FRM4GHG

Fiducial Reference Measurements for Greenhouse Gases

Preliminary datasets & results distributed among partners via project Web portal

(Semi-blind intercomparison)

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Proposal from February 16, 2016 plus comments from May 27, 2016

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1 Document change record

Issue	Date	Item	Comment
V0.0	2017-06-20	–	Initial version, for review M. De Mazière
V0.0	2017-06-22	–	Initial version, for feedback and completion by all participants to the campaign
V0.1	2017-06-26	–	Version with rainbow colour coded correlation plots
V0.2	2017-08-22	–	Final version, included AirCore plots and comments from ESA

2 Access list

This document is a deliverable "D3.1: Preliminary datasets & results distributed among partners via project Web portal (Semi-blind intercomparison)" created for the project FRM4GHG and will be submitted to ESA. The document will be a publicly accessible document and can be downloaded from the project webpage http://frm4ghg.aeronomie.be.

3 Applicable documents

Statement of Work: Fiducial Reference Measurements for Ground-Based FTIR Greenhouse Gas Observations (FRM4GHG)
Prepared by: T. Fehr/B. Bojkov (EOP-GMQ), Reference: ESA-EOPG-MOM-SOW-0007

4 Reference documents

FRM4GHG deliverable D2.3: Description of measurement strategy to ensure comparable observations, made available via the project website
http://frm4ghg.aeronomie.be/index.php/outreach/deliverables

FRM4GHG deliverable D2.5: Retrieval strategy & Intercomparison strategy and protocol, made available via the project website
http://frm4ghg.aeronomie.be/index.php/outreach/deliverables

5 Reference for software/tool mentioned

N/A

6 Purpose

This document presents the results of the semi-blind intercomparison study, which consisted of measurements performed by the five participating instruments in Sodankylä since the beginning of the campaign in March 2017 till June 10, 2017. Each individual team performed measurements according to their best practice as documented in deliverable D2.3. The data has been processed by the respective teams using their respective retrieval software and standard settings. All retrieval strategies used their own linelist for the semi-blind phase of intercomparison. The linelist is available on the project webpage[1] for each instrument. A detailed description of the semi-blind intercomparison strategy has been described in deliverable D2.5.

7 Document structure

Section 8 Referee – Presents the referee and describes the role of the referee in the project.

Section 9 Intercomparison data – Describes the data submission protocol for the semi-blind intercomparison study via the google sheets.

Section 10 File properties – Describes the properties of the files submitted by the individual team. It also gives header information for each file submitted via google sheets.

Section 11 Intercomparison execution – Describes the operations done to the dataset for executing the semi-blind intercomparison study.

Section 12 Results – Describes the results of the semi-blind intercomparison study for each species and the general remarks as a summary of the study.

8 Referee

BIRA-IASB is not in charge directly of performing measurements – and will therefore act as the 'referee' and be responsible of comparing the data from all participating instruments.

9 Intercomparison data

For the semi-blind intercomparison study it is necessary that the referee is neutral. In order to guarantee this, eight google sheets (see below) were created for the submission of the retrieval results. The links to the sheets were provided by email to all groups and also put up on the campaign webpage. The retrieval results from TCCON, our reference instrument, had to be put in File1 sheet. The other four groups had the choice to put their retrieval results in any of the other available seven sheets. Three redundant sheets were created to avoid any overlap during the data submission. Based on the measurement capabilities, the groups were asked to give some or all of the following parameters: measurement day/time; ground pressure; column values for O2, H2O, CO2, CH4, CO; and Xgas values for XCO2, XCH4, XCO. The deadline for the submission of the analysis results was June 16, 2017.

Links of the google sheets for submission of the analysis results

File1:https://docs.google.com/spreadsheets/d/1IQX6wKN4ETimj5p5-vfWRHpqjXMm8chDgVCZO__hpyo/edit?usp=sharing

[1] Linelist used by the participating teams can be found on the project webpage following this link: http://frm4ghg.aeronomie.be/index.php/documents/linelist .

File2:https://docs.google.com/spreadsheets/d/1McCs46wHMmswa68llgGtBduzLPH3gBfLmAKIBNQQFU8/edit?usp=sharing

File3:https://docs.google.com/spreadsheets/d/1GpjhBSzb6n9ezuKiUuVhmskBXF04vIO7s5AtRQJQoFo/edit?usp=sharing

File4:https://docs.google.com/spreadsheets/d/1Sa1cmWbDMiYKEI6UAhndIk9hAHzeL672FgLZfYgMseM/edit?usp=sharing

File5:https://docs.google.com/spreadsheets/d/1GsXM1dIcoIkFrnP_RzuTRE03gmDrhVDOVfW_7SHJd5o/edit?usp=sharing

File6:https://docs.google.com/spreadsheets/d/1Plkrtz1C84xnxzuBoll9PduoCW2q0JDGYGgk6Zn4C9c/edit?usp=sharing

File7:https://docs.google.com/spreadsheets/d/1enmemXh4jvnSXy0bahFFBscVDsON9Ots8Dw2T3Fww4M/edit?usp=sharing

File8:https://docs.google.com/spreadsheets/d/1IBneotOZDFVWbpw_DvslehOmbZUVp1BDAjy70oNIj9E/edit?usp=sharing

The following data sheets were used for the data submission: File1(TCCON), File2, File4, File5, File6. This nomenclature will be followed throughout the document and in the plots for addressing the retrieval results from the respective participating instruments.

10 File properties

The main climate relevant gases which are under consideration for this campaign are carbon dioxide (CO_2), methane (CH_4) and carbon monoxide (CO). The instruments participating in this campaign measure some or all of the target gases. The retrieval results are the total column concentrations of the gases and the column averaged dry air mole fraction of the gas (Xgas[2]). In addition they measure the total column concentration of water vapour (H2O) and oxygen (O2). Here is a list of the header line for each file describing the retrieved species by the respective instrument and the units in which the values are presented.

TCCON (File1):

DateTime(UT); Pressure(hPa); Column O2(molecules/cm2); Column H2O(molecules/cm2); Column CO2(molecules/cm2); Column CH4(molecules/cm2); Column CO(molecules/cm2); xCO2(ppm); xCH4(ppm); xCO(ppb)

File2:

DateTime_UTC; SrfPressure_AWS12LT_hPa ; Col-H2O_molec/cm2; Col-CO2_molec/cm2; XCO2_ppm

File4:

Year; day; hour; pins_mbar; xco_ppb; xch4_ppm; xco2_ppm; column_h2o; column_co; column_ch4; column_co2; column_o2

[2] Xgas according to TCCON standard is defined as:
$xgas = \frac{gascolumn}{O2column} * 0.2095; where\ 0.2095\ is\ the\ dry\ air\ O2\ mole$ fraction

Extra info: Units: column_h2o (molecules/m2); column_co (molecules/m2); column_ch4 (molecules/m2); column_co2 (molecules/m2); column_o2 (molecules/m2)

File5:

Year; day; hr_ut; min; sec; Press_hPa; O2_column; H2O_column; CH4_column; CO2_column; xCO2_ppm; xCH4_ppm

Extra info: Units: O2_column (molecules/m2); H2O_column (molecules/m2); CH4_column (molecules/m2); CO2_column (molecules/m2)

Warning: The CO2_column and the CH4_column are interchanged in the file.

File6:

JD; Date; HHMMSS; O2; H2O; CO2; CH4; CO; XCO2/ppm; XCH4/ppm; XCO/ppb; SZA; XCO2_SZAcorr, XCH4_SZAcorr; JD_Ground pressure; Ground pressure

Extra info: Units: O2 (molecules/m2); H2O (molecules/m2); CO2 (molecules/m2); CH4 (molecules/m2); CO (molecules/m2); SZA (degrees)

11 Intercomparison execution

The retrieval results from each instrument were plotted as time series plots for the complete data series. Difference plots of matching pairs of results from each instrument relative to the TCCON result using a coincidence criterion to find the matching pairs were made as well. As a coincidence criterion the retrieval results of each instrument are sorted and all data within a time interval of 5 min sequence are averaged and associated to the respective start time of the bin. As a result a new dataset of 5 minutes averages is created for all instruments. The timestamps of the TCCON data are then matched with the timestamps of the other instruments to find the coincident data pairs which are then used for the difference plots. In addition correlation plots were also made using the coincident data pairs for each target gases. Furthermore the data of the correlation plot was sorted on a monthly basis and plotted again in a separate figure.

A standard plotting template was created to make the comparison plots. If the to-be-plotted gas was missing for any of the instrument, then they were given “nan” values and were therefore not shown in the plot. There were few cases where the retrieval results of some gases were missing while the others had a sensible value. These missing values were also replaced by “nan” values.

The mean, standard deviation and the median of the difference between the individual instruments and the TCCON were calculated for each gas and are shown in difference plot. These statistical values give us an indication of the bias, scatter and seasonal variation of the individual instruments with respect to the TCCON. A linear regression line was fitted to the correlation dataset for each gas. The slope, the intercept, the correlation coefficient and the standard error are printed on the correlation plots. It is quite normal to have a small bias for the instruments w.r.t the TCCON. TCCON scales the calculated Xgas value by a factor, which is derived from calibration campaigns made at the sites globally, to bring the data to the WMO reference scale. As a result our goal is to calculate the calibration factor for each species for the individual instruments w.r.t the TCCON and to check if this factor stays constant over a longer period of time.

The plots are in two annexes at the end of the document: Annex 1 provides the combined plots and Annex II the individual comparison plots.

12 Results

The results of the semi-blind intercomparison dataset are discussed here for the most relevant gases under consideration for this study.

XCO2:

File6 has the smallest bias w.r.t the TCCON (mean = - 0.911 ppm). File4 (mean = 3.388 ppm) and File5 (mean = -5.633 ppm) are quite off. In this case we need to check with the respective teams for the calibration factors which were used to calculate the XCO2 value. Also File5 shows an increase in the ΔXCO2 values in the time series plot indicating a seasonal dependence which has to be further verified. From the correlation plots it can be seen that the March values are quite low for File5 as compared to the TCCON. Instrument which delivered File2 retrieval results have issue with their retrieval. They have a high bias w.r.t the TCCON as well as strong intra-day variability. They should revisit the whole data analysis procedure and check at each individual step what is going wrong.

XCH4:

File5 has the smallest bias w.r.t the TCCON (mean = - 0.002 ppm) followed by File6 (mean = - 0.018 ppm) and File4 (mean = 0.036 ppm). The slope in XCH4 is not so evident due to scatter in the value. File2 did not submit XCH4 as product.

XCO:

File4 (mean = 5.654 ppb) has a slightly smaller bias as compared to File6 (mean = 7.910 ppb). The scatter in both datasets is comparable. The XCO values for File4 and File6 do not show any obvious seasonal bias in the different plots. File2 and File5 did not submit any XCO product.

O2:

File4, File5 and File6 have submitted O2 product for this study. File6 has the smallest bias w.r.t the TCCON (mean = 3.8 e+21 molecules/cm2) followed by File5 (mean = 6.9 e+22 molecules/cm2) and File4 (mean = -8.0 e+22 molecules/cm2).

H2O:

File2, File4, File5 and File6 have submitted H2O product for this study. The H2O total column was quite low in March and kept on increasing with high values in May – June. The comparison with TCCON shows that File4 has the smallest bias (mean = 4.5 e+19 molecules/cm2) followed by File5 (mean = -1.1 e+21 molecules/cm2), File2 (mean = 2.1 e+21 molecules/cm2) and File6 (mean = 4.2 e+21 molecules/cm2).

CO2:

File2, File4, File5 and File6 have submitted CO2 product for this study. File5 shows a jump in the CO2 column values between measurements performed in March and April, in between there is no data submitted probably due to an instrument failure. However this jump is not seen in other species. This is to be further investigated if there is any problem with the CO2 retrieval for this instrument. The comparison with TCCON shows that File5 has the smallest bias (mean = 1.0 e+19 molecules/cm2) followed by File4 (mean = -8.3 e+19 molecules/cm2), File6 (mean = 9.1 e+19 molecules/cm2) and File2 (mean = -4.8 e+20 molecules/cm2). File2 shows also high diurnal variation in the CO2 column values indicating towards a retrieval problem.

CH4:

File4, File5 and File6 have submitted CH4 product for this study. The comparison with TCCON shows that File4 has the smallest bias (mean = 8.2 e+16 molecules/cm2) followed by File6 (mean = 5.2 e+17 molecules/cm2) and File5 (mean = 5.4 e+17 molecules/cm2)

CO:

File4 and File6 have submitted CO product for this study. The comparison with TCCON shows that File6 has the smallest bias (mean = 6.6 e+16 molecules/cm2) followed by File4 (mean = 9.4 e+16 molecules/cm2).

AirCore results:

Four AirCore launches were performed from the start of the campaign till the mid of May. The dates, time of the flights and comments about the flights are reported in Table 1.

Table 1: AirCore flight details performed at the Sodankylä site during the FRM4GHG campaign

Flights	Month	Date	Time (UTC)	Comments
1	April	20170421	07:39:24-08:23:10	good, final cal. needed
2	April	20170424	15:13:39-16:13:10	good, final cal. needed
3	April	20170426	09:16:15-10:00:05	datalogger didn't work; first sampler measurements; profile will be useful with a bit larger uncertainty
4	May	20170515	09:33:22-10:25:32	good, balloon burst at 21 km instead of normally 30 km

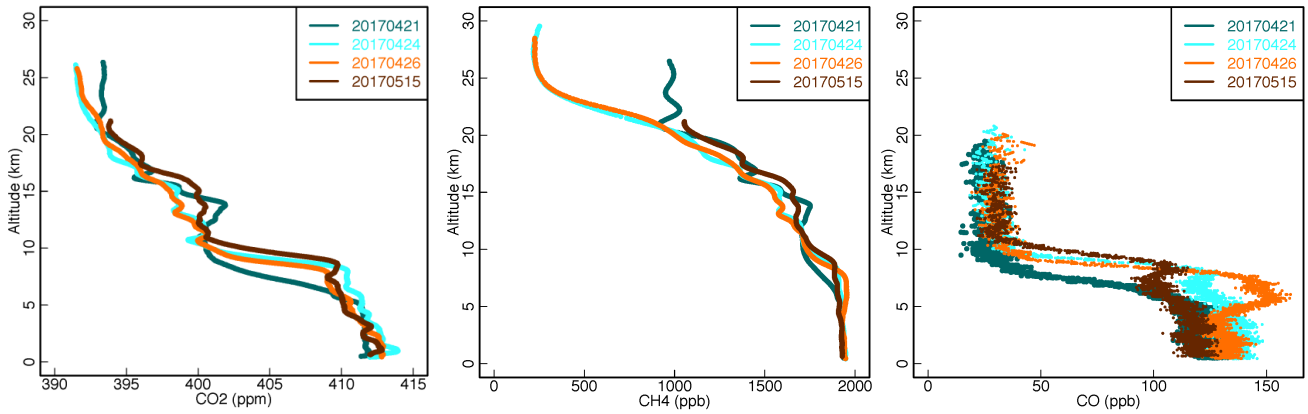


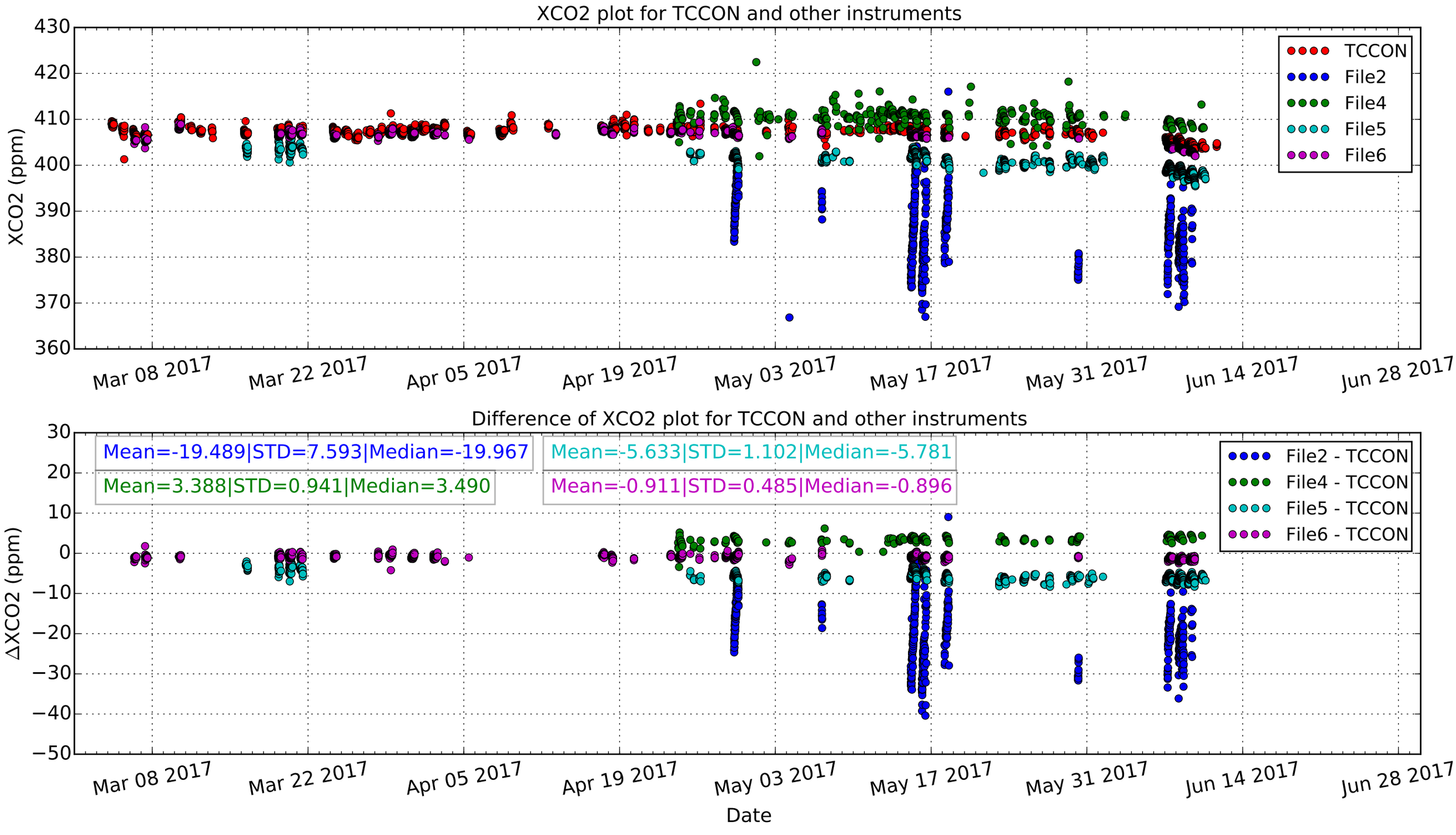
Figure 1: CO2, CH4 and CO vertical profile from the four AirCore flights performed at the Sodankylä site within the framework of the FRM4GHG campaign.

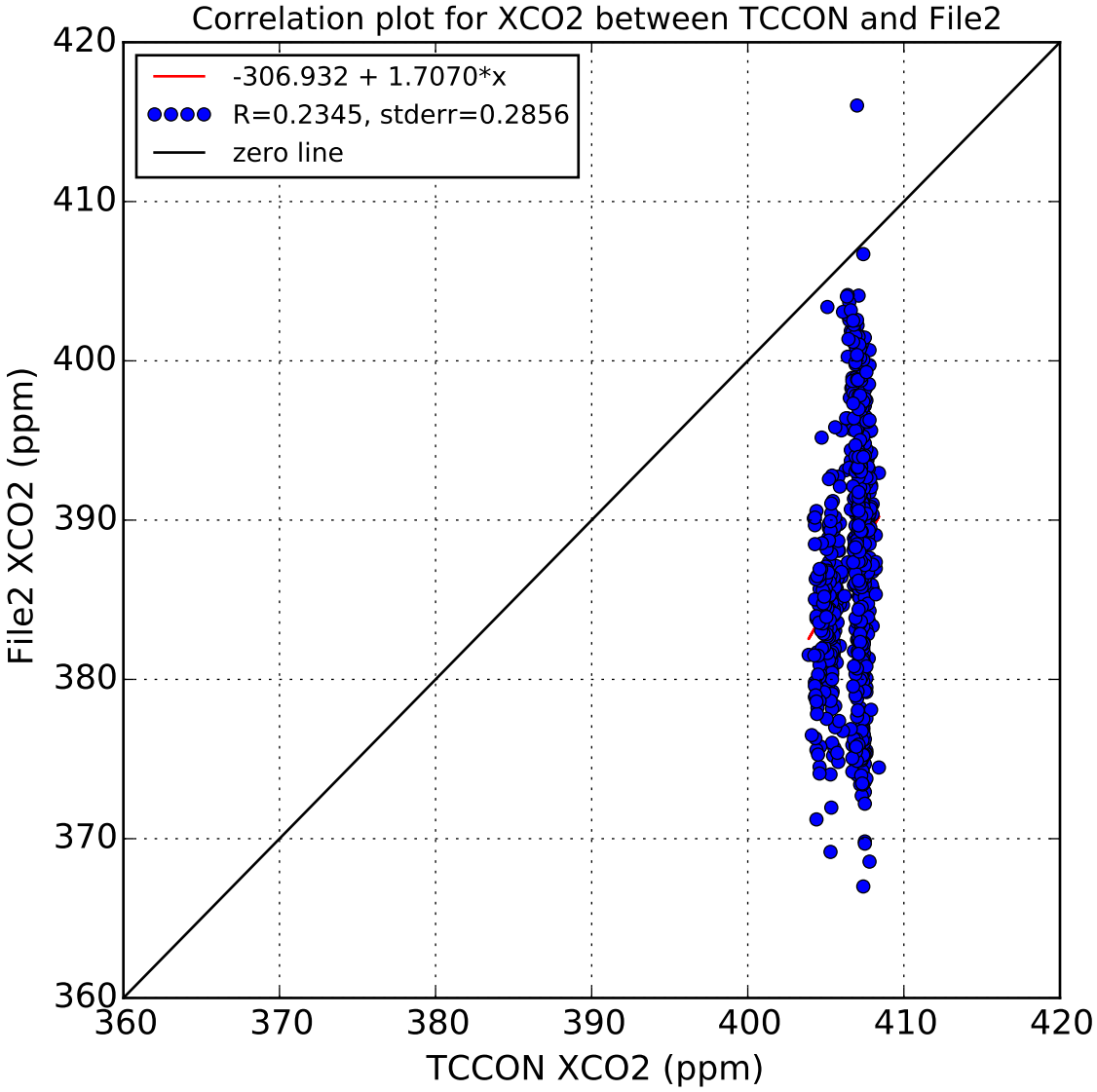
The AirCore flights were analysed and the preliminary data of the vertical profiles of CO2, CH4 and CO as shown in Figure 1 are now available via the project webpage in the results page http://frm4ghg.aeronomie.be/index.php/documents/results. These data will be used by the remote sensing teams in the next steps of data exploitation and inter-comparison exercises.

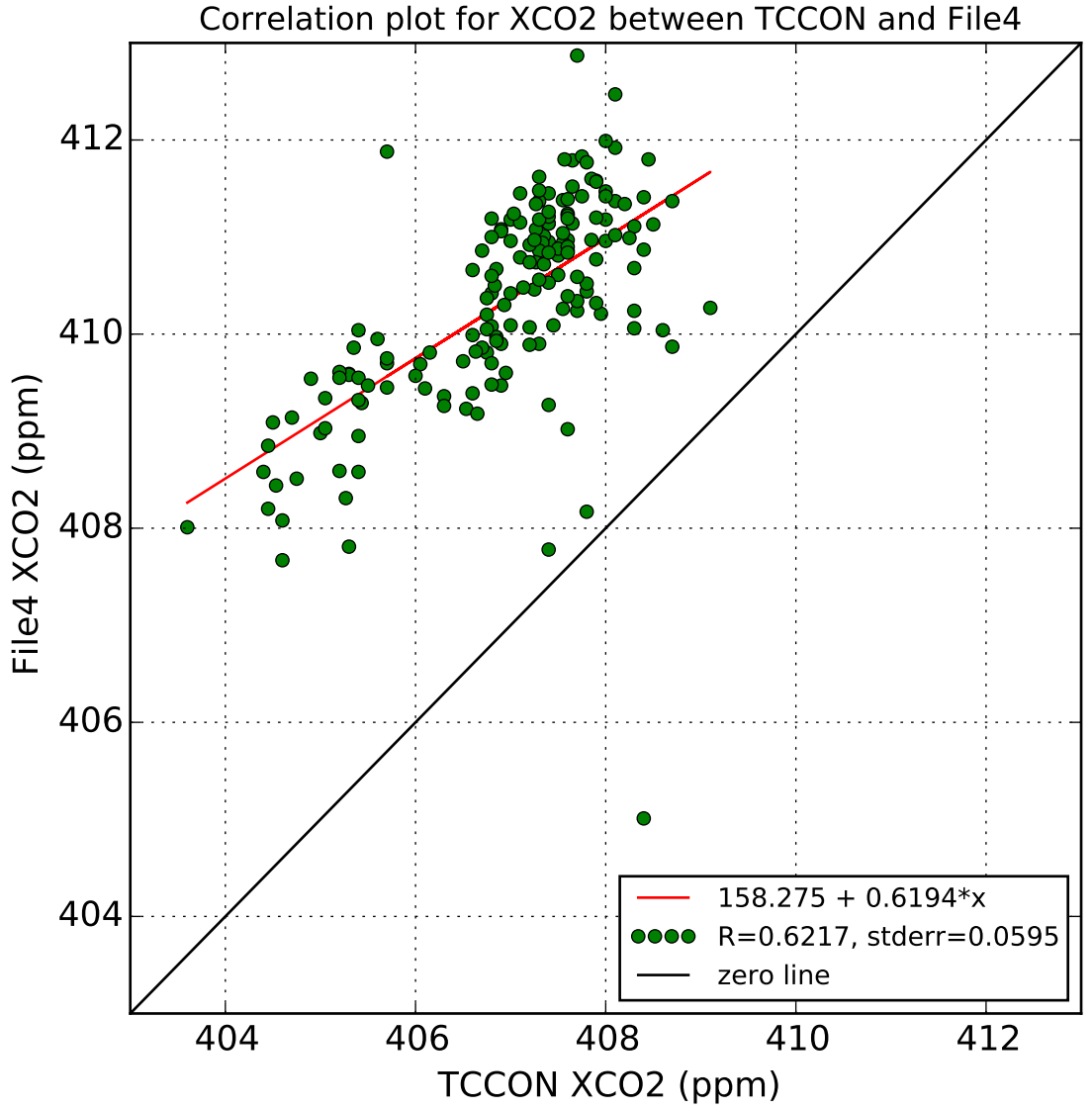
General remarks:

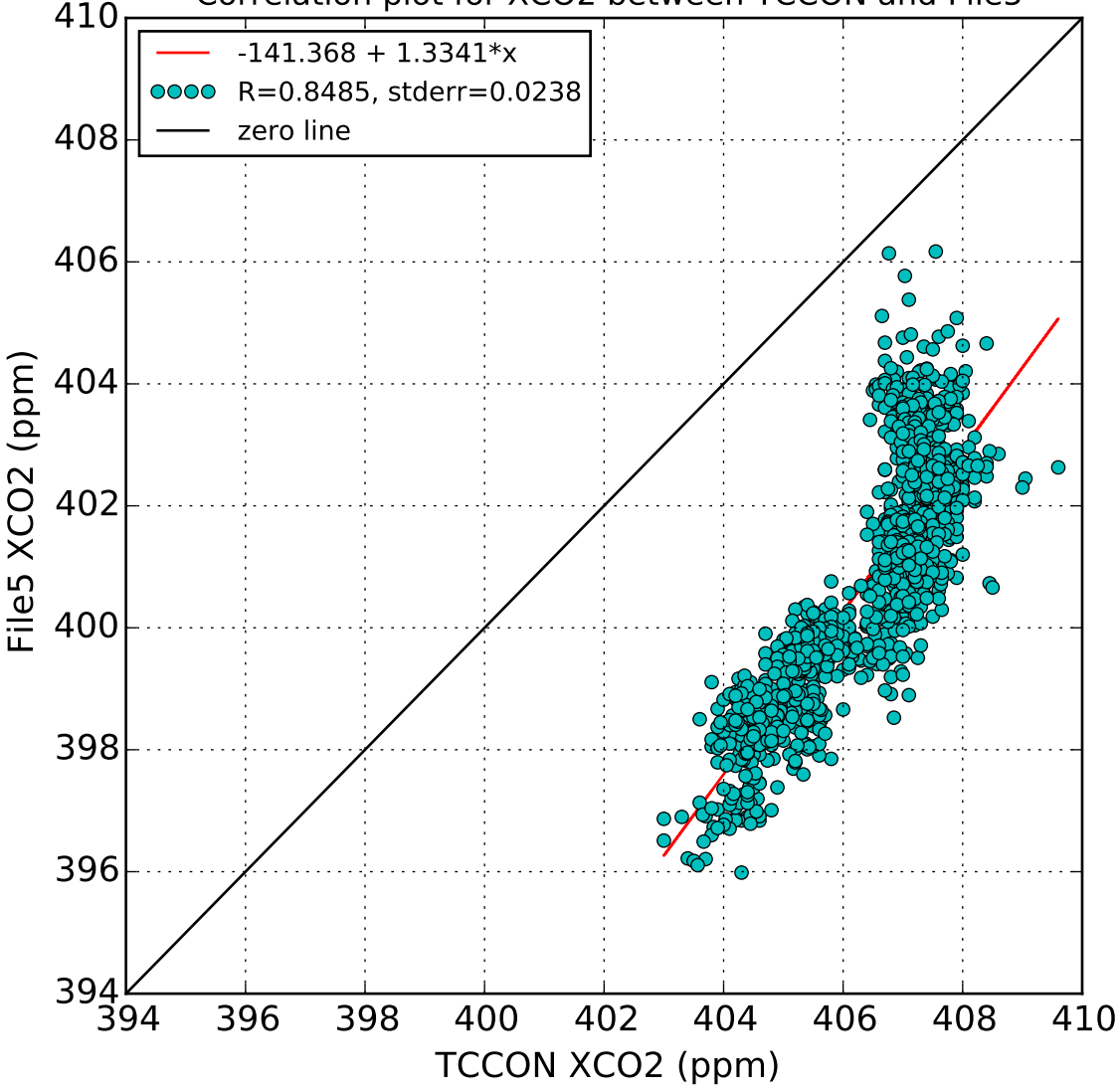
All instruments were operational, performed measurements and contributed with retrieval results for the semi-blind intercomparison study. File6 has the best agreement with TCCON for XCO2, File5 has the best agreement with TCCON for XCH4 and File4 has the best agreement with TCCON for XCO. File2 has the highest bias and scatter in the retrieval results. No evident slope was found in the Xgas values, except for File5 with few days of data recorded in March showing low values of XCO2 as compared to the TCCON. The interruption of data between end of March and mid of April indicates some instrumental error which could be the reason for this change.

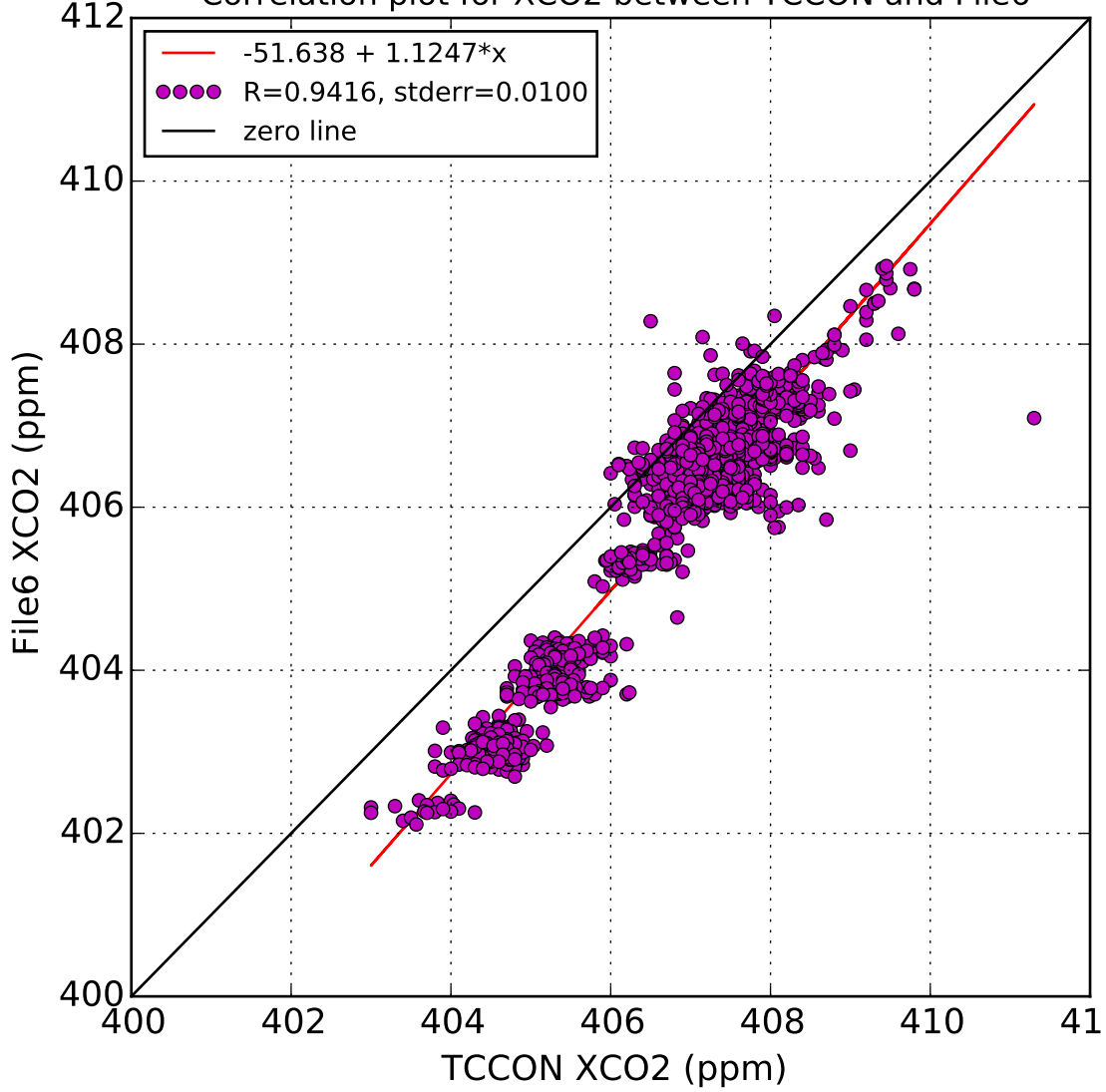
The results of the semi-blind intercomparison study will be discussed during a WebEx meeting with all team members working in the project. A further detailed analysis of the data will be done after the end of the semi-blind intercomparison study.

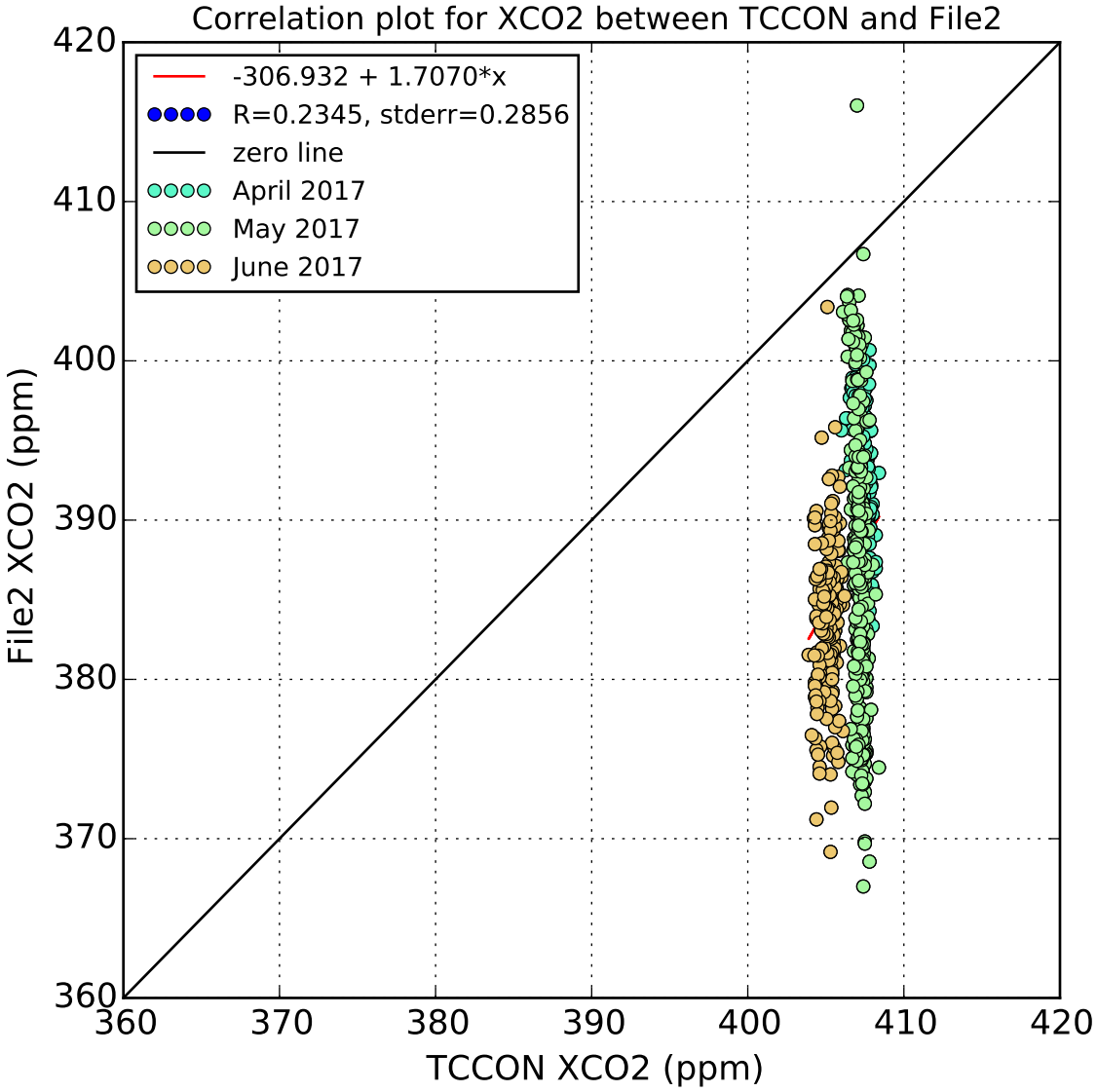

XCO2 plot for TCCON and other instruments
XCO2 (ppm)
430
420
410
400
390
380
370
360
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
TCCON
File2
File4
File5
File6
Difference of XCO2 plot for TCCON and other instruments
ΔXCO2 (ppm)
30
20
10
0
−10
−20
−30
−40
−50
Mean=-19.489|STD=7.593|Median=-19.967
Mean=-5.633|STD=1.102|Median=-5.781
Mean=3.388|STD=0.941|Median=3.490
Mean=-0.911|STD=0.485|Median=-0.896
File2 - TCCON
File4 - TCCON
File5 - TCCON
File6 - TCCON
Date

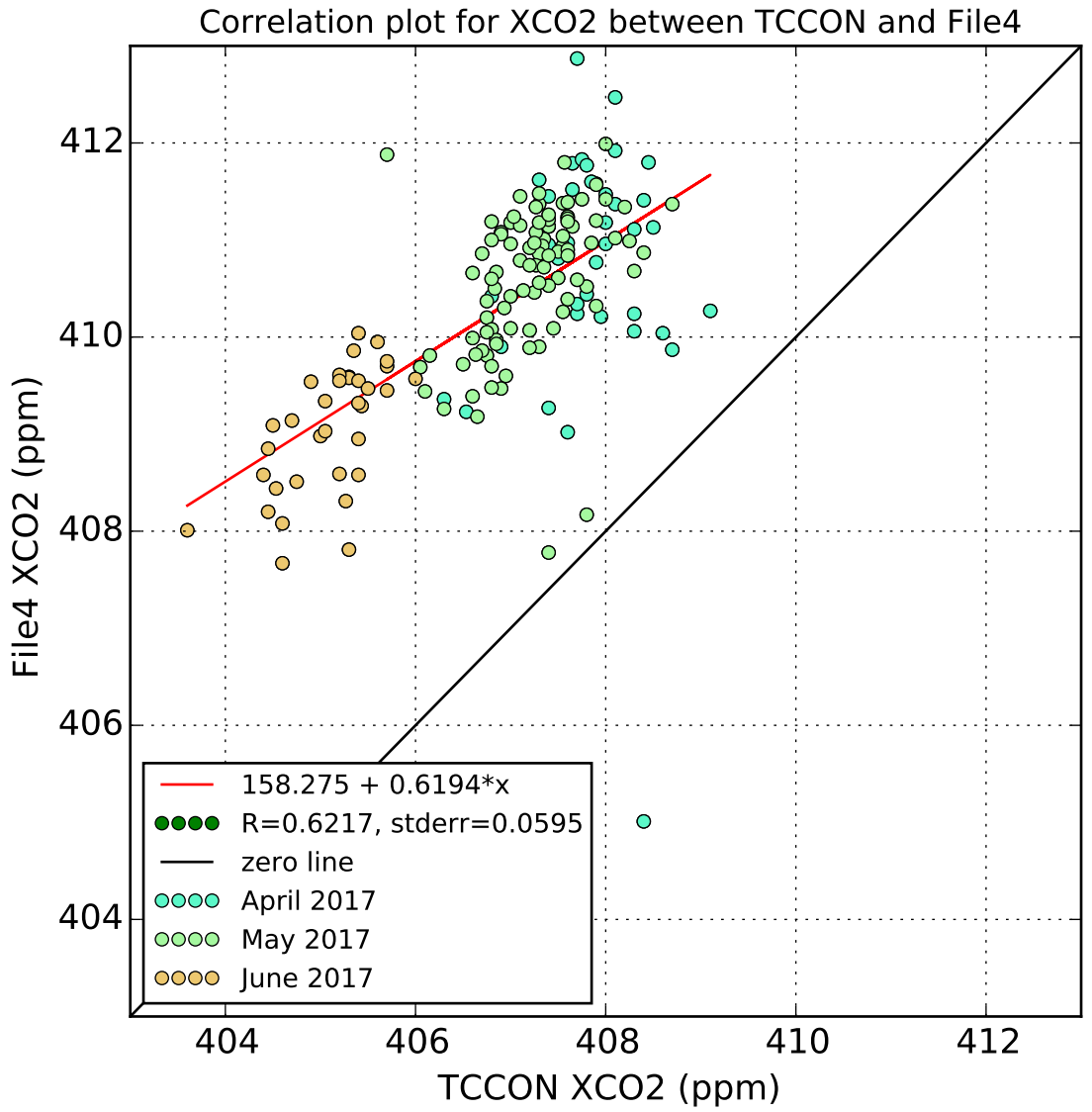

Correlation plot for XCO2 between TCCON and File2
-306.932 + 1.7070*x
R=0.2345, stderr=0.2856
zero line
File2 XCO2 (ppm)
TCCON XCO2 (ppm)
360
370
380
390
400
410
420

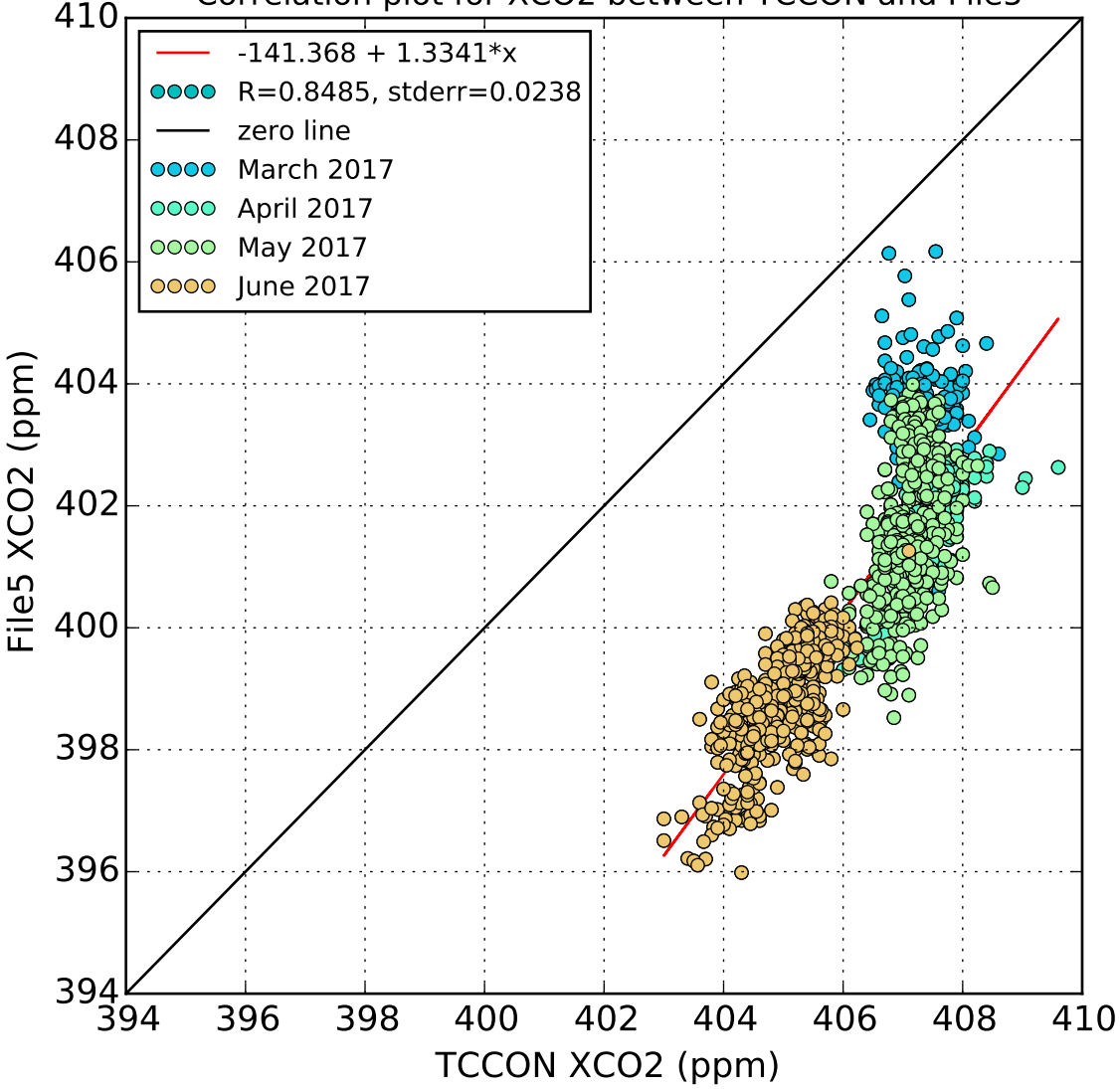

Correlation plot for XCO2 between TCCON and File4
158.275 + 0.6194*x
R=0.6217, stderr=0.0595
zero line
File4 XCO2 (ppm)
TCCON XCO2 (ppm)
404
406
408
410
412

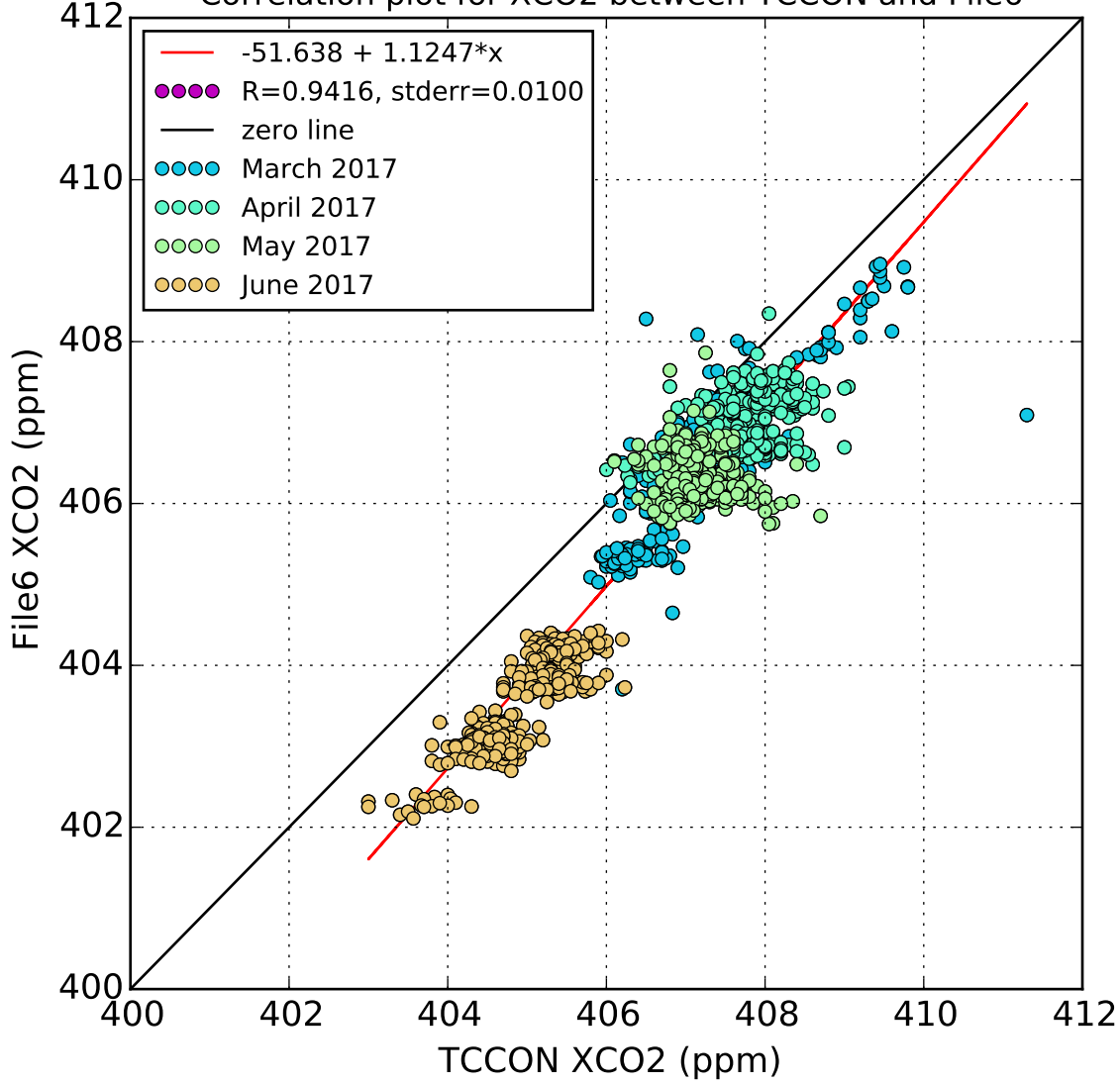

Correlation plot for XCO2 between TCCON and File5
-141.368 + 1.3341*x
R=0.8485, stderr=0.0238
zero line
File5 XCO2 (ppm)
TCCON XCO2 (ppm)
394
396
398
400
402
404
406
408
410

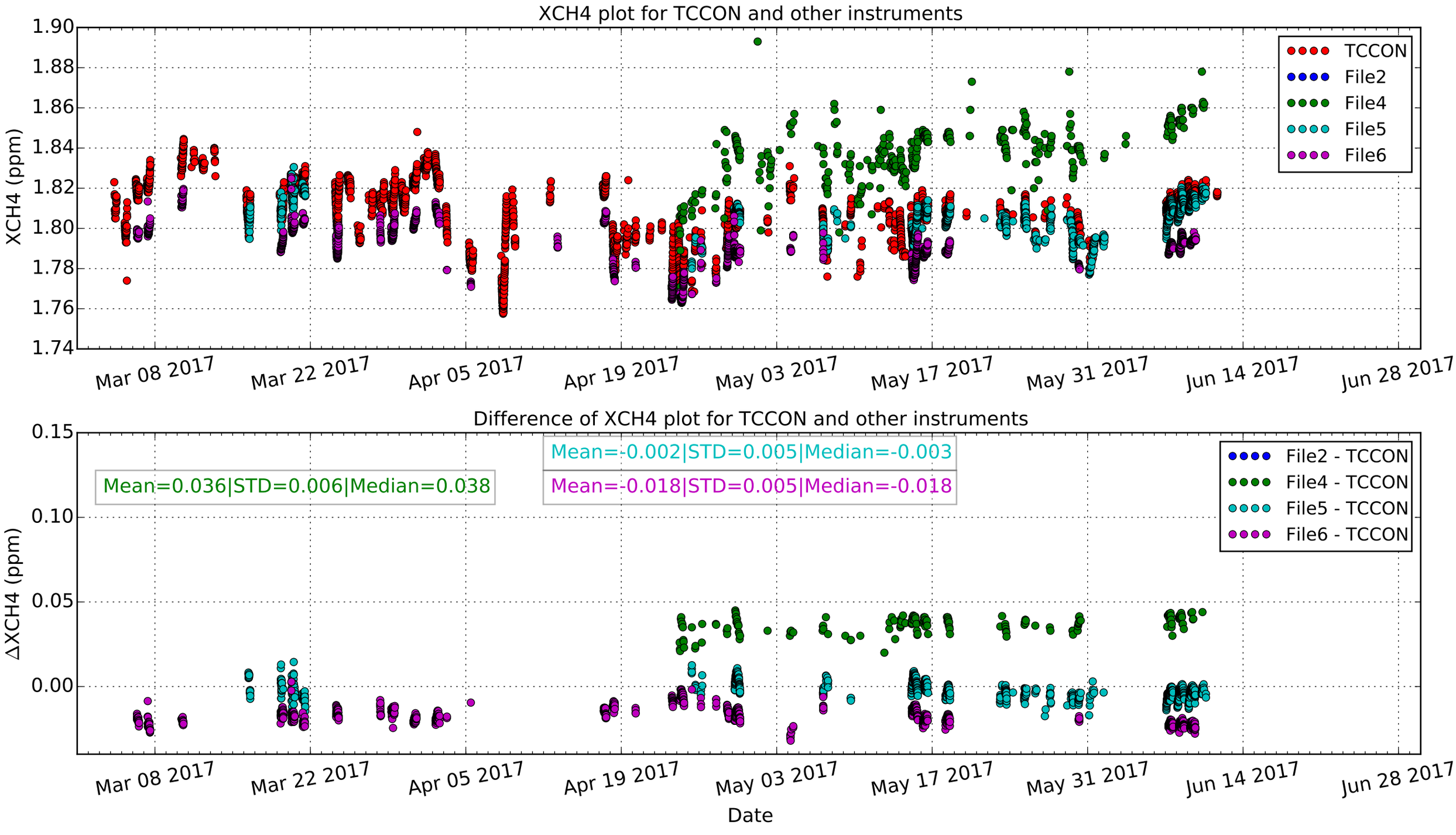

Correlation plot for XCO2 between TCCON and File6
-51.638 + 1.1247*x
R=0.9416, stderr=0.0100
zero line
File6 XCO2 (ppm)
TCCON XCO2 (ppm)
400
402
404
406
408
410
412


Correlation plot for XCO2 between TCCON and File2
-306.932 + 1.7070*x
R=0.2345, stderr=0.2856
zero line
April 2017
May 2017
June 2017
File2 XCO2 (ppm)
TCCON XCO2 (ppm)
360
370
380
390
400
410
420

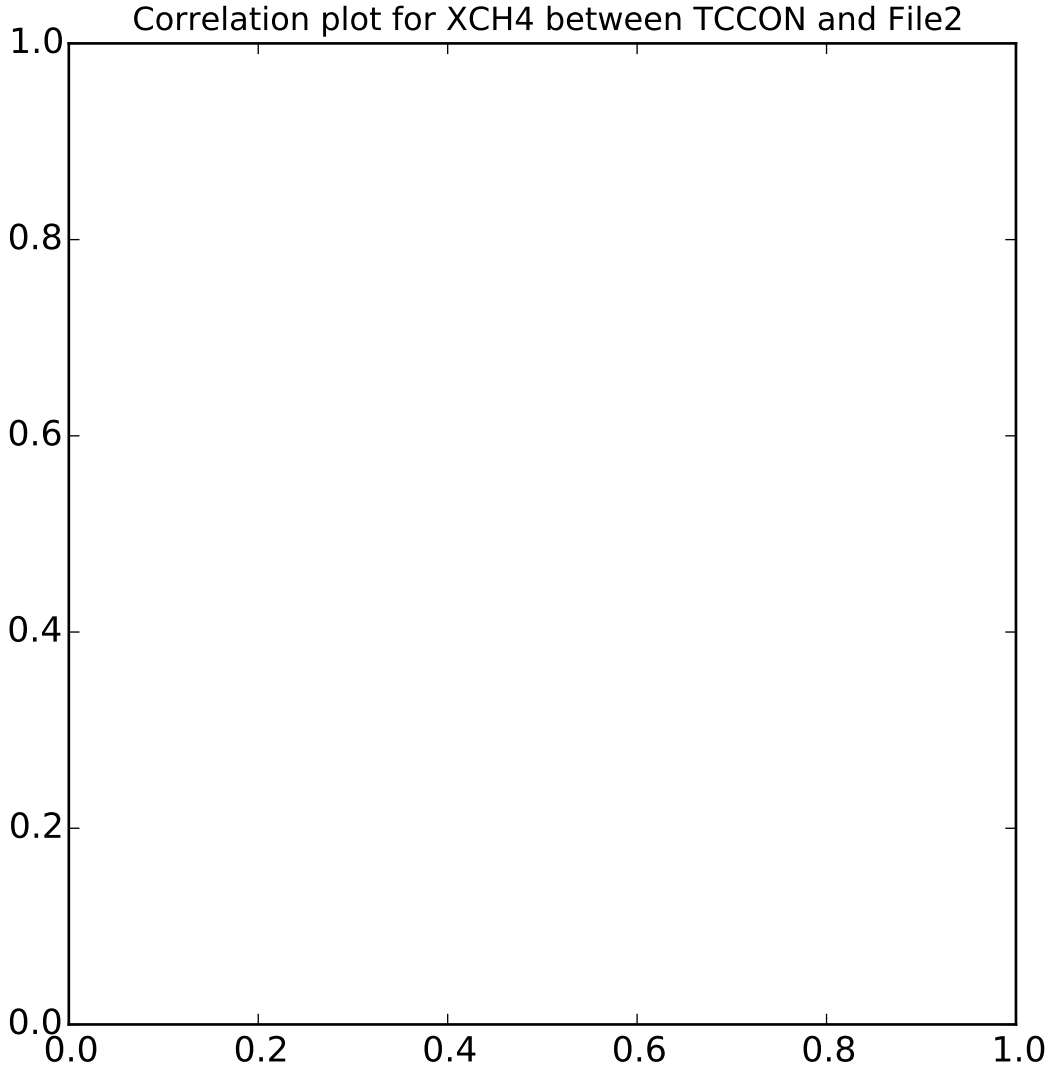

Correlation plot for XCO2 between TCCON and File4
158.275 + 0.6194*x
R=0.6217, stderr=0.0595
zero line
April 2017
May 2017
June 2017
File4 XCO2 (ppm)
TCCON XCO2 (ppm)
404
406
408
410
412


Correlation plot for XCO2 between TCCON and File5
-141.368 + 1.3341*x
R=0.8485, stderr=0.0238
zero line
March 2017
April 2017
May 2017
June 2017
File5 XCO2 (ppm)
TCCON XCO2 (ppm)
394
396
398
400
402
404
406
408
410

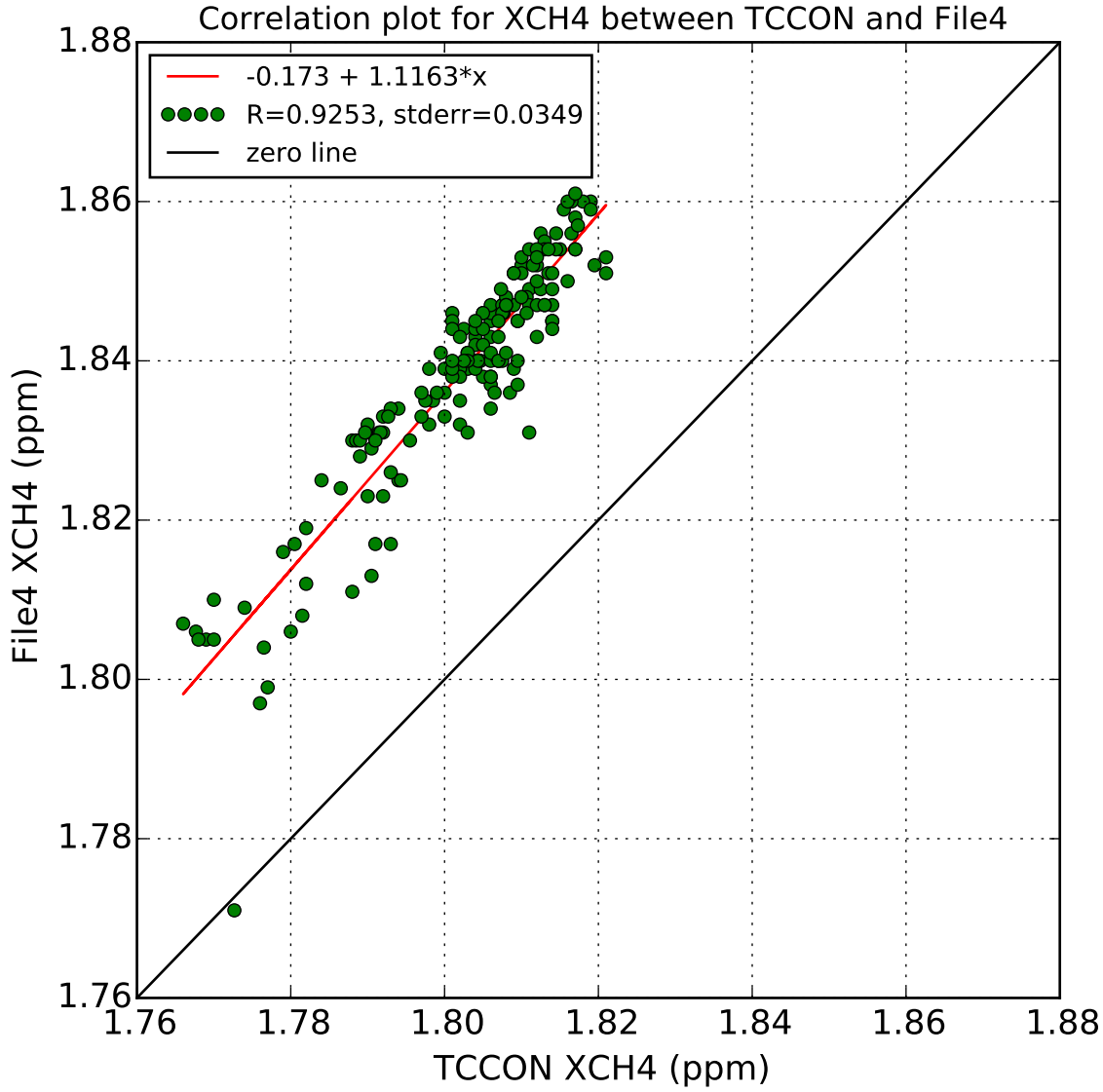

Correlation plot for XCO2 between TCCON and File6
-51.638 + 1.1247*x
R=0.9416, stderr=0.0100
zero line
March 2017
April 2017
May 2017
June 2017
File6 XCO2 (ppm)
TCCON XCO2 (ppm)
400
402
404
406
408
410
412


