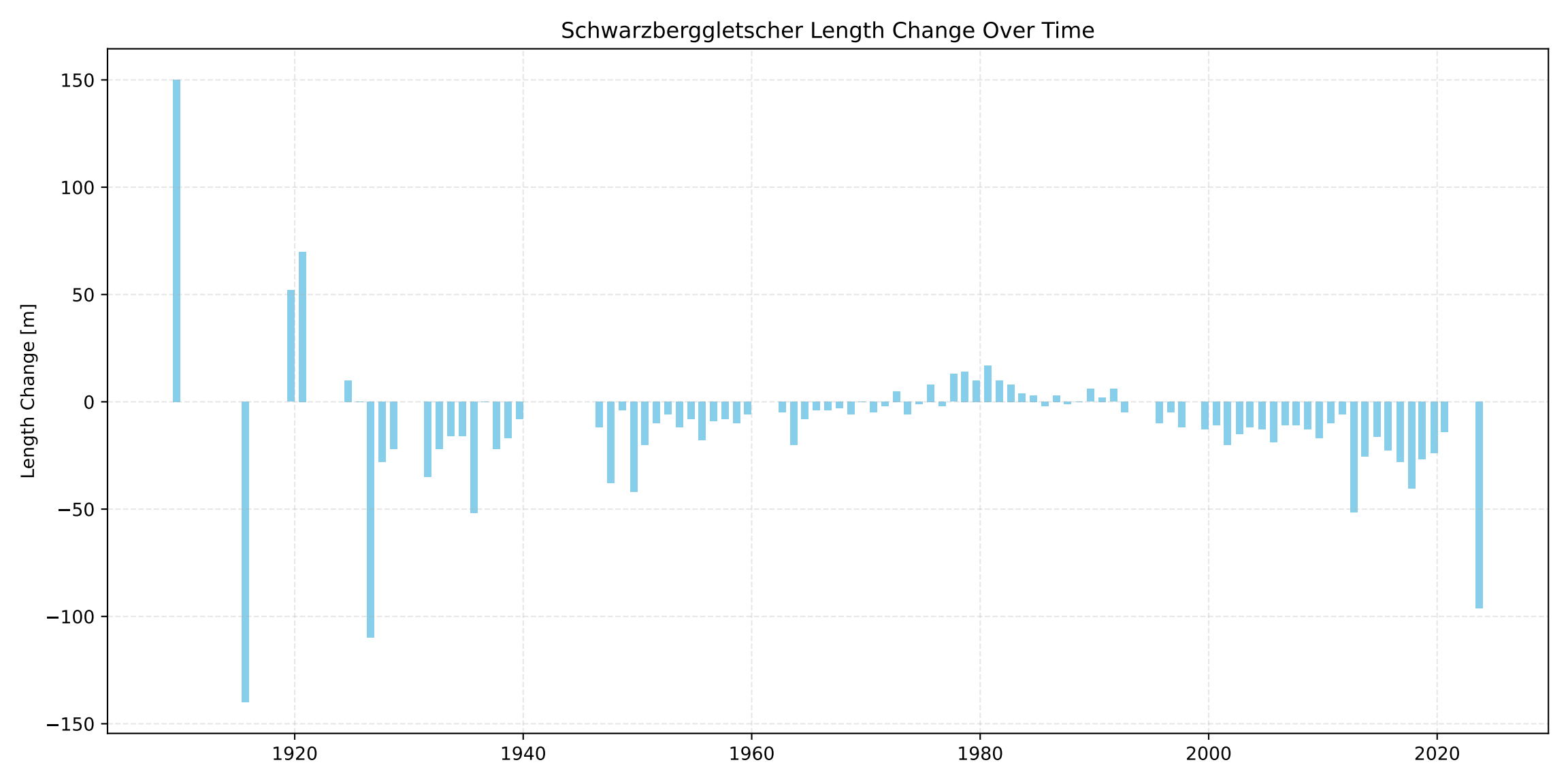
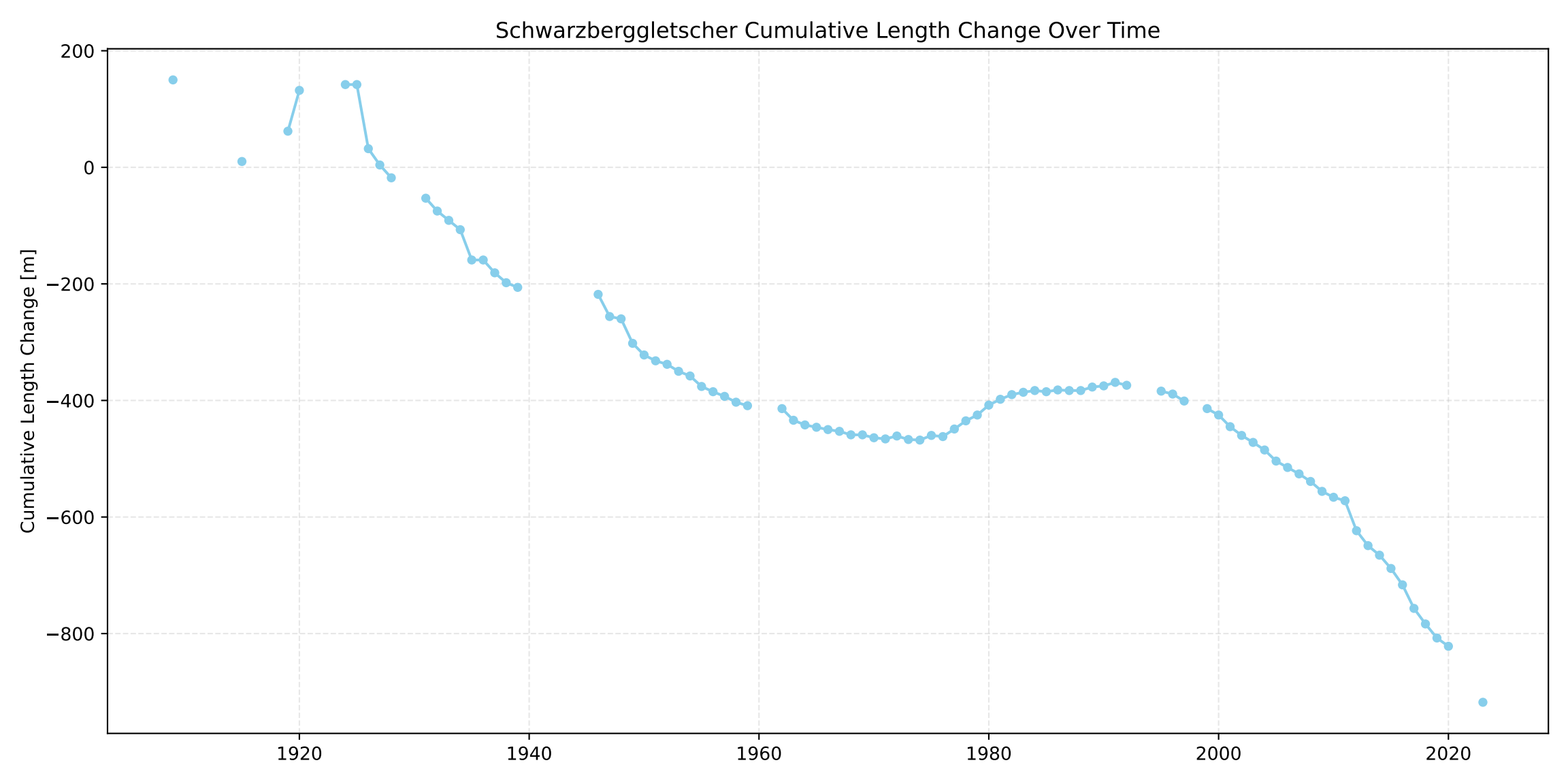
