Maritimes Region Atlantic Zone Monitoring Program Prince 5 Hydrographic and Indicators 1991 to 2020 Climatology

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MARITIMES REGION ATLANTIC ZONE MONITORING PROGRAM PRINCE 5 HYDROGRAPHIC AND INDICATORS 1991 TO 2020 CLIMATOLOGY

by

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ABSTRACT

Layton, C. 2026. Maritimes Region Atlantic Zone Monitoring Program Prince 5 Hydrographic and Indicators 1991 to 2020 Climatology. Can. Data Rep. Hydrogr. Ocean Sci. 233: vi + 47 p. https://doi.org/10.60825/w574-h020

The Atlantic Zone Monitoring Program began in year 1998. It proposed six fixed stations across the Atlantic zone to be sampled every two weeks to resolve dynamics at a finer timescale than the seasonal regional scale surveys. Two stations were included in the Maritimes region, one of them being Prince 5, which is located outside of Passamaquoddy Bay, New Brunswick, Canada in the Bay of Fundy. The depth binned daily and monthly temperature, salinity, and density as well as daily and monthly indicators of near-surface temperature, near-surface salinity, stratification, and mixed layer depths for the 1991 to 2020 climatology reference period are calculated to support annual reporting on variability. Details on data acquisition and coverage are also provided.

RÉSUMÉ

Layton, C. 2026. Maritimes Region Atlantic Zone Monitoring Program Prince 5 Hydrographic and Indicators 1991 to 2020 Climatology. Can. Data Rep. Hydrogr. Ocean Sci. 233: vi + 47 p. https://doi.org/10.60825/w574-h020

Le Programme de monitorage de la zone Atlantique a débuté en 1998. Il proposait six stations fixes réparties dans la zone Atlantique, échantillonnées toutes les deux semaines, afin de caractériser la dynamique à des échelles temporelles plus fines que celles couvertes par les relevés saisonniers régionaux. Deux stations ont été incluses dans la région des Maritimes, l'une d'entre elles est Prince 5, située à l'extérieur de la baie de Passamaquoddy, au Nouveau-Brunswick, au Canada, dans la baie de Fundy. Les températures, salinités et densités quotidiennes et mensuelles regroupées par tranches de profondeur, ainsi que les indicateurs quotidiens et mensuels de la température près de la surface, de la salinité près de la surface, de la stratification et de la profondeur de la couche de mélange, pour la période de référence climatologique 1991–2020, sont calculés afin d'appuyer les rapports annuels sur la variabilité. Des détails sur l'acquisition et la couverture des données sont également fournis.

1 Introduction

The Atlantic Zone Monitoring Program (AZMP) was proposed in year 1998 (Therriault et al. 1998). The AZMP identified six fixed stations that was suggested to be sampled bi-weekly from February to October and monthly from November to January to collect biological, chemical, and physical oceanographic samples to resolve dynamics at a finer time-scale than the seasonal section sampling across the Atlantic regions: Newfoundland and Labrador, Quebec, Gulf, and Maritimes. For the Maritimes region, two fixed stations were proposed, Station 2 and Prince 5. Prince 5 is located at 44.9300°N, 66.8500°W which is outside of Passamaquoddy Bay, New Brunswick, Canada in the Bay of Fundy at a depth of approximately 90 meters (m) (Figure 1). Monthly samples of temperature and salinity through the water column have been taken at Prince 5 since year 1921, and with sporadic biological sampling (Page et al. 2000). When the station became part of the AZMP, consistent biological and chemical sampling was added to align with the monitoring efforts across the Atlantic region.

For monitoring efforts, the World Meteorological Organization (WMO) recommends using reference period of years 1961 to 1990 as well as the most recent three decades (WMO 2017). While consistent monthly sampling of Prince 5 has occurred since year 1921, to align with other climatology calculations within the AZMP, only the two most recent overlapping three-decade periods, years 1981 to 2010 and years 1991 to 2020 will be calculated as well as the differences between the two. When differences are presented, they are the 1991 to 2020 value minus the 1981 to 2010 value.

Every year, conditions at Prince 5 are reported for the Maritimes region (e.g. Layton et al. (2025)) and the Atlantic Zone (e.g. Galbraith et al. (2025)). Conditions are compared by anomalies, which are deviations from the climatology reference period mean, or by normalized anomalies, the anomaly divided by the climatology reference period standard deviation (SD). The use of normalized anomalies and the same reference period allow for direct comparison among site variables. The anomalies on a monthly timescale for Prince 5 are used to calculate an annual composite to summarize long-term conditions. To support these calculations, the climatology for relevant variables is required. Hydrographic conditions, which include the variables temperature, salinity, and density, as a function of depth and time on daily and monthly timescales are reported for Prince 5 and a number of indicators on a monthly timescale. Indicators include near-surface temperature, near-surface salinity, stratification, and mixed layer depth. The calculation methodology for each variable will be described and the resulting climatology mean and SD for both recent three-decade reference periods are calculated.

2 Data

2.1 Archive

The archived continuous downcast CTD data from BIO was the primary source of data. Data from years 1981 to 2020 was searched. From years 1981 to 1999, data that fell within the defined bounds (Table 1) were retained. For years 2000 to 2020, a regular mission name, `BCD[yyyy]669` where `yyyy` is the year, was used to identify sampling associated with the station.

An occupation with that mission name was retained. The depth of the maximum depth of a measurement was compared to the inferred bottom depth. If the maximum measurement depth was greater than 40m off the bottom depth, the entire profile was omitted. Quality control flags were applied if available.

This data crawling exercise resulted in a total of 362 occupations.

2.2 Climate database

Another source of data used to attempt to fill in the time-series is the Climate database (Gregory 2004). First, data was queried from the database within the defined bounds (Table 1). The depth of the maximum measurement depth was compared to the inferred bottom depth. If the the measurement depth was greater than 40m off the bottom depth, the entire profile was omitted. This data source does not have any quality control flags, therefore, if any profile had a salinity less than 25, it was omitted. Five data types were retained, this includes expendable bathythermograph (XB), tesac message (TE), CTD downcast (CD), batfish profiles (BF), and bottle measurements (BO).

This data crawling exercise resulted in a total of 469 occupations. Of these, 39 were classified as being duplicates, 165 exist in the archive, and 1 were not one of the five data types. In total, 264 occupations were retained for climatology calculations.

3 Hydrographic

For both the daily and monthly hydrographic climatology, the data was vertically binned from 5m to 90m with a tolerance of 5m, such that the set intervals are open on the left and closed on the right. The total number of observations in each defined depth bin for the 1981 to 2010 and 1991 to 2020 climatology reference periods are markedly different (Figure 2). For the 1981 to 2010 reference period, the percent number of observations within the first ten years is 3.94% to 9.20% for temperature, 3.97% to 9.07% for salinity, and 3.97% to 9.07% for density, with zero bins for temperature, zero bins for salinity, and zero bins for density having 0%. The remaining data was obtained during the last 20 years of the reference period, which overlaps with the 1991 to 2020 reference period. The observation distribution at each depth bin is even throughout the water column, except for the deepest bins, 90m. The lower number of observations in the first 10 years of the climatology reference period can be attributed to almost exclusively bottle observations, which have a much lower vertical resolution compared to downcast CTD profiles.

For the 1991 to 2020 reference period, the percent number of observations in the last ten years is 32.58% to 34.70% for temperature, 32.77% to 34.85% for salinity, and 32.77% to 34.85% for density, which is the expected coverage. Overall, there are between 1.37 to 1.47 for temperature, 1.37 to 1.47 for salinity, and 1.37 to 1.47 for density times more observations in the 1991 to 2020 reference period. The difference is approximately equal throughout the water column and for each variable. Increased number of observations can be attributed to an higher frequency of continuous downcast CTD occupations.

When comparing the climatology for the two reference periods, while observation distribution is biased due to sampling methods, coverage of the station has been consistent.

3.1 Daily

3.1.1 Methods

At each depth bin, temperature, salinity, and density observations within the climatology reference periods were fitted against the year-day with a local polynomial regression to provide an estimate of the mean. The parameters used for the regression are a gaussian kernel weighting function, a polynomial degree of 2, and a neighborhood size of 0.5. In order to avoid boundary issues and to achieve continuous results, the beginning of the data set was padded with data from the last 28 days, so days 337 to 365, and the end of the data set was padded with data from the first 28 days. A local polynomial regression, with the same parameters above, was used to estimate the standard deviation following the methodology outlined by Weisberg (2005).

3.1.2 Results

For reference periods 1981 to 2010 and 1991 to 2020, observation distribution at each depth bin for temperature, salinity, and density throughout the year share similar characteristics (Figures 3 to 20). In general, observation distribution is clustered around the middle of each month as the station has been sampled consistently prior to the implementation of the AZMP.

The daily fits for temperature, salinity, and density at each depth bin for both reference periods are provided (Figures 3 to 20). Differences between both reference periods are provided for completeness (Figure 21).

3.2 Monthly

3.2.1 Methods

For each month and depth bin, the mean and standard deviation of temperature, salinity, and density, using observations within the climatology reference periods, were calculated.

3.2.2 Results

The number of profiles used to construct the monthly climatology profiles varies between months (Figure 22). Coverage for each variable is near-identical. There were more profiles for the 1981 to 2010 climatology. For the 1991 to 2020 climatology, the lowest coverage is in the month of April. This can be attributed to the ship availability.

The month binned profiles for both climatology reference periods are provided (Figures 23 to 34). As in Section 3.1.2, differences between reference periods are provided (Figure 35).

4 Derived Indicators

4.1 Depth average

4.1.1 Methods

Each profile was vertically binned from 5m to 90m with a tolerance of 5m, such that set intervals are open on the left and closed on the right. For the depth average temperature and salinity, profiles were integrated over the 5m to 50m bins, with the criteria that at least 2 data points are within the interval. The daily climatology for both reference periods using the calculated depth average values were fitted against the year-day with a local polynomial regression to provide an estimate of the mean and standard deviation using the same parameters as described in Section 3.1.1. The monthly climatology for both reference periods were calculated by taking the monthly mean and standard deviation of the calculated depth average values.

4.1.2 Results

For the 1981 to 2010 climatology reference period, of the 574 profiles, depth average temperature was calculated for 417 profiles and 410 for salinity. For the 1991 to 2020 climatology reference period, of the 514 profiles, depth average temperature was calculated for 506 profiles and 498 for salinity. Observation spread throughout the year, by day and month, along with the daily and monthly climatology for both reference periods are provided for temperature (Figure 36) and salinity (Figure 37).

4.2 Stratification

4.2.1 Methods

As done for the depth average metrics, Section 4.1.1, each profile was vertically binned. The stratification was calculated for each individual profile, which is defined as the difference between the density at the 5m and 50m bins. The daily climatology for both reference periods using the calculated stratification values were fitted against the year-day with a local polynomial regression to provide an estimate of the mean and standard deviation using the same parameters as described in Section 3.1.1. The monthly climatology for both reference periods were calculated by taking the monthly mean and standard deviation of the calculated stratification.

4.2.2 Results

For the 1981 to 2010 climatology reference period, of the 574 profiles, stratification was calculated for 318 profiles. For the 1991 to 2020 climatology reference period, of the 514 profiles, stratification was calculated for 411 profiles. Observation spread throughout the year, by day and month, along with the daily and monthly climatology for both reference periods are provided (Figure 38).

4.3 Stratification Index

4.3.1 Methods

As done for the depth average metrics, Section 4.1.1, each profile was vertically binned. To calculate the stratification index for each profile, the mean of the density values within 0.5m of 5m and 50m were calculated. The difference between these two values were divided by the difference of the mean bin depths. If the calculated stratification index was less than zero, the process was repeated with a threshold of 1m. The daily climatology for both reference periods using the calculated stratification index values were fitted against the year-day with a local polynomial regression to provide an estimate of the mean and standard deviation using the same parameters as described in Section 3.1.1. The monthly climatology for both reference periods were calculated by taking the monthly mean and standard deviation of the calculated stratification index.

4.3.2 Results

For the 1981 to 2010 climatology reference period, of the 574 profiles, stratification was calculated for 409 profiles. For the 1991 to 2020 climatology reference period, of the 514 profiles, stratification was calculated for 498 profiles. Observation spread throughout the year, by day and month, along with the daily and monthly climatology for both reference periods are provided (Figure 39).

4.4 Mixed layer depth

4.4.1 Methods

The mixed layer depth was calculated on profiles in their original resolution. The mixed layer is defined as the depth at which the density at 5m is exceeded by 0.03kg/m^3.

4.4.2 Results

For the 1981 to 2010 climatology reference period, of the 574 profiles, the mixed layer depth was calculated for 445 profiles. For the 1991 to 2020 climatology reference period, of the 514 profiles, the mixed layer depth was calculated for 446 profiles. Observation spread throughout the year, by day and month, along with the daily and monthly climatology for both reference periods are provided (Figure 40).

5 Data and code access

The resulting data products from the report are, at the time of this publication, available through Open Government Portal. To request the data used to create the data products presented in this report, please contact BIO data shop.

The code to extract data and perform calculations, as well as necessary components to assemble the current document is made available in a Git repository (Layton 2026). This will facilitate reproducible calculations and documents for future reference periods.

6 Acknowledgements

The author would like to thank the numerous program coordinators and technicians who facilitated the collection of data throughout the years, as well as numerous ship officers and crew.

7 References

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8 Tables

Table 1. Coordinates for the vertices defining the bounding box used to extract data for Prince 5.

Latitude	Longitude
44.8	-66.9
45.0	-66.9
45.0	-66.6
44.8	-66.6

9 Figures

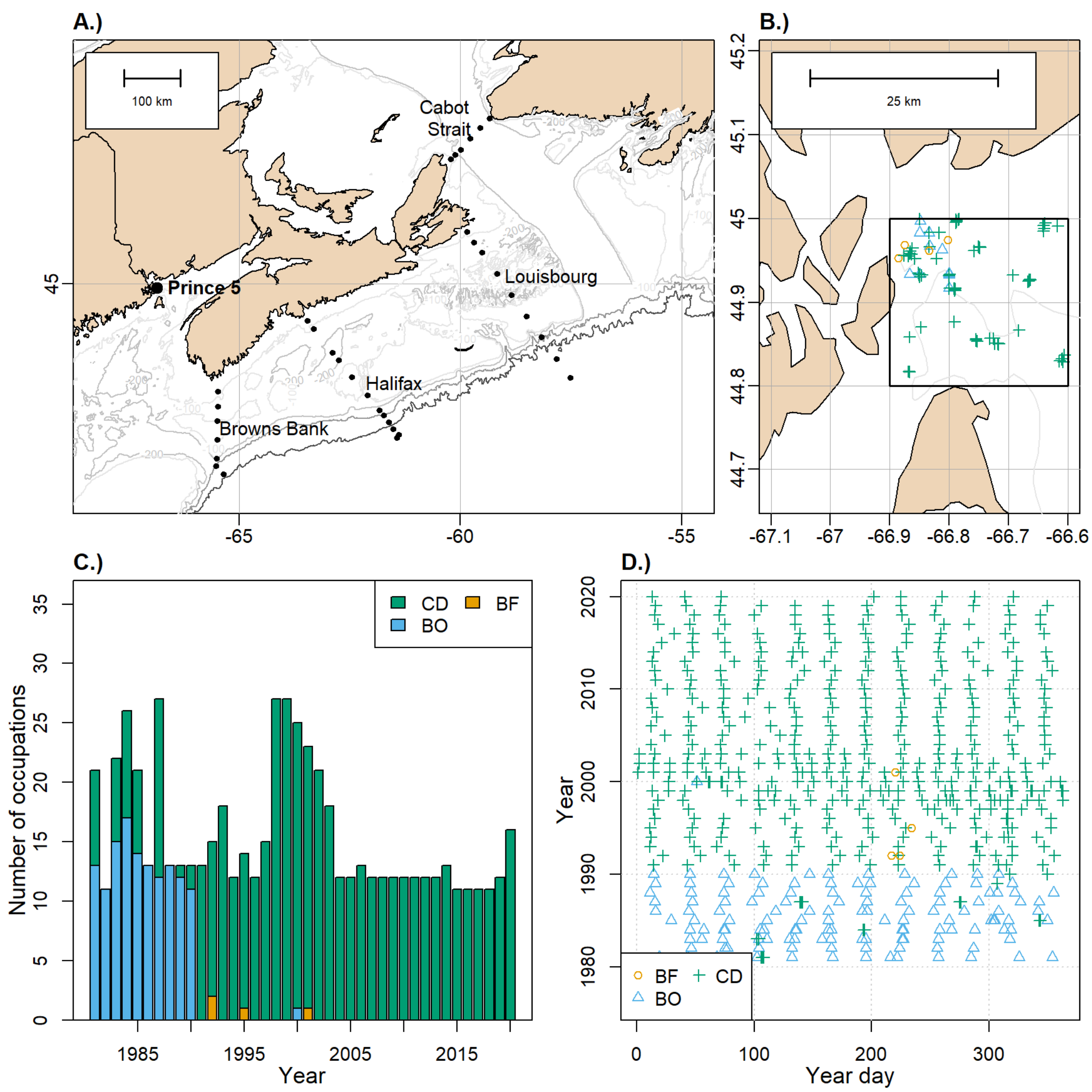

Figure 1. A.) A map of the Maritimes region Atlantic Zone Monitoring Program core transects, as labelled, with Prince 5. B.) A close up map of Prince 5 with the bounding box used to collate data, with the locations of the collated data which are distinguished by data type. C.) The annual total number of occupations, color coded by data type. D.) The sampling throughout the year, indicated by year day, color coded.

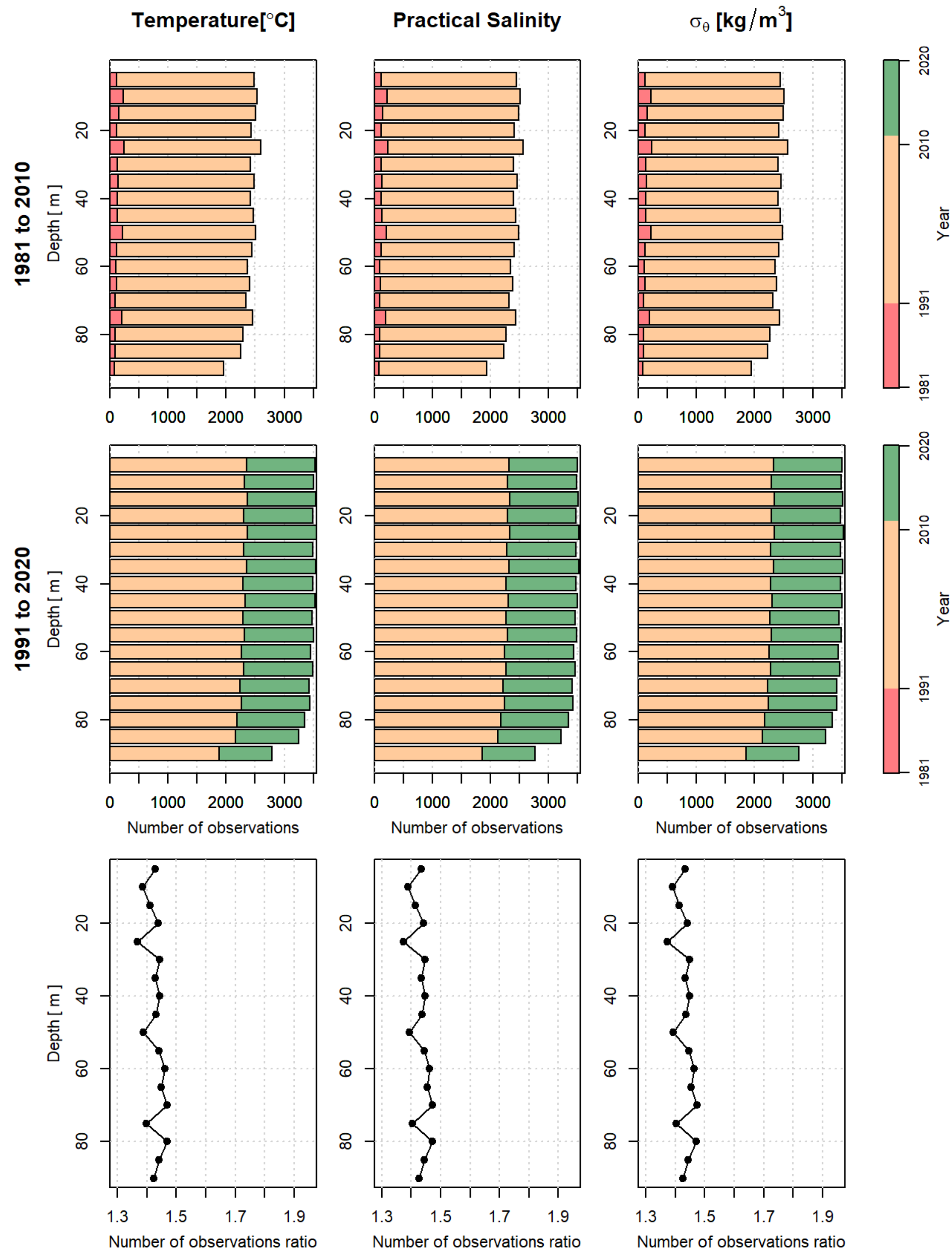

Figure 2. Total number of observations at each depth bin for the 1981 to 2010 (top row) and 1991 to 2020 (middle row) climatology reference periods, and the ratio of the total number of observations of the 1991 to 2020 reference period to the 1981 to 2010 reference period (bottom row) for temperature (left column), salinity (middle column), and density (right column).

