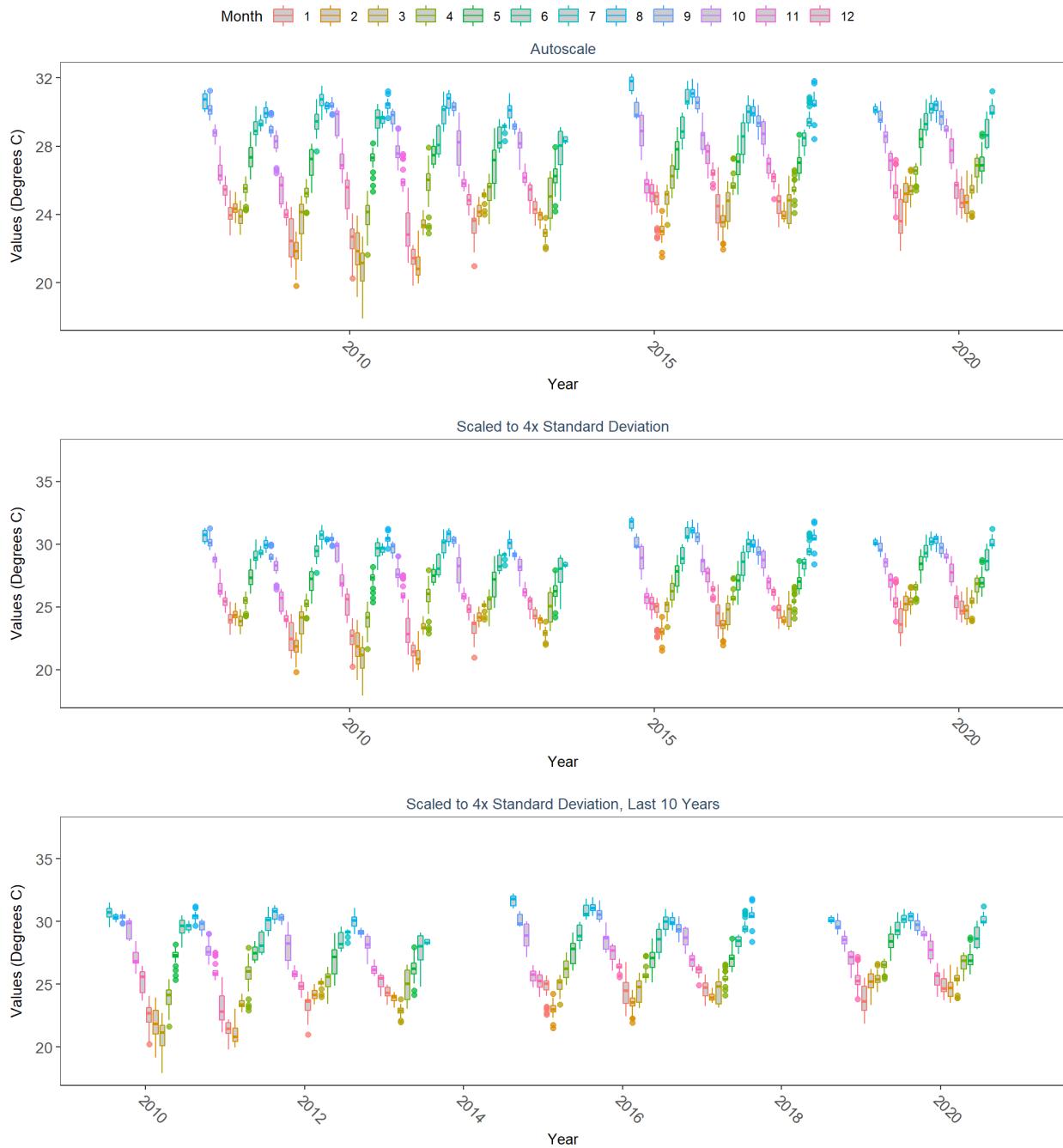
Scaled to 4x Standard Deviation, Last 10 Years



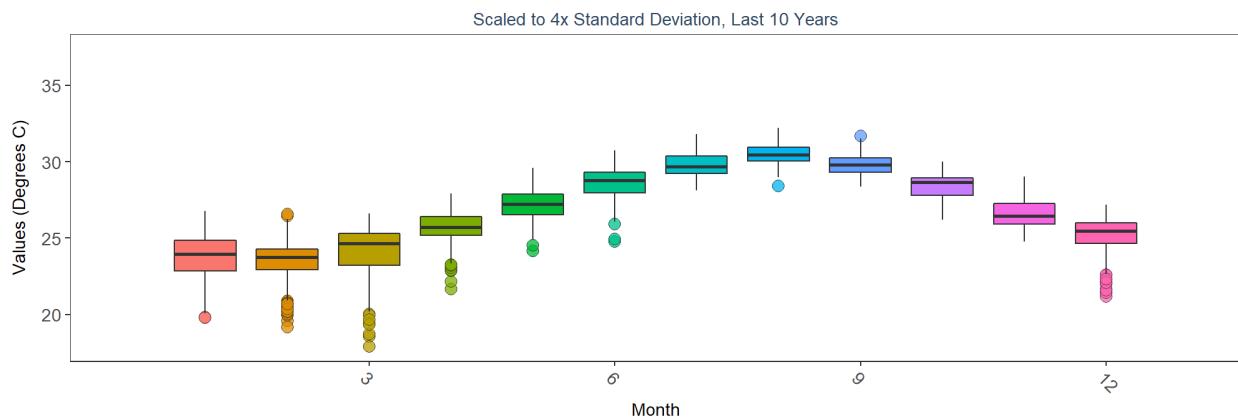
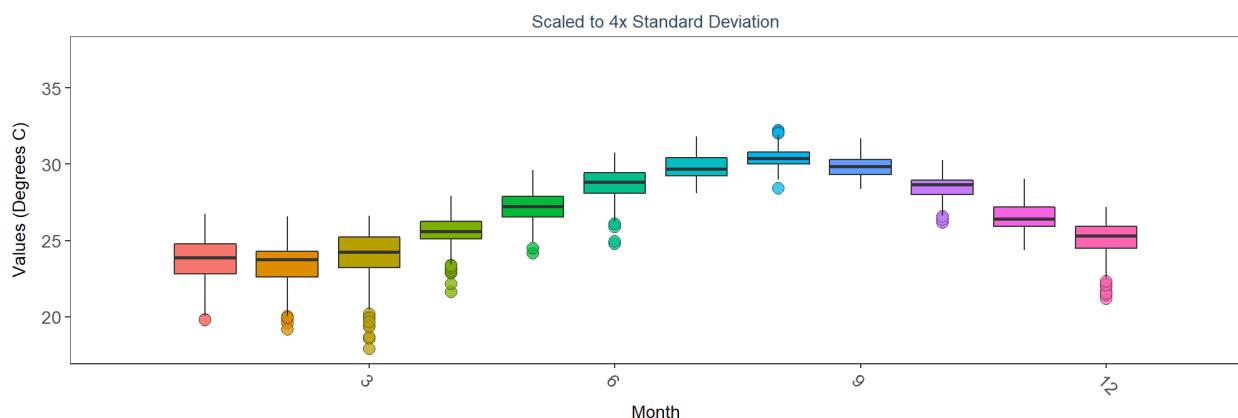
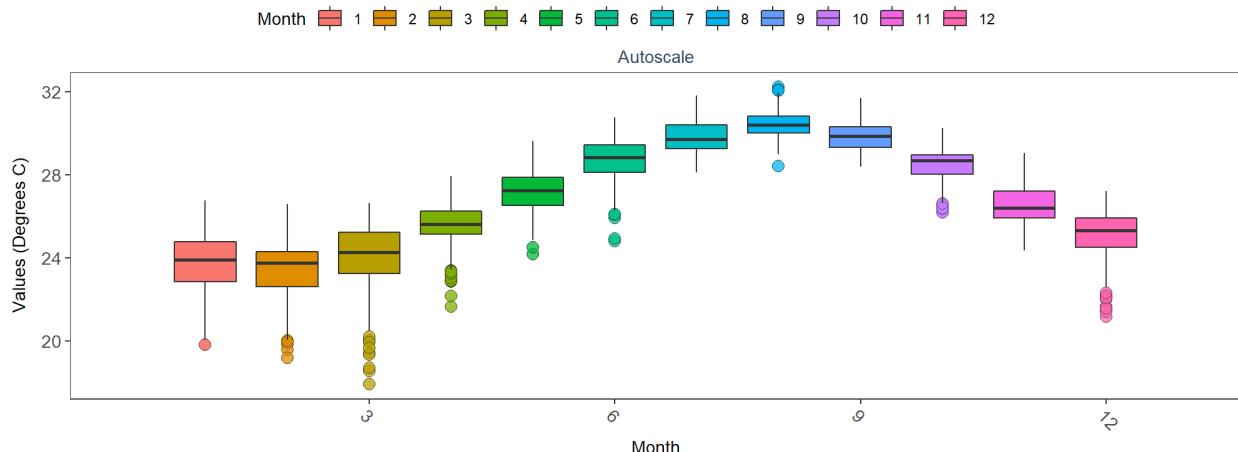
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
79  
By Year