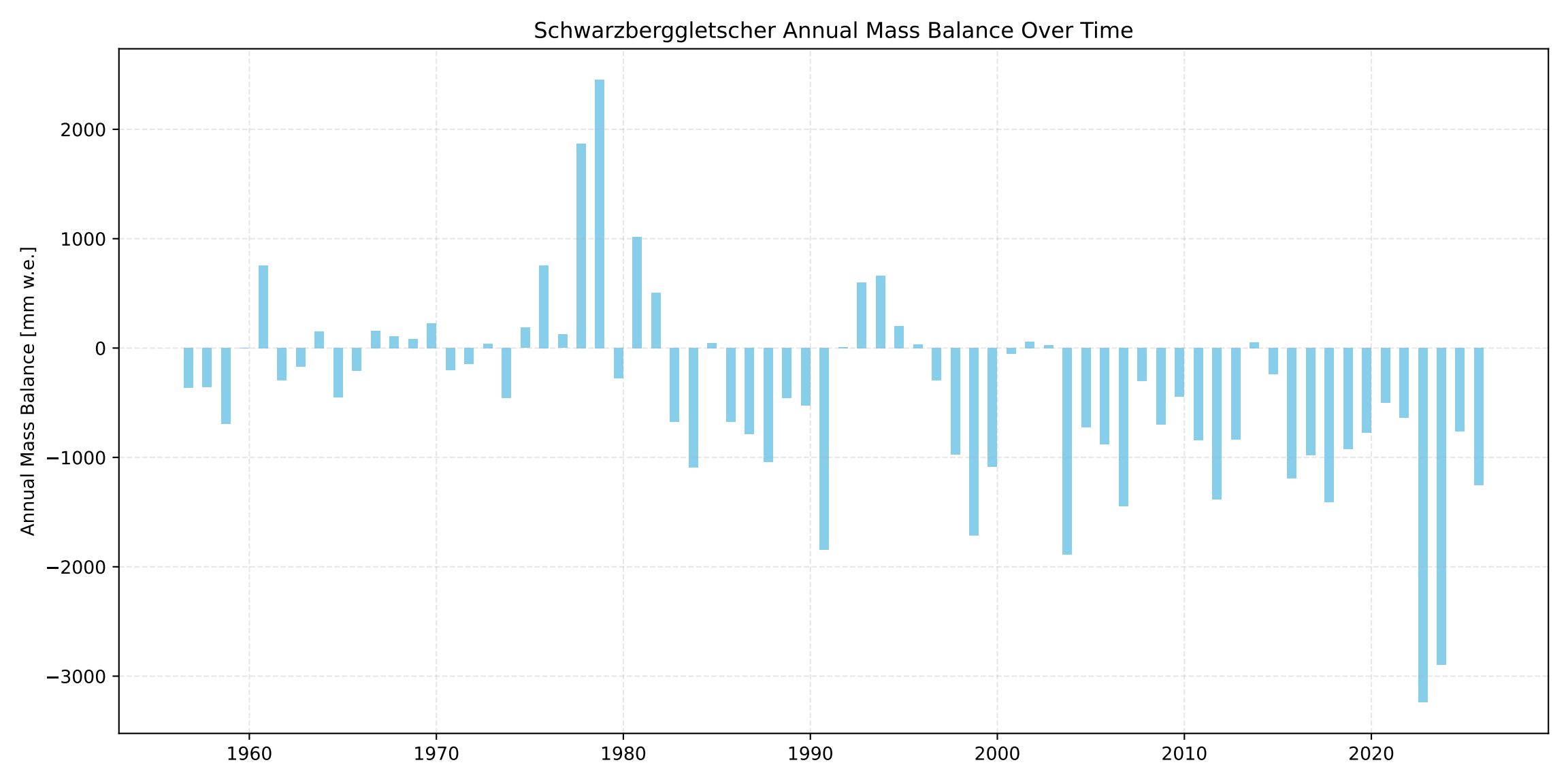