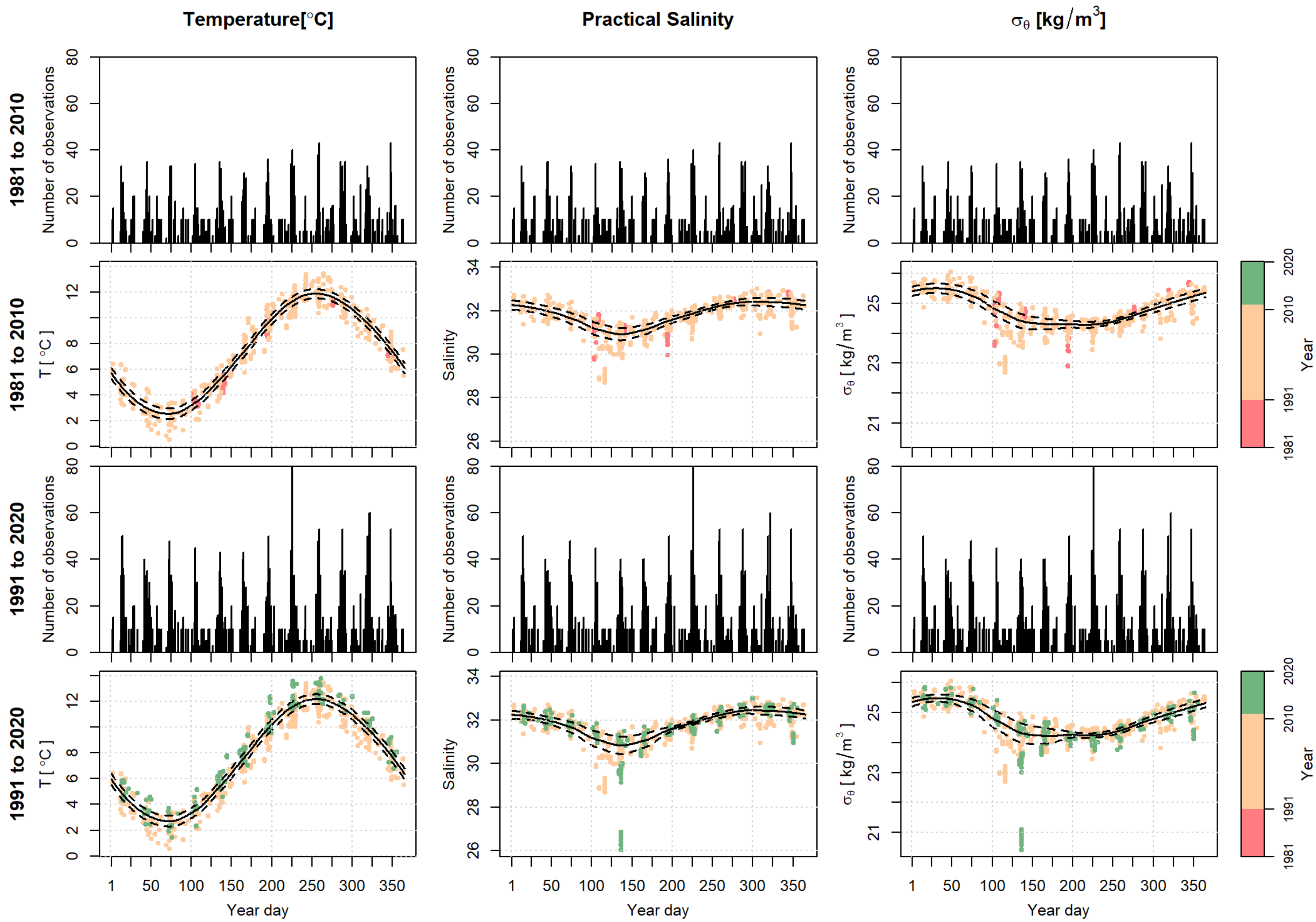

Figure 3. The 2.5m to 7.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and $\pm$ 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

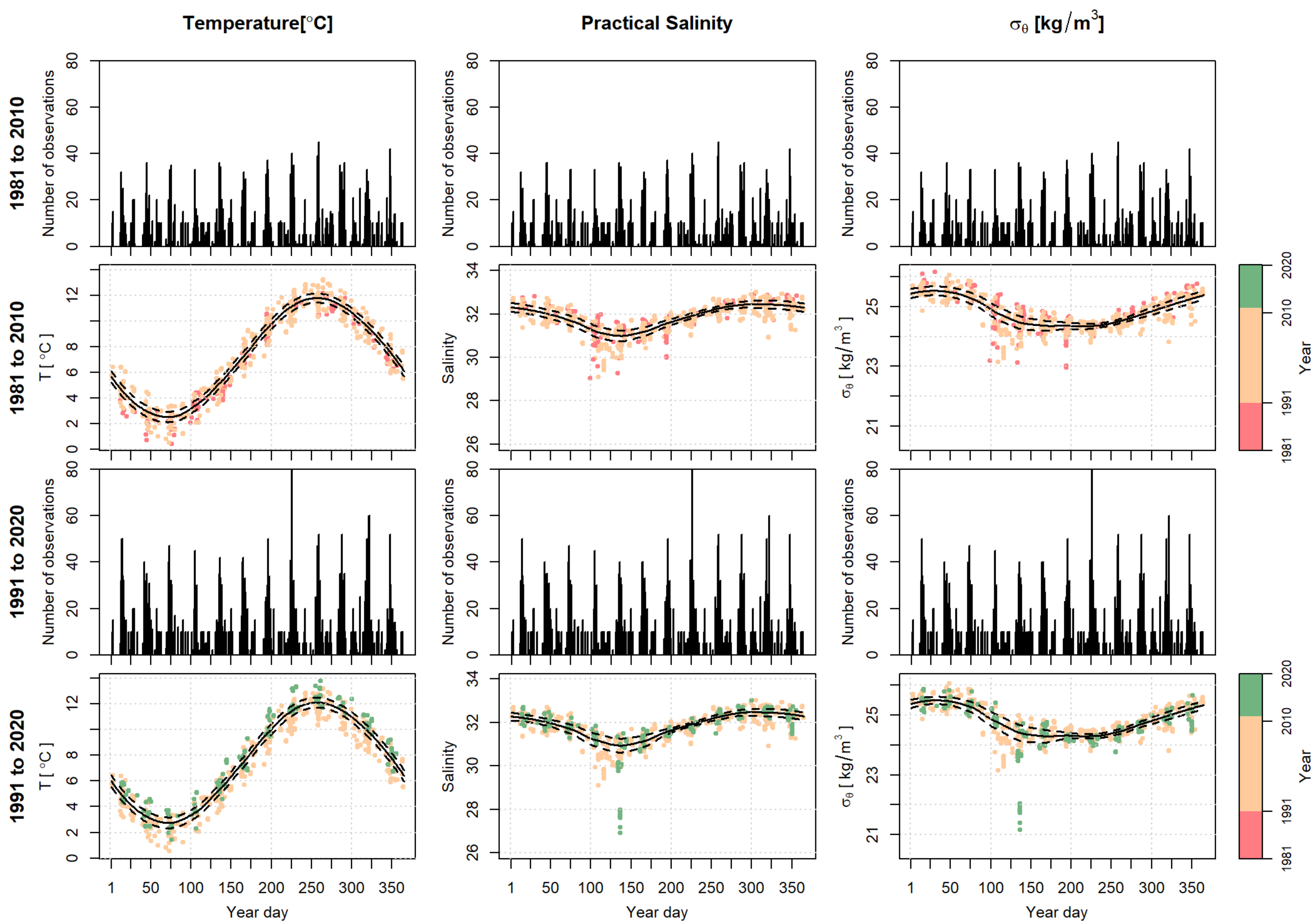

Figure 4. The 7.5m to 12.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

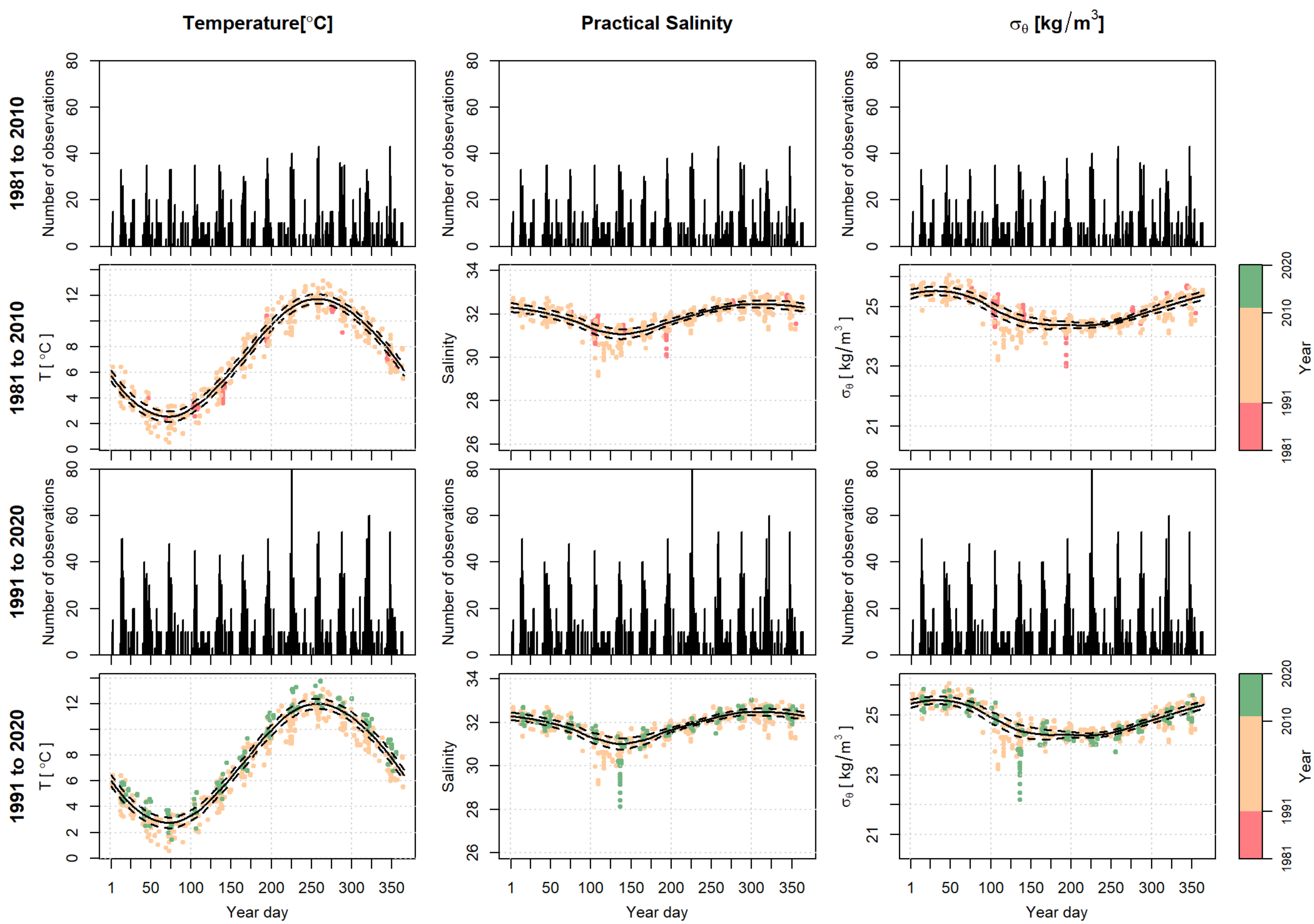

Figure 5. The 12.5m to 17.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and $\pm$ 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

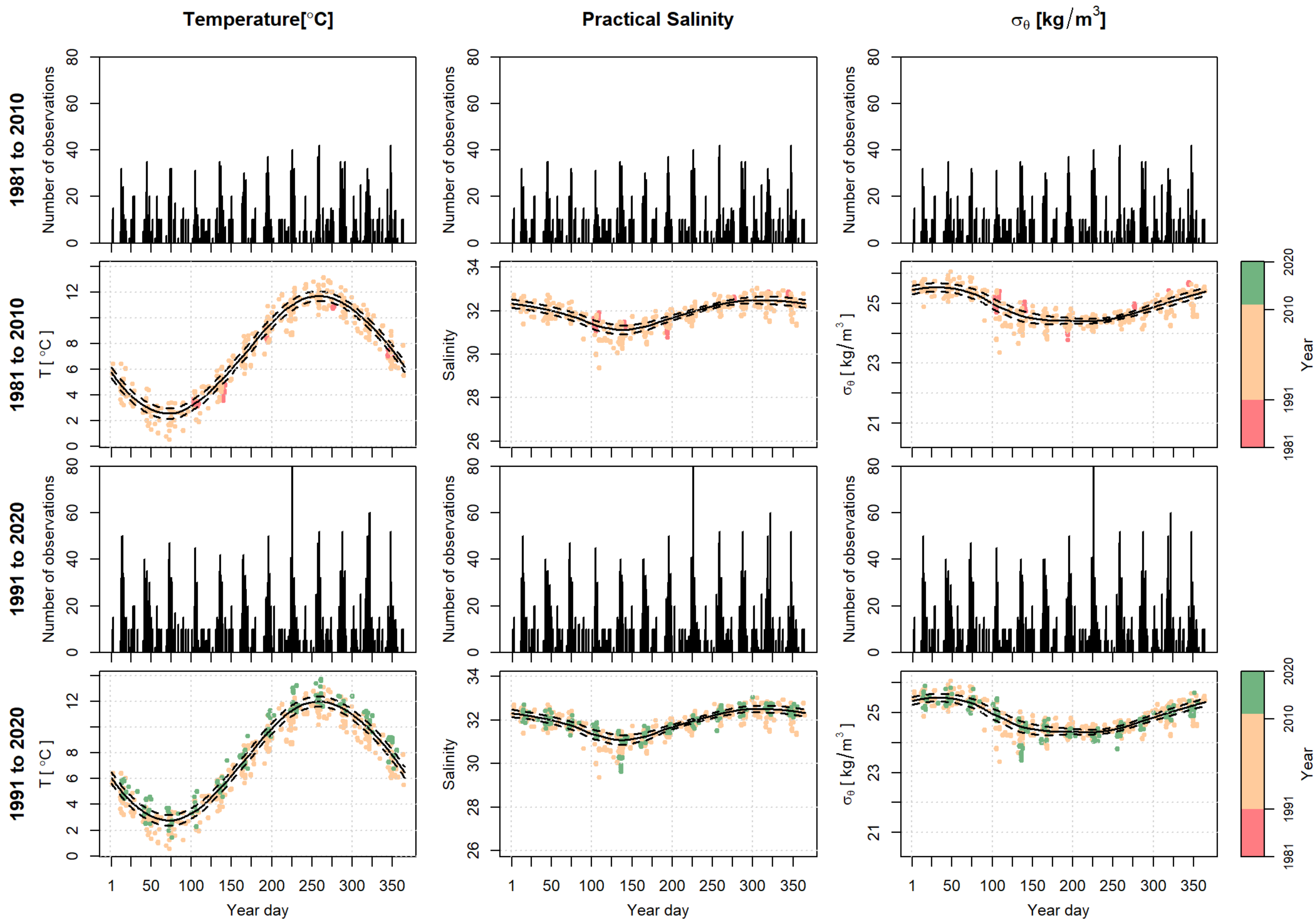

Figure 6. The 17.5m to 22.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

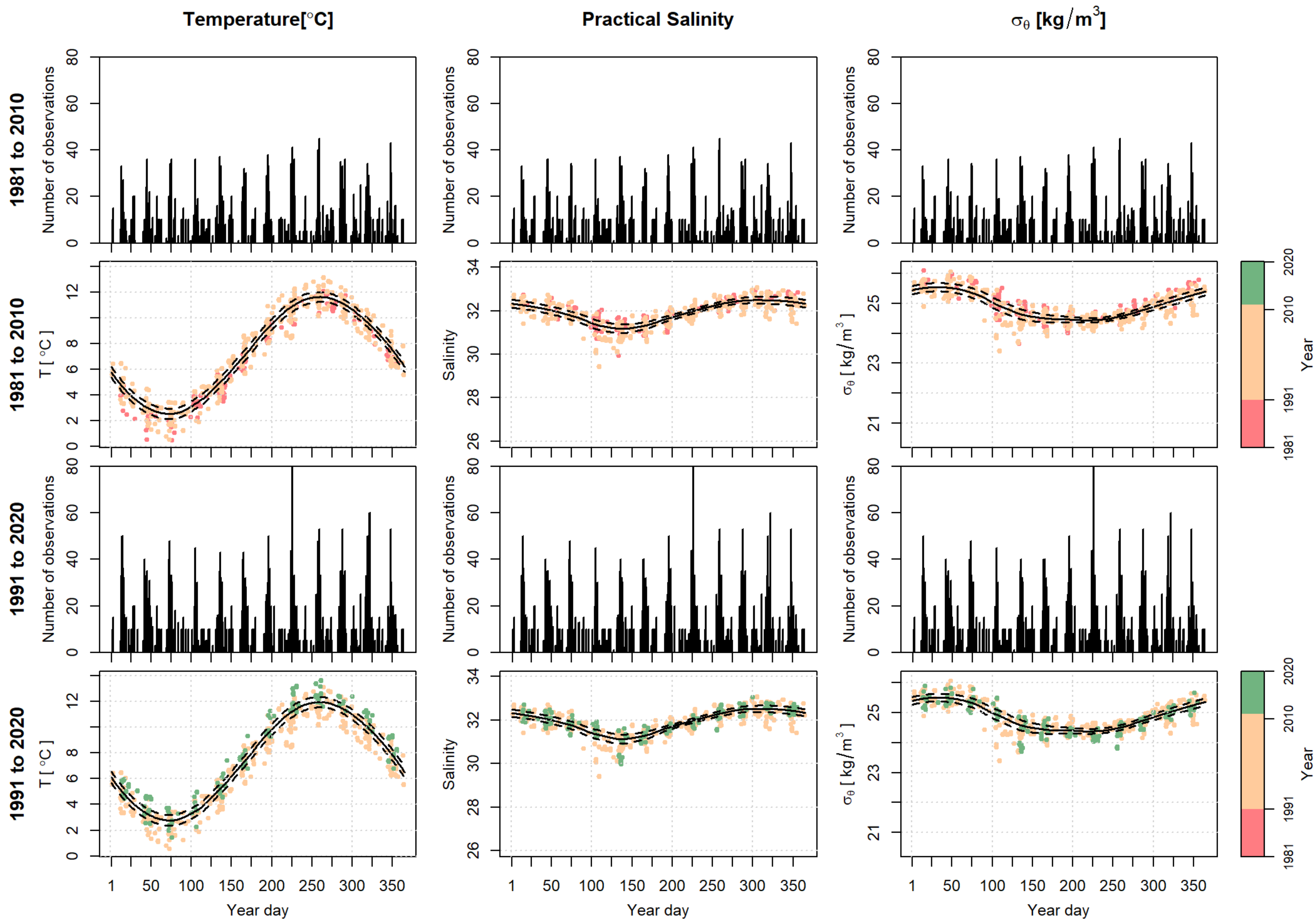

Figure 7. The 22.5m to 27.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

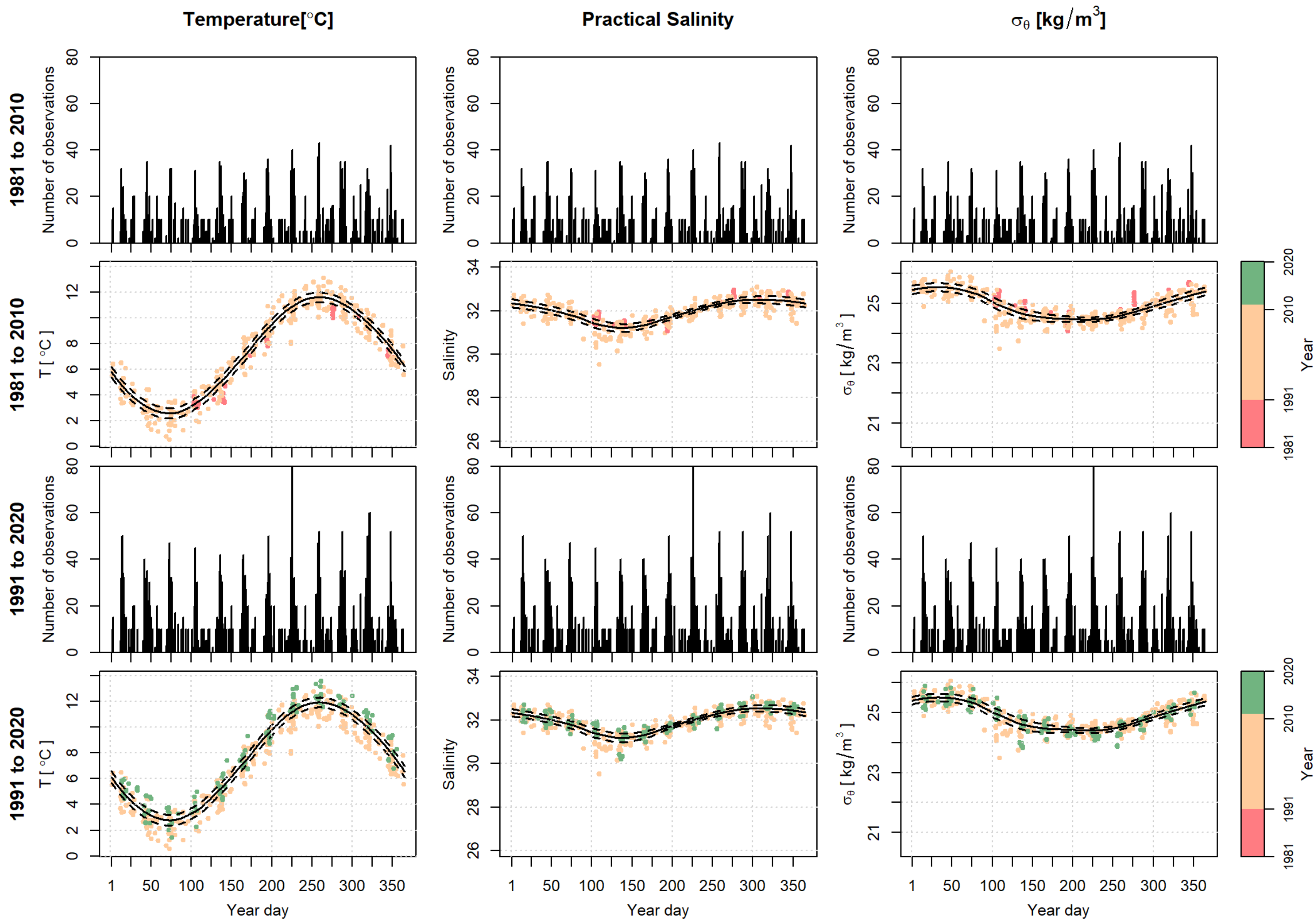

Figure 8. The 27.5m to 32.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and $\pm$ 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

