

Supplementary materials

Seamless mapping of long-term (2010-2020) daily global XCO₂ and XCH₄ from GOSAT, OCO-2, and CAMS-EGG4 with a spatiotemporally self-supervised fusion method

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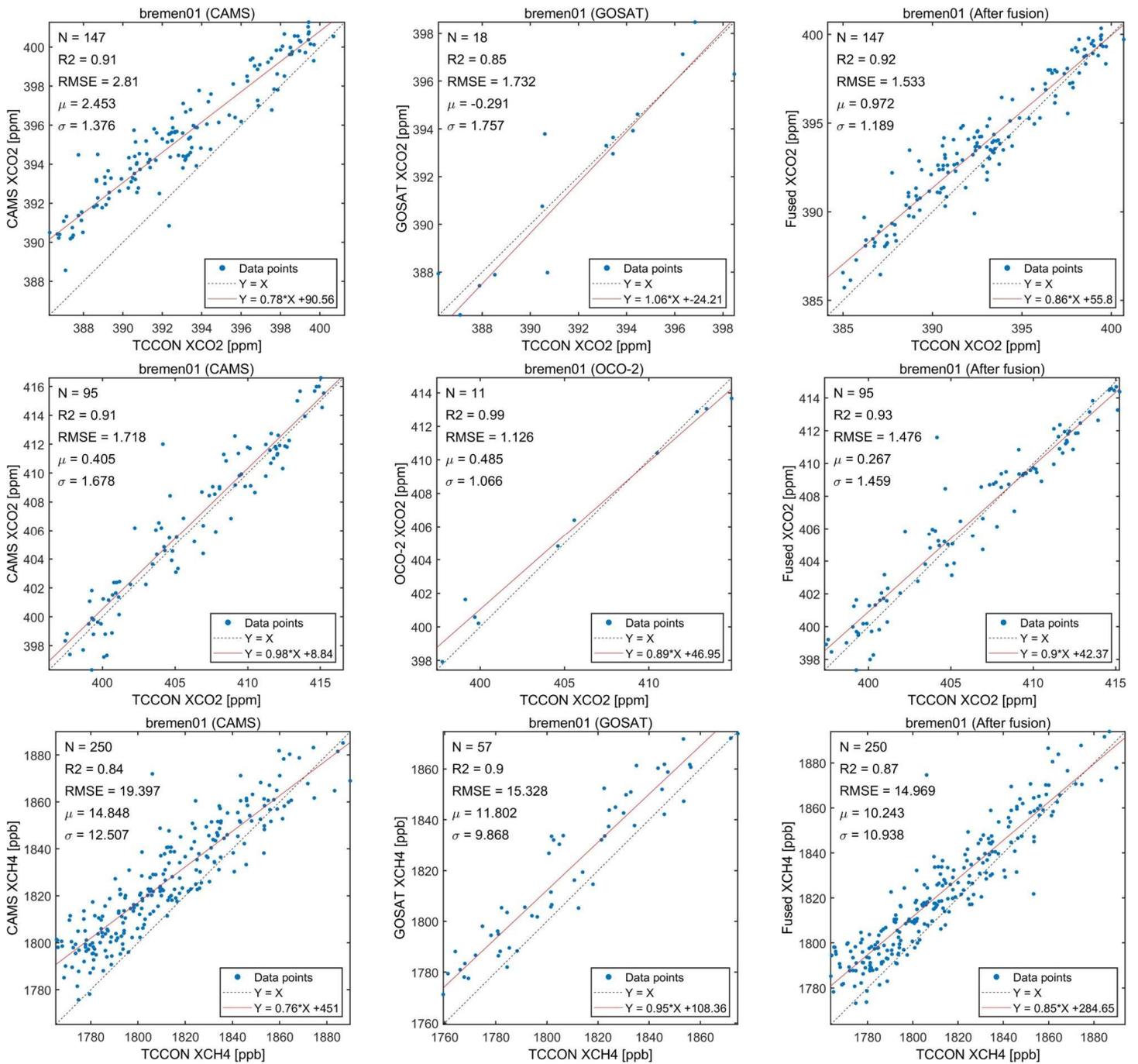


Figure S1. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on bremen01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

