

SEACAR Continuous Water Quality Analysis: SE Region for Water Temperature

Last compiled on 03 June, 2023

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Important Notes

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

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

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/WQ_Continuous/SEACAR_WC_Continuous_ReportRender.R).

Note: The top 2% of data is excluded when computing mean and standard deviations in plotting sections solely for the purpose of getting y-axis scales. The exclusion of the top 2% is not used in any statistics that are exported.

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 SEACAR_WC_Continuous_ReportRender.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-2023-Jun-01.txt**

```
data <- fread(file_in, sep="|", header=TRUE, stringsAsFactors=FALSE,
               select=c("ManagedAreaName", "ProgramID", "ProgramName",
                       "ProgramLocationID", "SampleDate", "Year", "Month",
                       "RelativeDepth", "ActivityType", "ParameterName",
                       "ResultValue", "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-2023-Jun-01.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/WQ_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/WQ_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) {
  # Get basic stats
  dat$Mean <- as.numeric(dat$Mean)
  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 Kendall 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)
}

# Creates a null data frame for storing kendall tau results
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="|")

# Removes data rows with no ResultValue (created by merging with MA_All)
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 = 60, 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)) +

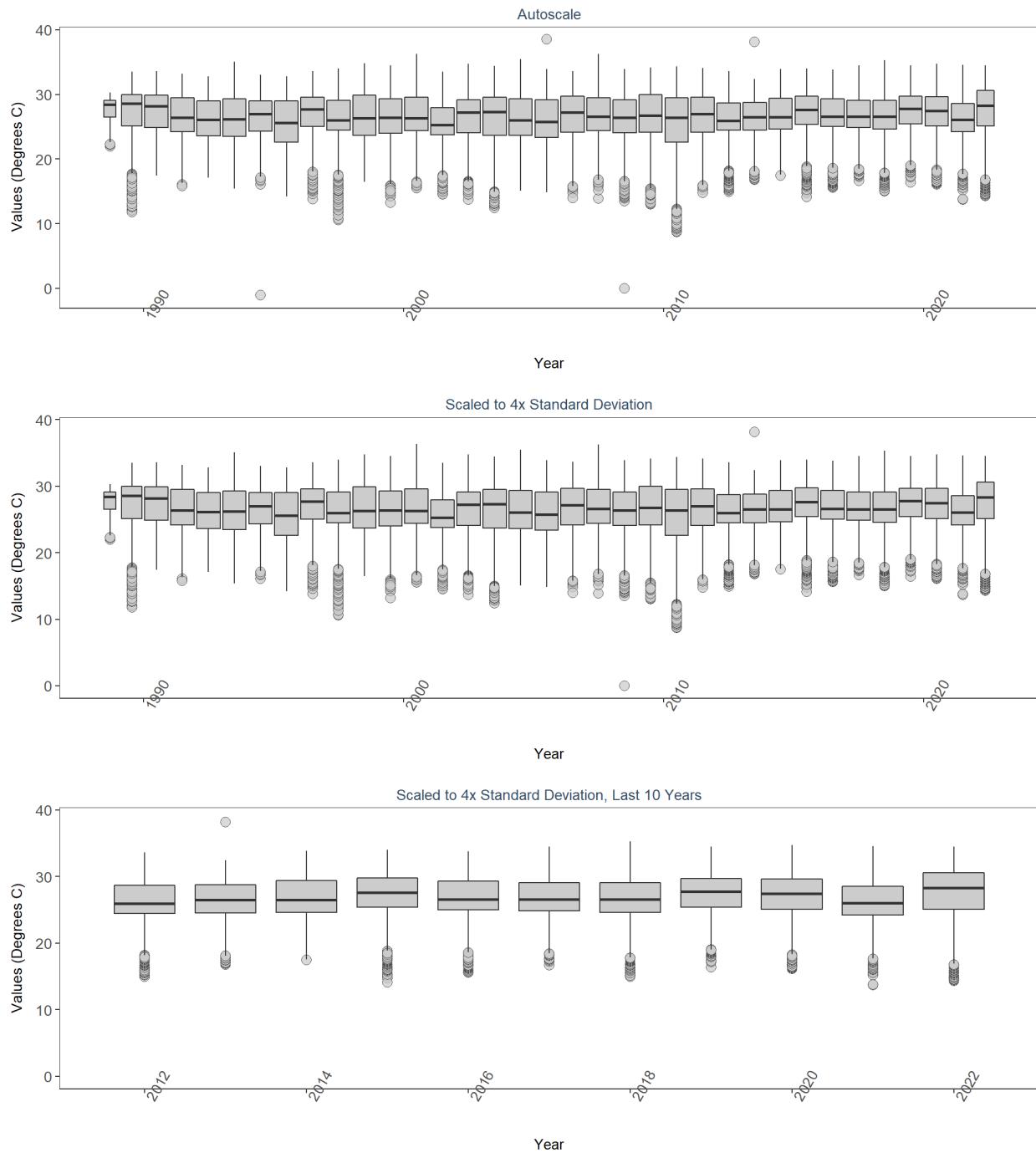
```

```

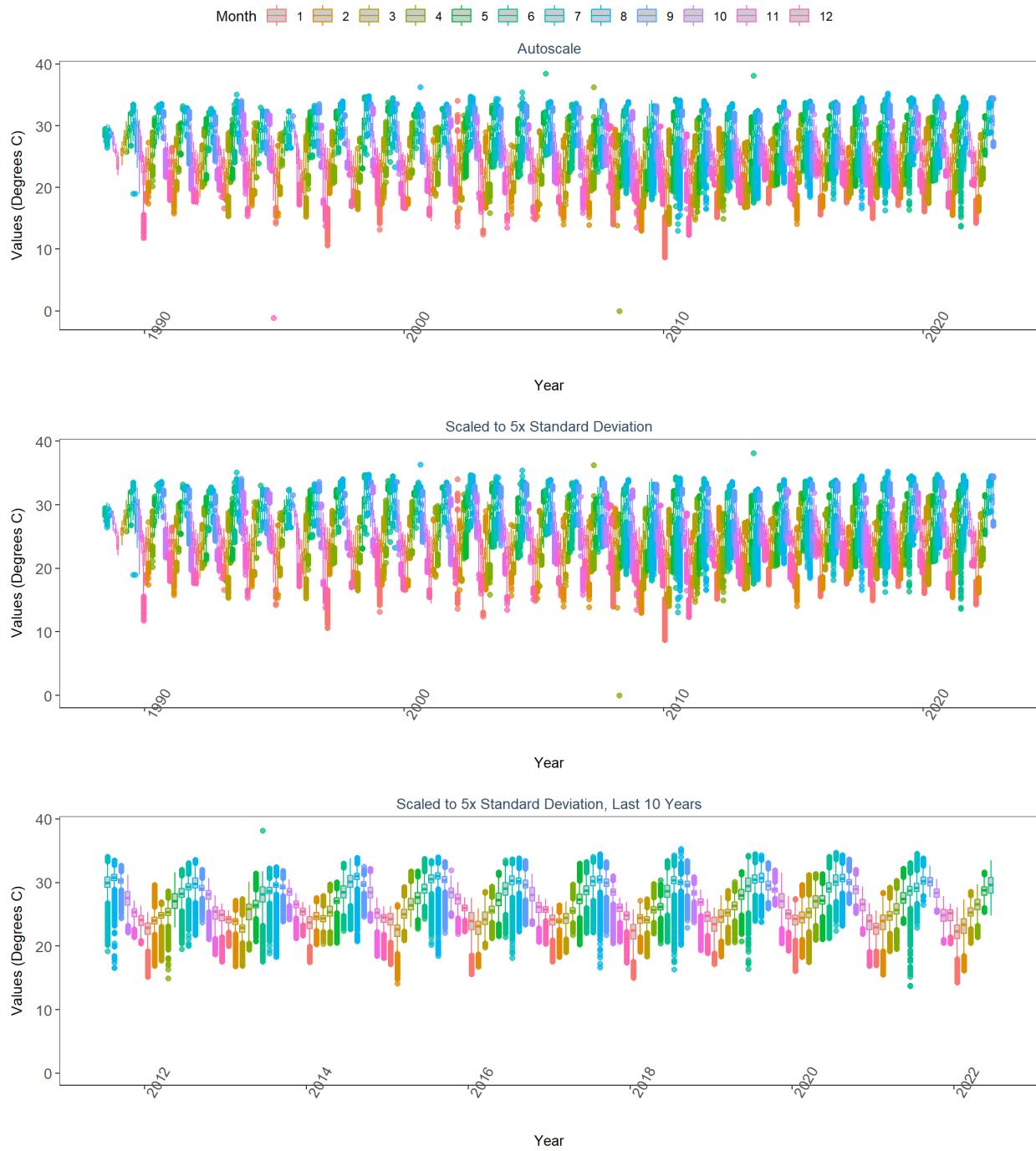
plot_theme +
  theme(legend.position="none")
# Create plot object for y-axis scaled plot for past 10 years
p3 <- ggplot(data=data[data$Include==TRUE &
                        data$Year >= max(data$Year) - 10, ],
              aes(x=Month, y=ResultValue,
                  group=Month, fill=as.factor(Month))) +
  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))

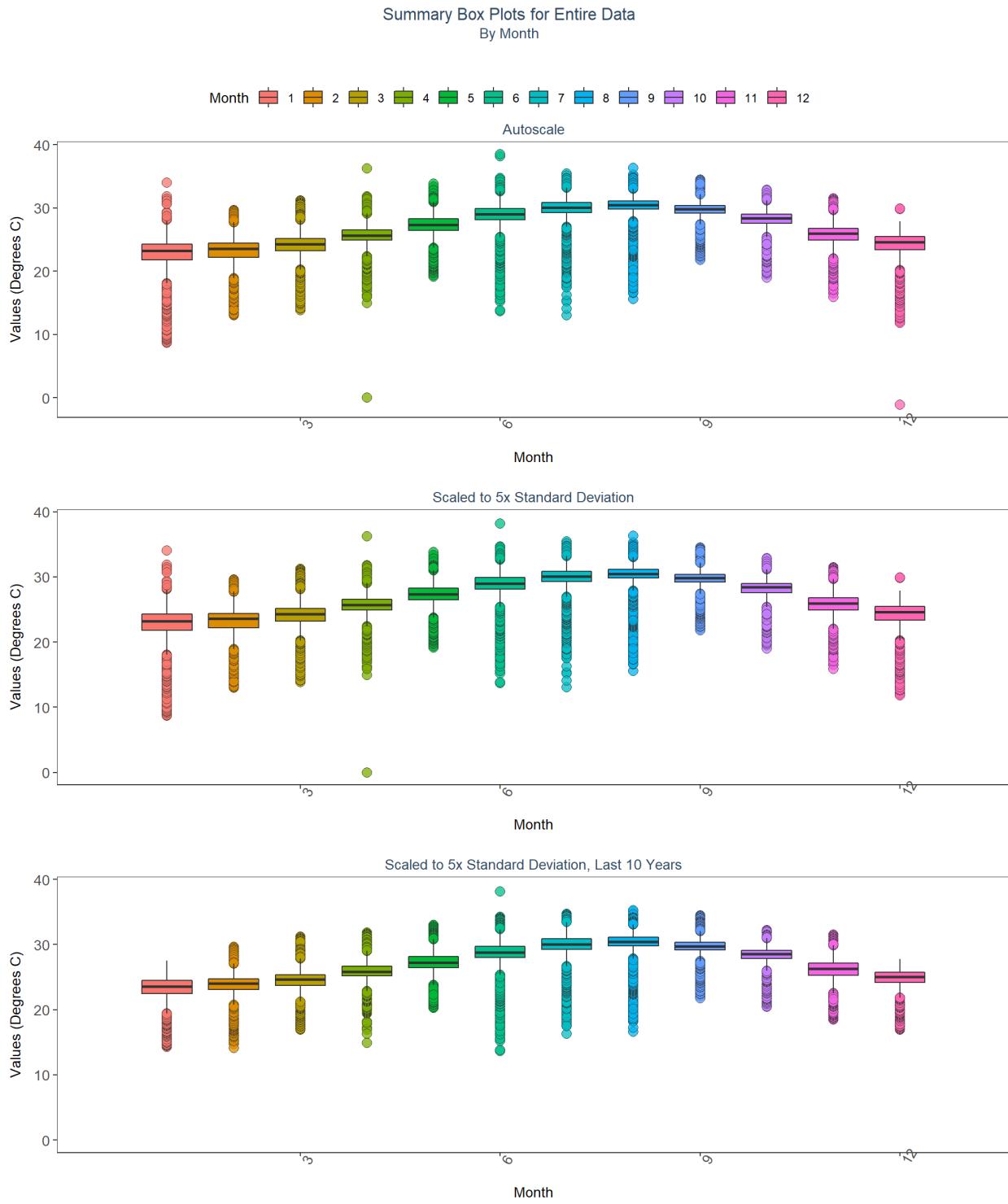
```

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),

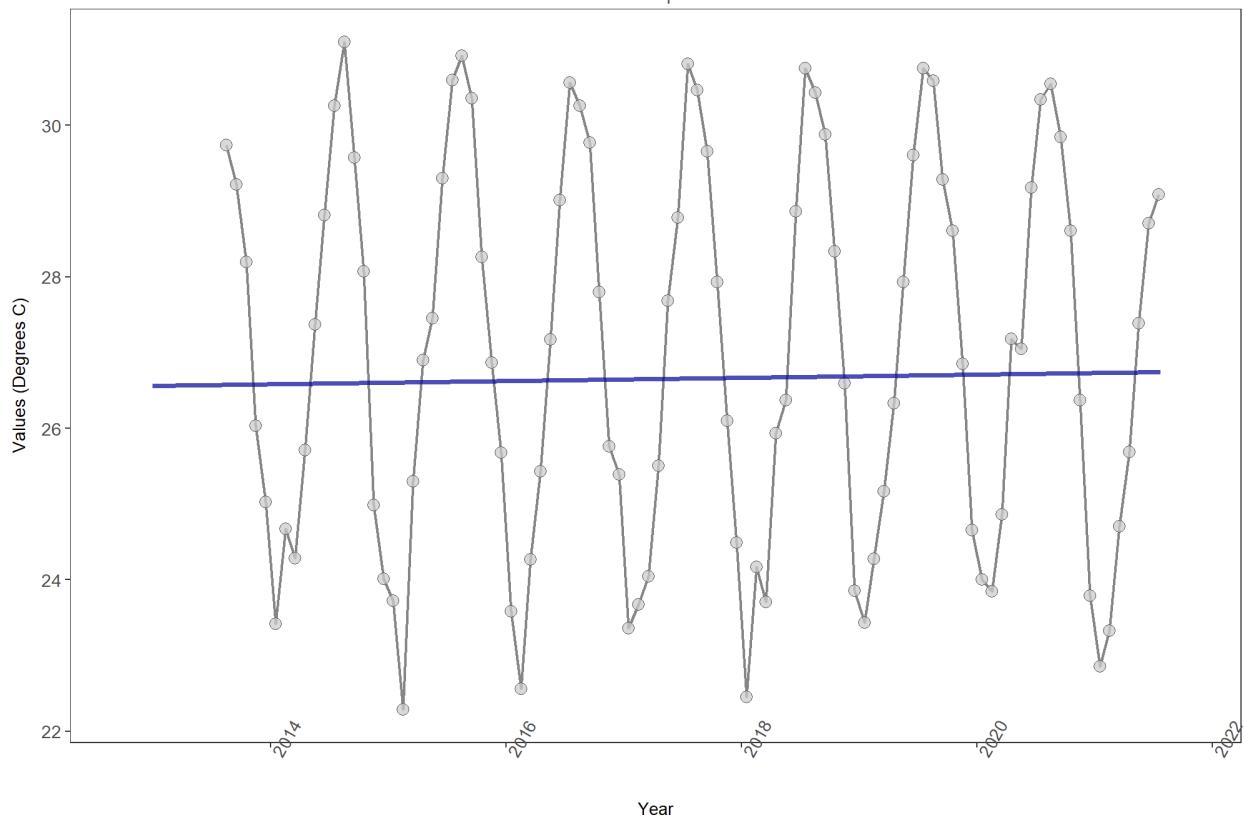
```

```

            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

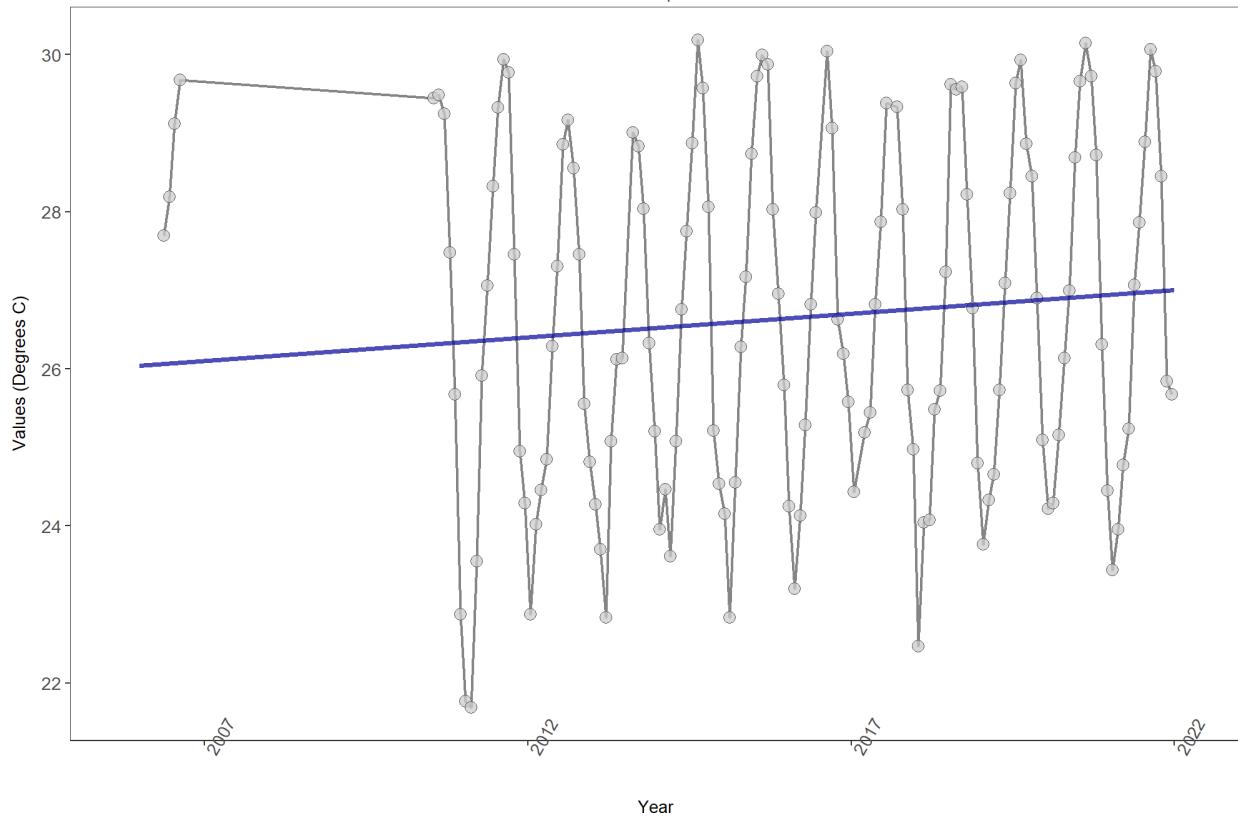


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	55288	9	26.74	1	0.0476	0.5922	0.02127766	26.56409	8.2449	0.6912	0

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
 5
 National Data Buoy Center
 LKWF1
 Water Temperature

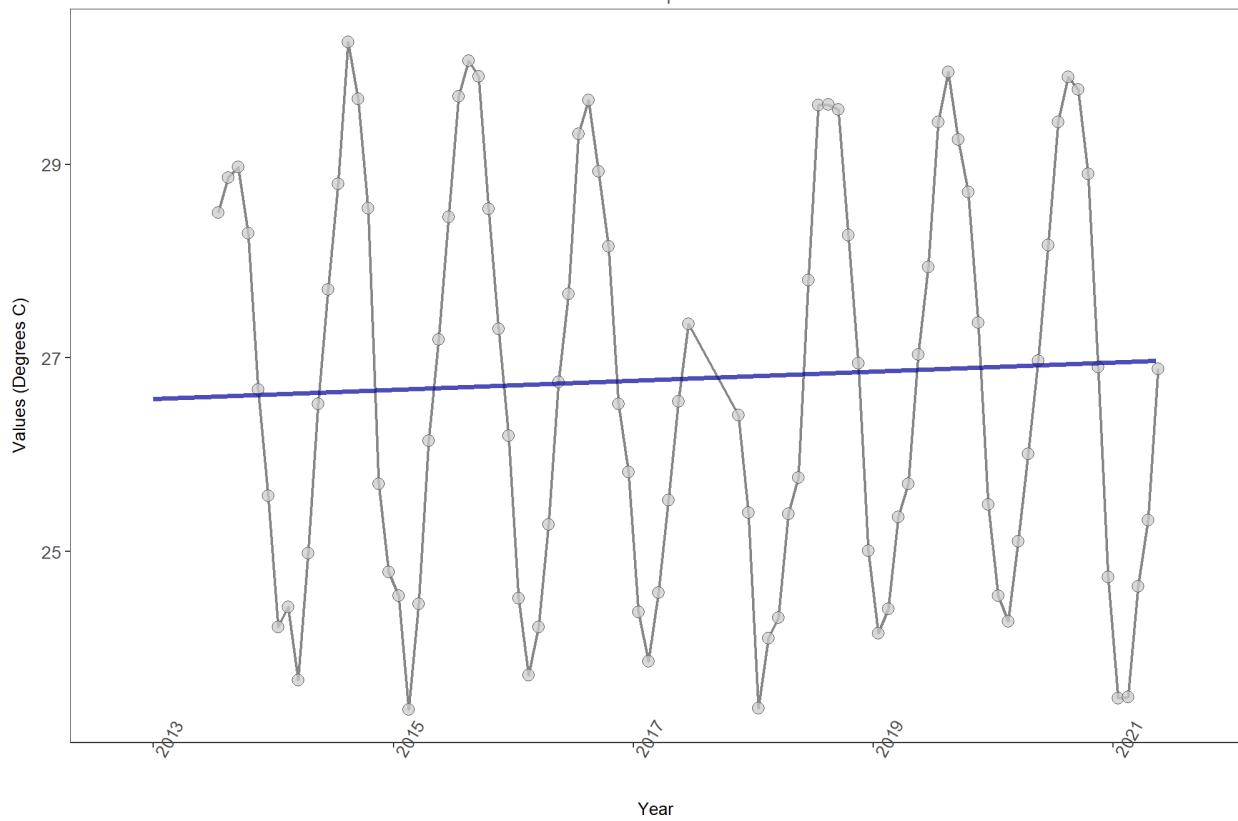


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
surface	891506	13	26.4	1	0.2829	0	0.06026849	26.04078	6.0334	0.8711	1

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

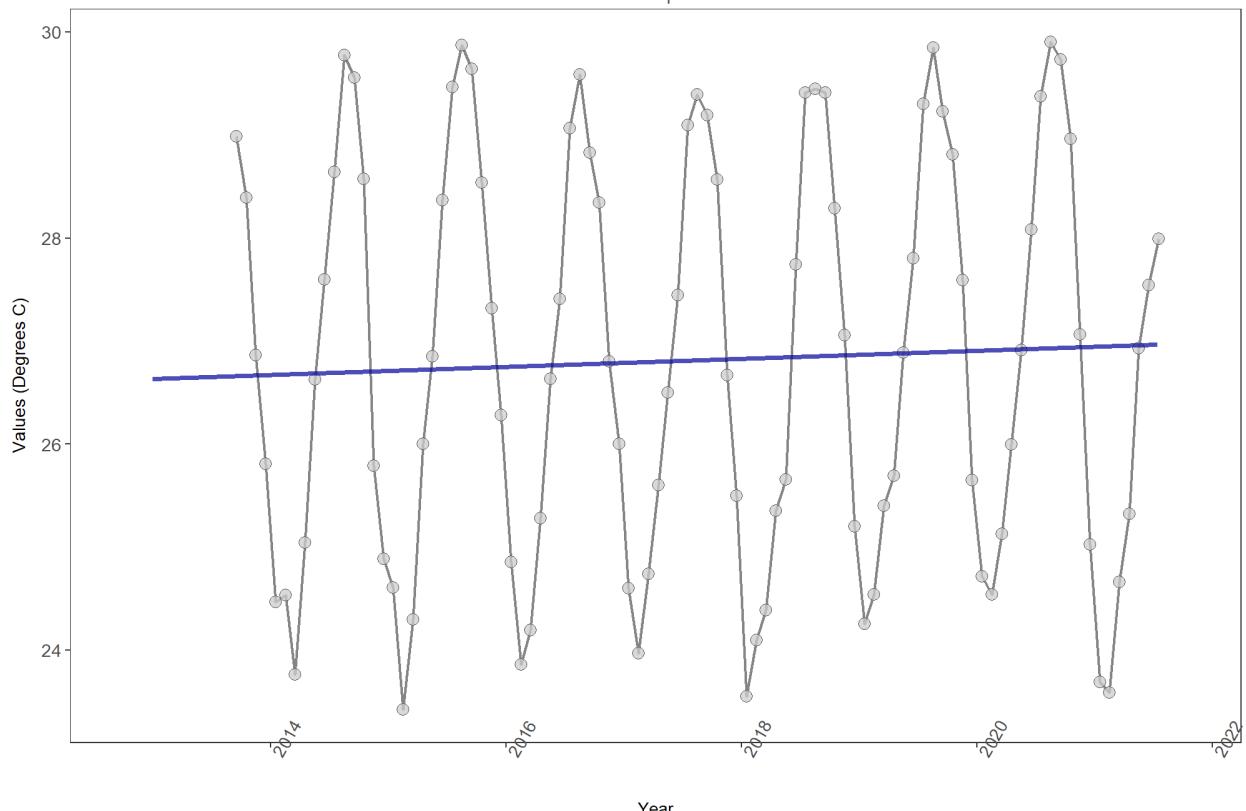


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	56348	9	26.37	1	0.1408	0.1248	0.04717633	26.5769	8.6852	0.6509	0

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

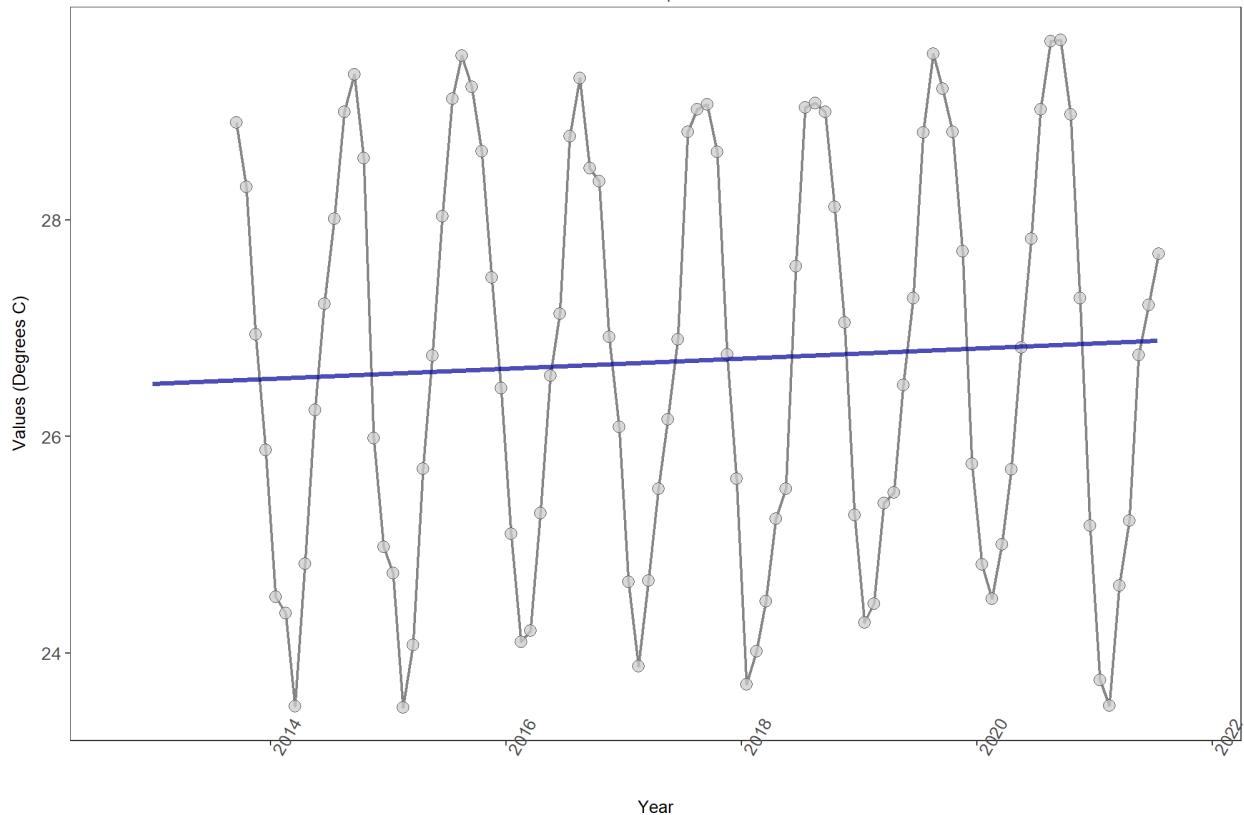


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	54773	9	26.62	1	0.185	0.0298	0.03843723	26.63527	8.2748	0.6885	1

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

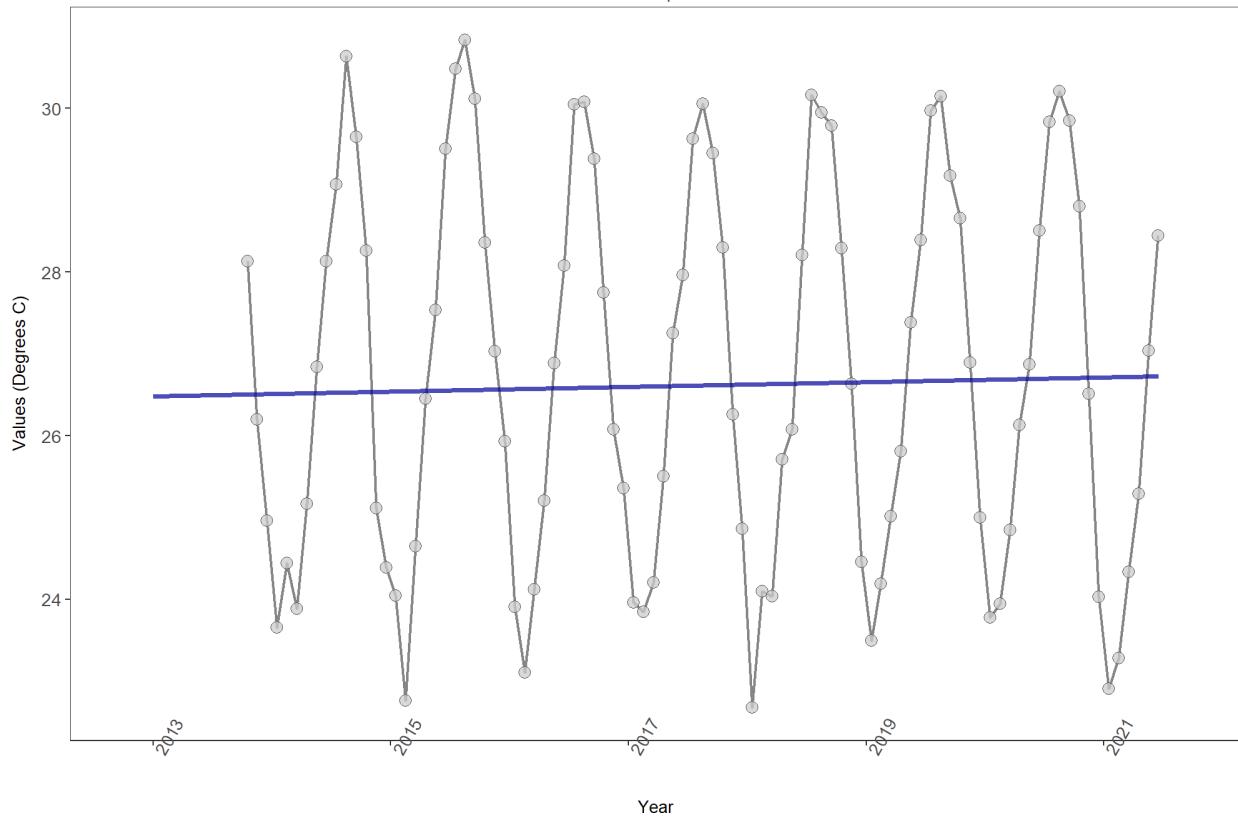


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	56027	9	26.62	1	0.1589	0.0703	0.04648819	26.48665	10.7311	0.4661	0

p < 0.00005 appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

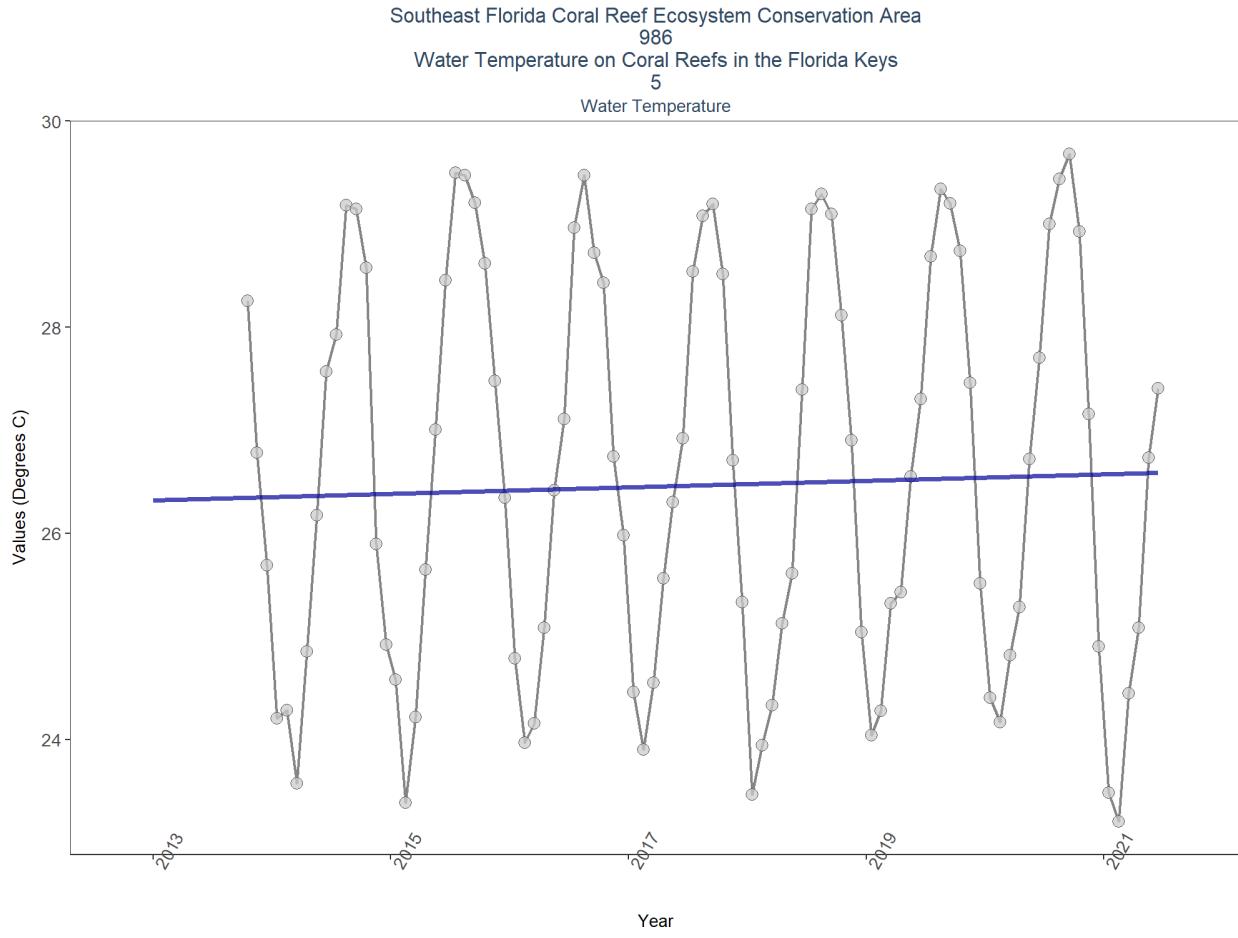
Southeast Florida Coral Reef Ecosystem Conservation Area
 986
 Water Temperature on Coral Reefs in the Florida Keys
 4
 Water Temperature



RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	60154	9	26.5	1	0.0855	0.2971	0.02890549	26.48012	11.1545	0.4304	0

p < 0.00005 appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

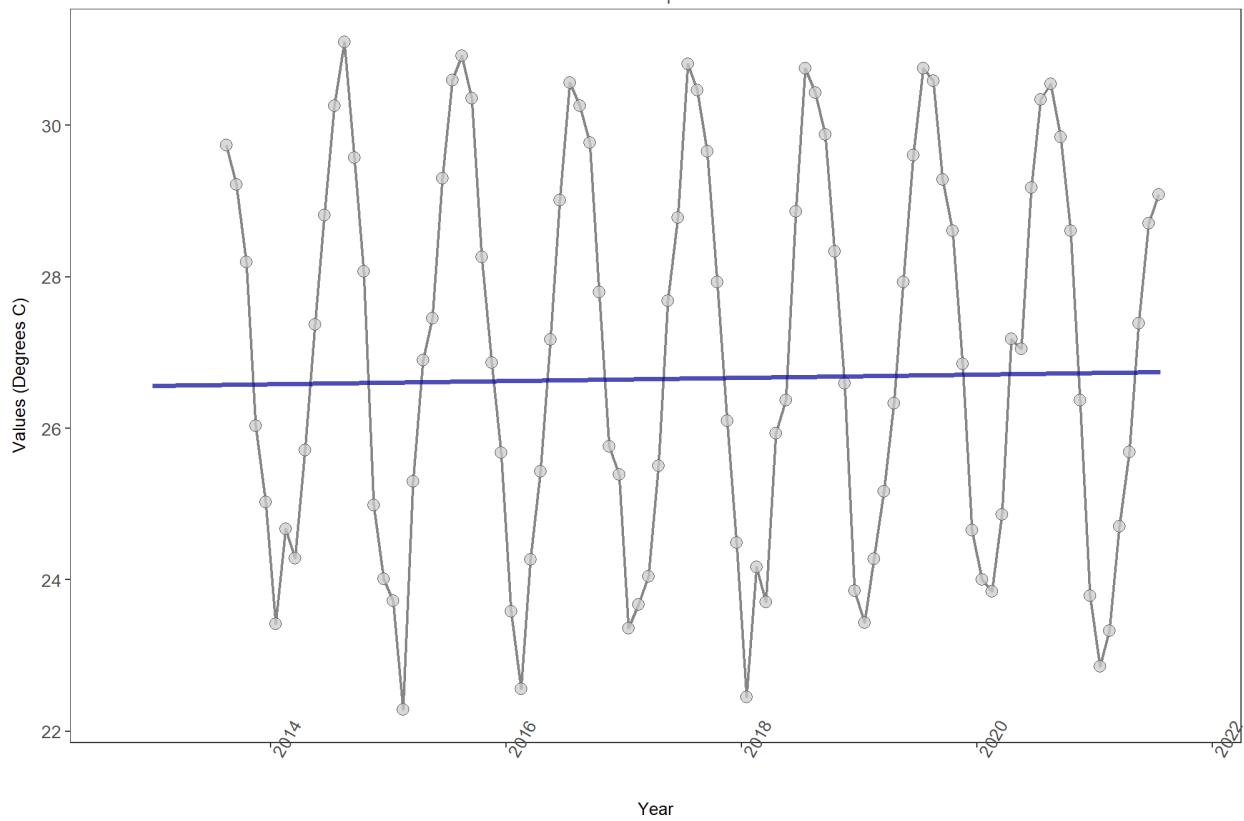


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	46781	9	26.54	1	0.0958	0.2971	0.03185847	26.32023	10.9984	0.4434	0

$p < 0.00005$ 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

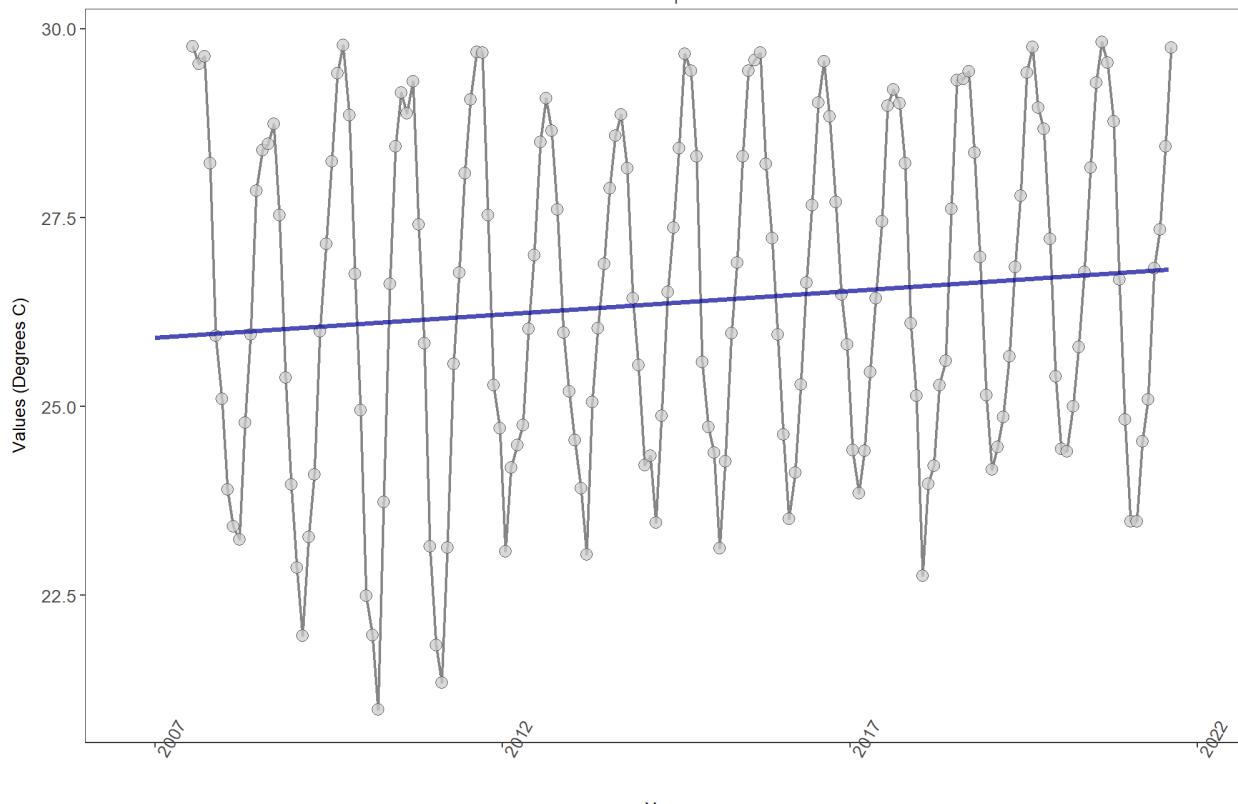


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	55288	9	26.74	1	0.0476	0.5922	0.02127766	26.56409	8.2449	0.6912	0

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

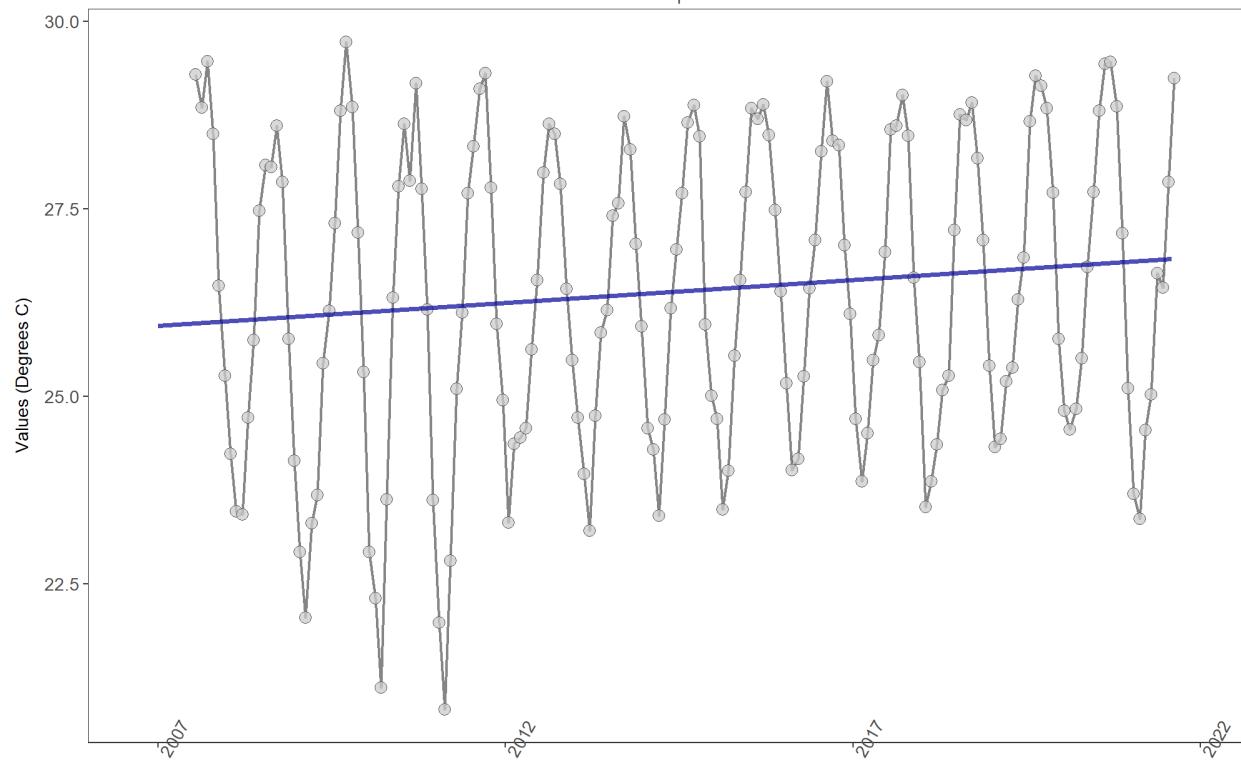


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	102574	15	26.3	1	0.3116	0	0.06197196	25.91381	10.3039	0.5033	1

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

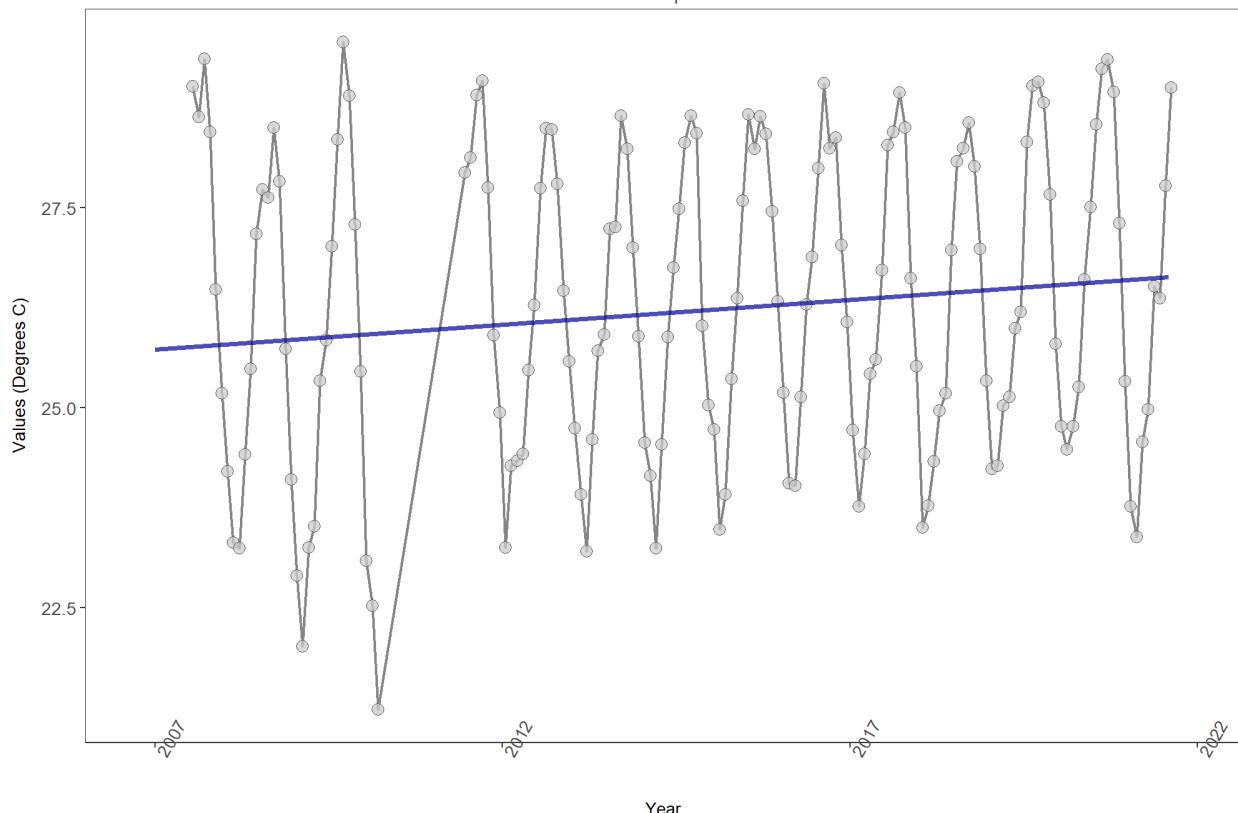


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	105599	15	26.23	1	0.2936	0	0.06126885	25.9398	10.0041	0.53	1

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

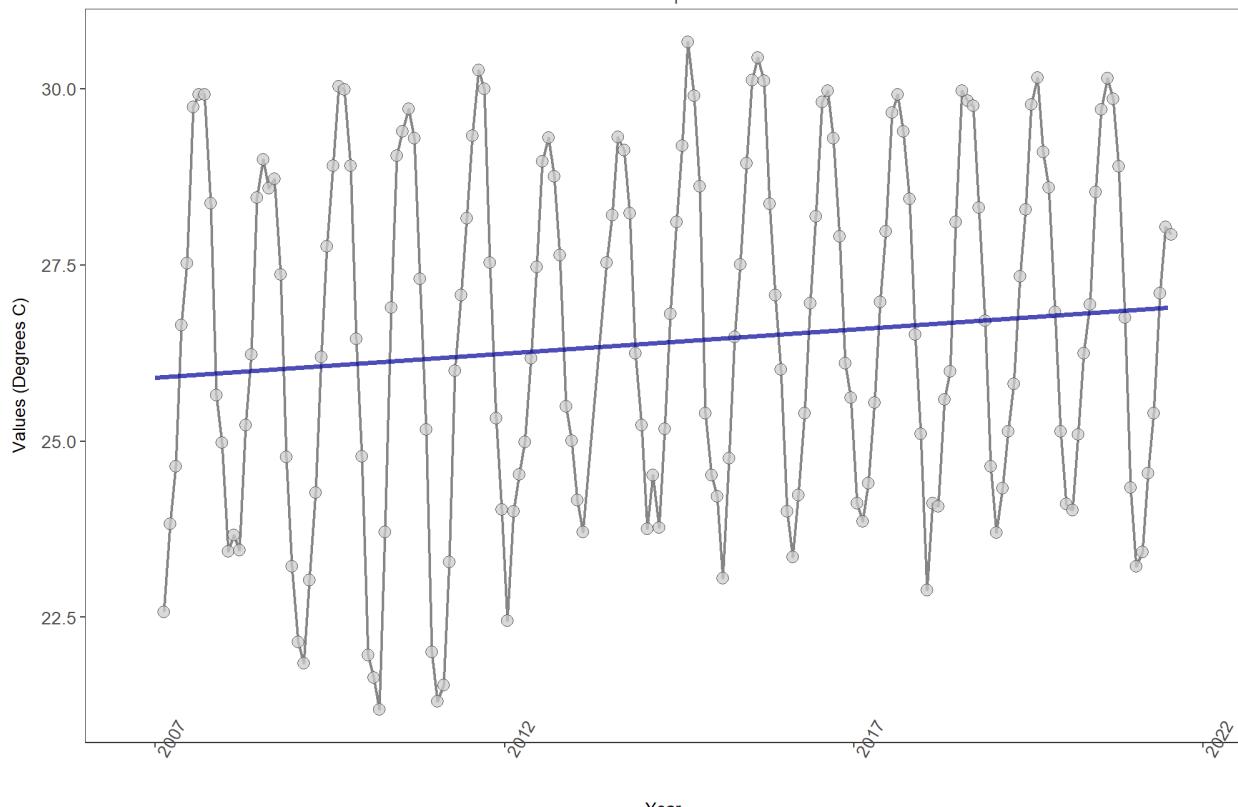


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	96223	15	26.13	1	0.3062	0	0.06211076	25.73083	9.2466	0.5991	1

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

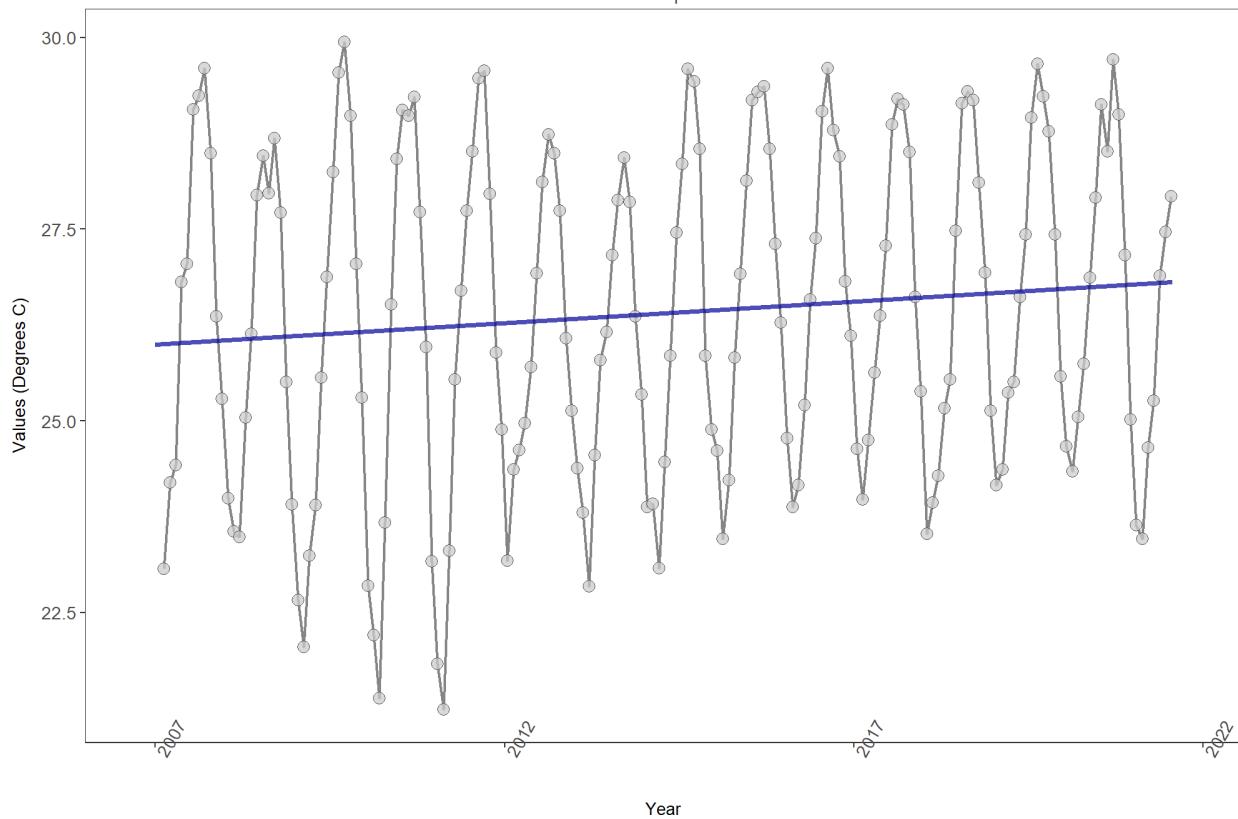


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	100174	15	26.44	1	0.2961	0	0.06834156	25.90513	6.9981	0.7992	1

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
 88
 Water Temperature

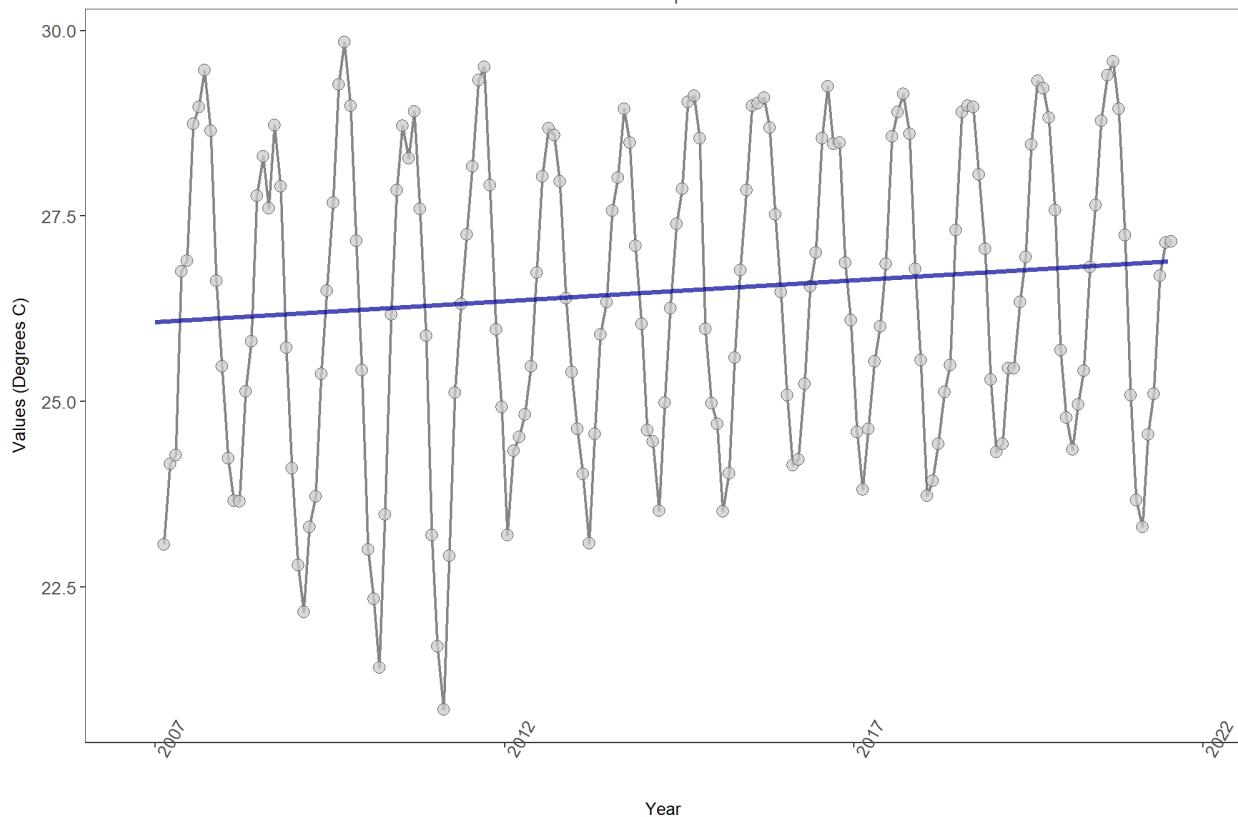


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	108002	15	26.29	1	0.2789	0	0.05636102	25.99256	8.7002	0.6495	1

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

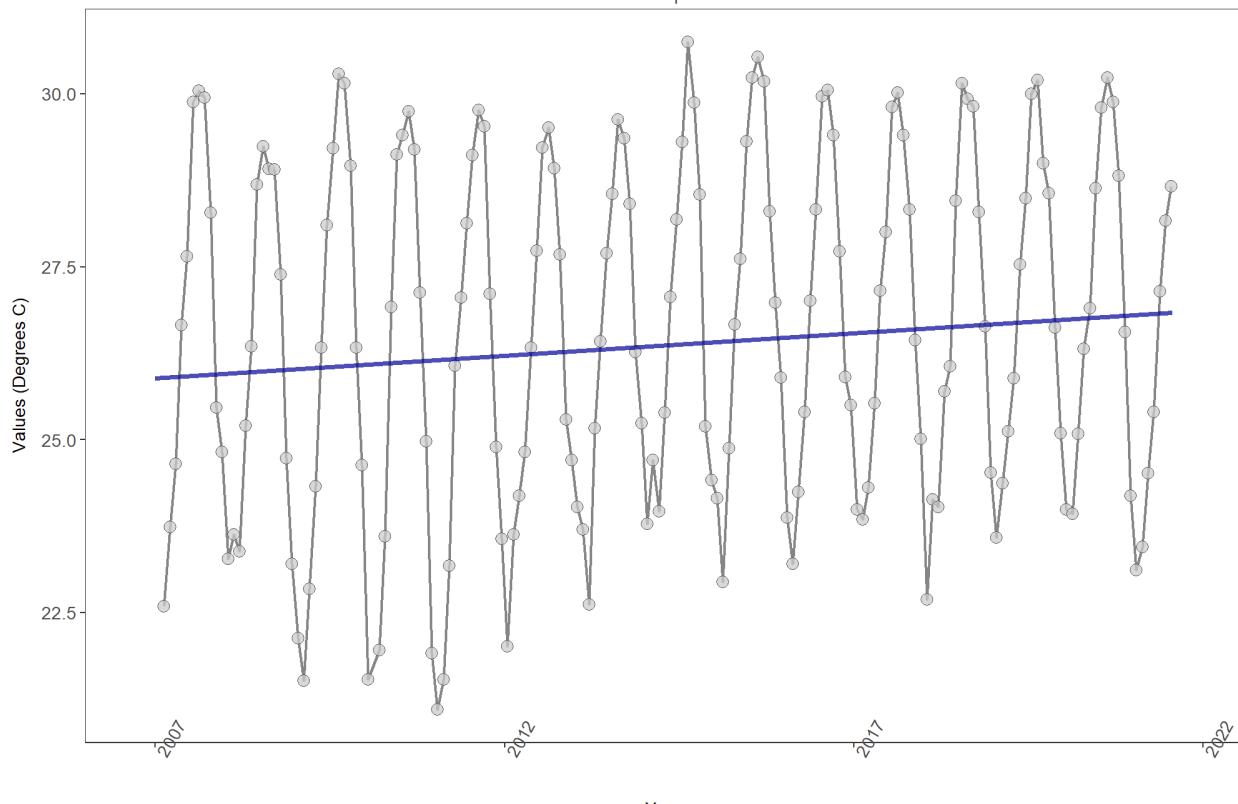


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	108985	15	26.23	1	0.2794	0	0.05620001	26.0713	7.1491	0.7869	1

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

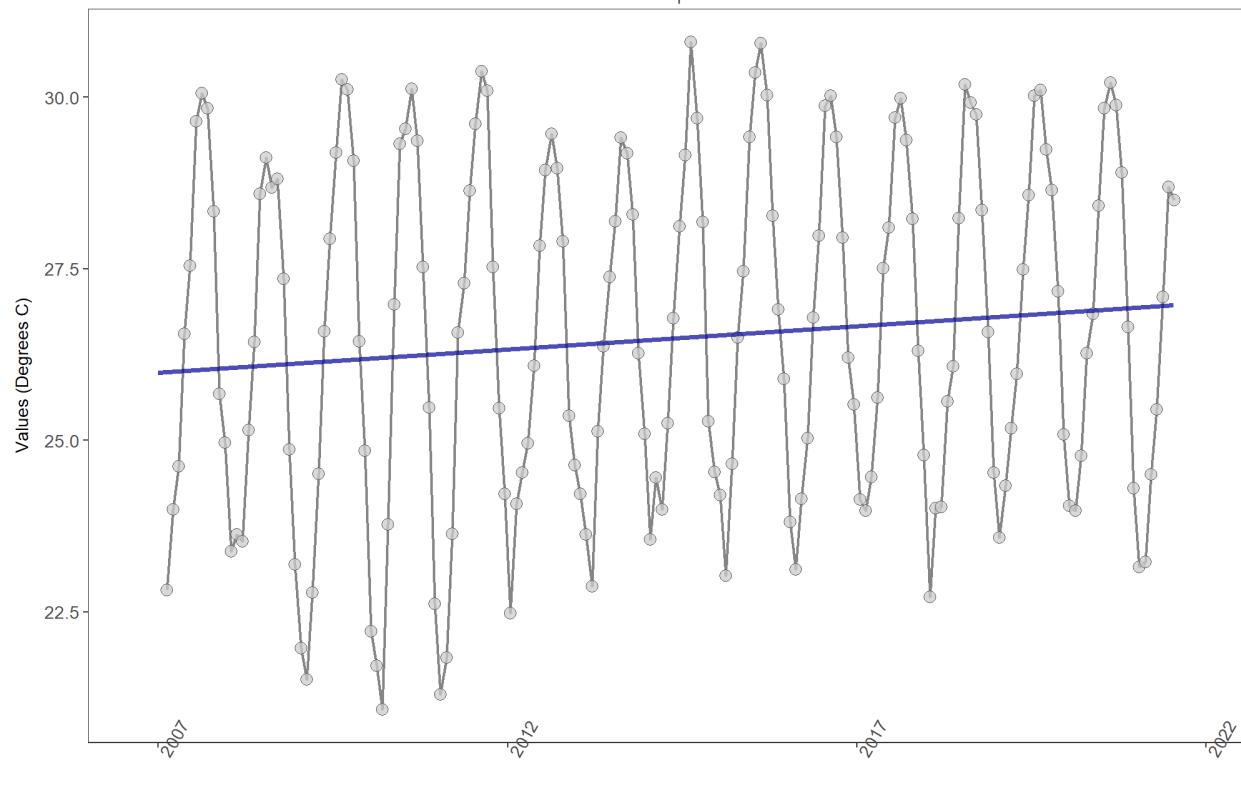


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	89309	15	26.44	1	0.314	0	0.06511425	25.88441	6.6634	0.8257	1

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

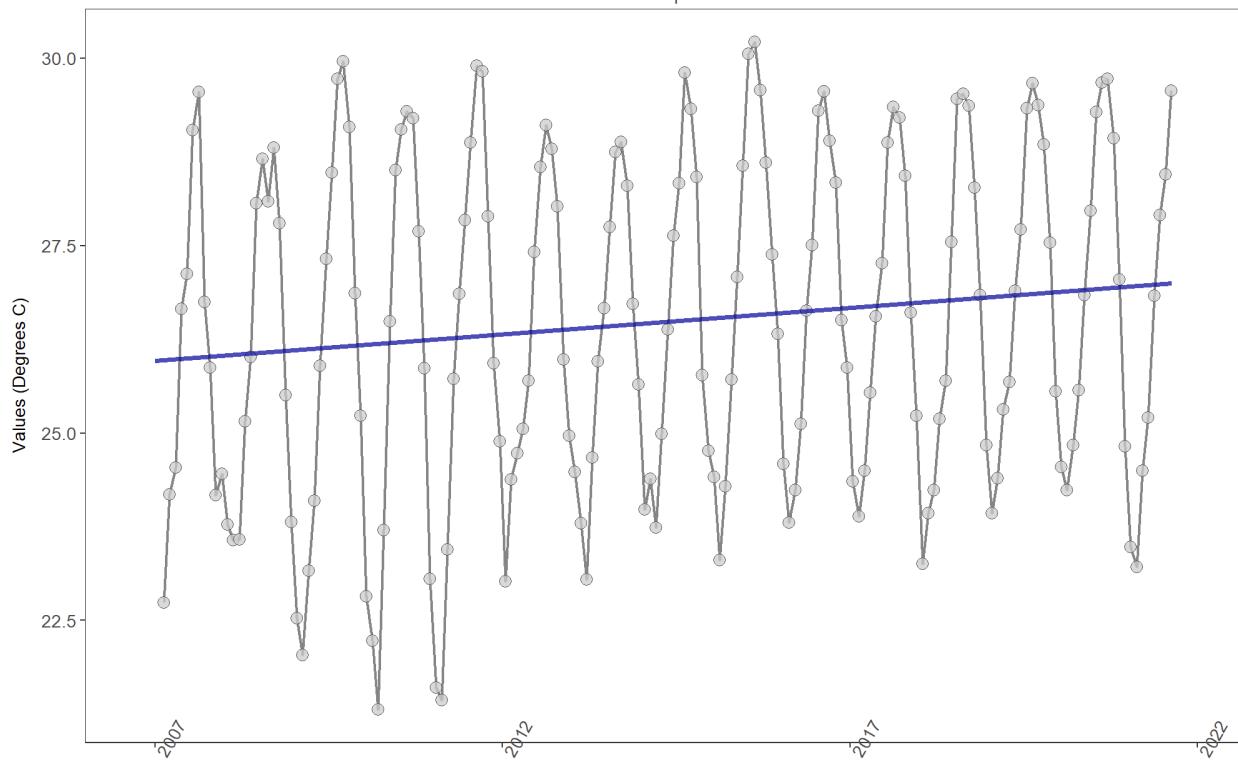


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	92917	15	26.47	1	0.2836	0	0.06798058	25.98298	6.8923	0.8077	1

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

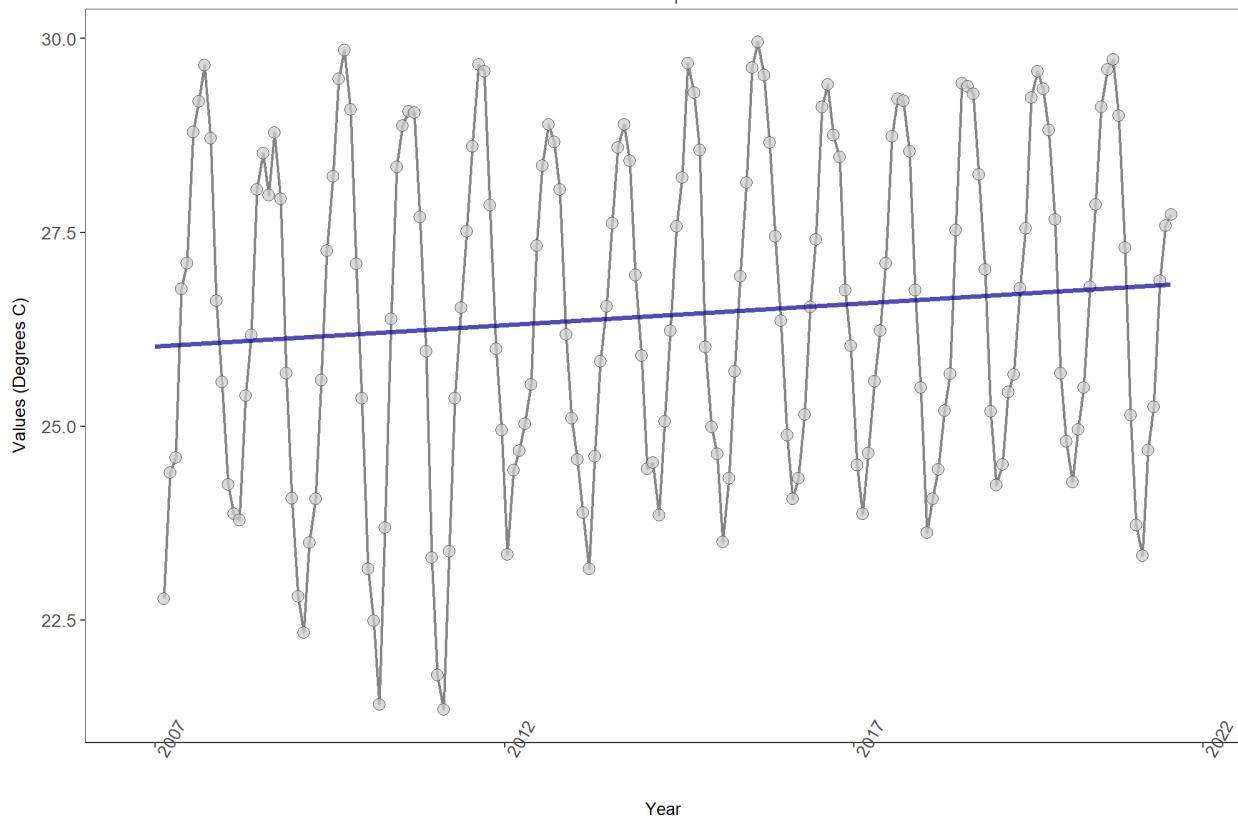


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	104243	15	26.42	1	0.3317	0	0.07032883	25.96539	6.4849	0.8391	1

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

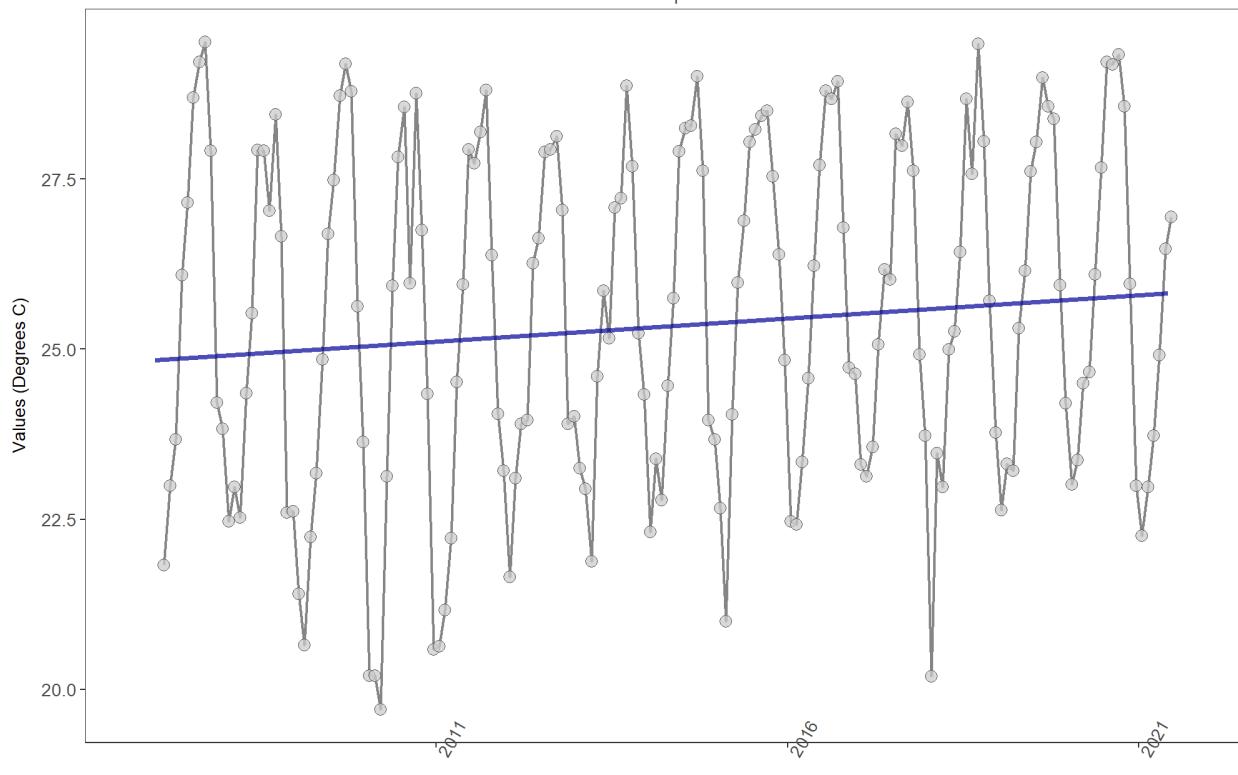


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	97446	15	26.42	1	0.2923	0	0.05490936	26.02629	5.2765	0.917	1

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

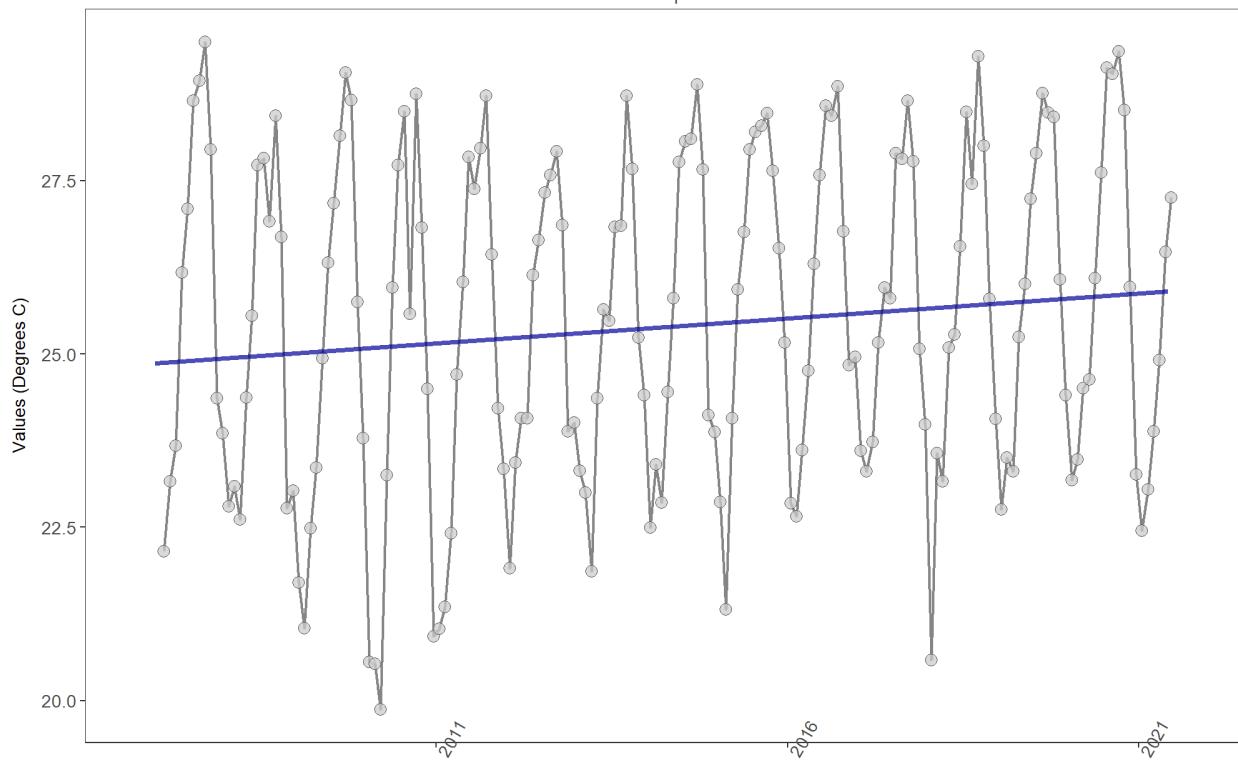


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	85742	15	25.5	1	0.2746	0	0.06802362	24.84157	10.5233	0.484	1

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

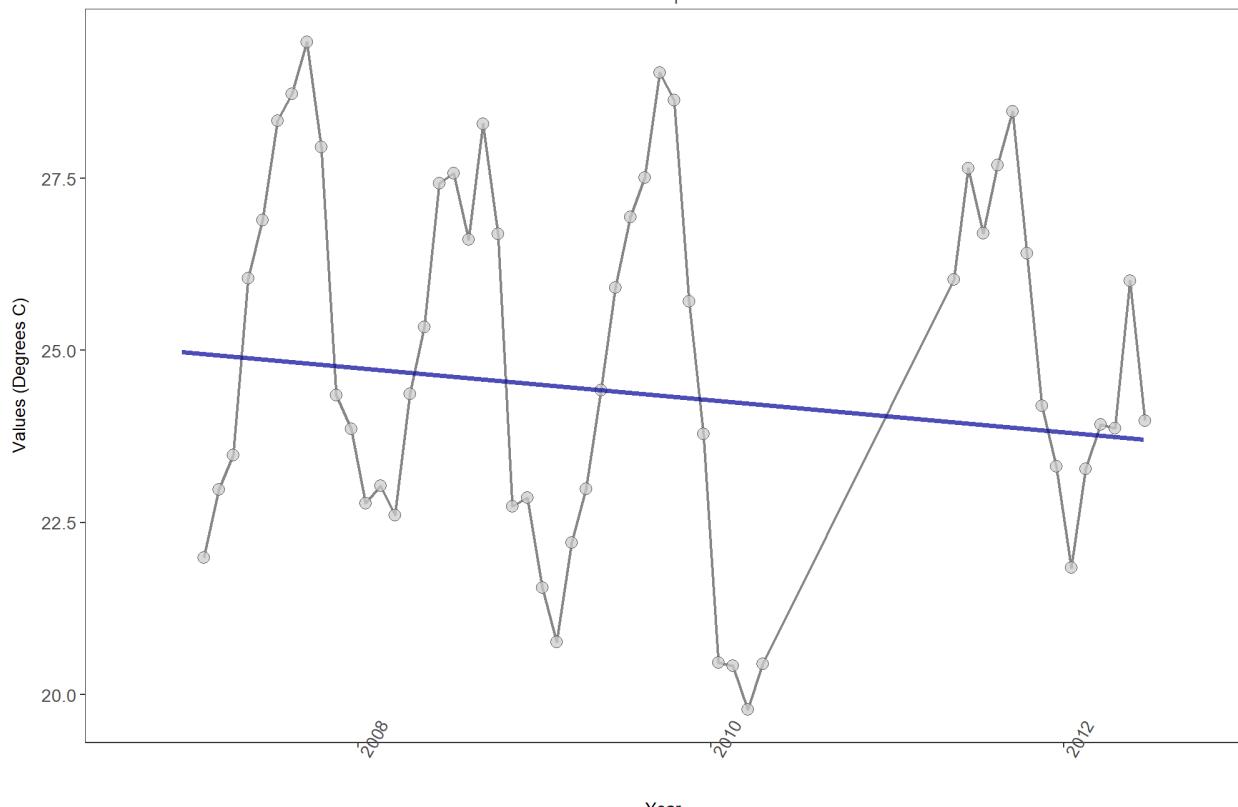


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	93569	15	25.52	1	0.2813	0	0.07204081	24.86054	7.795	0.7315	1

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

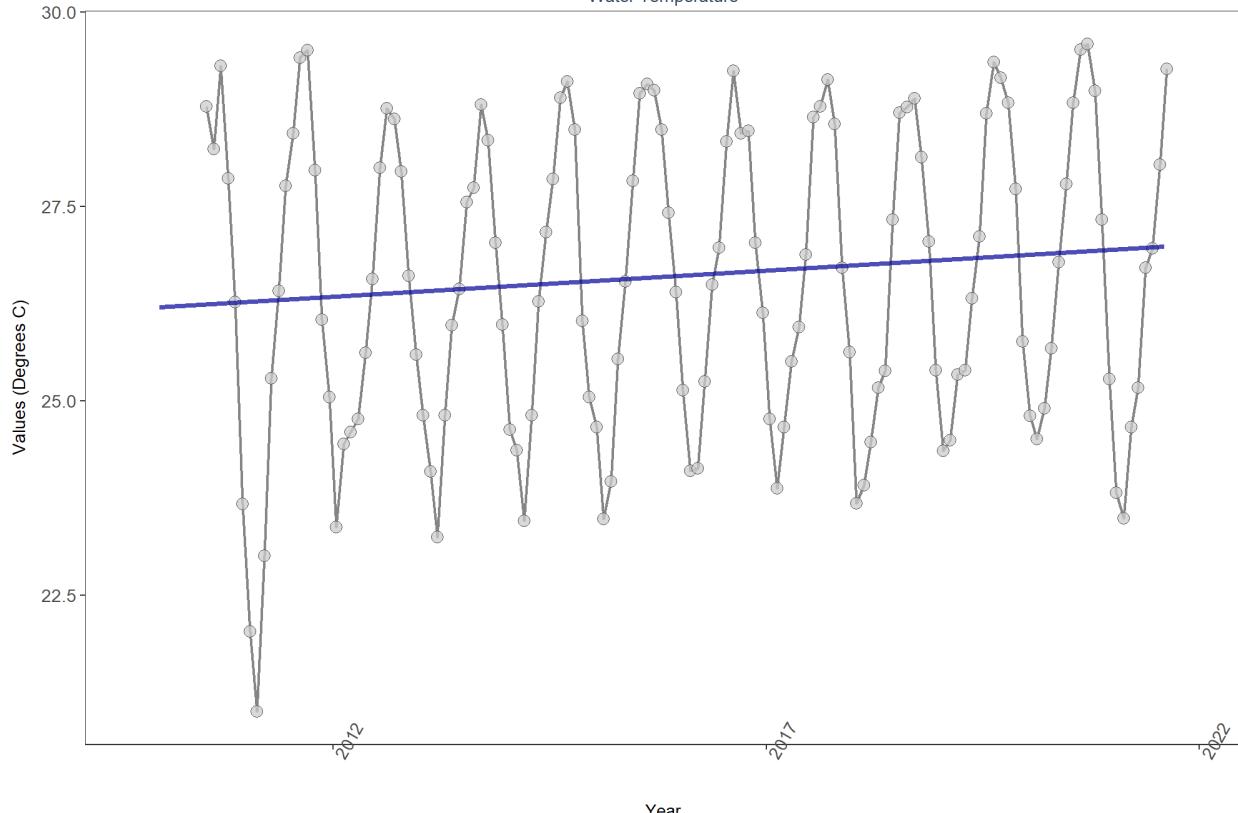


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	25550	6	24.87	1	-0.2516	0.0801	-0.2336878	24.98051	3.2022	0.9878	0

$p < 0.00005$ 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
 97
 Water Temperature

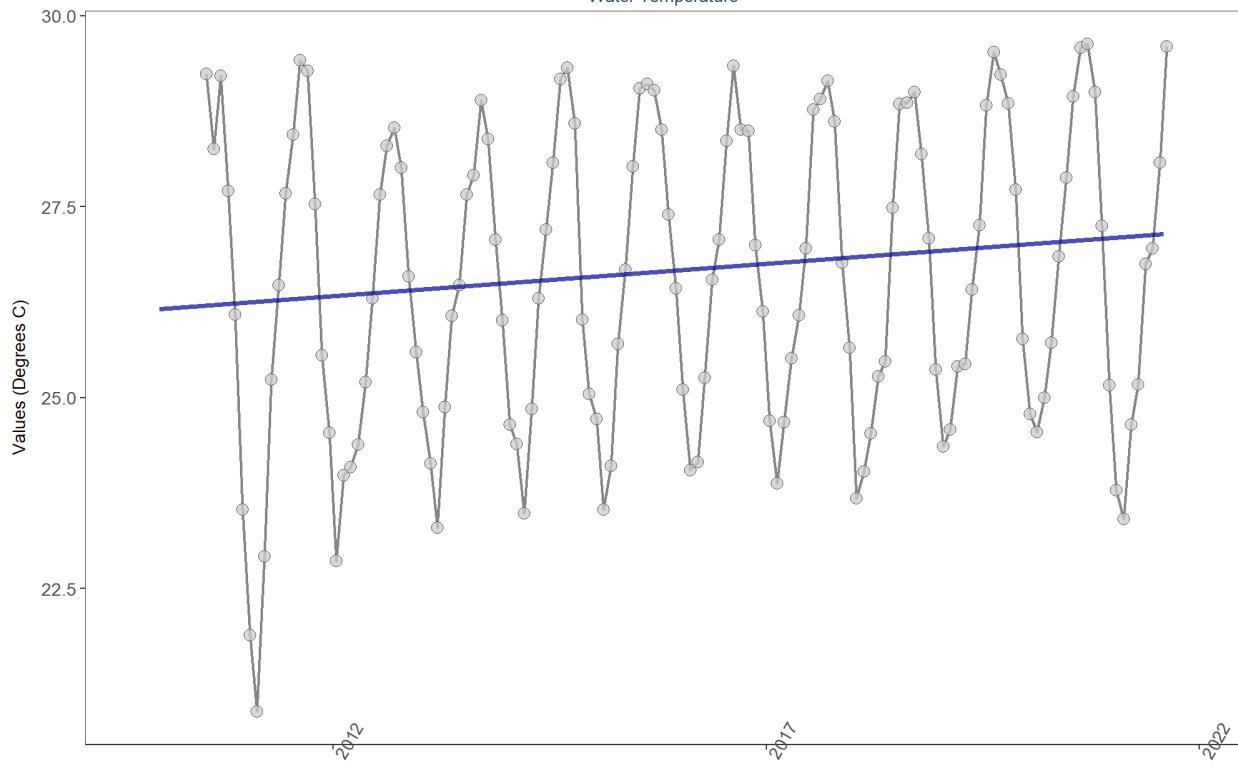


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	89132	12	26.45	1	0.3115	0	0.06684606	26.20531	8.829	0.6377	1

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

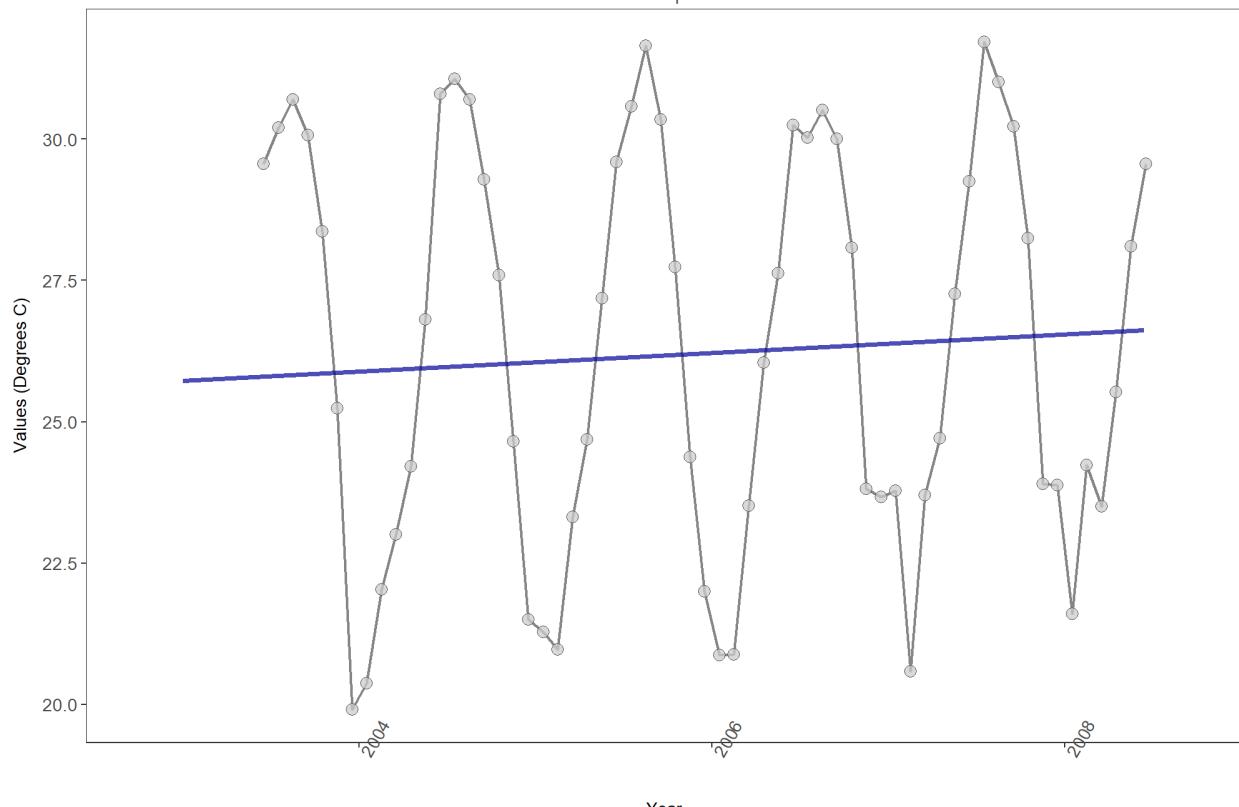


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	79860	12	26.37	1	0.3441	0	0.08494045	26.15856	10.4019	0.4946	1

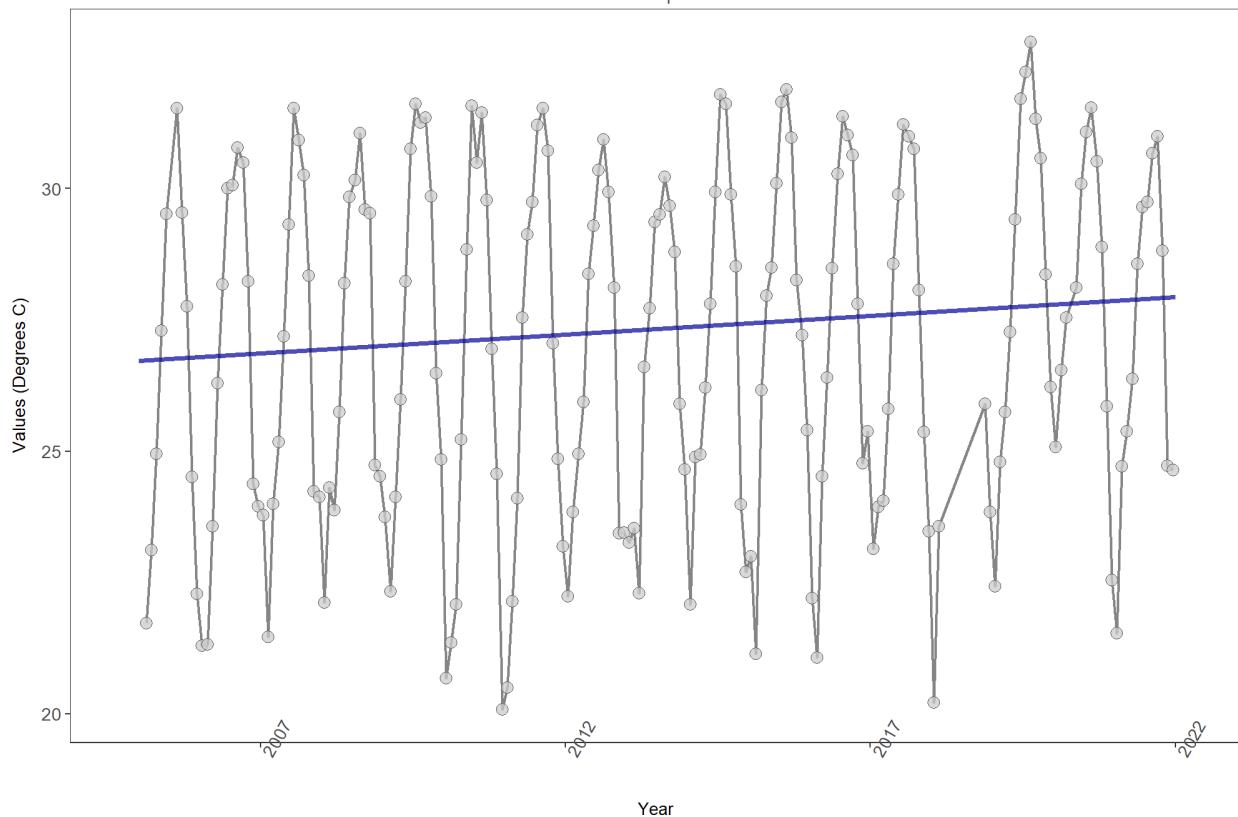
p < 0.00005 appear as 0 due to rounding.

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



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

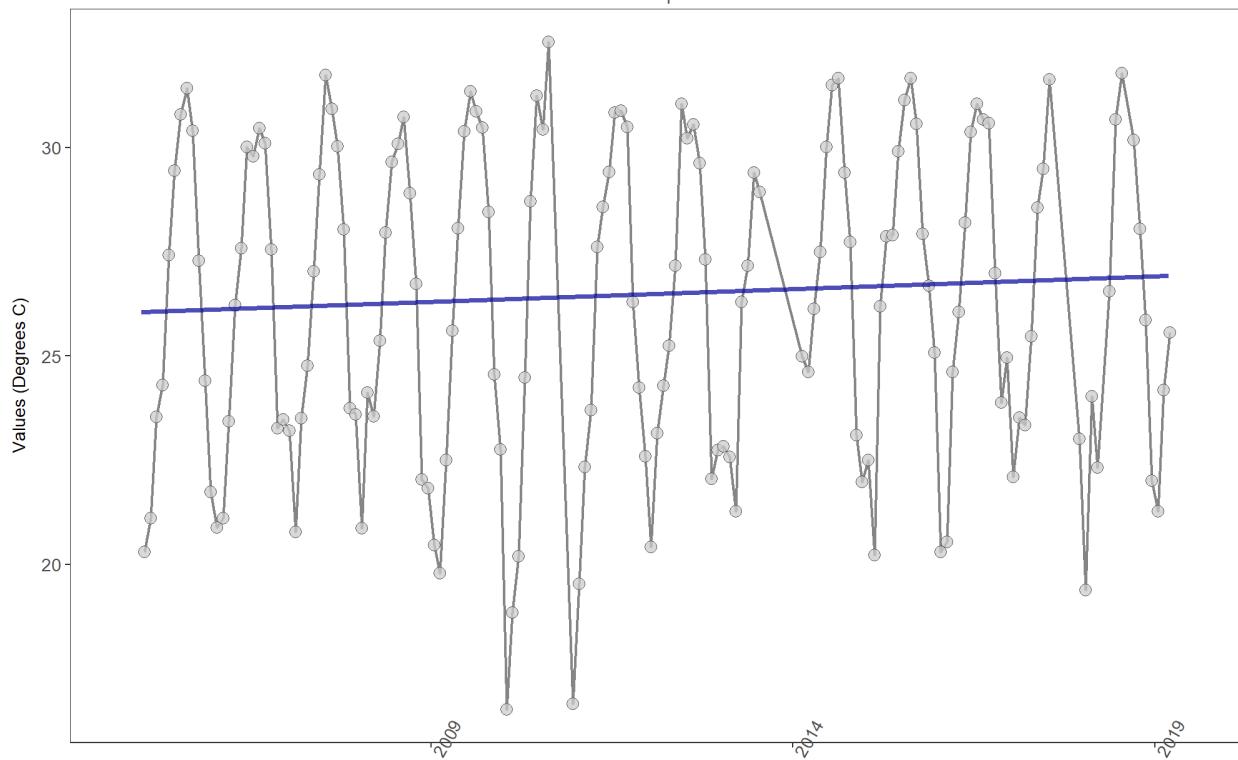


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
surface	1225747	17	27.5	1	0.2724	0	0.07180951	26.71699	7.1785	0.7844	1

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

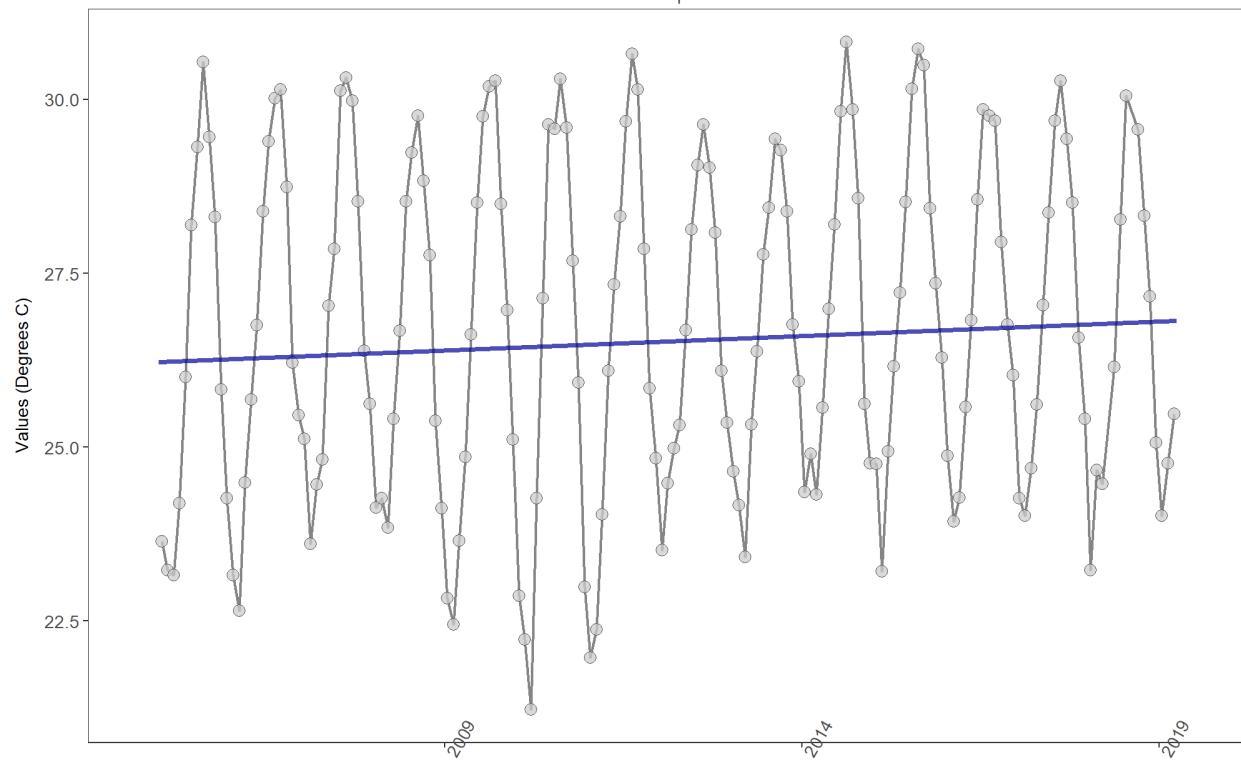


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
surface	107173	15	26.3	1	0.1852	0.0022	0.0606754	26.05832	3.2552	0.9869	1

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

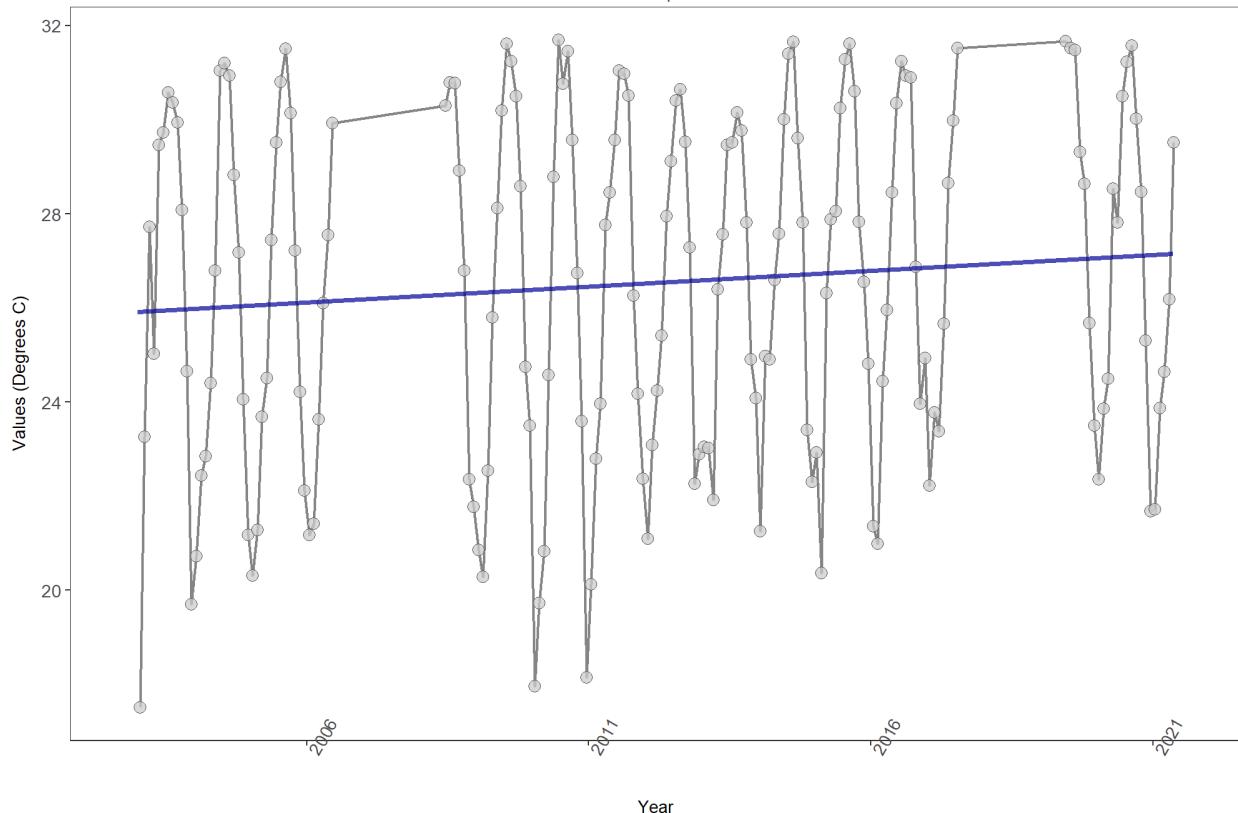


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
surface	111537	15	26.5	1	0.1913	0.0009	0.04159201	26.22273	7.5875	0.7497	1

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

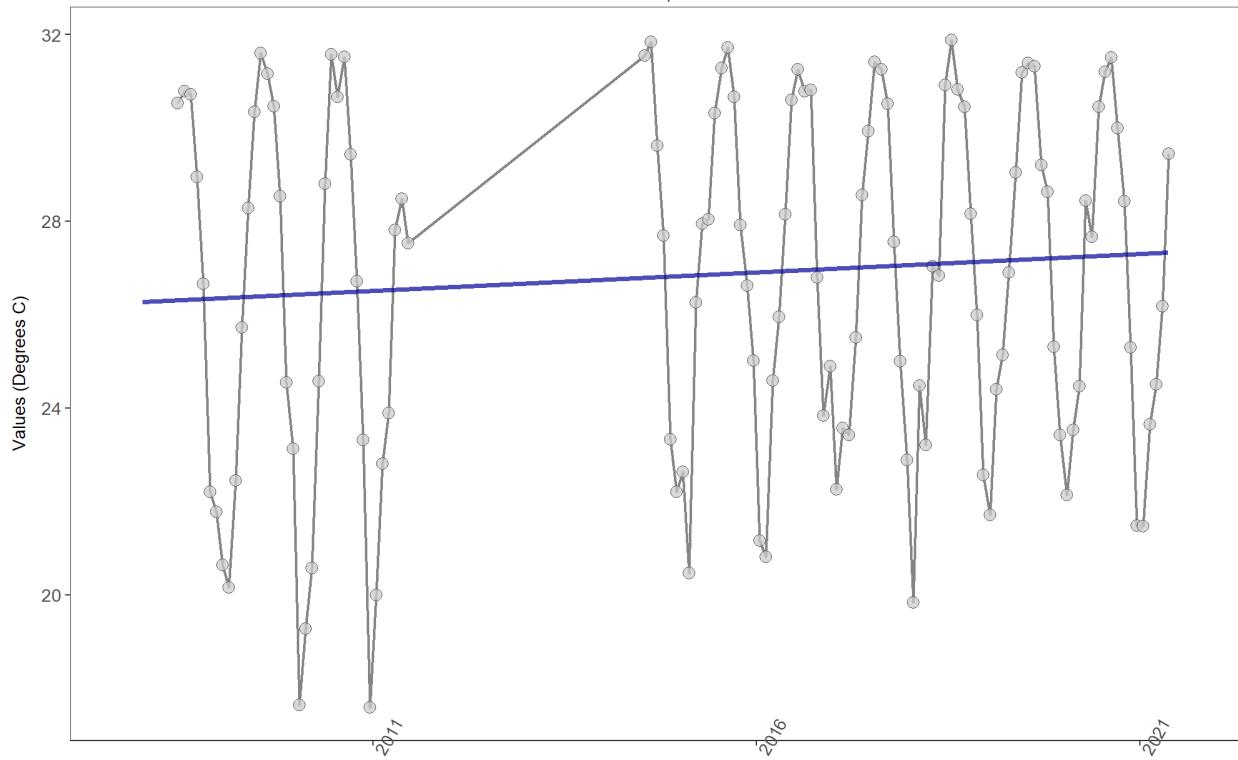


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	218391	17	26.744	1	0.3094	0	0.06702255	25.92034	4.1264	0.9661	1

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

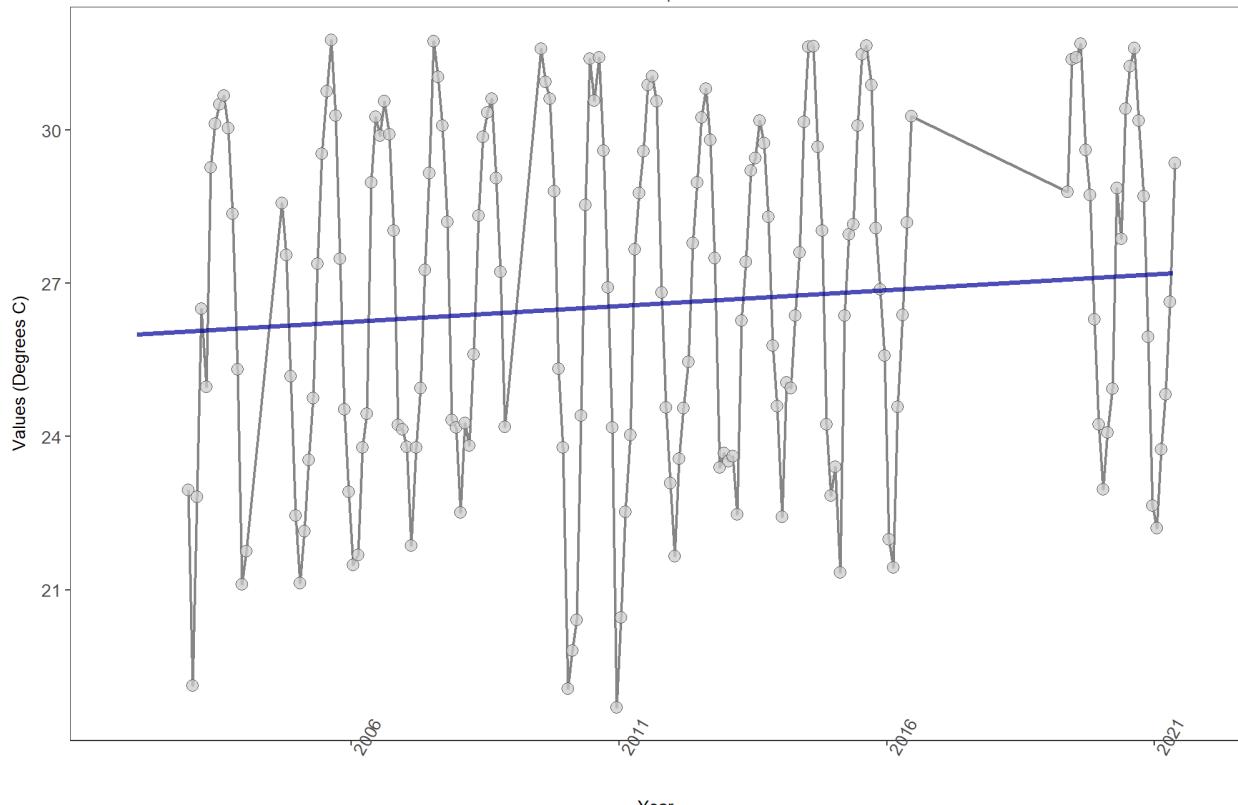


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	127791	12	27.06	1	0.2444	0.0007	0.07923582	26.26821	6.272	0.8546	1

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

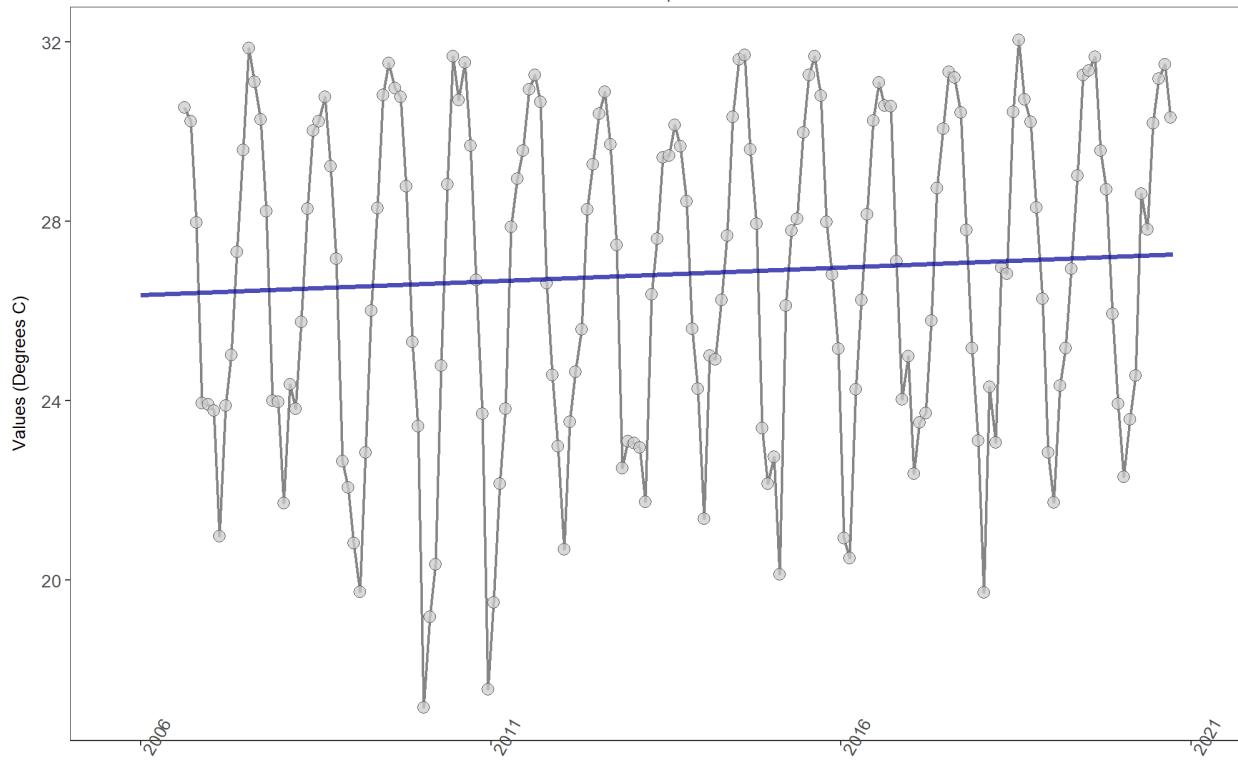


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	214859	18	26.81	1	0.2371	0	0.06153697	26.00622	5.6853	0.8935	1

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

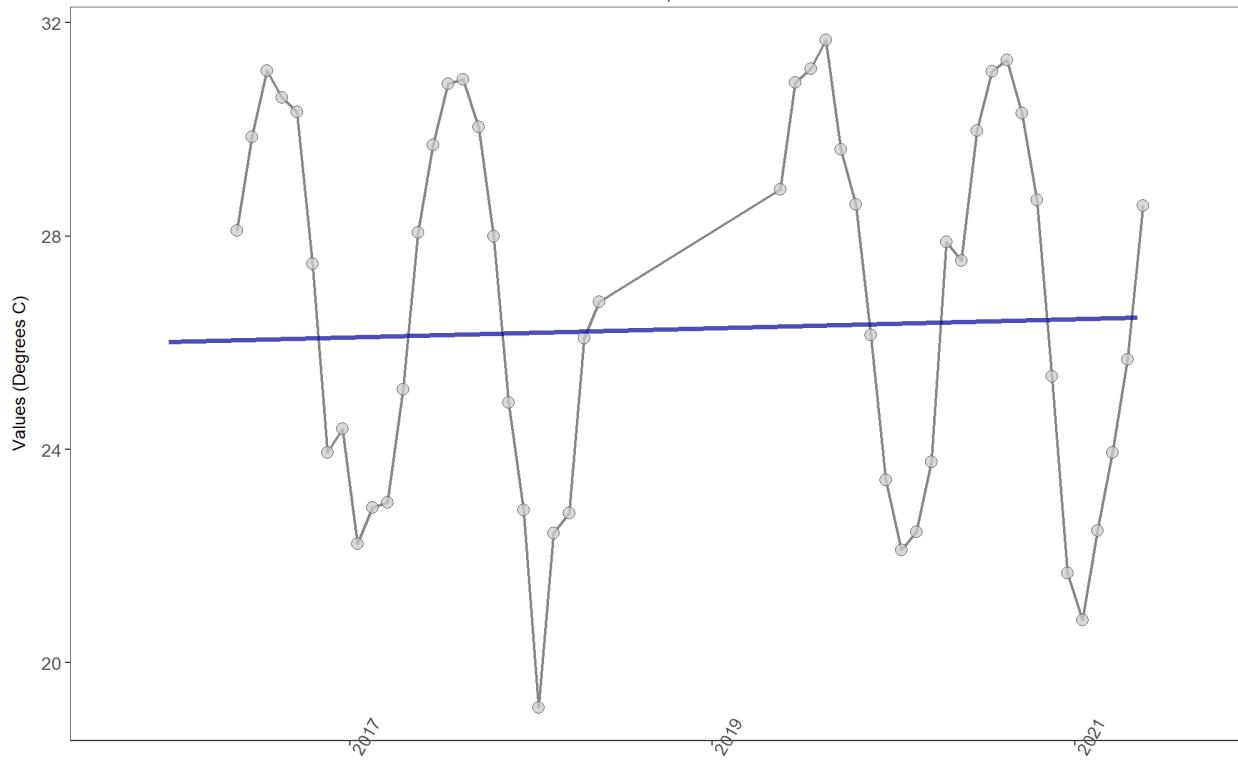


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	203688	15	26.965	1	0.1835	0.0016	0.06102195	26.36201	5.8029	0.8862	1

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

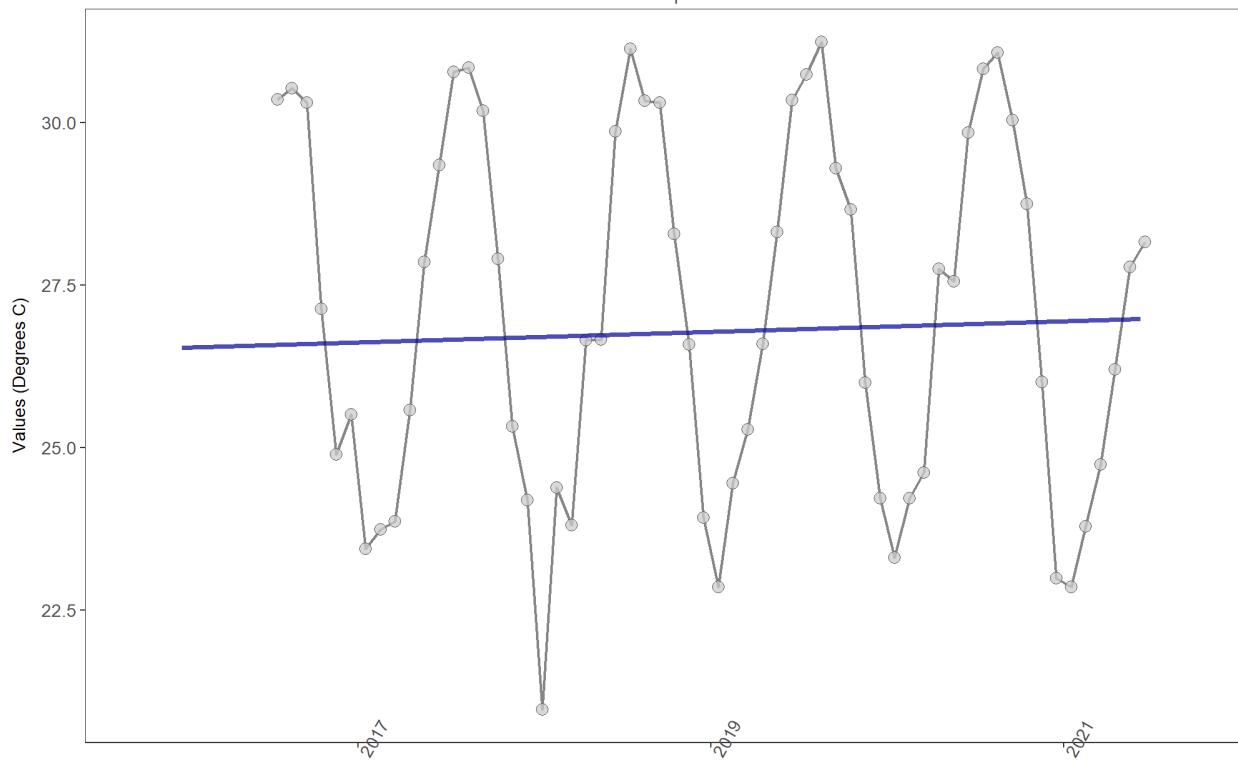


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	35145	6	27.03	1	0.1947	0.2081	0.085	26.01417	11.3835	0.4117	0

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
21
Water Temperature

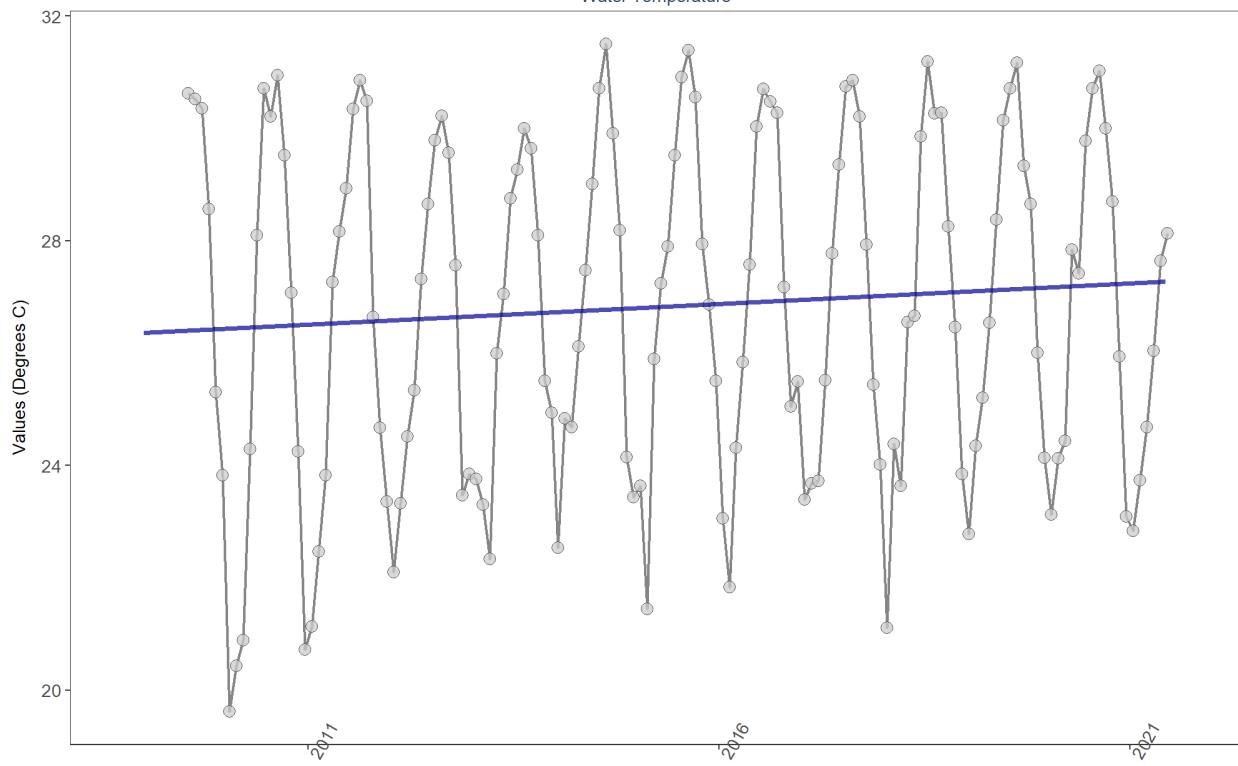


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	46266	6	27.06	1	0.1333	0.2888	0.08087366	26.53762	14.56	0.2035	0

$p < 0.00005$ 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

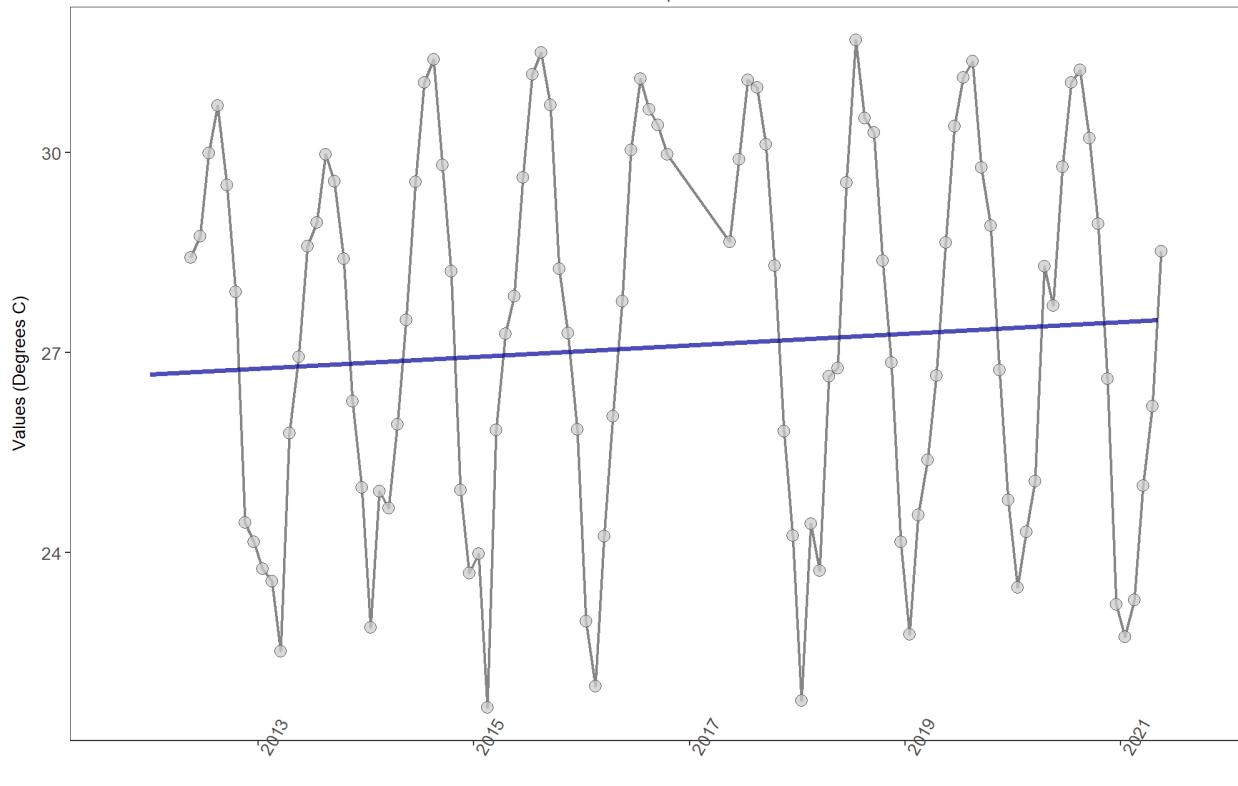


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	161906	13	26.842	1	0.2323	0.0003	0.07307622	26.36122	5.9185	0.8787	1

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

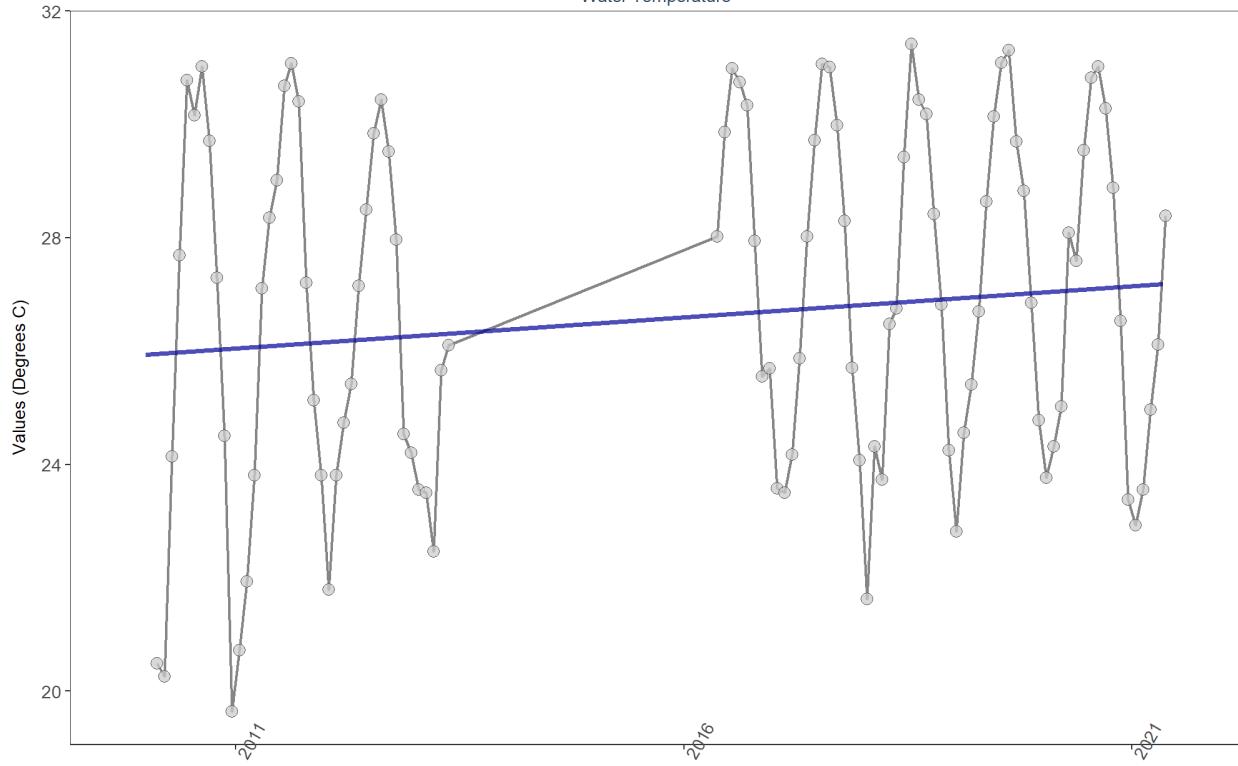


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	104253	10	27.333	1	0.2148	0.0059	0.08664875	26.67486	10.7713	0.4626	1

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

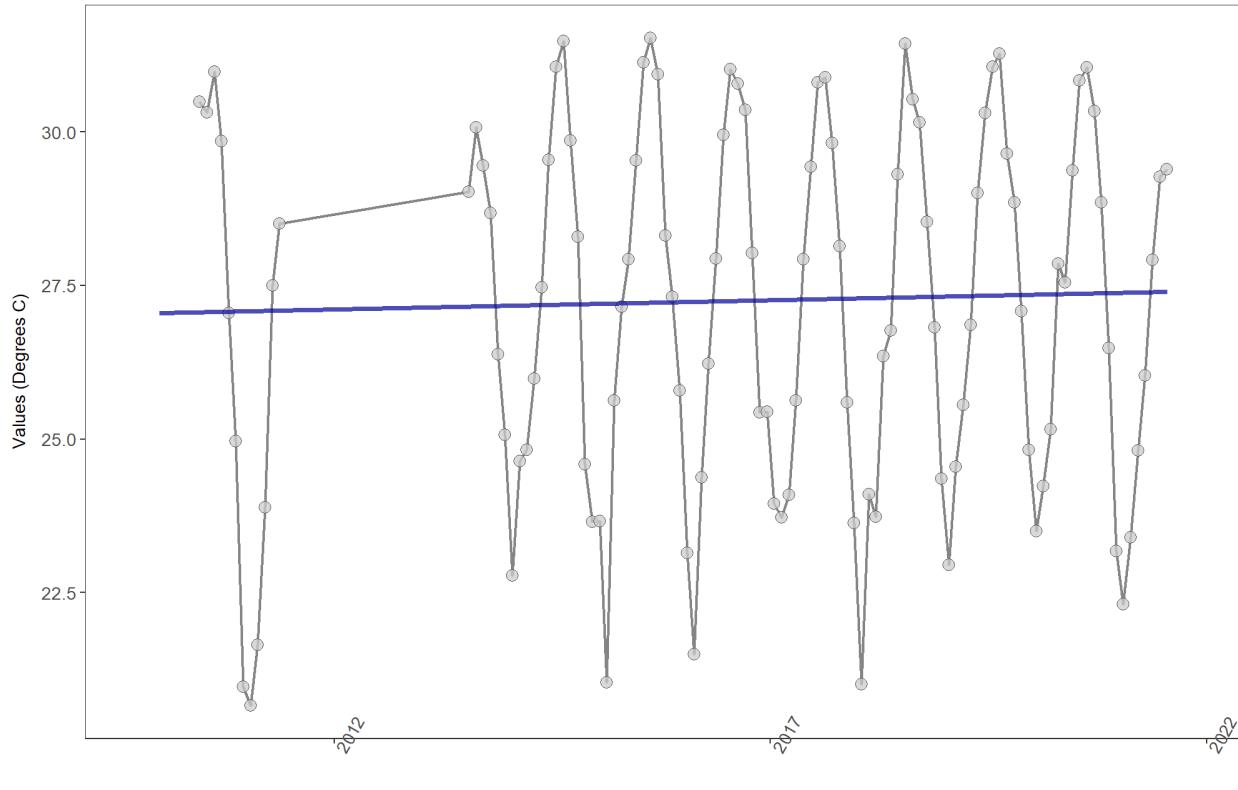


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	102435	10	26.867	1	0.3798	0	0.1094549	25.94205	11.3927	0.411	1

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

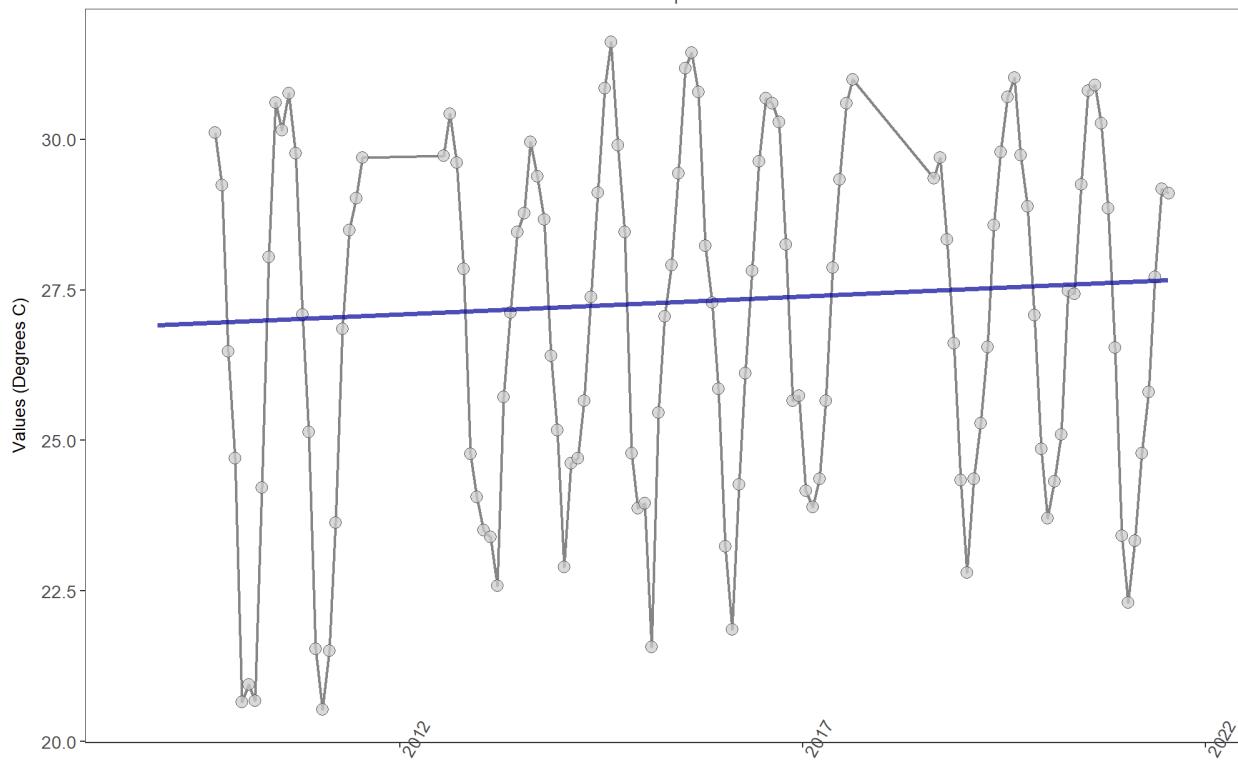


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	109474	11	27.235	1	0.0657	0.4063	0.02975694	27.05543	10.6803	0.4704	0

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

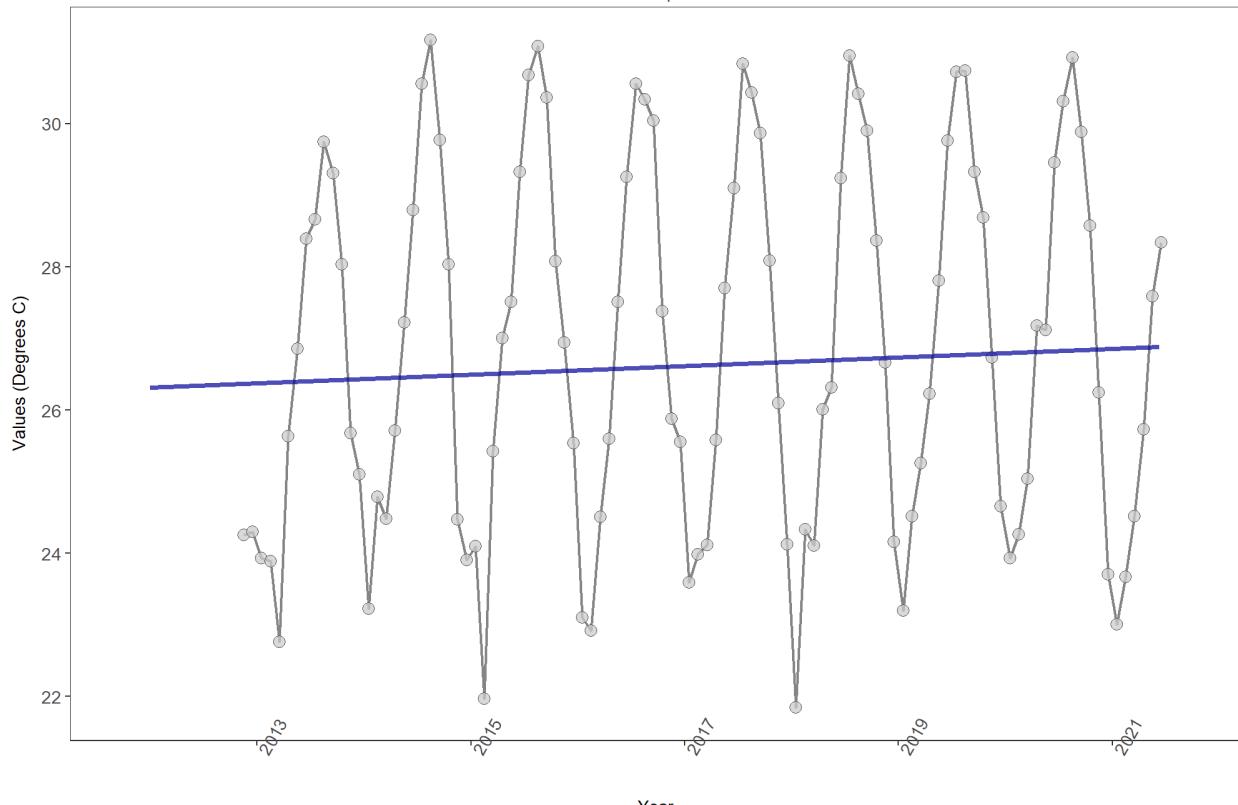


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	133997	13	26.98	1	0.1967	0.0064	0.06011357	26.91013	5.194	0.9214	1

$p < 0.00005$ 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

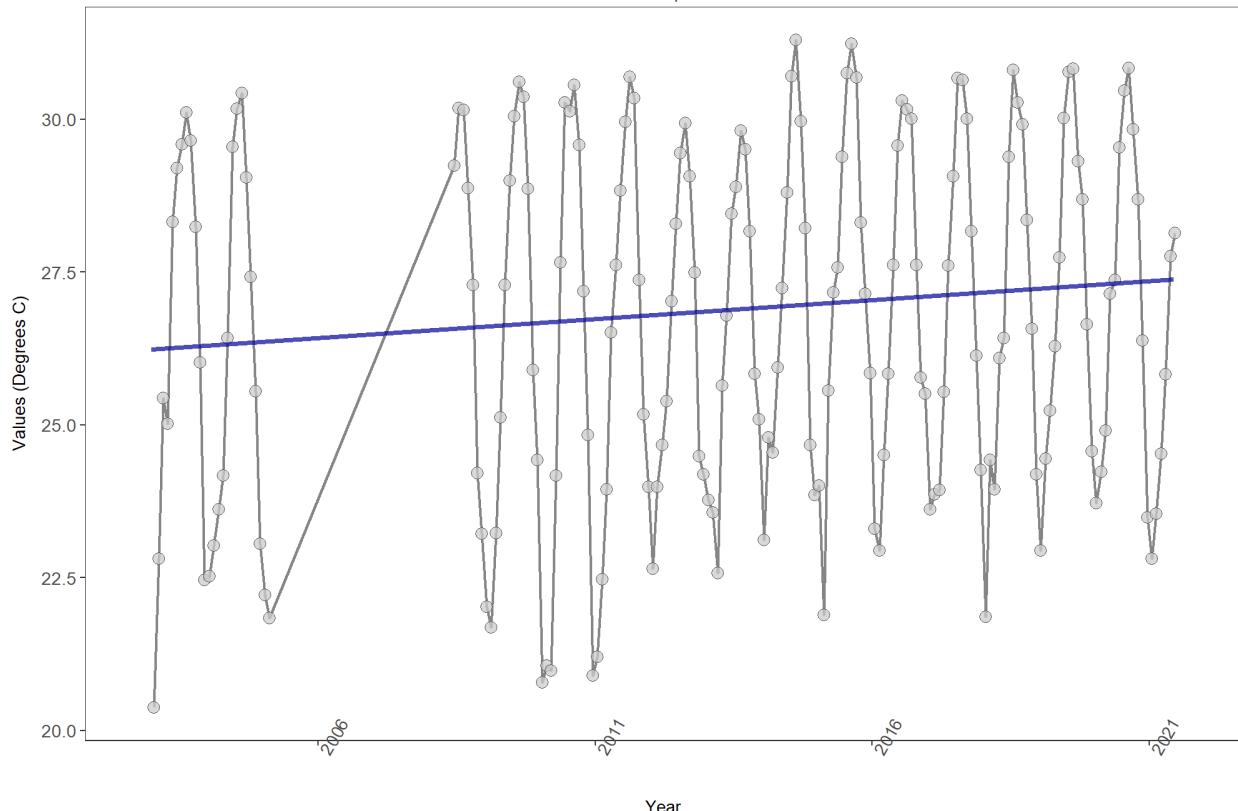


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	107029	10	26.54	1	0.1999	0.0148	0.05948701	26.31795	11.5014	0.4023	1

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
 32
 Water Temperature

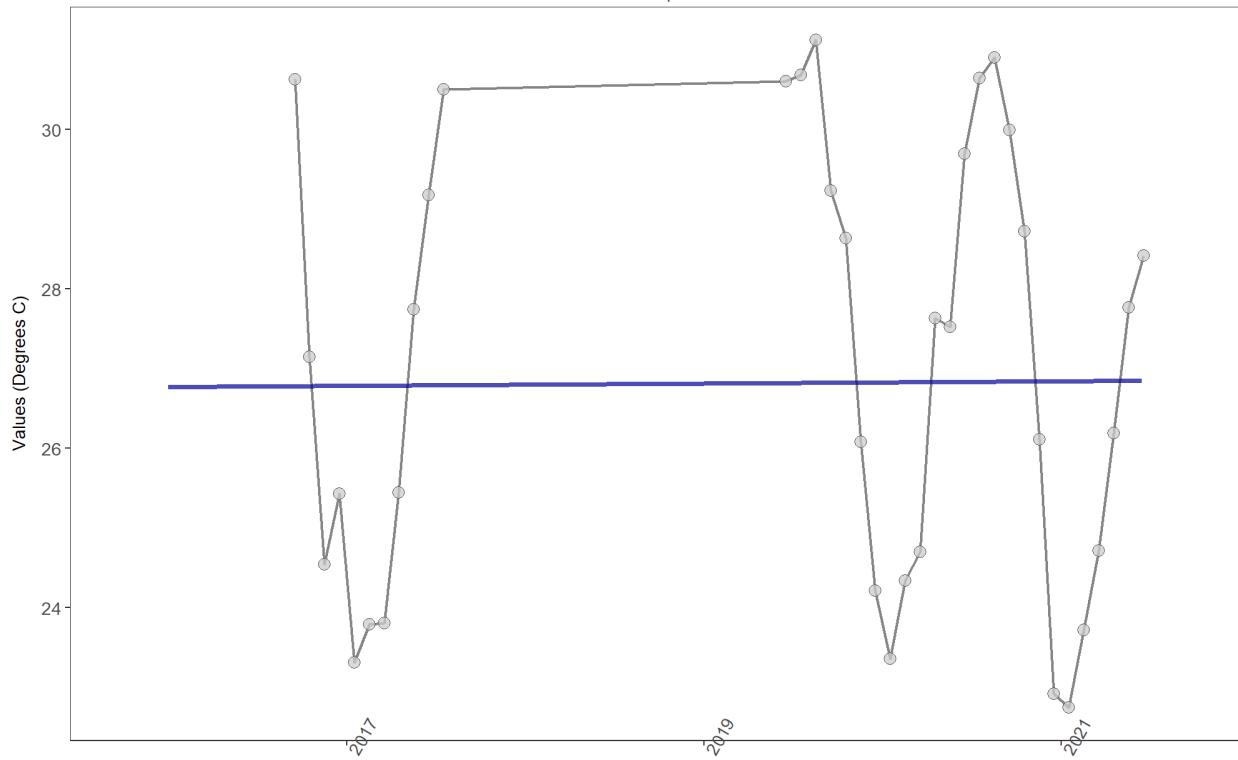


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	213529	17	26.64	1	0.3018	0	0.06218592	26.22876	6.703	0.8226	1

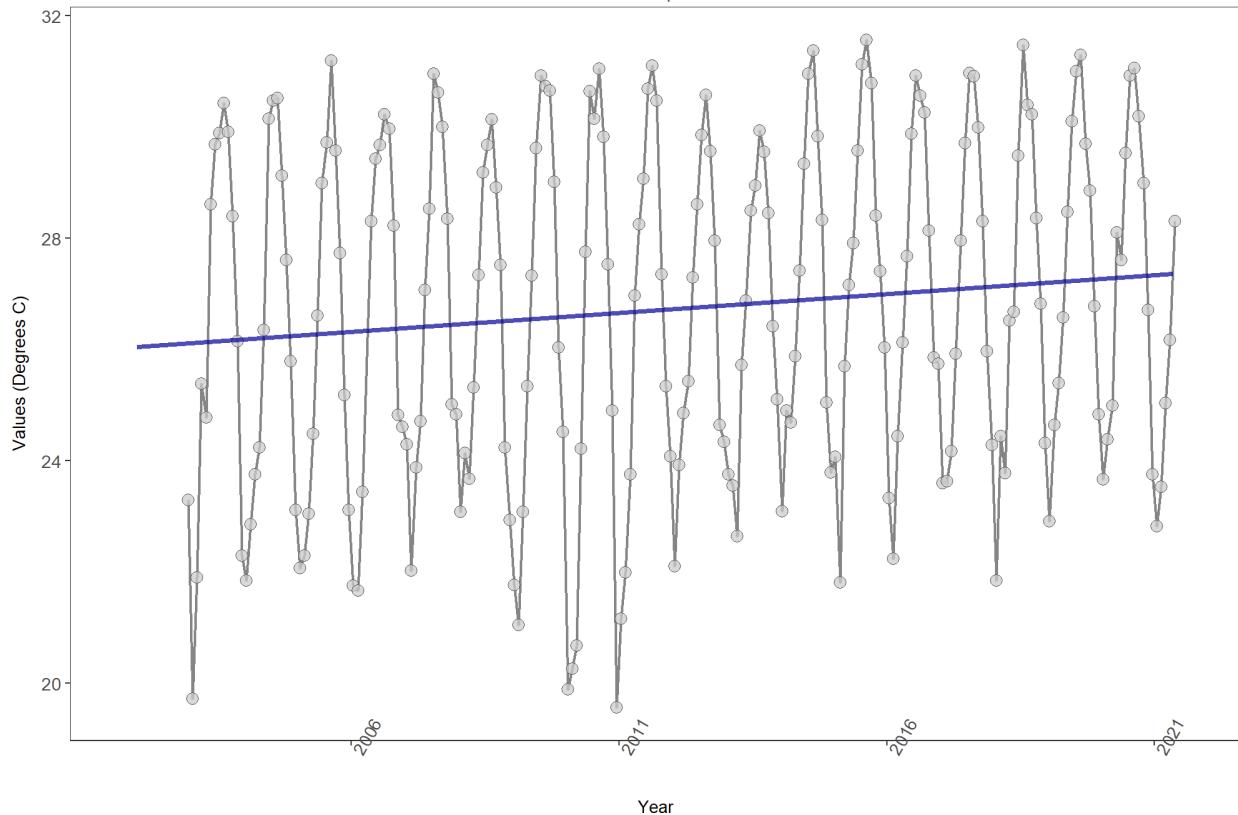
p < 0.00005 appear as 0 due to rounding.

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
 33
 Water Temperature



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

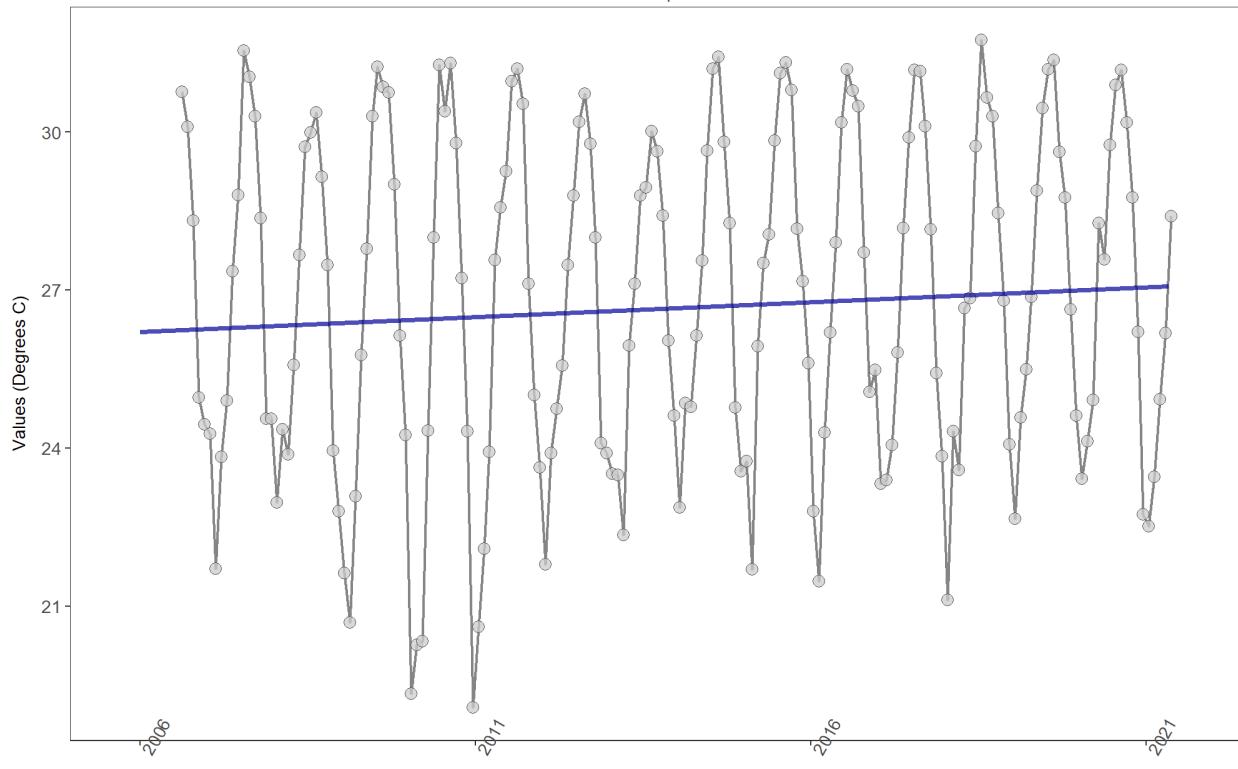


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	265056	20	26.695	1	0.31	0	0.06820049	26.04688	6.9029	0.8069	1

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

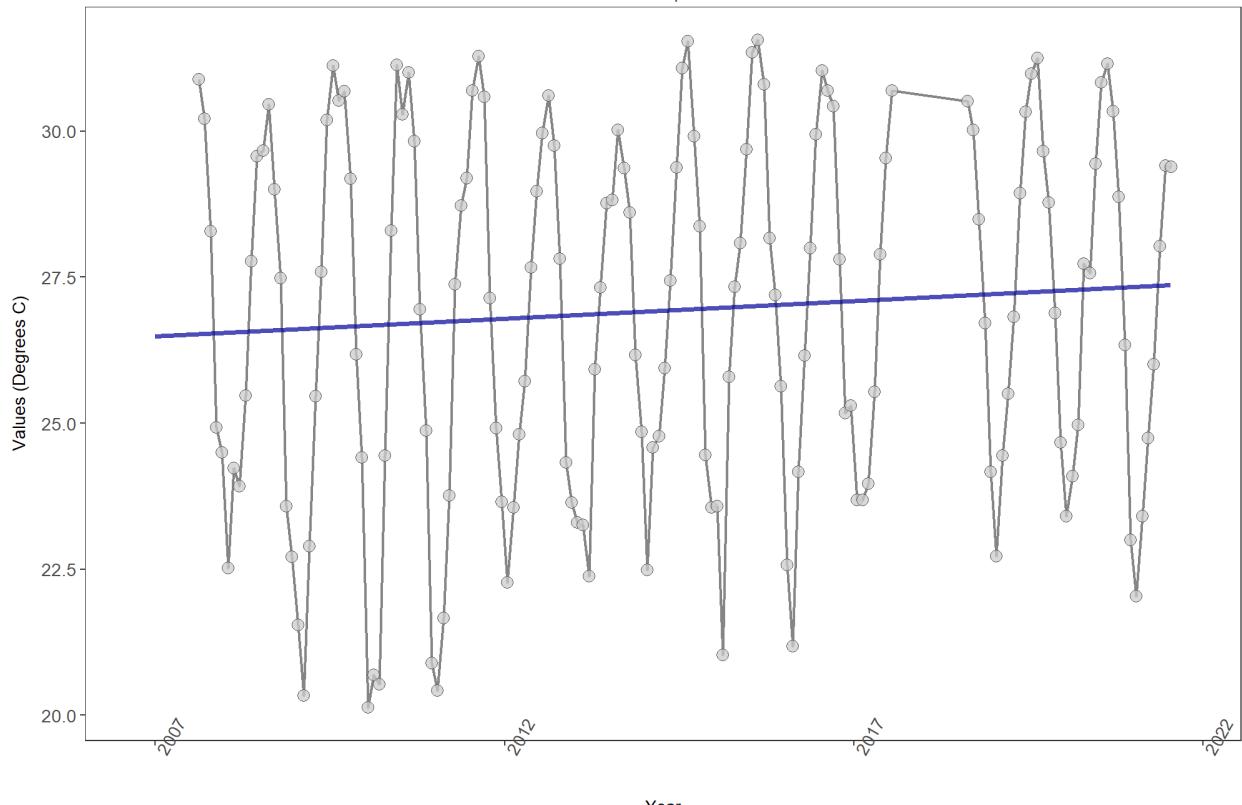


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	208736	16	26.84	1	0.2199	0.0001	0.05631794	26.20334	8.612	0.6577	1

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

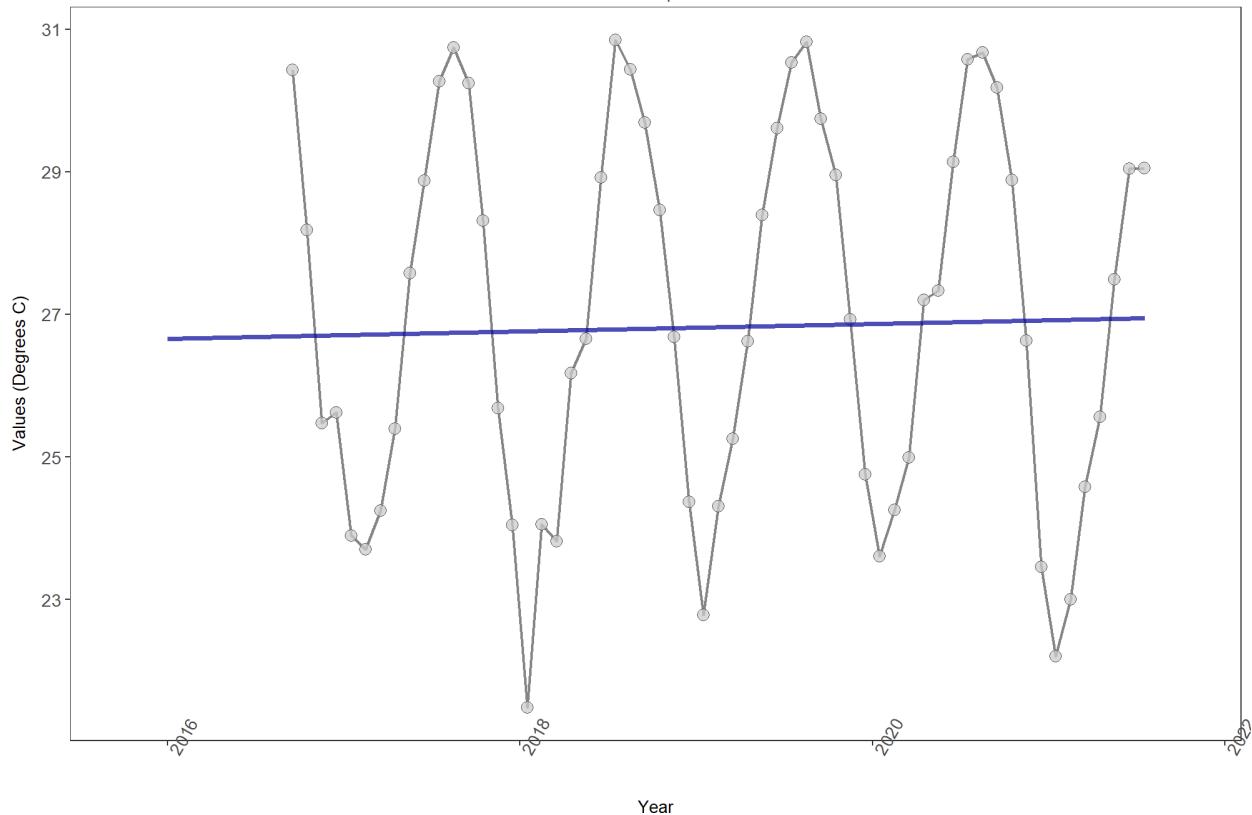


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	184903	15	26.91	1	0.2244	0.0002	0.06080839	26.48316	7.0012	0.799	1

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

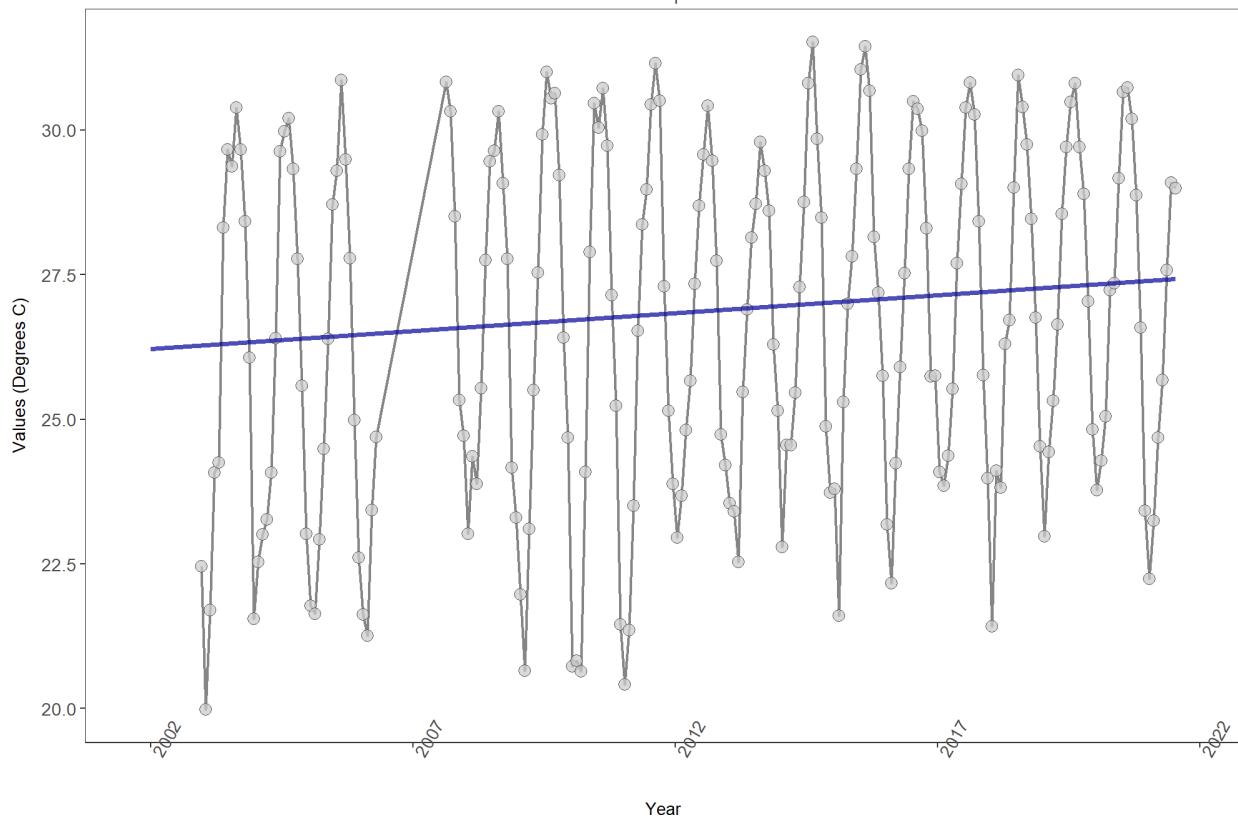


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	44575	6	26.79	1	0.1017	0.4273	0.05200067	26.65445	9.84	0.5448	0

$p < 0.00005$ 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
 38
 Water Temperature

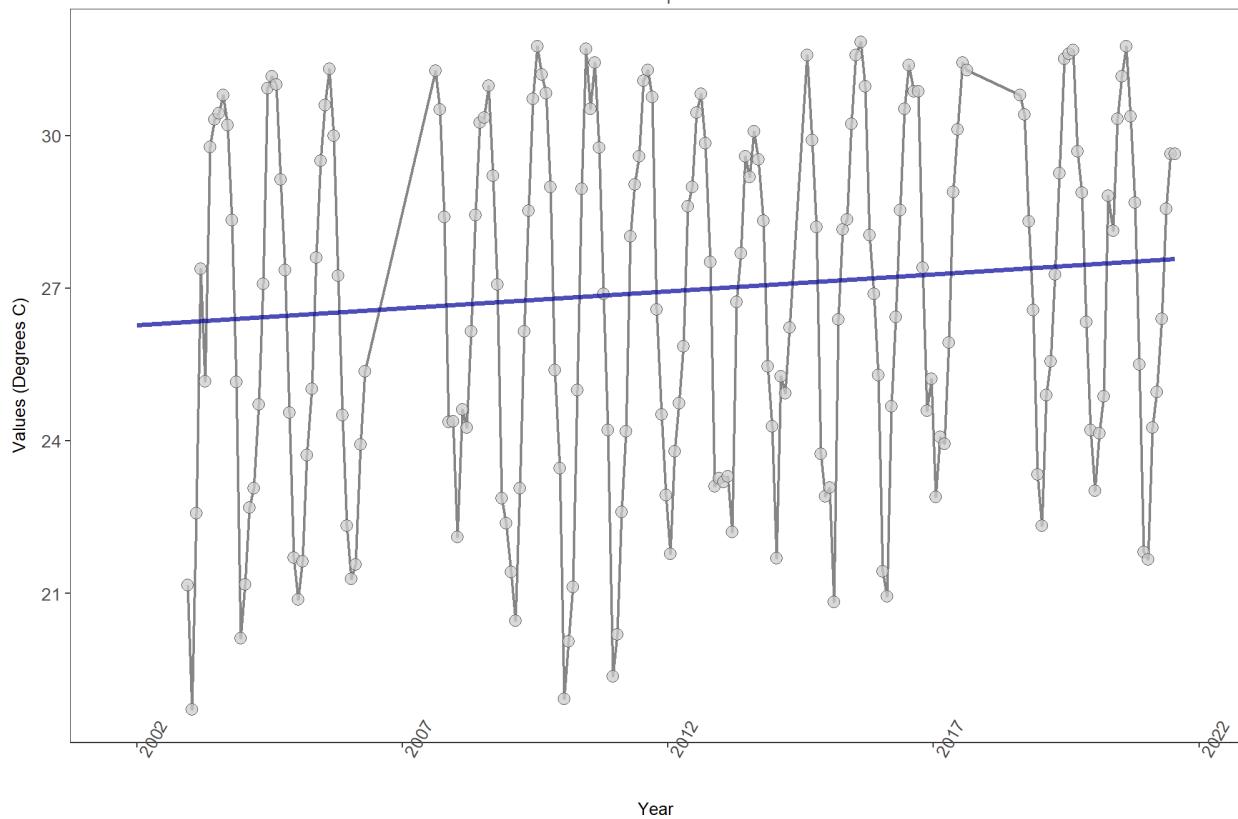


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	248375	20	26.451	1	0.2634	0	0.06201253	26.21361	12.0758	0.358	1

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

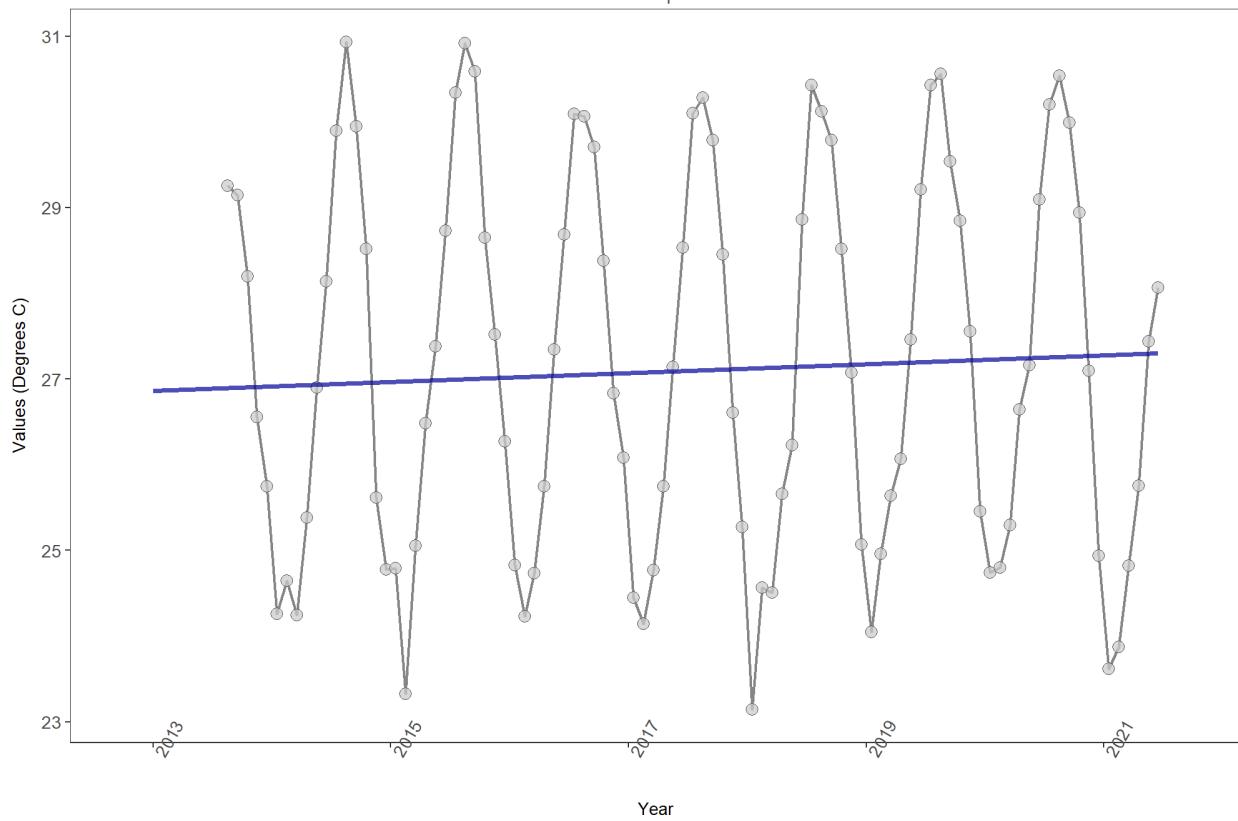


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	236342	20	26.79	1	0.2653	0	0.06703101	26.26851	8.3032	0.6859	1

p < 0.00005 appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

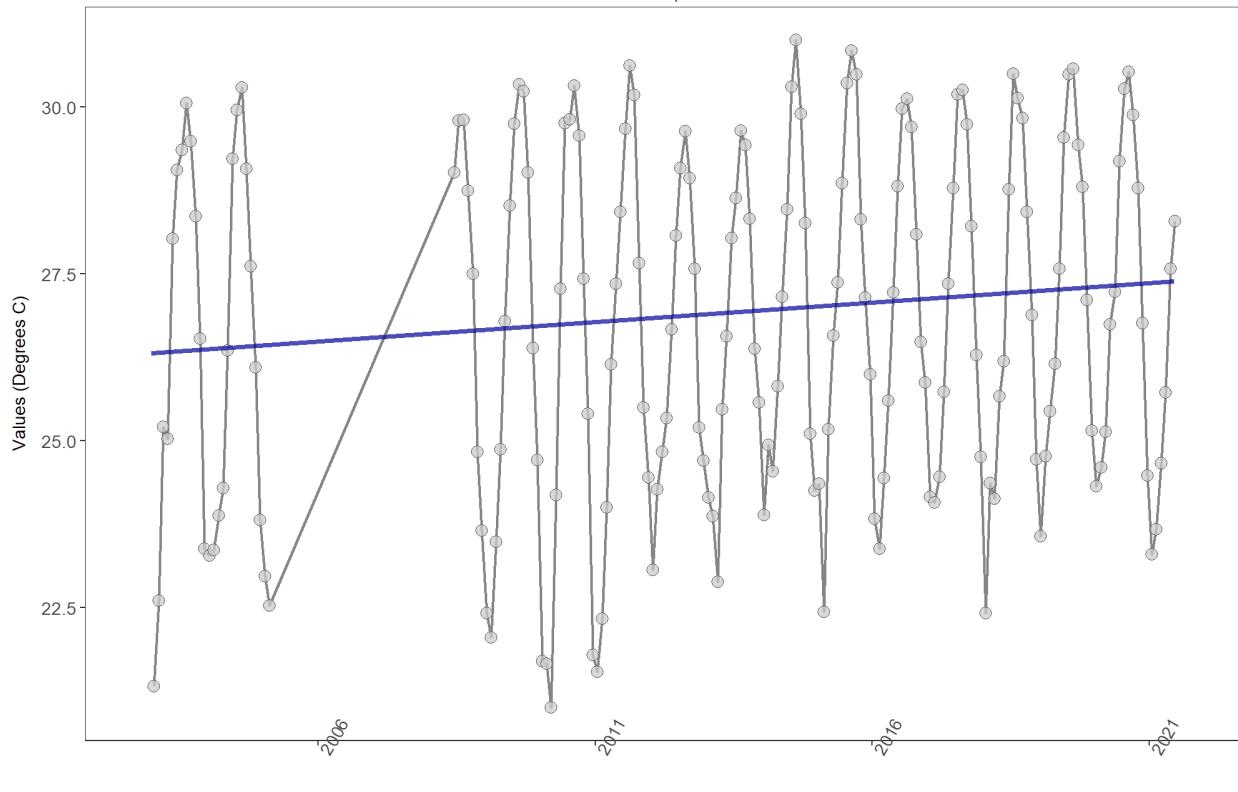
Florida Keys National Marine Sanctuary
 986
 Water Temperature on Coral Reefs in the Florida Keys
 50
 Water Temperature



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

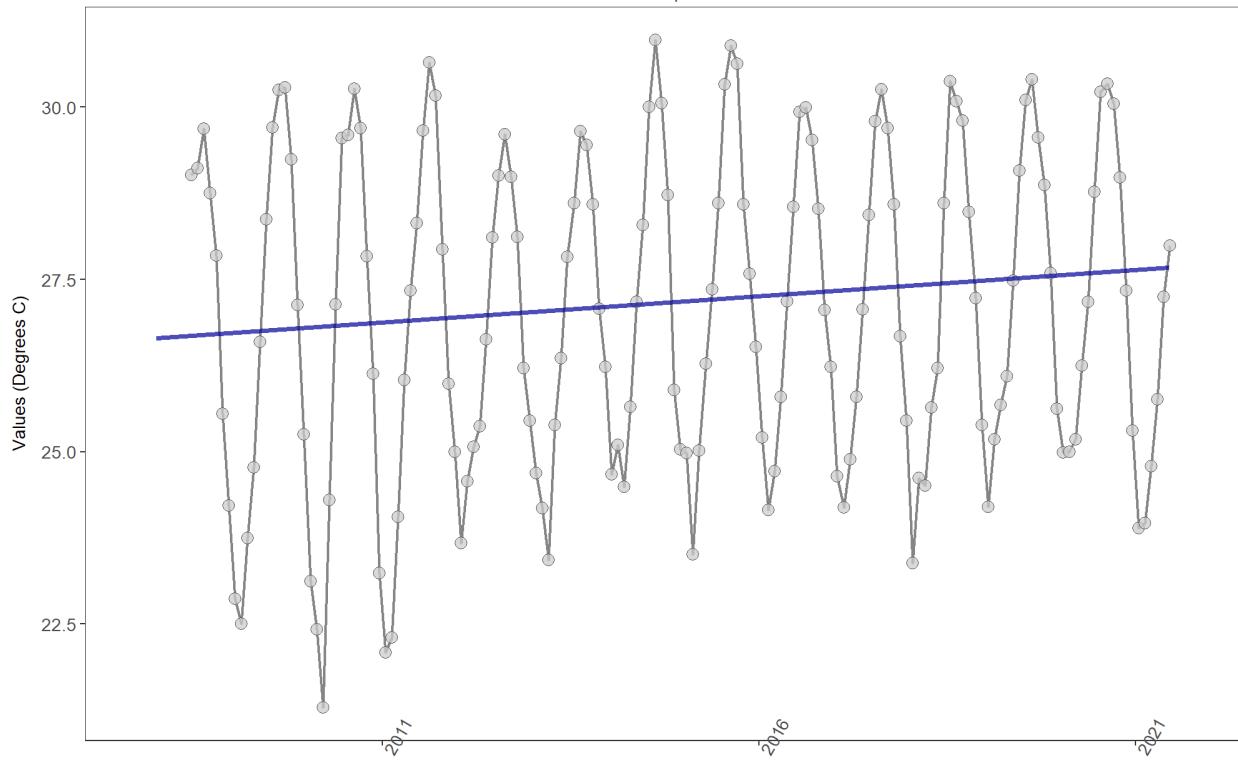


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	213322	17	26.64	1	0.2994	0	0.05830561	26.31248	8.5442	0.6639	1

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

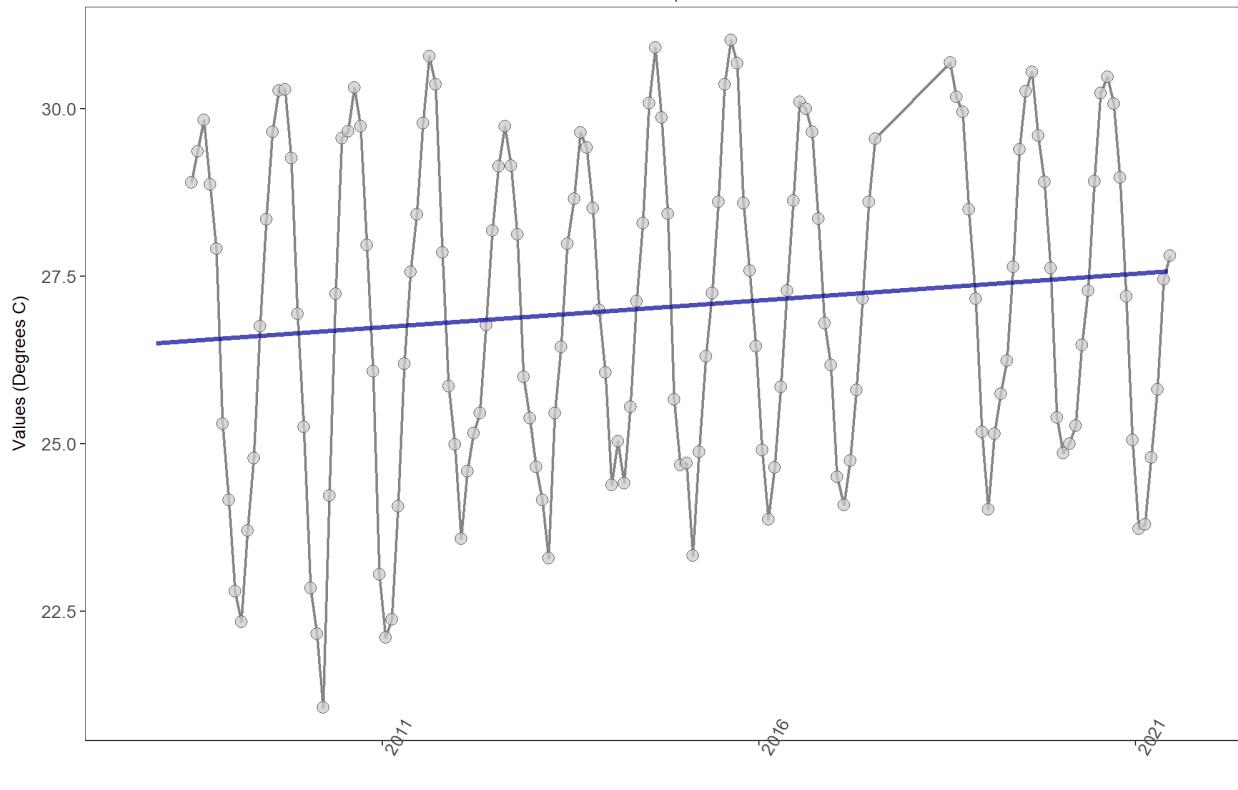


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	178708	14	26.89	1	0.3257	0	0.07589916	26.65121	5.8396	0.8838	1

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

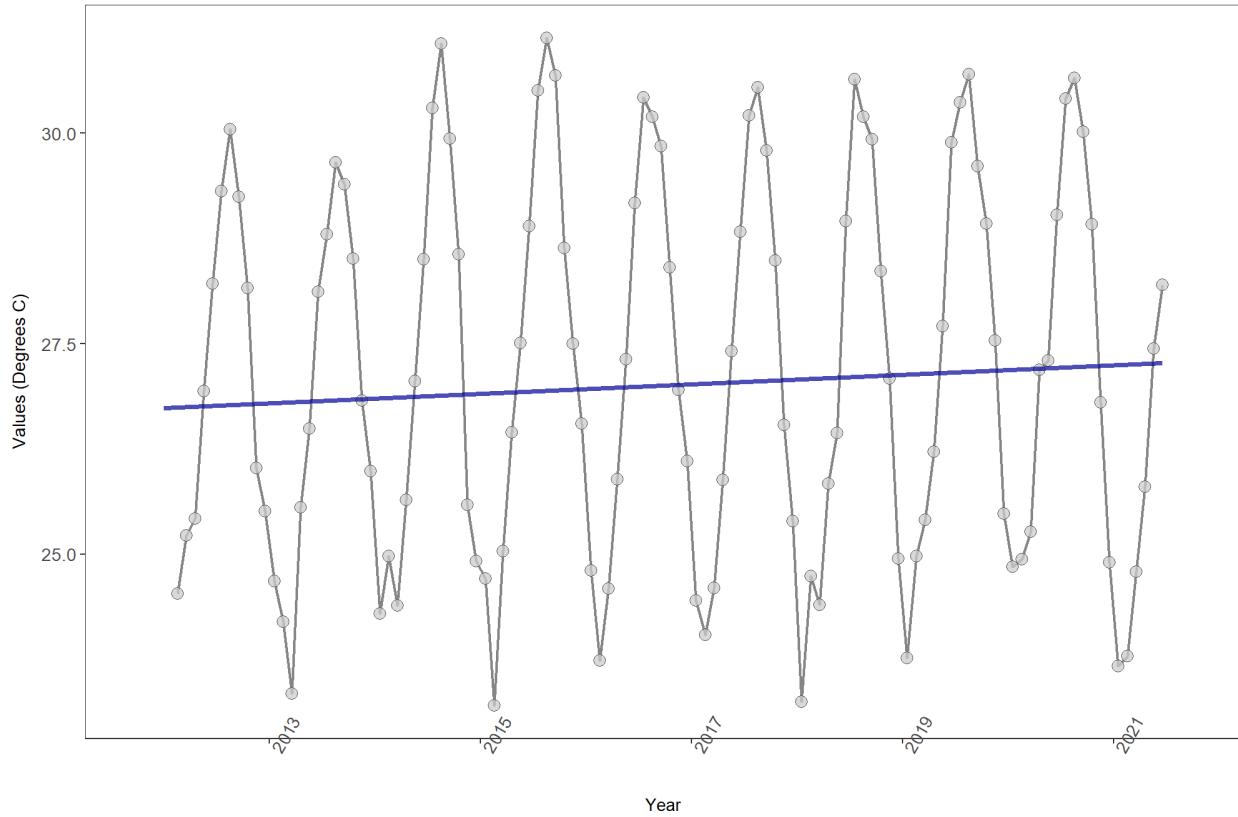


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	169828	14	26.96	1	0.3697	0	0.07990024	26.4967	5.7797	0.8877	1

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

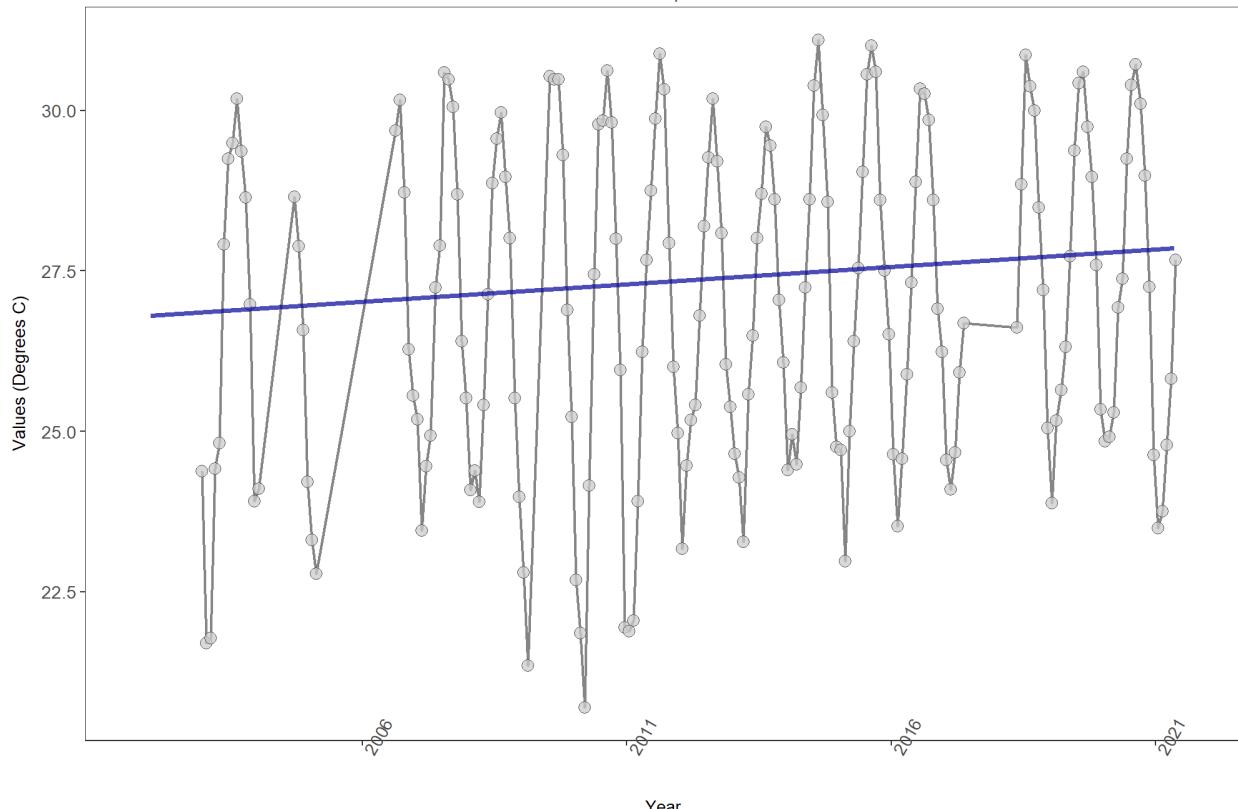


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	119502	10	26.965	1	0.2242	0.0024	0.05693811	26.73481	9.0305	0.6191	1

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

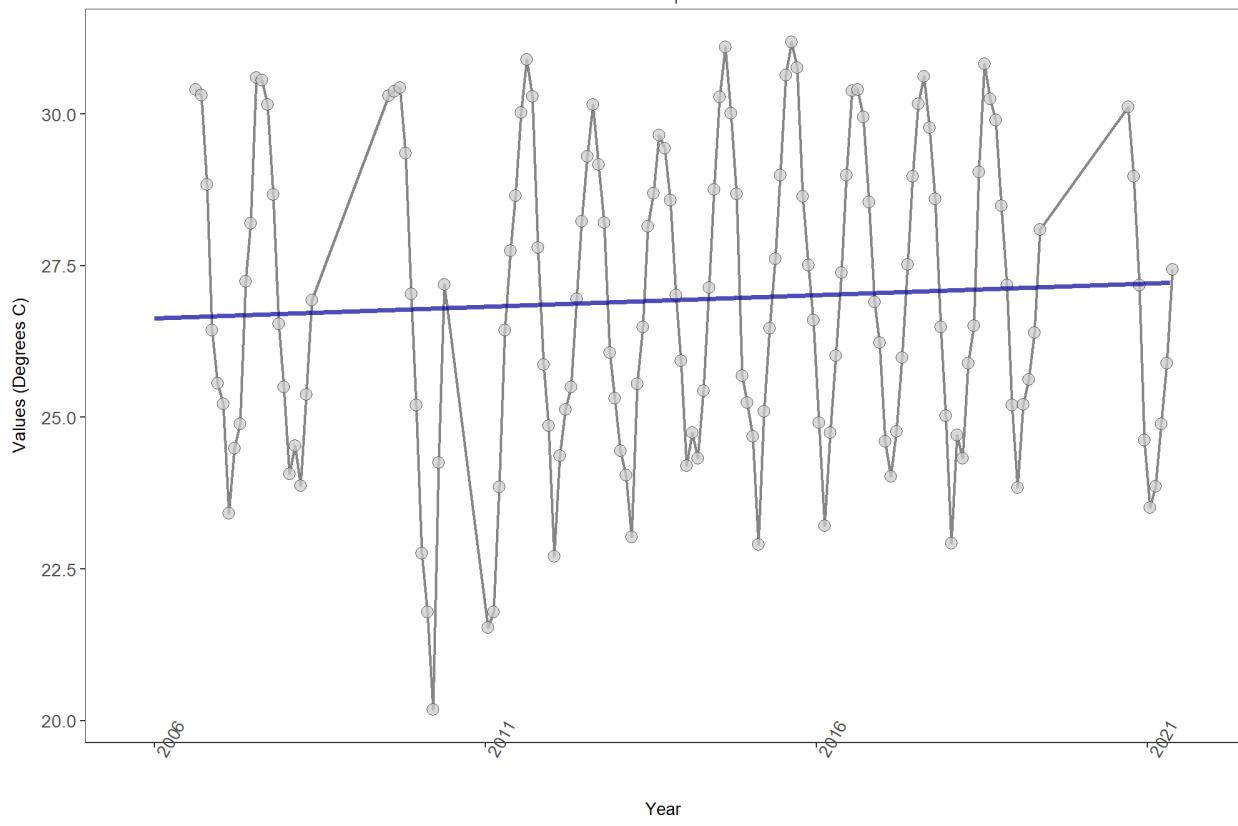


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	216638	20	26.84	1	0.2853	0	0.0544839	26.79716	7.8781	0.7242	1

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

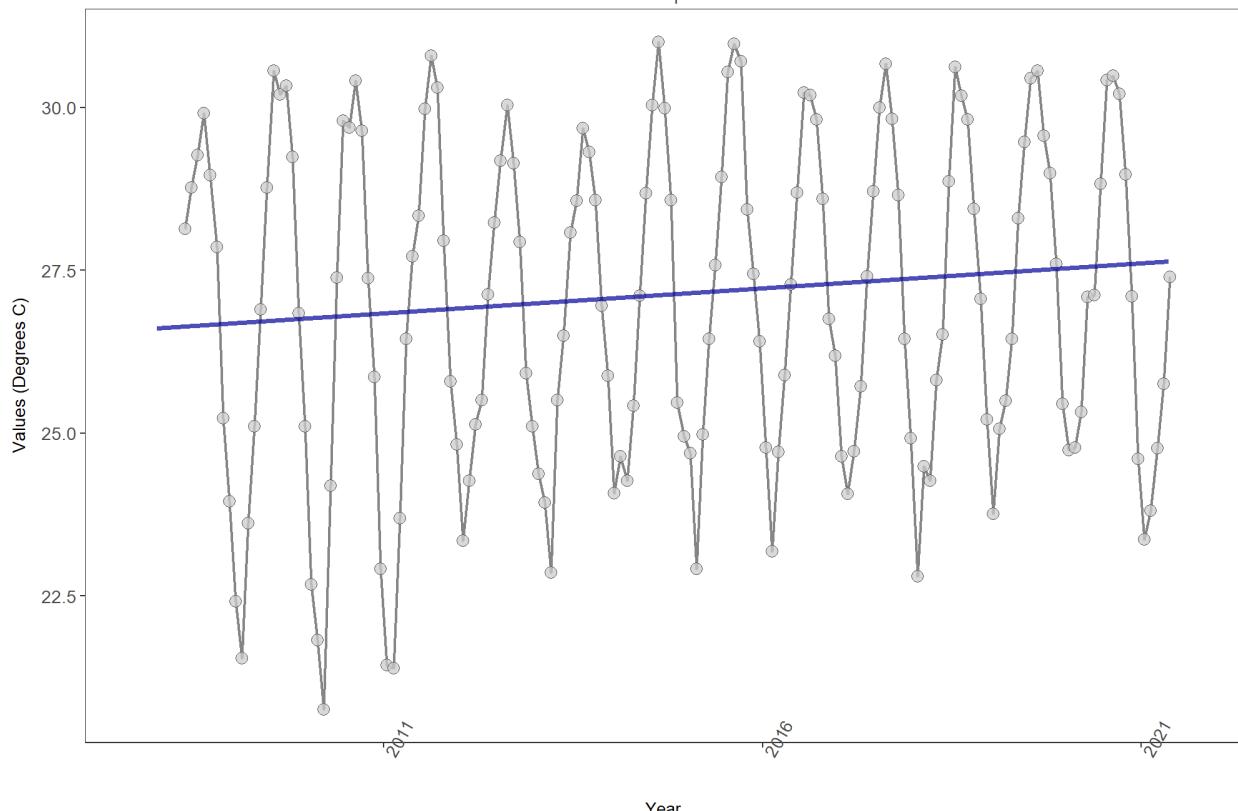


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	166716	16	26.646	1	0.1478	0.026	0.03790529	26.63508	12.6453	0.3171	1

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
 57
 Water Temperature

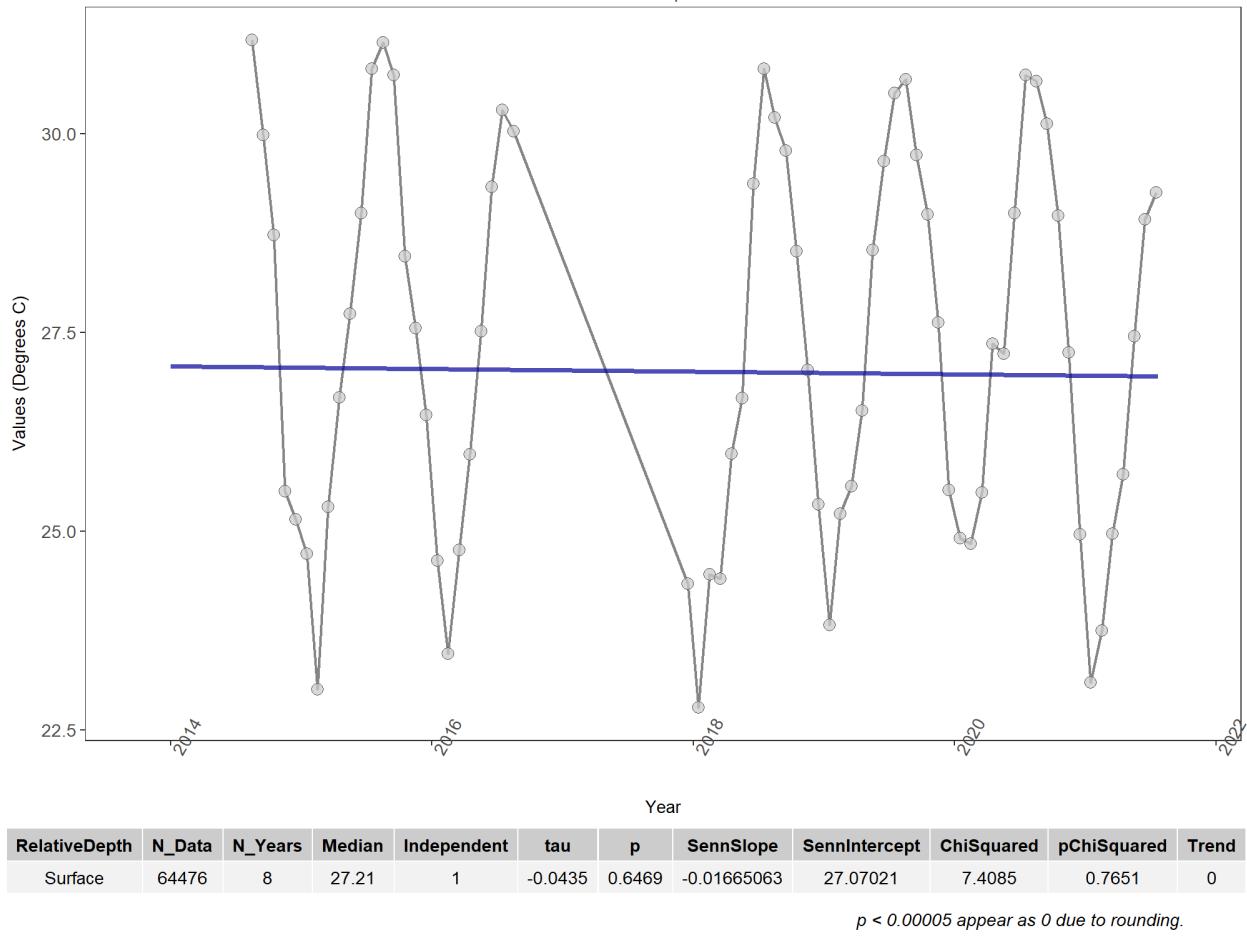


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	178985	14	26.965	1	0.3175	0	0.07662102	26.6105	8.0755	0.7065	1

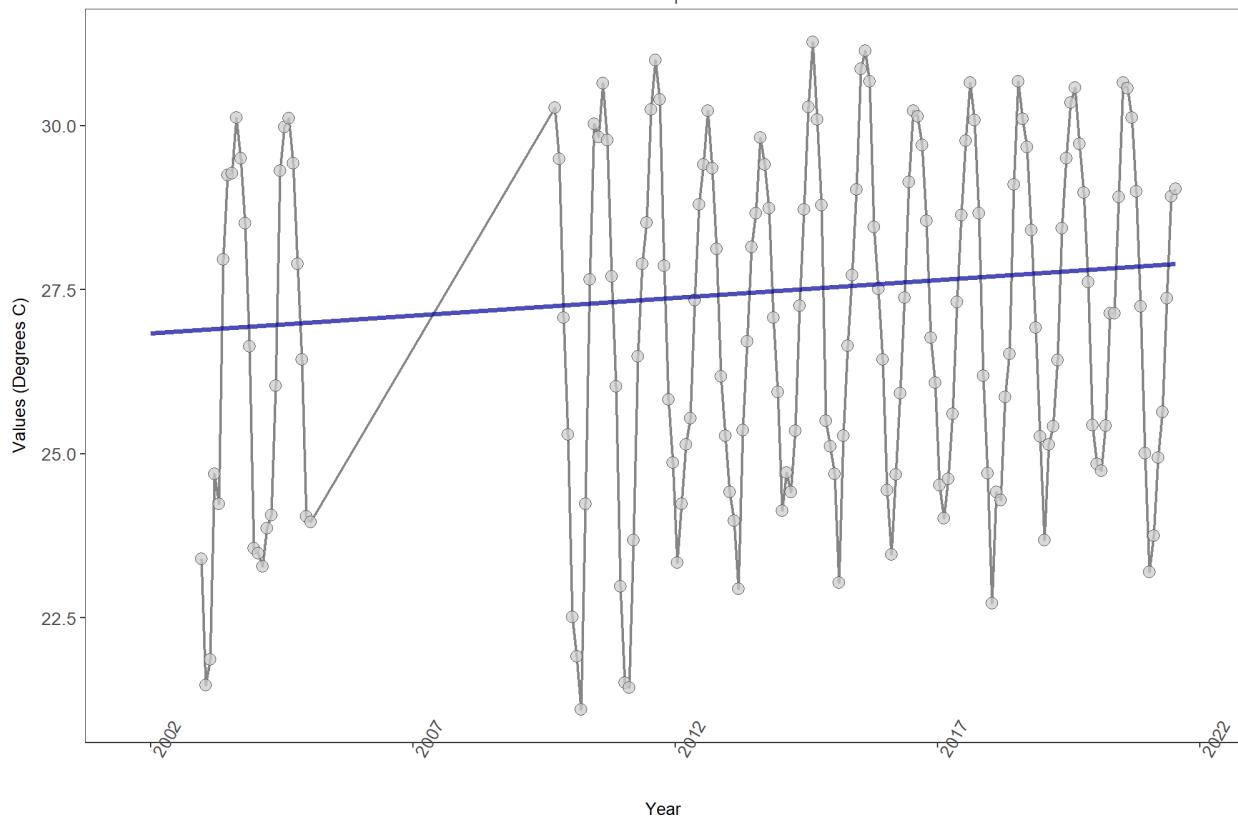
p < 0.00005 appear as 0 due to rounding.