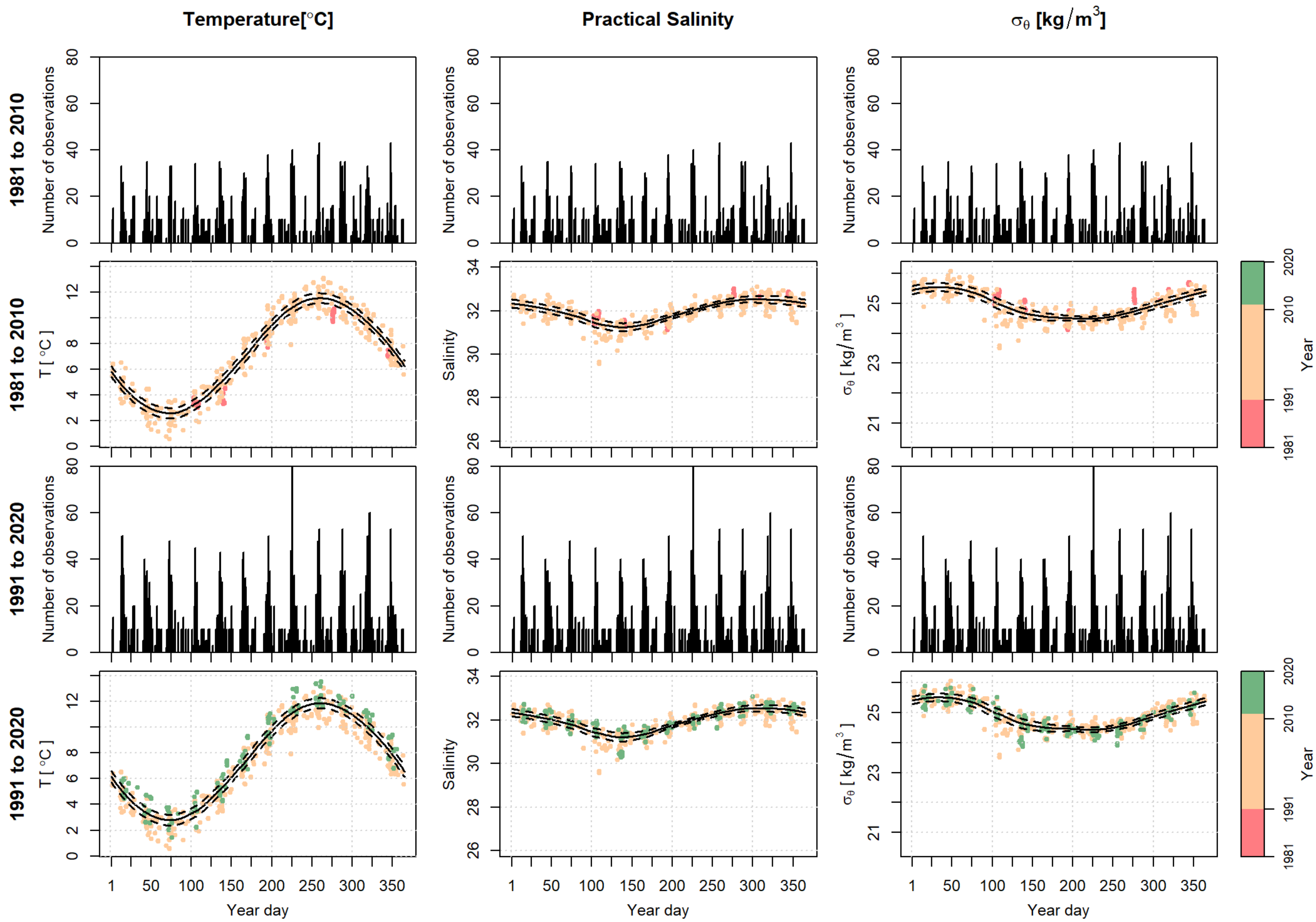

Figure 9. The 32.5m to 37.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

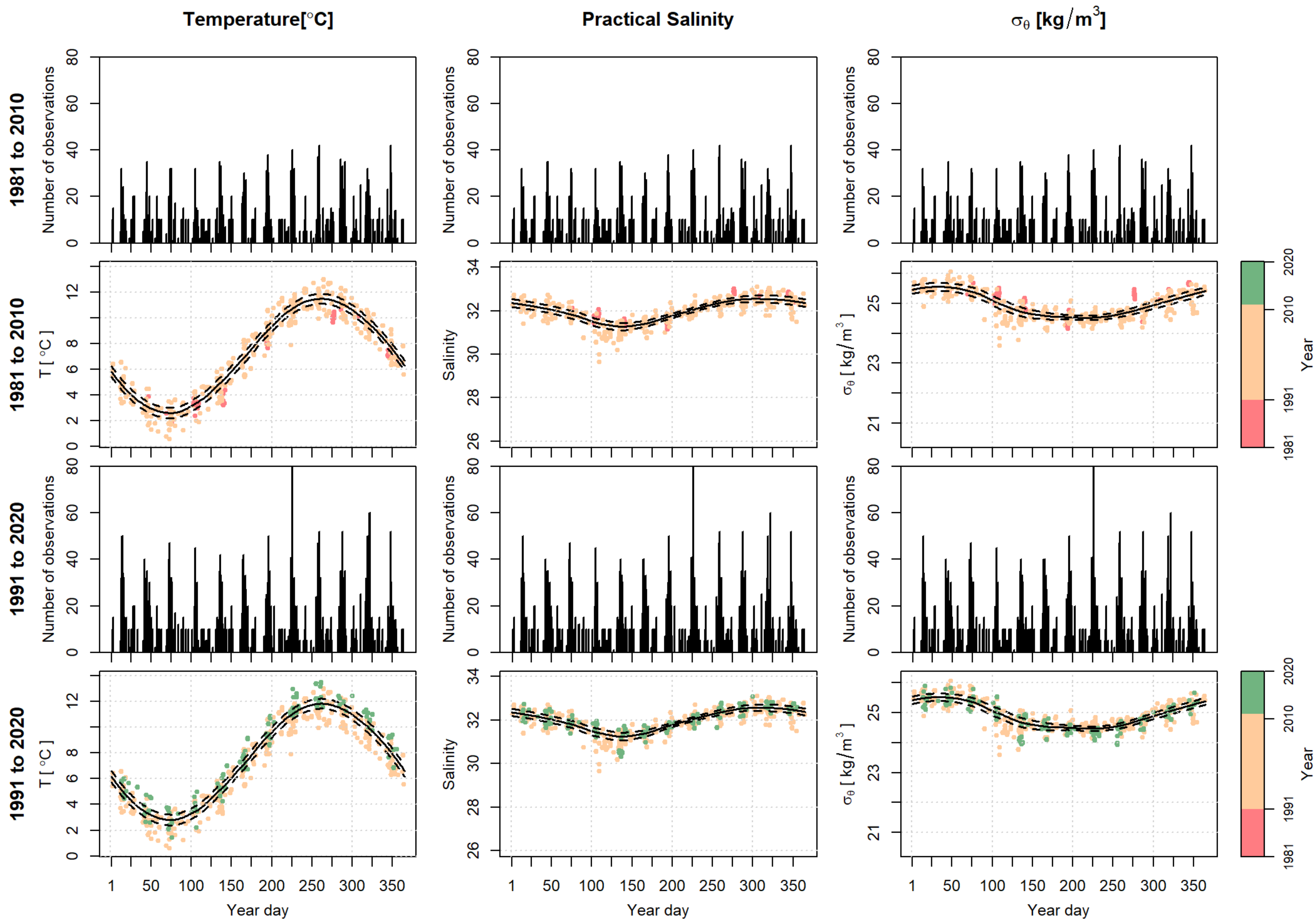

Figure 10. The 37.5m to 42.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

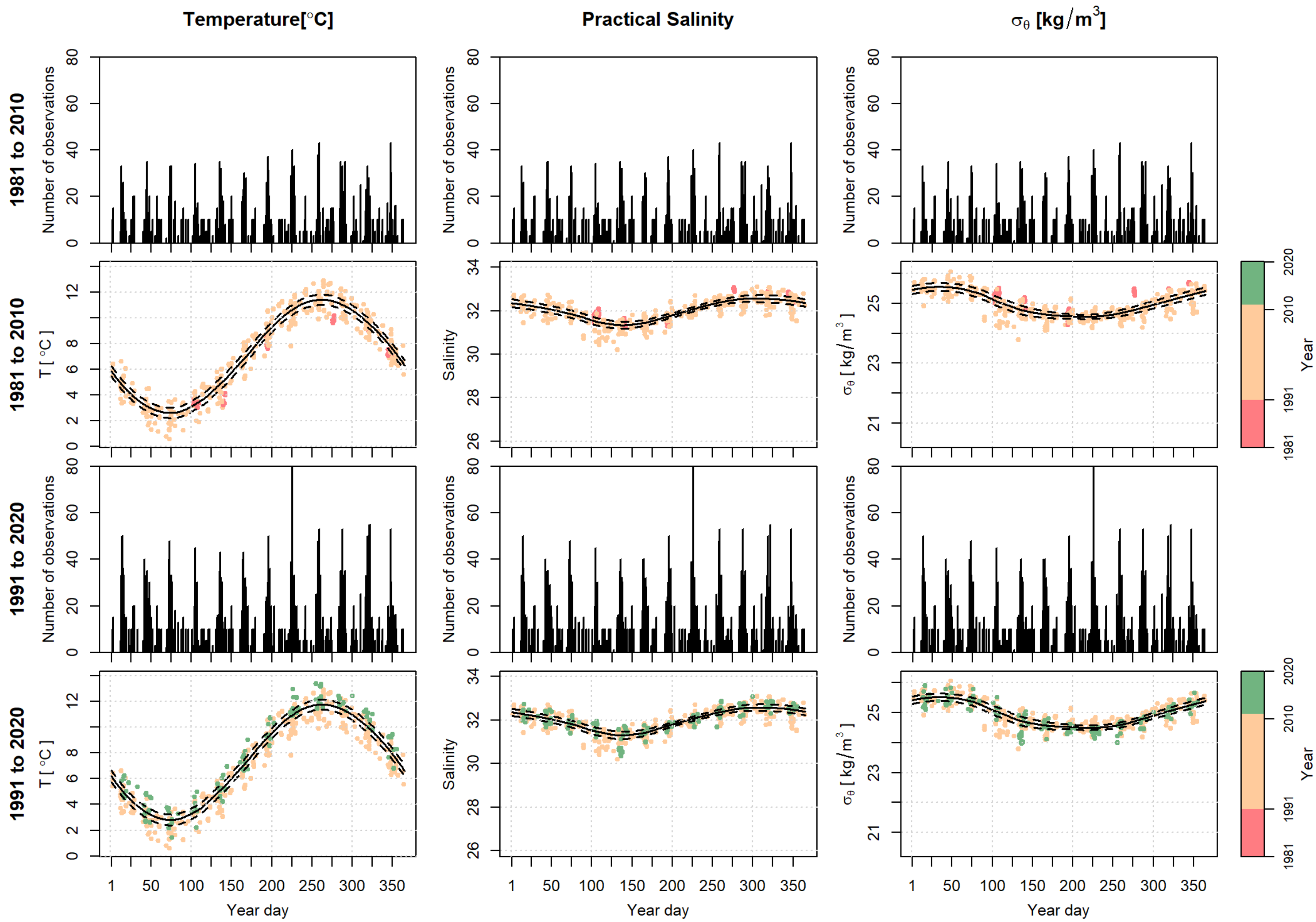

Figure 11. The 42.5m to 47.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

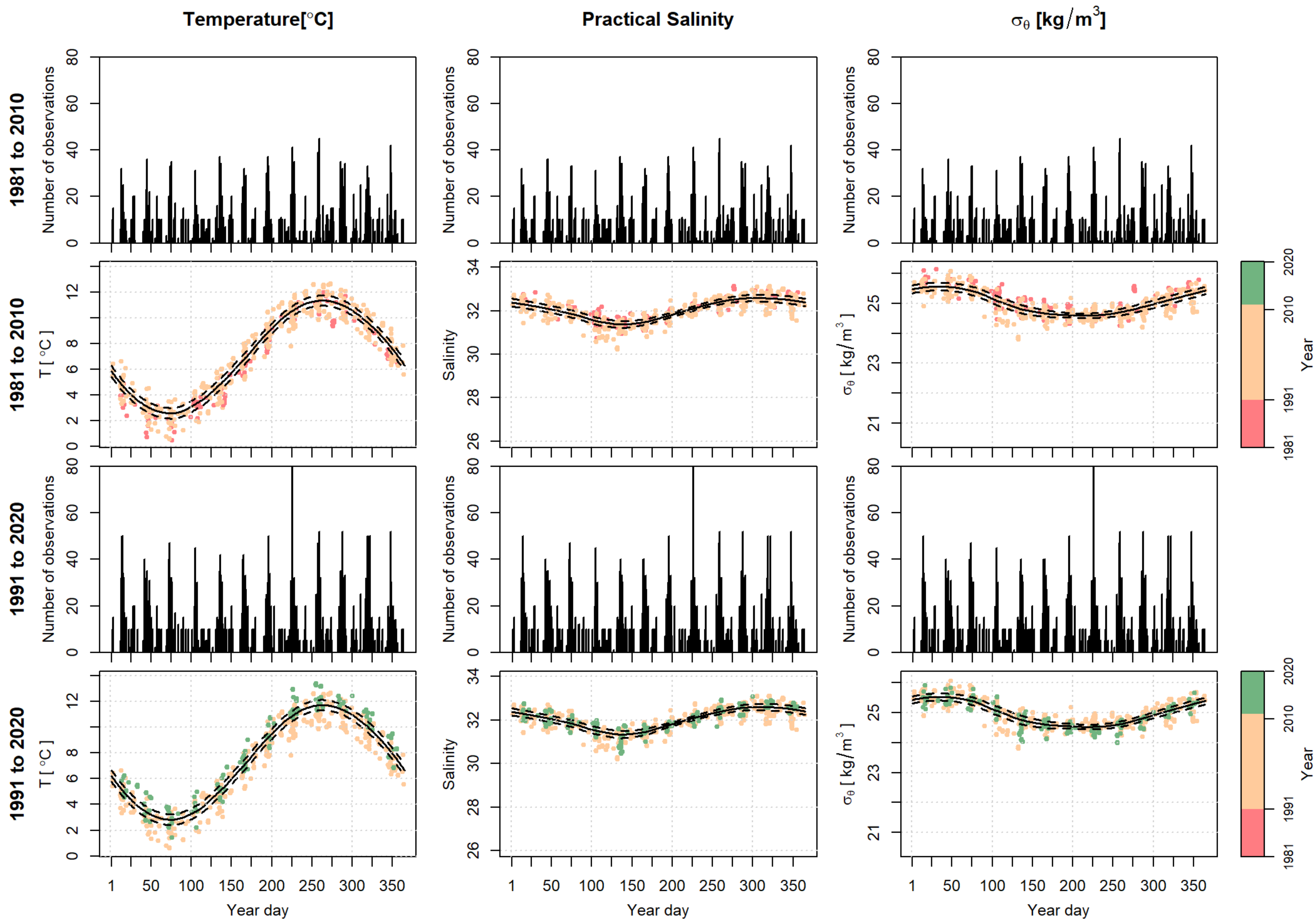

Figure 12. The 47.5m to 52.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and $\pm$ 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

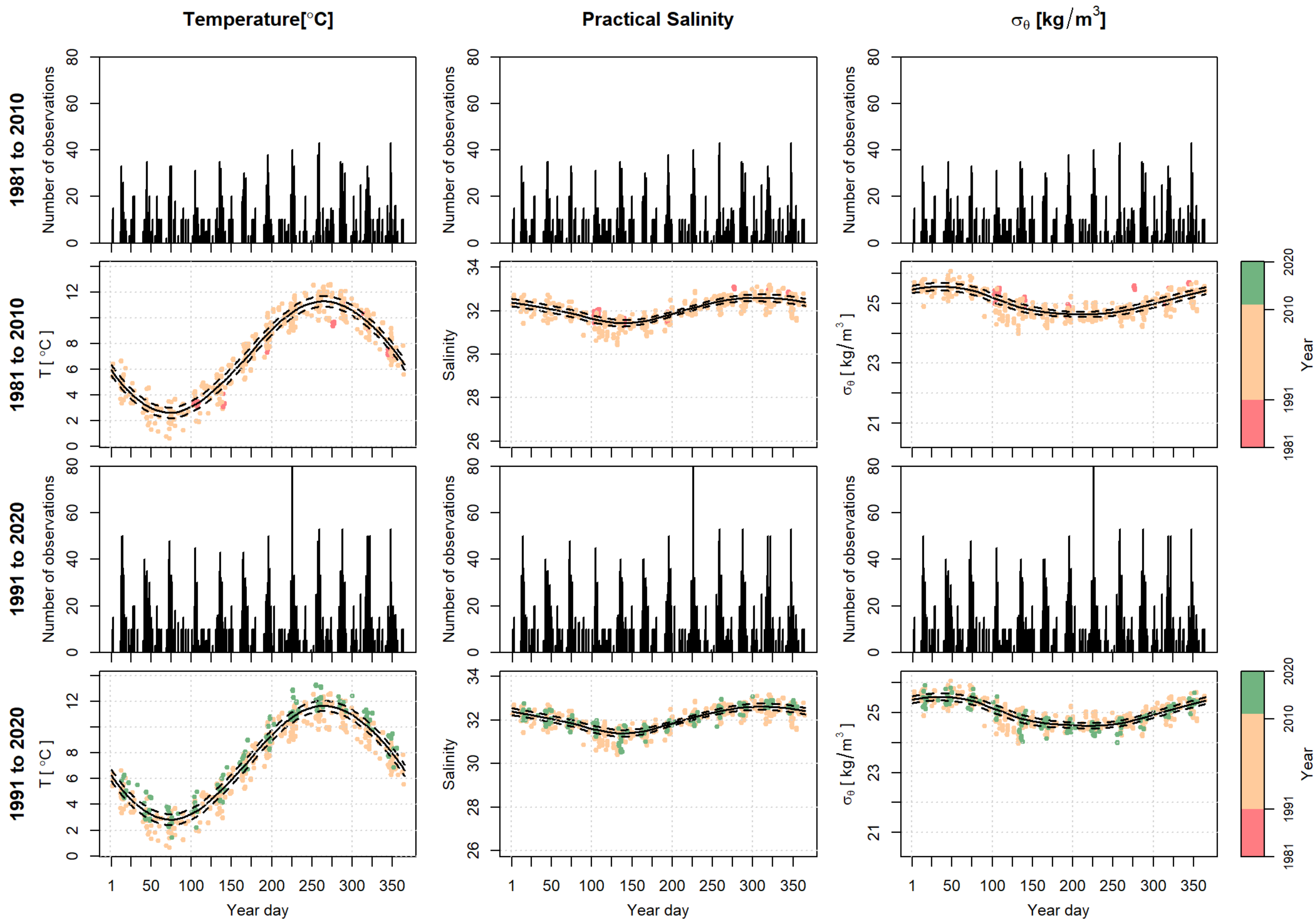

Figure 13. The 52.5m to 57.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and $\pm$ 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

