Supplement of Intercomparison of Sentinel-5P TROPOMI cloud products for tropospheric trace gas retrievals

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S1 Additional plots of the comparison between version 1 and version 2 cloud fractions and cloud heights for Europe and Africa

Figure S1: Scatter plots between the version 1 and version 2 cloud fractions from (a) ROCINN CRB, (b) ROCINN CAL, (c) OCRA a priori, (d) FRESCO, (e) the NO\textsubscript{2} fitting window, and (f) VIIRS for Europe and the summer day (30 June 2018).
Figure S2: As Figure S1 but for the winter day (5 January 2019).

Figure S3: As Figure S1 but for the fall day (20 September 2019).
Figure S4: Scatter plots between the version 1 and version 2 cloud fractions from (a) ROCINN CRB, (b) ROCINN CAL, (c) OCRA a priori, (d) FRESCO, (e) the NO$_2$ fitting window, and (f) VIIRS for Africa and the spring day (4 April 2019).

Figure S5: As Figure S4 but for the fall day (20 September 2019).
Figure S6: Scatter plots between the version 1 and version 2 cloud heights from (a) ROCINN CRB, (b) ROCINN CAL top, and (c) FRESCO from the TROPOMI NO$_2$ product (ch$_{fresco}^*$) for Europe and the summer day (30 June 2018).

Figure S7: As Figure S6 but for the winter day (5 January 2019).

Figure S8: As Figure S6 but for the spring day (4 April 2019).

Figure S9: As Figure S6 but for the fall day (20 September 2019).
Figure S10: Scatter plots between the version 1 and version 2 cloud heights from (a) ROCINN CRB, (b) ROCINN CAL top, and (c) FRESCO from the TROPOMI NO2 product (ch_fresco*) for Africa and the winter day (5 January 2019).

Figure S11: As Figure S10 but for the spring day (4 April 2019).

Figure S12: As Figure S10 but for the fall day (20 September 2019).
S2 Tabular intercomparison of the statistics between the version 2 cloud fractions for China

Figure S13: Tabular intercomparison of the correlations between the version 2 cloud fractions from ROCINN CRB, ROCINN CAL, OCRA a priori, the NO$_2$ fitting window (cf$_{fit}$), FRESCO, O2-O2, MICRU, and VIIRS for China and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.

Figure S14: Tabular intercomparison of the slopes of the scatter plots between the version 2 cloud fractions from ROCINN CRB, ROCINN CAL, OCRA a priori, the NO$_2$ fitting window (cf$_{fit}$), FRESCO, O2-O2, MICRU, and VIIRS for China and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.
Figure S15: Tabular intercomparison of the y-intercepts of the scatter plots between the version 2 cloud fractions from ROCINN CRB, ROCINN CAL, OCRA a priori, the NO$_2$ fitting window (cf$_{fit}$), FRESCO, O2-O2, MICRU, and VIIRS for China and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.
S3 Tabular intercomparison of the statistics between the version 1 cloud fractions for Europe, Africa, and China

Figure S16: Tabular intercomparison of the correlations between the version 1 cloud fractions from ROCINN CRB, ROCINN CAL, OCRA a priori, the NO$_2$ fitting window (cf$^*$fit), FRESCO, MICRU, and VIIRS for Europe and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.

Figure S17: Tabular intercomparison of the slopes of the scatter plots between the version 1 cloud fractions from ROCINN CRB, ROCINN CAL, OCRA a priori, the NO$_2$ fitting window (cf$^*$fit), FRESCO, MICRU, and VIIRS for Europe and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.
Figure S18: Tabular intercomparison of the y-intercepts of the scatter plots between the version 1 cloud fractions from ROCINN CRB, ROCINN CAL, OCRA a priori, the NO$_2$ fitting window (cf$_{fit}$), FRESCO, MICRU, and VIIRS for Europe and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.

Figure S19: As Figure S16 but for Africa.
Figure S20: As Figure S17 but for Africa.

