

# PyCAMA report generated by tropl2-proc

tropl2-proc

2025-02-10 (02:31)

## 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]                                                 | $0.596 \pm 0.293$                  | 7147247 | 0.705                  | 0.300                  | 0.700                  | 0.0     | 1.000                  |
| carbonmonoxide total column [mol m <sup>-2</sup> ]           | $(2.431 \pm 1.164) \times 10^{-2}$ | 7147247 | $1.330 \times 10^{-2}$ | $1.949 \times 10^{-2}$ | $2.445 \times 10^{-2}$ | 0.0     | 0.358                  |
| carbonmonoxide total column precision [mol m <sup>-2</sup> ] | $(1.050 \pm 0.557) \times 10^{-3}$ | 7147247 | $6.650 \times 10^{-4}$ | $6.187 \times 10^{-4}$ | $8.957 \times 10^{-4}$ | 0.0     | $3.662 \times 10^{-2}$ |
| number of spectral points in retrieval [1]                   | $154 \pm 1$                        | 7147247 | 155                    | 2.00                   | 154                    | 107     | 156                    |
| chi square [1]                                               | $(0.179 \pm 1.145) \times 10^4$    | 7147247 | 518                    | $1.427 \times 10^3$    | $1.234 \times 10^3$    | 193     | $6.304 \times 10^6$    |
| degrees of freedom [1]                                       | $7.40 \pm 0.51$                    | 7147247 | 7.95                   | 0.896                  | 7.42                   | 4.00    | 8.00                   |
| number of iterations [1]                                     | $8.51 \pm 1.28$                    | 7147247 | 8.17                   | 1.000                  | 8.00                   | 5.00    | 15.0                   |

| Table 2: Percentile ranges                                   |                        |                        |                        |                        |                        |                        |                        |                        |                        |                        |
|--------------------------------------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Variable                                                     | 1 %                    | 5 %                    | 10 %                   | 15.9 %                 | 25 %                   | 75 %                   | 84.1 %                 | 90 %                   | 95 %                   | 99 %                   |
| qa value [1]                                                 | 0.0                    | 0.0                    | 0.0                    | 0.400                  | 0.400                  | 0.700                  | 0.700                  | 1.000                  | 1.000                  | 1.000                  |
| carbonmonoxide total column [mol m <sup>-2</sup> ]           | $6.137 \times 10^{-3}$ | $7.941 \times 10^{-3}$ | $9.431 \times 10^{-3}$ | $1.131 \times 10^{-2}$ | $1.391 \times 10^{-2}$ | $3.340 \times 10^{-2}$ | $3.591 \times 10^{-2}$ | $3.777 \times 10^{-2}$ | $4.056 \times 10^{-2}$ | $5.709 \times 10^{-2}$ |
| carbonmonoxide total column precision [mol m <sup>-2</sup> ] | $3.576 \times 10^{-4}$ | $4.529 \times 10^{-4}$ | $5.177 \times 10^{-4}$ | $5.765 \times 10^{-4}$ | $6.555 \times 10^{-4}$ | $1.274 \times 10^{-3}$ | $1.554 \times 10^{-3}$ | $1.848 \times 10^{-3}$ | $2.226 \times 10^{-3}$ | $2.843 \times 10^{-3}$ |
| number of spectral points in retrieval [1]                   | 151                    | 152                    | 153                    | 153                    | 153                    | 155                    | 155                    | 156                    | 156                    | 156                    |
| chi square [1]                                               | 341                    | 418                    | 487                    | 564                    | 696                    | $2.123 \times 10^3$    | $2.656 \times 10^3$    | $3.190 \times 10^3$    | $4.054 \times 10^3$    | $6.841 \times 10^3$    |
| degrees of freedom [1]                                       | 6.00                   | 6.53                   | 7.00                   | 7.00                   | 7.00                   | 7.90                   | 7.96                   | 7.98                   | 8.00                   | 8.00                   |
| number of iterations [1]                                     | 6.00                   | 7.00                   | 8.00                   | 8.00                   | 8.00                   | 9.00                   | 9.00                   | 9.00                   | 11.0                   | 14.0                   |

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]                                                 | $0.582 \pm 0.301$                  | 3179729 | 0.300                  | 0.700                  | 0.0     | 1.000                  | 0.400                  | 0.700                  |
| carbonmonoxide total column [mol m <sup>-2</sup> ]           | $(3.381 \pm 0.736) \times 10^{-2}$ | 3179729 | $7.099 \times 10^{-3}$ | $3.364 \times 10^{-2}$ | 0.0     | 0.161                  | $2.984 \times 10^{-2}$ | $3.694 \times 10^{-2}$ |
| carbonmonoxide total column precision [mol m <sup>-2</sup> ] | $(1.115 \pm 0.605) \times 10^{-3}$ | 3179729 | $6.846 \times 10^{-4}$ | $9.529 \times 10^{-4}$ | 0.0     | $2.877 \times 10^{-2}$ | $6.857 \times 10^{-4}$ | $1.370 \times 10^{-3}$ |
| number of spectral points in retrieval [1]                   | $154 \pm 1$                        | 3179729 | 2.00                   | 154                    | 148     | 156                    | 153                    | 155                    |
| chi square [1]                                               | $(0.171 \pm 0.965) \times 10^4$    | 3179729 | $1.337 \times 10^3$    | $1.149 \times 10^3$    | 193     | $3.168 \times 10^6$    | 666                    | $2.002 \times 10^3$    |
| degrees of freedom [1]                                       | $7.40 \pm 0.48$                    | 3179729 | 0.869                  | 7.38                   | 5.00    | 8.00                   | 7.00                   | 7.87                   |
| number of iterations [1]                                     | $8.40 \pm 1.15$                    | 3179729 | 1.000                  | 8.00                   | 5.00    | 15.0                   | 8.00                   | 9.00                   |

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]                                                 | $0.607 \pm 0.286$                  | 3967518 | 0.300                  | 0.700                  | 0.0     | 1.000                  | 0.400                  | 0.700                  |
| carbonmonoxide total column [mol m <sup>-2</sup> ]           | $(1.670 \pm 0.839) \times 10^{-2}$ | 3967518 | $1.042 \times 10^{-2}$ | $1.478 \times 10^{-2}$ | 0.0     | 0.358                  | $1.067 \times 10^{-2}$ | $2.108 \times 10^{-2}$ |
| carbonmonoxide total column precision [mol m <sup>-2</sup> ] | $(9.983 \pm 5.092) \times 10^{-4}$ | 3967518 | $5.686 \times 10^{-4}$ | $8.520 \times 10^{-4}$ | 0.0     | $3.662 \times 10^{-2}$ | $6.380 \times 10^{-4}$ | $1.207 \times 10^{-3}$ |
| number of spectral points in retrieval [1]                   | $154 \pm 1$                        | 3967518 | 2.00                   | 154                    | 107     | 156                    | 153                    | 155                    |
| chi square [1]                                               | $(0.185 \pm 1.270) \times 10^4$    | 3967518 | $1.484 \times 10^3$    | $1.309 \times 10^3$    | 209     | $6.304 \times 10^6$    | 724                    | $2.209 \times 10^3$    |
| degrees of freedom [1]                                       | $7.40 \pm 0.54$                    | 3967518 | 0.915                  | 7.45                   | 4.00    | 8.00                   | 7.00                   | 7.92                   |
| number of iterations [1]                                     | $8.60 \pm 1.37$                    | 3967518 | 1.000                  | 8.00                   | 5.00    | 15.0                   | 8.00                   | 9.00                   |

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]                                                  | $0.628 \pm 0.192$                  | 3547260 | 0.0                    | 0.700                  | 0.0     | 1.000                  | 0.700                  | 0.700                  |
| carbonmonoxide total column [ $\text{mol m}^{-2}$ ]           | $(2.429 \pm 0.986) \times 10^{-2}$ | 3547260 | $1.592 \times 10^{-2}$ | $2.284 \times 10^{-2}$ | 0.0     | 0.358                  | $1.584 \times 10^{-2}$ | $3.176 \times 10^{-2}$ |
| carbonmonoxide total column precision [ $\text{mol m}^{-2}$ ] | $(1.200 \pm 0.623) \times 10^{-3}$ | 3547260 | $8.263 \times 10^{-4}$ | $1.022 \times 10^{-3}$ | 0.0     | $3.662 \times 10^{-2}$ | $7.159 \times 10^{-4}$ | $1.542 \times 10^{-3}$ |
| number of spectral points in retrieval [1]                    | $154 \pm 1$                        | 3547260 | 2.00                   | 154                    | 147     | 156                    | 153                    | 155                    |
| chi square [1]                                                | $(0.196 \pm 1.427) \times 10^4$    | 3547260 | $1.394 \times 10^3$    | $1.420 \times 10^3$    | 218     | $6.304 \times 10^6$    | 839                    | $2.233 \times 10^3$    |
| degrees of freedom [1]                                        | $7.59 \pm 0.43$                    | 3547260 | 0.772                  | 7.78                   | 4.01    | 8.00                   | 7.18                   | 7.95                   |
| number of iterations [1]                                      | $8.76 \pm 1.45$                    | 3547260 | 1.000                  | 8.00                   | 5.00    | 15.0                   | 8.00                   | 9.00                   |

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]                                                 | $0.555 \pm 0.379$                  | 2705638 | 1.000                  | 0.700                  | 0.0     | 1.000                  | 0.0                    | 1.000                  |
| carbonmonoxide total column [mol m <sup>-2</sup> ]           | $(2.143 \pm 1.320) \times 10^{-2}$ | 2705638 | $2.309 \times 10^{-2}$ | $1.811 \times 10^{-2}$ | 0.0     | 0.161                  | $9.440 \times 10^{-3}$ | $3.253 \times 10^{-2}$ |
| carbonmonoxide total column precision [mol m <sup>-2</sup> ] | $(8.846 \pm 4.305) \times 10^{-4}$ | 2705638 | $4.769 \times 10^{-4}$ | $7.897 \times 10^{-4}$ | 0.0     | $7.564 \times 10^{-3}$ | $5.887 \times 10^{-4}$ | $1.066 \times 10^{-3}$ |
| number of spectral points in retrieval [1]                   | $154 \pm 1$                        | 2705638 | 2.00                   | 154                    | 144     | 156                    | 153                    | 155                    |
| chi square [1]                                               | $(0.158 \pm 0.691) \times 10^4$    | 2705638 | $1.356 \times 10^3$    | 930                    | 193     | $3.168 \times 10^6$    | 560                    | $1.915 \times 10^3$    |
| degrees of freedom [1]                                       | $7.16 \pm 0.52$                    | 2705638 | 0.515                  | 7.02                   | 4.00    | 8.00                   | 7.00                   | 7.51                   |
| number of iterations [1]                                     | $8.26 \pm 0.97$                    | 2705638 | 1.000                  | 8.00                   | 5.00    | 15.0                   | 8.00                   | 9.00                   |

### 3 Granule outlines

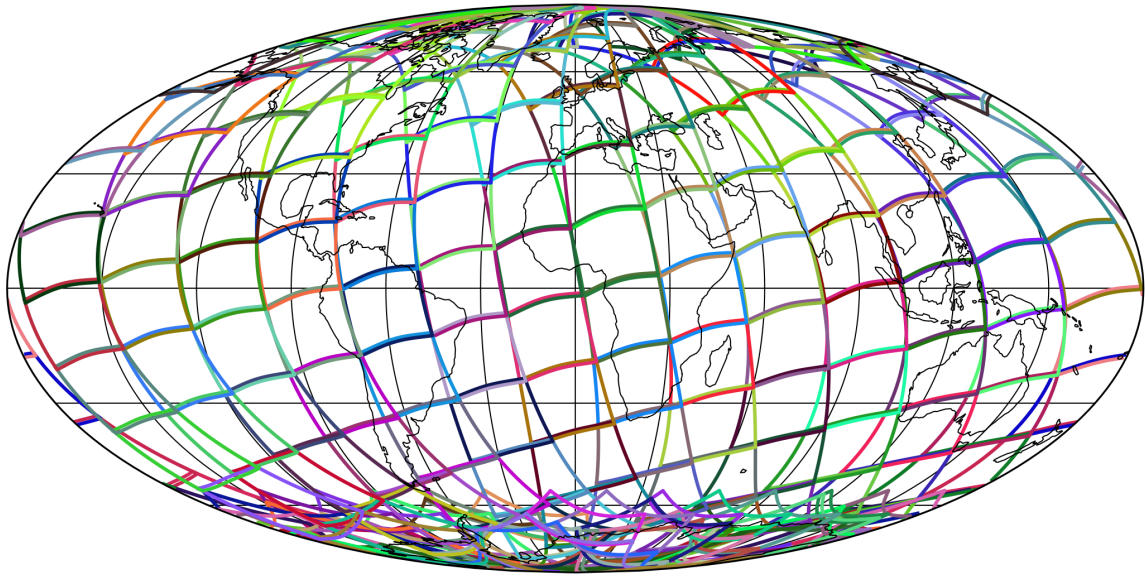


Figure 1: Outline of the granules.

