

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

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## Important Notes

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

[https://github.com/FloridaSEACAR/SEACAR\\_Panzik](https://github.com/FloridaSEACAR/SEACAR_Panzik)

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.

```

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

```

## File Import

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

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

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

```

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)

```

## 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.docx

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.

The script then gets the units of the parameter, sets the `SampleDate` as a date object, and creates various scales of the date to be used by plotting functions.

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.

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 managed area, which is that each managed area has 5 year or more of unique year entries for observation that pass the initial filter. If data passes the first set of filtering criteria and the time criteria, they are used in the analysis.

```

data$Include <- as.logical(data$Include)
data <- data[data$Include==TRUE,]
data <- data[!is.na(data$ResultValue),]
data <- data[!is.na(data$RelativeDepth),]
data <- data[!grep("Blank", data$ActivityType),]

if(param_name=="Water_Temperature"){
  data <- data[data$ResultValue>=-5,]
} else{
  data <- data[data$ResultValue>=0,]
}

data <- data %>%
  group_by(ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           SampleDate) %>%
  summarise(Year=unique(Year), Month=unique(Month),
            RelativeDepth=unique(RelativeDepth),
            ResultValue=mean(ResultValue), Include=unique(Include))

data <- merge.data.frame(MA_All[,c("AreaID", "ManagedAreaName")],
                         data, by="ManagedAreaName", all=TRUE)

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)

data <- data %>%
  group_by(ManagedAreaName, ProgramID, ProgramName, ProgramLocationID) %>%
  mutate(MonitoringID=cur_group_id())

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]),
            SufficientData=ifelse(N_Data>0 & N_Years>=10, TRUE, FALSE))

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

```

```

data <- merge.data.frame(data, Mon_Summ[,c("MonitoringID", "SufficientData")],
                         by="MonitoringID")

data$Use_In_Analysis <- ifelse(data$Include==TRUE &
                                 data$SufficientData==TRUE, TRUE, FALSE)

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

```

Mon_YM_Stats <- data[data$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Year, Month) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            EarliestSampleDate=min(SampleDate),
            LastSampleDate=max(SampleDate), N=length(ResultValue),
            Min=min(ResultValue), Max=max(ResultValue),
            Median=median(ResultValue), Mean=mean(ResultValue),
            StandardDeviation=sd(ResultValue))
Mon_YM_Stats <- as.data.table(Mon_YM_Stats[order(Mon_YM_Stats$ManagedAreaName,
                                                    Mon_YM_Stats$ProgramID,
                                                    Mon_YM_Stats$ProgramName,
                                                    Mon_YM_Stats$ProgramLocationID,
                                                    Mon_YM_Stats$Year,
                                                    Mon_YM_Stats$Month), ])
fwrite(Mon_YM_Stats, paste0(out_dir, "/", param_name, "_", region,
                           "_MonitoringLoc_YearMonth_Stats.txt"), sep="|")

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))
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), ])
fwrite(Mon_Y_Stats, paste0(out_dir, "/", param_name, "_", region,
                           "_MonitoringLoc_Year_Stats.txt"), sep="|")

Mon_M_Stats <- data[data$Use_In_Analysis==TRUE, ] %>%
  group_by(AreaID, ManagedAreaName, ProgramID, ProgramName, ProgramLocationID,
           Month) %>%
  summarize(ParameterName=parameter,
            RelativeDepth=unique(RelativeDepth),
            EarliestSampleDate=min(SampleDate),
            LastSampleDate=max(SampleDate), N=length(ResultValue),
            Min=min(ResultValue), Max=max(ResultValue),
            Median=median(ResultValue), Mean=mean(ResultValue),
            StandardDeviation=sd(ResultValue))
Mon_M_Stats <- as.data.table(Mon_M_Stats[order(Mon_M_Stats$ManagedAreaName,
                                                Mon_M_Stats$ProgramID,
                                                Mon_M_Stats$ProgramName,
                                                Mon_M_Stats$ProgramLocationID,
                                                Mon_M_Stats$Month), ])
fwrite(Mon_M_Stats, paste0(out_dir, "/", param_name, "_", region,
                           "_MonitoringLoc_Month_Stats.txt"), sep="|")

```

## 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
  - Click this text to open Git directory with output files
8. Add the Monitoring IDS to `KTStats` for easier use while plotting.

```
tauSeasonal <- function(data, independent, stats.median, stats.minYear,
                         stats.maxYear) {
  tau <- NULL
  tryCatch({ken <- kendallSeasonalTrendTest(
    y=data$resultValue,
    season=data$Month,
    year=data$Year,
    independent.obs=independent)

  tau <- ken$estimate[1]
  p <- ken$p.value[2]
  slope <- ken$estimate[2]
  intercept <- ken$estimate[3]
  trend <- trend_calculator(slope, stats.median, p)
  rm(ken)
  }, 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
  }
})
}
```

```

KT <- c(unique(data$MonitoringID),
        stats.median,
        independent,
        tau,
        p,
        slope,
        intercept,
        trend)
return(KT)
}
runStats <- function(data) {
  data$Index <- as.Date(data$SampleDate) # , "%Y-%m-%d")
  data$ResultValue <- as.numeric(data$ResultValue)
  # Calculate basic stats
  stats.median <- median(data$ResultValue, na.rm=TRUE)
  stats.minYear <- min(data$Year, na.rm=TRUE)
  stats.maxYear <- max(data$Year, na.rm=TRUE)
  # Calculate Kendall Tau and Slope stats,
  # then update appropriate columns and table
  KT <- tauSeasonal(data, TRUE, stats.median,
                     stats.minYear, stats.maxYear)
  if (is.null(KT[8])) {
    KT <- tauSeasonal(data, FALSE, stats.median,
                      stats.minYear, stats.maxYear)
  }
  if (is.null(KT$Stats)==TRUE) {
    KT$Stats <- KT
  } else{
    KT$Stats <- rbind(KT$Stats, KT)
  }
  return(KT$Stats)
}
trend_calculator <- function(slope, median_value, p) {
  trend <-
    if (p < .05 & abs(slope) > abs(median_value) / 10.) {
      if (slope > 0) {
        2
      }
      else {
        -2
      }
    }
    else if (p < .05 & abs(slope) < abs(median_value) / 10.) {
      if (slope > 0) {
        1
      }
      else {
        -1
      }
    }
    else
      0
  return(trend)
}

```

```

}

KT.Stats <- NULL
# Loop that goes through each managed area.
# List of managed areas stored in MA_Years$ManagedAreaName
c_names <- c("MonitoringID", "Median", "Independent", "tau", "p",
           "SennSlope", "SennIntercept", "Trend")
if(n==0){
  KT.Stats <- data.frame(matrix(ncol=length(c_names),
                                 nrow=nrow(Mon_Summ)))
  colnames(KT.Stats) <- c_names
  KT.Stats[, c("MonitoringID")] <- Mon_Summ[, c("MonitoringID")]
} else{
  for (i in 1:n) {
    x <- nrow(data[data$Use_In_Analysis==TRUE &
                   data$MonitoringID==Mon_IDs[i], ])
    if (x>0) {
      KT.Stats <- runStats(data[data$Use_In_Analysis==TRUE &
                                  data$MonitoringID==Mon_IDs[i], ])
    }
  }
  KT.Stats <- as.data.frame(KT.Stats)

  if(dim(KT.Stats)[2]==1){
    KT.Stats <- as.data.frame(t(KT.Stats))
  }
  colnames(KT.Stats) <- c_names
  rownames(KT.Stats) <- seq(1:nrow(KT.Stats))
  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$Trend <- as.integer(KT.Stats$Trend)
}

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), ])

KT.Stats$MonitoringID <- NULL
fwrite(KT.Stats, paste0(out_dir, "/", param_name, "_", region,
                       "_KendallTau_Stats.txt"), sep="|")

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

```

## 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.

```

plot_theme <- theme_bw() +
  theme(text=element_text(family="Segoe UI"),
        title=element_text(face="bold"),
        plot.title=element_text(hjust=0.5, size=14, color="#314963"),
        plot.subtitle=element_text(hjust=0.5, size=10, color="#314963"),
        axis.title.x = element_text(margin = margin(t = 5, r = 0,
                                                    b = 10, l = 0)),
        axis.title.y = element_text(margin = margin(t = 0, r = 10,
                                                    b = 0, l = 0)),
        axis.text=element_text(size=10),
        axis.text.x=element_text(face="bold", angle = 60, hjust = 1),
        axis.text.y=element_text(face="bold"))

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)])
y_scale <- mn_RV + 4 * sd_RV

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

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

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

set <- ggarrange(p1, p2, p3, ncol=1)

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())

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.

```

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))

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")

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")

leg <- get_legend(p1)
set <- ggarrange(leg, p1 + theme(legend.position="none"), p2, p3, ncol=1,

```

```

        heights=c(0.1, 1, 1, 1))

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())

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.

```

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))

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")

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")

leg <- get_legend(p1)
set <- ggarrange(leg, p1 + theme(legend.position="none"), p2, p3, ncol=1,
                 heights=c(0.1, 1, 1, 1))

p0 <- ggplot() + labs(title="Summary Box Plots for Entire Data",

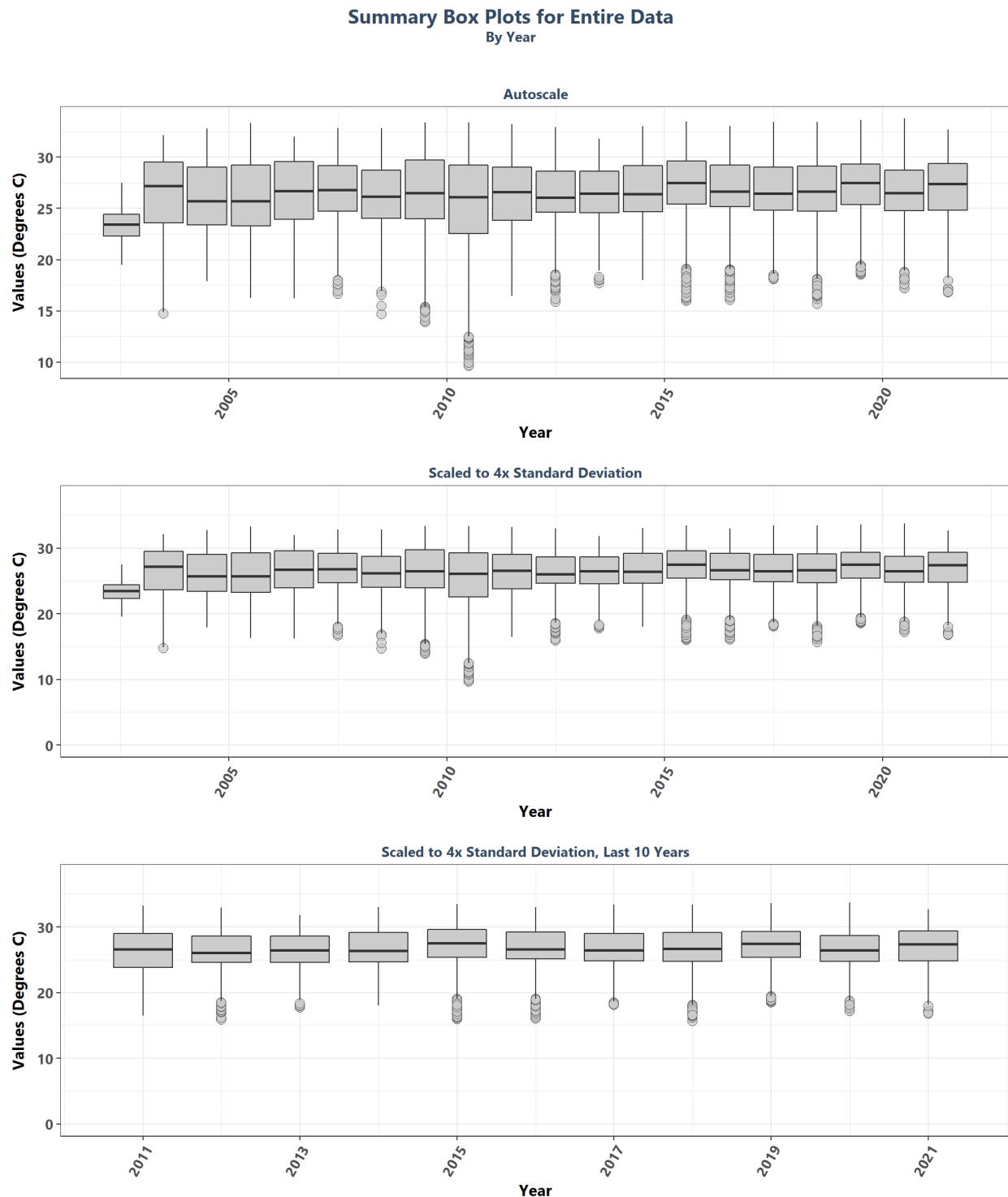
```

```

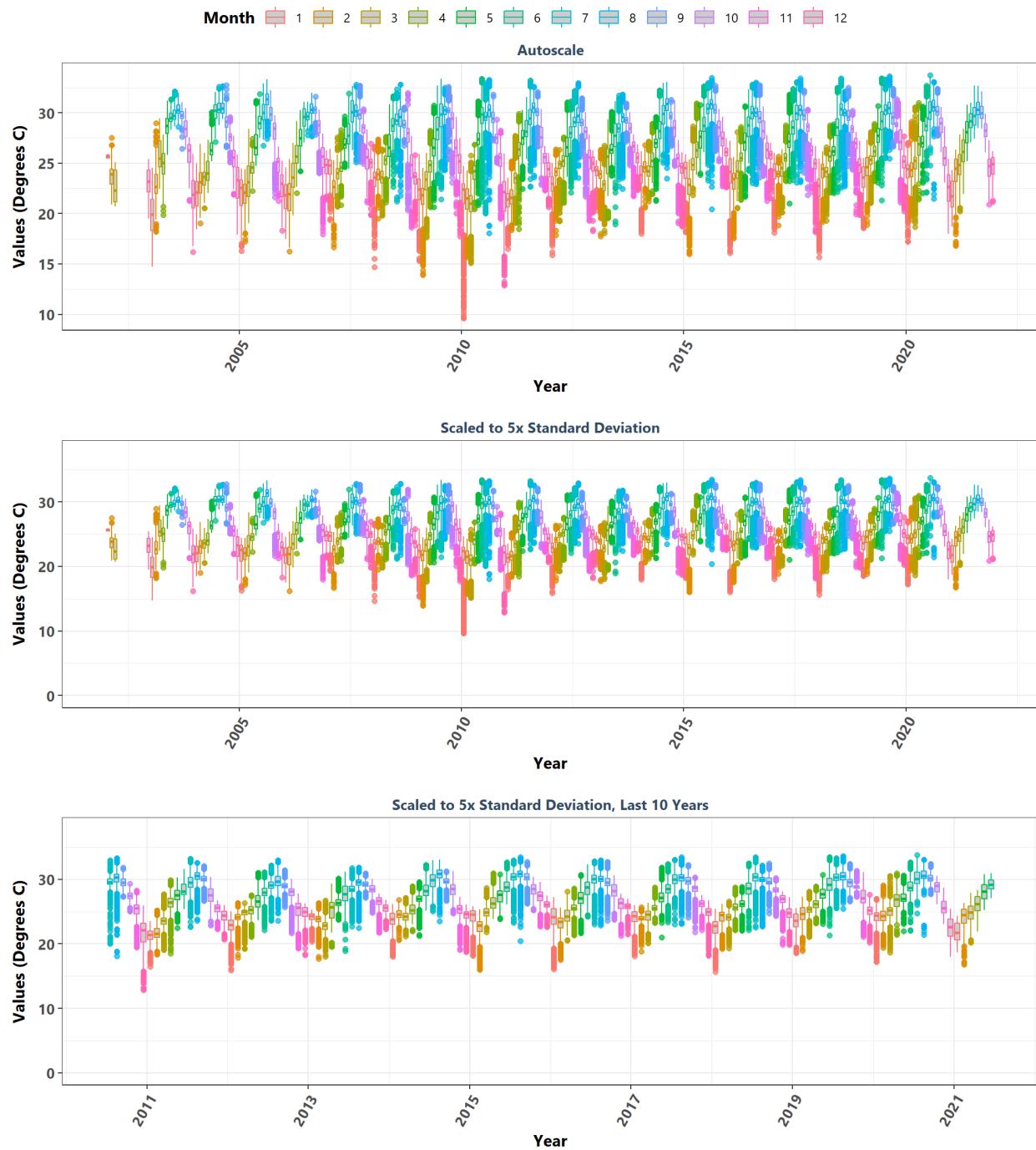
        subtitle="By Month") + plot_theme +
theme(panel.border=element_blank(), panel.grid.major=element_blank(),
      panel.grid.minor=element_blank(), axis.line=element_blank())

Mset <- ggarrange(p0, set, ncol=1, heights=c(0.07, 1))

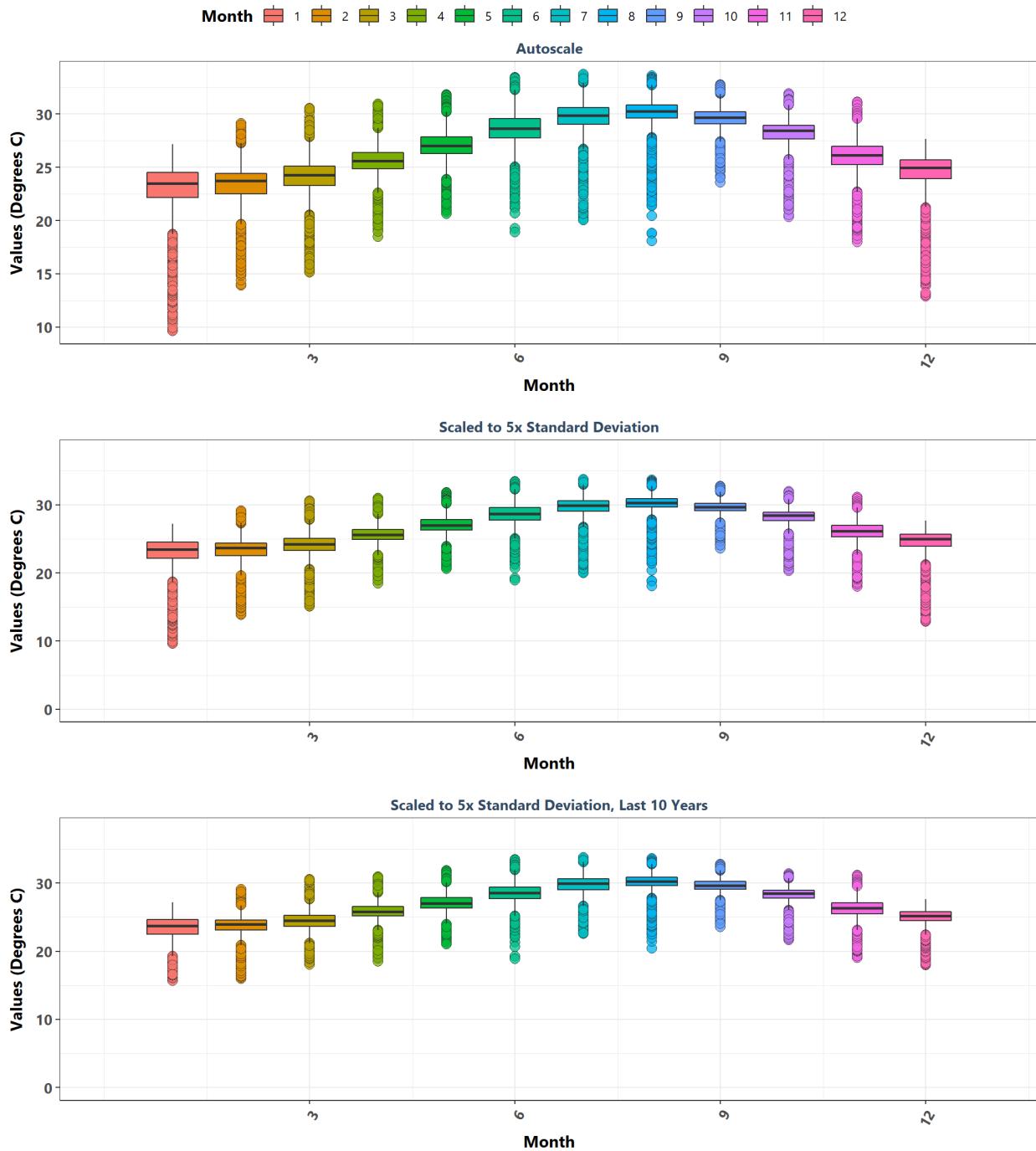
```



**Summary Box Plots for Entire Data**  
By Year & Month



### Summary Box Plots for Entire Data By Month



## Appendix II: Excluded Monitoring Locations

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

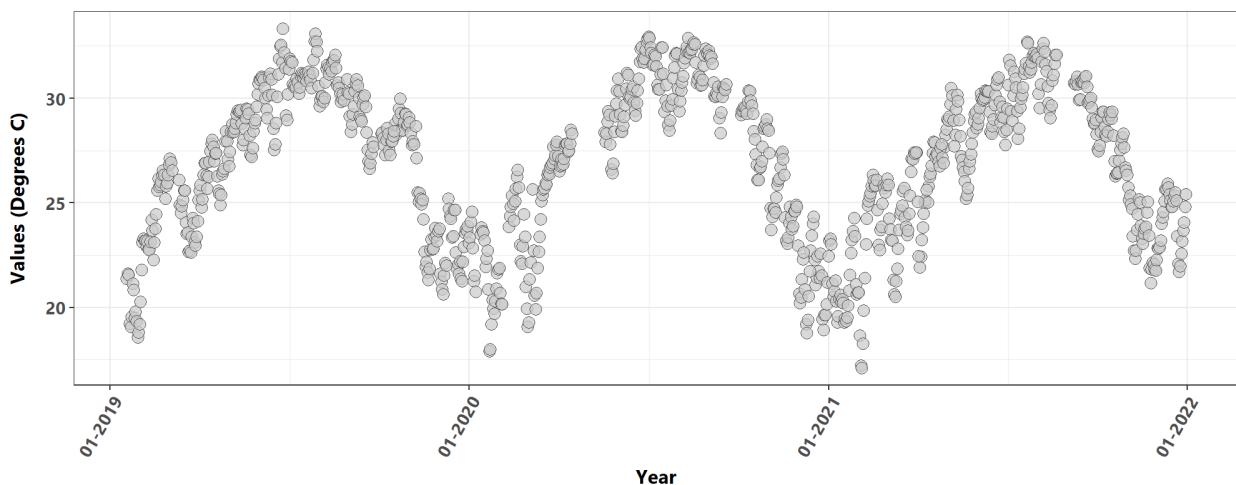
```

Mon_Exclude <- Mon_Summ[Mon_Summ$N_Years<5 & Mon_Summ$N_Years>0,]
Mon_Exclude <- Mon_Exclude[order(Mon_Exclude$MonitoringID),]
z=nrow(Mon_Exclude)

if(z==0){
  print("There are no monitoring locations that qualify.")
} else {
  for(i in 1:z){
    MA_name <- unique(data$ManagedAreaName[
      data$MonitoringID==Mon_Exclude$MonitoringID[i]])
    Mon_name <- paste0(unique(data$ProgramID[
      data$MonitoringID==Mon_Exclude$MonitoringID[i]]), " | ",
      unique(data$ProgramName[
        data$MonitoringID==Mon_Exclude$MonitoringID[i]]), "\n",
      unique(data$ProgramLocationID[
        data$MonitoringID==Mon_Exclude$MonitoringID[i]])))
  }
}

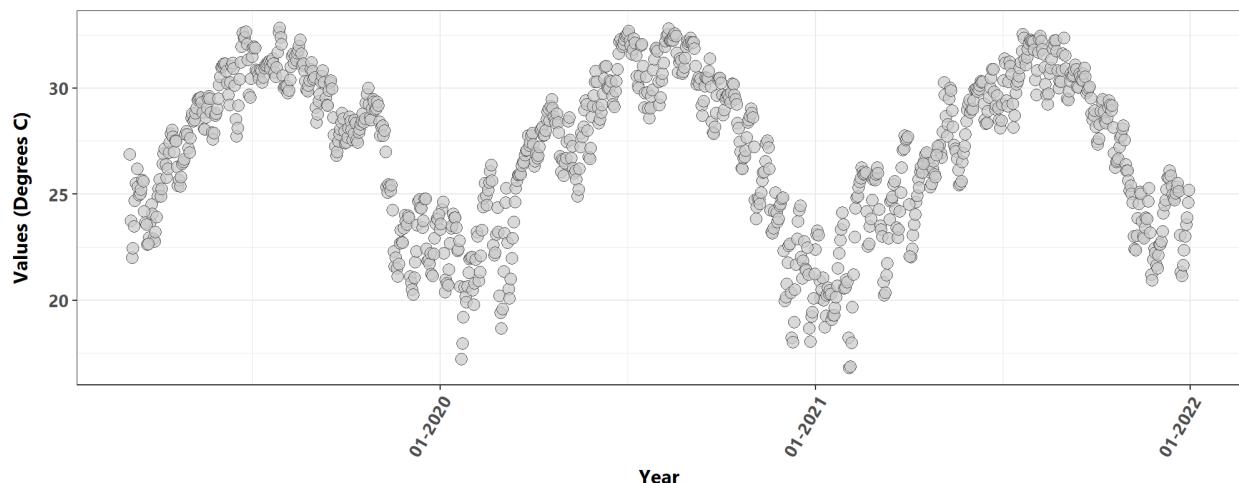
```

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



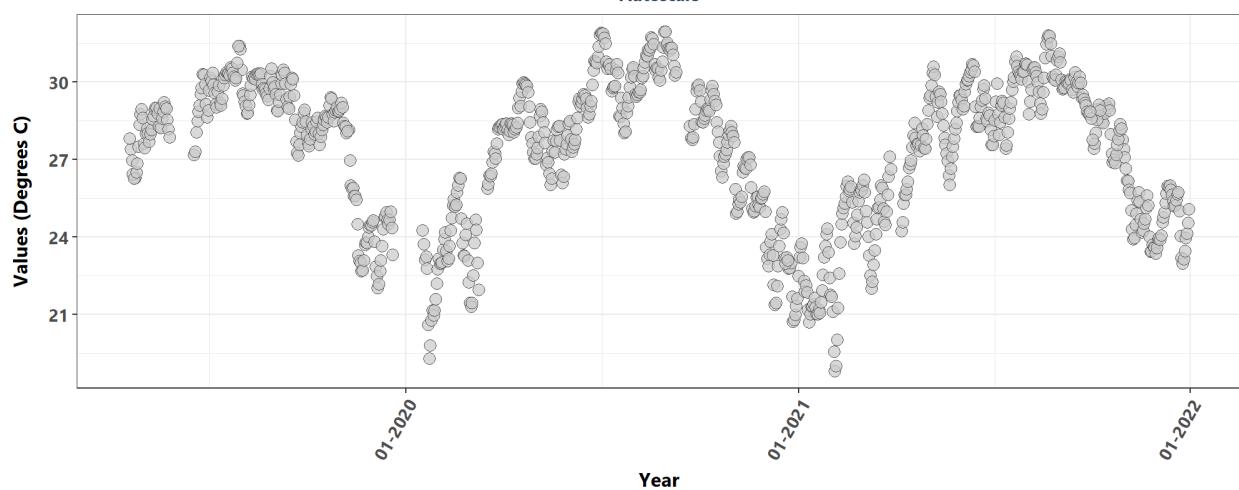
Biscayne Bay Aquatic Preserve  
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring  
BBJT71 (3 Unique Years)

Autoscale



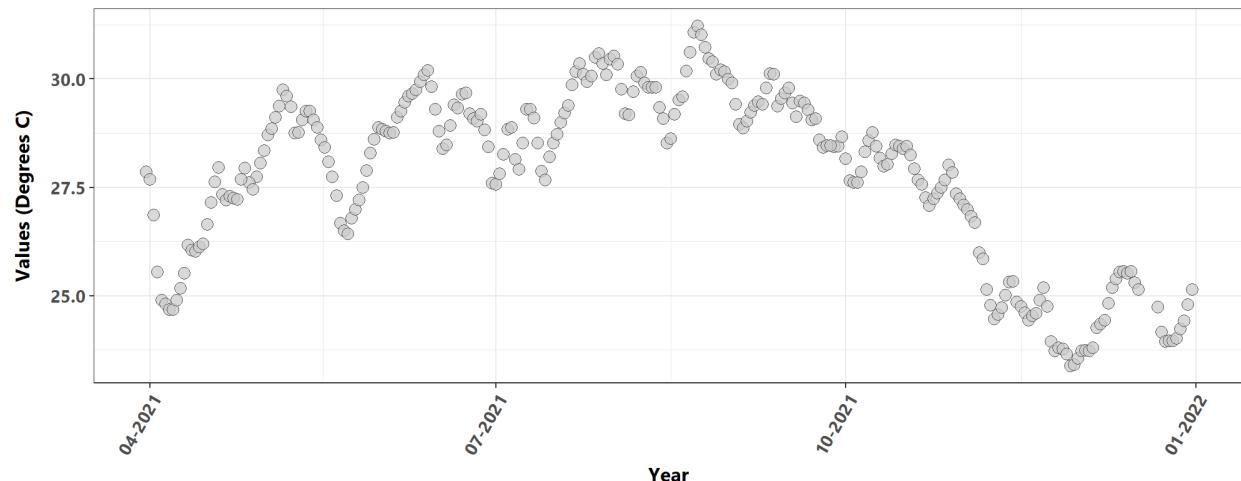
Biscayne Bay Aquatic Preserve  
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring  
BBLR03 (3 Unique Years)

Autoscale



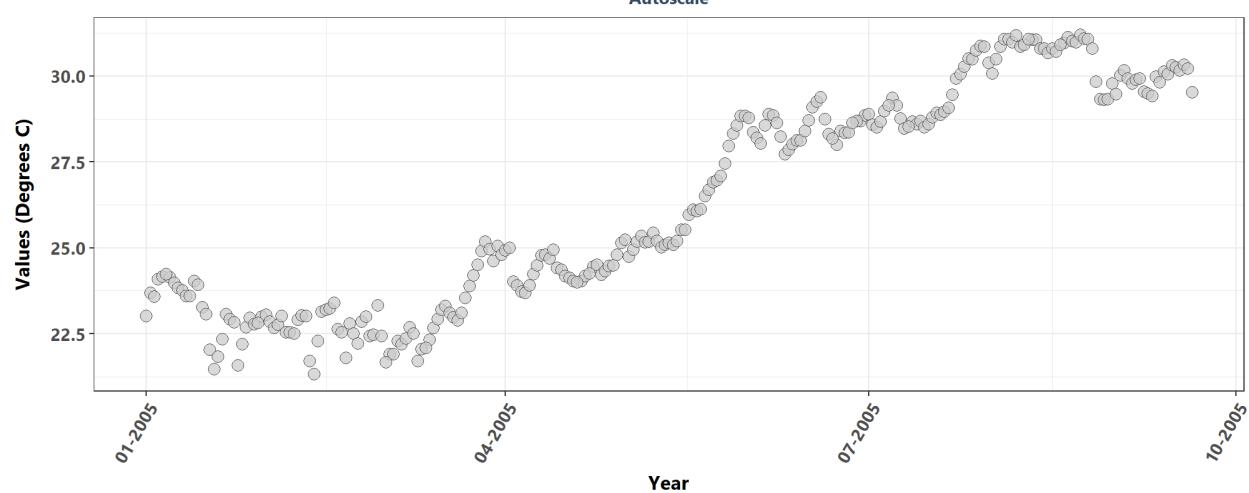
**Biscayne Bay Aquatic Preserve**  
5077 | Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring  
**BBMRDW (1 Unique Years)**

Autoscale



**Florida Keys National Marine Sanctuary**  
5 | National Data Buoy Center  
**SANF1 (1 Unique Years)**

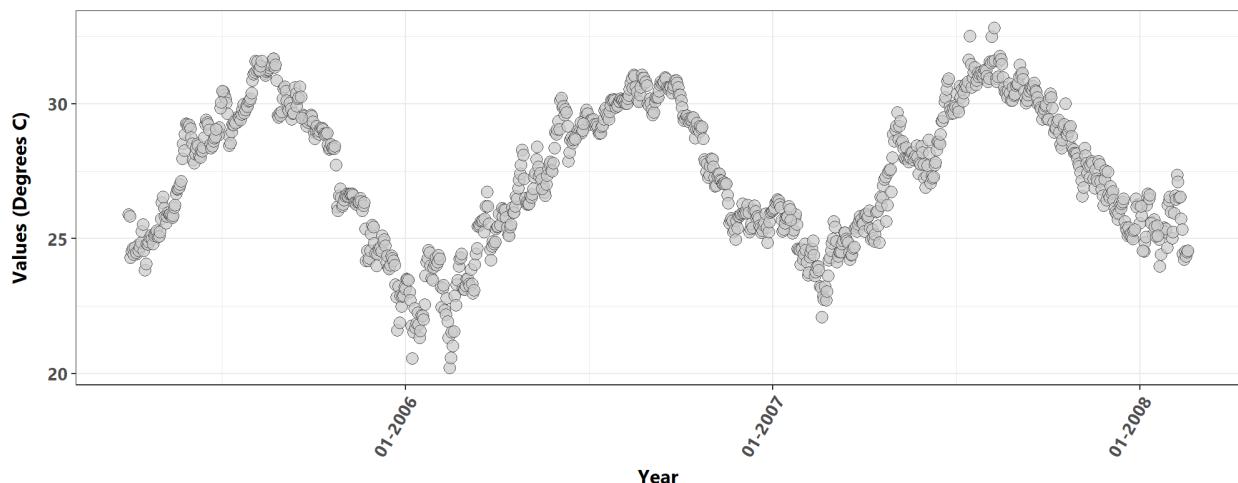
Autoscale



**Florida Keys National Marine Sanctuary**

**5 | National Data Buoy Center  
SMKF1 (4 Unique Years)**

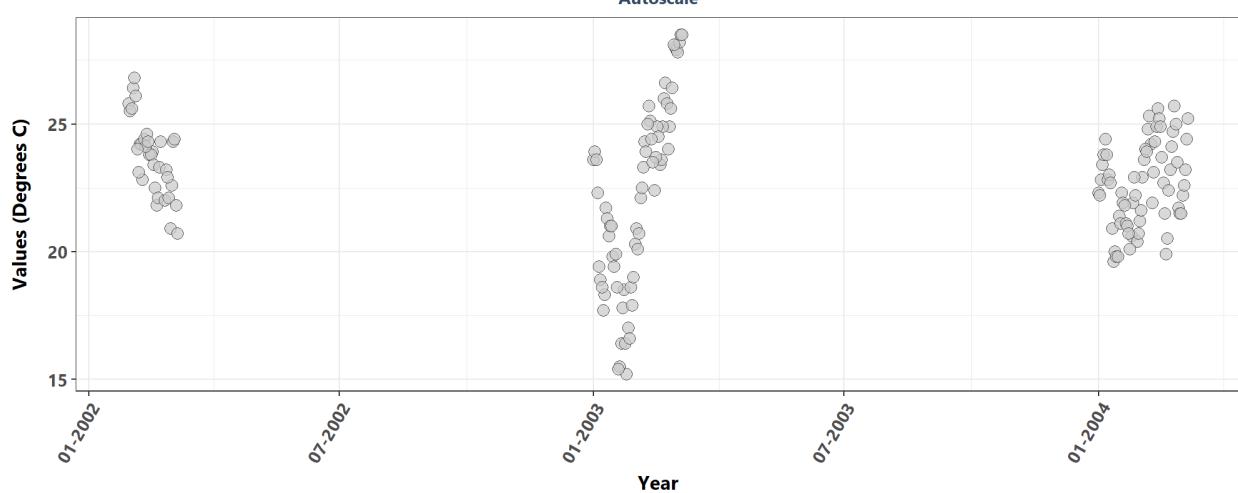
Autoscale



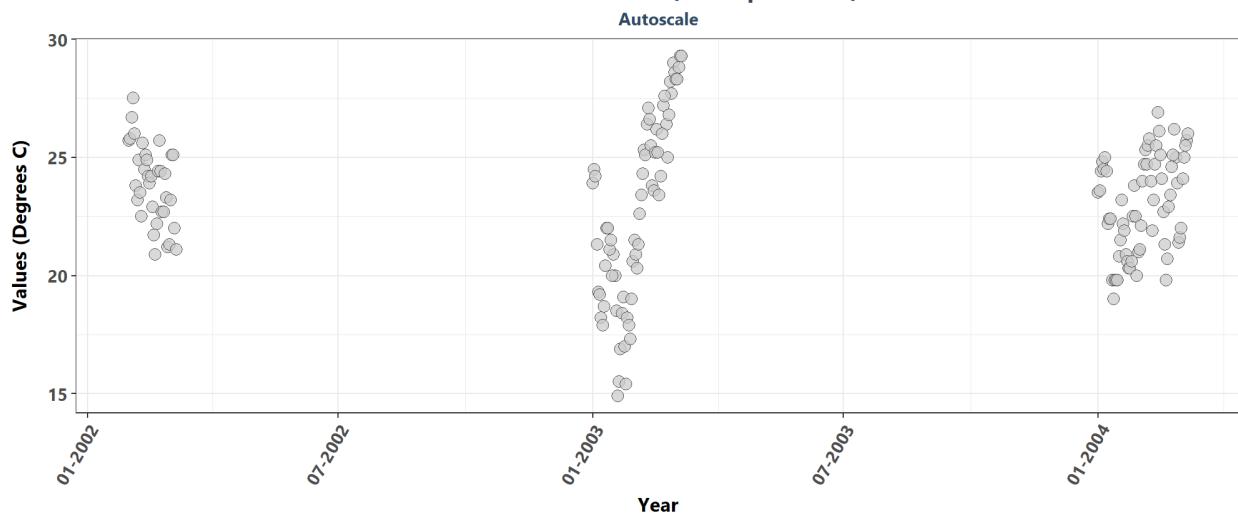
**Florida Keys National Marine Sanctuary**

**7 | National Water Information System  
245323080410100 (3 Unique Years)**

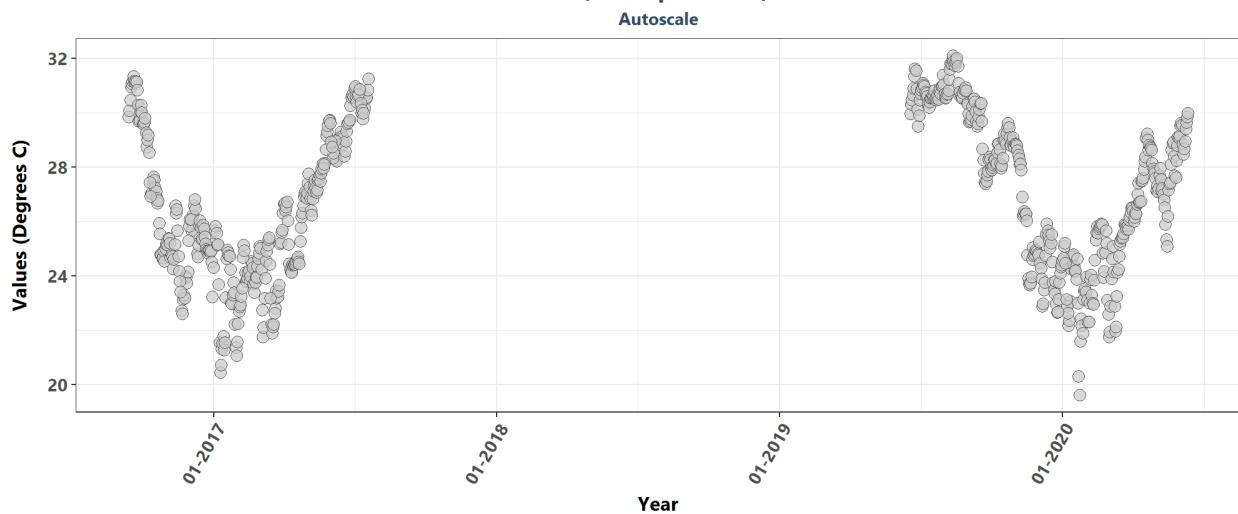
Autoscale



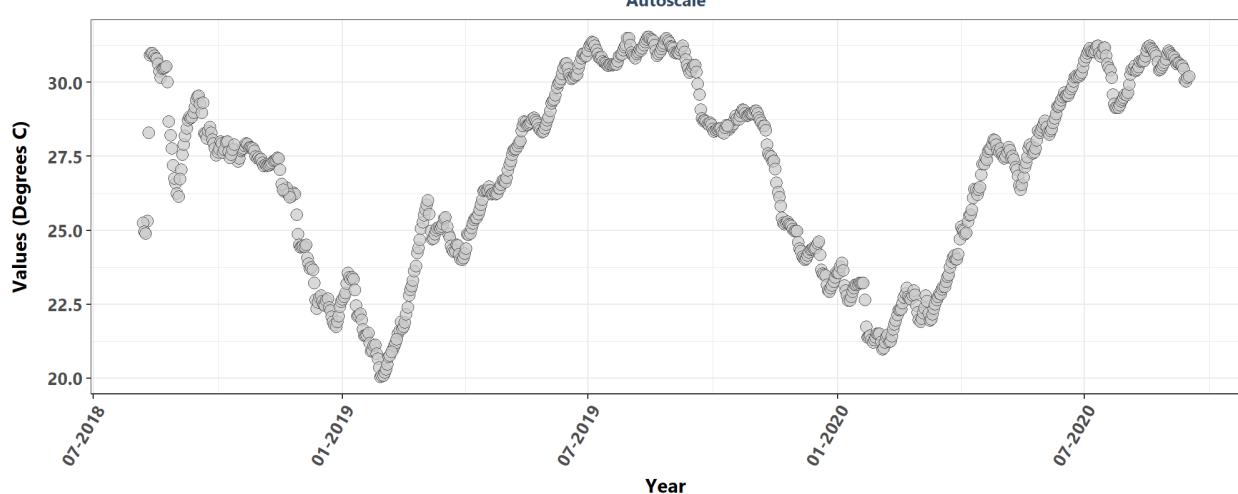
**Florida Keys National Marine Sanctuary**  
7 | National Water Information System  
245622080364200 (3 Unique Years)



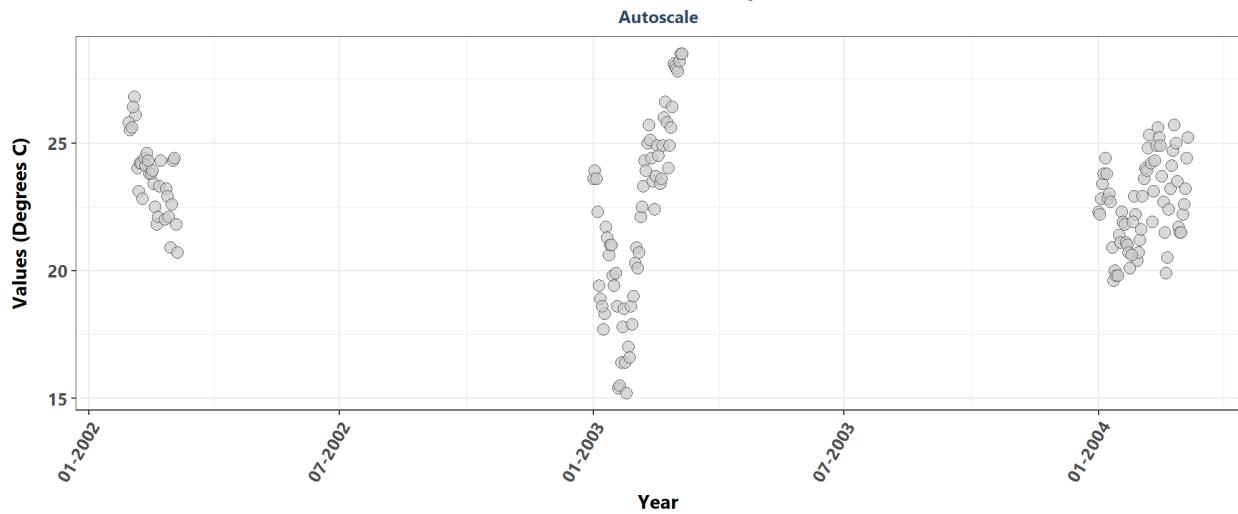
**Florida Keys National Marine Sanctuary**  
986 | Water Temperature on Coral Reefs in the Florida Keys  
33 (4 Unique Years)



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



**Lignumvitae Key Aquatic Preserve**  
**7 | National Water Information System**  
**245323080410100 (3 Unique Years)**



### Appendix III: 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 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 plots

5. Set the plot type as a point plot with the size of the points
6. Add the linear trend
7. Create the title, x-axis, y-axis, and color fill labels
8. Set the y and x limits
9. Make the axis labels bold
10. Plot the arrangement as a set of panels

```

if(n==0){
  print("There are no monitoring locations that qualify.")
} else {
  for (i in 1:n) {
    plot_data <- data[data$Use_In_Analysis==TRUE &
                        data$MonitoringID==Mon_IDs[i],]
    year_lower <- min(plot_data$Year)
    year_upper <- max(plot_data$Year)
    min_RV <- min(plot_data$ResultValue)
    mn_RV <- mean(plot_data$ResultValue[plot_data$ResultValue <
                                              quantile(plot_data$ResultValue, 0.98)])
    sd_RV <- sd(plot_data$ResultValue[plot_data$ResultValue <
                                              quantile(plot_data$ResultValue, 0.98)])
    x_scale <- ifelse(year_upper - year_lower > 30, 10, 5)
    y_scale <- mn_RV + 4 * sd_RV

    tau <- KT.Stats$tau[KT.Stats$MonitoringID==Mon_IDs[i]]
    s_slope <- KT.Stats$SennSlope[KT.Stats$MonitoringID==Mon_IDs[i]]
    s_int <- KT.Stats$SennIntercept[KT.Stats$MonitoringID==Mon_IDs[i]]
    trend <- KT.Stats$Trend[KT.Stats$MonitoringID==Mon_IDs[i]]
    p <- KT.Stats$p[KT.Stats$MonitoringID==Mon_IDs[i]]

    MA_name <- KT.Stats$ManagedAreaName[KT.Stats$MonitoringID==Mon_IDs[i]]
    Mon_name <- paste0(KT.Stats$ProgramID[KT.Stats$MonitoringID==Mon_IDs[i]],
                       " | ", KT.Stats$ProgramName[KT.Stats$MonitoringID==Mon_IDs[i]], "\n",
                       KT.Stats$ProgramLocationID[KT.Stats$MonitoringID==Mon_IDs[i]])

    p1 <- ggplot(data=plot_data,
                  aes(x=DecDate, y=ResultValue)) +
      geom_point(shape=21, size=3, color="#333333", fill="#cccccc",
                 alpha=0.75) +
      geom_abline(aes(slope=s_slope, intercept=s_int),
                  color="#000099", size=1.2, alpha=0.7) +
      labs(subtitle="Autoscale",
            x="Year", y=paste0("Values (", unit, ")")) +
      plot_theme

    p2 <- ggplot(data=plot_data,
                  aes(x=DecDate, y=ResultValue)) +
      geom_point(shape=21, size=3, color="#333333", fill="#cccccc",
                 alpha=0.75) +
      geom_abline(aes(slope=s_slope, intercept=s_int),
                  color="#000099", size=1.2, alpha=0.7) +
      ylim(min_RV-0.1*y_scale, y_scale) +
      labs(subtitle="Scaled to 4x Standard Deviation",
            x="Year", y=paste0("Values (", unit, ")"))
  }
}

```

```

plot_theme

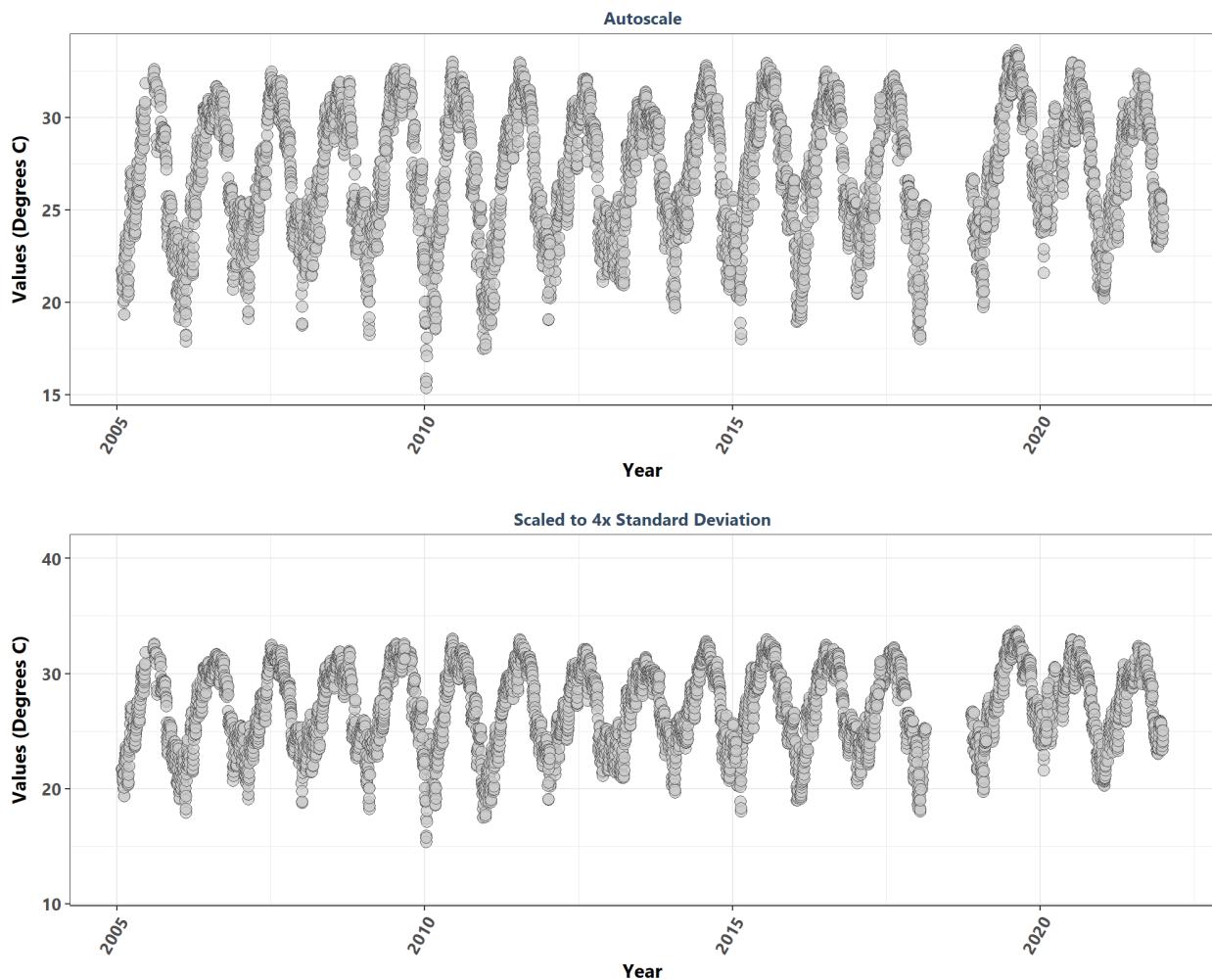
KTset <- ggarrange(p1, p2, ncol=1, heights=c(1, 1))