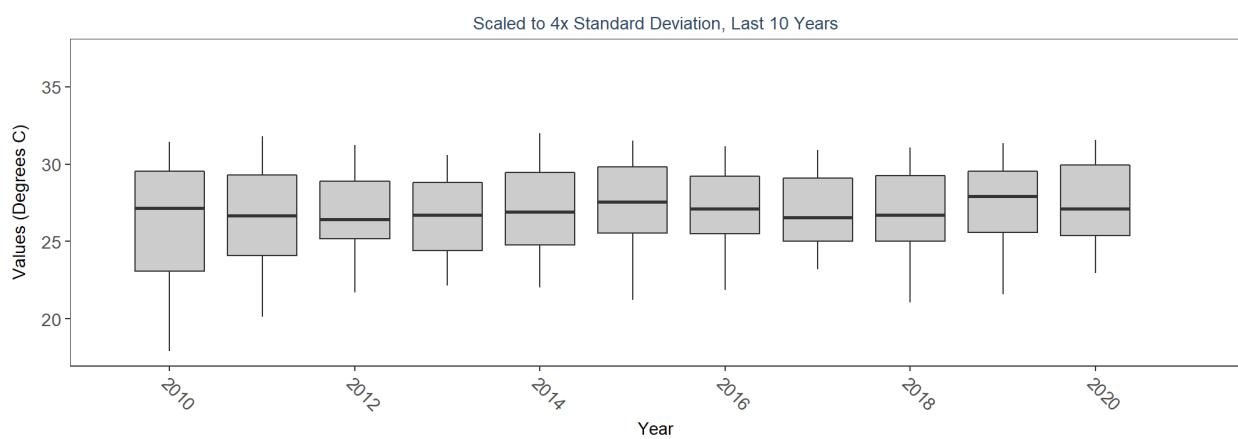
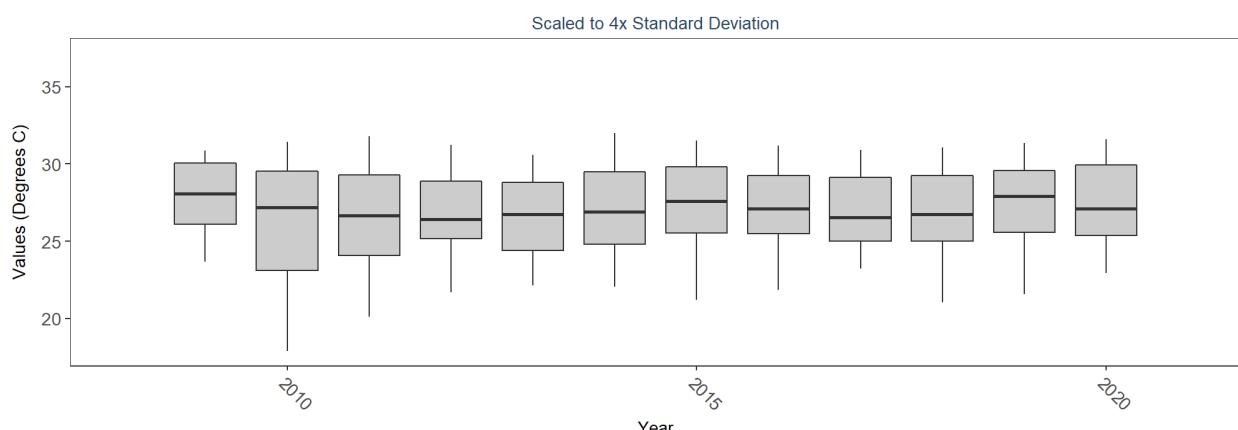
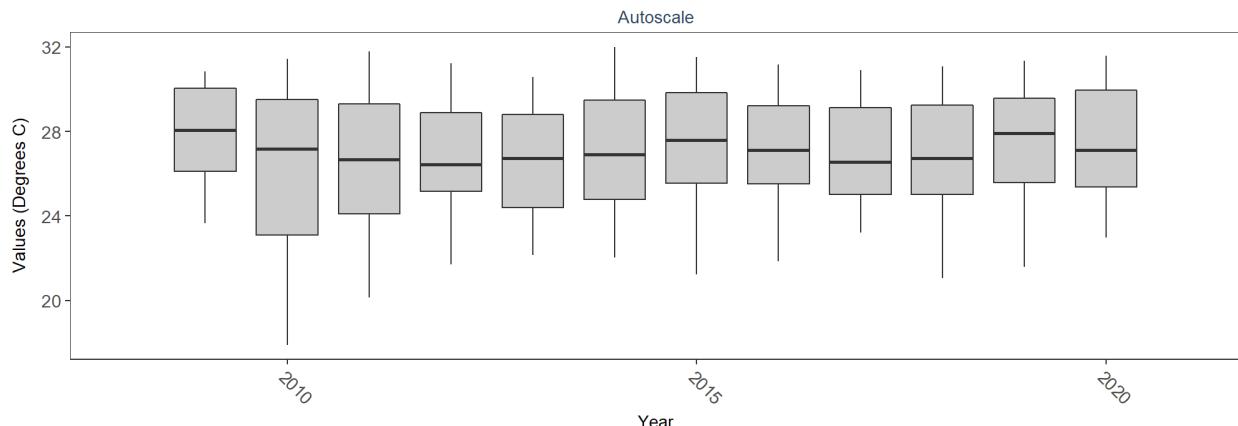
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 79  
 By Year & Month



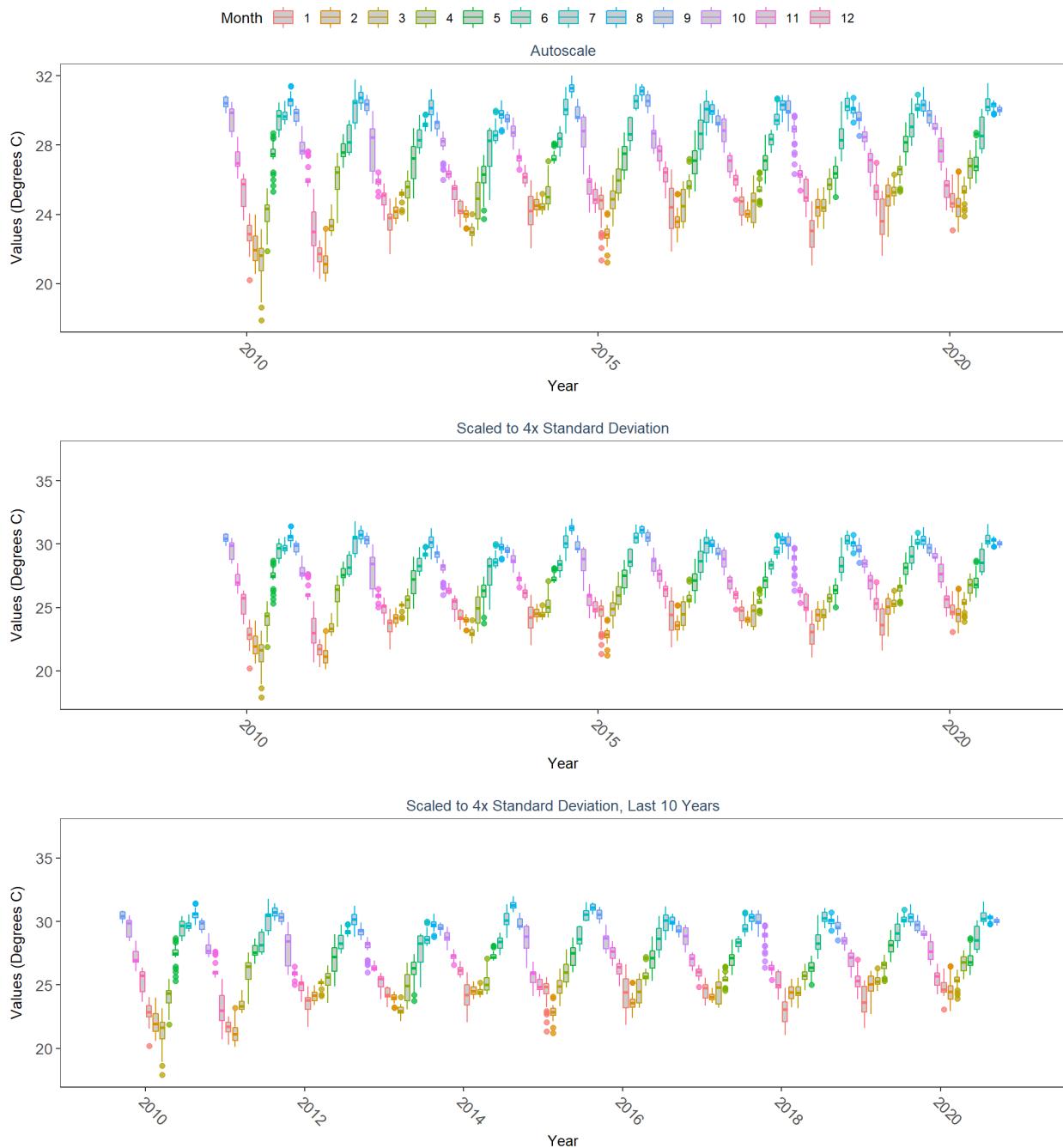
Florida Keys National Marine Sanctuary  
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 Water Temperature on Coral Reefs in the Florida Keys  
 79  
 By Month



