

# PyCAMA report generated by tropl2-proc

tropl2-proc

2023-12-14 (03:18)

## 1 Short Introduction

### 1.1 The list of parameters

You may want to keep the list given in table 1 at hand when viewing the results.

## 2 Definitions

The averages shown here are *unweighed* averages:

$$\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i \quad (1)$$

with  $N$  the number of observations in the dataset.

The spread of the measurements is indicated with the variance  $V(x)$ , or rather the standard deviation  $\sigma(x) = \sqrt{V(x)}$ .

$$V(x) = \frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2 \quad (2)$$

We also report the more robust statistics median, minimum, maximum, various percentiles and inter quartile range.

The median  $m$  is the value of parameter  $x$  for which half of the observations of  $x$  is smaller than  $m$ :

$$P(x \leq m) = P(x \geq m) = \int_{-\infty}^m f(x) dx = \frac{1}{2} \quad (3)$$

with  $f(x)$  the probability density function.

The median is a special case of a percentile. Instead of 1/2 in equation 3, other threshold values can be used. We report results for 1 %, 5 %, 10 %, 15.9 %, 25 %, 75 %, 84.1 %, 90 %, 95 % and 99 %. The inter quartile range is the difference between the 75 % and 25 % percentiles. Similarly the minimum and maximum values correspond to the 0 % and 100 % percentiles respectively.

For normally distributed parameters the mean and median are the same, while the  $\mu \pm \sigma$  values and the 15.9 % and 84.1 % percentiles coincide.

To get a measure for the relation of one variable  $x_{(k)}$  with another  $x_{(l)}$ , we calculate the covariance matrix  $C_{kl}$ .

$$C_{kl} = C(x_{(k)}, x_{(l)}) = \frac{1}{N-1} \sum_{i=1}^N (x_{(k),i} - \bar{x}_{(k)})(x_{(l),i} - \bar{x}_{(l)}) \quad (4)$$

Rather than a dimensionally dependent covariance, it is often easier to interpret a correlation matrix  $R_{kl}$ , a matrix of Pearson's  $r$  coefficients:

$$R_{kl} = R(x_{(k)}, x_{(l)}) = \frac{C_{kl}}{\sqrt{C_{kk}C_{ll}}} = \frac{C_{kl}}{\sqrt{V(x_{(k)})V(x_{(l)})}} \quad (5)$$

The diagonal elements of the covariance matrix are the variances of the elements,  $V(x_{(k)}) = C_{kk}$  and obviously  $R_{kk} = 1$ .

Table 1: Parameterlist and basic statistics for the analysis

| Variable                                                     | mean $\pm \sigma$                  | Count    | Mode                   | IQR                    | Median                 | Minimum                | Maximum                |
|--------------------------------------------------------------|------------------------------------|----------|------------------------|------------------------|------------------------|------------------------|------------------------|
| qa value [1]                                                 | $0.840 \pm 0.205$                  | 24223482 | 0.905                  | 0.200                  | 0.900                  | 0.0                    | 1.000                  |
| ozone total vertical column [mol m <sup>-2</sup> ]           | $0.127 \pm 0.026$                  | 24223482 | 0.112                  | $3.224 \times 10^{-2}$ | 0.127                  | $5.393 \times 10^{-2}$ | 0.243                  |
| ozone total vertical column precision [mol m <sup>-2</sup> ] | $(7.151 \pm 3.307) \times 10^{-4}$ | 24223482 | $5.500 \times 10^{-4}$ | $2.823 \times 10^{-4}$ | $6.552 \times 10^{-4}$ | $2.445 \times 10^{-4}$ | $7.421 \times 10^{-3}$ |
| root mean square slant column fit [1]                        | $(1.227 \pm 0.671) \times 10^{-3}$ | 24223482 | $8.700 \times 10^{-4}$ | $4.182 \times 10^{-4}$ | $1.020 \times 10^{-3}$ | $3.930 \times 10^{-4}$ | 0.270                  |
| ozone effective temperature [K]                              | $232 \pm 6$                        | 24223482 | 231                    | 6.09                   | 232                    | 39.8                   | 409                    |
| ozone ghost column [mol m <sup>-2</sup> ]                    | $(1.334 \pm 1.922) \times 10^{-3}$ | 24223482 | $5.000 \times 10^{-5}$ | $1.774 \times 10^{-3}$ | $5.188 \times 10^{-4}$ | 0.0                    | $5.323 \times 10^{-2}$ |
| number of iterations vertical column [1]                     | $3.69 \pm 0.68$                    | 24223482 | 4.05                   | 1.000                  | 4.00                   | 1.000                  | 6.00                   |

| Table 2: Percentile ranges                                   |                        |                        |                        |                        |                        |                        |                        |                        |                        |                        |
|--------------------------------------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Variable                                                     | 1 %                    | 5 %                    | 10 %                   | 15.9 %                 | 25 %                   | 75 %                   | 84.1 %                 | 90 %                   | 95 %                   | 99 %                   |
| qa value [1]                                                 | 0.130                  | 0.360                  | 0.600                  | 0.620                  | 0.800                  | 1.000                  | 1.000                  | 1.000                  | 1.000                  | 1.000                  |
| ozone total vertical column [mol m <sup>-2</sup> ]           | $7.410 \times 10^{-2}$ | $8.132 \times 10^{-2}$ | $8.802 \times 10^{-2}$ | 0.103                  | 0.112                  | 0.144                  | 0.151                  | 0.157                  | 0.169                  | 0.194                  |
| ozone total vertical column precision [mol m <sup>-2</sup> ] | $3.764 \times 10^{-4}$ | $4.262 \times 10^{-4}$ | $4.551 \times 10^{-4}$ | $4.817 \times 10^{-4}$ | $5.219 \times 10^{-4}$ | $8.042 \times 10^{-4}$ | $8.597 \times 10^{-4}$ | $9.573 \times 10^{-4}$ | $1.196 \times 10^{-3}$ | $2.146 \times 10^{-3}$ |
| root mean square slant column fit [1]                        | $6.513 \times 10^{-4}$ | $7.343 \times 10^{-4}$ | $7.822 \times 10^{-4}$ | $8.223 \times 10^{-4}$ | $8.743 \times 10^{-4}$ | $1.292 \times 10^{-3}$ | $1.538 \times 10^{-3}$ | $1.886 \times 10^{-3}$ | $2.526 \times 10^{-3}$ | $4.141 \times 10^{-3}$ |
| ozone effective temperature [K]                              | 211                    | 221                    | 225                    | 227                    | 229                    | 235                    | 238                    | 239                    | 241                    | 243                    |
| ozone ghost column [mol m <sup>-2</sup> ]                    | 0.0                    | 0.0                    | 0.0                    | 0.0                    | $3.890 \times 10^{-7}$ | $1.775 \times 10^{-3}$ | $2.935 \times 10^{-3}$ | $4.109 \times 10^{-3}$ | $5.627 \times 10^{-3}$ | $8.355 \times 10^{-3}$ |
| number of iterations vertical column [1]                     | 2.00                   | 3.00                   | 3.00                   | 3.00                   | 3.00                   | 4.00                   | 4.00                   | 5.00                   | 5.00                   | 5.00                   |

Table 3: Parameterlist and basic statistics for the analysis for observations in the northern hemisphere

| Variable                                                     | mean $\pm \sigma$                  | Count   | IQR                    | Median                 | Minimum                | Maximum                | 25 % percentile        | 75 % percentile        |
|--------------------------------------------------------------|------------------------------------|---------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| qa value [1]                                                 | $0.852 \pm 0.216$                  | 9301744 | 0.140                  | 0.900                  | 0.0                    | 1.000                  | 0.860                  | 1.000                  |
| ozone total vertical column [mol m <sup>-2</sup> ]           | $0.134 \pm 0.025$                  | 9301744 | $3.309 \times 10^{-2}$ | 0.127                  | $8.161 \times 10^{-2}$ | 0.230                  | 0.114                  | 0.148                  |
| ozone total vertical column precision [mol m <sup>-2</sup> ] | $(8.514 \pm 4.281) \times 10^{-4}$ | 9301744 | $2.745 \times 10^{-4}$ | $7.642 \times 10^{-4}$ | $2.784 \times 10^{-4}$ | $7.421 \times 10^{-3}$ | $6.295 \times 10^{-4}$ | $9.040 \times 10^{-4}$ |
| root mean square slant column fit [1]                        | $(1.354 \pm 0.790) \times 10^{-3}$ | 9301744 | $5.882 \times 10^{-4}$ | $1.090 \times 10^{-3}$ | $3.930 \times 10^{-4}$ | $9.961 \times 10^{-2}$ | $8.982 \times 10^{-4}$ | $1.486 \times 10^{-3}$ |
| ozone effective temperature [K]                              | $227 \pm 6$                        | 9301744 | 6.35                   | 229                    | 78.9                   | 362                    | 225                    | 231                    |
| ozone ghost column [mol m <sup>-2</sup> ]                    | $(1.897 \pm 2.388) \times 10^{-3}$ | 9301744 | $2.850 \times 10^{-3}$ | $8.486 \times 10^{-4}$ | 0.0                    | $1.547 \times 10^{-2}$ | $7.184 \times 10^{-5}$ | $2.922 \times 10^{-3}$ |
| number of iterations vertical column [1]                     | $3.73 \pm 0.71$                    | 9301744 | 1.000                  | 4.00                   | 1.000                  | 6.00                   | 3.00                   | 4.00                   |



Table 4: Parameterlist and basic statistics for the analysis for observations in the southern hemisphere

| Variable                                                     | mean $\pm \sigma$                   | Count    | IQR                    | Median                 | Minimum                | Maximum                | 25 % percentile        | 75 % percentile        |
|--------------------------------------------------------------|-------------------------------------|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| qa value [1]                                                 | $0.832 \pm 0.198$                   | 14921738 | 0.270                  | 0.900                  | 0.0                    | 1.000                  | 0.730                  | 1.000                  |
| ozone total vertical column [mol m <sup>-2</sup> ]           | $0.122 \pm 0.026$                   | 14921738 | $4.184 \times 10^{-2}$ | 0.126                  | $5.393 \times 10^{-2}$ | 0.243                  | 0.101                  | 0.143                  |
| ozone total vertical column precision [mol m <sup>-2</sup> ] | $(6.302 \pm 2.110) \times 10^{-4}$  | 14921738 | $2.395 \times 10^{-4}$ | $5.914 \times 10^{-4}$ | $2.445 \times 10^{-4}$ | $4.551 \times 10^{-3}$ | $4.895 \times 10^{-4}$ | $7.290 \times 10^{-4}$ |
| root mean square slant column fit [1]                        | $(1.148 \pm 0.569) \times 10^{-3}$  | 14921738 | $3.341 \times 10^{-4}$ | $9.911 \times 10^{-4}$ | $4.023 \times 10^{-4}$ | 0.270                  | $8.630 \times 10^{-4}$ | $1.197 \times 10^{-3}$ |
| ozone effective temperature [K]                              | $234 \pm 4$                         | 14921738 | 6.68                   | 234                    | 39.8                   | 409                    | 231                    | 238                    |
| ozone ghost column [mol m <sup>-2</sup> ]                    | $(9.826 \pm 14.573) \times 10^{-4}$ | 14921738 | $1.283 \times 10^{-3}$ | $3.903 \times 10^{-4}$ | 0.0                    | $5.323 \times 10^{-2}$ | $1.650 \times 10^{-7}$ | $1.283 \times 10^{-3}$ |
| number of iterations vertical column [1]                     | $3.67 \pm 0.67$                     | 14921738 | 1.000                  | 4.00                   | 1.000                  | 6.00                   | 3.00                   | 4.00                   |

Table 5: Parameterlist and basic statistics for the analysis for observations over water

| Variable                                                     | mean $\pm \sigma$                  | Count    | IQR                    | Median                 | Minimum                | Maximum                | 25 % percentile        | 75 % percentile        |
|--------------------------------------------------------------|------------------------------------|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| qa value [1]                                                 | $0.887 \pm 0.170$                  | 15182571 | 0.1000                 | 0.900                  | 0.0                    | 1.000                  | 0.900                  | 1.000                  |
| ozone total vertical column [mol m <sup>-2</sup> ]           | $0.132 \pm 0.021$                  | 15182571 | $3.074 \times 10^{-2}$ | 0.131                  | $6.383 \times 10^{-2}$ | 0.243                  | 0.115                  | 0.146                  |
| ozone total vertical column precision [mol m <sup>-2</sup> ] | $(6.963 \pm 2.565) \times 10^{-4}$ | 15182571 | $2.384 \times 10^{-4}$ | $6.601 \times 10^{-4}$ | $2.784 \times 10^{-4}$ | $7.421 \times 10^{-3}$ | $5.478 \times 10^{-4}$ | $7.862 \times 10^{-4}$ |
| root mean square slant column fit [1]                        | $(1.098 \pm 0.565) \times 10^{-3}$ | 15182571 | $2.796 \times 10^{-4}$ | $9.477 \times 10^{-4}$ | $3.930 \times 10^{-4}$ | 0.270                  | $8.390 \times 10^{-4}$ | $1.119 \times 10^{-3}$ |
| ozone effective temperature [K]                              | $232 \pm 4$                        | 15182571 | 4.12                   | 231                    | 66.3                   | 352                    | 230                    | 234                    |
| ozone ghost column [mol m <sup>-2</sup> ]                    | $(1.492 \pm 1.984) \times 10^{-3}$ | 15182571 | $1.865 \times 10^{-3}$ | $6.848 \times 10^{-4}$ | 0.0                    | $5.323 \times 10^{-2}$ | $1.446 \times 10^{-4}$ | $2.010 \times 10^{-3}$ |
| number of iterations vertical column [1]                     | $3.54 \pm 0.64$                    | 15182571 | 1.000                  | 3.00                   | 1.000                  | 6.00                   | 3.00                   | 4.00                   |

Table 6: Parameterlist and basic statistics for the analysis for observations over land

| Variable                                                     | mean $\pm \sigma$                   | Count   | IQR                    | Median                 | Minimum                | Maximum                | 25 % percentile        | 75 % percentile        |
|--------------------------------------------------------------|-------------------------------------|---------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| qa value [1]                                                 | $0.768 \pm 0.218$                   | 7672532 | 0.300                  | 0.870                  | 0.0                    | 1.000                  | 0.600                  | 0.900                  |
| ozone total vertical column [mol m <sup>-2</sup> ]           | $0.114 \pm 0.029$                   | 7672532 | $4.735 \times 10^{-2}$ | 0.114                  | $5.393 \times 10^{-2}$ | 0.229                  | $8.623 \times 10^{-2}$ | 0.134                  |
| ozone total vertical column precision [mol m <sup>-2</sup> ] | $(6.954 \pm 3.616) \times 10^{-4}$  | 7672532 | $3.435 \times 10^{-4}$ | $5.948 \times 10^{-4}$ | $2.445 \times 10^{-4}$ | $6.890 \times 10^{-3}$ | $4.724 \times 10^{-4}$ | $8.159 \times 10^{-4}$ |
| root mean square slant column fit [1]                        | $(1.379 \pm 0.682) \times 10^{-3}$  | 7672532 | $5.032 \times 10^{-4}$ | $1.183 \times 10^{-3}$ | $4.295 \times 10^{-4}$ | 0.132                  | $9.922 \times 10^{-4}$ | $1.495 \times 10^{-3}$ |
| ozone effective temperature [K]                              | $233 \pm 7$                         | 7672532 | 10.2                   | 234                    | 39.8                   | 409                    | 229                    | 239                    |
| ozone ghost column [mol m <sup>-2</sup> ]                    | $(8.787 \pm 16.248) \times 10^{-4}$ | 7672532 | $9.954 \times 10^{-4}$ | $6.836 \times 10^{-5}$ | 0.0                    | $1.670 \times 10^{-2}$ | 0.0                    | $9.954 \times 10^{-4}$ |
| number of iterations vertical column [1]                     | $3.95 \pm 0.66$                     | 7672532 | 0.0                    | 4.00                   | 1.000                  | 6.00                   | 4.00                   | 4.00                   |

Table 7: Correlation matrix

| Viewing zenith angle    | Solar zenith angle      | Latitude               | O <sub>3</sub> vertical column | O <sub>3</sub> vertical column precision | Effective temperature   | O <sub>3</sub> ghost column |
|-------------------------|-------------------------|------------------------|--------------------------------|------------------------------------------|-------------------------|-----------------------------|
| 1.000                   | $1.701 \times 10^{-3}$  | $2.337 \times 10^{-4}$ | $1.261 \times 10^{-2}$         | -0.124                                   | $-2.459 \times 10^{-2}$ | 0.126                       |
| $1.701 \times 10^{-3}$  | 1.000                   | $6.323 \times 10^{-2}$ | $-2.121 \times 10^{-2}$        | 0.332                                    | $-8.322 \times 10^{-2}$ | 0.110                       |
| $2.337 \times 10^{-4}$  | $6.323 \times 10^{-2}$  | 1.000                  | 0.440                          | 0.435                                    | -0.773                  | 0.293                       |
| $1.261 \times 10^{-2}$  | $-2.121 \times 10^{-2}$ | 0.440                  | 1.000                          | 0.413                                    | -0.421                  | 0.235                       |
| -0.124                  | 0.332                   | 0.435                  | 0.413                          | 1.000                                    | -0.489                  | 0.103                       |
| $-2.459 \times 10^{-2}$ | $-8.322 \times 10^{-2}$ | -0.773                 | -0.421                         | -0.489                                   | 1.000                   | -0.271                      |
| 0.126                   | 0.110                   | 0.293                  | 0.235                          | 0.103                                    | -0.271                  | 1.000                       |

Table 8: Covariance matrix

| Viewing zenith angle    | Solar zenith angle      | Latitude               | O <sub>3</sub> vertical column | O <sub>3</sub> vertical column precision | Effective temperature   | O <sub>3</sub> ghost column |
|-------------------------|-------------------------|------------------------|--------------------------------|------------------------------------------|-------------------------|-----------------------------|
| 384                     | 0.655                   | 0.214                  | $6.416 \times 10^{-3}$         | $-8.069 \times 10^{-4}$                  | -2.91                   | $4.757 \times 10^{-3}$      |
| 0.655                   | 385                     | 57.9                   | $-1.081 \times 10^{-2}$        | $2.154 \times 10^{-3}$                   | -9.88                   | $4.153 \times 10^{-3}$      |
| 0.214                   | 57.9                    | $2.173 \times 10^3$    | 0.532                          | $6.699 \times 10^{-3}$                   | -218                    | $2.623 \times 10^{-2}$      |
| $6.416 \times 10^{-3}$  | $-1.081 \times 10^{-2}$ | 0.532                  | $6.735 \times 10^{-4}$         | $3.542 \times 10^{-6}$                   | $-6.598 \times 10^{-2}$ | $1.171 \times 10^{-5}$      |
| $-8.069 \times 10^{-4}$ | $2.154 \times 10^{-3}$  | $6.699 \times 10^{-3}$ | $3.542 \times 10^{-6}$         | $1.094 \times 10^{-7}$                   | $-9.783 \times 10^{-4}$ | $6.530 \times 10^{-8}$      |
| -2.91                   | -9.88                   | -218                   | $-6.598 \times 10^{-2}$        | $-9.783 \times 10^{-4}$                  | 36.5                    | $-3.151 \times 10^{-3}$     |
| $4.757 \times 10^{-3}$  | $4.153 \times 10^{-3}$  | $2.623 \times 10^{-2}$ | $1.171 \times 10^{-5}$         | $6.530 \times 10^{-8}$                   | $-3.151 \times 10^{-3}$ | $3.695 \times 10^{-6}$      |

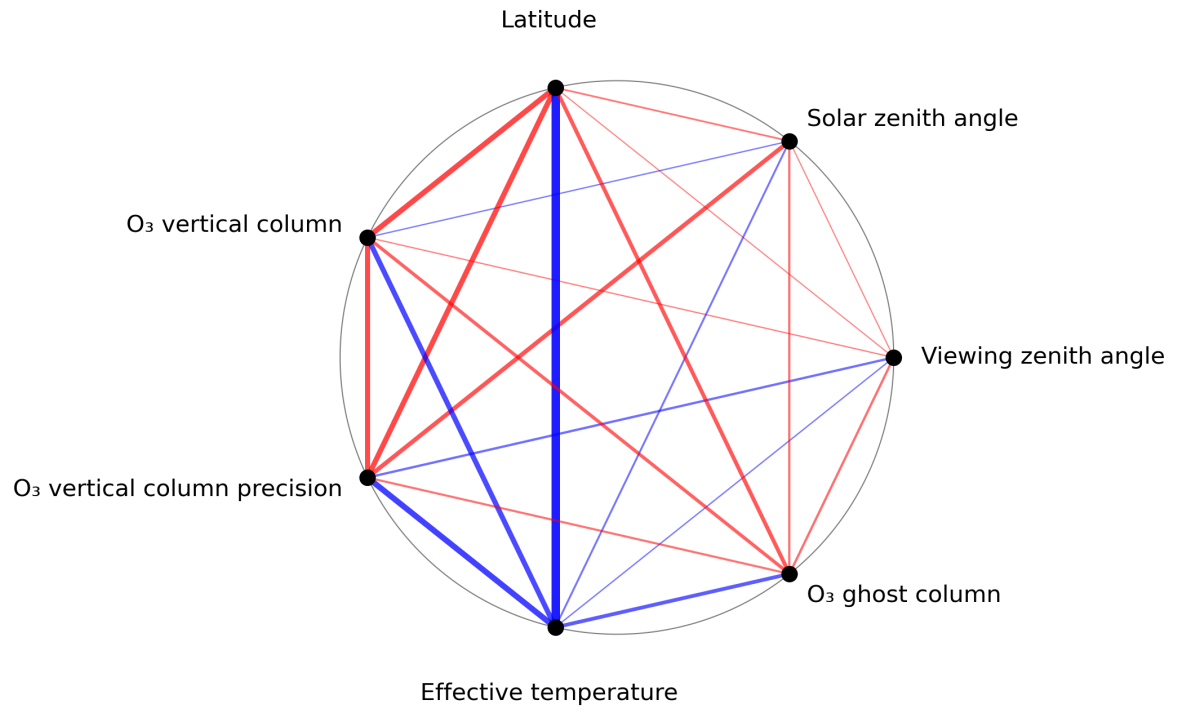


Figure 1: Map of correlation graph for 2023-11-28 to 2023-11-30.

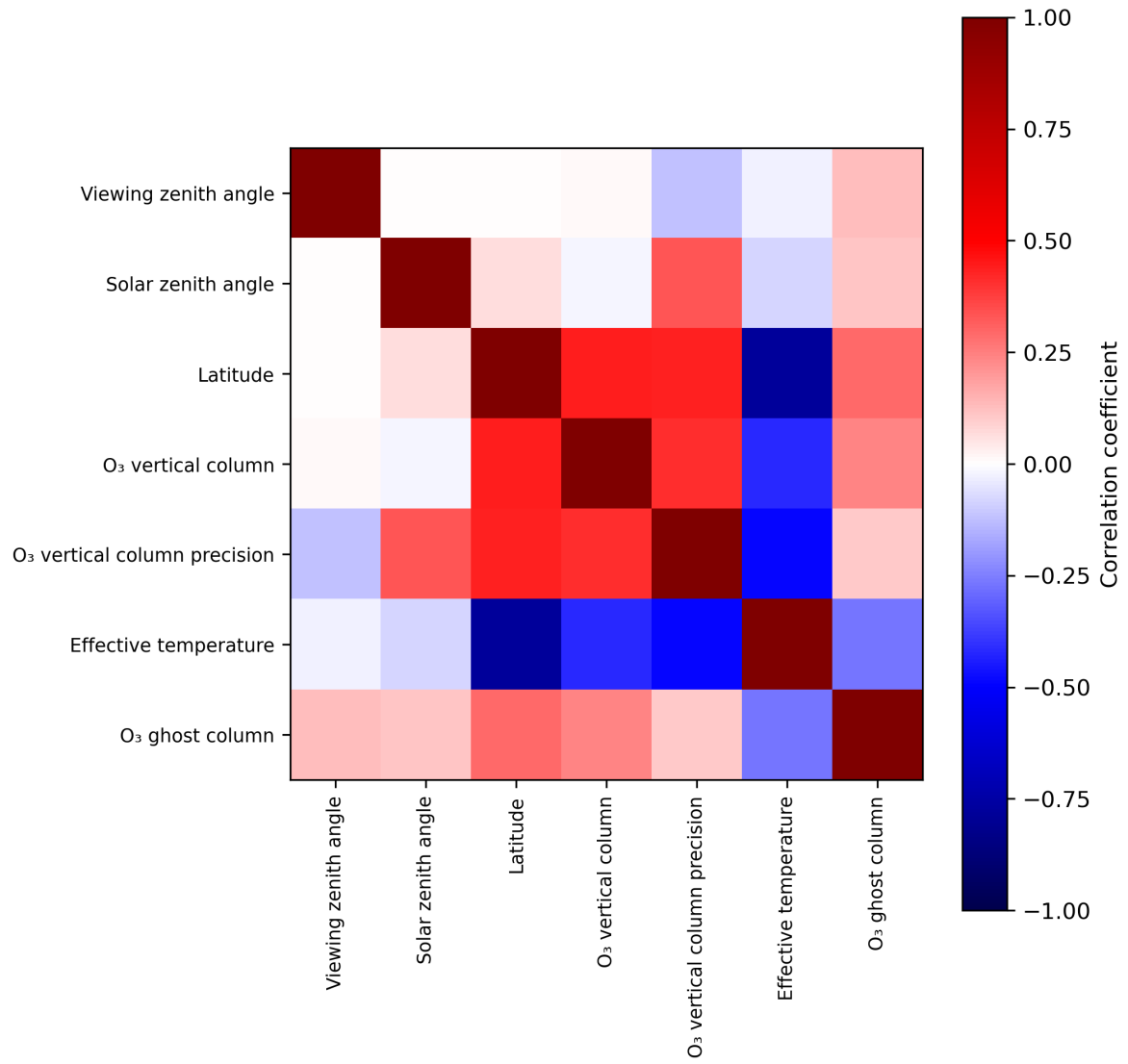


Figure 2: Map of correlation matrix for 2023-11-28 to 2023-11-30.

### 3 Granule outlines

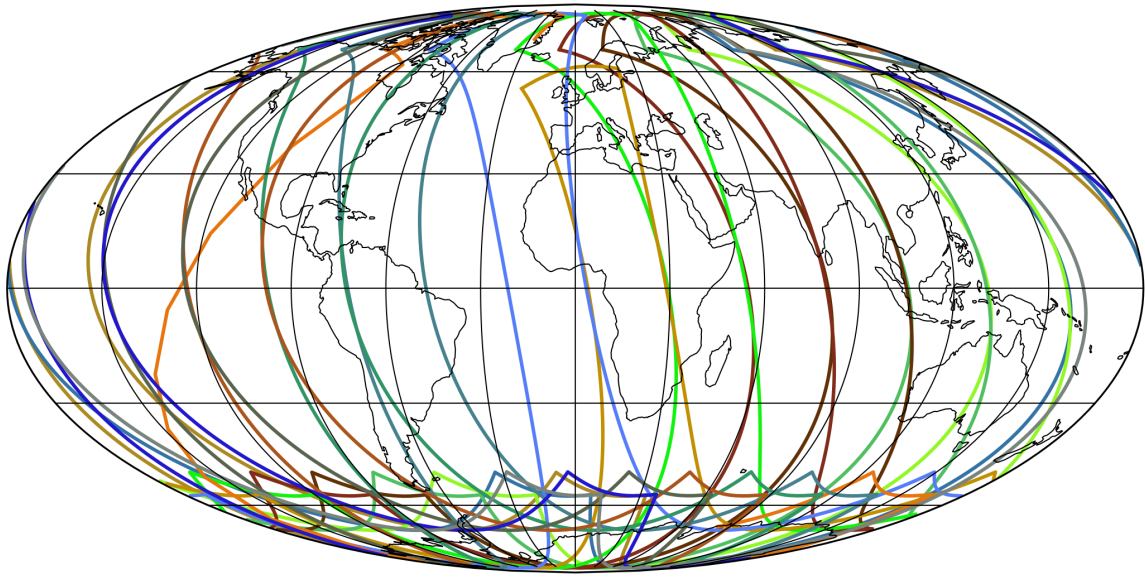


Figure 3: Outline of the granules.