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

print(ggarrange(p0, KTset, ncol=1, heights=c(0.1, 1)))
cat('\n')
print(KT$Stats[KT$Stats$MonitoringID==Mon_IDs[i], ] %>%
  select(N_Data, Median, tau, SennSlope, SennIntercept, p, Trend) %>%
  kable(format="latex") %>%
  row_spec(0, bold=TRUE) %>%
  kable_styling(latex_options = "HOLD_position") %>%
  add_footnote(
    "p < 0.00005 appear as 0 due to rounding"))
cat('\n')
rm(plot_data)
rm(KTset, leg)
}
}

```

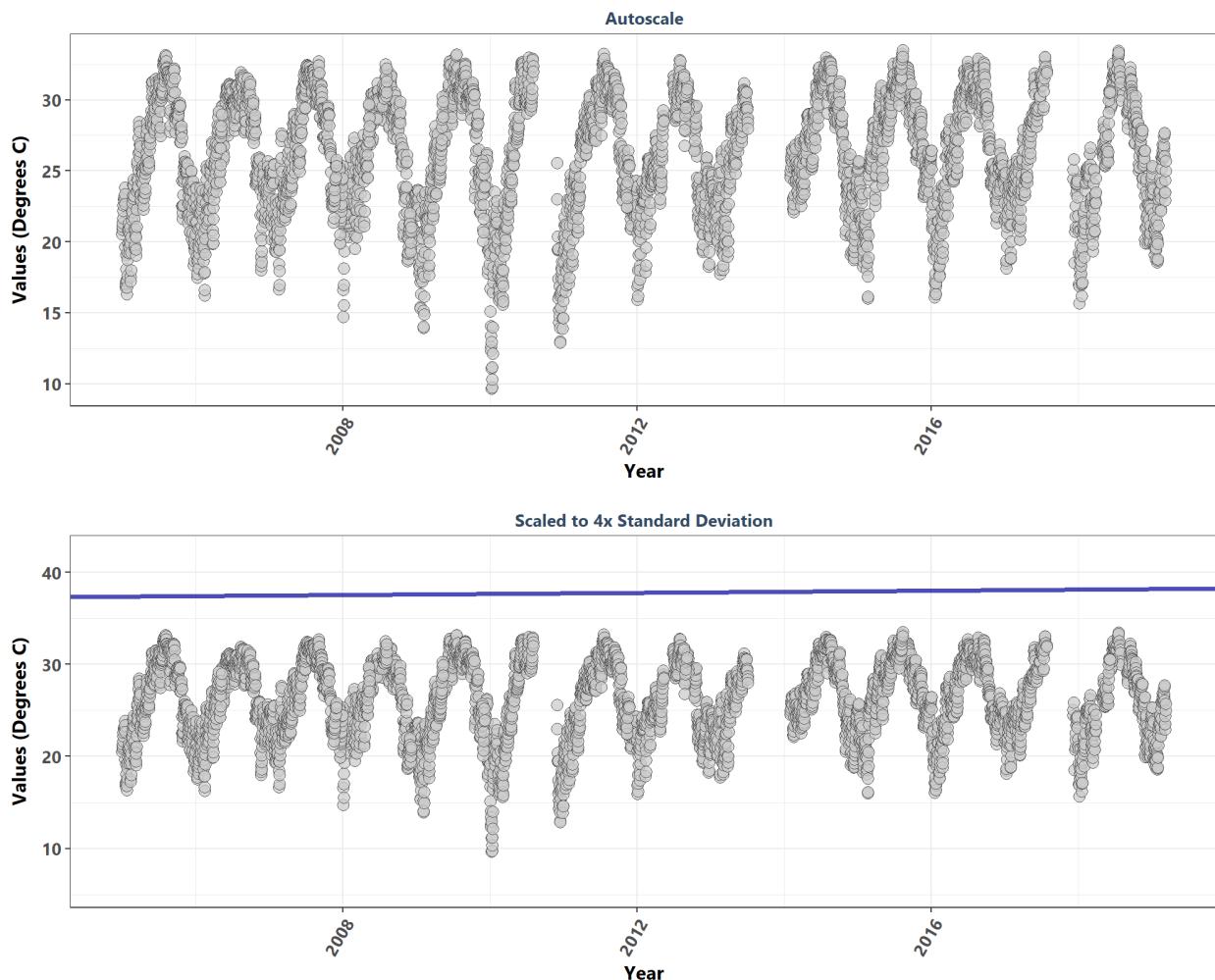
**Florida Keys National Marine Sanctuary**  
**5 | National Data Buoy Center**  
**KYWF1**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
5739	27.17059	0.1565	0.0705616	-91.80213	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

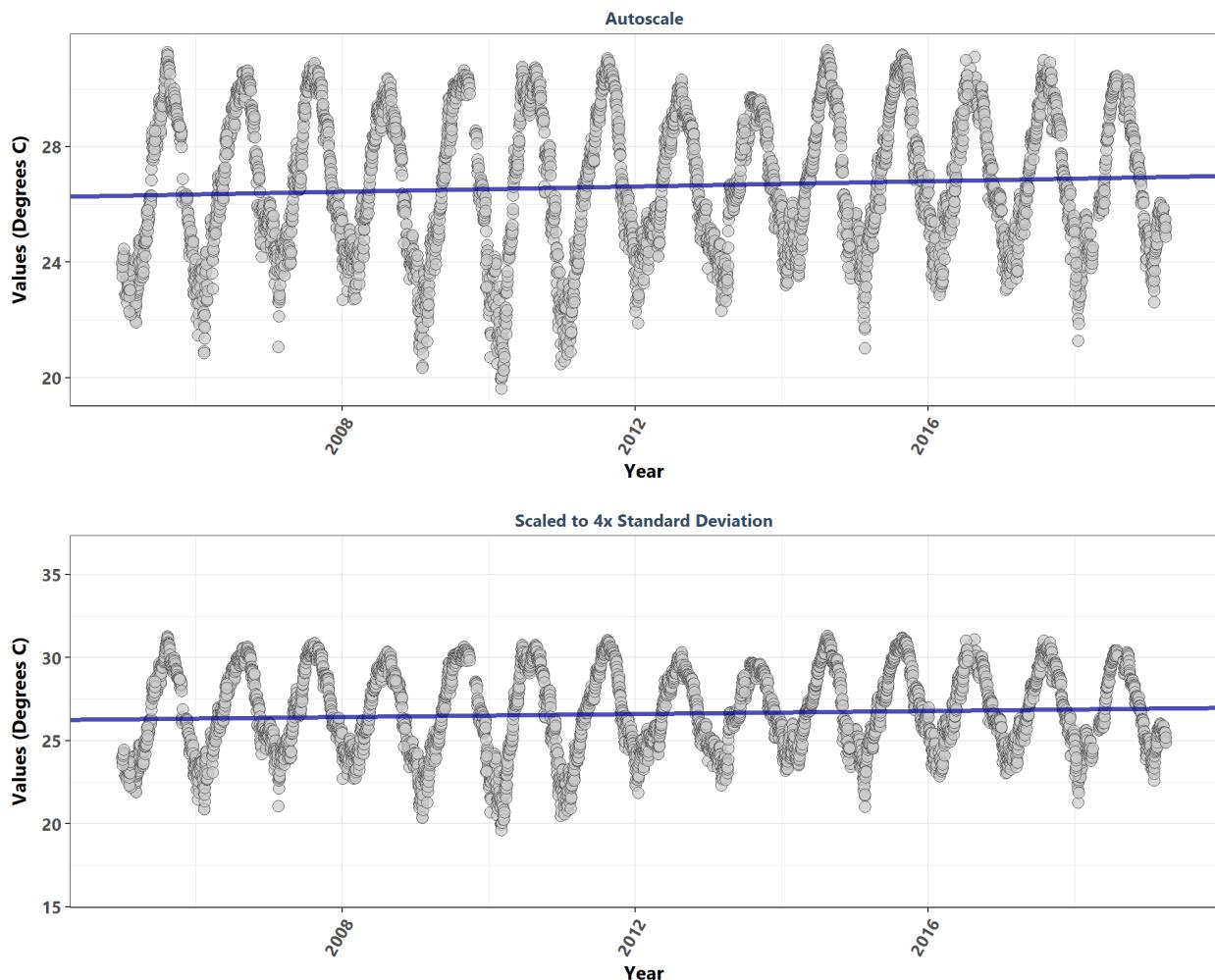
**Florida Keys National Marine Sanctuary**  
**5 | National Data Buoy Center**  
**LONF1**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4583	26.25	0.087	0.059375	-81.69391	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

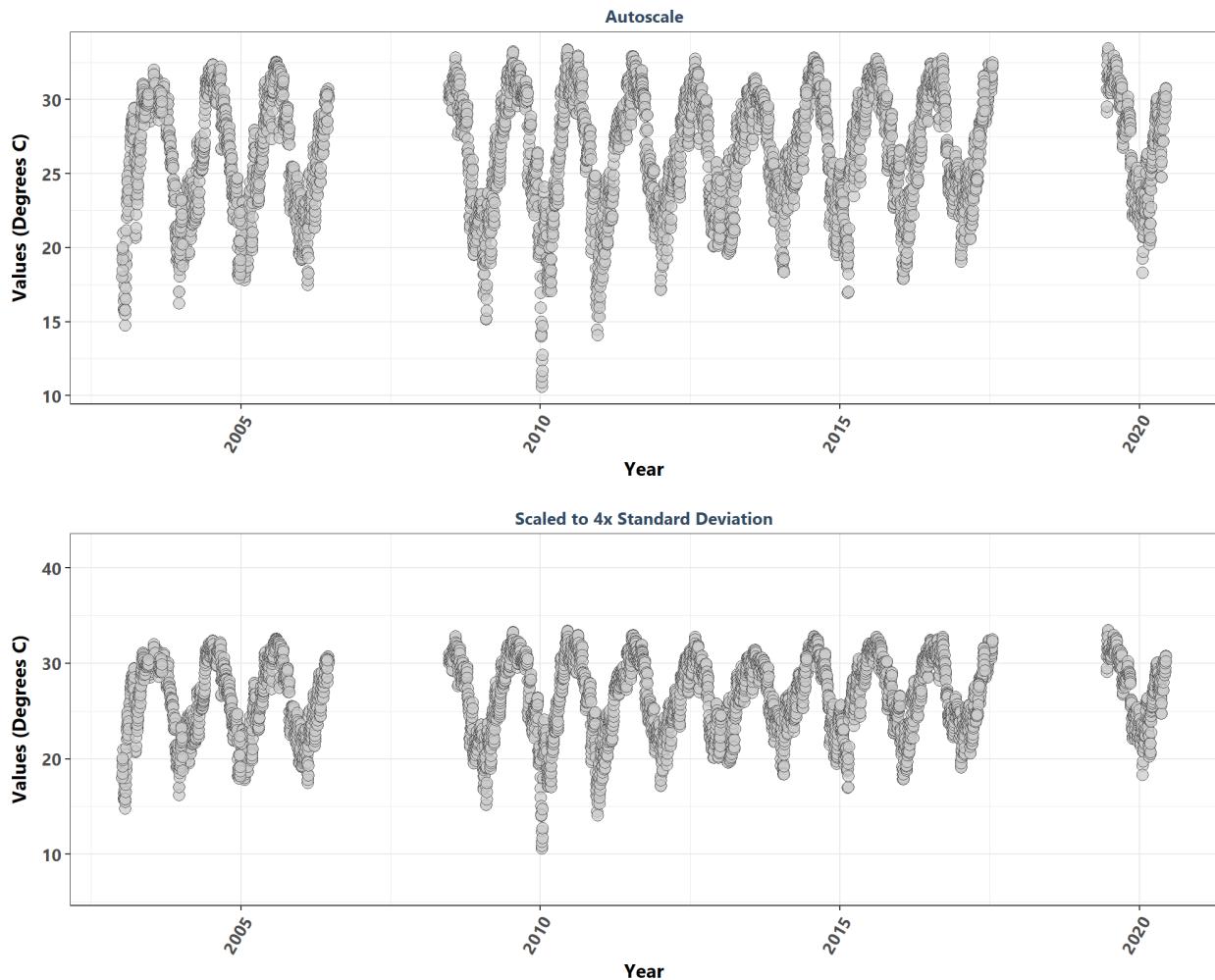
**Florida Keys National Marine Sanctuary**  
**5 | National Data Buoy Center**  
**MLRF1**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
5038	26.55436	0.1486	0.0458333	-65.58958	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

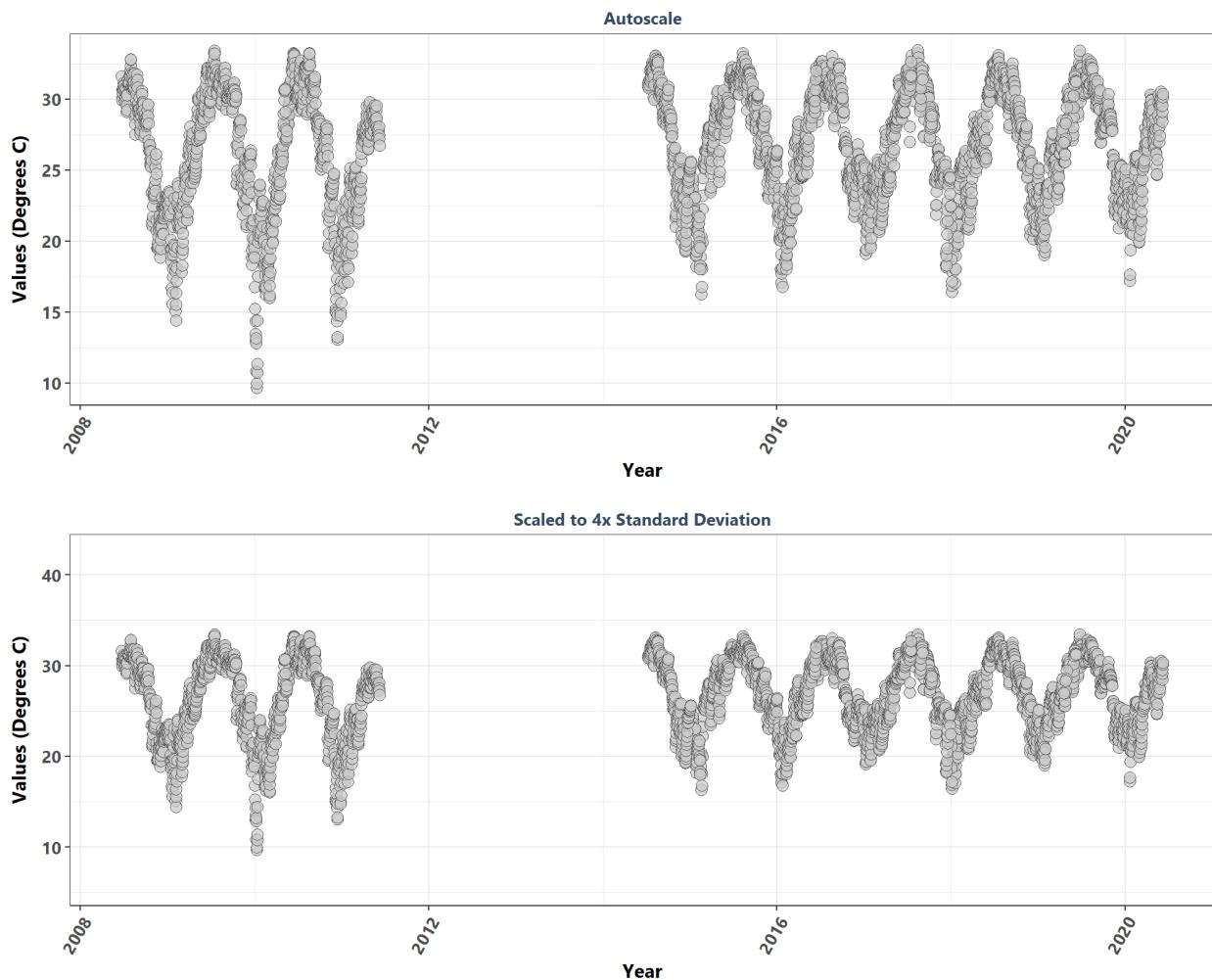
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**11**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4935	26.84461	0.13	0.0652314	-47.20631	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

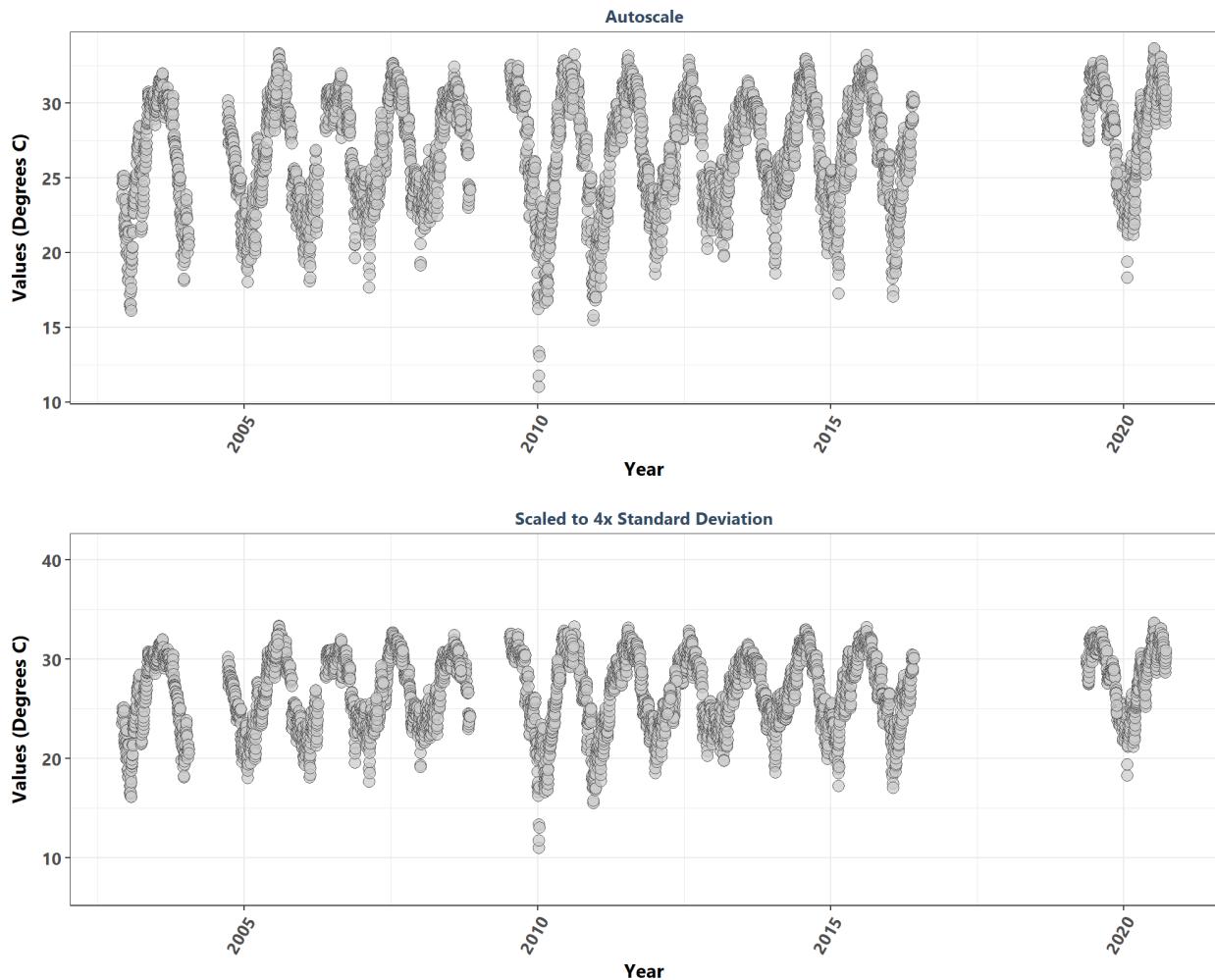
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**12**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3244	27.10842	0.1381	0.0945063	-210.2482	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

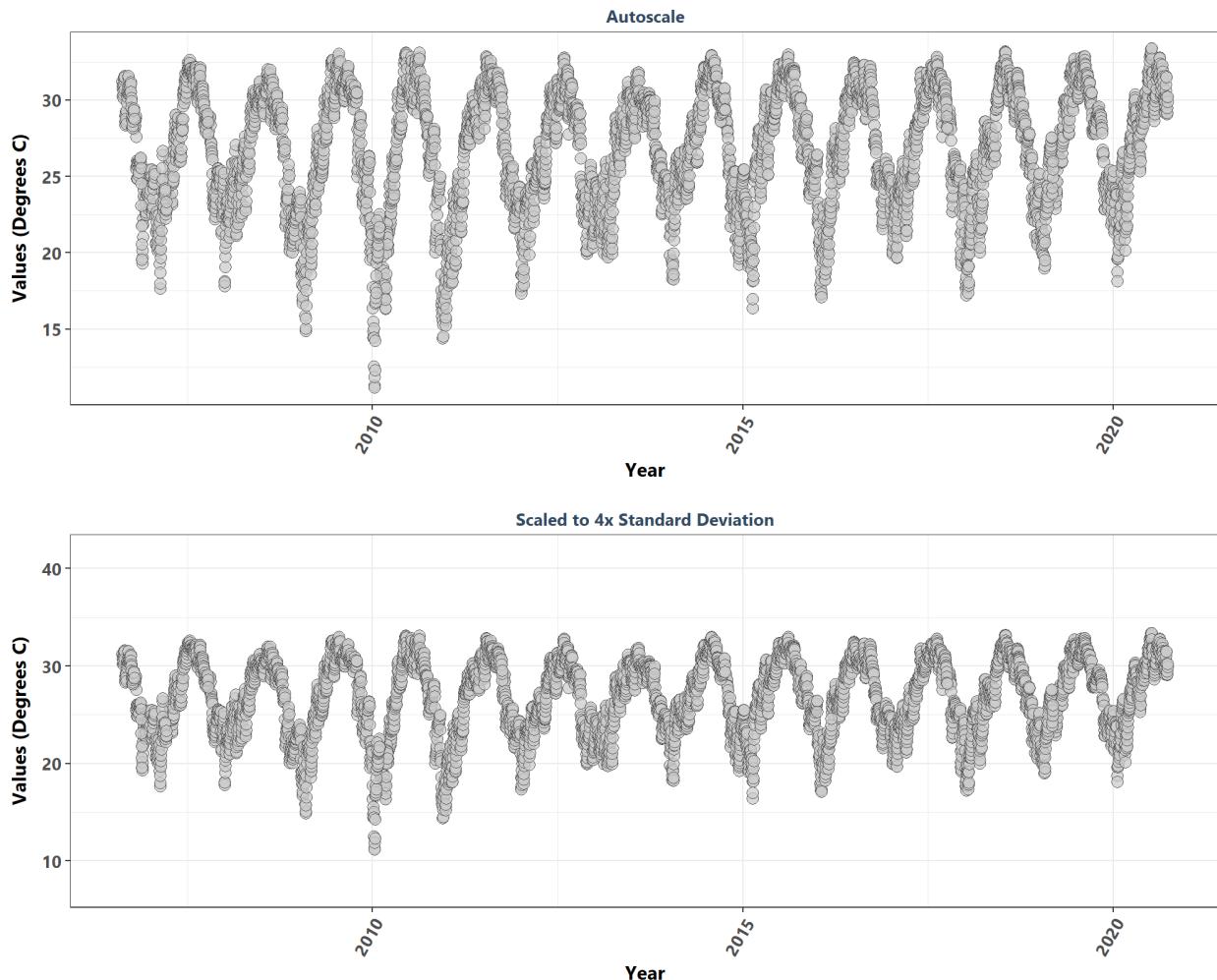
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**14**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4887	27.15683	0.1295	0.0594758	-71.18832	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

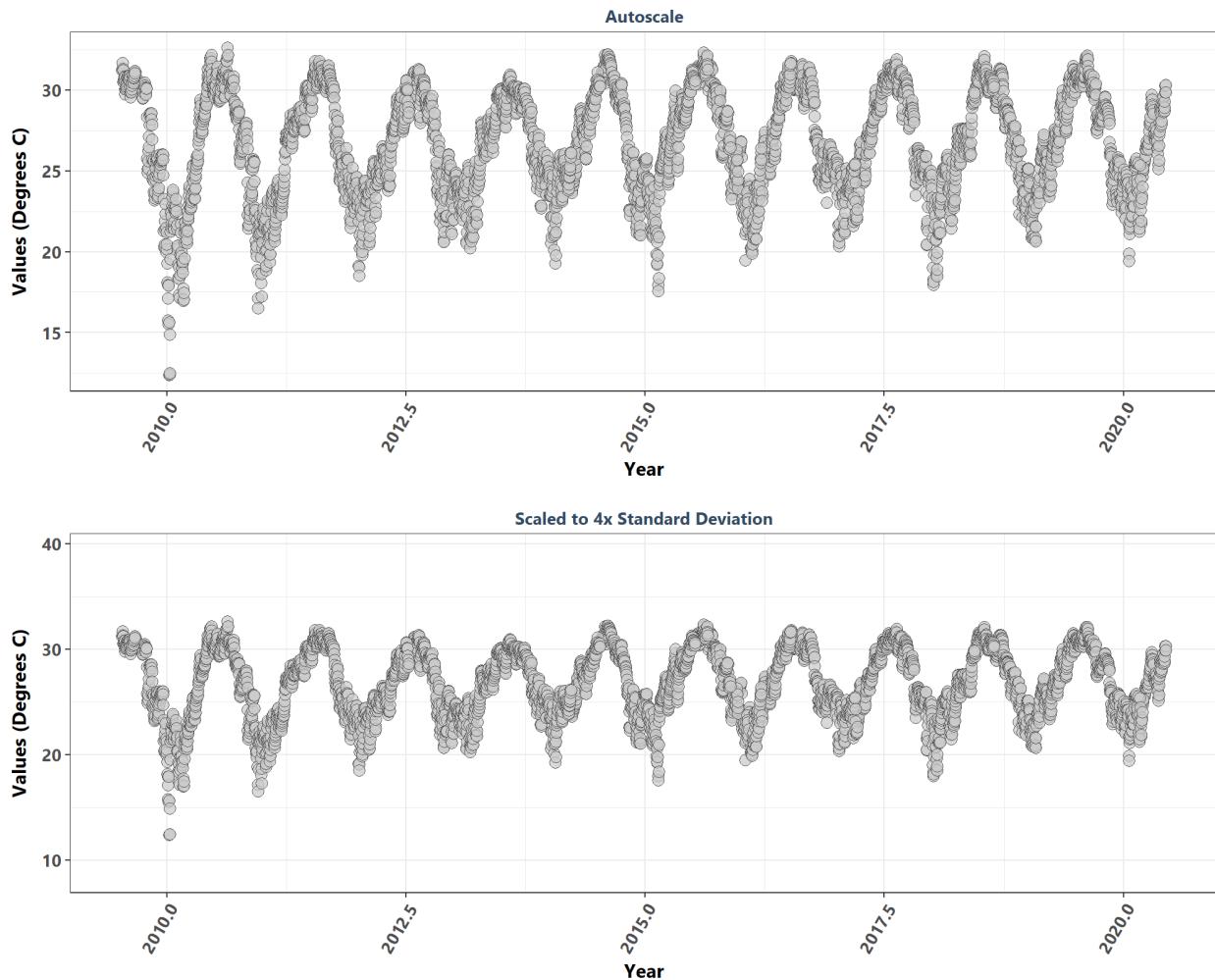
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**15**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
5157	27.16943	0.1056	0.0569885	-44.89812	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

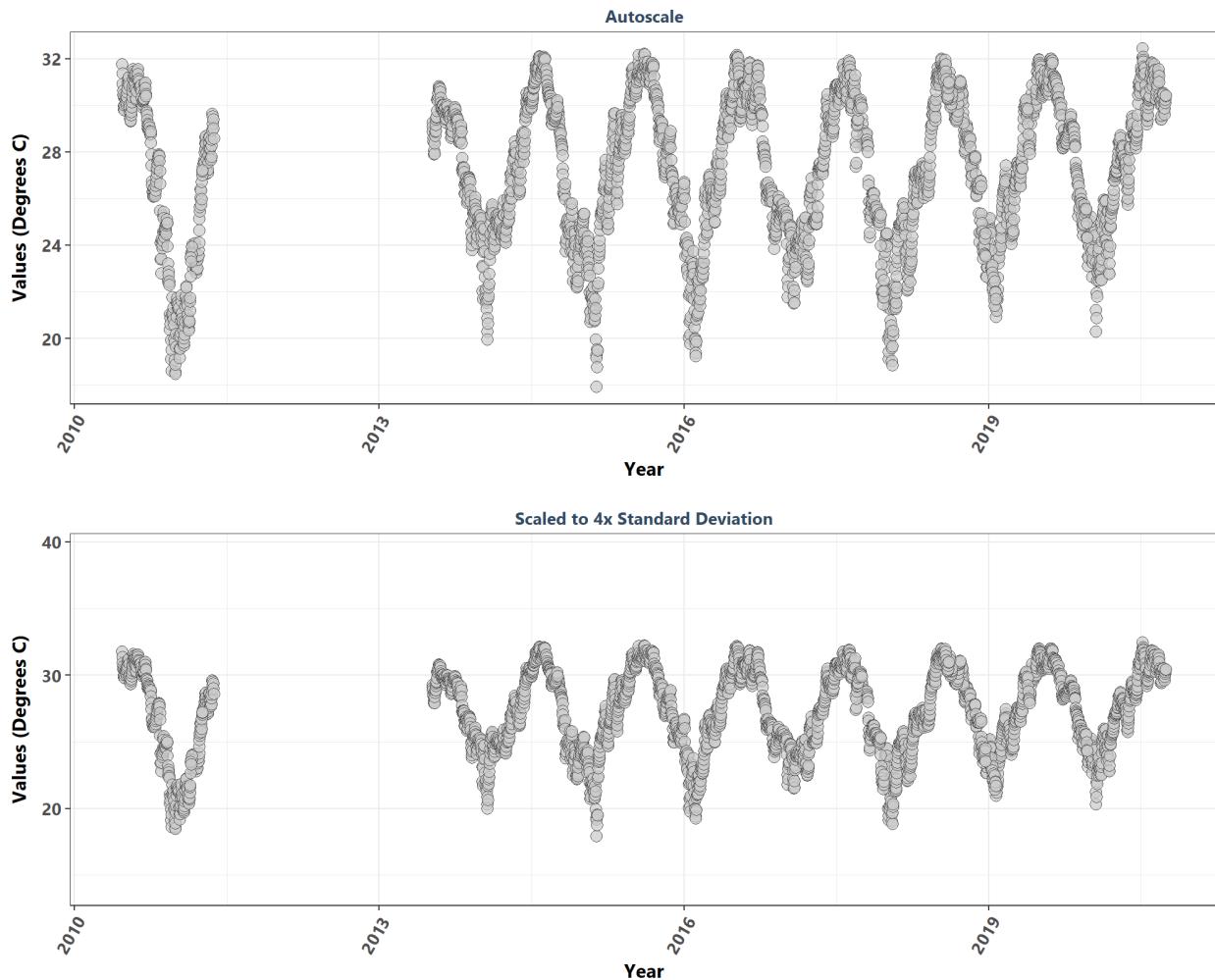
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**22**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3986	26.89638	0.1386	0.0825765	-199.533	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

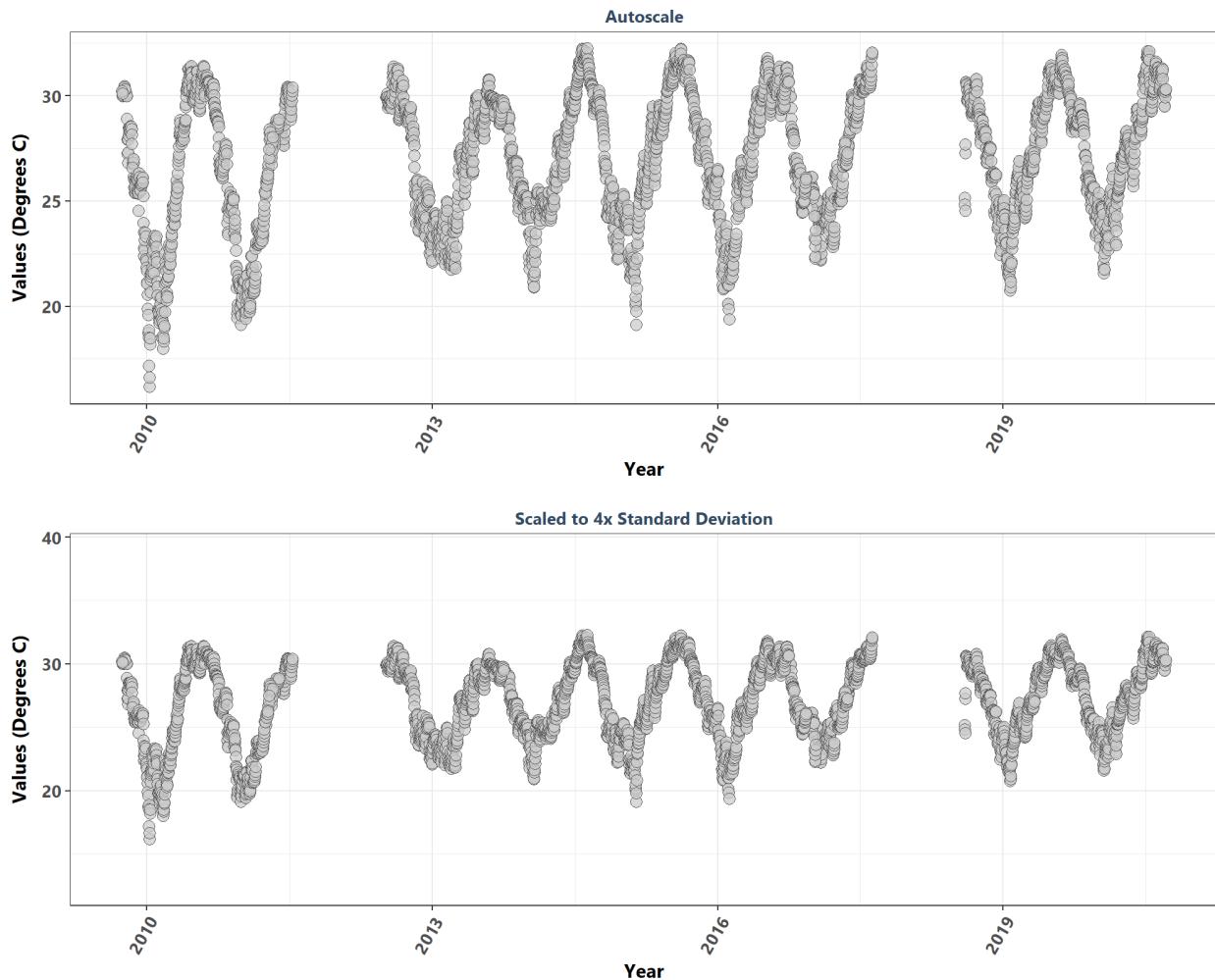
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**25**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
2968	27.33426	0.125	0.0775189	-148.6225	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

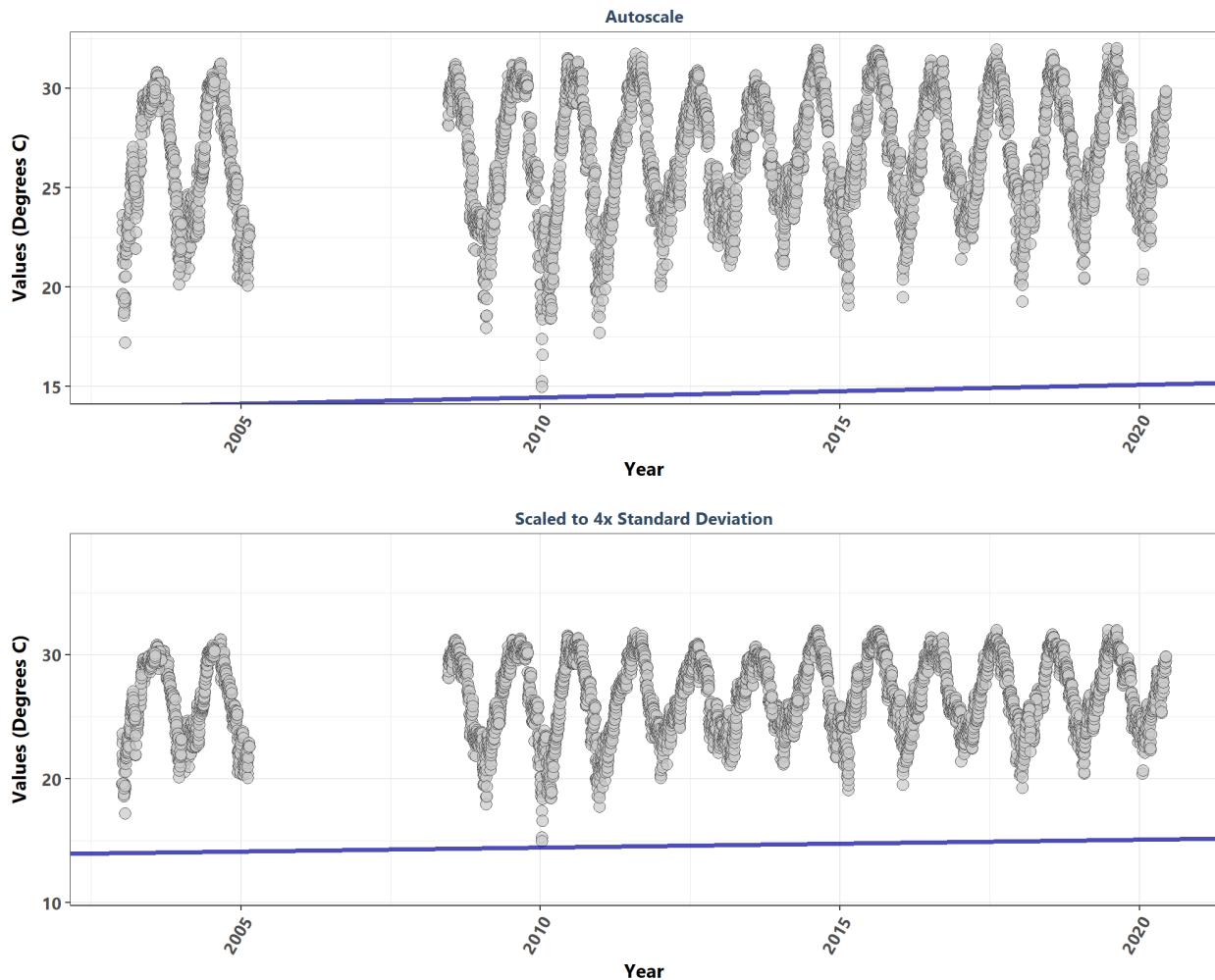
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**26**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3295	27.16333	0.1783	0.1031001	-222.0138	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

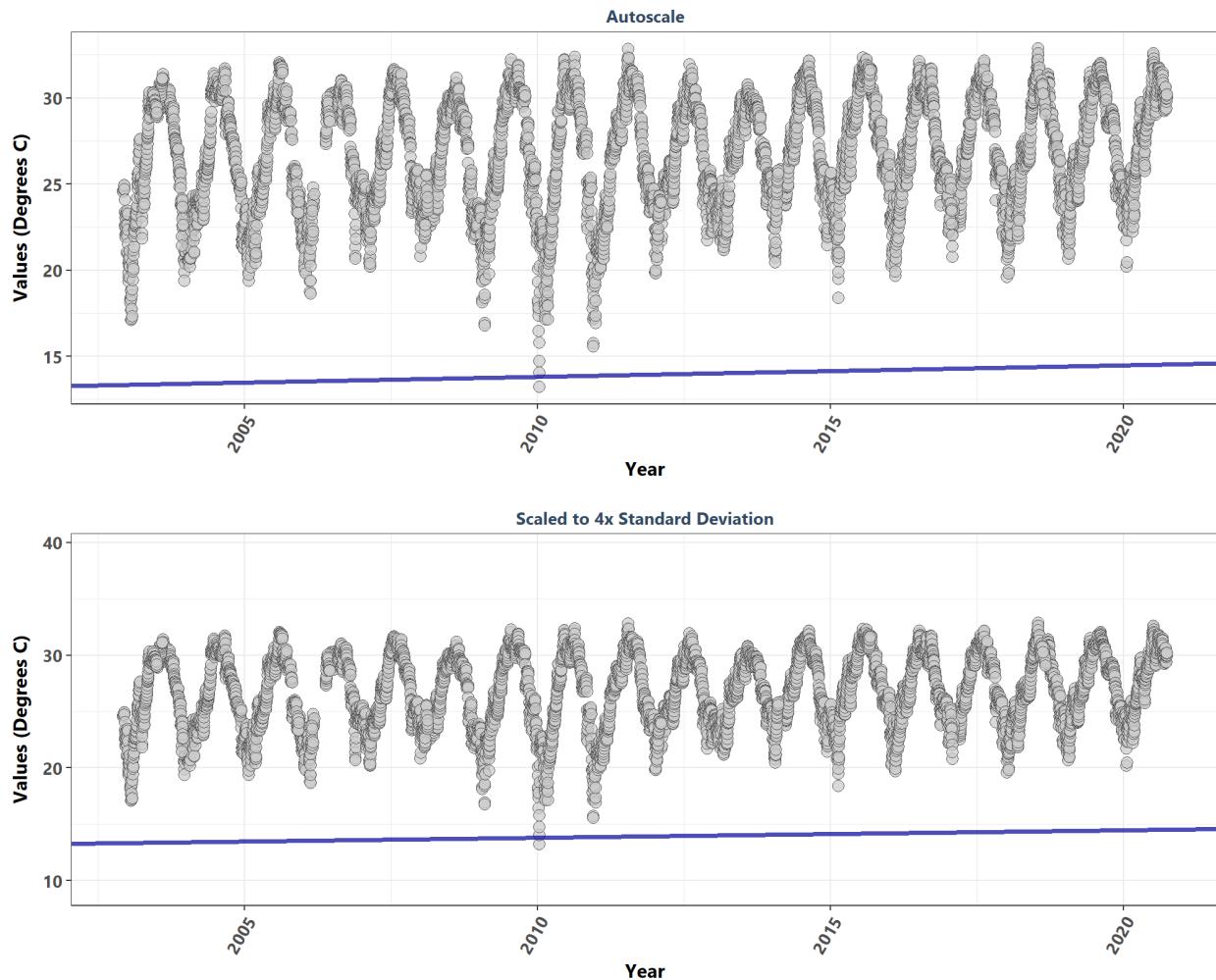
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**32**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
5152	26.68022	0.186	0.0636217	-113.4153	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

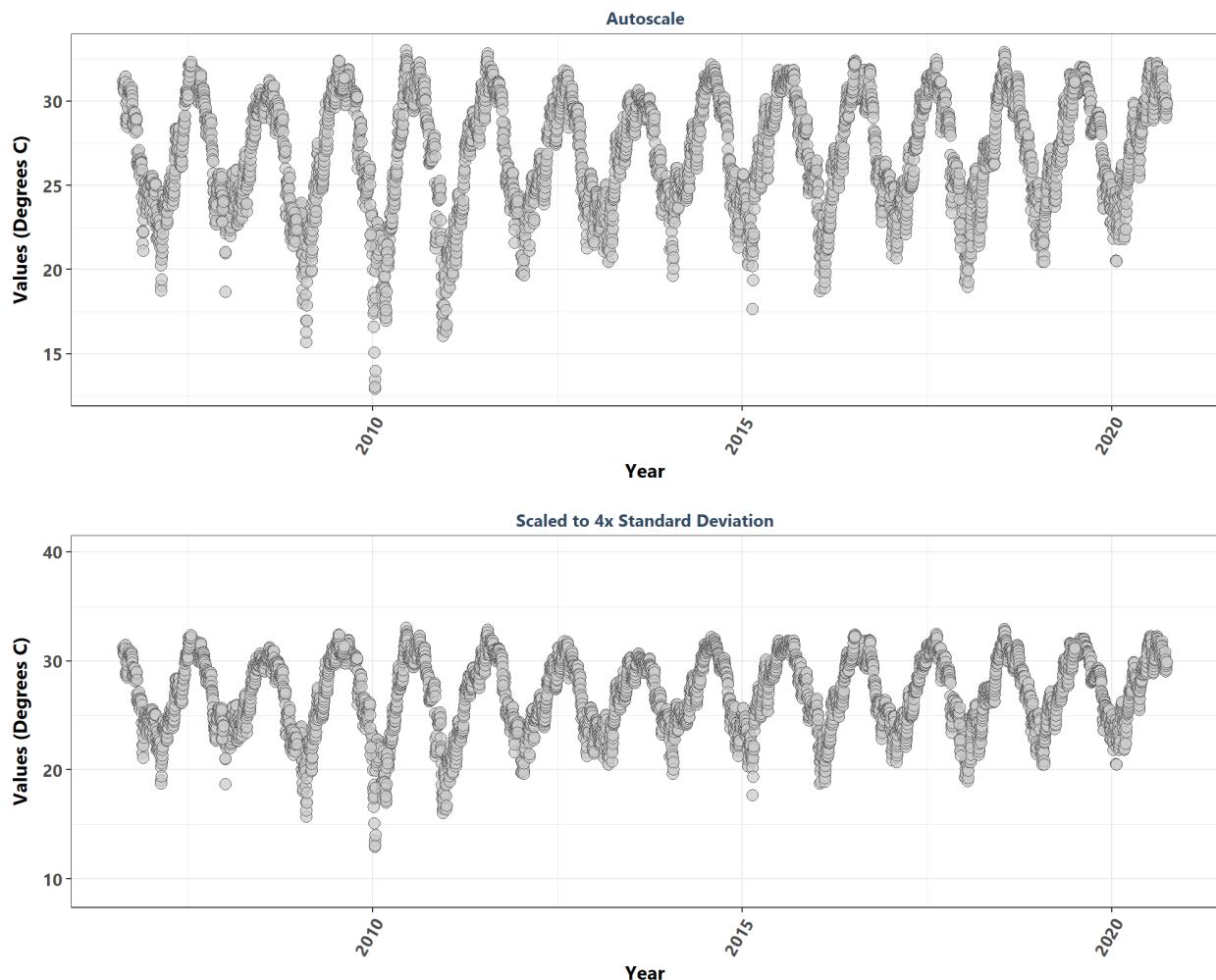
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**34**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
6438	26.88342	0.1999	0.0661096	-119.0666	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

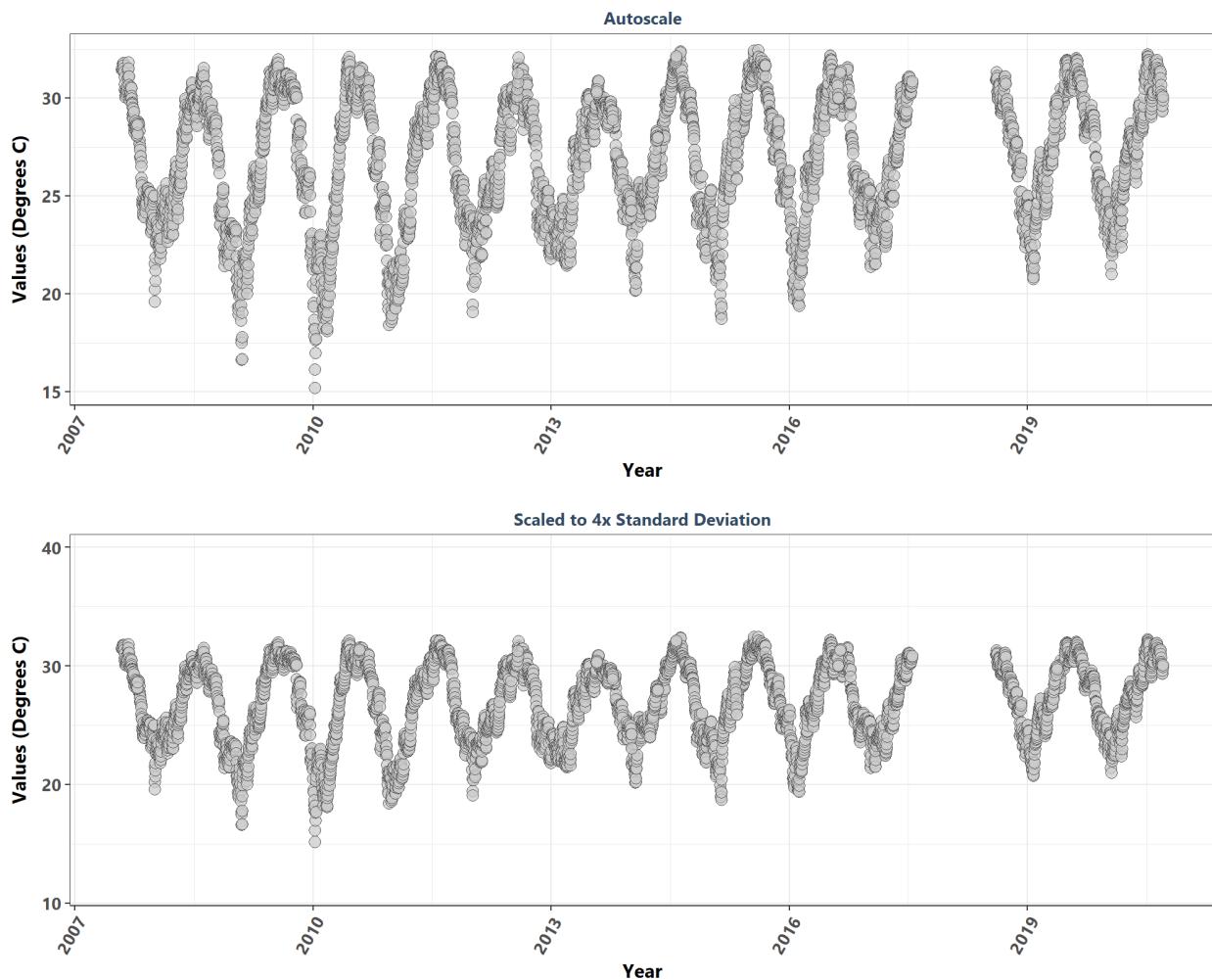
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**35**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
5158	27.08659	0.1356	0.0598519	-69.23407	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

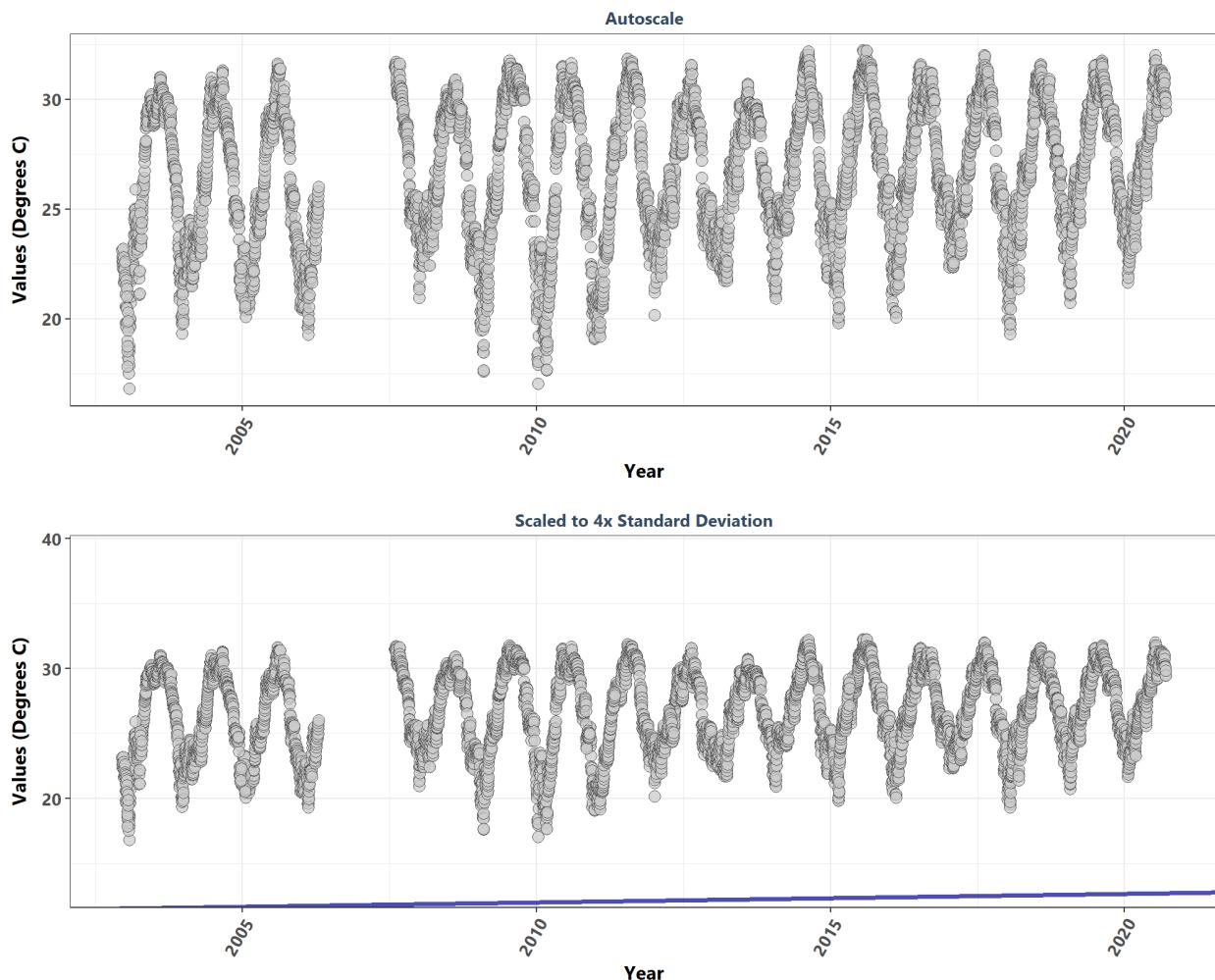
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**36**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4408	27.12104	0.1673	0.0798956	-186.4808	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

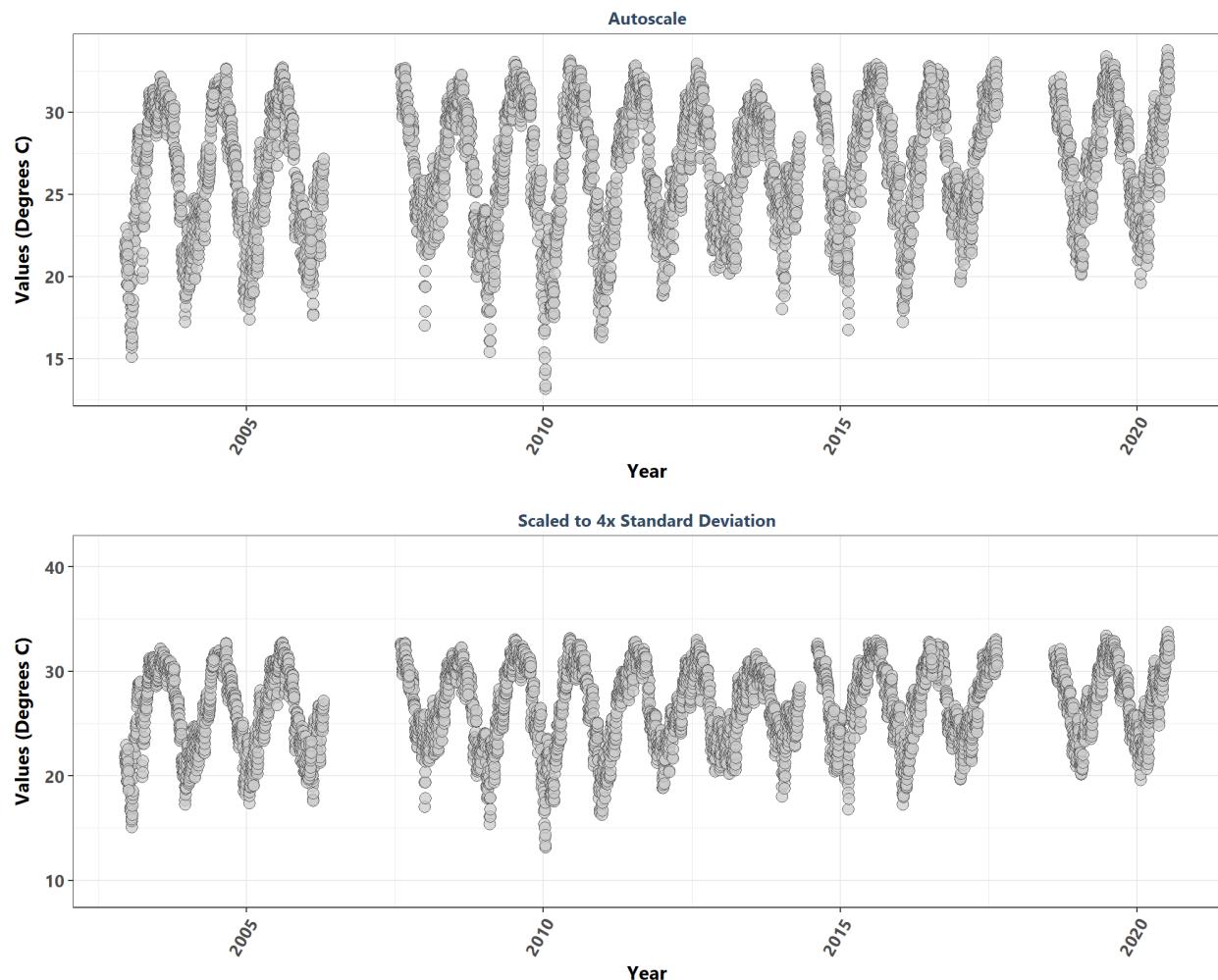
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**38**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
6009	26.66885	0.1975	0.0663659	-121.3882	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

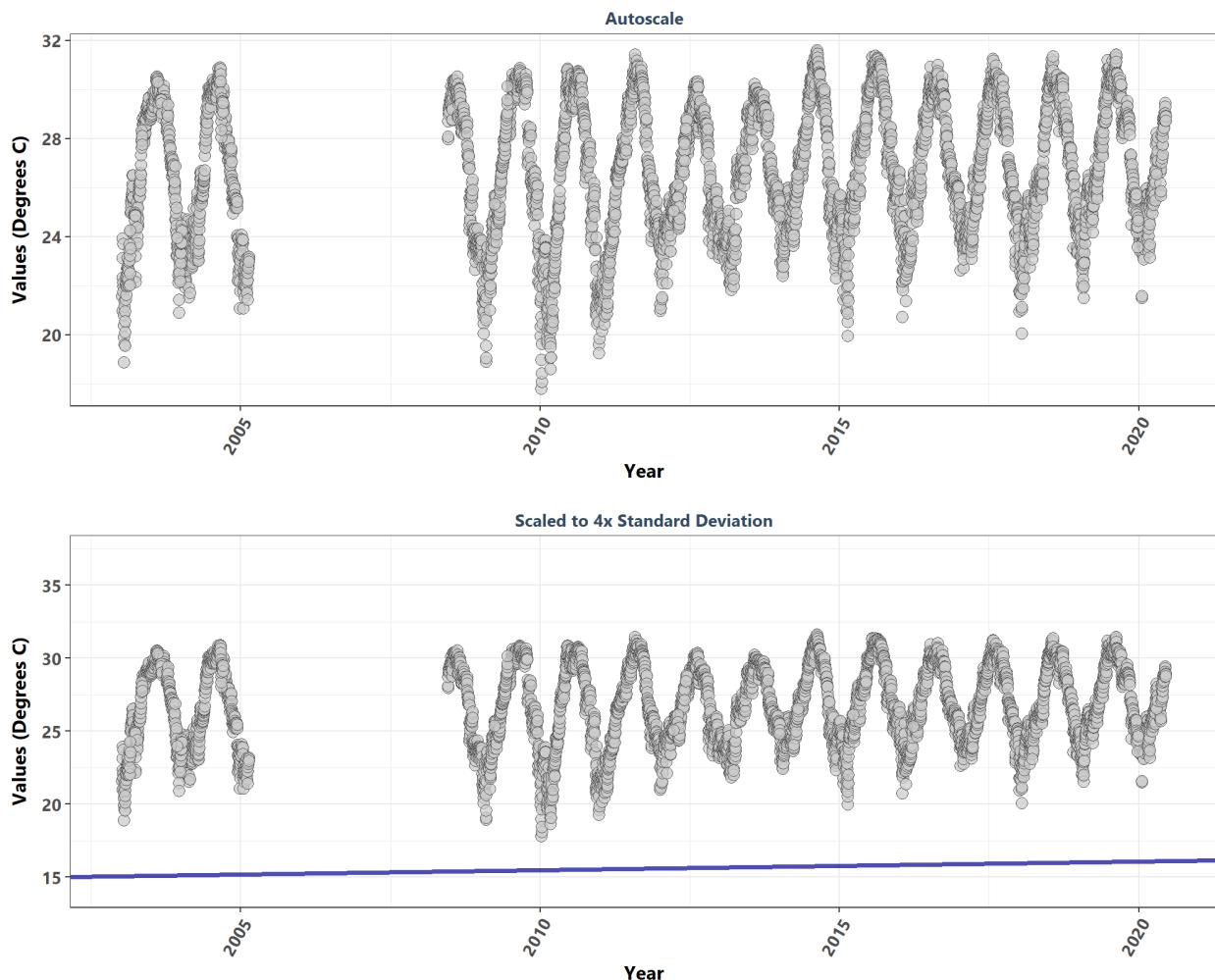
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**40**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
5490	26.94318	0.1476	0.0719112	-98.45028	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

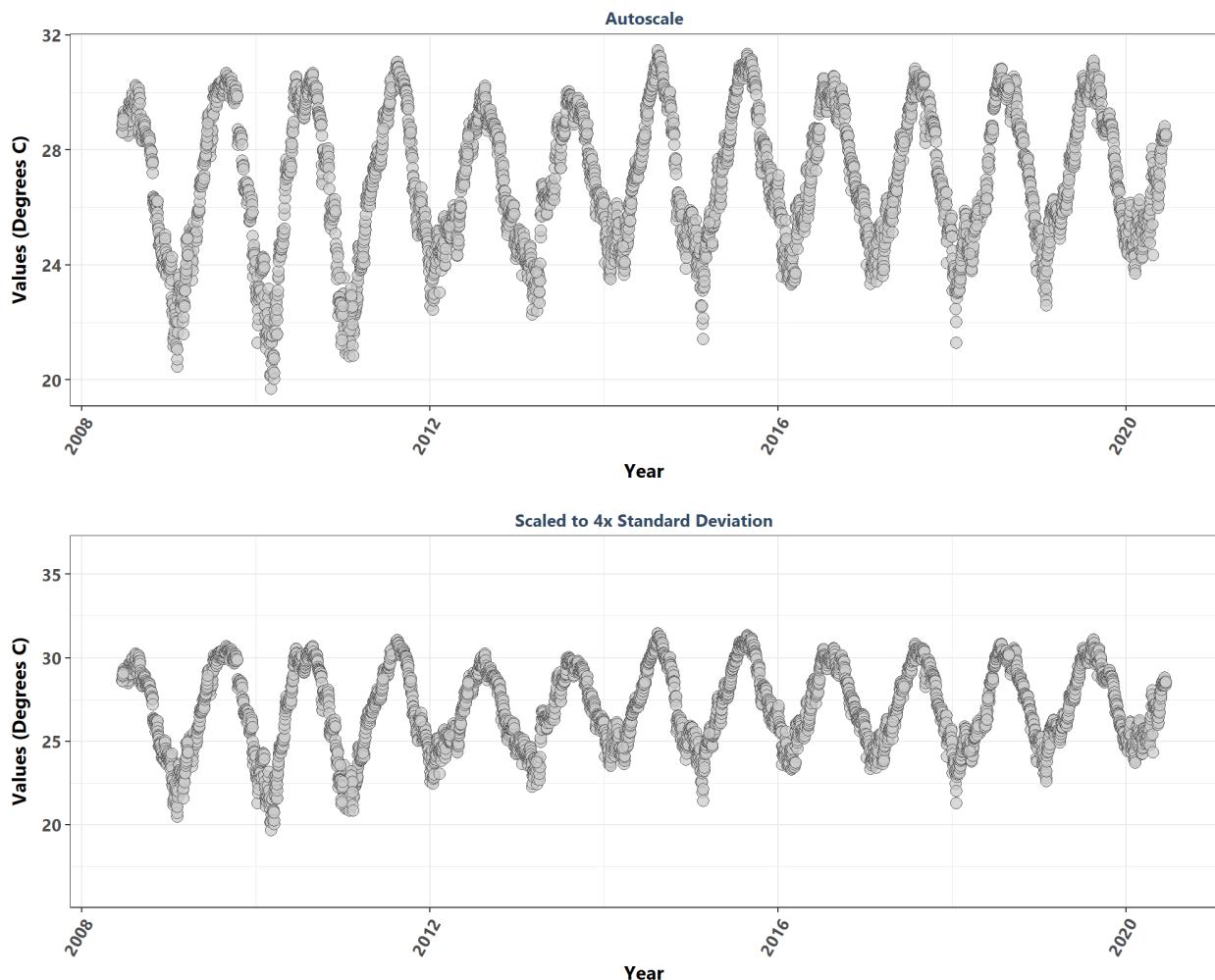
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**51**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
5157	26.6782	0.2012	0.0588069	-102.7345	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

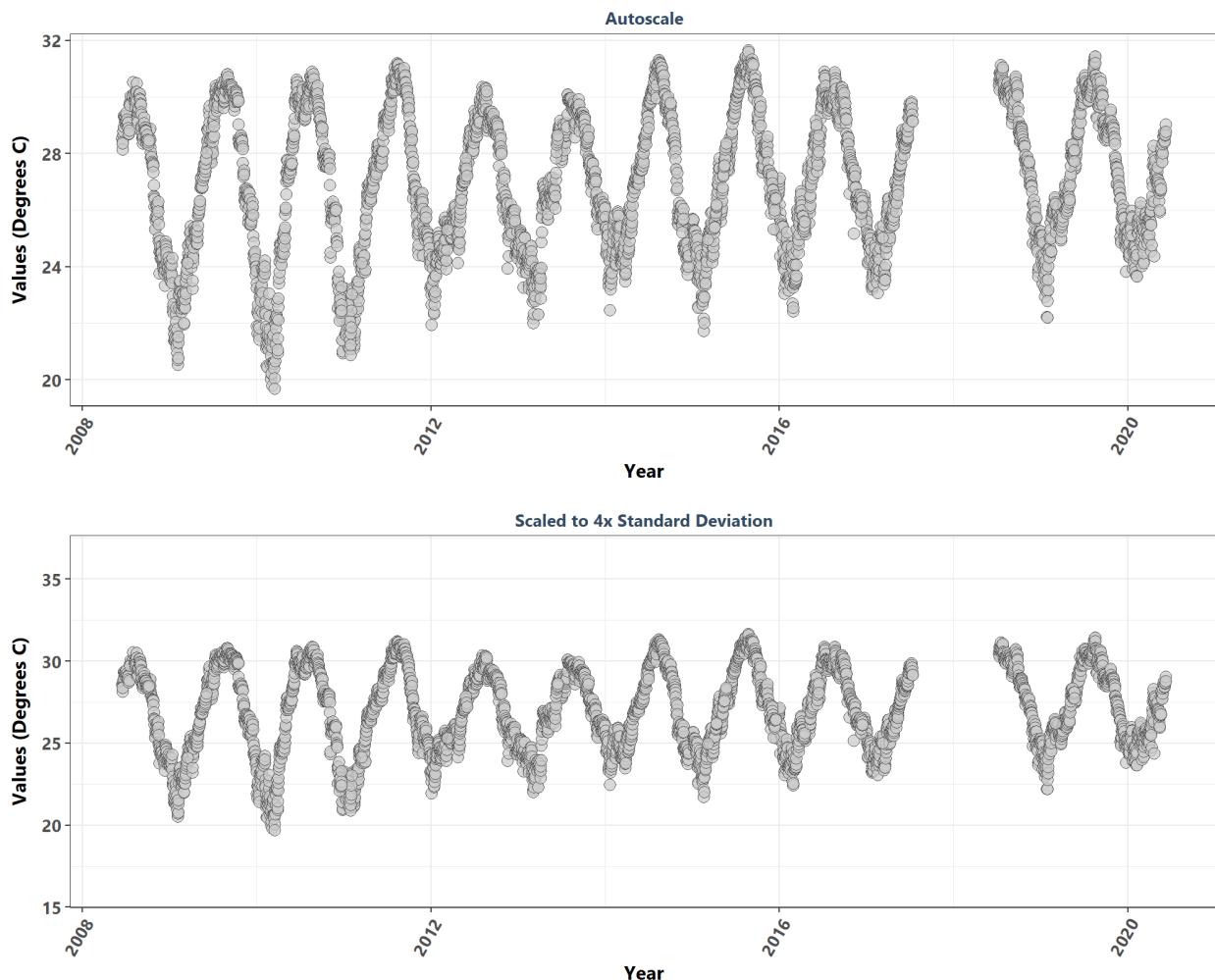
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**52**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4380	26.90952	0.2355	0.0843993	-160.2501	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

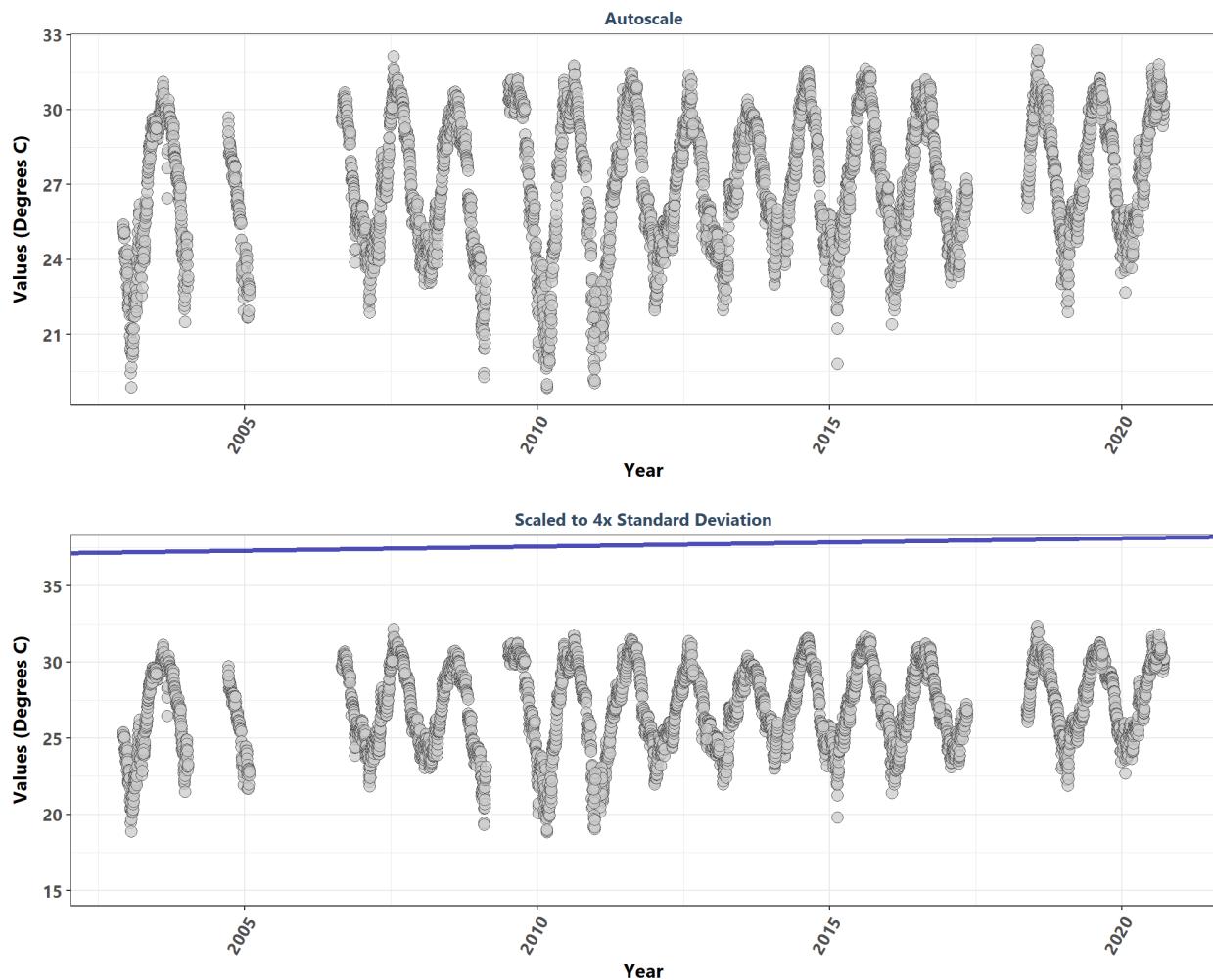
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**53**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4016	26.98982	0.2527	0.097412	-186.6311	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

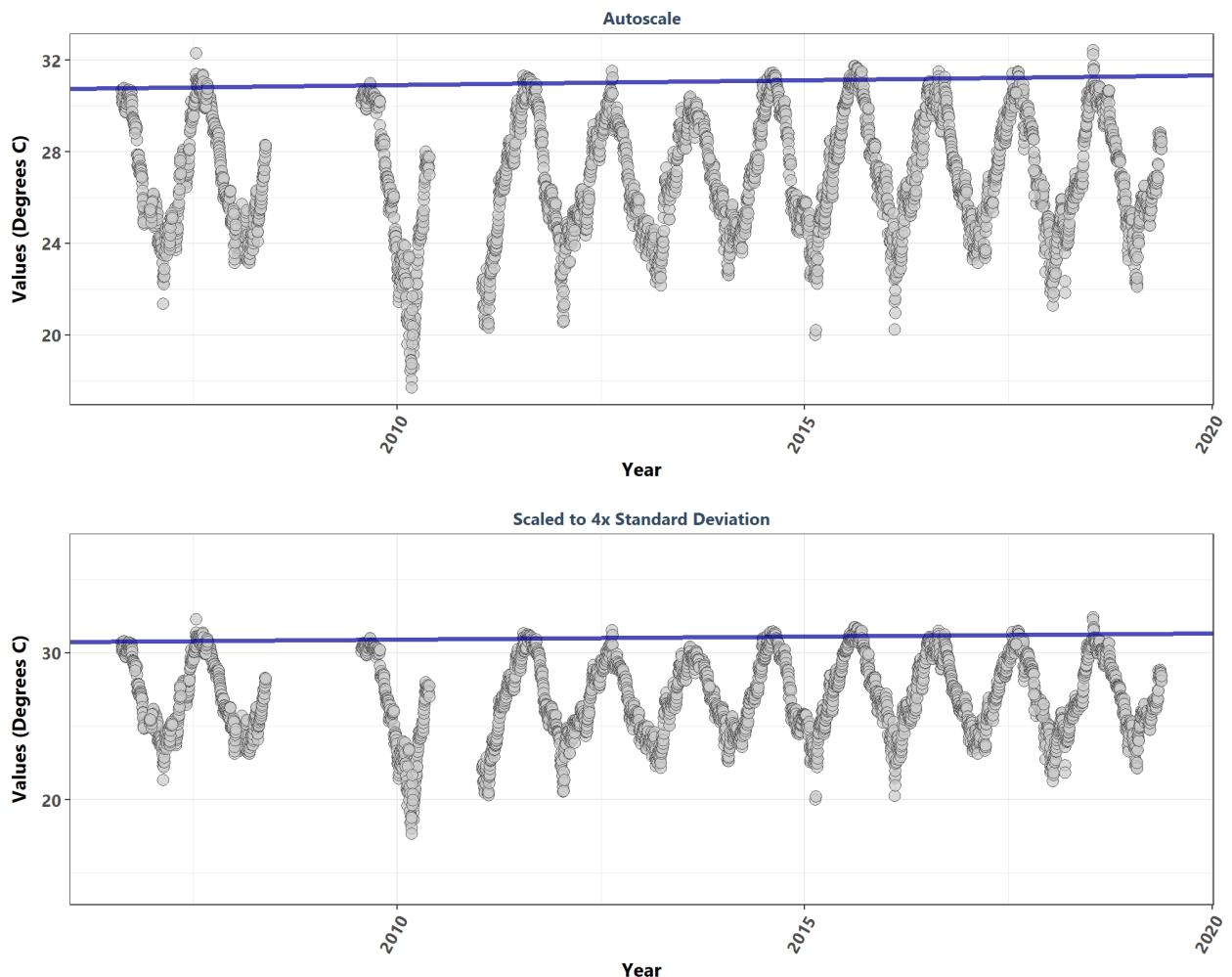
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**55**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
5165	26.9747	0.1877	0.0537424	-70.44324	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

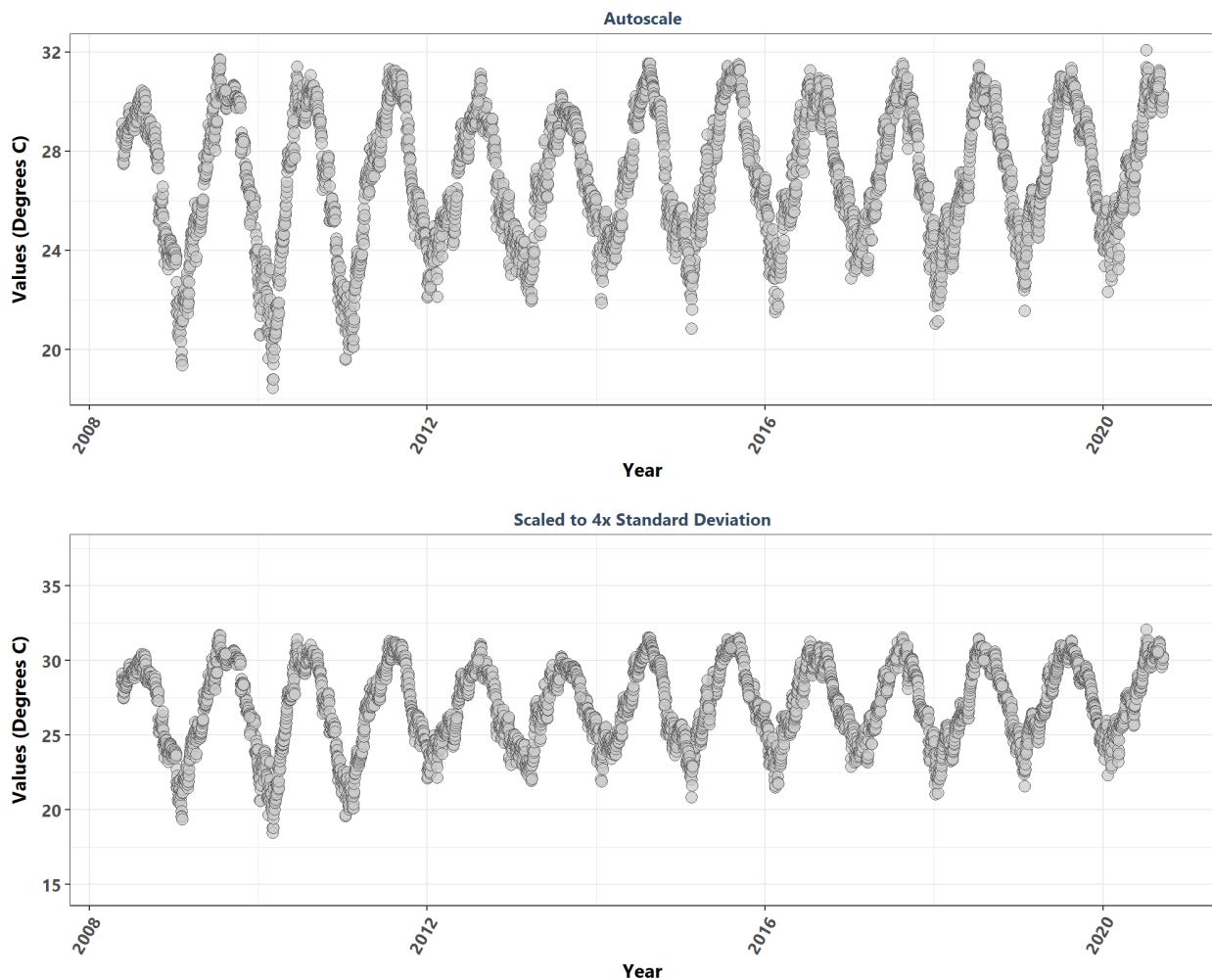
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**56**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3992	26.73152	0.1111	0.0418452	-53.18688	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

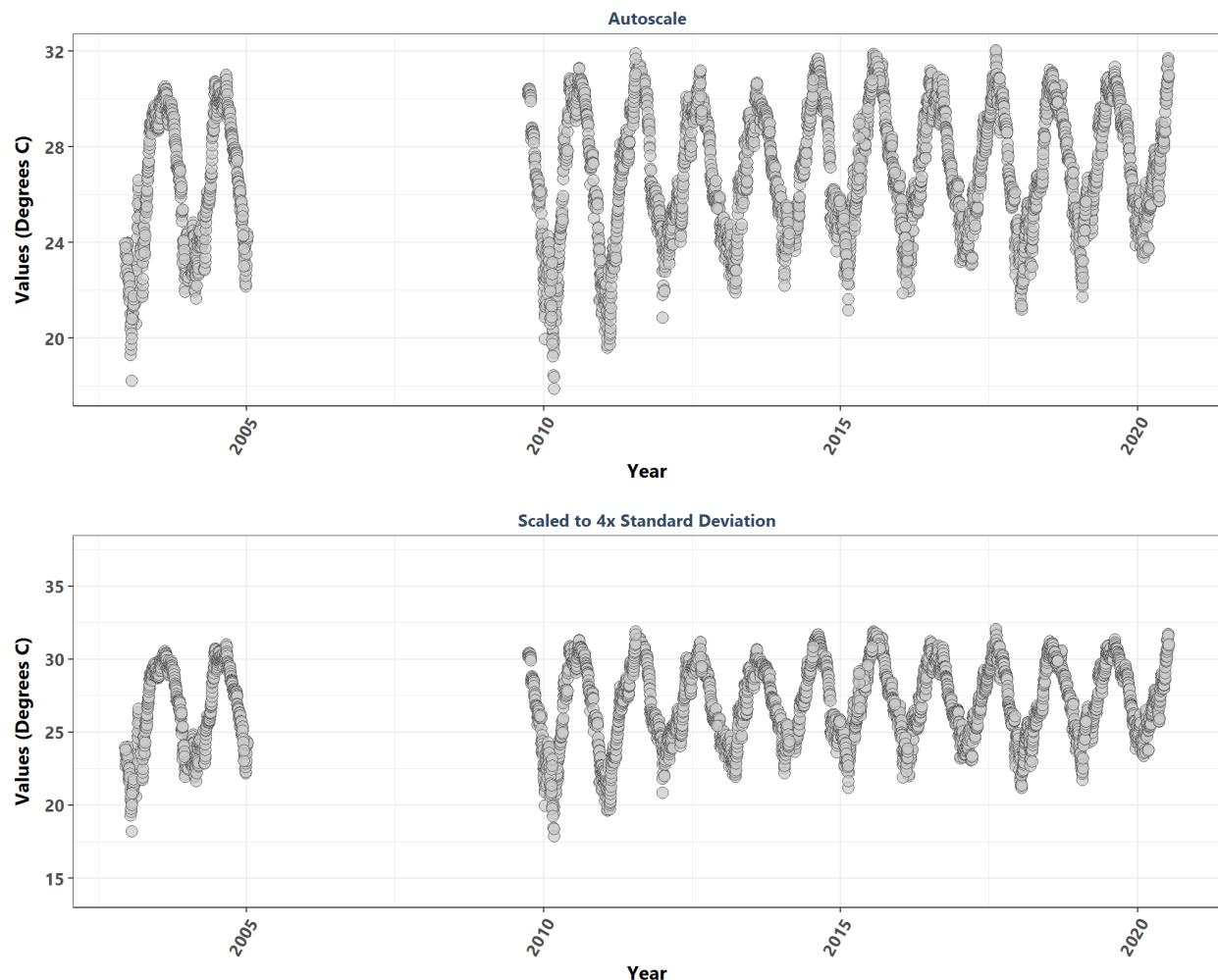
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**57**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4503	27.09896	0.2325	0.0904457	-197.0984	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

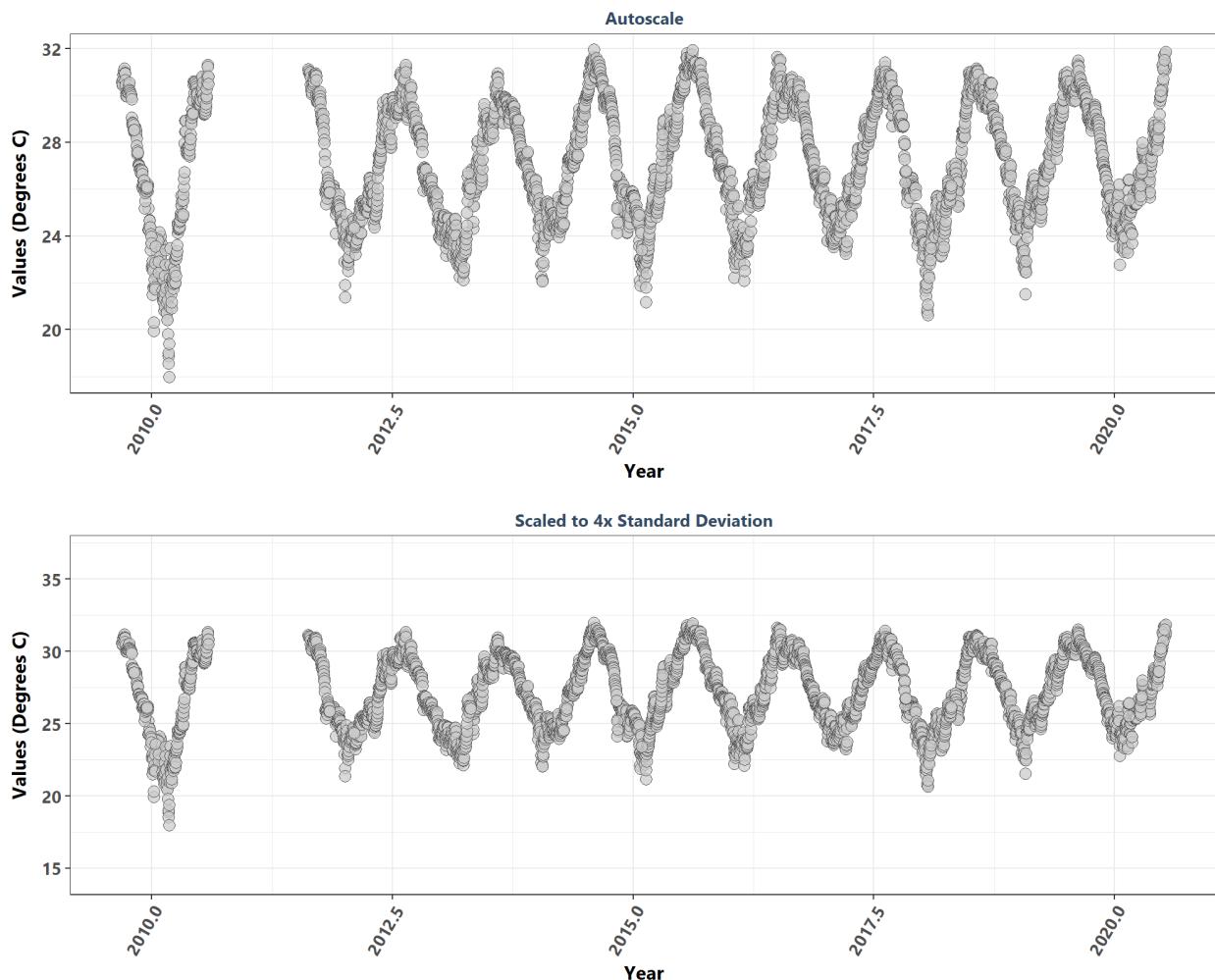
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**59**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4695	26.875	0.204	0.0632917	-84.60159	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

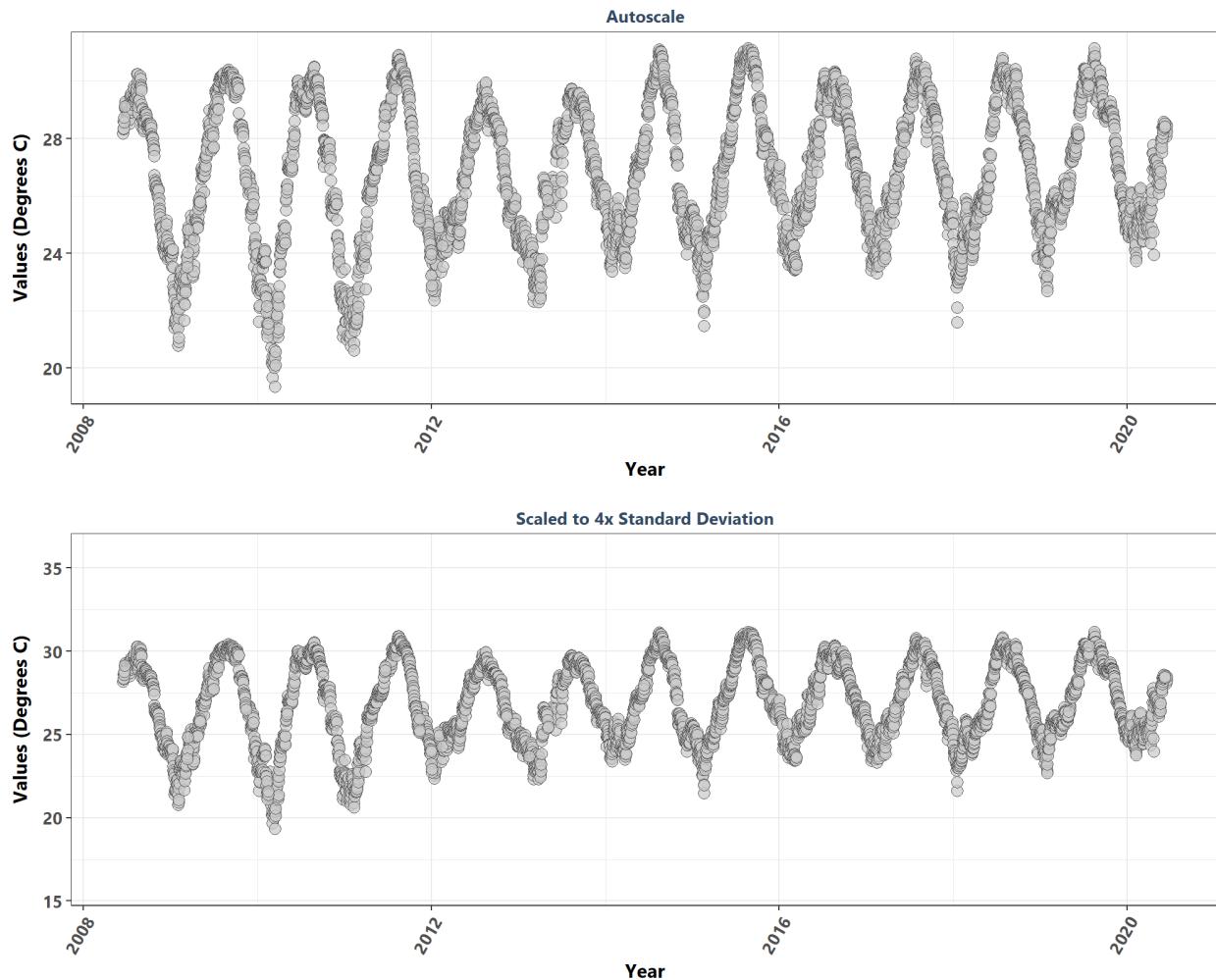
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**60**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3583	26.97375	0.1295	0.062495	-77.23023	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

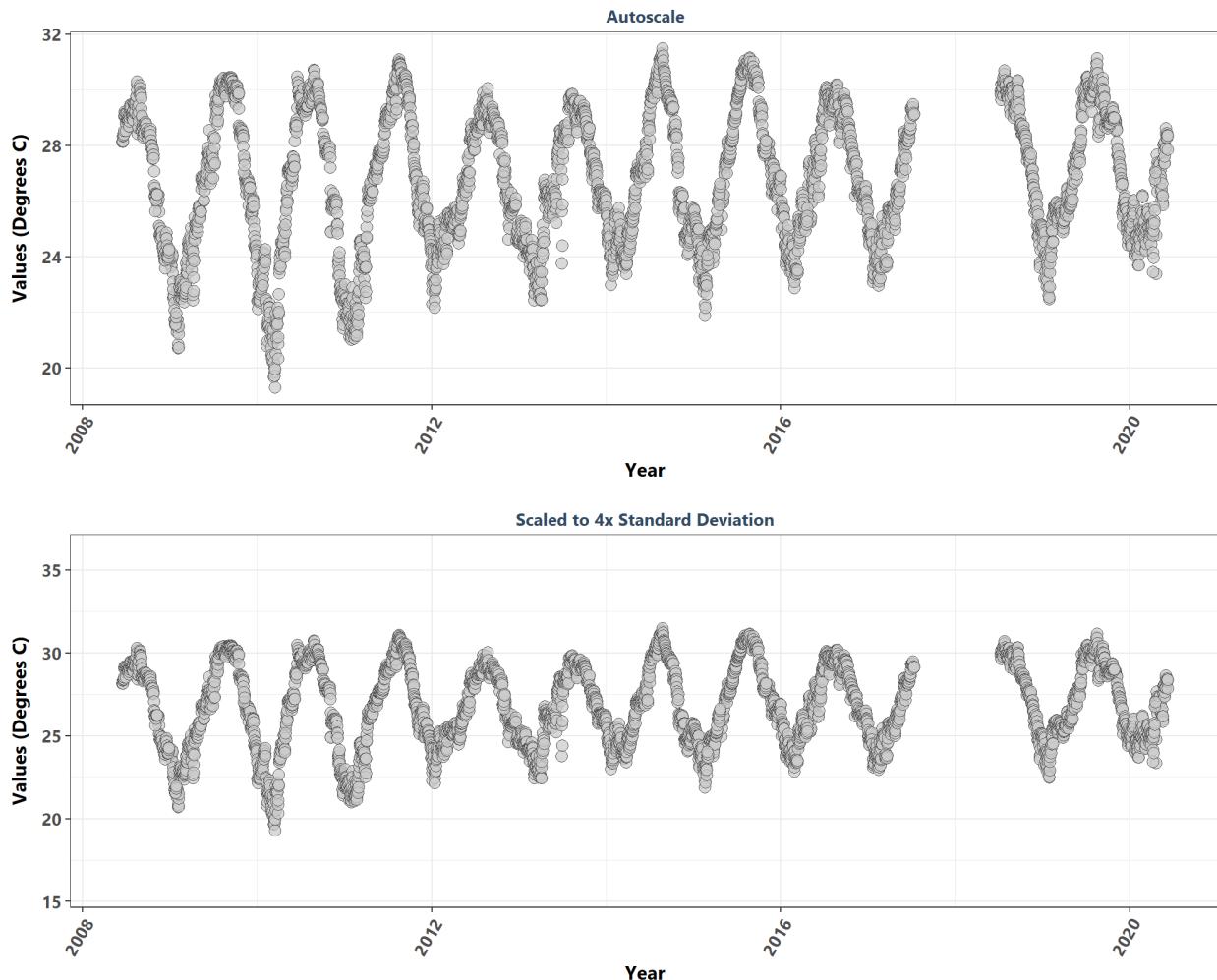
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**72**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4382	26.75365	0.2687	0.09585	-183.2822	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

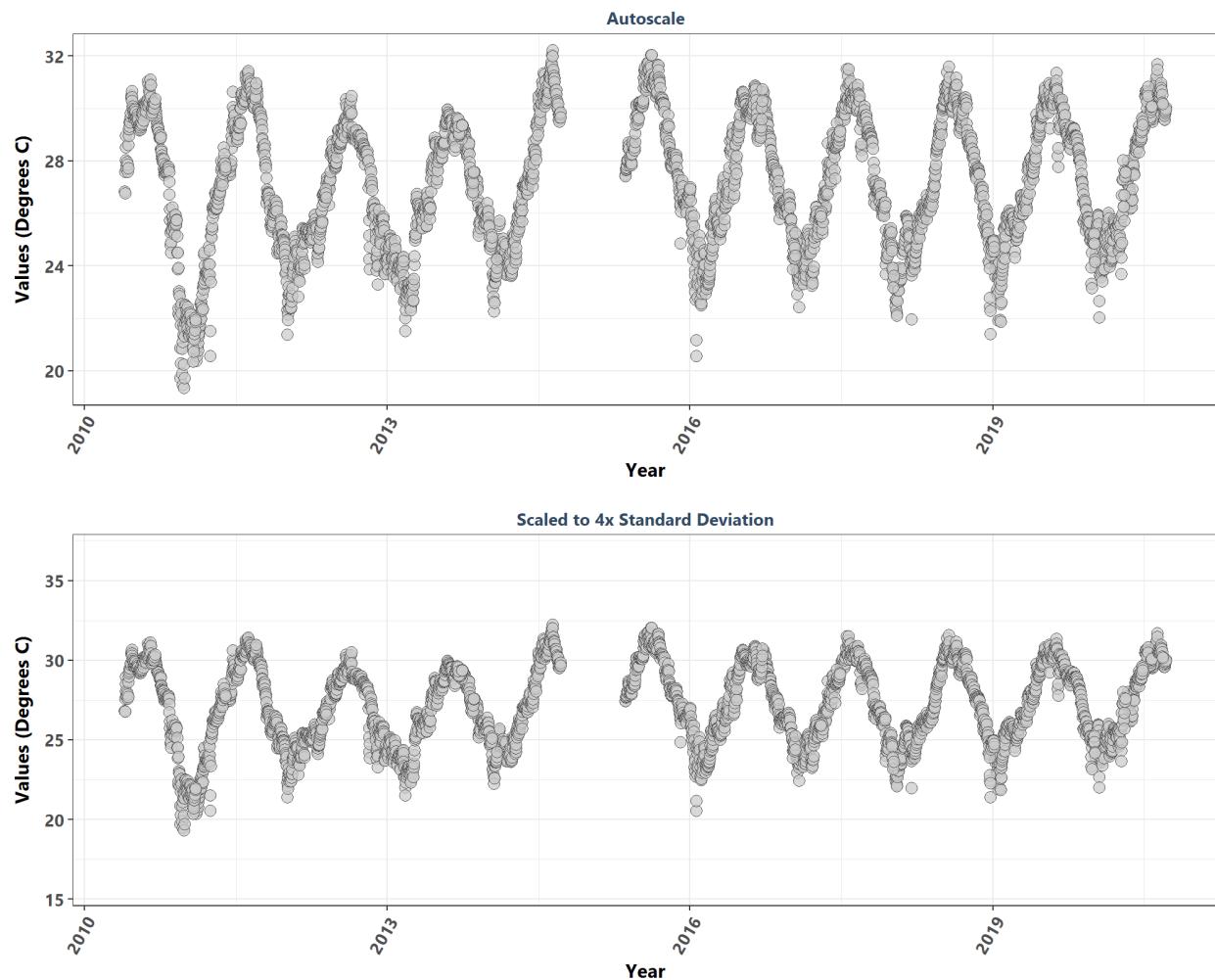
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**73**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4016	26.74342	0.2473	0.0936005	-175.1452	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

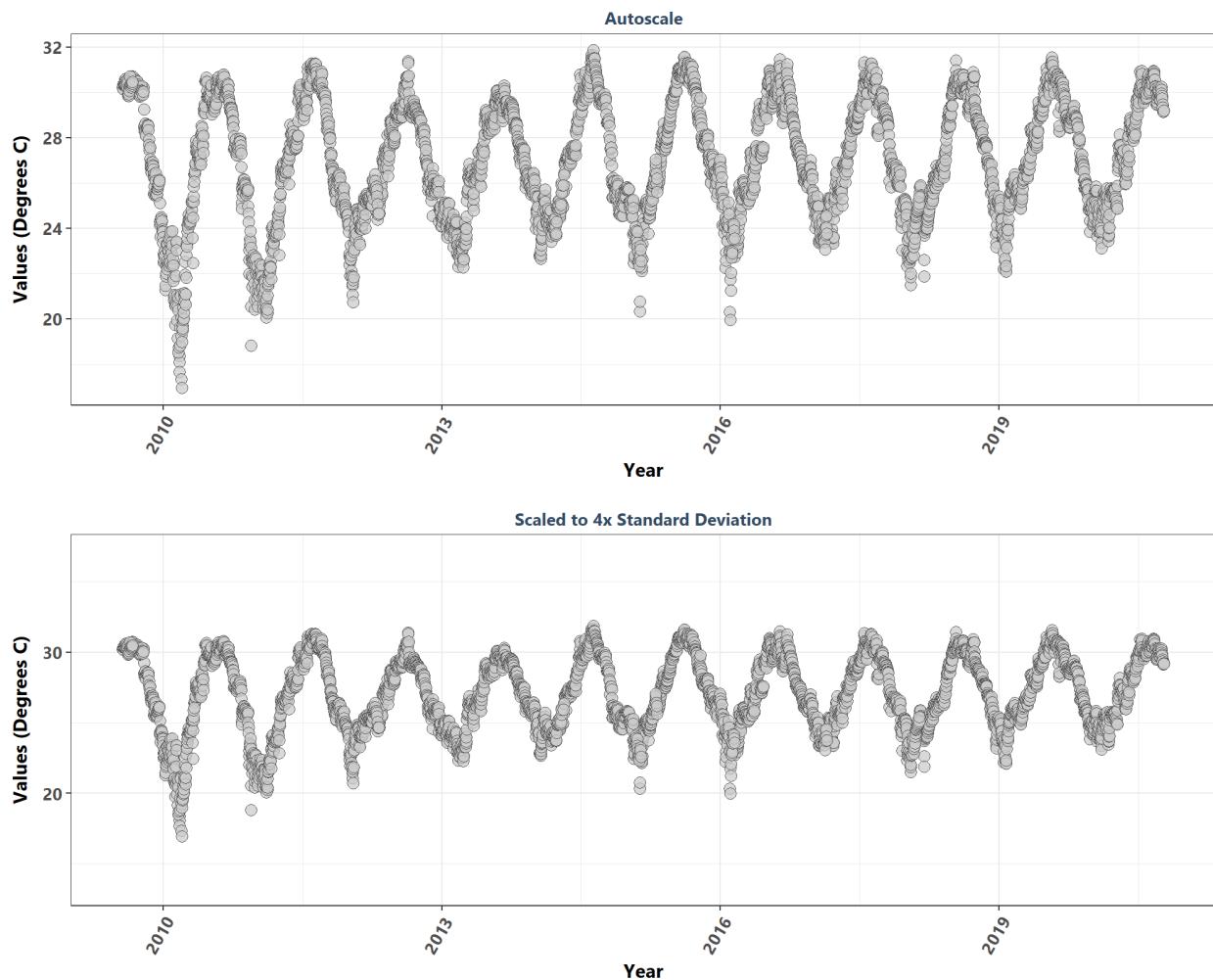
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**75**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3538	27.21346	0.209	0.0880342	-167.3994	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

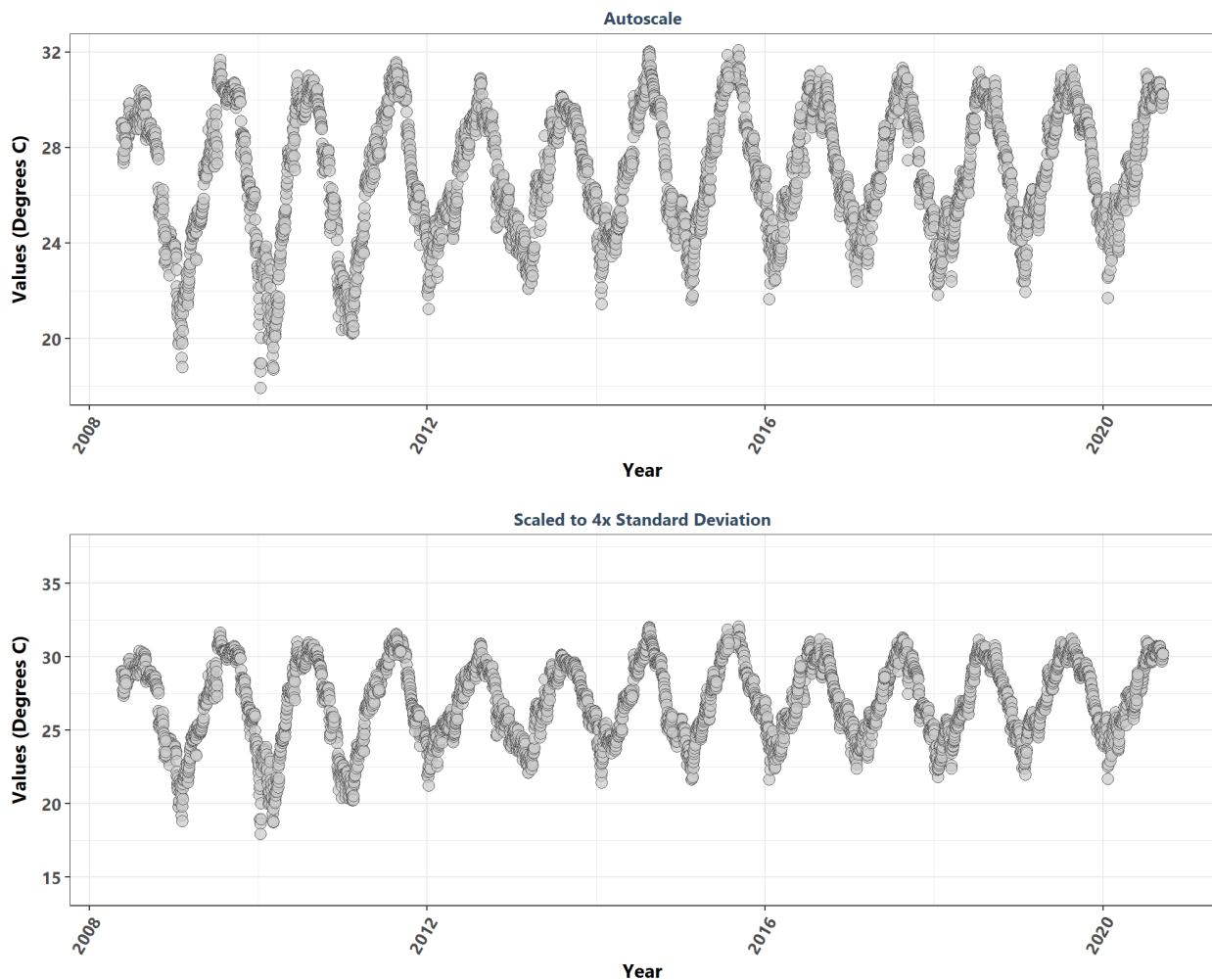
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**76**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4096	26.99153	0.1886	0.0773076	-159.277	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

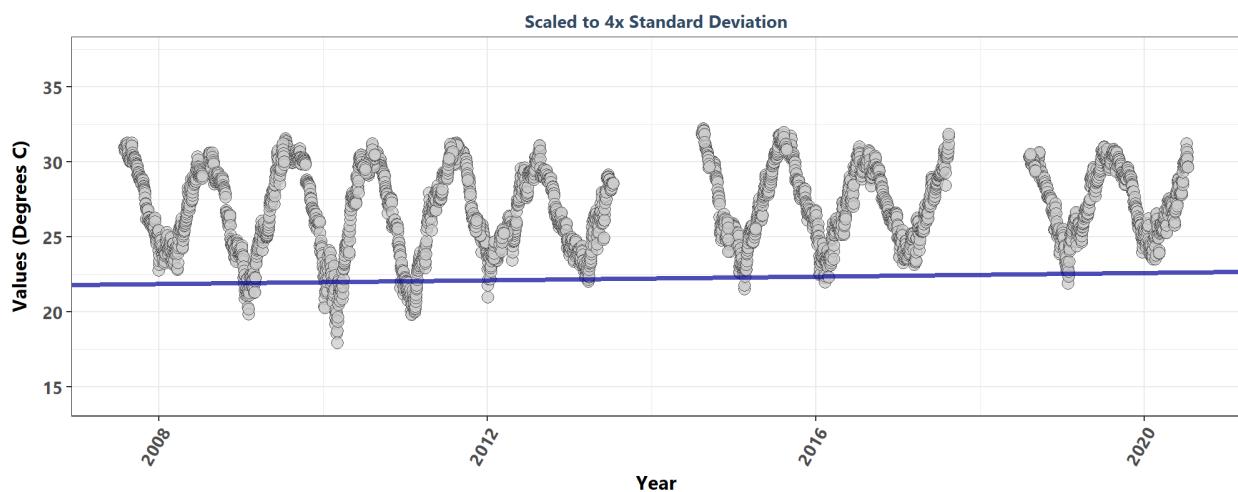
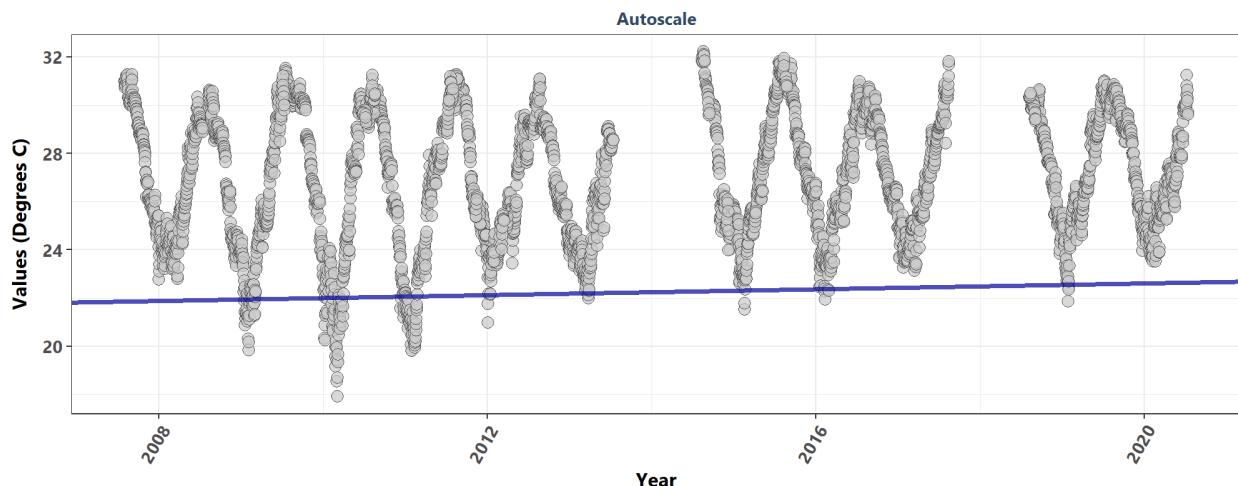
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**77**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4503	27.03584	0.2244	0.0893925	-186.7379	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

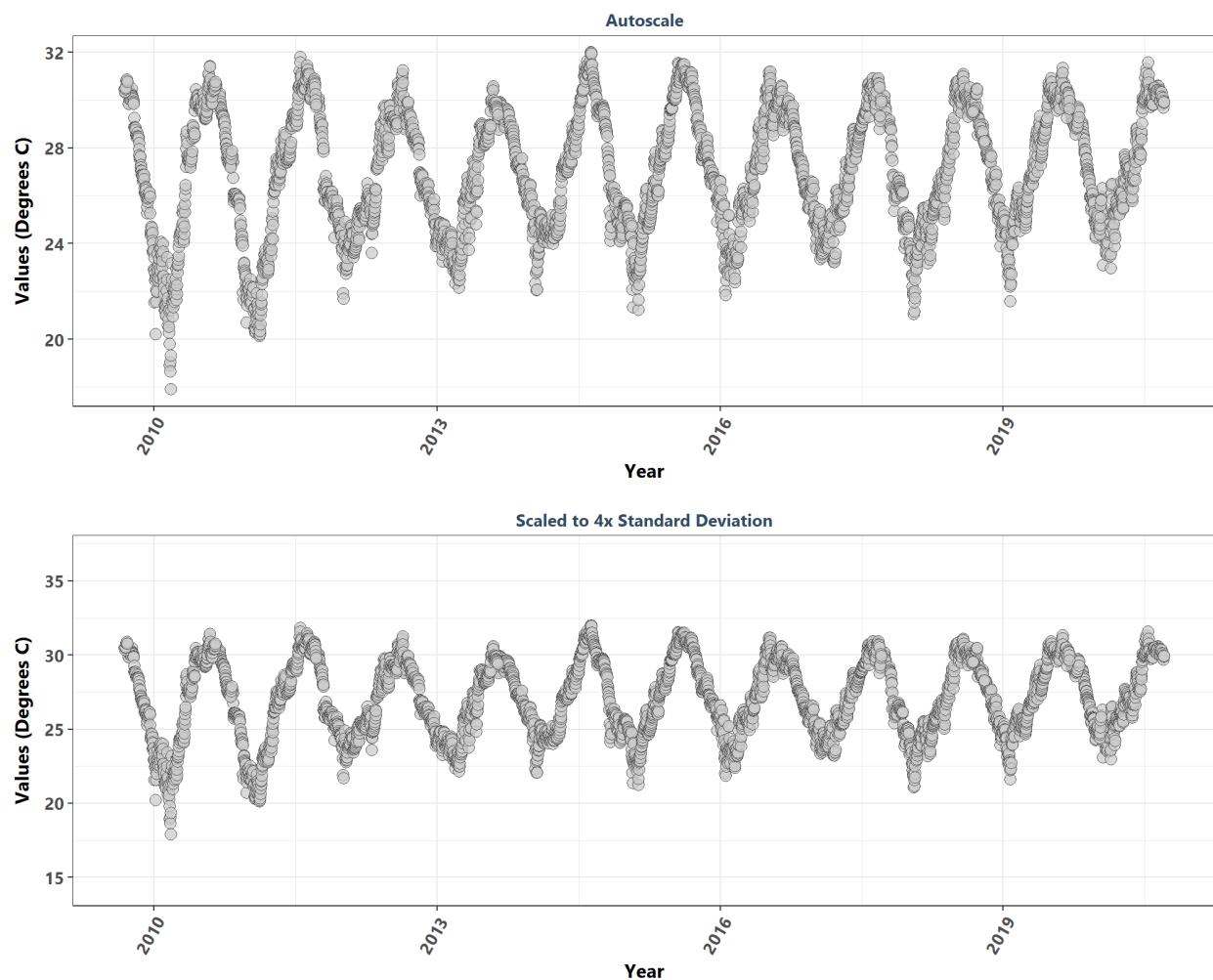
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**79**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3981	26.87258	0.1651	0.0607639	-100.1408	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

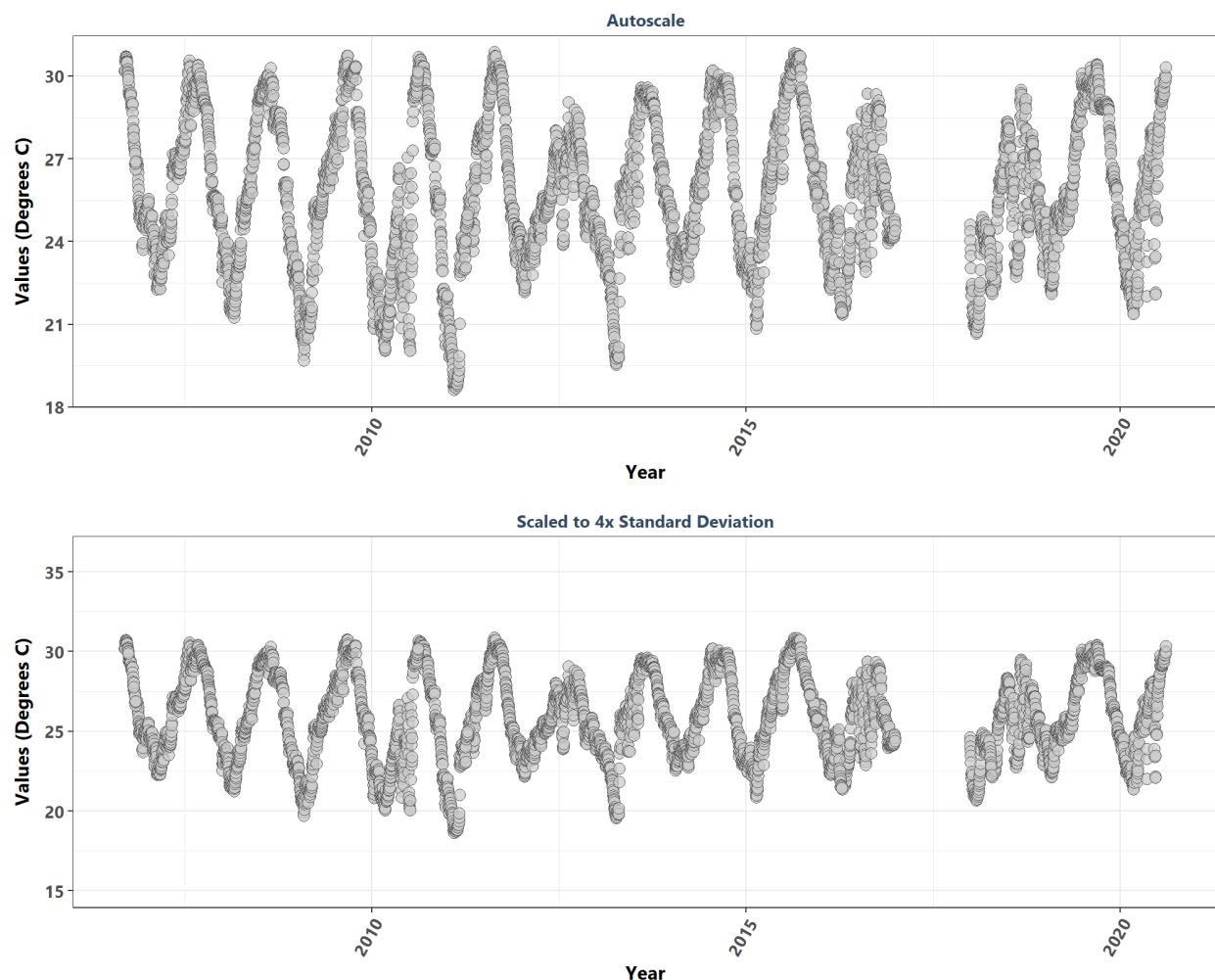
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**80**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4023	27.0368	0.1536	0.0672597	-133.0251	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

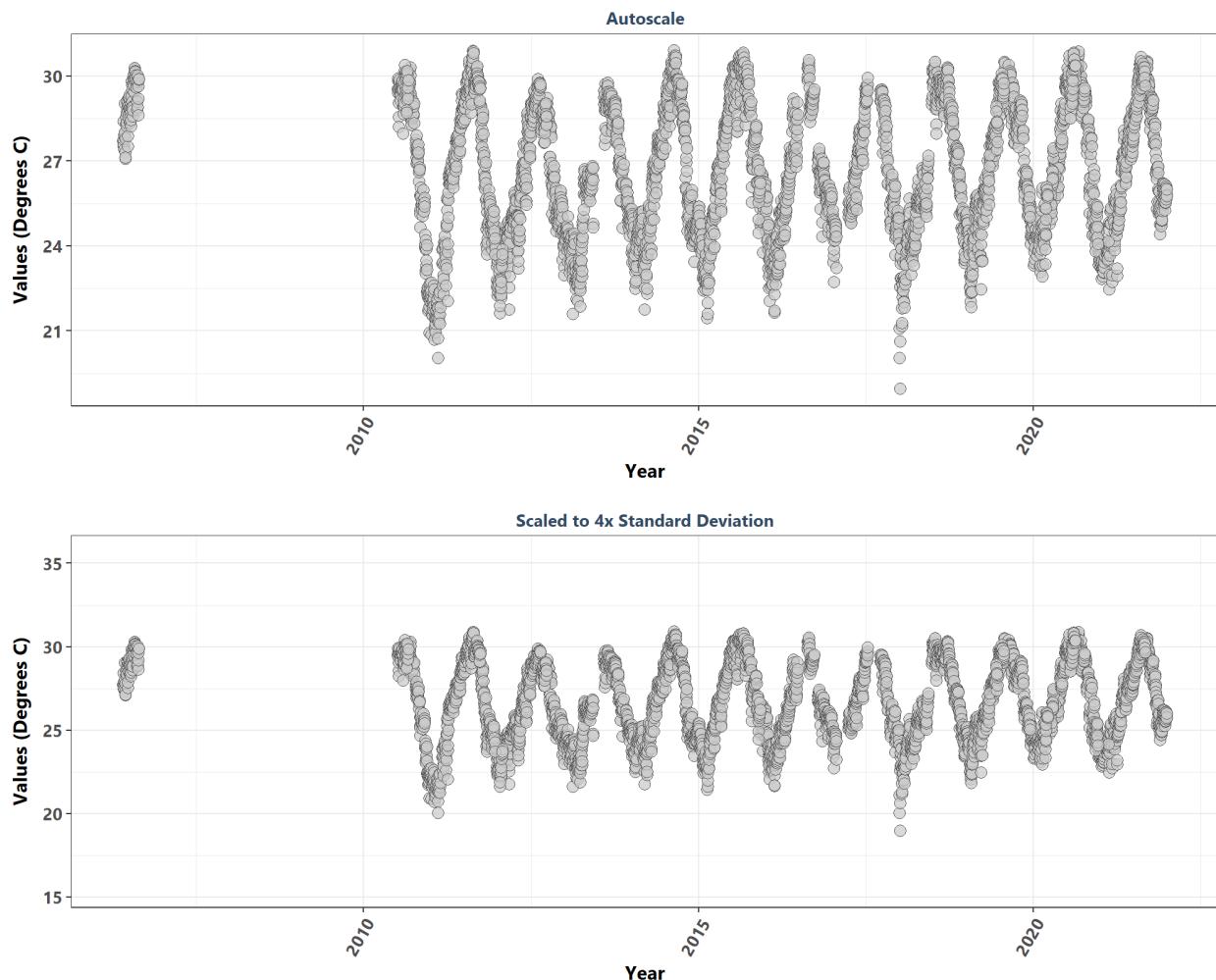
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**83**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4716	25.69146	0.0331	0.0147222	-28.11476	0.0005	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

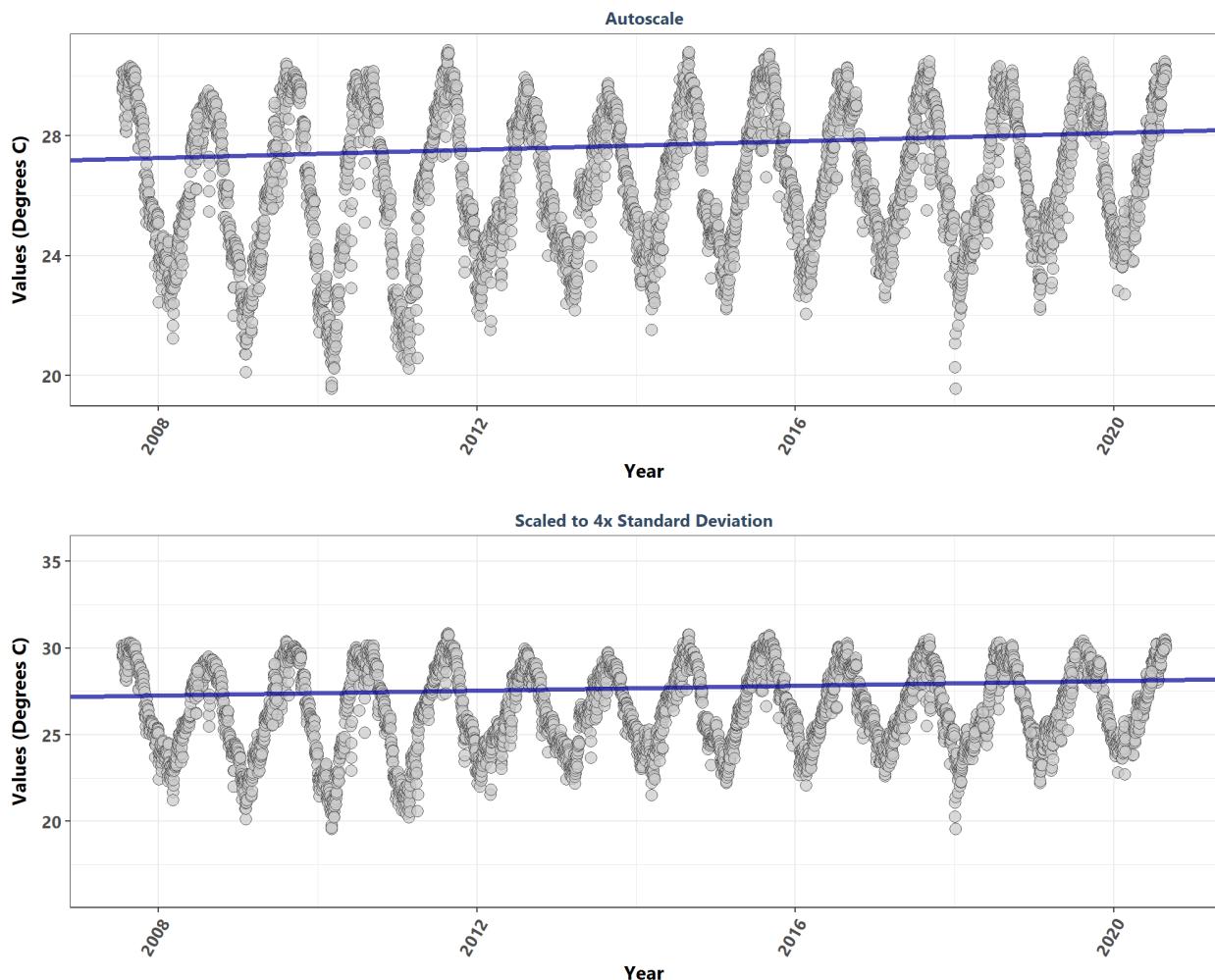
**Southeast Florida Coral Reef Ecosystem Conservation Area**  
**5 | National Data Buoy Center**  
**LKWF1**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3914	26.50739	0.1684	0.0595355	-108.1017	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

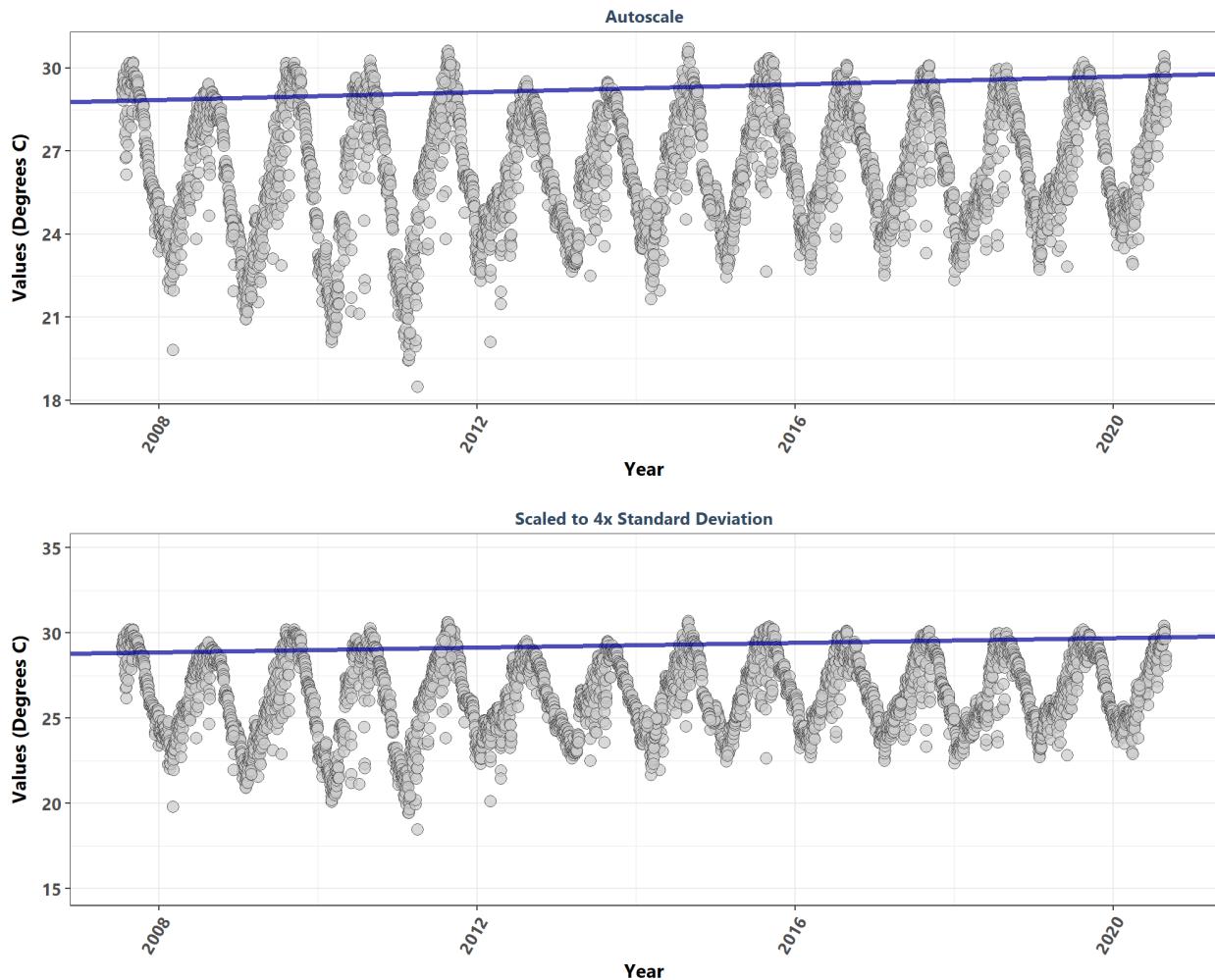
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
84**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4790	26.3375	0.1995	0.0698611	-113.0159	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

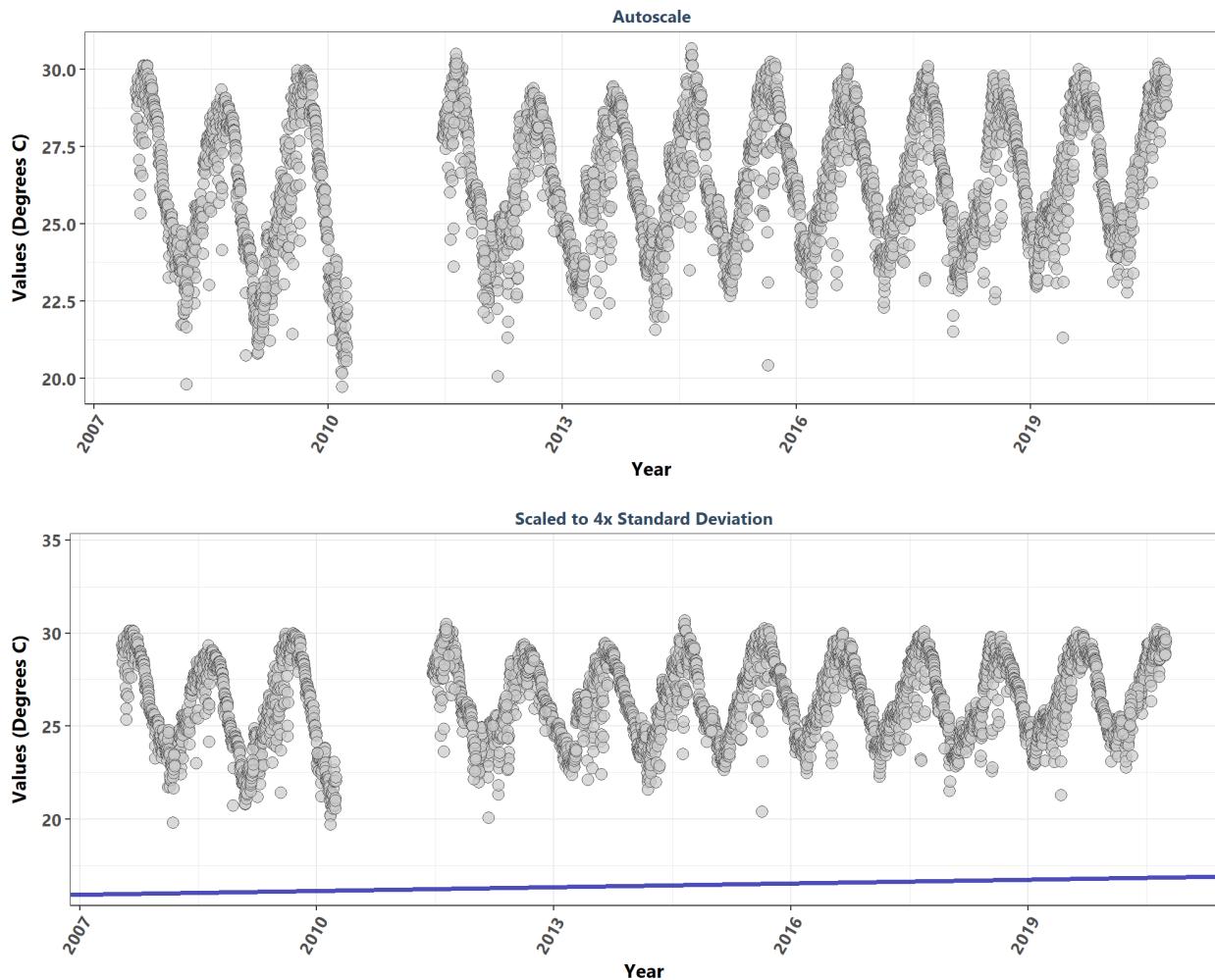
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
85



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4793	26.19917	0.1913	0.0698611	-111.4237	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

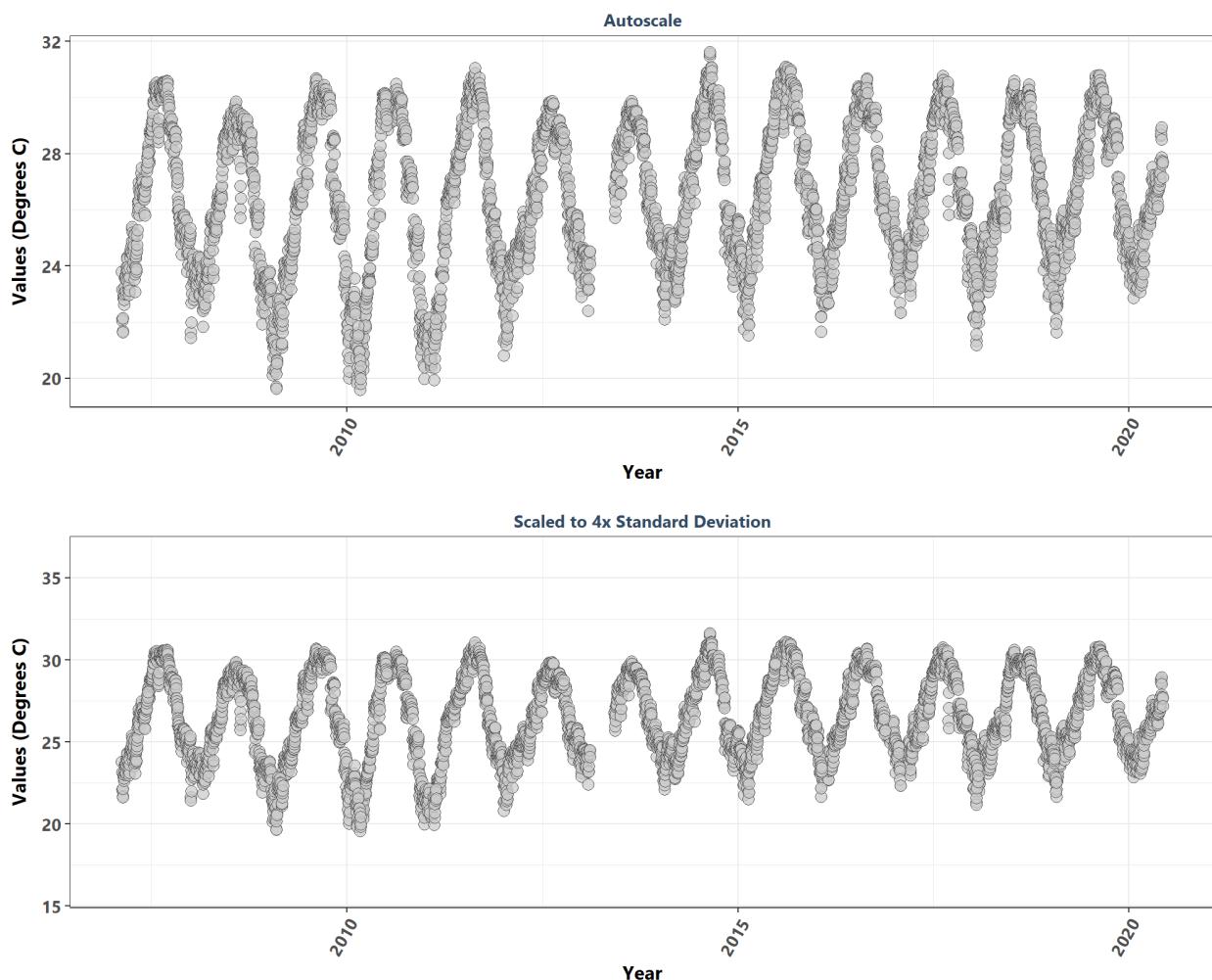
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
86**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4379	26.155	0.1948	0.0672652	-119.0423	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

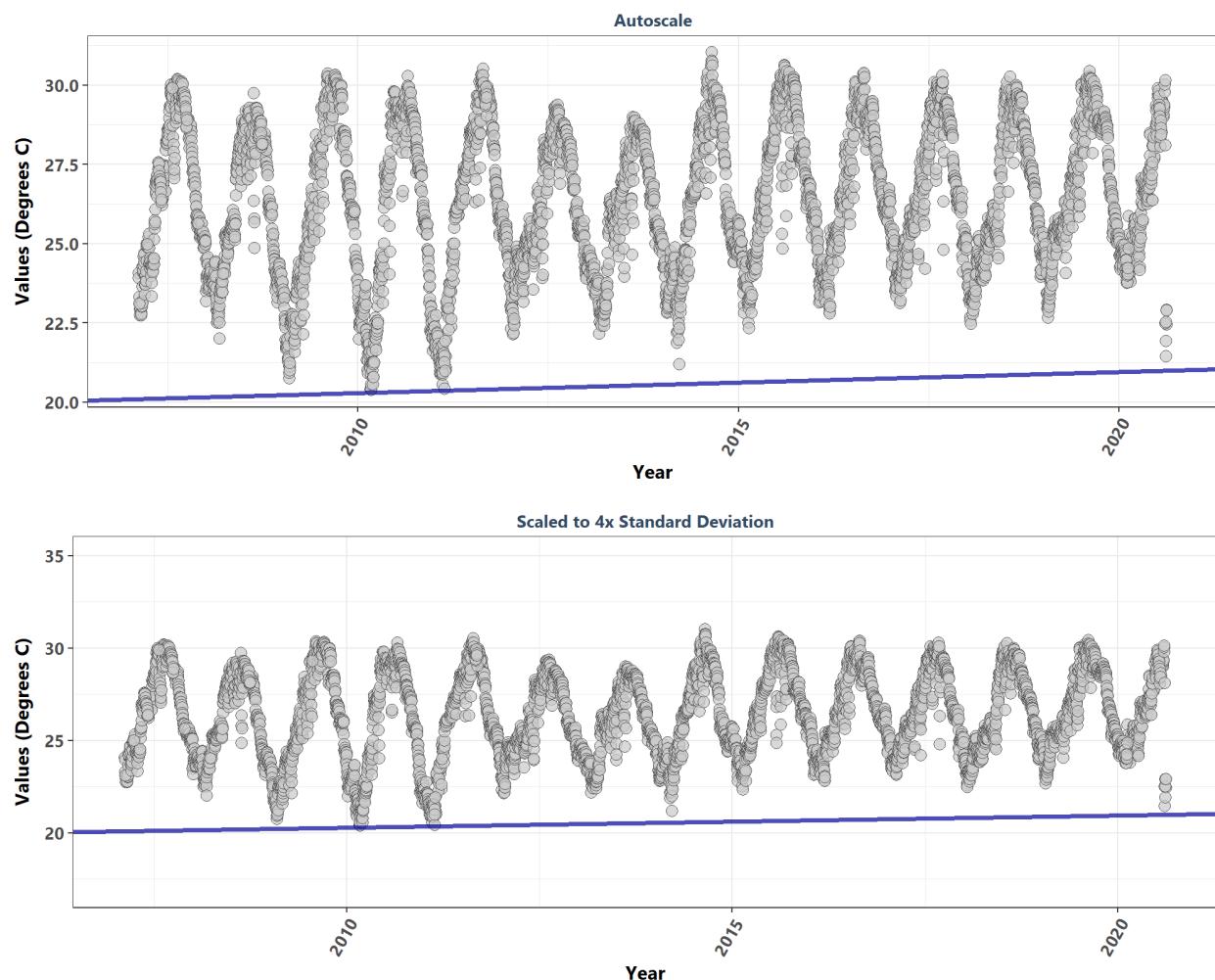
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
87**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4748	26.46292	0.2106	0.0751413	-154.0523	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

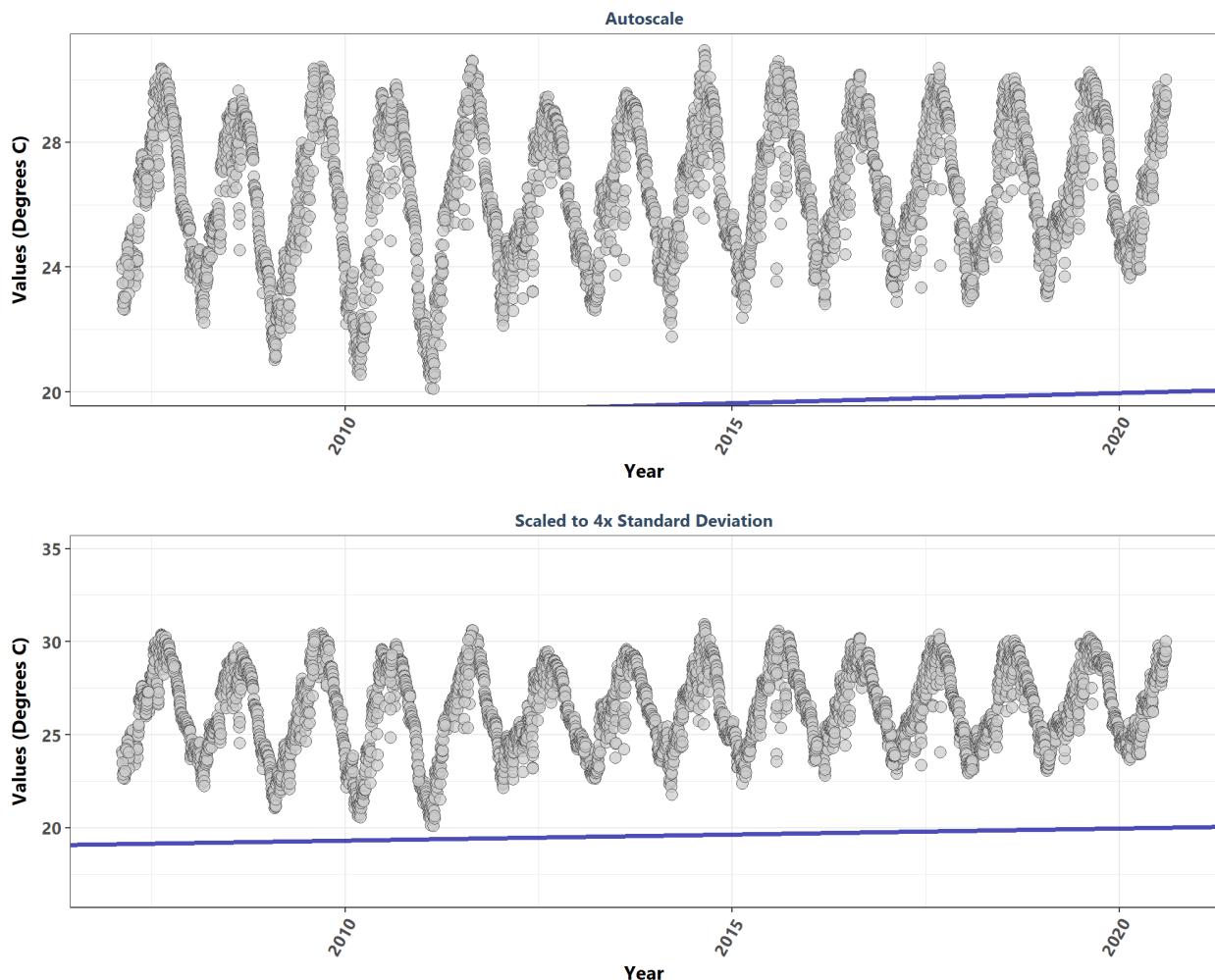
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
88**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4934	26.29812	0.1915	0.0664015	-113.1771	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

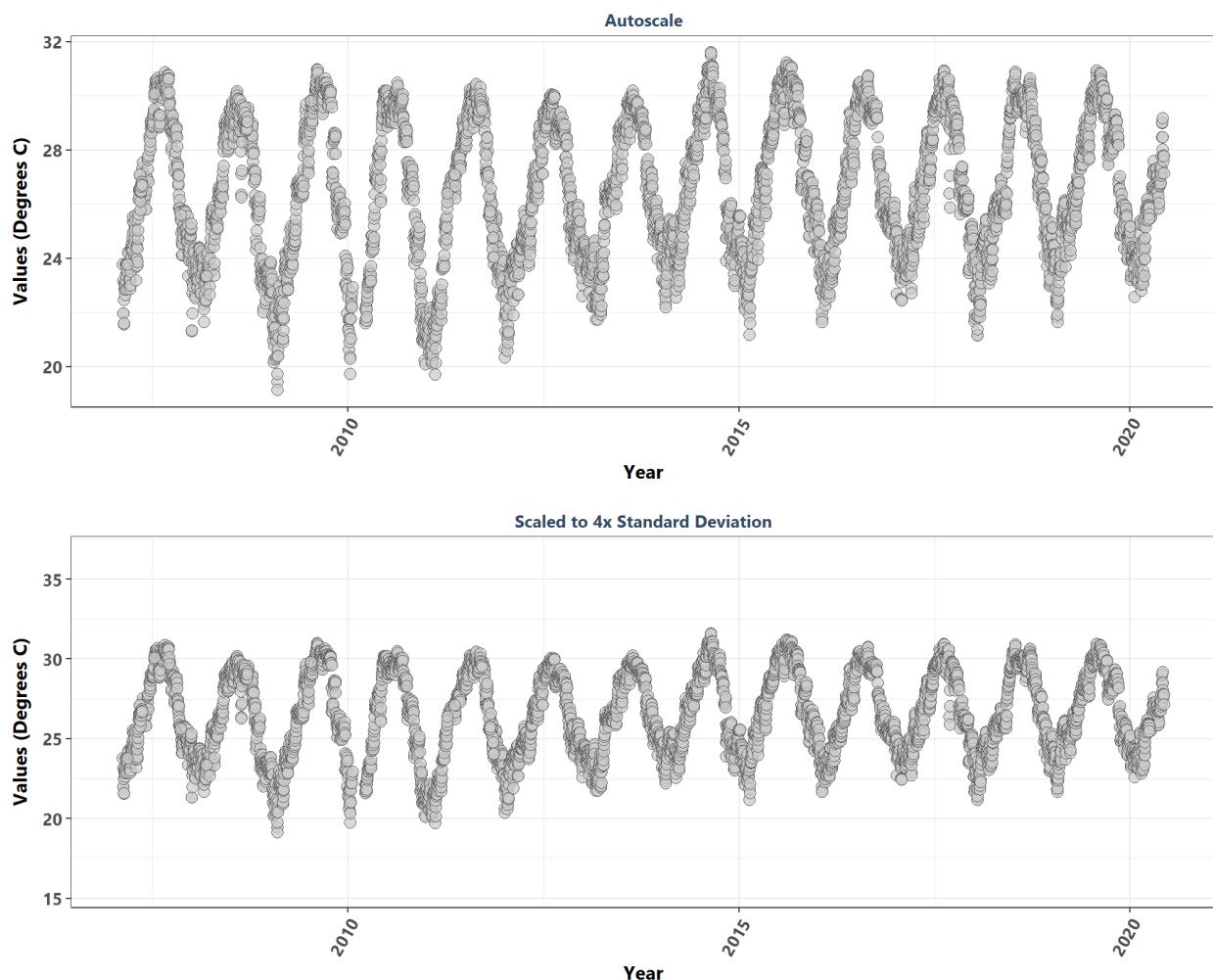
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
89**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4926	26.28871	0.1839	0.0651786	-111.6961	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

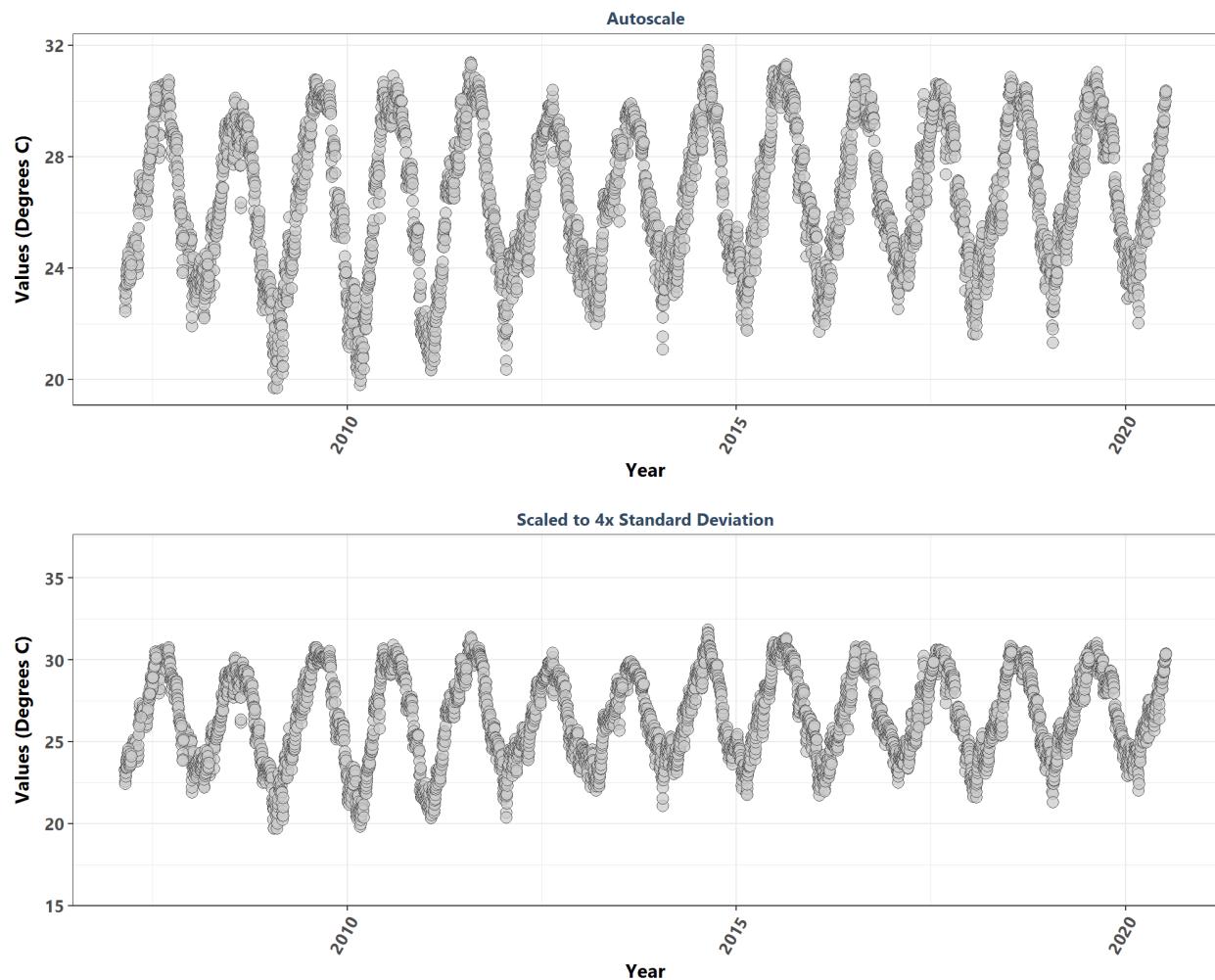
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
90**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4798	26.43958	0.207	0.07525	-162.2107	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

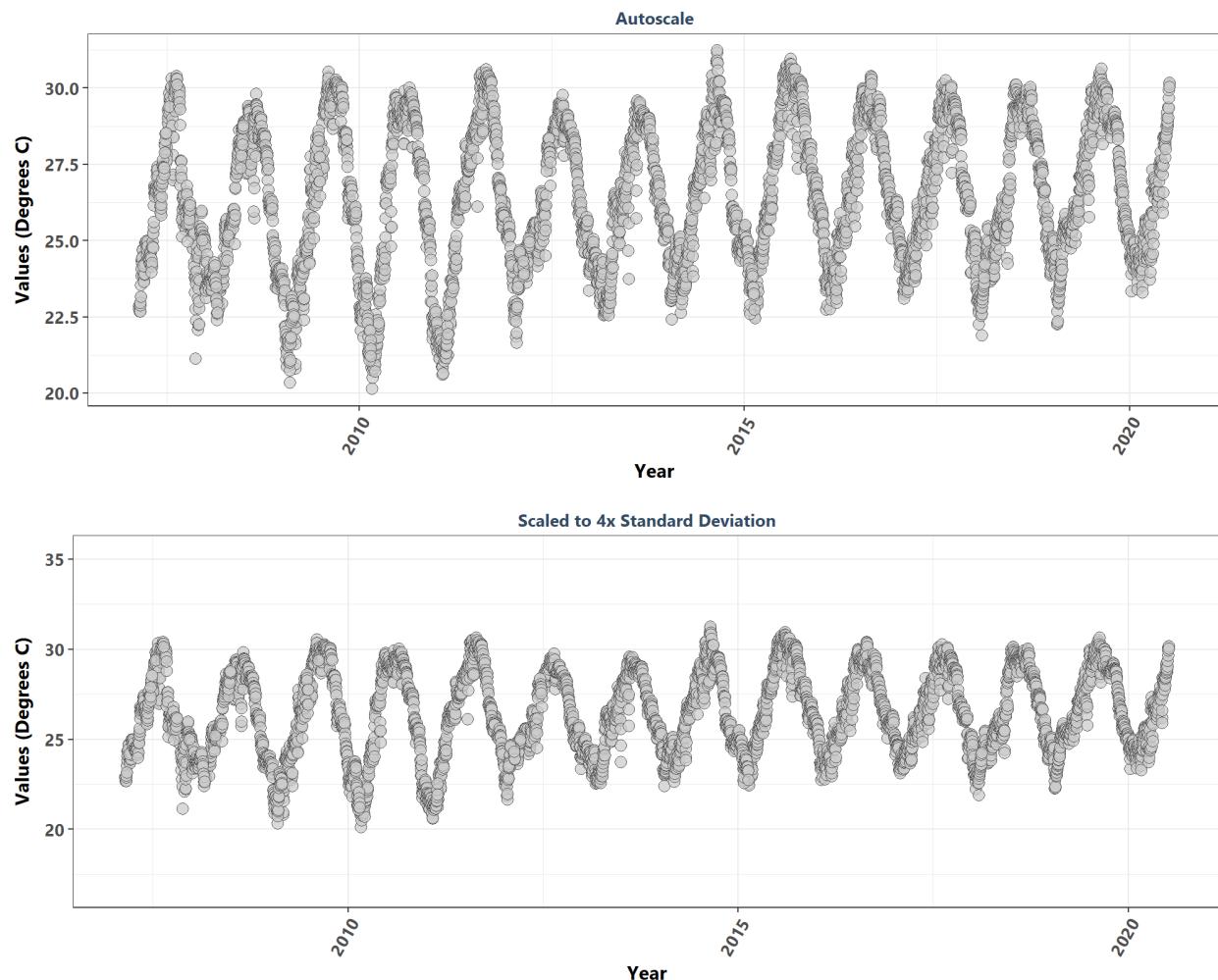
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
91**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4887	26.49333	0.1919	0.0695	-138.263	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

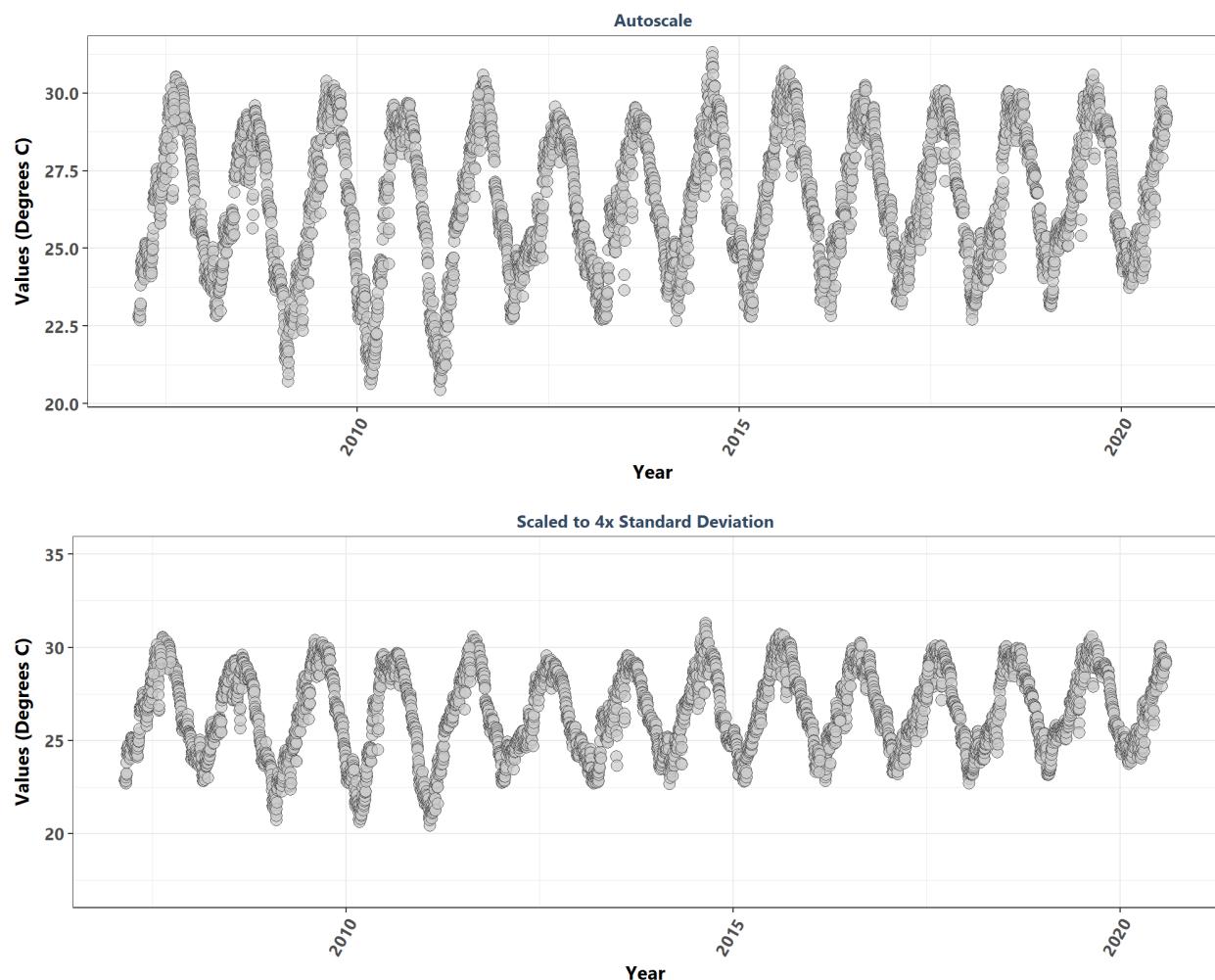
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
92**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4887	26.26083	0.2254	0.0795238	-165.9366	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

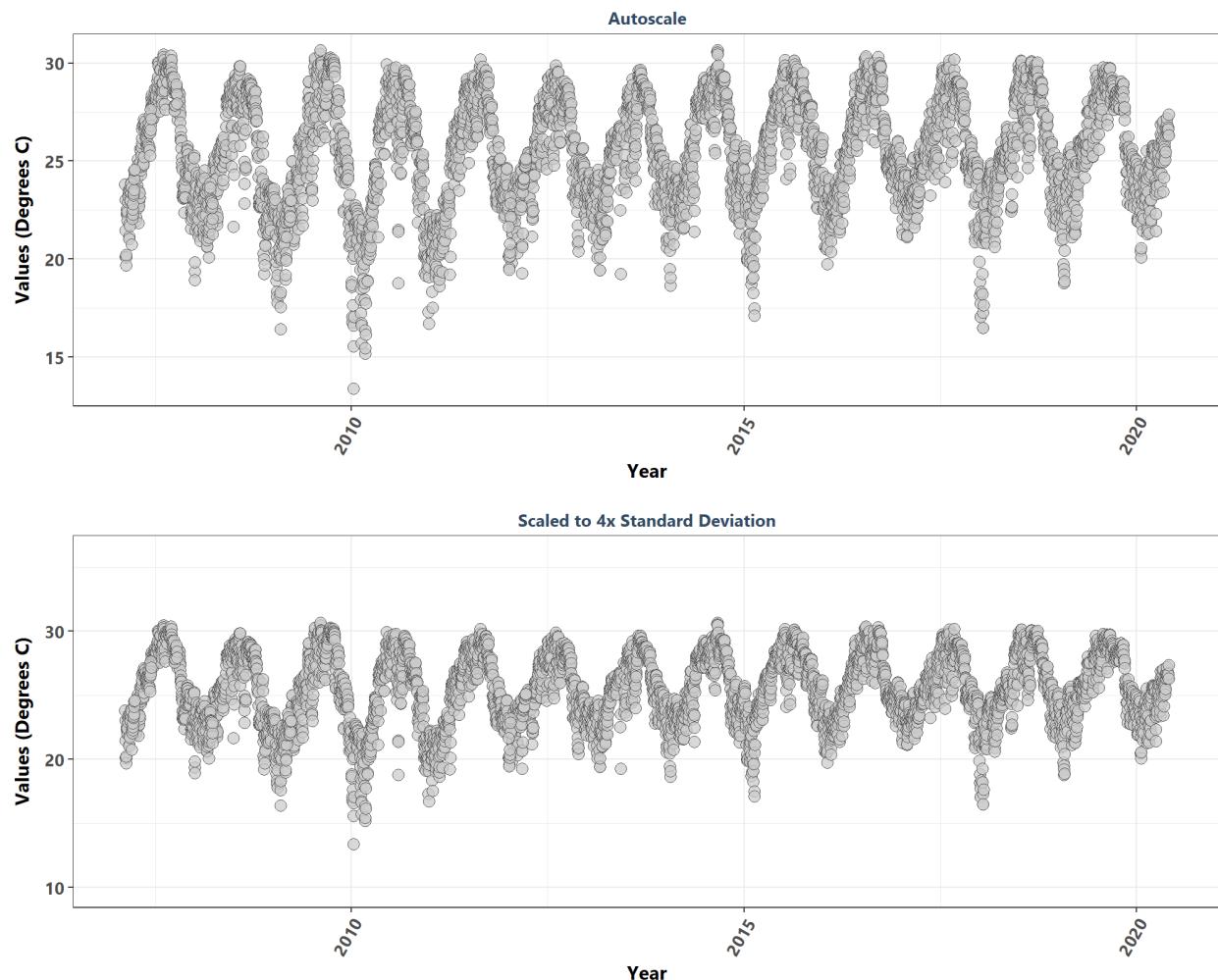
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
93**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4913	26.381	0.184	0.0585	-108.0317	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

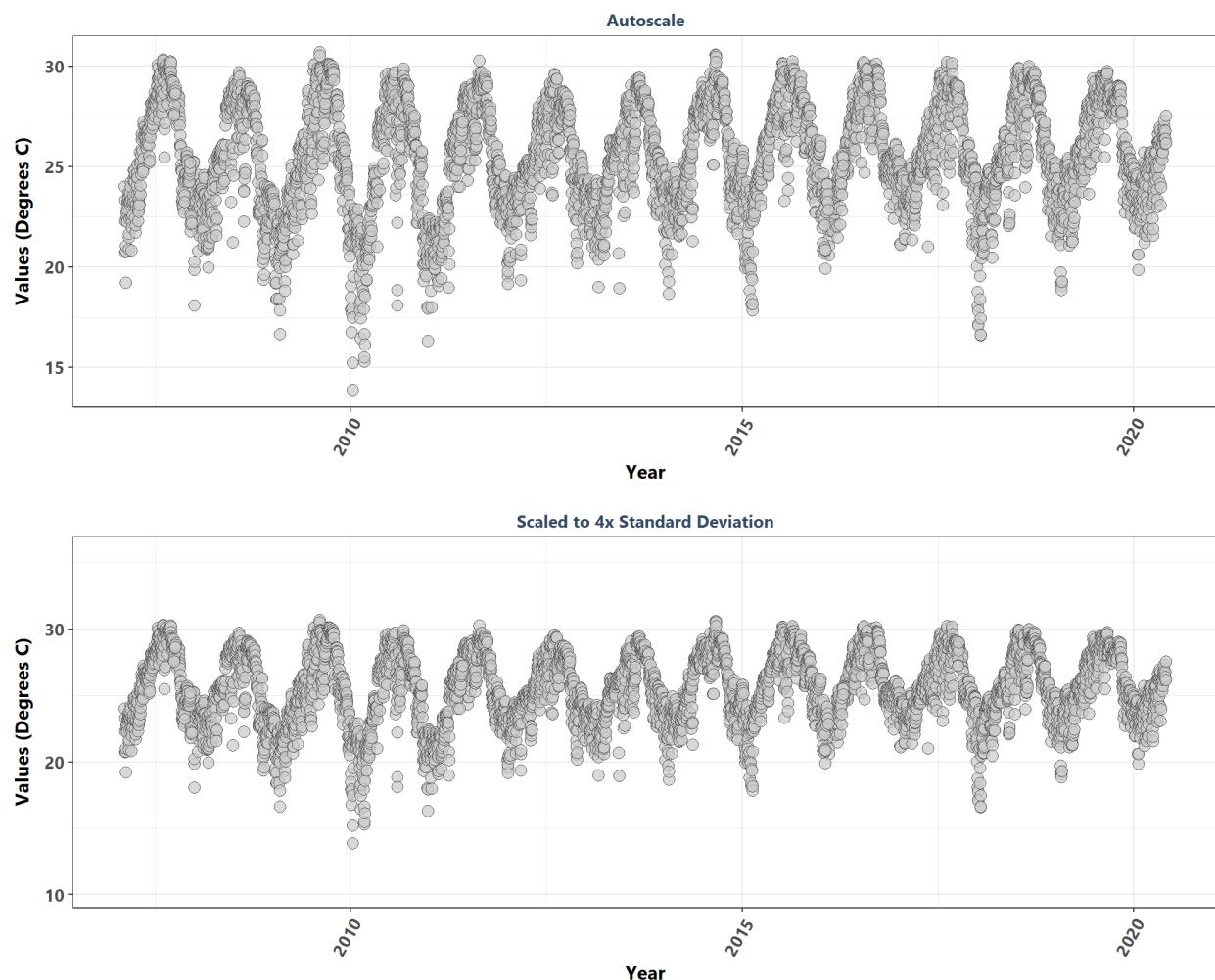
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
94**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4832	25.45917	0.133	0.0687879	-136.3981	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

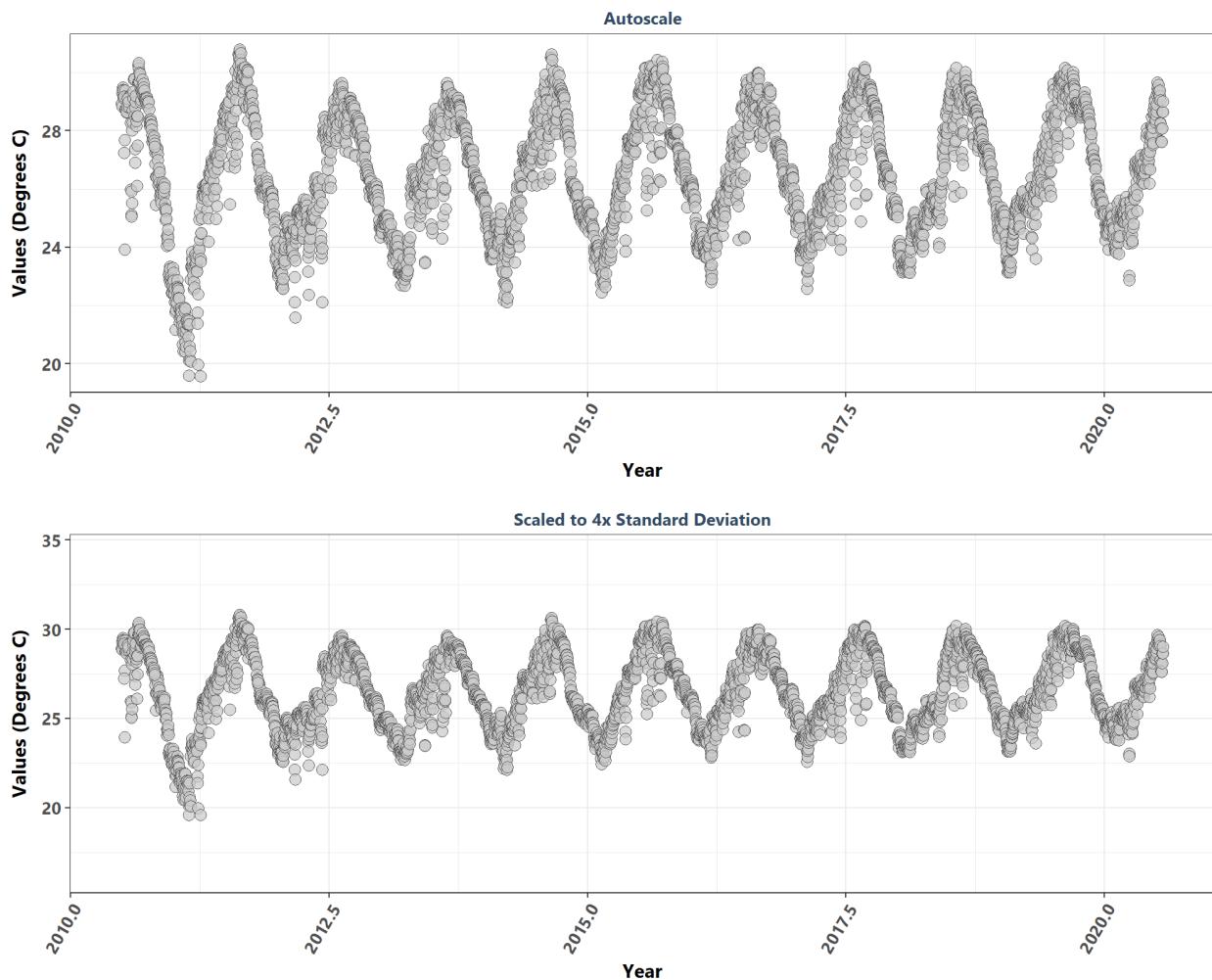
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
95**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
4857	25.45167	0.1302	0.0666667	-130.1462	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

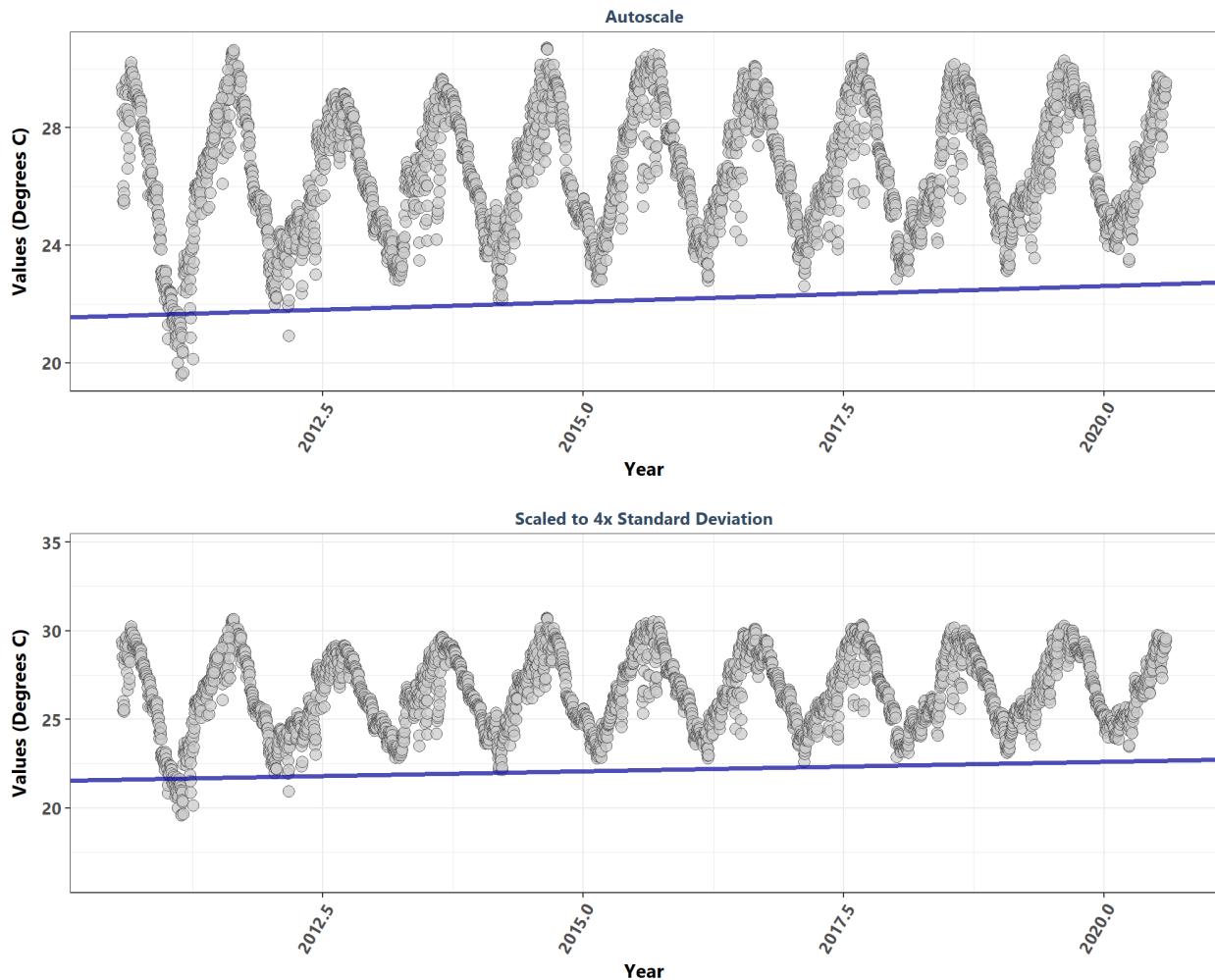
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys  
97**



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3678	26.34469	0.1695	0.0743981	-99.19847	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

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



N_Data	Median	tau	SennSlope	SennIntercept	p	Trend
3661	26.36478	0.2318	0.1072917	-194.1158	0	1

<sup>a</sup> p < 0.00005 appear as 0 due to rounding

## Appendix IV: 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