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



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

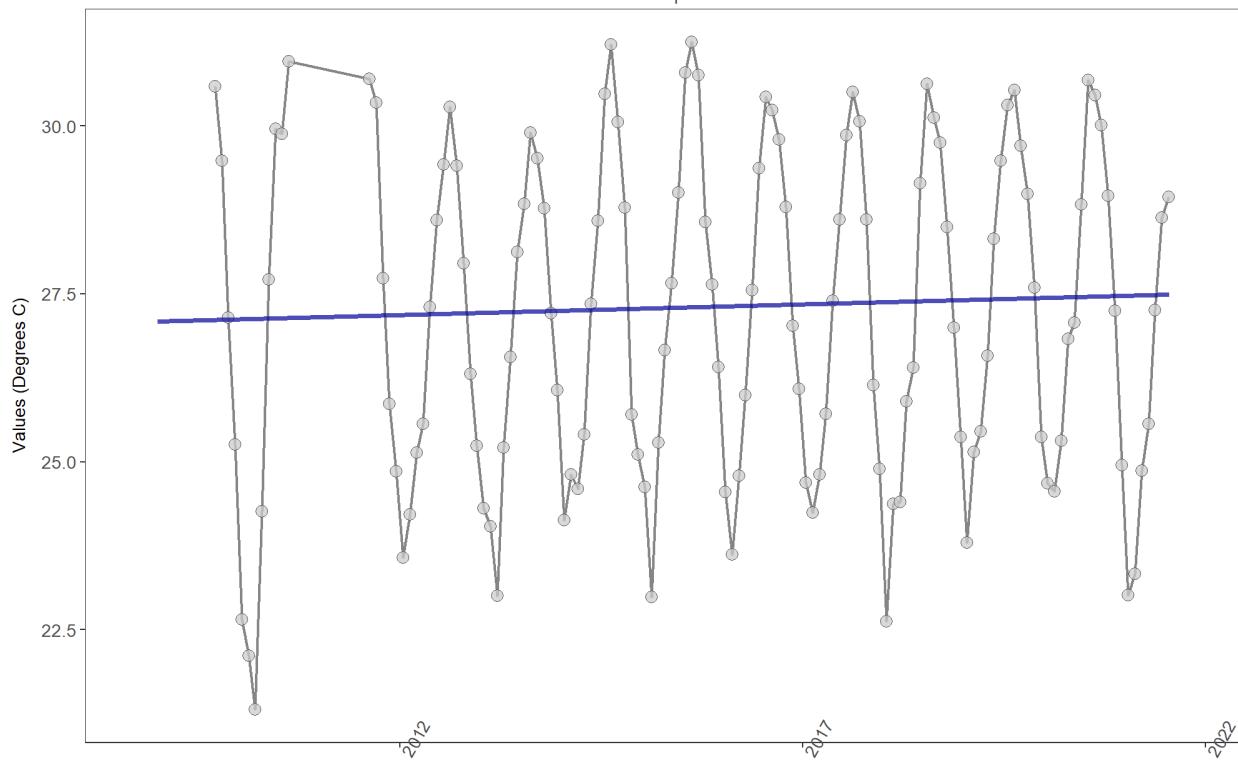


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	183805	17	26.818	1	0.253	0	0.05390625	26.8366	10.5348	0.483	1

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

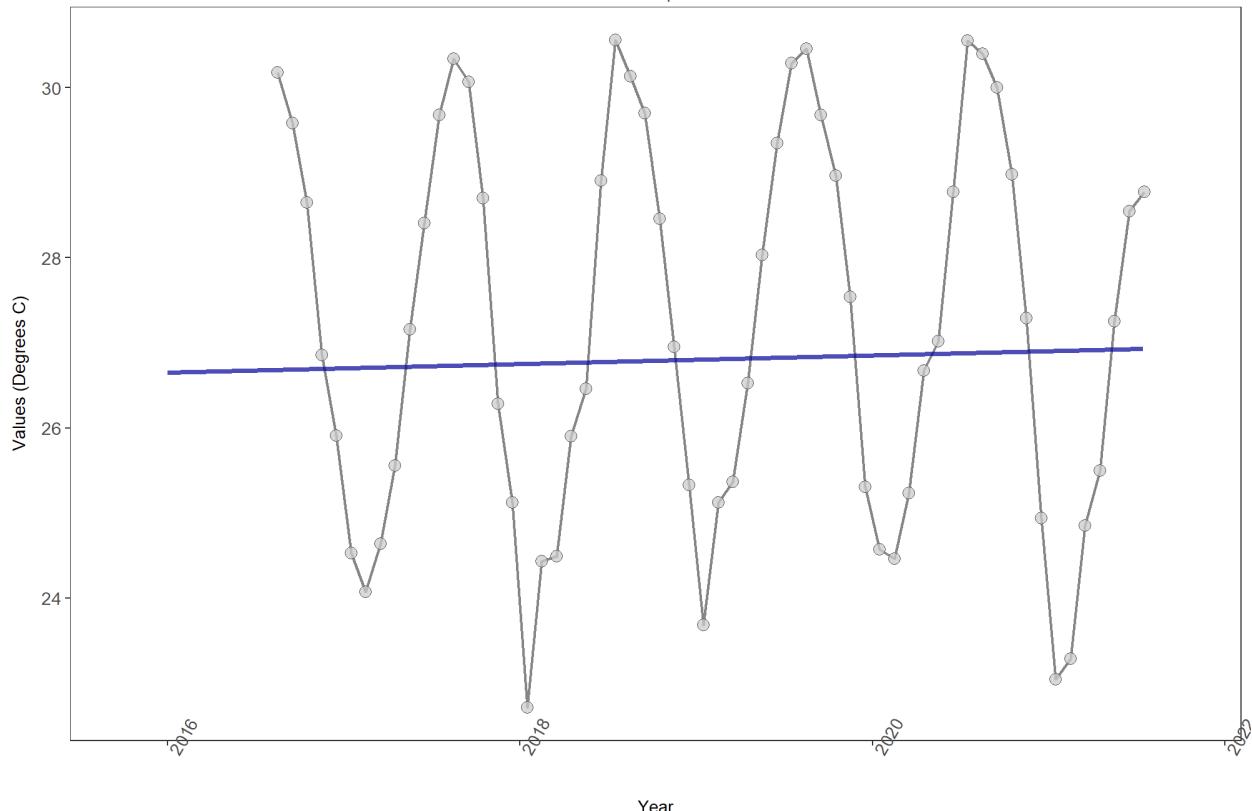


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	142216	13	26.96	1	0.1394	0.0408	0.0317376	27.09074	8.9374	0.6277	1

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

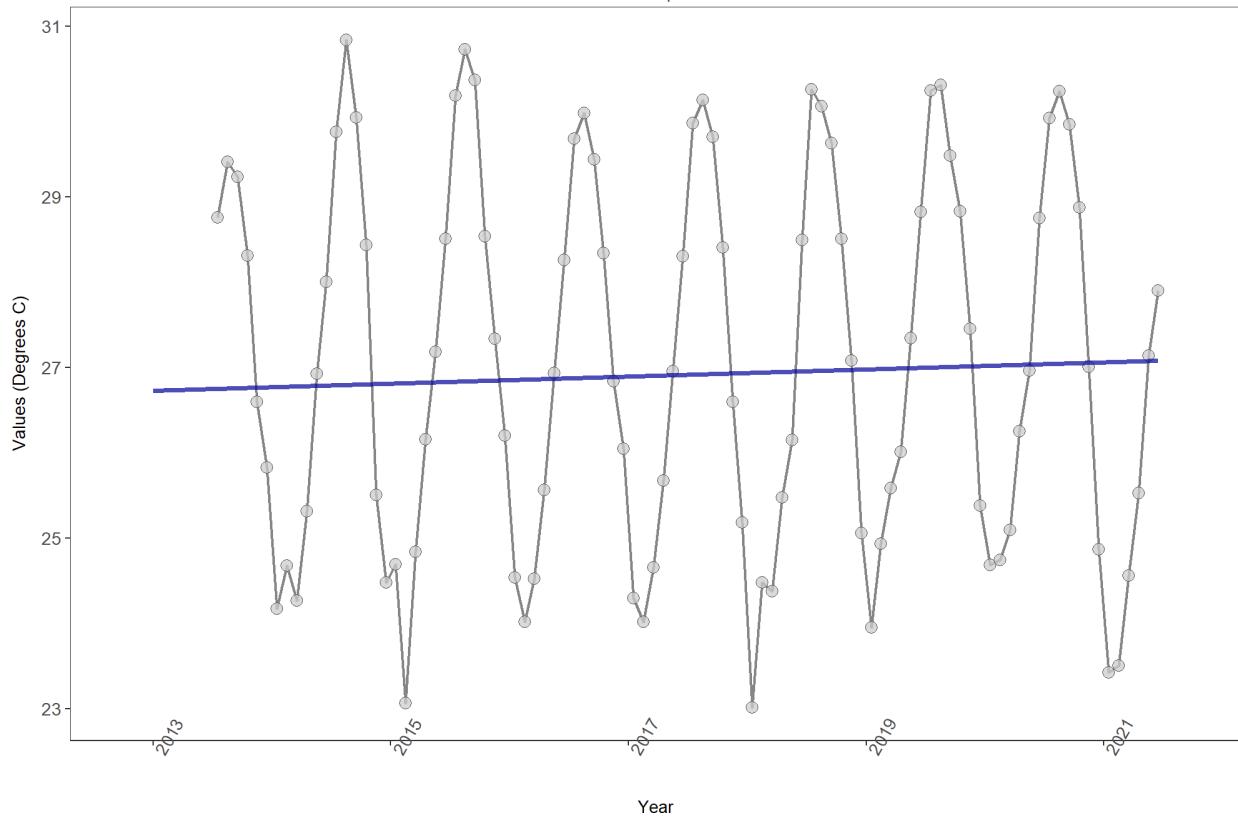


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	46150	6	27.18	1	0.1333	0.2888	0.04961196	26.65384	7.36	0.7692	0

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
 70
 Water Temperature

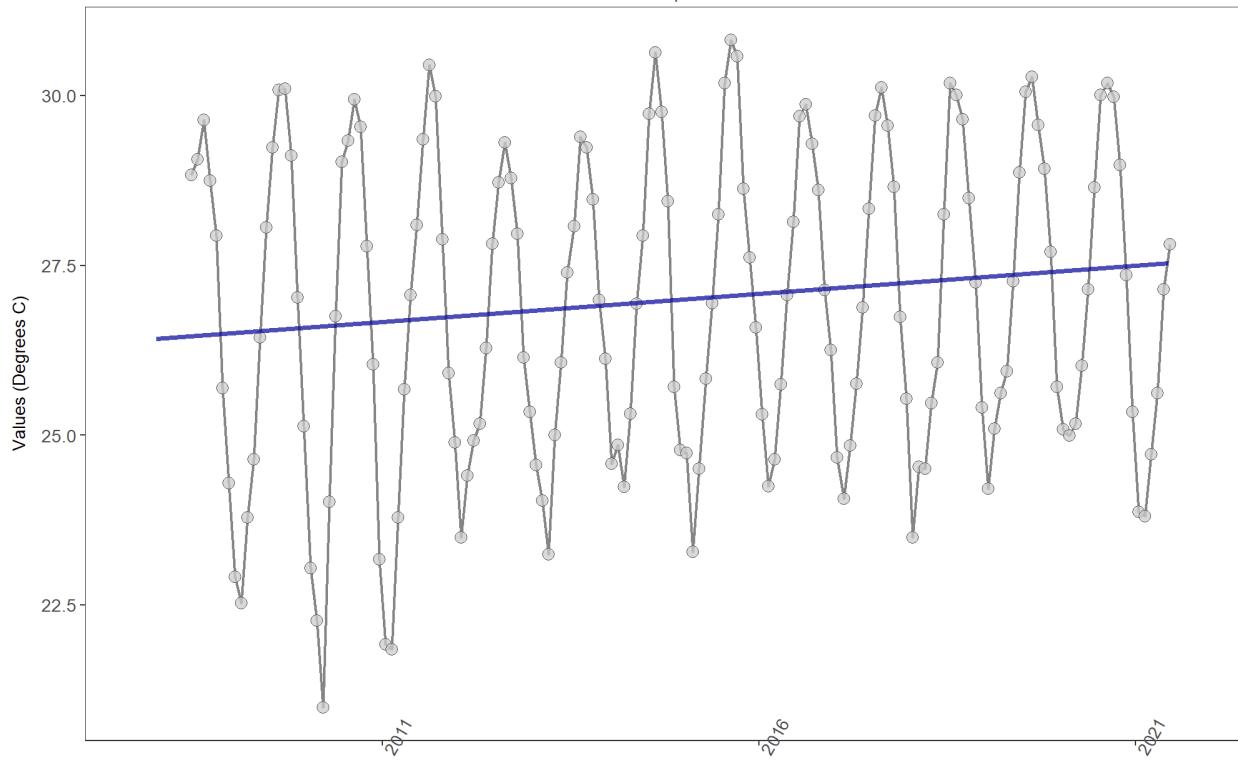


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	95384	9	26.89	1	0.1905	0.0244	0.04127407	26.72817	9.9592	0.5341	1

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
 72
 Water Temperature

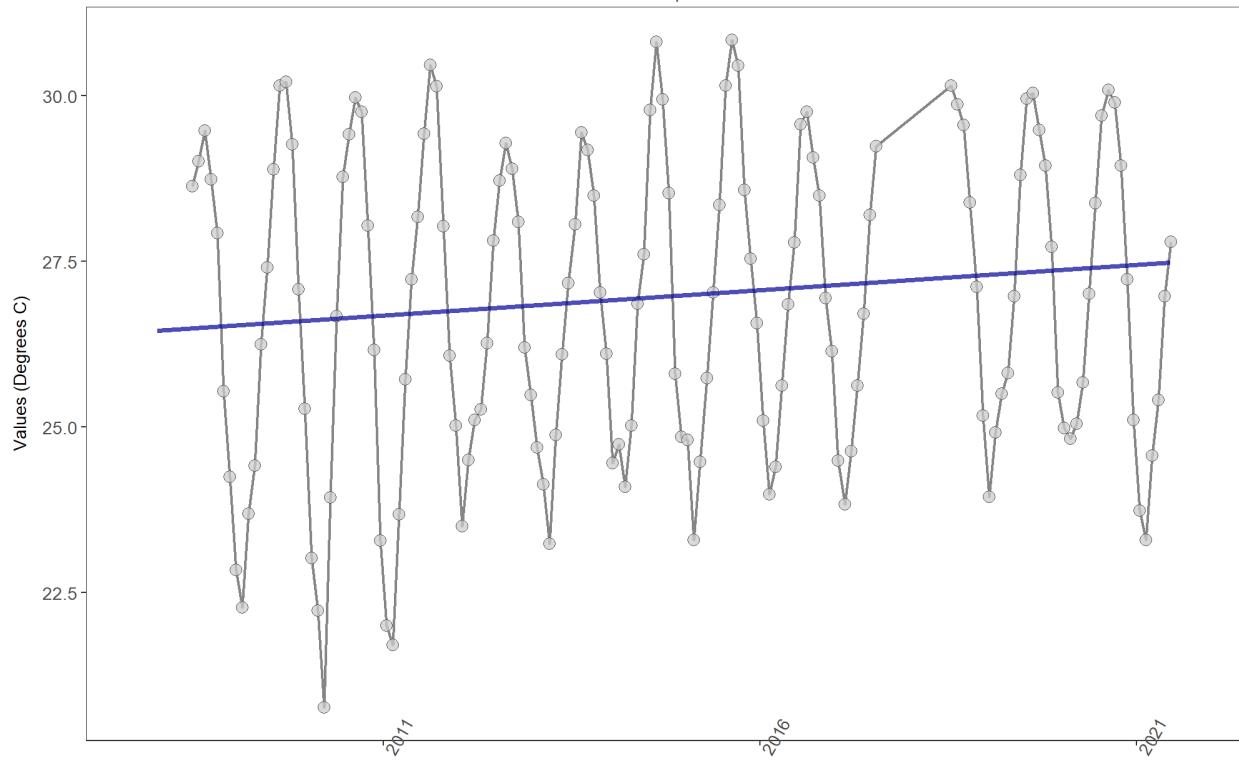


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	178618	14	26.744	1	0.3977	0	0.08307034	26.41537	6.5562	0.8338	1

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

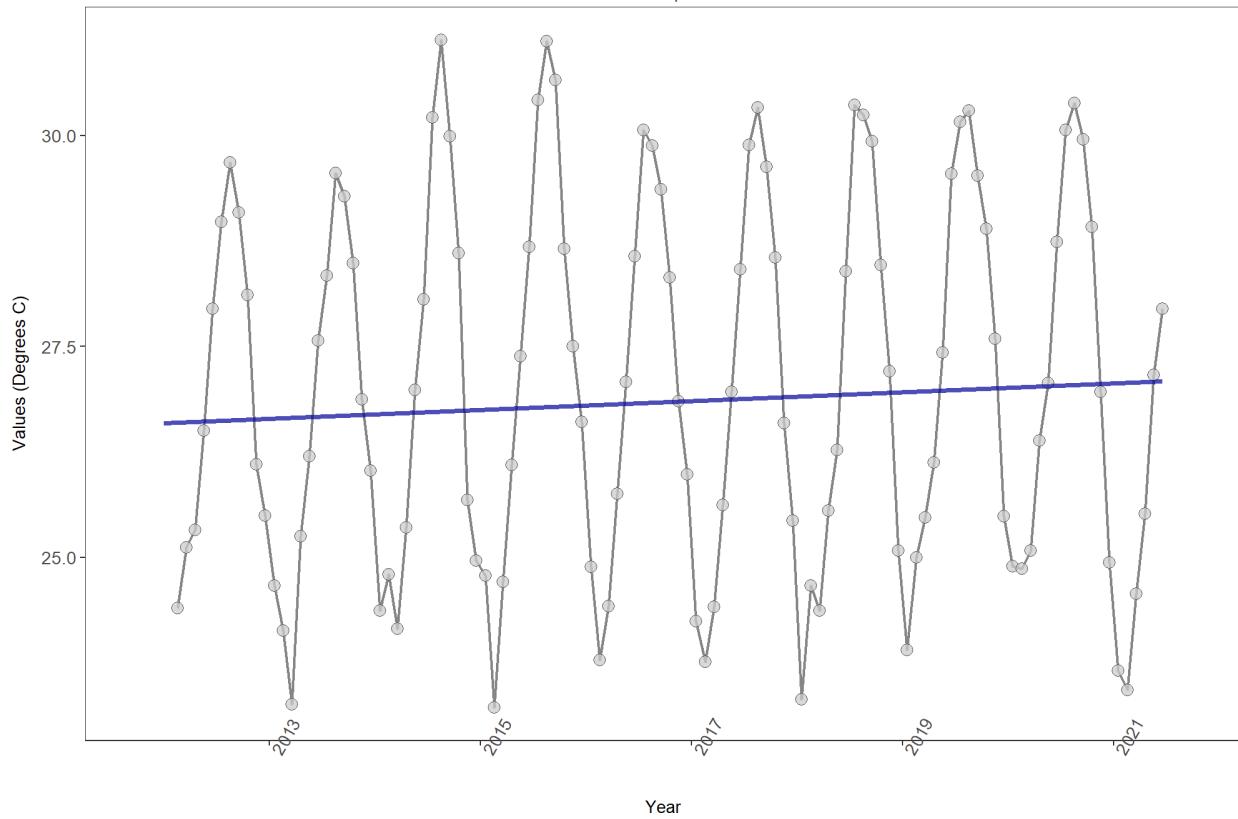


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	169932	14	26.69	1	0.3323	0	0.07646026	26.45925	5.6013	0.8986	1

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

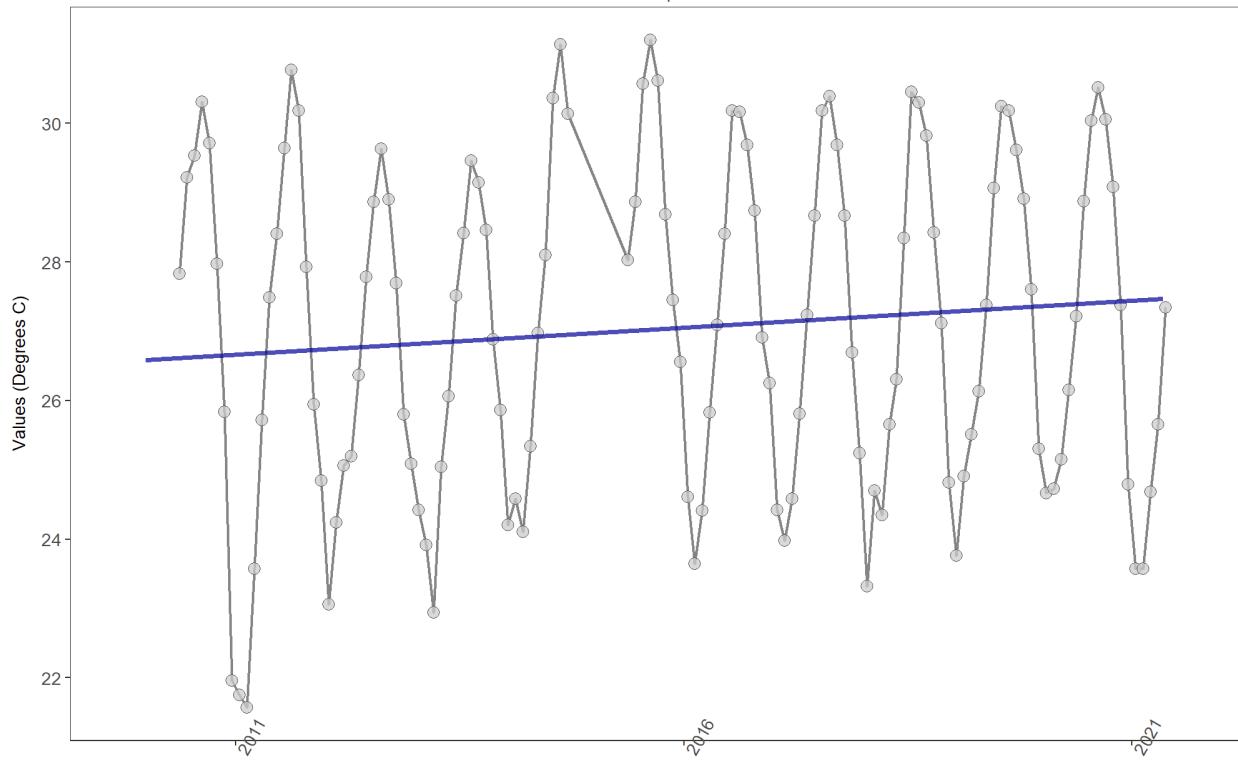


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	119436	10	26.793	1	0.1996	0.007	0.05245836	26.59364	11.2709	0.4209	1

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

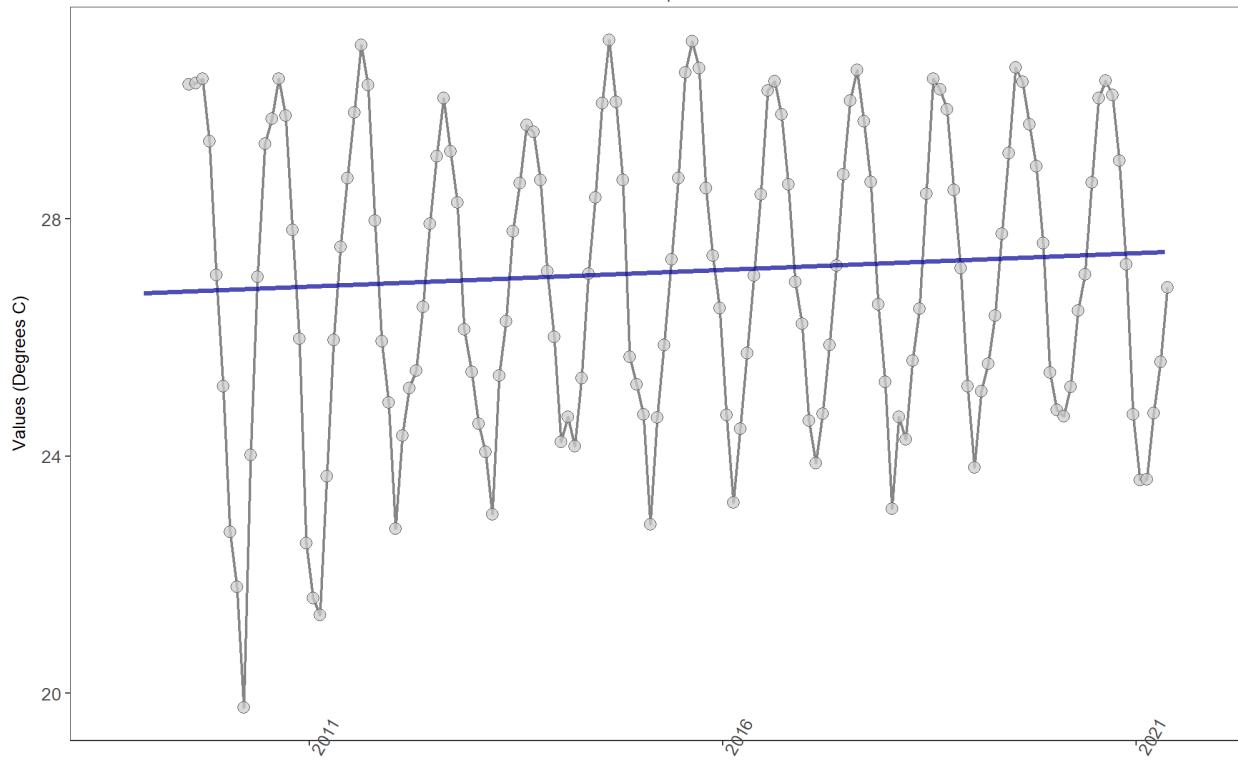


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	135590	12	27.08	1	0.2709	0.0002	0.07720869	26.58939	7.9908	0.7141	1

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
 76
 Water Temperature

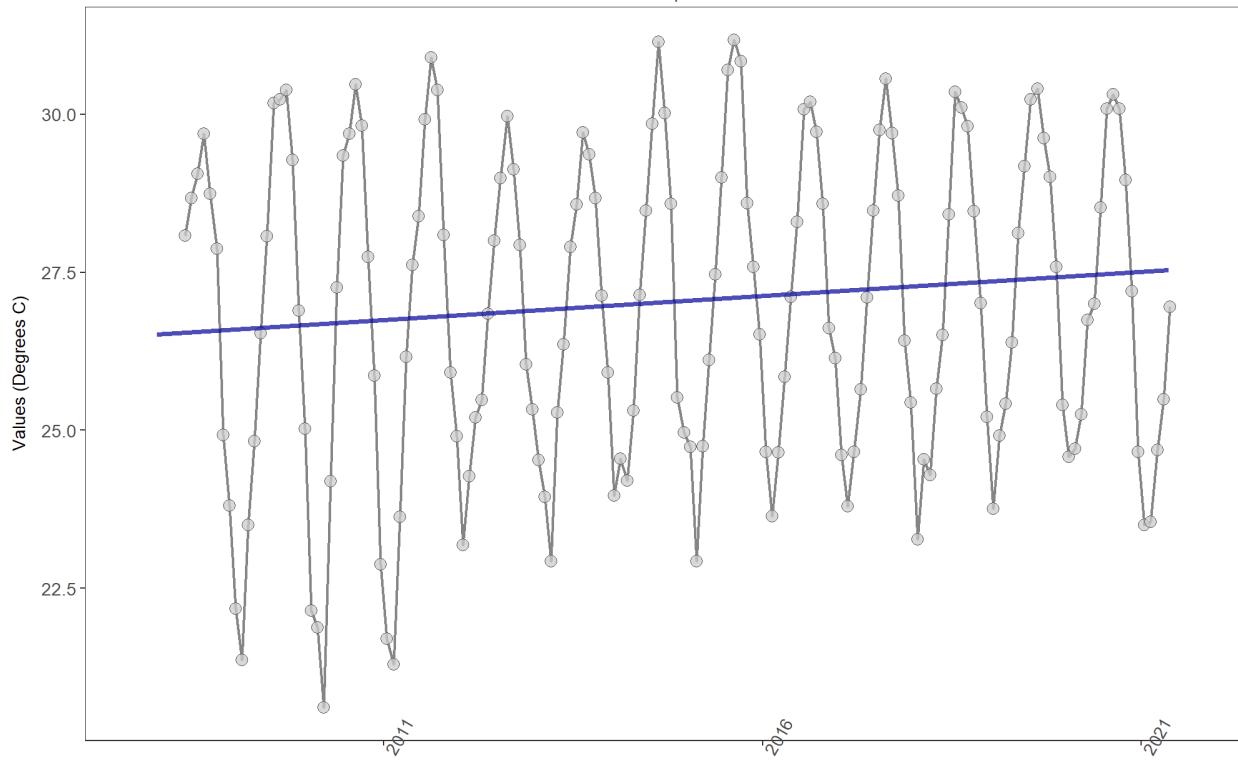


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	159983	13	26.842	1	0.2437	0.0001	0.05576643	26.75169	8.656	0.6536	1

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

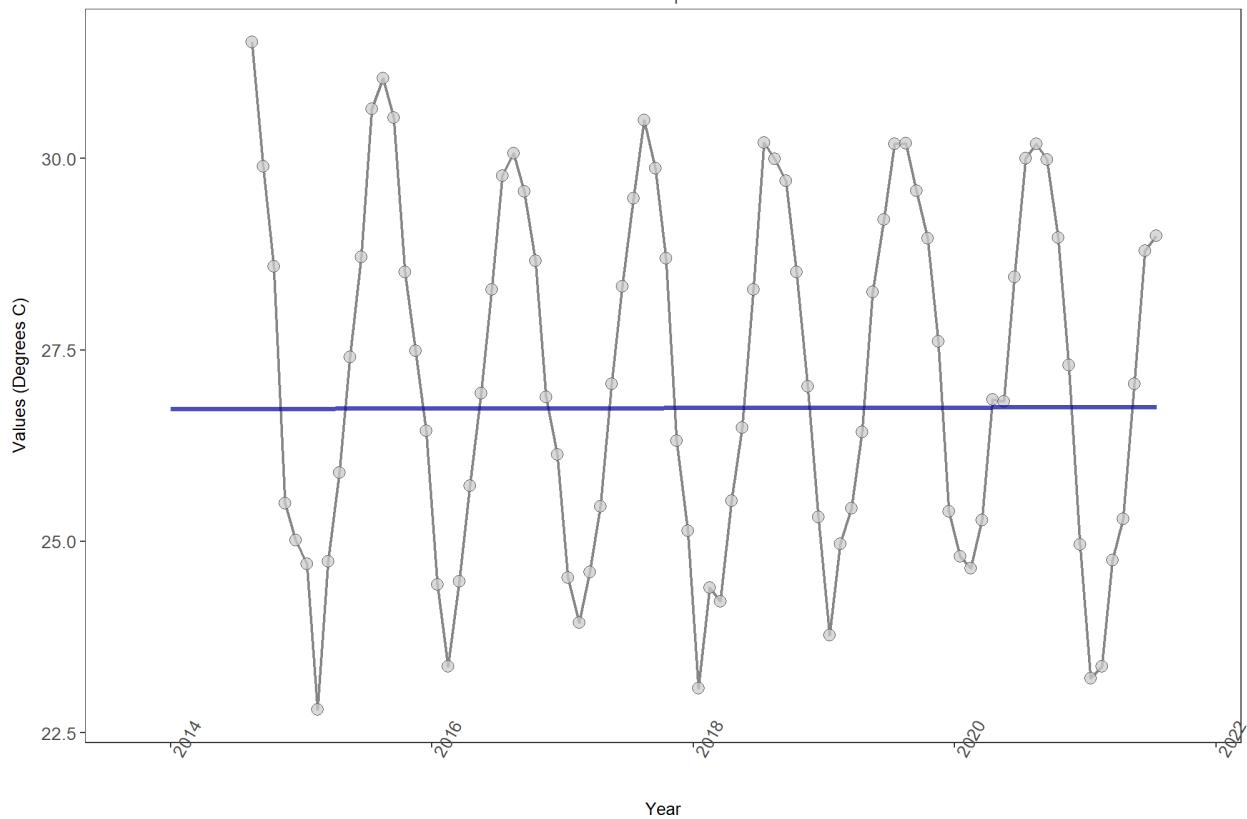


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	179404	14	26.89	1	0.2783	0	0.07603218	26.51603	10.5306	0.4834	1

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

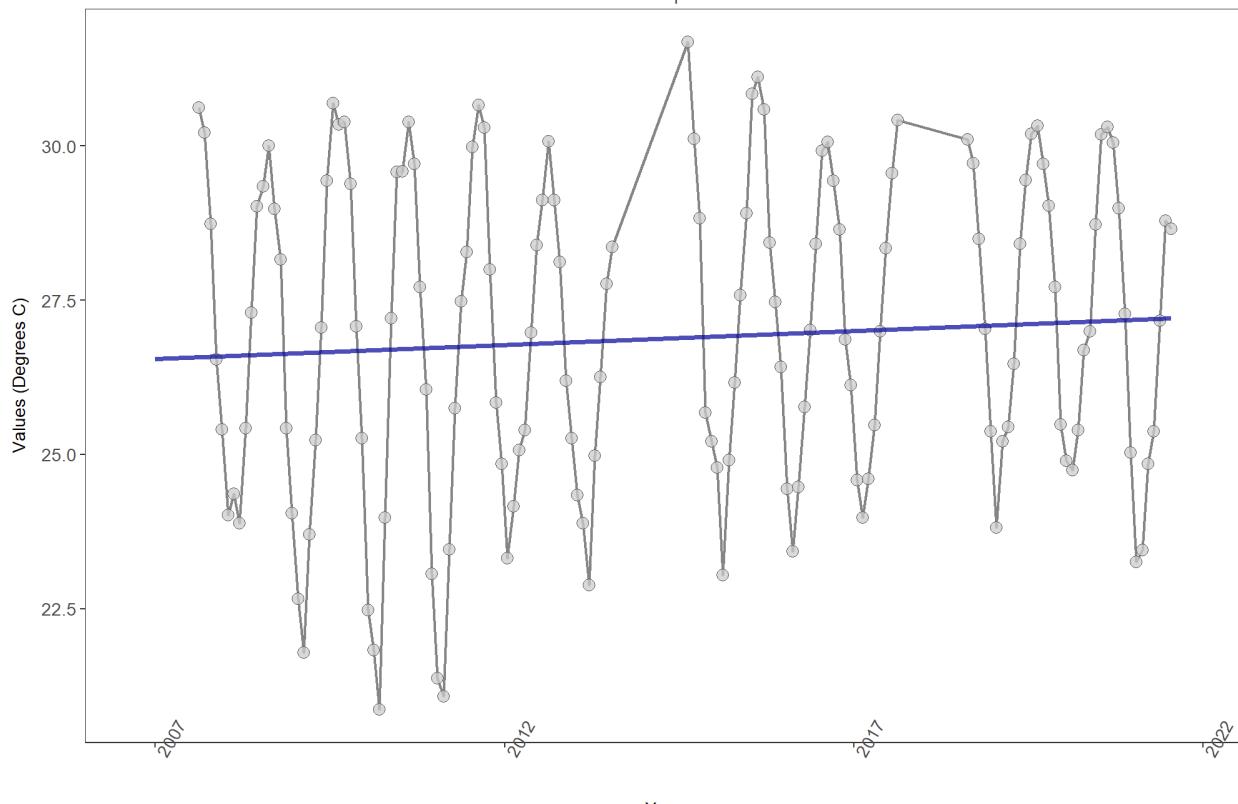


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	80030	8	27.03	1	0.0317	0.7615	0.003411781	26.72587	15.3083	0.1688	0

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

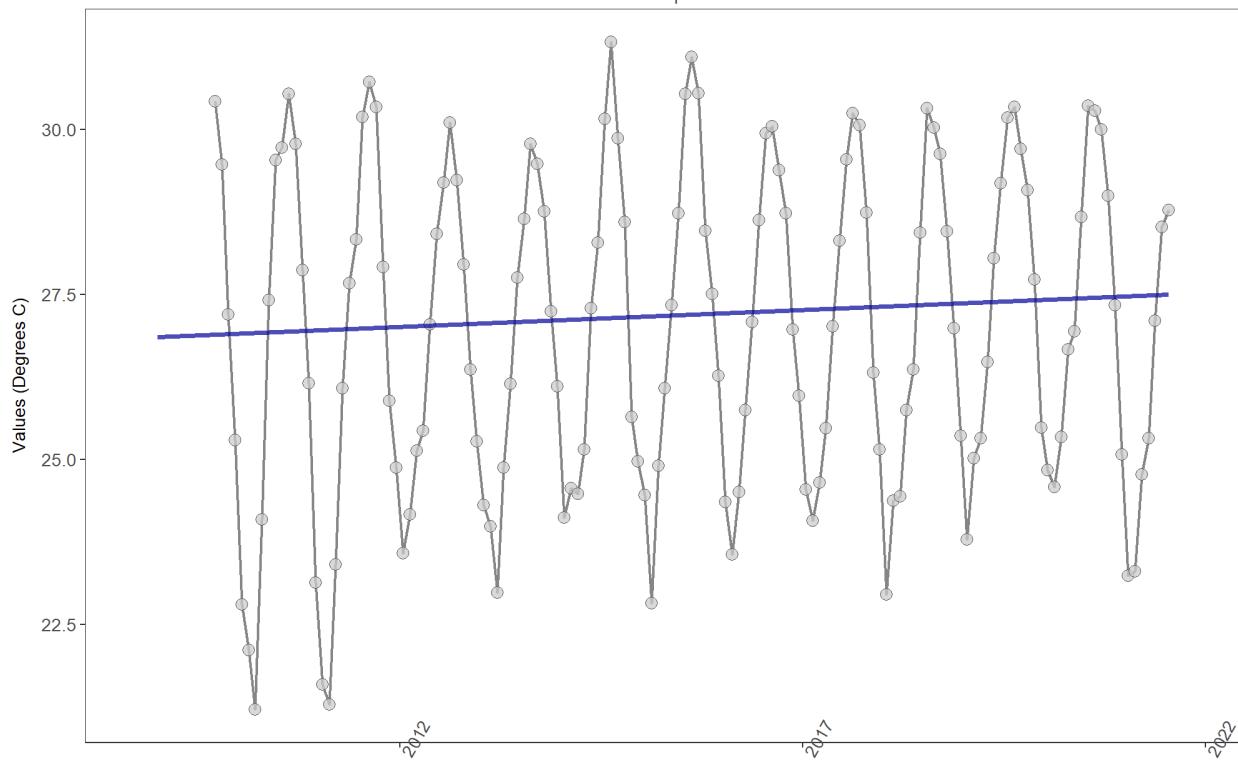


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	167474	15	26.793	1	0.181	0.0051	0.04474392	26.55387	8.9627	0.6253	1

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

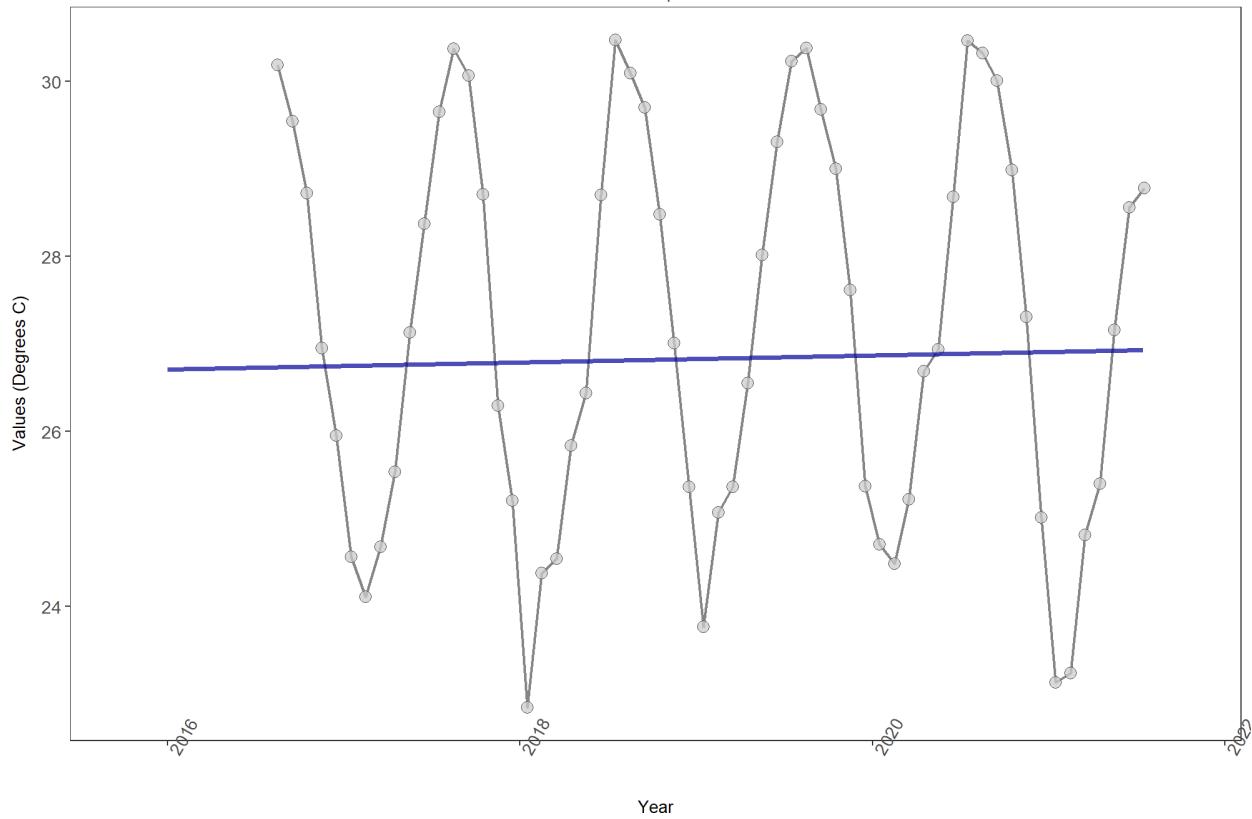


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	159586	13	26.91	1	0.1936	0.0024	0.05126736	26.85856	10.5352	0.483	1

p < 0.00005 appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

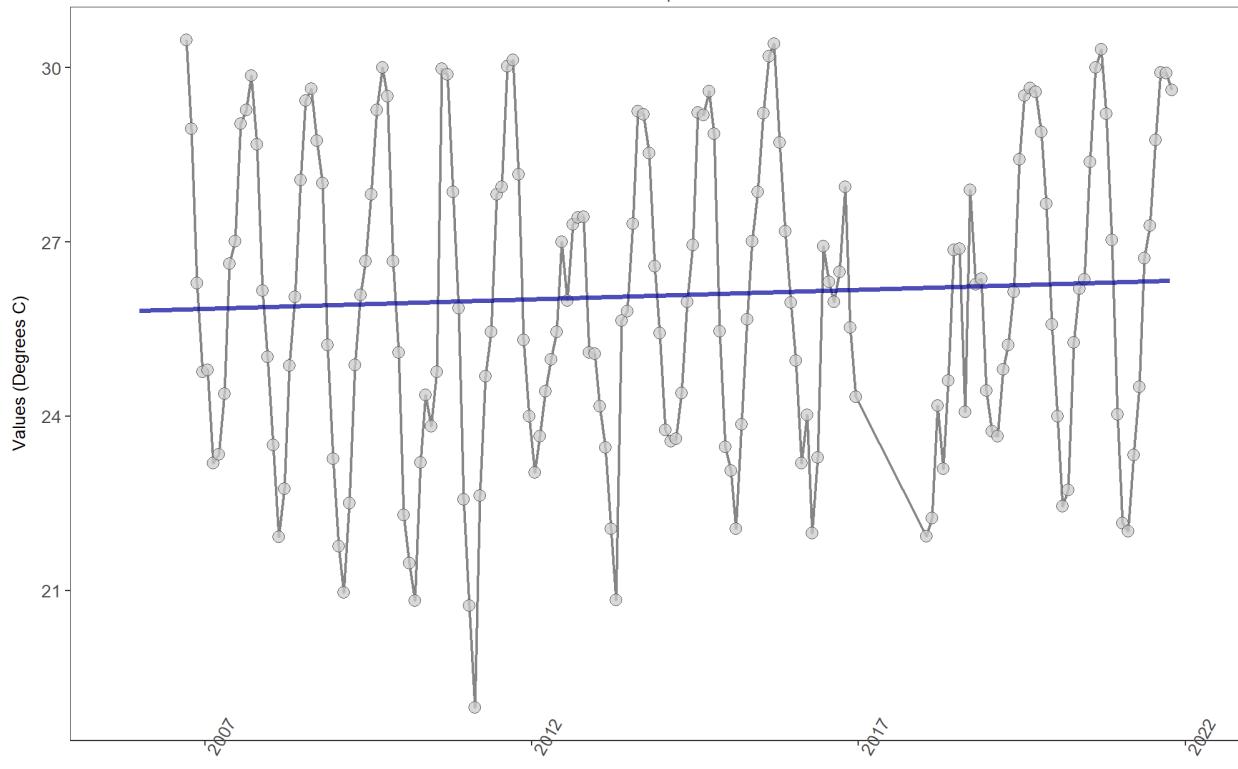
Florida Keys National Marine Sanctuary
 986
 Water Temperature on Coral Reefs in the Florida Keys
 81
 Water Temperature



$p < 0.00005$ 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

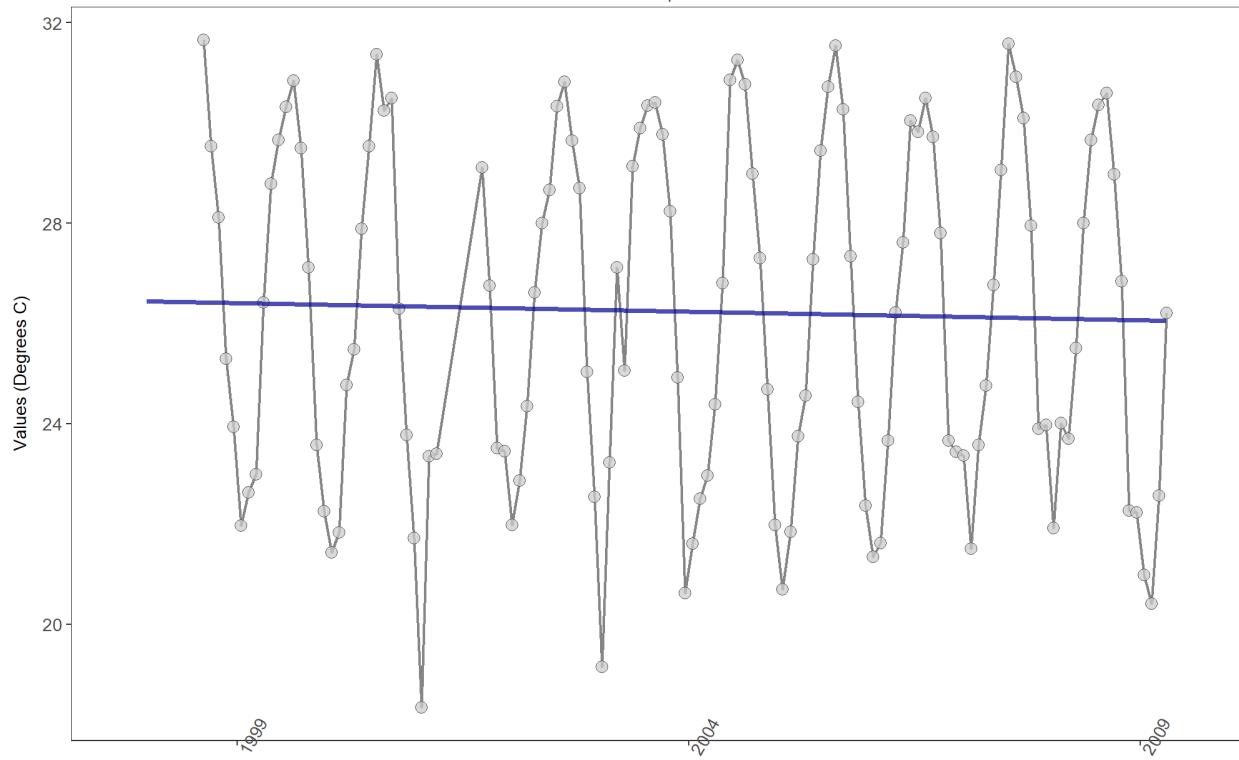


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
Surface	123165	15	25.79	1	0.1047	0.0744	0.03298669	25.81632	3.4656	0.983	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_200YR_HD
 Water Temperature

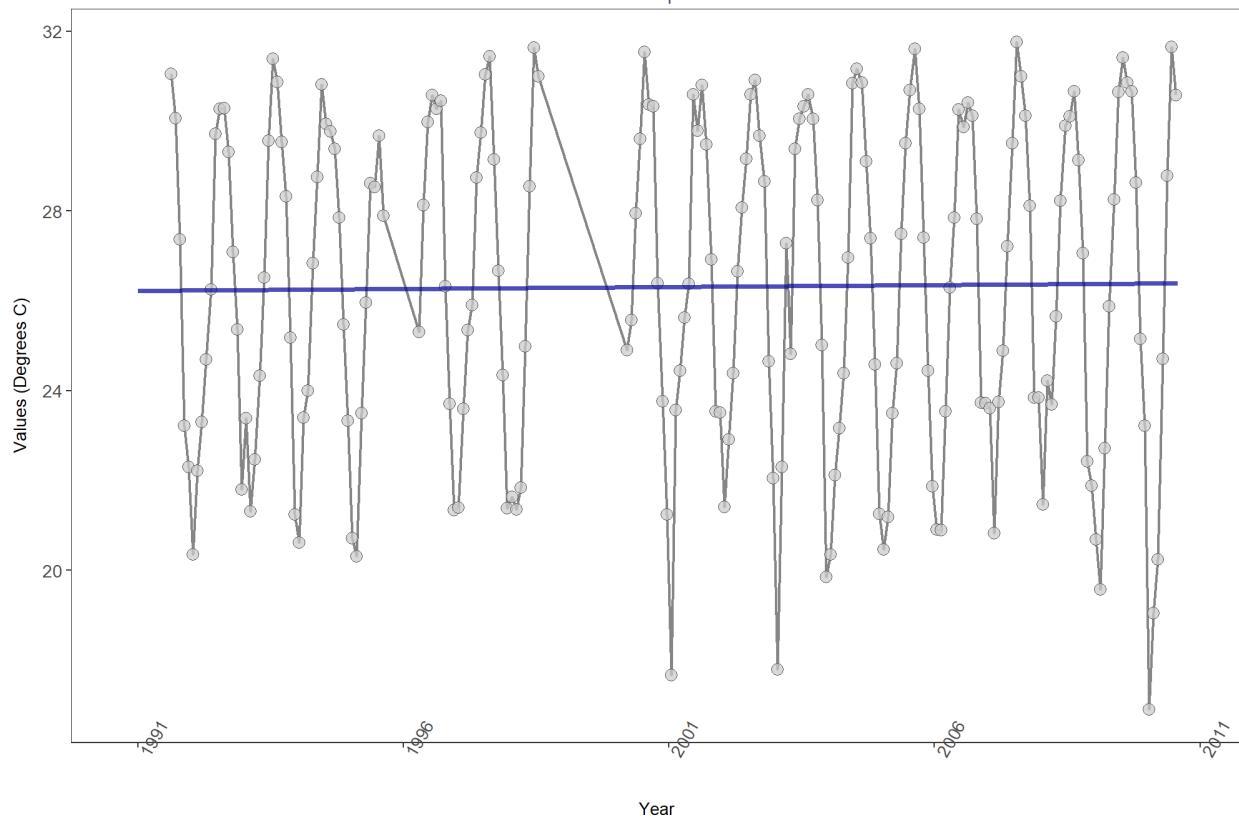


Year														
RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend			
bottom	44601	12	26.1024	1	-0.0961	0.172	-0.03503859	26.44961	5.3004	0.9158	0			

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_7MILE_BR
 Water Temperature

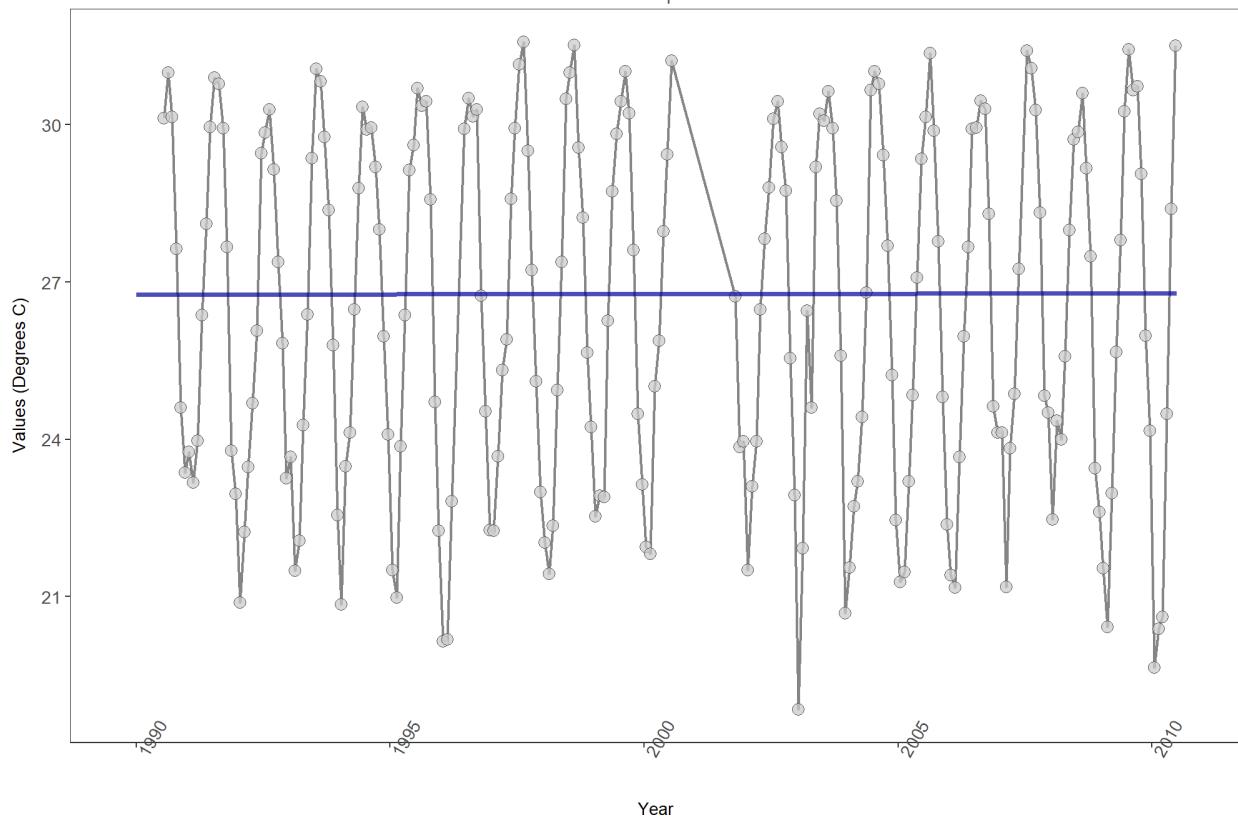


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	73055	19	26.6562	1	0.0465	0.3549	0.008583988	26.2211	10.1261	0.5191	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_9FT_SHOAL
 Water Temperature

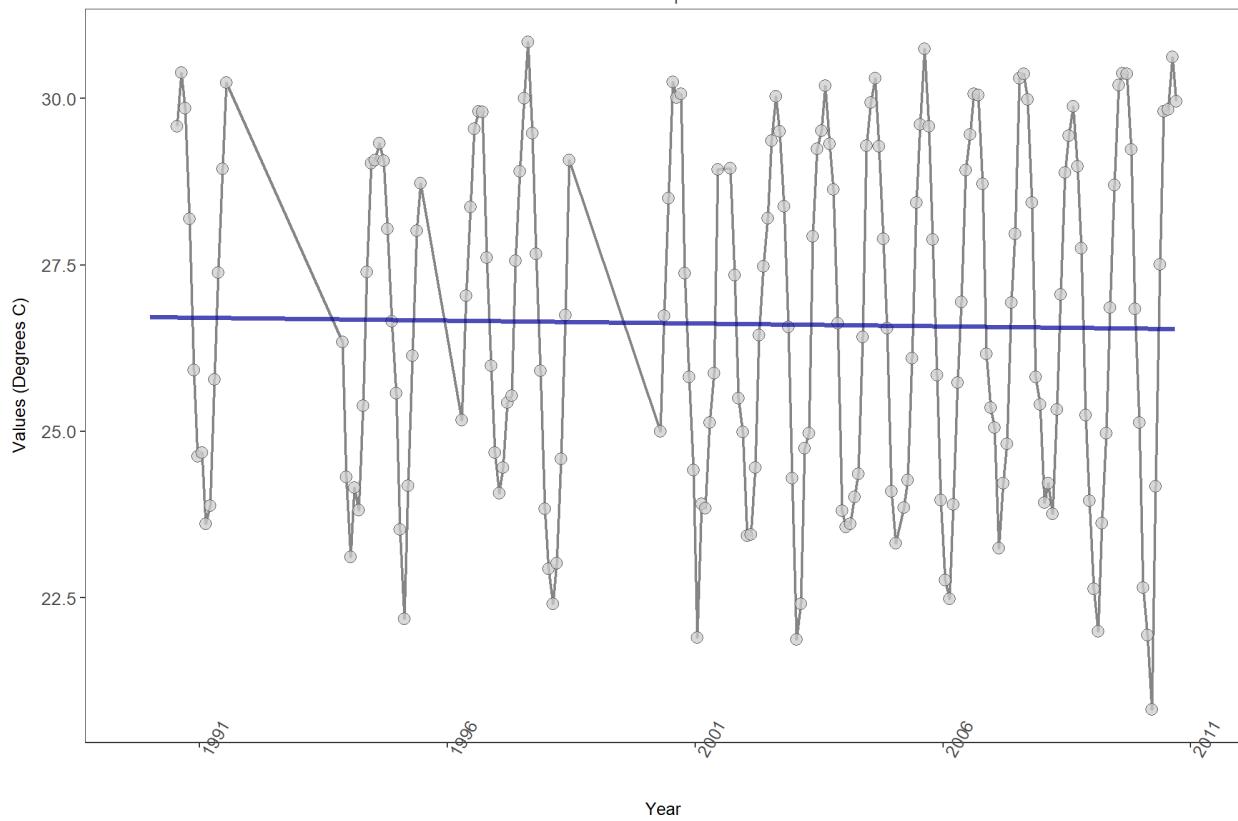


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	80299	21	26.5	1	0.0016	0.9917	0.0008159053	26.76346	7.908	0.7215	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_ALLIGATOR
 Water Temperature

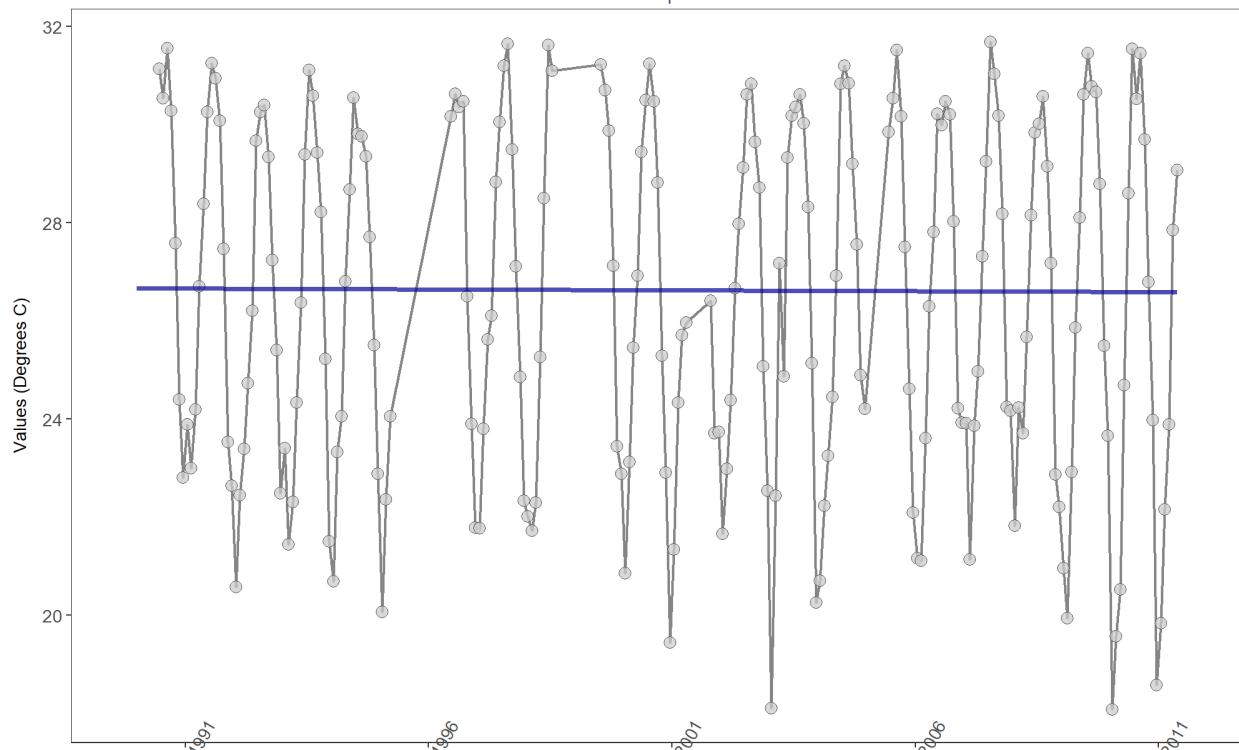


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	65144	19	26.54545	1	-0.059	0.2339	-0.008569064	26.71909	13.8065	0.2439	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_BHONDA_BR
 Water Temperature

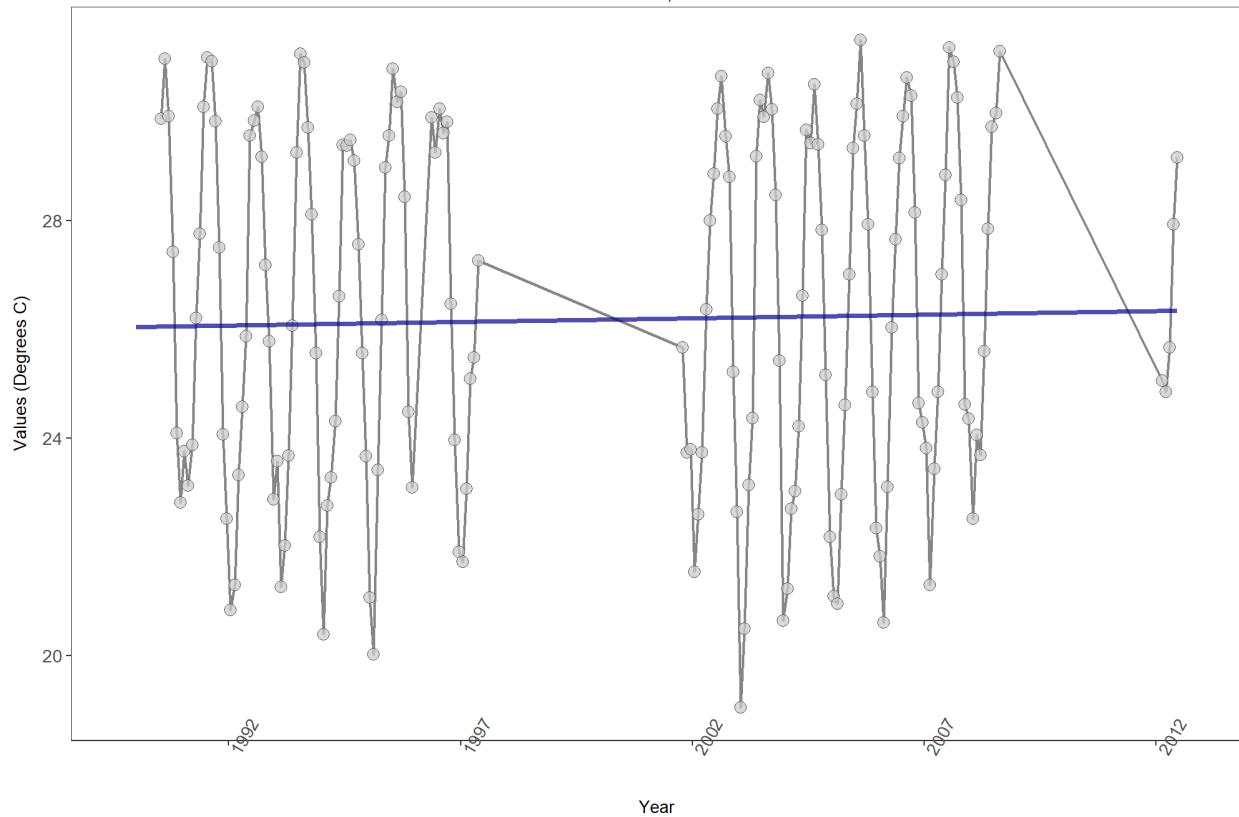


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	77111	22	26.6	1	-0.0217	0.6571	-0.004045514	26.67081	7.3456	0.7704	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_BOCA_GRND
 Water Temperature

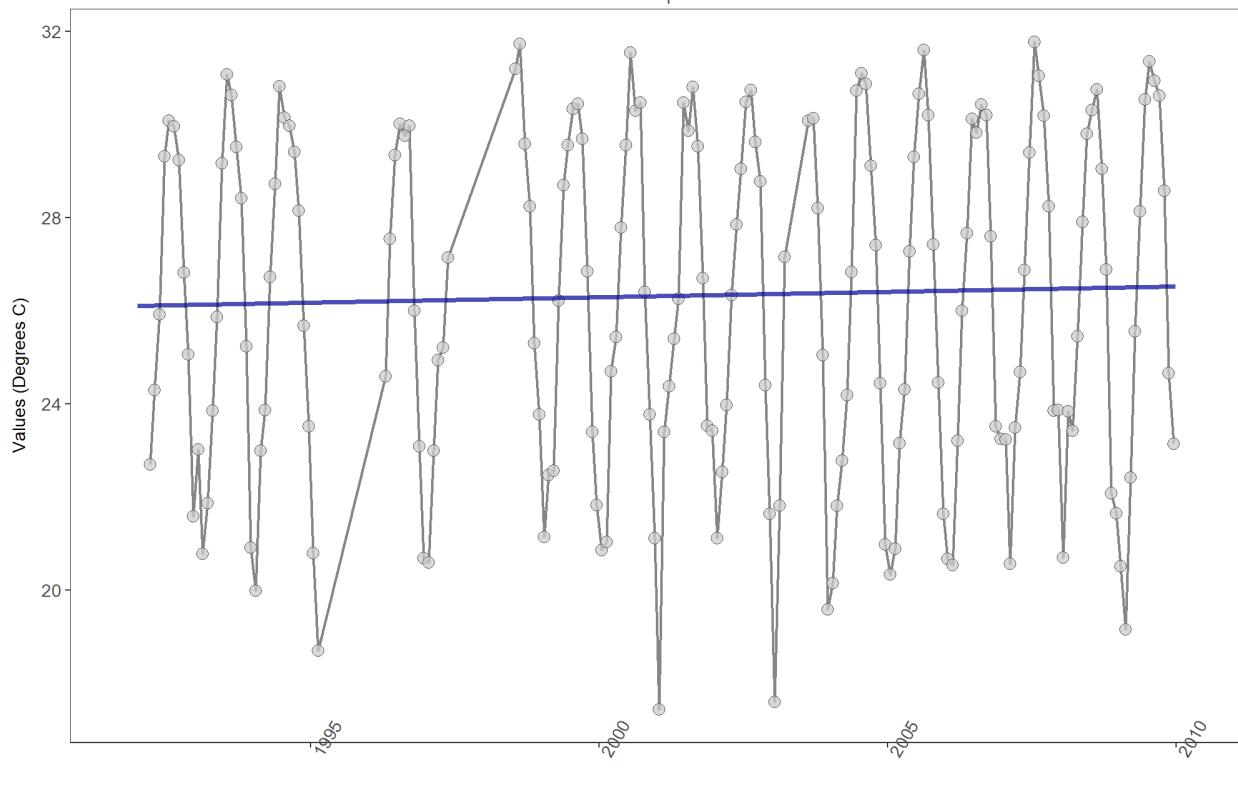


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	73434	17	26.14295	1	0.0814	0.1662	0.01333094	26.04008	6.7244	0.8209	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_BULLARD
 Water Temperature

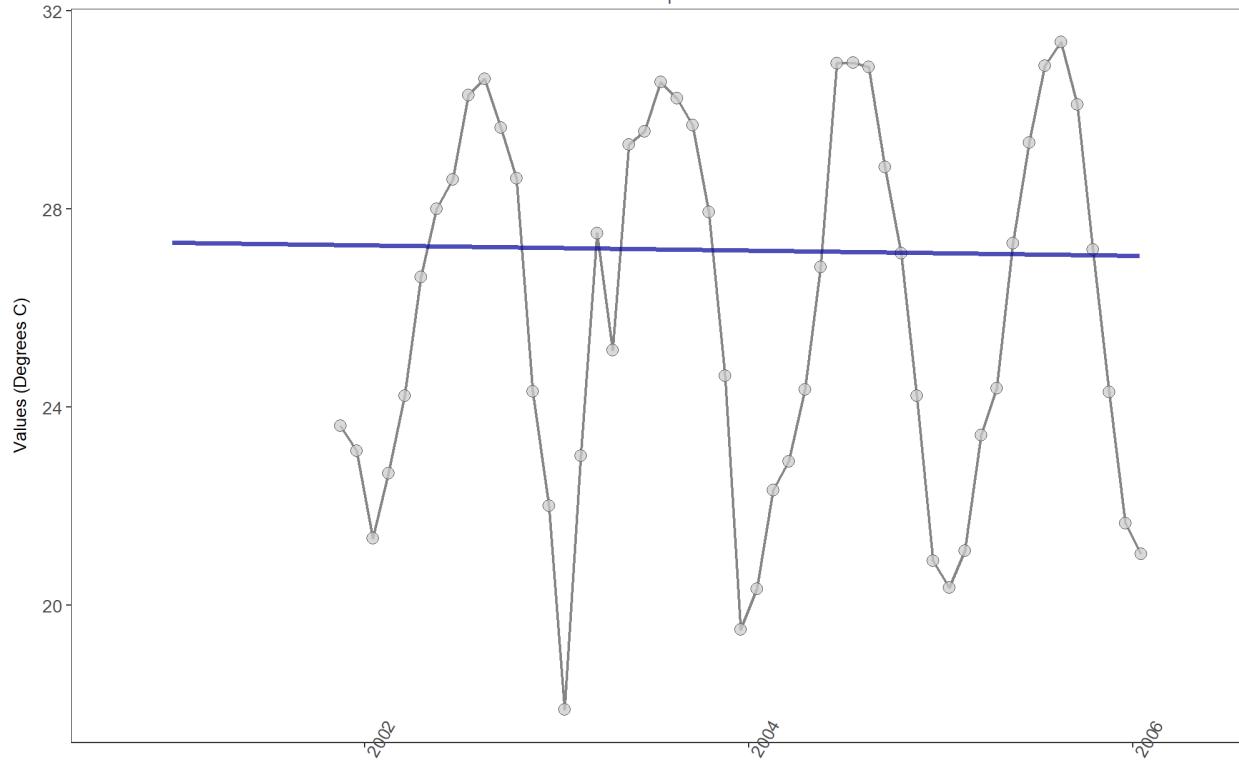


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	66230	18	26.30925	1	0.1179	0.0313	0.02315278	26.10559	11.2537	0.4223	1

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKMS_CARD_SND
 Water Temperature

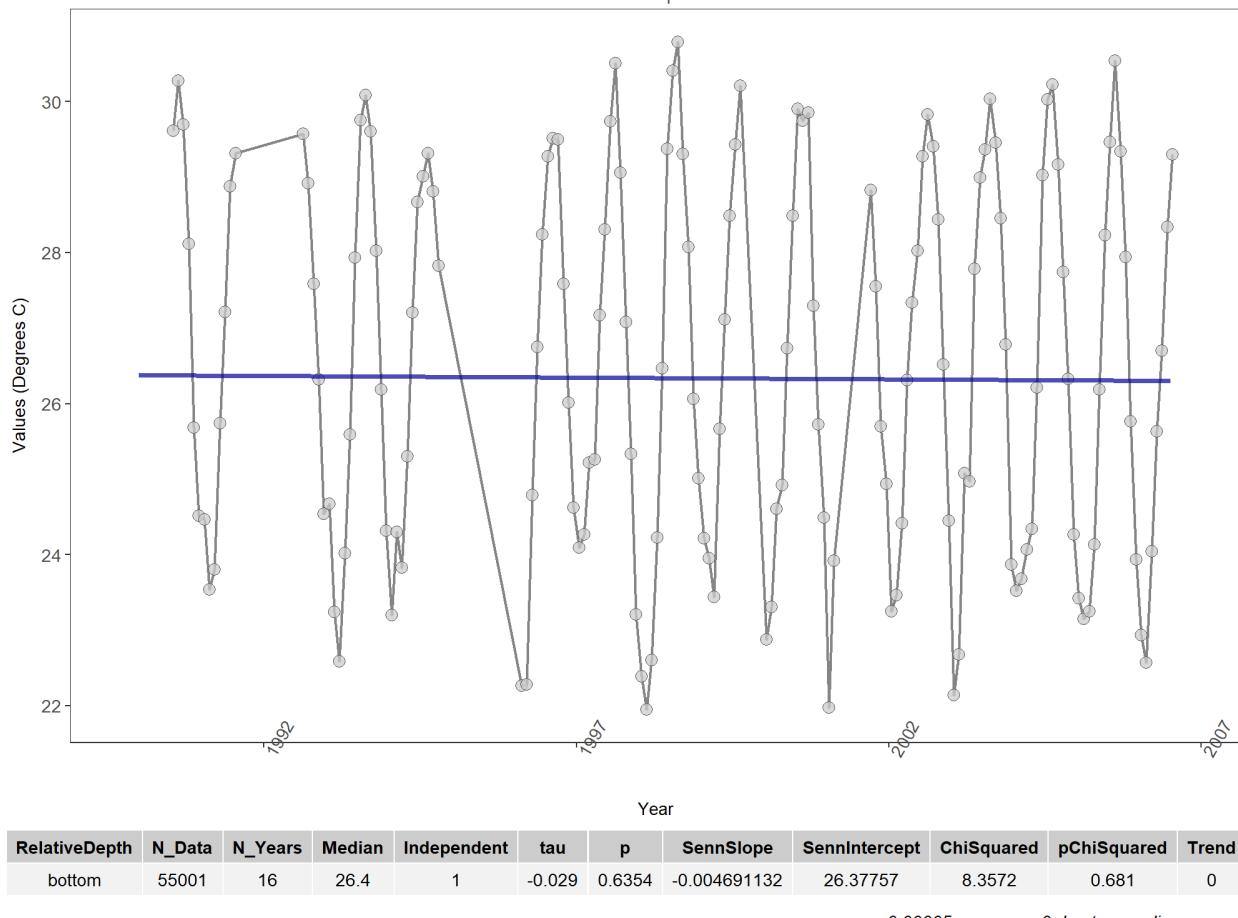


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	18249	6	26.5198	1	-0.0523	0.7909	-0.05242602	27.32067	12.3631	0.337	0

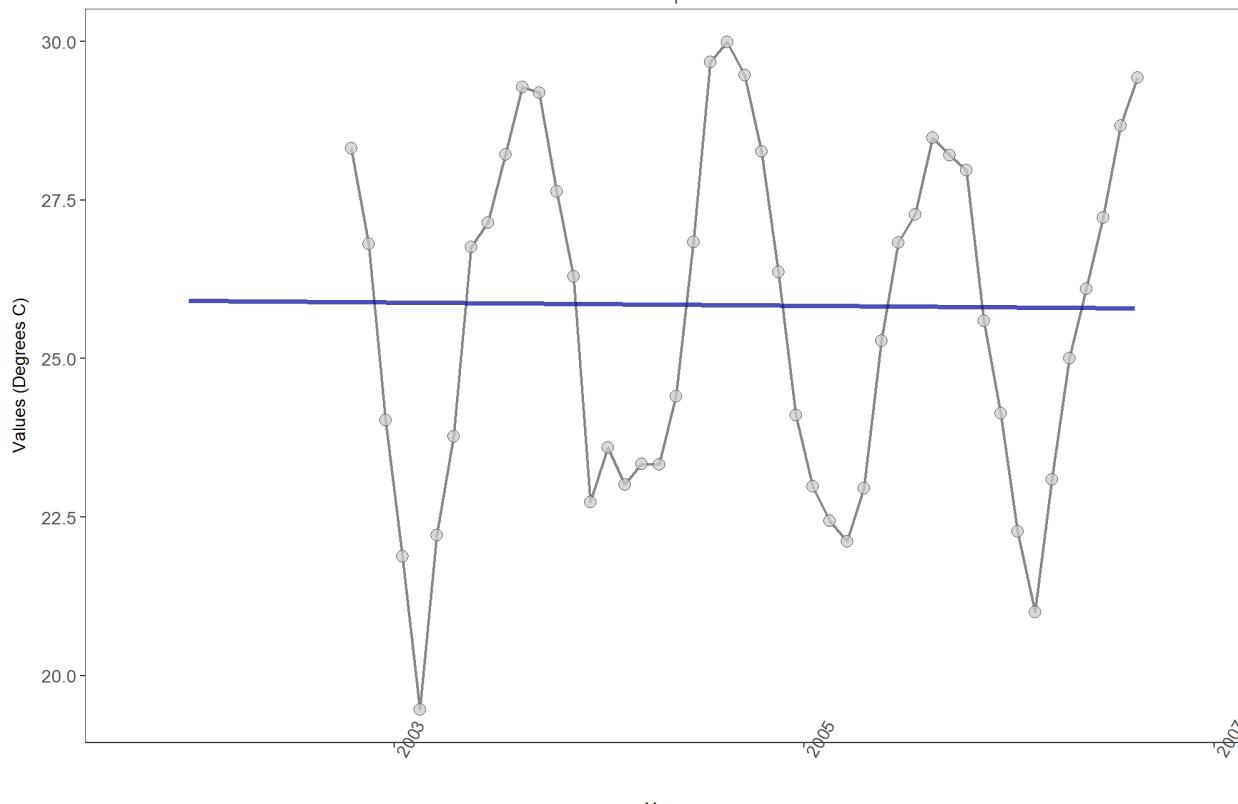
p < 0.00005 appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_CARYSFORT
 Water Temperature



Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_DIEGO_TER
 Water Temperature

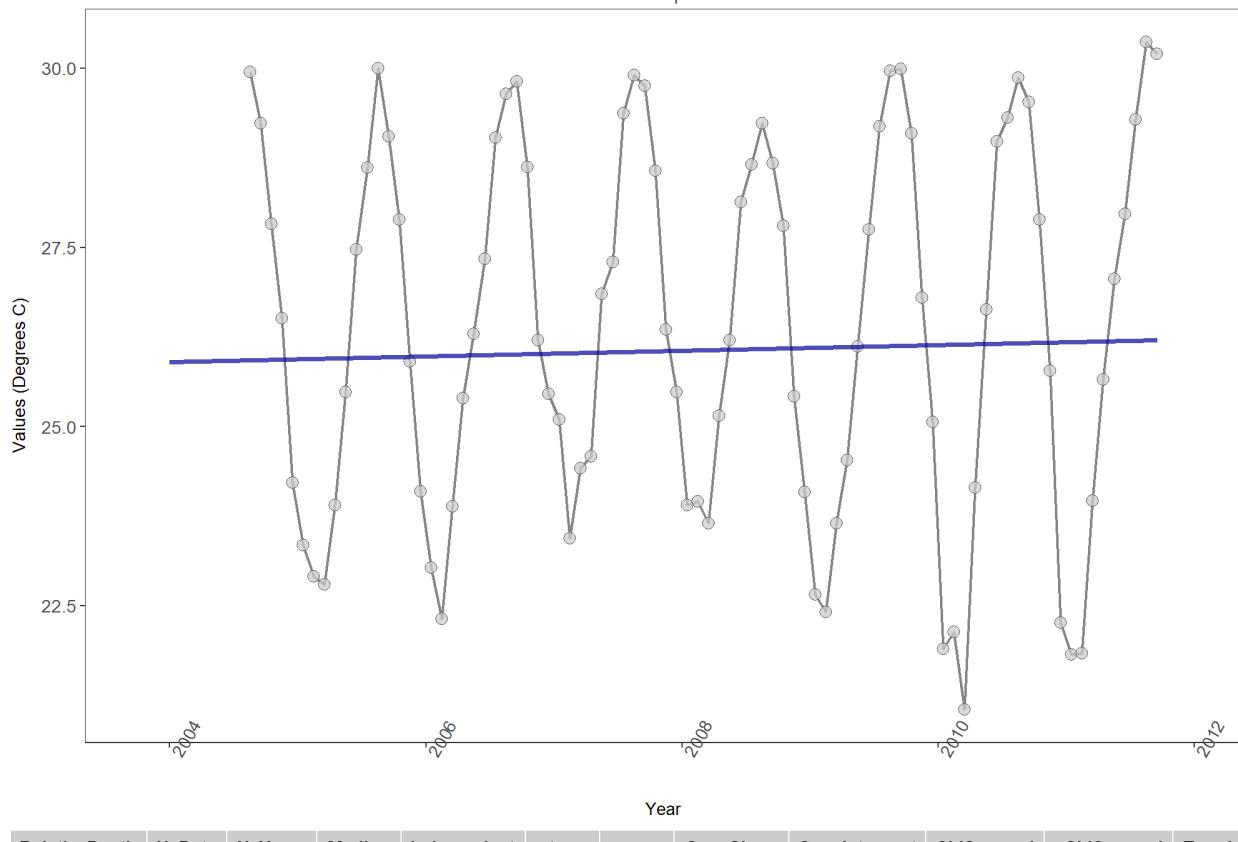


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	16693	5	25.5793	1	-0.0496	0.8407	-0.0252168	25.91058	4.3063	0.9601	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_ELPIS
 Water Temperature

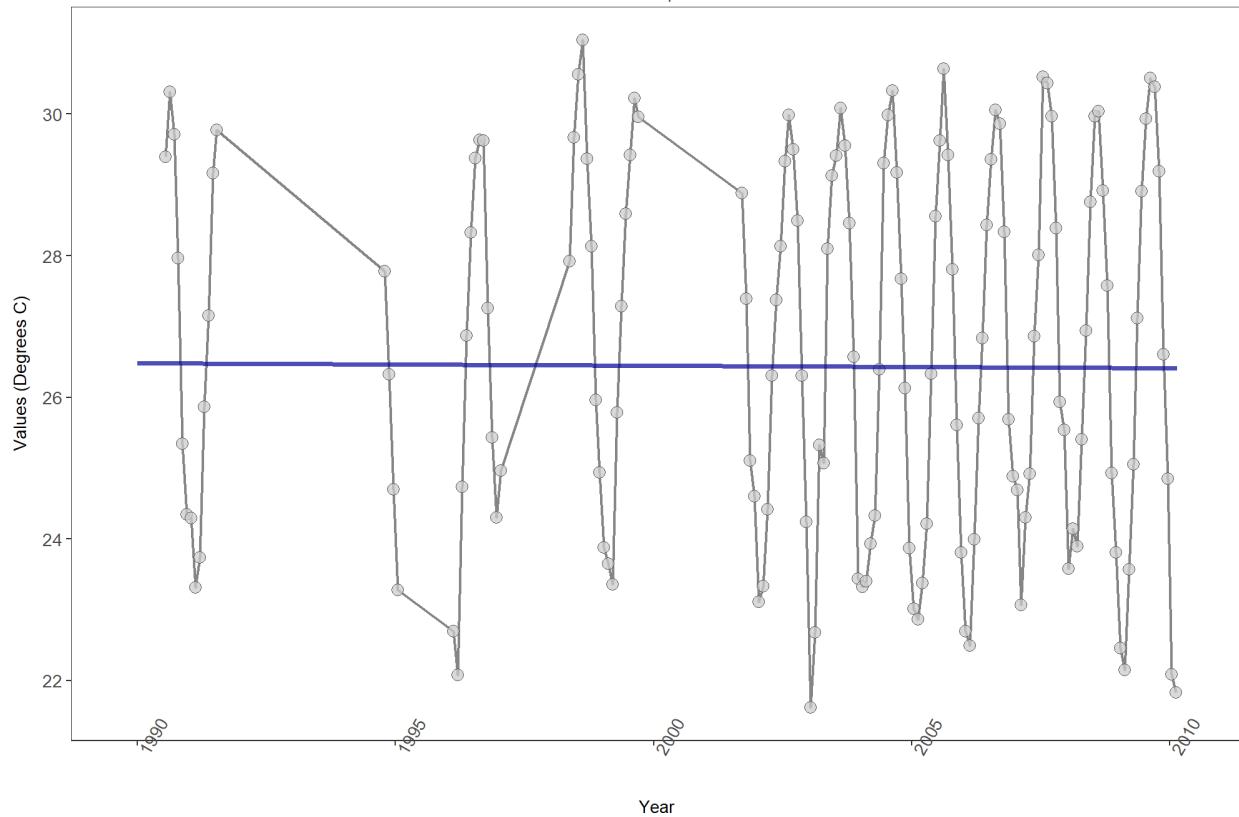


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	31035	8	26.3487	1	0.0554	0.5313	0.04028765	25.89604	13.9061	0.2382	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_GRECIAN
 Water Temperature

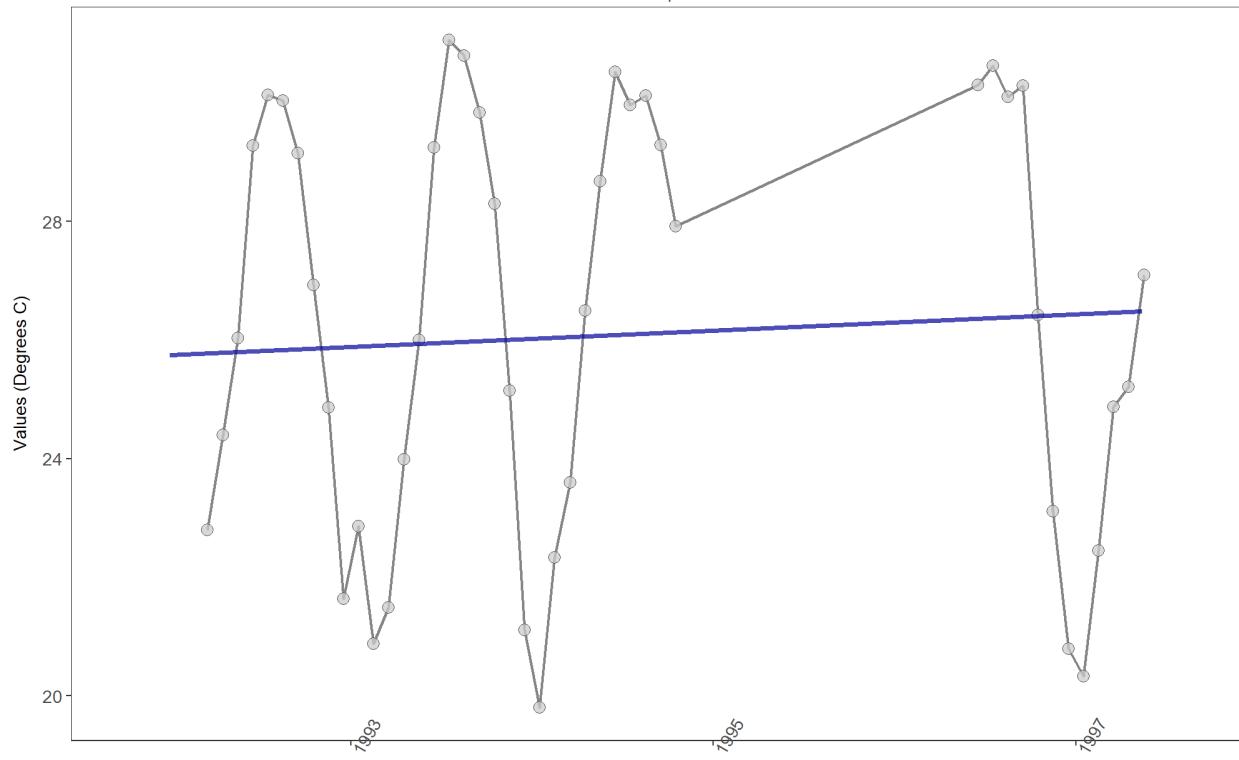


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	51723	18	26.6537	1	-0.0317	0.6634	-0.003490323	26.47889	10.1713	0.515	0

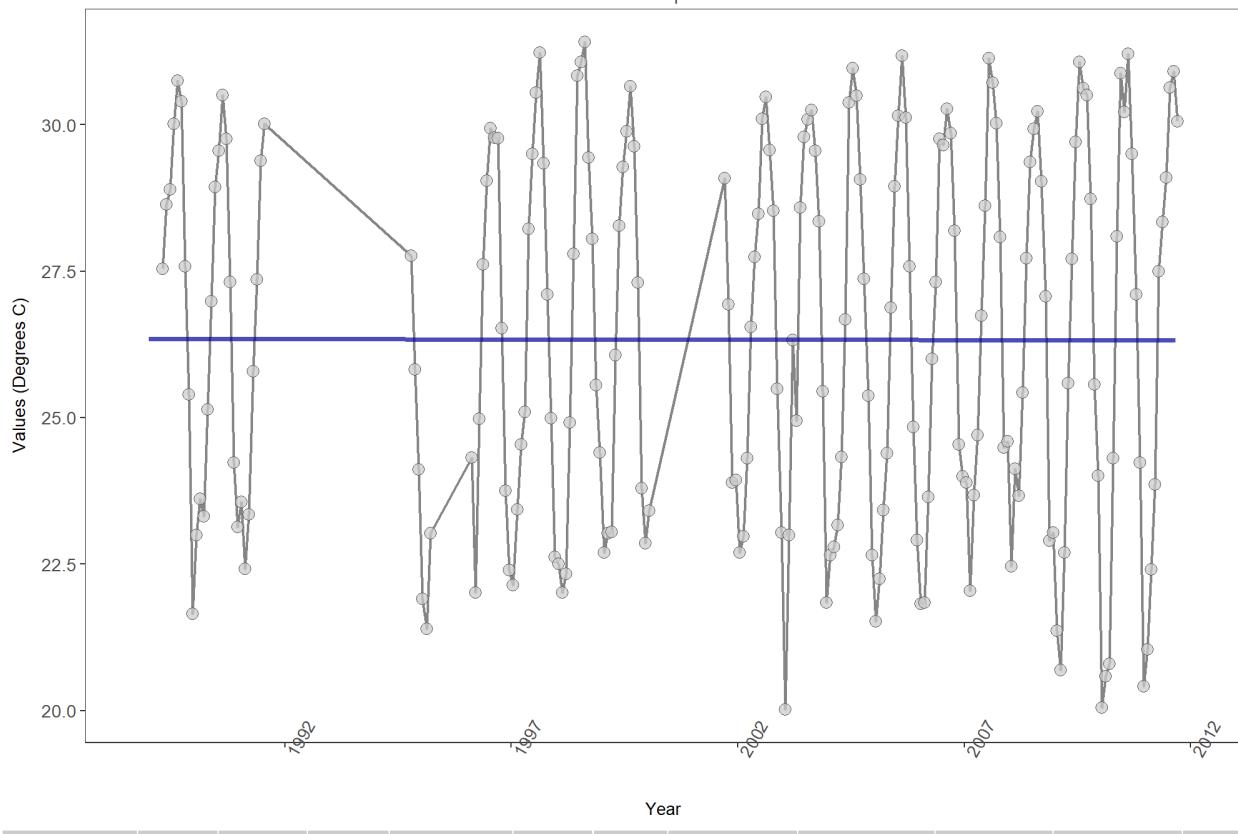
p < 0.00005 appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_HARBORKEY
 Water Temperature



Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_HEN&CHIX
 Water Temperature

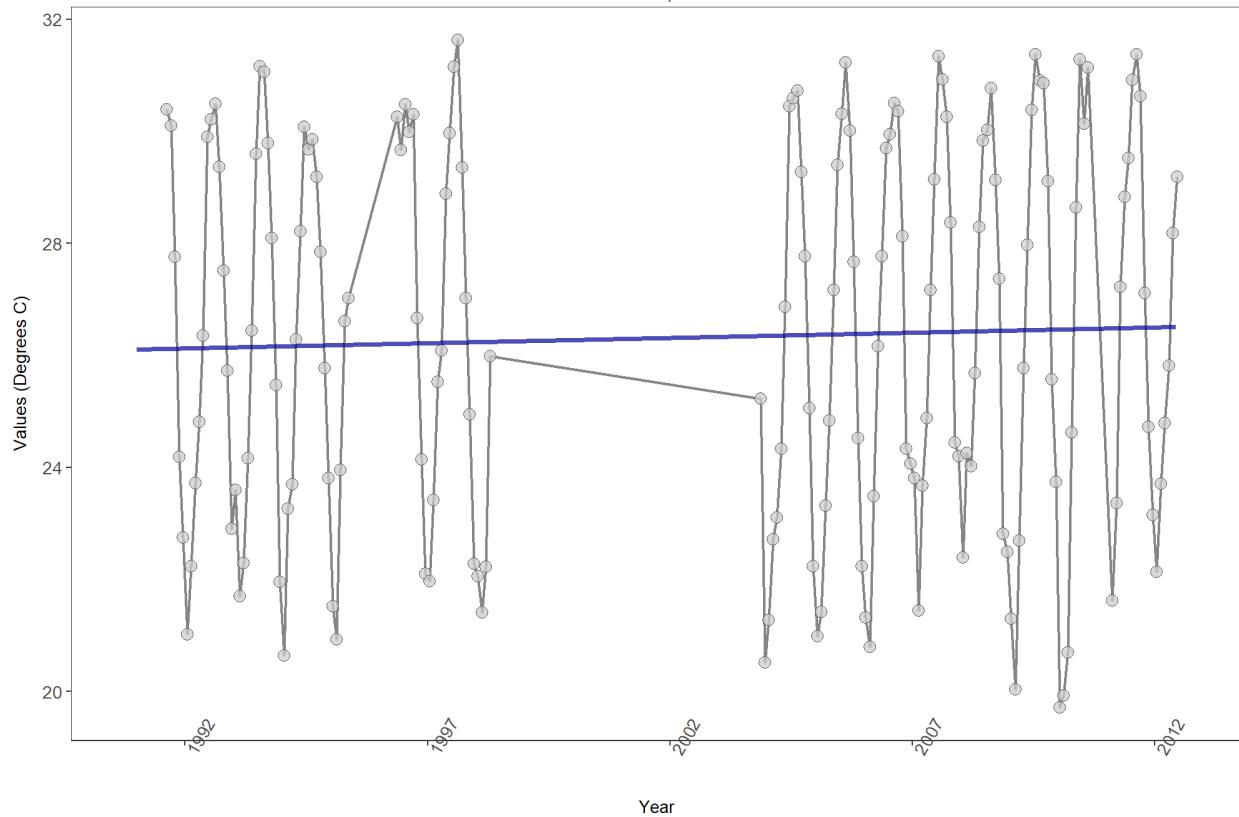


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	72285	21	26.5	1	-0.0085	0.8763	-0.001228167	26.34774	14.6961	0.1968	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKMS_KW_CHANL
 Water Temperature

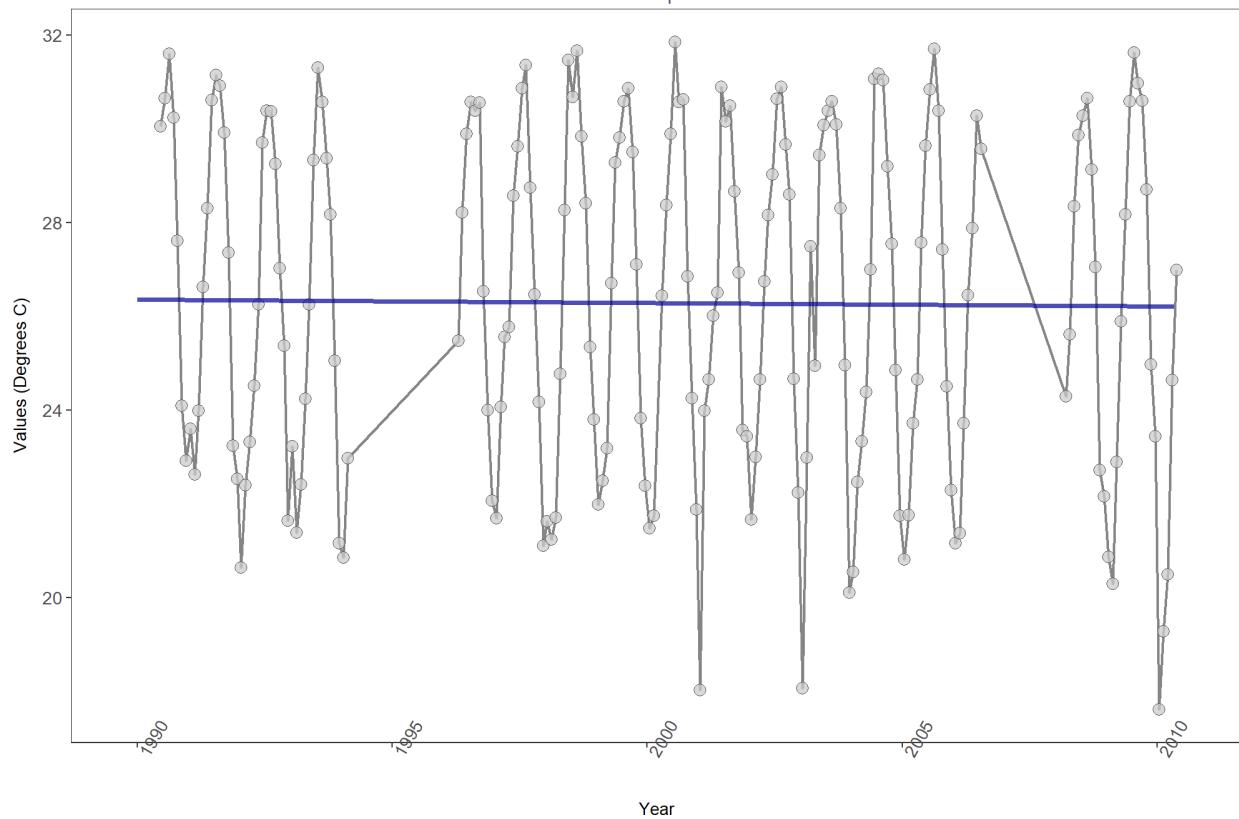


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	123578	18	26.2719	1	0.1034	0.0805	0.01870402	26.10889	10.0738	0.5238	0

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

SennIntercept is intercept value at beginning of record for monitoring location

Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_LONG_KEY
 Water Temperature

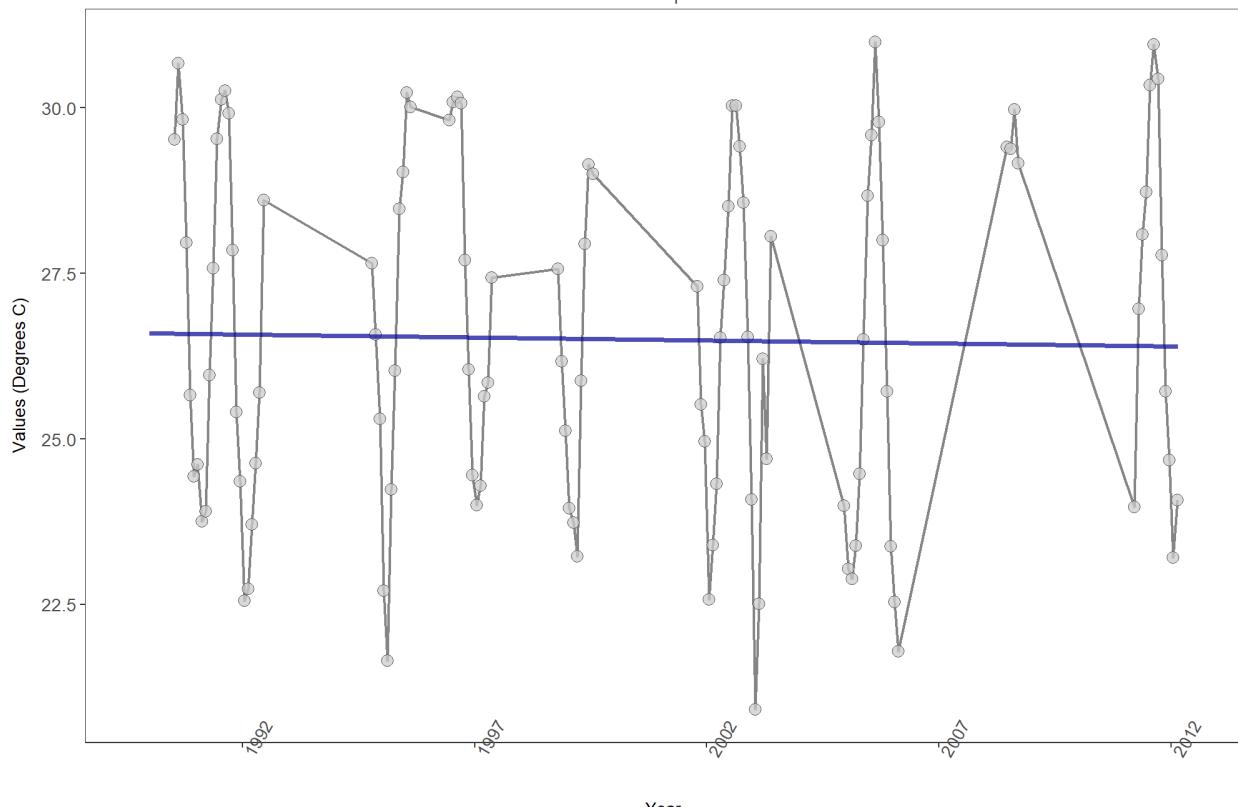


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	69656	19	26.63535	1	-0.0313	0.5769	-0.006707473	26.35111	9.5462	0.5716	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_LOOE_BACK
 Water Temperature

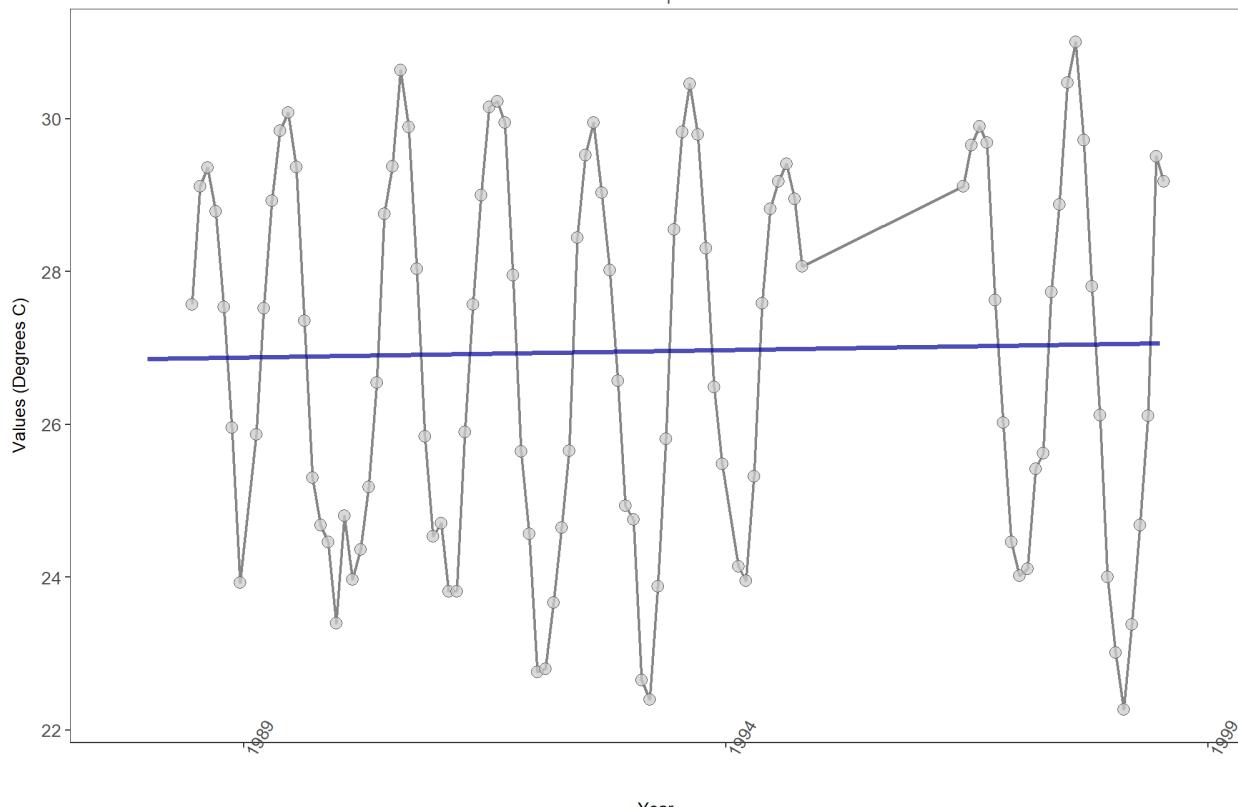


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	84984	18	26.8	1	-0.0588	0.4216	-0.009048563	26.5961	2.7471	0.9937	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_LOOE_BUOY5
 Water Temperature

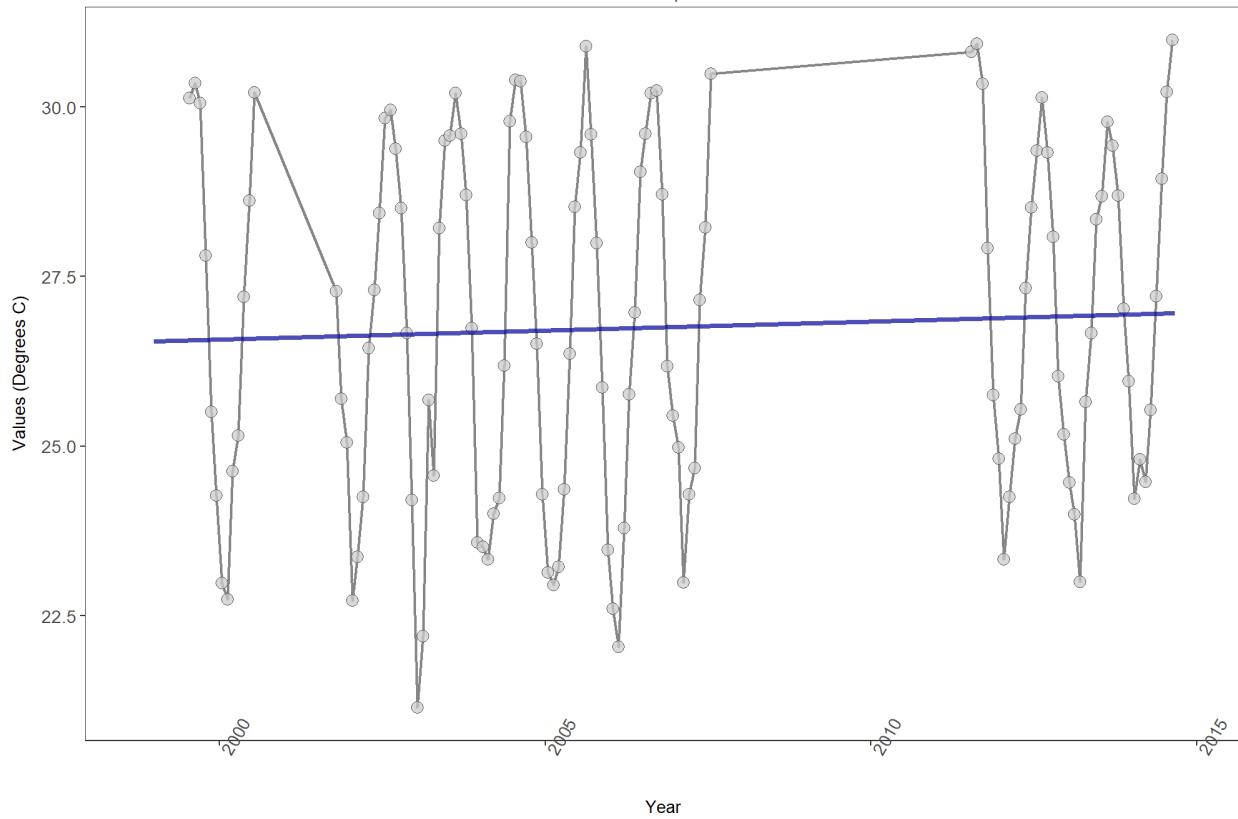


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	35252	10	26.9	1	0.0493	0.3627	0.01930272	26.85949	13.6928	0.2505	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_LOOE_ISELIN
 Water Temperature

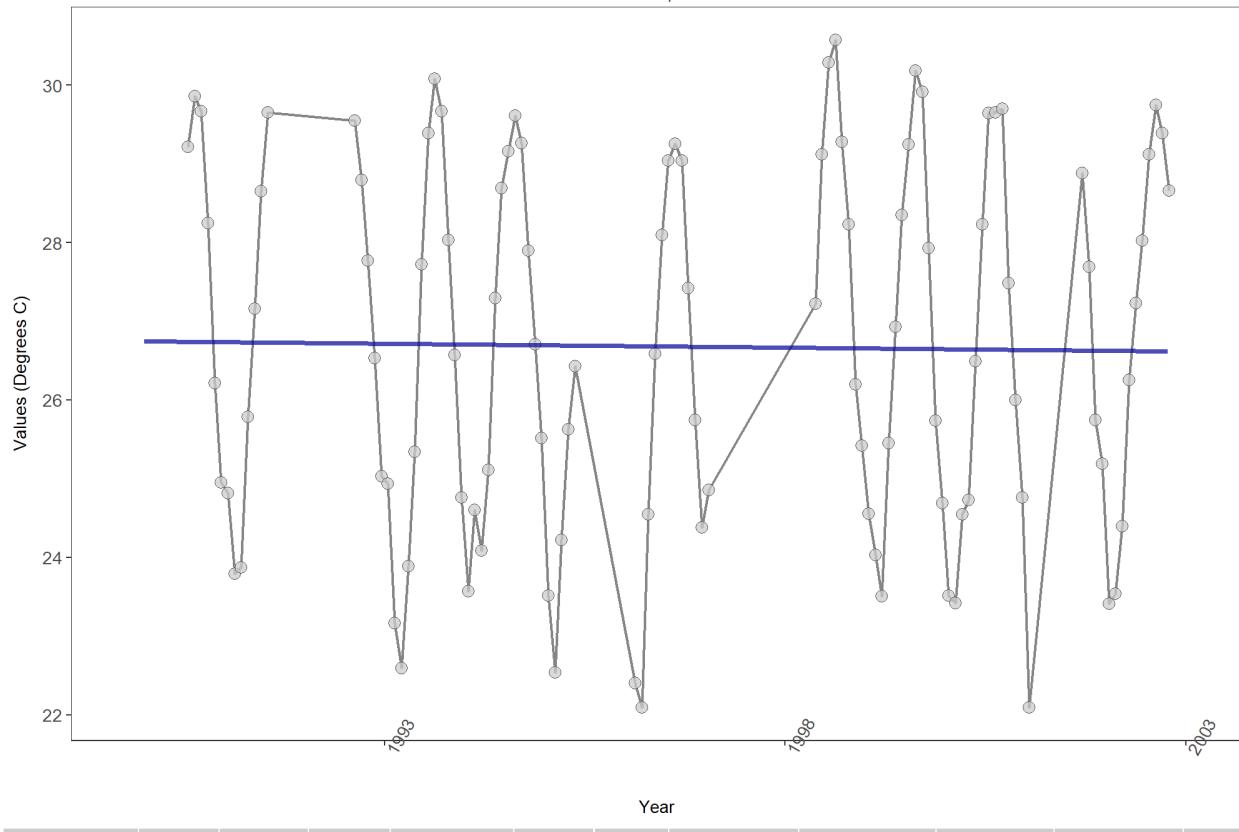


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	194367	13	26.8781	1	0.1294	0.0801	0.02613332	26.54692	8.8436	0.6363	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKMS_MOLASSES
 Water Temperature

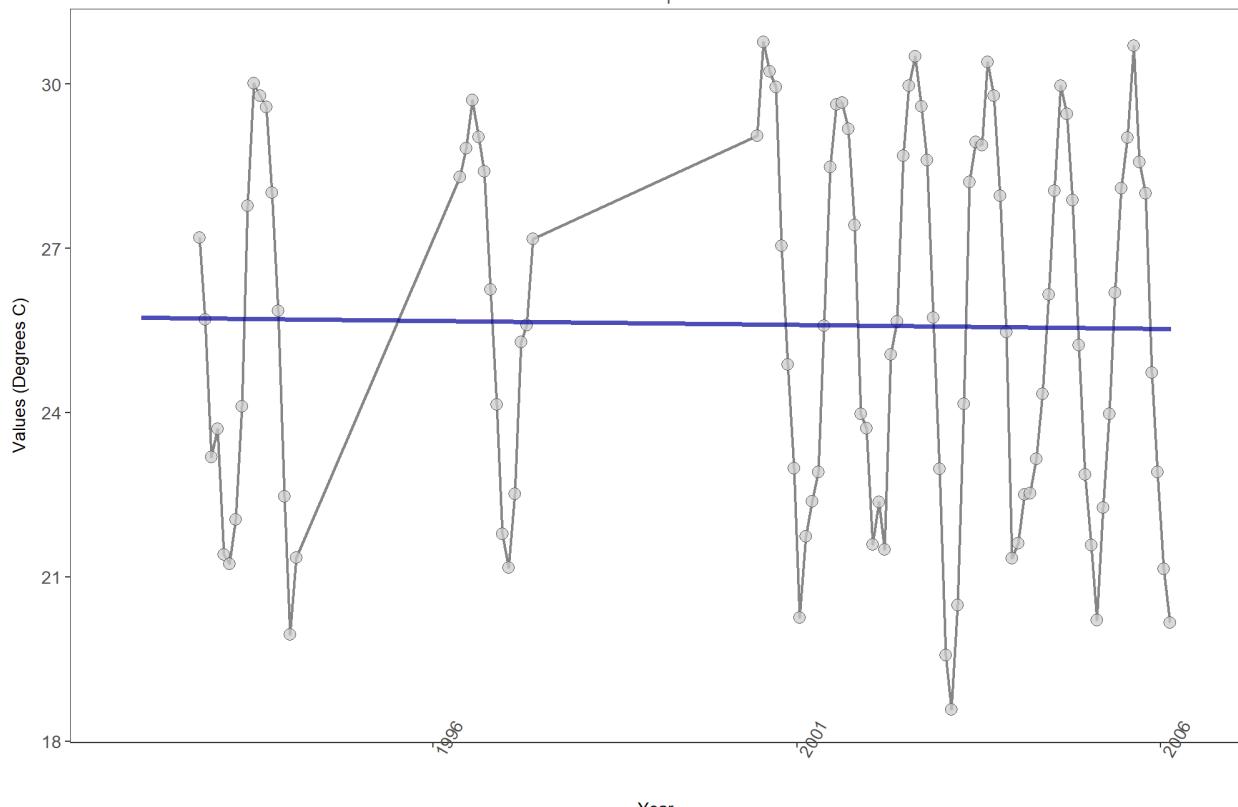


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	36146	13	26.7	1	-0.0539	0.4806	-0.009538945	26.74323	10.5494	0.4817	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_NEWSGROUND
 Water Temperature

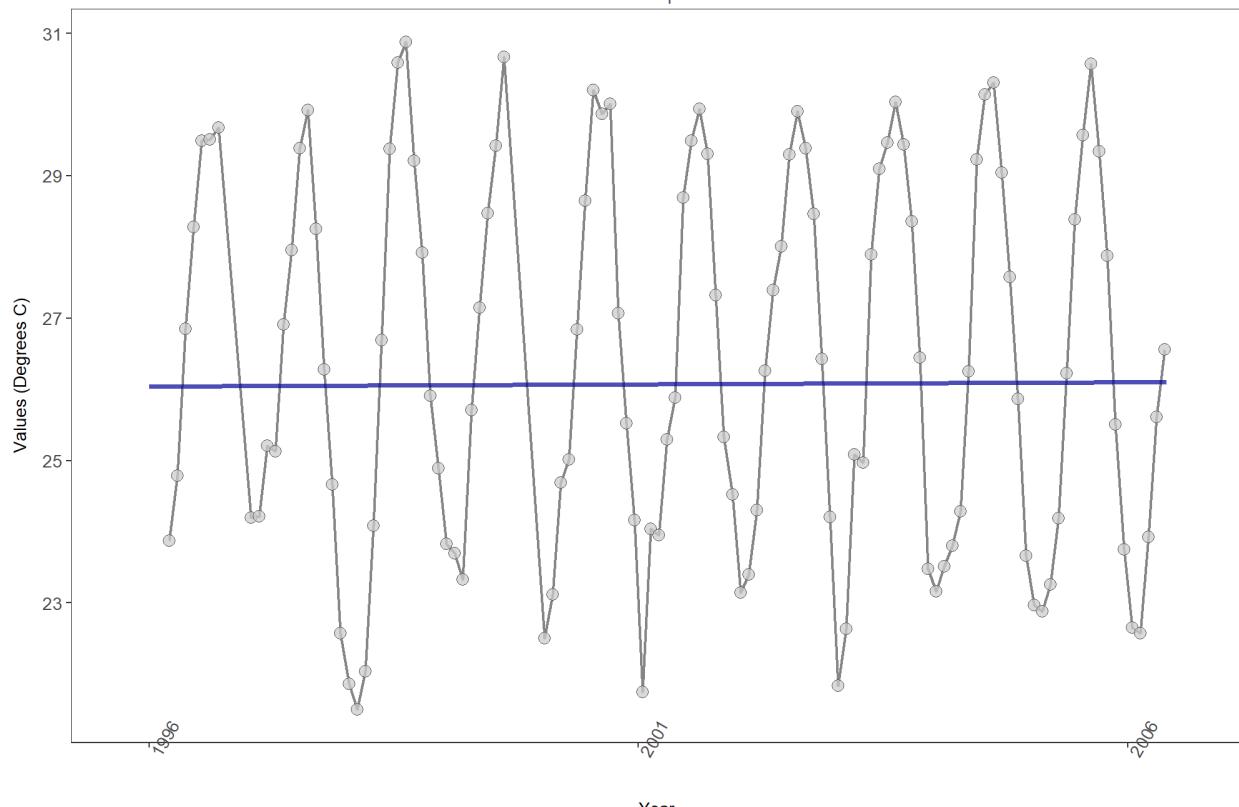


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	35329	12	25.4929	1	-0.0534	0.5207	-0.01390845	25.72914	10.2425	0.5087	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_PILLAR
 Water Temperature

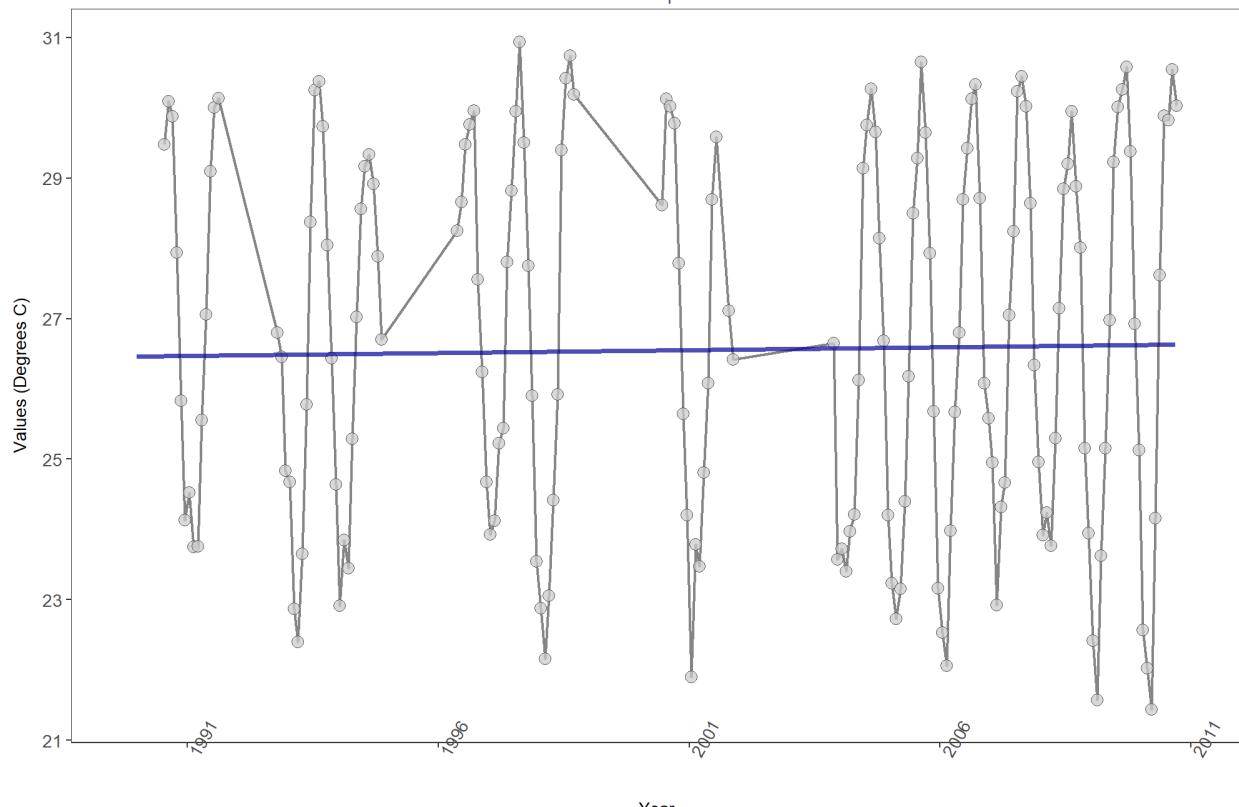


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	40805	11	26.243	1	0.0163	0.9363	0.006506991	26.03793	7.3311	0.7717	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_SAND_KEY
 Water Temperature

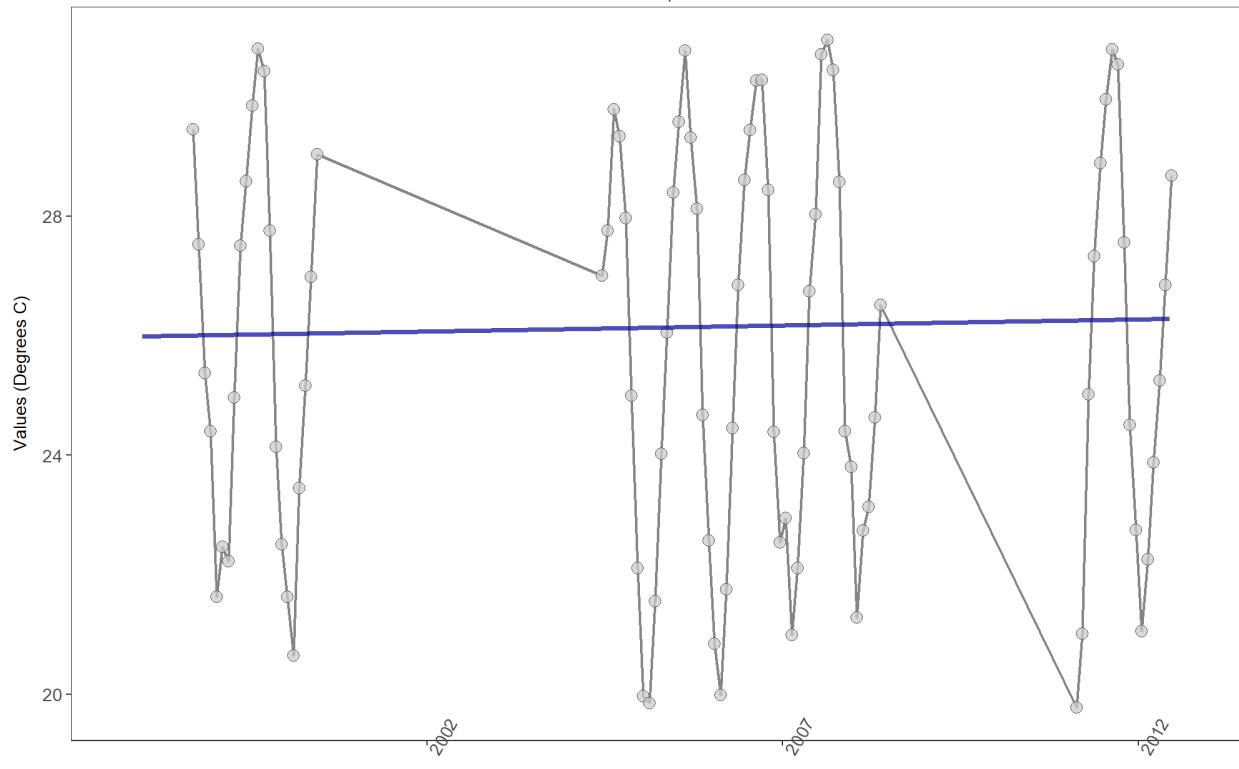


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	59287	18	26.7	1	0.0532	0.323	0.00790518	26.46411	12.8275	0.3047	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SMITH_SHL
 Water Temperature

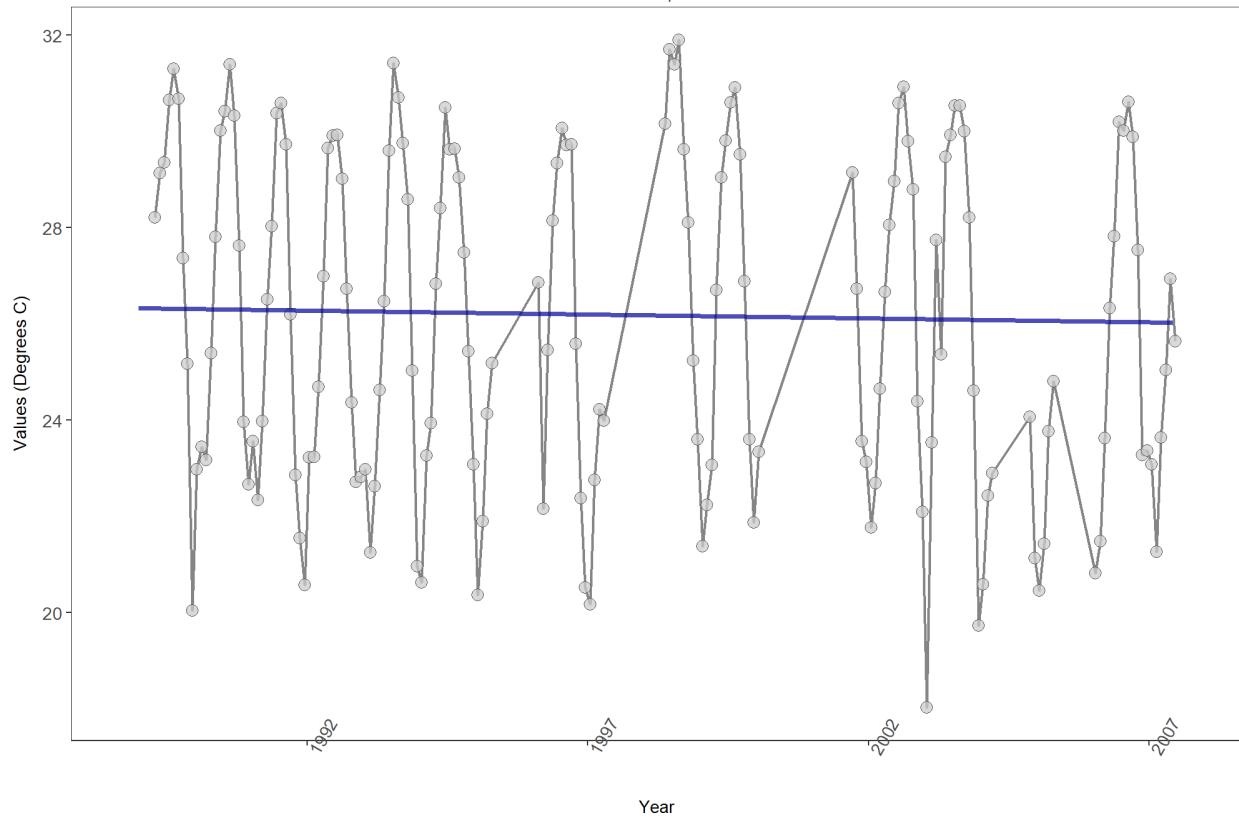


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	94527	10	25.4464	1	0.1271	0.1933	0.02024458	25.98996	6.1795	0.8611	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_SNAKE_CRK
 Water Temperature

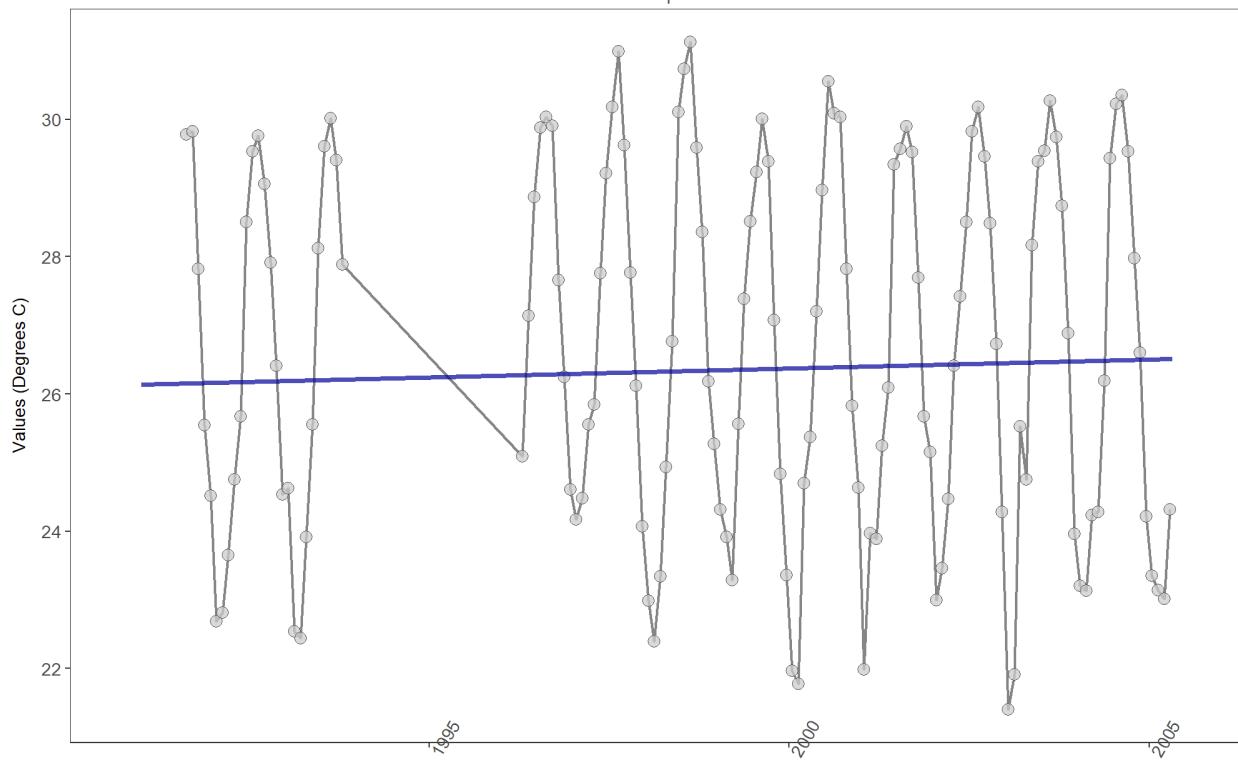


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	56777	19	26.1553	1	-0.0585	0.2771	-0.01634269	26.32951	8.7565	0.6444	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SOMBREO
 Water Temperature

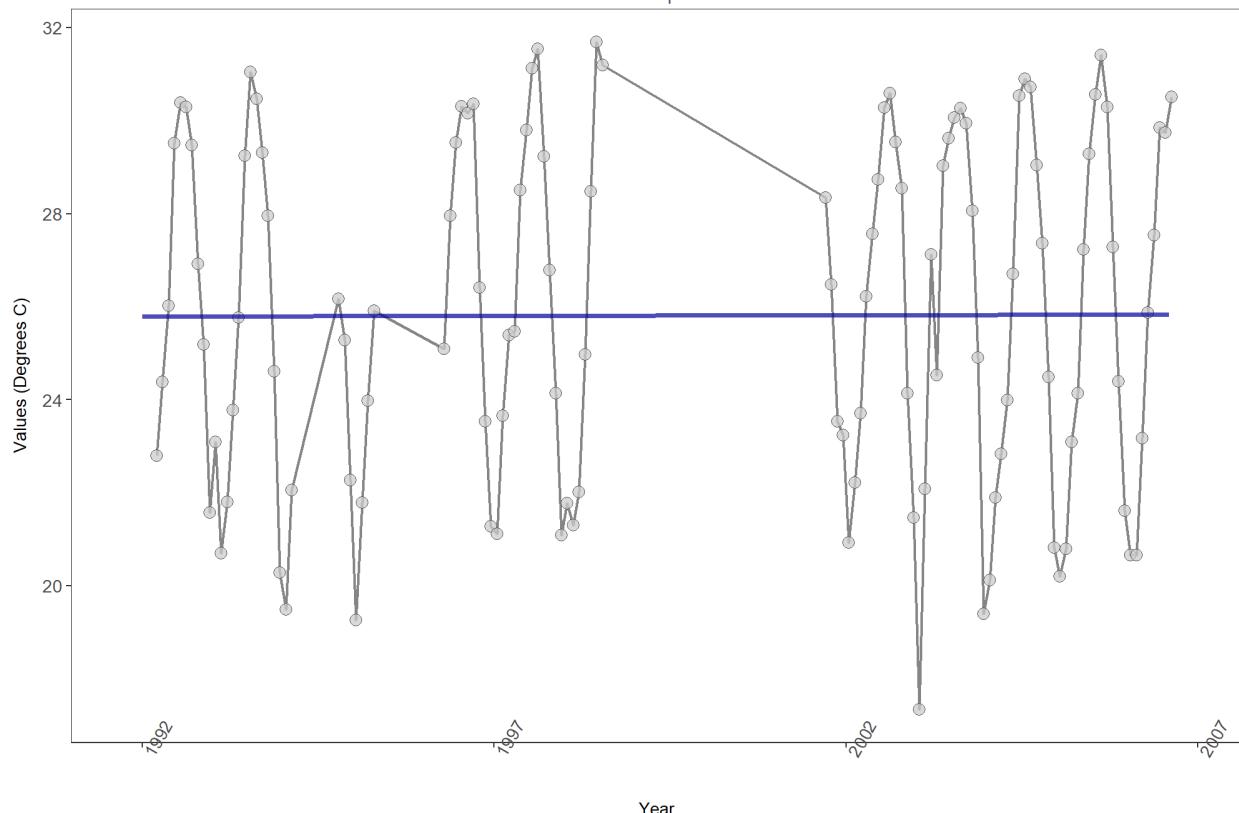


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	48974	13	26.5	1	0.1297	0.0508	0.02626158	26.13611	8.8227	0.6383	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_SPRIGGER
 Water Temperature

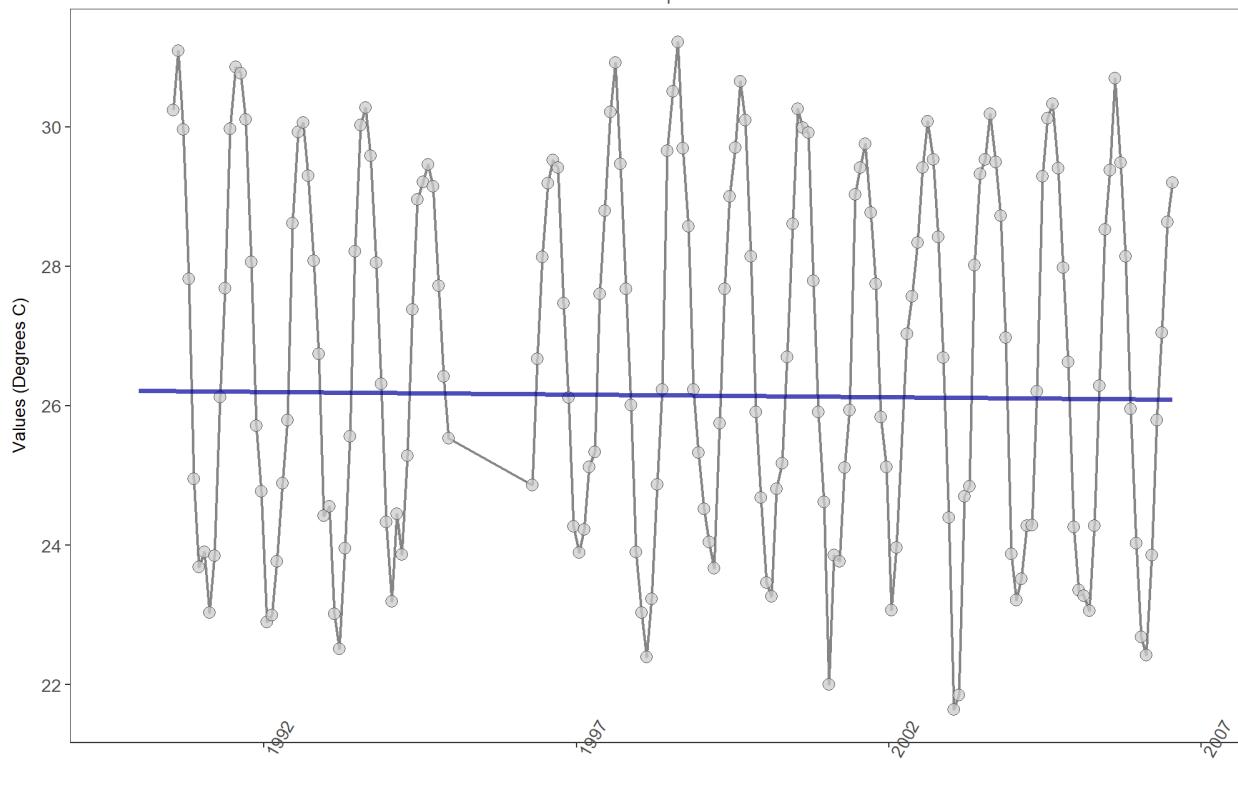


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	41834	13	26.1	1	0.0176	0.8553	0.002975159	25.78396	6.9677	0.8017	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_TENN_REEF
 Water Temperature

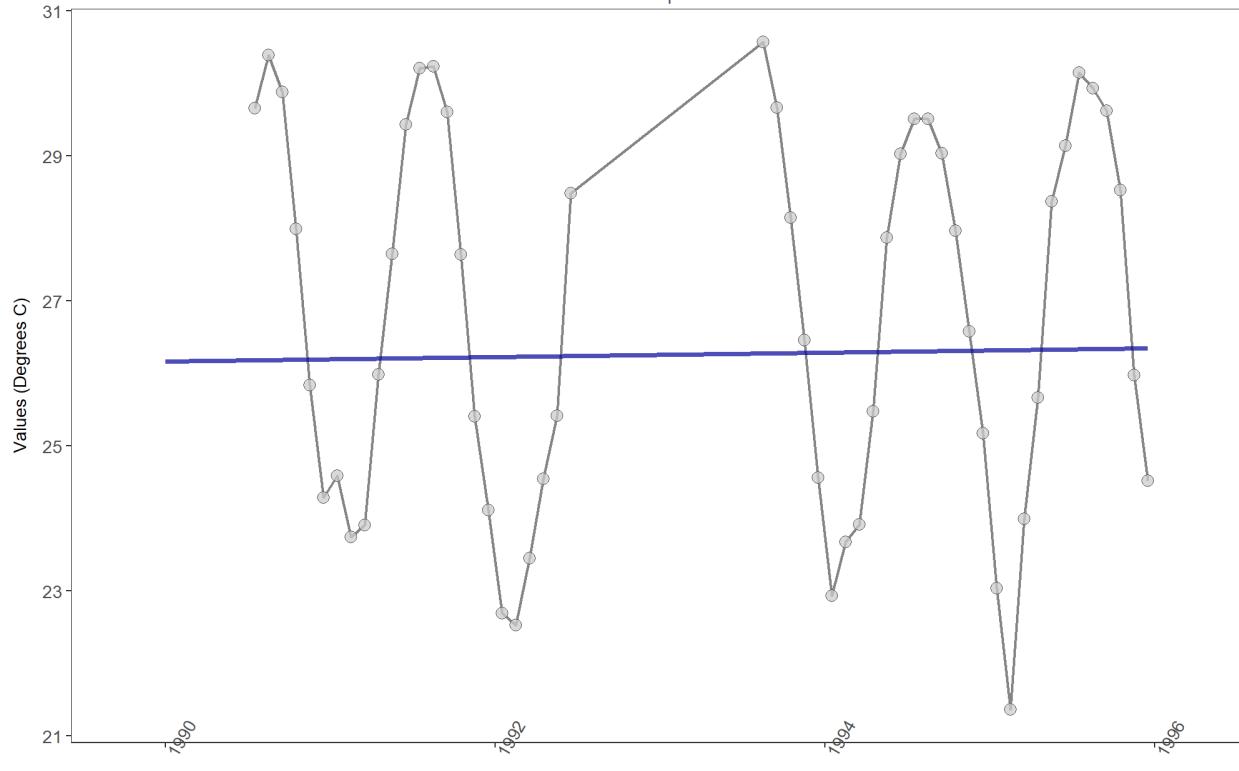


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	63260	16	26.7	1	-0.0607	0.2738	-0.007926261	26.21651	8.028	0.7108	0

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
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_W_SAMBO
 Water Temperature

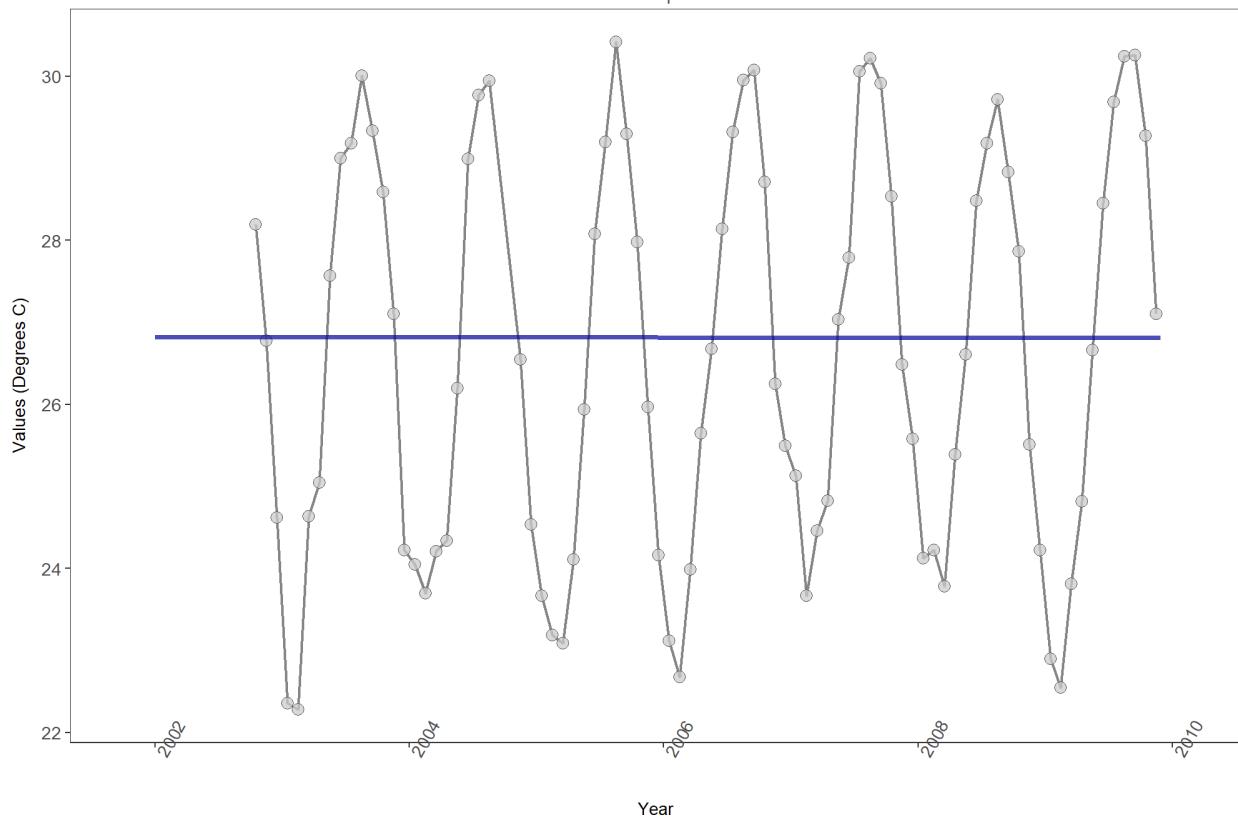


RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	18786	6	26.9	1	0.0881	0.5597	0.03038889	26.16243	9.8827	0.541	0

p < 0.00005 appear as 0 due to rounding.

SennIntercept is intercept value at beginning of record for monitoring location

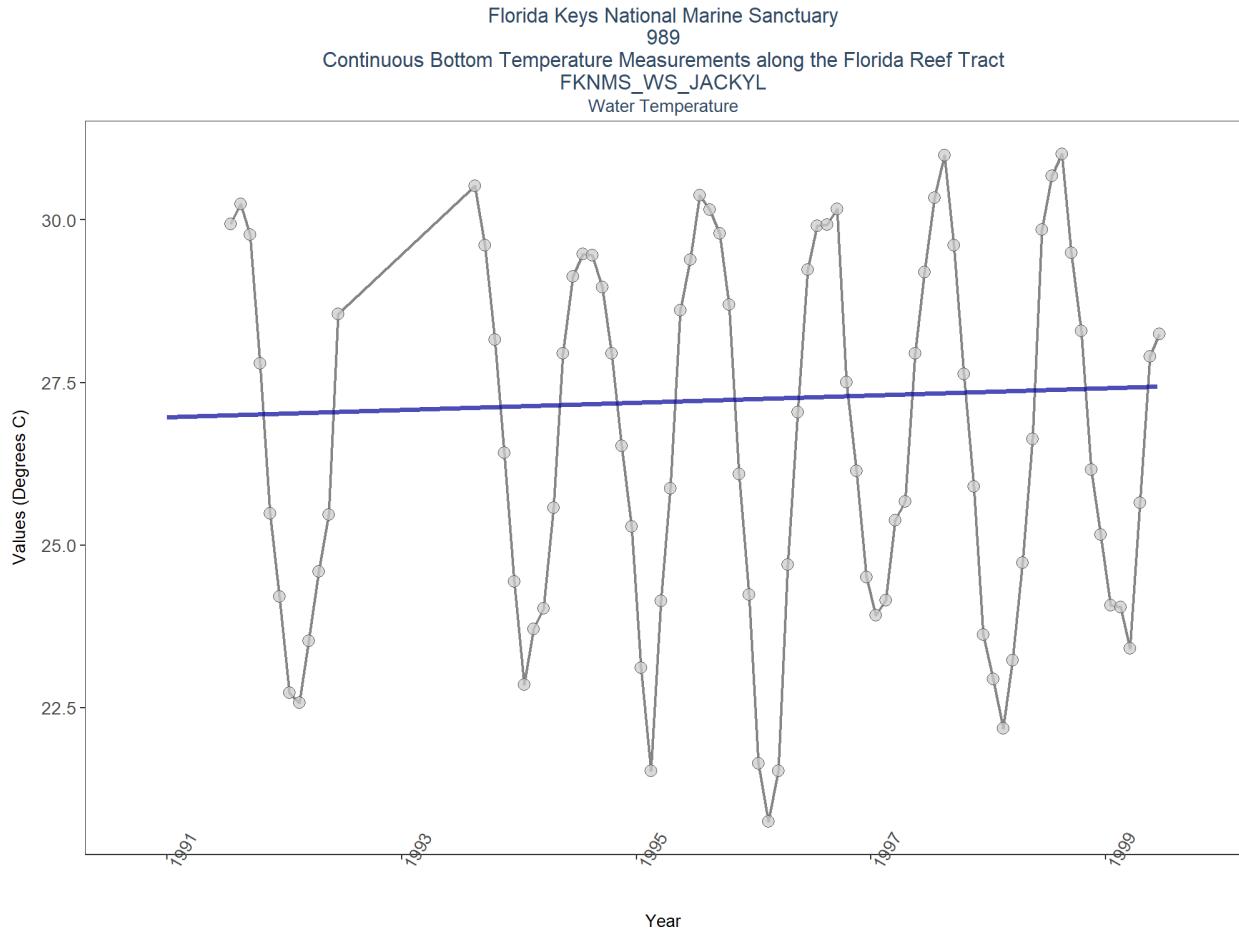
Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_WELLWOOD
 Water Temperature



RelativeDepth	N_Data	N_Years	Median	Independent	tau	p	SennSlope	SennIntercept	ChiSquared	pChiSquared	Trend
bottom	30427	8	26.43	1	0.0018	1	-0.0002133333	26.8169	4.1607	0.965	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 {
  # Begin looping through monitoringg locations
  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[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))) +
      # Add a layer for the most recent 10 years
      geom_boxplot(data = data[data$Year >= year_upper - 10, ],
                    color="#333333", fill="#cccccc", outlier.shape=21,
                    outlier.size=3, outlier.color="#333333",
                    outlier.fill="#cccccc", outlier.alpha=0.75) +
      # Add a layer for the most recent 5 years
      geom_boxplot(data = data[data$Year >= year_upper - 5, ],
                    color="#333333", fill="#cccccc", outlier.shape=21,
                    outlier.size=3, outlier.color="#333333",
                    outlier.fill="#cccccc", outlier.alpha=0.75) +
      # Add a layer for the most recent 1 year
      geom_boxplot(data = data[data$Year == year_upper, ],
                    color="#333333", fill="#cccccc", outlier.shape=21,
                    outlier.size=3, outlier.color="#333333",
                    outlier.fill="#cccccc", outlier.alpha=0.75)
```

```

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
leg1 <- get_legend(p5)
# Arrange plots and legend
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 +

```

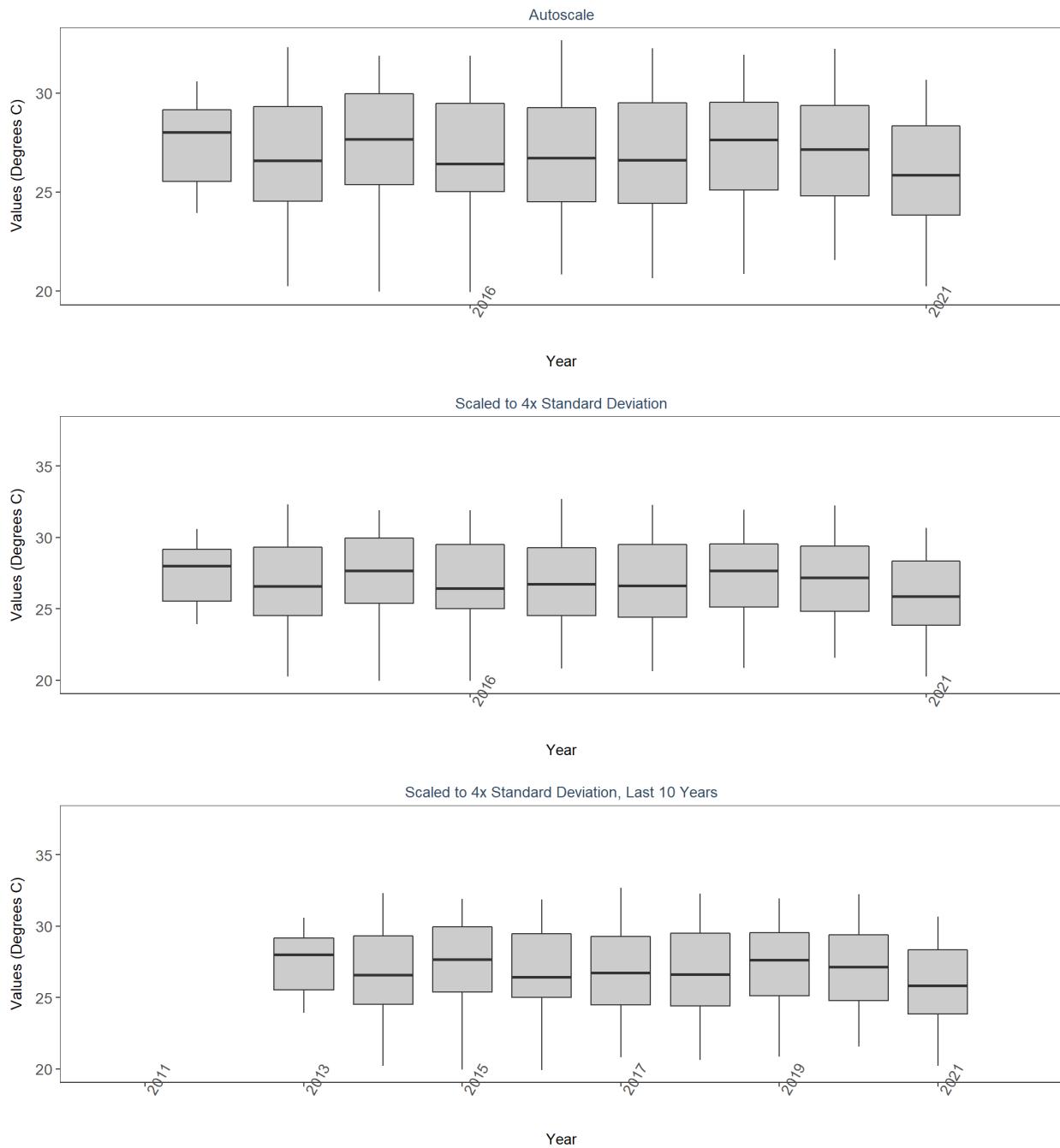
```

    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)))