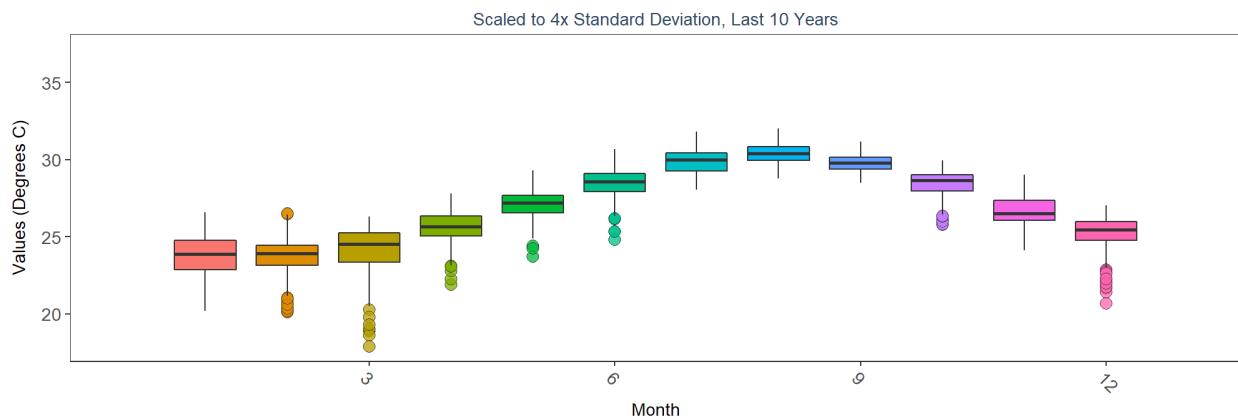
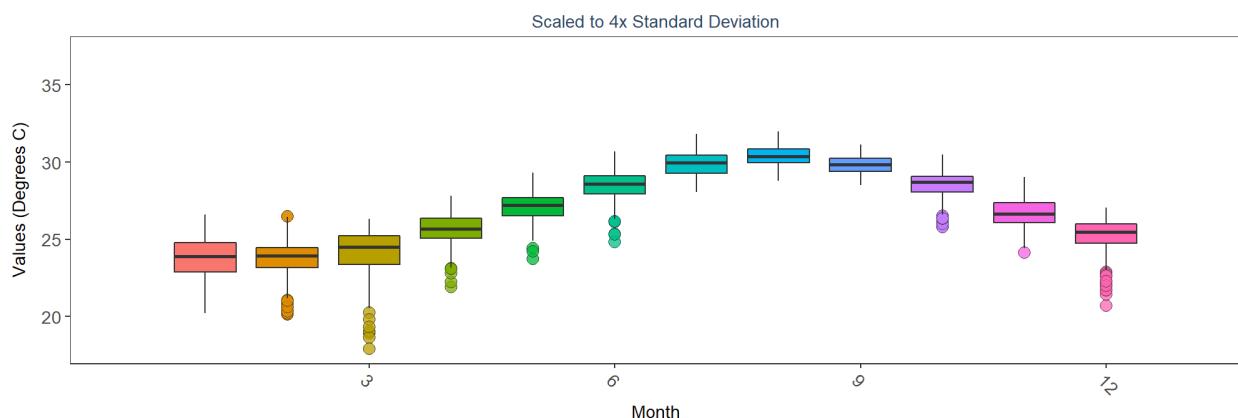
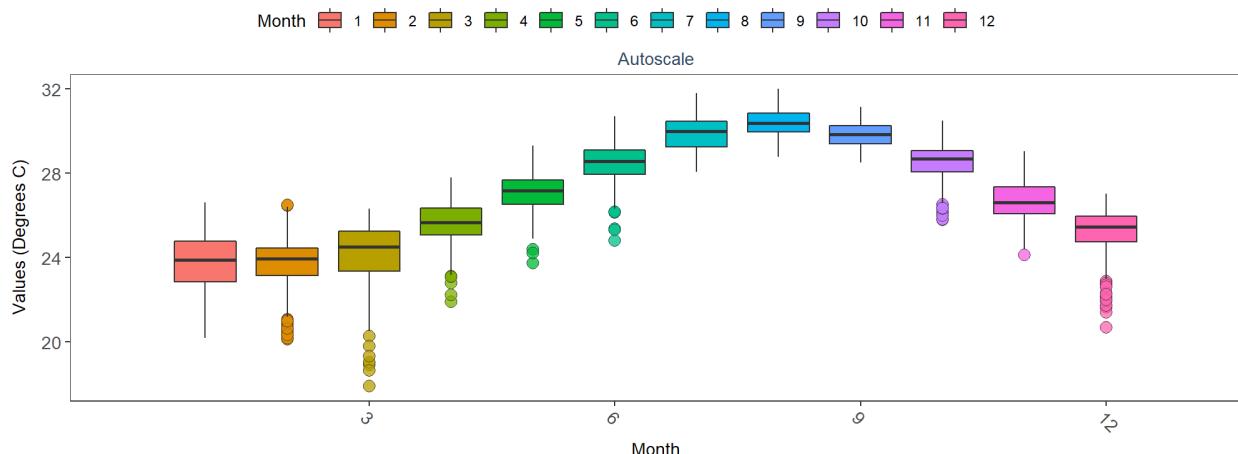
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
80  
By Year



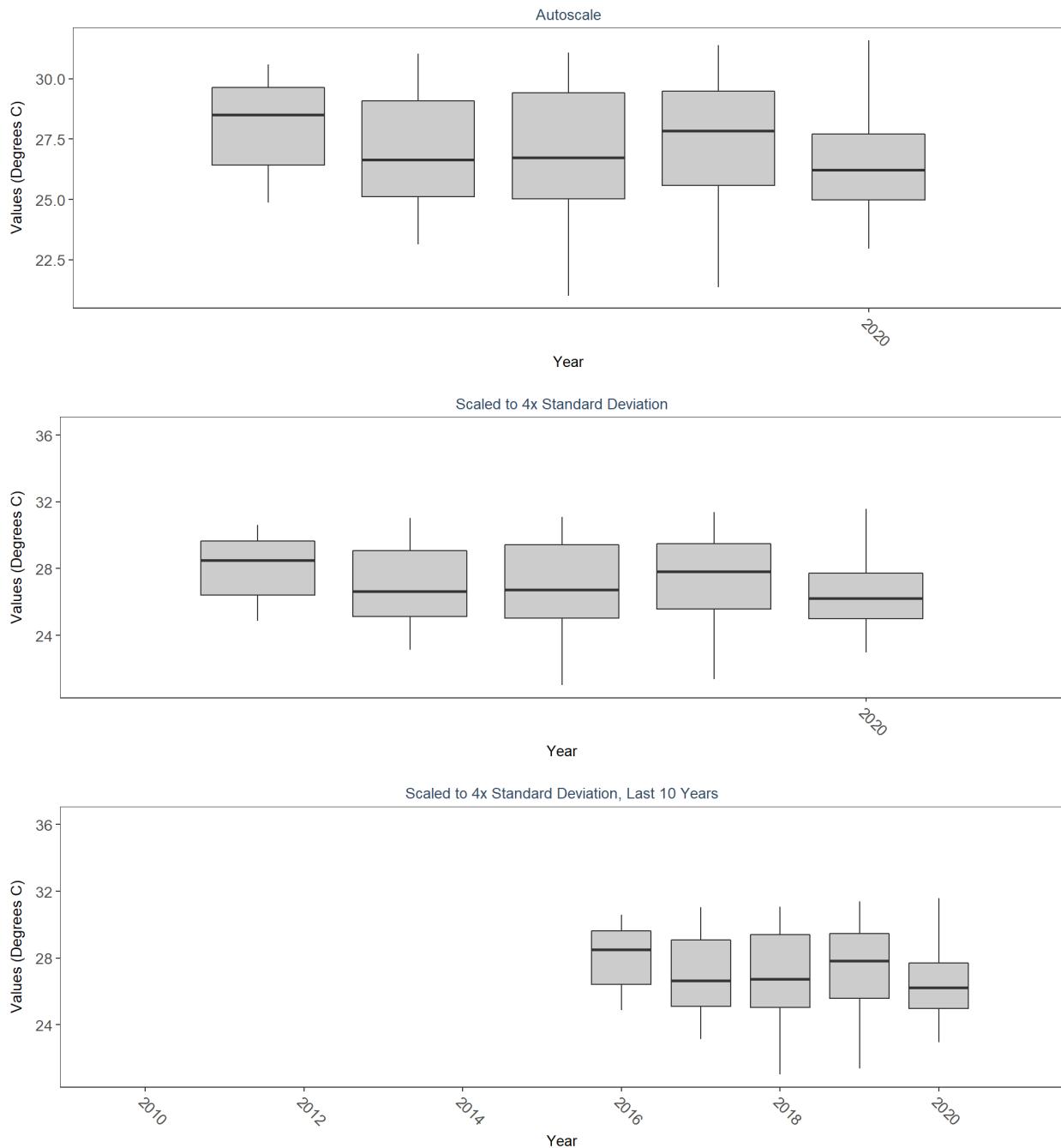
**Florida Keys National Marine Sanctuary**  
**986**  
**Water Temperature on Coral Reefs in the Florida Keys**  
**80**  
**By Year & Month**