```

if(n==0){
  print("There are no monitoring locations that qualify.")
} else {
  for (i in 1:n) {
    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]])
    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$ResultValue, 0.98)])
    x_scale <- ifelse(year_upper - year_lower > 30, 10, 5)
    y_scale <- mn_RV + 4 * sd_RV
    MA_name <- KT.Stats$ManagedAreaName[KT.Stats$MonitoringID==Mon_IDs[i]]
    Mon_name <- paste0(KT.Stats$ProgramID[KT.Stats$MonitoringID==Mon_IDs[i]],
                       " | ", KT.Stats$ProgramName[KT.Stats$MonitoringID==Mon_IDs[i]], "\n",
                       KT.Stats$ProgramLocationID[KT.Stats$MonitoringID==Mon_IDs[i]])

    ##Year plots
    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))) +
      plot_theme

    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

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

Yset <- ggarrange(p1, p2, p3, ncol=1)

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
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")

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))

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")

leg1 <- get_legend(p5)
YMset <- ggarrange(leg1, p4, p5 + theme(legend.position="none"), p6,
    ncol=1, heights=c(0.1, 1, 1, 1))

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
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")

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))

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")

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

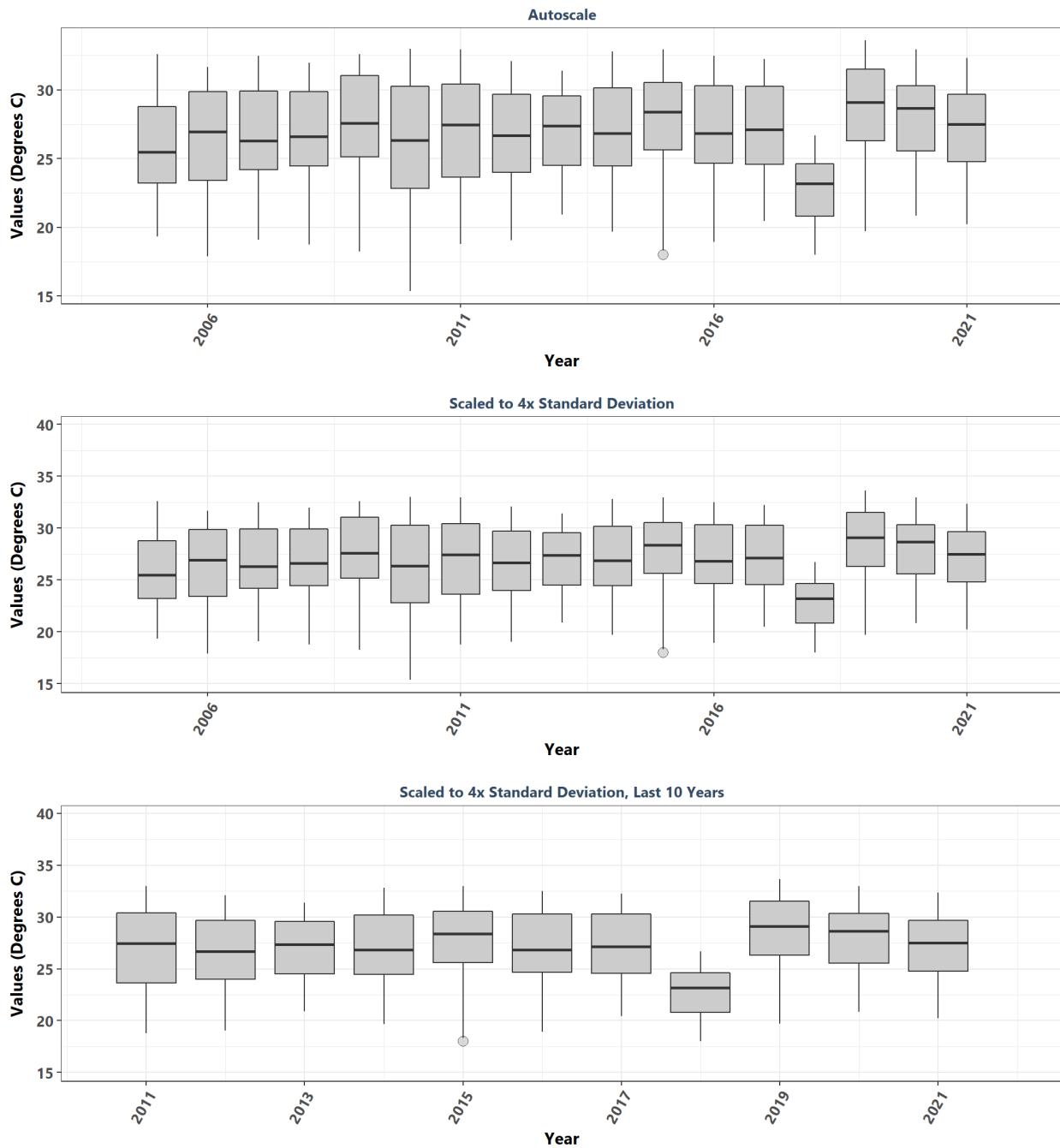
p000 <- ggplot() + labs(title=paste0(MA_name, "\n", Mon_name),
                         subtitle="By Month") + plot_theme +
  theme(panel.border=element_blank(),
        panel.grid.major=element_blank(),
        panel.grid.minor=element_blank(), axis.line=element_blank())

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)))