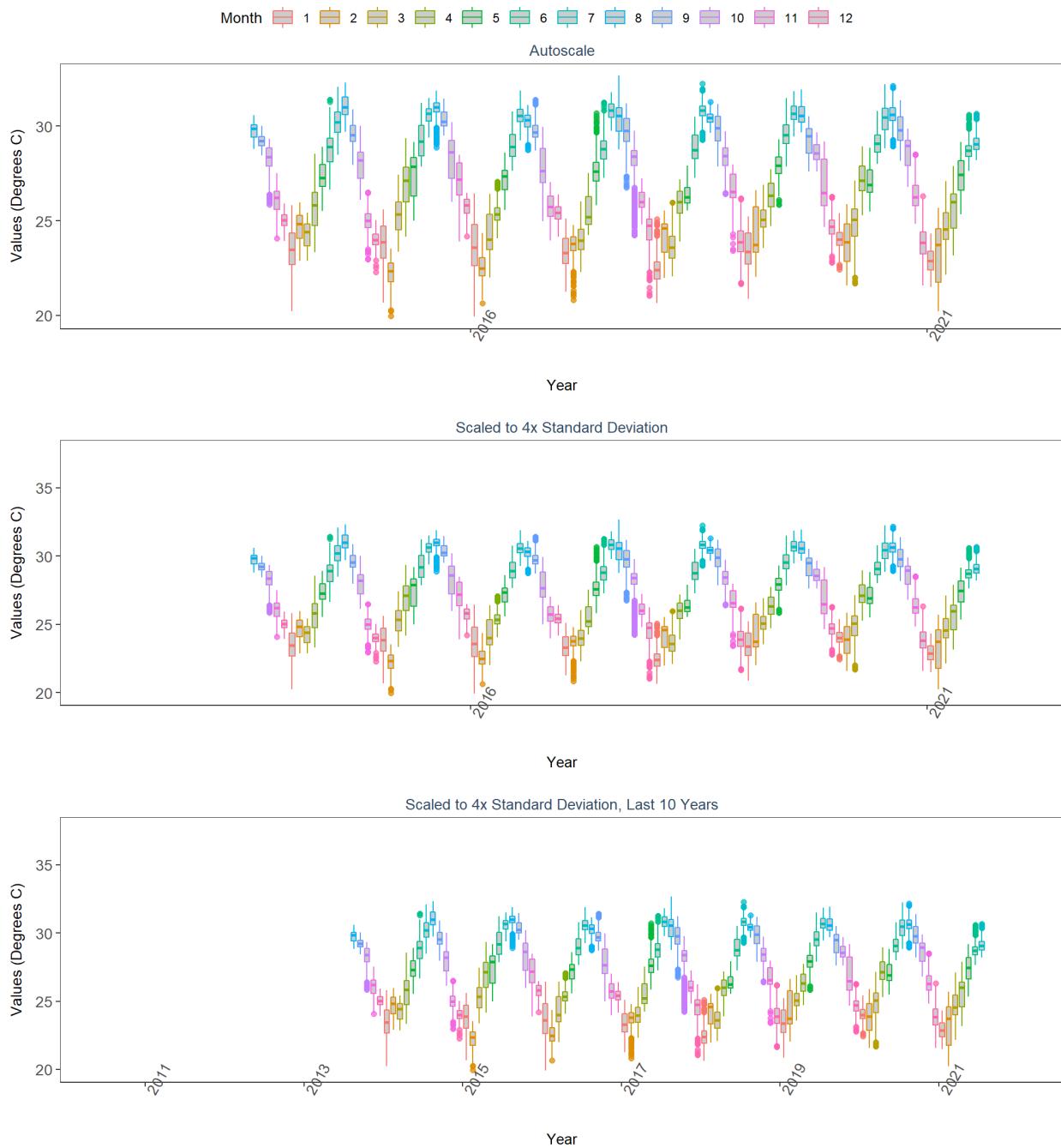
rm(plot_data)
rm(p1, p2, p3, p4, p5, p6, p7, p8, p9, p0, p00, p000, leg1, leg2,
    Yset, YMset, Mset)
}
}

```

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

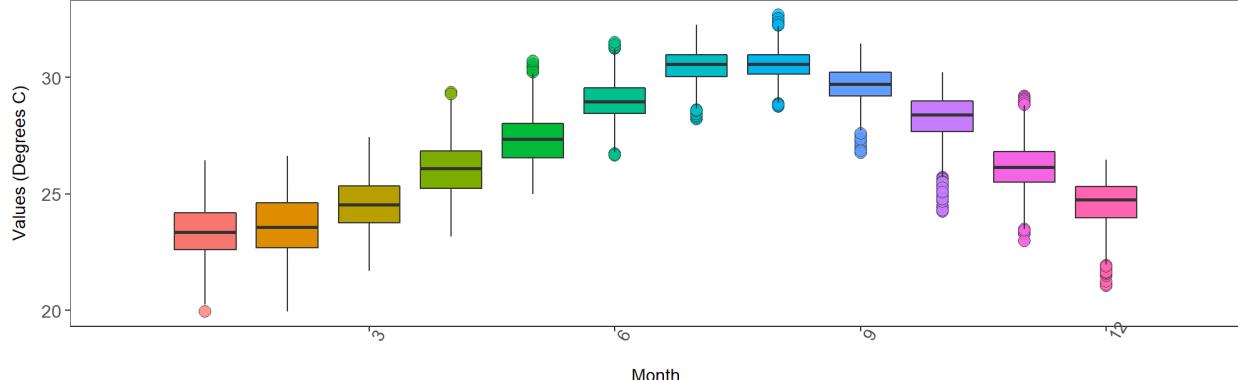
Water Temperature on Coral Reefs in the Florida Keys

6

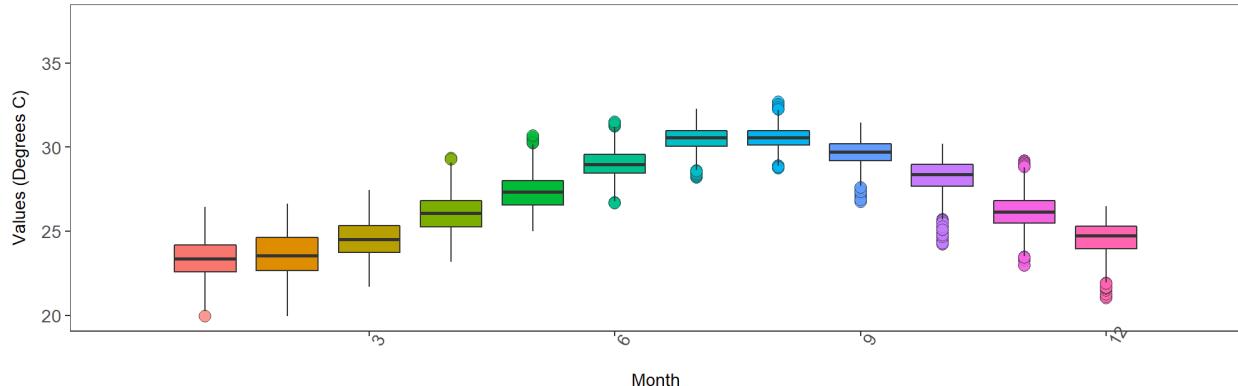
By Month

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

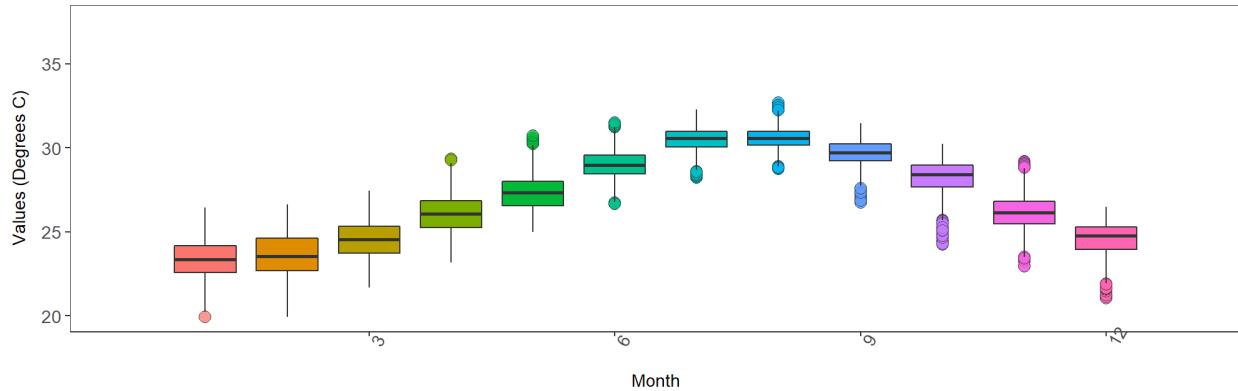
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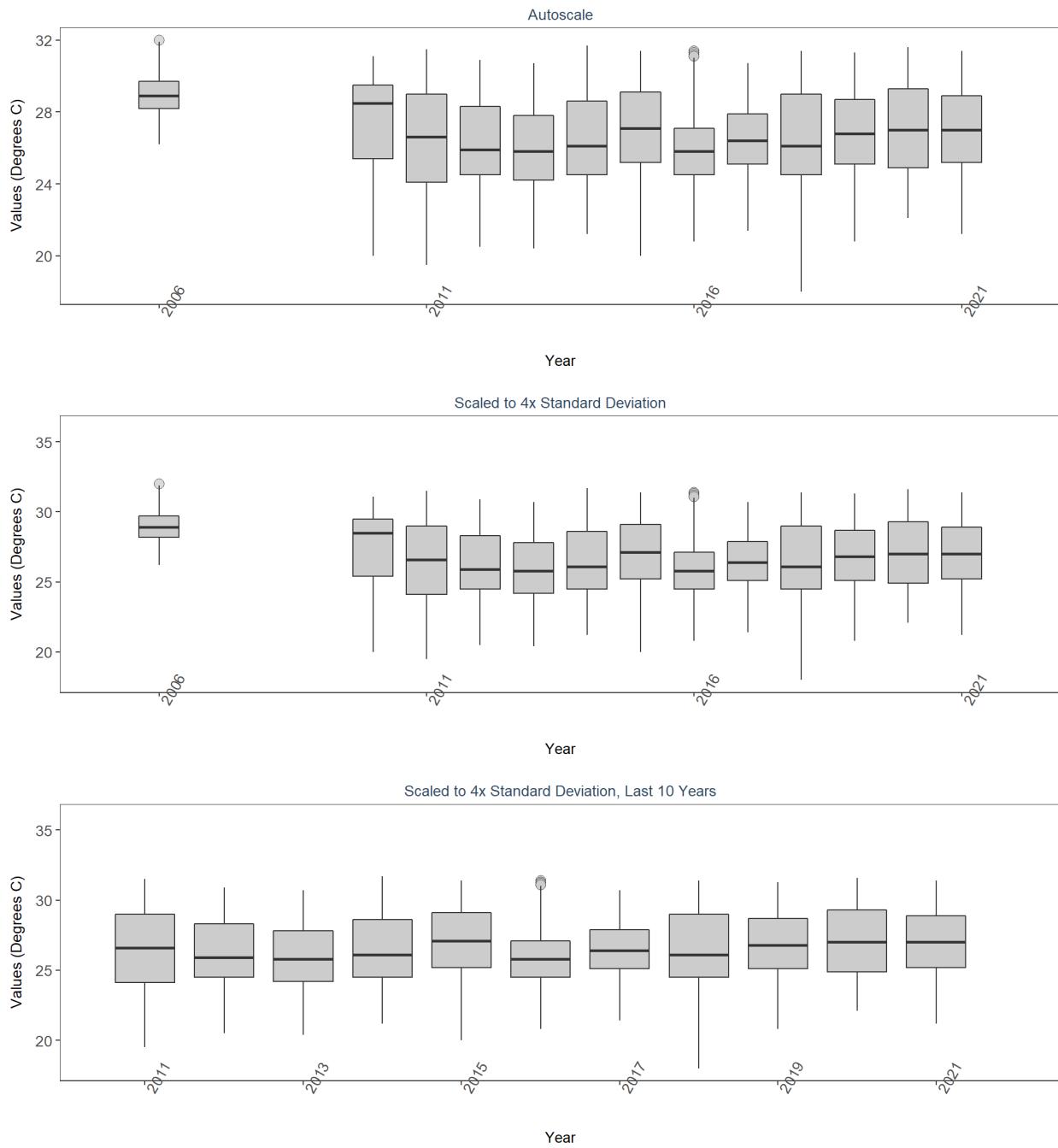
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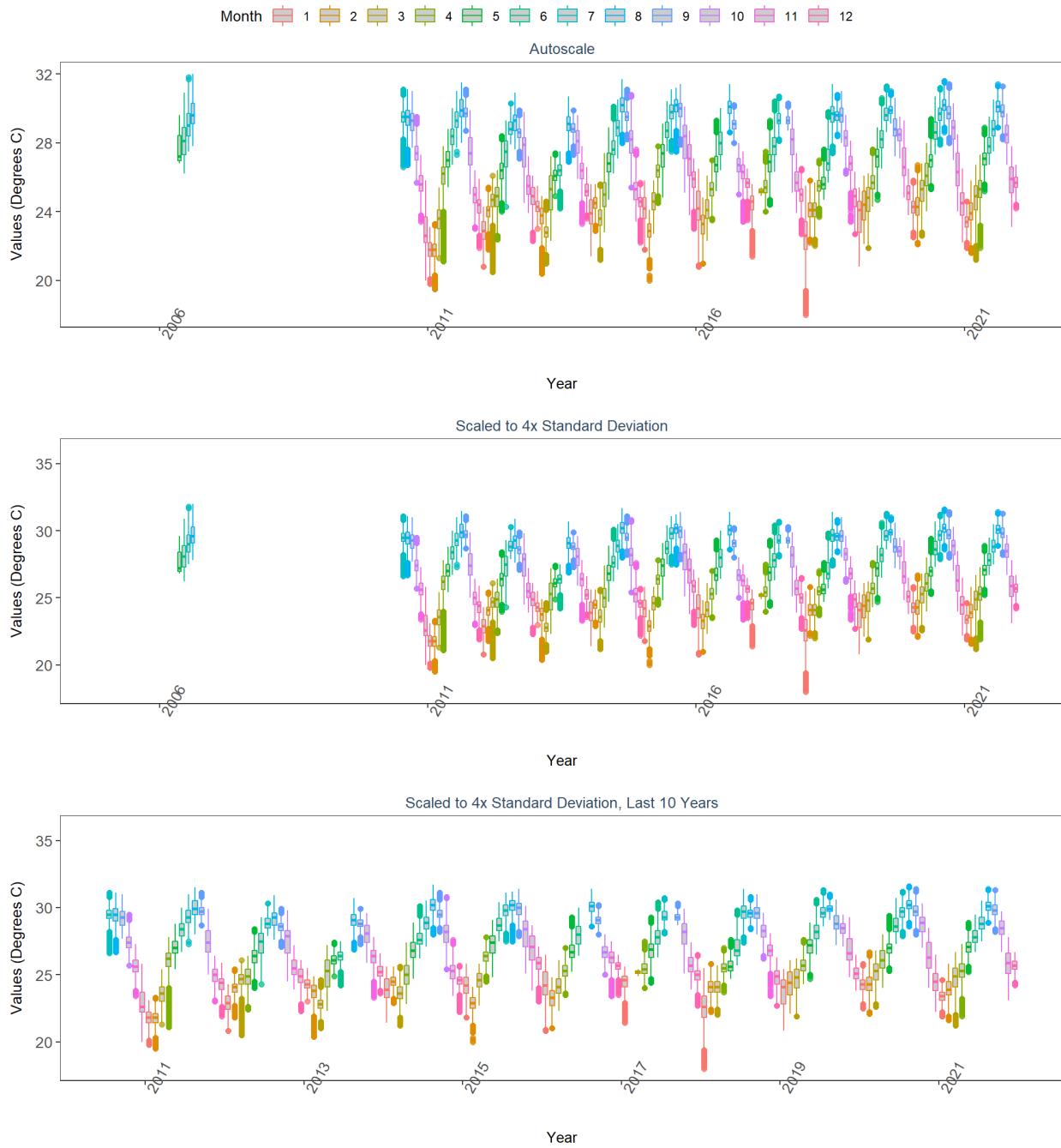
Scaled to 4x Standard Deviation, Last 10 Years



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

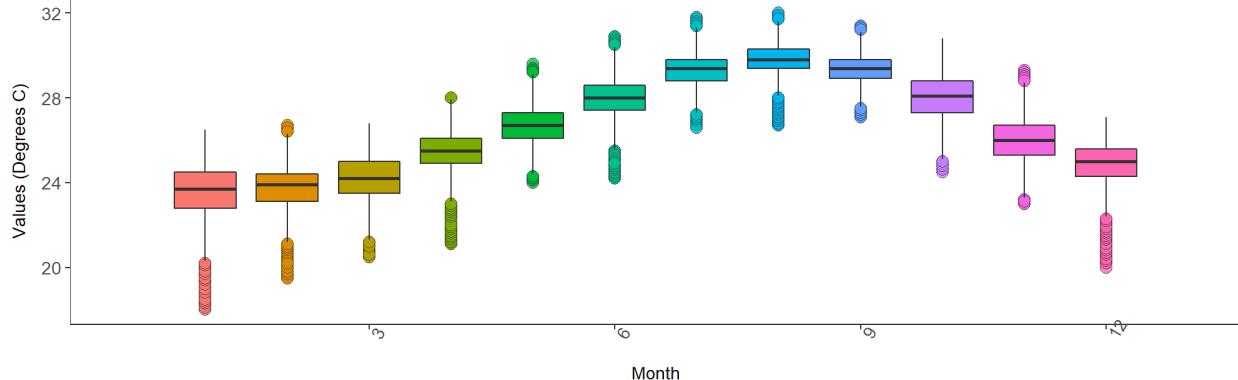
National Data Buoy Center

LKWF1

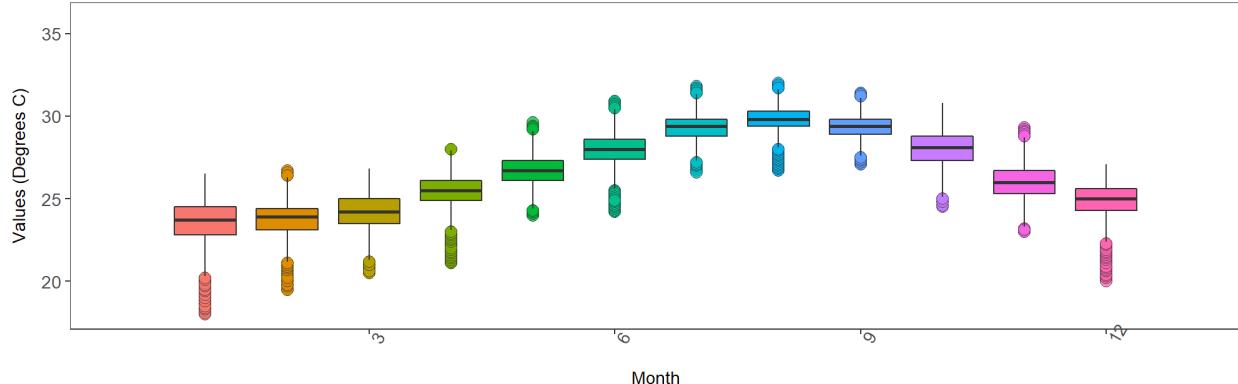
By Month

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

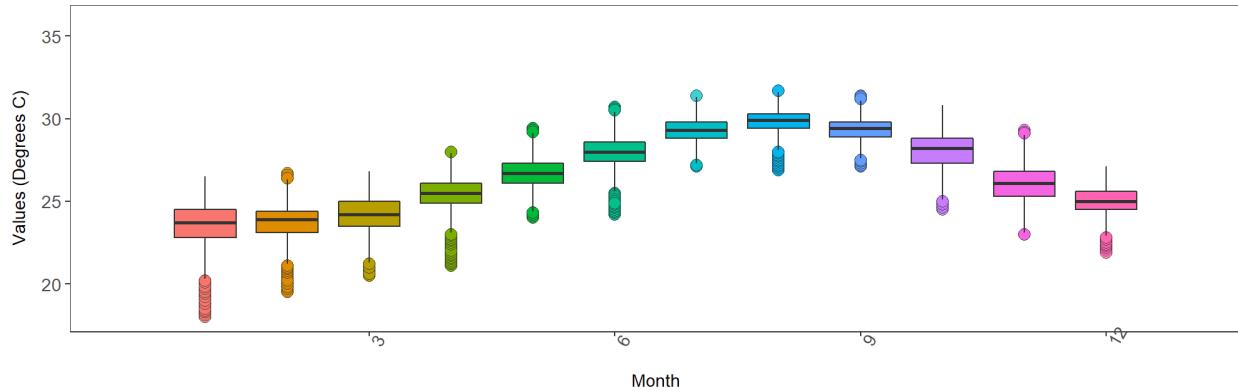
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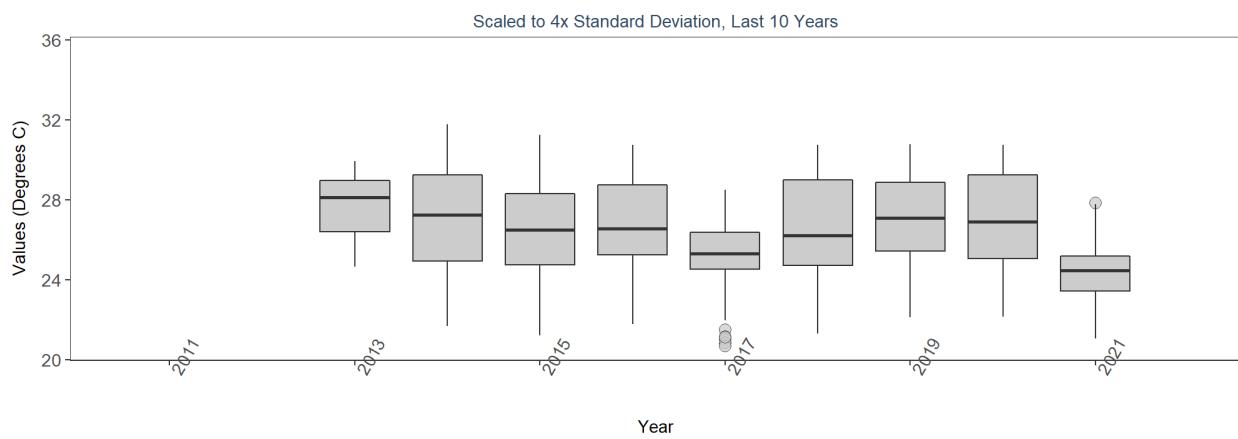
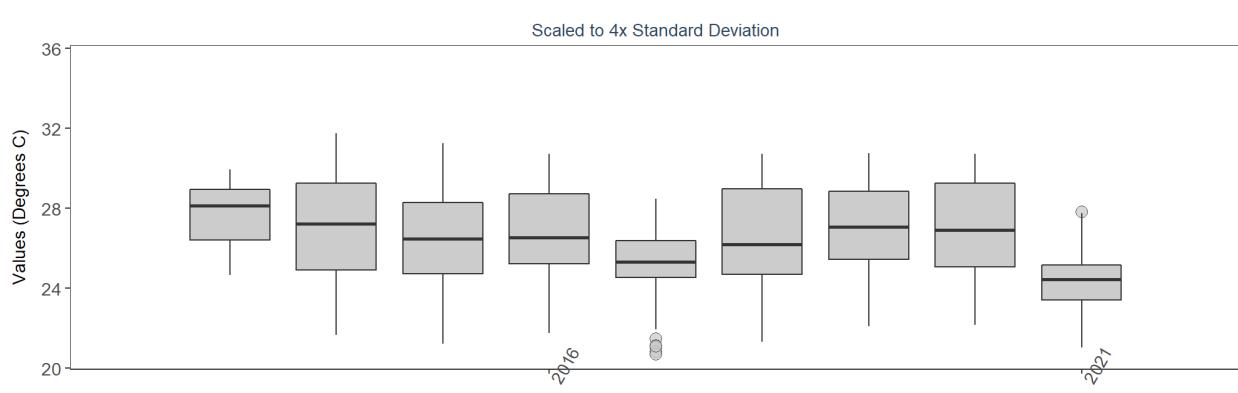
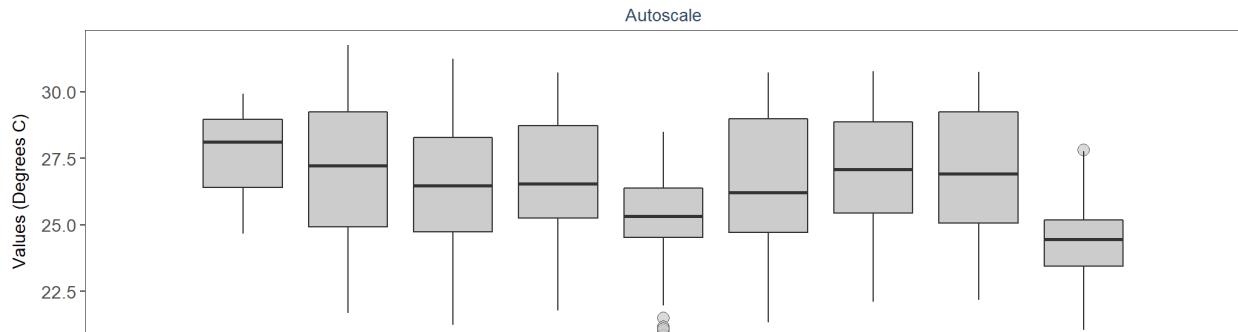
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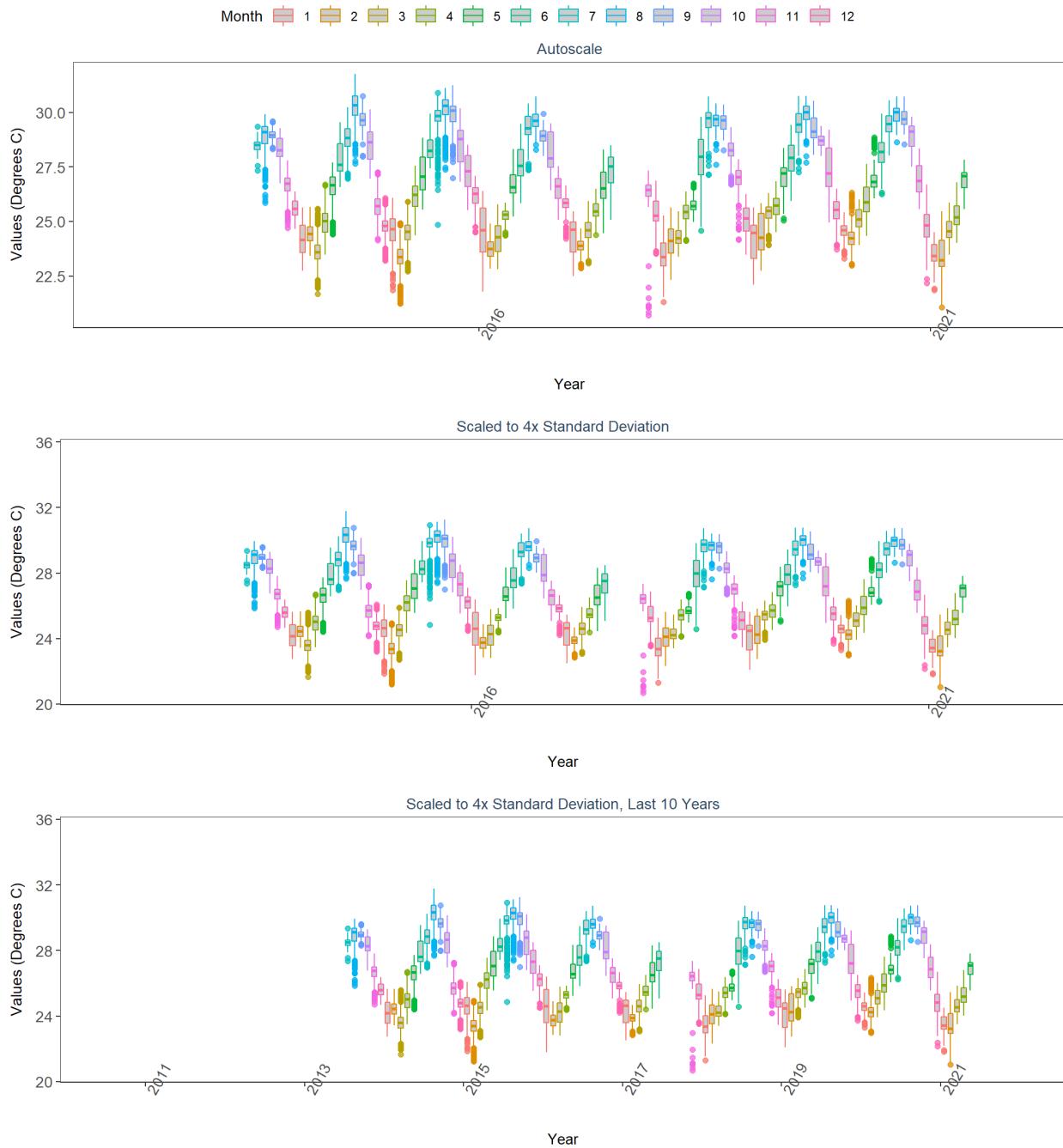
Scaled to 4x Standard Deviation, Last 10 Years



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



Southeast Florida Coral Reef Ecosystem Conservation Area

986

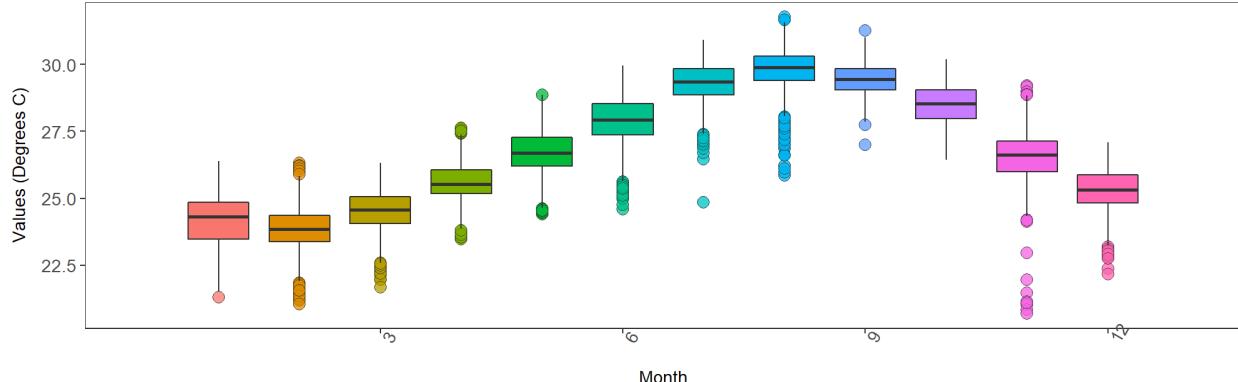
Water Temperature on Coral Reefs in the Florida Keys

1

By Month

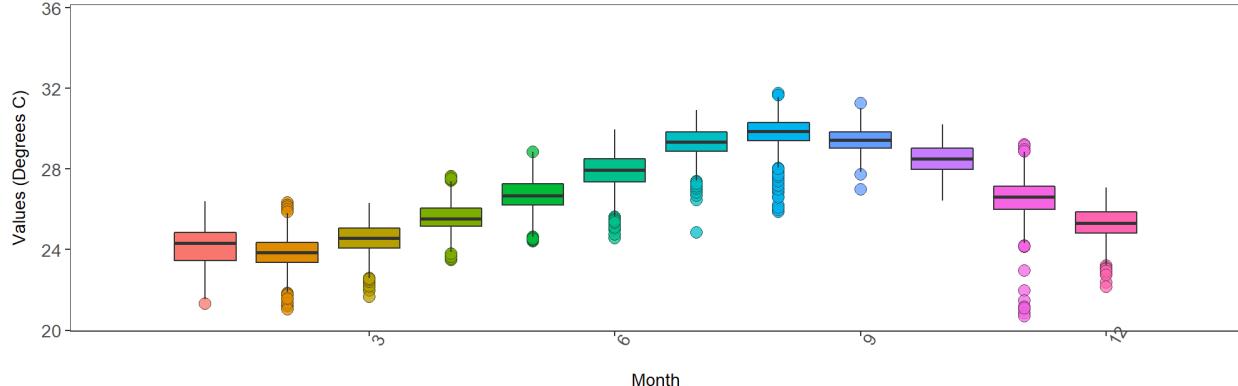
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Autoscale



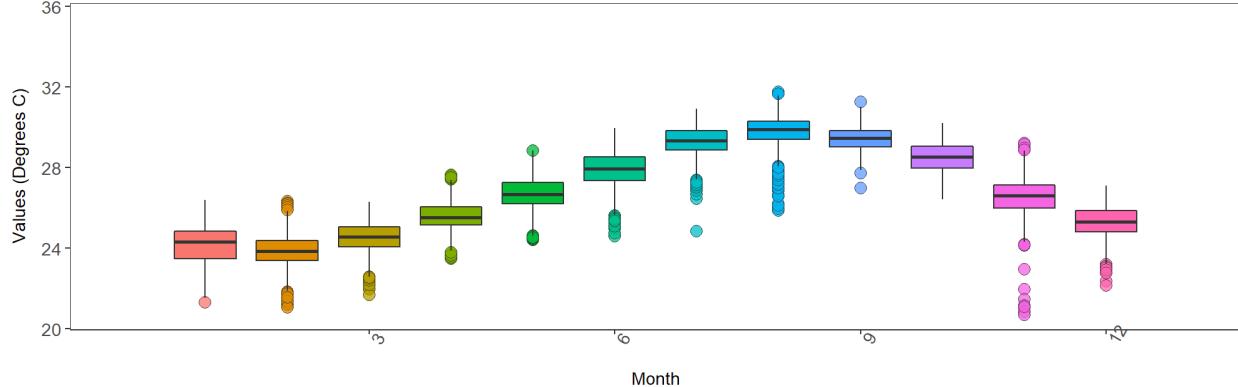
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Scaled to 4x Standard Deviation



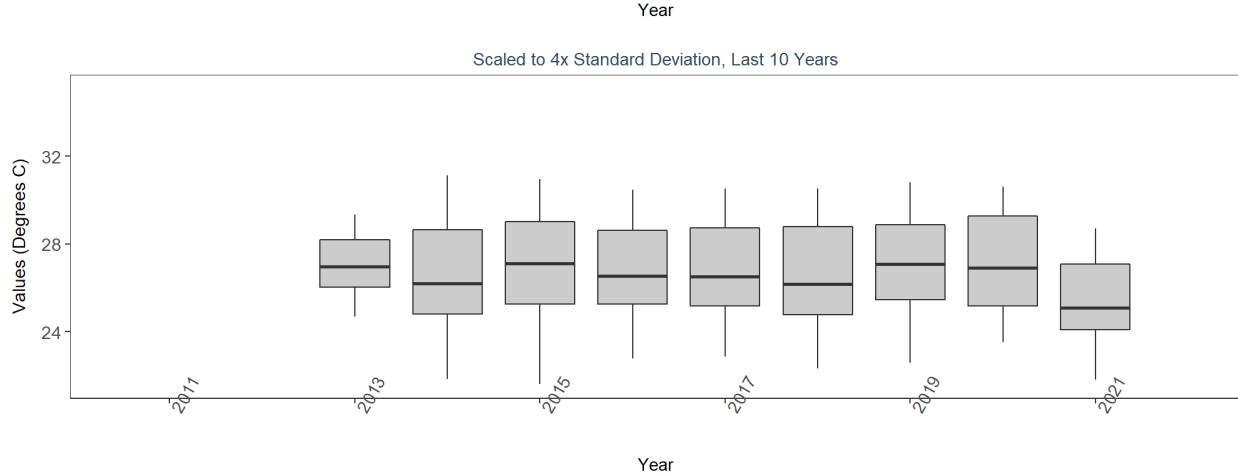
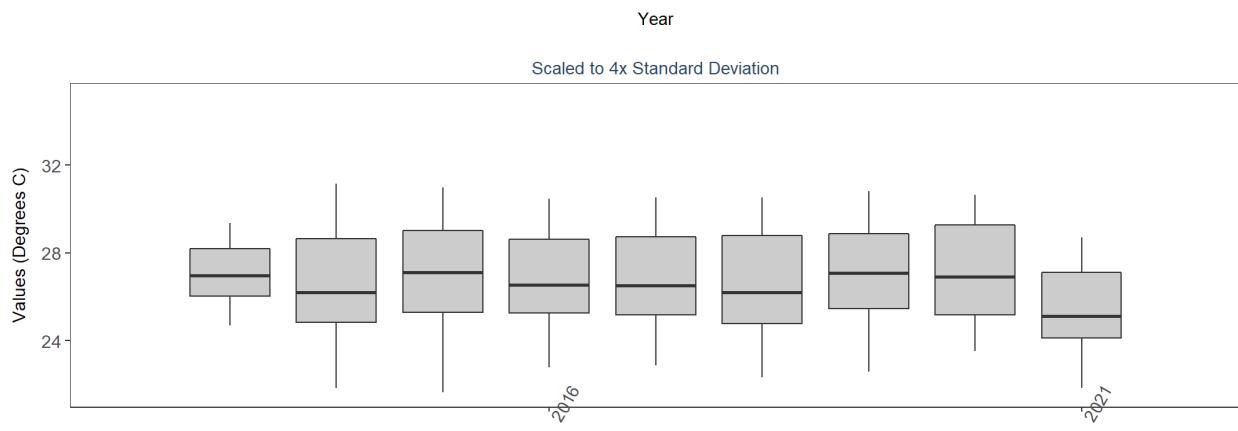
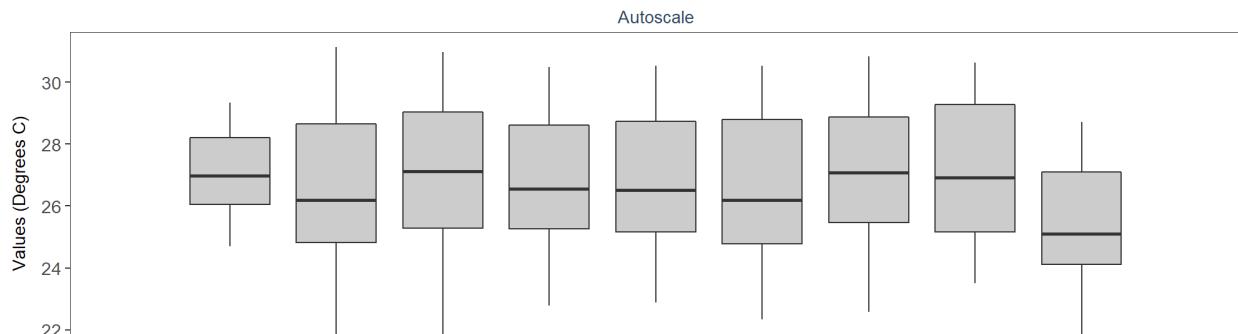
Month

Scaled to 4x Standard Deviation, Last 10 Years

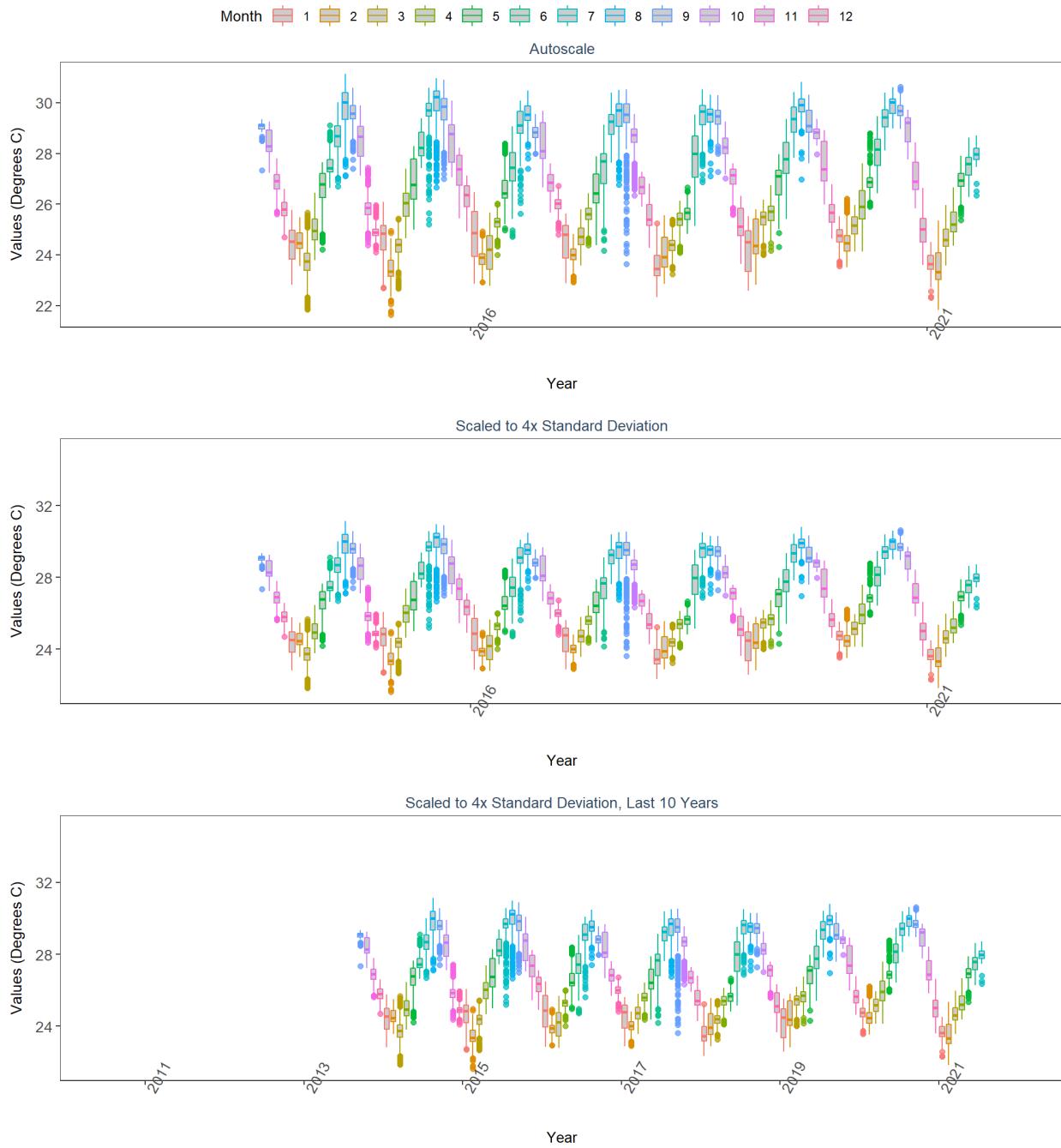


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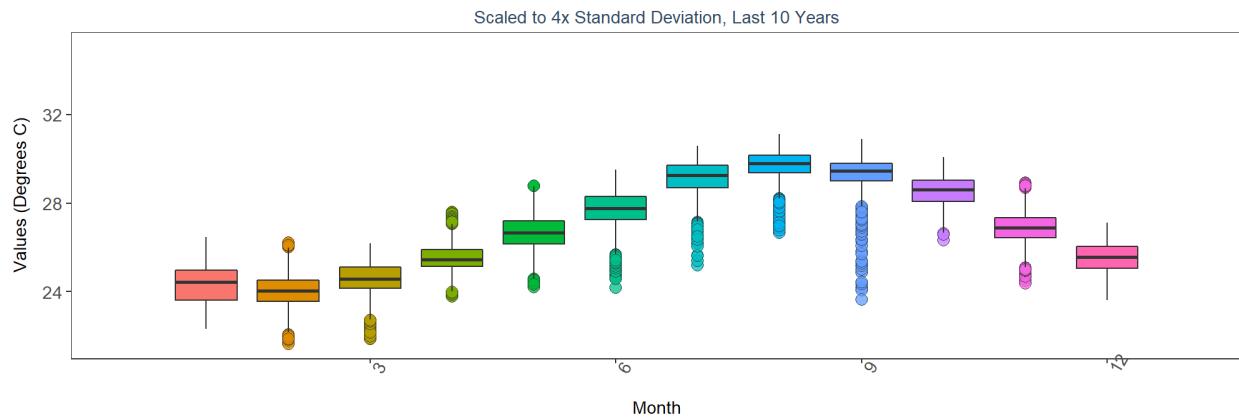
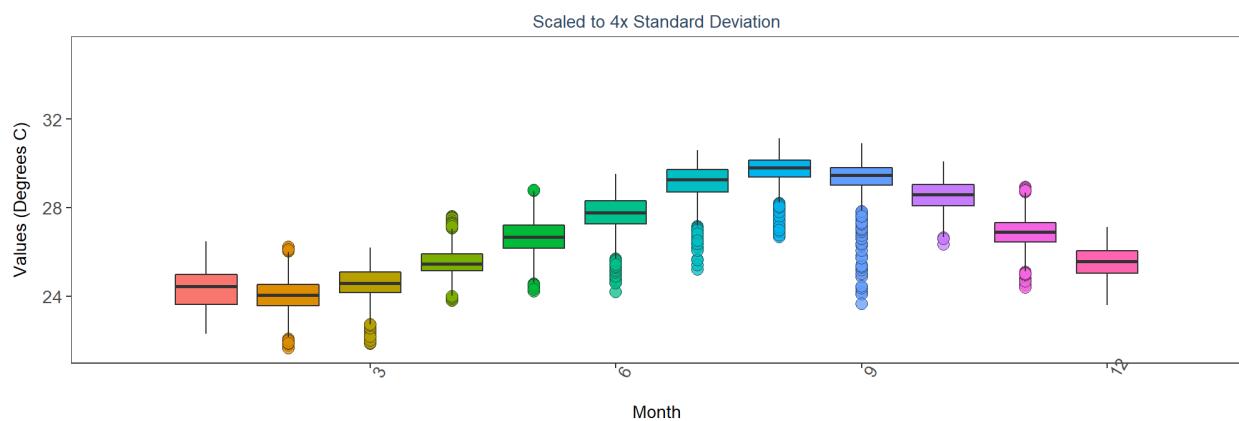
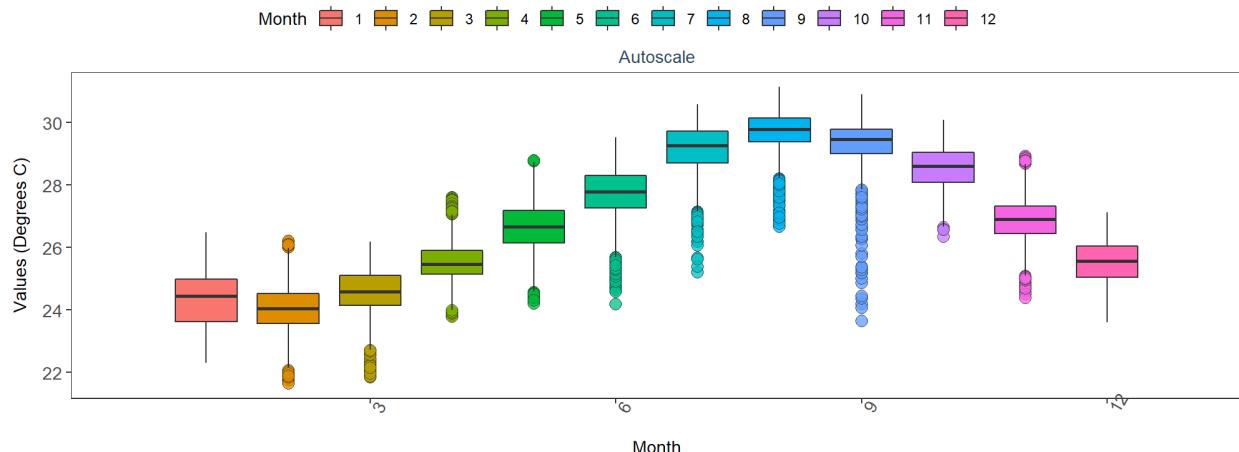
Southeast Florida Coral Reef Ecosystem Conservation Area
 986
 Water Temperature on Coral Reefs in the Florida Keys
 2
 By Year



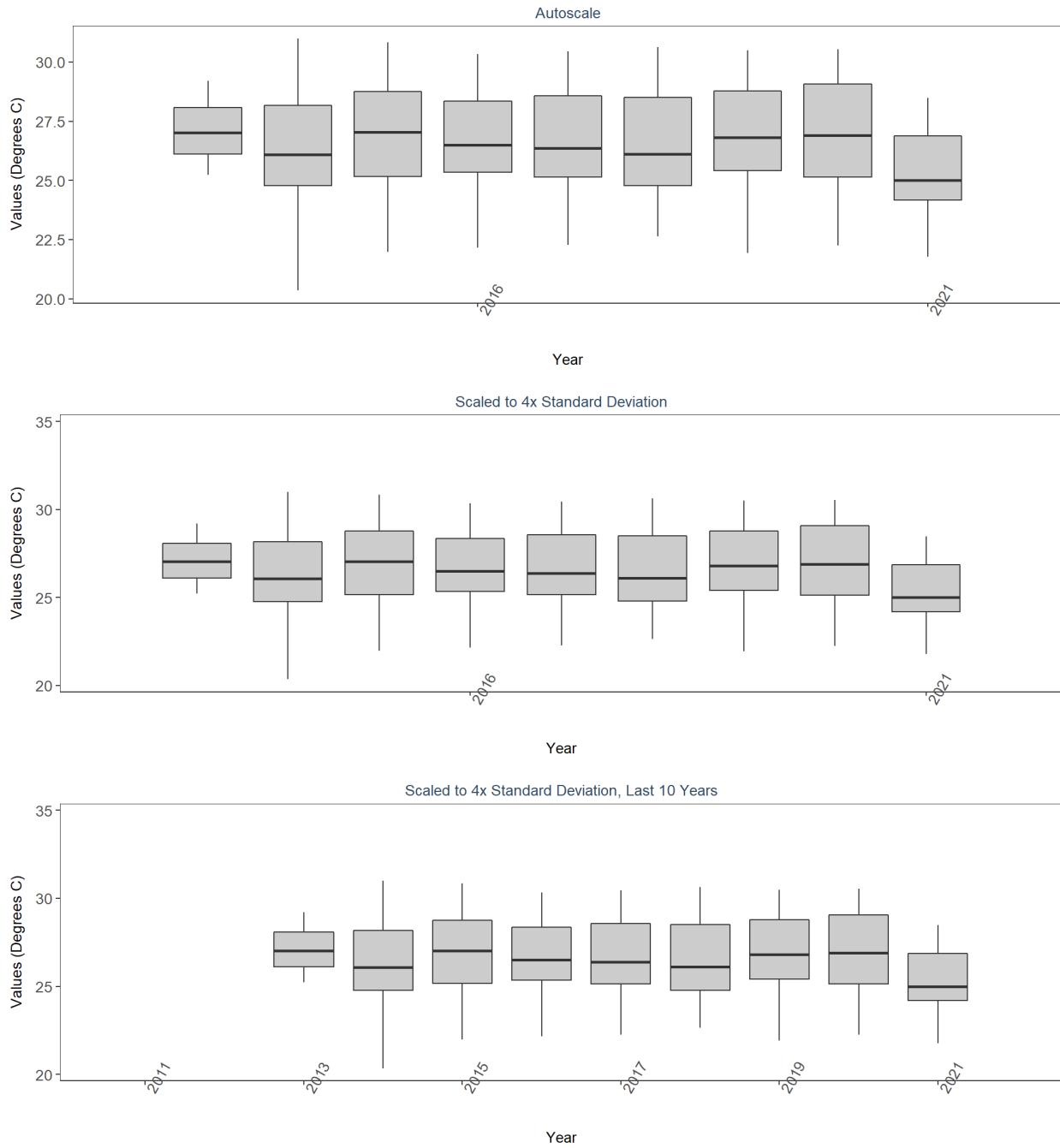
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
 2
 By Year & Month



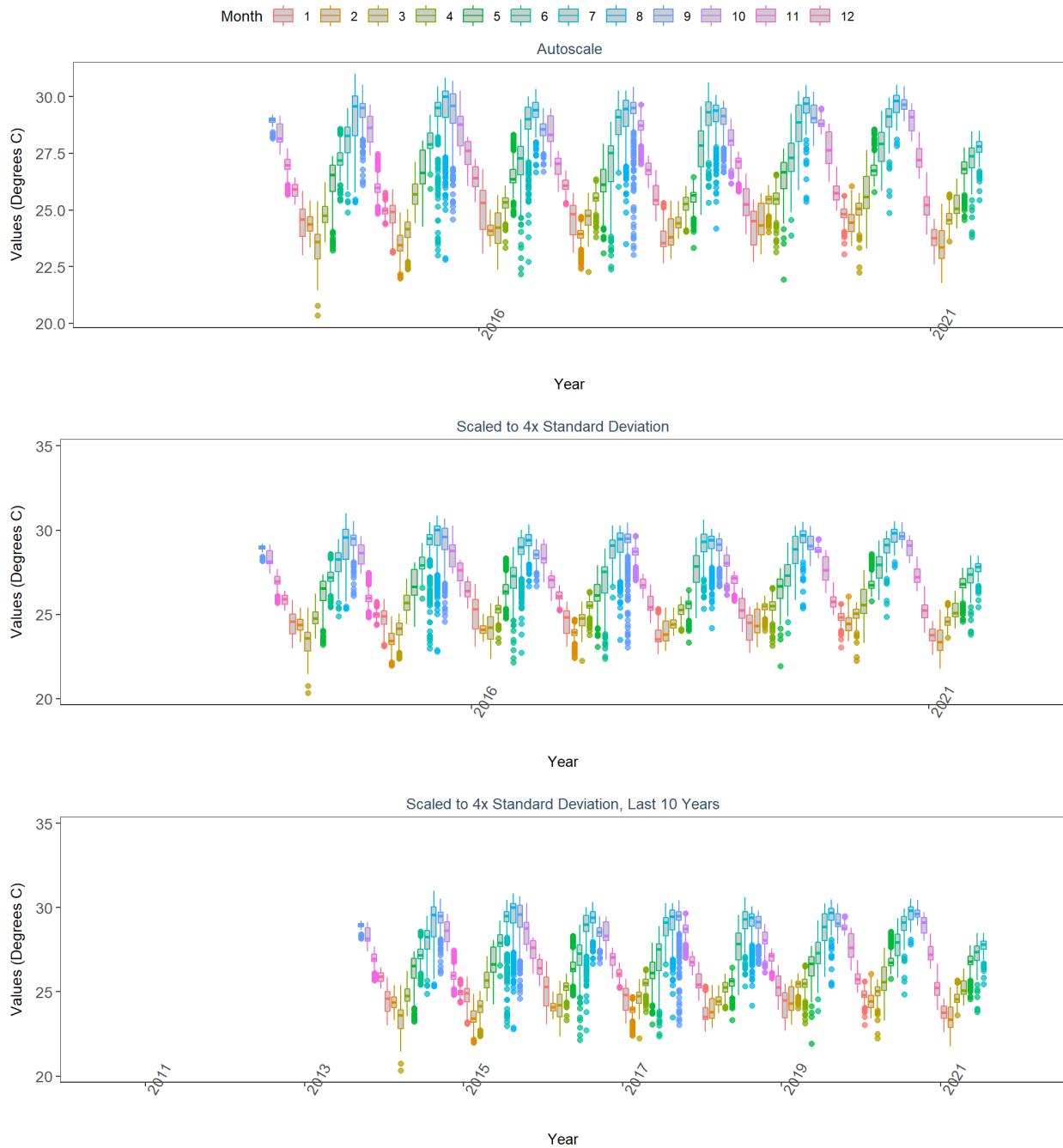
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
 2
 By Month



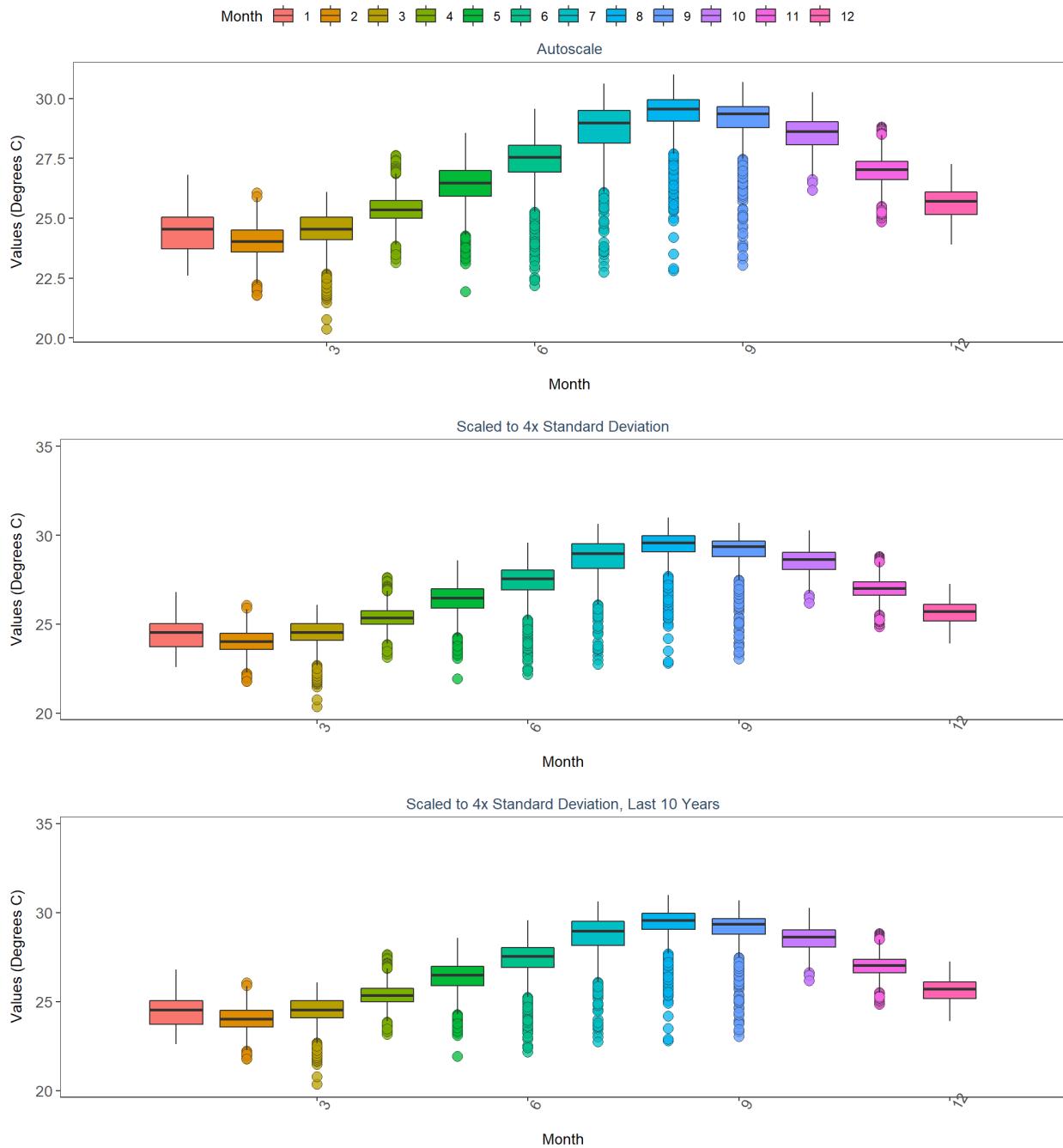
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 Water Temperature on Coral Reefs in the Florida Keys
 3
 By Year



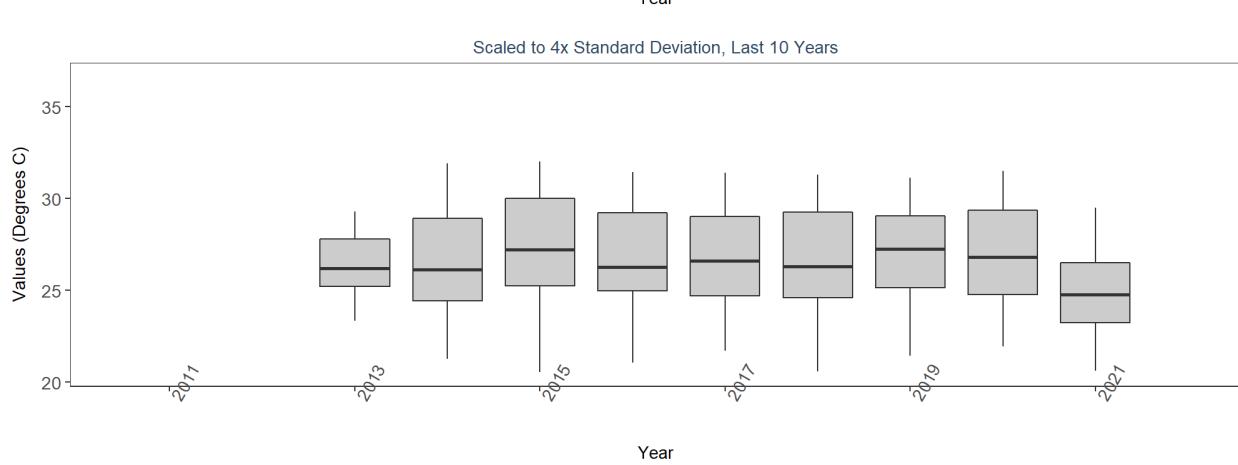
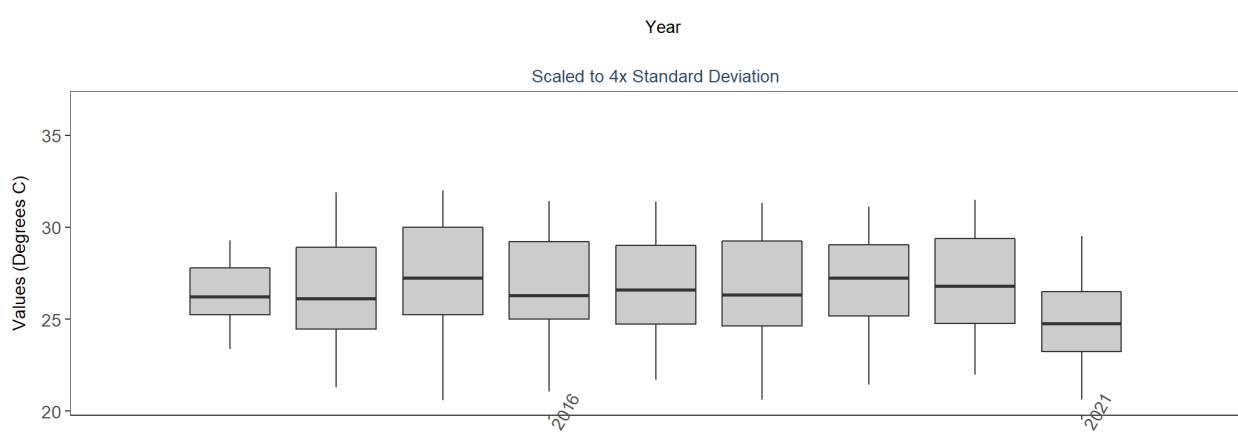
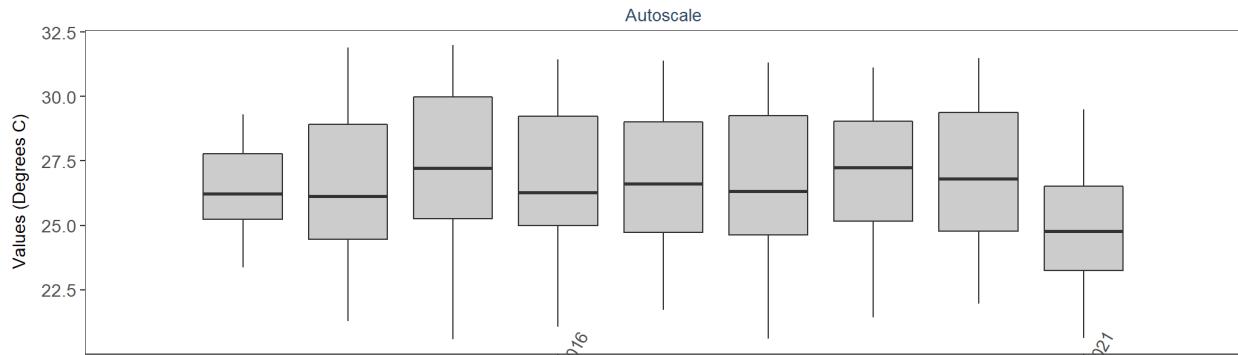
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
 3
 By Year & Month



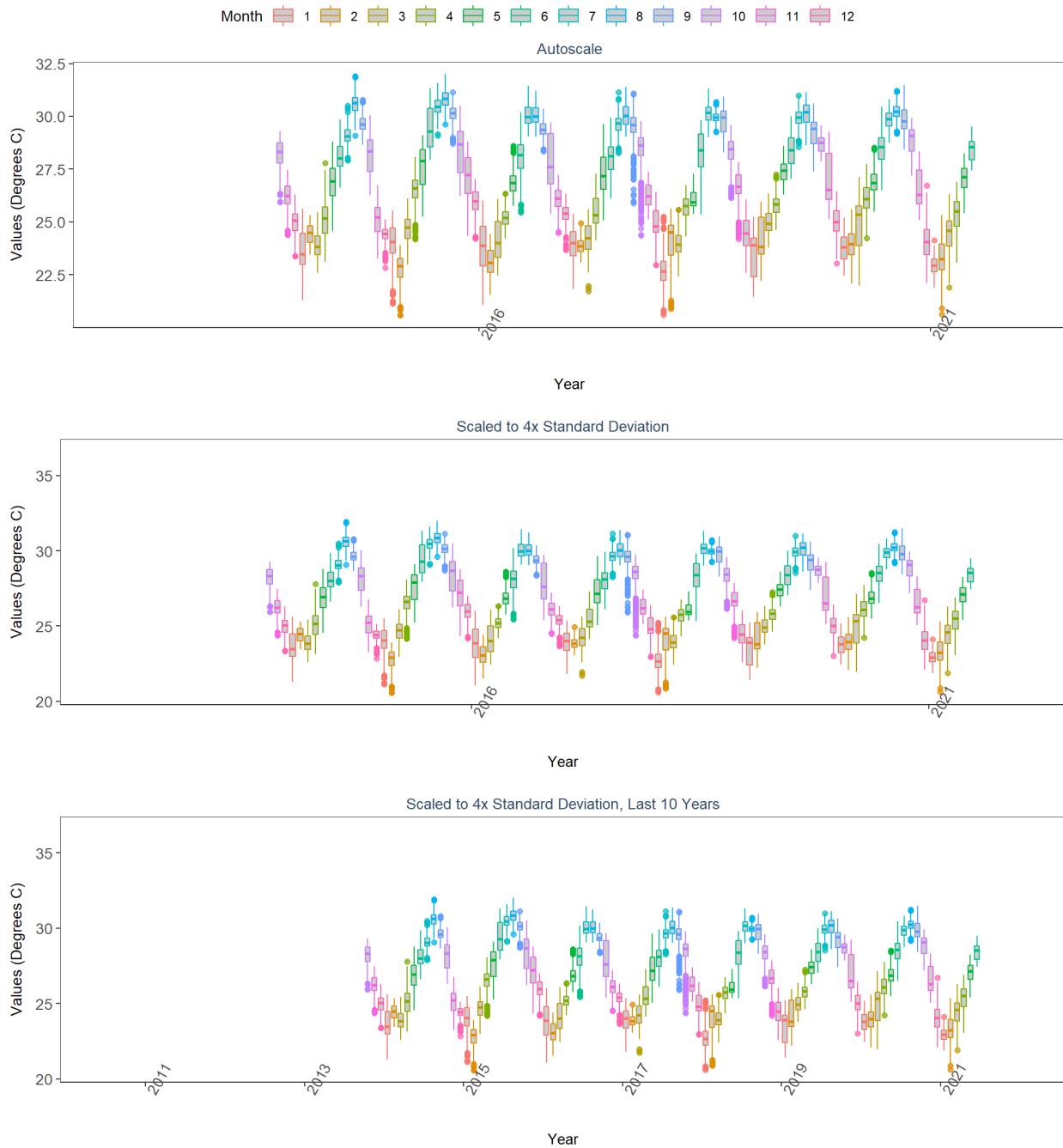
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 Water Temperature on Coral Reefs in the Florida Keys
 3
 By Month



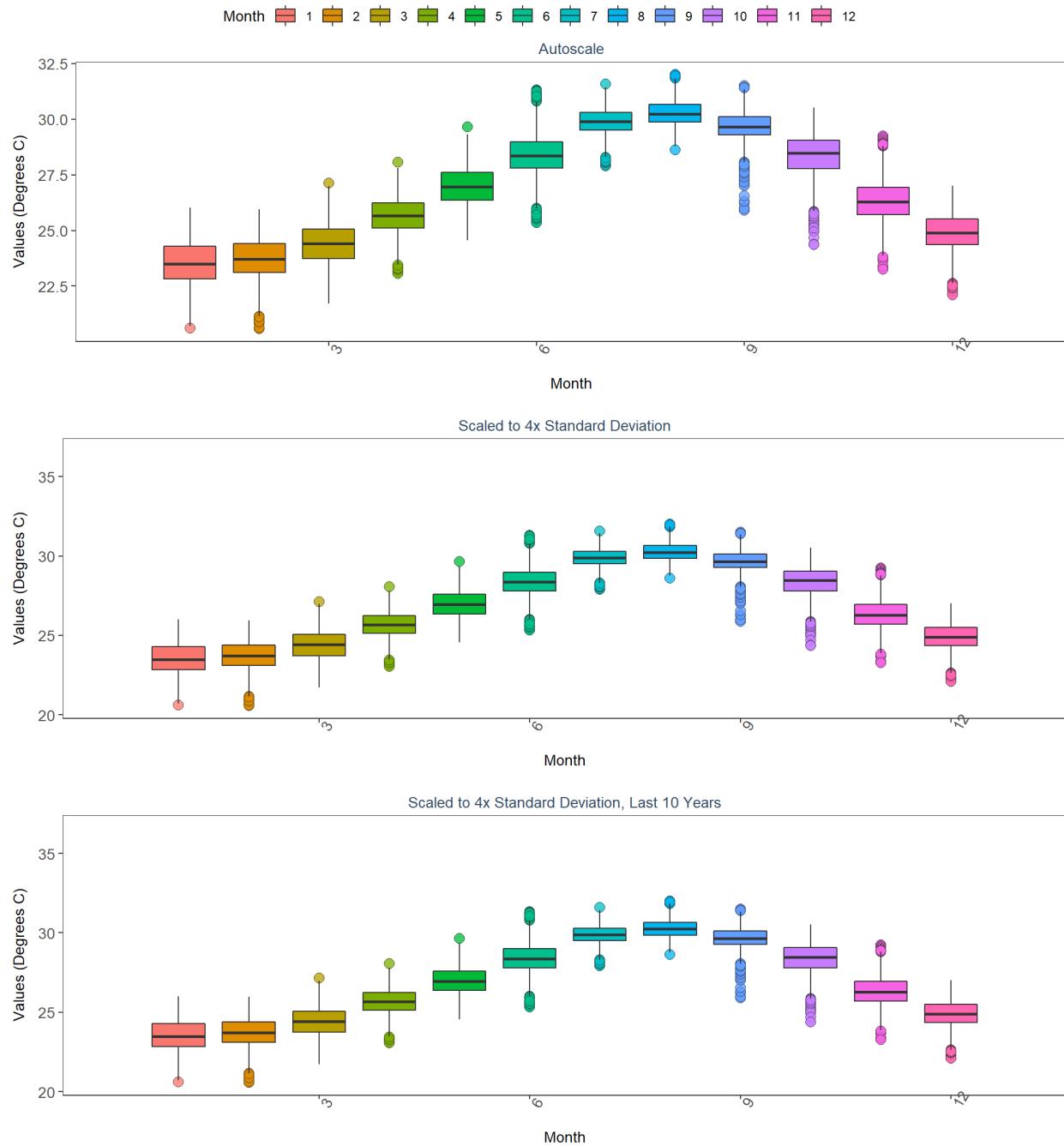
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 Water Temperature on Coral Reefs in the Florida Keys
 4
 By Year



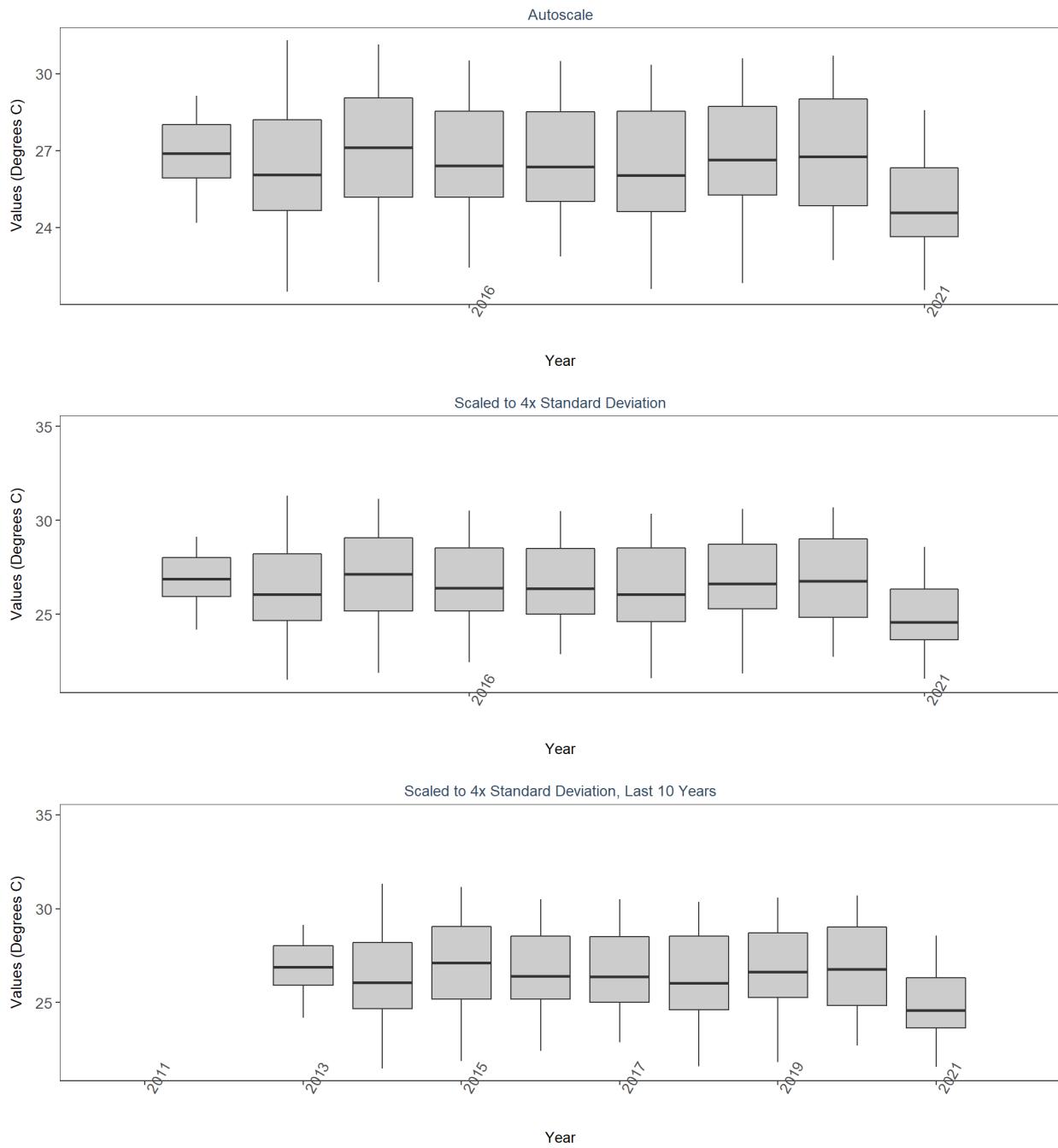
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
 4
 By Year & Month



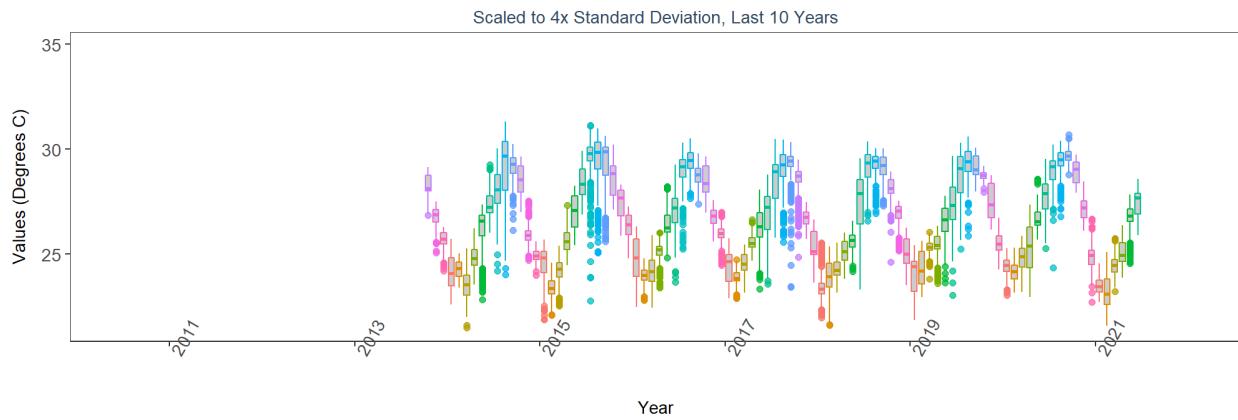
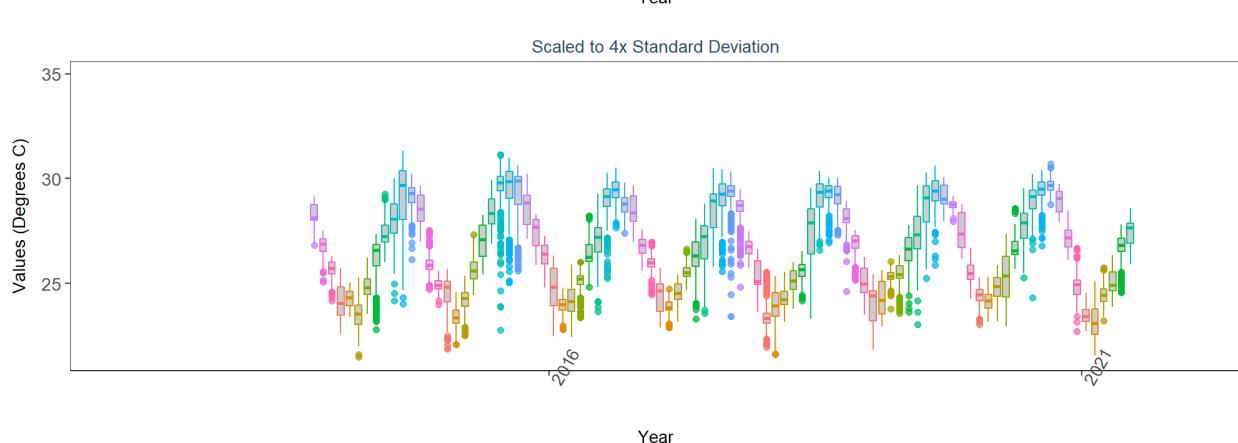
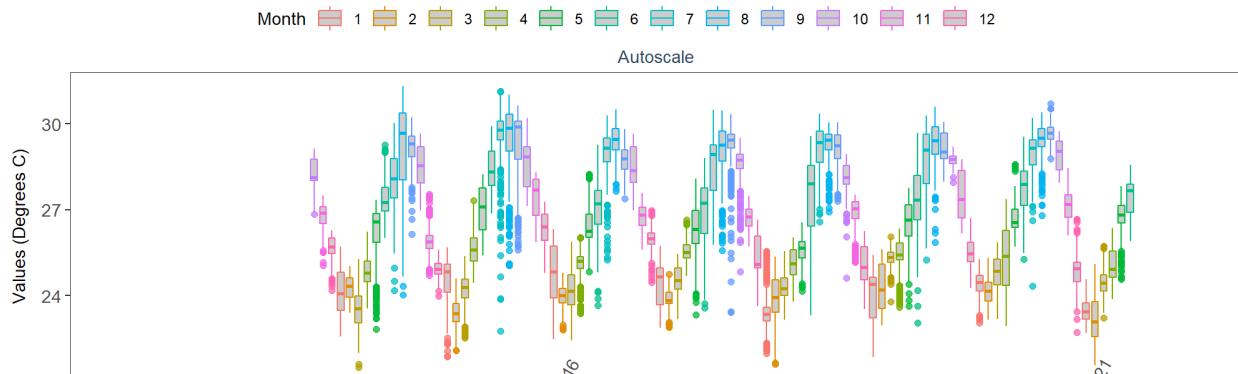
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 Water Temperature on Coral Reefs in the Florida Keys
 4
 By Month



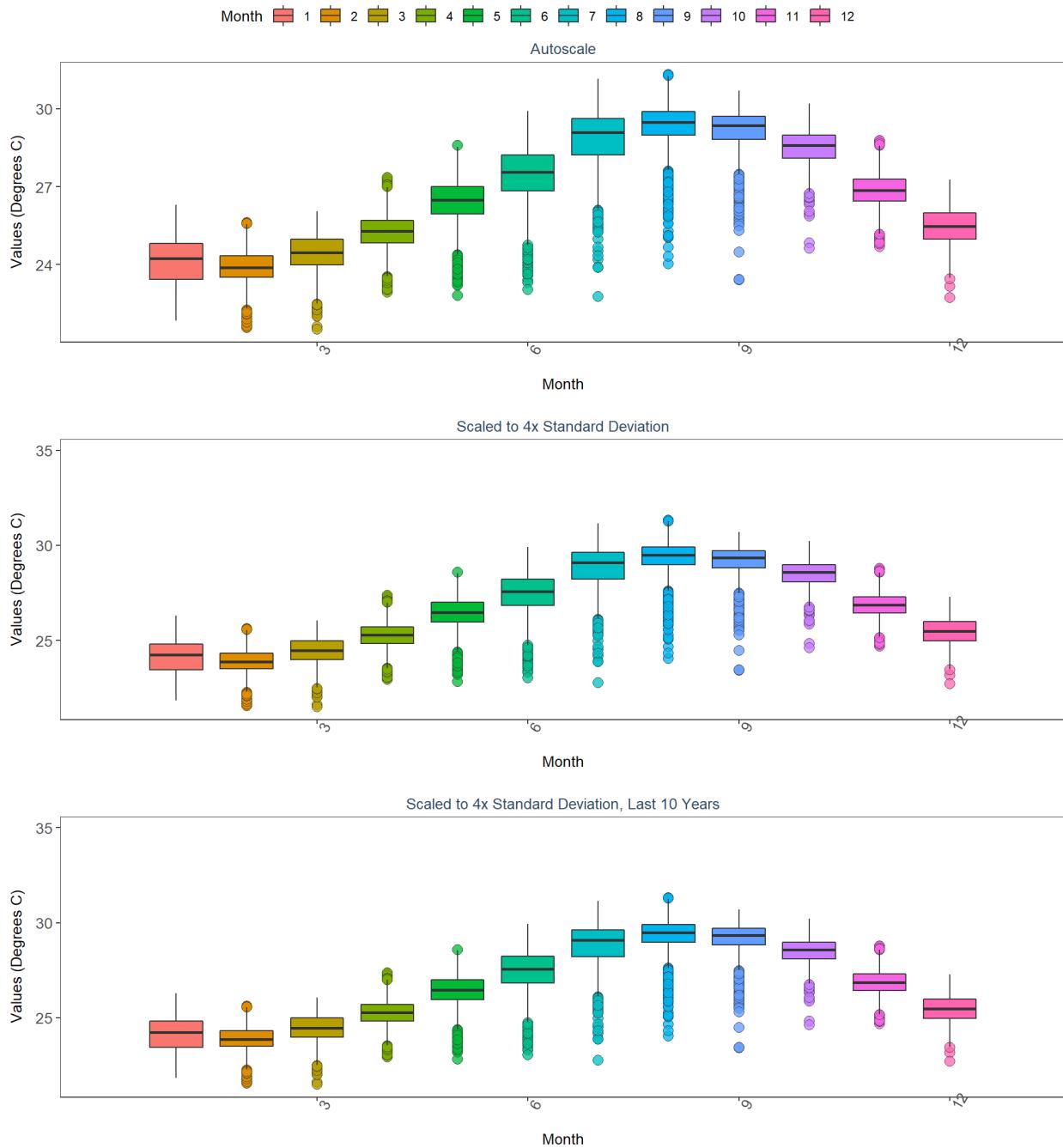
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Water Temperature on Coral Reefs in the Florida Keys
5
By Year



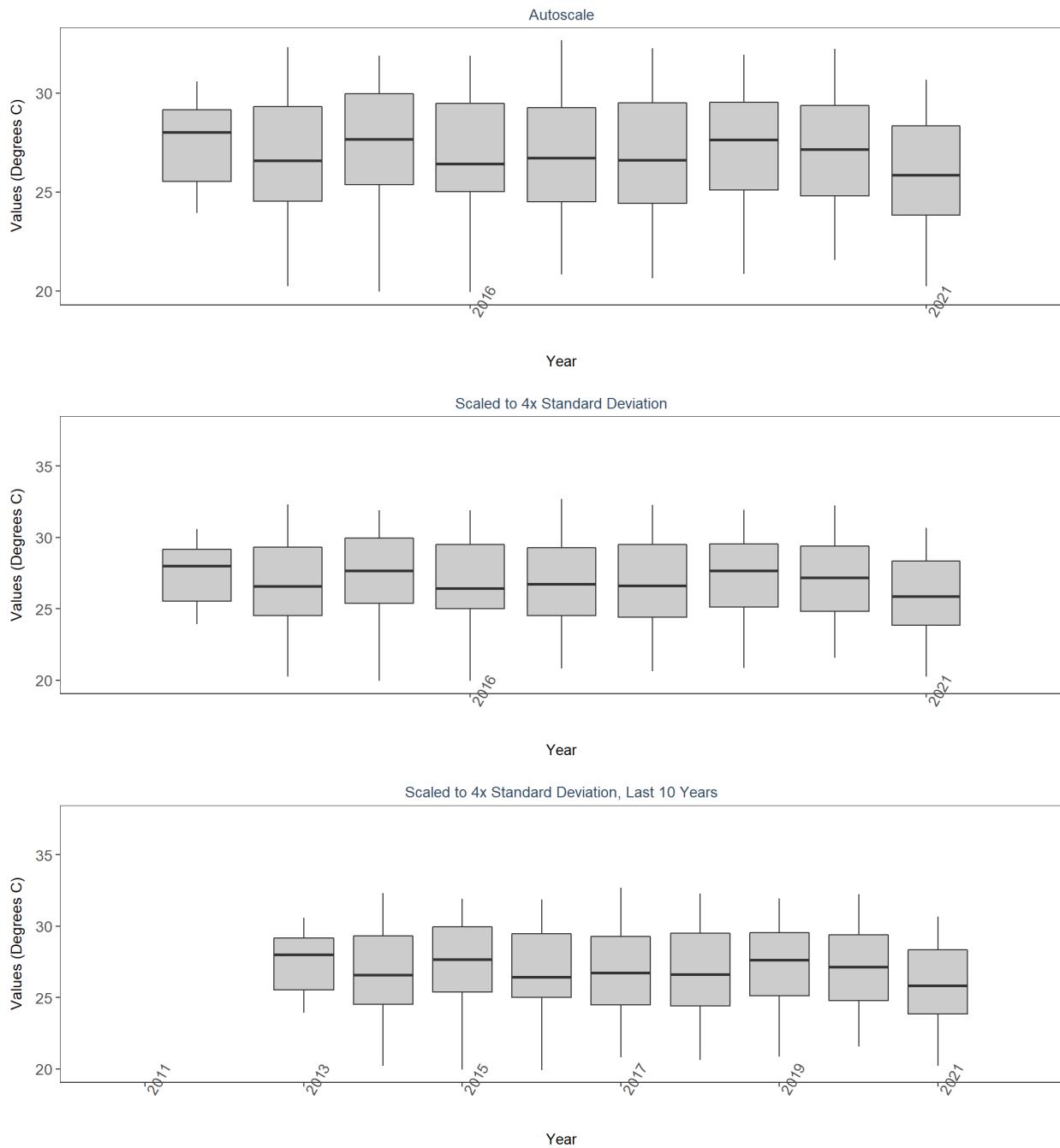
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 Water Temperature on Coral Reefs in the Florida Keys
 5
 By Year & Month



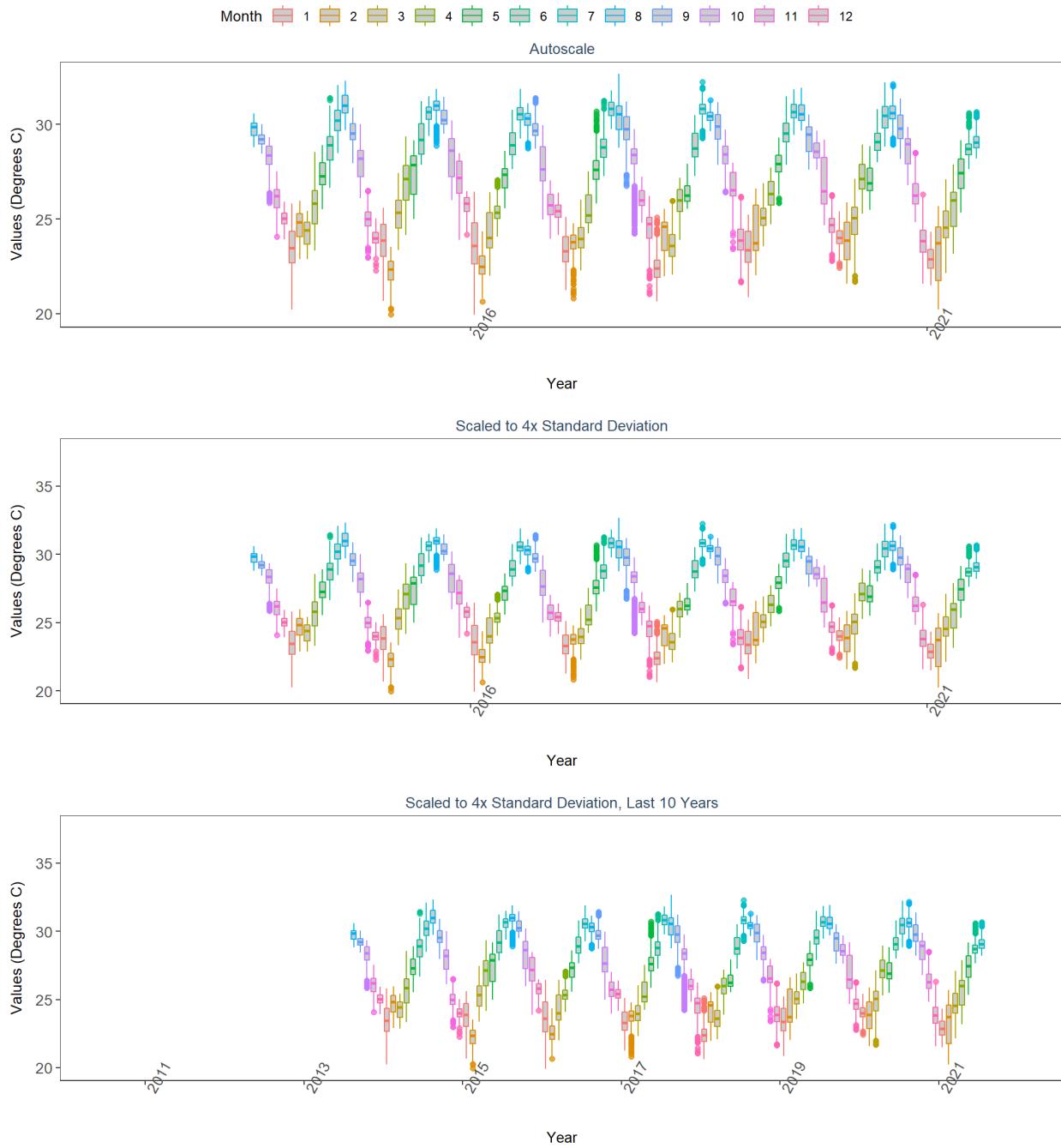
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 Water Temperature on Coral Reefs in the Florida Keys
 5
 By Month



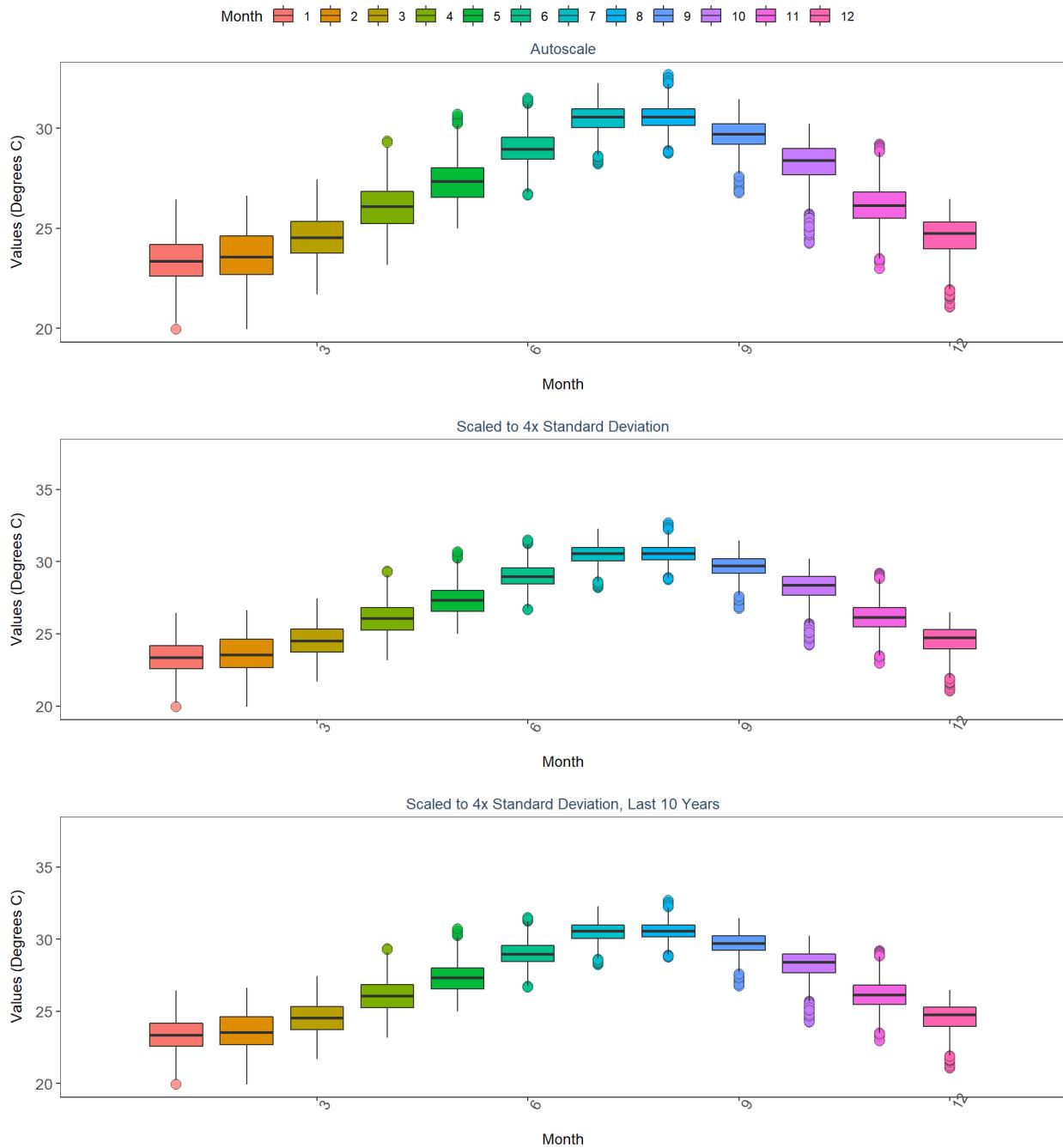
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 Water Temperature on Coral Reefs in the Florida Keys
 6
 By Year



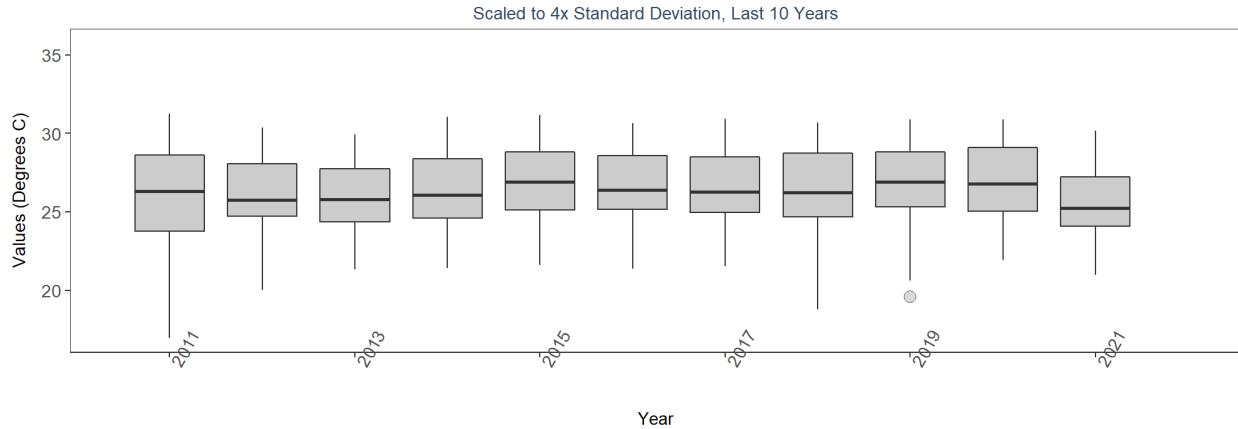
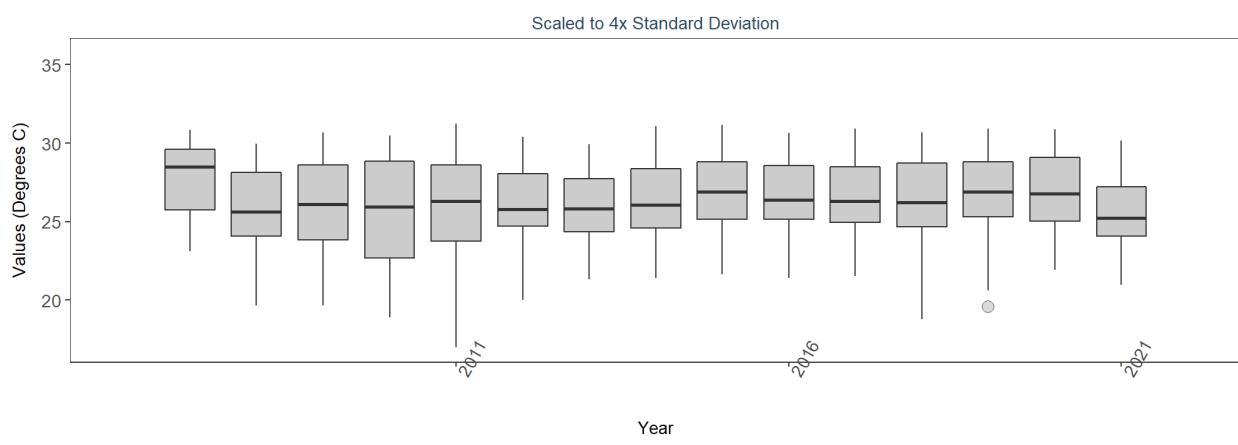
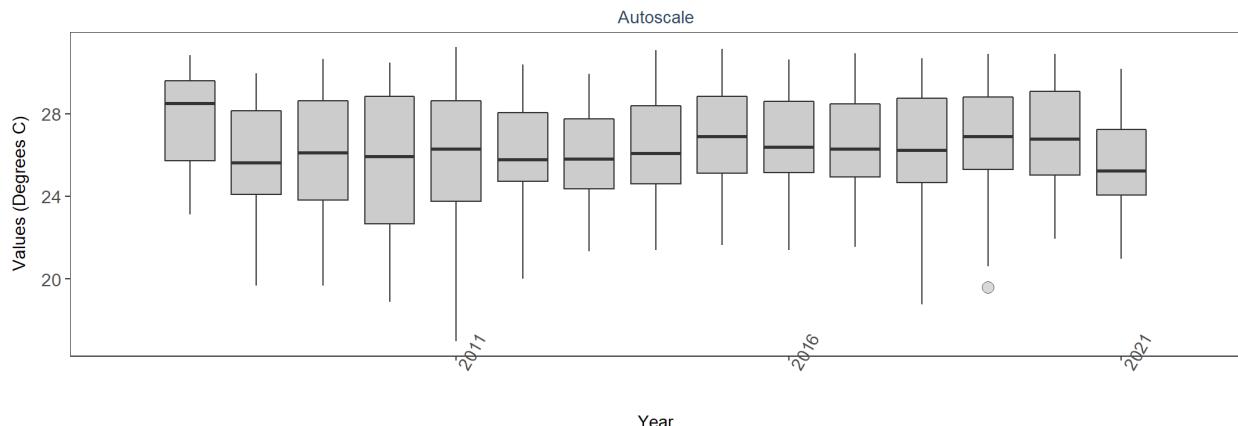
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
 6
 By Year & Month



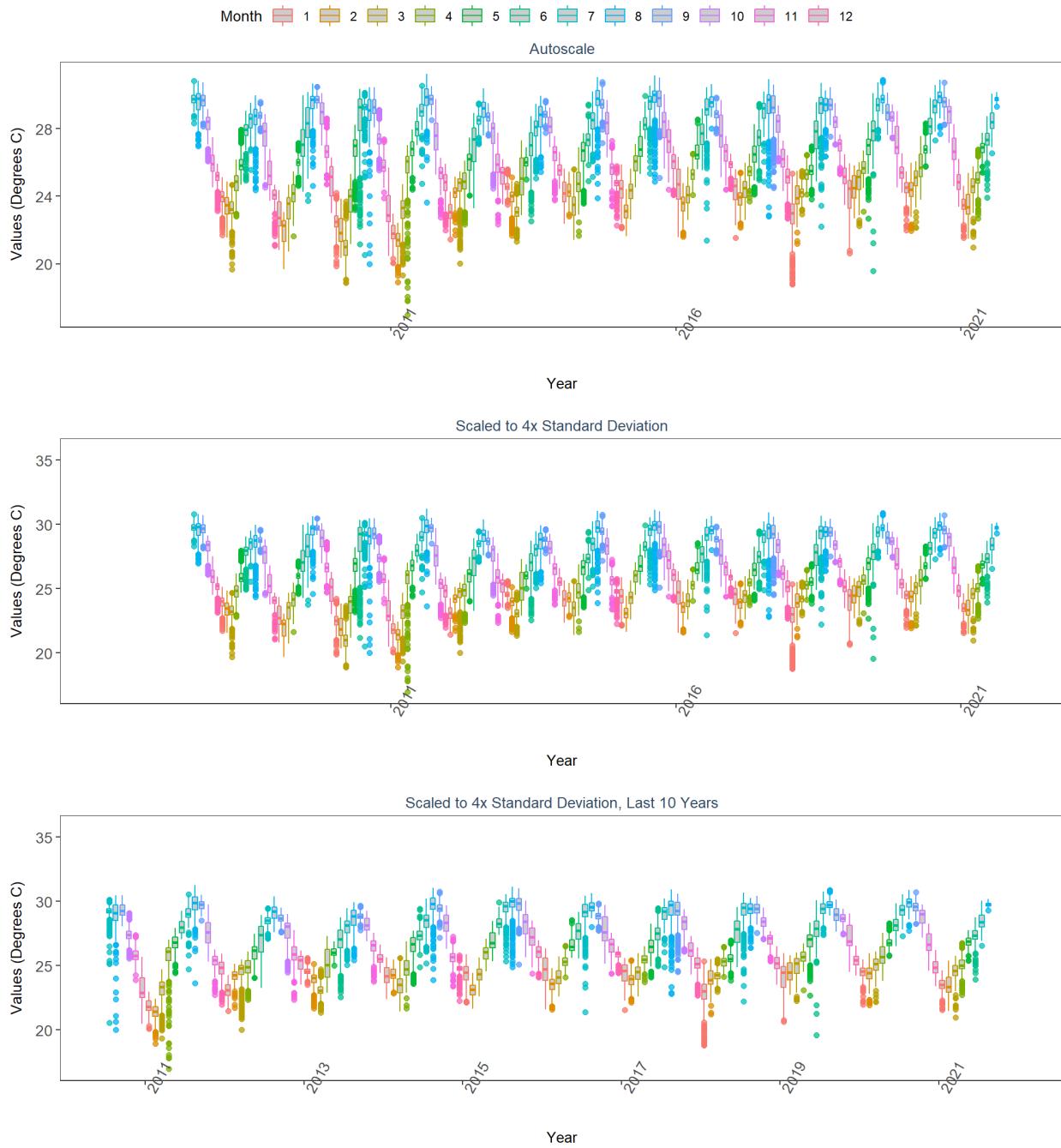
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 Water Temperature on Coral Reefs in the Florida Keys
 6
 By Month



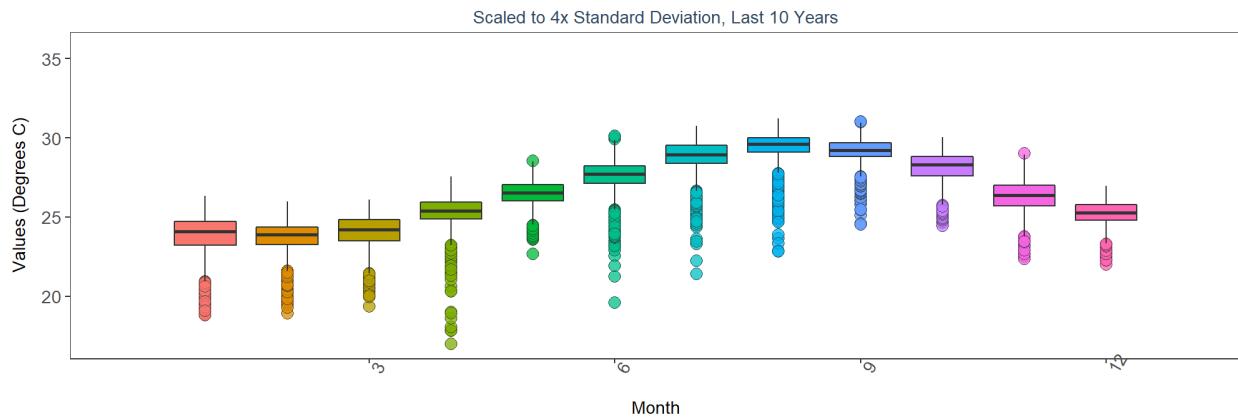
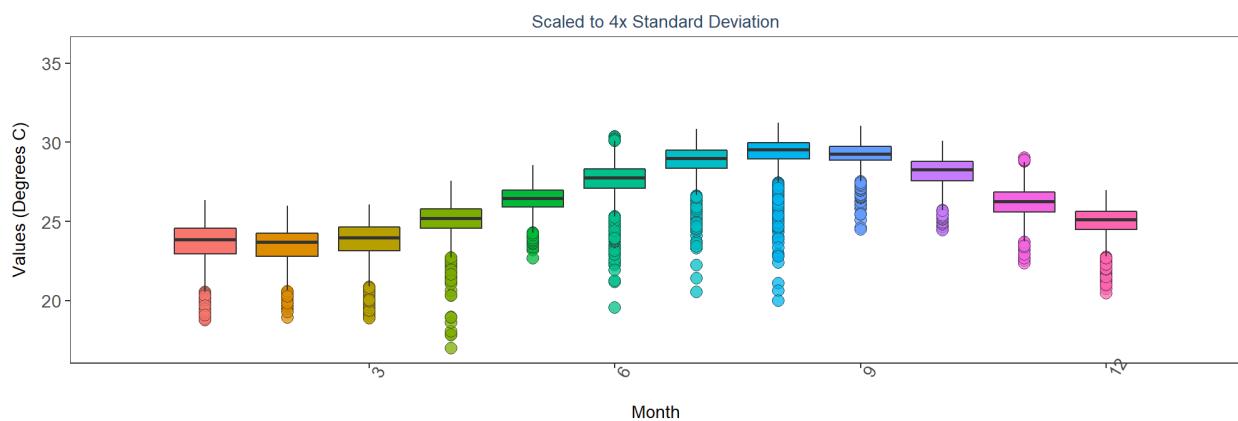
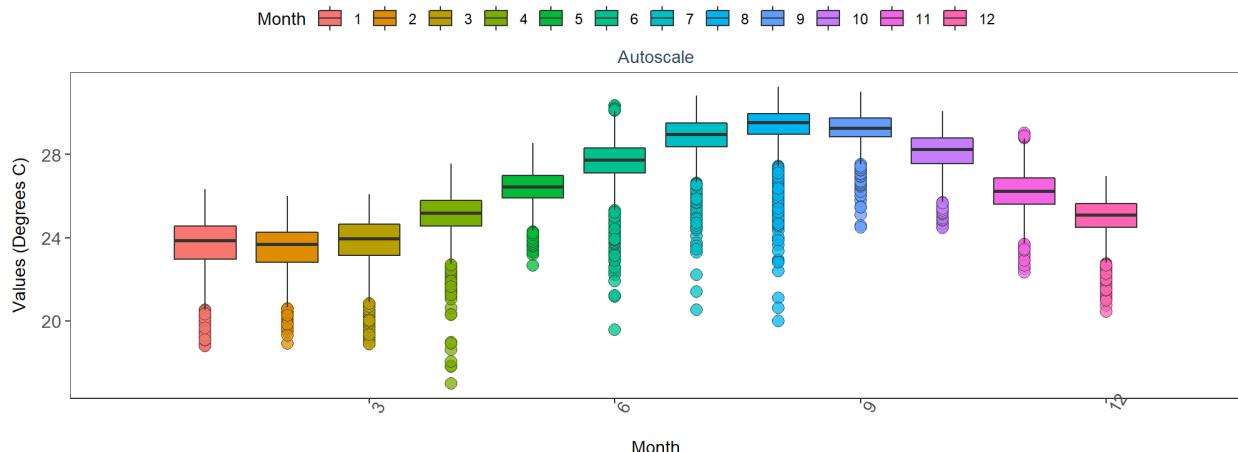
Southeast Florida Coral Reef Ecosystem Conservation Area
 986
 Water Temperature on Coral Reefs in the Florida Keys
 84
 By Year



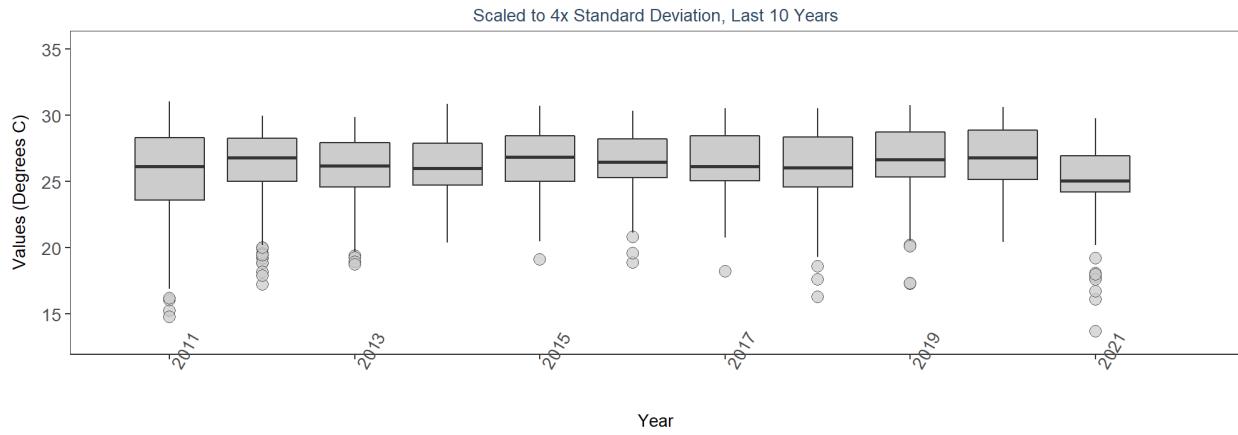
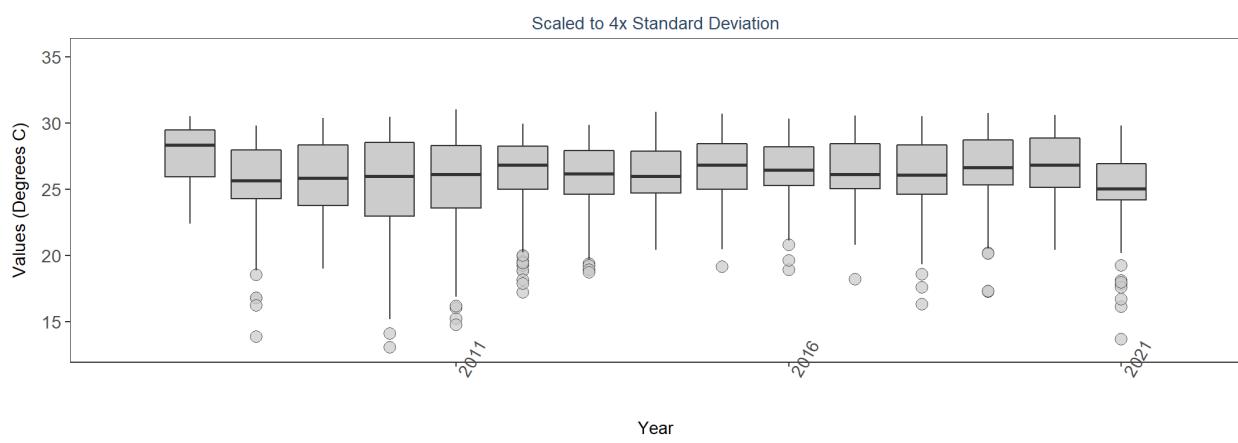
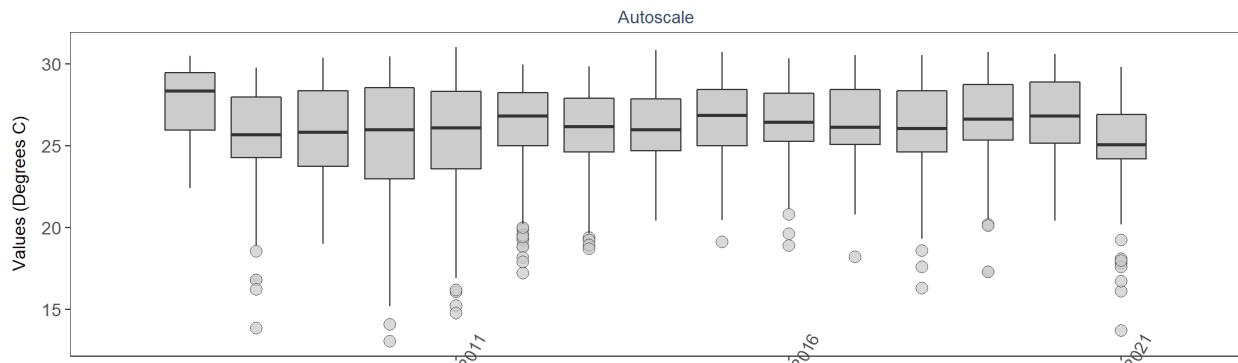
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 Water Temperature on Coral Reefs in the Florida Keys
 84
 By Year & Month



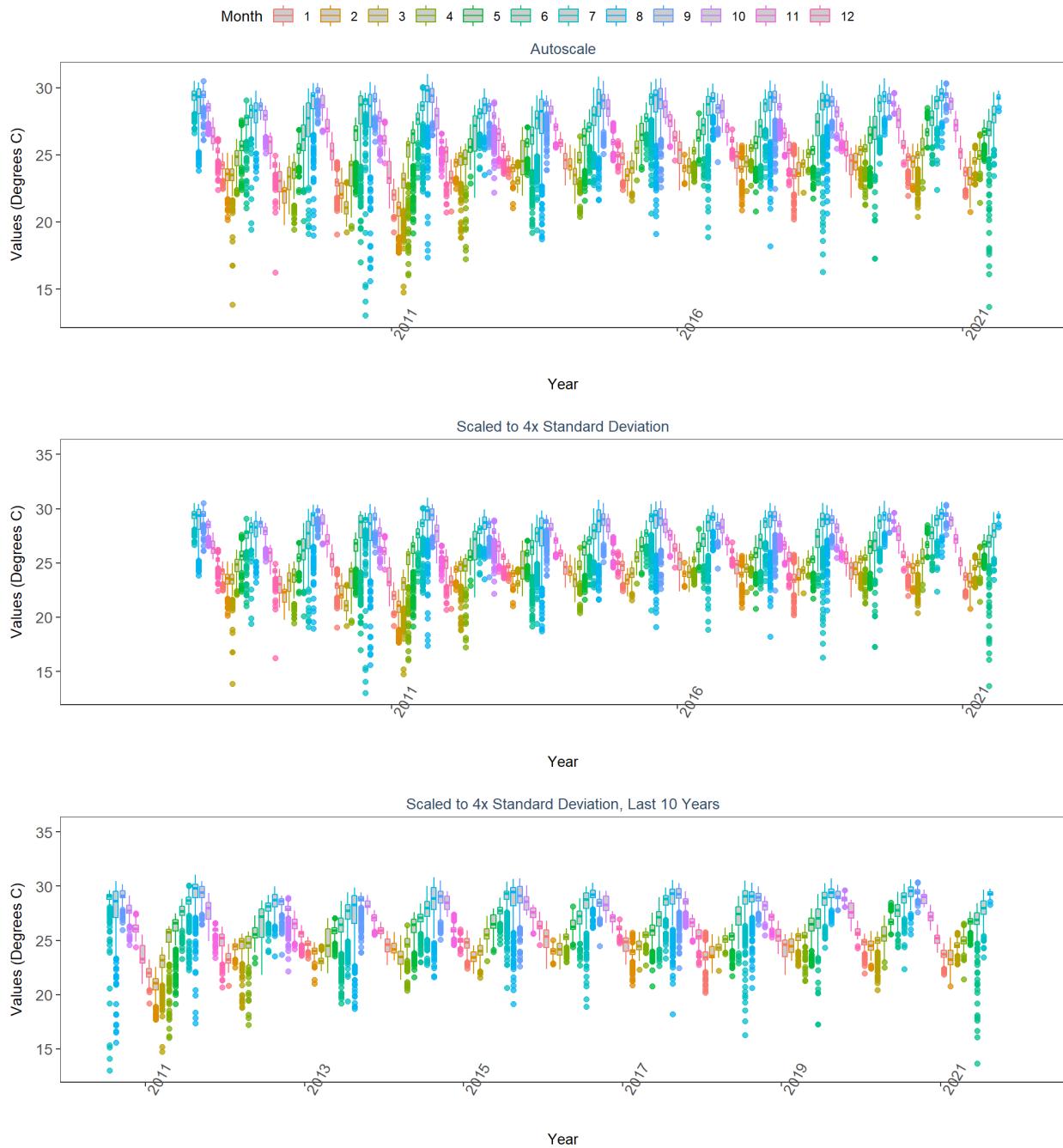
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 Water Temperature on Coral Reefs in the Florida Keys
 84
 By Month



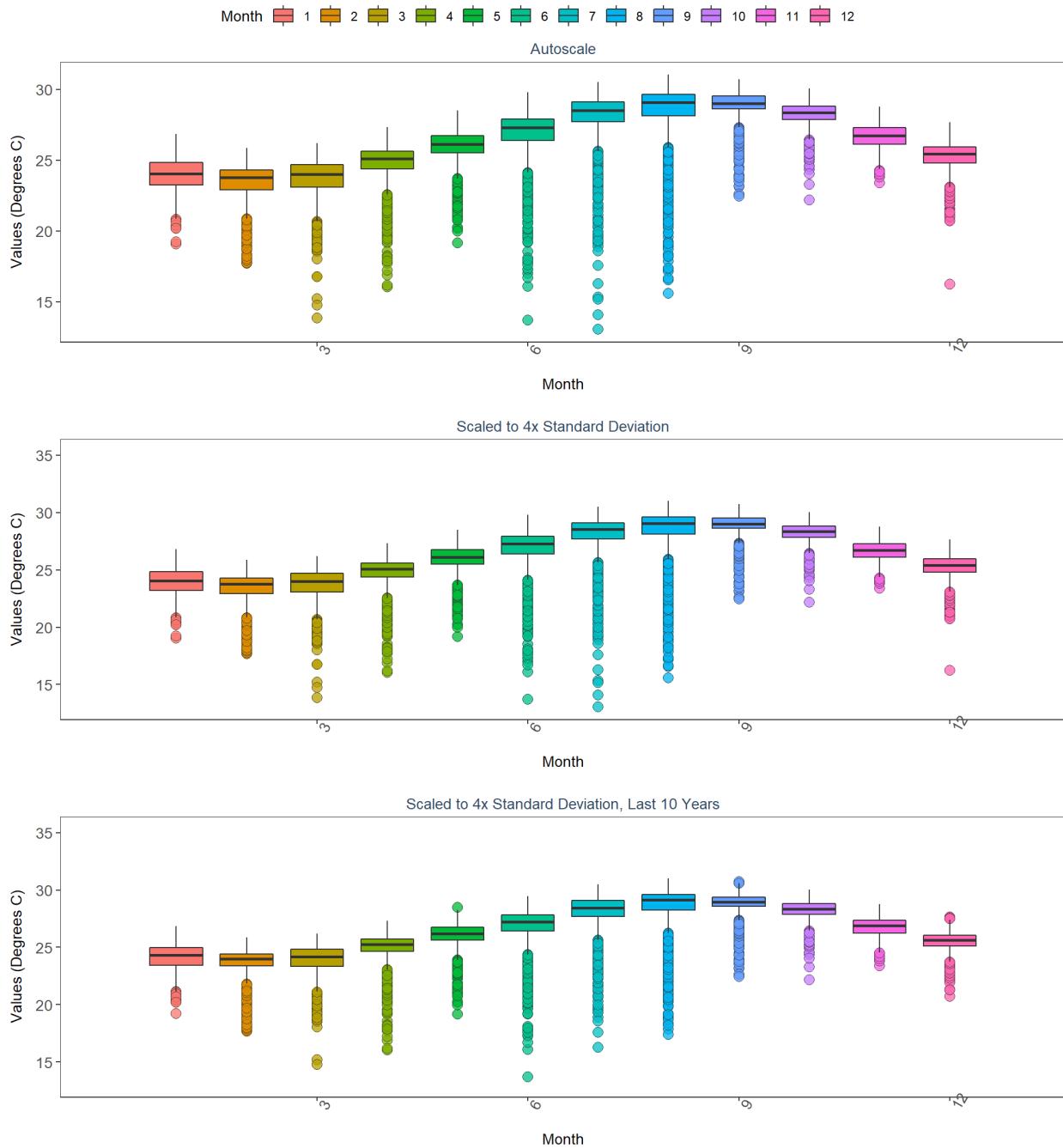
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 Water Temperature on Coral Reefs in the Florida Keys
 85
 By Year



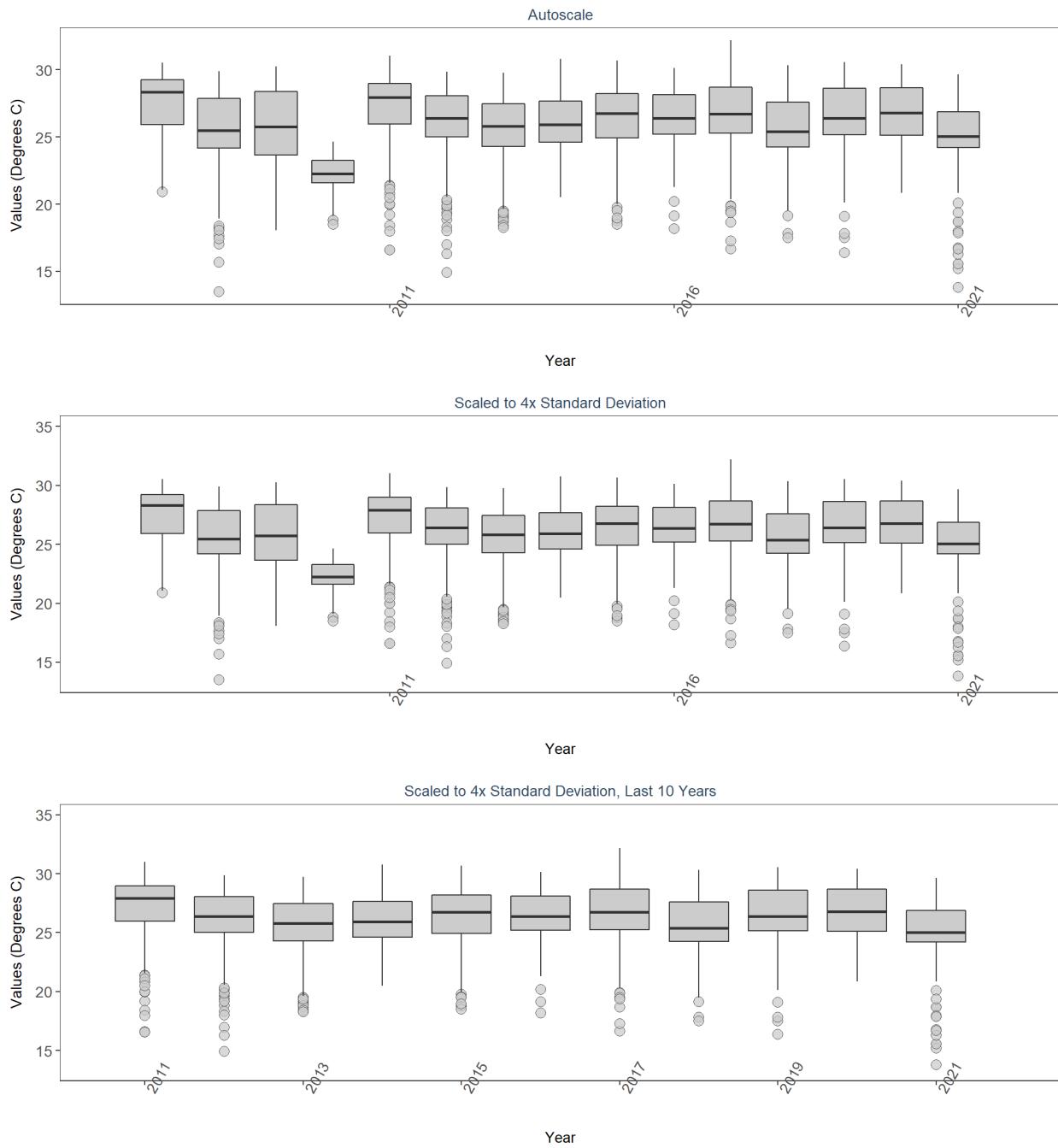
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



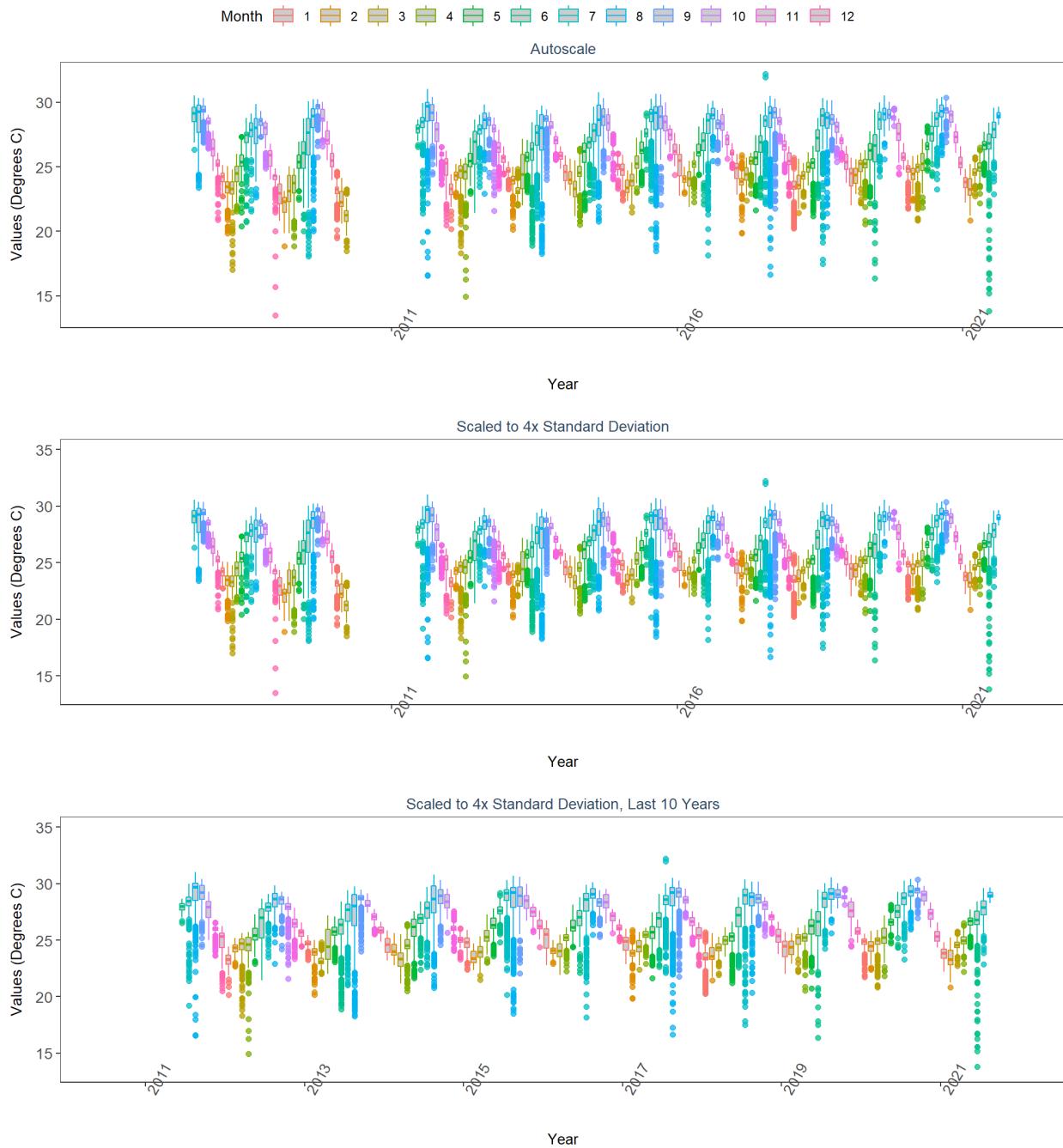
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 By Month



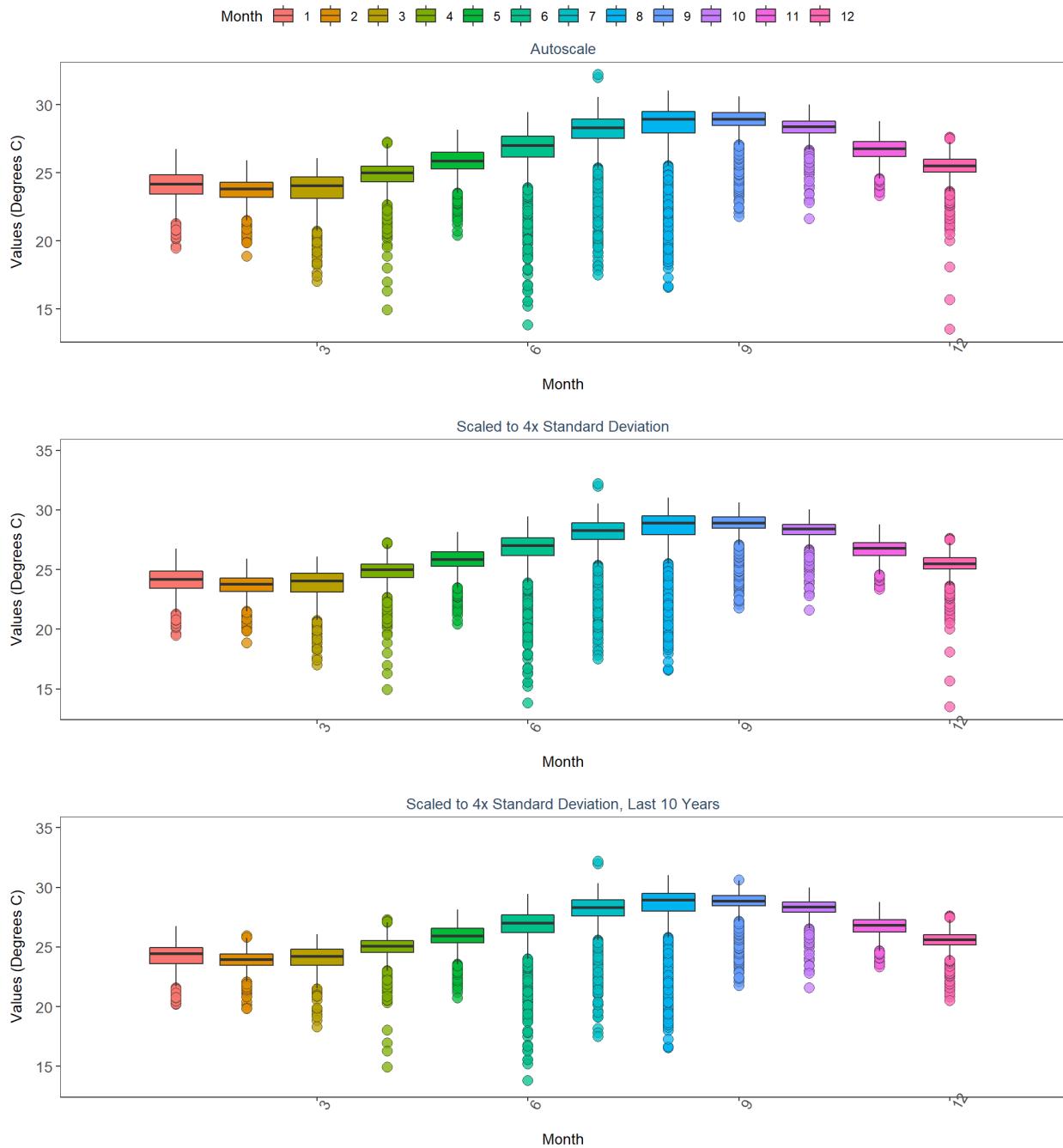
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



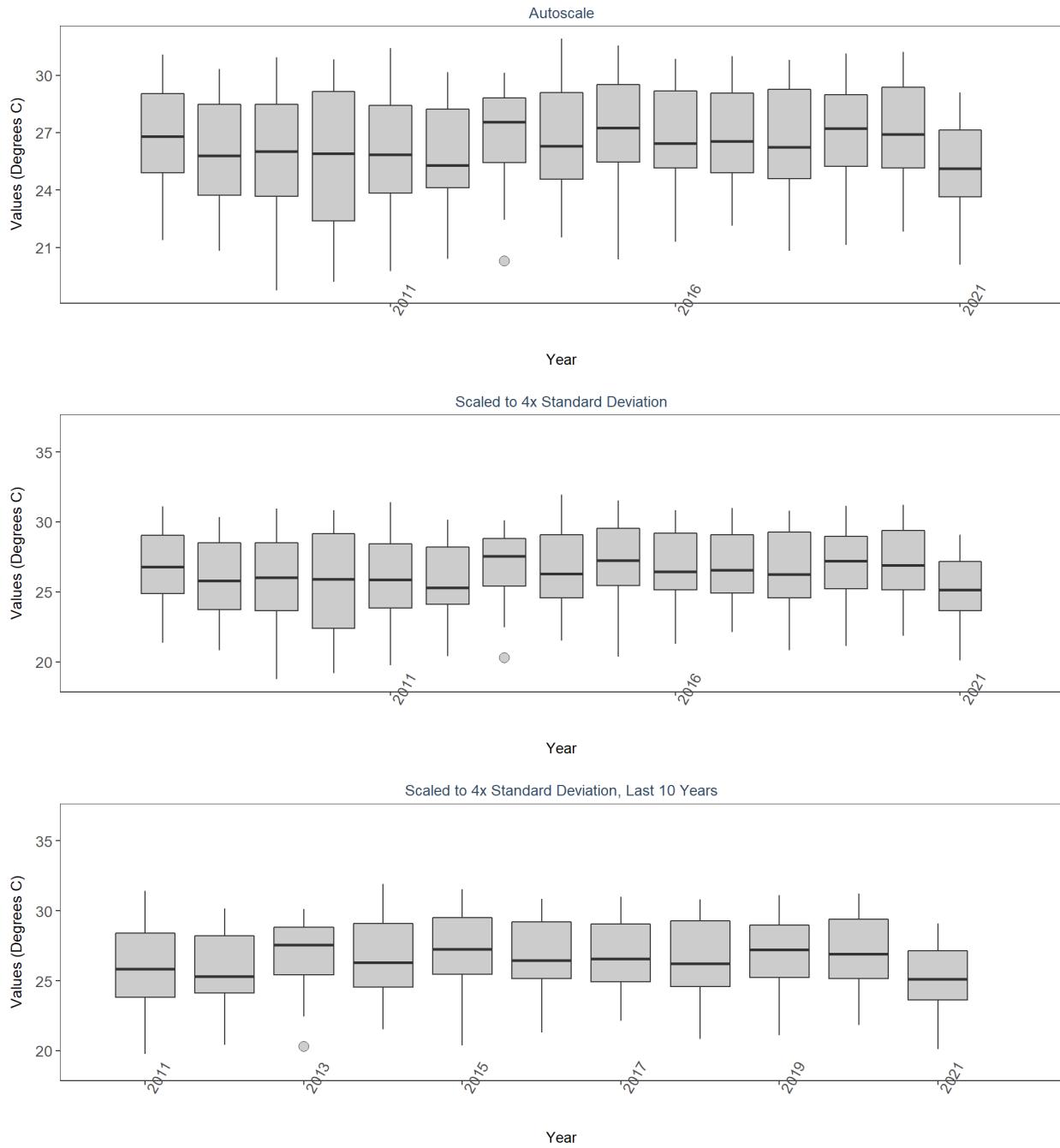
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



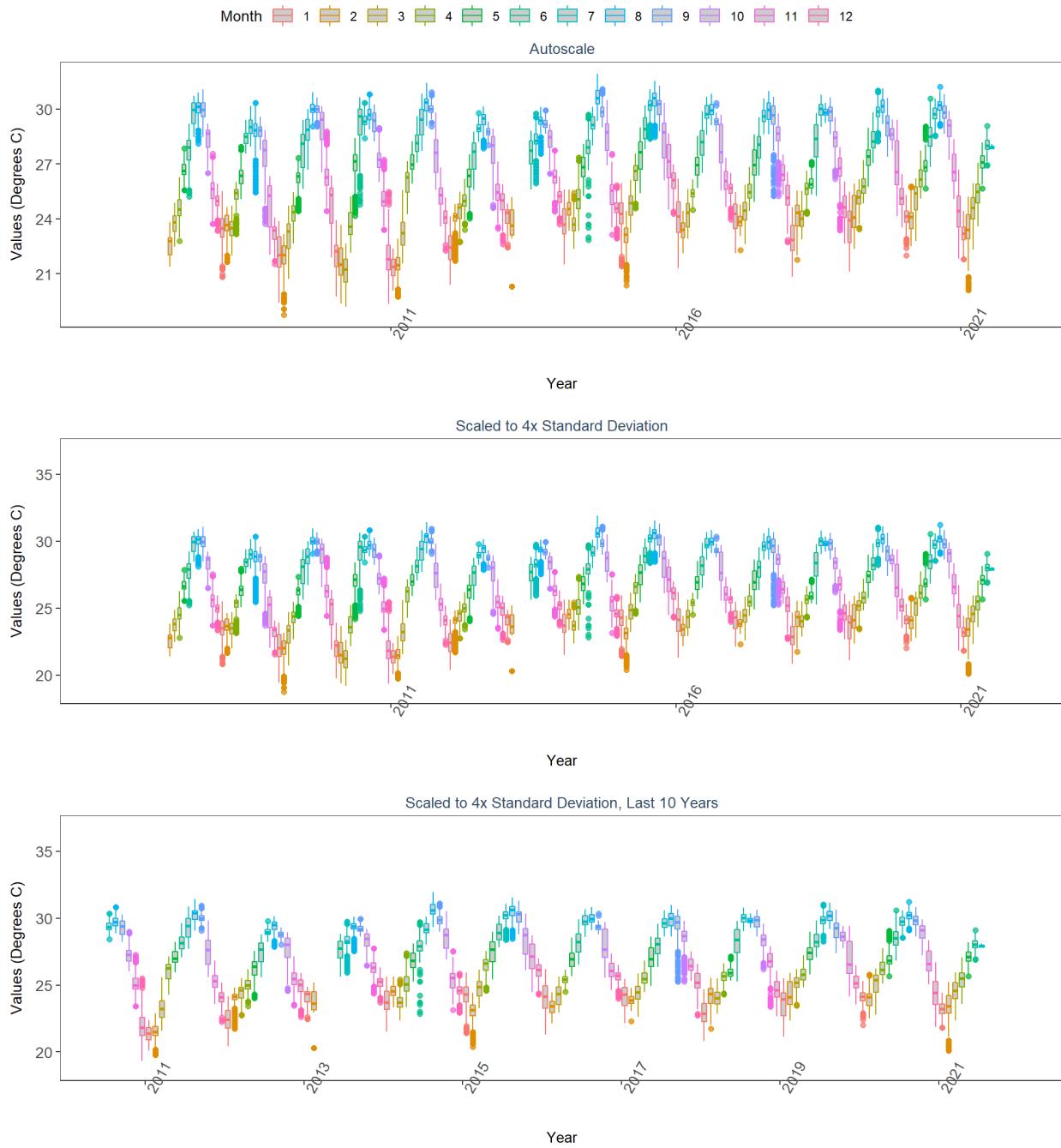
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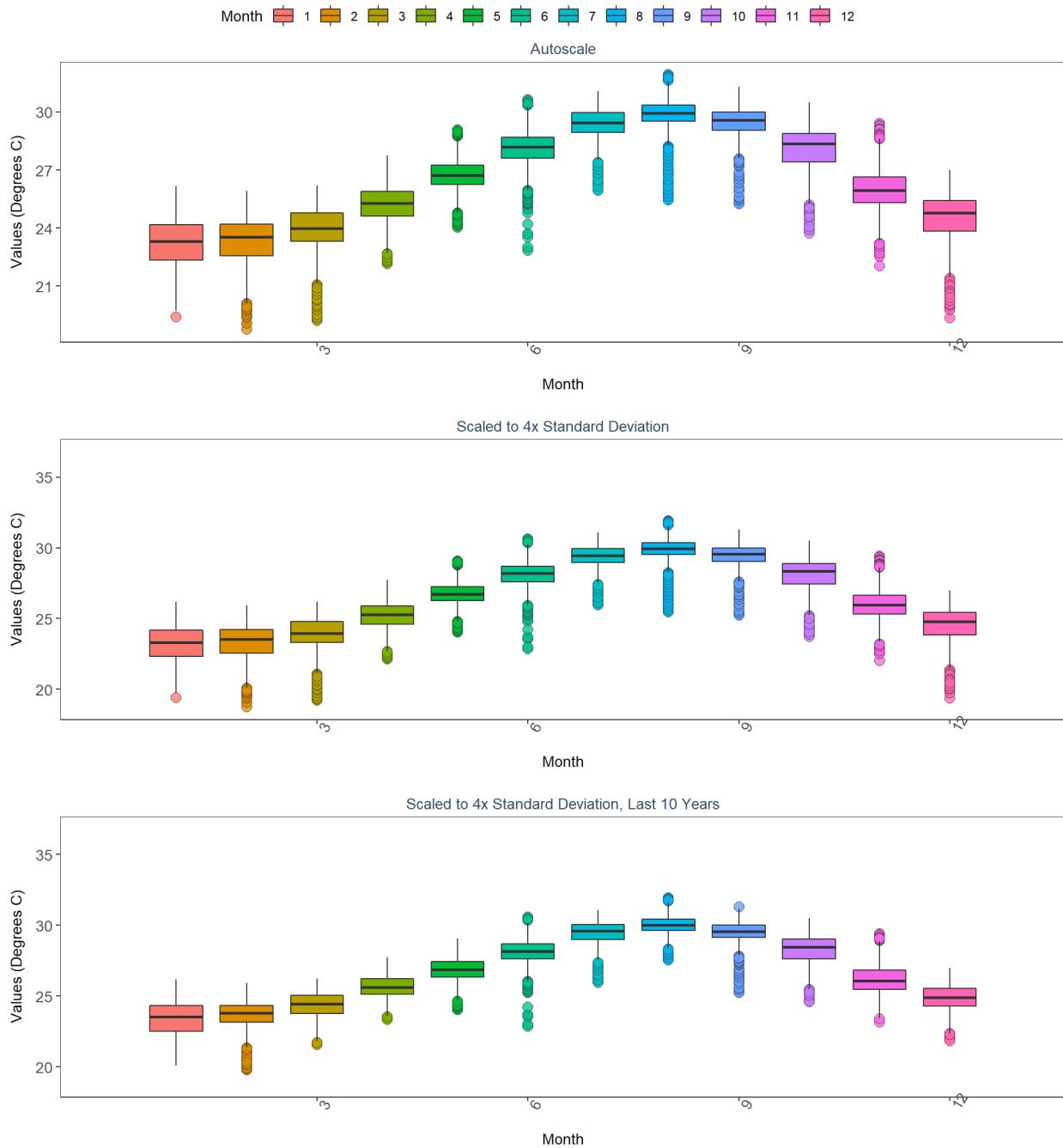
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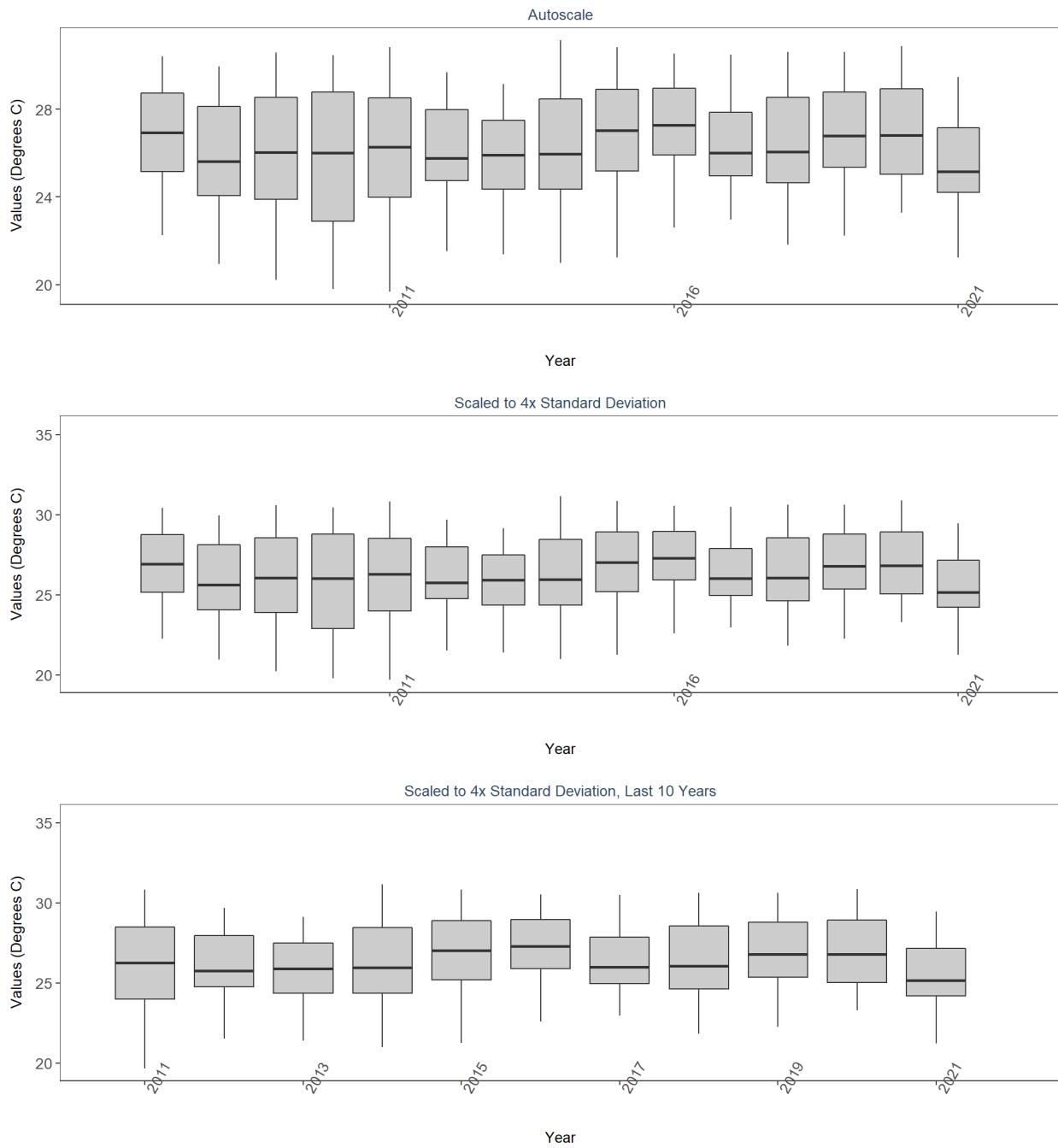
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



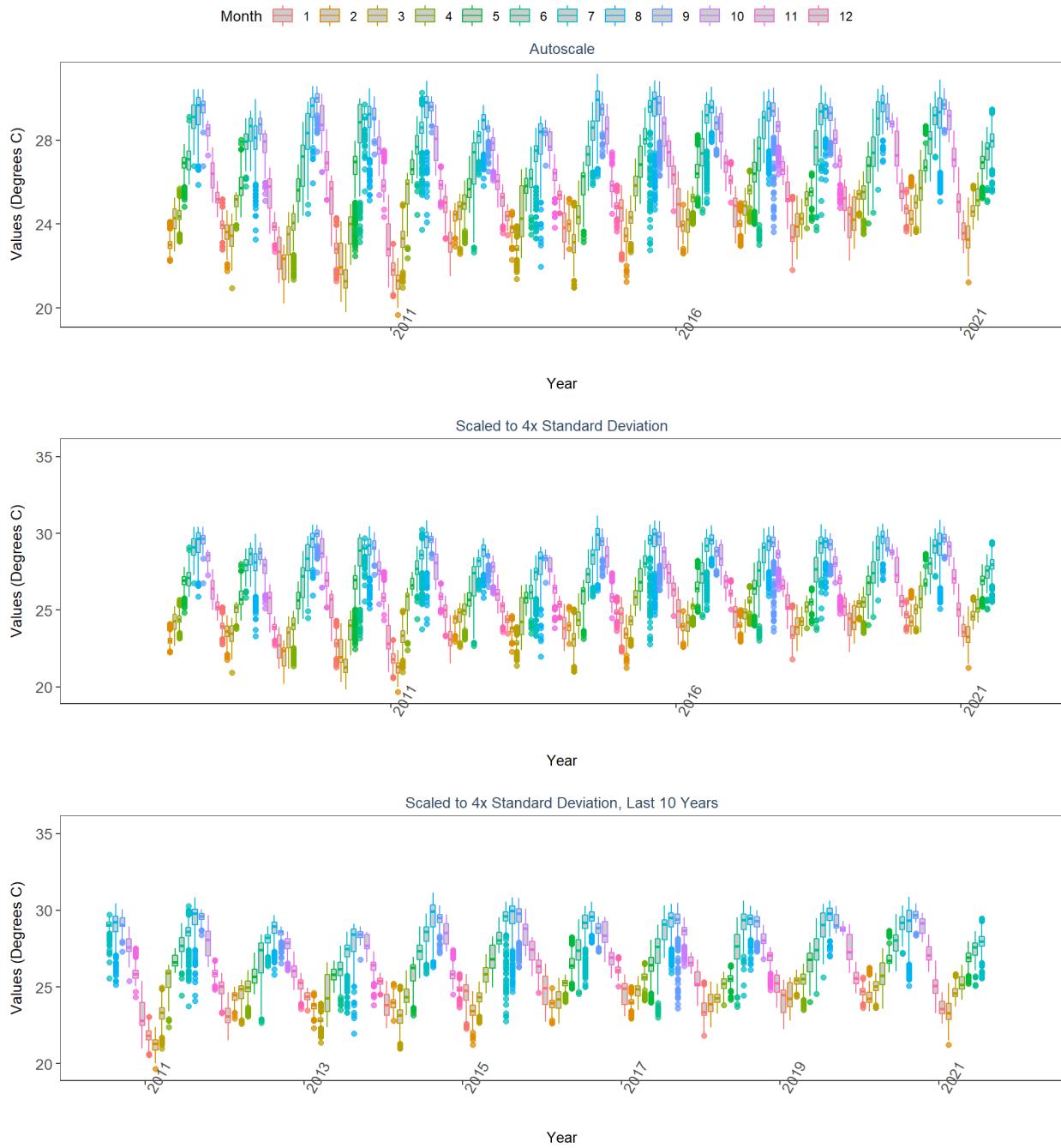
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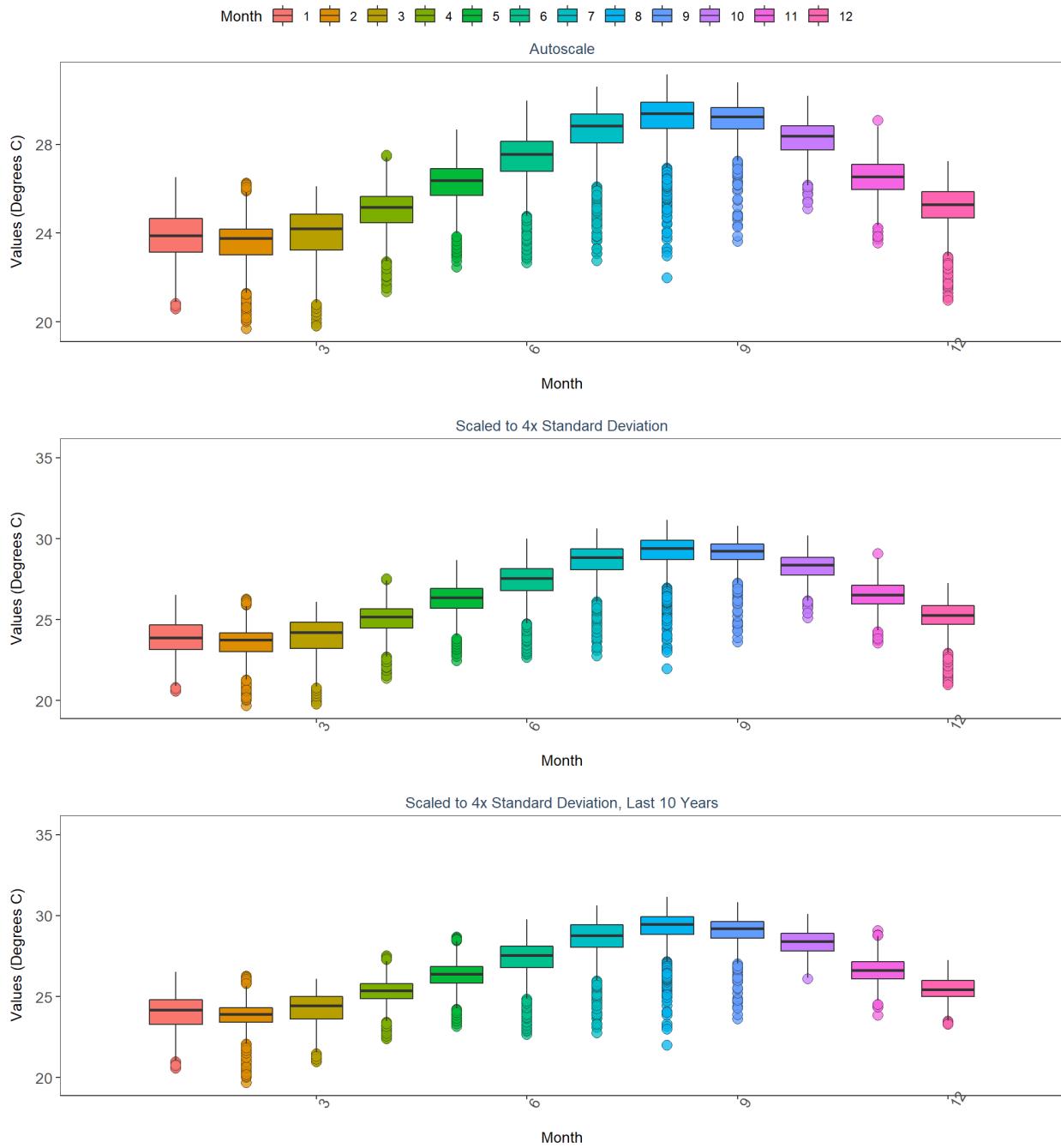
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 Water Temperature on Coral Reefs in the Florida Keys
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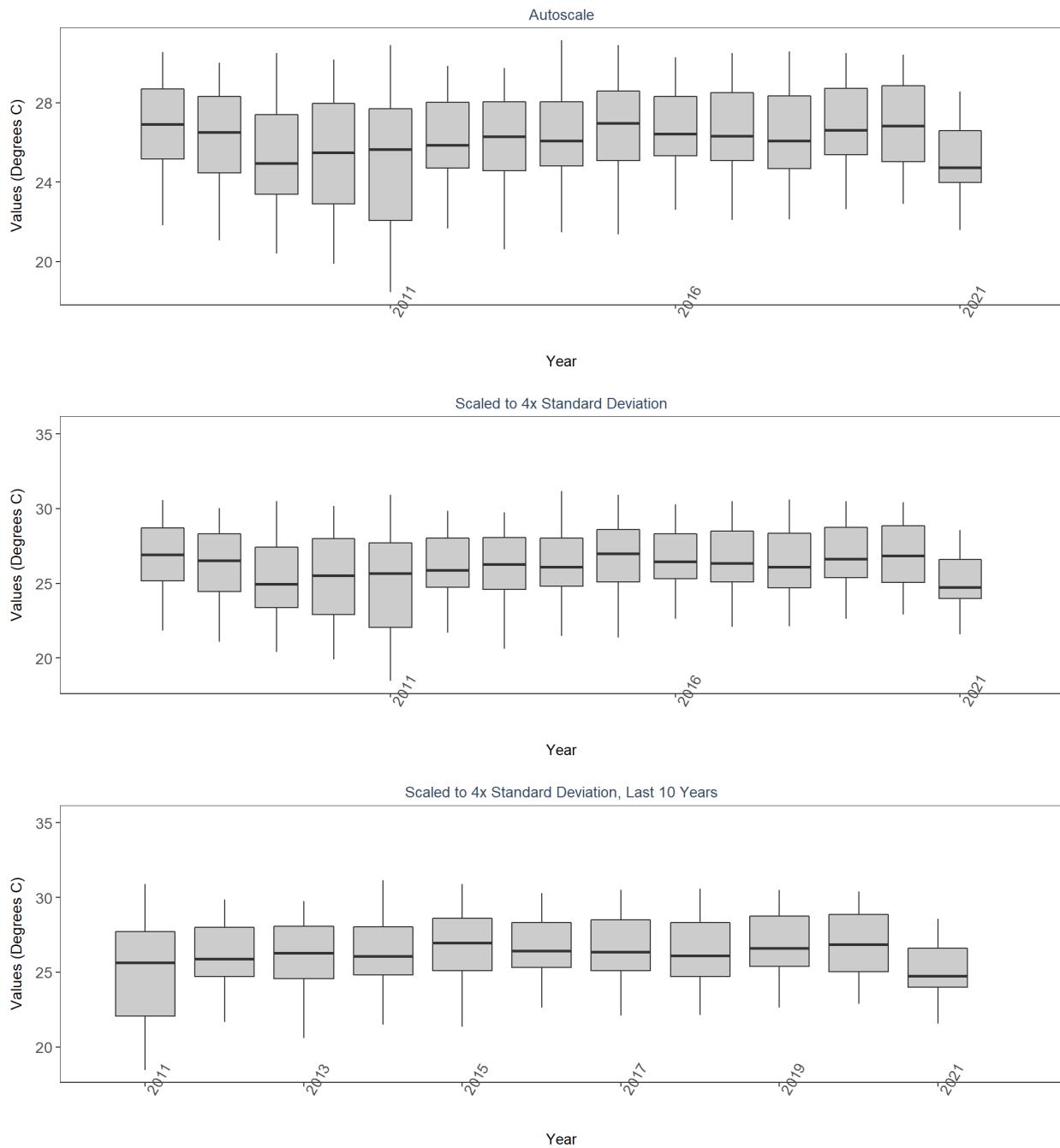
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 Water Temperature on Coral Reefs in the Florida Keys
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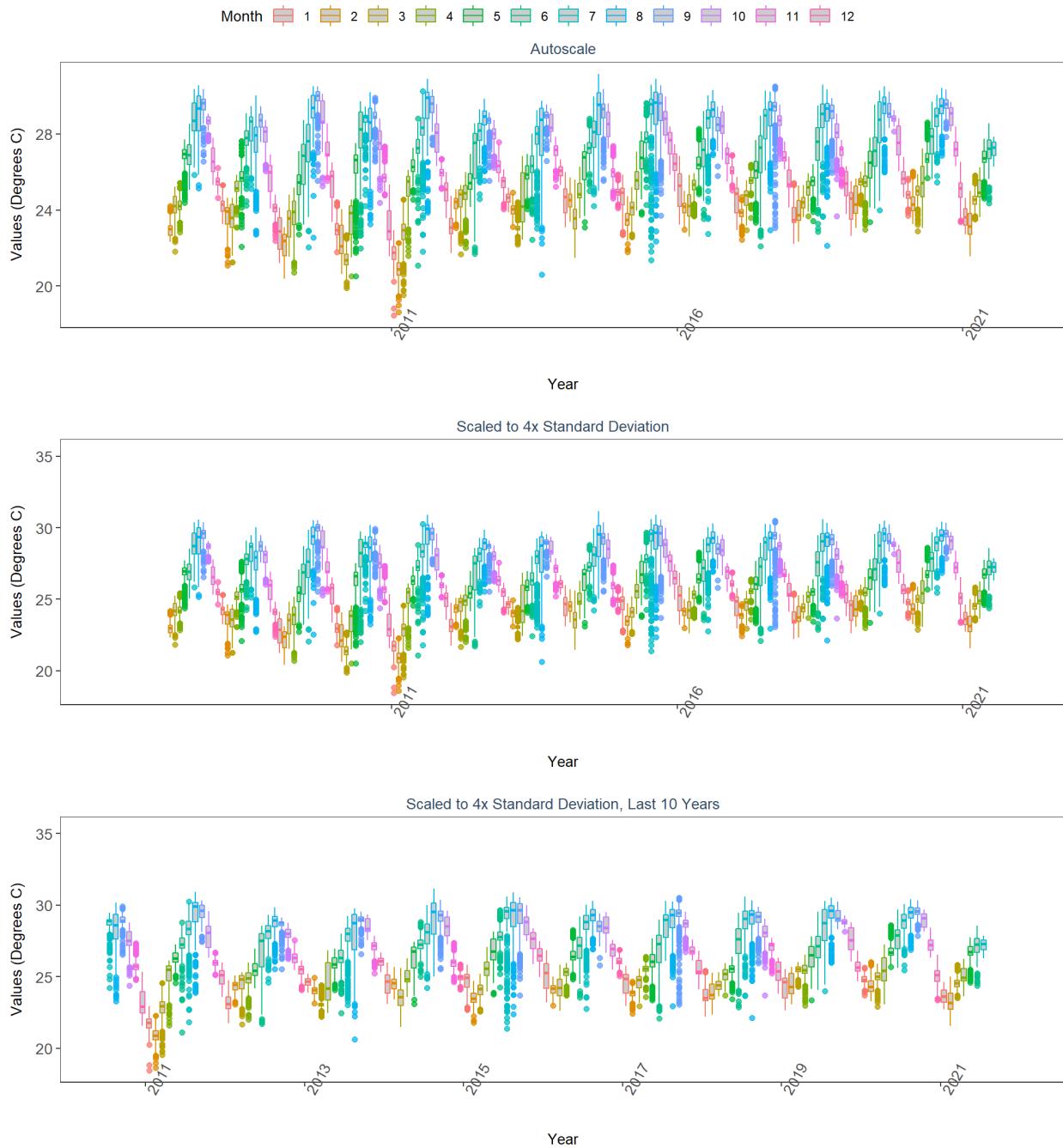
Southeast Florida Coral Reef Ecosystem Conservation Area
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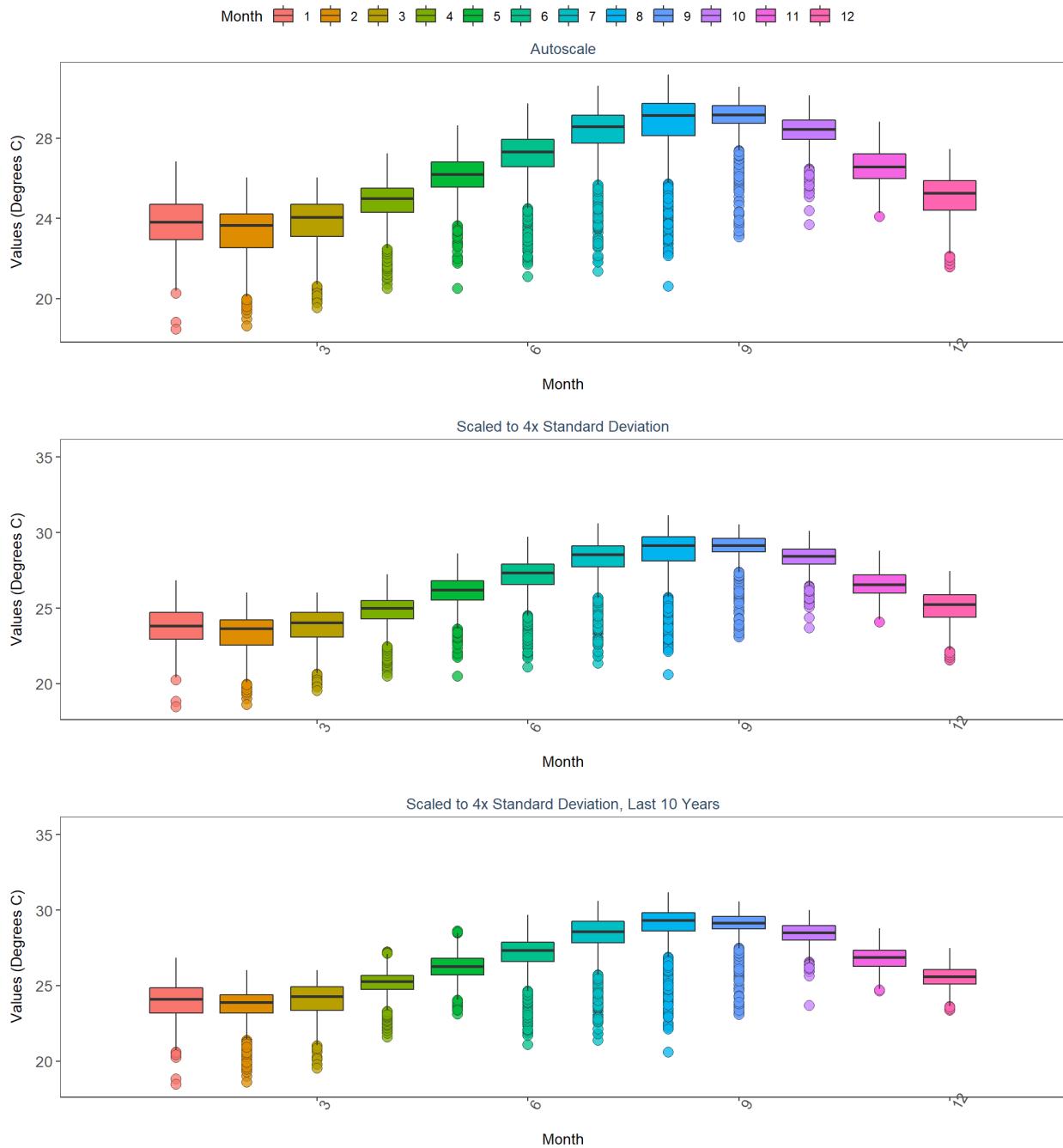
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 Water Temperature on Coral Reefs in the Florida Keys
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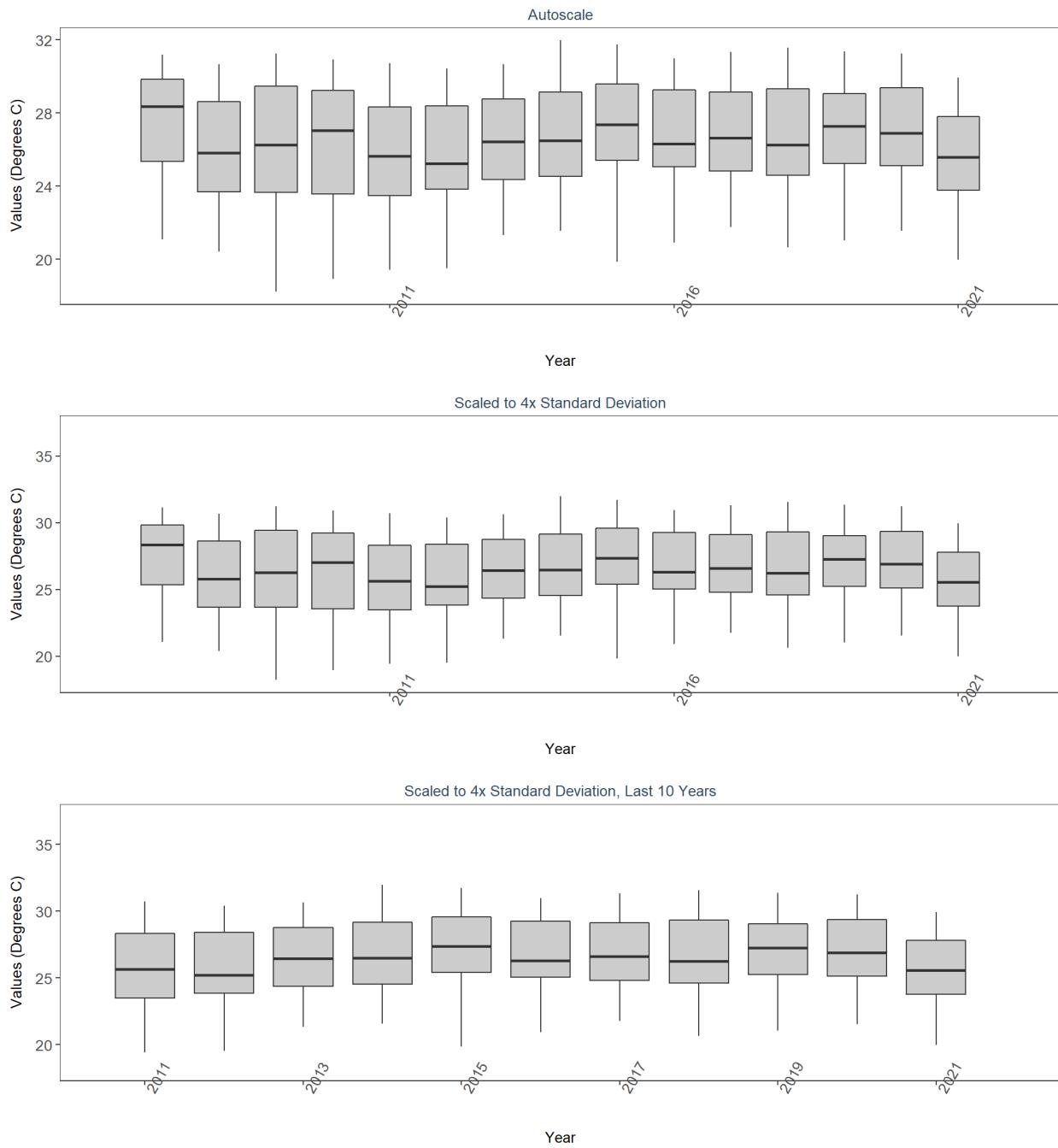
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
 89
 By Year & Month



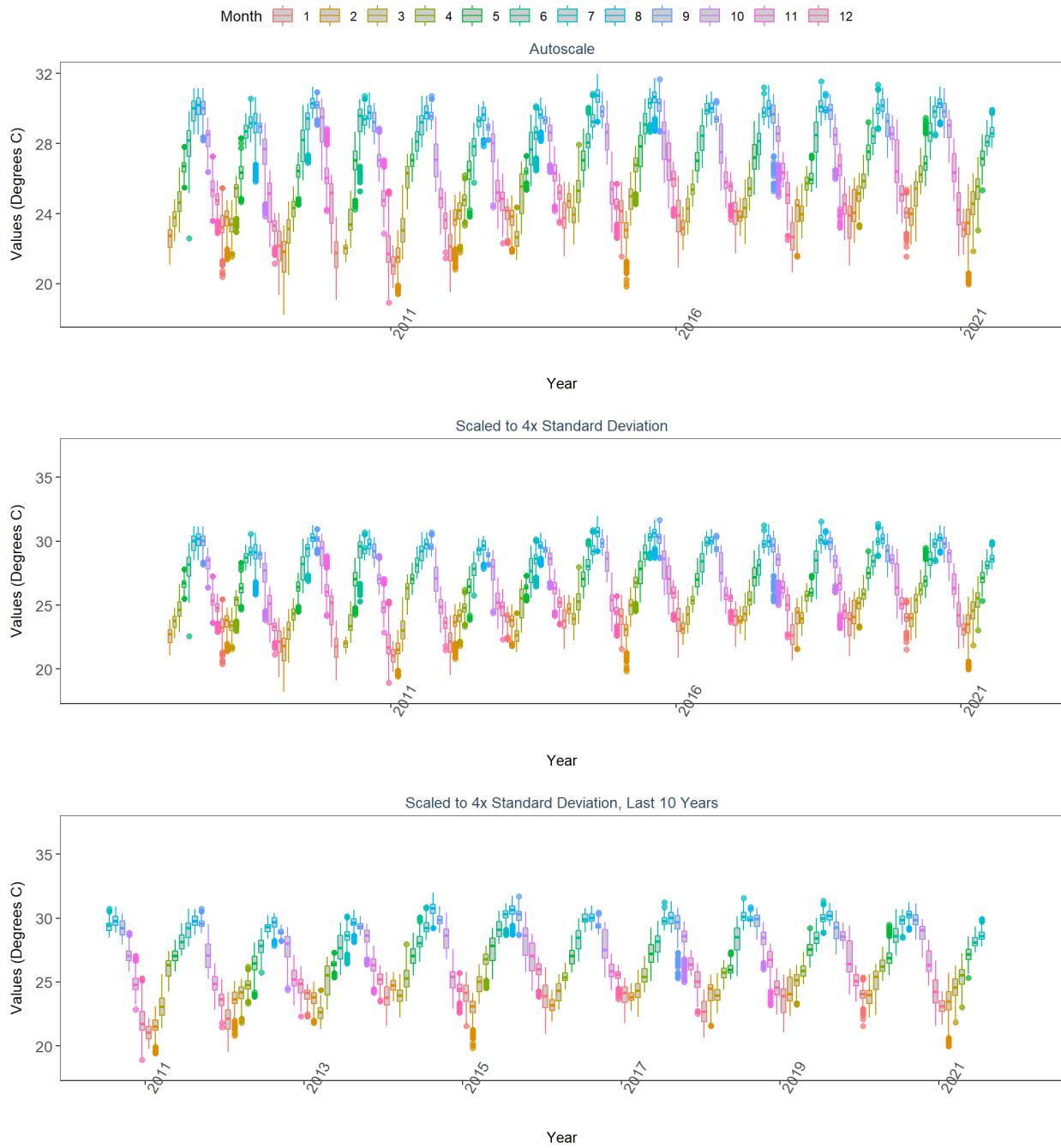
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
 89
 By Month



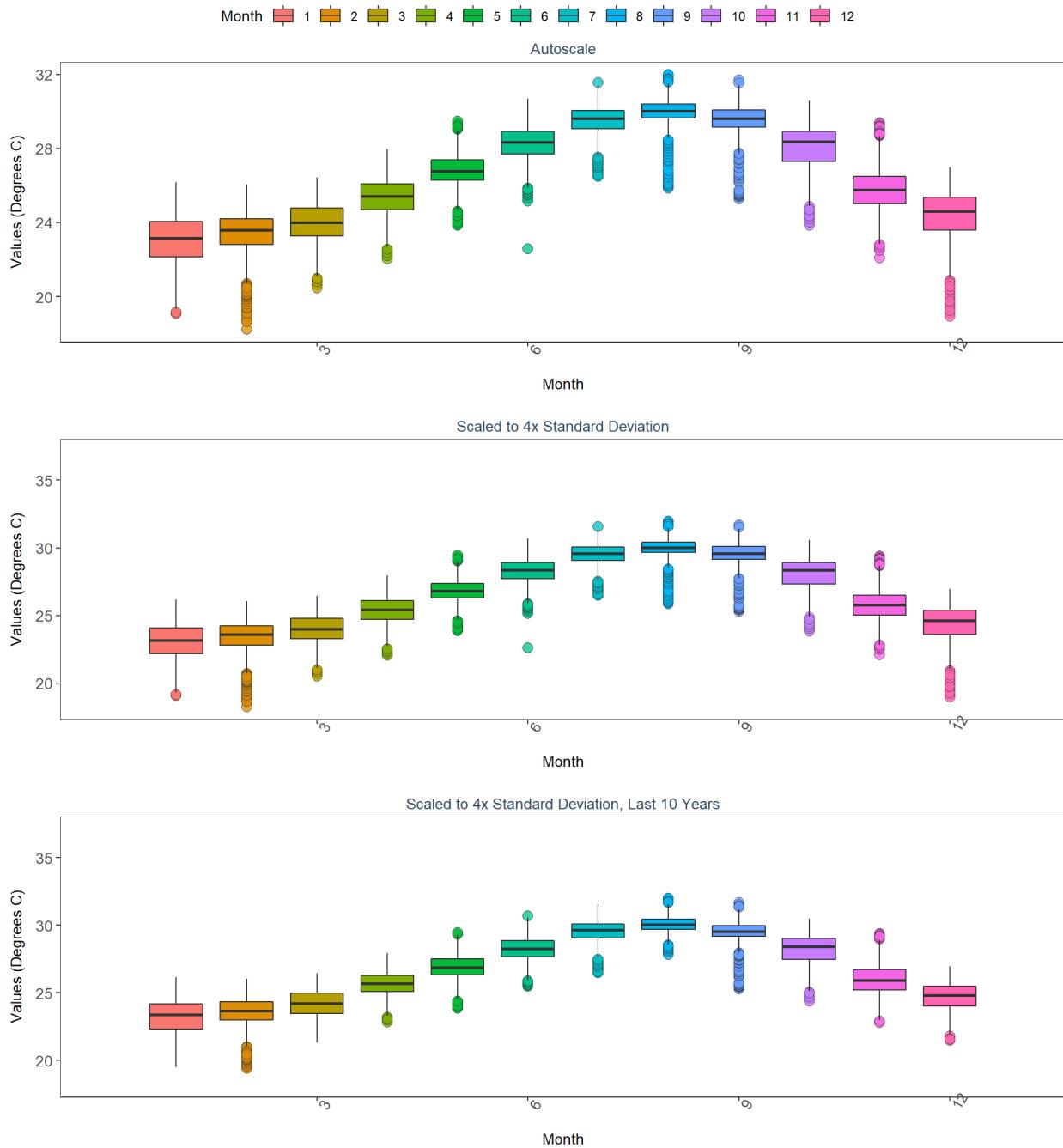
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
 90
 By Year



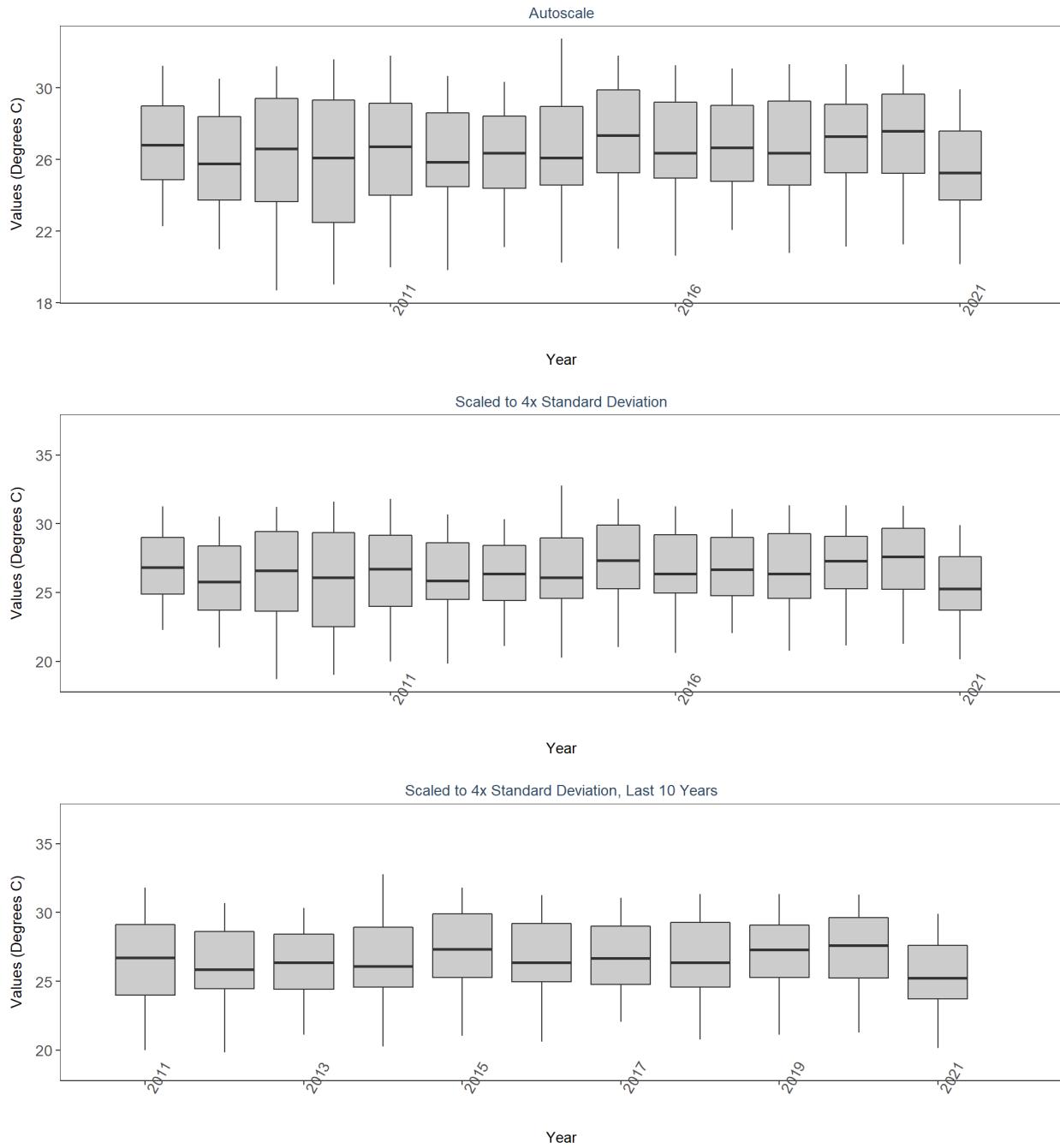
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
 90
 By Year & Month



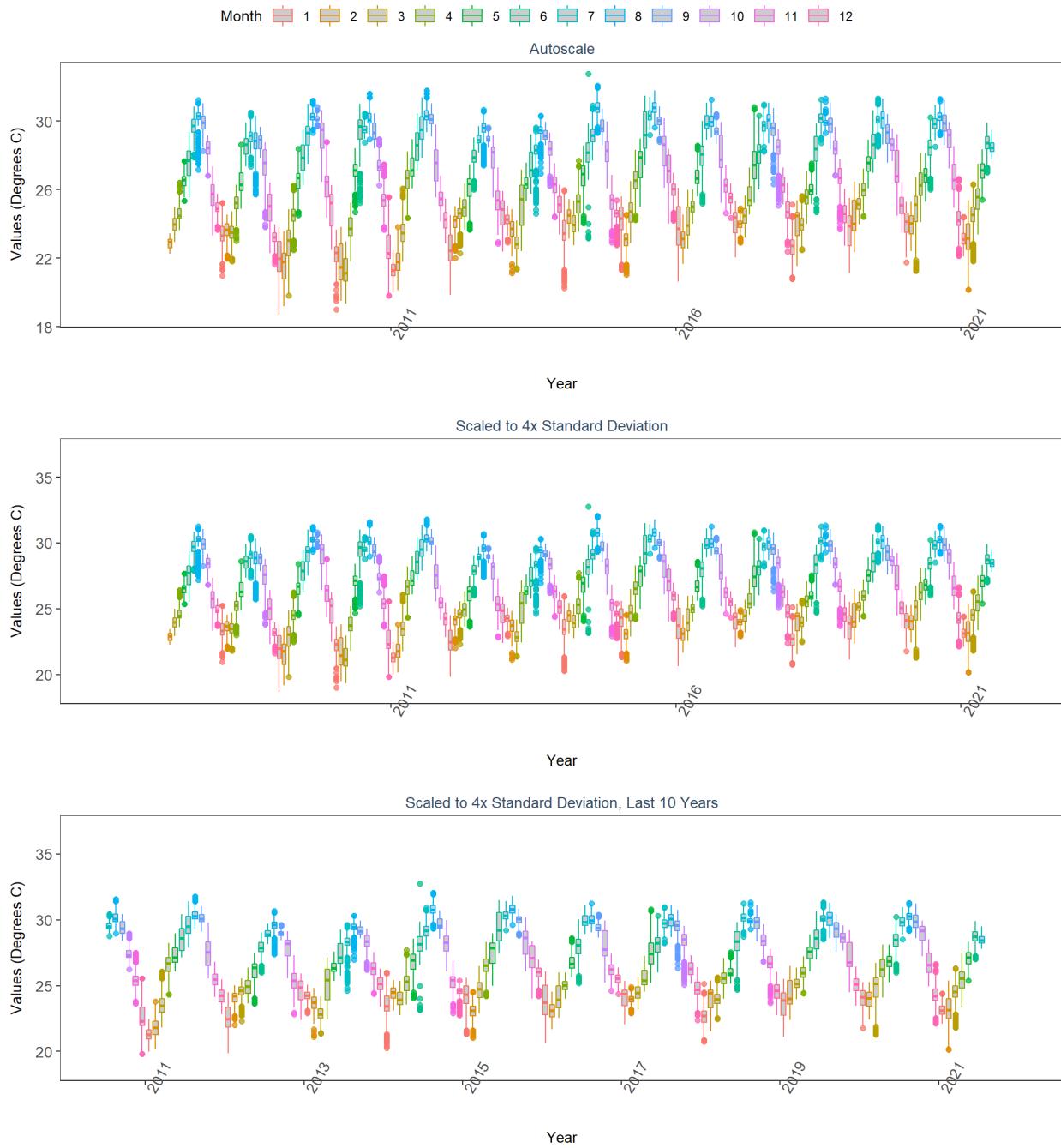
Southeast Florida Coral Reef Ecosystem Conservation Area
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



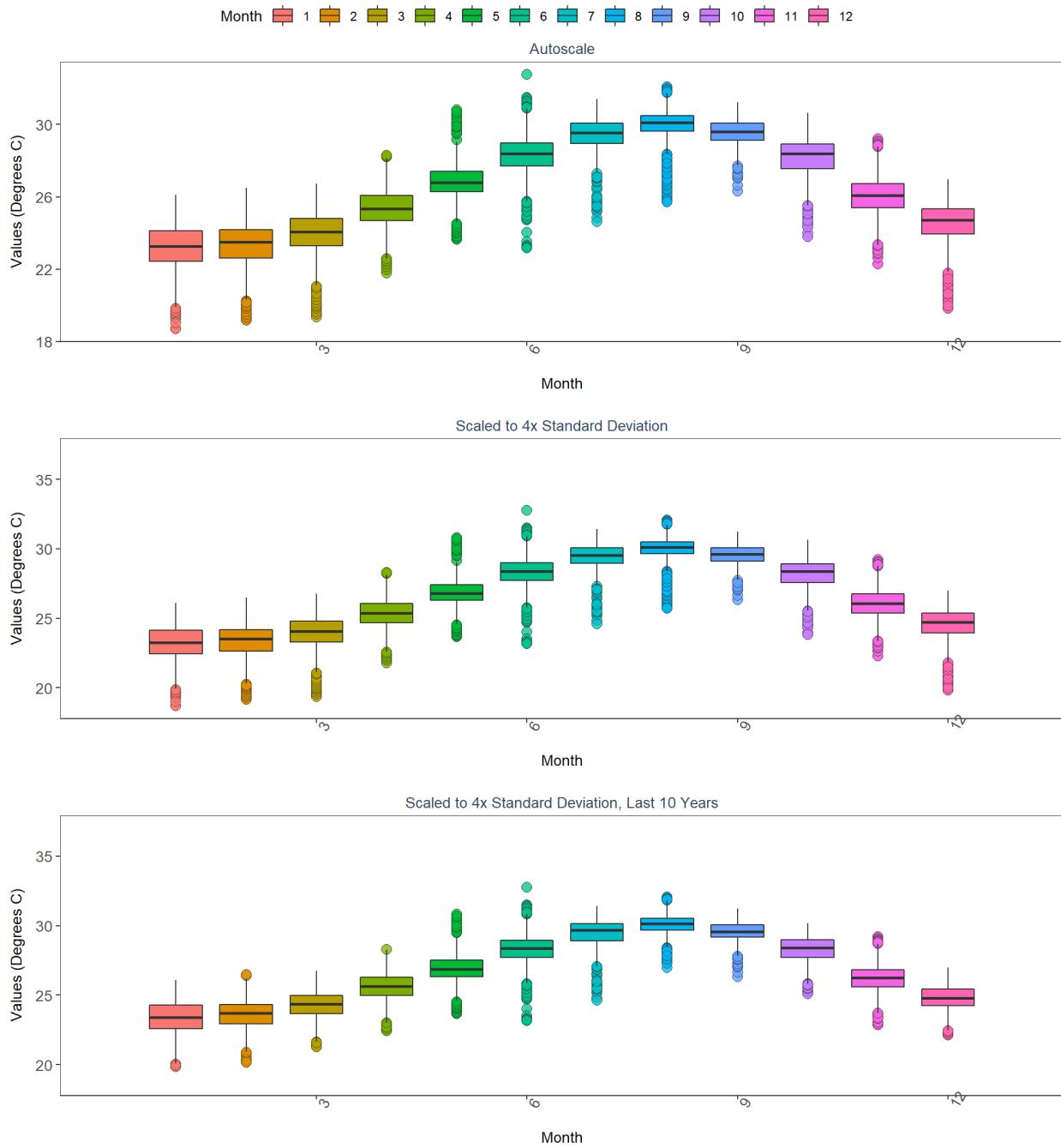
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 Water Temperature on Coral Reefs in the Florida Keys
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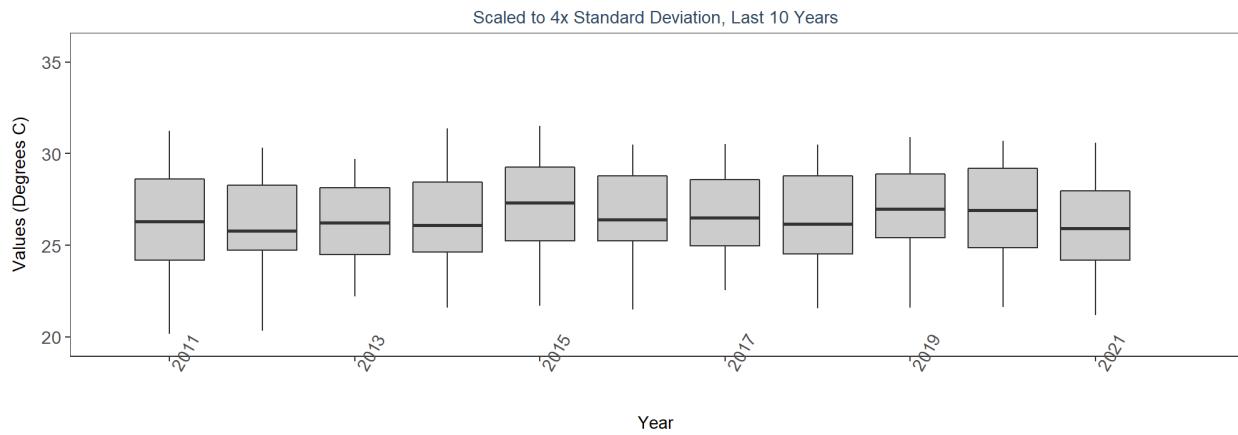
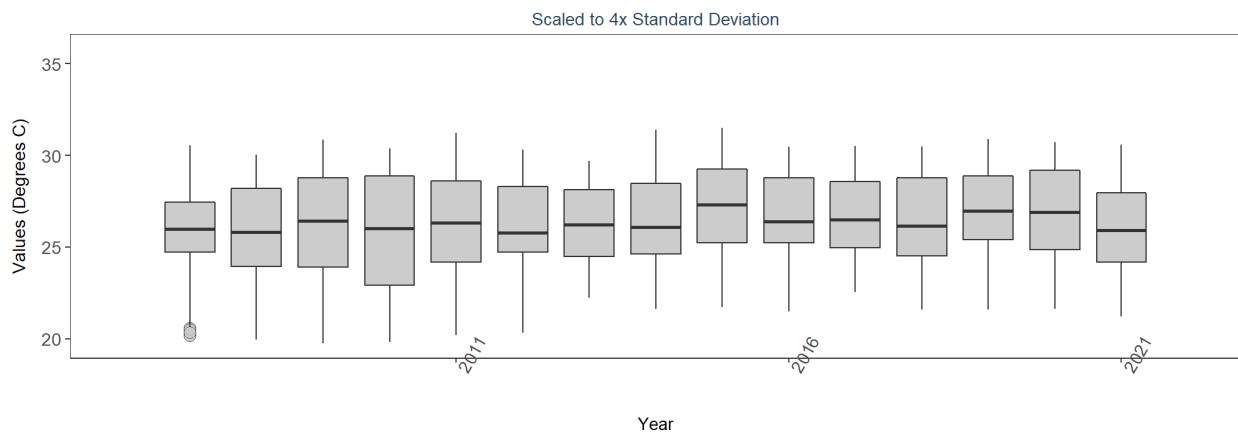
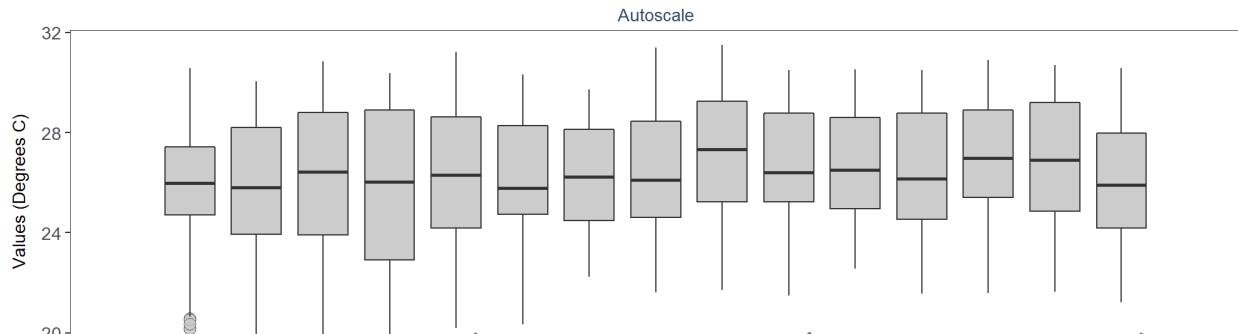
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 986
 Water Temperature on Coral Reefs in the Florida Keys
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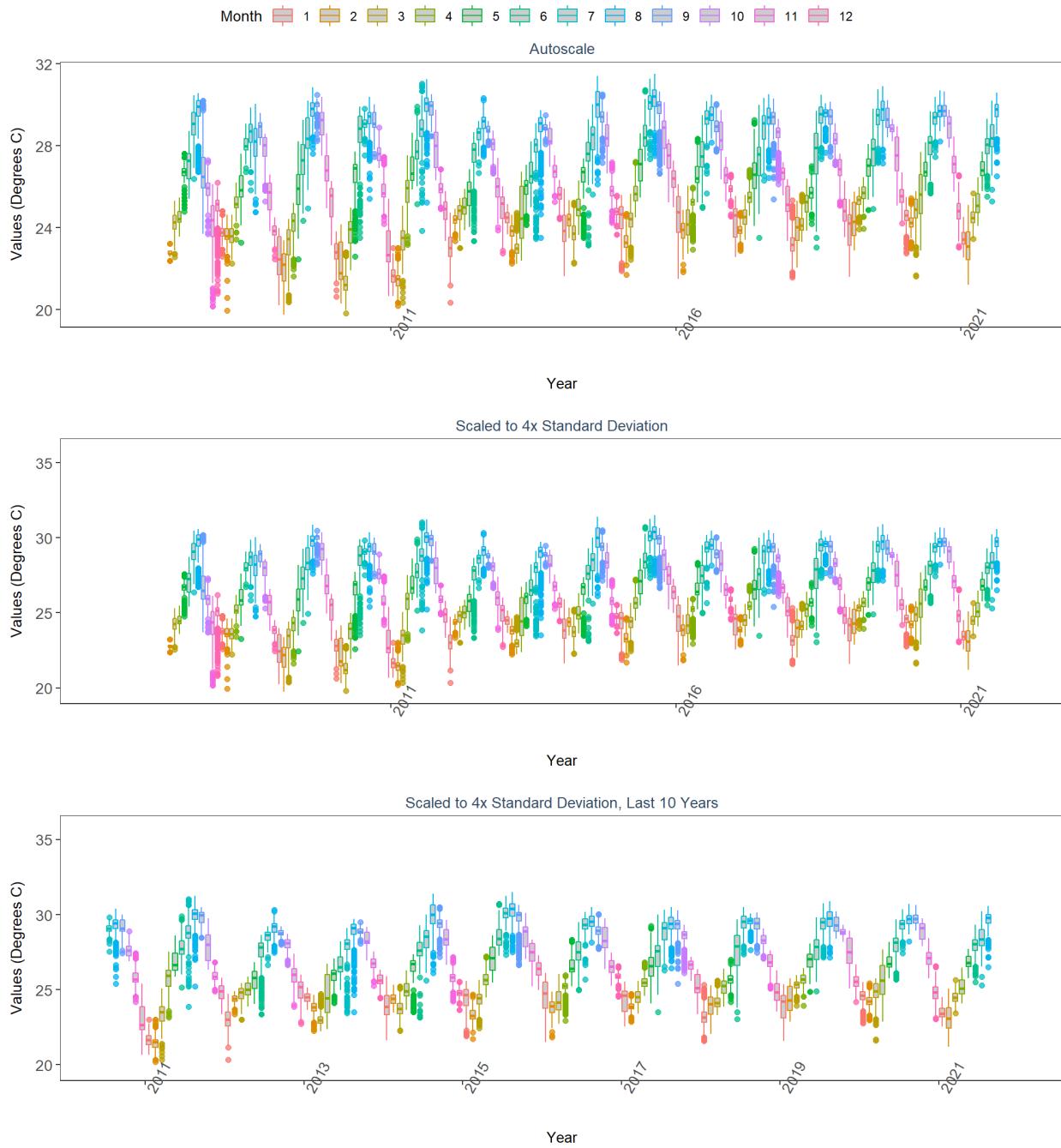
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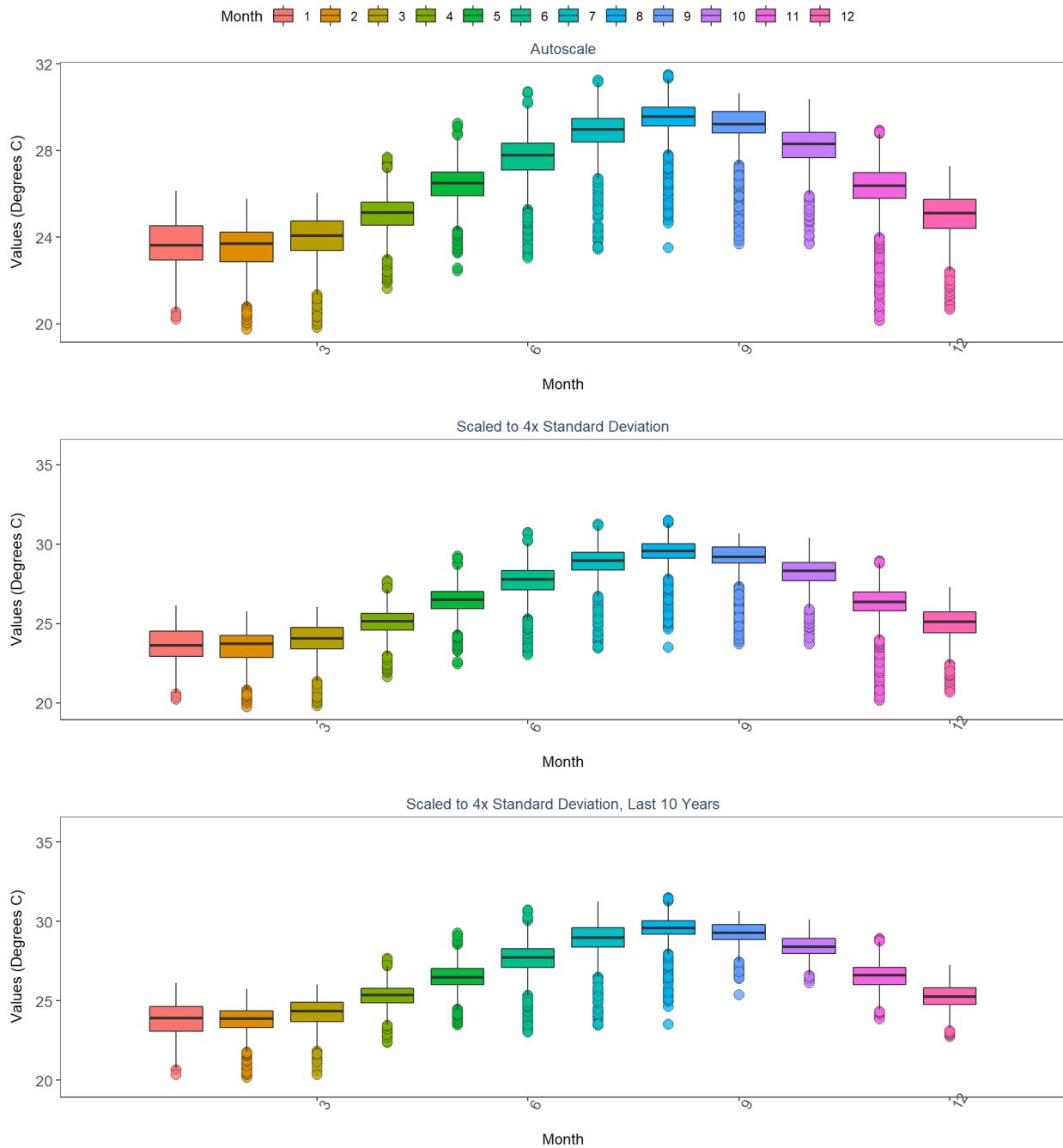
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 Water Temperature on Coral Reefs in the Florida Keys
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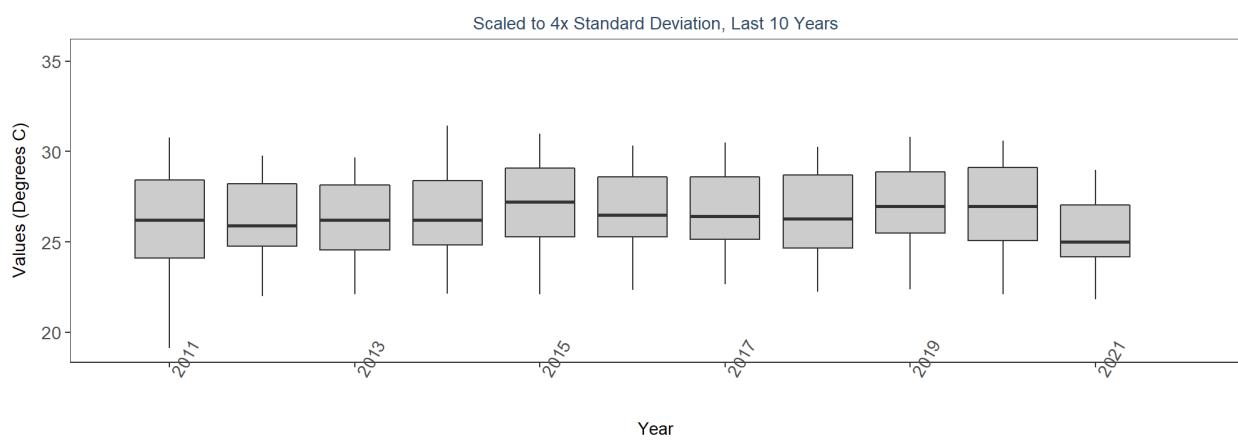
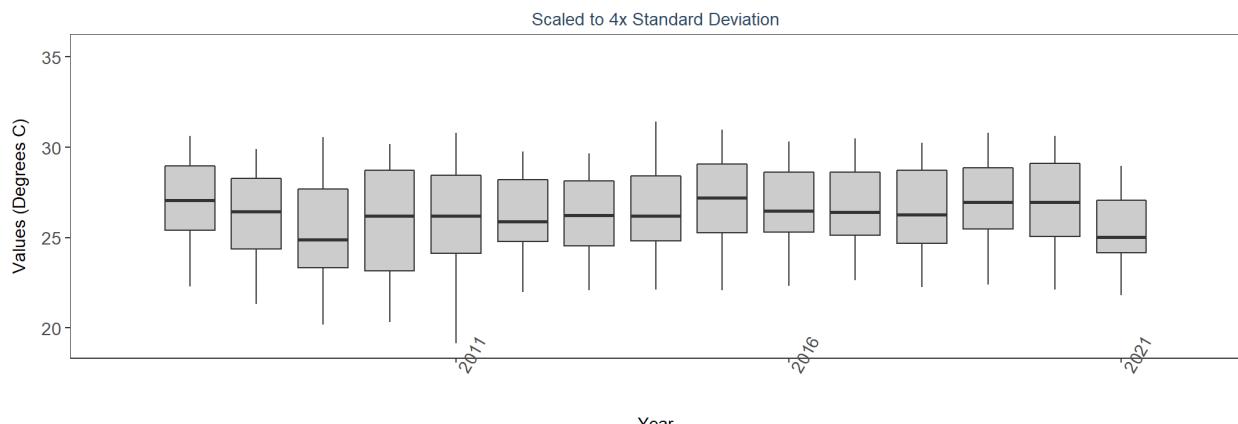
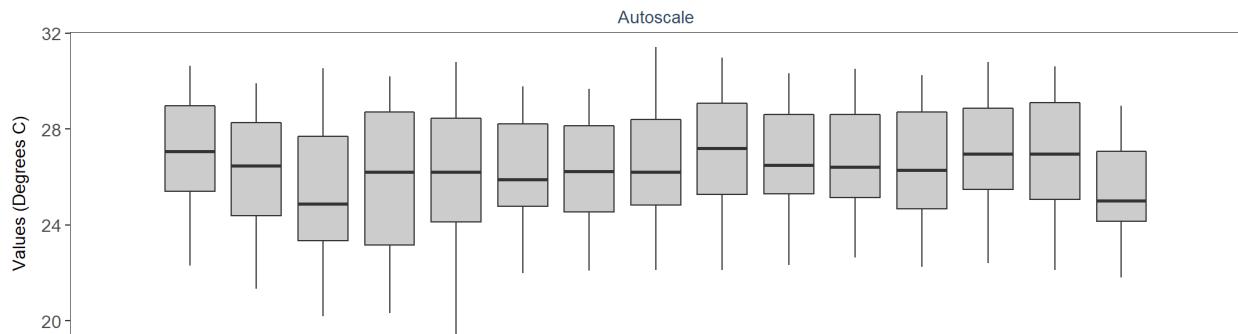
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 By Year & Month



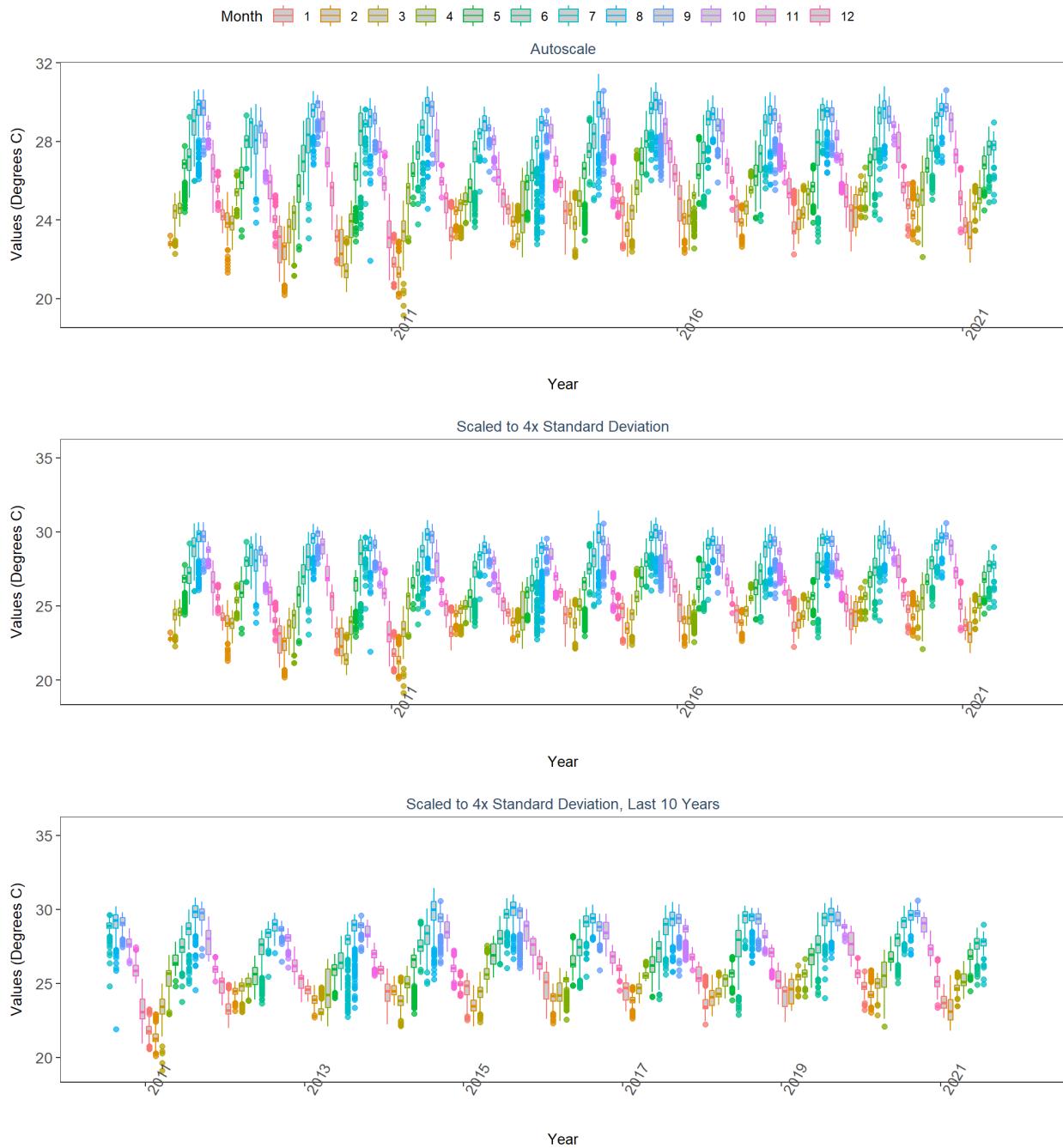
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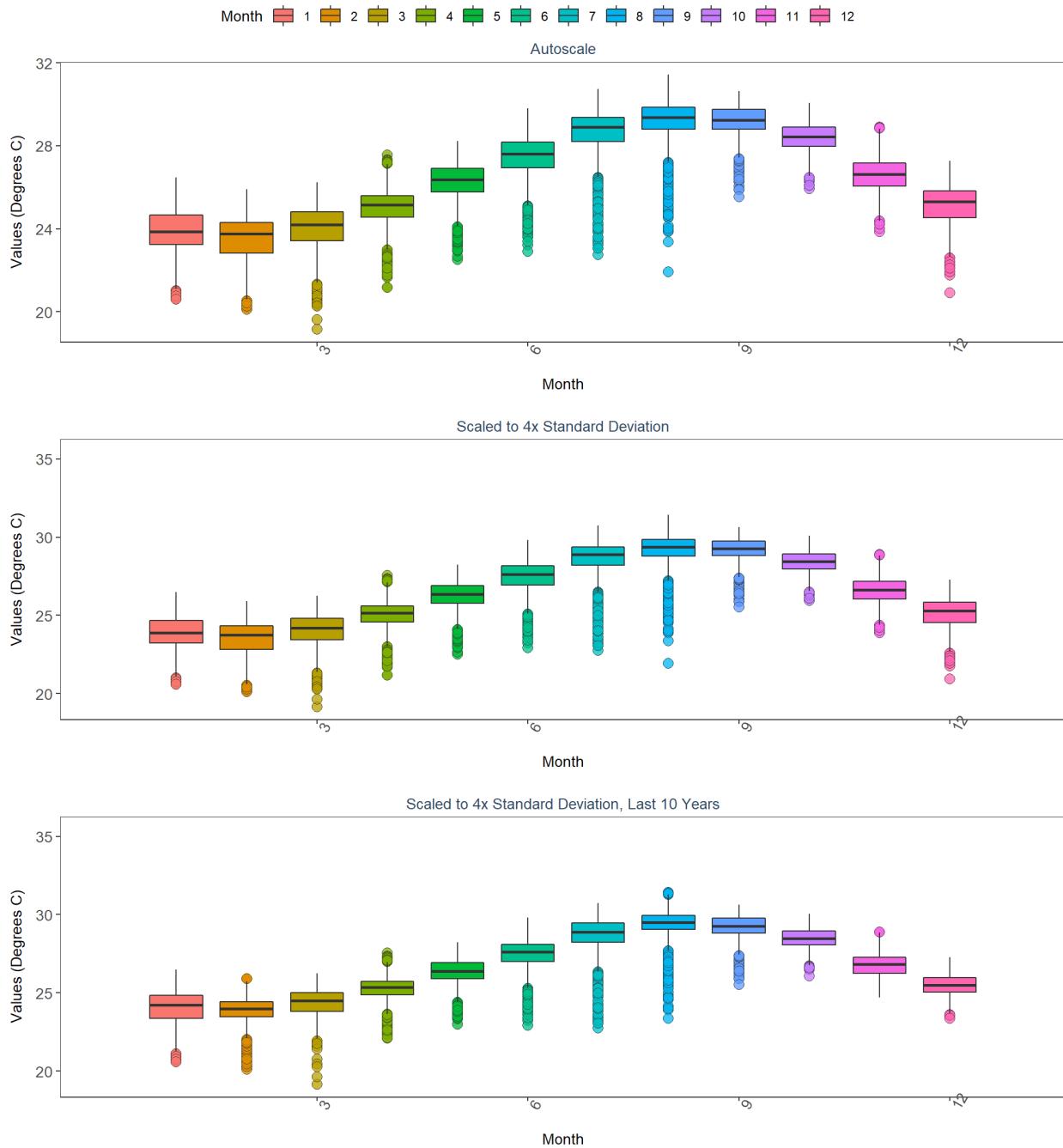
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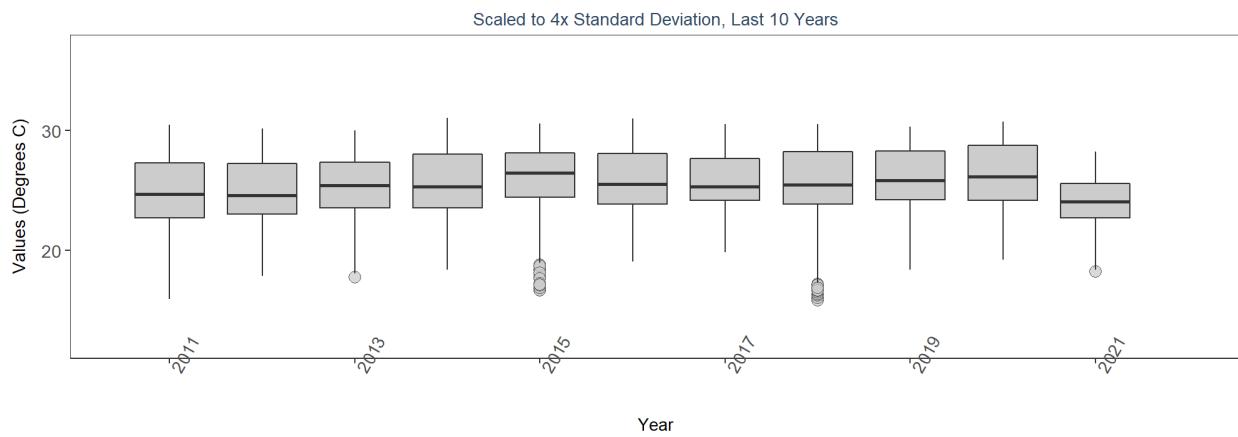
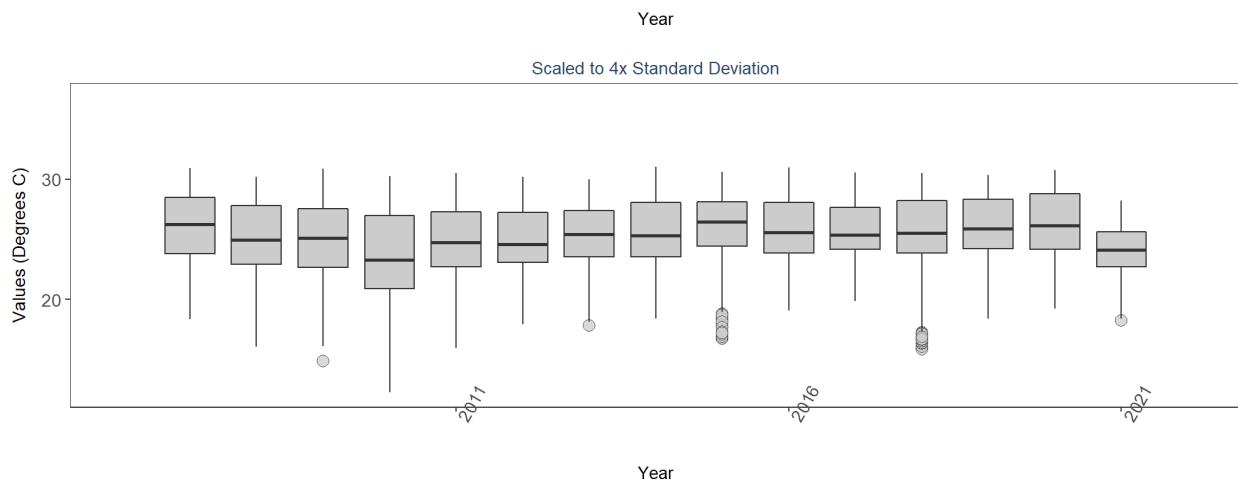
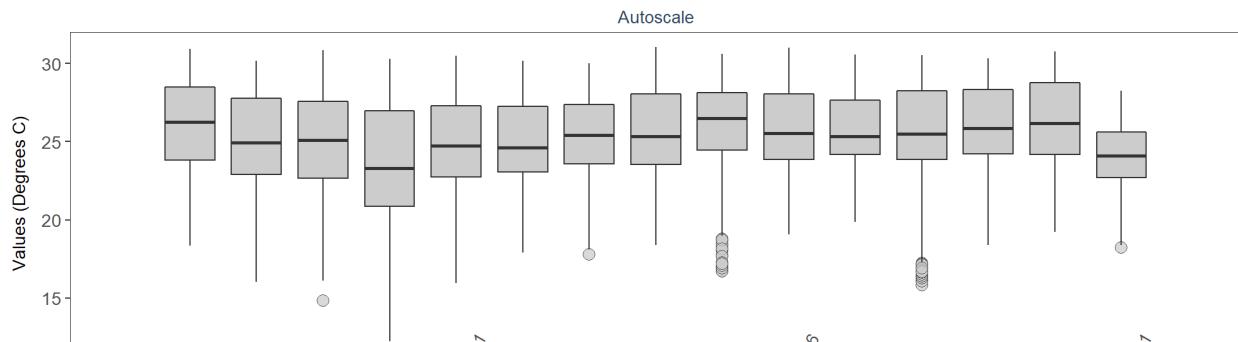
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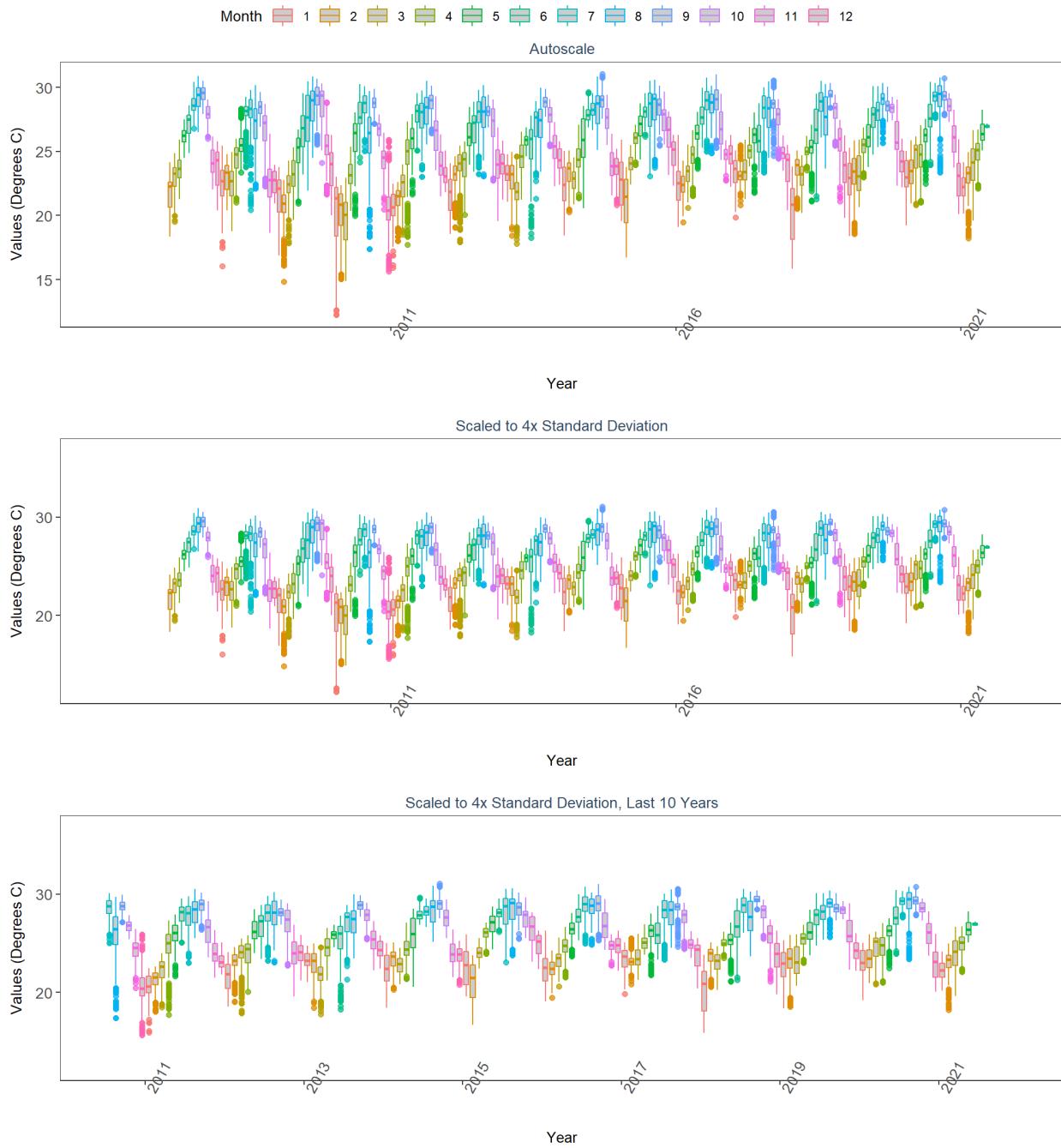