## 4 Input data monitoring

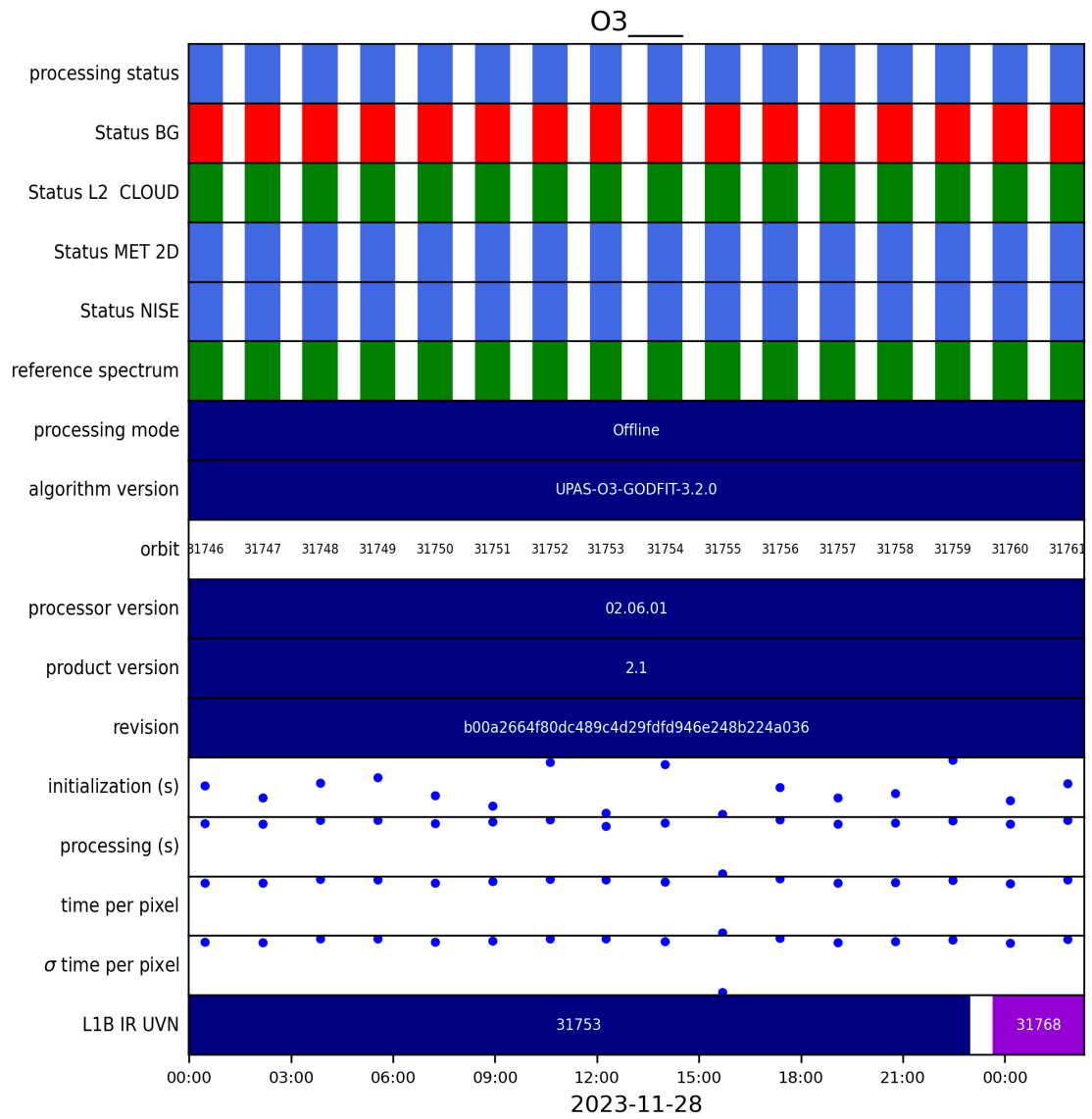


Figure 4: Input data per granule

## 5 Warnings and errors

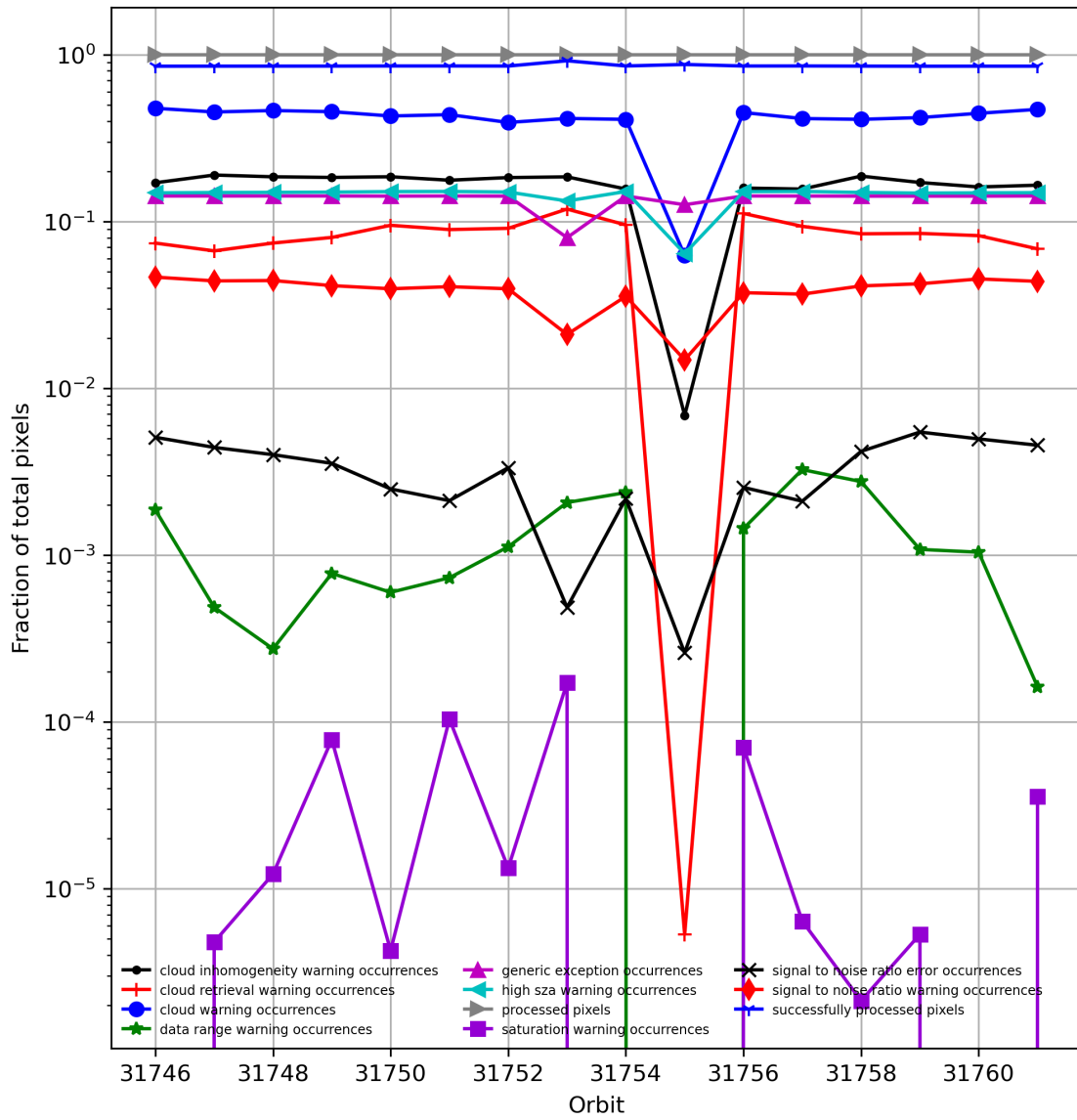


Figure 5: Fraction of pixels with specific warnings and errors during processing

## 6 World maps

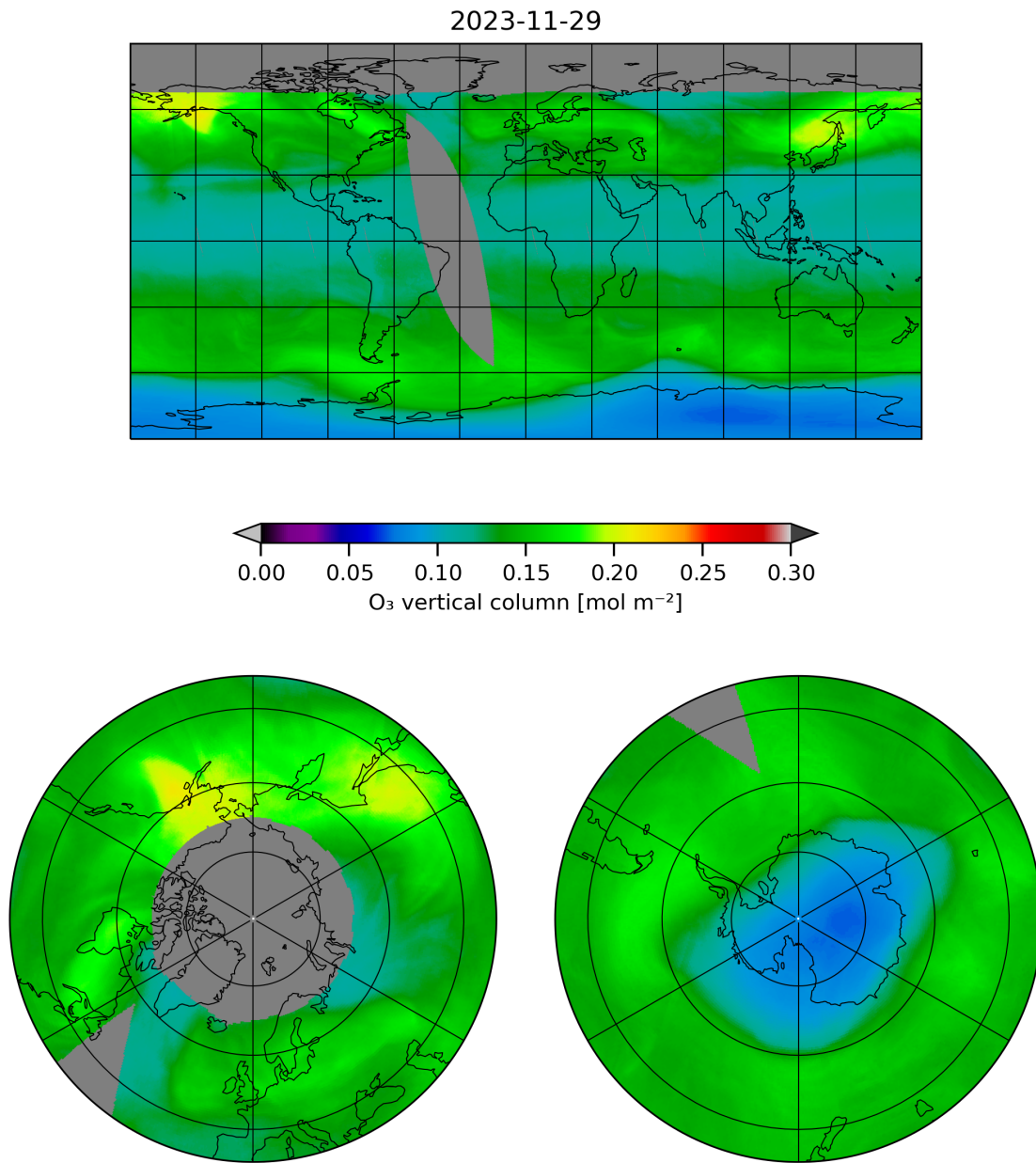


Figure 6: Map of “O<sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30

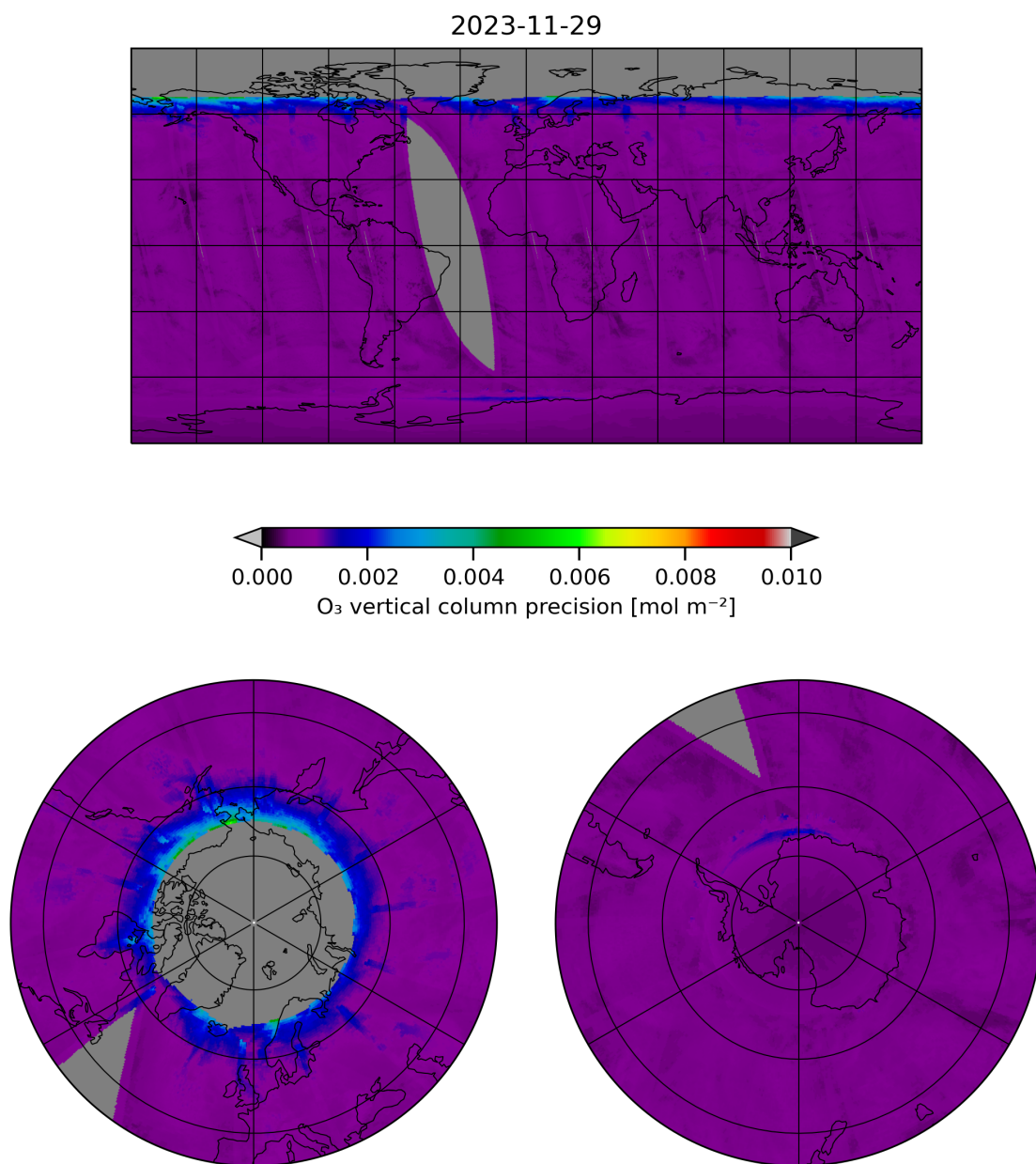


Figure 7: Map of “O<sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30

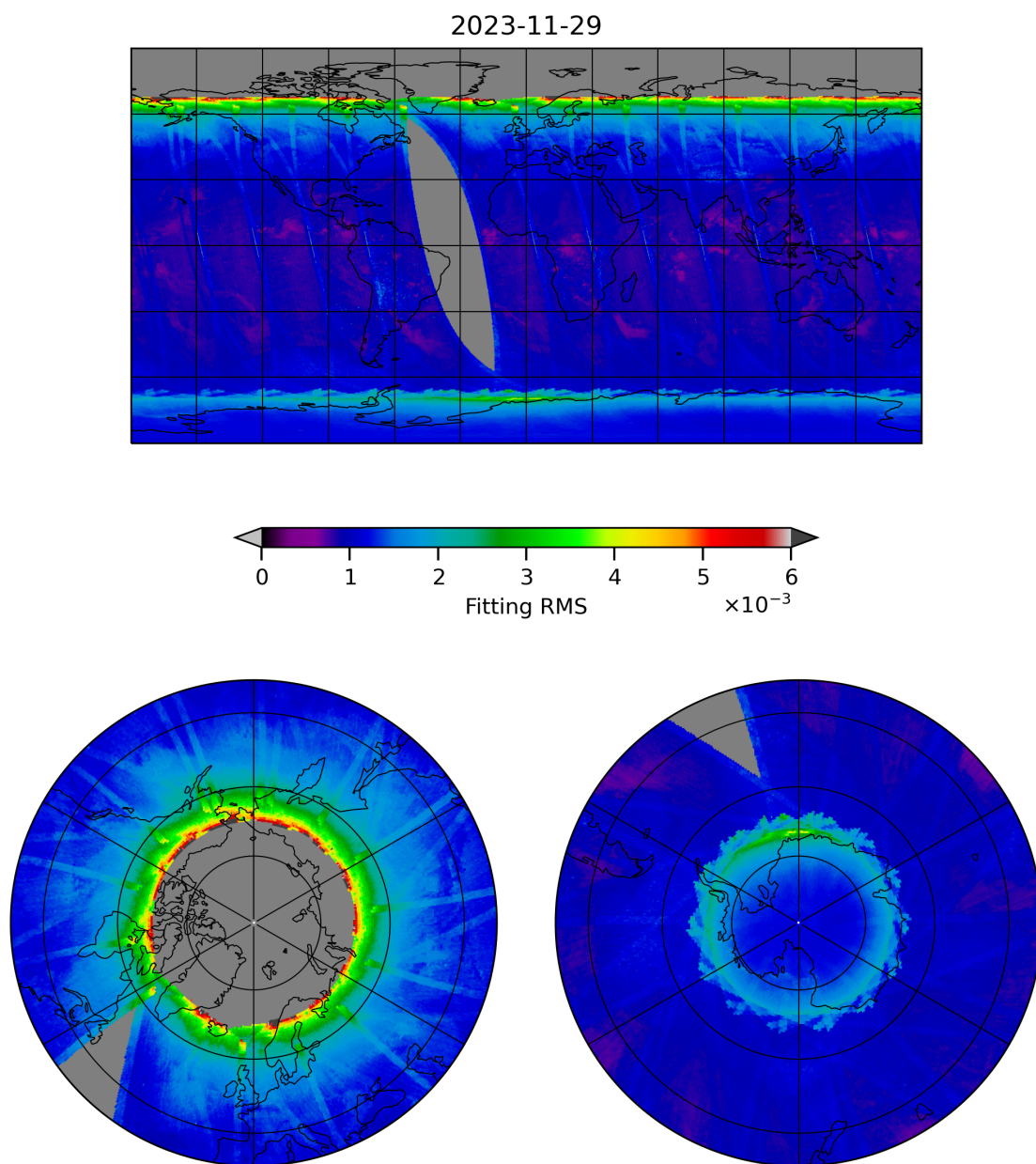


Figure 8: Map of “Fitting RMS” for 2023-11-28 to 2023-11-30

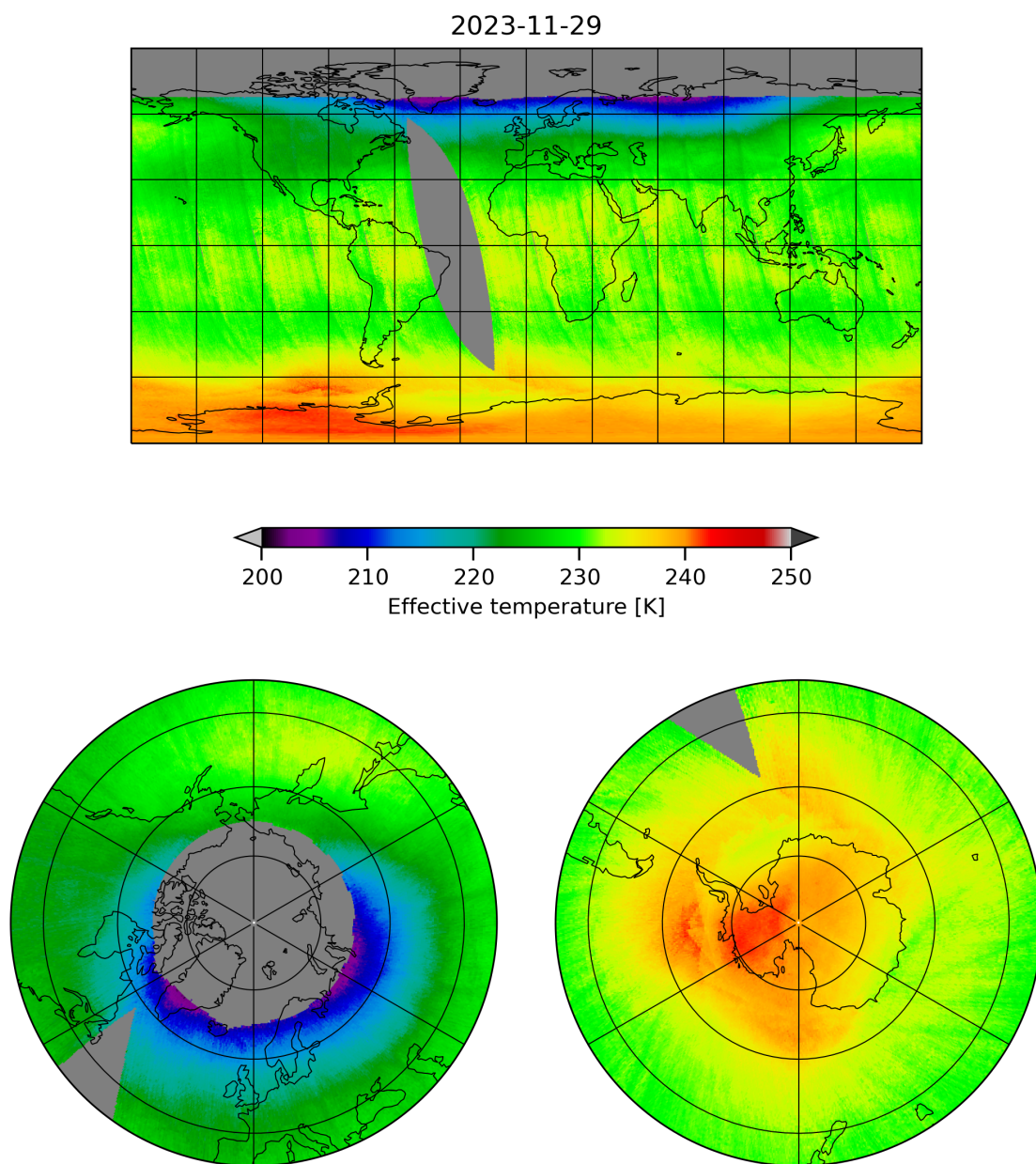


Figure 9: Map of “Effective temperature” for 2023-11-28 to 2023-11-30



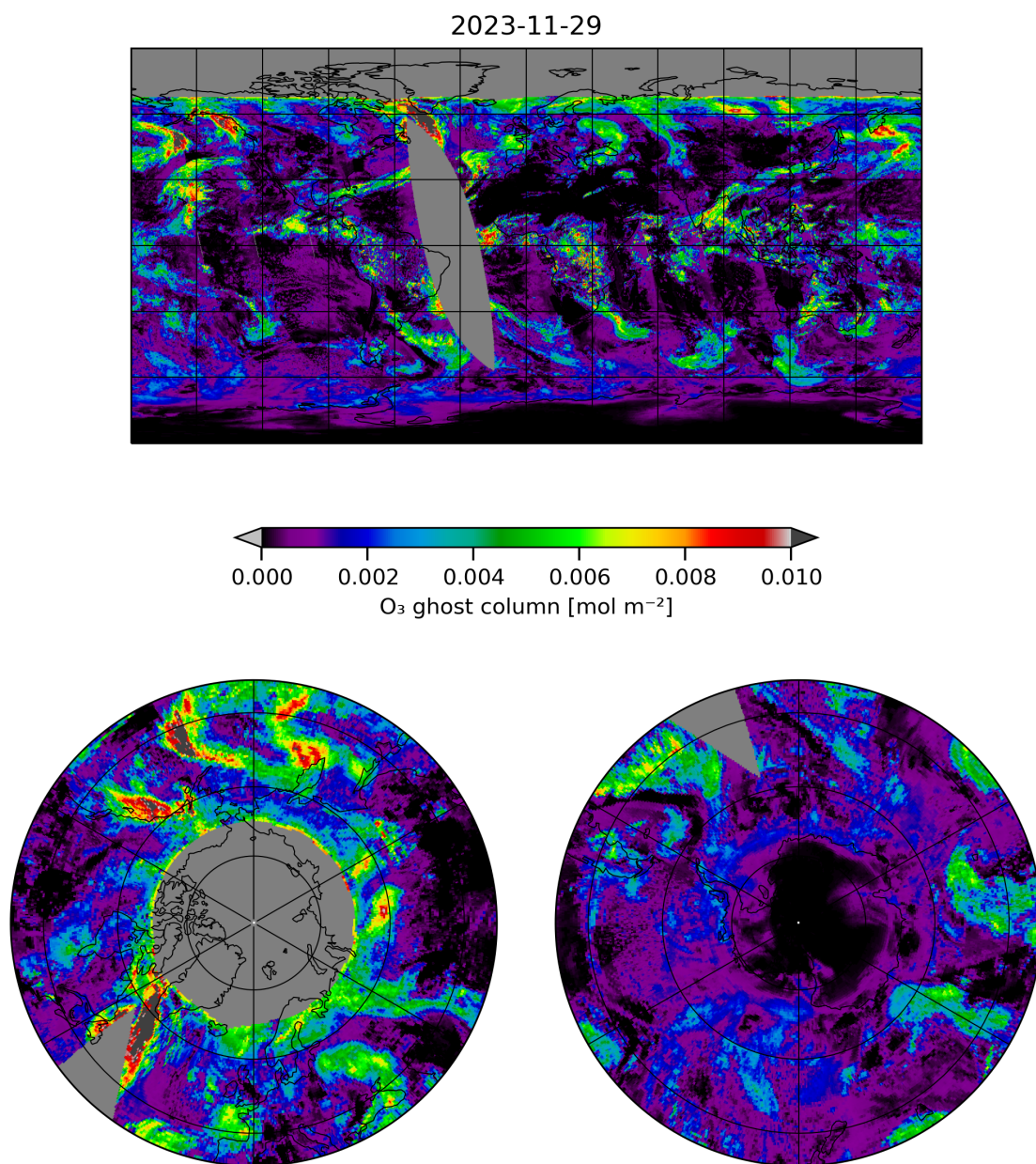


Figure 10: Map of “ $\text{O}_3$  ghost column” for 2023-11-28 to 2023-11-30

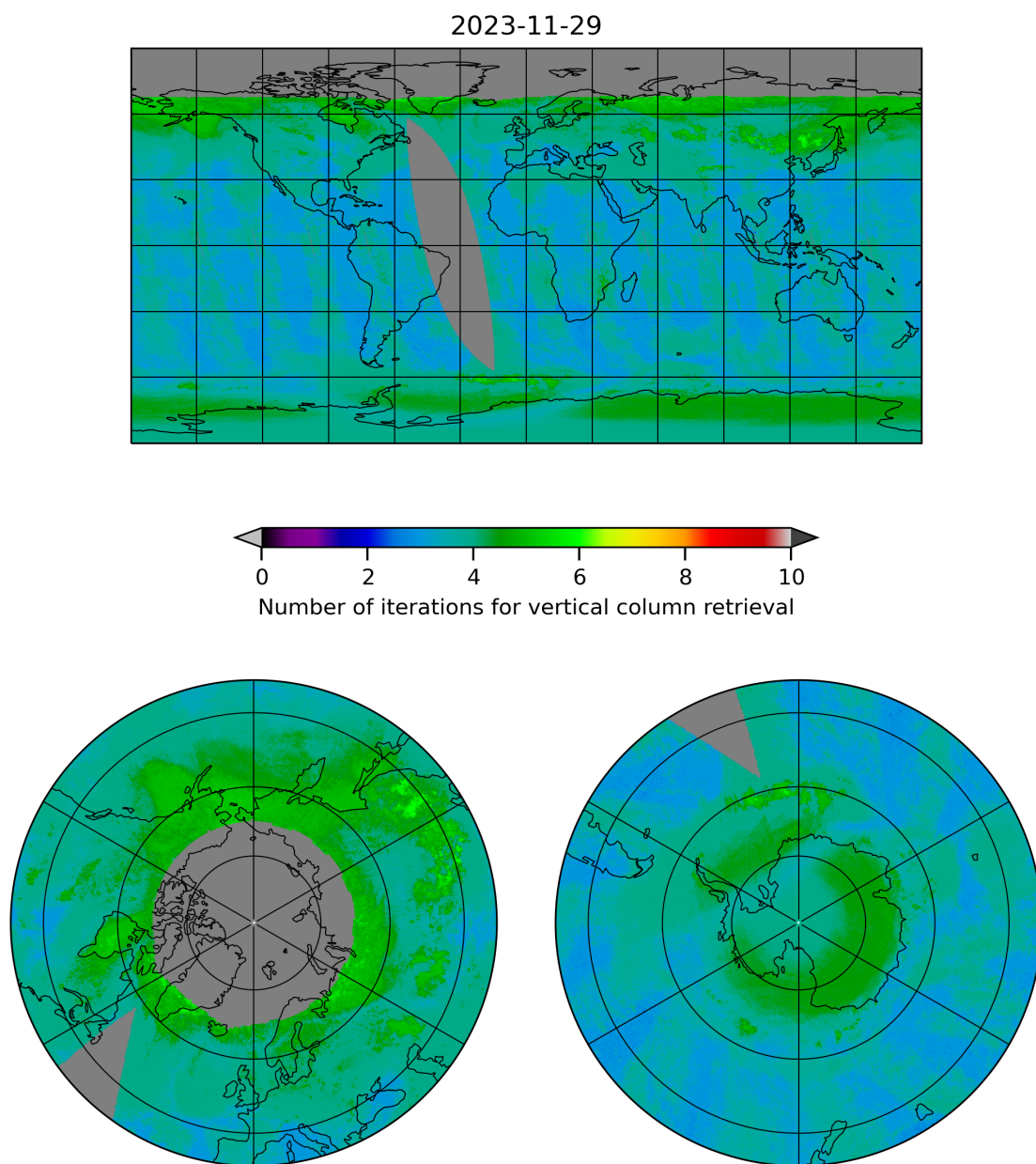


Figure 11: Map of “Number of iterations for vertical column retrieval” for 2023-11-28 to 2023-11-30