## 4 Input data monitoring

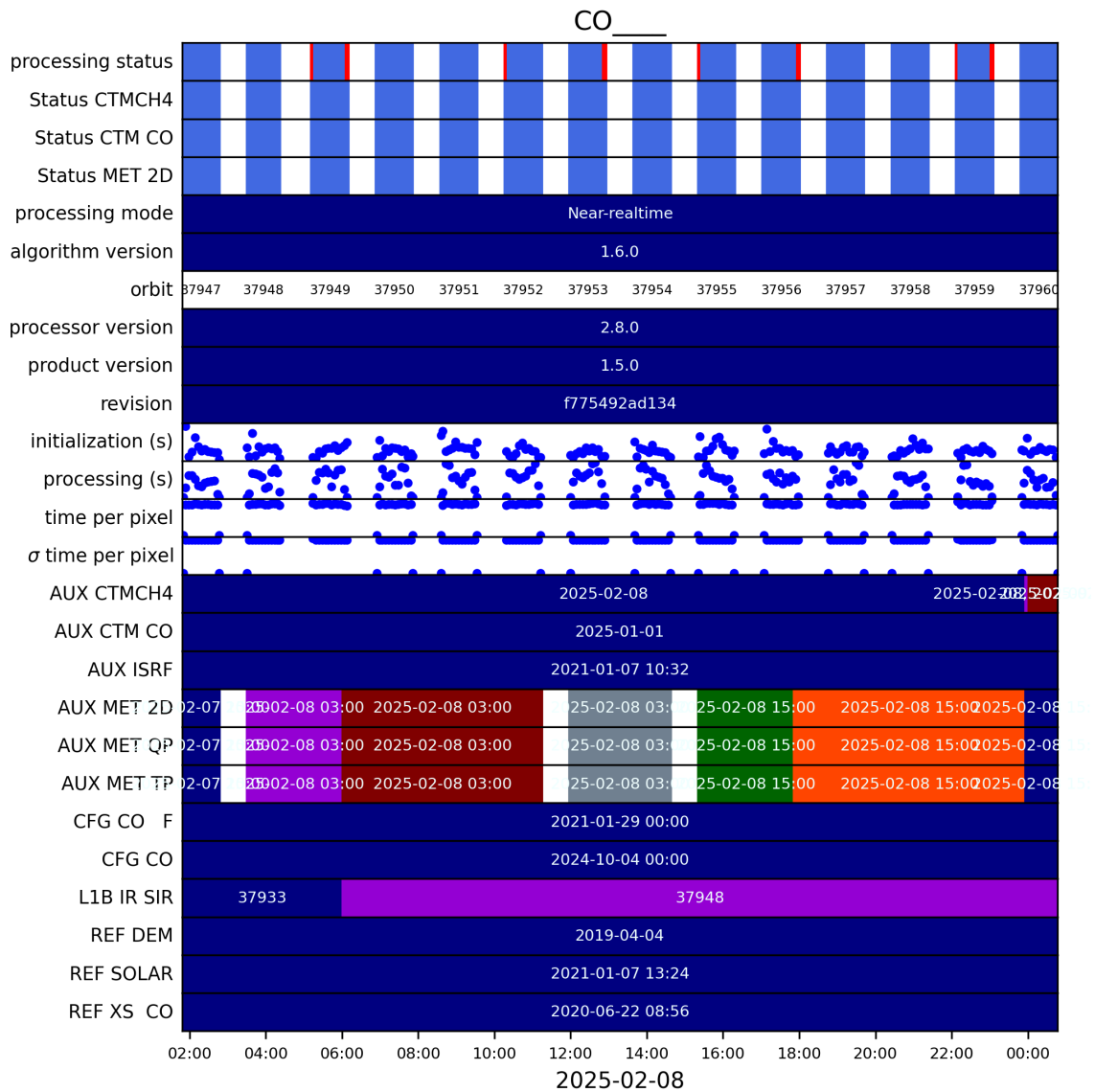


Figure 2: Input data per granule

## 5 Warnings and errors

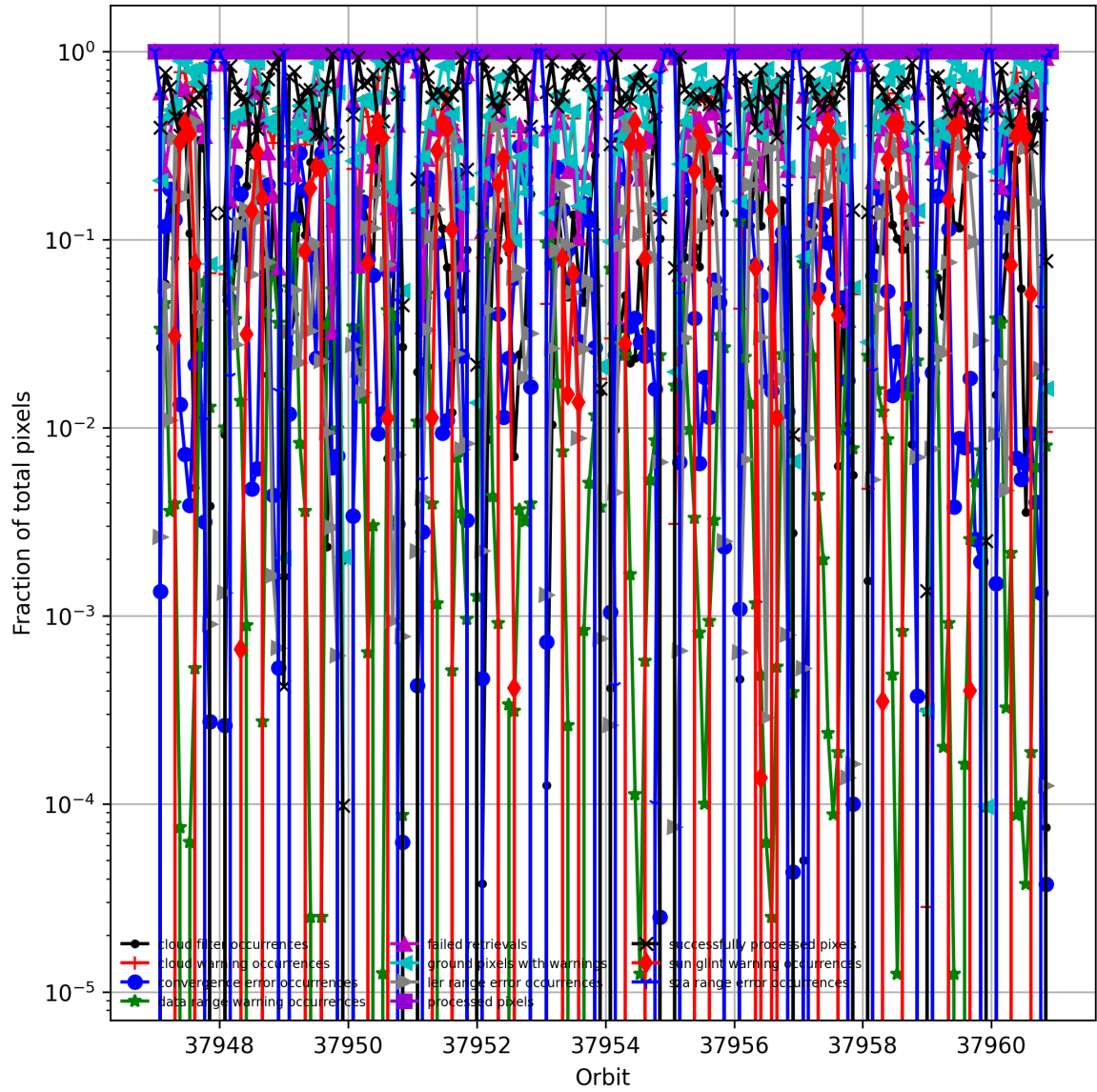


Figure 3: Fraction of pixels with specific warnings and errors during processing

## 6 World maps

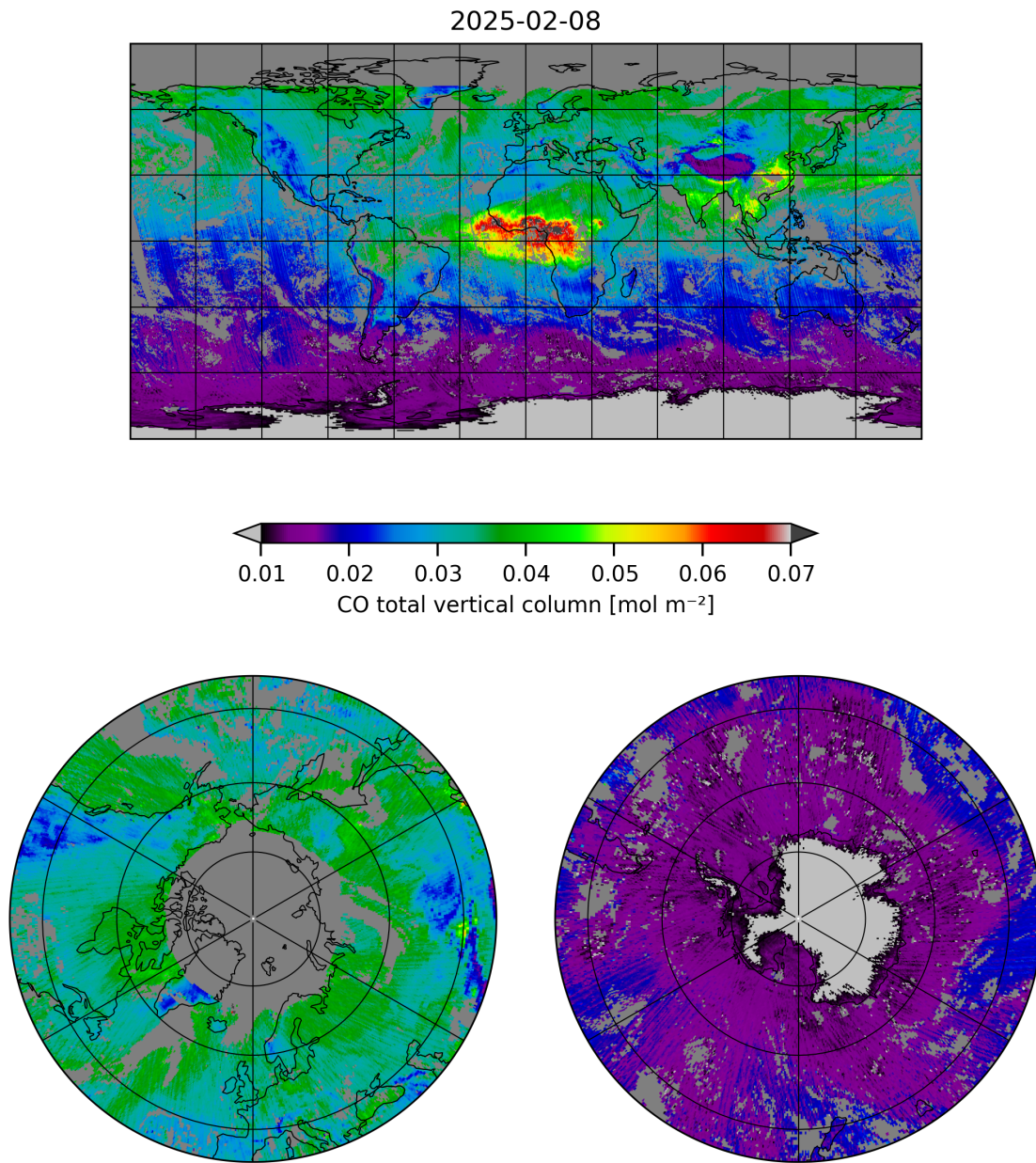


Figure 4: Map of “CO total vertical column” for 2025-02-08 to 2025-02-09

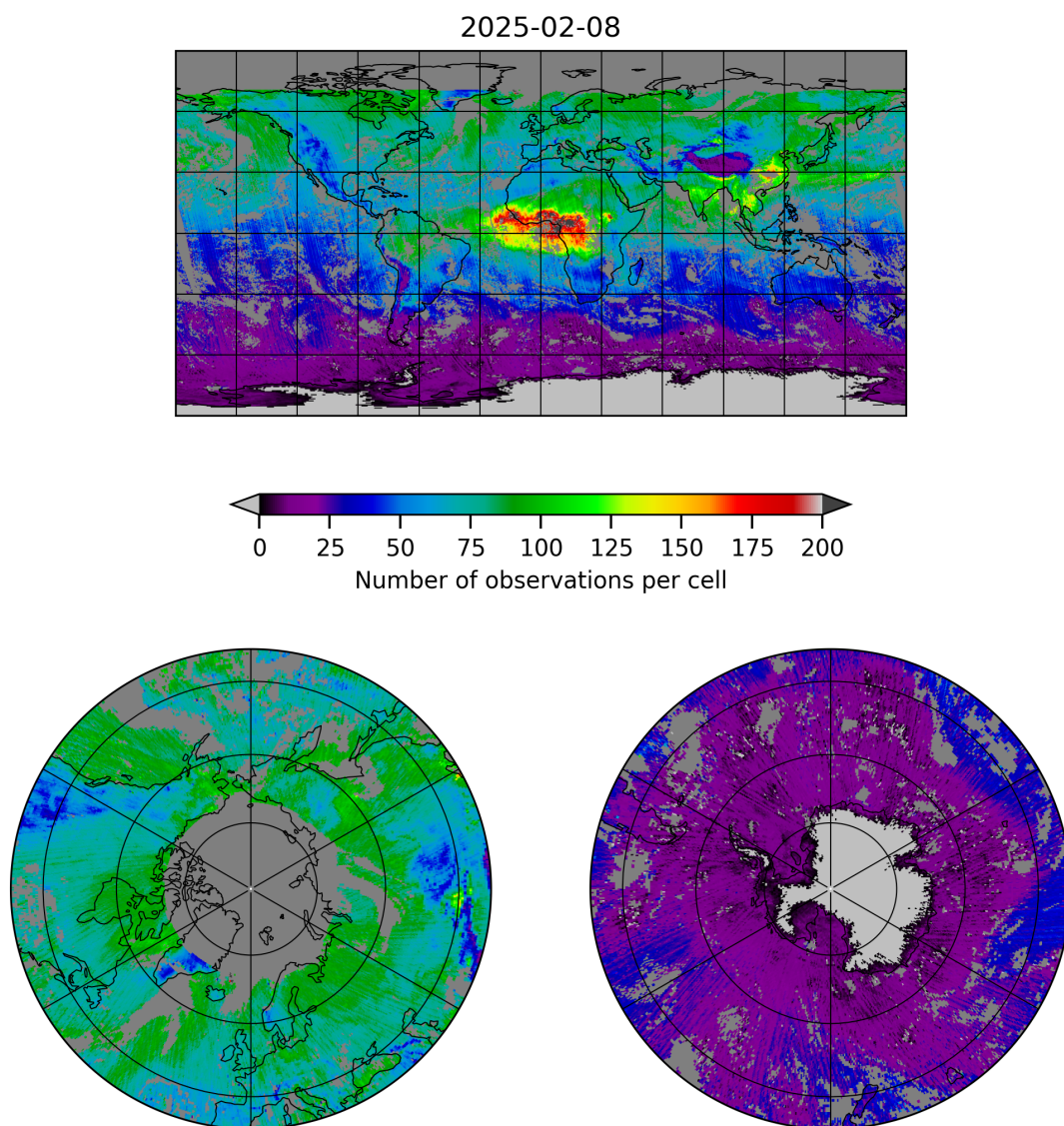