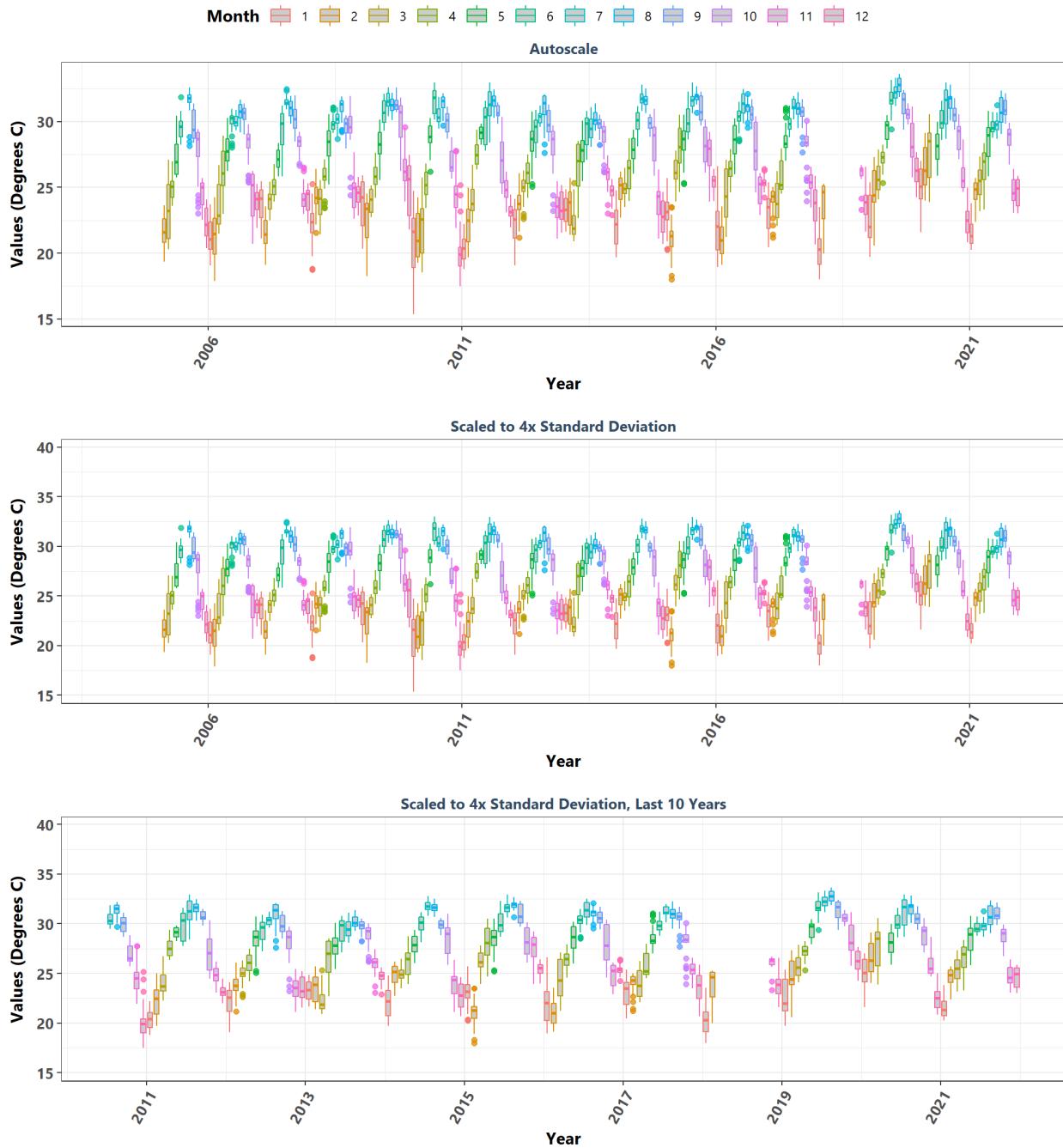
rm(plot_data)
rm(p1, p2, p3, p4, p5, p6, p7, p8, p9, p0, p00, p000, leg1, leg2,
    Yset, YMset, Mset)
}
}

```

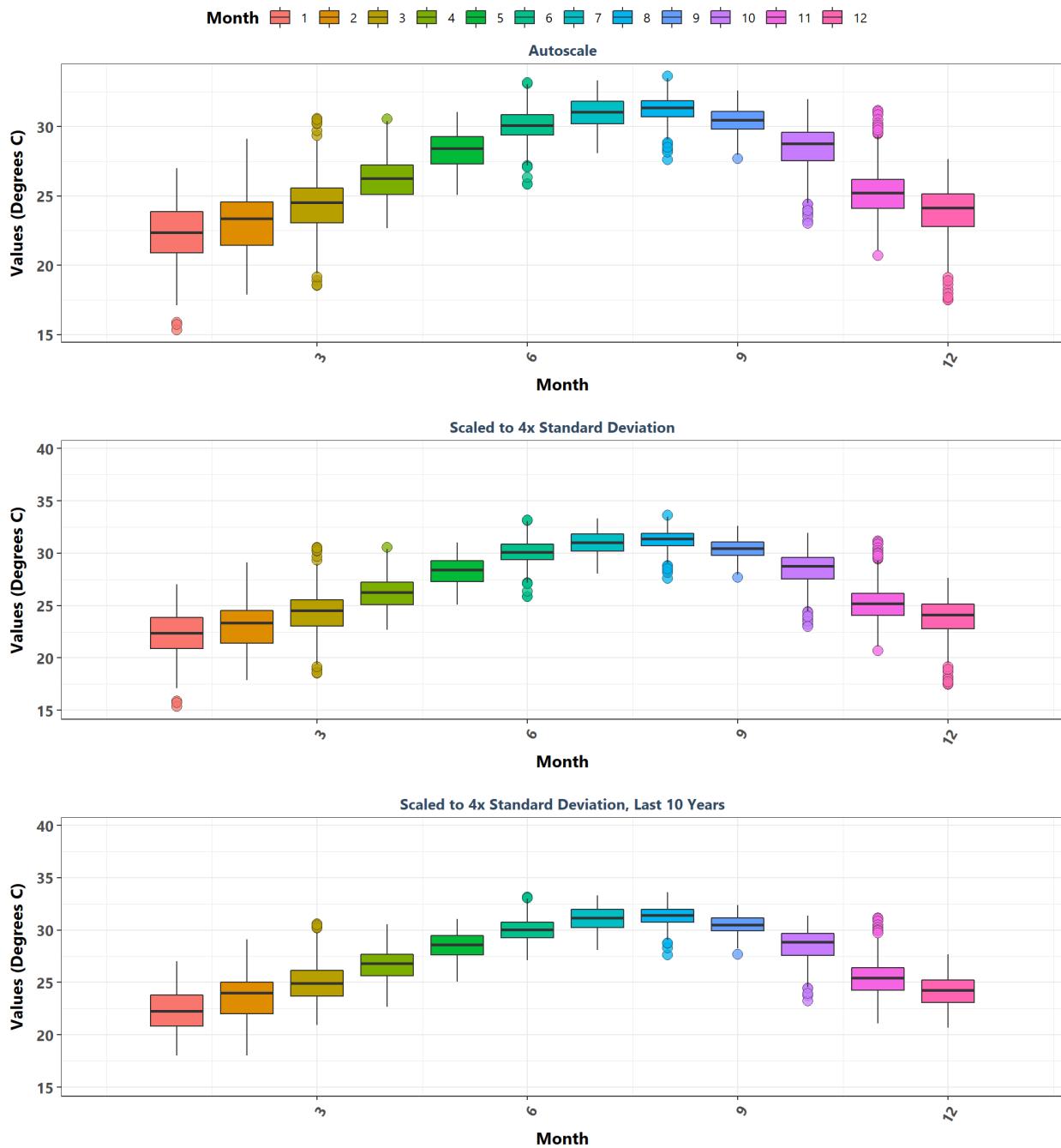
**Florida Keys National Marine Sanctuary**  
**5 | National Data Buoy Center**  
**KYWF1**  
**By Year**



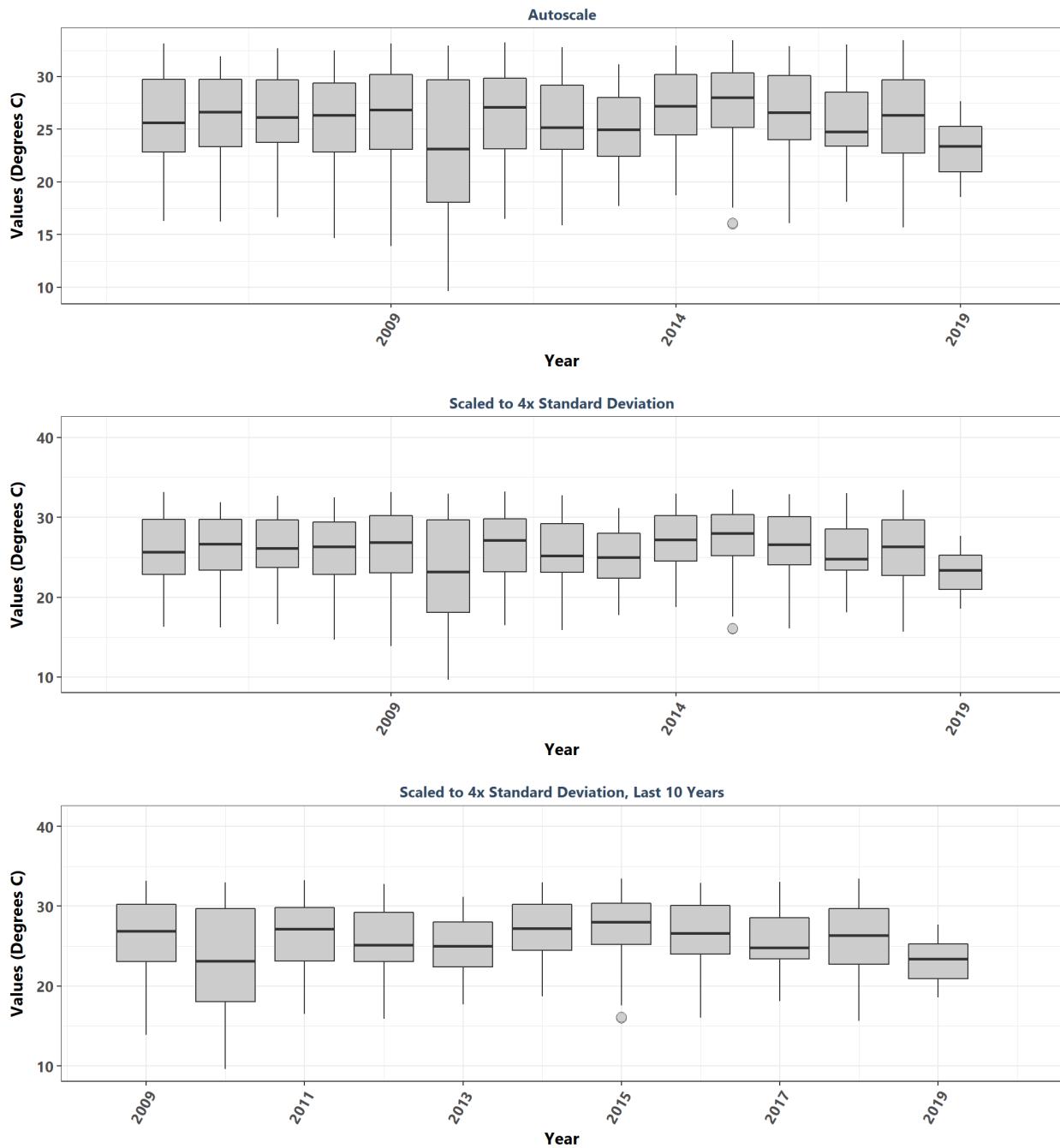
**Florida Keys National Marine Sanctuary**  
**5 | National Data Buoy Center**  
**KYWF1**  
**By Year & Month**



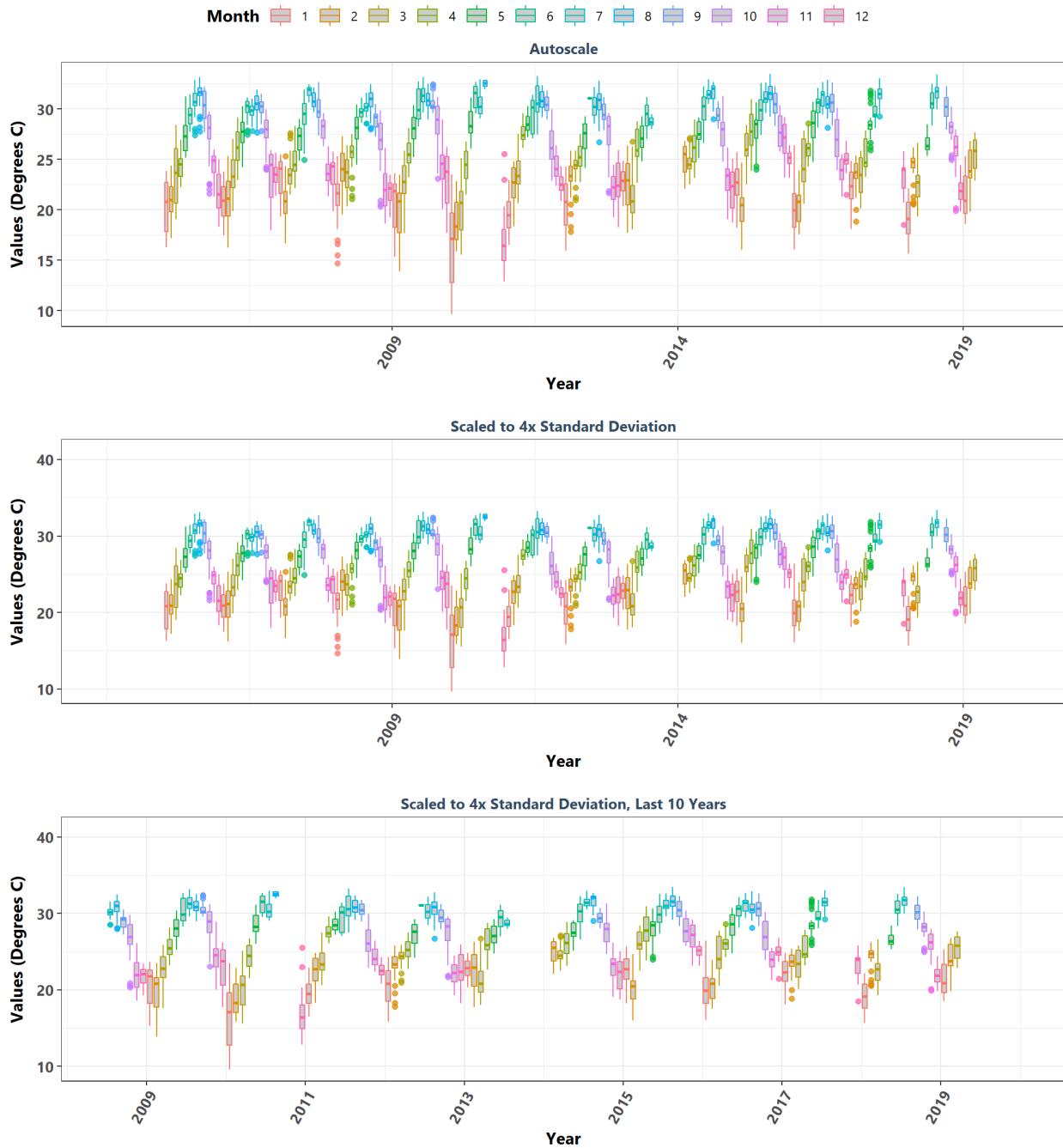
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**KYWF1**  
**By Month**



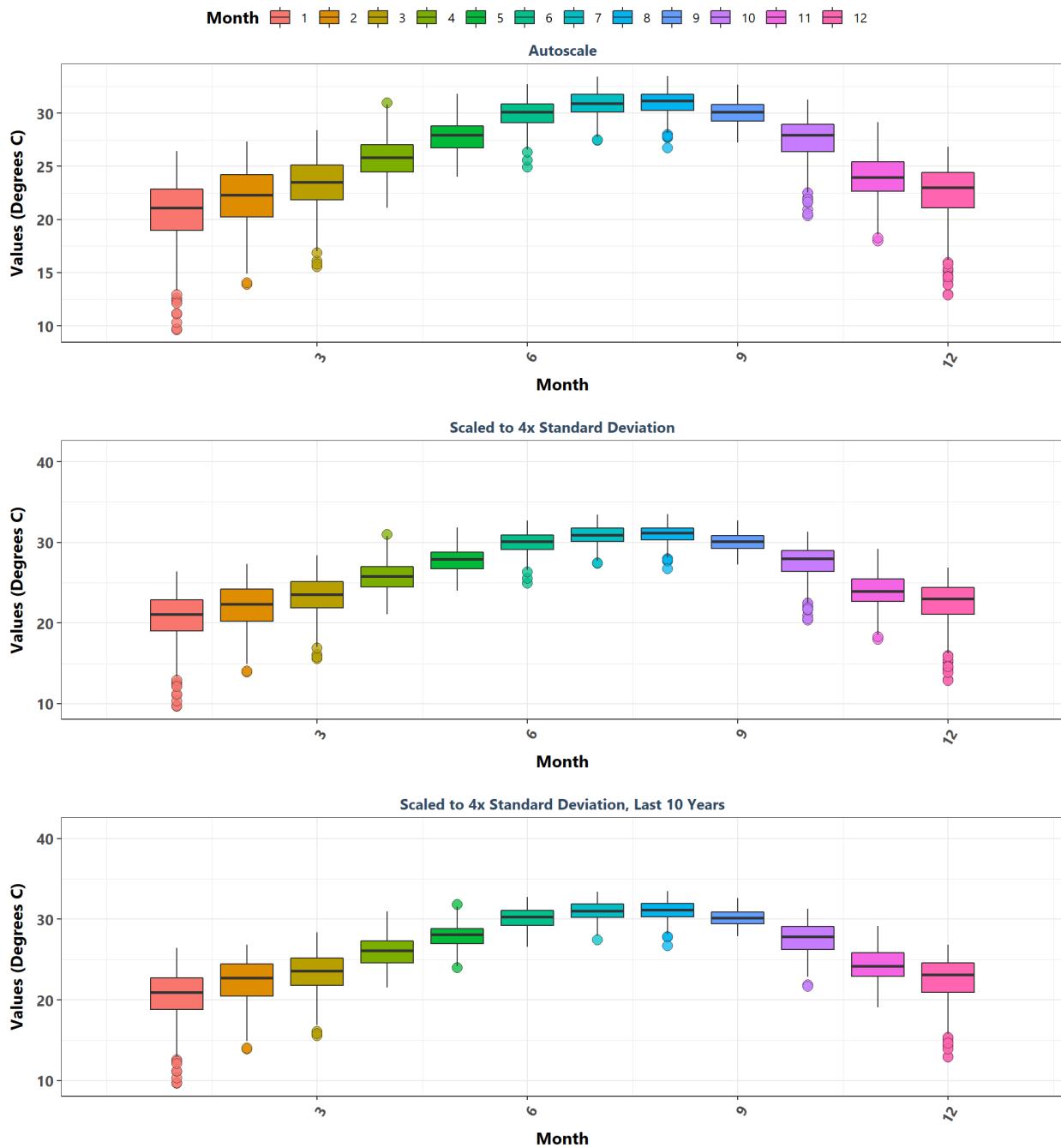
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**LONF1**  
**By Year**



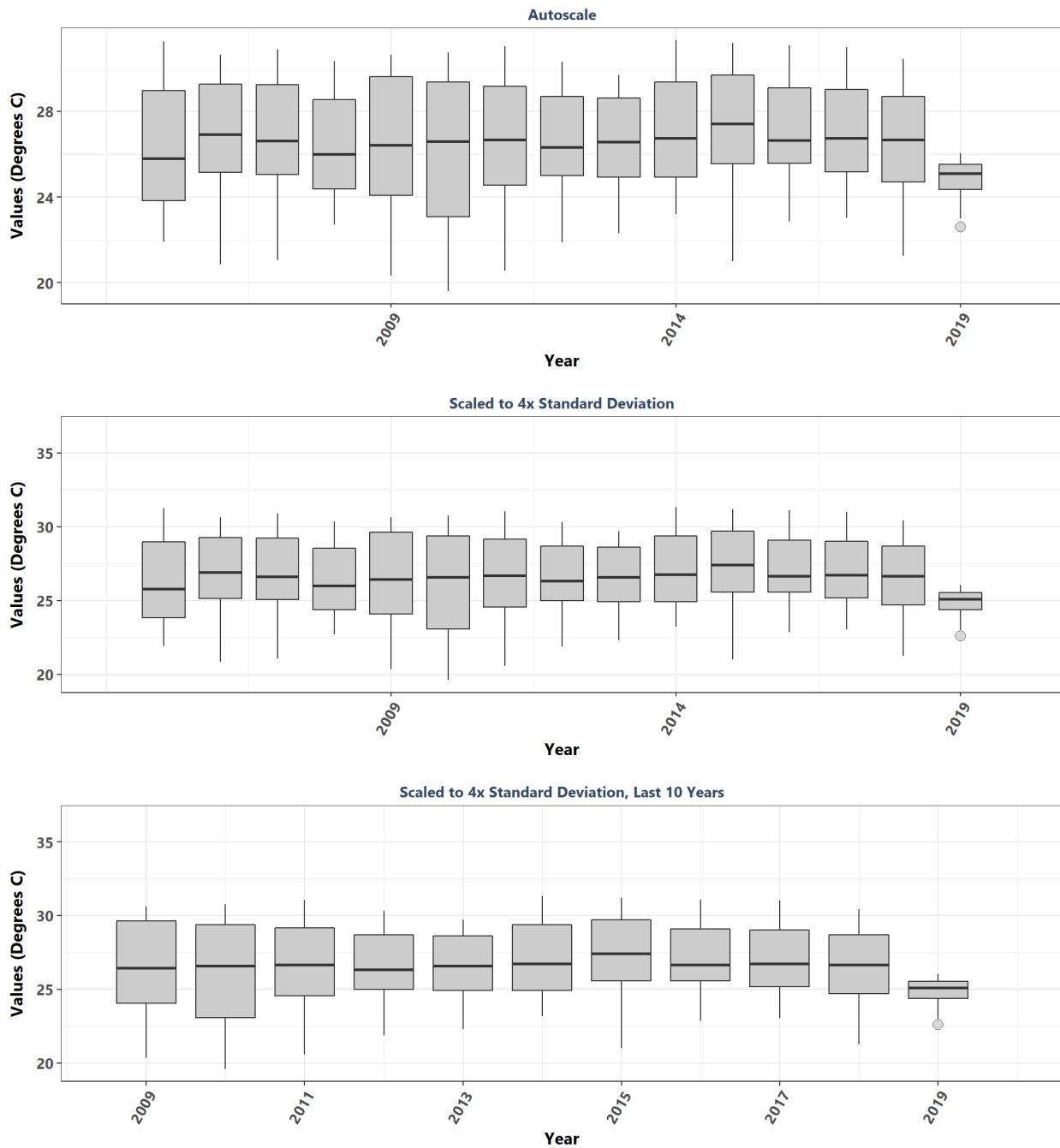
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**LONF1**  
**By Year & Month**



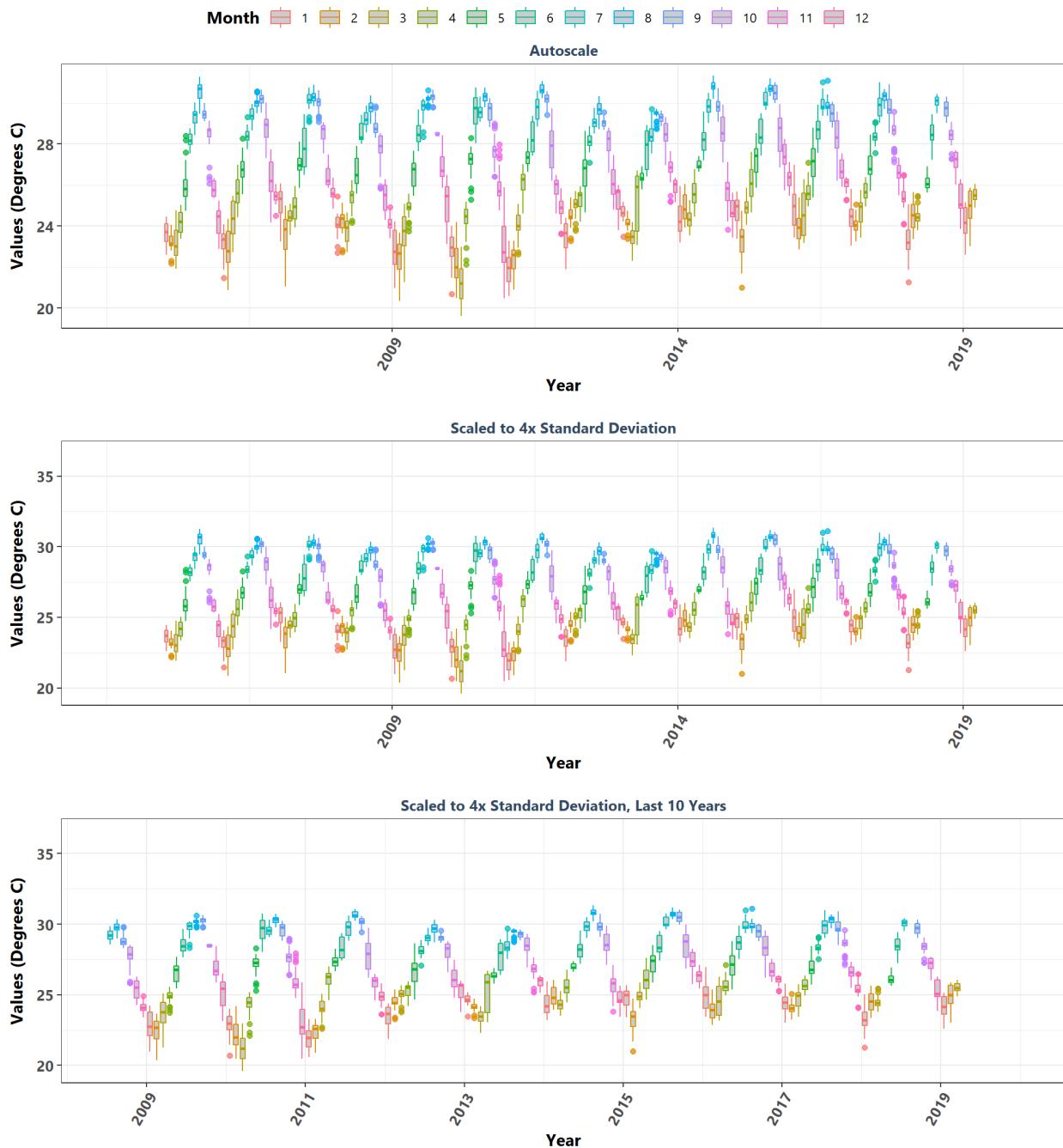
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**5 | National Data Buoy Center**  
**LONF1**  
**By Month**



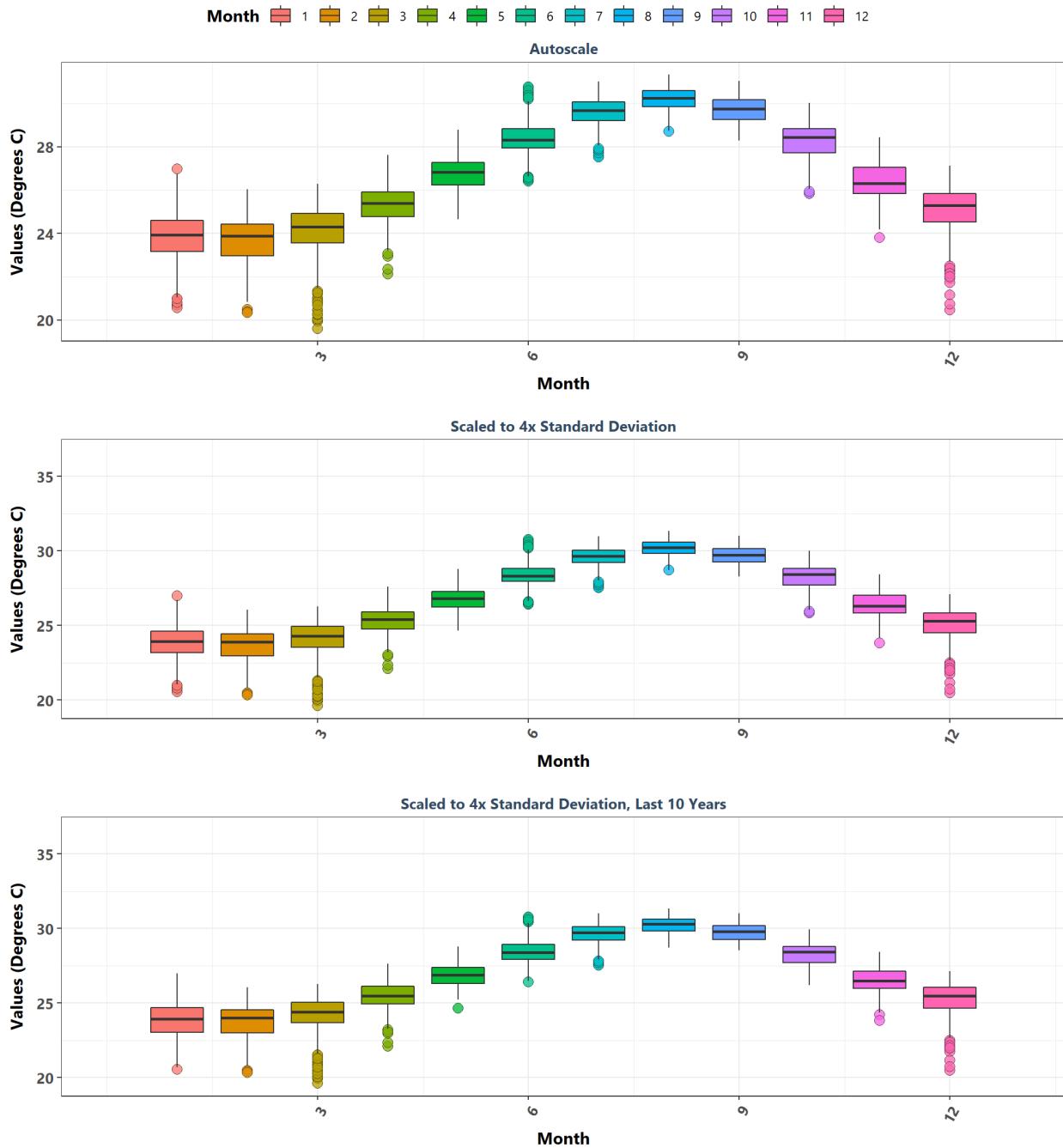
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5 | **National Data Buoy Center**  
**MLRF1**  
By Year



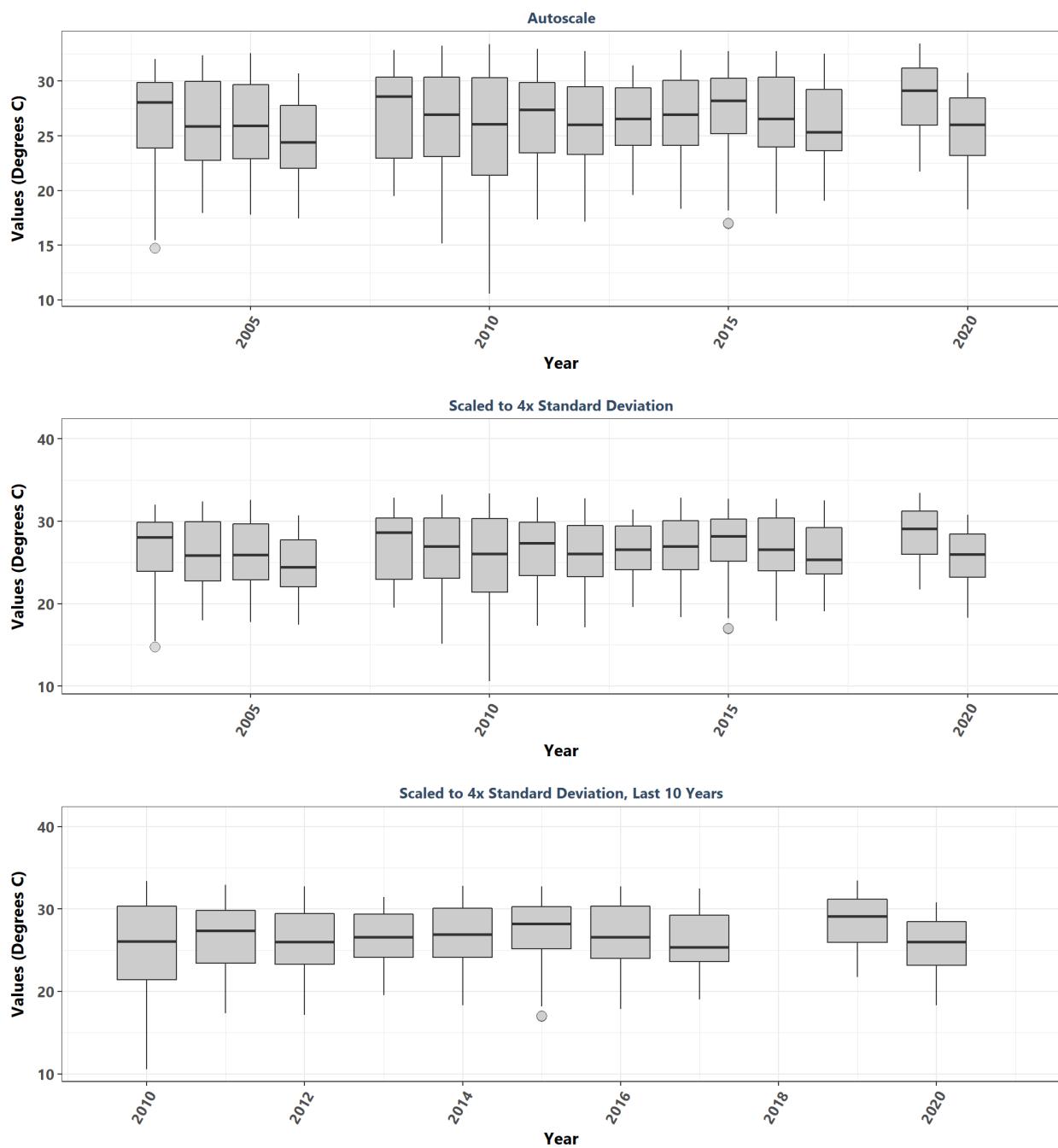
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**5 | National Data Buoy Center**  
**MLRF1**  
**By Year & Month**



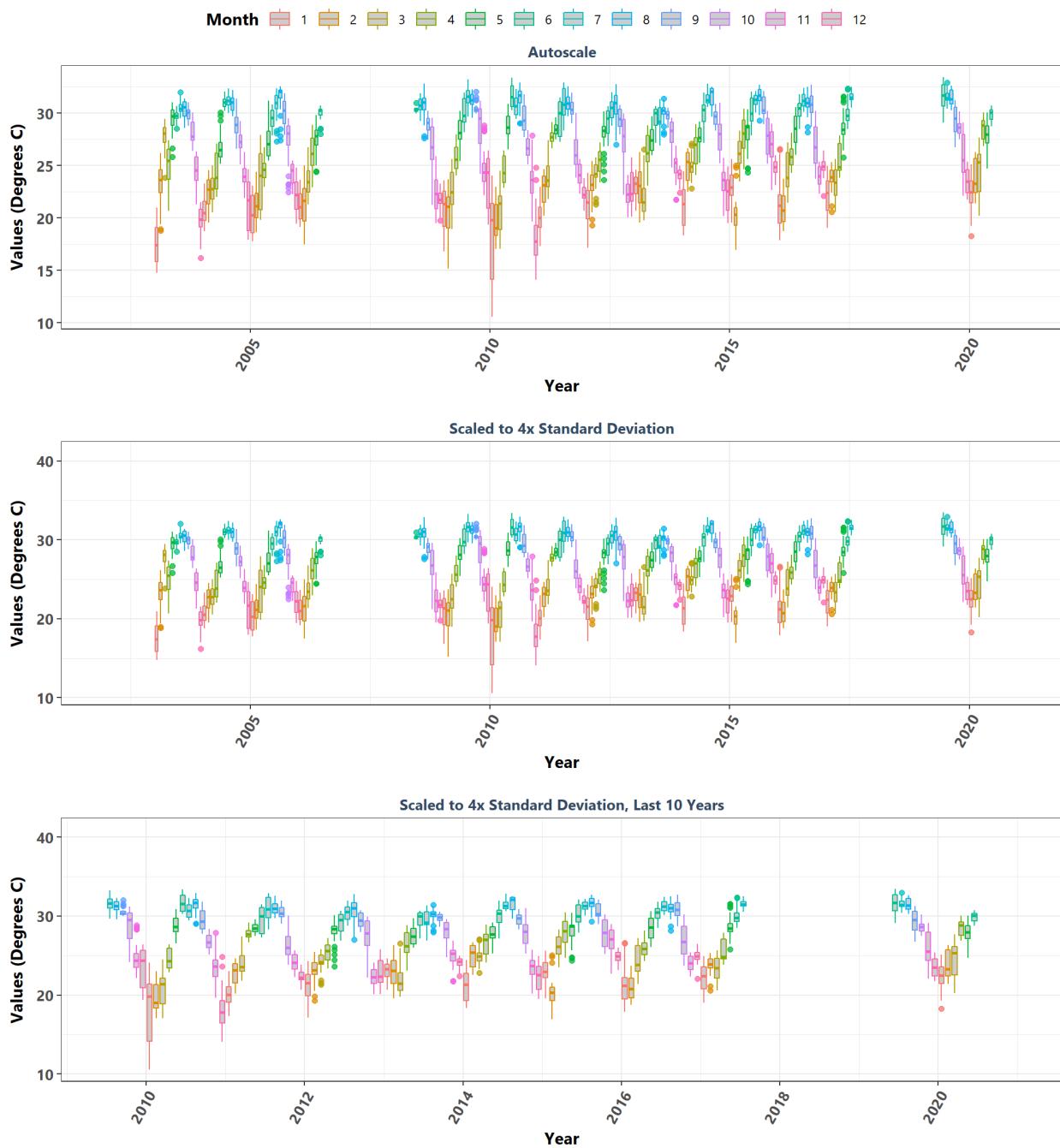
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**5 | National Data Buoy Center**  
**MLRF1**  
**By Month**



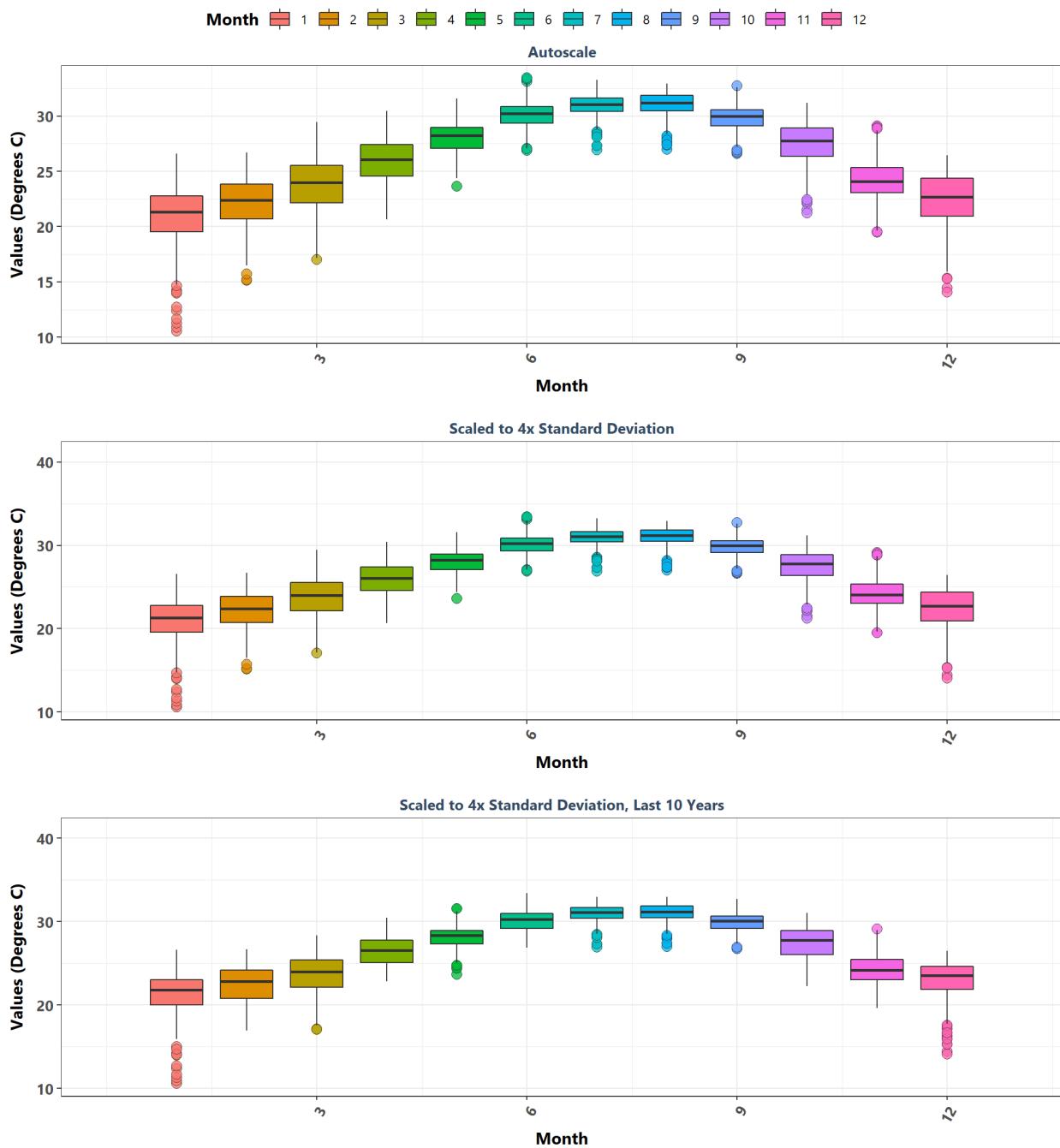
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**11**  
By Year



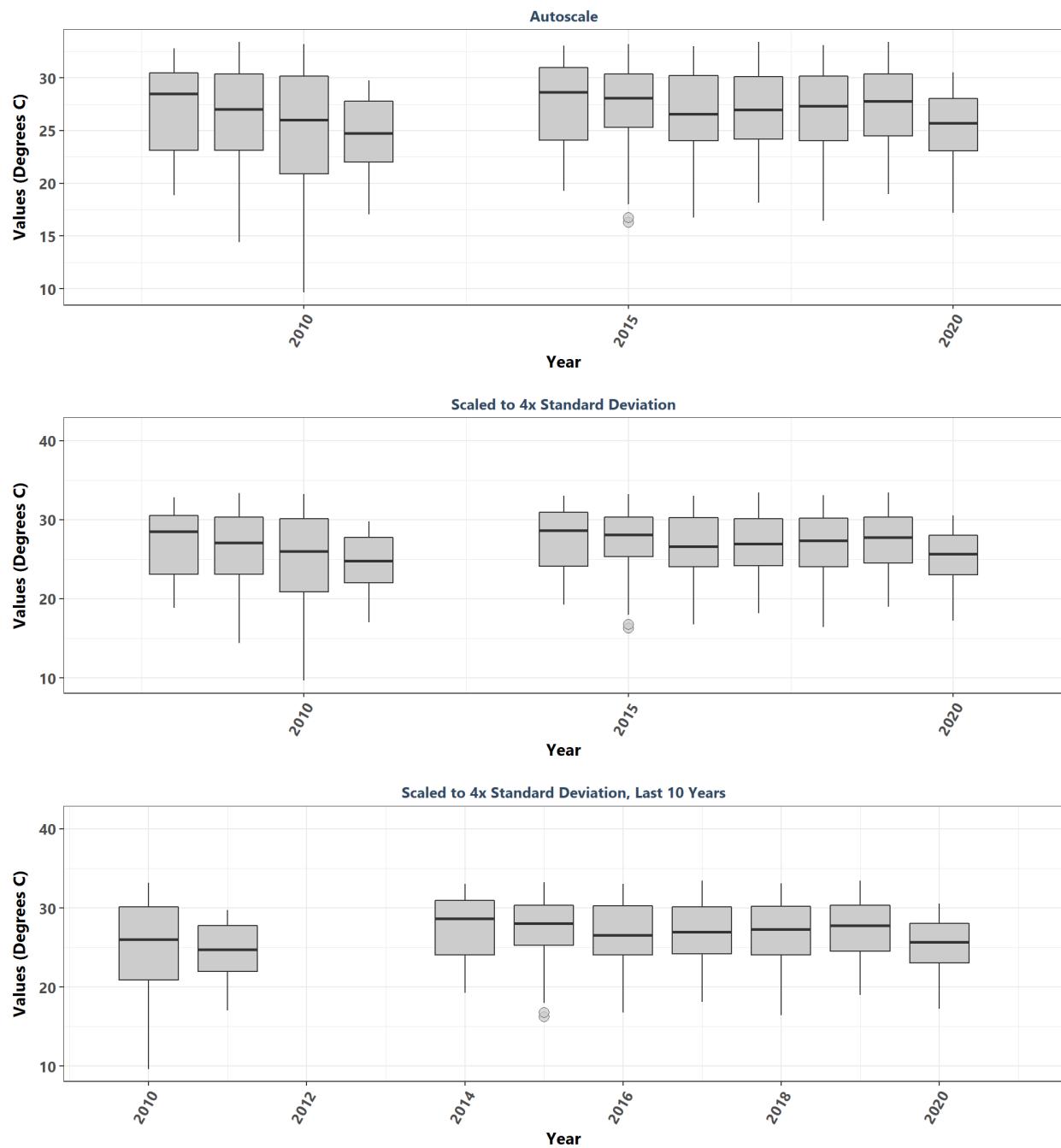
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**11**  
**By Year & Month**



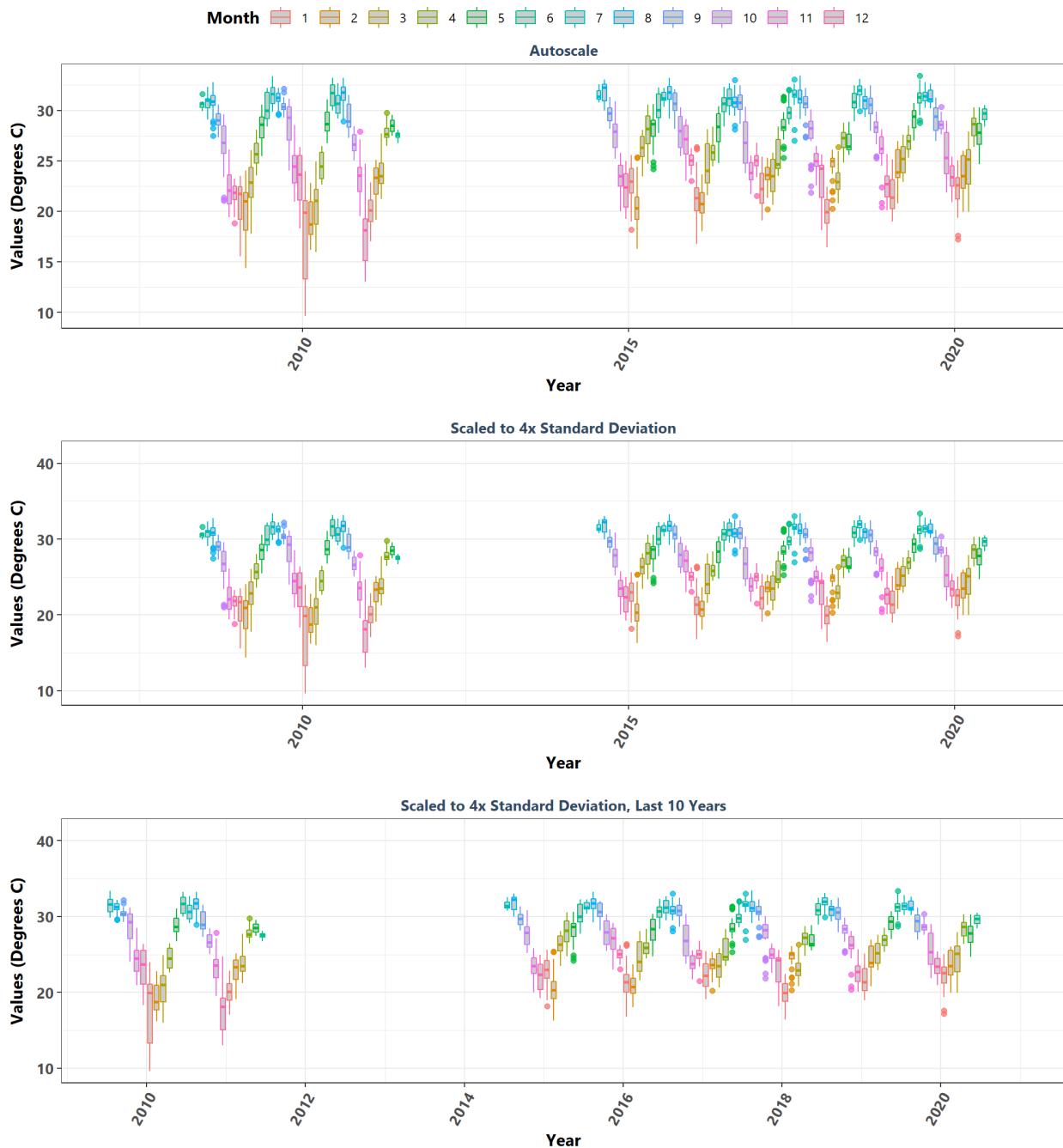
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**11**  
**By Month**



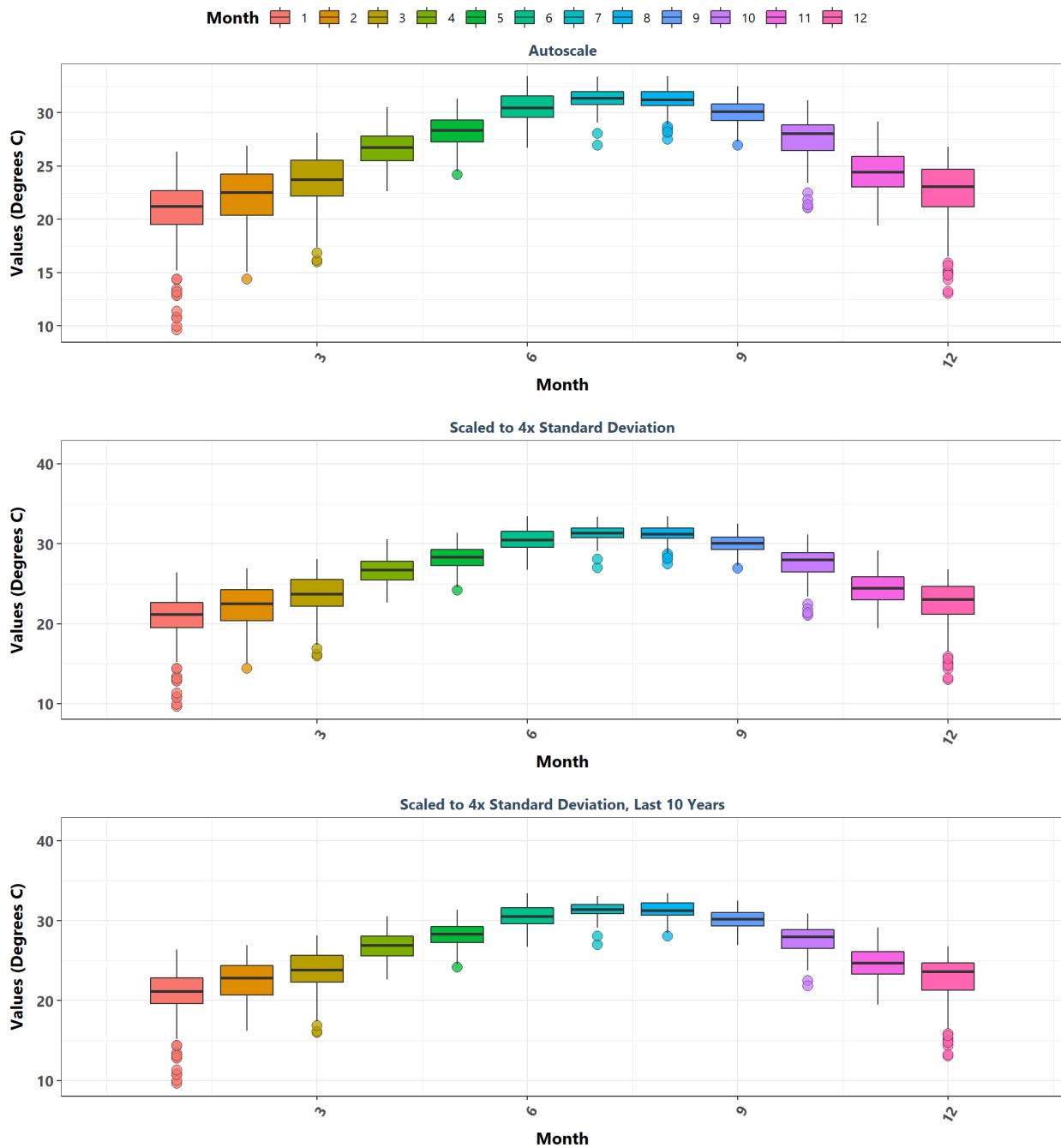
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986 | Water Temperature on Coral Reefs in the Florida Keys  
12  
By Year



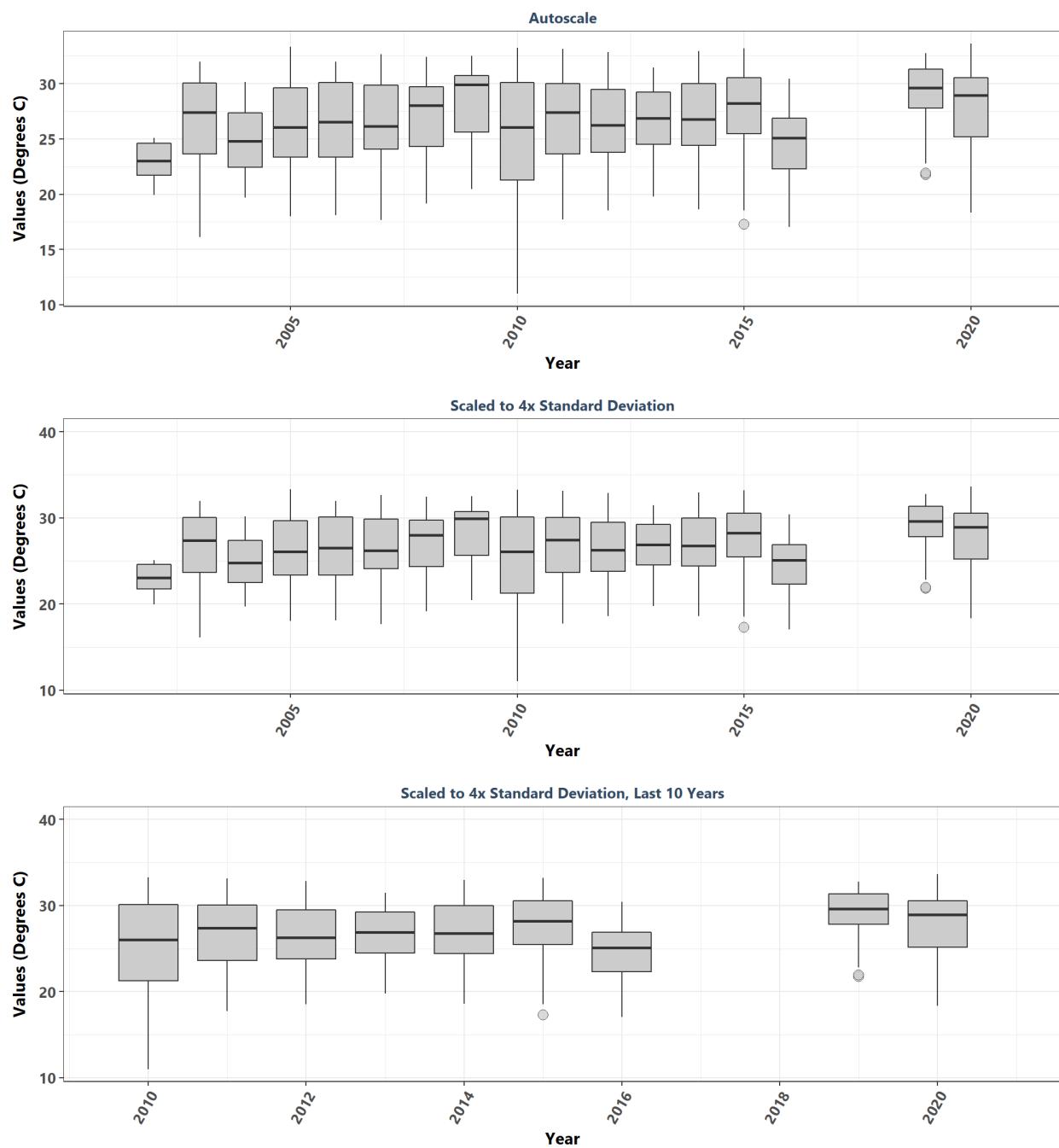
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**12**  
**By Year & Month**



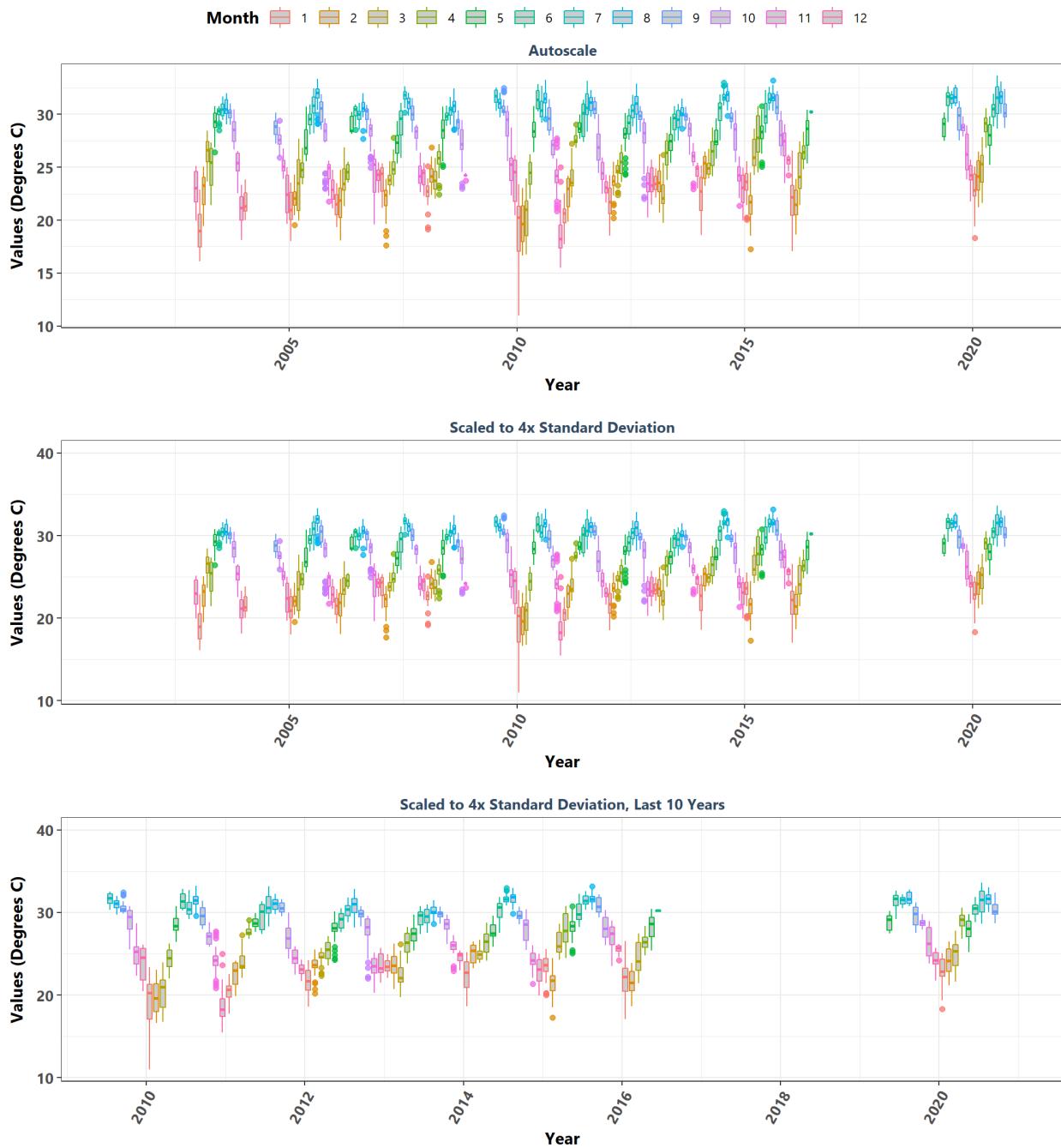
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**12**  
**By Month**



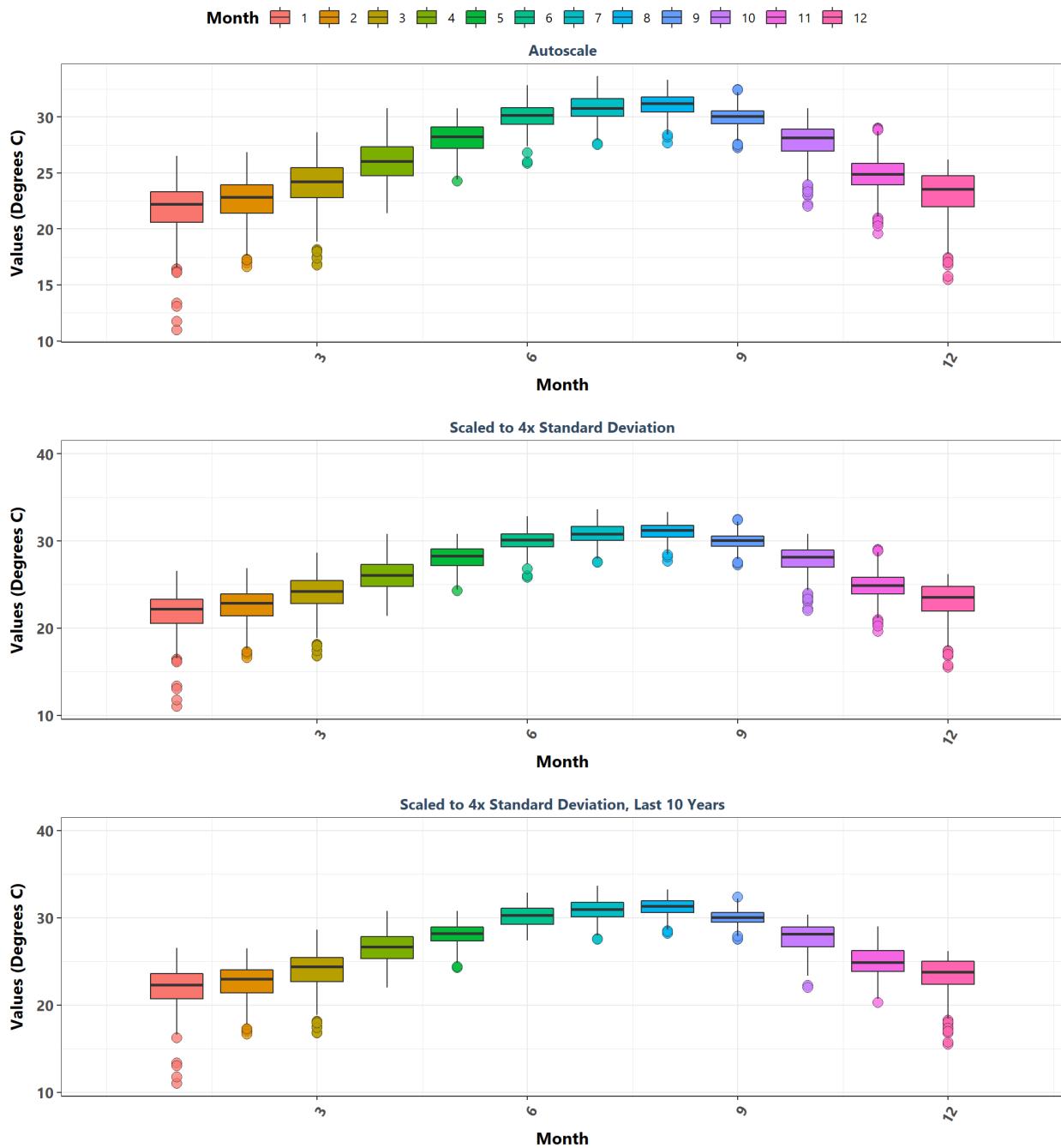
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**14**  
**By Year**



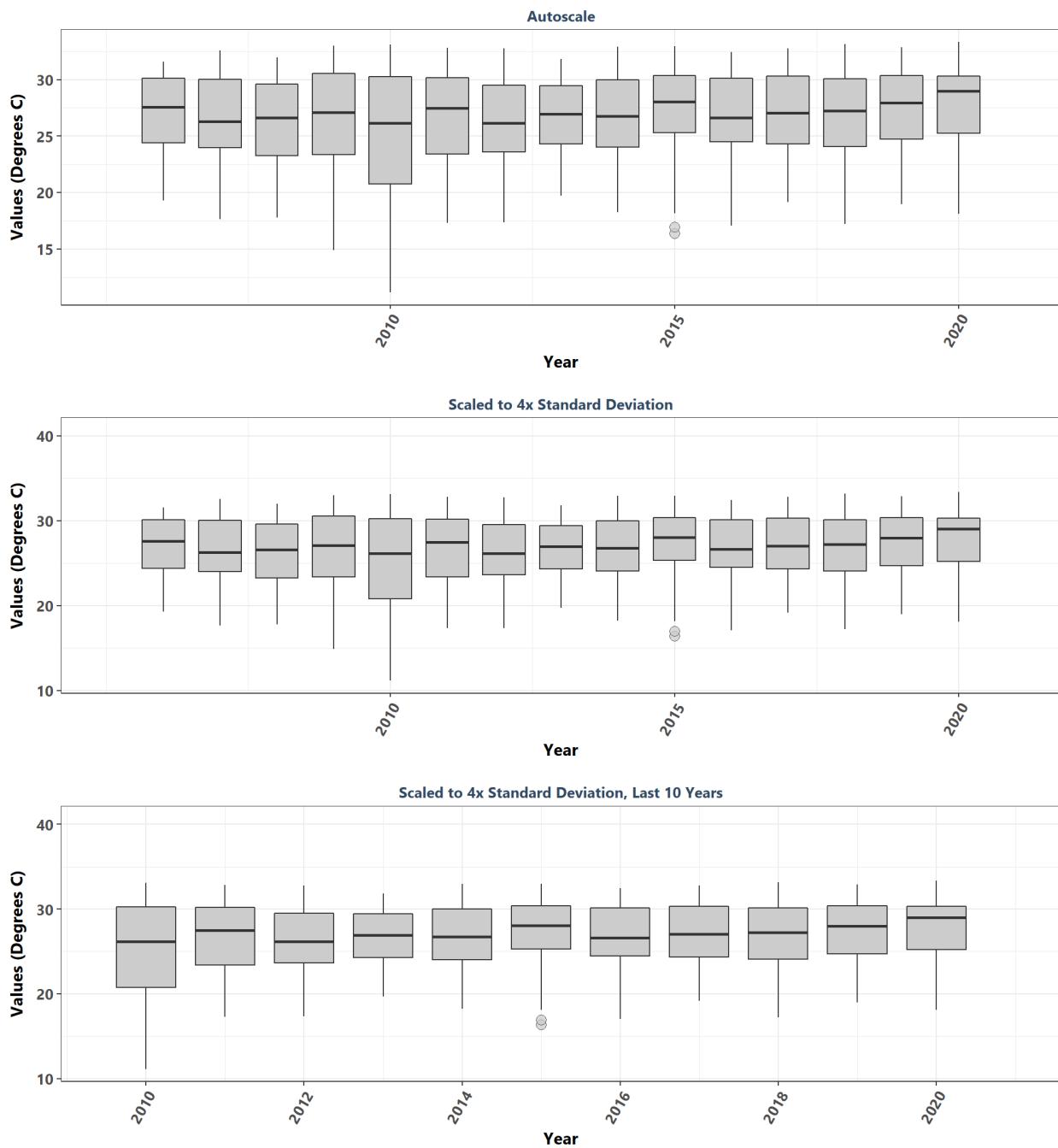
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**14**  
**By Year & Month**



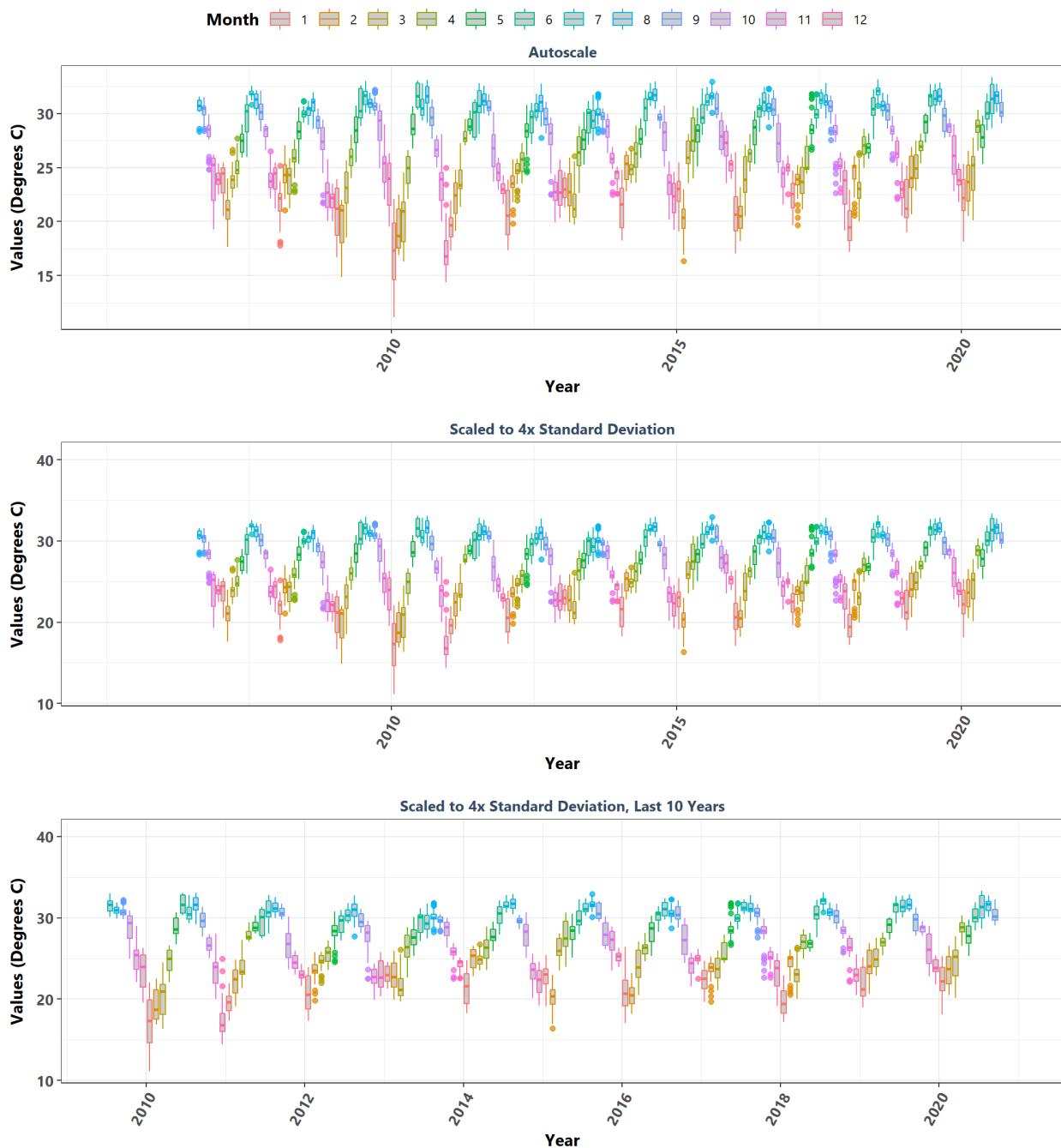
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**14**  
**By Month**



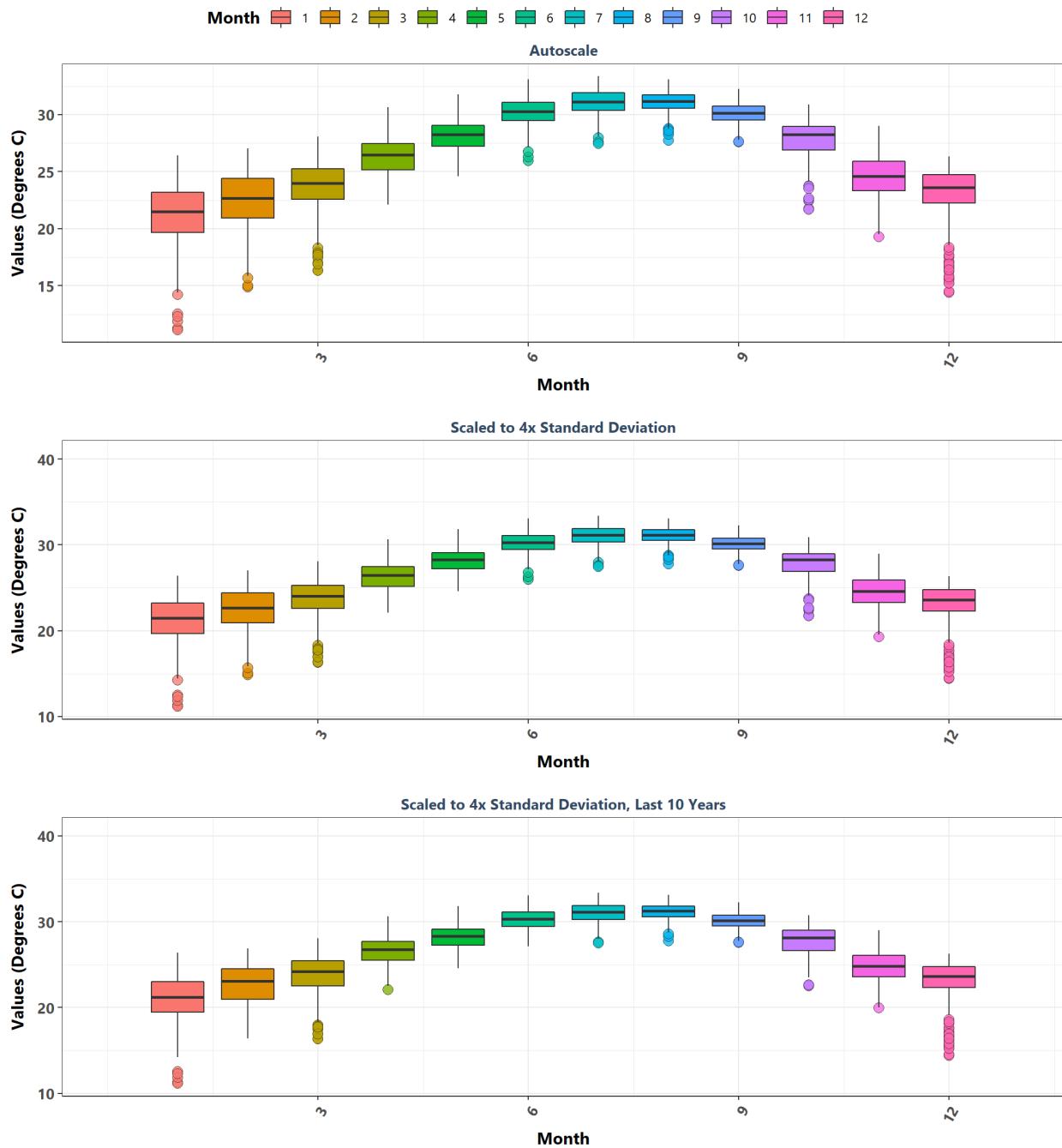
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
15  
By Year



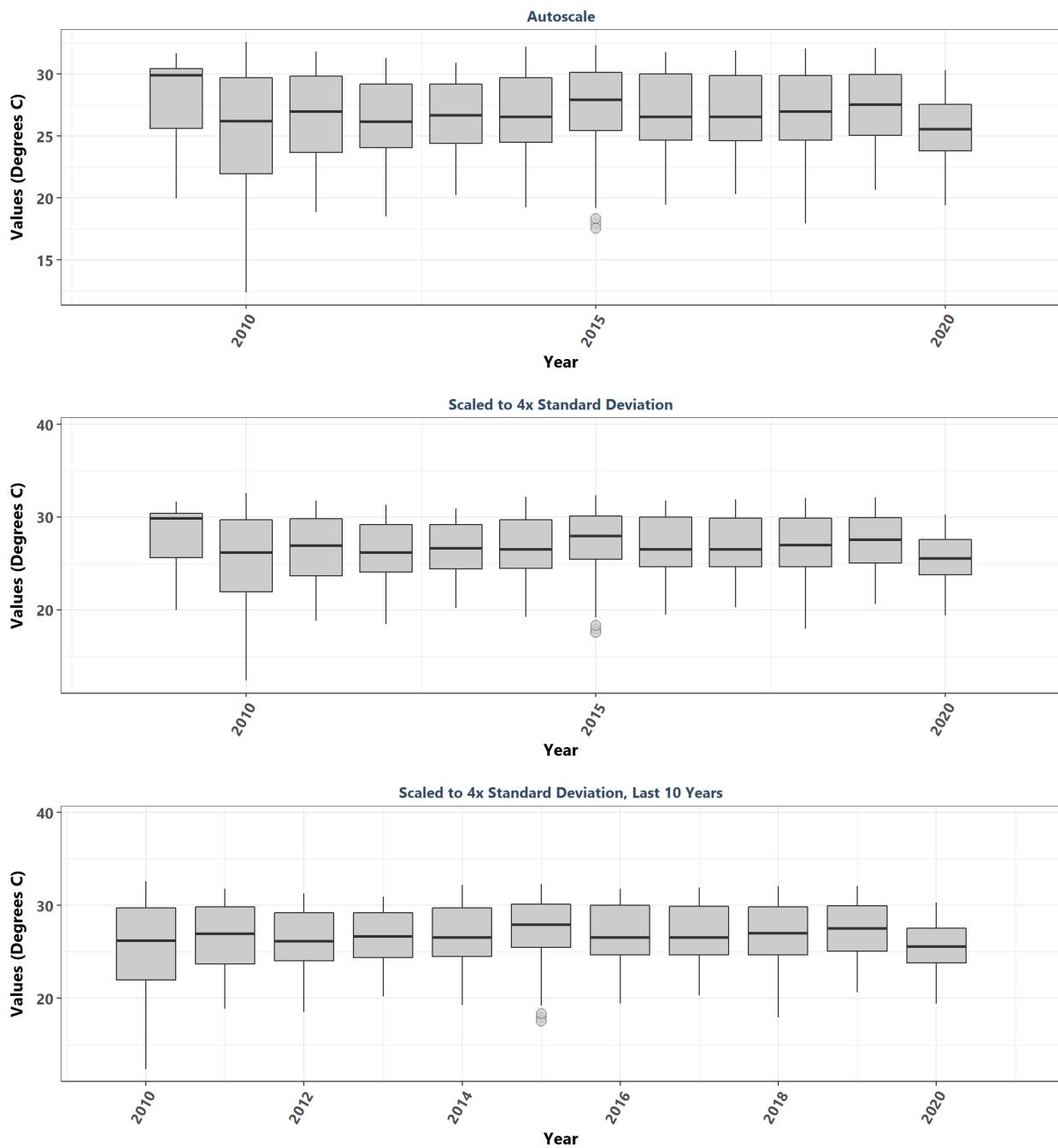
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**15**  
**By Year & Month**



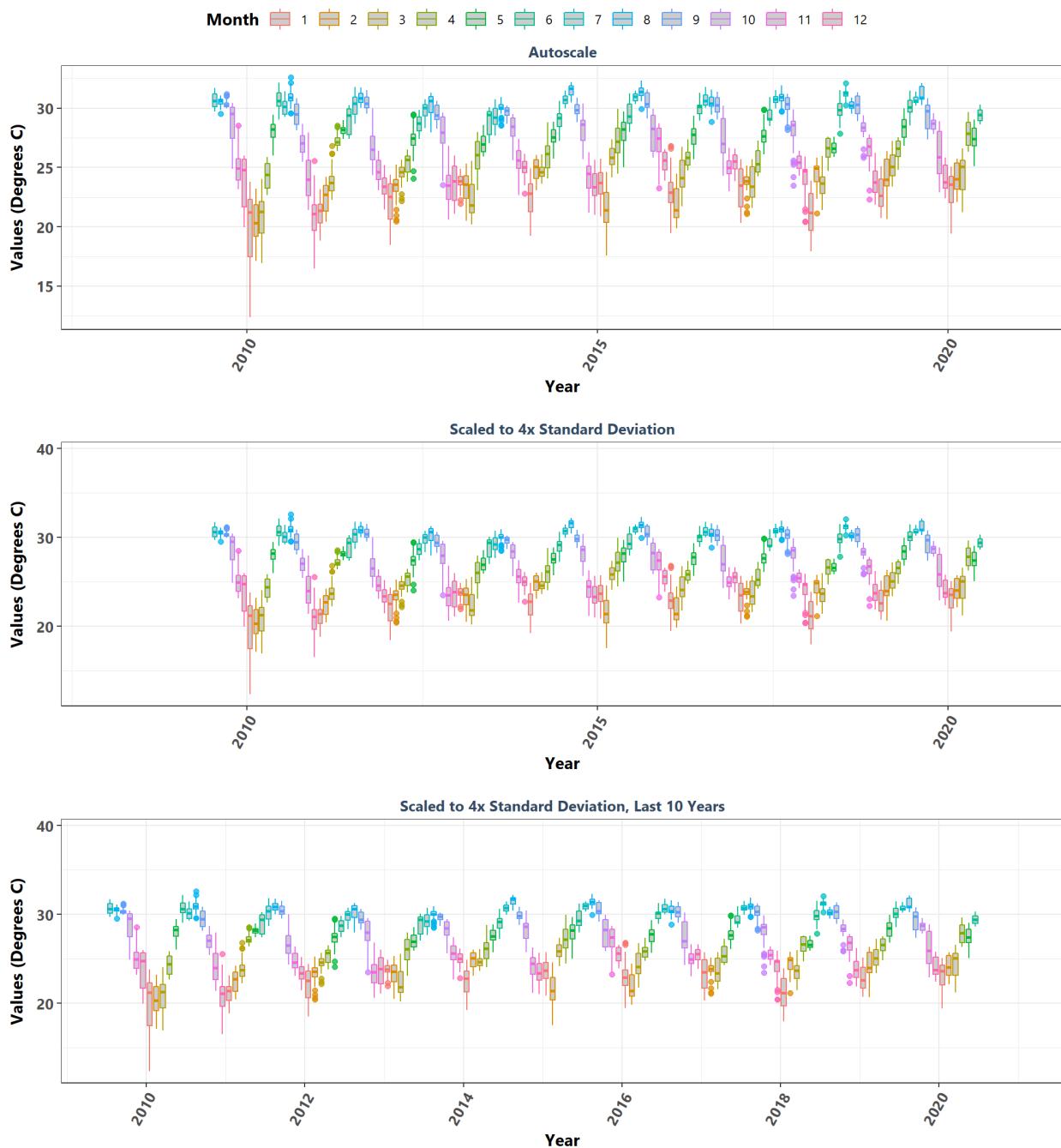
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**15**  
**By Month**



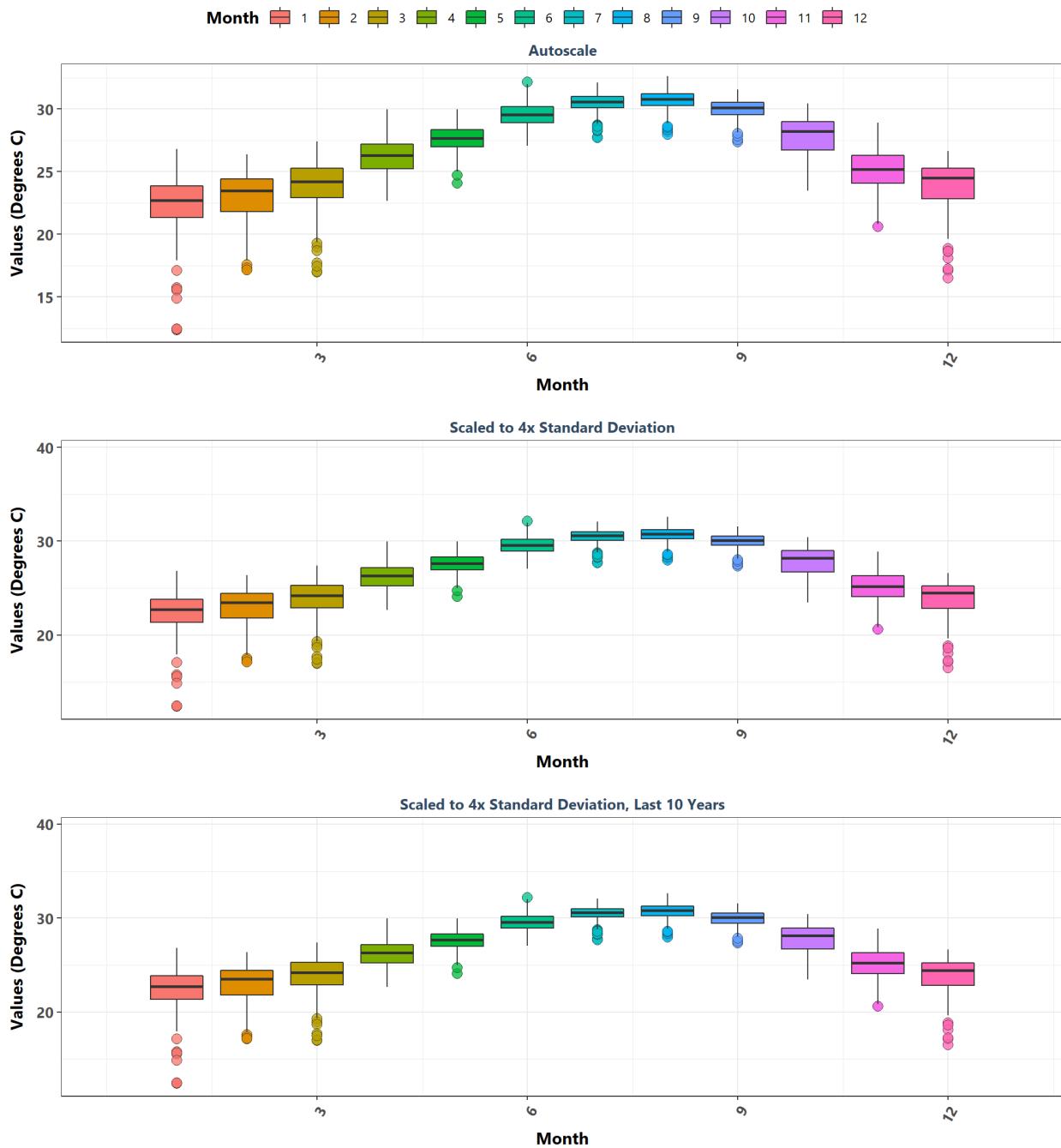
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
22  
By Year



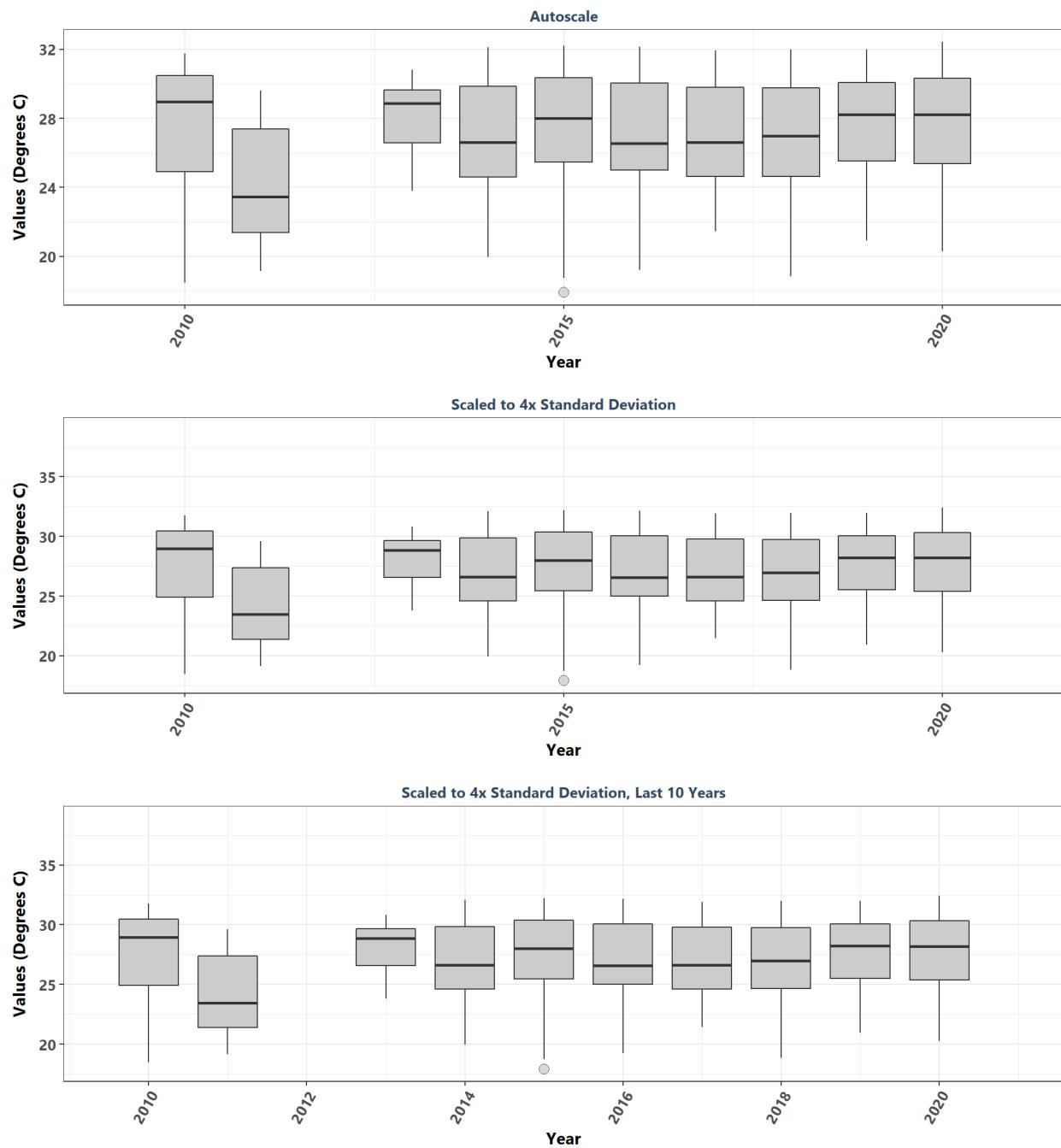
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**22**  
**By Year & Month**



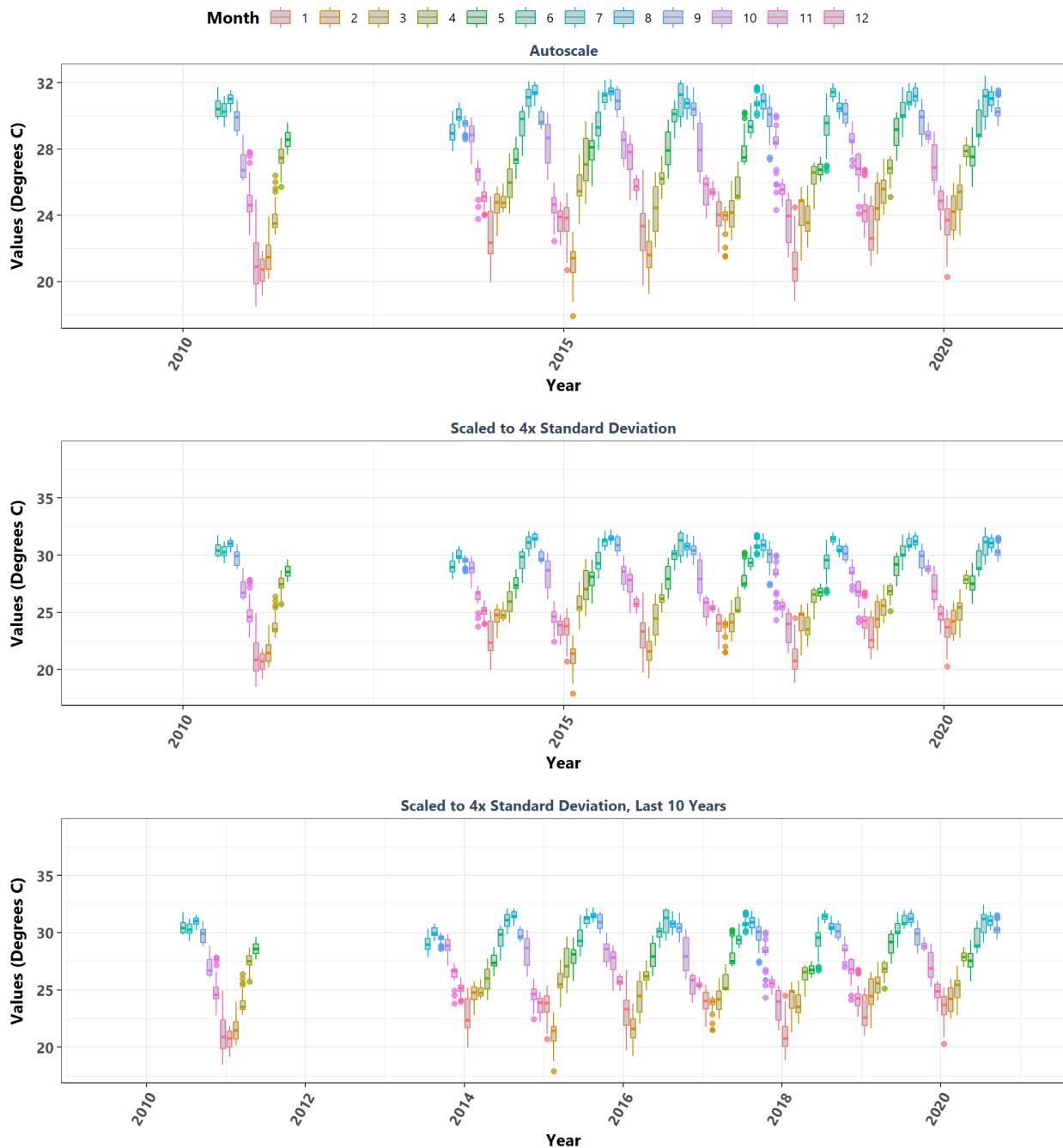
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**22**  
**By Month**



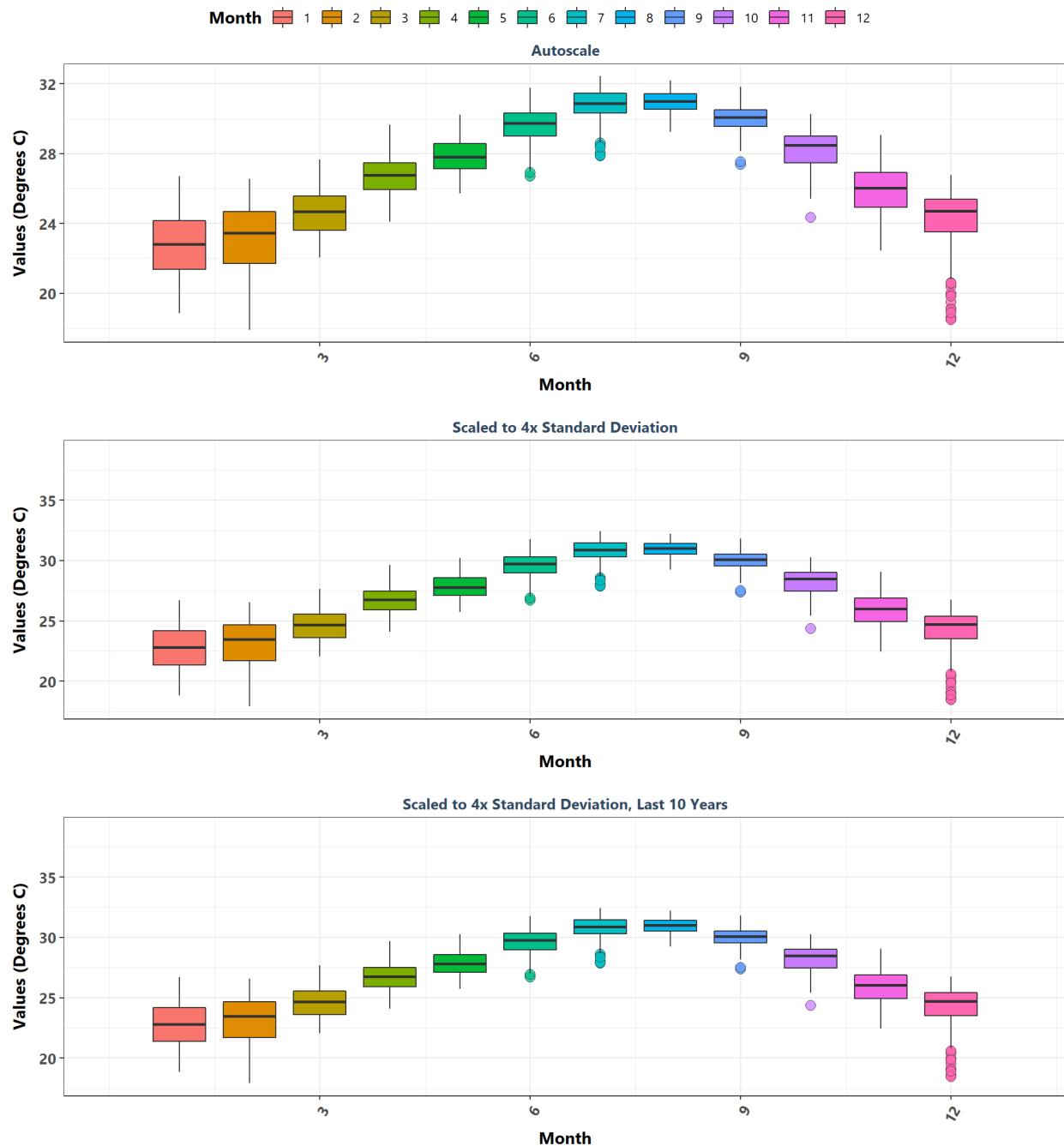
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**25**  
**By Year**



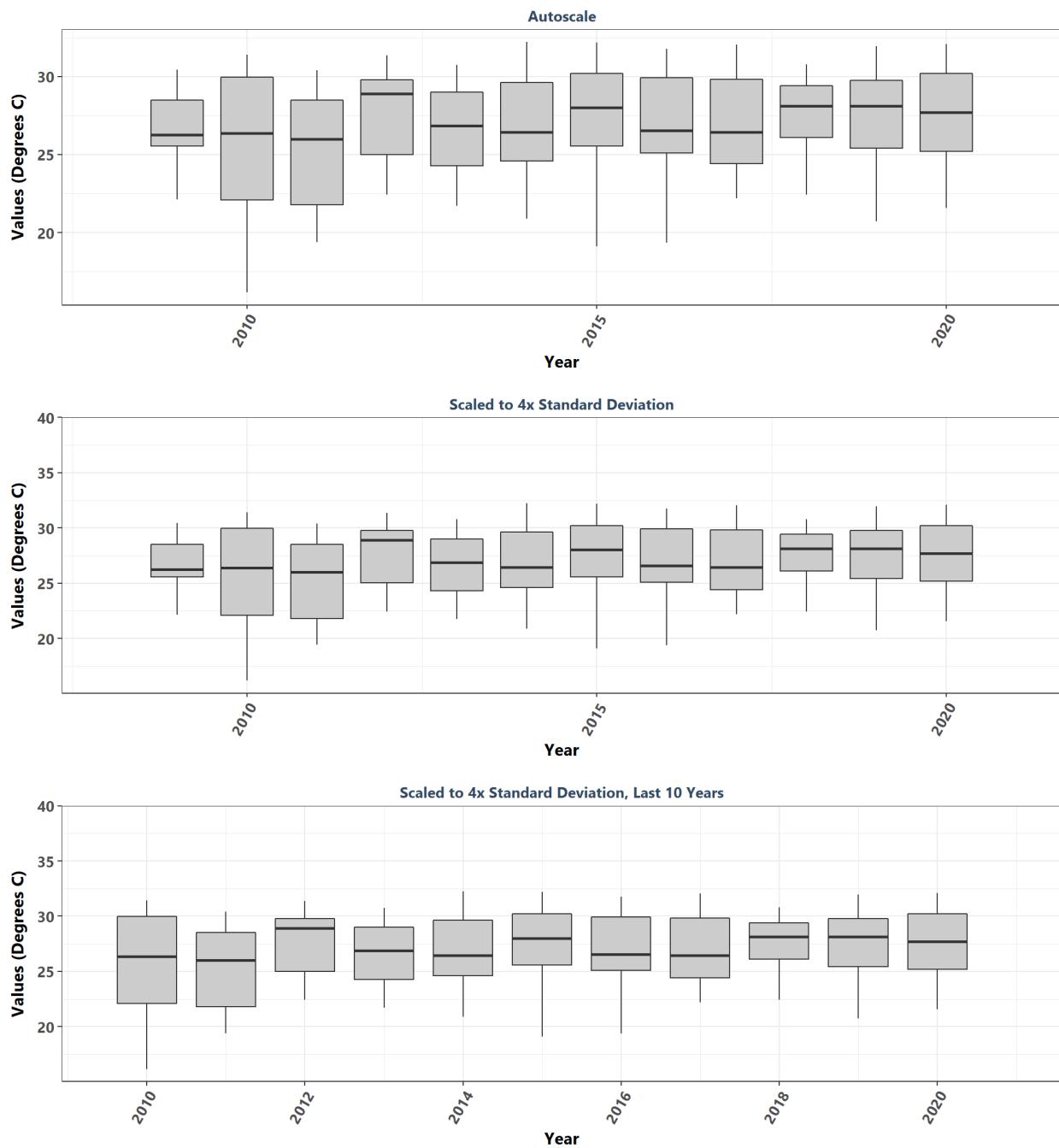
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**25**  
**By Year & Month**



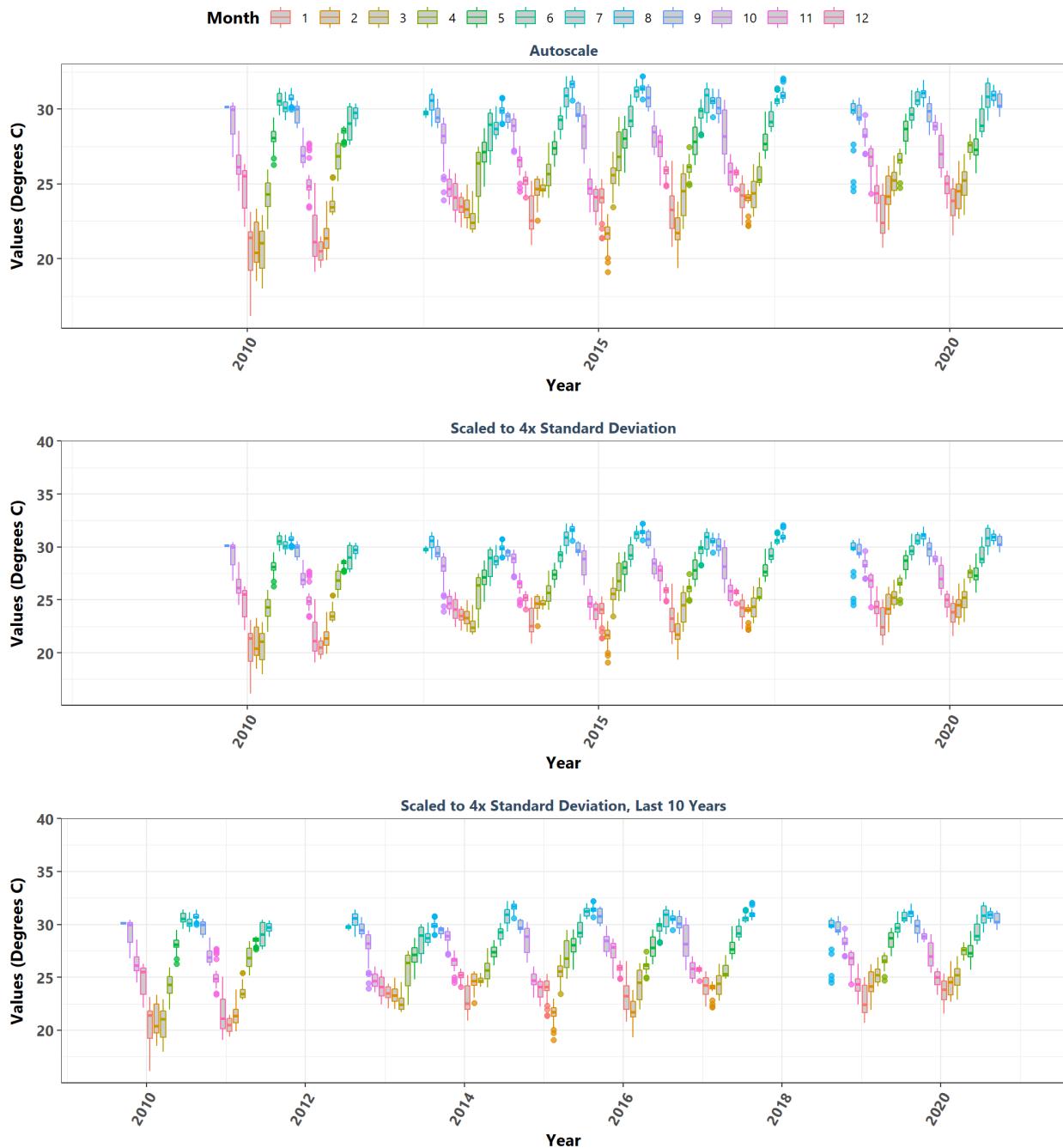