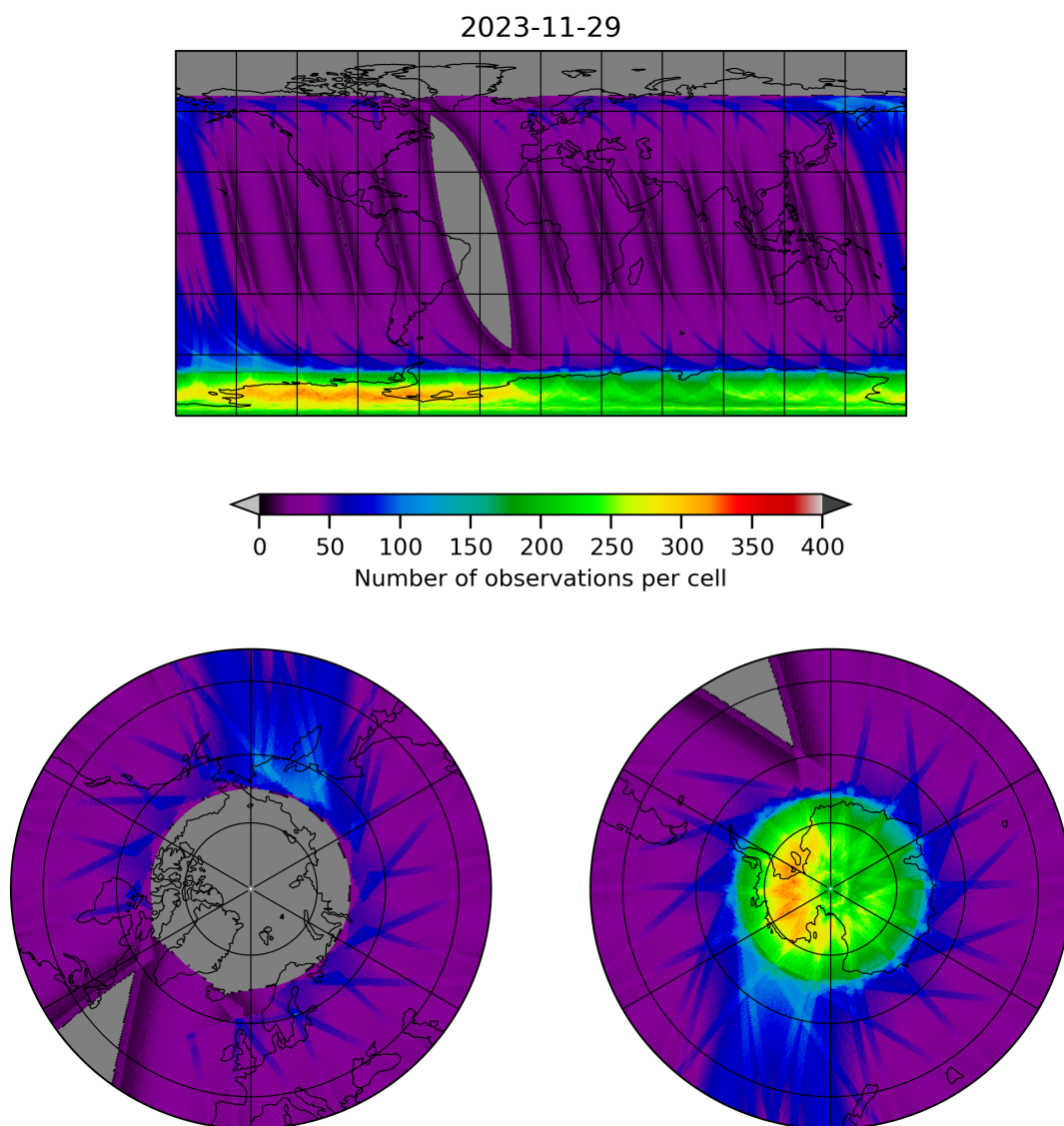


Figure 12: Map of the number of observations for 2023-11-28 to 2023-11-30

## 7 Zonal average

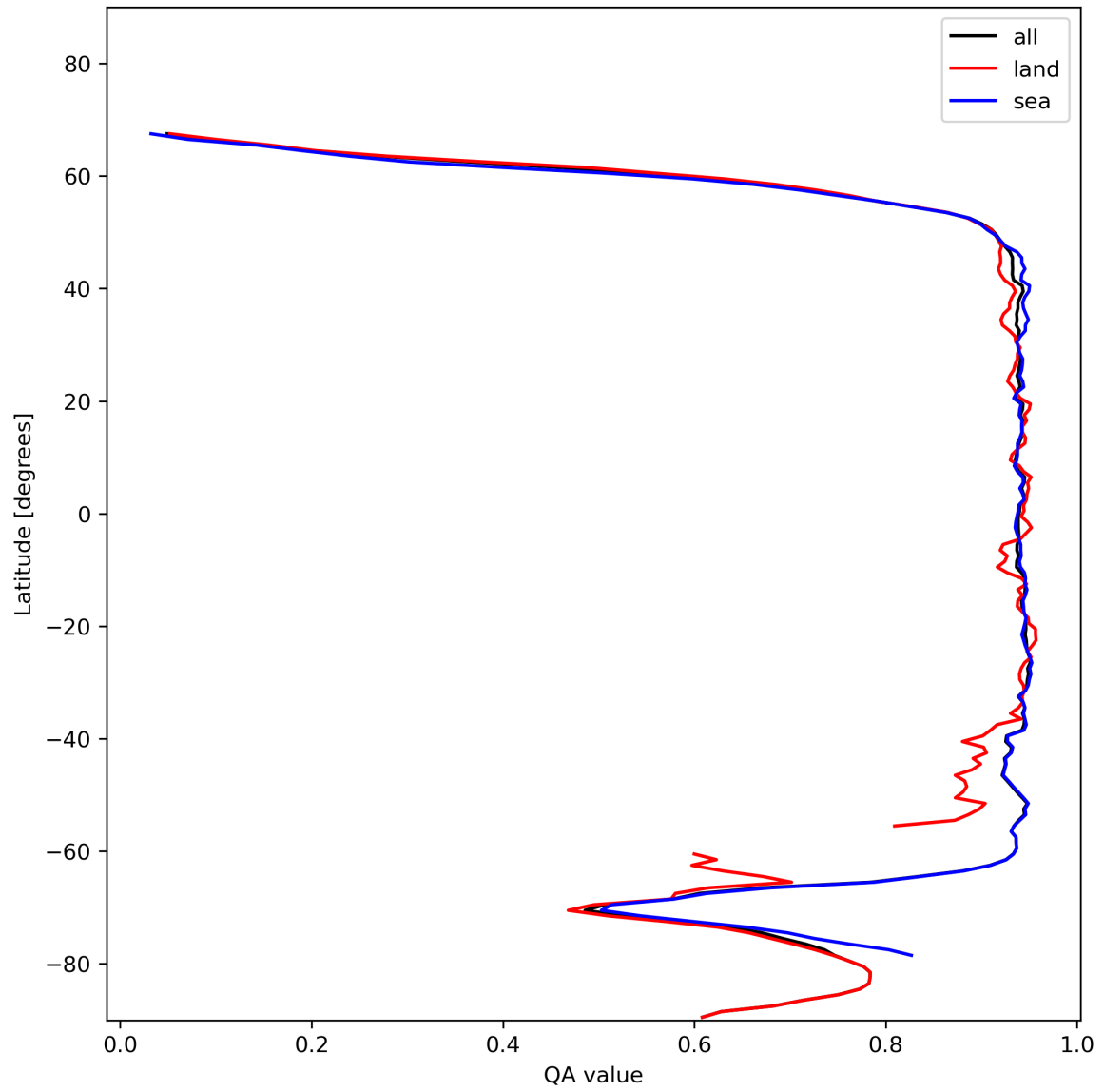


Figure 13: Zonal average of “QA value” for 2023-11-28 to 2023-11-30.

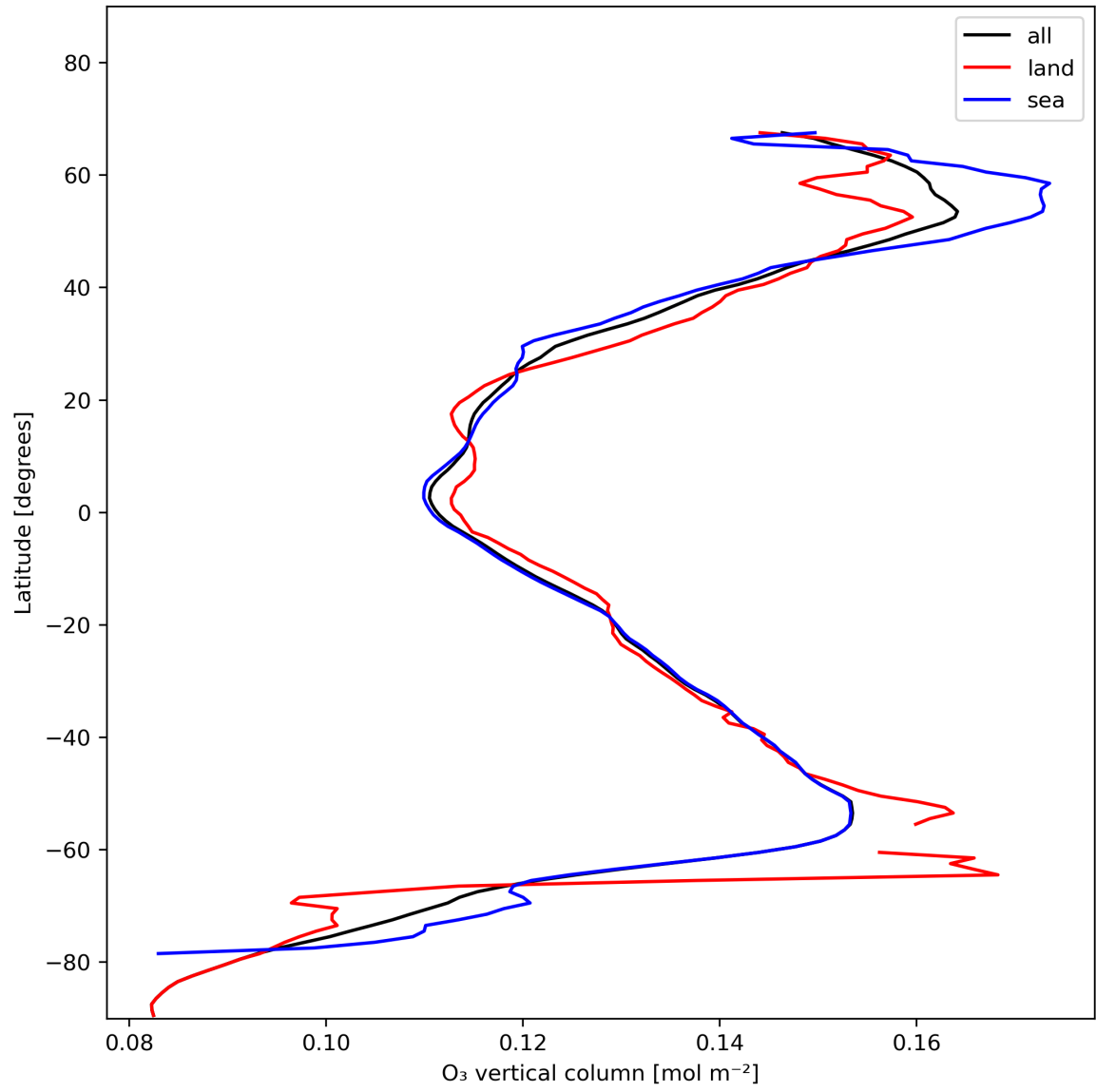


Figure 14: Zonal average of “O<sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30.

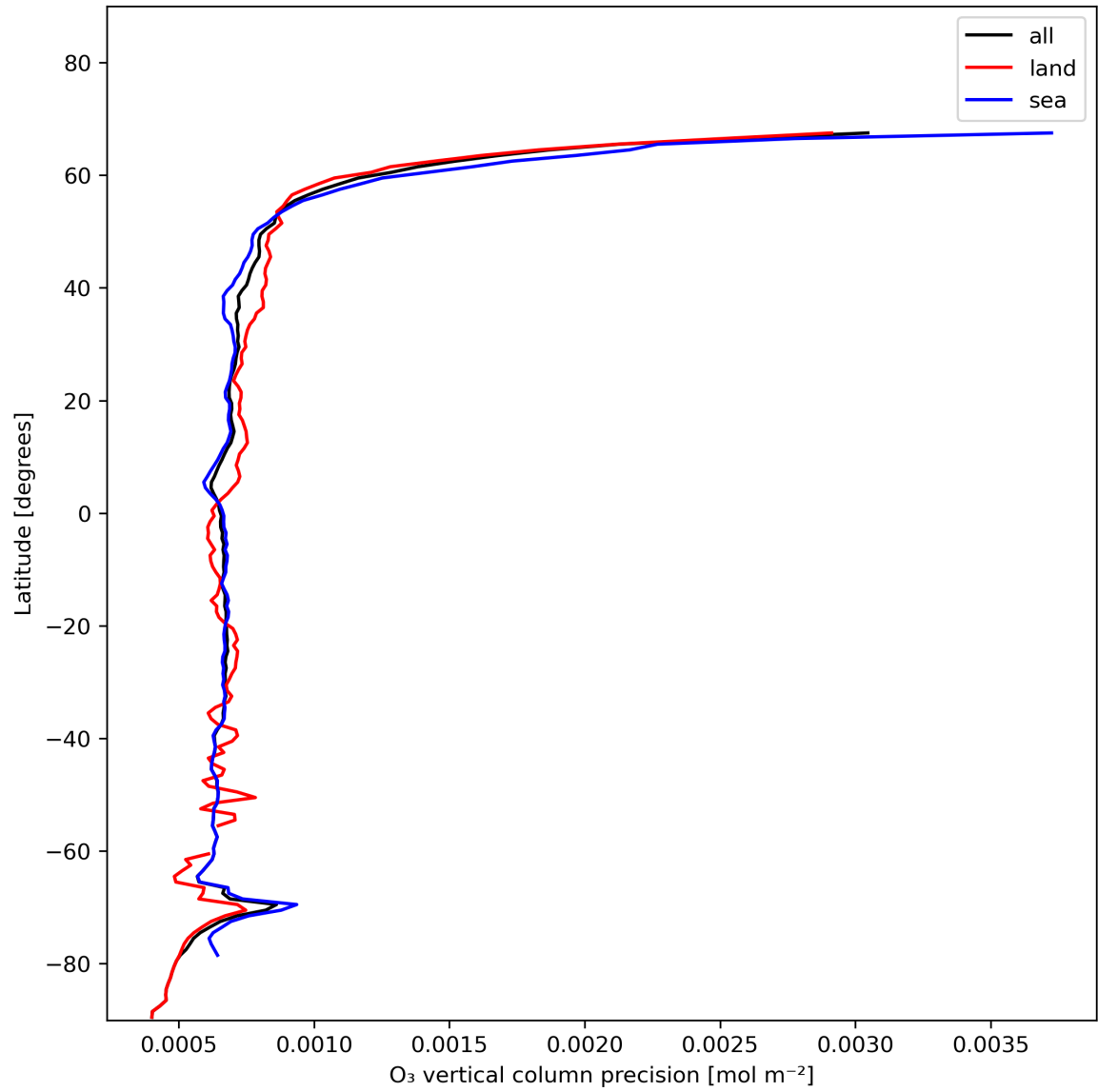


Figure 15: Zonal average of “O<sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30.

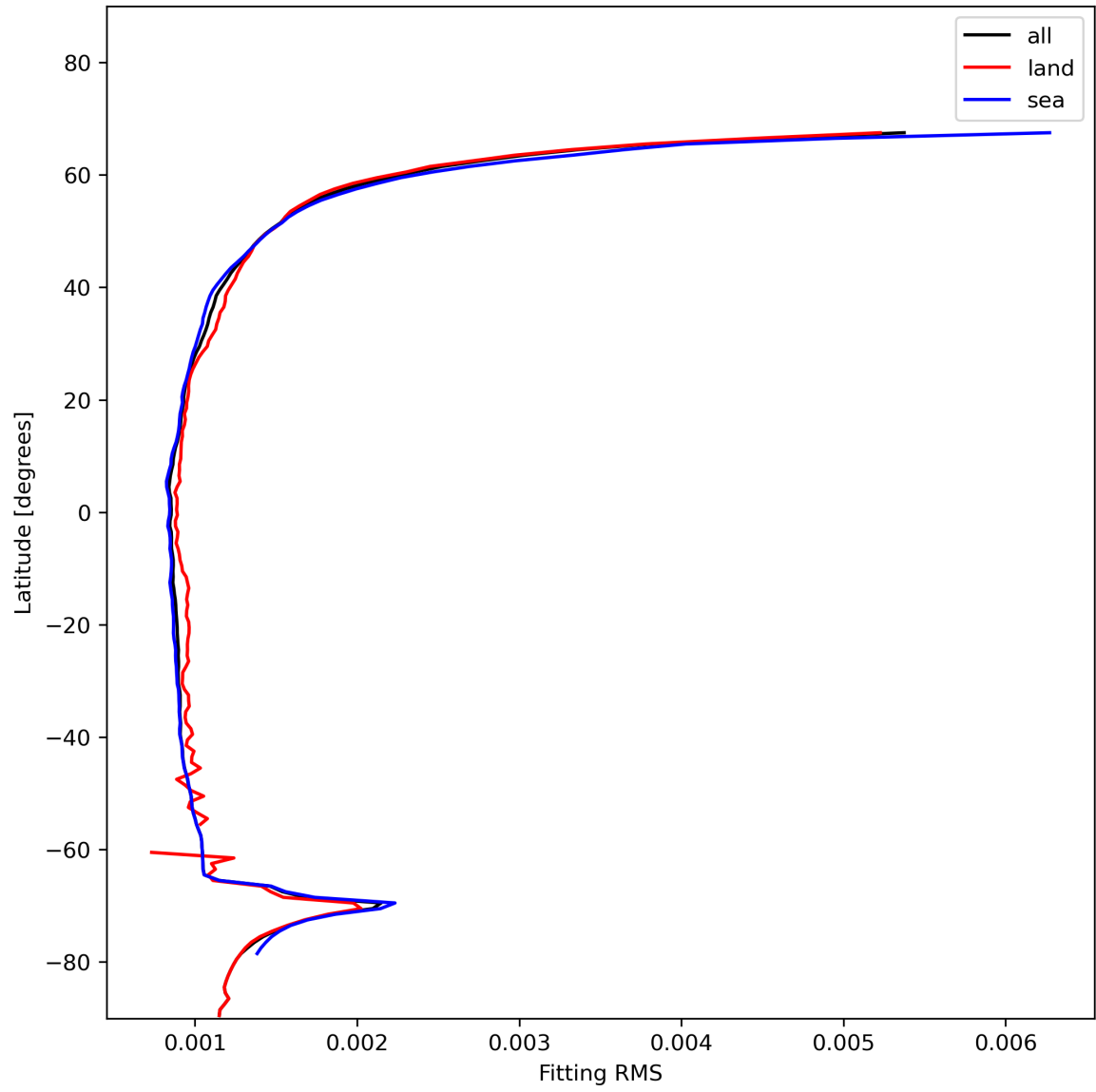


Figure 16: Zonal average of “Fitting RMS” for 2023-11-28 to 2023-11-30.

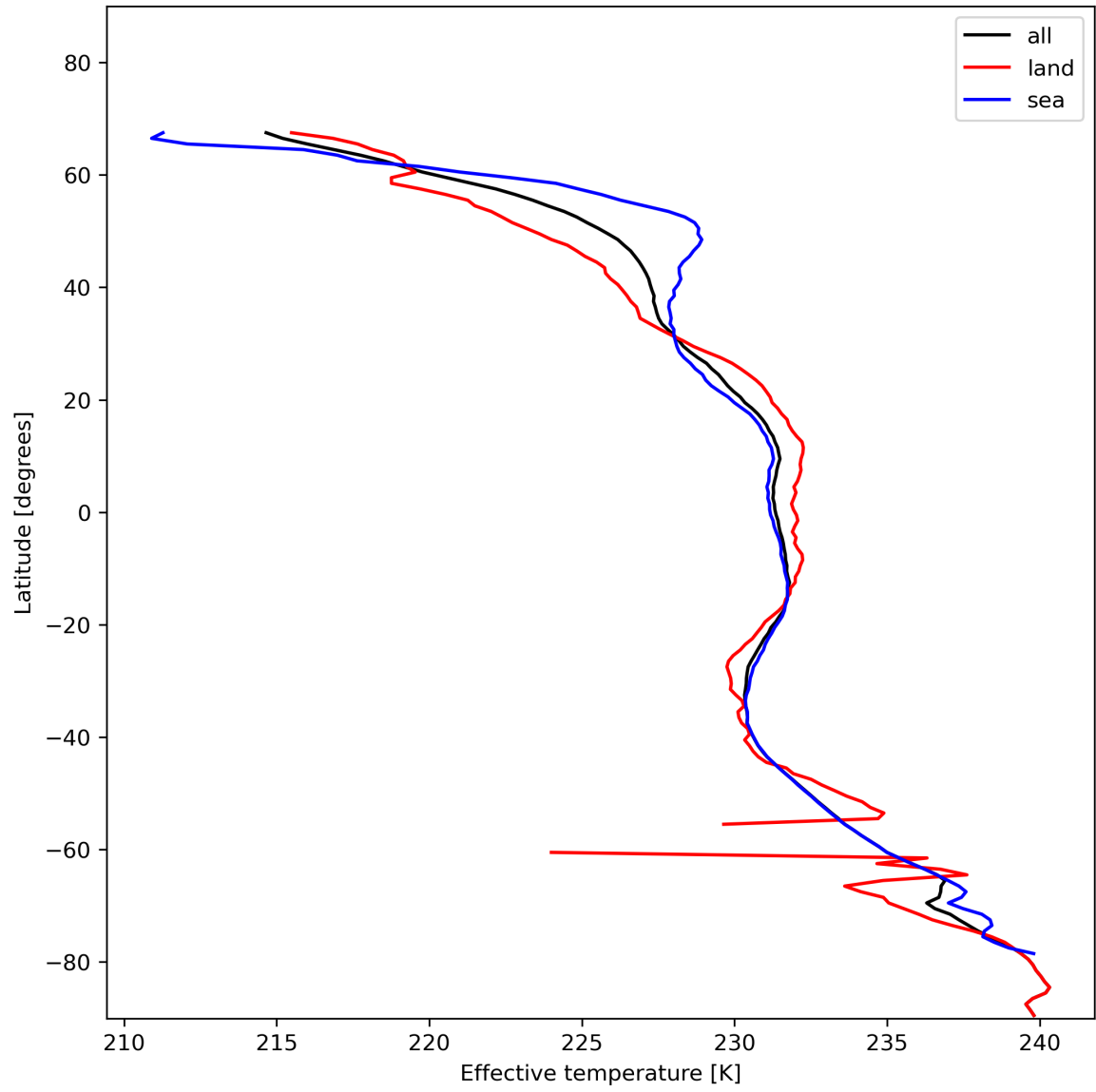


Figure 17: Zonal average of “Effective temperature” for 2023-11-28 to 2023-11-30.

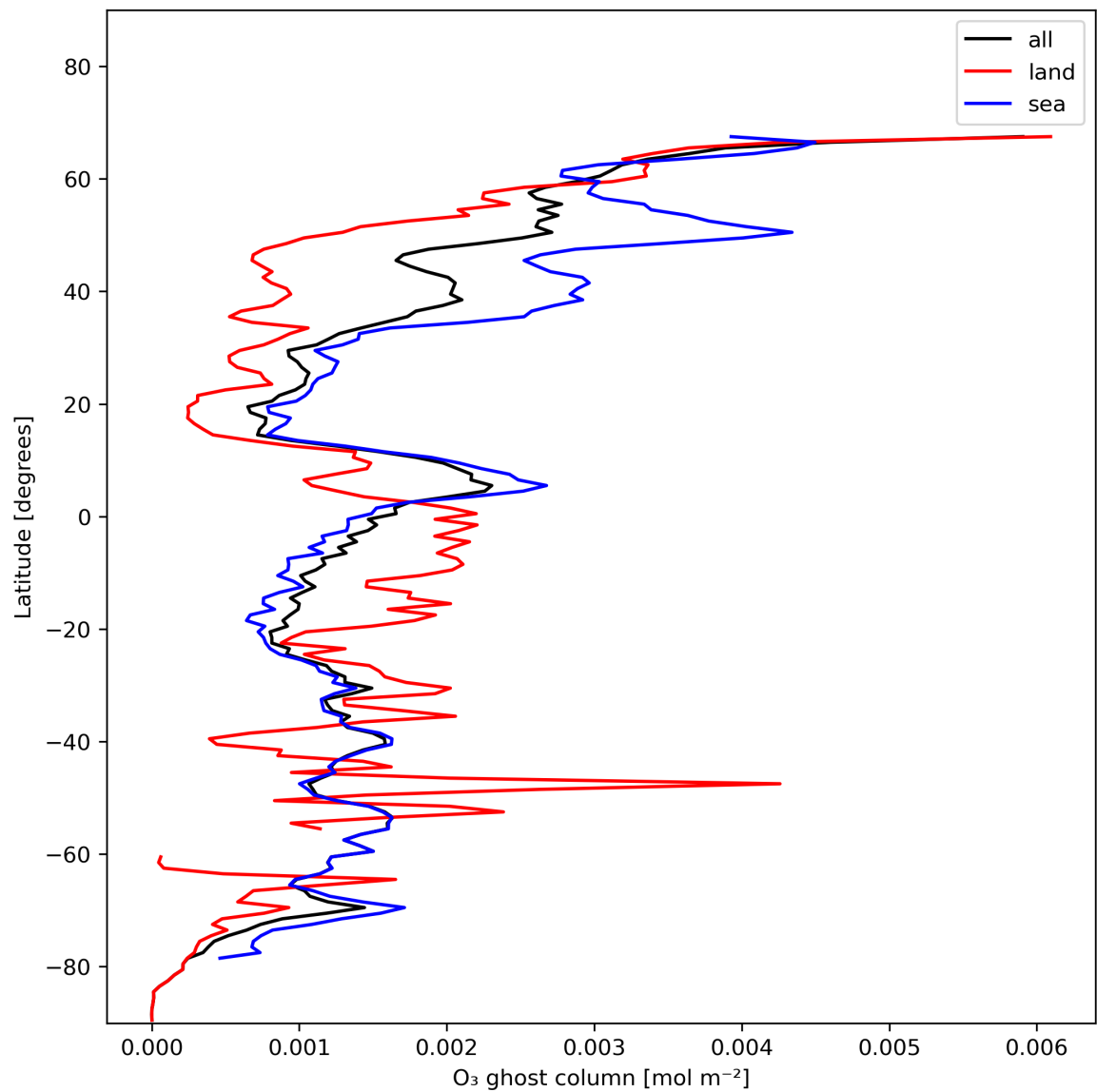


Figure 18: Zonal average of “O<sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30.