Figure 5: Map of the number of observations for 2025-02-08 to 2025-02-09

## 7 Zonal average

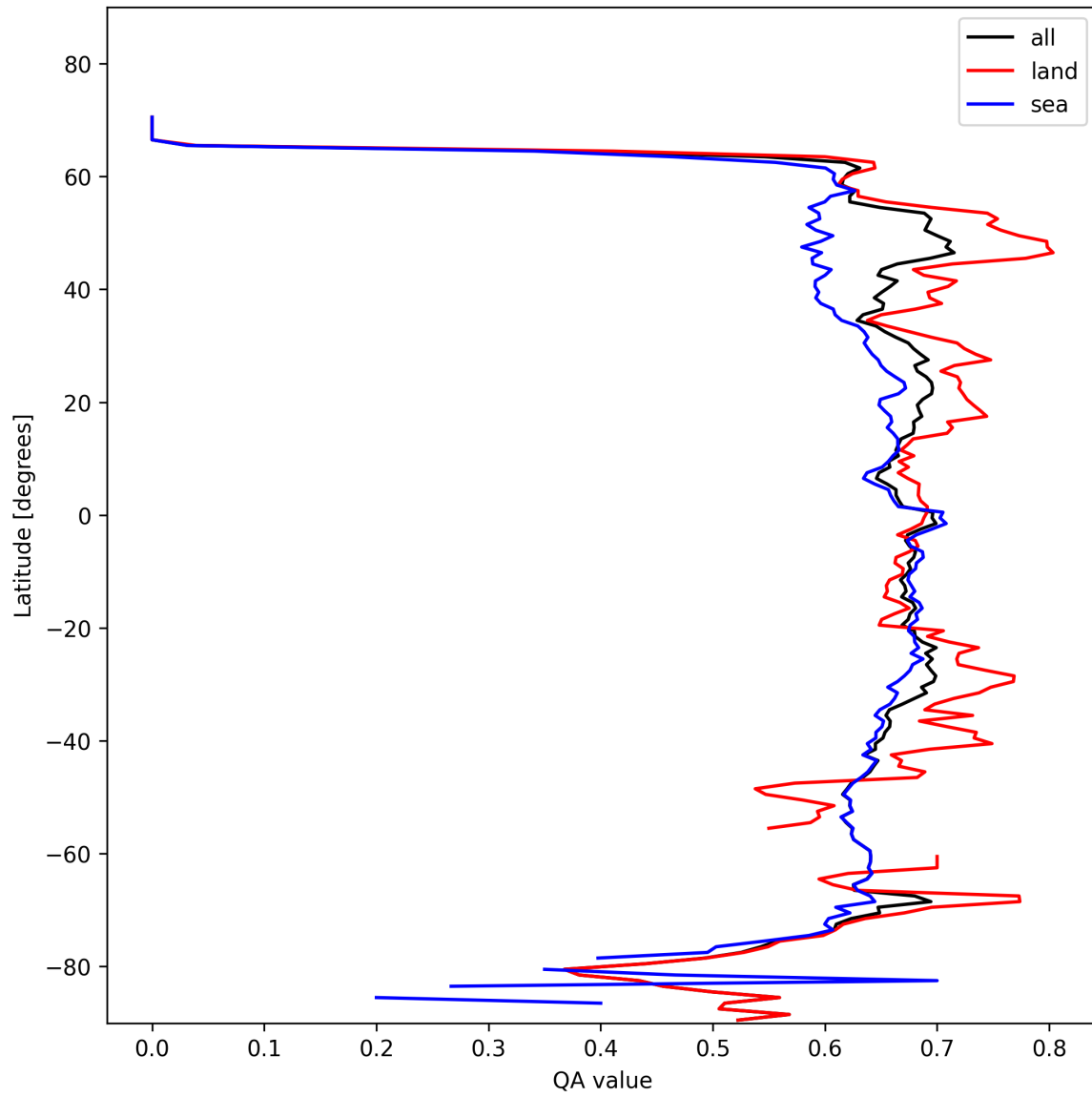


Figure 6: Zonal average of “QA value” for 2025-02-08 to 2025-02-09.

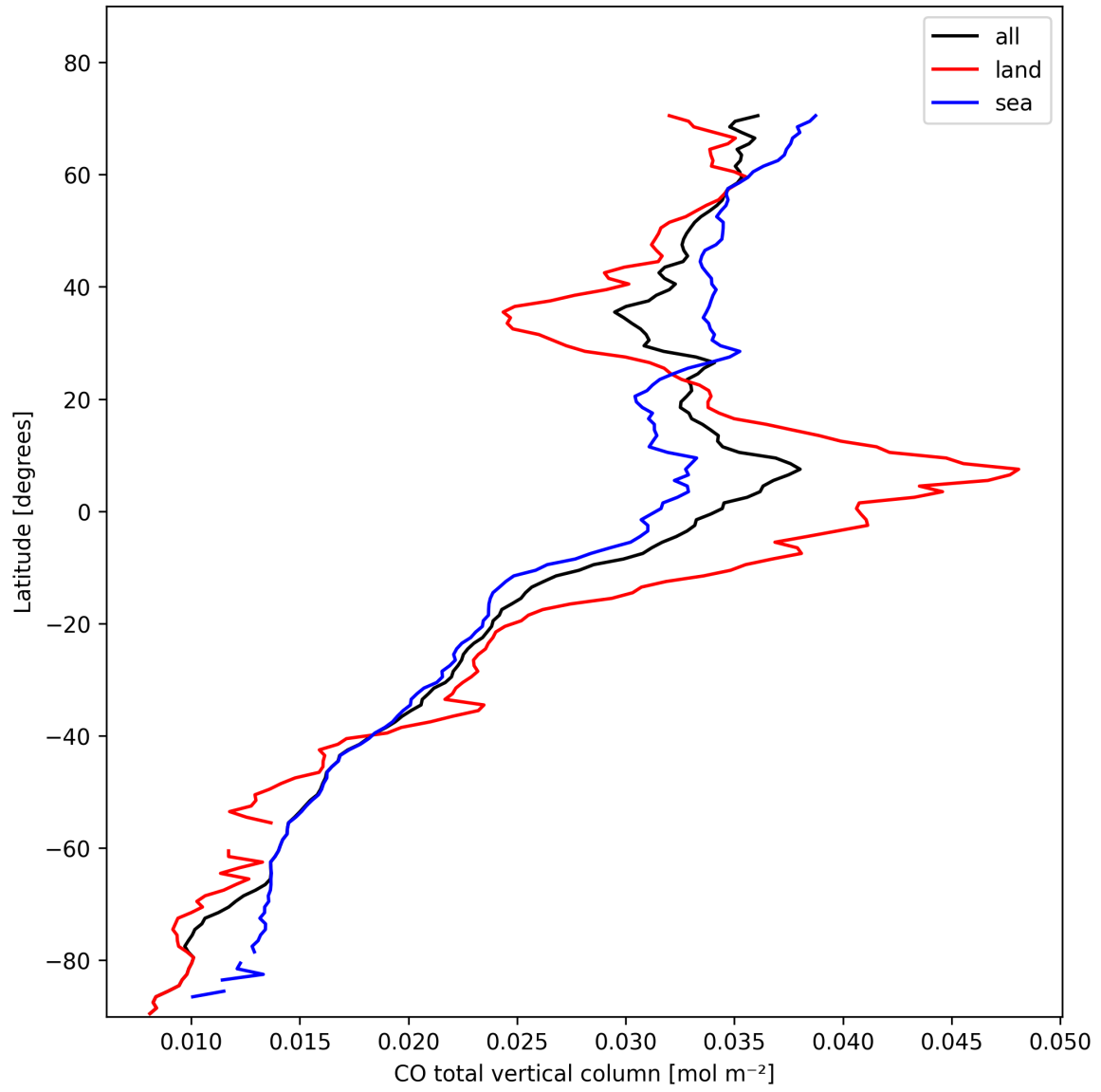


Figure 7: Zonal average of “CO total vertical column” for 2025-02-08 to 2025-02-09.

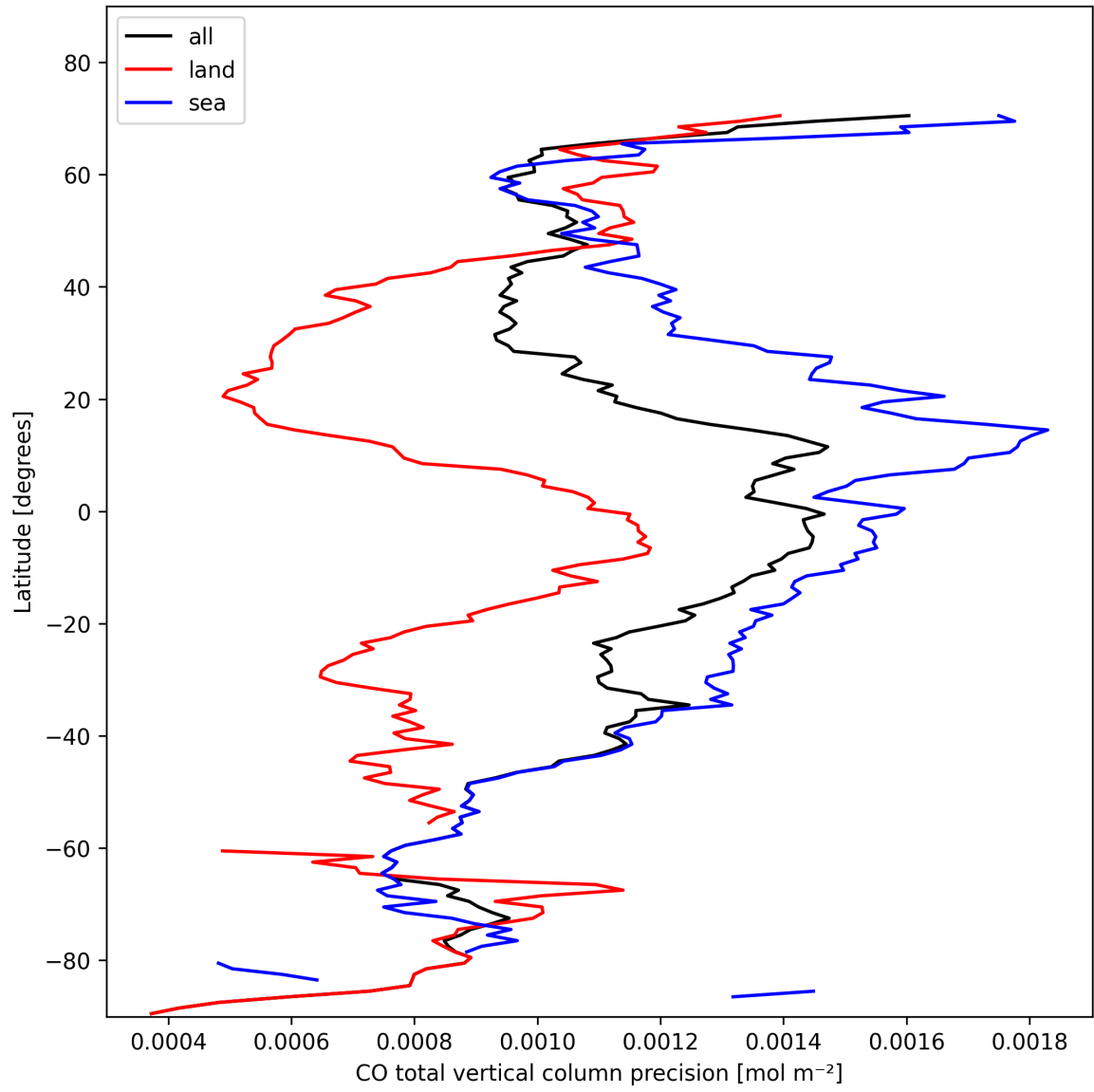


Figure 8: Zonal average of “CO total vertical column precision” for 2025-02-08 to 2025-02-09.