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**25**  
**By Month**



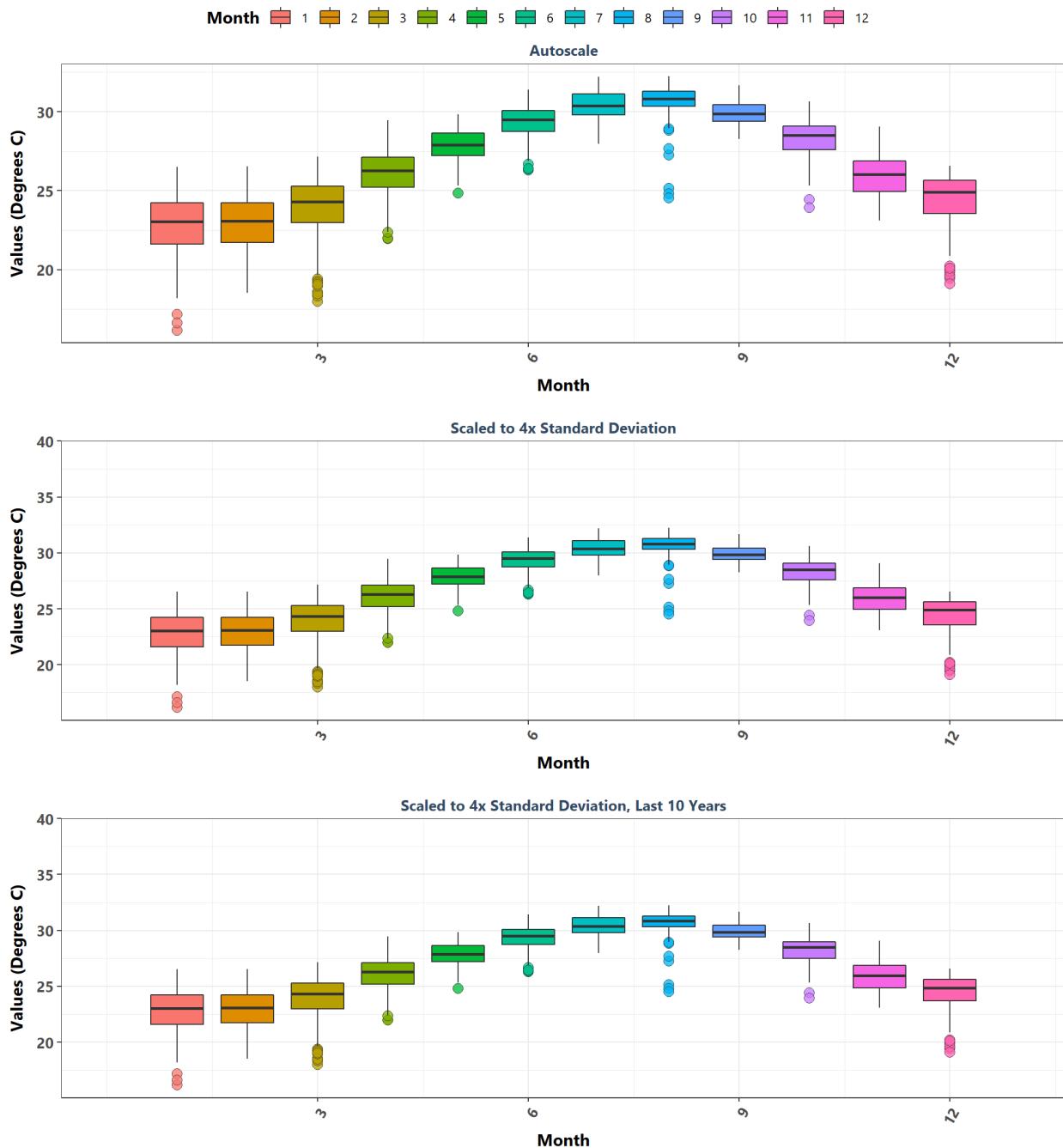
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
26  
By Year



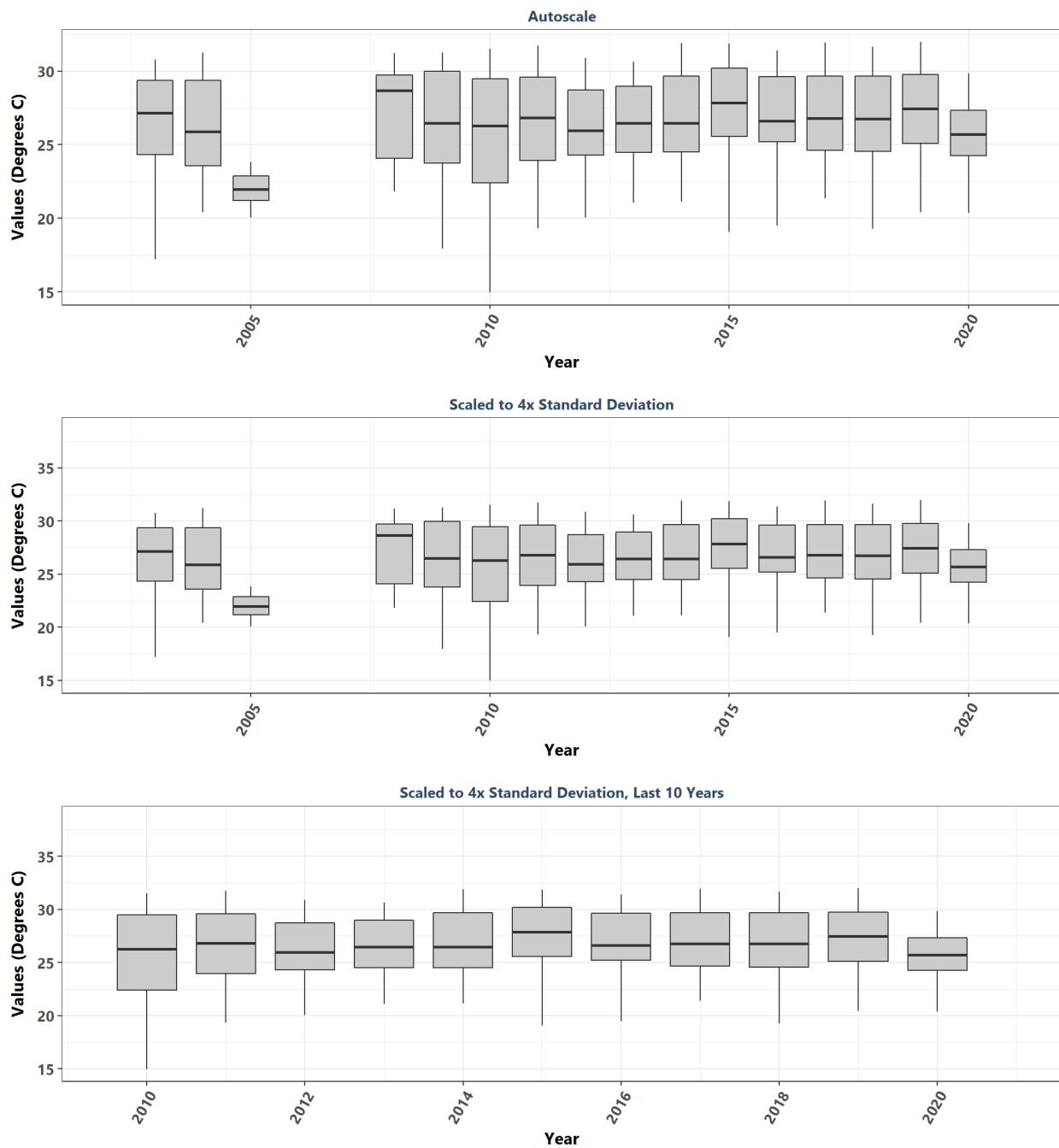
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**26**  
**By Year & Month**



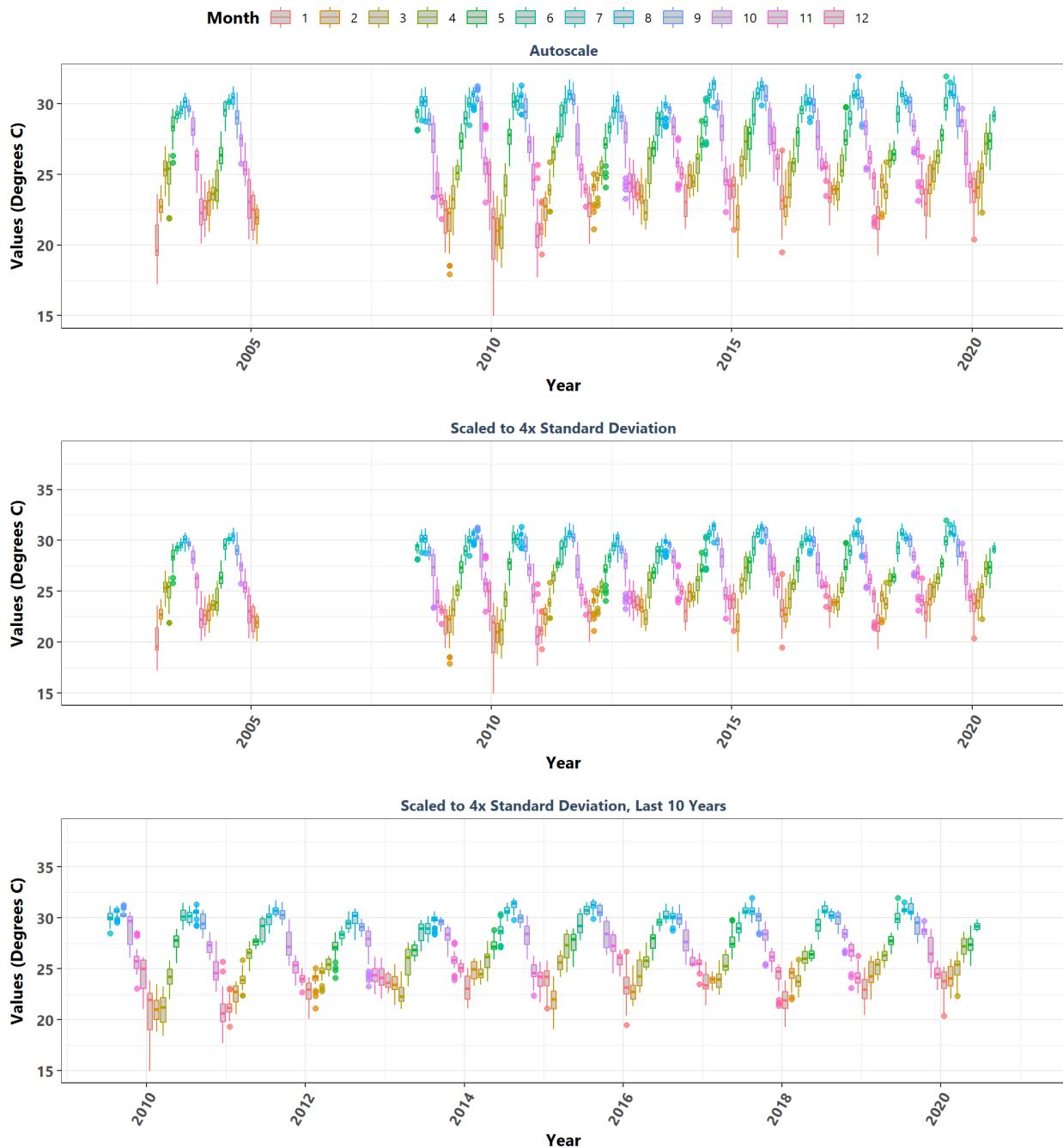
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**26**  
**By Month**



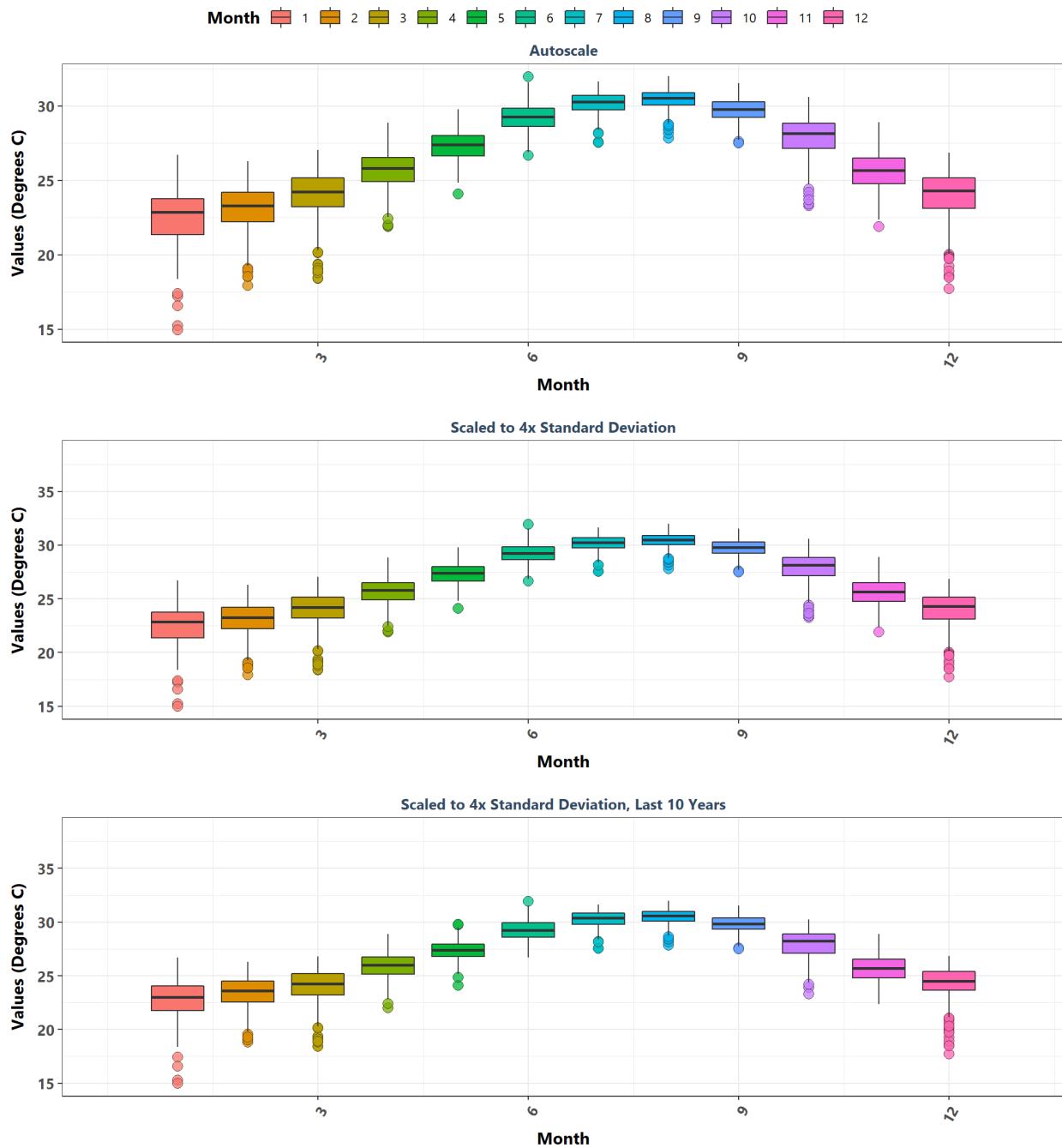
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32  
By Year



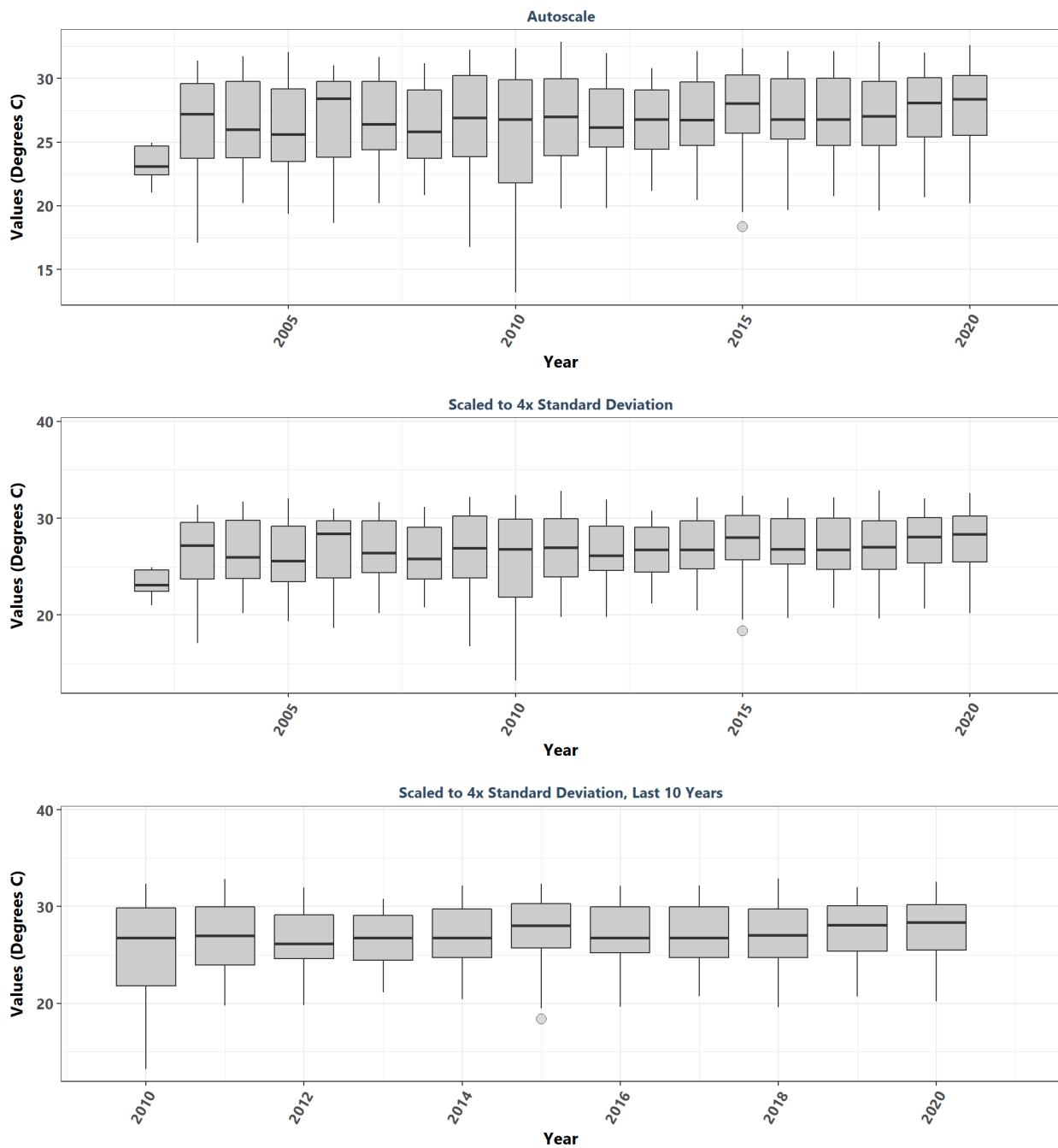
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**32**  
**By Year & Month**



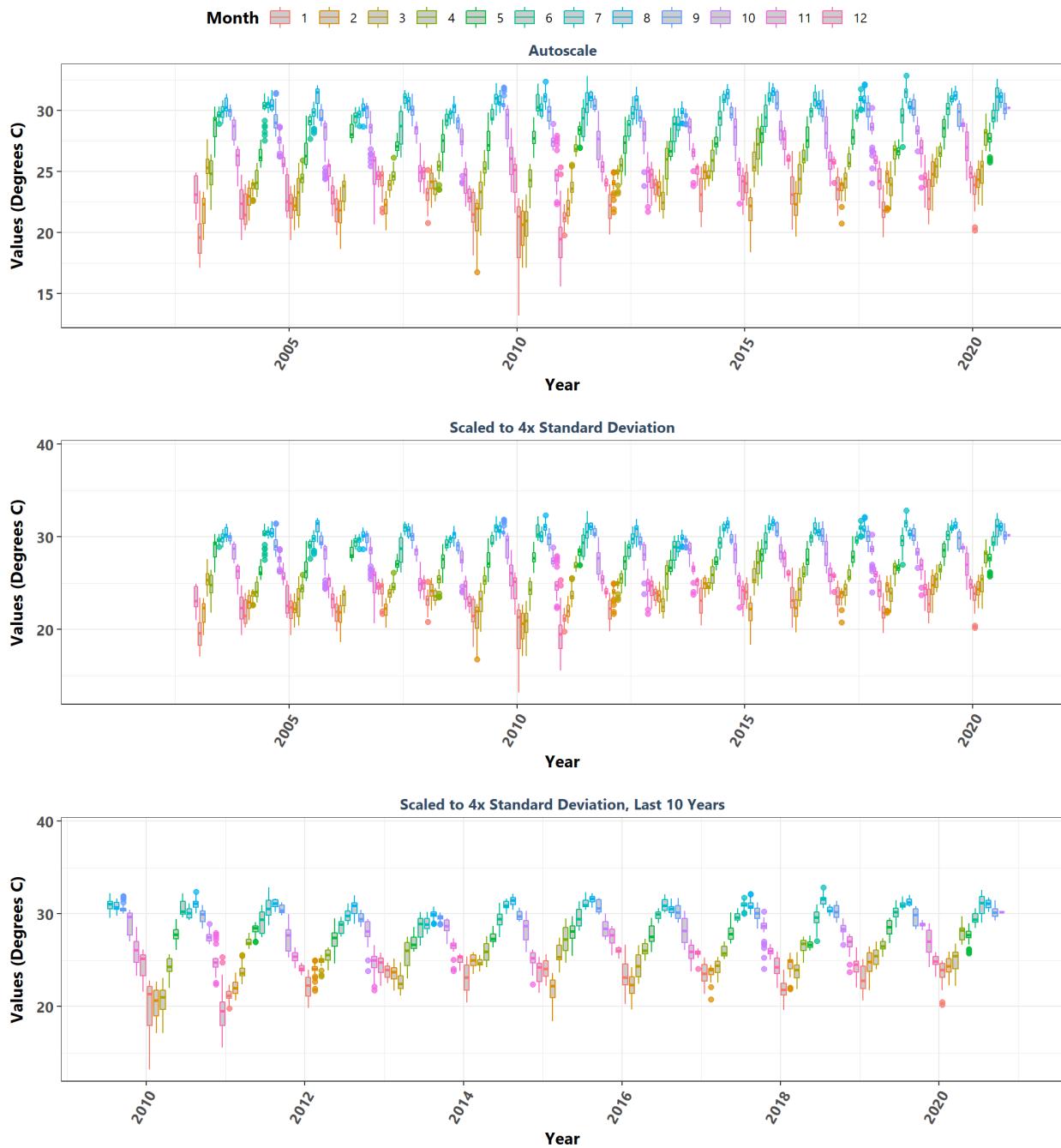
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**32**  
**By Month**



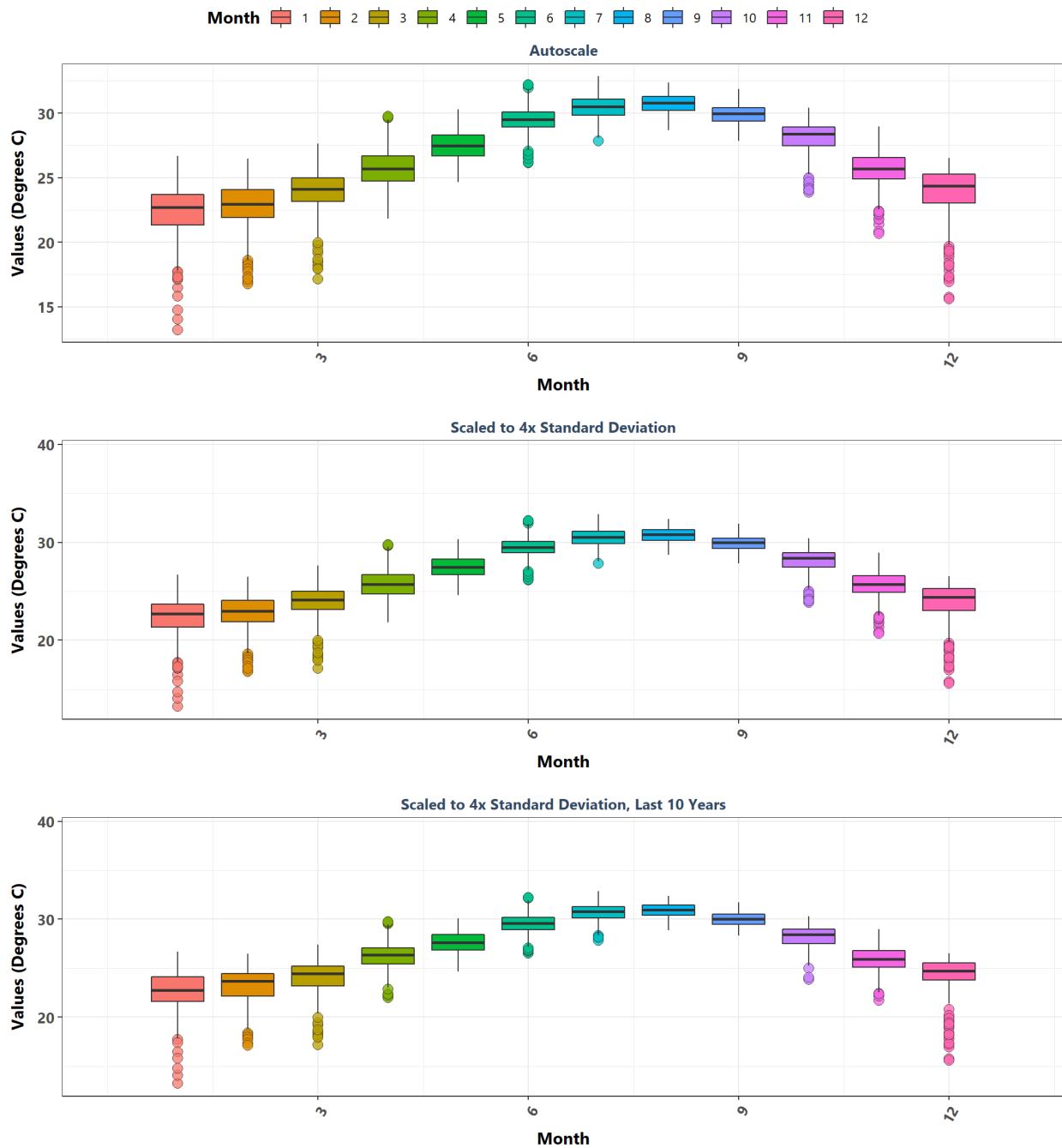
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**34**  
**By Year**



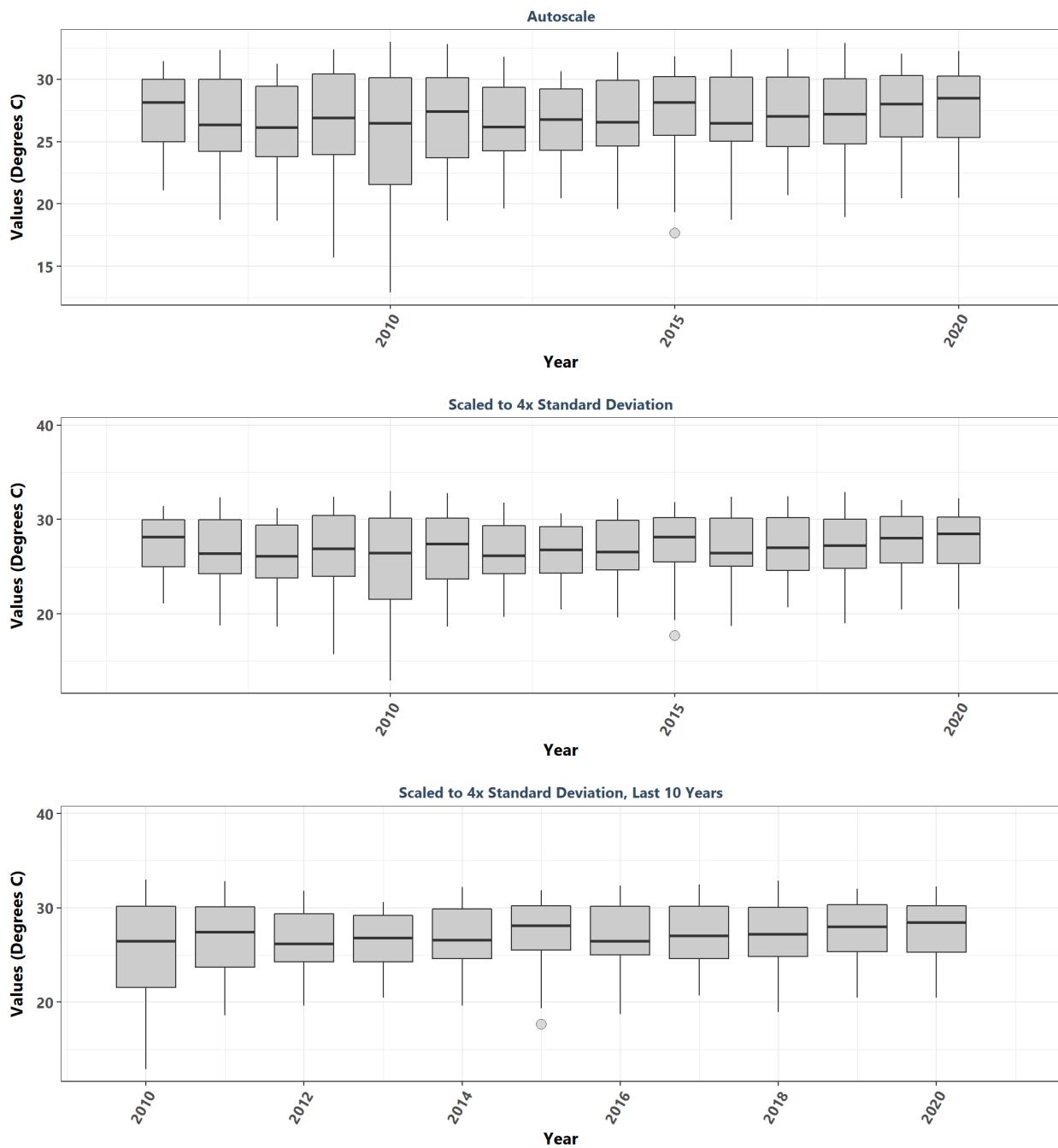
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**34**  
**By Year & Month**



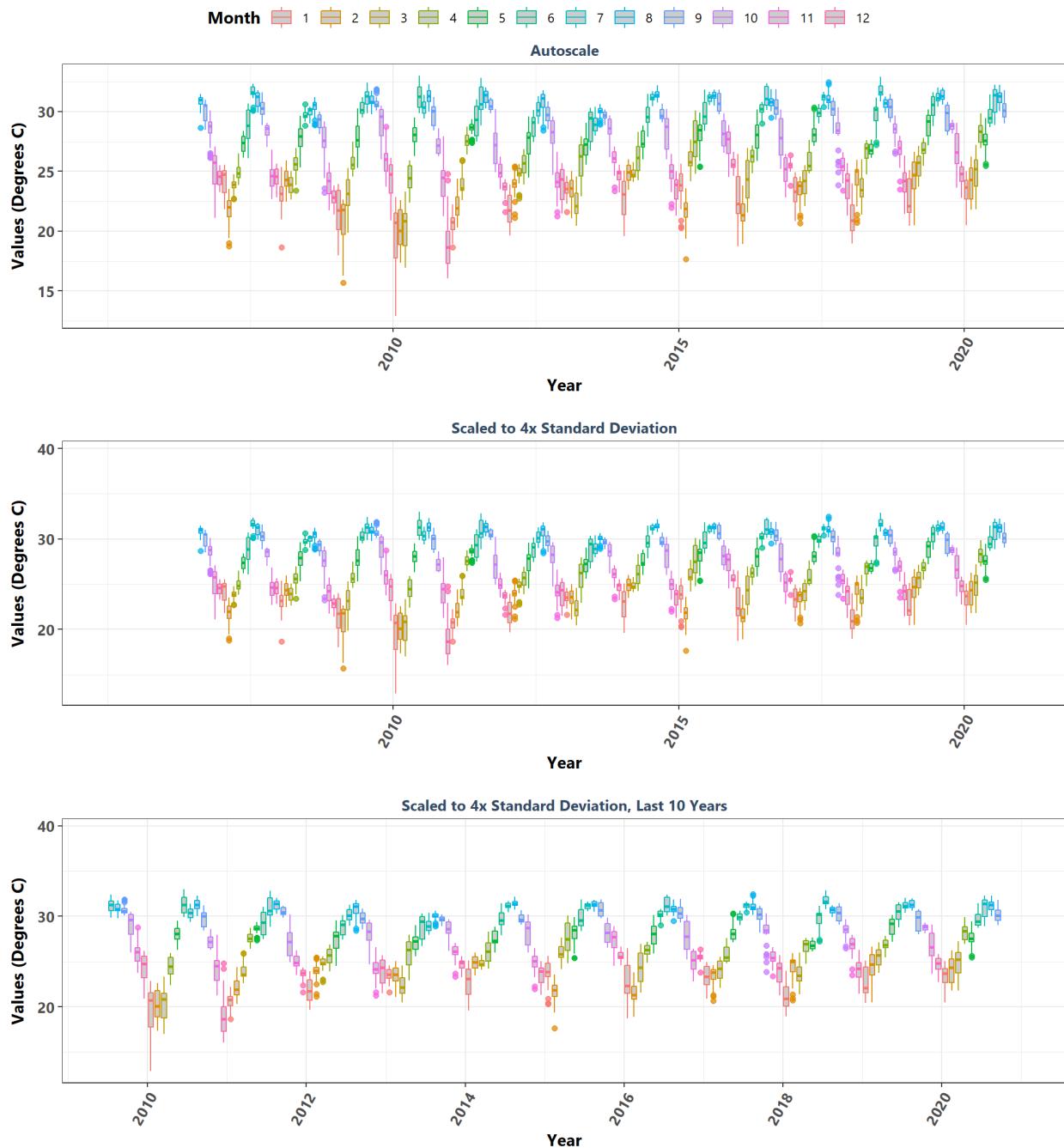
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**34**  
**By Month**



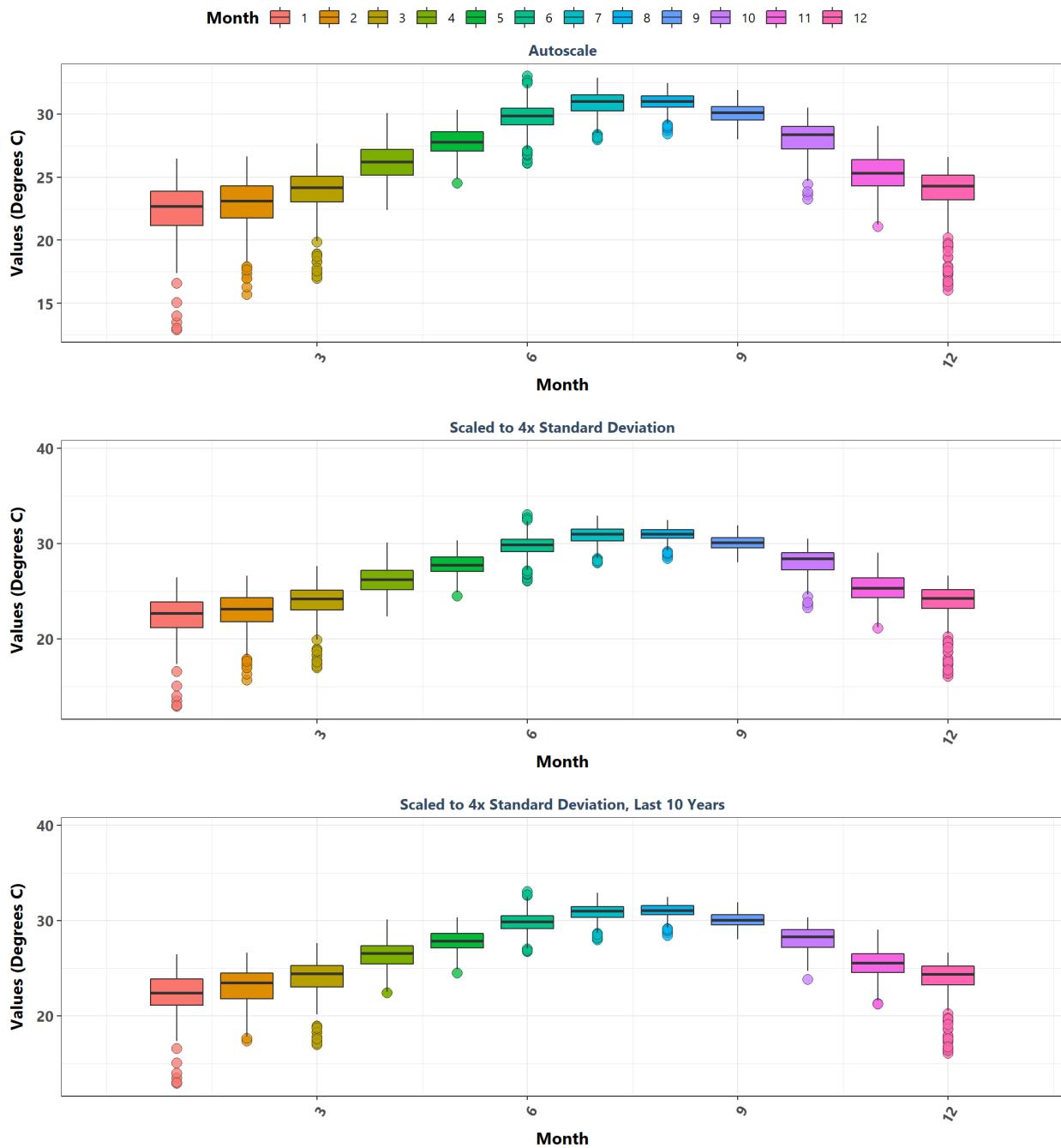
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
35  
By Year



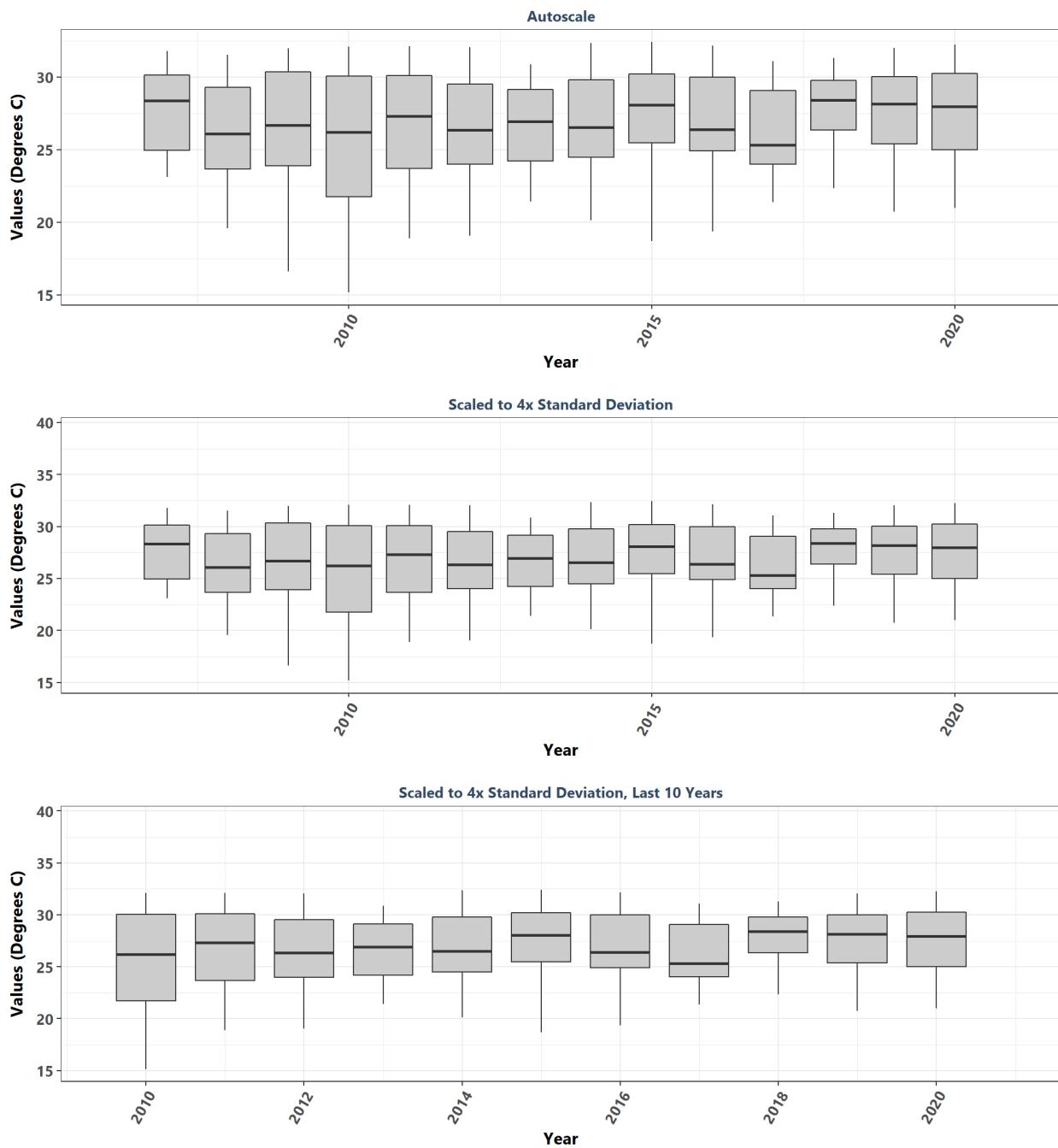
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**35**  
**By Year & Month**



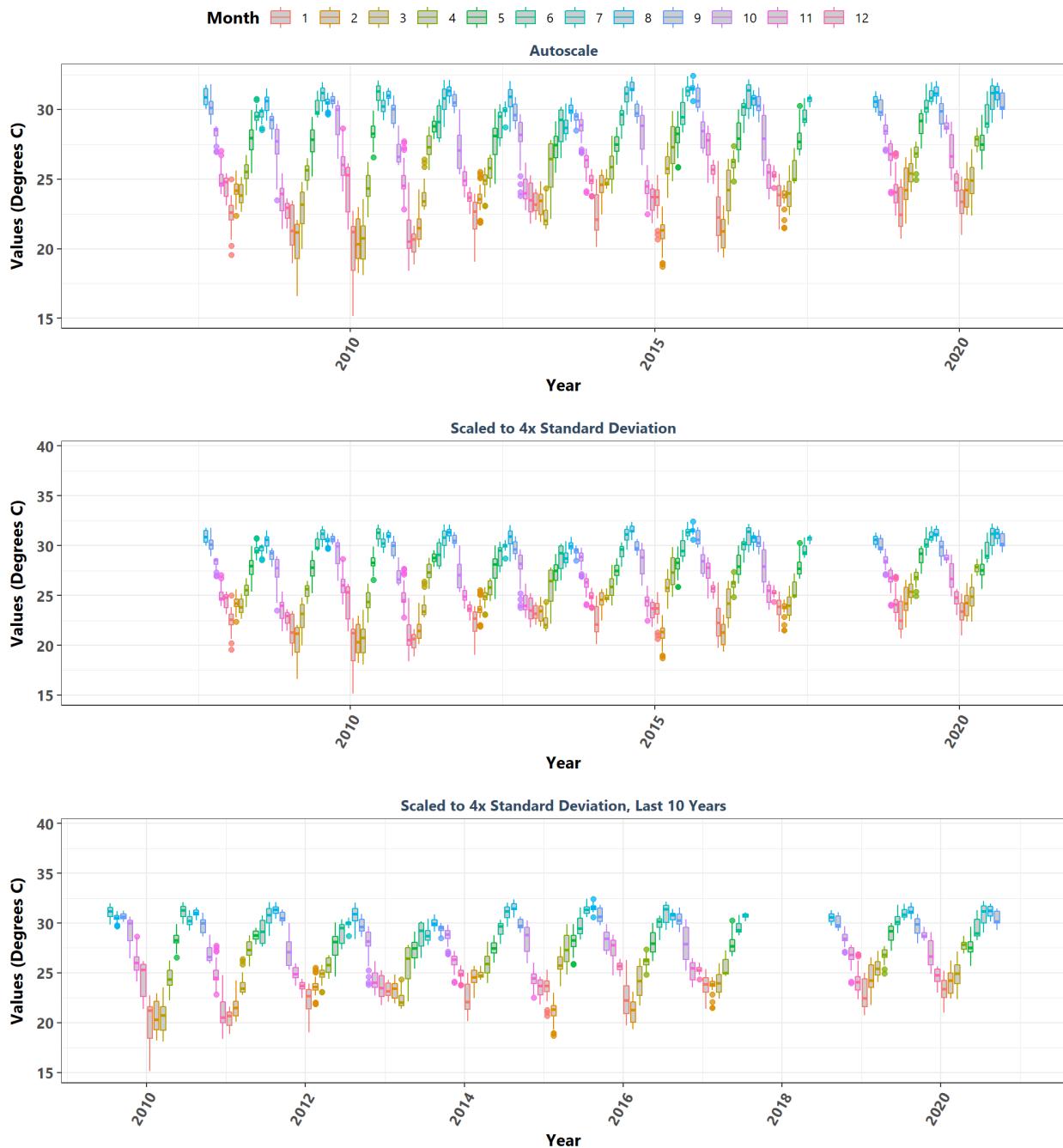
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**35**  
**By Month**



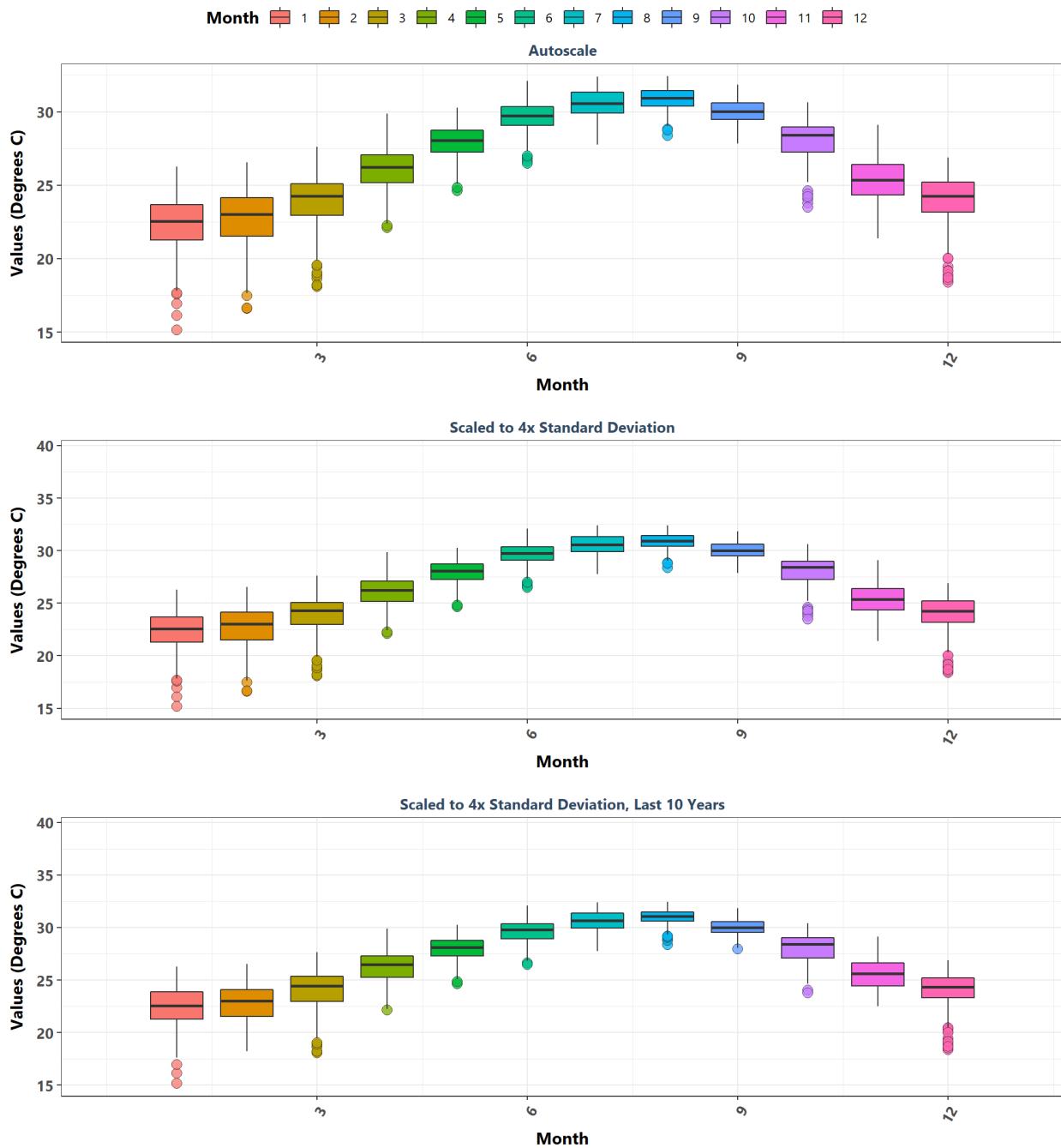
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**36**  
**By Year**



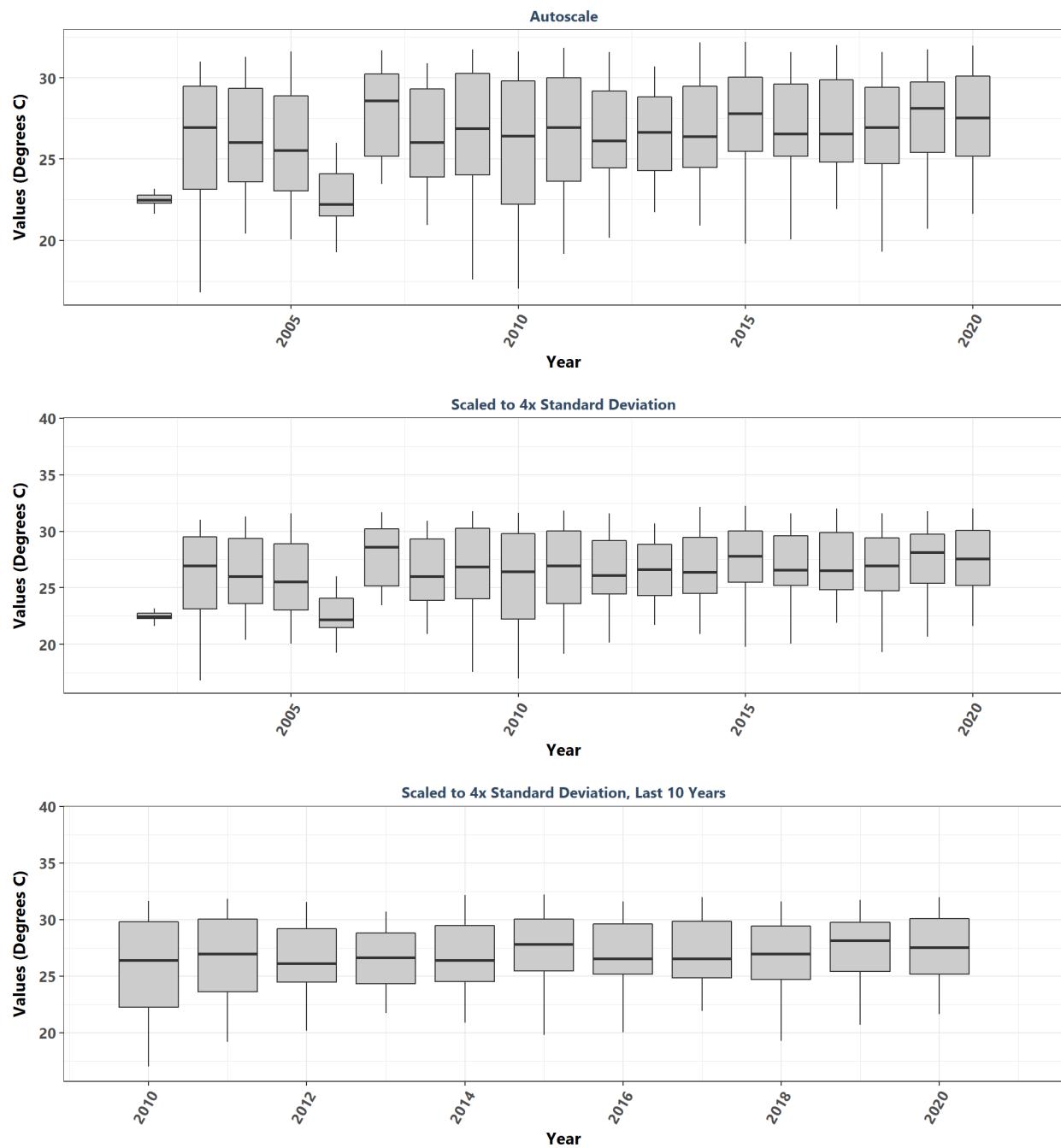
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**36**  
**By Year & Month**



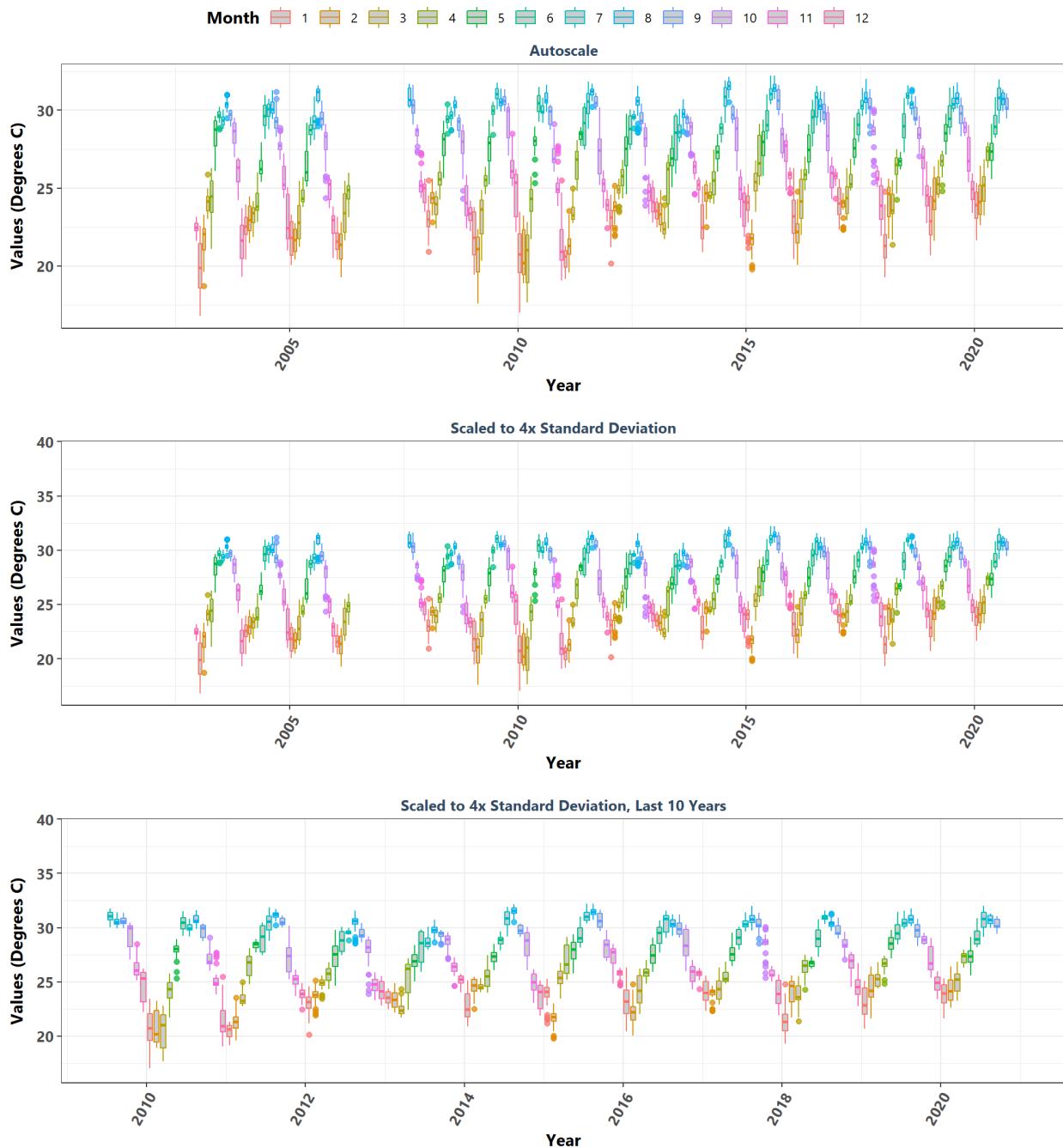
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**36**  
**By Month**



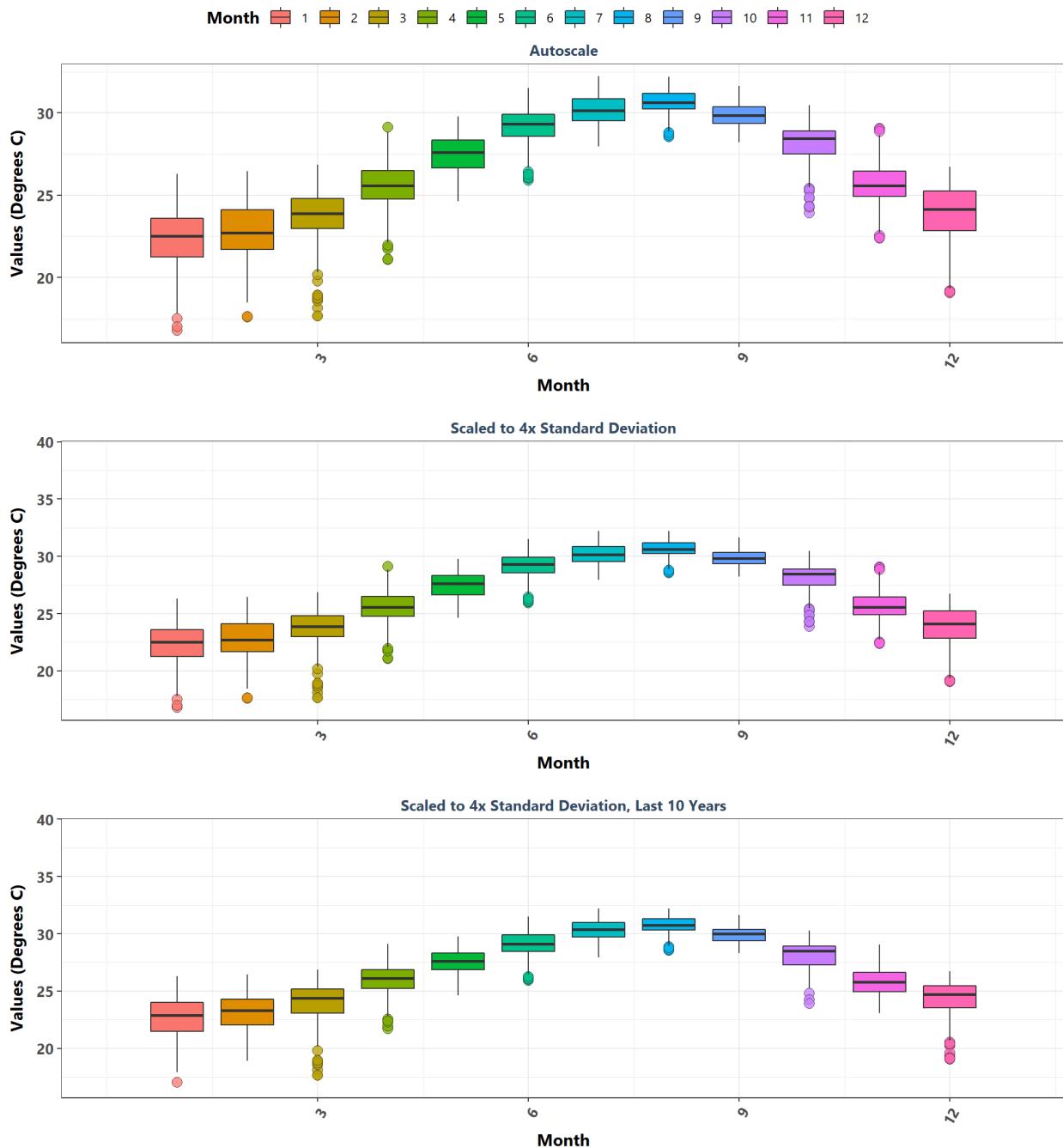
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**38**  
**By Year**



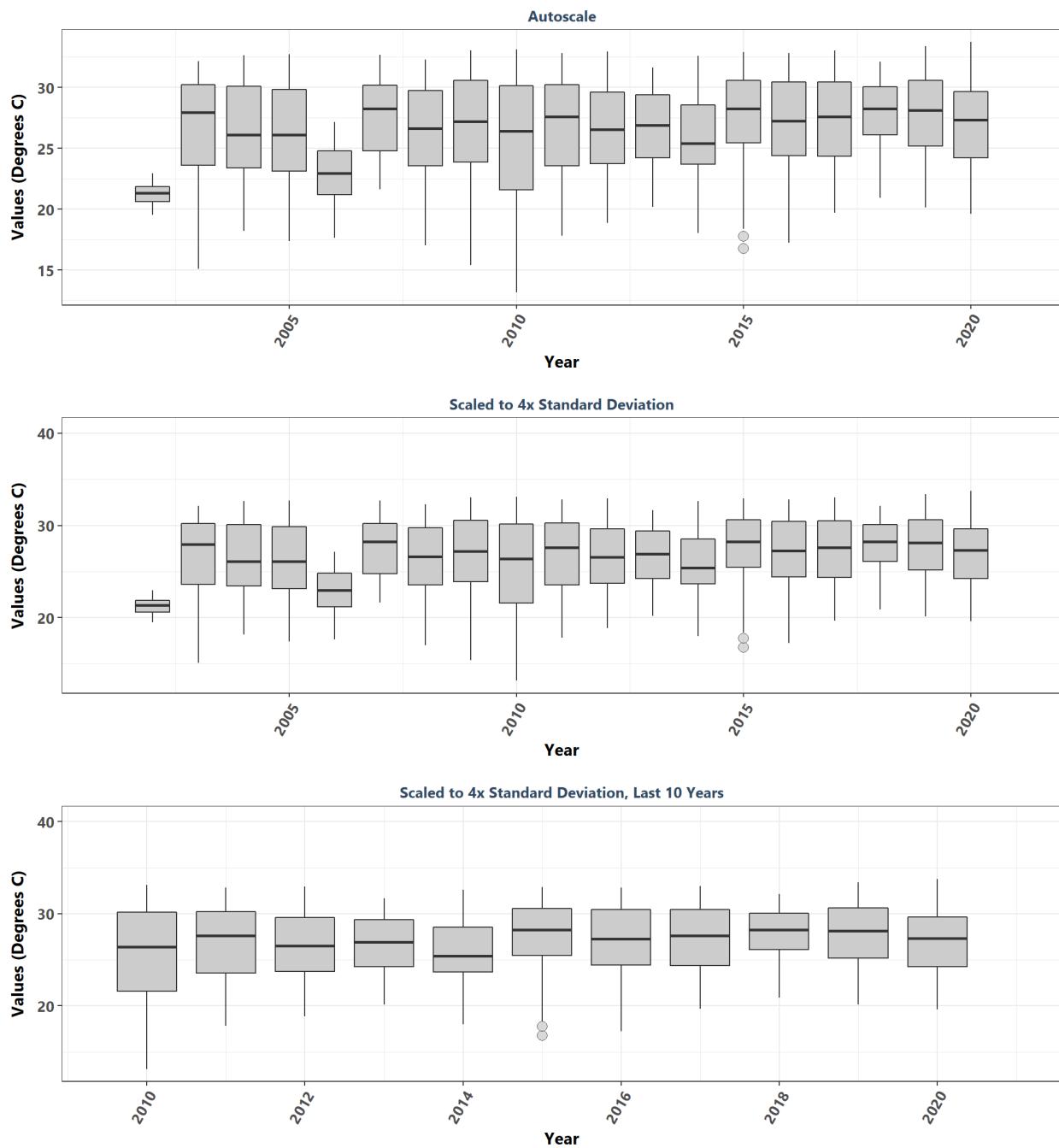
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**38**  
**By Year & Month**



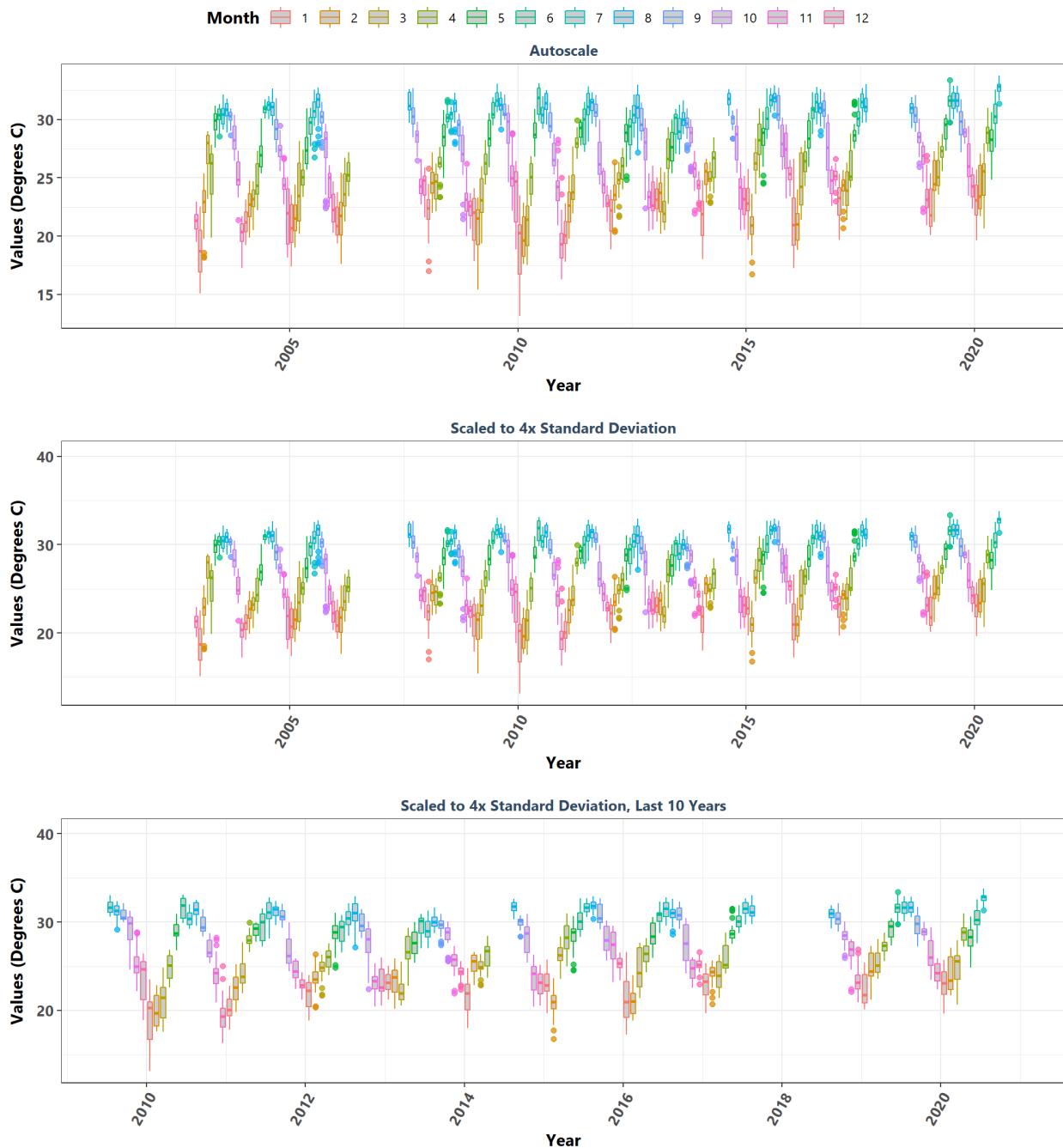
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**38**  
**By Month**



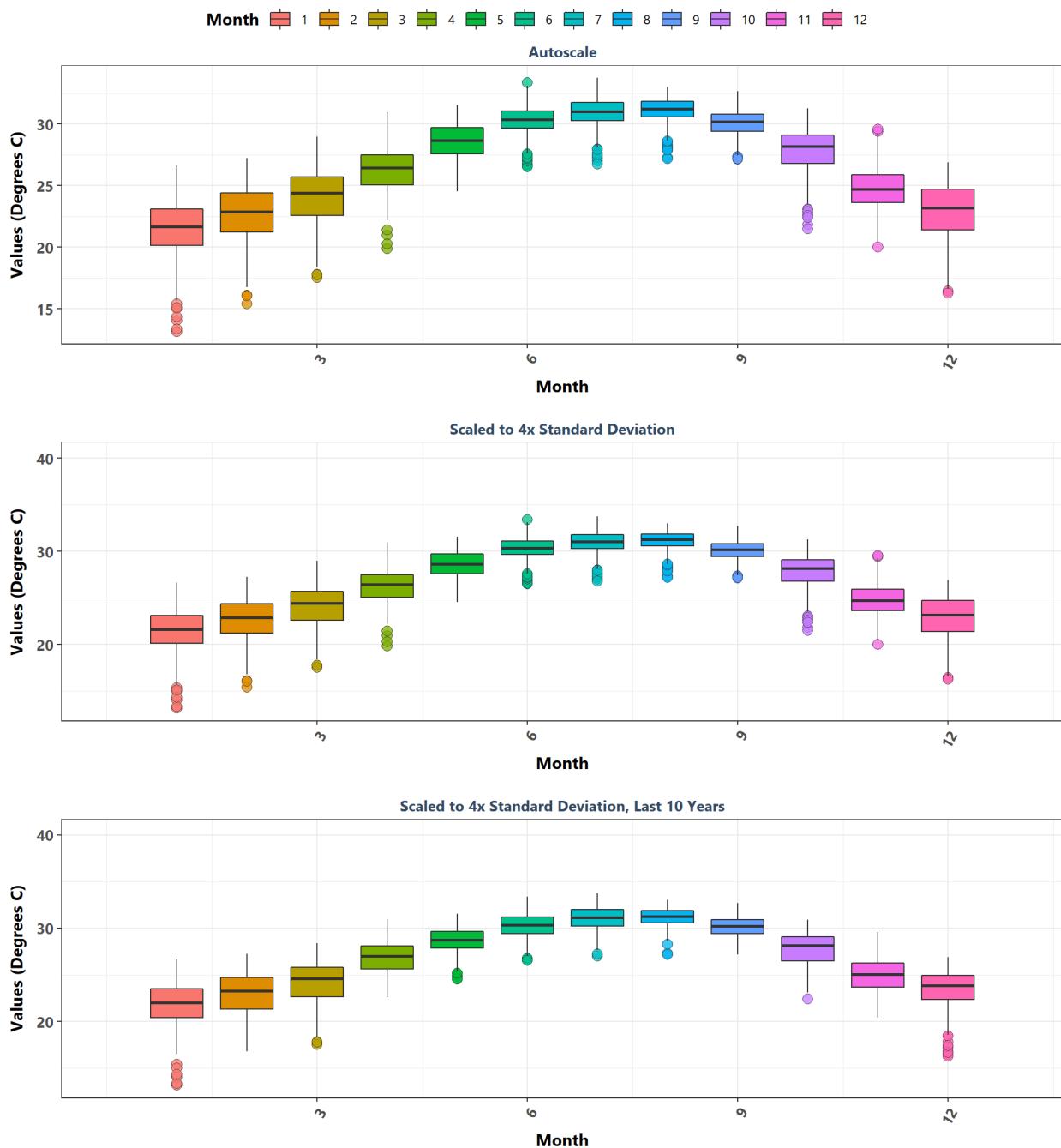
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**40**  
**By Year**



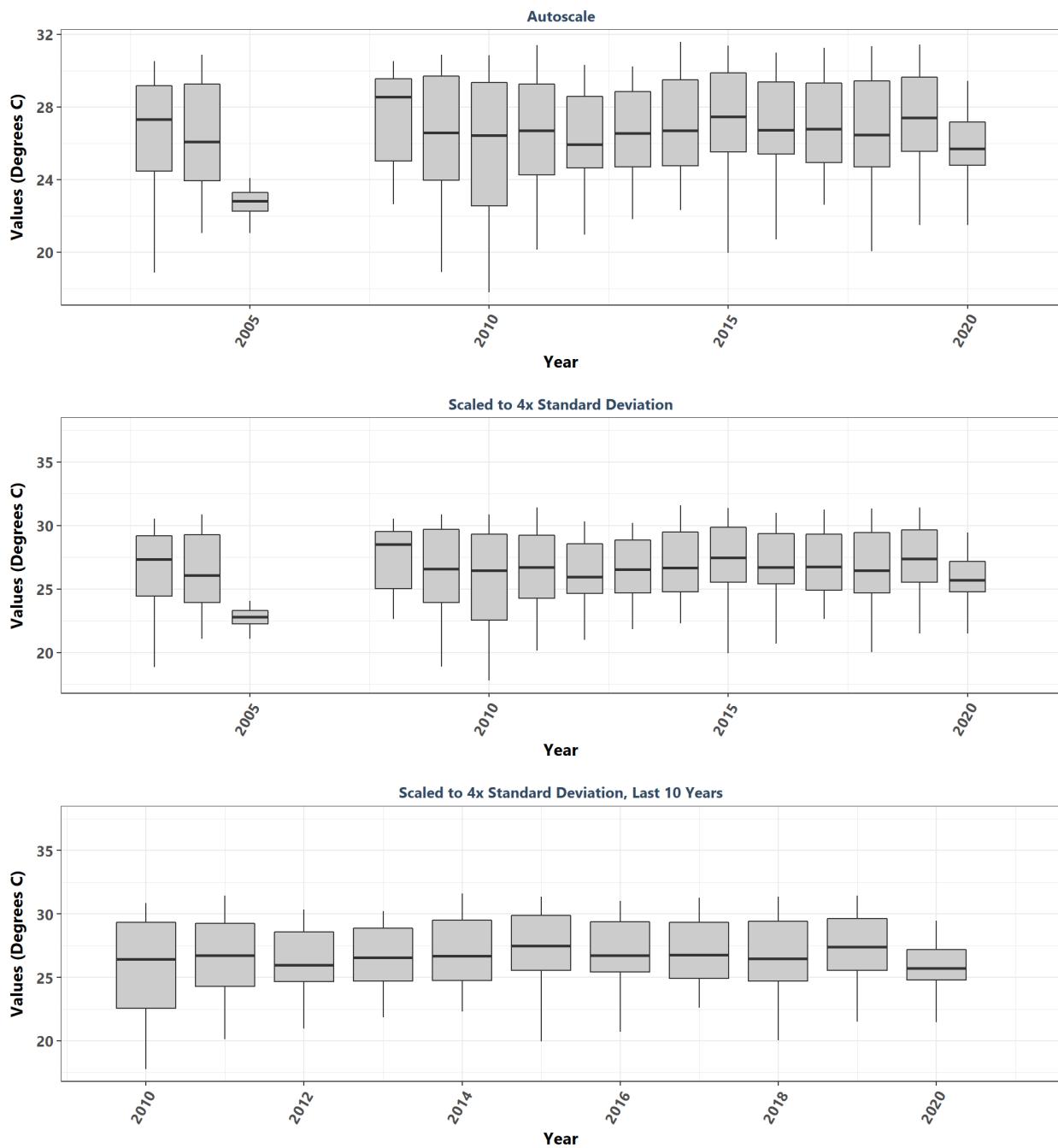
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**40**  
**By Year & Month**



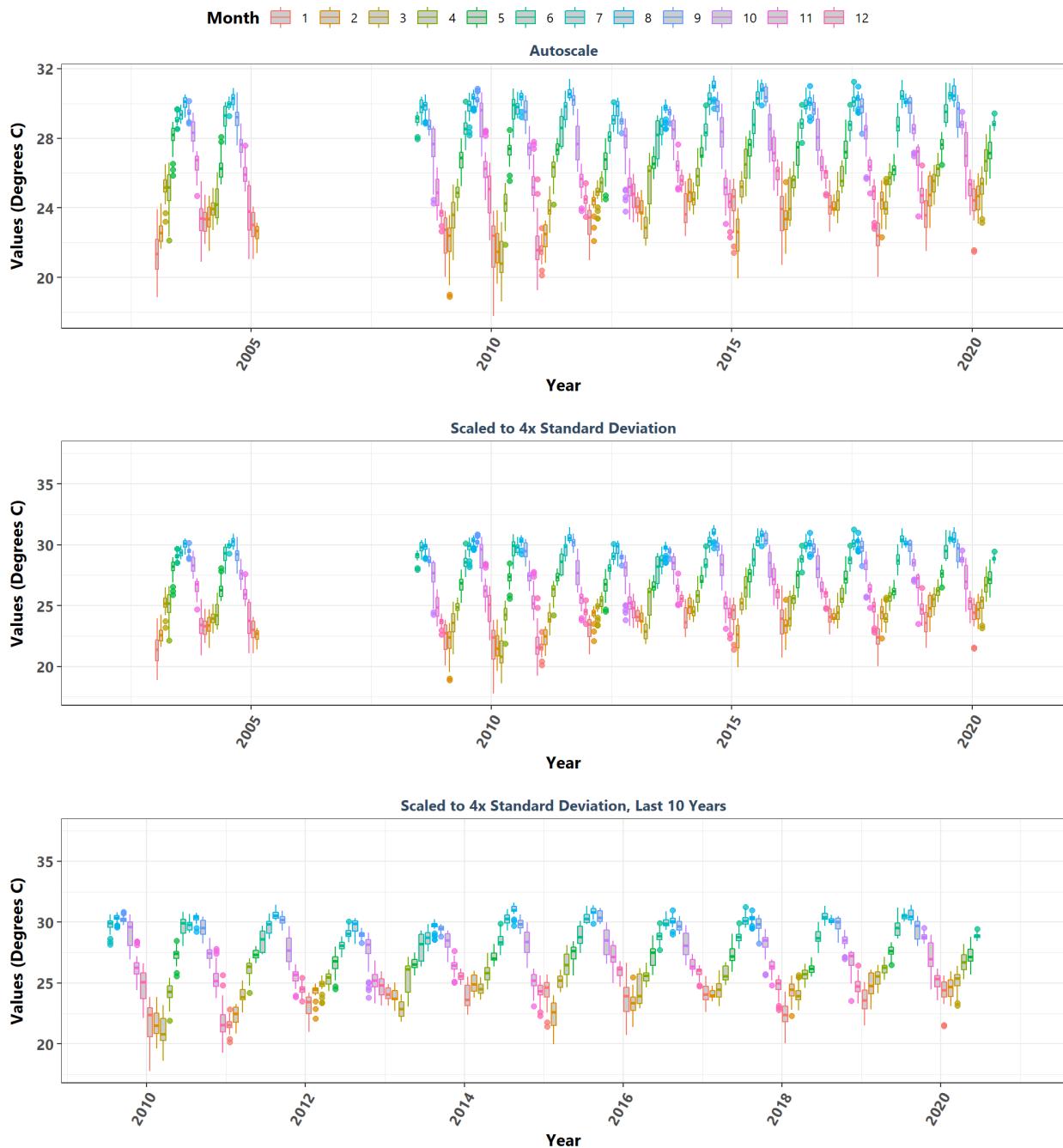
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**40**  
**By Month**



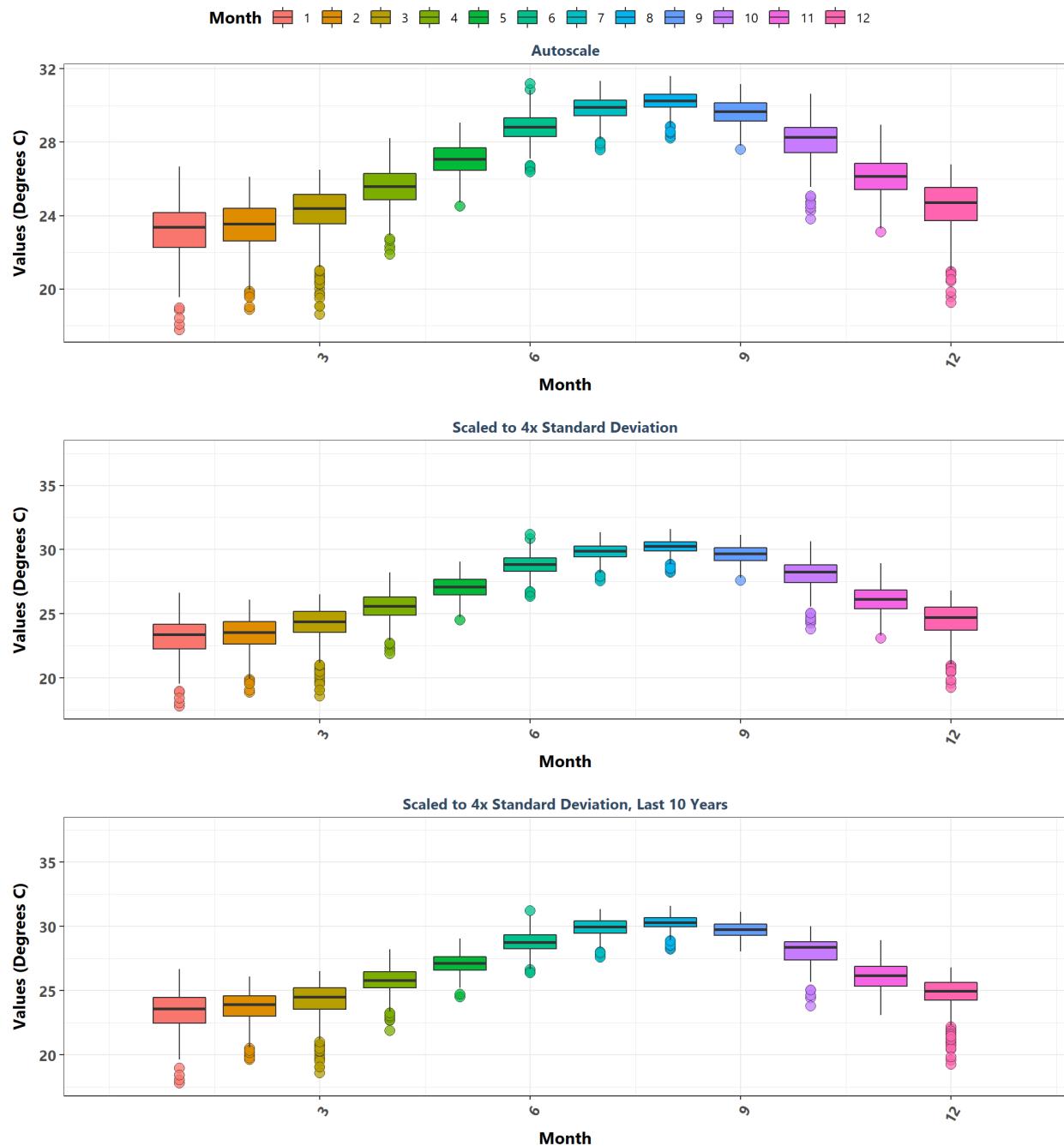
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51  
By Year



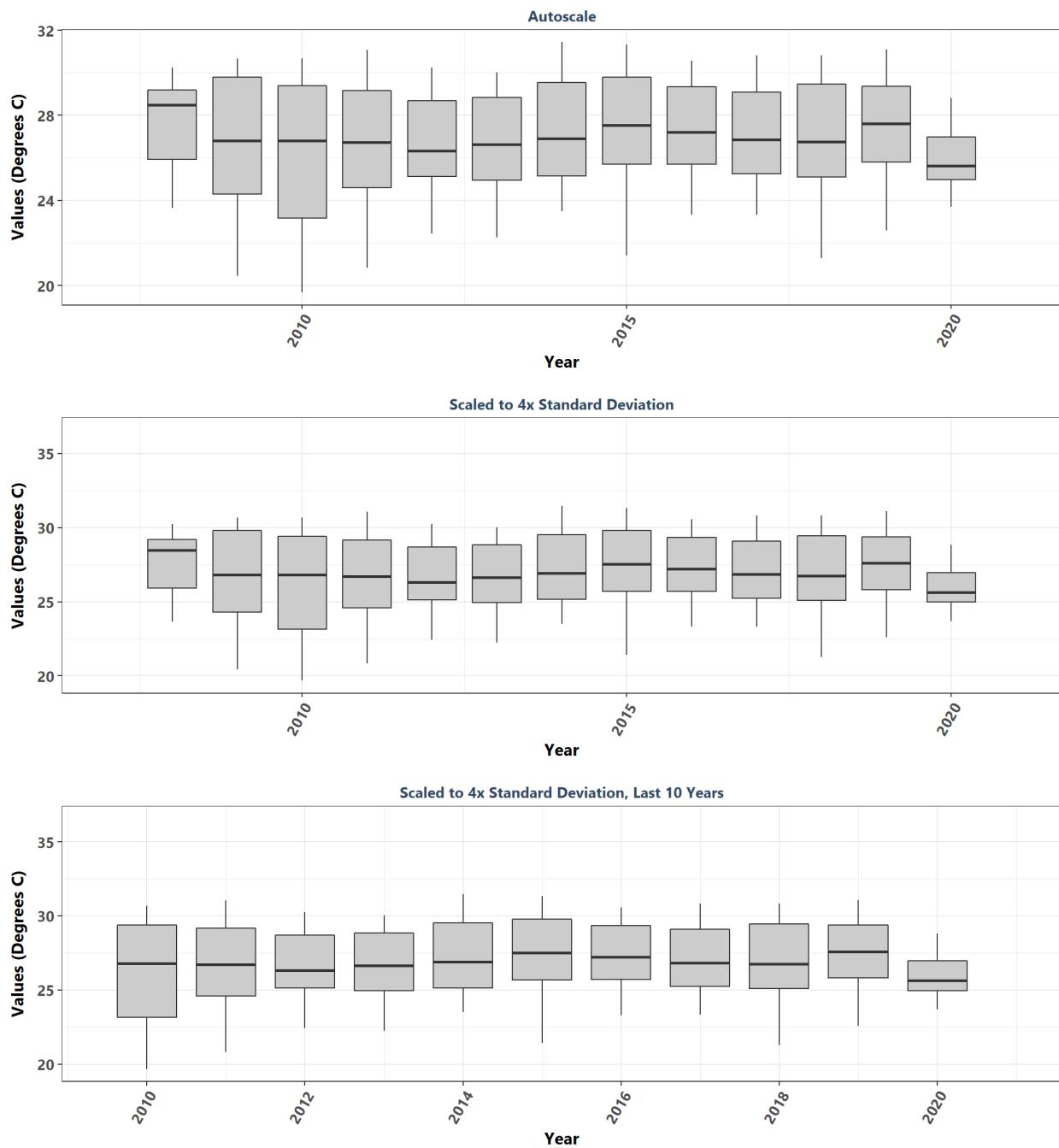
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**51**  
**By Year & Month**



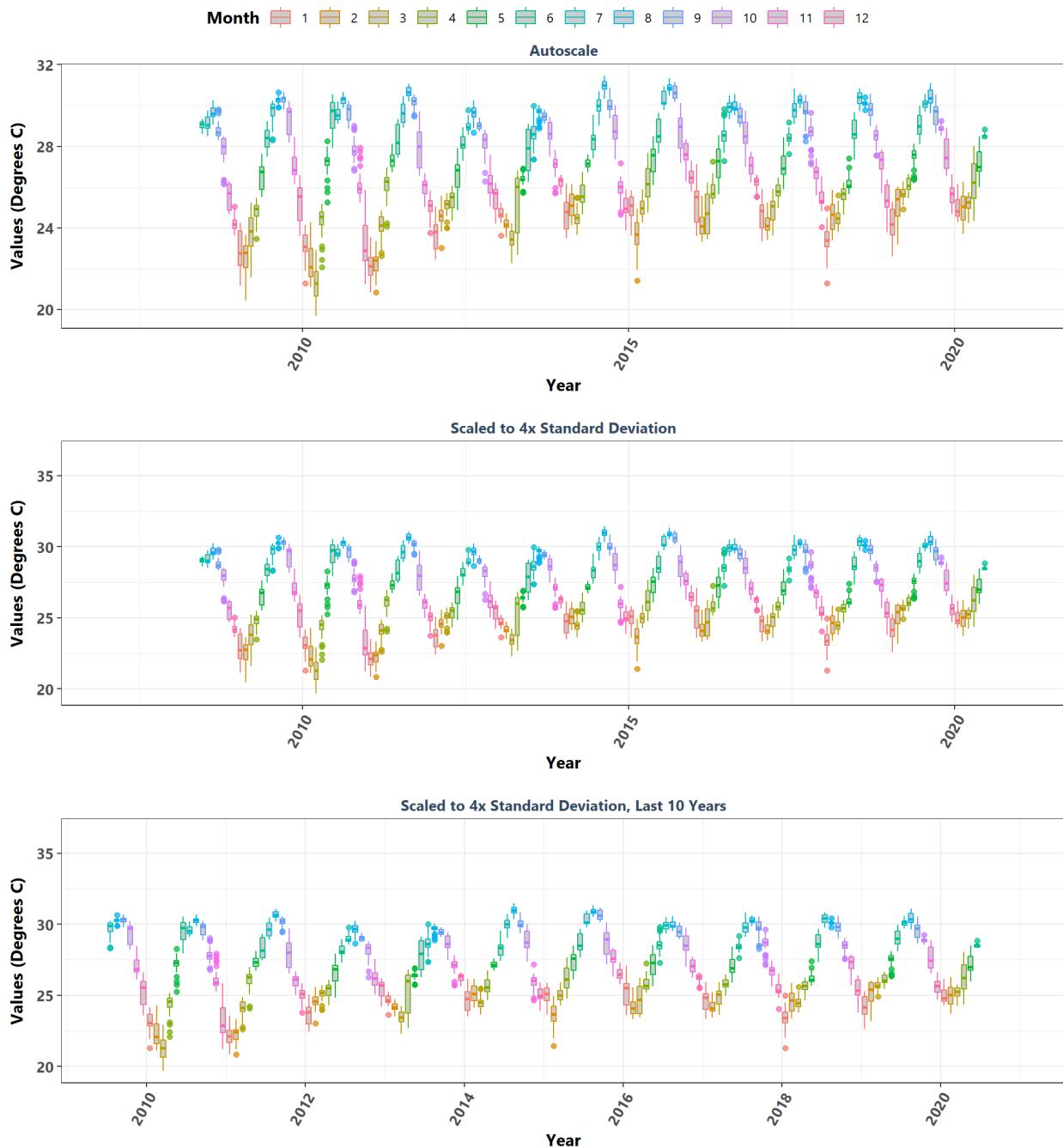
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**51**  
**By Month**



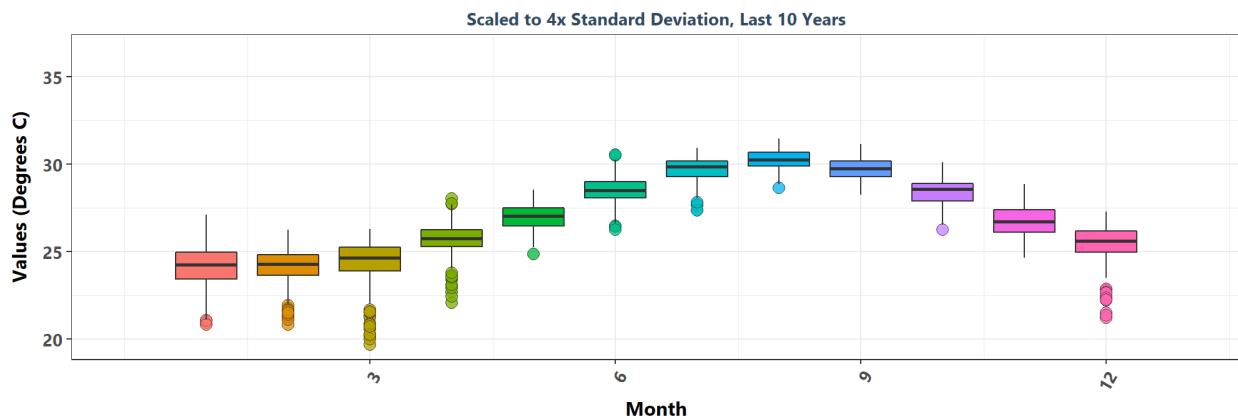
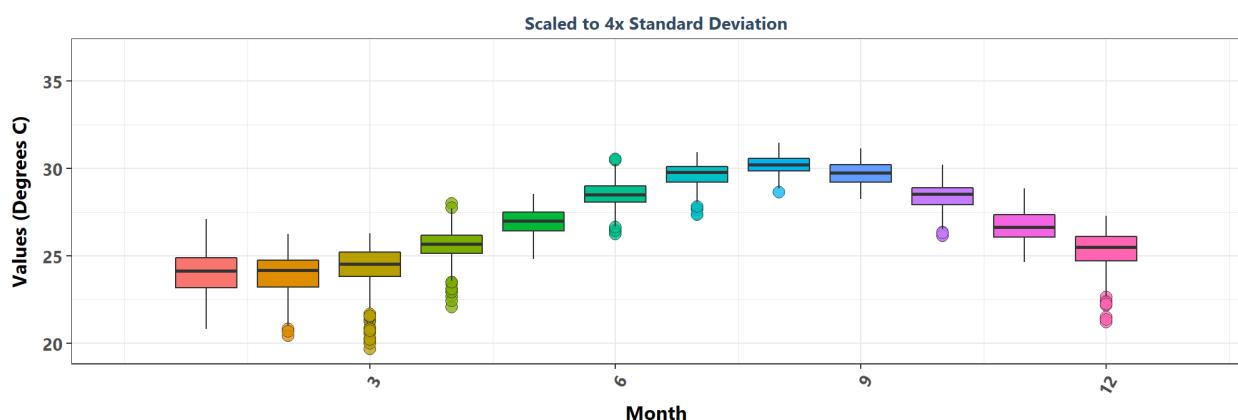
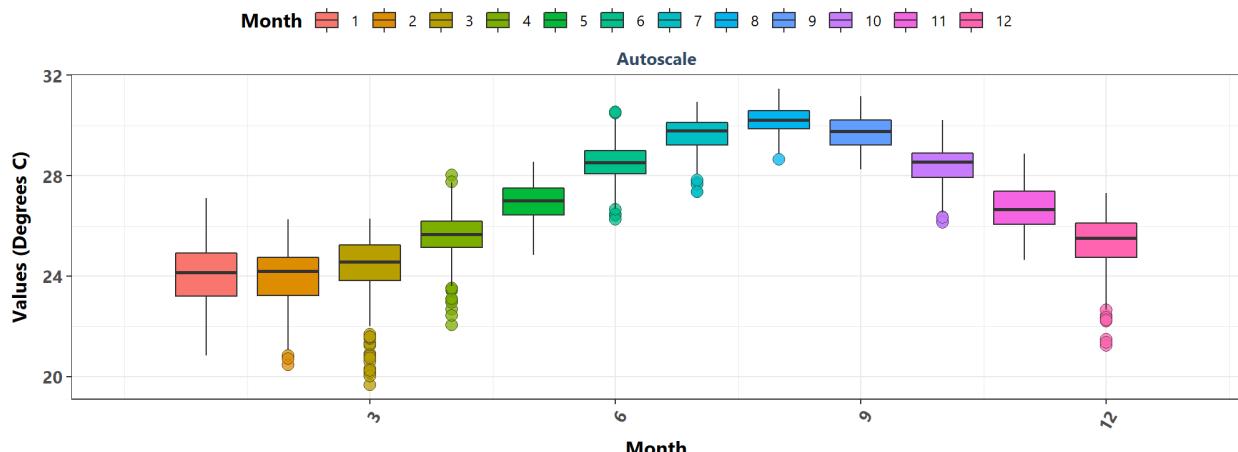
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52  
By Year



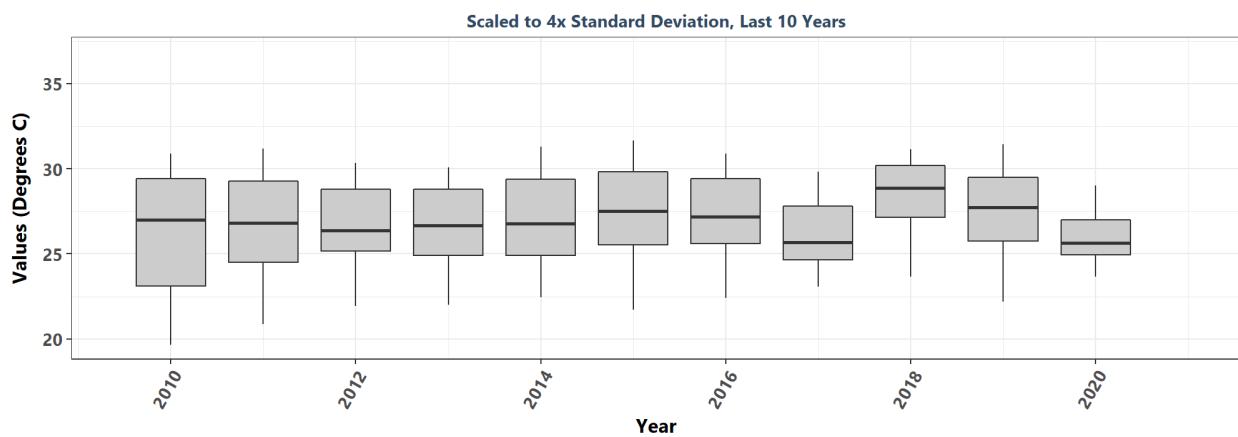
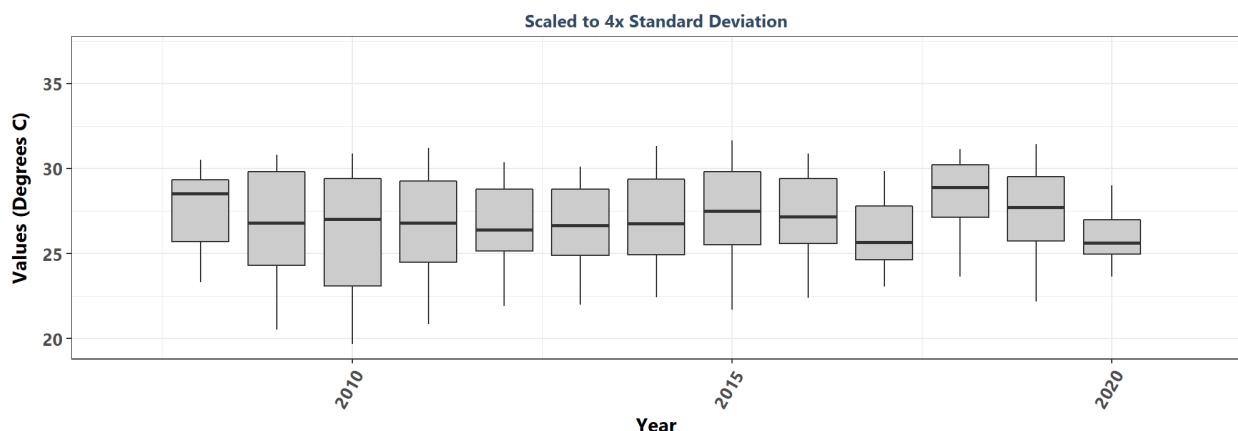
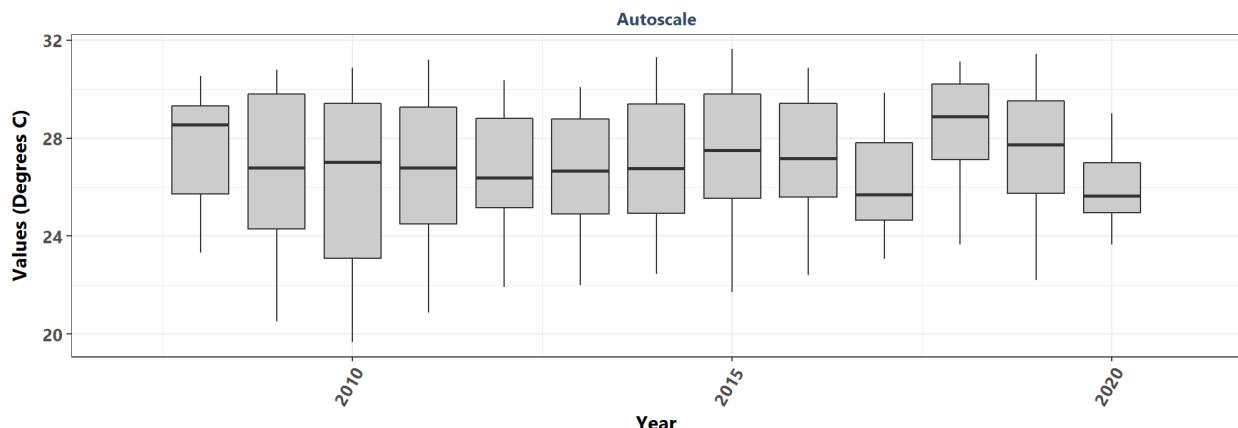
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**52**  
**By Year & Month**



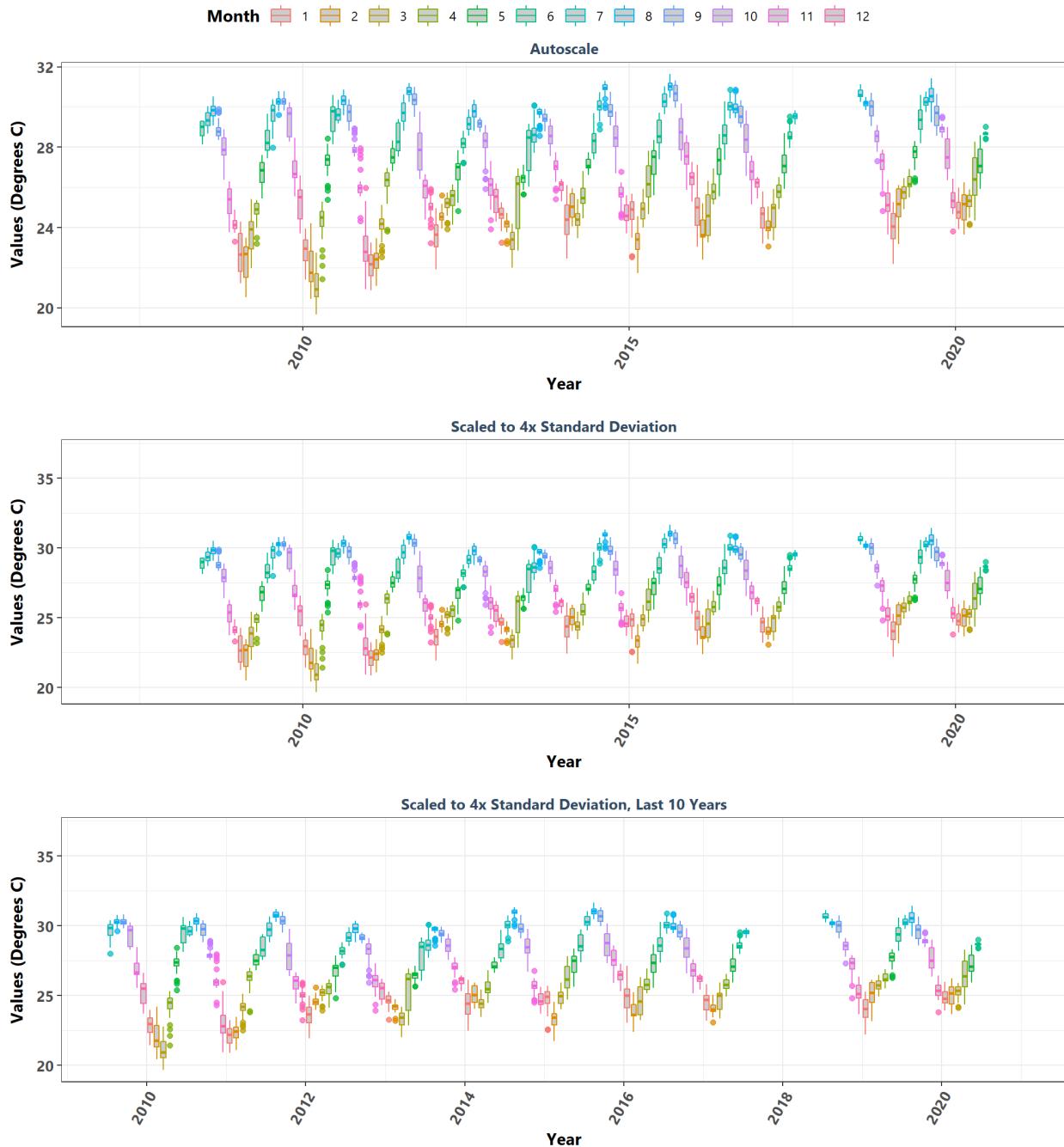
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**52**  
**By Month**



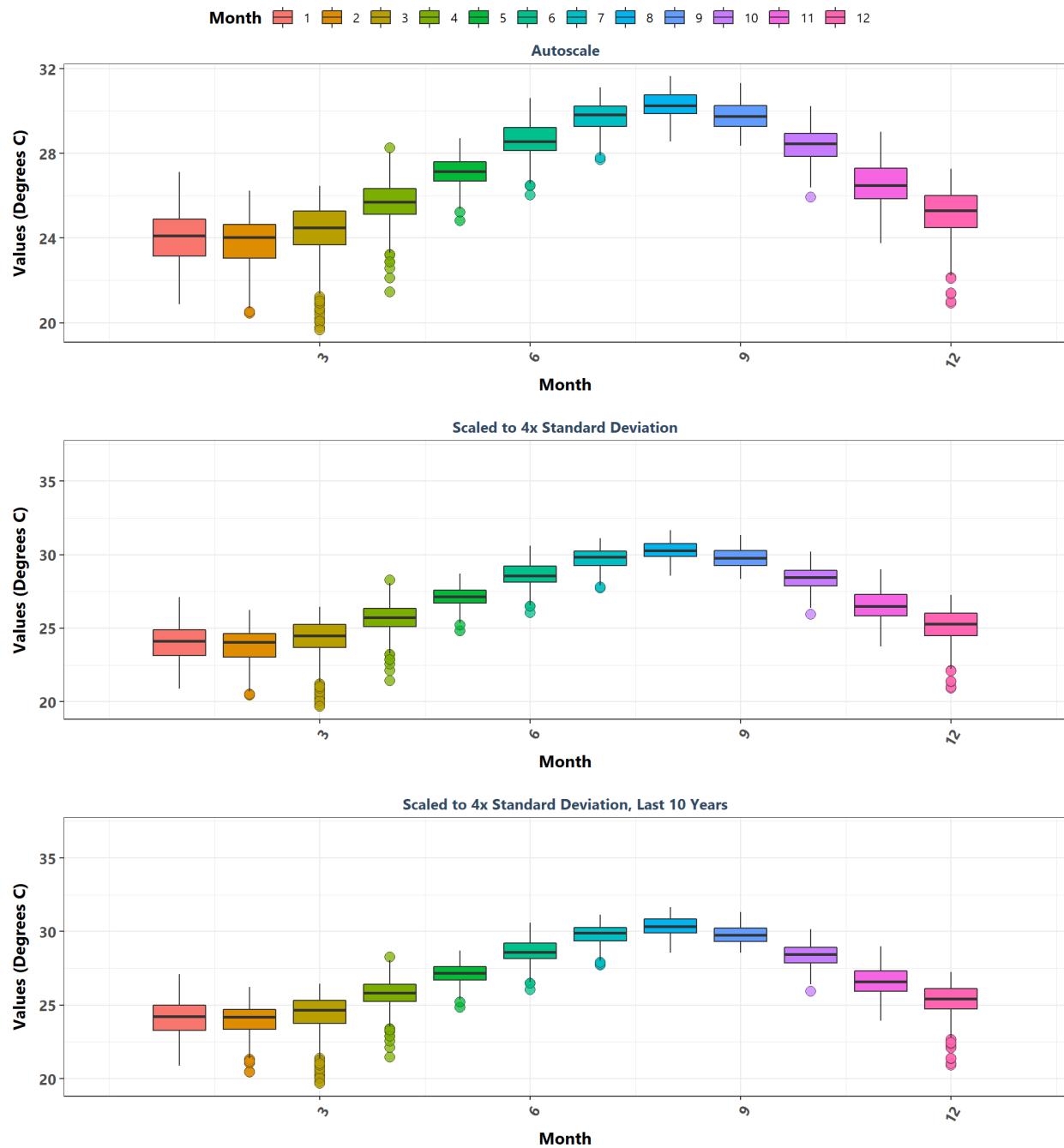
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986 | Water Temperature on Coral Reefs in the Florida Keys  