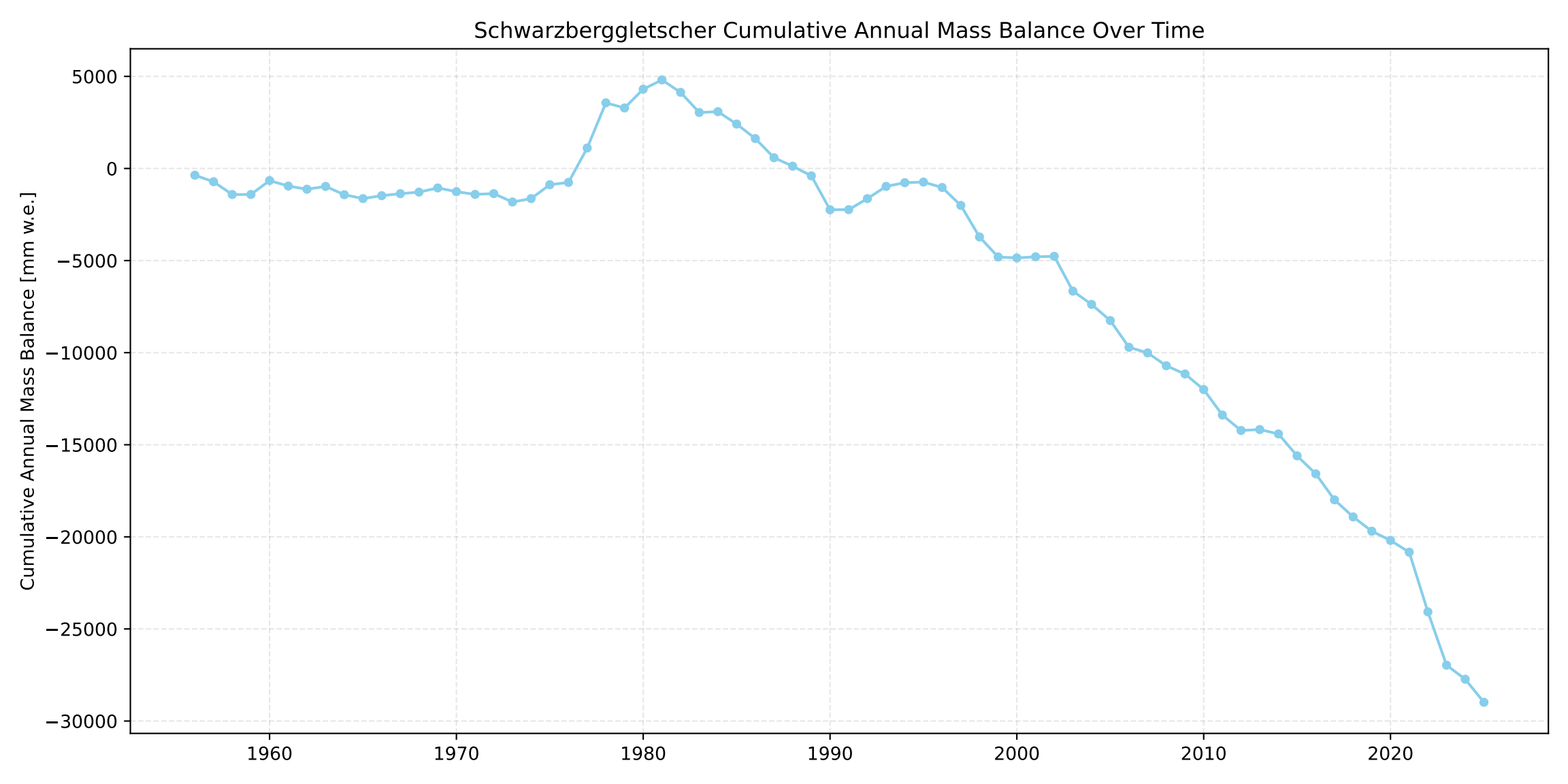
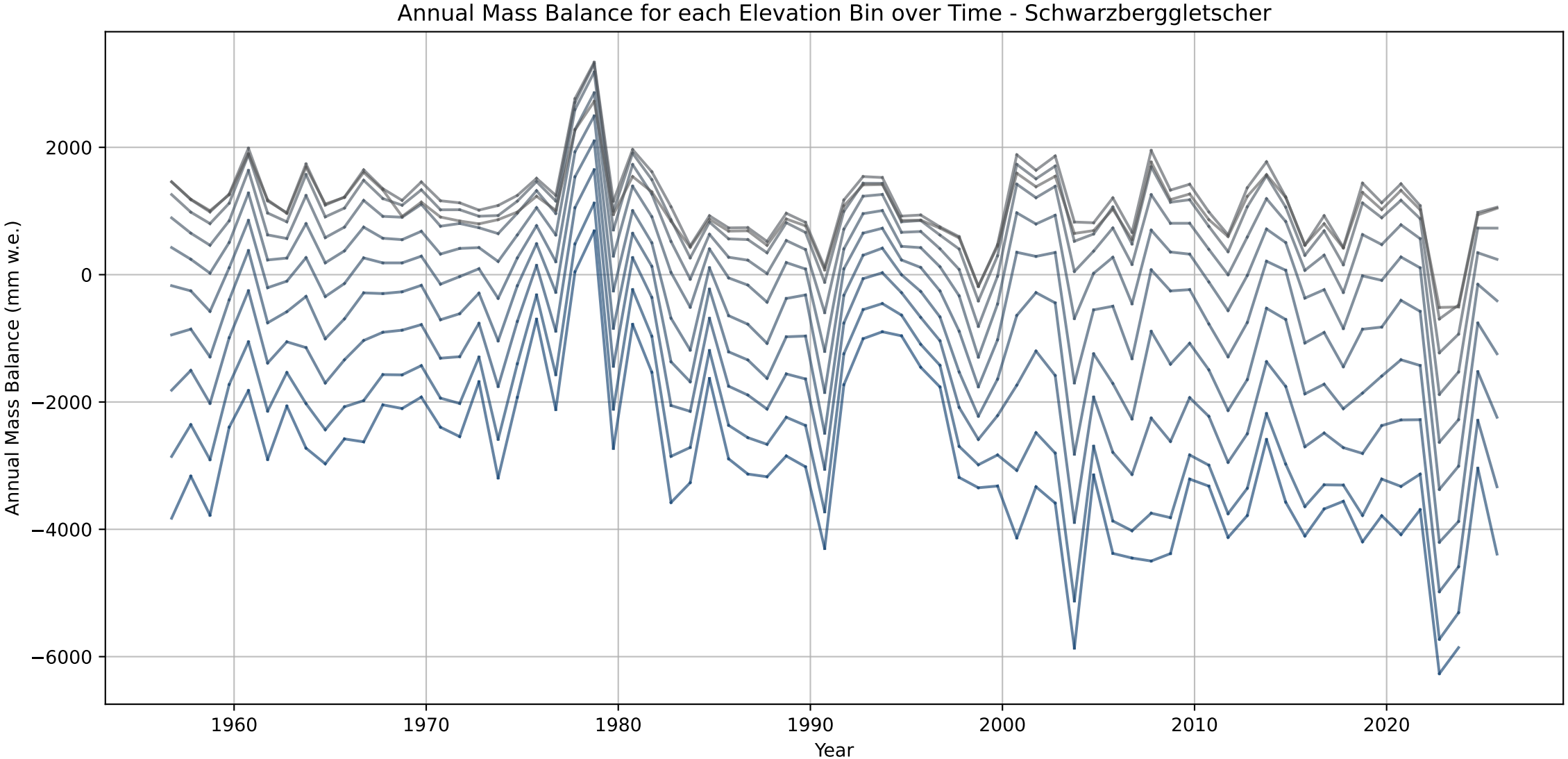