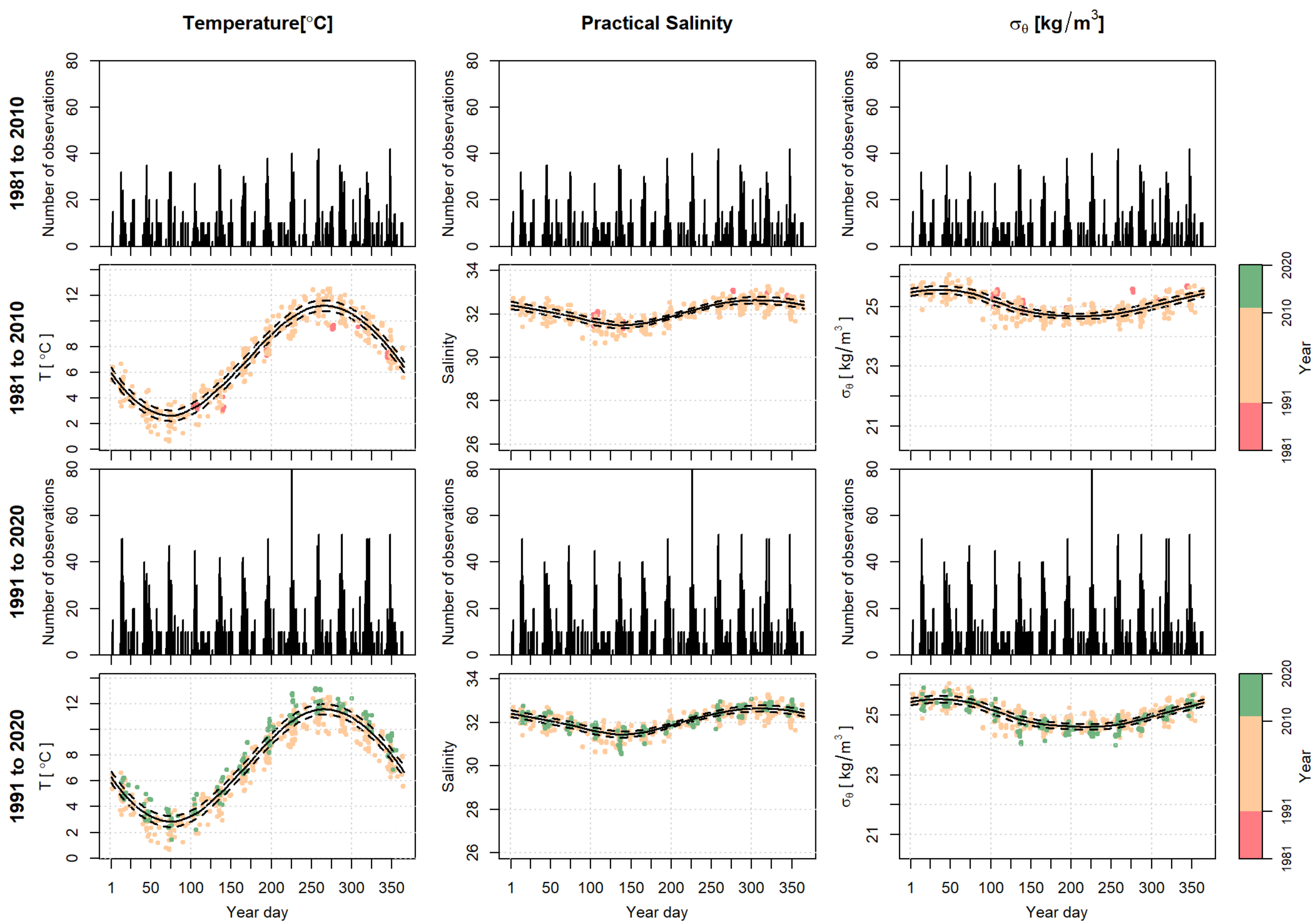

Figure 14. The 57.5m to 62.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

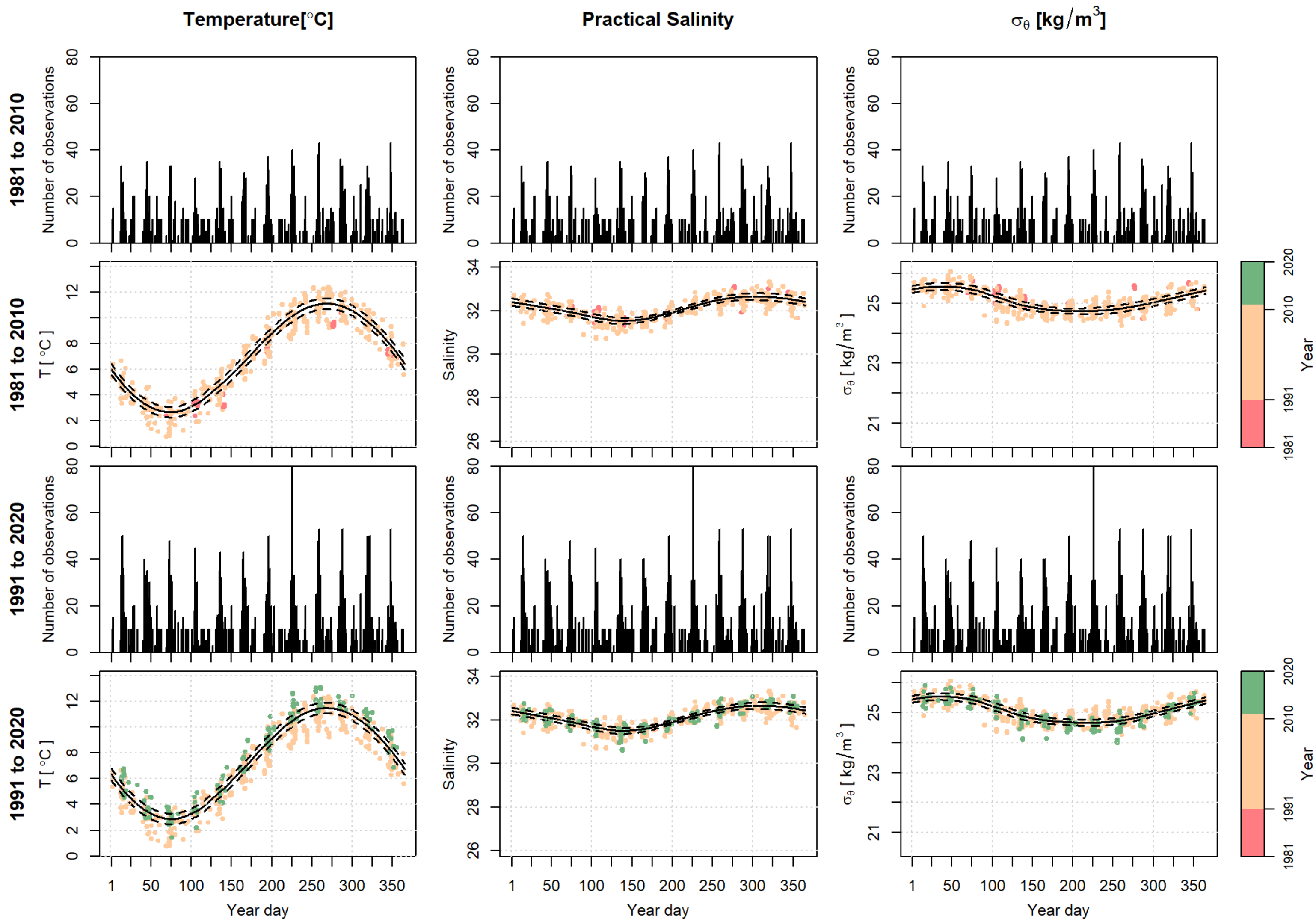

Figure 15. The 62.5m to 67.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

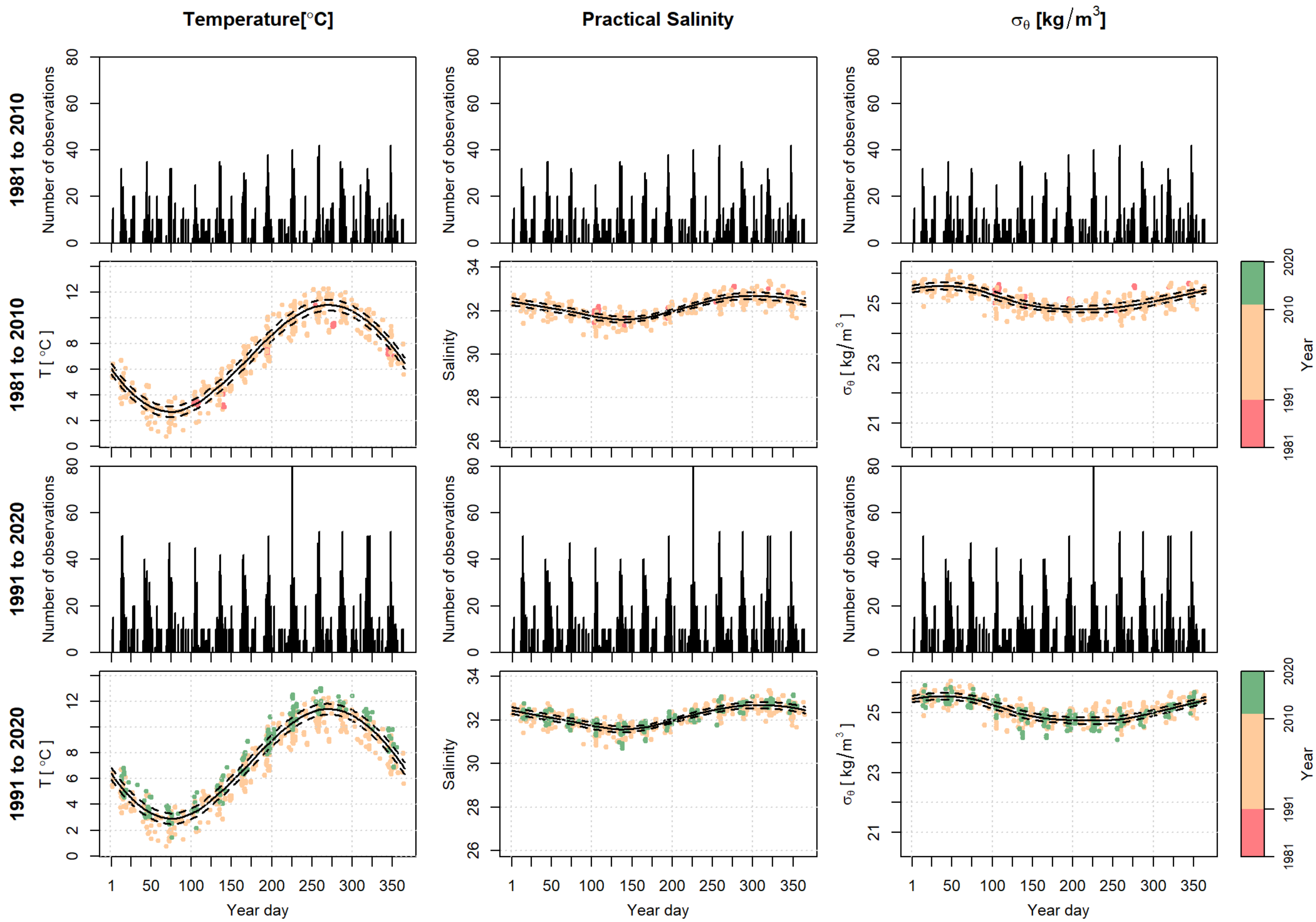

Figure 16. The 67.5m to 72.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

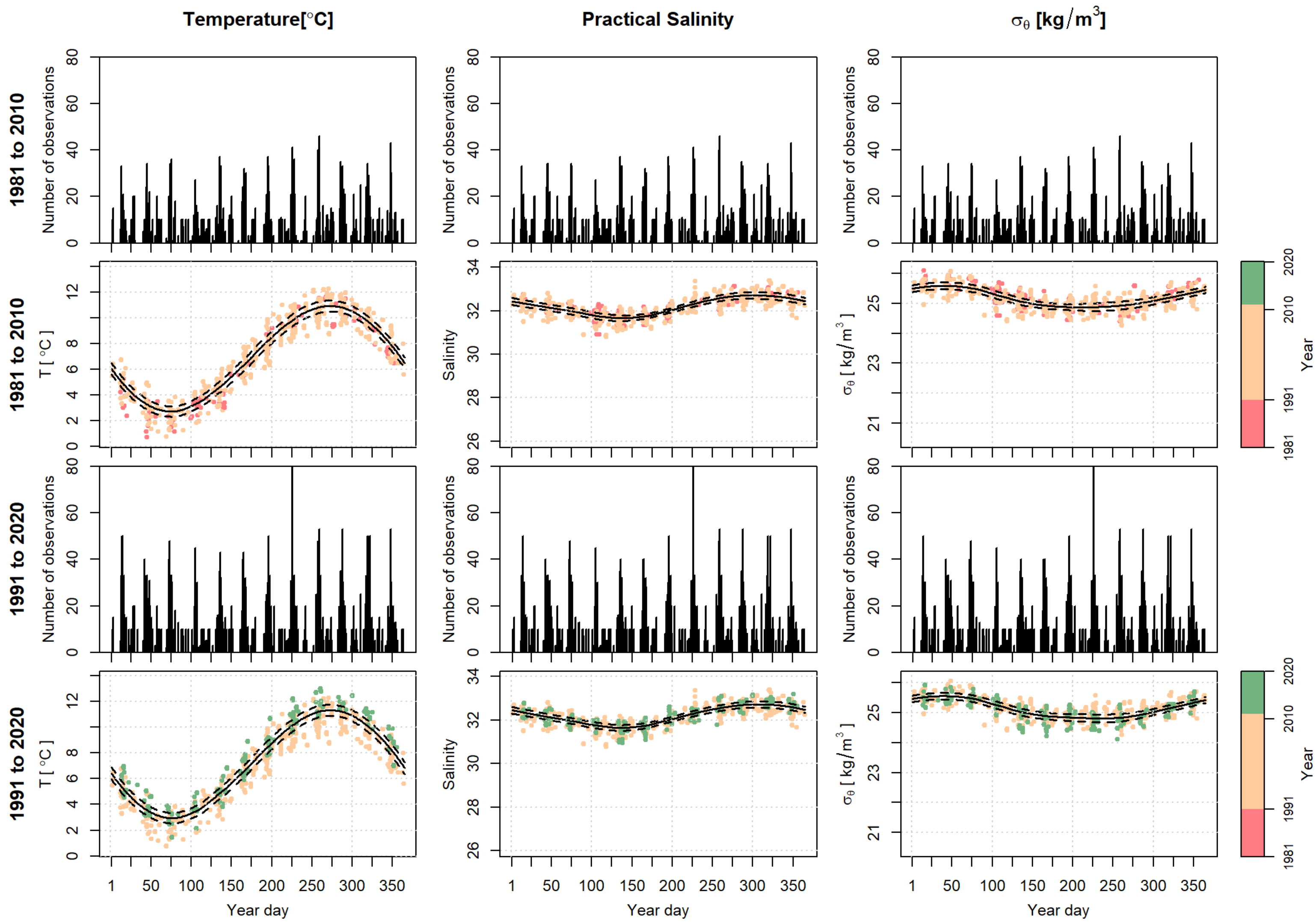

Figure 17. The 72.5m to 77.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

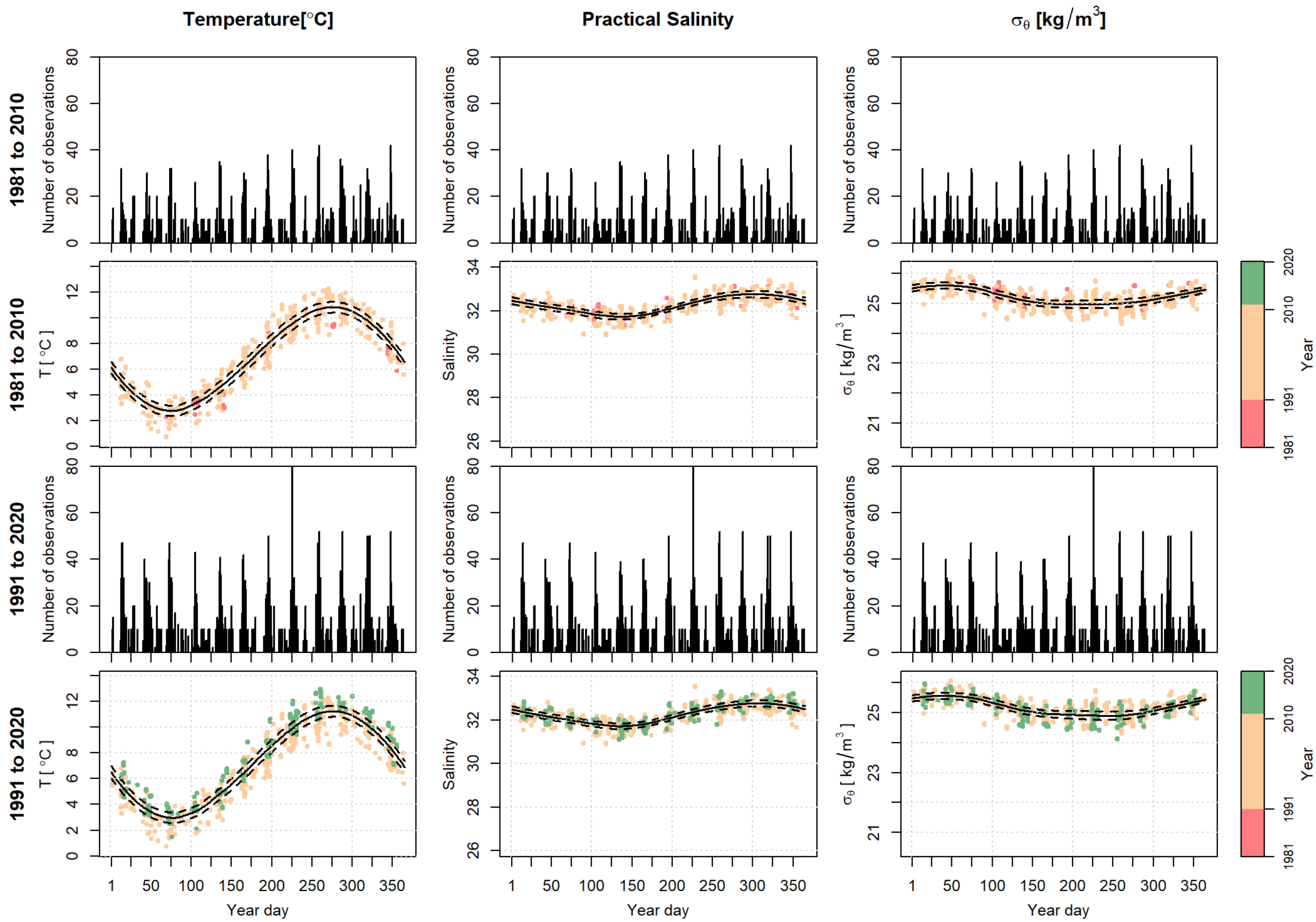

Figure 18. The 77.5m to 82.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

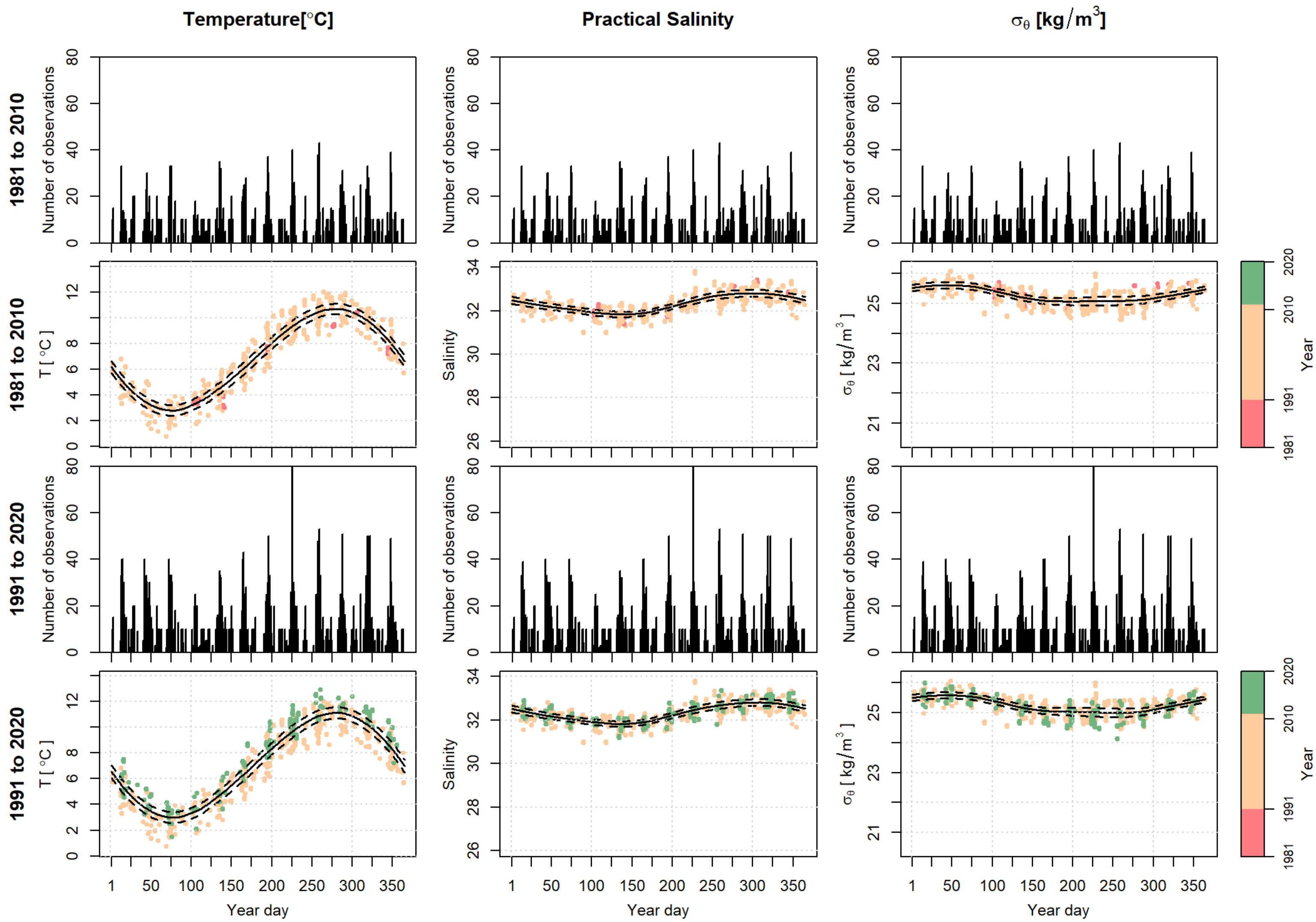

Figure 19. The 82.5m to 87.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

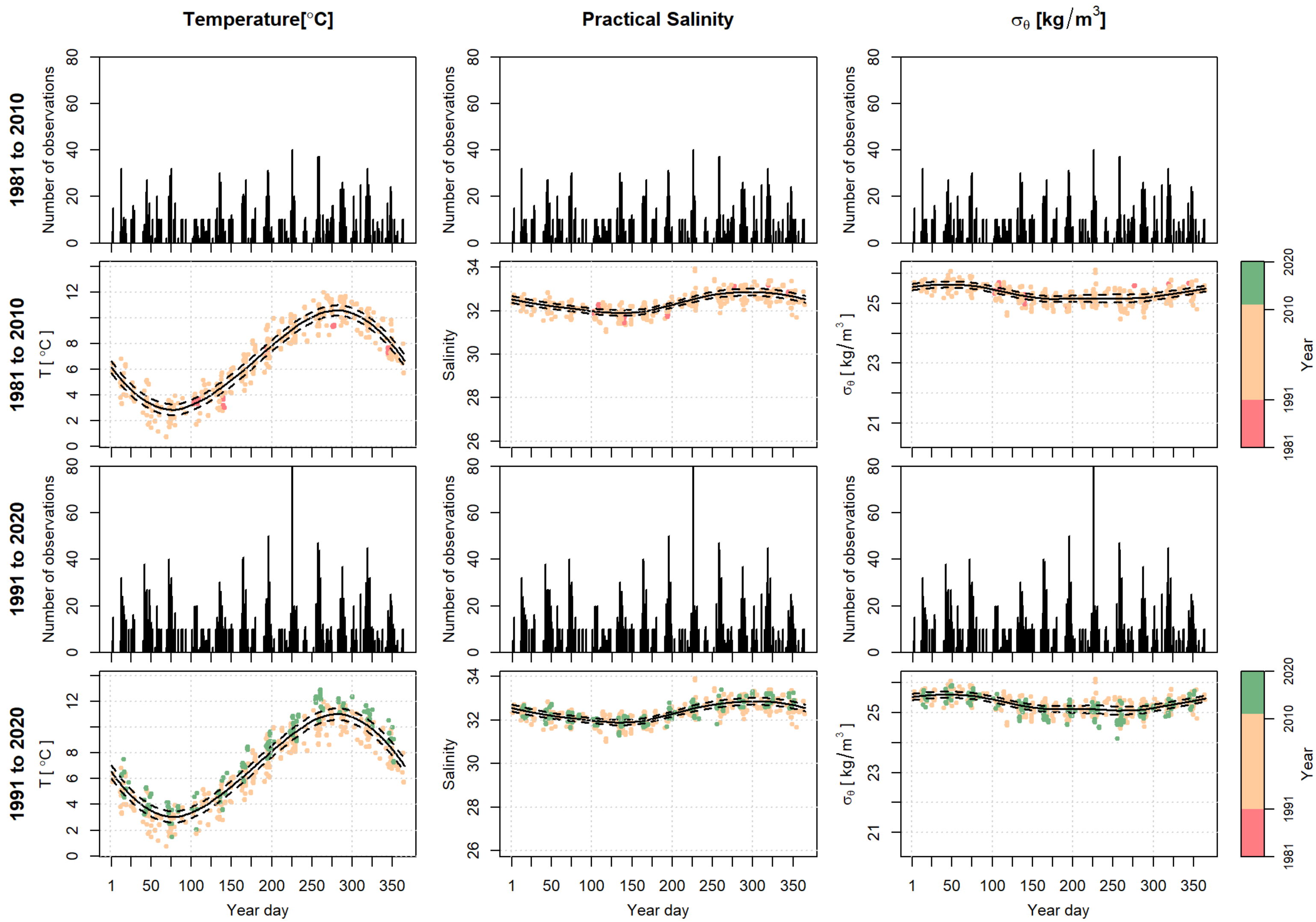

Figure 20. The 87.5m to 92.5m depth bin total number of observations per year day for the 1981 to 2010 (top row) and the 1991 to 2020 (third row) reference period and the scatter plot of data, color coded by year, with the mean (thick black line) and ± 1SD (dashed black line) local polynomial regression fits for the 1981 to 2010 (second row) and the 1991 to 2020 (bottom row) reference period for temperature (left column), salinity (middle column), and density (right column).