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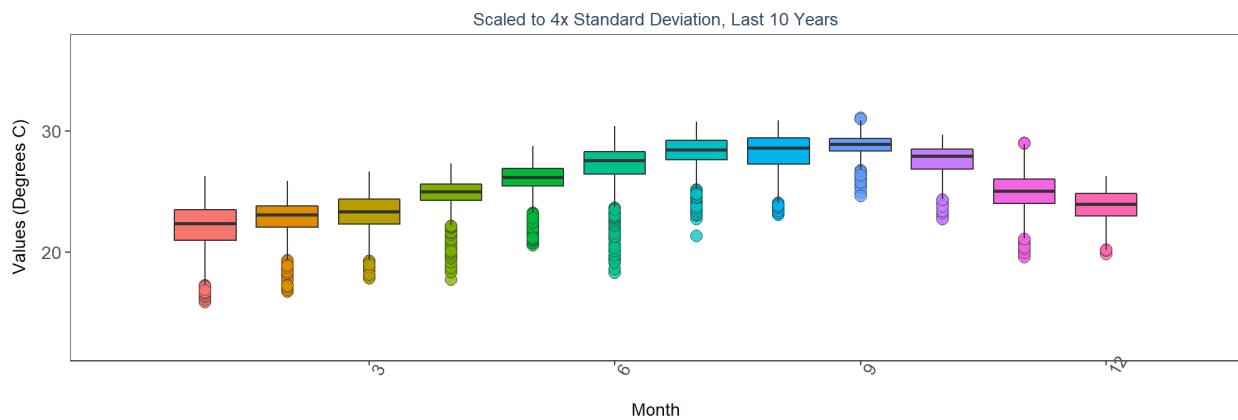
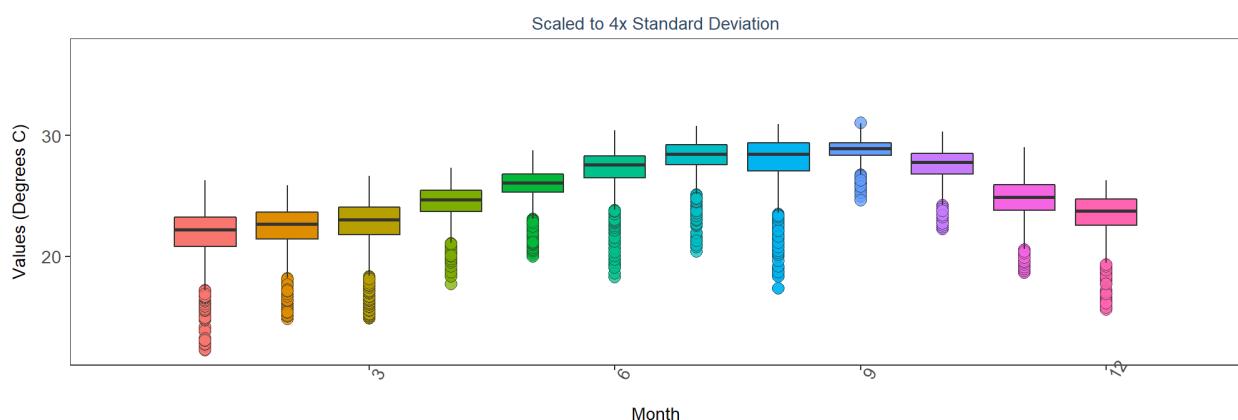
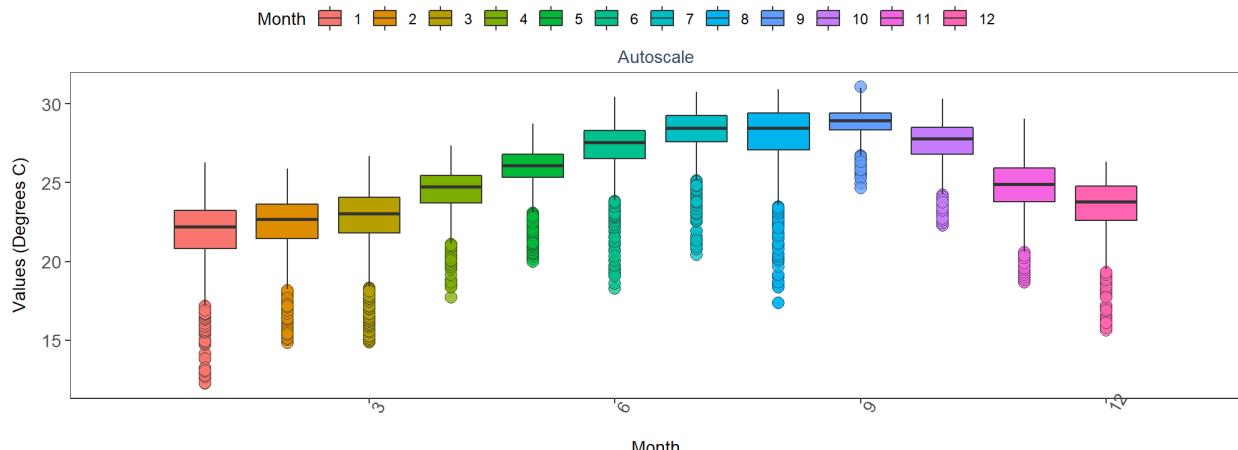
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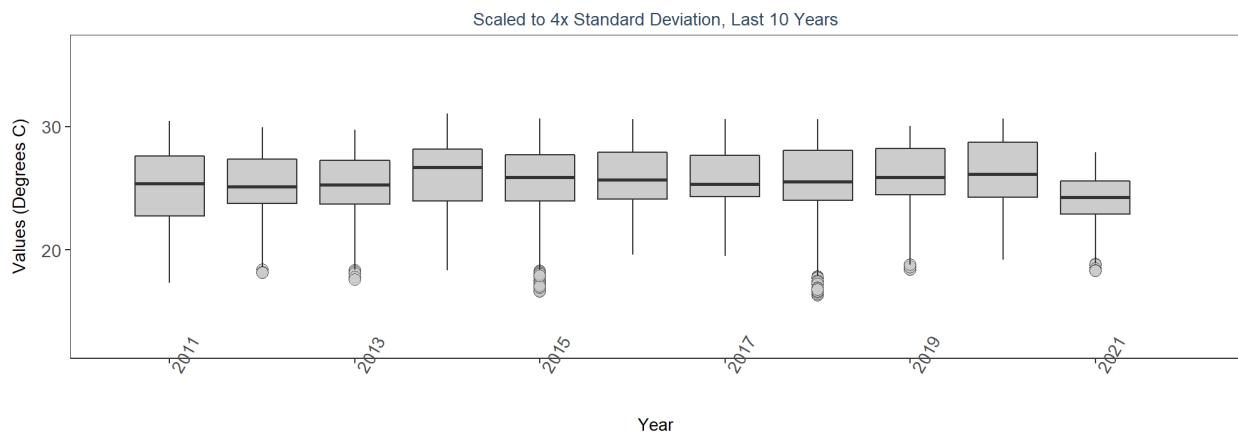
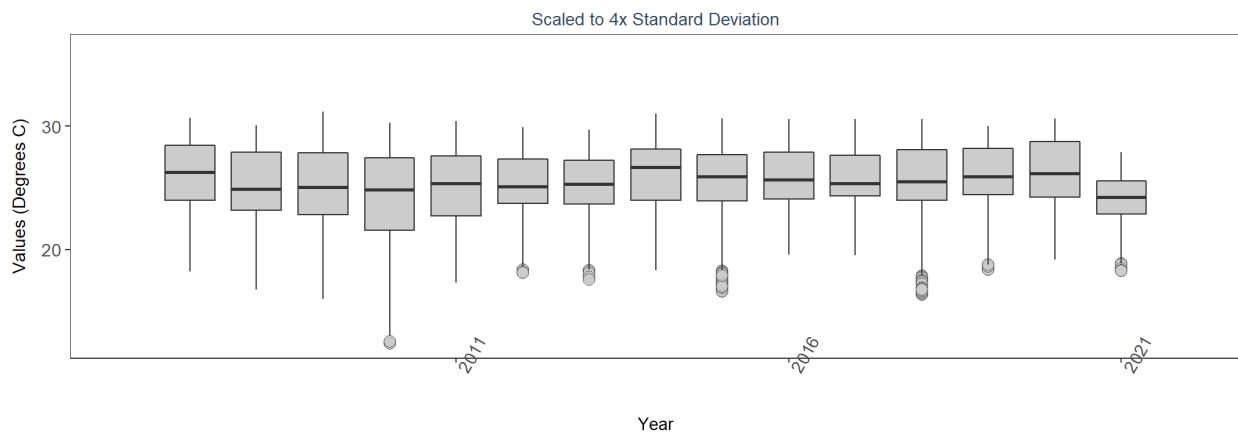
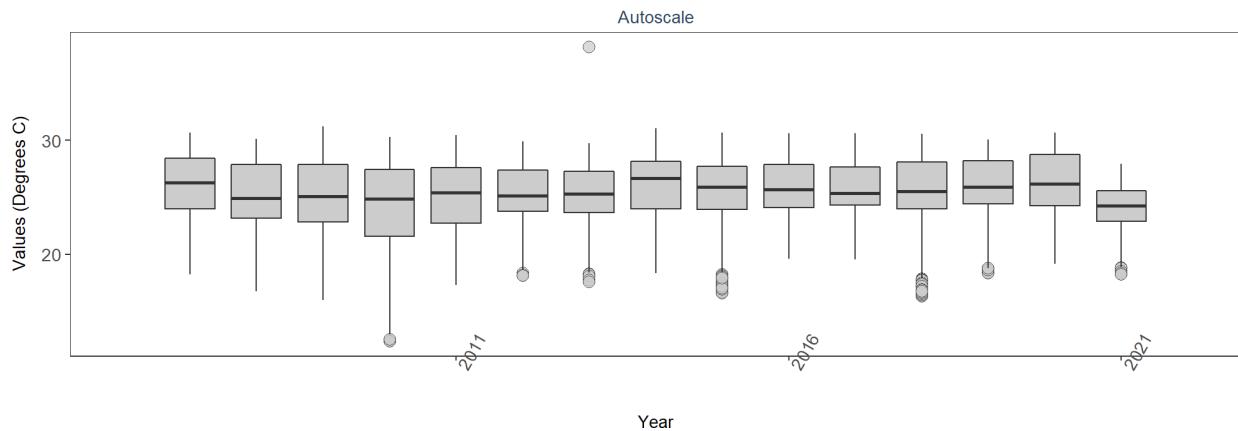
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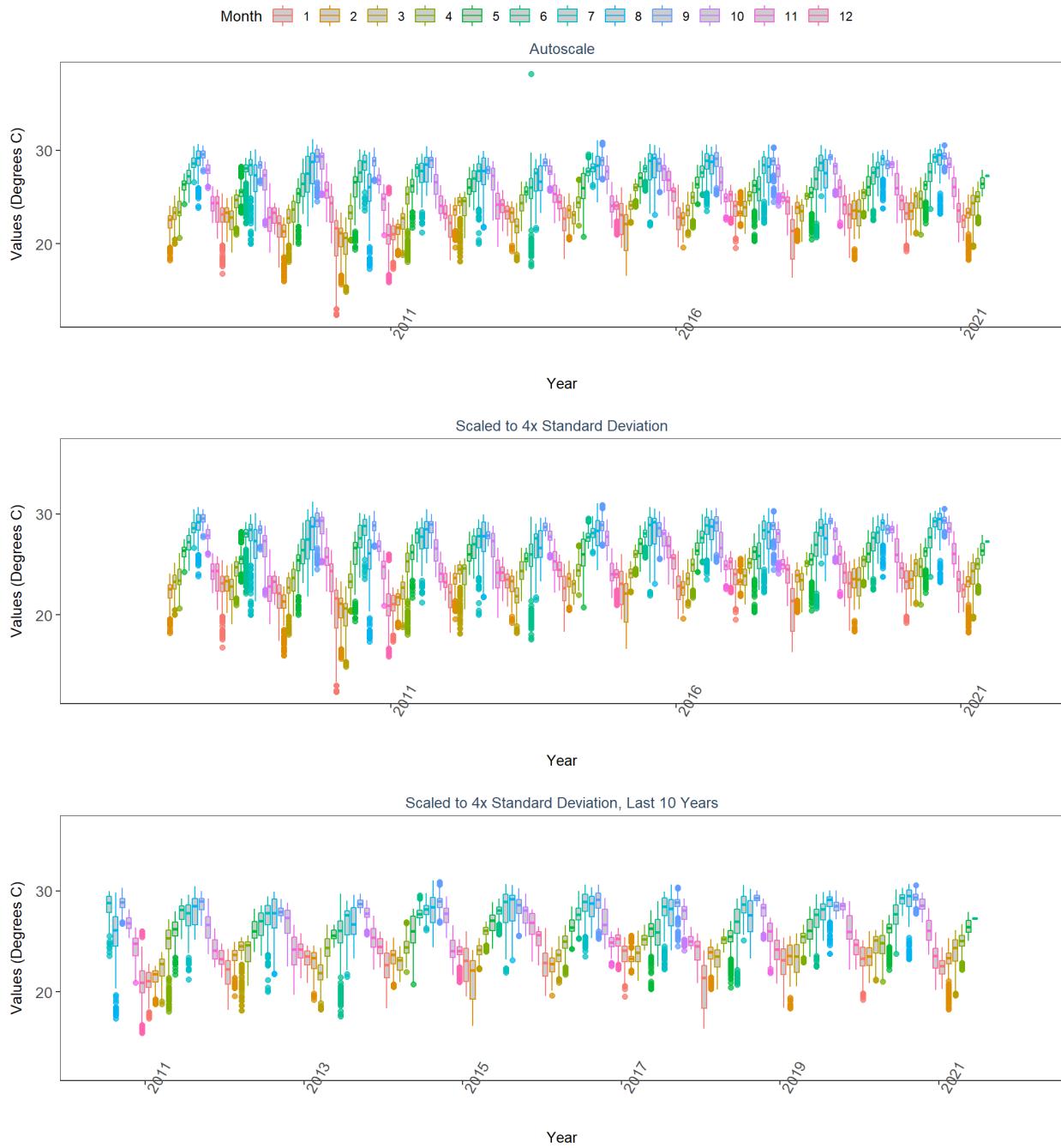
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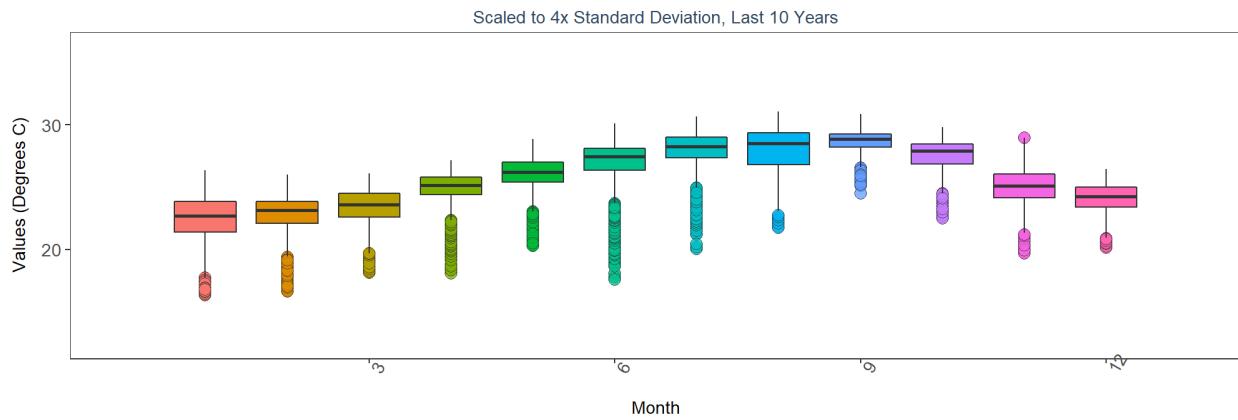
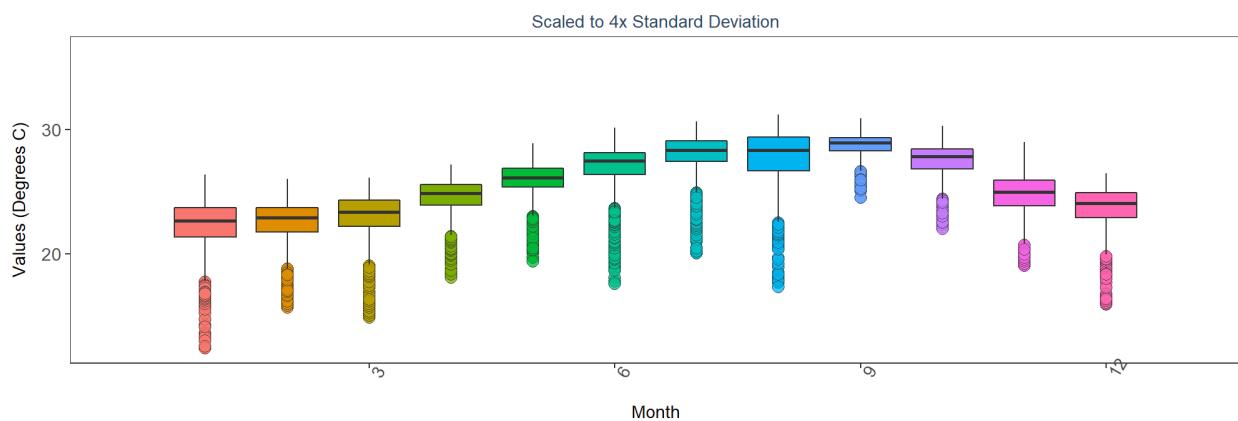
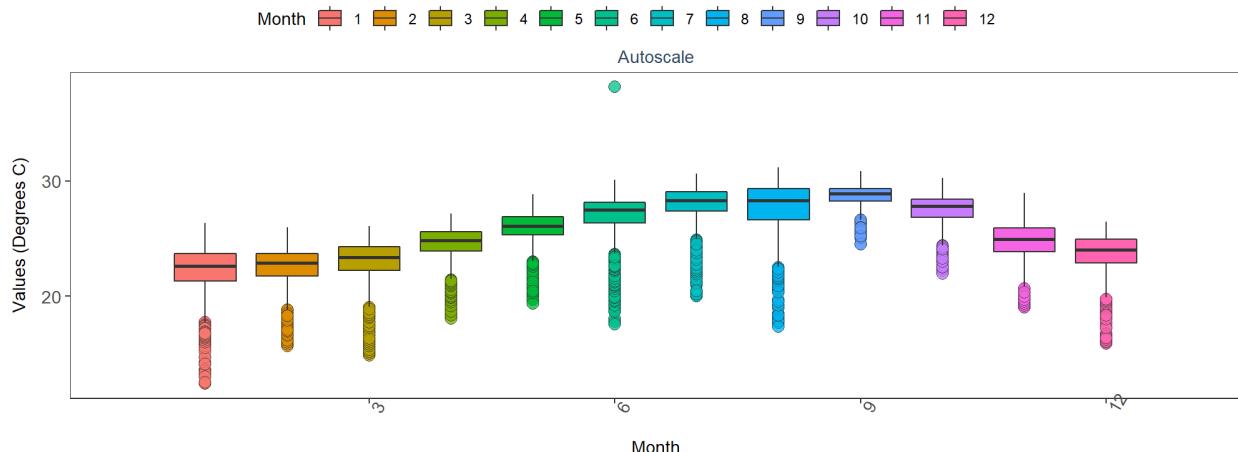
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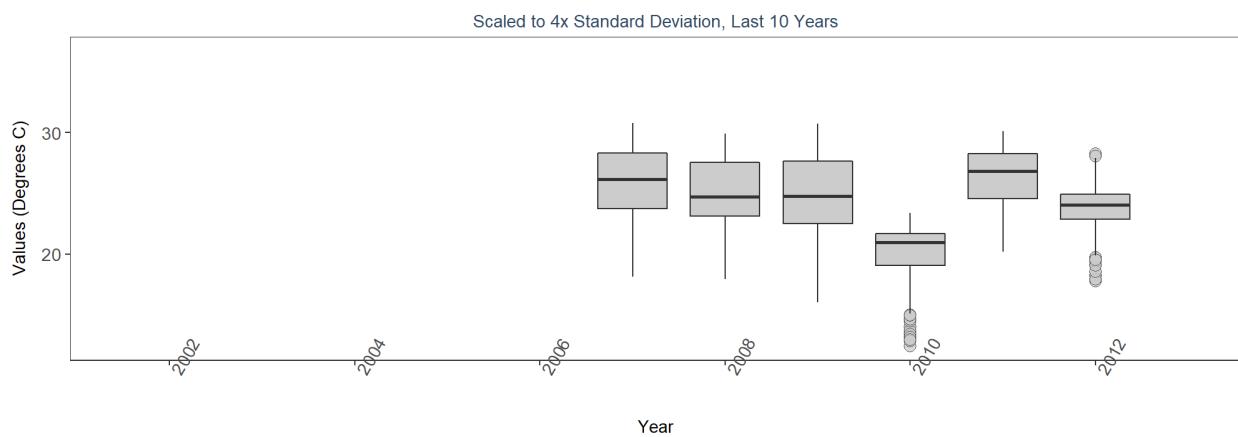
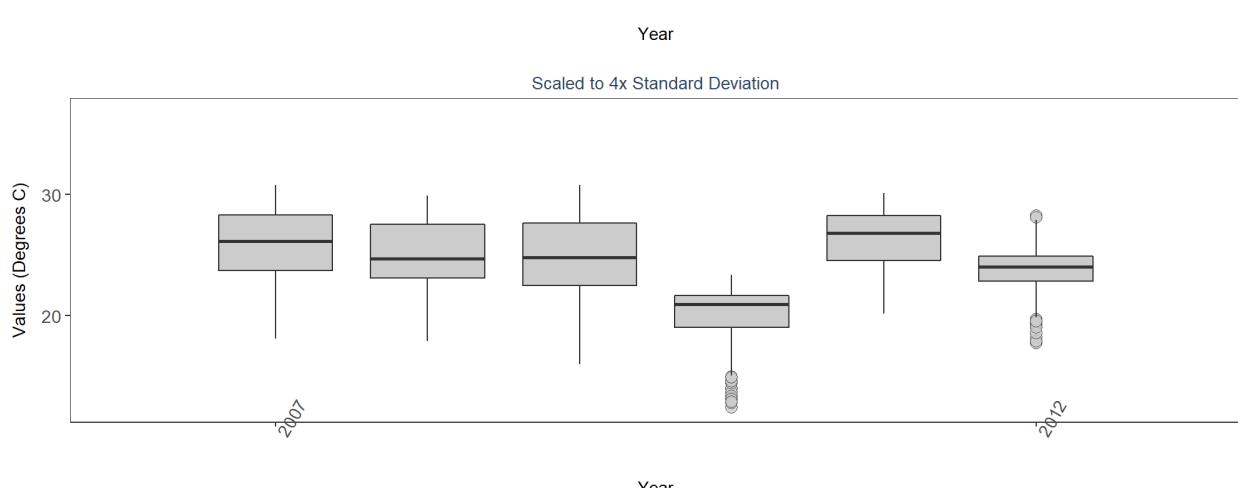
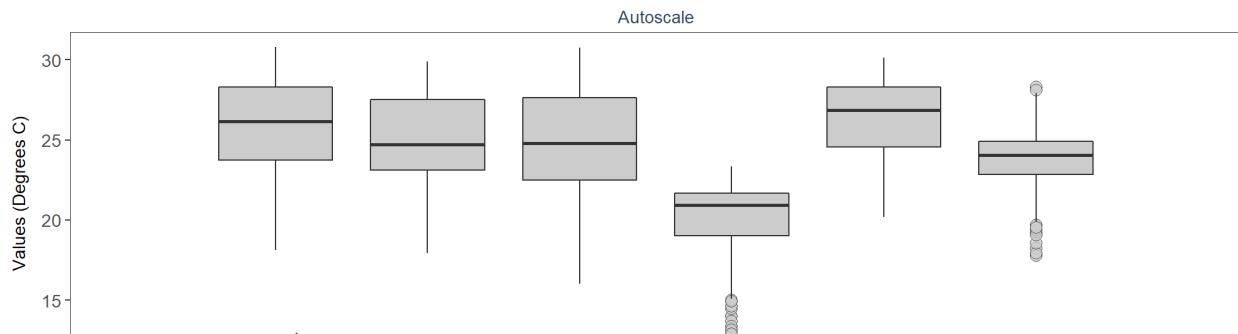
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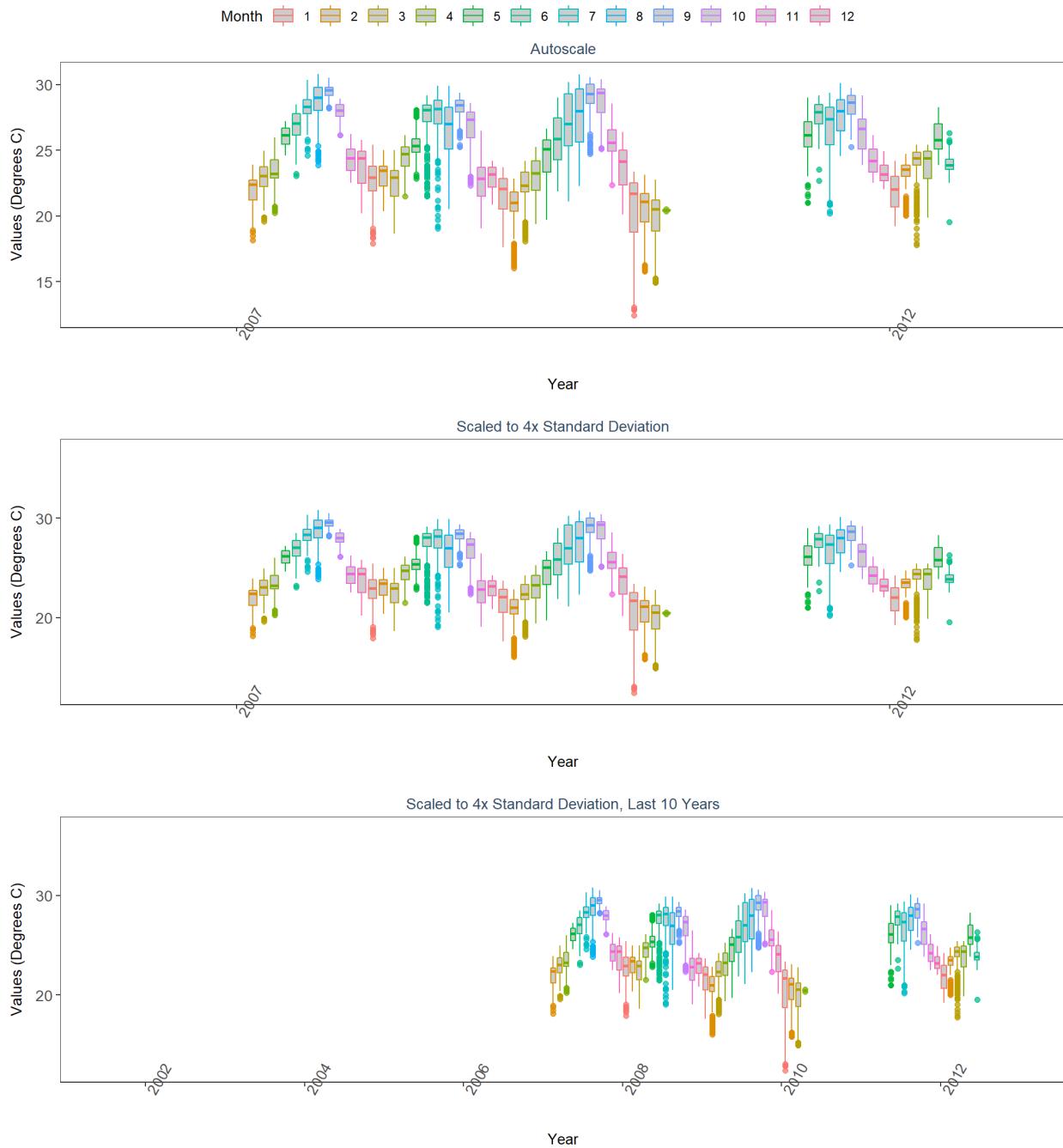
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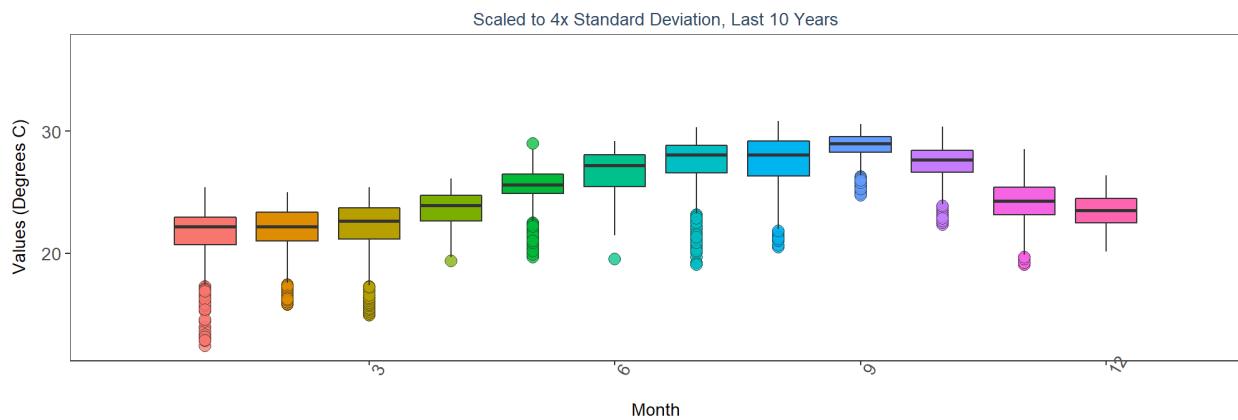
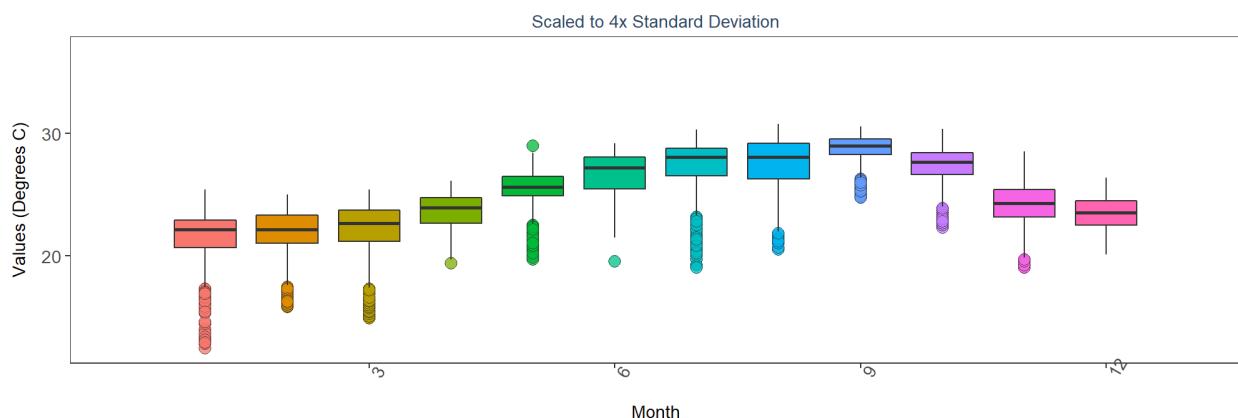
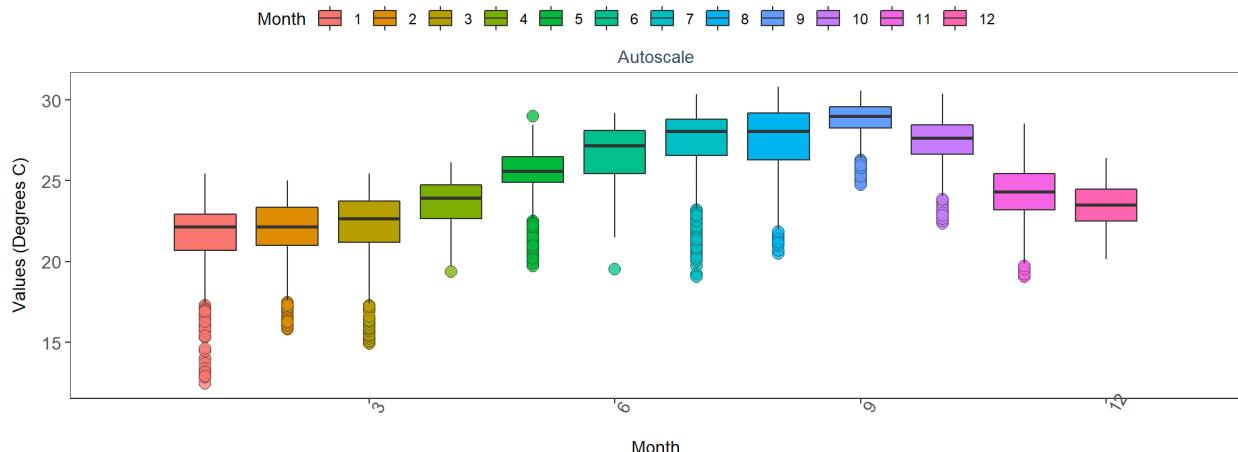
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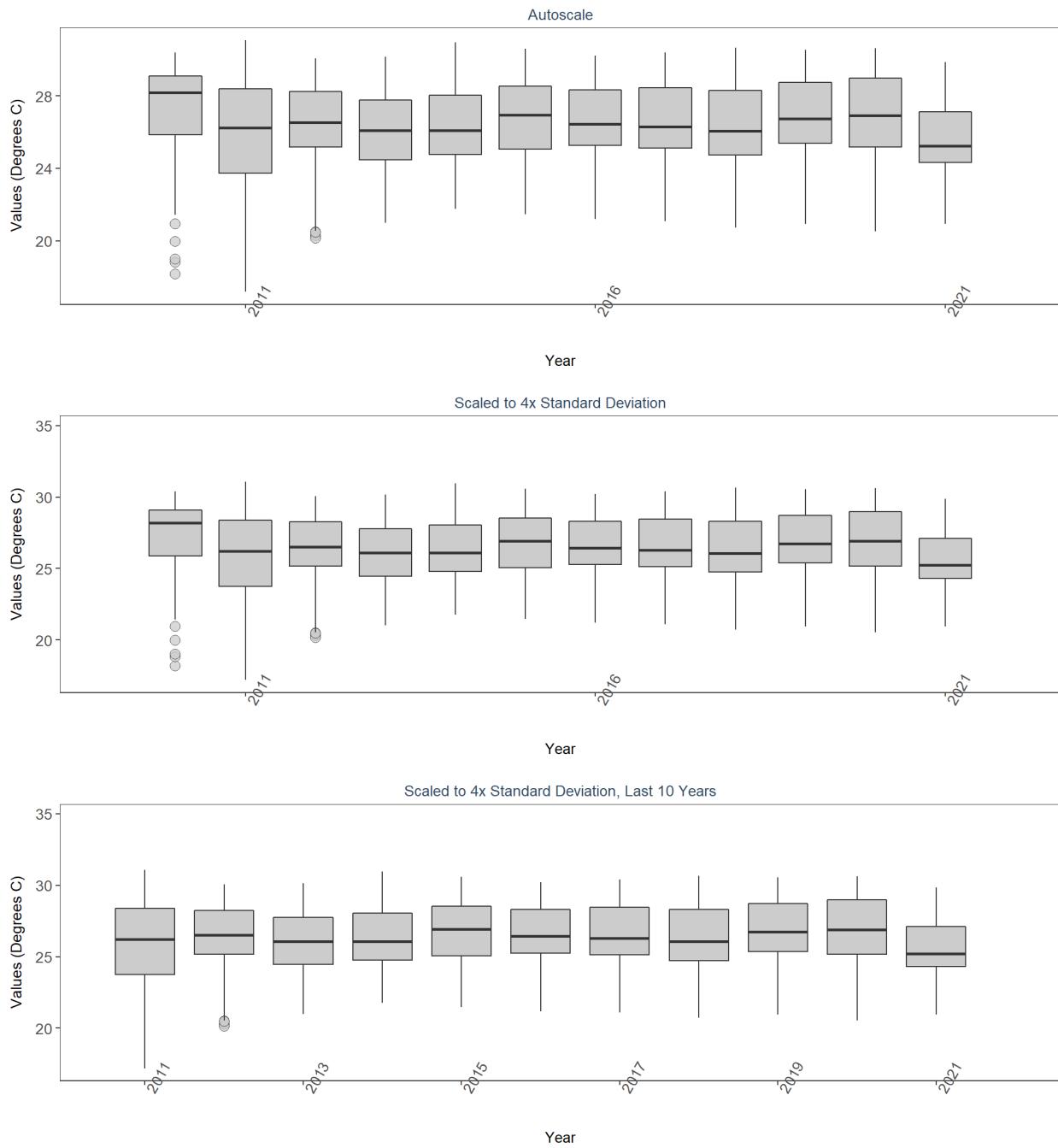
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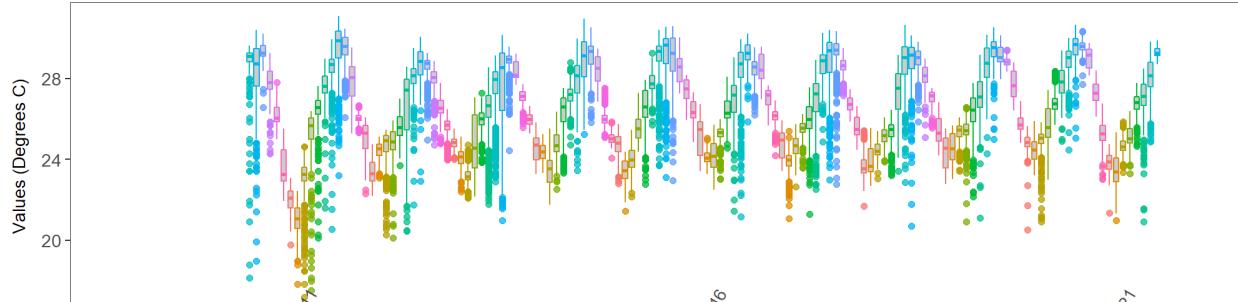
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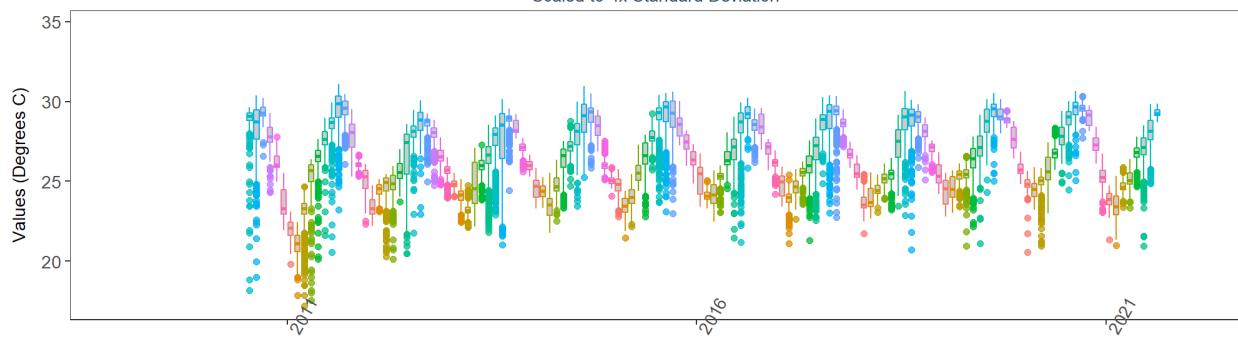
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Autoscale



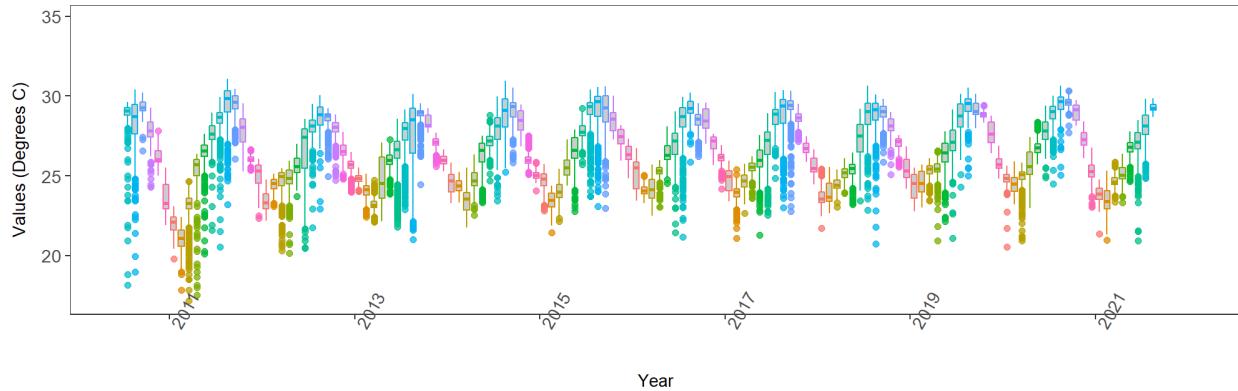
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Scaled to 4x Standard Deviation



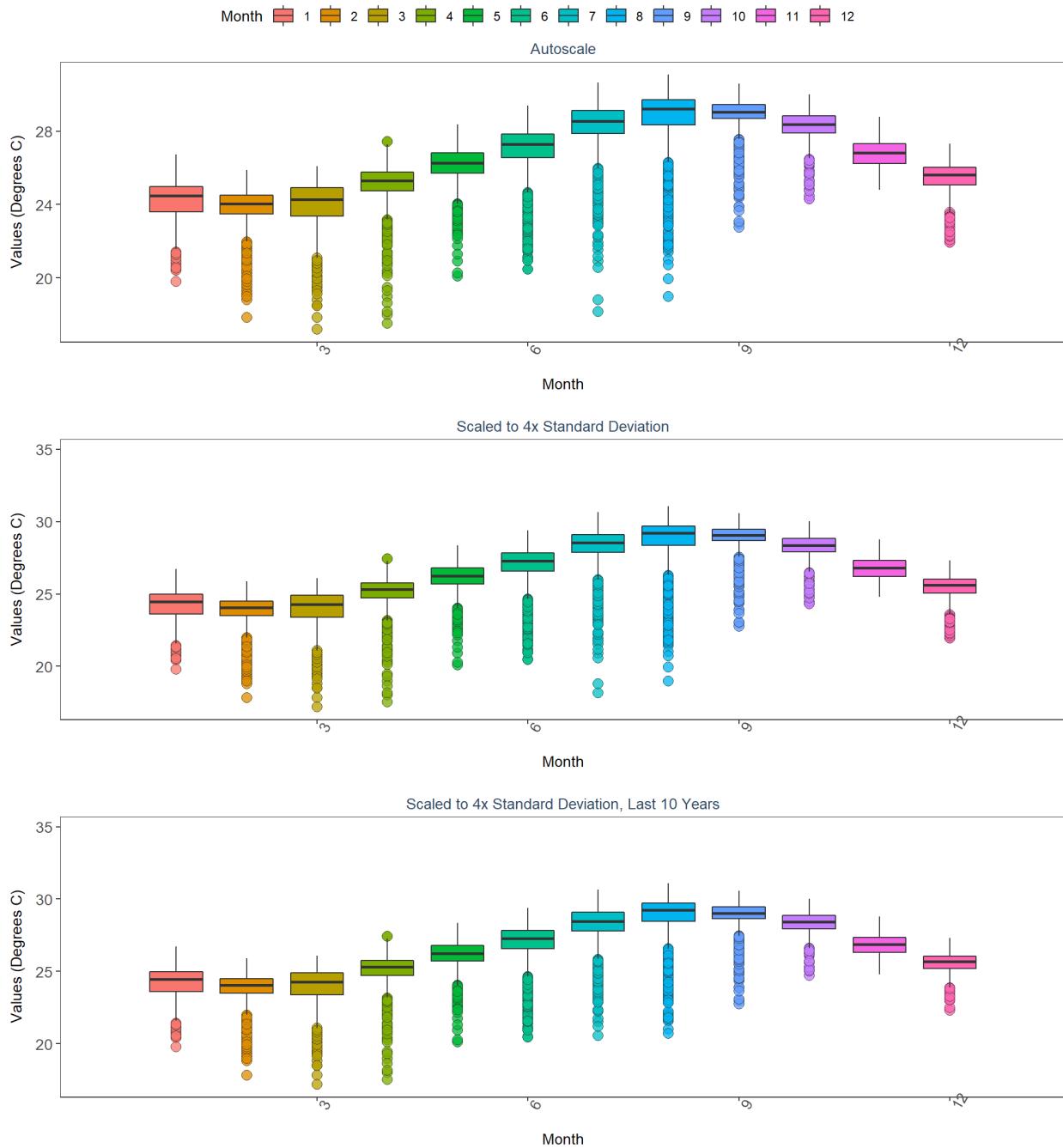
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Scaled to 4x Standard Deviation, Last 10 Years

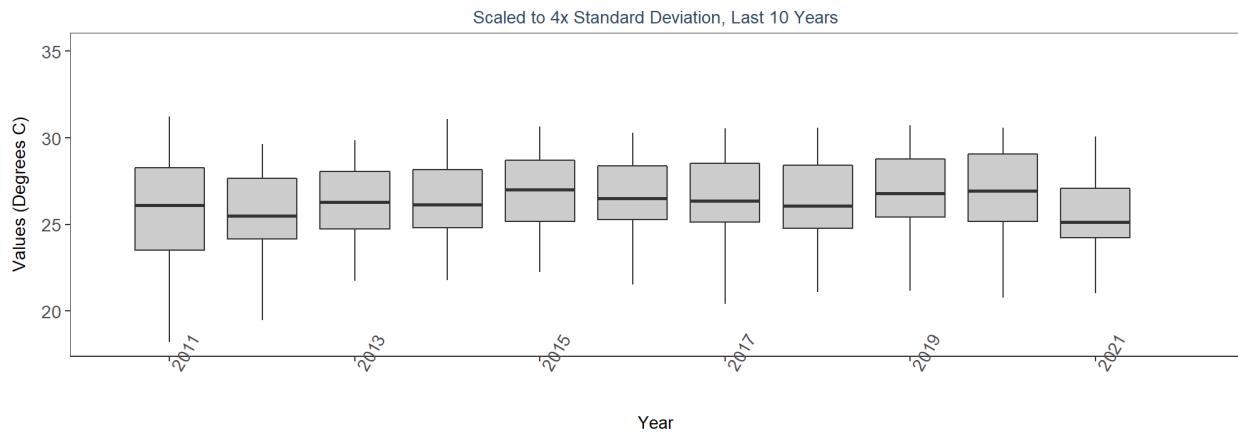
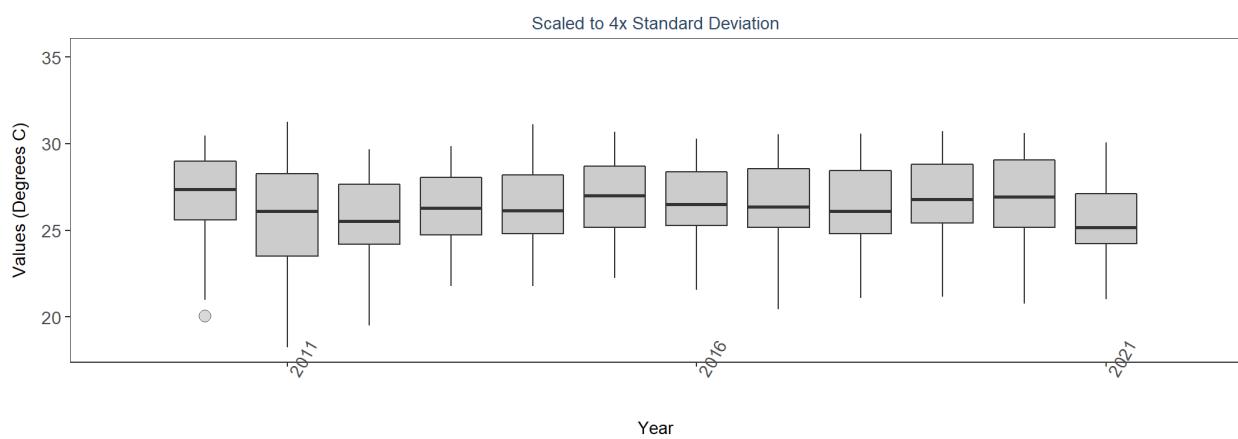
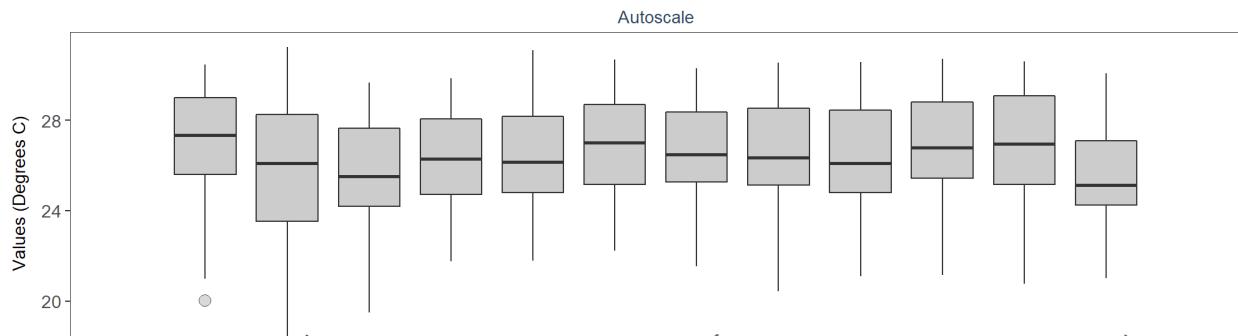


Year

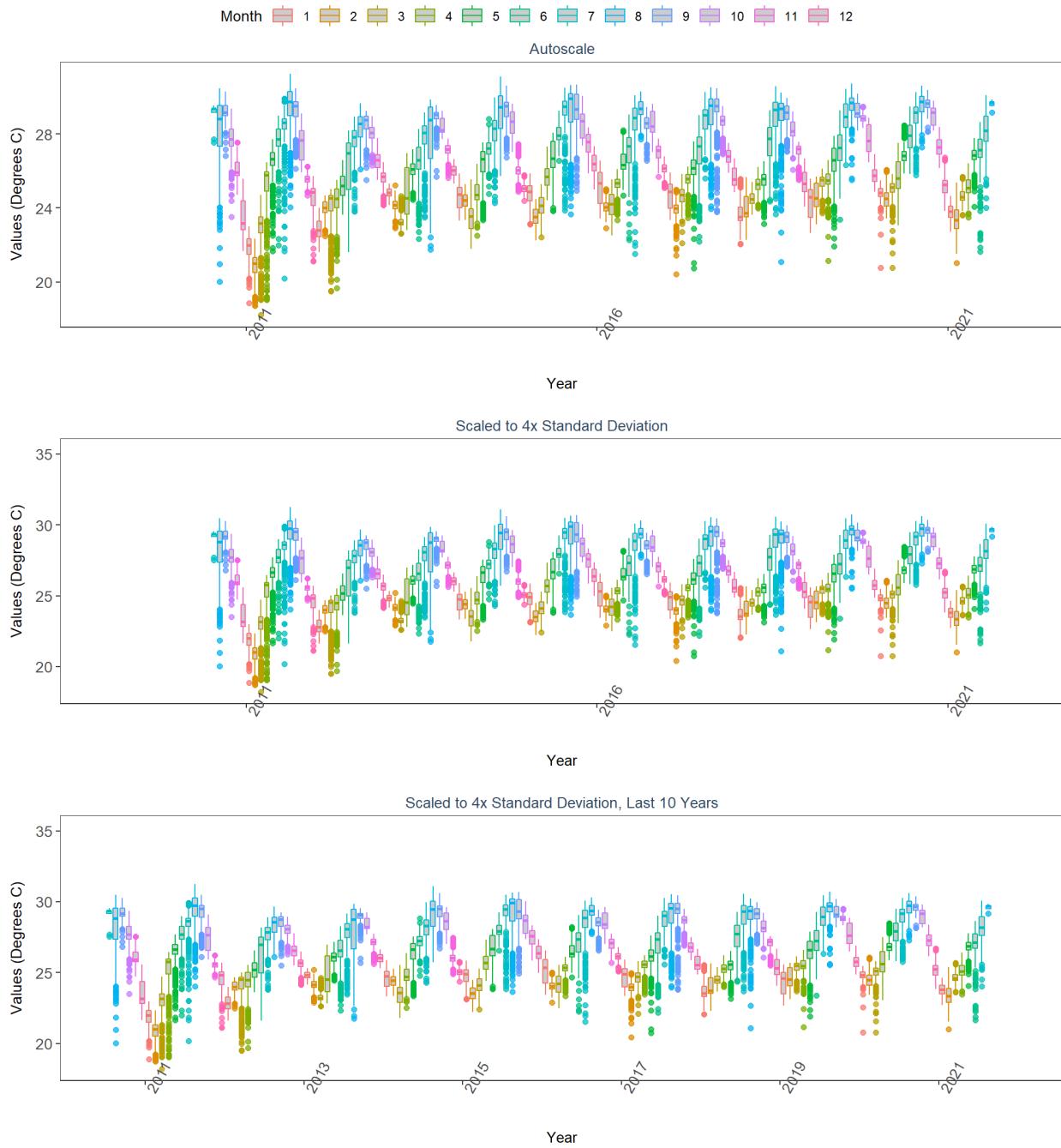
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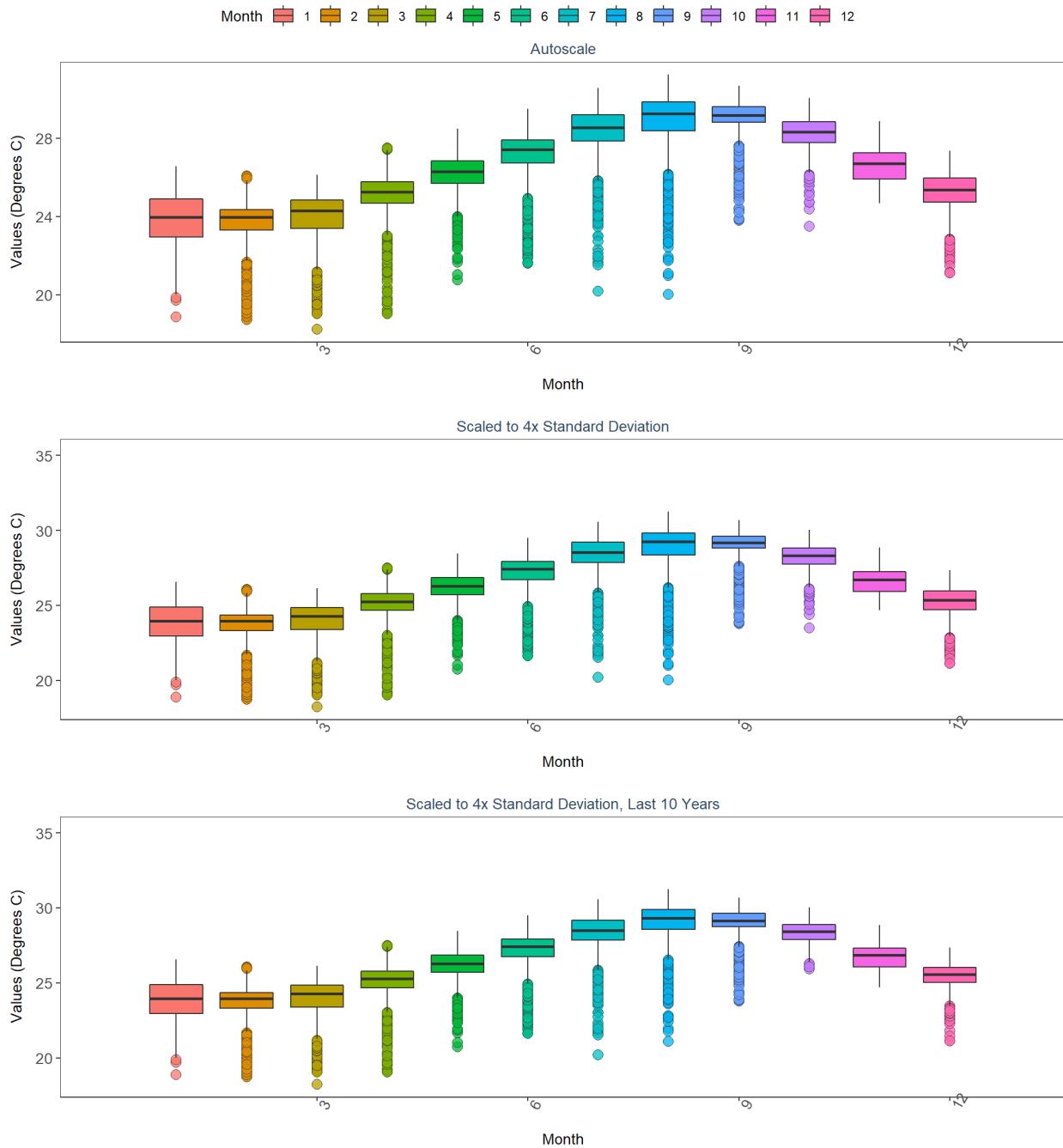
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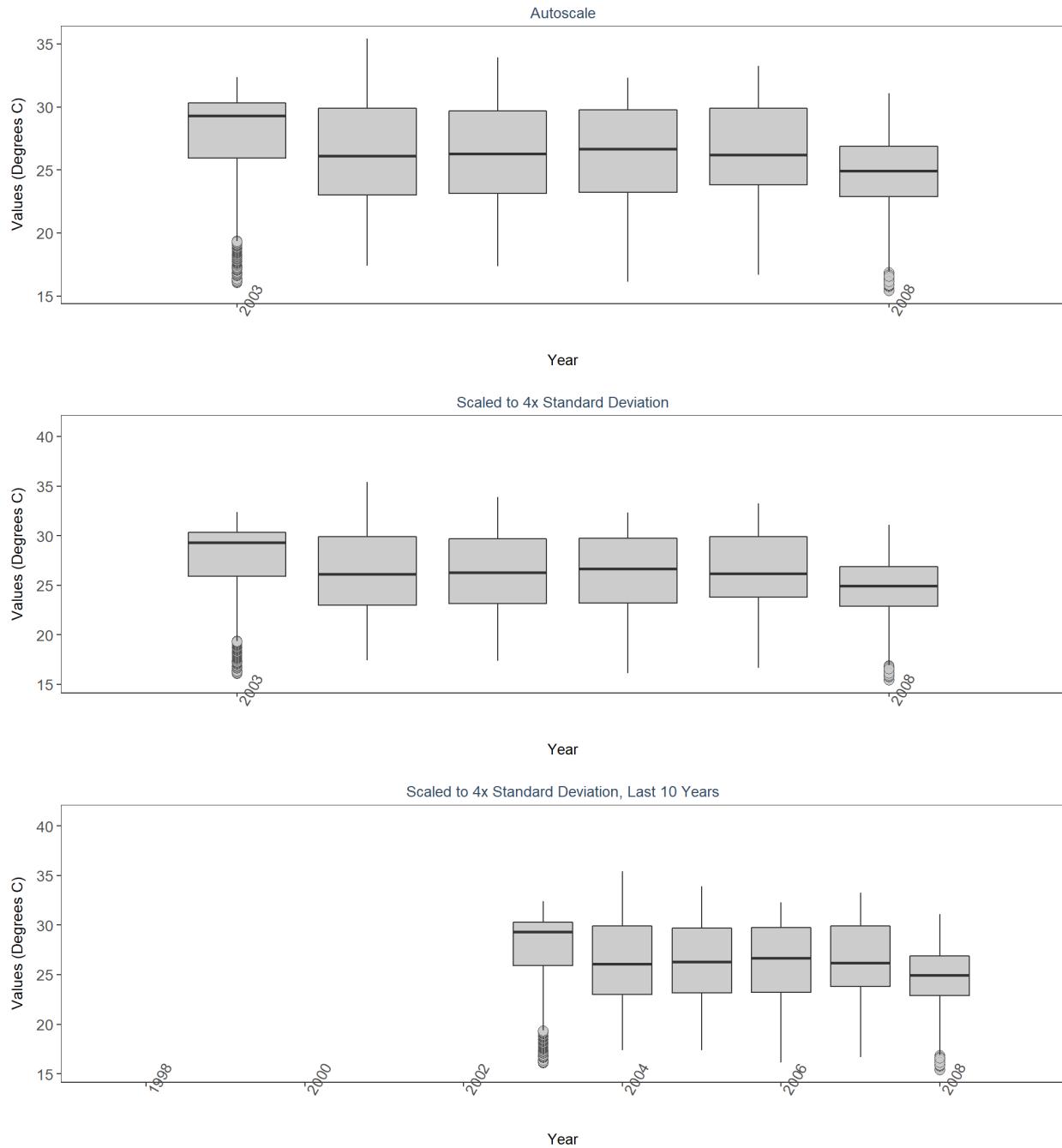
Southeast Florida Coral Reef Ecosystem Conservation Area
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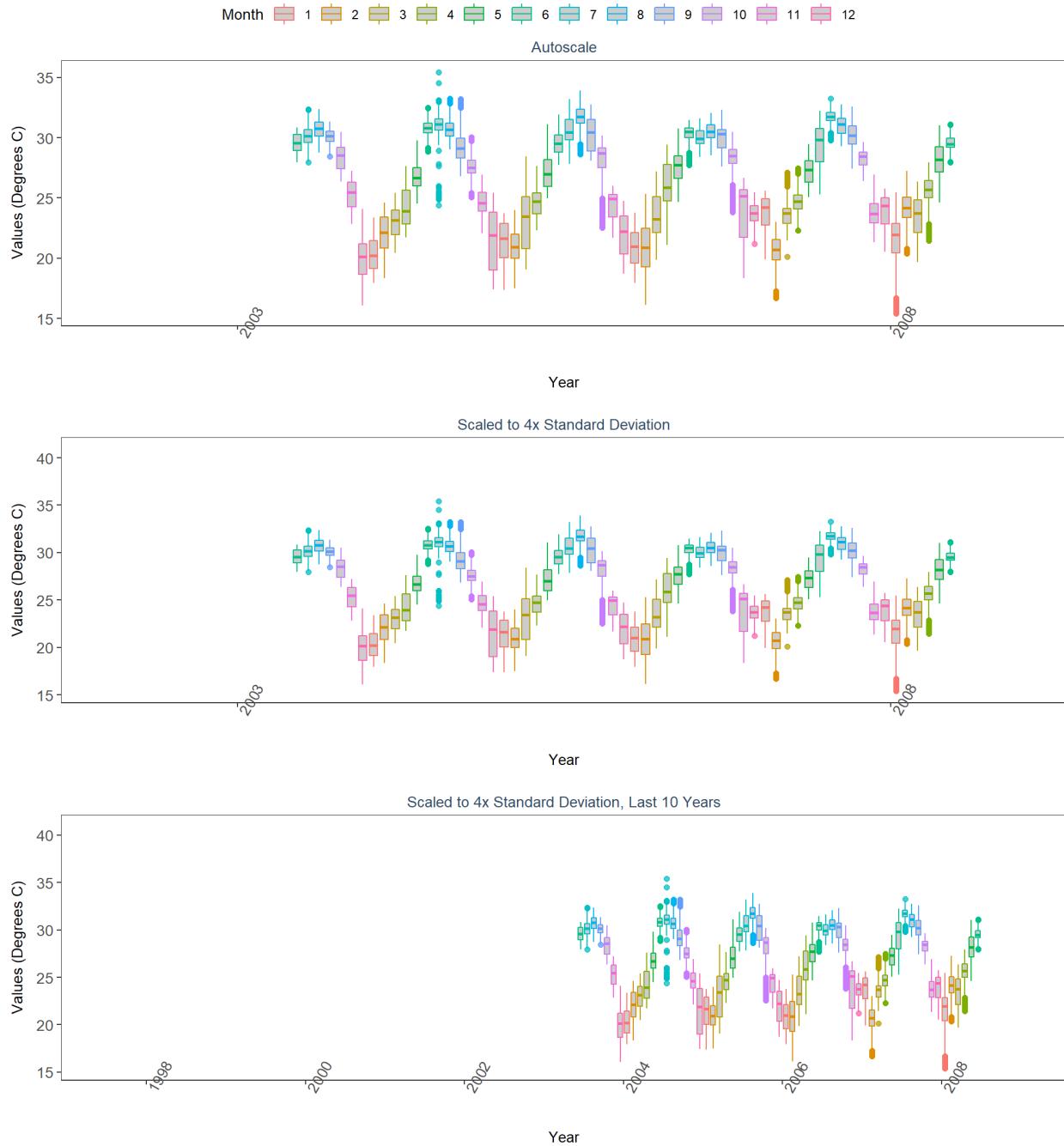
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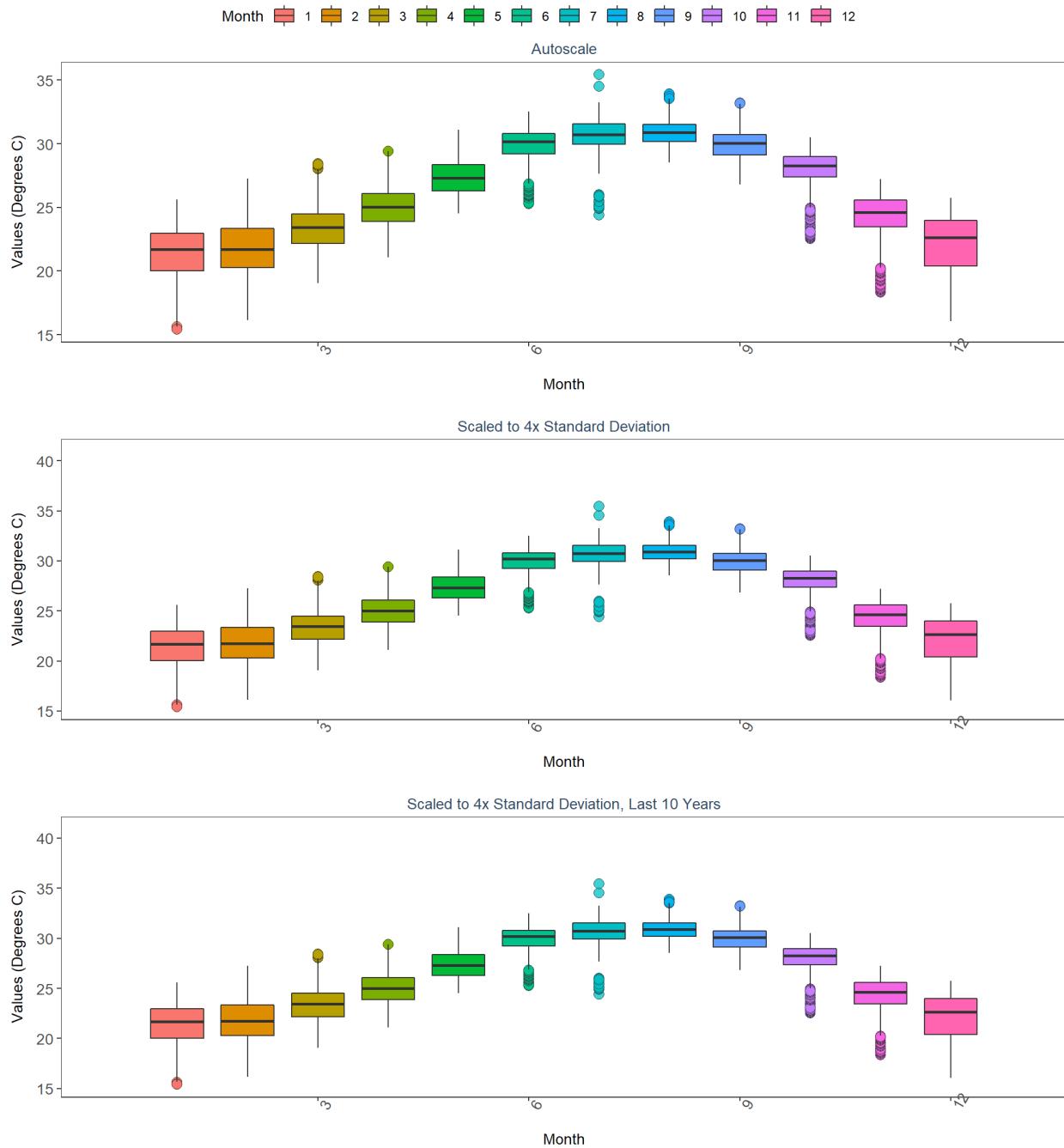
Florida Keys National Marine Sanctuary
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 Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array
 1B
 By Year



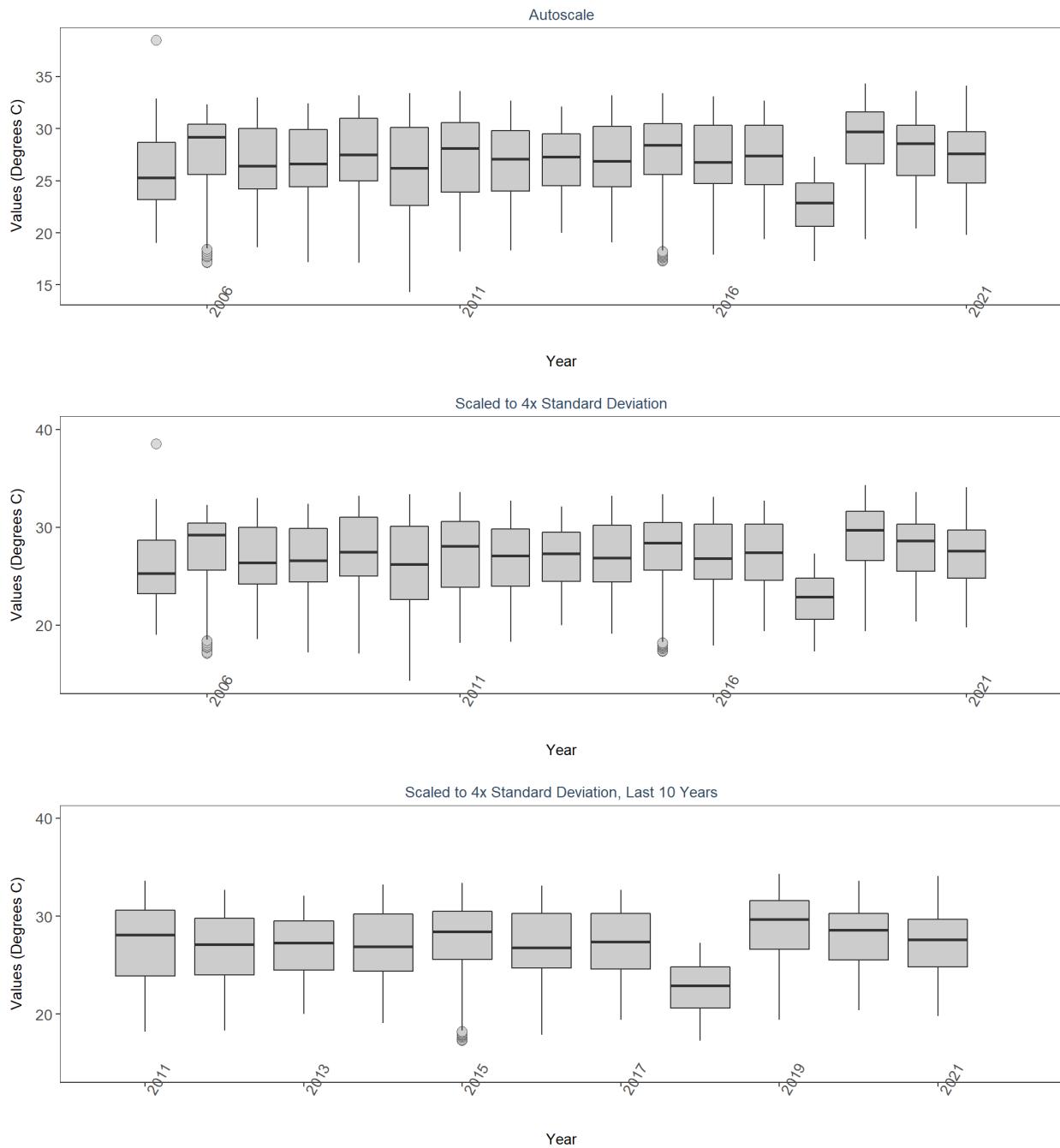
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 Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array
 1B
 By Year & Month



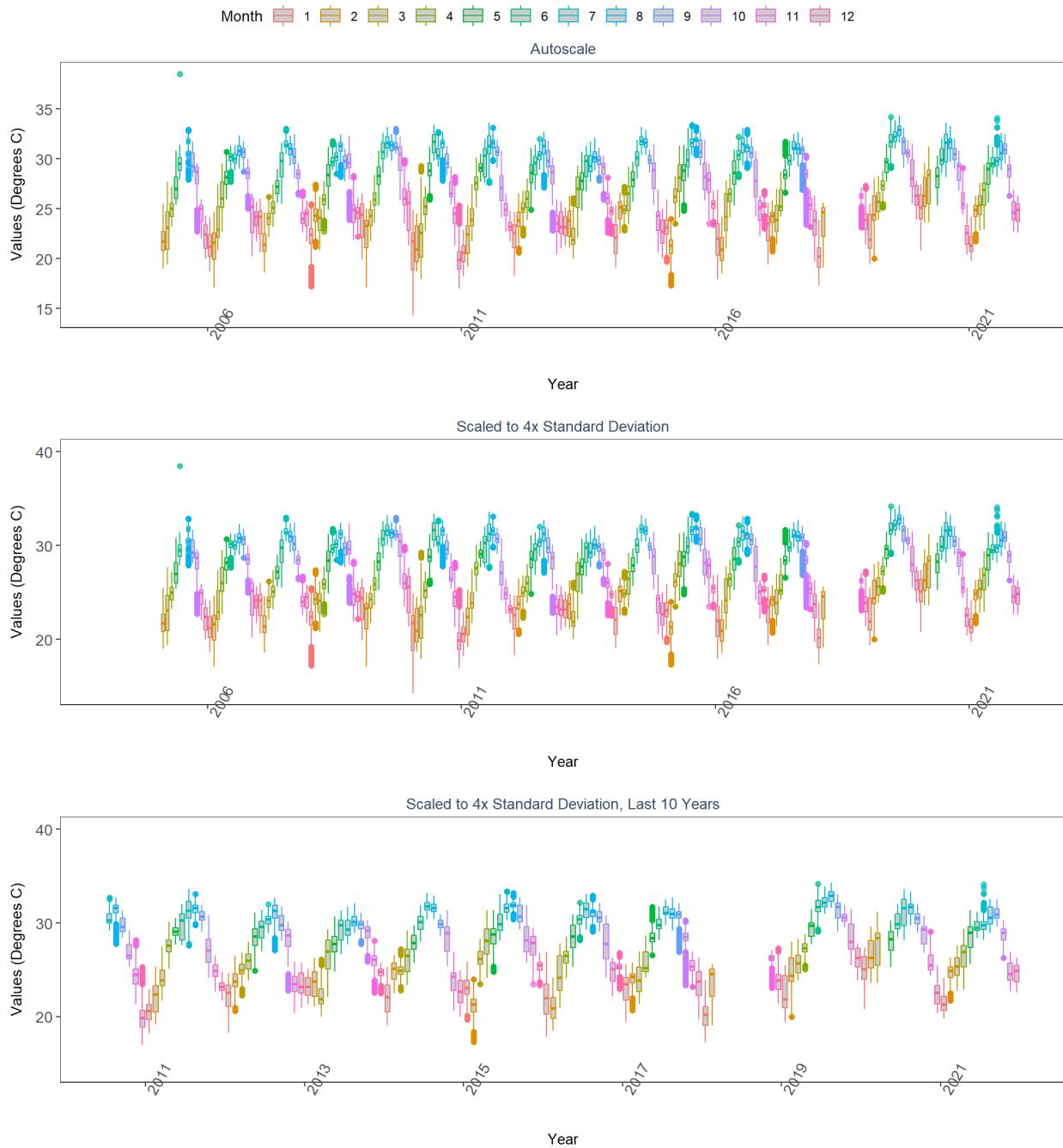
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 Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array
 1B
 By Month



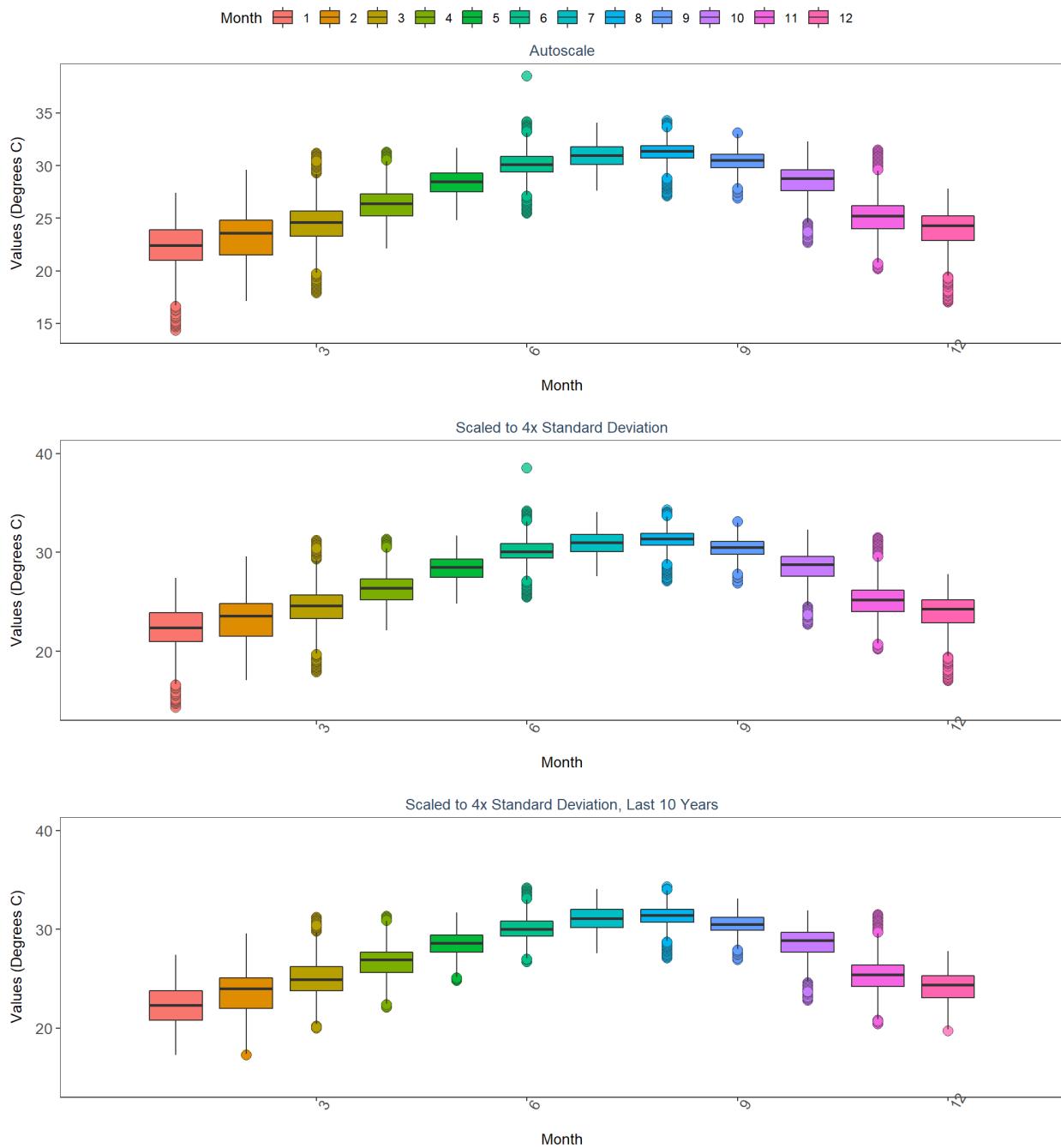
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5
National Data Buoy Center
KYWF1
By Year



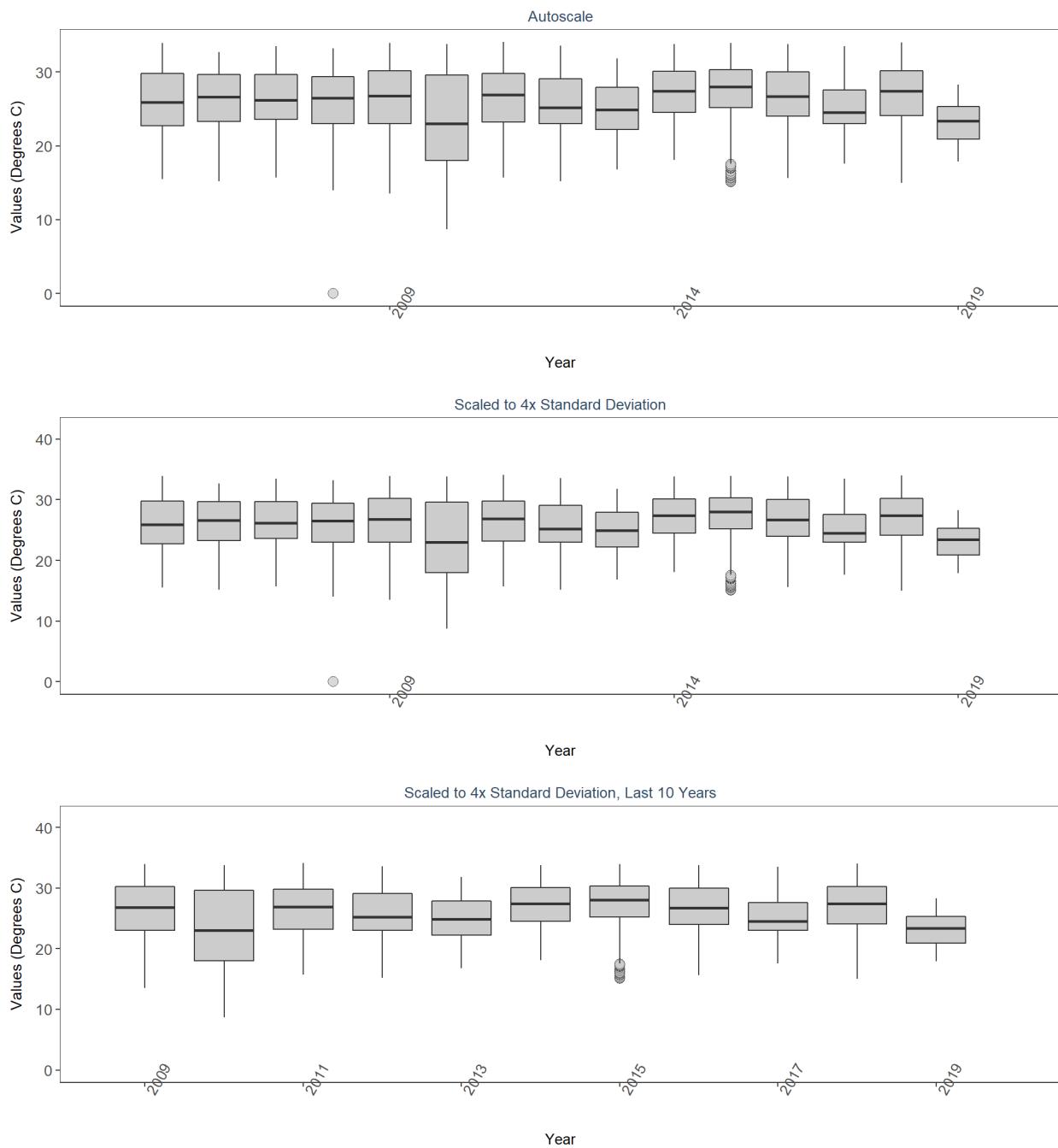
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 National Data Buoy Center
 KYWF1
 By Year & Month



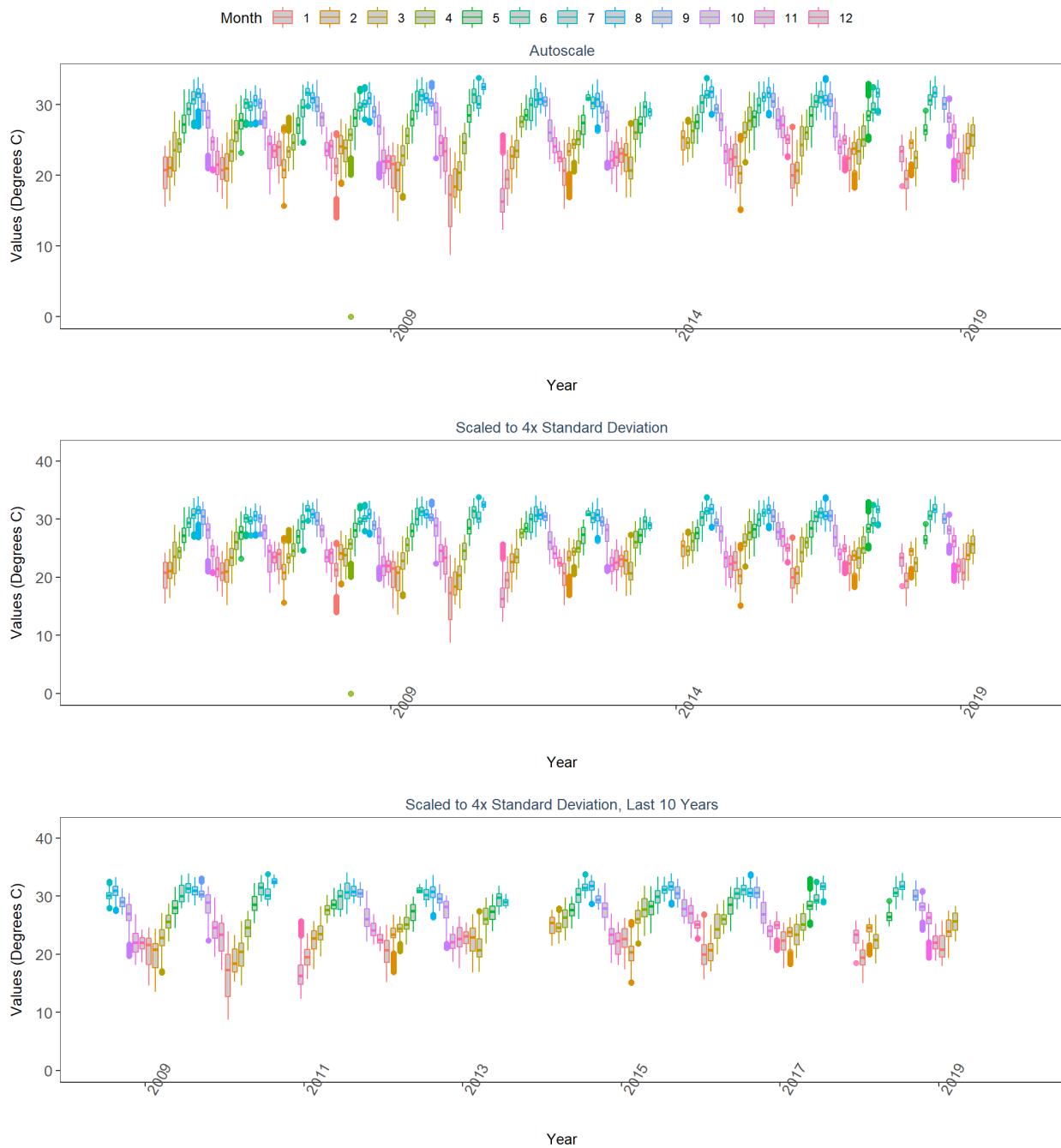
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National Data Buoy Center
KYWF1
By Month



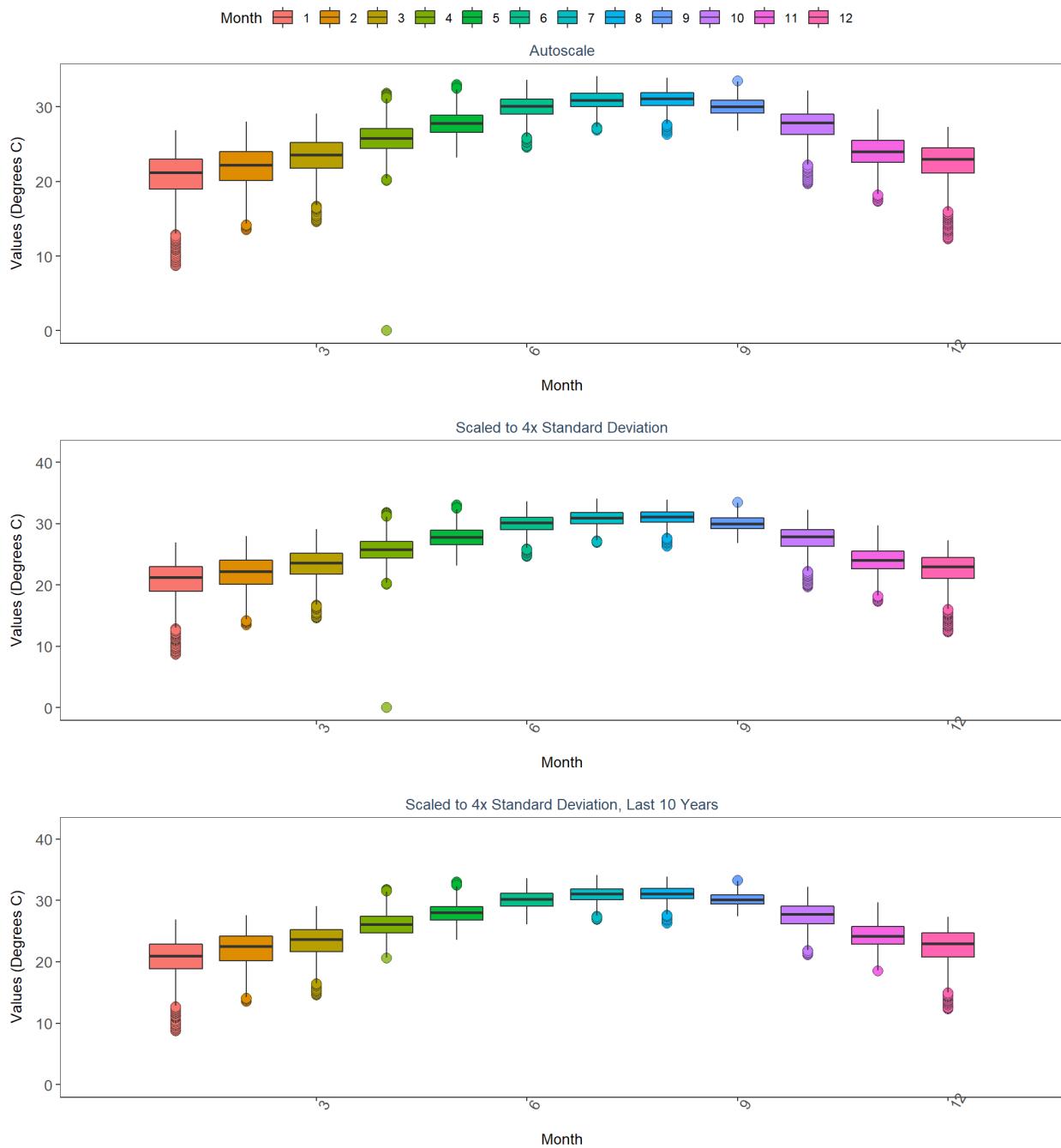
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National Data Buoy Center
LONF1
By Year



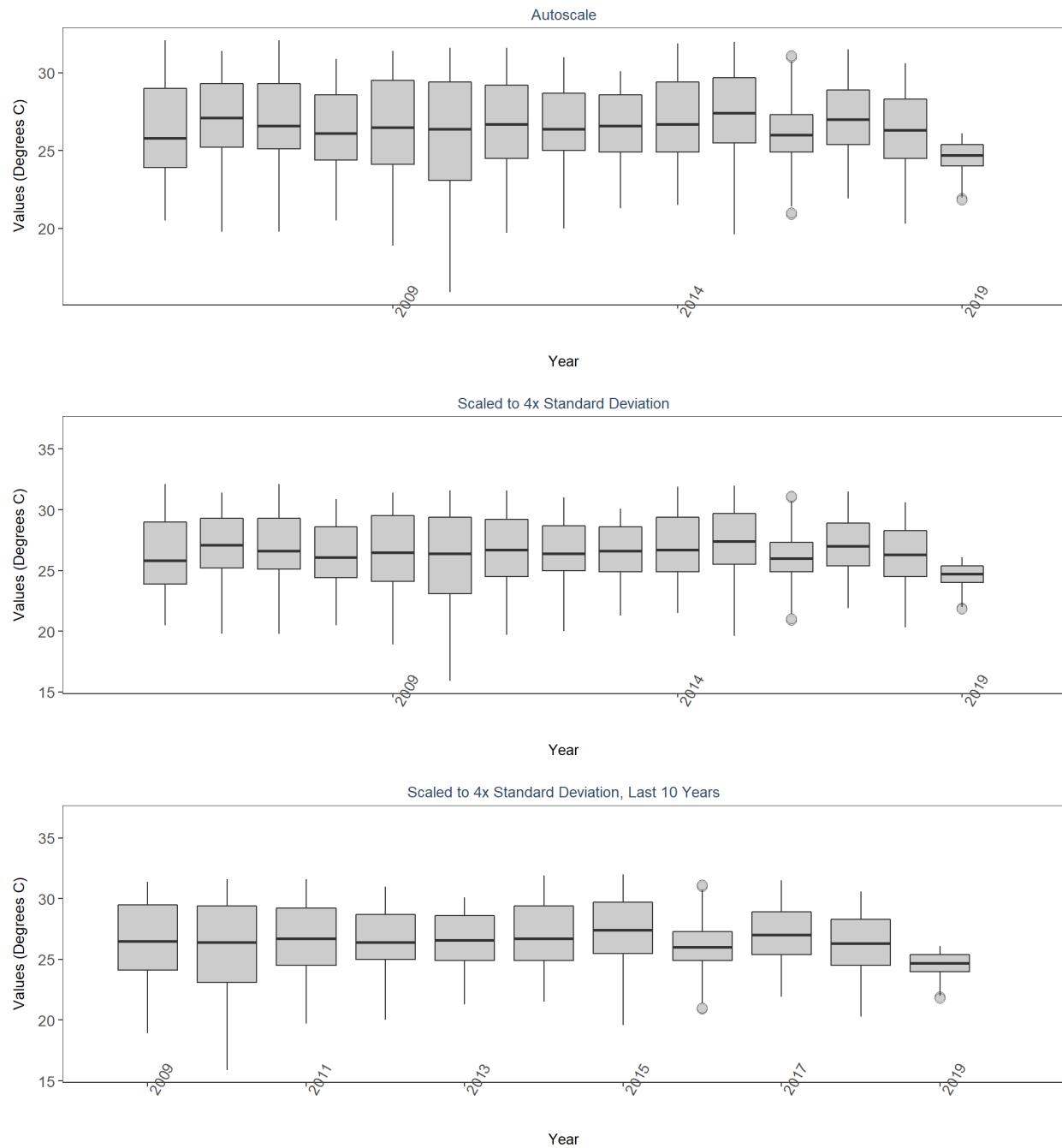
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 National Data Buoy Center
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 By Year & Month



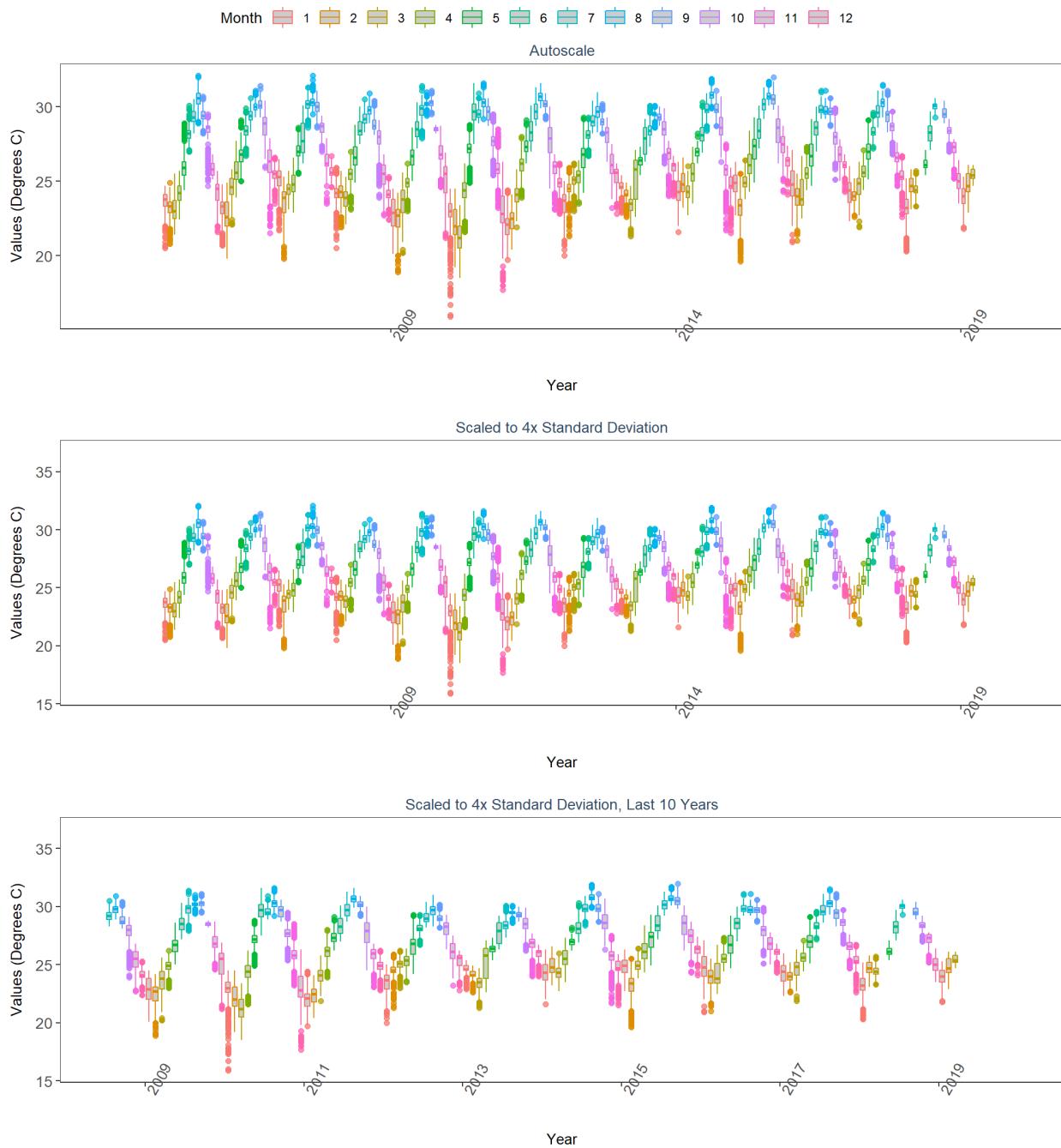
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By Month



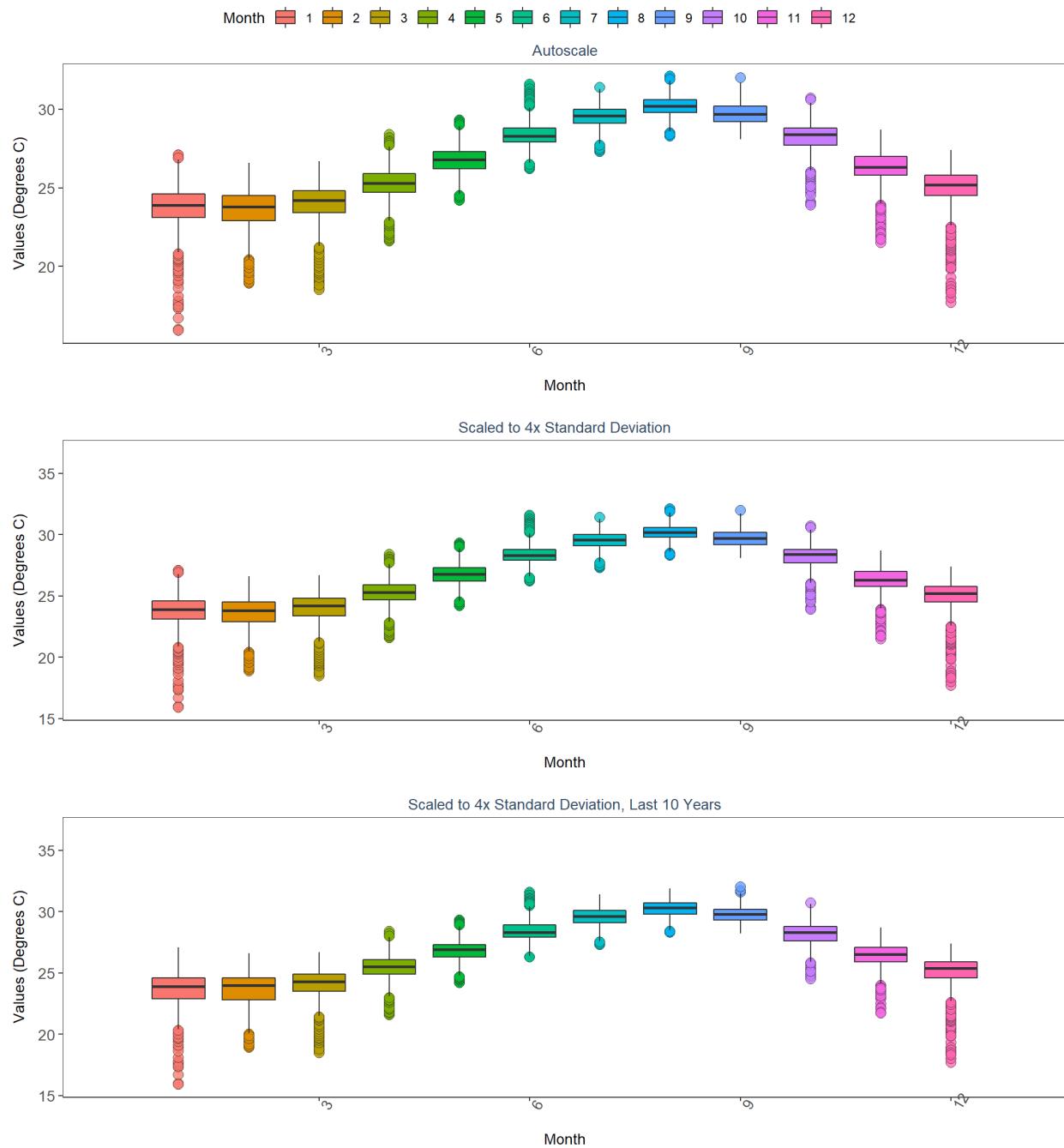
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National Data Buoy Center
MLRF1
By Year



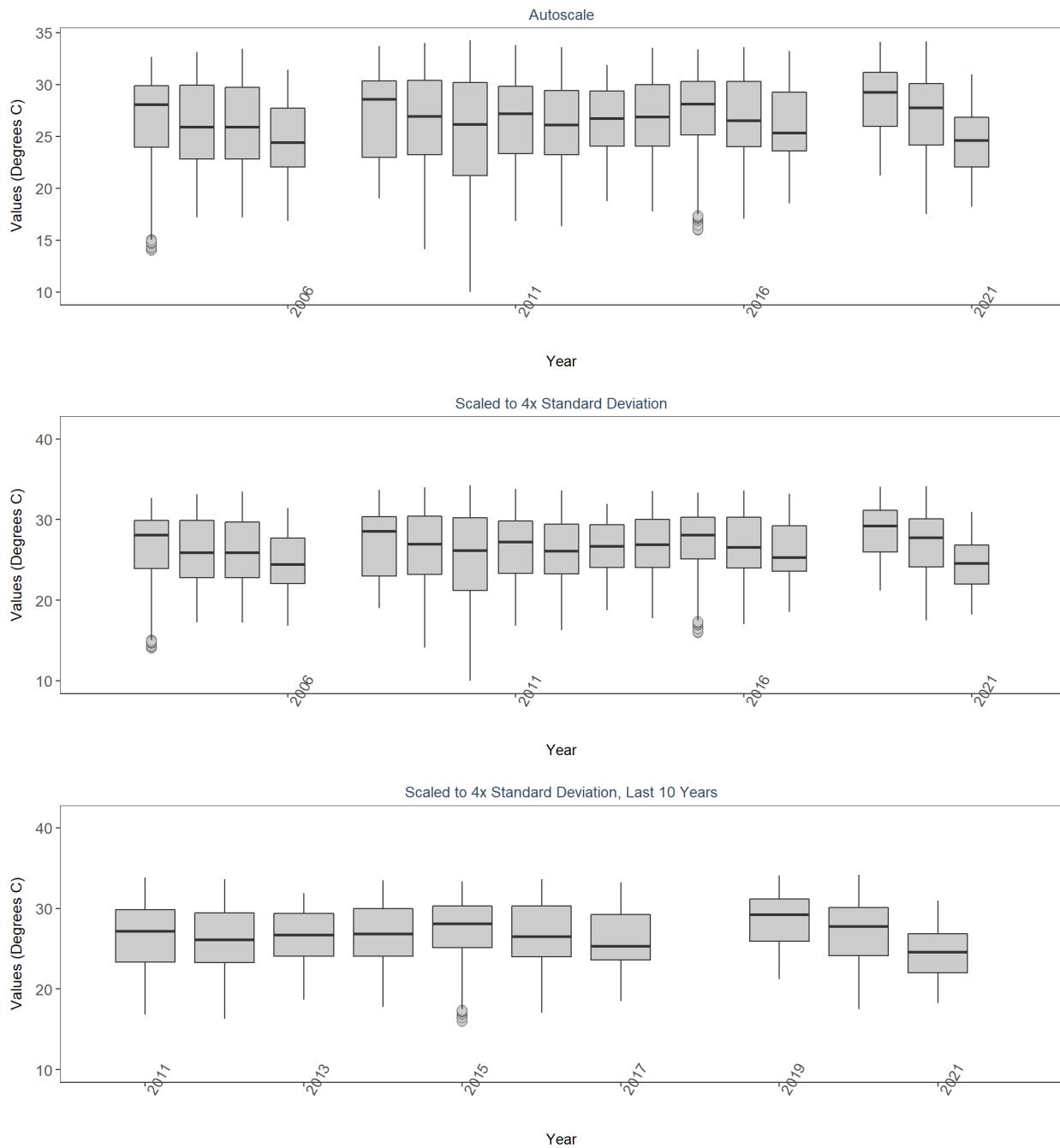
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 By Year & Month



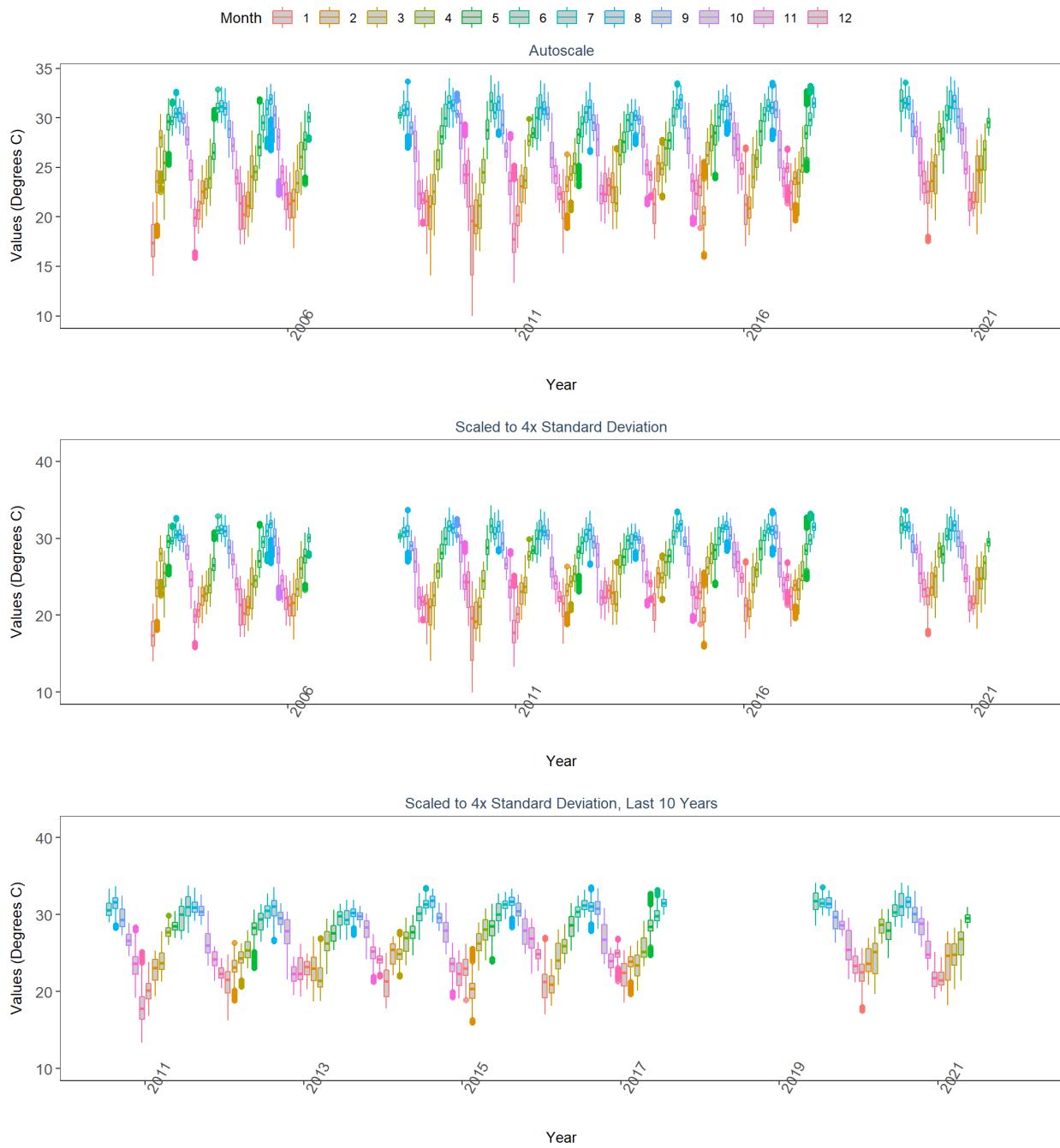
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National Data Buoy Center
MLRF1
By Month



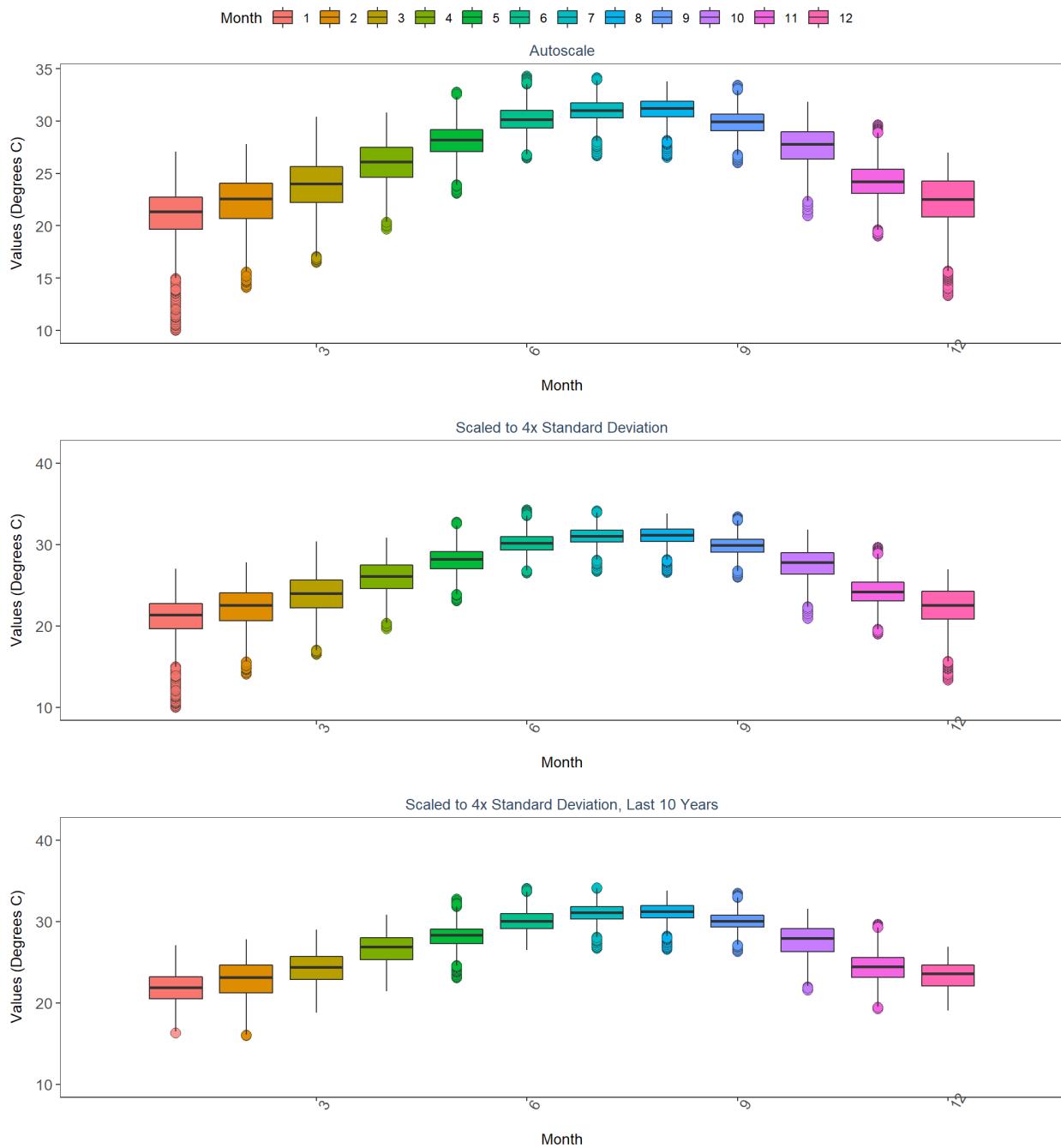
Florida Keys National Marine Sanctuary
 986
 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



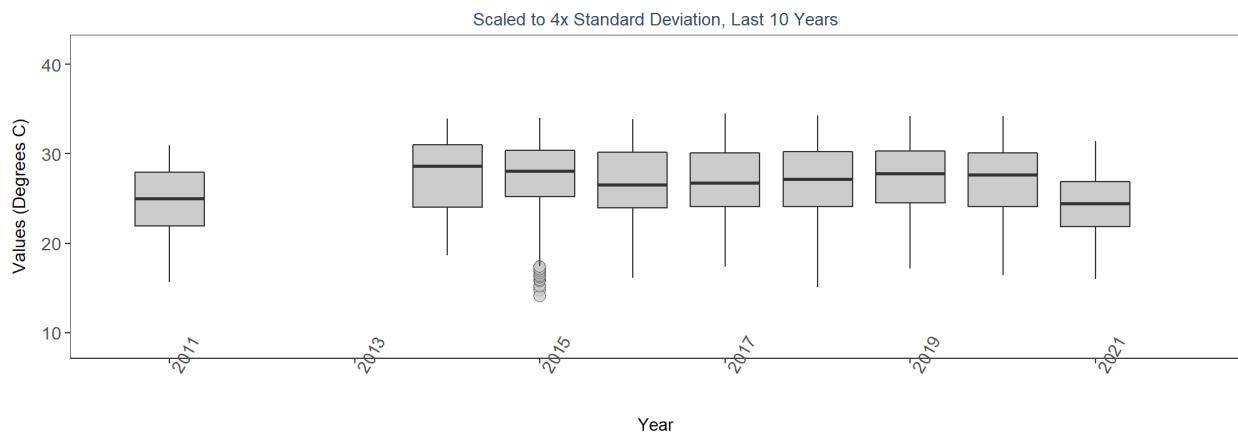
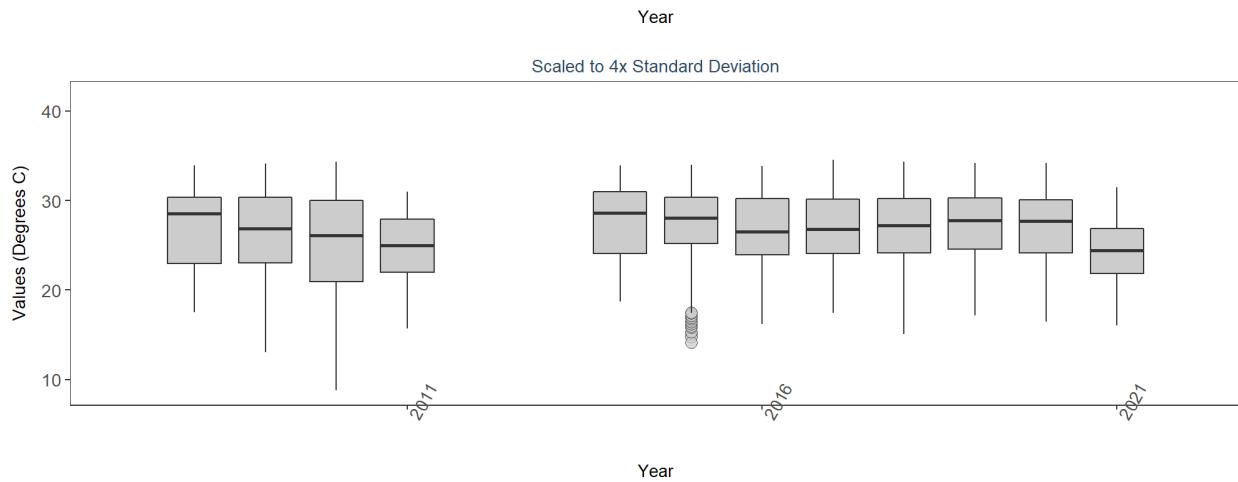
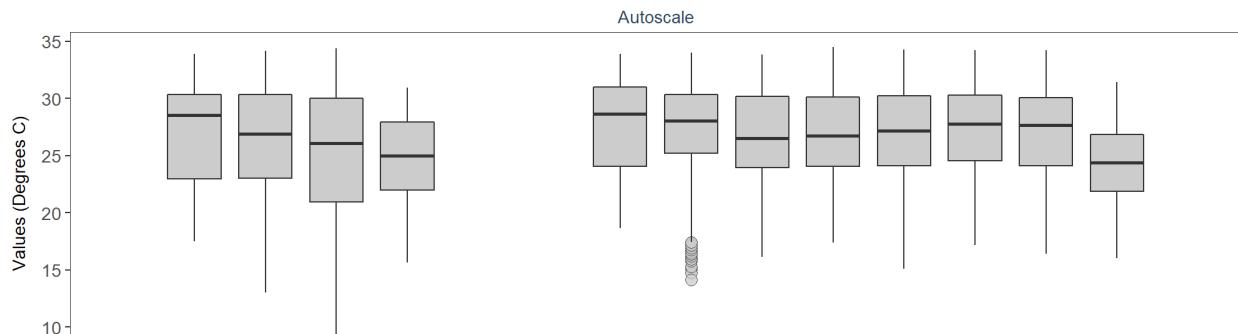
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 Water Temperature on Coral Reefs in the Florida Keys
 11
 By Year & Month



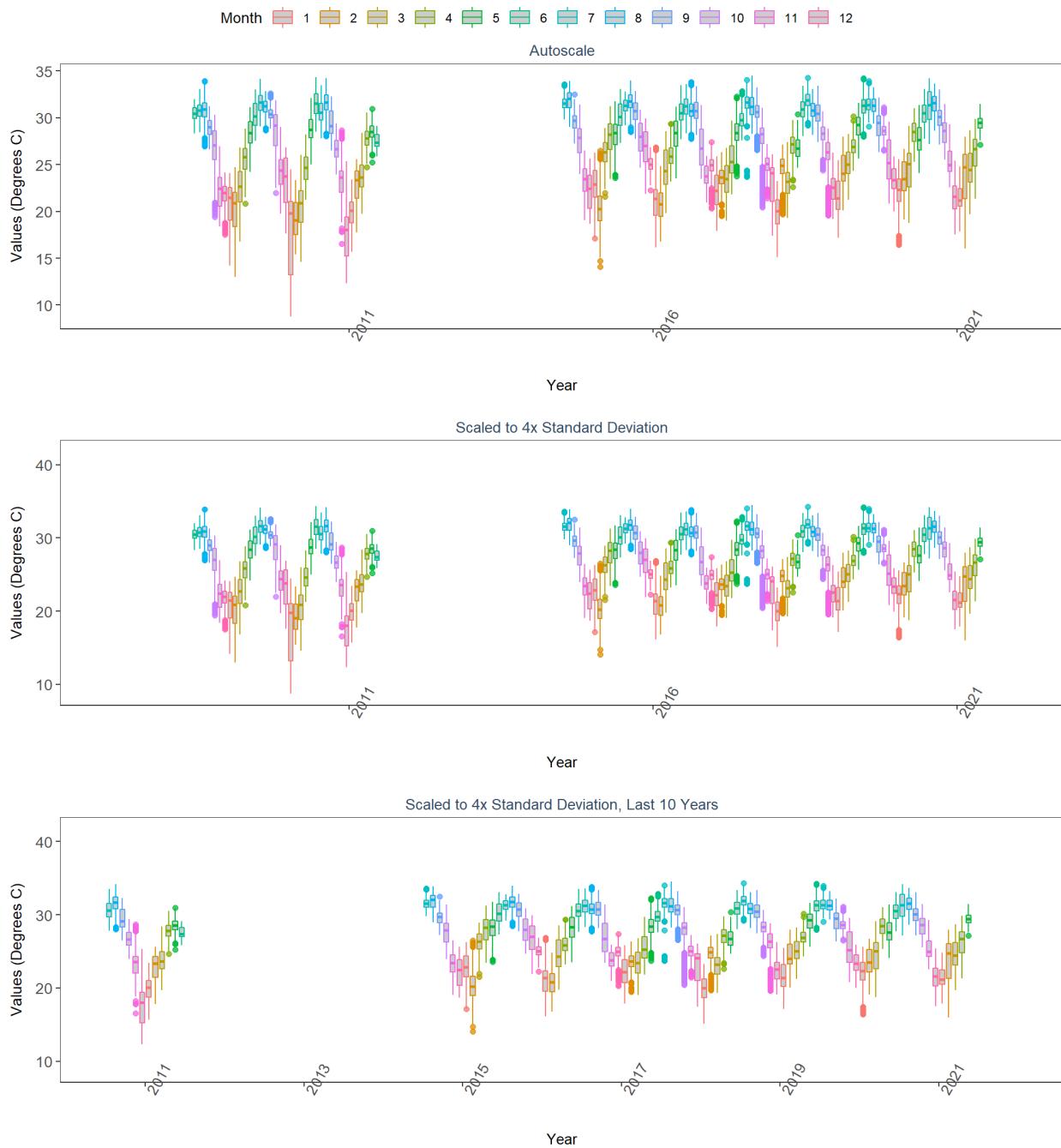
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



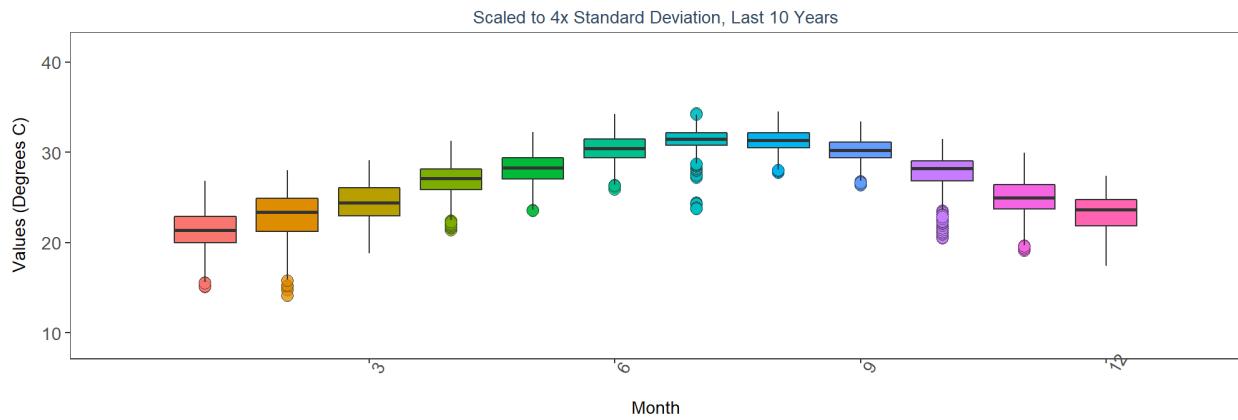
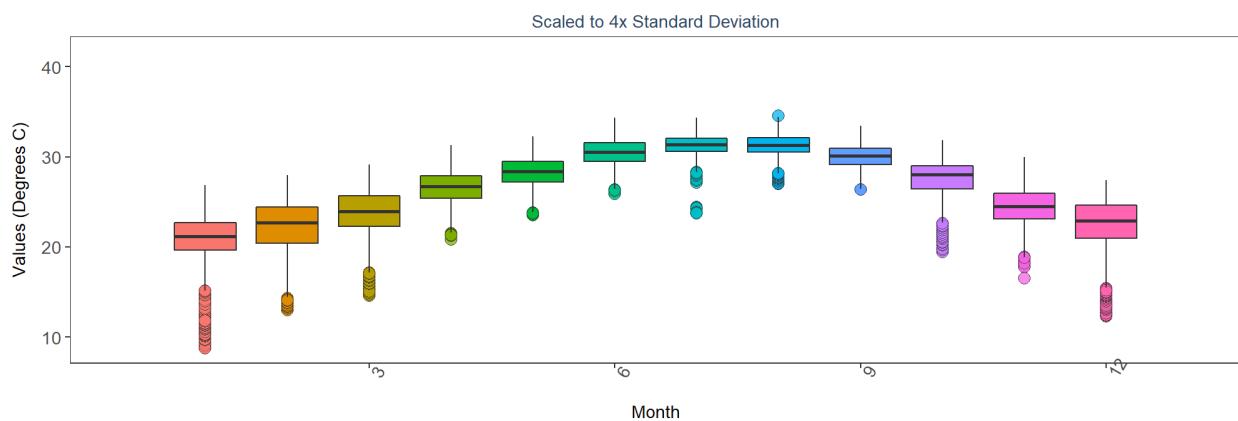
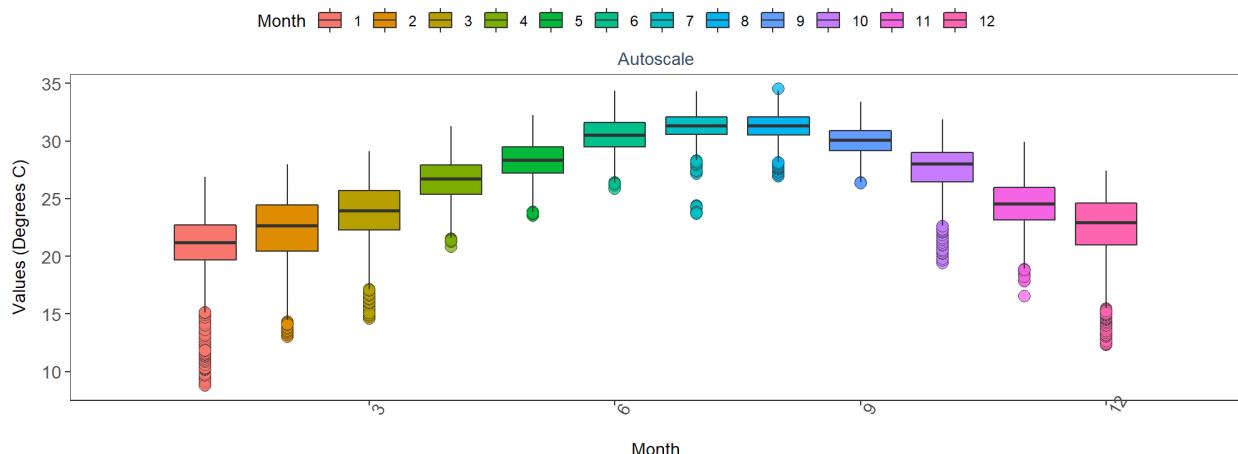
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



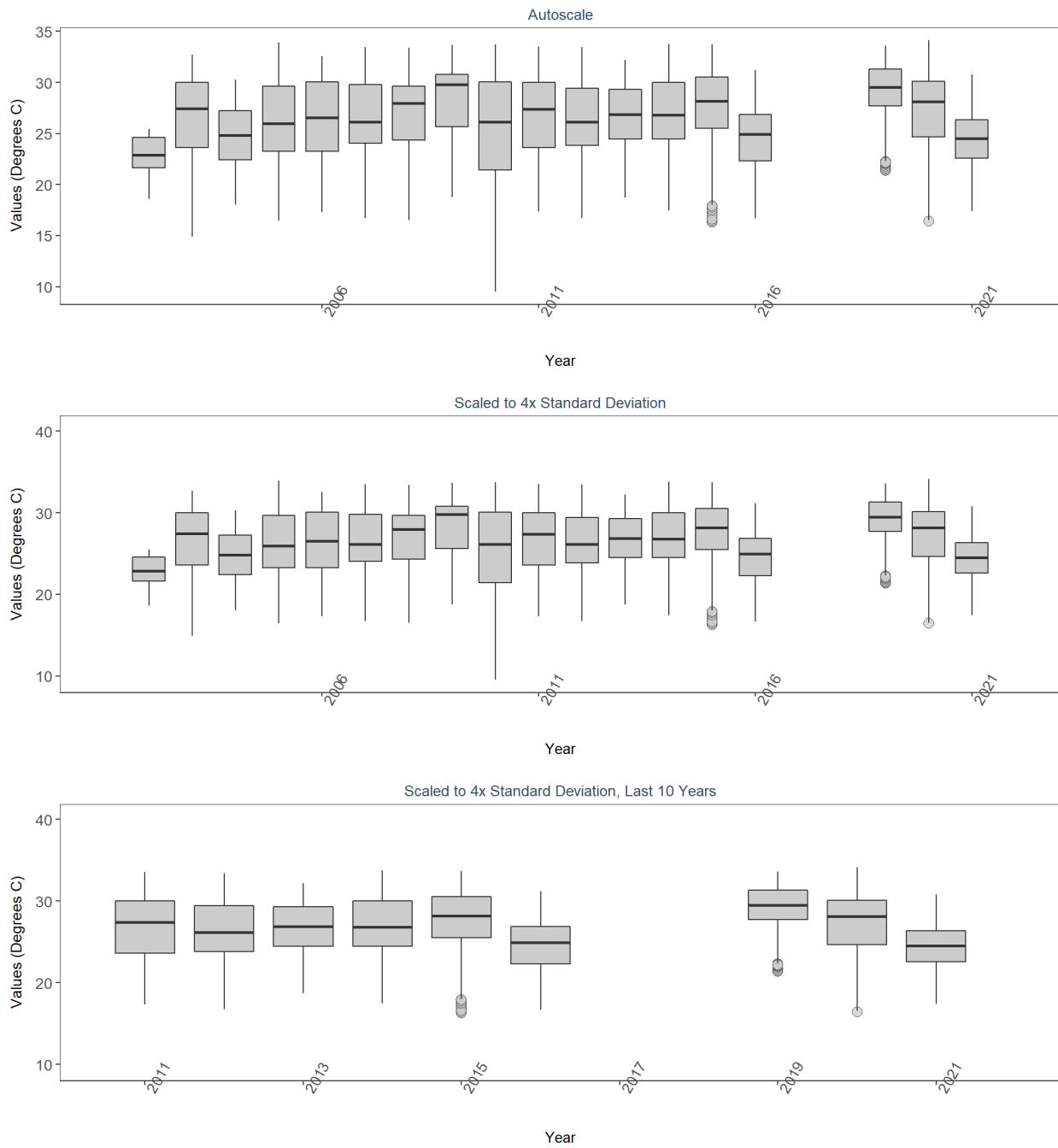
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 Water Temperature on Coral Reefs in the Florida Keys
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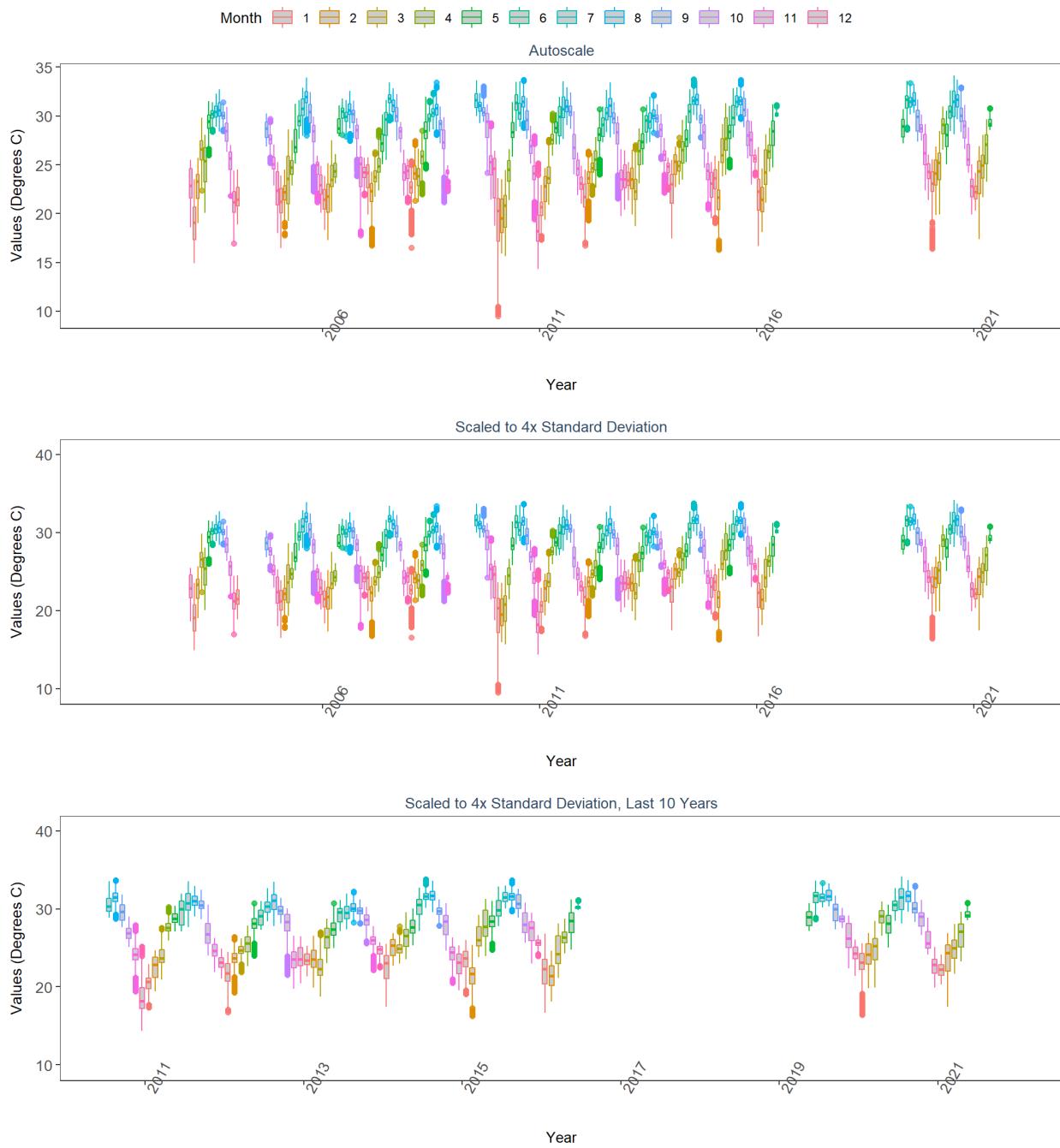
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 By Month



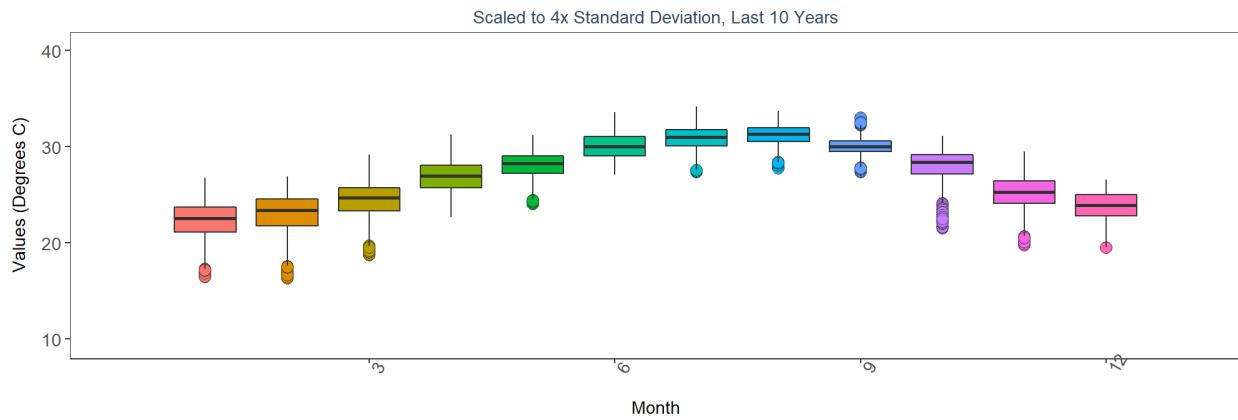
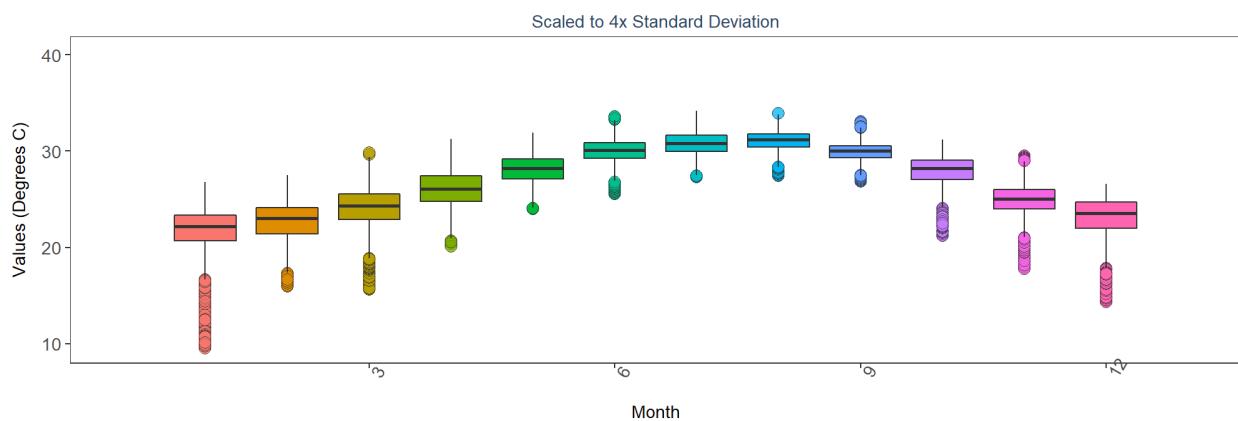
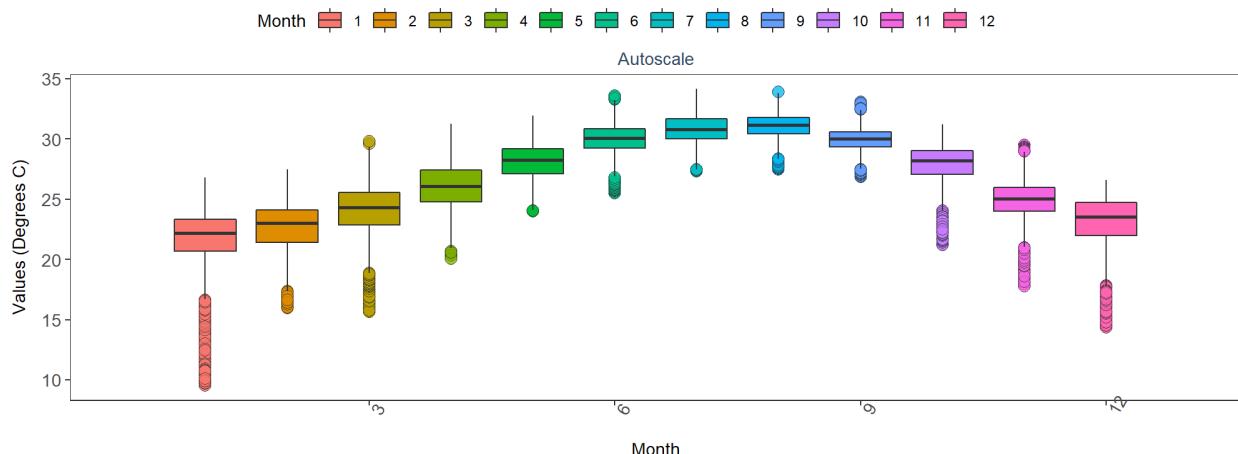
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



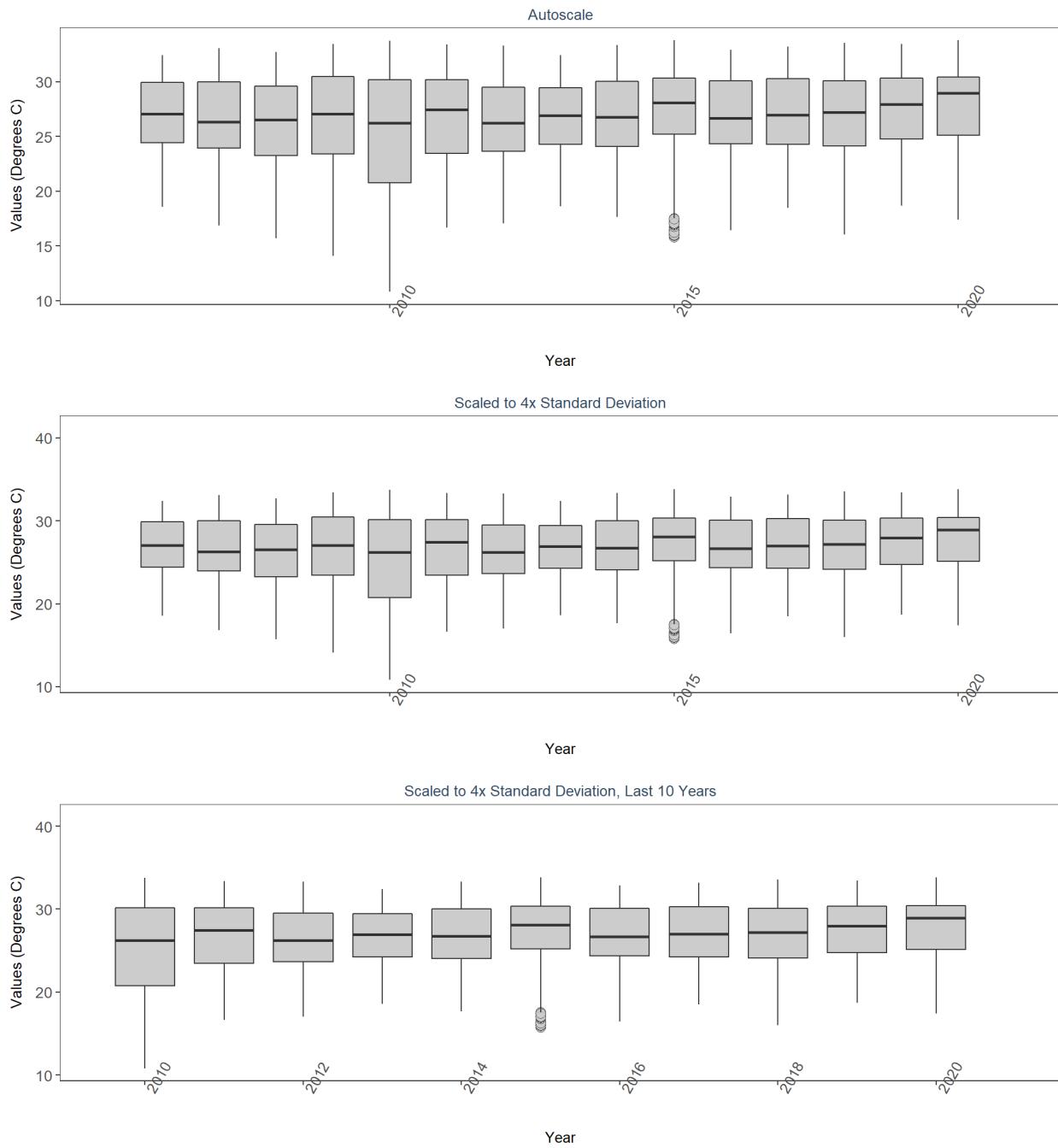
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Water Temperature on Coral Reefs in the Florida Keys
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By Year & Month



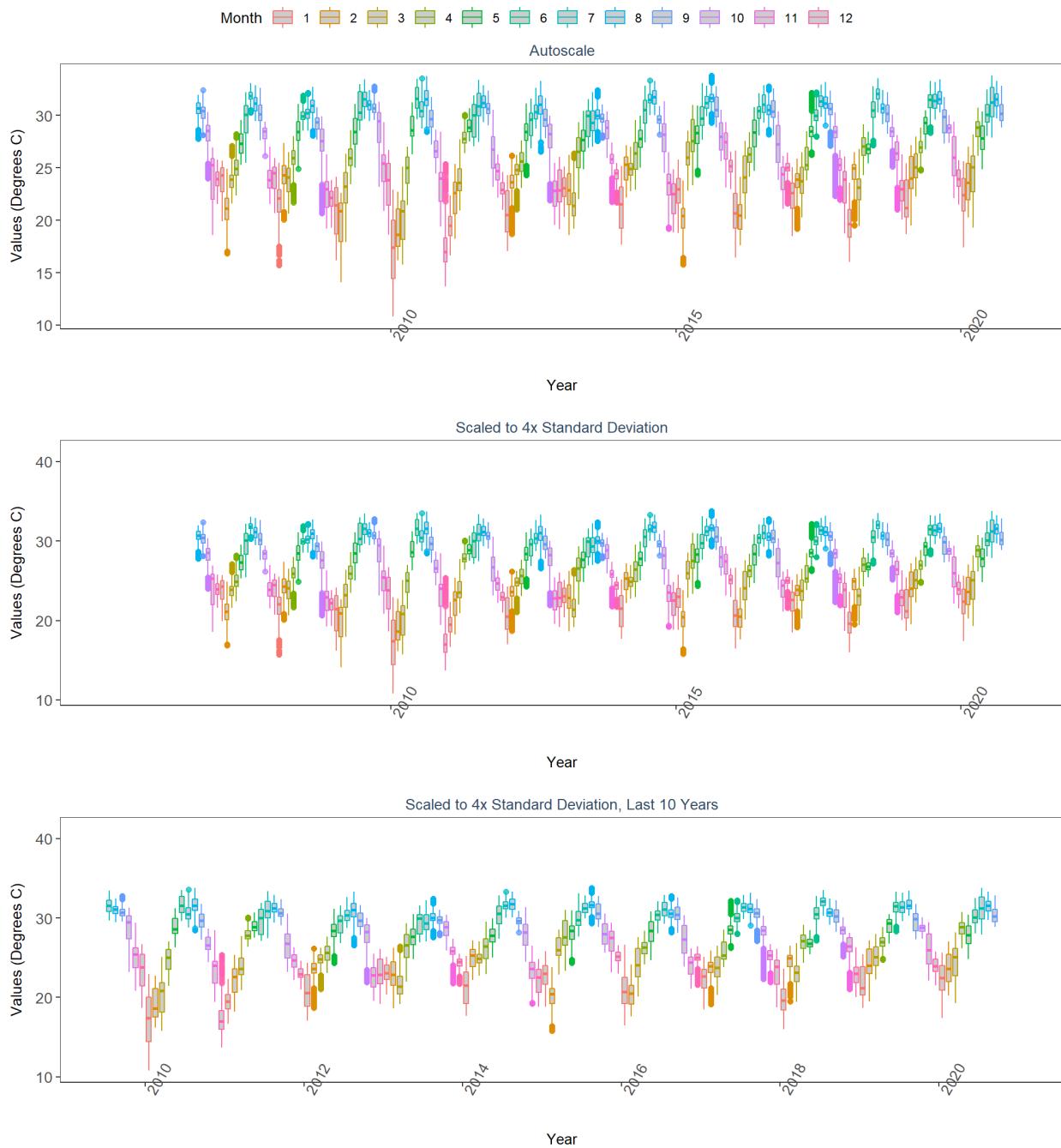
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 Water Temperature on Coral Reefs in the Florida Keys
 14
 By Month



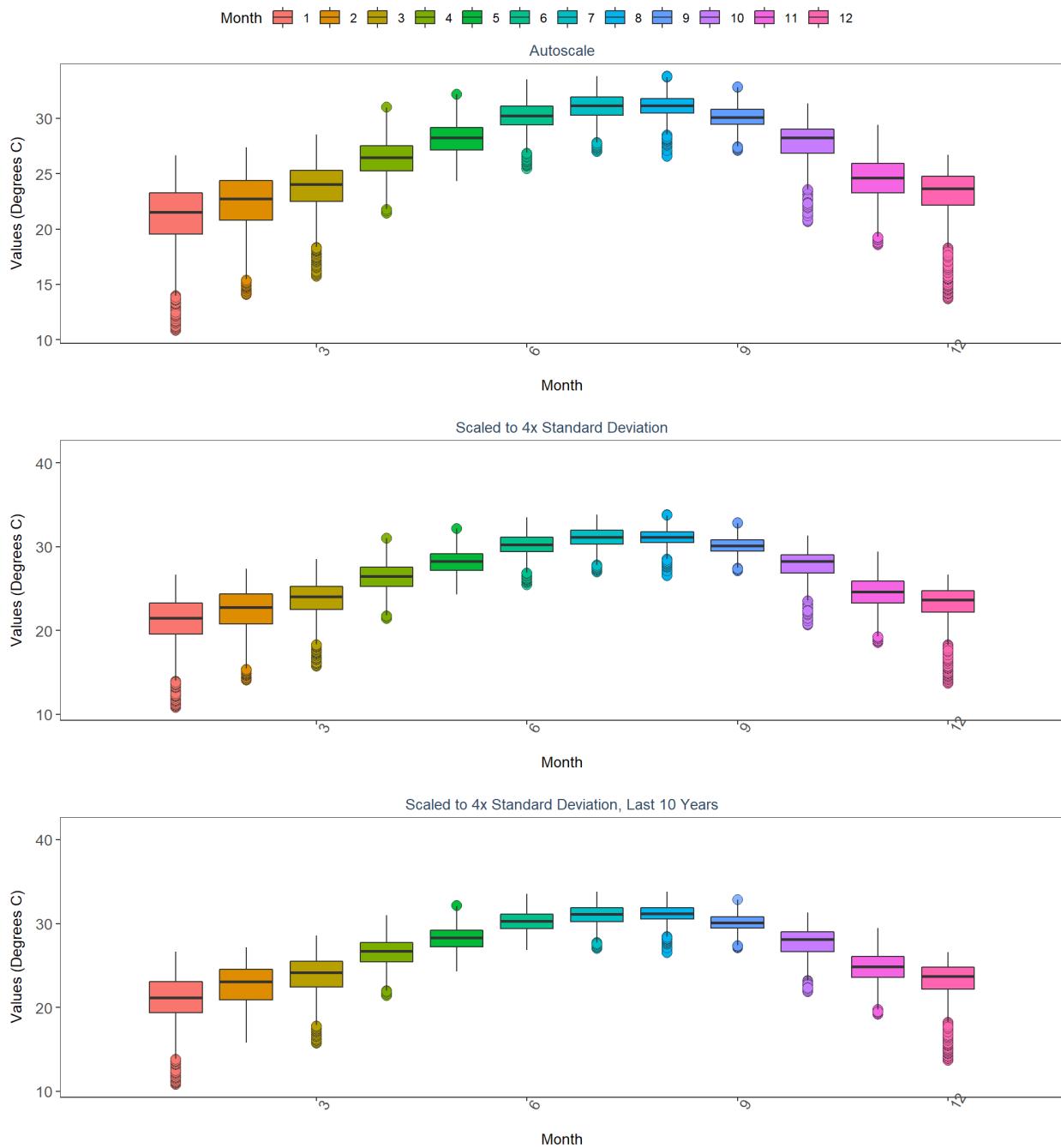
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



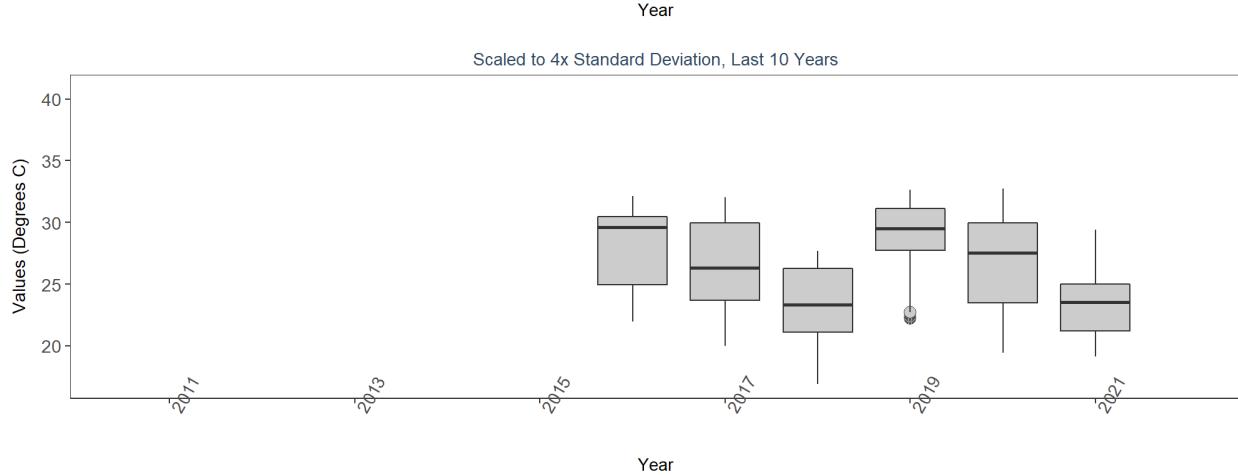
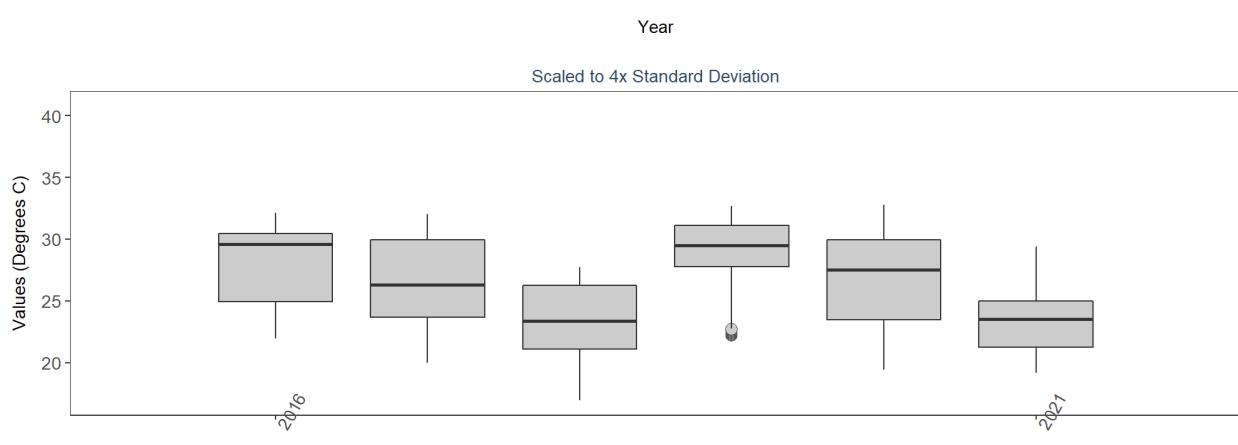
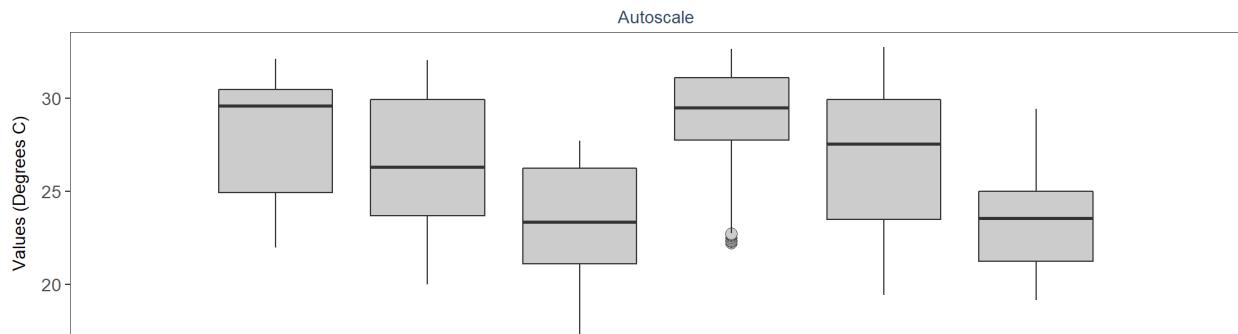
Florida Keys National Marine Sanctuary
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Water Temperature on Coral Reefs in the Florida Keys
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By Year & Month



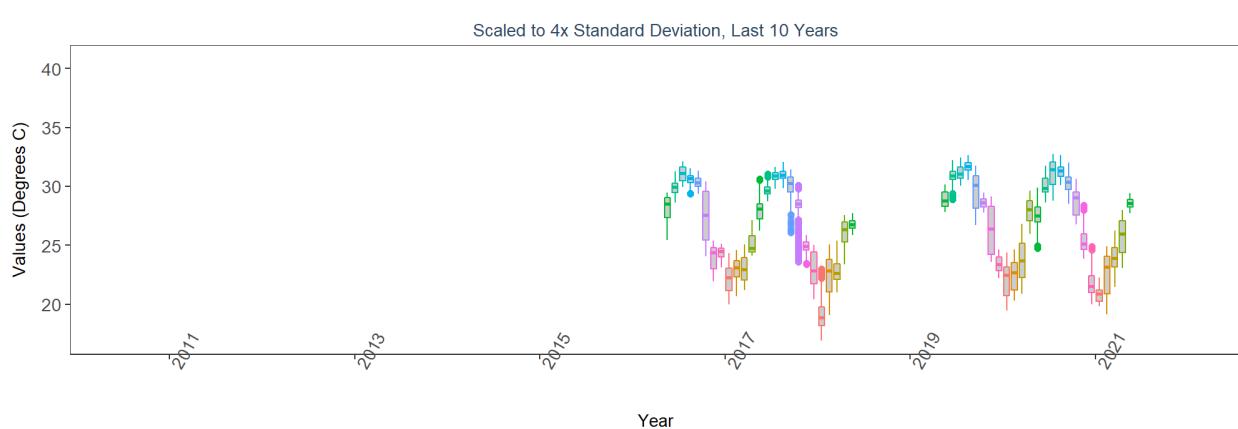
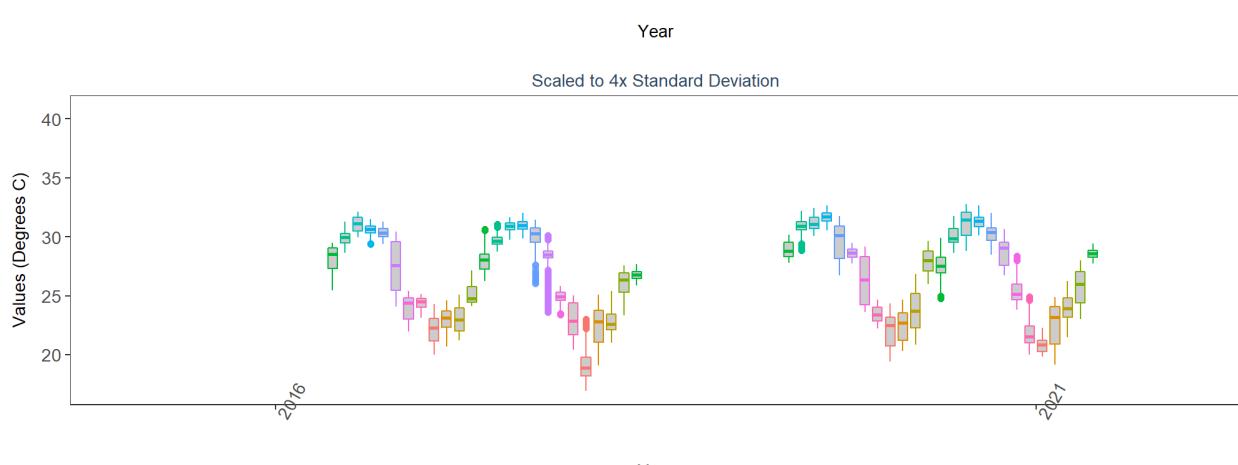
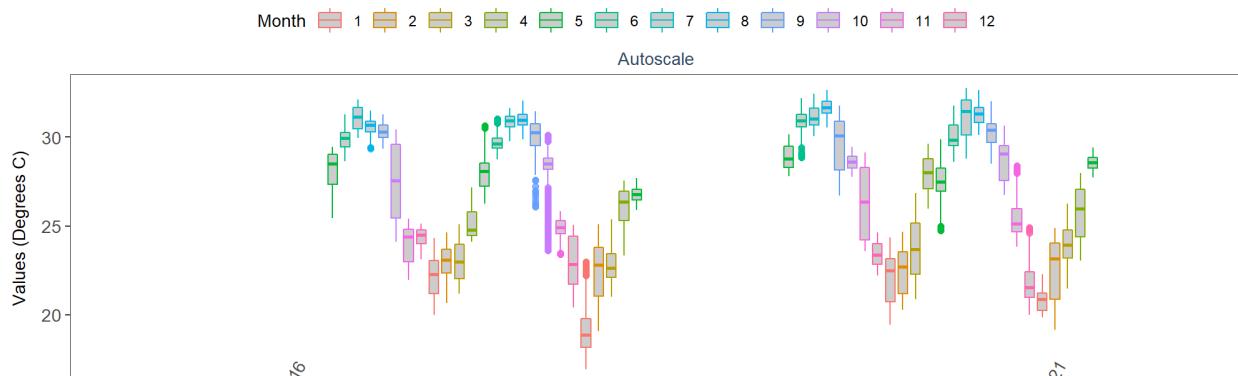
Florida Keys National Marine Sanctuary
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 Water Temperature on Coral Reefs in the Florida Keys
 15
 By Month



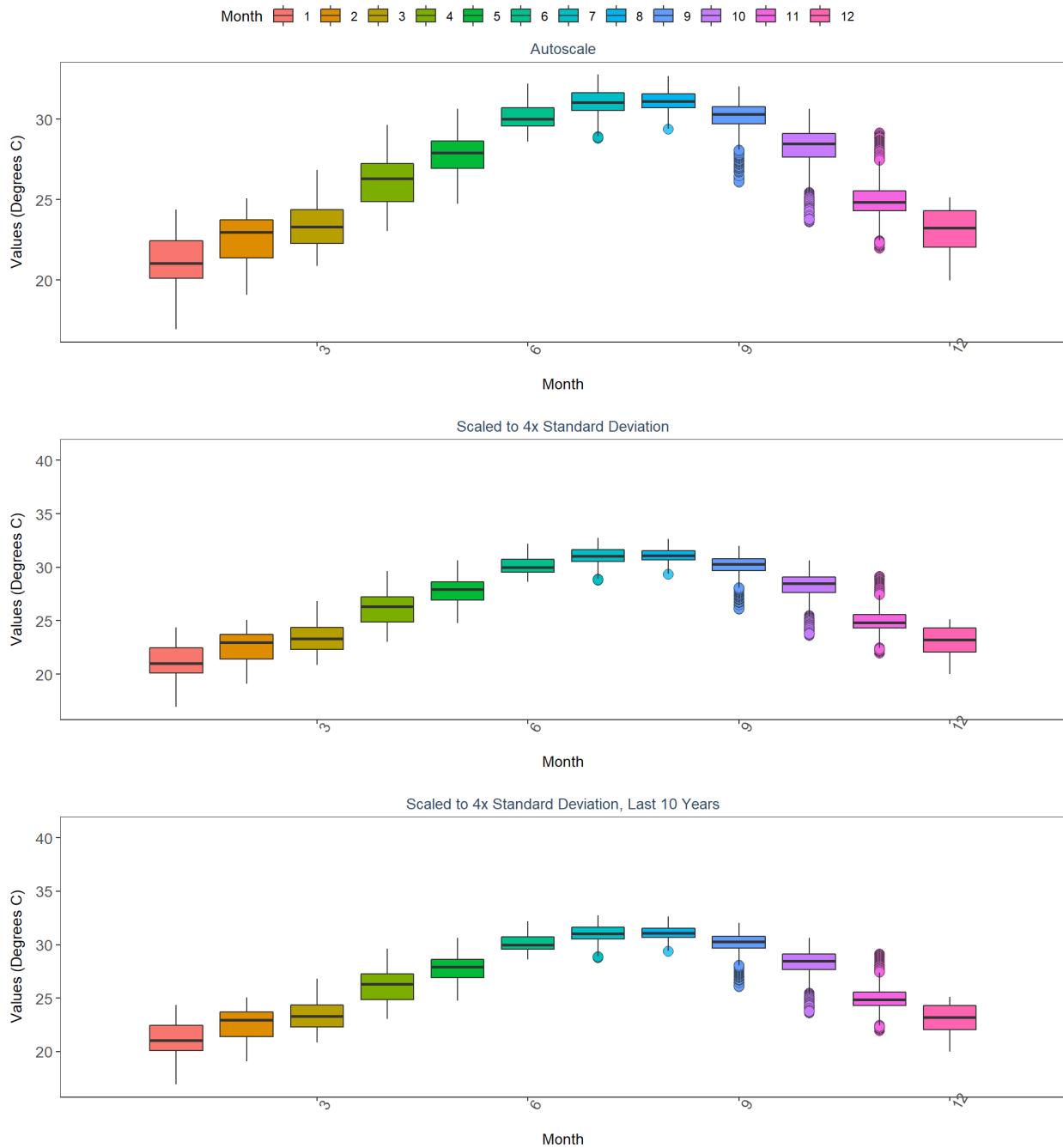
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 Water Temperature on Coral Reefs in the Florida Keys
 18
 By Year



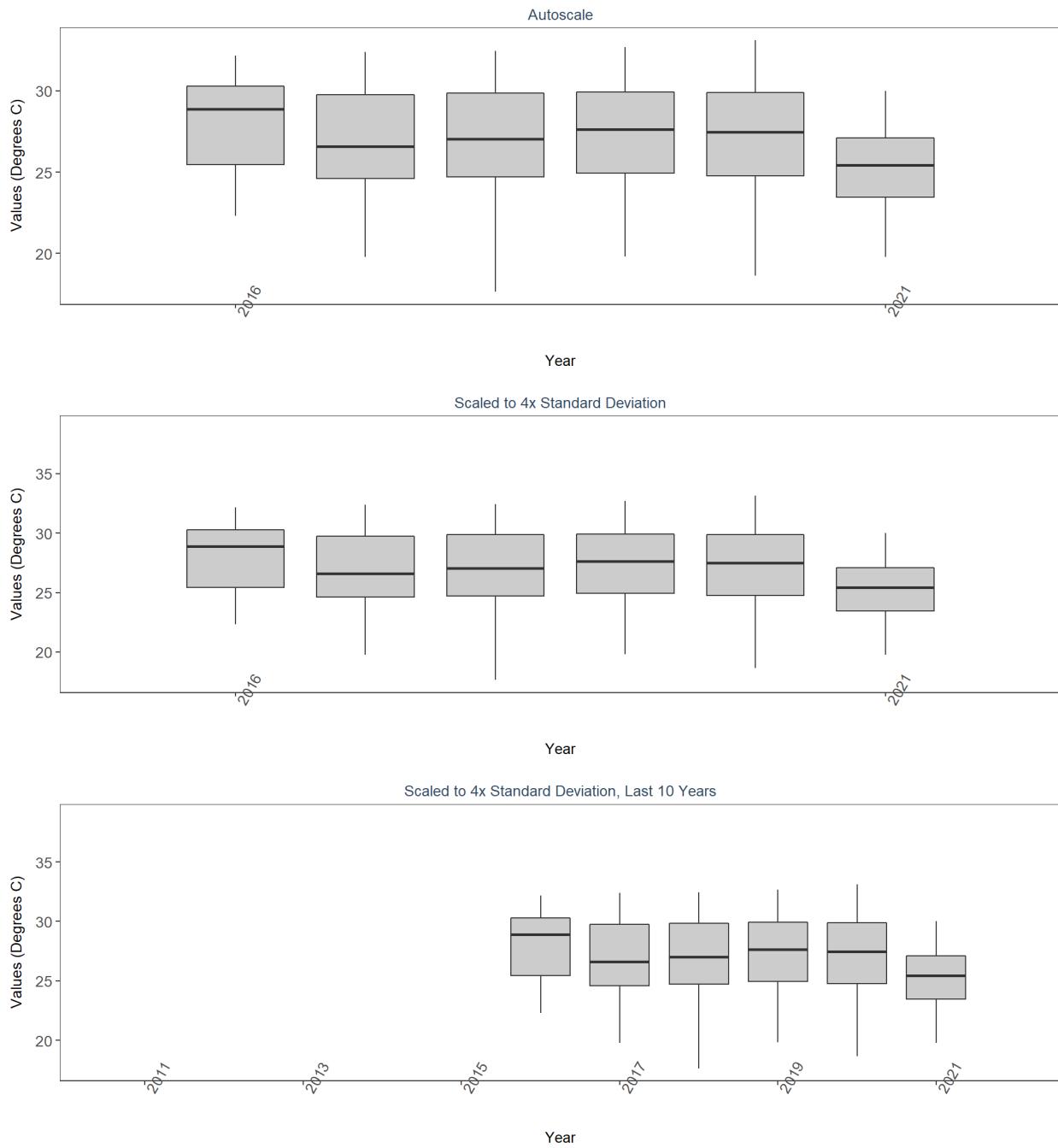
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 Water Temperature on Coral Reefs in the Florida Keys
 18
 By Year & Month



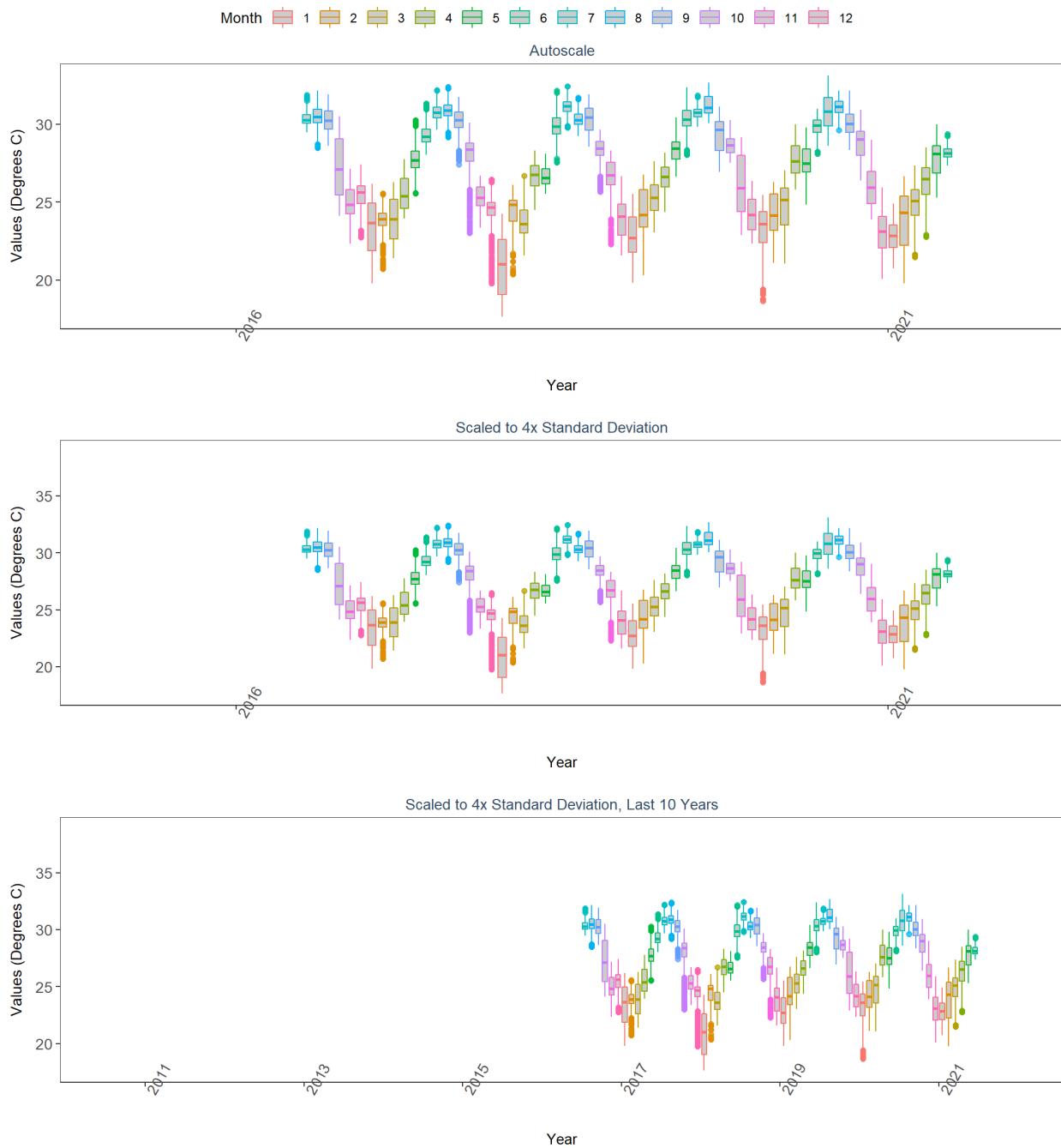
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 Water Temperature on Coral Reefs in the Florida Keys
 18
 By Month



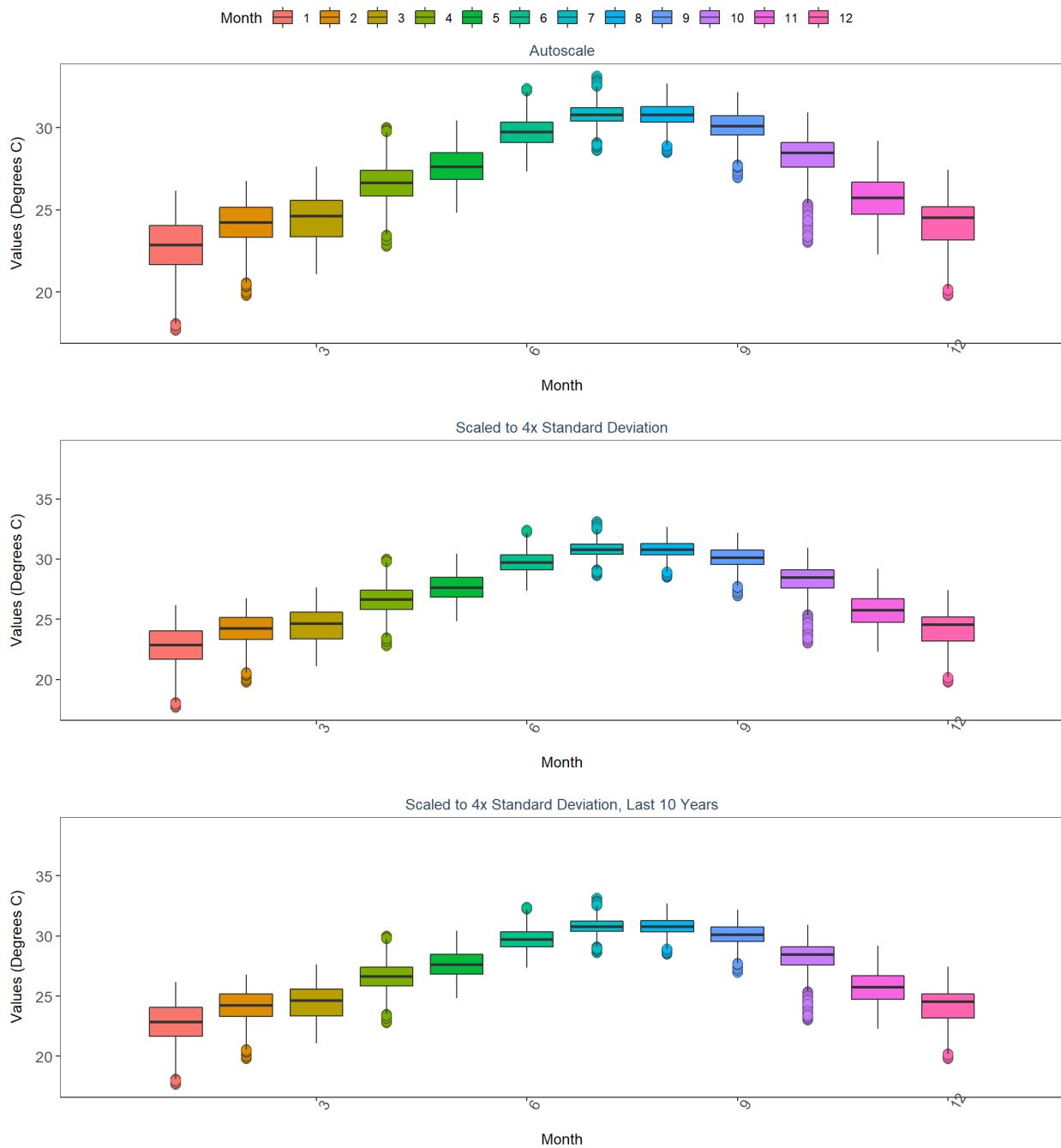
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Water Temperature on Coral Reefs in the Florida Keys
21
By Year



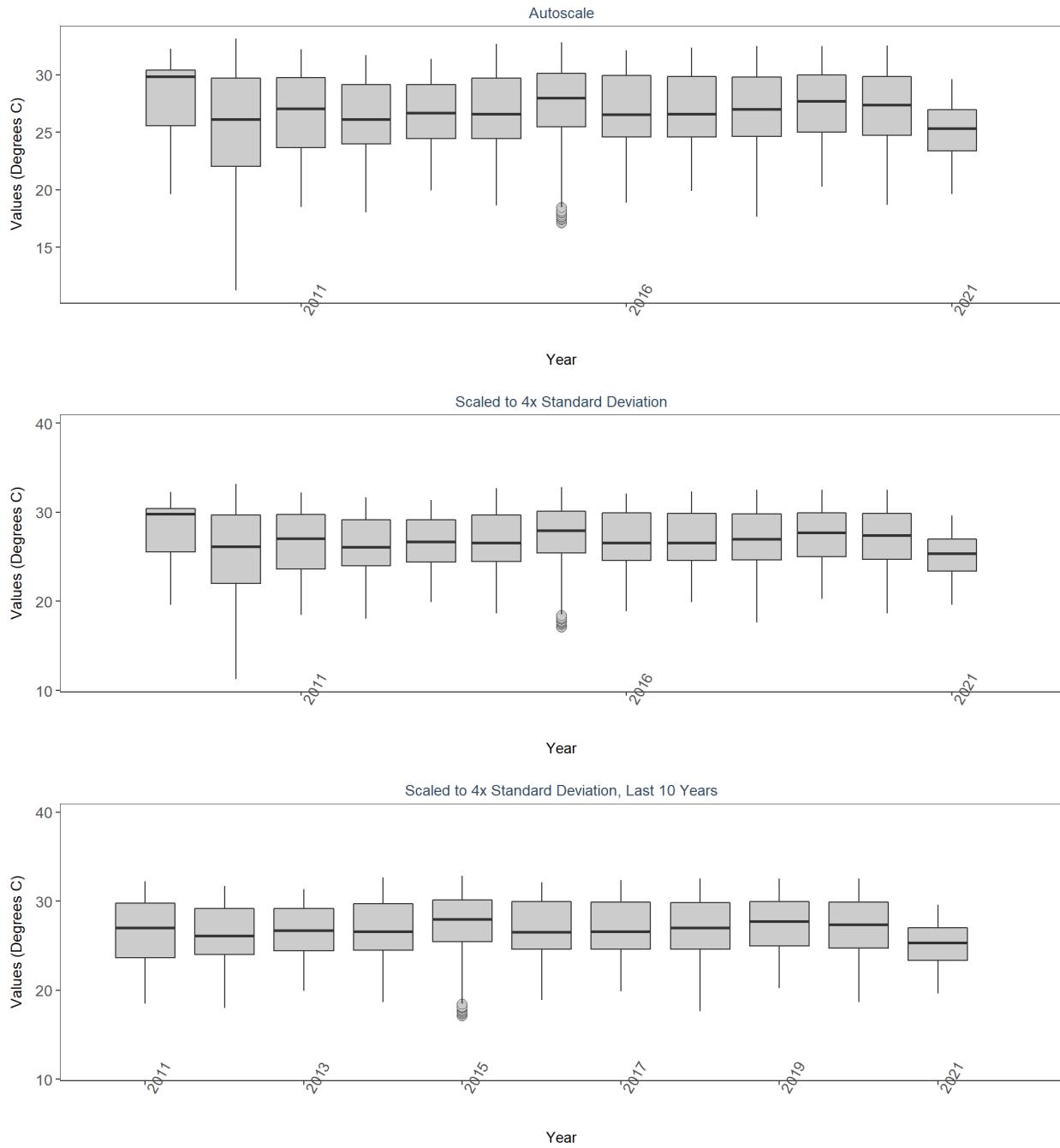
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 Water Temperature on Coral Reefs in the Florida Keys
 21
 By Year & Month



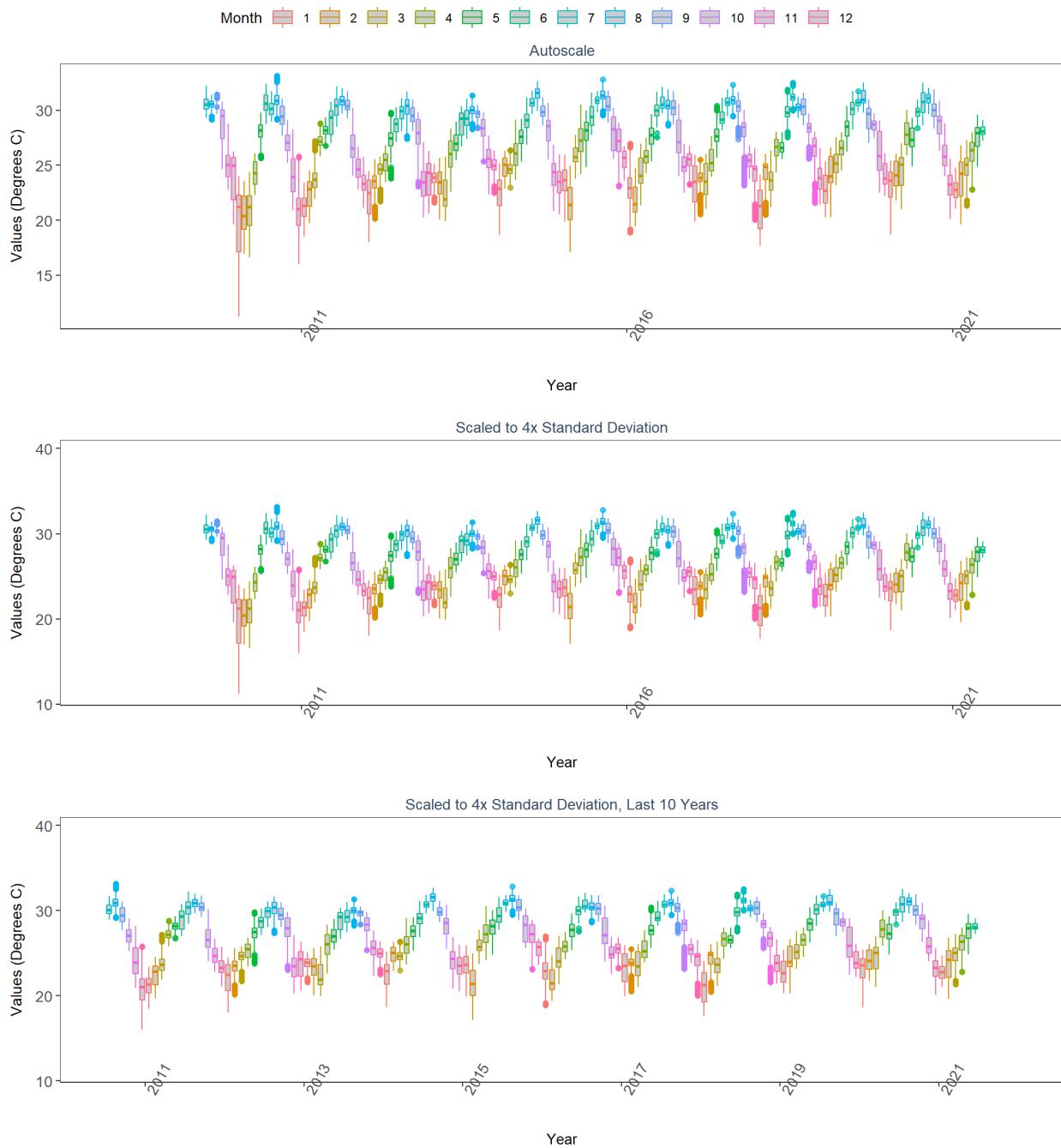
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



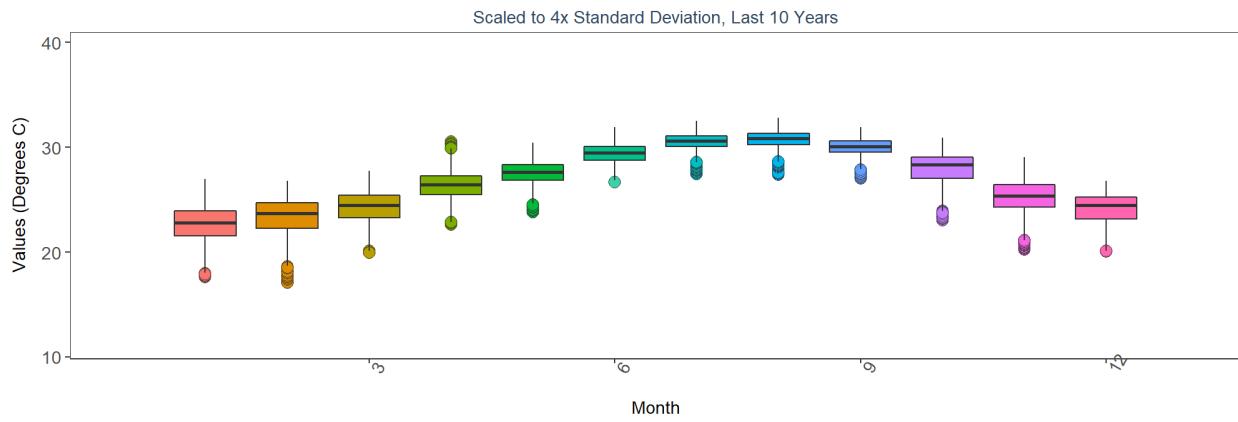
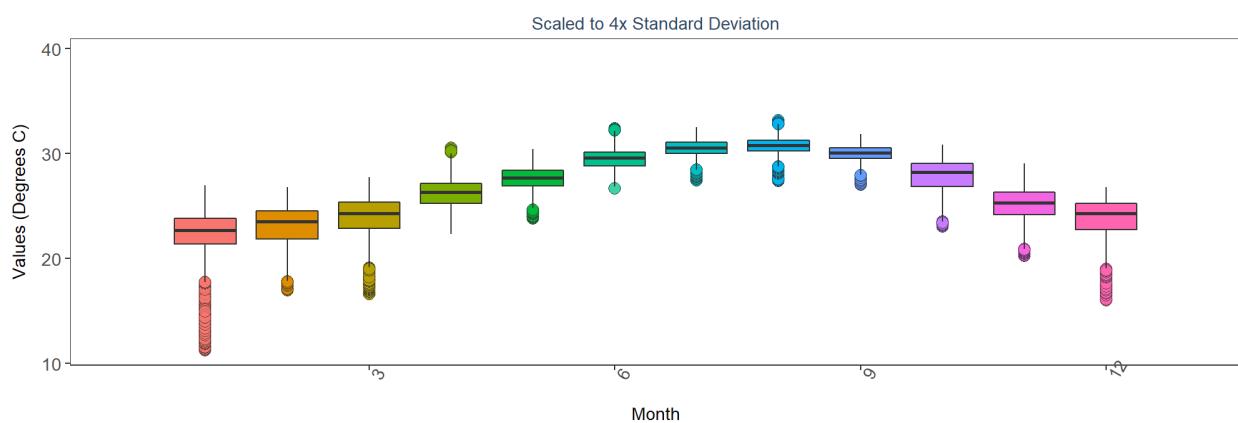
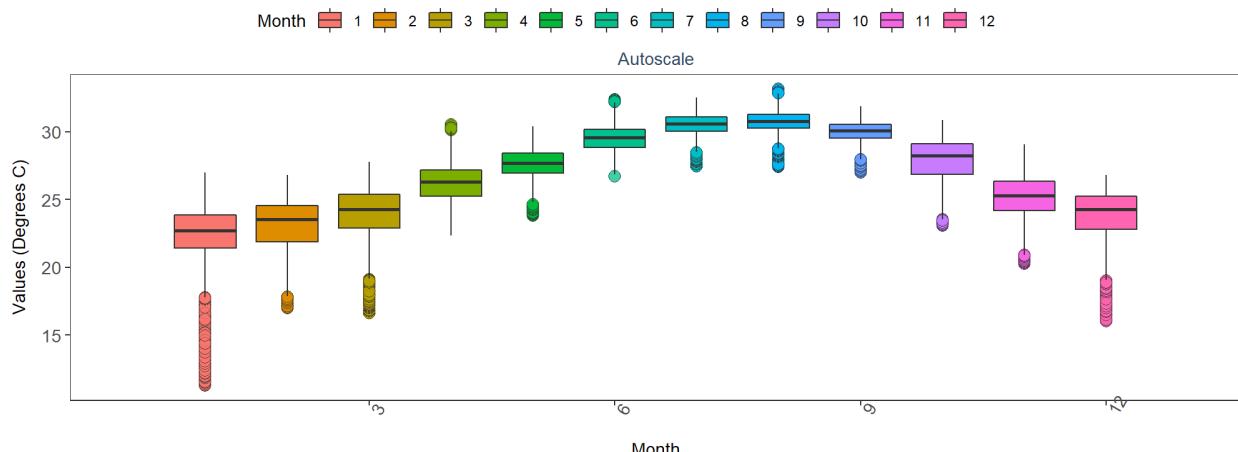
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 Water Temperature on Coral Reefs in the Florida Keys
 22
 By Year



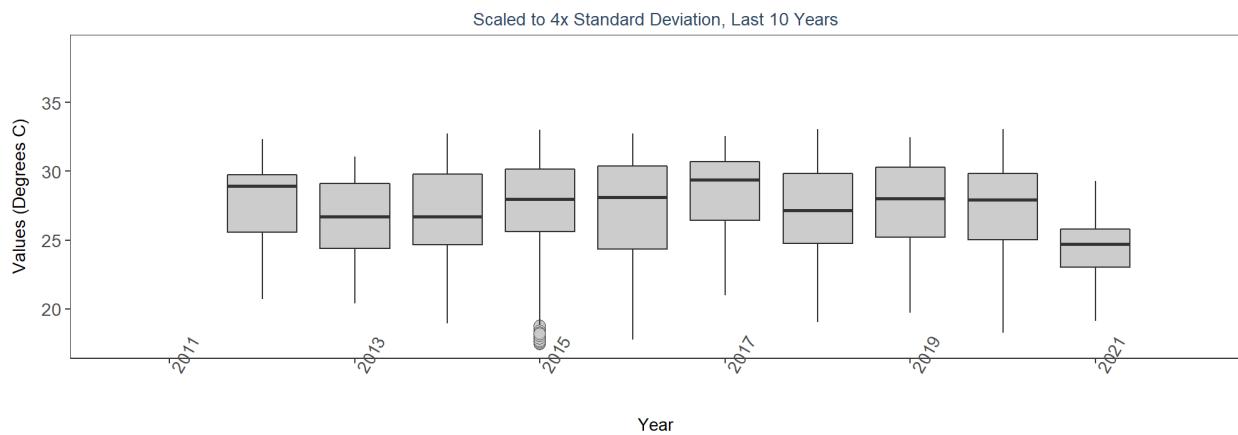
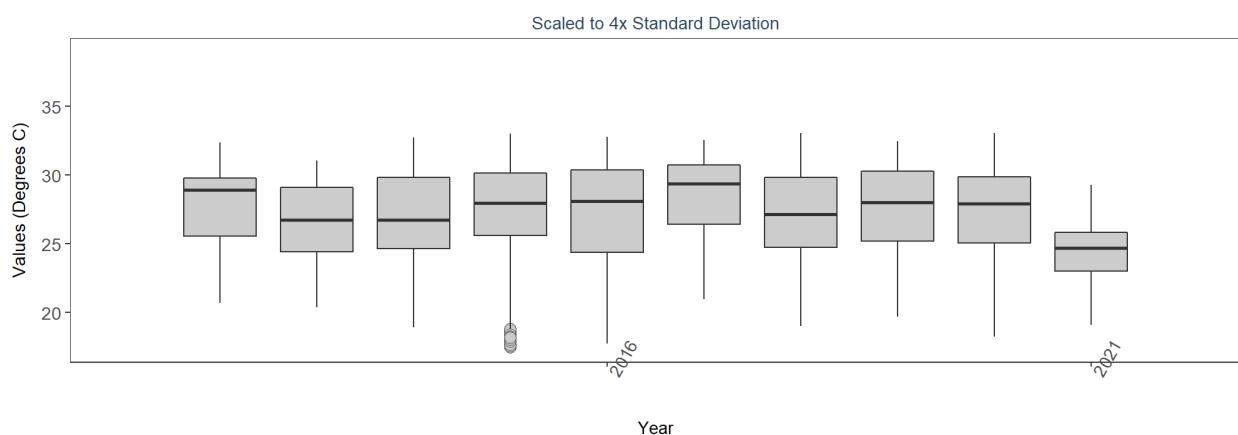
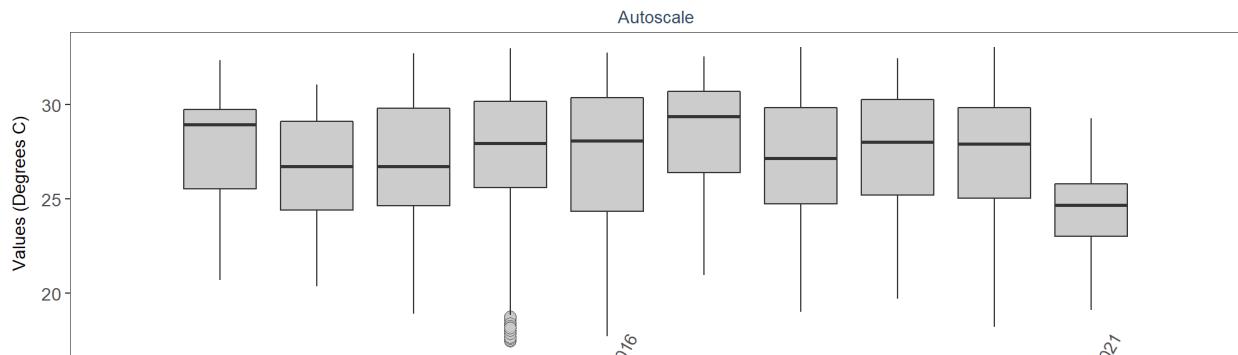
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 Water Temperature on Coral Reefs in the Florida Keys
 22
 By Year & Month



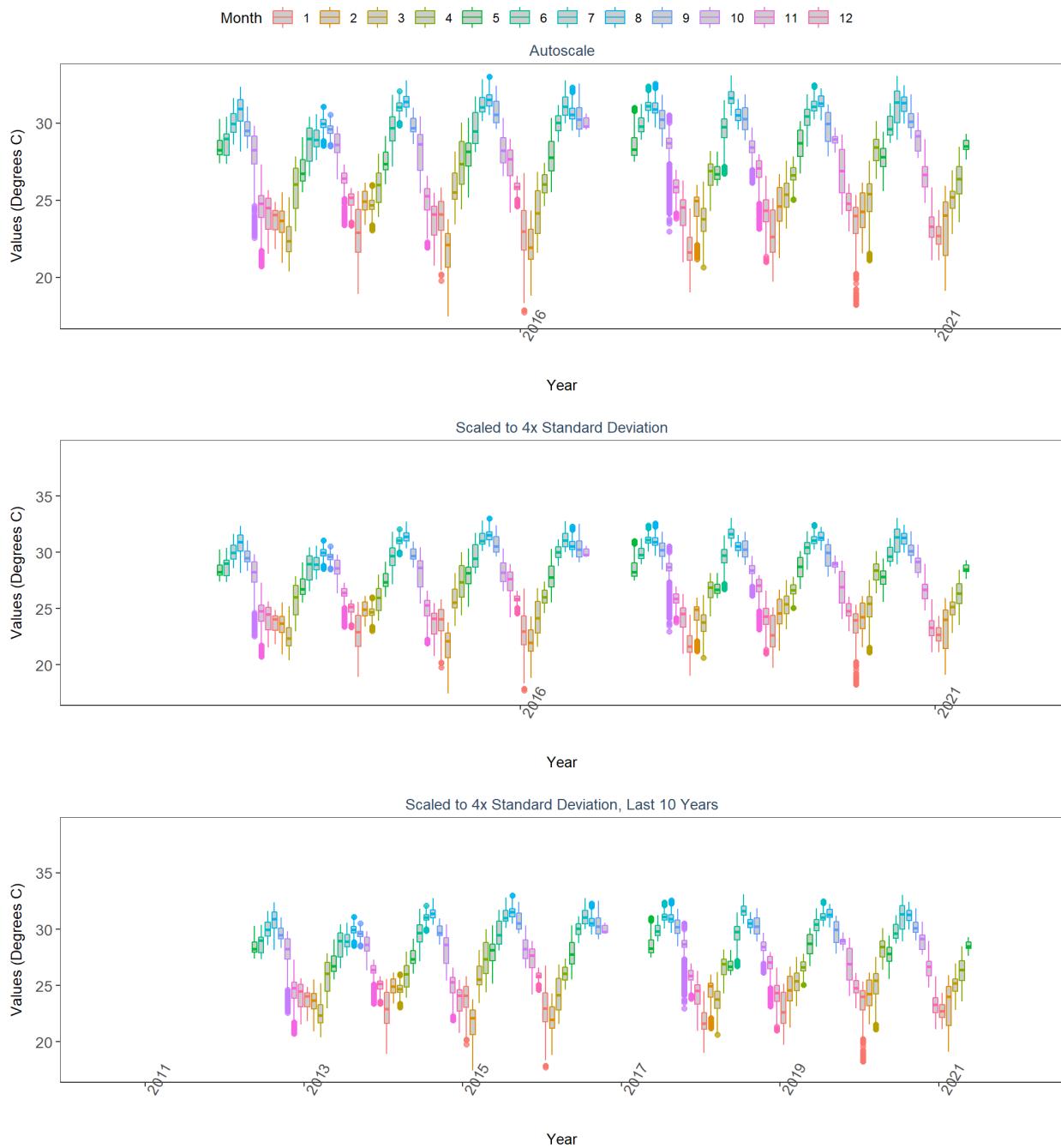
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 Water Temperature on Coral Reefs in the Florida Keys
 22
 By Month



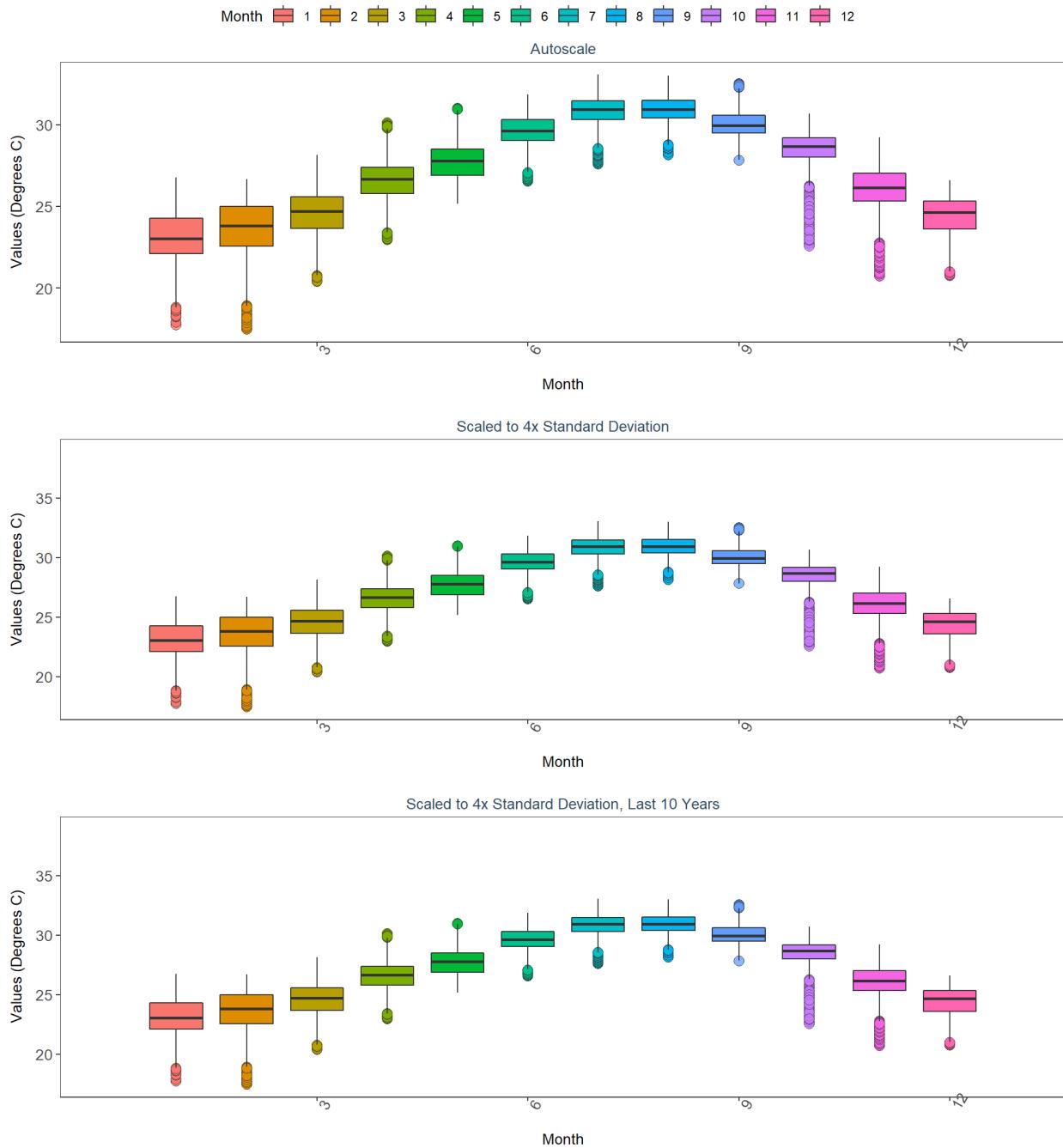
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 By Year



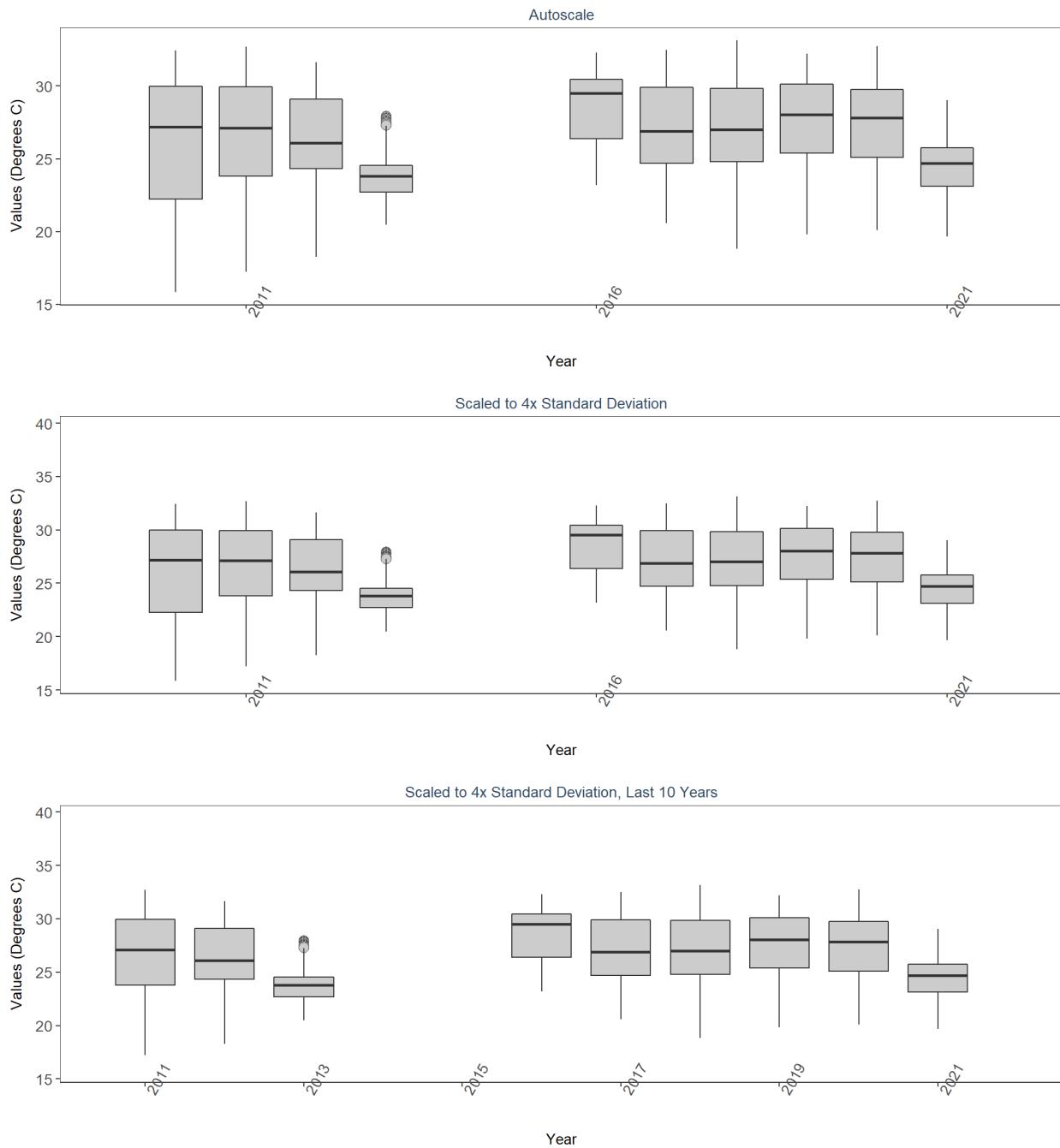
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 Water Temperature on Coral Reefs in the Florida Keys
 23
 By Year & Month



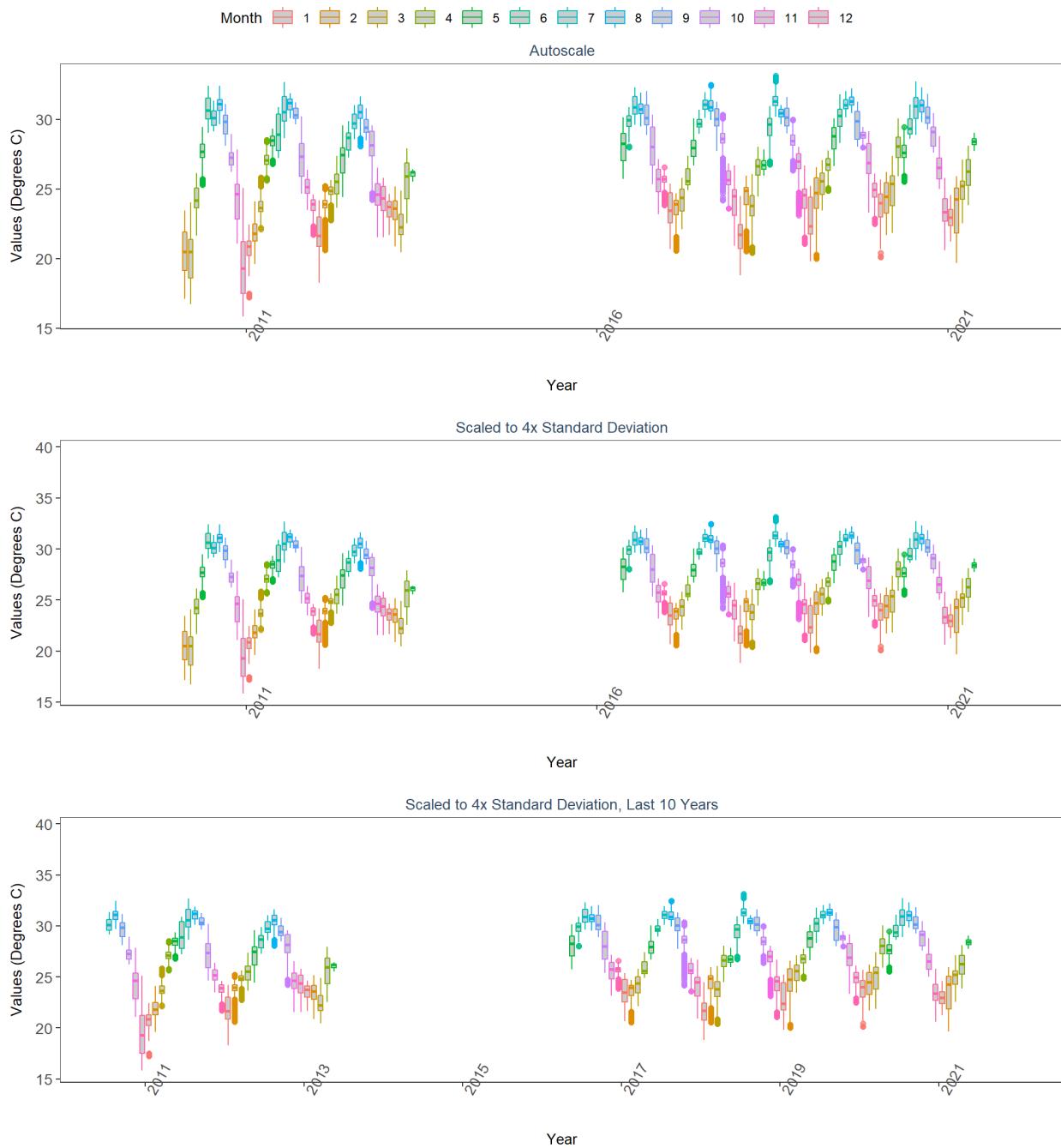
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 Water Temperature on Coral Reefs in the Florida Keys
 23
 By Month



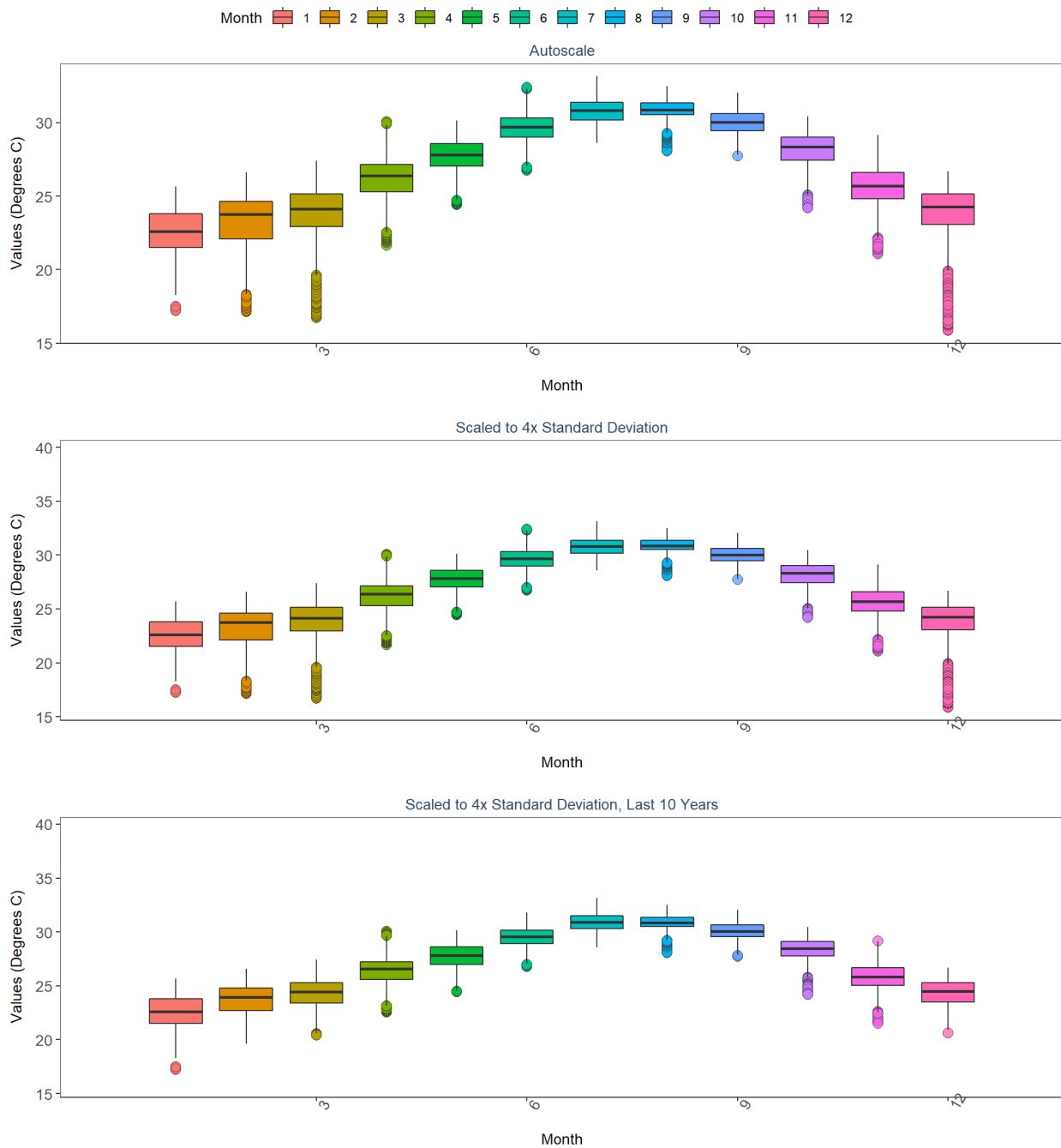
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



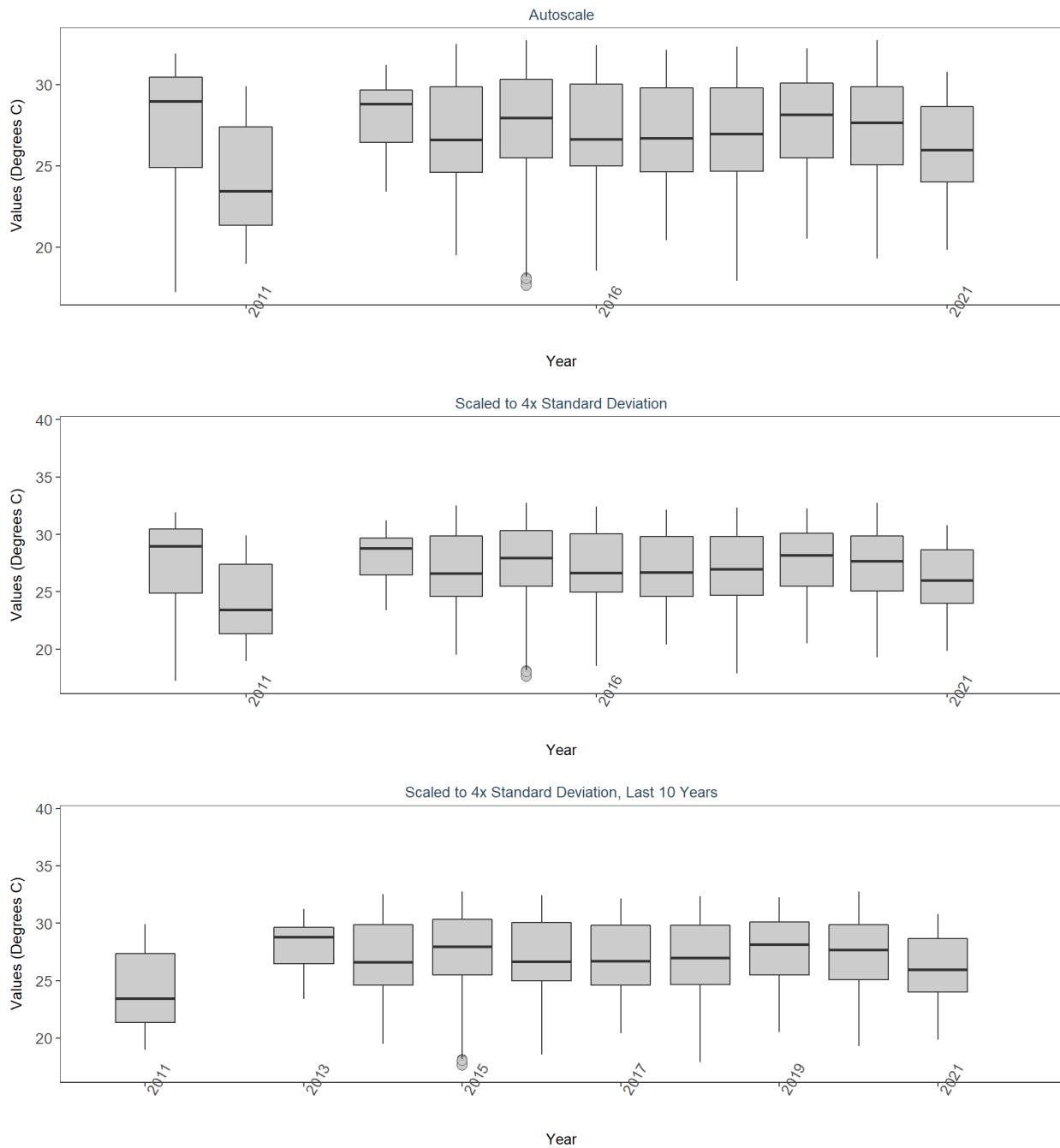
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 Water Temperature on Coral Reefs in the Florida Keys
 24
 By Year & Month



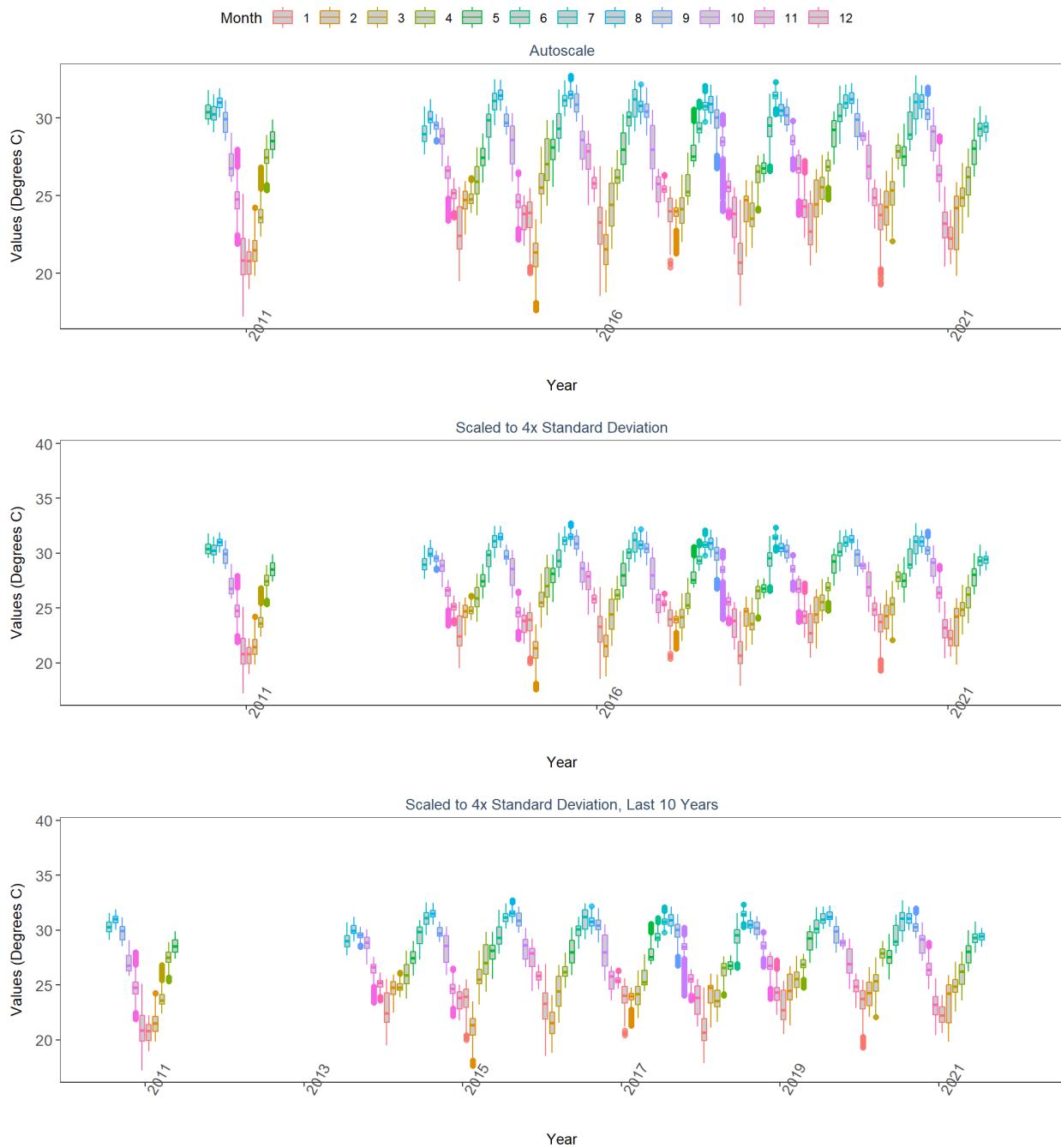
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 Water Temperature on Coral Reefs in the Florida Keys
 24
 By Month



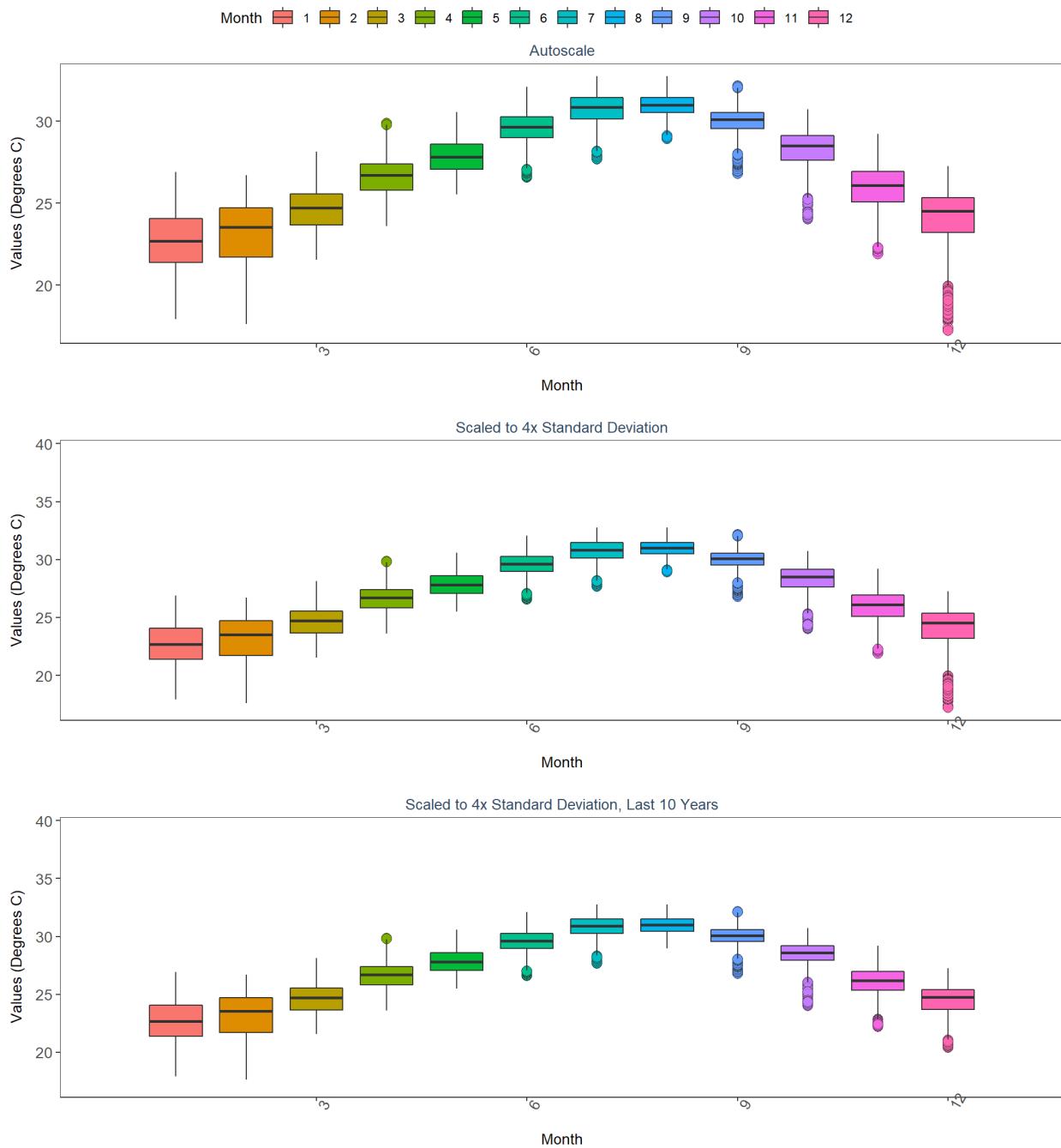
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