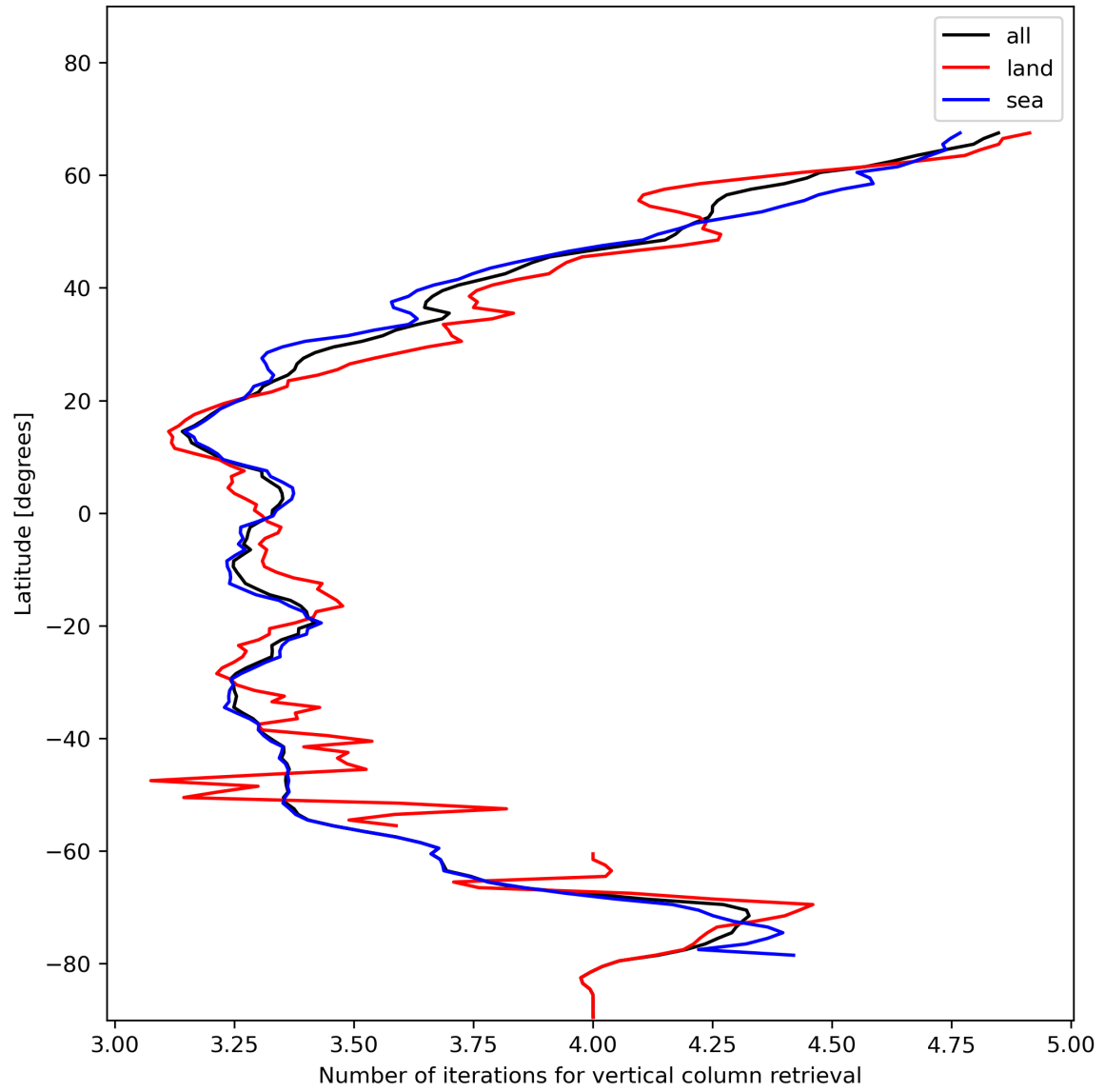


Figure 19: Zonal average of “Number of iterations for vertical column retrieval” for 2023-11-28 to 2023-11-30.



## 8 Histograms

The definitions of the parameters given in this section can be found in section 2.

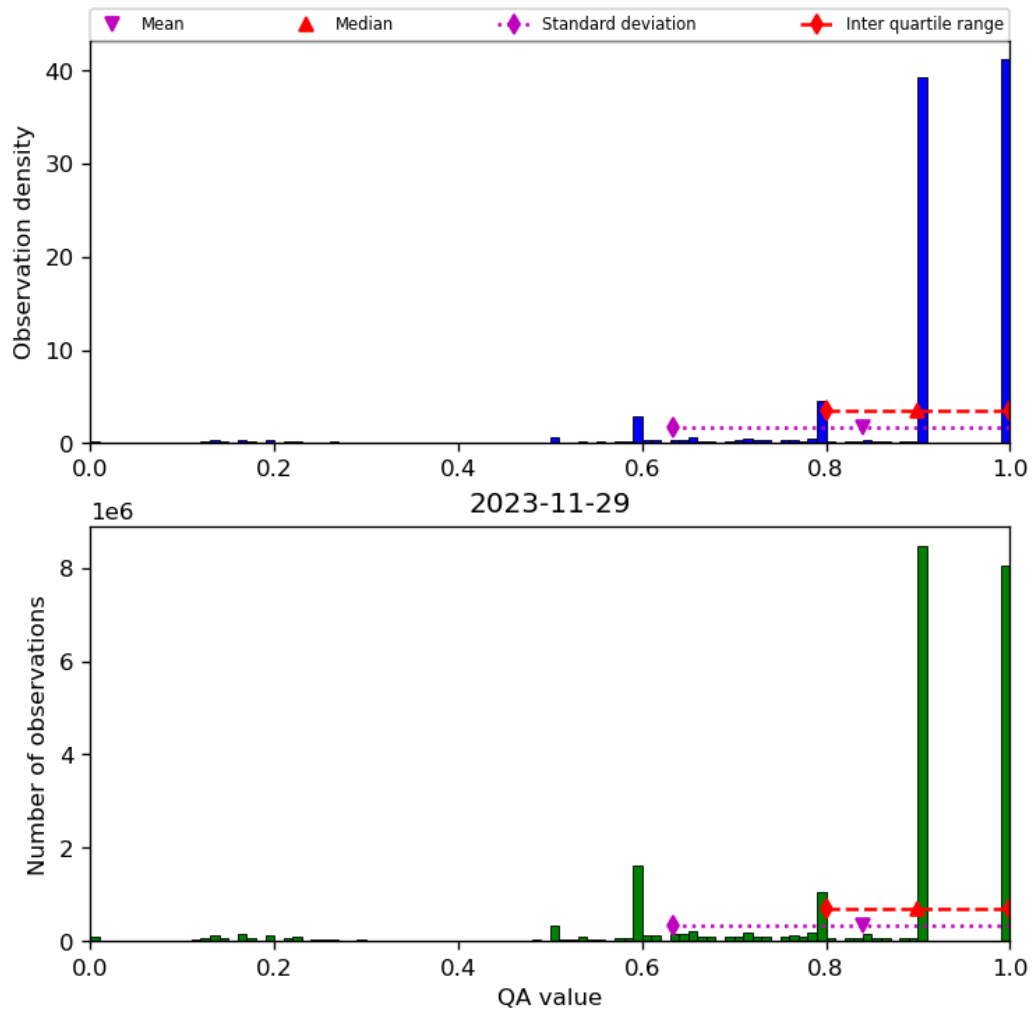


Figure 20: Histogram of “QA value” for 2023-11-28 to 2023-11-30

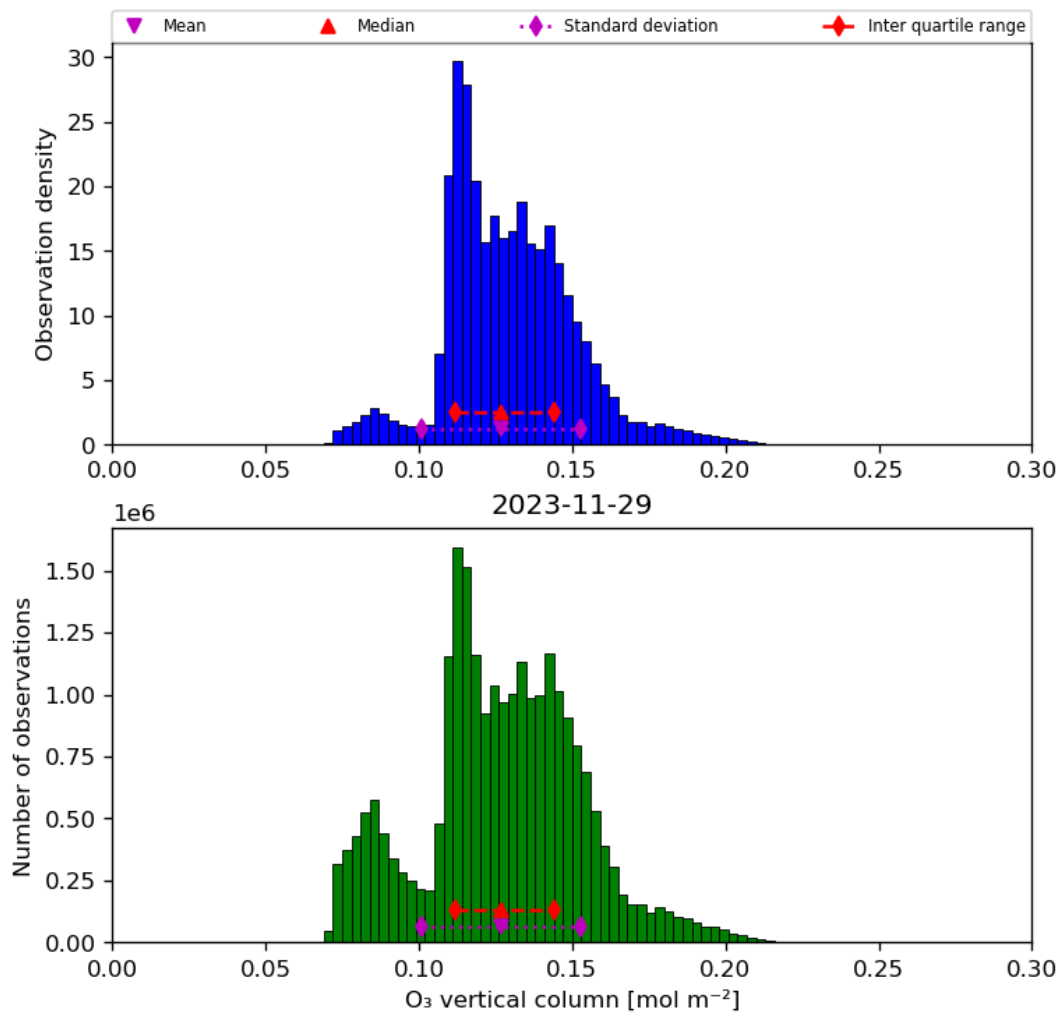


Figure 21: Histogram of “O<sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30

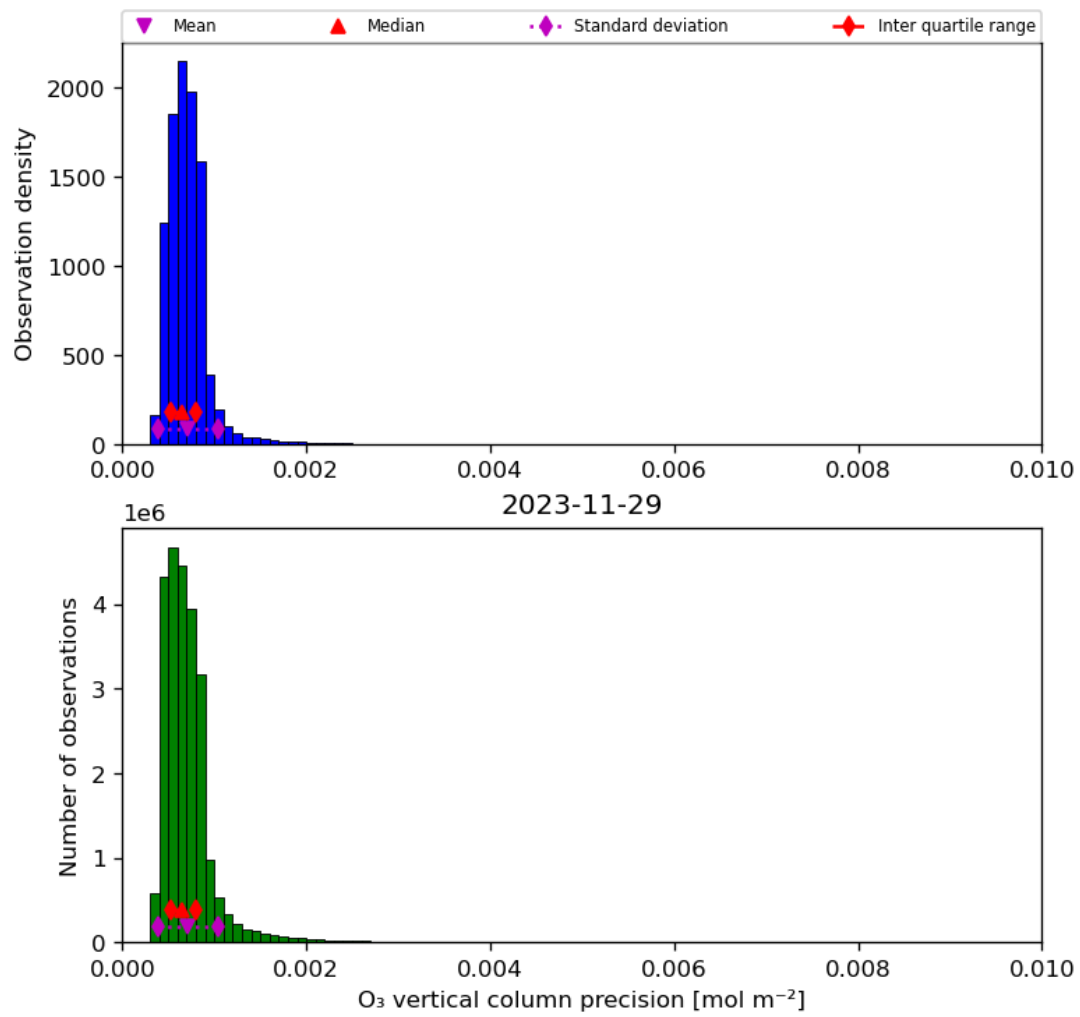


Figure 22: Histogram of “O<sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30

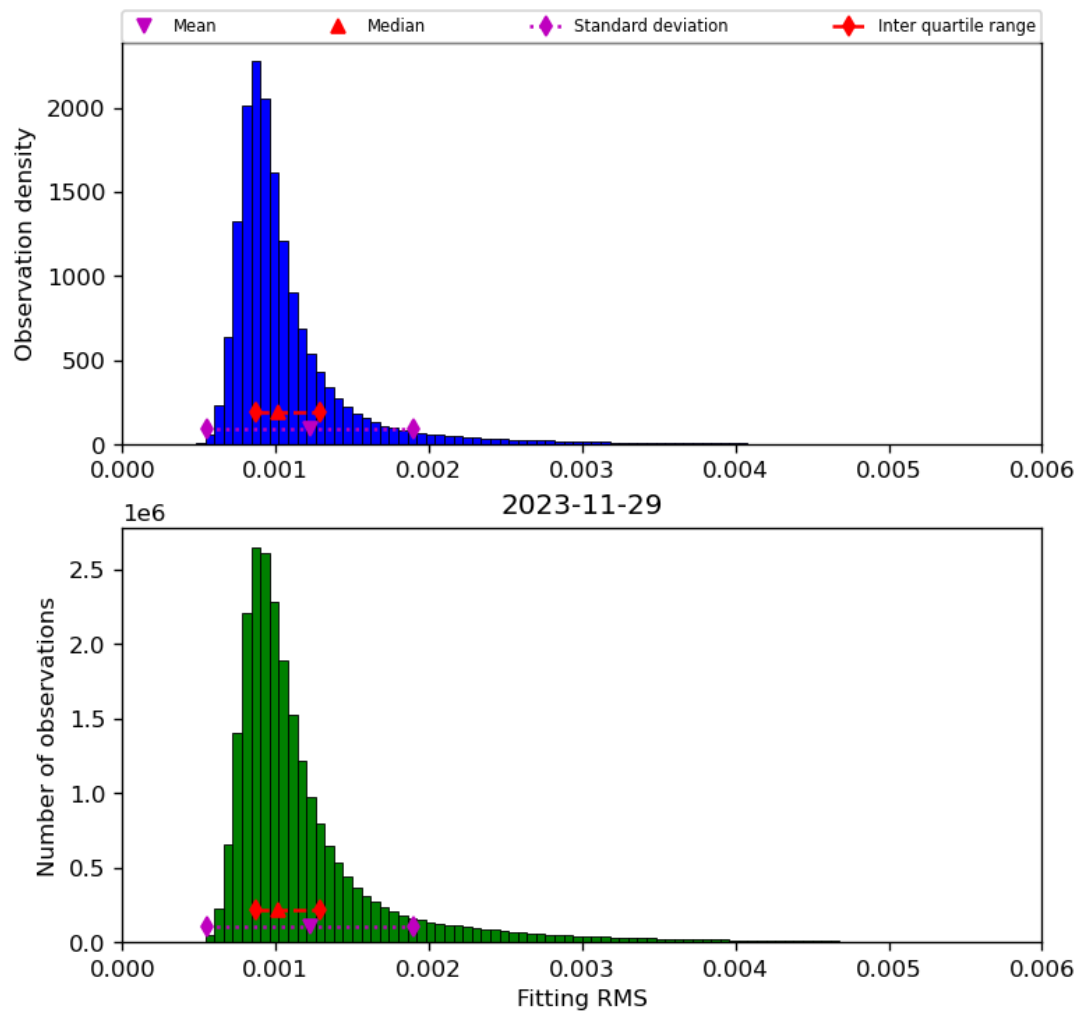


Figure 23: Histogram of “Fitting RMS” for 2023-11-28 to 2023-11-30

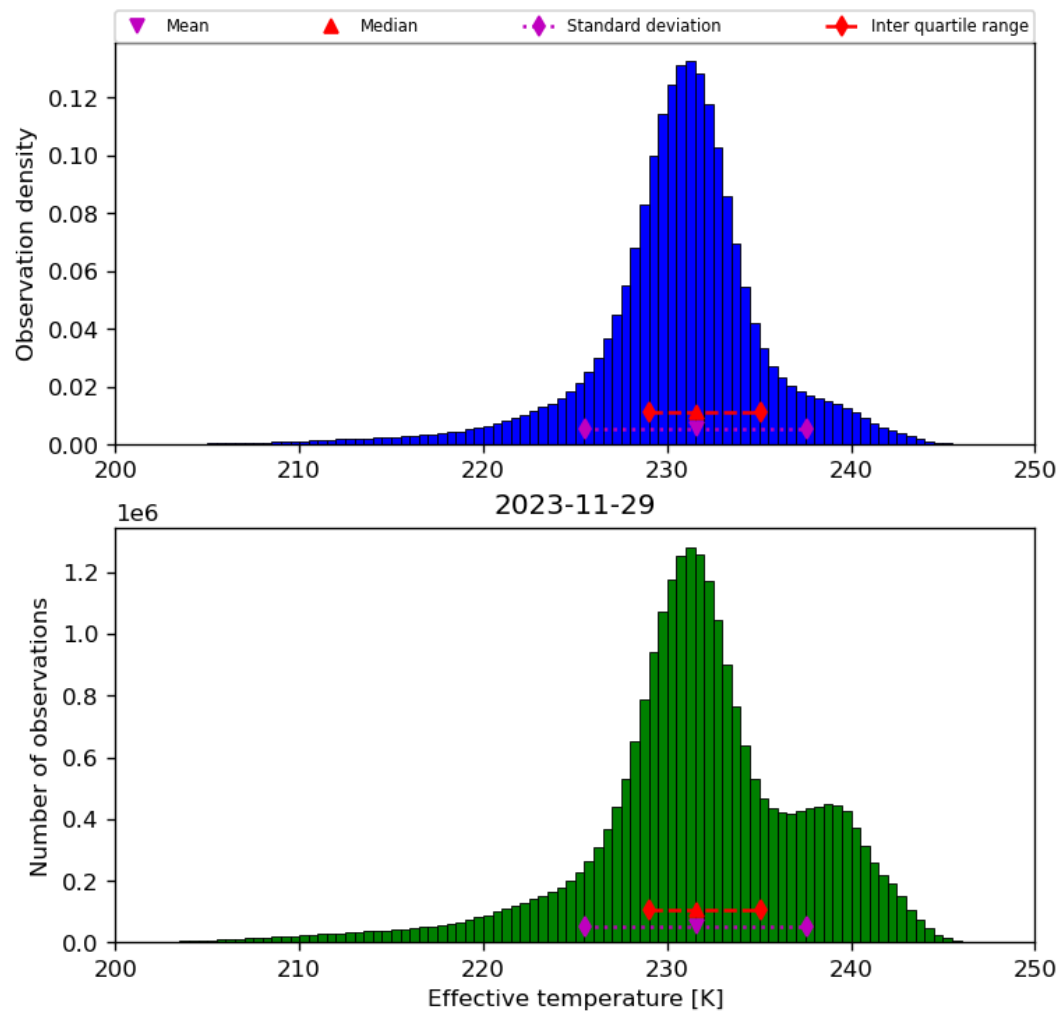


Figure 24: Histogram of “Effective temperature” for 2023-11-28 to 2023-11-30

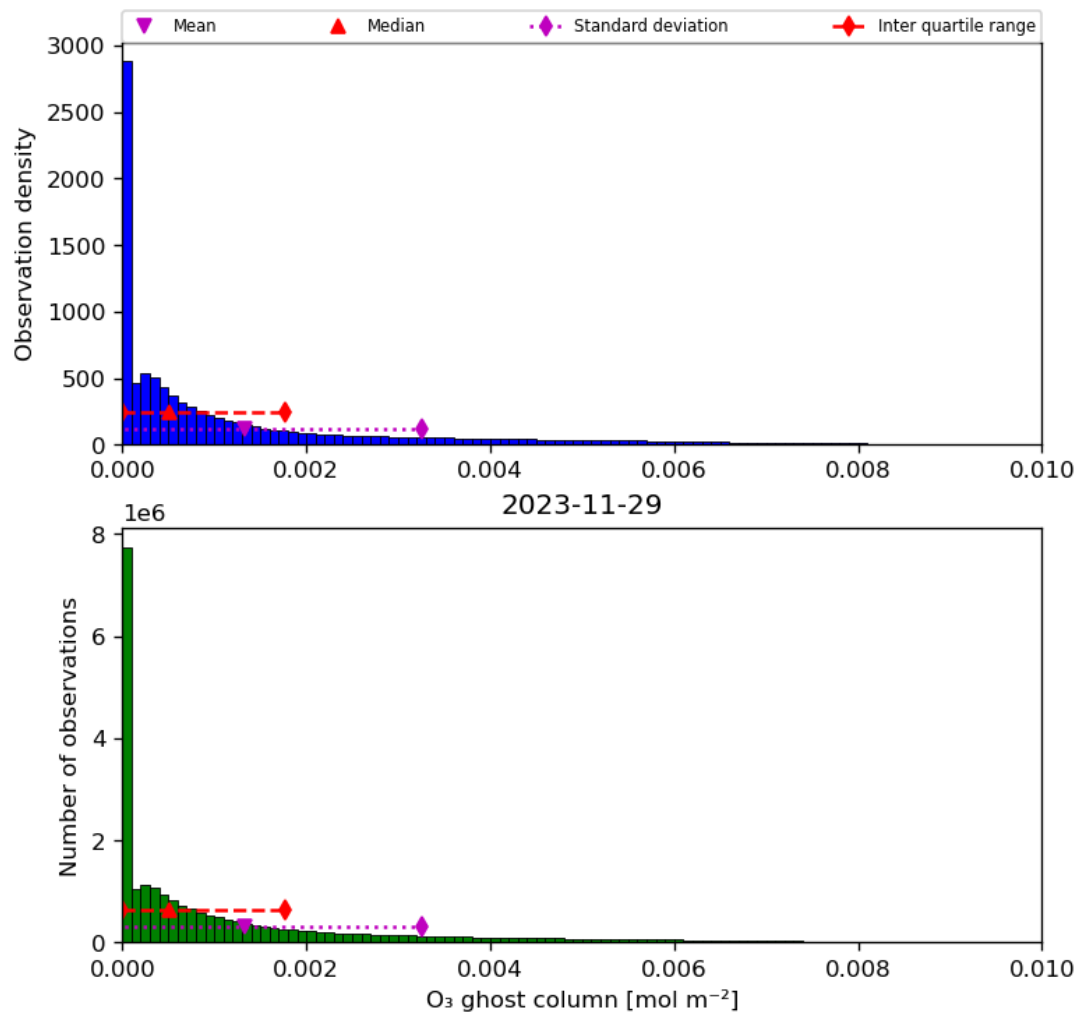


Figure 25: Histogram of “O<sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30

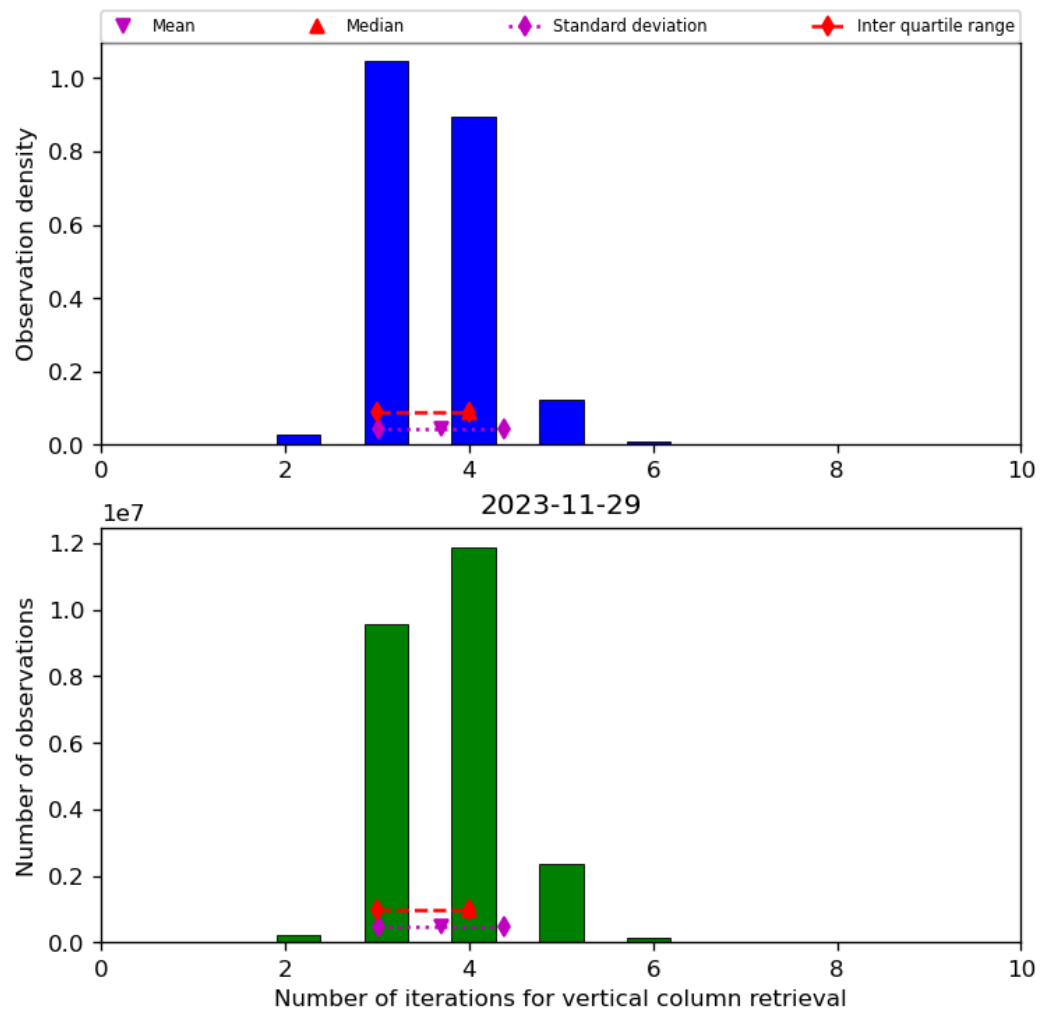


Figure 26: Histogram of “Number of iterations for vertical column retrieval” for 2023-11-28 to 2023-11-30

## 9 Along track statistics

The TROPOMI instrument uses different binned detector rows for different viewing directions. In this section statistics are presented for each of the binned rows in the instrument.