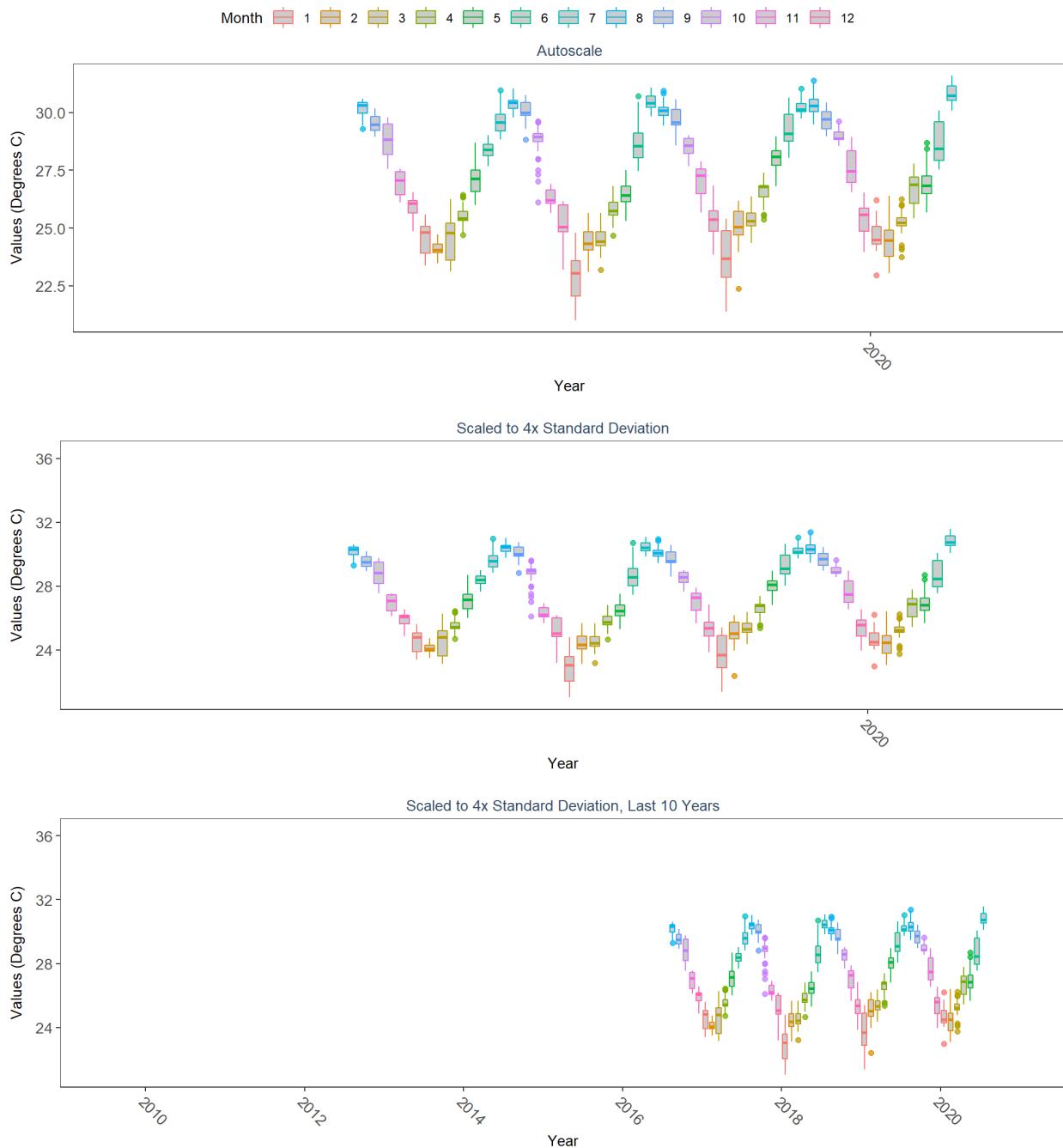
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
80  
By Month



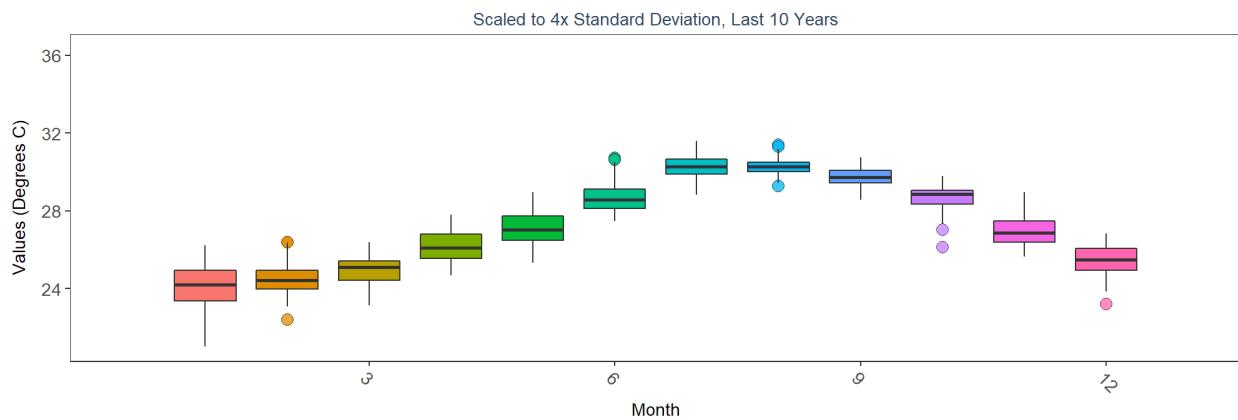
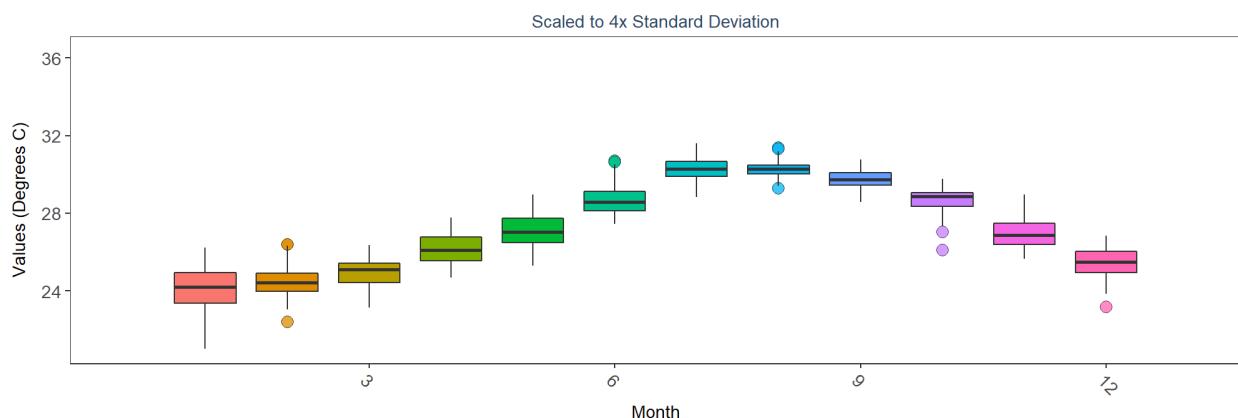
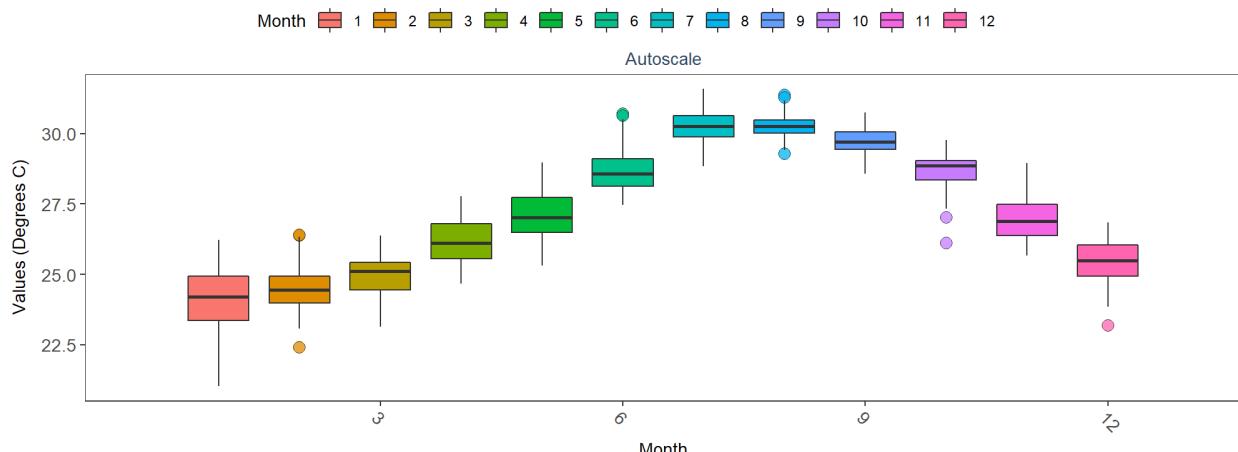
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
81  
By Year