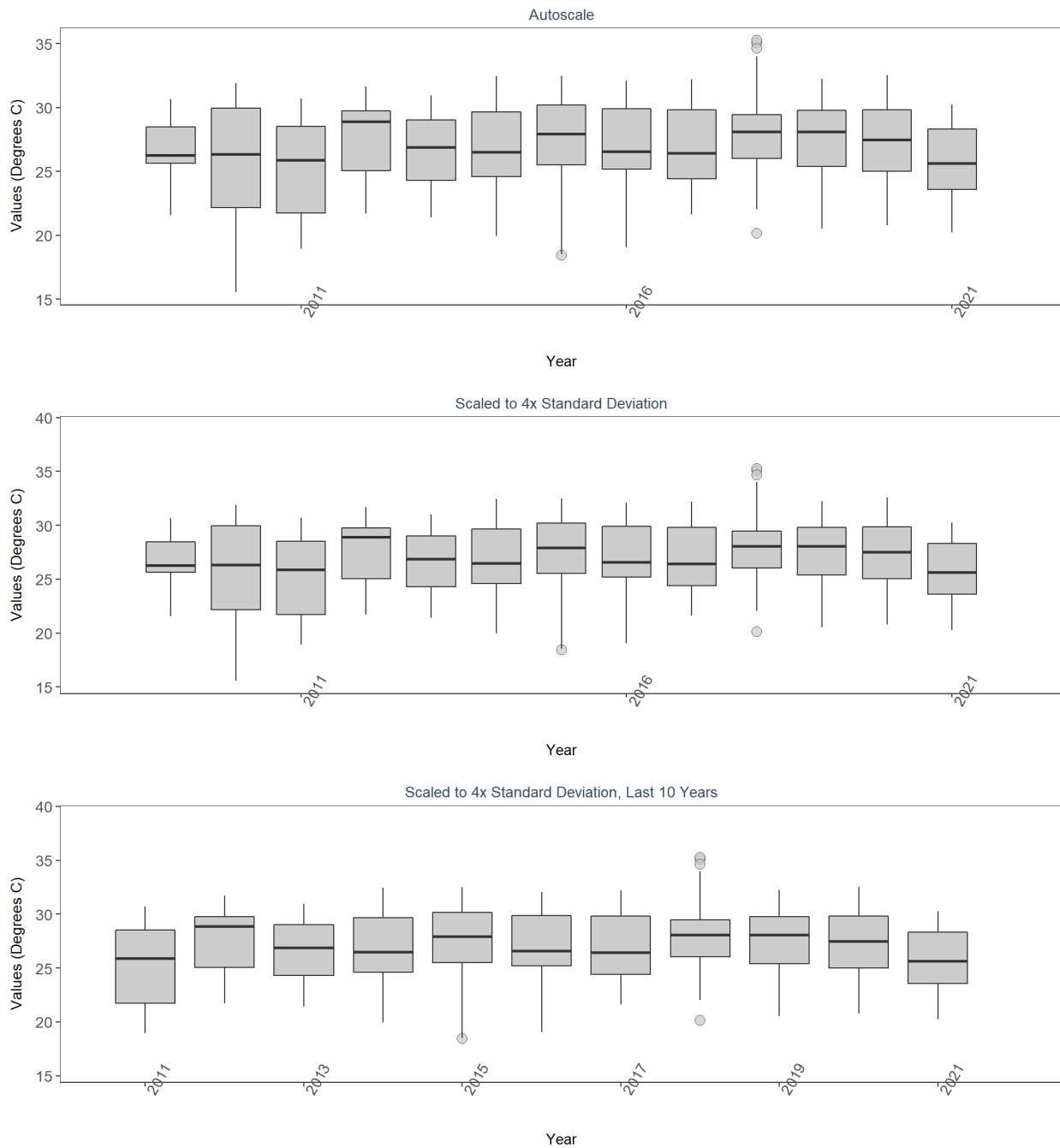
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 Water Temperature on Coral Reefs in the Florida Keys
 25
 By Year & Month



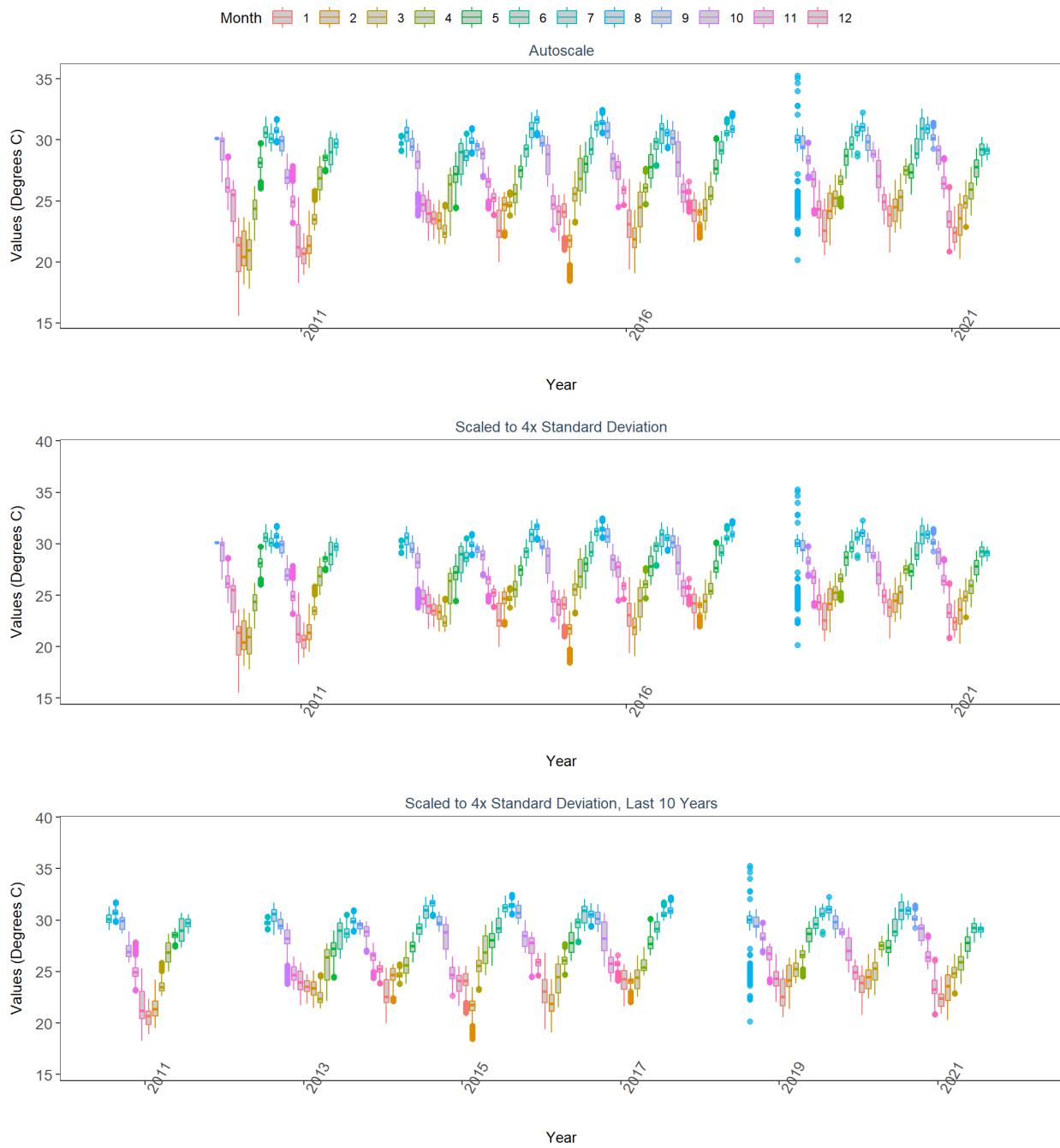
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 Water Temperature on Coral Reefs in the Florida Keys
 25
 By Month



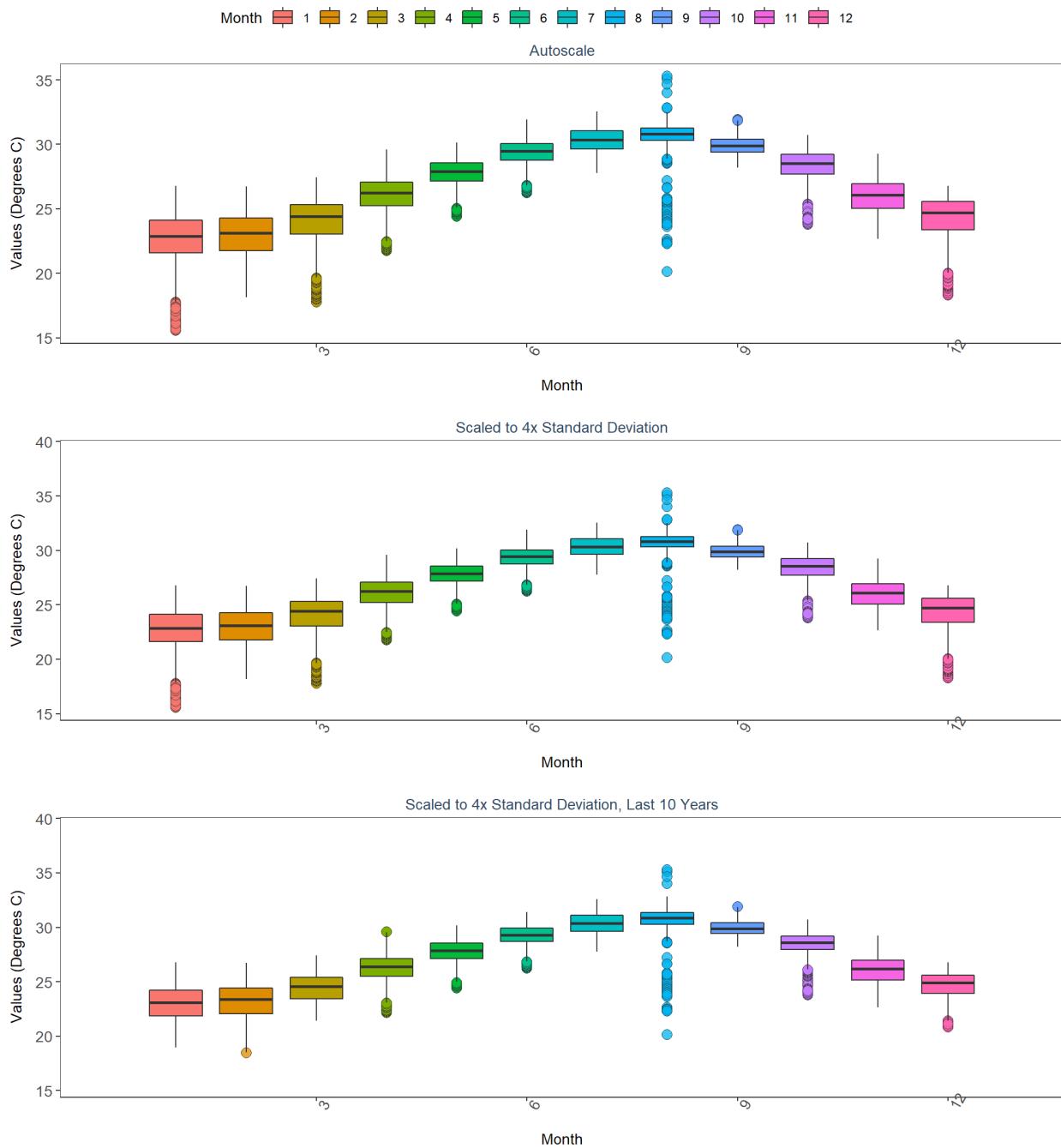
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 Water Temperature on Coral Reefs in the Florida Keys
 26
 By Year



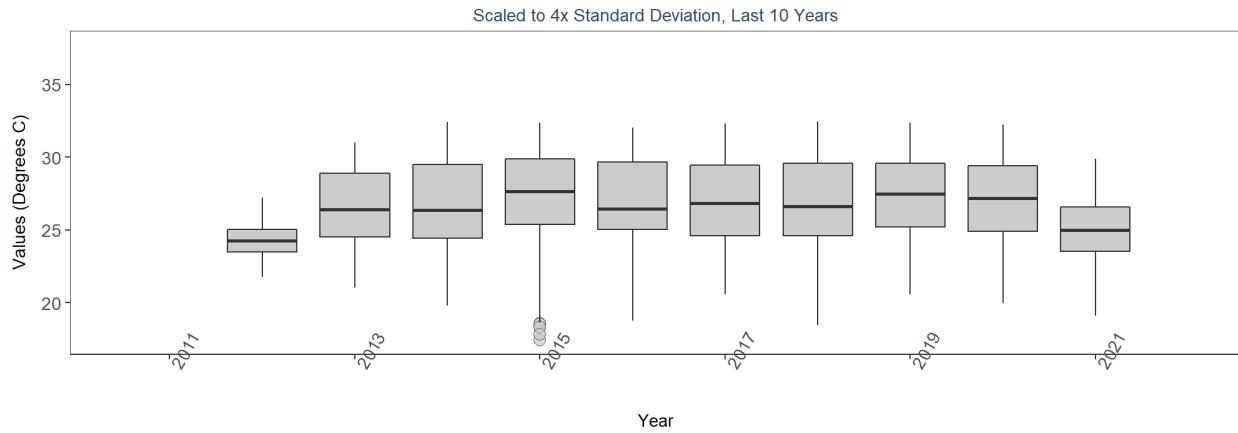
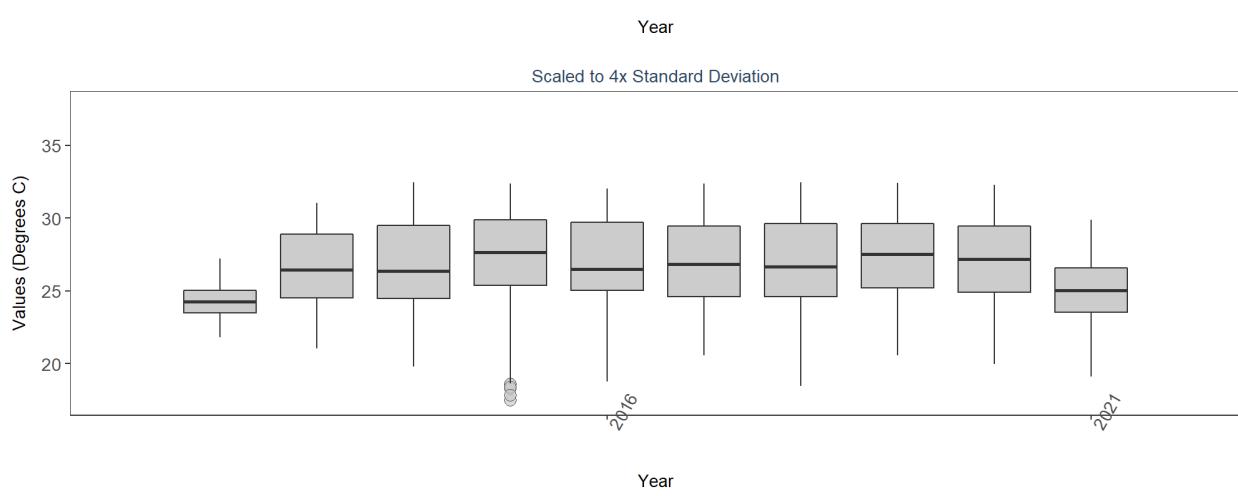
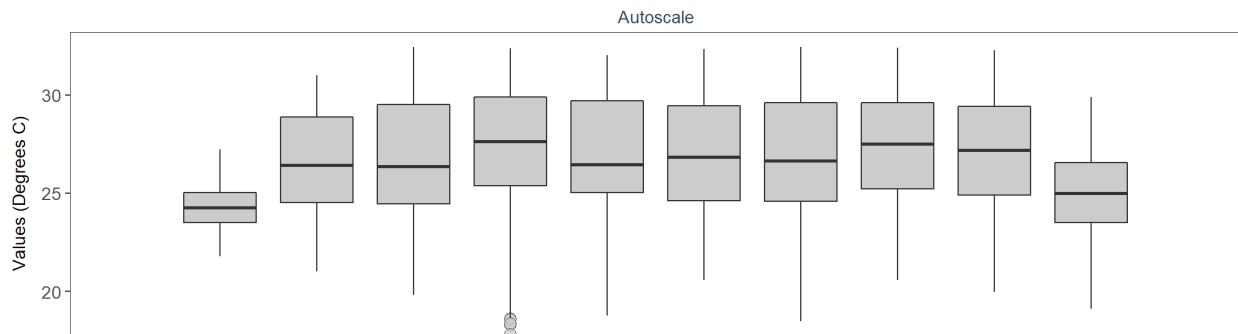
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 Water Temperature on Coral Reefs in the Florida Keys
 26
 By Year & Month



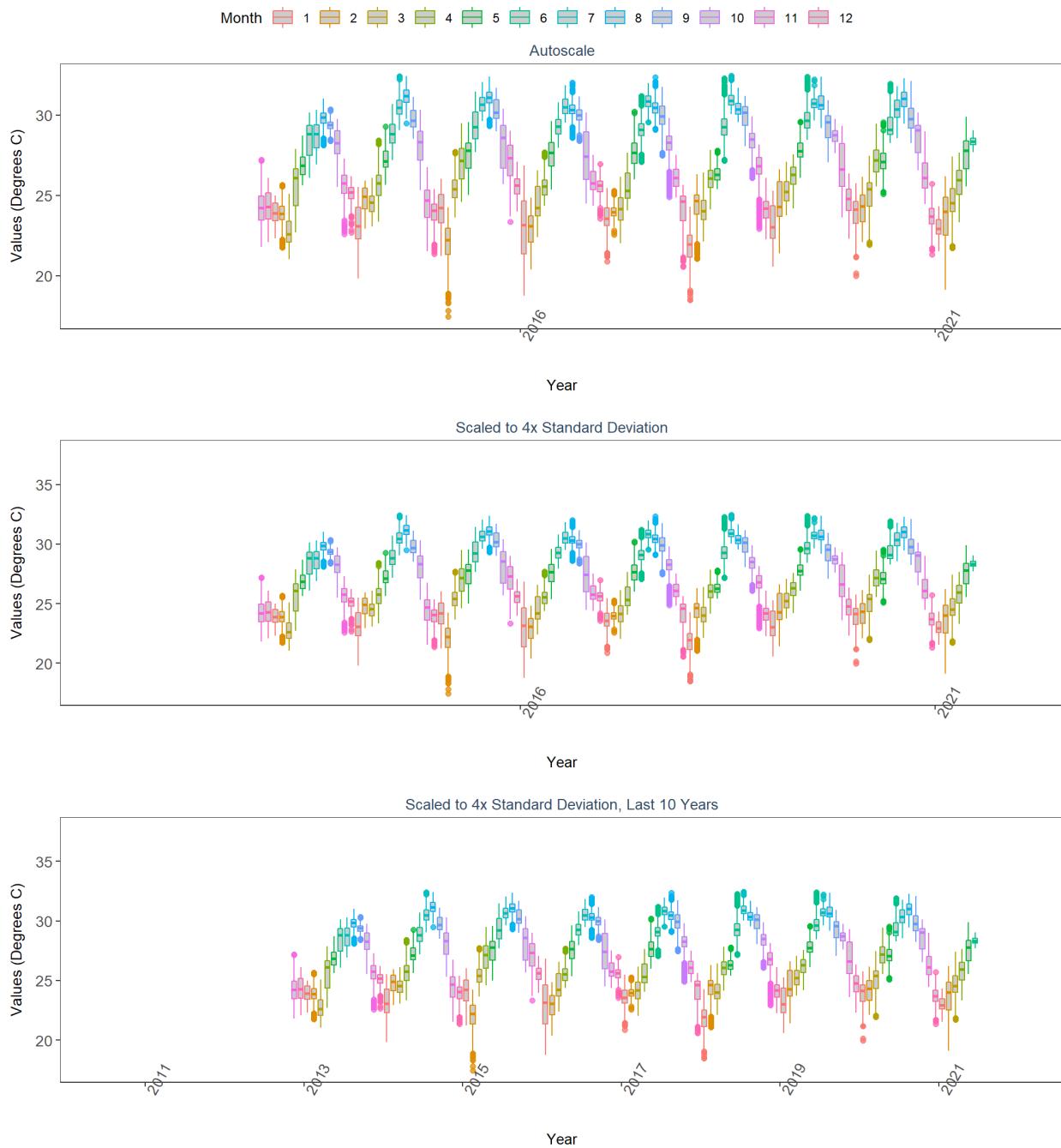
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 By Month



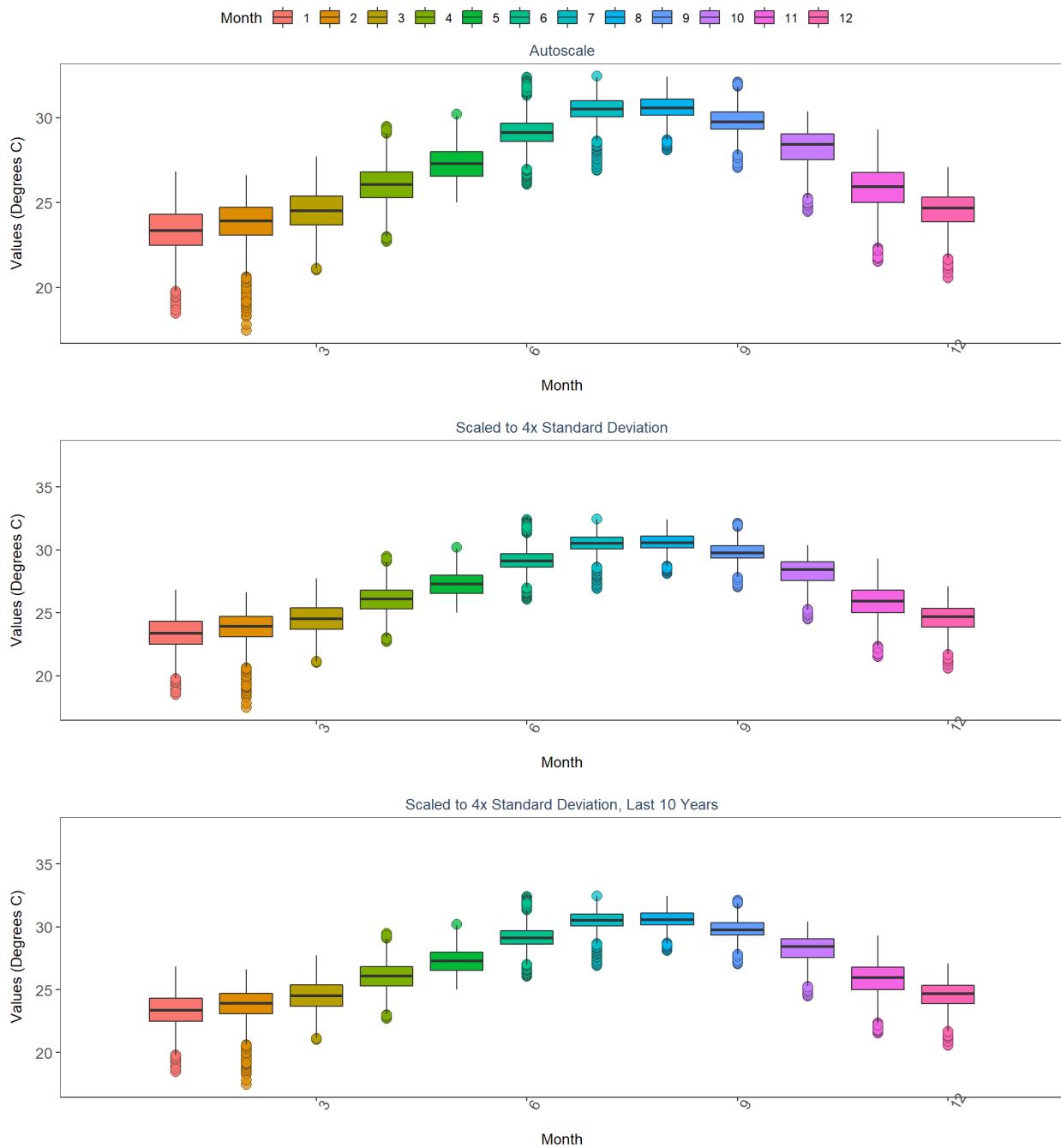
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 Water Temperature on Coral Reefs in the Florida Keys
 30
 By Year



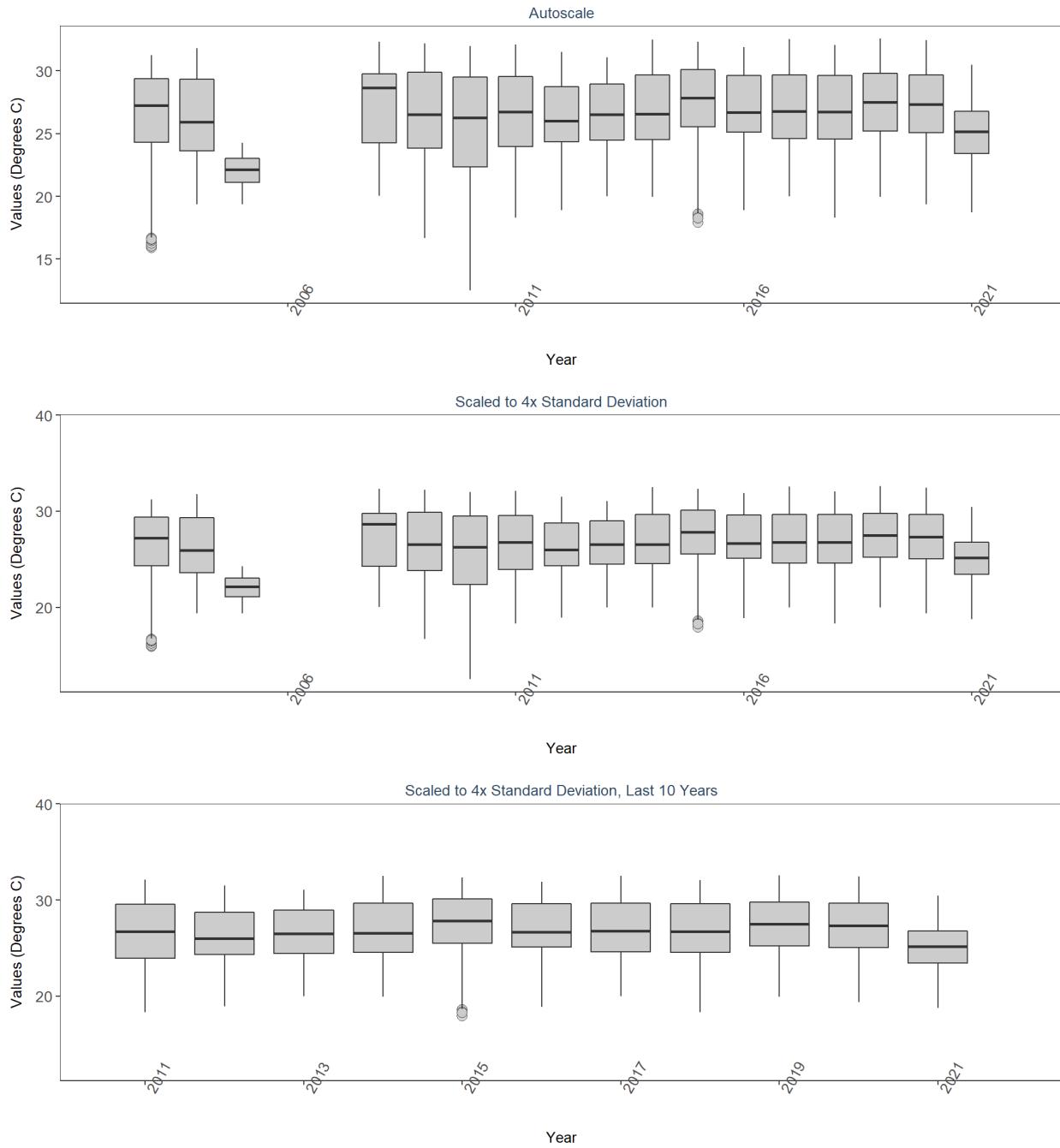
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Water Temperature on Coral Reefs in the Florida Keys
30
By Year & Month



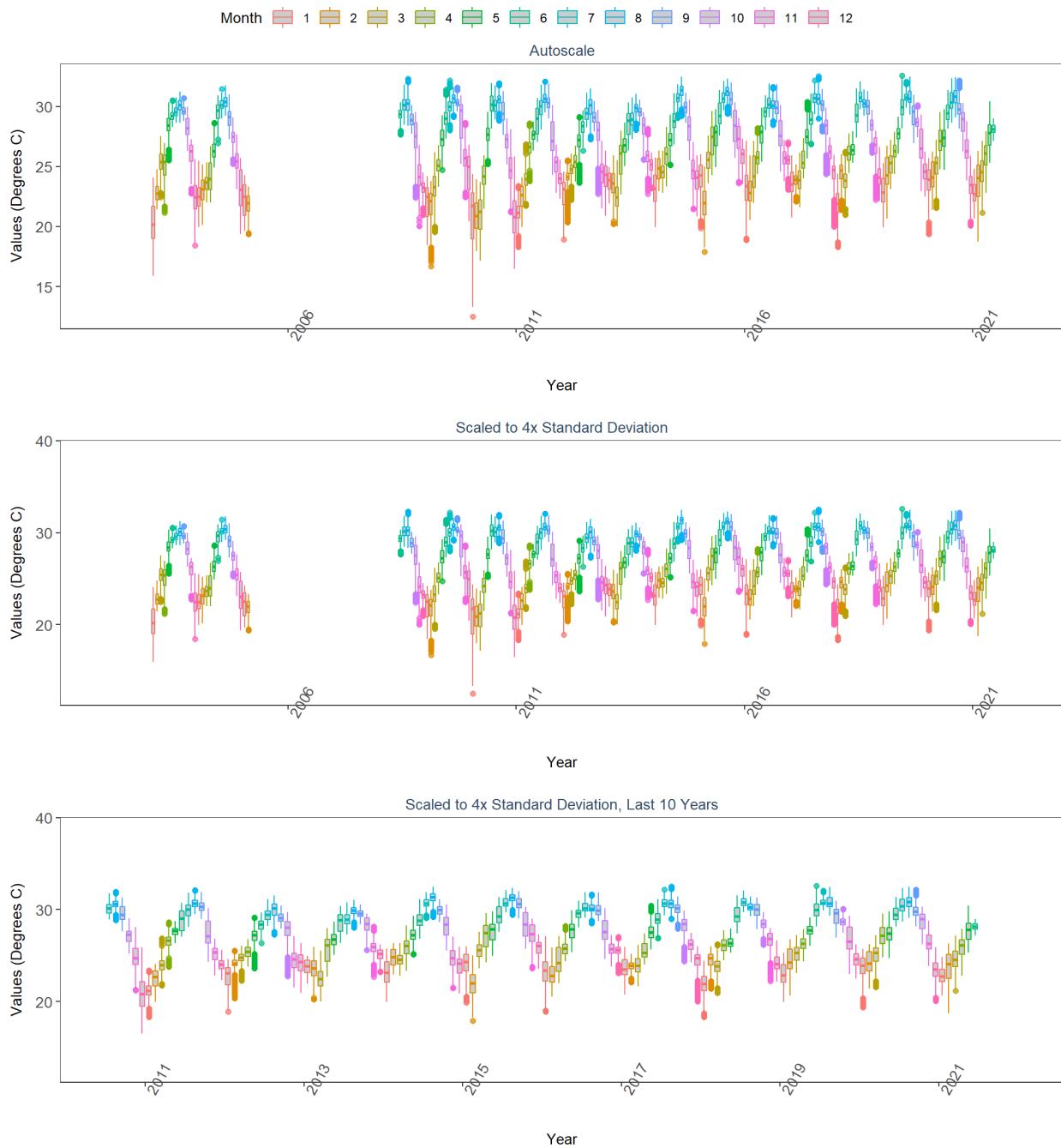
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



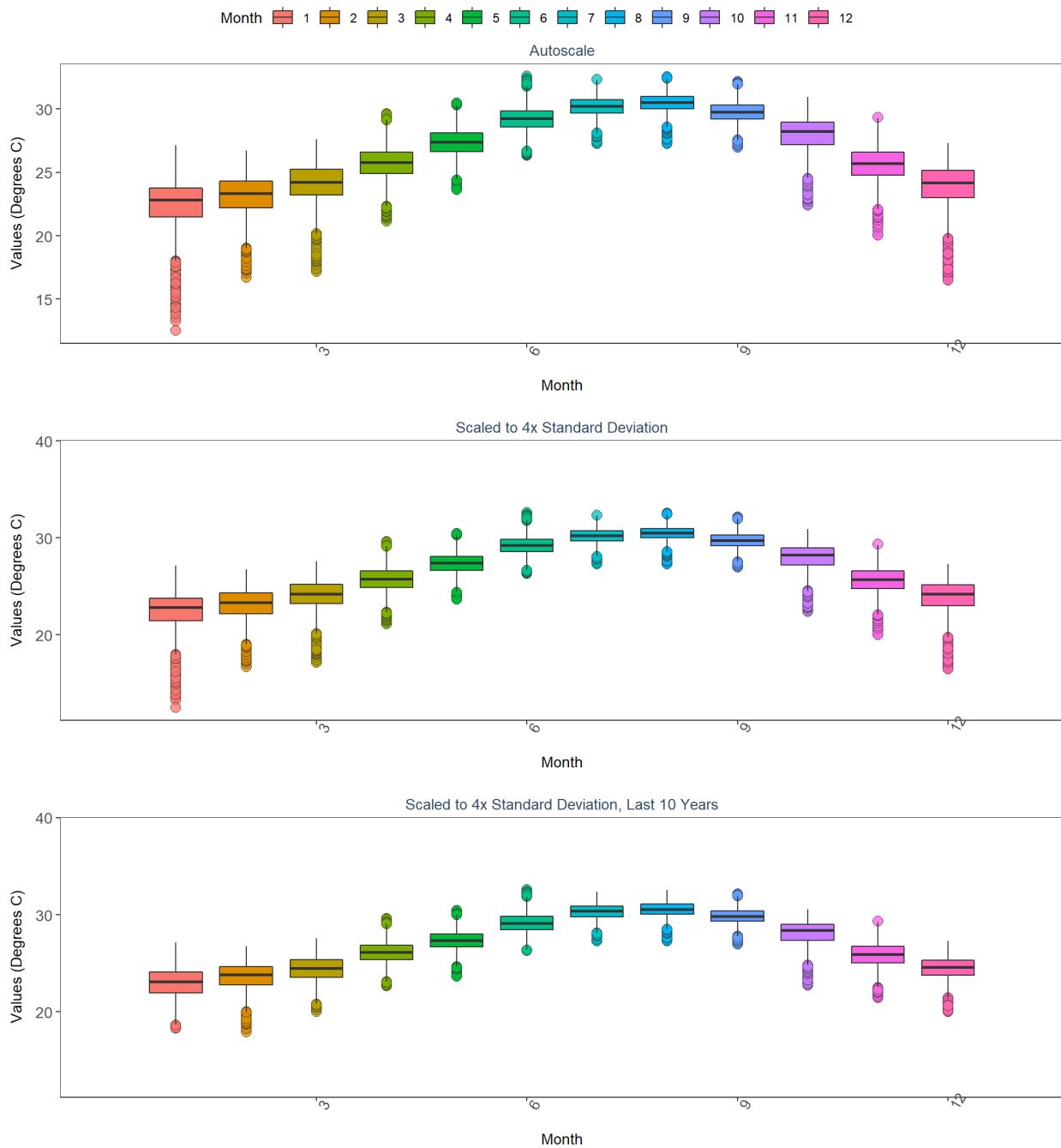
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 Water Temperature on Coral Reefs in the Florida Keys
 32
 By Year



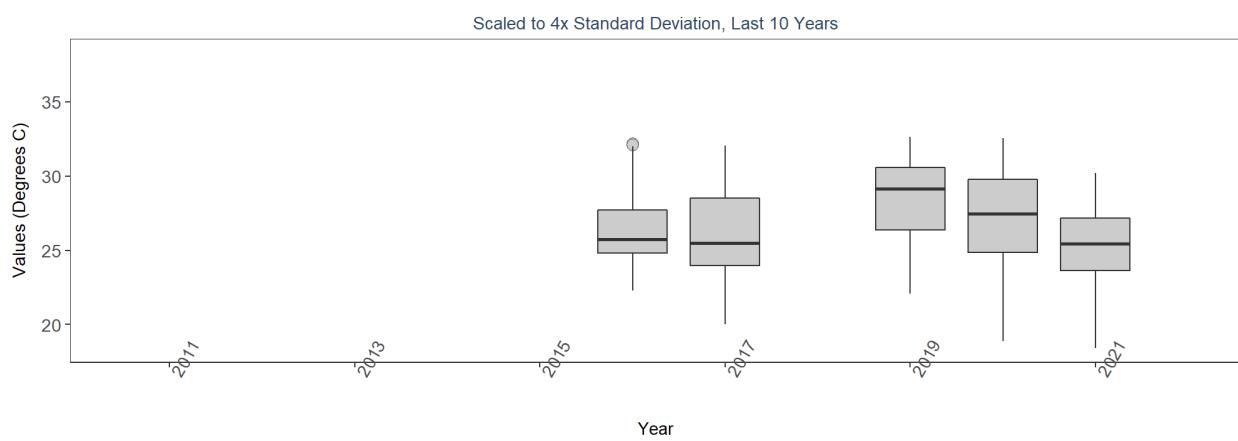
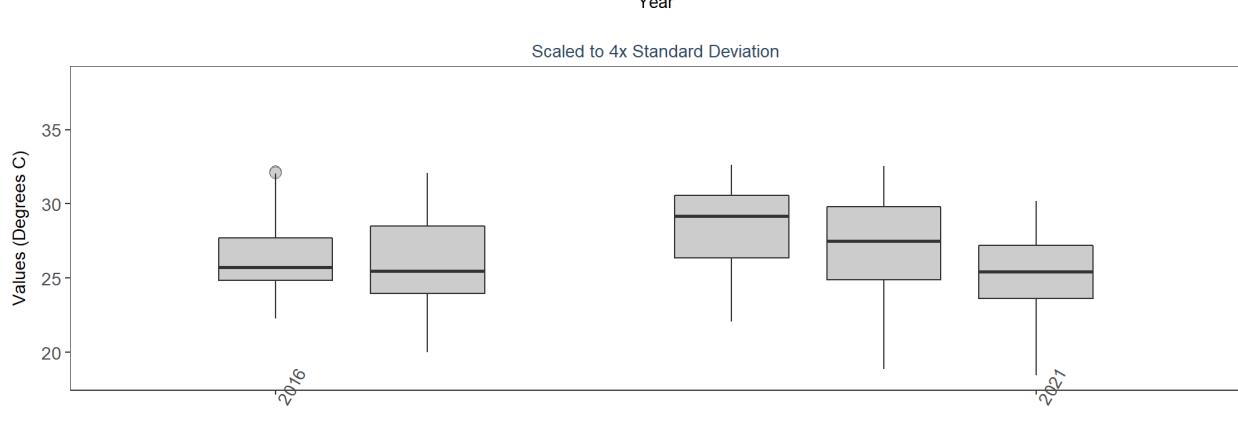
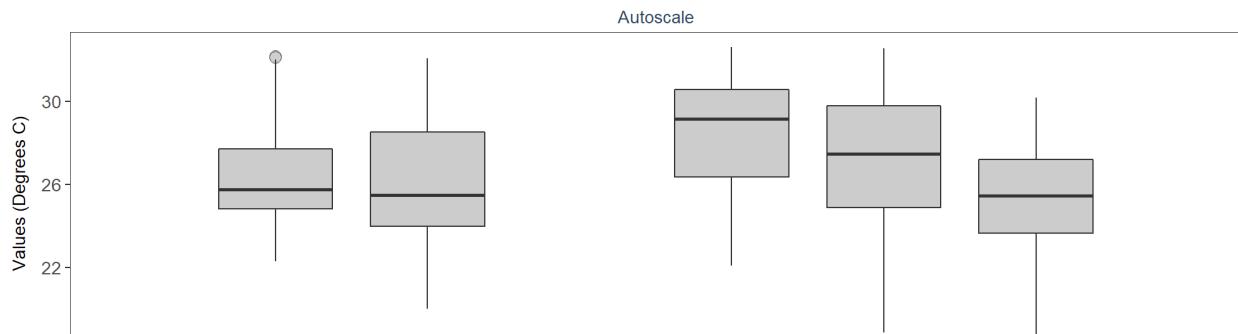
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 Water Temperature on Coral Reefs in the Florida Keys
 32
 By Year & Month



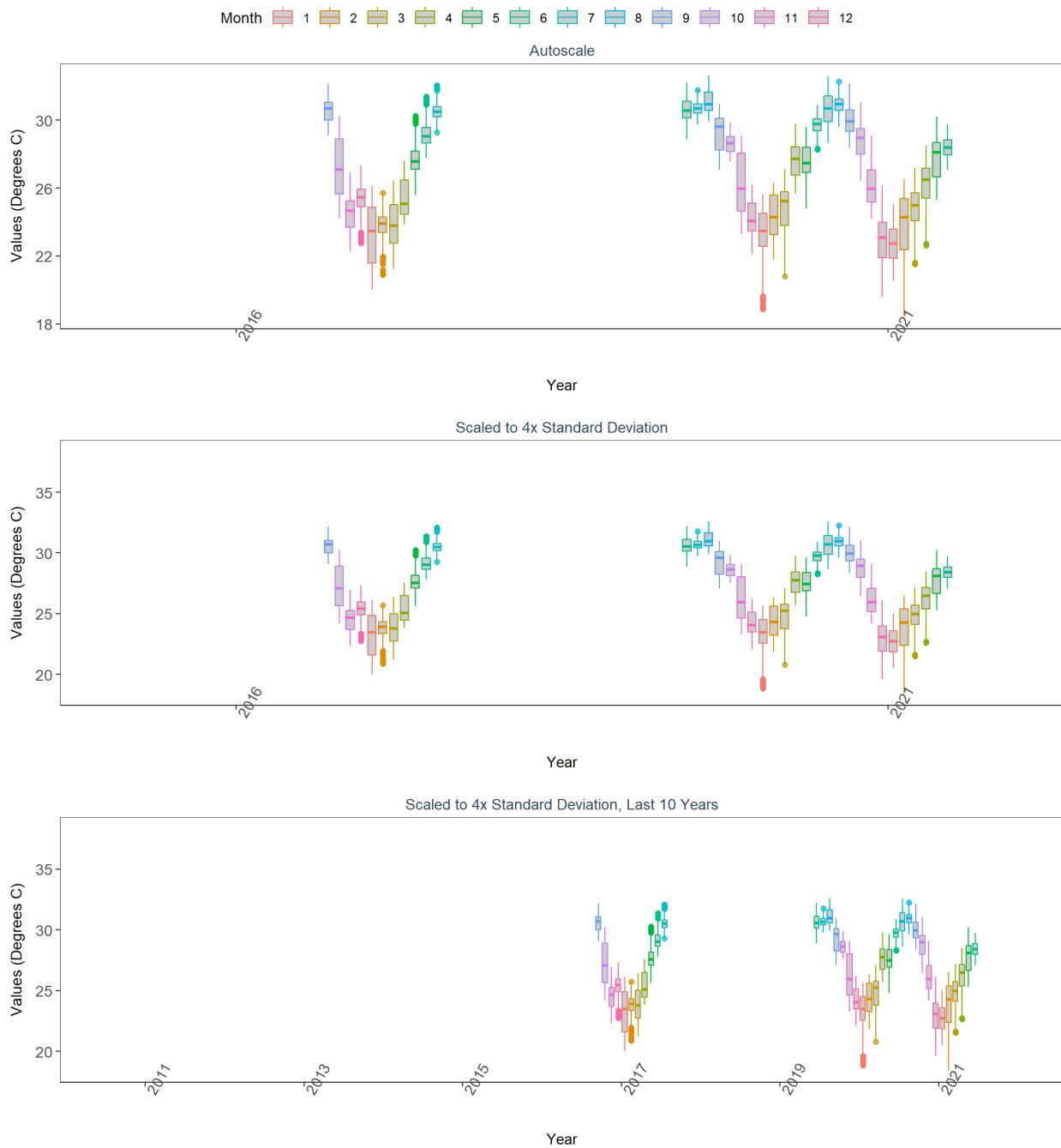
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



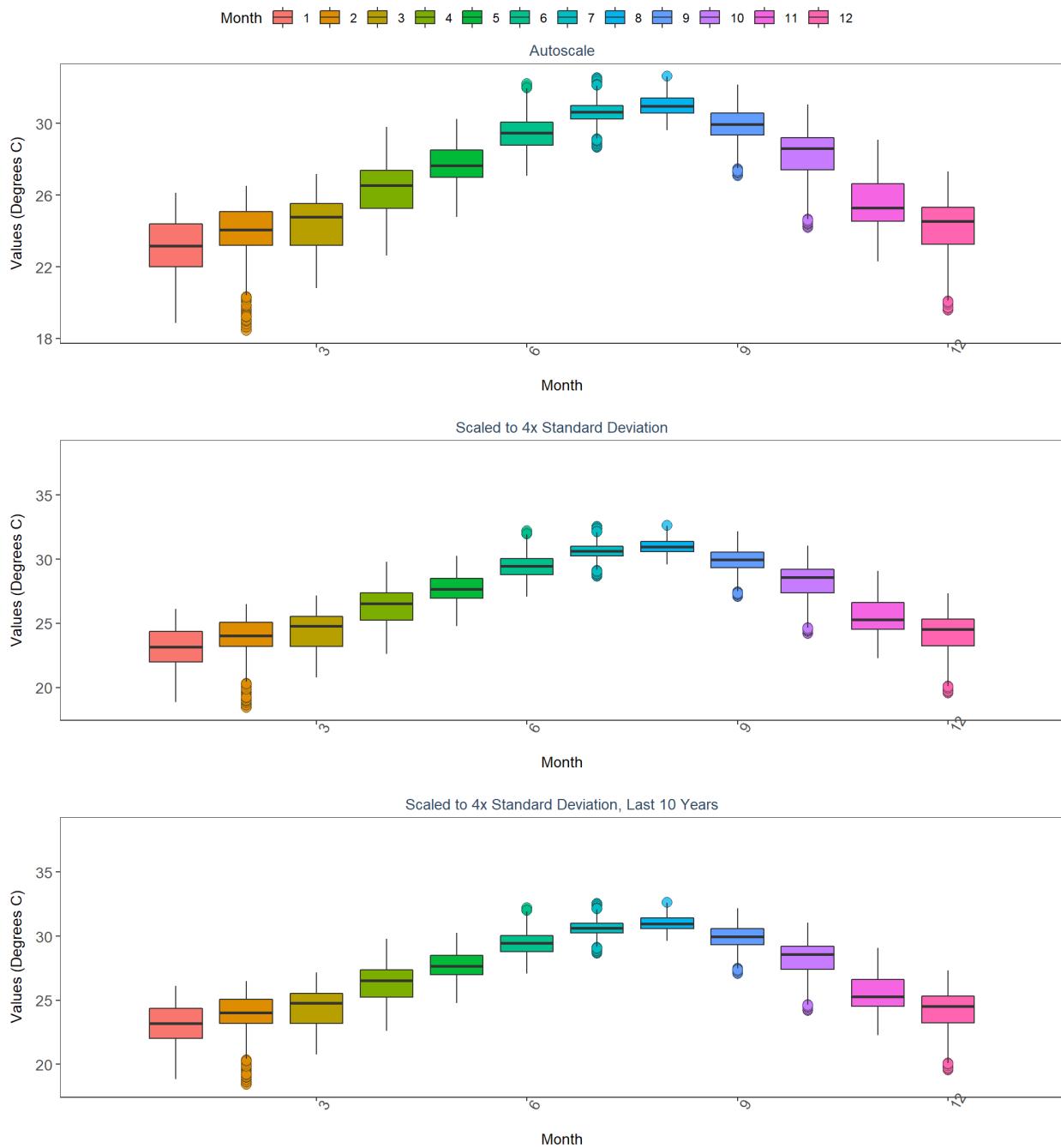
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Water Temperature on Coral Reefs in the Florida Keys
33
By Year



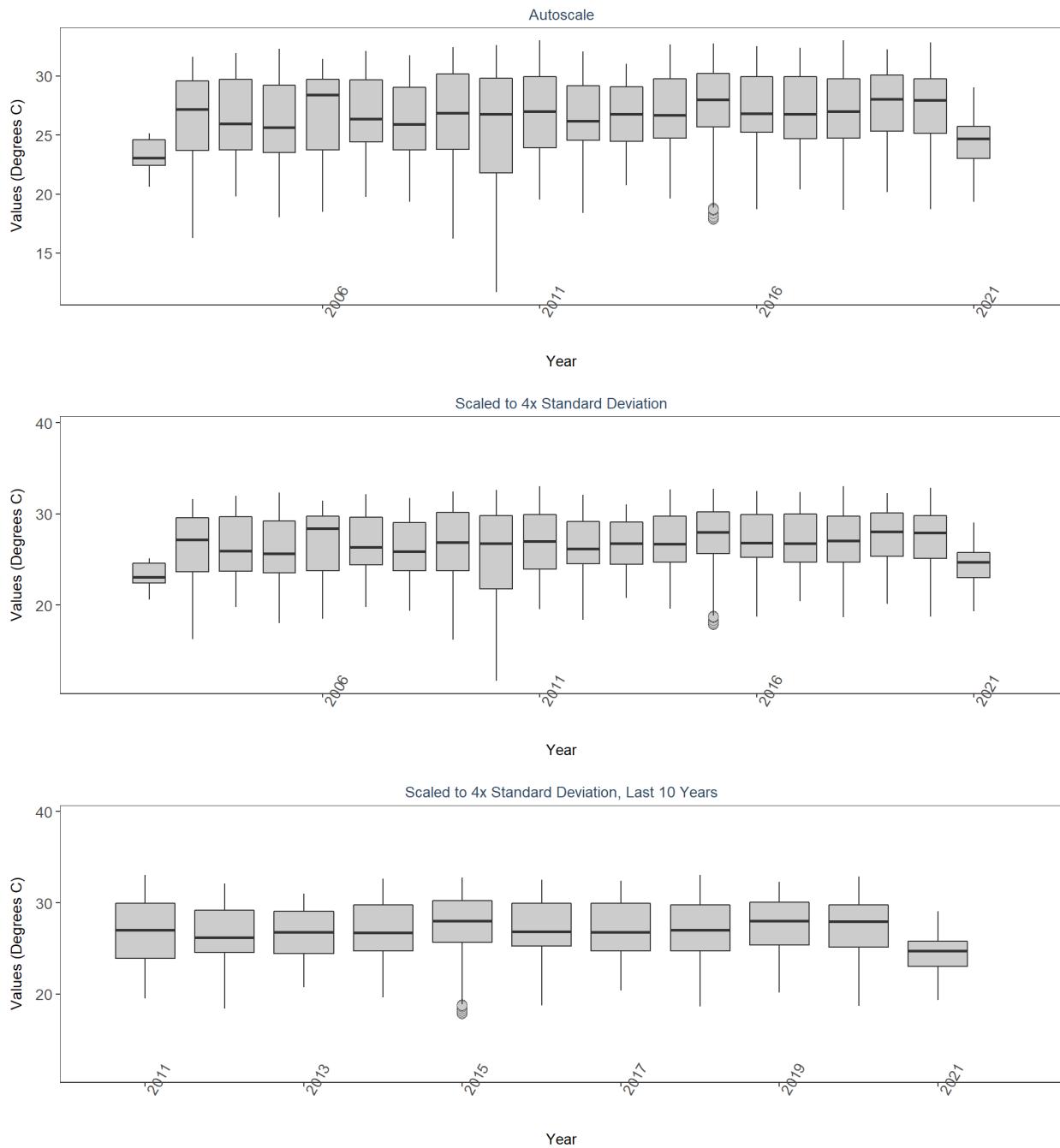
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 Water Temperature on Coral Reefs in the Florida Keys
 33
 By Year & Month



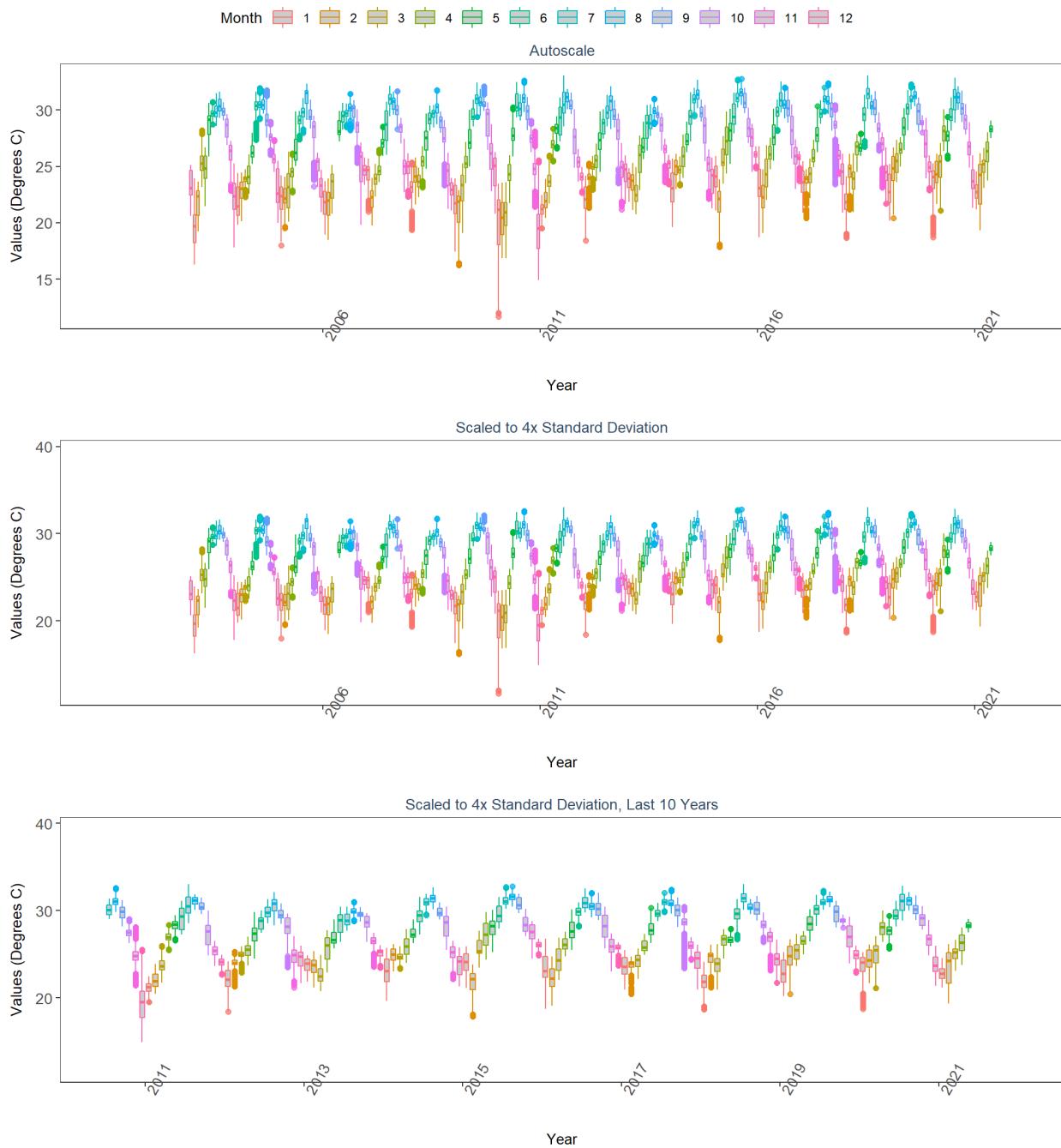
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 Water Temperature on Coral Reefs in the Florida Keys
 33
 By Month



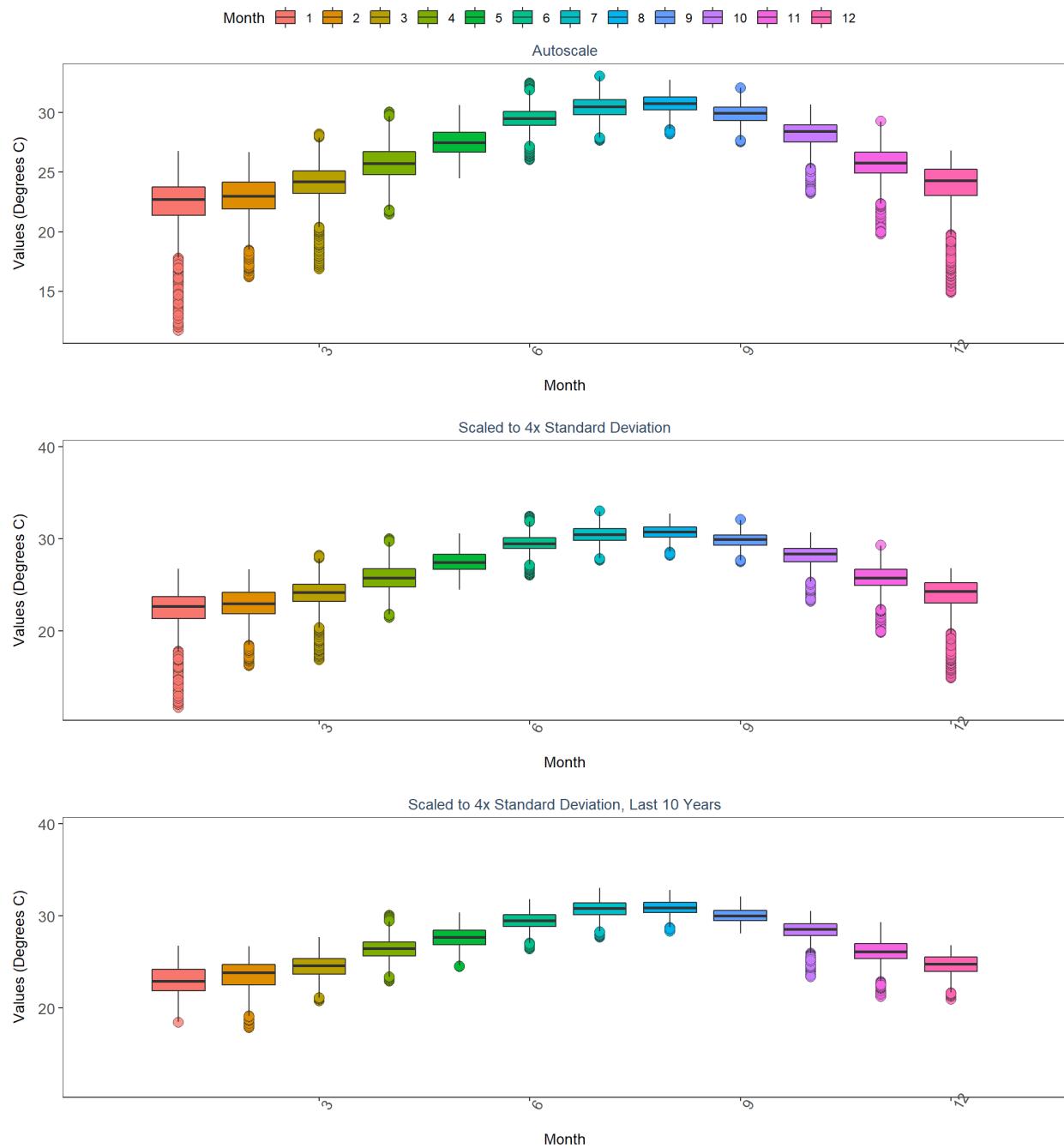
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 Water Temperature on Coral Reefs in the Florida Keys
 34
 By Year



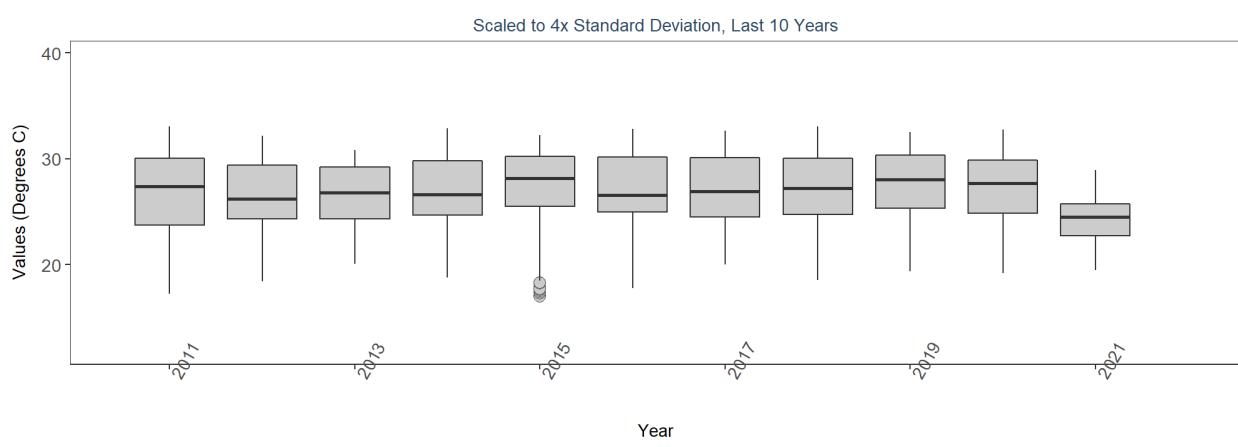
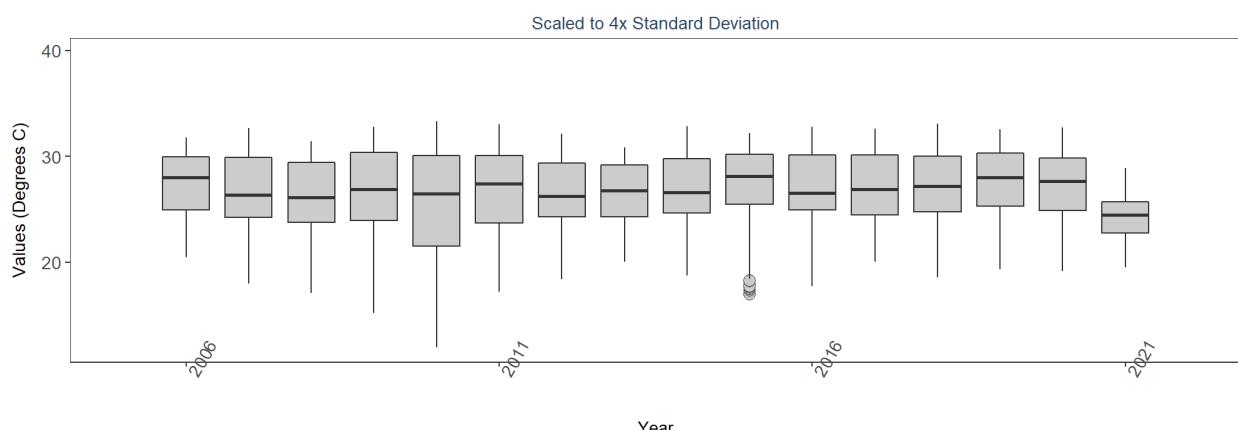
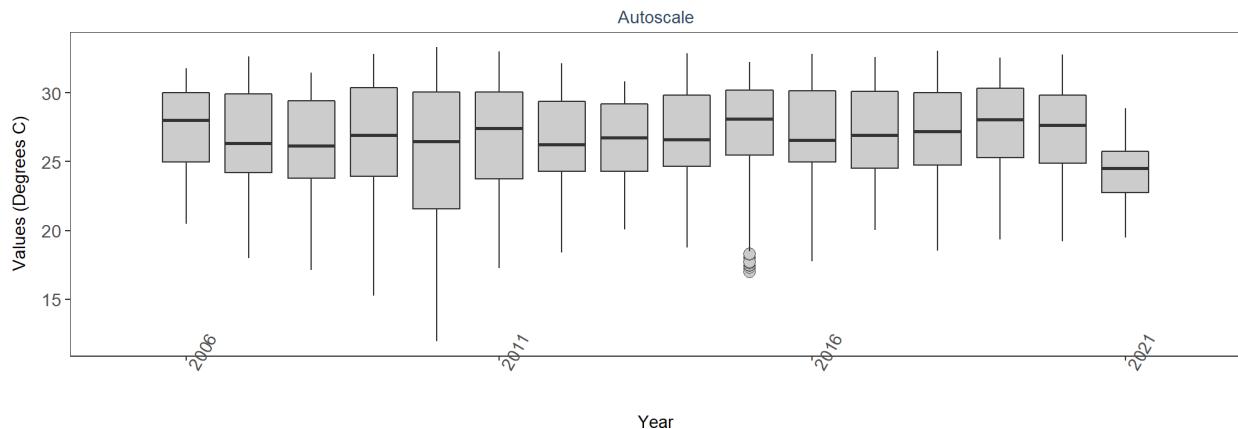
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



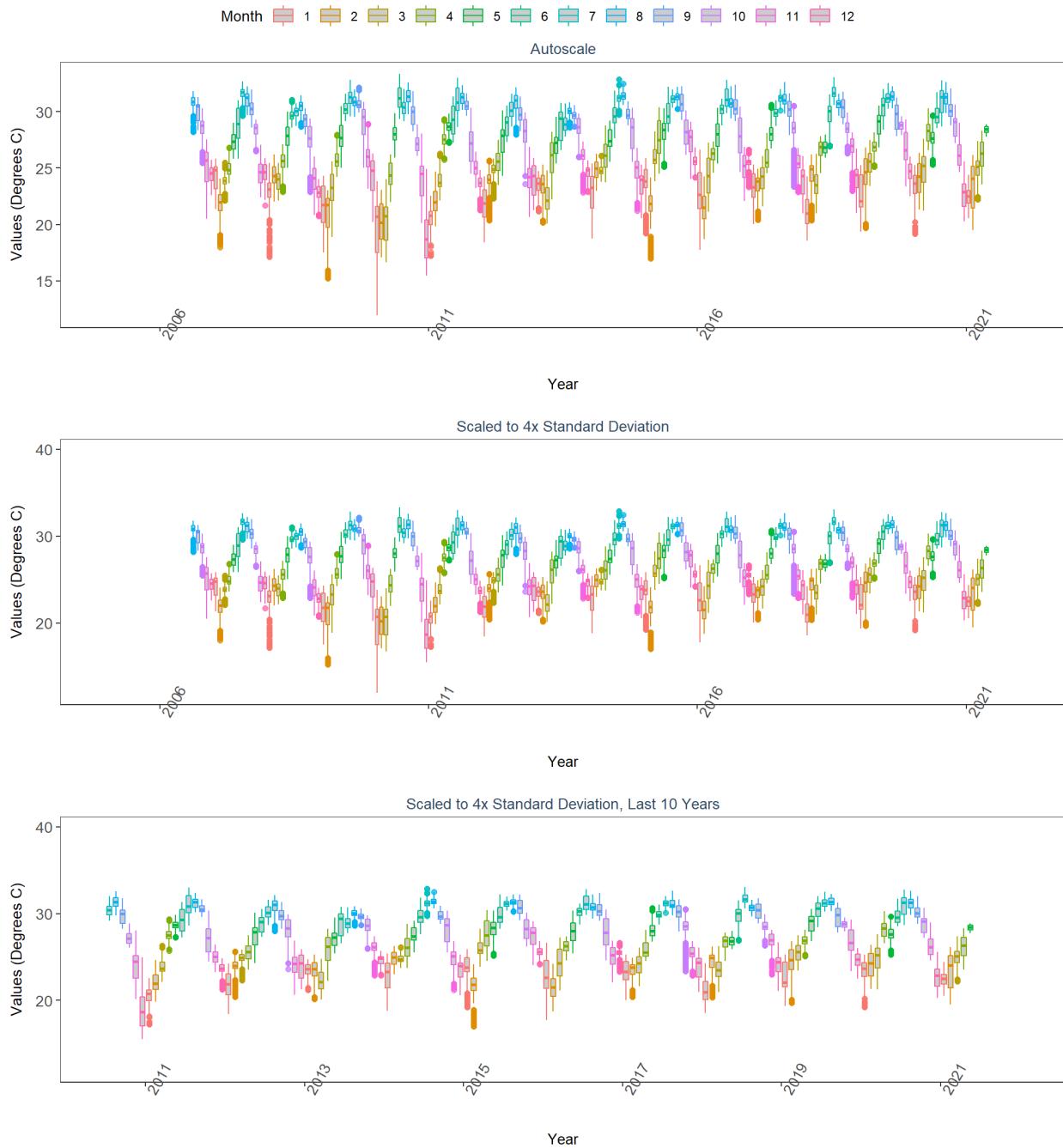
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 Water Temperature on Coral Reefs in the Florida Keys
 34
 By Month



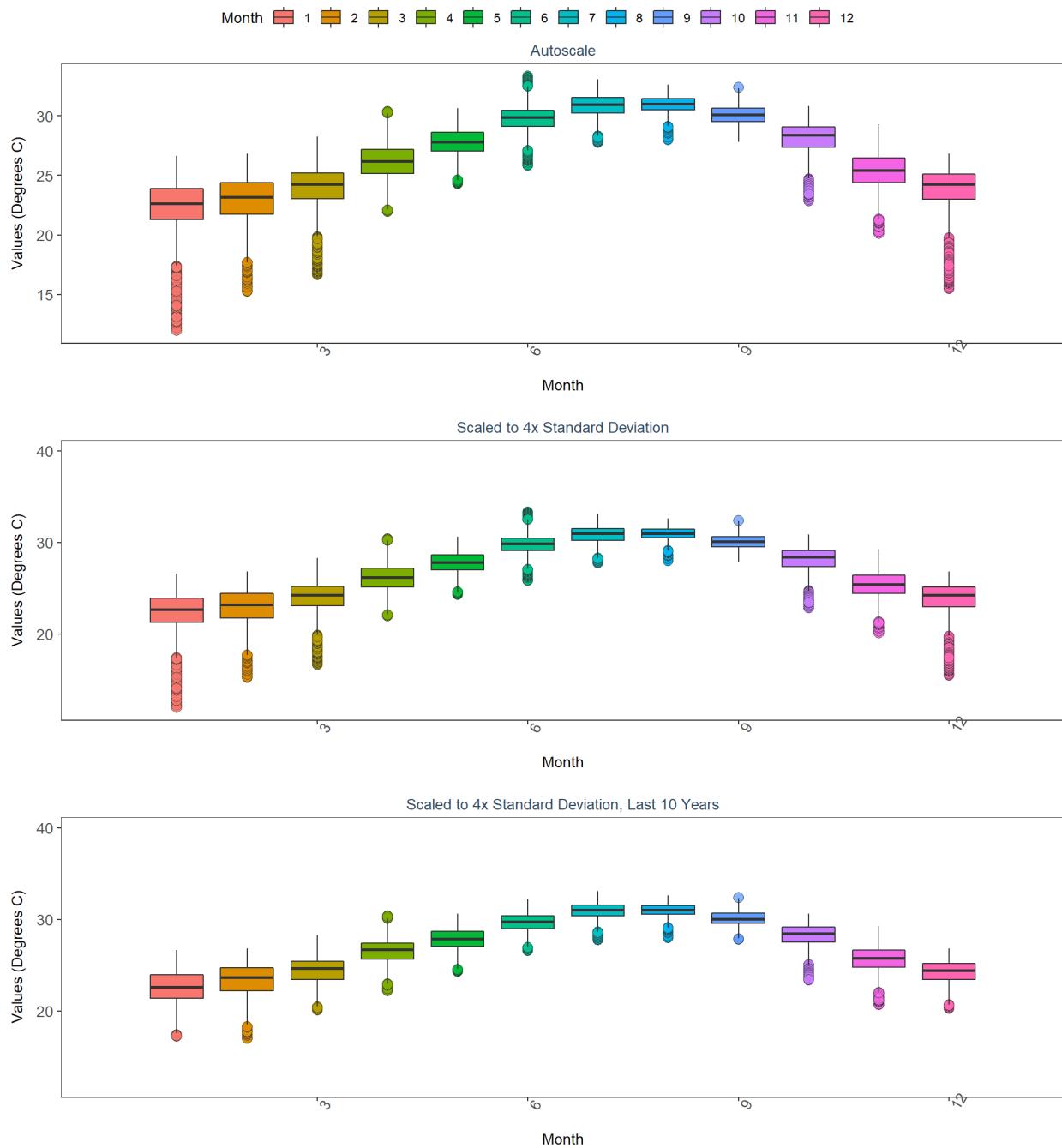
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 Water Temperature on Coral Reefs in the Florida Keys
 35
 By Year



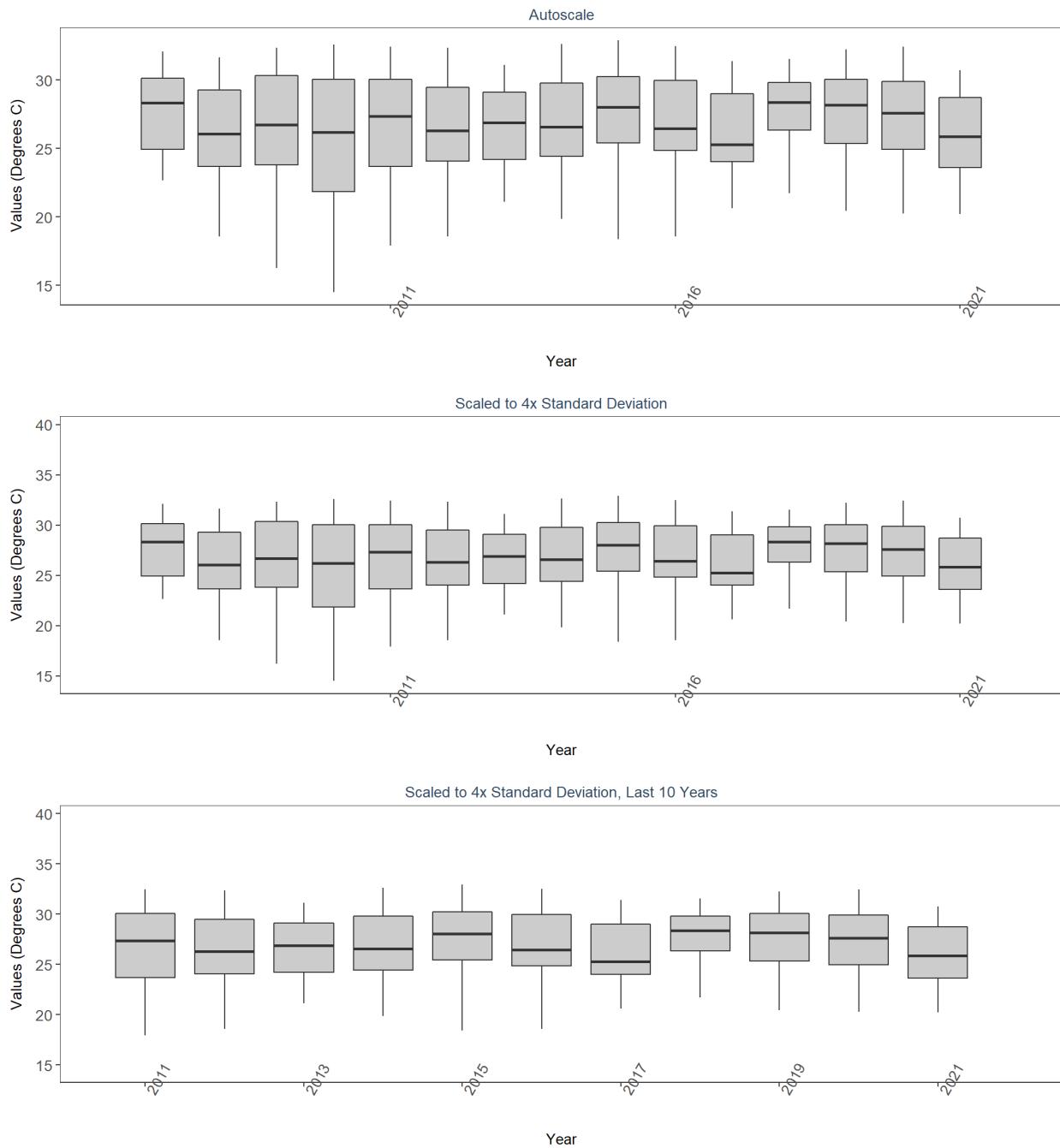
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Water Temperature on Coral Reefs in the Florida Keys
35
By Year & Month



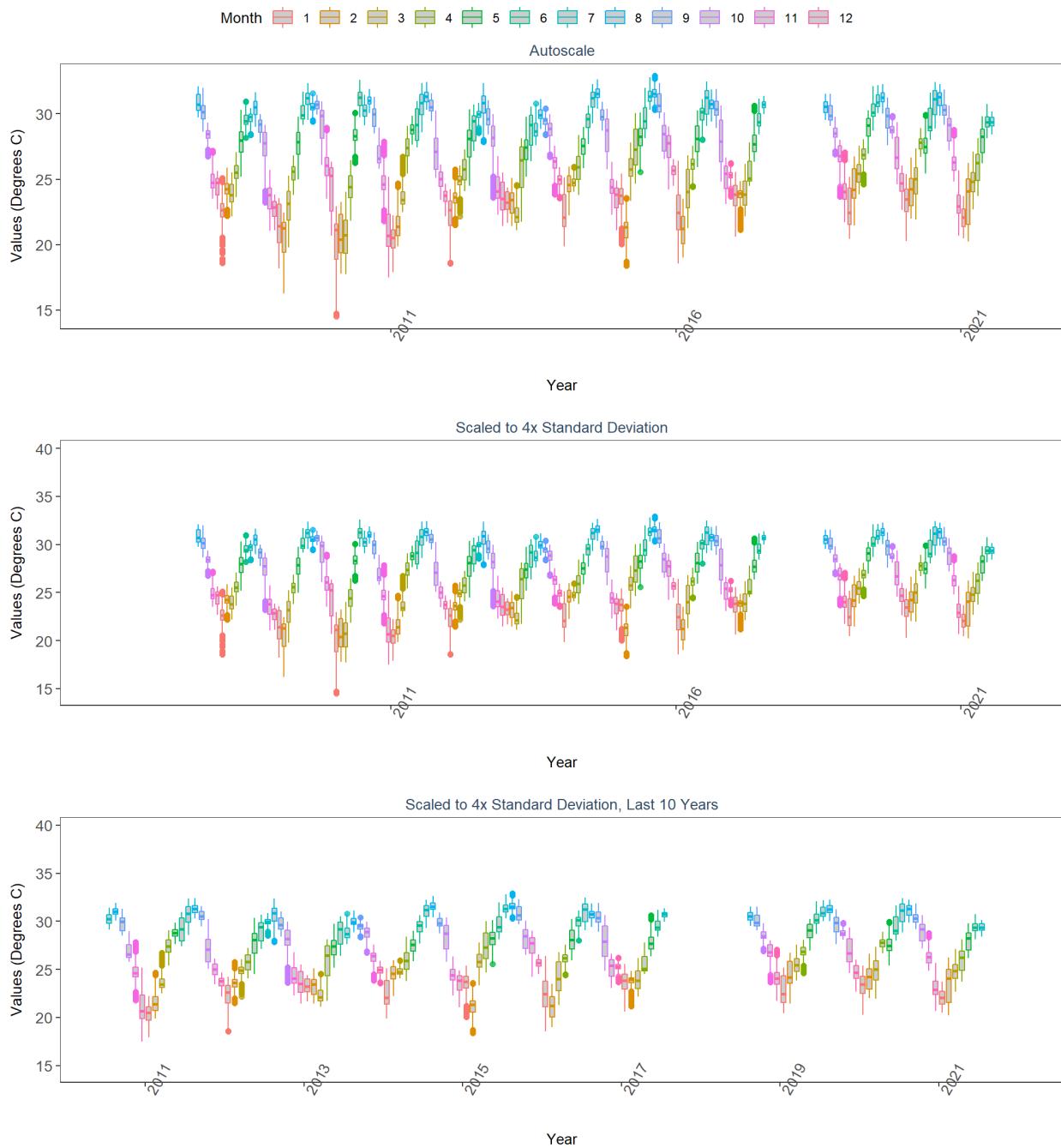
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



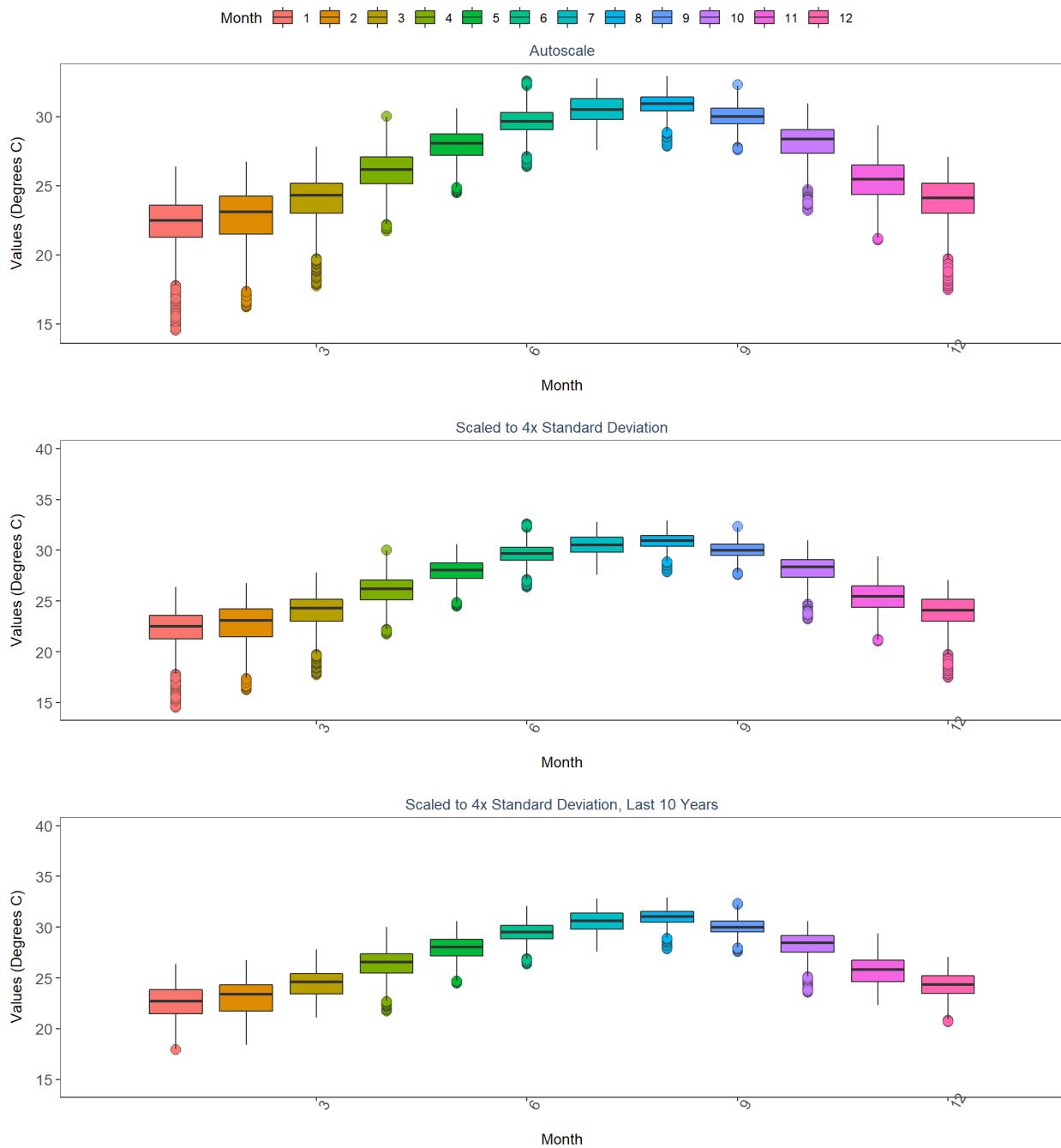
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



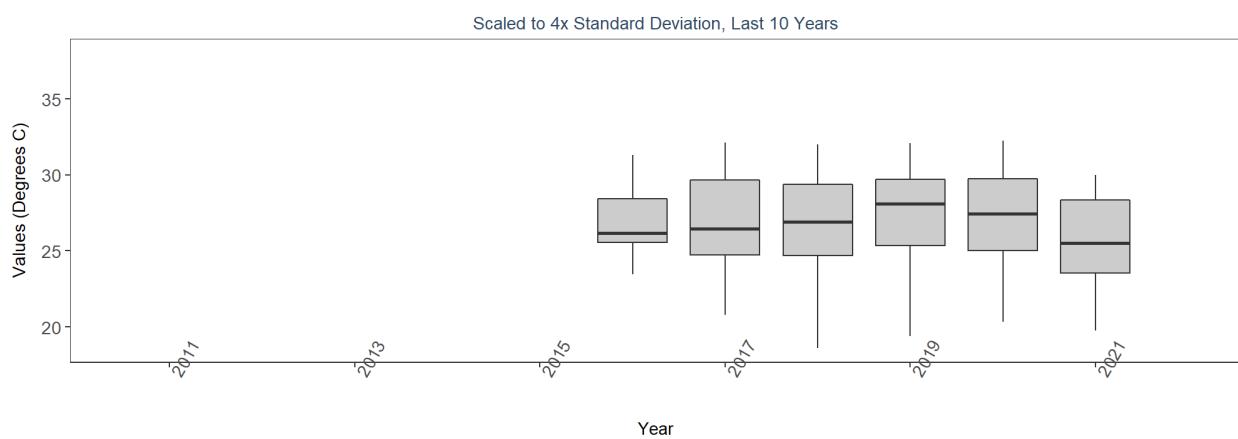
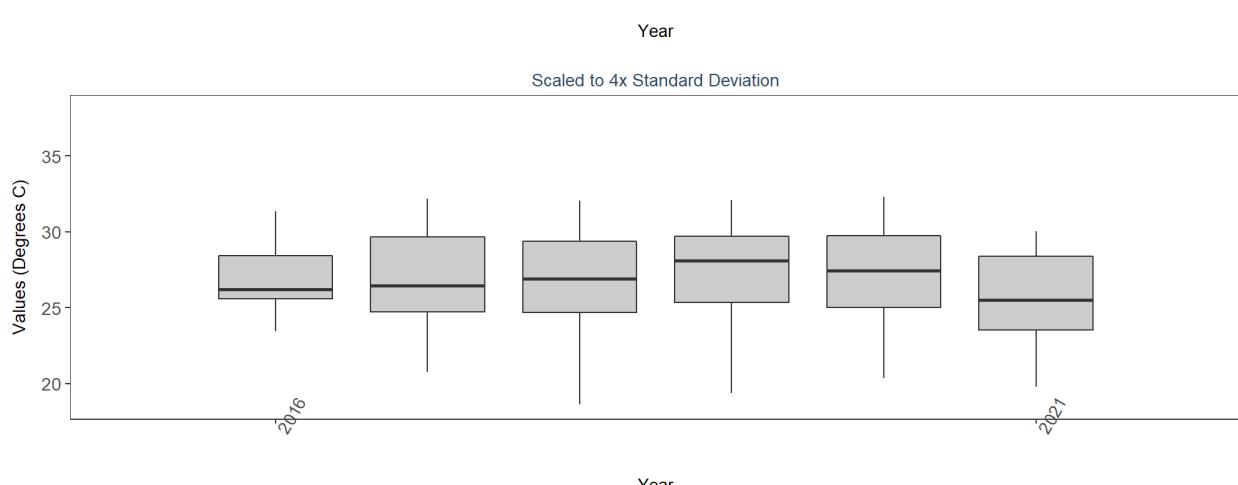
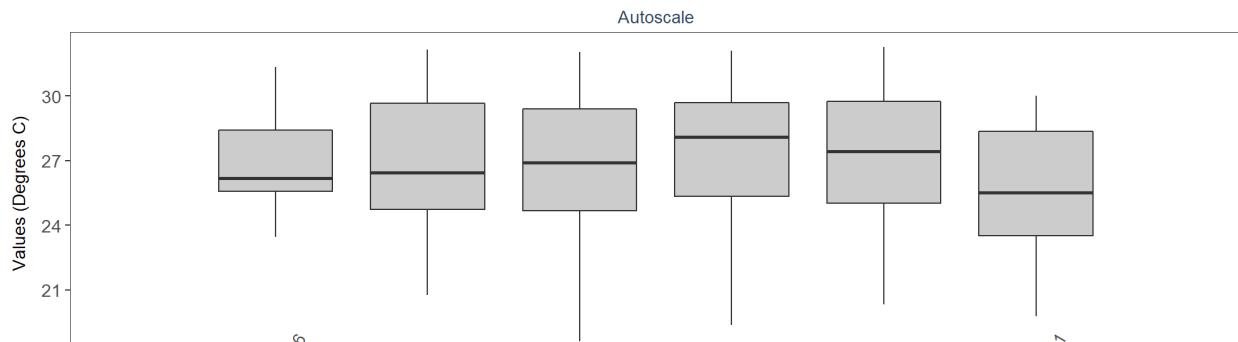
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 Water Temperature on Coral Reefs in the Florida Keys
 36
 By Year & Month



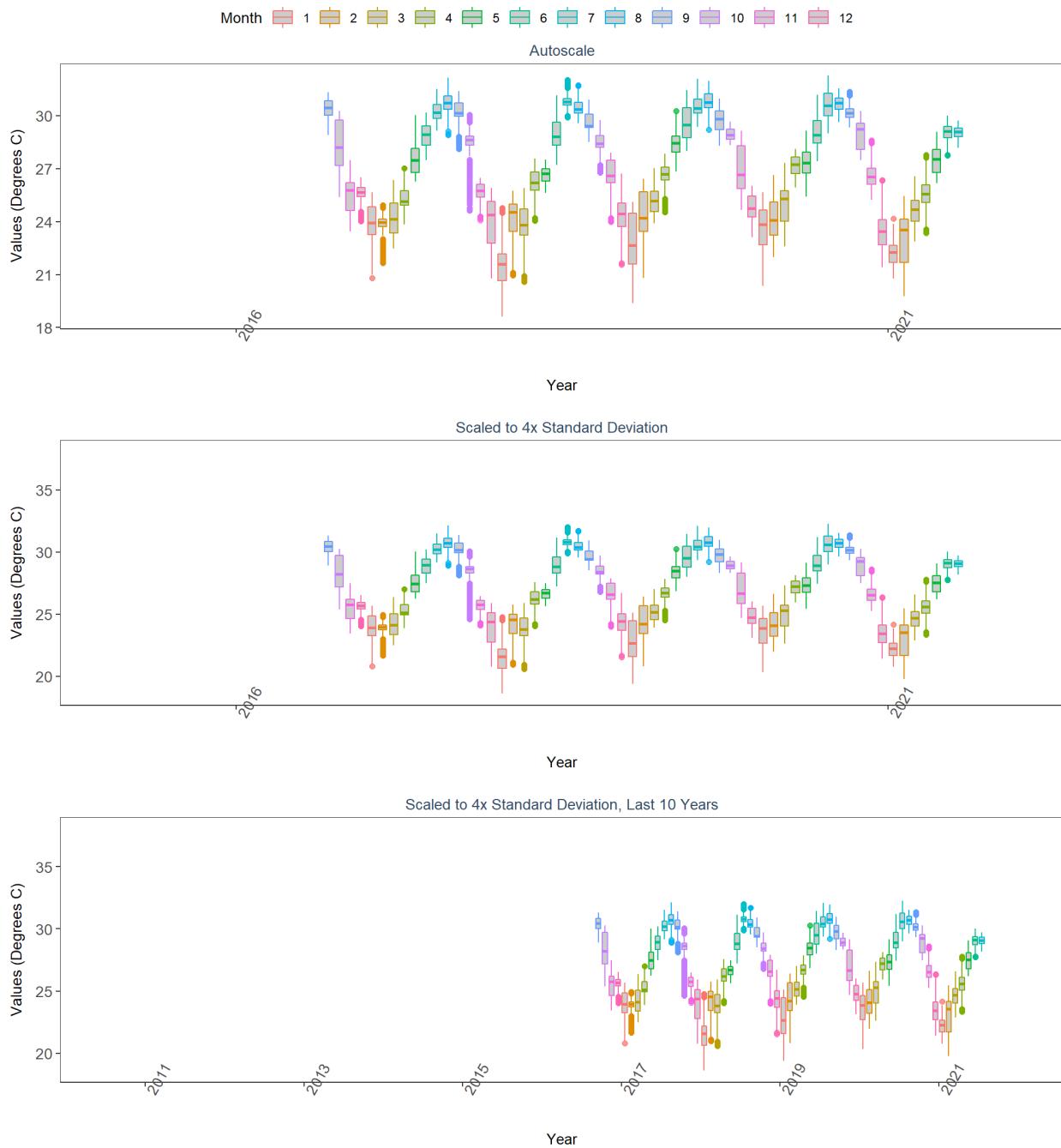
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



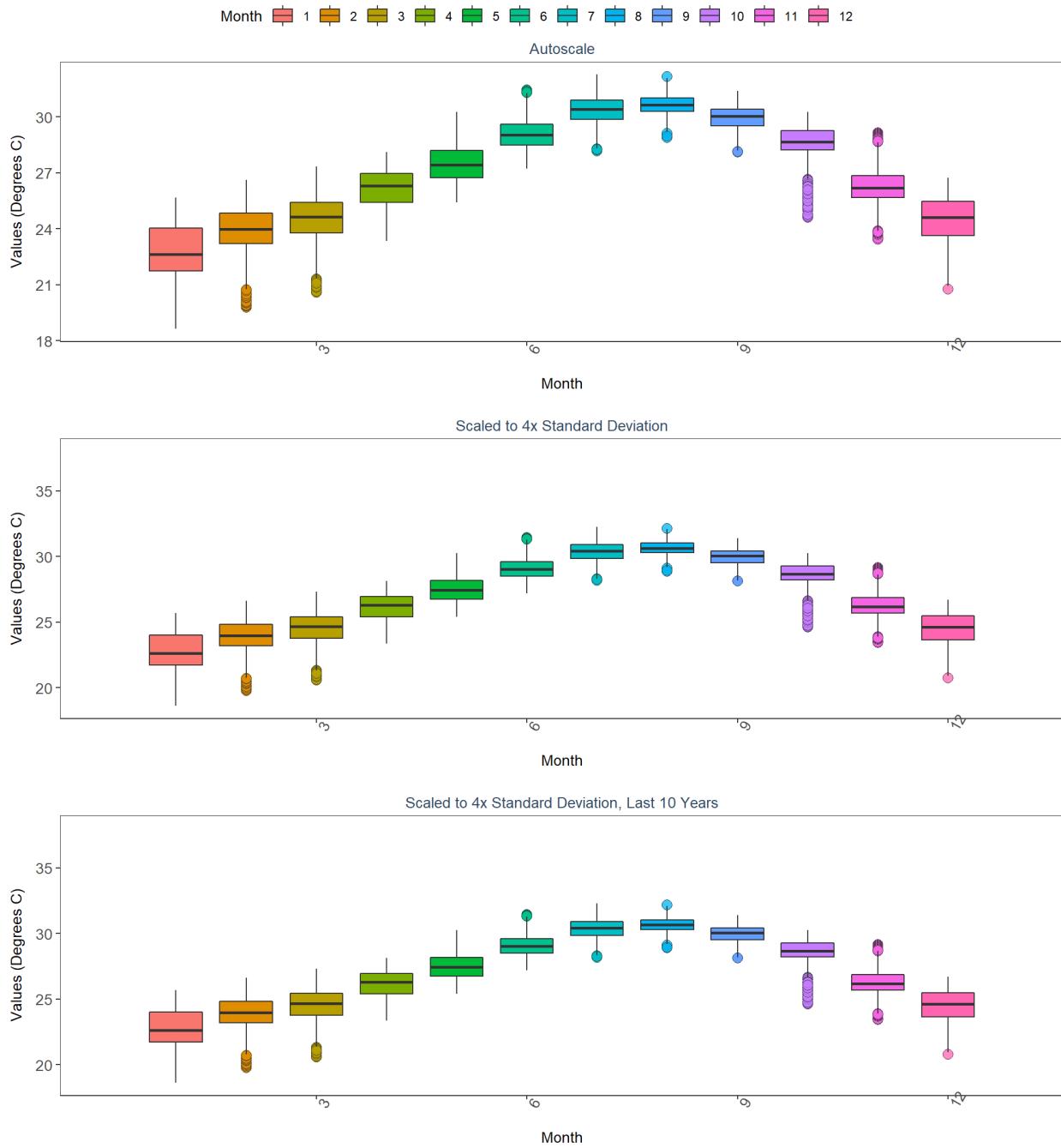
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Water Temperature on Coral Reefs in the Florida Keys
37
By Year



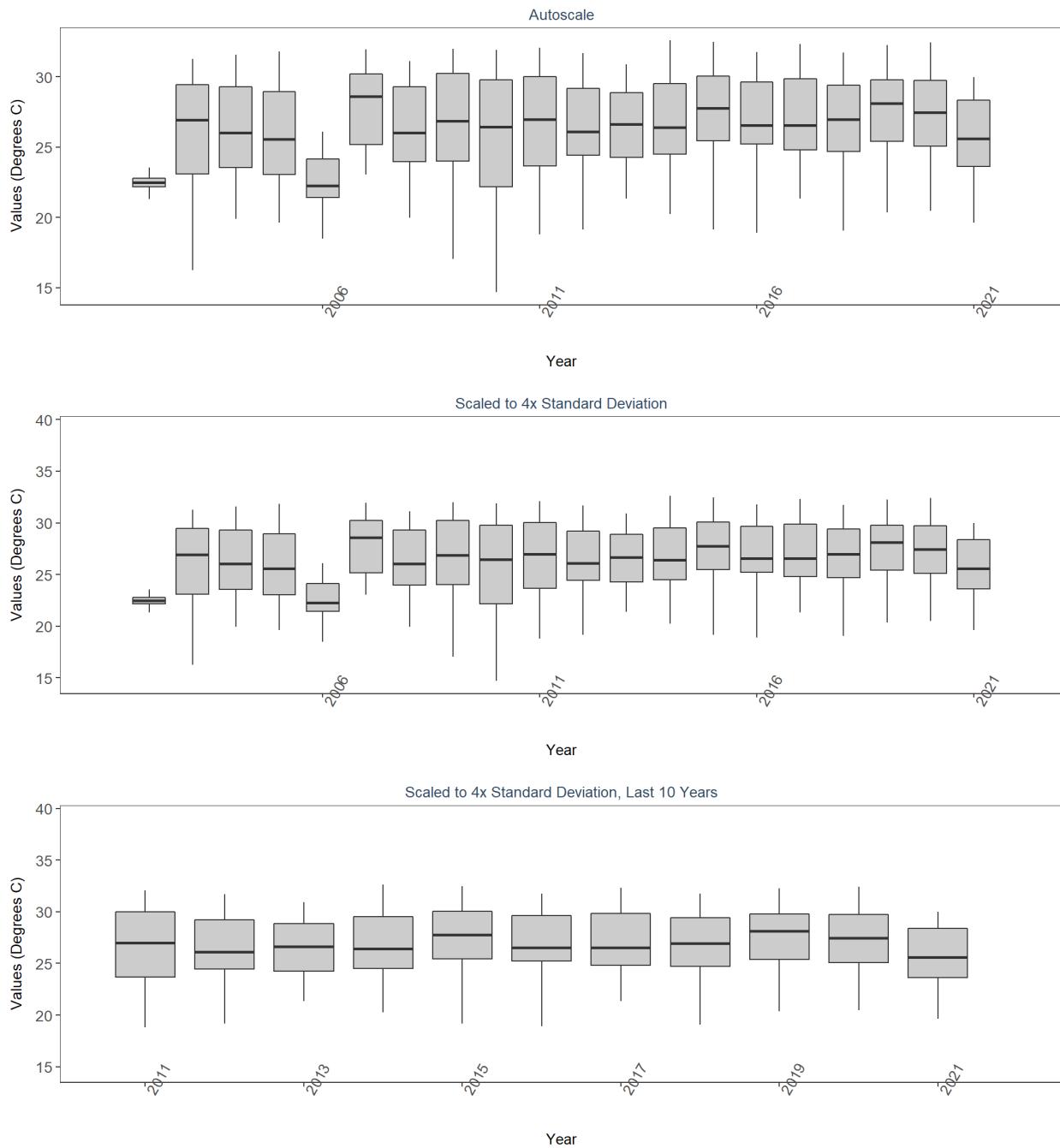
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 Water Temperature on Coral Reefs in the Florida Keys
 37
 By Year & Month



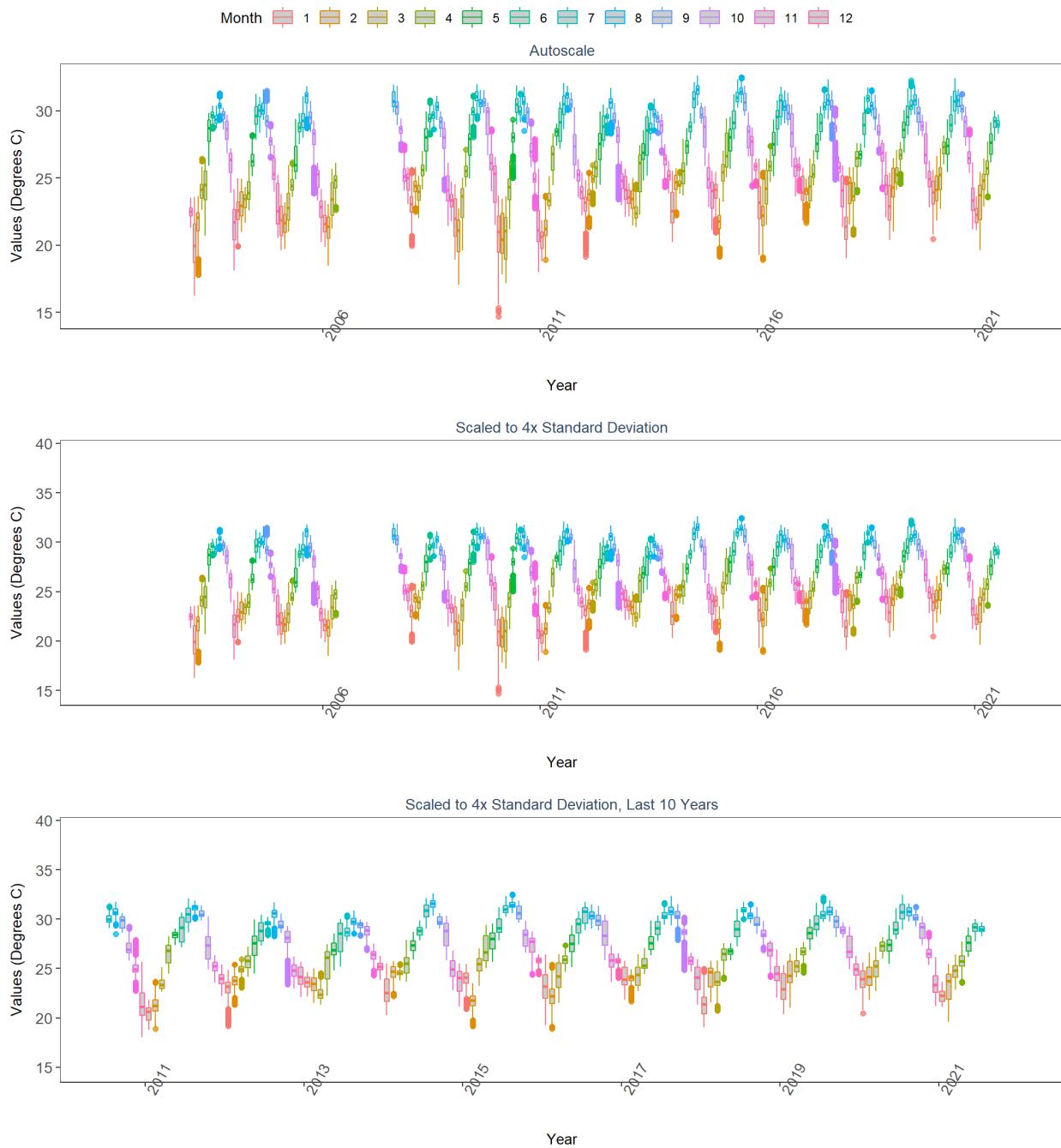
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



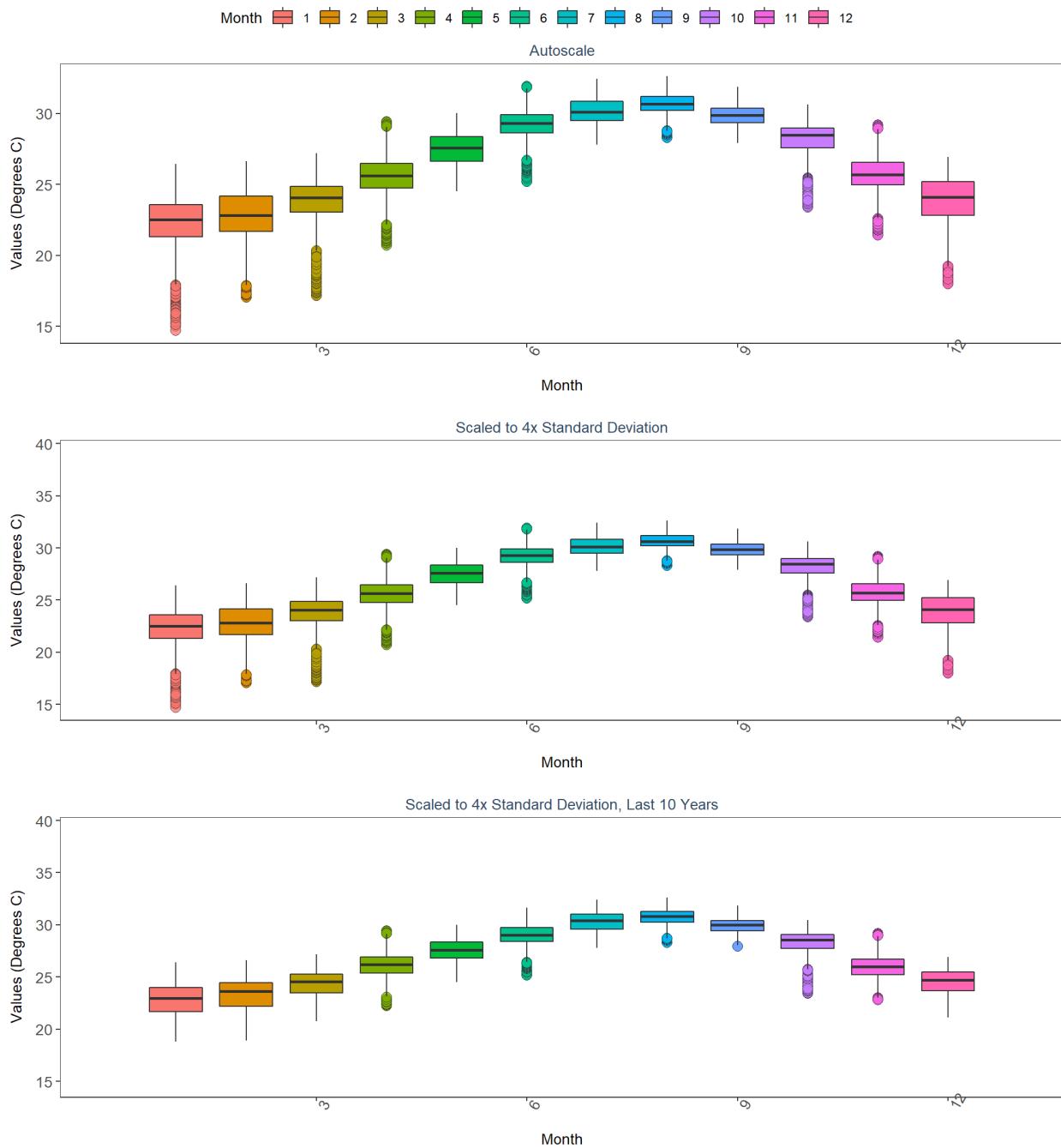
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



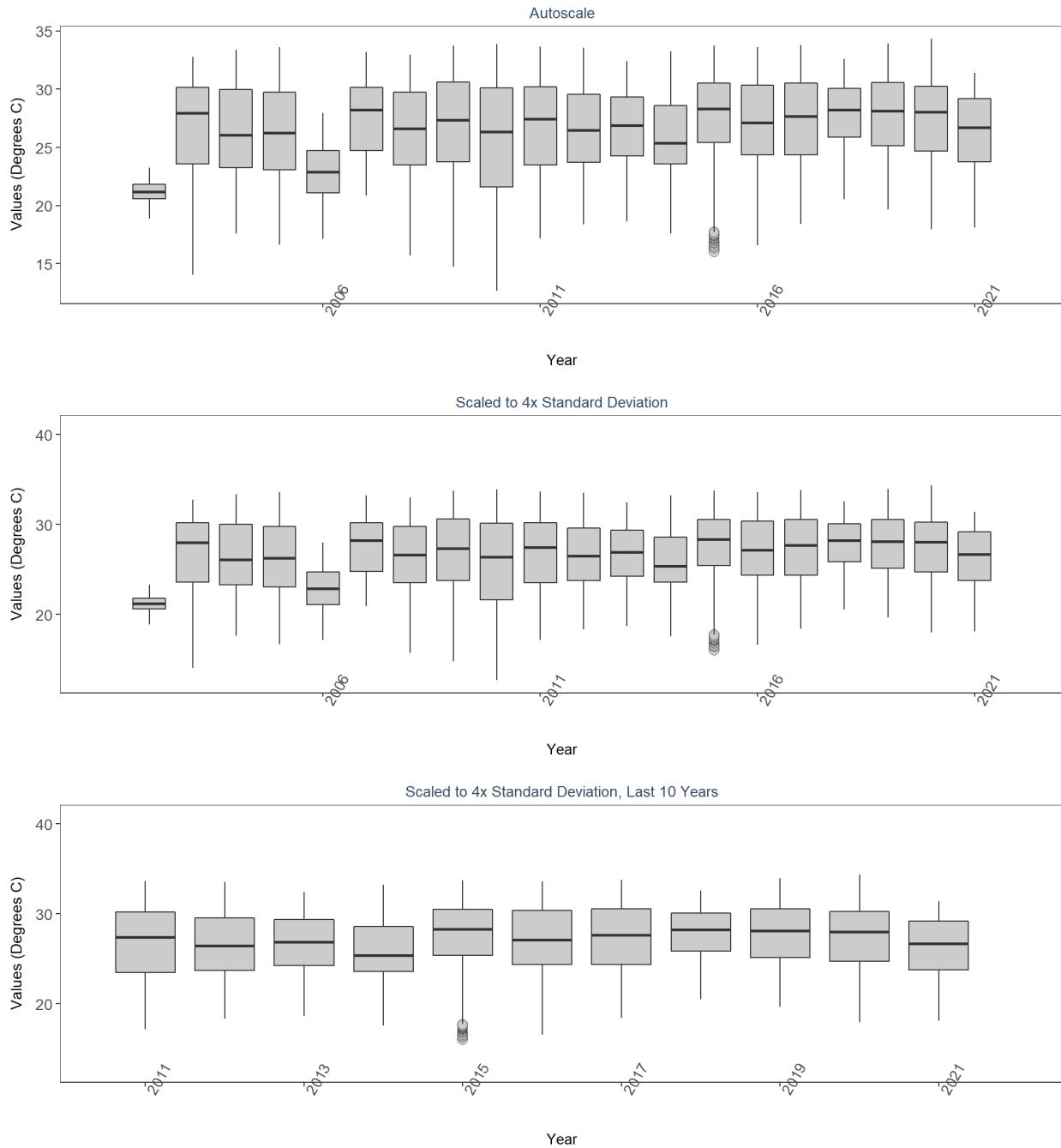
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



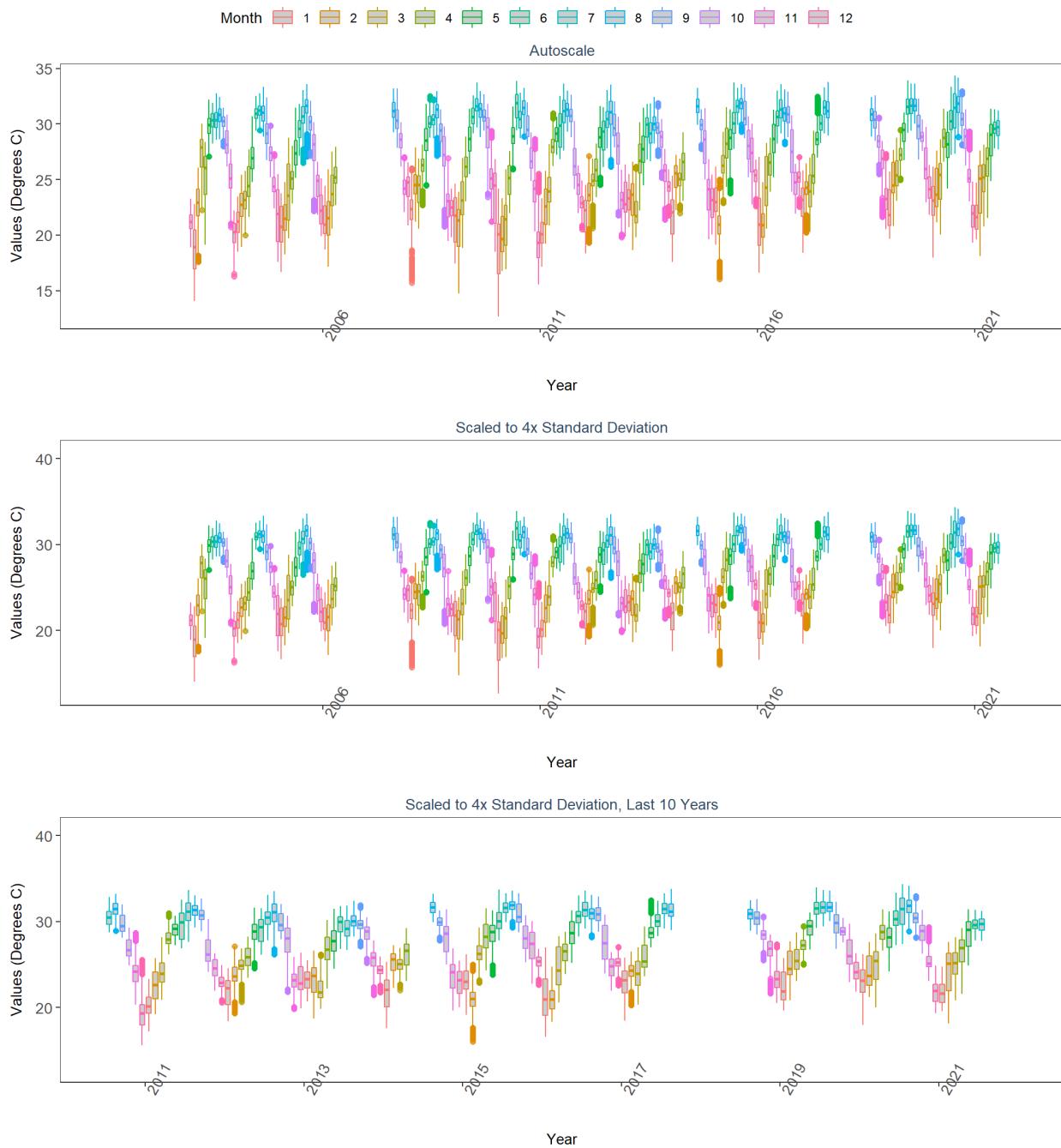
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 By Month



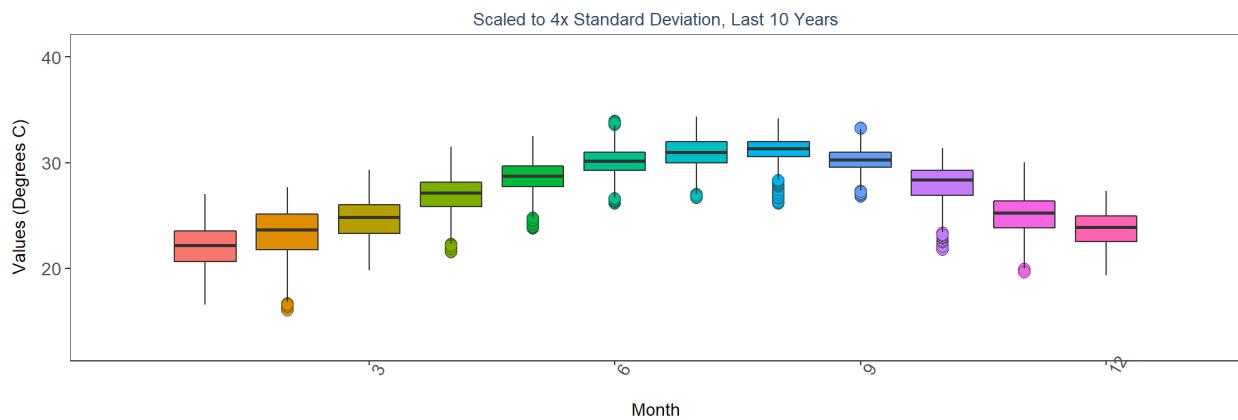
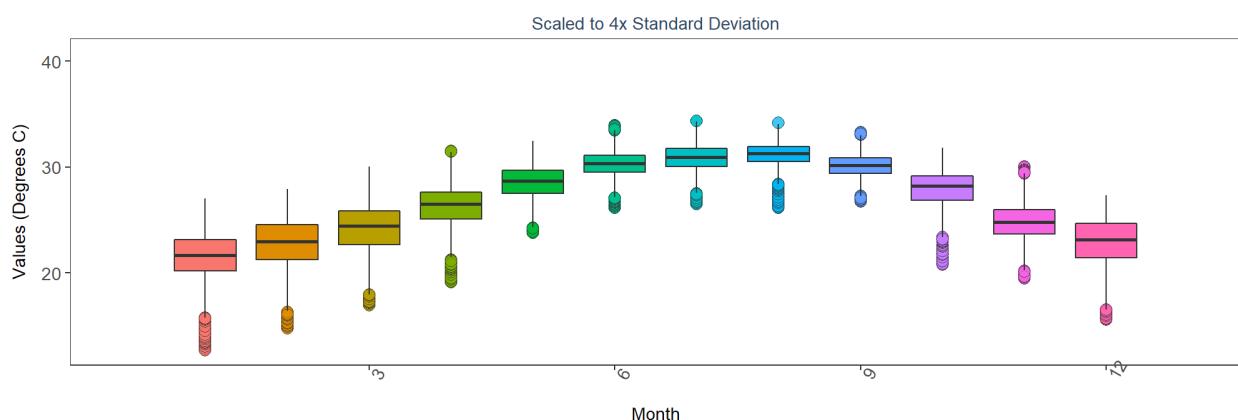
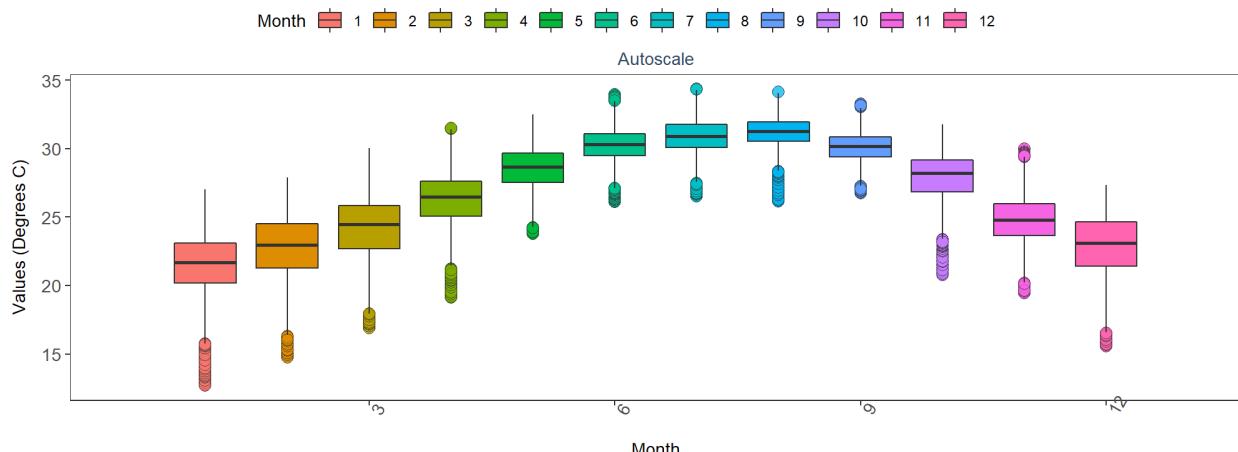
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 Water Temperature on Coral Reefs in the Florida Keys
 40
 By Year



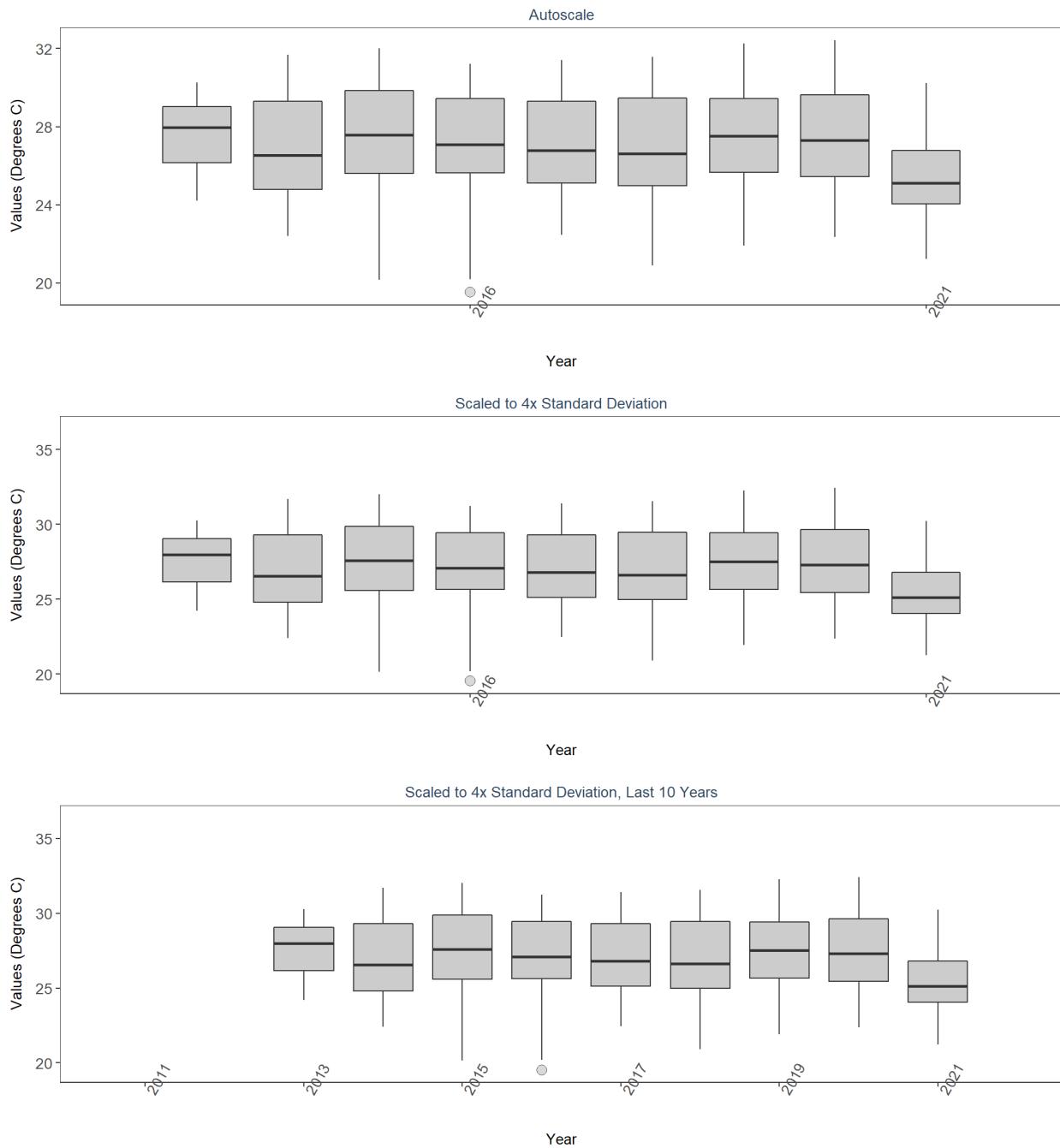
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Water Temperature on Coral Reefs in the Florida Keys
40
By Year & Month



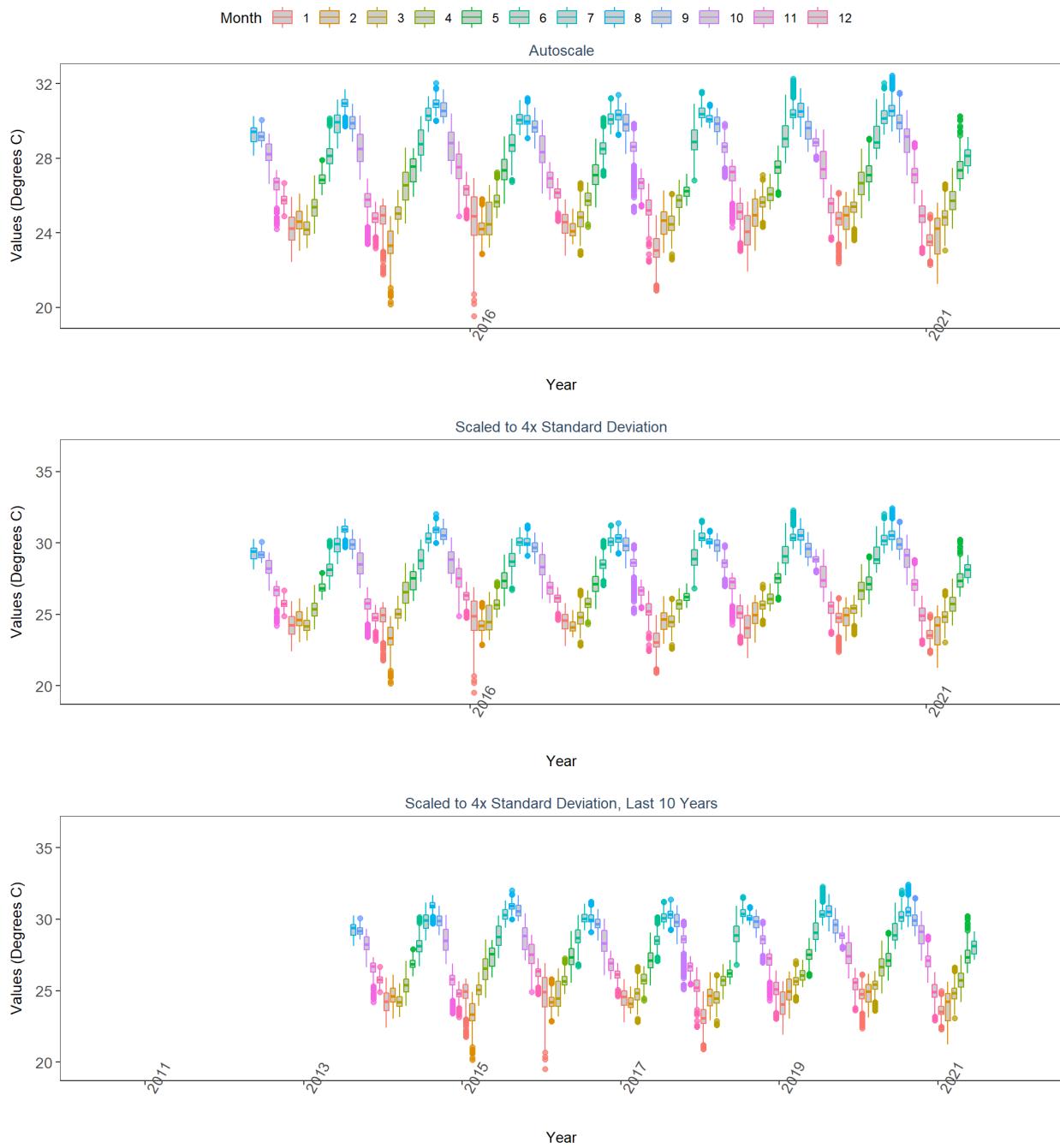
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 By Month



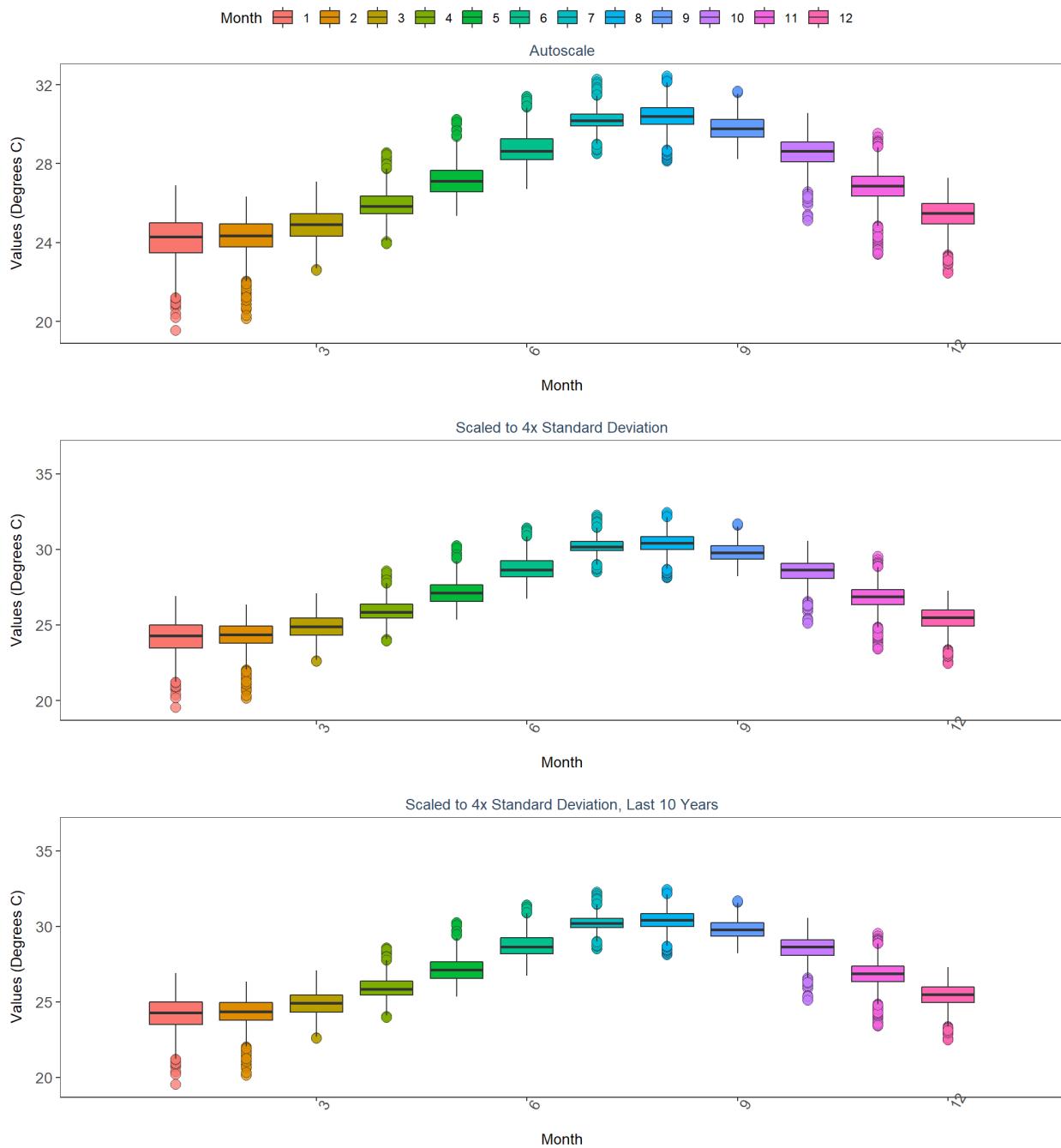
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Water Temperature on Coral Reefs in the Florida Keys
50
By Year



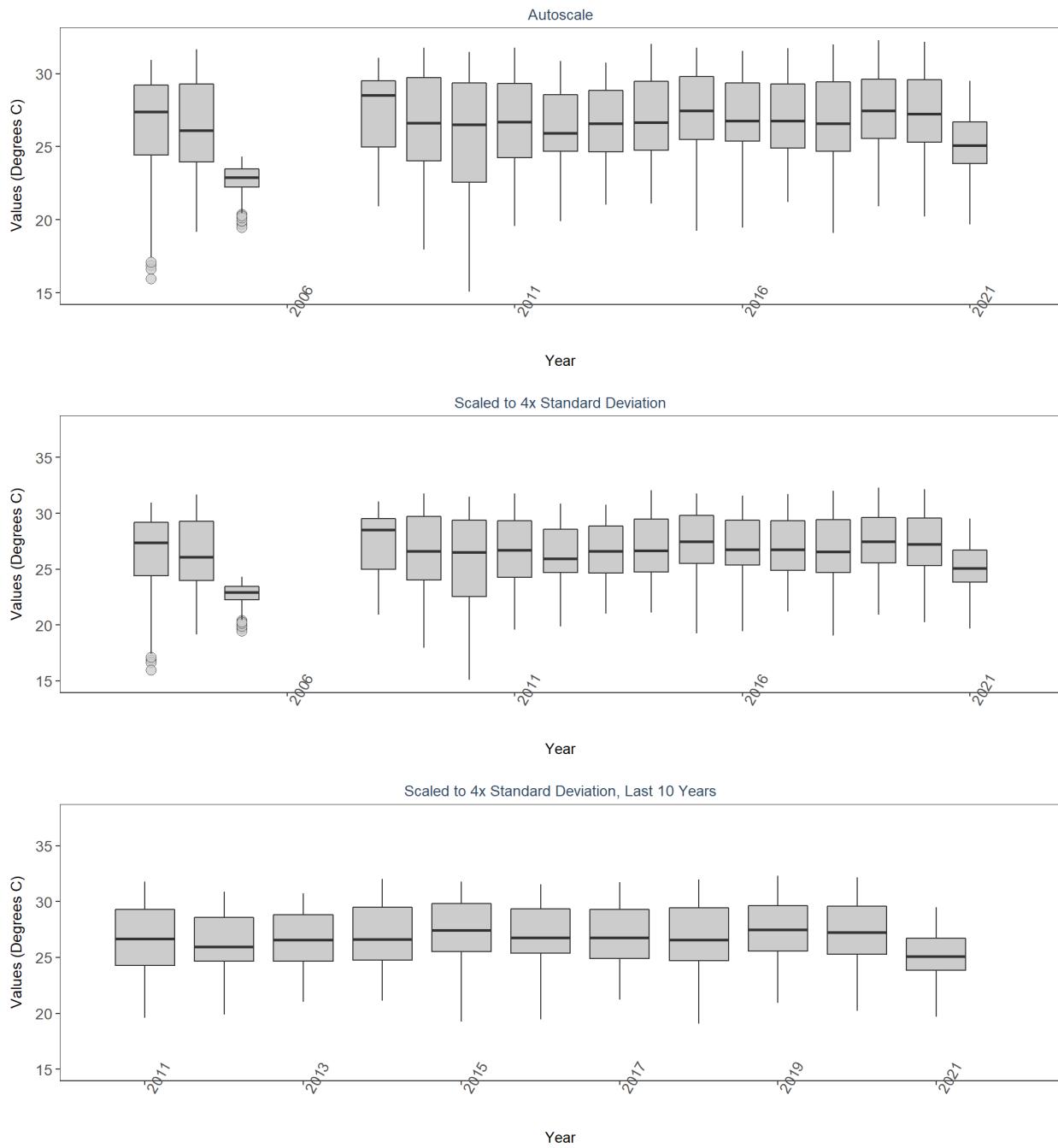
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 Water Temperature on Coral Reefs in the Florida Keys
 50
 By Year & Month



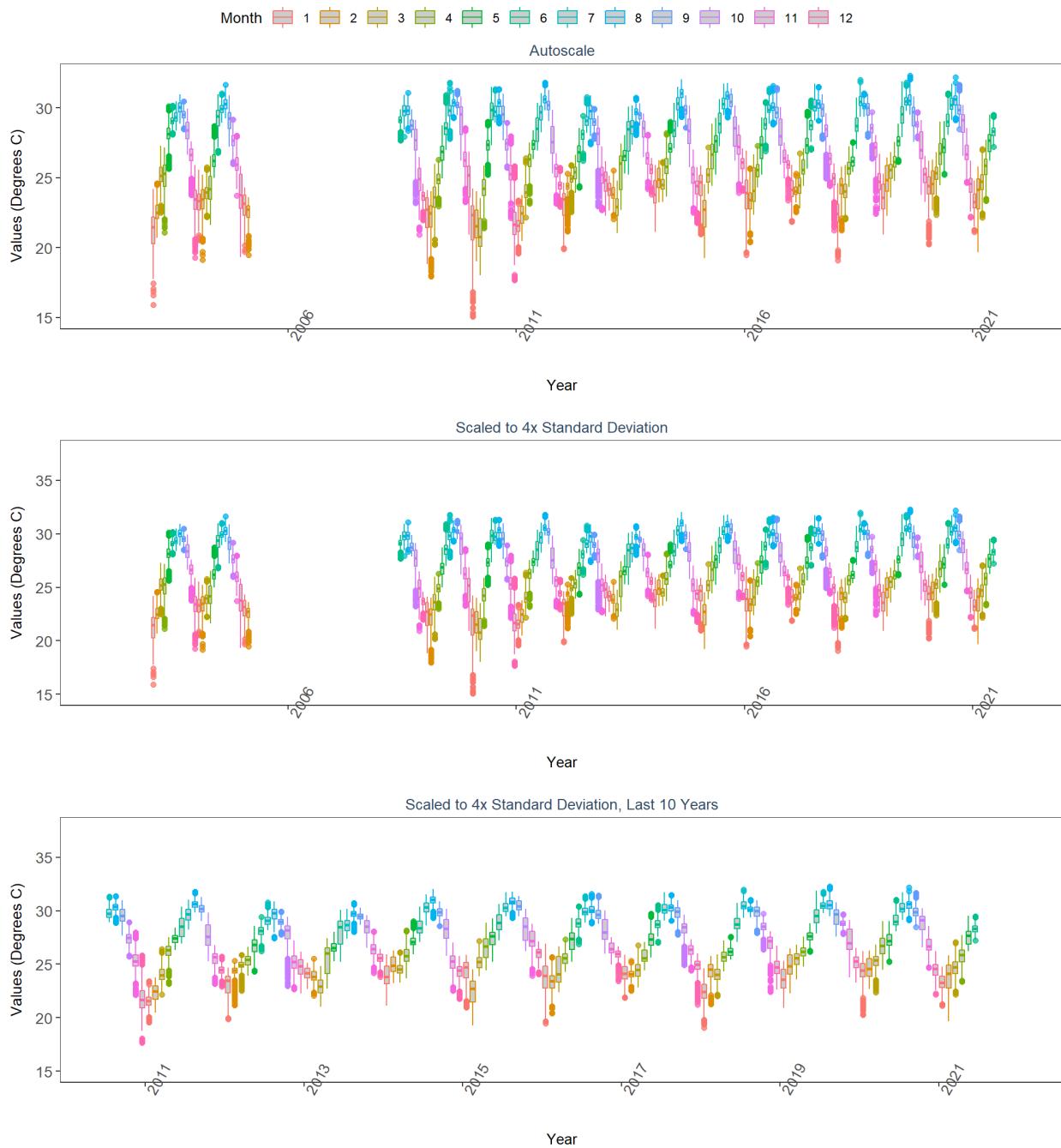
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 Water Temperature on Coral Reefs in the Florida Keys
 50
 By Month



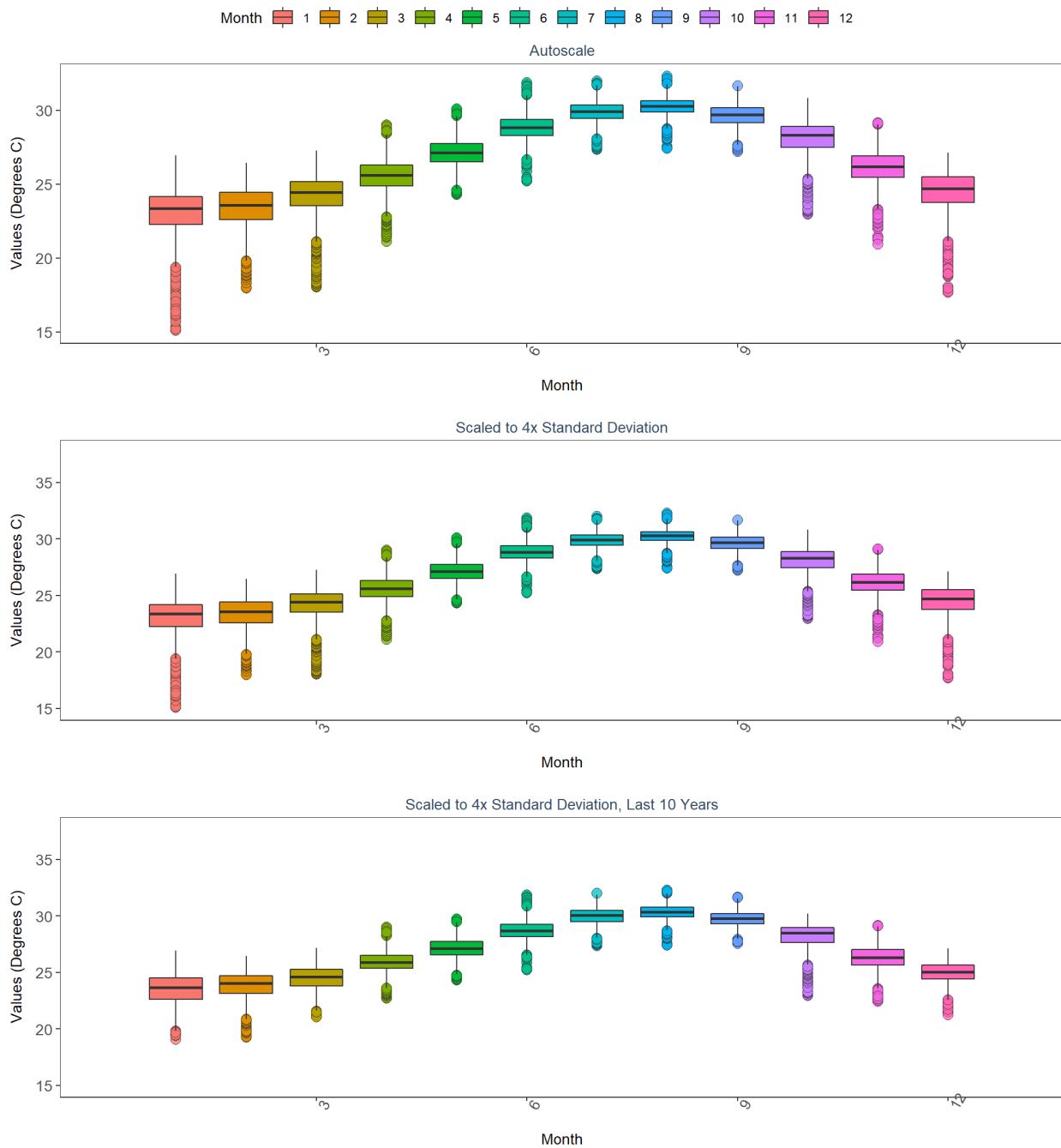
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 51
 By Year



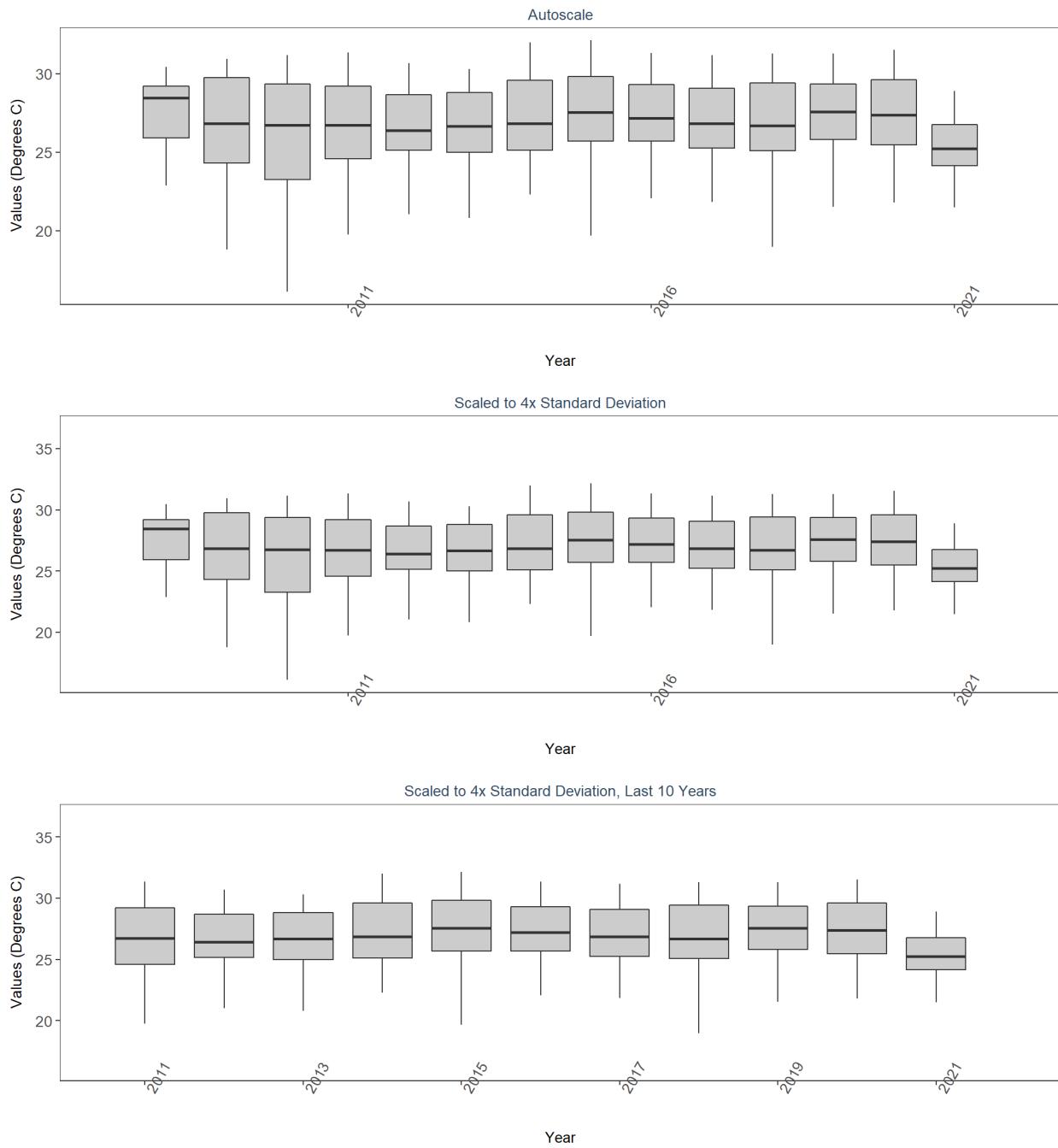
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



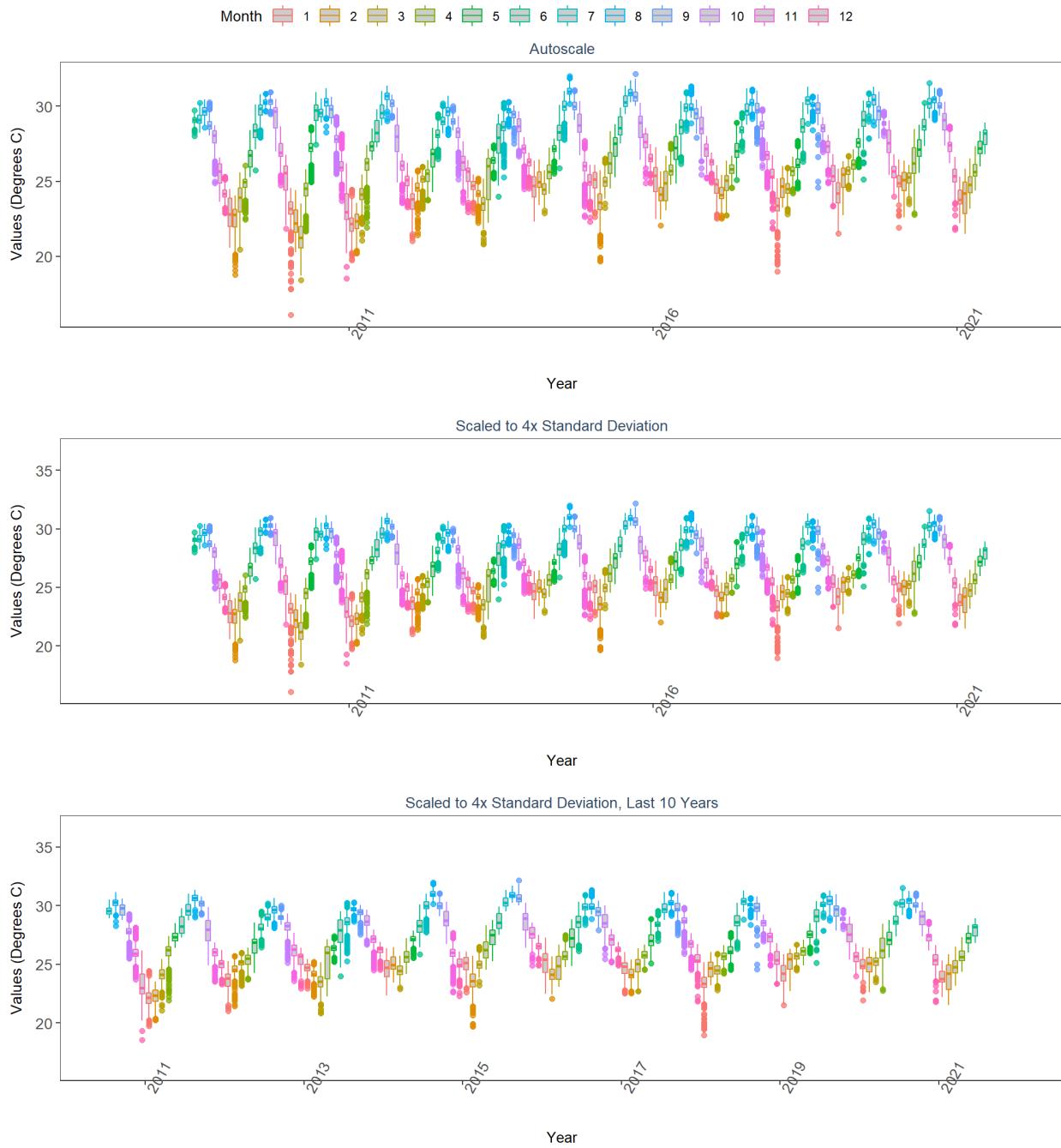
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 Water Temperature on Coral Reefs in the Florida Keys
 51
 By Month



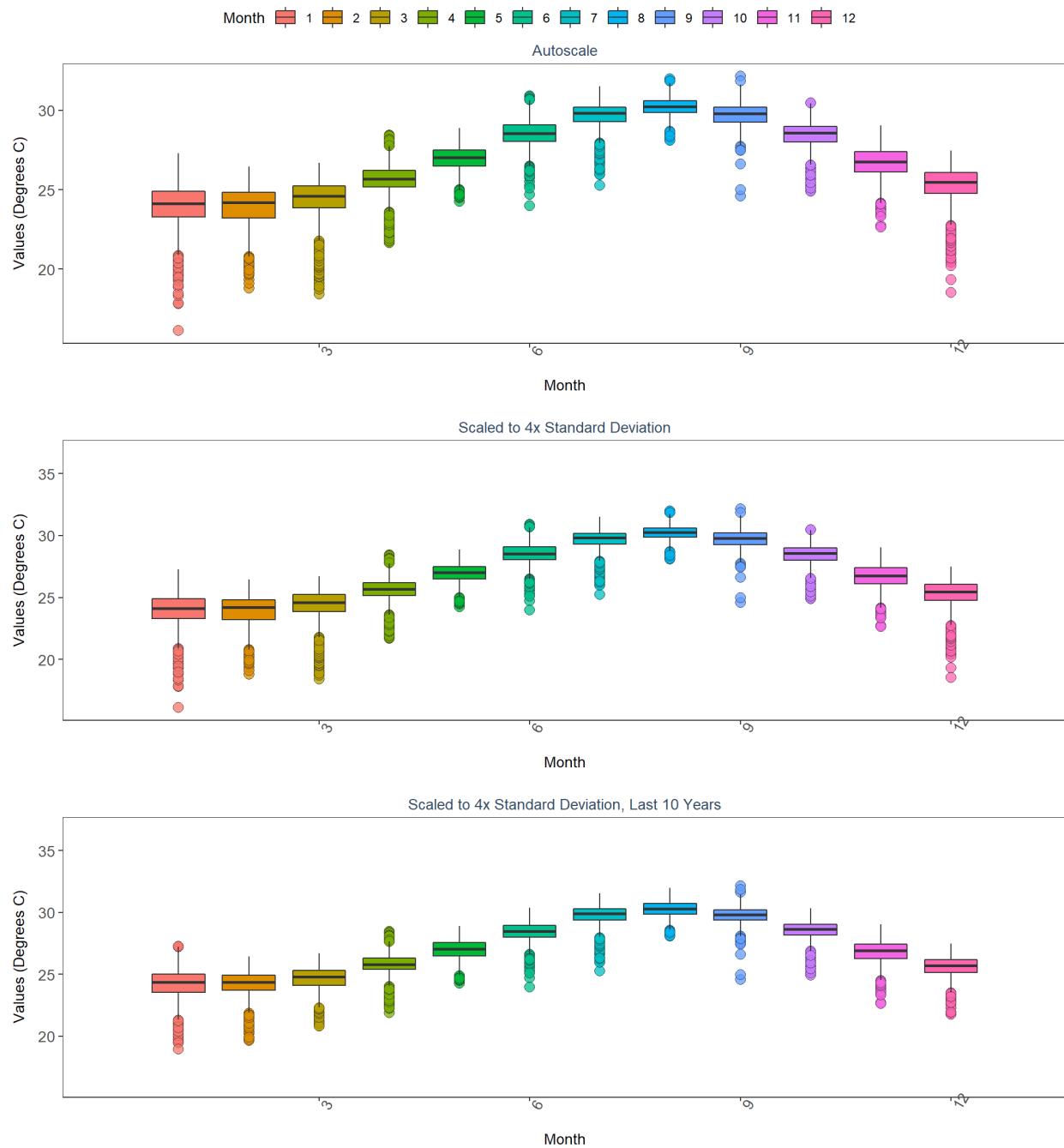
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 52
 By Year



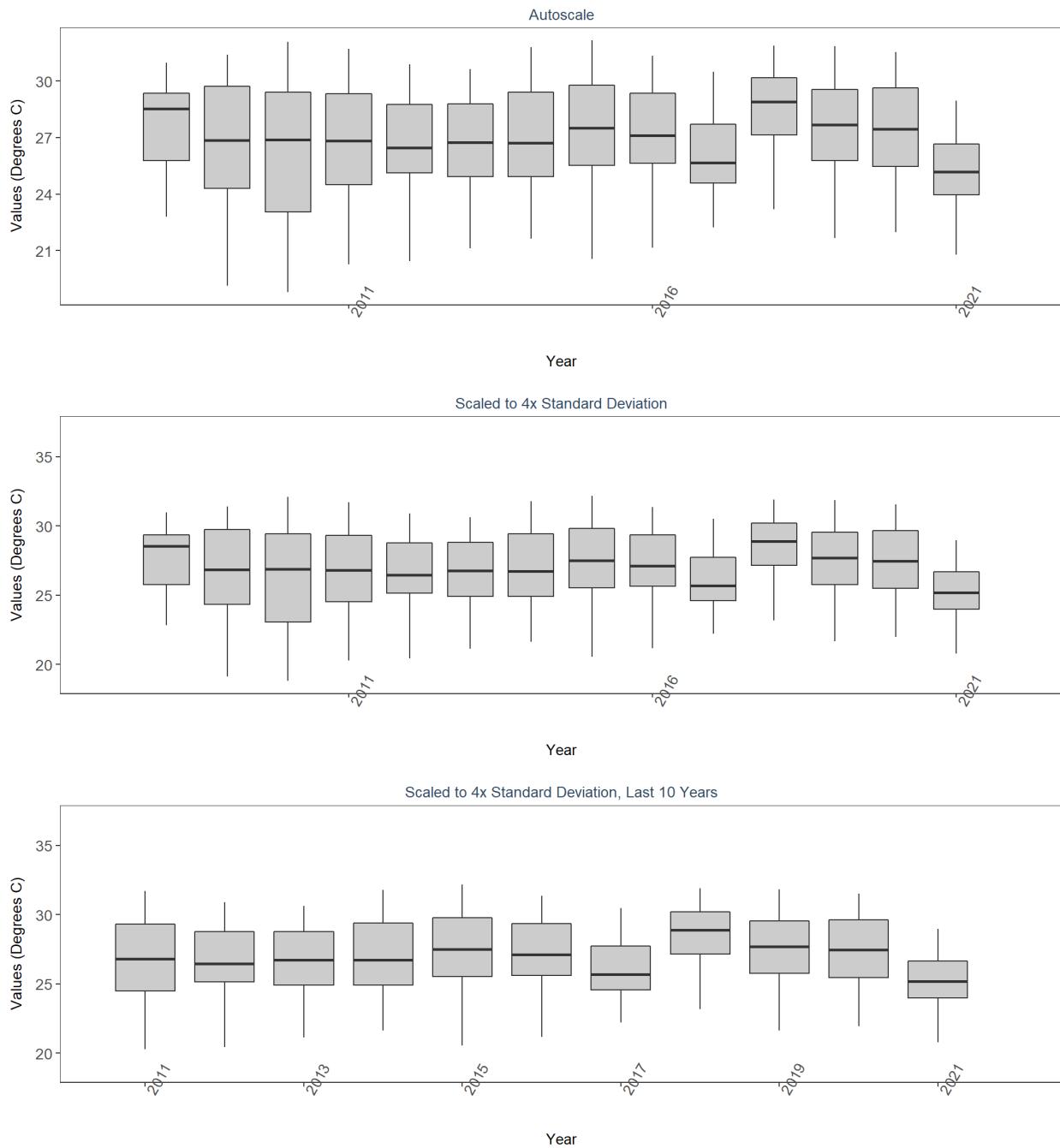
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Water Temperature on Coral Reefs in the Florida Keys
52
By Year & Month



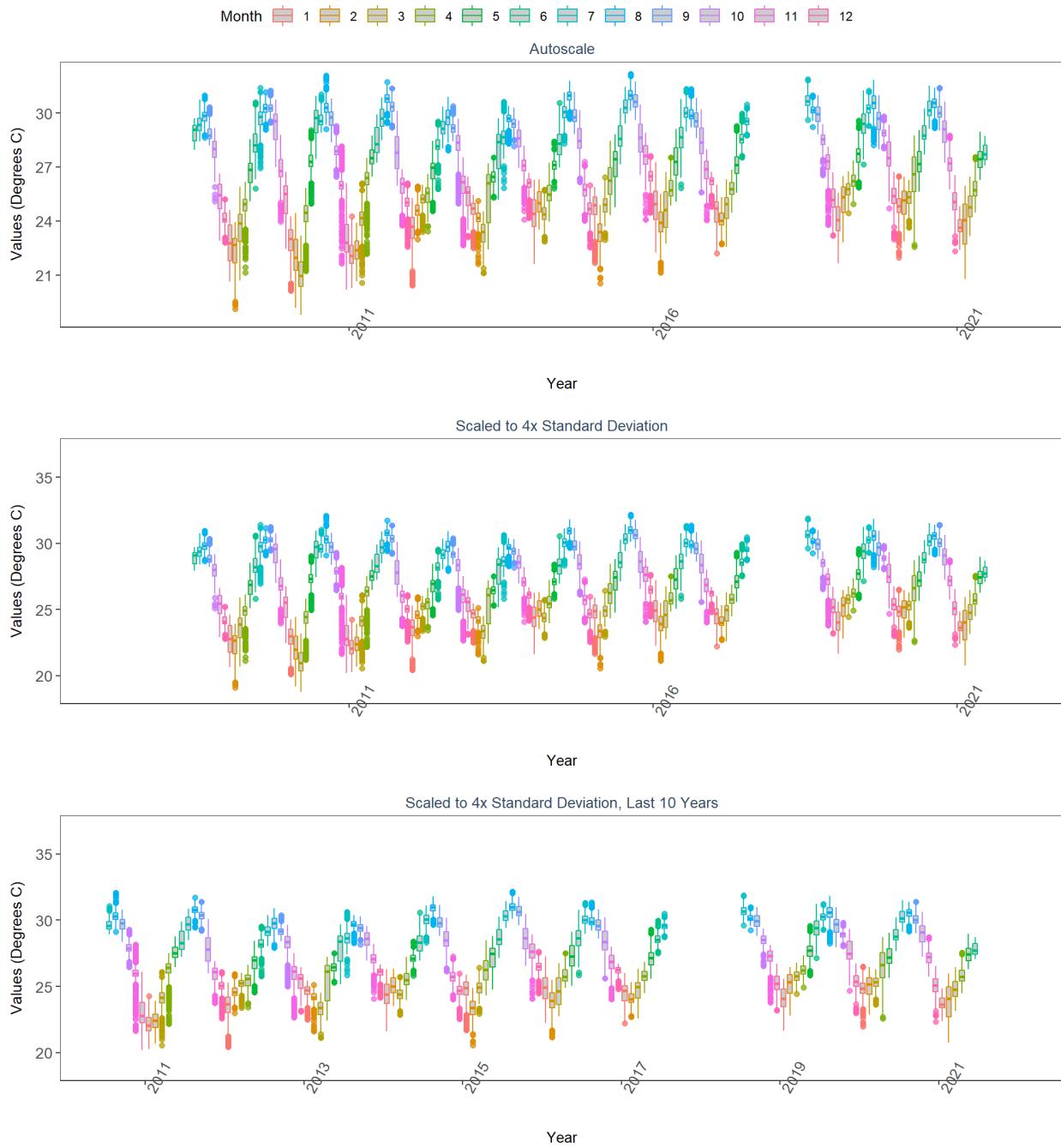
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



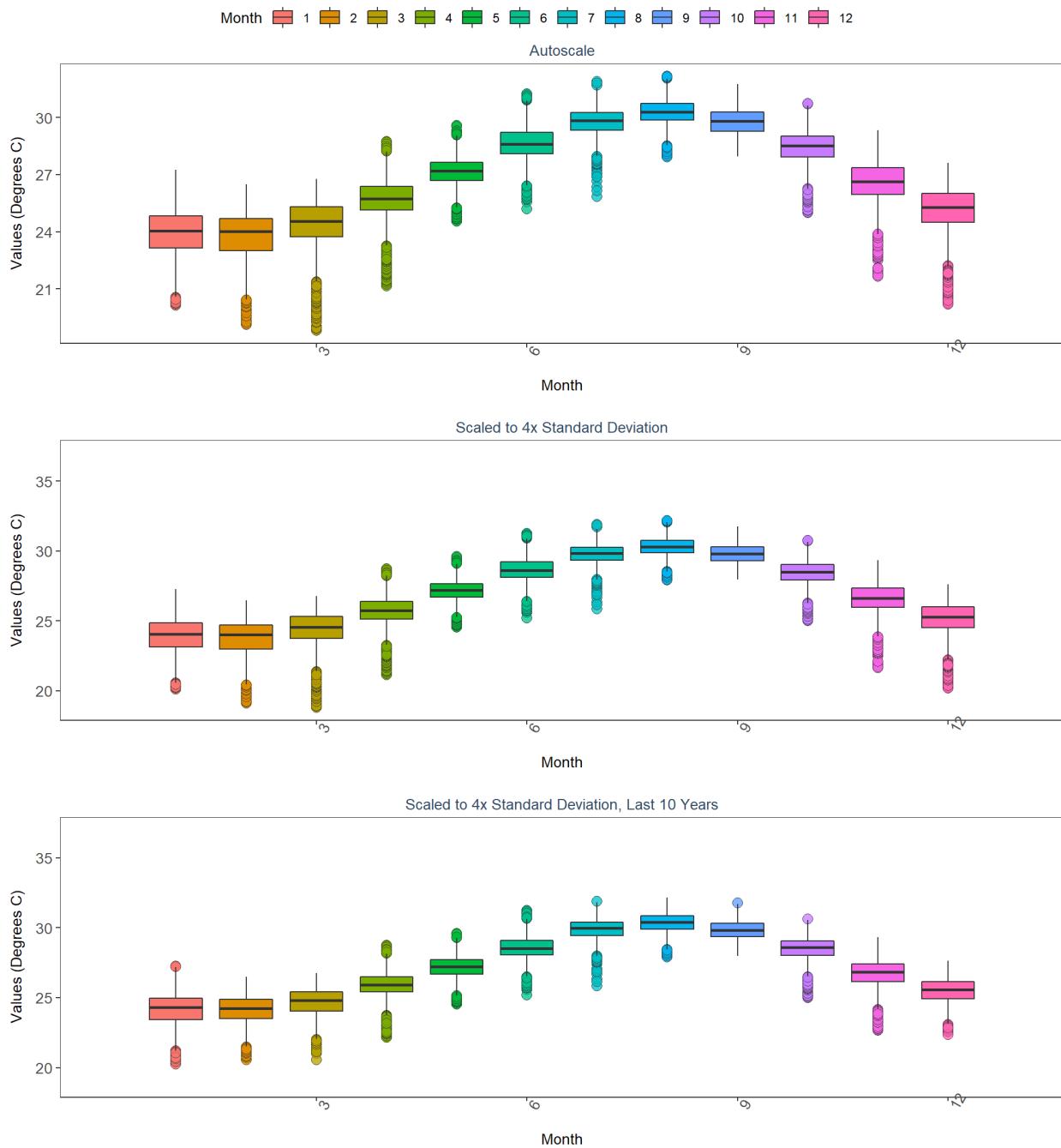
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



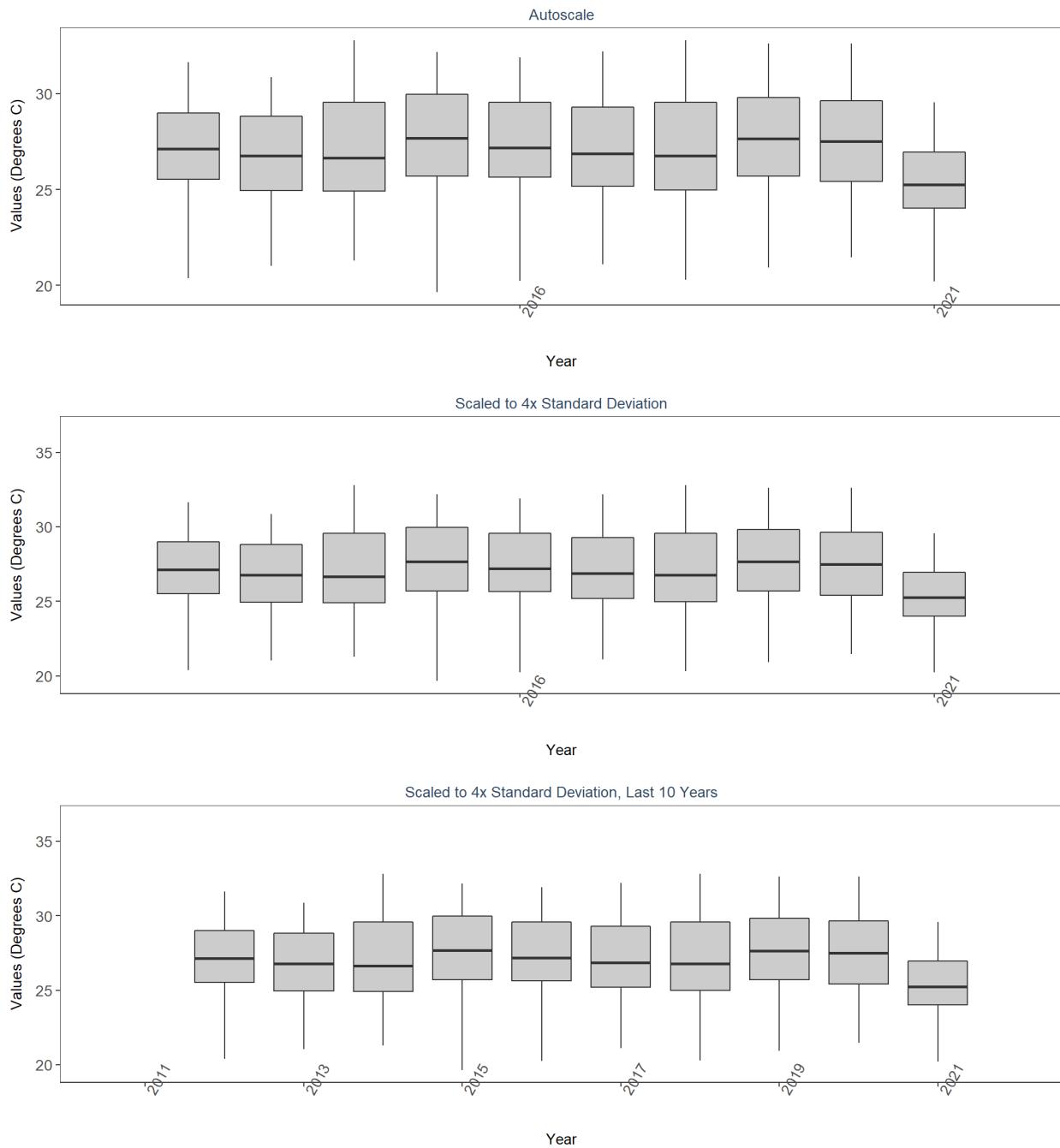
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 Water Temperature on Coral Reefs in the Florida Keys
 53
 By Year & Month



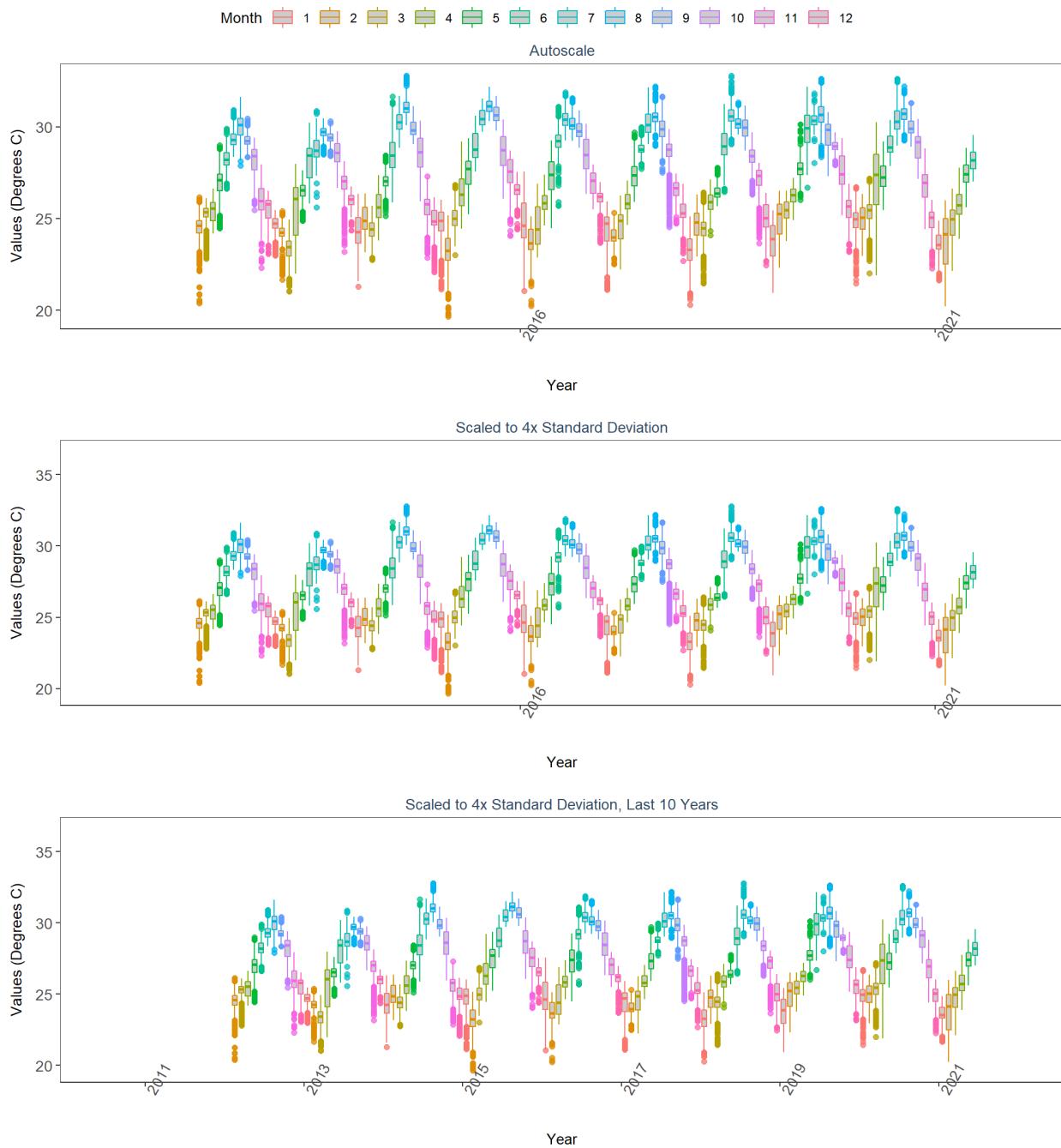
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 By Month



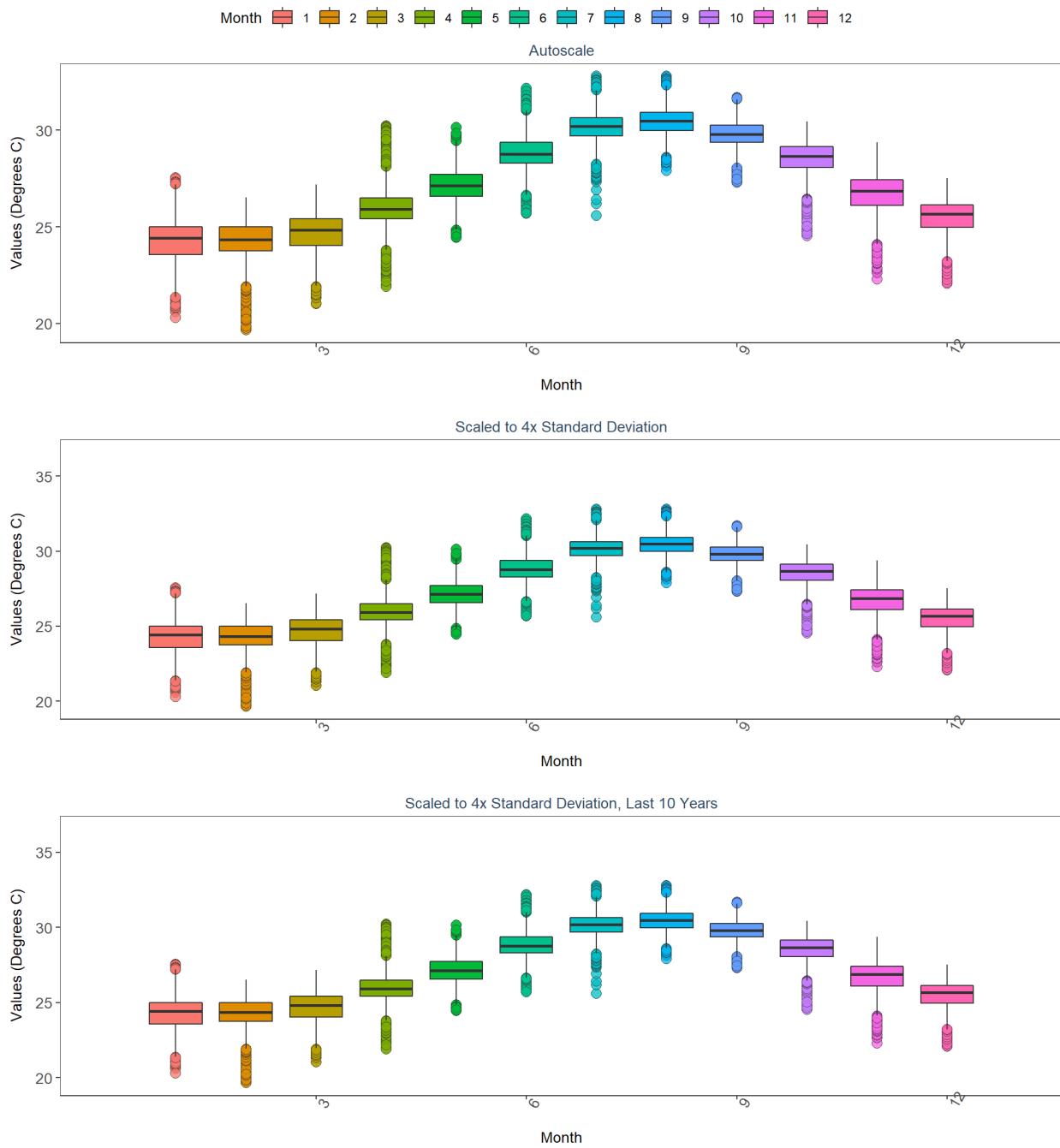
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



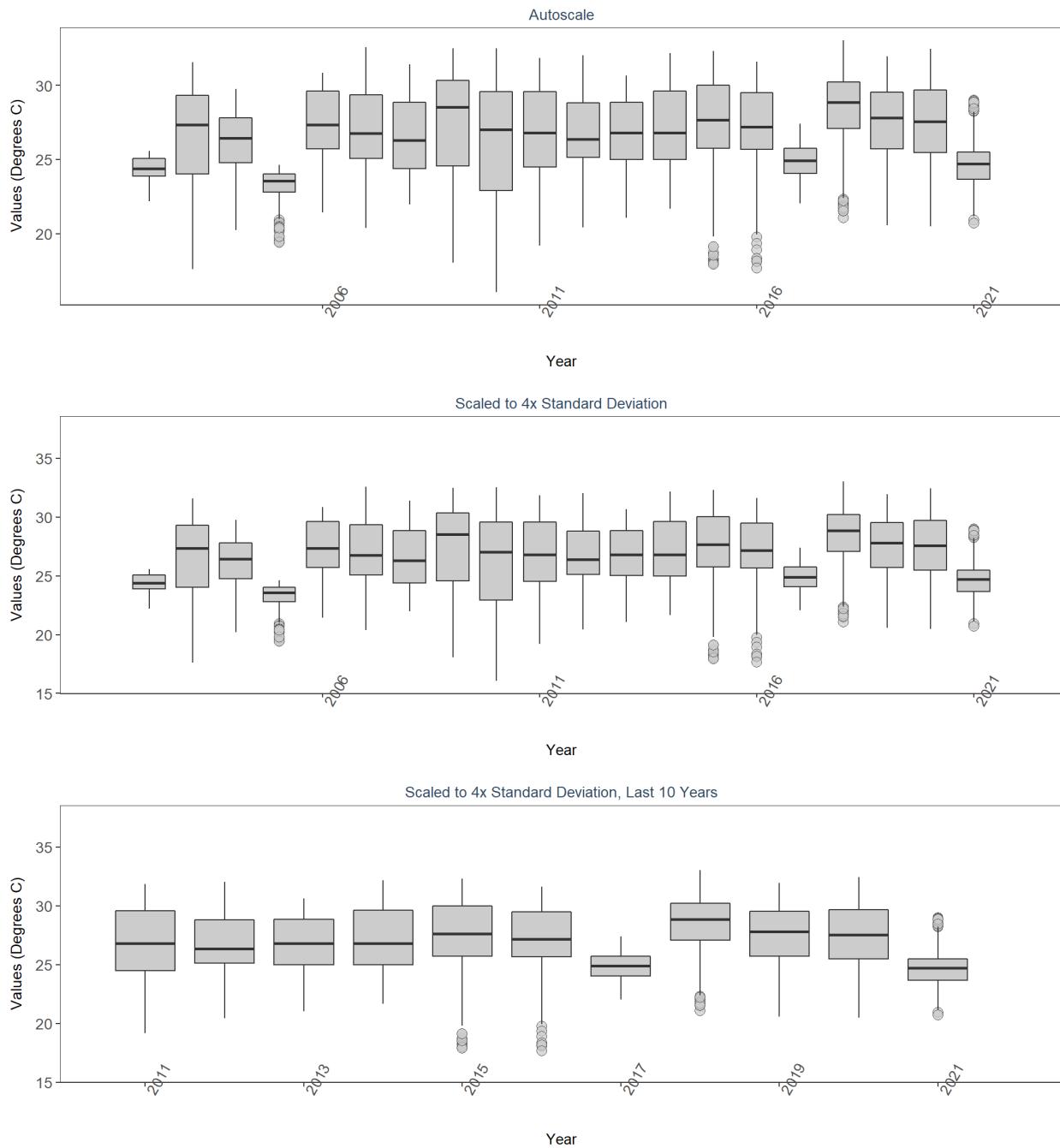
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



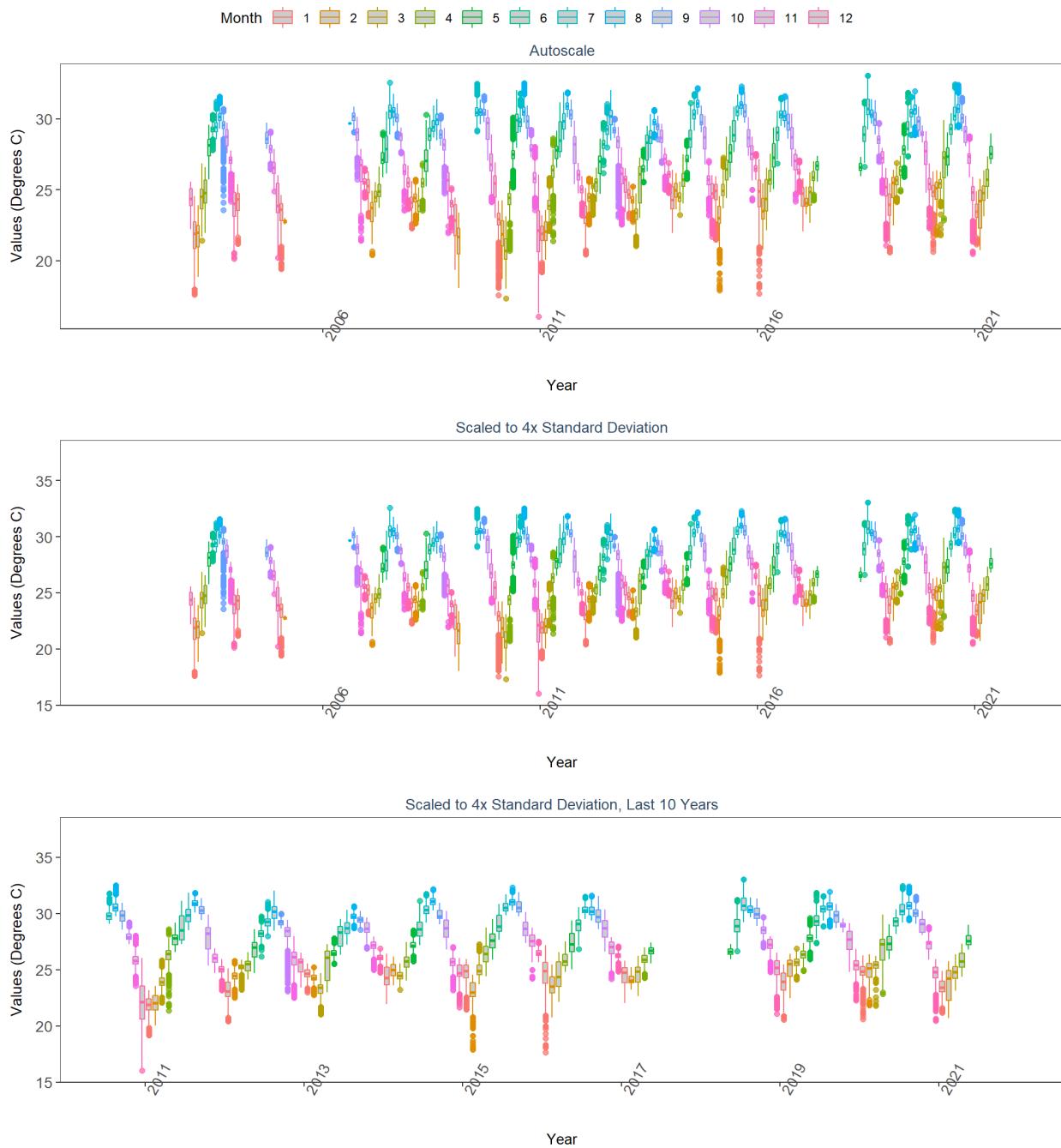
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 By Month



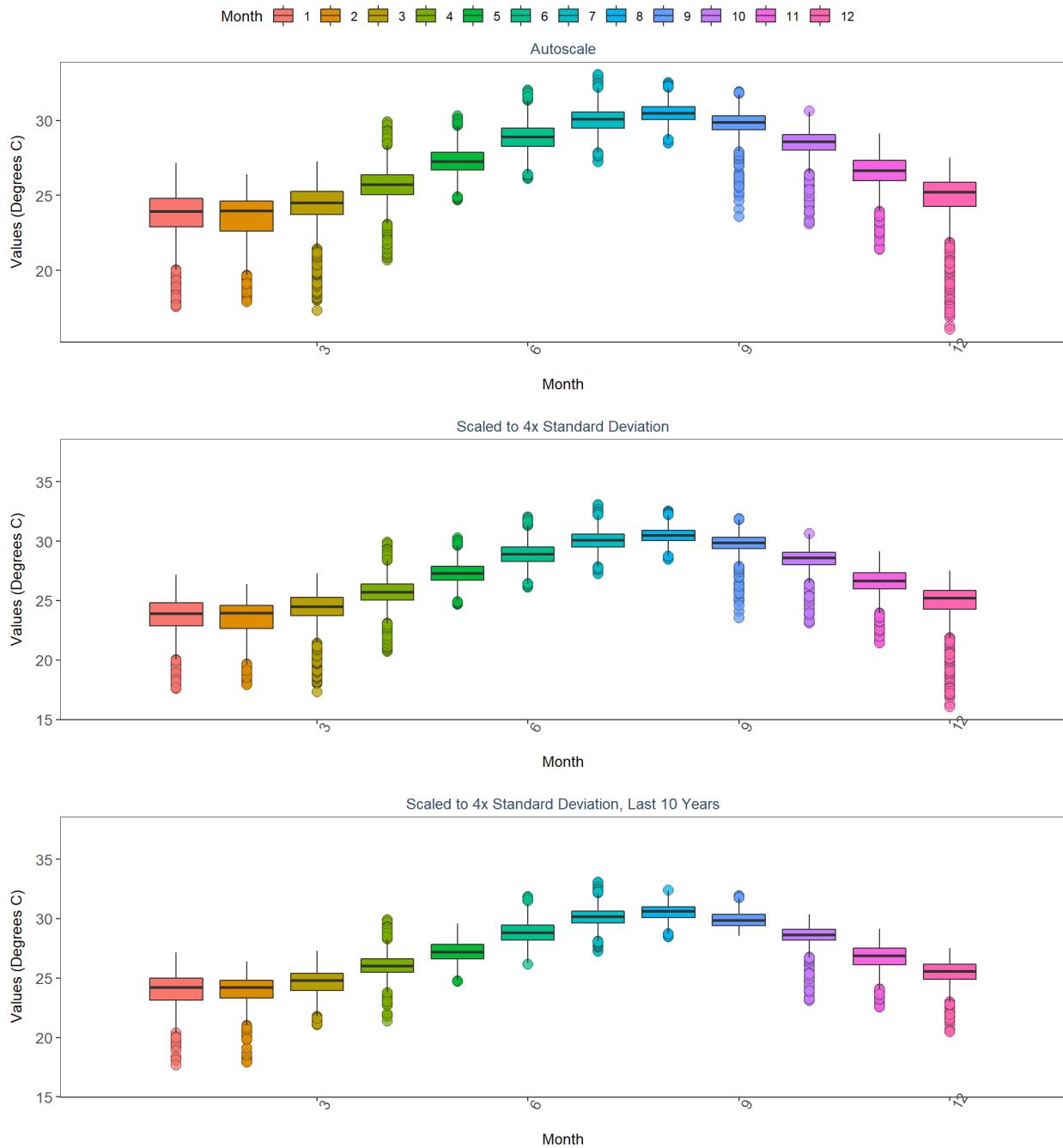
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 By Year



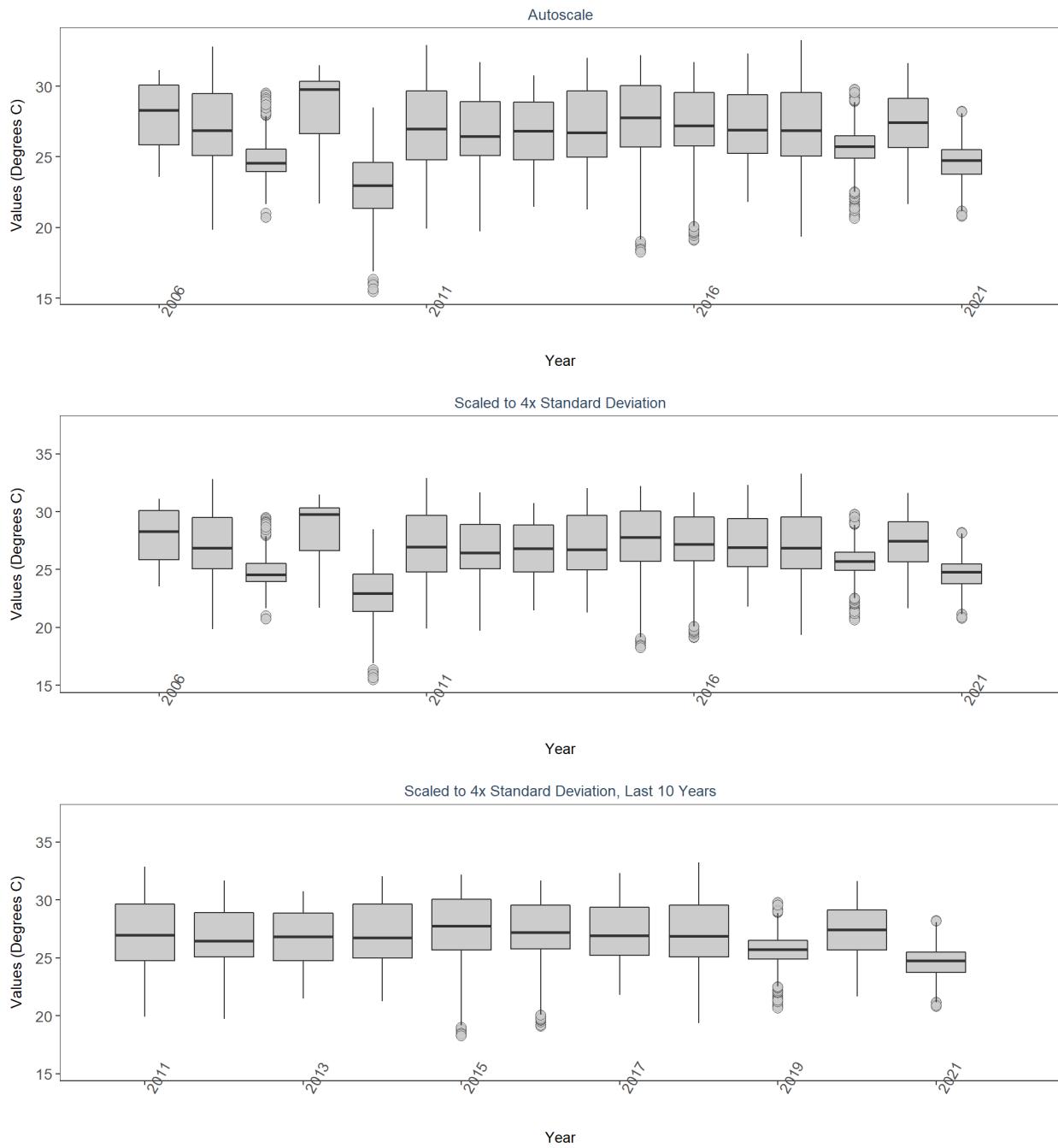
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



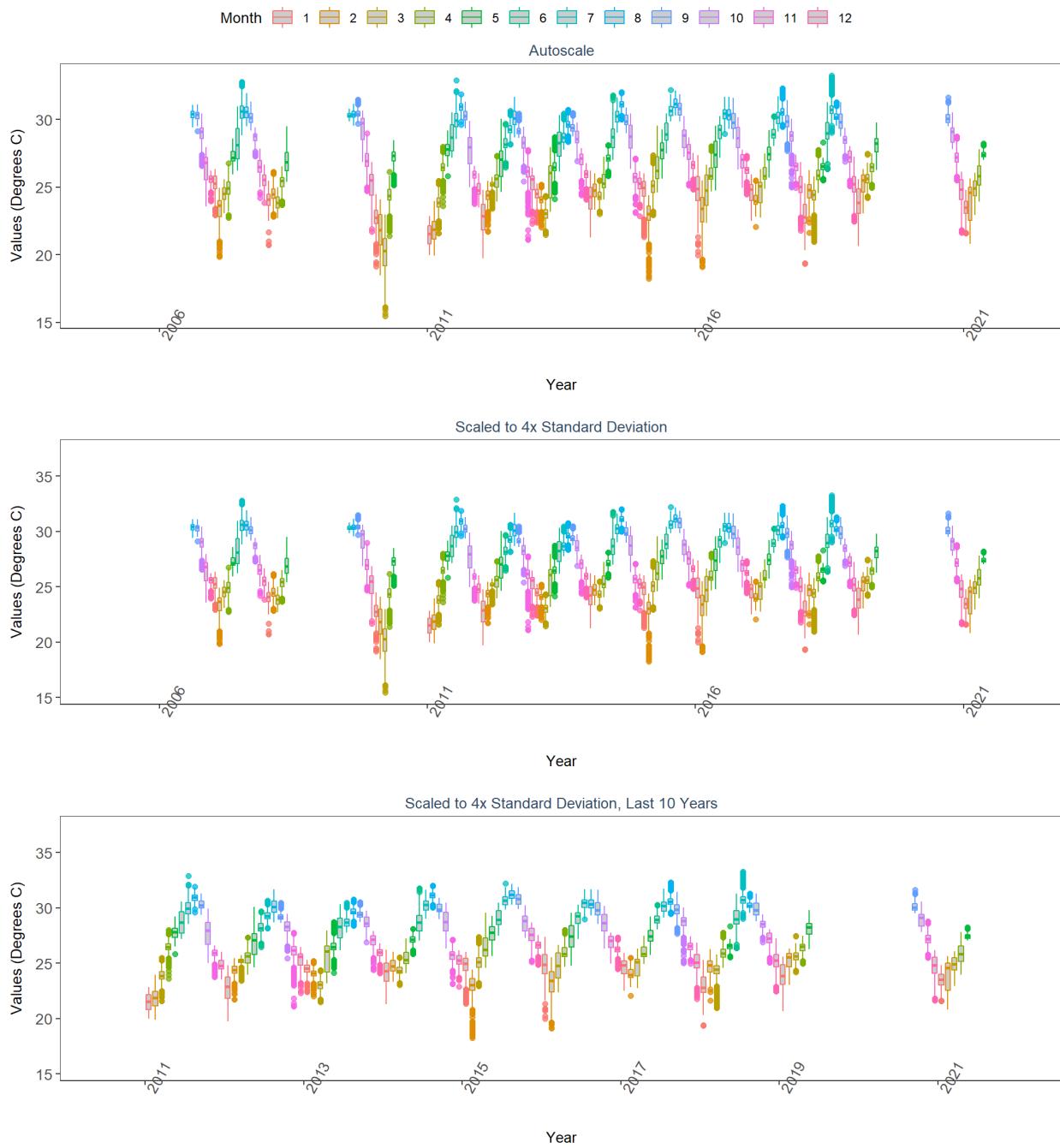
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 By Month



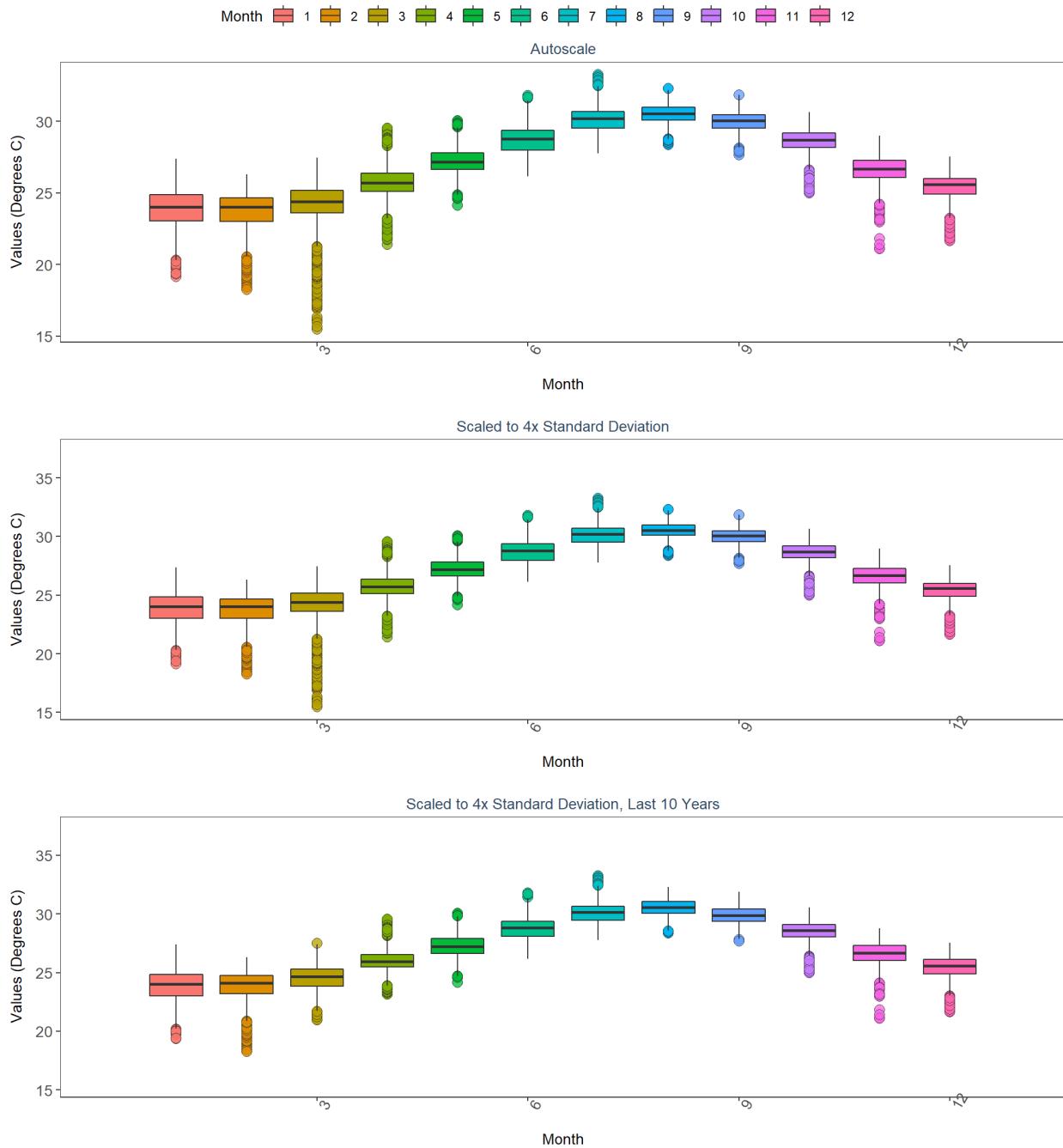
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



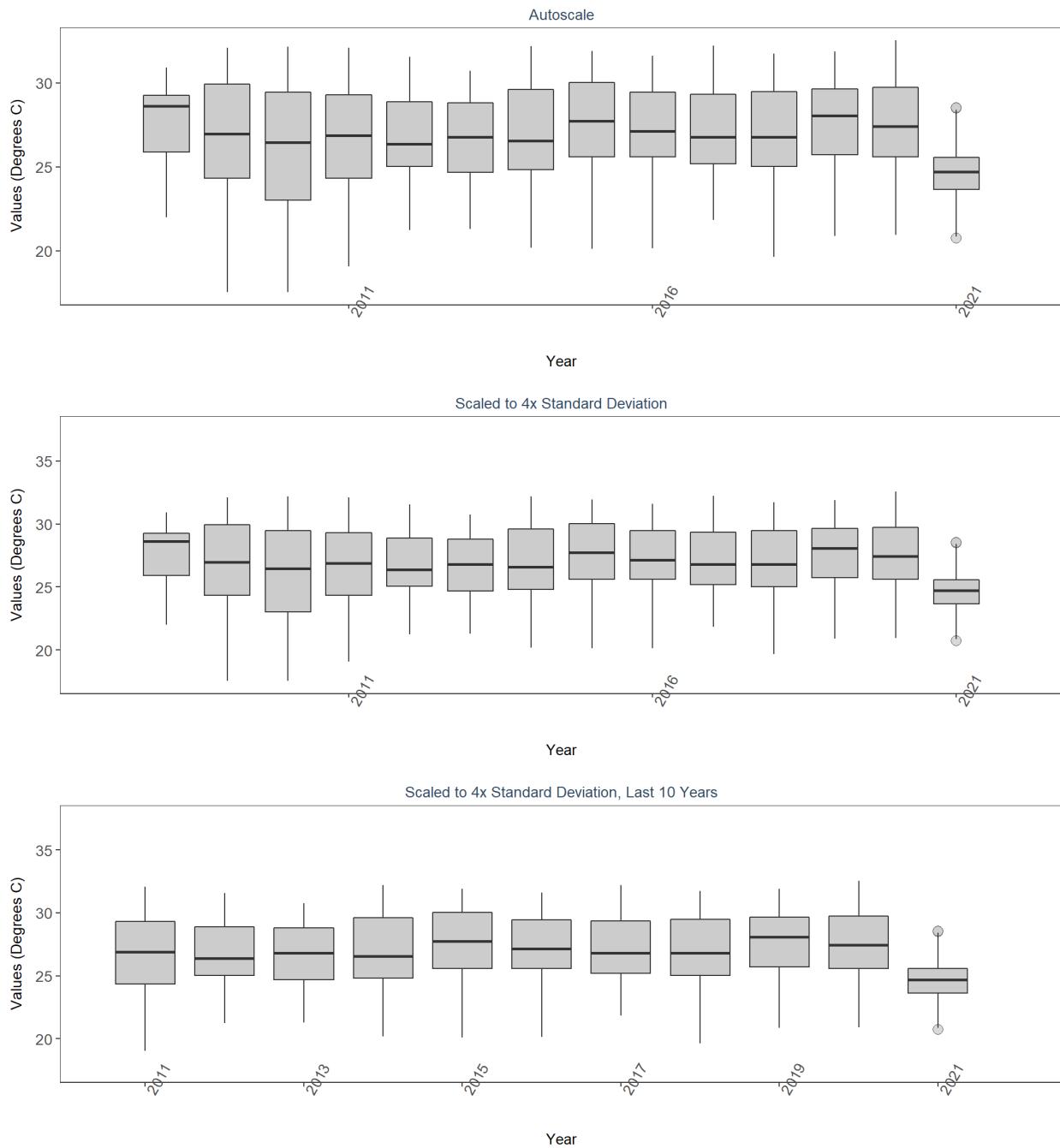
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



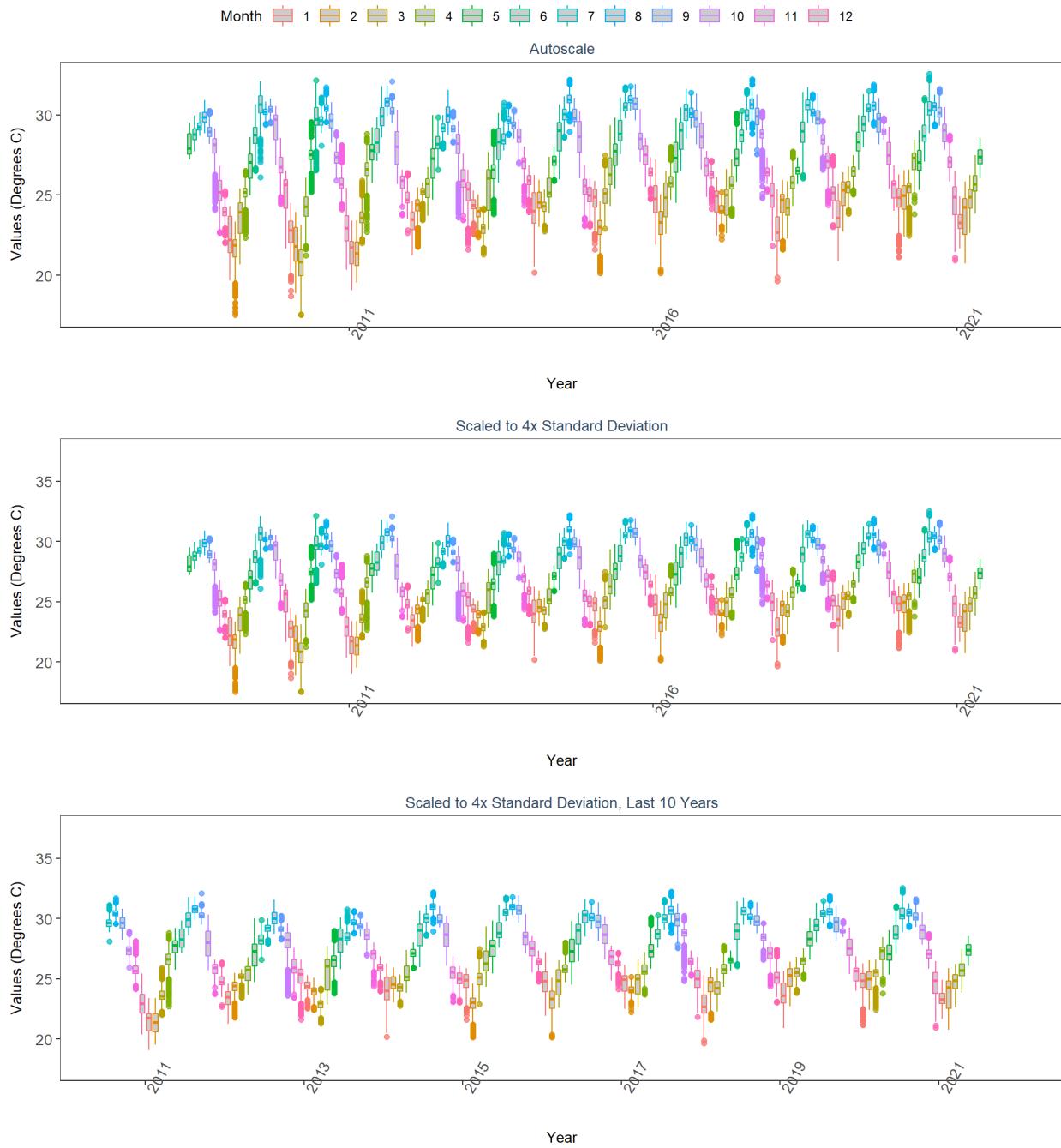
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



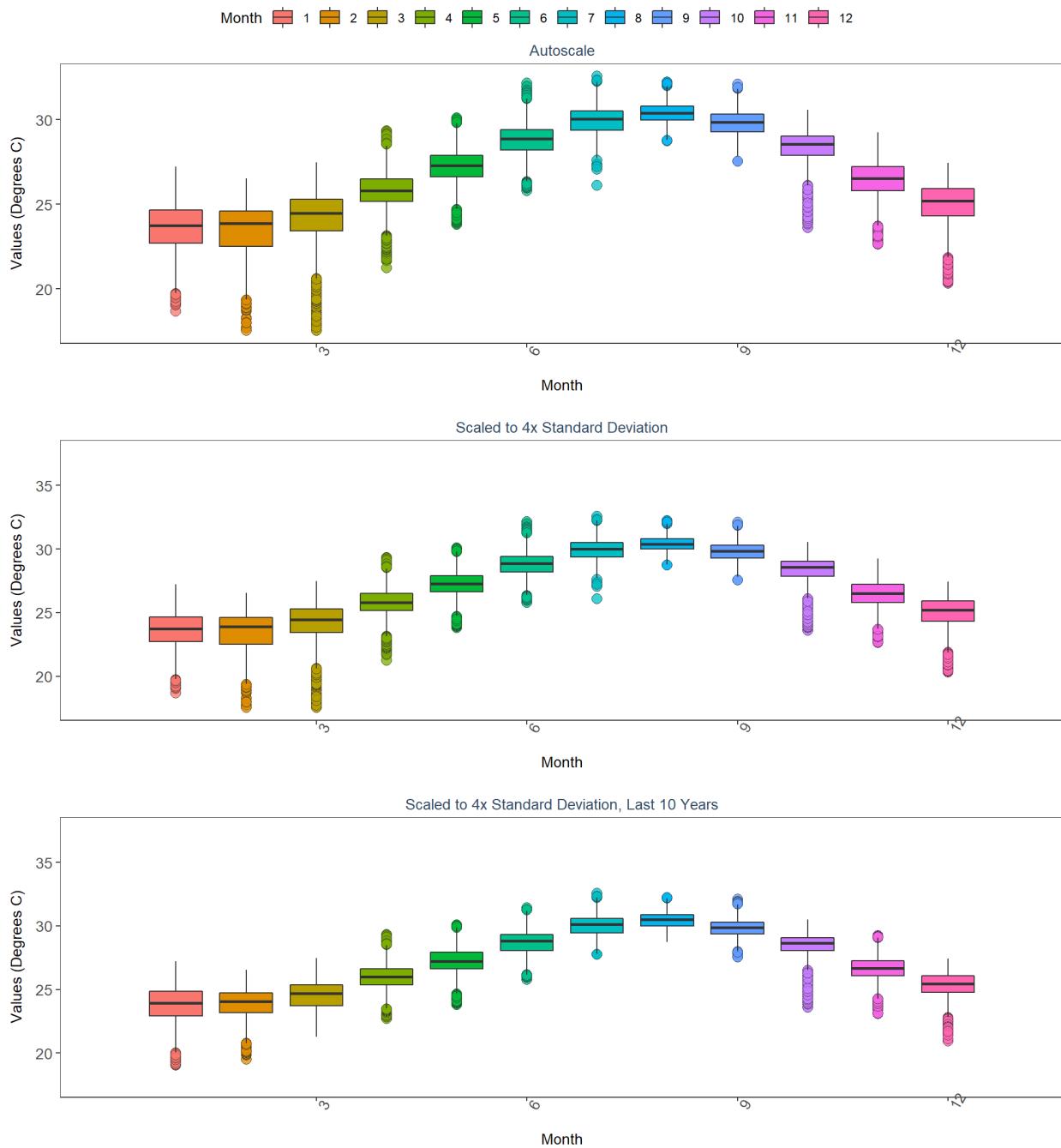
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



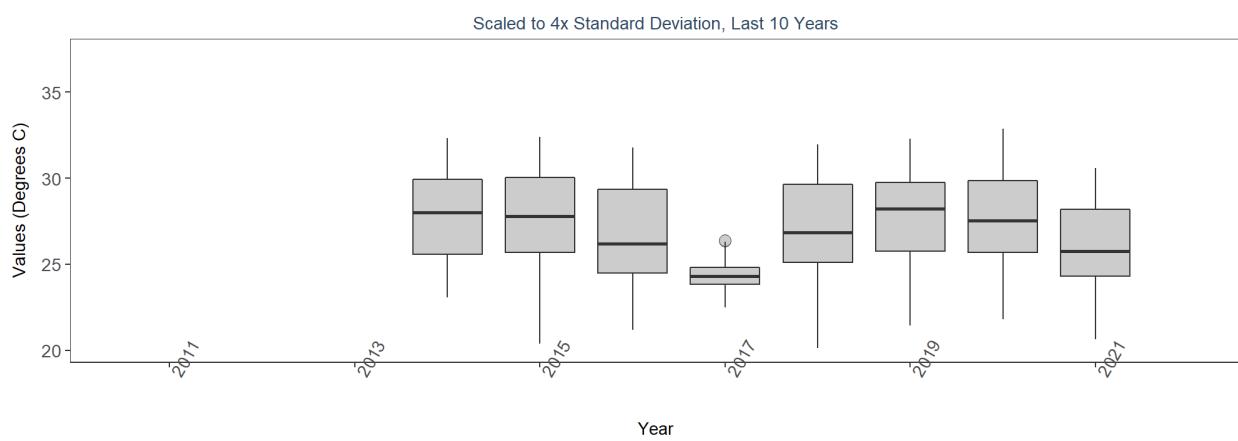
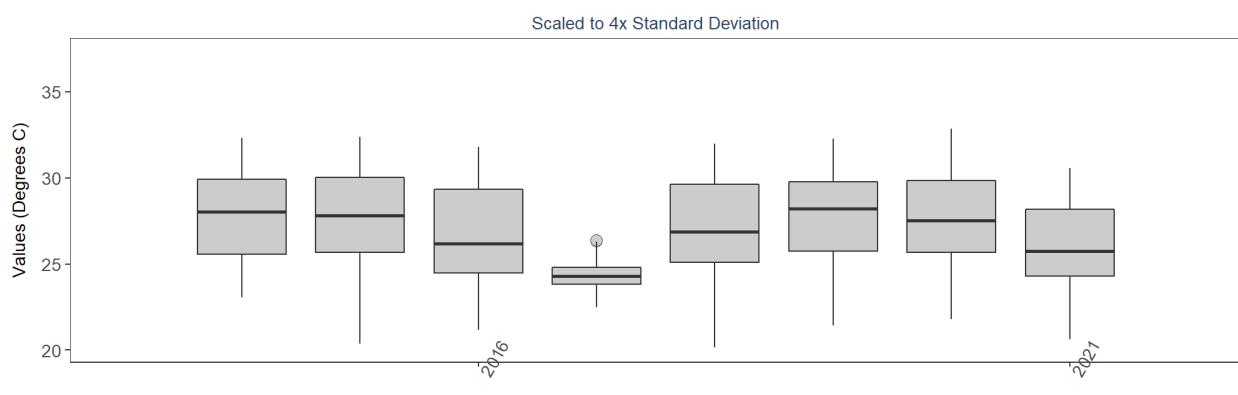
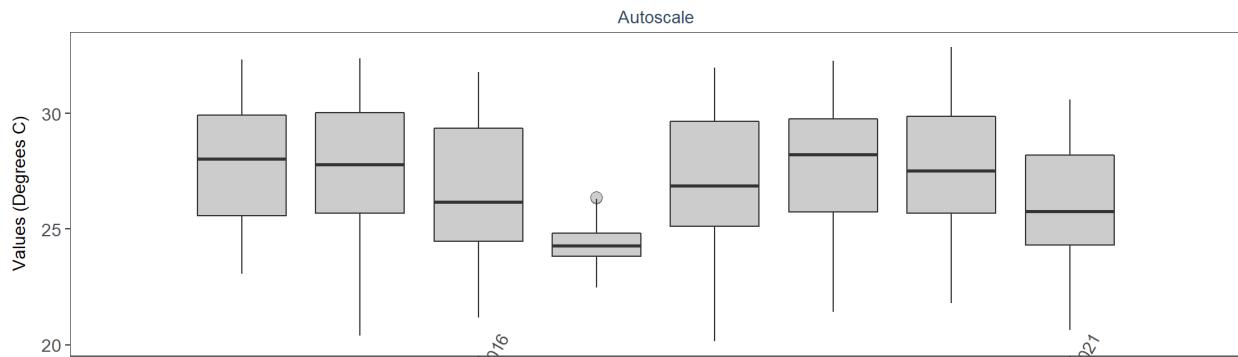
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



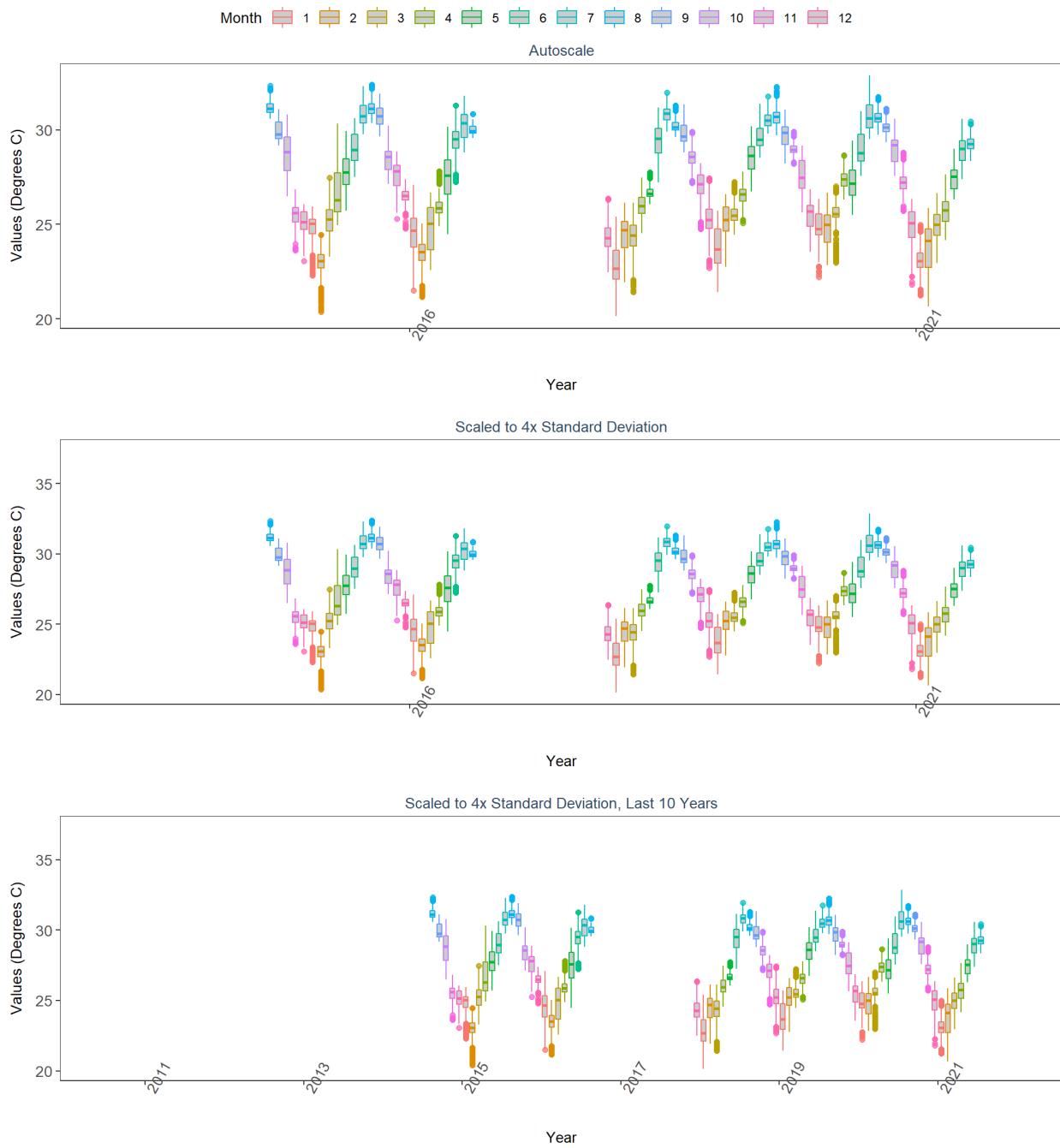
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 Water Temperature on Coral Reefs in the Florida Keys
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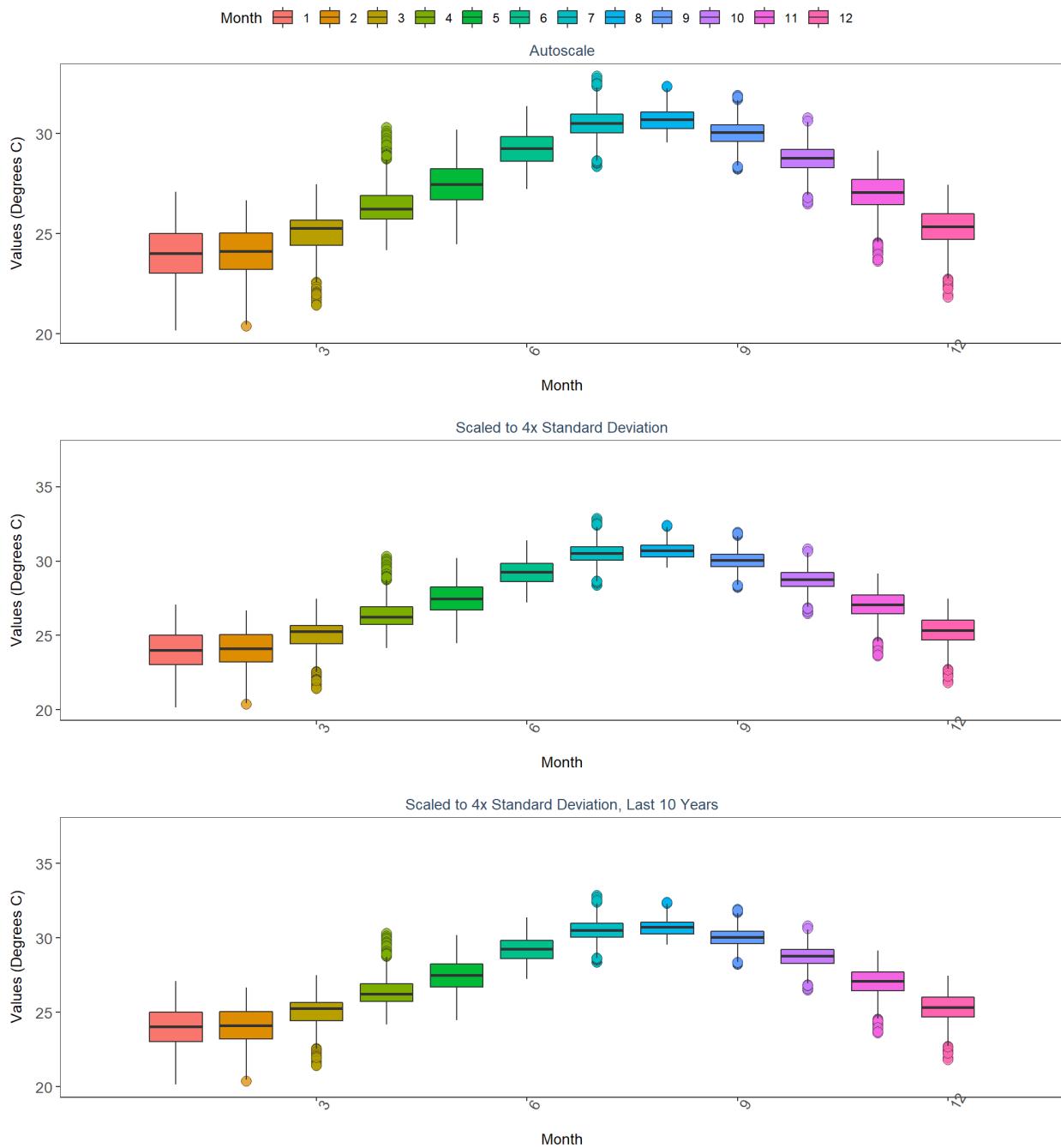
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Water Temperature on Coral Reefs in the Florida Keys
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By Year



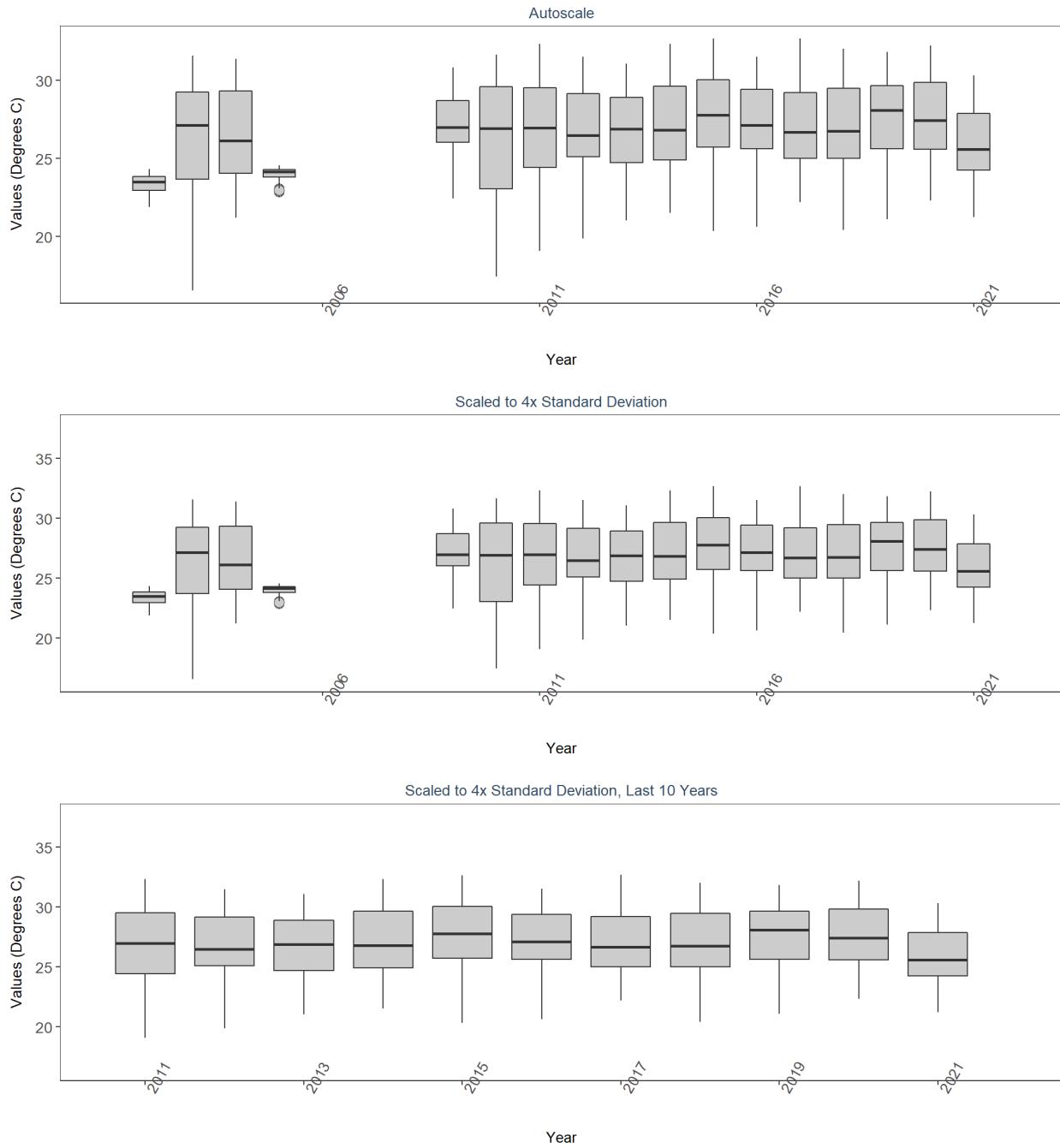
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



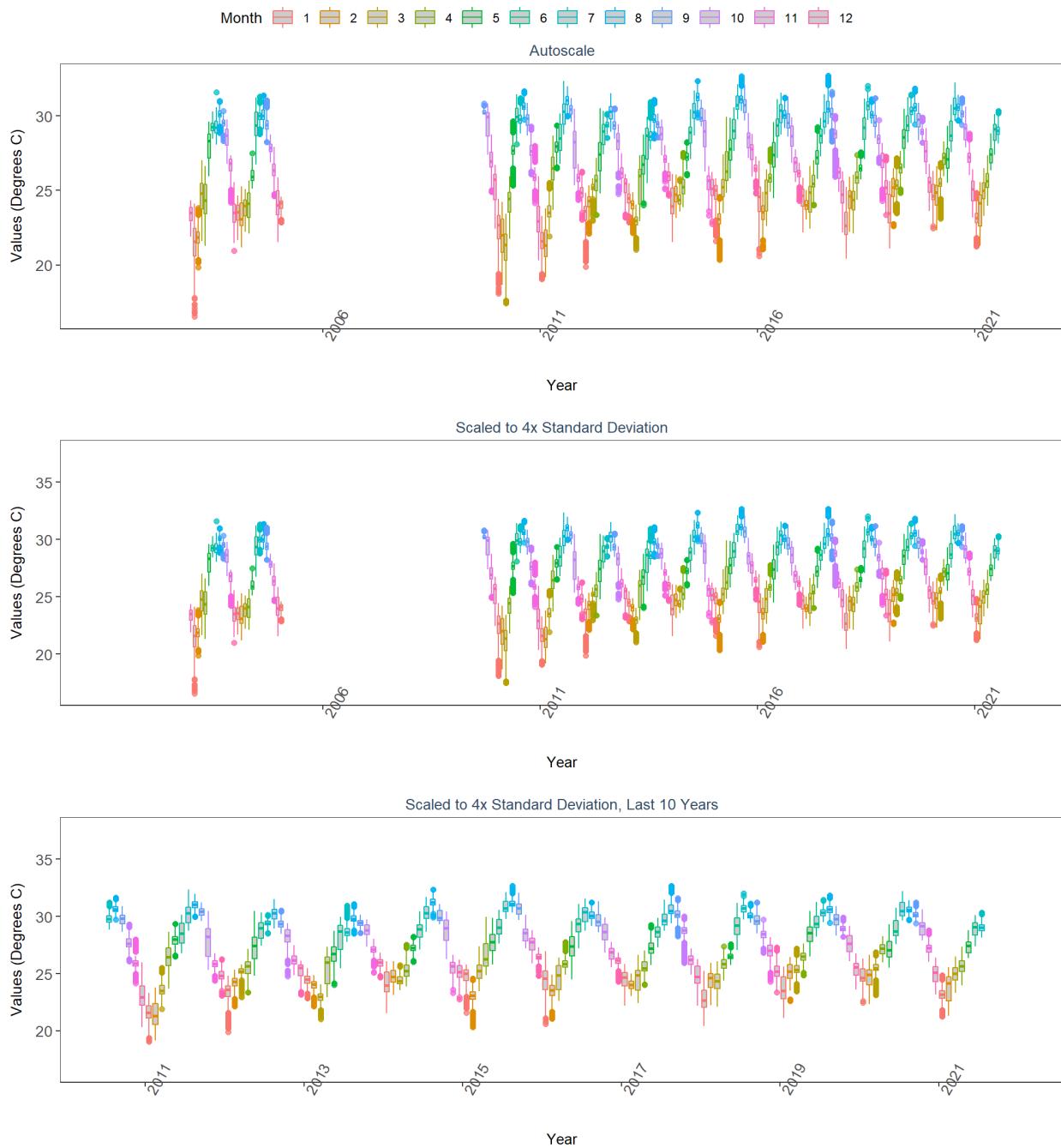
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



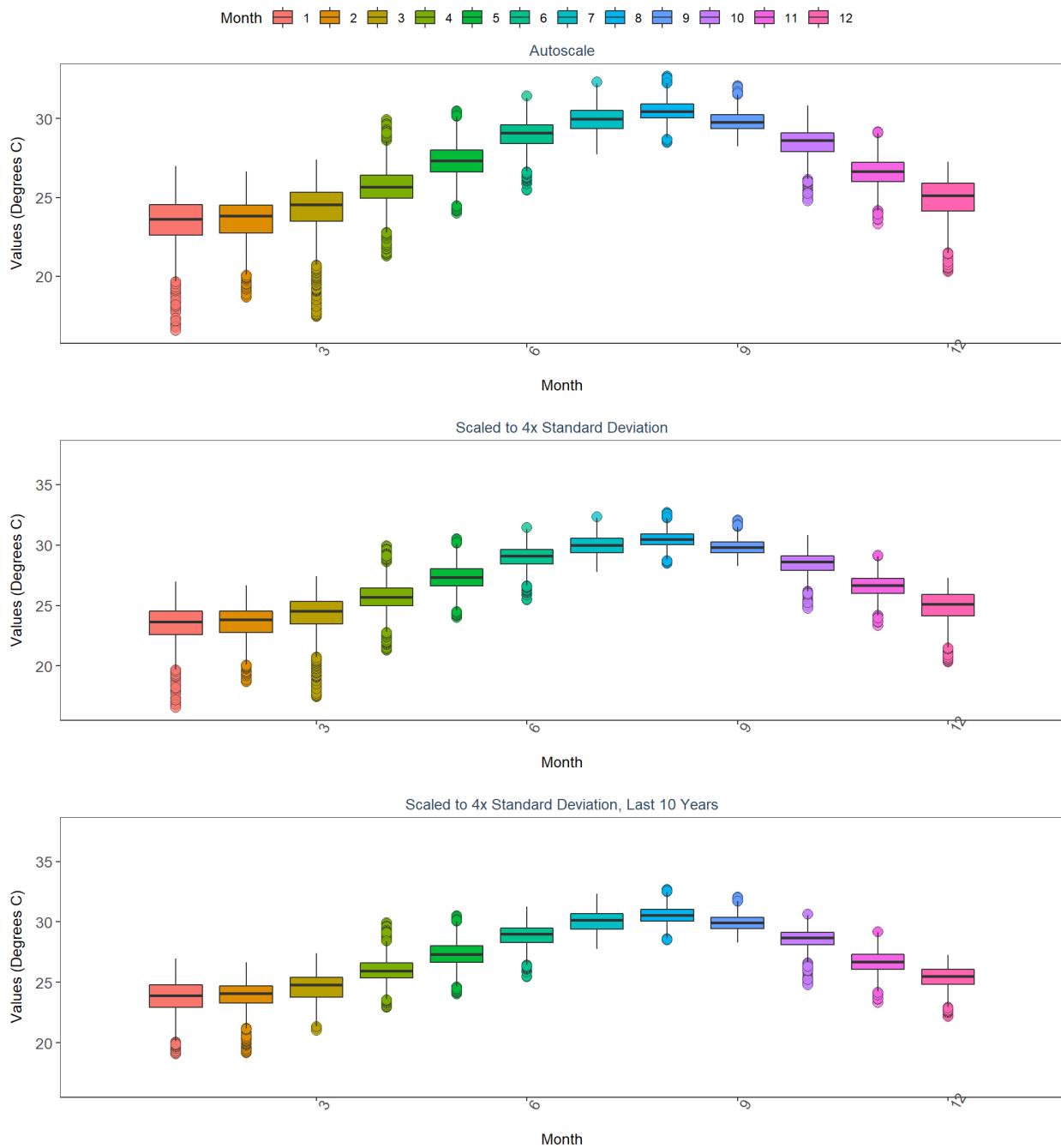
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



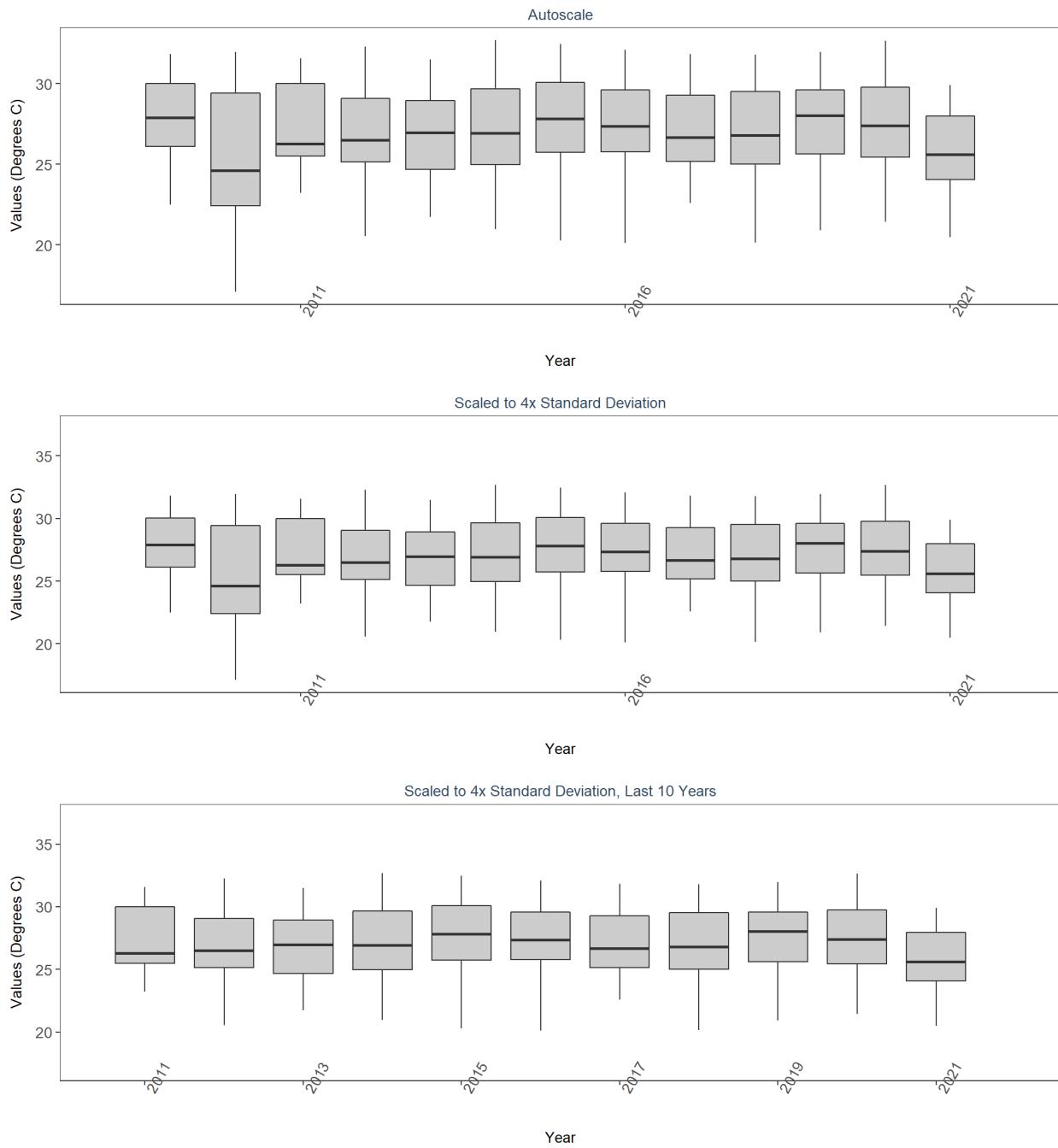
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



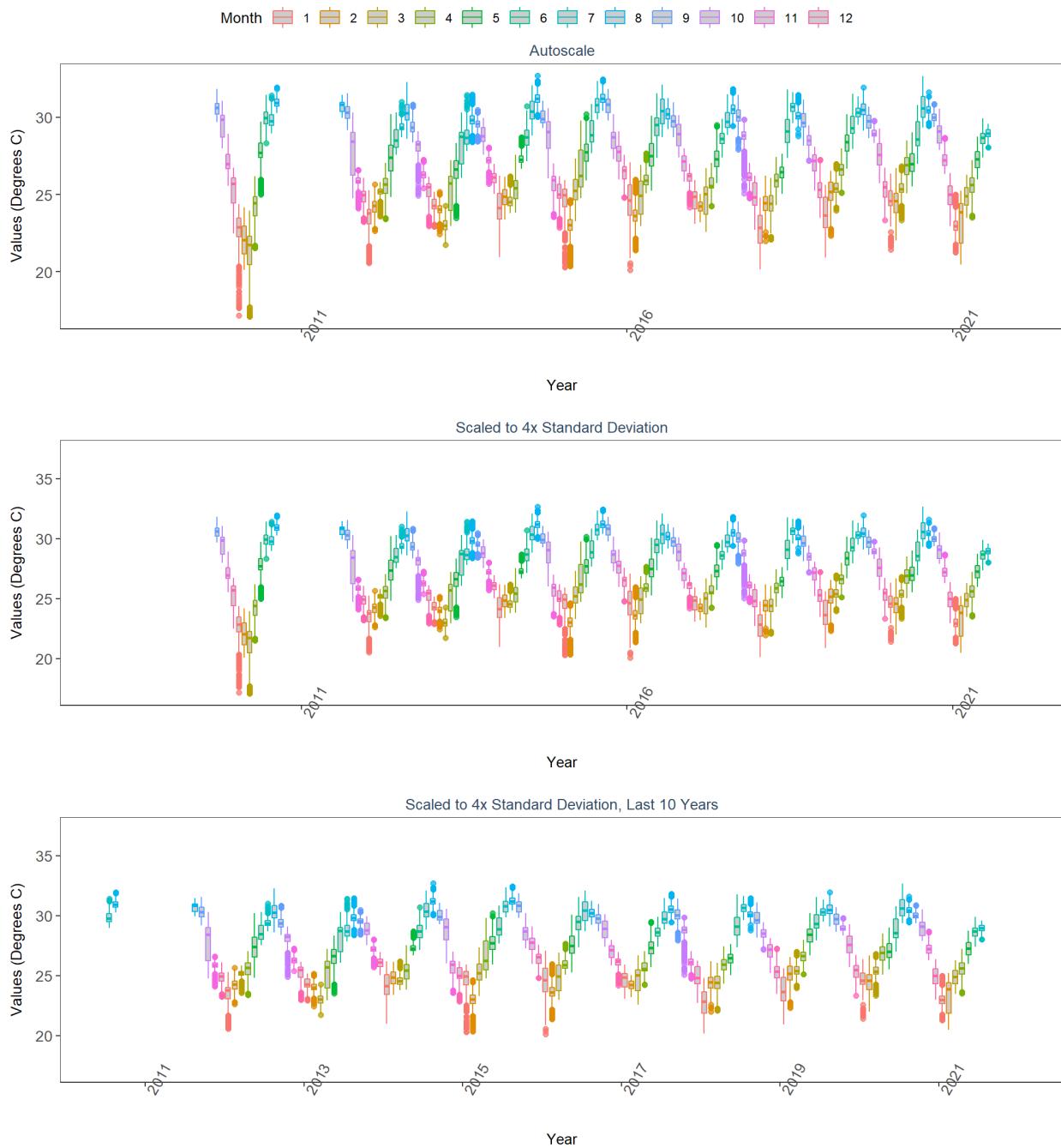
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Month



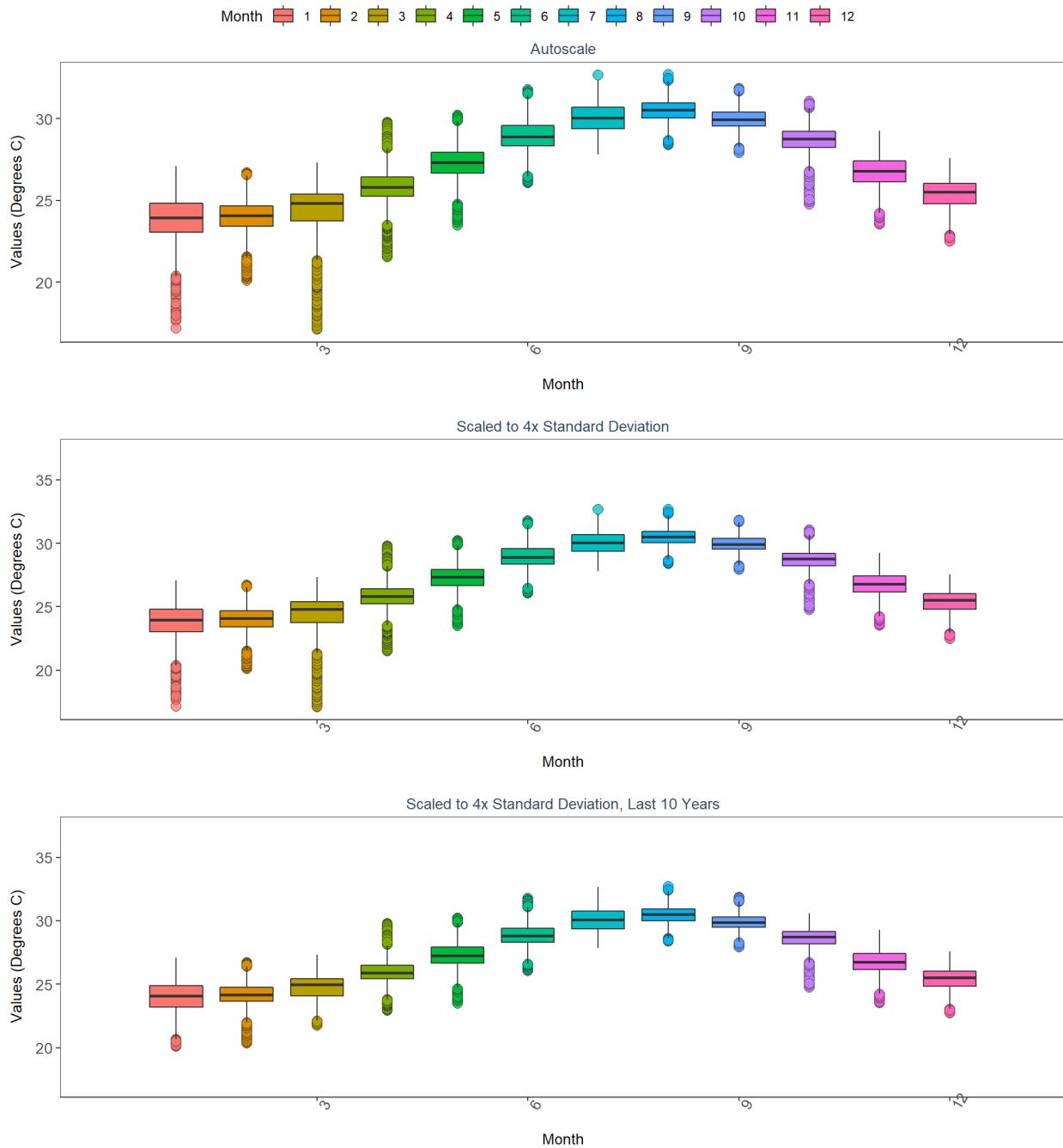
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



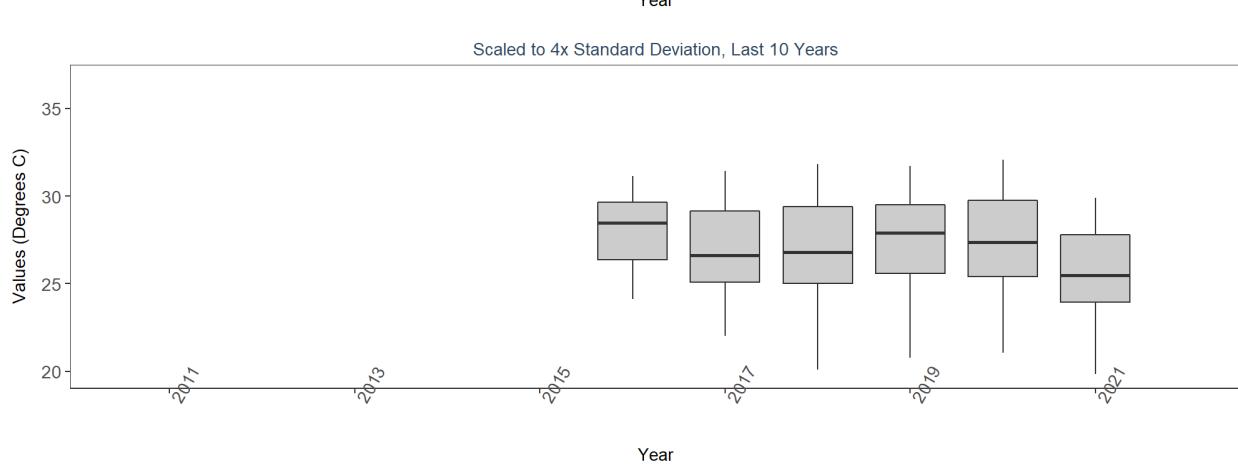
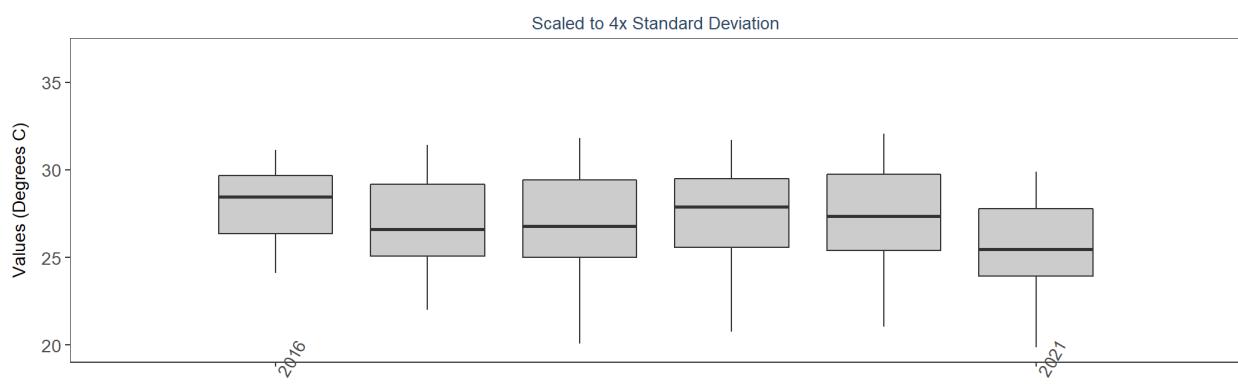
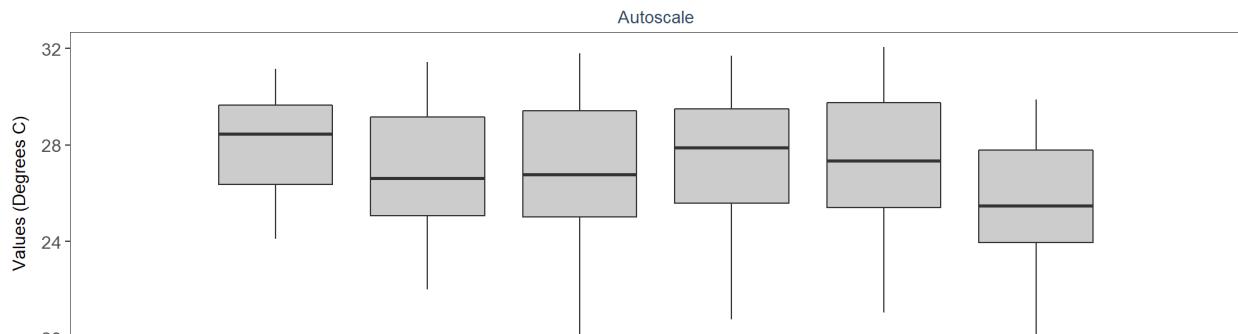