XCH4 plot for TCCON and other instruments
XCH4 (ppm)
1.90
1.88
1.86
1.84
1.82
1.80
1.78
1.76
1.74
TCCON
File2
File4
File5
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCH4 plot for TCCON and other instruments
ΔXCH4 (ppm)
0.15
0.10
0.05
0.00
Mean=0.036|STD=0.006|Median=0.038
Mean=-0.002|STD=0.005|Median=-0.003
Mean=-0.018|STD=0.005|Median=-0.018
File2 - TCCON
File4 - TCCON
File5 - TCCON
File6 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

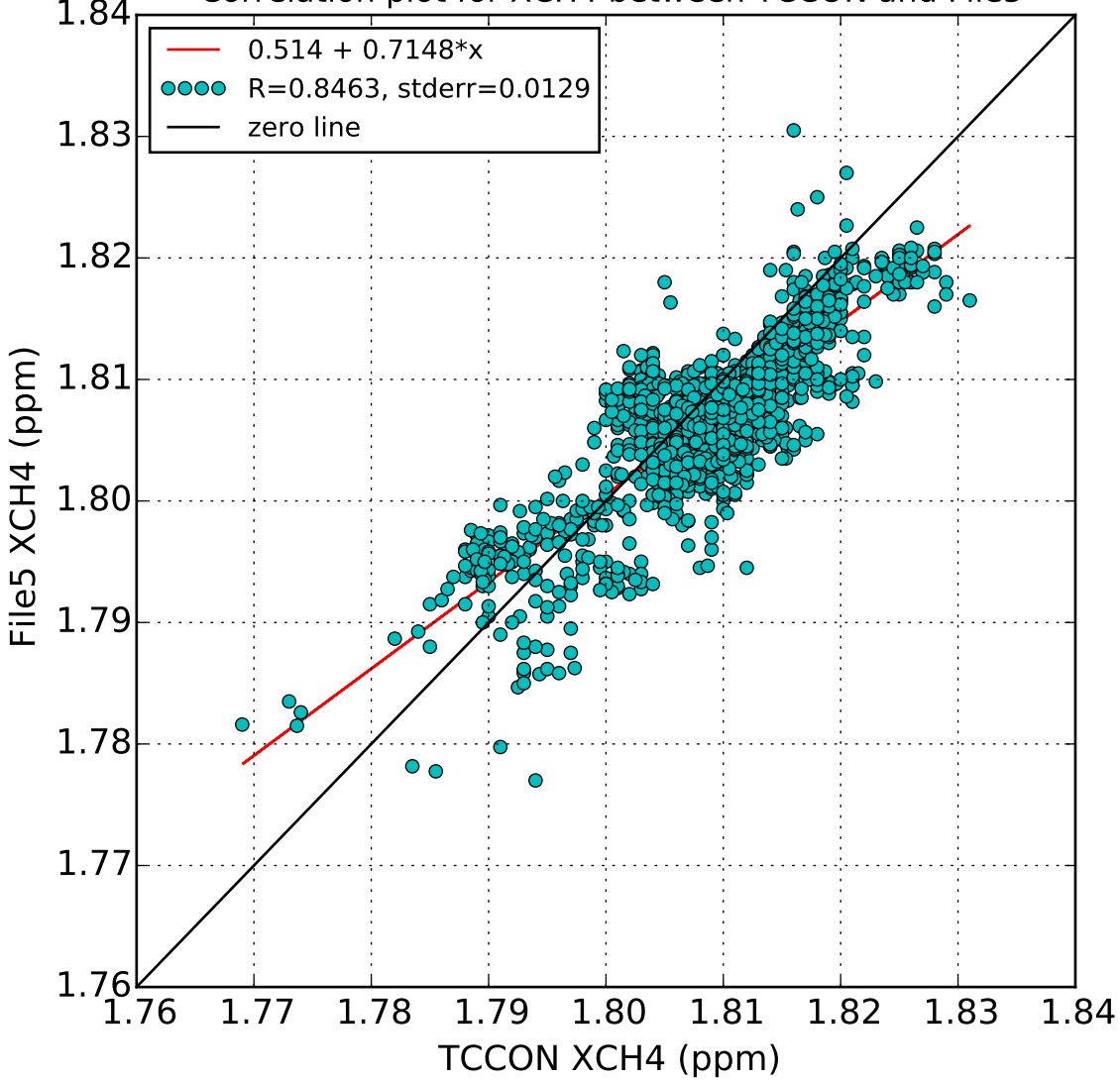
Correlation plot for XCH4 between TCCON and File2



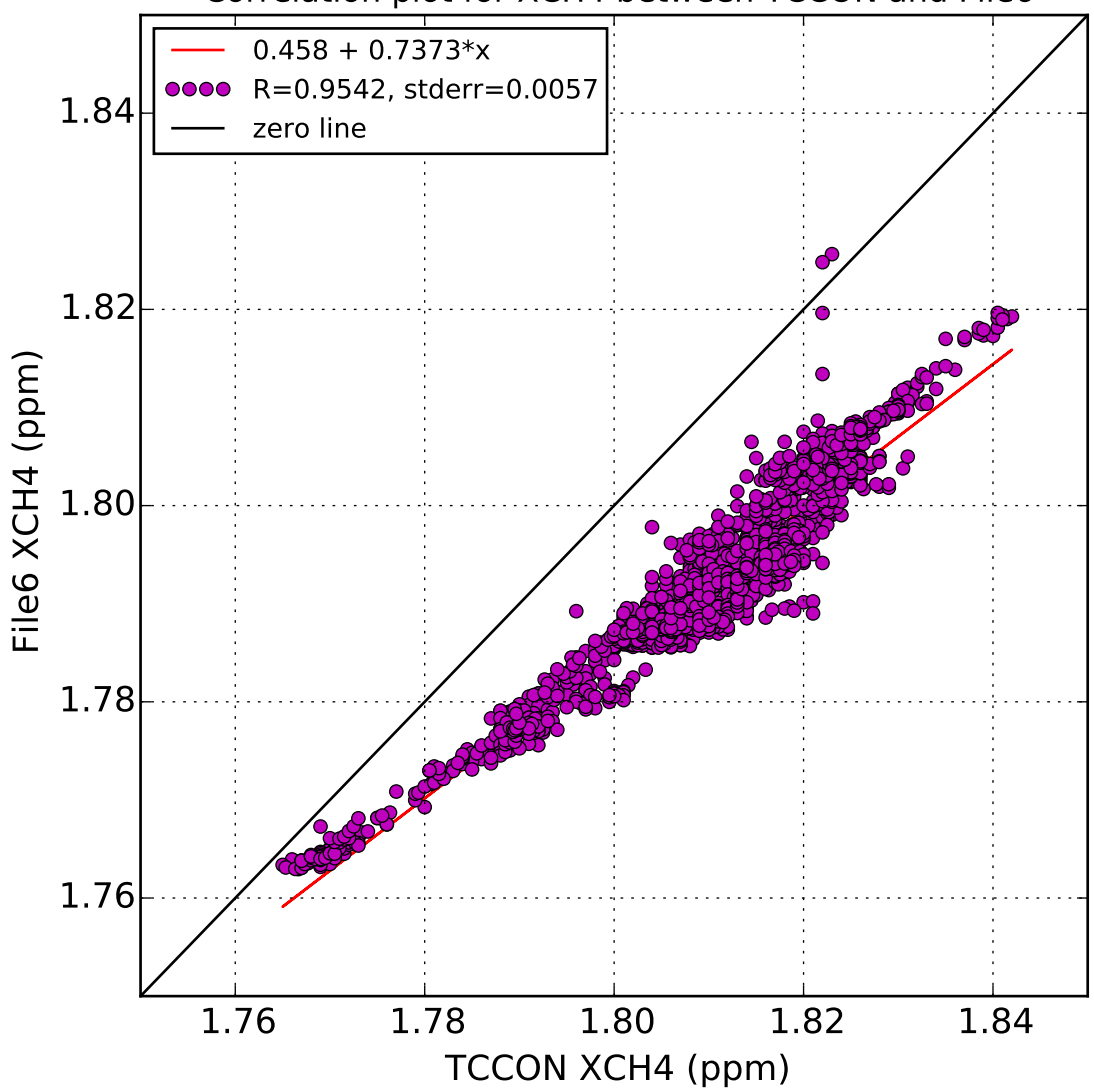
Correlation plot for XCH4 between TCCON and File4



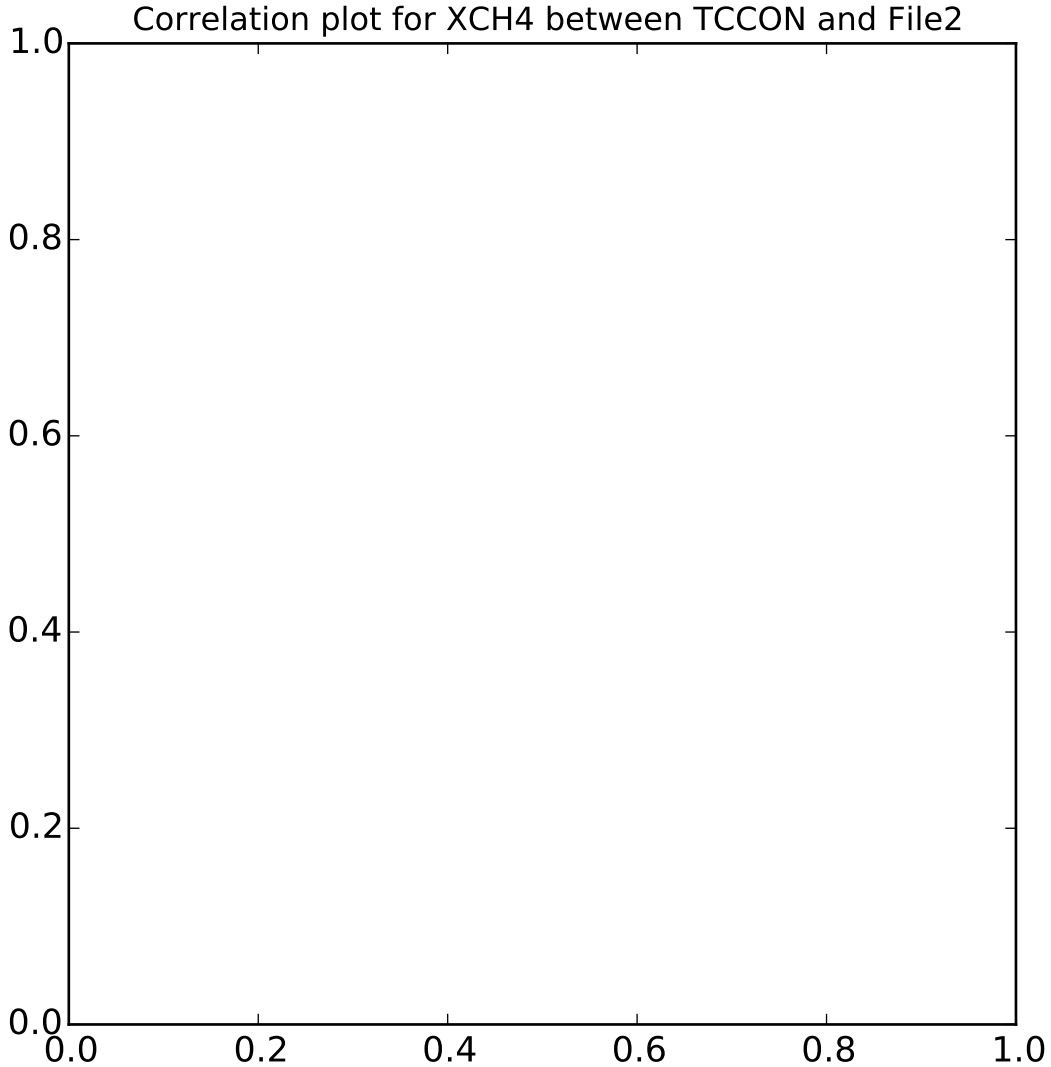
Correlation plot for XCH4 between TCCON and File5



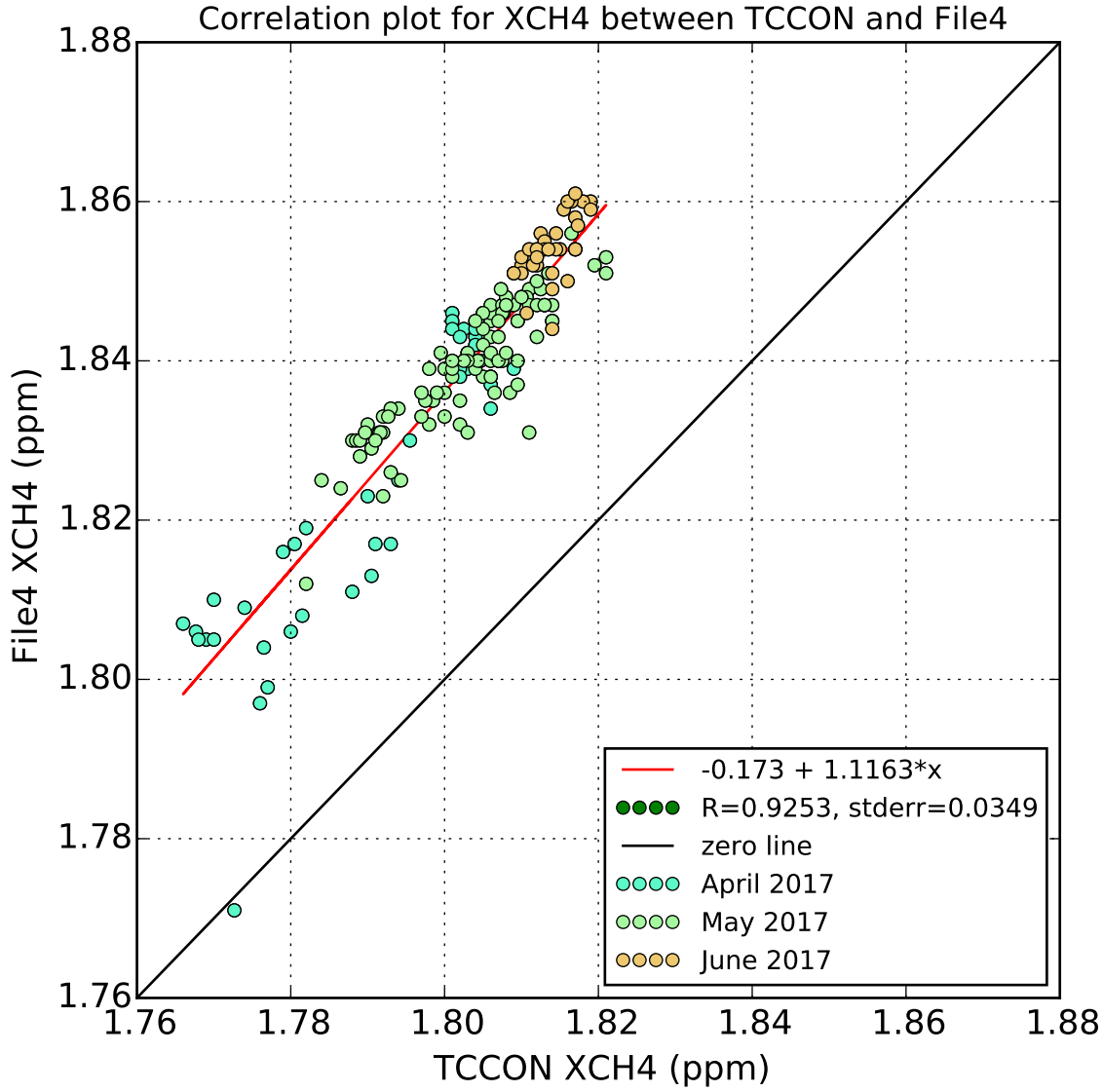
Correlation plot for XCH4 between TCCON and File6



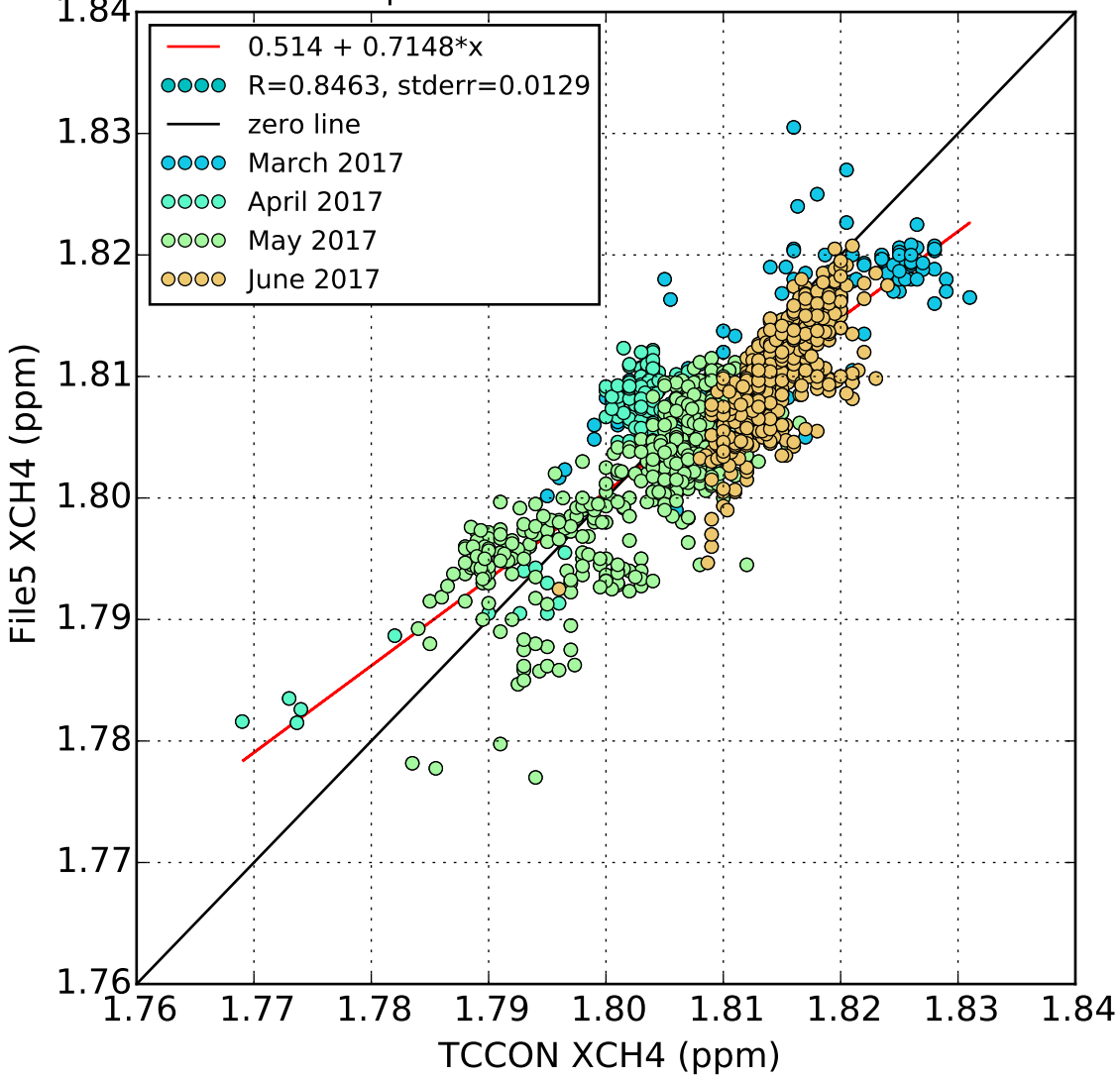
Correlation plot for XCH4 between TCCON and File2



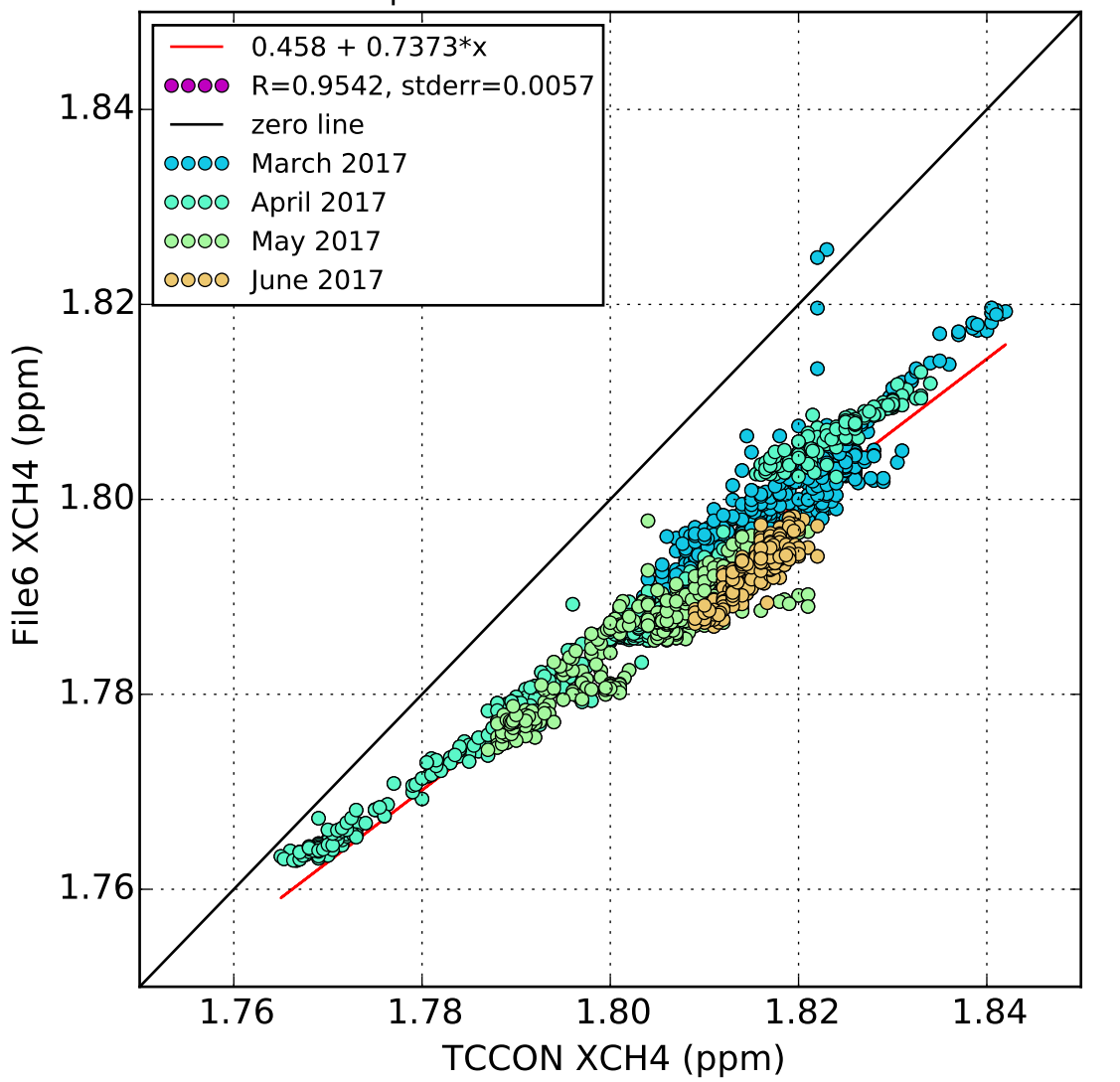
Correlation plot for XCH4 between TCCON and File4

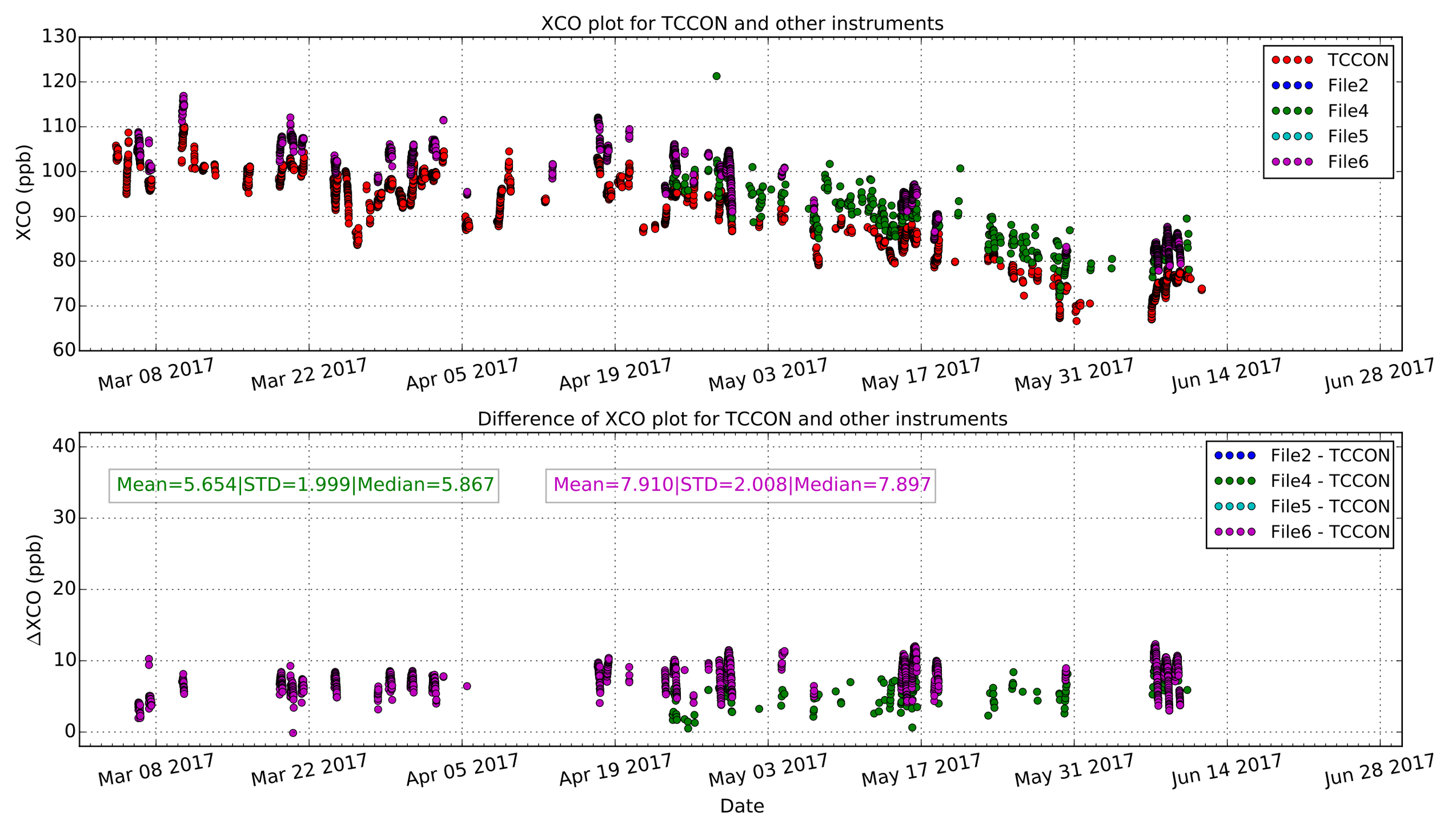


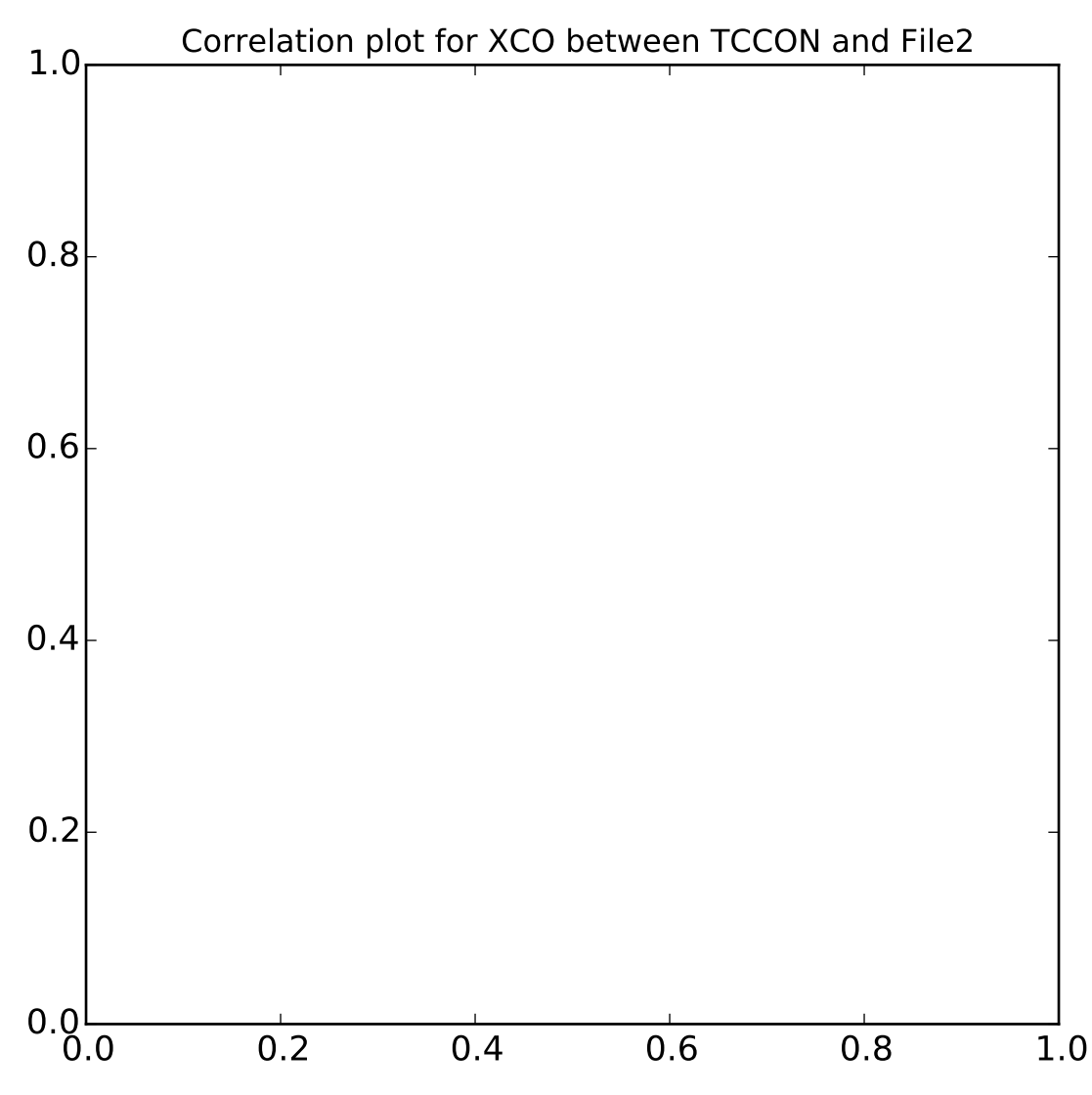
Correlation plot for XCH4 between TCCON and File5

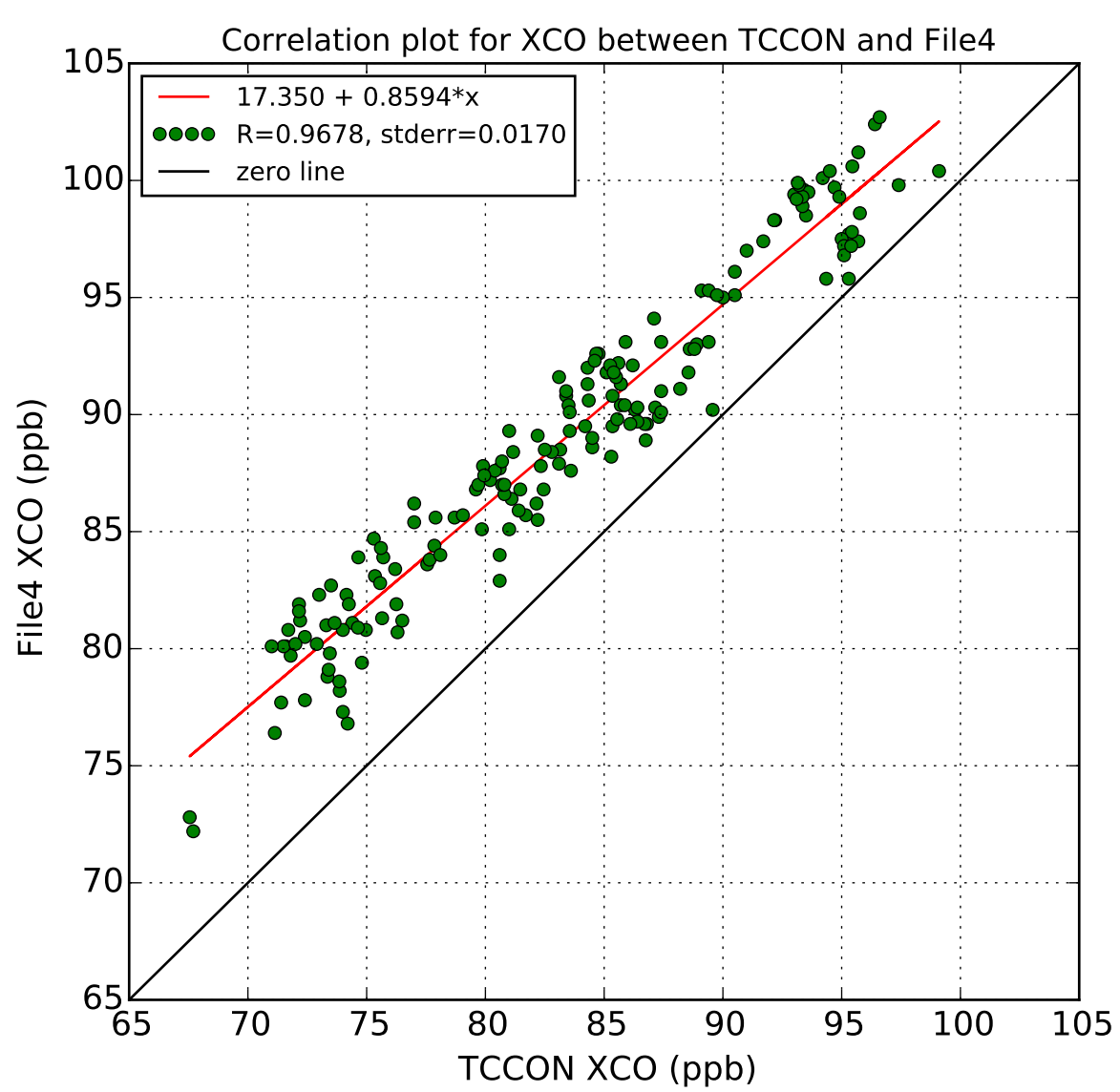


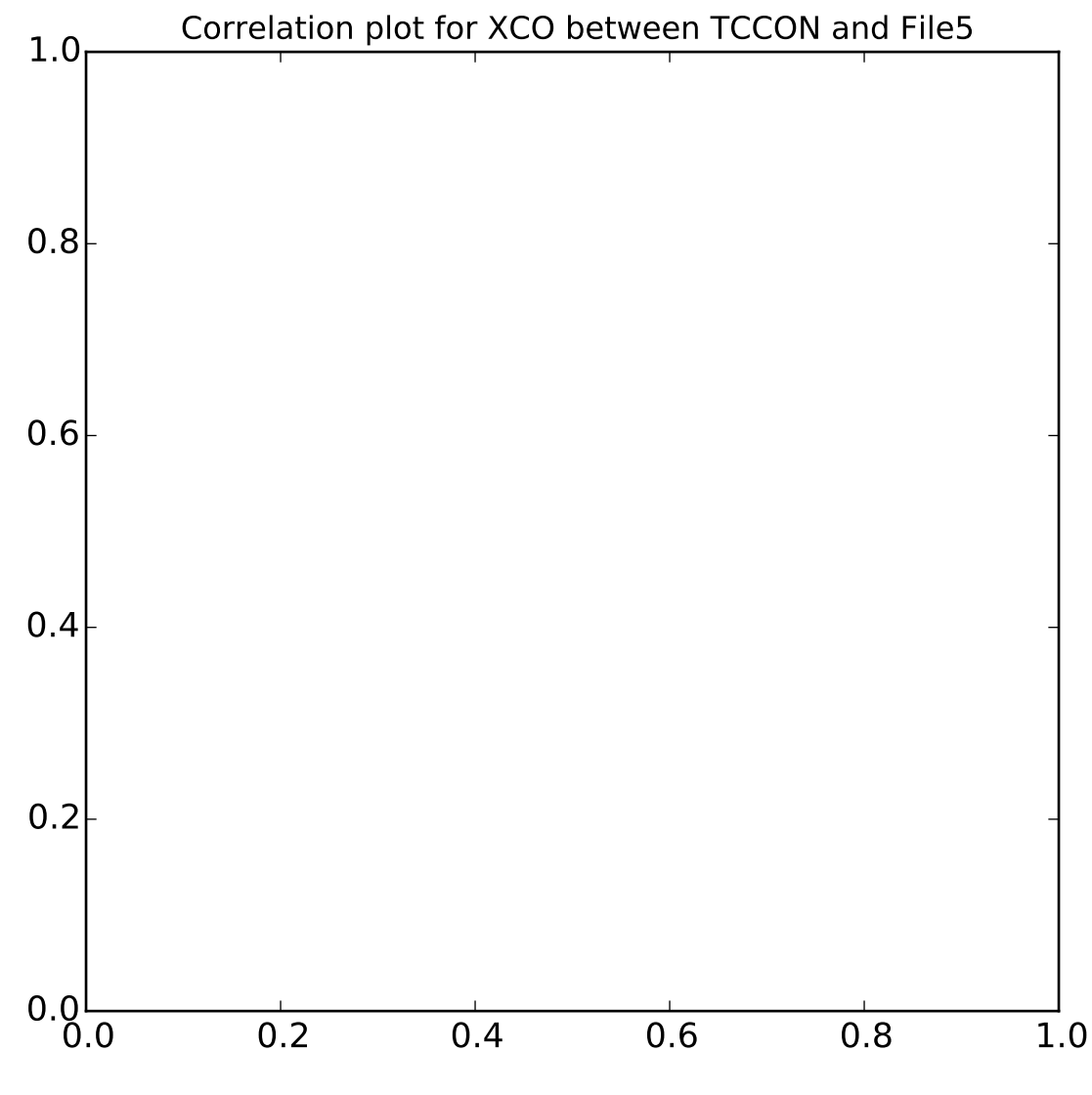
Correlation plot for XCH4 between TCCON and File6

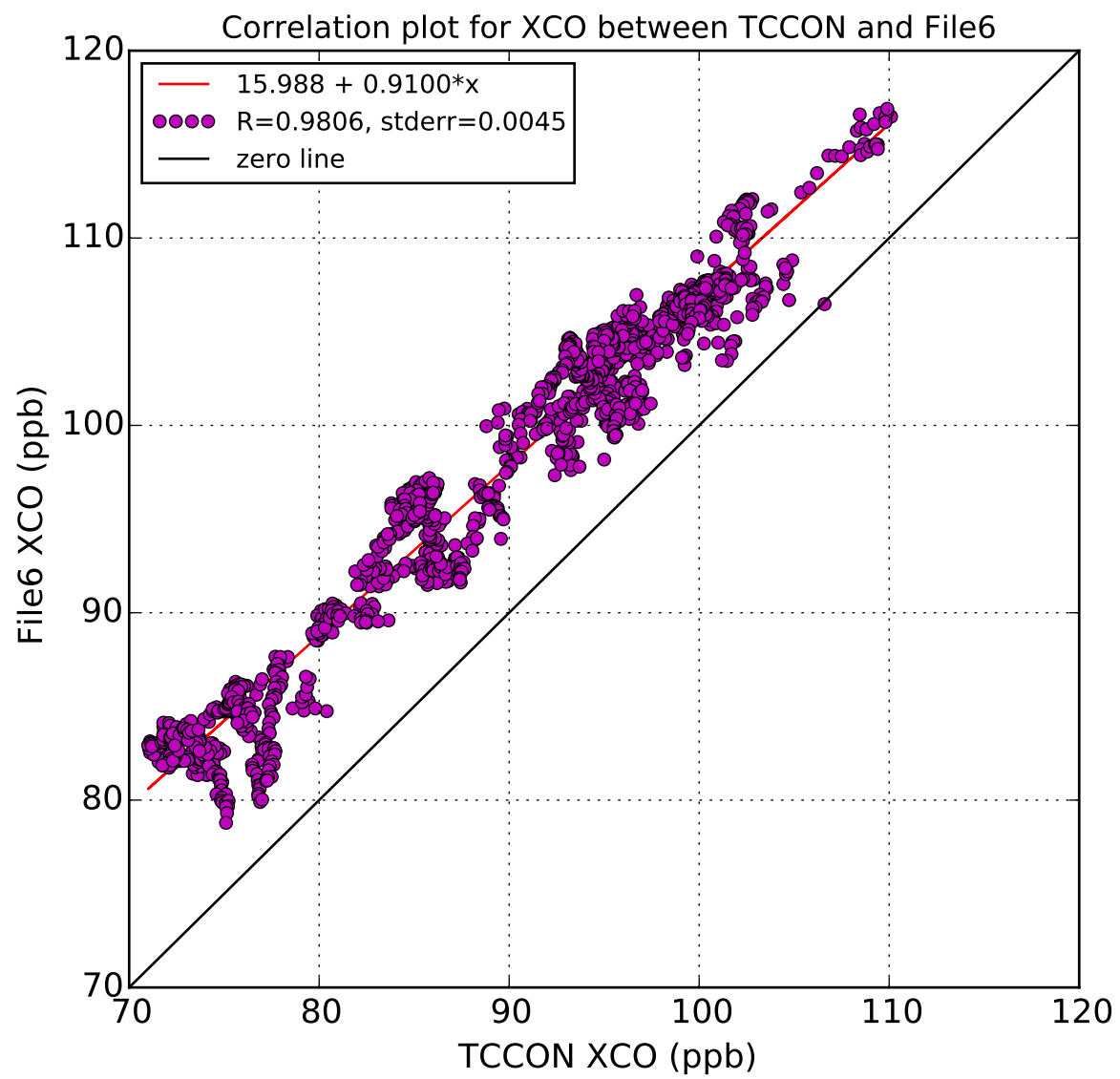



XCO plot for TCCON and other instruments
XCO (ppb)
130
120
110
100
90
80
70
60
TCCON
File2
File4
File5
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCO plot for TCCON and other instruments
ΔXCO (ppb)
40
30
20
10
0
Mean=5.654|STD=1.999|Median=5.867
Mean=7.910|STD=2.008|Median=7.897
File2 - TCCON
File4 - TCCON
File5 - TCCON
File6 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

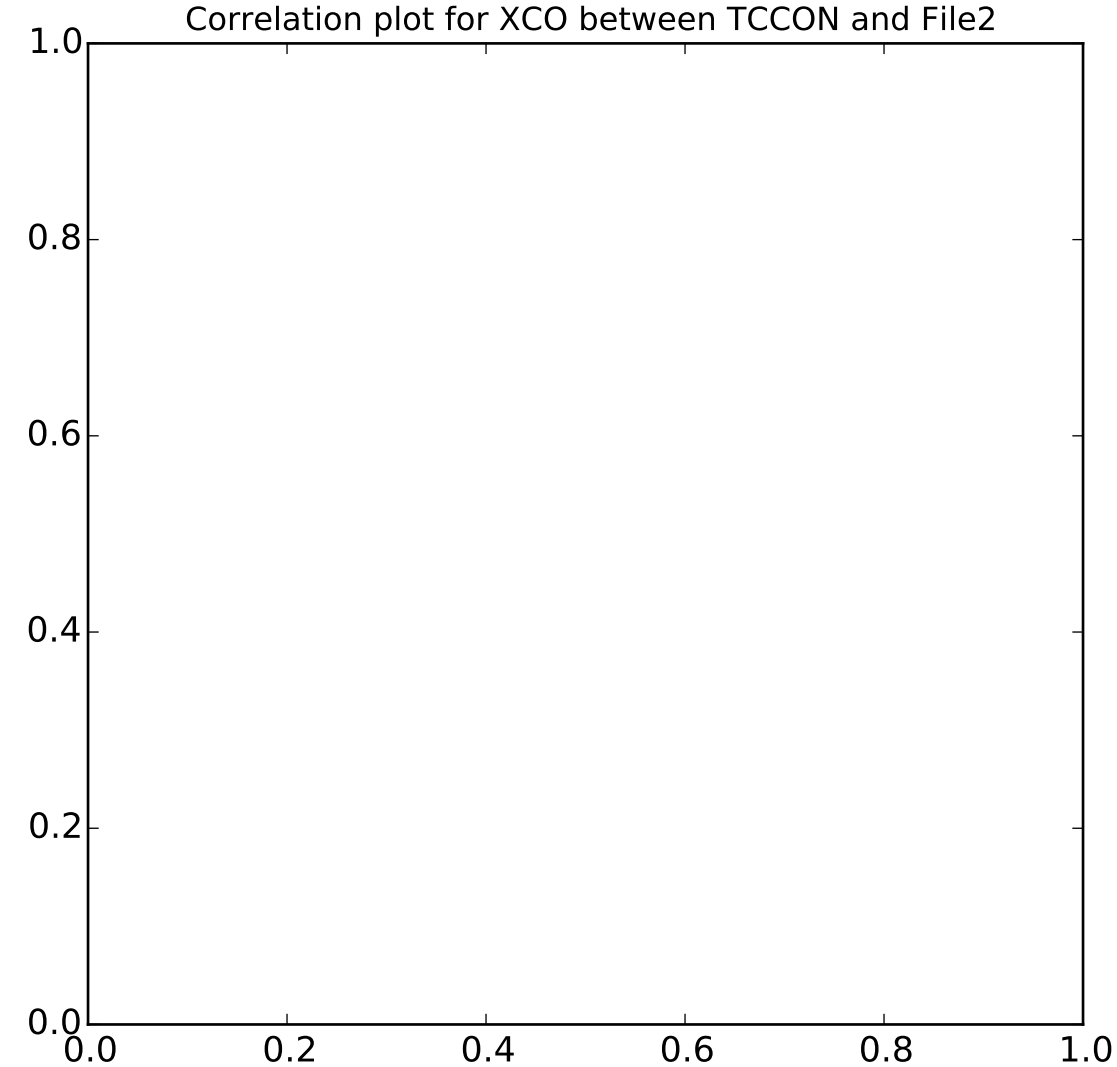

Correlation plot for XCO between TCCON and File2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Correlation plot for XCO between TCCON and File4
17.350 + 0.8594*x
R=0.9678, stderr=0.0170
zero line
File4 XCO (ppb)
TCCON XCO (ppb)
105
100
95
90
85
80
75
70
65
65
70
75
80
85
90
95
100
105

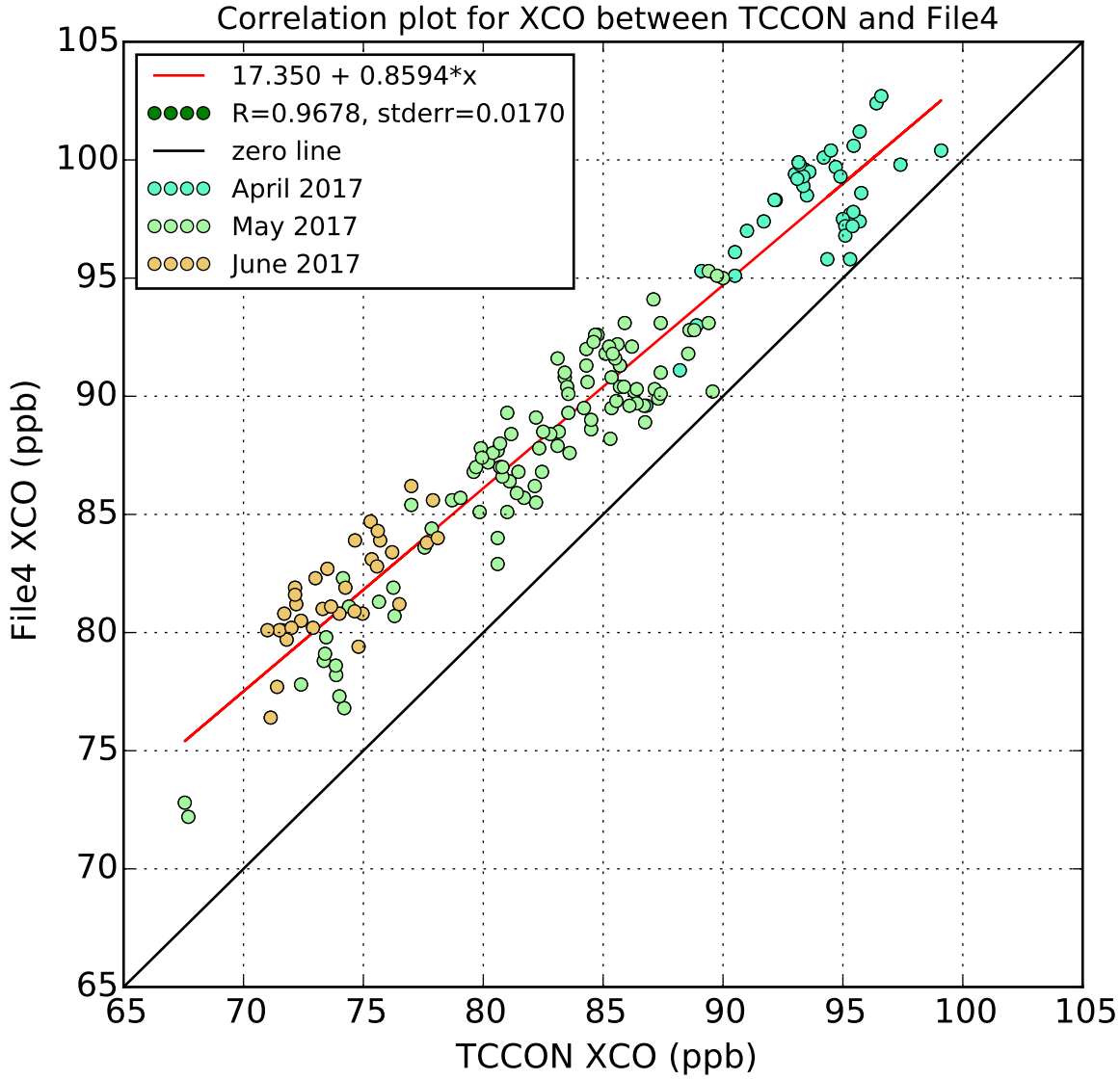

Correlation plot for XCO between TCCON and File5
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Correlation plot for XCO between TCCON and File6
15.988 + 0.9100*x
R=0.9806, stderr=0.0045
zero line
File6 XCO (ppb)
TCCON XCO (ppb)
120
110
100
90
80
70
70
80
90
100
110
120

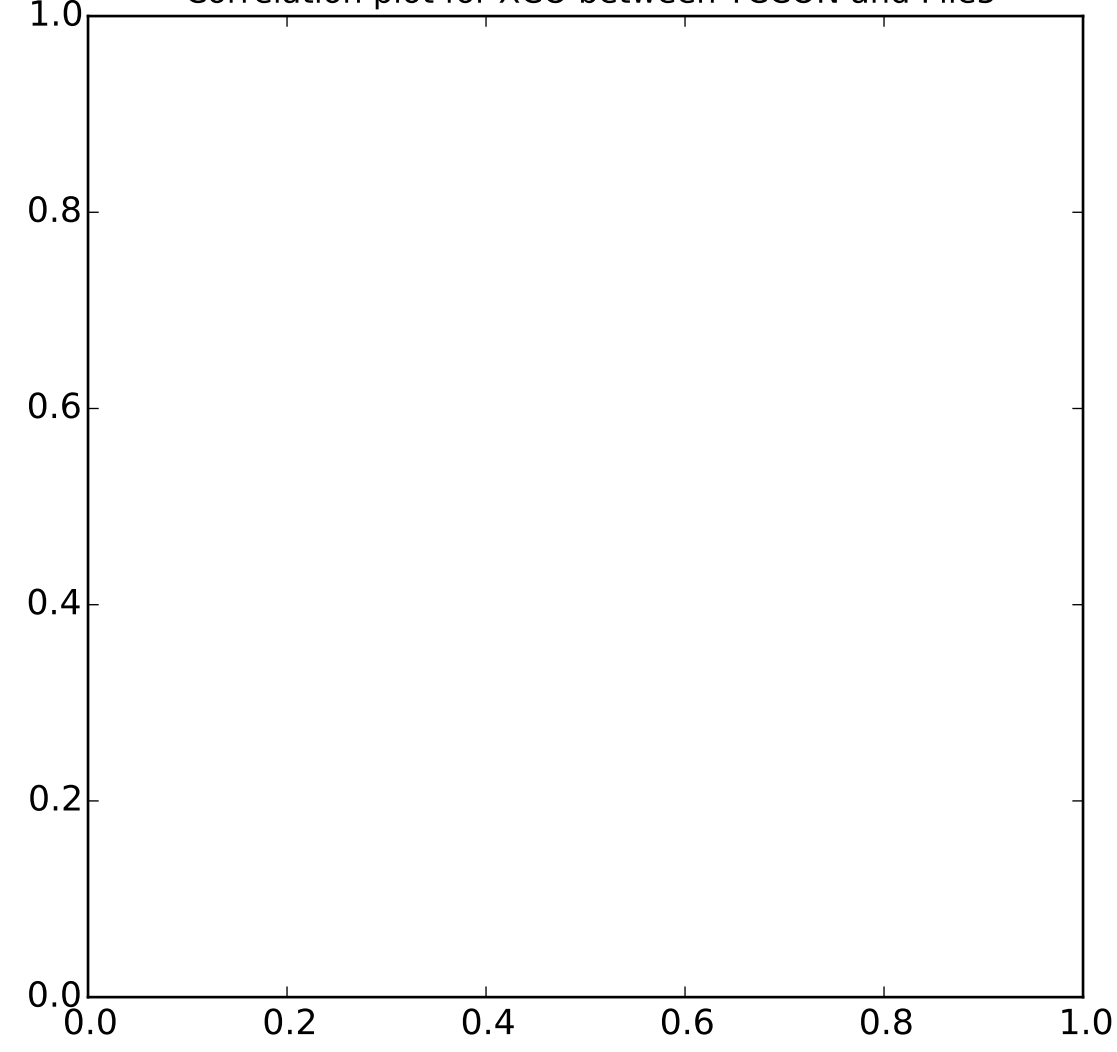
Correlation plot for XCO between TCCON and File2



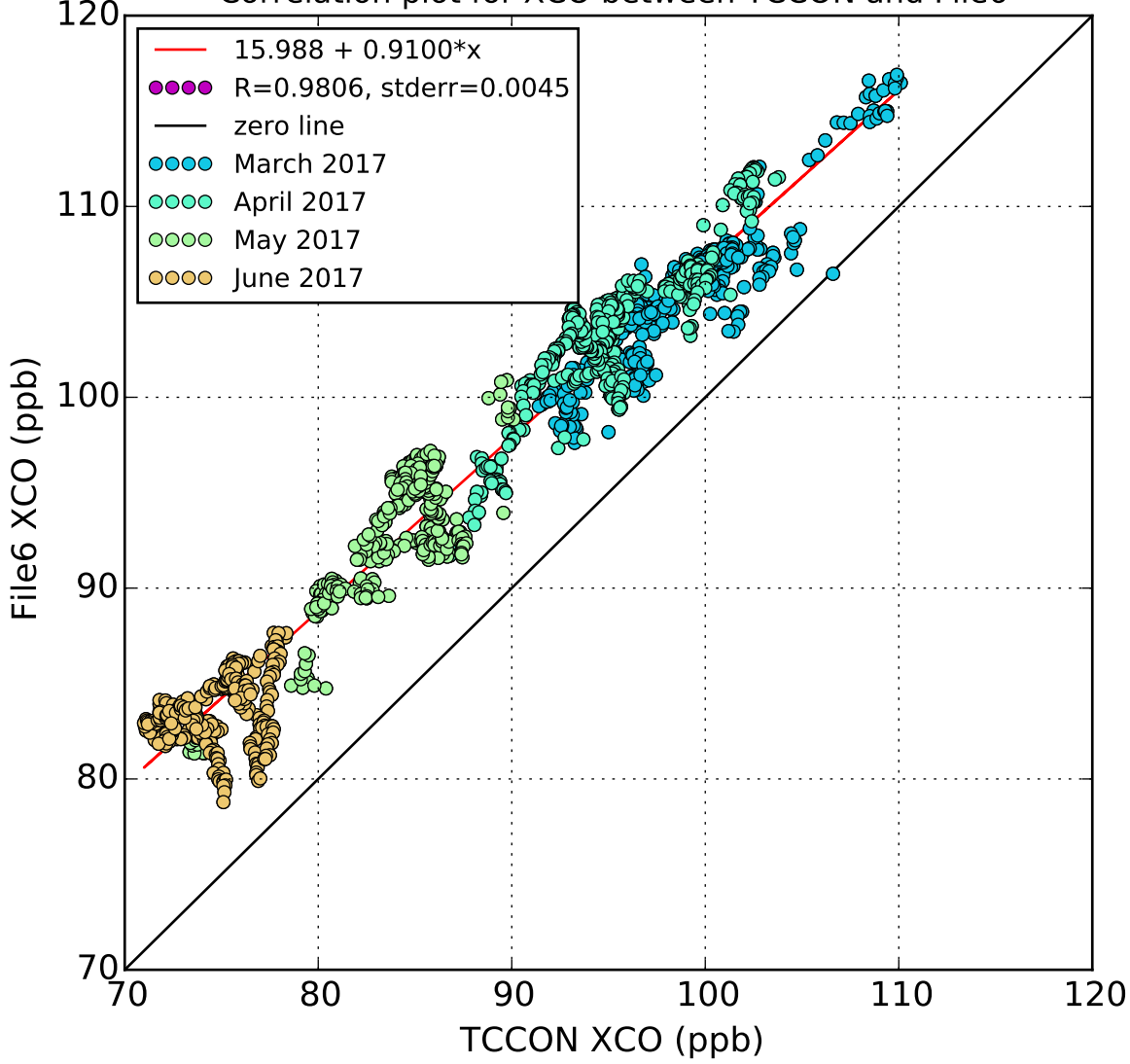
Correlation plot for XCO between TCCON and File4