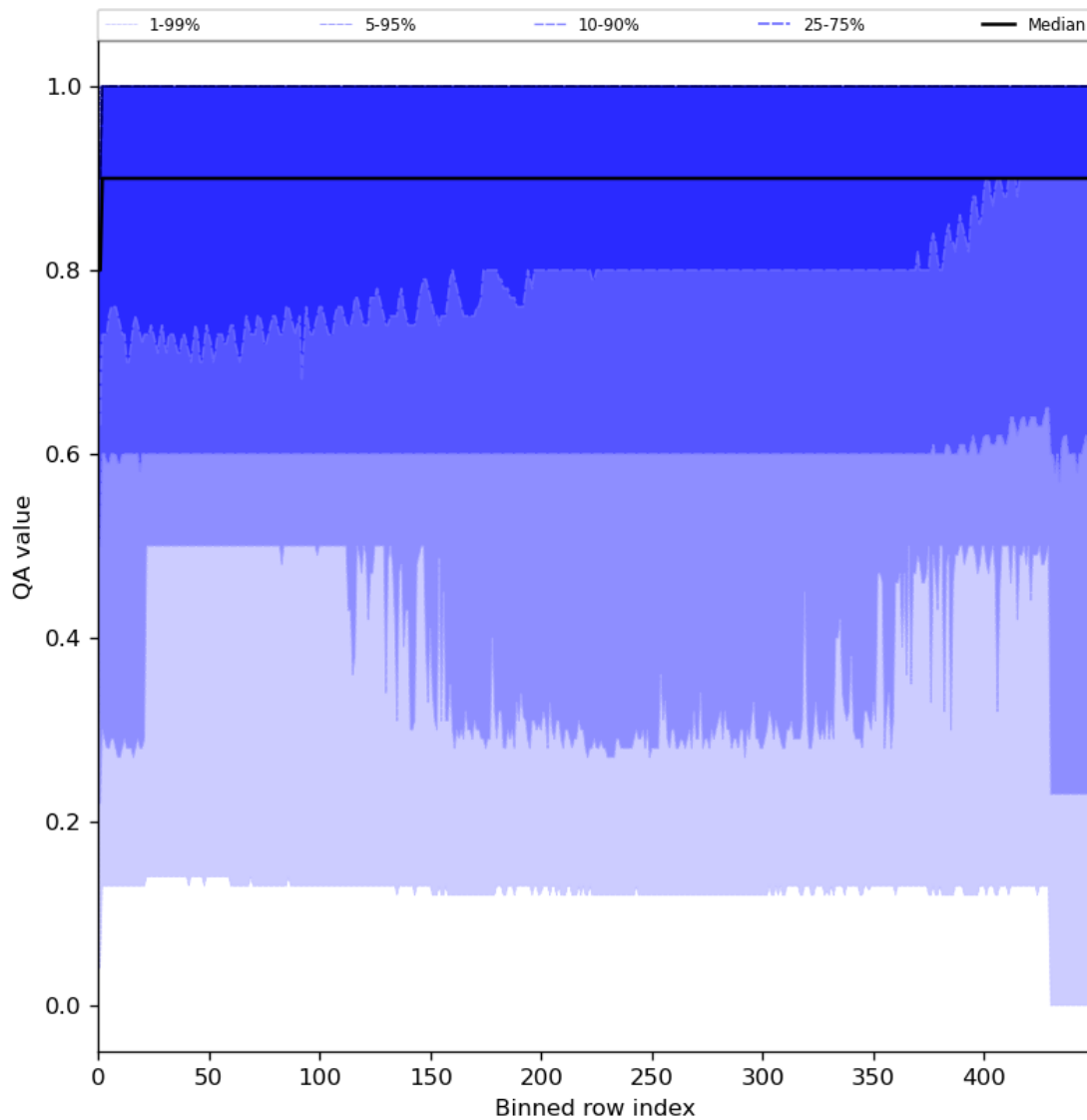


Figure 27: Along track statistics of “QA value” for 2023-11-28 to 2023-11-30



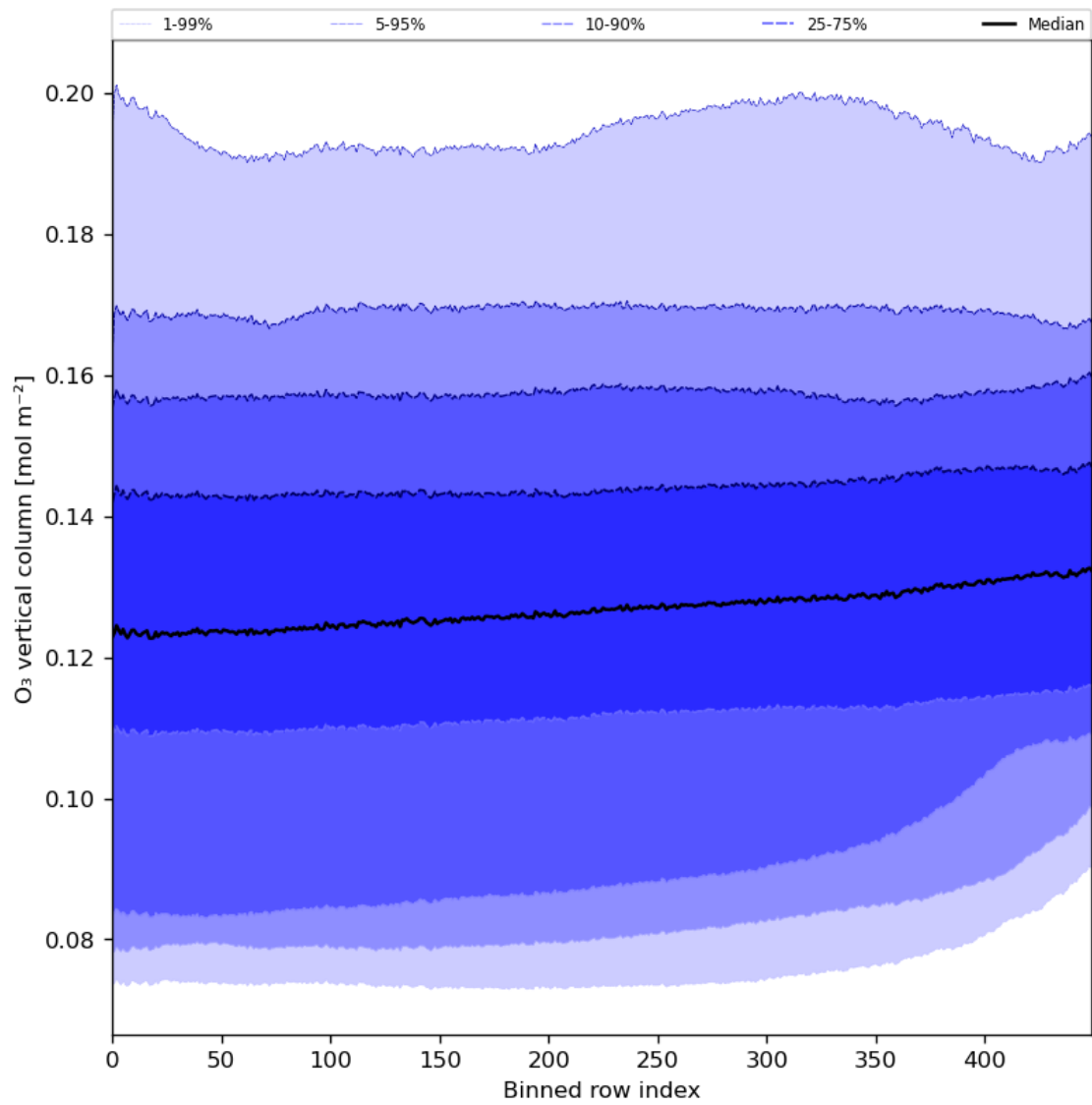


Figure 28: Along track statistics of “O<sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30

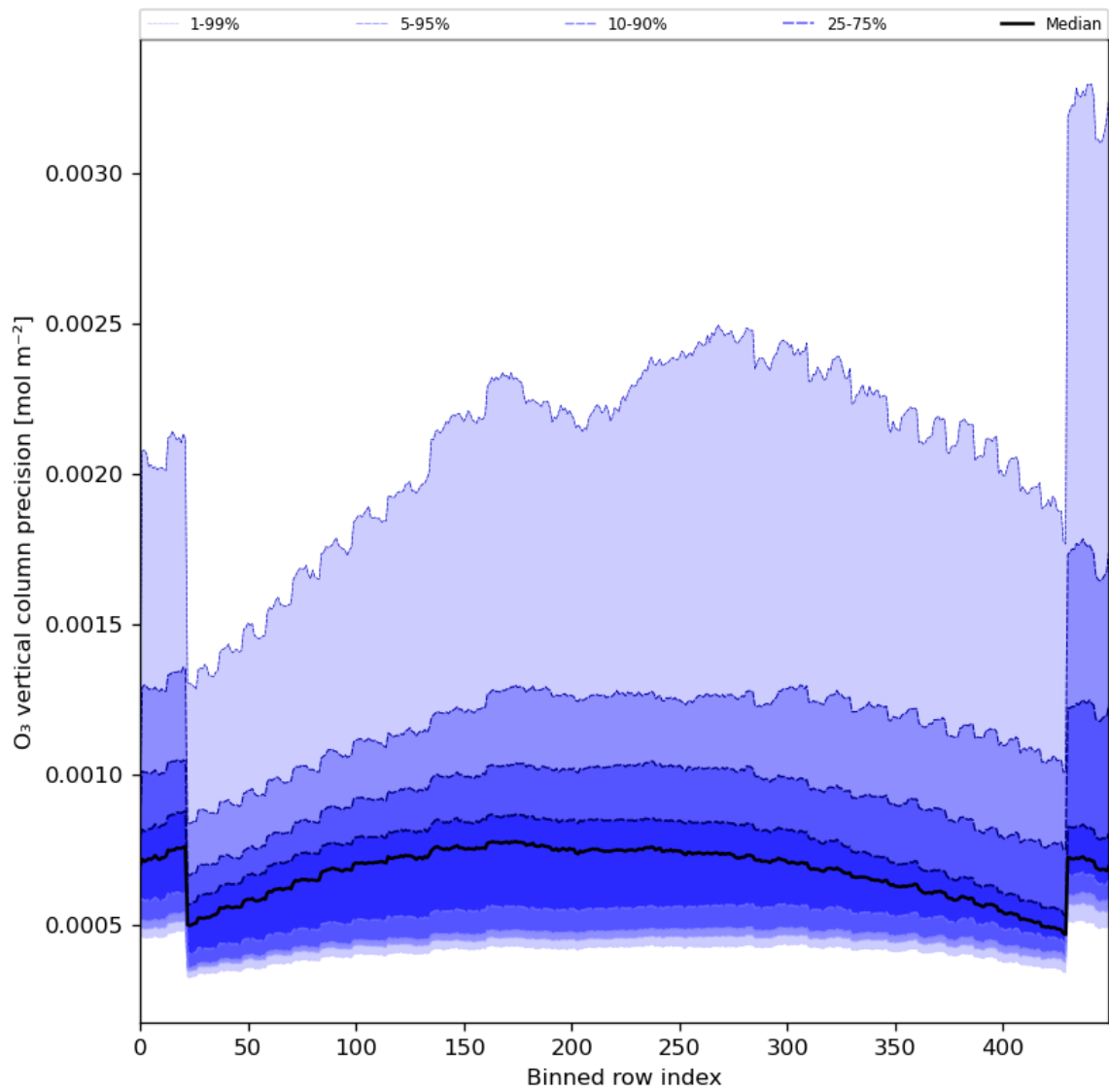


Figure 29: Along track statistics of “O<sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30

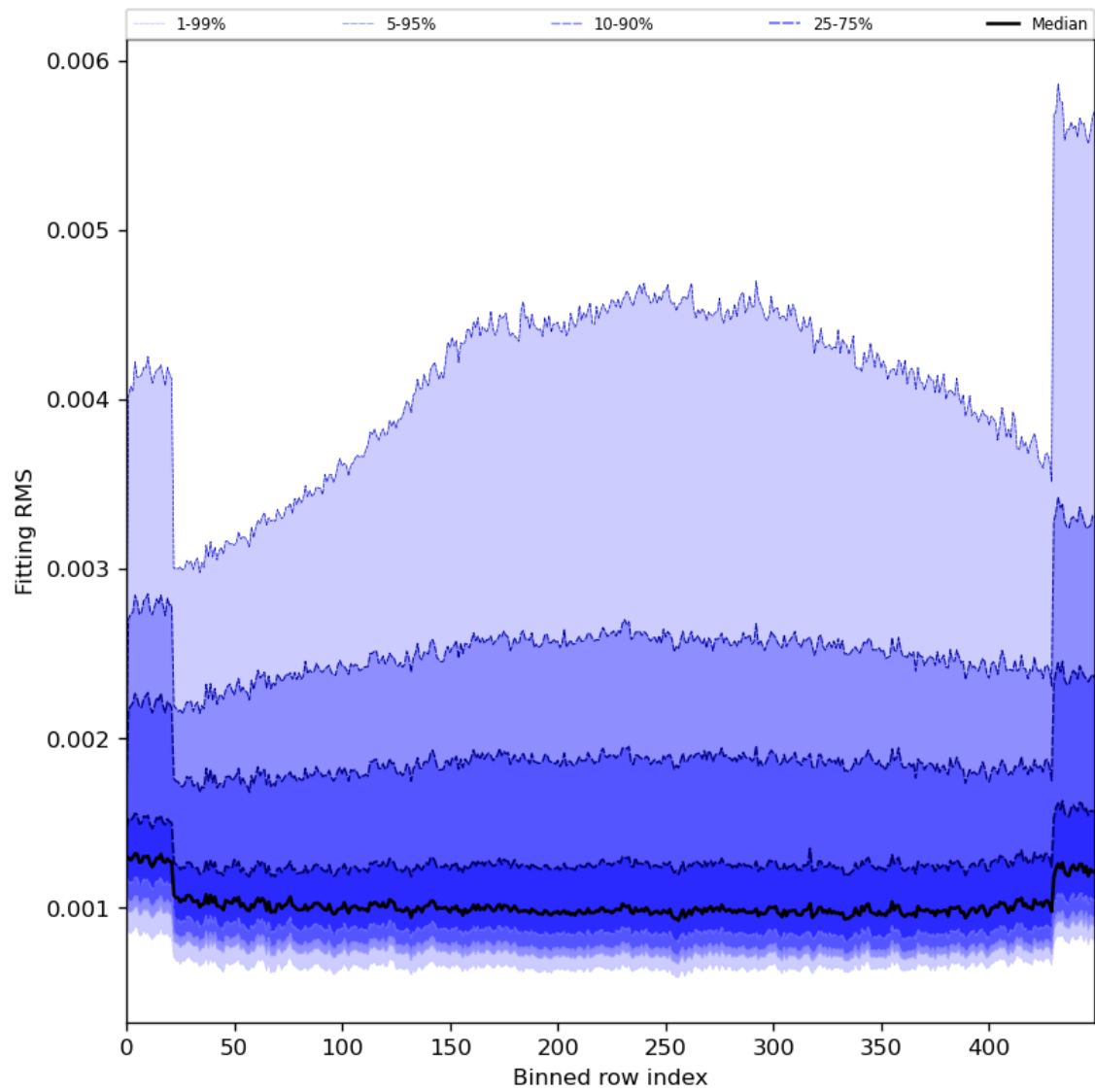


Figure 30: Along track statistics of “Fitting RMS” for 2023-11-28 to 2023-11-30

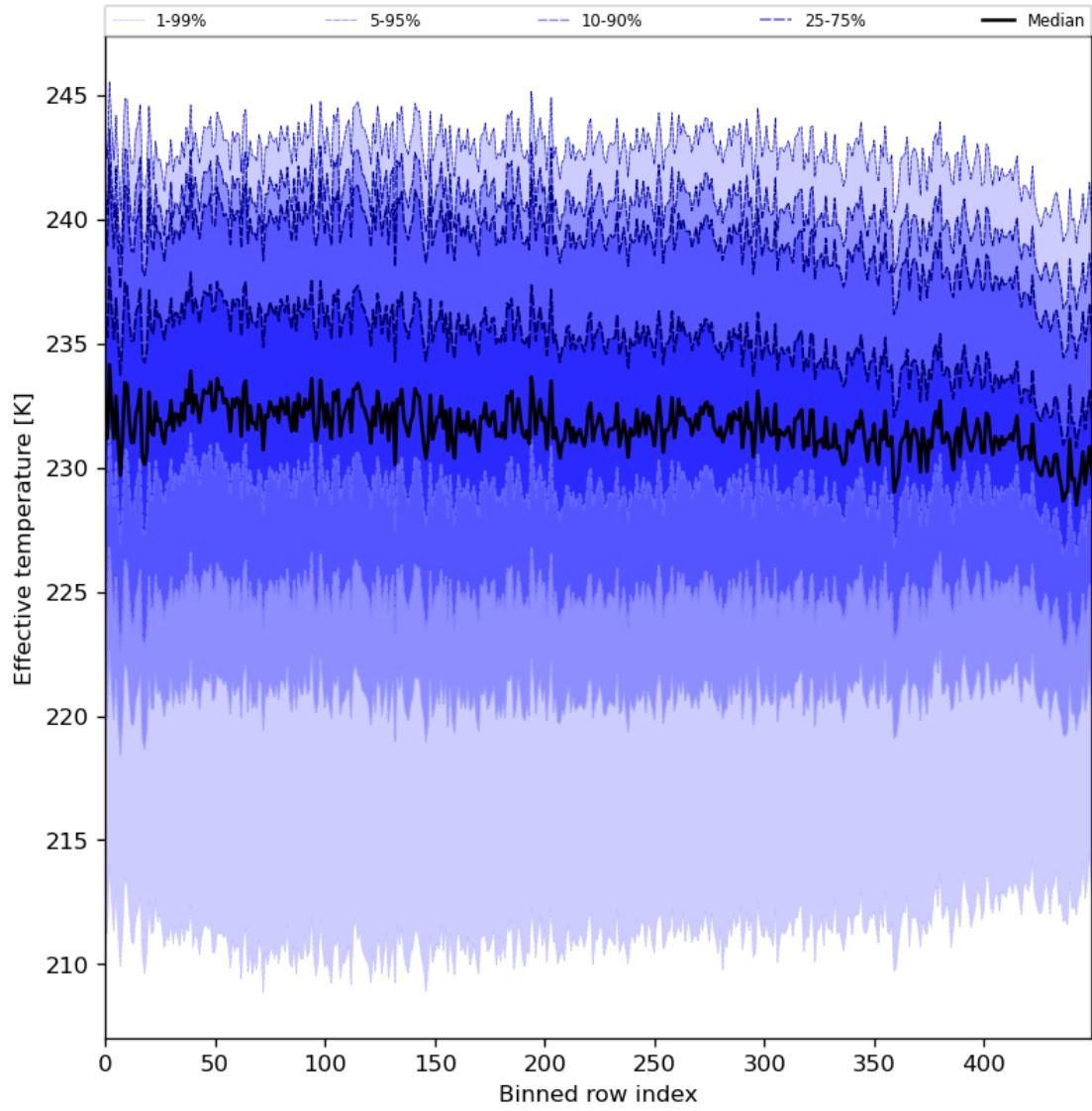


Figure 31: Along track statistics of “Effective temperature” for 2023-11-28 to 2023-11-30

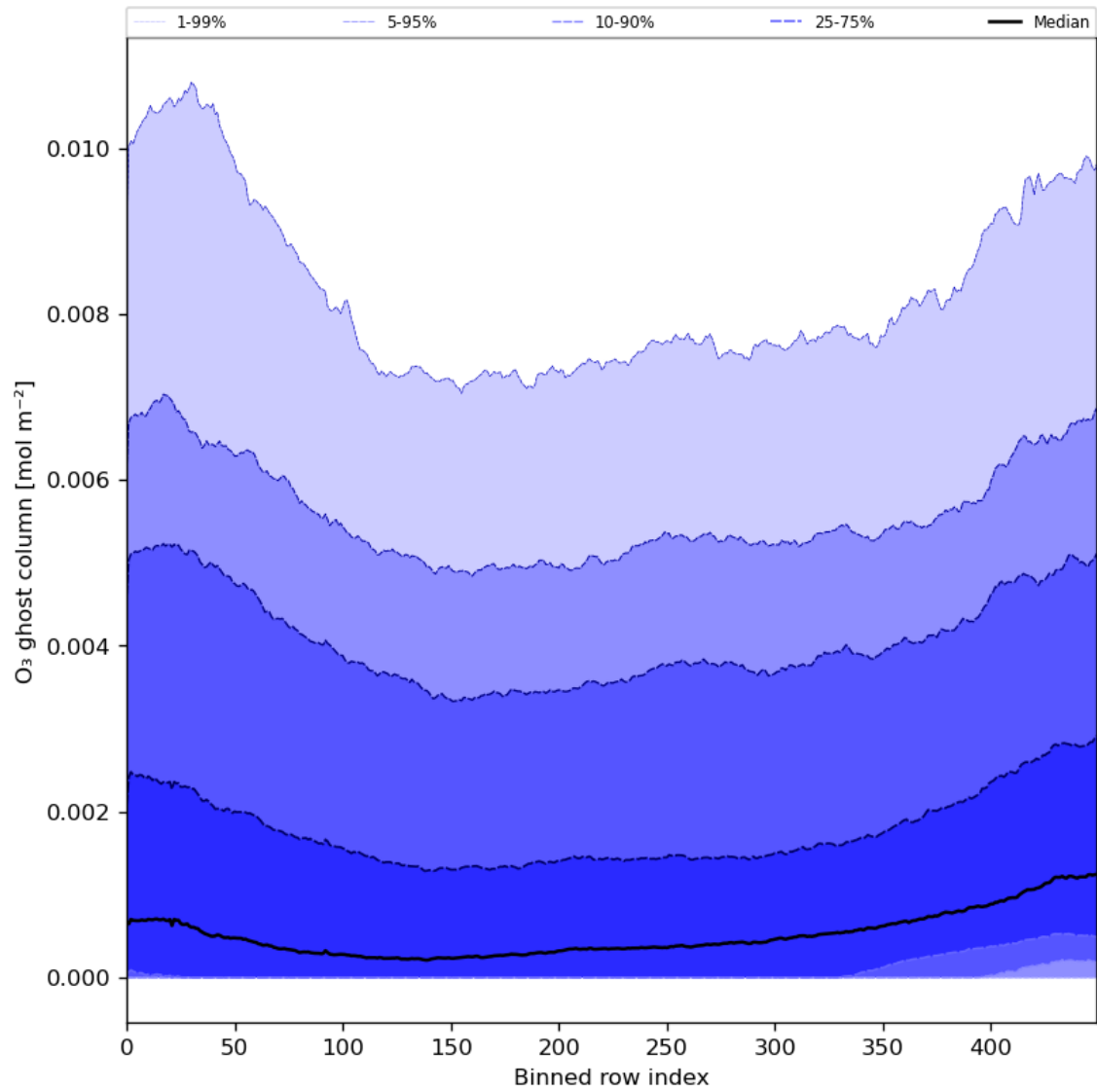


Figure 32: Along track statistics of “O<sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30

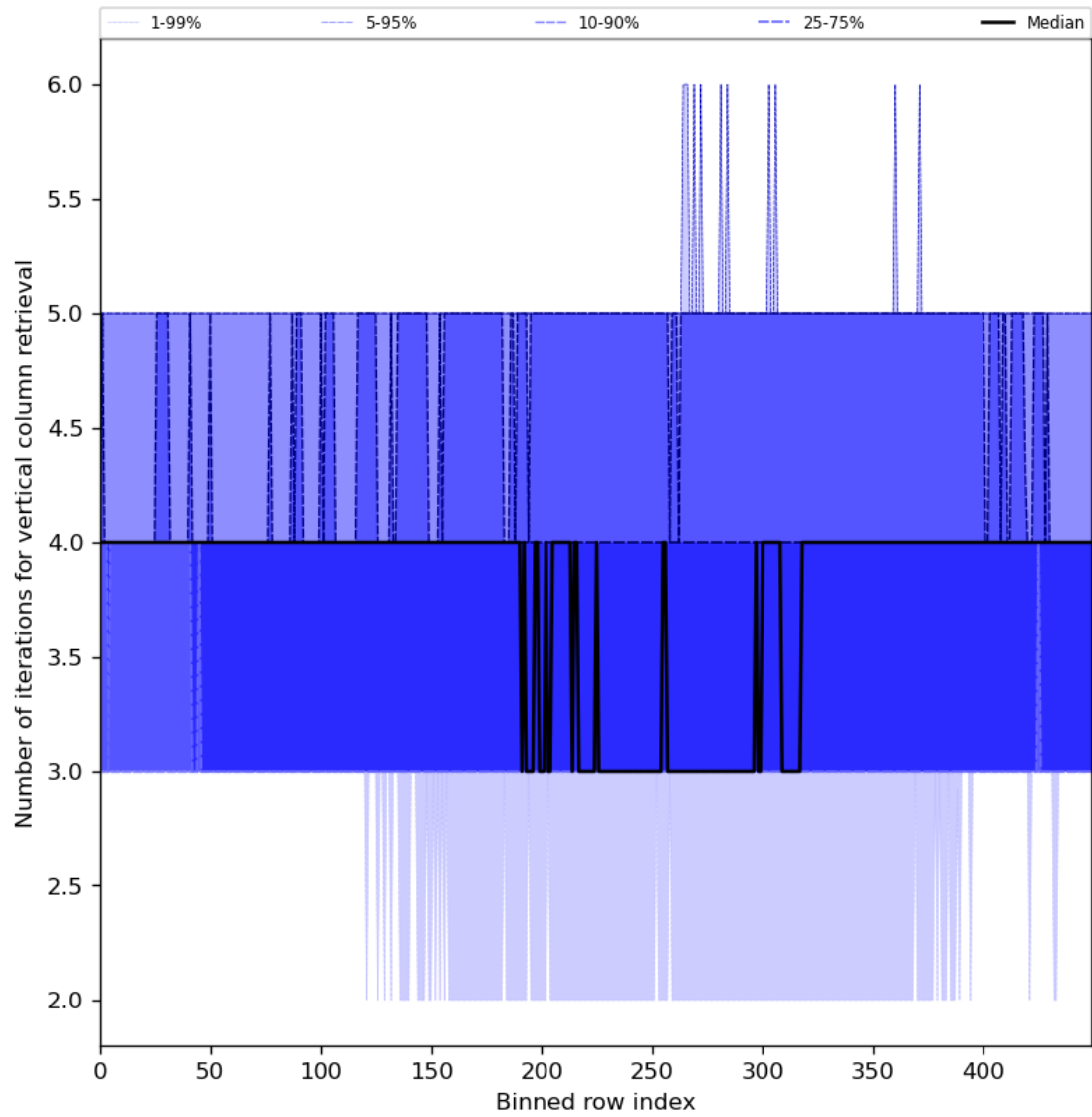


Figure 33: Along track statistics of “Number of iterations for vertical column retrieval” for 2023-11-28 to 2023-11-30

## 10 Coincidence density

To investigate the relation between parameters scatter density plots are produced. These include some ‘hidden’ parameters, latitude and the solar- and viewing geometries, in addition to all configured parameters. All combinations of pairs of parameters are included *once*, in one direction alone.

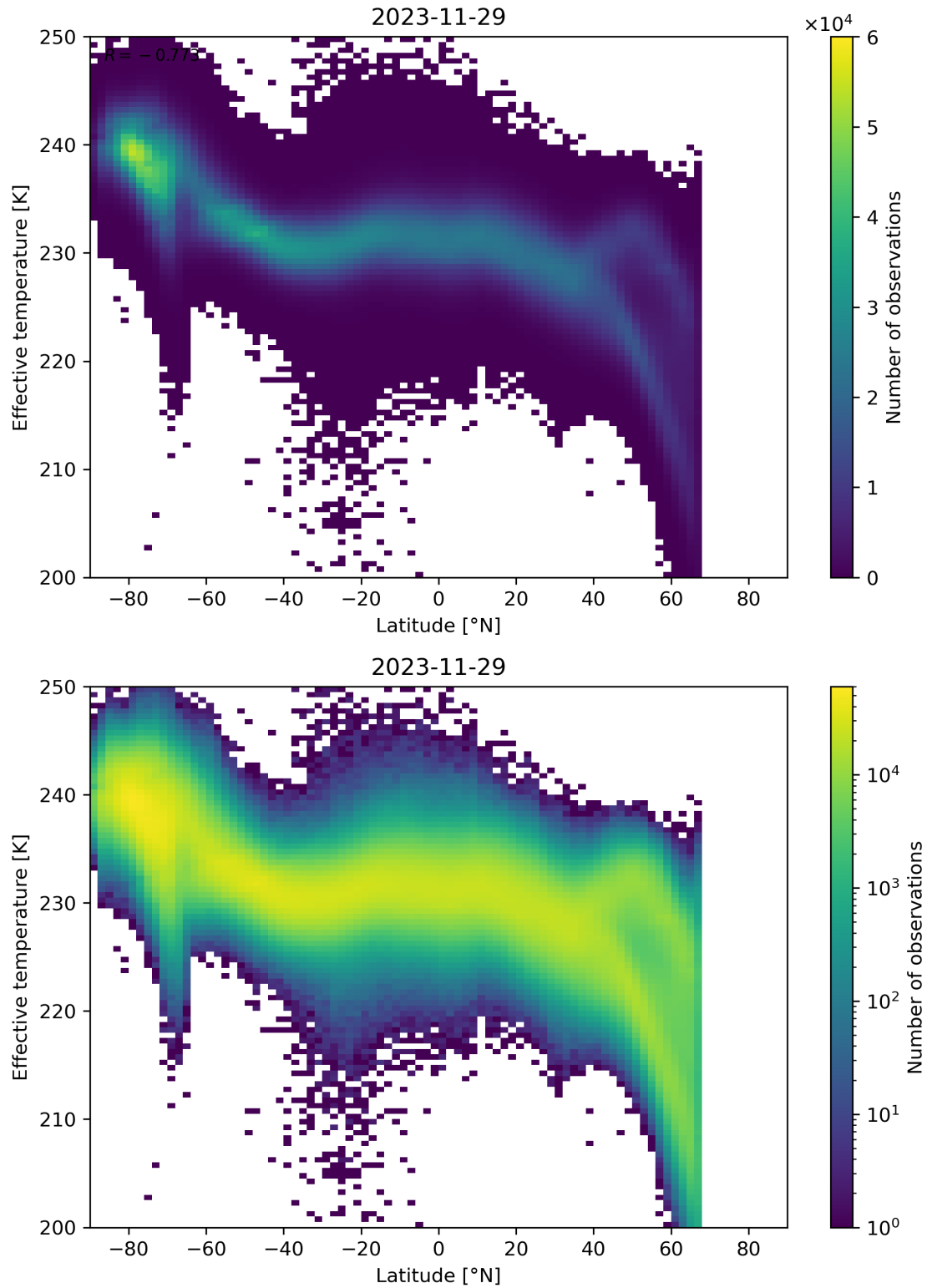


Figure 34: Scatter density plot of “Latitude” against “Effective temperature” for 2023-11-28 to 2023-11-30.