53  
By Year



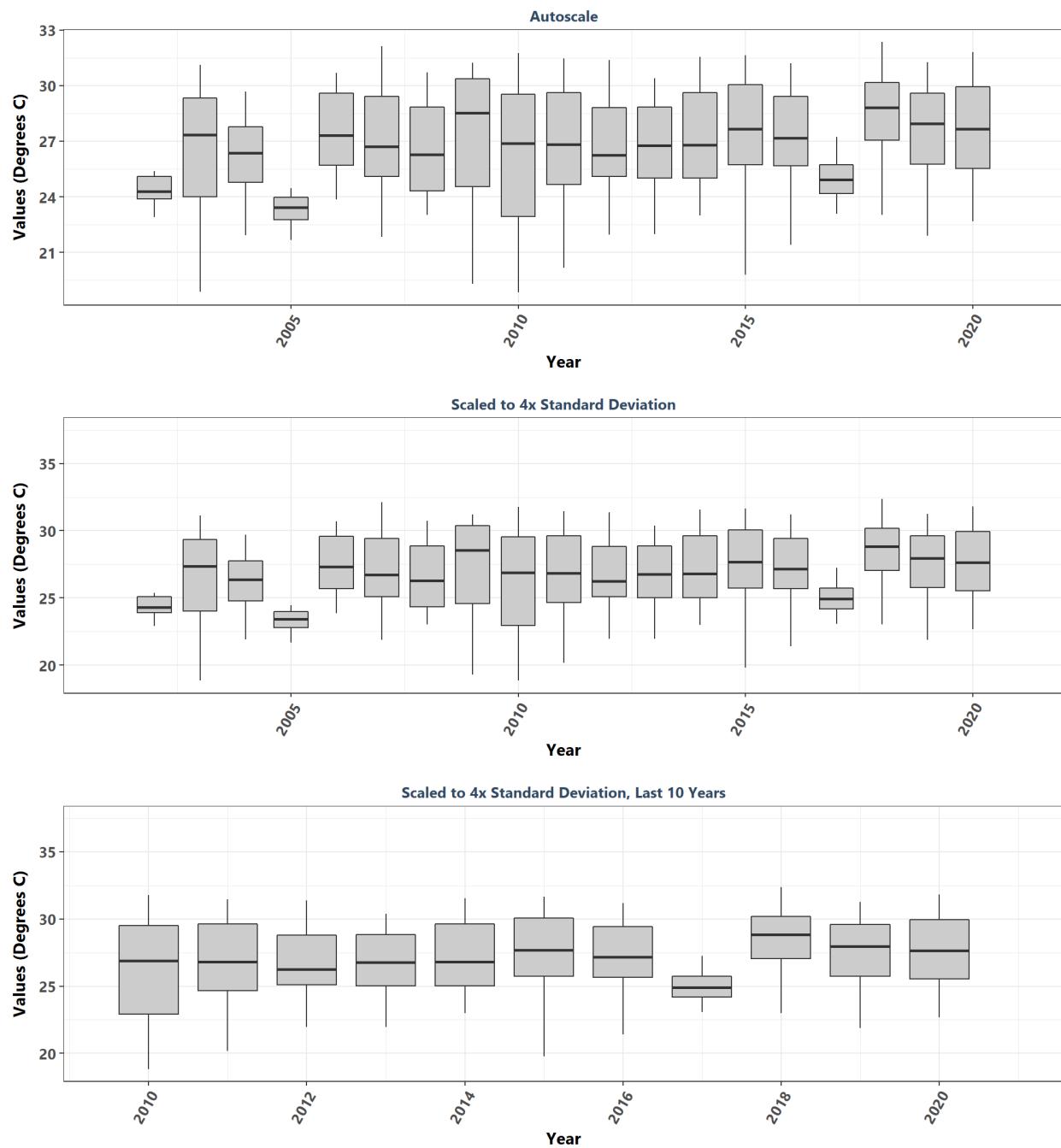
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**53**  
**By Year & Month**



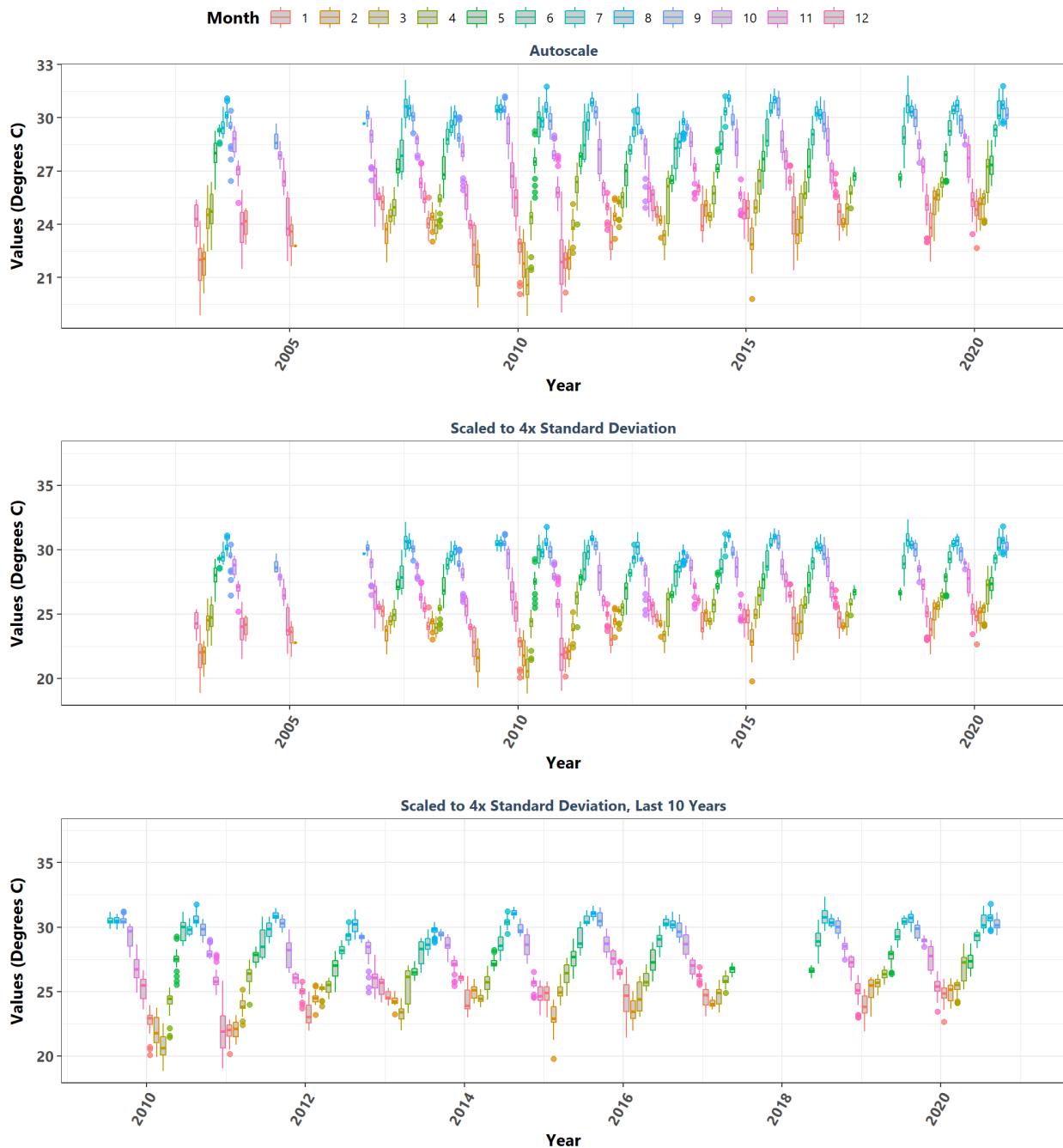
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**53**  
**By Month**



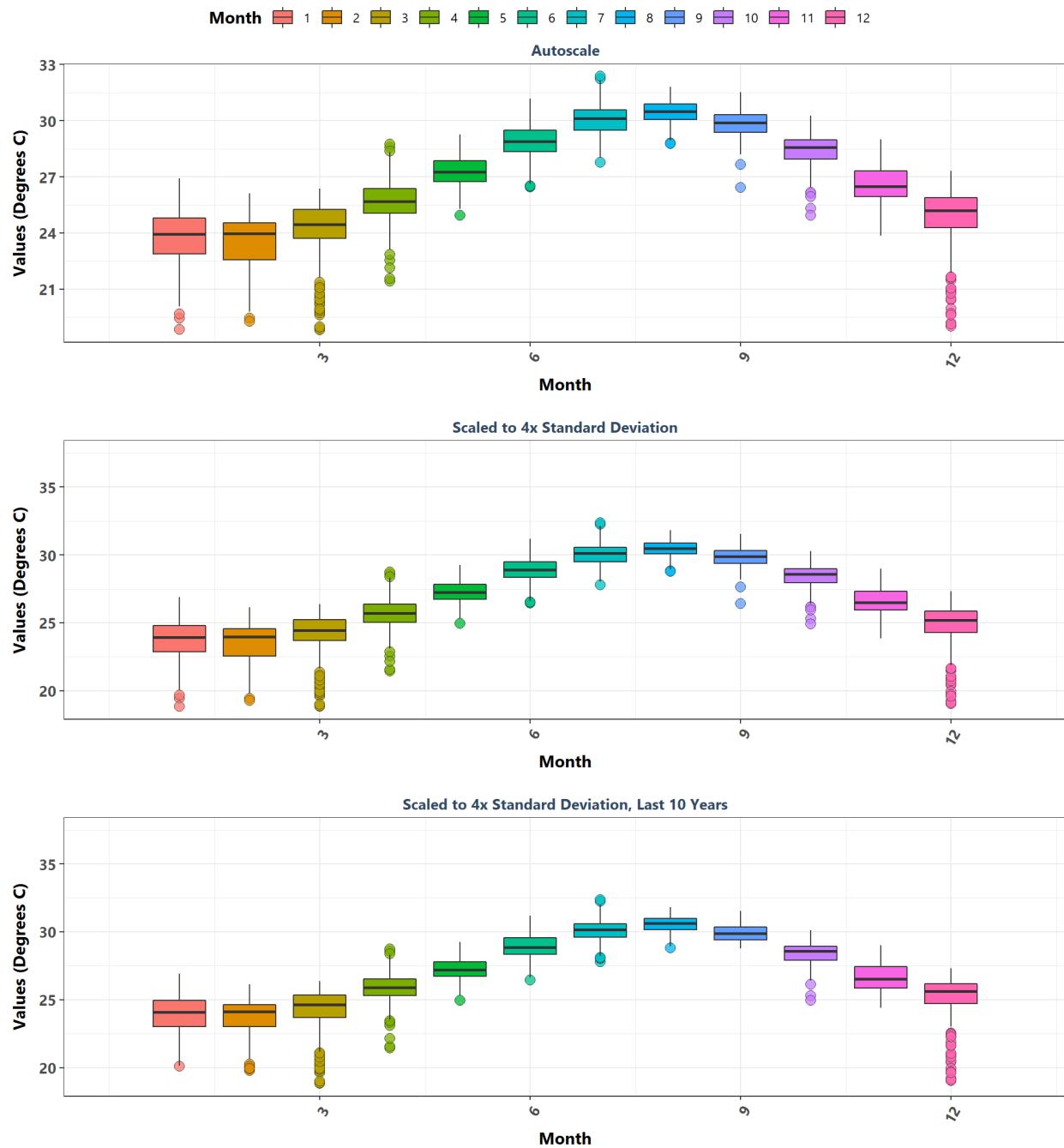
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**55**  
**By Year**



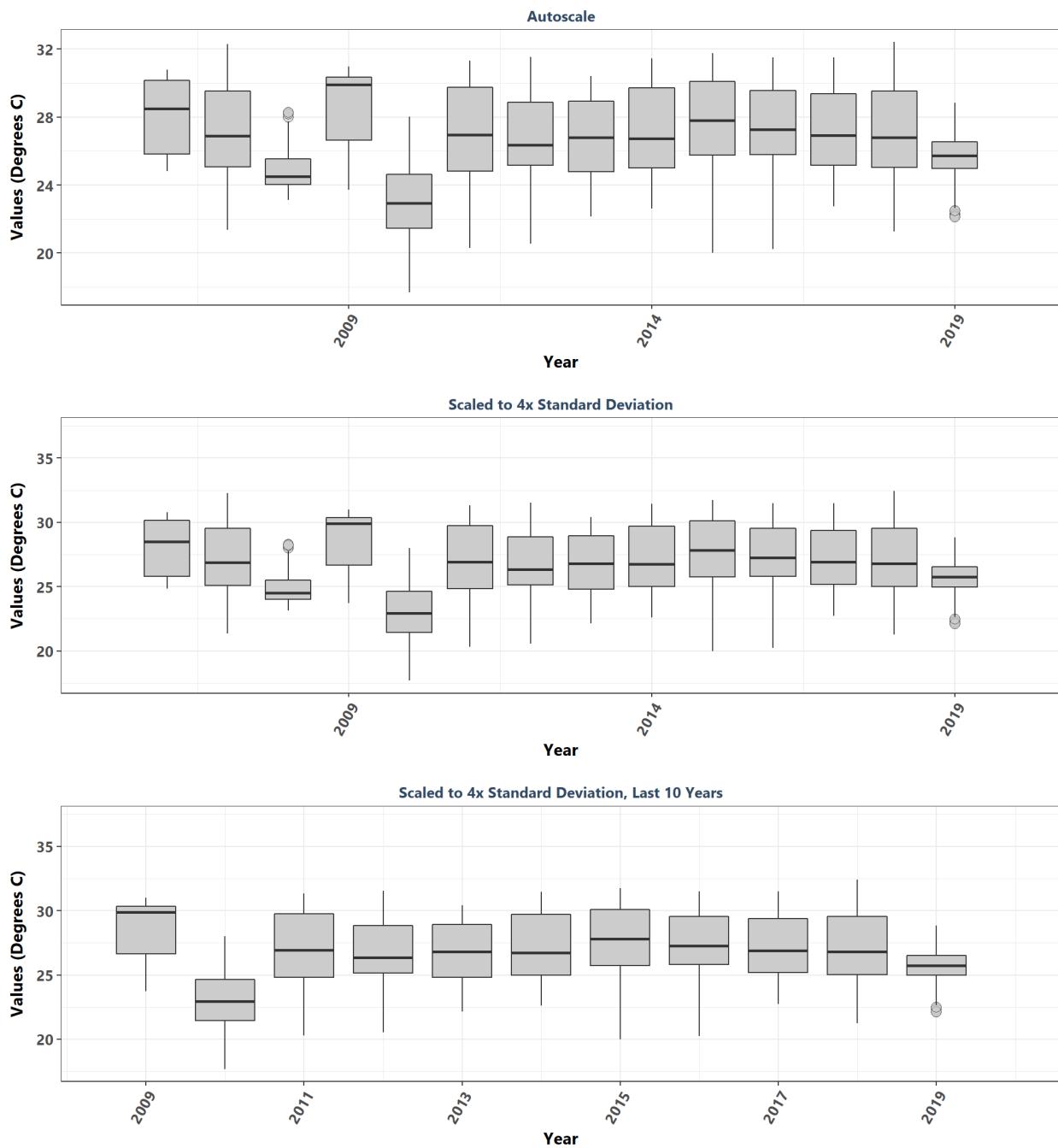
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**55**  
**By Year & Month**



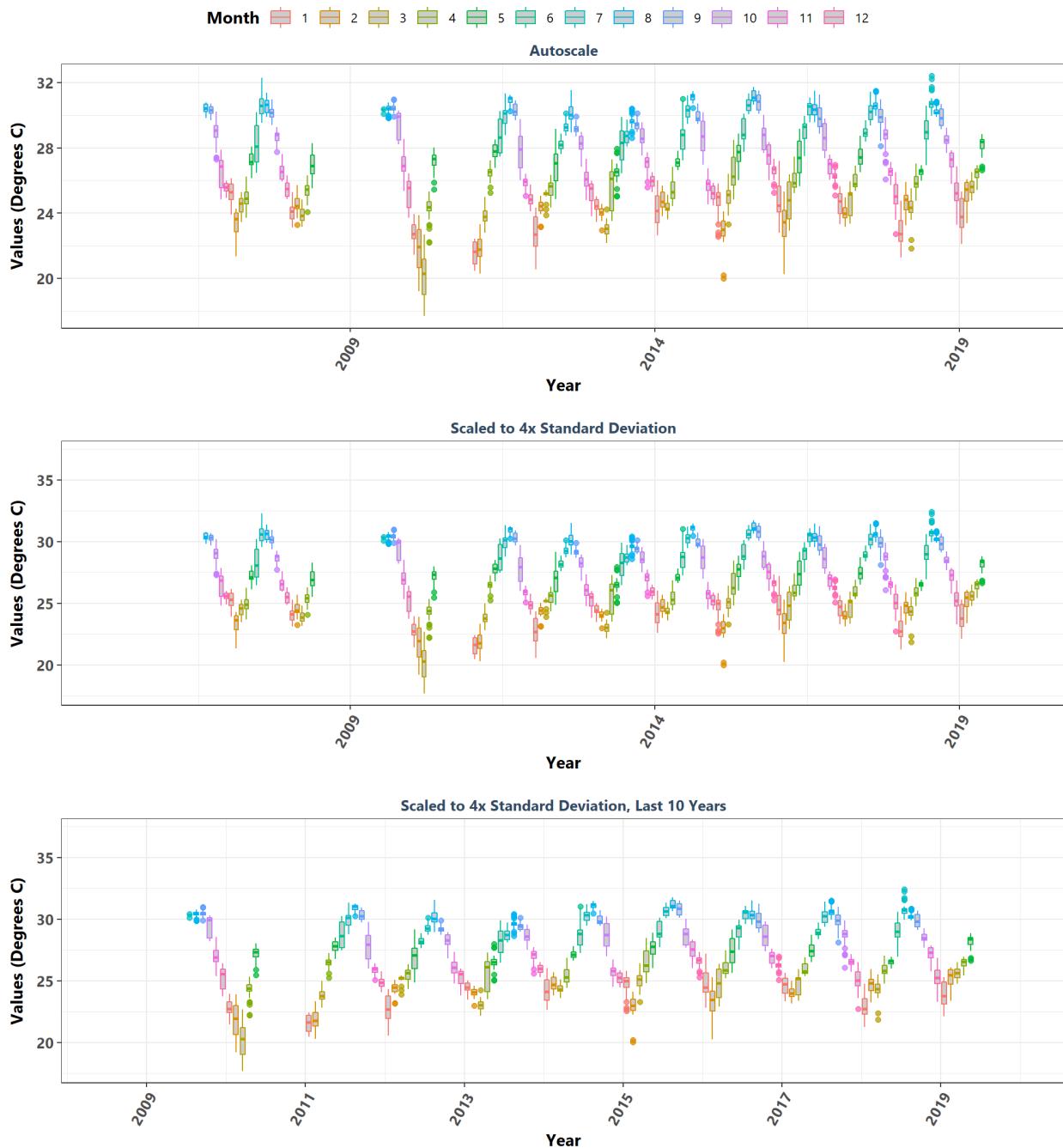
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**55**  
**By Month**



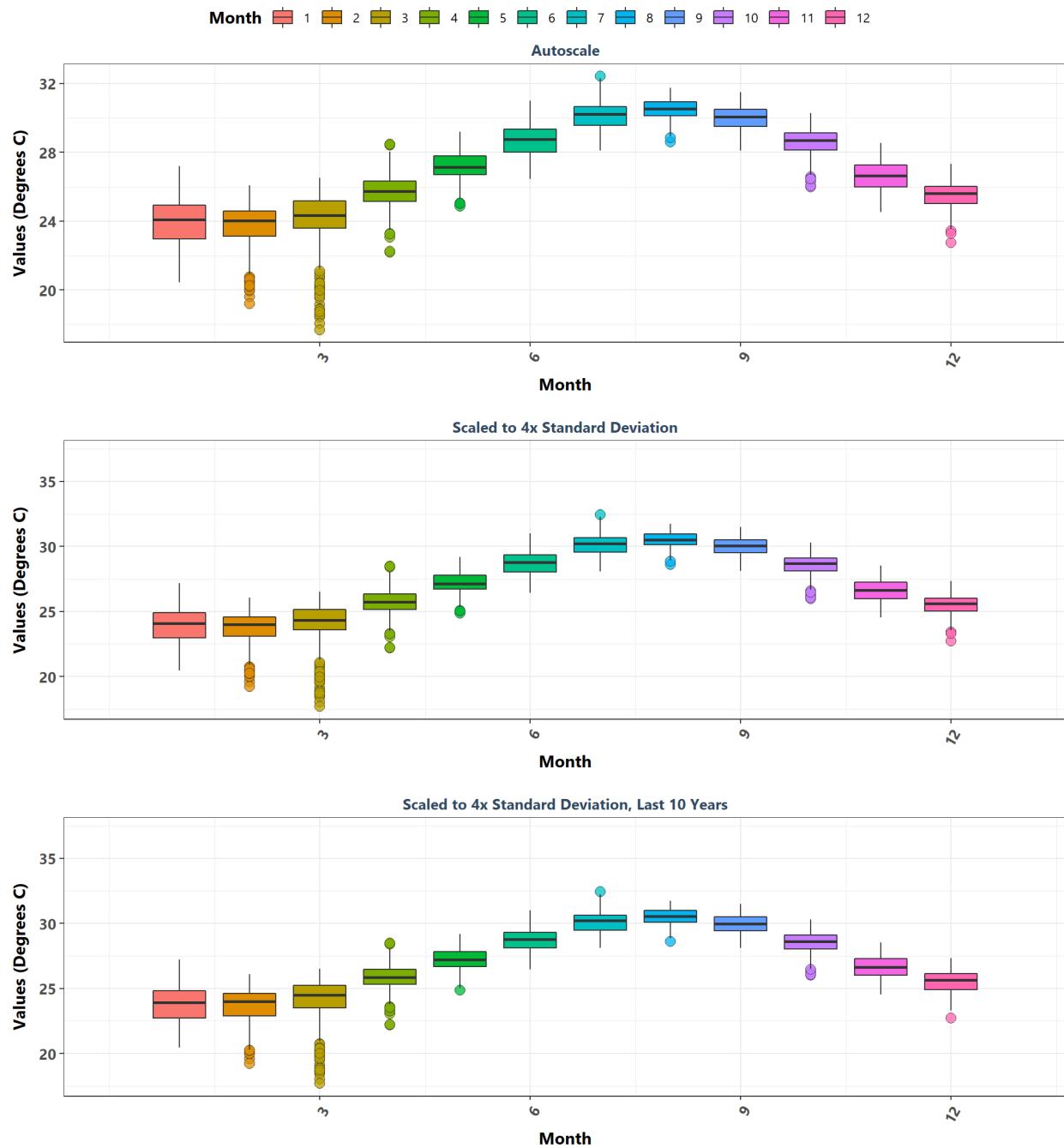
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56  
By Year



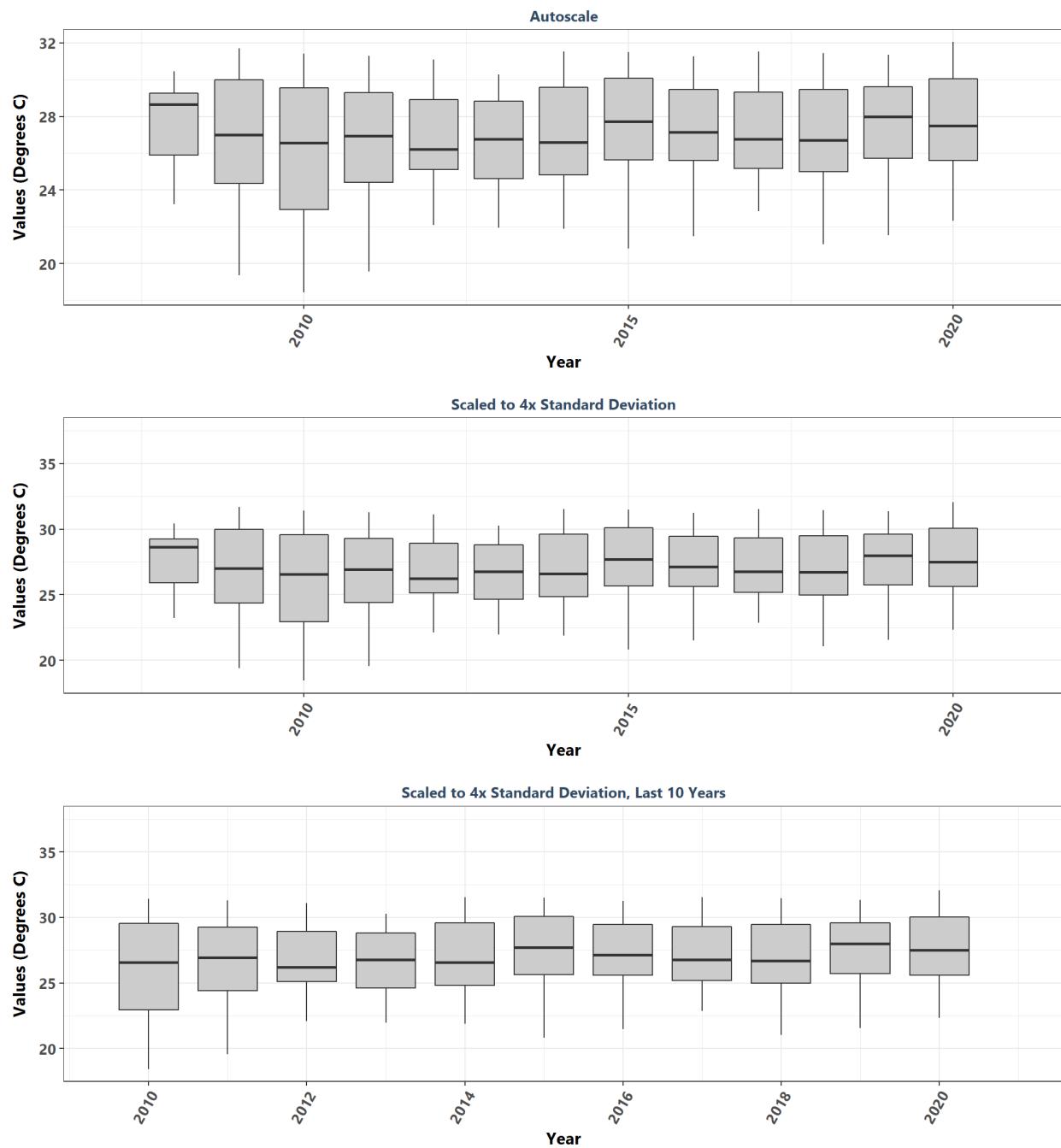
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**56**  
**By Year & Month**



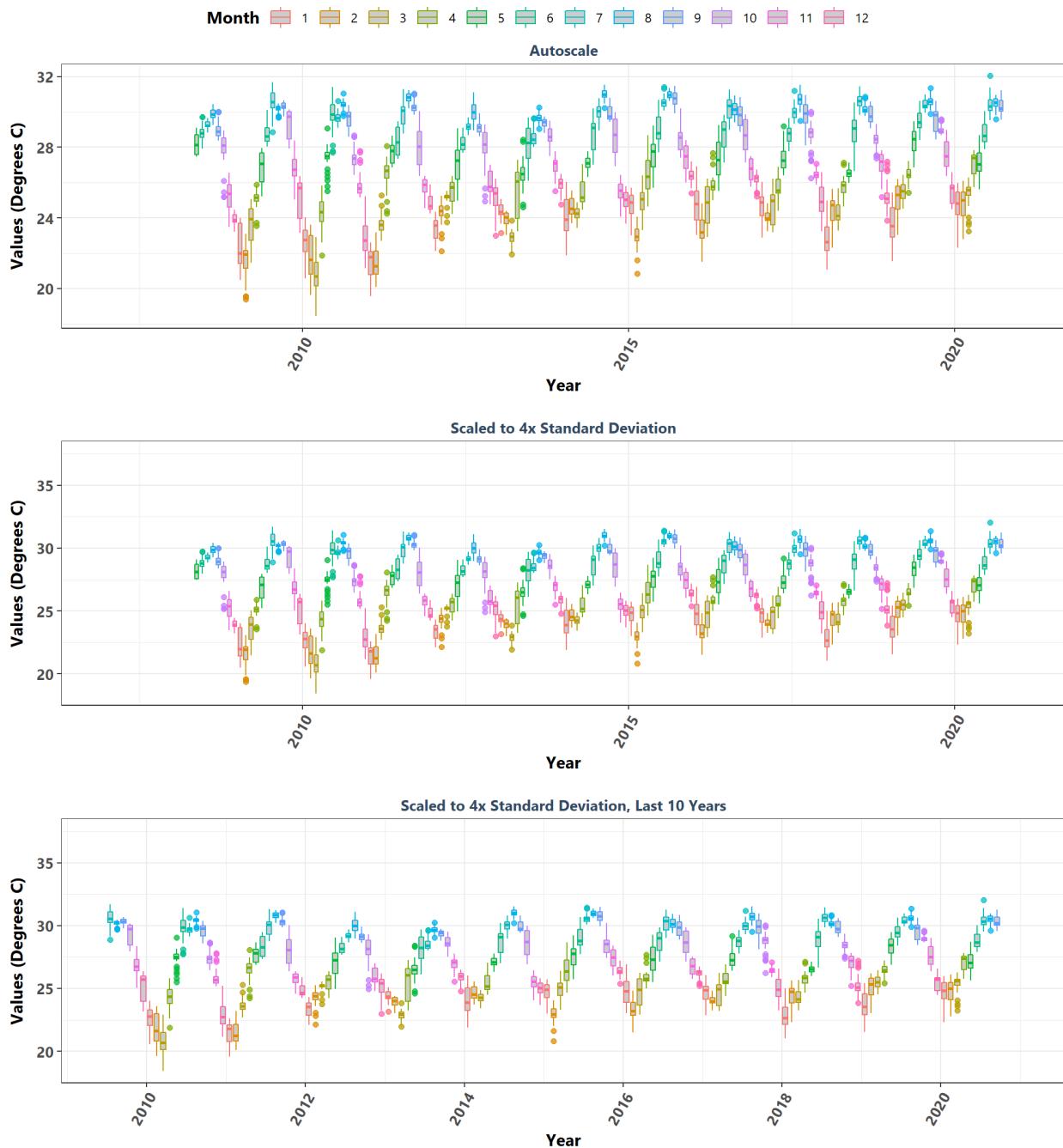
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**56**  
**By Month**



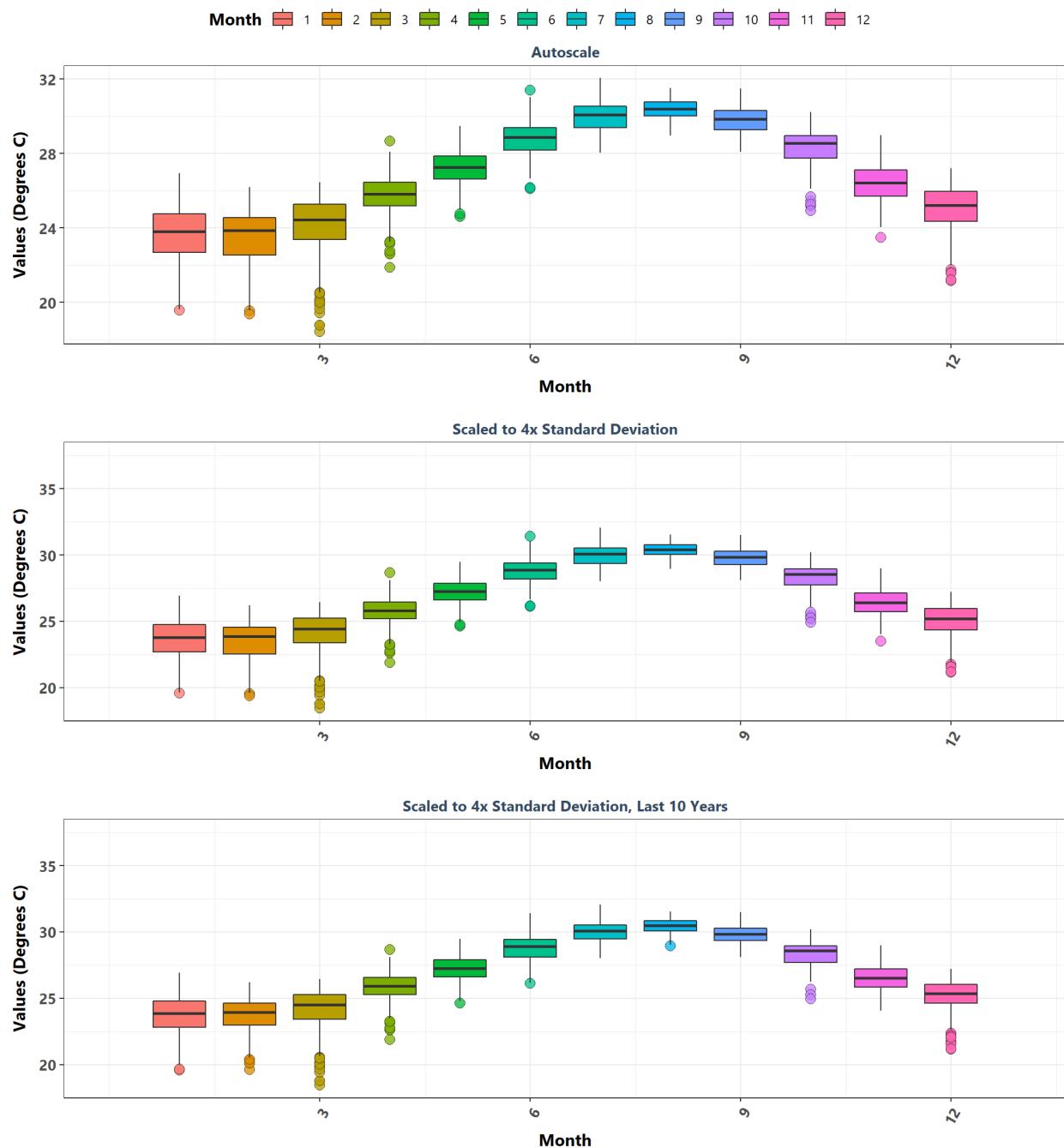
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**57**  
**By Year**



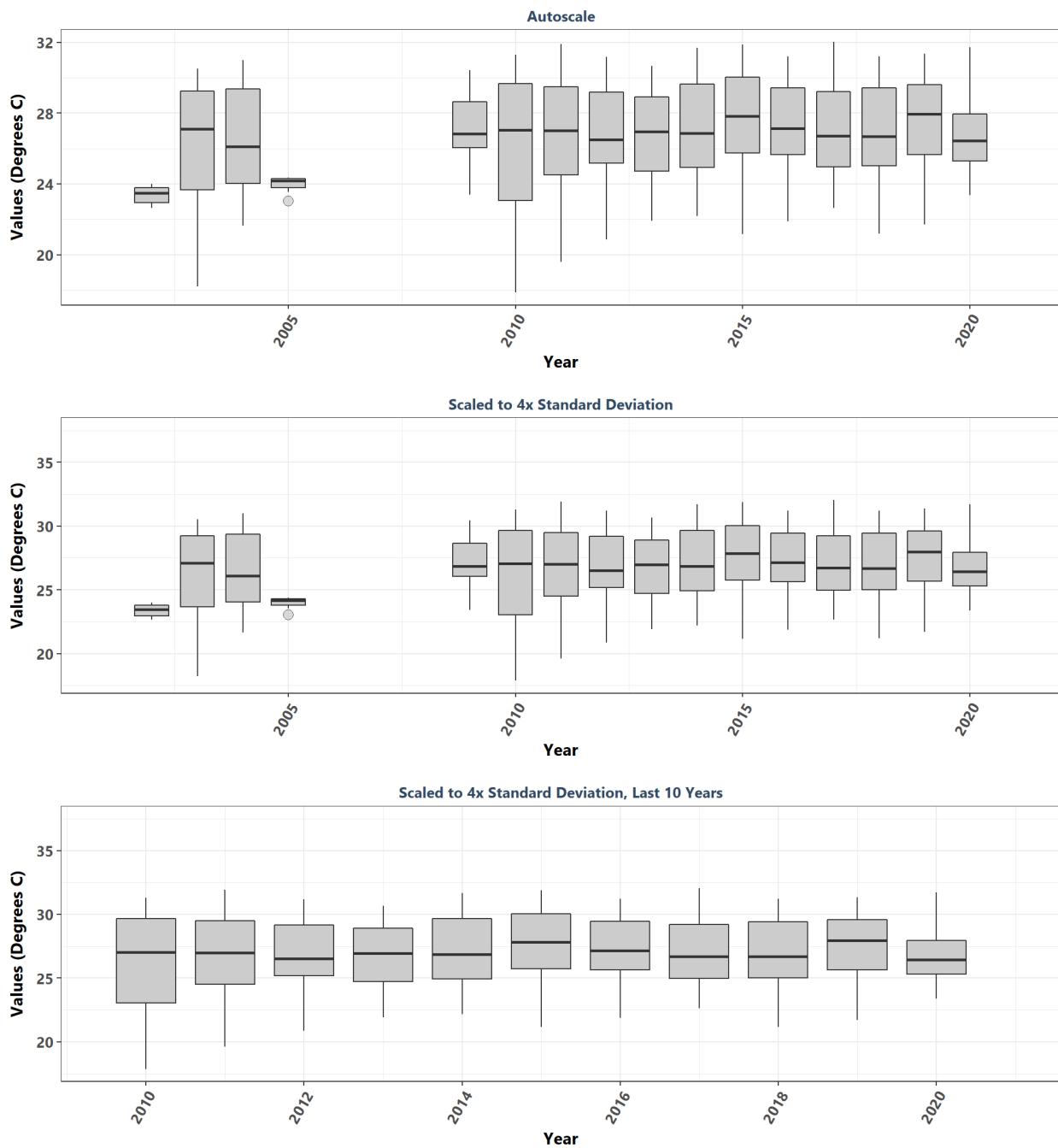
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**57**  
**By Year & Month**



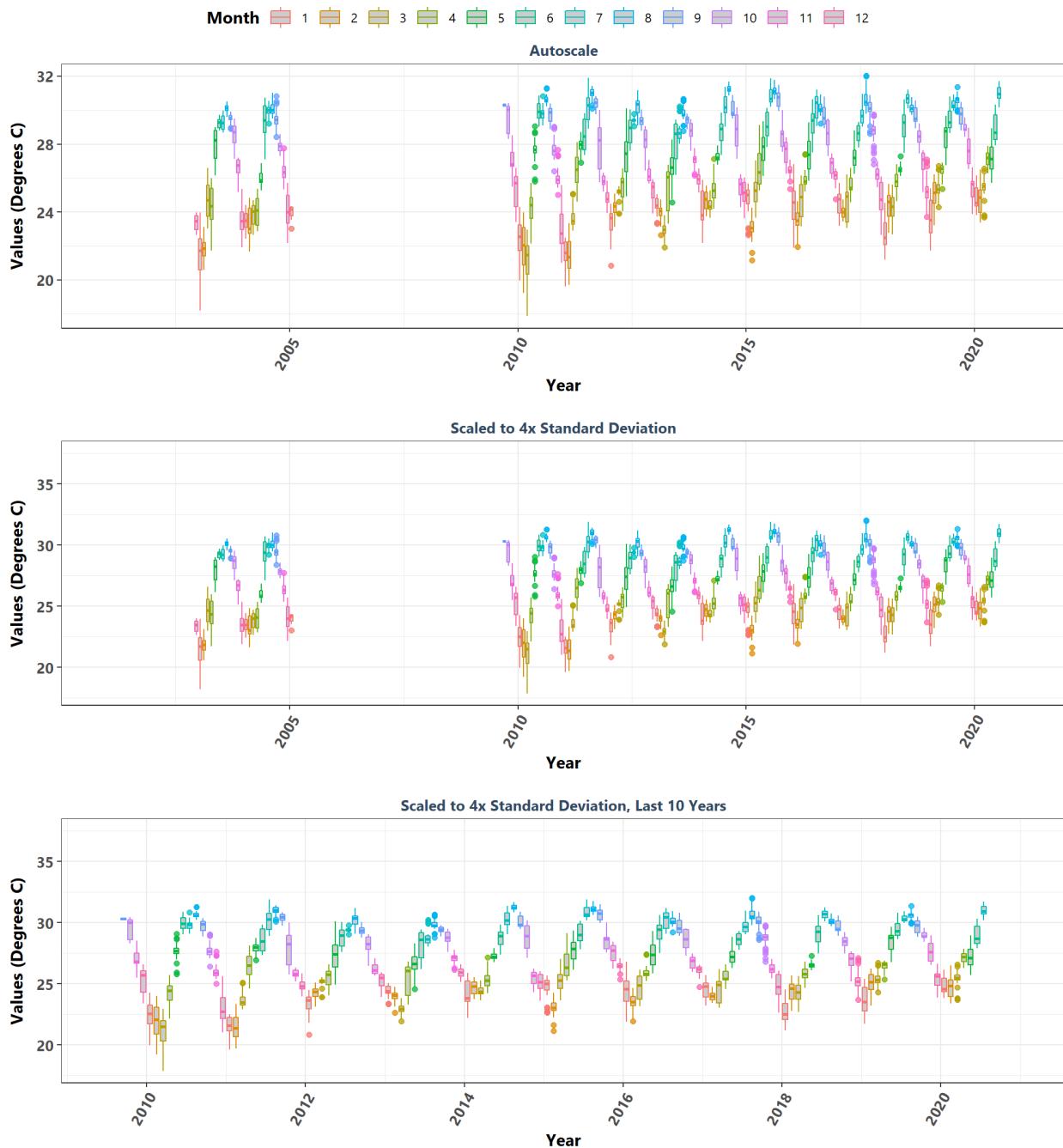
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**57**  
**By Month**



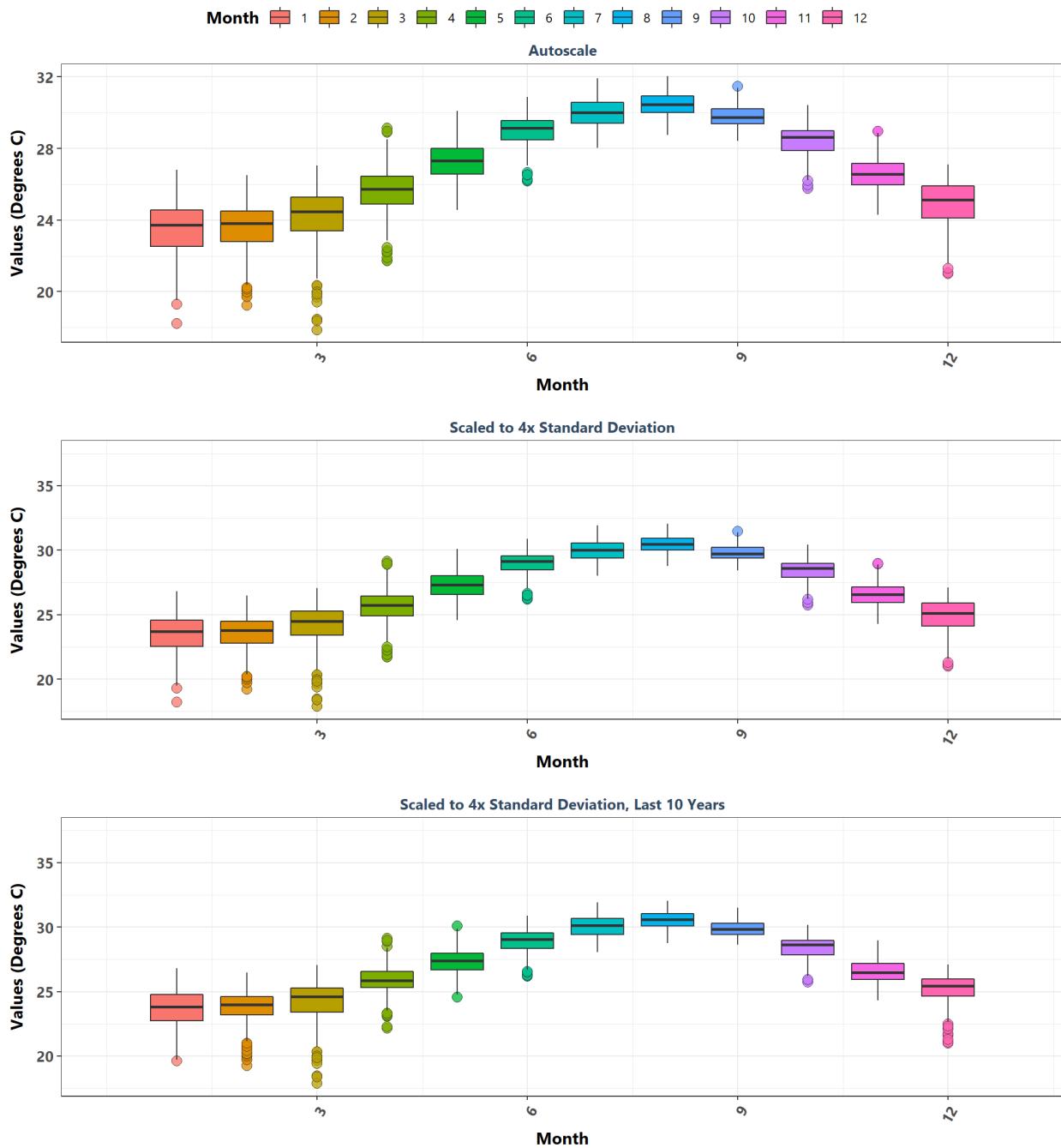
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
59  
By Year



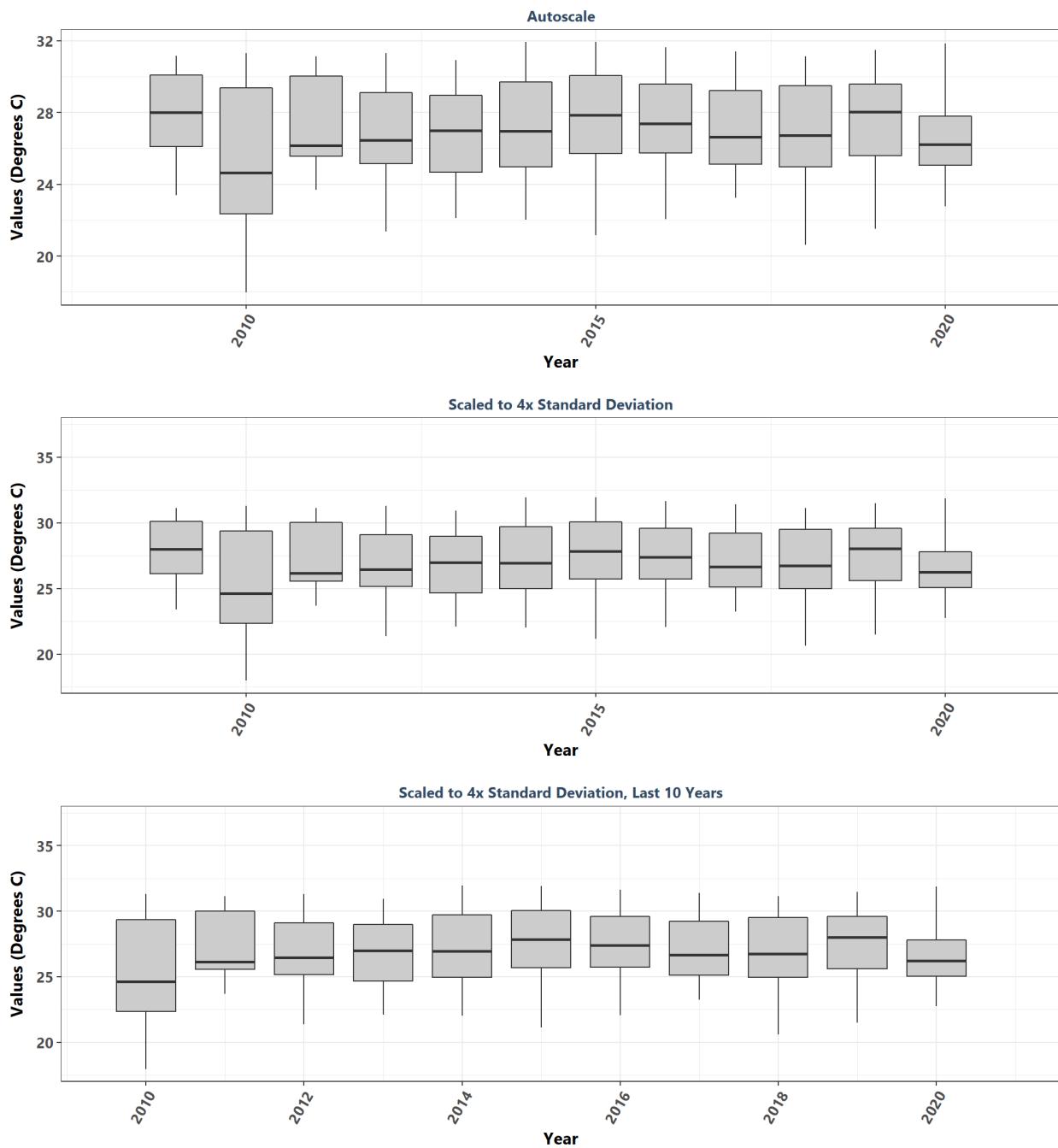
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**59**  
**By Year & Month**



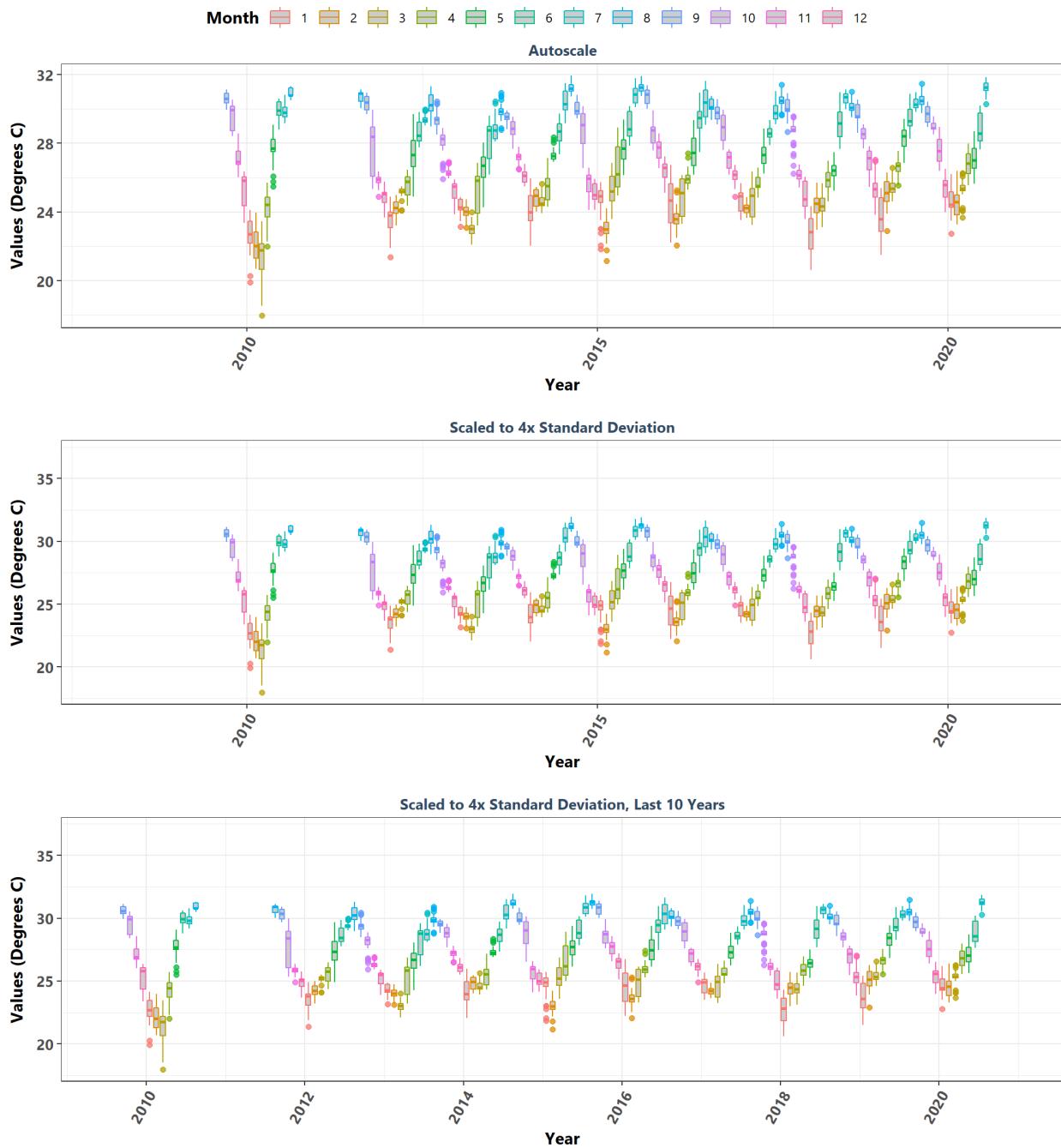
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**59**  
**By Month**



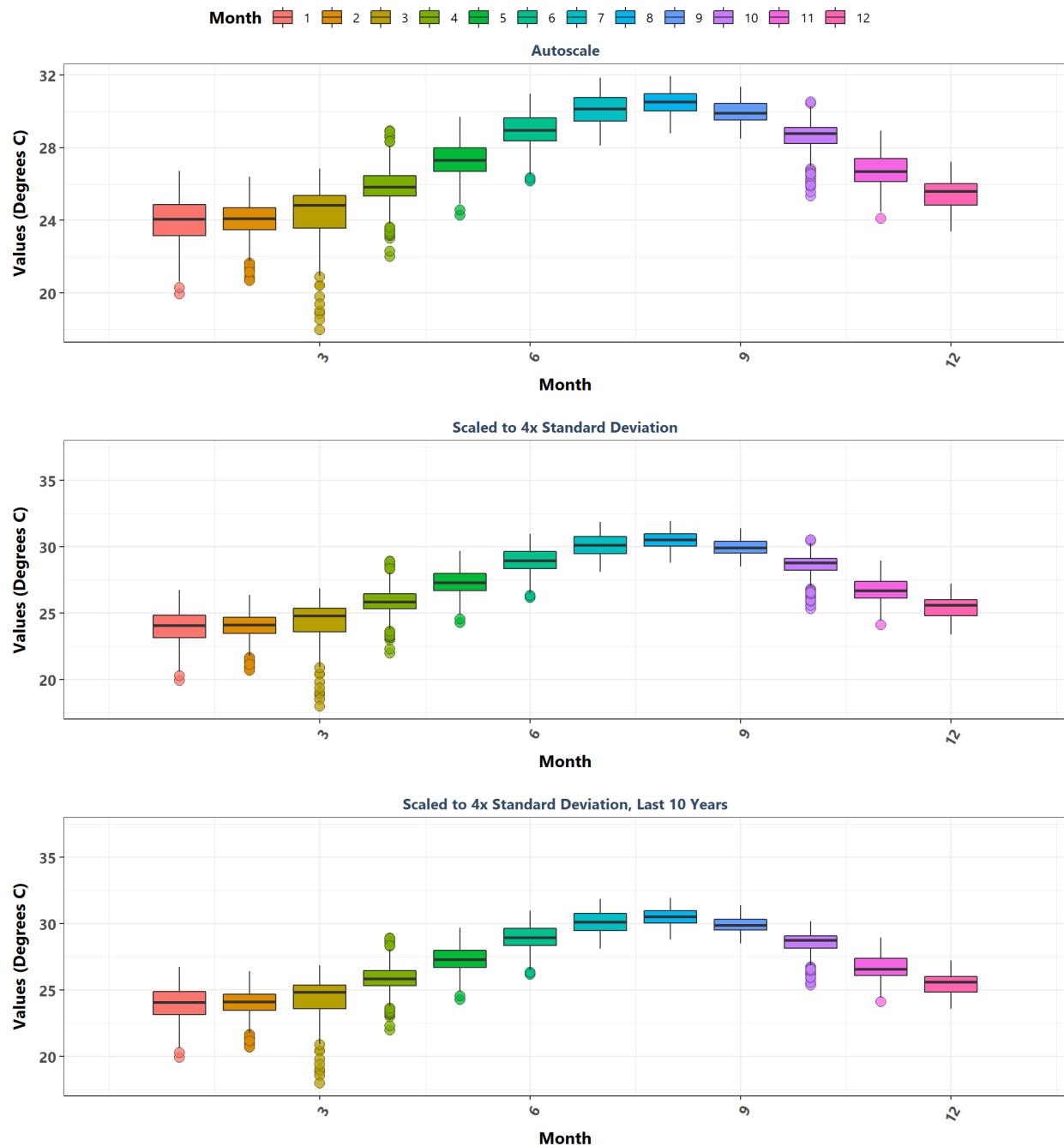
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
60  
By Year



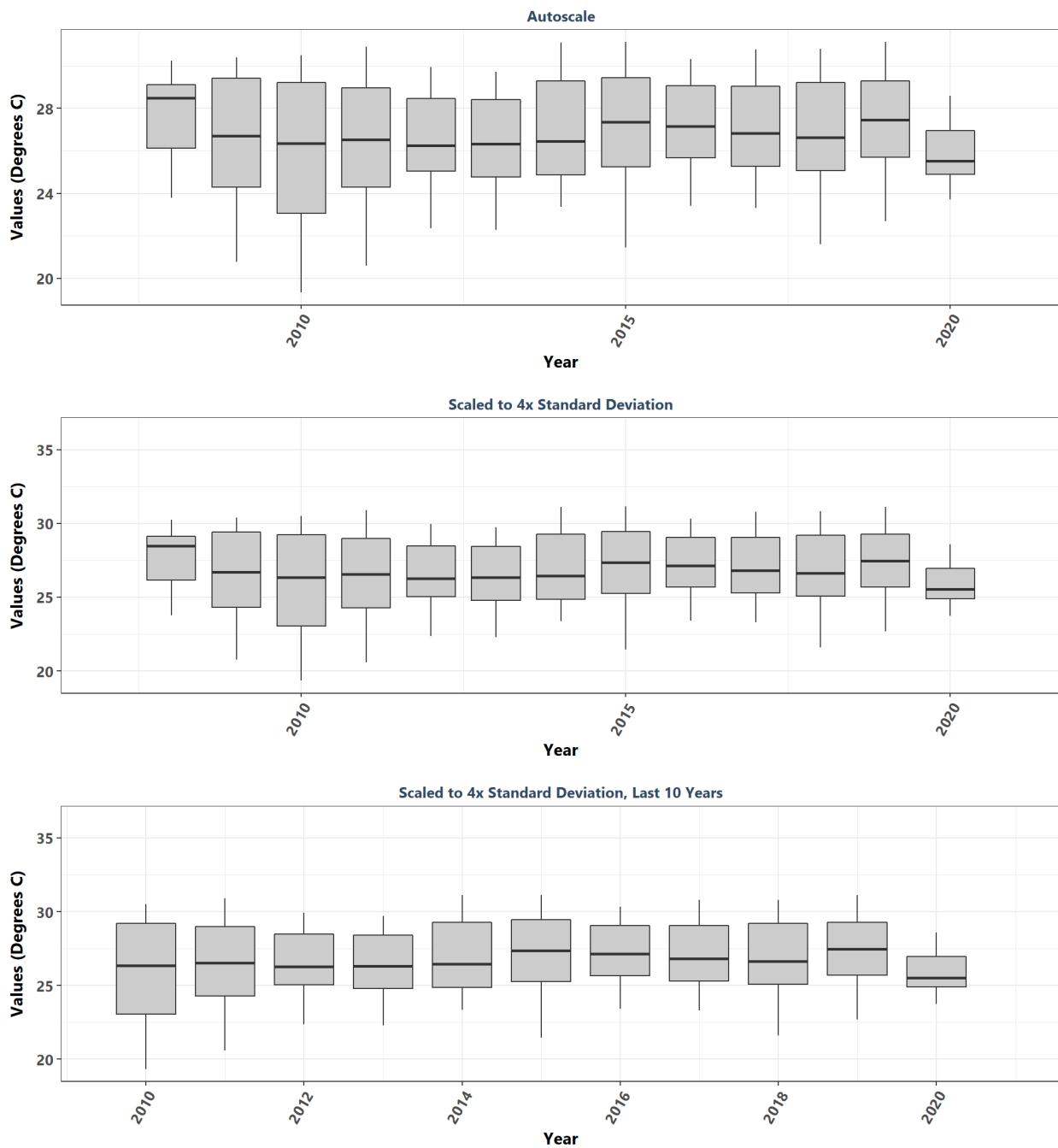
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**60**  
**By Year & Month**



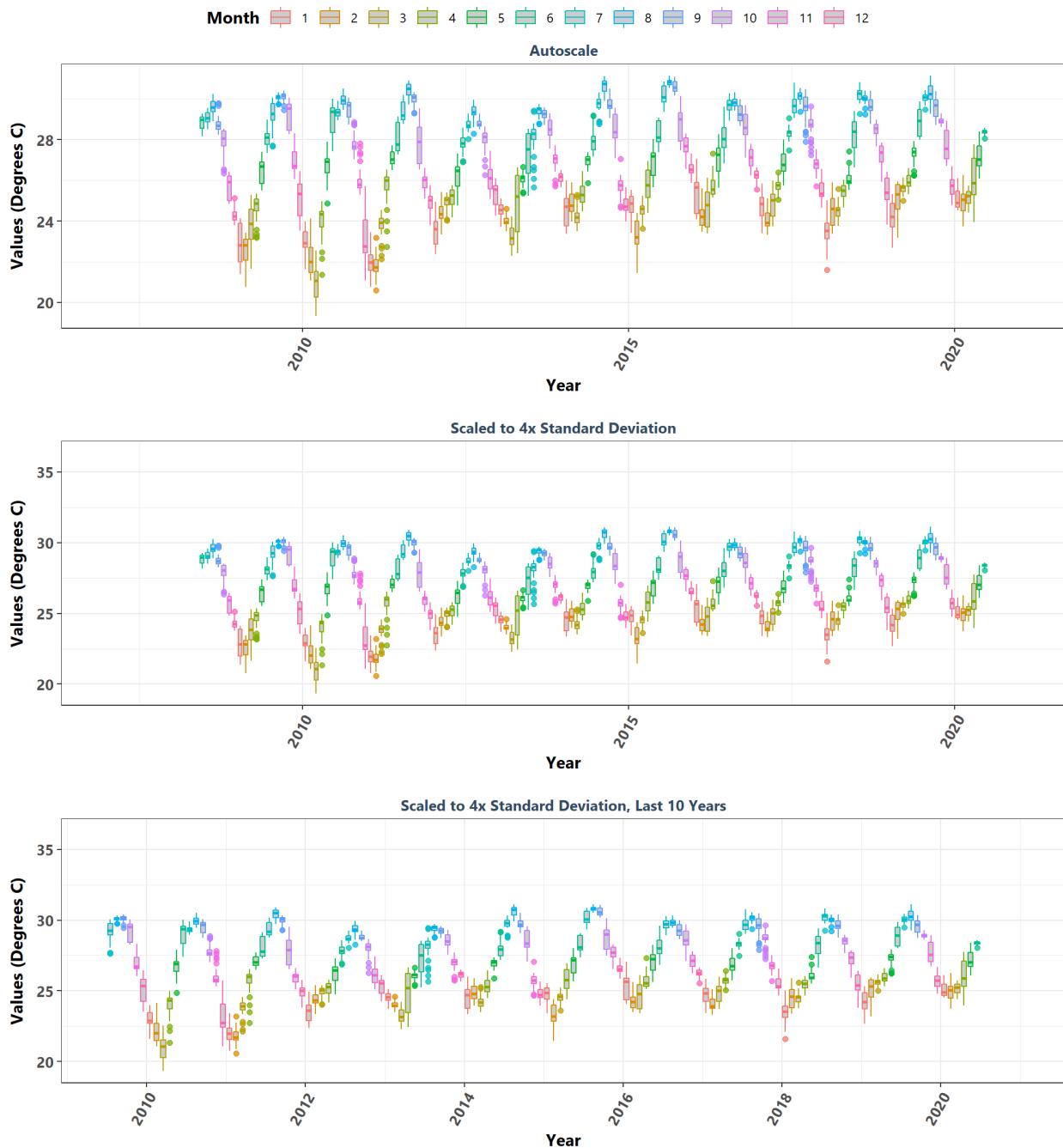
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**60**  
**By Month**



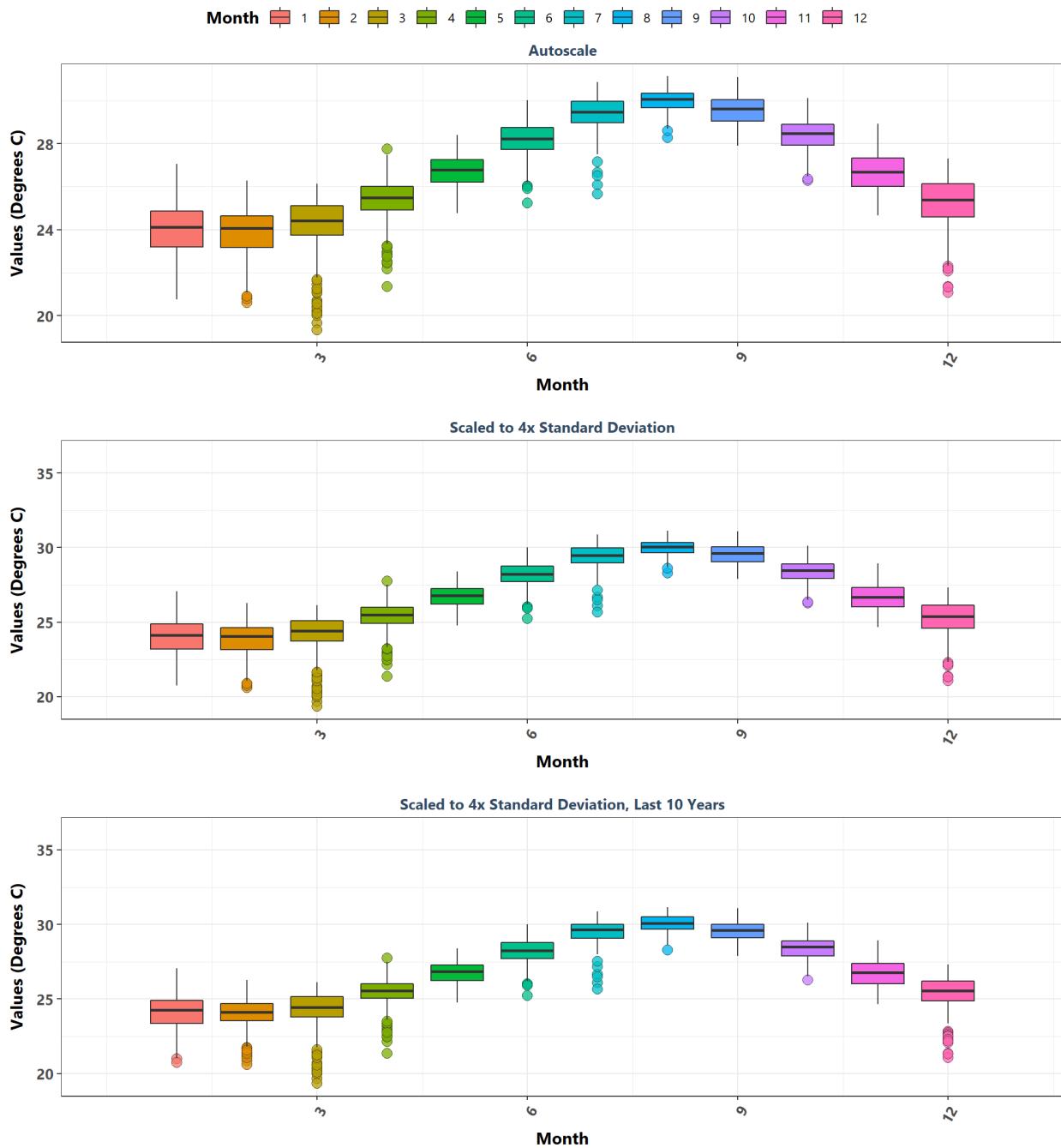
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
72  
By Year



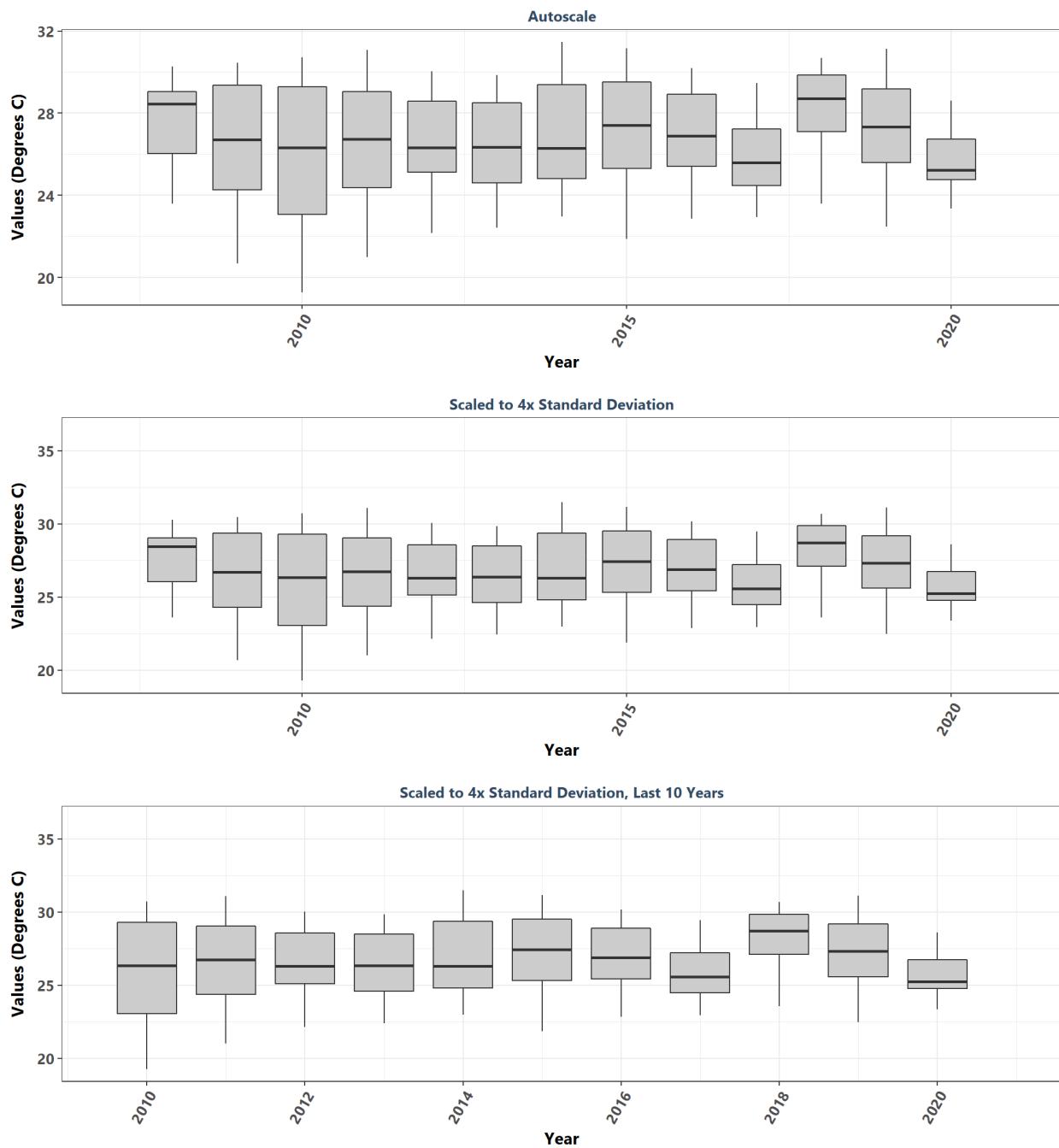
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**72**  
**By Year & Month**



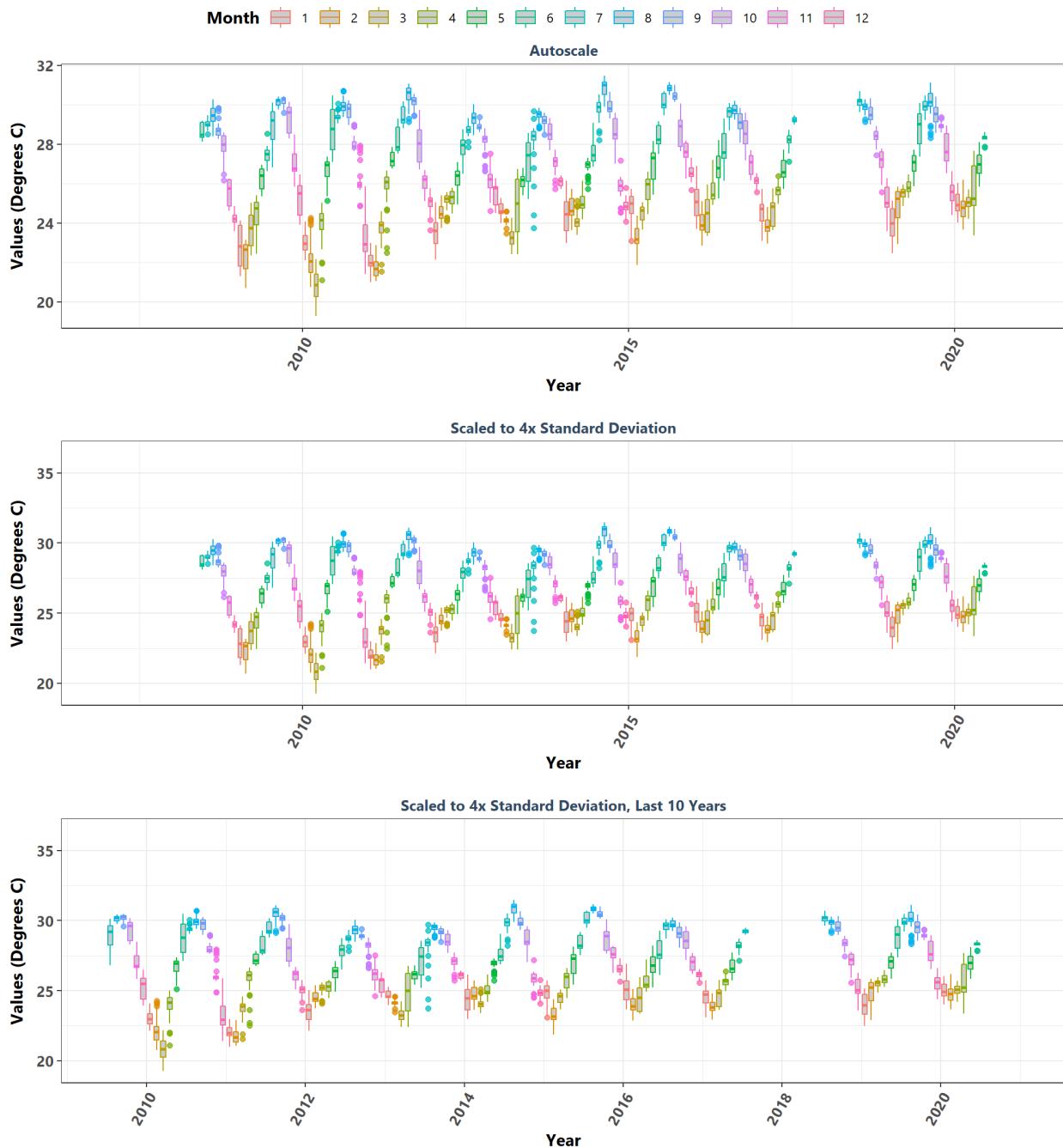
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**72**  
**By Month**



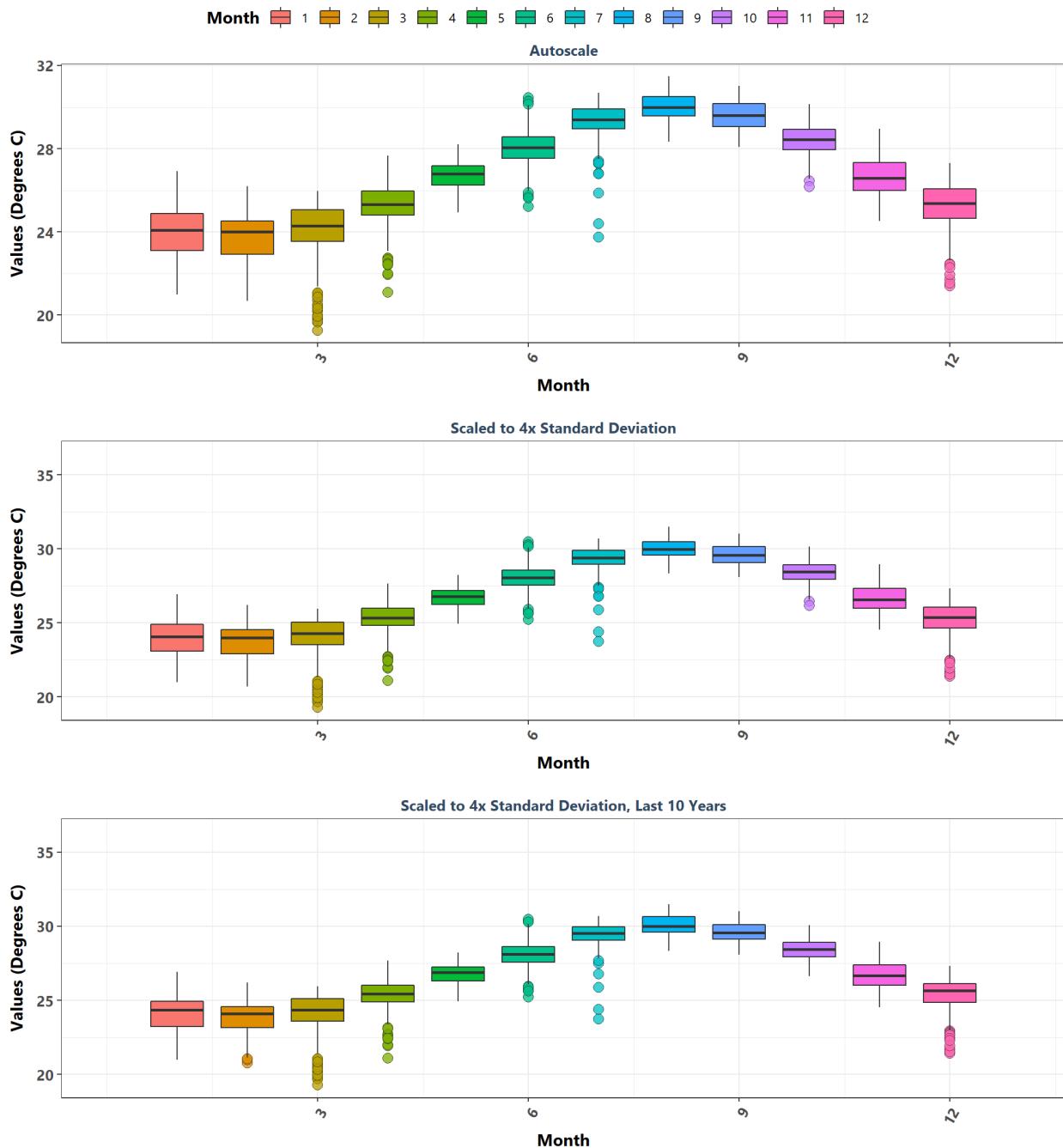
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
73  
By Year



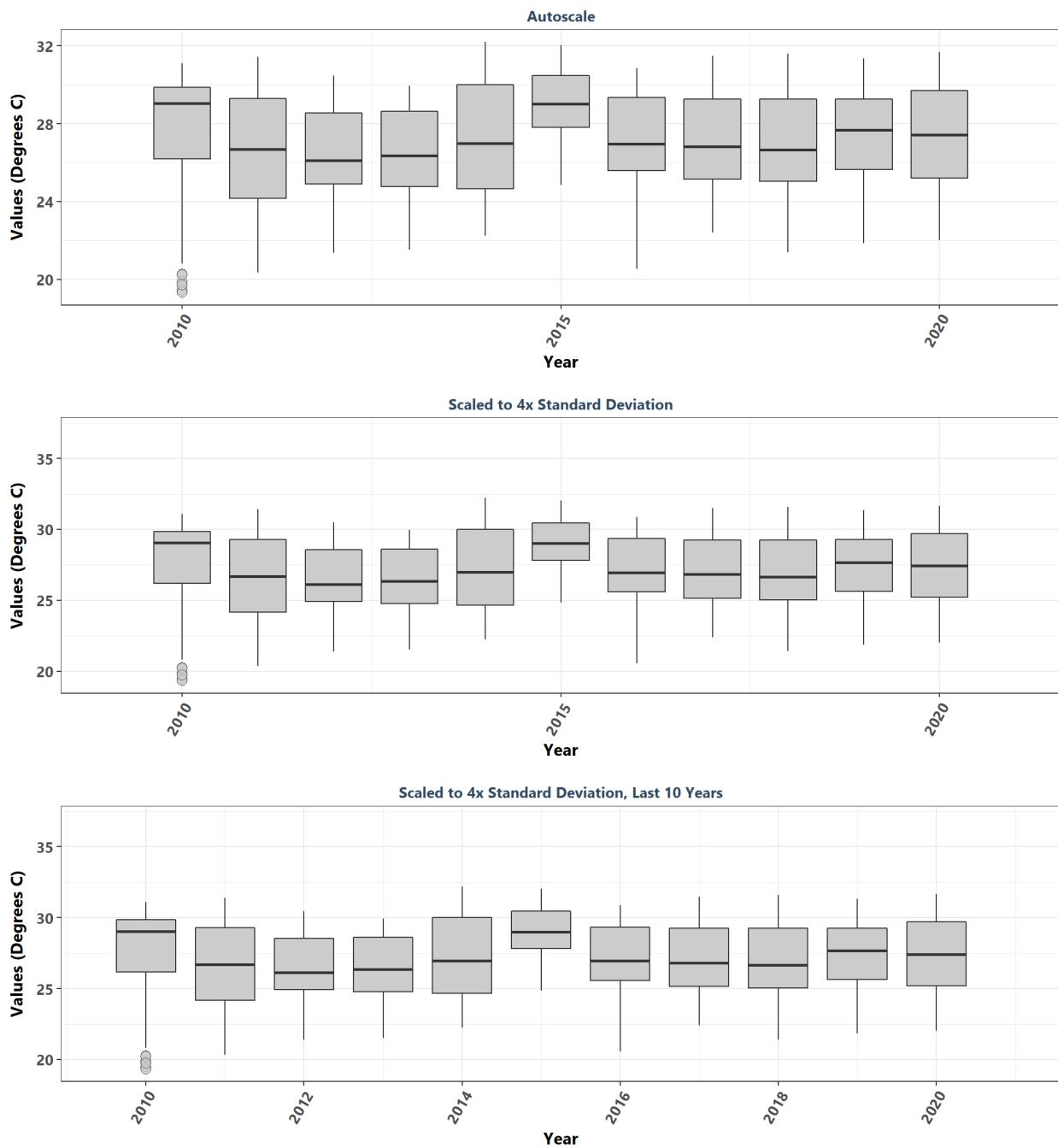
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**73**  
**By Year & Month**



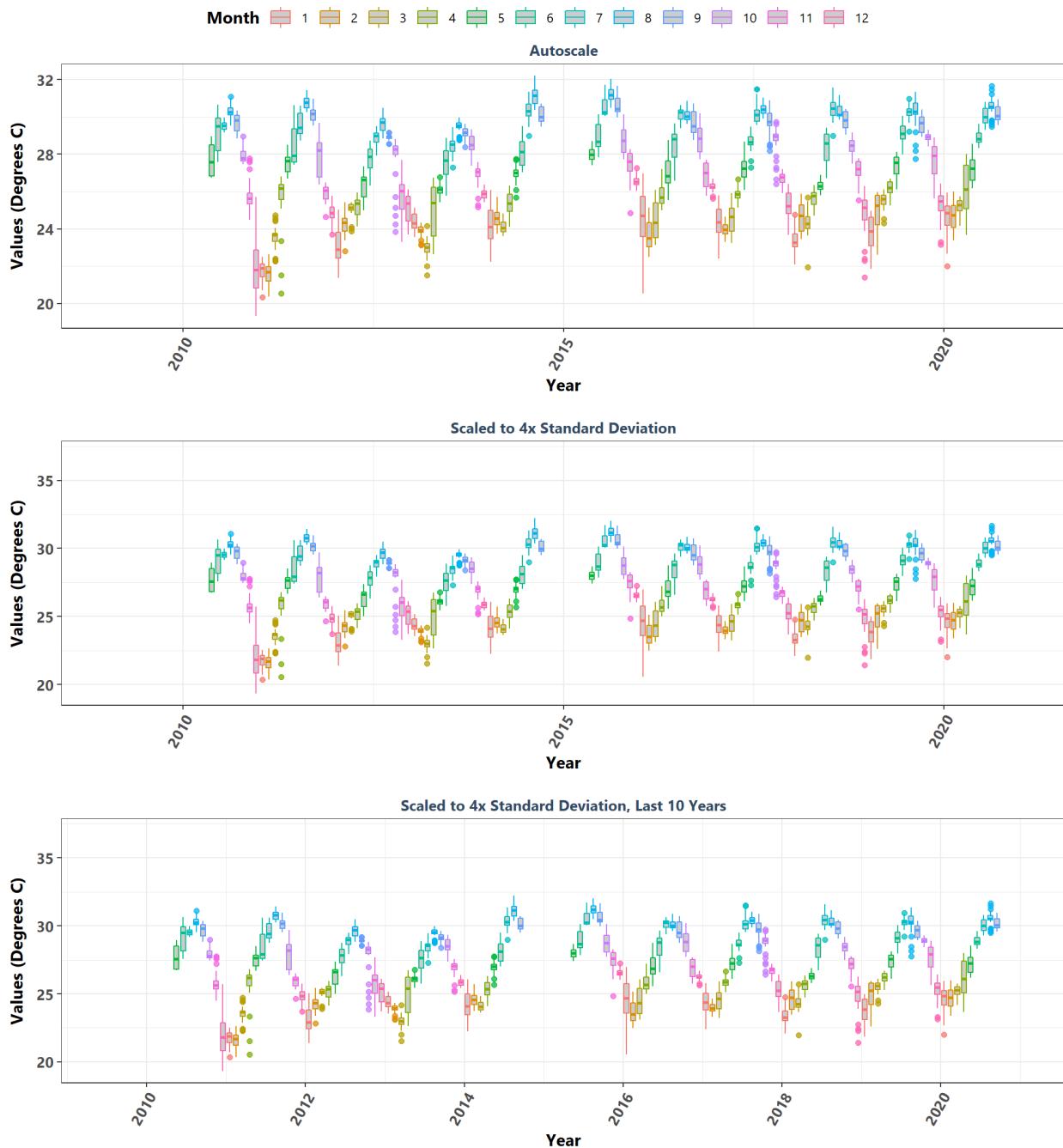
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**73**  
**By Month**



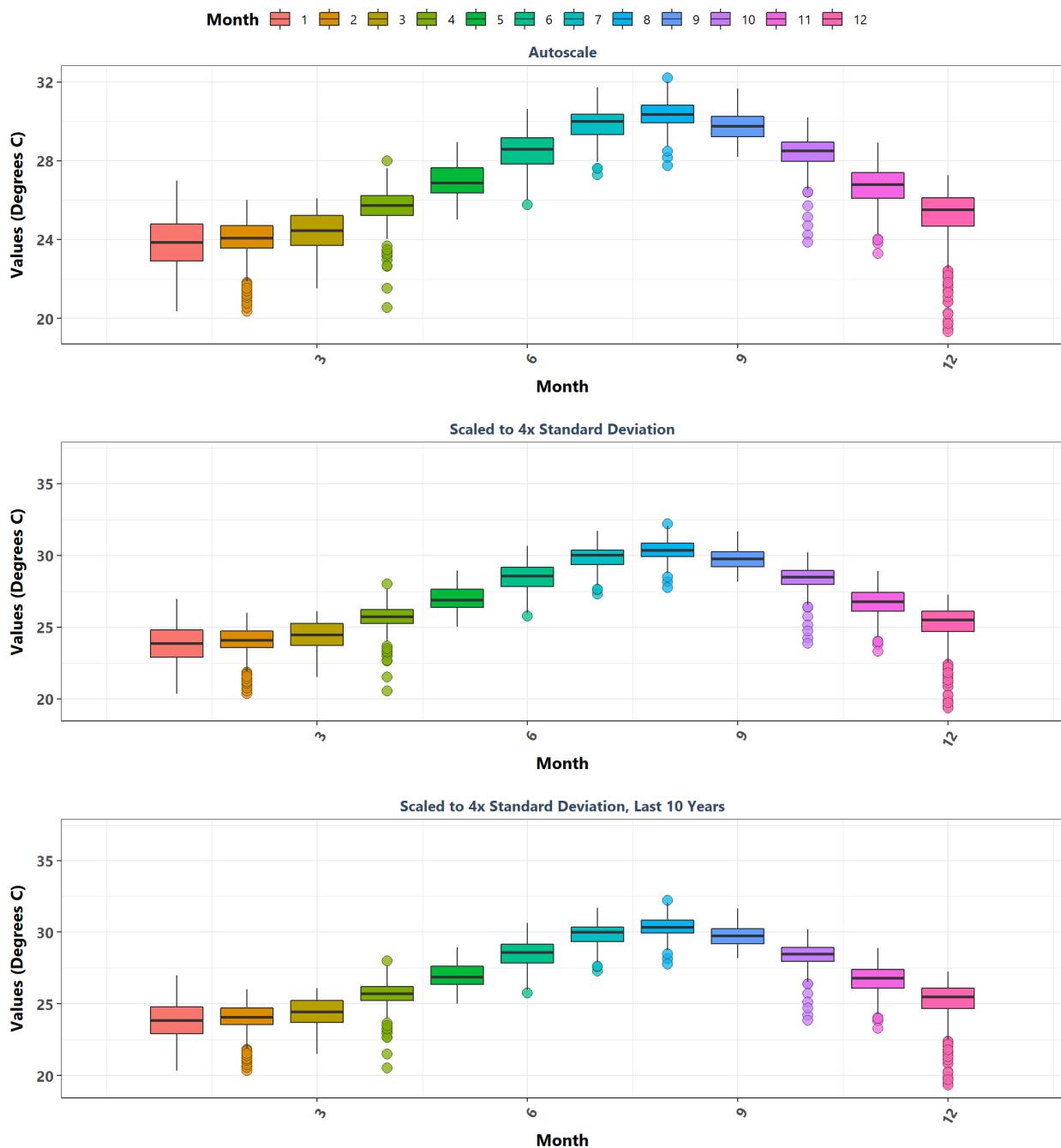
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
 75  
 By Year



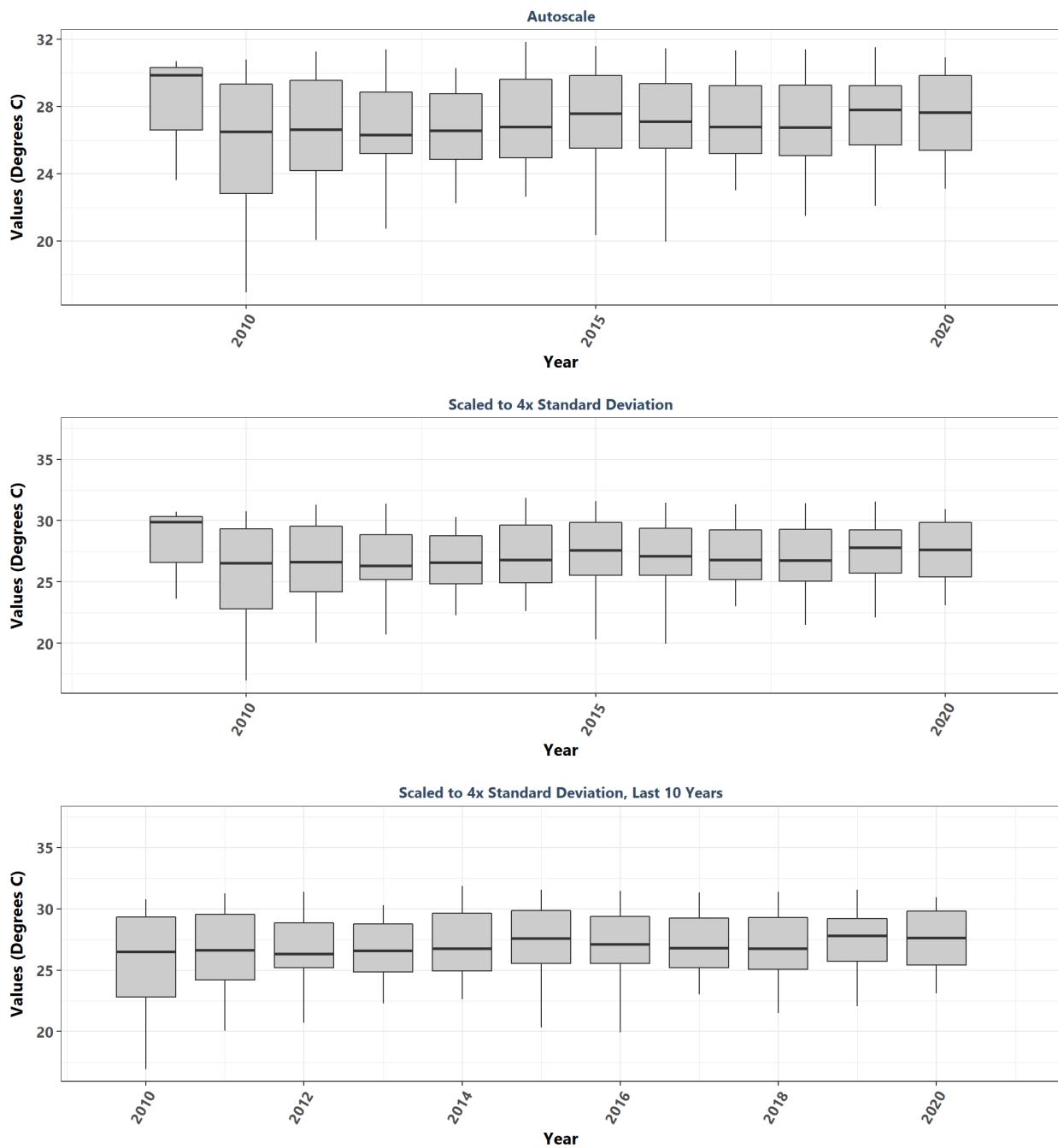
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**75**  
**By Year & Month**



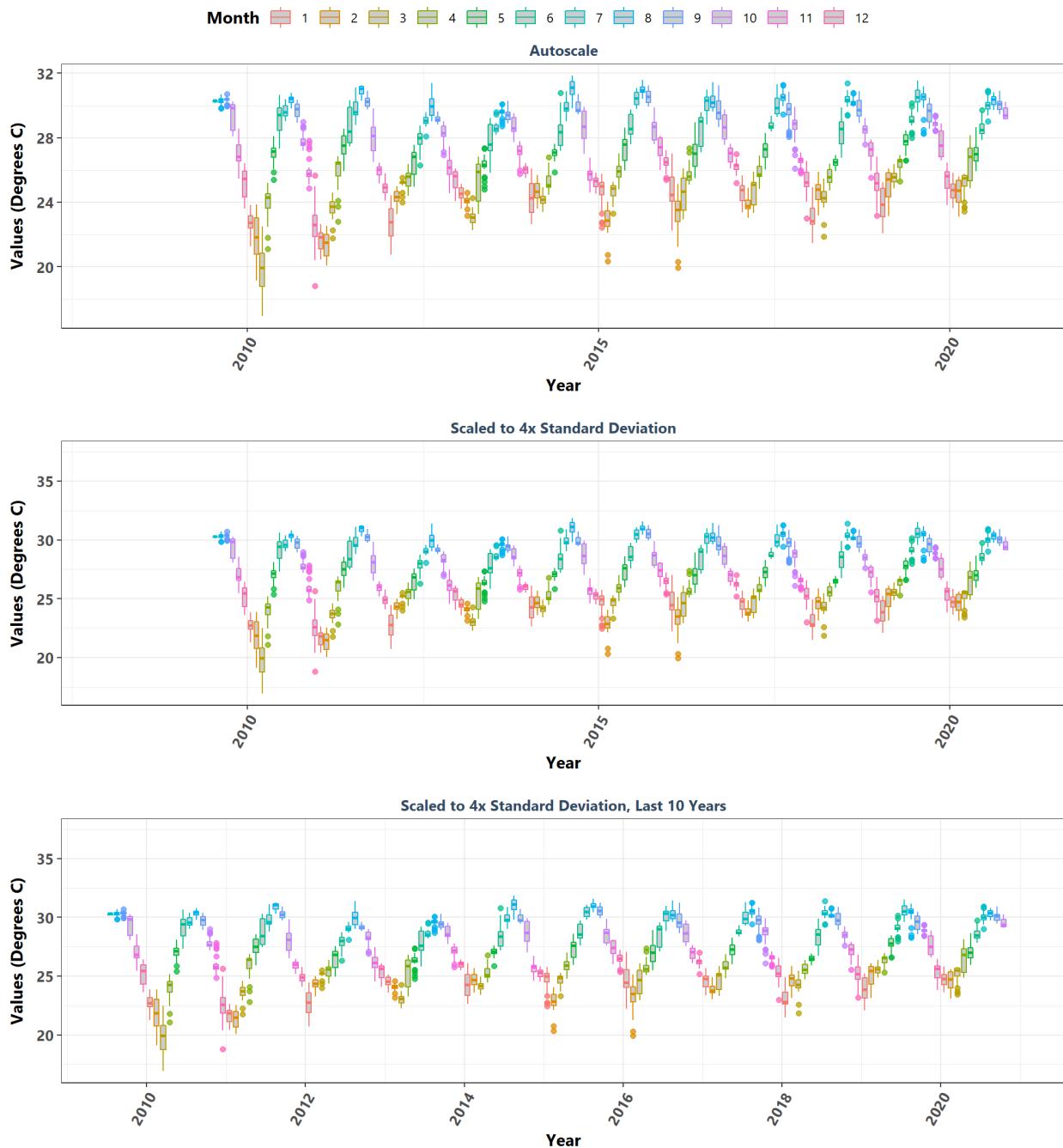
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
 75  
 By Month



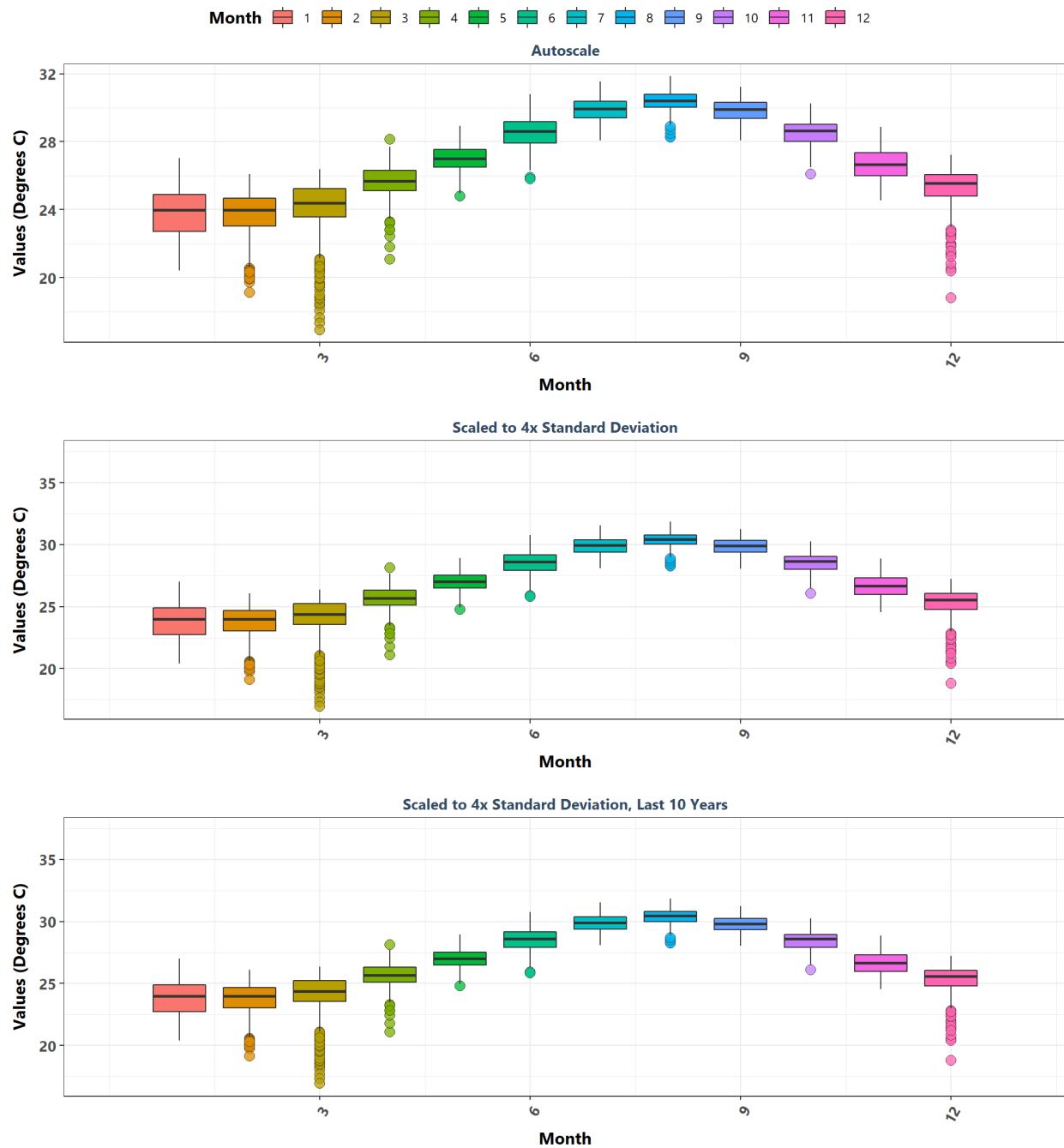
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
76  
By Year



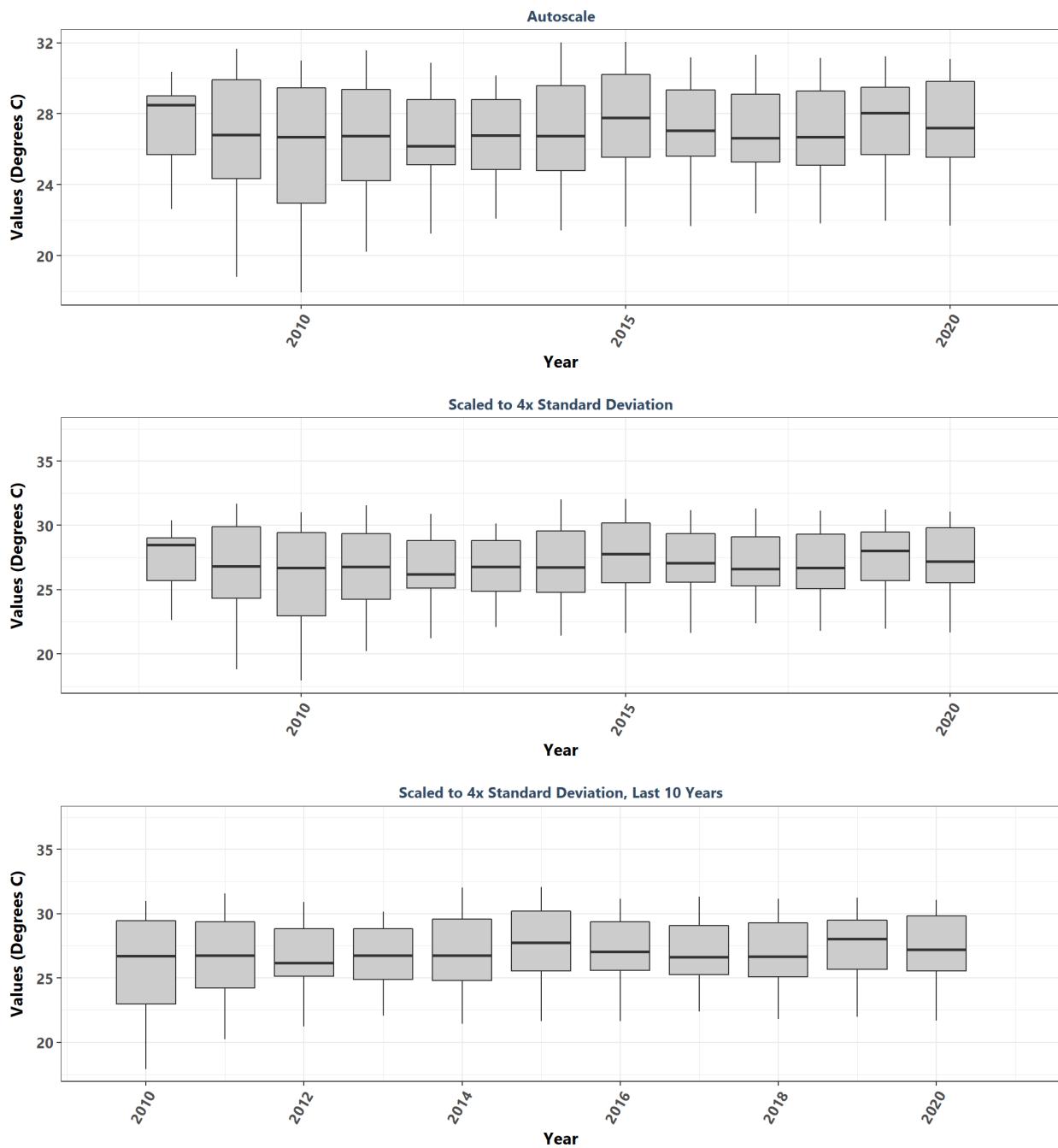
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**76**  
**By Year & Month**



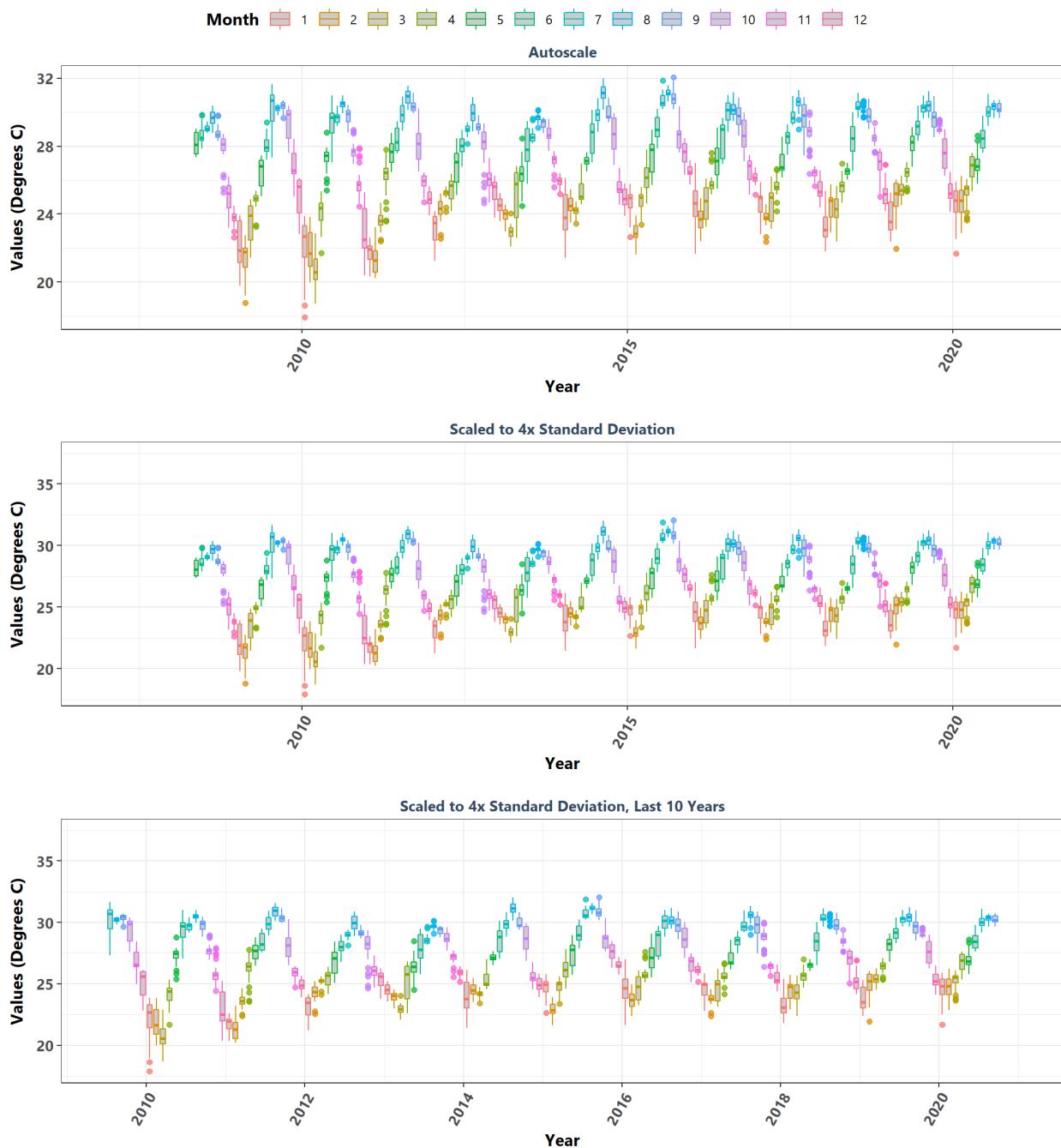
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**76**  
**By Month**



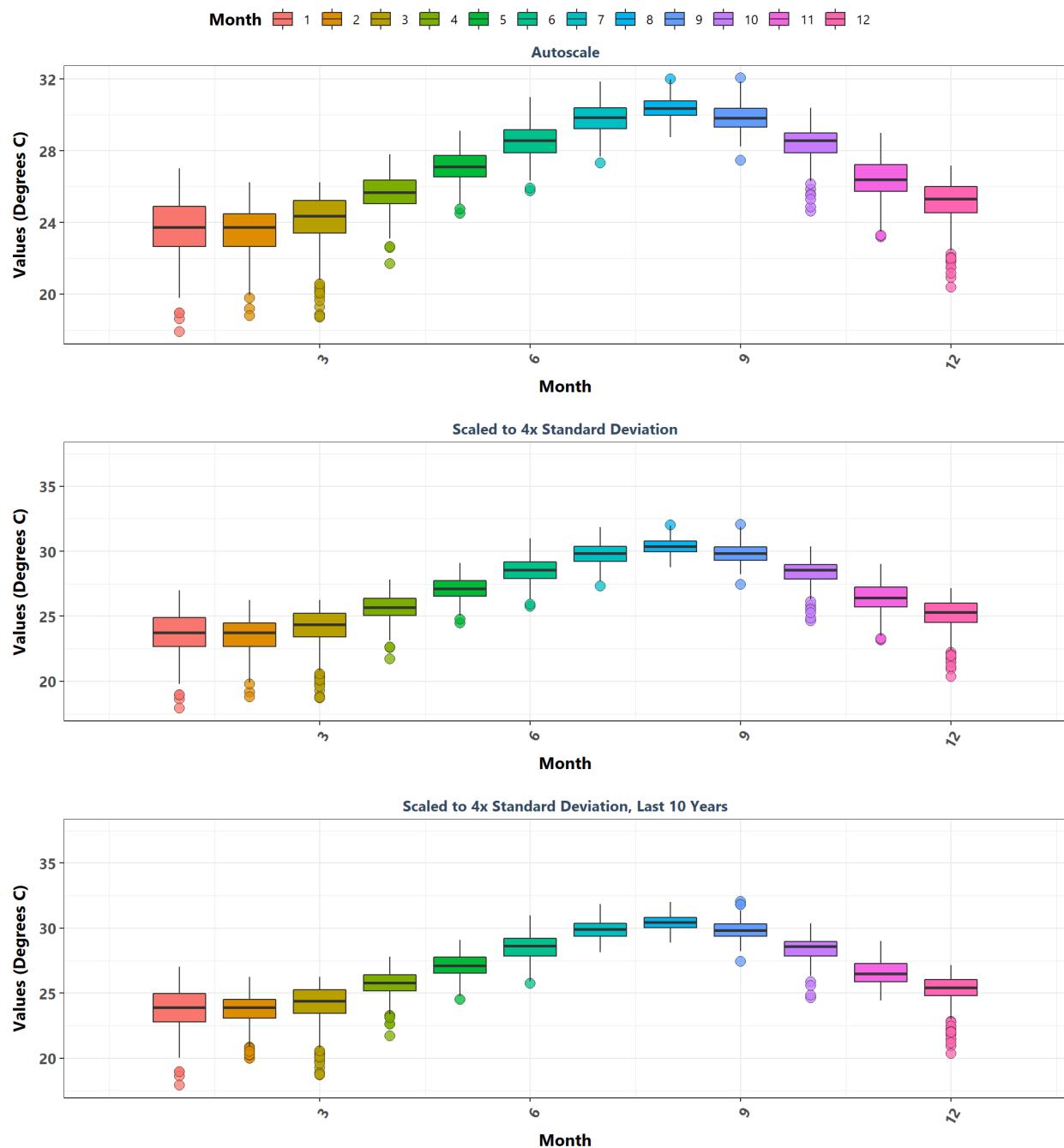
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
77  
By Year