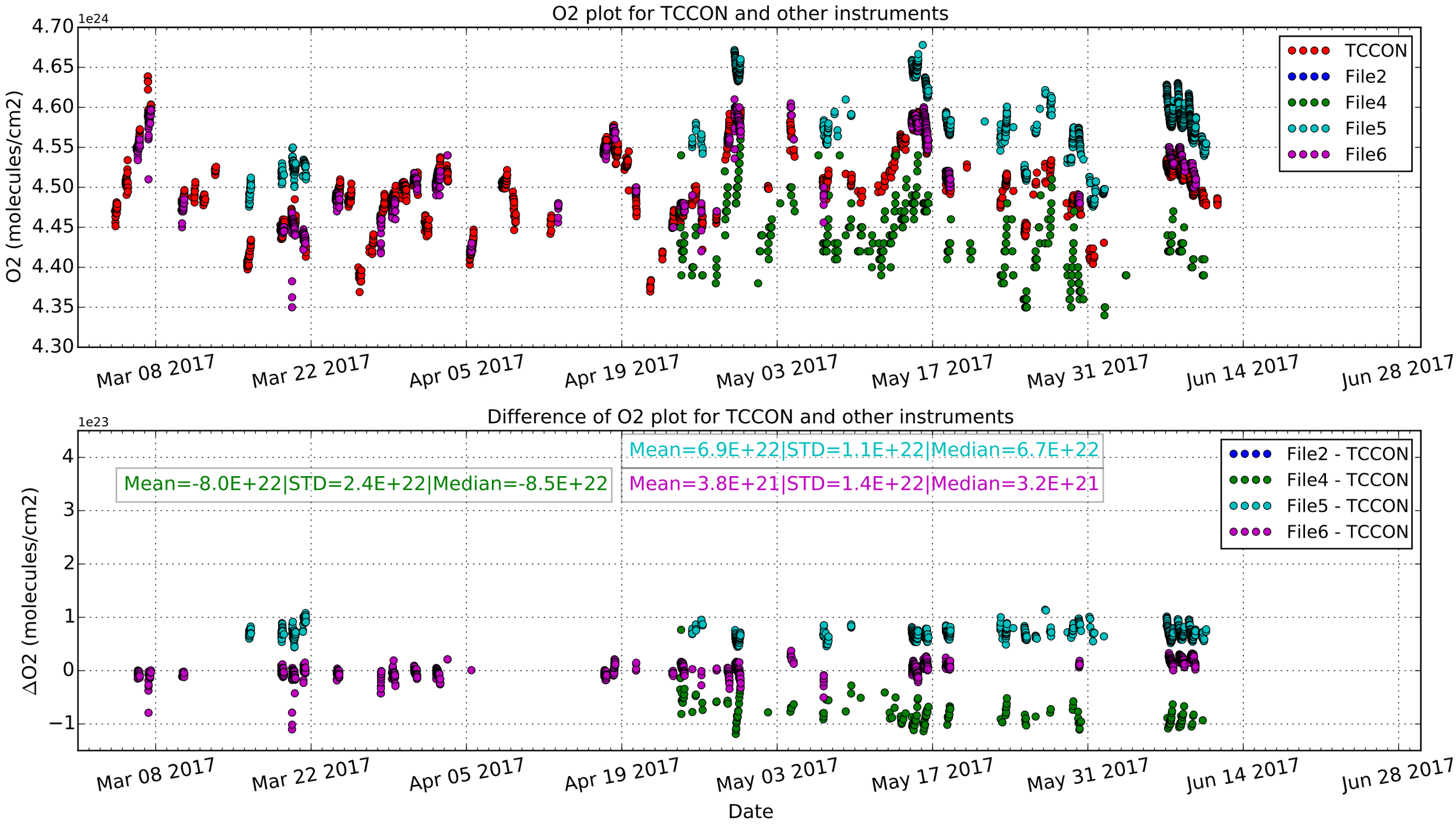


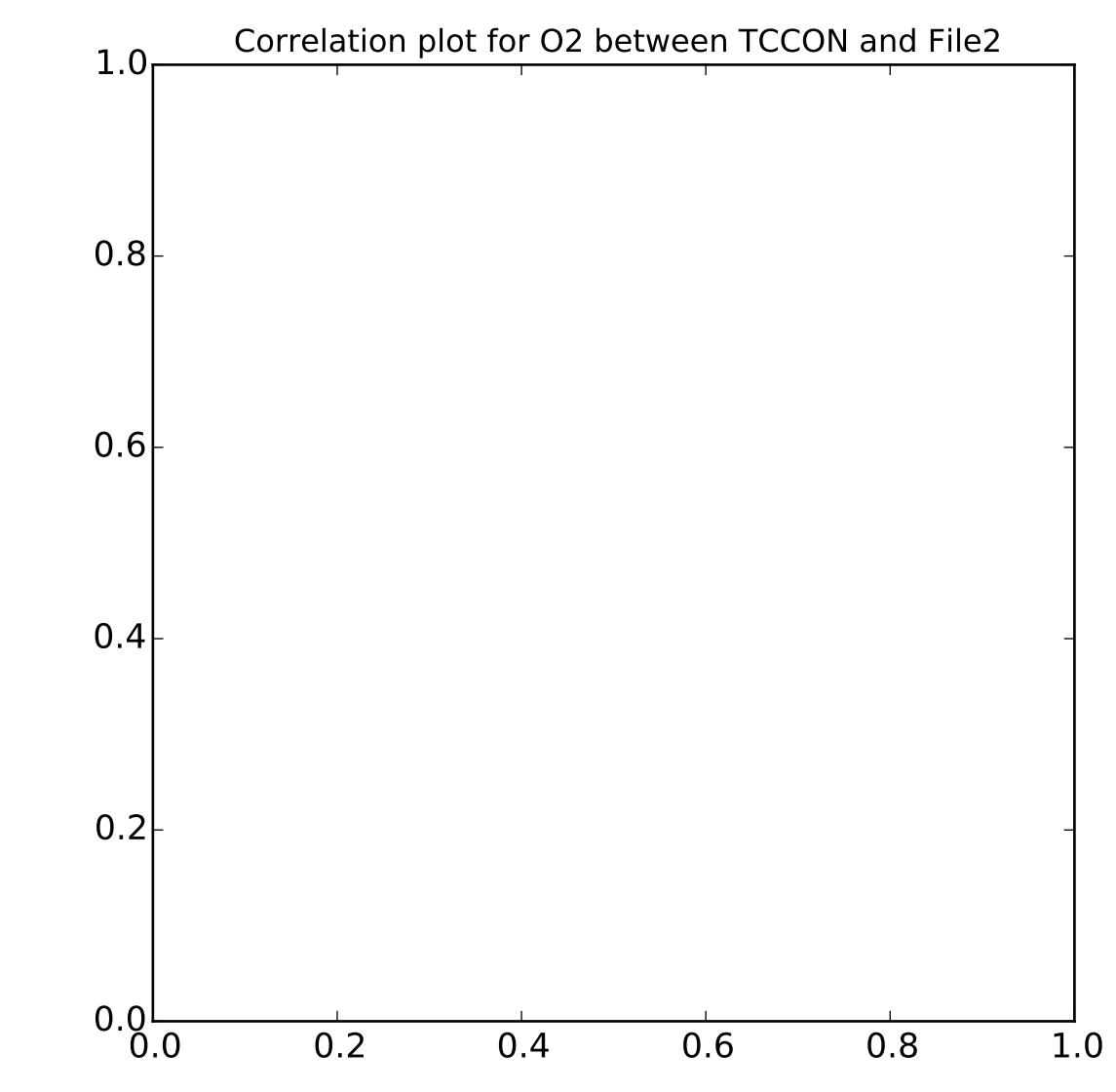
Correlation plot for XCO between TCCON and File5

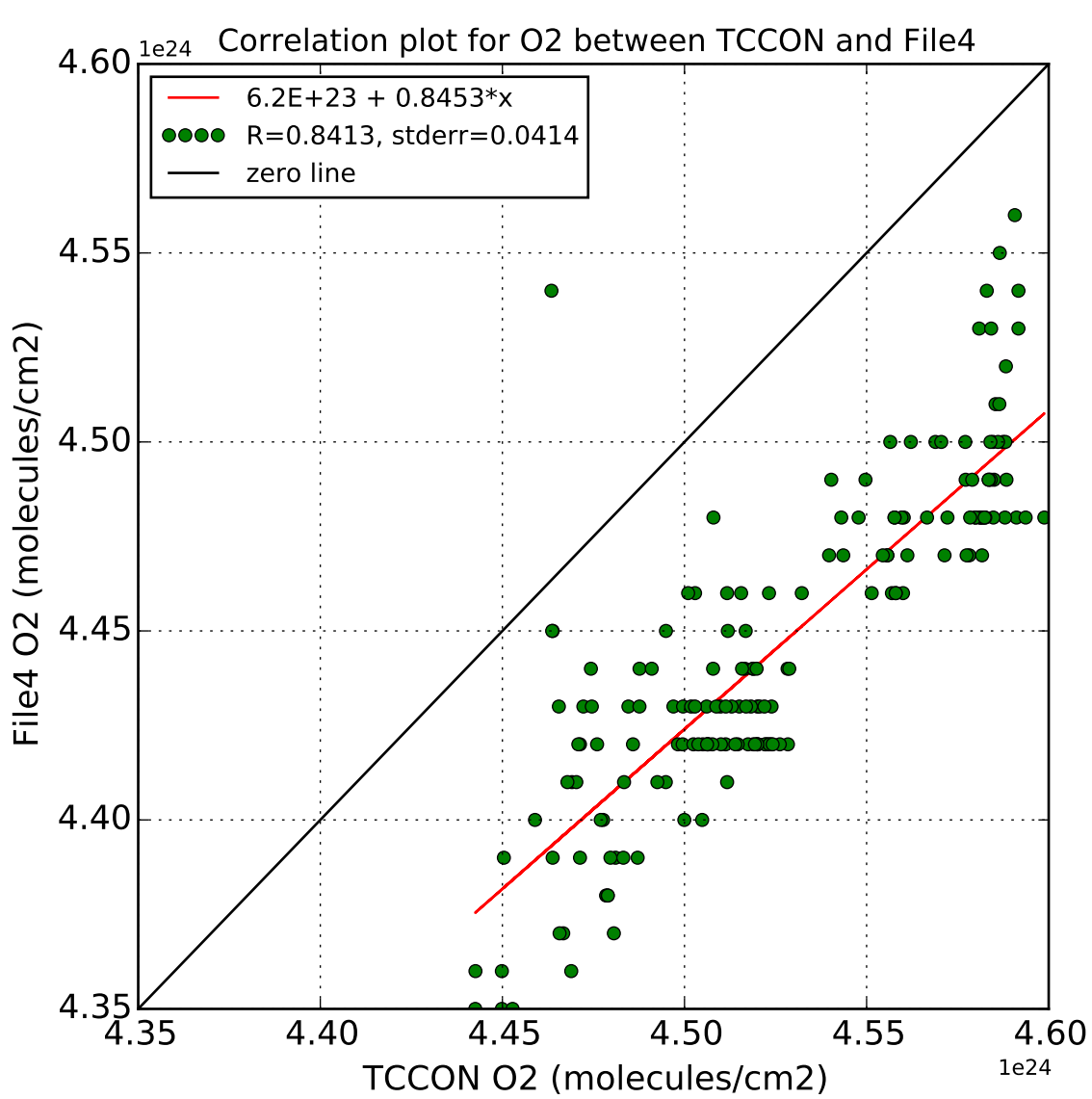


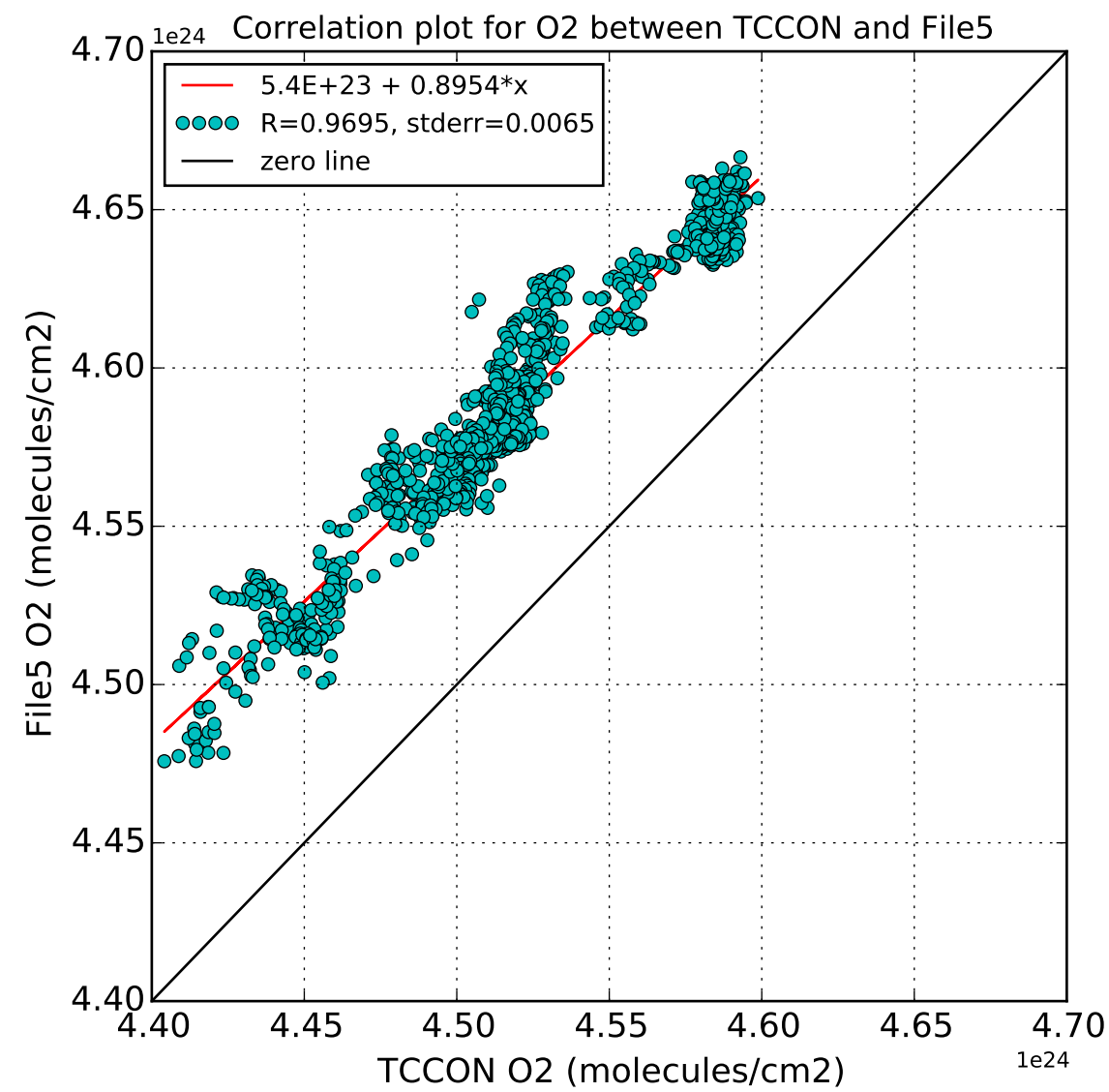
Correlation plot for XCO between TCCON and File6

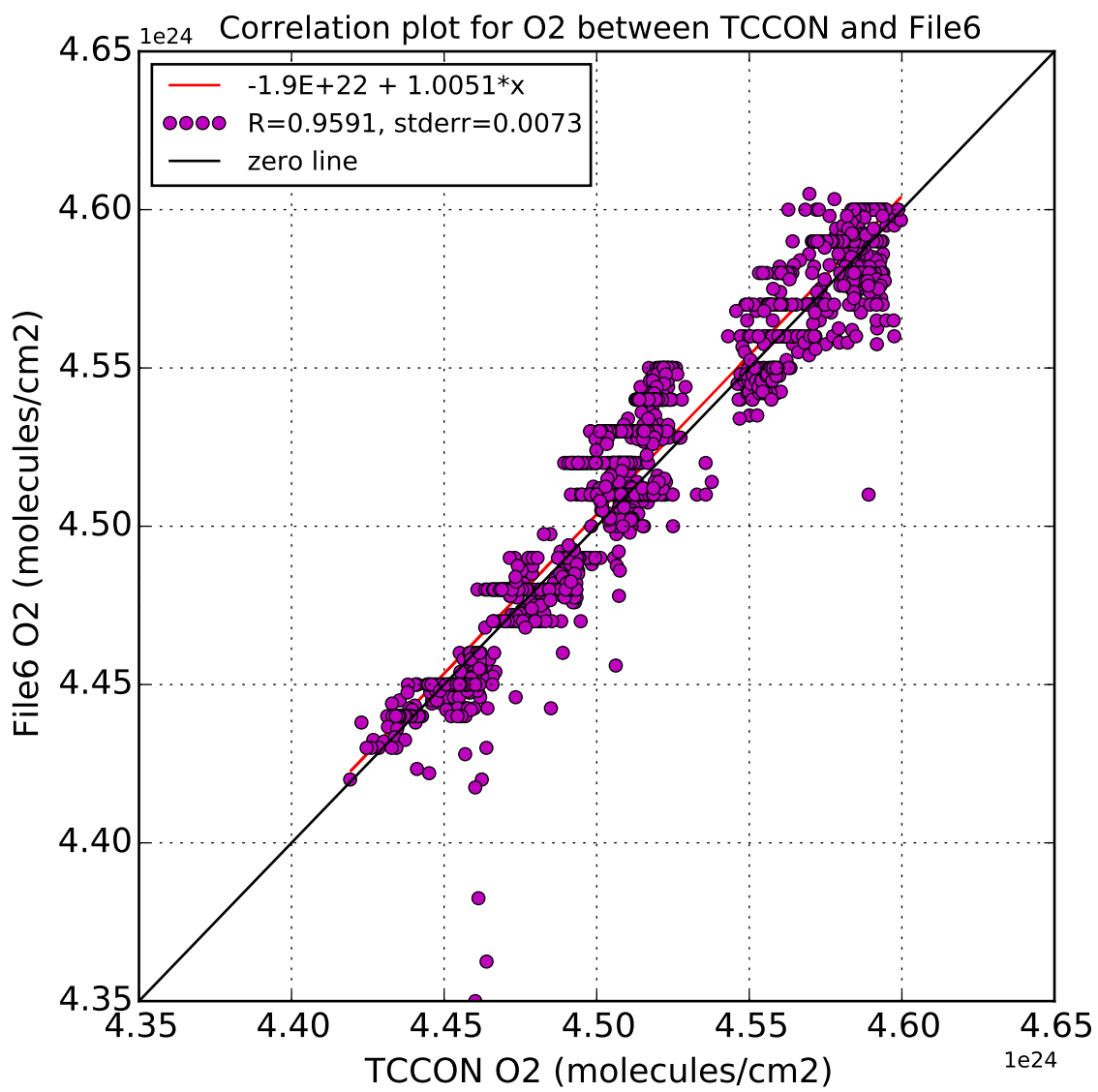


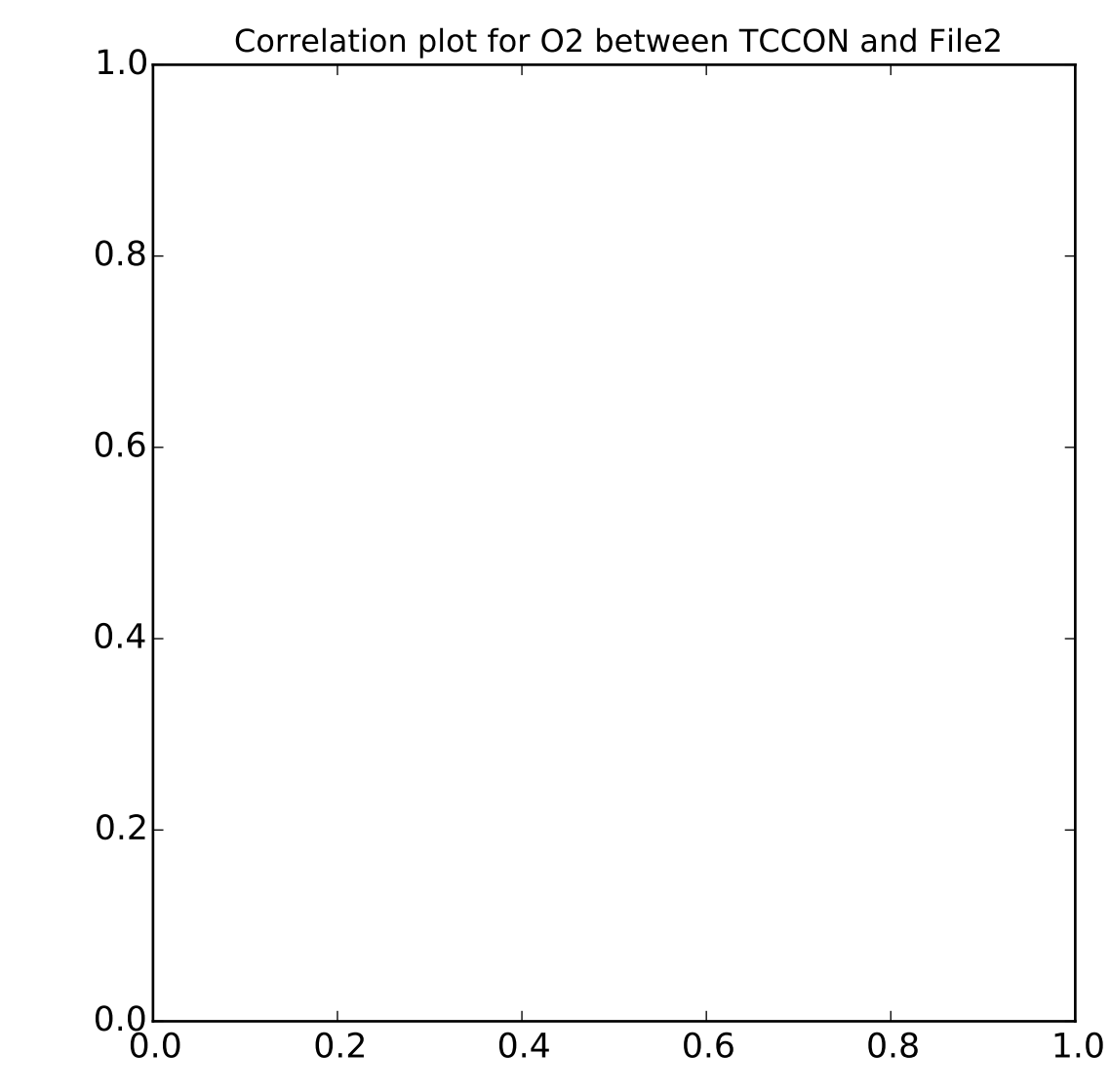

O2 plot for TCCON and other instruments
1e24
4.70
4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.30
O2 (molecules/cm2)
TCCON
File2
File4
File5
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of O2 plot for TCCON and other instruments
1e23
Mean=-8.0E+22|STD=2.4E+22|Median=-8.5E+22
Mean=6.9E+22|STD=1.1E+22|Median=6.7E+22
Mean=3.8E+21|STD=1.4E+22|Median=3.2E+21
File2 - TCCON
File4 - TCCON
File5 - TCCON
File6 - TCCON
4
3
2
1
0
−1
ΔO2 (molecules/cm2)
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

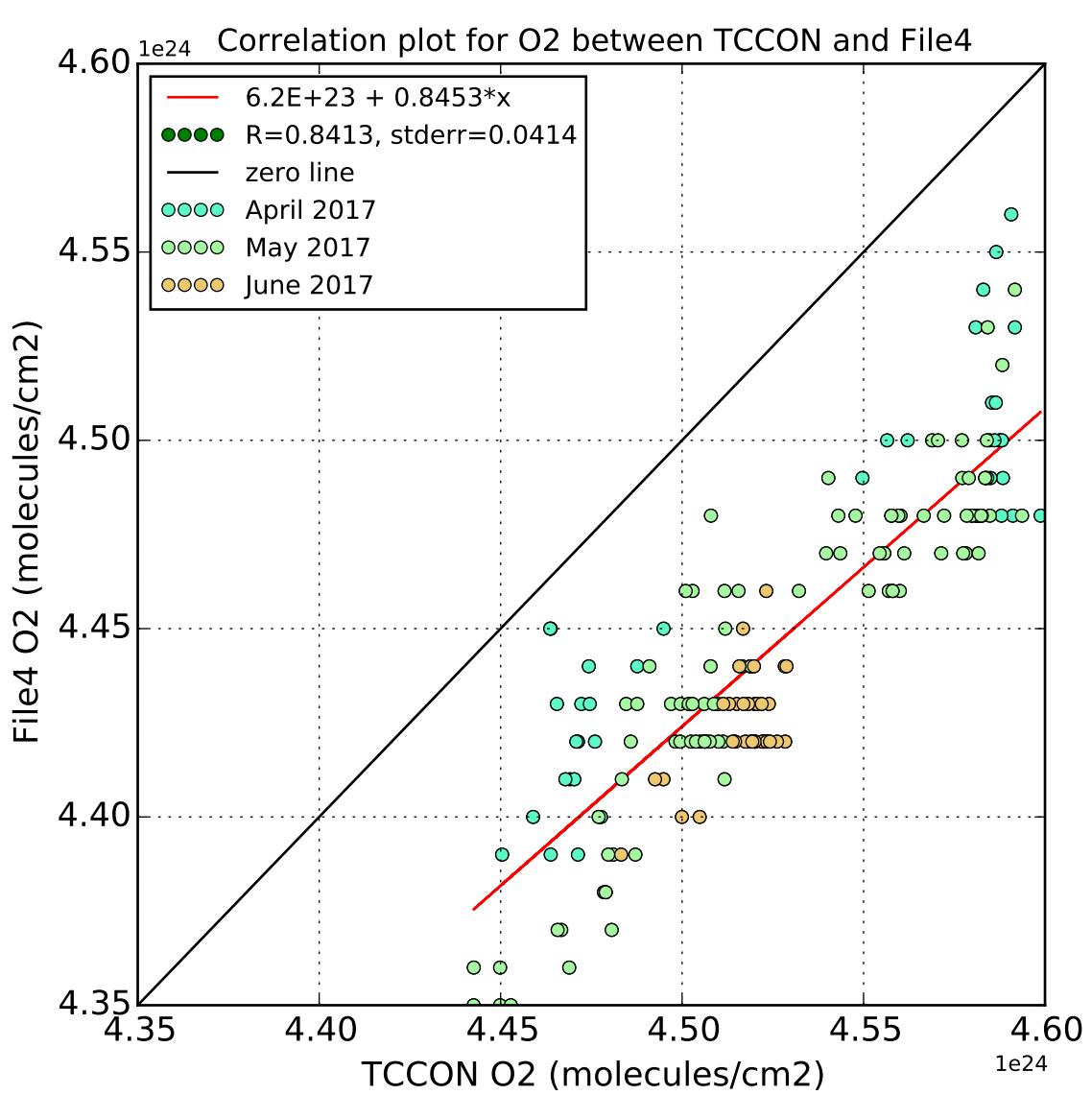

Correlation plot for O2 between TCCON and File2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

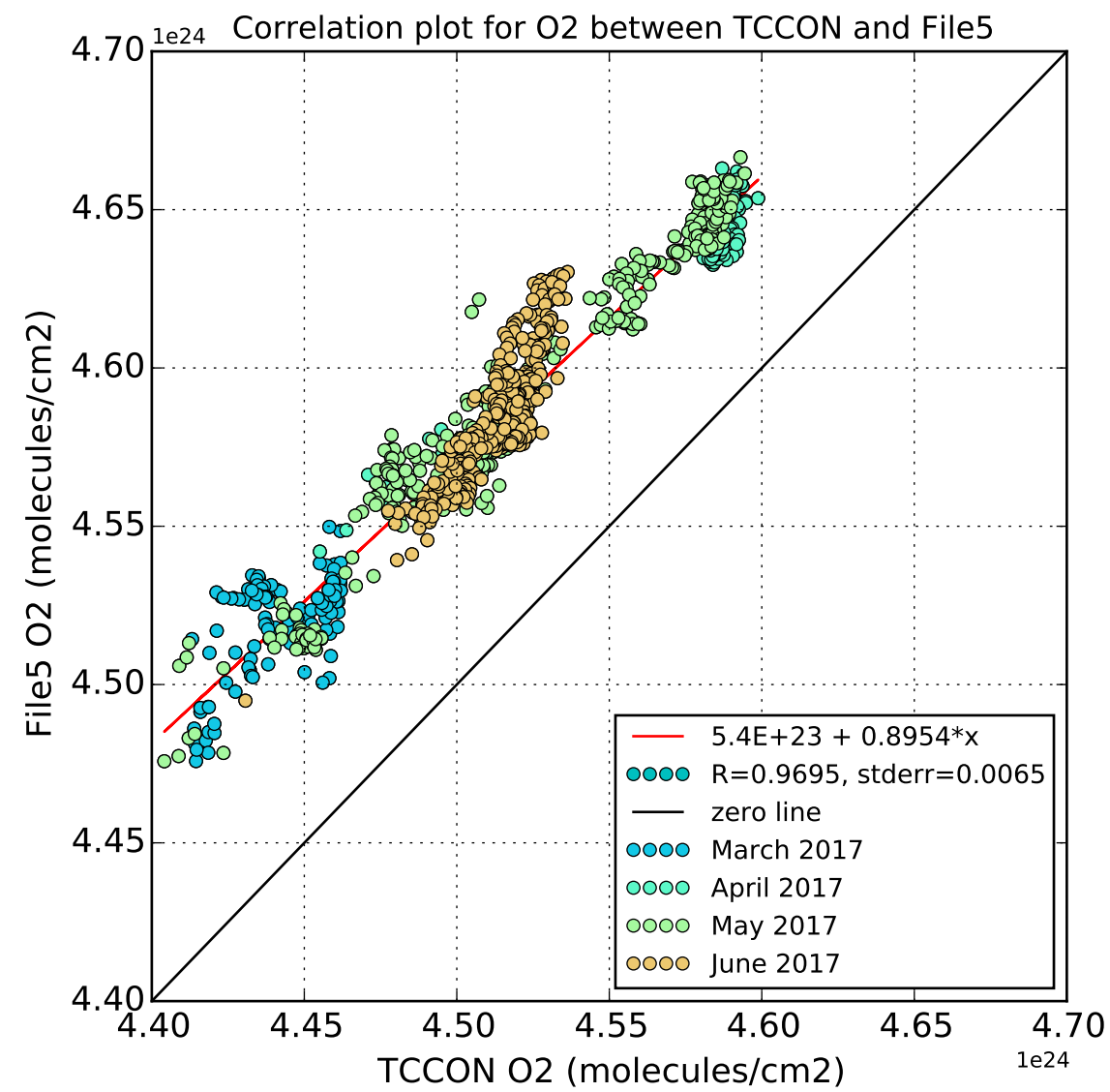

Correlation plot for O2 between TCCON and File4
1e24
6.2E+23 + 0.8453*x
R=0.8413, stderr=0.0414
zero line
File4 O2 (molecules/cm2)
TCCON O2 (molecules/cm2)
1e24
4.60
4.55
4.50
4.45
4.40
4.35
4.35
4.40
4.45
4.50
4.55
4.60

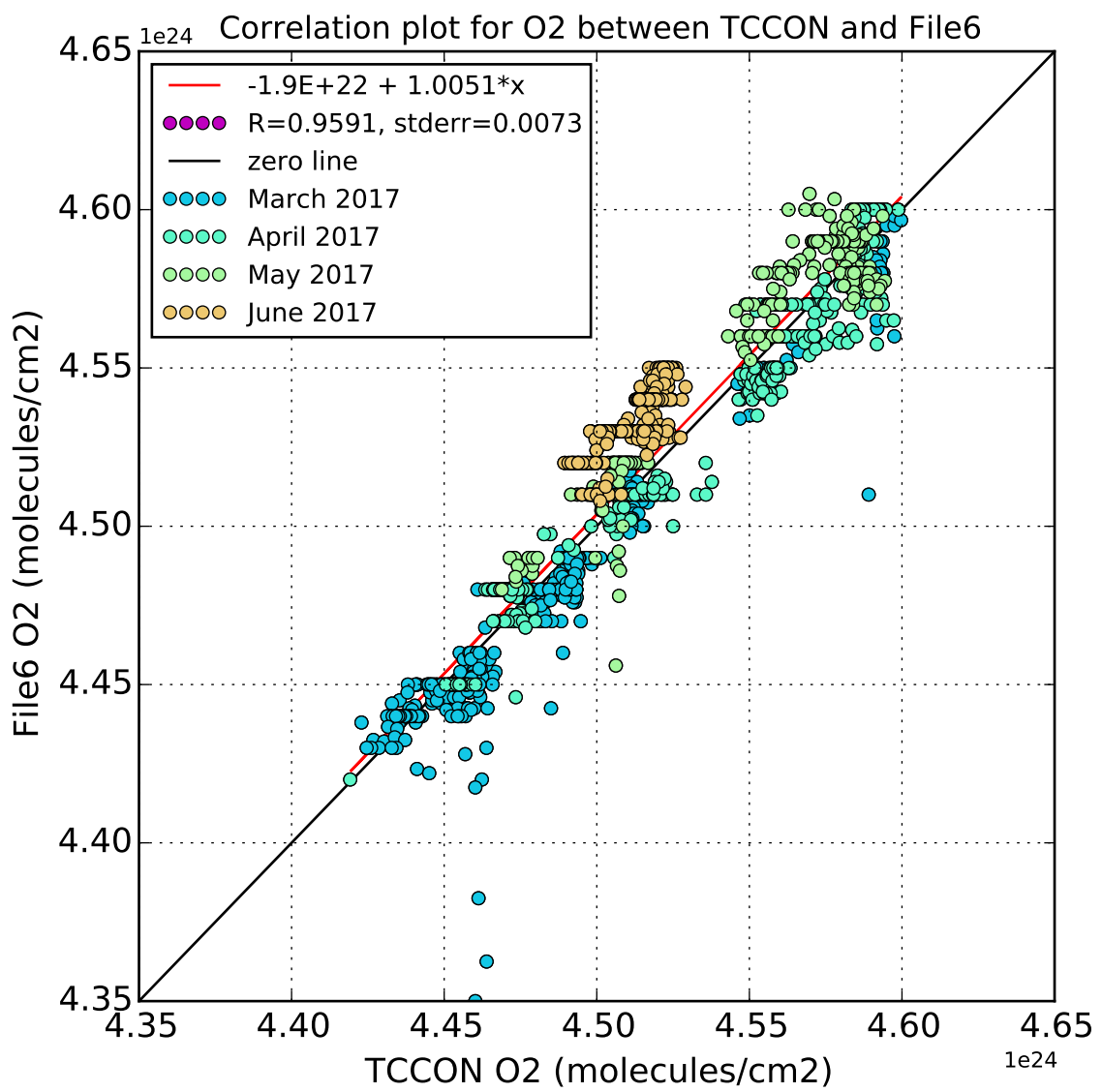

Correlation plot for O2 between TCCON and File5
1e24
5.4E+23 + 0.8954*x
R=0.9695, stderr=0.0065
zero line
File5 O2 (molecules/cm2)
TCCON O2 (molecules/cm2)
1e24
4.70
4.65
4.60
4.55
4.50
4.45
4.40
4.40
4.45
4.50
4.55
4.60
4.65
4.70

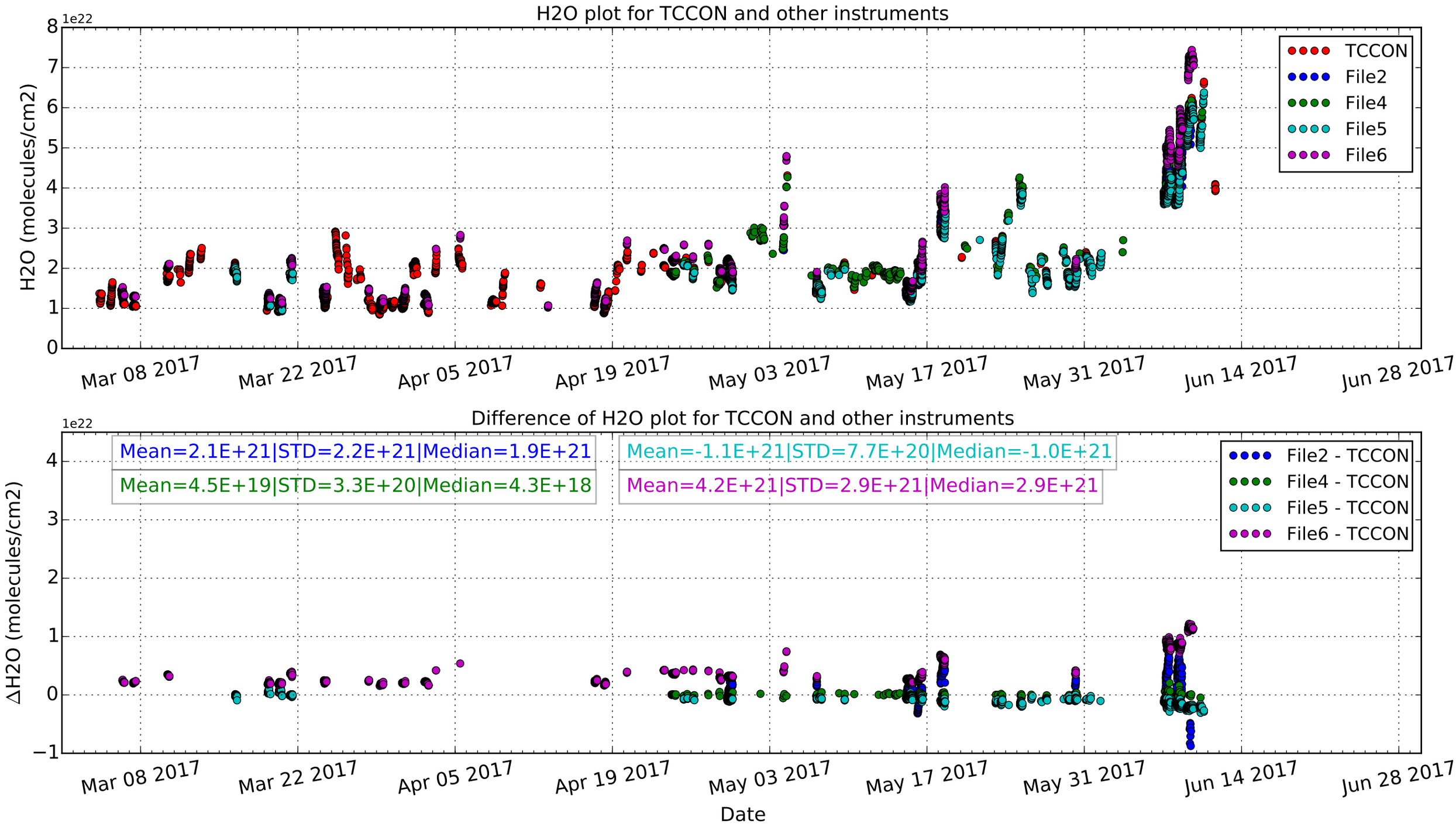

Correlation plot for O2 between TCCON and File6
1e24
-1.9E+22 + 1.0051*x
R=0.9591, stderr=0.0073
zero line
File6 O2 (molecules/cm2)
TCCON O2 (molecules/cm2)
1e24
4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.35
4.40
4.45
4.50
4.55
4.60
4.65

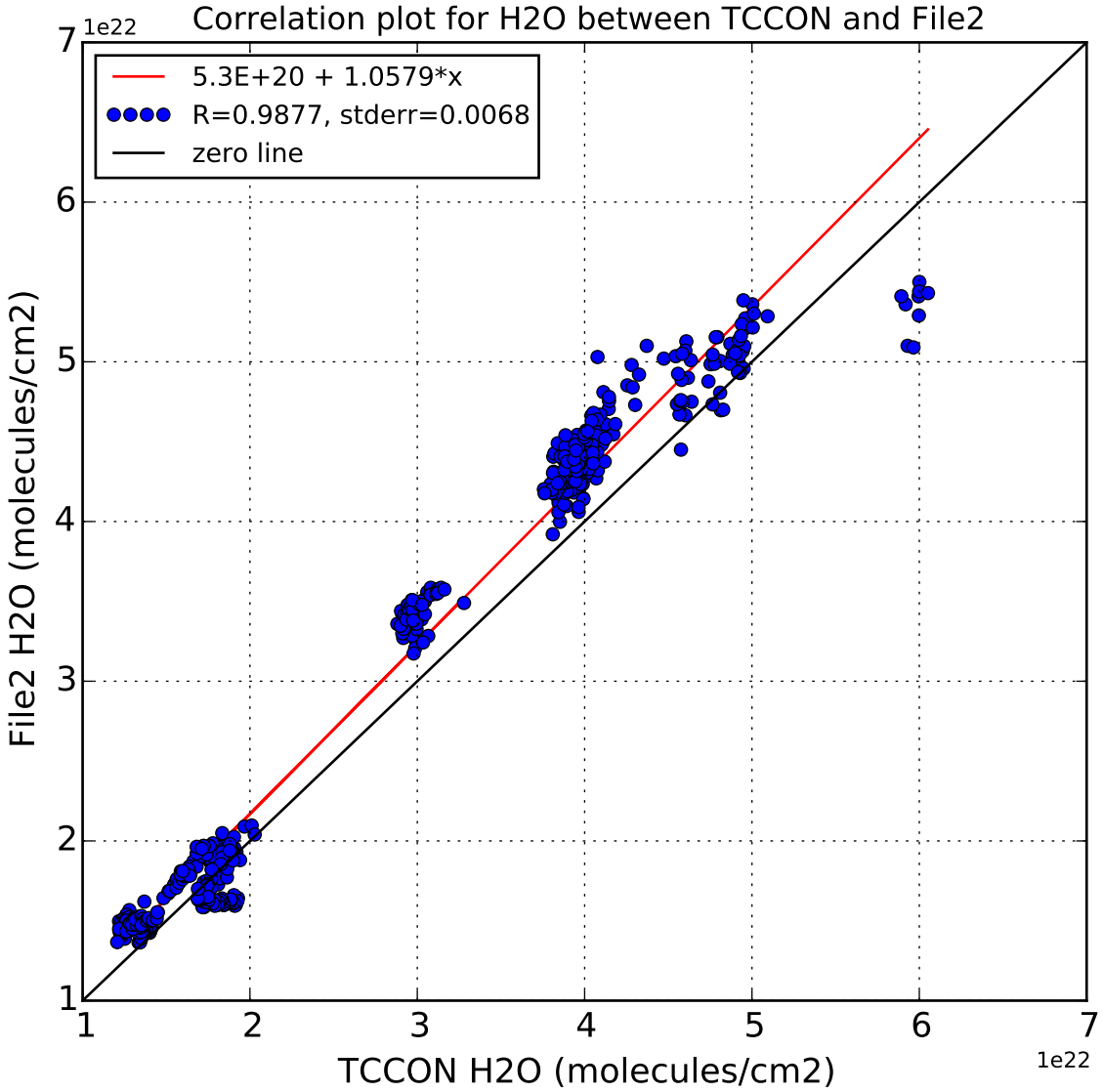

Correlation plot for O2 between TCCON and File2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

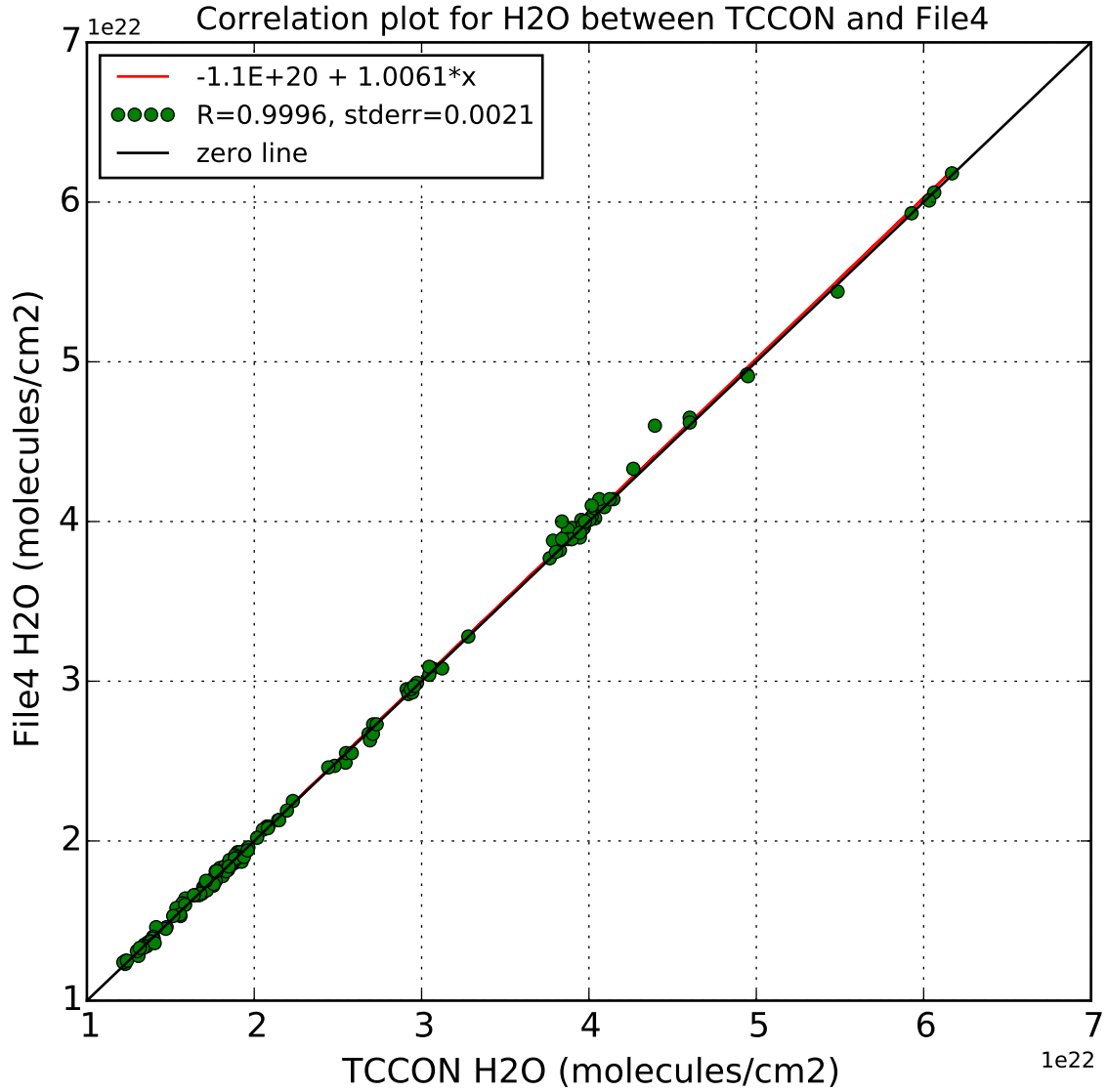

Correlation plot for O2 between TCCON and File4
1e24
4.60
4.55
4.50
4.45
4.40
4.35
File4 O2 (molecules/cm2)
6.2E+23 + 0.8453*x
R=0.8413, stderr=0.0414
zero line
April 2017
May 2017
June 2017
4.35
4.40
4.45
4.50
4.55
4.60
1e24
TCCON O2 (molecules/cm2)

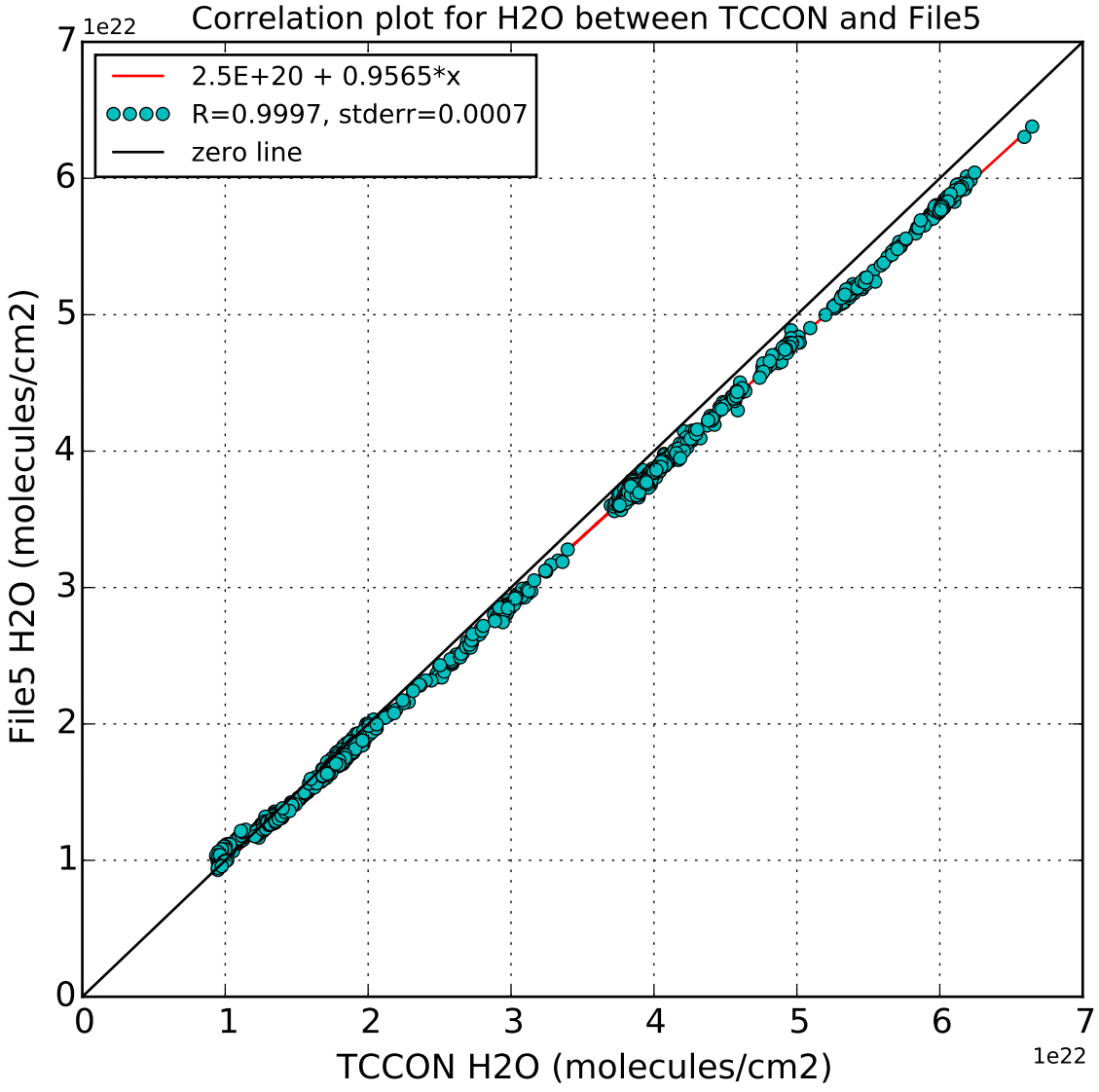

Correlation plot for O2 between TCCON and File5
1e24
4.70
4.65
4.60
4.55
4.50
4.45
4.40
File5 O2 (molecules/cm2)
5.4E+23 + 0.8954*x
R=0.9695, stderr=0.0065
zero line
March 2017
April 2017
May 2017
June 2017
4.40
4.45
4.50
4.55
4.60
4.65
4.70
1e24
TCCON O2 (molecules/cm2)

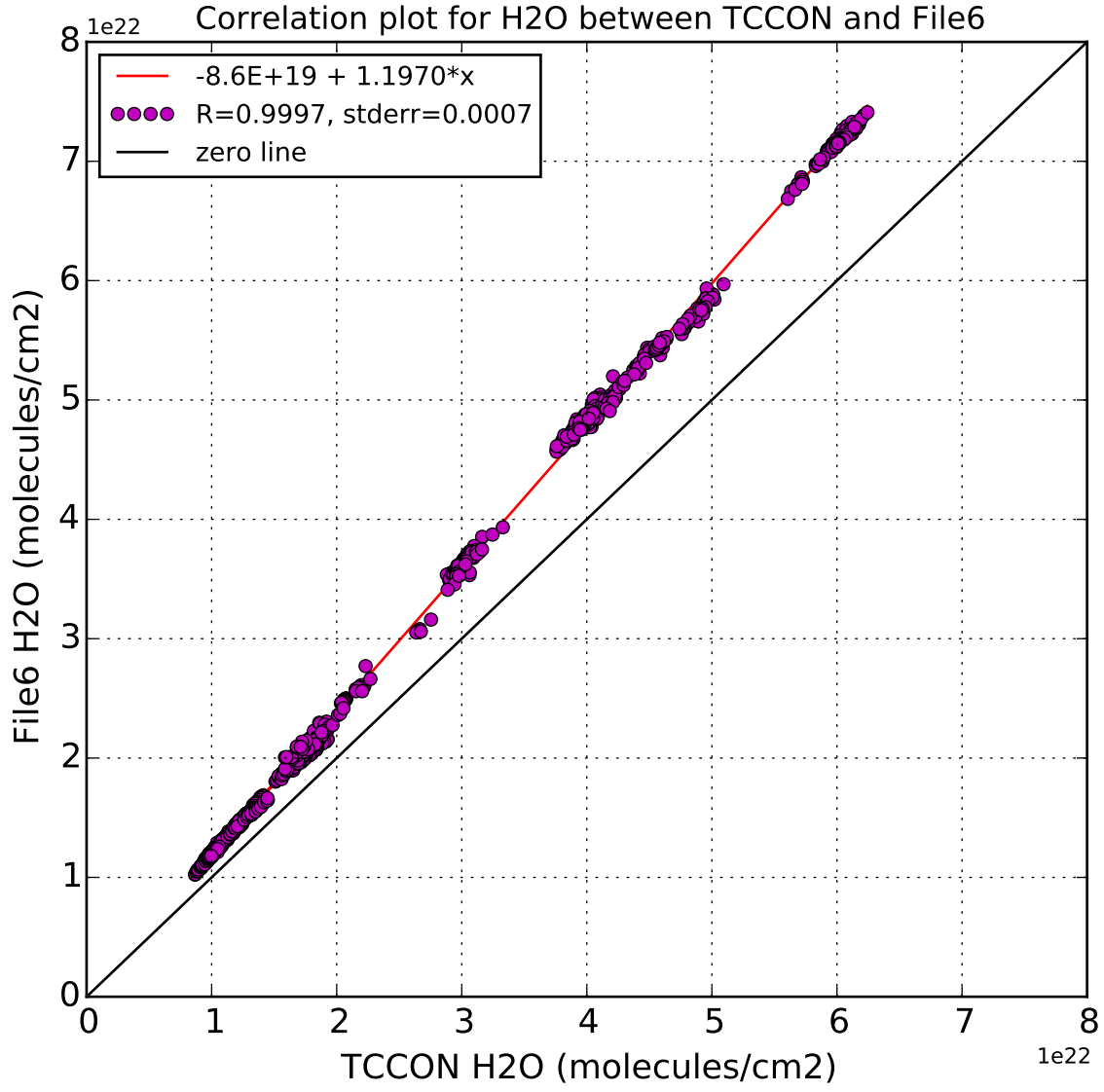

Correlation plot for O2 between TCCON and File6
1e24
4.65
4.60
4.55
4.50
4.45
4.40
4.35
File6 O2 (molecules/cm2)
-1.9E+22 + 1.0051*x
R=0.9591, stderr=0.0073
zero line
March 2017
April 2017
May 2017
June 2017
4.35
4.40
4.45
4.50
4.55
4.60
4.65
1e24
TCCON O2 (molecules/cm2)

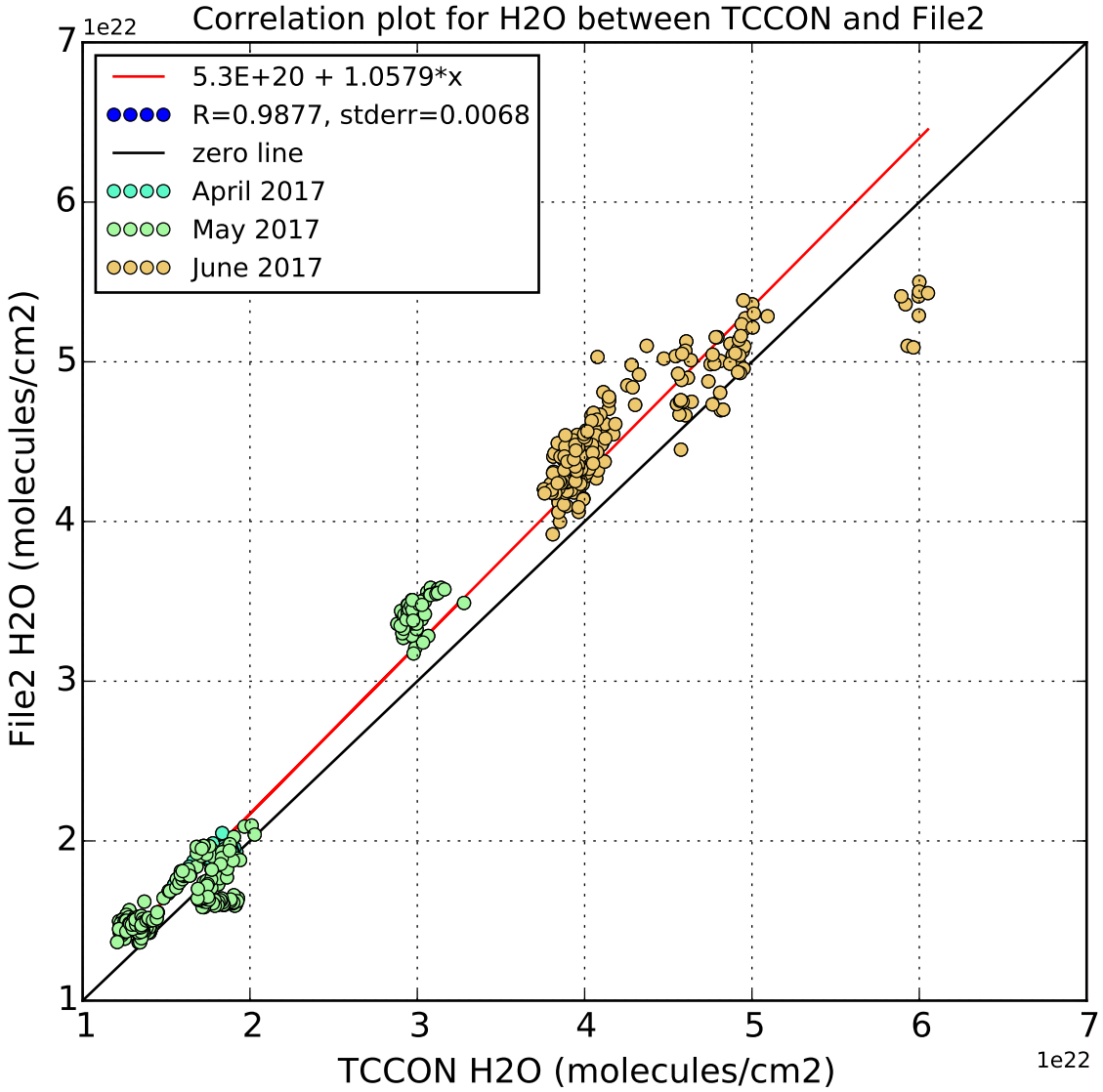

H2O plot for TCCON and other instruments
1e22
H2O (molecules/cm2)
TCCON
File2
File4
File5
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of H2O plot for TCCON and other instruments
Mean=2.1E+21|STD=2.2E+21|Median=1.9E+21
Mean=-1.1E+21|STD=7.7E+20|Median=-1.0E+21
Mean=4.5E+19|STD=3.3E+20|Median=4.3E+18
Mean=4.2E+21|STD=2.9E+21|Median=2.9E+21
File2 - TCCON
File4 - TCCON
File5 - TCCON
File6 - TCCON
ΔH2O (molecules/cm2)
Date

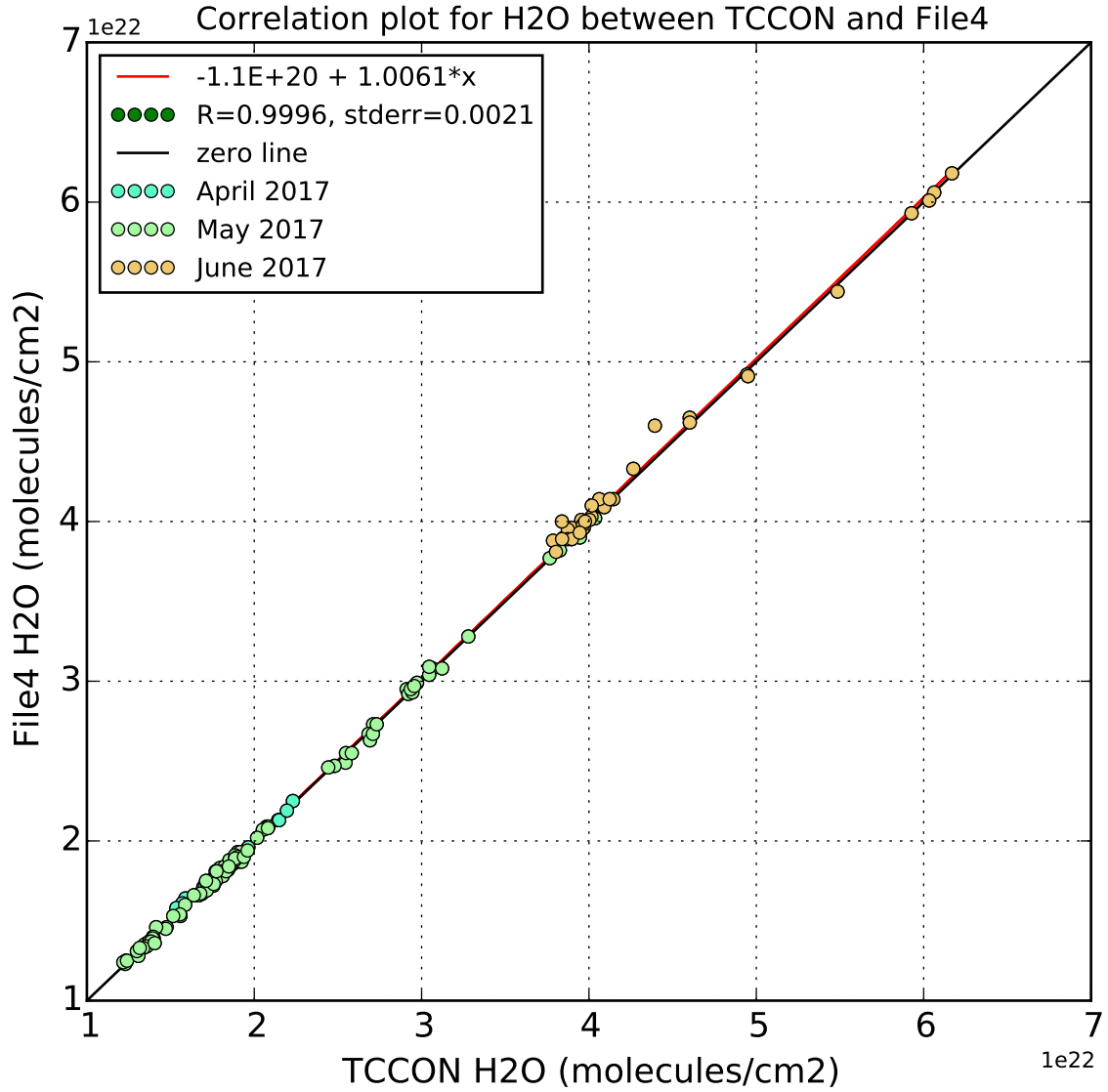

Correlation plot for H2O between TCCON and File2
5.3E+20 + 1.0579*x
R=0.9877, stderr=0.0068
zero line
1e22
File2 H2O (molecules/cm2)
TCCON H2O (molecules/cm2)
1e22