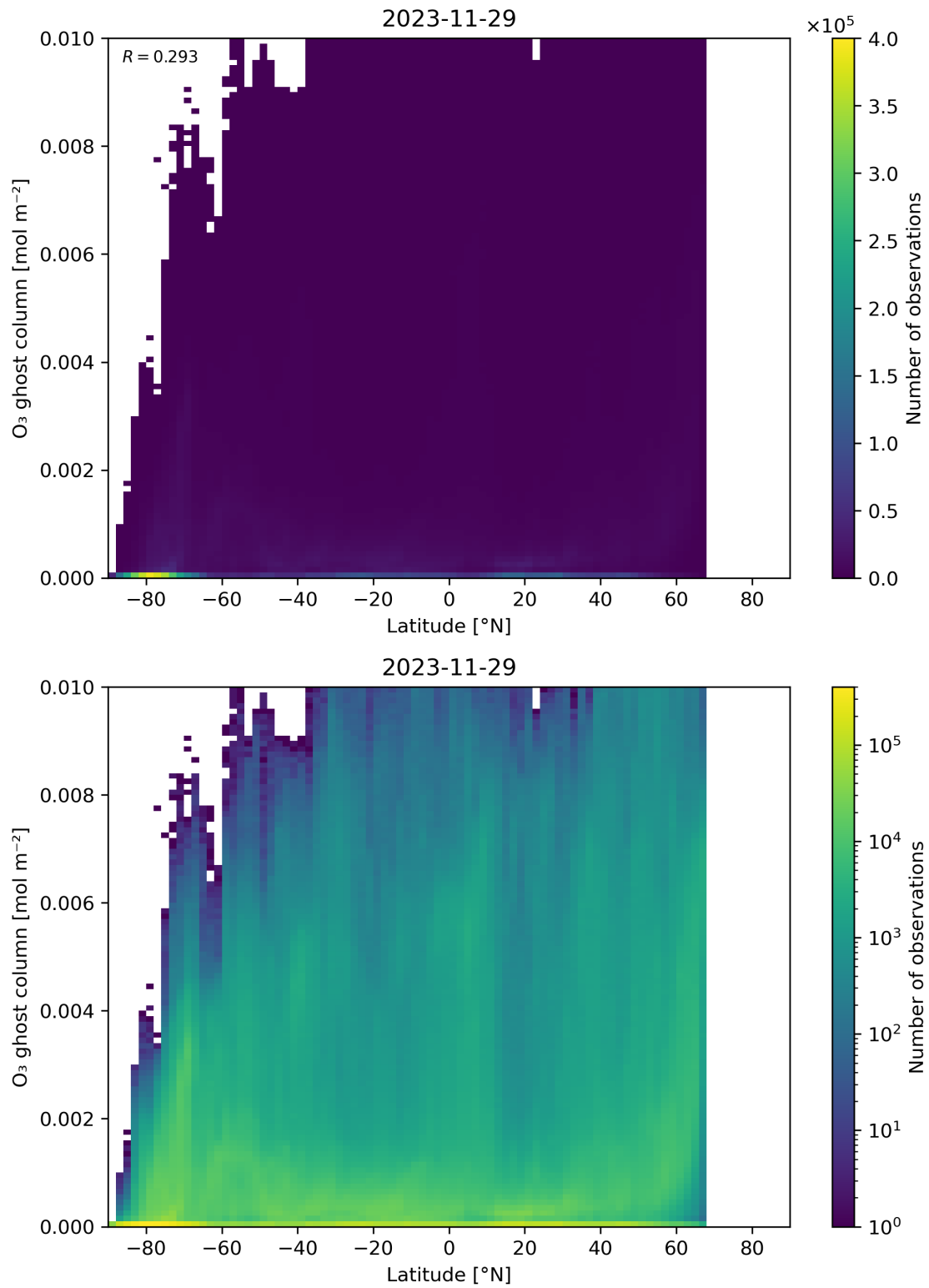


Figure 35: Scatter density plot of “Latitude” against “O<sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30.



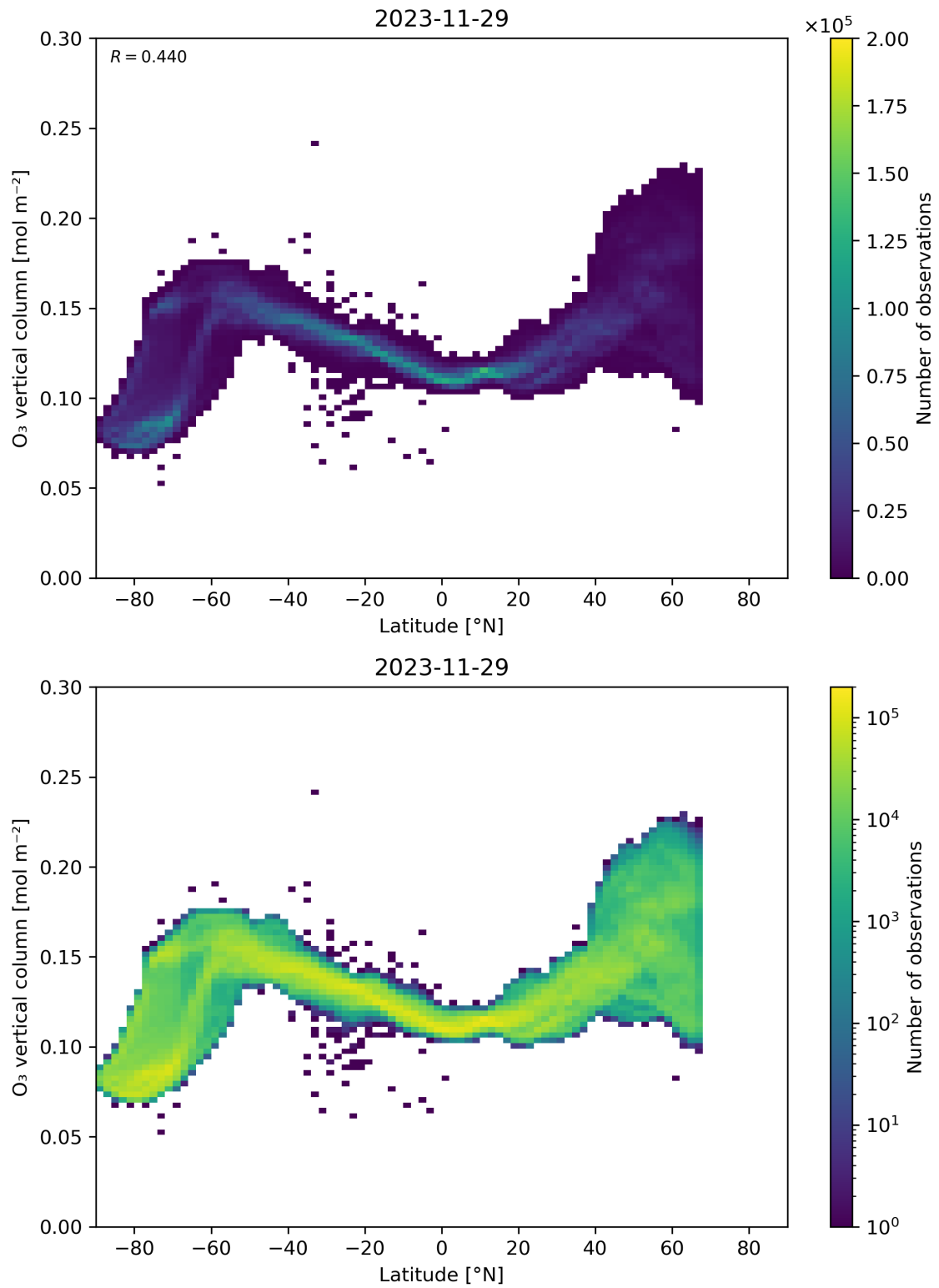


Figure 36: Scatter density plot of “Latitude” against “O<sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30.

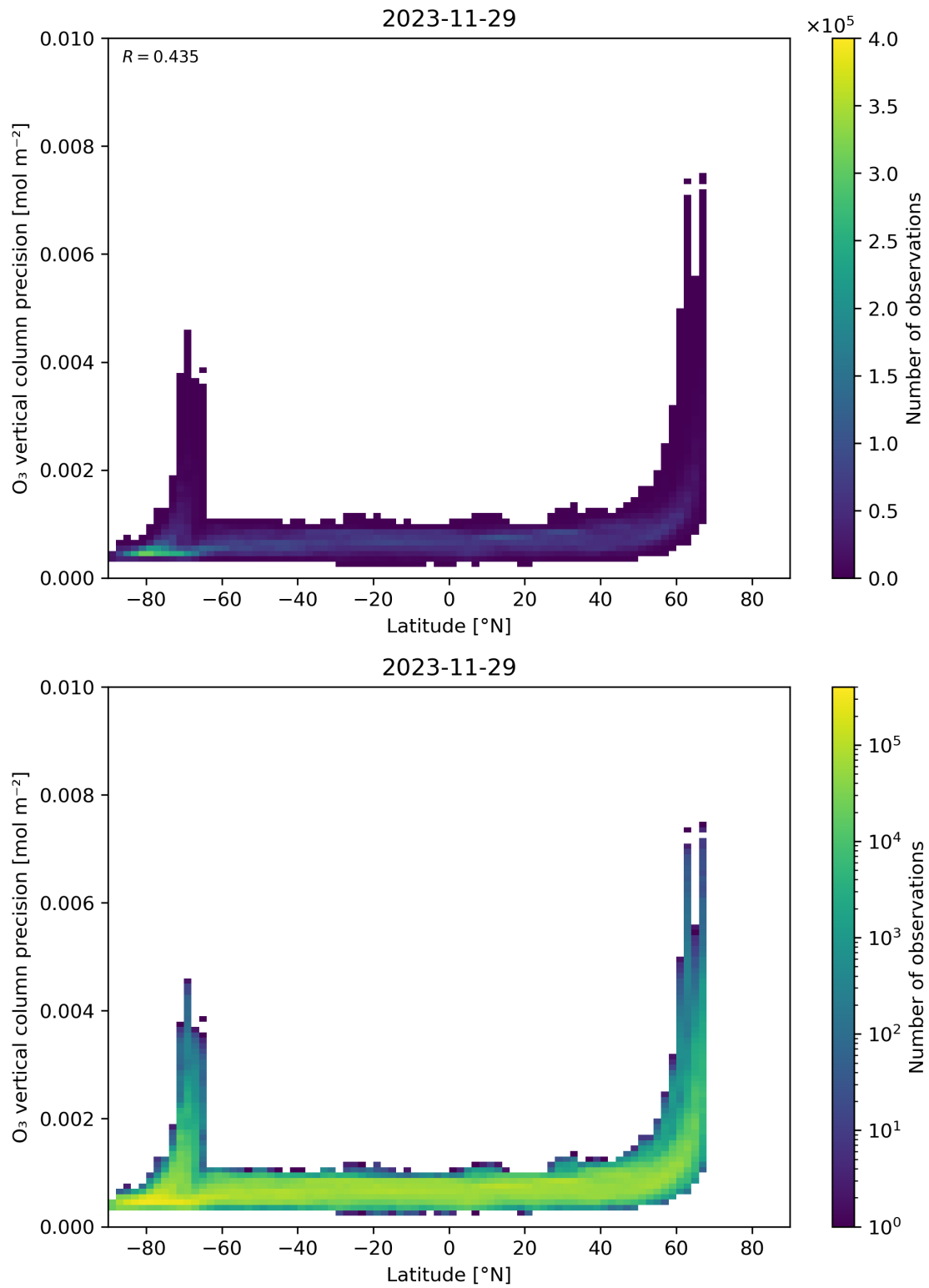


Figure 37: Scatter density plot of “Latitude” against “O<sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30.

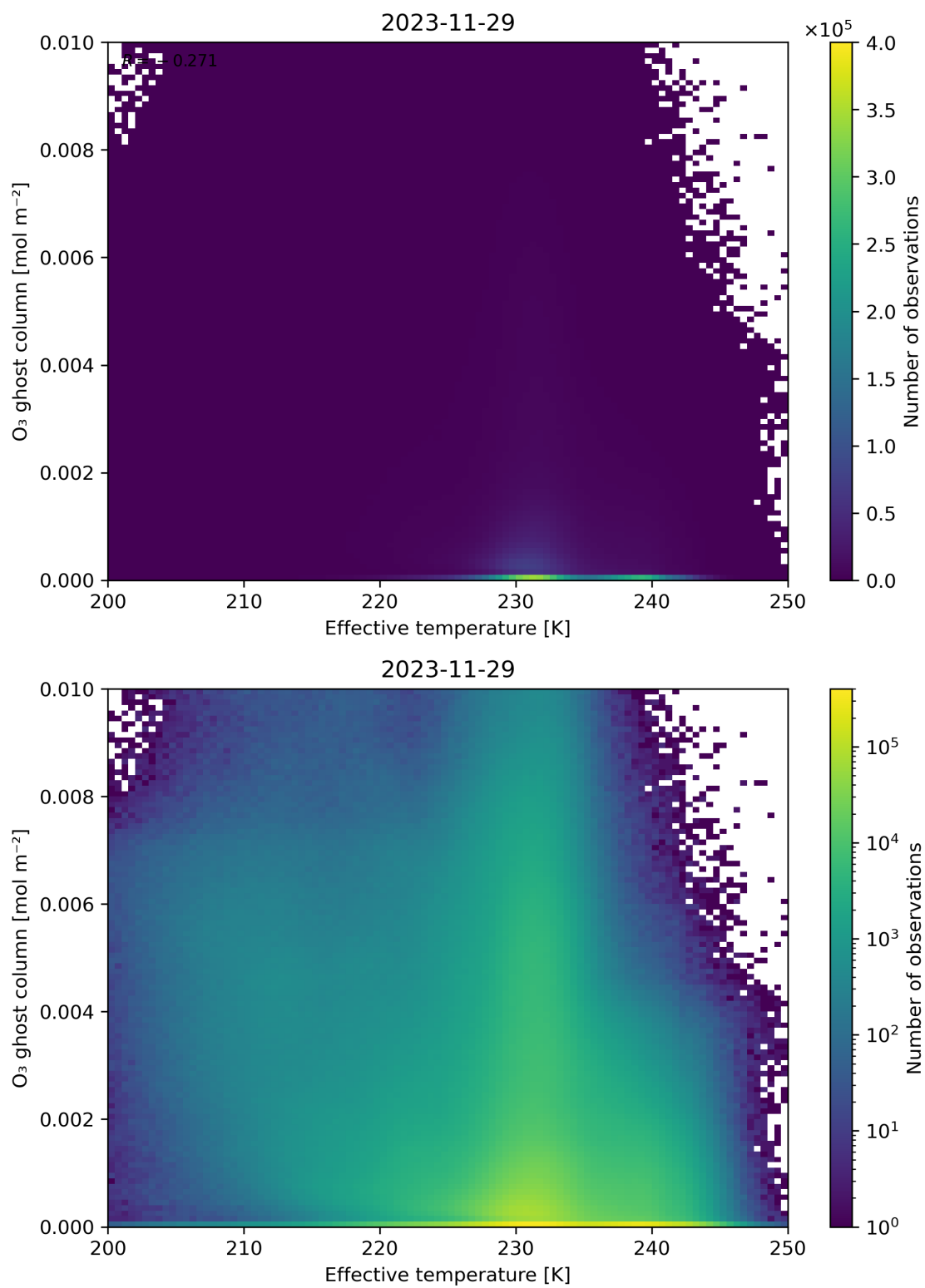


Figure 38: Scatter density plot of “Effective temperature” against “O<sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30.

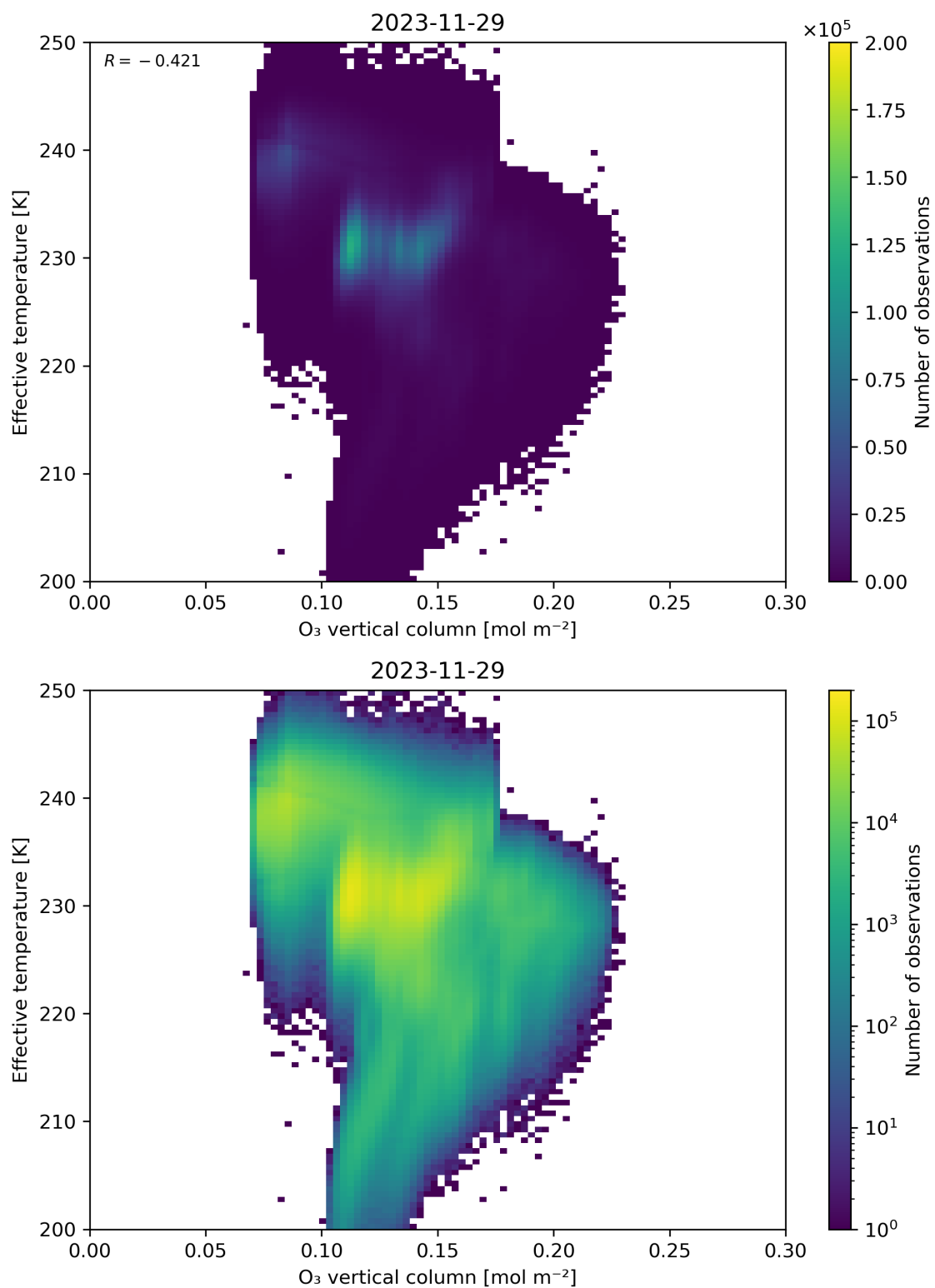


Figure 39: Scatter density plot of “O<sub>3</sub> vertical column” against “Effective temperature” for 2023-11-28 to 2023-11-30.

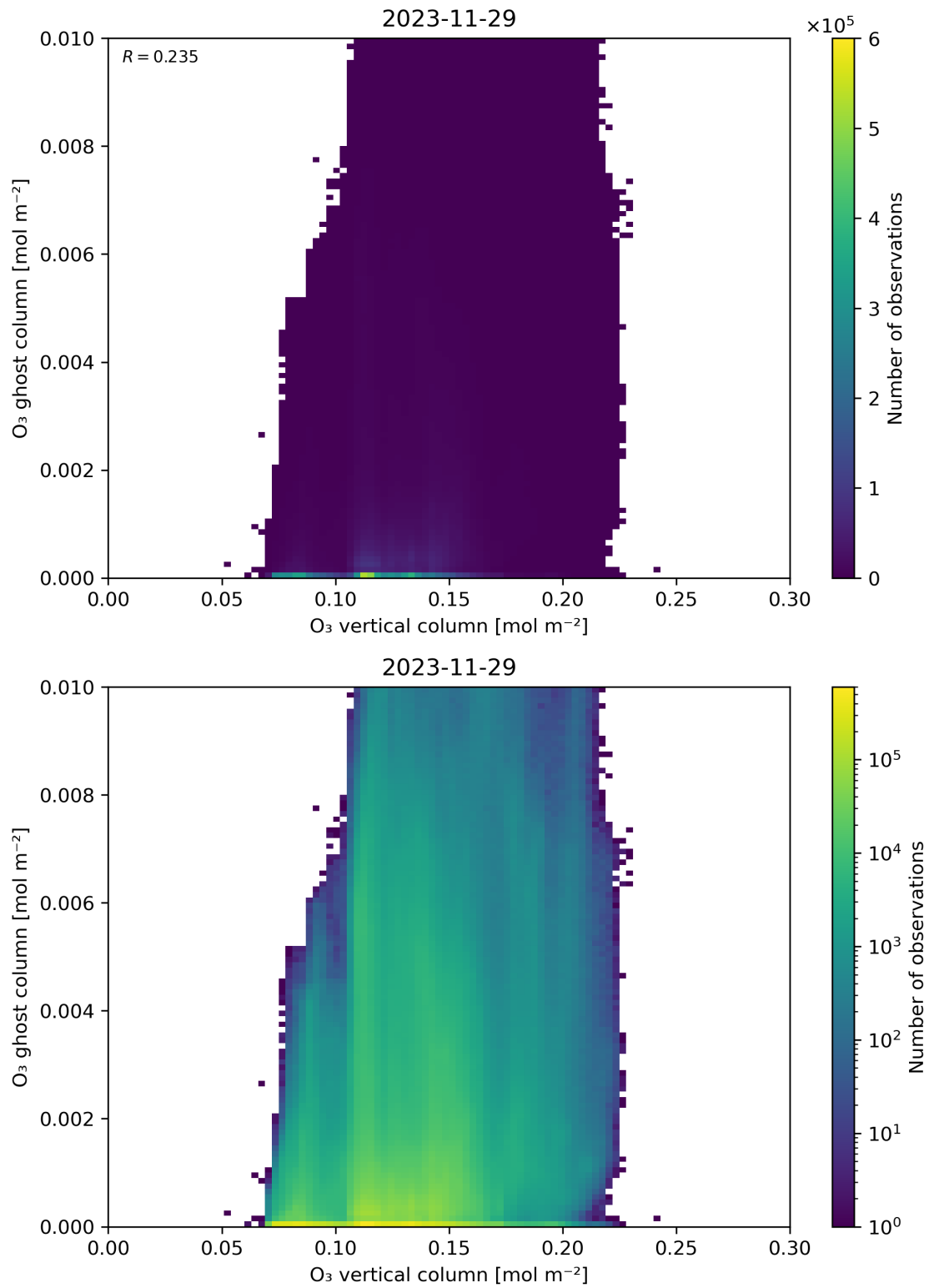


Figure 40: Scatter density plot of “O<sub>3</sub> vertical column” against “O<sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30.

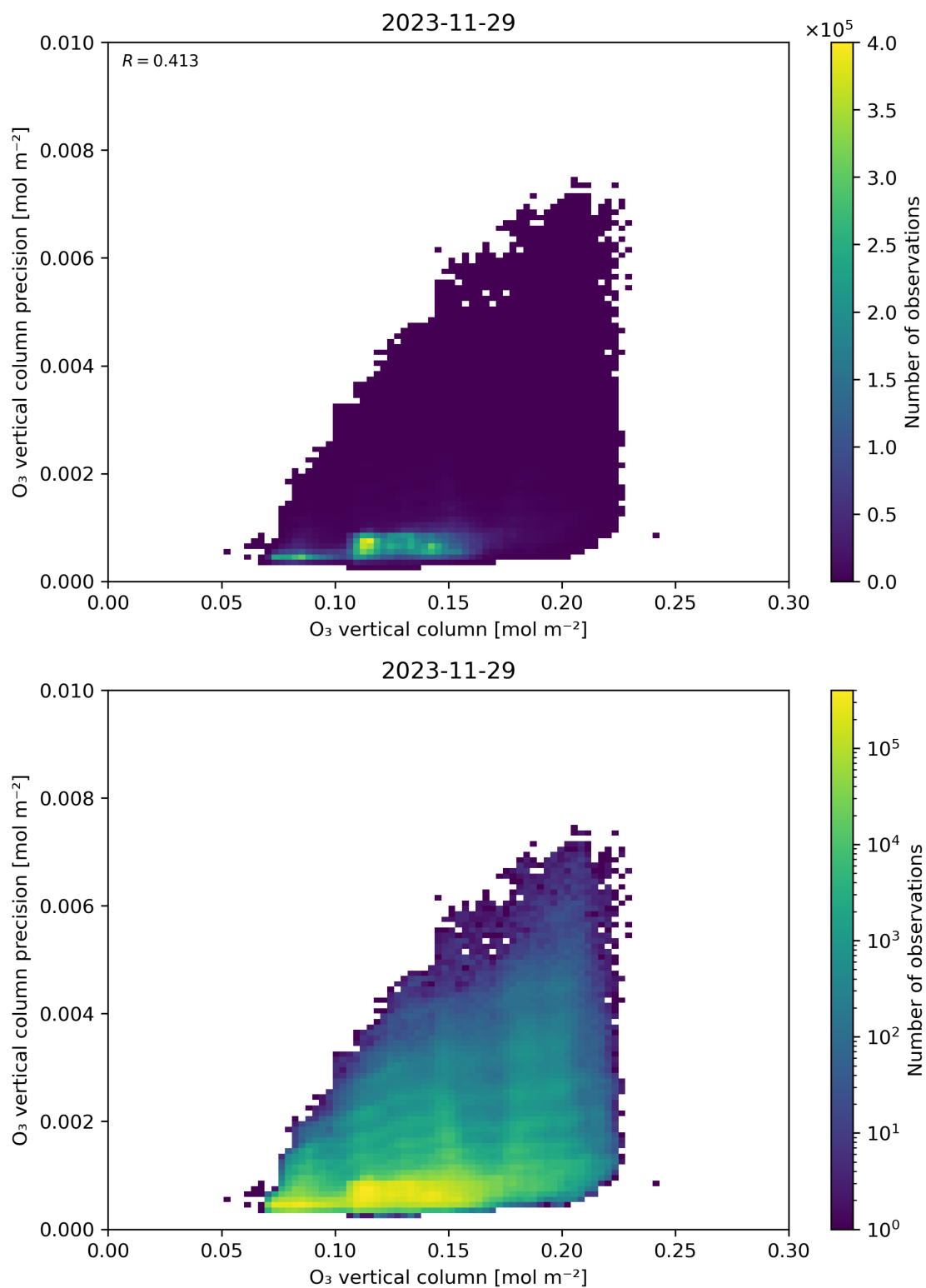


Figure 41: Scatter density plot of “O<sub>3</sub> vertical column” against “O<sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30.