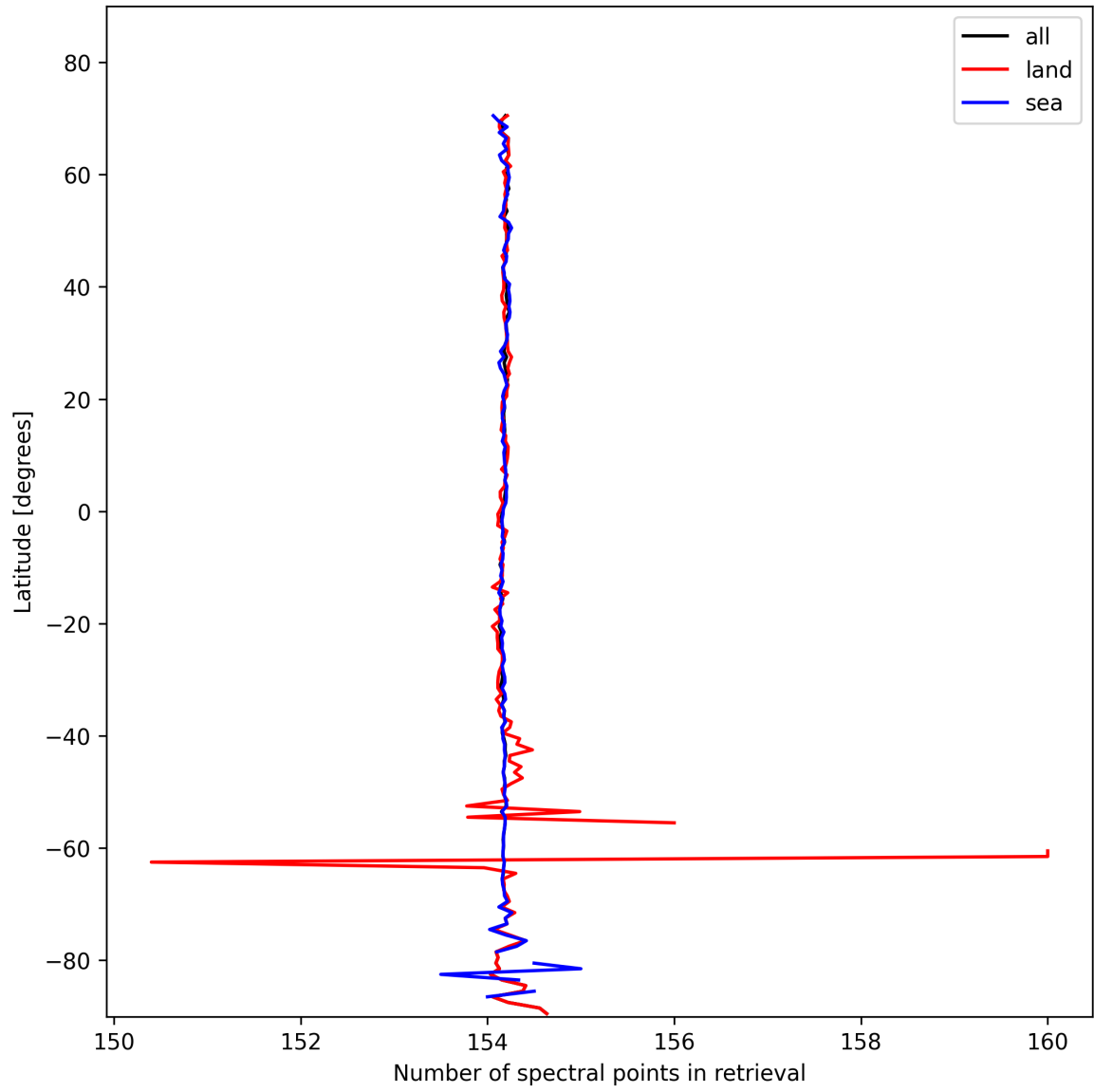


Figure 9: Zonal average of “Number of spectral points in retrieval” for 2025-02-08 to 2025-02-09.

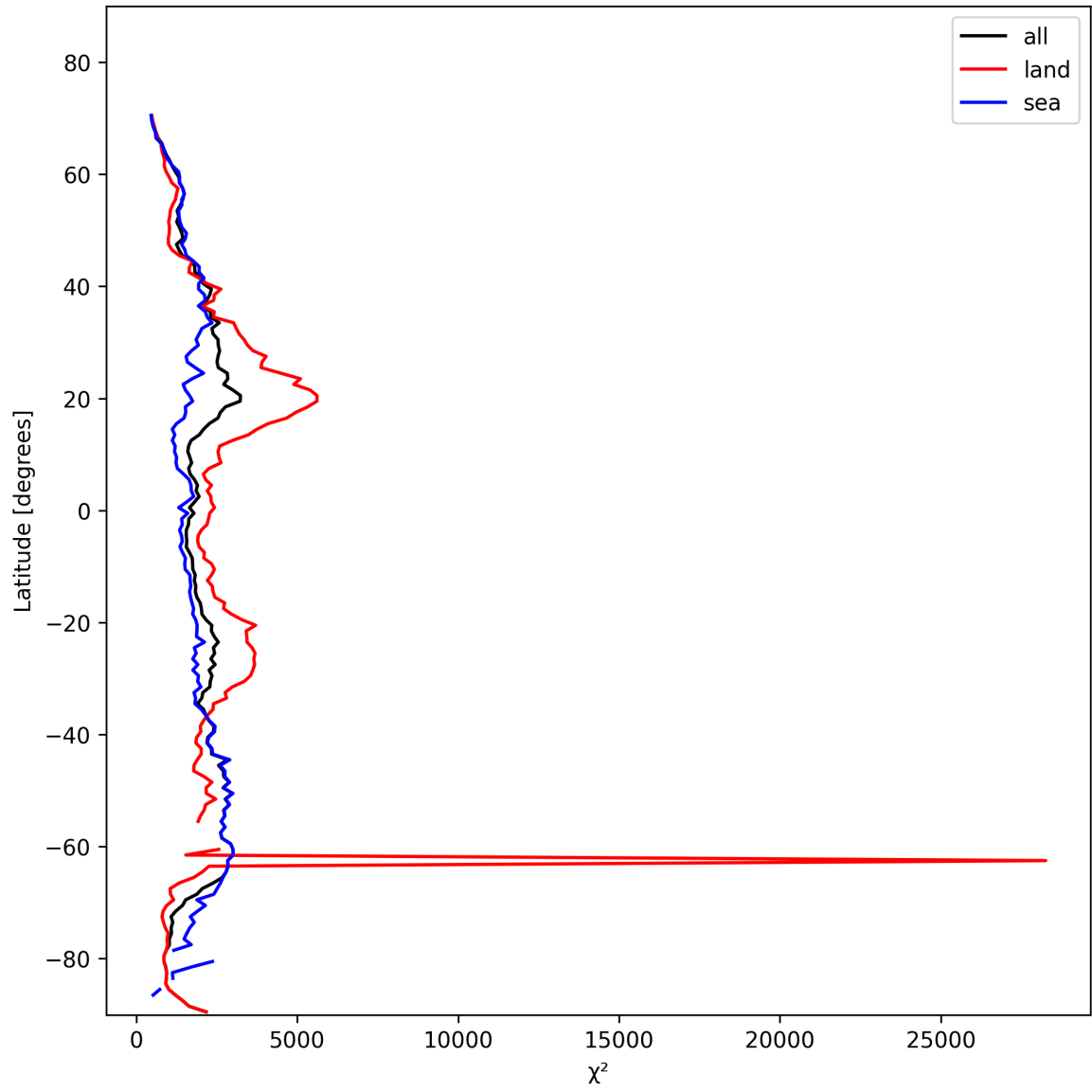


Figure 10: Zonal average of “ $\chi^2$ ” for 2025-02-08 to 2025-02-09.

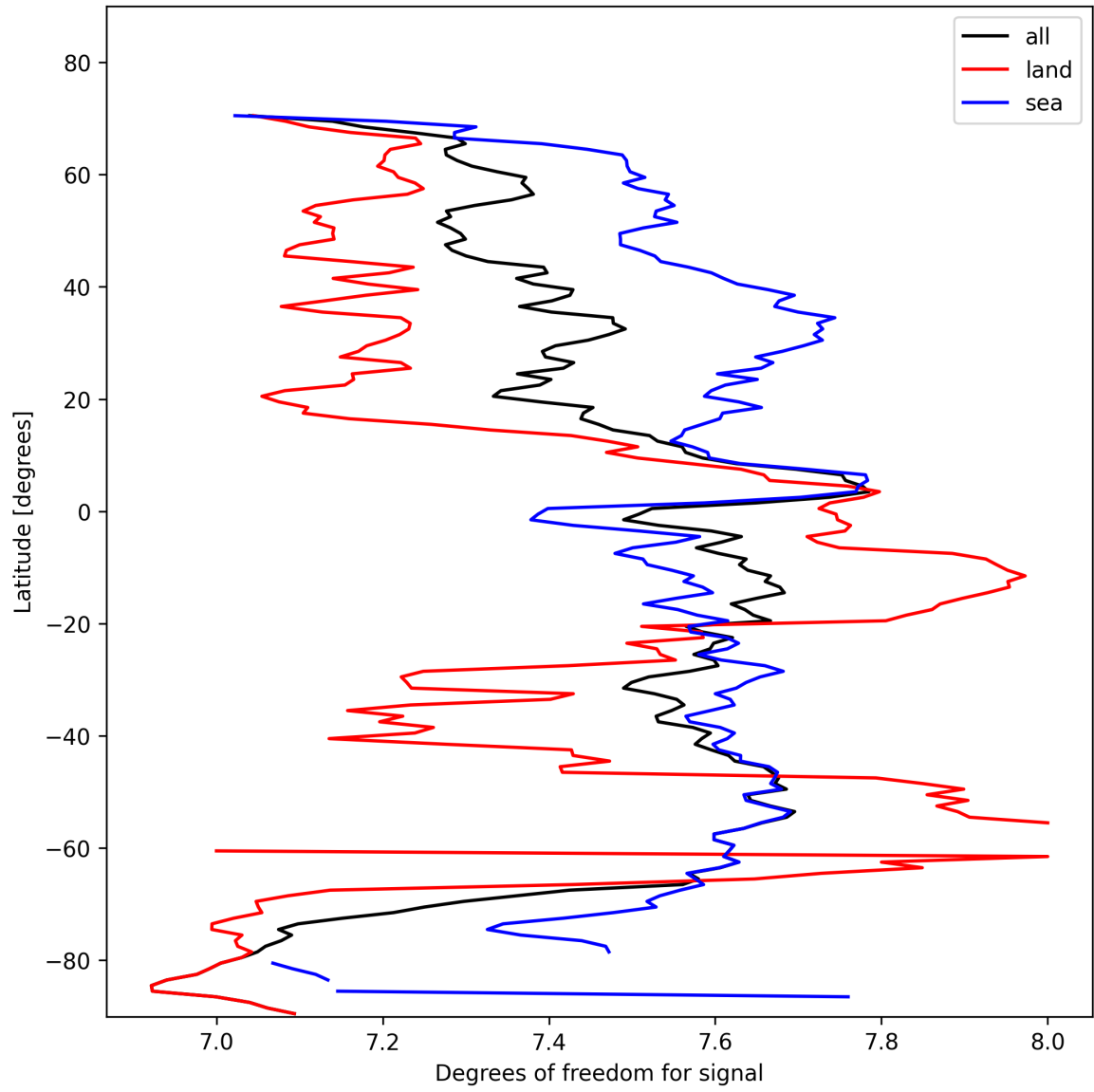


Figure 11: Zonal average of “Degrees of freedom for signal” for 2025-02-08 to 2025-02-09.

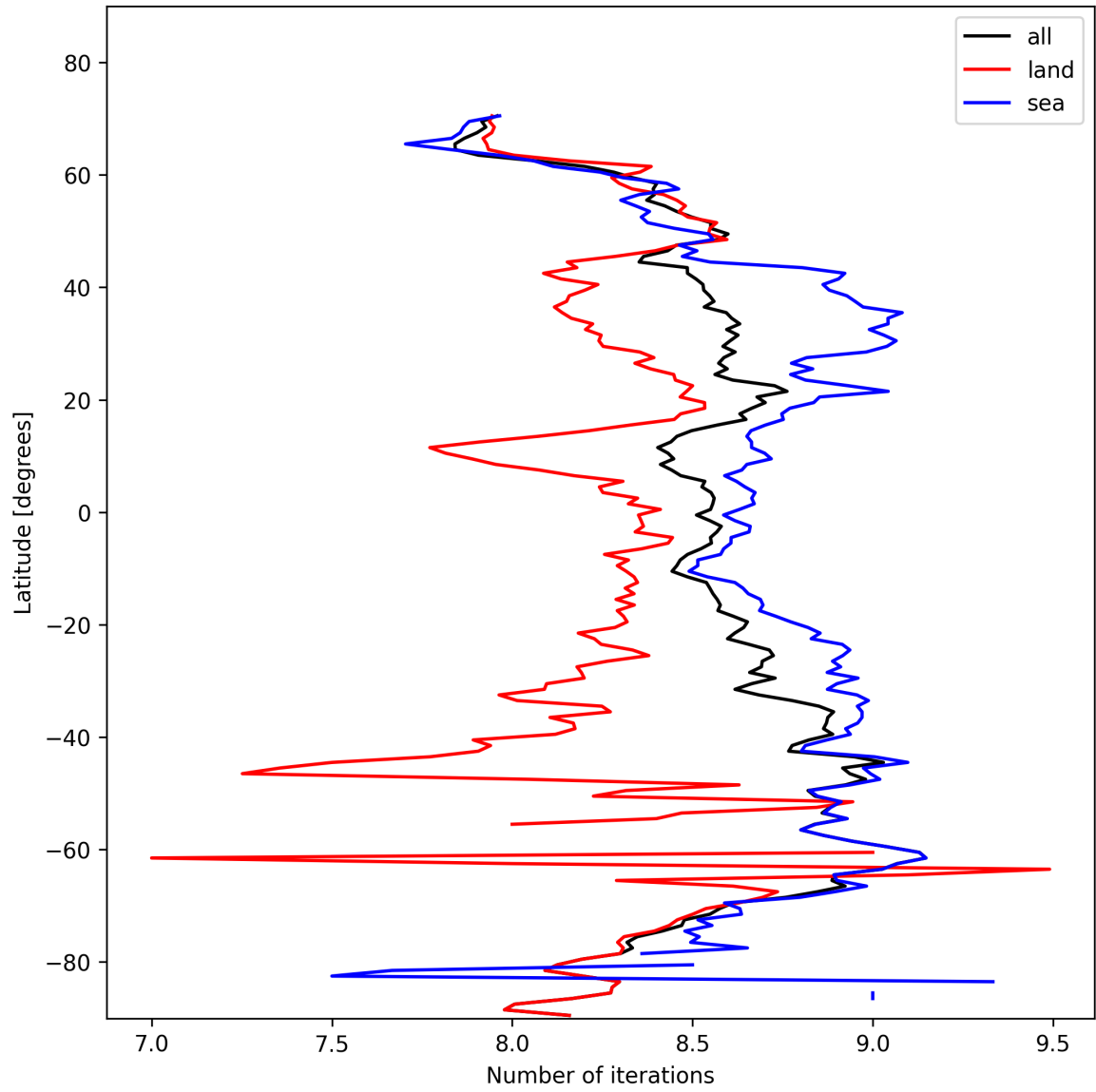


Figure 12: Zonal average of “Number of iterations” for 2025-02-08 to 2025-02-09.