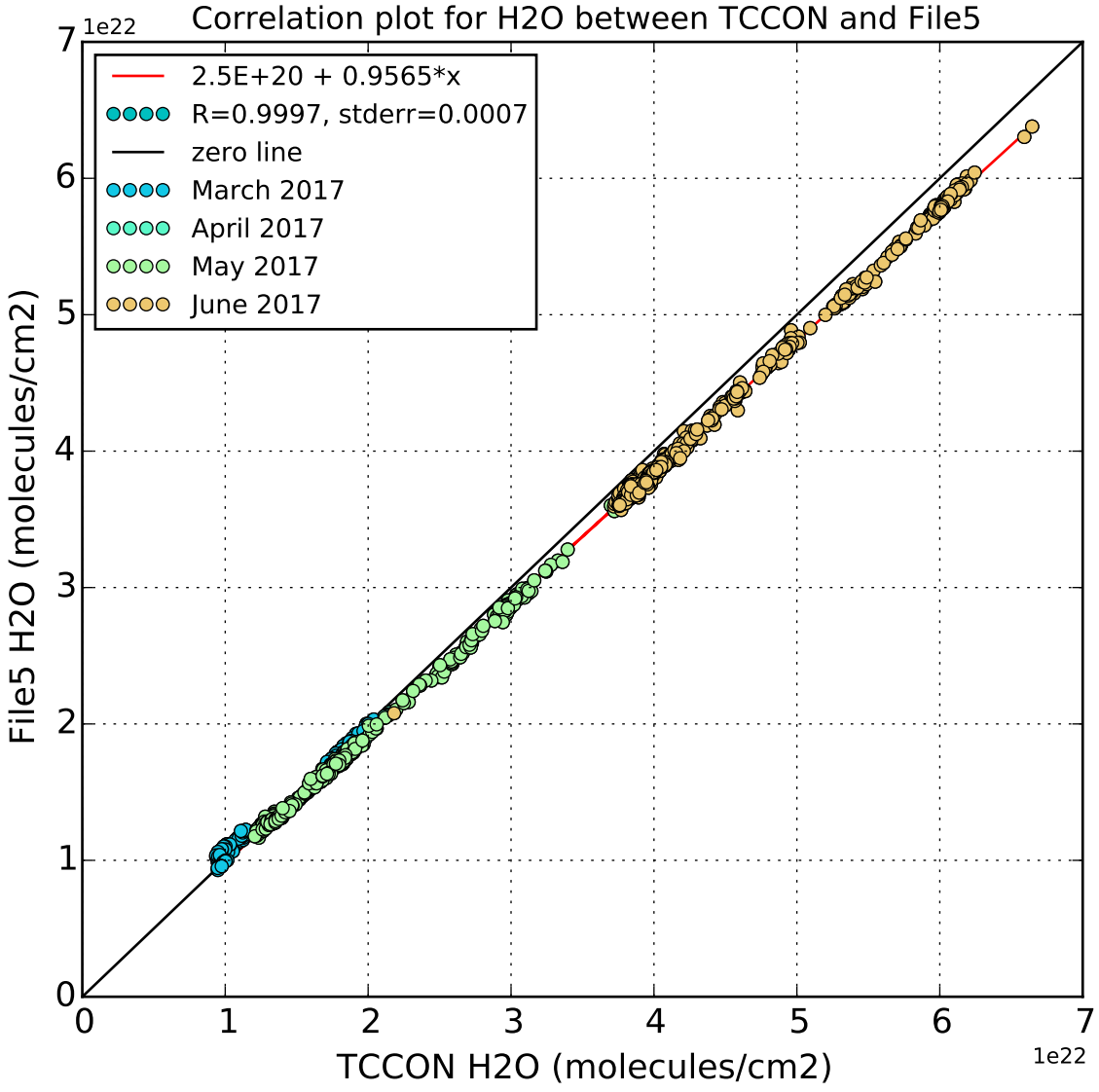

Correlation plot for H2O between TCCON and File4
-1.1E+20 + 1.0061*x
R=0.9996, stderr=0.0021
zero line
1e22
File4 H2O (molecules/cm2)
TCCON H2O (molecules/cm2)
1e22

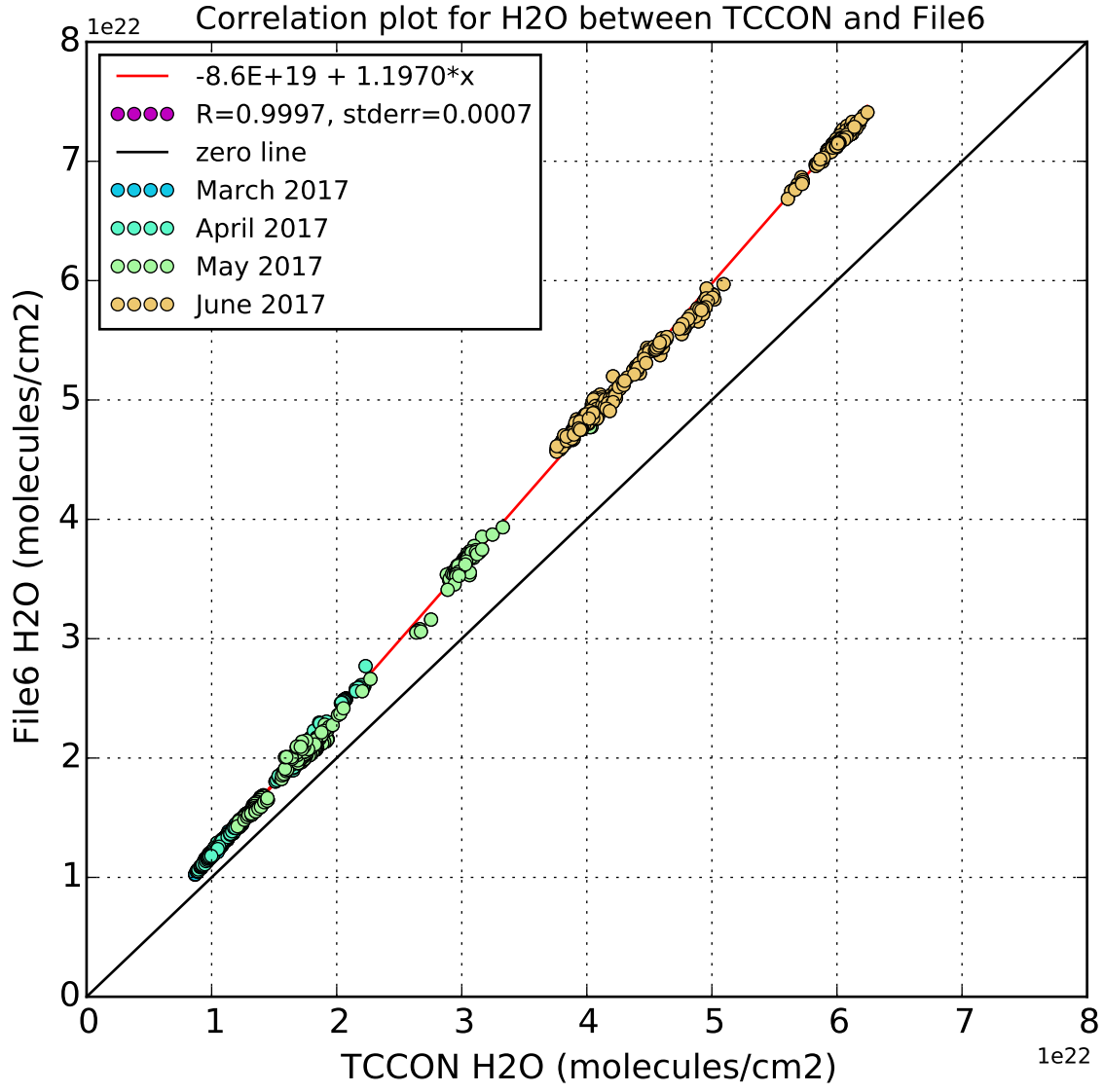

Correlation plot for H2O between TCCON and File5
2.5E+20 + 0.9565*x
R=0.9997, stderr=0.0007
zero line
1e22
File5 H2O (molecules/cm2)
TCCON H2O (molecules/cm2)
1e22

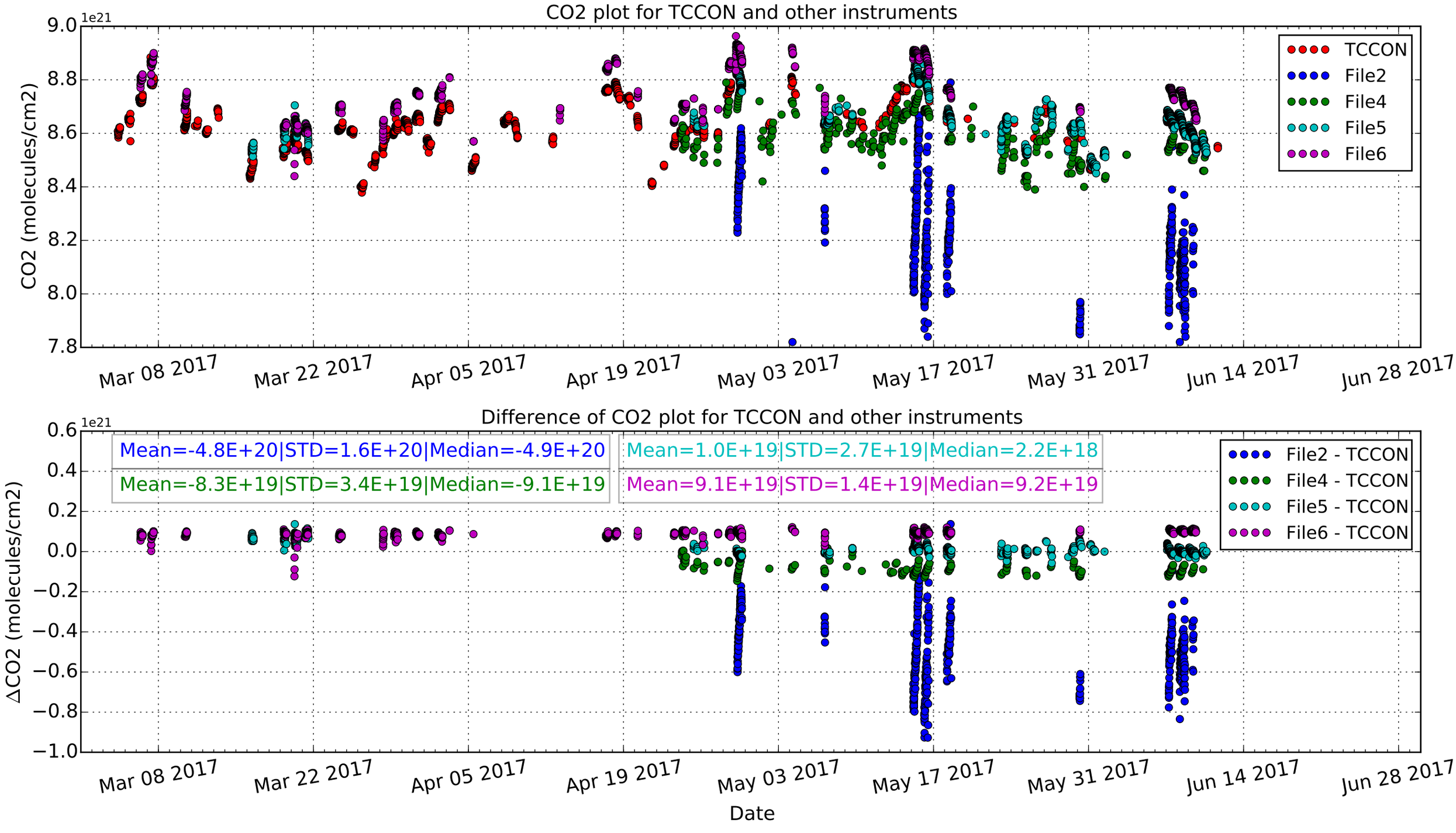

Correlation plot for H2O between TCCON and File6
-8.6E+19 + 1.1970*x
R=0.9997, stderr=0.0007
zero line
1e22
File6 H2O (molecules/cm2)
TCCON H2O (molecules/cm2)
1e22

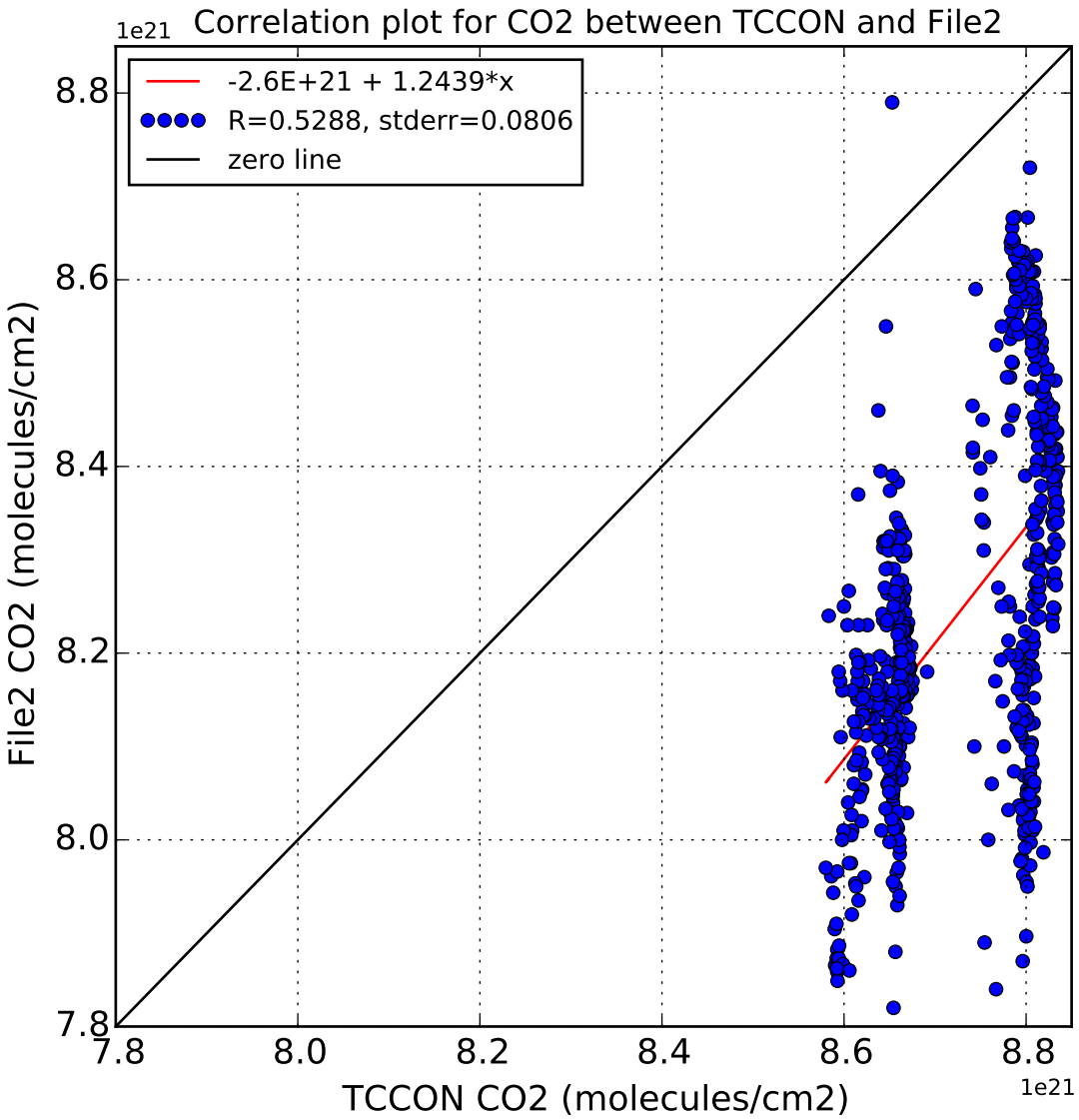

Correlation plot for H2O between TCCON and File2
1e22
5.3E+20 + 1.0579*x
R=0.9877, stderr=0.0068
zero line
April 2017
May 2017
June 2017
File2 H2O (molecules/cm2)
TCCON H2O (molecules/cm2)
1e22

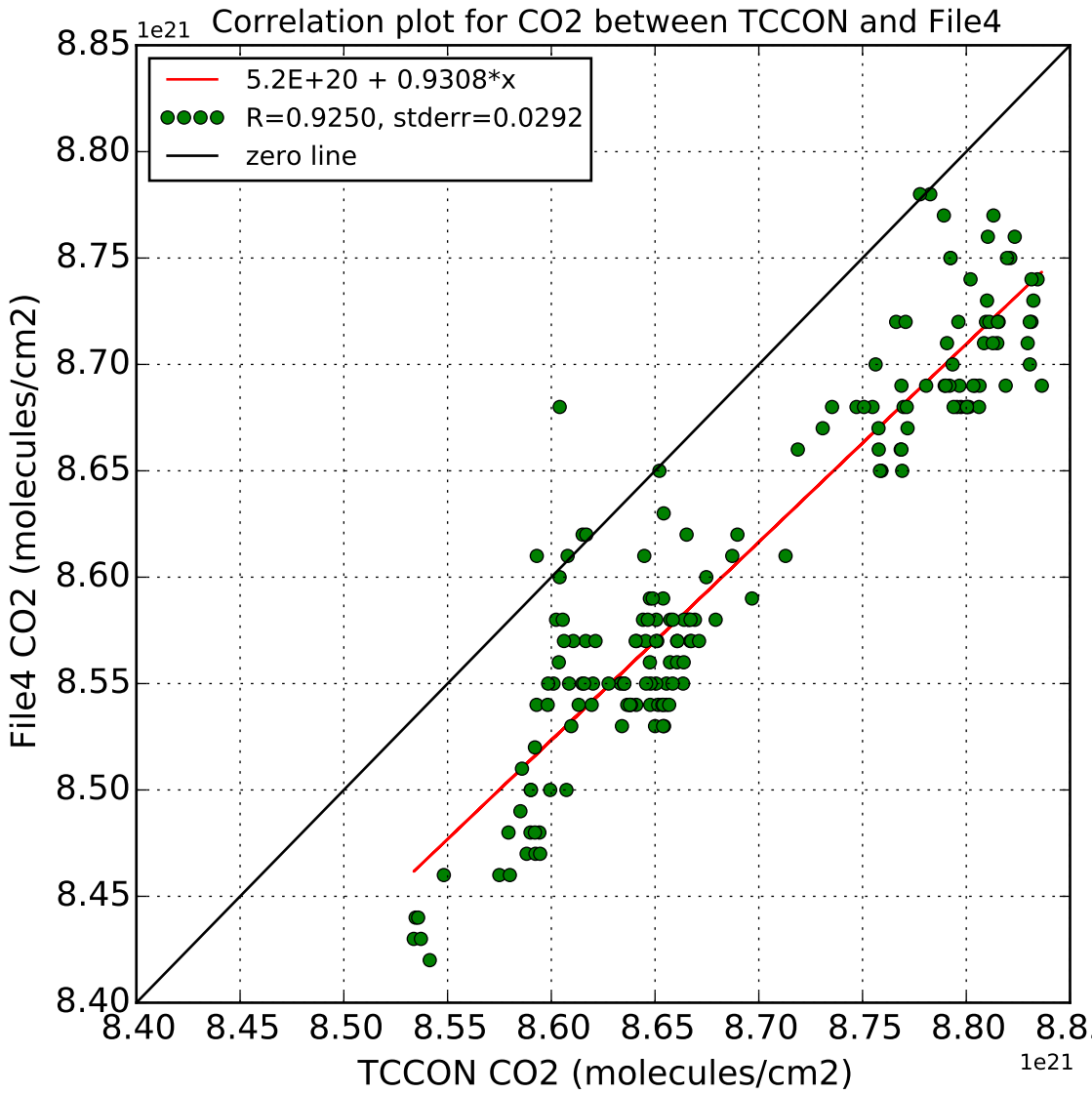

Correlation plot for H2O between TCCON and File4
1e22
-1.1E+20 + 1.0061*x
R=0.9996, stderr=0.0021
zero line
April 2017
May 2017
June 2017
File4 H2O (molecules/cm2)
TCCON H2O (molecules/cm2)
1e22

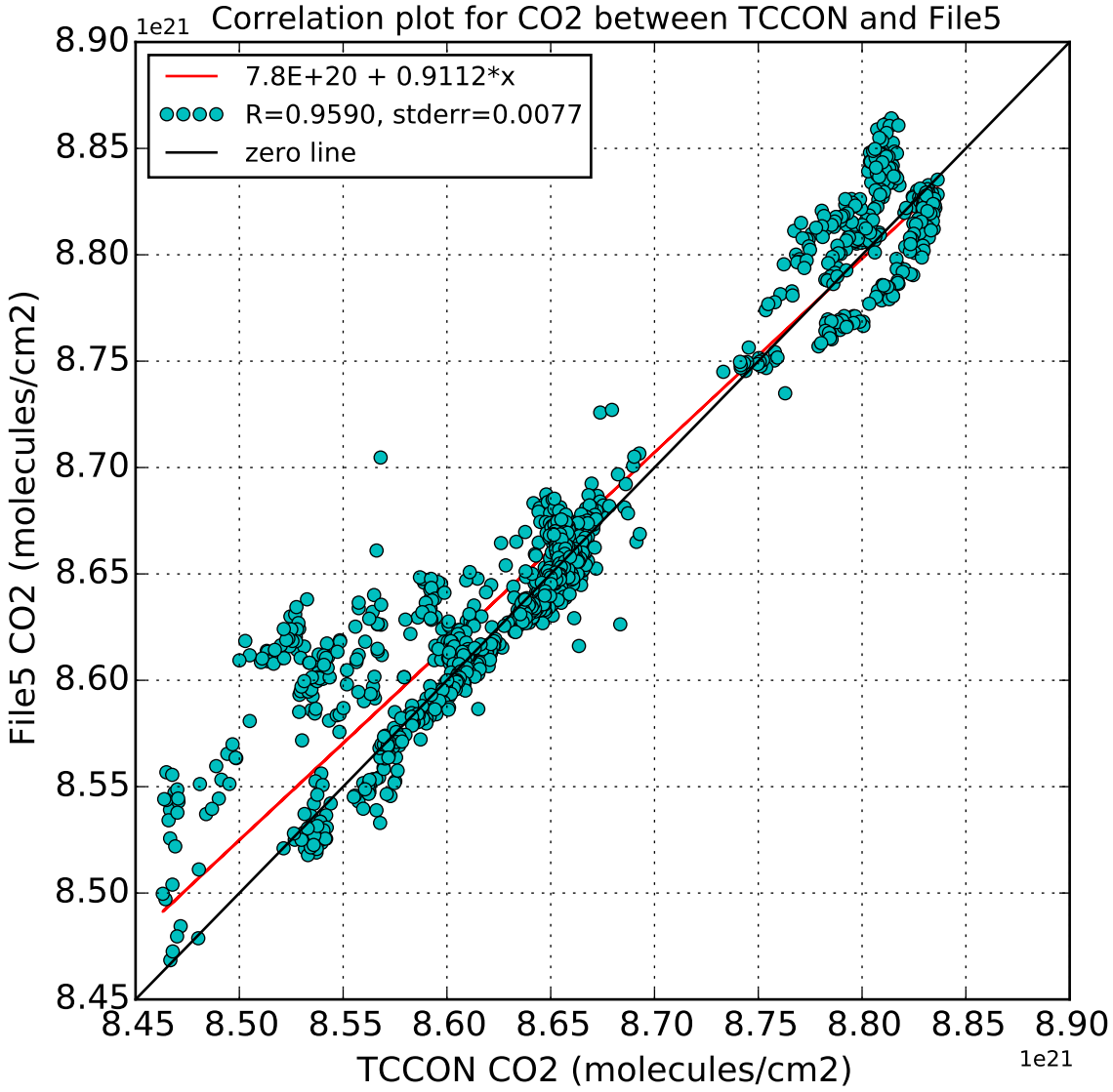

Correlation plot for H2O between TCCON and File5
1e22
2.5E+20 + 0.9565*x
R=0.9997, stderr=0.0007
zero line
March 2017
April 2017
May 2017
June 2017
File5 H2O (molecules/cm2)
TCCON H2O (molecules/cm2)
1e22

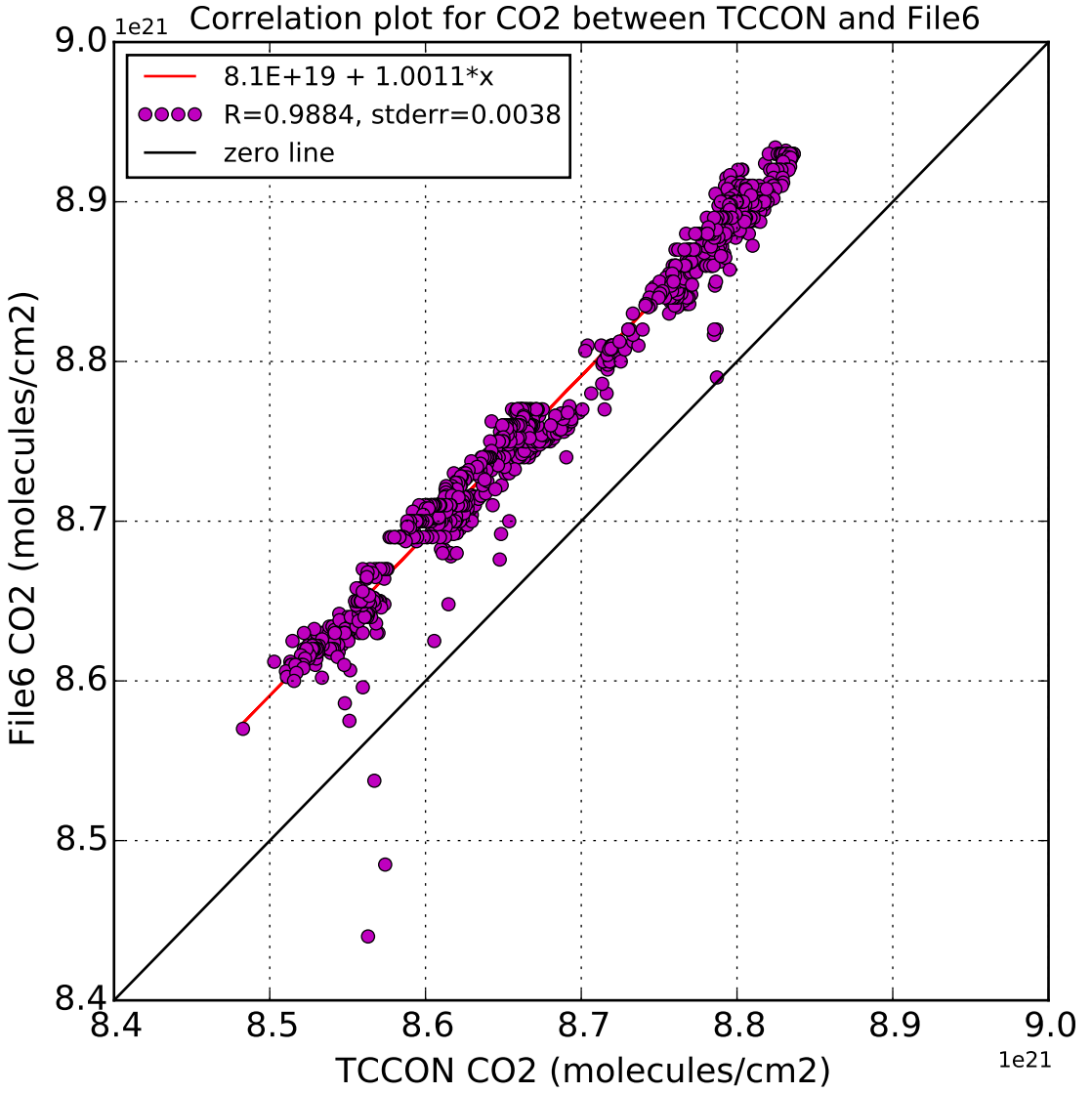

Correlation plot for H2O between TCCON and File6
1e22
-8.6E+19 + 1.1970*x
R=0.9997, stderr=0.0007
zero line
March 2017
April 2017
May 2017
June 2017
File6 H2O (molecules/cm2)
TCCON H2O (molecules/cm2)
1e22

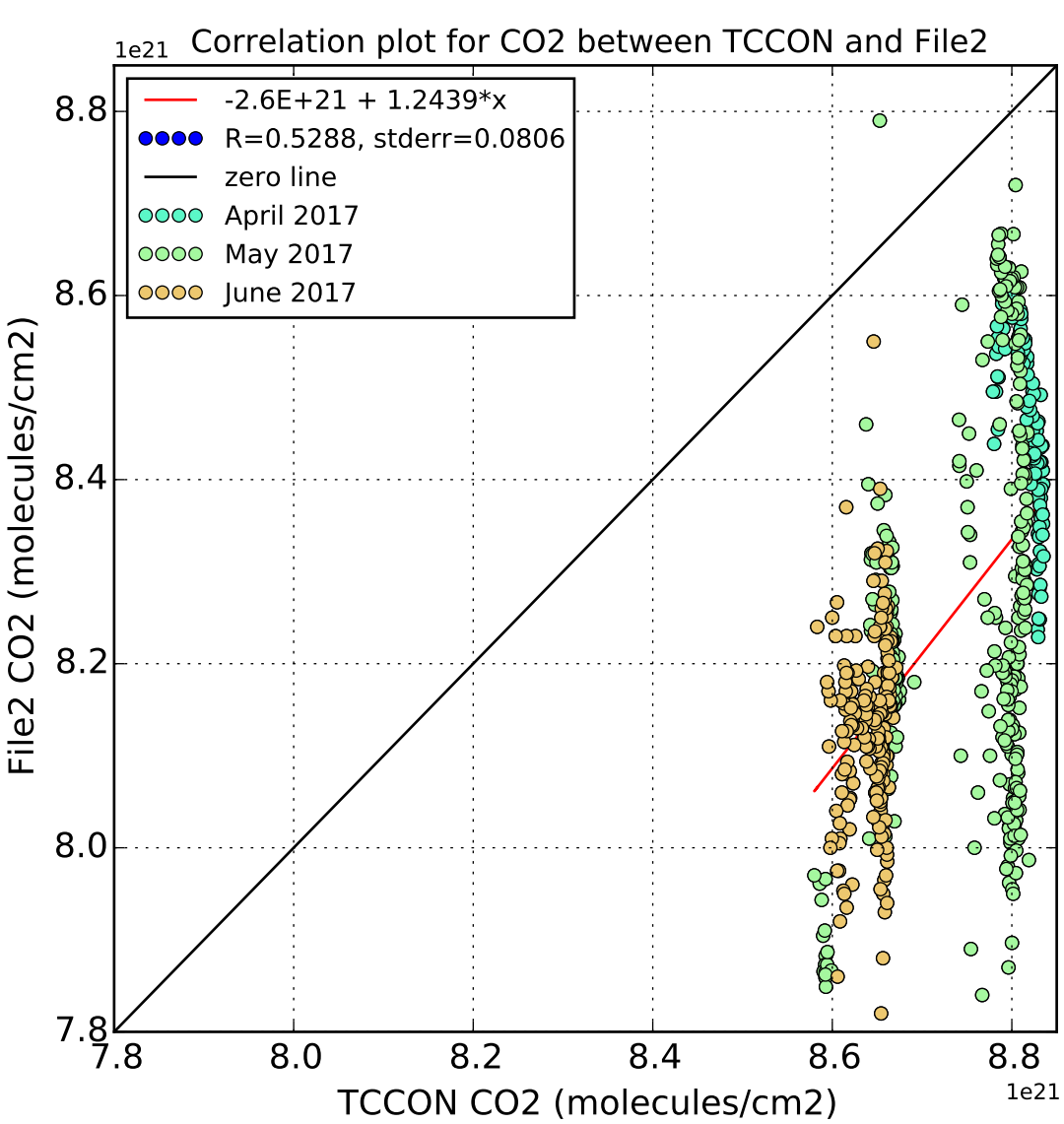

CO2 plot for TCCON and other instruments
1e21
9.0
8.8
8.6
8.4
8.2
8.0
7.8
CO2 (molecules/cm2)
TCCON
File2
File4
File5
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CO2 plot for TCCON and other instruments
1e21
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
ΔCO2 (molecules/cm2)
Mean=-4.8E+20|STD=1.6E+20|Median=-4.9E+20
Mean=1.0E+19|STD=2.7E+19|Median=2.2E+18
Mean=-8.3E+19|STD=3.4E+19|Median=-9.1E+19
Mean=9.1E+19|STD=1.4E+19|Median=9.2E+19
File2 - TCCON
File4 - TCCON
File5 - TCCON
File6 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

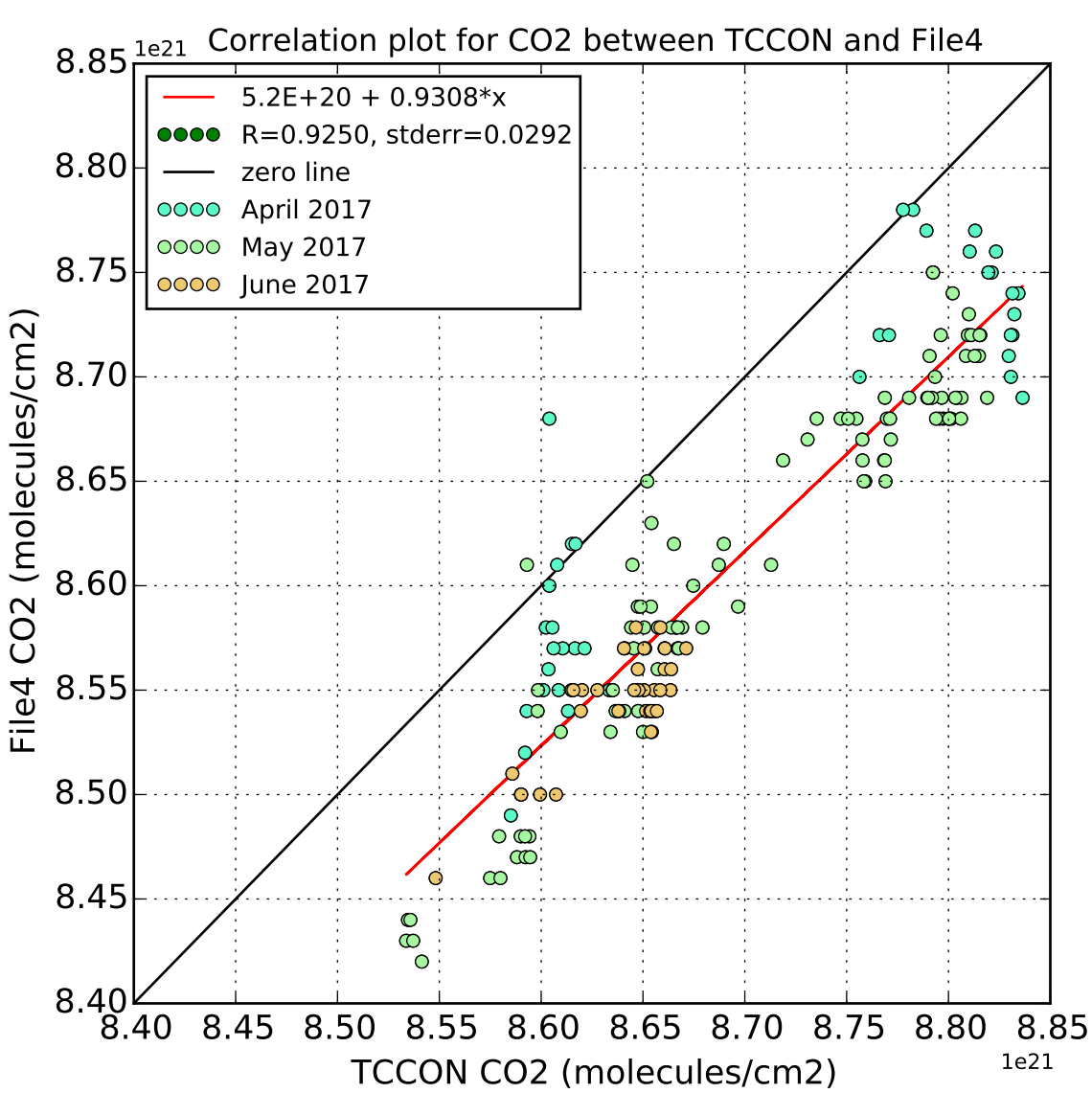

Correlation plot for CO2 between TCCON and File2
-2.6E+21 + 1.2439*x
R=0.5288, stderr=0.0806
zero line
File2 CO2 (molecules/cm2)
TCCON CO2 (molecules/cm2)
1e21

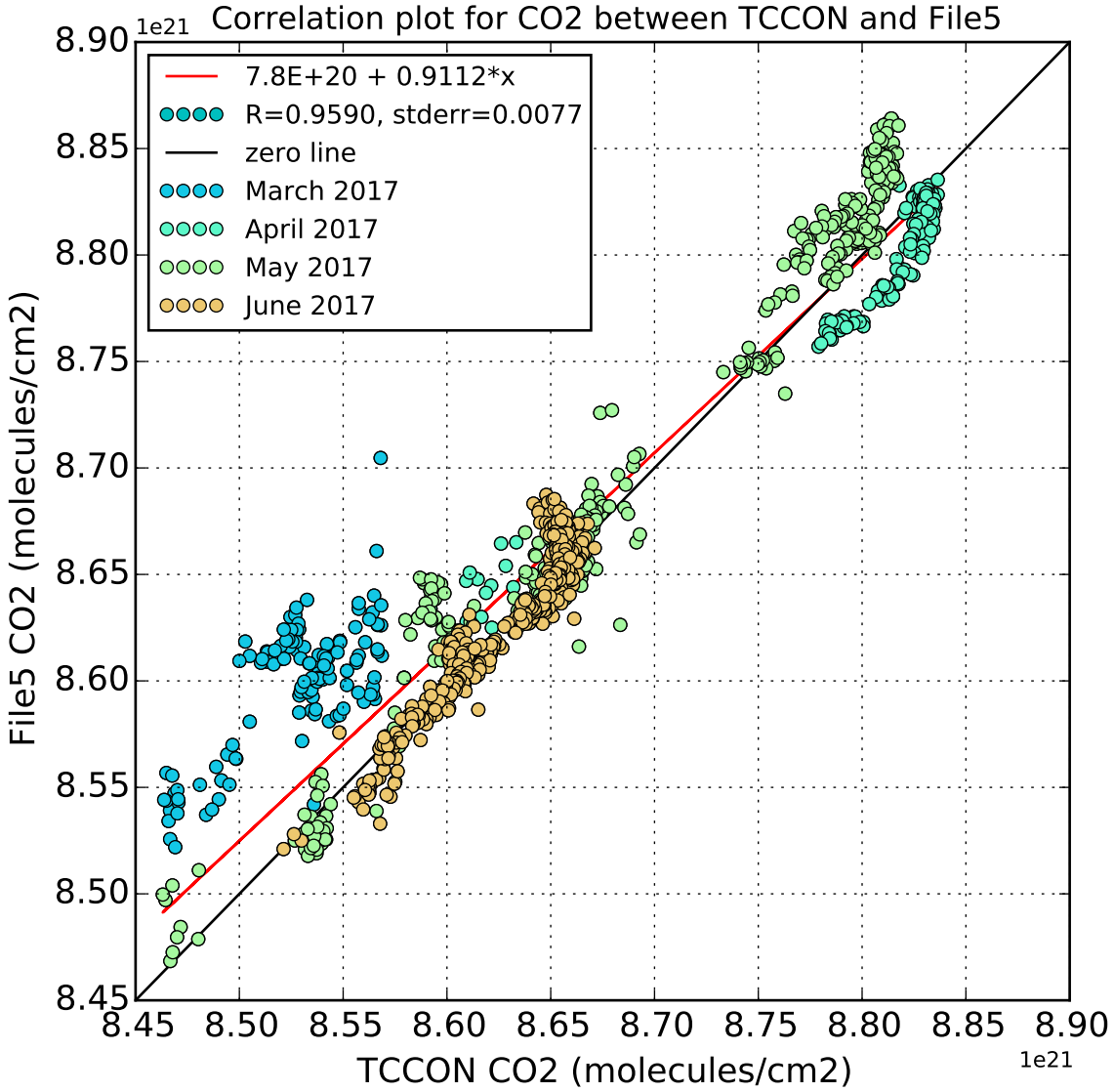

Correlation plot for CO2 between TCCON and File4
5.2E+20 + 0.9308*x
R=0.9250, stderr=0.0292
zero line
File4 CO2 (molecules/cm2)
TCCON CO2 (molecules/cm2)
1e21

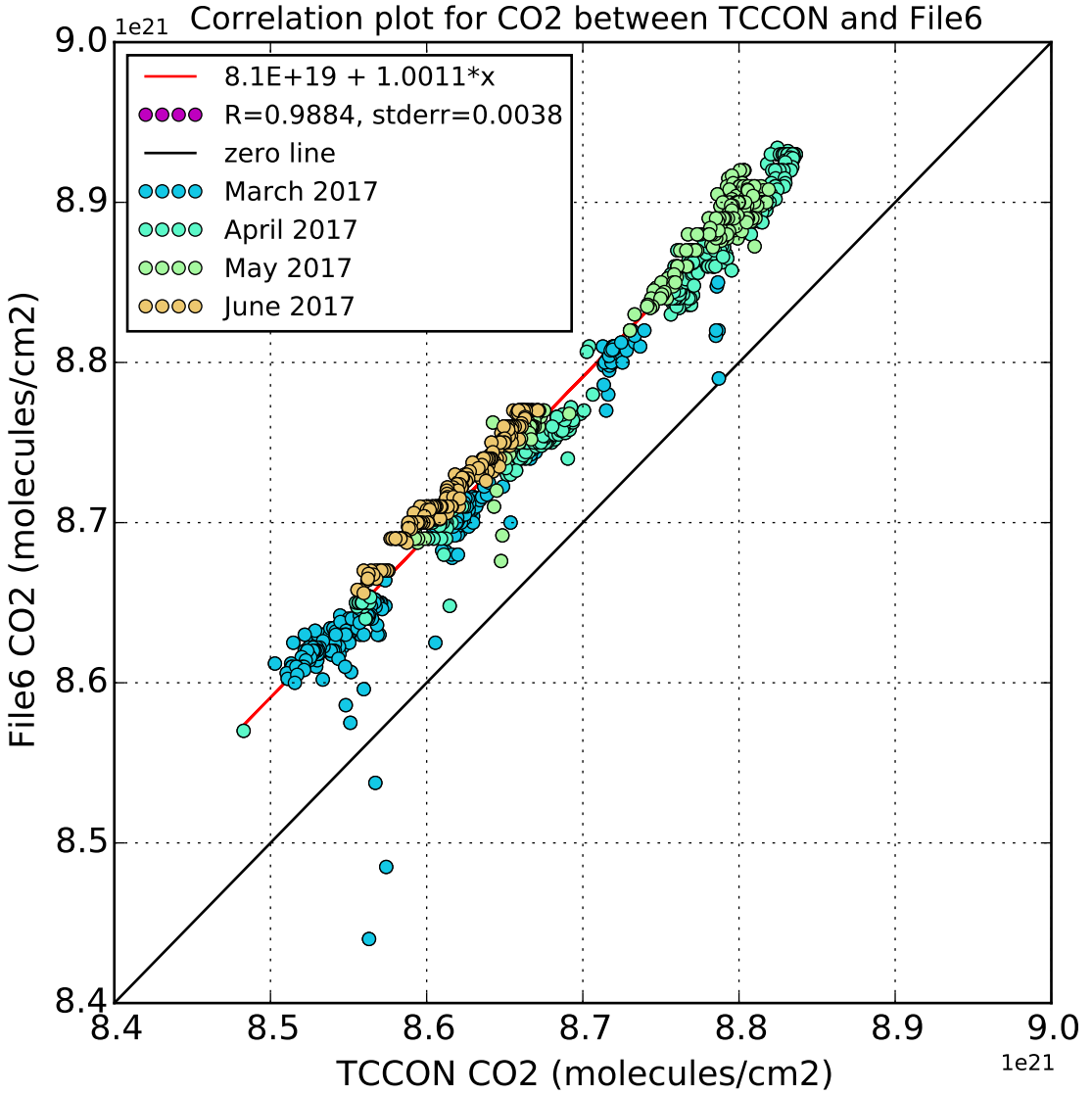

Correlation plot for CO2 between TCCON and File5
7.8E+20 + 0.9112*x
R=0.9590, stderr=0.0077
zero line
File5 CO2 (molecules/cm2)
TCCON CO2 (molecules/cm2)
1e21

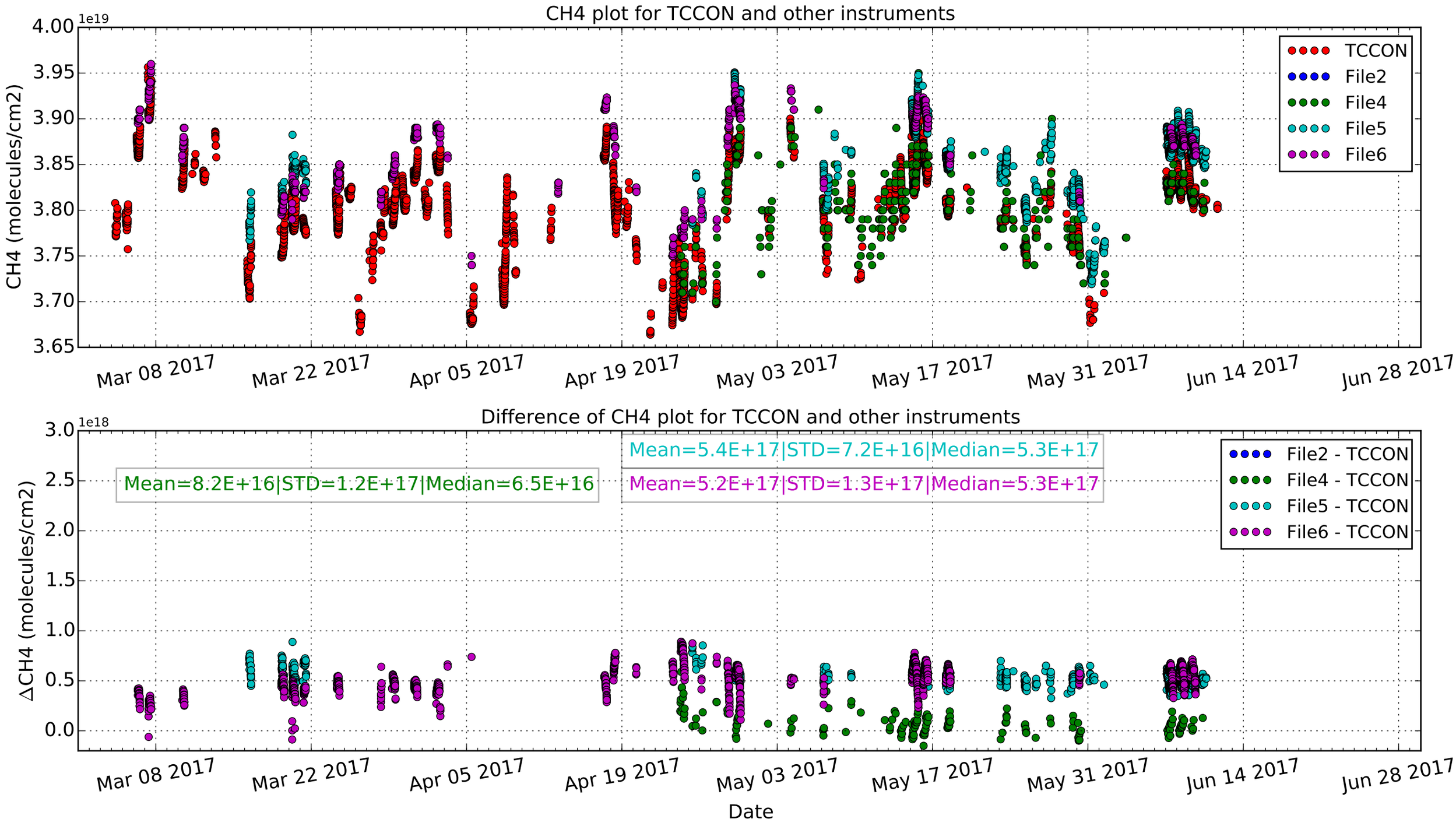

Correlation plot for CO2 between TCCON and File6
8.1E+19 + 1.0011*x
R=0.9884, stderr=0.0038
zero line
File6 CO2 (molecules/cm2)
TCCON CO2 (molecules/cm2)
1e21

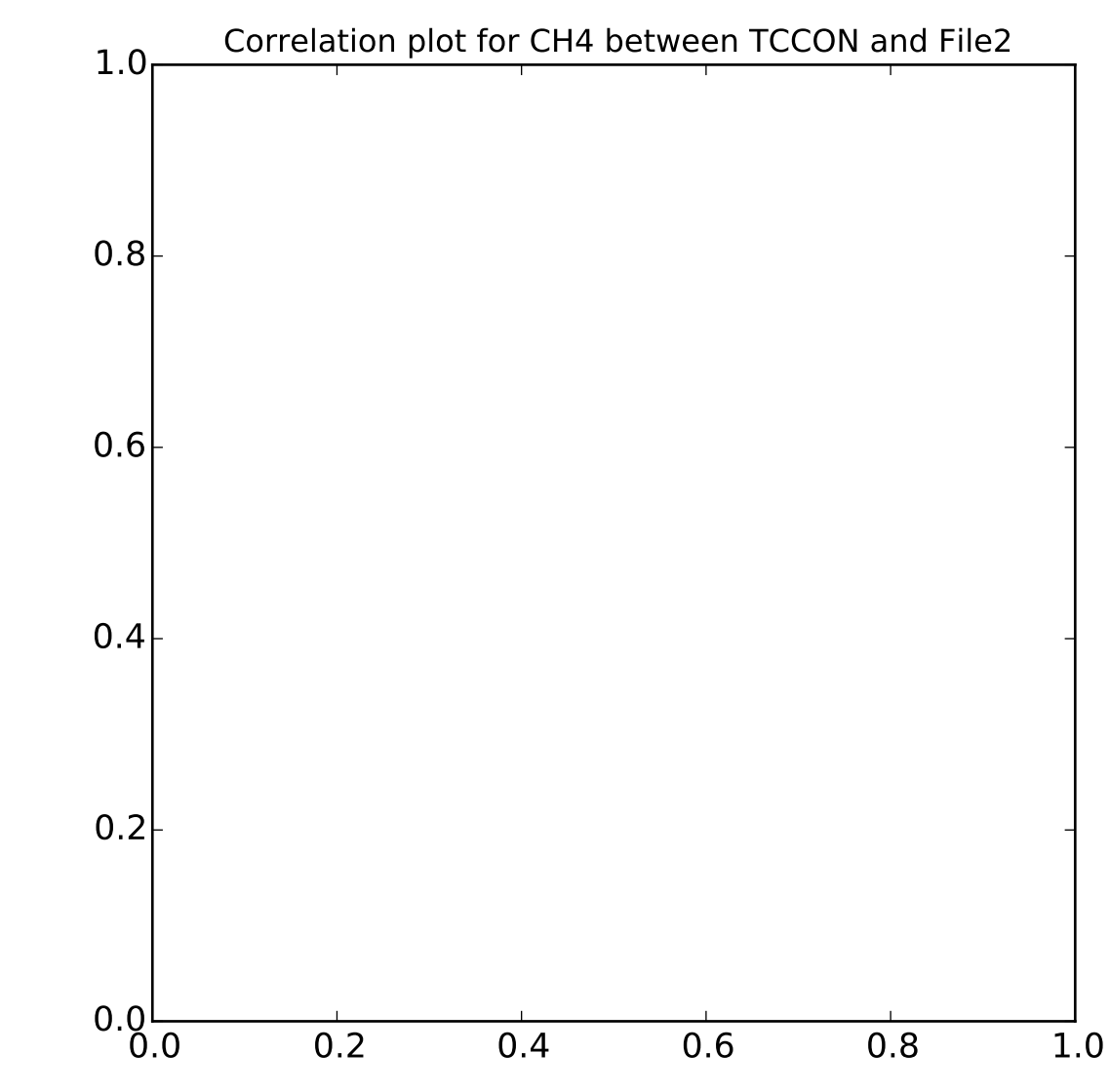

Correlation plot for CO2 between TCCON and File2
1e21
-2.6E+21 + 1.2439*x
R=0.5288, stderr=0.0806
zero line
April 2017
May 2017
June 2017
File2 CO2 (molecules/cm2)
TCCON CO2 (molecules/cm2)
1e21
7.8
8.0
8.2
8.4
8.6
8.8

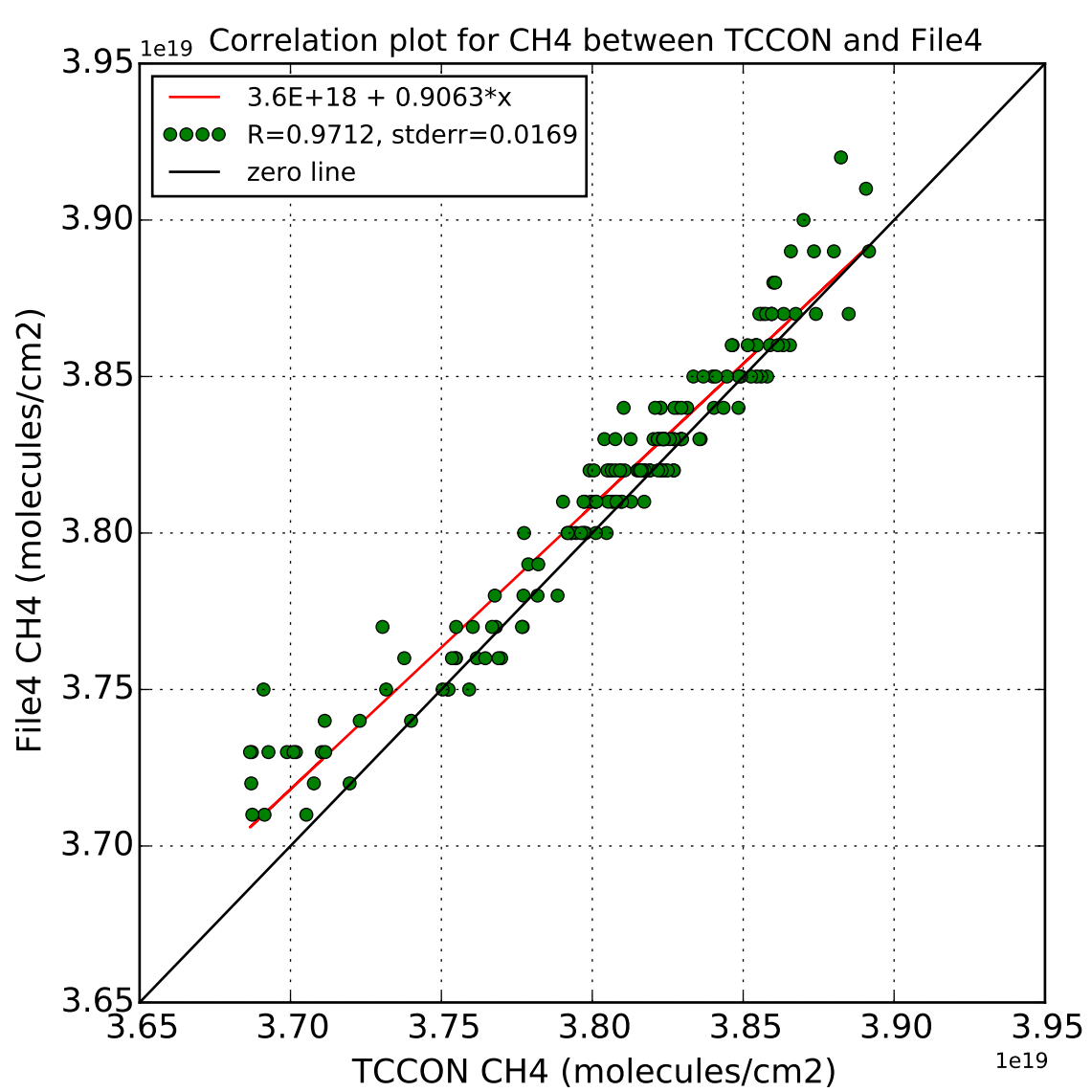

Correlation plot for CO2 between TCCON and File4
1e21
5.2E+20 + 0.9308*x
R=0.9250, stderr=0.0292
zero line
April 2017
May 2017
June 2017
File4 CO2 (molecules/cm2)
TCCON CO2 (molecules/cm2)
1e21
8.40
8.45
8.50
8.55
8.60
8.65
8.70
8.75
8.80
8.85

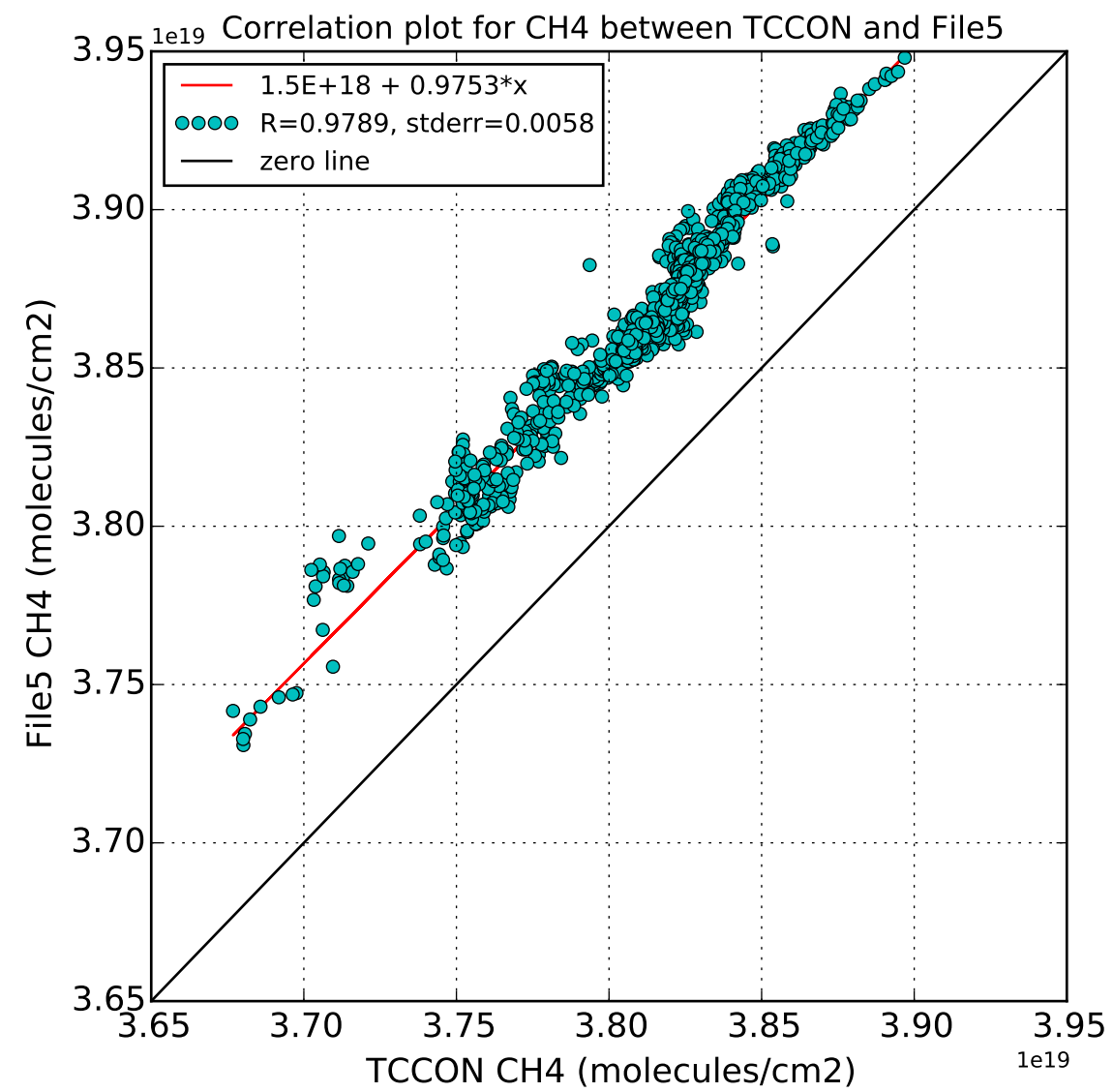

Correlation plot for CO2 between TCCON and File5
1e21
7.8E+20 + 0.9112*x
R=0.9590, stderr=0.0077
zero line
March 2017
April 2017
May 2017
June 2017
File5 CO2 (molecules/cm2)
TCCON CO2 (molecules/cm2)
1e21
8.45
8.50
8.55
8.60
8.65
8.70
8.75
8.80
8.85
8.90