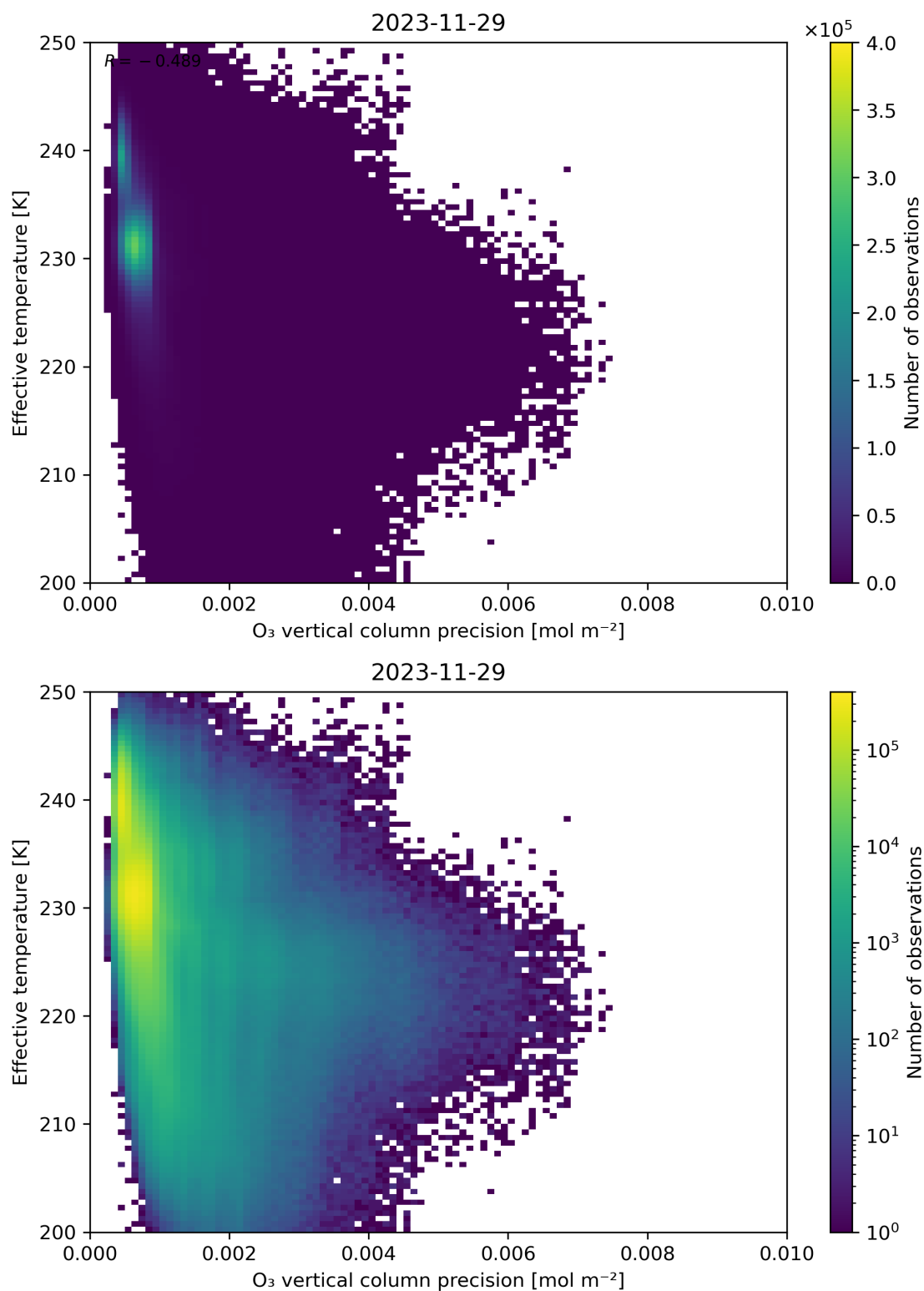


Figure 42: Scatter density plot of “O<sub>3</sub> vertical column precision” against “Effective temperature” for 2023-11-28 to 2023-11-30.

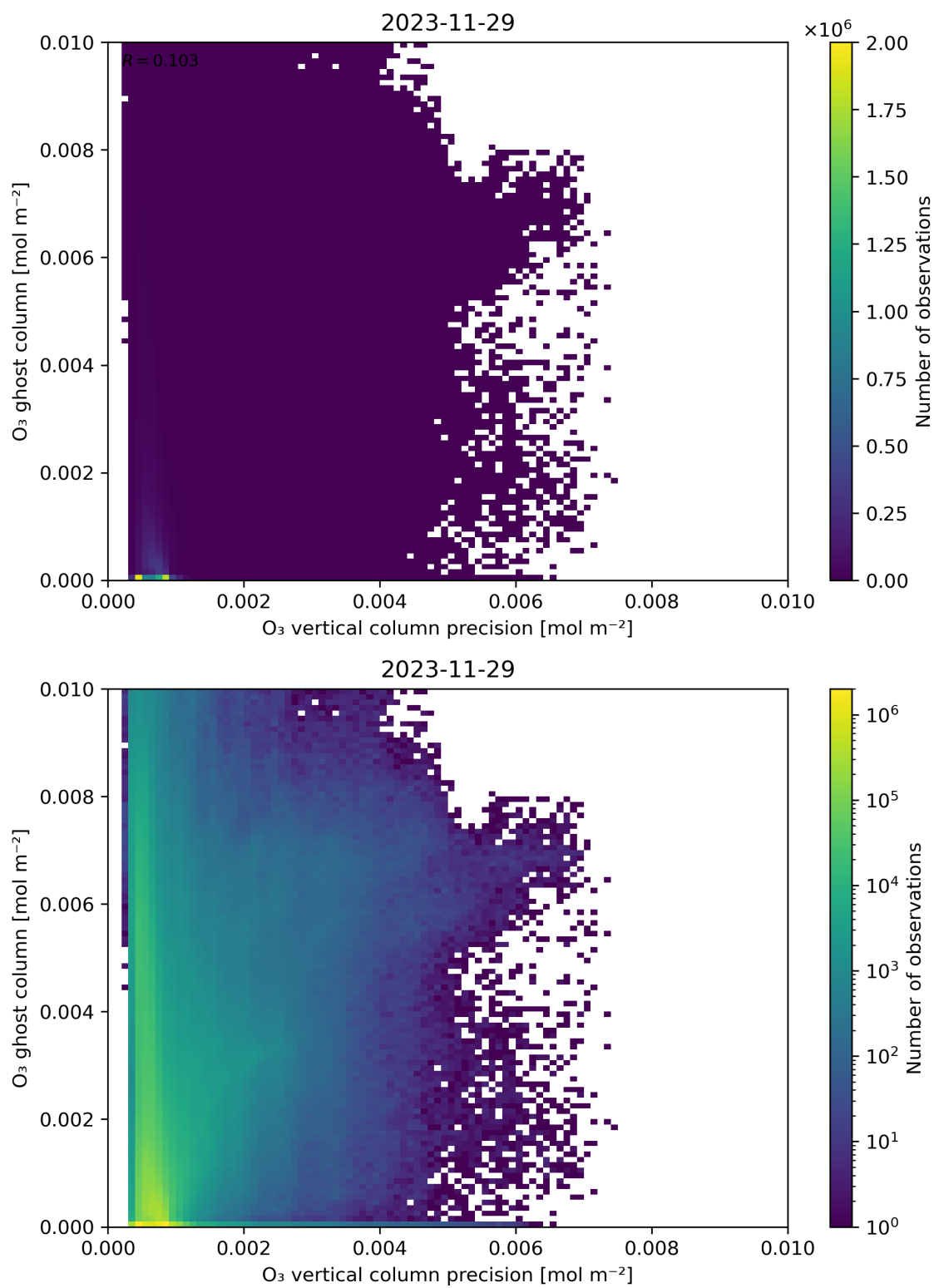


Figure 43: Scatter density plot of “ $\text{O}_3$  vertical column precision” against “ $\text{O}_3$  ghost column” for 2023-11-28 to 2023-11-30.



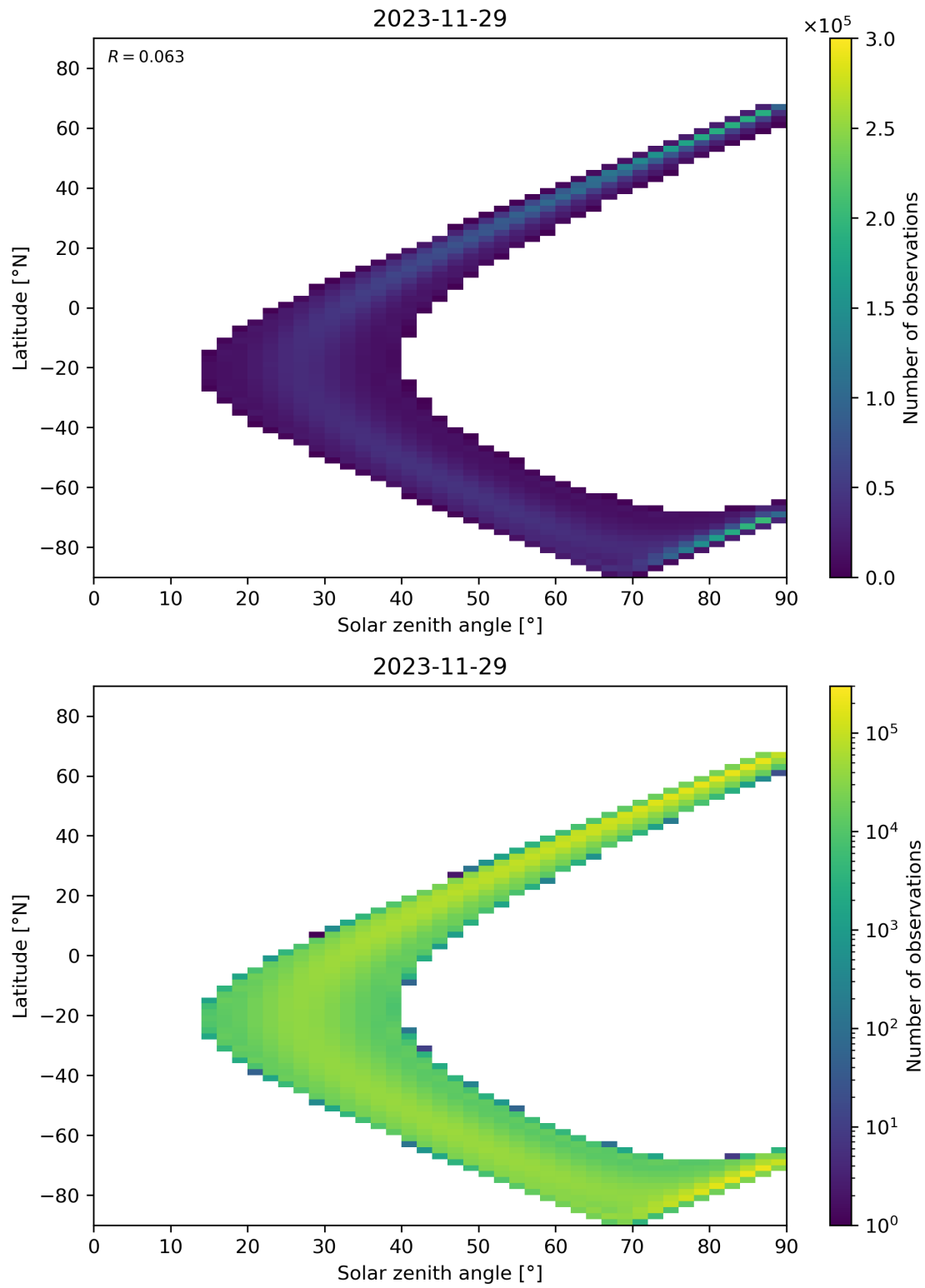


Figure 44: Scatter density plot of “Solar zenith angle” against “Latitude” for 2023-11-28 to 2023-11-30.

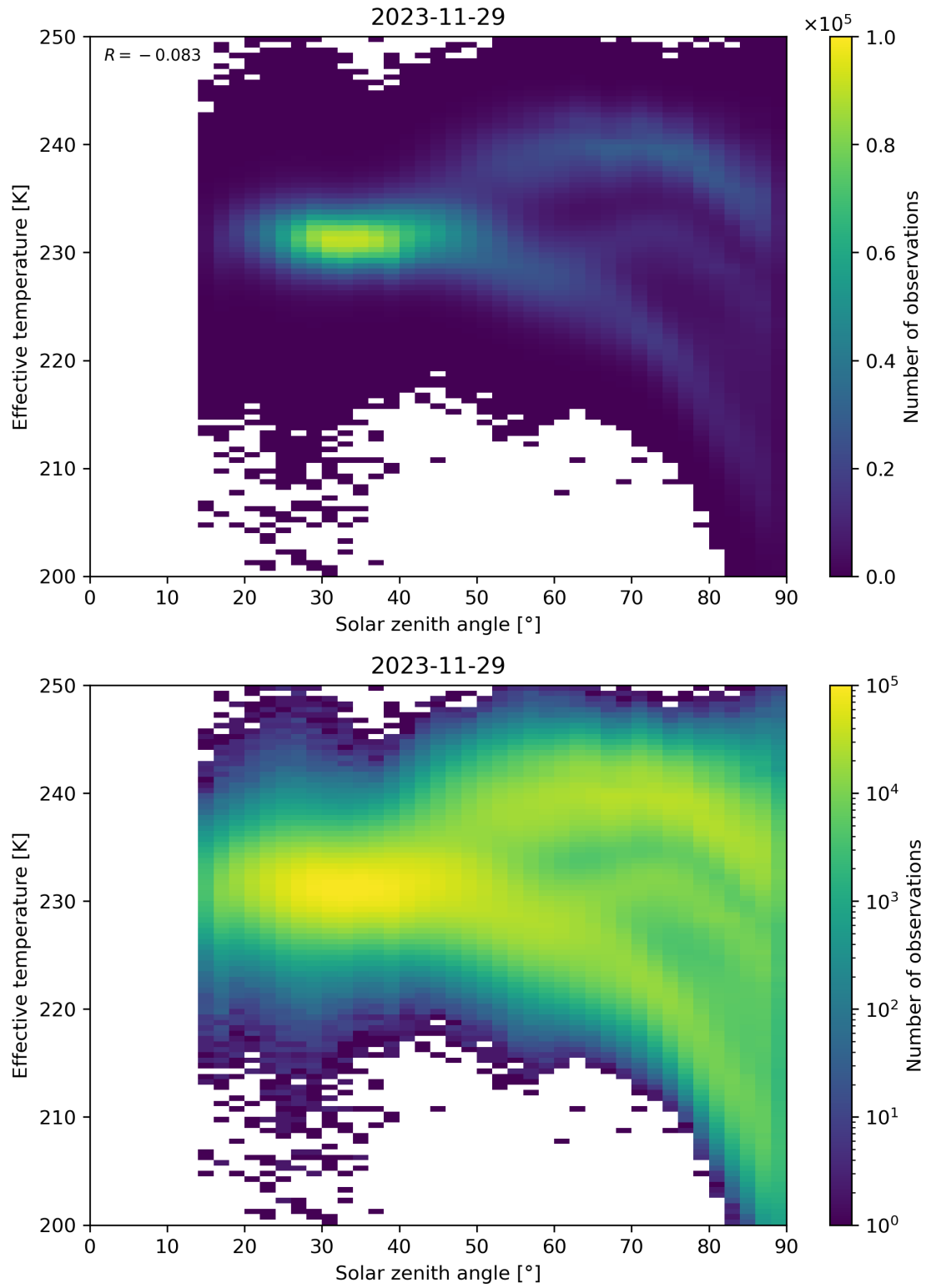


Figure 45: Scatter density plot of “Solar zenith angle” against “Effective temperature” for 2023-11-28 to 2023-11-30.

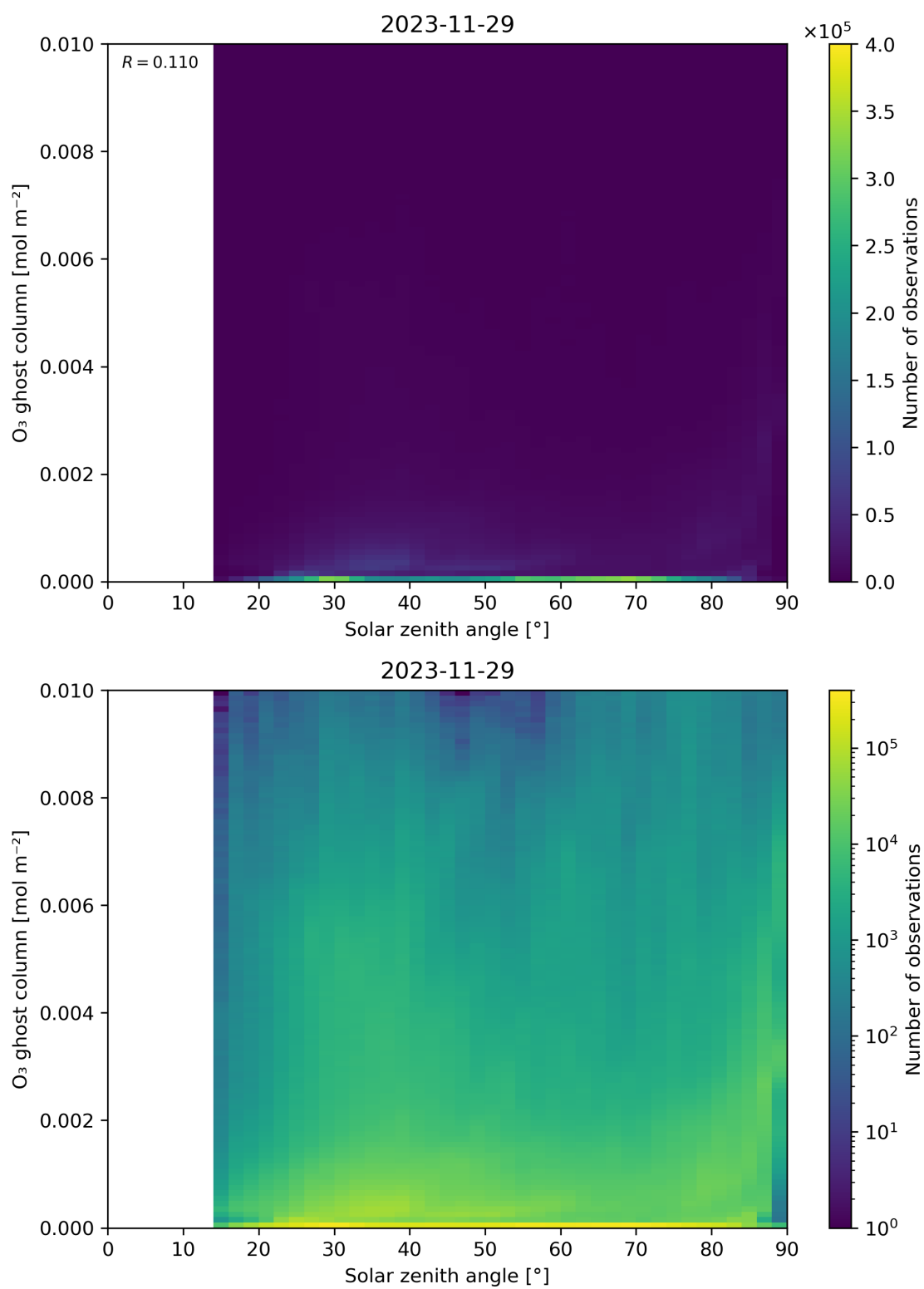


Figure 46: Scatter density plot of “Solar zenith angle” against “O<sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30.

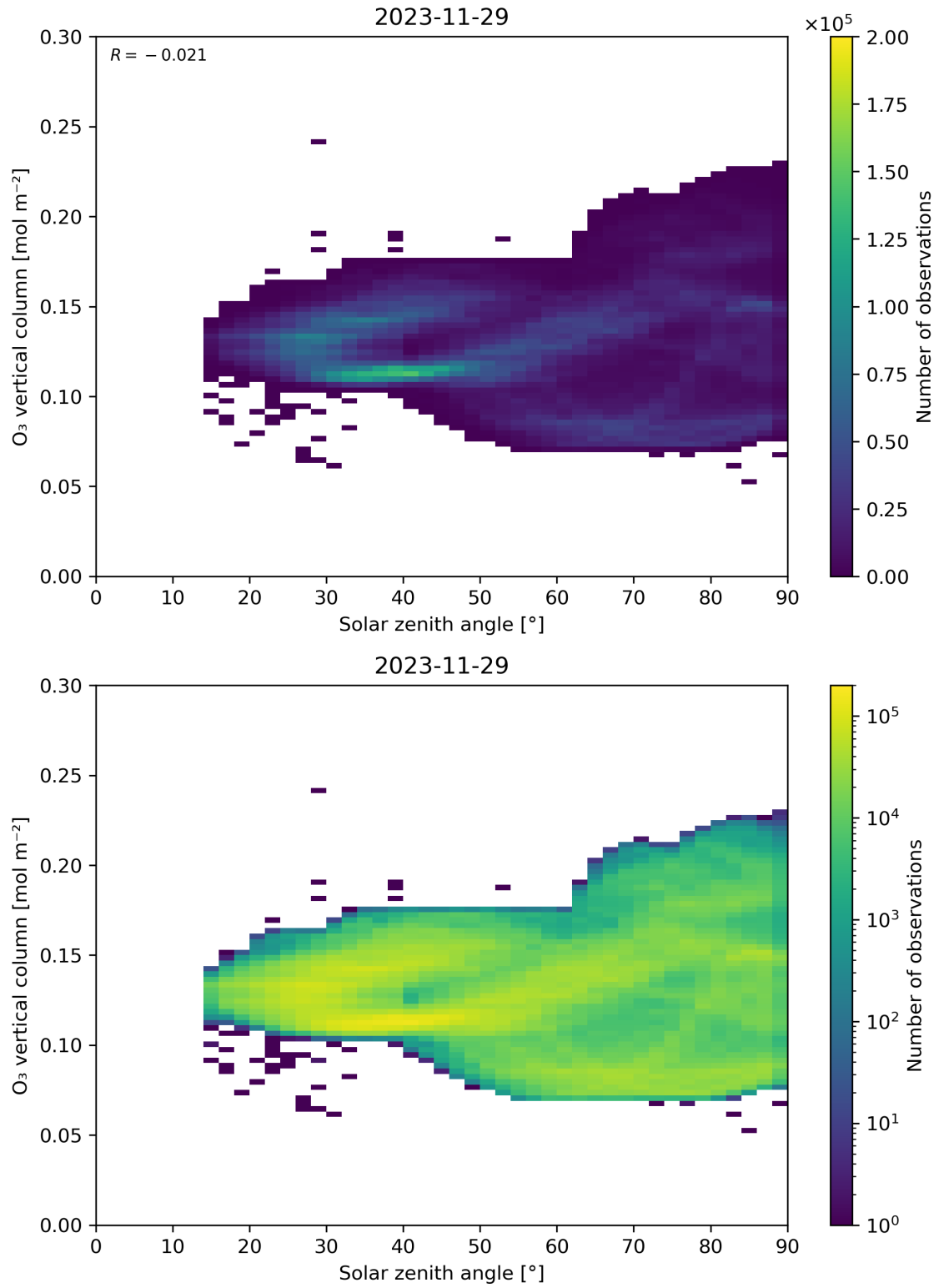


Figure 47: Scatter density plot of “Solar zenith angle” against “O<sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30.

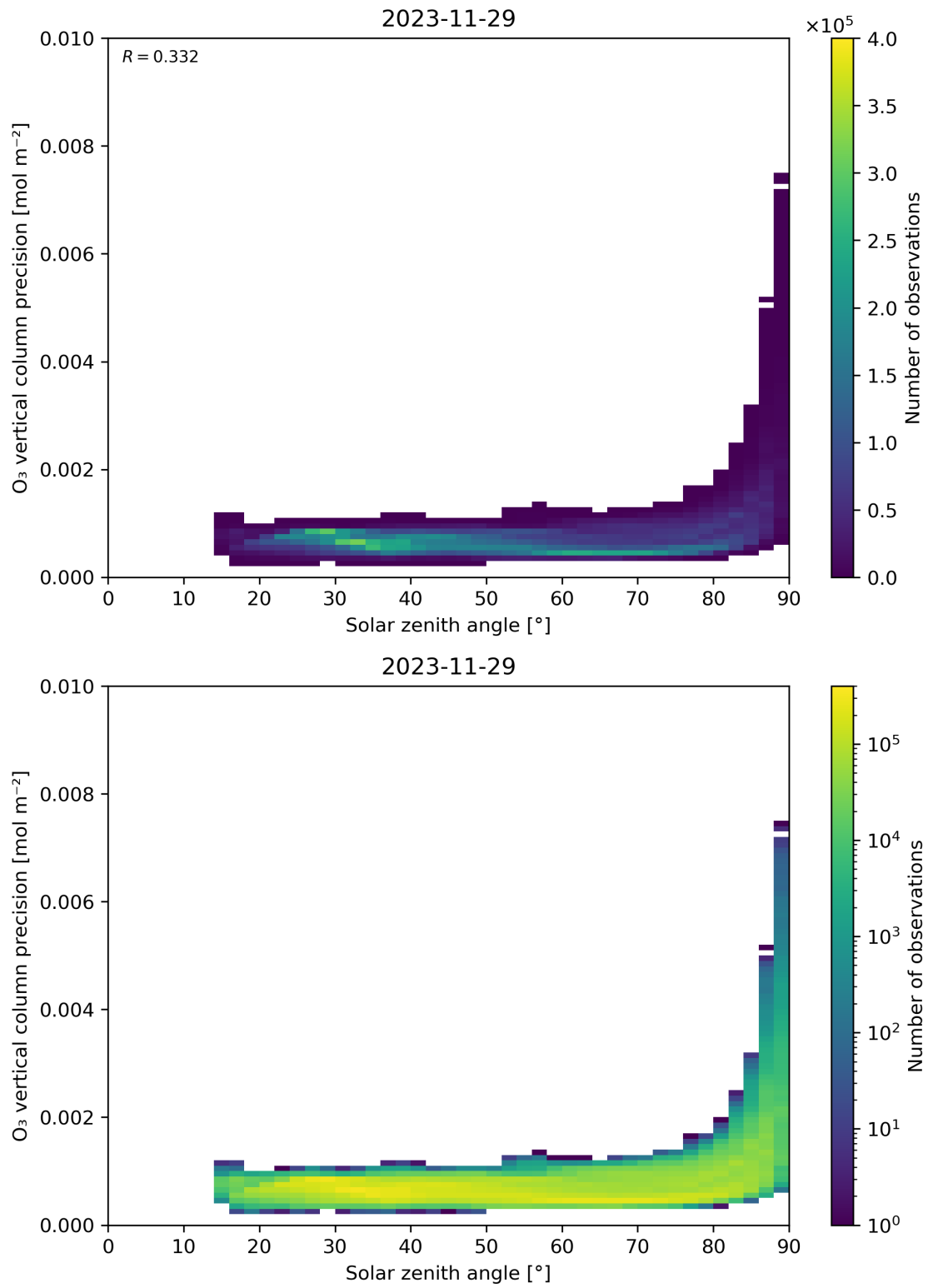


Figure 48: Scatter density plot of “Solar zenith angle” against “O<sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30.

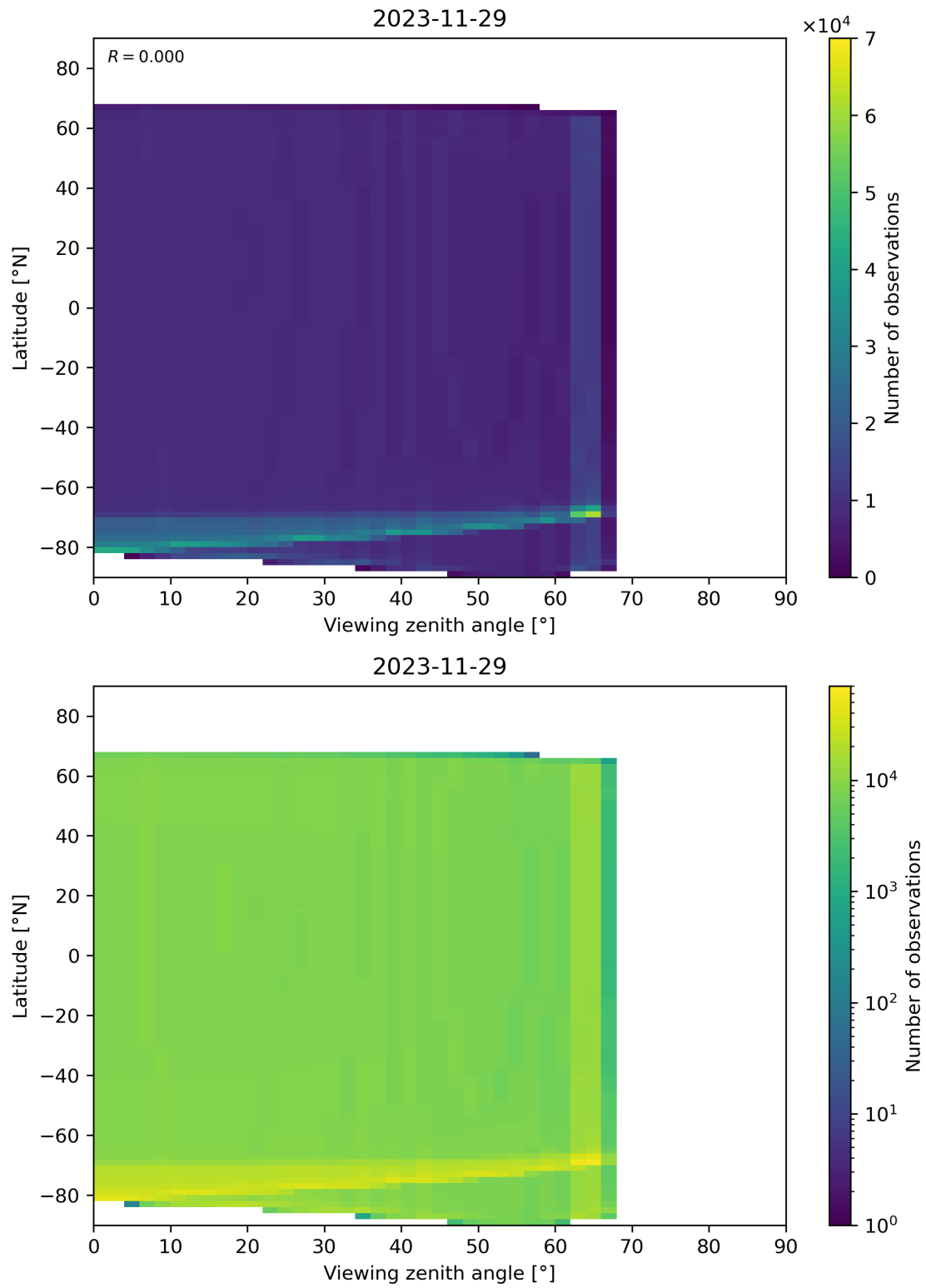


Figure 49: Scatter density plot of “Viewing zenith angle” against “Latitude” for 2023-11-28 to 2023-11-30.