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Water Temperature on Coral Reefs in the Florida Keys
60
By Year & Month



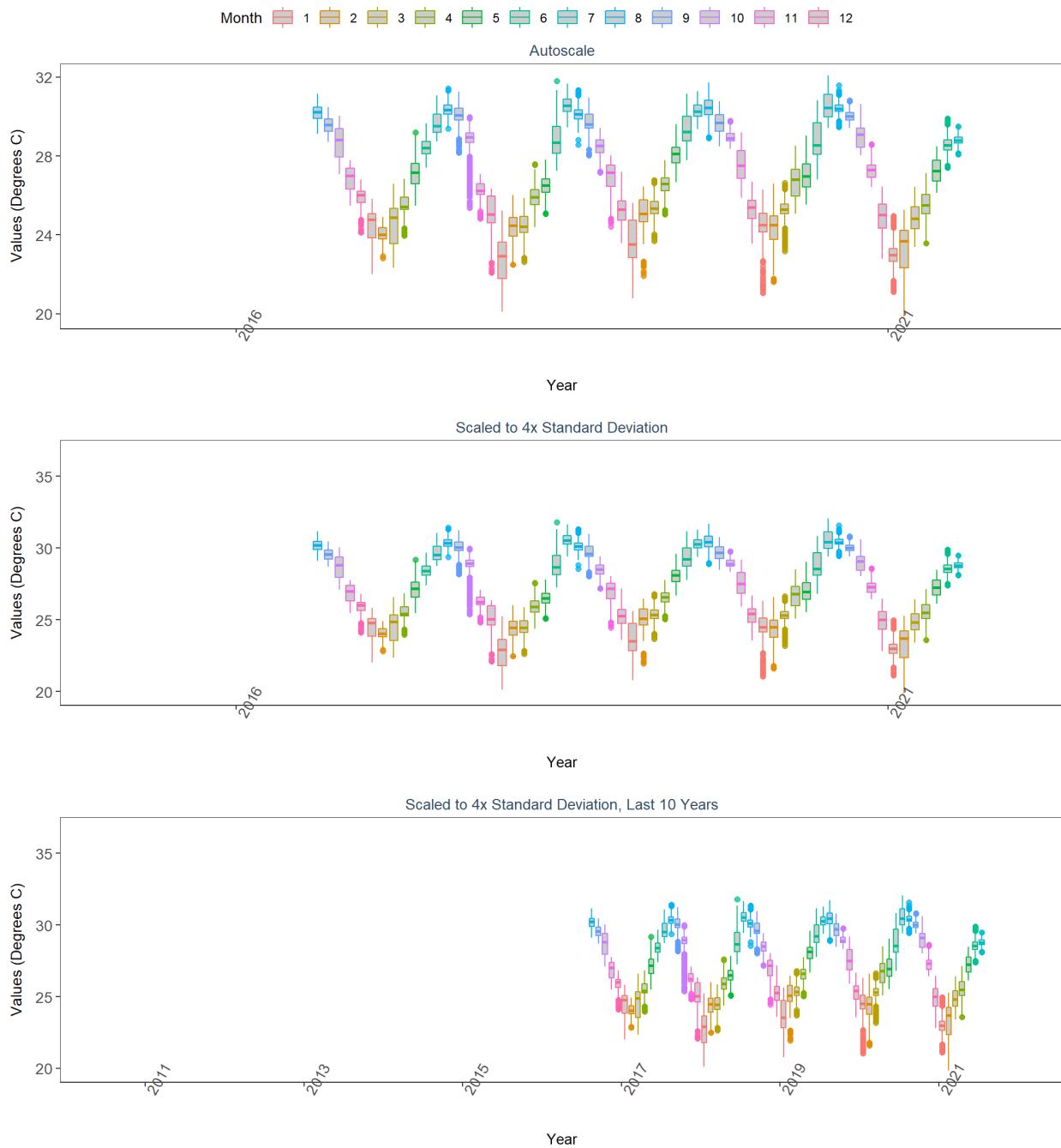
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 Water Temperature on Coral Reefs in the Florida Keys
 60
 By Month



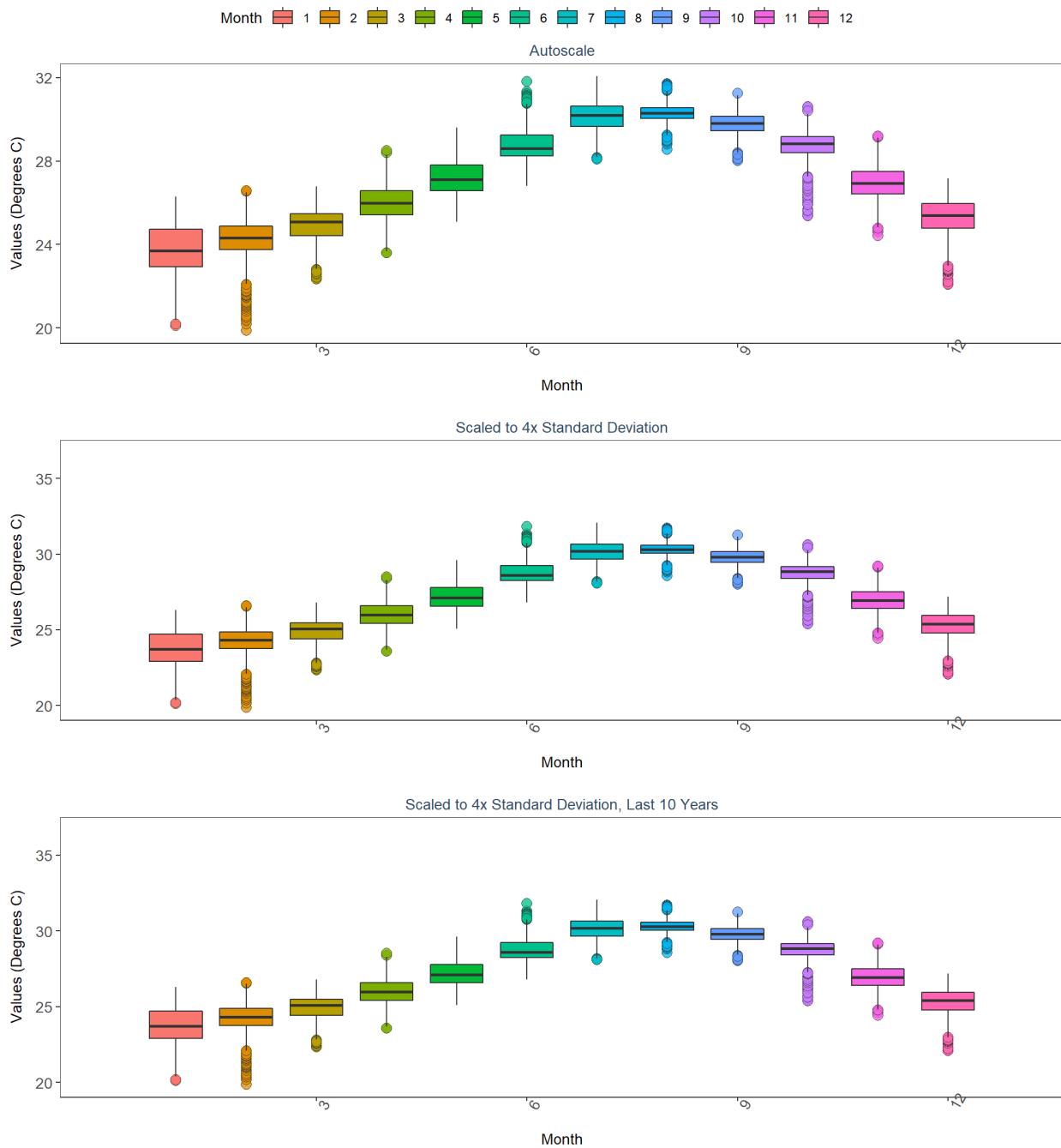
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Water Temperature on Coral Reefs in the Florida Keys
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By Year



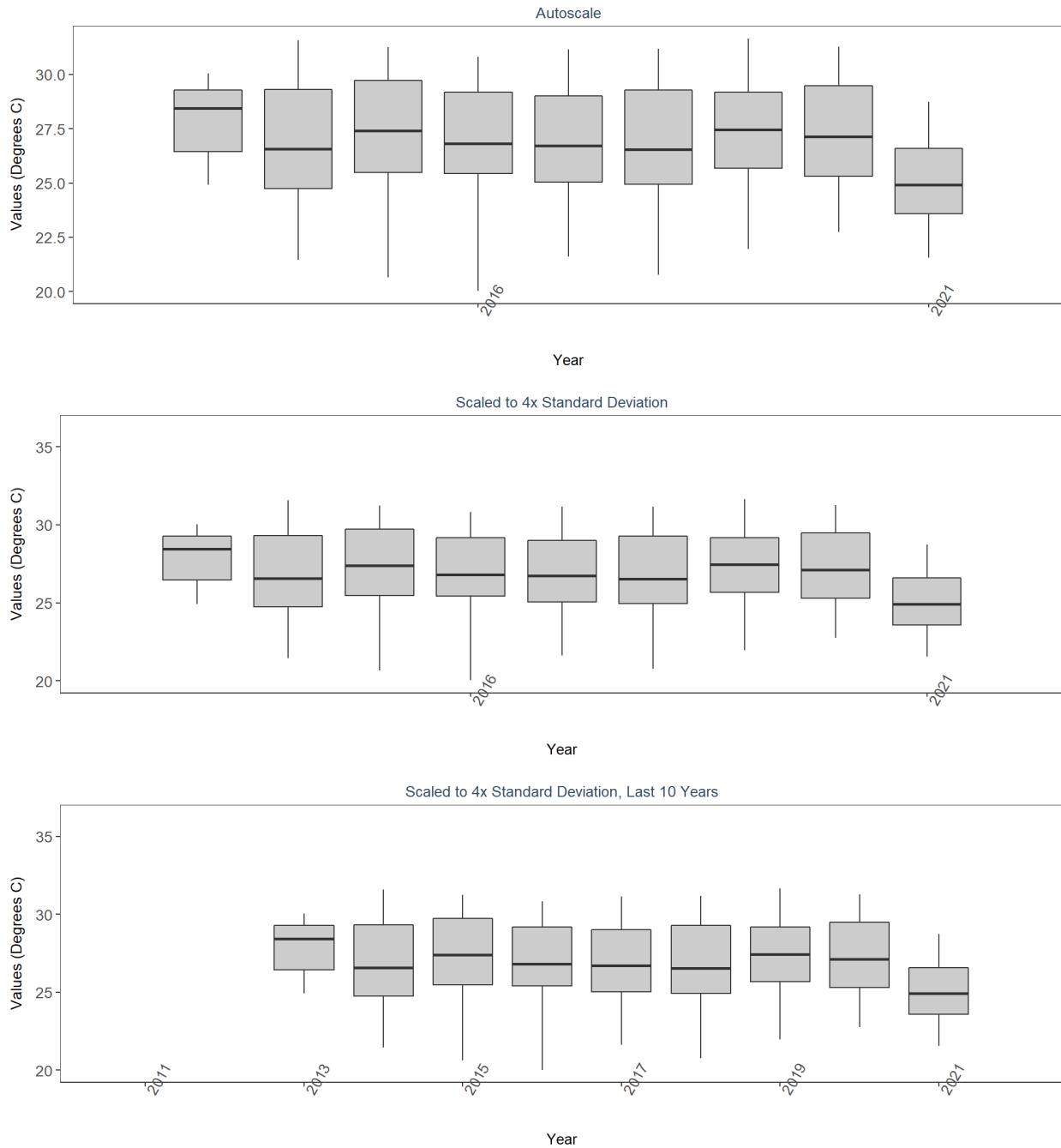
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 Water Temperature on Coral Reefs in the Florida Keys
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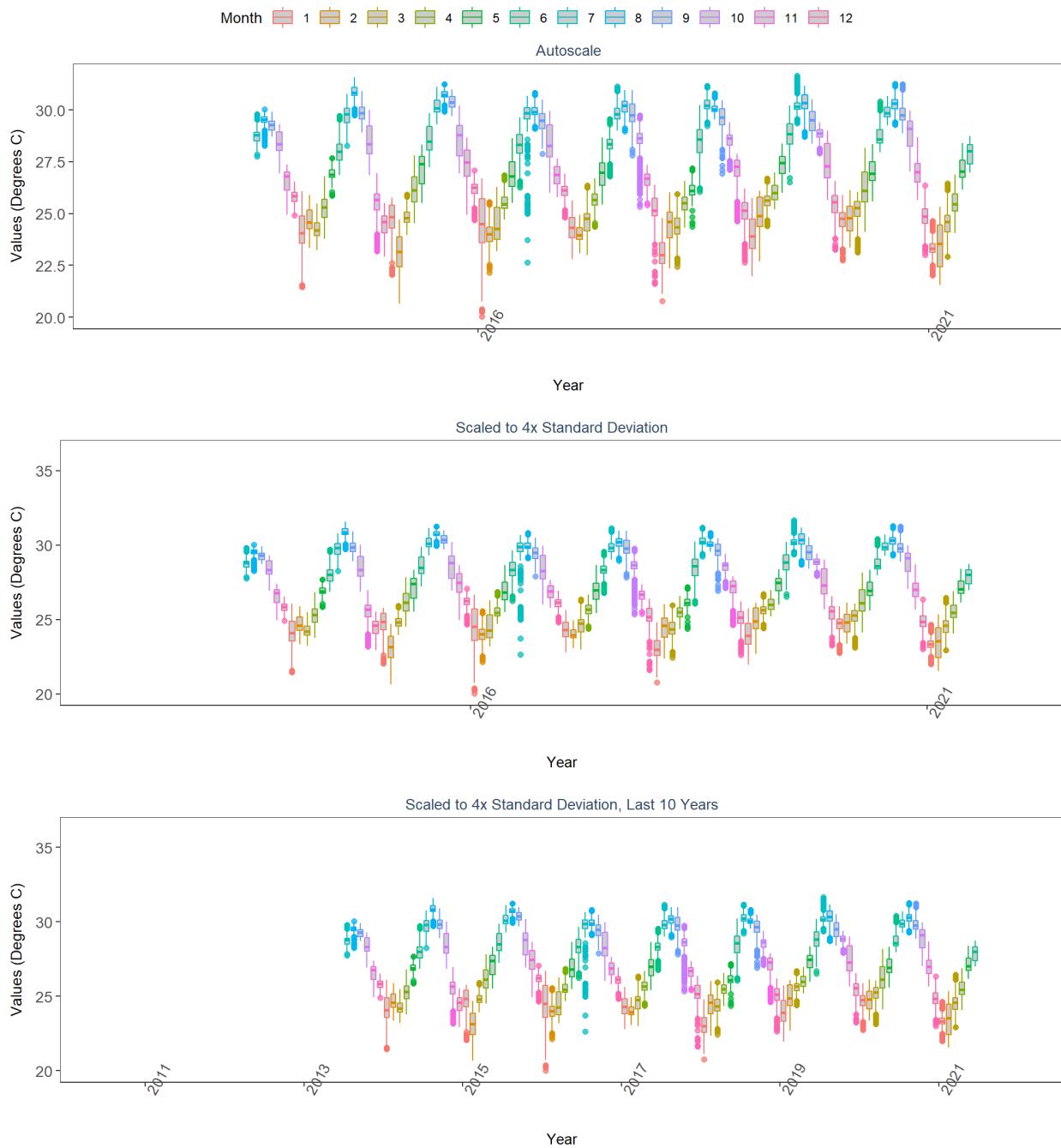
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 Water Temperature on Coral Reefs in the Florida Keys
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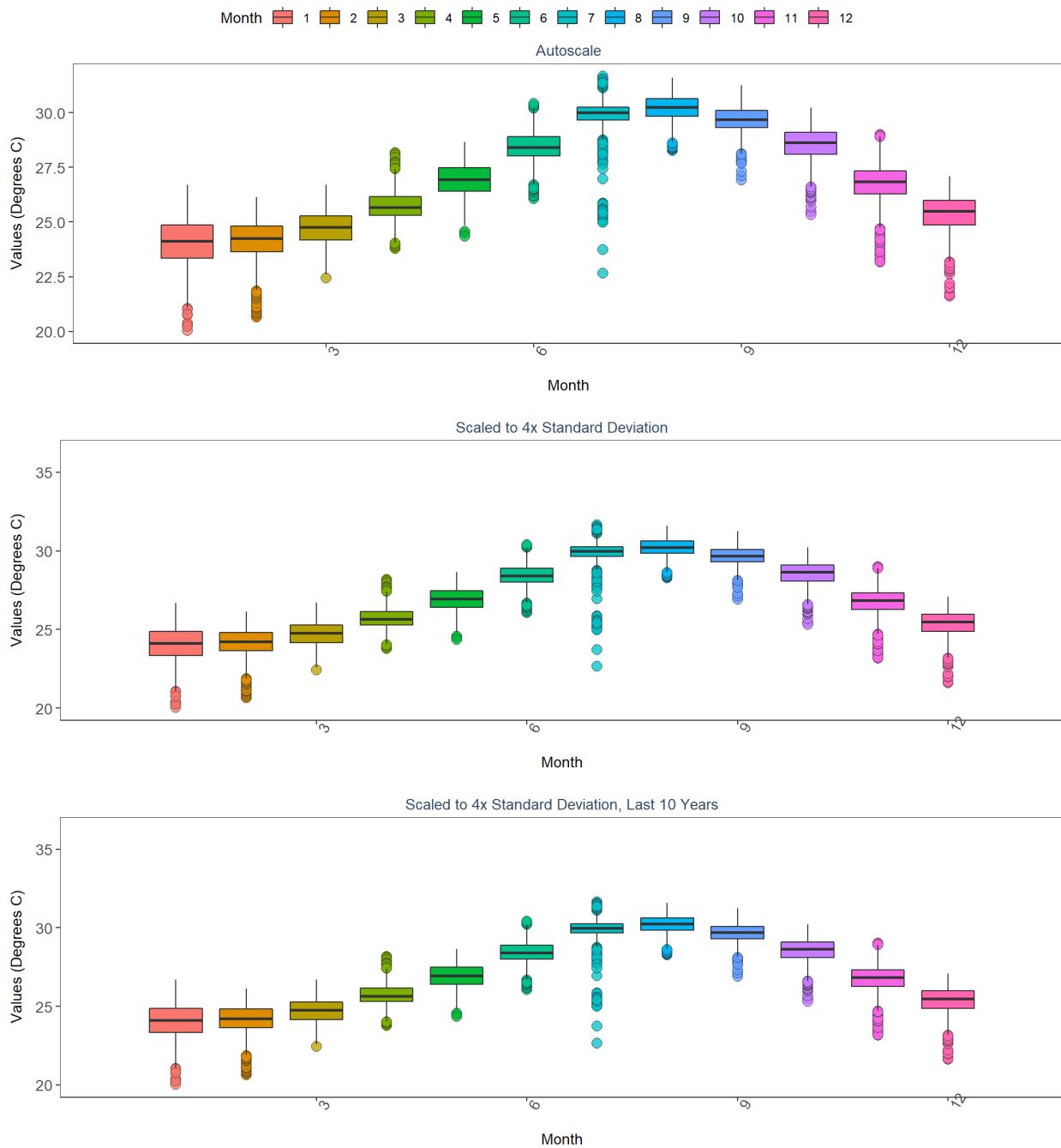
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Water Temperature on Coral Reefs in the Florida Keys
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By Year



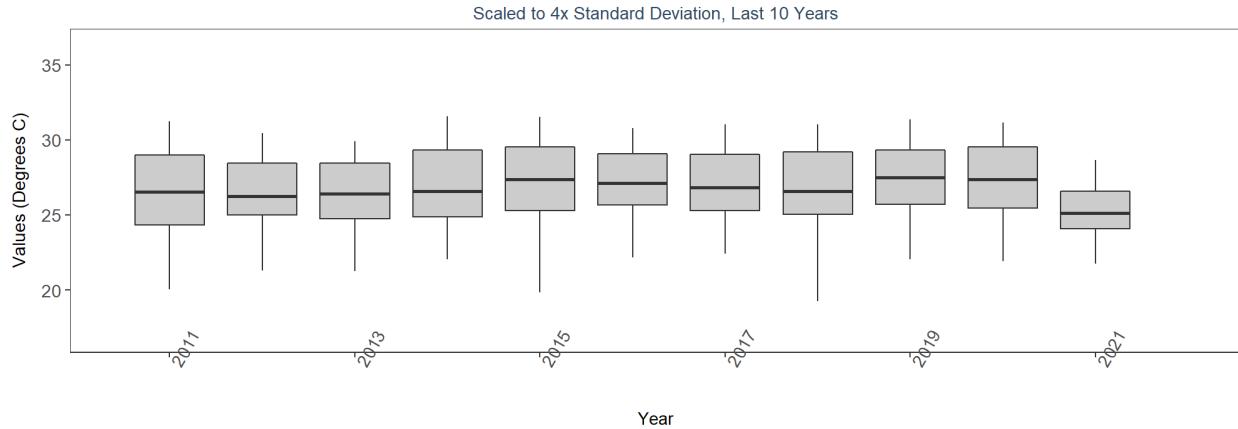
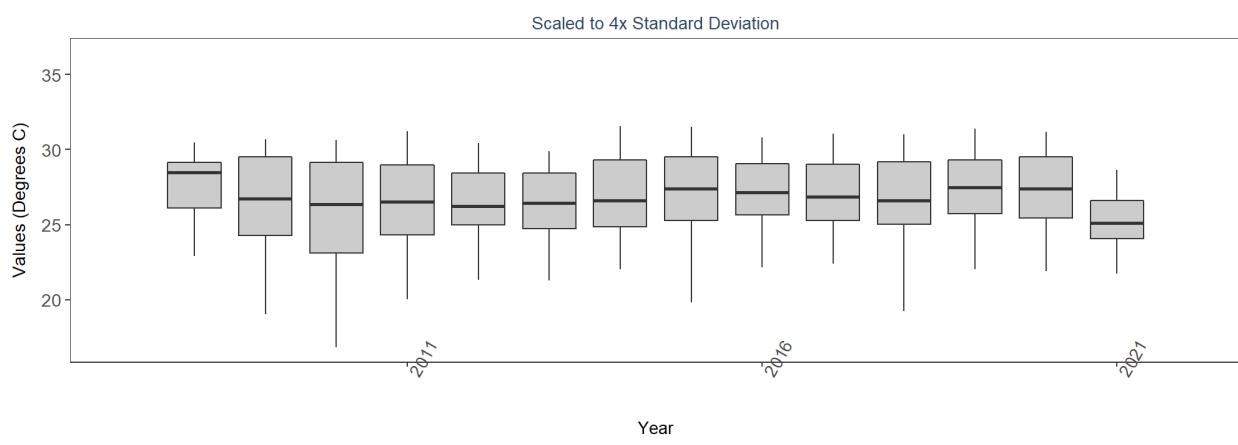
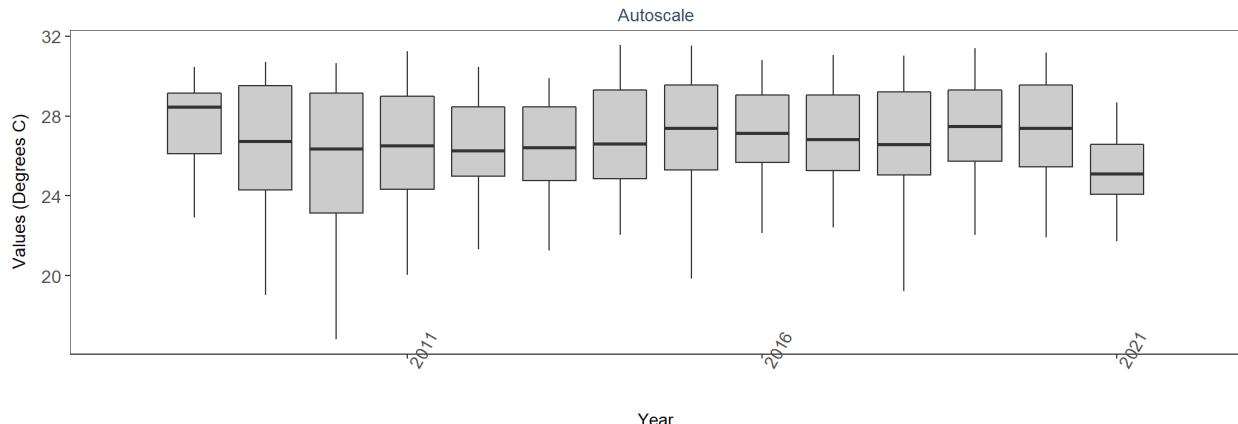
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Water Temperature on Coral Reefs in the Florida Keys
70
By Year & Month



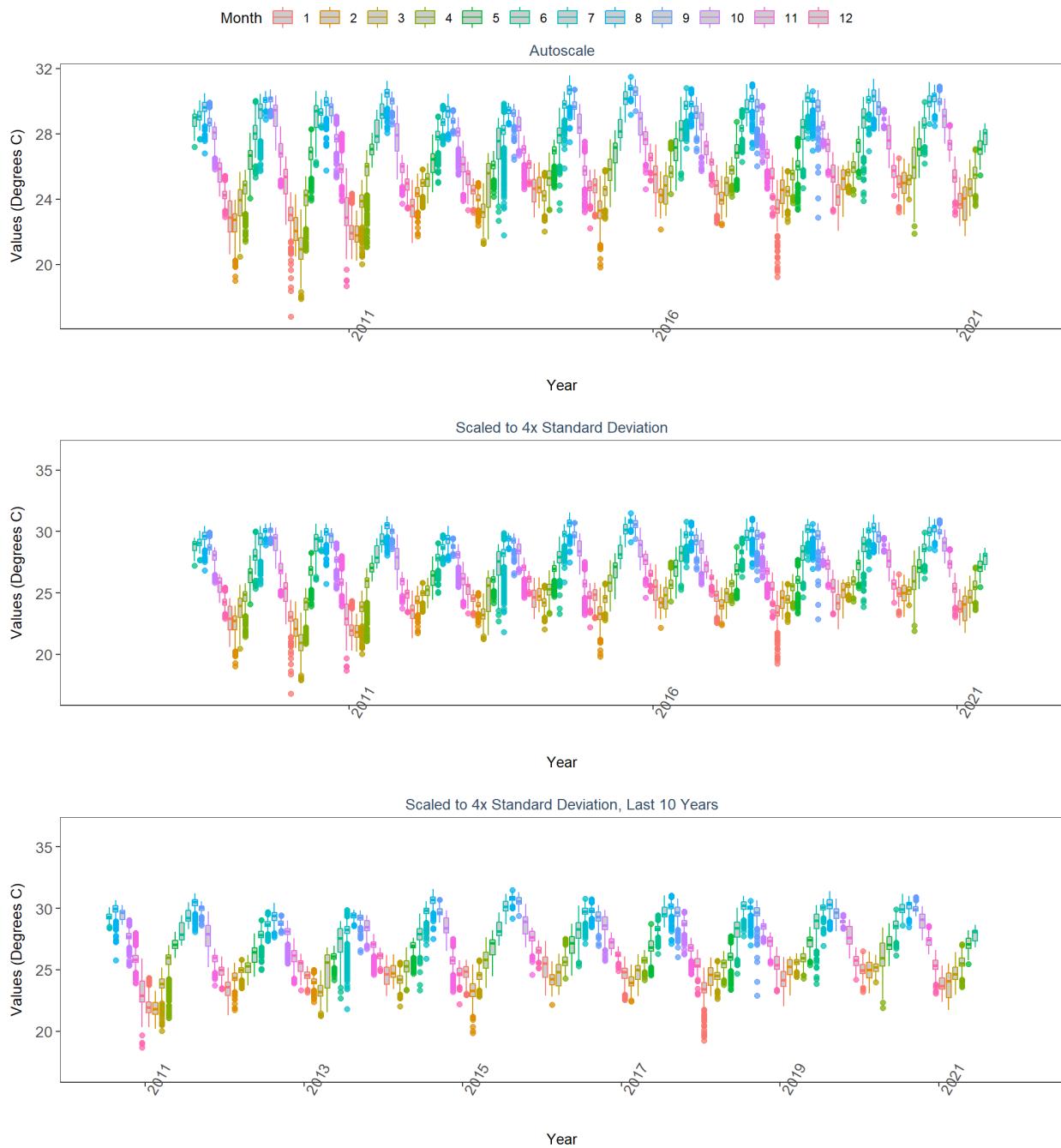
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 Water Temperature on Coral Reefs in the Florida Keys
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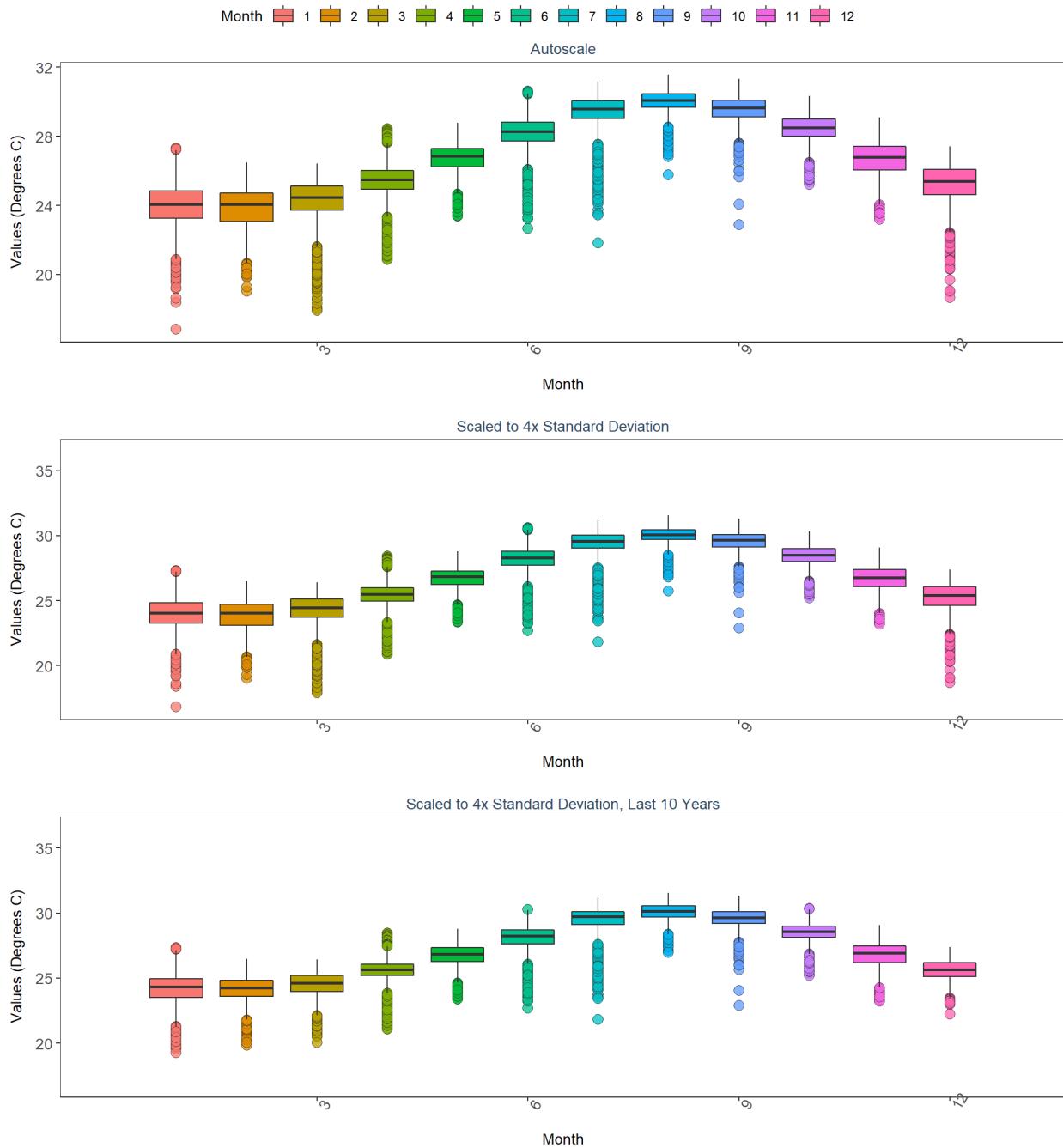
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year



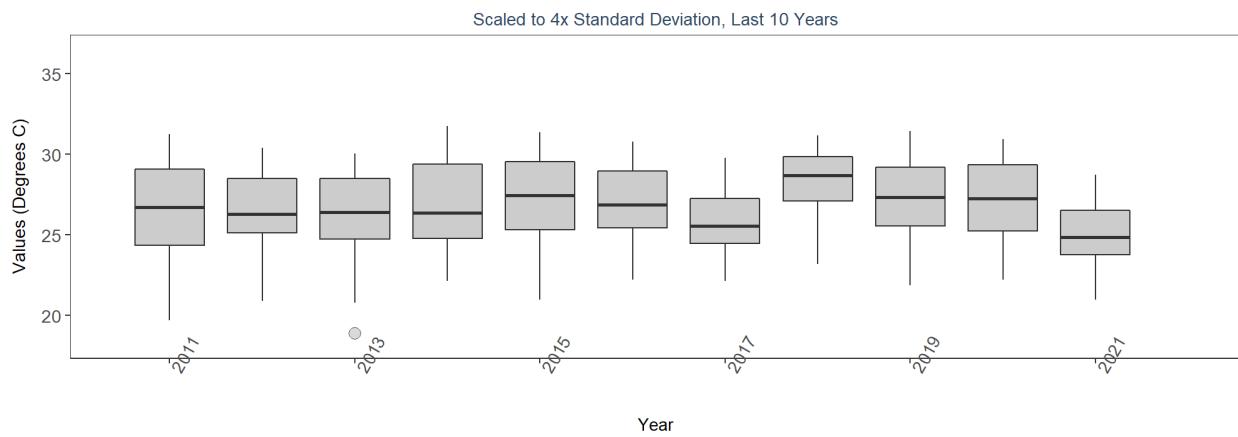
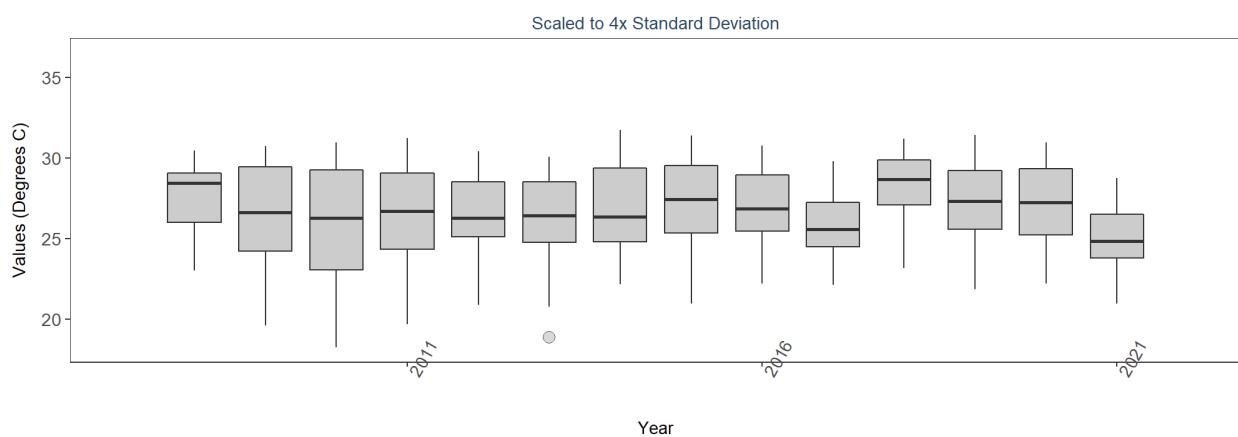
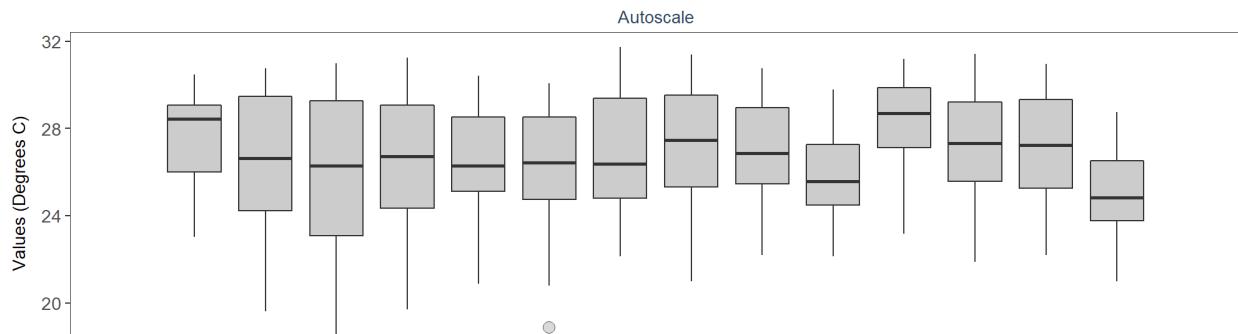
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 Water Temperature on Coral Reefs in the Florida Keys
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 By Year & Month



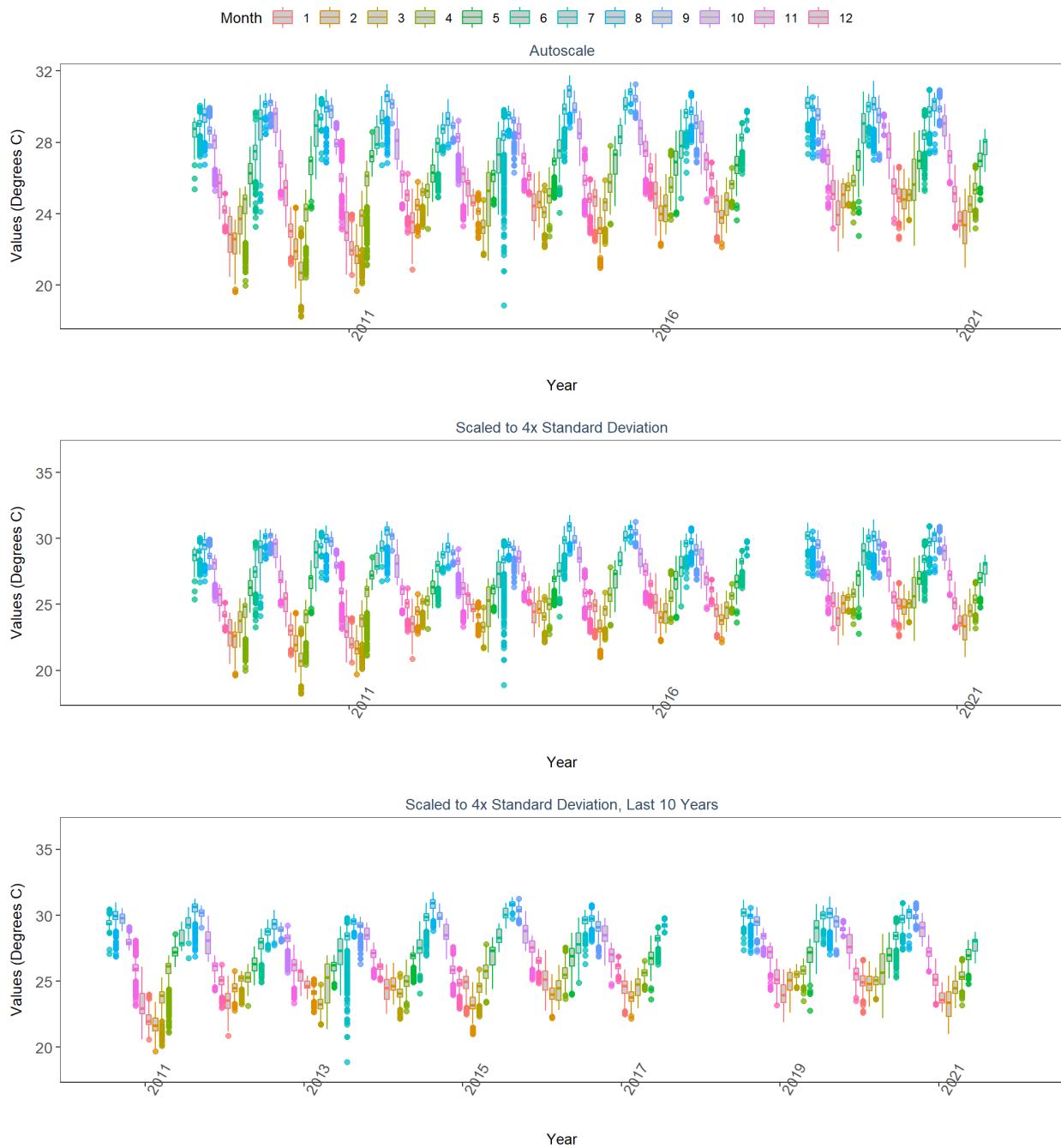
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 Water Temperature on Coral Reefs in the Florida Keys
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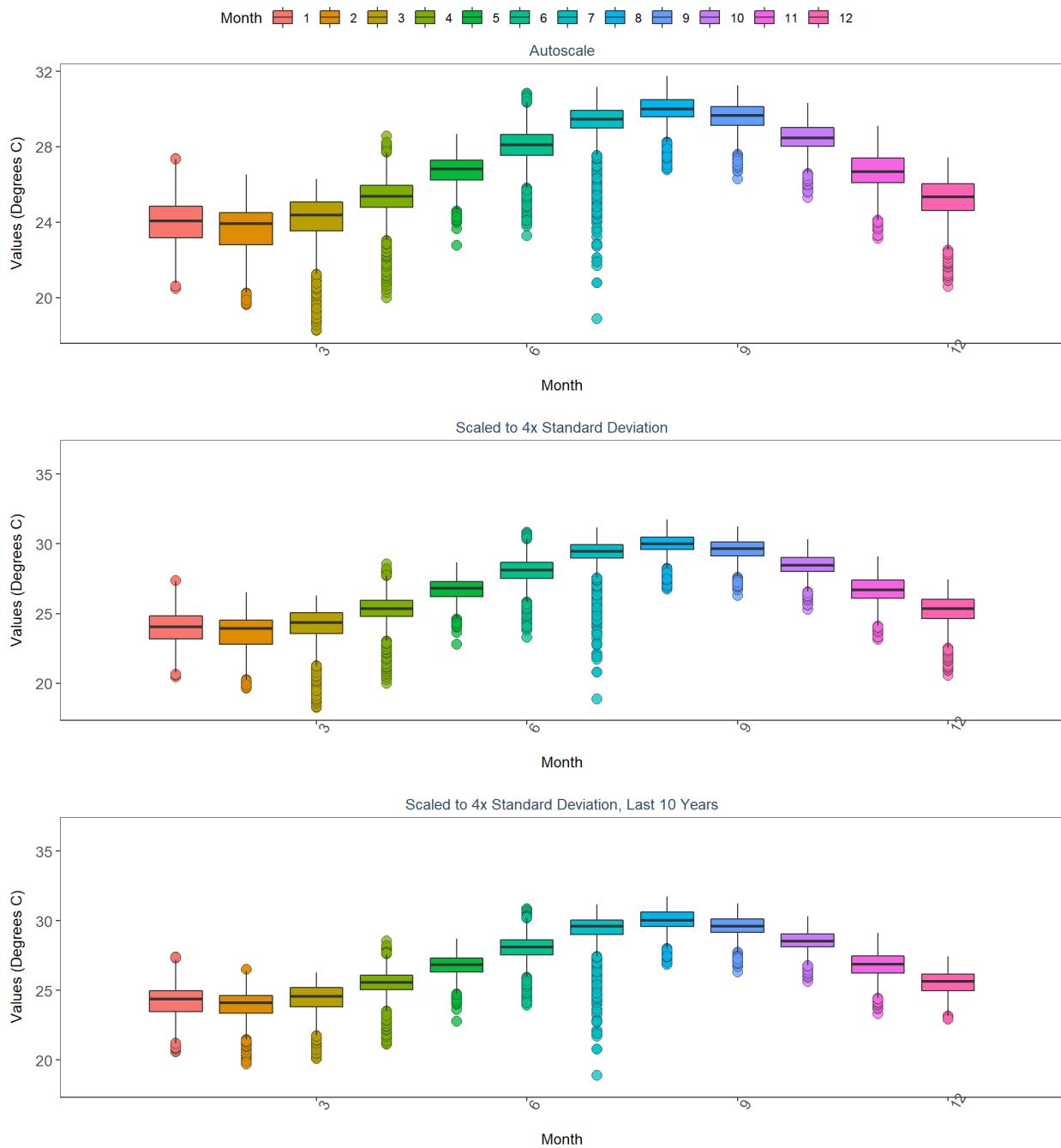
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 Water Temperature on Coral Reefs in the Florida Keys
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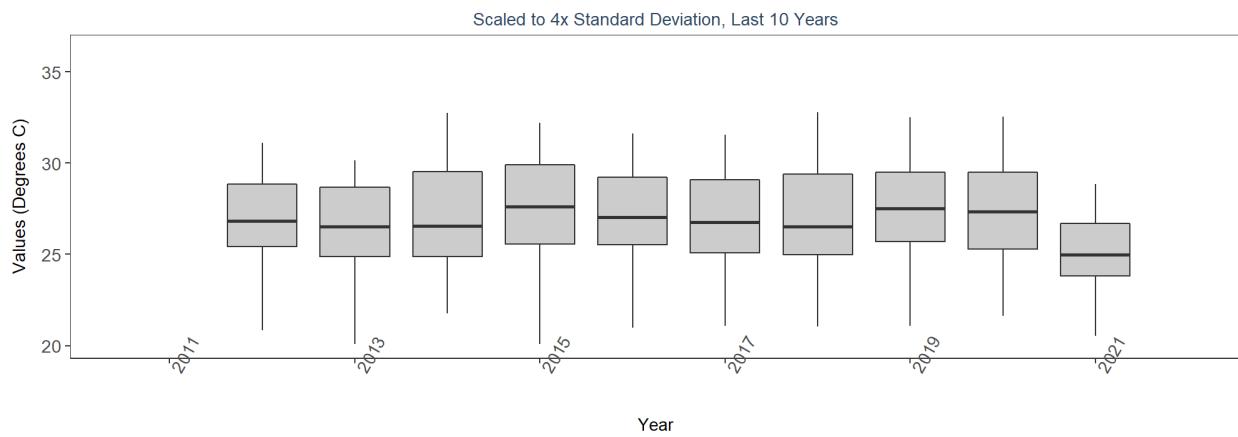
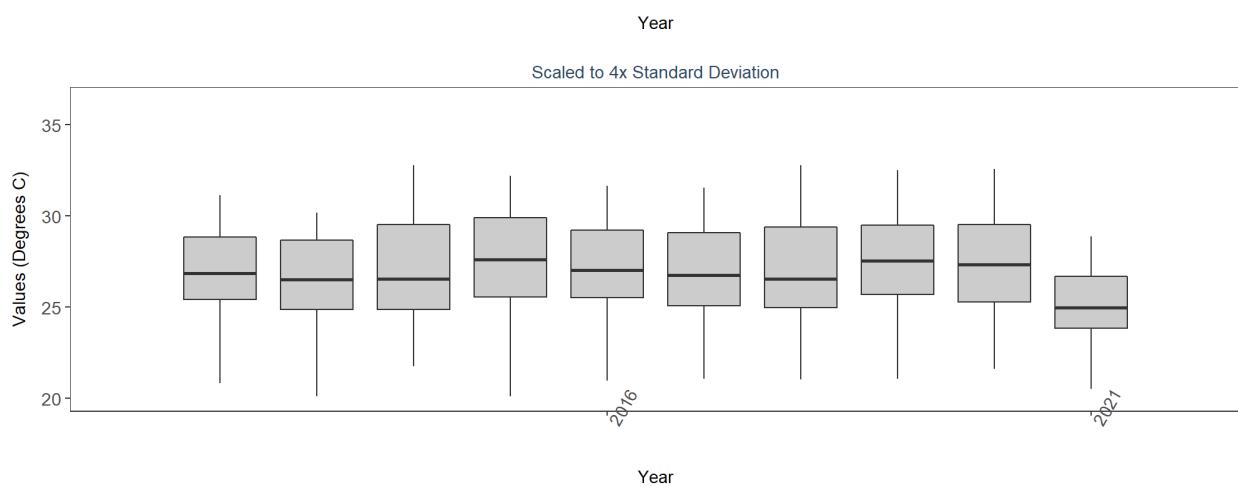
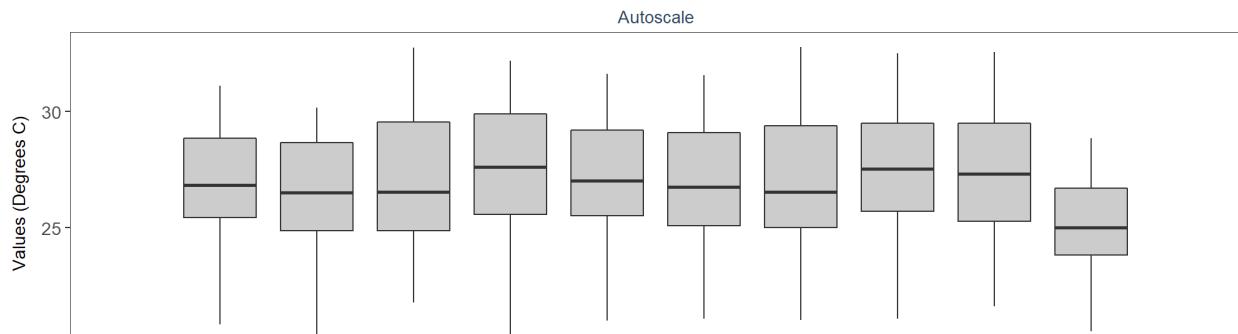
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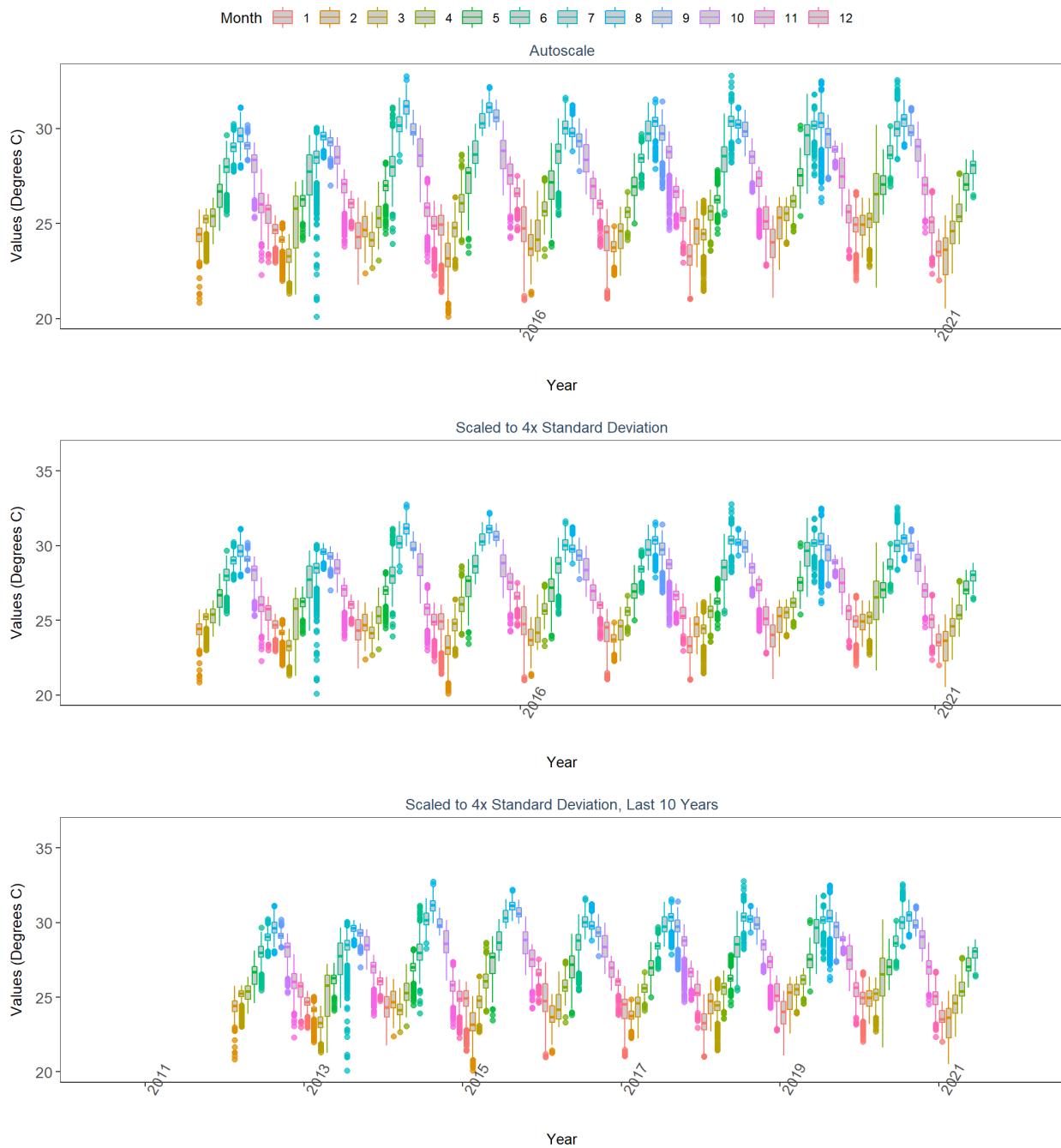
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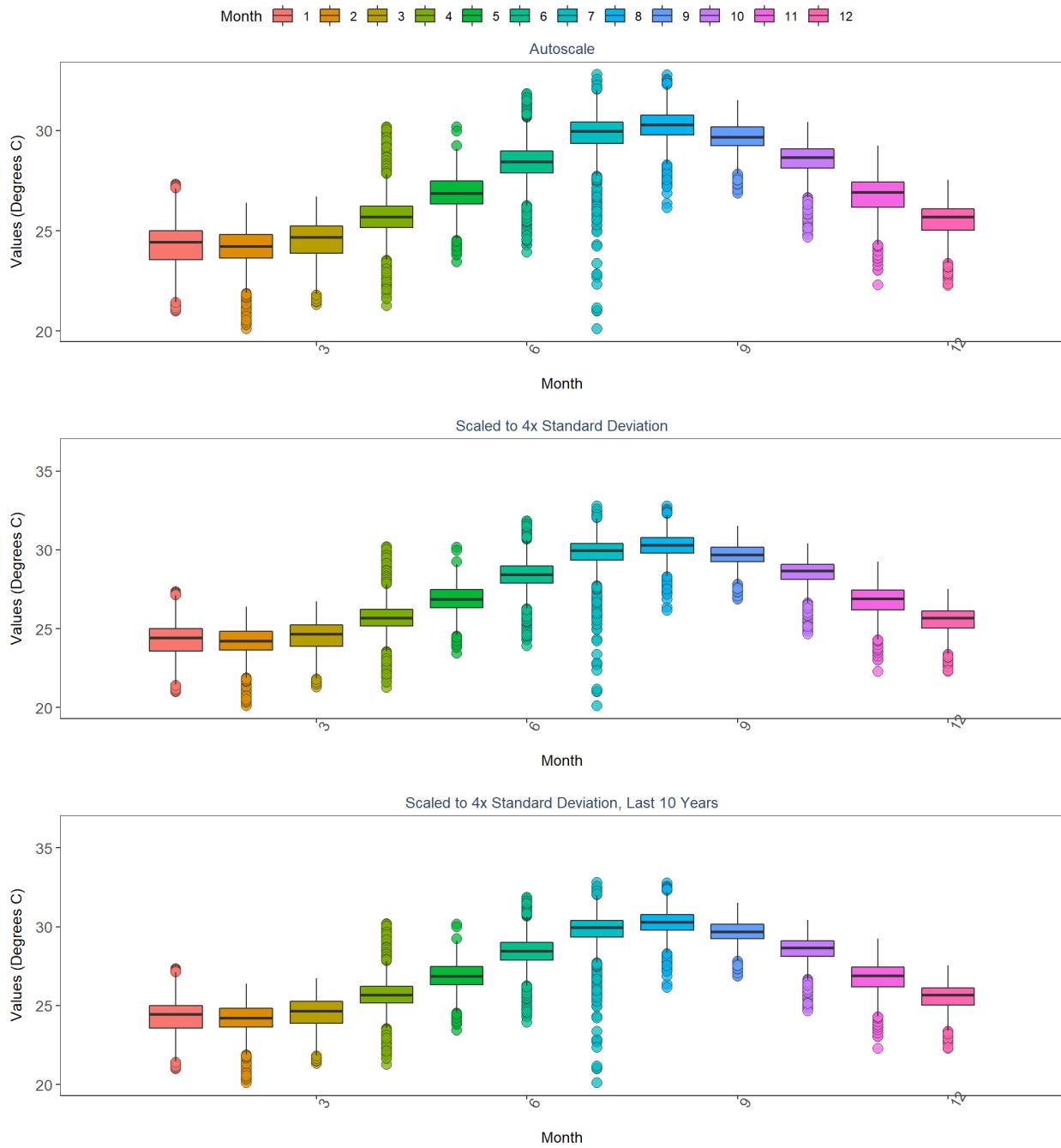
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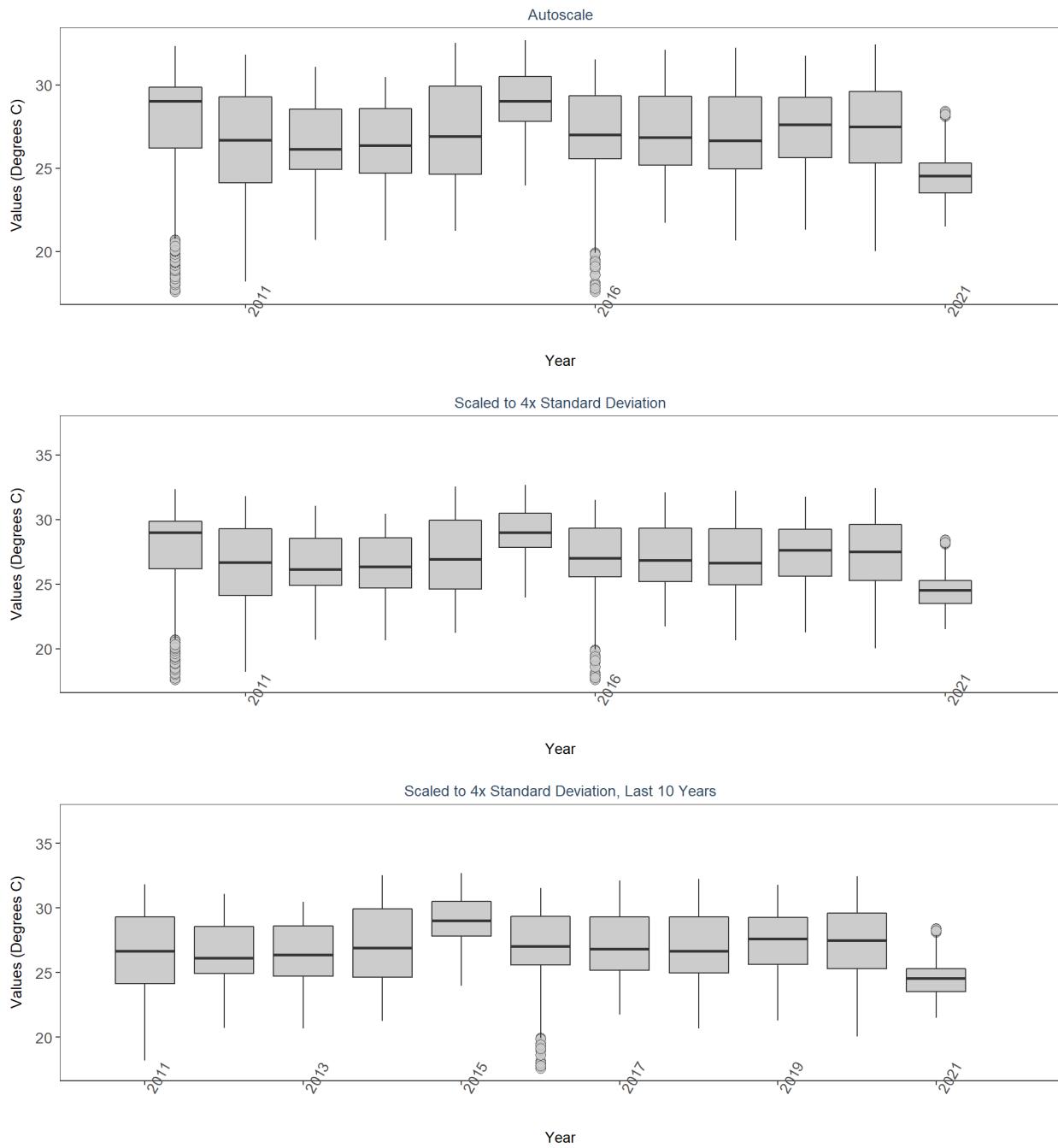
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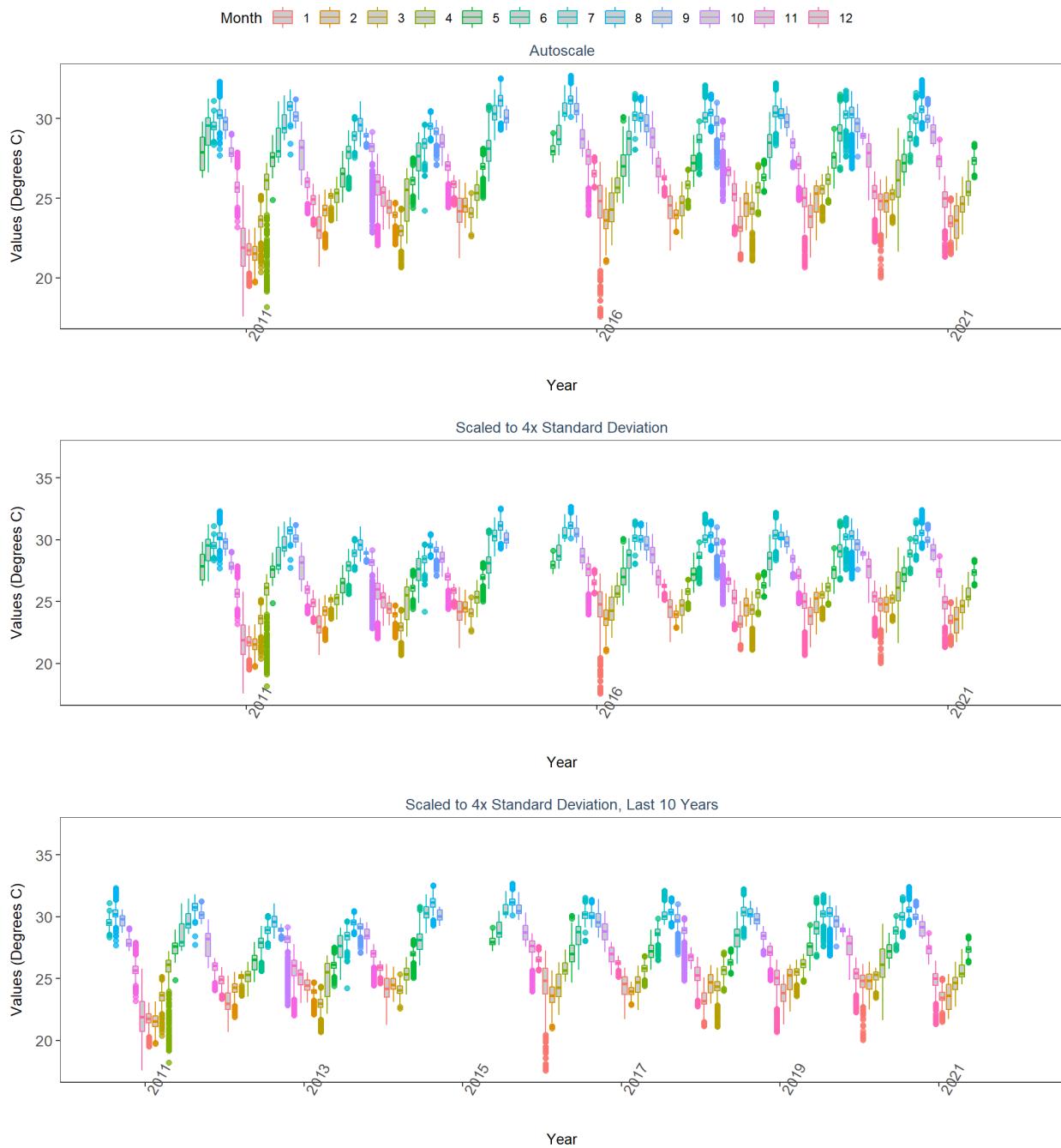
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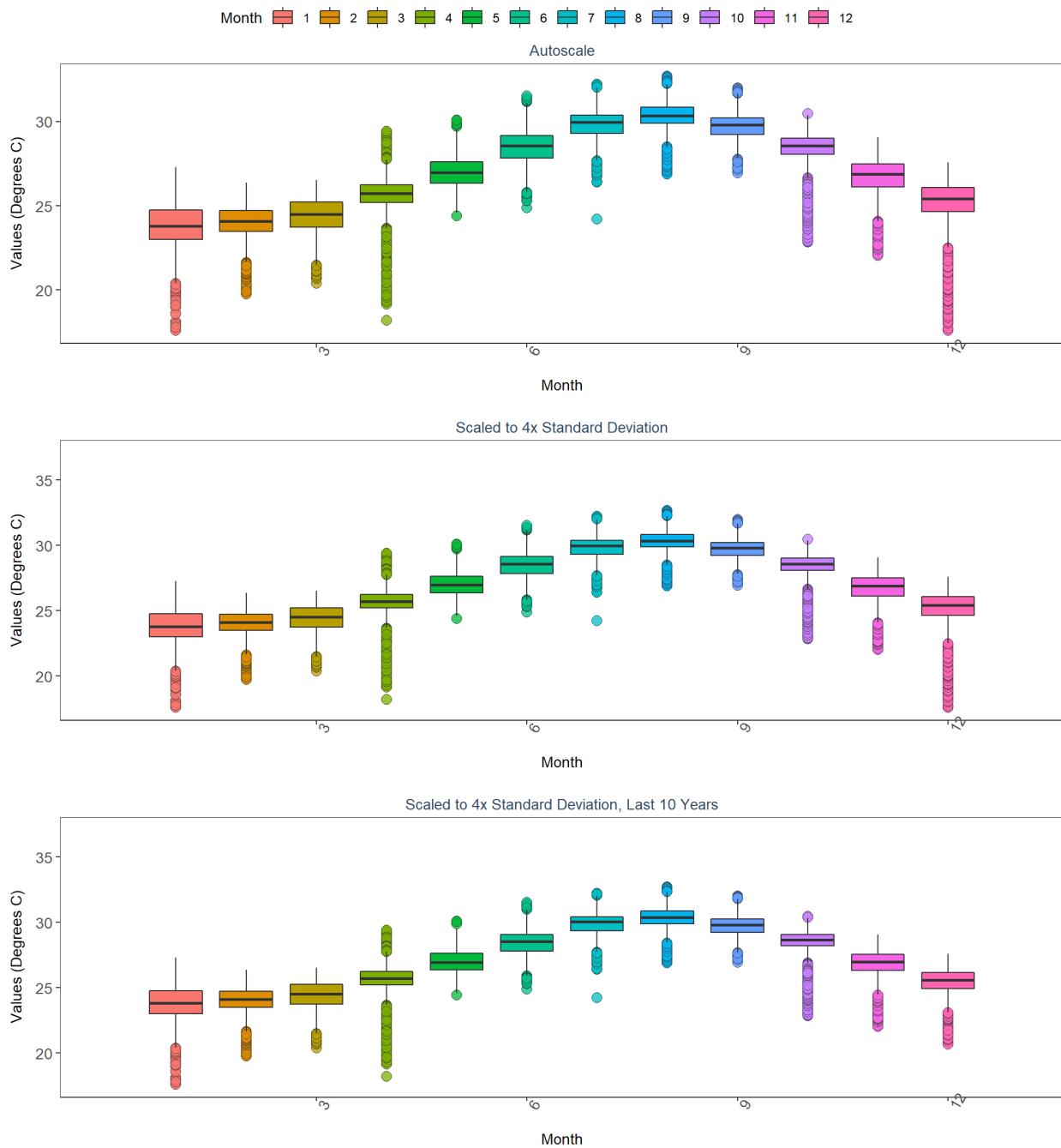
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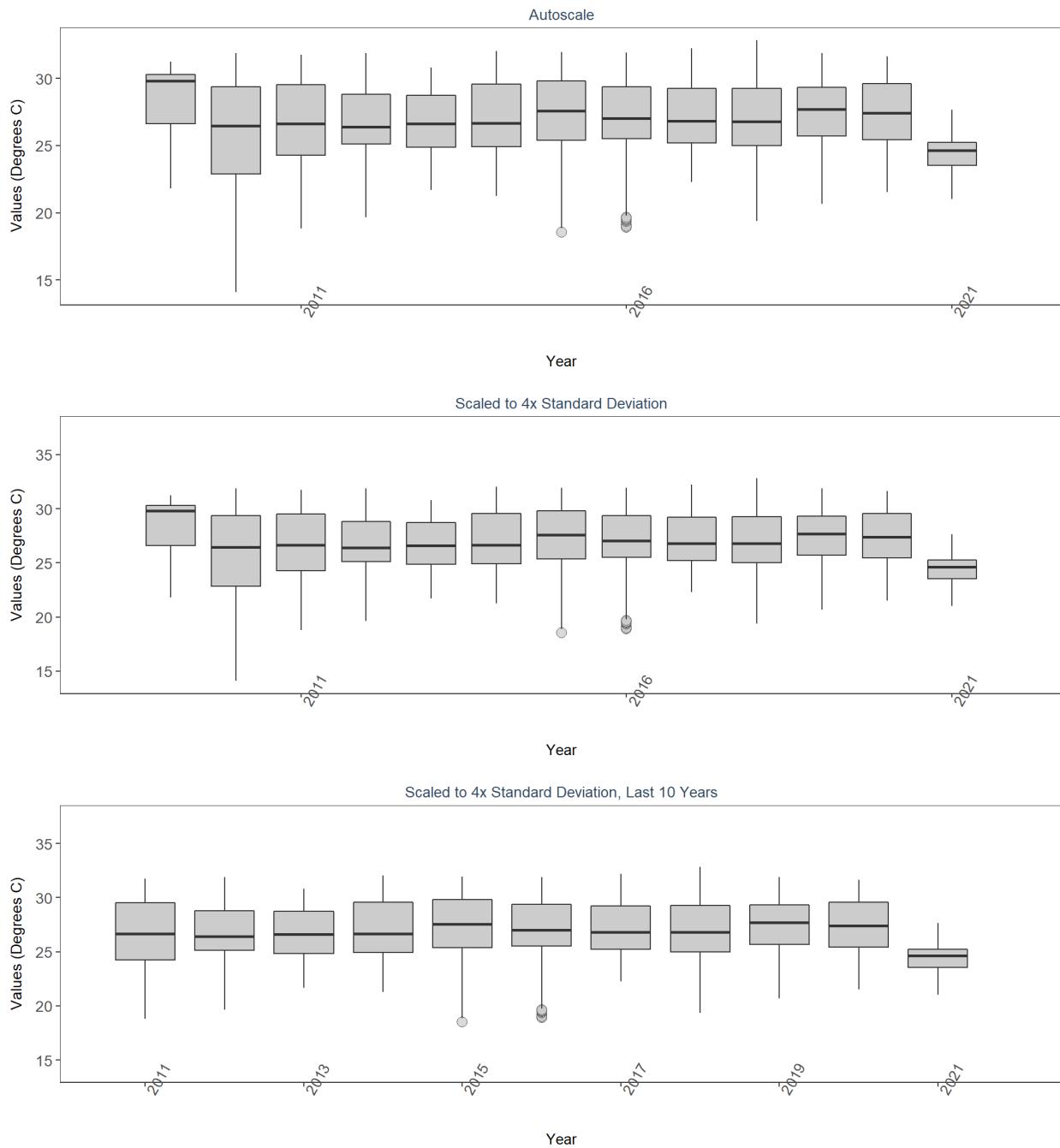
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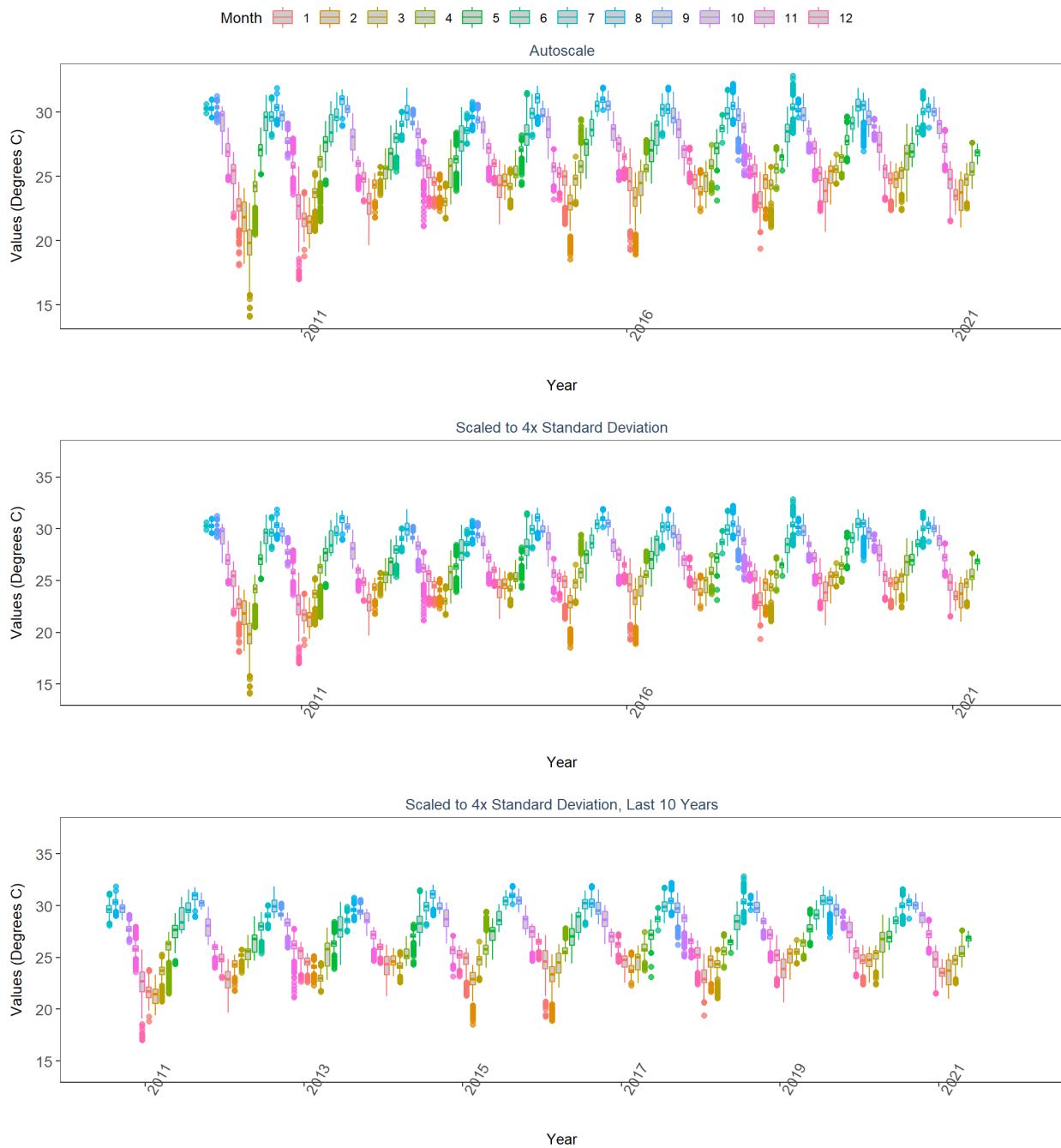
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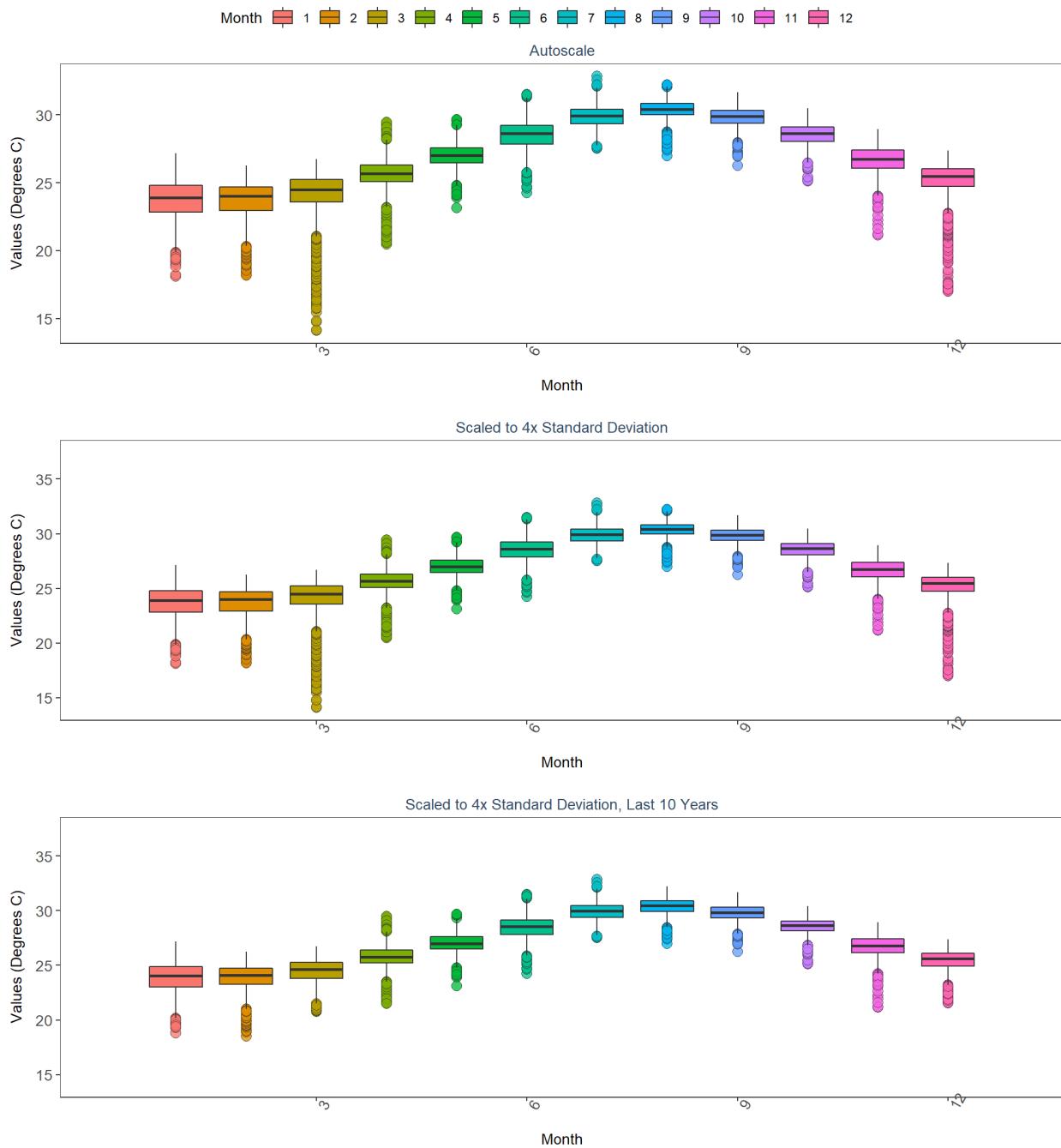
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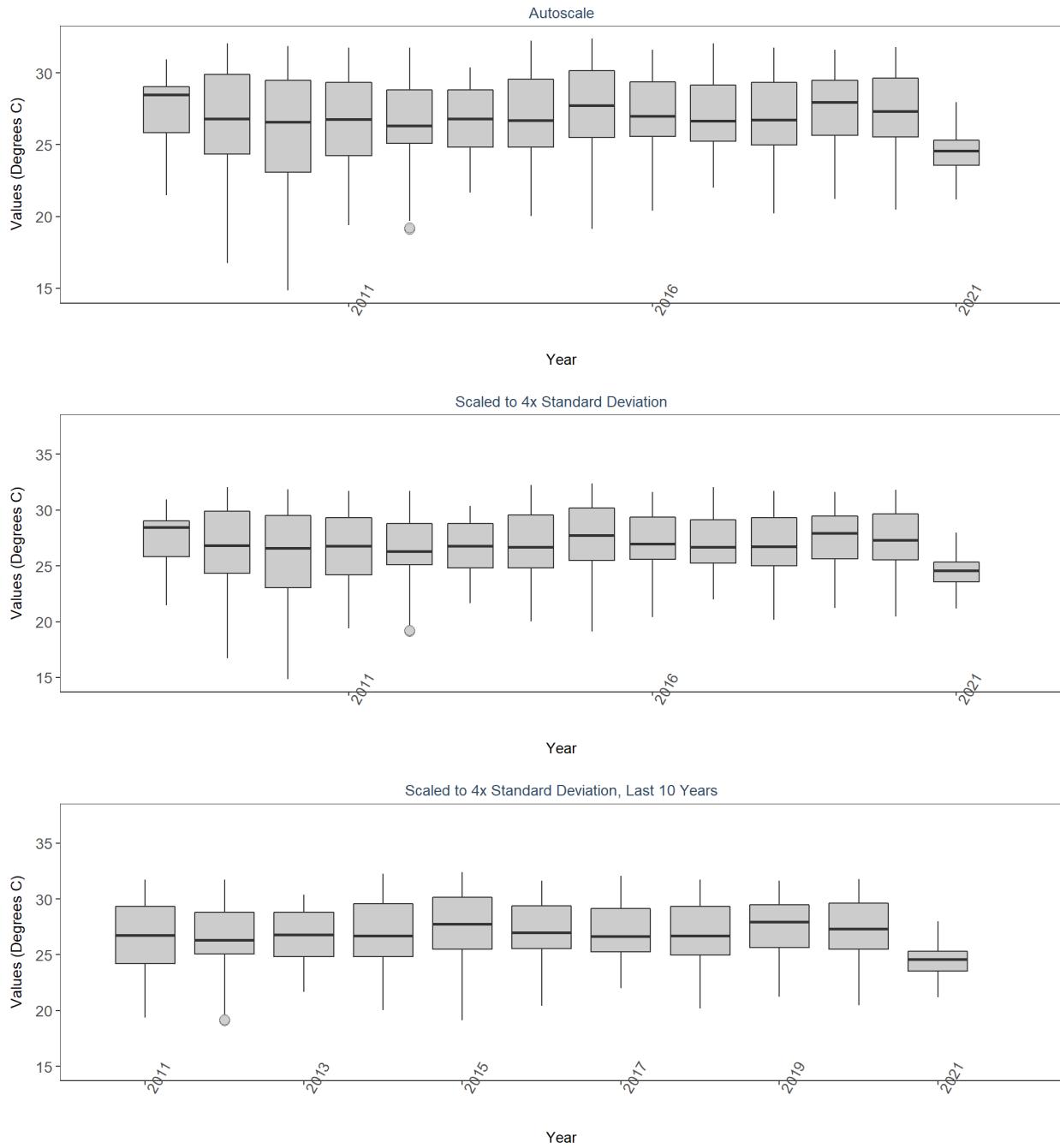
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Water Temperature on Coral Reefs in the Florida Keys
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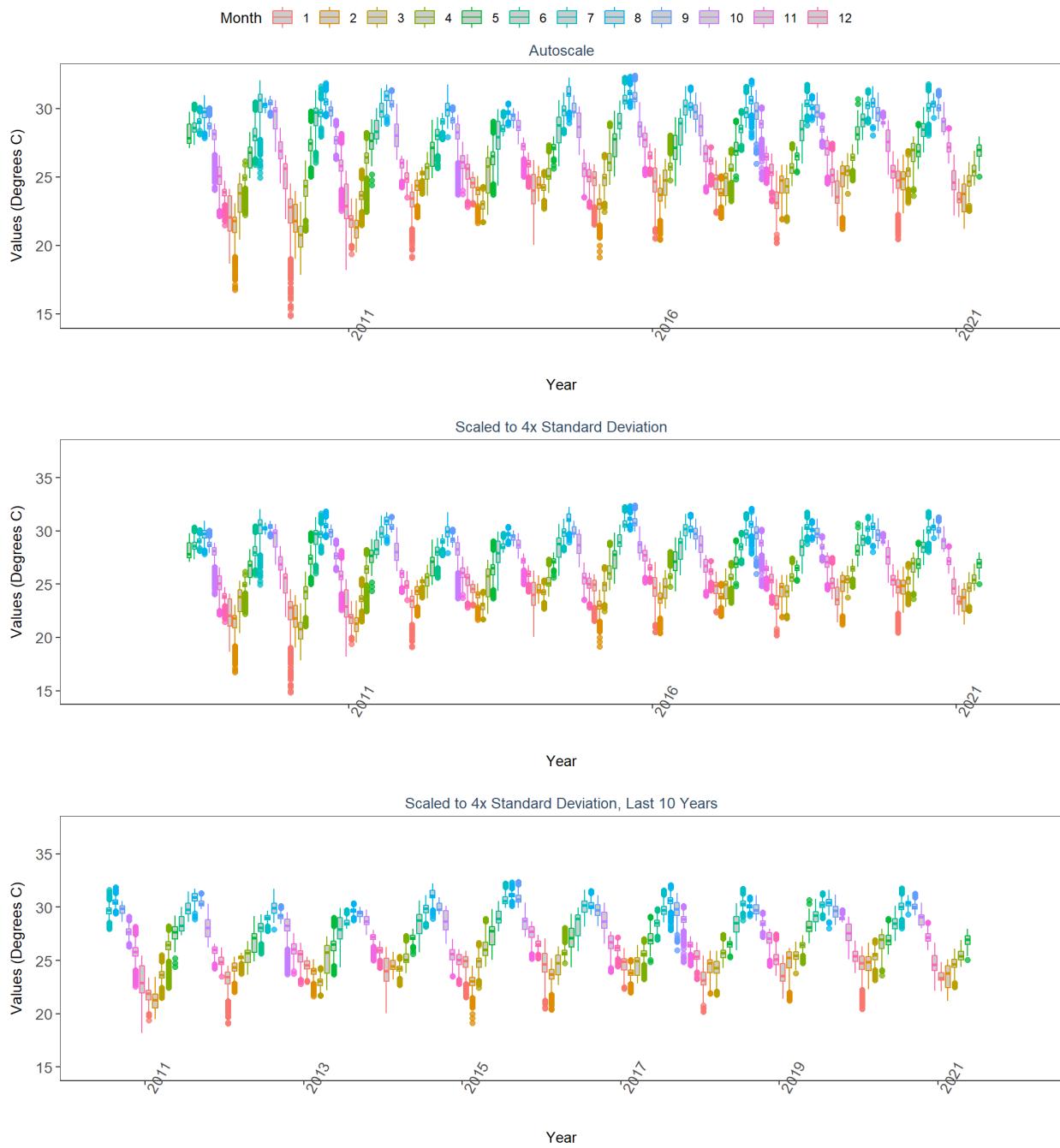
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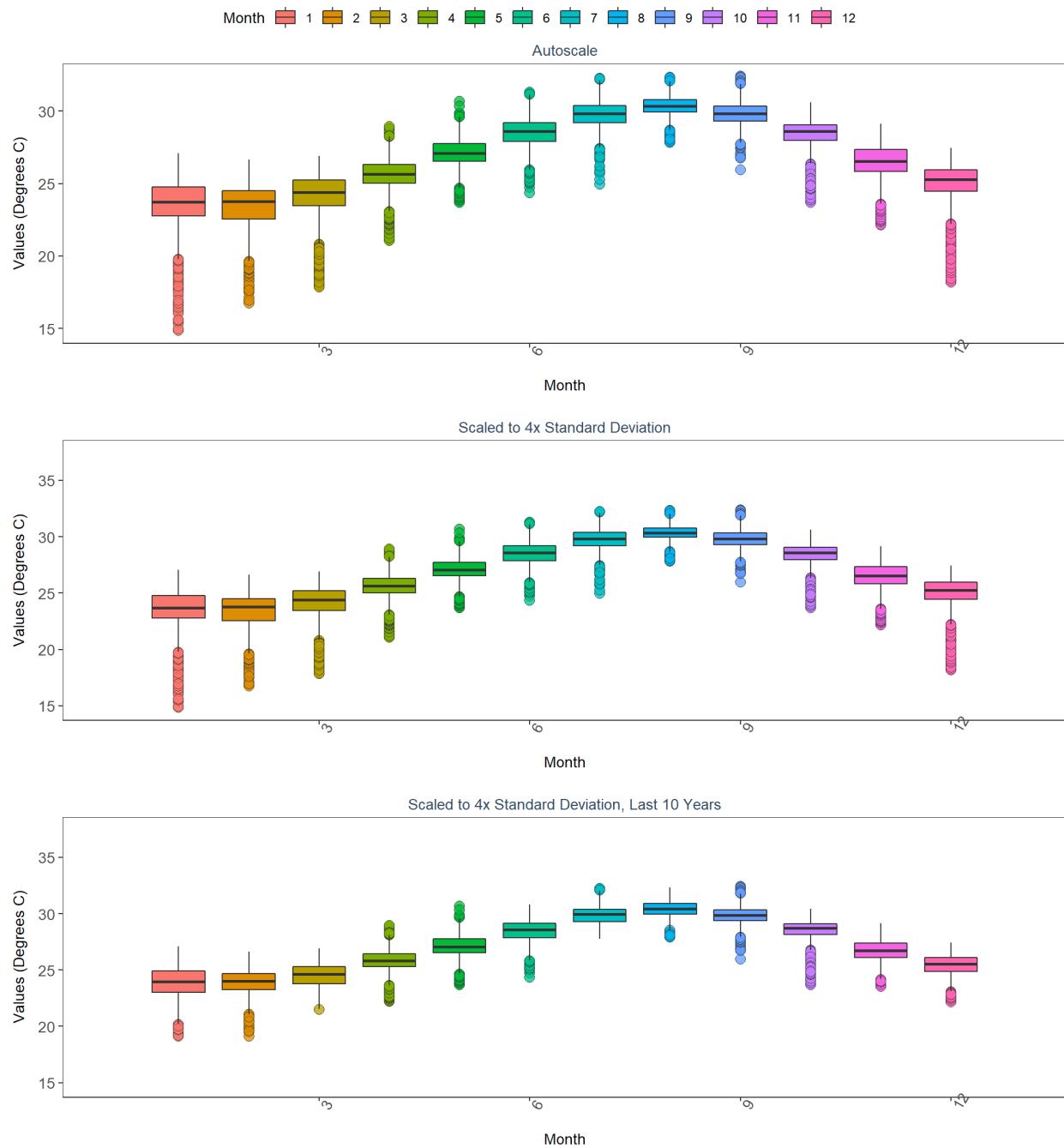
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 Water Temperature on Coral Reefs in the Florida Keys
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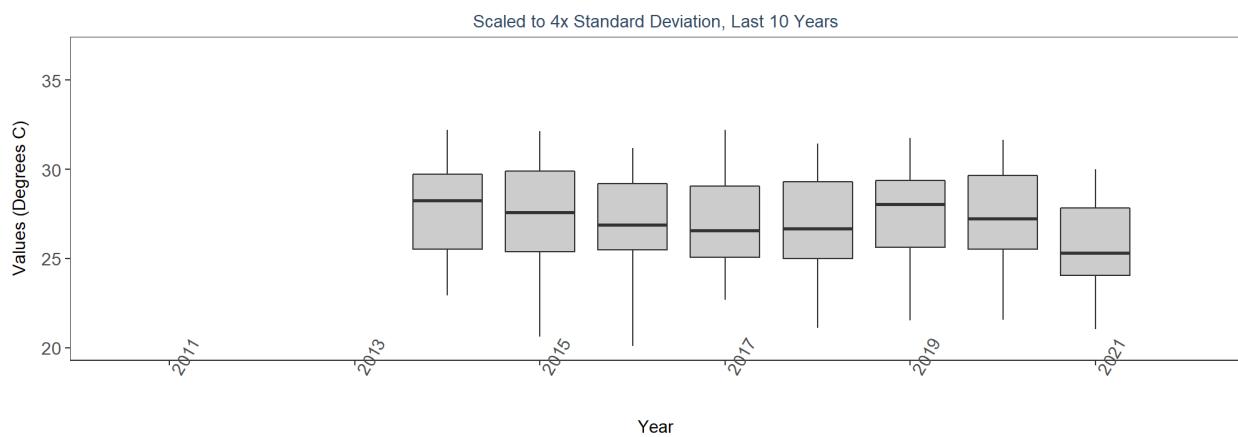
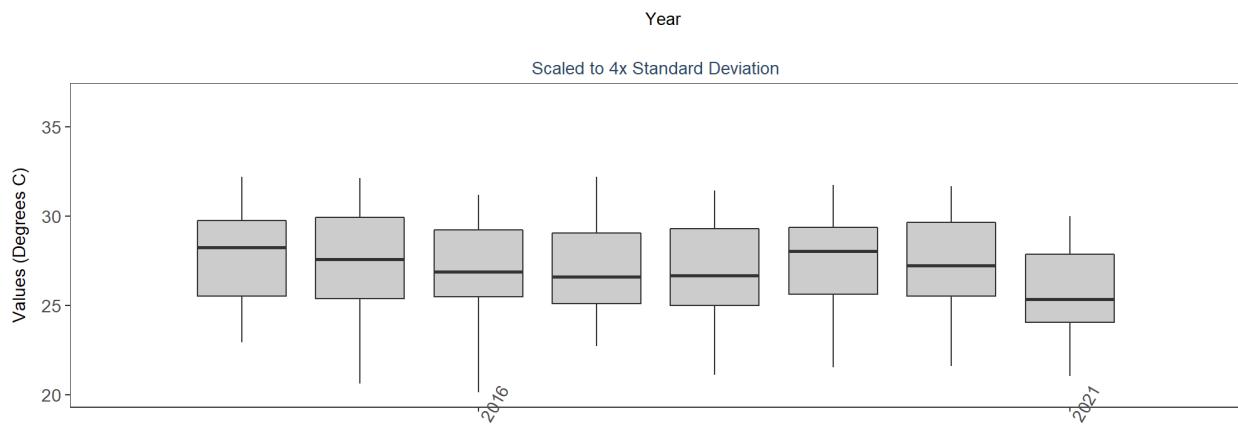
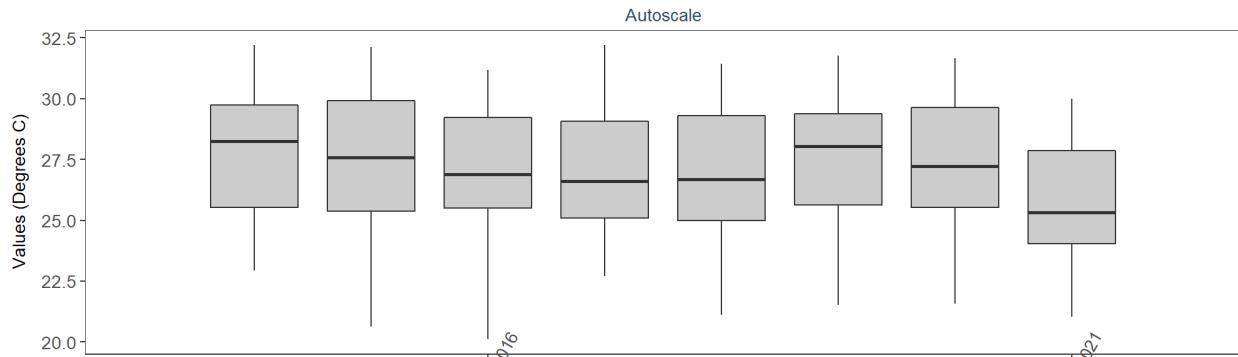
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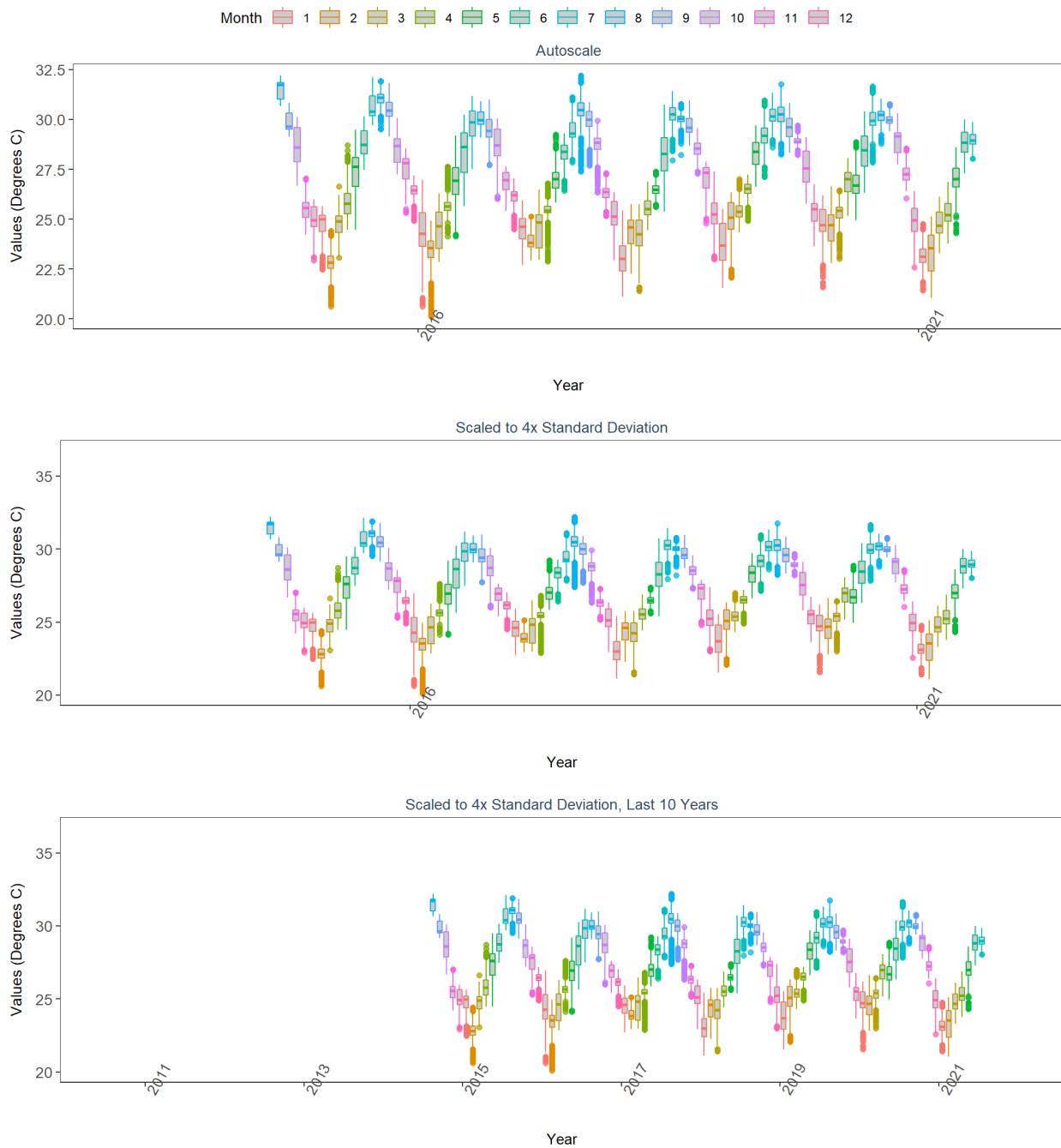
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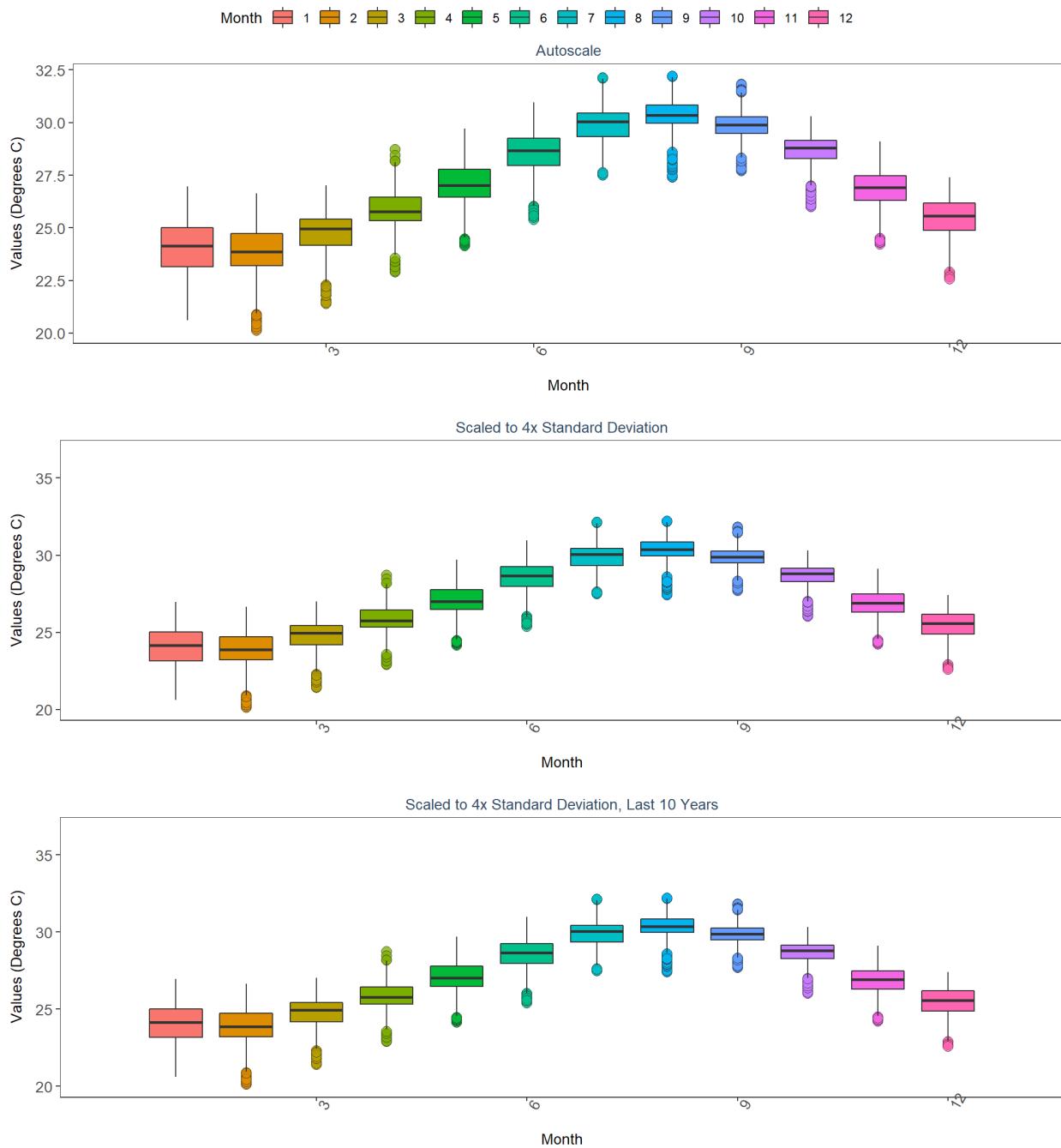
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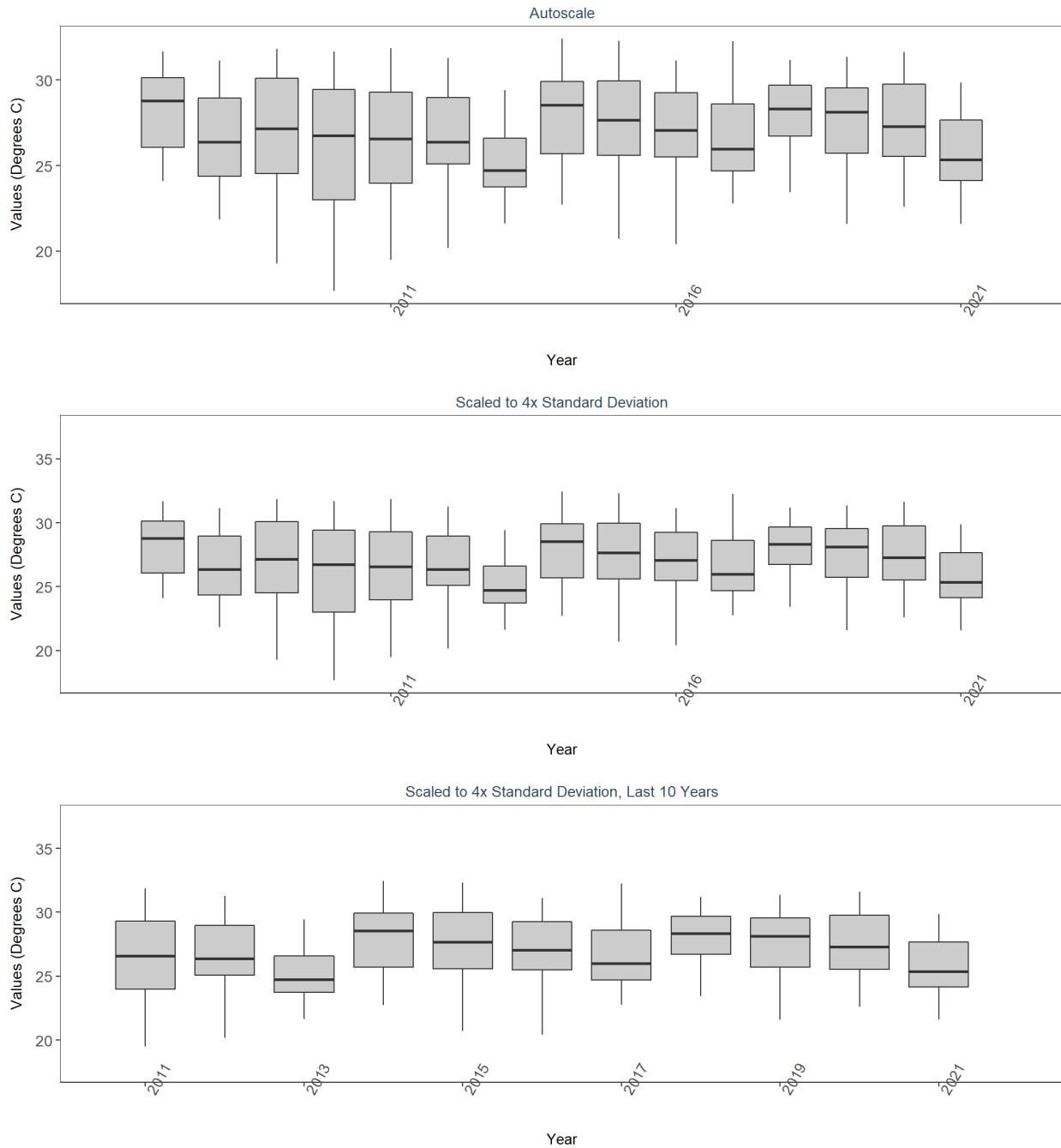
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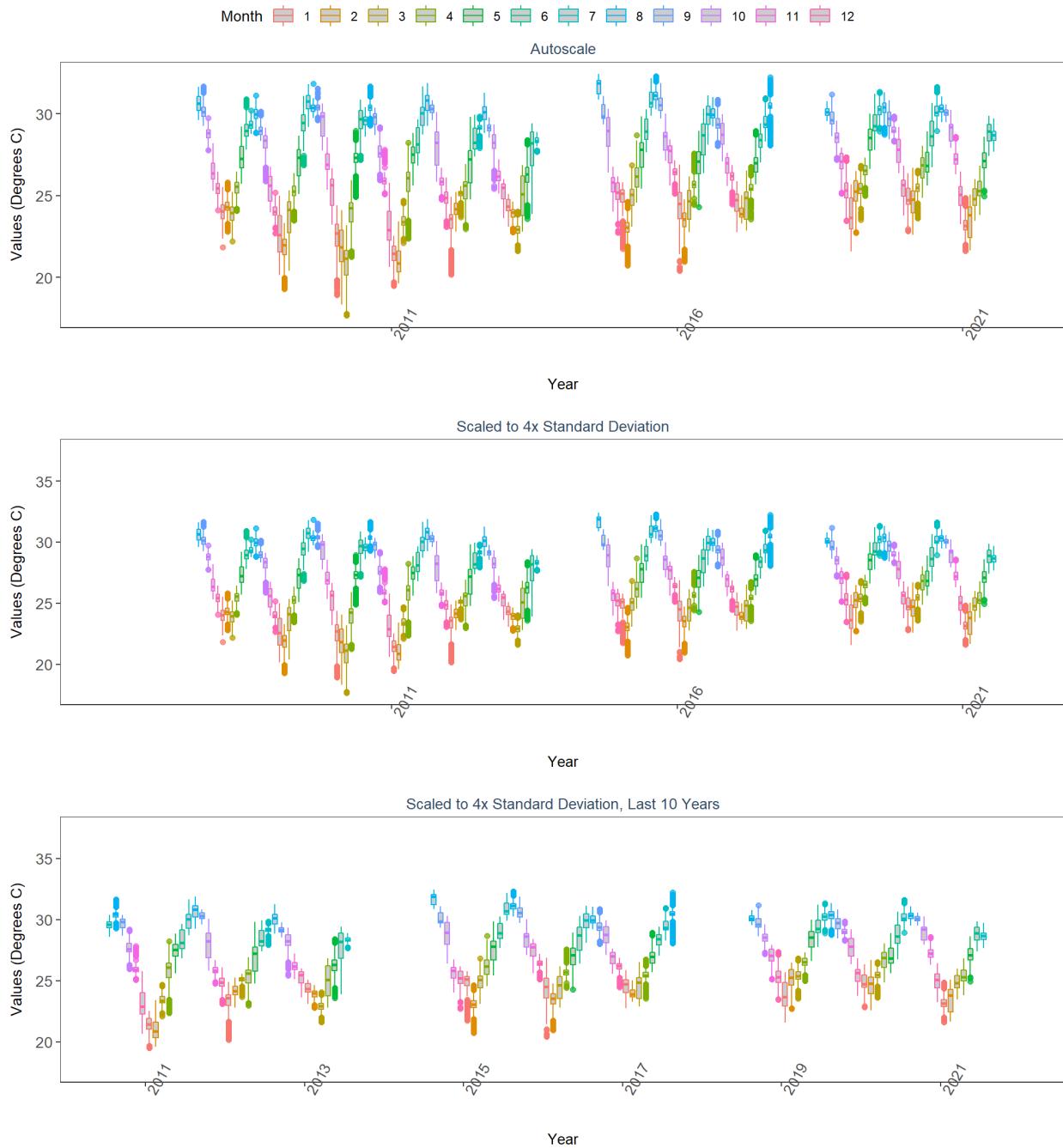
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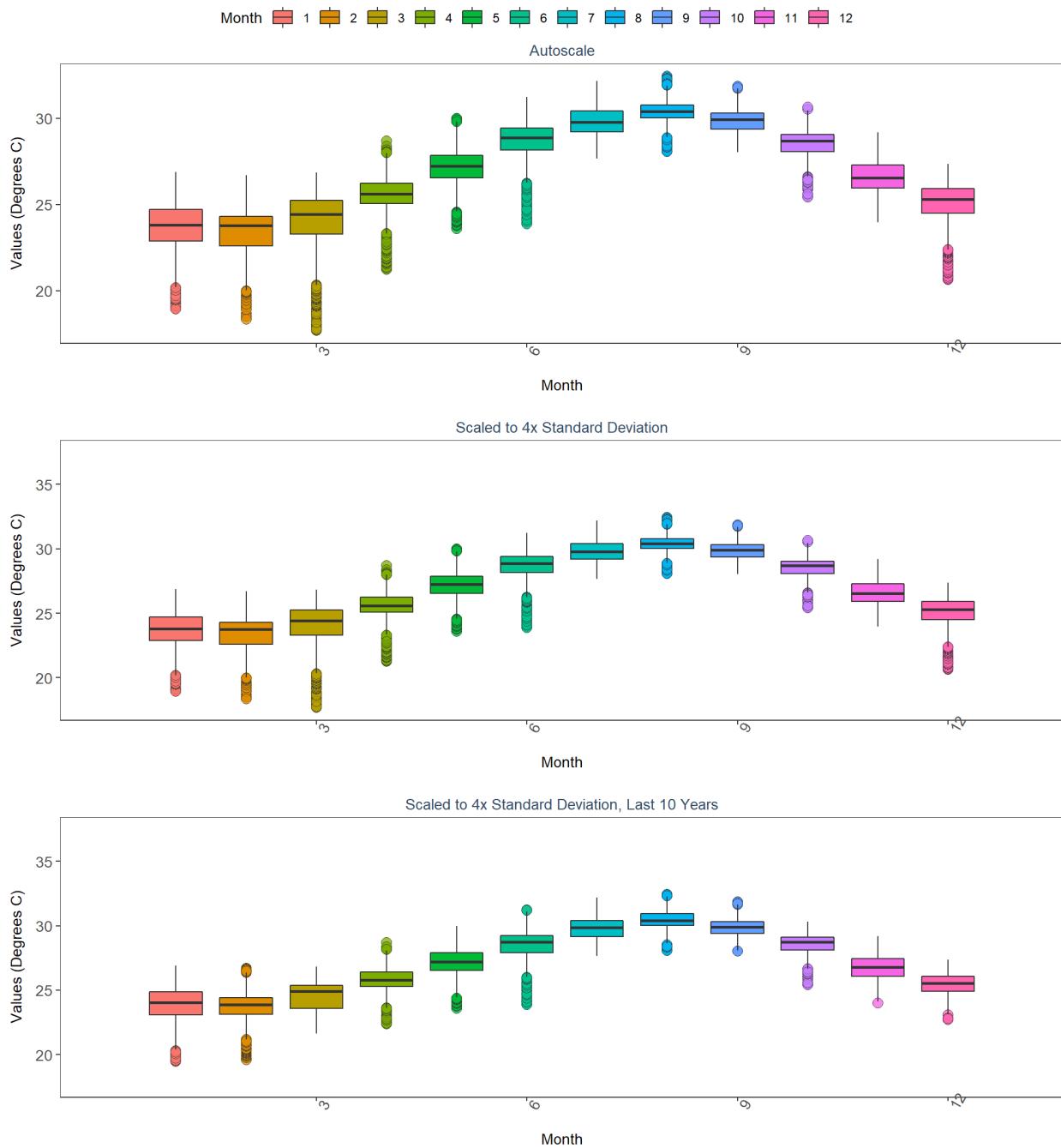
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Water Temperature on Coral Reefs in the Florida Keys
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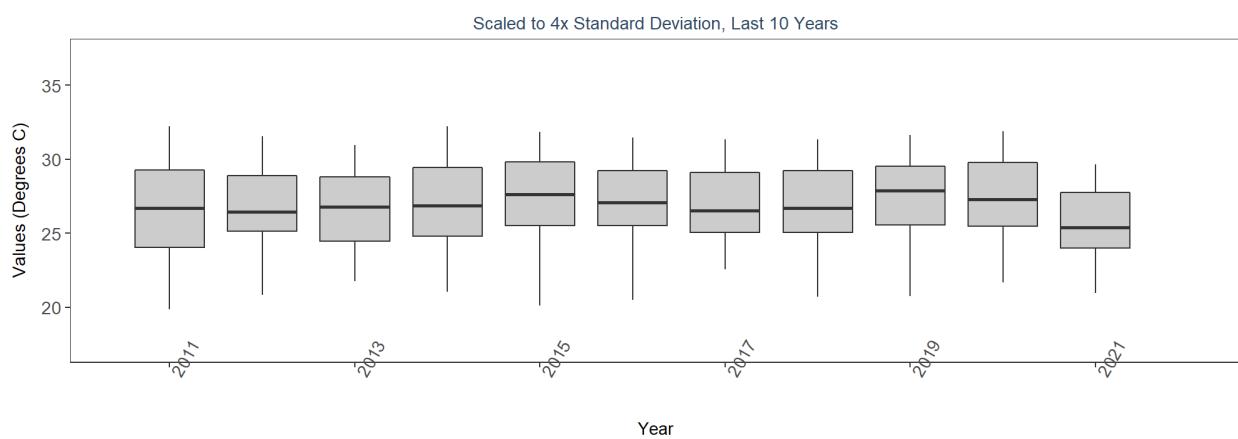
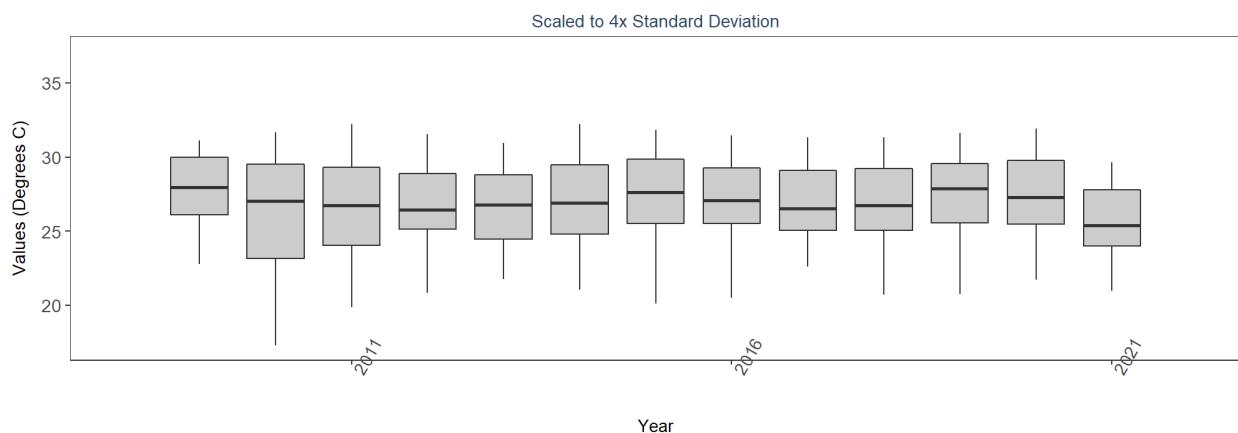
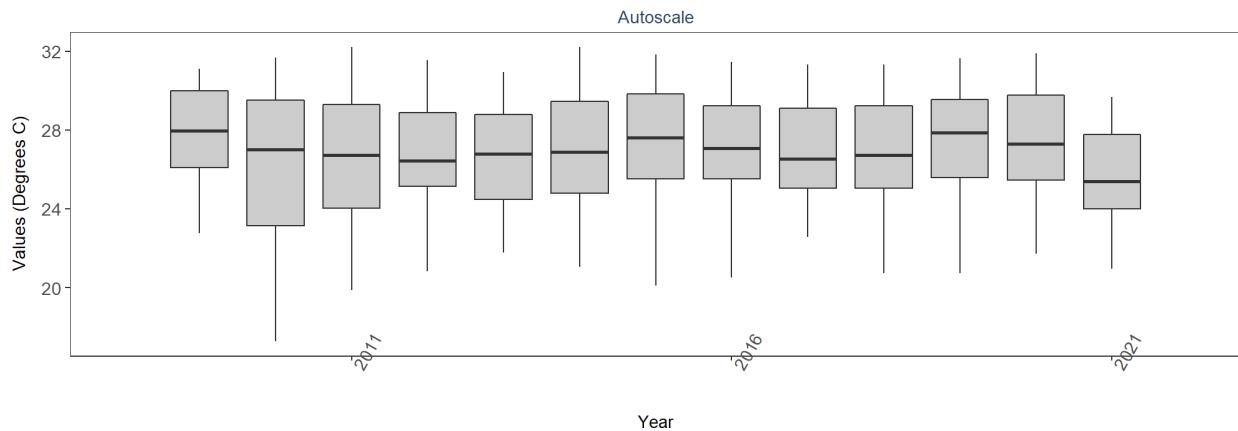
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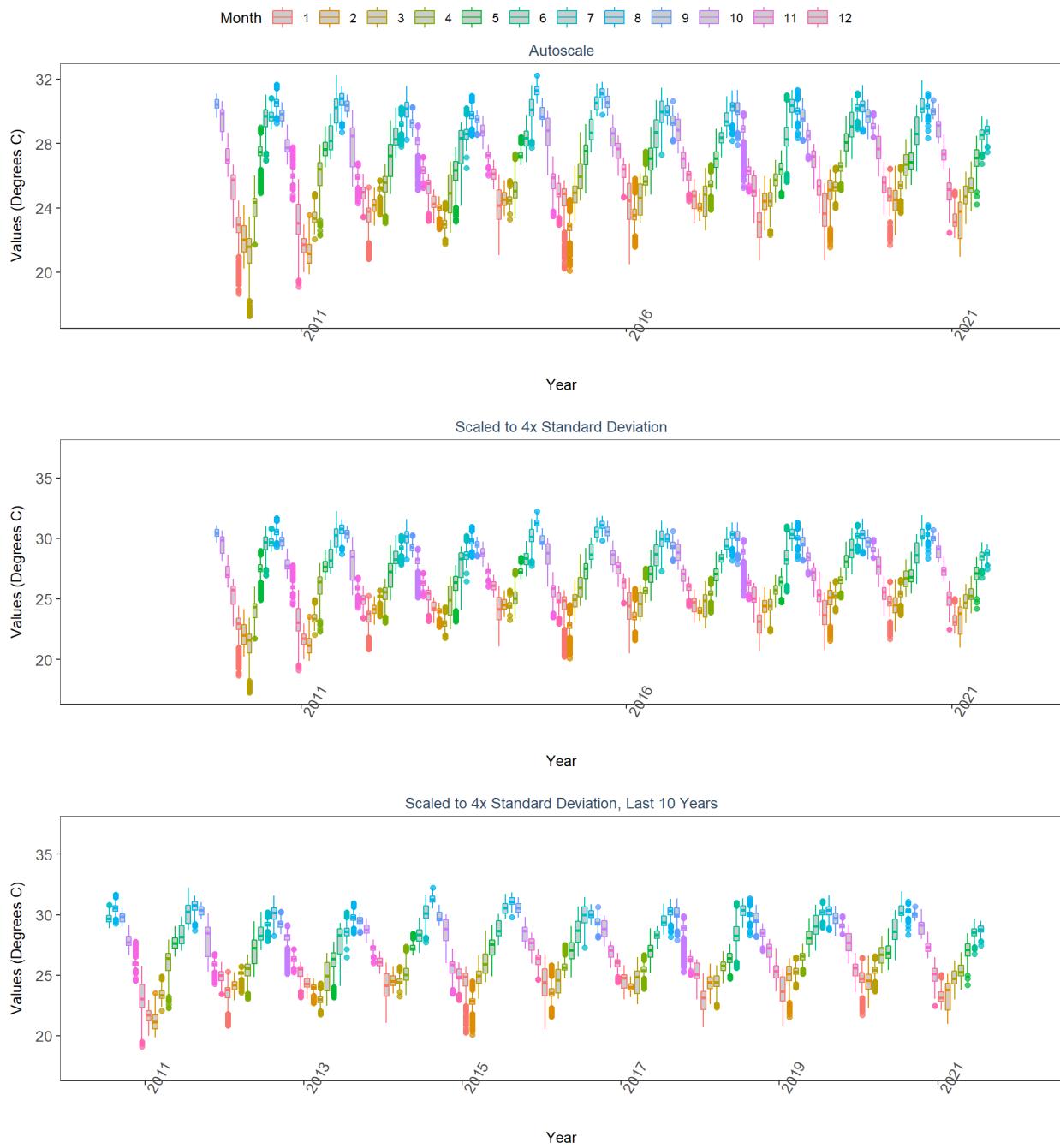
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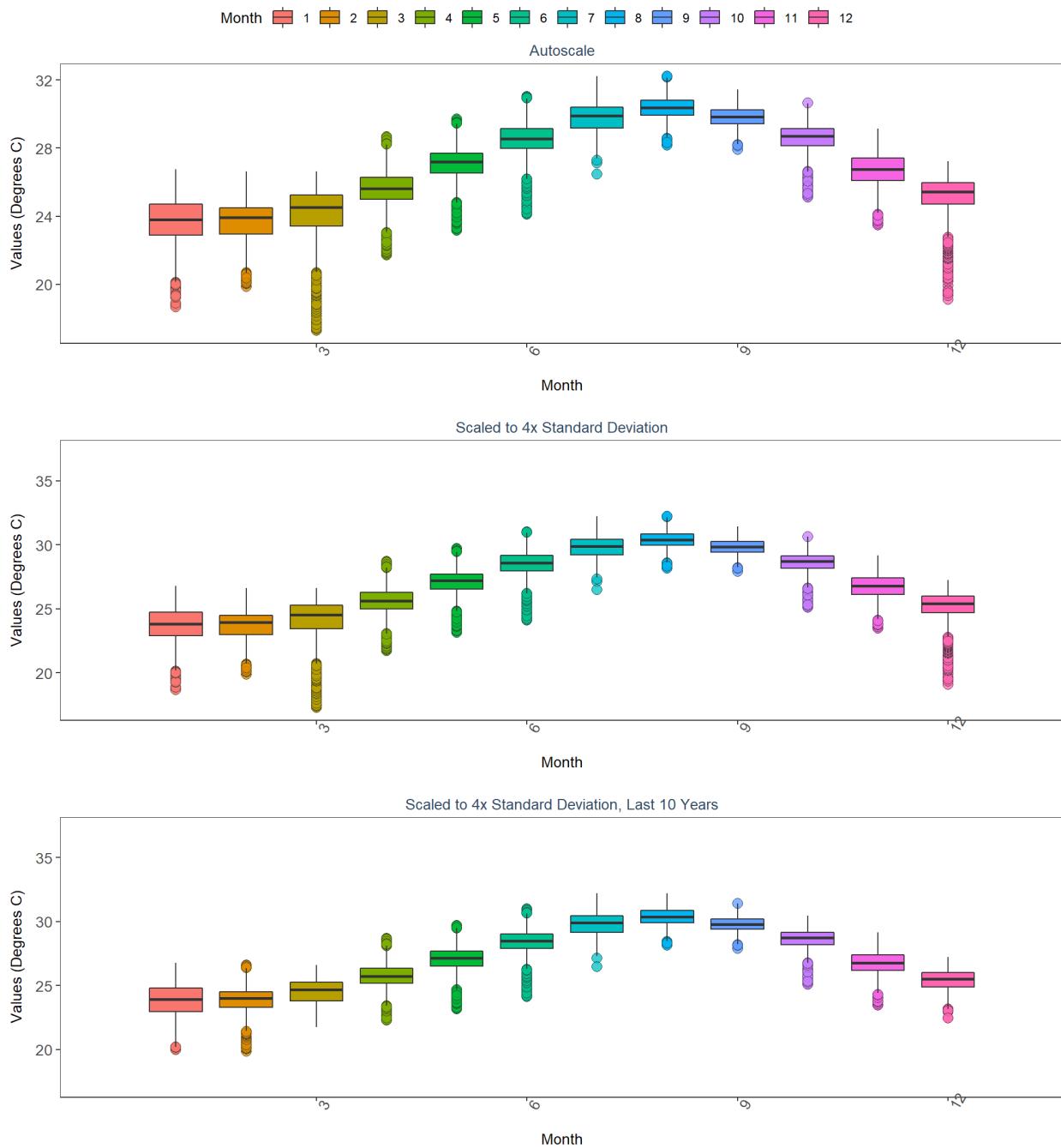
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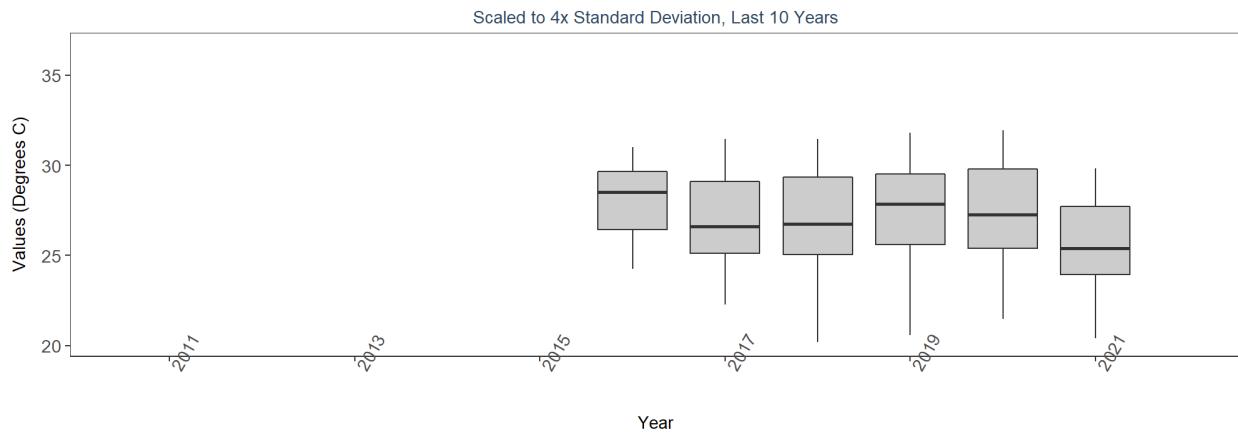
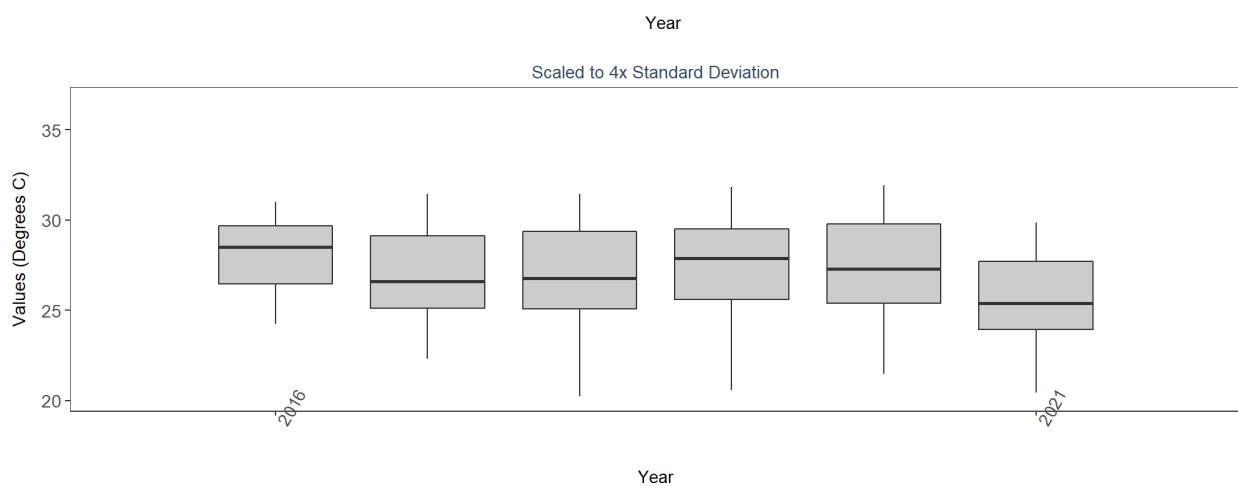
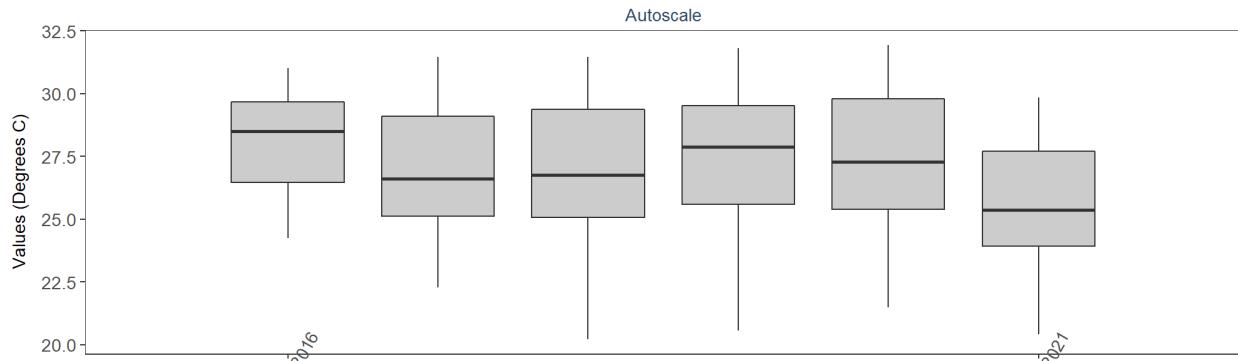
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Water Temperature on Coral Reefs in the Florida Keys
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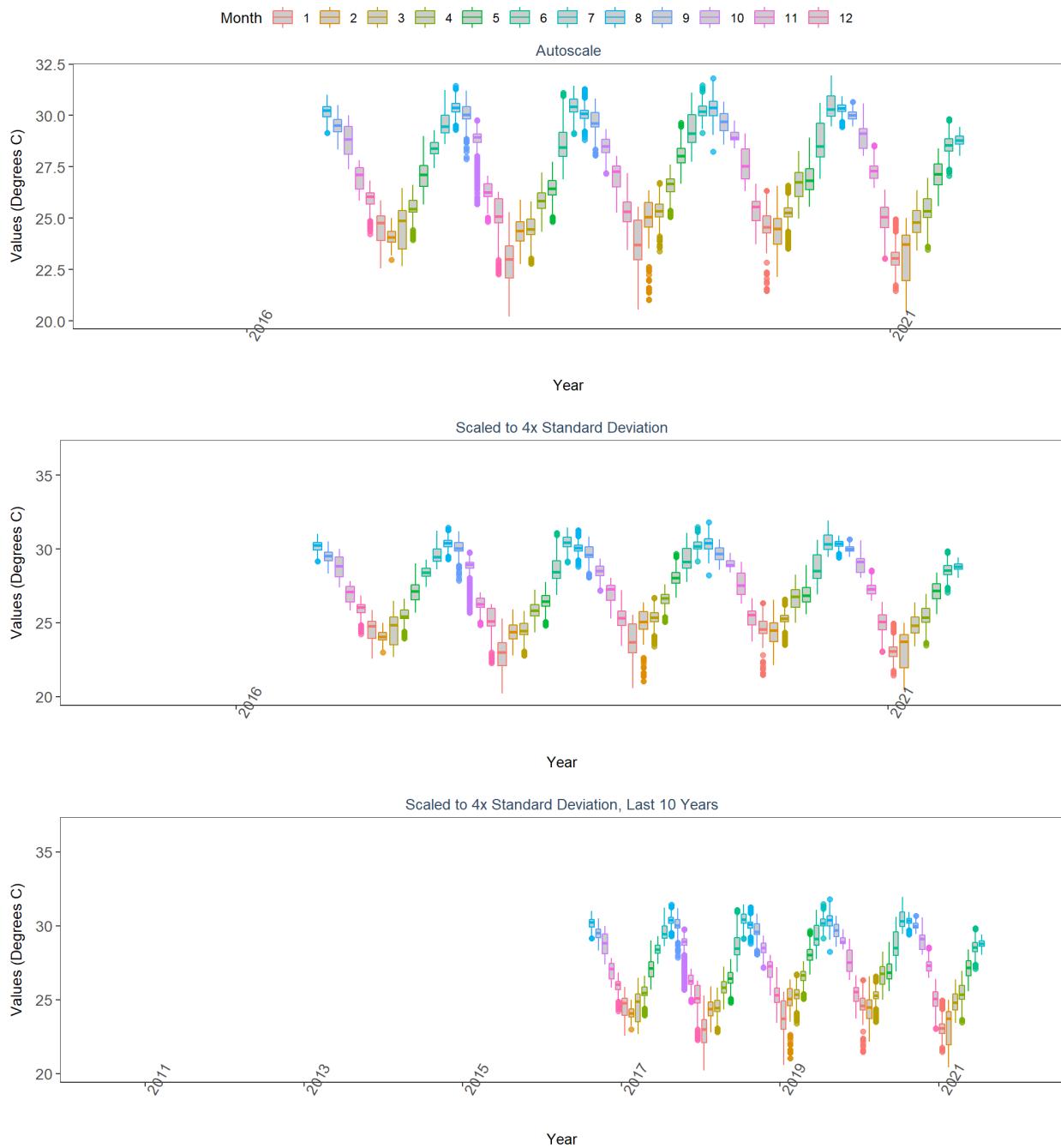
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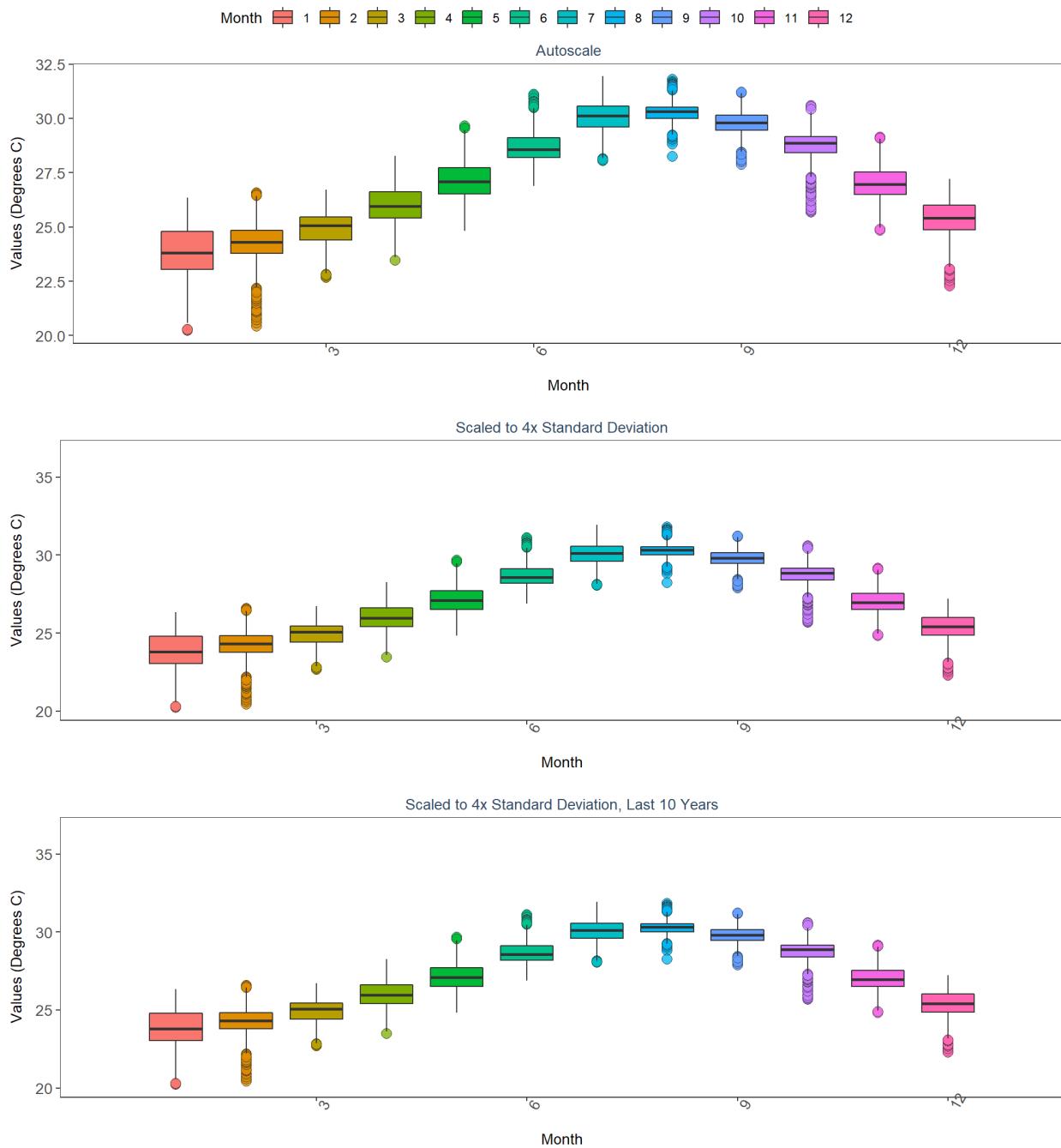
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986
Water Temperature on Coral Reefs in the Florida Keys
81
By Year



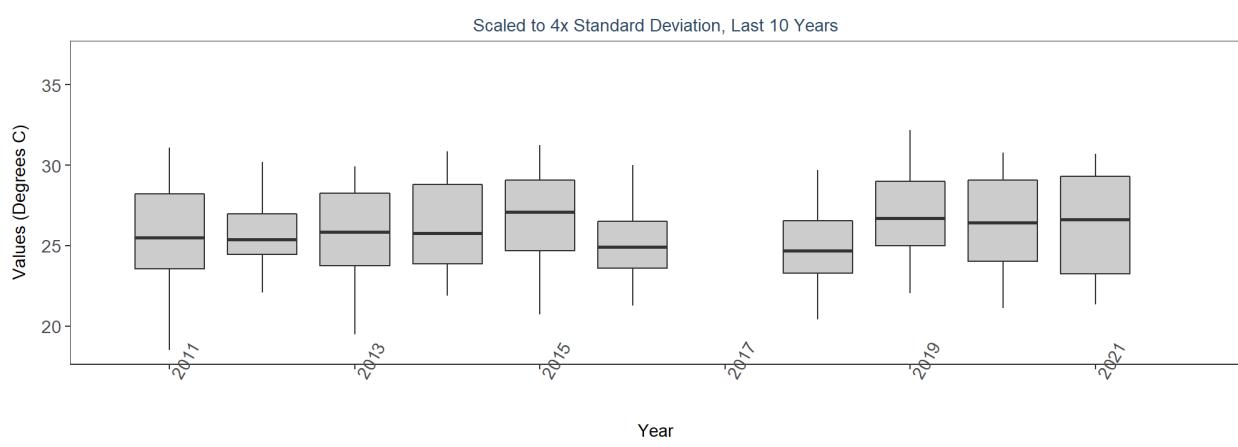
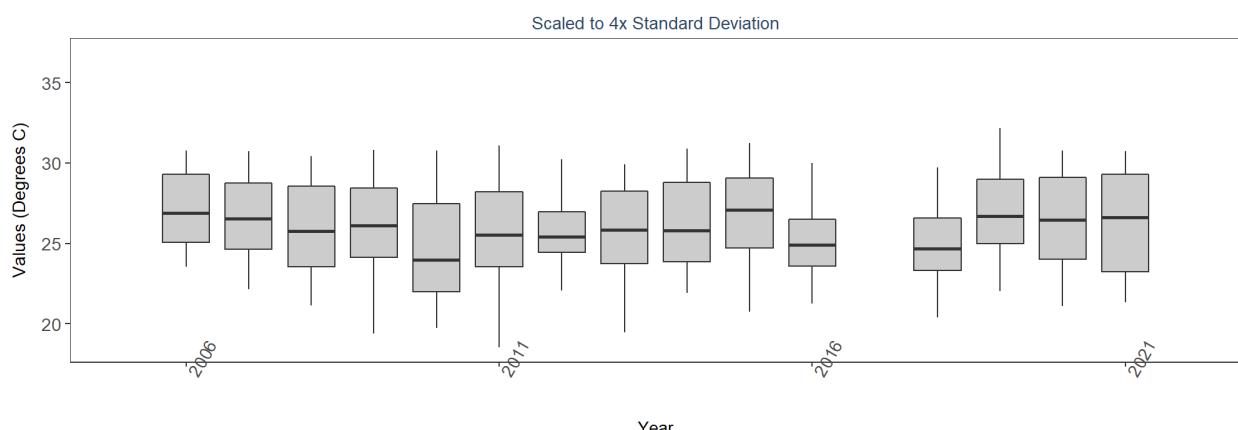
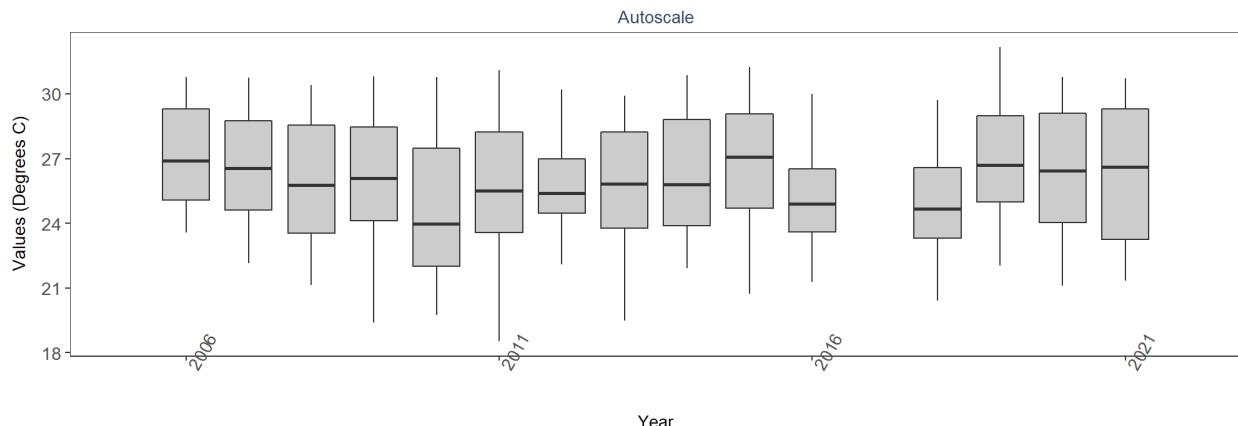
Florida Keys National Marine Sanctuary
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 Water Temperature on Coral Reefs in the Florida Keys
 81
 By Year & Month



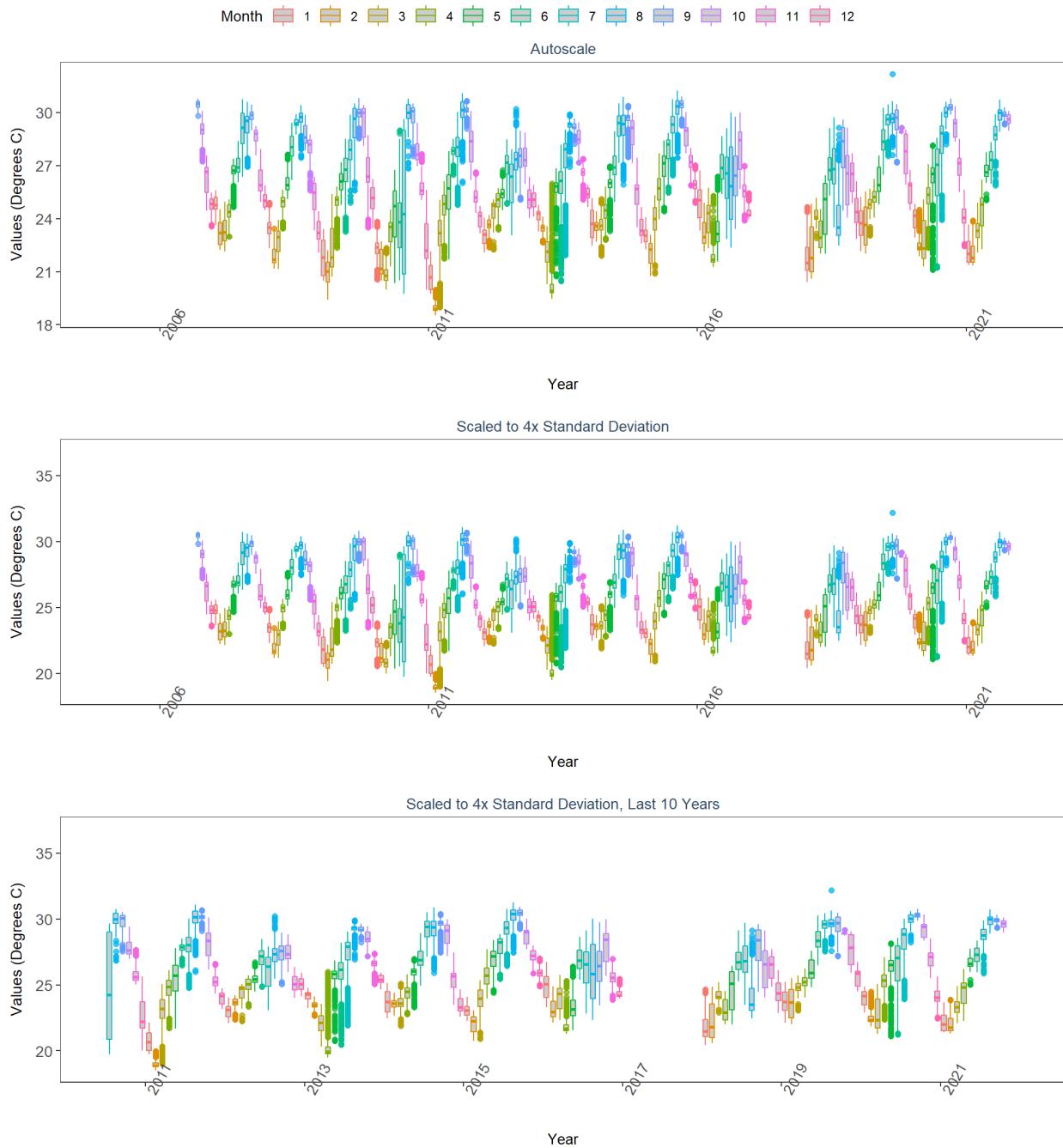
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 Water Temperature on Coral Reefs in the Florida Keys
 81
 By Month



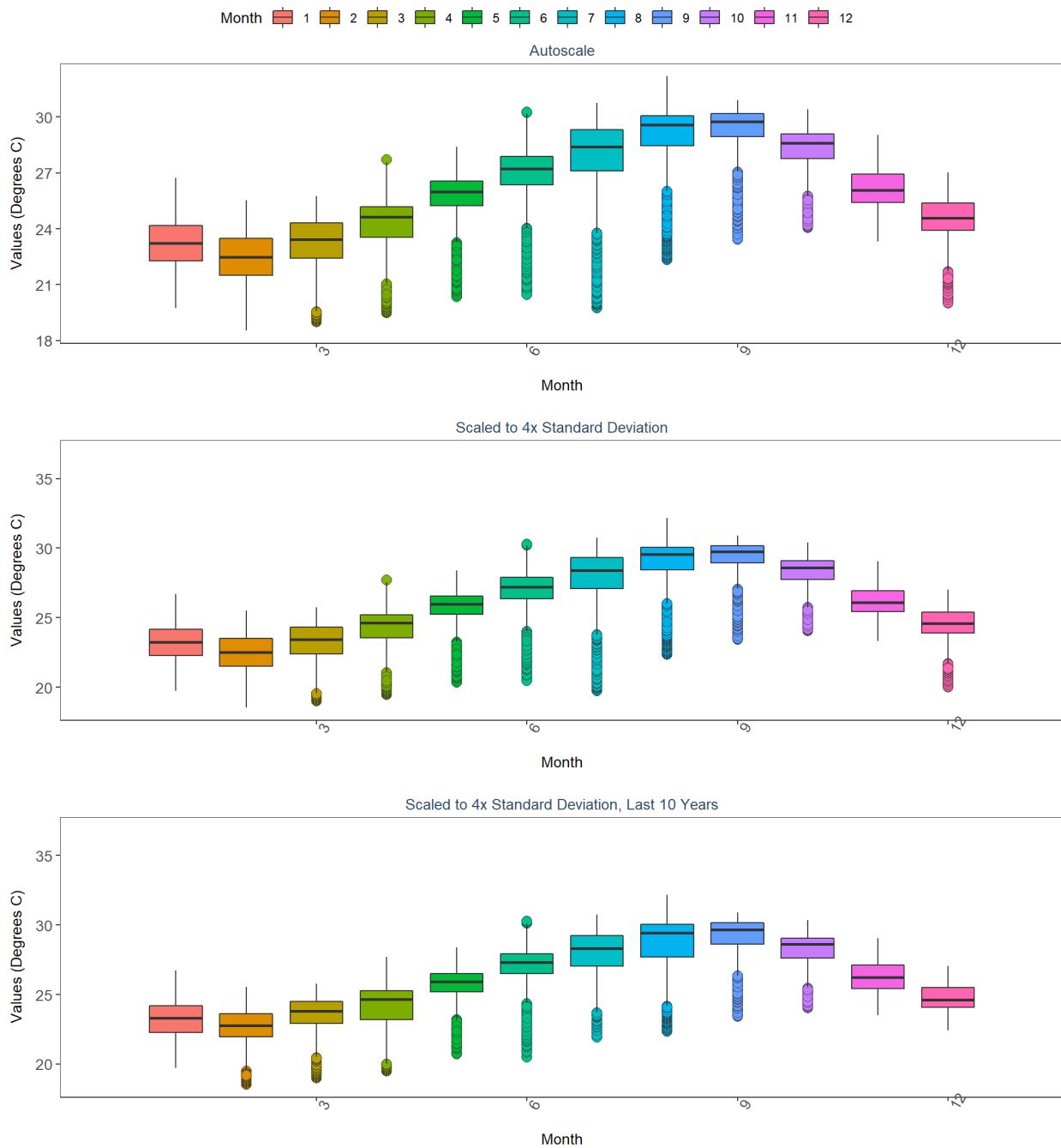
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 Water Temperature on Coral Reefs in the Florida Keys
 83
 By Year



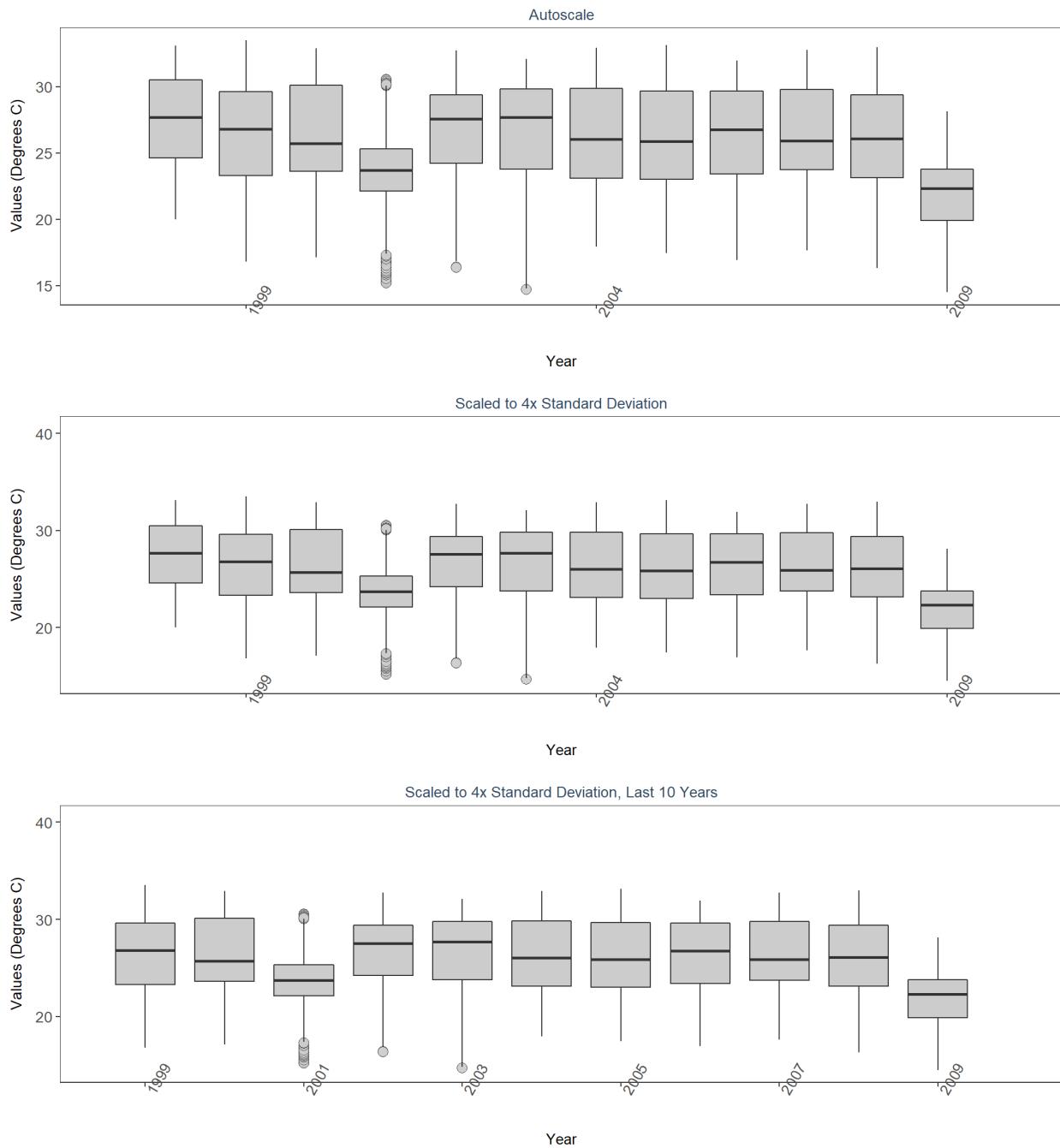
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 Water Temperature on Coral Reefs in the Florida Keys
 83
 By Year & Month



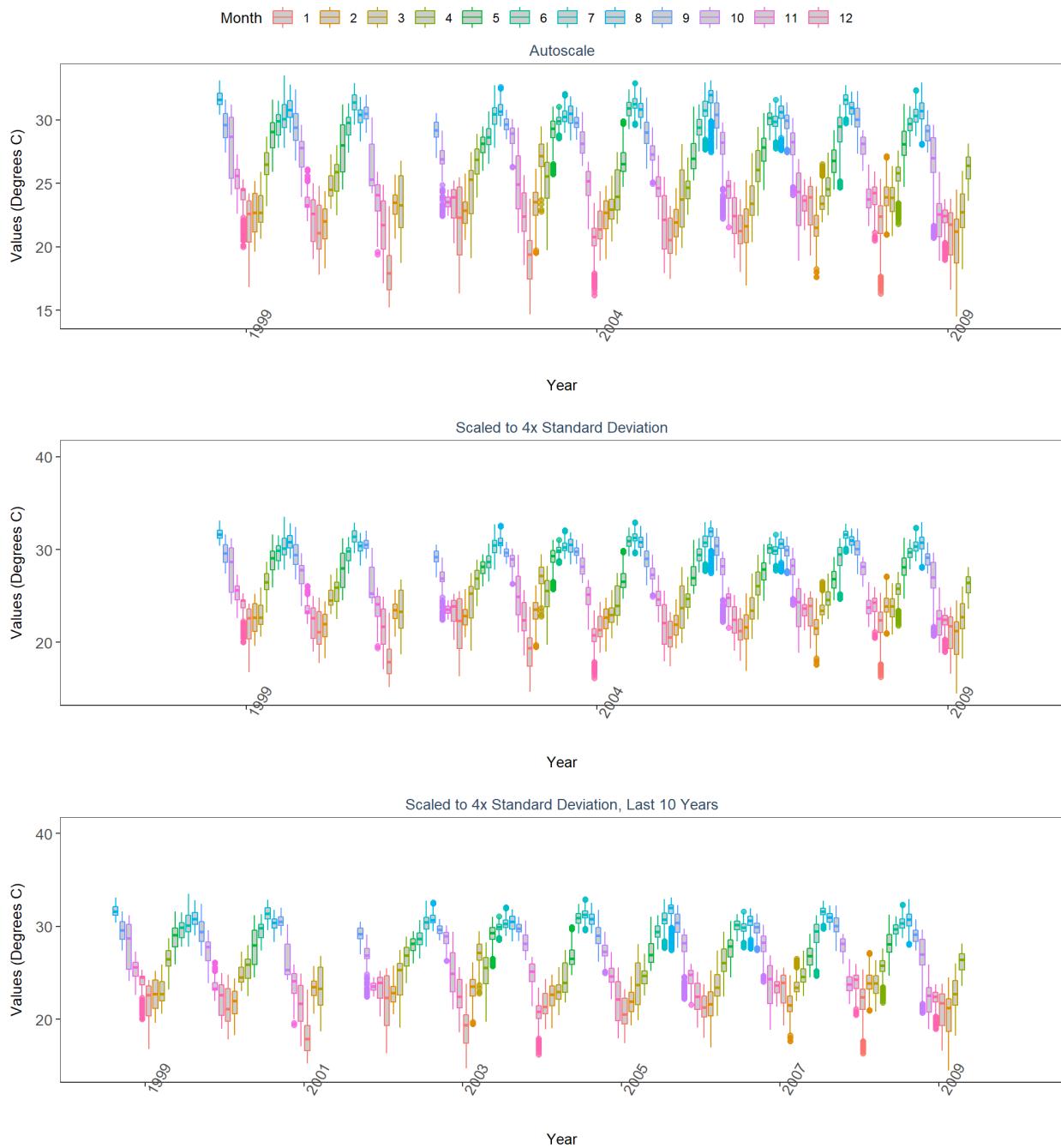
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 Water Temperature on Coral Reefs in the Florida Keys
 83
 By Month



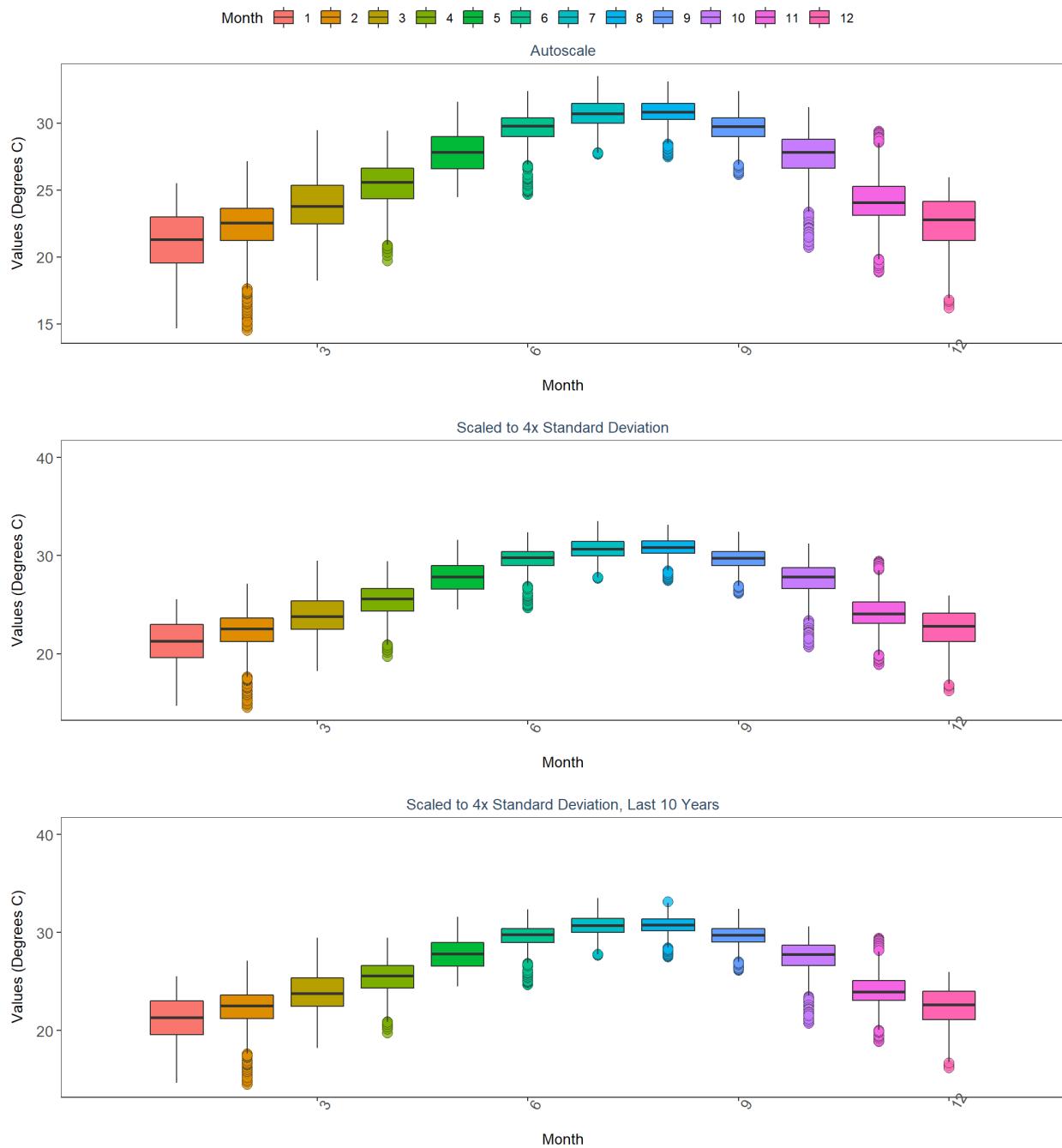
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_200YR_HD
 By Year



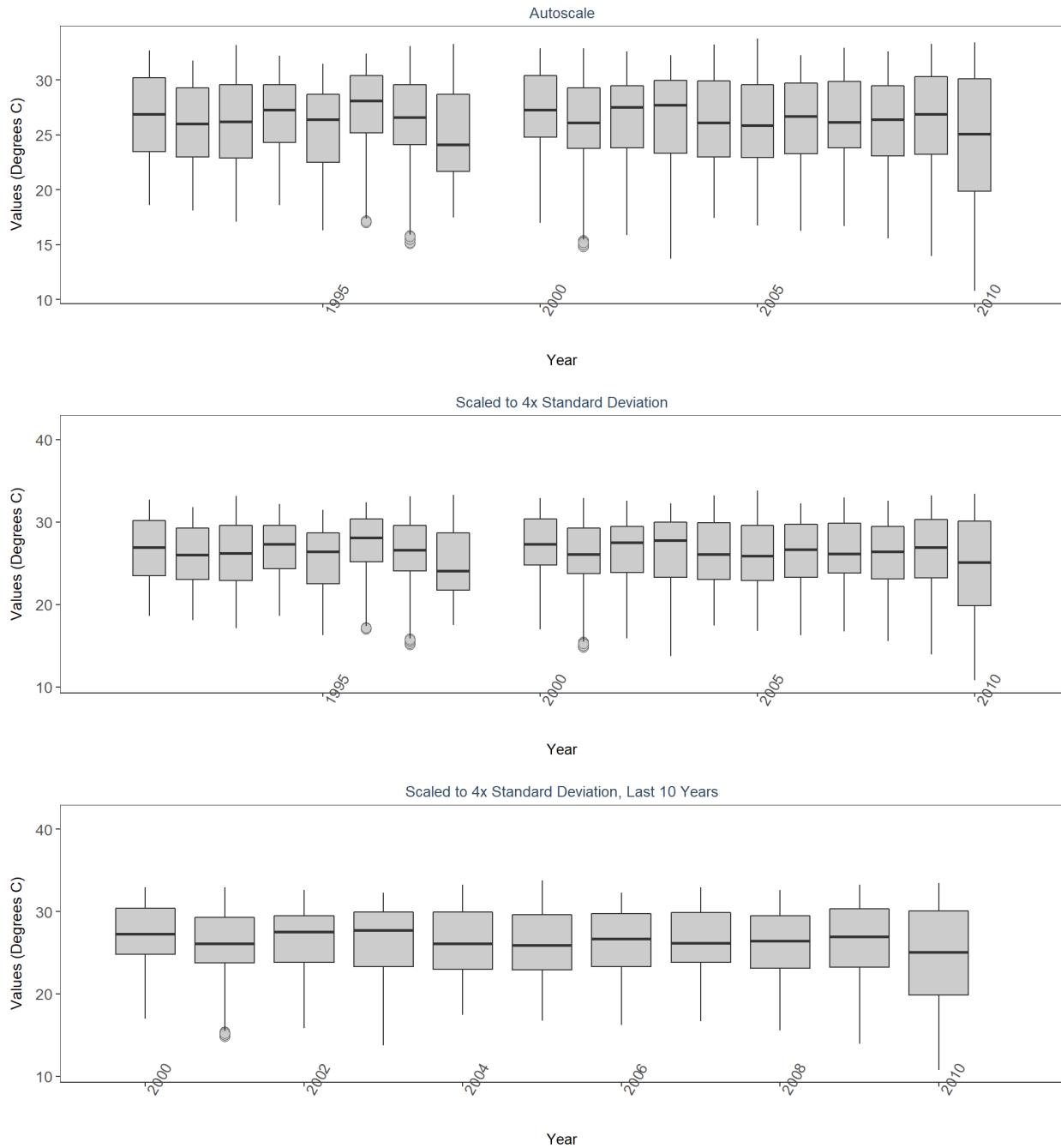
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Year & Month



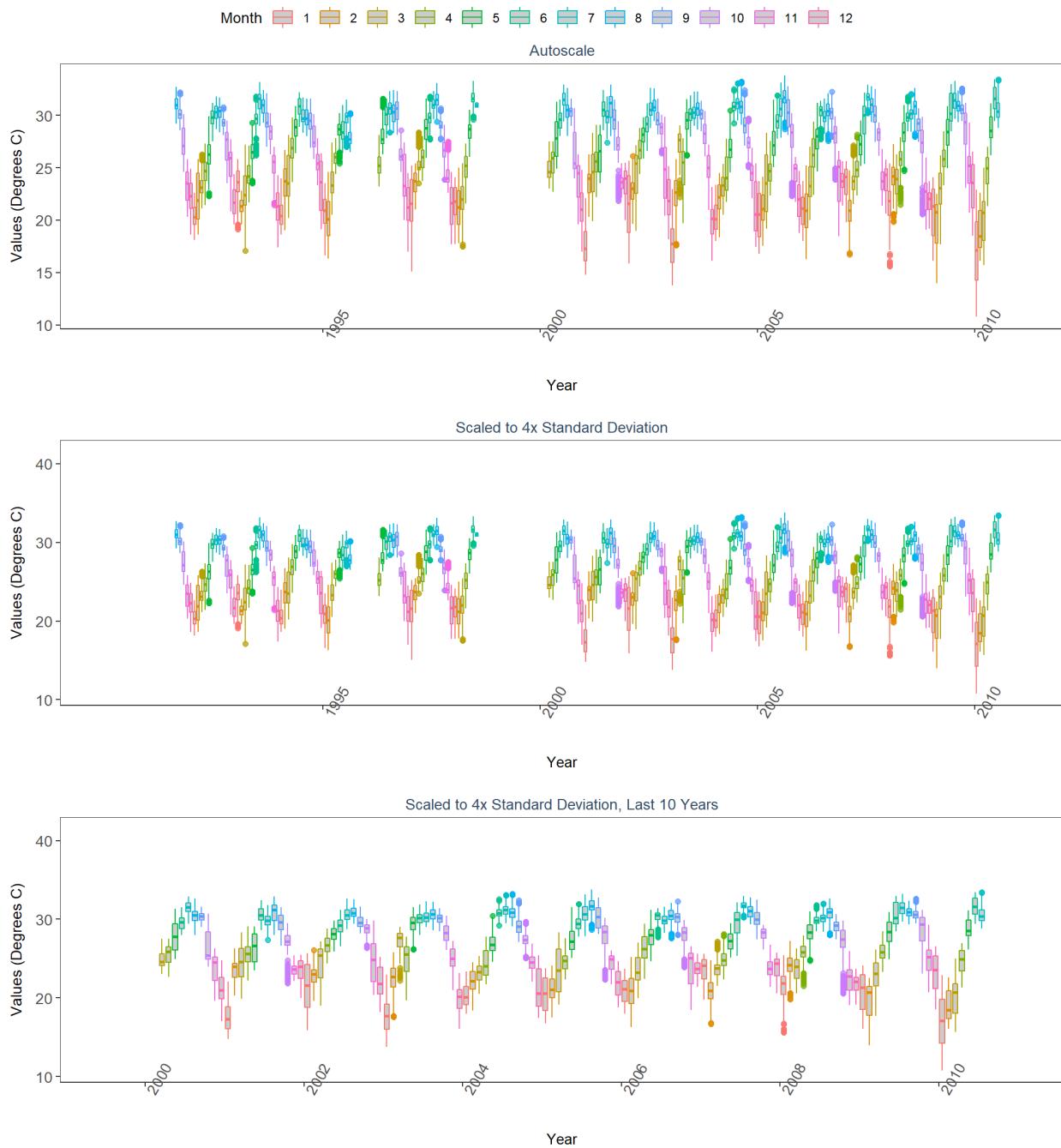
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 By Month



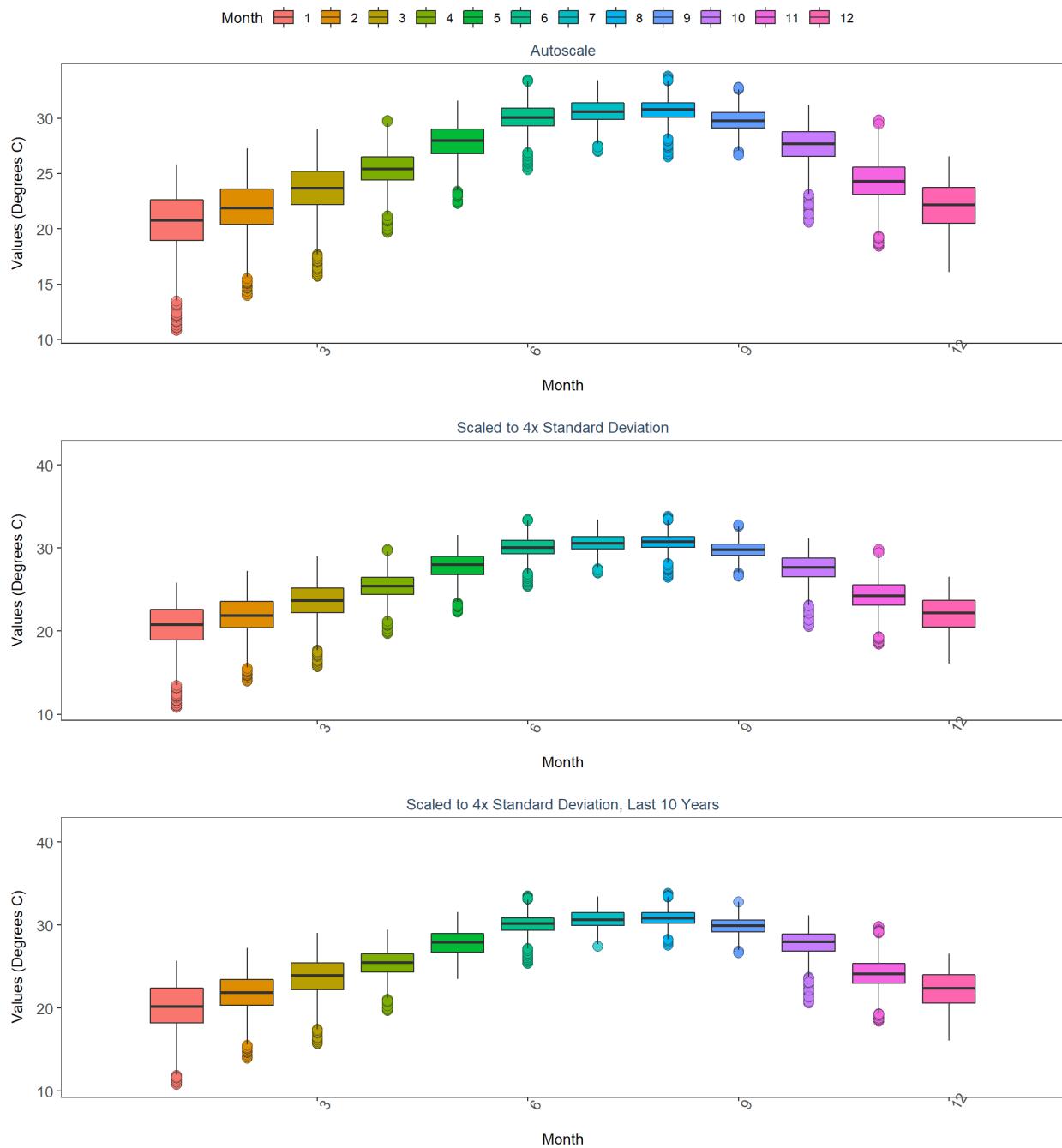
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Year



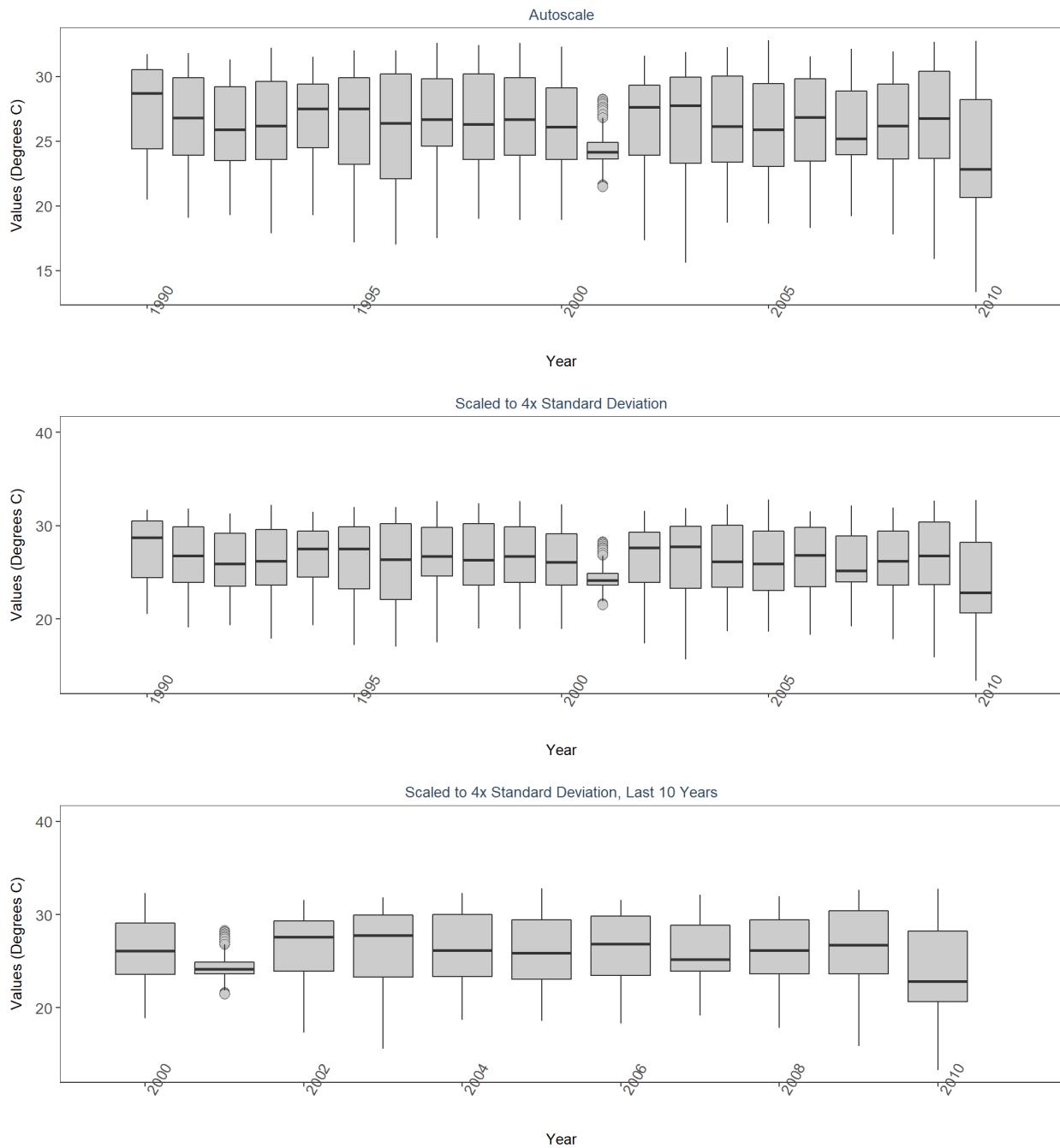
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 By Year & Month



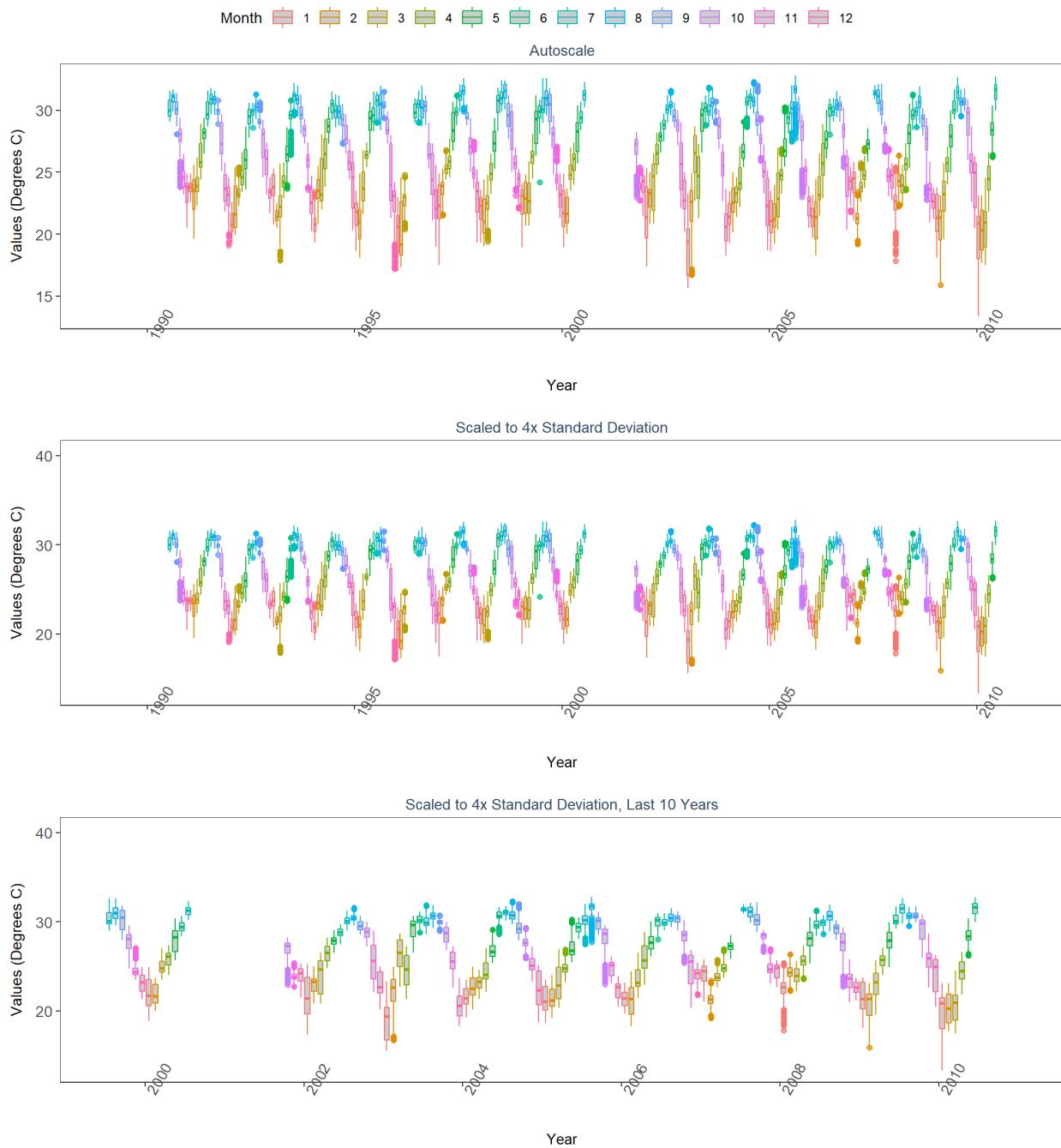
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 By Month



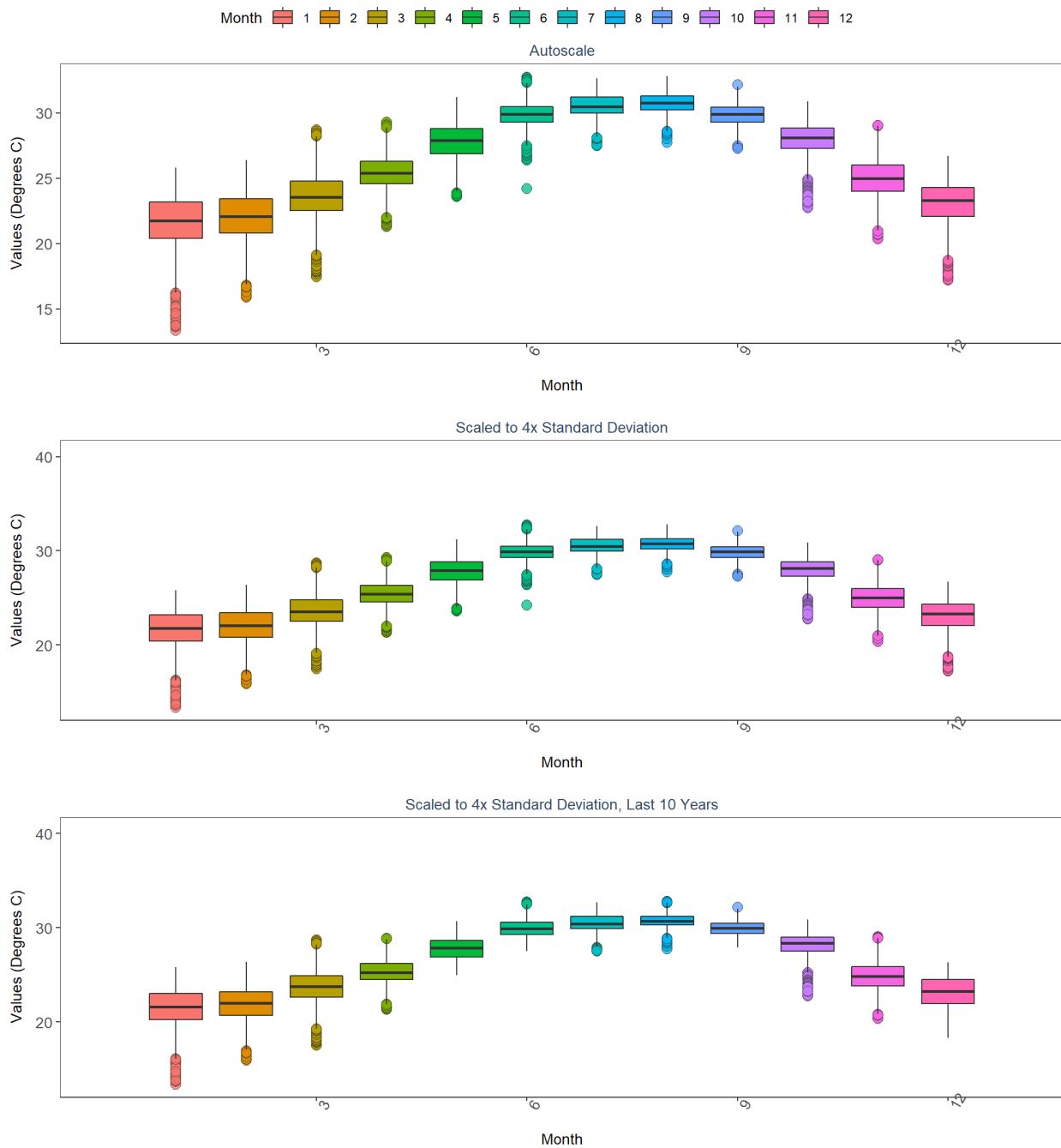
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 By Year



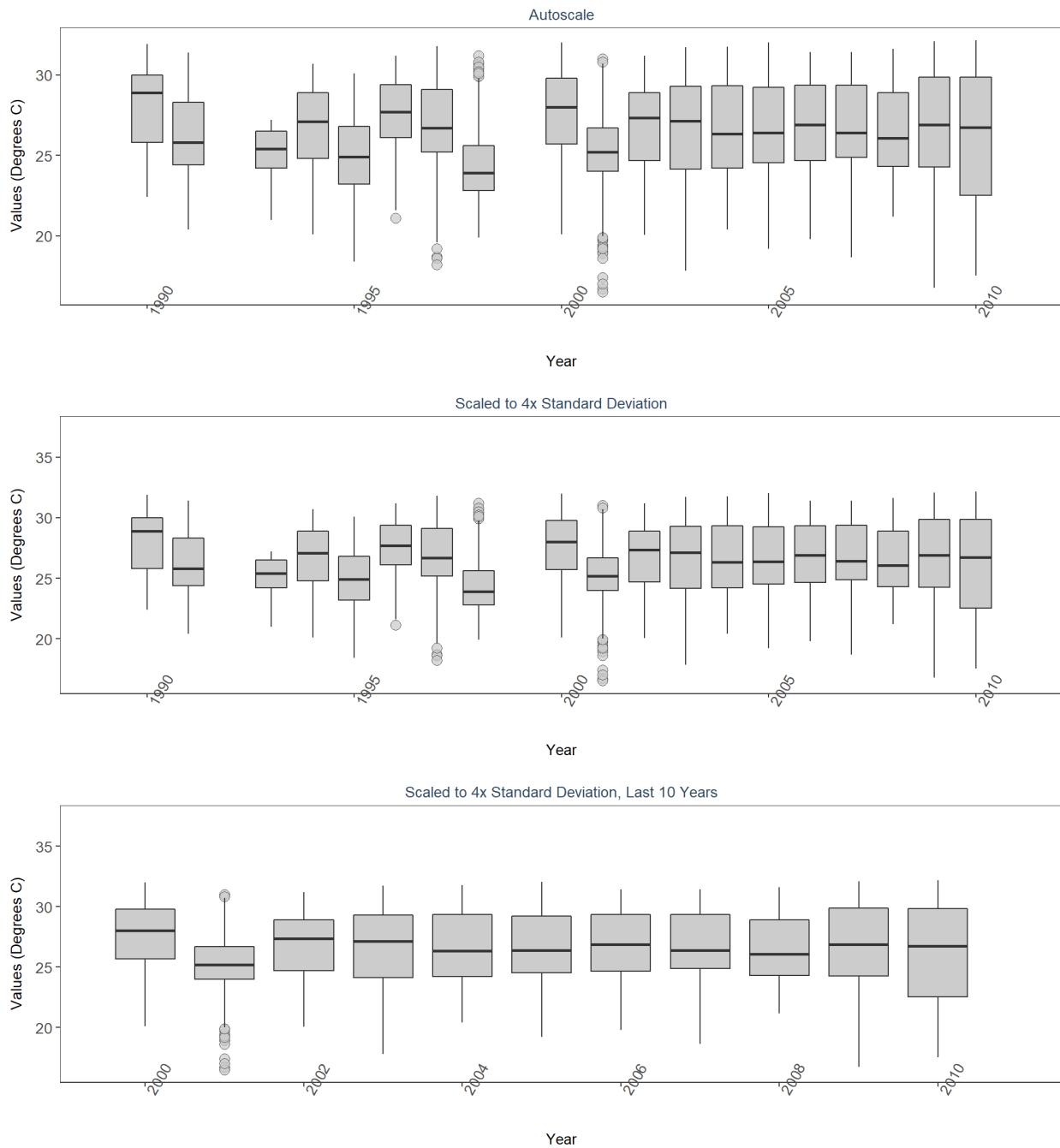
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Year & Month



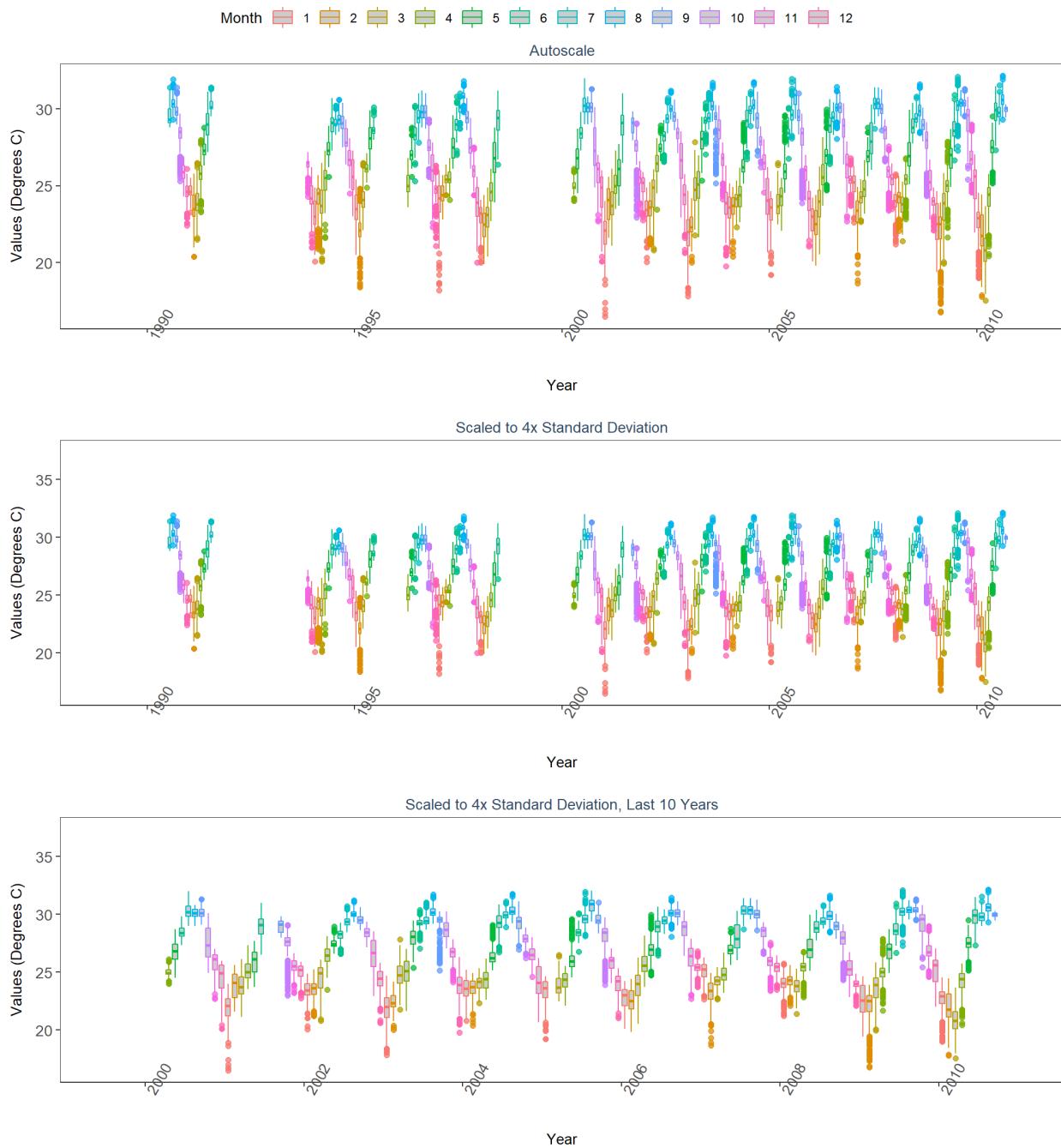
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 By Month



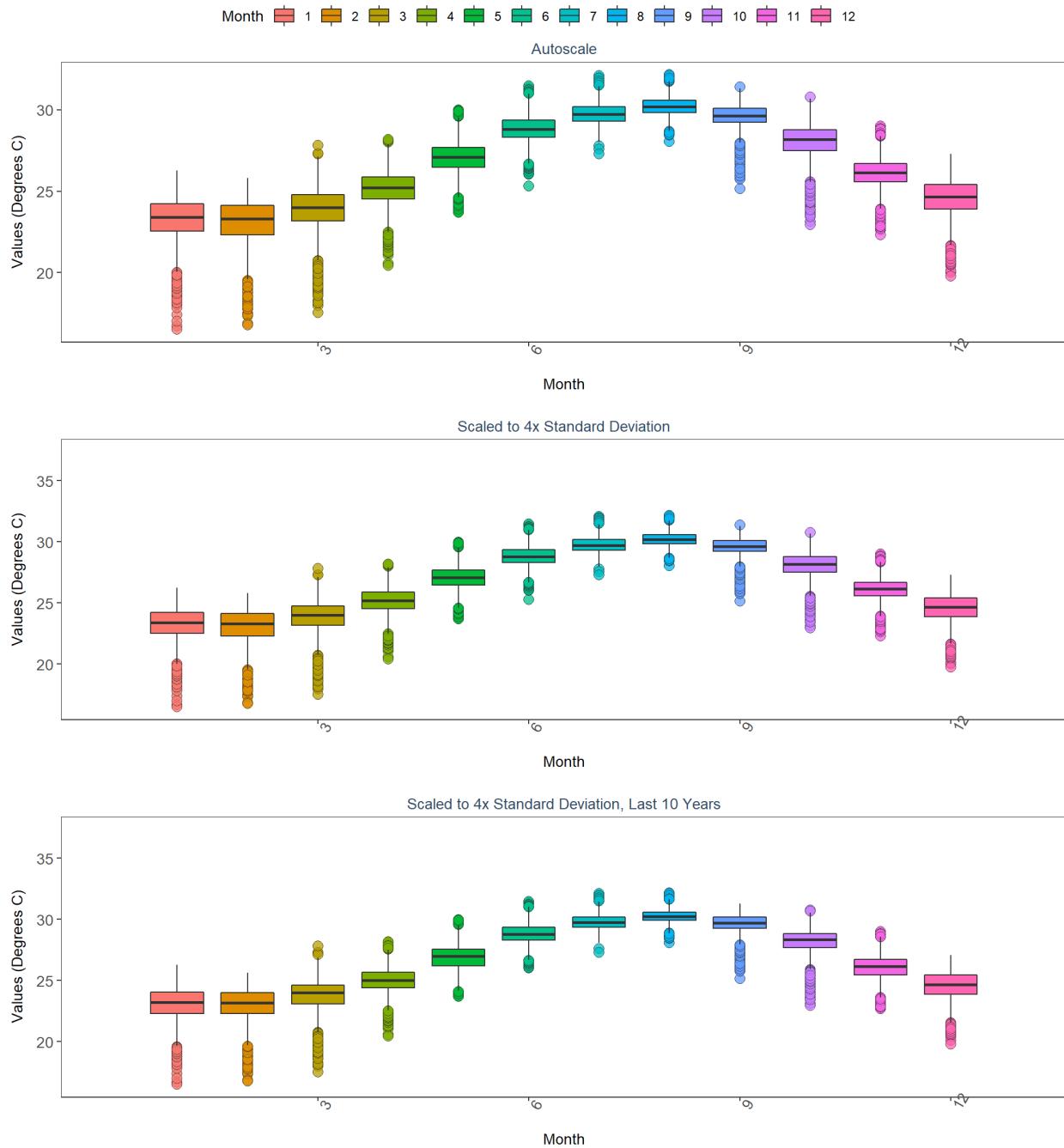
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Year



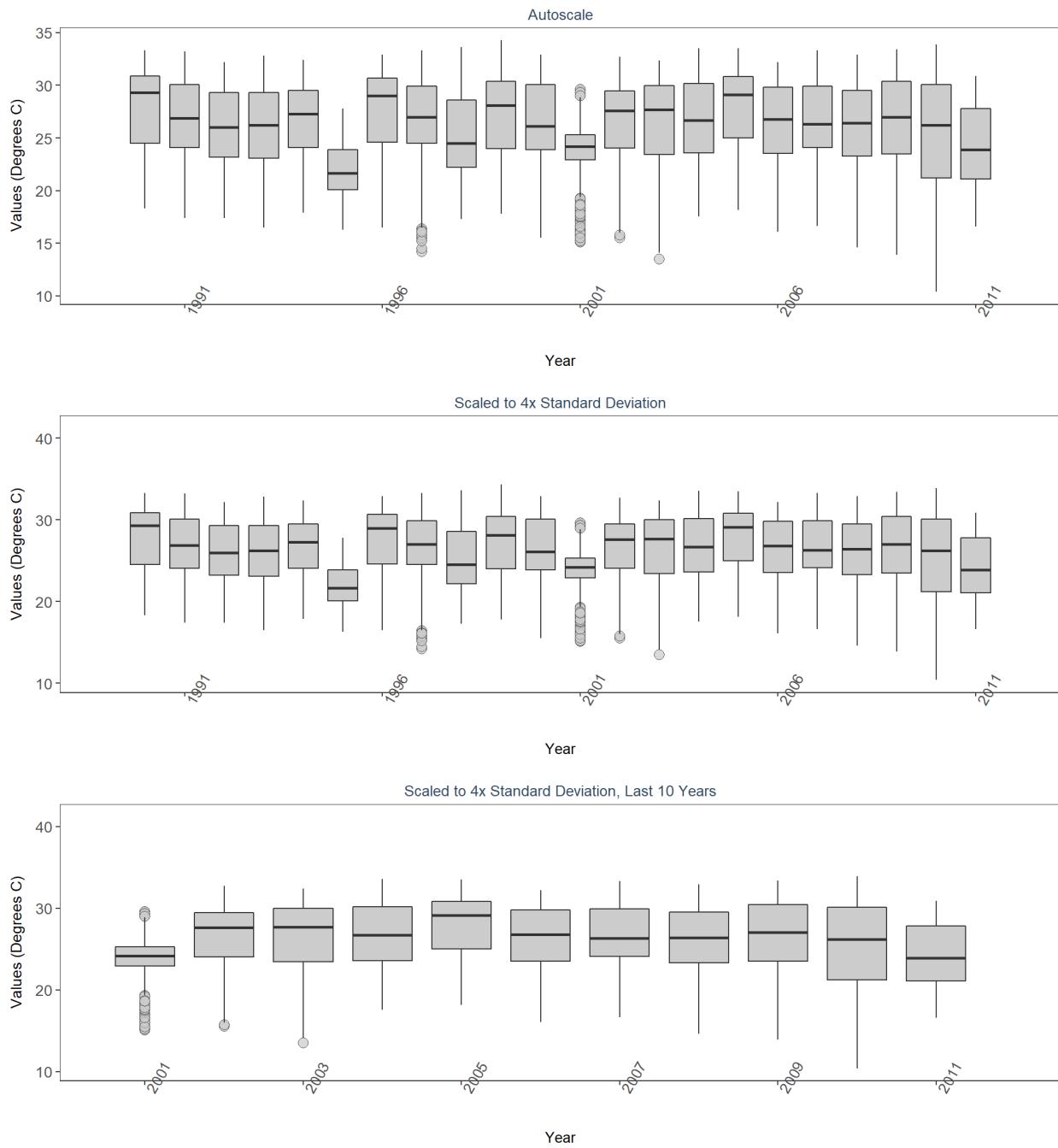
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 By Year & Month



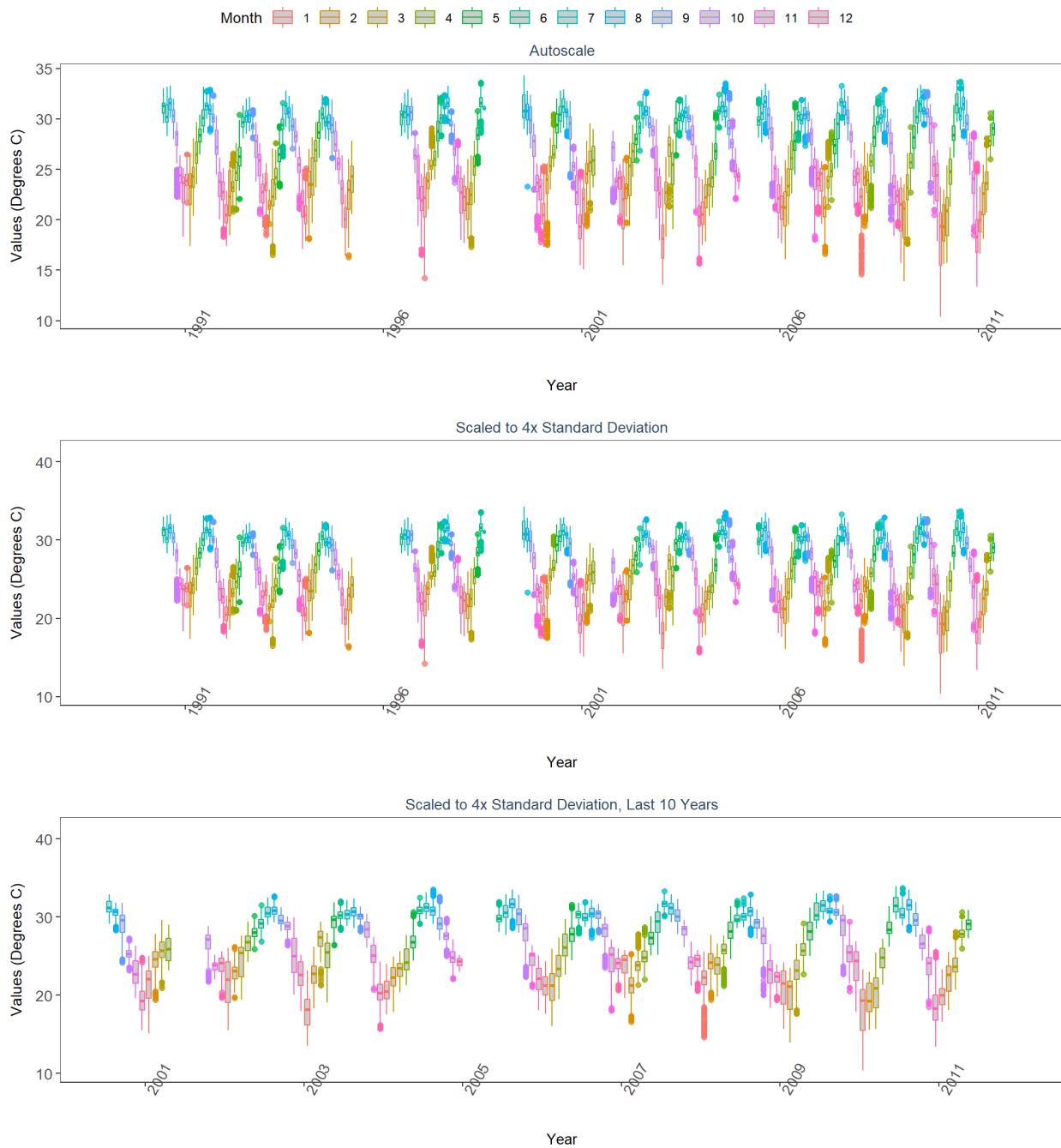
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 By Month



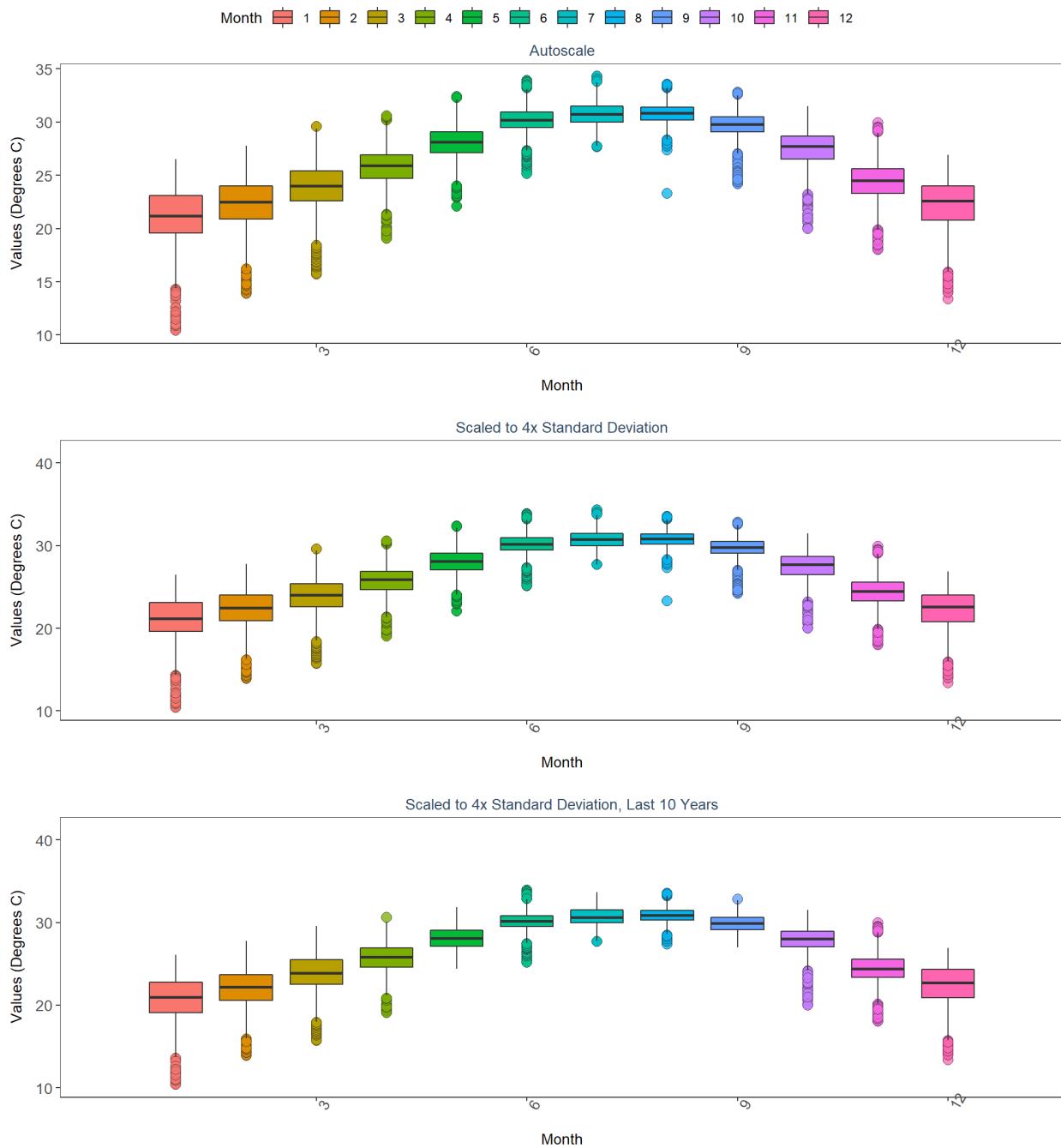
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Year



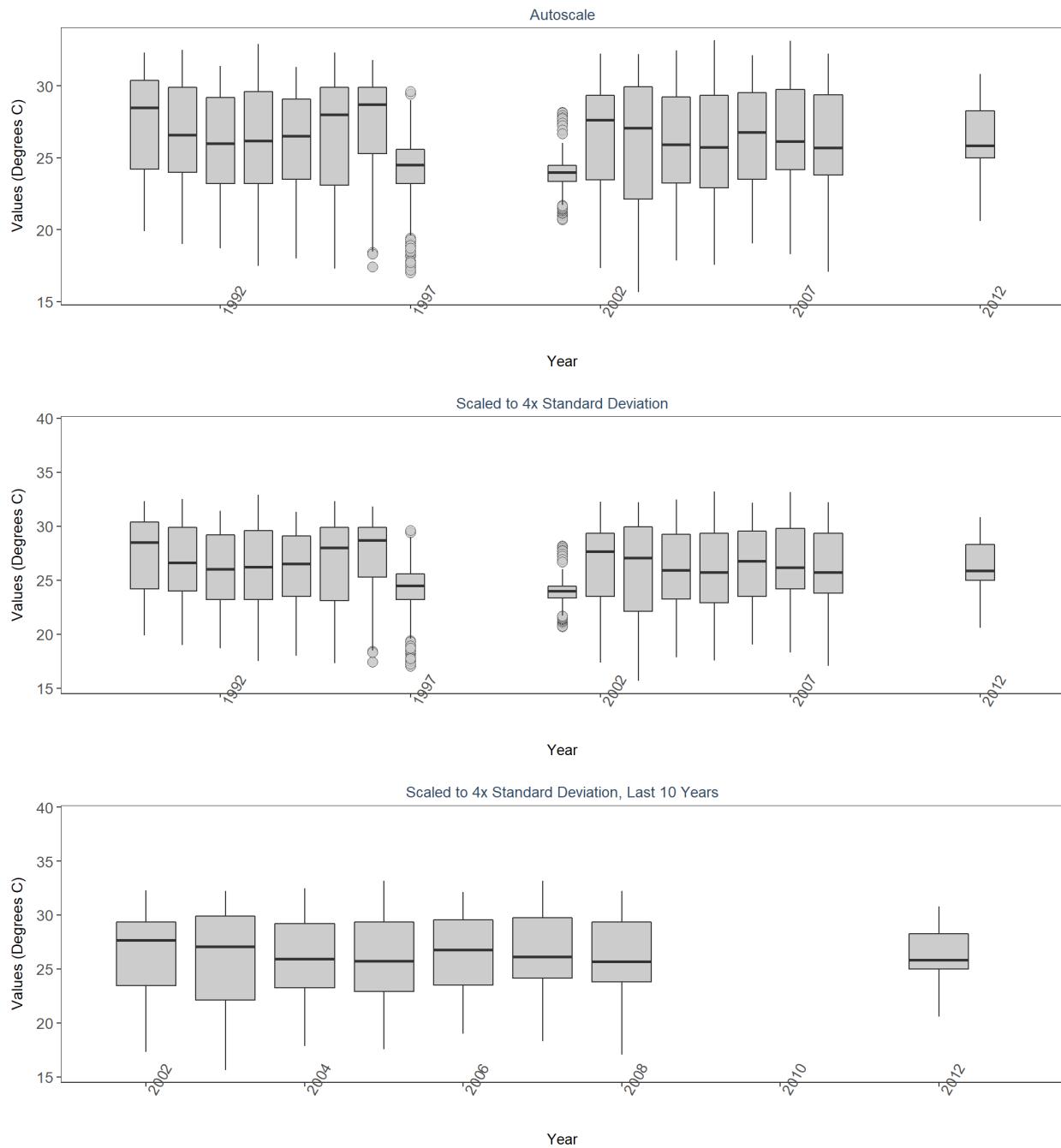
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 By Year & Month



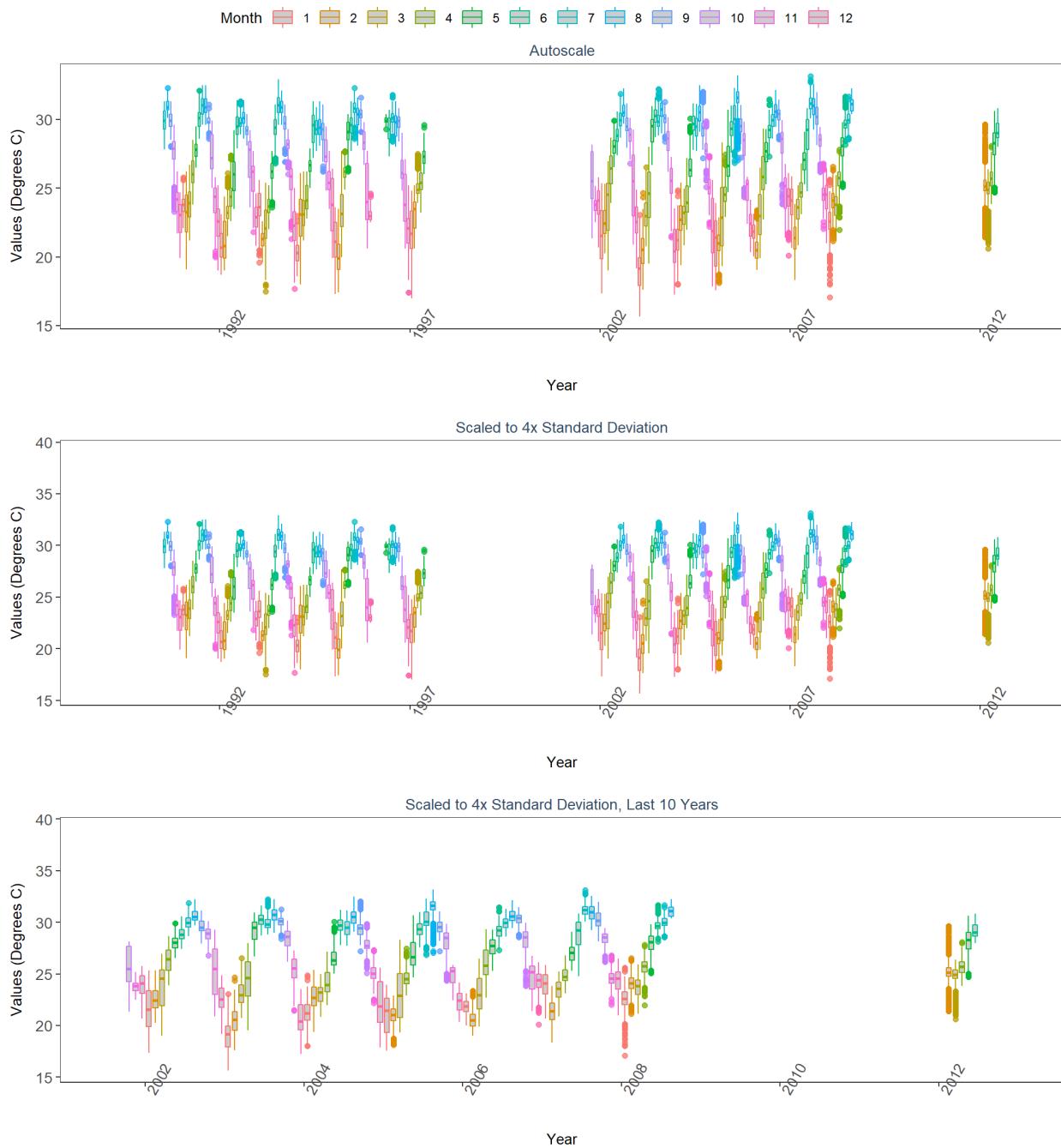
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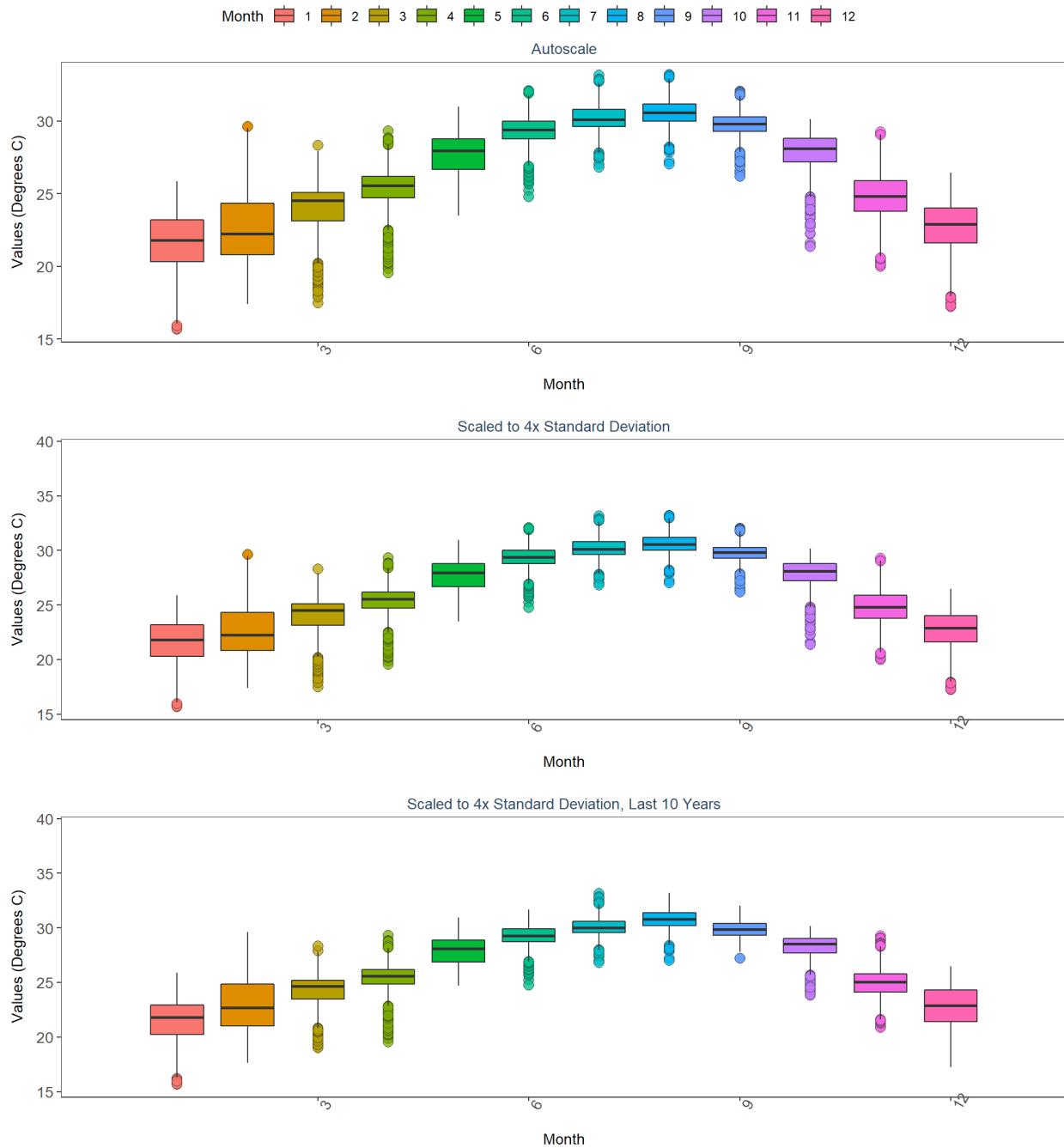
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 FKNMS_BOCA_GRND
 By Year



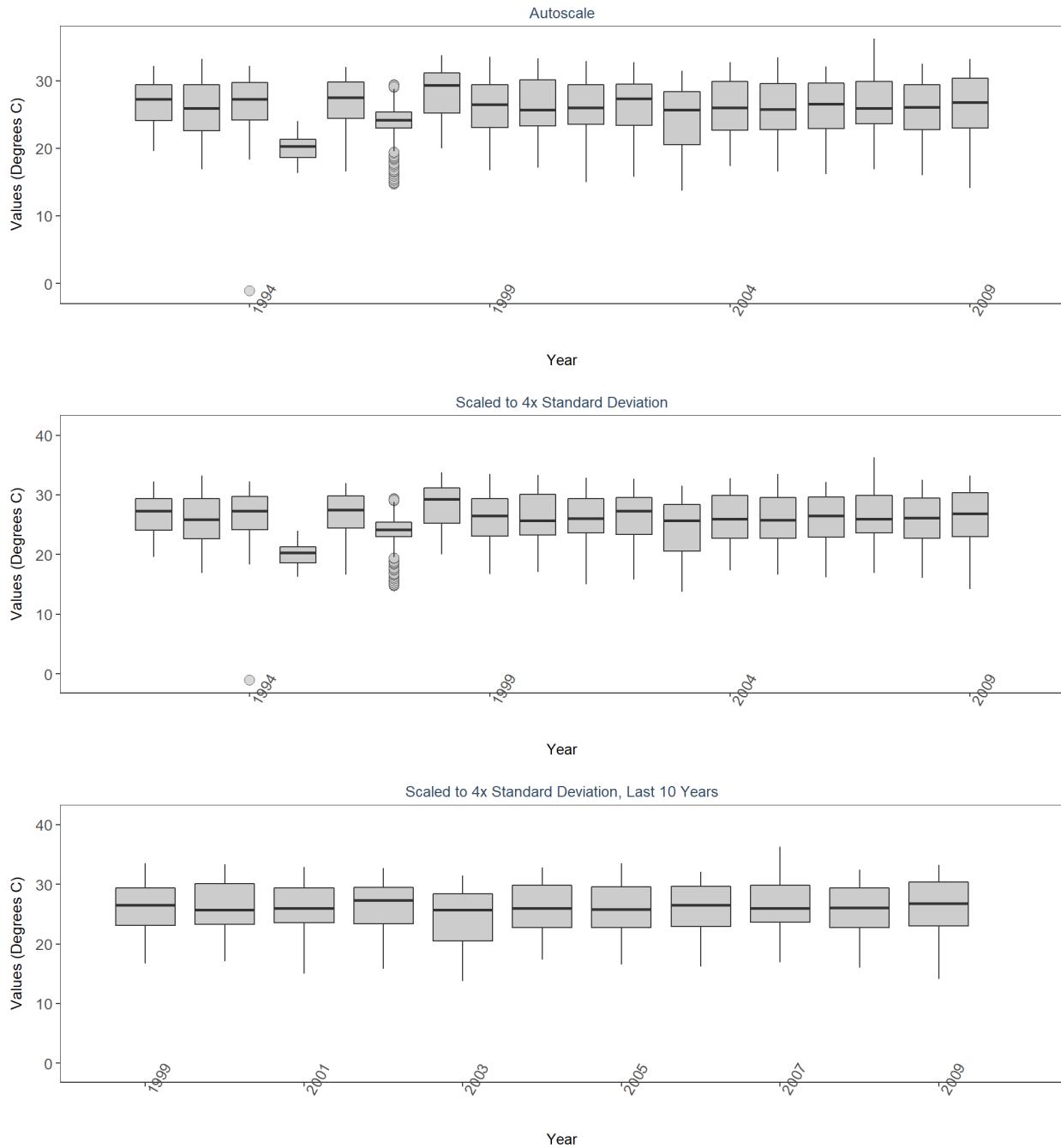
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 By Year & Month



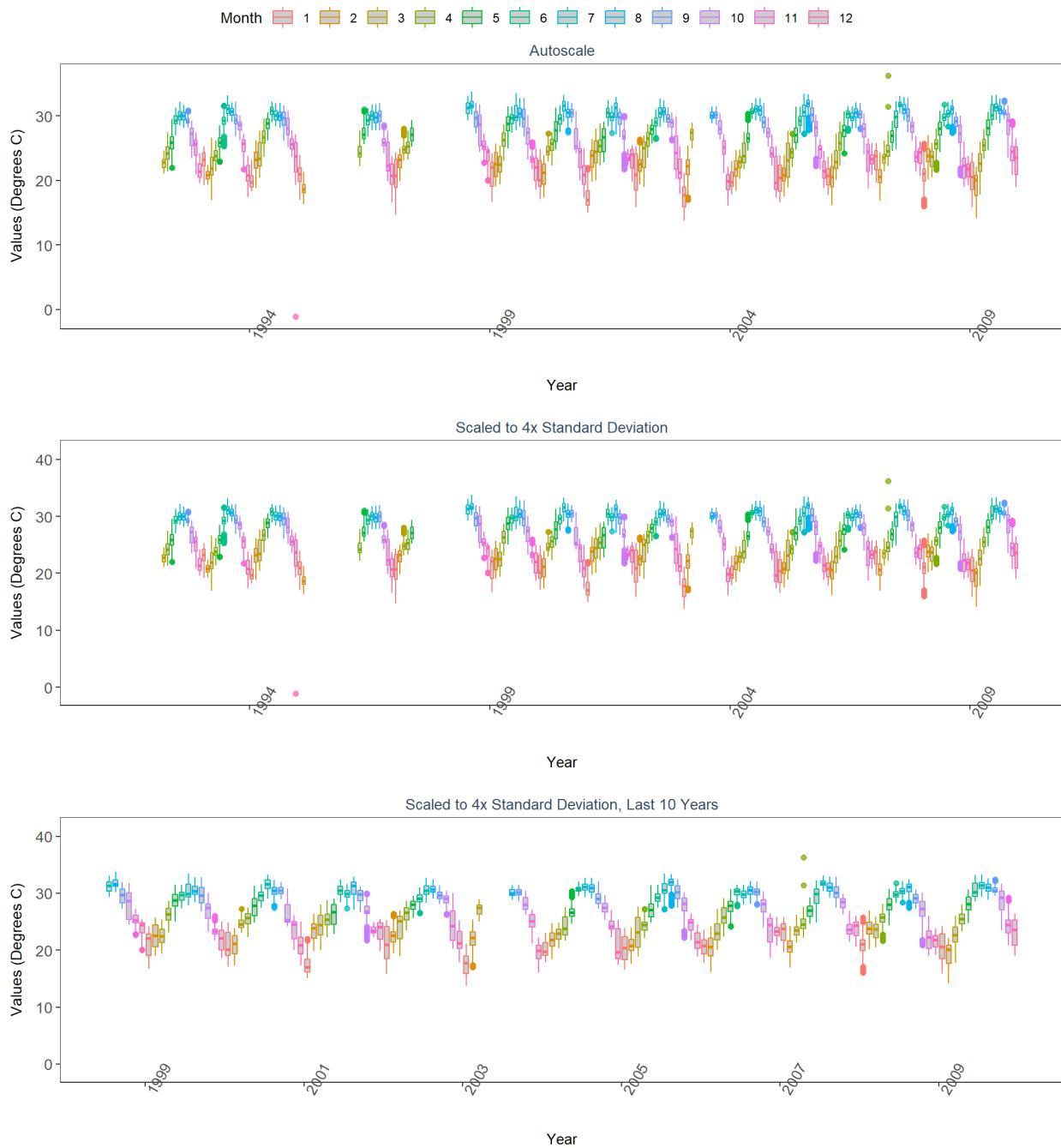
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 By Month



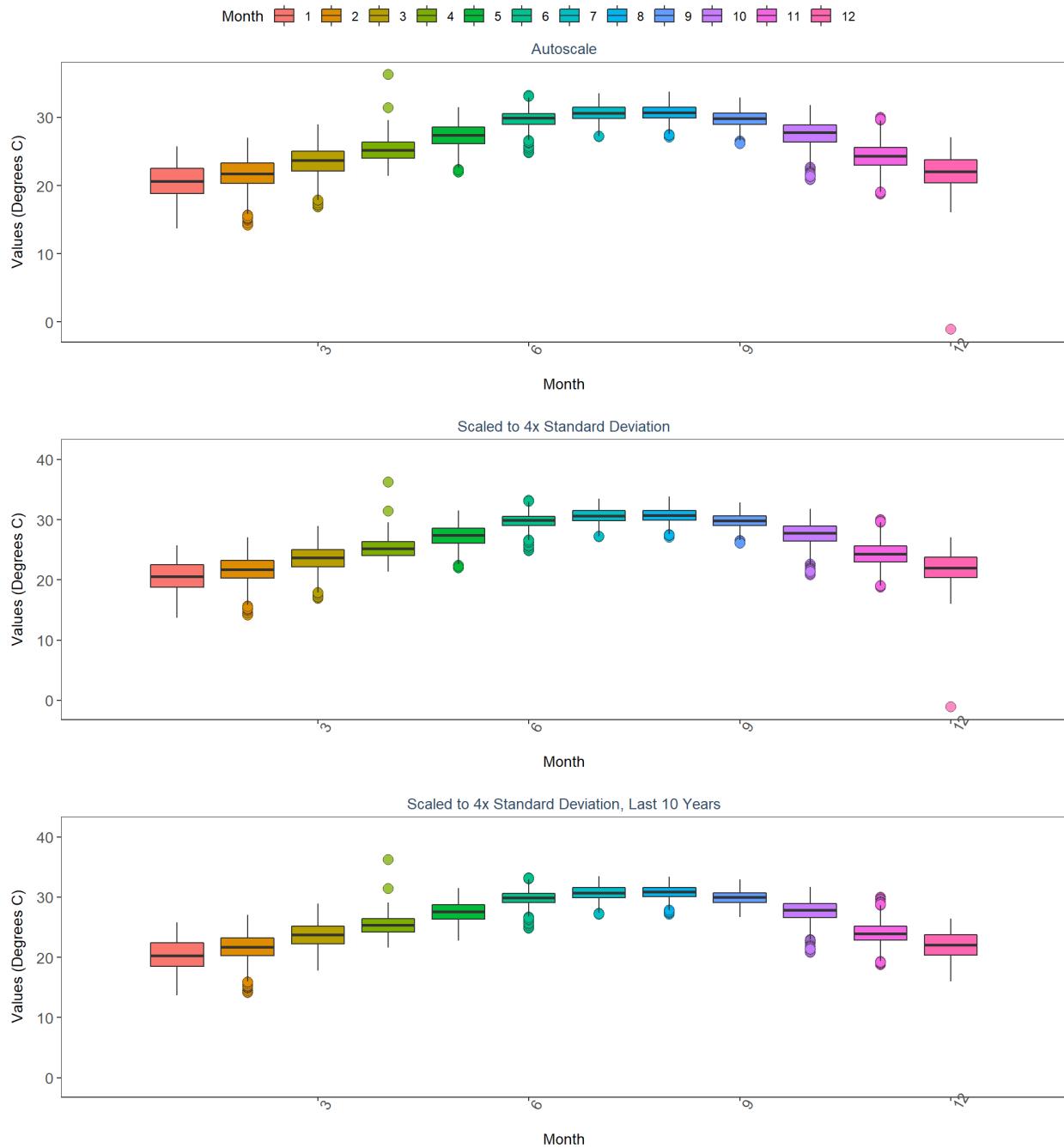
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Year



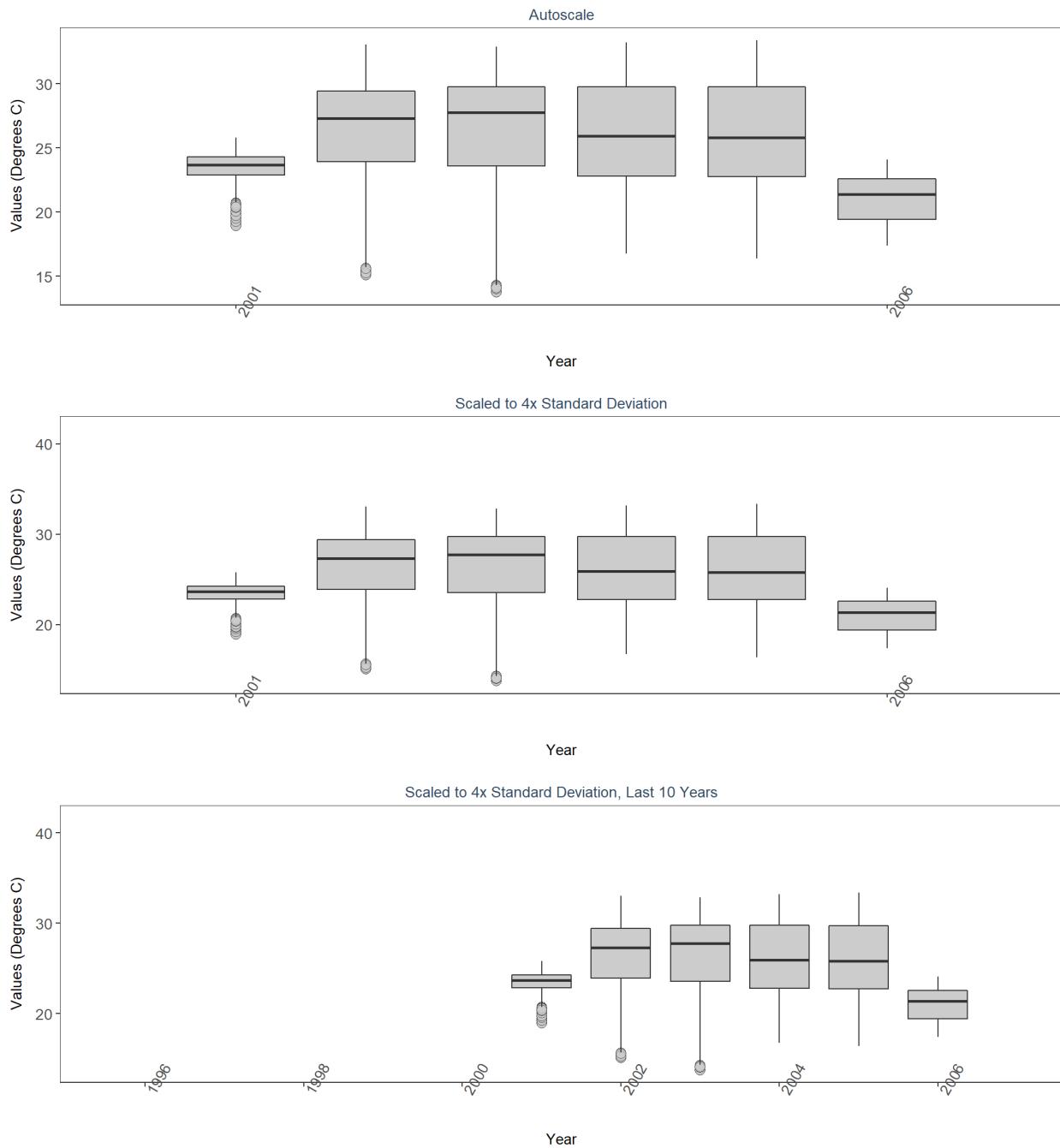
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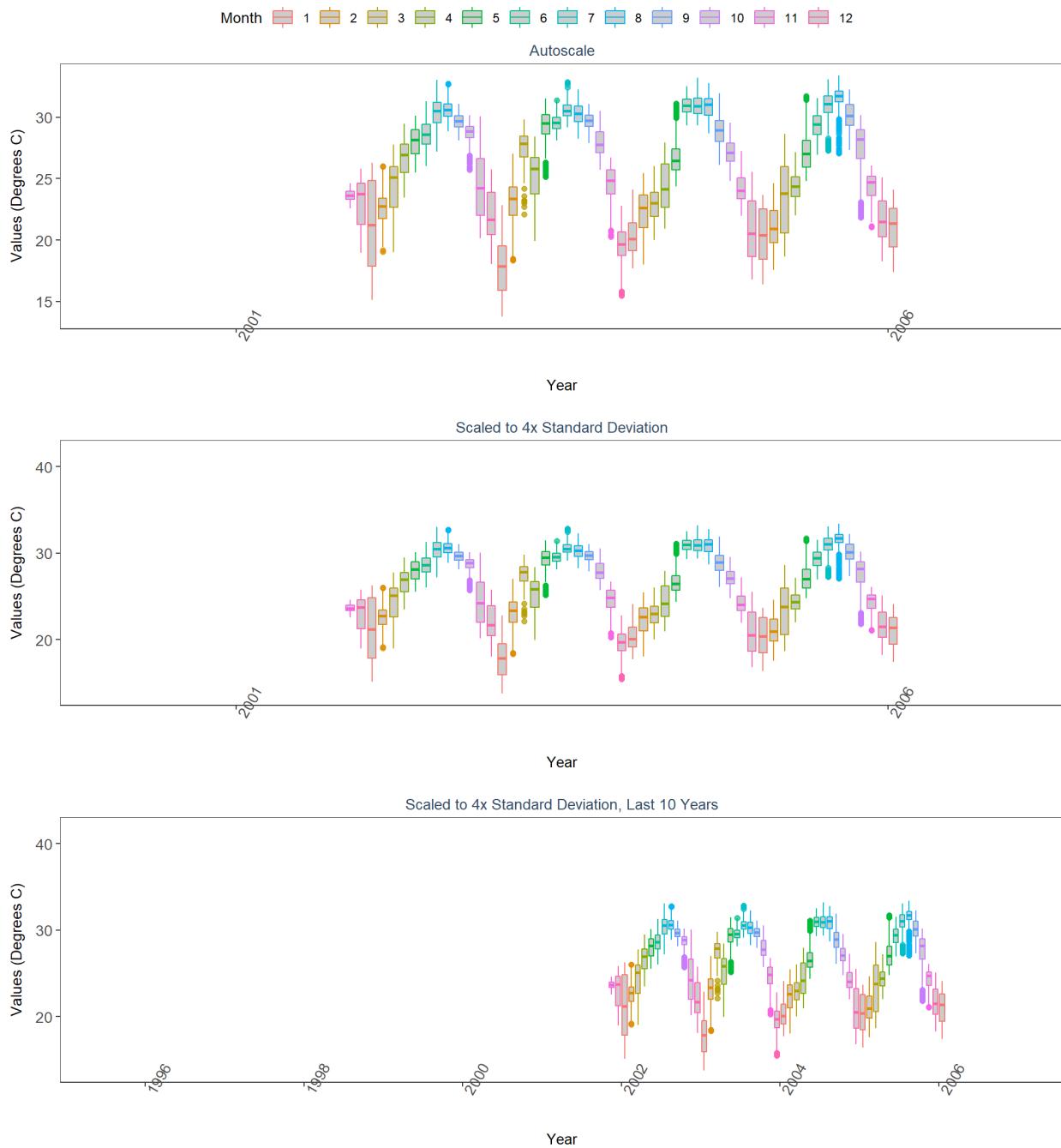
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 FKNMS_BULLARD
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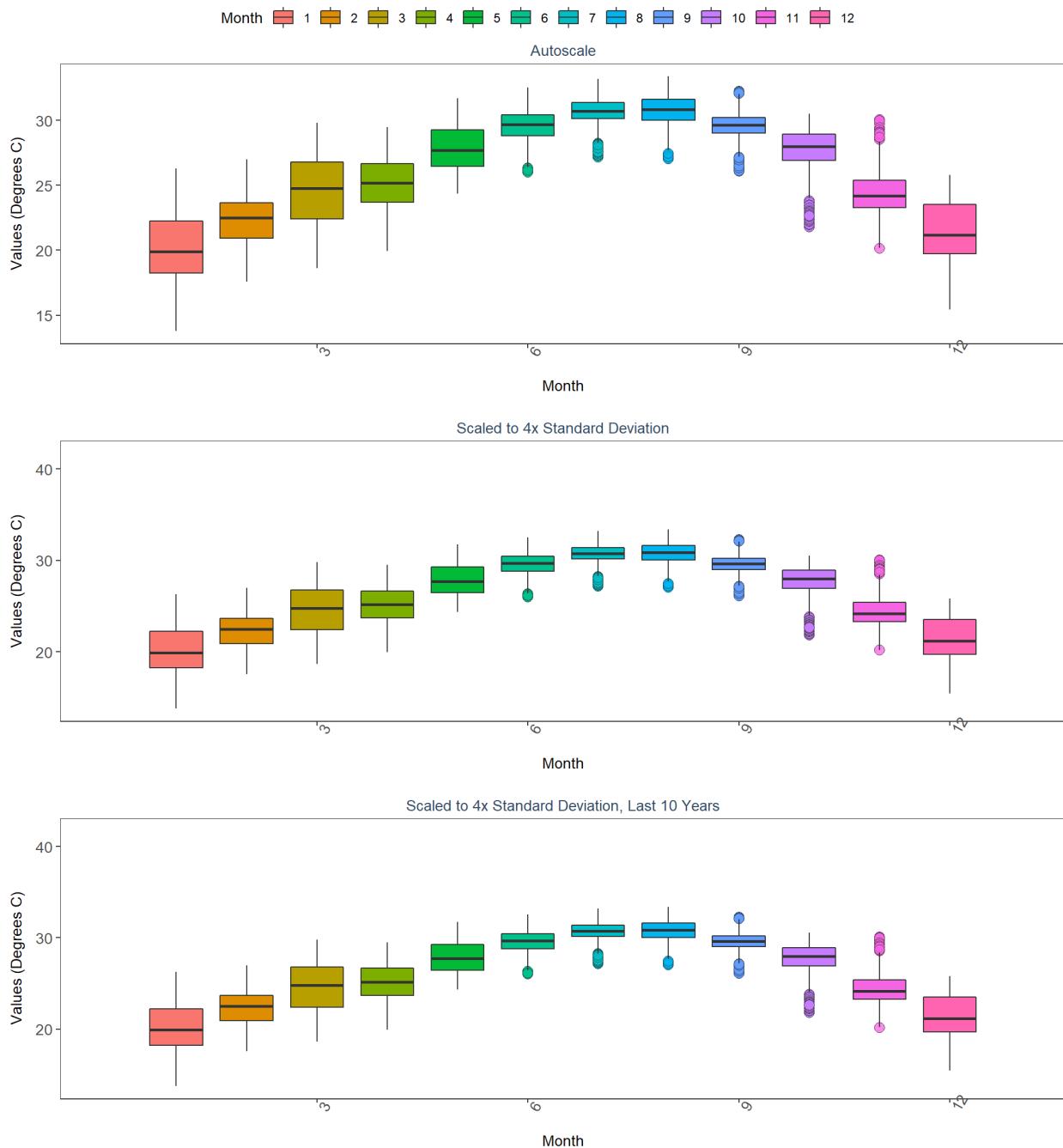
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Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_CARD_SND
By Year



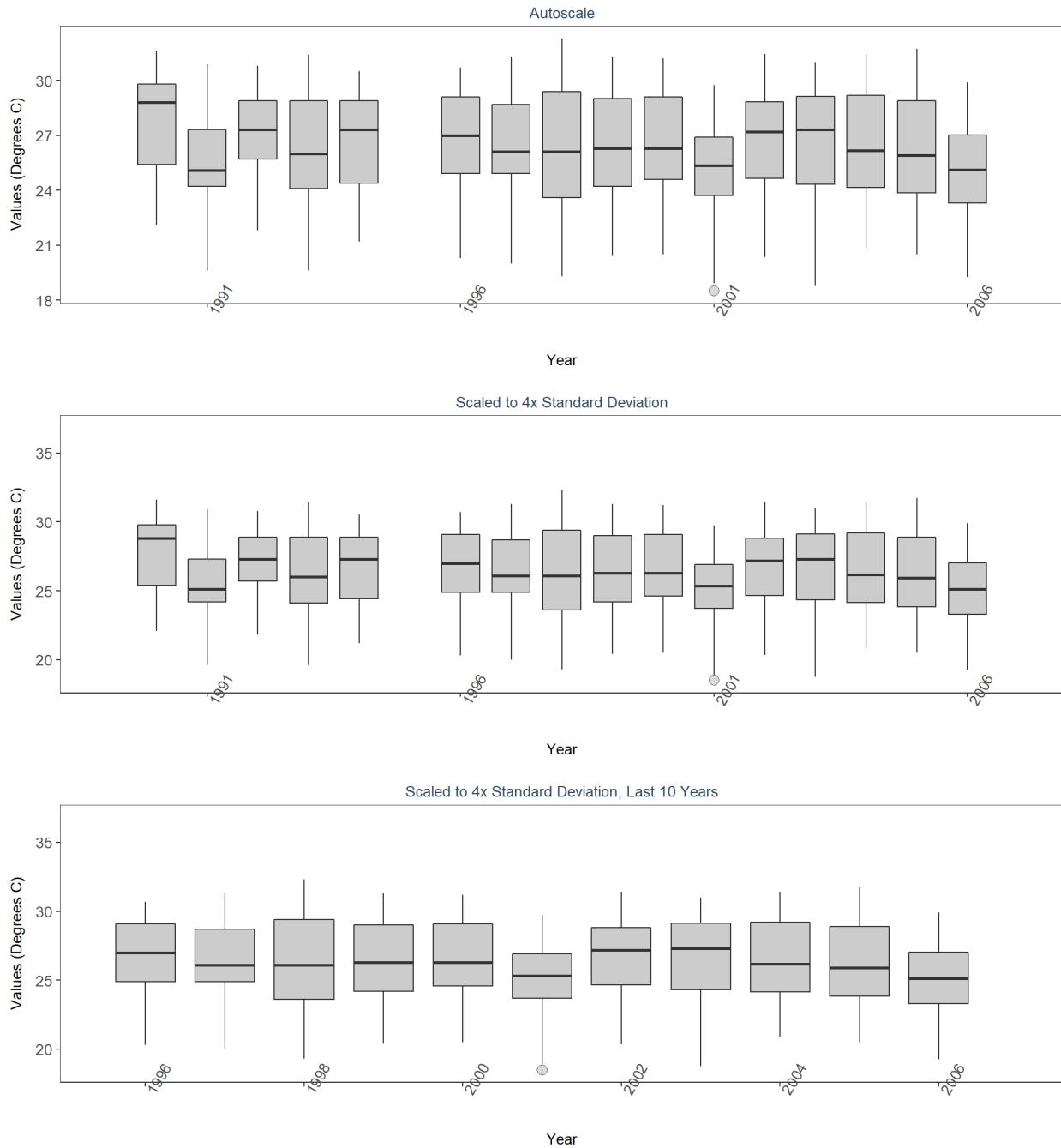