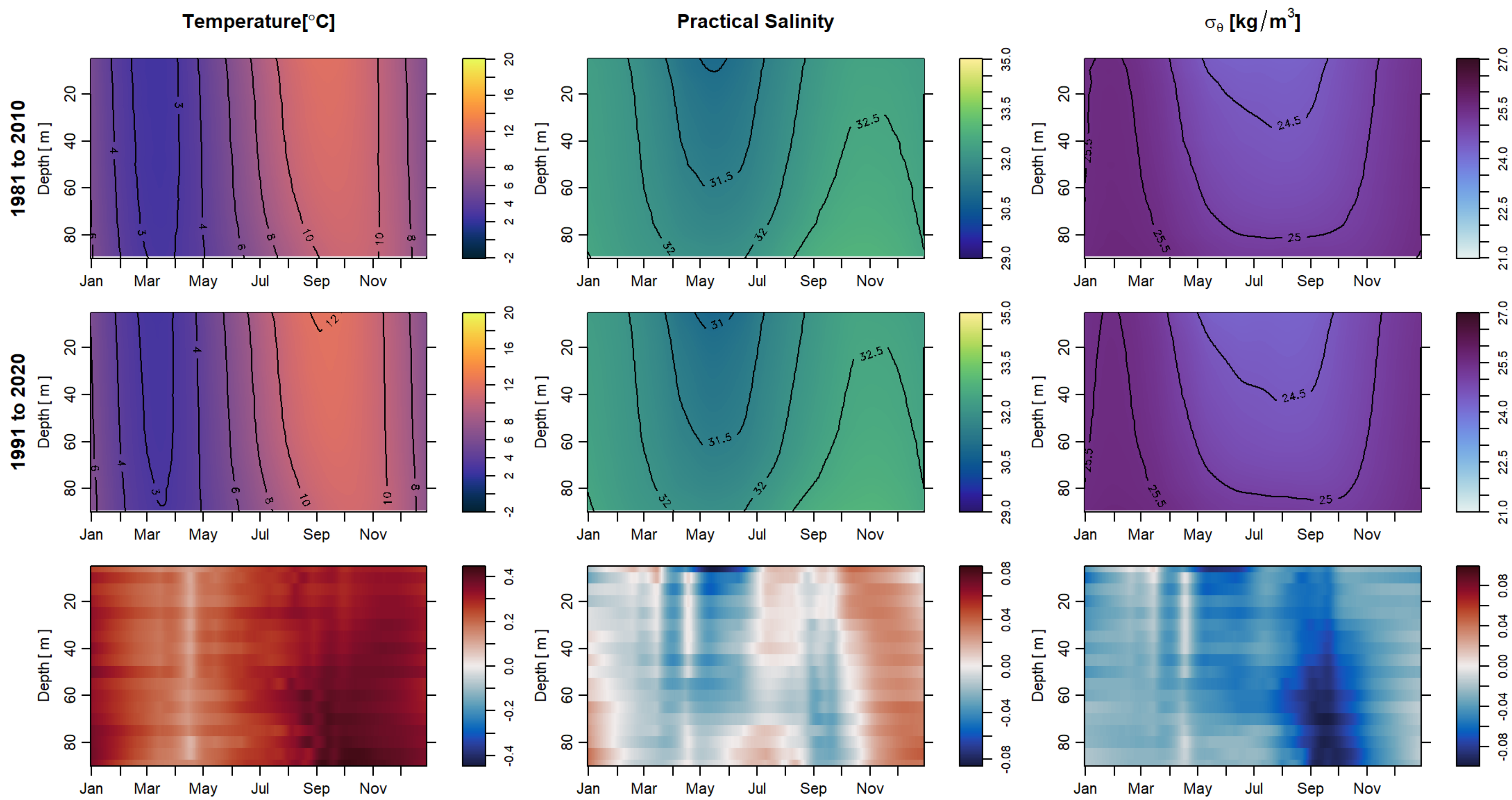

Figure 21. Section plot of the daily temperature (left column), salinity (middle column), and density (right column) climatology for the 1981 to 2010 reference period (top row) and 1991 to 2020 reference period (middle row). The quantized difference between the reference periods, the 1991 to 2020 minus the 1981 to 2010 reference period, of the daily climatology (bottom row).

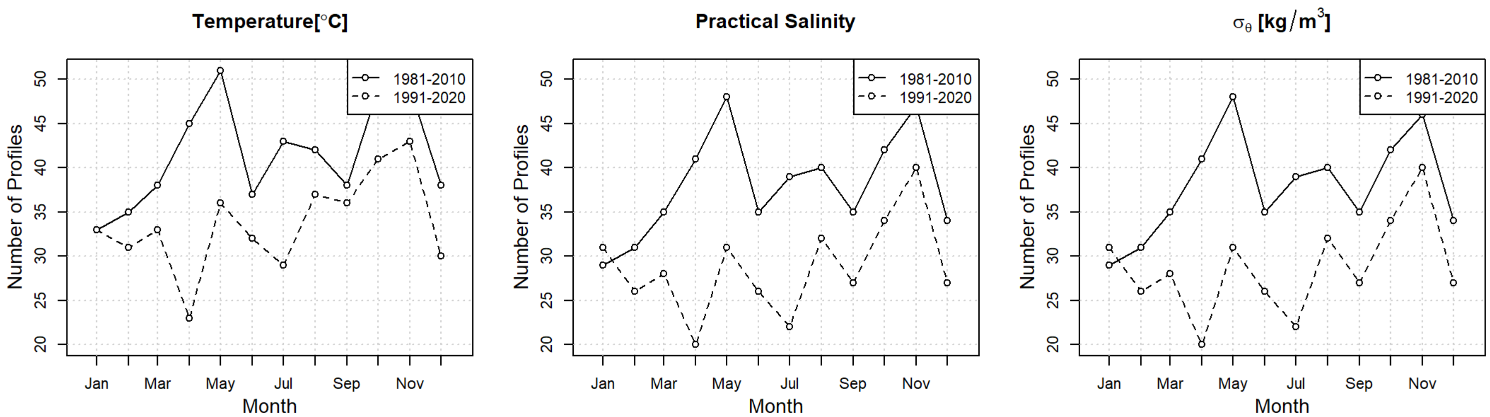

Figure 22. Monthly number of occupations for both climatology reference periods for temperature (left), salinity (middle), and density (right).

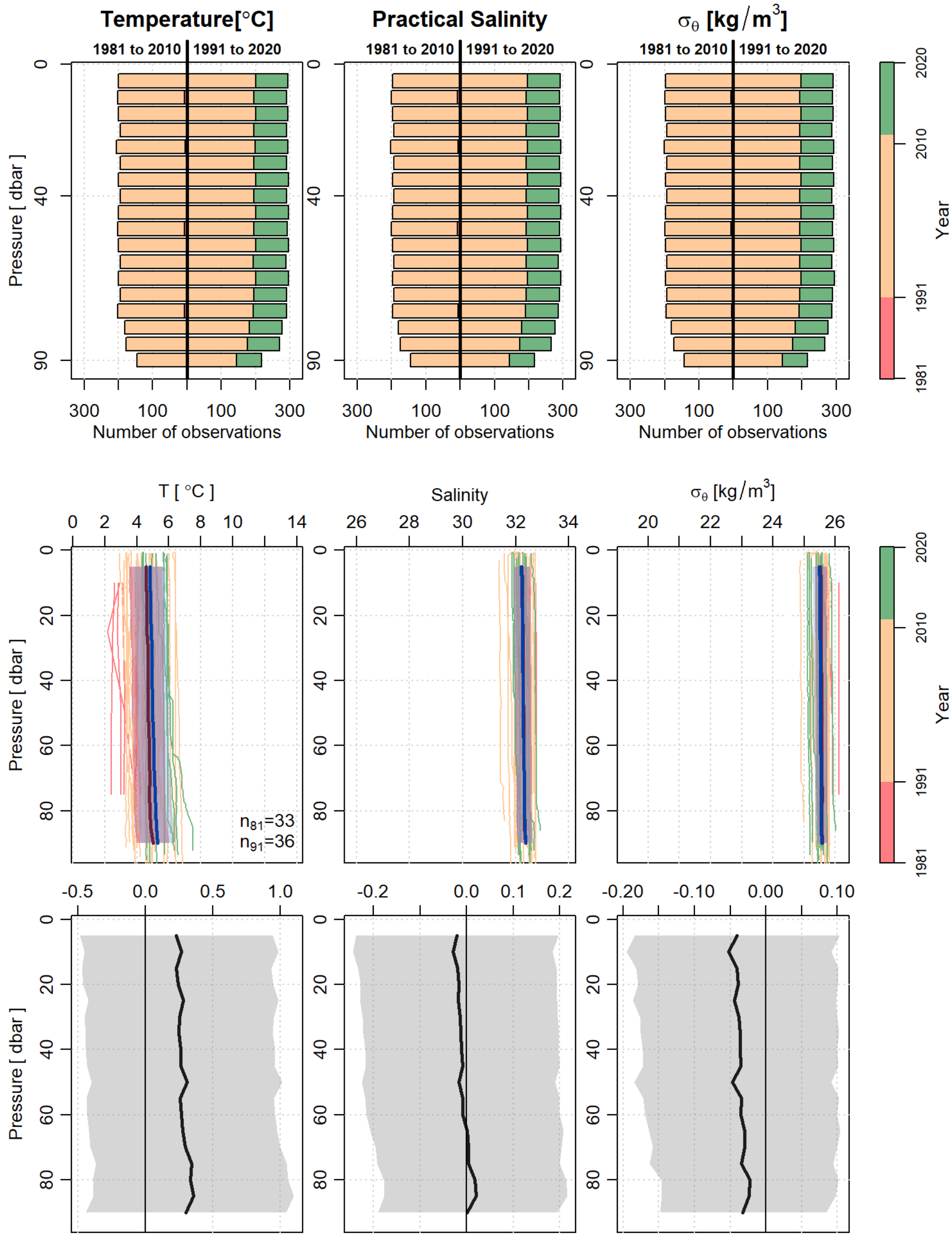

Figure 23. The January number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the $\pm$ 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and $\pm$ 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

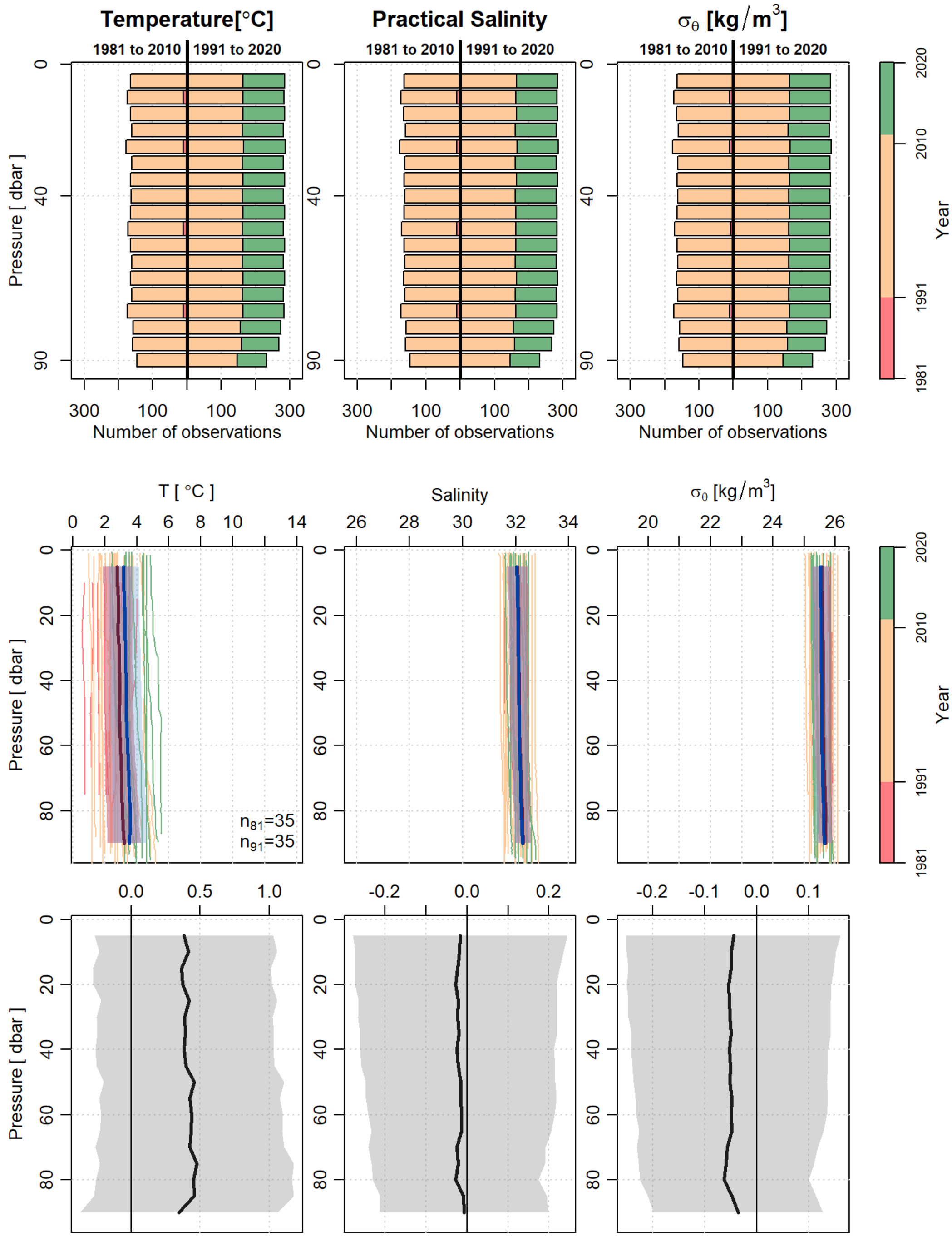

Figure 24. The February number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the $\pm$ 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and $\pm$ 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