Figure S21: As Figure S18 but for Africa.
Figure S22: As Figure S16 but for China.

Figure S23: As Figure S17 but for China.
Figure S24: As Figure S18 but for China.
S4 Tabular intercomparison of the statistics between the version 2 cloud heights for Europe and Africa

Figure S25: Tabular intercomparison of the correlations between the version 2 cloud heights from ROCINN CAL base and top, ROCINN CRB, FRESCO from the TROPOMI NO$_2$ product (ch_fresco*), and O2-O2 for Europe and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.

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Figure S26: Tabular intercomparison of the slopes of the scatter plots between the version 2 cloud heights from ROCINN CAL base and top, ROCINN CRB, FRESCO from the TROPOMI NO$_2$ product (ch_fresco*), and O2-O2 for Europe and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.
Figure S27: Tabular intercomparison of the y-intercepts of the scatter plots between the version 2 cloud heights from ROCNN CAL base and top, ROCNN CRB, FRESCO from the TROPOMI NO2 product (ch_fresco*), and O2-O2 for Europe and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.

Figure S28: As Figure S25 but for Africa.
Figure S29: As Figure S26 but for Africa.

Figure S30: As Figure S27 but for Africa.
S5 Tabular intercomparison of the statistics between the version 1 cloud heights for China, Europe, and Africa

Figure S31: Tabular intercomparison of the correlations between the version 1 cloud heights from ROCINN CAL base and top, ROCINN CRB, and FRESCO from the TROPOMI NO₂ product (ch_fresco*) for China and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.

Figure S32: Tabular intercomparison of the slopes of the scatter plots between the version 1 cloud heights from ROCINN CAL base and top, ROCINN CRB, and FRESCO from the TROPOMI NO₂ product (ch_fresco*) for China and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.
Figure S33: Tabular intercomparison of the y-intercepts of the scatter plots between the version 1 cloud heights from ROCINN CAL base and top, ROCINN CRB, and FRESCO from the TROPOMI NO₂ product (ch_fresco⁶) for China and (a) the summer day, (b) the winter day, (c) the spring day, (d) the fall day.

Figure S34: As Figure S31 but for Europe.
Figure S35: As Figure S32 but for Europe.

Figure S36: As Figure S33 but for Europe.
Figure S37: As Figure S31 but for Africa.

Figure S38: As Figure S32 but for Africa.
Figure S39: As Figure S33 but for Africa.
S6: Additional plots of the intercomparison between the version 2 cloud fractions for Europe and Africa

Figure S40: Scatter plots between the version 2 cloud fractions from (a) ROCINN CRB, (b) ROCINN CAL, (c) OCRA a priori, (d) FRESCO, (e) O2-O2, (f) MICRU, and (g) VIIRS and the cloud fraction from the NO2 fitting window (cf_fit) for Europe and the summer day (30 June 2018).

Figure S41: Differences between the version 2 cloud fractions from (a) ROCINN CRB, (b) ROCINN CAL, (c) OCRA a priori, (d) FRESCO, (e) O2-O2, (f) MICRU, and (g) VIIRS and the cloud fraction from the NO2 fitting window (cf_fit) for Europe and the summer day (30 June 2018).
Figure S42: As Figure S40 but for the winter day (5 January 2019).

Figure S43: As Figure S41 but for the winter day (5 January 2019).
Figure S44: As Figure S40 but for the fall day (20 September 2019).

Figure S45: As Figure S41 but for the fall day (20 September 2019).
Figure S46: Scatter plots between the version 2 cloud fractions from (a) ROCINN CRB, (b) ROCINN CAL, (c) OCRA a priori, (d) FRESCO, (e) O2-O2, (f) MICRU, and (g) VIIRS and the cloud fraction from the NO₂ fitting window (cf_fit) for Africa and the summer day (30 June 2018).