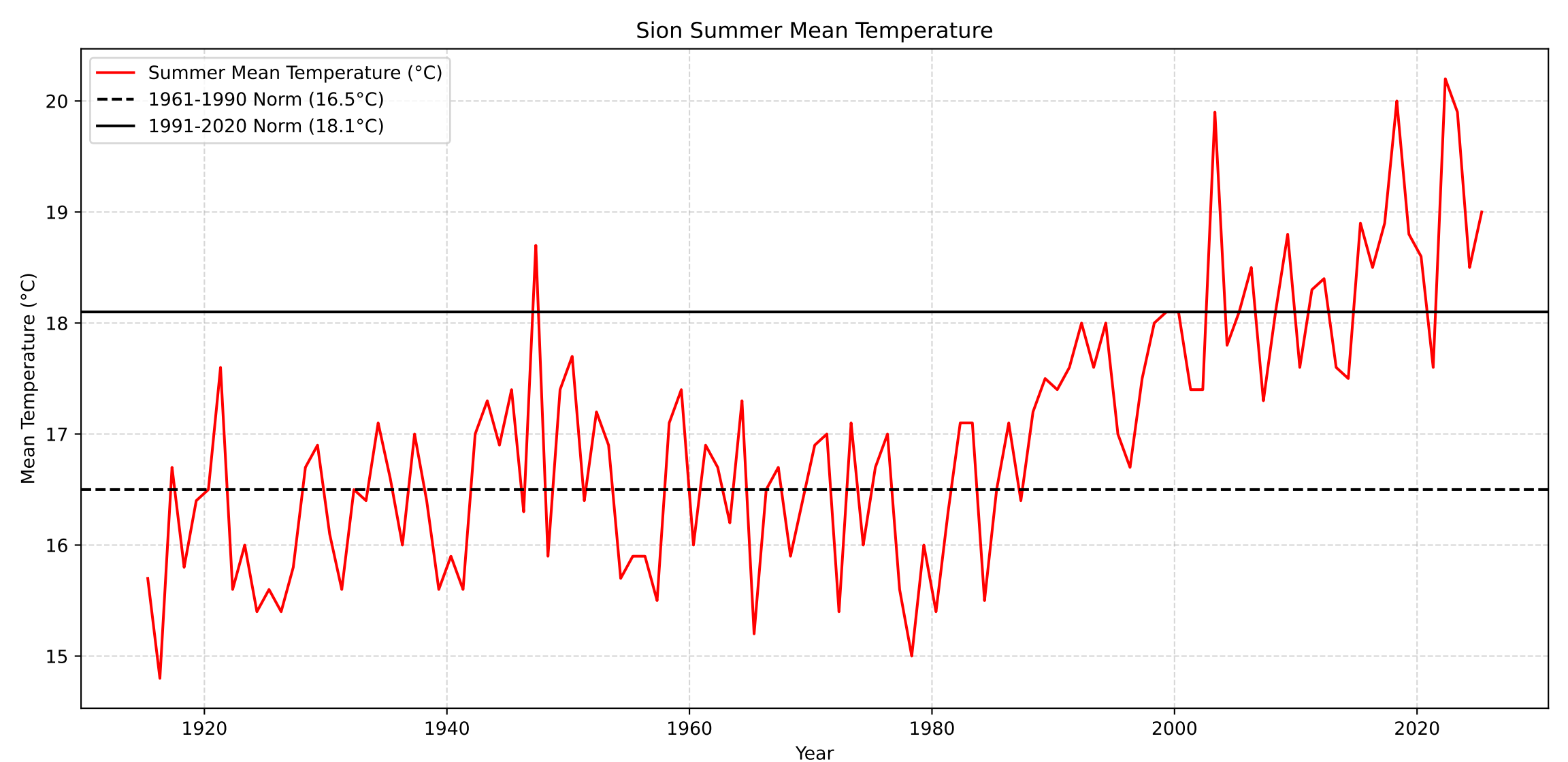