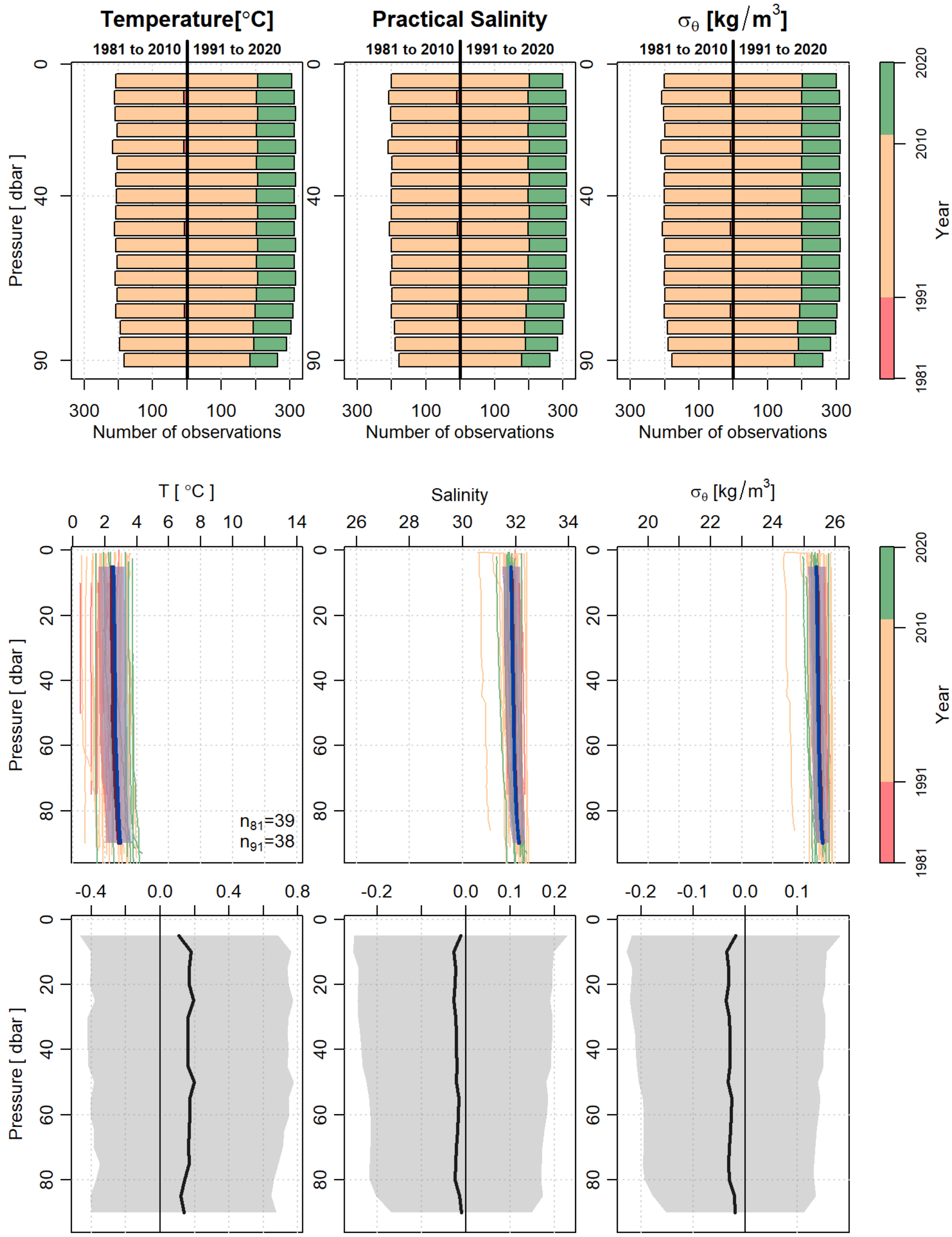

Figure 25. The March number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the ± 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and ± 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

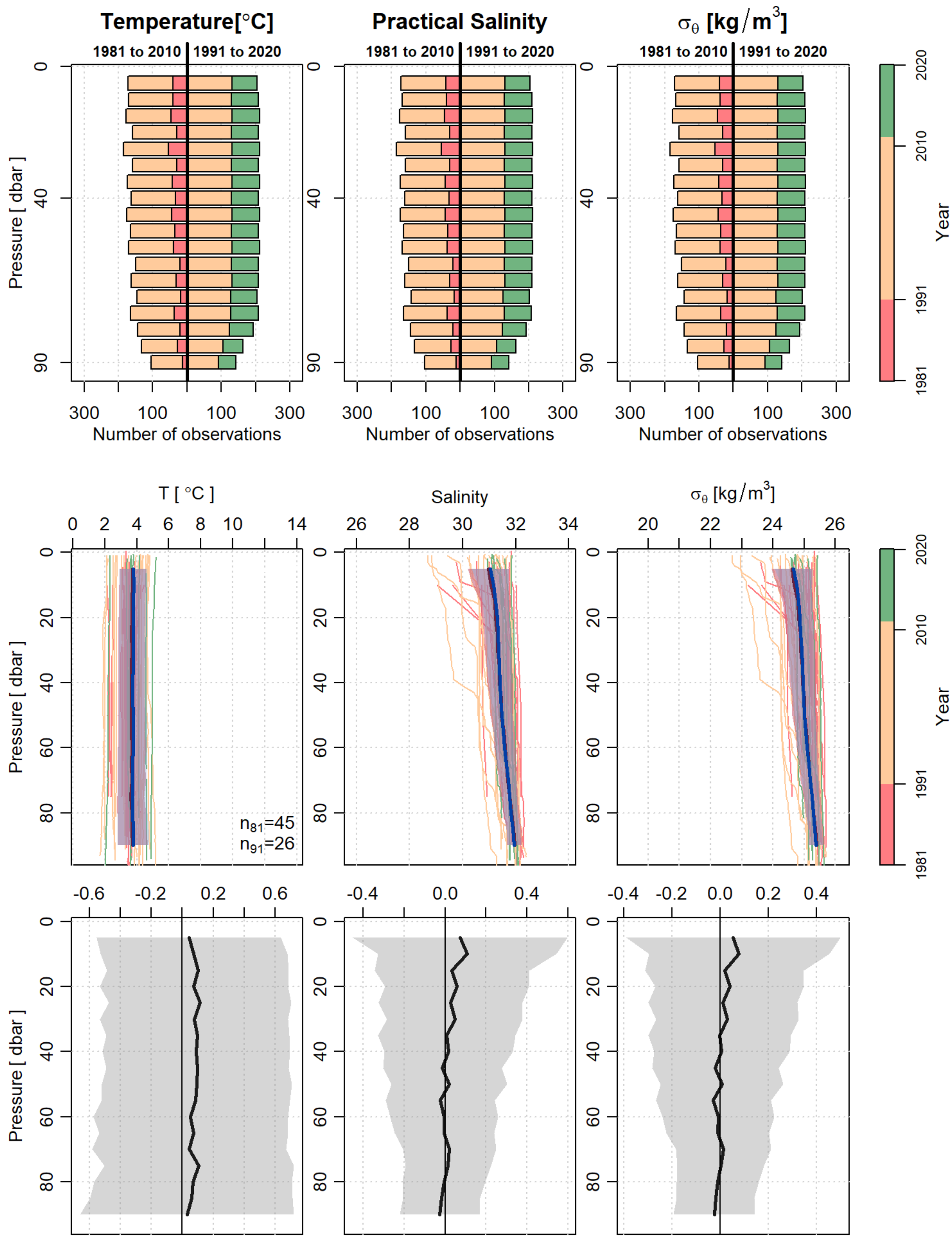

Figure 26. The April number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the $\pm$ 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and $\pm$ 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

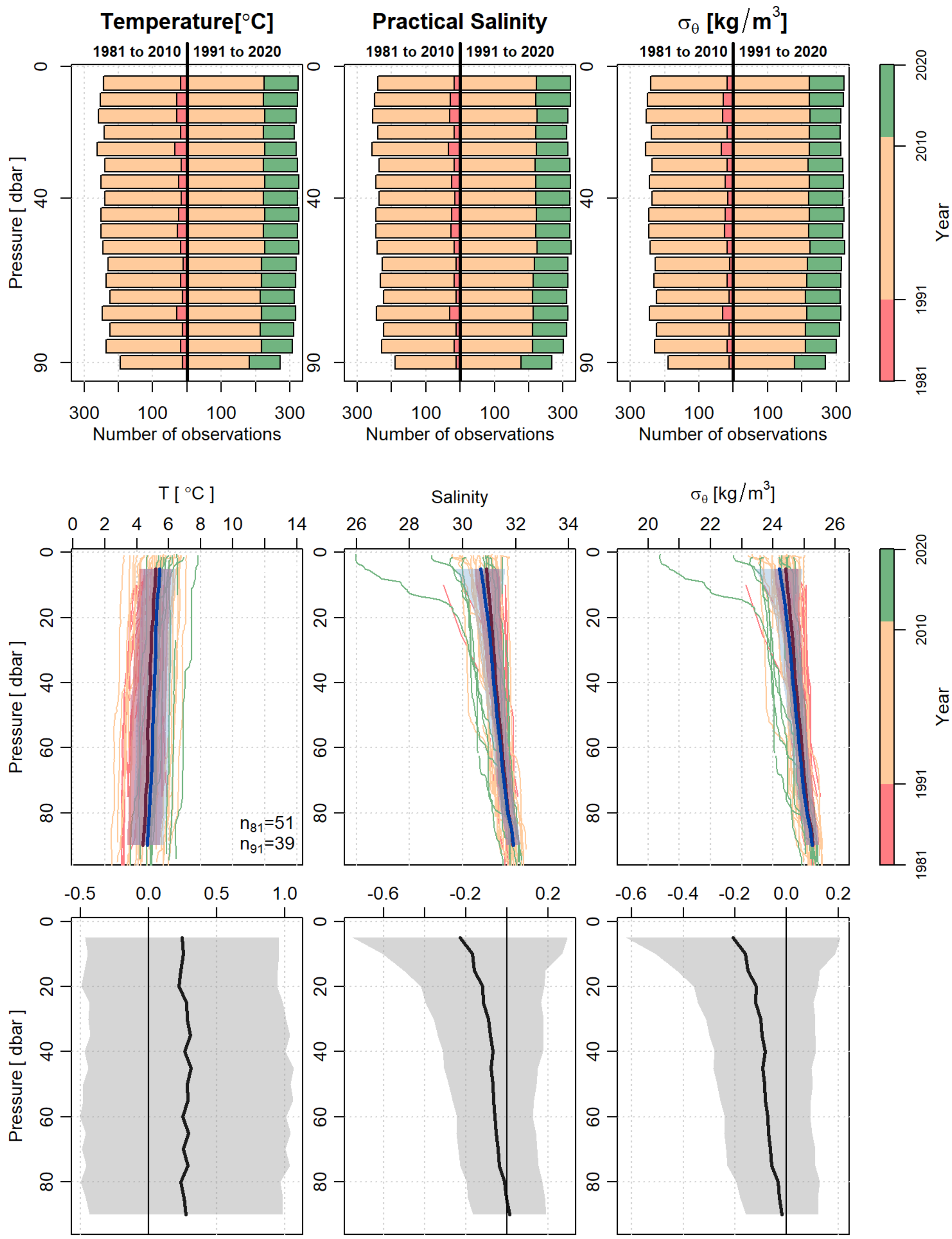

Figure 27. The May number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the $\pm$ 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and $\pm$ 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

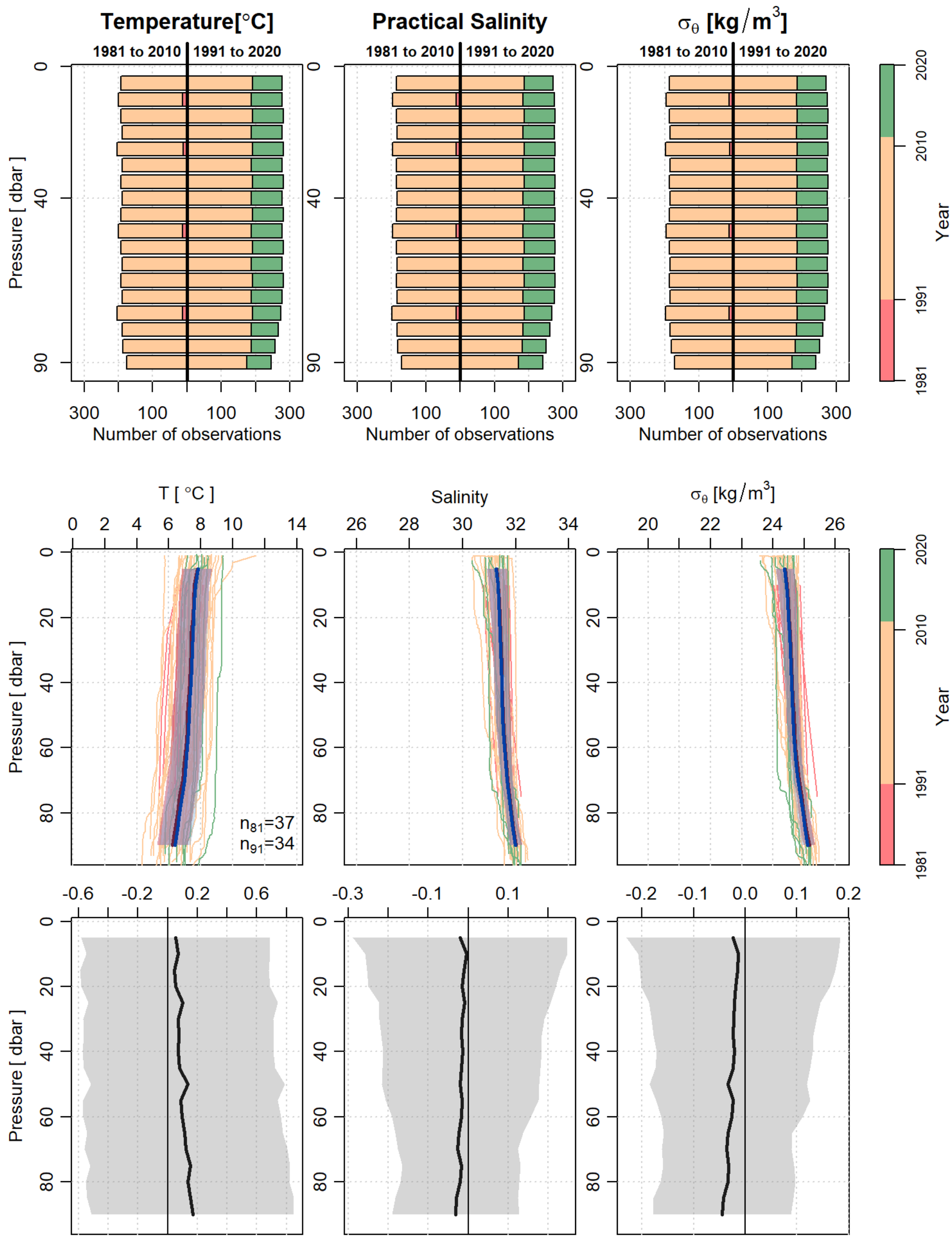

Figure 28. The June number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the $\pm$ 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and $\pm$ 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

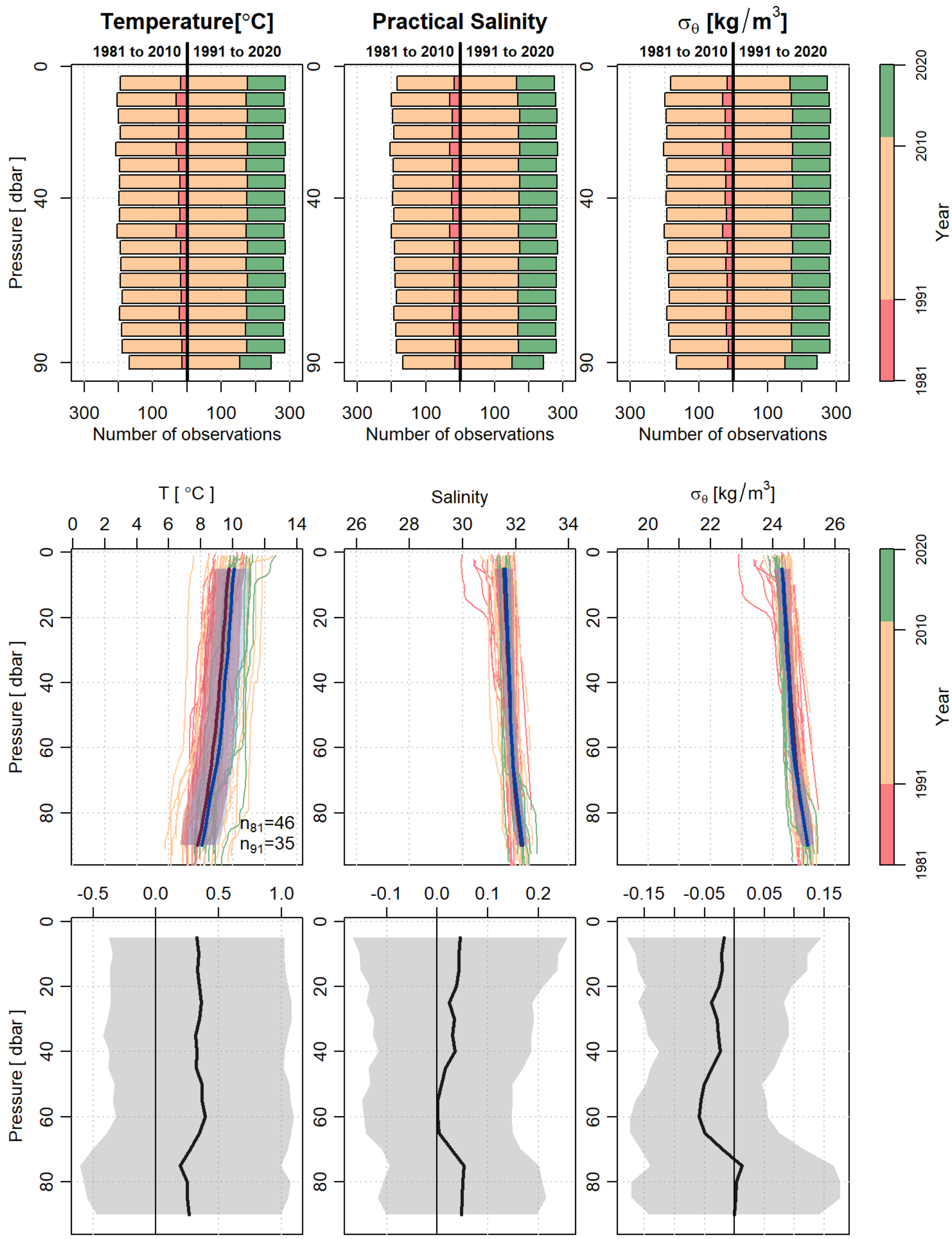

Figure 29. The July number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the $\pm$ 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and $\pm$ 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

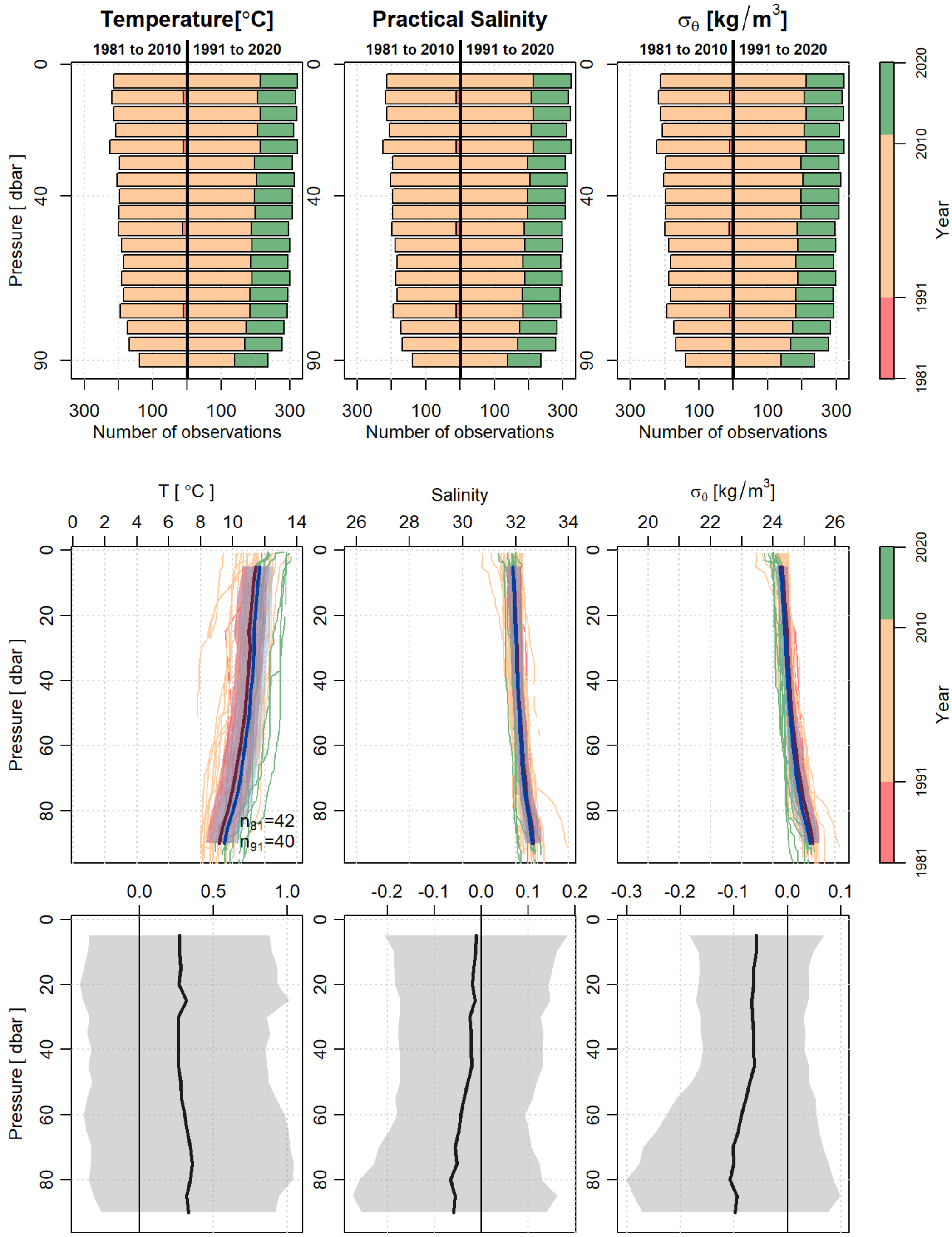

Figure 30. The August number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the $\pm$ 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and $\pm$ 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