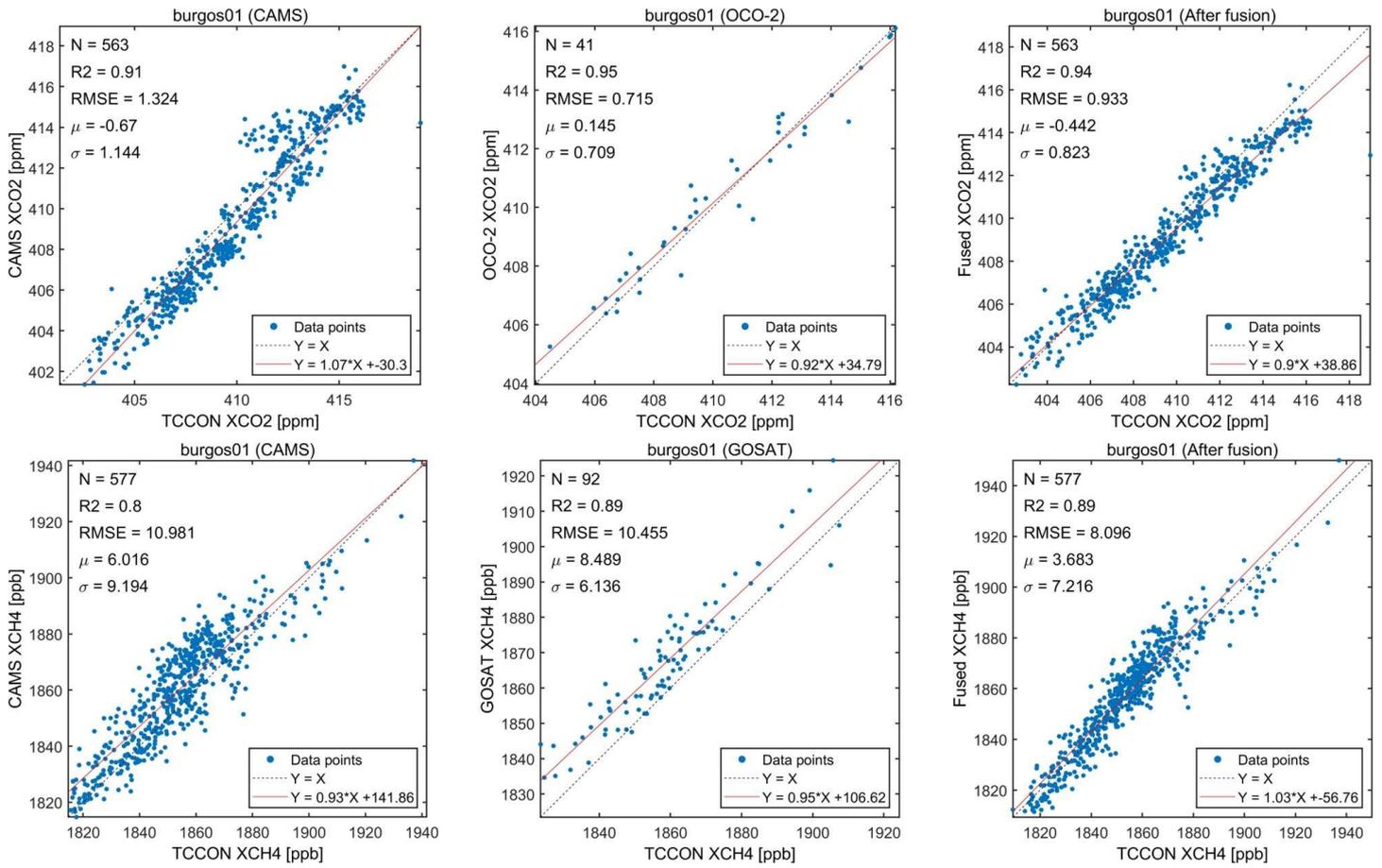


Figure S2. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on burgos01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