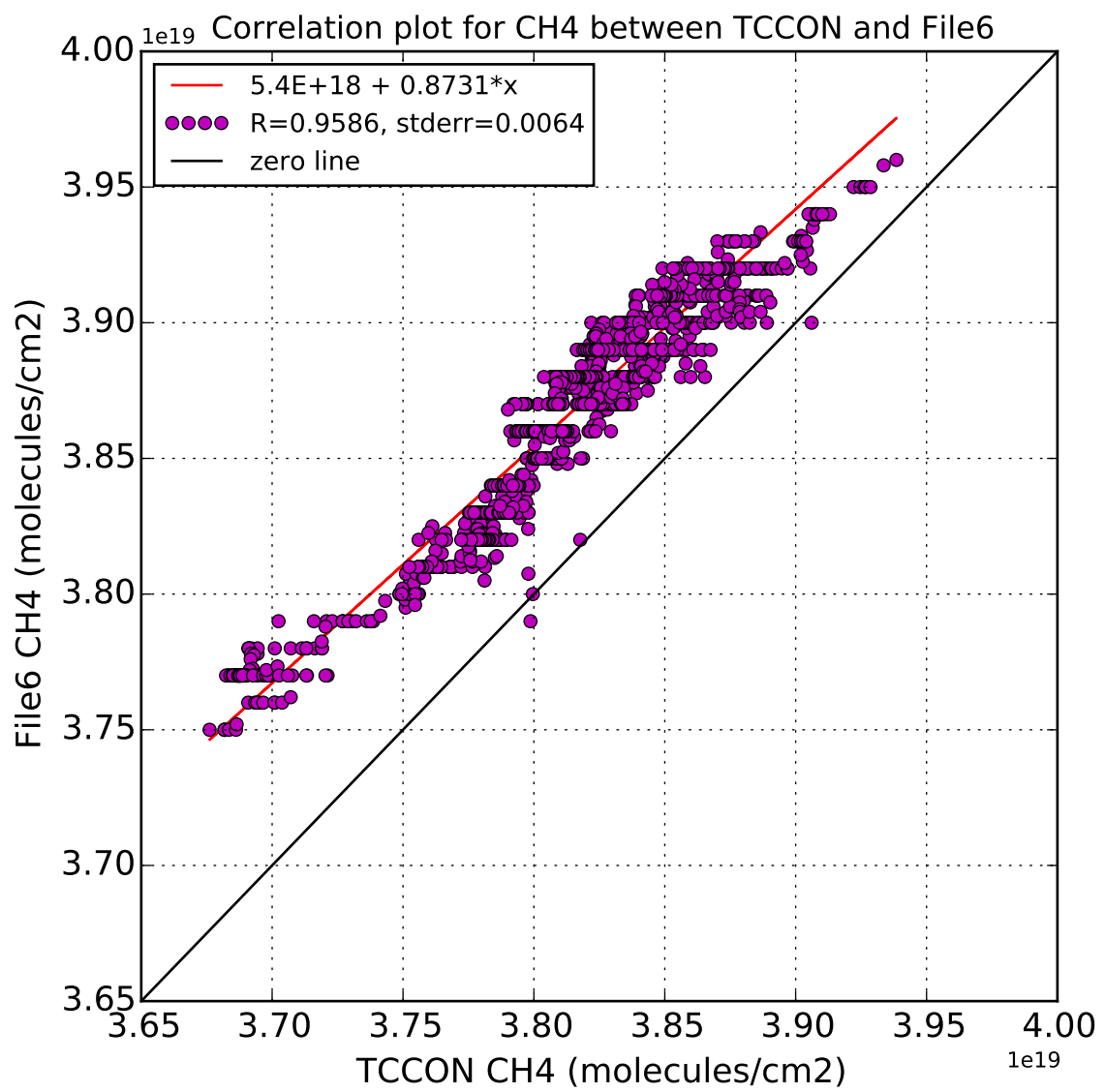

Correlation plot for CO2 between TCCON and File6
1e21
8.1E+19 + 1.0011*x
R=0.9884, stderr=0.0038
zero line
March 2017
April 2017
May 2017
June 2017
File6 CO2 (molecules/cm2)
TCCON CO2 (molecules/cm2)
1e21
8.4
8.5
8.6
8.7
8.8
8.9
9.0

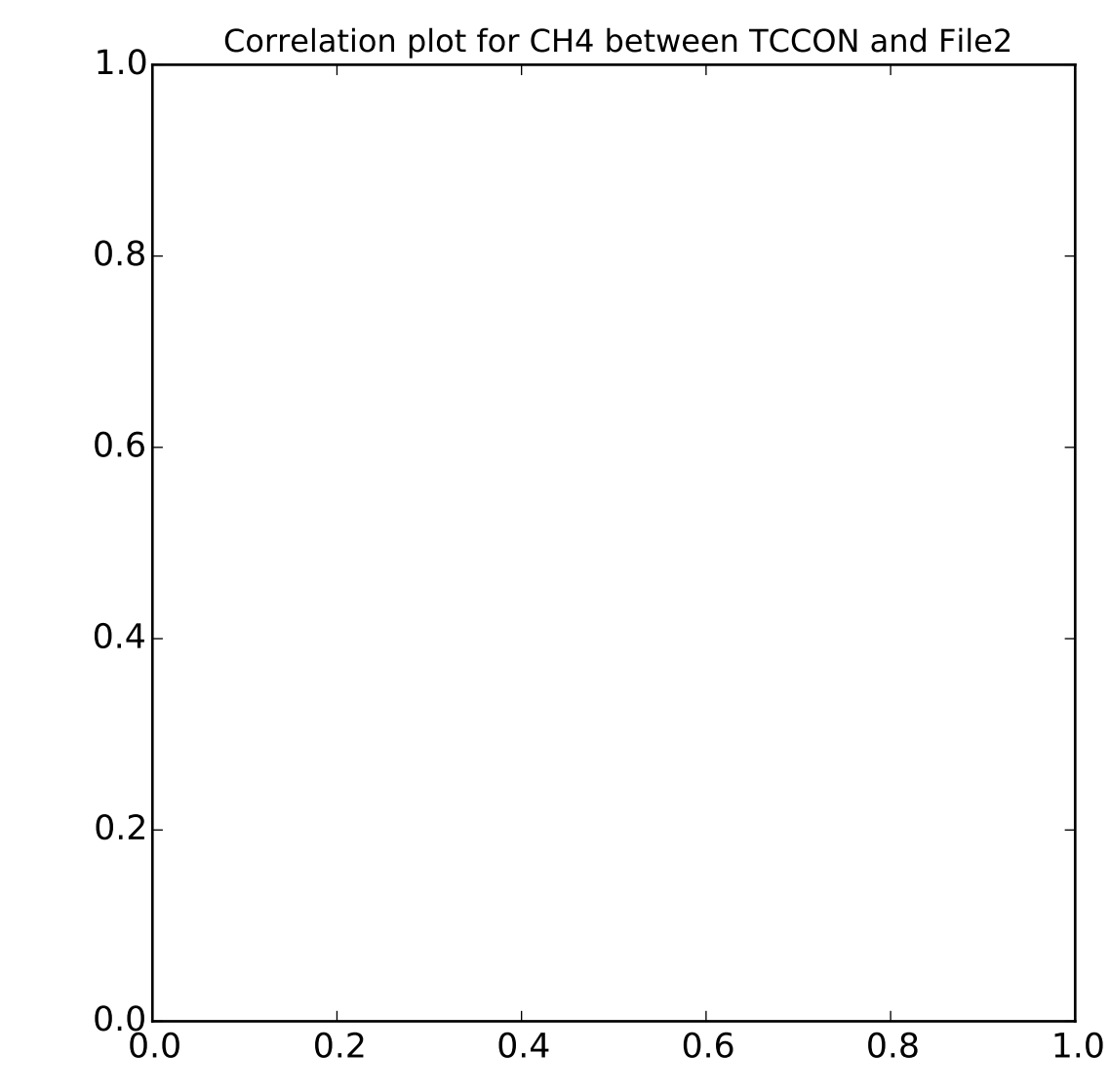

CH4 plot for TCCON and other instruments
1e19
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
CH4 (molecules/cm2)
TCCON
File2
File4
File5
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CH4 plot for TCCON and other instruments
1e18
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ΔCH4 (molecules/cm2)
Mean=8.2E+16|STD=1.2E+17|Median=6.5E+16
Mean=5.4E+17|STD=7.2E+16|Median=5.3E+17
Mean=5.2E+17|STD=1.3E+17|Median=5.3E+17
File2 - TCCON
File4 - TCCON
File5 - TCCON
File6 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

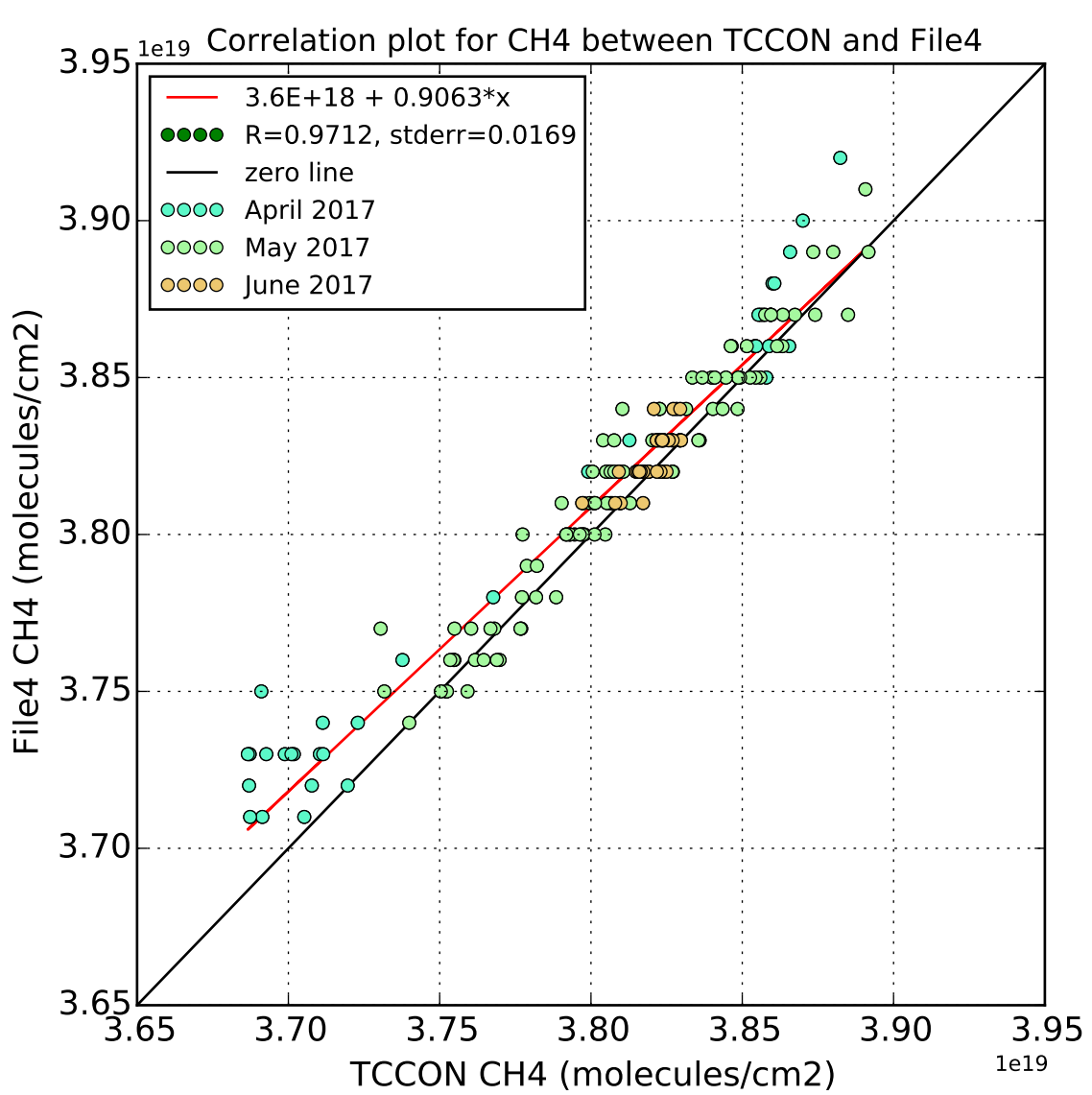

Correlation plot for CH4 between TCCON and File2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

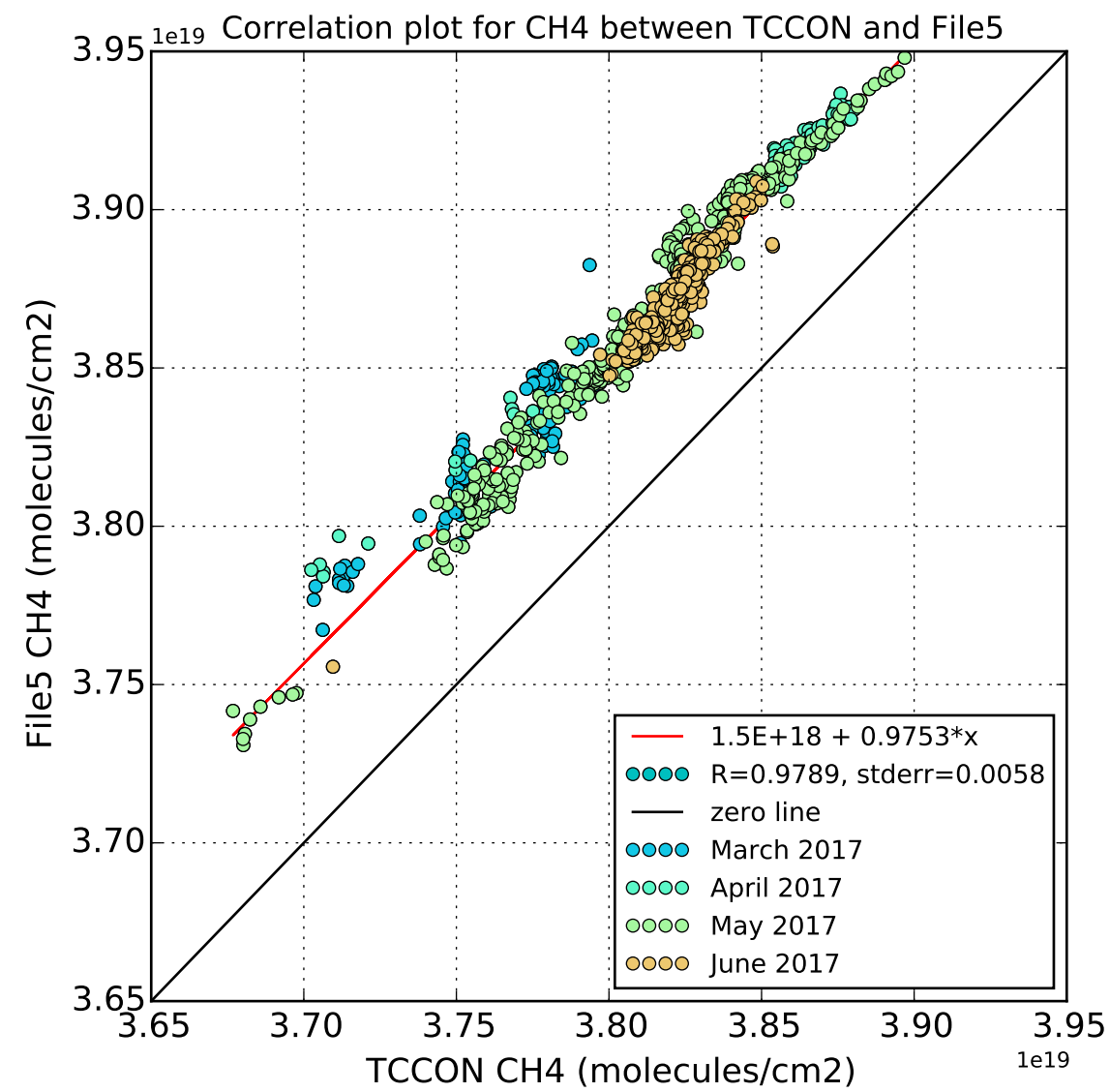

Correlation plot for CH4 between TCCON and File4
1e19
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.65
3.70
3.75
3.80
3.85
3.90
3.95
1e19
File4 CH4 (molecules/cm2)
TCCON CH4 (molecules/cm2)
3.6E+18 + 0.9063*x
R=0.9712, stderr=0.0169
zero line

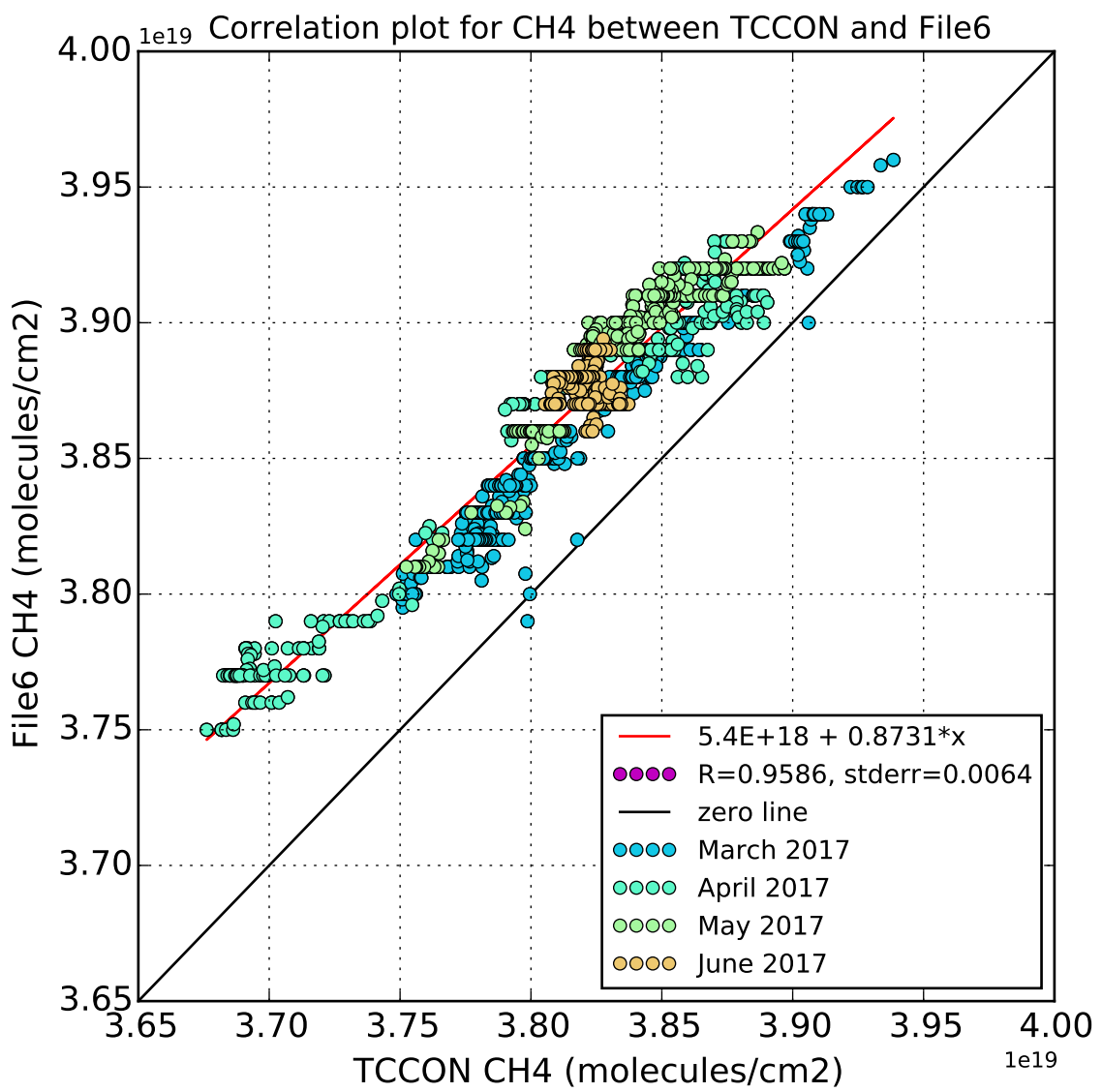

Correlation plot for CH4 between TCCON and File5
1e19
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.65
3.70
3.75
3.80
3.85
3.90
3.95
1e19
File5 CH4 (molecules/cm2)
TCCON CH4 (molecules/cm2)
1.5E+18 + 0.9753*x
R=0.9789, stderr=0.0058
zero line

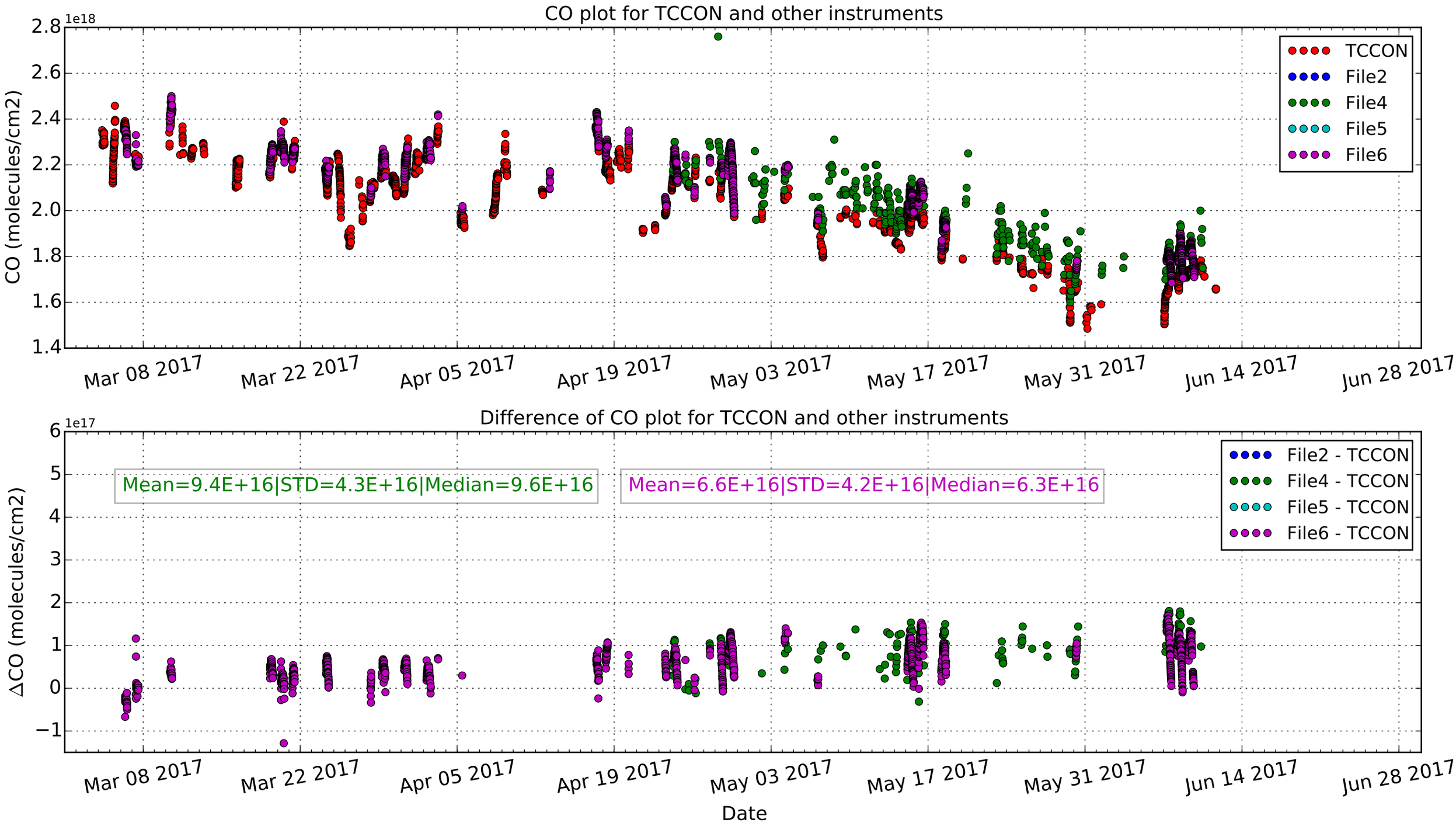

Correlation plot for CH4 between TCCON and File6
1e19
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.65
3.70
3.75
3.80
3.85
3.90
3.95
4.00
1e19
File6 CH4 (molecules/cm2)
TCCON CH4 (molecules/cm2)
5.4E+18 + 0.8731*x
R=0.9586, stderr=0.0064
zero line

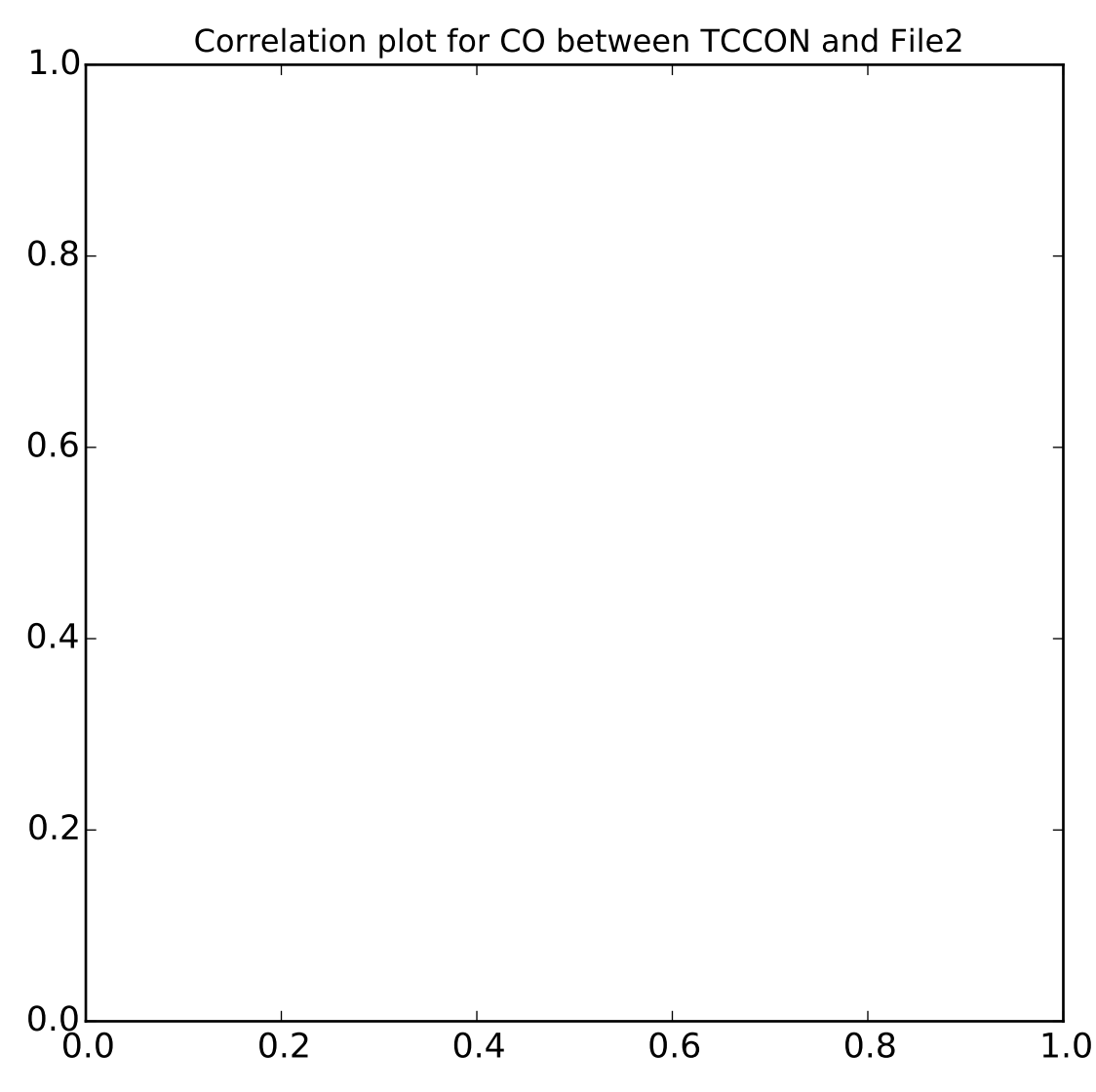

Correlation plot for CH4 between TCCON and File2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

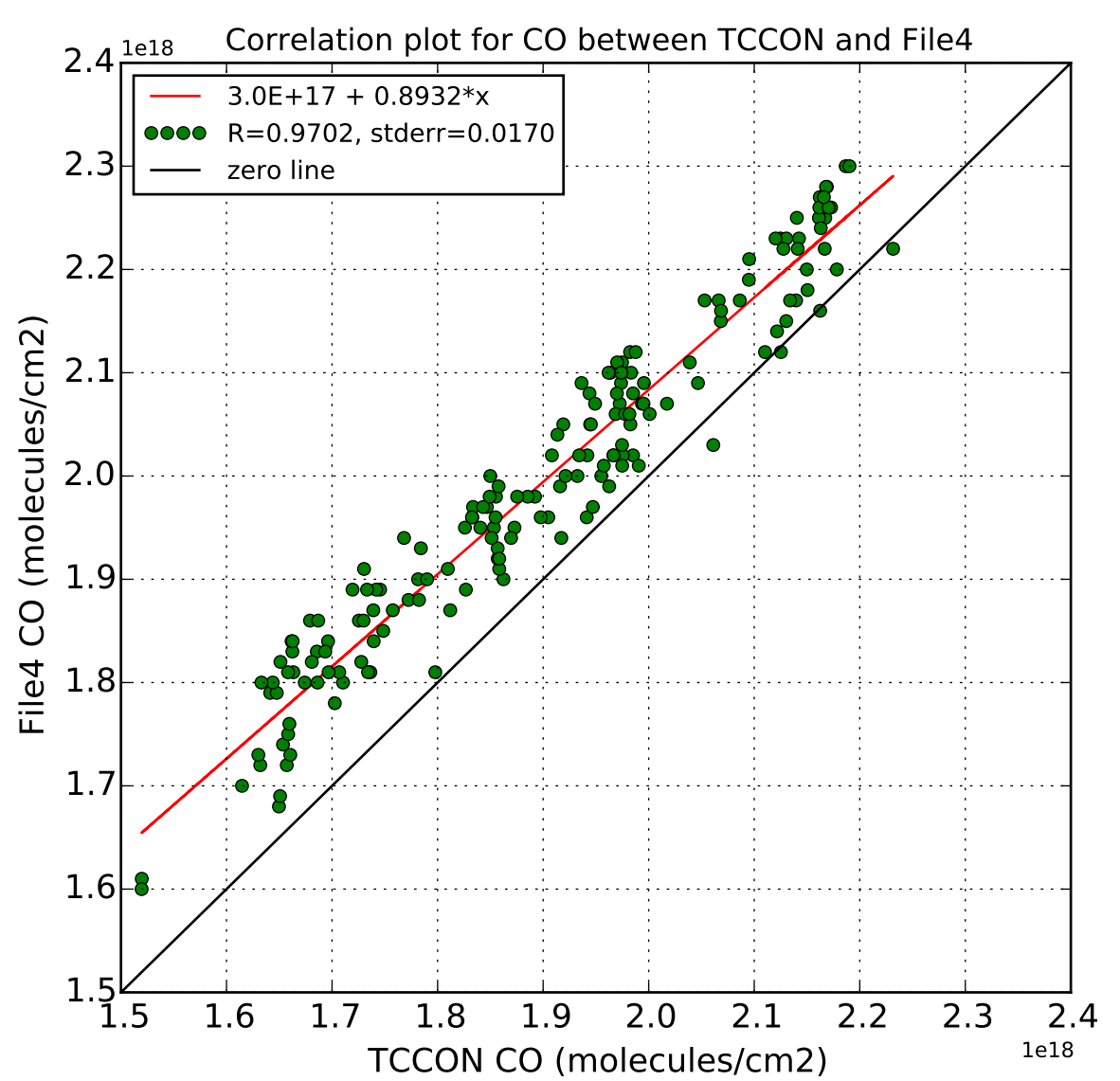

Correlation plot for CH4 between TCCON and File4
1e19
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.65
3.70
3.75
3.80
3.85
3.90
3.95
1e19
File4 CH4 (molecules/cm2)
TCCON CH4 (molecules/cm2)
3.6E+18 + 0.9063*x
R=0.9712, stderr=0.0169
zero line
April 2017
May 2017
June 2017

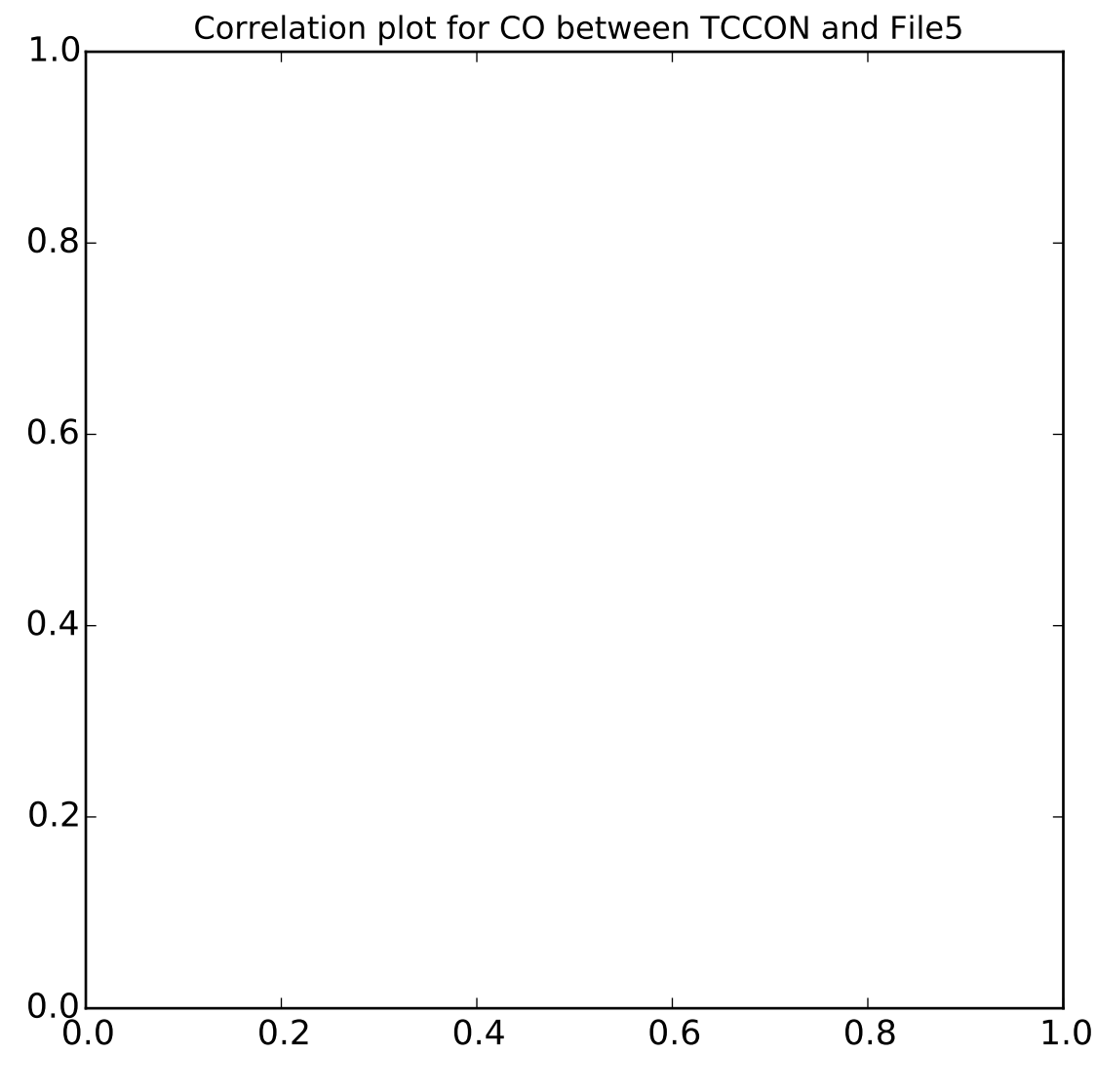

Correlation plot for CH4 between TCCON and File5
1e19
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.65
3.70
3.75
3.80
3.85
3.90
3.95
1e19
File5 CH4 (molecules/cm2)
TCCON CH4 (molecules/cm2)
1.5E+18 + 0.9753*x
R=0.9789, stderr=0.0058
zero line
March 2017
April 2017
May 2017
June 2017

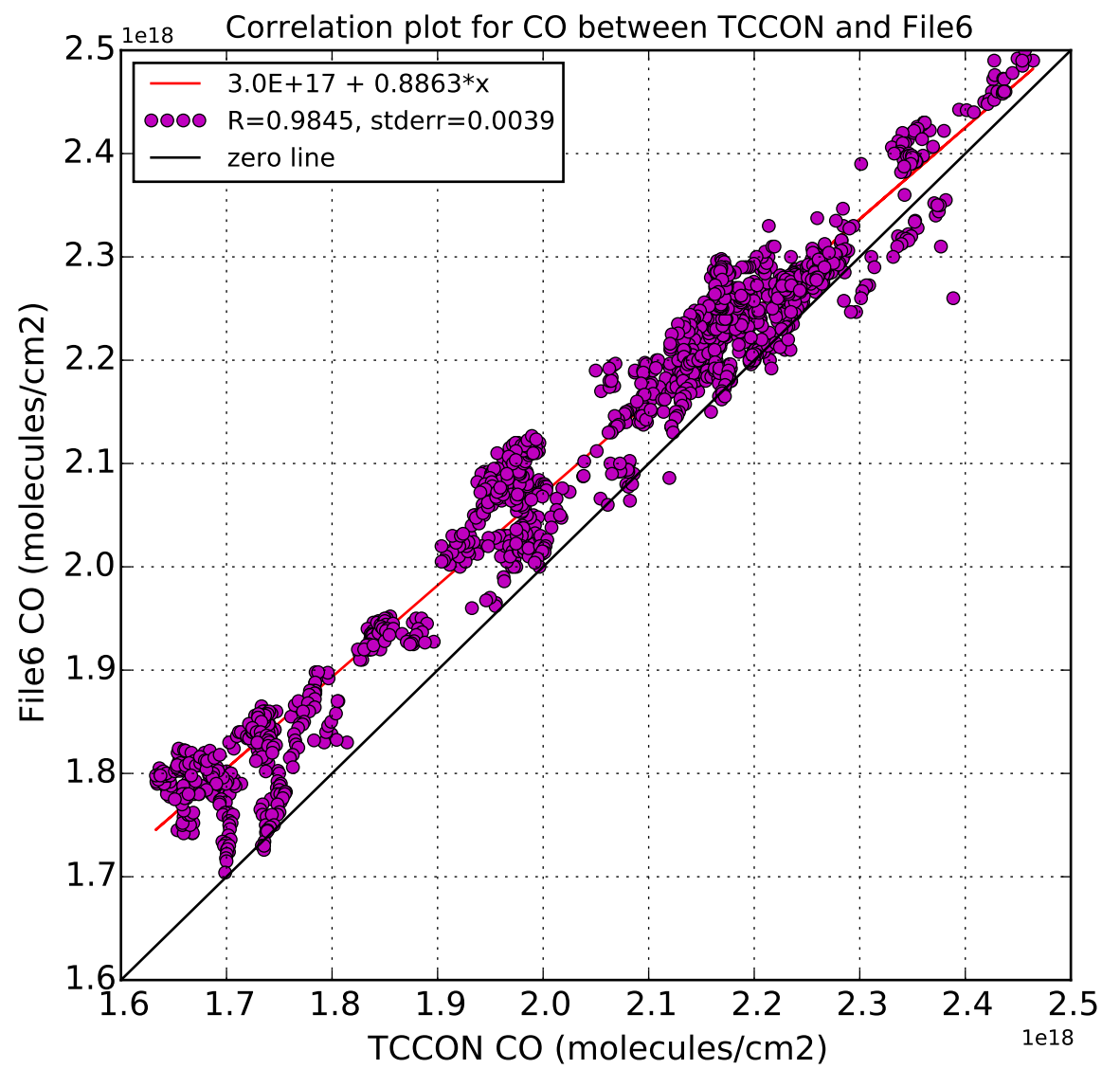

Correlation plot for CH4 between TCCON and File6
1e19
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.65
3.70
3.75
3.80
3.85
3.90
3.95
4.00
1e19
File6 CH4 (molecules/cm2)
TCCON CH4 (molecules/cm2)
5.4E+18 + 0.8731*x
R=0.9586, stderr=0.0064
zero line
March 2017
April 2017
May 2017
June 2017

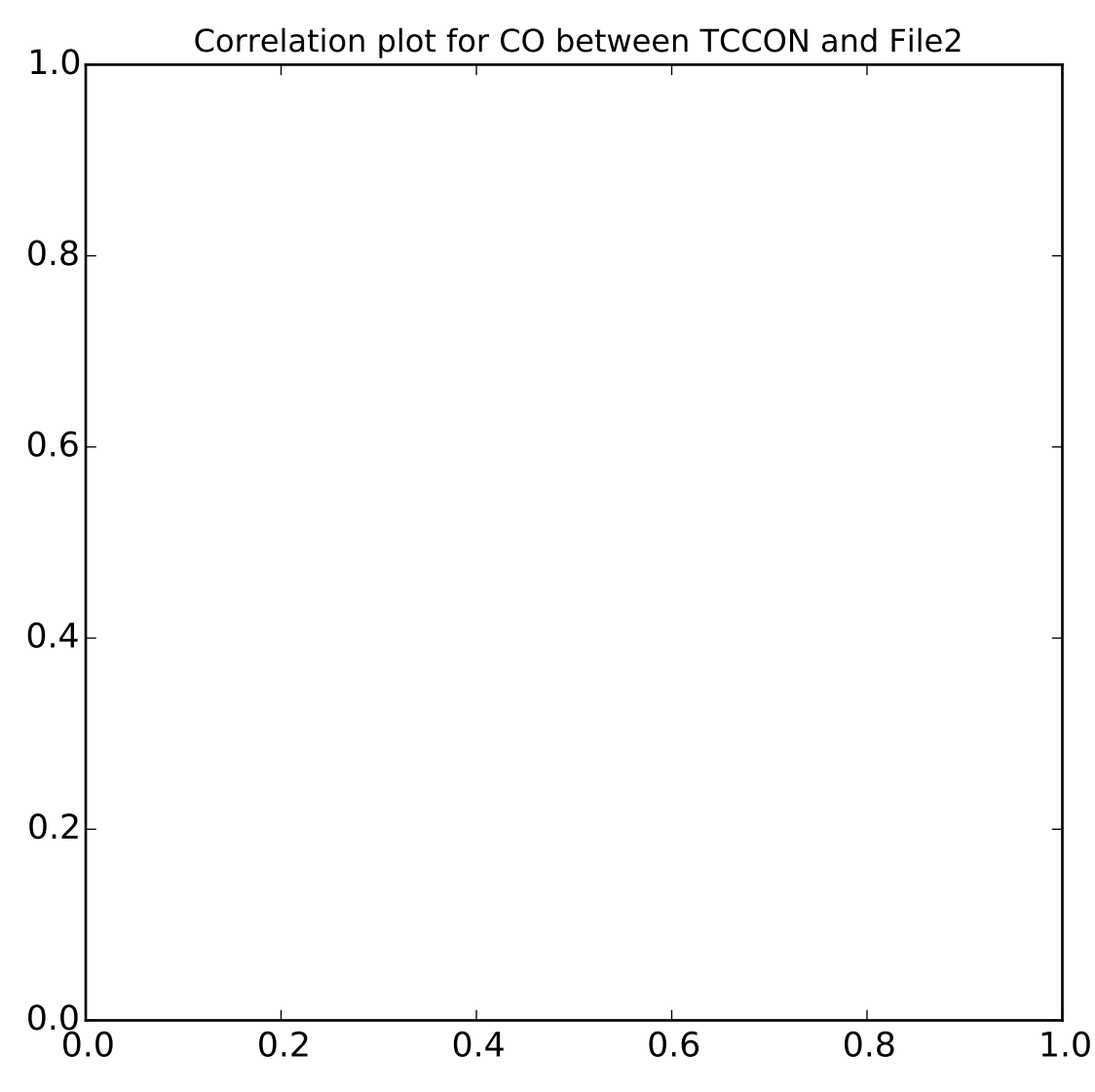

CO plot for TCCON and other instruments
1e18
CO (molecules/cm2)
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
TCCON
File2
File4
File5
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CO plot for TCCON and other instruments
1e17
ΔCO (molecules/cm2)
6
5
4
3
2
1
0
−1
Mean=9.4E+16|STD=4.3E+16|Median=9.6E+16
Mean=6.6E+16|STD=4.2E+16|Median=6.3E+16
File2 - TCCON
File4 - TCCON
File5 - TCCON
File6 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

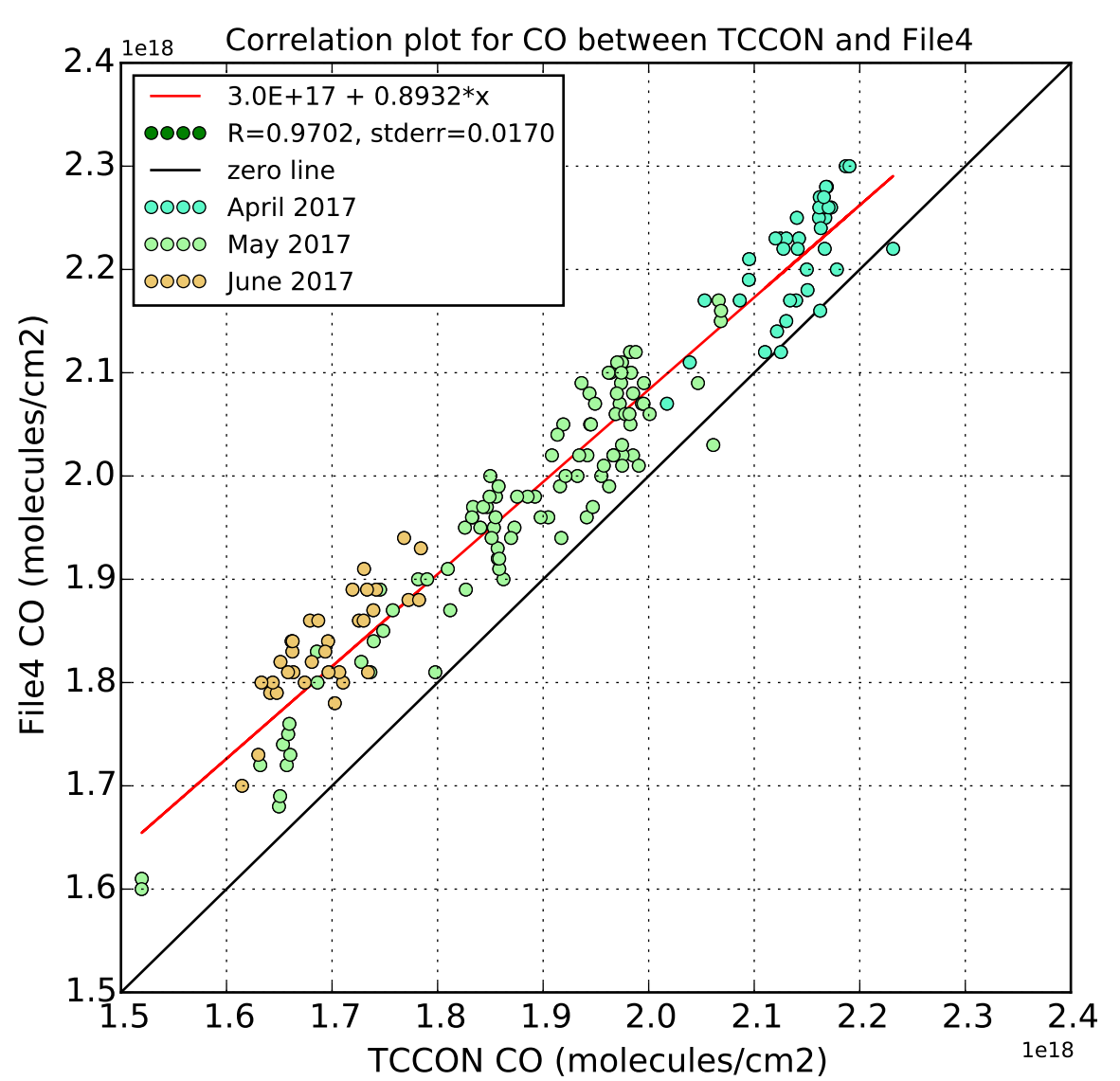

Correlation plot for CO between TCCON and File2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

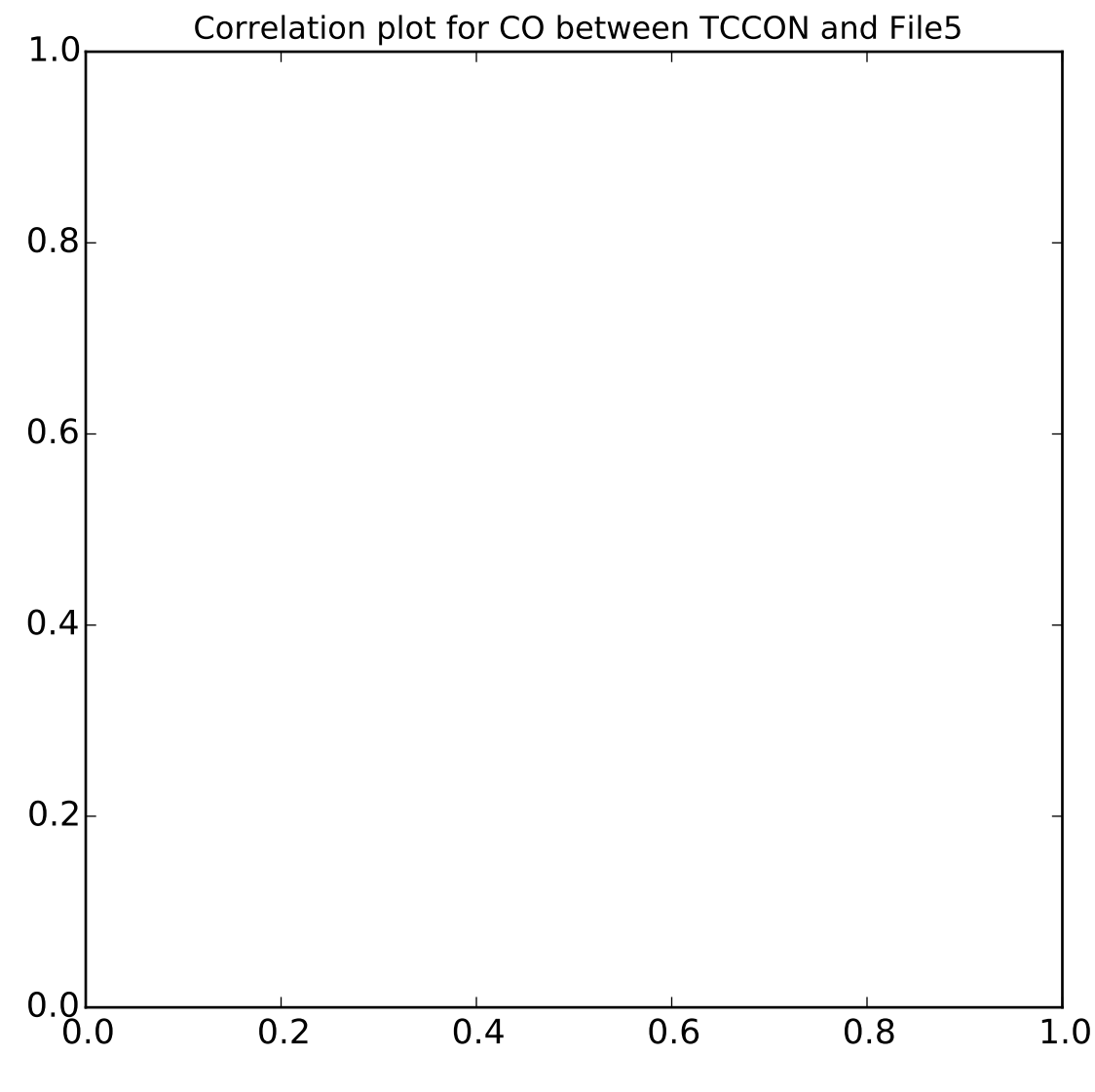

Correlation plot for CO between TCCON and File4
1e18
3.0E+17 + 0.8932*x
R=0.9702, stderr=0.0170
zero line
File4 CO (molecules/cm2)
TCCON CO (molecules/cm2)
1e18
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4

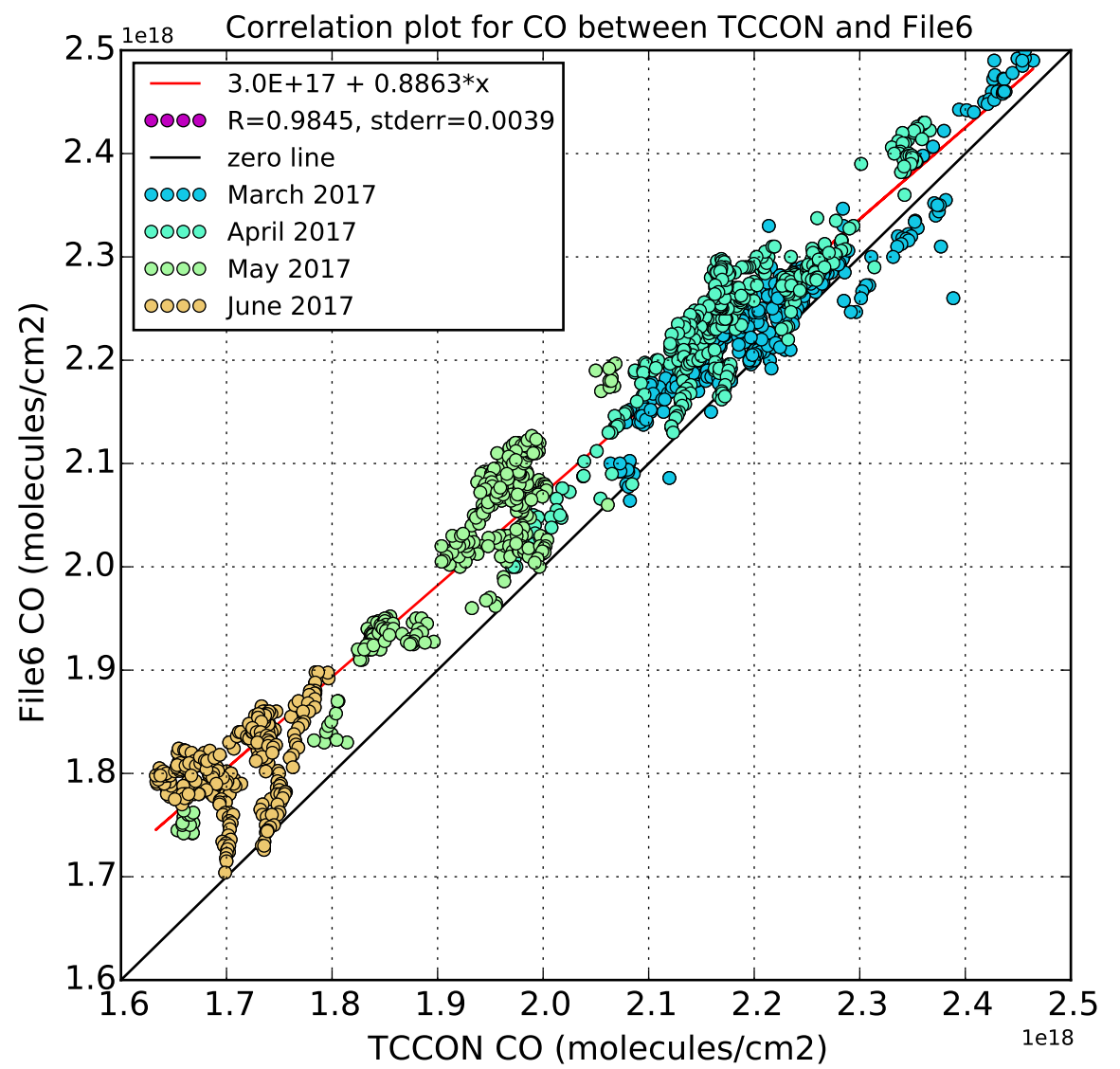

Correlation plot for CO between TCCON and File5
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0

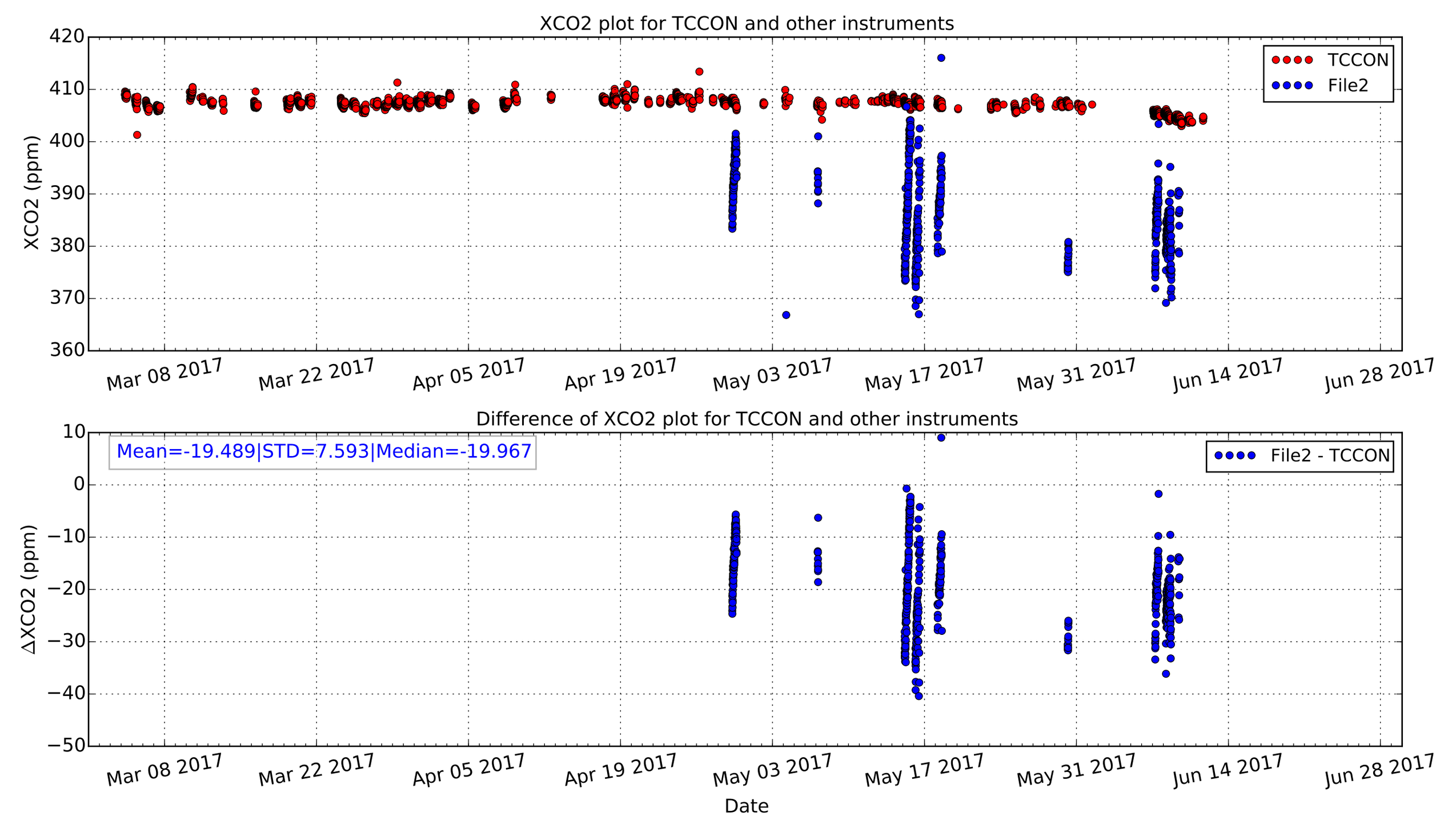

Correlation plot for CO between TCCON and File6
1e18
3.0E+17 + 0.8863*x
R=0.9845, stderr=0.0039
zero line
File6 CO (molecules/cm2)
TCCON CO (molecules/cm2)
1e18
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5


Correlation plot for CO between TCCON and File2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Correlation plot for CO between TCCON and File4
1e18
3.0E+17 + 0.8932*x
R=0.9702, stderr=0.0170
zero line
April 2017
May 2017
June 2017
File4 CO (molecules/cm2)
TCCON CO (molecules/cm2)
1e18
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4


Correlation plot for CO between TCCON and File5
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


Correlation plot for CO between TCCON and File6
1e18
3.0E+17 + 0.8863*x
R=0.9845, stderr=0.0039
zero line
March 2017
April 2017
May 2017
June 2017
File6 CO (molecules/cm2)
TCCON CO (molecules/cm2)
1e18
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5


XCO2 plot for TCCON and other instruments
XCO2 (ppm)
420
410
400
390
380
370
360
TCCON
File2
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCO2 plot for TCCON and other instruments
Mean=-19.489|STD=7.593|Median=-19.967
File2 - TCCON
ΔXCO2 (ppm)
10
0
−10
−20
−30
−40
−50
Date

Correlation plot for XCO2 between TCCON and File2

-306.932 + 1.7070*x
R=0.2345, stderr=0.2856
zero line

File2 XCO2 (ppm)