Figure S47: Differences between the version 2 cloud fractions from (a) ROCINN CRB, (b) ROCINN CAL, (c) OCRA a priori, (d) FRESCO, (e) O2-O2, (f) MICRU, and (g) VIIRS and the cloud fraction from the NO₂ fitting window (cf_fit) for Africa and the summer day (30 June 2018).
Figure S48: As Figure S46 but for the spring day (4 April 2019).

Figure S49: As Figure S47 but for the spring day (4 April 2019).
Figure S50: As Figure S46 but for the fall day (20 September 2019).

Figure S51: As Figure S47 but for the fall day (20 September 2019).
S7: Additional scatter plots of the intercomparison between the version 2 cloud heights for China

Figure S52: Scatter plots between the version 2 (a) ROCINN CAL CBH, (b) ROCINN CAL CTH, (c) ROCINN CRB CH, and (d) O2-O2 CH and the FRESCO CH from the TROPOMI NO2 product (ch_fresco*) for China and the summer day (30 June 2018).

Figure S53: Differences between the version 2 (a) ROCINN CAL CBH, (b) ROCINN CAL CTH, (c) ROCINN CRB CH, and (d) O2-O2 CH and the FRESCO CH from the TROPOMI NO2 product (ch_fresco*) for China and the summer day (30 June 2018).
Figure S54: As Figure S52 but for the winter day (5 January 2019).

Figure S55: As Figure S53 but for the winter day (5 January 2019).
Figure S56: As Figure S52 but for the spring day (4 April 2019).

Figure S57: As Figure S53 but for the spring day (4 April 2019).
Figure S58: Scatter plots between the version 2 (a) ROCINN CAL CBH, (b) ROCINN CAL CTH, (c) ROCINN CRB CH, and (d) O2-O2 CH and the FRESCO CH from the TROPOMI NO2 product (ch_fresco*) for China and the summer day (30 June 2018) with a cloud fraction threshold of 0.2 (only CH for scenes with cloud fractions ≤ 0.2).

Figure S59: As Figure S58 but for the winter day (5 January 2019).
Figure S60: As Figure S58 but for the spring day (4 April 2019).

Figure S61: Scatter plots between the version 2 (a) ROCINN CAL CBH, (b) ROCINN CAL CTH, (c) ROCINN CRB CH, and (d) O2-O2 CH and the FRESCO CH from the TROPOMI NO2 product (ch_fresco*) for China and the summer day (30 June 2018) with a cloud fraction threshold of 0.2 for cloud heights lower than or equal 2 km (only CH ≤ 2 km for scenes with cloud fractions ≤ 0.2).
Figure S62: As Figure S61 but for the winter day (5 January 2019).

Figure S63: As Figure S61 but for the spring day (4 April 2019).
S8 Across-track dependency plots of the version 1 cloud fractions and cloud heights for the globe, Africa, Europe, and China

Figure S64: Mean values of version 1 cloud fractions, as a function of the across-track index, from ROCINN CRB, ROCINN CAL, OCRA a priori, the NO2 fitting window (cf_fit), FRESCO, MICRU, and VIIRS for the globe and (a) the summer day, (b) the winter day, (c) the spring day, and (d) the fall day with quality- and snow-/ice-flagging, and including only pixels having valid values for all products.

Figure S65: As Figure S64 but for Africa.
Figure S66: As Figure S64 but for Europe.
Figure S67: As Figure S64 but for China.
Figure S68: Mean values of version 1 cloud heights, as a function of the across-track index, from ROCINN CRB, ROCINN CAL top and base, and FRESCO from the TROPOMI NO₂ product (ch_fresco*) for the globe and (a) the summer day, (b) the winter day, (c) the spring day, and (d) the fall day with quality- and snow/ice-flagging, and including only pixels having valid values for all products.

Figure S69: As Figure S68 but for Africa.
Figure S70: As Figure S68 but for Europe.

Figure S71: As Figure S68 but for China.