Schwarzberggletscher Length Change Over Time
Length Change [m]
150
100
50
0
−50
−100
−150
1920
1940
1960
1980
2000
2020

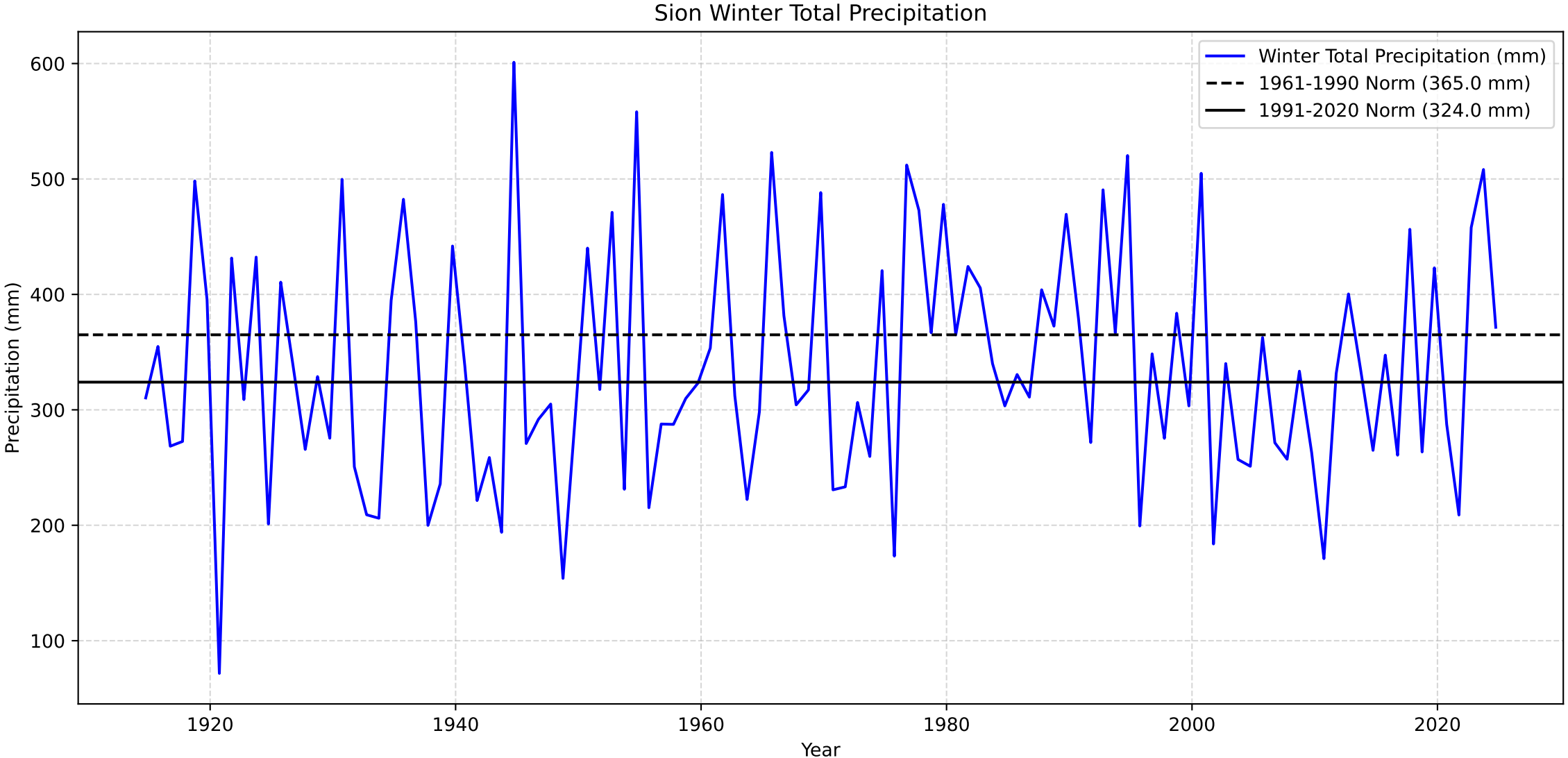

Schwarzberggletscher Cumulative Length Change Over Time
Cumulative Length Change [m]
200
0
−200
−400
−600
−800
1920
1940
1960
1980
2000
2020