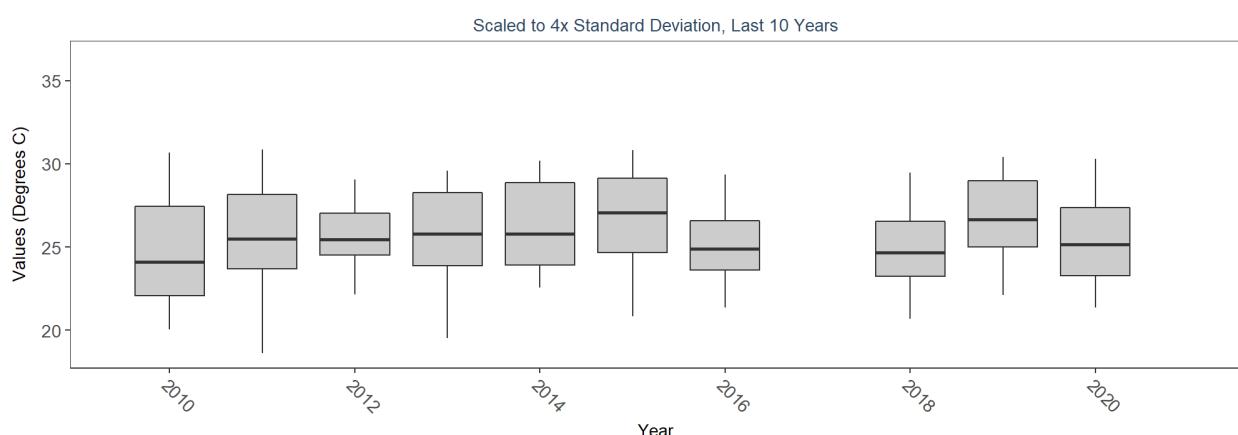
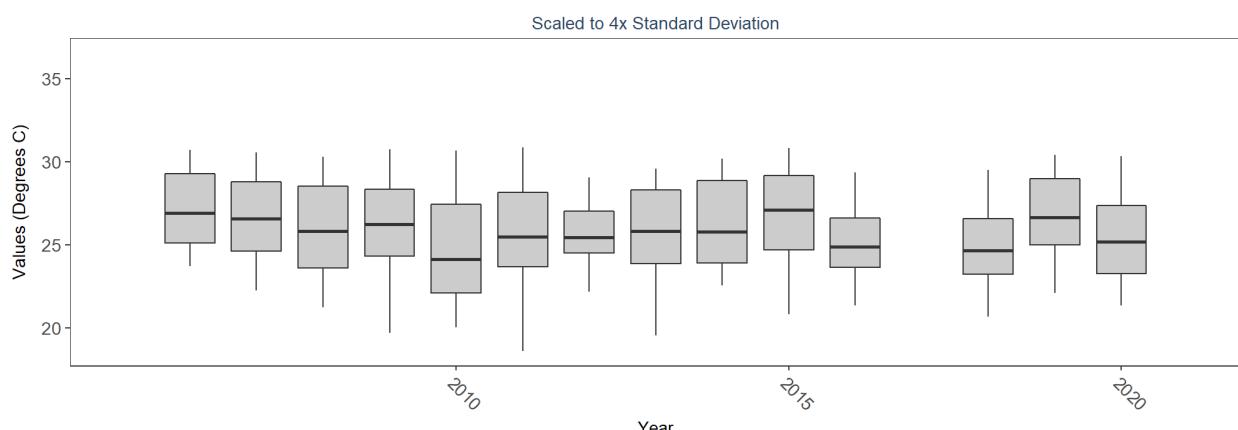
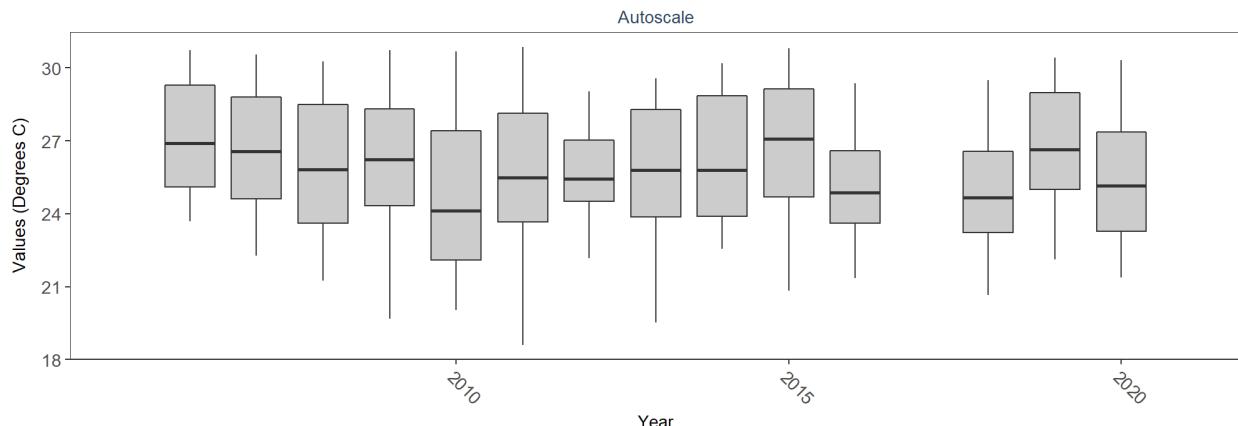
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 81  
 By Year & Month



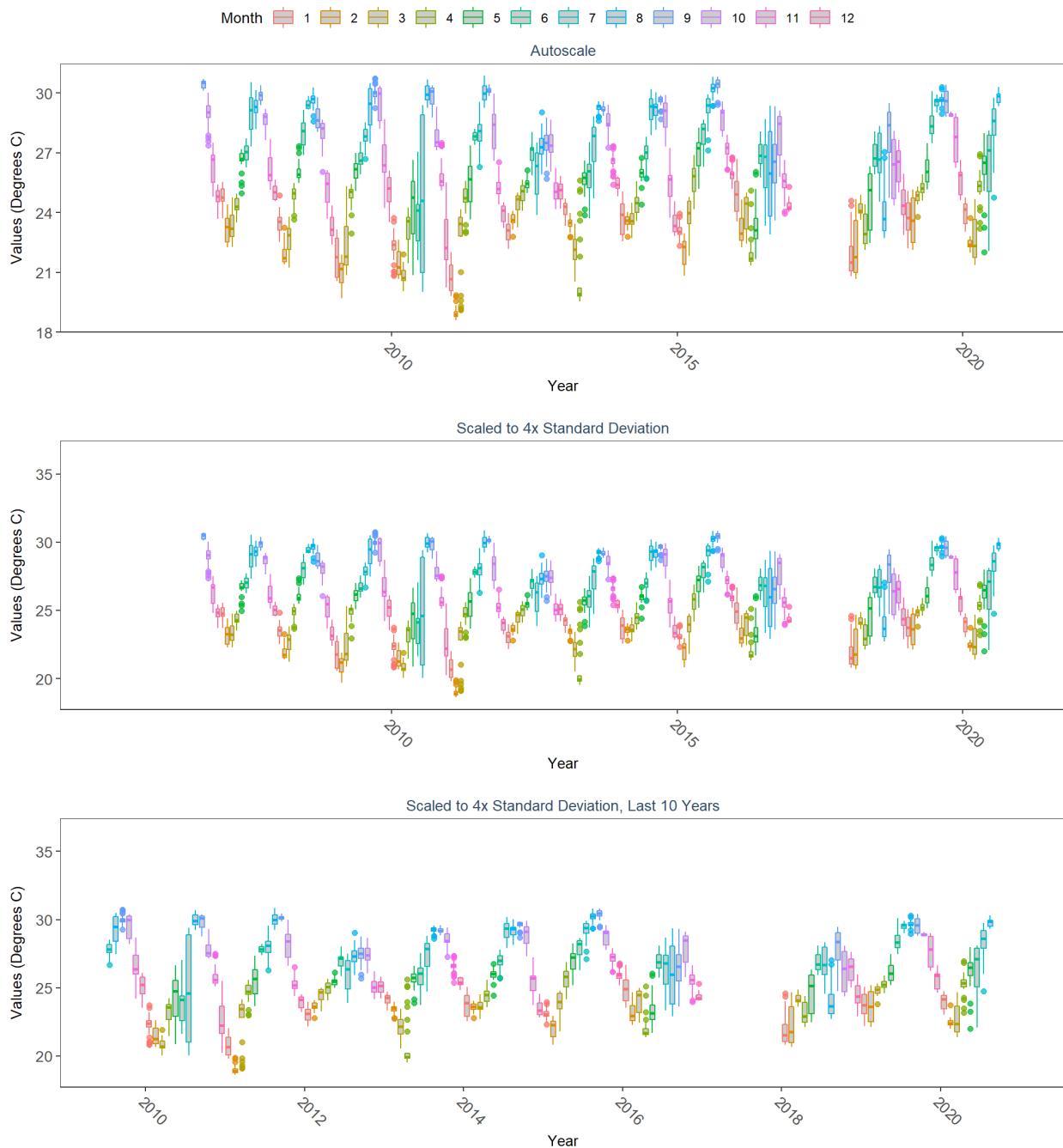
Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 81  
 By Month



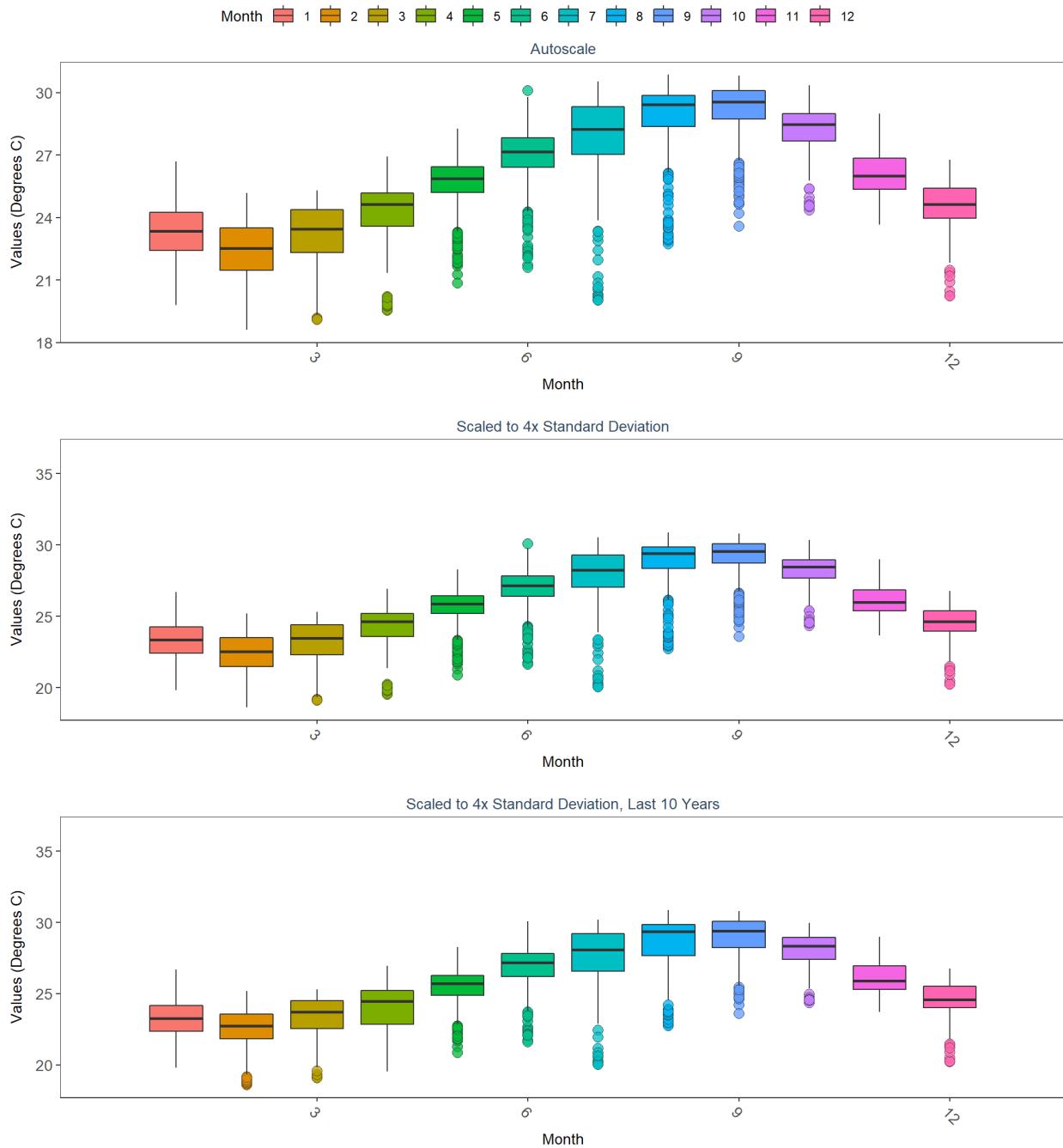
Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
83  
By Year



Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 83  
 By Year & Month



Florida Keys National Marine Sanctuary  
 986  
 Water Temperature on Coral Reefs in the Florida Keys  
 83  
 By Month



## Appendix IV: Excluded Monitoring Locations

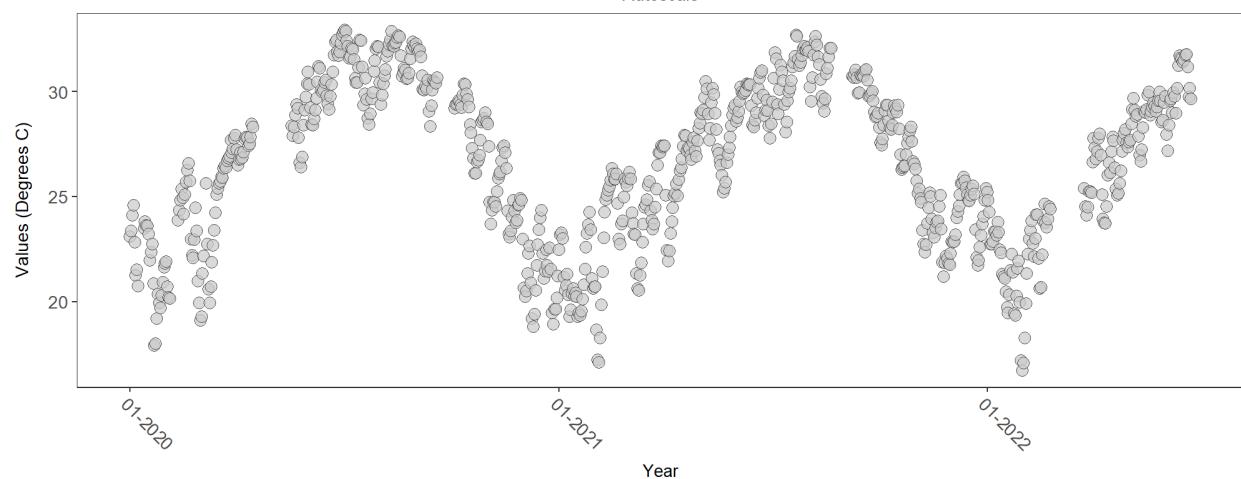
Scatter plots of data values are created for monitoring locations that have fewer than 5 separate years of data entries.

```

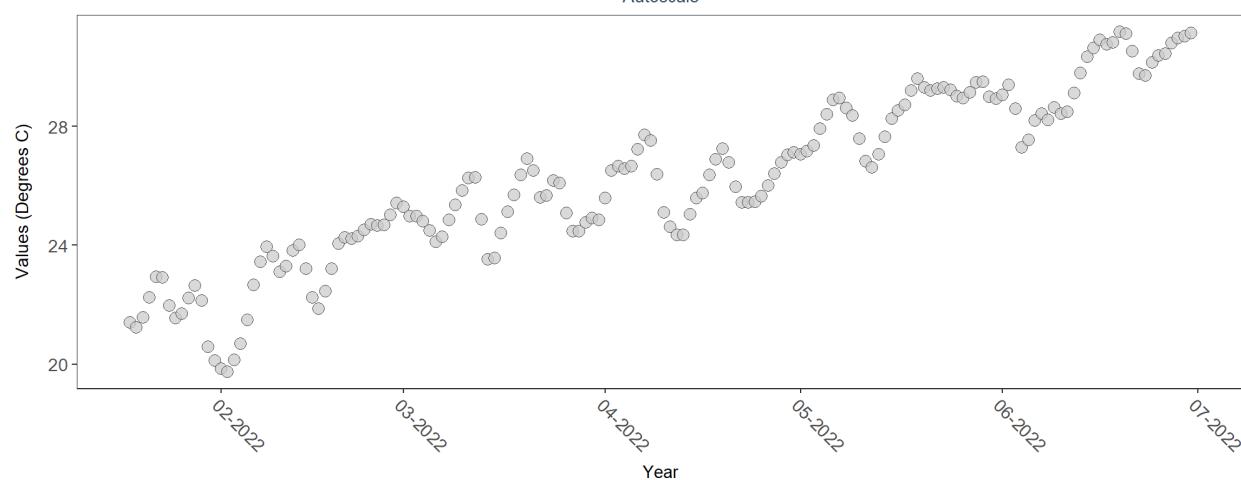
# Get list of monitoring locations that have data, but without sufficient data
Mon_Exclude <- Mon_Summ[Mon_Summ$SufficientData==FALSE & N_Years>0,]
Mon_Exclude <- Mon_Exclude[order(Mon_Exclude$MonitoringID),]
z=nrow(Mon_Exclude)
# Determines whether excluded monitoring locations exist. If they do, begins
# looping through them
if(z==0){
  print("There are no monitoring locations that qualify.")
} else {
  for(i in 1:z){
    # Get managed area name for title
    MA_name <- unique(data$ManagedAreaName[
      data$MonitoringID==Mon_Exclude$MonitoringID[i]])
    # Get program name for title
    Mon_name <- paste0(unique(data$ProgramID[
      data$MonitoringID==Mon_Exclude$MonitoringID[i]]), "\n",
      unique(data$ProgramName[
        data$MonitoringID==Mon_Exclude$MonitoringID[i]]), "\n",
      unique(data$ProgramLocationID[
        data$MonitoringID==Mon_Exclude$MonitoringID[i]])))
    # Create scatter plot with data
    p1<-ggplot(data=data[data$MonitoringID==Mon_Exclude$MonitoringID[i] &
      data$Include==TRUE, ],
      aes(x=SampleDate, y=ResultValue)) +
      geom_point(shape=21, size=3, color="#333333", fill="#cccccc",
      alpha=0.75) +
      labs(title=paste0(MA_name, "\n",
        Mon_name, " (", Mon_Exclude$N_Years[i],
        " Unique Years)"),
        subtitle="Autoscale", x="Year",
        y=paste0("Values (", unit, ")")) +
      plot_theme +
      scale_x_date(labels=date_format("%m-%Y"))
    print(p1)
  }
}

```

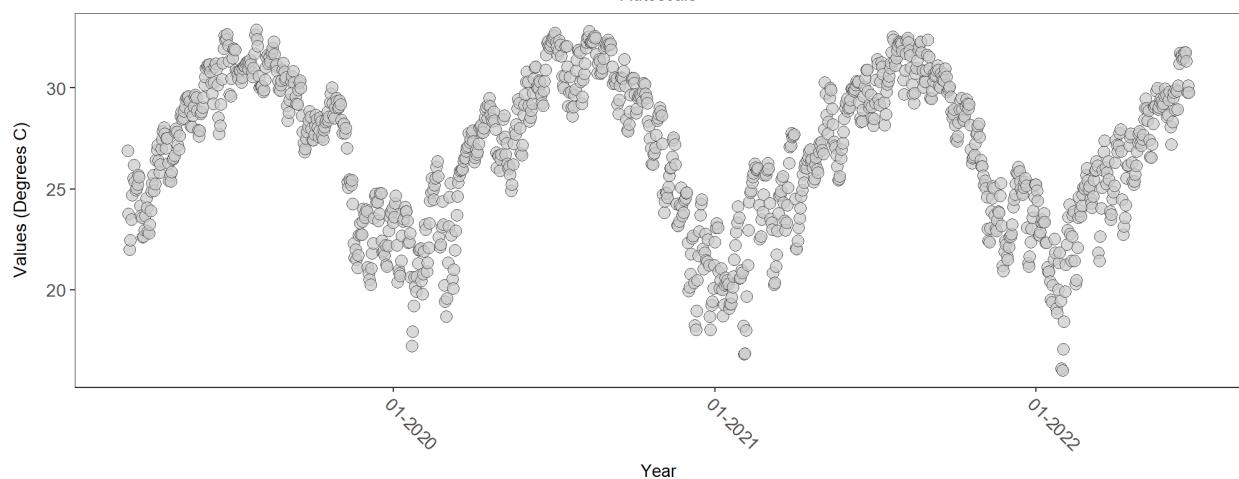
Biscayne Bay Aquatic Preserve  
5077  
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring  
BBBB14 (3 Unique Years)  
Autoscale