## 8 Histograms

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

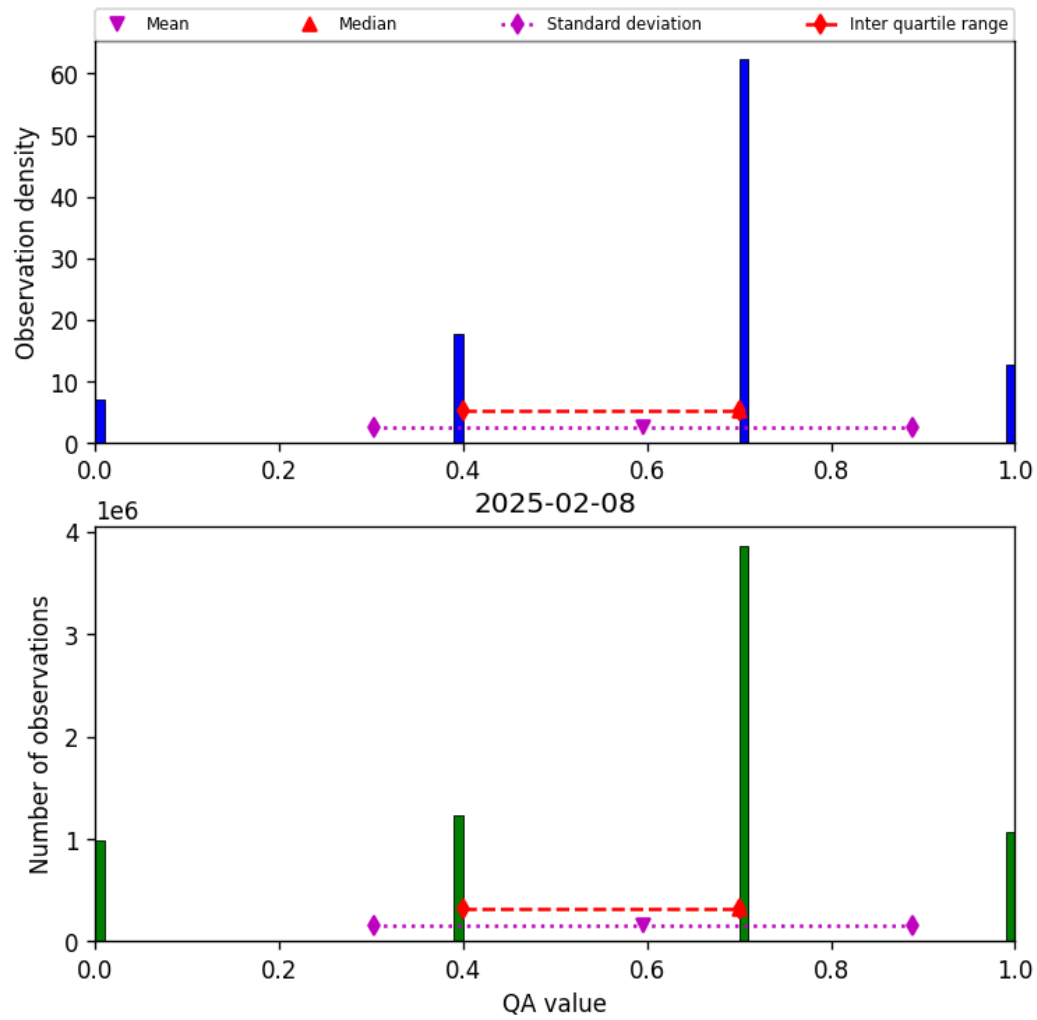


Figure 13: Histogram of “QA value” for 2025-02-08 to 2025-02-09

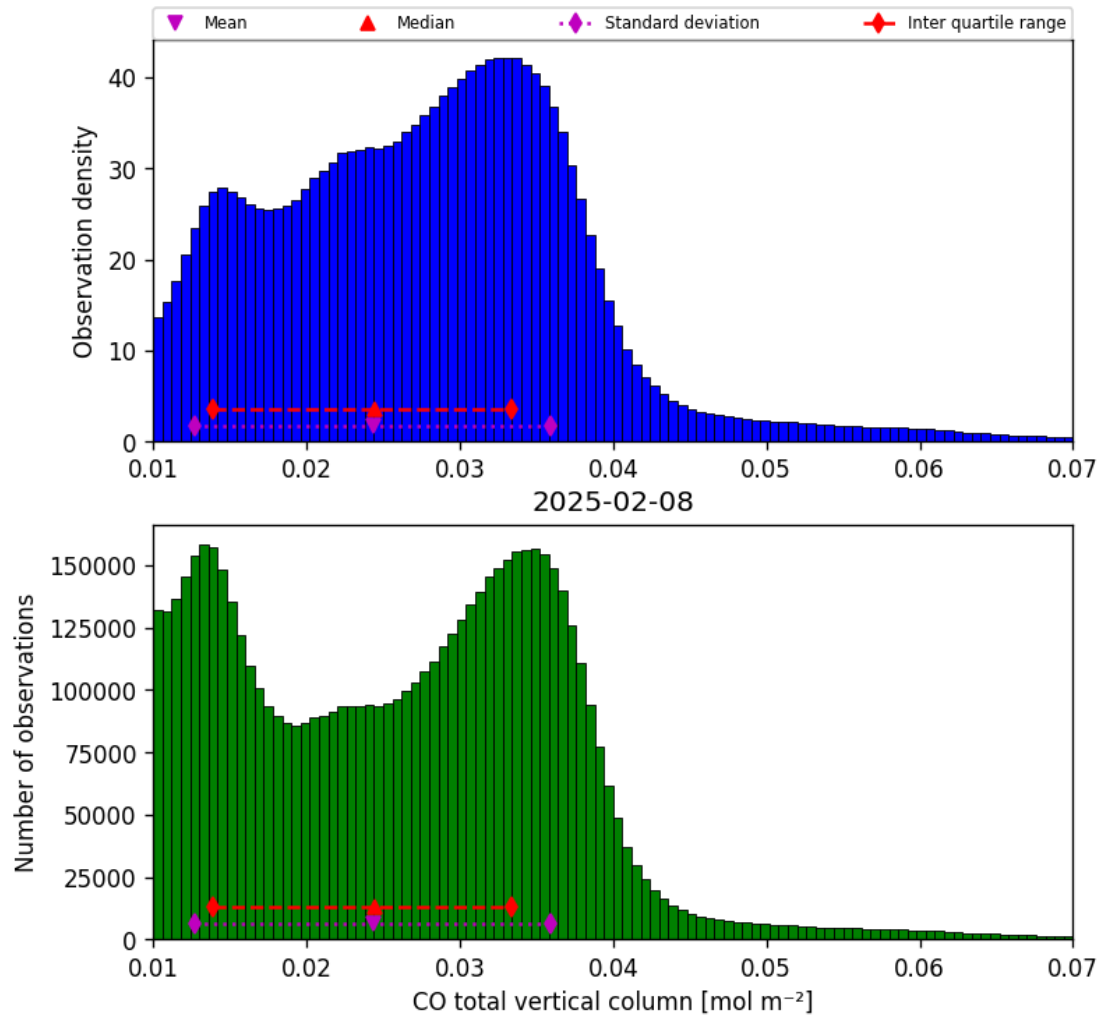


Figure 14: Histogram of “CO total vertical column” for 2025-02-08 to 2025-02-09

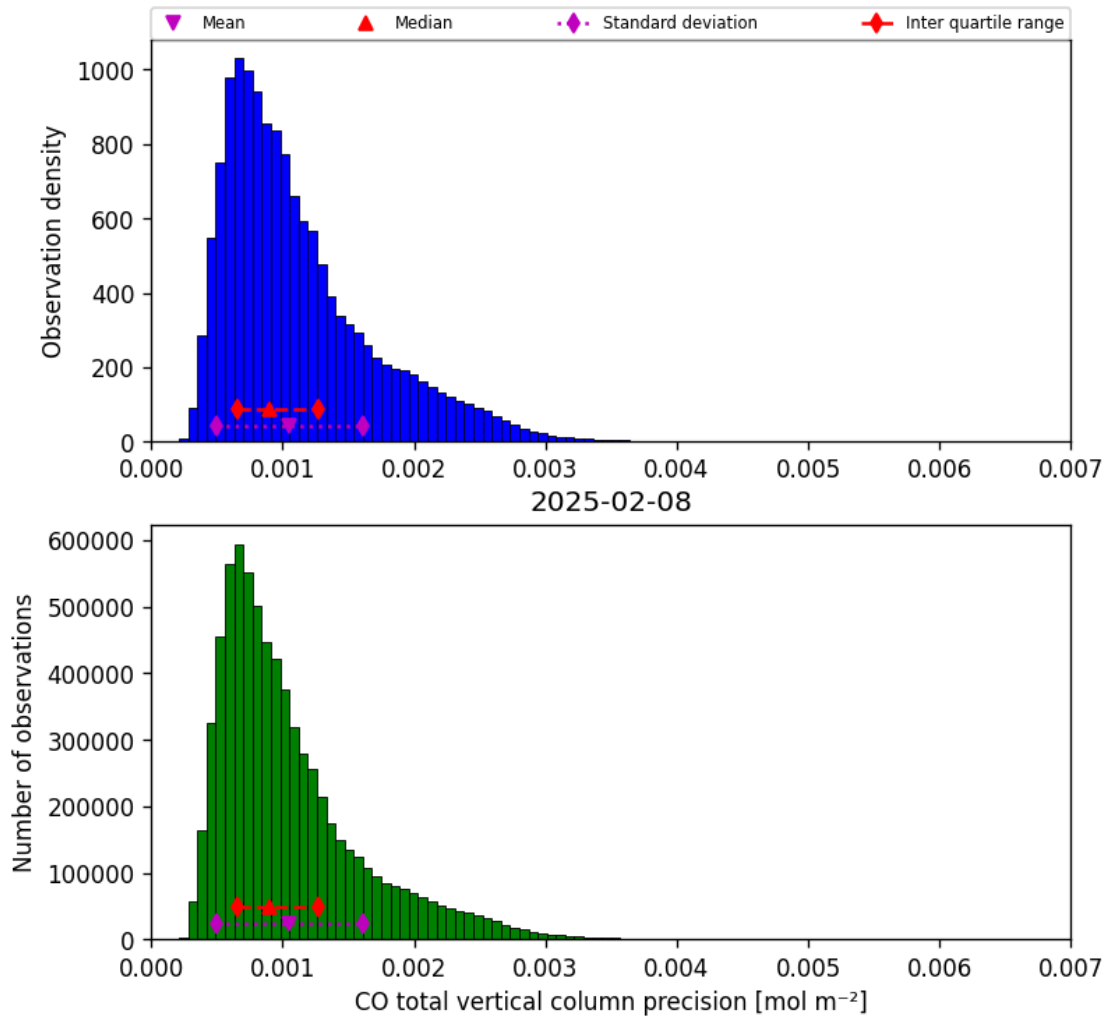


Figure 15: Histogram of “CO total vertical column precision” for 2025-02-08 to 2025-02-09