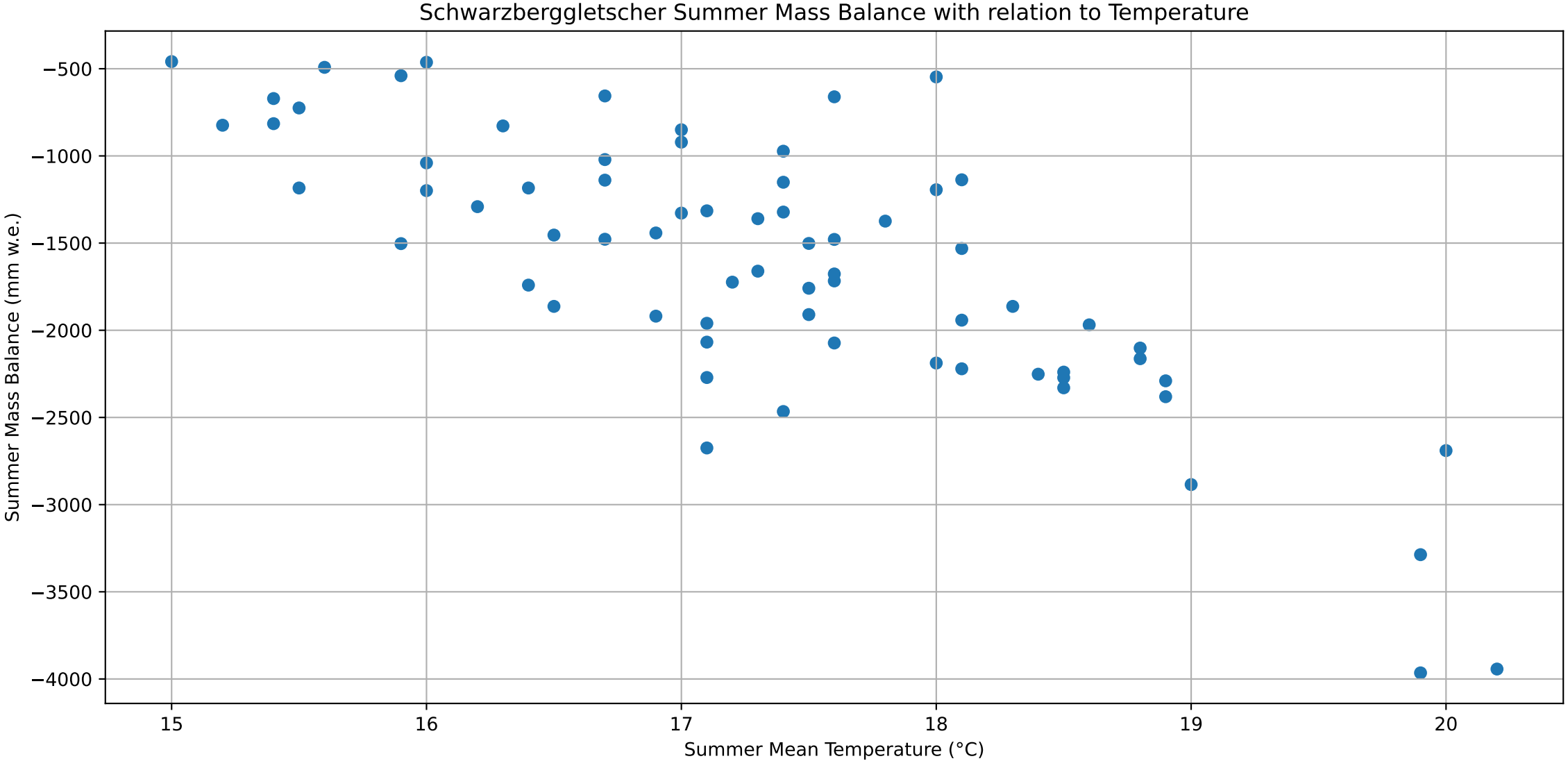

Schwarzberggletscher Annual Mass Balance Over Time
Annual Mass Balance [mm w.e.]
2000
1000
0
−1000
−2000
−3000
1960
1970
1980
1990
2000
2010
2020


Schwarzberggletscher Cumulative Annual Mass Balance Over Time
Cumulative Annual Mass Balance [mm w.e.]
5000
0
−5000
−10000
−15000
−20000
−25000
−30000
1960
1970
1980
1990
2000
2010
2020


Annual Mass Balance for each Elevation Bin over Time - Schwarzberggletscher
Annual Mass Balance (mm w.e.)
2000
0
−2000
−4000
−6000
1960
1970
1980
1990
2000
2010
2020
Year


Sion Summer Mean Temperature
Summer Mean Temperature (°C)
1961-1990 Norm (16.5°C)
1991-2020 Norm (18.1°C)
Mean Temperature (°C)
Year
15
16
17
18
19
20
1920
1940
1960
1980
2000
2020


Sion Winter Total Precipitation
Winter Total Precipitation (mm)
1961-1990 Norm (365.0 mm)
1991-2020 Norm (324.0 mm)
Precipitation (mm)
600
500
400
300
200
100
1920
1940
1960
1980
2000
2020
Year


Schwarzberggletscher Summer Mass Balance with relation to Temperature
Summer Mass Balance (mm w.e.)
−500
−1000
−1500
−2000
−2500
−3000
−3500
−4000
15
16
17
18
19
20
Summer Mean Temperature (°C)

Regression: Monthly 1961-1990

```
================================================================================
MONTHLY DEVIATIONS ANALYSIS USING 1961-1990 CLIMATE NORMS
================================================================================

================================================================================
MONTHLY DEVIATIONS for Schwarzberggletscher (1961-1990 norms)
================================================================================

Correlation Analysis with Significance Testing:
        Variable  Correlation Coefficient       P-value  Significant (p < 0.05)
6     october_pd                 0.136419  2.601277e-01                   False
11      march_pd                 0.125403  3.009506e-01                   False
7    november_pd                 0.122187  3.136170e-01                   False
10   february_pd                 0.101011  4.053910e-01                   False
8    december_pd                 0.070149  5.639044e-01                   False
9     january_pd                 0.060120  6.210324e-01                   False
12      april_pd                -0.053554  6.597125e-01                   False
1         may_td                -0.437913  1.499031e-04                    True
5   september_td                -0.453572  8.035801e-05                    True
4      august_td                -0.517207  4.552076e-06                    True
2        june_td                -0.544123  1.123852e-06                    True
3        july_td                -0.570124  2.579128e-07                    True
0          const                      NaN           NaN                   False

Number of observations: 70

Regression Summary:
                              OLS Regression Results
================================================================================================
Dep. Variable:     annual mass balance (mm w.e.)   R-squared:                       0.582
Model:                                       OLS   Adj. R-squared:                  0.494
Method:                            Least Squares   F-statistic:                     6.623
Date:                           Mon, 08 Dec 2025   Prob (F-statistic):           3.05e-07
Time:                                   12:08:38   Log-Likelihood:                -543.16
No. Observations:                             70   AIC:                             1112.
Df Residuals:                                 57   BIC:                             1142.
Df Model:                                     12
Covariance Type:                       nonrobust
================================================================================
                   coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------
const         1.891e+04   2349.511      8.048      0.000    1.42e+04    2.36e+04
may_td         -93.5242     60.040     -1.558      0.125    -213.752      26.704
june_td        -87.6040     56.599     -1.548      0.127    -200.941      25.733
july_td       -161.3010     60.725     -2.656      0.010    -282.901     -39.701
august_td      -83.2476     71.653     -1.162      0.250    -226.730      60.234
september_td  -141.9432     57.014     -2.490      0.016    -256.111     -27.775
october_pd       2.2736      2.793      0.814      0.419      -3.319       7.866
november_pd      3.1229      2.075      1.505      0.138      -1.033       7.278
december_pd      3.7424      1.734      2.158      0.035       0.269       7.215
january_pd       2.0974      2.111      0.994      0.325      -2.129       6.324
february_pd     -0.6711      1.639     -0.409      0.684      -3.953       2.611
march_pd         1.7394      2.413      0.721      0.474      -3.092       6.571
april_pd         2.0444      3.685      0.555      0.581      -5.335       9.424
==============================================================================
Omnibus:                        0.273   Durbin-Watson:                   1.180
Prob(Omnibus):                  0.872   Jarque-Bera (JB):                0.042
Skew:                          -0.051   Prob(JB):                        0.979
Kurtosis:                       3.063   Cond. No.                     2.44e+03
```