TCCON XCO2 (ppm)

360
370
380
390
400
410
420

Correlation plot for XCO2 between TCCON and File2

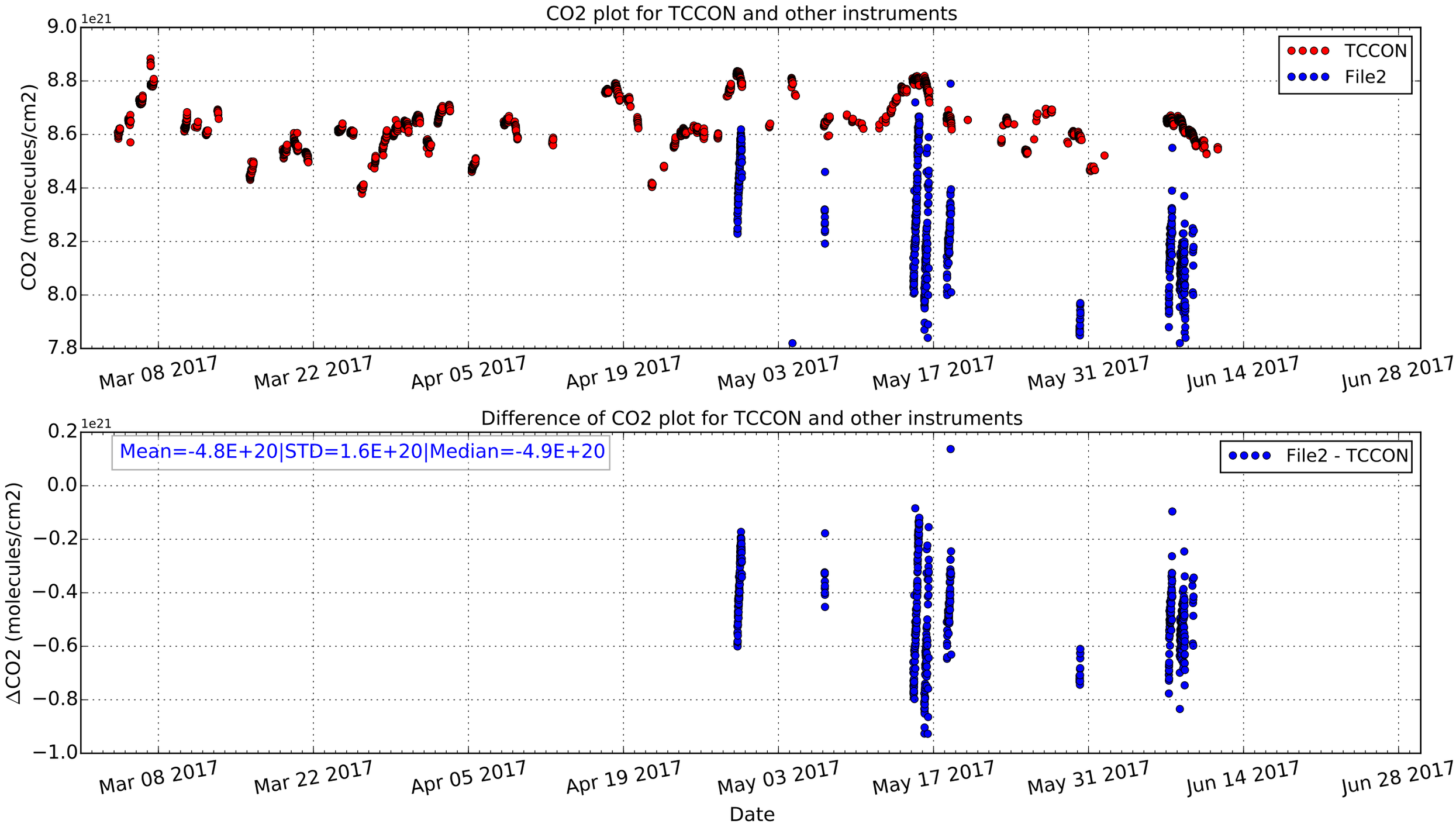
-306.932 + 1.7070*x
R=0.2345, stderr=0.2856
zero line
April 2017
May 2017
June 2017

File2 XCO2 (ppm)

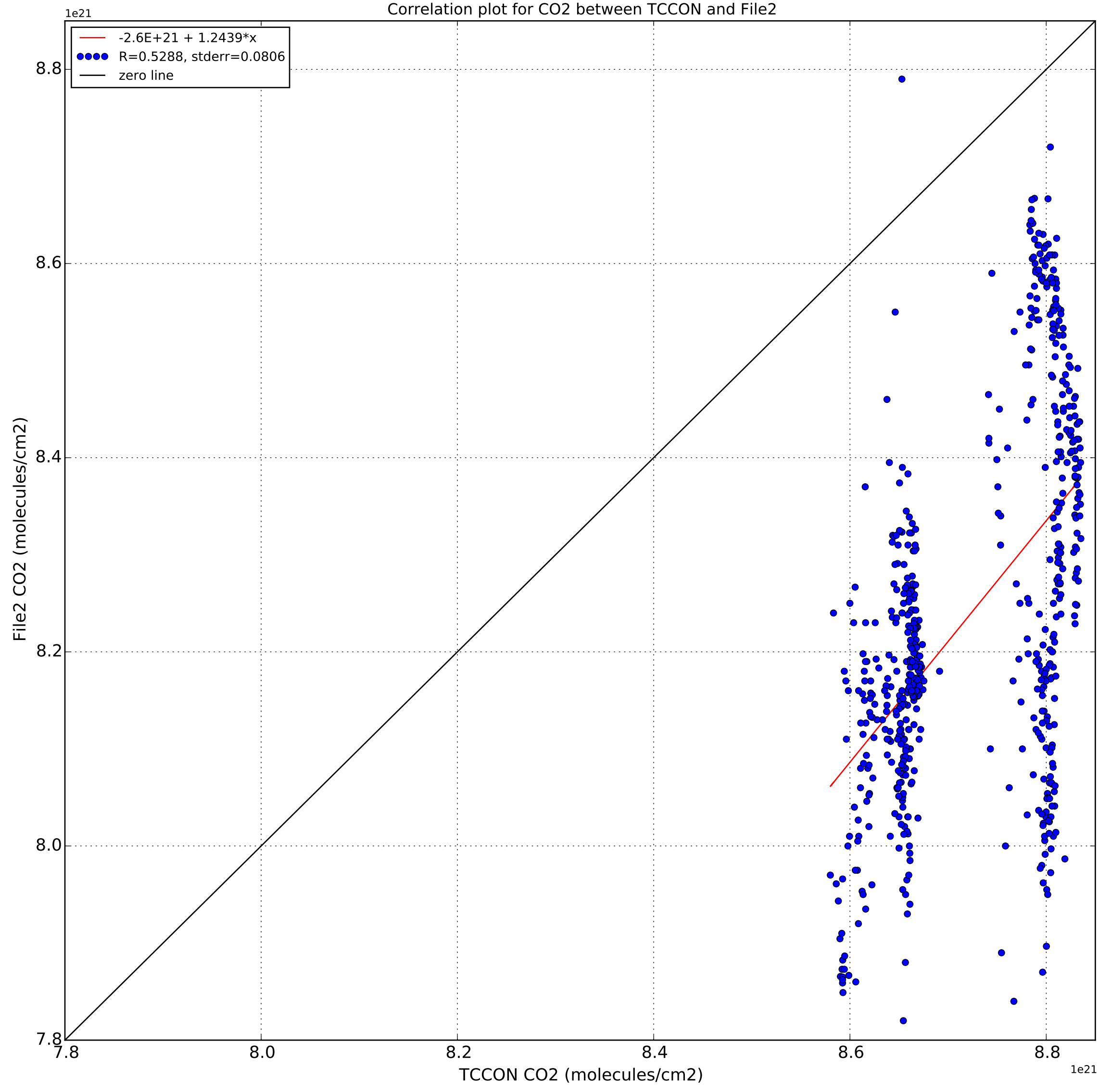
420
410
400
390
380
370
360

TCCON XCO2 (ppm)

360
370
380
390
400
410
420


CO2 plot for TCCON and other instruments
1e21
9.0
8.8
8.6
8.4
8.2
8.0
7.8
CO2 (molecules/cm2)
TCCON
File2
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CO2 plot for TCCON and other instruments
1e21
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
ΔCO2 (molecules/cm2)
Mean=-4.8E+20|STD=1.6E+20|Median=-4.9E+20
File2 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for CO2 between TCCON and File2



Correlation plot for CO2 between TCCON and File2

1e21

-2.6E+21 + 1.2439*x
R=0.5288, stderr=0.0806
zero line
April 2017
May 2017
June 2017

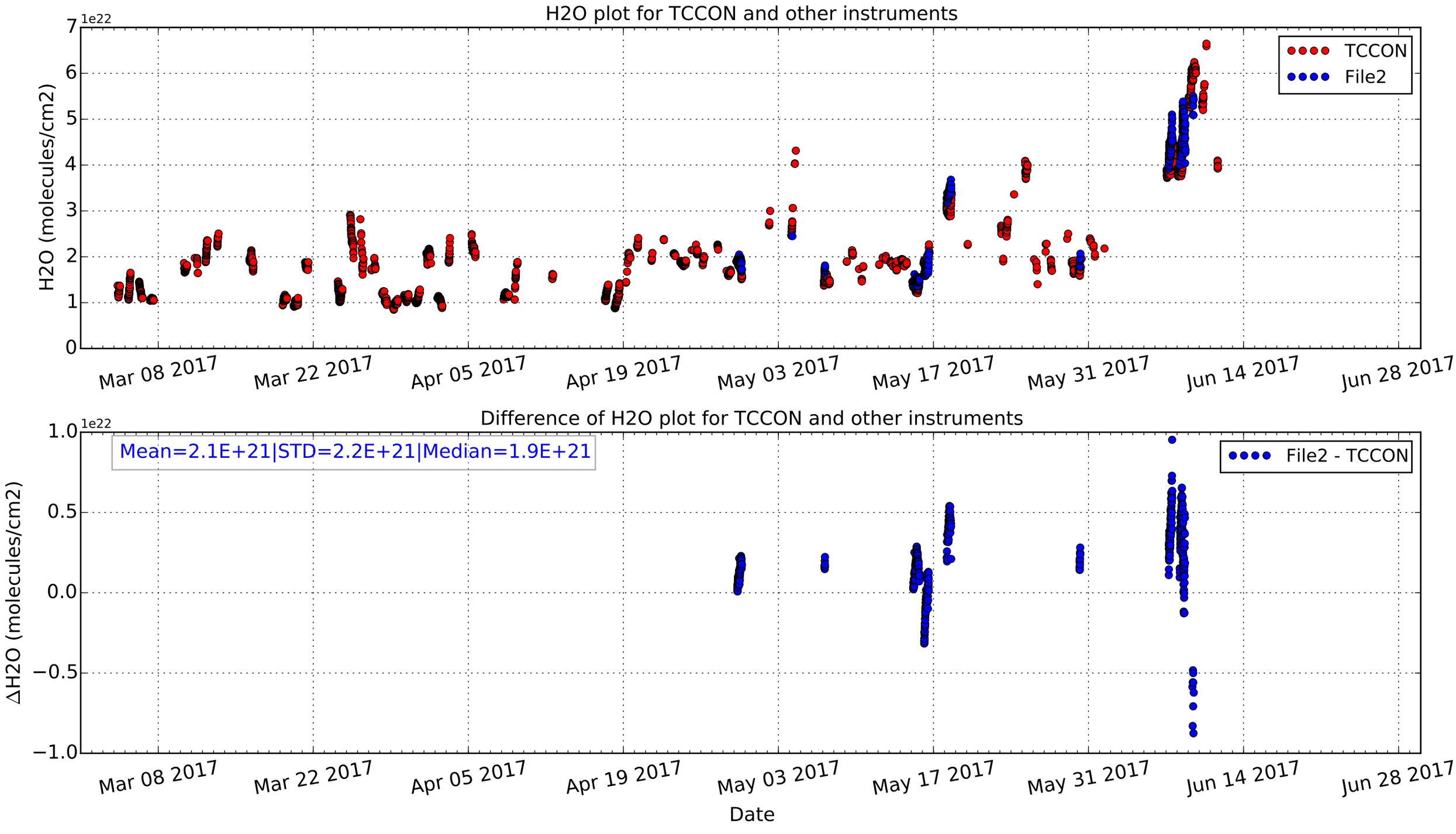
File2 CO2 (molecules/cm2)

8.8
8.6
8.4
8.2
8.0
7.8

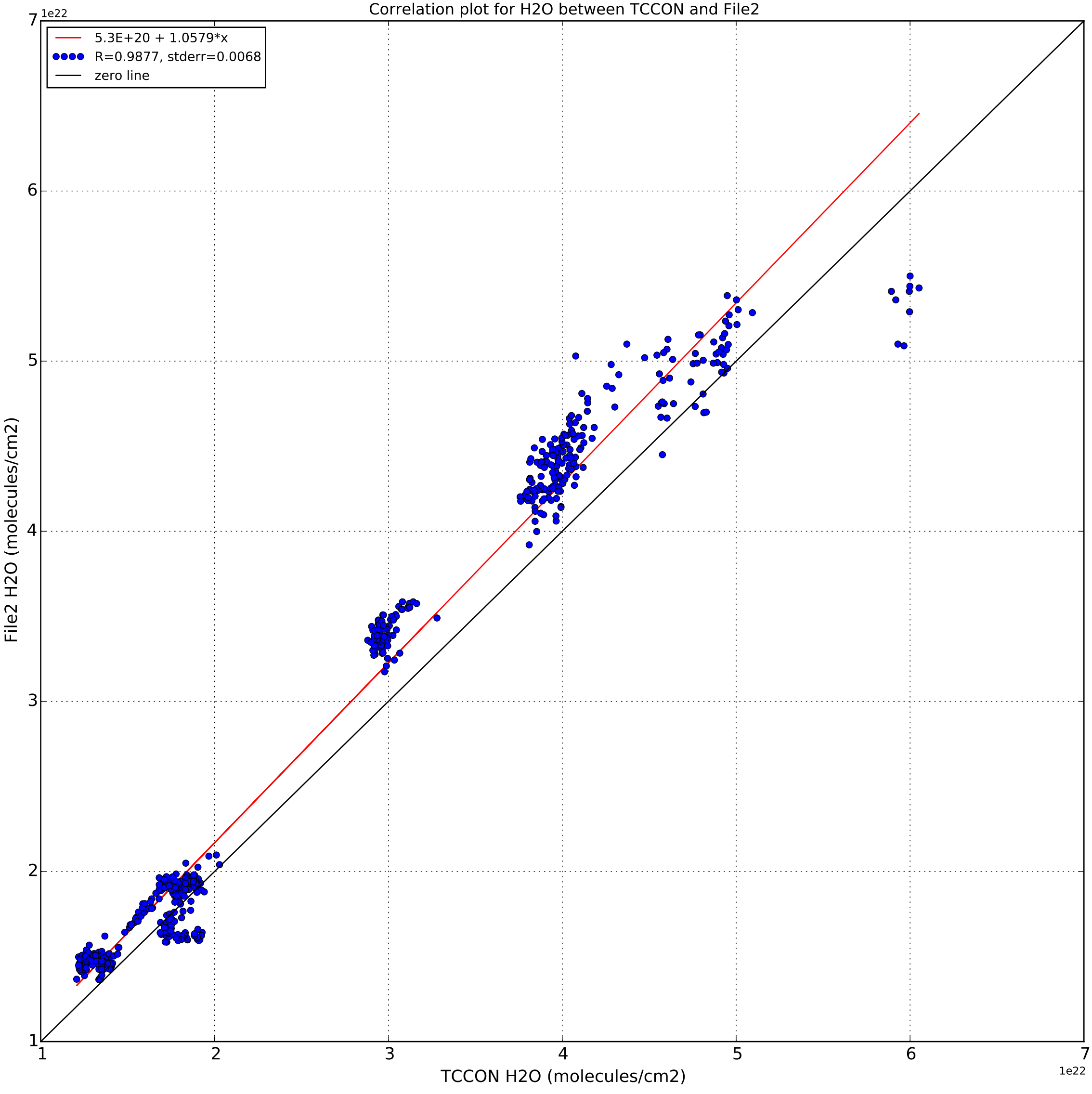
7.8
8.0
8.2
8.4
8.6
8.8

TCCON CO2 (molecules/cm2)

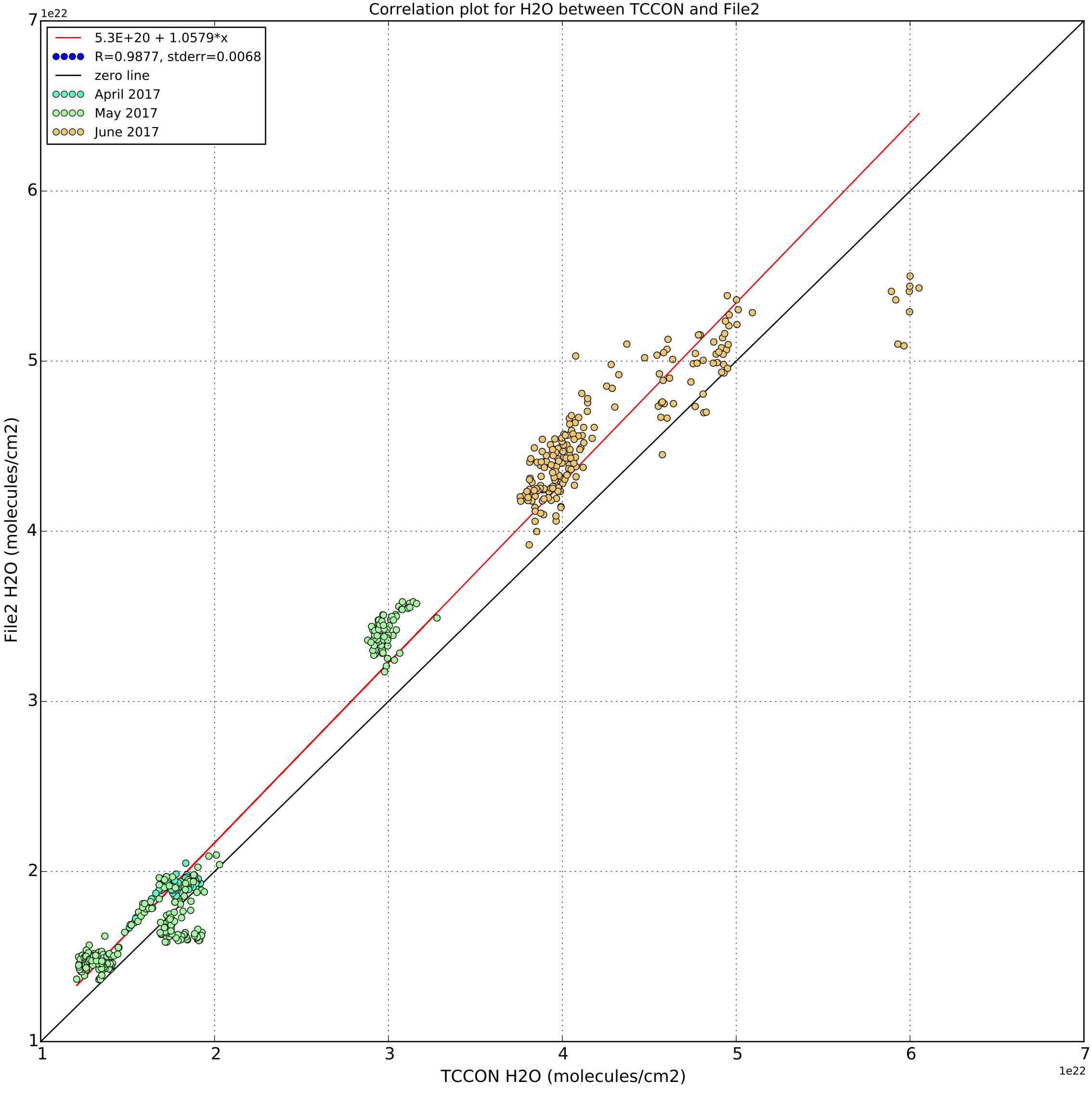
1e21

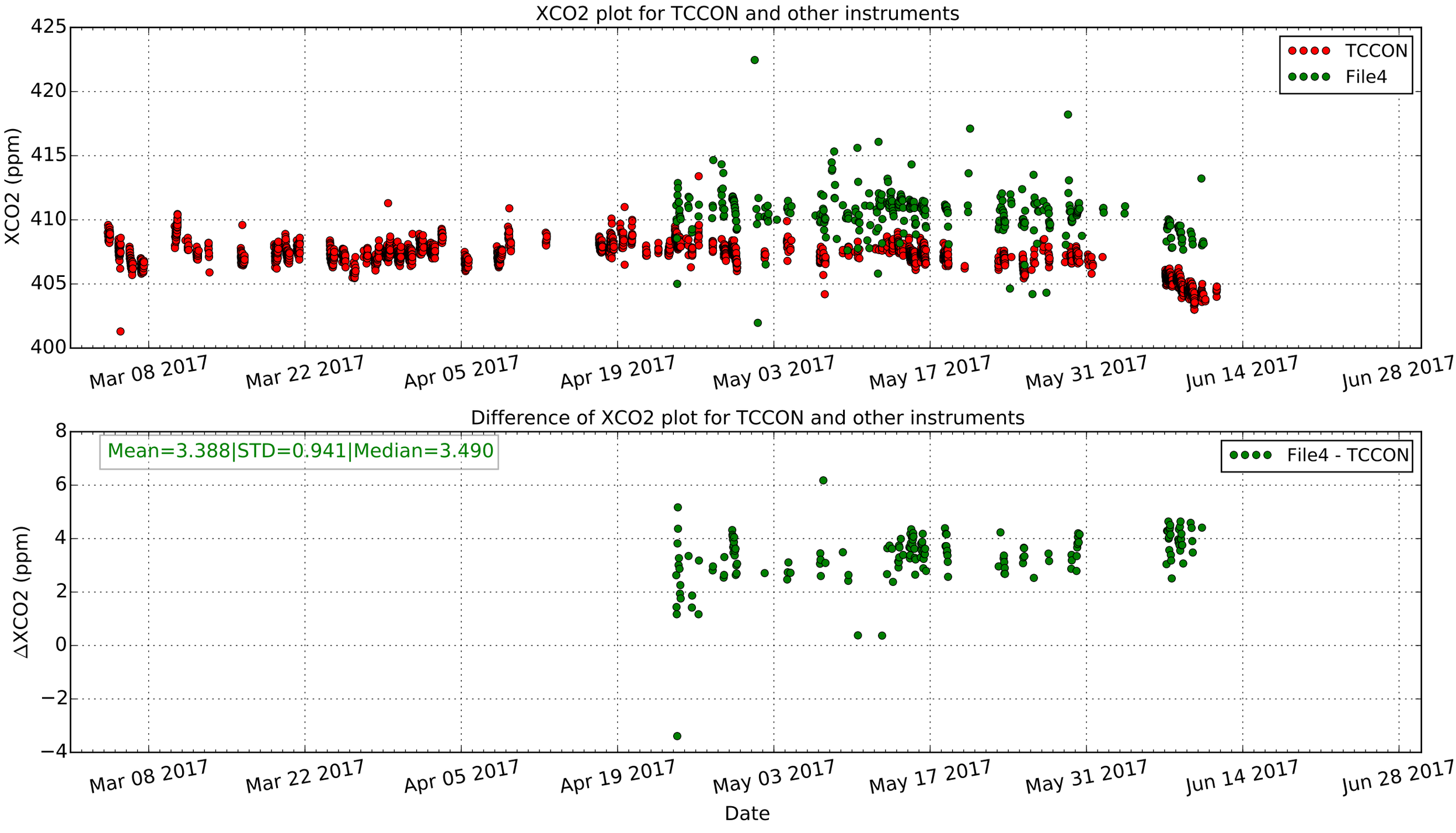

H2O plot for TCCON and other instruments
1e22
H2O (molecules/cm2)
TCCON
File2
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of H2O plot for TCCON and other instruments
Mean=2.1E+21|STD=2.2E+21|Median=1.9E+21
File2 - TCCON
ΔH2O (molecules/cm2)
Date

Correlation plot for H2O between TCCON and File2



Correlation plot for H2O between TCCON and File2




XCO2 plot for TCCON and other instruments
XCO2 (ppm)
425
420
415
410
405
400
TCCON
File4
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCO2 plot for TCCON and other instruments
Mean=3.388|STD=0.941|Median=3.490
File4 - TCCON
ΔXCO2 (ppm)
8
6
4
2
0
−2
−4
Date

Correlation plot for XCO2 between TCCON and File4

158.275 + 0.6194*x
R=0.6217, stderr=0.0595
zero line

412
410
408
406
404

File4 XCO2 (ppm)

404
406
408
410
412

TCCON XCO2 (ppm)

Correlation plot for XCO2 between TCCON and File4

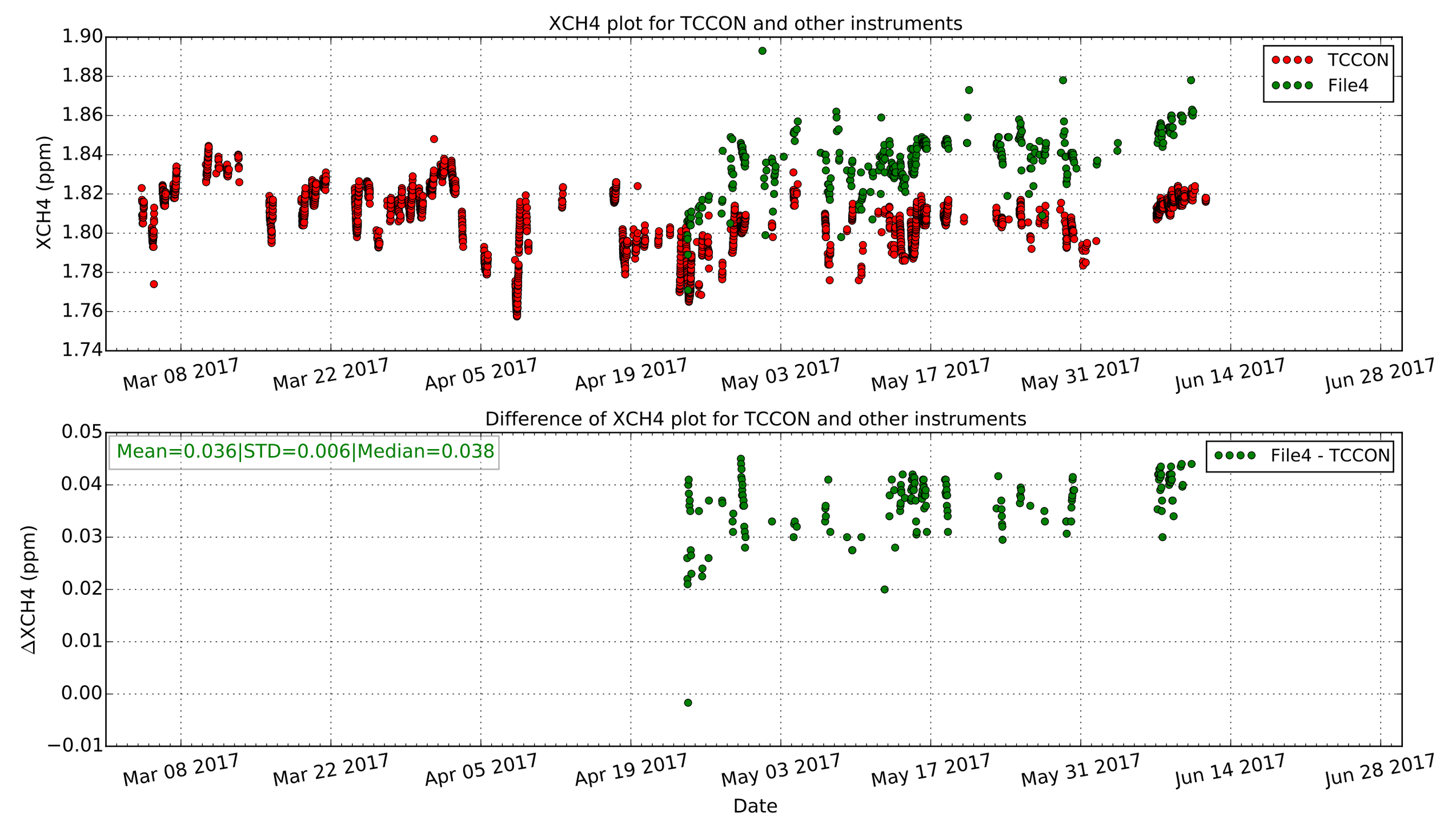
158.275 + 0.6194*x
R=0.6217, stderr=0.0595
zero line
April 2017
May 2017
June 2017

412
410
408
406
404

File4 XCO2 (ppm)

404
406
408
410
412

TCCON XCO2 (ppm)


XCH4 plot for TCCON and other instruments
XCH4 (ppm)
1.90
1.88
1.86
1.84
1.82
1.80
1.78
1.76
1.74
TCCON
File4
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCH4 plot for TCCON and other instruments
Mean=0.036|STD=0.006|Median=0.038
File4 - TCCON
ΔXCH4 (ppm)
0.05
0.04
0.03
0.02
0.01
0.00
−0.01
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for XCH4 between TCCON and File4

-0.173 + 1.1163*x
R=0.9253, stderr=0.0349
zero line

File4 XCH4 (ppm)

1.88
1.86
1.84
1.82
1.80
1.78
1.76

1.76 1.78 1.80 1.82 1.84 1.86 1.88

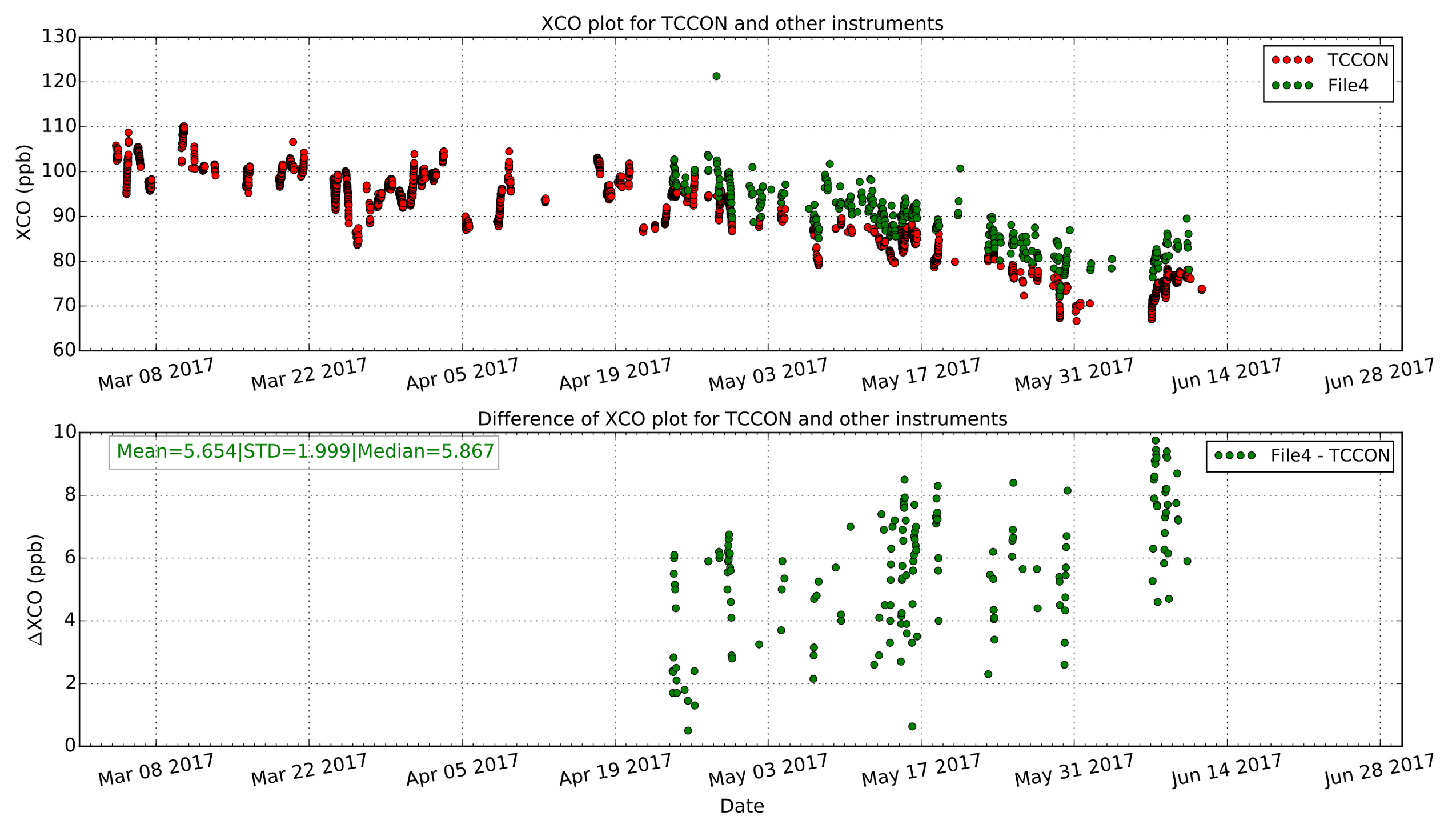
TCCON XCH4 (ppm)

Correlation plot for XCH4 between TCCON and File4

-0.173 + 1.1163*x
R=0.9253, stderr=0.0349
zero line
April 2017
May 2017
June 2017

File4 XCH4 (ppm)
1.88
1.86
1.84
1.82
1.80
1.78
1.76

TCCON XCH4 (ppm)
1.76
1.78
1.80
1.82
1.84
1.86
1.88


XCO plot for TCCON and other instruments
XCO (ppb)
130
120
110
100
90
80
70
60
TCCON
File4
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCO plot for TCCON and other instruments
Mean=5.654|STD=1.999|Median=5.867
ΔXCO (ppb)
10
8
6
4
2
0
File4 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for XCO between TCCON and File4

17.350 + 0.8594*x
R=0.9678, stderr=0.0170
zero line

File4 XCO (ppb)

TCCON XCO (ppb)

105
100
95
90
85
80
75
70
65

65
70
75
80
85
90
95
100
105

Correlation plot for XCO between TCCON and File4

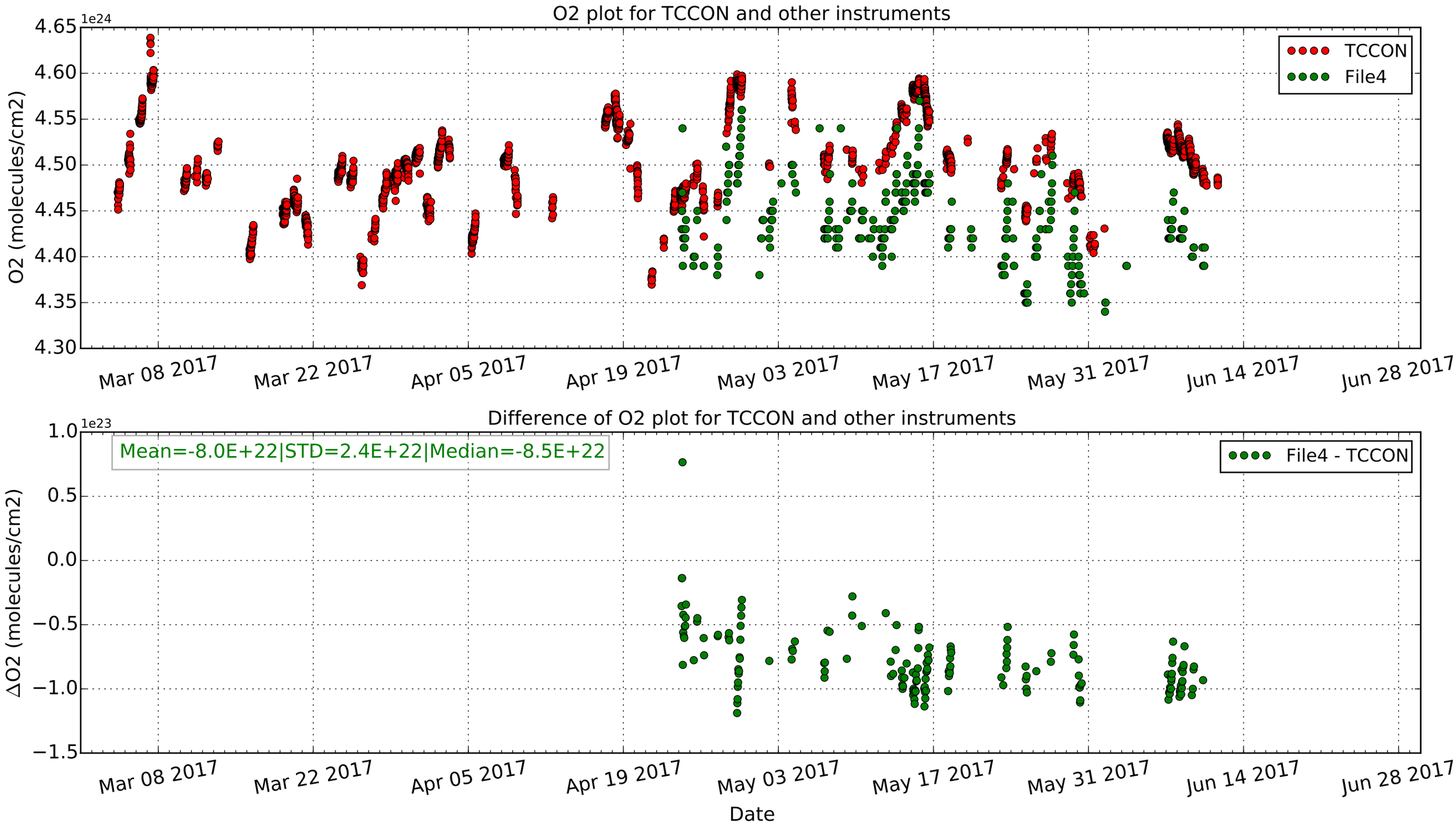
17.350 + 0.8594*x
R=0.9678, stderr=0.0170
zero line
April 2017
May 2017
June 2017

File4 XCO (ppb)

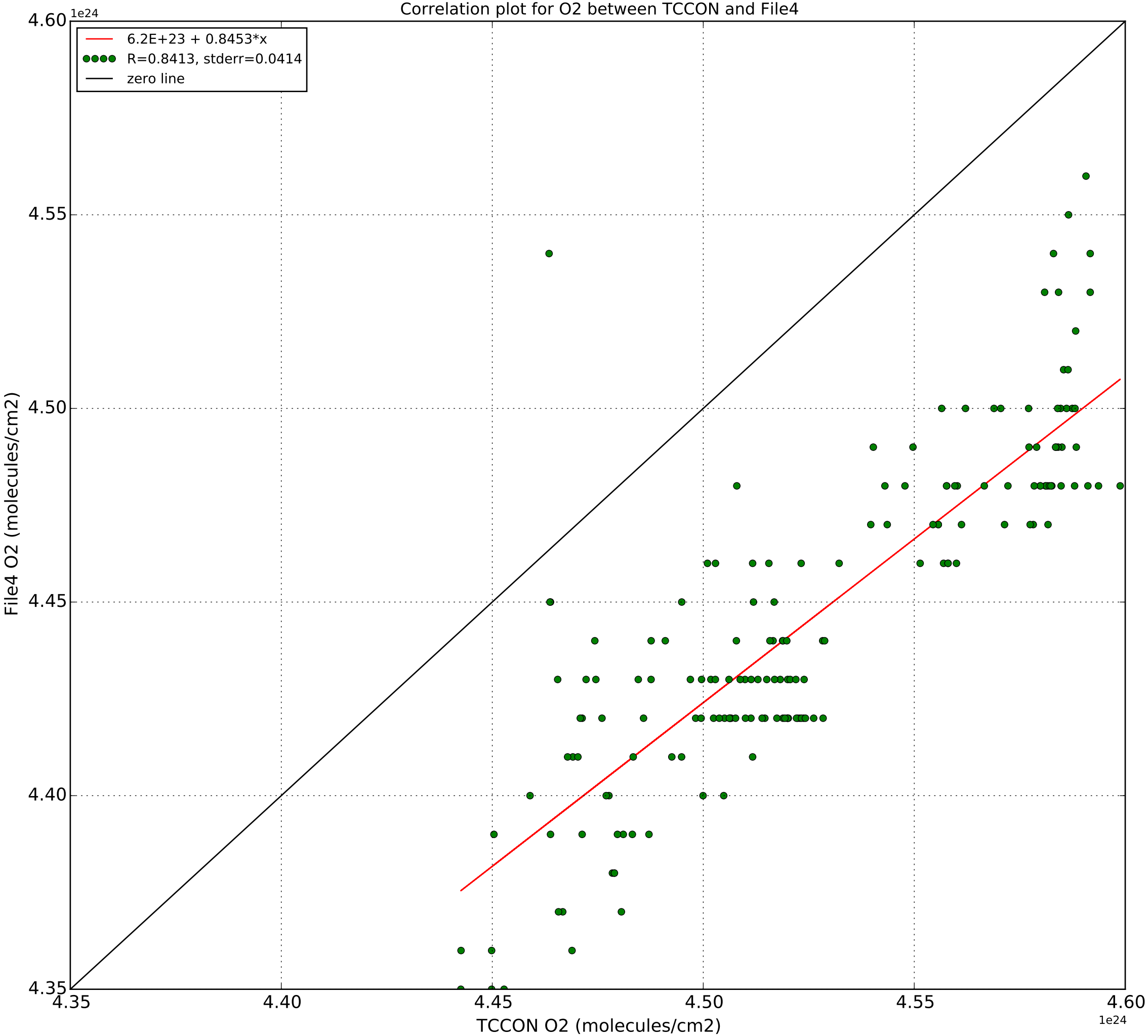
TCCON XCO (ppb)

105
100
95
90
85
80
75
70
65

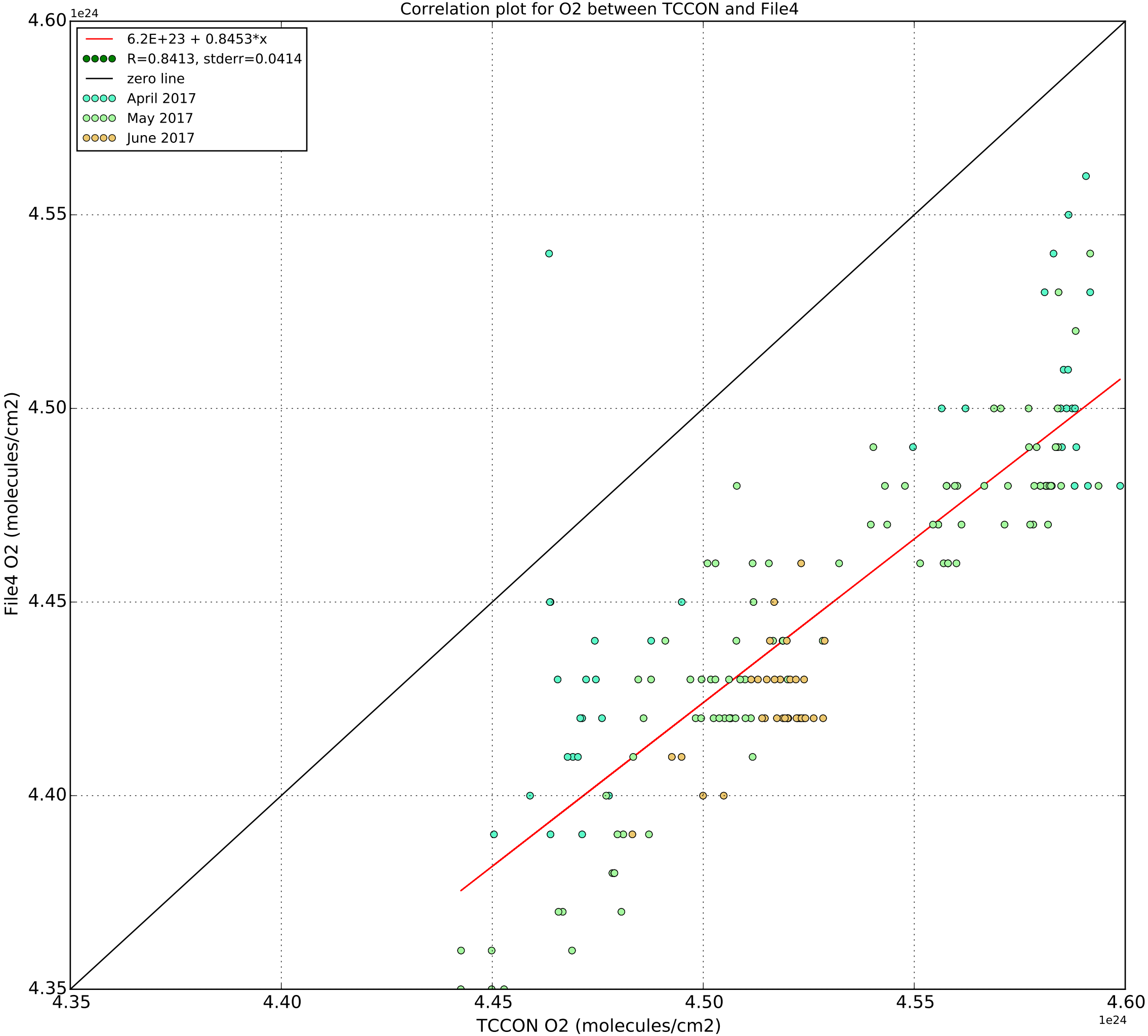
65
70
75
80
85
90
95
100
105

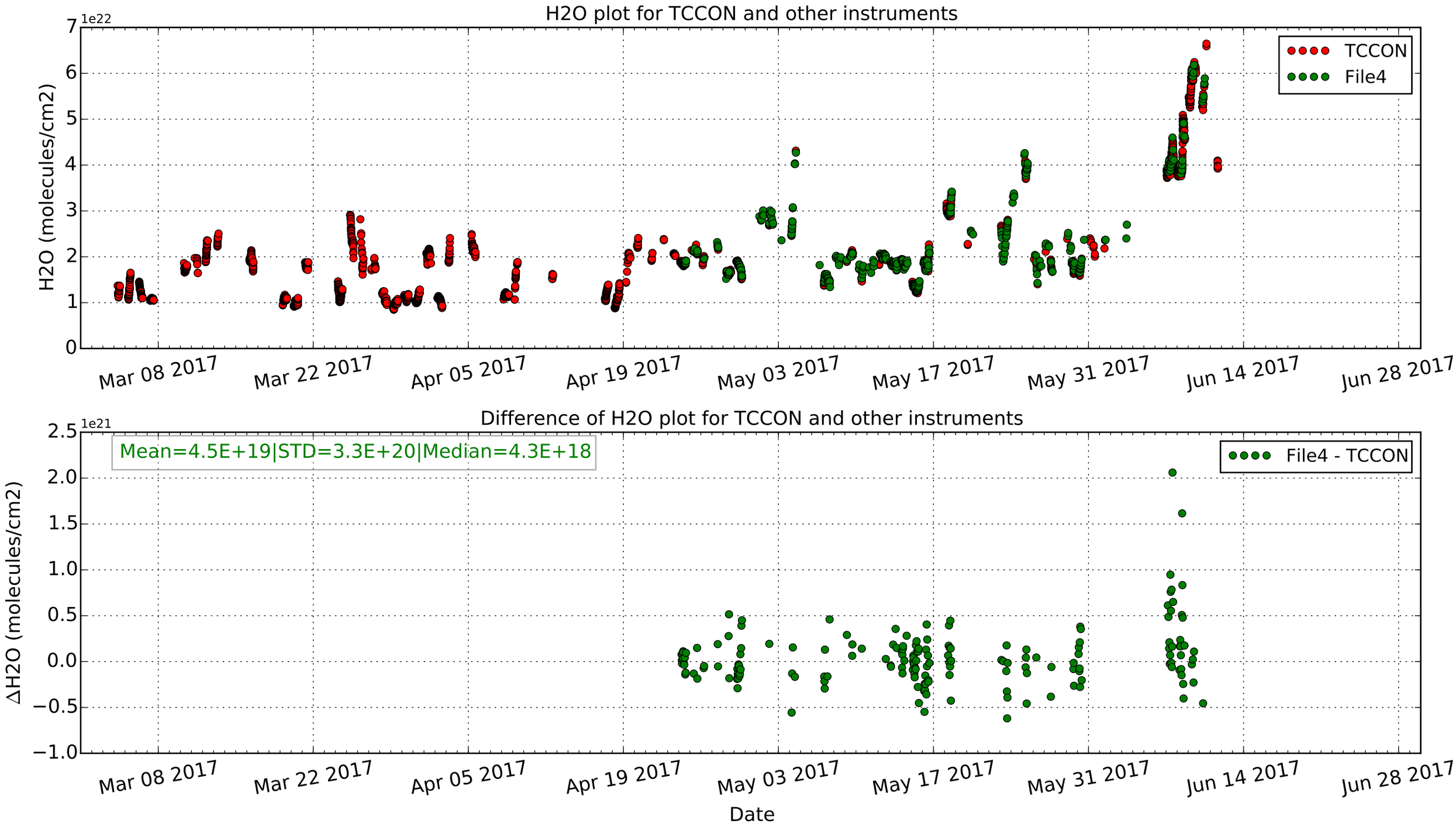

O2 plot for TCCON and other instruments
1e24
4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.30
O2 (molecules/cm2)
TCCON
File4
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of O2 plot for TCCON and other instruments
1e23
1.0
0.5
0.0
−0.5
−1.0
−1.5
ΔO2 (molecules/cm2)
Mean=-8.0E+22|STD=2.4E+22|Median=-8.5E+22
File4 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for O2 between TCCON and File4

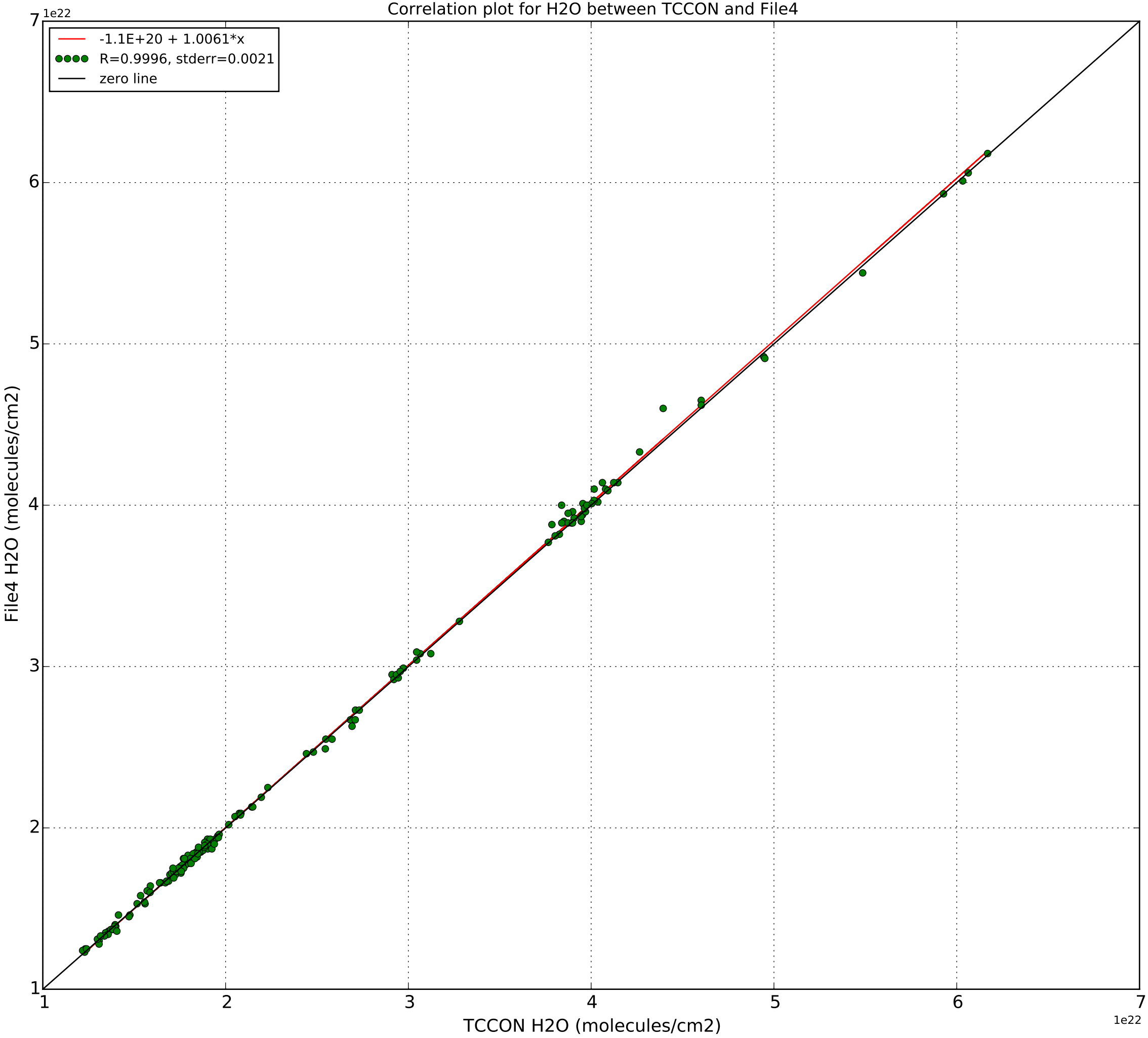


Correlation plot for O2 between TCCON and File4

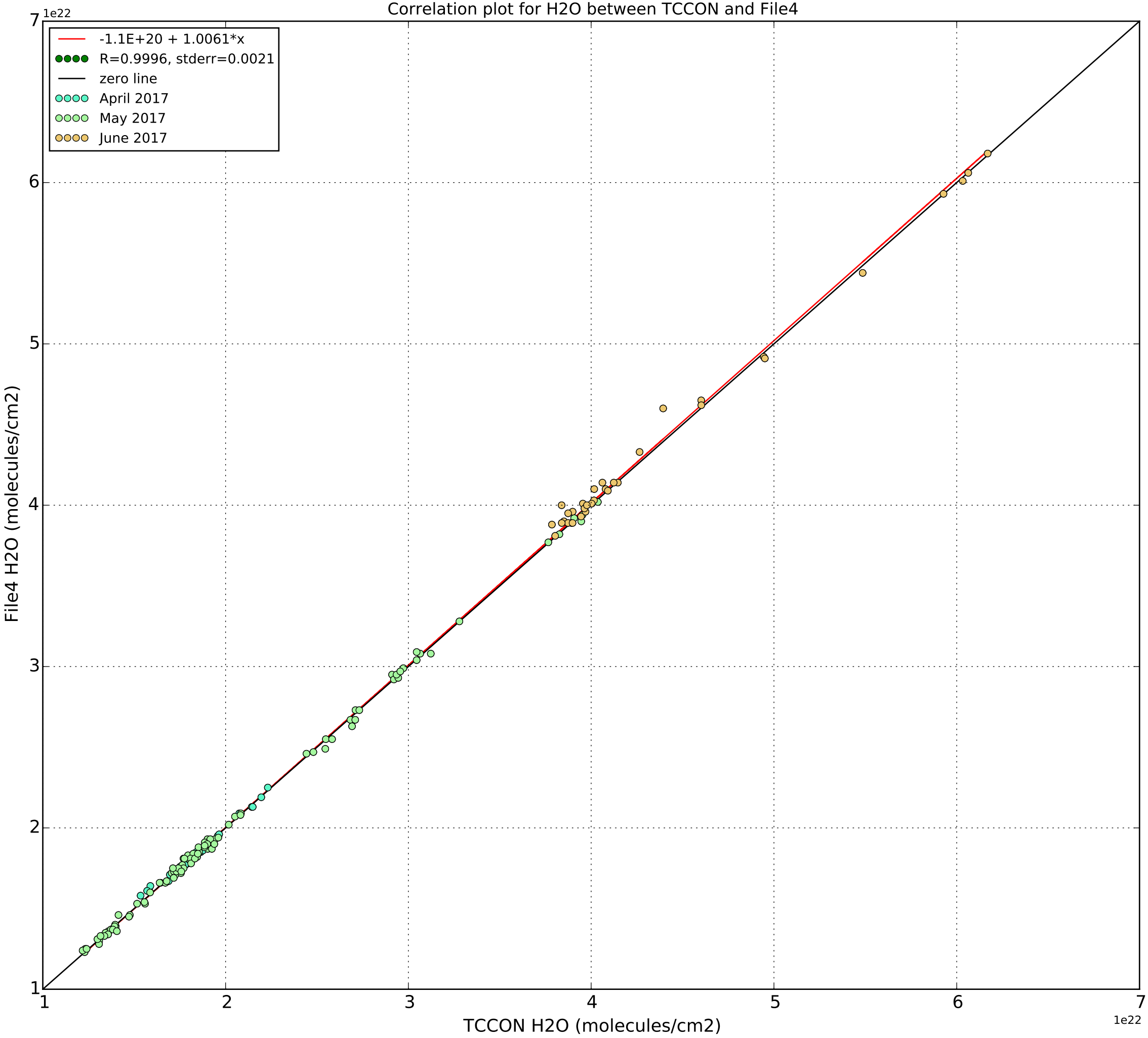


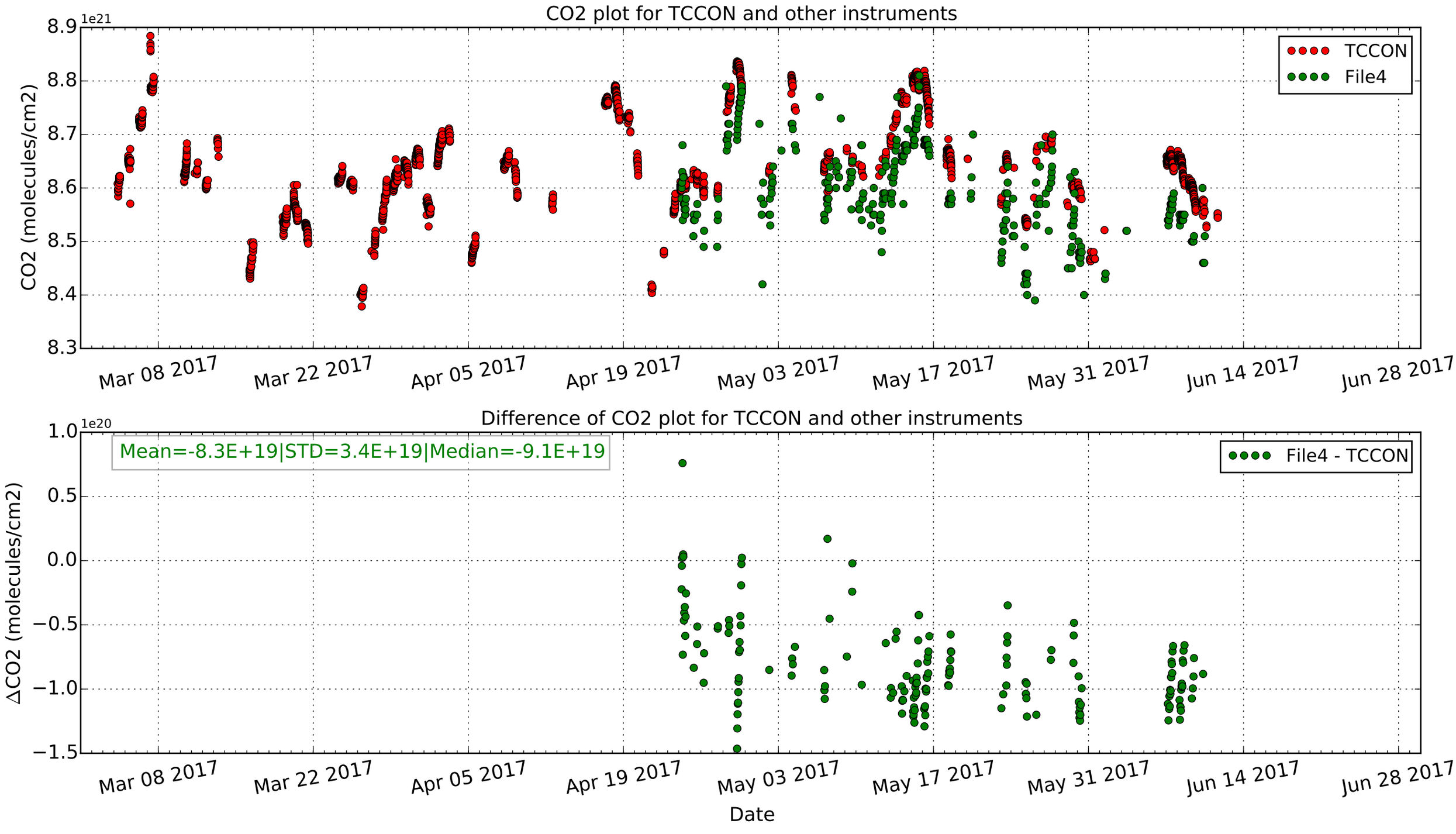

H2O plot for TCCON and other instruments
1e22
H2O (molecules/cm2)
TCCON
File4
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of H2O plot for TCCON and other instruments
1e21
Mean=4.5E+19|STD=3.3E+20|Median=4.3E+18
File4 - TCCON
ΔH2O (molecules/cm2)
Date