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 FKNMS_CARD_SND
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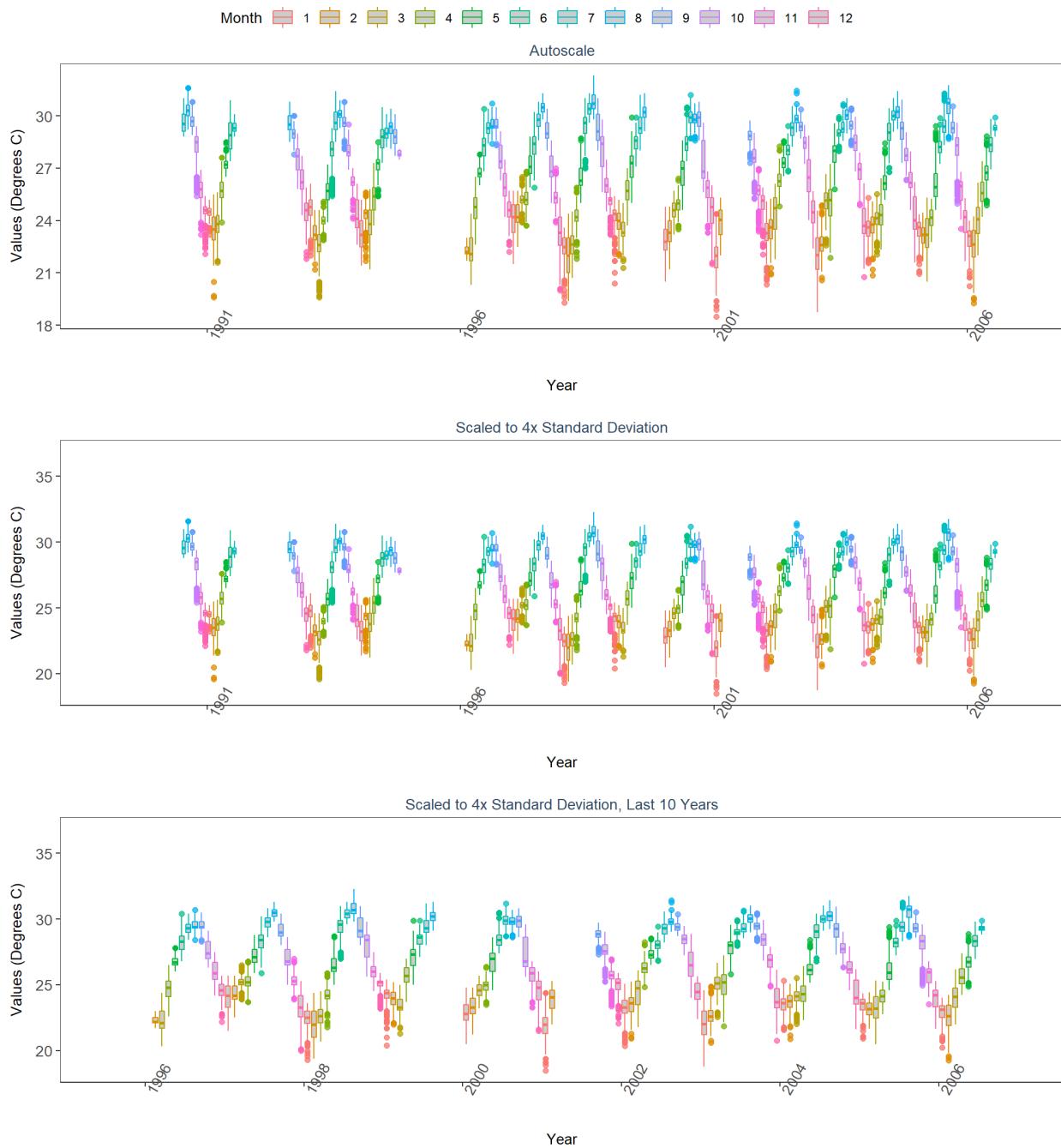
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_CARD_SND
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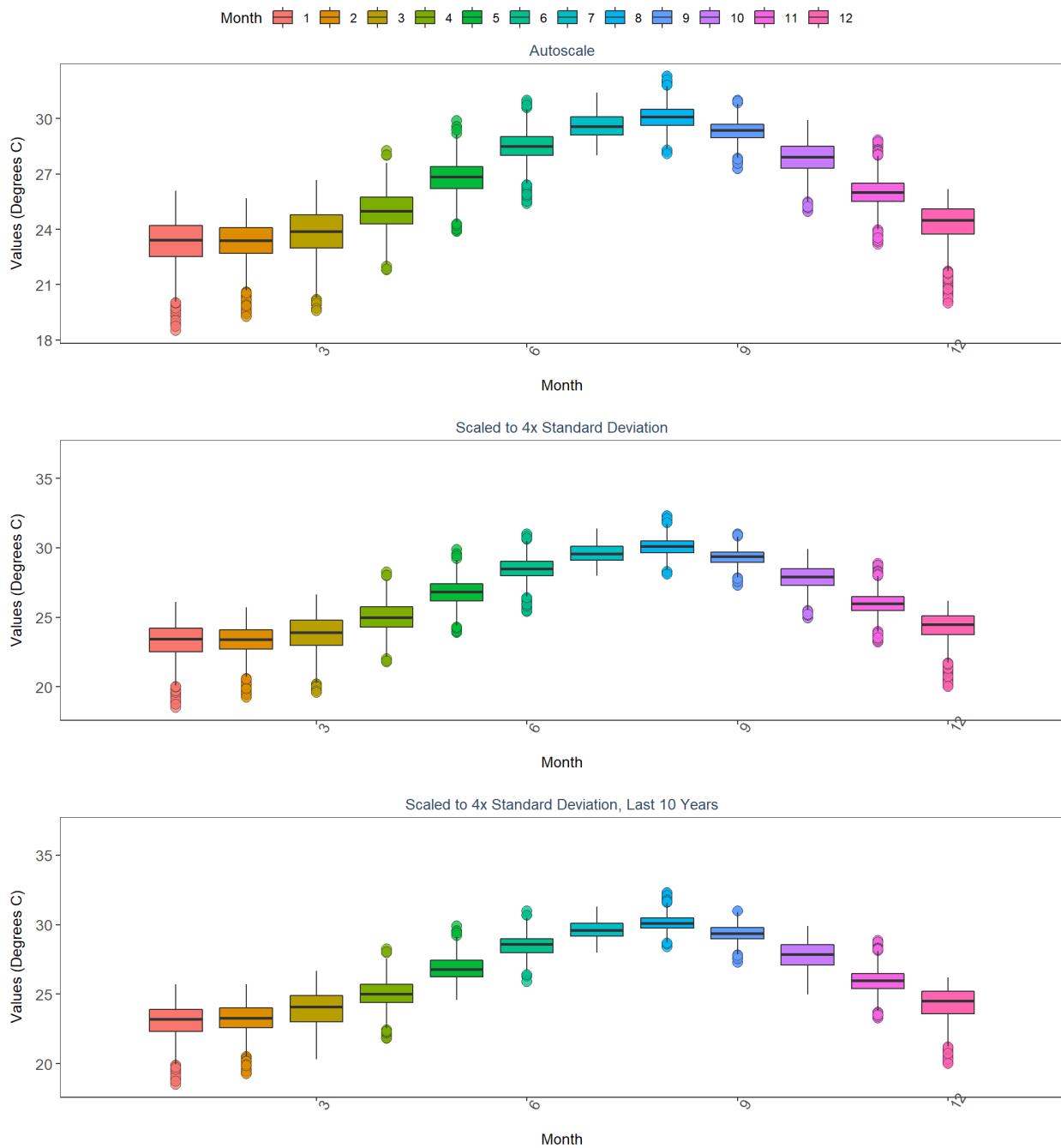
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 By Year



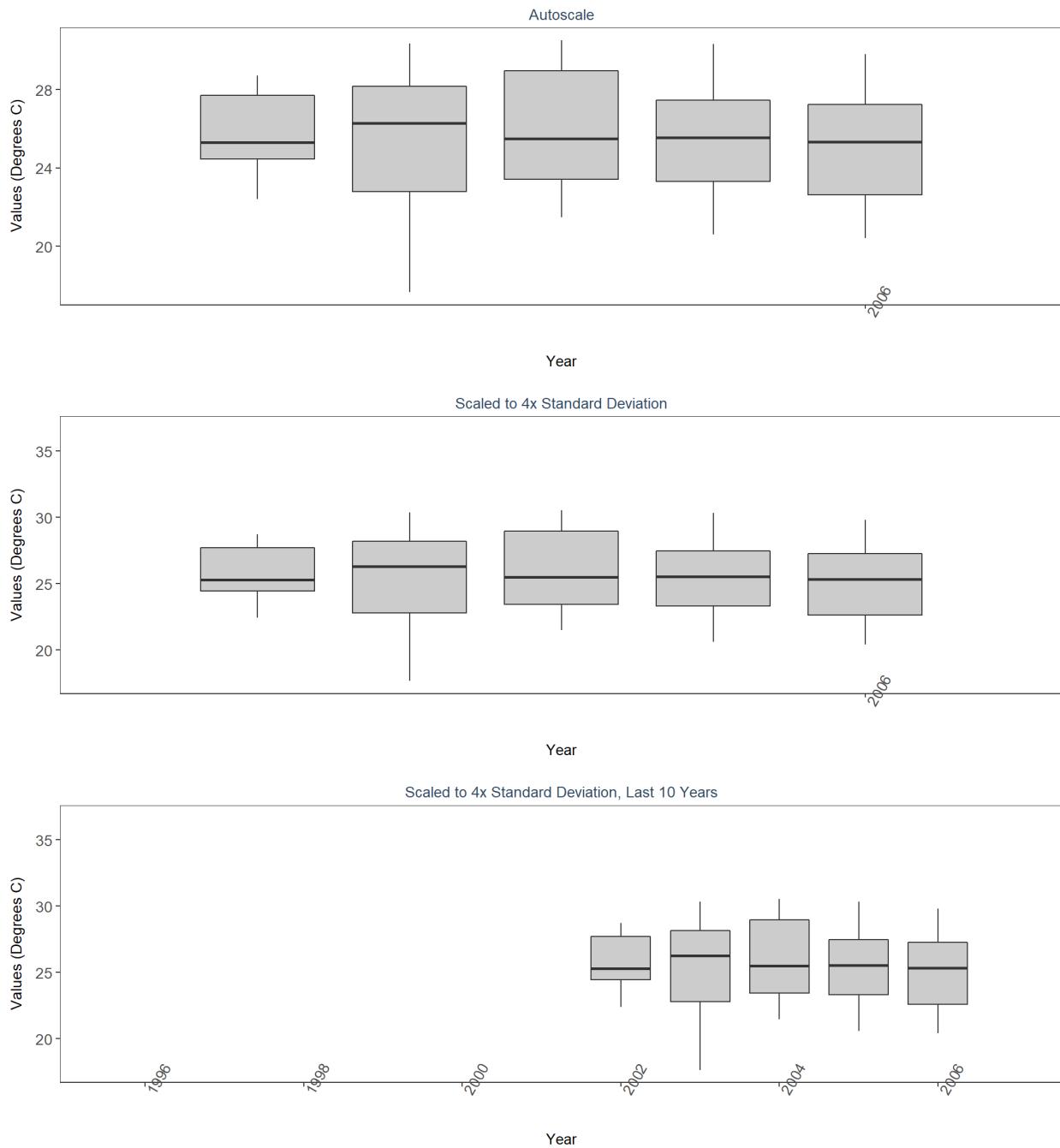
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 By Year & Month



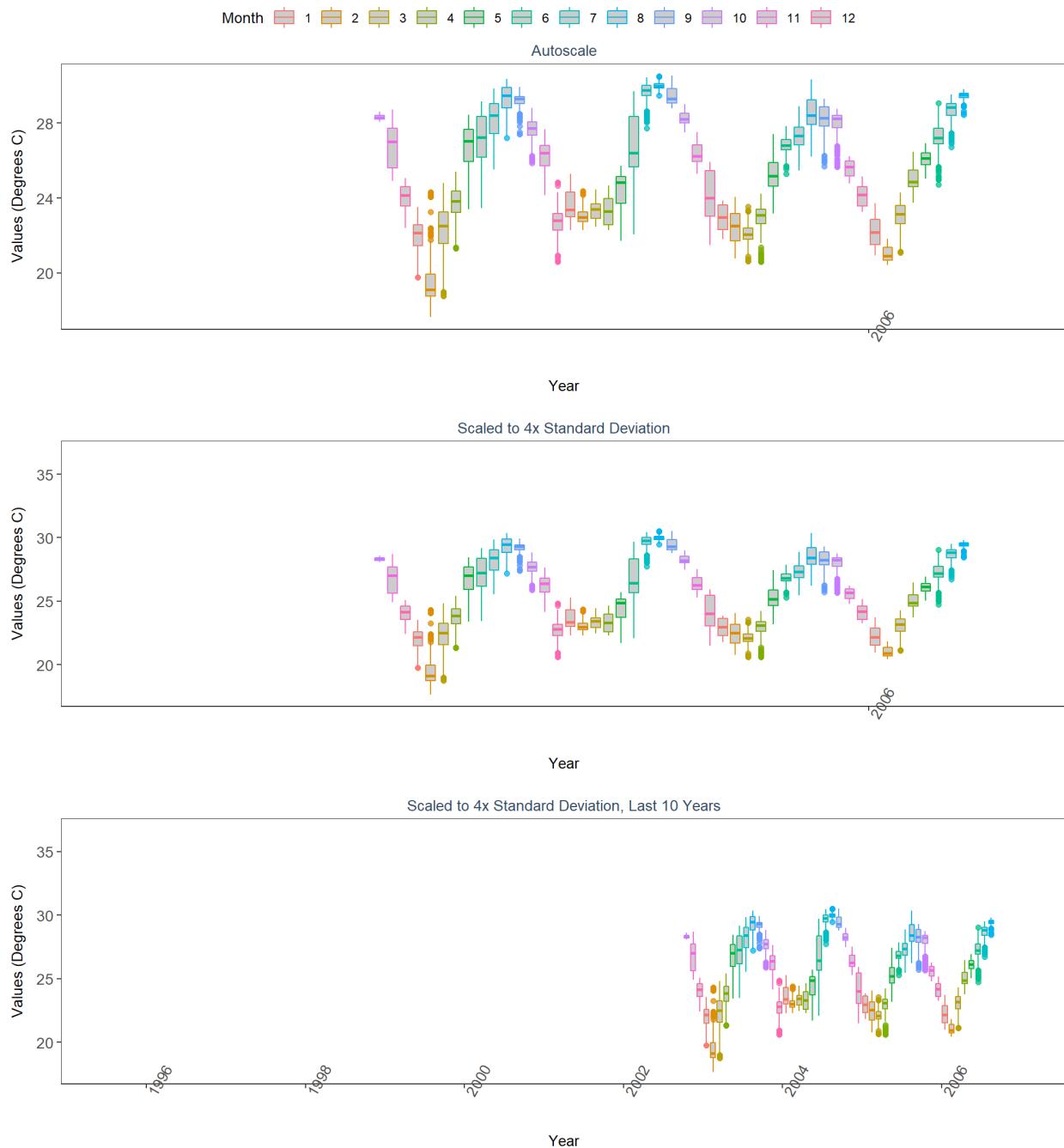
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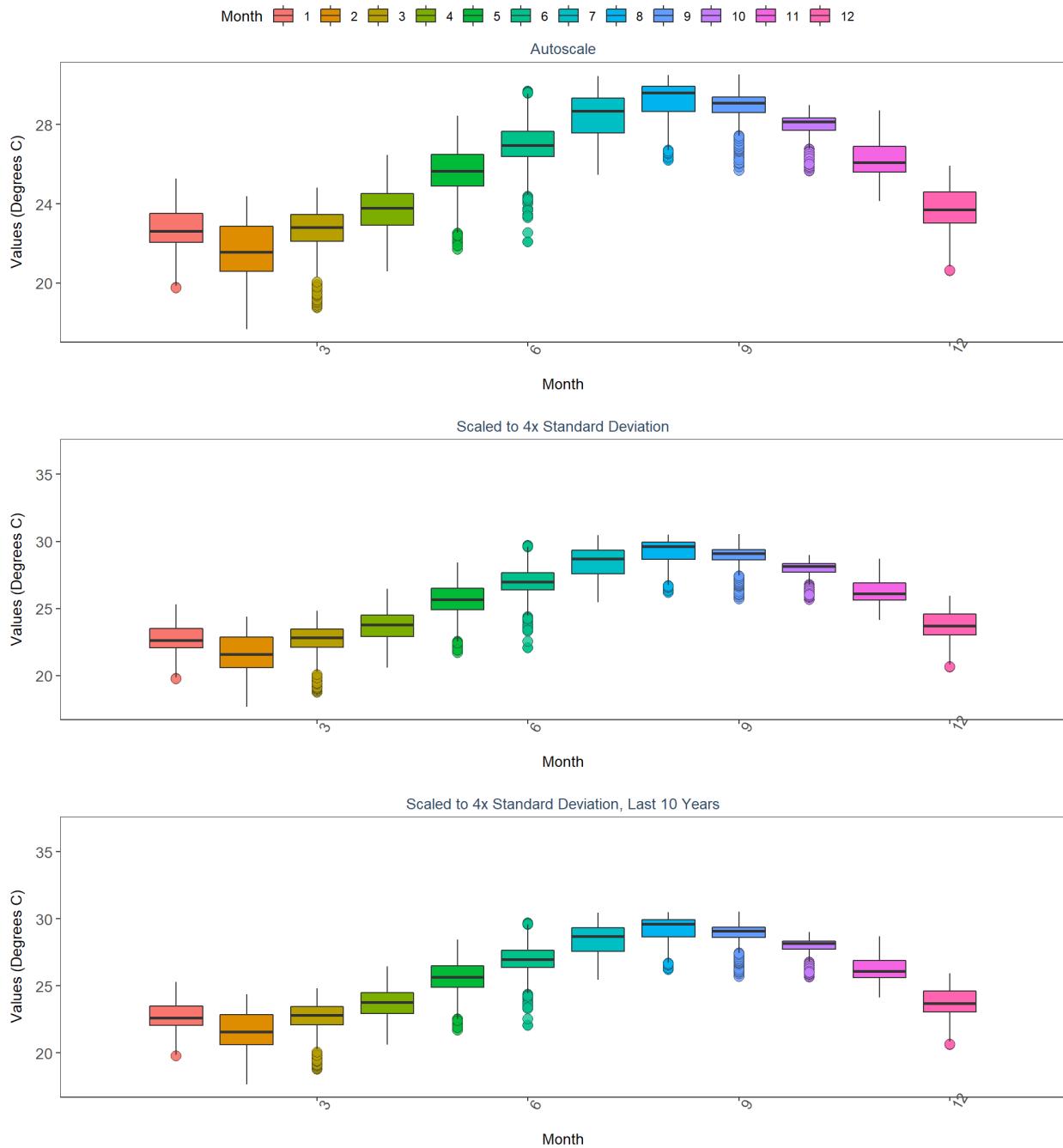
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Continuous Bottom Temperature Measurements along the Florida Reef Tract
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By Year



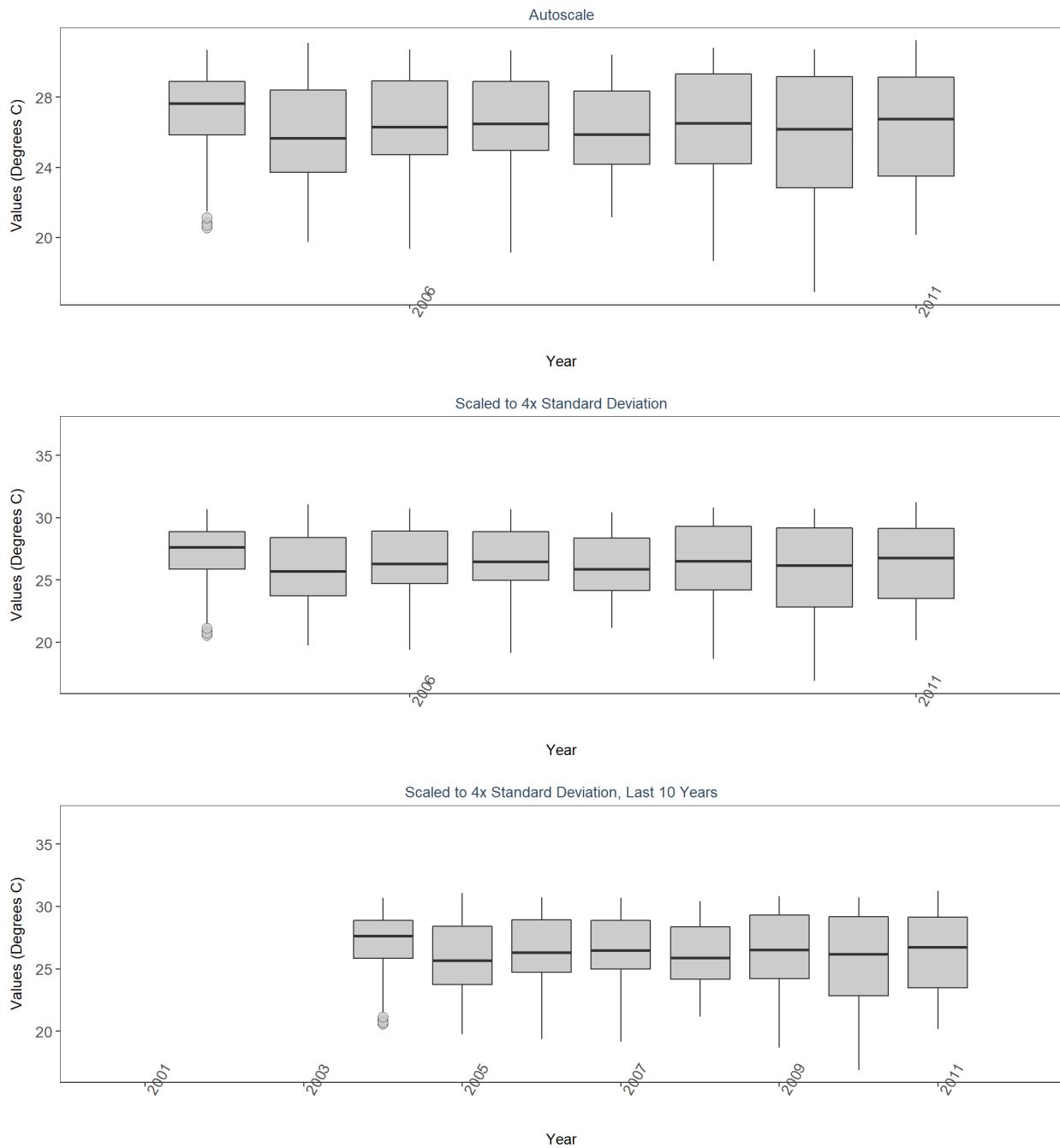
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_DIEGO_TER
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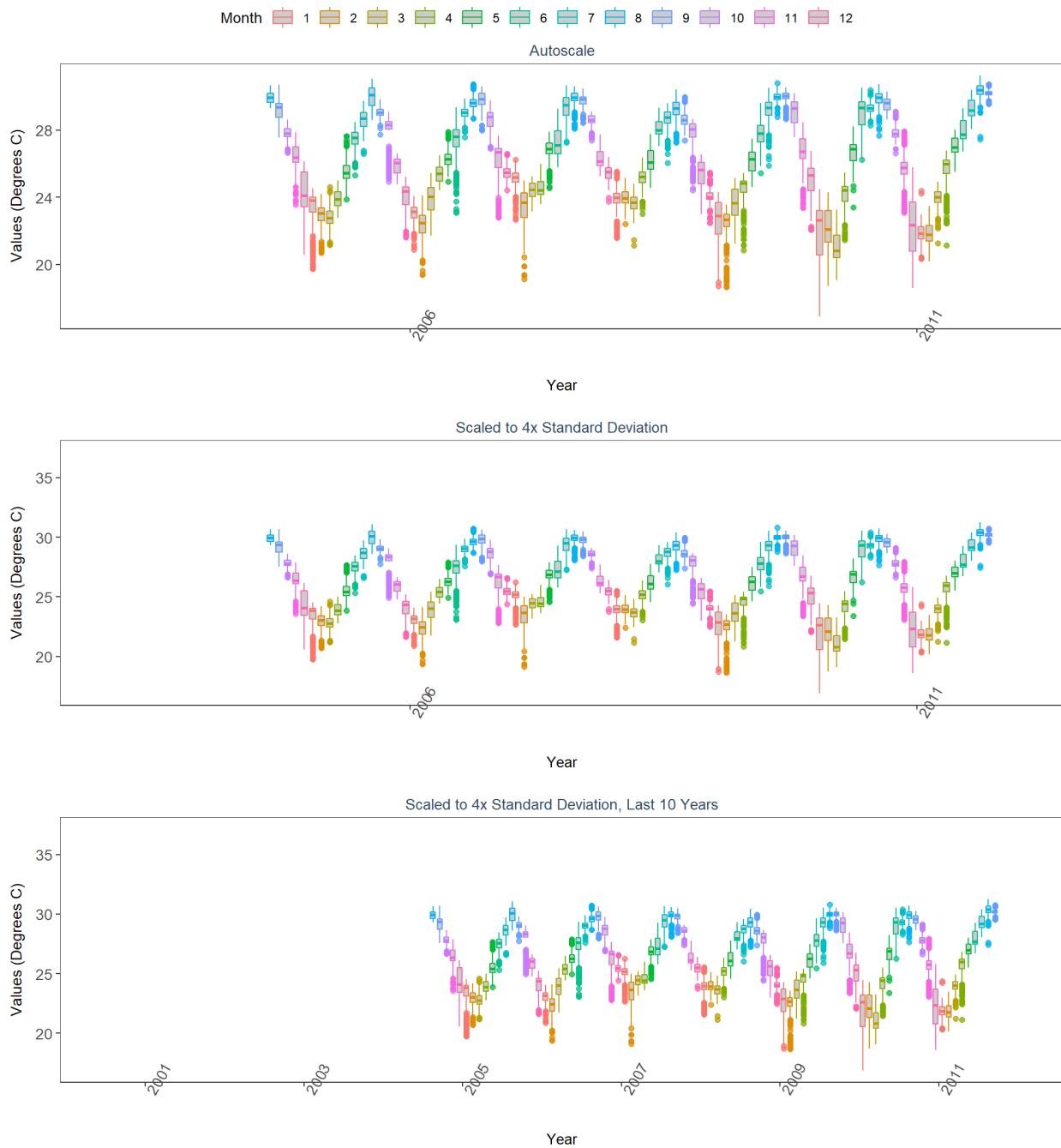
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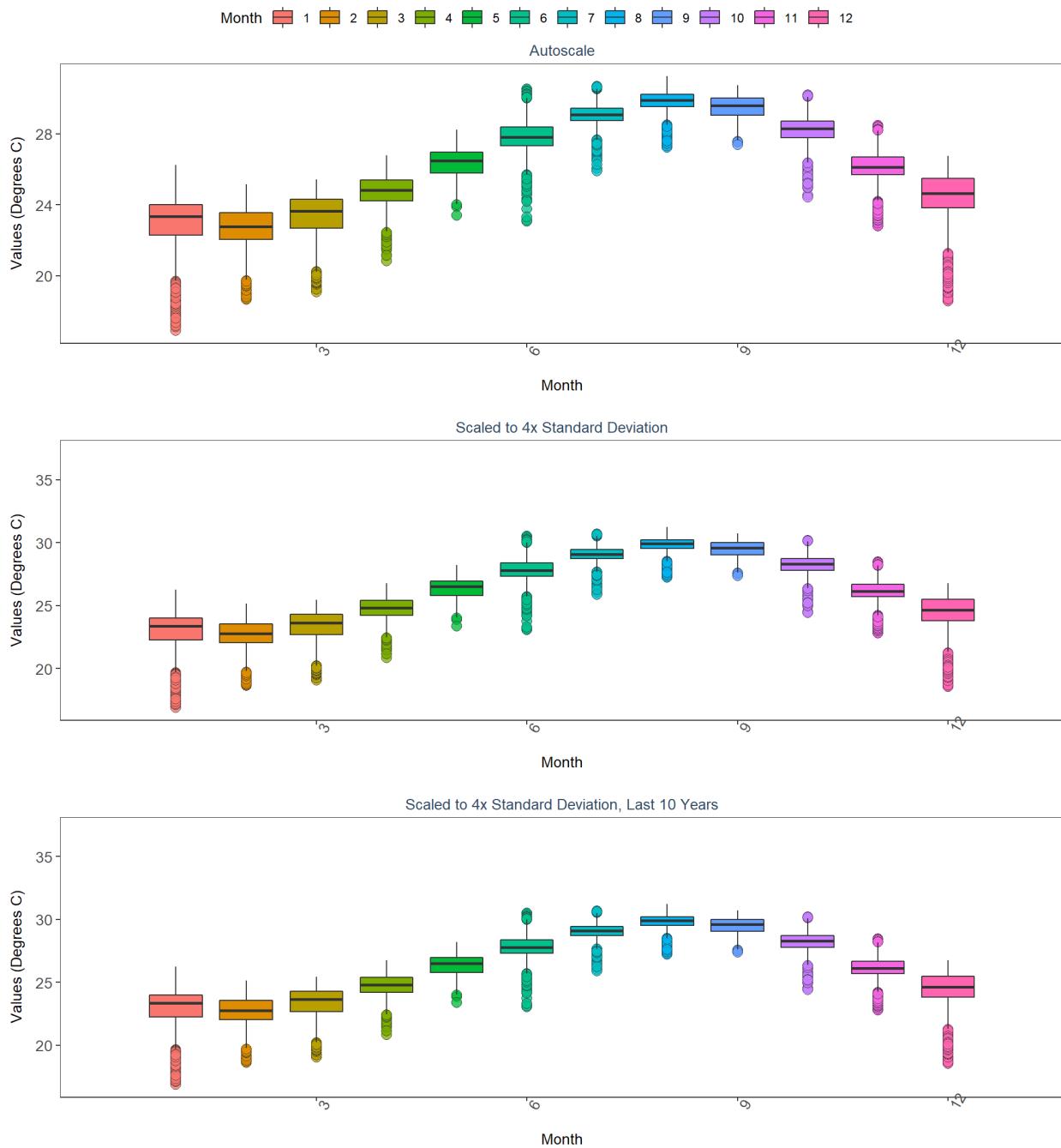
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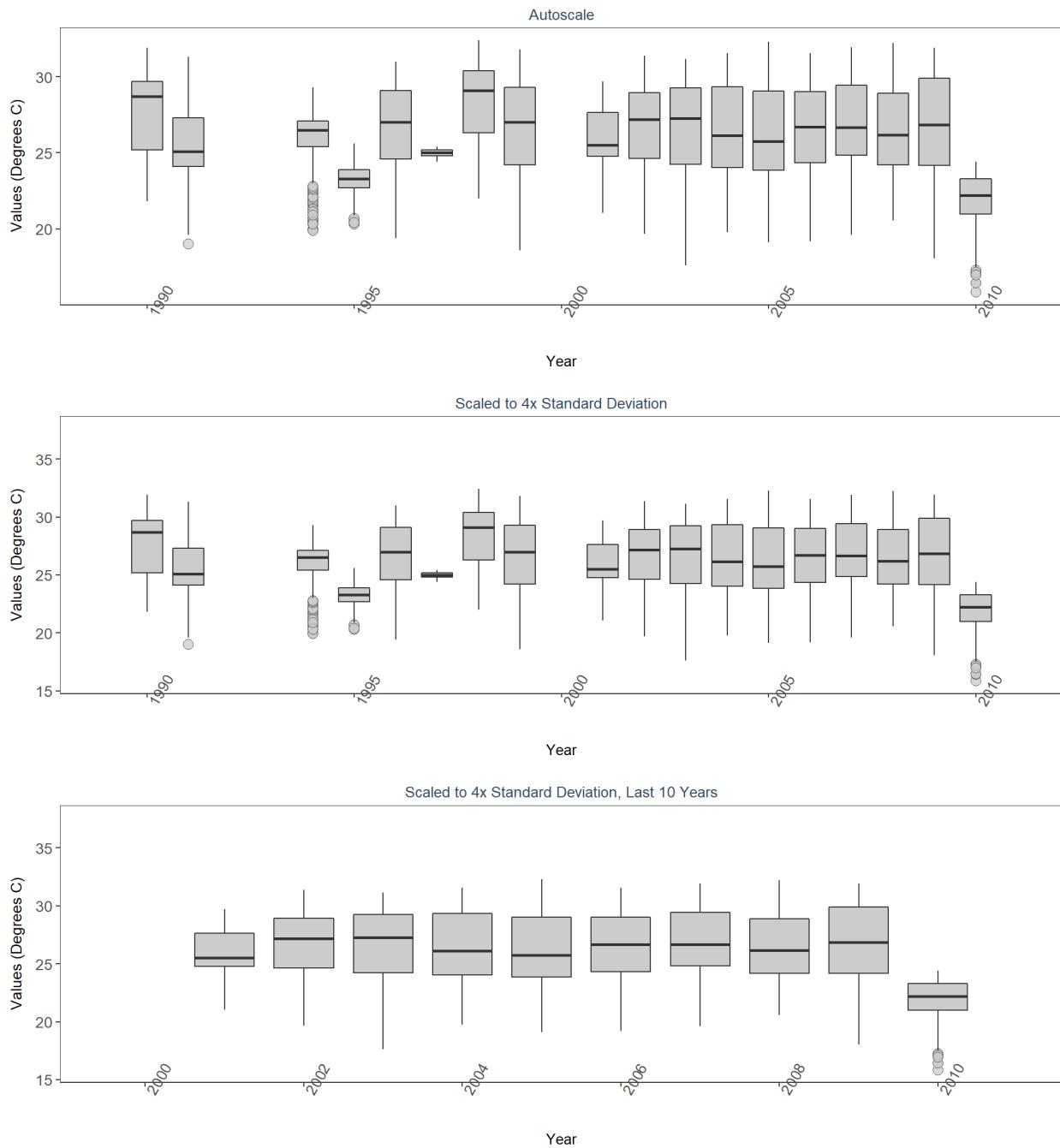
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 By Year & Month



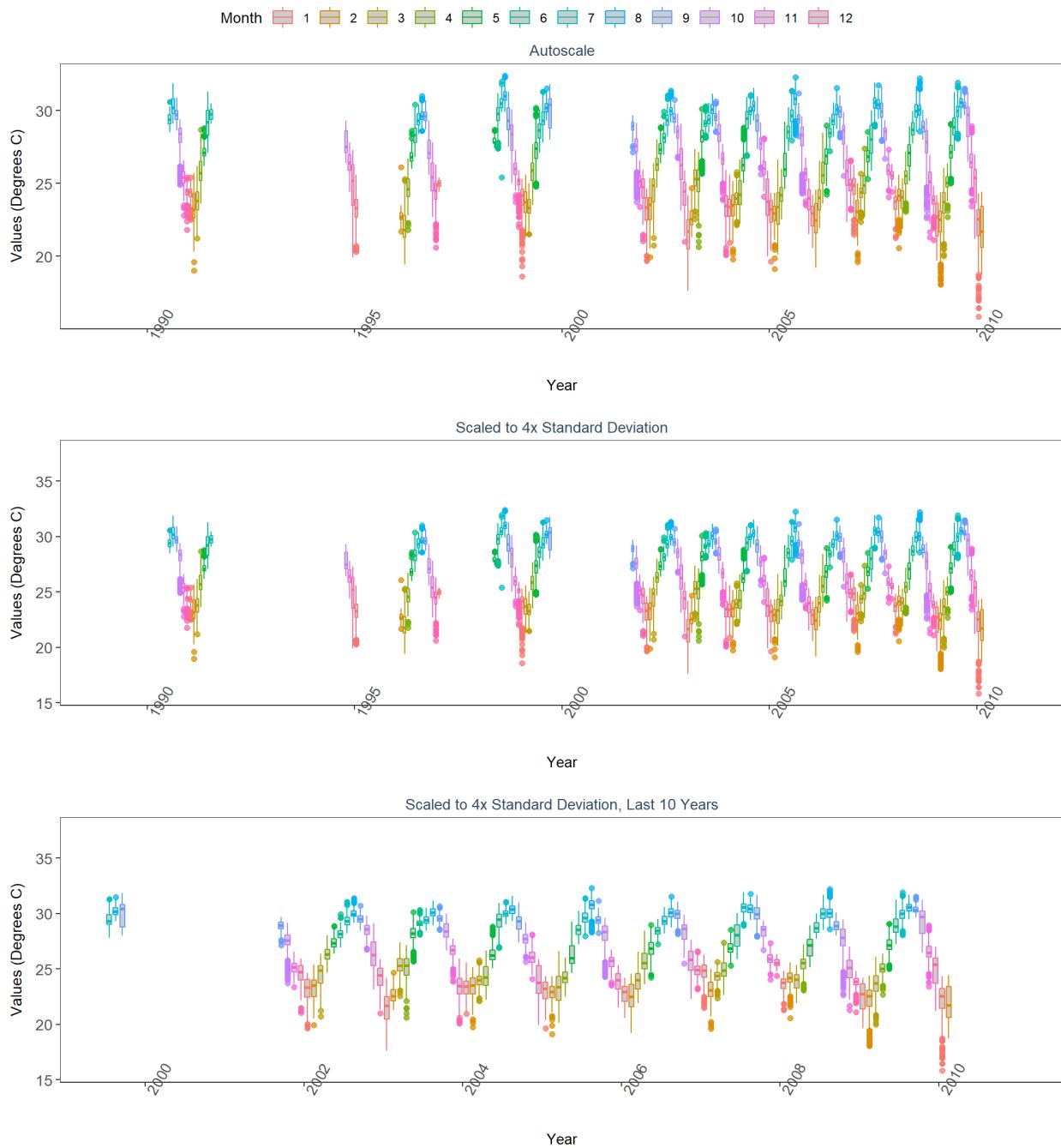
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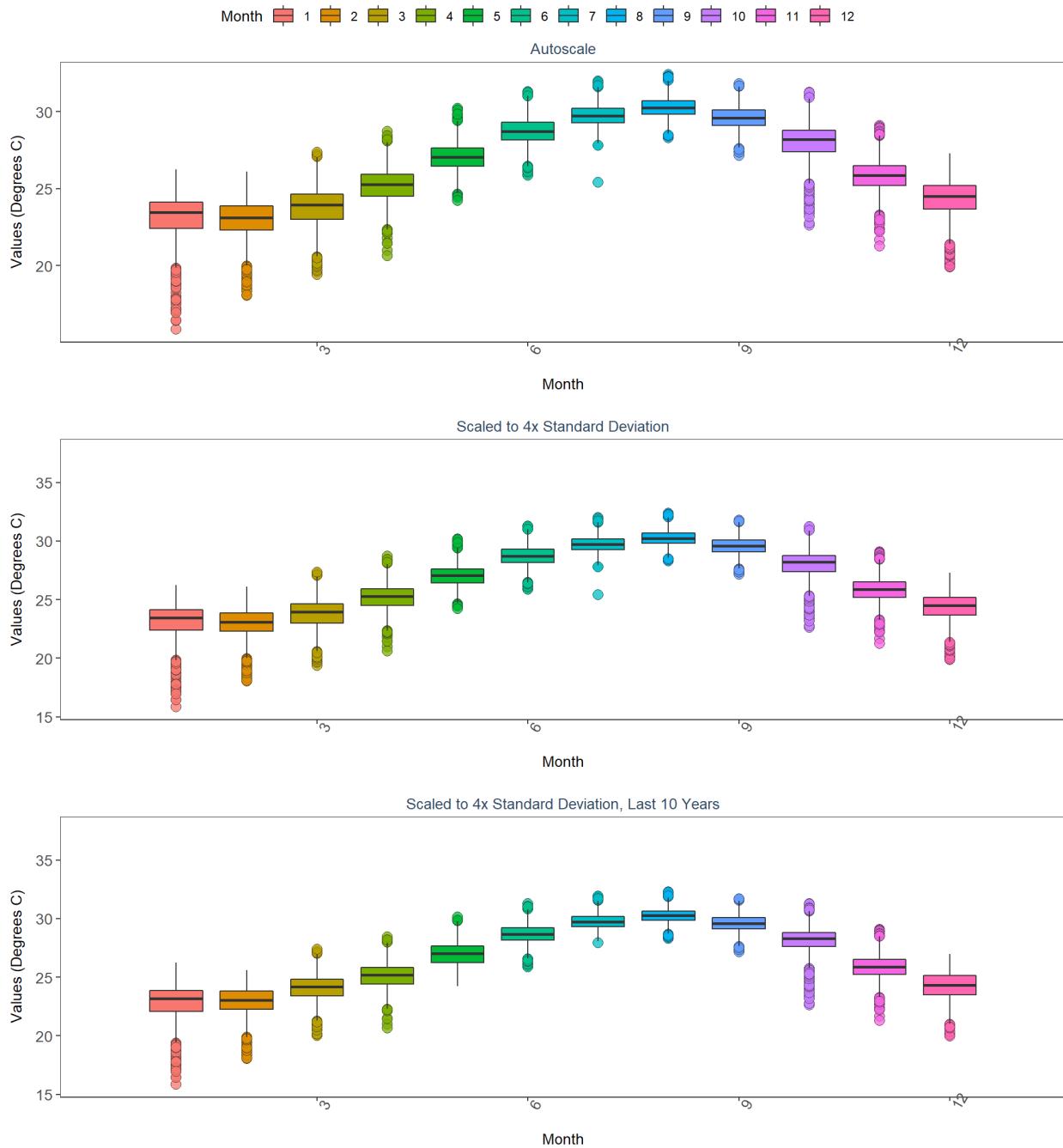
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Year



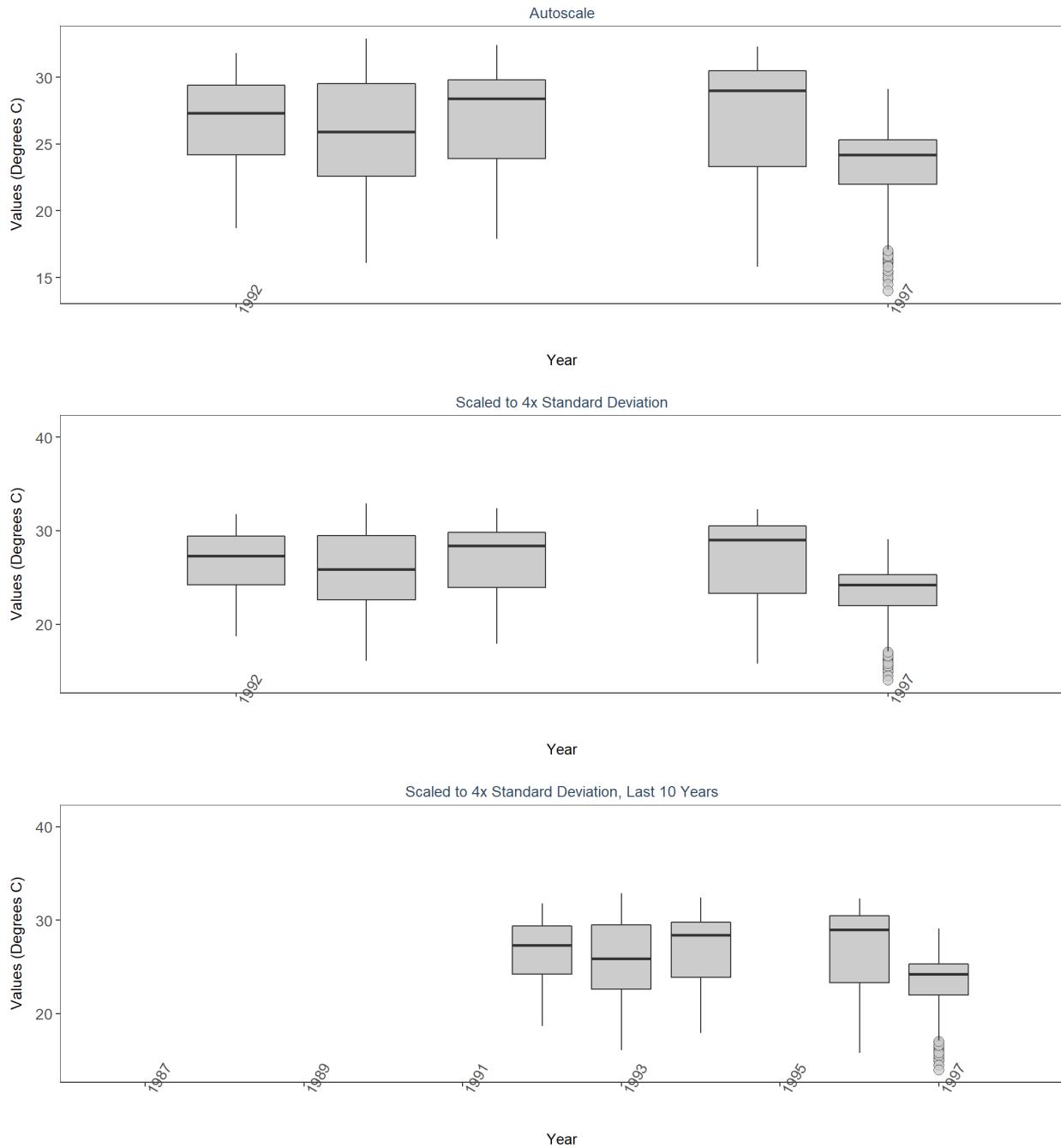
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 FKNMS_GRECIAN
 By Year & Month



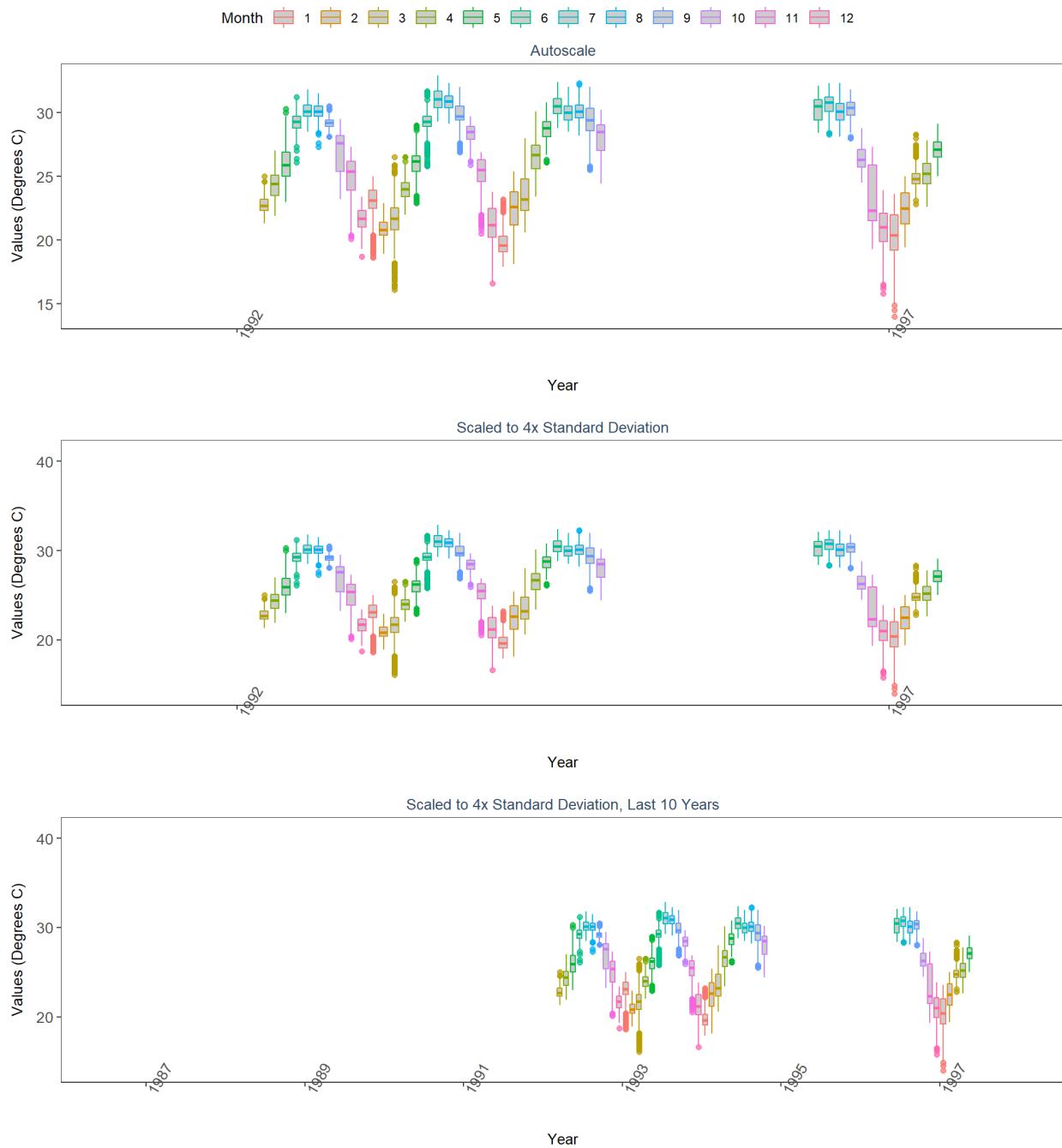
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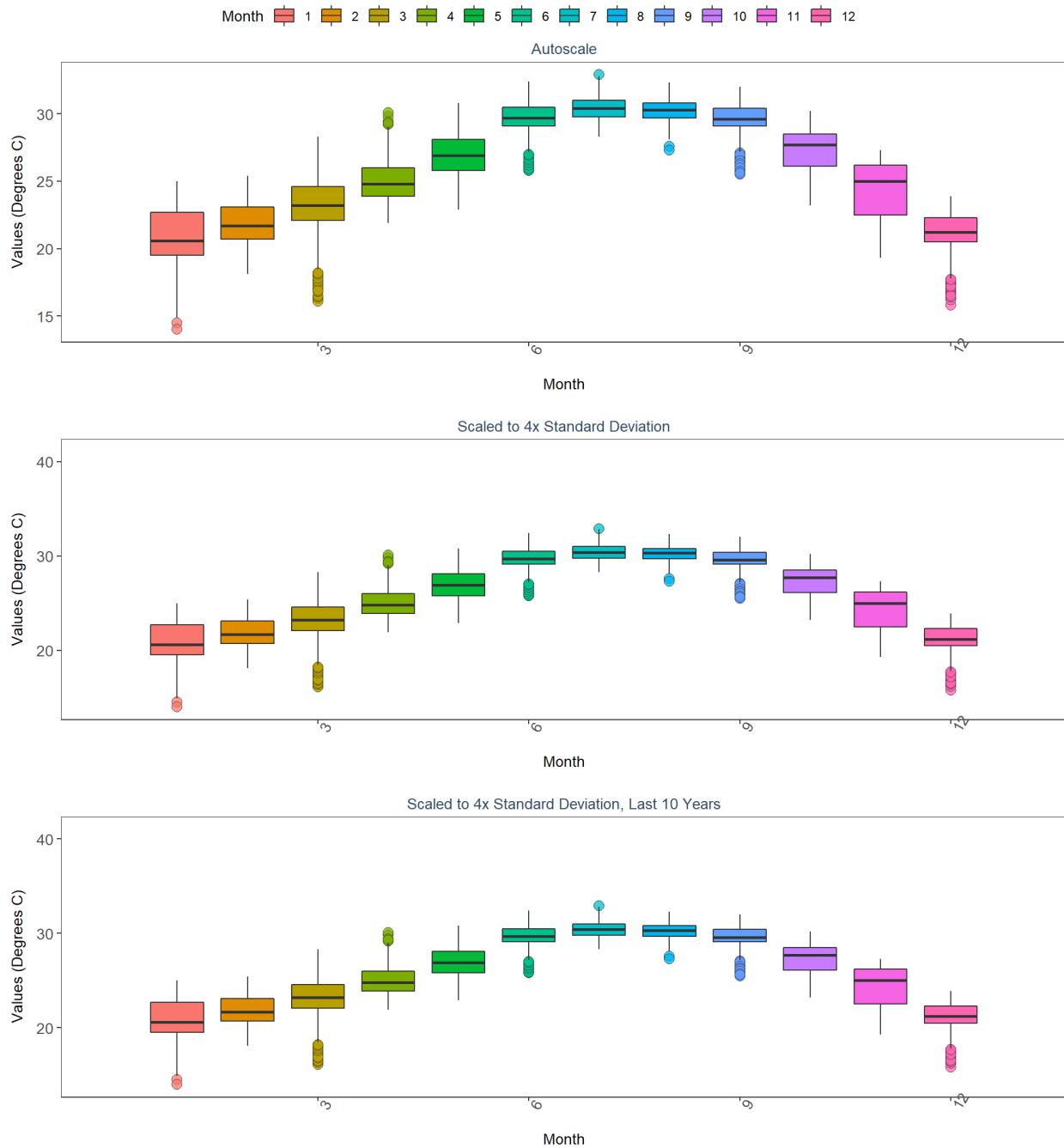
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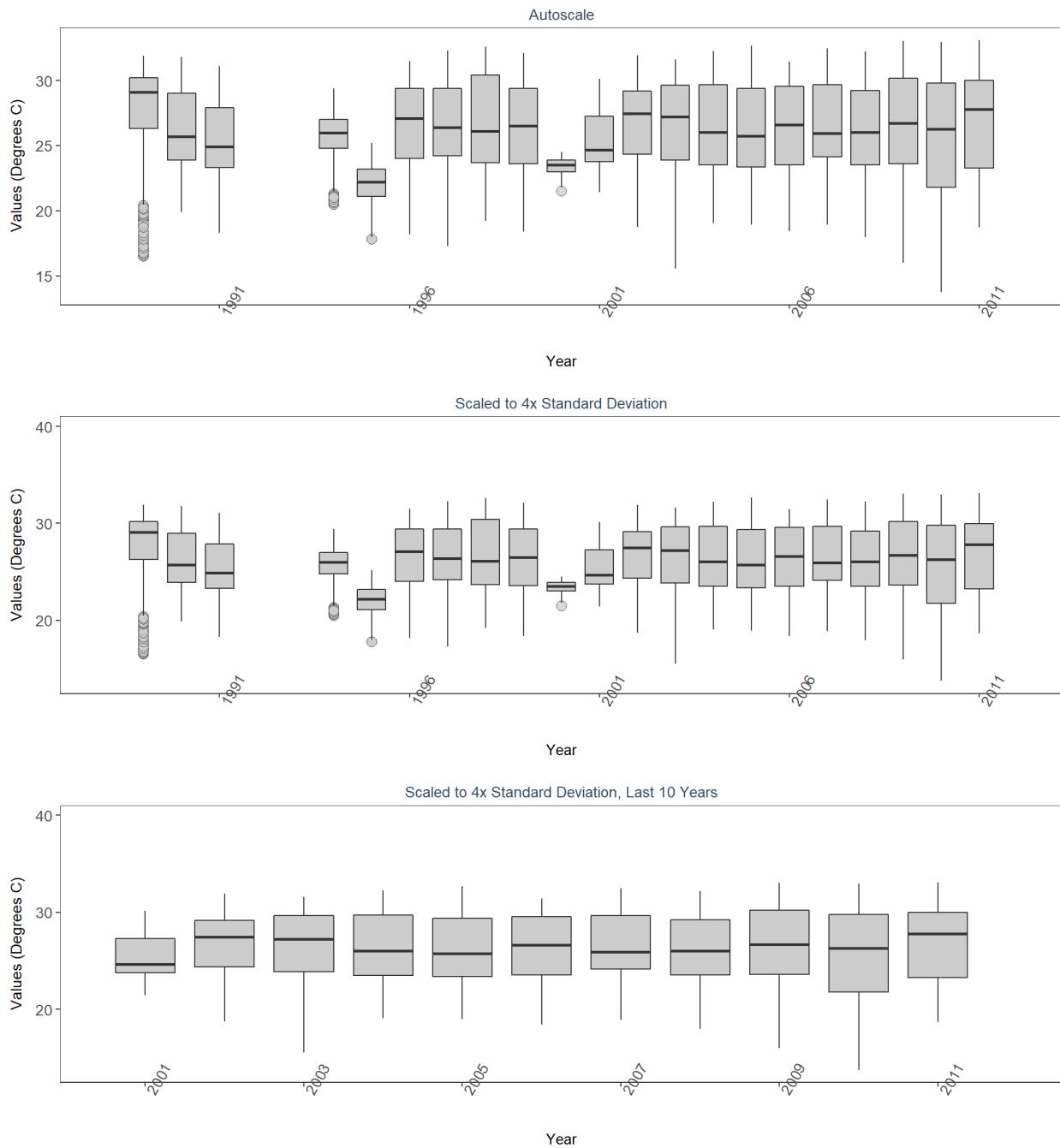
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_HARBORKEY
 By Year & Month



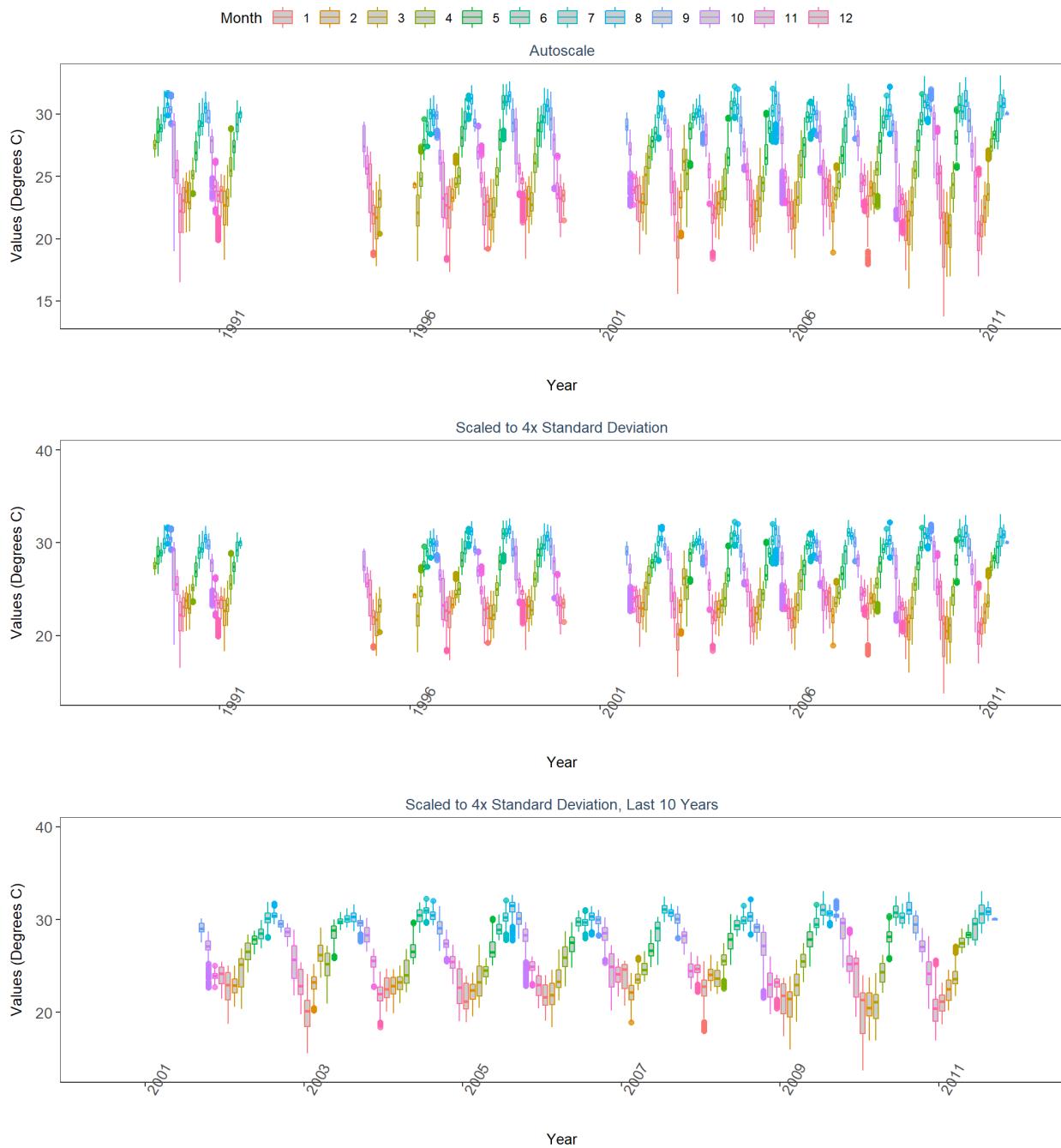
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Month



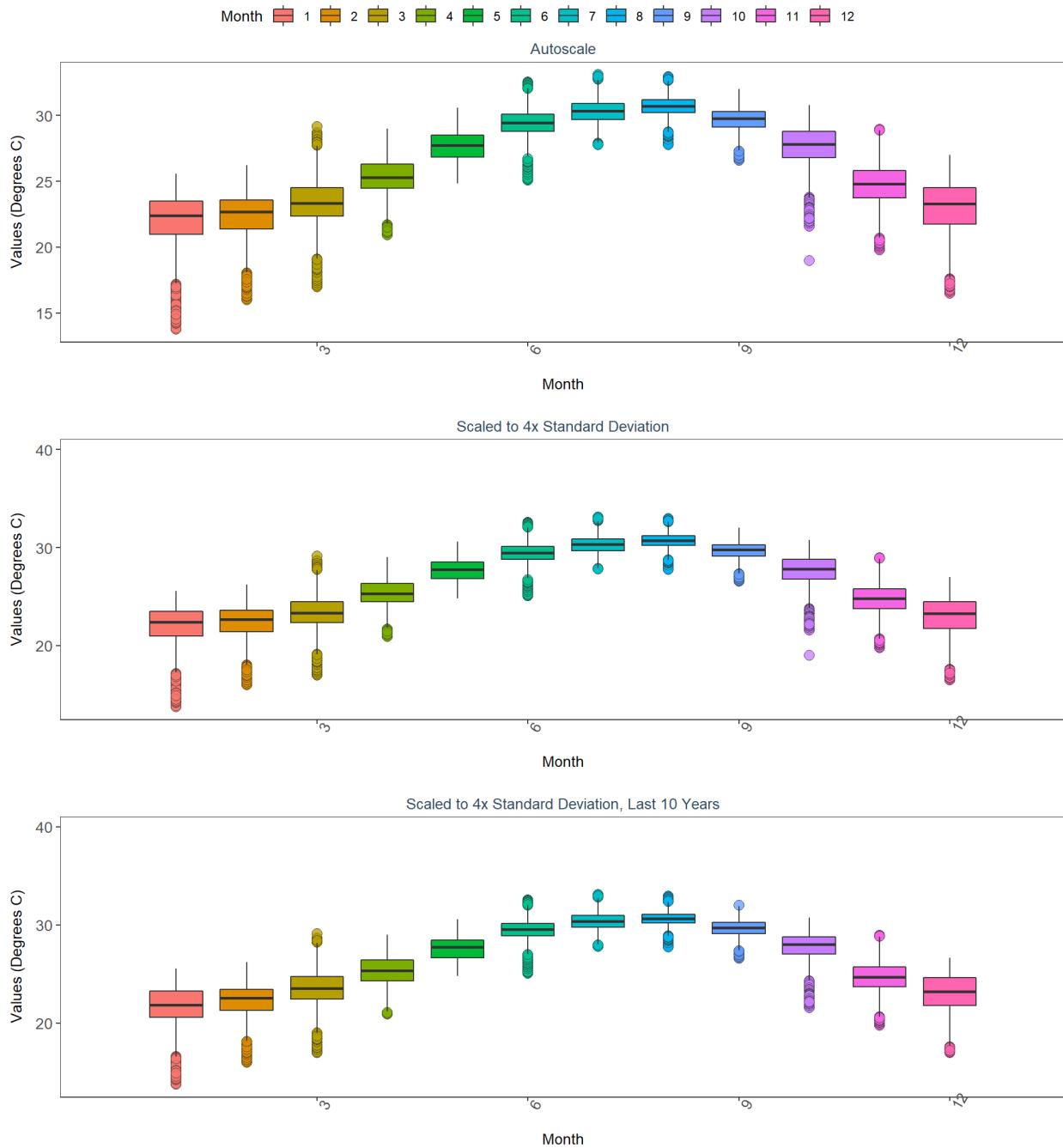
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Year



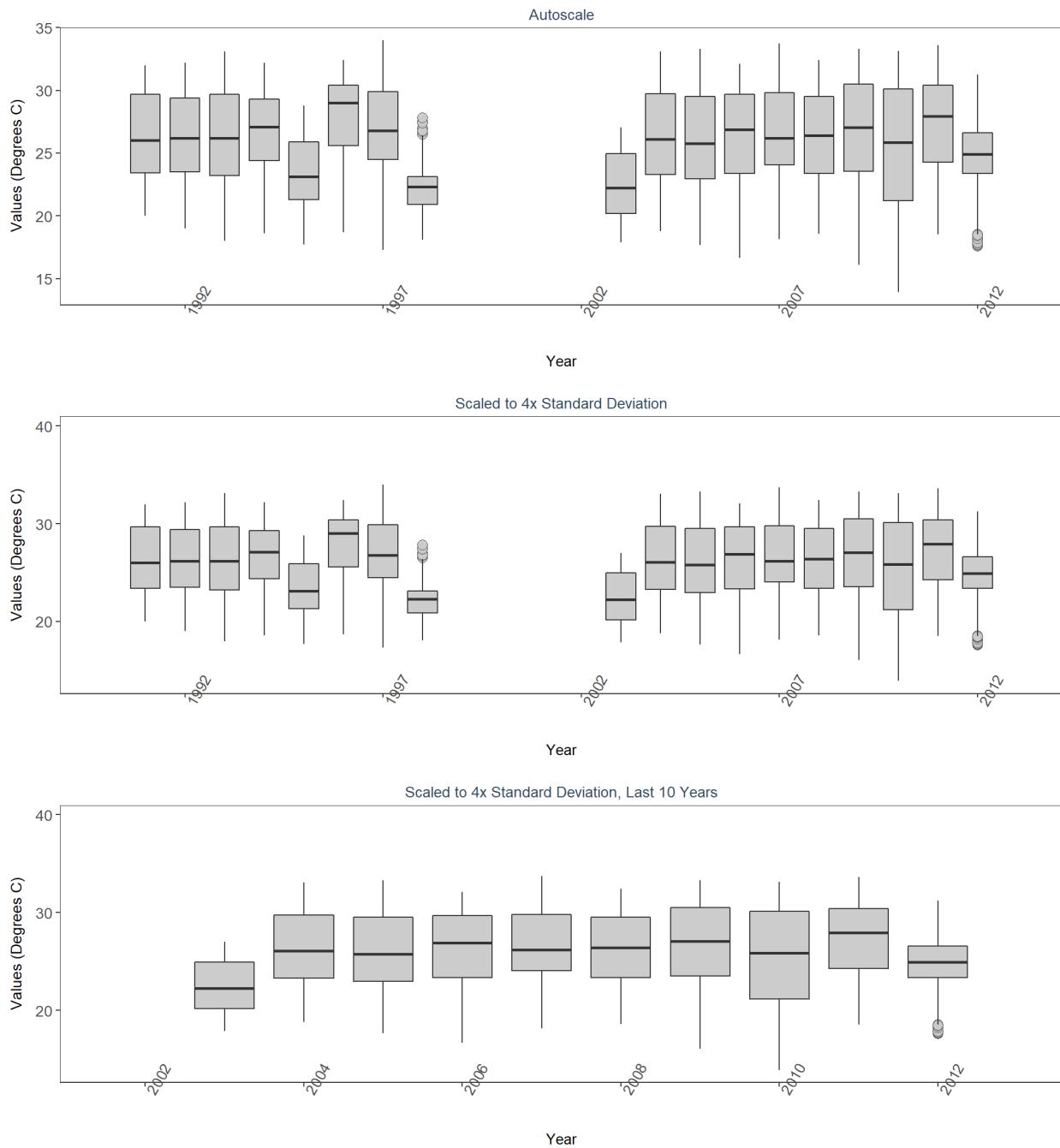
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_HEN&CHIX
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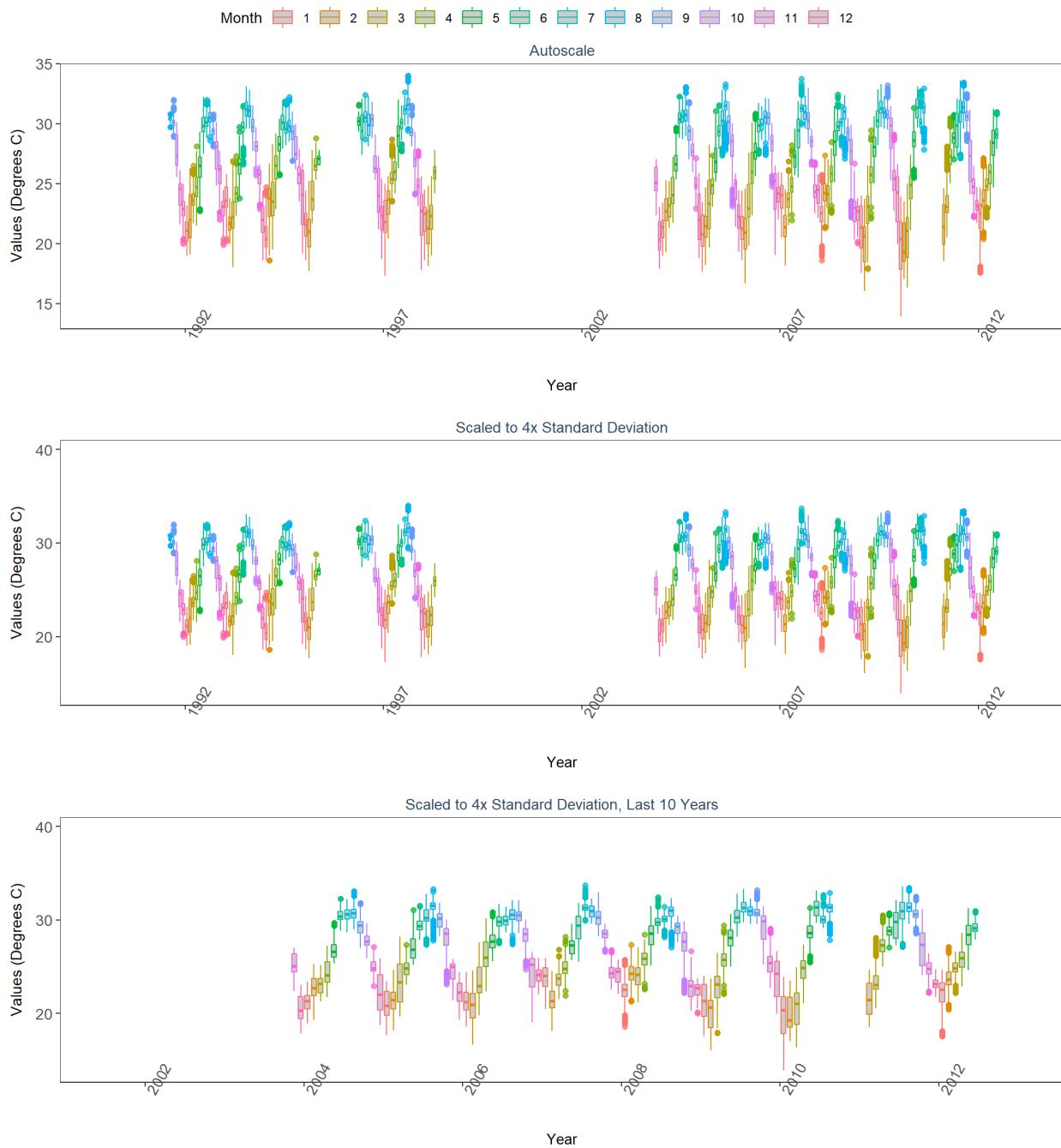
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 FKNMS_HEN&CHIX
 By Month



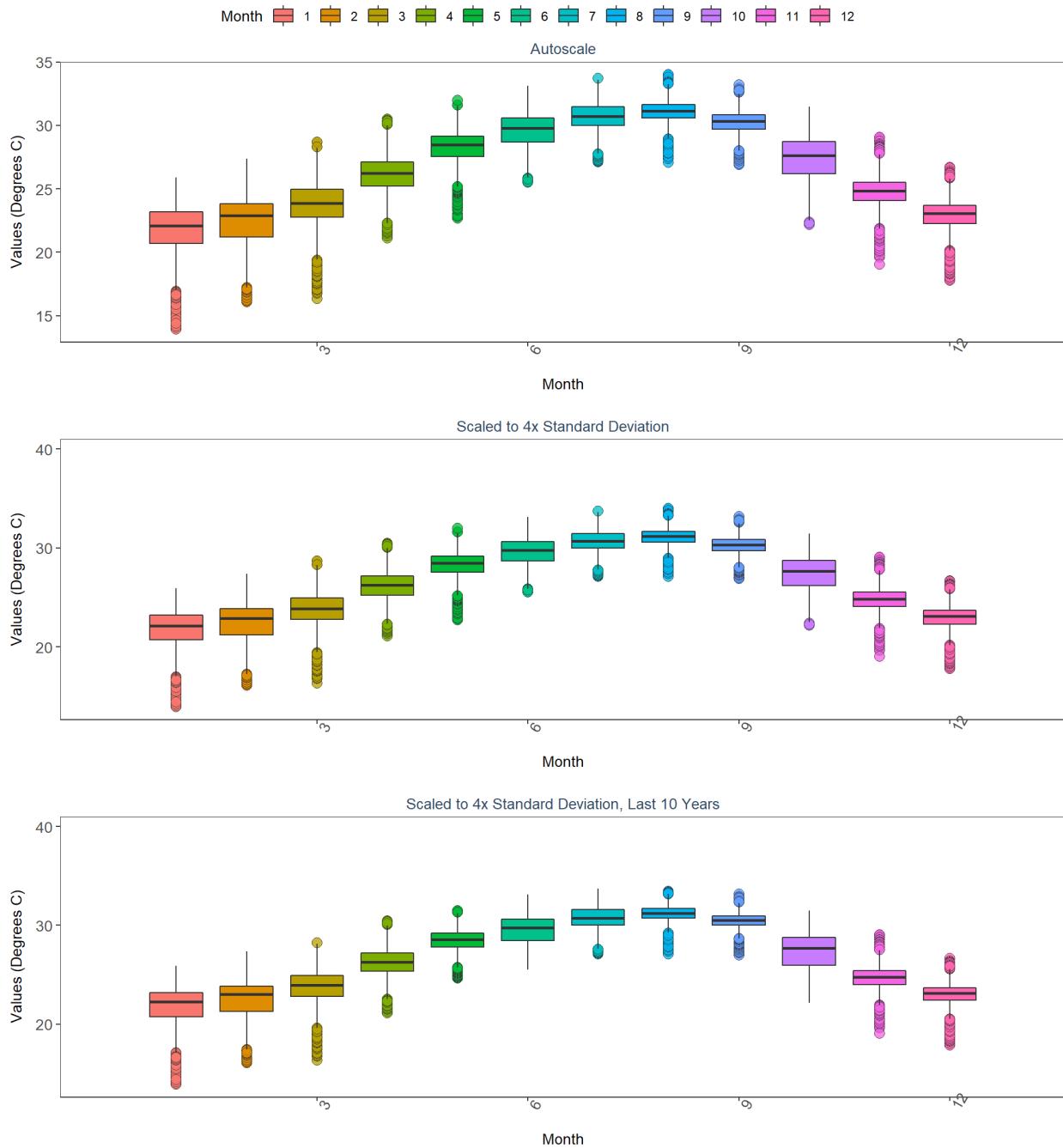
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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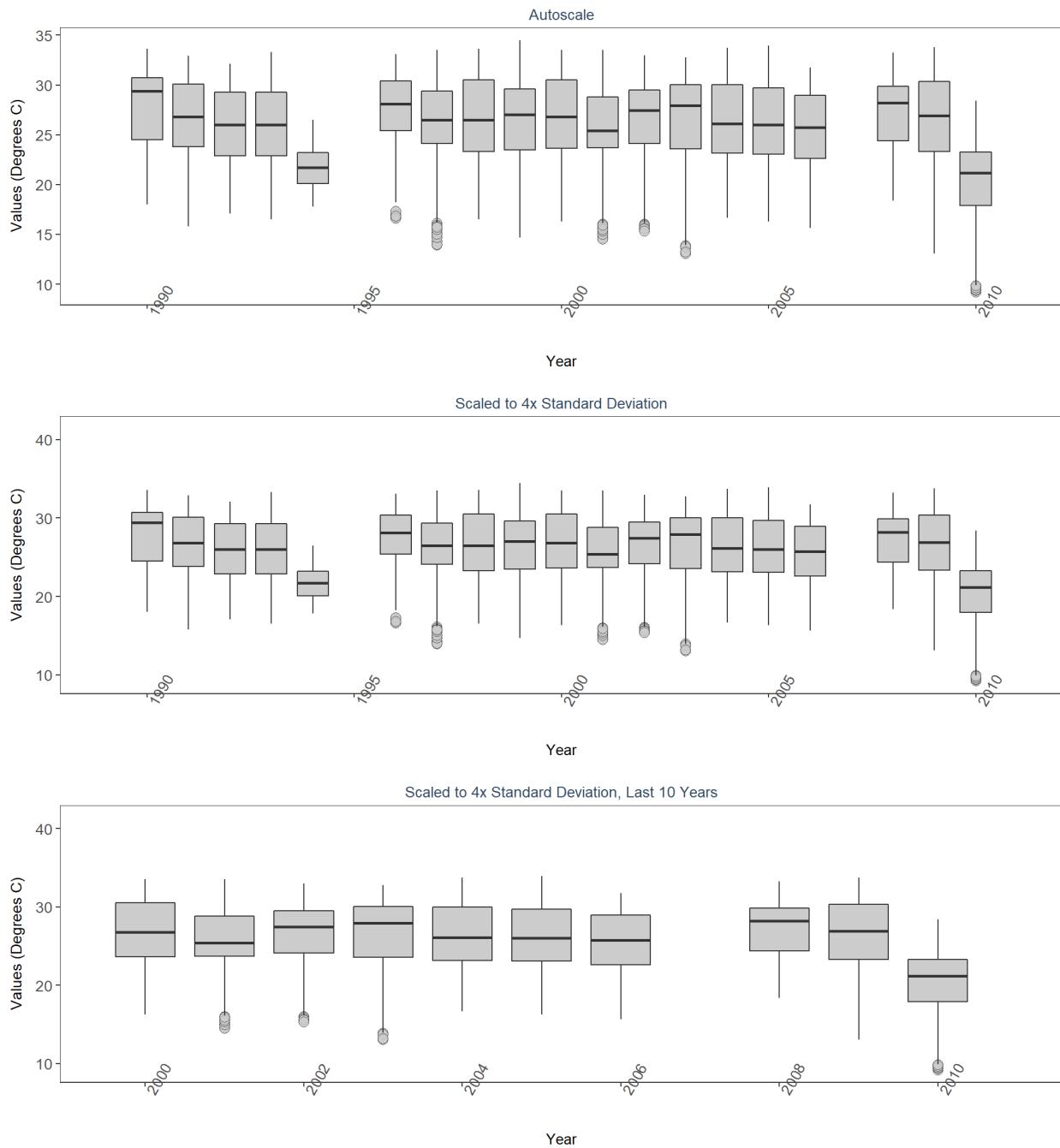
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_KW_CHANL
 By Year & Month



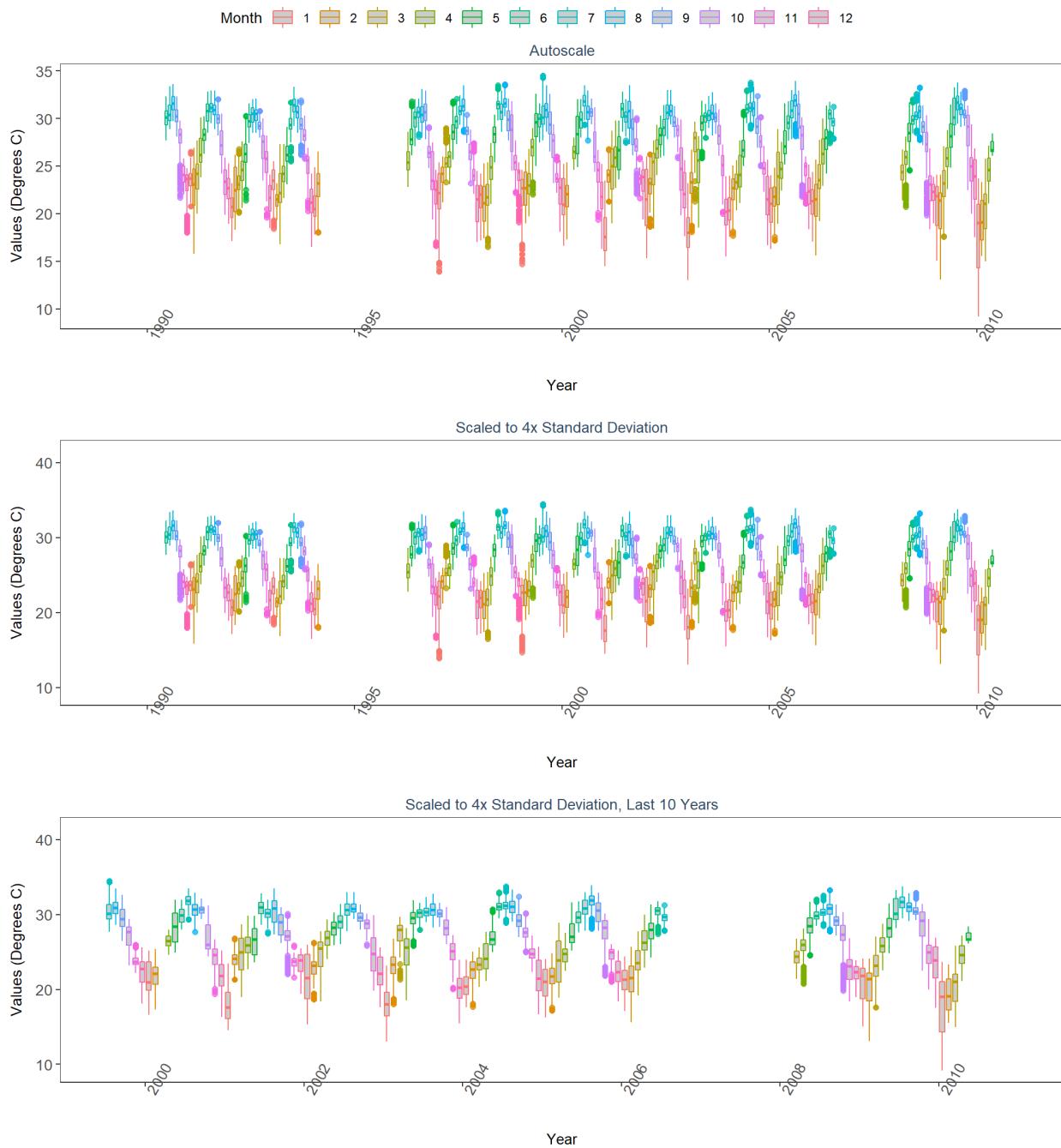
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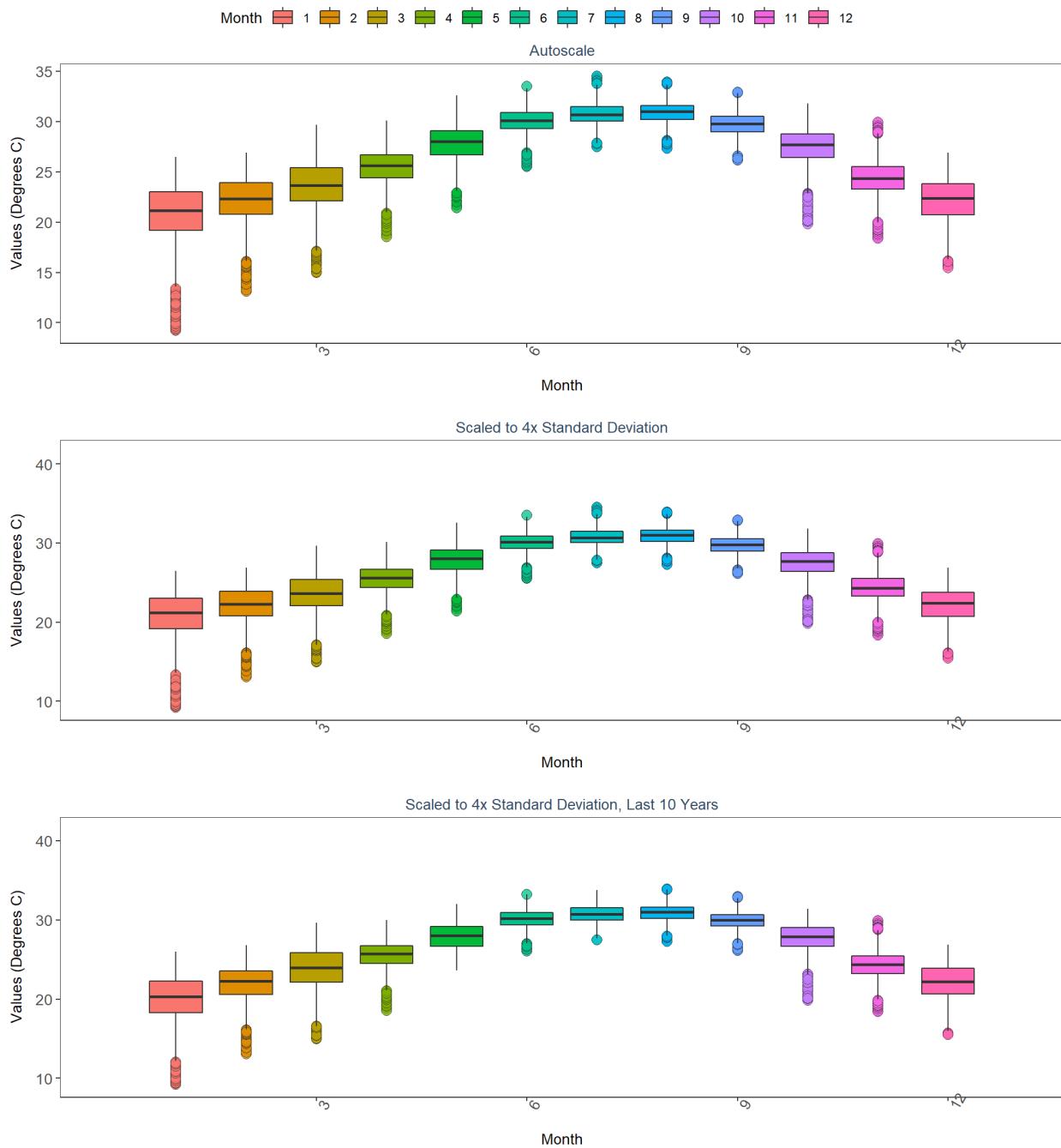
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_LONG_KEY
 By Year



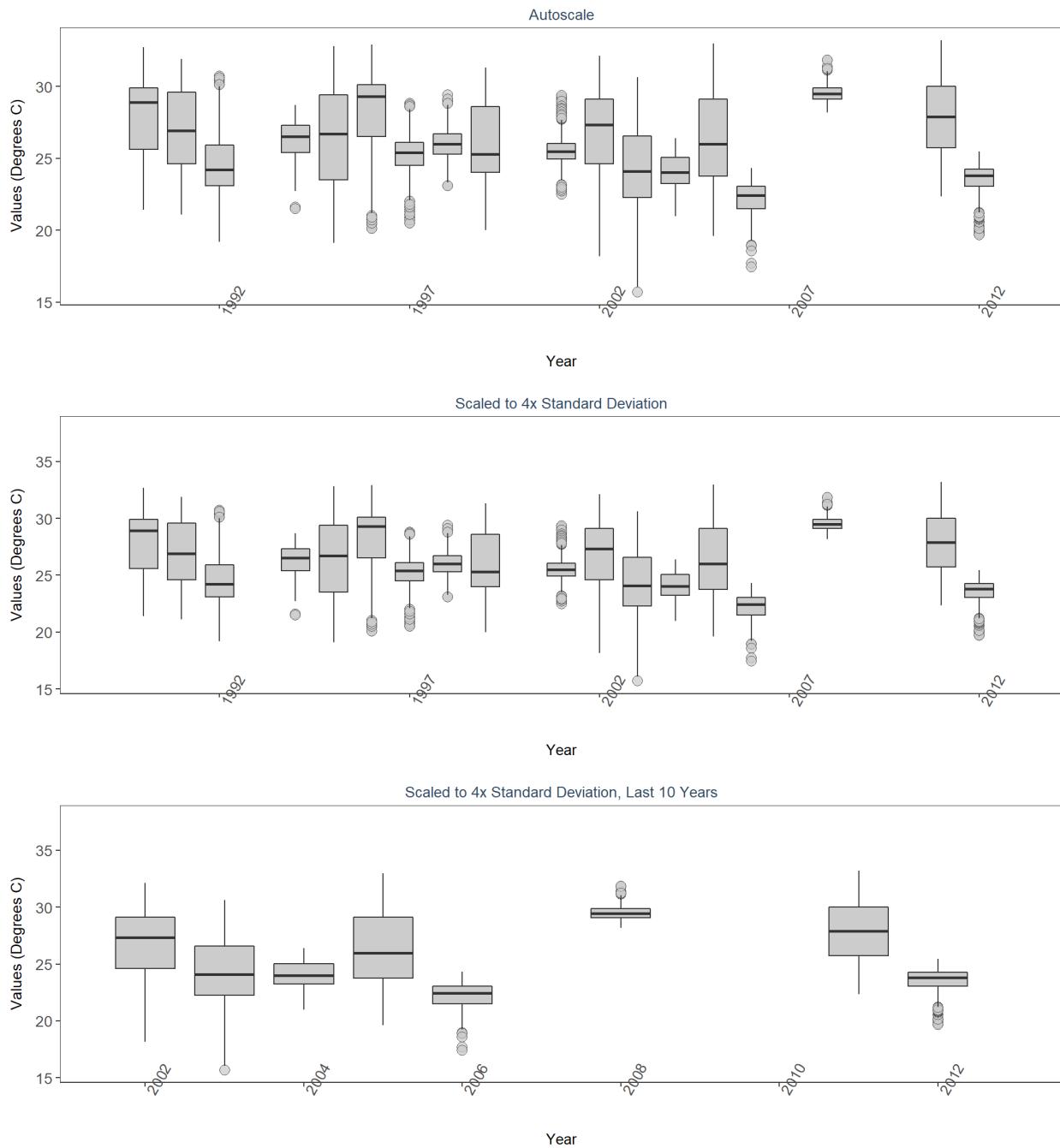
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_LONG_KEY
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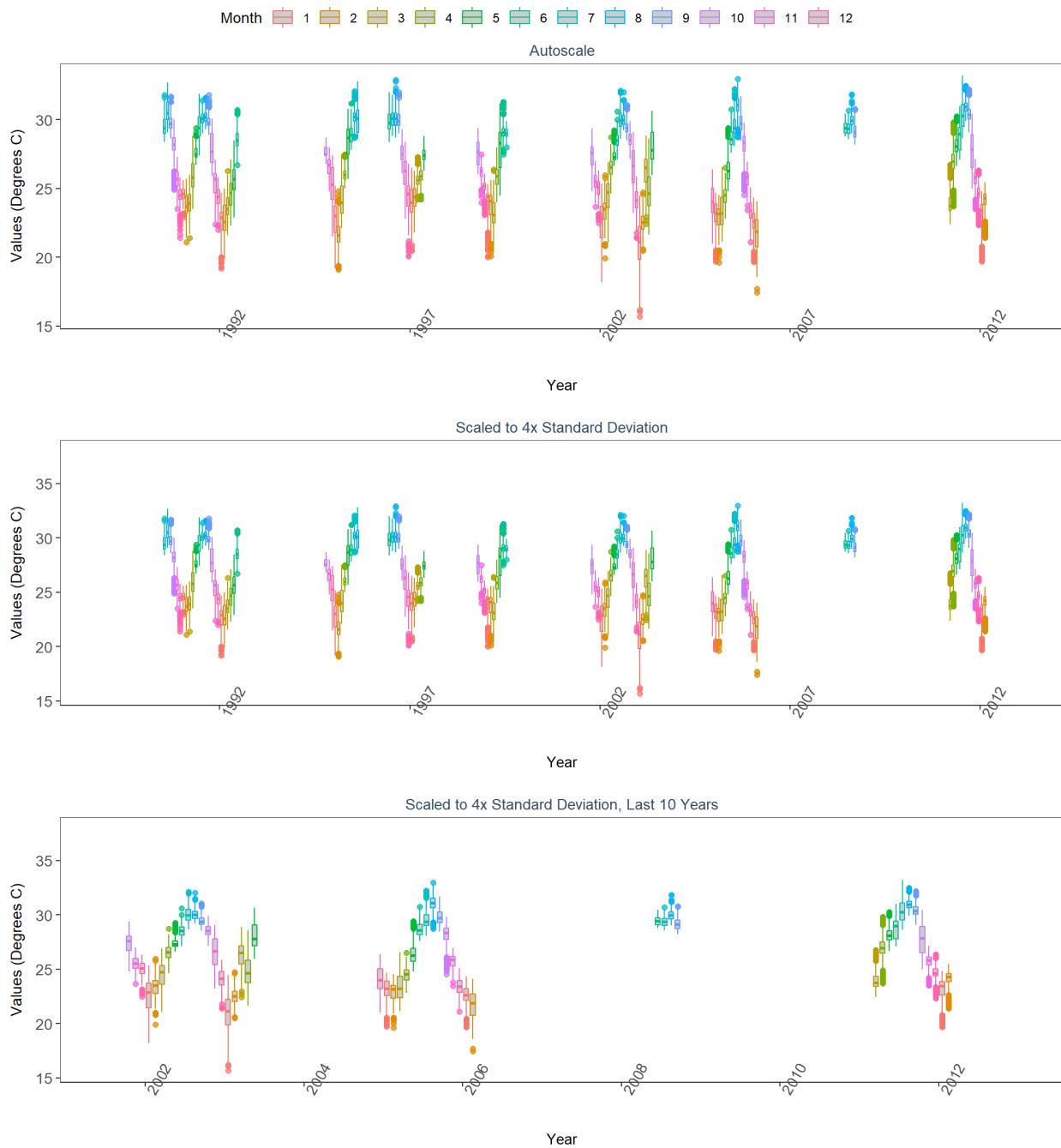
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_LONG_KEY
 By Month



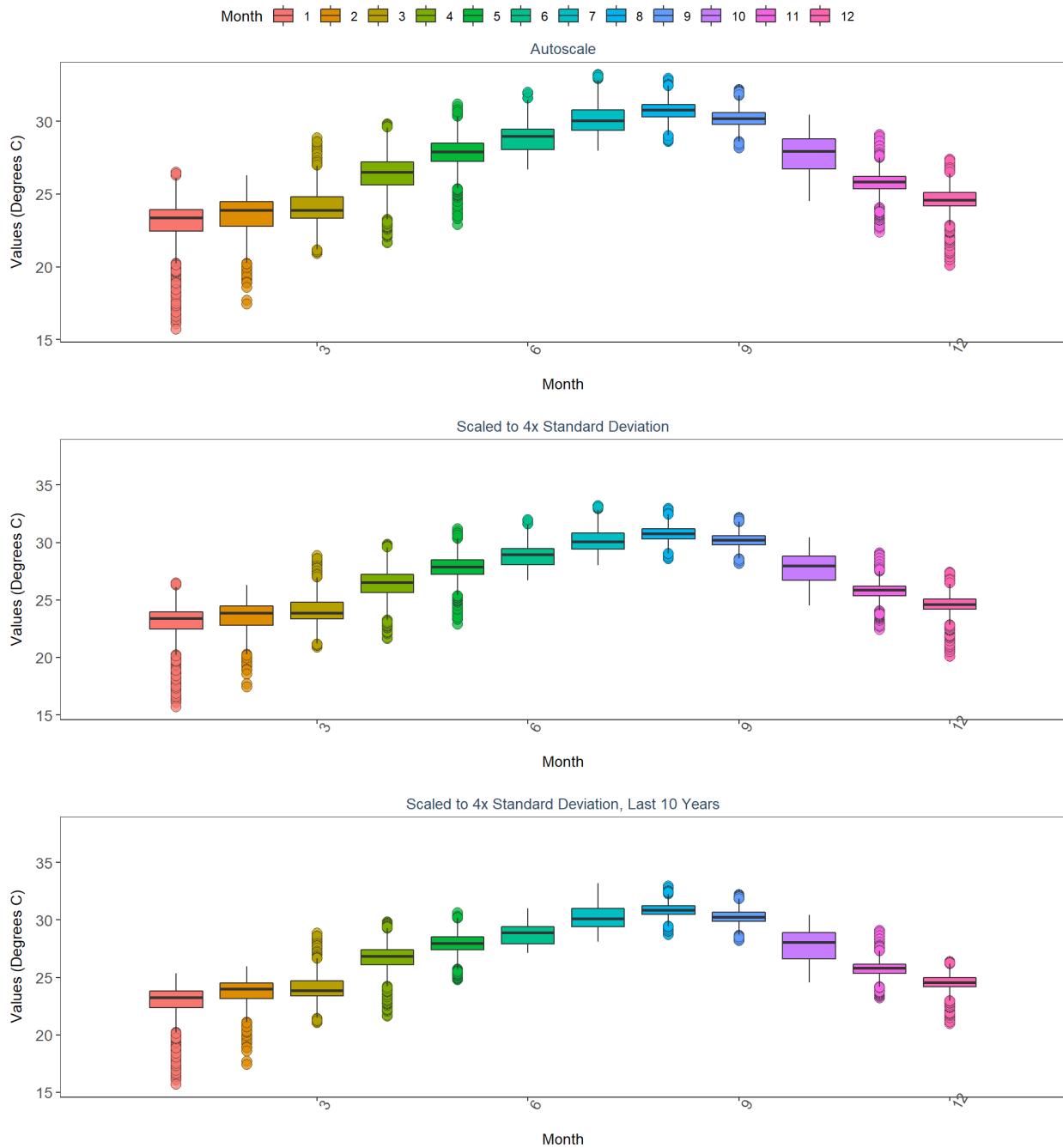
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
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 By Year



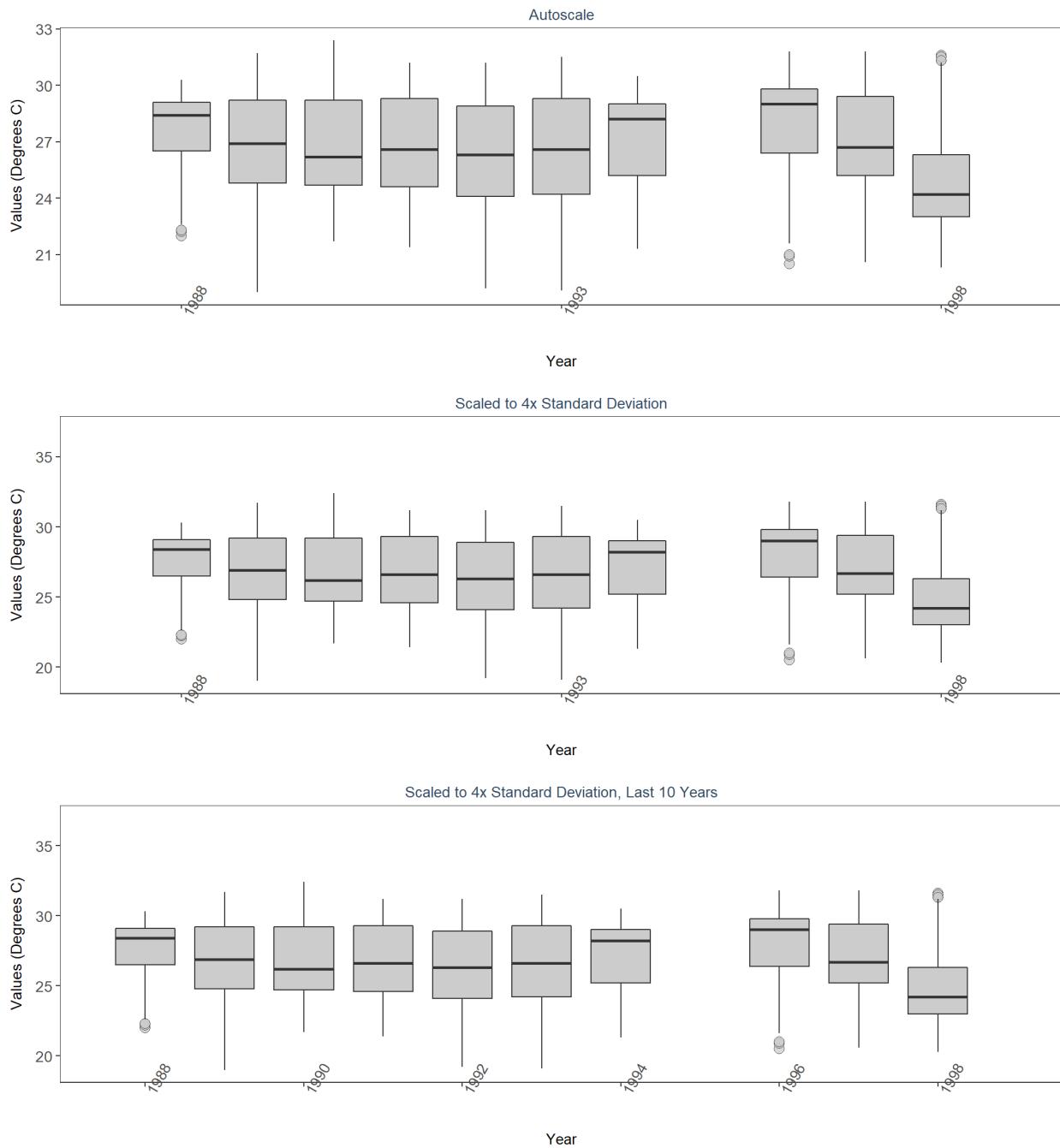
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 FKNMS_LOOE_BACK
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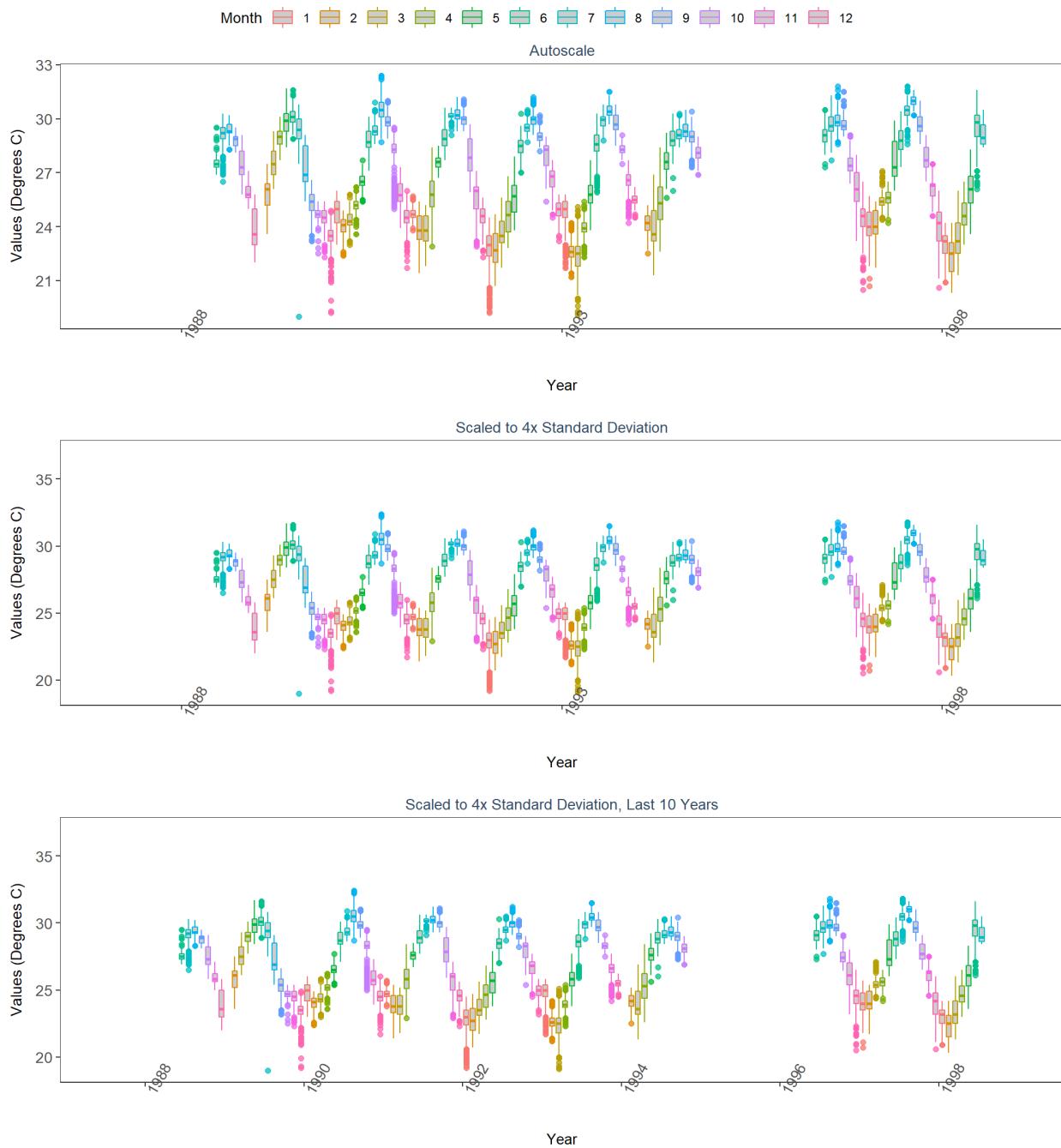
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 By Month



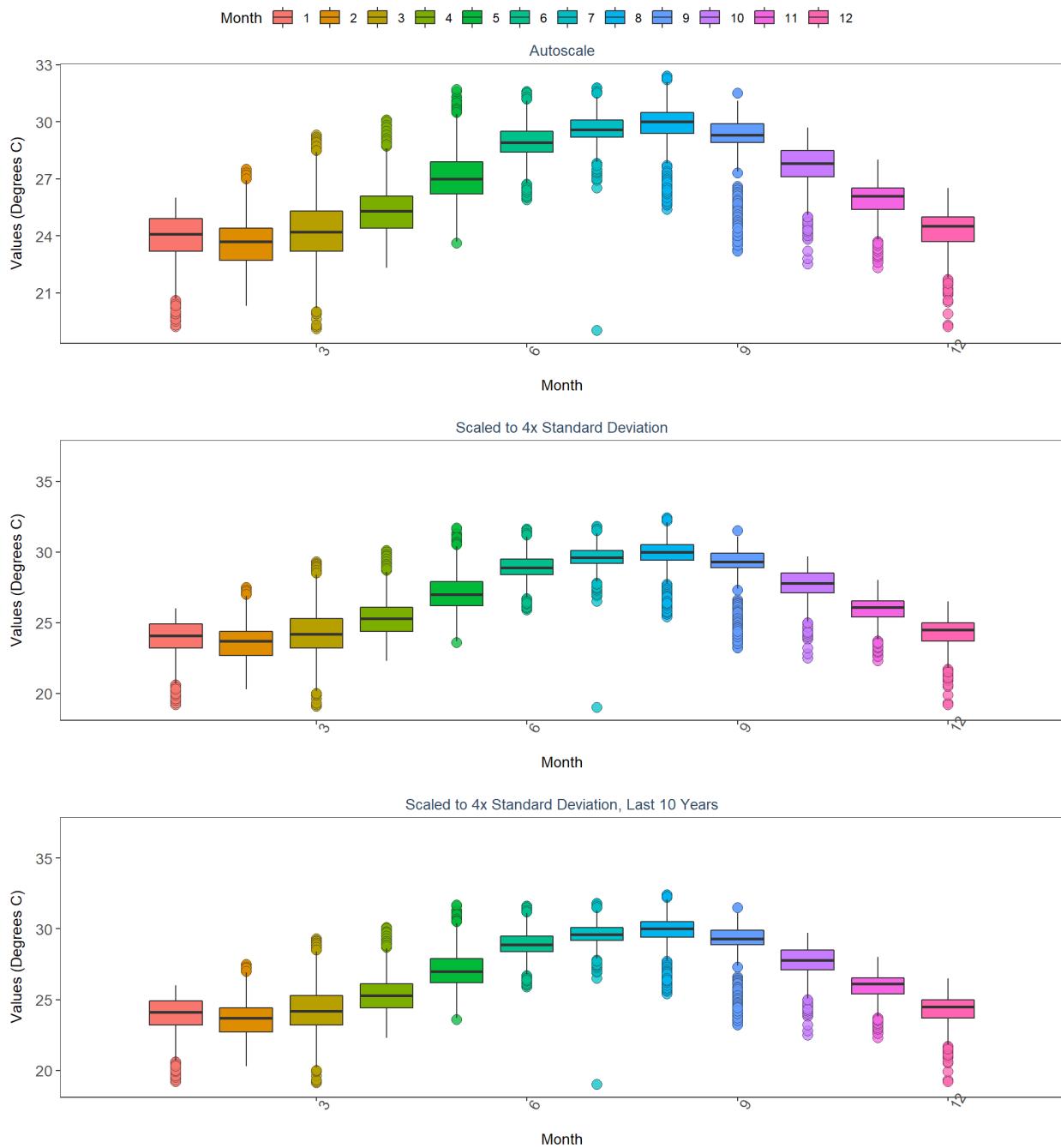
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 By Year



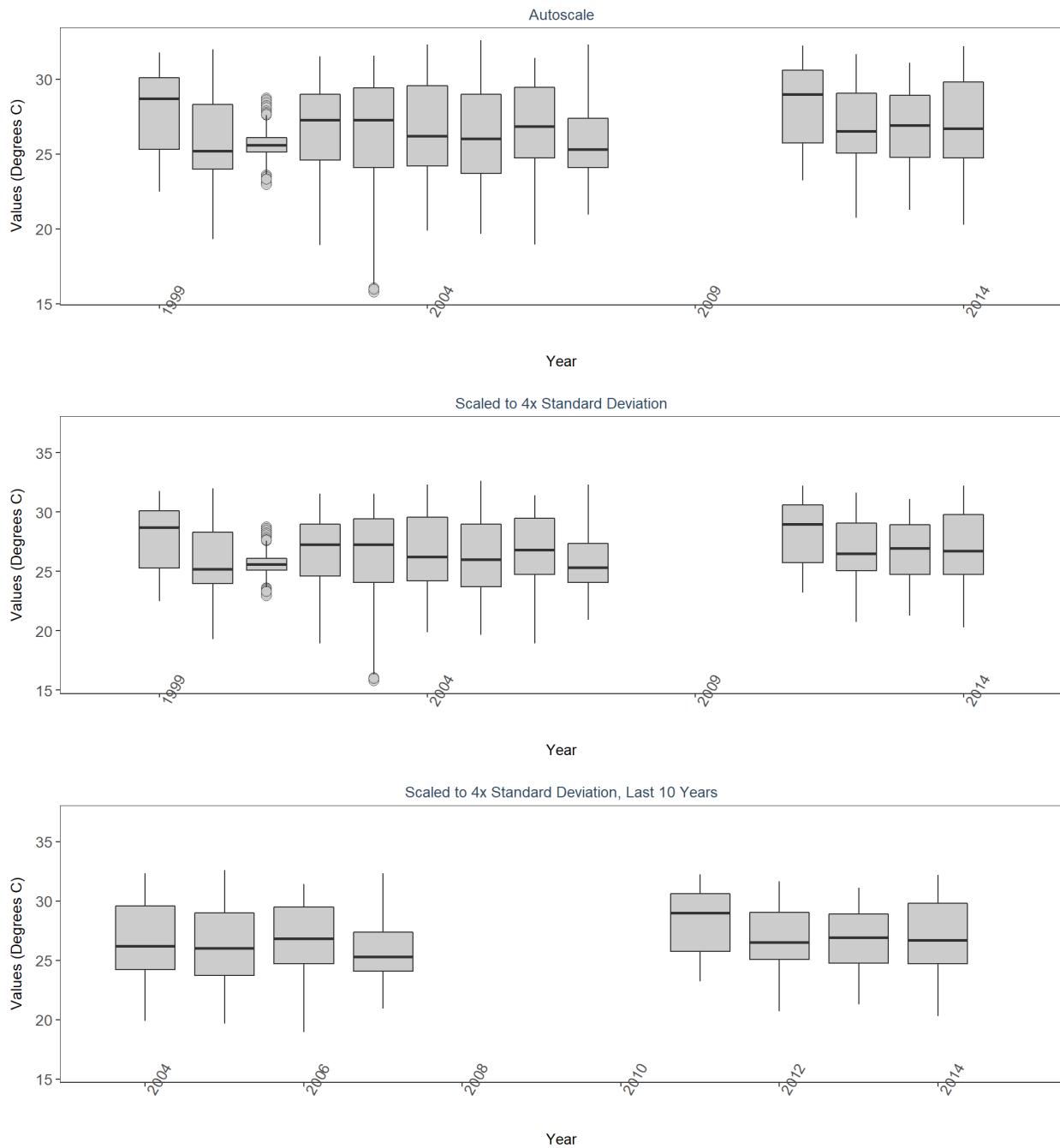
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 FKNMS_LOOE_BUOY5
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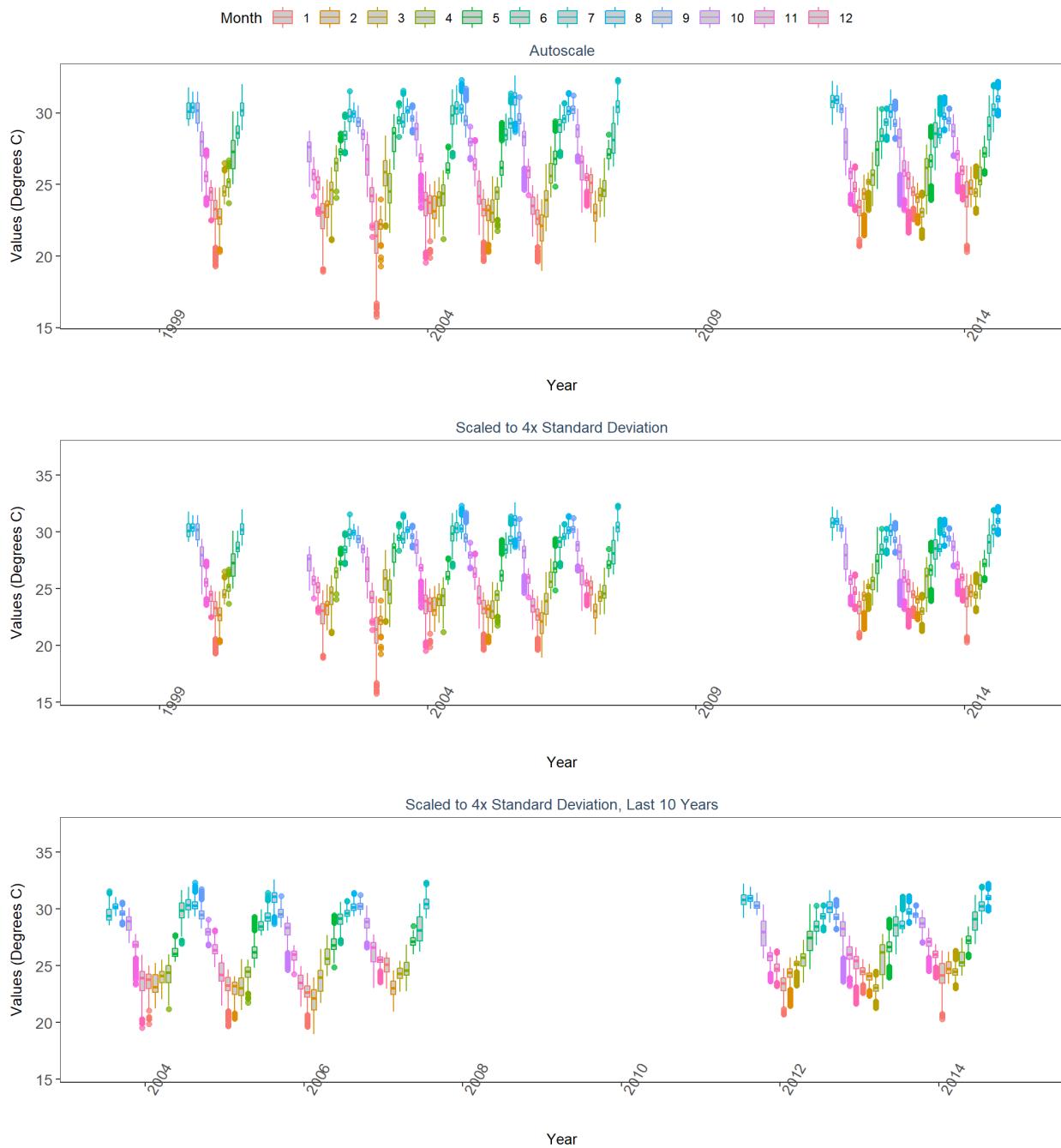
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 By Month



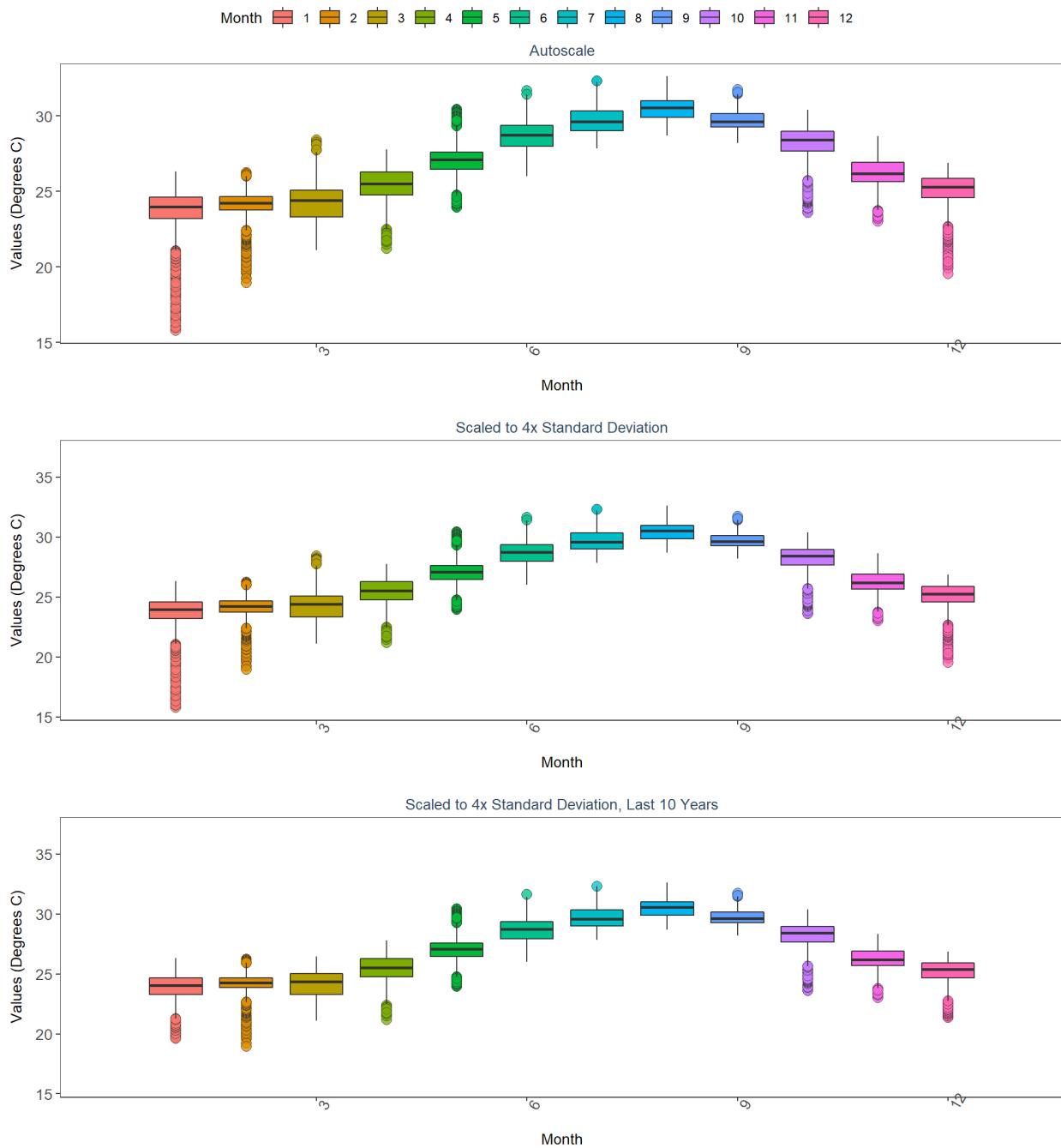
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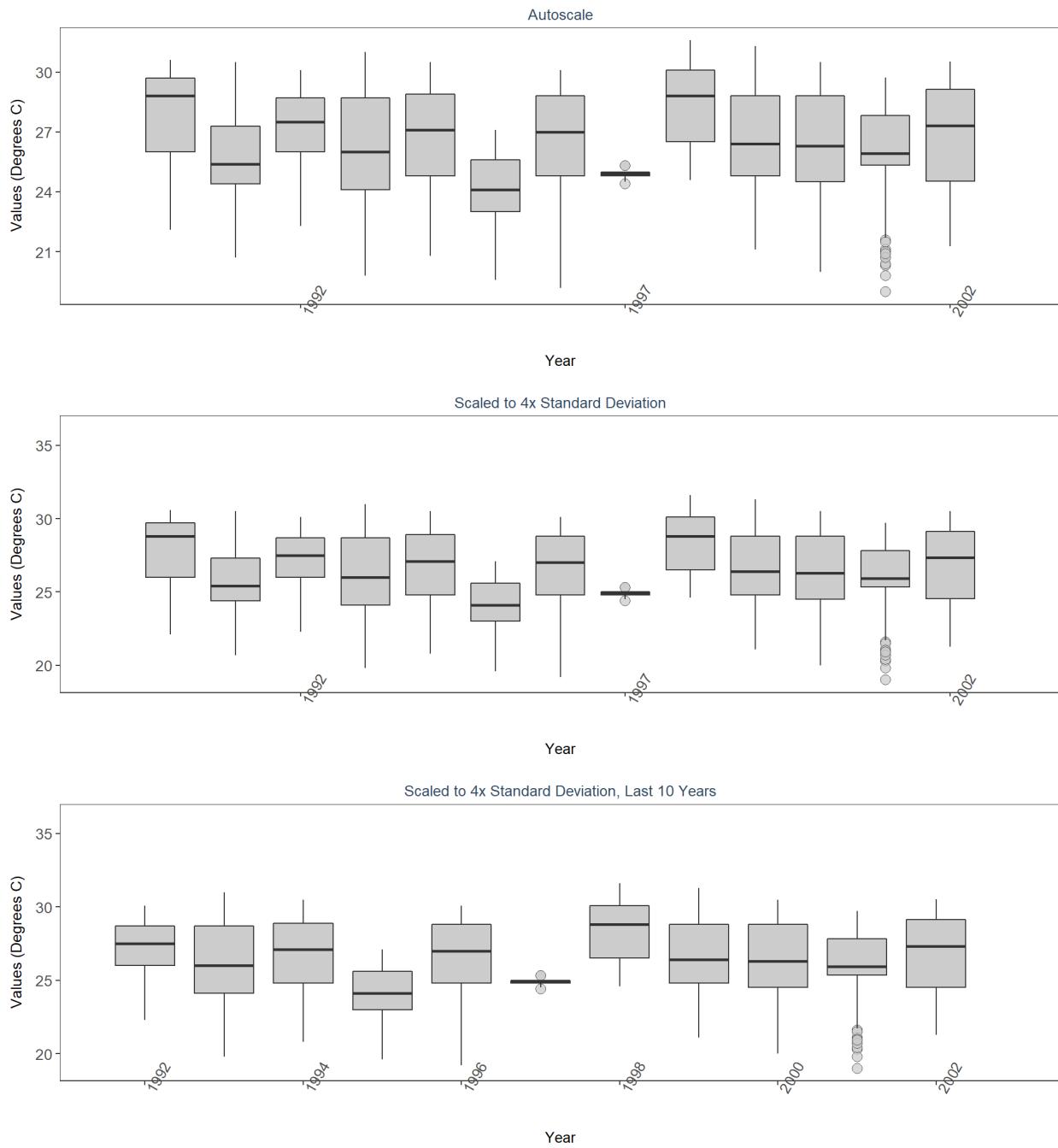
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 By Year & Month



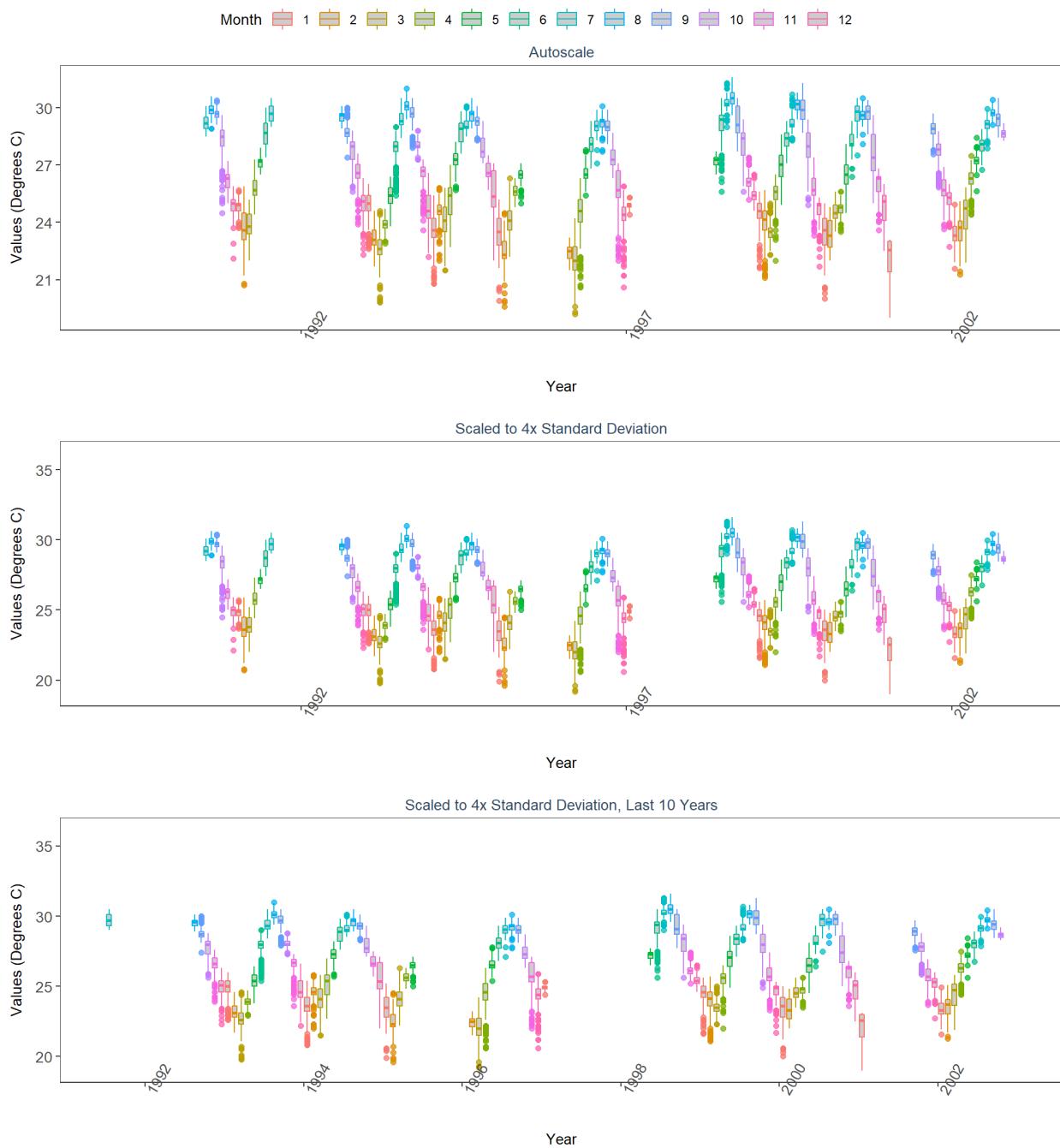
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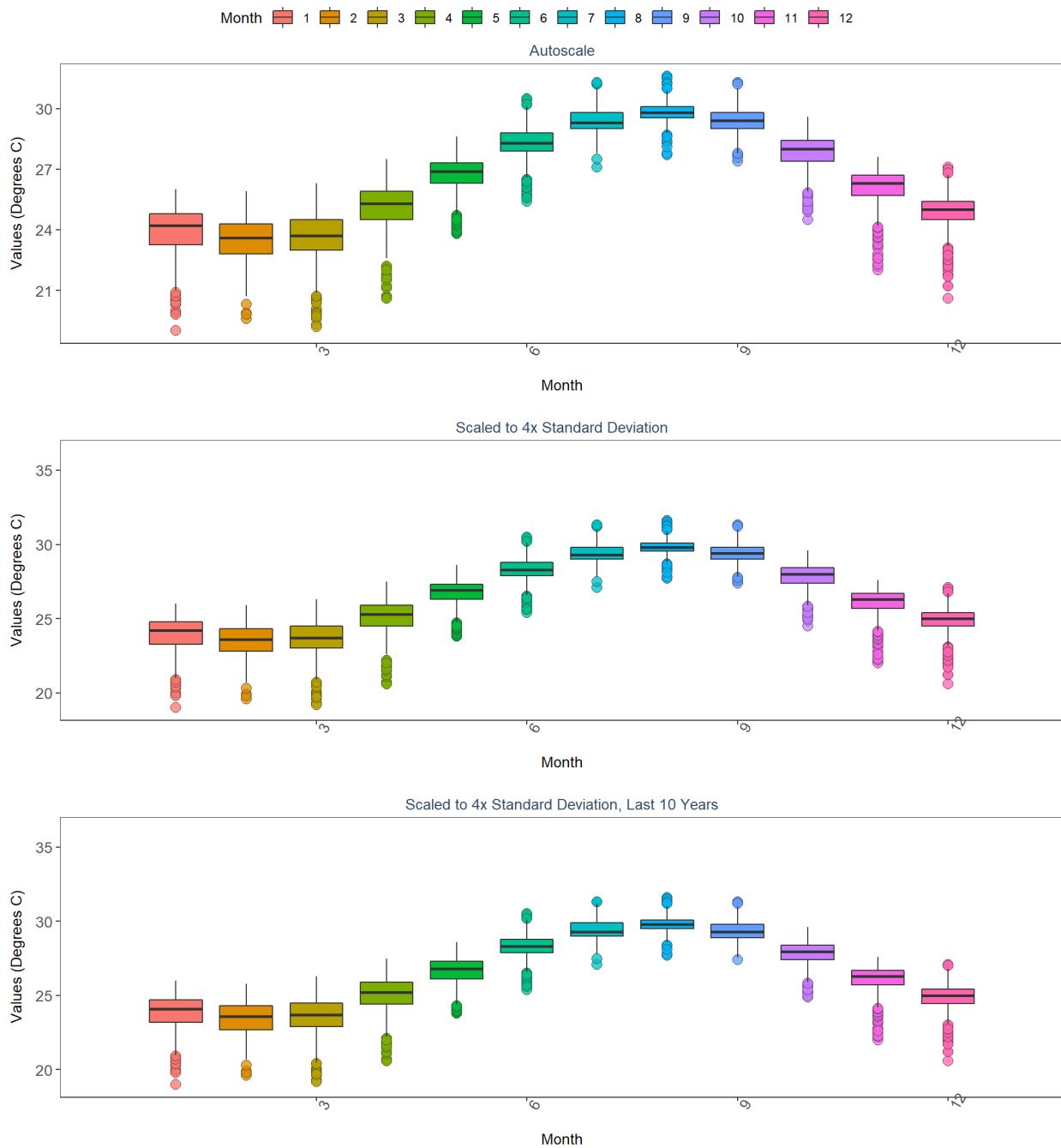
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_MOLASSES
 By Year



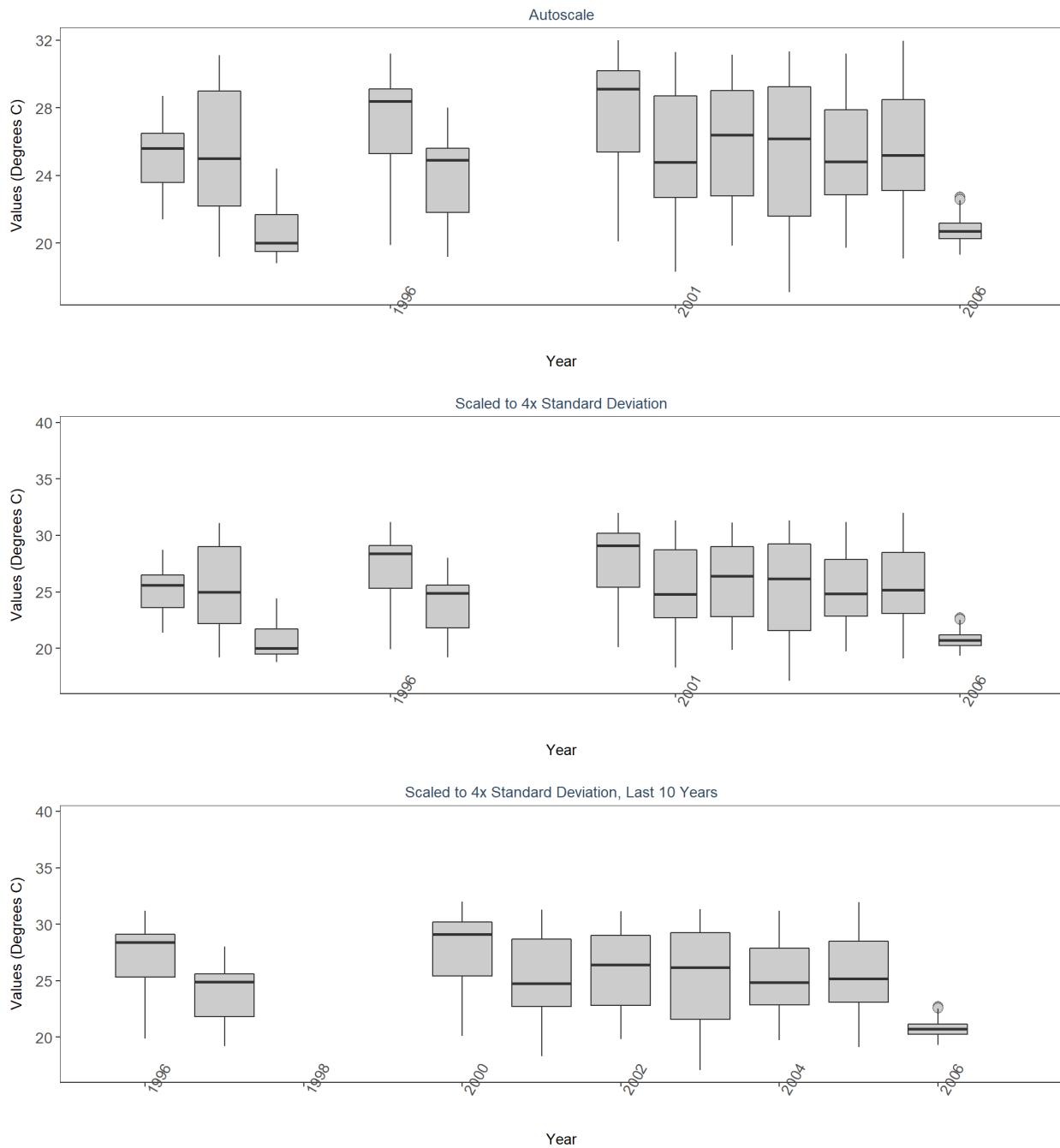
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 FKNMS_MOLASSES
 By Year & Month



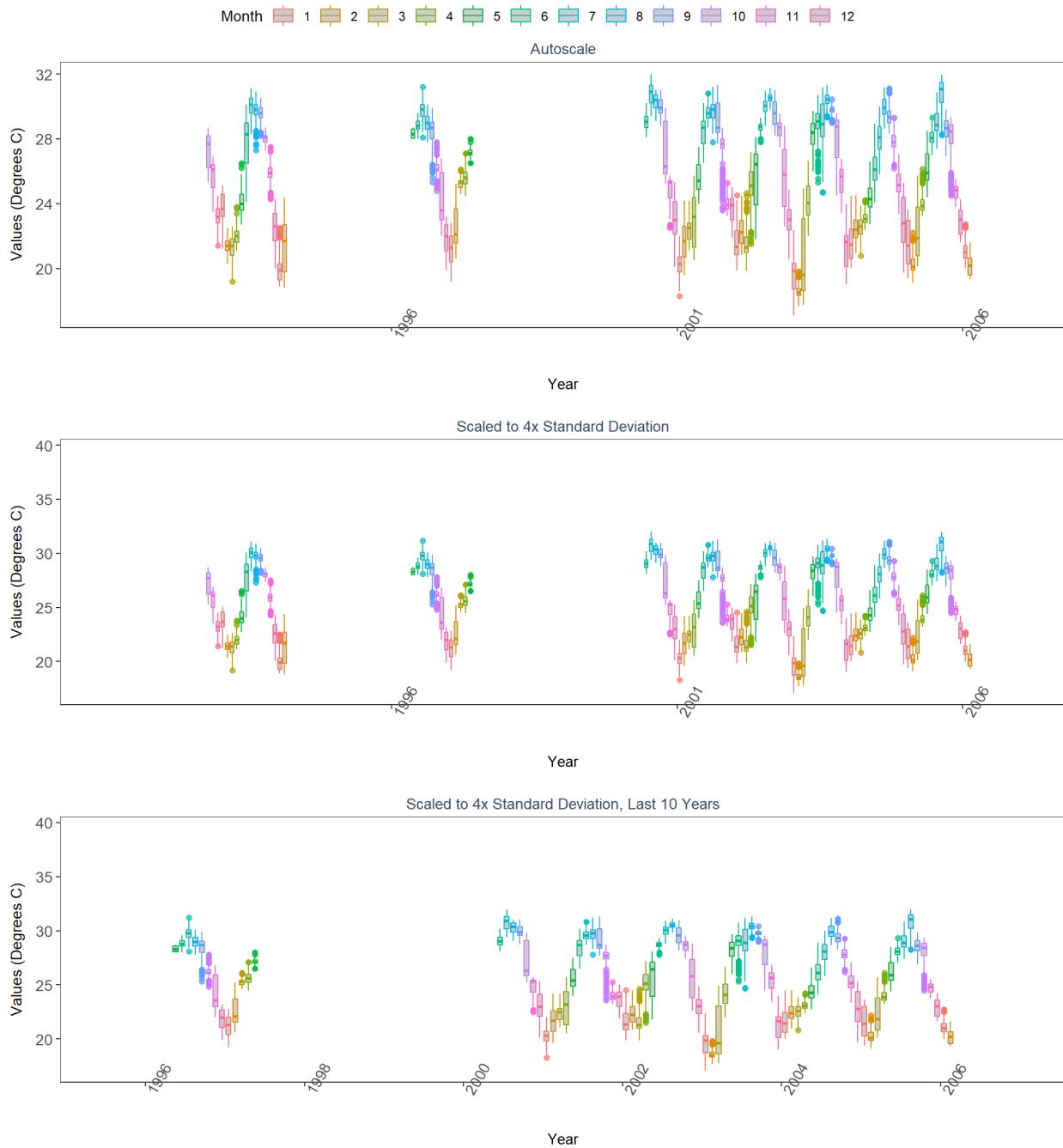
Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_MOLASSES
 By Month



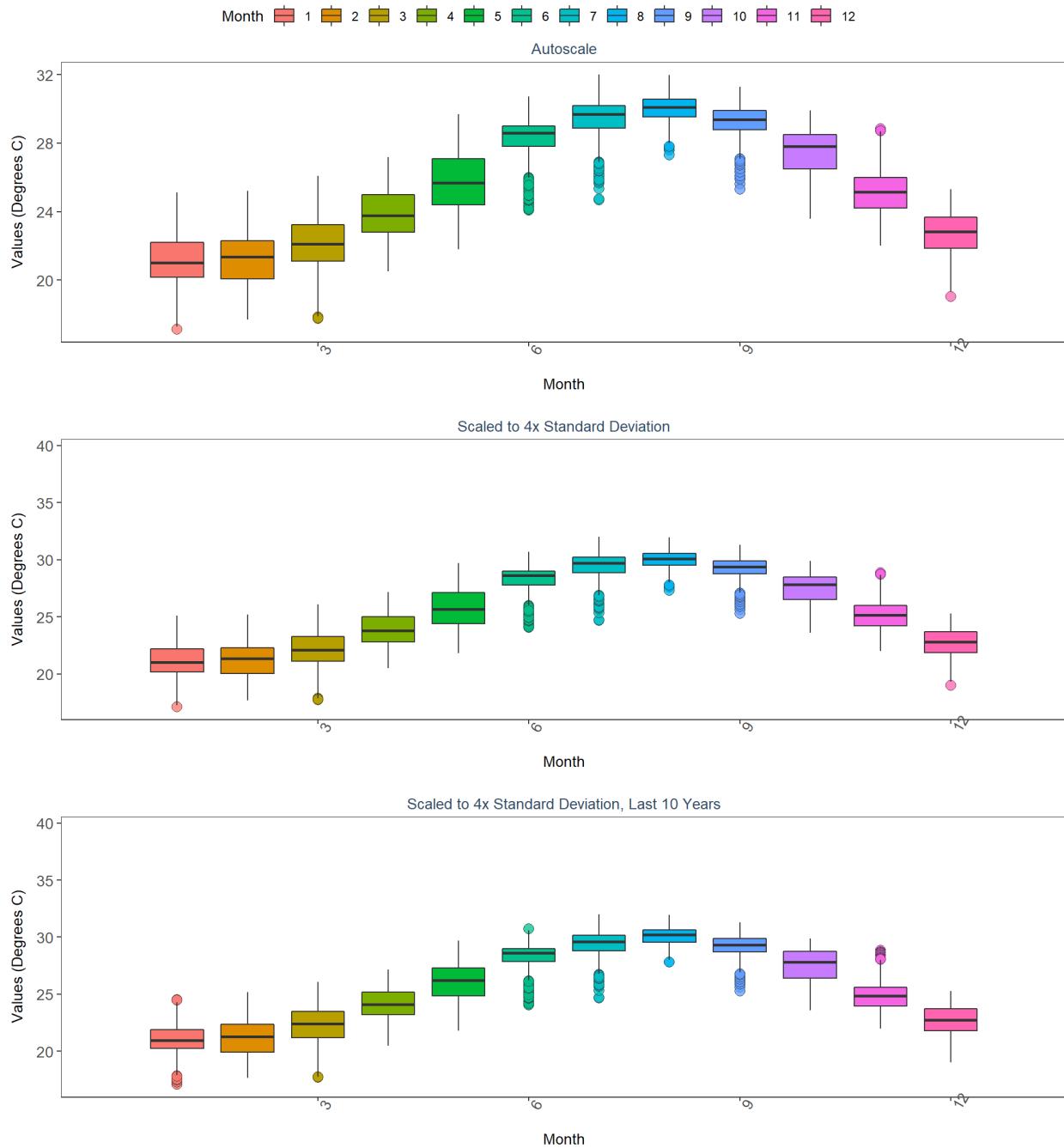
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_NEWSGROUND
 By Year



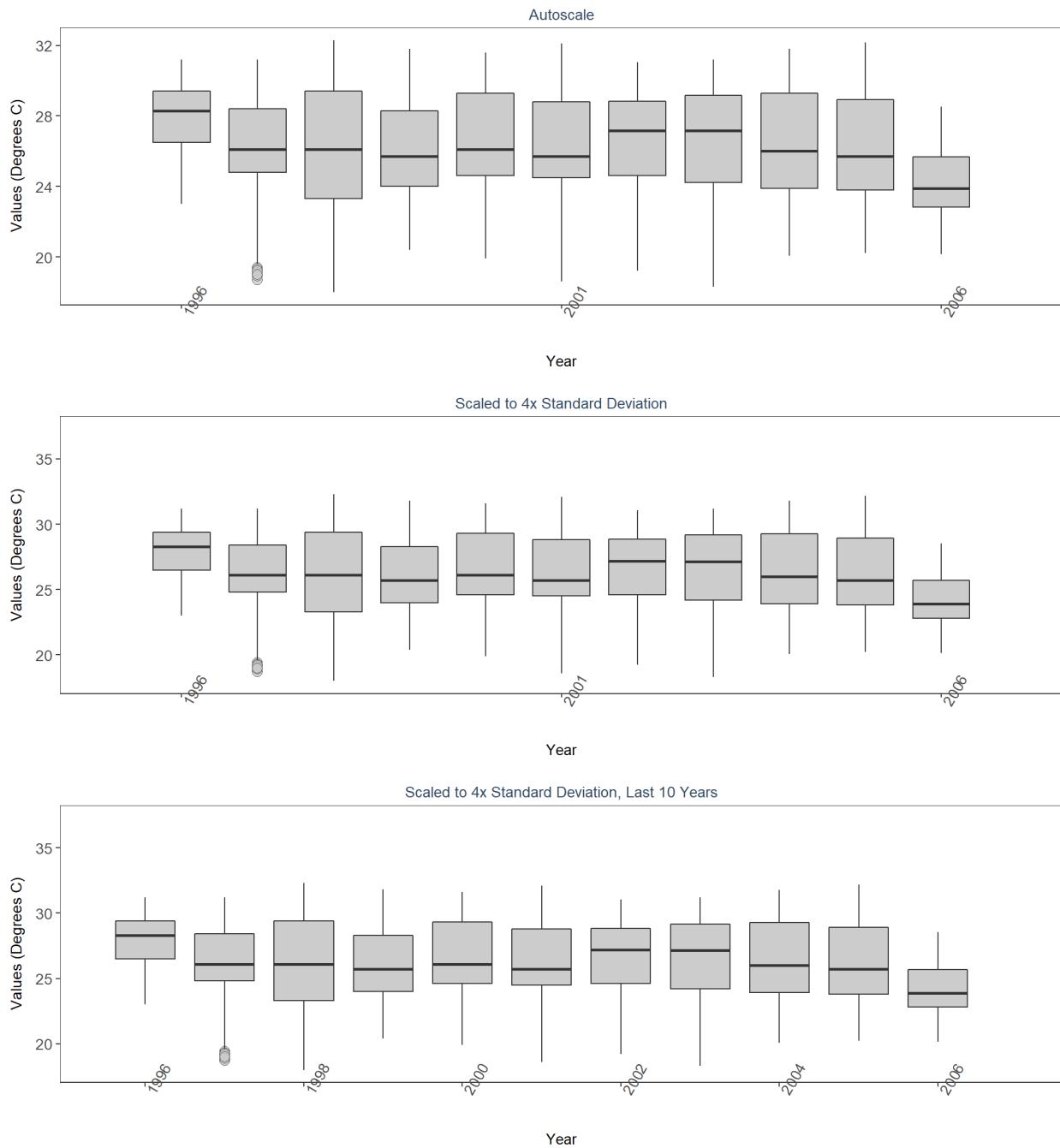
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_NEWSGROUND
 By Year & Month



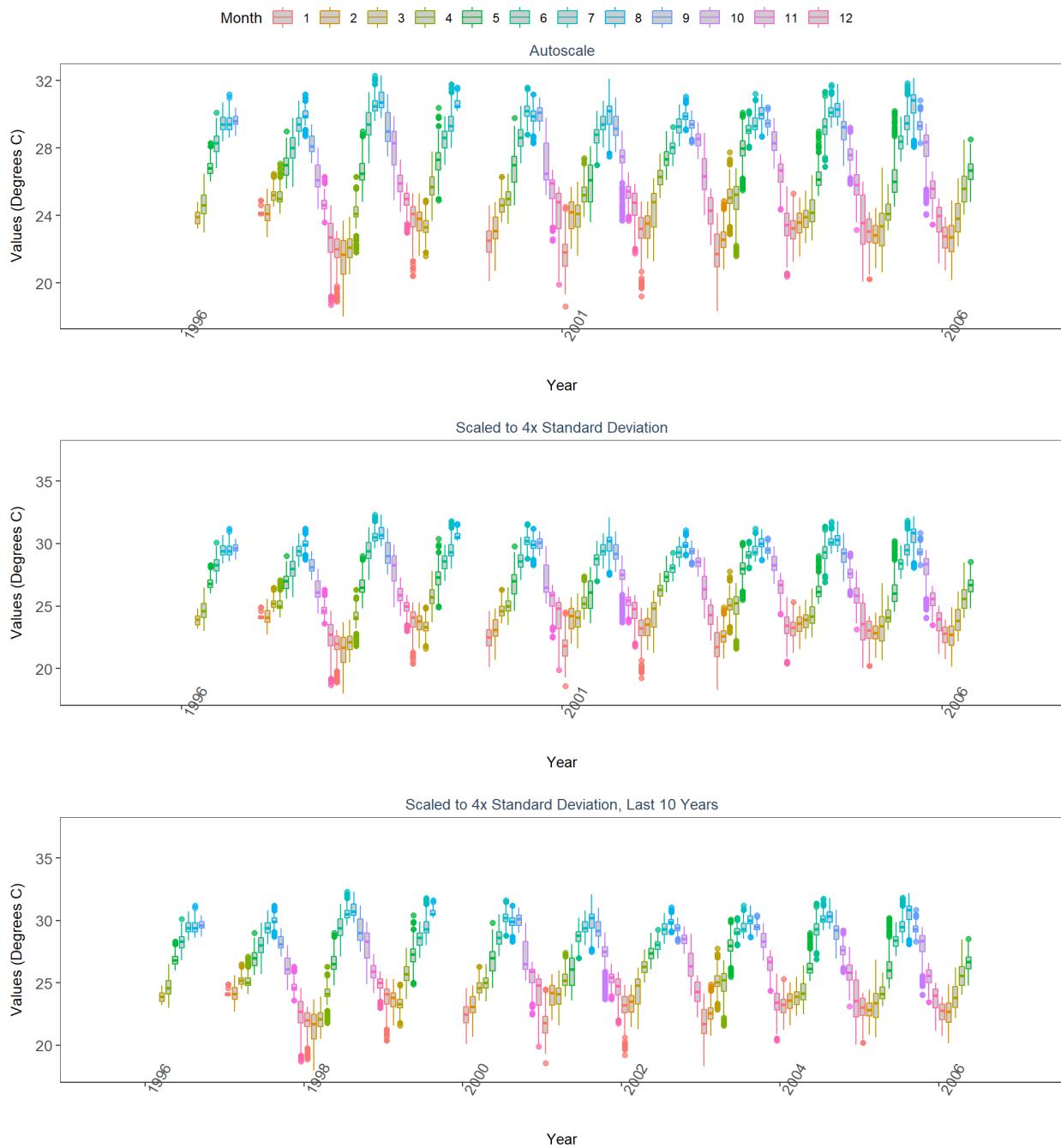
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_NEWSGROUND
 By Month



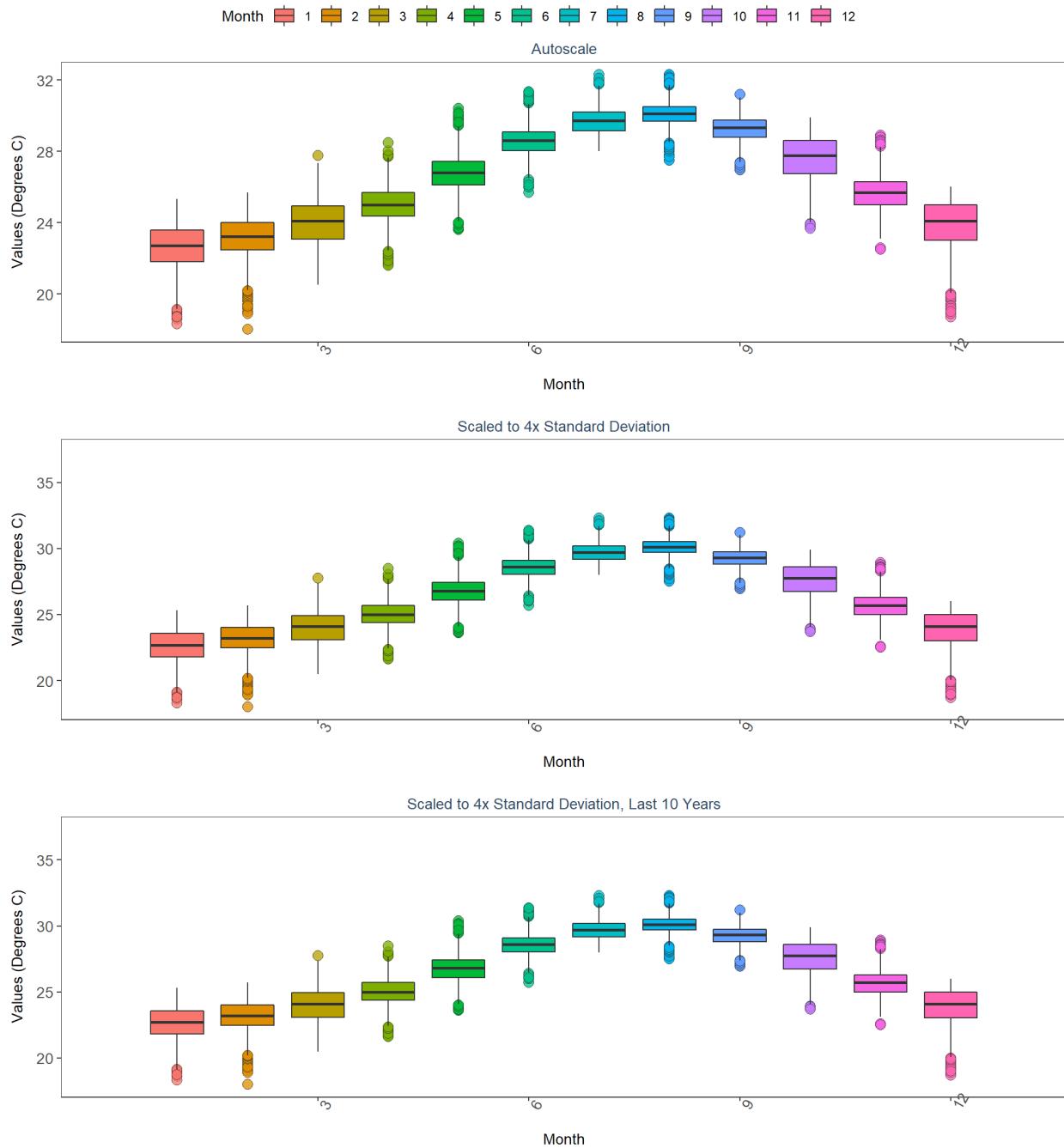
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_PILLAR
 By Year



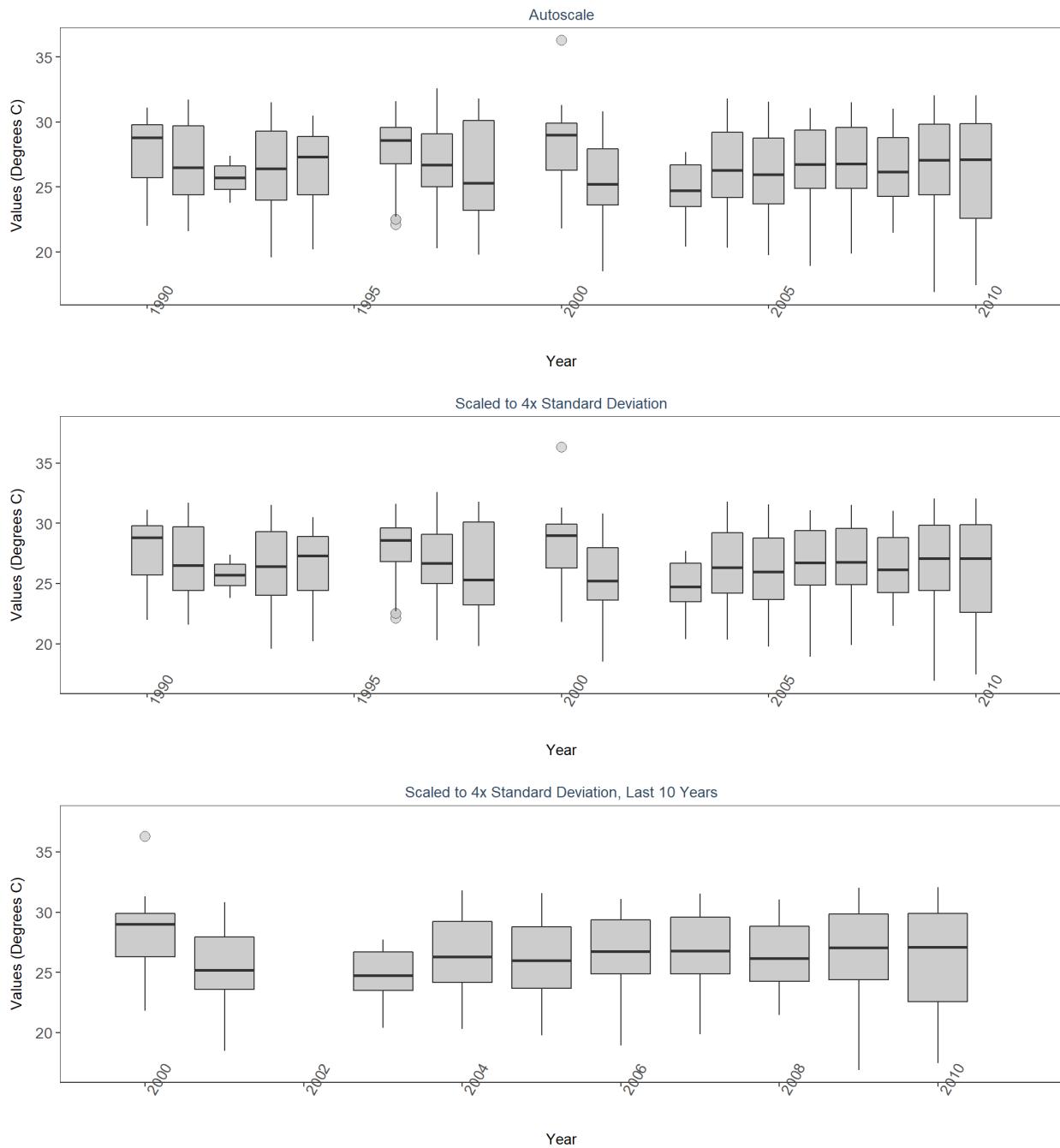
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_PILLAR
 By Year & Month



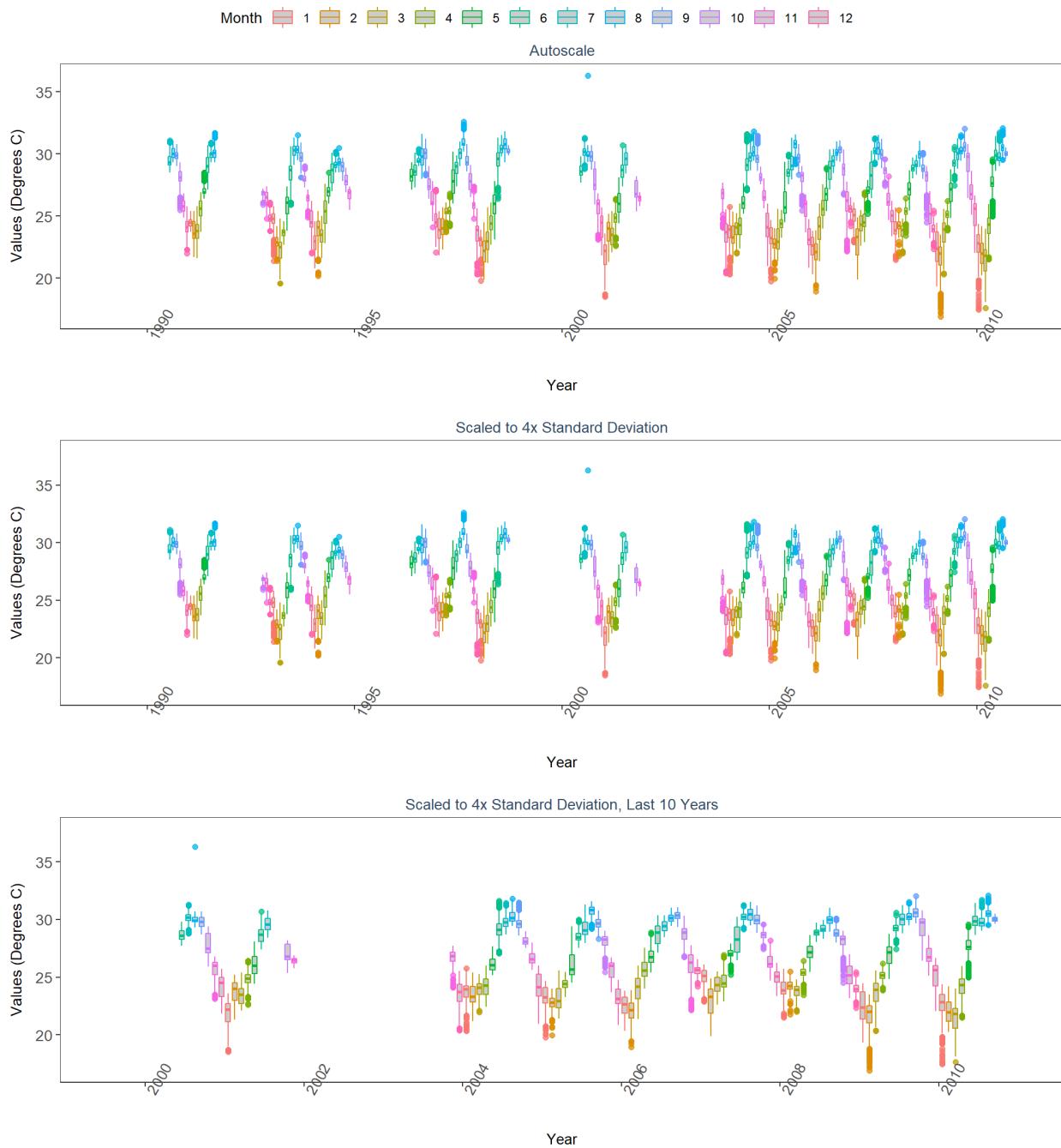
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_PILLAR
 By Month



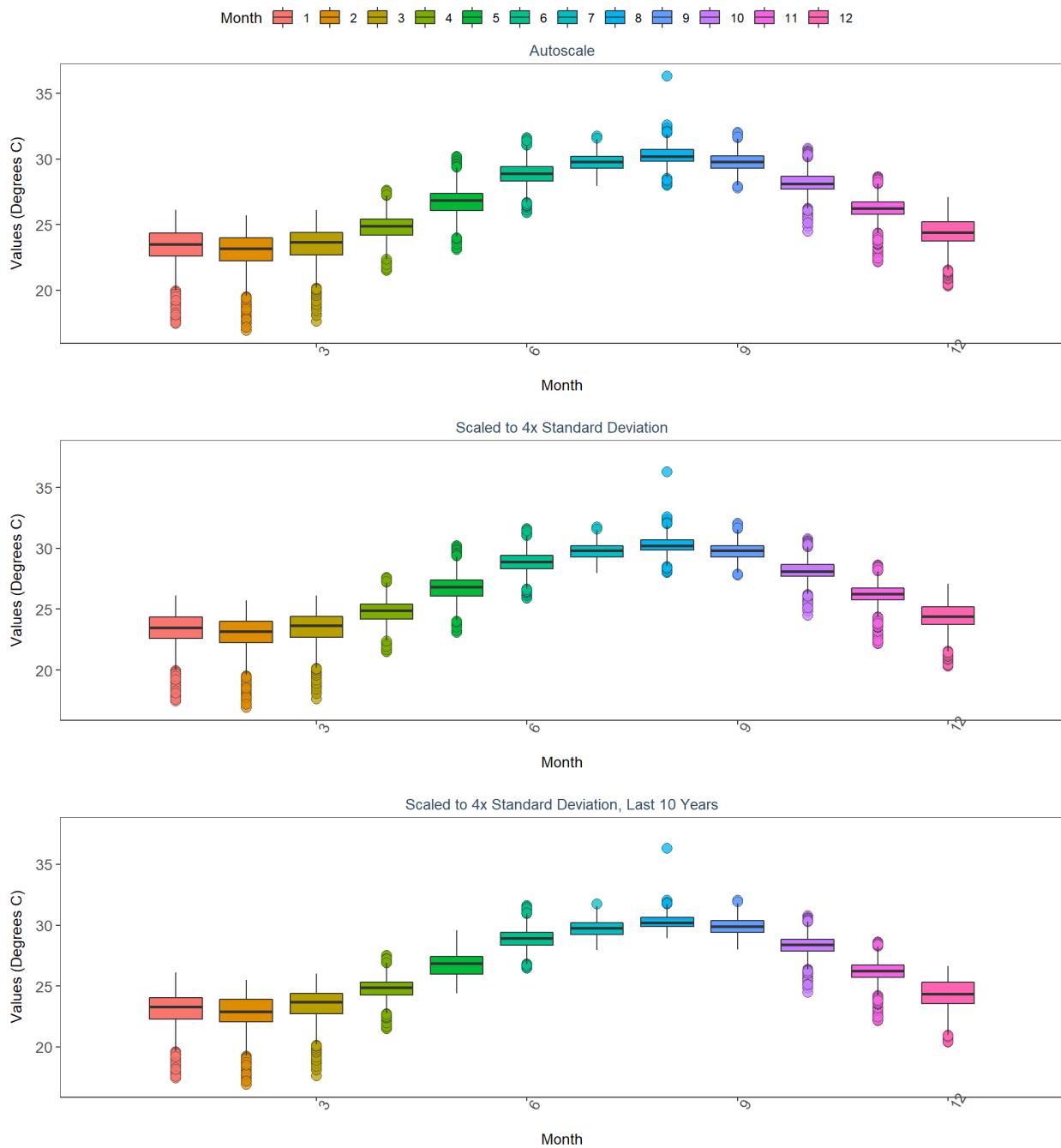
Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SAND_KEY
 By Year



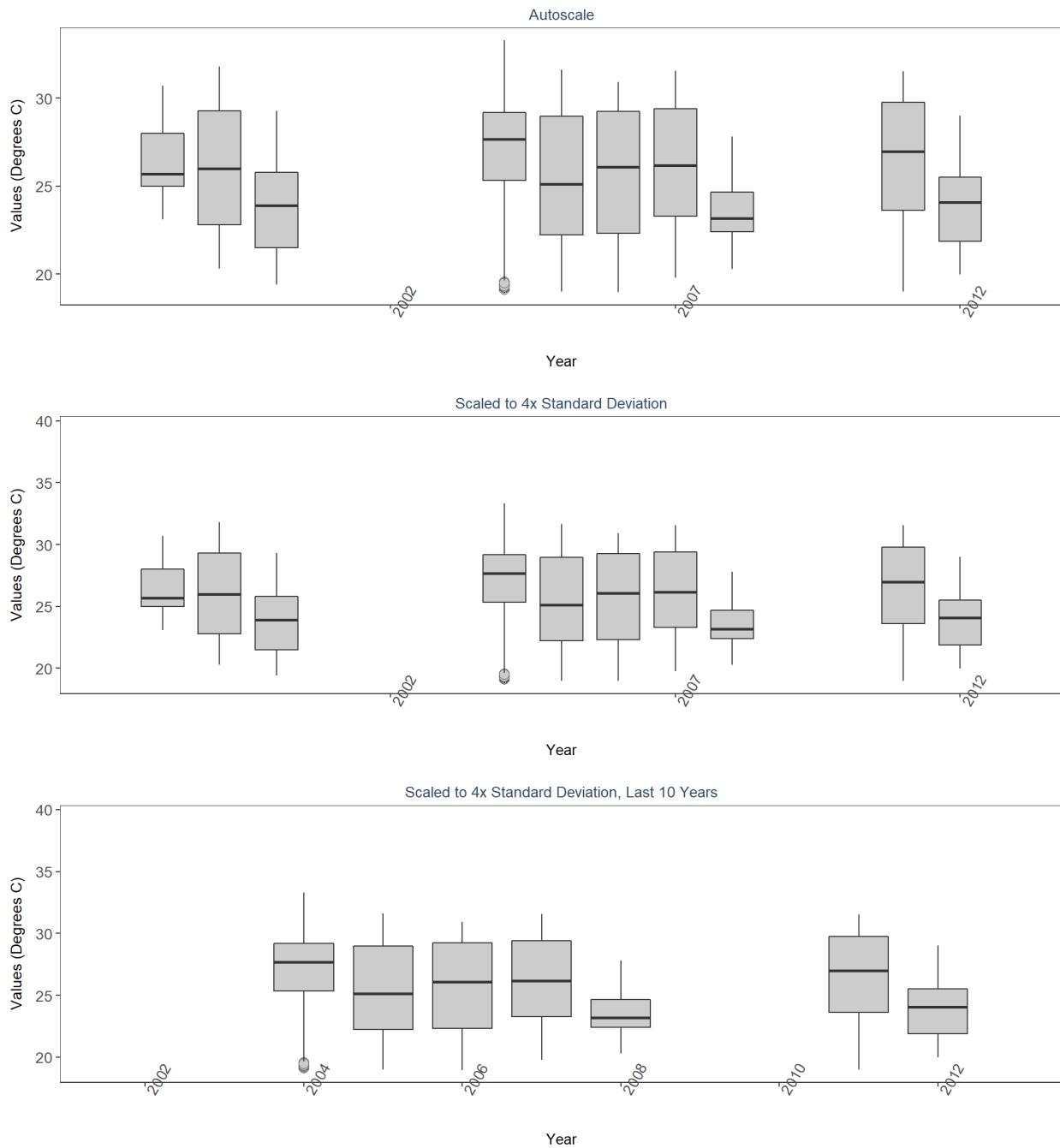
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SAND_KEY
 By Year & Month



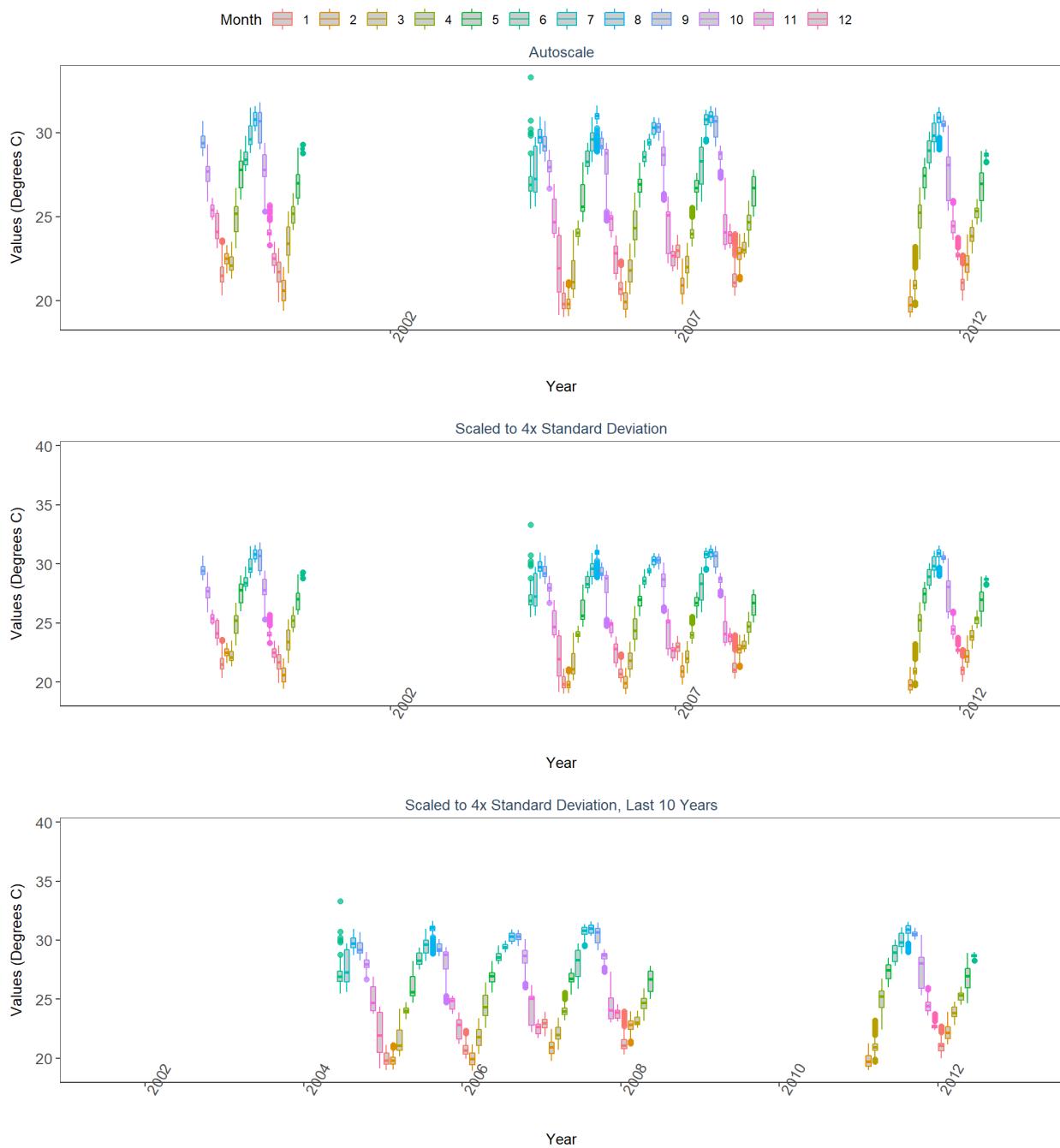
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SAND_KEY
 By Month



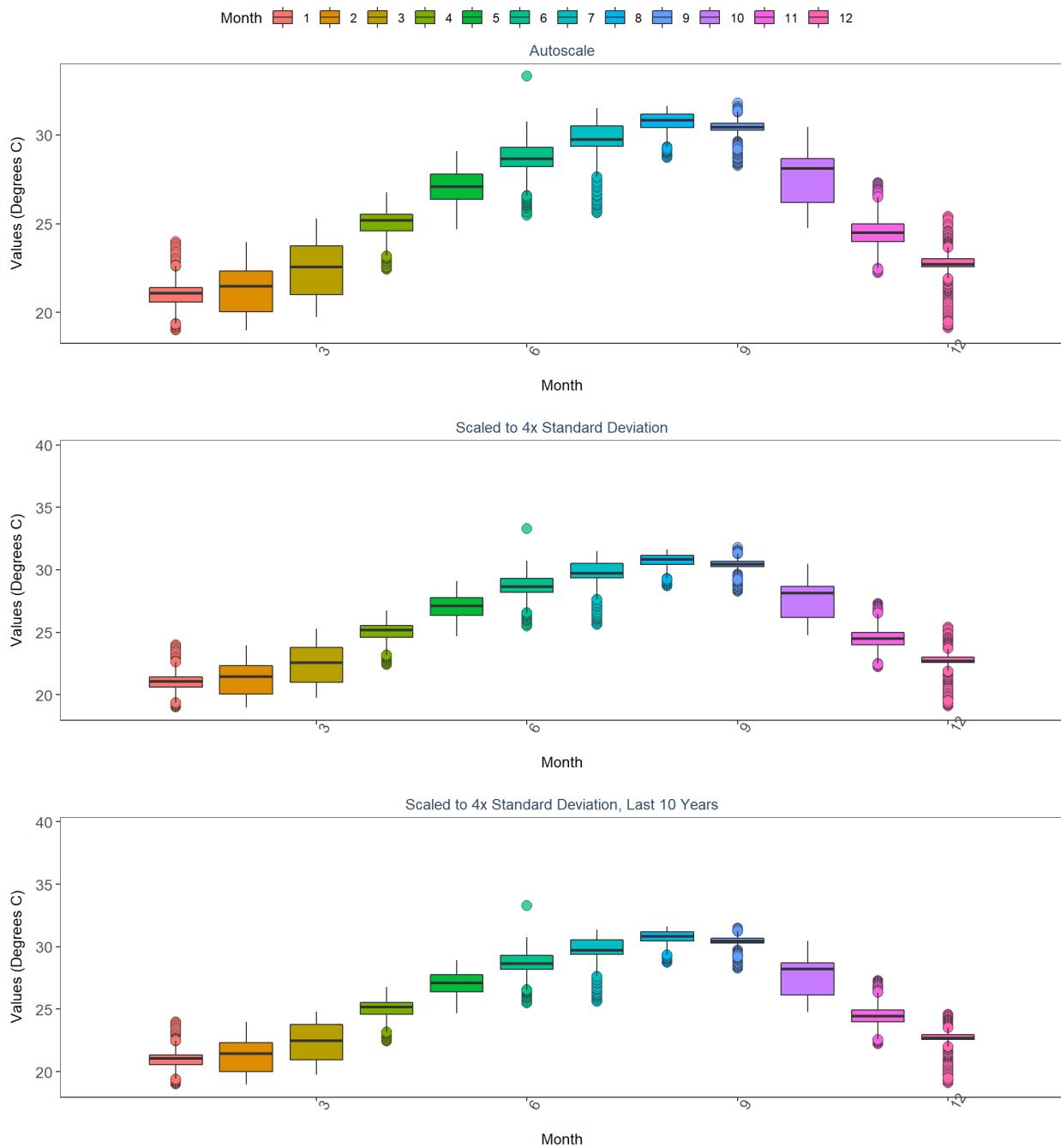
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SMITH_SHL
 By Year



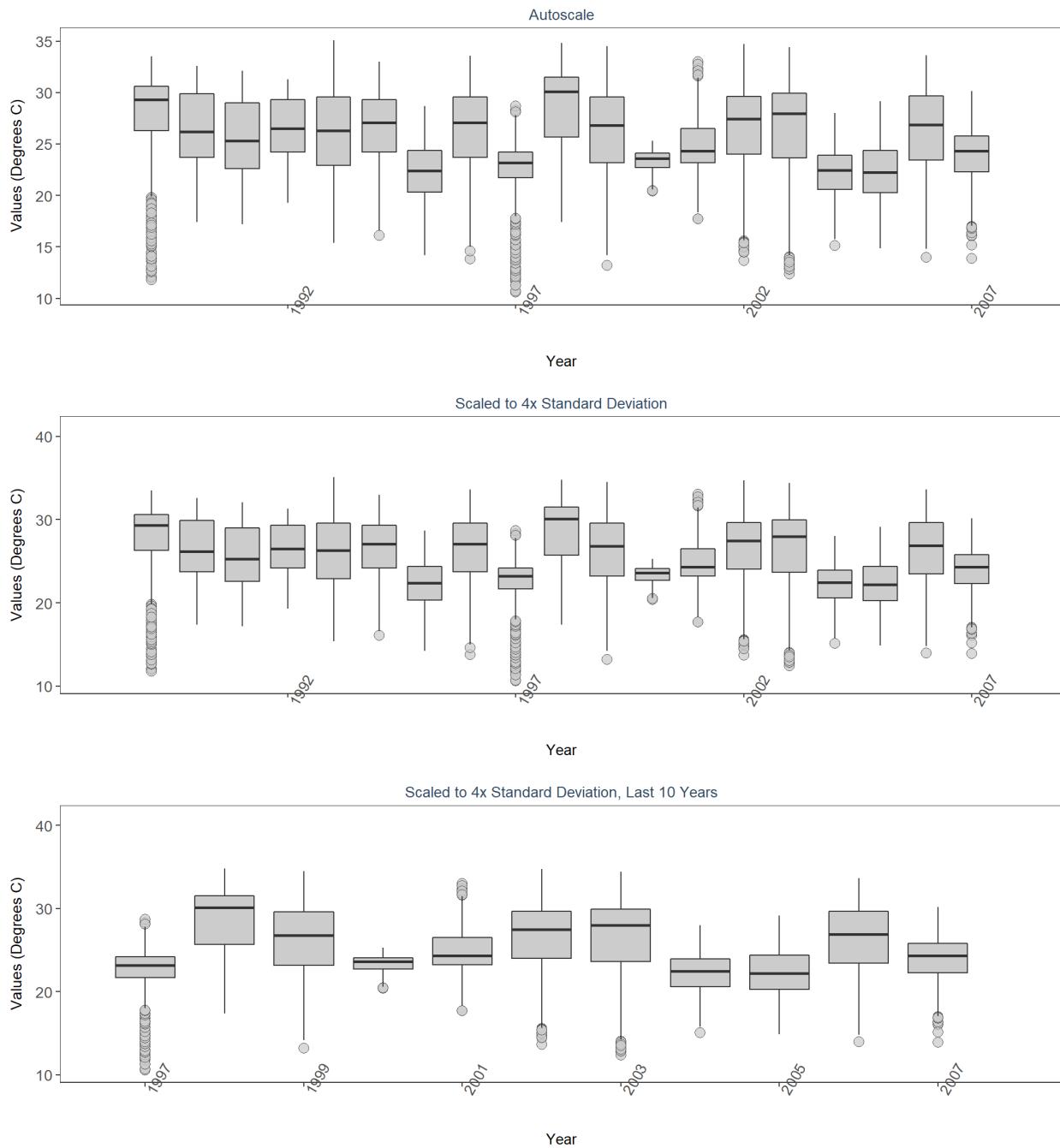
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SMITH_SHL
 By Year & Month



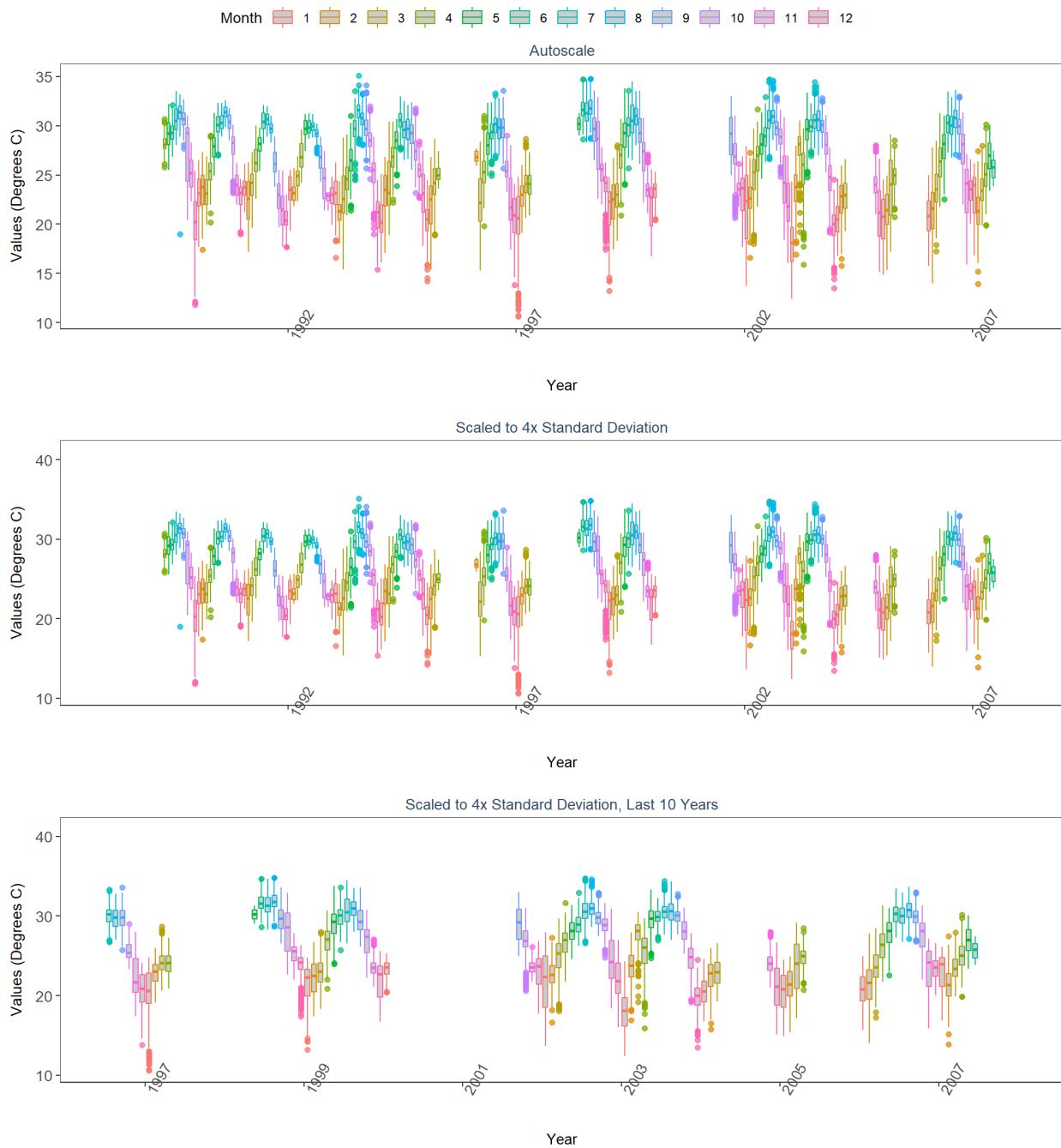
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SMITH_SHL
 By Month



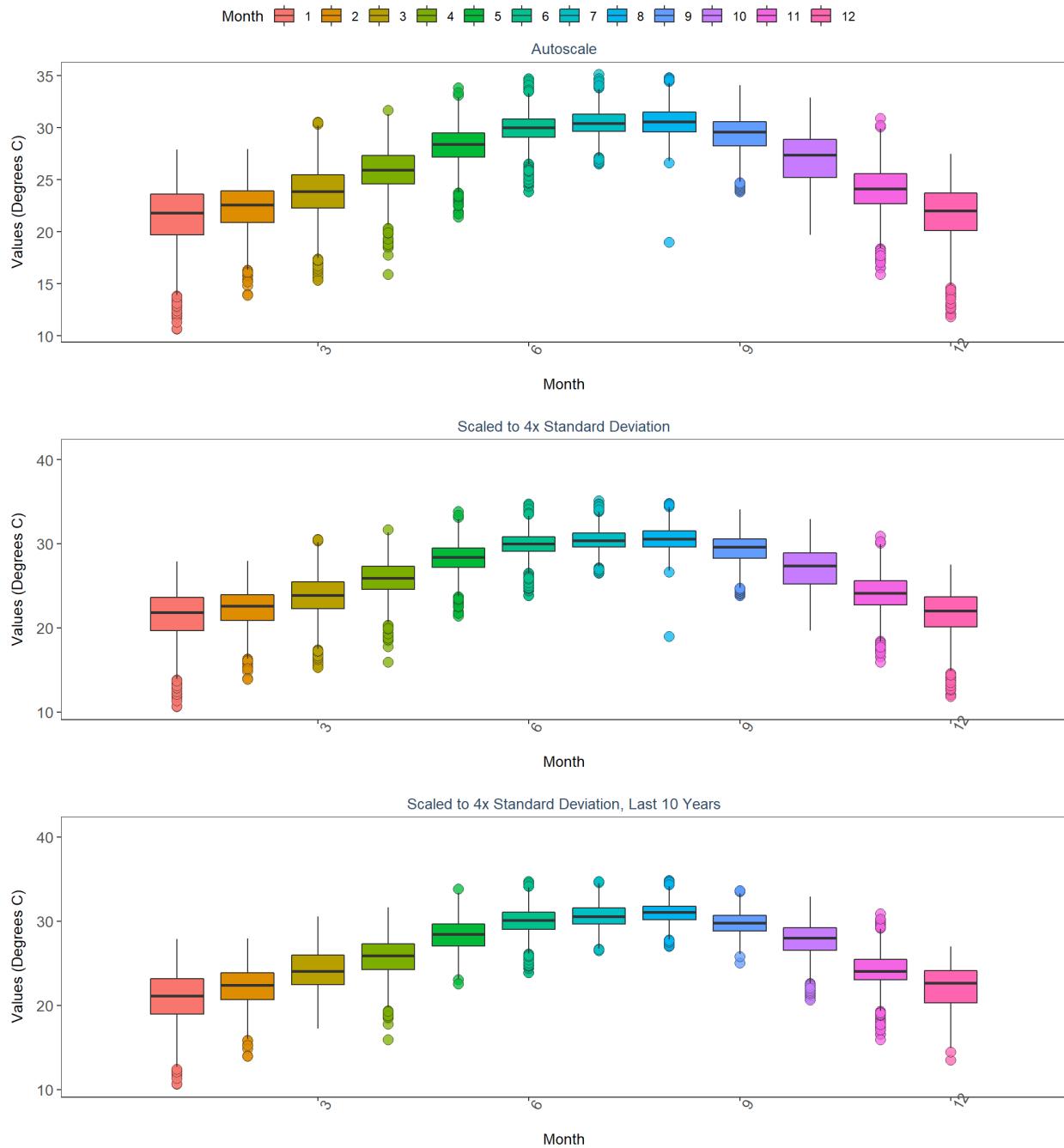
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SNAKE_CRK
 By Year



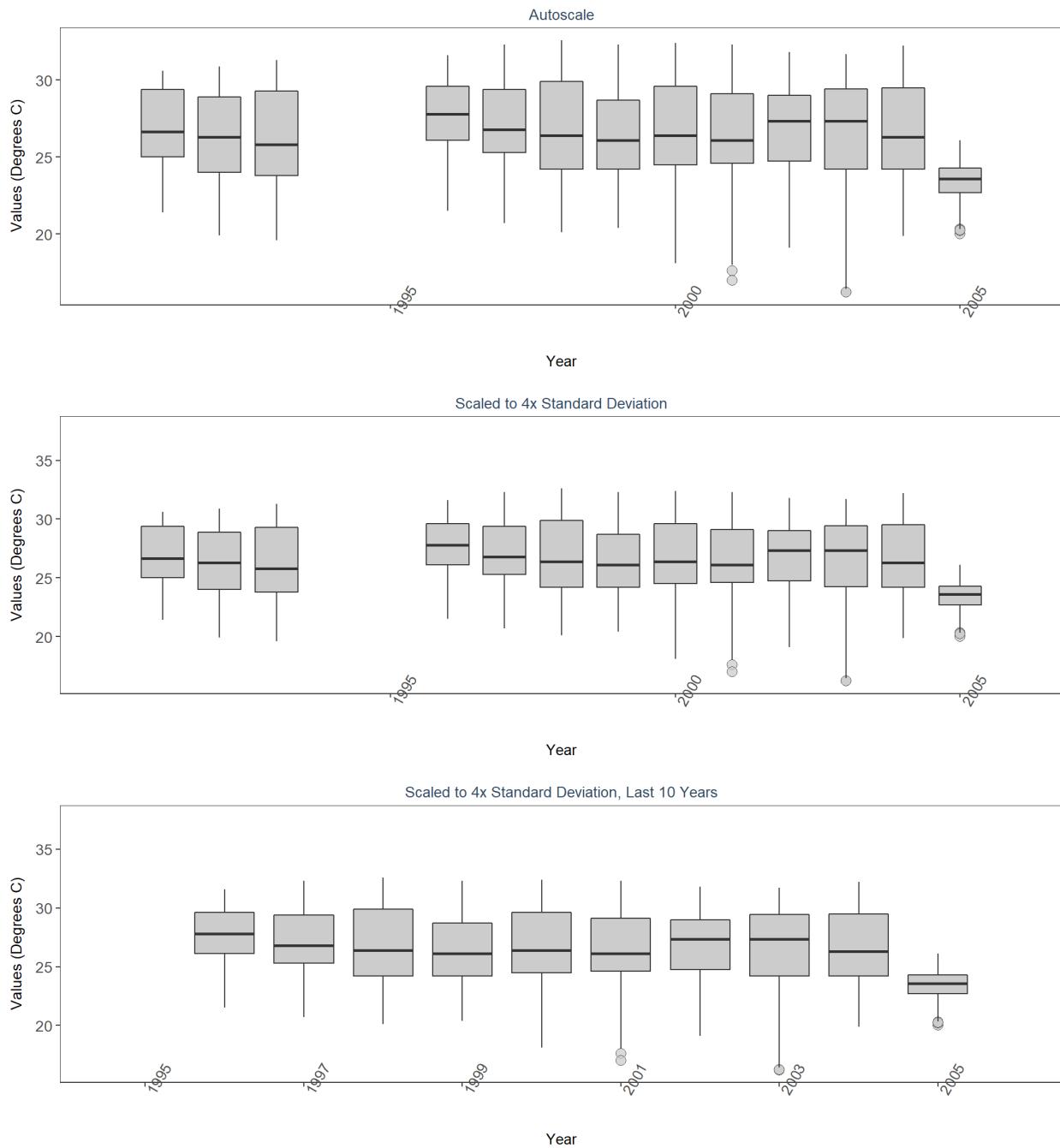
Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SNAKE_CRK
 By Year & Month



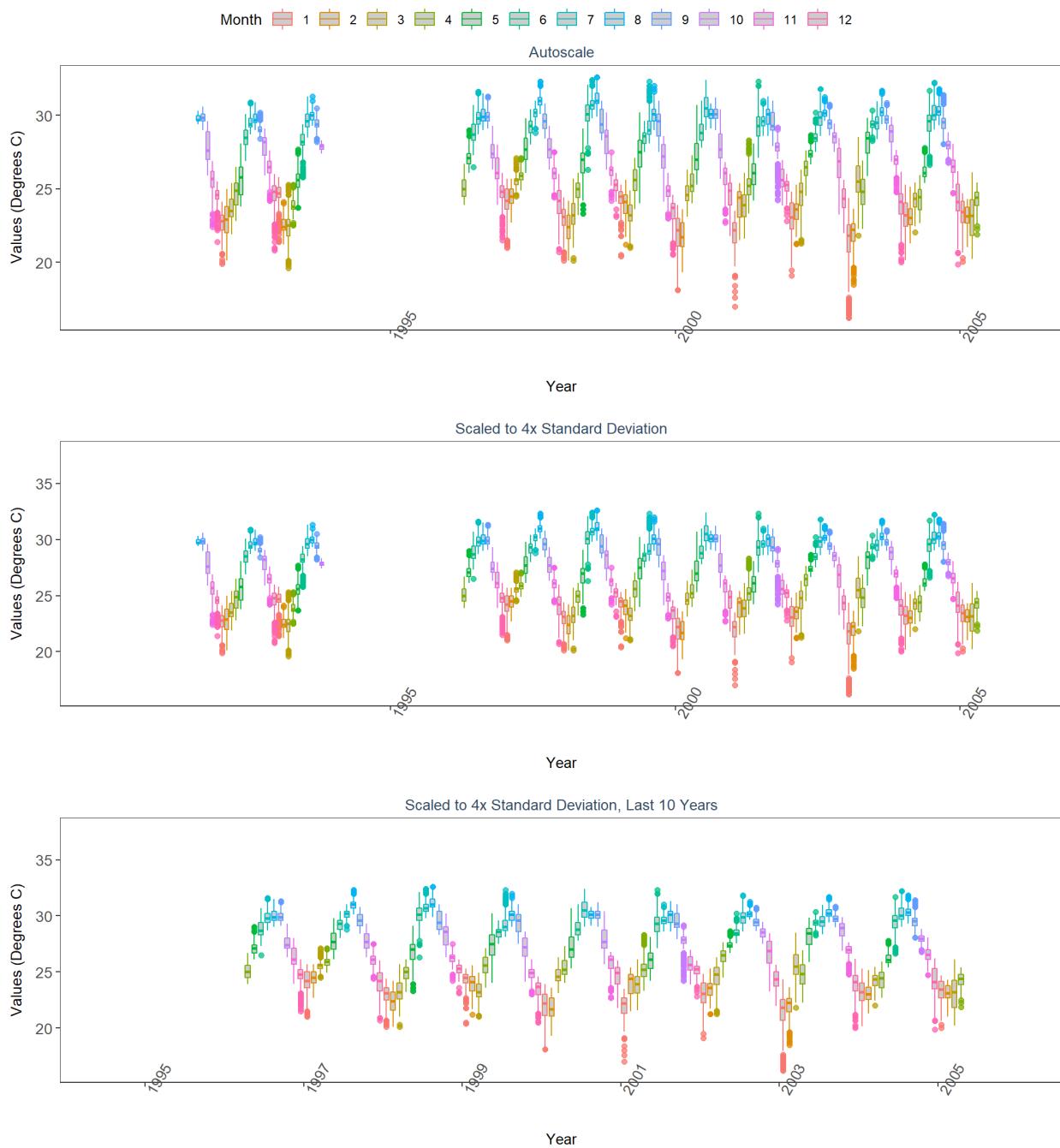
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SNAKE_CRK
 By Month



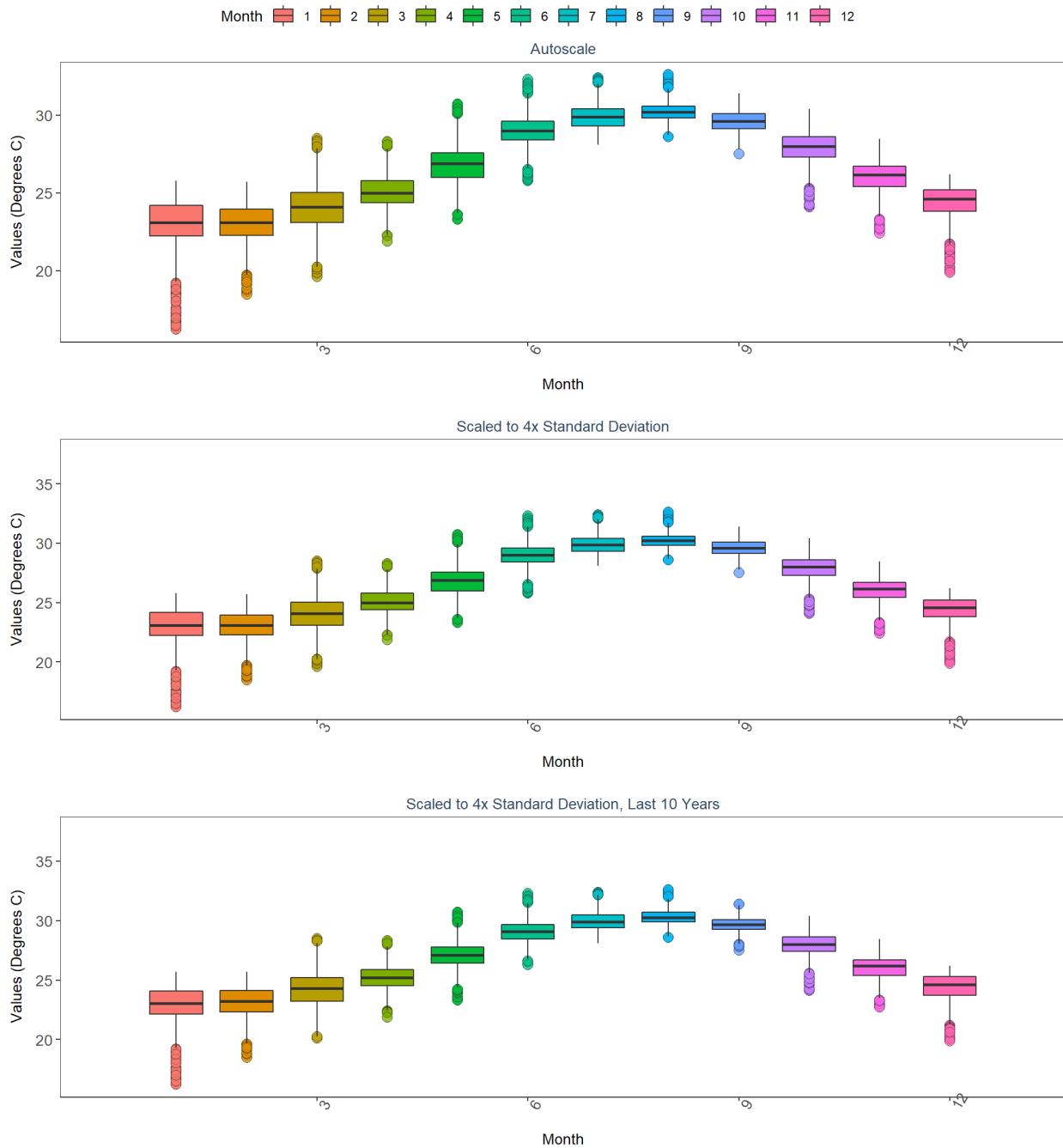
Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SOMBRERO
 By Year



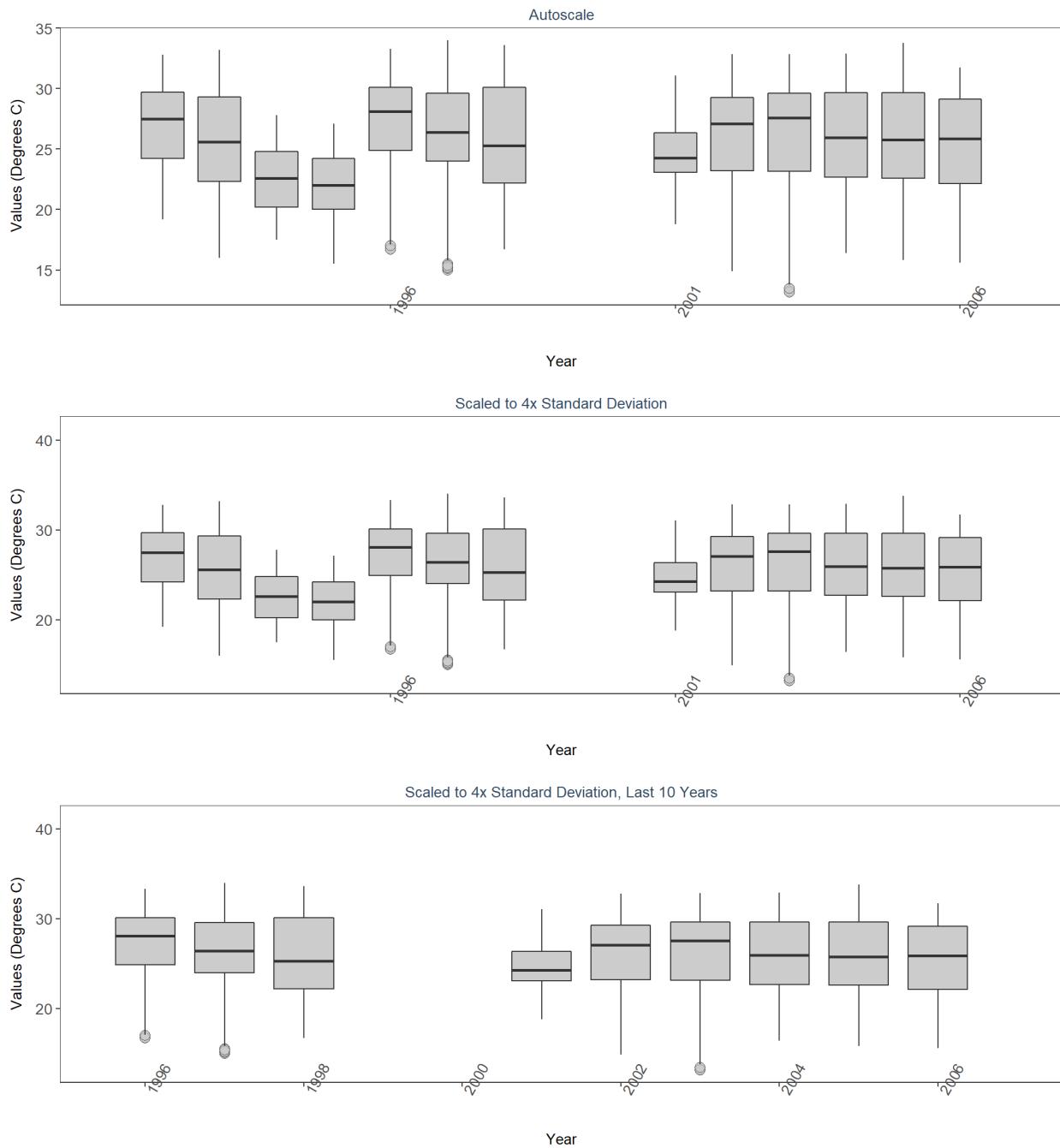
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SOMBRERO
 By Year & Month



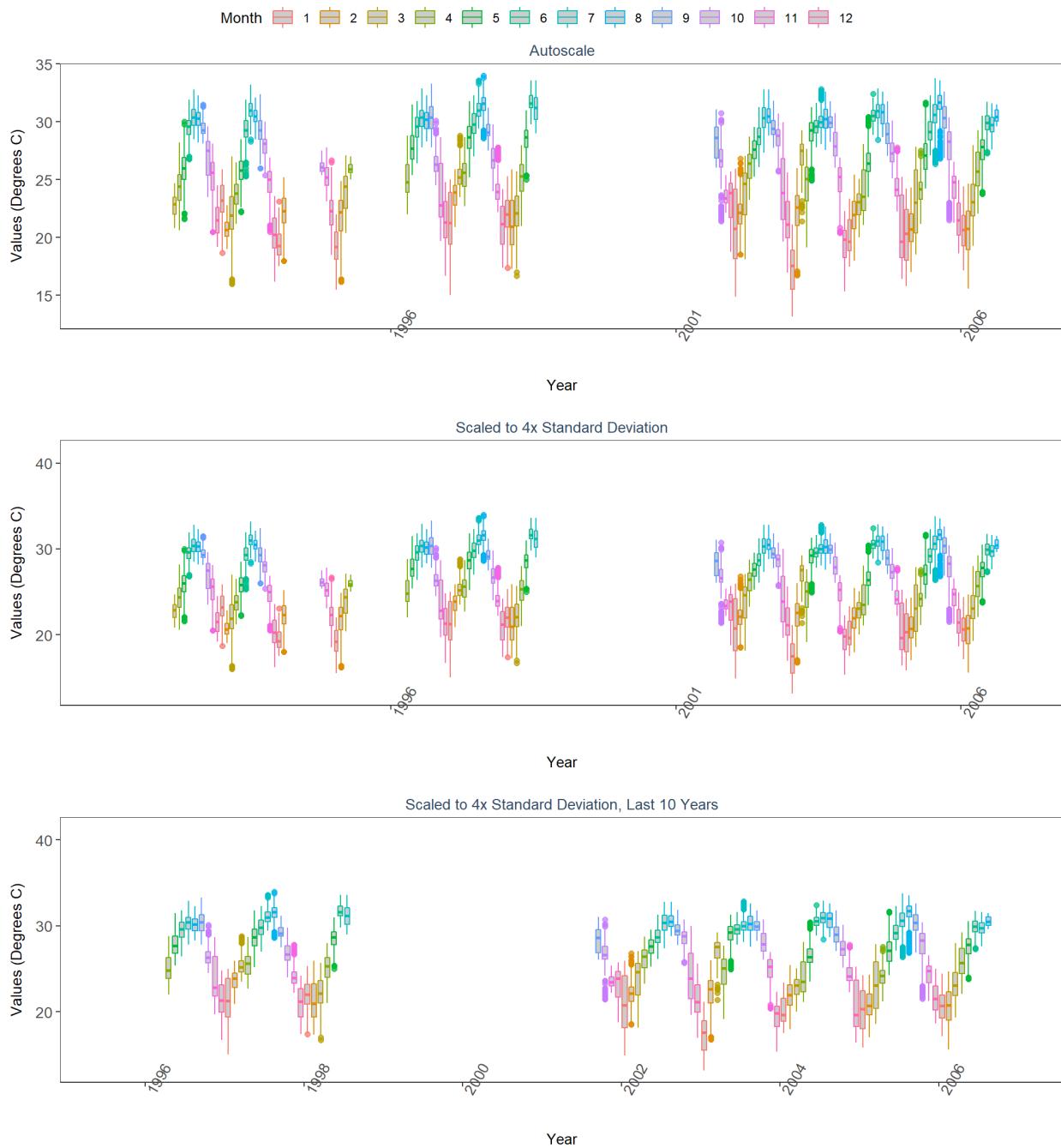
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SOMBRERO
 By Month



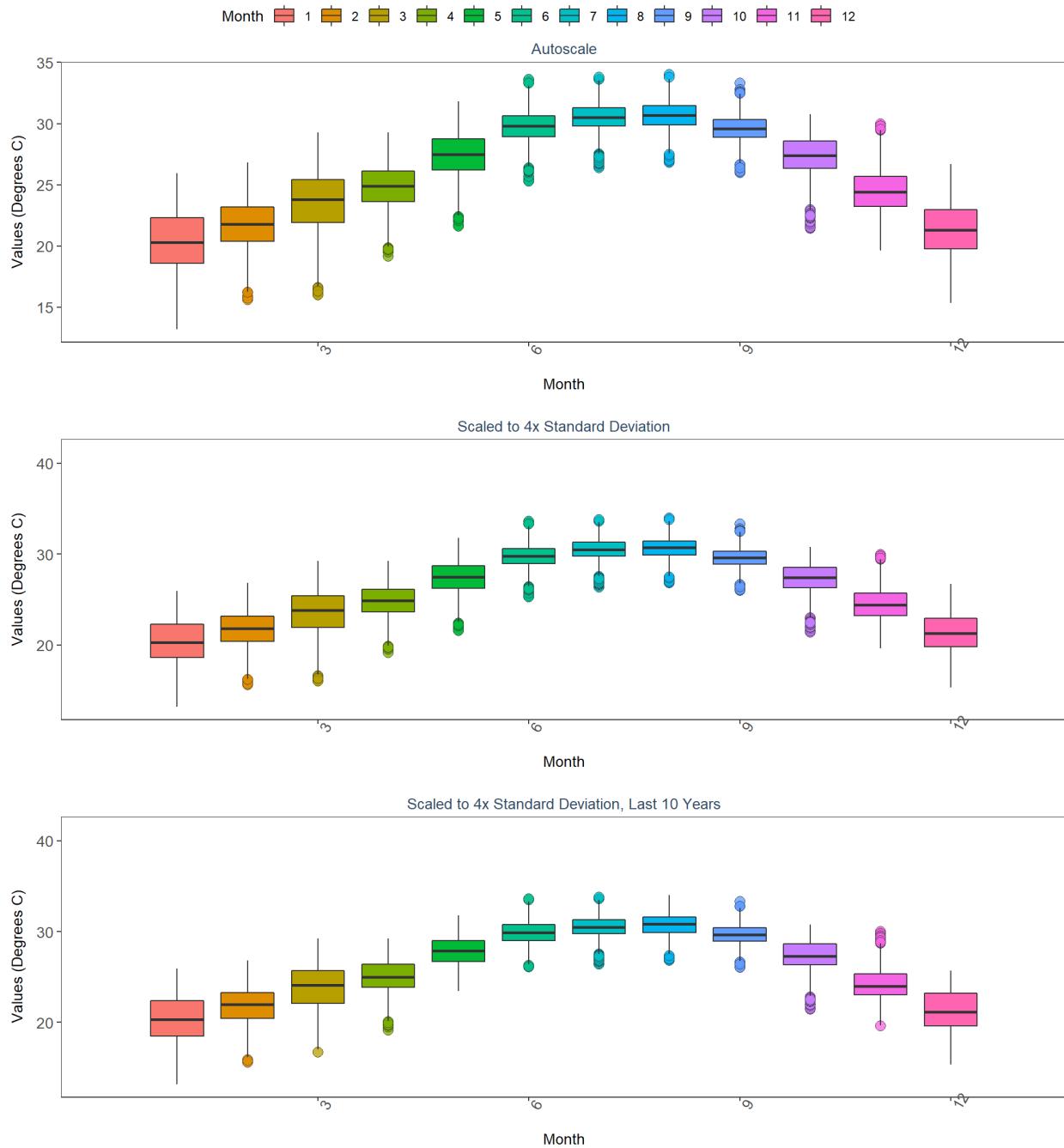
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SPRIGGER
 By Year



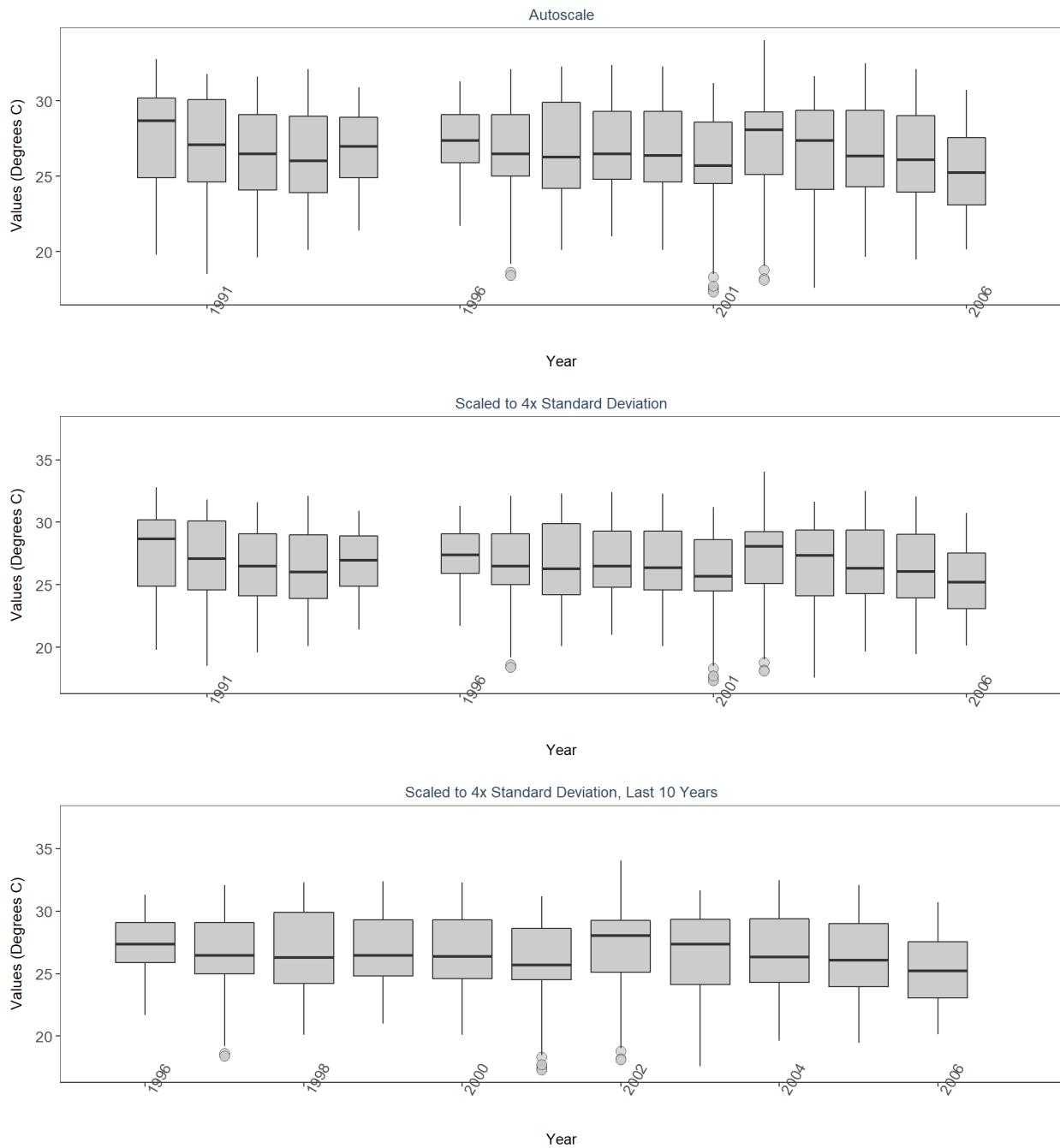
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SPRIGGER
 By Year & Month



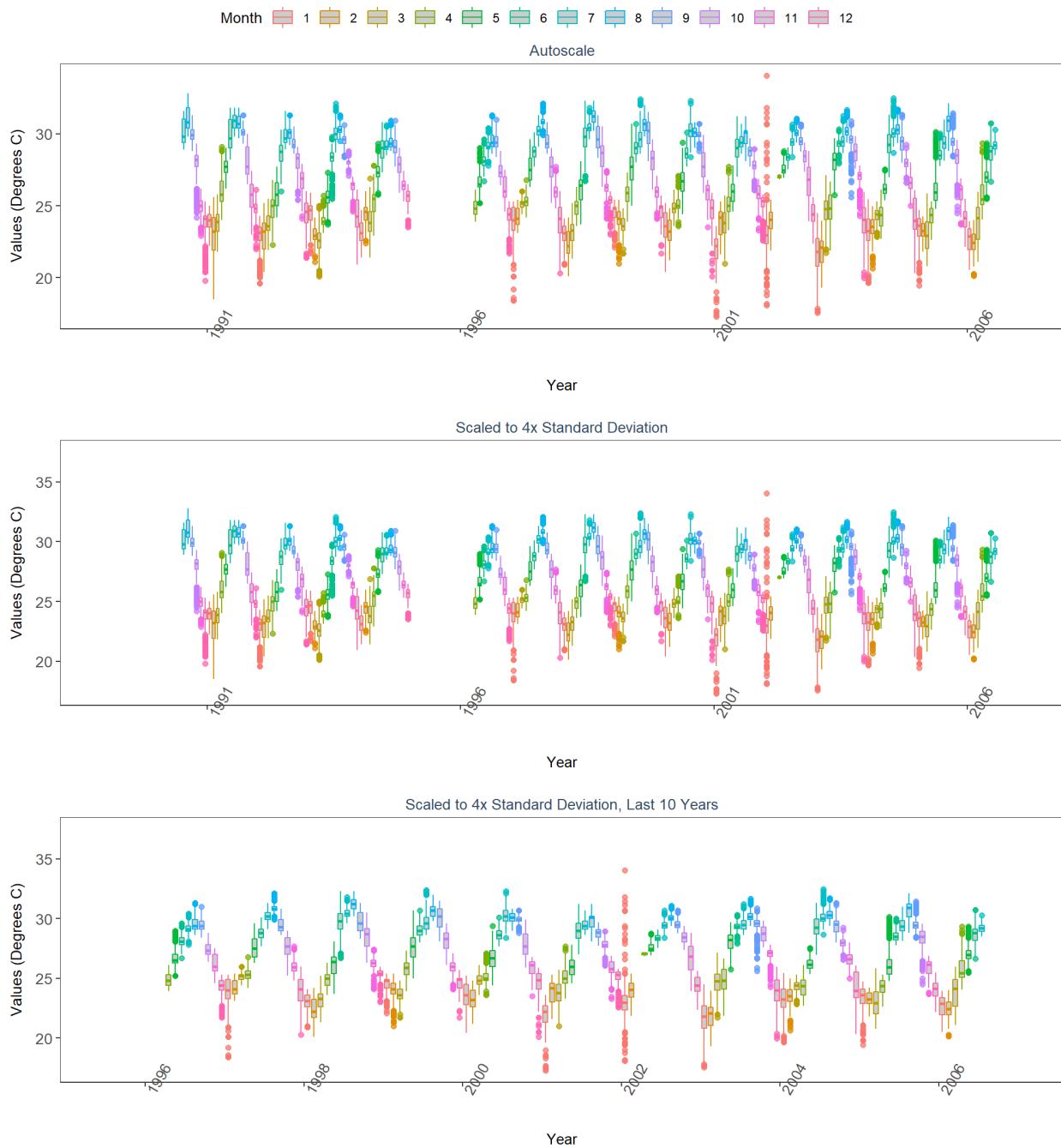
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_SPRIGGER
 By Month



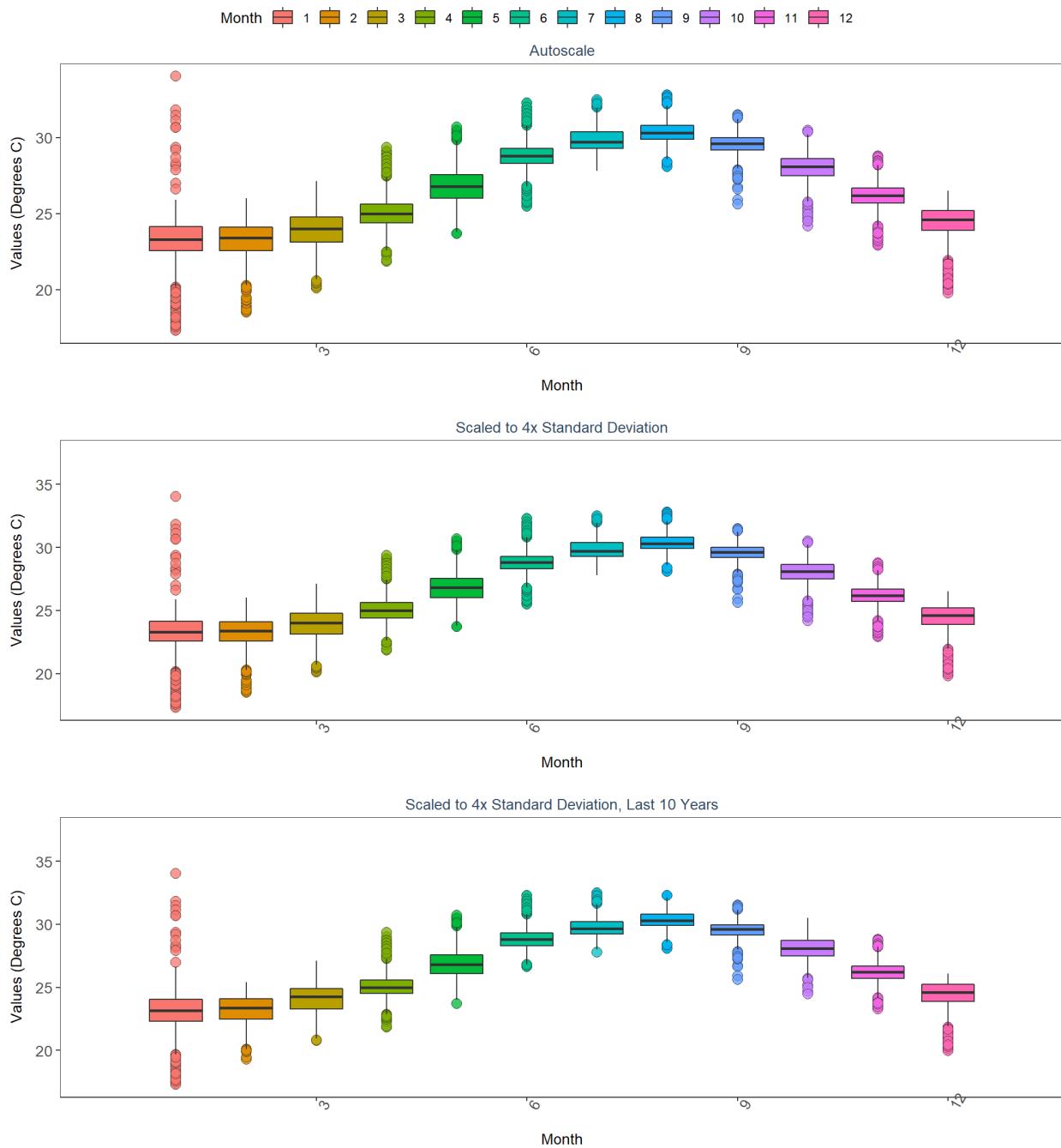
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_TENN_REF
 By Year



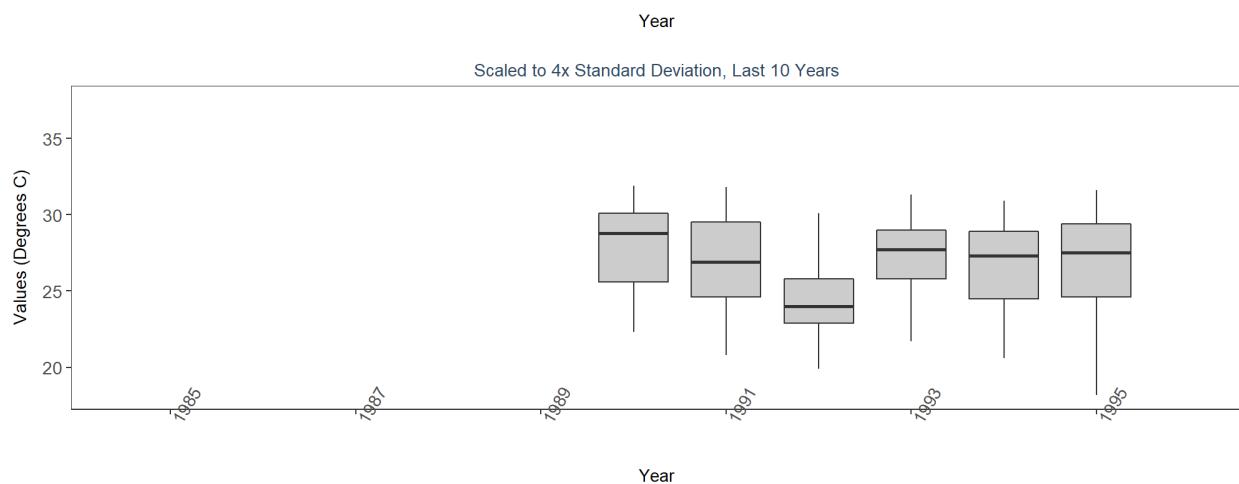
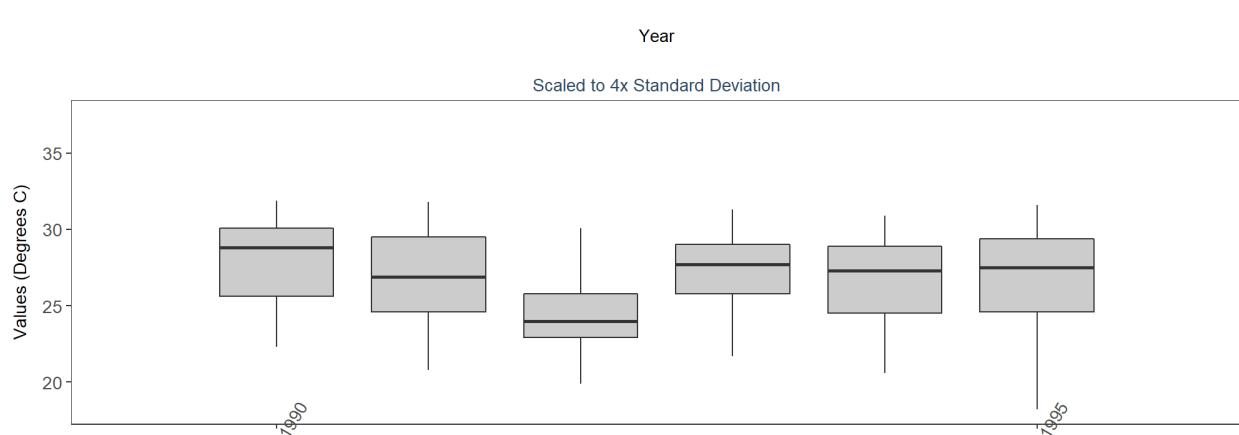
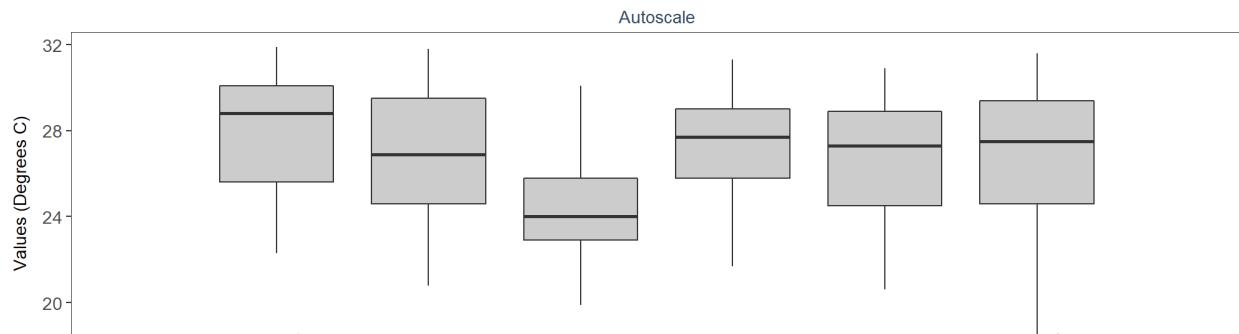
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_TENN_REF
 By Year & Month



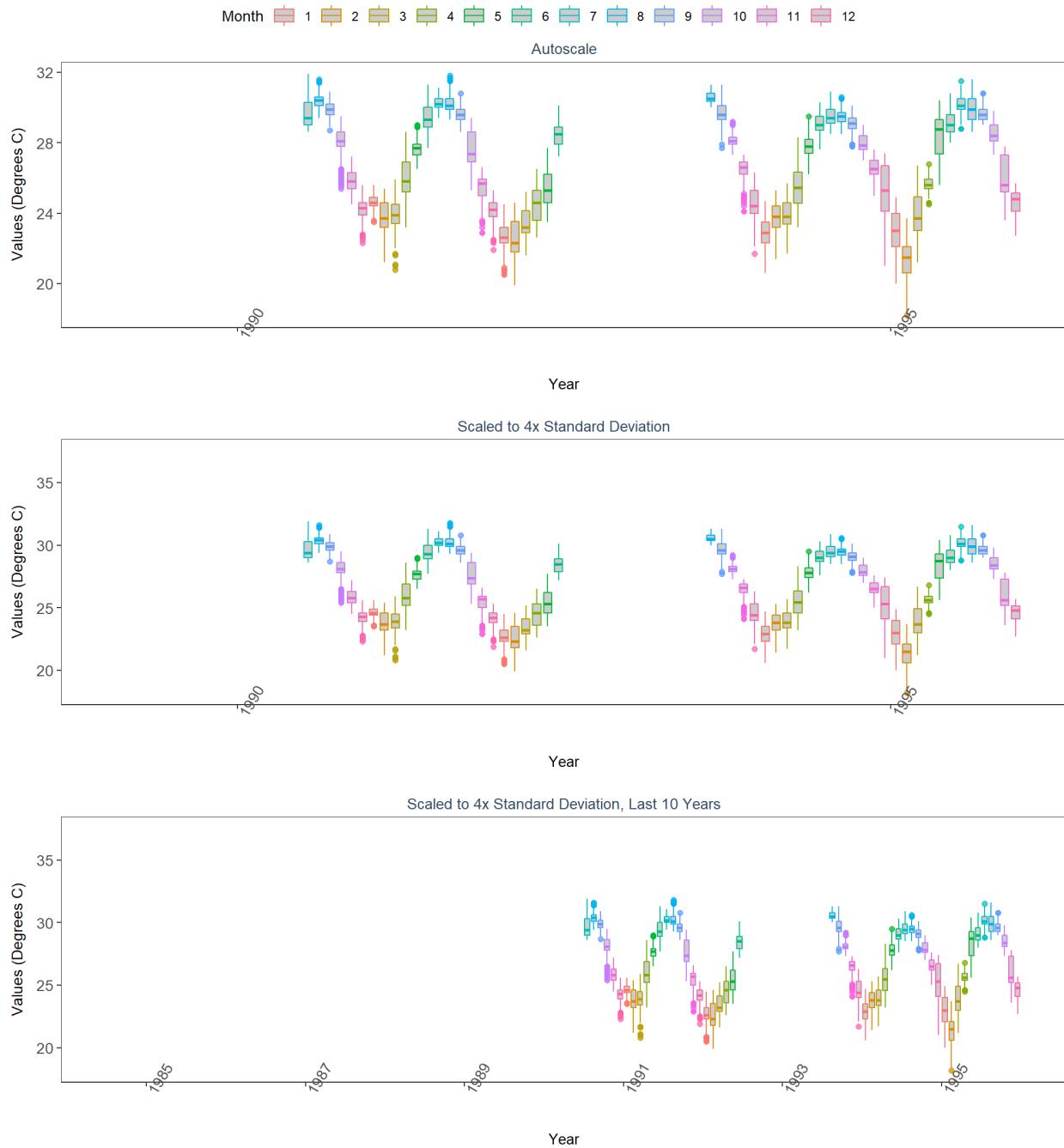
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_TENN_REF
 By Month



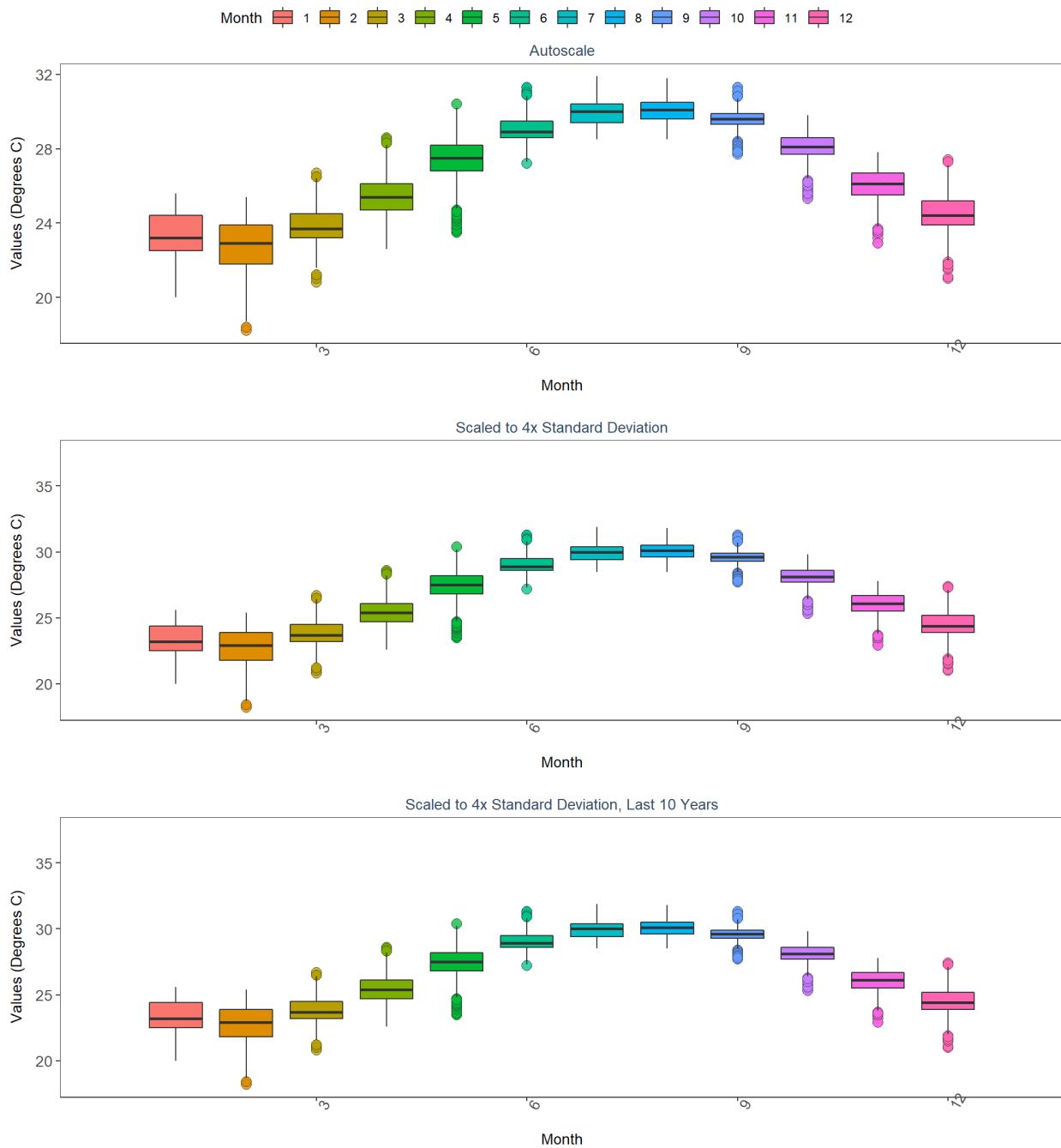
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_W_SAMBO
 By Year



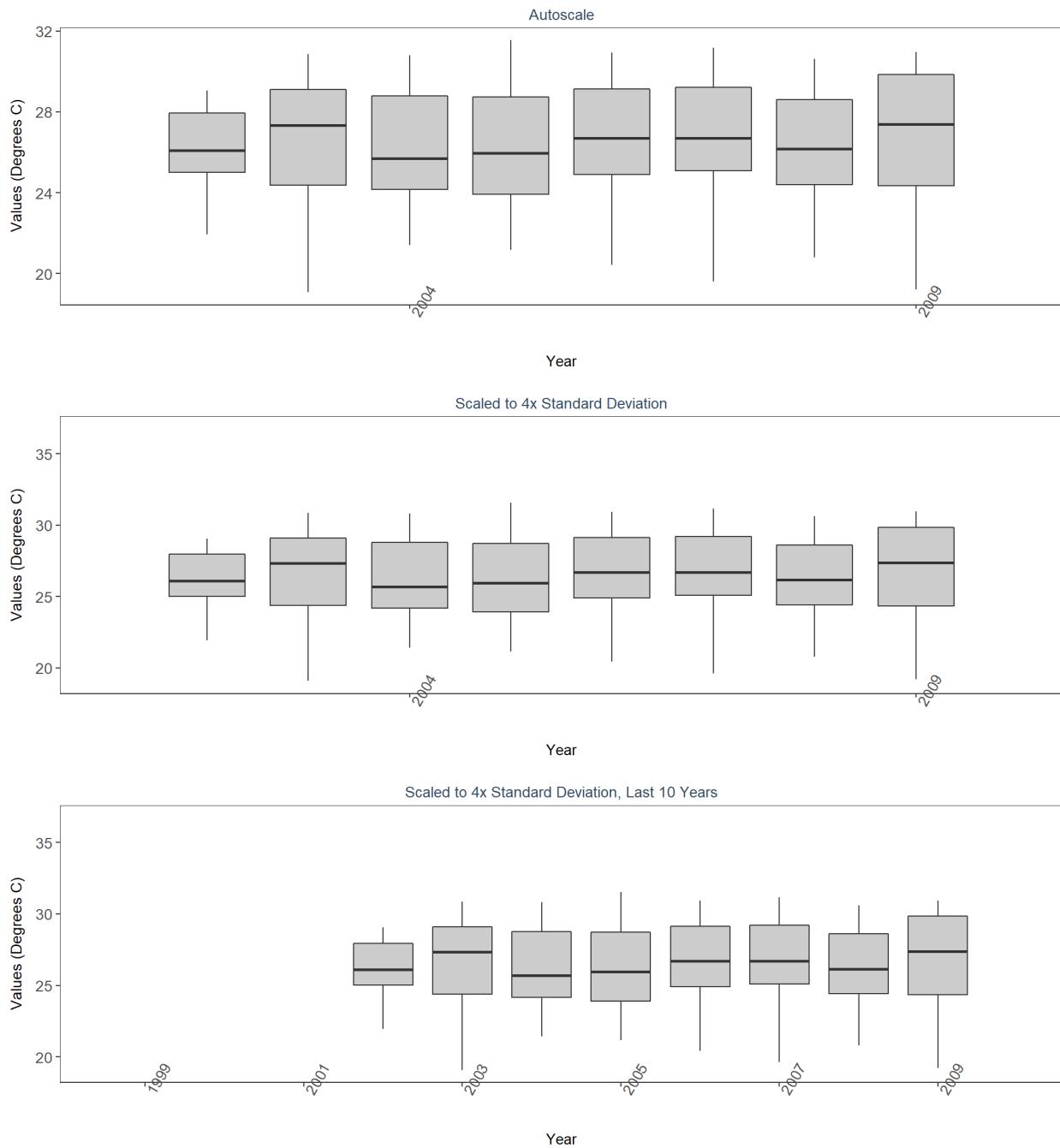
Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_W_SAMBO
 By Year & Month



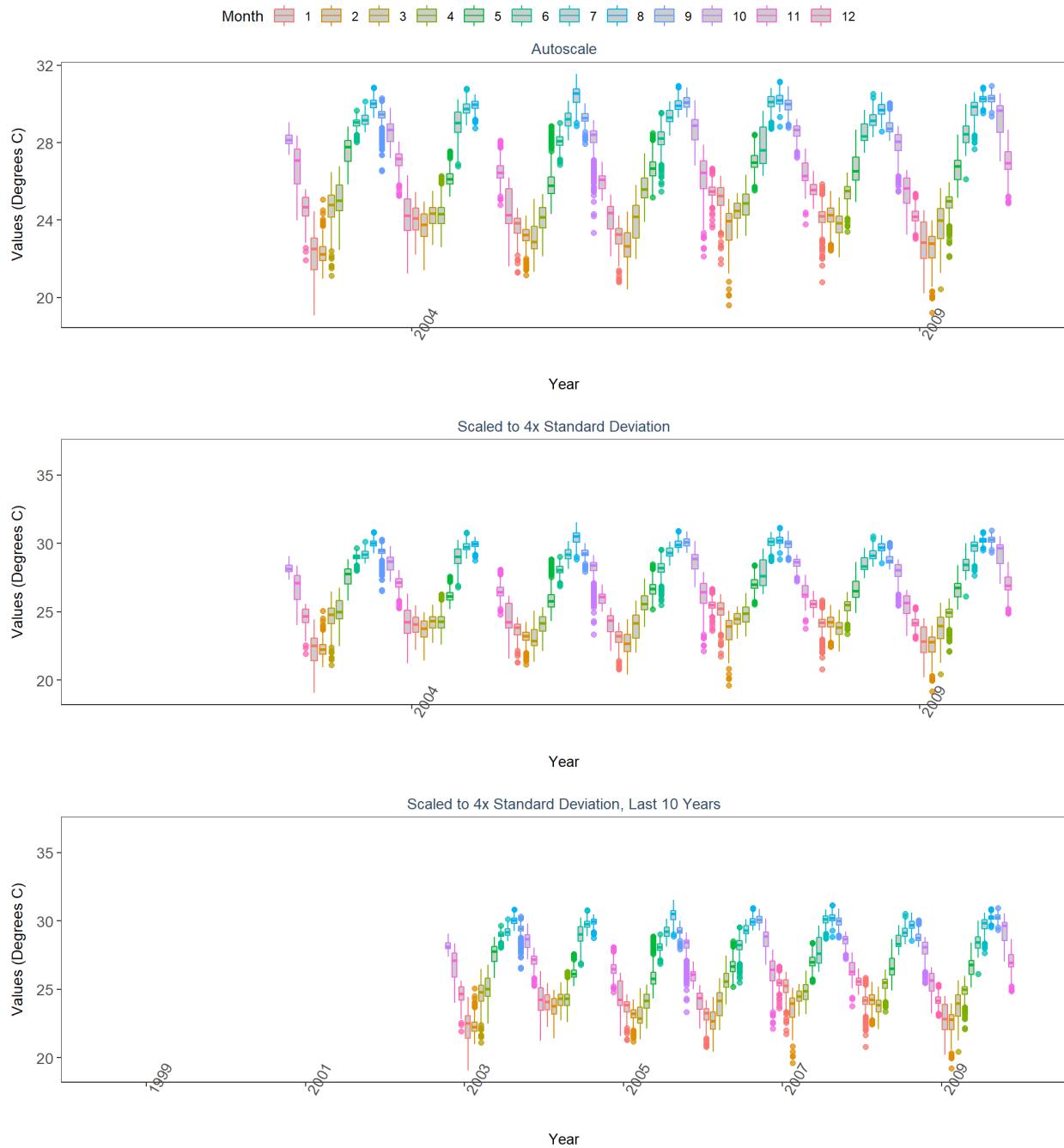
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_W_SAMBO
 By Month



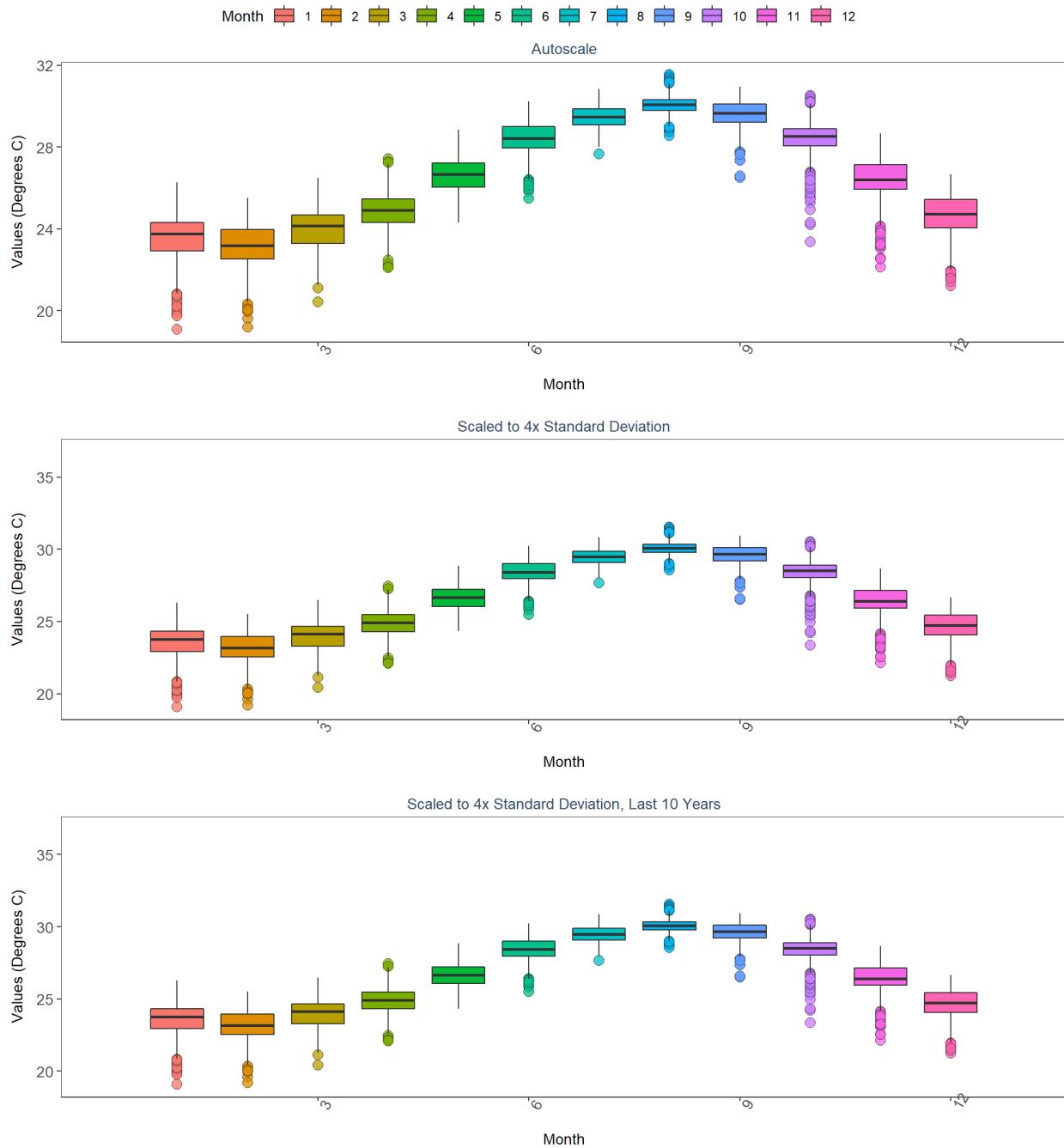
Florida Keys National Marine Sanctuary
989
Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_WELLWOOD
By Year



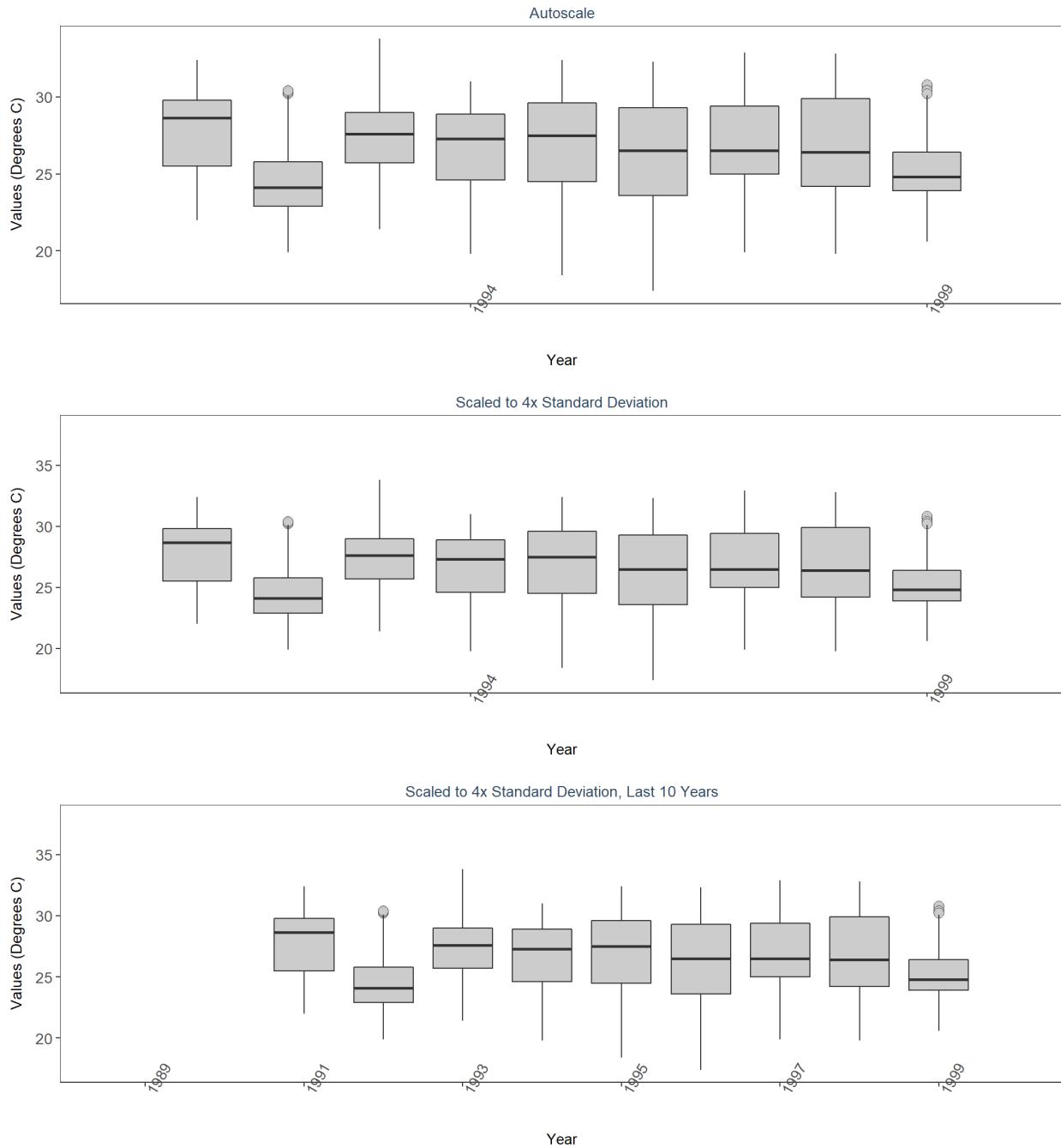
Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_WELLWOOD
 By Year & Month



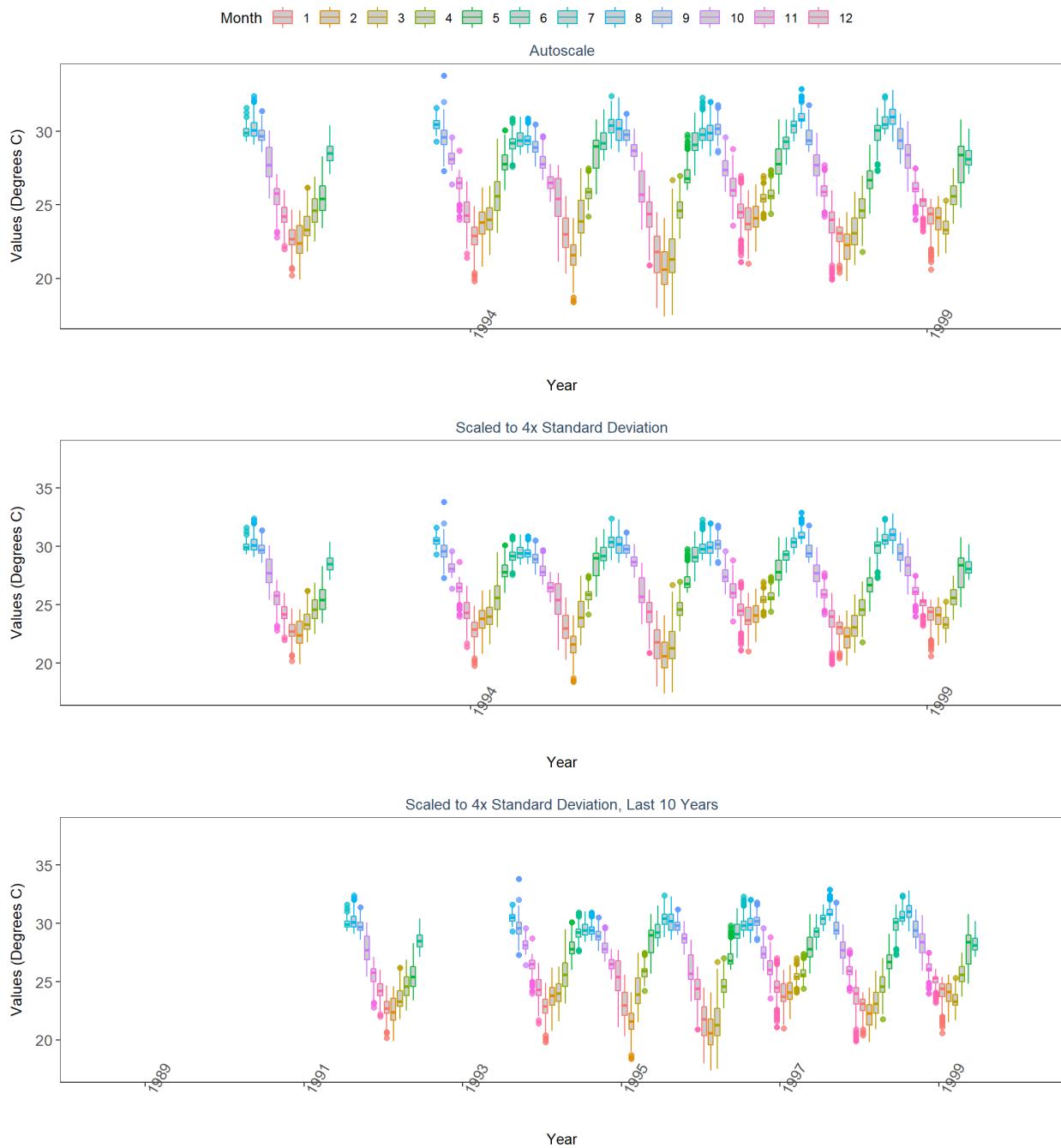
Florida Keys National Marine Sanctuary
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 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_WELLWOOD
 By Month



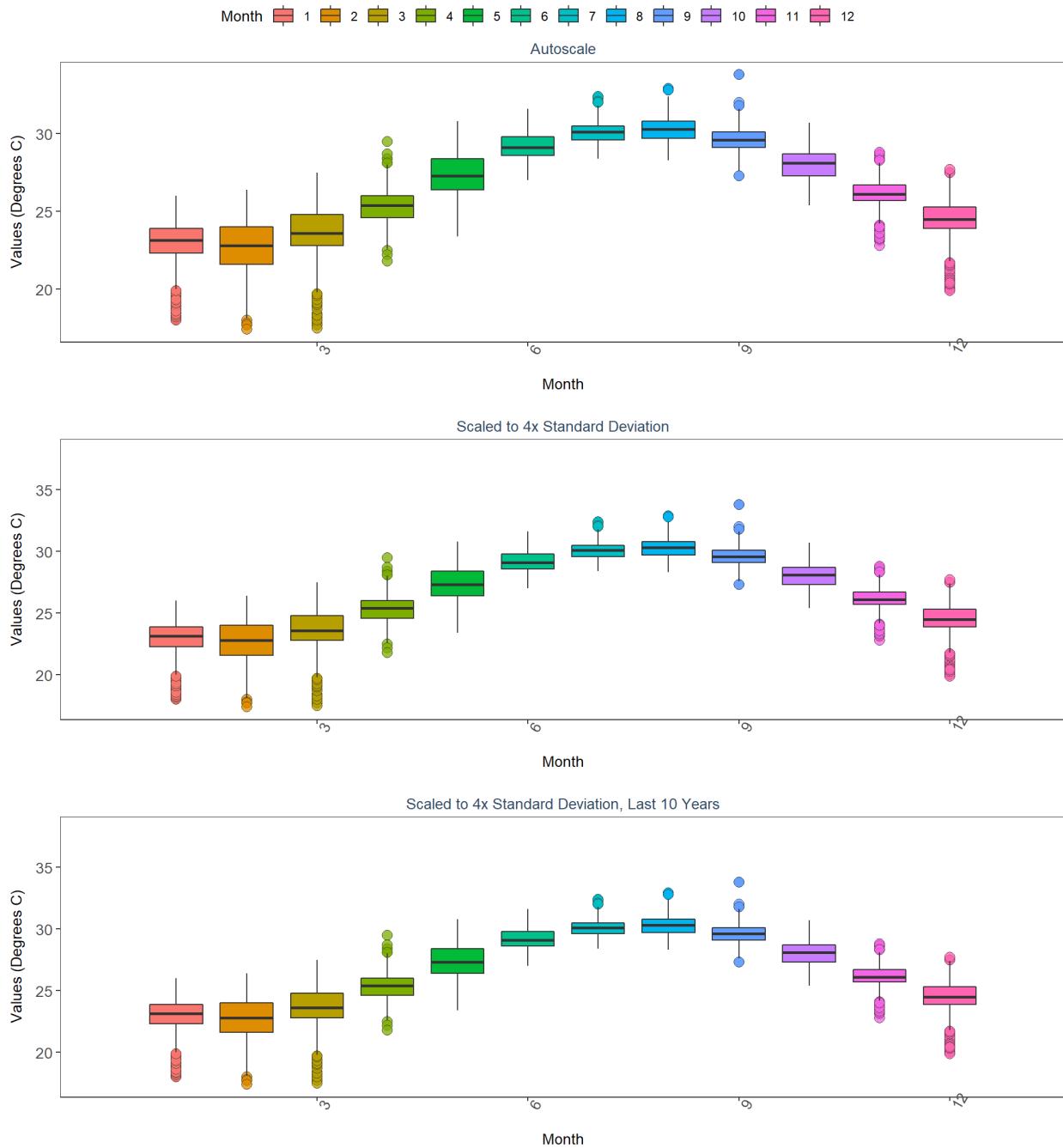
Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_WS_JACKYL
 By Year



Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_WS_JACKYL
 By Year & Month



Florida Keys National Marine Sanctuary
 989
 Continuous Bottom Temperature Measurements along the Florida Reef Tract
 FKNMS_WS_JACKYL
 By Month



Appendix IV: Excluded Monitoring Locations

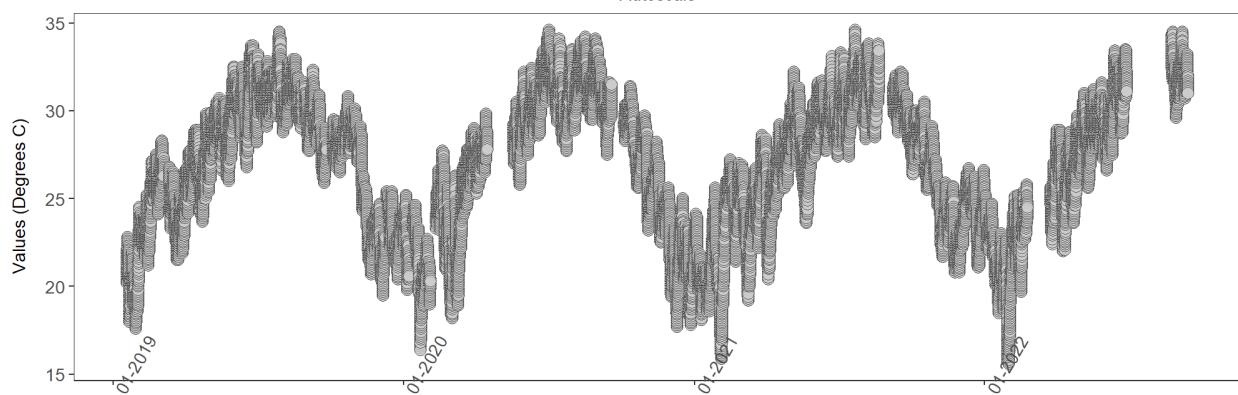
Scatter plots of data values are created for monitoring locations that have fewer than 5 separate years of data entries.