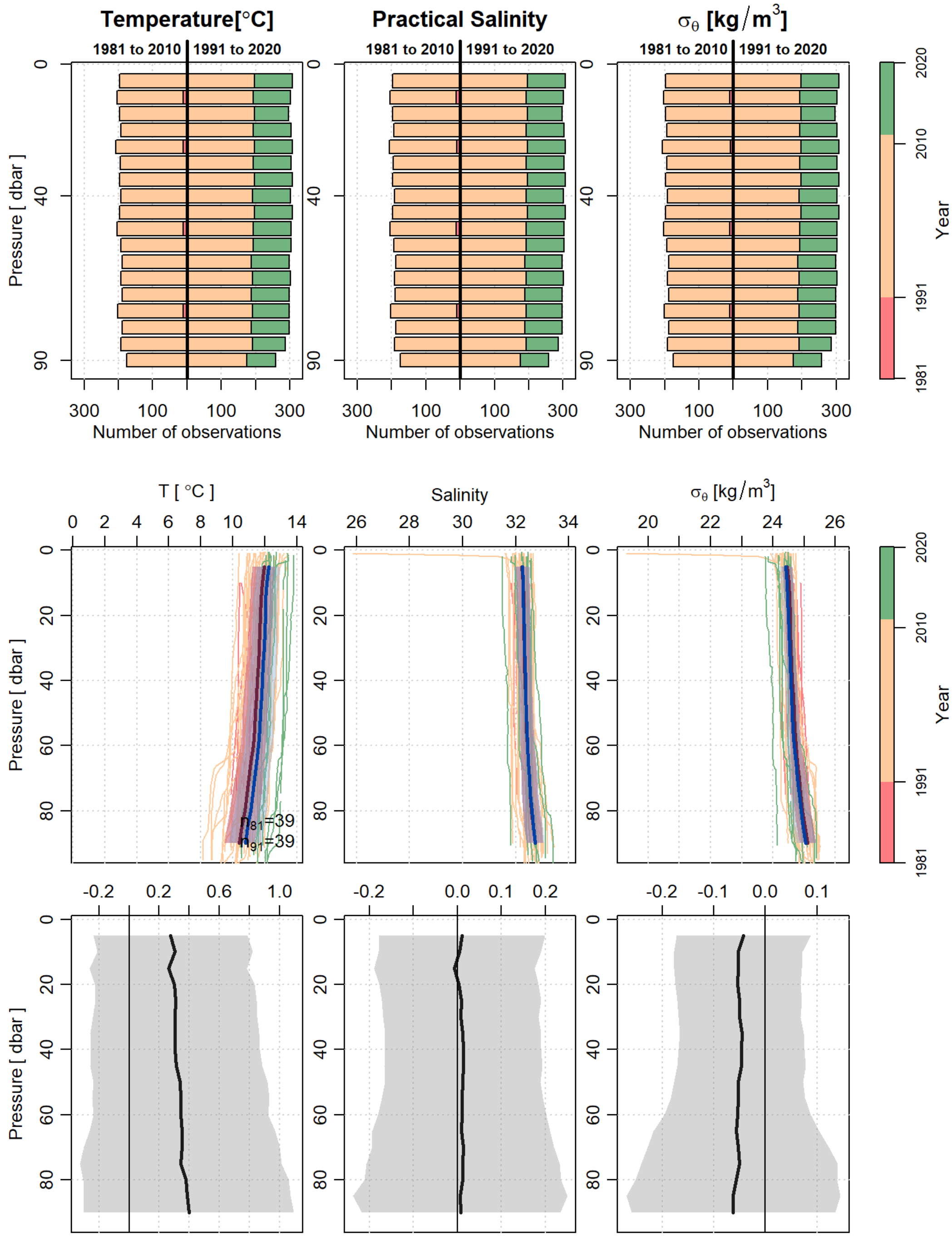

Figure 31. The September number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the $\pm$ 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and $\pm$ 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

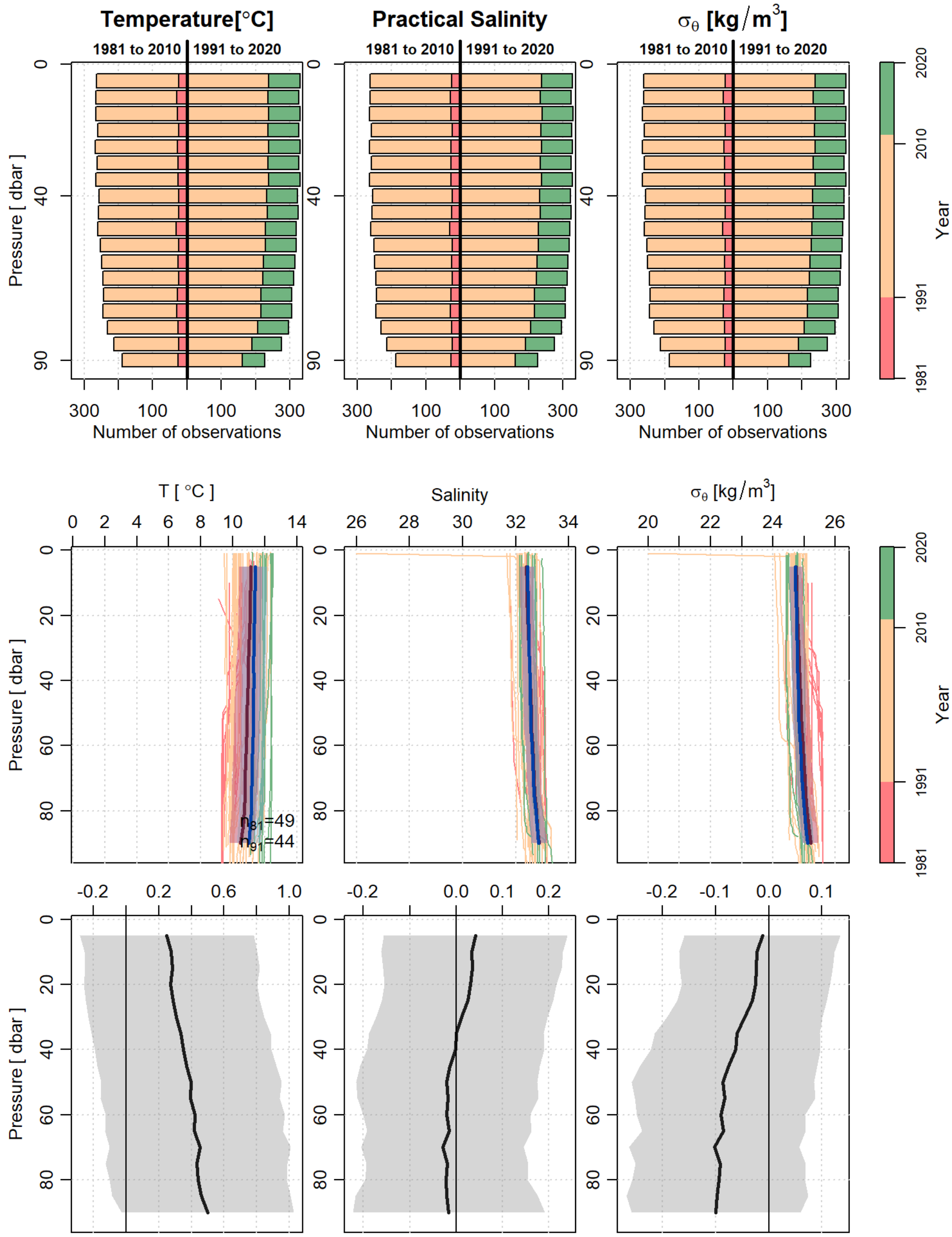

Figure 32. The October number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the ± 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and ± 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

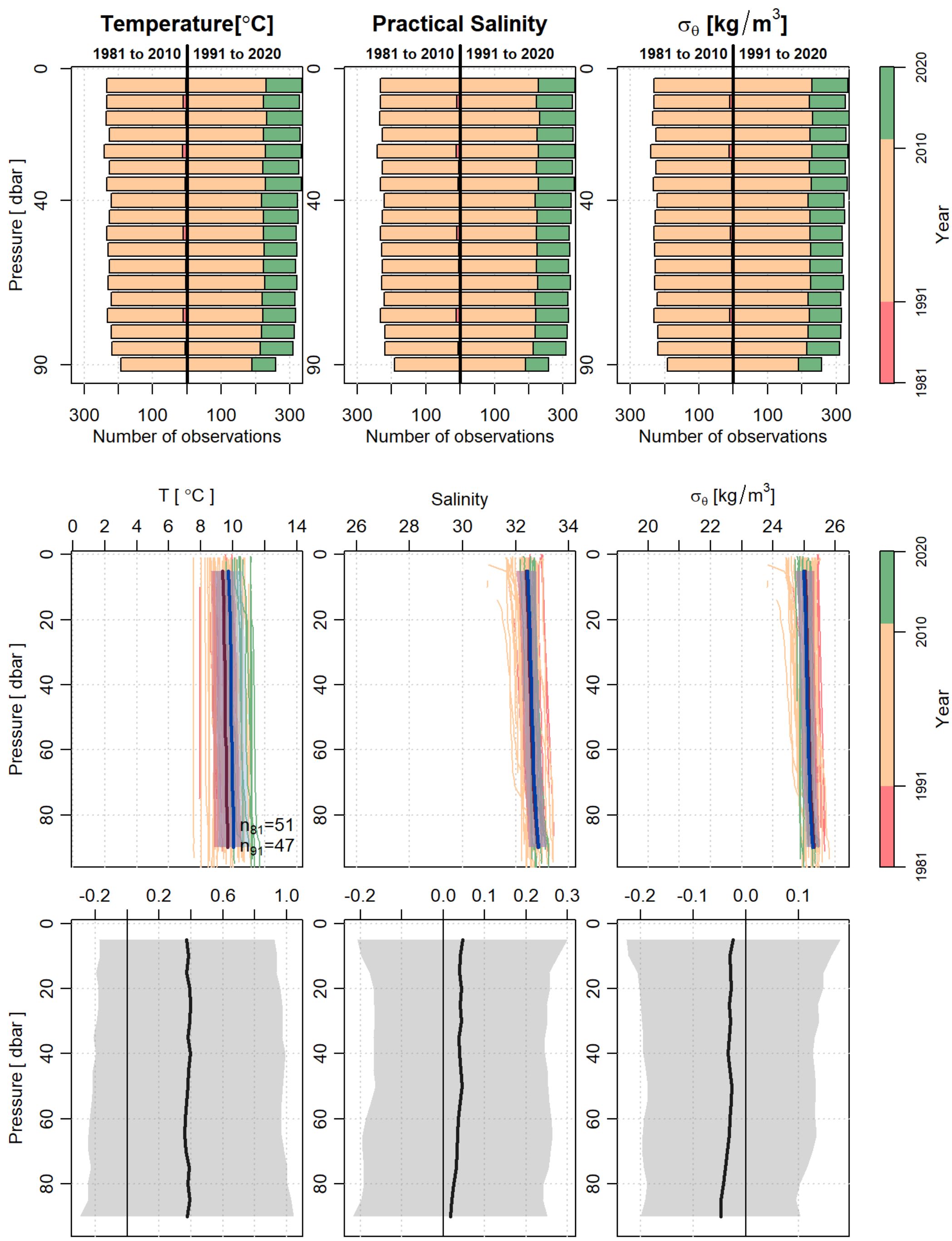

Figure 33. The November number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the $\pm$ 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and $\pm$ 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

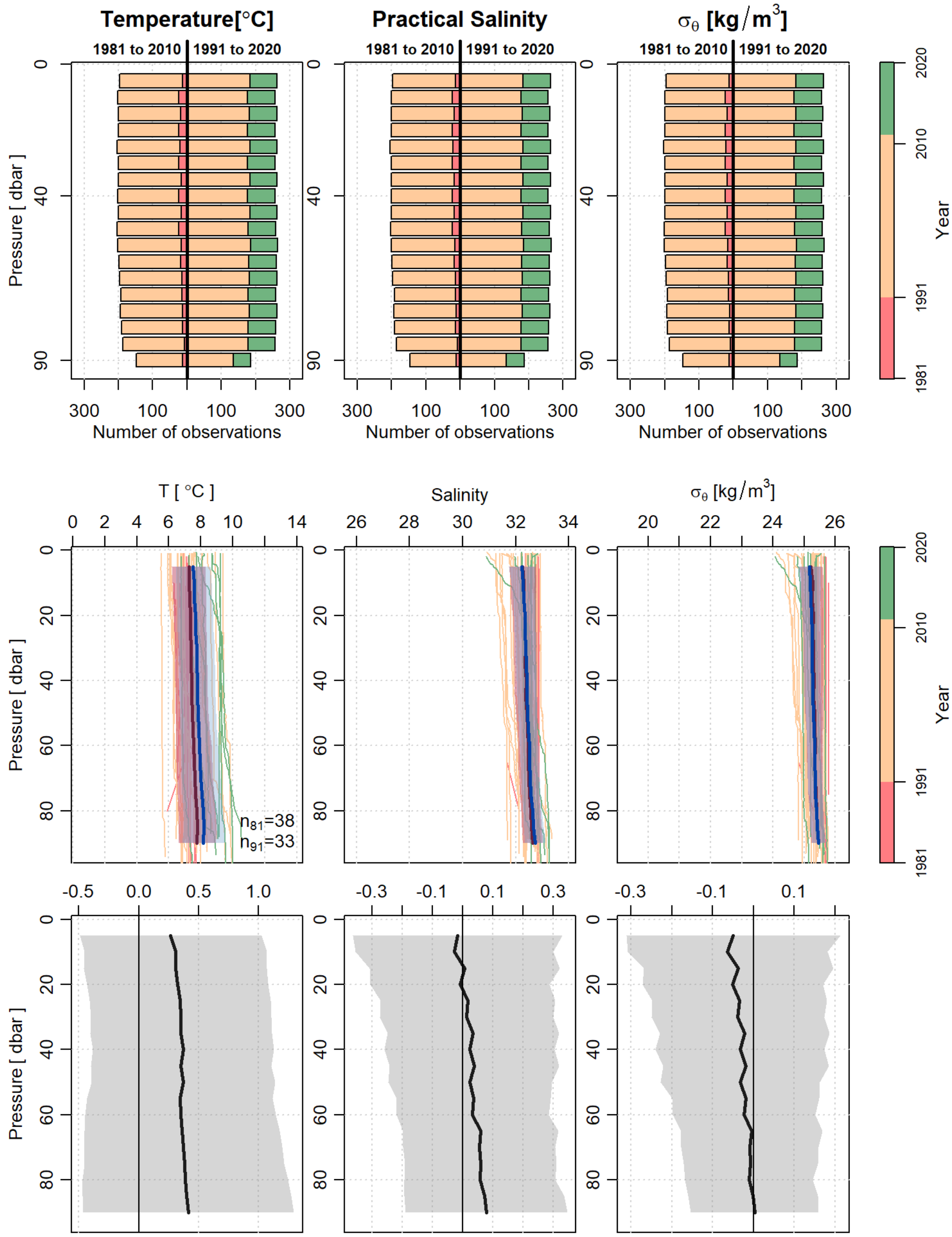

Figure 34. The December number of observations for each climatology reference period, as indicated by the label on the top axis, color coded by year (top row). Mean profiles (thick line) and the ± 0.5SD (indicated by shading) for the 1981 to 2010 reference period (red) and 1991 to 2020 reference period (blue) (middle row). Thin lines, color coded by year, are the profile observations that were used in the mean and standard deviation calculations.The difference, 1991 to 2020 minus 1981 to 2010, of the two mean profiles and ± 0.5SD for temperature (bottom left), salinity (bottom middle), and density (bottom right). Vertical thin black line denotes a difference of zero.

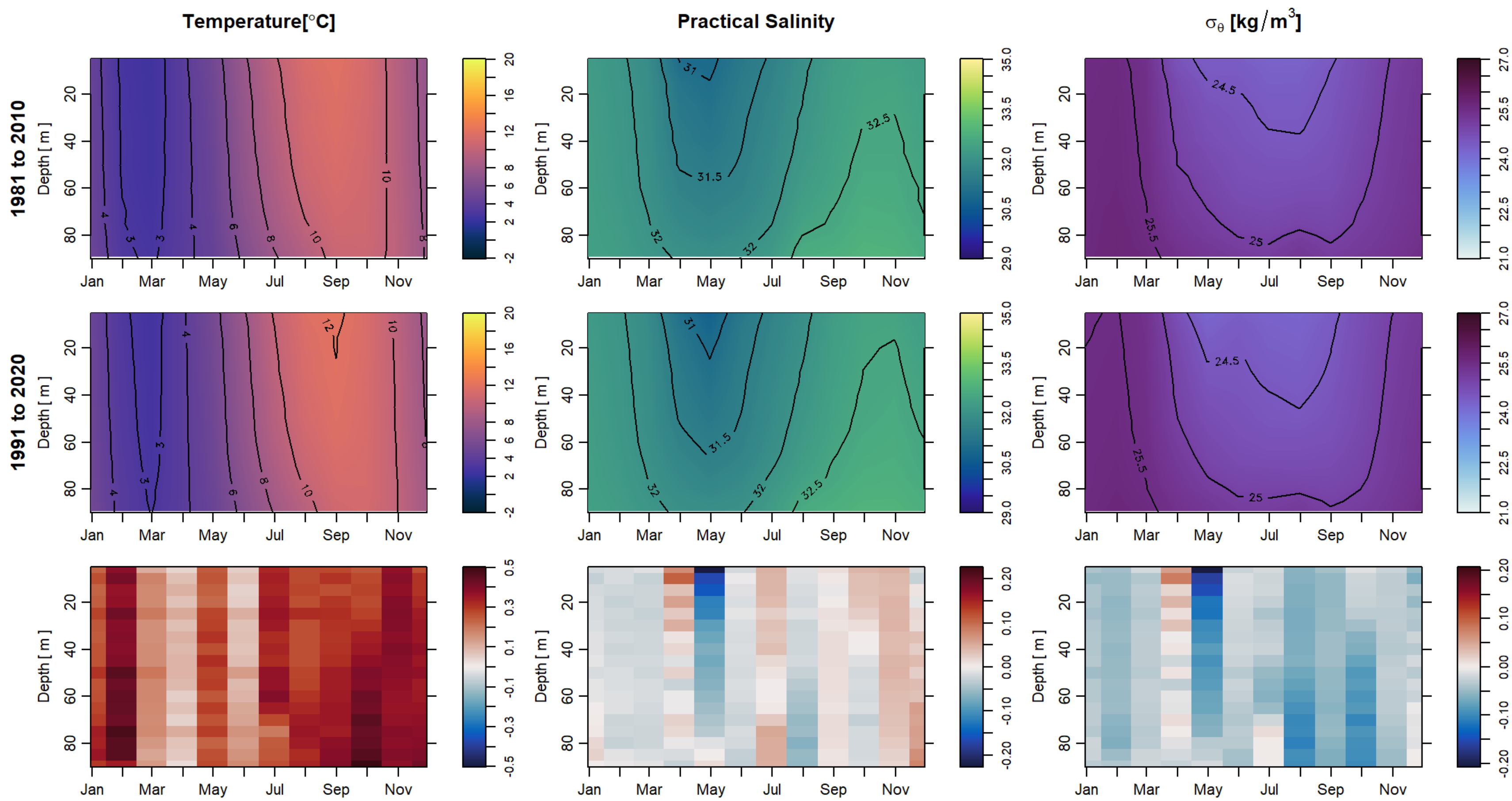

Figure 35. Section plot of the monthly temperature (left column), salinity (middle column), and density (right column) climatology for the 1981 to 2010 reference period (top row) and 1991 to 2020 reference period (middle row). The quantized difference between the reference periods, the 1991 to 2020 minus the 1981 to 2010 reference period, of the monthly climatology (bottom row).