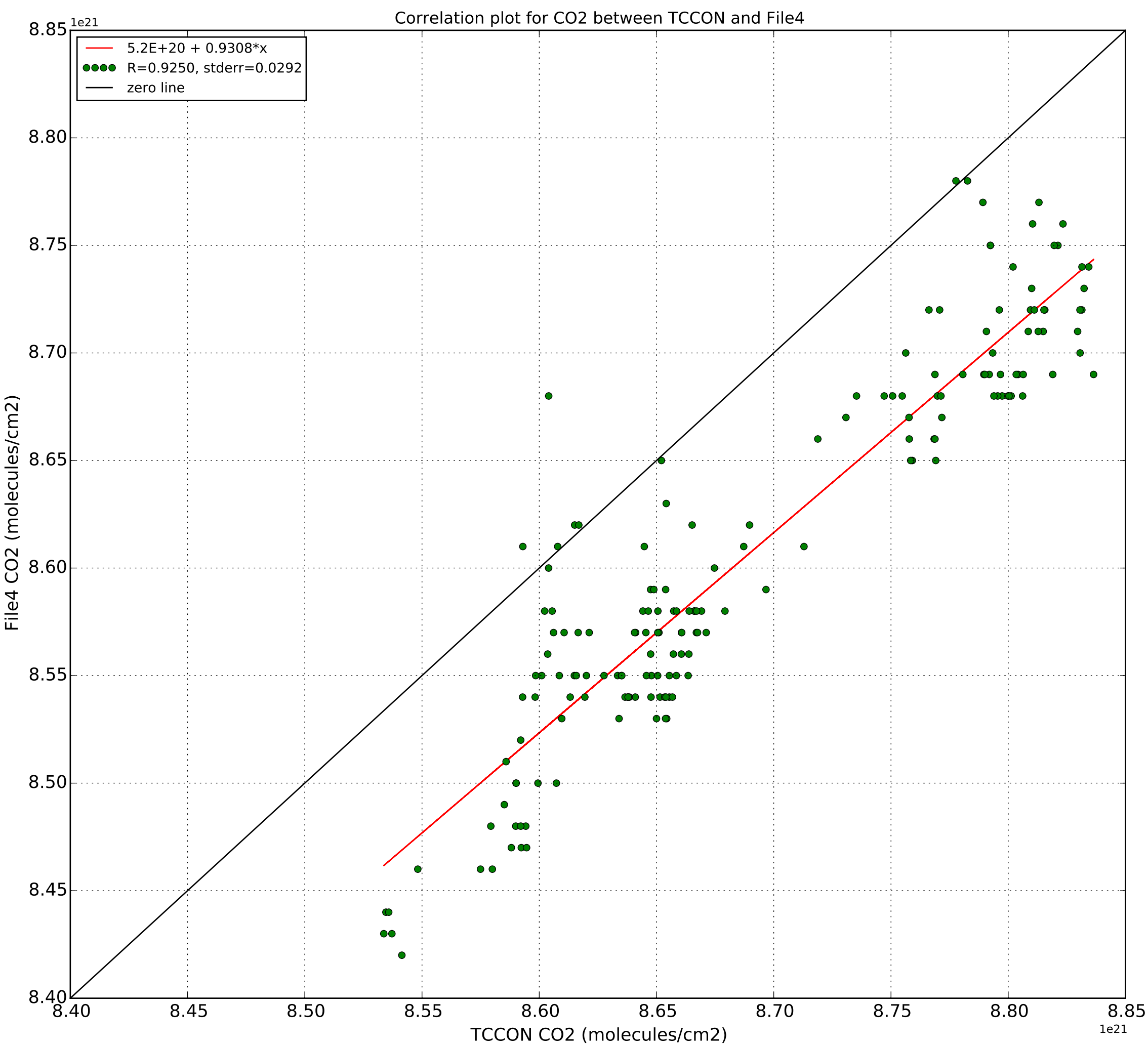
Correlation plot for H2O between TCCON and File4



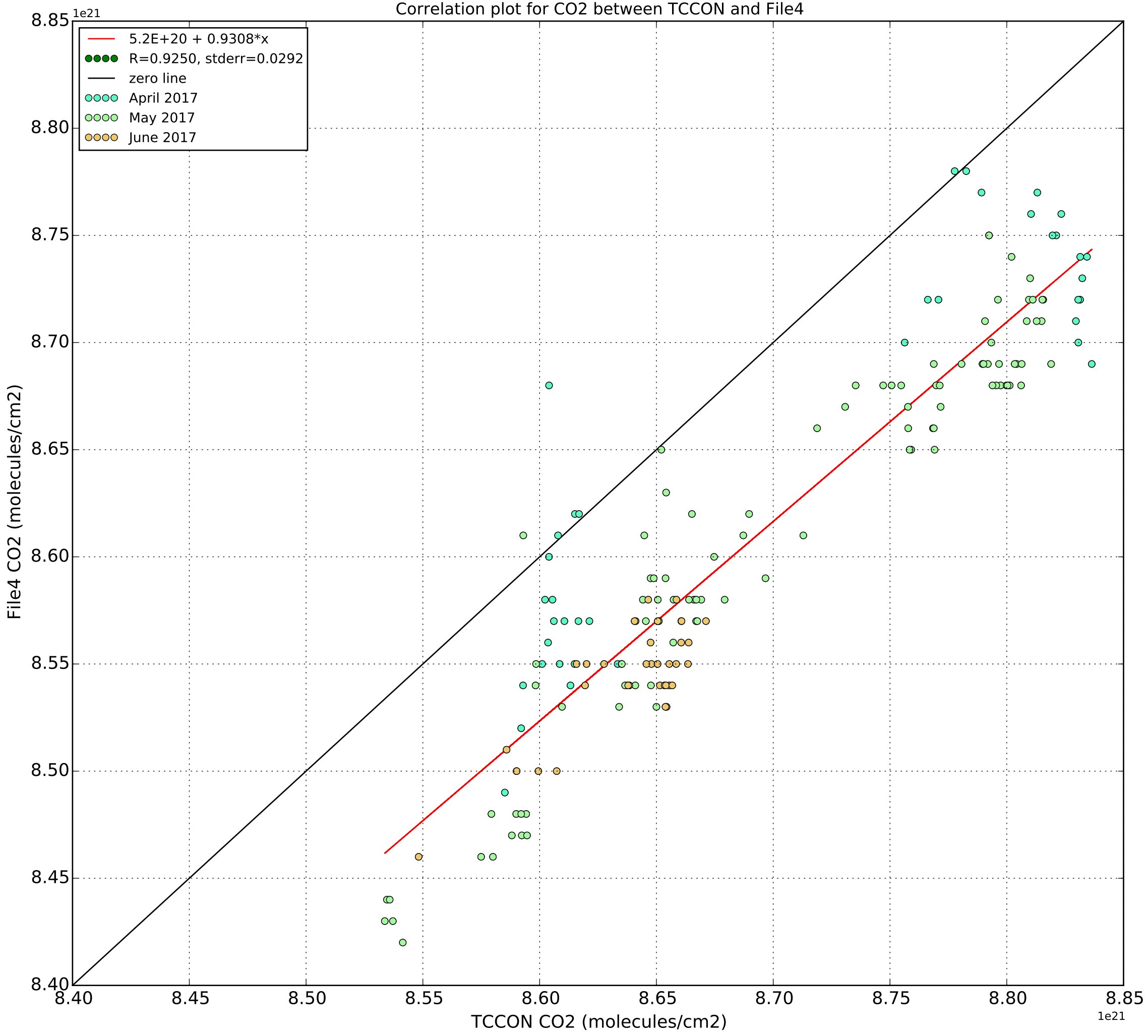
Correlation plot for H2O between TCCON and File4

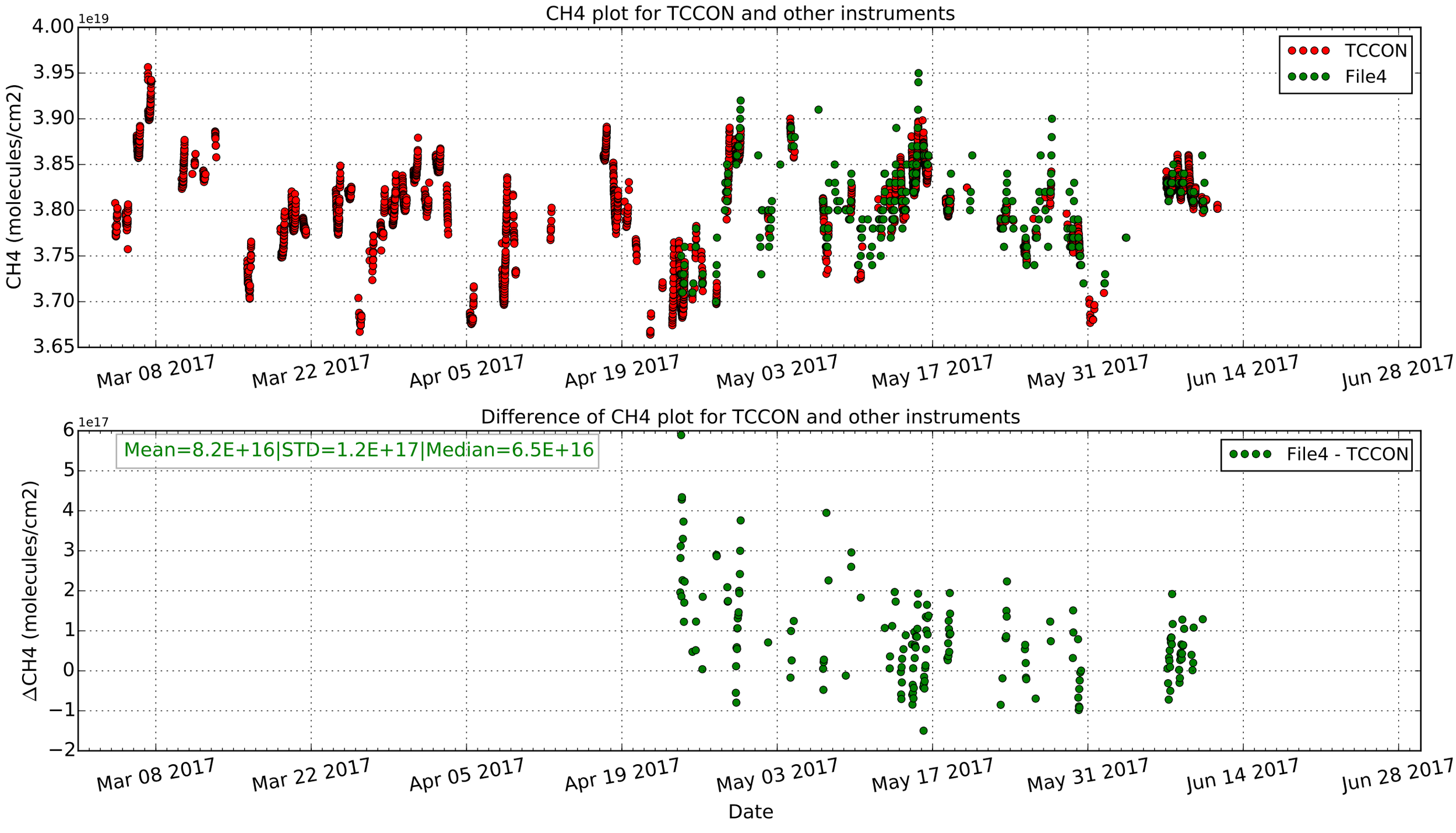



CO2 plot for TCCON and other instruments
1e21
CO2 (molecules/cm2)
8.9
8.8
8.7
8.6
8.5
8.4
8.3
TCCON
File4
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CO2 plot for TCCON and other instruments
1e20
Mean=-8.3E+19|STD=3.4E+19|Median=-9.1E+19
File4 - TCCON
ΔCO2 (molecules/cm2)
1.0
0.5
0.0
−0.5
−1.0
−1.5
Date


Correlation plot for CO2 between TCCON and File4
5.2E+20 + 0.9308*x
R=0.9250, stderr=0.0292
zero line
1e21
8.85
8.80
8.75
8.70
8.65
8.60
8.55
8.50
8.45
8.40
File4 CO2 (molecules/cm2)
8.40
8.45
8.50
8.55
8.60
8.65
8.70
8.75
8.80
8.85
1e21
TCCON CO2 (molecules/cm2)

Correlation plot for CO2 between TCCON and File4




CH4 plot for TCCON and other instruments
1e19
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
CH4 (molecules/cm2)
TCCON
File4
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CH4 plot for TCCON and other instruments
1e17
Mean=8.2E+16|STD=1.2E+17|Median=6.5E+16
File4 - TCCON
6
5
4
3
2
1
0
−1
−2
ΔCH4 (molecules/cm2)
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for CH4 between TCCON and File4

3.6E+18 + 0.9063*x
R=0.9712, stderr=0.0169
zero line

1e19

File4 CH4 (molecules/cm2)

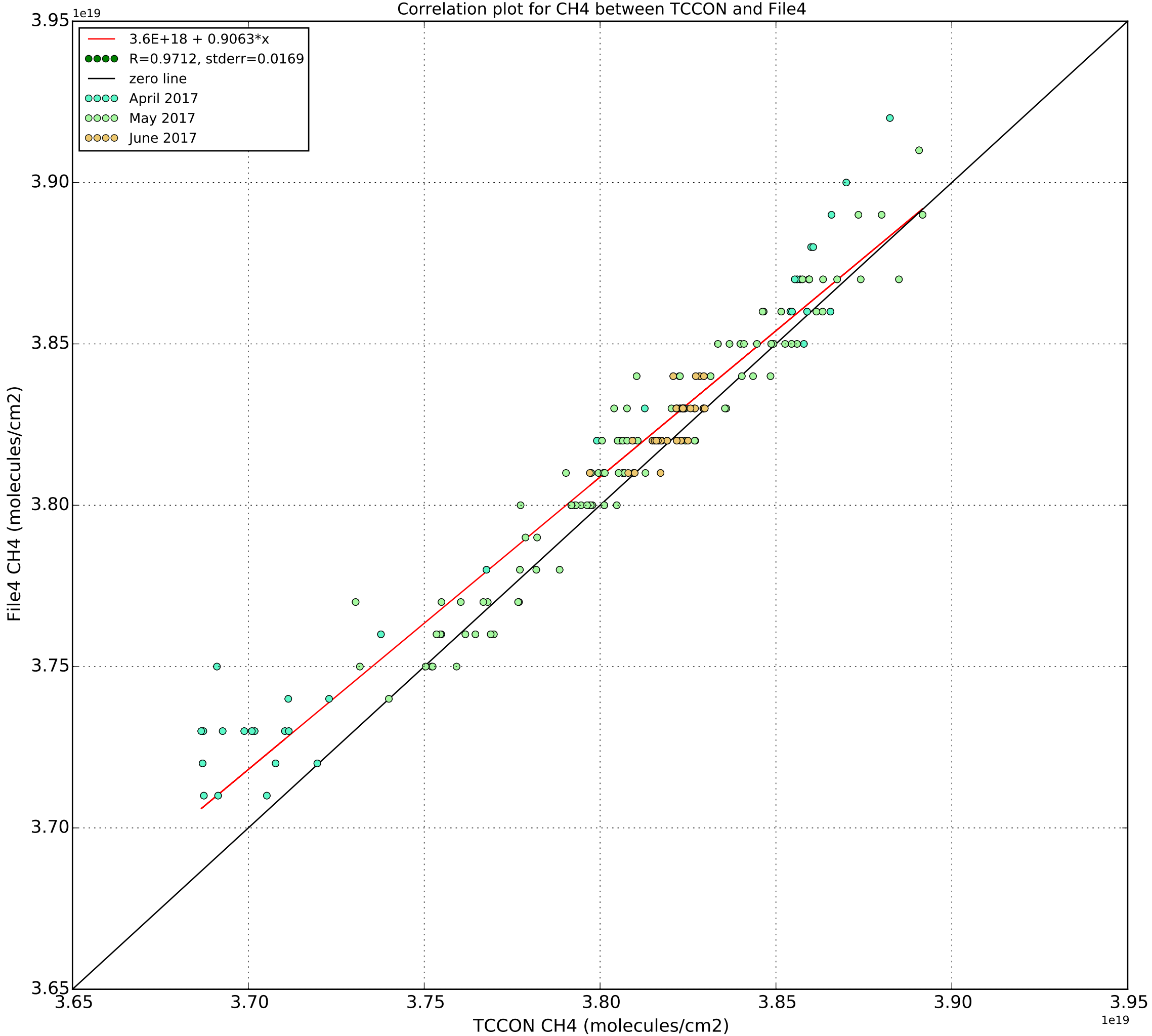
3.95
3.90
3.85
3.80
3.75
3.70
3.65

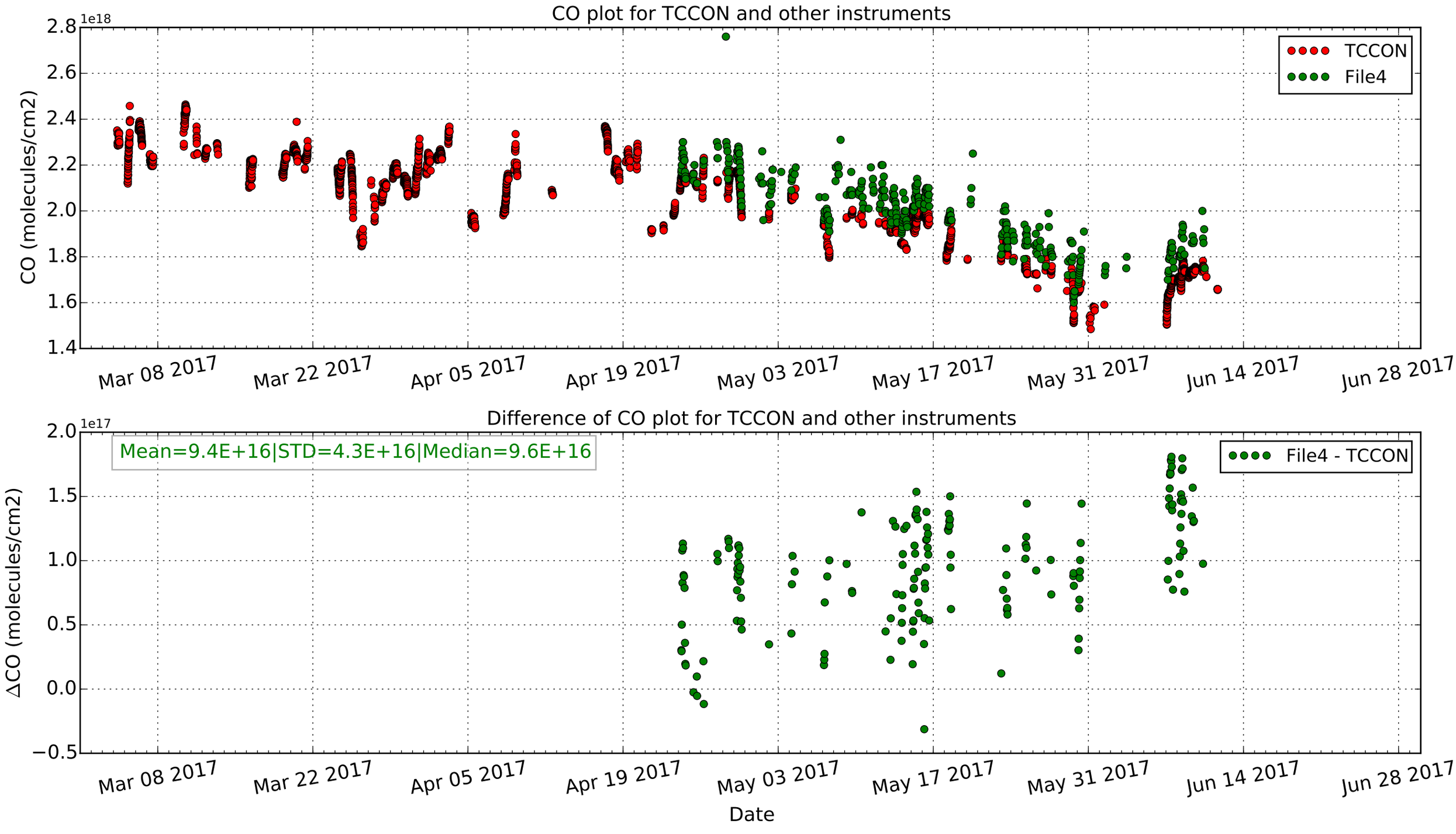
3.65 3.70 3.75 3.80 3.85 3.90 3.95

1e19

TCCON CH4 (molecules/cm2)

Correlation plot for CH4 between TCCON and File4




CO plot for TCCON and other instruments
1e18
CO (molecules/cm2)
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
TCCON
File4
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CO plot for TCCON and other instruments
1e17
Mean=9.4E+16|STD=4.3E+16|Median=9.6E+16
File4 - TCCON
ΔCO (molecules/cm2)
2.0
1.5
1.0
0.5
0.0
−0.5
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for CO between TCCON and File4

3.0E+17 + 0.8932*x
R=0.9702, stderr=0.0170
zero line

File4 CO (molecules/cm2)
1e18
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5

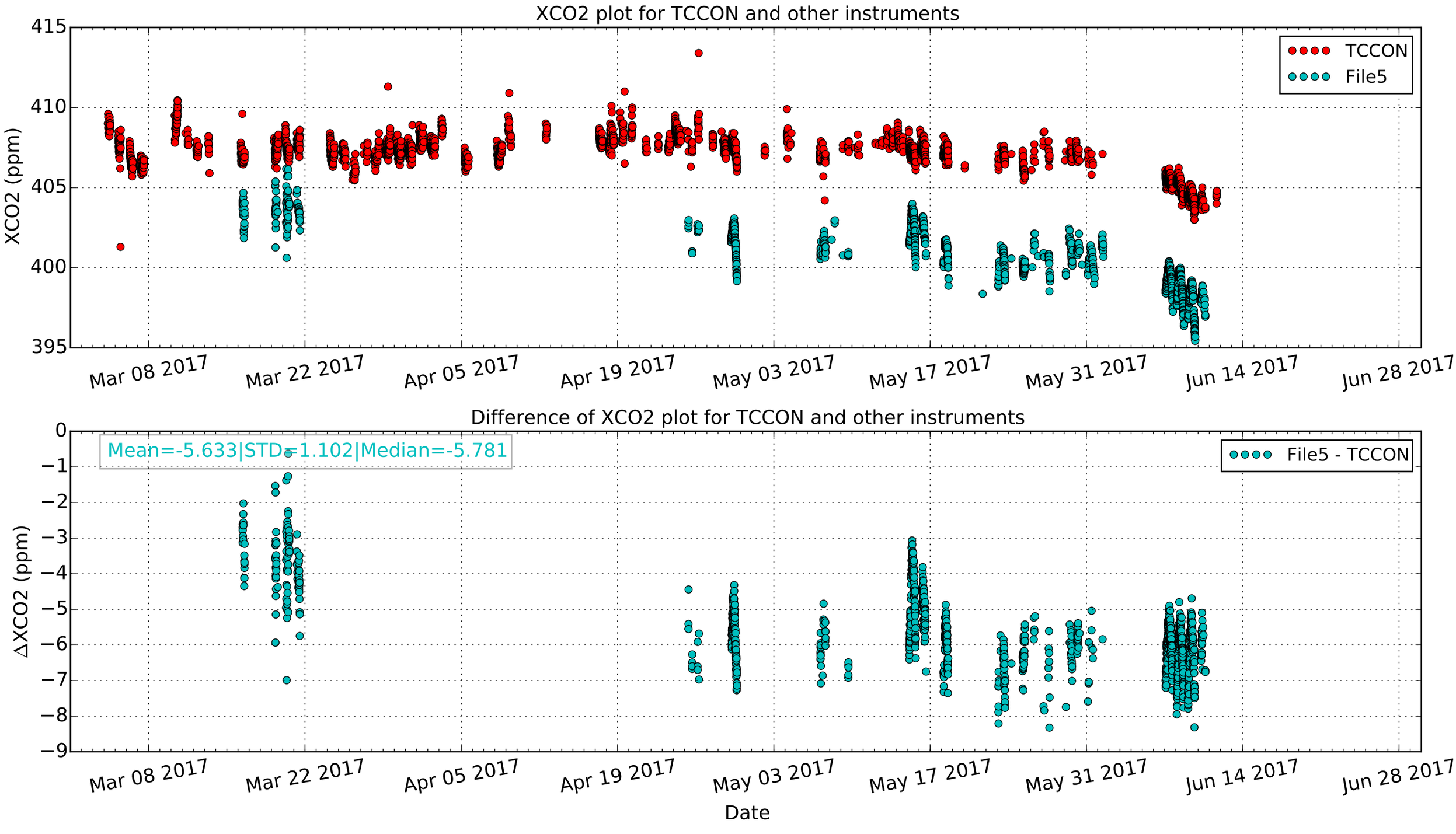
TCCON CO (molecules/cm2)
1e18
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4

Correlation plot for CO between TCCON and File4

3.0E+17 + 0.8932*x
R=0.9702, stderr=0.0170
zero line
April 2017
May 2017
June 2017

File4 CO (molecules/cm2)
1e18
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5

TCCON CO (molecules/cm2)
1e18
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4


XCO2 plot for TCCON and other instruments
XCO2 (ppm)
415
410
405
400
395
TCCON
File5
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCO2 plot for TCCON and other instruments
Mean=-5.633|STD=1.102|Median=-5.781
File5 - TCCON
ΔXCO2 (ppm)
0
−1
−2
−3
−4
−5
−6
−7
−8
−9
Date

Correlation plot for XCO2 between TCCON and File5

-141.368 + 1.3341*x
R=0.8485, stderr=0.0238
zero line

File5 XCO2 (ppm)

410
408
406
404
402
400
398
396
394

394 396 398 400 402 404 406 408 410

TCCON XCO2 (ppm)

Correlation plot for XCO2 between TCCON and File5

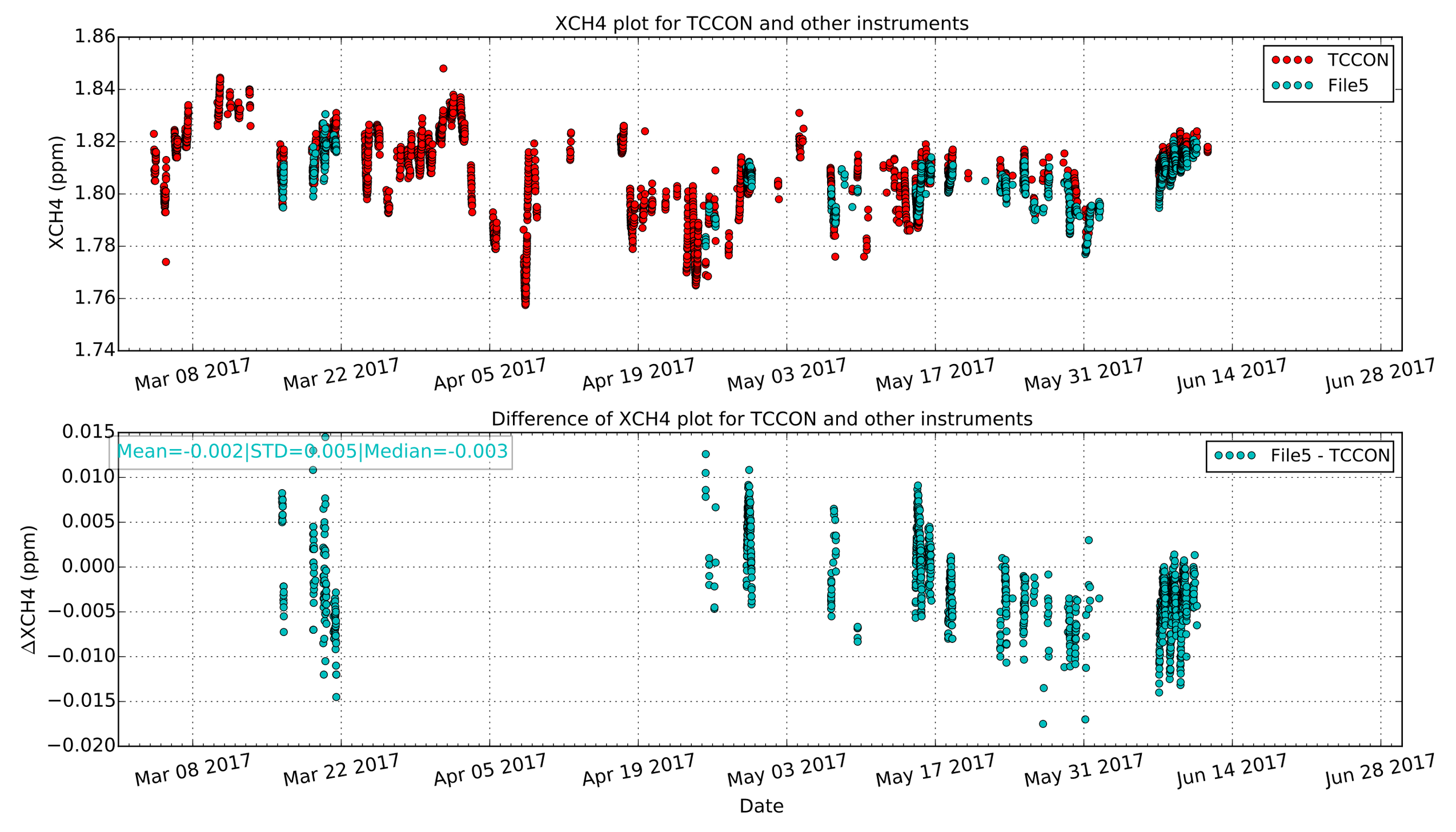
-141.368 + 1.3341*x
R=0.8485, stderr=0.0238
zero line
March 2017
April 2017
May 2017
June 2017

File5 XCO2 (ppm)

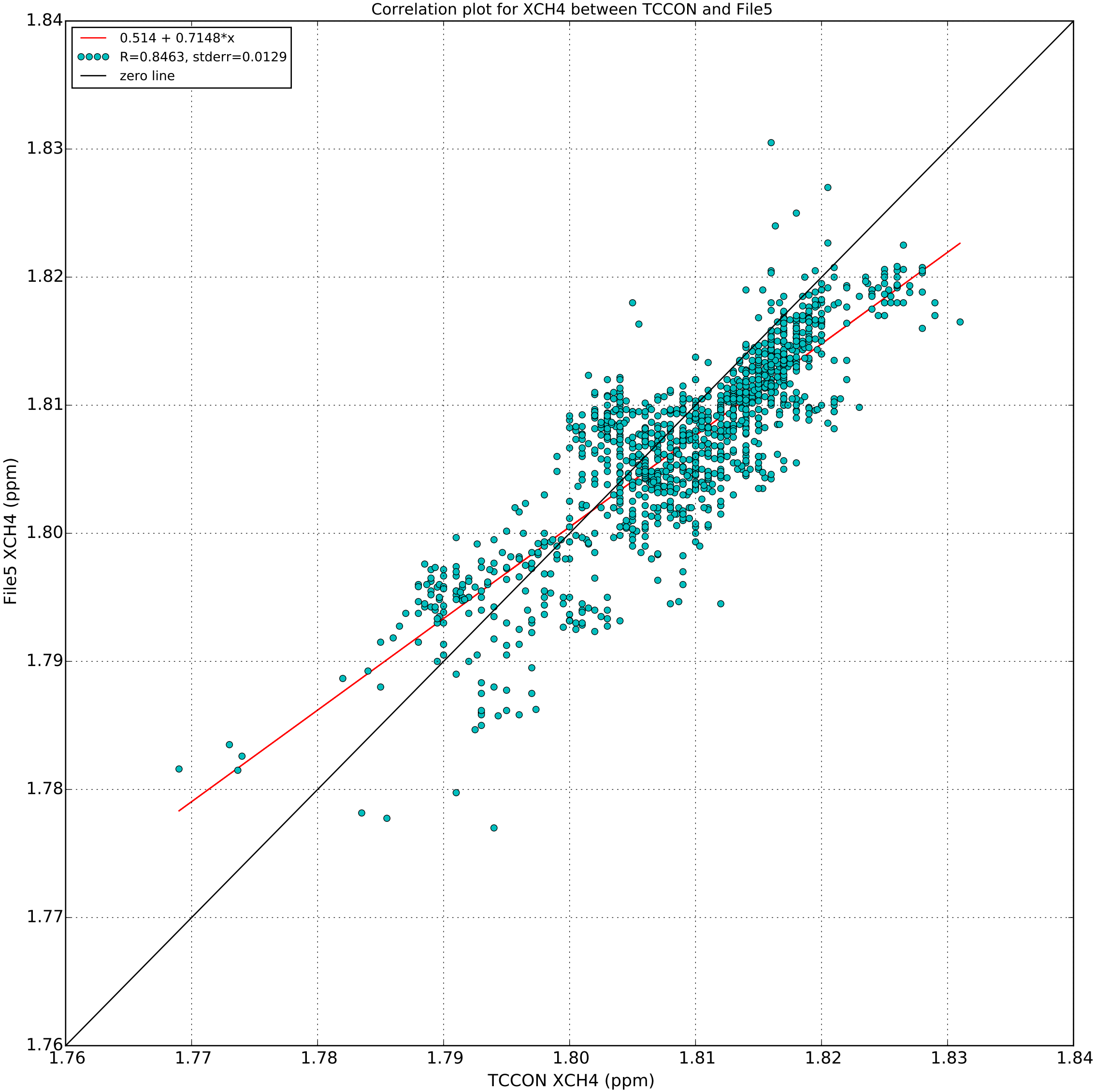
410
408
406
404
402
400
398
396
394

394
396
398
400
402
404
406
408
410

TCCON XCO2 (ppm)


XCH4 plot for TCCON and other instruments
XCH4 (ppm)
1.86
1.84
1.82
1.80
1.78
1.76
1.74
TCCON
File5
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCH4 plot for TCCON and other instruments
Mean=-0.002|STD=0.005|Median=-0.003
File5 - TCCON
ΔXCH4 (ppm)
0.015
0.010
0.005
0.000
−0.005
−0.010
−0.015
−0.020
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for XCH4 between TCCON and File5



Correlation plot for XCH4 between TCCON and File5

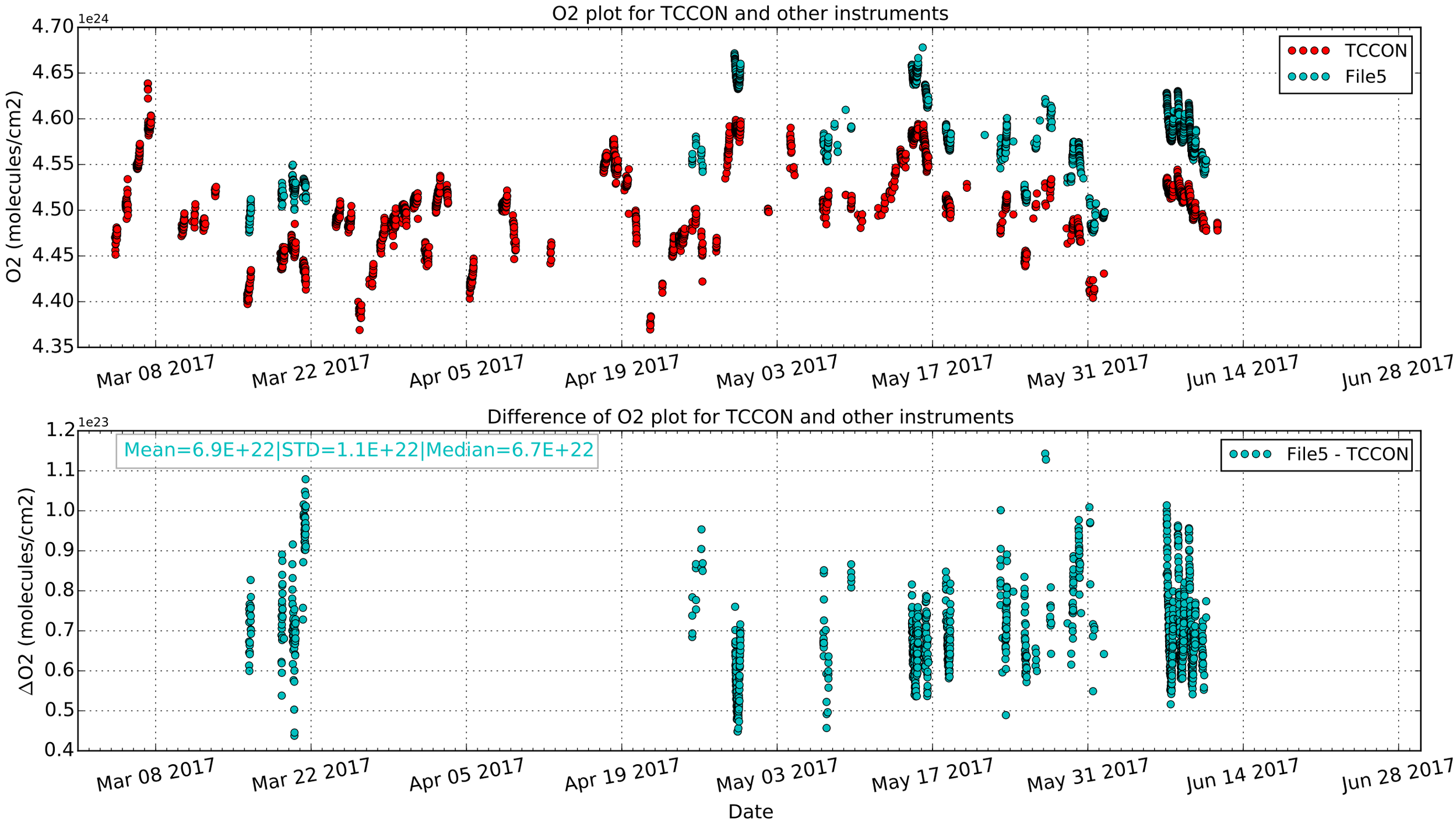
0.514 + 0.7148*x
R=0.8463, stderr=0.0129
zero line
March 2017
April 2017
May 2017
June 2017

File5 XCH4 (ppm)

1.84
1.83
1.82
1.81
1.80
1.79
1.78
1.77
1.76

1.76 1.77 1.78 1.79 1.80 1.81 1.82 1.83 1.84

TCCON XCH4 (ppm)


O2 plot for TCCON and other instruments
1e24
4.70
4.65
4.60
4.55
4.50
4.45
4.40
4.35
O2 (molecules/cm2)
TCCON
File5
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of O2 plot for TCCON and other instruments
1e23
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
ΔO2 (molecules/cm2)
Mean=6.9E+22|STD=1.1E+22|Median=6.7E+22
File5 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for O2 between TCCON and File5

5.4E+23 + 0.8954*x
R=0.9695, stderr=0.0065
zero line

1e24
4.70
4.65
4.60
4.55
4.50
4.45
4.40

File5 O2 (molecules/cm2)

4.40
4.45
4.50
4.55
4.60
4.65
4.70
1e24

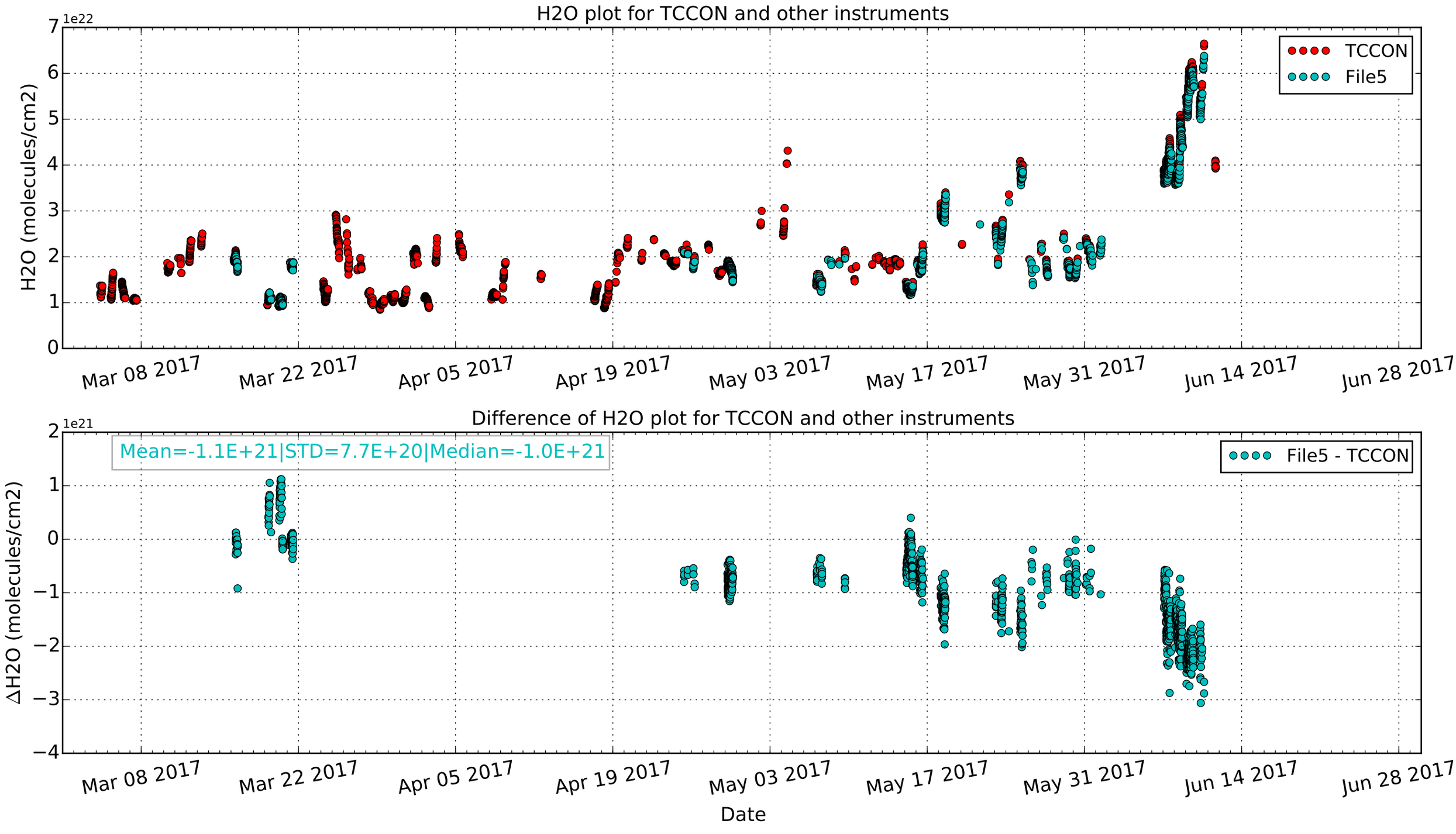
TCCON O2 (molecules/cm2)

Correlation plot for O2 between TCCON and File5

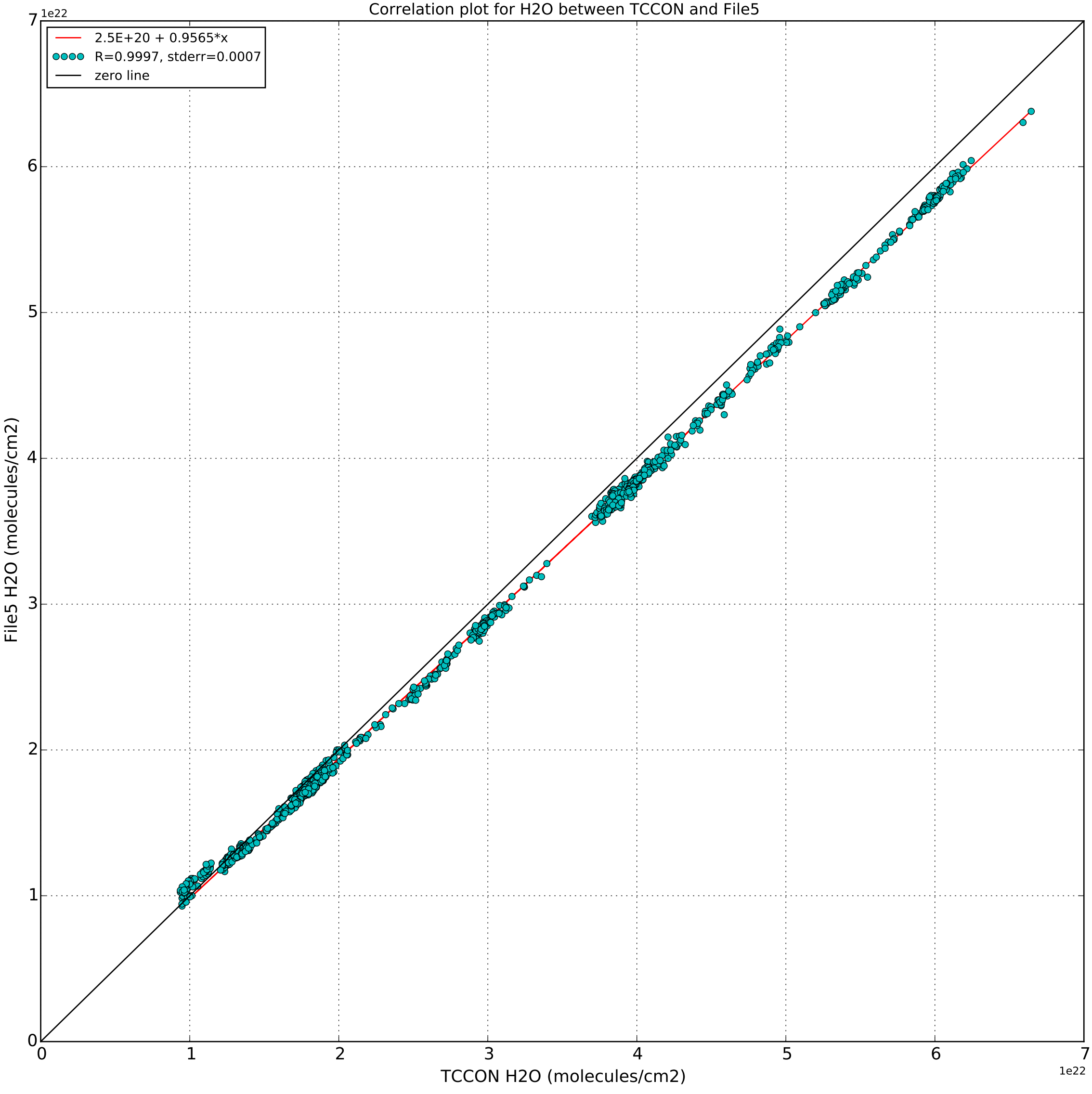
5.4E+23 + 0.8954*x
R=0.9695, stderr=0.0065
zero line
March 2017
April 2017
May 2017
June 2017

File5 O2 (molecules/cm2)
1e24
4.70
4.65
4.60
4.55
4.50
4.45
4.40

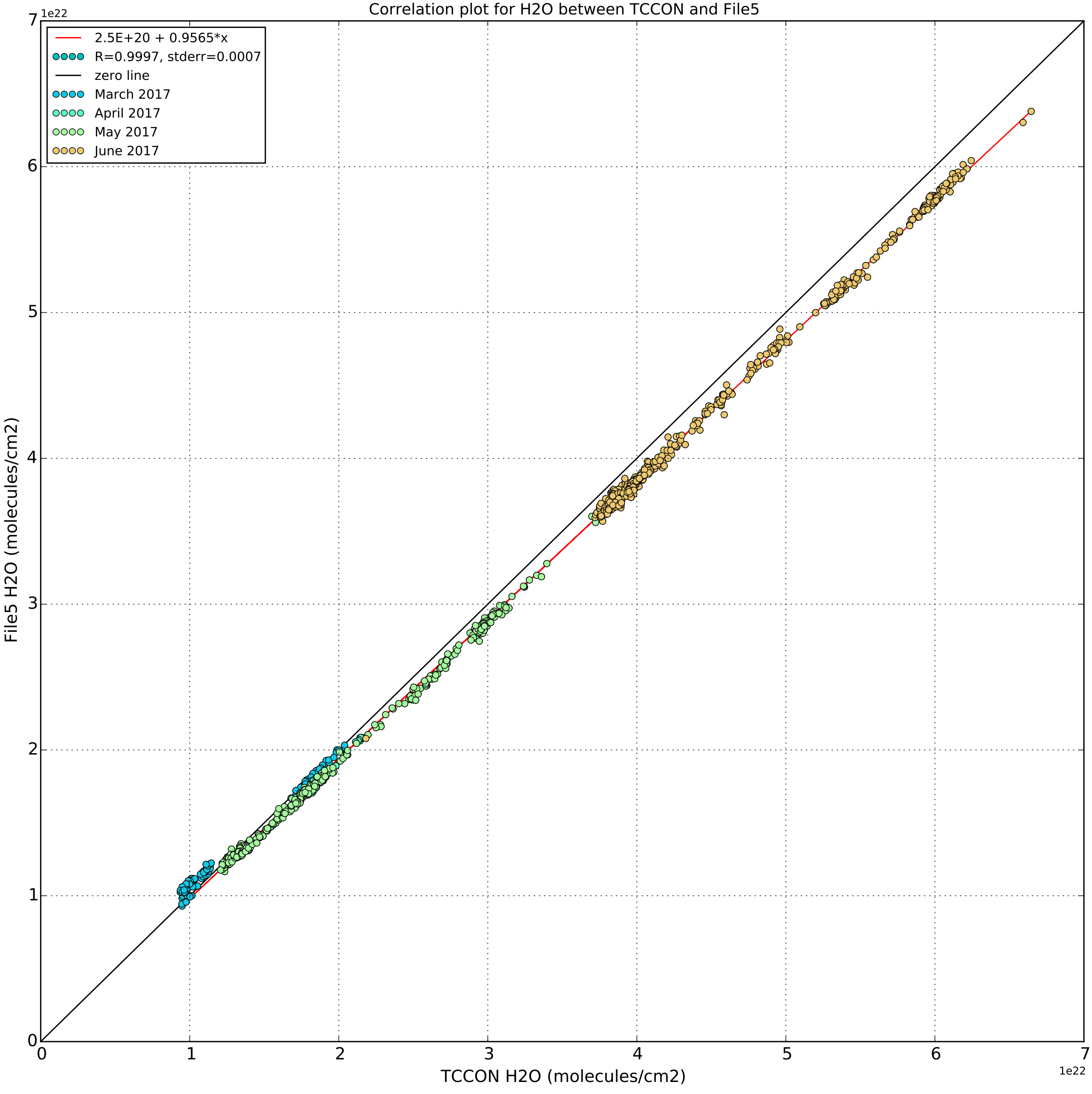
TCCON O2 (molecules/cm2)
1e24
4.40
4.45
4.50
4.55
4.60
4.65
4.70

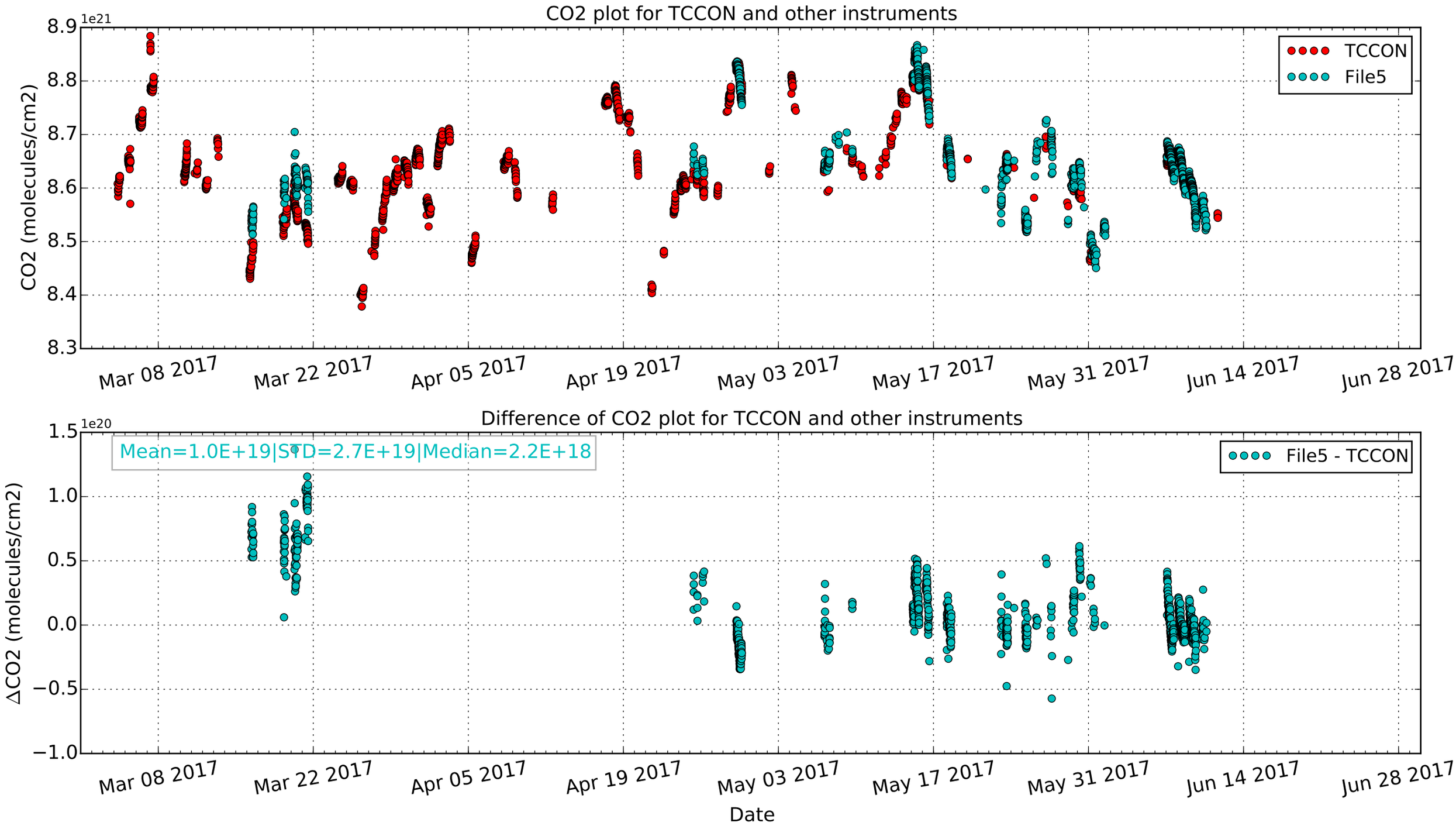

H2O plot for TCCON and other instruments
1e22
H2O (molecules/cm2)
TCCON
File5
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of H2O plot for TCCON and other instruments
1e21
Mean=-1.1E+21|STD=7.7E+20|Median=-1.0E+21
File5 - TCCON
ΔH2O (molecules/cm2)
Date

Correlation plot for H2O between TCCON and File5



Correlation plot for H2O between TCCON and File5




CO2 plot for TCCON and other instruments
1e21
CO2 (molecules/cm2)
8.9
8.8
8.7
8.6
8.5
8.4
8.3
TCCON
File5
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CO2 plot for TCCON and other instruments
1e20
ΔCO2 (molecules/cm2)
1.5
1.0
0.5
0.0
−0.5
−1.0
Mean=1.0E+19|STD=2.7E+19|Median=2.2E+18
File5 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for CO2 between TCCON and File5

7.8E+20 + 0.9112*x
R=0.9590, stderr=0.0077
zero line

1e21
8.90
8.85
8.80
8.75
8.70
8.65
8.60
8.55
8.50
8.45

File5 CO2 (molecules/cm2)

8.45 8.50 8.55 8.60 8.65 8.70 8.75 8.80 8.85 8.90
1e21

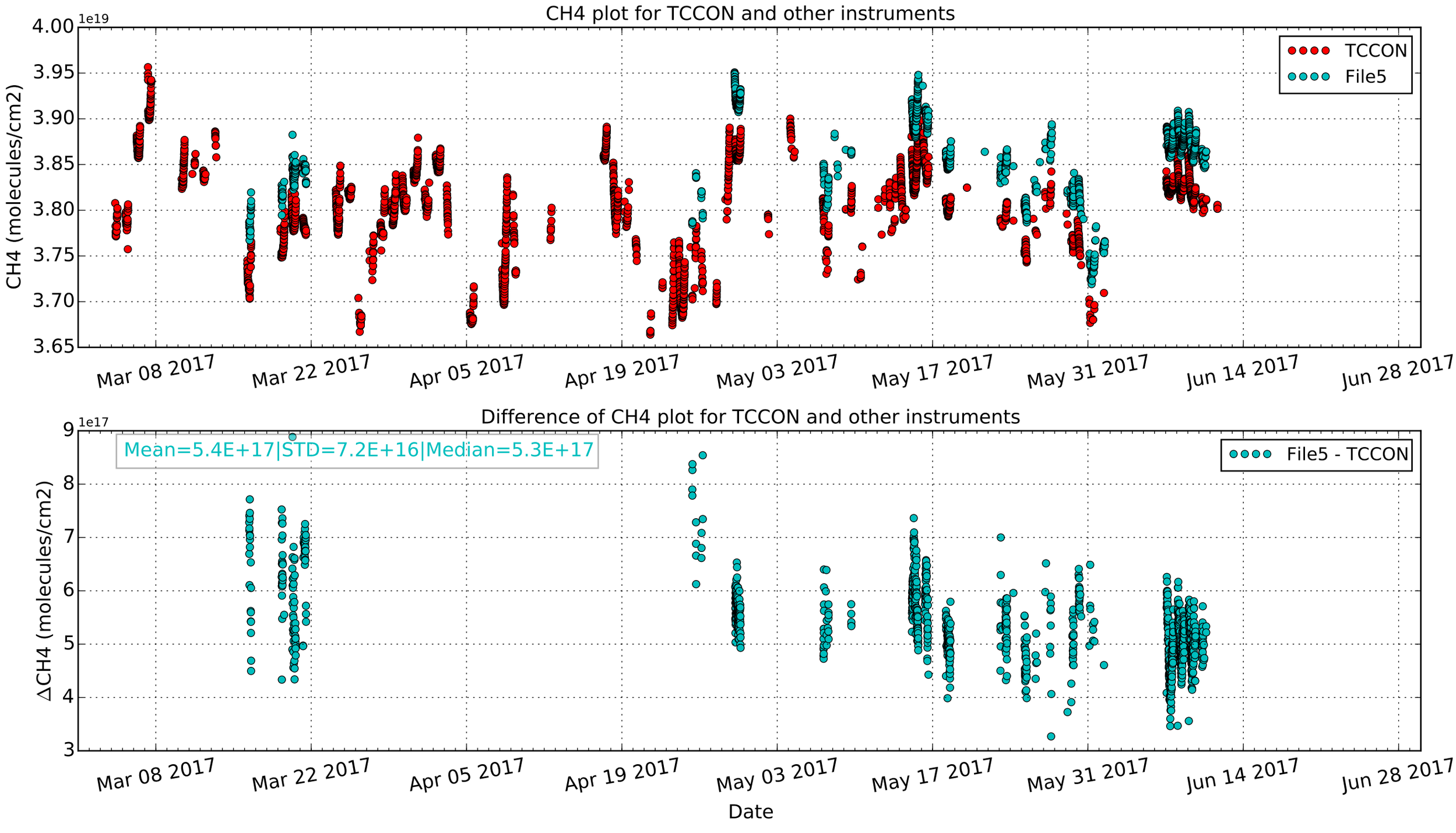
TCCON CO2 (molecules/cm2)

Correlation plot for CO2 between TCCON and File5

7.8E+20 + 0.9112*x
R=0.9590, stderr=0.0077
zero line
March 2017
April 2017
May 2017
June 2017

File5 CO2 (molecules/cm2)
1e21
8.90
8.85
8.80
8.75
8.70
8.65
8.60
8.55
8.50
8.45

TCCON CO2 (molecules/cm2)
1e21
8.45
8.50
8.55
8.60
8.65
8.70
8.75
8.80
8.85
8.90


CH4 plot for TCCON and other instruments
1e19
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
CH4 (molecules/cm2)
TCCON
File5
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CH4 plot for TCCON and other instruments
1e17
9
8
7
6
5
4
3
Mean=5.4E+17|STD=7.2E+16|Median=5.3E+17
File5 - TCCON
ΔCH4 (molecules/cm2)
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for CH4 between TCCON and File5

1.5E+18 + 0.9753*x
R=0.9789, stderr=0.0058
zero line

1e19
3.95
3.90
3.85
3.80
3.75
3.70
3.65

File5 CH4 (molecules/cm2)

3.65
3.70
3.75
3.80
3.85
3.90
3.95
1e19

TCCON CH4 (molecules/cm2)

Correlation plot for CH4 between TCCON and File5

1e19

1.5E+18 + 0.9753*x
R=0.9789, stderr=0.0058
zero line
March 2017
April 2017
May 2017
June 2017