```

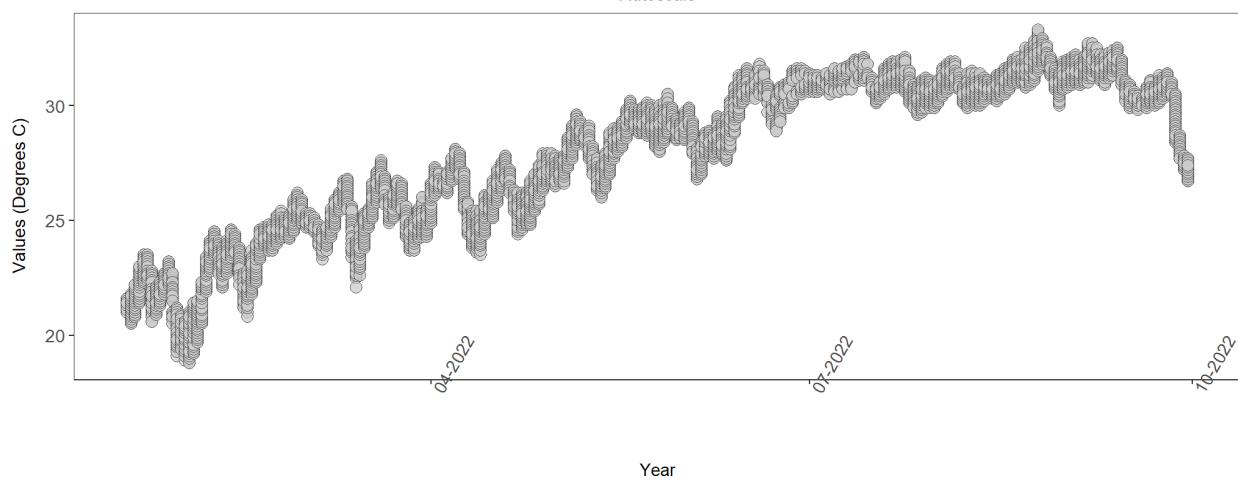
# Get list of monitoring locations that have data, but without sufficient data
Mon_Exclude <- Mon_Summ[Mon_Summ$SufficientData==FALSE & N_Years>0,]
Mon_Exclude <- Mon_Exclude[order(Mon_Exclude$MonitoringID),]
z=nrow(Mon_Exclude)
# Determines whether excluded monitoring locations exist. If they do, begins
# 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)
  }
}

```

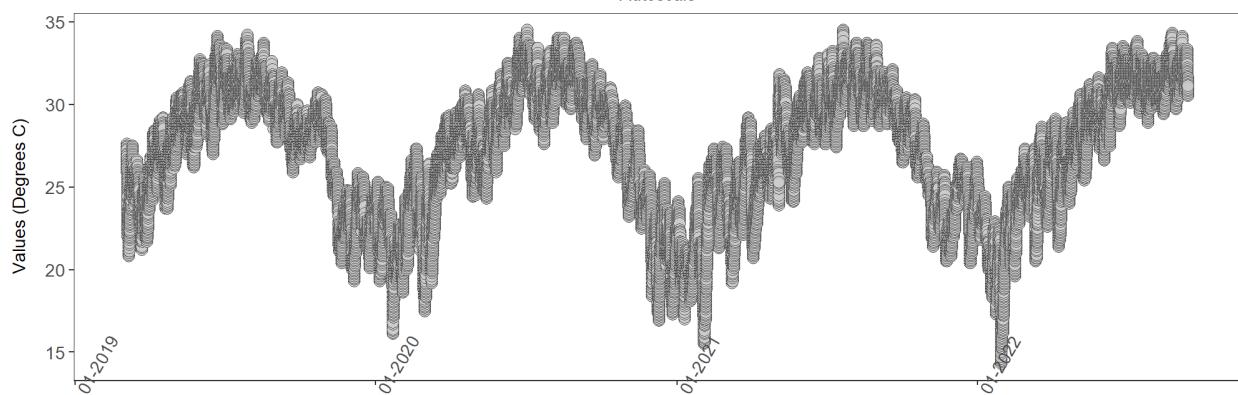
Biscayne Bay Aquatic Preserve
5077
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring
BBBB14 (4 Unique Years)
Autoscale



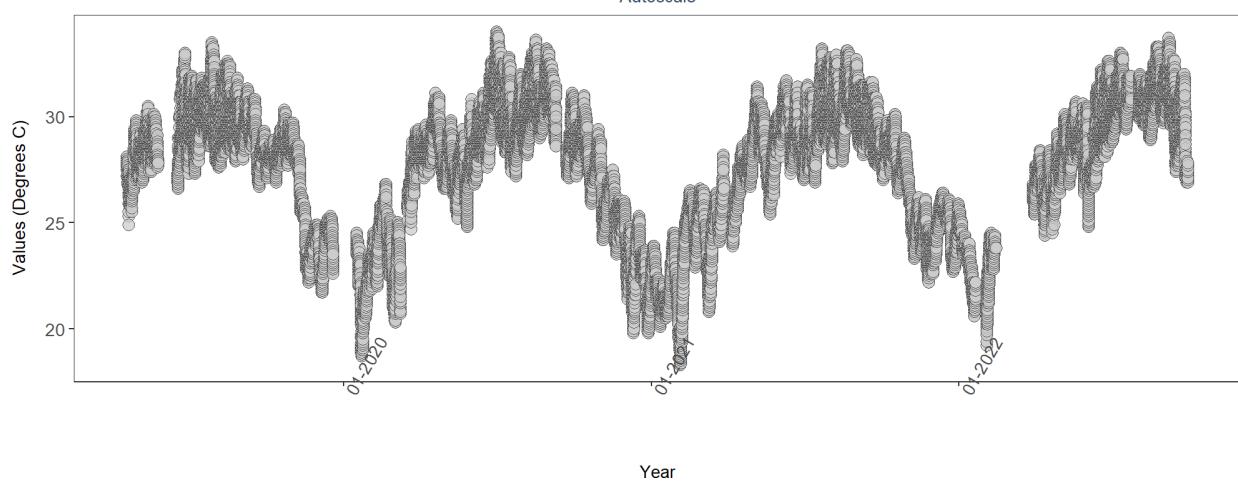
Biscayne Bay Aquatic Preserve
5077
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring
BBCWA4 (1 Unique Years)
Autoscale



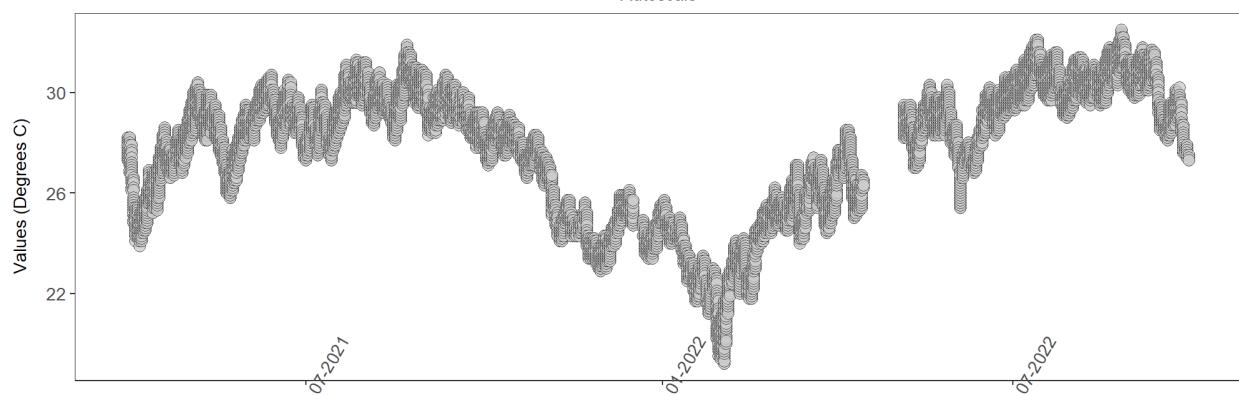
Biscayne Bay Aquatic Preserve
5077
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring
BBJT71 (4 Unique Years)
Autoscale



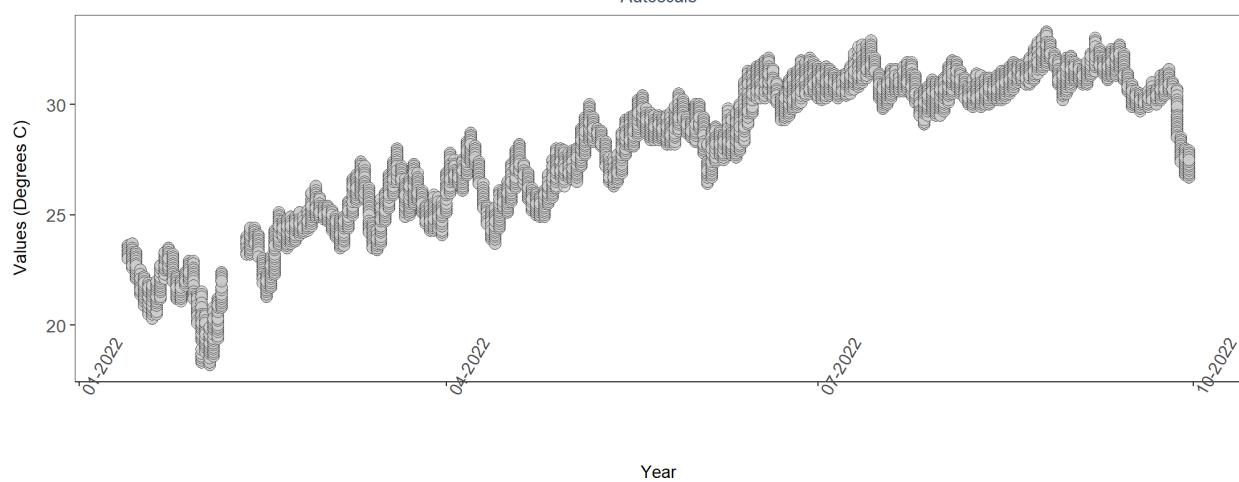
Biscayne Bay Aquatic Preserve
5077
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring
BBLR03 (4 Unique Years)
Autoscale

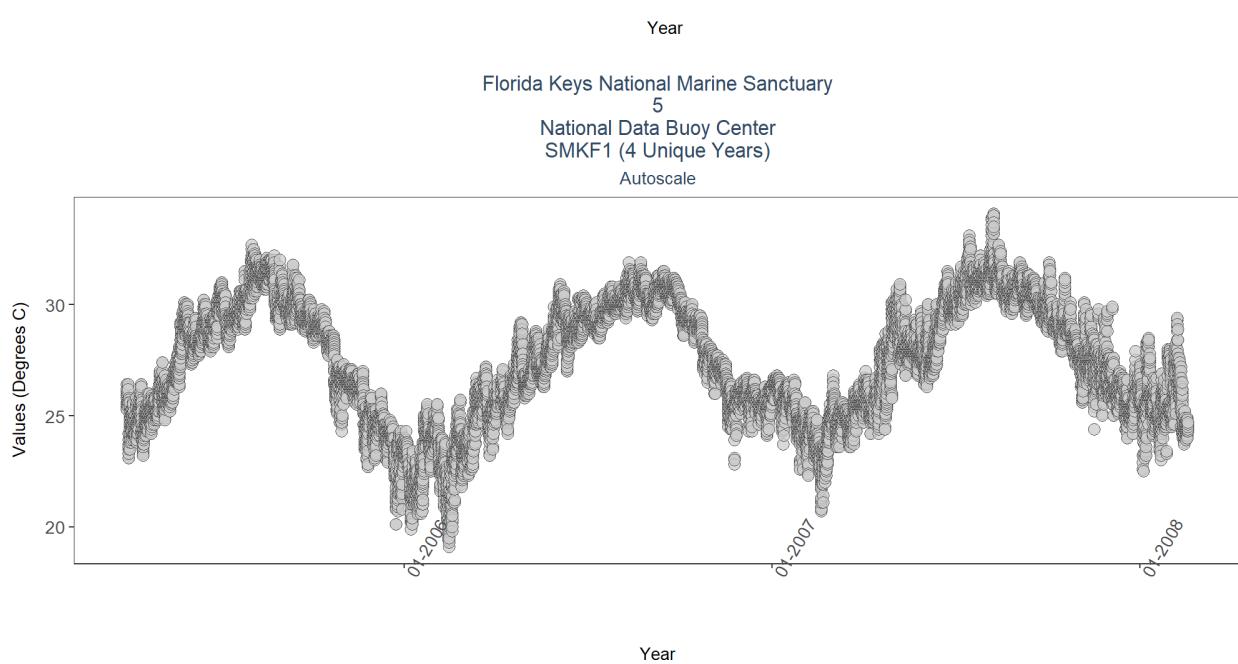
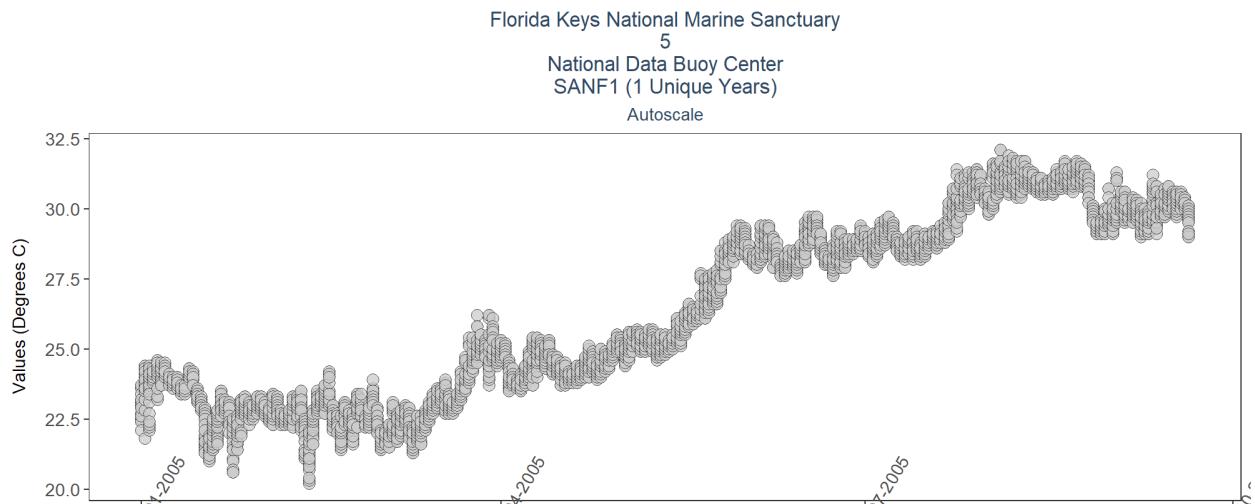


Biscayne Bay Aquatic Preserve
5077
Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring
BBMRDW (2 Unique Years)
Autoscale



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



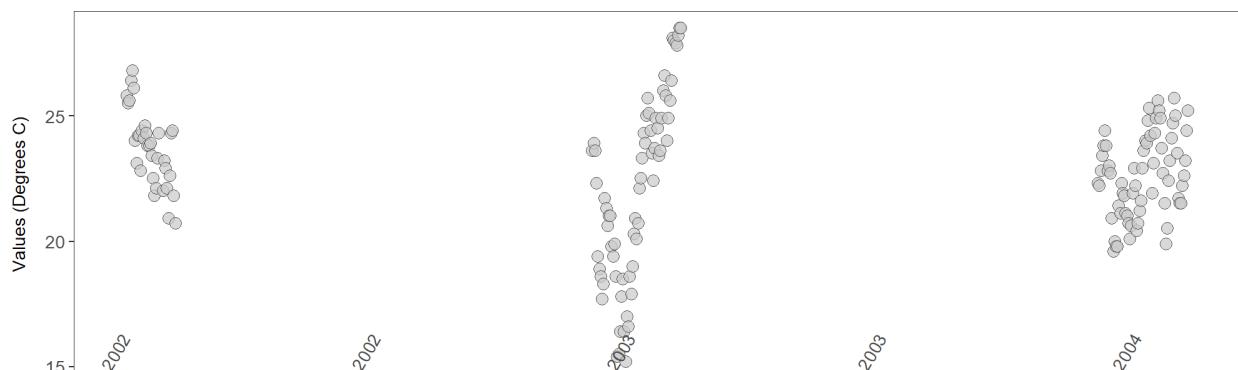


Florida Keys National Marine Sanctuary

7

National Water Information System
245323080410100 (3 Unique Years)

Autoscale

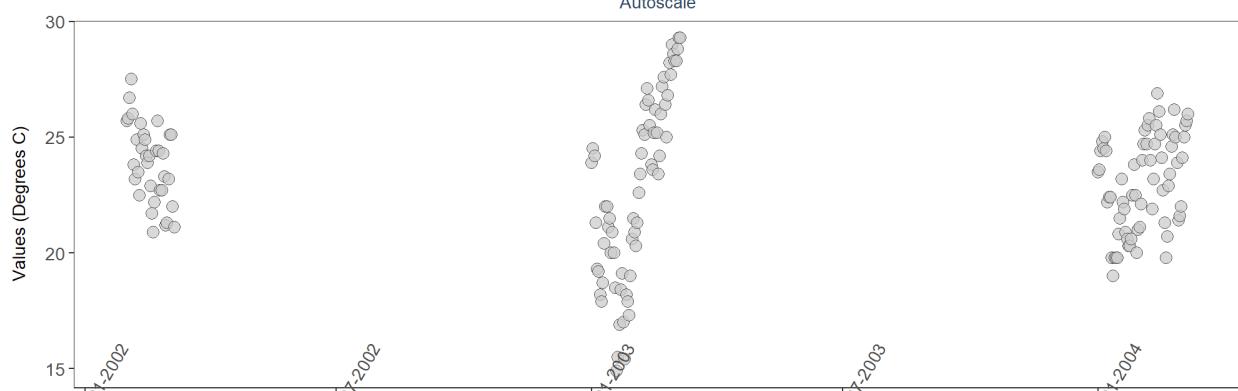


Florida Keys National Marine Sanctuary

7

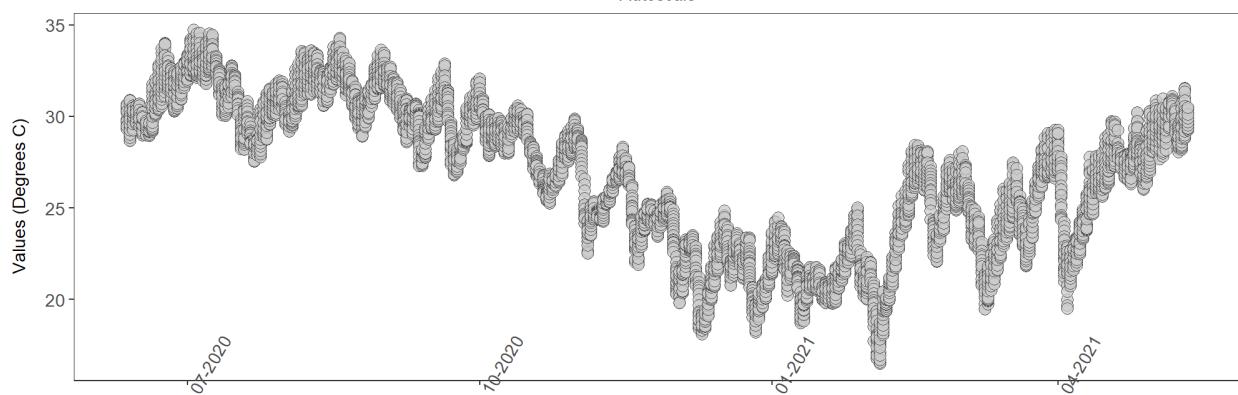
National Water Information System
245622080364200 (3 Unique Years)

Autoscale

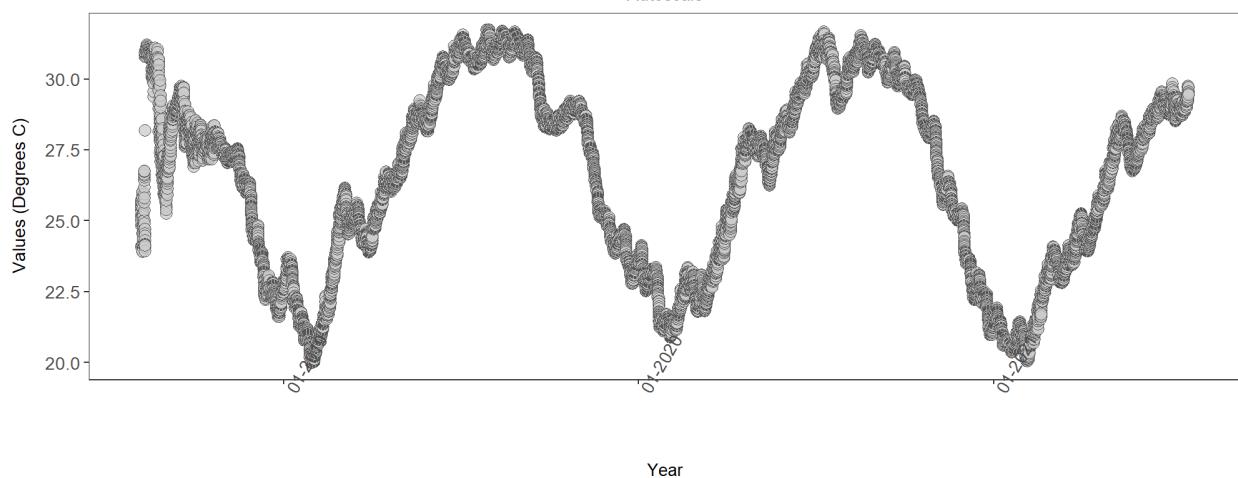


Year

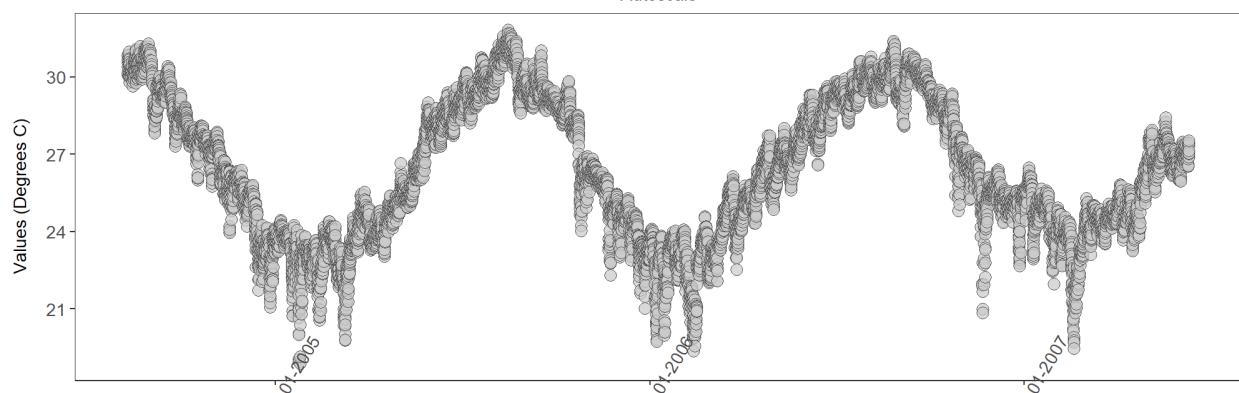
Florida Keys National Marine Sanctuary
986
Water Temperature on Coral Reefs in the Florida Keys
10 (2 Unique Years)
Autoscale



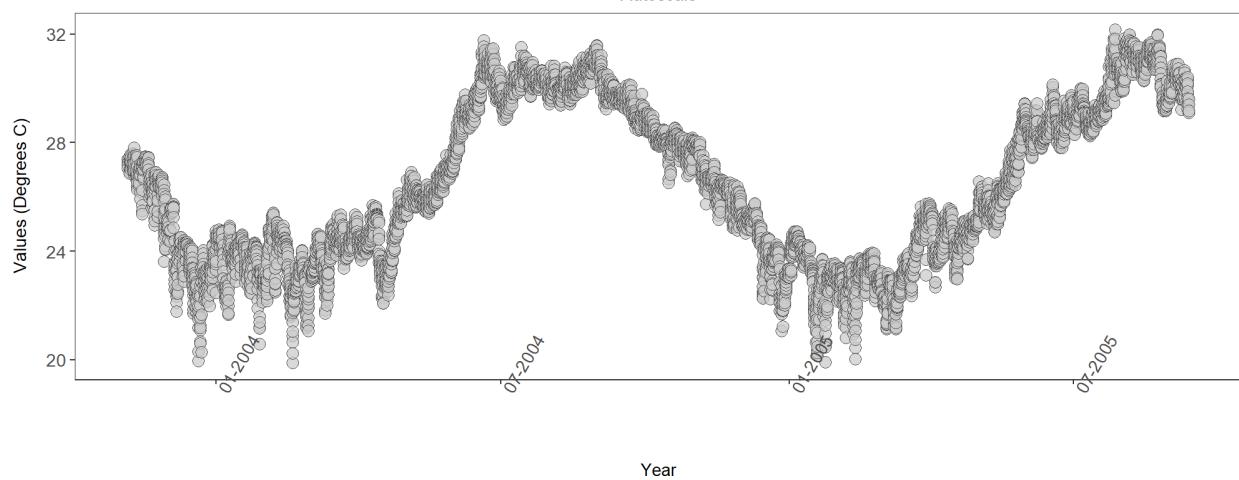
Year
Florida Keys National Marine Sanctuary
986
Water Temperature on Coral Reefs in the Florida Keys
39 (4 Unique Years)
Autoscale



Florida Keys National Marine Sanctuary
989
Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_MAITLAND (4 Unique Years)
Autoscale



Florida Keys National Marine Sanctuary
989
Continuous Bottom Temperature Measurements along the Florida Reef Tract
FKNMS_WS_BUOY16 (3 Unique Years)
Autoscale



Lignumvitae Key Aquatic Preserve

7

National Water Information System

245323080410100 (3 Unique Years)

Autoscale