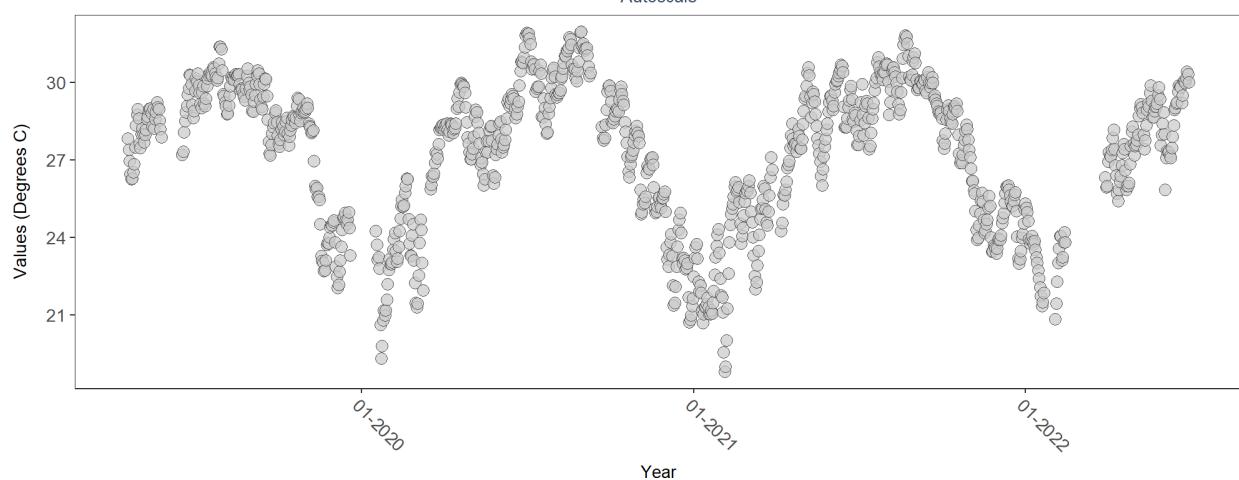
Biscayne Bay Aquatic Preserve  
5077  
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring  
BBCWA4 (1 Unique Years)  
Autoscale



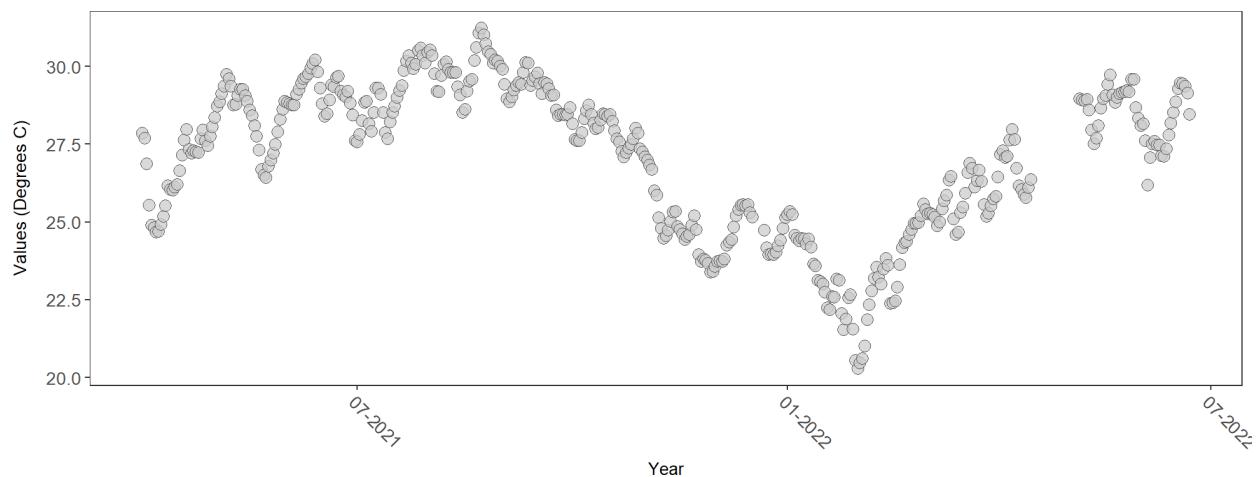
Biscayne Bay Aquatic Preserve  
5077  
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring  
BBJT71 (4 Unique Years)  
Autoscale



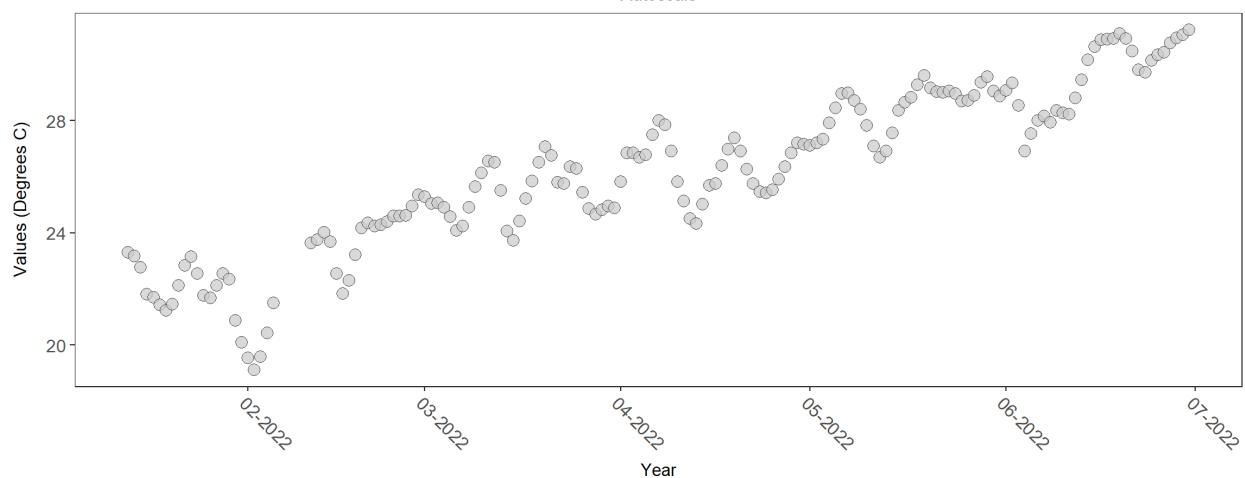
Biscayne Bay Aquatic Preserve  
5077  
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring  
BBLR03 (4 Unique Years)  
Autoscale

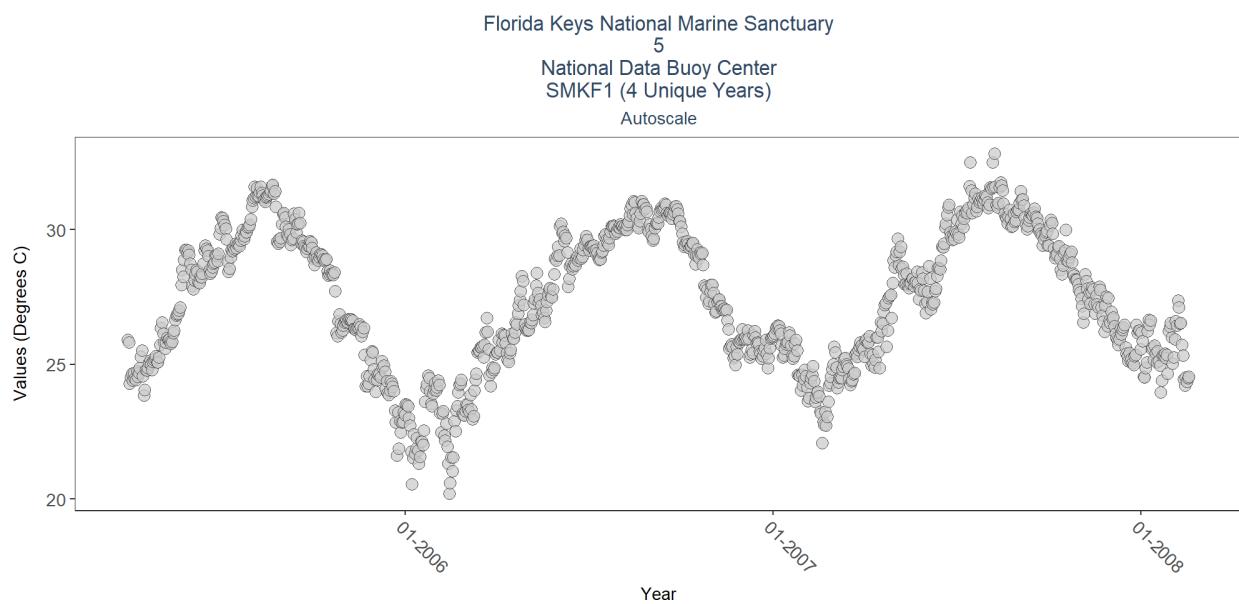
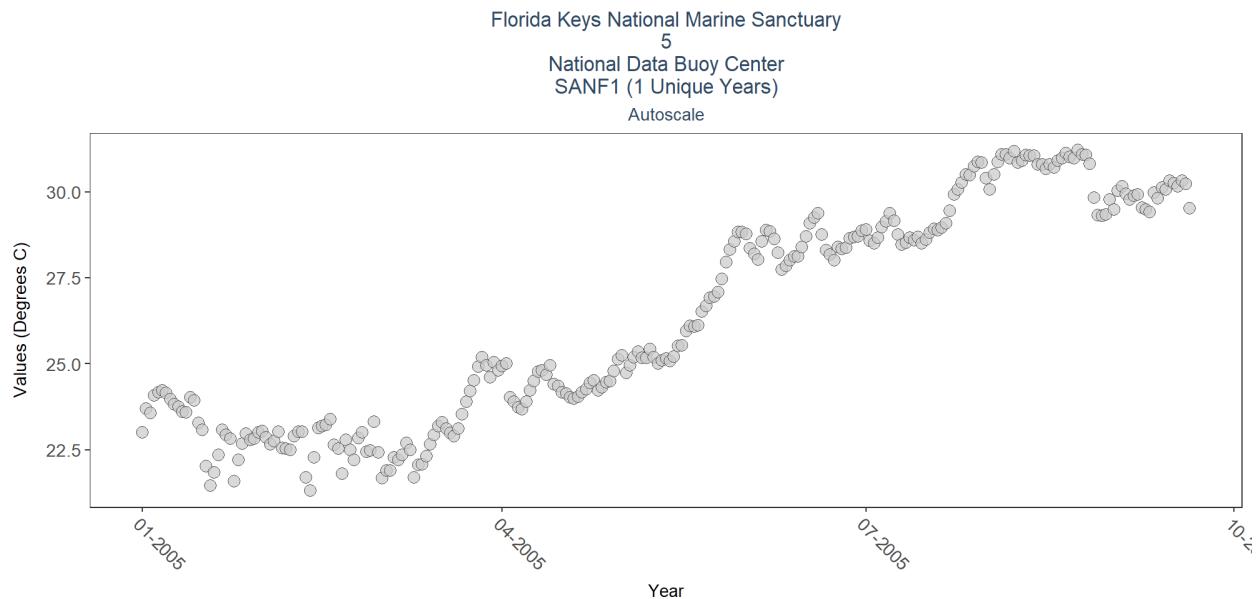