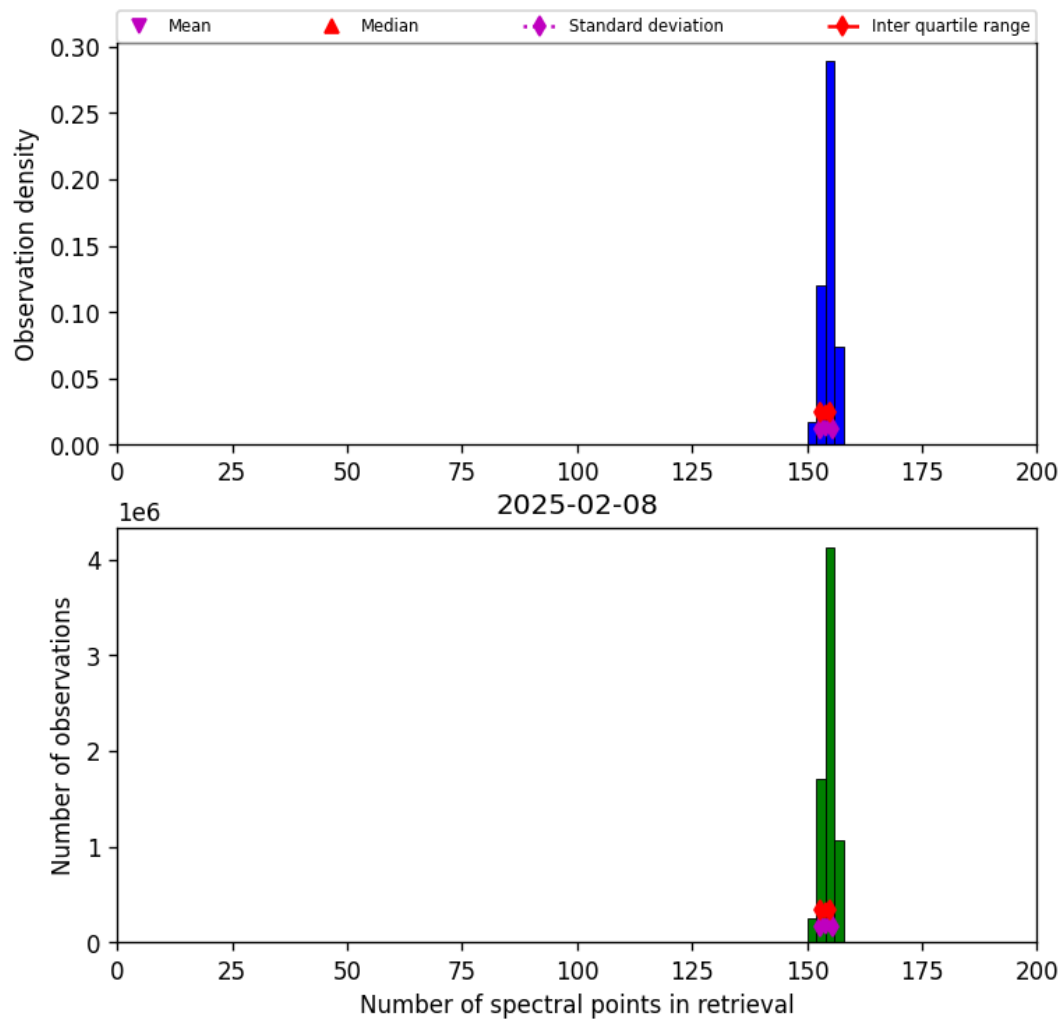


Figure 16: Histogram of “Number of spectral points in retrieval” for 2025-02-08 to 2025-02-09

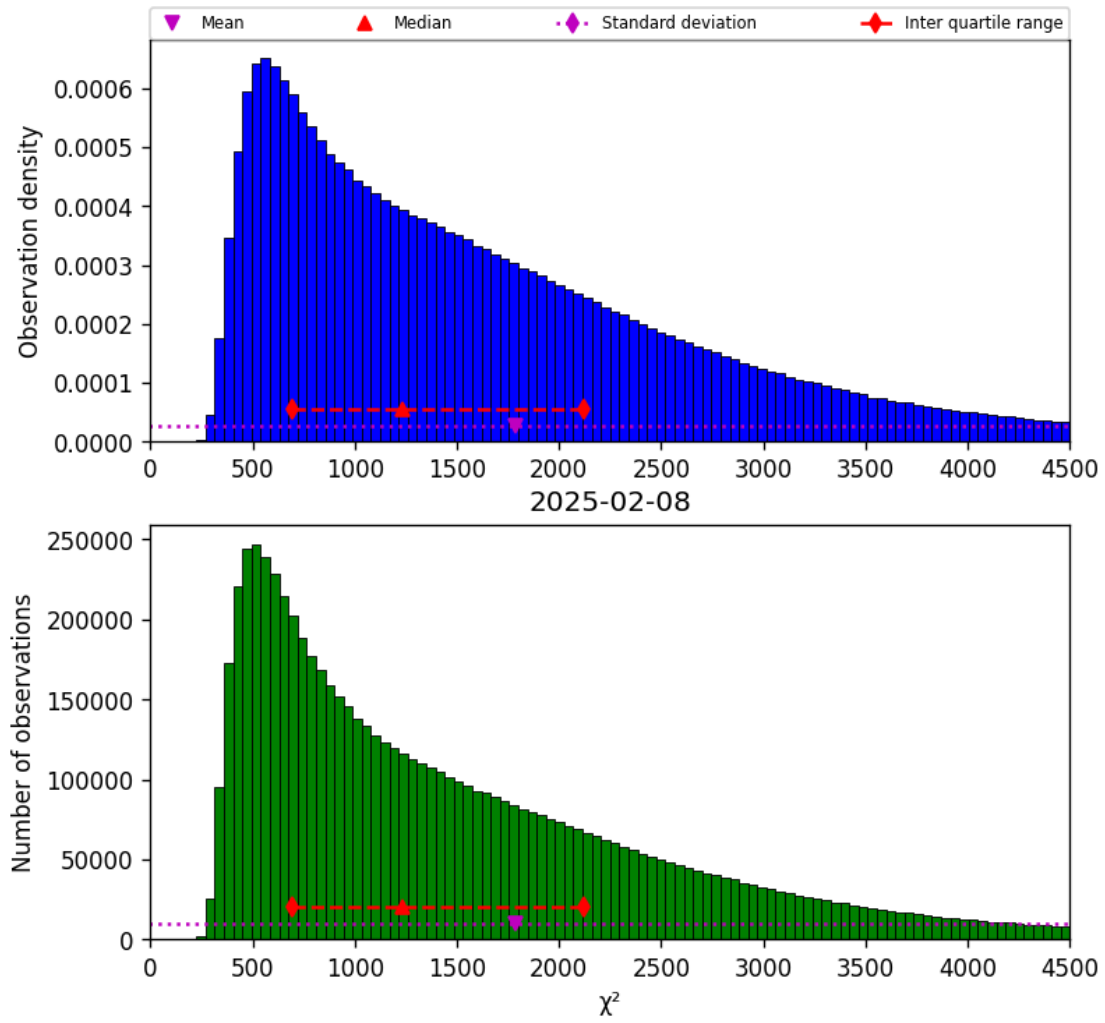


Figure 17: Histogram of “ $\chi^2$ ” for 2025-02-08 to 2025-02-09

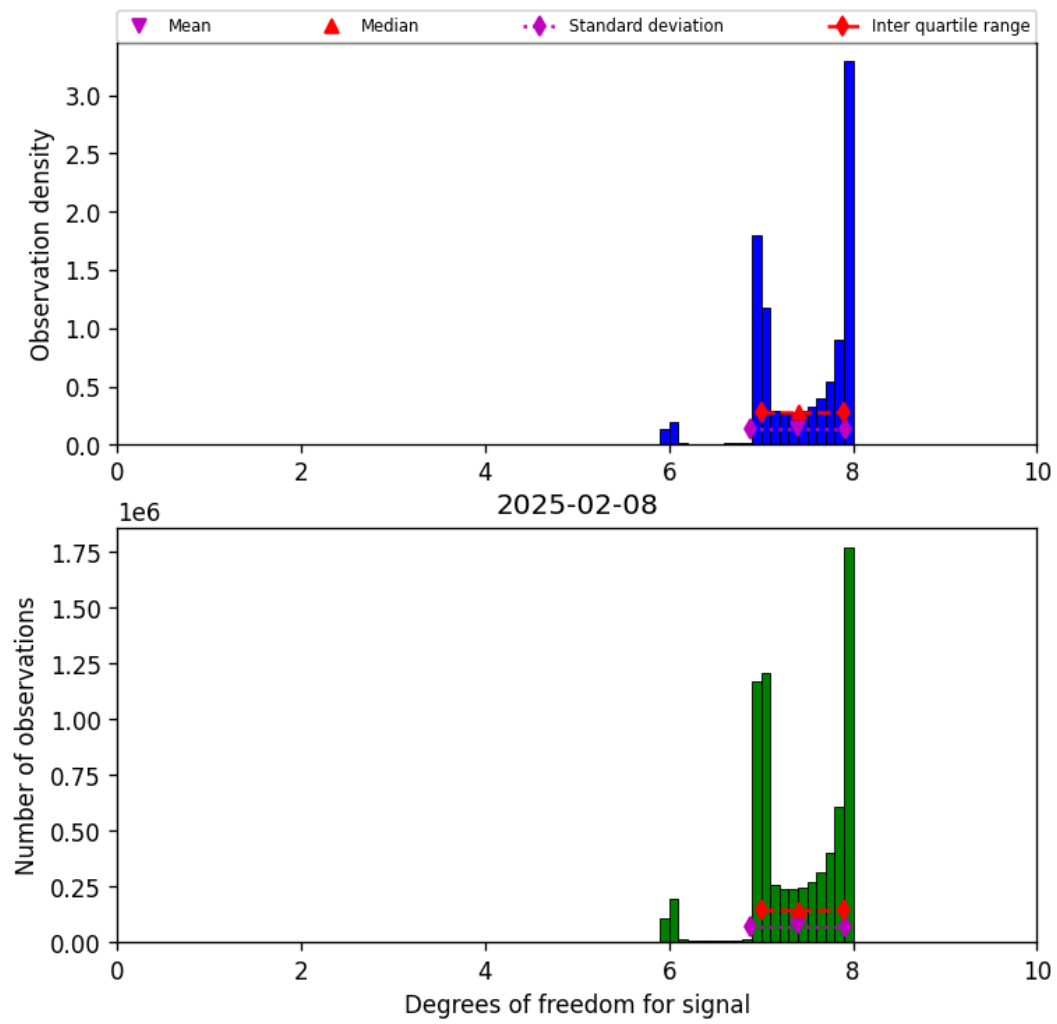


Figure 18: Histogram of “Degrees of freedom for signal” for 2025-02-08 to 2025-02-09