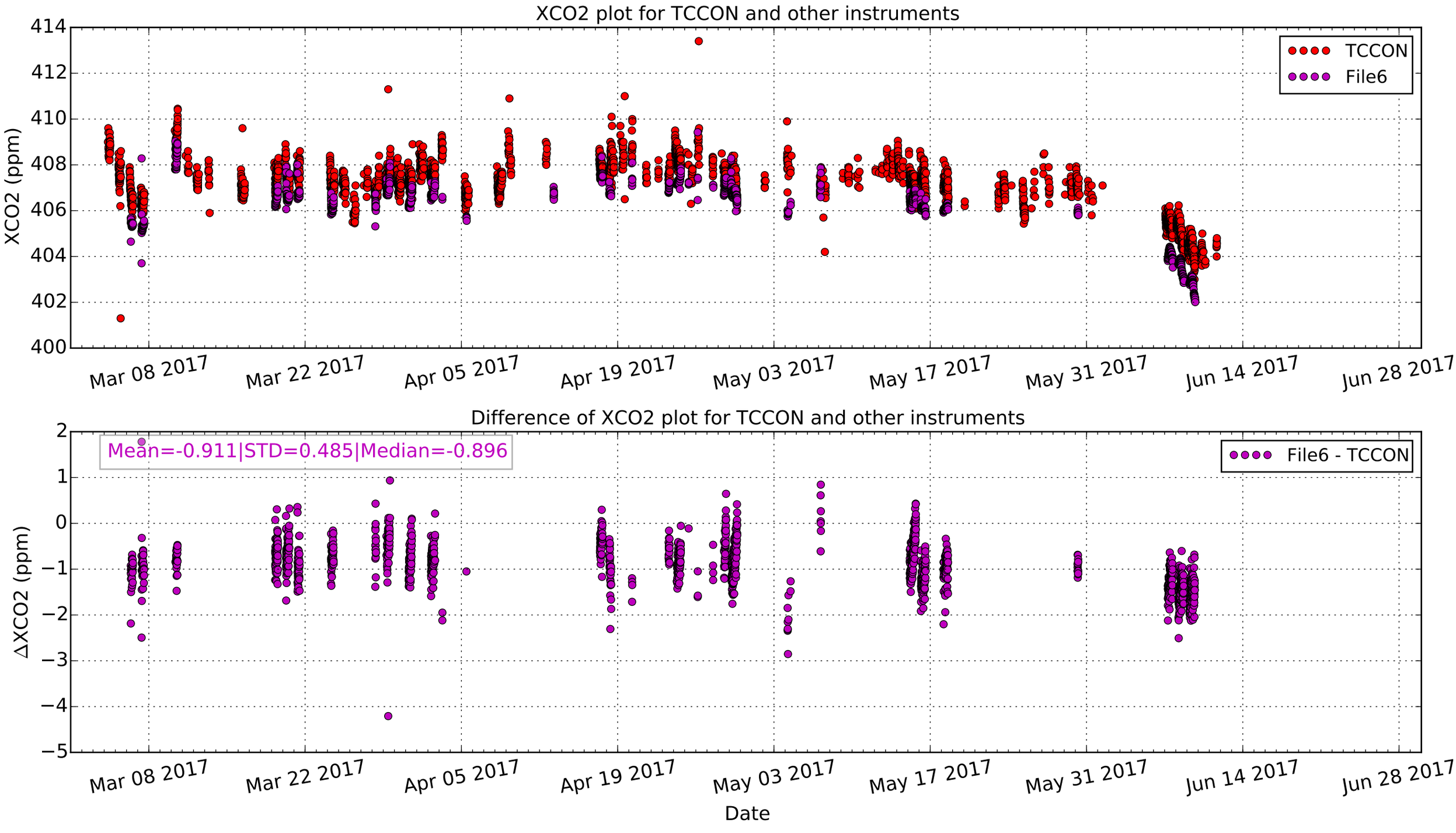
File5 CH4 (molecules/cm2)

3.95
3.90
3.85
3.80
3.75
3.70
3.65

TCCON CH4 (molecules/cm2)

3.65 3.70 3.75 3.80 3.85 3.90 3.95

1e19


XCO2 plot for TCCON and other instruments
XCO2 (ppm)
414
412
410
408
406
404
402
400
TCCON
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCO2 plot for TCCON and other instruments
Mean=-0.911|STD=0.485|Median=-0.896
File6 - TCCON
ΔXCO2 (ppm)
2
1
0
−1
−2
−3
−4
−5
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for XCO2 between TCCON and File6

-51.638 + 1.1247*x
R=0.9416, stderr=0.0100
zero line

File6 XCO2 (ppm)

412
410
408
406
404
402
400

TCCON XCO2 (ppm)

400
402
404
406
408
410
412

Correlation plot for XCO2 between TCCON and File6

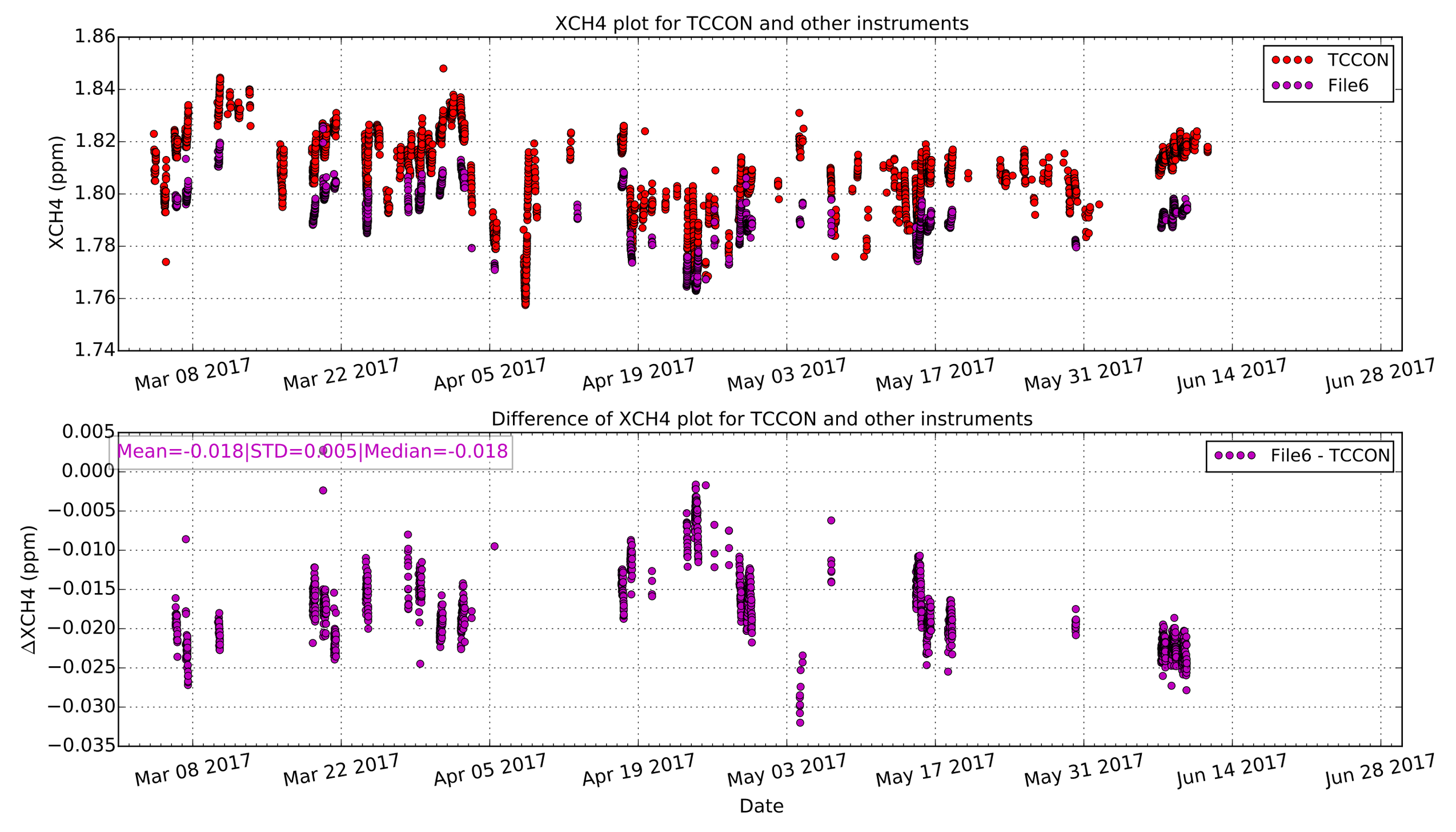
-51.638 + 1.1247*x
R=0.9416, stderr=0.0100
zero line
March 2017
April 2017
May 2017
June 2017

File6 XCO2 (ppm)

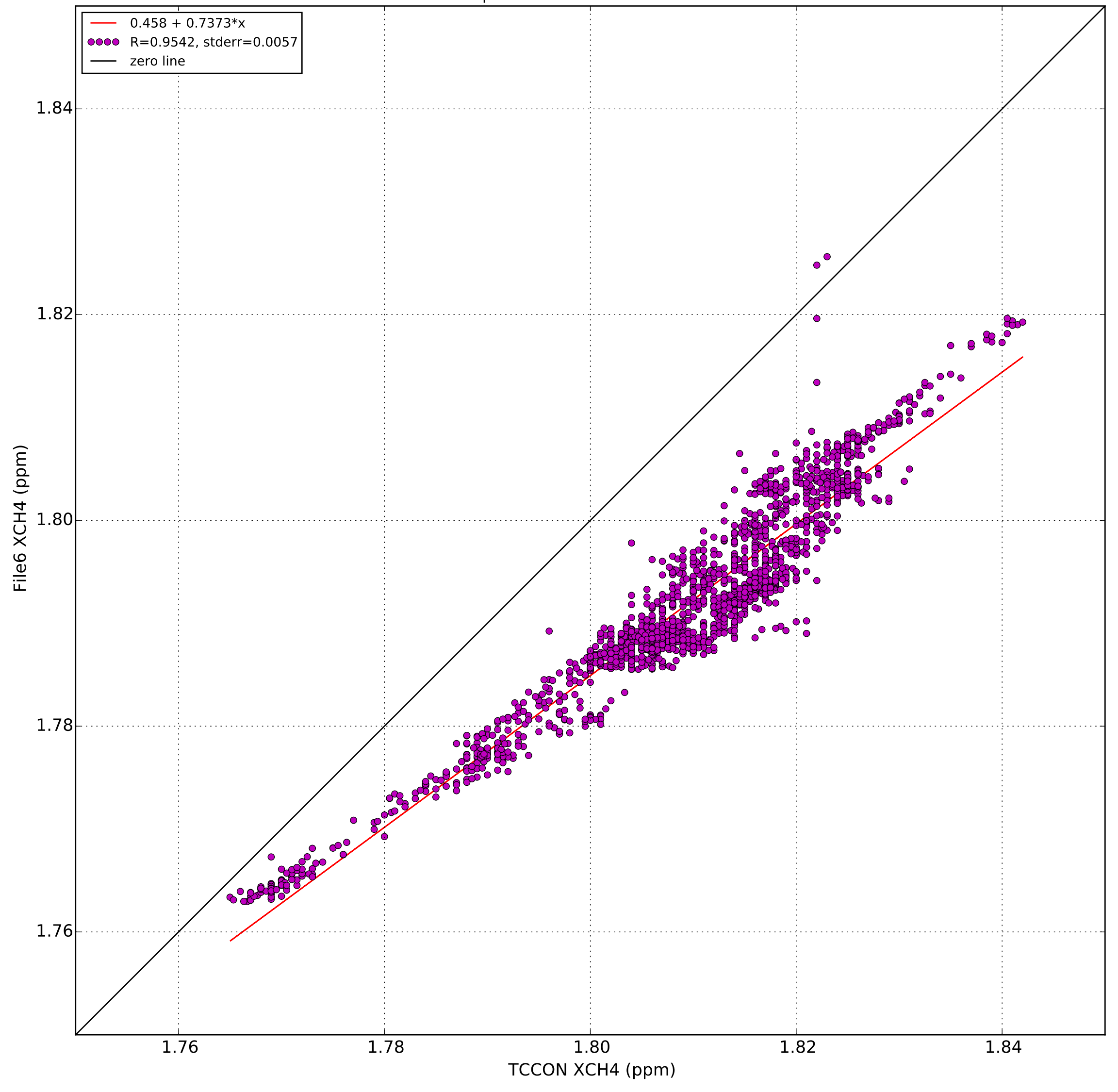
412
410
408
406
404
402
400

TCCON XCO2 (ppm)

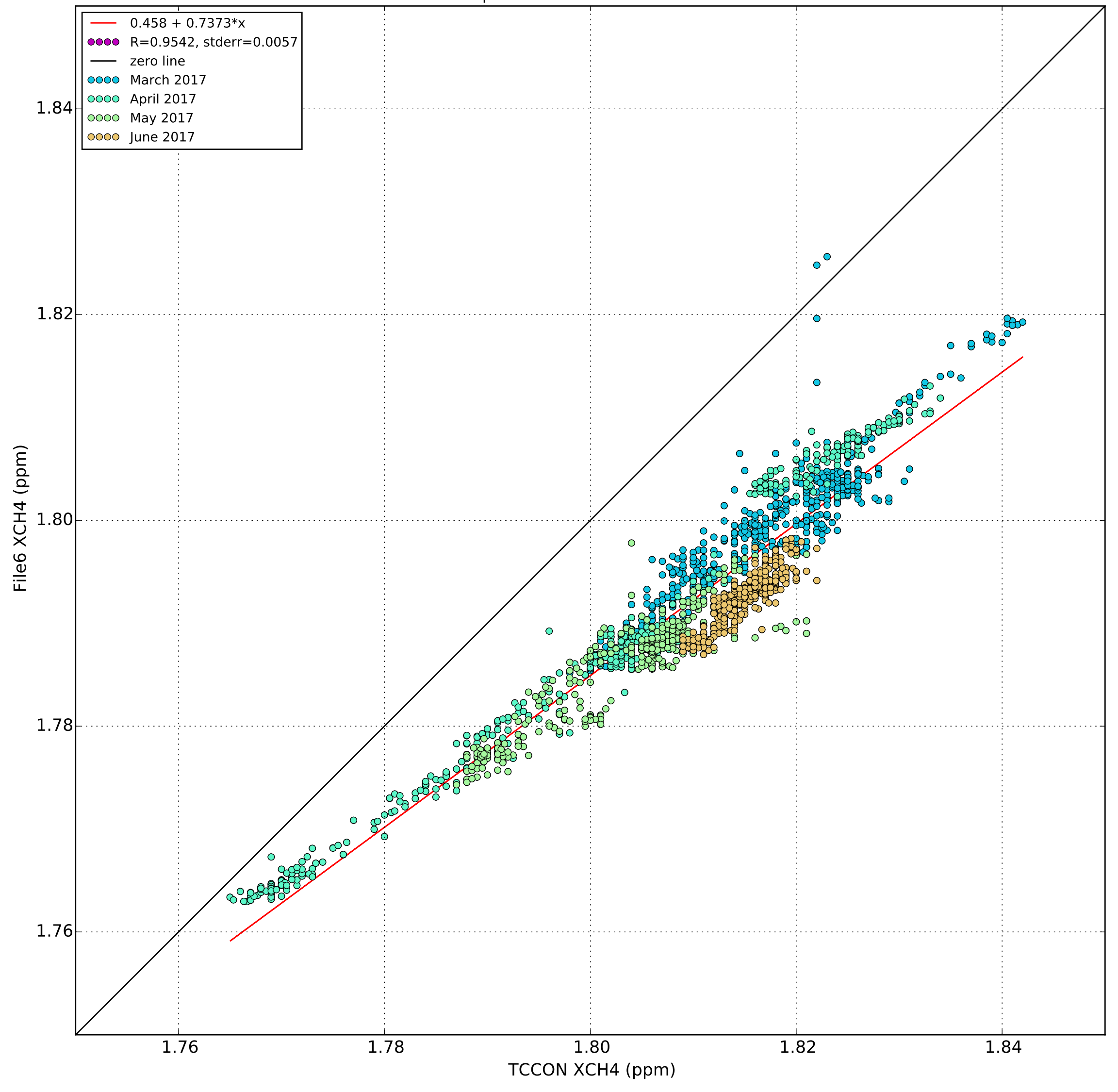
400
402
404
406
408
410
412

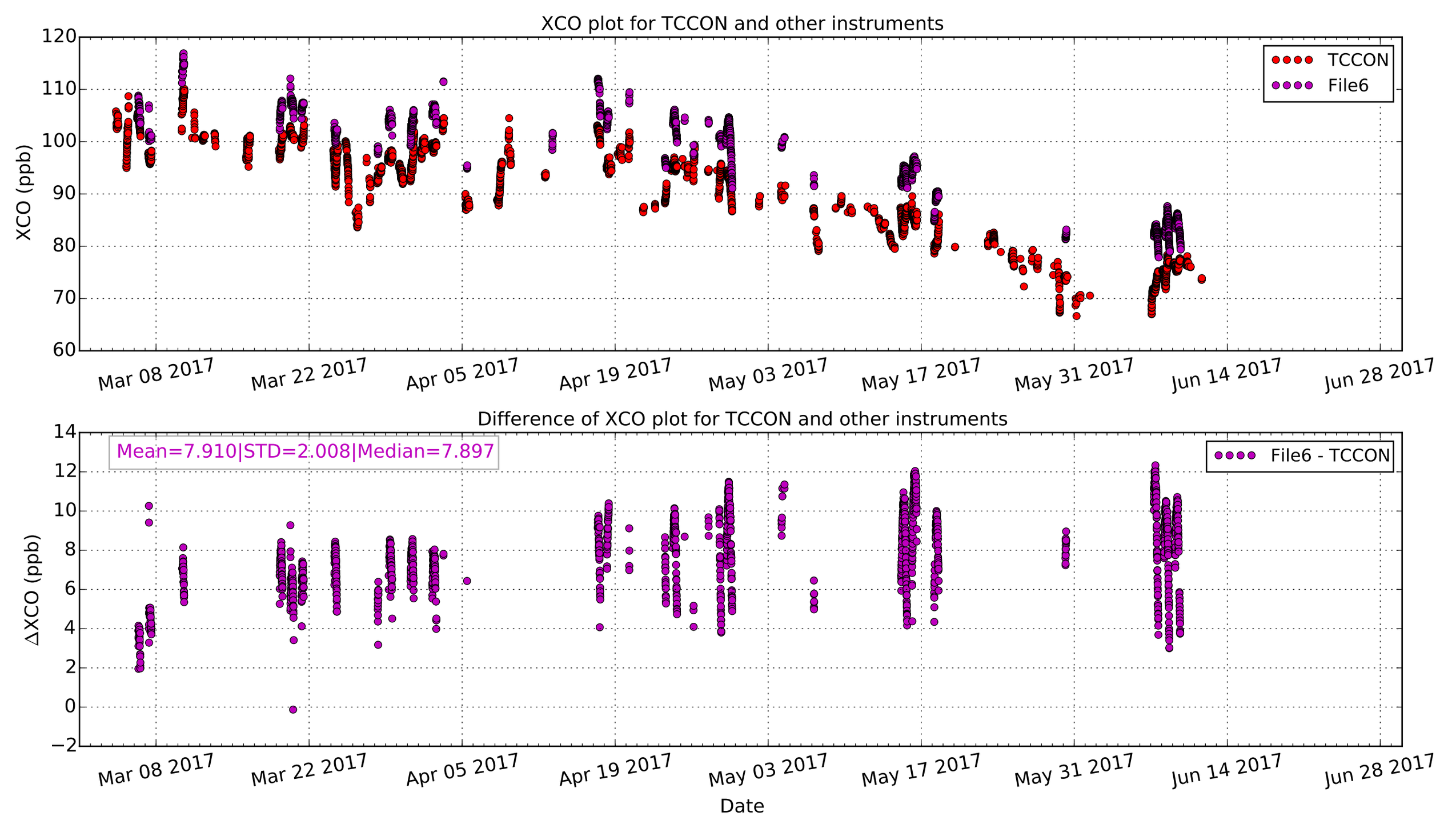

XCH4 plot for TCCON and other instruments
XCH4 (ppm)
1.86
1.84
1.82
1.80
1.78
1.76
1.74
TCCON
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCH4 plot for TCCON and other instruments
Mean=-0.018|STD=0.005|Median=-0.018
File6 - TCCON
ΔXCH4 (ppm)
0.005
0.000
−0.005
−0.010
−0.015
−0.020
−0.025
−0.030
−0.035
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

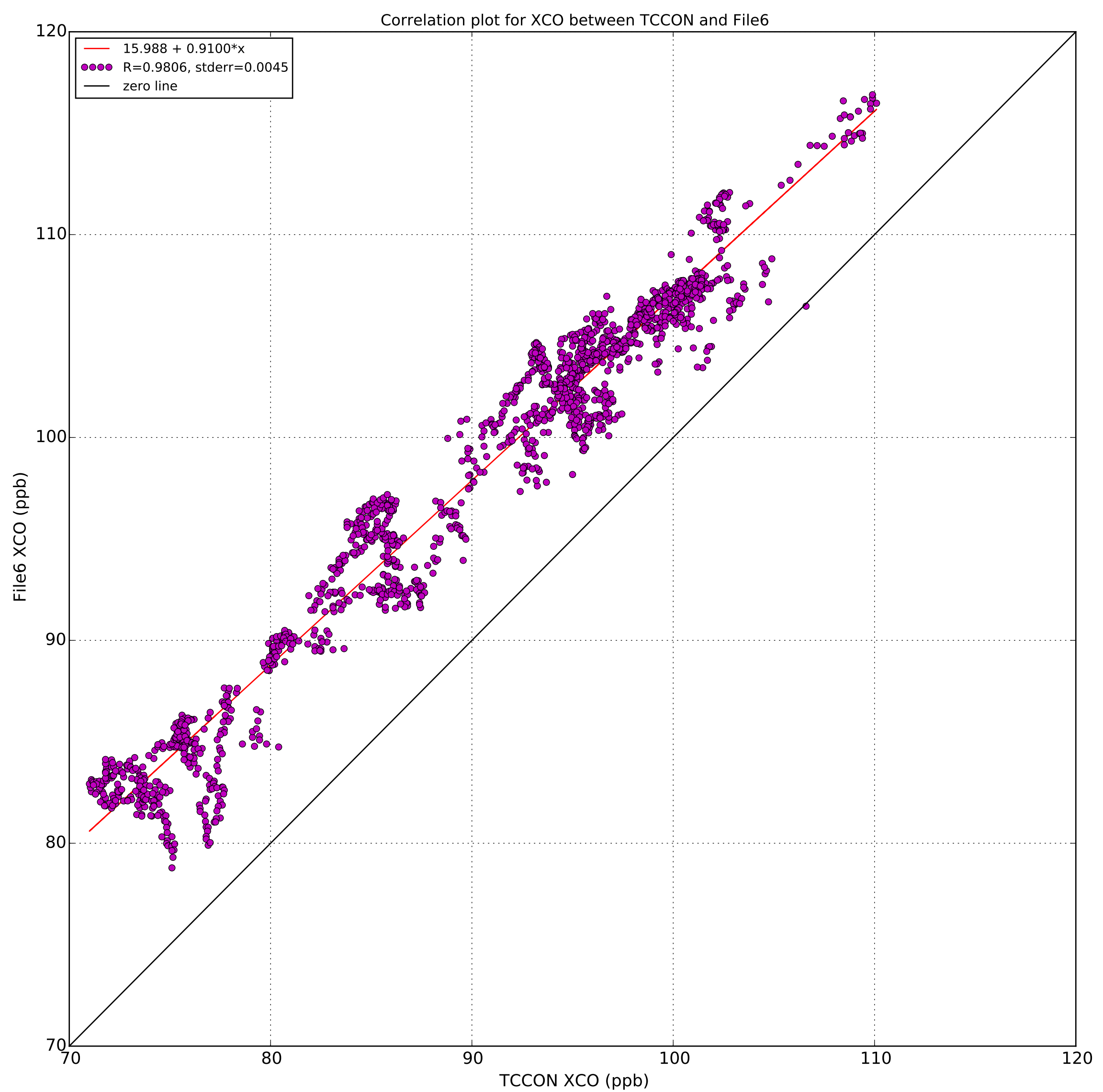
Correlation plot for XCH4 between TCCON and File6



Correlation plot for XCH4 between TCCON and File6




XCO plot for TCCON and other instruments
XCO (ppb)
TCCON
File6
120
110
100
90
80
70
60
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of XCO plot for TCCON and other instruments
Mean=7.910|STD=2.008|Median=7.897
File6 - TCCON
ΔXCO (ppb)
14
12
10
8
6
4
2
0
−2
Date


Correlation plot for XCO between TCCON and File6
15.988 + 0.9100*x
R=0.9806, stderr=0.0045
zero line
File6 XCO (ppb)
TCCON XCO (ppb)
120
110
100
90
80
70
70
80
90
100
110
120

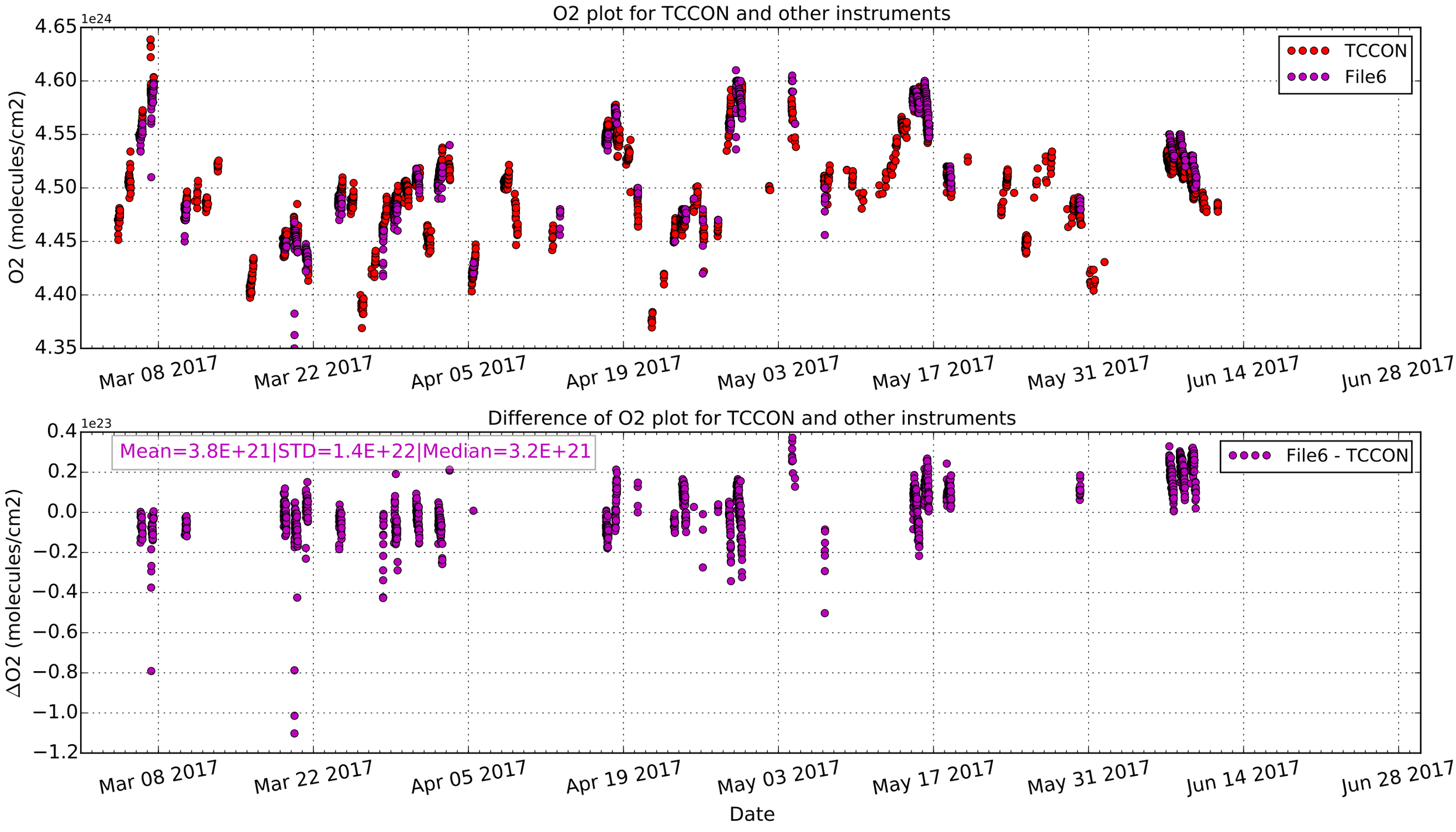
Correlation plot for XCO between TCCON and File6

15.988 + 0.9100*x
R=0.9806, stderr=0.0045
zero line
March 2017
April 2017
May 2017
June 2017

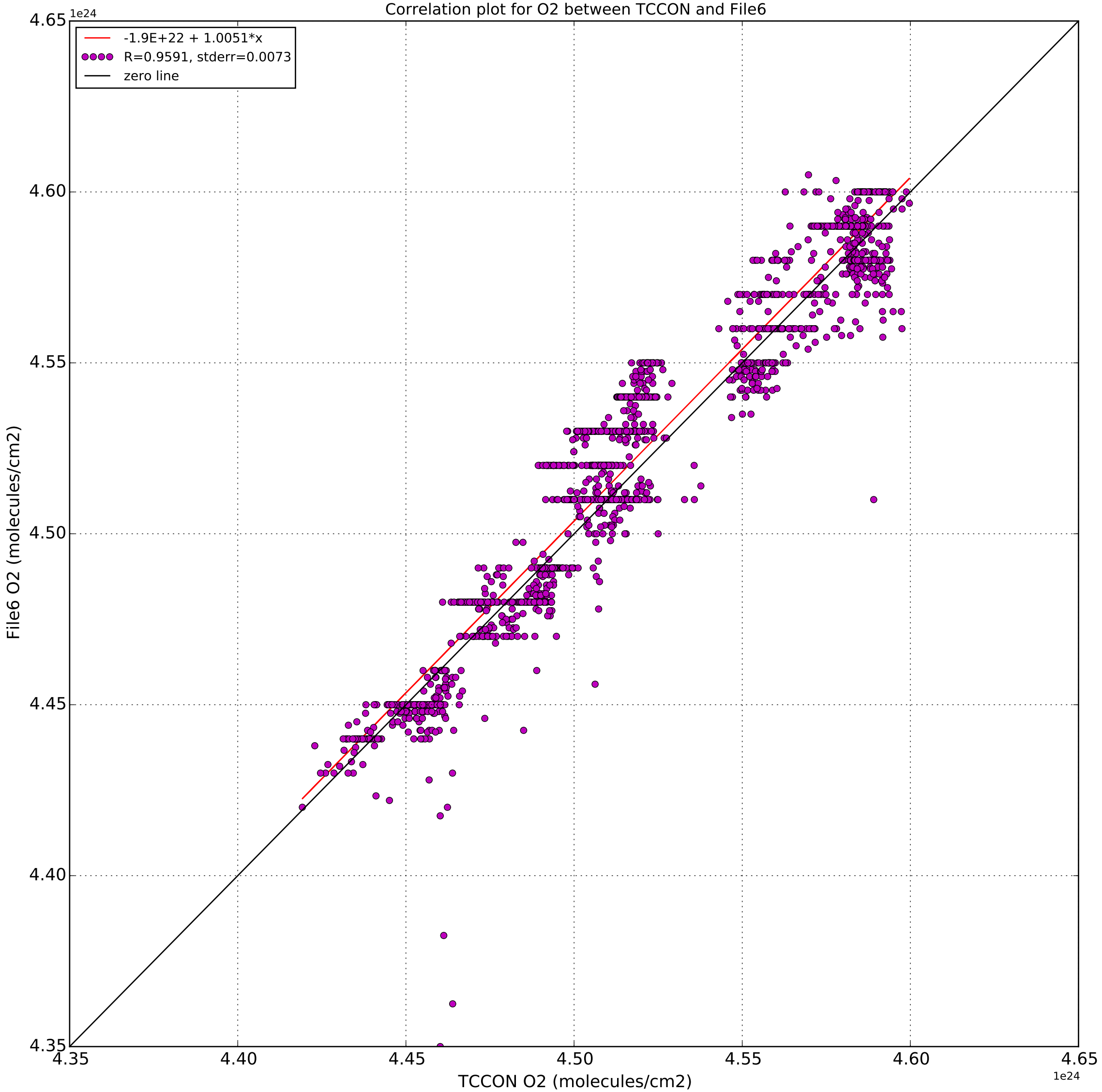
File6 XCO (ppb)

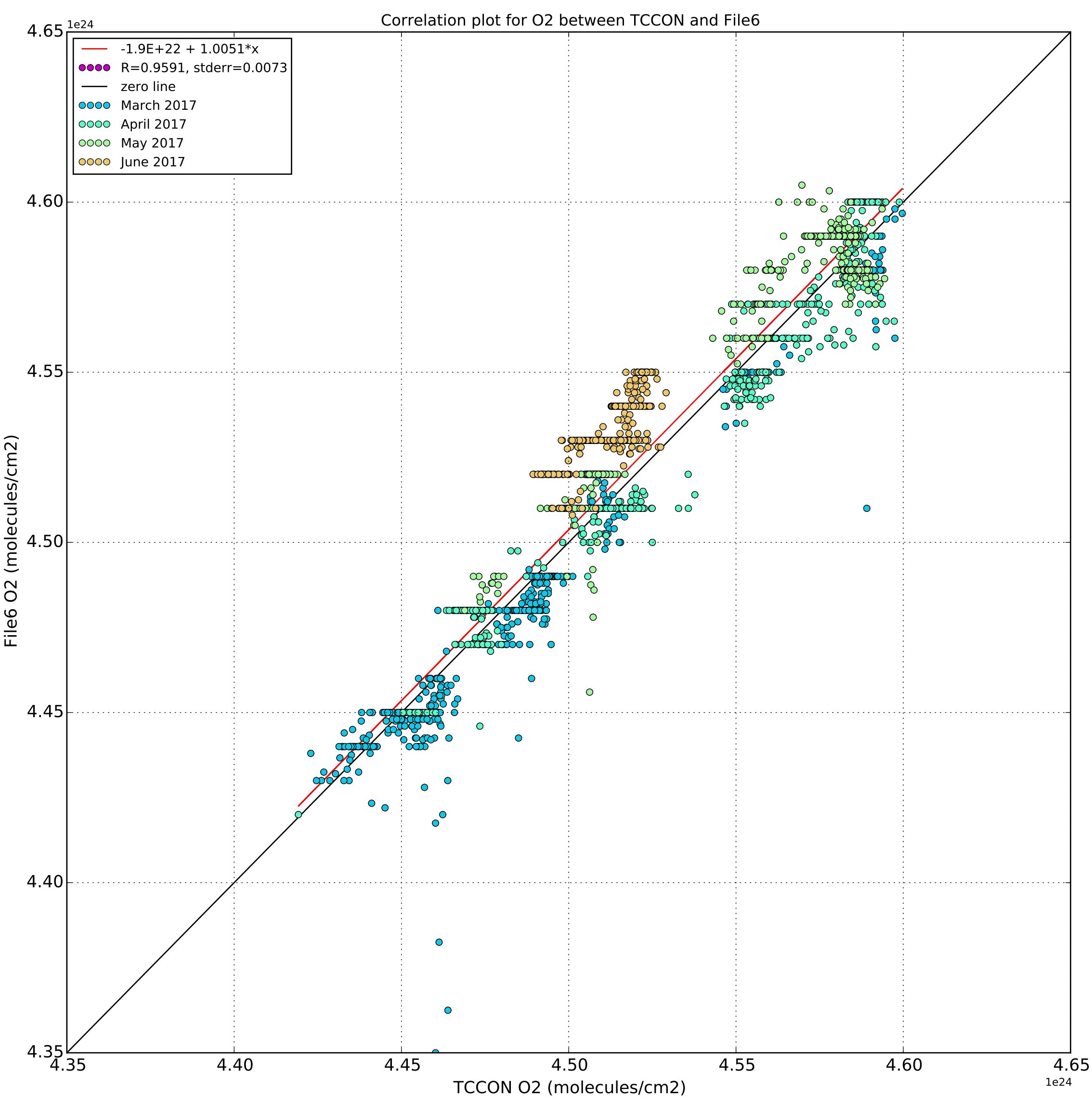
TCCON XCO (ppb)

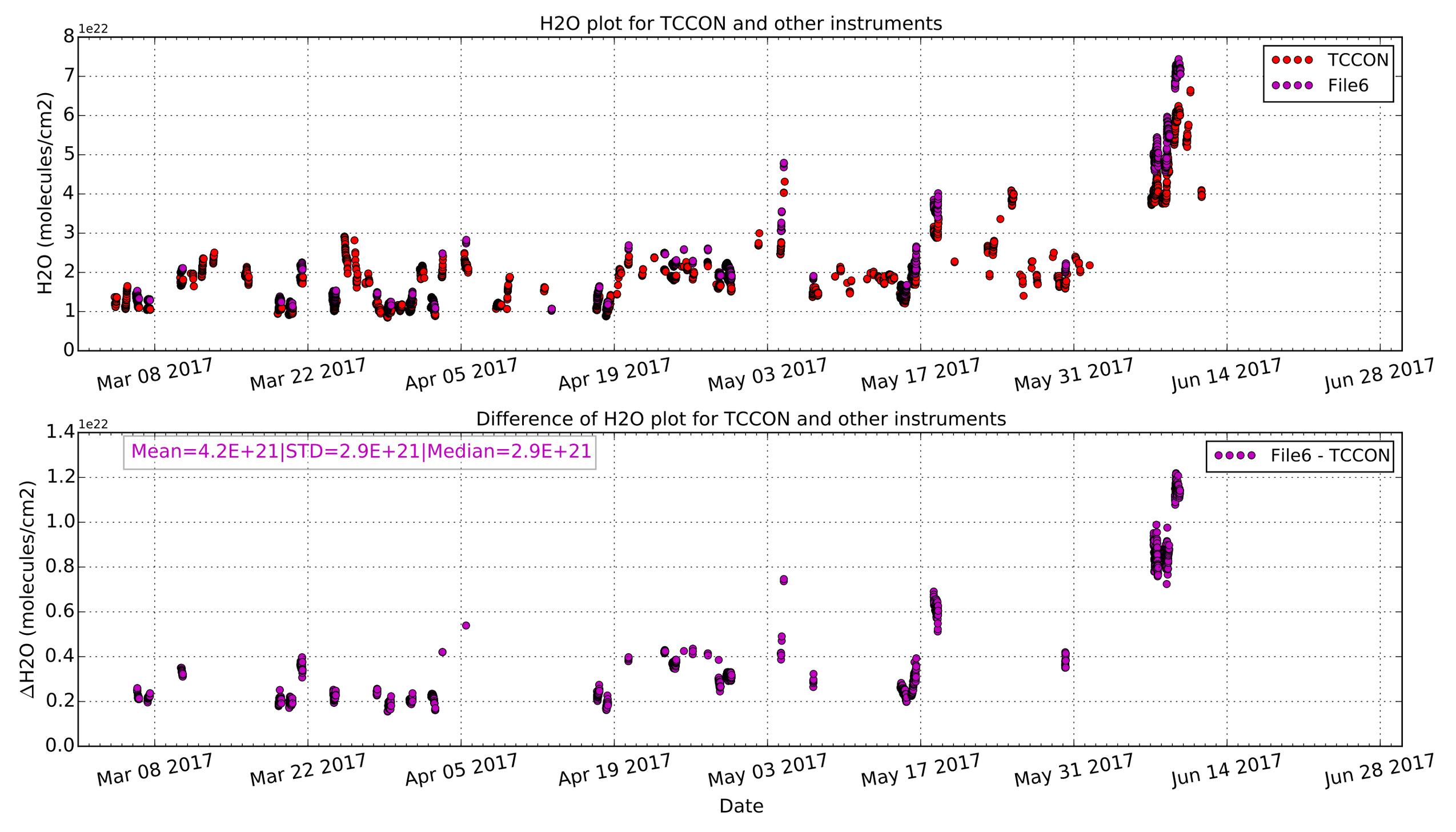
70
80
90
100
110
120


O2 plot for TCCON and other instruments
1e24
4.65
4.60
4.55
4.50
4.45
4.40
4.35
O2 (molecules/cm2)
TCCON
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of O2 plot for TCCON and other instruments
1e23
Mean=3.8E+21|STD=1.4E+22|Median=3.2E+21
File6 - TCCON
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
ΔO2 (molecules/cm2)
Date

Correlation plot for O2 between TCCON and File6




Correlation plot for O2 between TCCON and File6
1e24
-1.9E+22 + 1.0051*x
R=0.9591, stderr=0.0073
zero line
March 2017
April 2017
May 2017
June 2017
File6 O2 (molecules/cm2)
TCCON O2 (molecules/cm2)
1e24
4.65
4.60
4.55
4.50
4.45
4.40
4.35
4.35
4.40
4.45
4.50
4.55
4.60
4.65


H2O plot for TCCON and other instruments
1e22
H2O (molecules/cm2)
TCCON
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of H2O plot for TCCON and other instruments
Mean=4.2E+21|STD=2.9E+21|Median=2.9E+21
File6 - TCCON
ΔH2O (molecules/cm2)
Date

Correlation plot for H2O between TCCON and File6

-8.6E+19 + 1.1970*x
R=0.9997, stderr=0.0007
zero line

1e22

File6 H2O (molecules/cm2)

TCCON H2O (molecules/cm2)

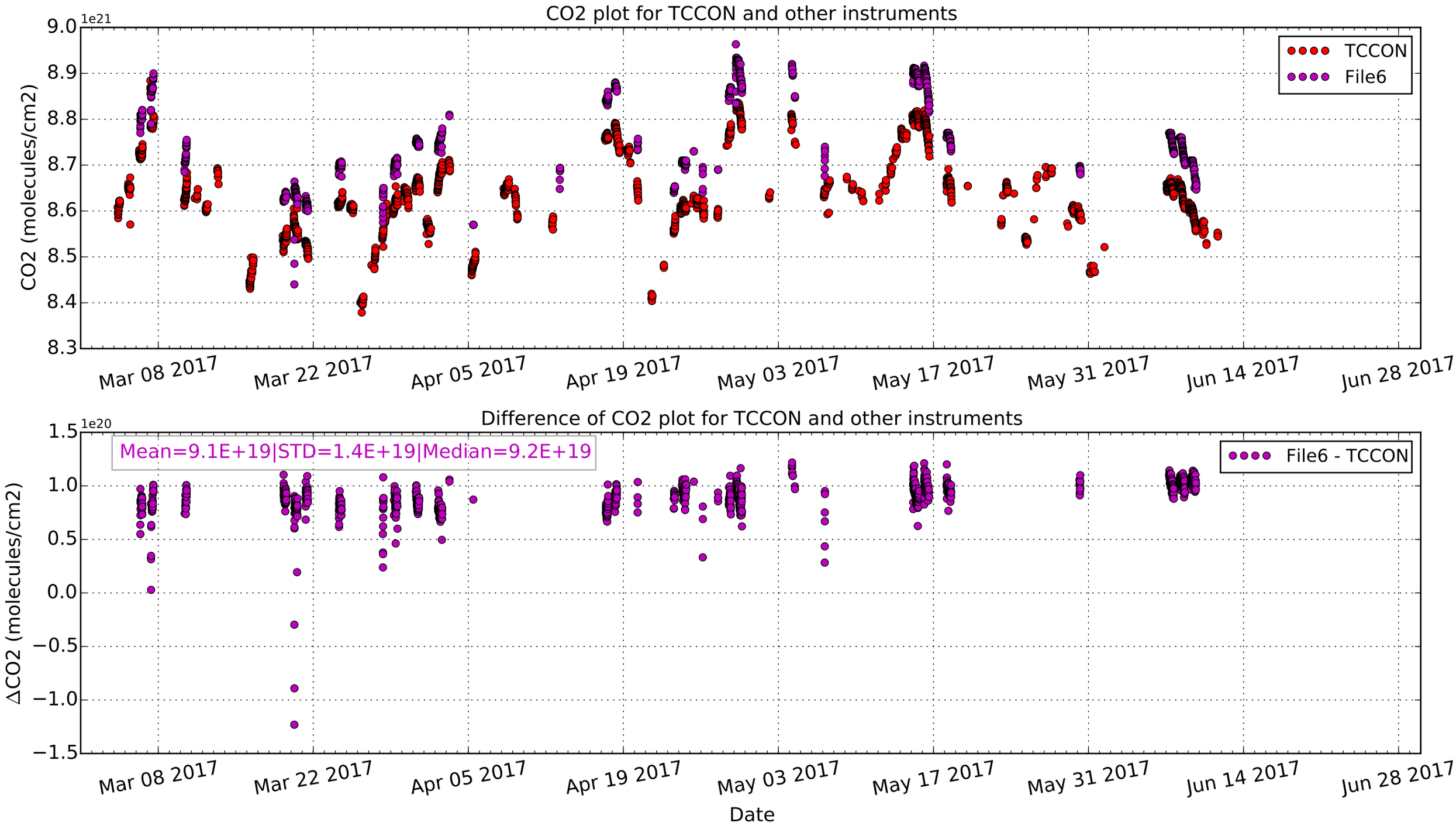
1e22

Correlation plot for H2O between TCCON and File6

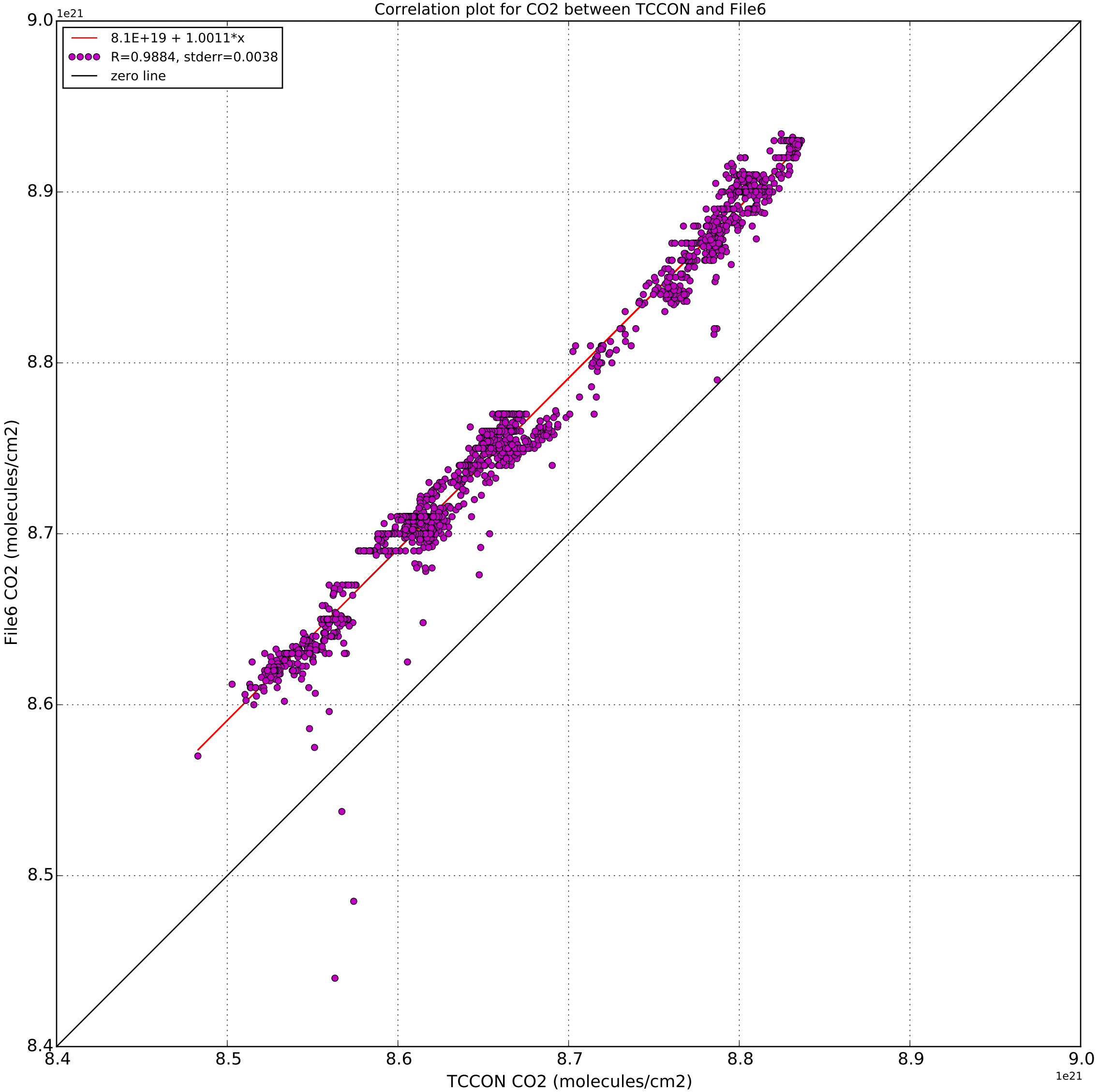
-8.6E+19 + 1.1970*x
R=0.9997, stderr=0.0007
zero line
March 2017
April 2017
May 2017
June 2017

File6 H2O (molecules/cm2)
1e22

TCCON H2O (molecules/cm2)
1e22


CO2 plot for TCCON and other instruments
1e21
9.0
8.9
8.8
8.7
8.6
8.5
8.4
8.3
CO2 (molecules/cm2)
TCCON
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CO2 plot for TCCON and other instruments
1e20
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Mean=9.1E+19|STD=1.4E+19|Median=9.2E+19
File6 - TCCON
ΔCO2 (molecules/cm2)
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for CO2 between TCCON and File6

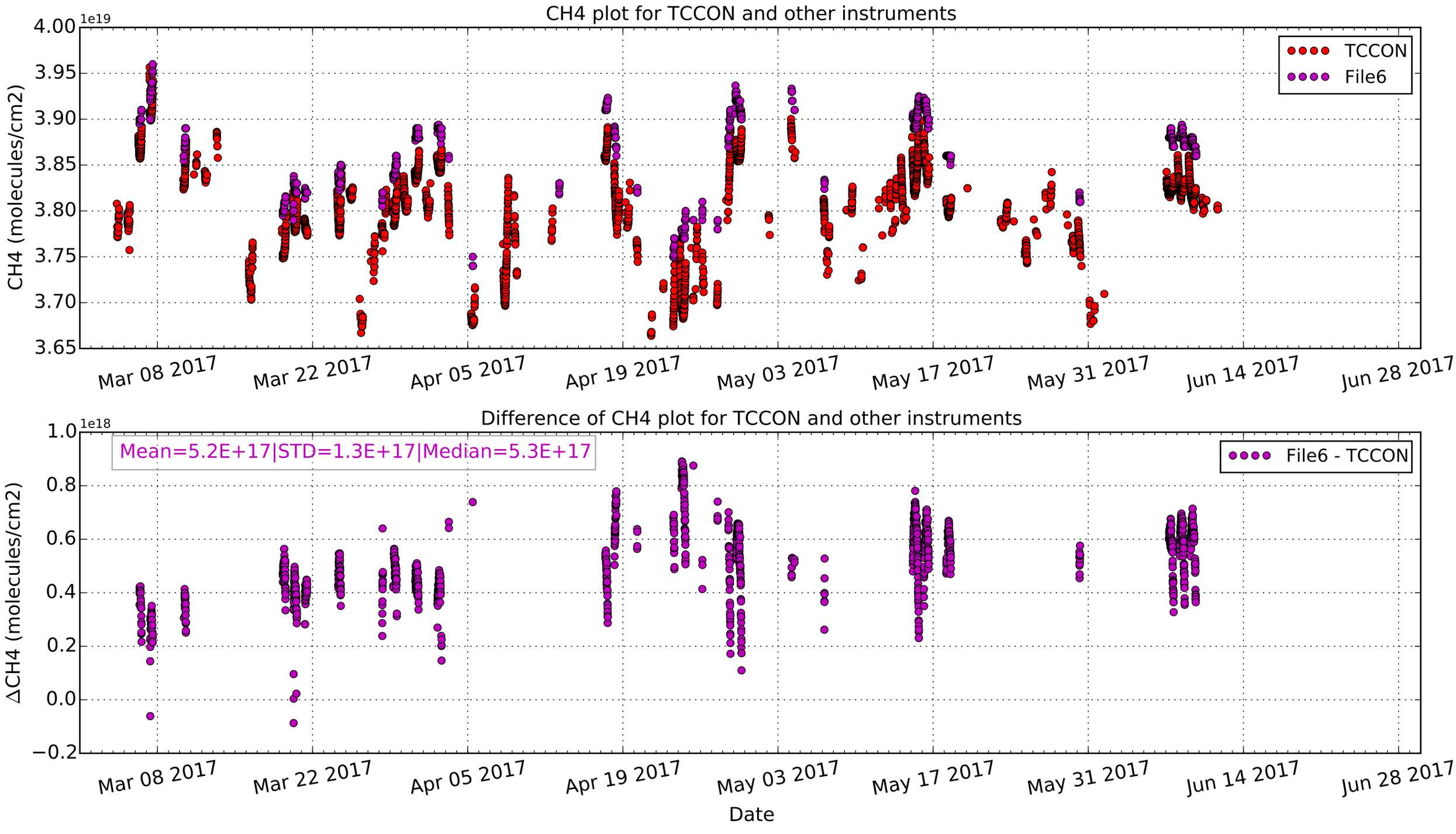


Correlation plot for CO2 between TCCON and File6

8.1E+19 + 1.0011*x
R=0.9884, stderr=0.0038
zero line
March 2017
April 2017
May 2017
June 2017

1e21
9.0
8.9
8.8
8.7
8.6
8.5
8.4
File6 CO2 (molecules/cm2)

8.4
8.5
8.6
8.7
8.8
8.9
9.0
1e21
TCCON CO2 (molecules/cm2)


CH4 plot for TCCON and other instruments
1e19
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
CH4 (molecules/cm2)
TCCON
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CH4 plot for TCCON and other instruments
1e18
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
ΔCH4 (molecules/cm2)
Mean=5.2E+17|STD=1.3E+17|Median=5.3E+17
File6 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for CH4 between TCCON and File6

5.4E+18 + 0.8731*x
R=0.9586, stderr=0.0064
zero line

File6 CH4 (molecules/cm2)
1e19
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65

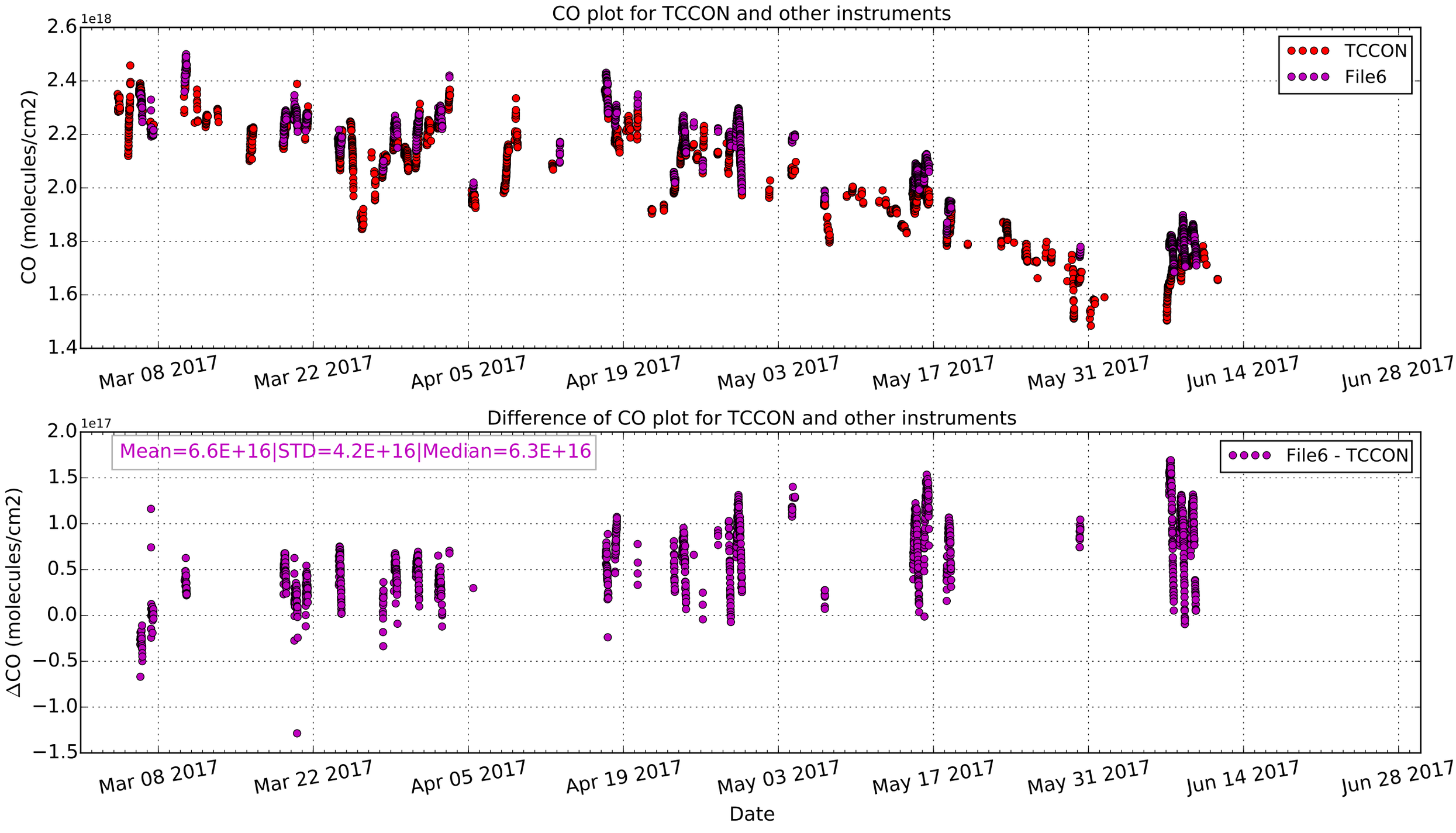
TCCON CH4 (molecules/cm2)
1e19
3.65
3.70
3.75
3.80
3.85
3.90
3.95
4.00

Correlation plot for CH4 between TCCON and File6

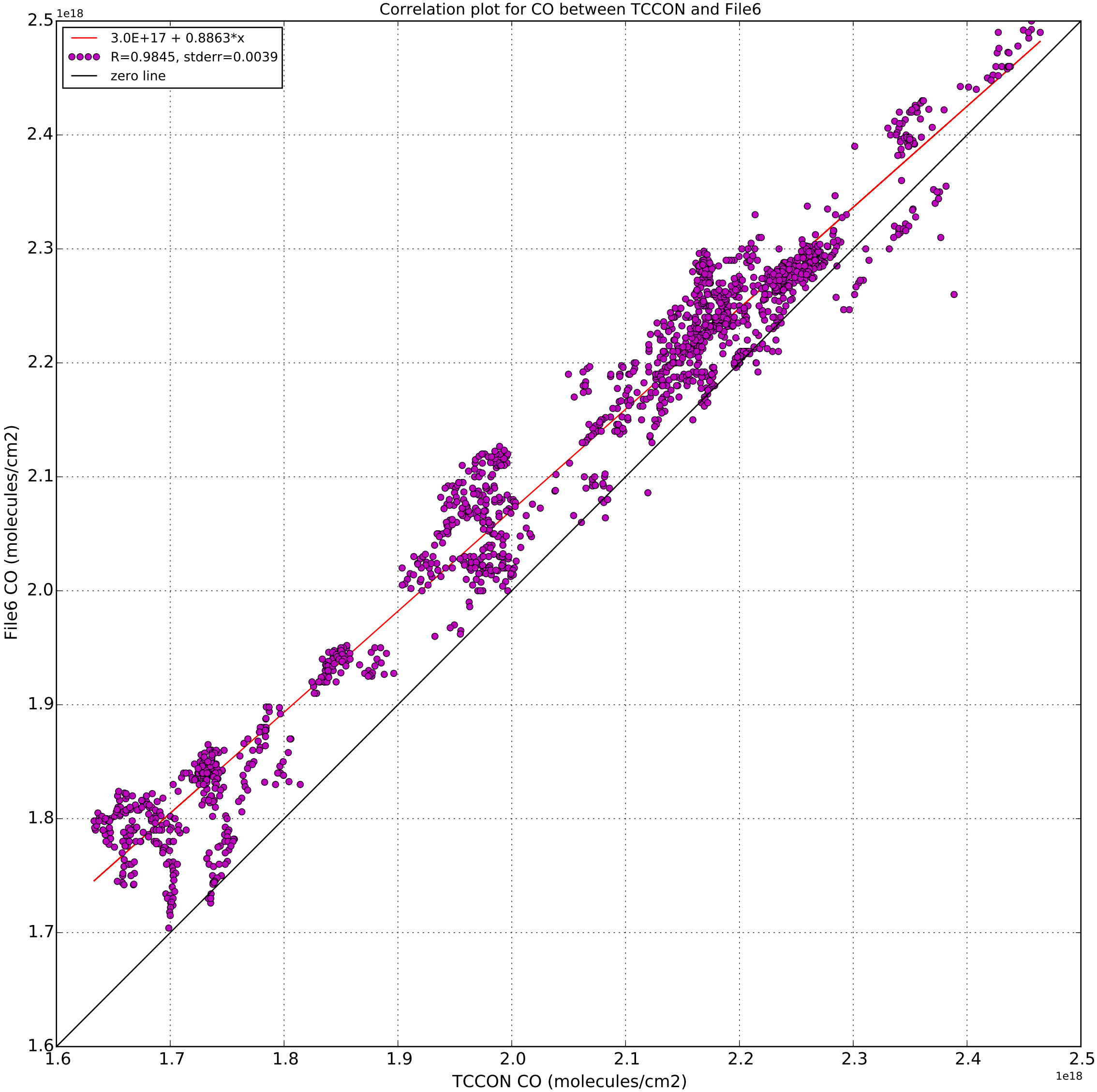
5.4E+18 + 0.8731*x
R=0.9586, stderr=0.0064
zero line
March 2017
April 2017
May 2017
June 2017

File6 CH4 (molecules/cm2)
1e19
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65

3.65
3.70
3.75
3.80
3.85
3.90
3.95
4.00
1e19
TCCON CH4 (molecules/cm2)


CO plot for TCCON and other instruments
1e18
2.6
2.4
2.2
2.0
1.8
1.6
1.4
CO (molecules/cm2)
TCCON
File6
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Difference of CO plot for TCCON and other instruments
1e17
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
ΔCO (molecules/cm2)
Mean=6.6E+16|STD=4.2E+16|Median=6.3E+16
File6 - TCCON
Mar 08 2017
Mar 22 2017
Apr 05 2017
Apr 19 2017
May 03 2017
May 17 2017
May 31 2017
Jun 14 2017
Jun 28 2017
Date

Correlation plot for CO between TCCON and File6



Correlation plot for CO between TCCON and File6