Biscayne Bay Aquatic Preserve  
5077  
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring  
BBMRDW (2 Unique Years)  
Autoscale



Biscayne Bay Aquatic Preserve  
5077  
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring  
BBMRRB (1 Unique Years)  
Autoscale



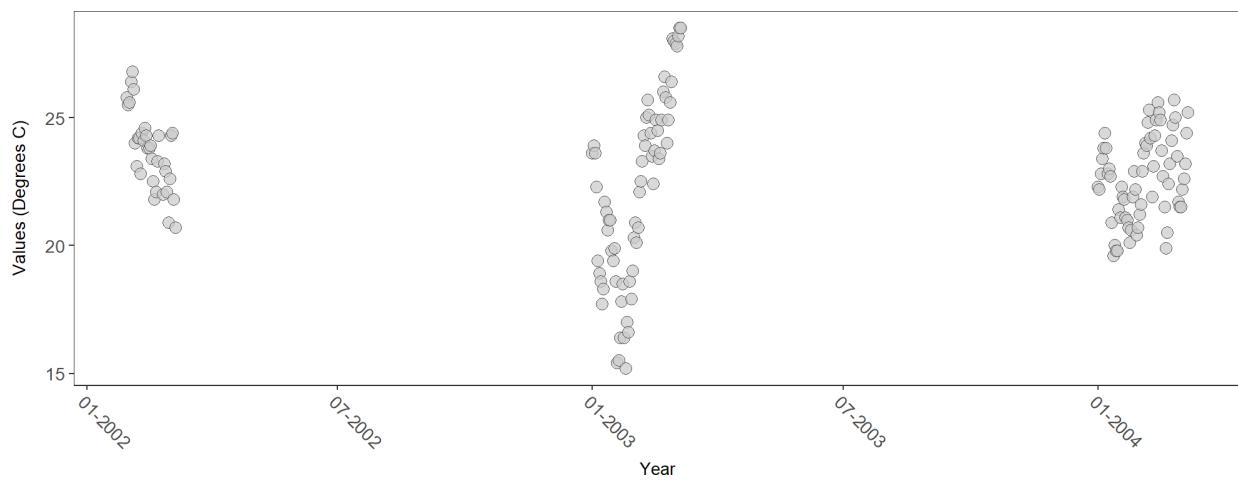


Florida Keys National Marine Sanctuary

7

National Water Information System  
245323080410100 (3 Unique Years)

Autoscale

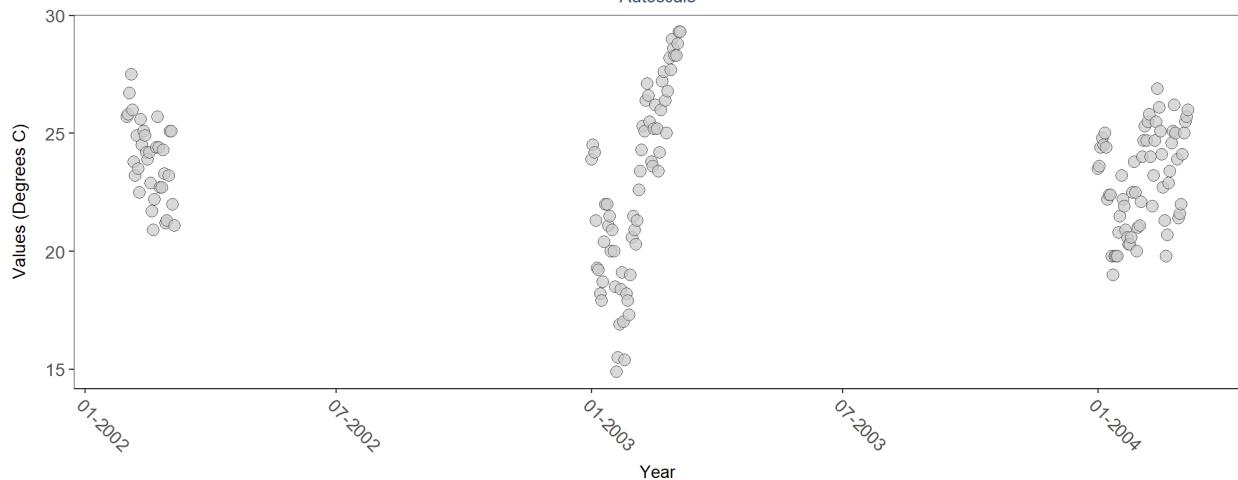


Florida Keys National Marine Sanctuary

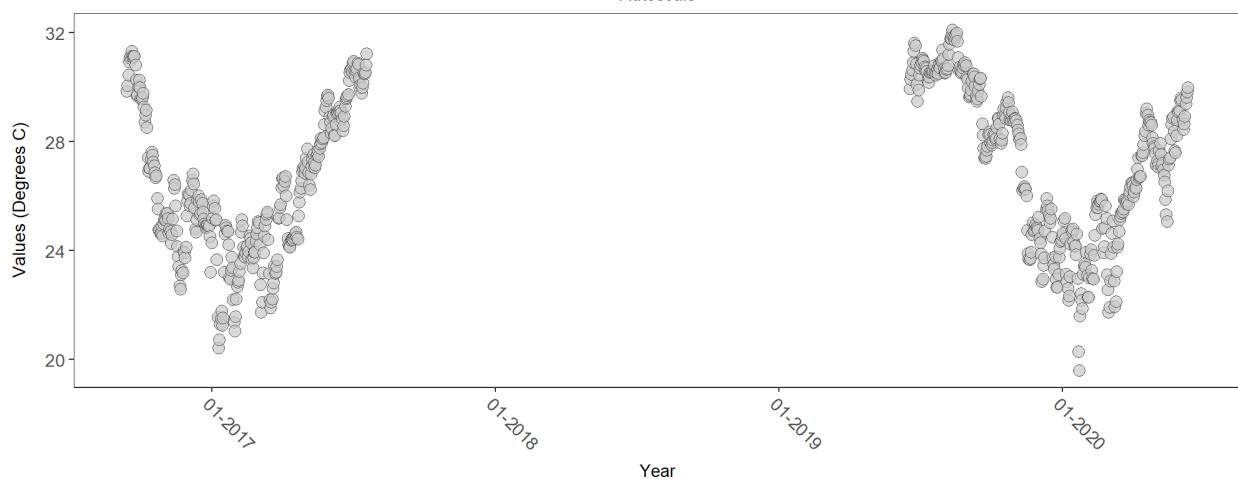
7

National Water Information System  
245622080364200 (3 Unique Years)

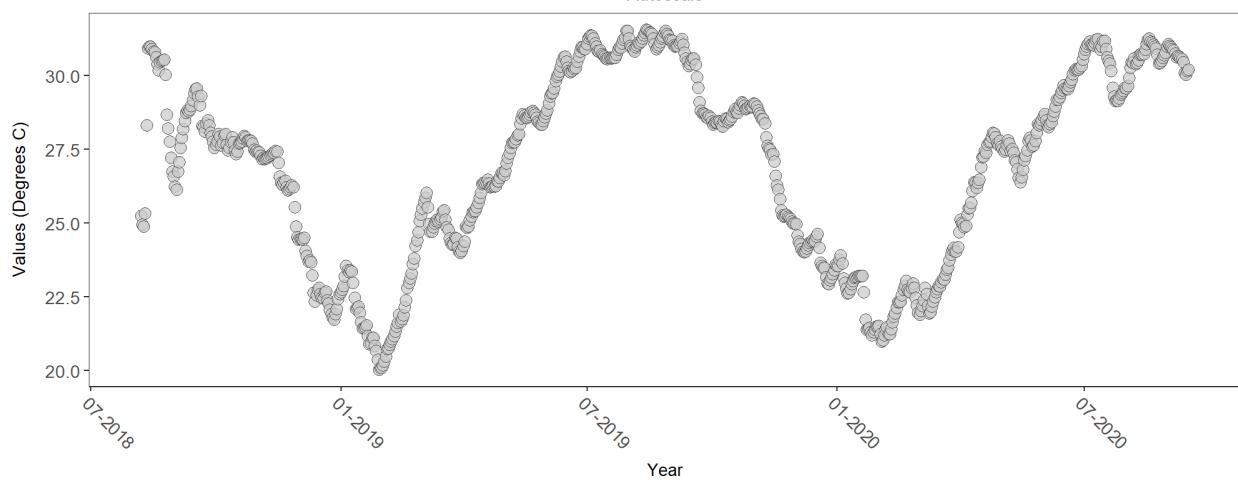
Autoscale



Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
33 (4 Unique Years)  
Autoscale



Florida Keys National Marine Sanctuary  
986  
Water Temperature on Coral Reefs in the Florida Keys  
39 (3 Unique Years)  
Autoscale



Lignumvitae Key Aquatic Preserve

7

National Water Information System  
245323080410100 (3 Unique Years)

Autoscale