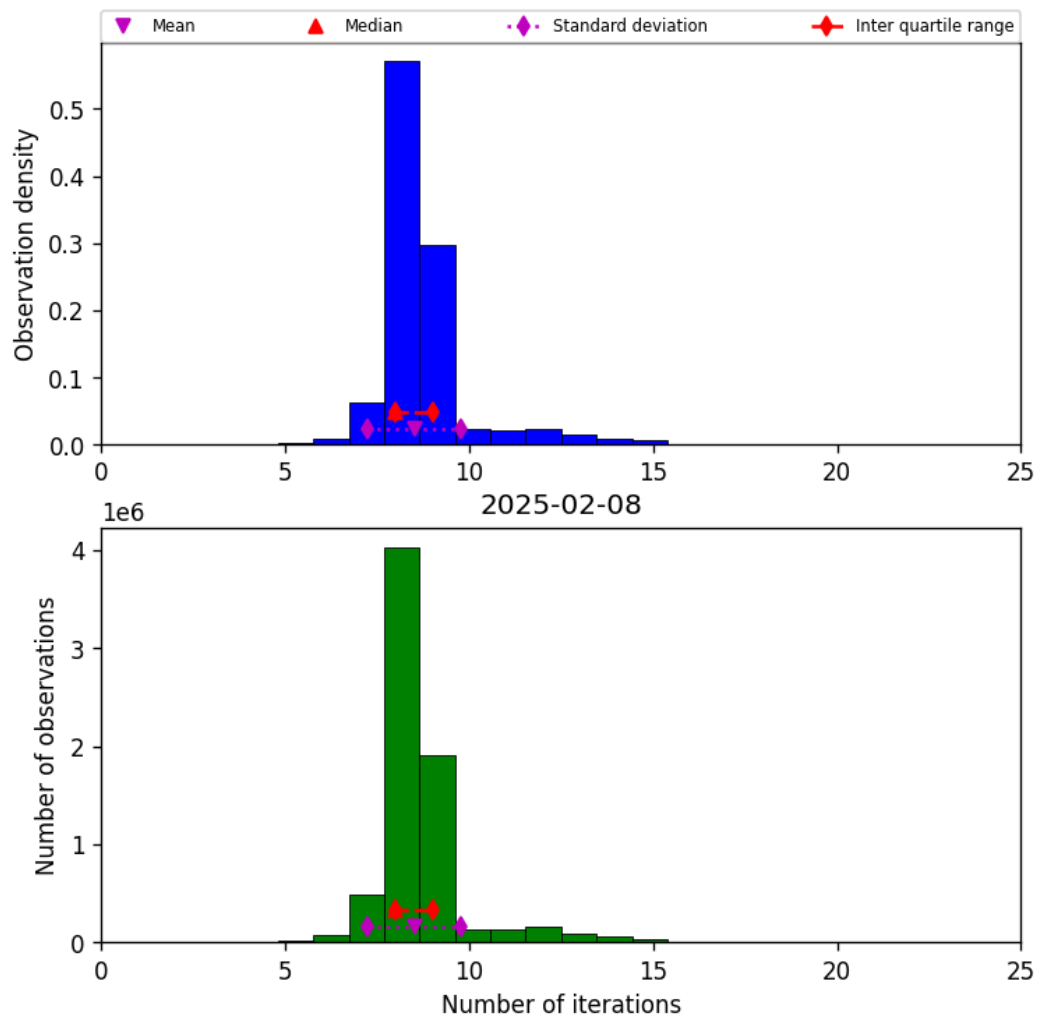


Figure 19: Histogram of “Number of iterations” for 2025-02-08 to 2025-02-09

## 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.

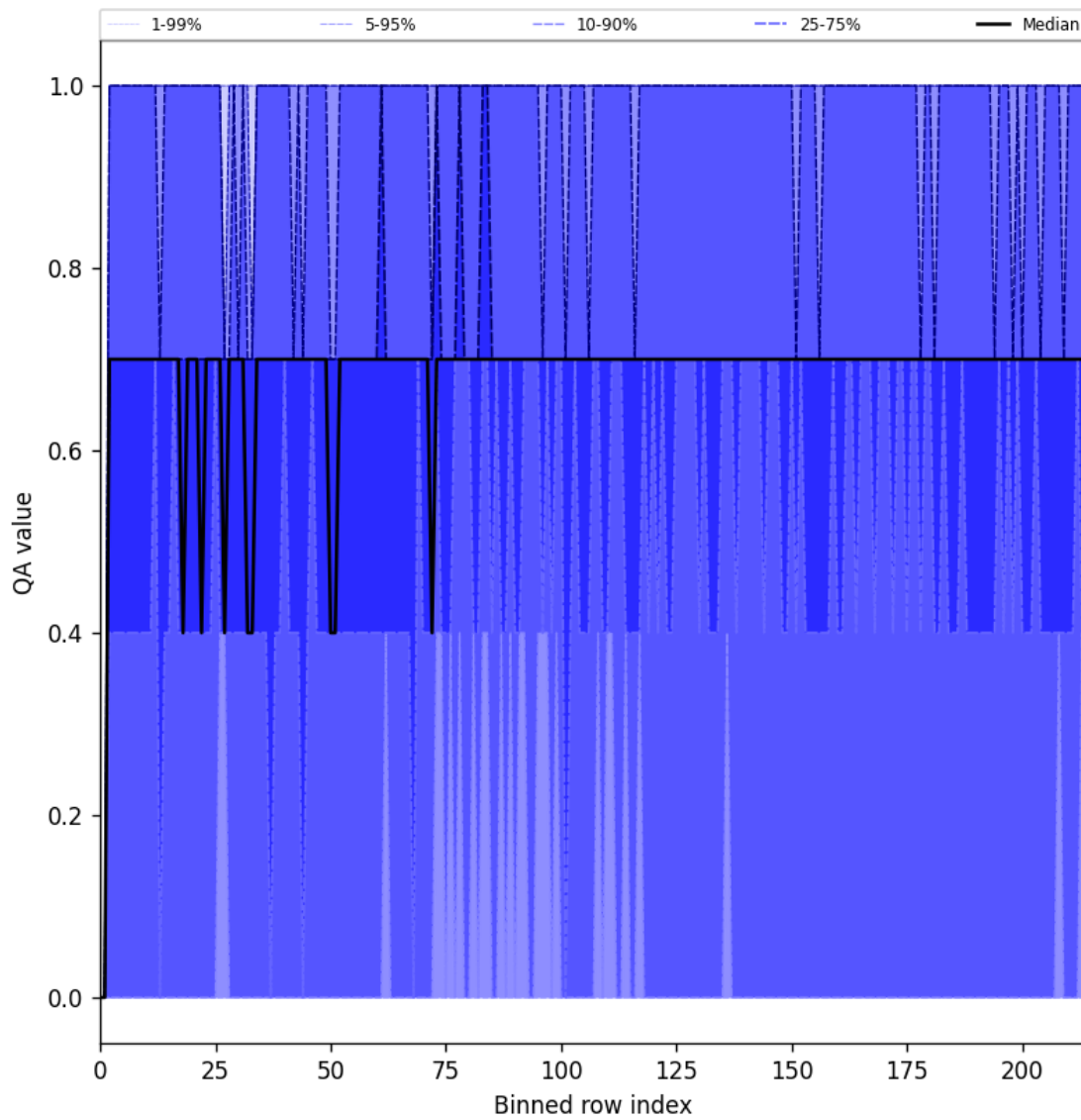


Figure 20: Along track statistics of “QA value” for 2025-02-08 to 2025-02-09

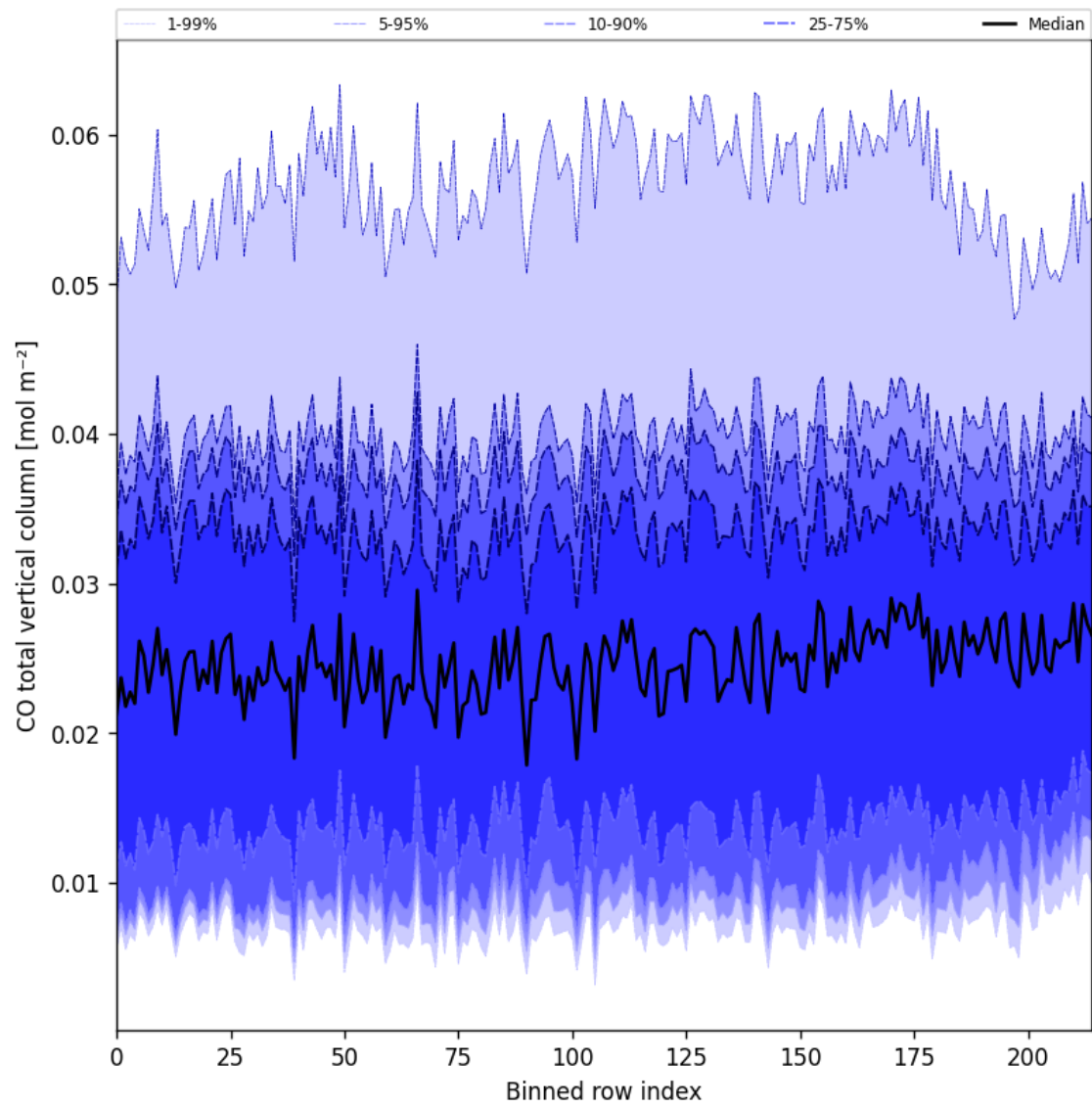


Figure 21: Along track statistics of “CO total vertical column” for 2025-02-08 to 2025-02-09

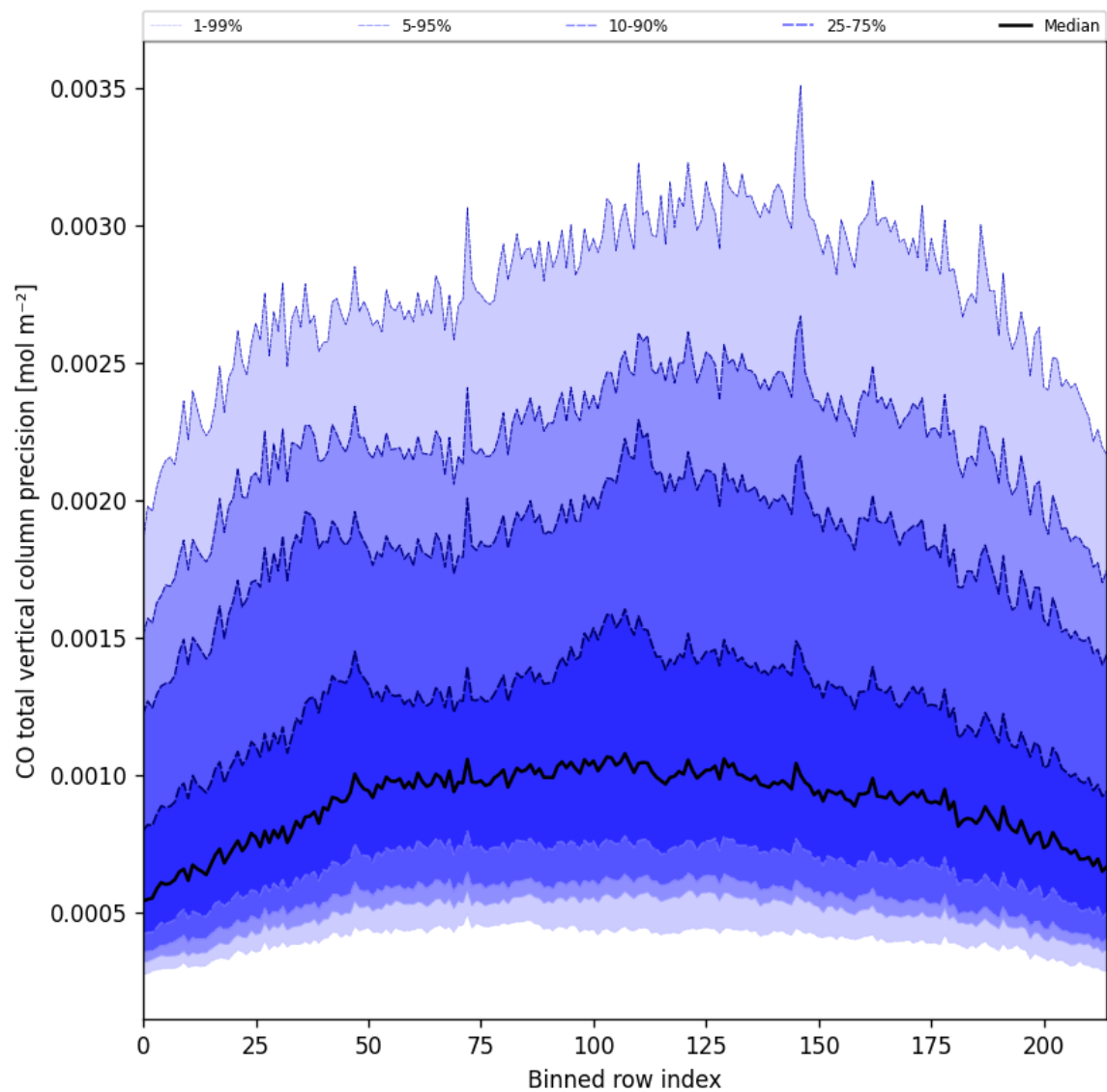


Figure 22: Along track statistics of “CO total vertical column precision” for 2025-02-08 to 2025-02-09

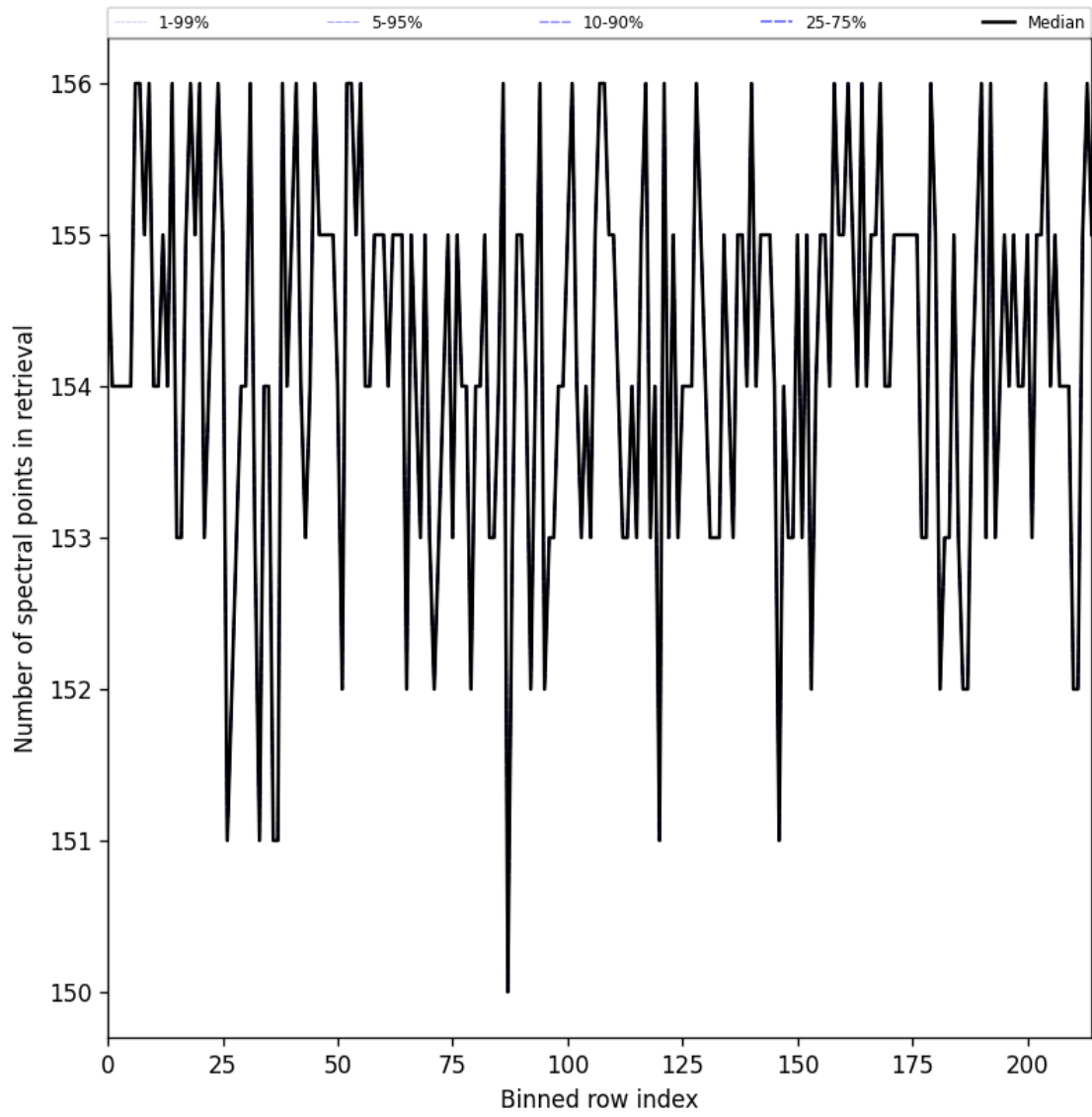


Figure 23: Along track statistics of “Number of spectral points in retrieval” for 2025-02-08 to 2025-02-09