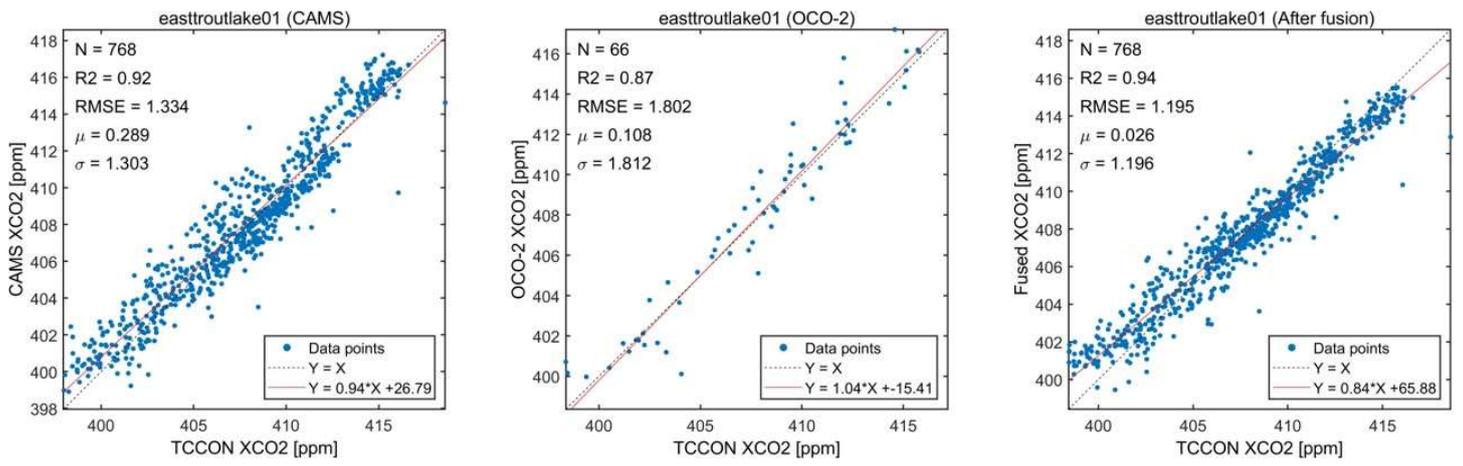


Figure S3. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), OCO-2 (middle), and fused results (right) on easttroutlake01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON XCO₂; Y: CAMS-EGG4/OCO-2/fused XCO₂. Unit: ppm to XCO₂ for RMSE, μ , and σ .

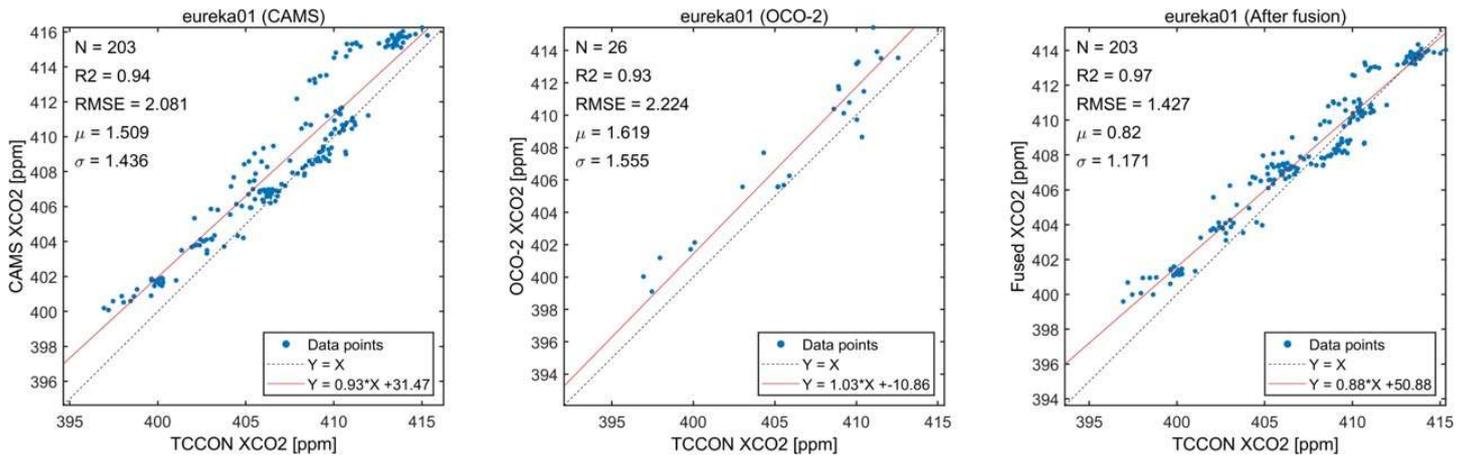


Figure S4. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), OCO-2 (middle), and fused results (right) on eureka01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON XCO₂; Y: CAMS-EGG4/OCO-2/fused XCO₂. Unit: ppm to XCO₂ for RMSE, μ , and σ .