Regression: Optimal 1961-1990

```
================================================================================
OPTIMAL SEASONAL DEVIATIONS ANALYSIS USING 1961-1990 CLIMATE NORMS
================================================================================

================================================================================
OPTIMAL SEASONAL DEVIATIONS for Schwarzberggletscher (1961-1990 norms)
================================================================================

Correlation Analysis with Significance Testing:
        Variable  Correlation Coefficient       P-value  Significant (p < 0.05)
2  opt_season_pd                 0.241944  4.360289e-02                    True
1  opt_season_td                -0.674677  1.514337e-10                    True
0          const                      NaN           NaN                   False

Number of observations: 70

Regression Summary:
                                OLS Regression Results
==============================================================================================
Dep. Variable:     annual mass balance (mm w.e.)   R-squared:                       0.485
Model:                                       OLS   Adj. R-squared:                  0.470
Method:                            Least Squares   F-statistic:                     31.53
Date:                           Mon, 08 Dec 2025   Prob (F-statistic):           2.23e-10
Time:                                   12:08:38   Log-Likelihood:                -550.50
No. Observations:                             70   AIC:                             1107.
Df Residuals:                                 67   BIC:                             1114.
Df Model:                                      2
Covariance Type:                       nonrobust
================================================================================================
                     coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------------------------
const           1.55e+04   2133.173      7.265      0.000    1.12e+04    1.98e+04
opt_season_td  -456.6696     61.325     -7.447      0.000    -579.074    -334.265
opt_season_pd     1.8749      0.954      1.965      0.054      -0.029       3.779
==============================================================================
Omnibus:                        0.826   Durbin-Watson:                   1.161
Prob(Omnibus):                  0.662   Jarque-Bera (JB):                0.297
Skew:                          -0.014   Prob(JB):                        0.862
Kurtosis:                       3.318   Cond. No.                     2.29e+03
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 2.29e+03. This might indicate that there are
strong multicollinearity or other numerical problems.

Coefficient Interpretation:
Intercept (normal mass balance): 15497.06 (p=0.0000)
opt_season_td: -456.67 (p=0.0000)
opt_season_pd: 1.87 (p=0.0535)

Variance Inflation Factors (VIF):
        Variable         VIF
0          const  768.775289
1  opt_season_td    1.011060
2  opt_season_pd    1.011060

R-squared: 0.4849
Adjusted R-squared: 0.4695
```

Regression: Seasonal 1961-1990

```
================================================================================
SUMMER/WINTER SEASONAL DEVIATIONS ANALYSIS USING 1961-1990 CLIMATE NORMS
================================================================================

================================================================================
SUMMER/WINTER SEASONAL DEVIATIONS for Schwarzberggletscher (1961-1990 norms)
================================================================================

Correlation Analysis with Significance Testing:
    Variable  Correlation Coefficient       P-value  Significant (p < 0.05)
2  winter_pd                 0.245330  4.065650e-02                    True
1  summer_td                -0.700628  1.459817e-11                    True
0      const                      NaN           NaN                   False

Number of observations: 70

Regression Summary:
                                OLS Regression Results
==============================================================================================
Dep. Variable:     annual mass balance (mm w.e.)   R-squared:                       0.531
Model:                                       OLS   Adj. R-squared:                  0.517
Method:                            Least Squares   F-statistic:                     37.86
Date:                           Mon, 08 Dec 2025   Prob (F-statistic):           9.98e-12
Time:                                   12:08:38   Log-Likelihood:                -547.25
No. Observations:                             70   AIC:                             1101.
Df Residuals:                                 67   BIC:                             1107.
Df Model:                                      2
Covariance Type:                       nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       1.704e+04   2125.747      8.018      0.000    1.28e+04    2.13e+04
summer_td   -515.0859     62.870     -8.193      0.000    -640.574    -389.598
winter_pd      1.8994      0.798      2.379      0.020       0.306       3.493
==============================================================================
Omnibus:                        0.903   Durbin-Watson:                   1.237
Prob(Omnibus):                  0.637   Jarque-Bera (JB):                0.373
Skew:                          -0.100   Prob(JB):                        0.830
Kurtosis:                       3.297   Cond. No.                     2.76e+03
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 2.76e+03. This might indicate that there are
strong multicollinearity or other numerical problems.

Coefficient Interpretation:
Intercept (normal mass balance): 17044.71 (p=0.0000)
summer_td: -515.09 (p=0.0000)
winter_pd: 1.90 (p=0.0202)

Variance Inflation Factors (VIF):
    Variable         VIF
0      const  837.655805
1  summer_td    1.004453
2  winter_pd    1.004453

R-squared: 0.5305
Adjusted R-squared: 0.5165
```