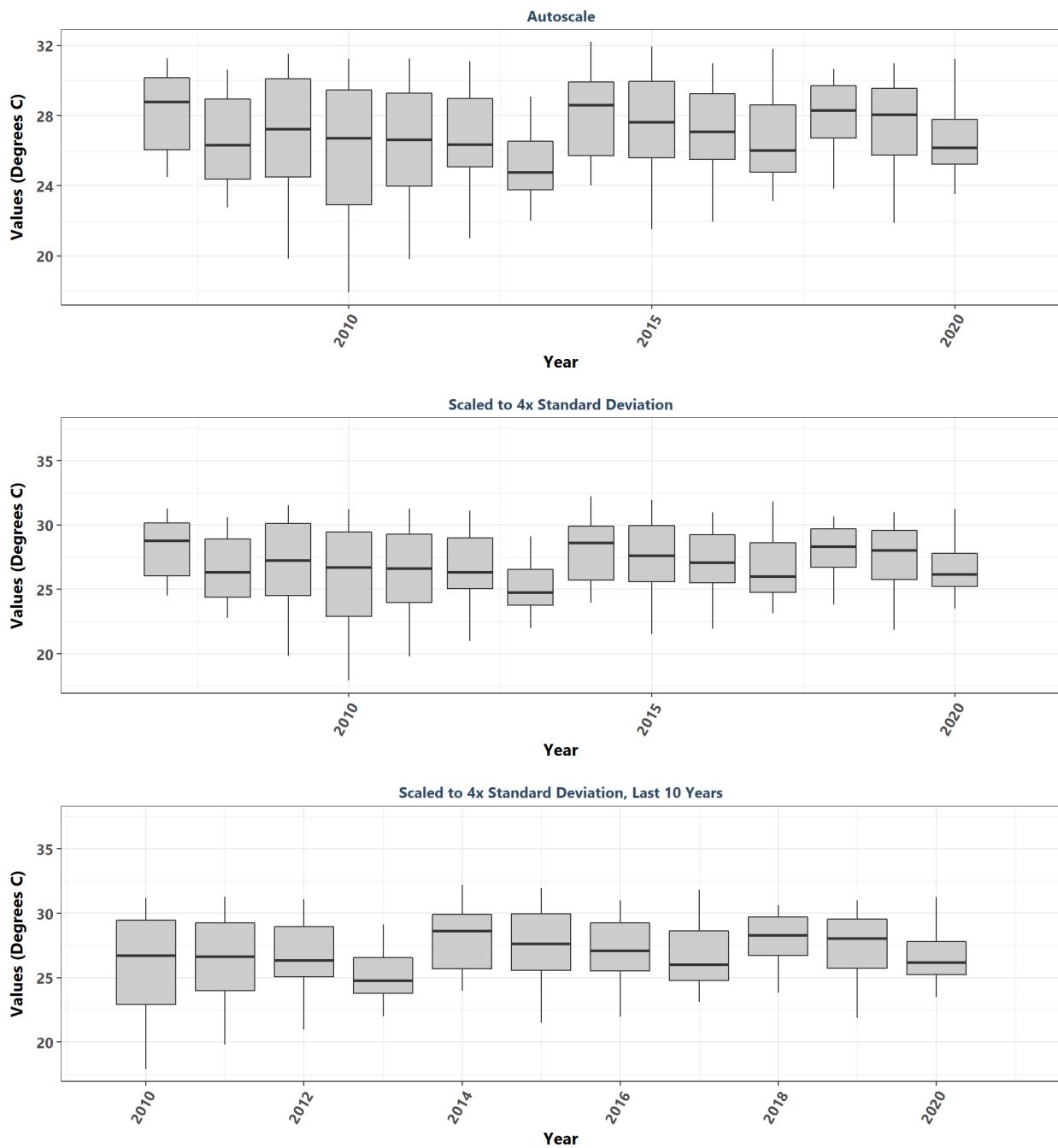
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**77**  
**By Year & Month**



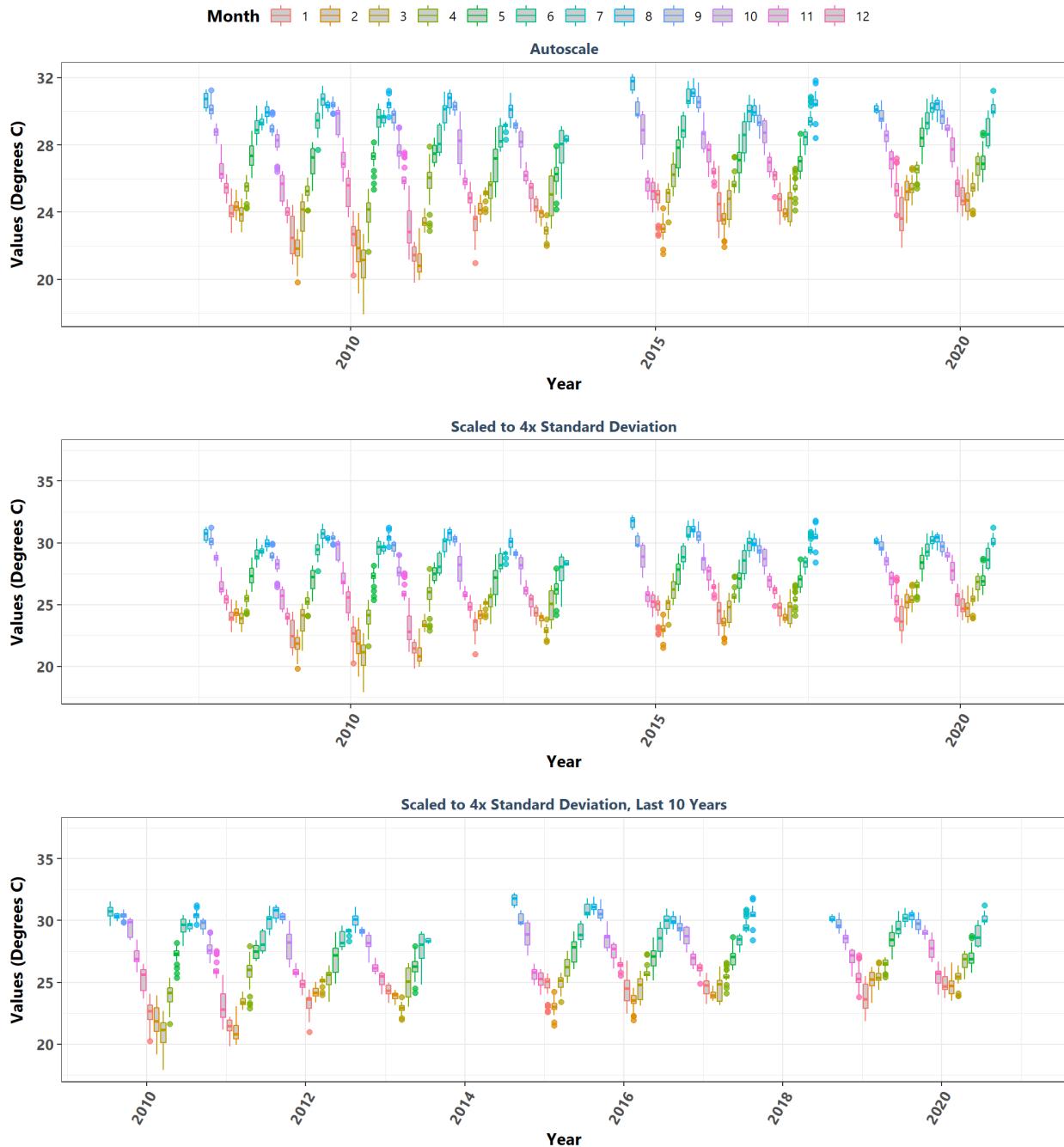
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**77**  
**By Month**



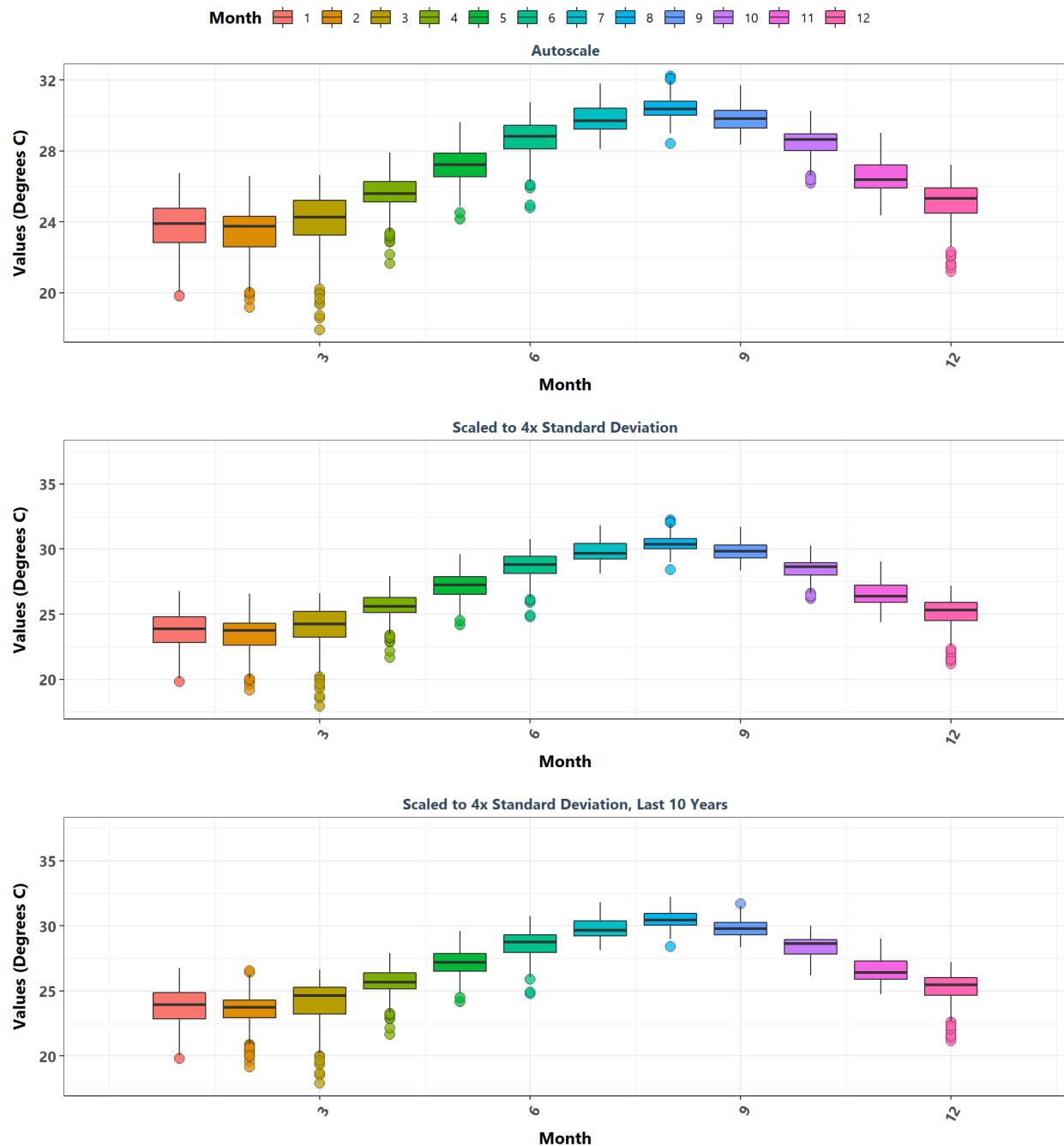
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
79  
By Year



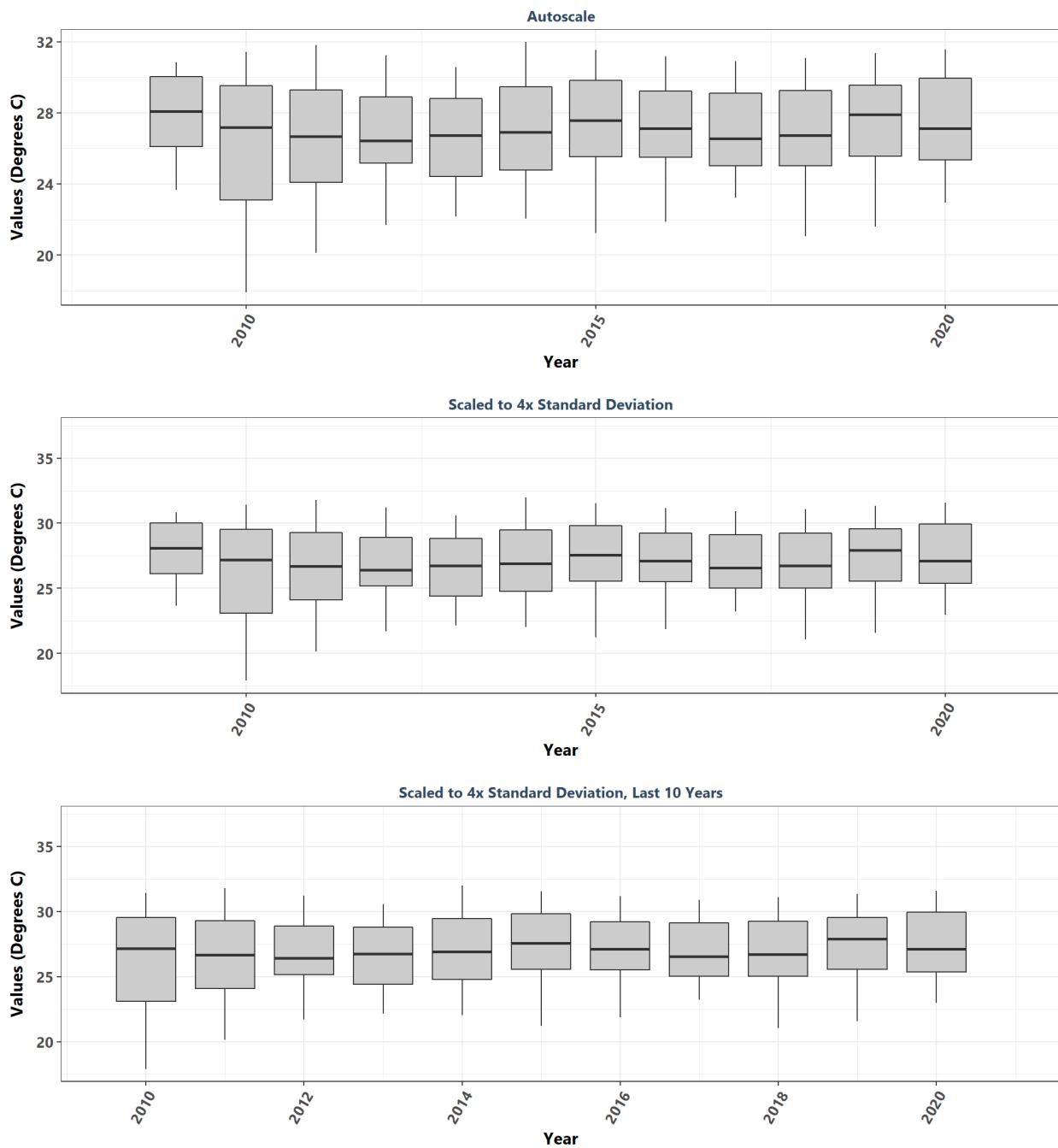
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**79**  
**By Year & Month**



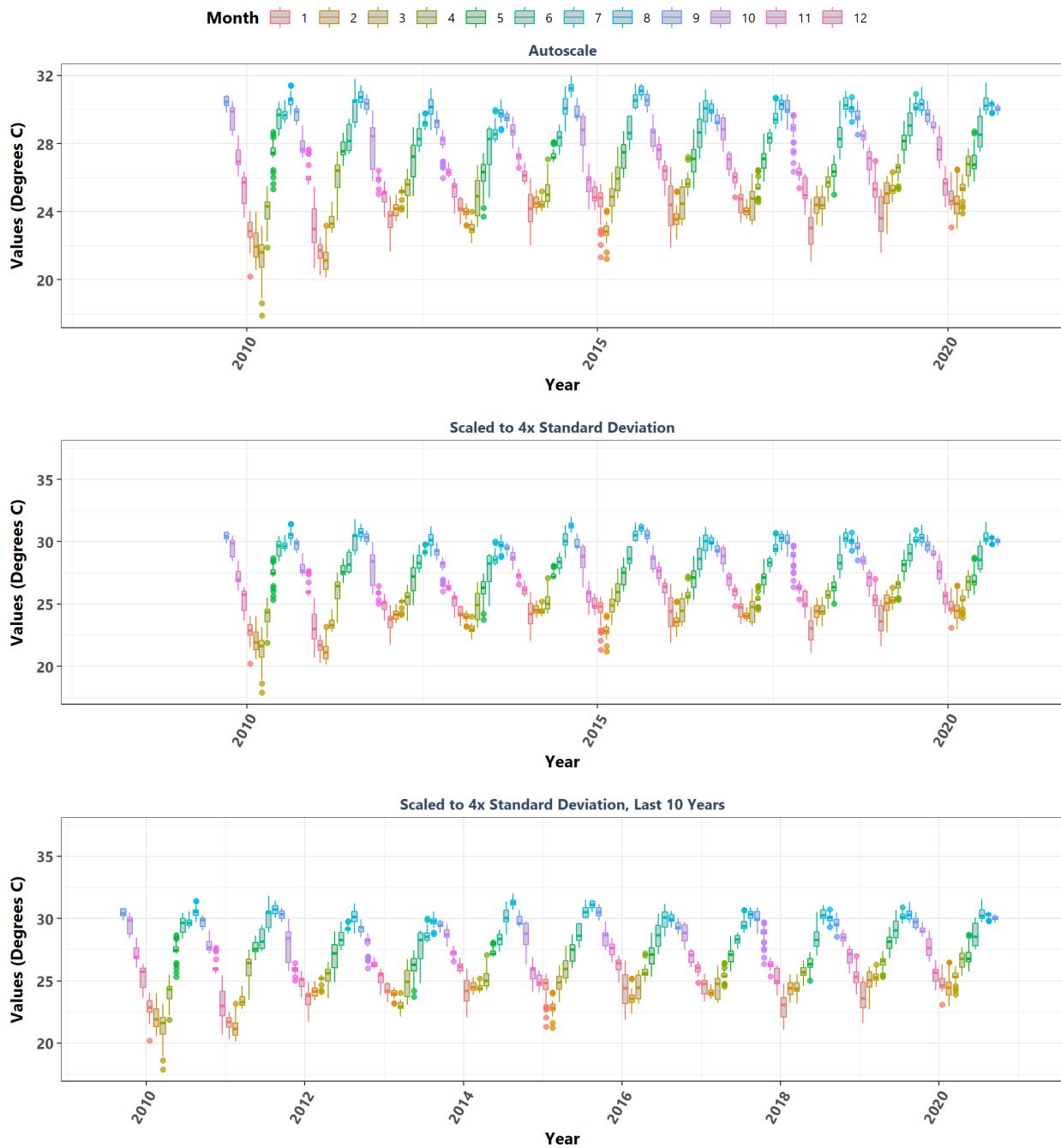
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**79**  
**By Month**



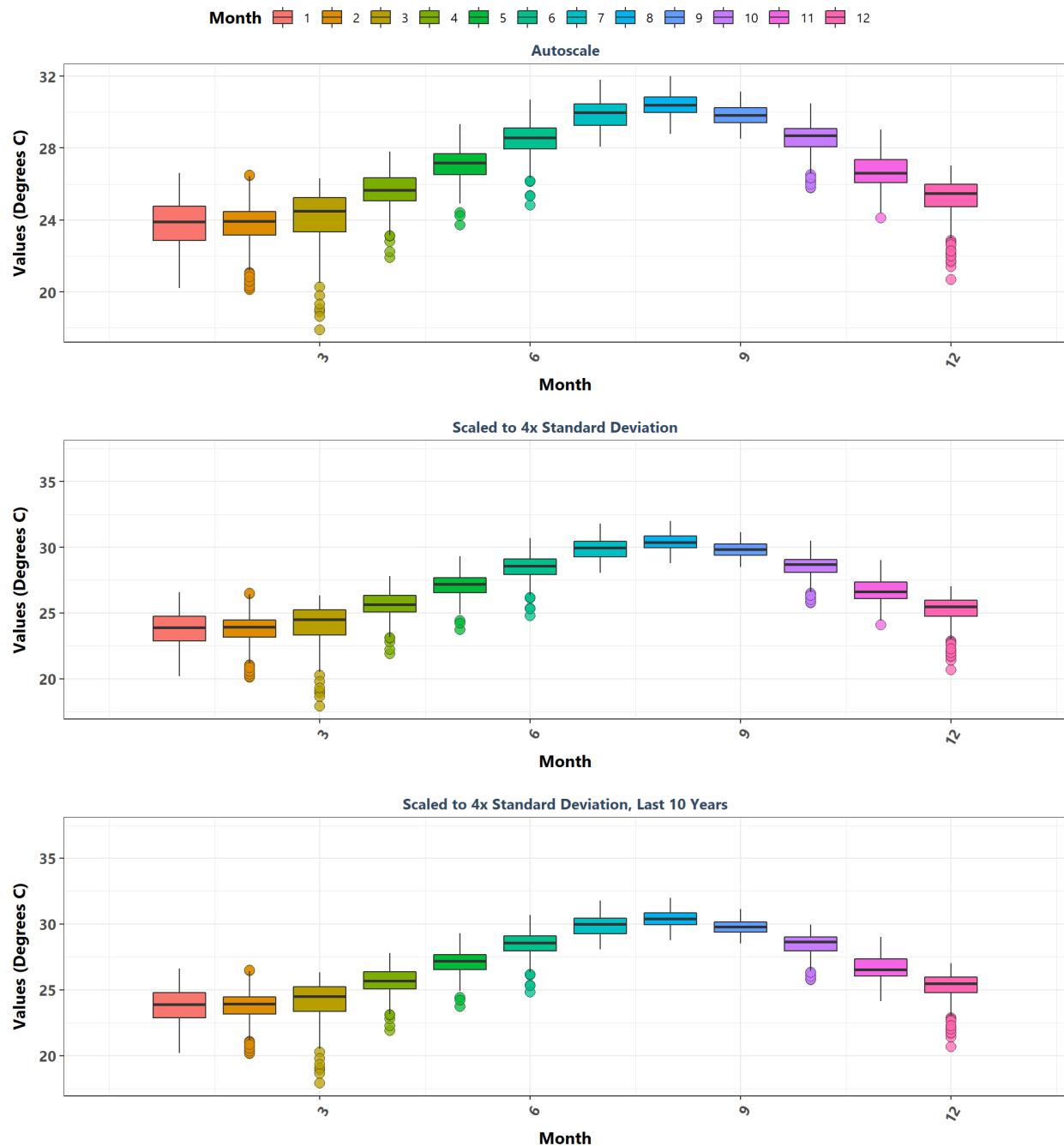
**Florida Keys National Marine Sanctuary**  
986 | Water Temperature on Coral Reefs in the Florida Keys  
80  
By Year



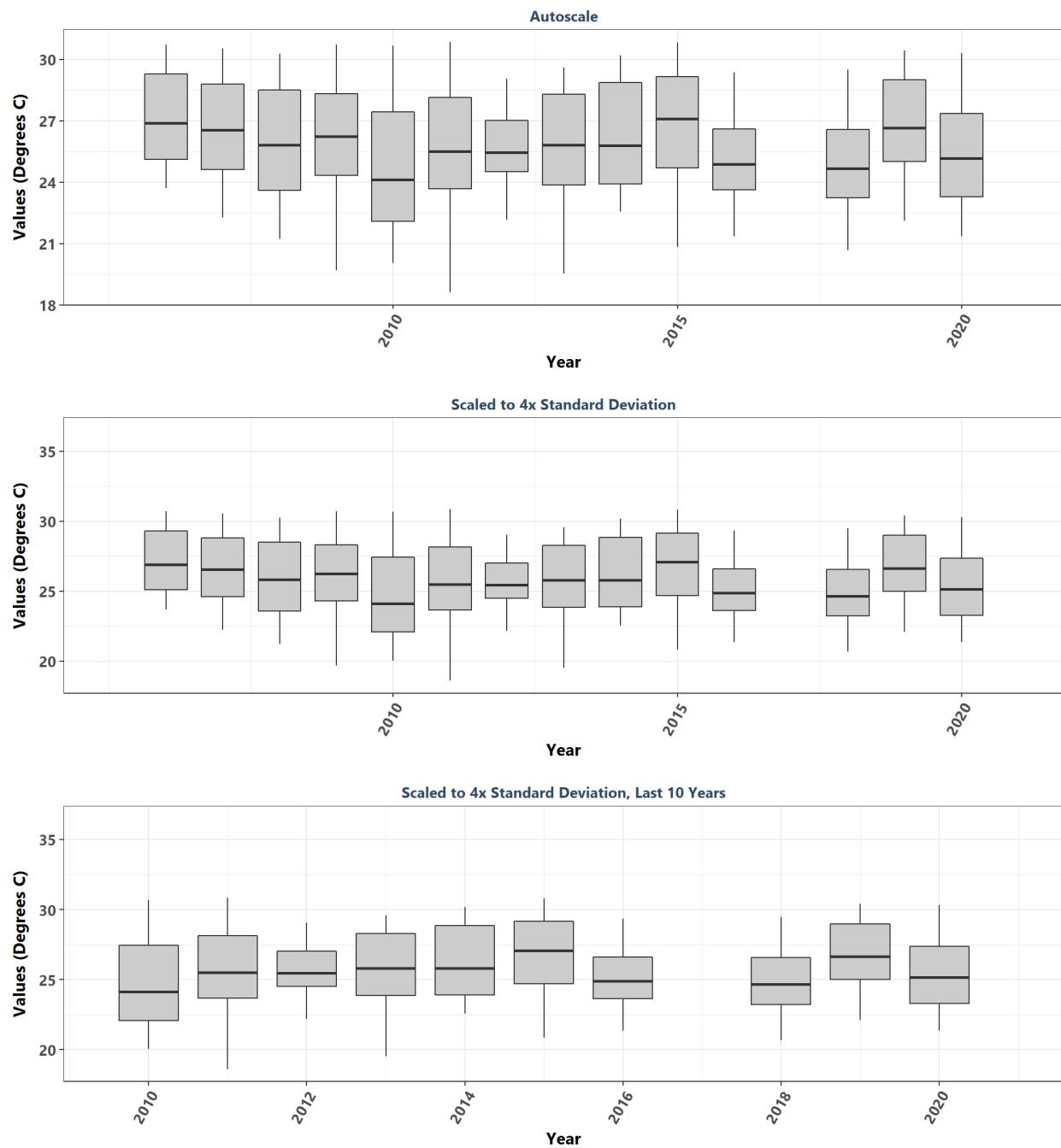
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**80**  
**By Year & Month**



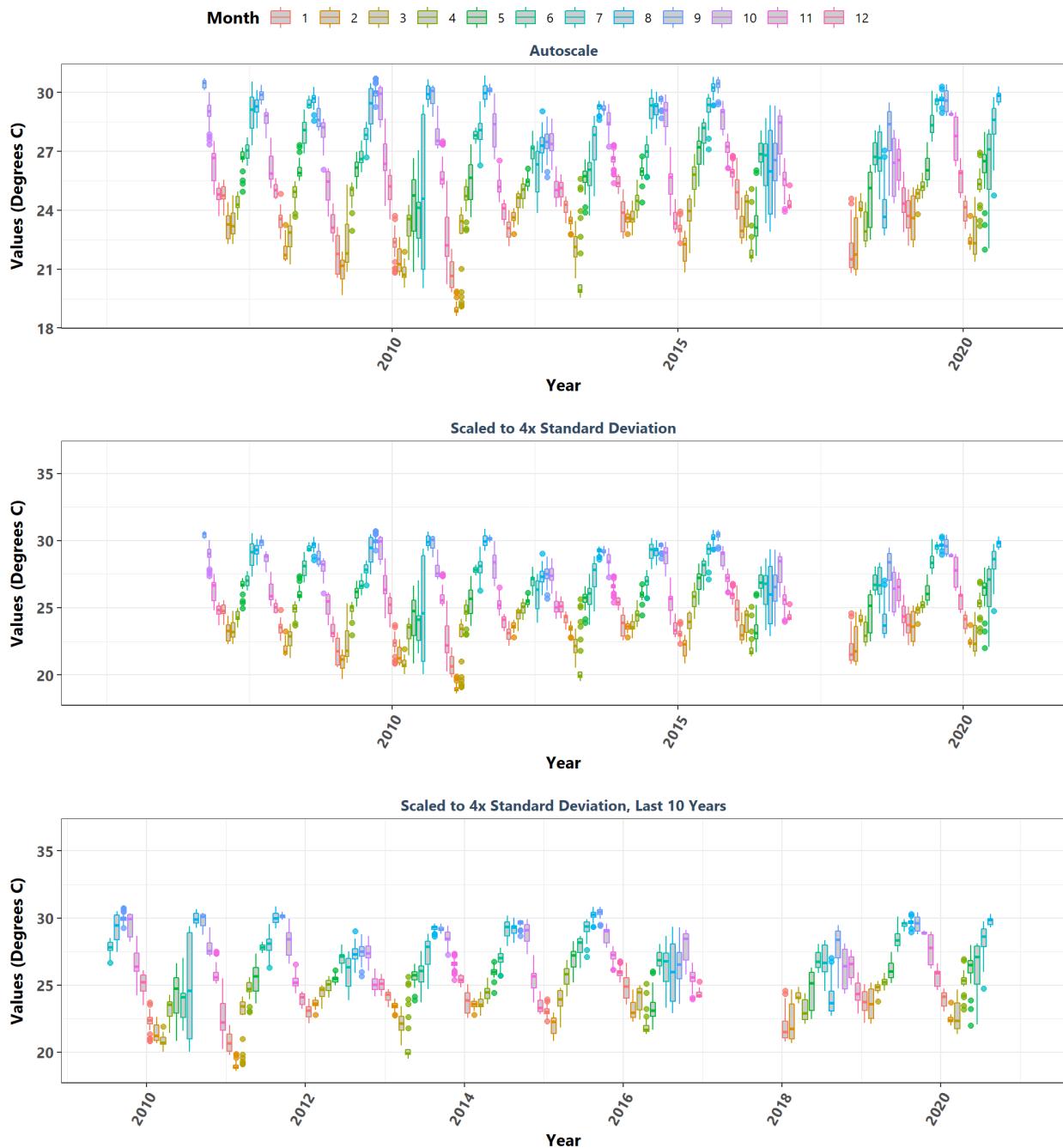
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**80**  
**By Month**



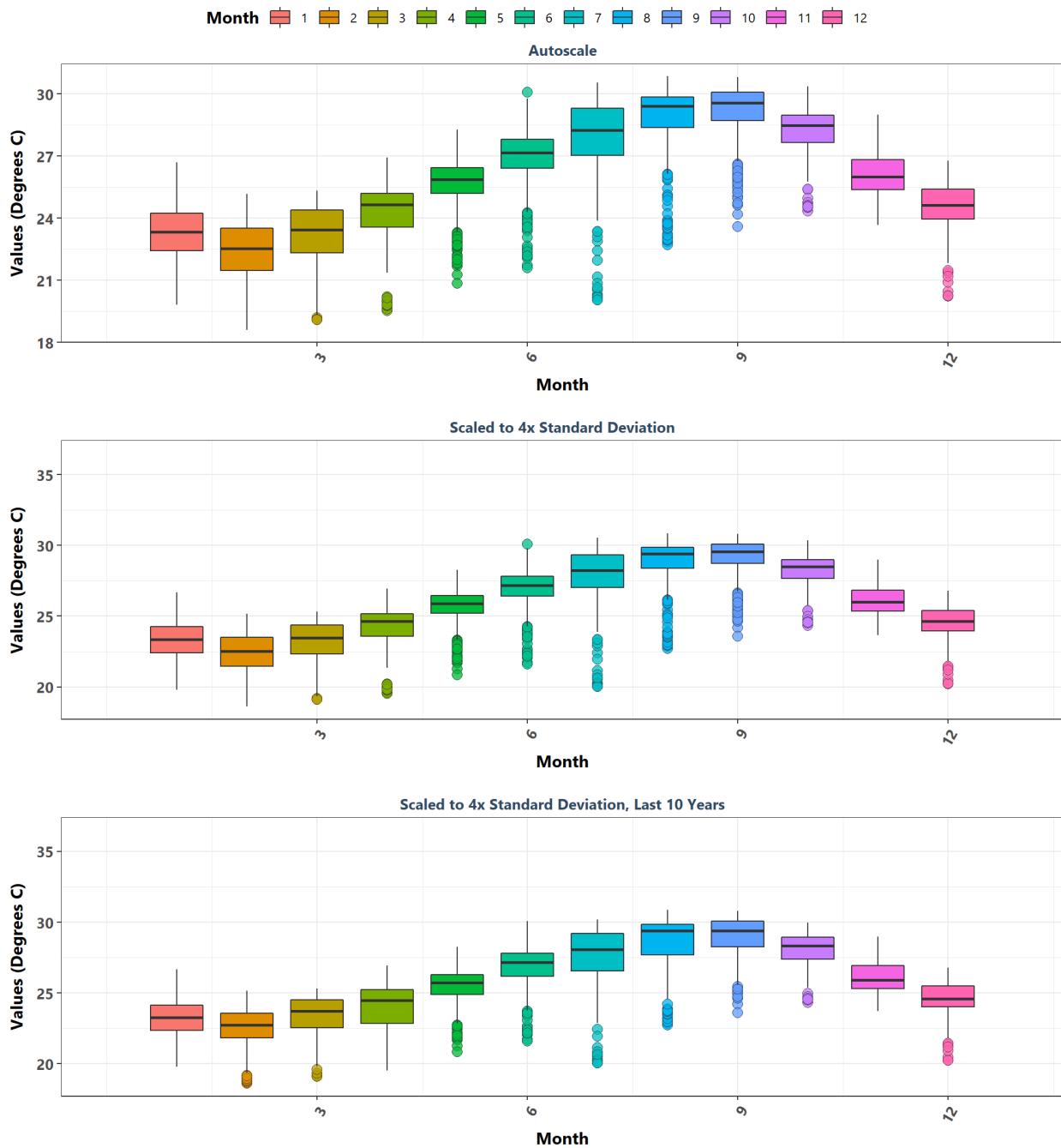
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**83**  
**By Year**



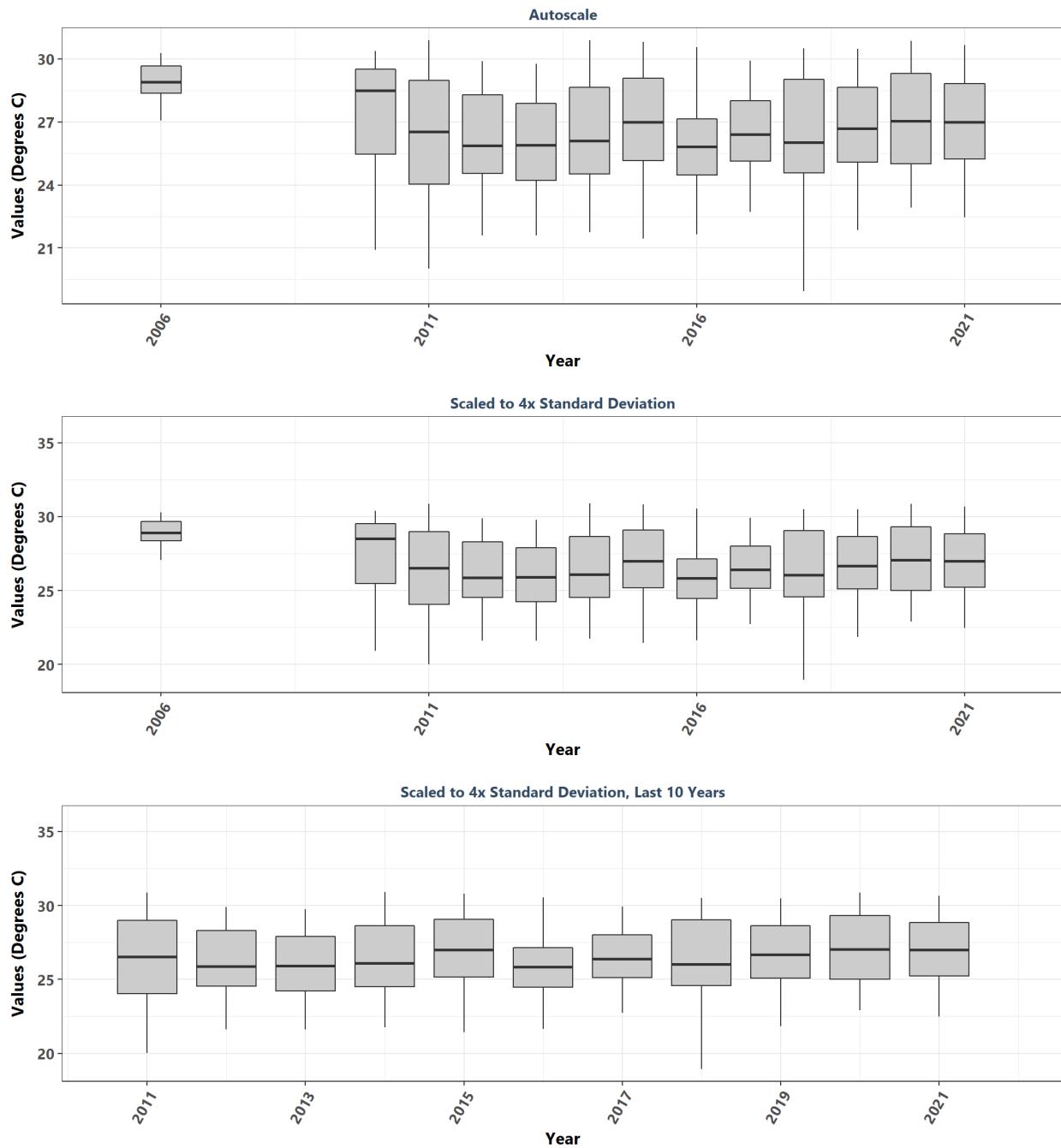
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**83**  
**By Year & Month**



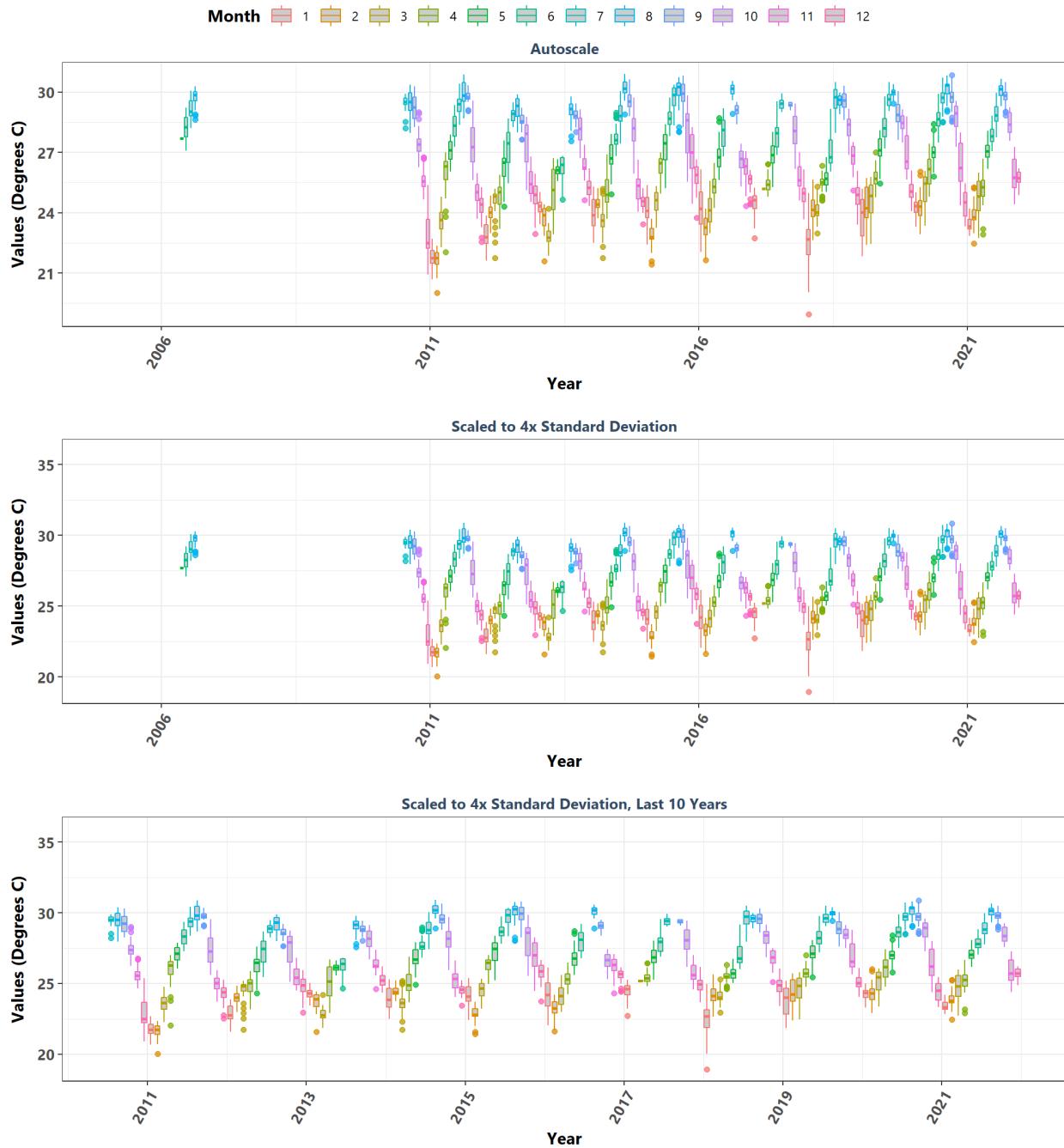
**Florida Keys National Marine Sanctuary**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**83**  
**By Month**



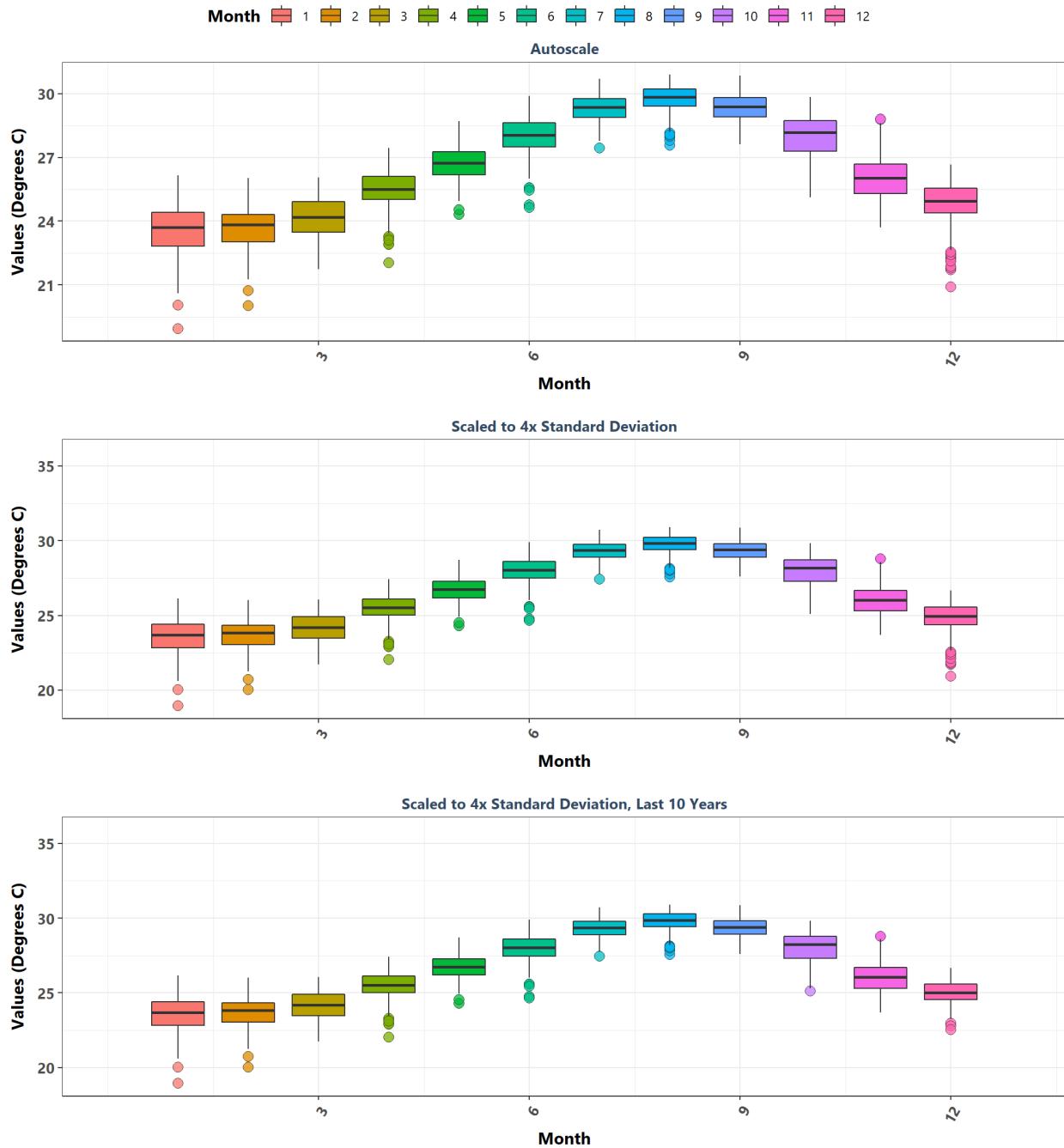
**Southeast Florida Coral Reef Ecosystem Conservation Area**  
5 | National Data Buoy Center  
**LKWF1**  
By Year



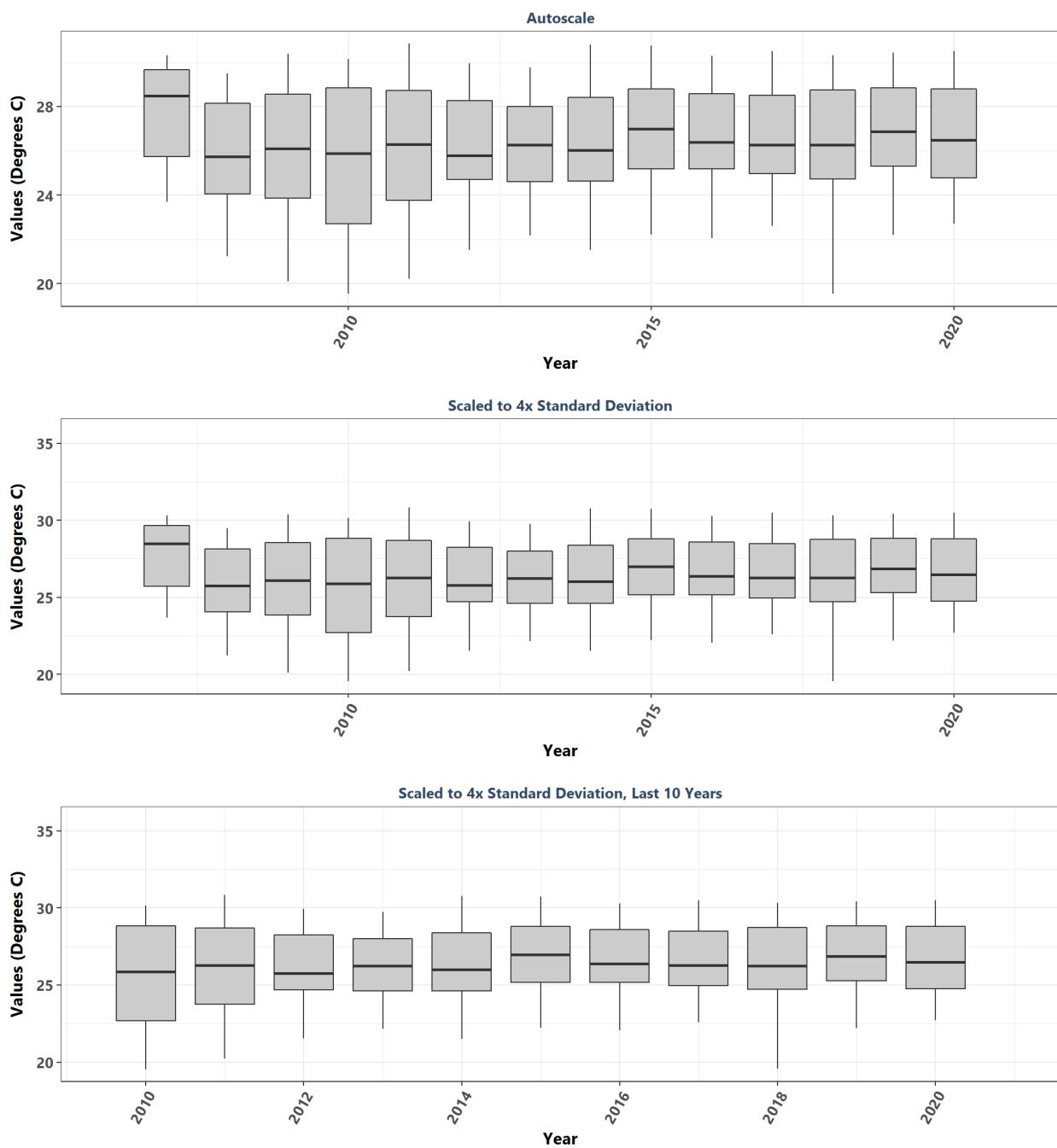
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**5 | National Data Buoy Center**  
**LKWF1**  
**By Year & Month**



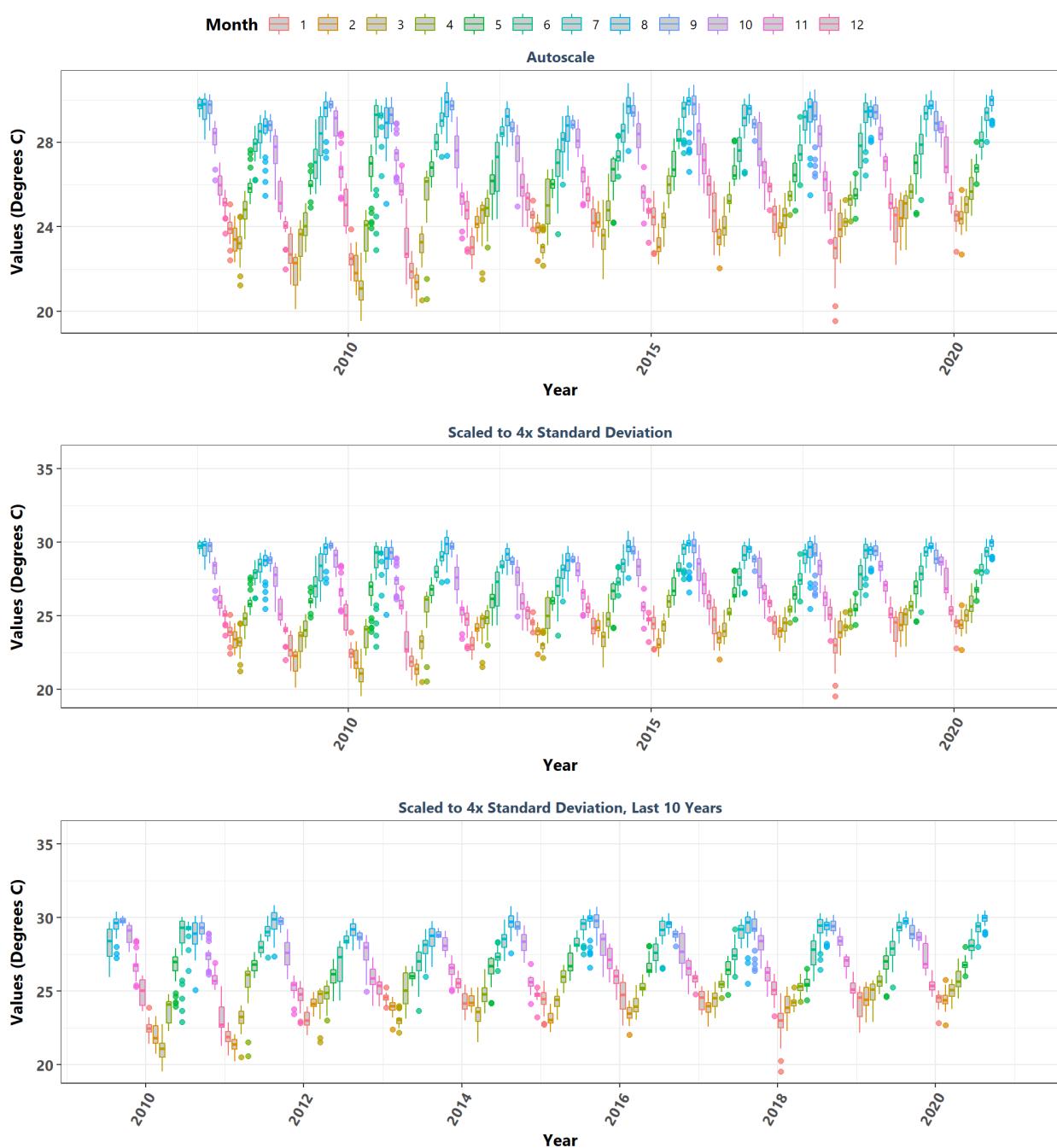
**Southeast Florida Coral Reef Ecosystem Conservation Area**  
**5 | National Data Buoy Center**  
**LKWF1**  
**By Month**



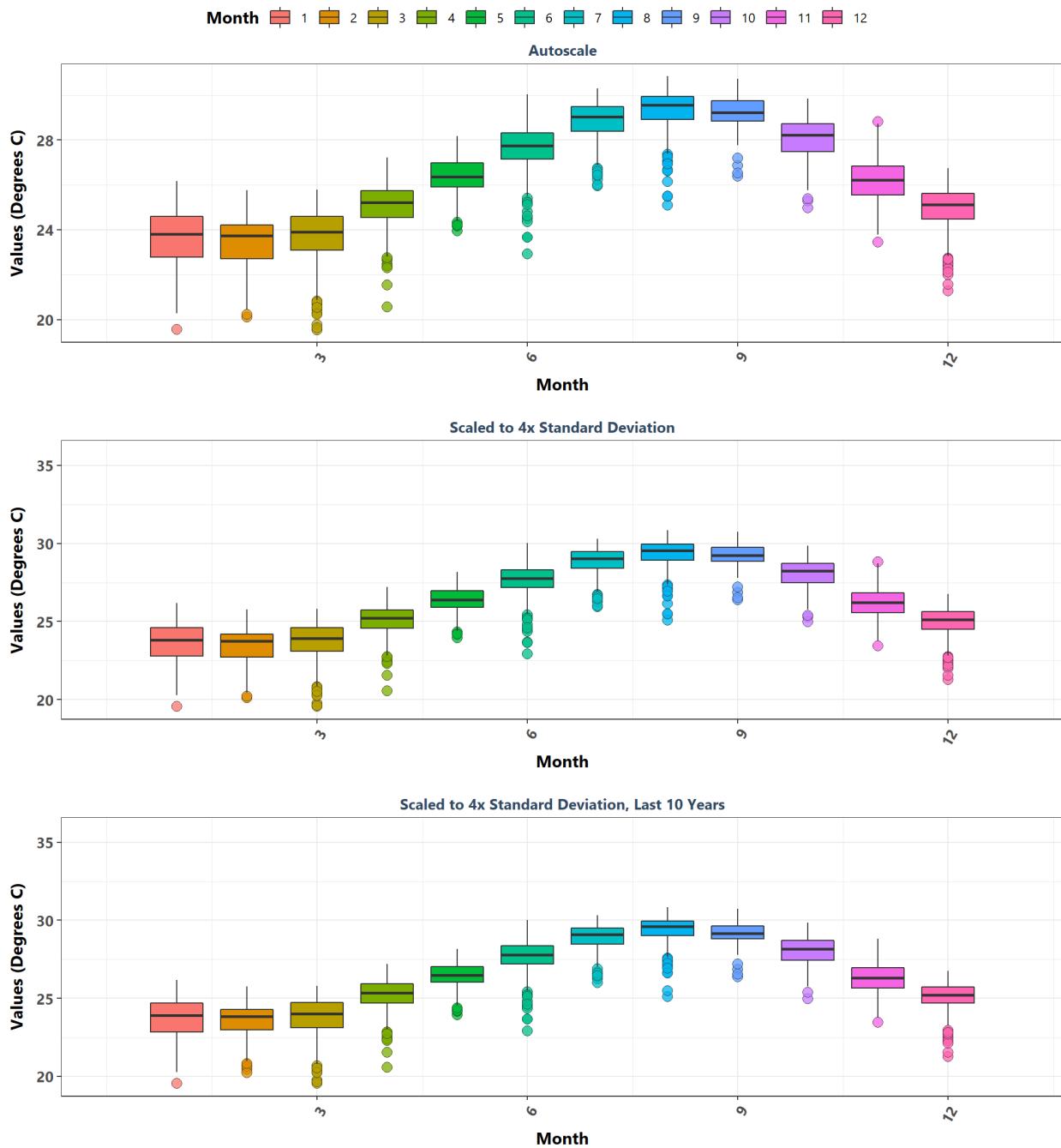
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
**84**  
By Year



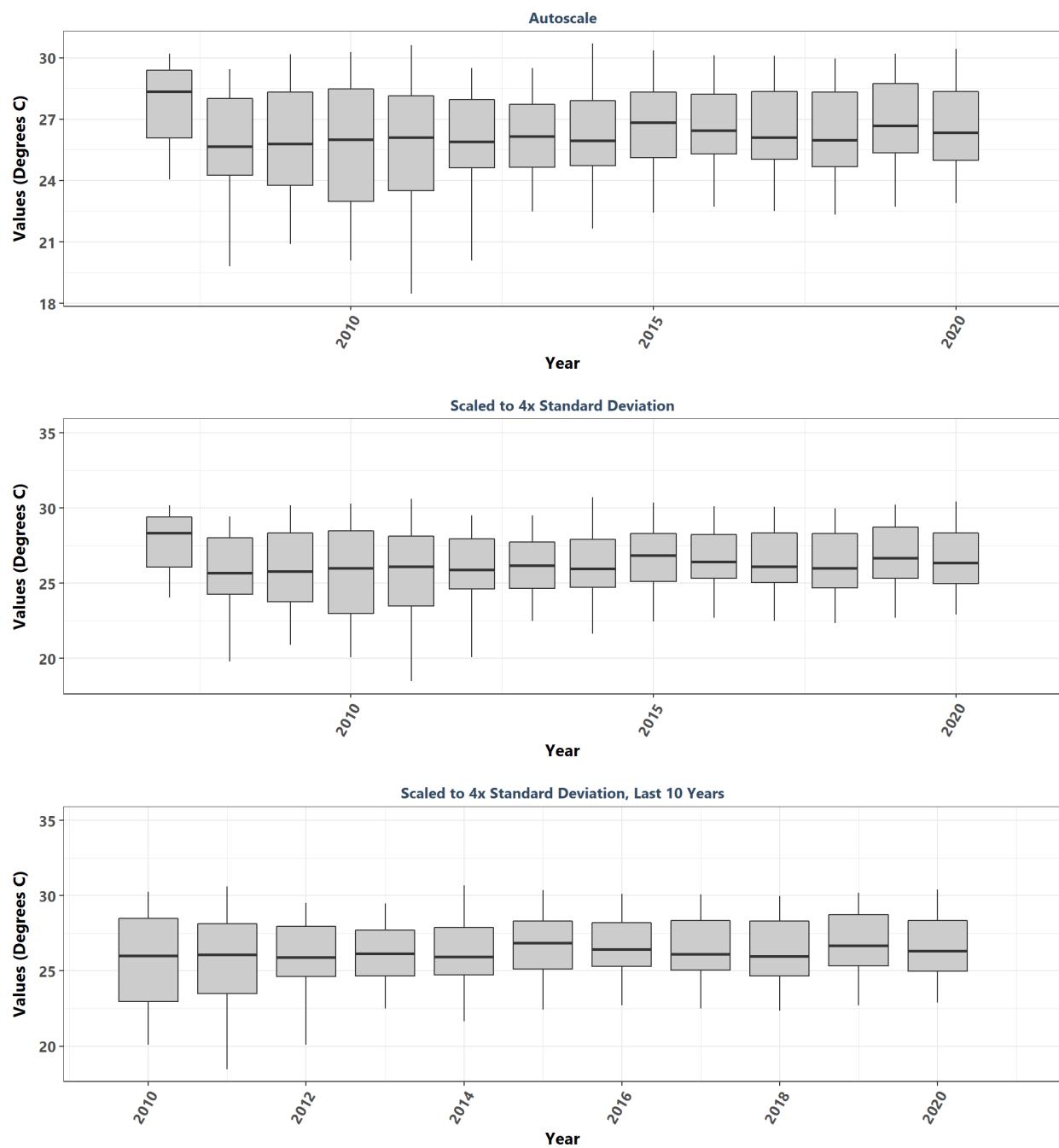
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**84**  
**By Year & Month**



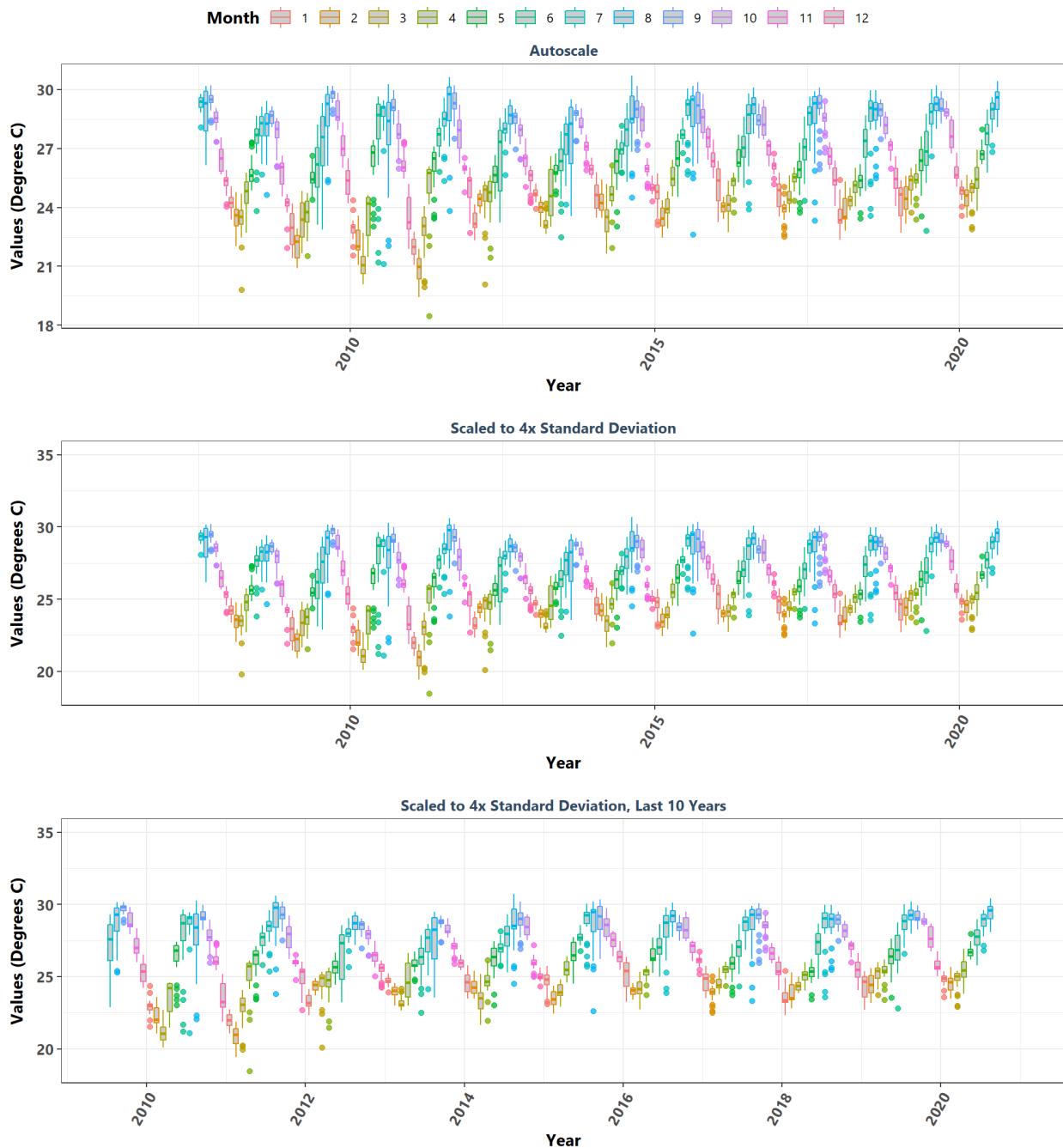
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986 | Water Temperature on Coral Reefs in the Florida Keys  
84**  
By Month



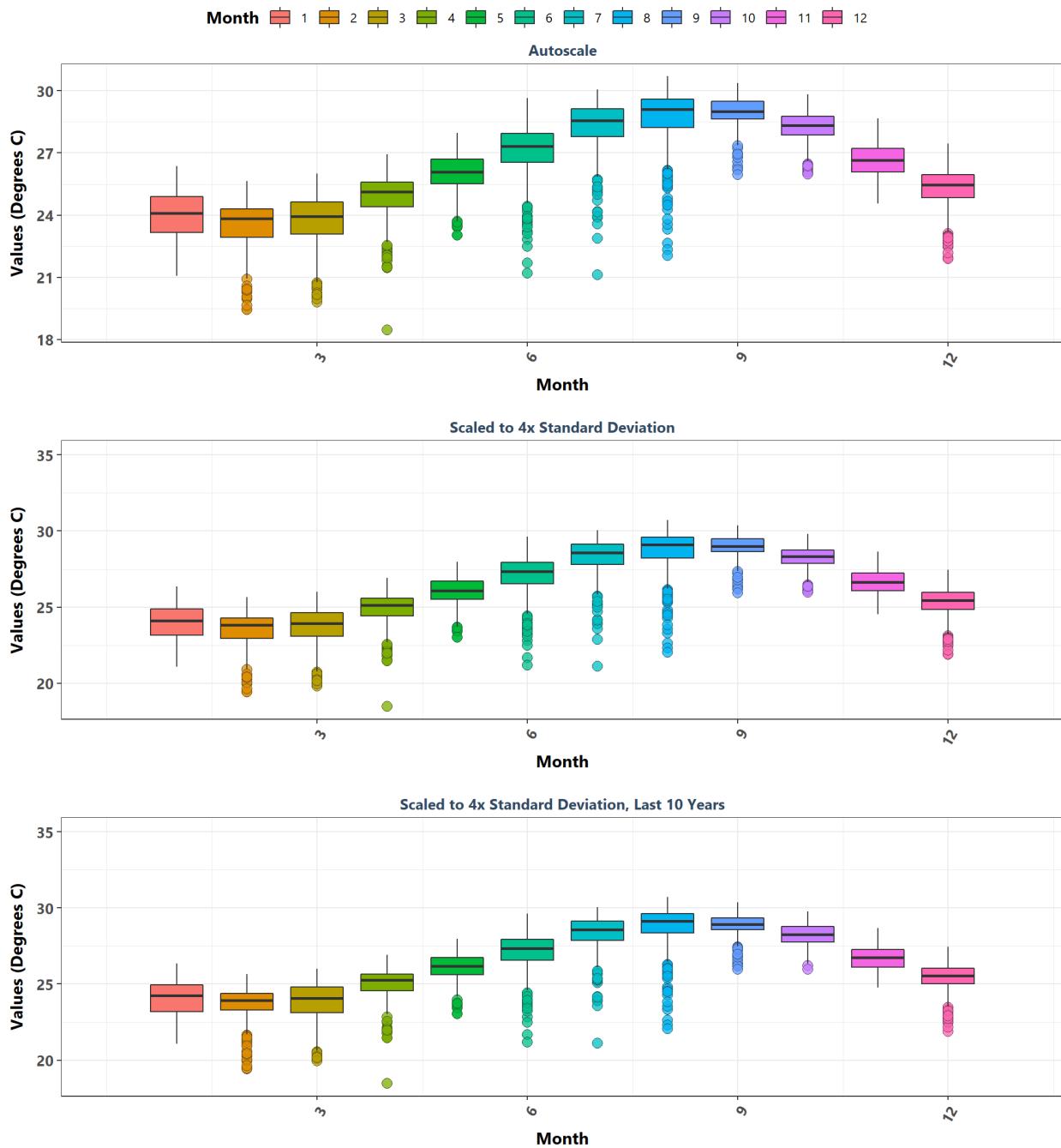
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
85  
By Year



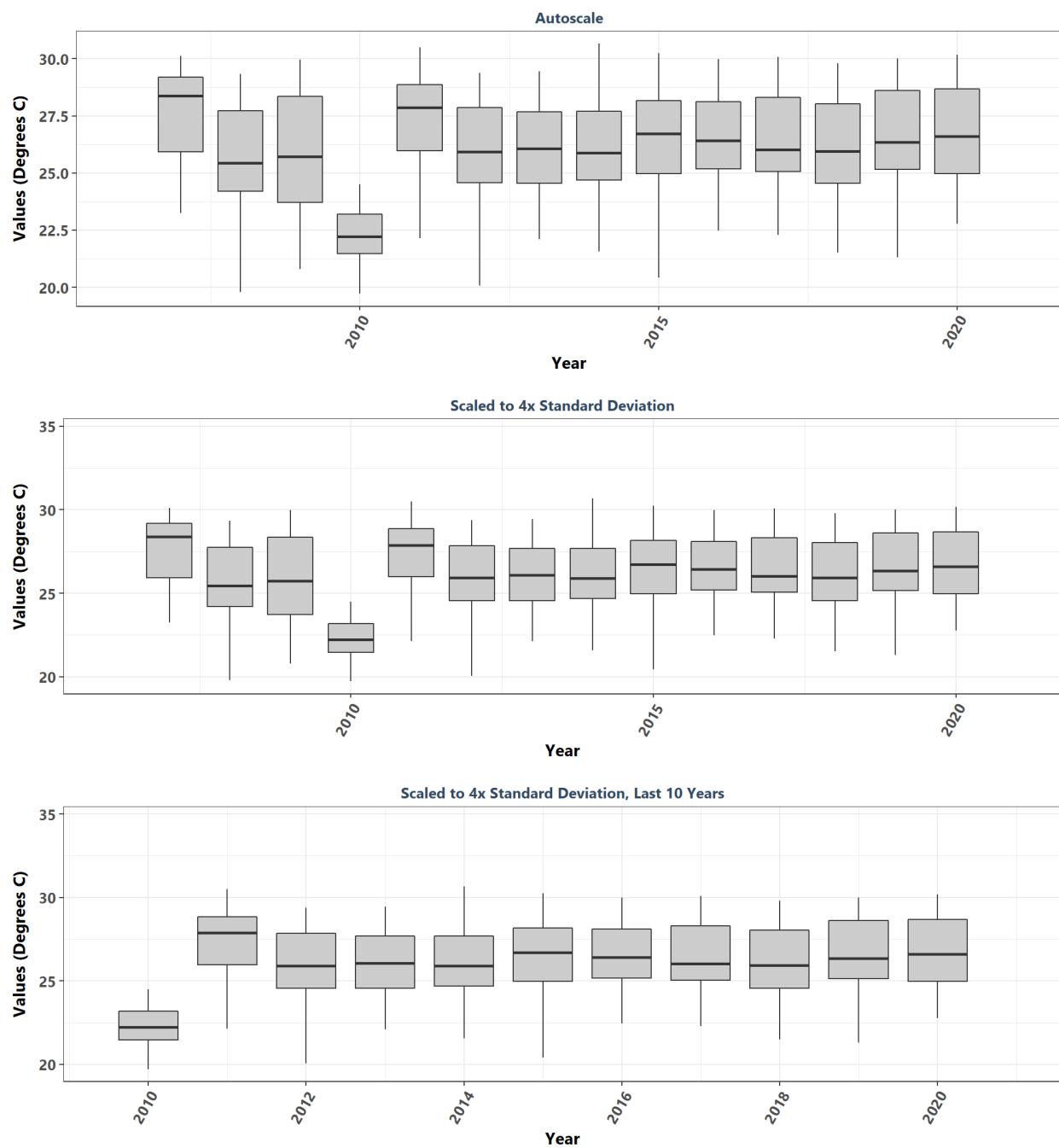
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**85**  
**By Year & Month**



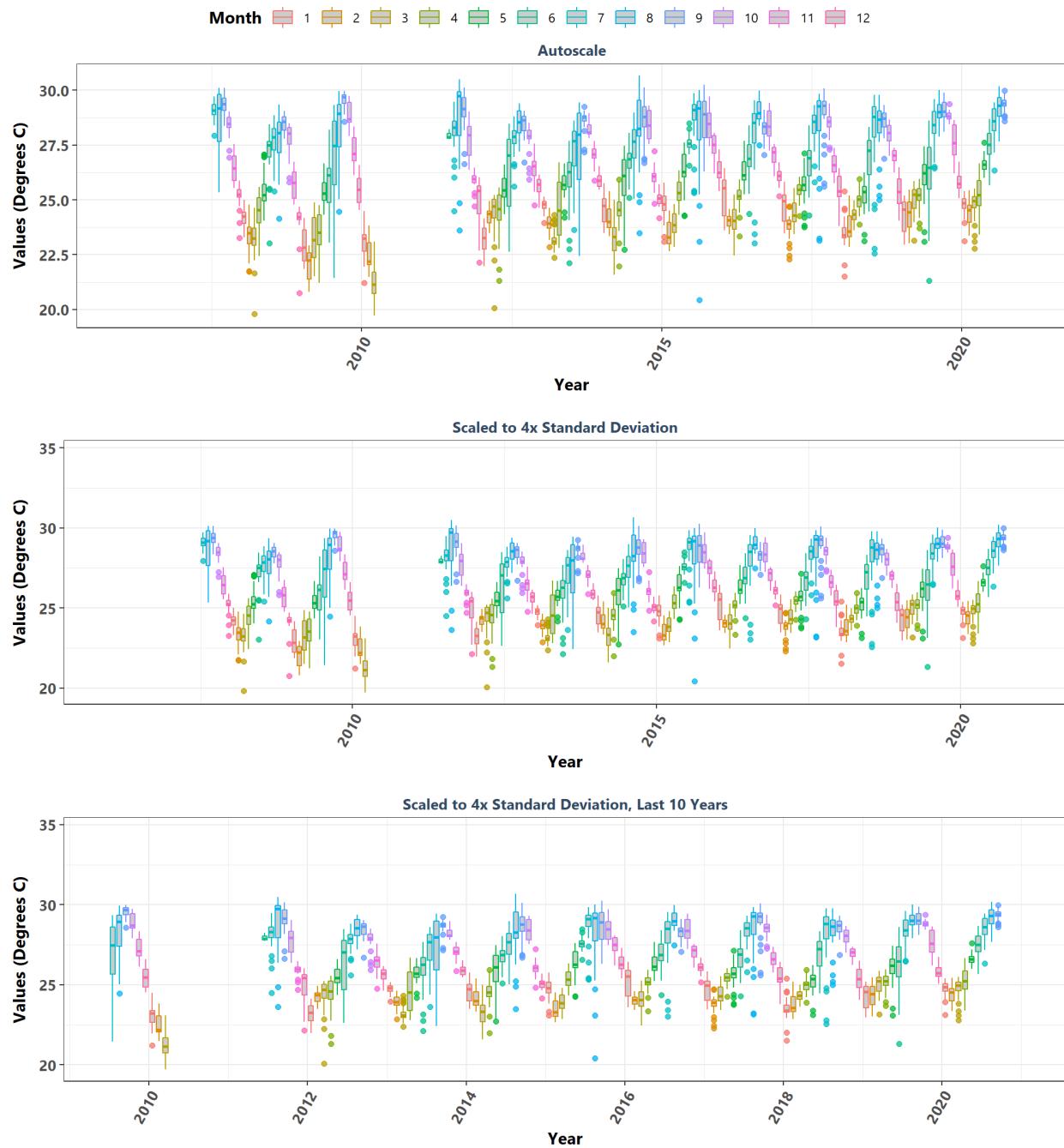
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
**85**  
**By Month**



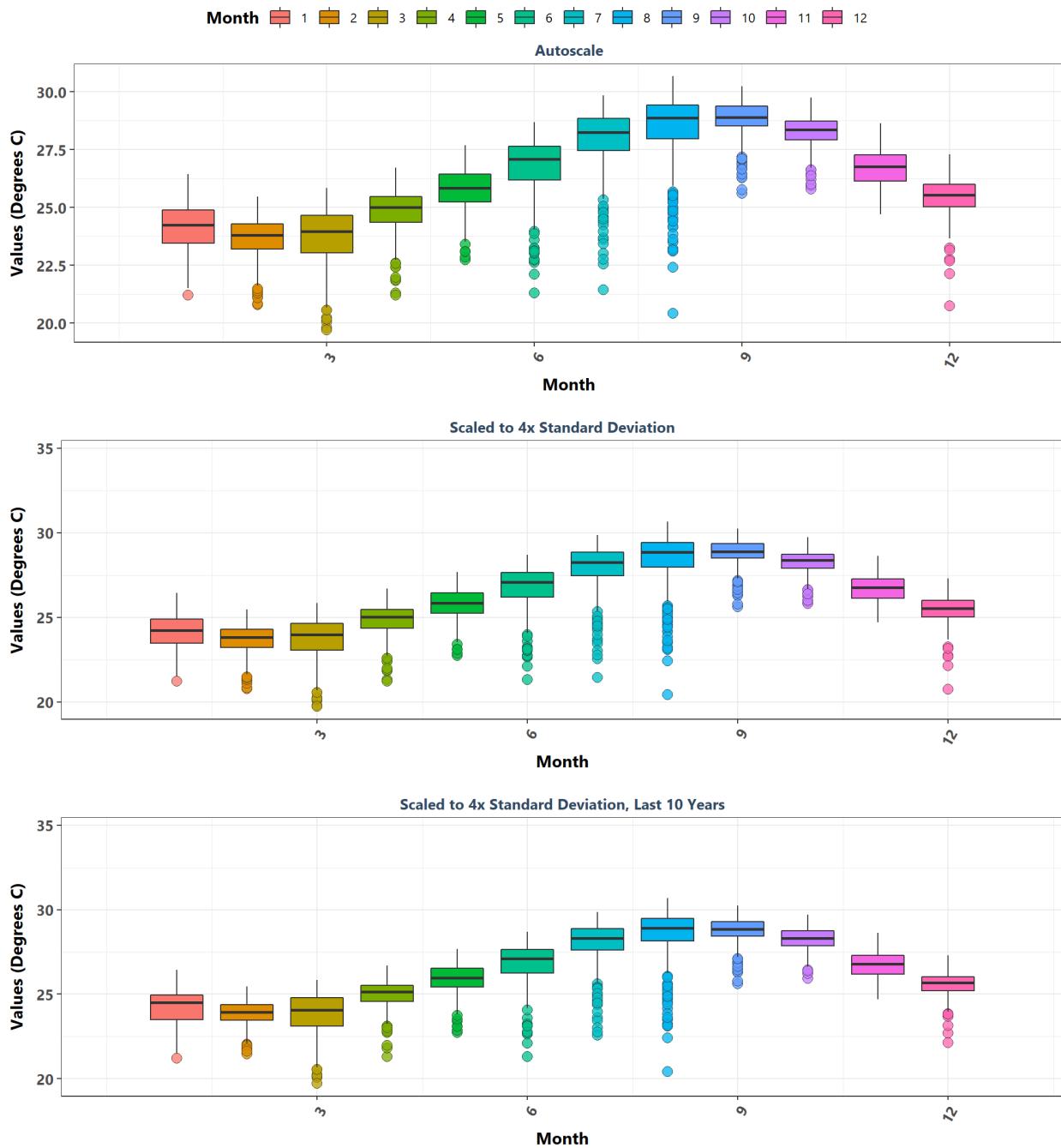
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986 | Water Temperature on Coral Reefs in the Florida Keys**  
**86**  
**By Year**



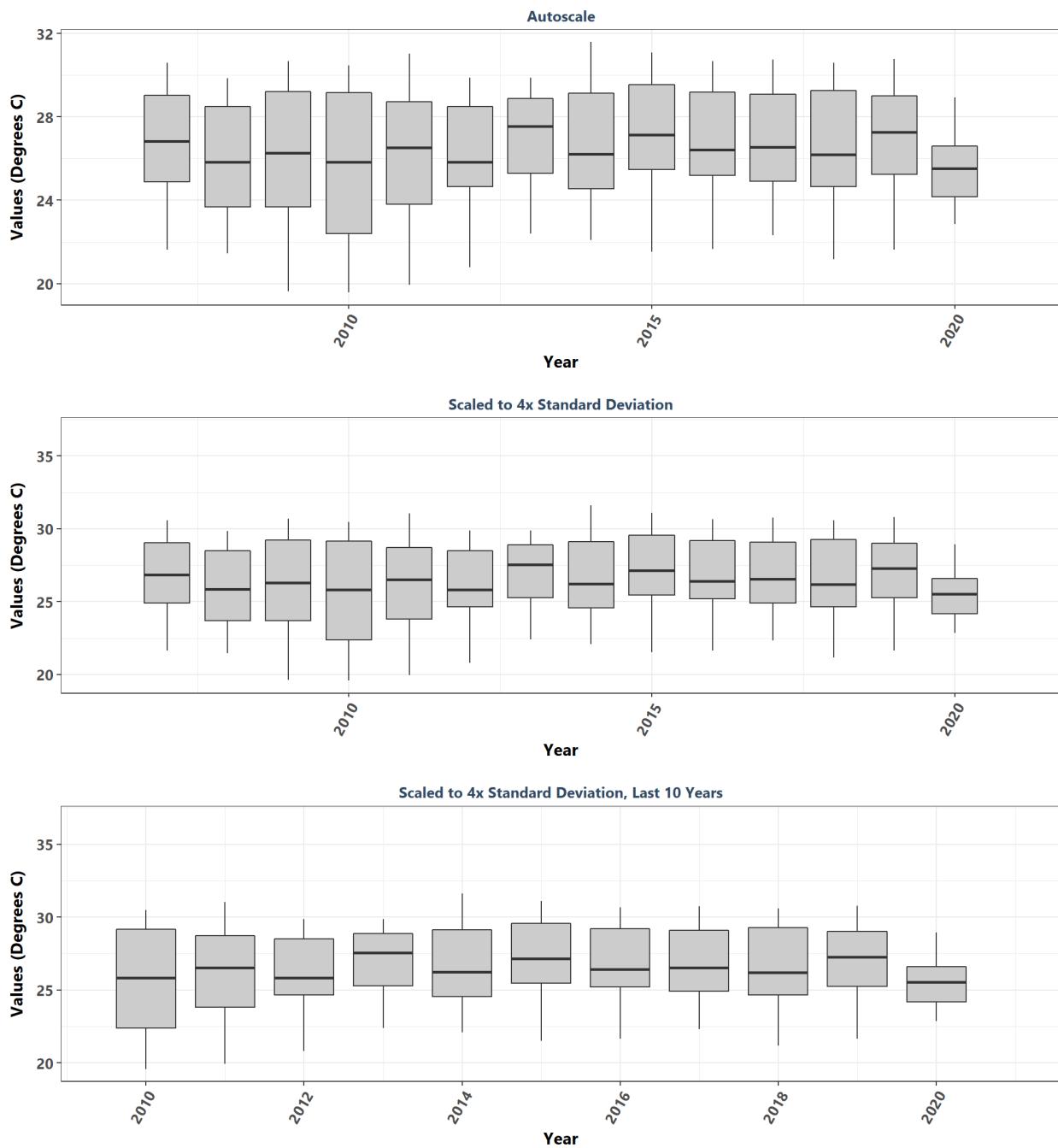
**Southeast Florida Coral Reef Ecosystem Conservation Area**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**86**  
**By Year & Month**



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

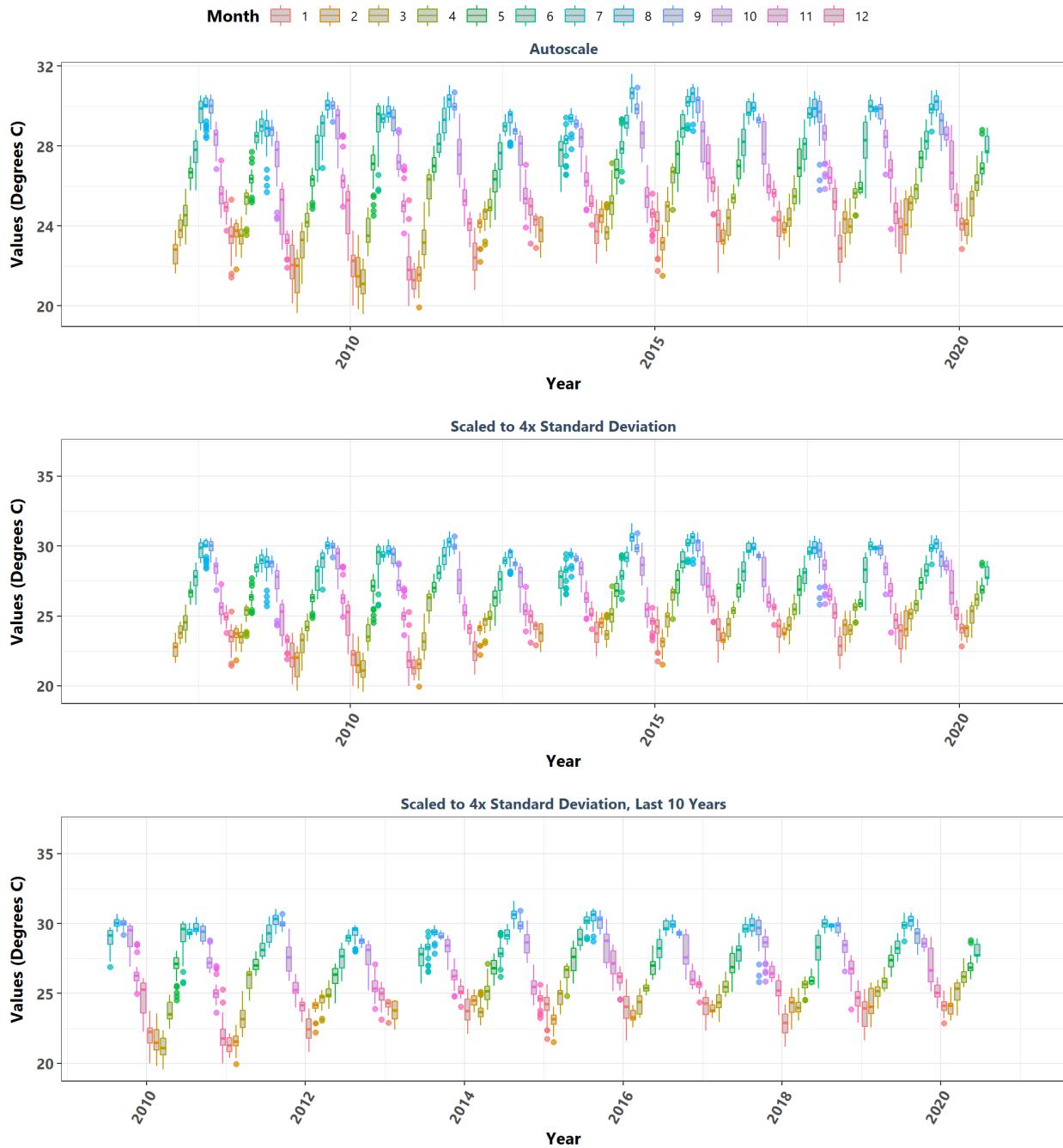


**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
**87**  
By Year

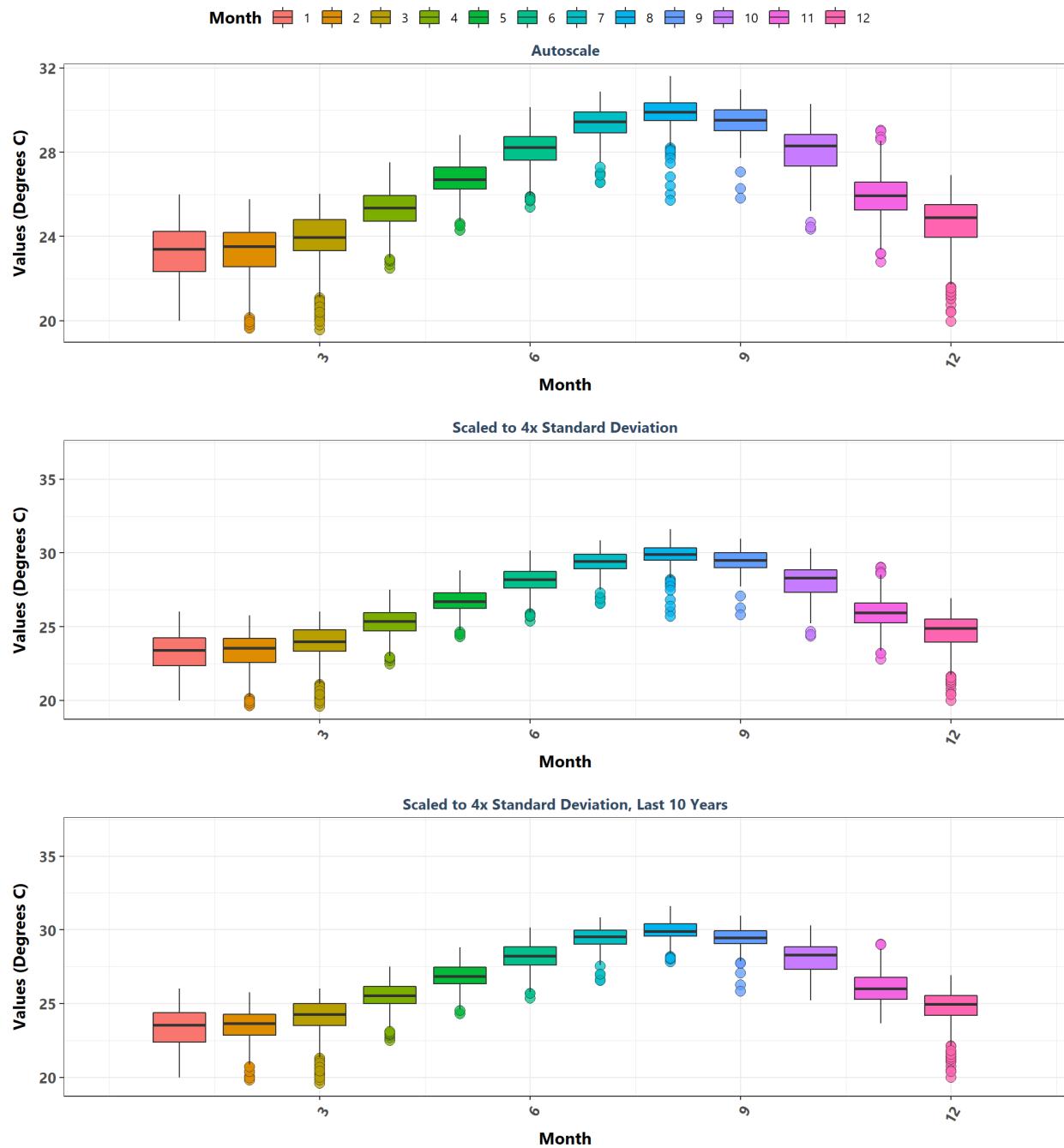


**Southeast Florida Coral Reef Ecosystem Conservation Area**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**87**

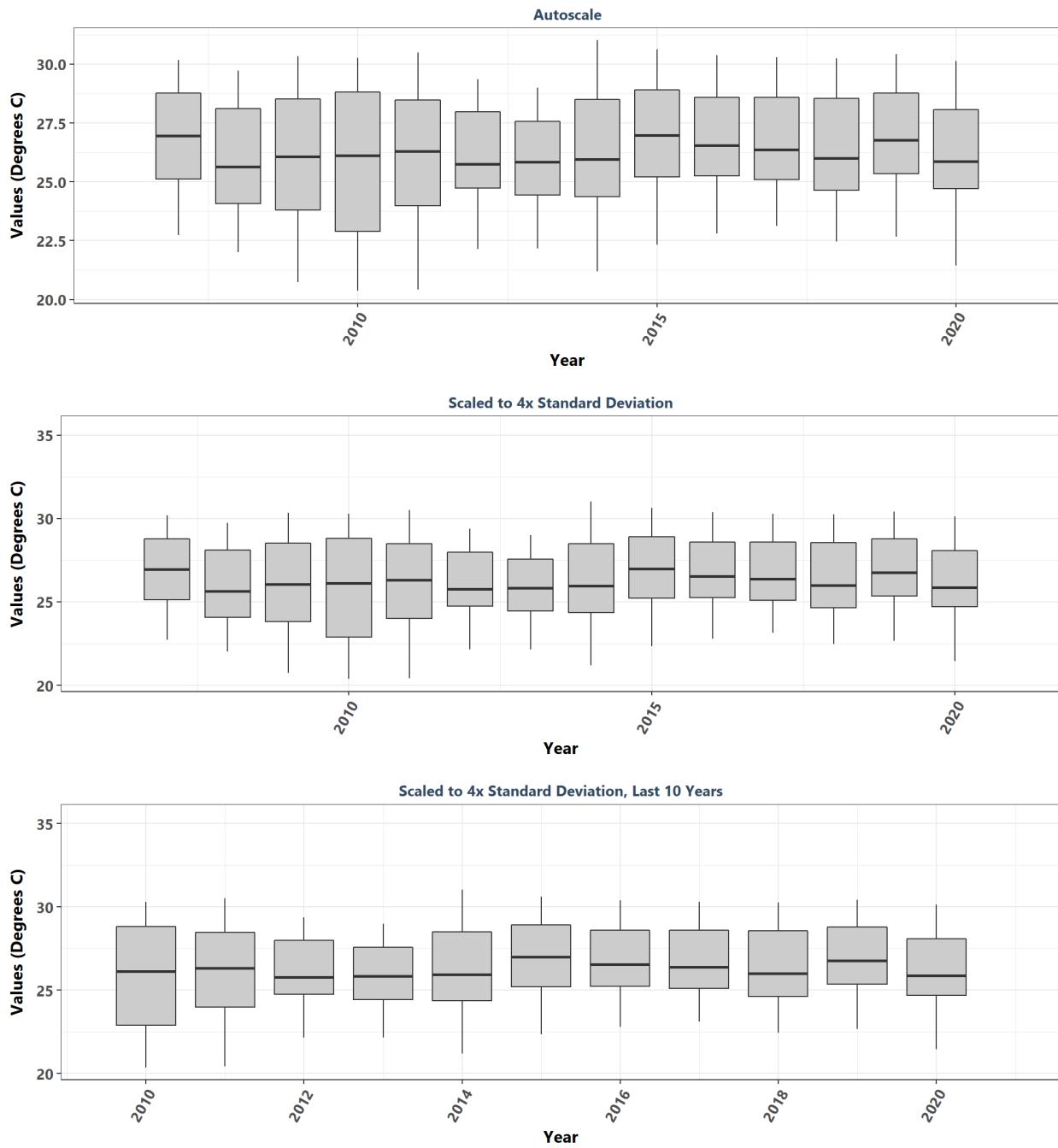
By Year & Month



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

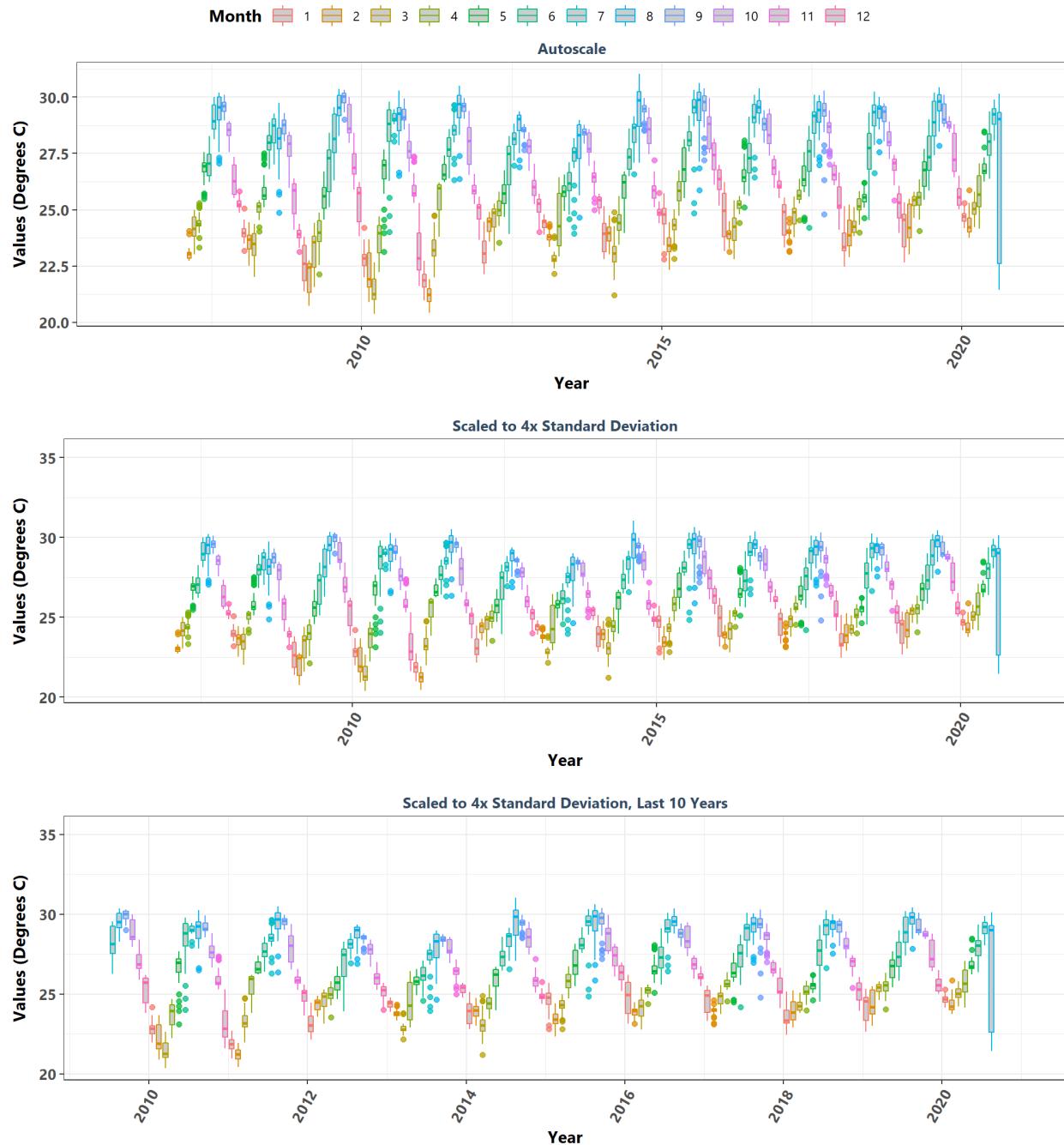


**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
**88**  
By Year