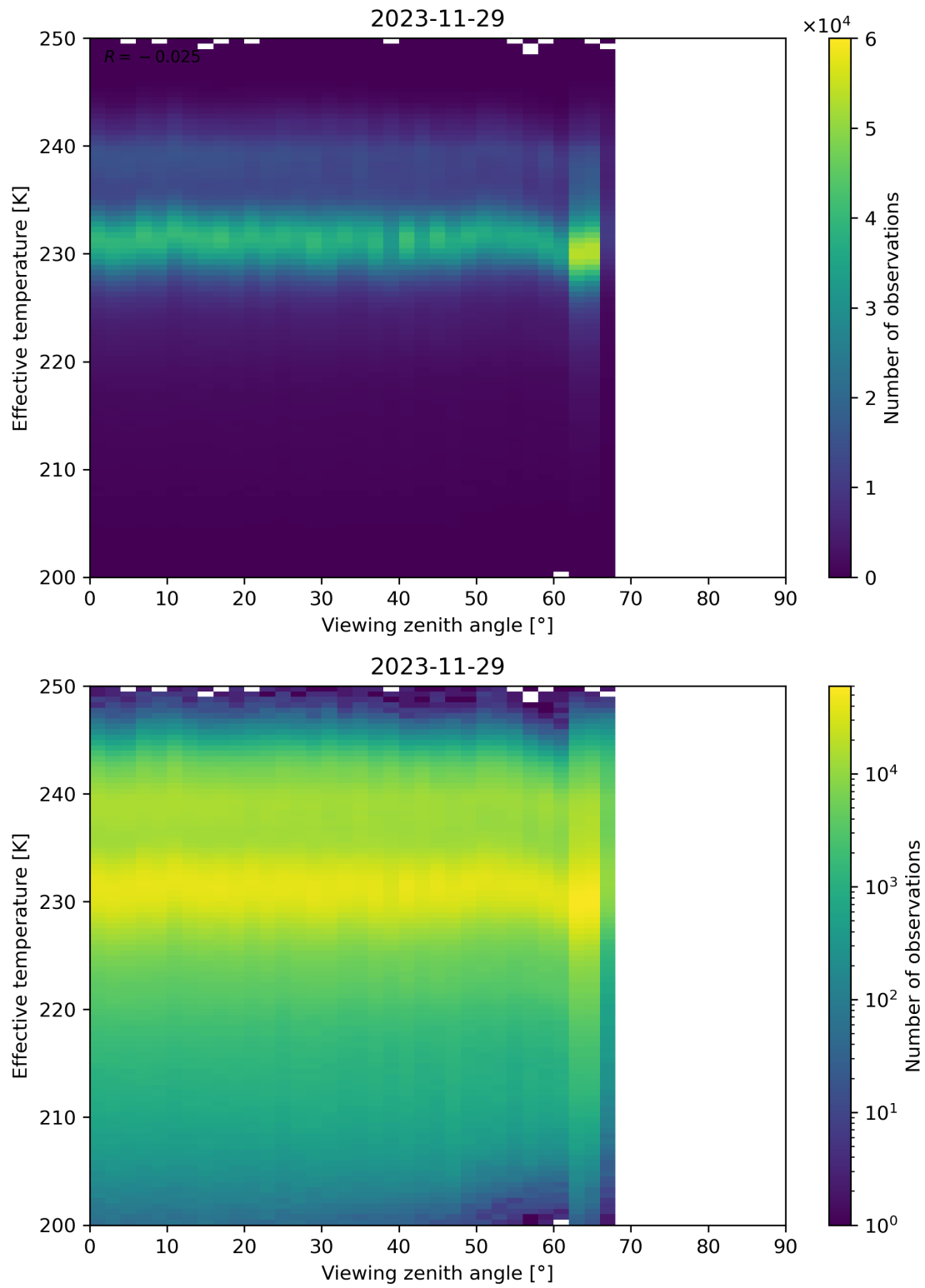


Figure 50: Scatter density plot of “Viewing zenith angle” against “Effective temperature” for 2023-11-28 to 2023-11-30.

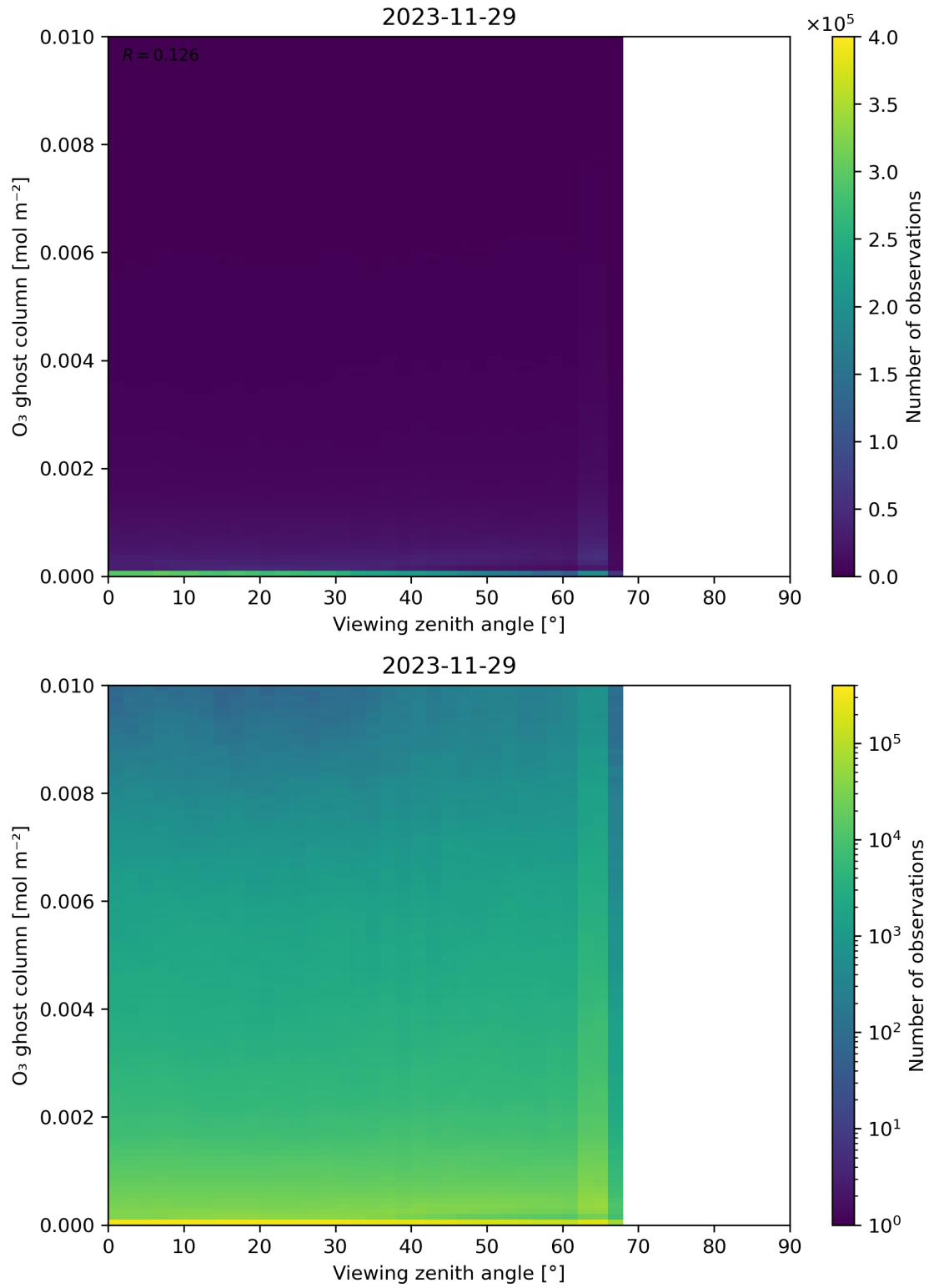


Figure 51: Scatter density plot of “Viewing zenith angle” against “O<sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30.



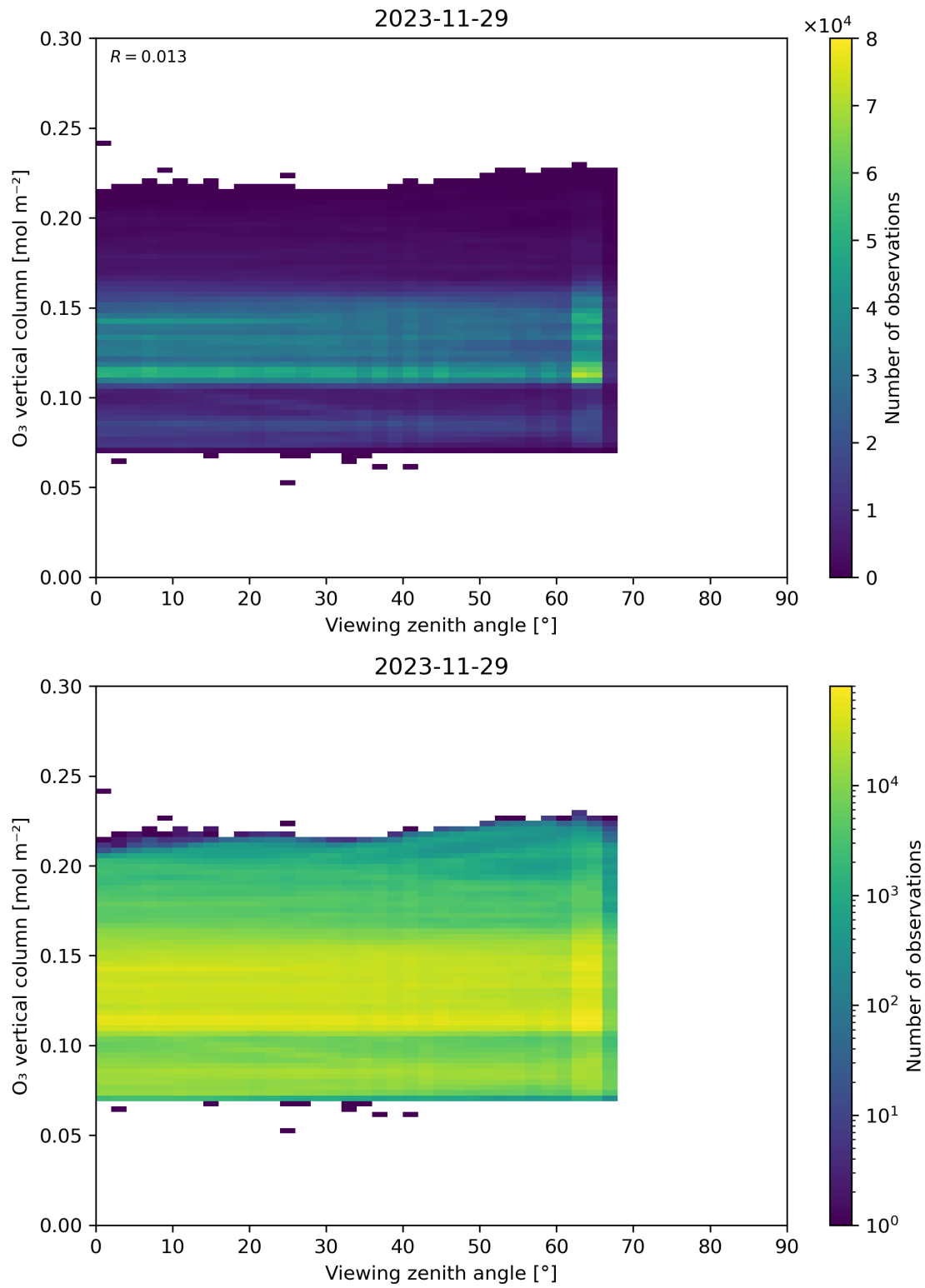


Figure 52: Scatter density plot of “Viewing zenith angle” against “O<sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30.

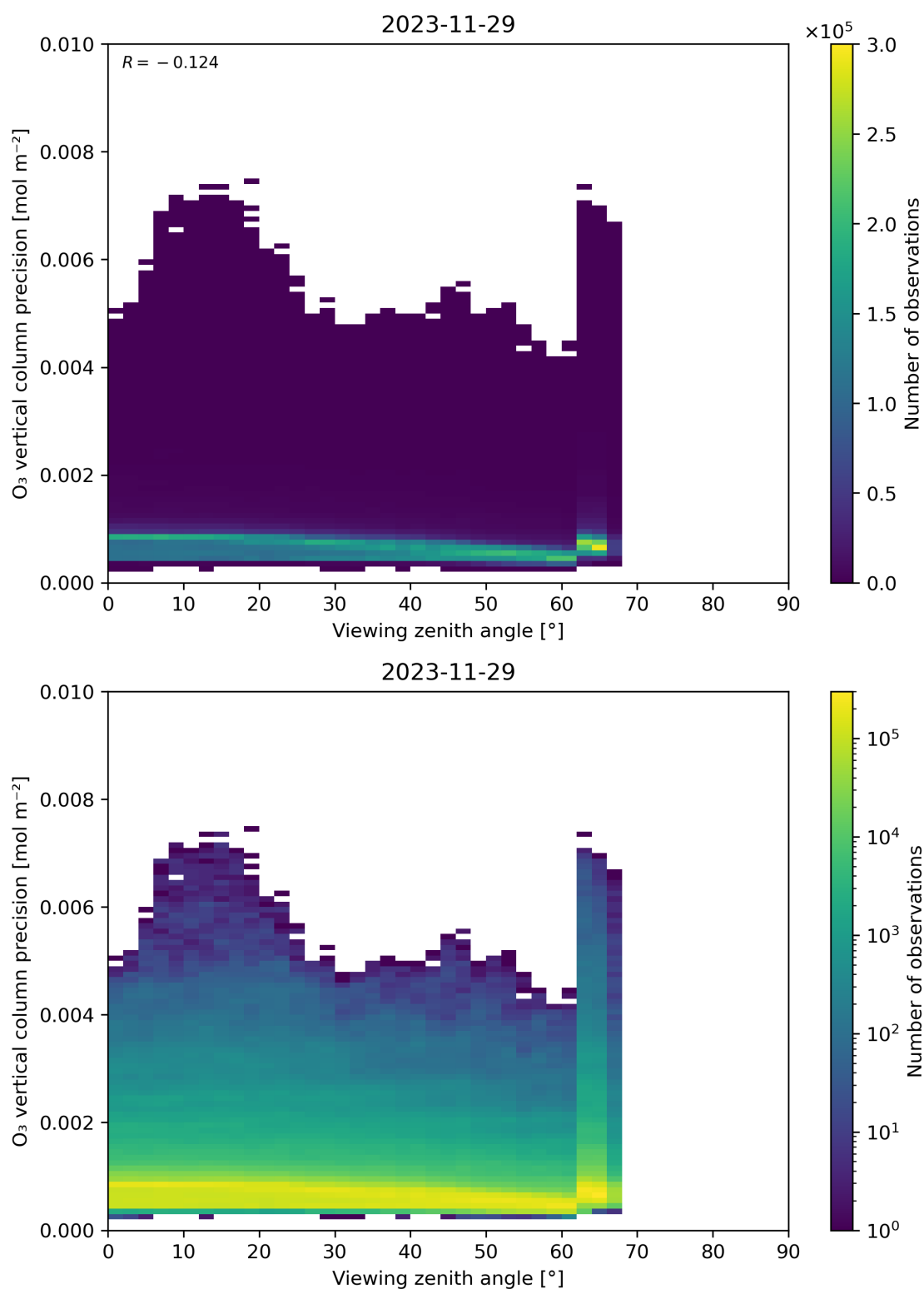


Figure 53: Scatter density plot of “Viewing zenith angle” against “O<sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30.

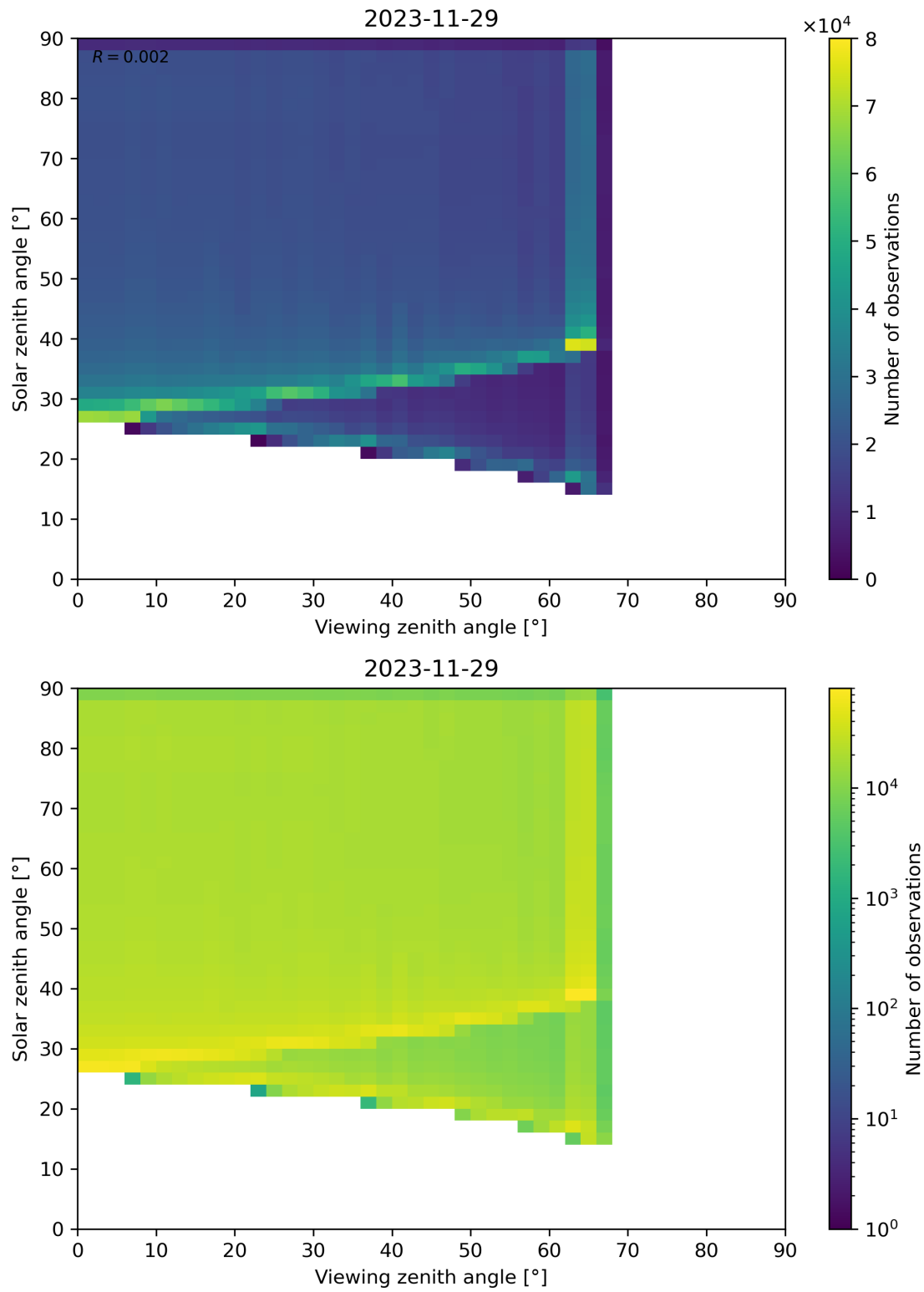


Figure 54: Scatter density plot of “Viewing zenith angle” against “Solar zenith angle” for 2023-11-28 to 2023-11-30.

# Contents

|           |                                          |           |
|-----------|------------------------------------------|-----------|
| <b>1</b>  | <b>Short Introduction</b>                | <b>1</b>  |
| 1.1       | The list of parameters . . . . .         | 1         |
| <b>2</b>  | <b>Definitions</b>                       | <b>1</b>  |
| <b>3</b>  | <b>Granule outlines</b>                  | <b>12</b> |
| <b>4</b>  | <b>Input data monitoring</b>             | <b>13</b> |
| <b>5</b>  | <b>Warnings and errors</b>               | <b>14</b> |
| <b>6</b>  | <b>World maps</b>                        | <b>15</b> |
| <b>7</b>  | <b>Zonal average</b>                     | <b>22</b> |
| <b>8</b>  | <b>Histograms</b>                        | <b>29</b> |
| <b>9</b>  | <b>Along track statistics</b>            | <b>36</b> |
| <b>10</b> | <b>Coincidence density</b>               | <b>43</b> |
| <b>11</b> | <b>Copyright information of ‘PyCAMA’</b> | <b>64</b> |

## List of Figures

|    |                                                                                                                       |    |
|----|-----------------------------------------------------------------------------------------------------------------------|----|
| 1  | Map of correlation graph for 2023-11-28 to 2023-11-30. . . . .                                                        | 10 |
| 2  | Map of correlation matrix for 2023-11-28 to 2023-11-30. . . . .                                                       | 11 |
| 3  | Outline of the granules. . . . .                                                                                      | 12 |
| 4  | Input data per granule . . . . .                                                                                      | 13 |
| 5  | Fraction of pixels with specific warnings and errors during processing . . . . .                                      | 14 |
| 6  | Map of “O <sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30 . . . . .                                        | 15 |
| 7  | Map of “O <sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30 . . . . .                              | 16 |
| 8  | Map of “Fitting RMS” for 2023-11-28 to 2023-11-30 . . . . .                                                           | 17 |
| 9  | Map of “Effective temperature” for 2023-11-28 to 2023-11-30 . . . . .                                                 | 18 |
| 10 | Map of “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30 . . . . .                                           | 19 |
| 11 | Map of “Number of iterations for vertical column retrieval” for 2023-11-28 to 2023-11-30 . . . . .                    | 20 |
| 12 | Map of the number of observations for 2023-11-28 to 2023-11-30 . . . . .                                              | 21 |
| 13 | Zonal average of “QA value” for 2023-11-28 to 2023-11-30. . . . .                                                     | 22 |
| 14 | Zonal average of “O <sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30. . . . .                               | 23 |
| 15 | Zonal average of “O <sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30. . . . .                     | 24 |
| 16 | Zonal average of “Fitting RMS” for 2023-11-28 to 2023-11-30. . . . .                                                  | 25 |
| 17 | Zonal average of “Effective temperature” for 2023-11-28 to 2023-11-30. . . . .                                        | 26 |
| 18 | Zonal average of “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30. . . . .                                  | 27 |
| 19 | Zonal average of “Number of iterations for vertical column retrieval” for 2023-11-28 to 2023-11-30. . . . .           | 28 |
| 20 | Histogram of “QA value” for 2023-11-28 to 2023-11-30 . . . . .                                                        | 29 |
| 21 | Histogram of “O <sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30 . . . . .                                  | 30 |
| 22 | Histogram of “O <sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30 . . . . .                        | 31 |
| 23 | Histogram of “Fitting RMS” for 2023-11-28 to 2023-11-30 . . . . .                                                     | 32 |
| 24 | Histogram of “Effective temperature” for 2023-11-28 to 2023-11-30 . . . . .                                           | 33 |
| 25 | Histogram of “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30 . . . . .                                     | 34 |
| 26 | Histogram of “Number of iterations for vertical column retrieval” for 2023-11-28 to 2023-11-30 . . . . .              | 35 |
| 27 | Along track statistics of “QA value” for 2023-11-28 to 2023-11-30 . . . . .                                           | 36 |
| 28 | Along track statistics of “O <sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30 . . . . .                     | 37 |
| 29 | Along track statistics of “O <sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30 . . . . .           | 38 |
| 30 | Along track statistics of “Fitting RMS” for 2023-11-28 to 2023-11-30 . . . . .                                        | 39 |
| 31 | Along track statistics of “Effective temperature” for 2023-11-28 to 2023-11-30 . . . . .                              | 40 |
| 32 | Along track statistics of “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30 . . . . .                        | 41 |
| 33 | Along track statistics of “Number of iterations for vertical column retrieval” for 2023-11-28 to 2023-11-30 . . . . . | 42 |
| 34 | Scatter density plot of “Latitude” against “Effective temperature” for 2023-11-28 to 2023-11-30. . . . .              | 43 |
| 35 | Scatter density plot of “Latitude” against “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30. . . . .        | 44 |
| 36 | Scatter density plot of “Latitude” against “O <sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30. . . . .     | 45 |

|    |                                                                                                                                                   |    |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------|----|
| 37 | Scatter density plot of “Latitude” against “O <sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30. . .                           | 46 |
| 38 | Scatter density plot of “Effective temperature” against “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30. . .                           | 47 |
| 39 | Scatter density plot of “O <sub>3</sub> vertical column” against “Effective temperature” for 2023-11-28 to 2023-11-30. . .                        | 48 |
| 40 | Scatter density plot of “O <sub>3</sub> vertical column” against “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30. . . .                | 49 |
| 41 | Scatter density plot of “O <sub>3</sub> vertical column” against “O <sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30. . . . . | 50 |
| 42 | Scatter density plot of “O <sub>3</sub> vertical column precision” against “Effective temperature” for 2023-11-28 to 2023-11-30. . . . .          | 51 |
| 43 | Scatter density plot of “O <sub>3</sub> vertical column precision” against “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30. . . . .    | 52 |
| 44 | Scatter density plot of “Solar zenith angle” against “Latitude” for 2023-11-28 to 2023-11-30. . . . .                                             | 53 |
| 45 | Scatter density plot of “Solar zenith angle” against “Effective temperature” for 2023-11-28 to 2023-11-30. . .                                    | 54 |
| 46 | Scatter density plot of “Solar zenith angle” against “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30. . . .                            | 55 |
| 47 | Scatter density plot of “Solar zenith angle” against “O <sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30. . .                           | 56 |
| 48 | Scatter density plot of “Solar zenith angle” against “O <sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30. . . . .             | 57 |
| 49 | Scatter density plot of “Viewing zenith angle” against “Latitude” for 2023-11-28 to 2023-11-30. . . . .                                           | 58 |
| 50 | Scatter density plot of “Viewing zenith angle” against “Effective temperature” for 2023-11-28 to 2023-11-30. . .                                  | 59 |
| 51 | Scatter density plot of “Viewing zenith angle” against “O <sub>3</sub> ghost column” for 2023-11-28 to 2023-11-30. . .                            | 60 |
| 52 | Scatter density plot of “Viewing zenith angle” against “O <sub>3</sub> vertical column” for 2023-11-28 to 2023-11-30. . .                         | 61 |
| 53 | Scatter density plot of “Viewing zenith angle” against “O <sub>3</sub> vertical column precision” for 2023-11-28 to 2023-11-30. . . . .           | 62 |
| 54 | Scatter density plot of “Viewing zenith angle” against “Solar zenith angle” for 2023-11-28 to 2023-11-30. . .                                     | 63 |

## List of Tables

|   |                                                                                                           |   |
|---|-----------------------------------------------------------------------------------------------------------|---|
| 1 | Parameterlist and basic statistics for the analysis . . . . .                                             | 2 |
| 2 | Percentile ranges . . . . .                                                                               | 3 |
| 3 | Parameterlist and basic statistics for the analysis for observations in the northern hemisphere . . . . . | 4 |
| 4 | Parameterlist and basic statistics for the analysis for observations in the southern hemisphere . . . . . | 5 |
| 5 | Parameterlist and basic statistics for the analysis for observations over water . . . . .                 | 6 |
| 6 | Parameterlist and basic statistics for the analysis for observations over land . . . . .                  | 7 |
| 7 | Correlation matrix . . . . .                                                                              | 8 |
| 8 | Covariance matrix . . . . .                                                                               | 9 |

## 11 Copyright information of ‘PyCAMA’

Copyright © 2005 – 2023, Maarten Sneep (KNMI).

All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. Neither the name of the copyright holder nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

*This software is provided by the copyright holders and contributors “as is” and any express or implied warranties, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose are disclaimed. In no event shall the copyright holder or contributors be liable for any direct, indirect, incidental, special, exemplary, or consequential damages (including, but not limited to, procurement of substitute goods or services; loss of use, data, or profits; or business interruption) however caused and on any theory of liability, whether in contract, strict liability, or tort (including negligence or otherwise) arising in any way out of the use of this software, even if advised of the possibility of such damage.*

Maarten Sneep (maarten.sneep@knmi.nl).