Regression: Monthly 1991-2020

```
================================================================================
MONTHLY DEVIATIONS ANALYSIS USING 1991-2020 CLIMATE NORMS
================================================================================

================================================================================
MONTHLY DEVIATIONS for Schwarzberggletscher (1991-2020 norms)
================================================================================

Correlation Analysis with Significance Testing:
        Variable  Correlation Coefficient       P-value  Significant (p < 0.05)
6     october_pd                 0.136419  2.601277e-01                   False
11      march_pd                 0.125403  3.009506e-01                   False
7    november_pd                 0.122187  3.136170e-01                   False
10   february_pd                 0.101011  4.053910e-01                   False
8    december_pd                 0.070149  5.639044e-01                   False
9     january_pd                 0.060120  6.210324e-01                   False
12      april_pd                -0.053554  6.597125e-01                   False
1         may_td                -0.437913  1.499031e-04                    True
5   september_td                -0.453572  8.035801e-05                    True
4      august_td                -0.517207  4.552076e-06                    True
2        june_td                -0.544123  1.123852e-06                    True
3        july_td                -0.570124  2.579128e-07                    True
0          const                      NaN           NaN                   False

Number of observations: 70

Regression Summary:
                                OLS Regression Results
================================================================================================
Dep. Variable:     annual mass balance (mm w.e.)   R-squared:                       0.582
Model:                                       OLS   Adj. R-squared:                  0.494
Method:                            Least Squares   F-statistic:                     6.623
Date:                           Mon, 08 Dec 2025   Prob (F-statistic):           3.05e-07
Time:                                   12:08:38   Log-Likelihood:                -543.16
No. Observations:                             70   AIC:                             1112.
Df Residuals:                                 57   BIC:                             1142.
Df Model:                                     12
Covariance Type:                       nonrobust
================================================================================
                   coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------
const         -843.0152     91.842     -9.179      0.000   -1026.926    -659.104
may_td         -93.5242     60.040     -1.558      0.125    -213.752      26.704
june_td        -87.6040     56.599     -1.548      0.127    -200.941      25.733
july_td       -161.3010     60.725     -2.656      0.010    -282.901     -39.701
august_td      -83.2476     71.653     -1.162      0.250    -226.730      60.234
september_td  -141.9432     57.014     -2.490      0.016    -256.111     -27.775
october_pd       2.2736      2.793      0.814      0.419      -3.319       7.866
november_pd      3.1229      2.075      1.505      0.138      -1.033       7.278
december_pd      3.7424      1.734      2.158      0.035       0.269       7.215
january_pd       2.0974      2.111      0.994      0.325      -2.129       6.324
february_pd     -0.6711      1.639     -0.409      0.684      -3.953       2.611
march_pd         1.7394      2.413      0.721      0.474      -3.092       6.571
april_pd         2.0444      3.685      0.555      0.581      -5.335       9.424
==============================================================================
Omnibus:                        0.273   Durbin-Watson:                   1.180
Prob(Omnibus):                  0.872   Jarque-Bera (JB):                0.042
Skew:                          -0.051   Prob(JB):                        0.979
Kurtosis:                       3.063   Cond. No.                         65.8
```

Regression: Optimal 1991-2020

```
================================================================================
OPTIMAL SEASONAL DEVIATIONS ANALYSIS USING 1991-2020 CLIMATE NORMS
================================================================================

================================================================================
OPTIMAL SEASONAL DEVIATIONS for Schwarzberggletscher (1991-2020 norms)
================================================================================

Correlation Analysis with Significance Testing:
        Variable  Correlation Coefficient       P-value  Significant (p < 0.05)
2  opt_season_pd                 0.241944  4.360289e-02                    True
1  opt_season_td                -0.676153  1.334027e-10                    True
0          const                      NaN           NaN                   False

Number of observations: 70

Regression Summary:
                                OLS Regression Results
==============================================================================================
Dep. Variable:     annual mass balance (mm w.e.)   R-squared:                       0.485
Model:                                       OLS   Adj. R-squared:                  0.470
Method:                            Least Squares   F-statistic:                     31.59
Date:                           Mon, 08 Dec 2025   Prob (F-statistic):           2.17e-10
Time:                                   12:08:38   Log-Likelihood:                -550.47
No. Observations:                             70   AIC:                             1107.
Df Residuals:                                 67   BIC:                             1114.
Df Model:                                      2
Covariance Type:                       nonrobust
================================================================================================
                     coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------------------------
const          -822.2518     92.603     -8.879      0.000   -1007.088    -637.415
opt_season_td  -457.0050     61.315     -7.453      0.000    -579.390    -334.620
opt_season_pd     1.8258      0.954      1.913      0.060      -0.079       3.731
==============================================================================
Omnibus:                        0.687   Durbin-Watson:                   1.161
Prob(Omnibus):                  0.709   Jarque-Bera (JB):                0.208
Skew:                          -0.004   Prob(JB):                        0.901
Kurtosis:                       3.267   Cond. No.                         107.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Coefficient Interpretation:
Intercept (normal mass balance): -822.25 (p=0.0000)
opt_season_td: -457.01 (p=0.0000)
opt_season_pd: 1.83 (p=0.0600)

Variance Inflation Factors (VIF):
        Variable       VIF
0          const  1.449949
1  opt_season_td  1.012557
2  opt_season_pd  1.012557

R-squared: 0.4853
Adjusted R-squared: 0.4699
```

Regression: Seasonal 1991-2020

```
================================================================================
SUMMER/WINTER SEASONAL DEVIATIONS ANALYSIS USING 1991-2020 CLIMATE NORMS
================================================================================

================================================================================
SUMMER/WINTER SEASONAL DEVIATIONS for Schwarzberggletscher (1991-2020 norms)
================================================================================

Correlation Analysis with Significance Testing:
    Variable  Correlation Coefficient       P-value  Significant (p < 0.05)
2  winter_pd                 0.245330  4.065650e-02                    True
1  summer_td                -0.702701  1.198032e-11                    True
0      const                      NaN           NaN                   False

Number of observations: 70

Regression Summary:
                                OLS Regression Results
==============================================================================================
Dep. Variable:     annual mass balance (mm w.e.)   R-squared:                       0.534
Model:                                       OLS   Adj. R-squared:                  0.520
Method:                            Least Squares   F-statistic:                     38.40
Date:                           Mon, 08 Dec 2025   Prob (F-statistic):           7.75e-12
Time:                                   12:08:38   Log-Likelihood:                -546.99
No. Observations:                             70   AIC:                             1100.
Df Residuals:                                 67   BIC:                             1107.
Df Model:                                      2
Covariance Type:                       nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       -842.3214     88.023     -9.569      0.000   -1018.016    -666.627
summer_td   -516.2801     62.546     -8.254      0.000    -641.122    -391.439
winter_pd      1.9136      0.795      2.406      0.019       0.326       3.501
==============================================================================
Omnibus:                        1.147   Durbin-Watson:                   1.229
Prob(Omnibus):                  0.564   Jarque-Bera (JB):                0.548
Skew:                          -0.105   Prob(JB):                        0.760
Kurtosis:                       3.379   Cond. No.                         124.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Coefficient Interpretation:
Intercept (normal mass balance): -842.32 (p=0.0000)
summer_td: -516.28 (p=0.0000)
winter_pd: 1.91 (p=0.0189)

Variance Inflation Factors (VIF):
    Variable       VIF
0      const  1.447098
1  summer_td  1.004137
2  winter_pd  1.004137

R-squared: 0.5340
Adjusted R-squared: 0.5201
```