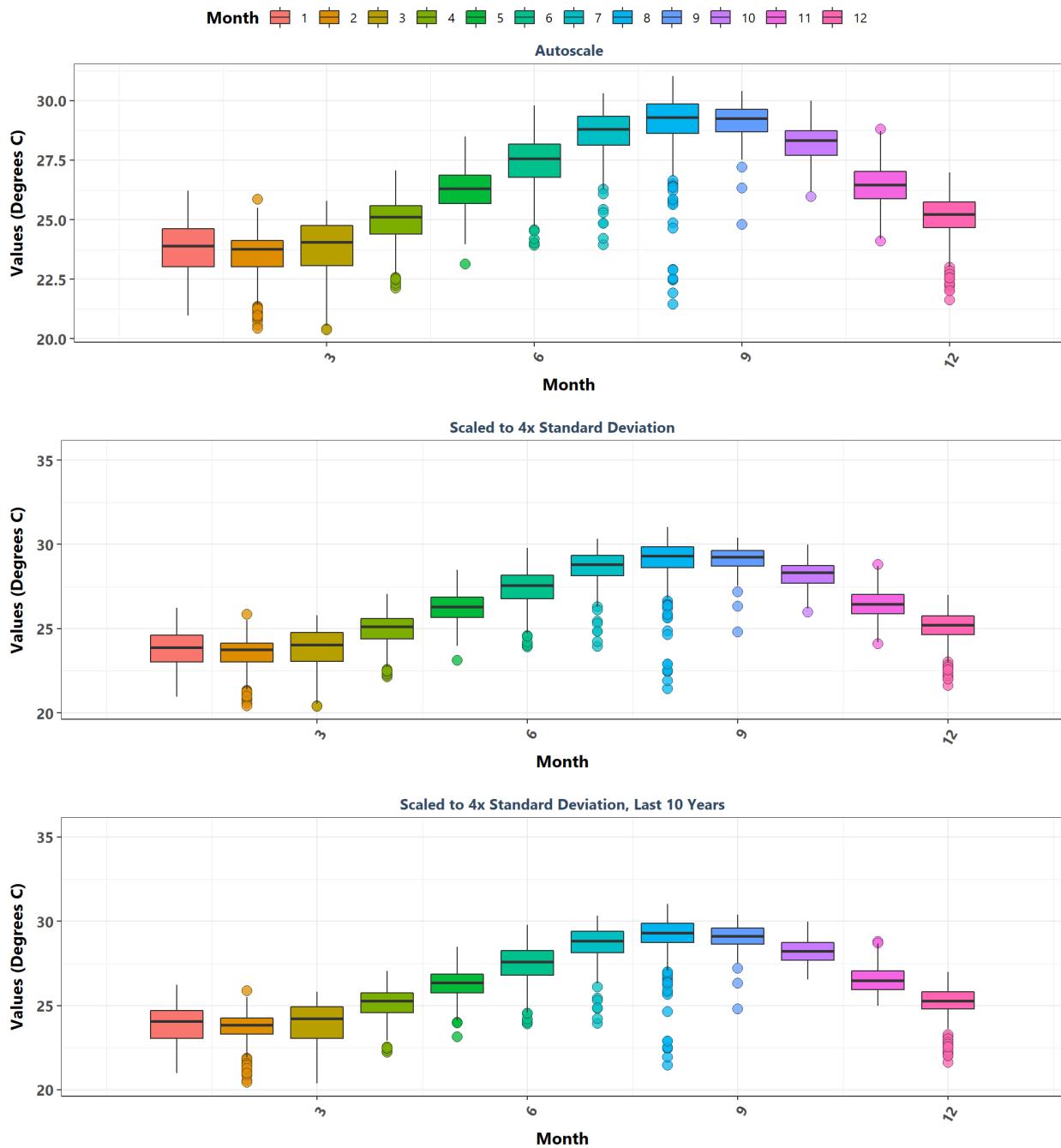


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986 | Water Temperature on Coral Reefs in the Florida Keys**  
**88**

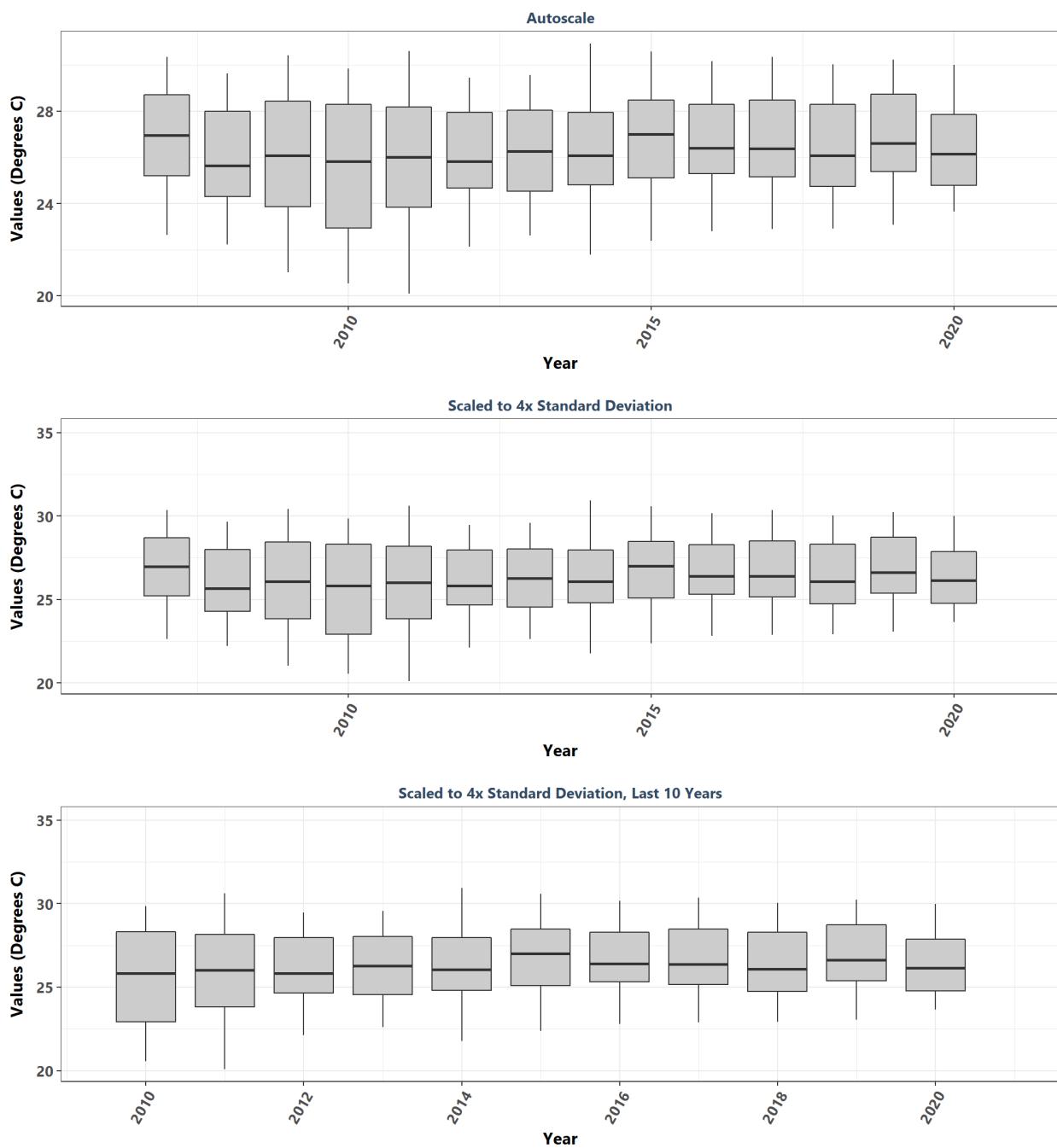
By Year & Month



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

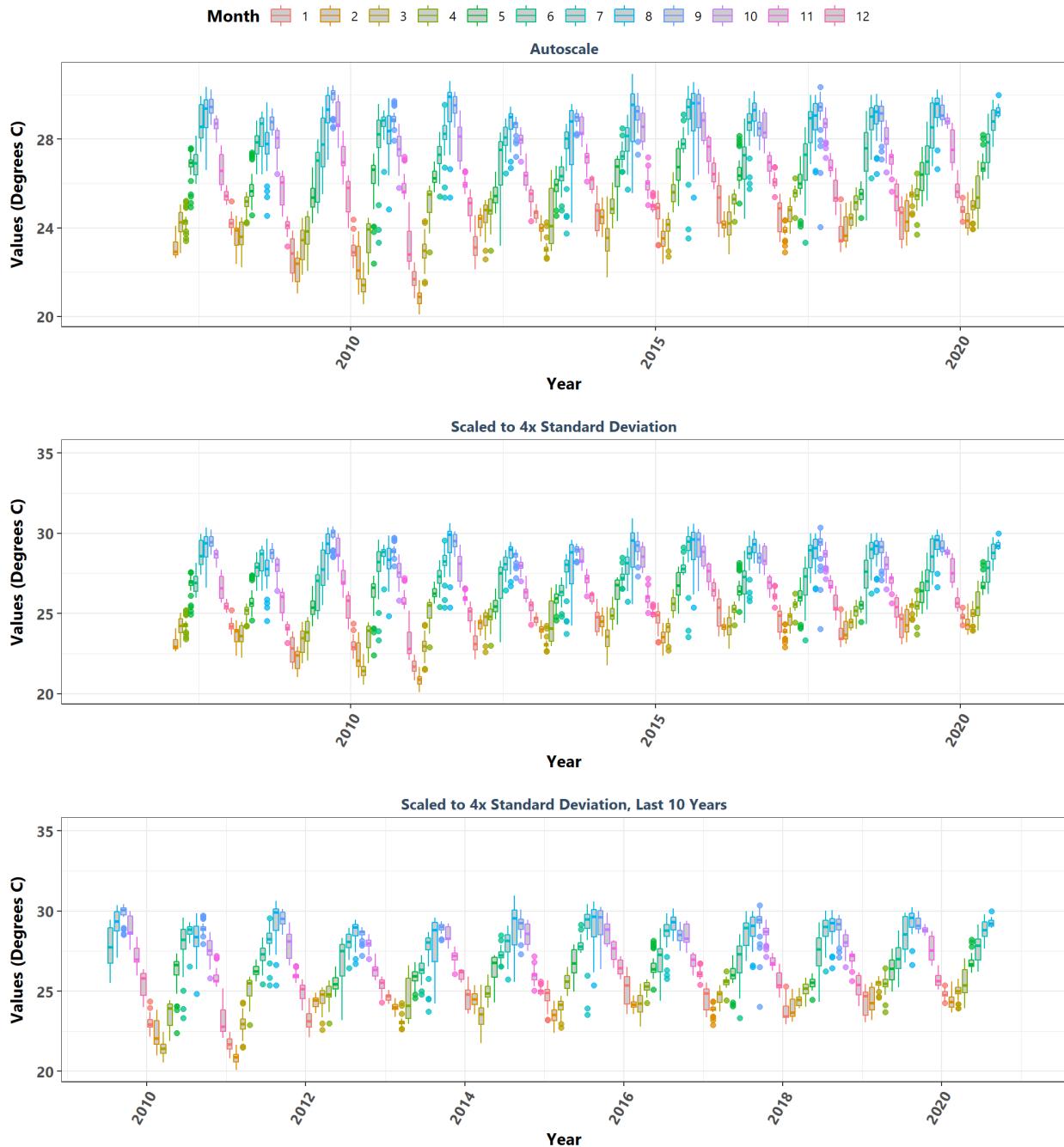


**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
**89**  
By Year

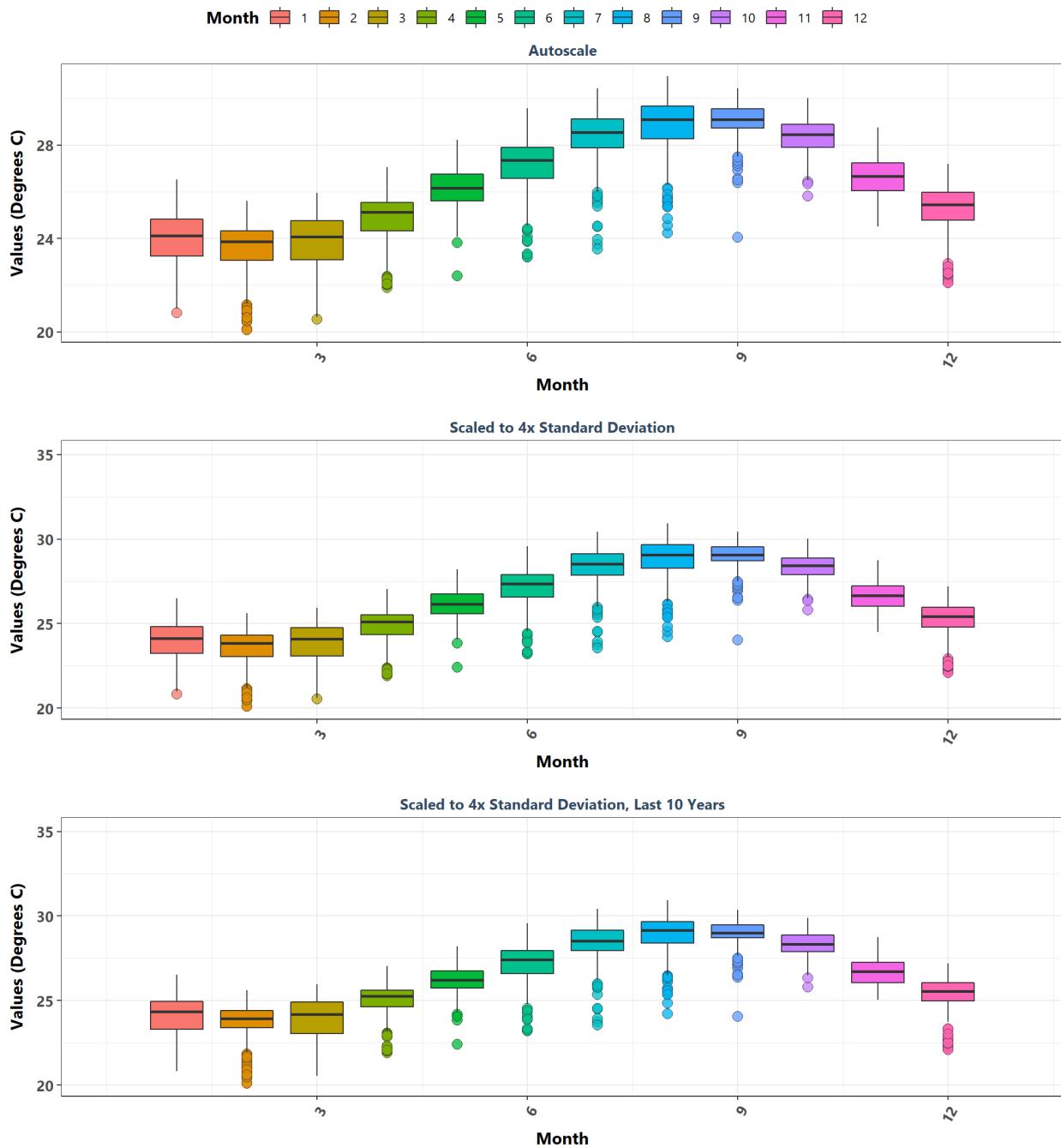


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986 | Water Temperature on Coral Reefs in the Florida Keys  
89**

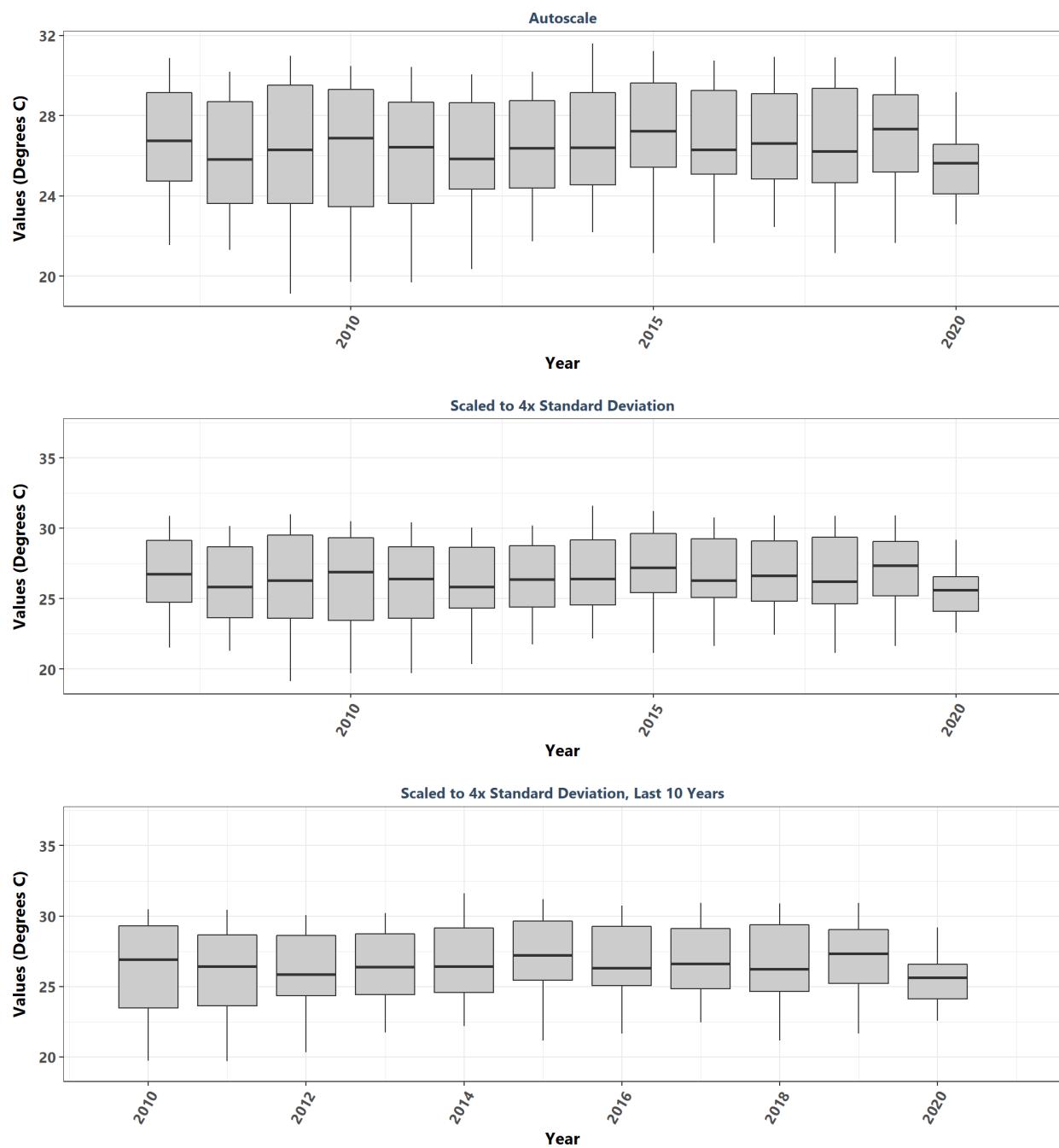
By Year & Month



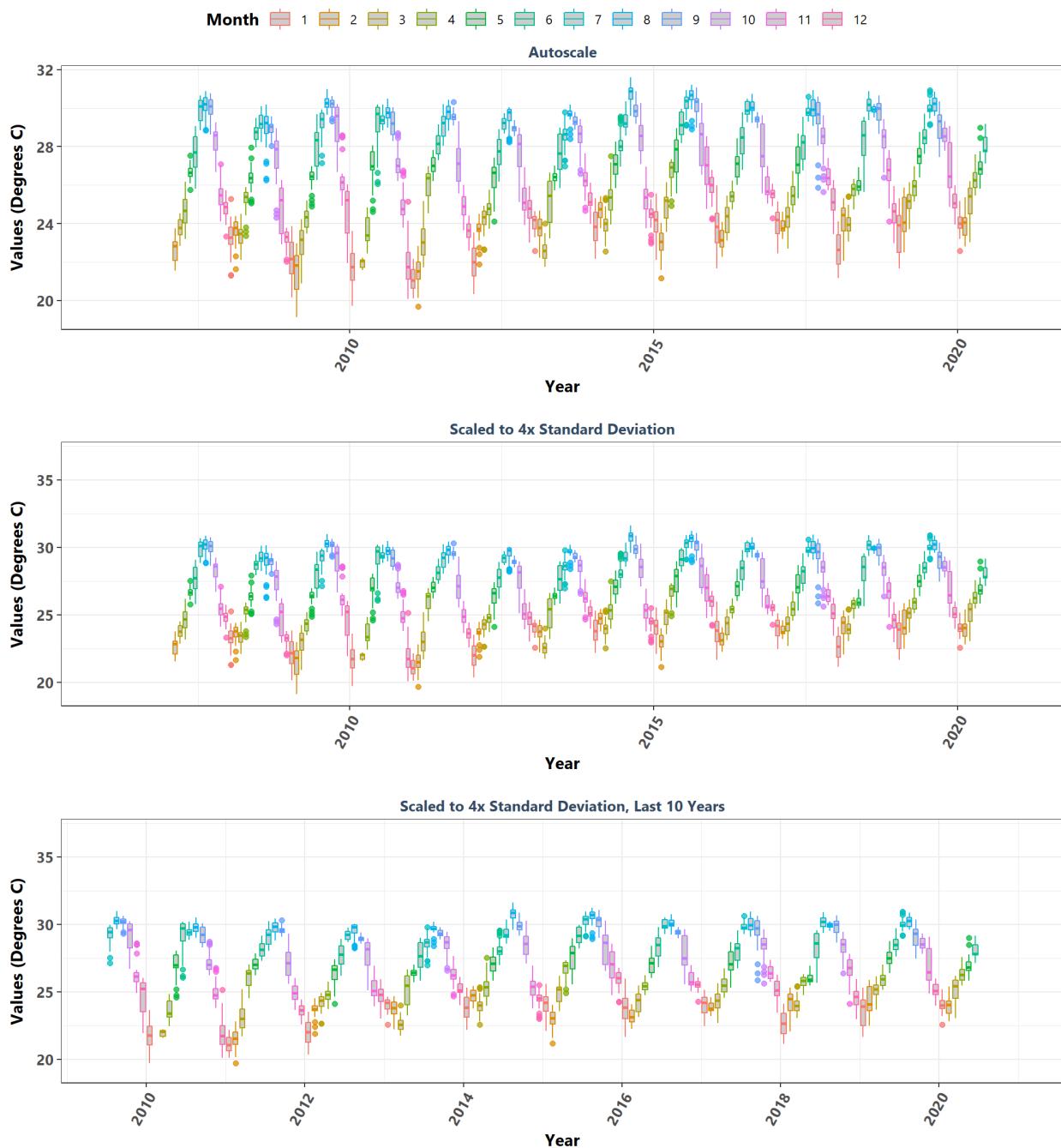
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**89**  
**By Month**



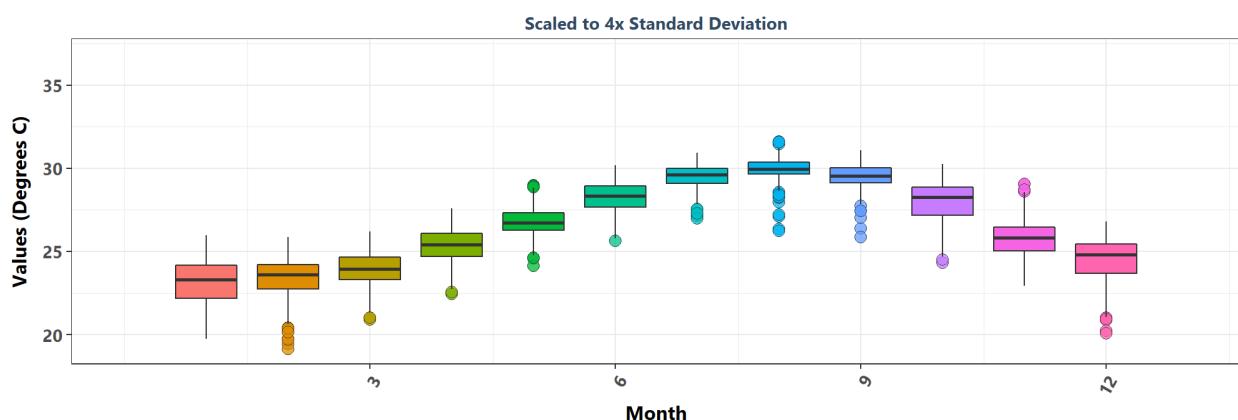
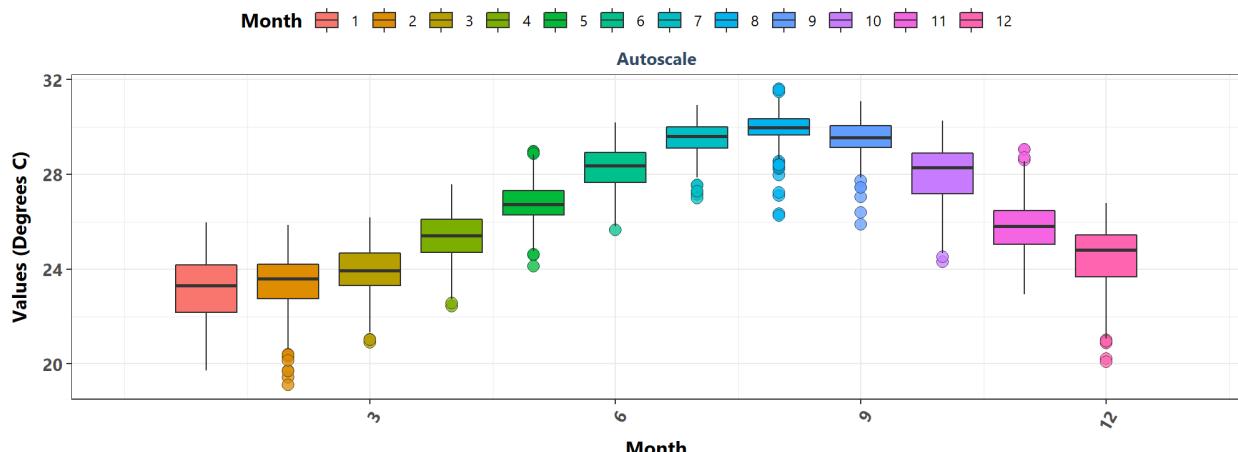
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986 | Water Temperature on Coral Reefs in the Florida Keys**  
90  
By Year



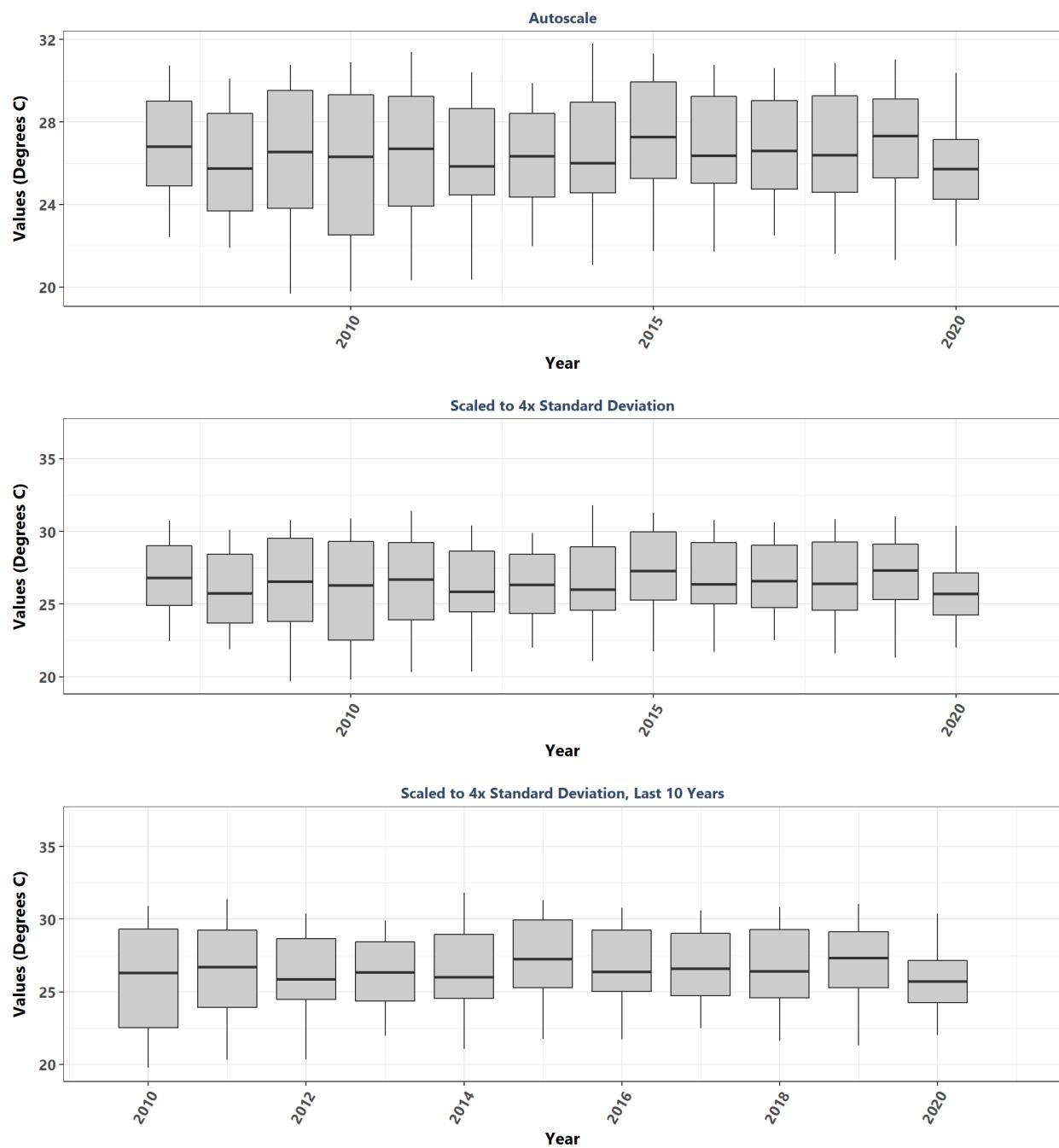
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**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**90**  
**By Year & Month**



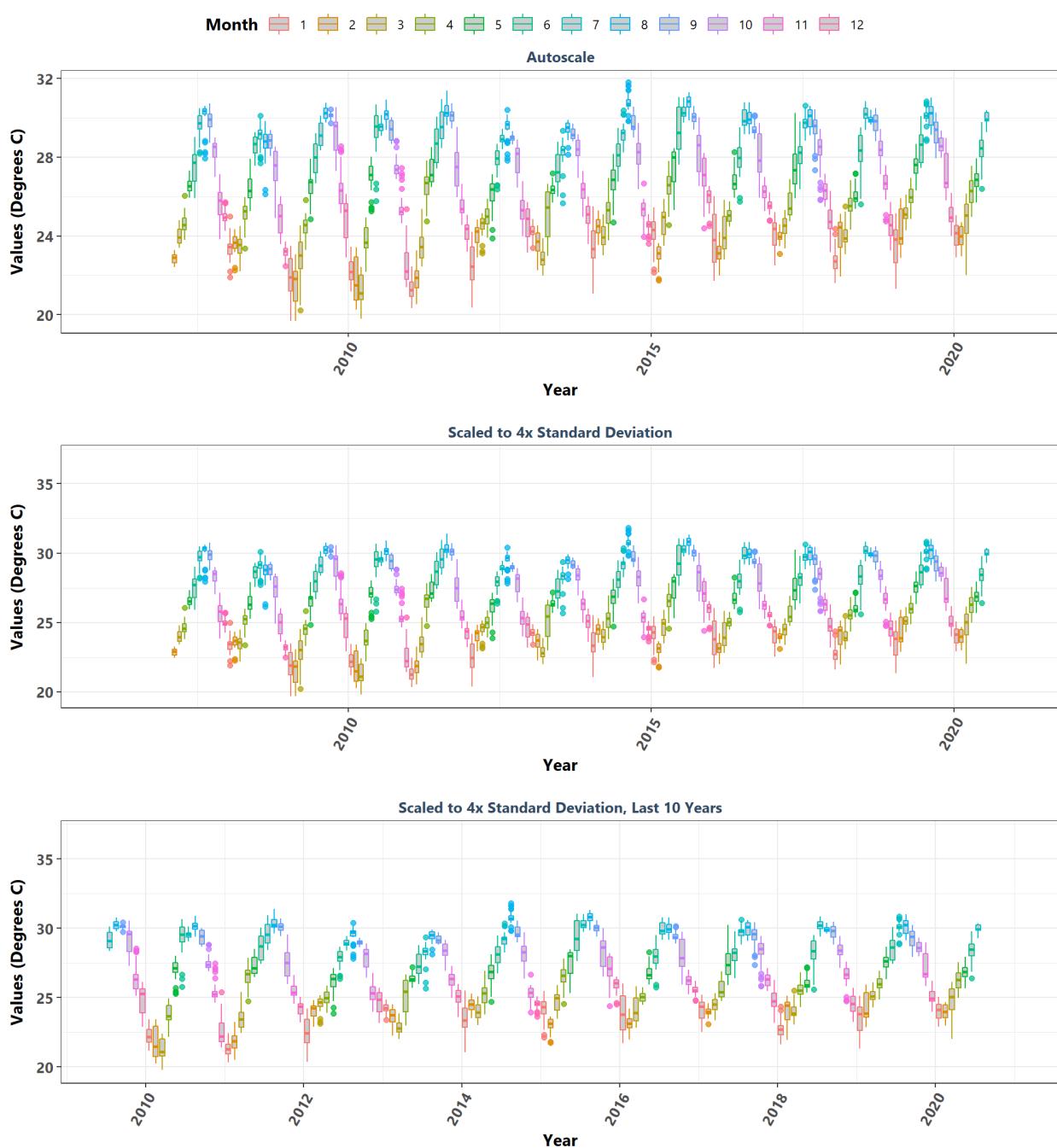
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986 | Water Temperature on Coral Reefs in the Florida Keys  
90**  
By Month



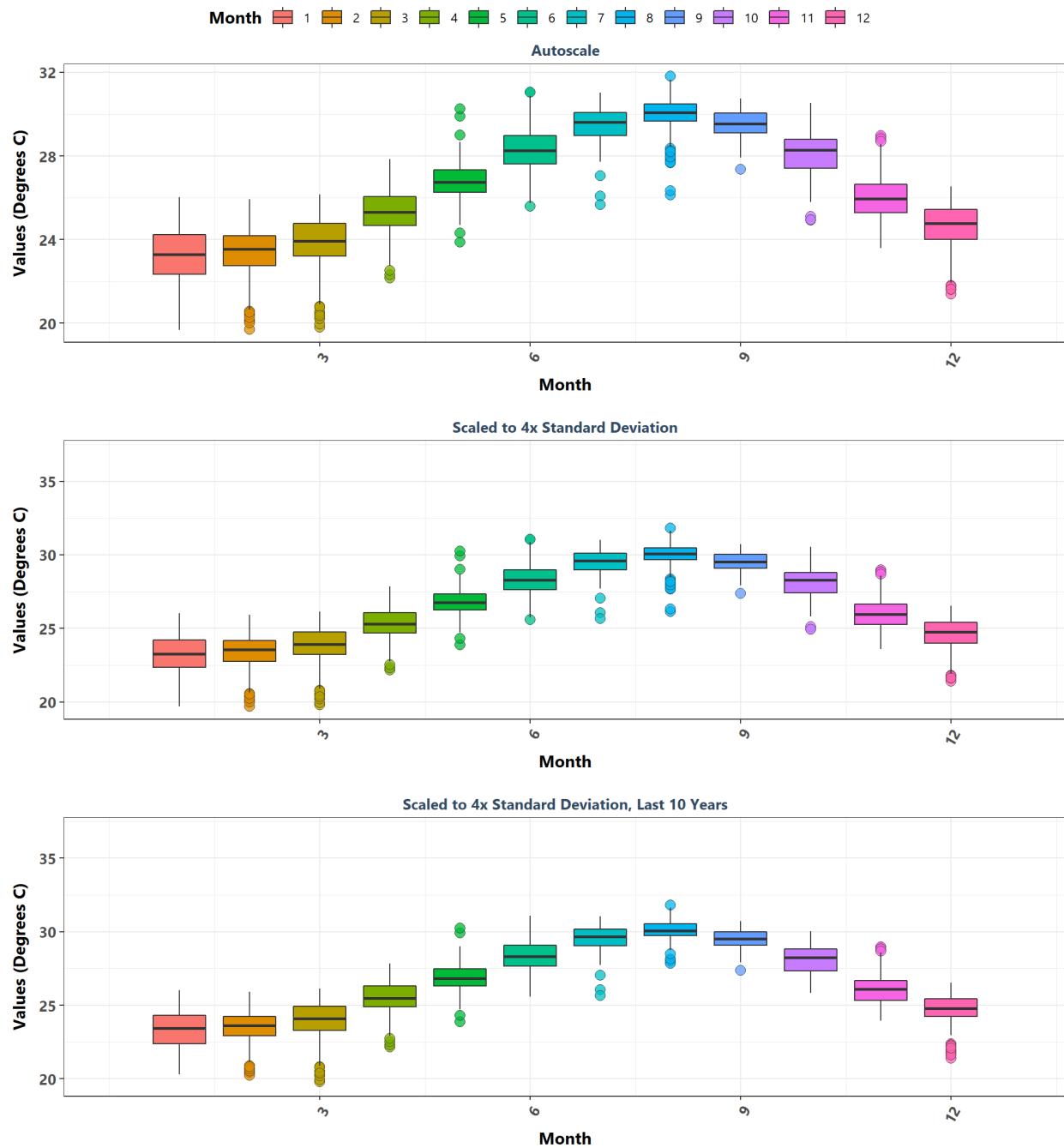
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986 | Water Temperature on Coral Reefs in the Florida Keys**  
**91**  
By Year



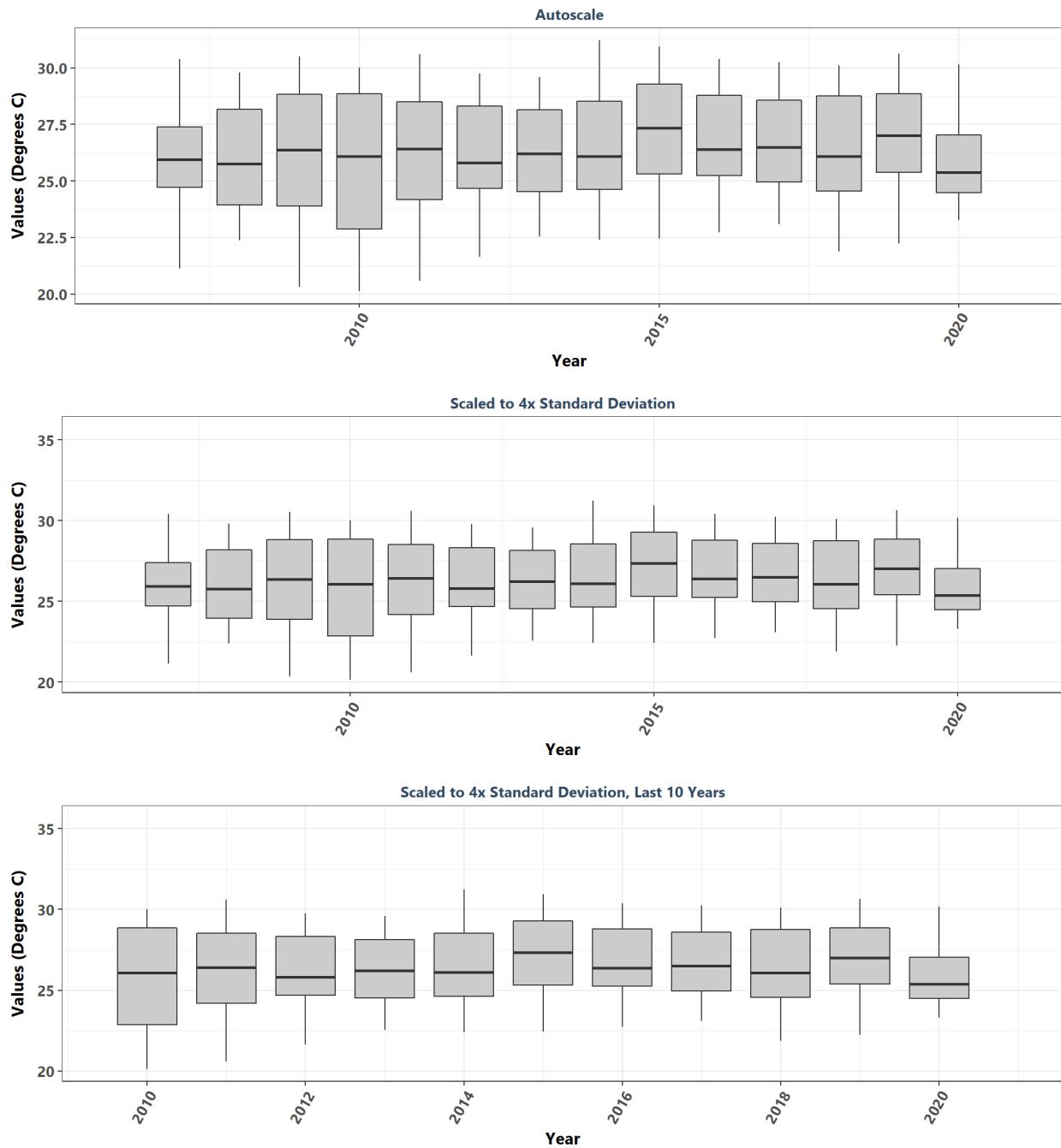
**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
**91**  
**By Year & Month**



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

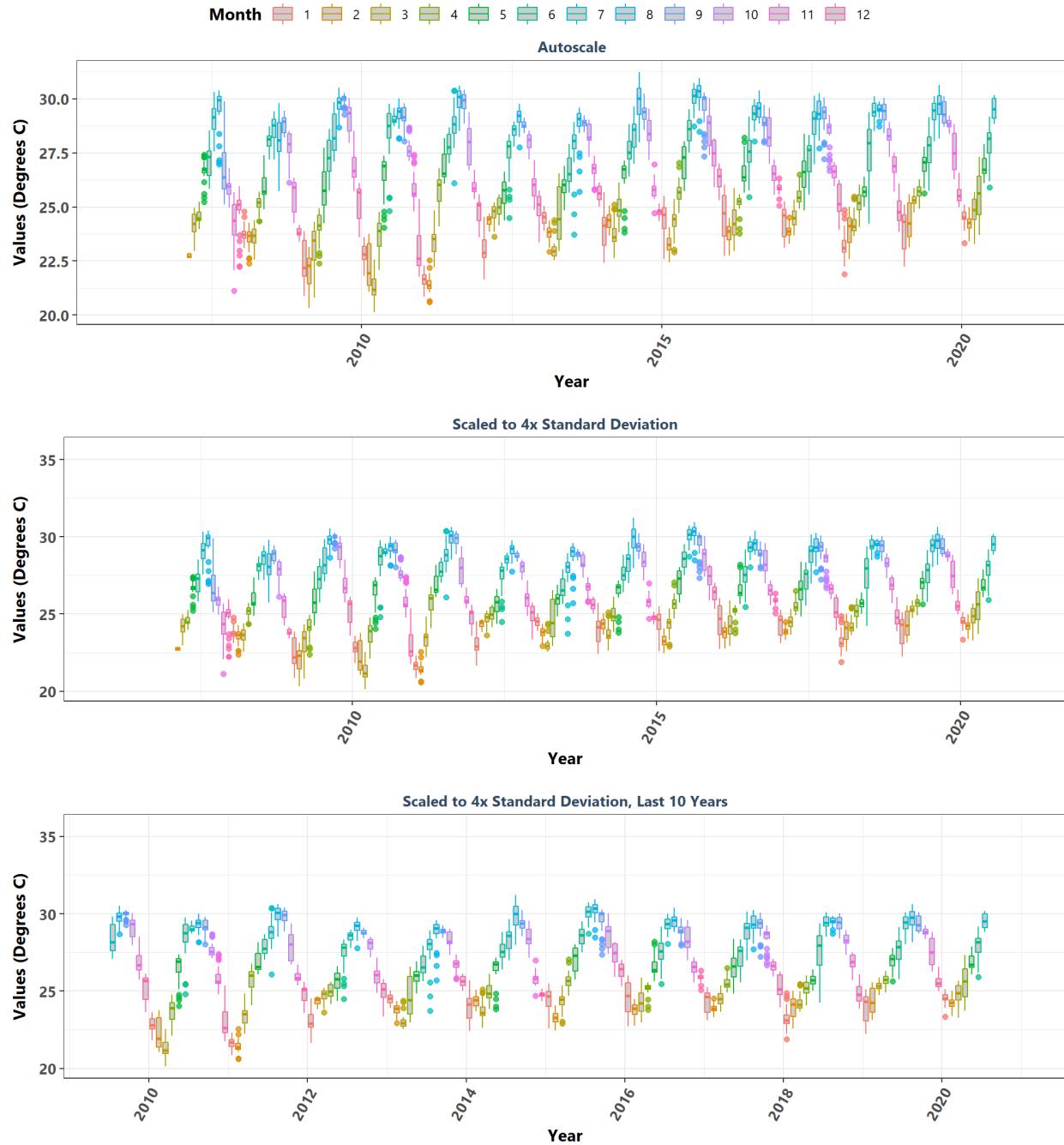


**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
**92**  
**By Year**

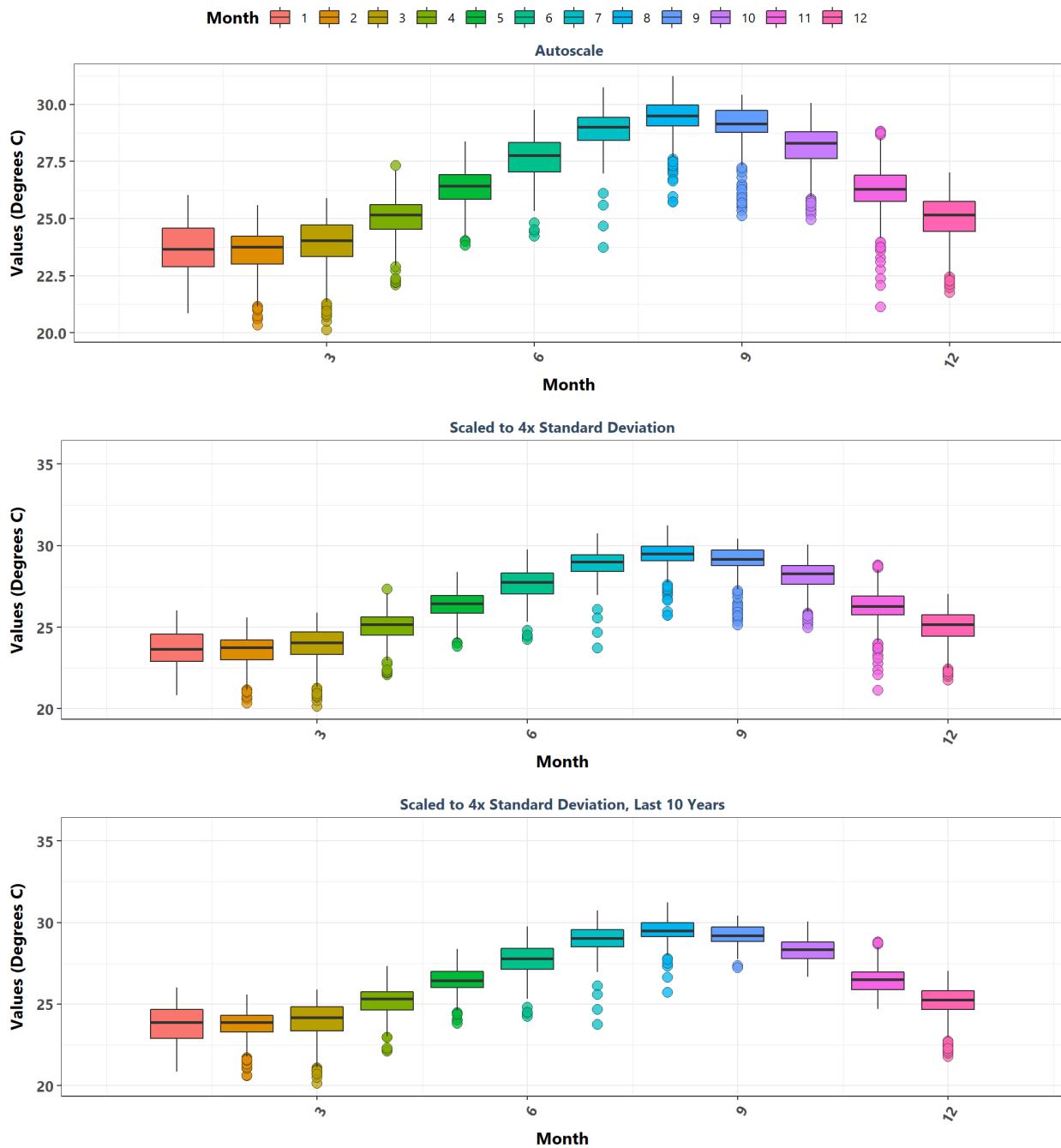


**Southeast Florida Coral Reef Ecosystem Conservation Area**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**92**

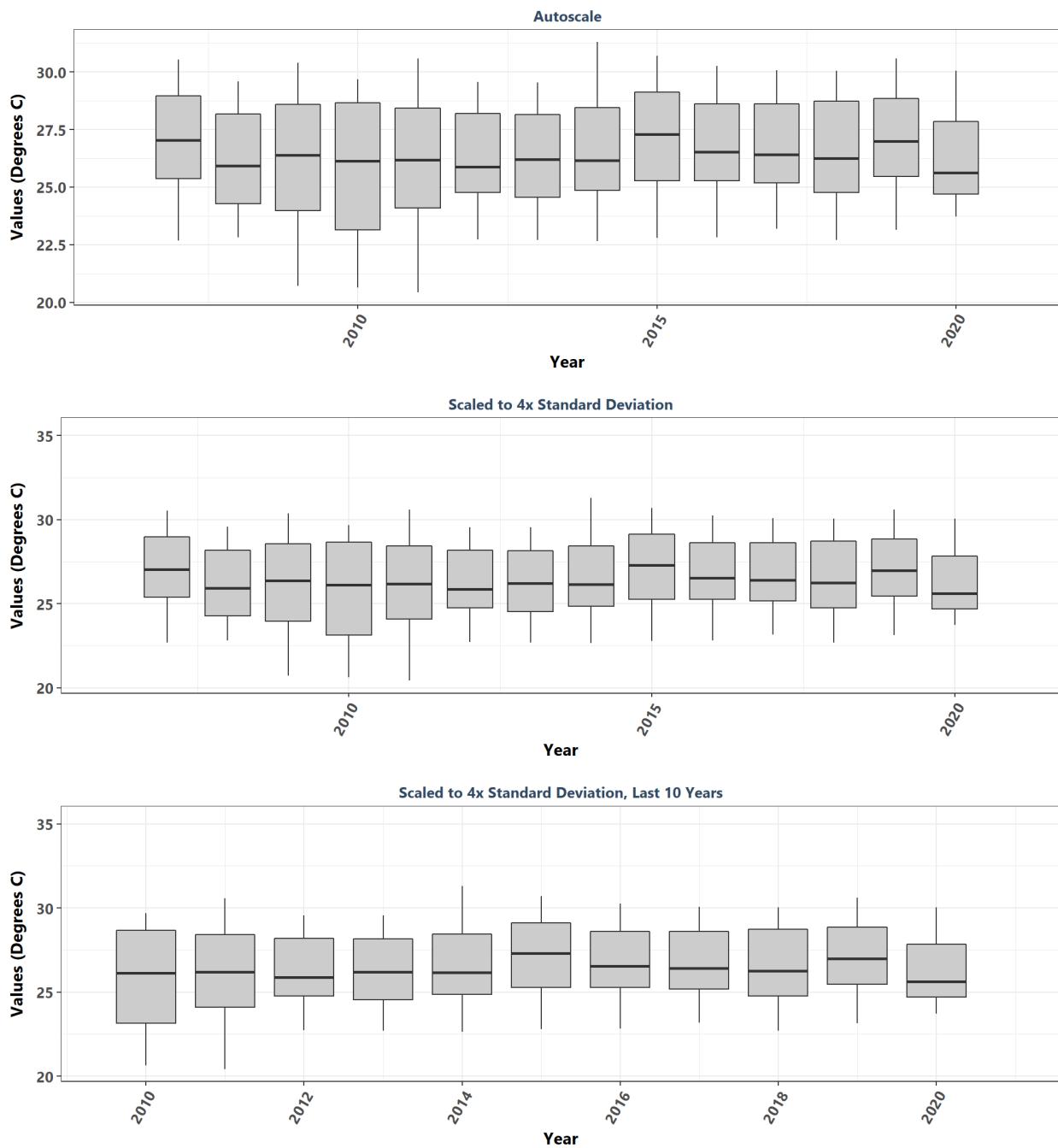
By Year & Month



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

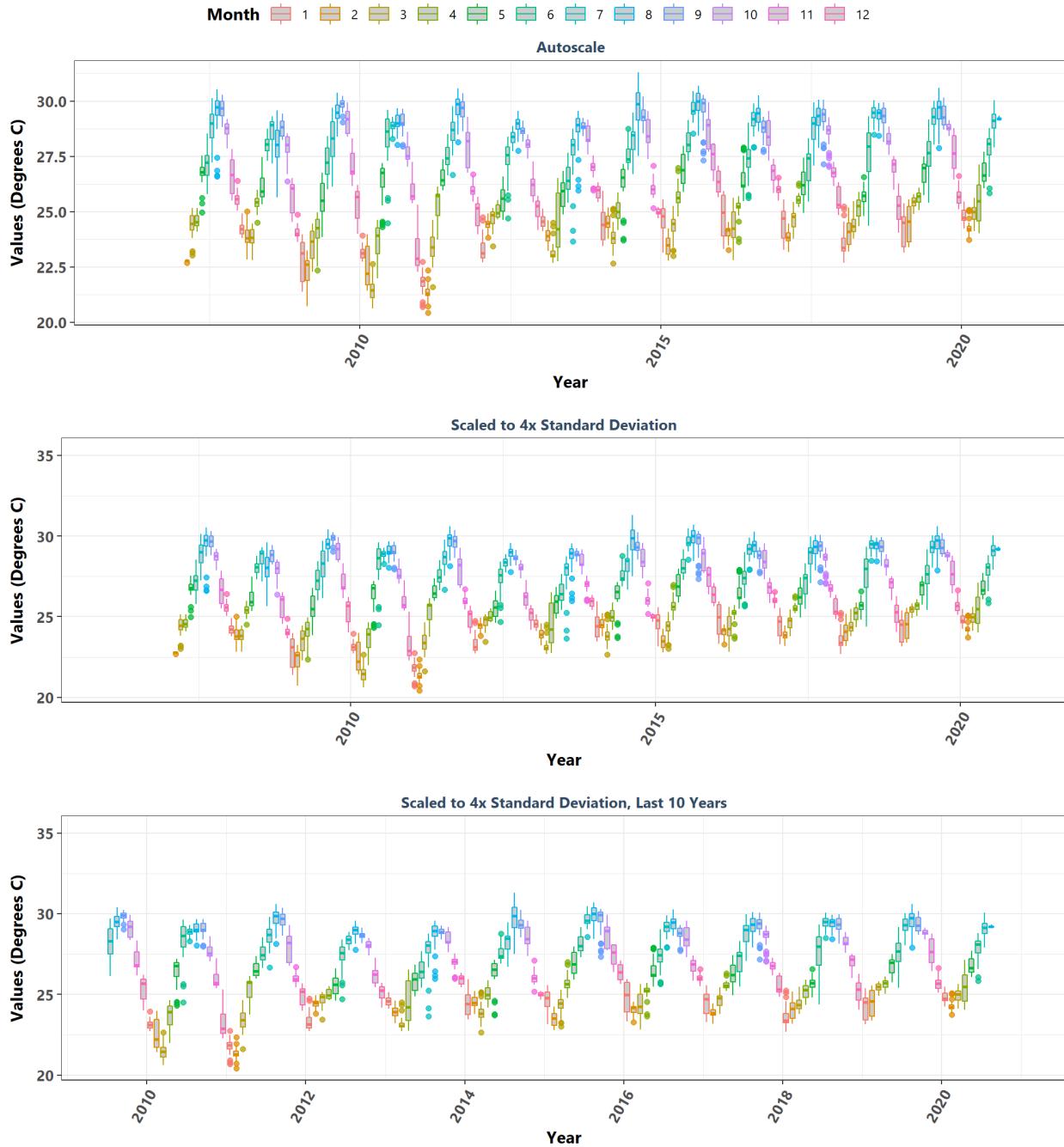


**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
93  
By Year

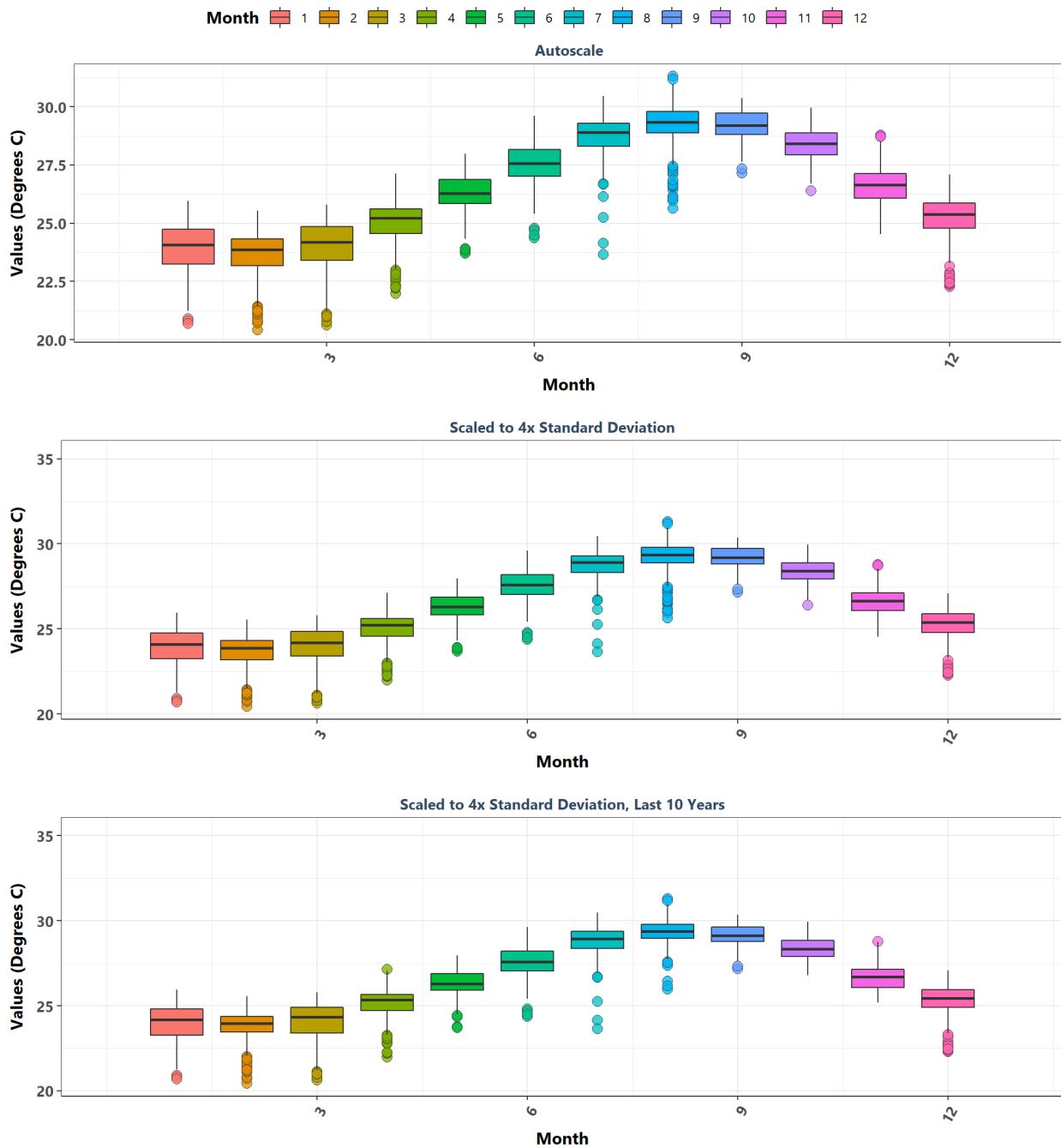


**Southeast Florida Coral Reef Ecosystem Conservation Area**  
**986 | Water Temperature on Coral Reefs in the Florida Keys**  
**93**

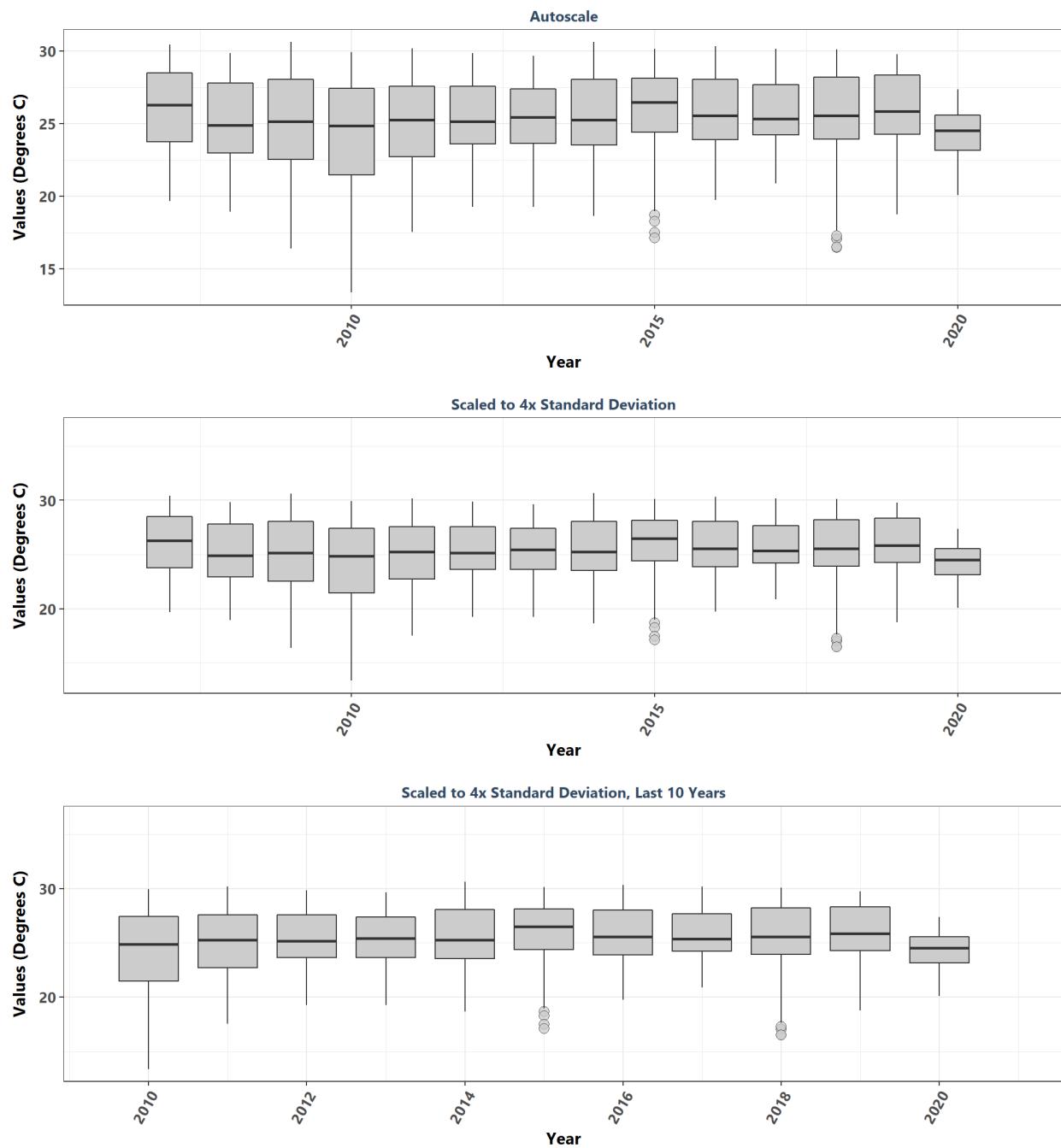
By Year & Month



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

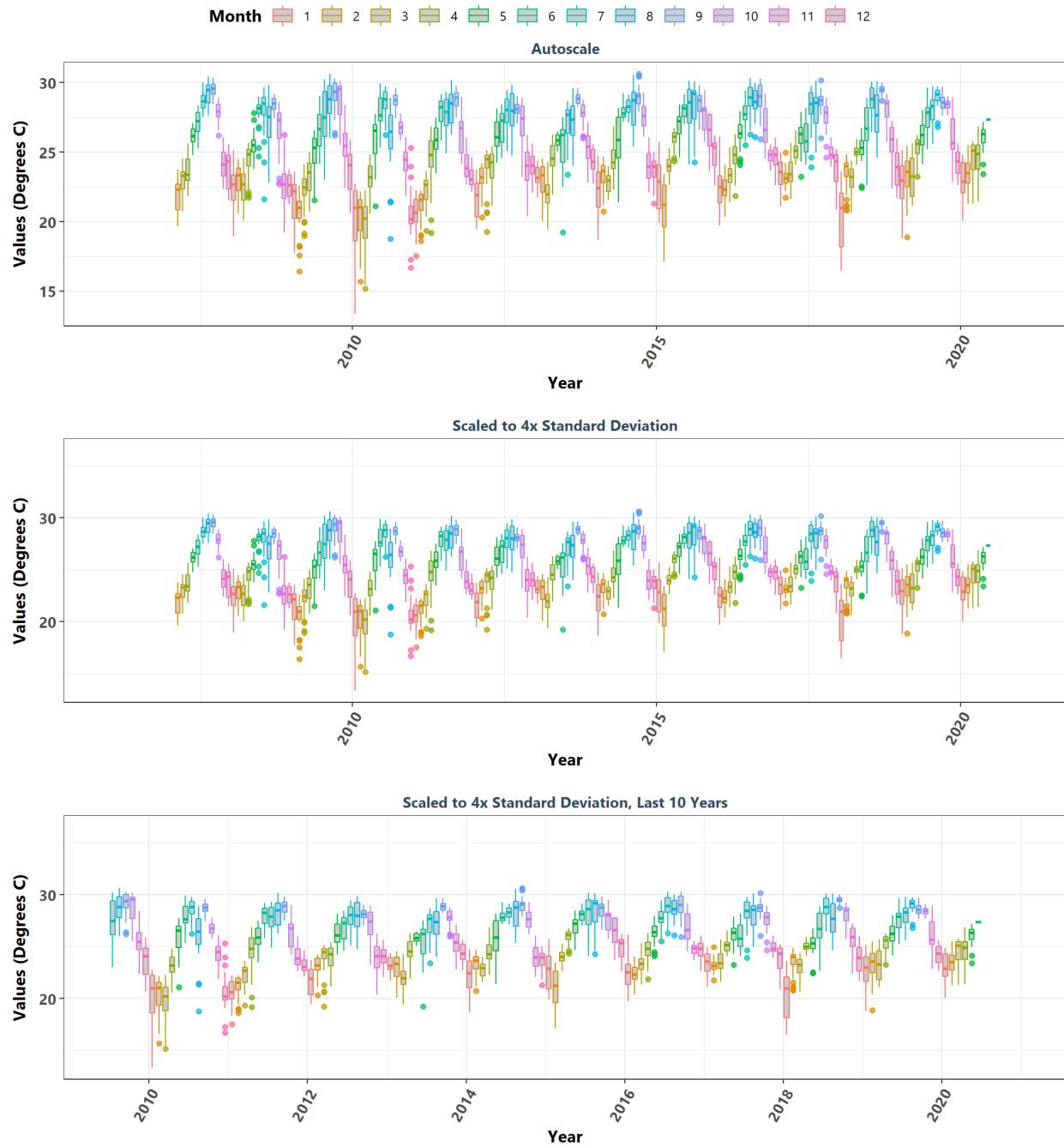


**Southeast Florida Coral Reef Ecosystem Conservation Area  
986 | Water Temperature on Coral Reefs in the Florida Keys**  
**94**  
By Year

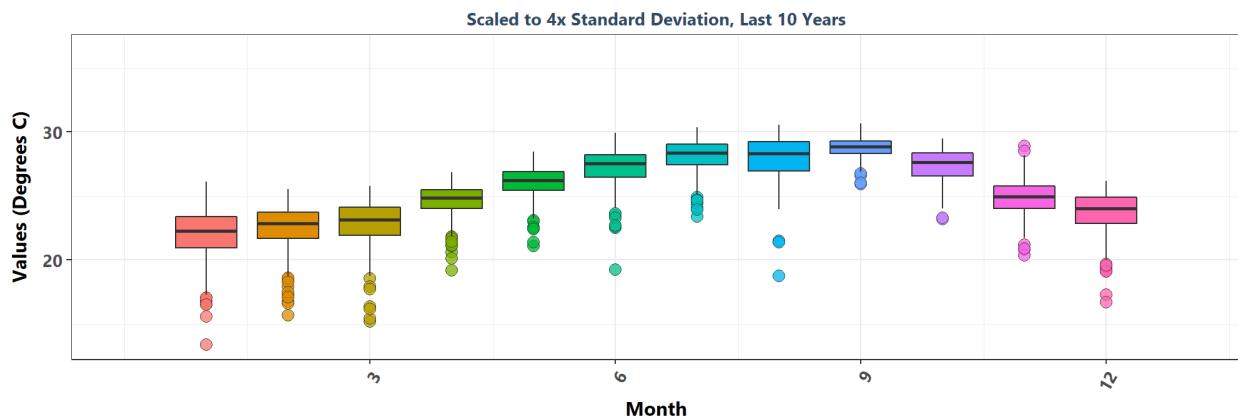
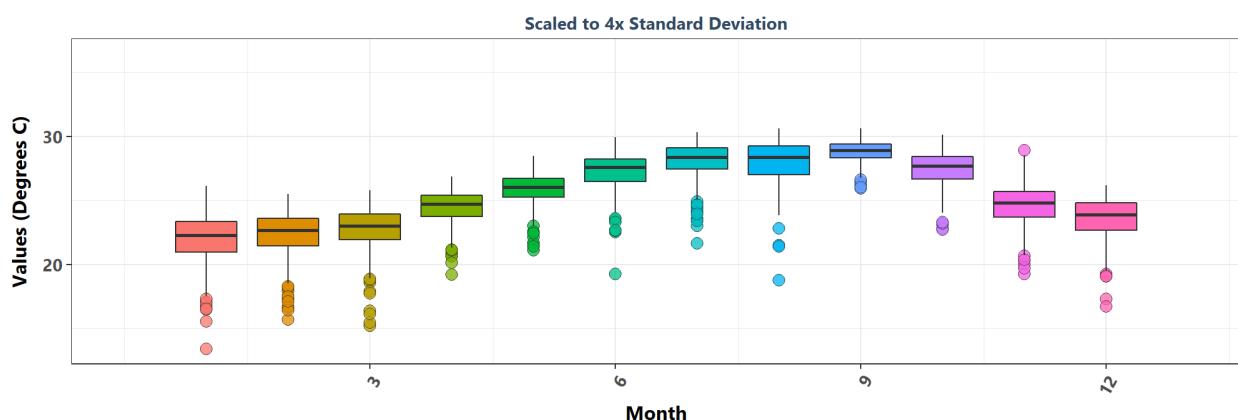
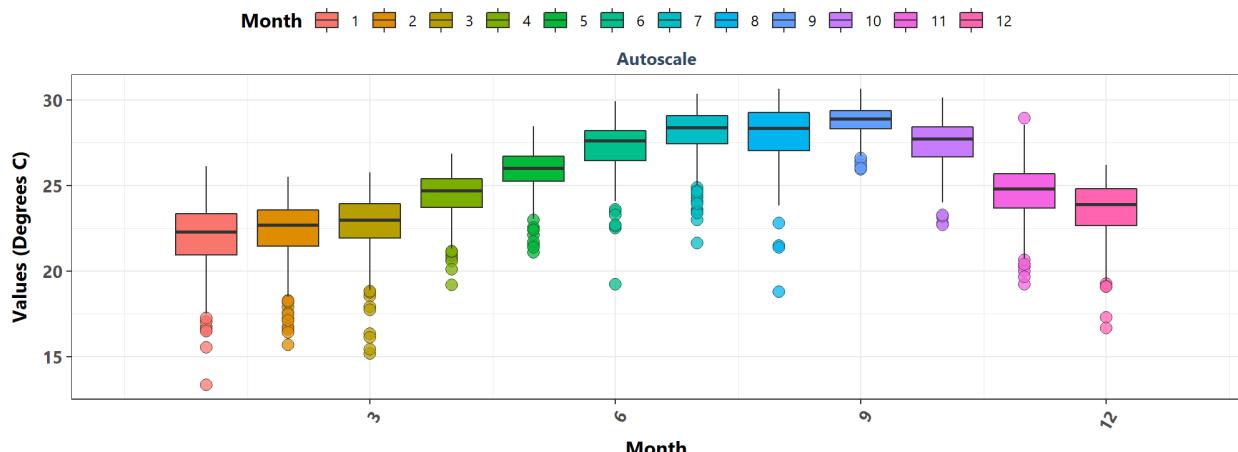


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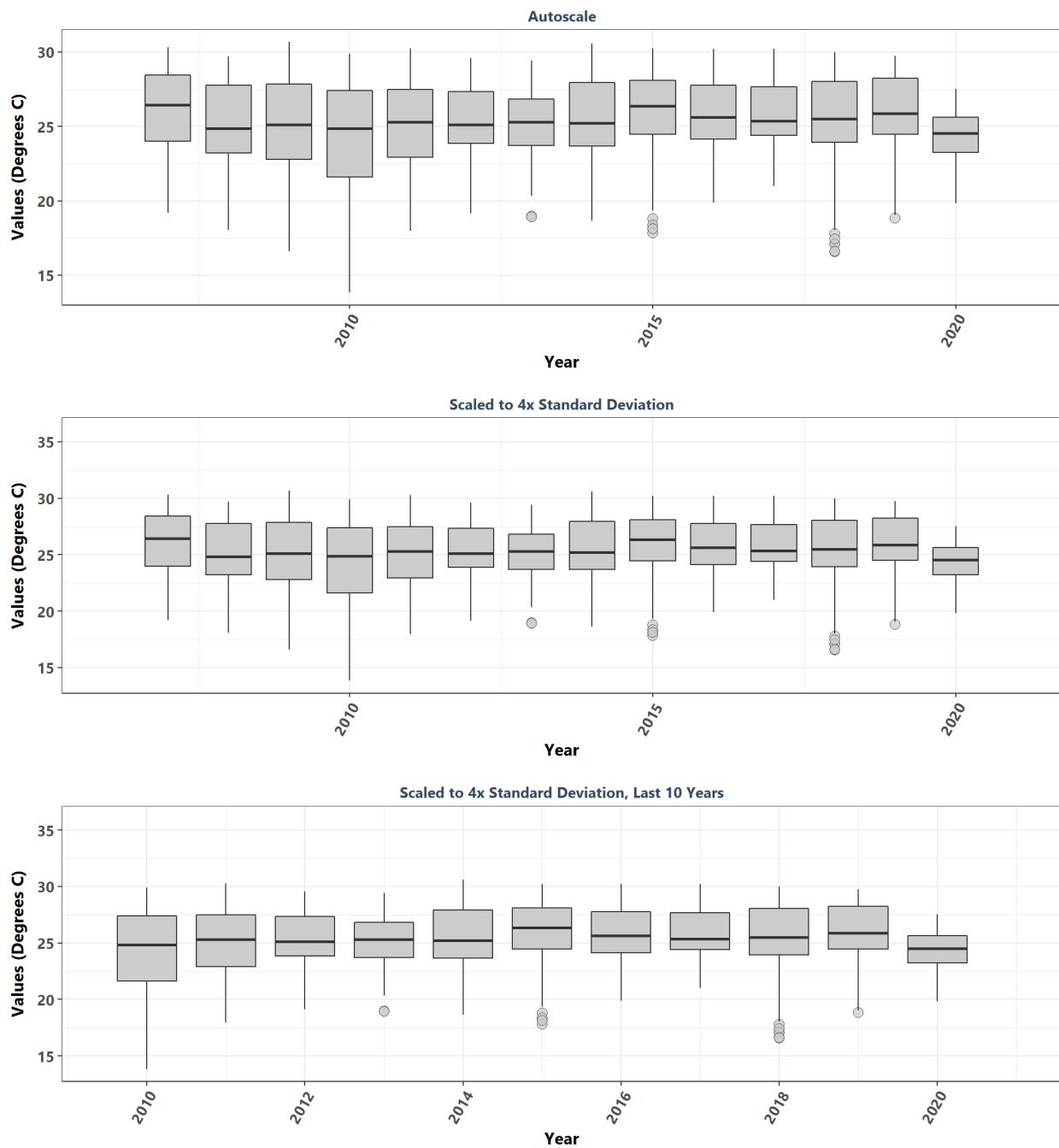
By Year & Month



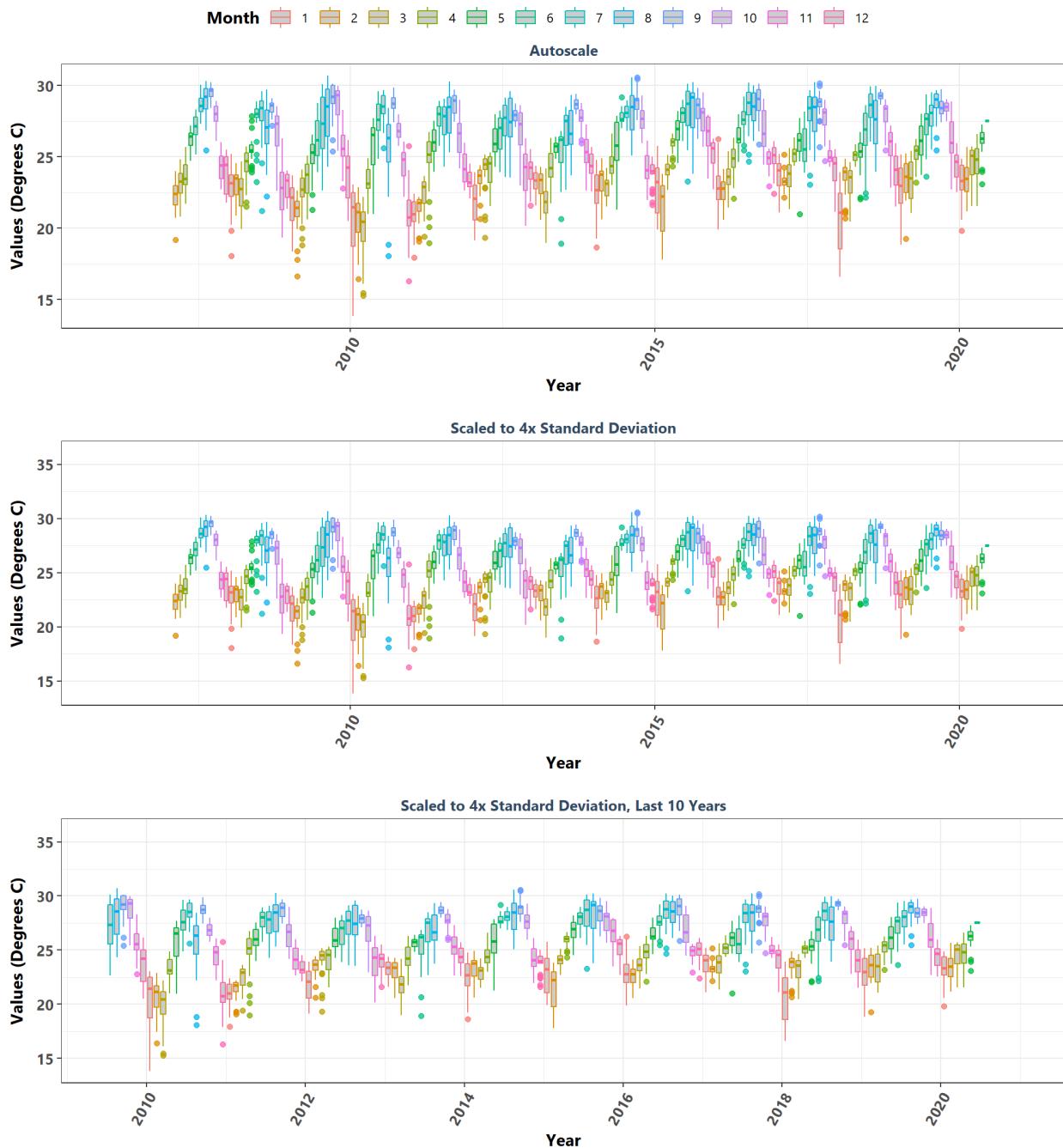
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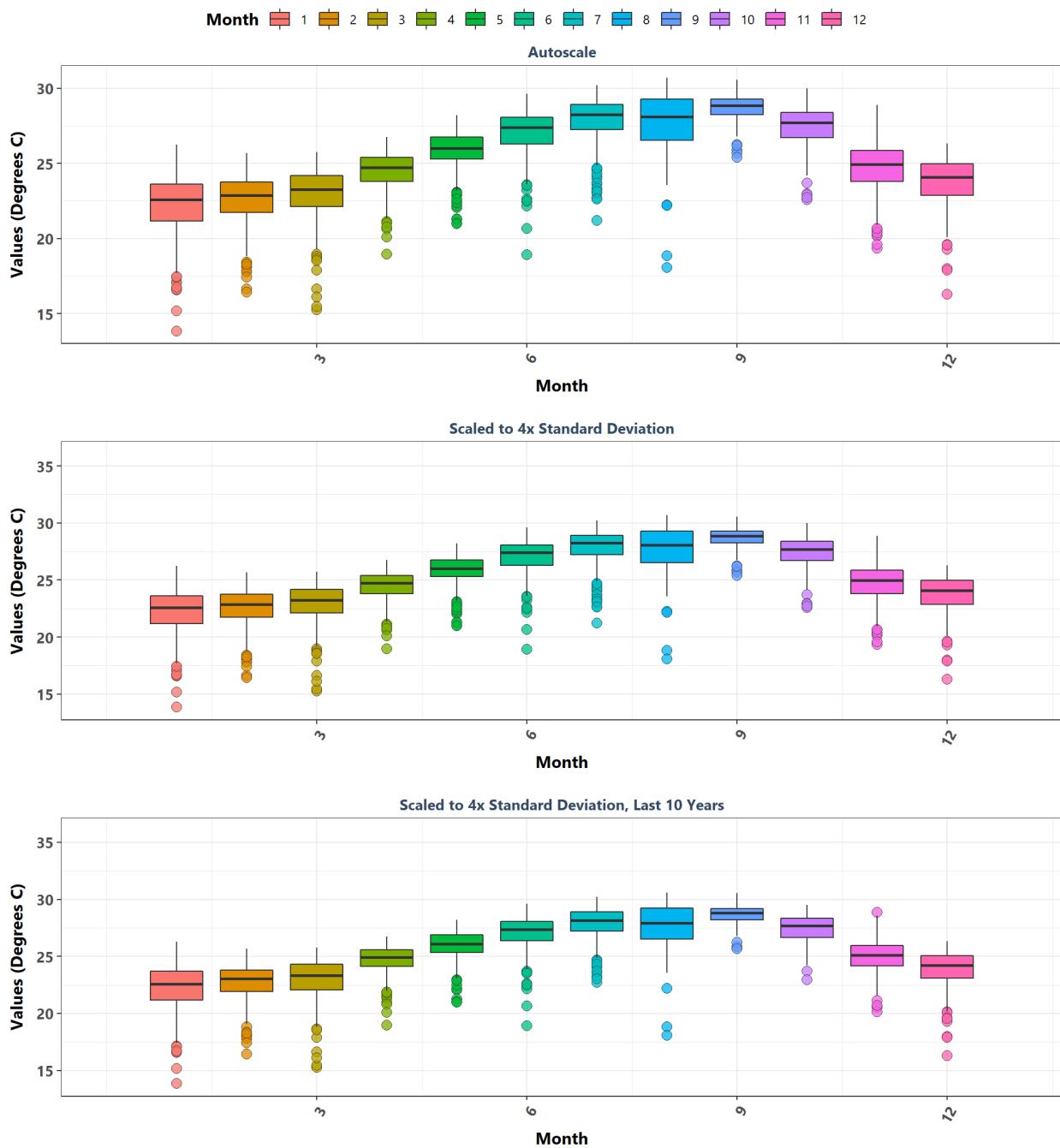
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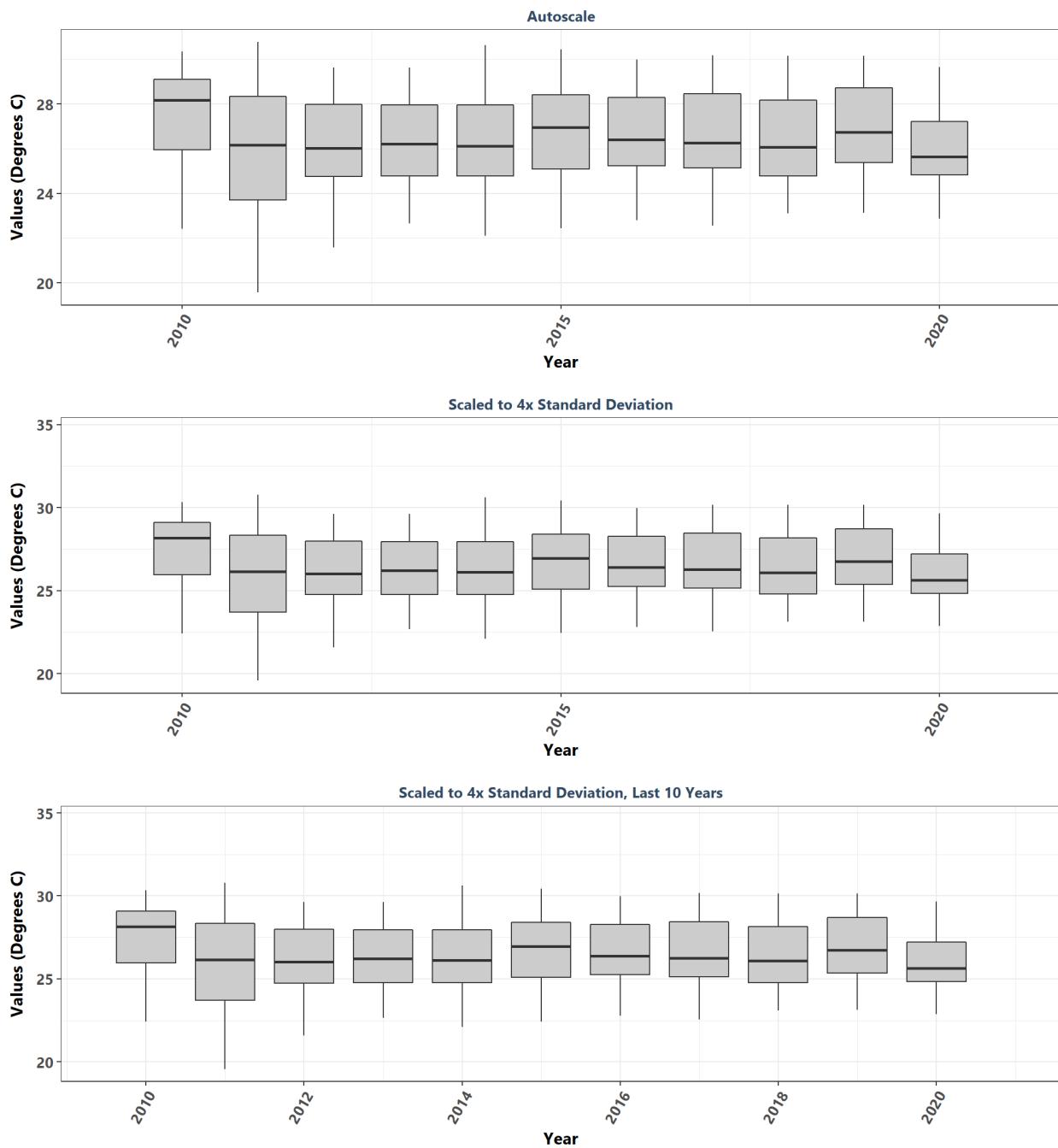
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**By Year & Month**



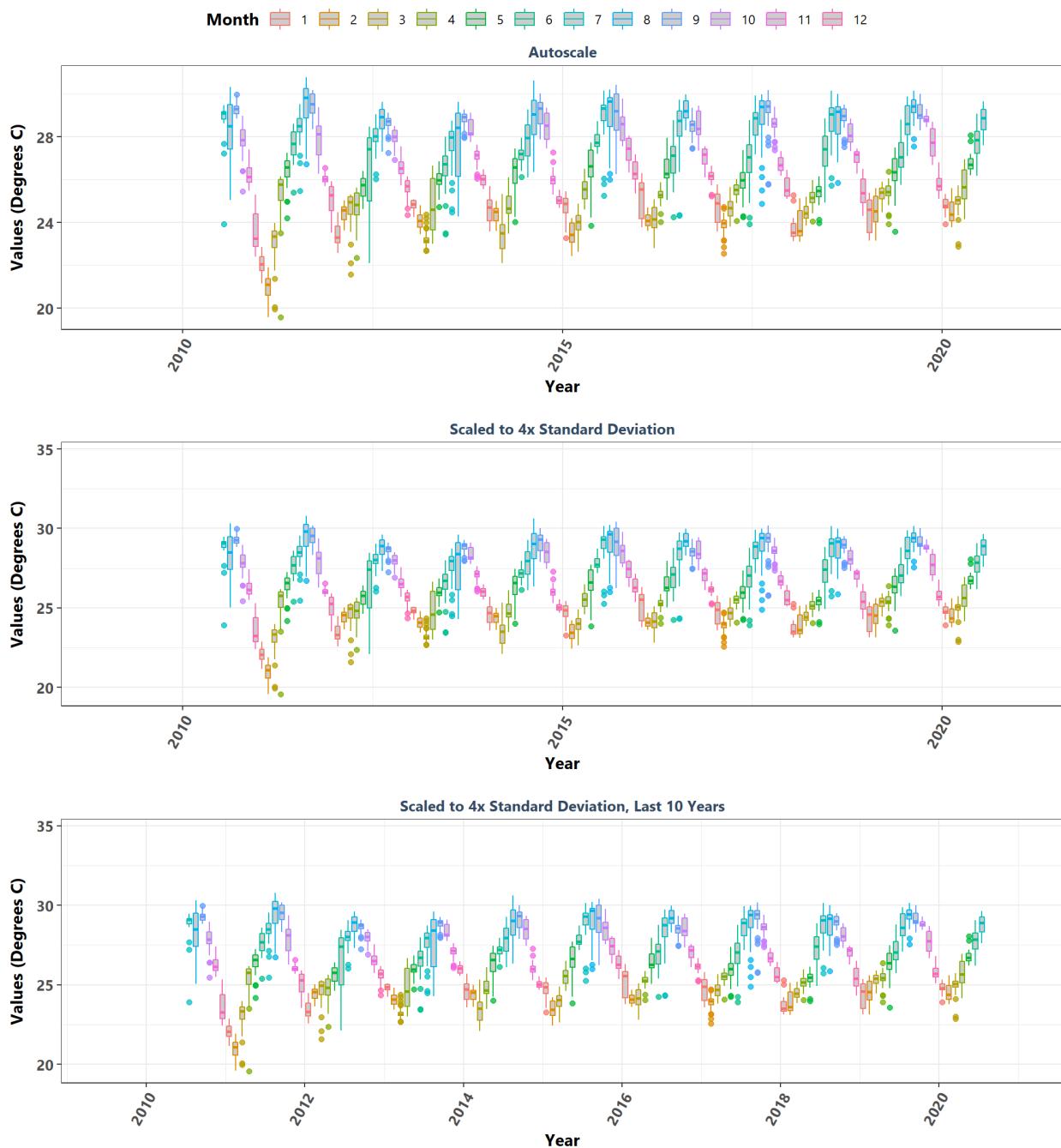
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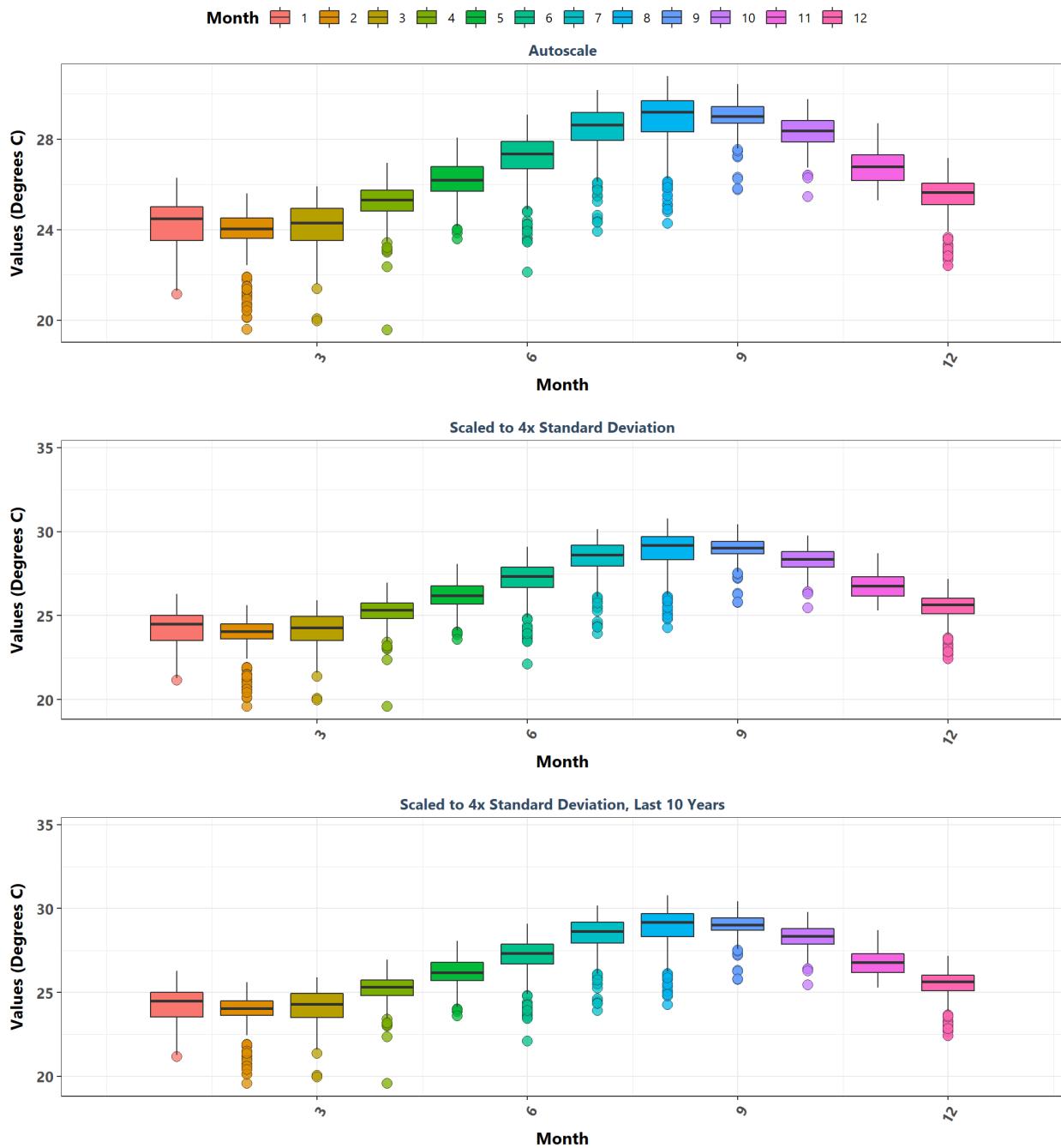
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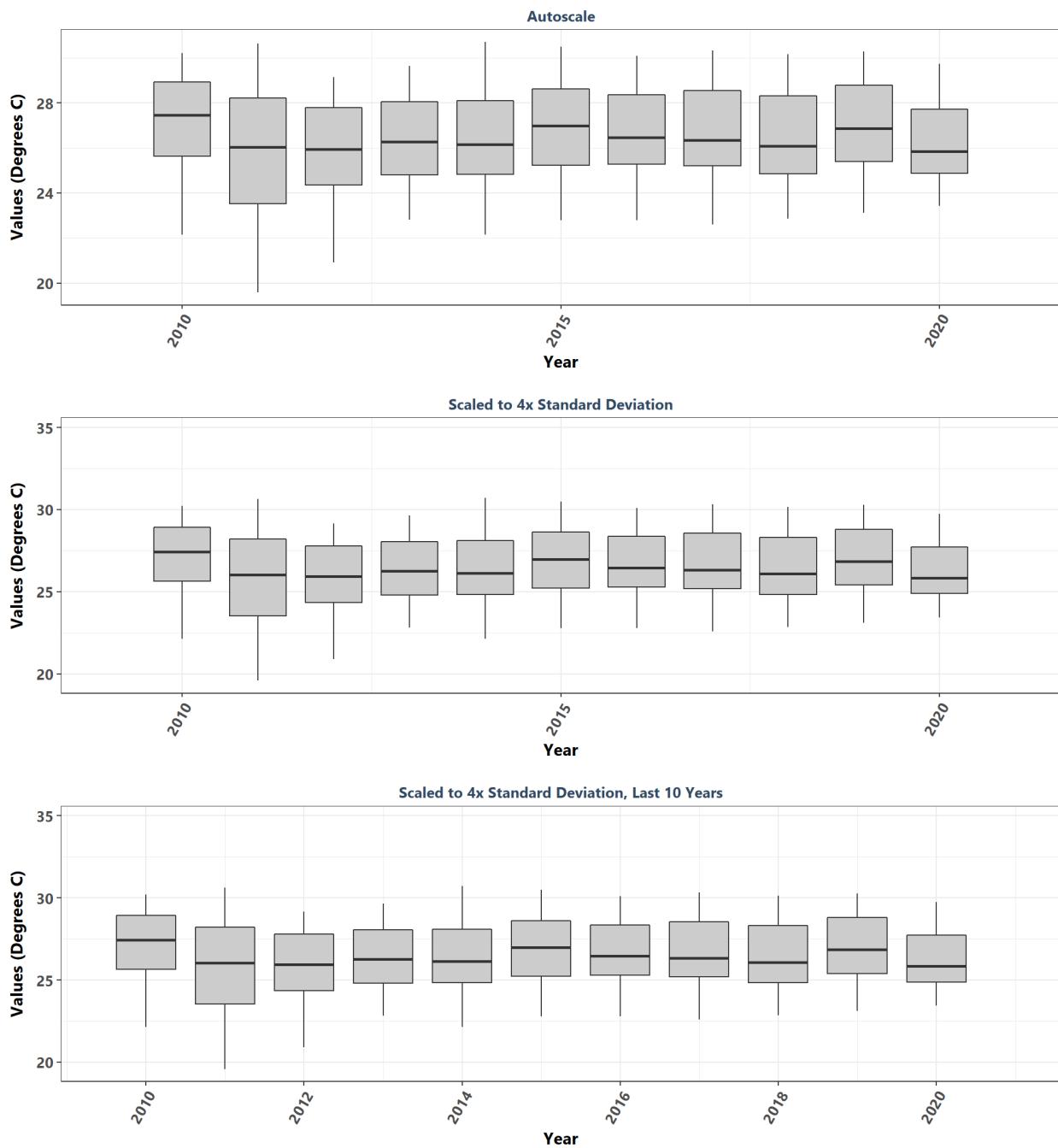
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**By Year & Month**



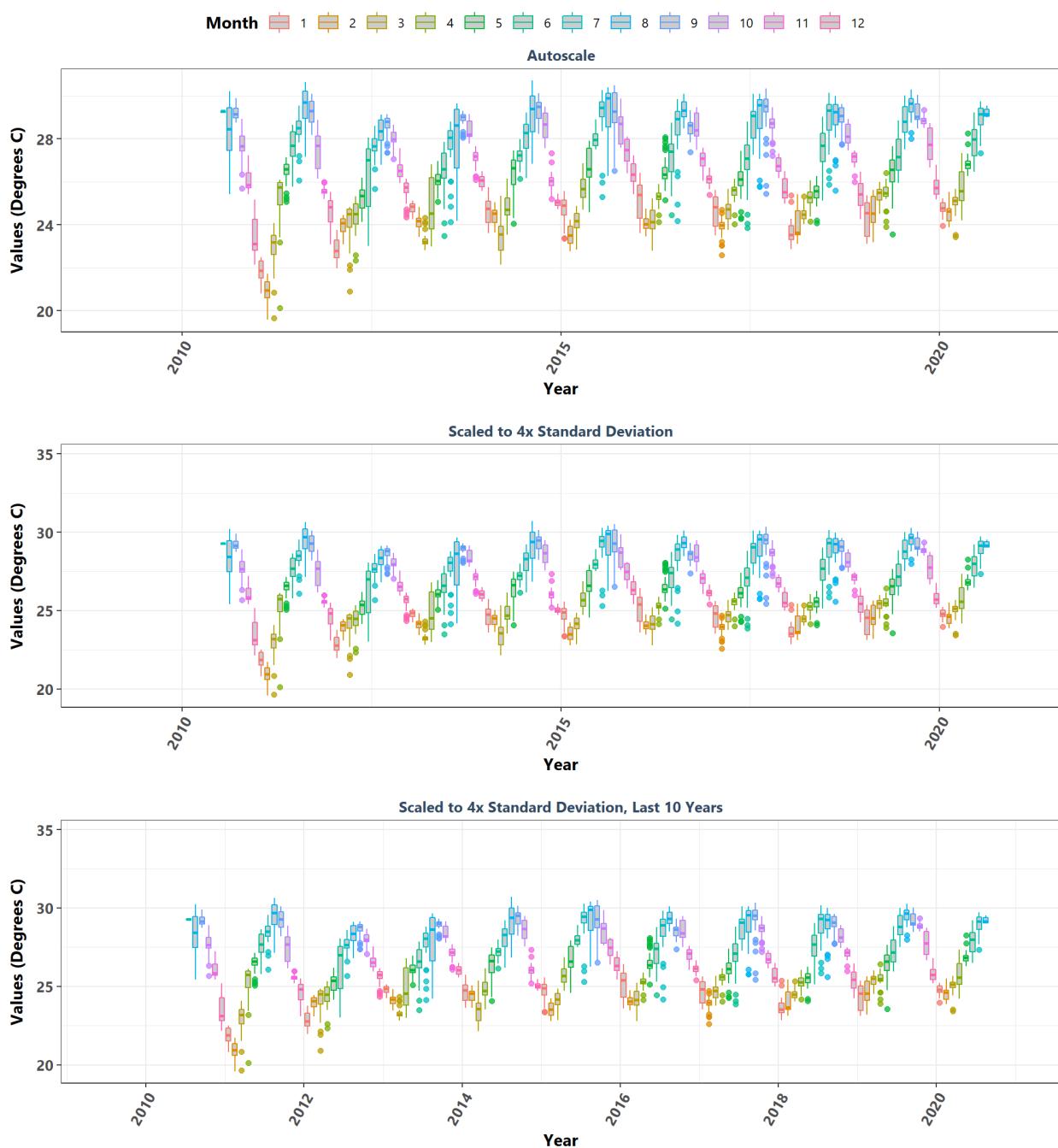
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