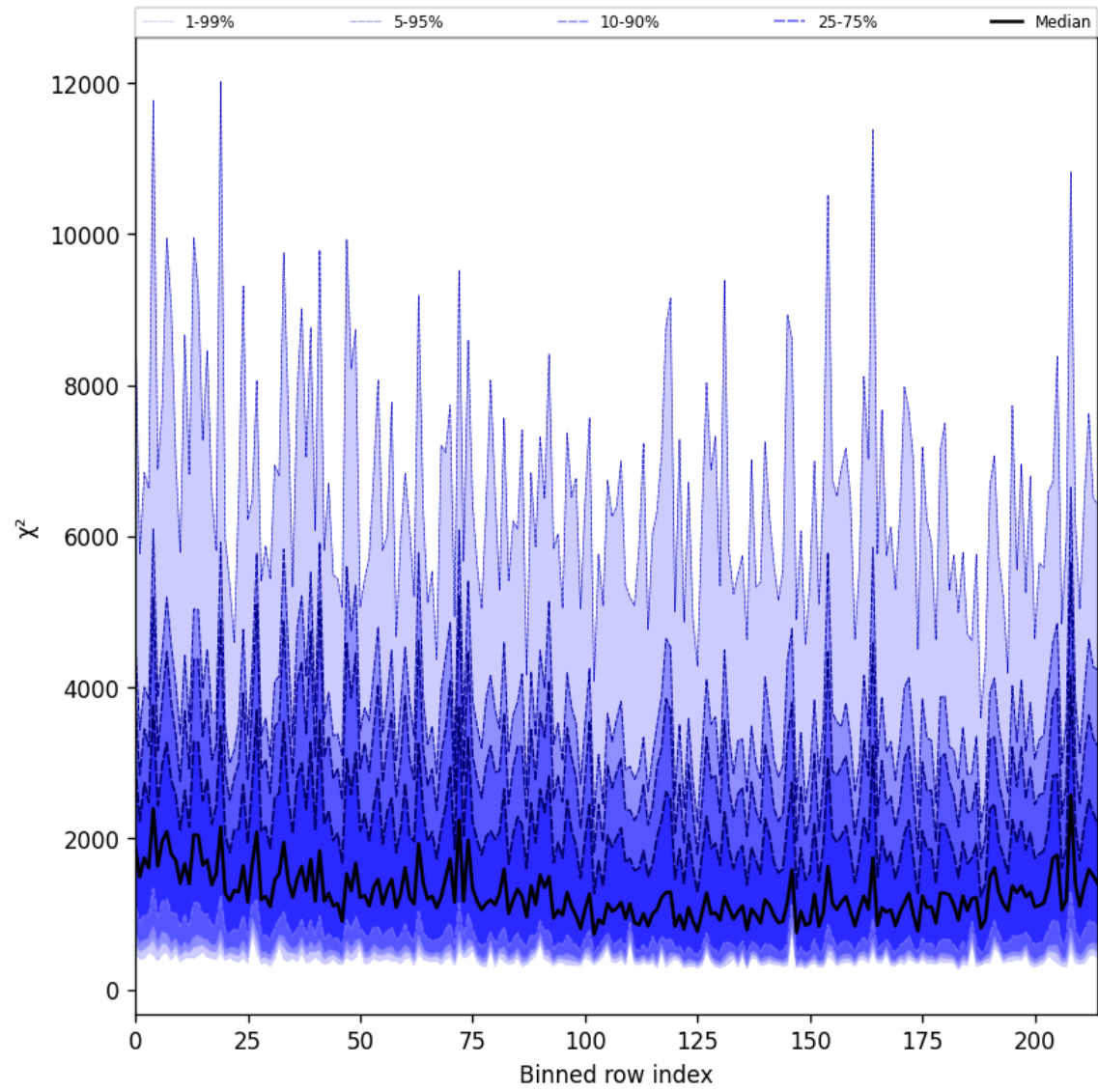


Figure 24: Along track statistics of “ $\chi^2$ ” for 2025-02-08 to 2025-02-09

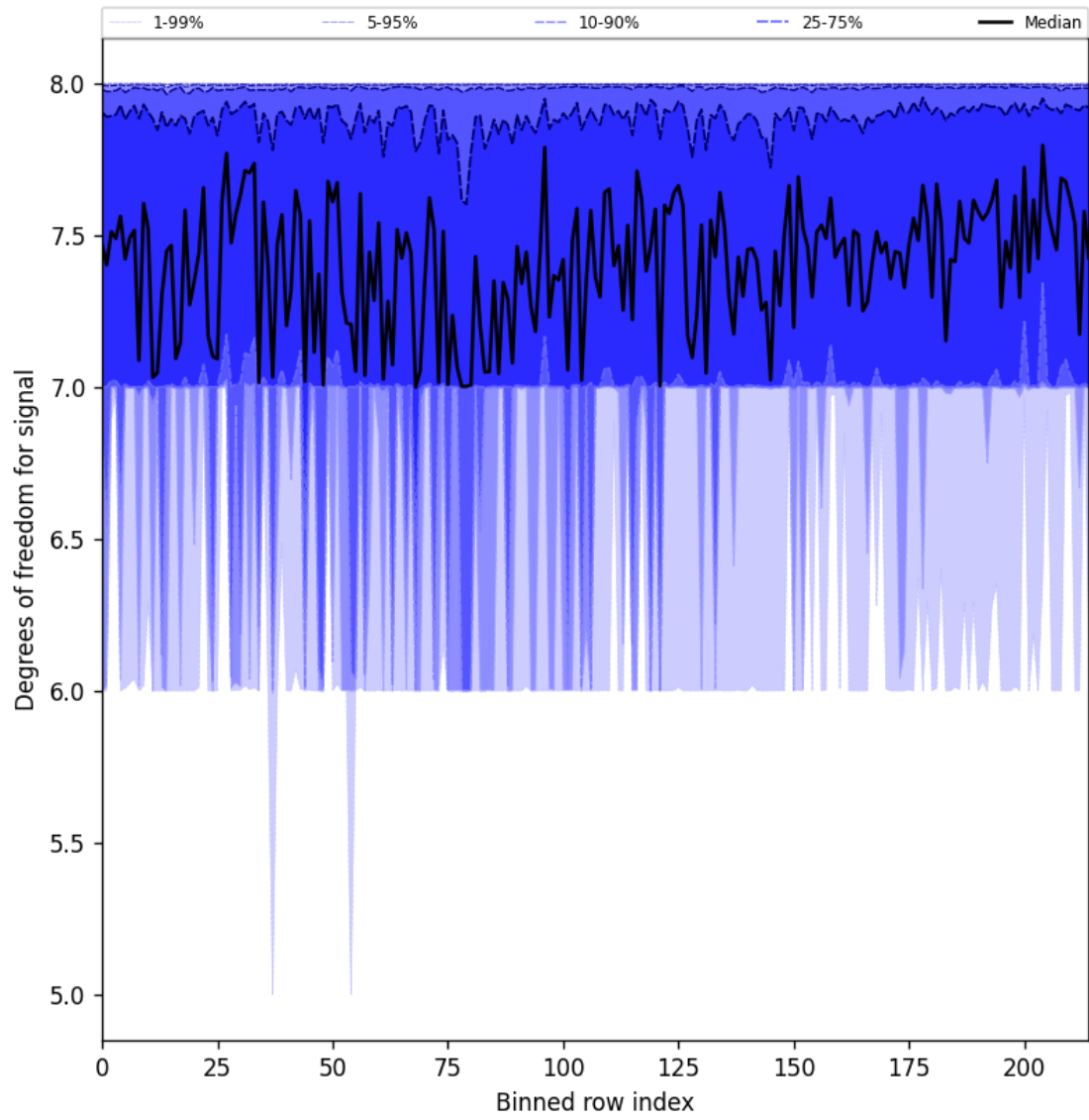


Figure 25: Along track statistics of “Degrees of freedom for signal” for 2025-02-08 to 2025-02-09

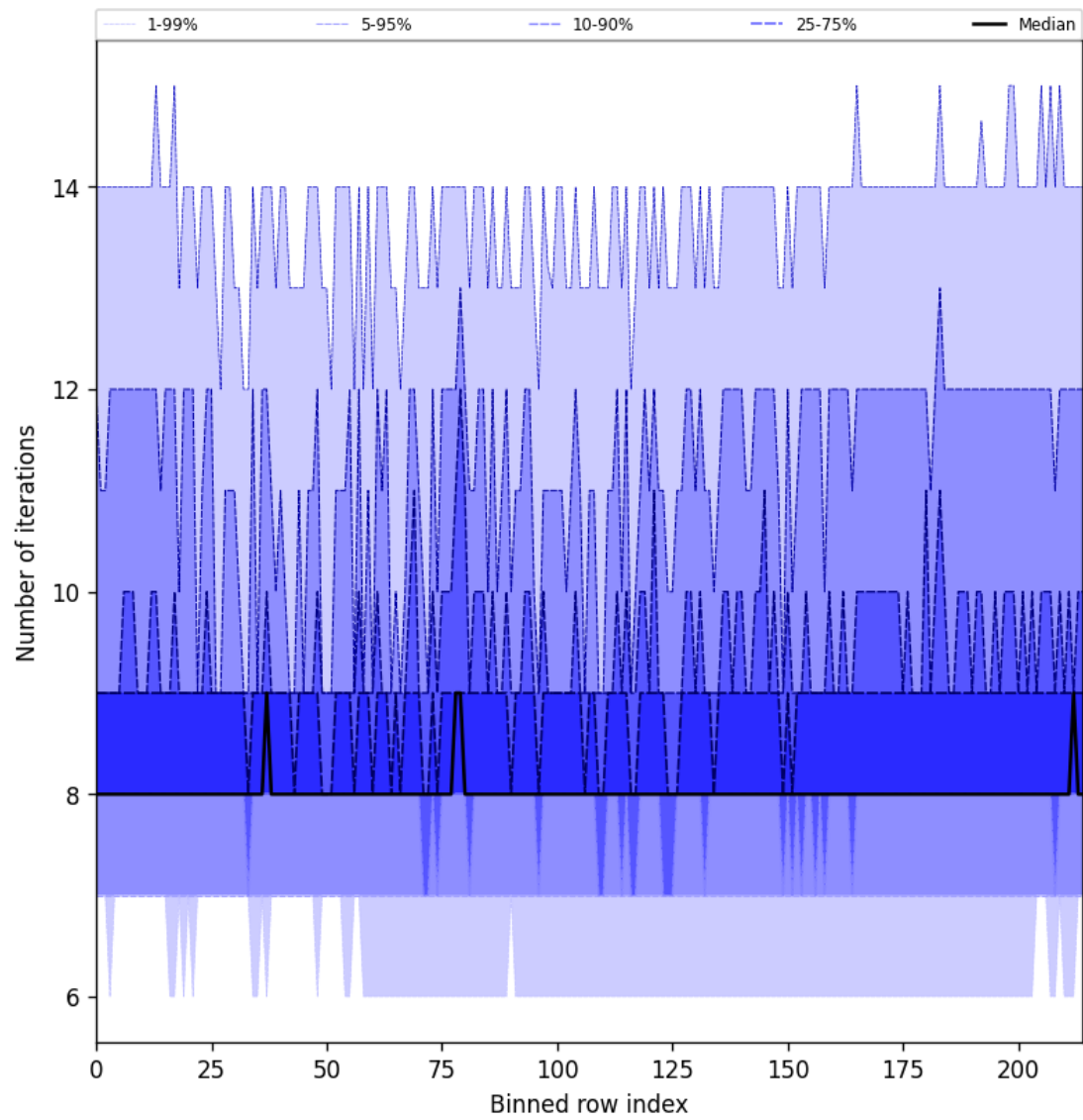


Figure 26: Along track statistics of “Number of iterations” for 2025-02-08 to 2025-02-09

## 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.

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