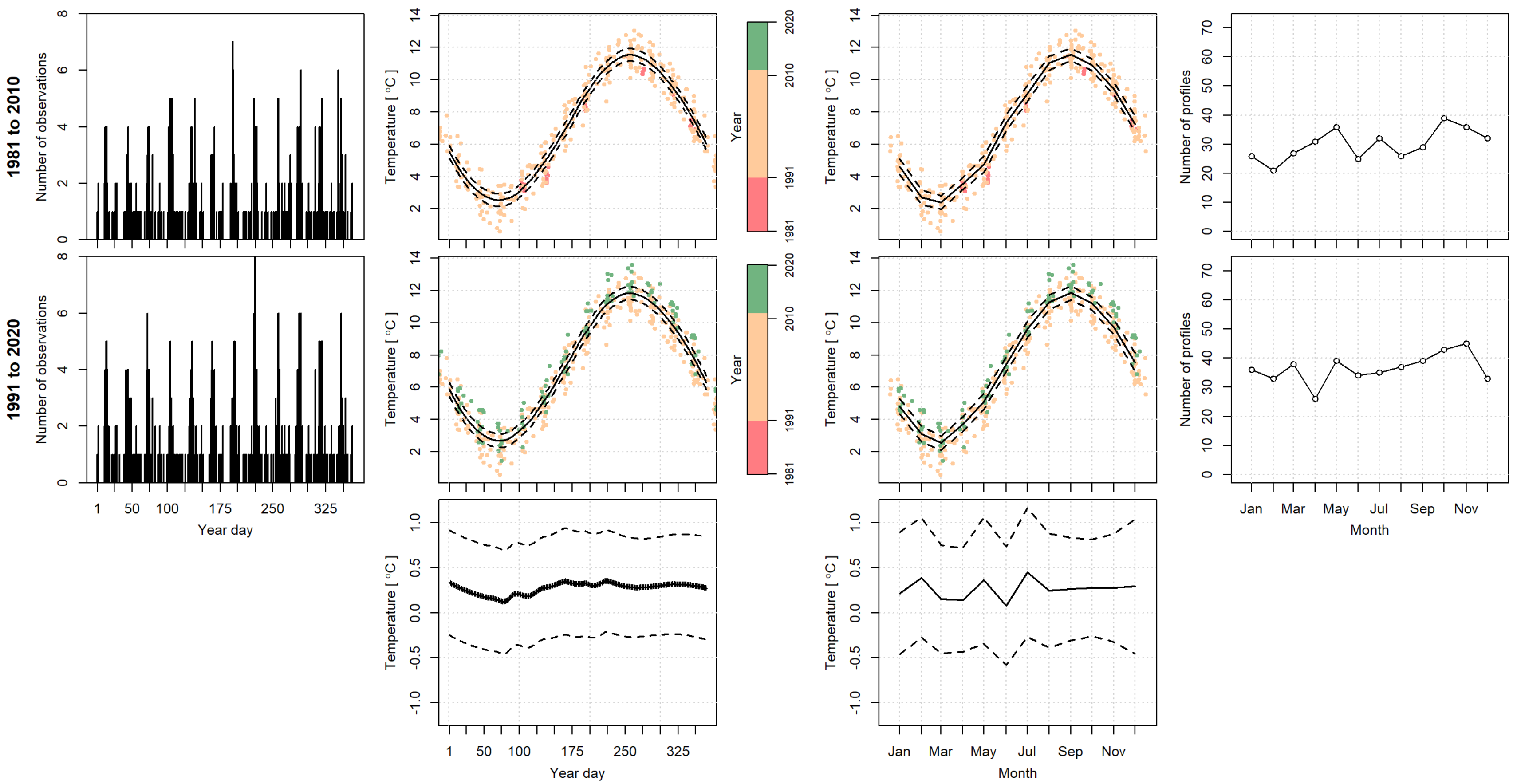

Figure 36. The integrated temperature over depths 5 to 50m, from left to right, the total number of calculated values per year day, the daily mean local polynomial regression fits (thick black line) and ±0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, the monthly mean (thick black line) and ±0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, and the total number of observations per month for the 1981 to 2010 (top row) and 1991 to 2020 (middle row) climatology reference periods. The difference (1991 to 2020 minus the 1981 to 2010) of the climatology reference periods mean (thick black line) and the propagated uncertainty (dashed black lines) for the daily and monthly fits (bottom row).

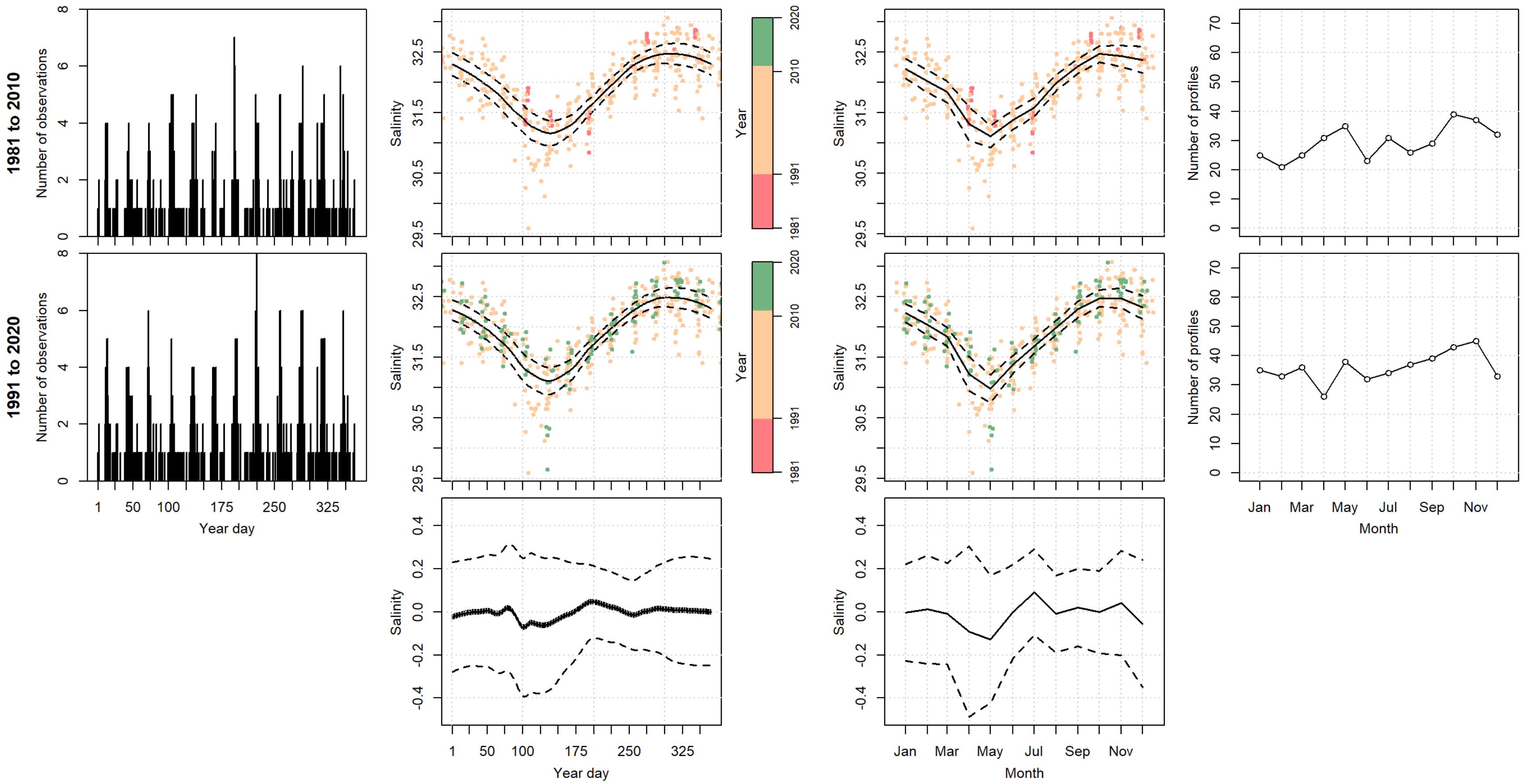

Figure 37. The integrated salinity over depths 5 to 50m, from left to right, the total number of calculated values per year day, the daily mean local polynomial regression fits (thick black line) and ± 0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, the monthly mean (thick black line) and ± 0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, and the total number of observations per month for the 1981 to 2010 (top row) and 1991 to 2020 (middle row) climatology reference periods. The difference (1991 to 2020 minus the 1981 to 2010) of the climatology reference periods mean (thick black line) and the propagated uncertainty (dashed black lines) for the daily and monthly fits (bottom row).

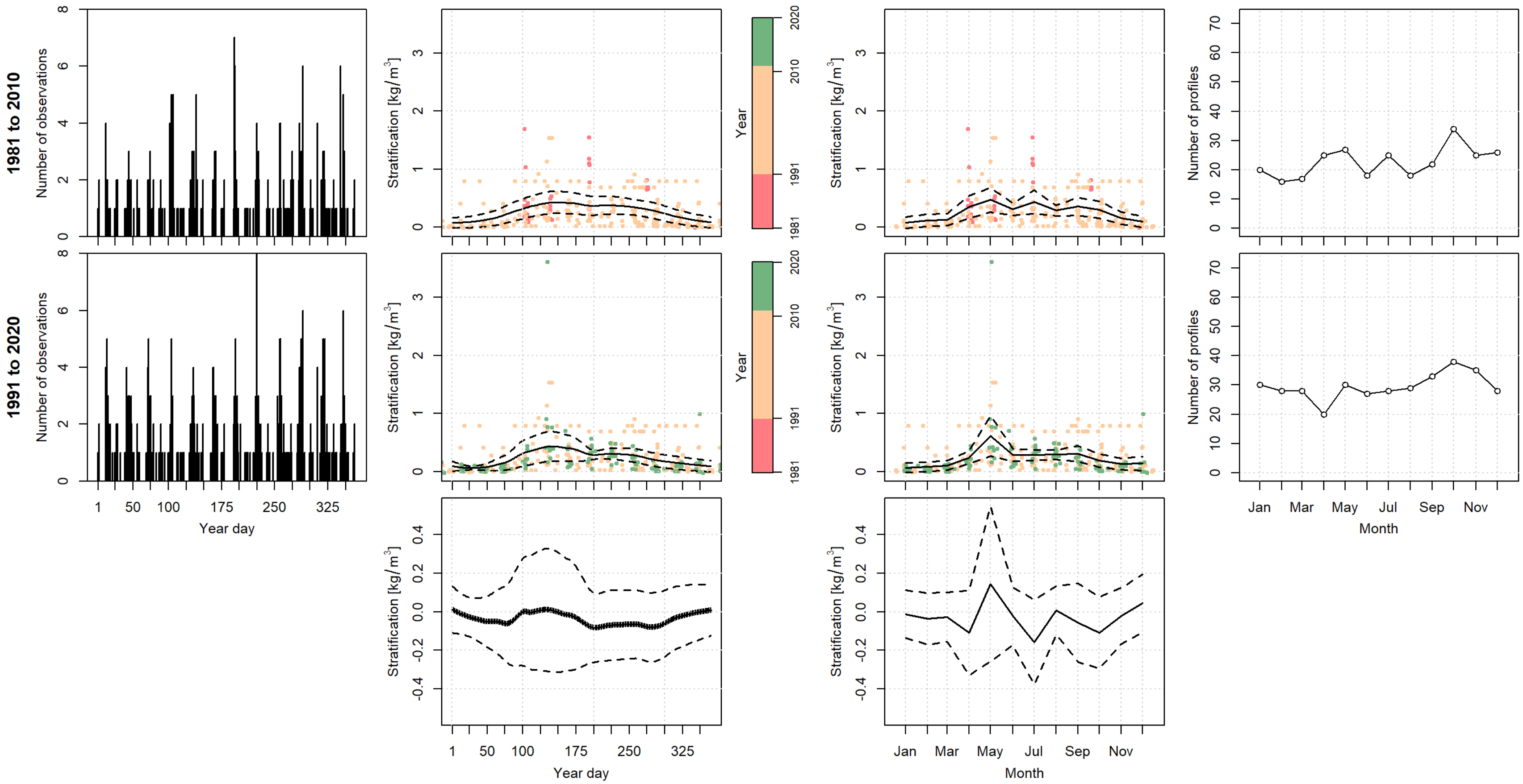

Figure 38. The stratification calculated between depths 5 to 50m, from left to right, the total number of calculated values per year day, the daily mean local polynomial regression fits (thick black line) and ±0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, the monthly mean (thick black line) and ±0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, and the total number of observations per month for the 1981 to 2010 (top row) and 1991 to 2020 (middle row) climatology reference periods. The difference (1991 to 2020 minus the 1981 to 2010) of the climatology reference periods mean (thick black line) and the propagated uncertainty (dashed black lines) for the daily and monthly fits (bottom row).

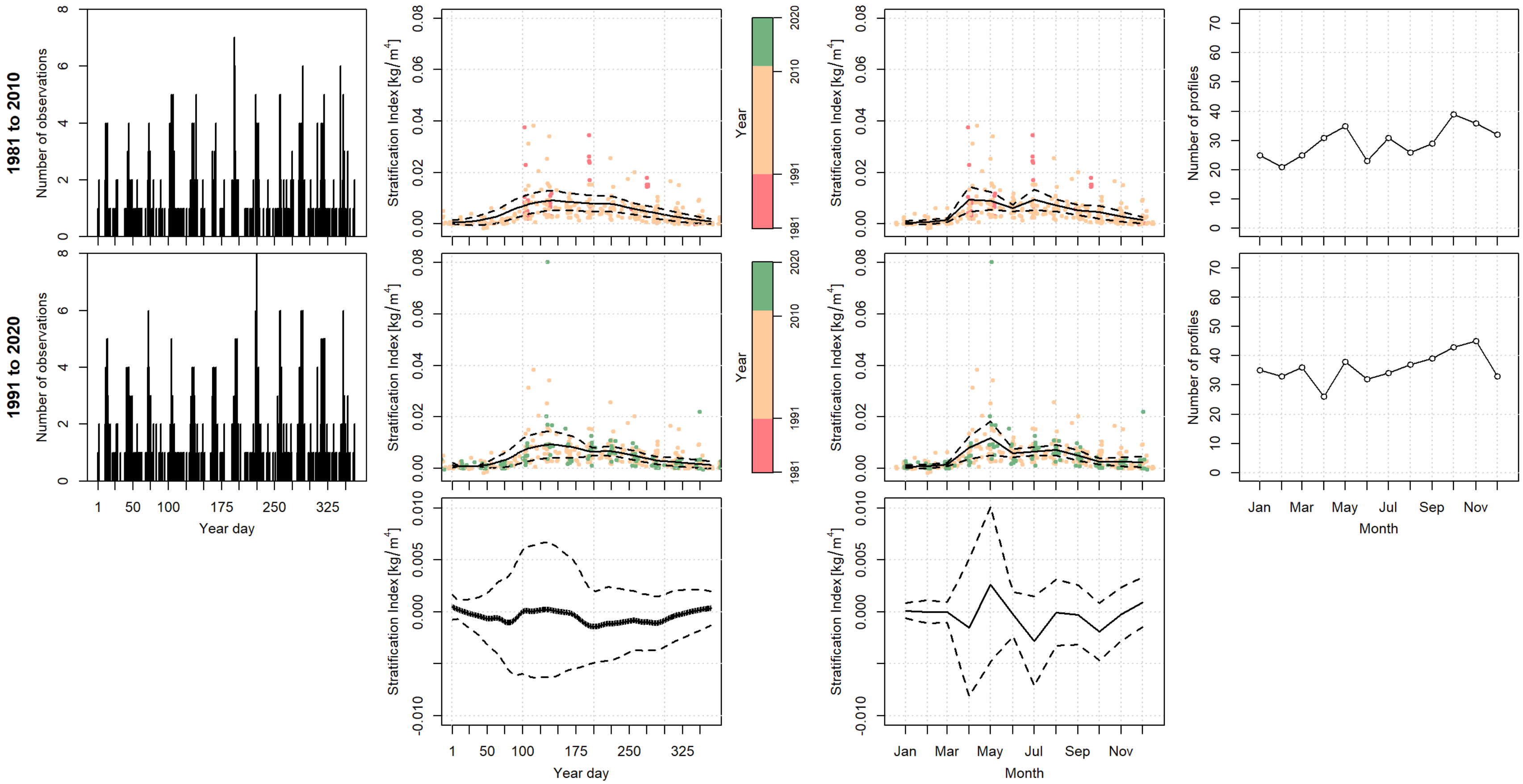

Figure 39. The stratification index calculated between depths 5 to 50m, from left to right, the total number of calculated values per year day, the daily mean local polynomial regression fits (thick black line) and ±0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, the monthly mean (thick black line) and ±0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, and the total number of observations per month for the 1981 to 2010 (top row) and 1991 to 2020 (middle row) climatology reference periods. The difference (1991 to 2020 minus the 1981 to 2010) of the climatology reference periods mean (thick black line) and the propagated uncertainty (dashed black lines) for the daily and monthly fits (bottom row).

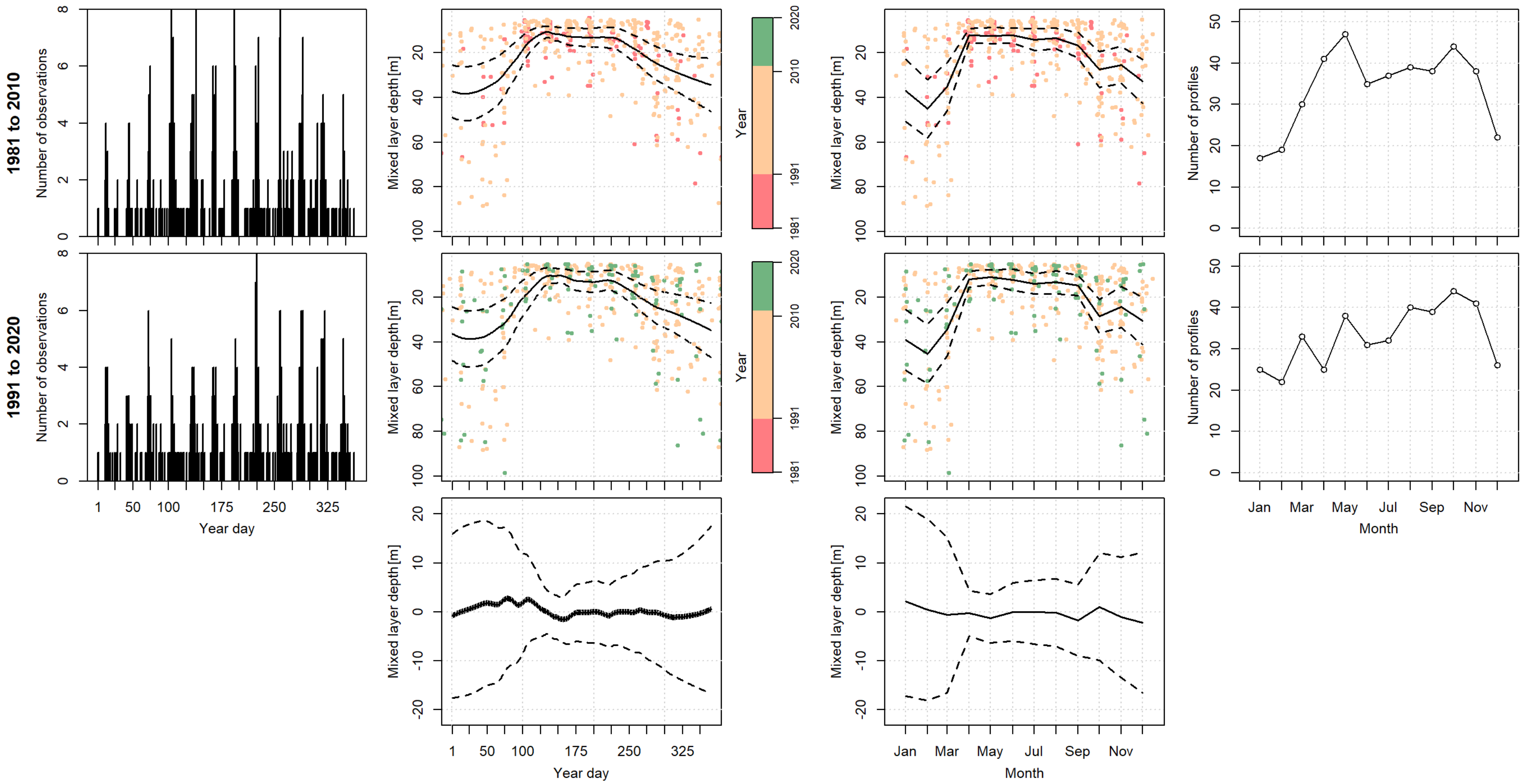

Figure 40. The mixed layer depth, from left to right, total number of calculated values per year day, daily mean local polynomial regression fits (thick black line) and ±0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, monthly mean (thick black line) and ±0.5SD (dashed black lines) with a scatter plot of the calculated values colour coded by year, and total number of observations per month for the 1981 to 2010 (top row) and 1991 to 2020 (middle row) climatology reference periods. The difference (1991 to 2020 minus the 1981 to 2010) of the climatology reference periods mean (thick black line) and the propagated uncertainty (dashed black lines) for the daily and monthly fits (bottom row).