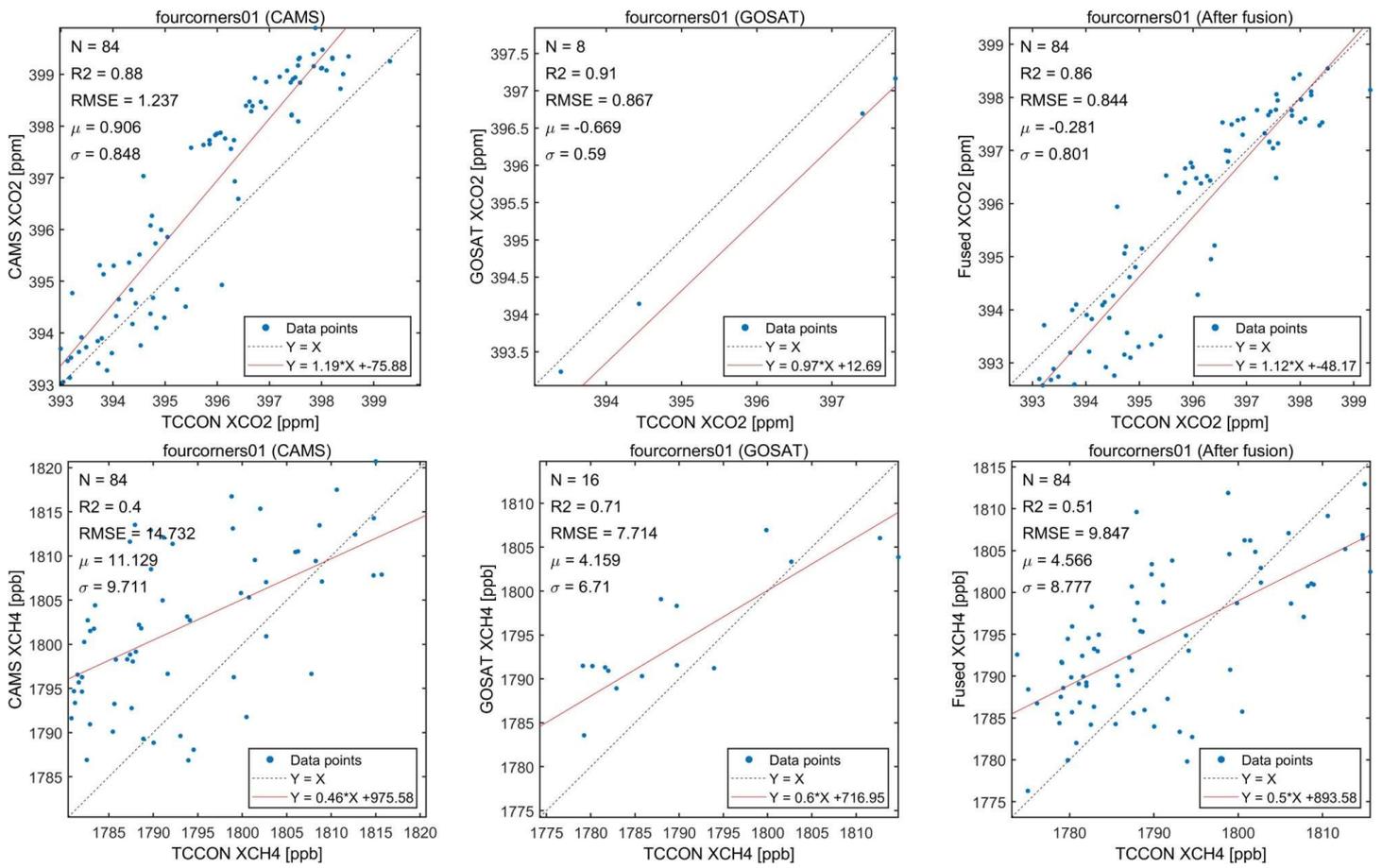


Figure S5. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT (middle), and fused results (right) on fourcorners01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

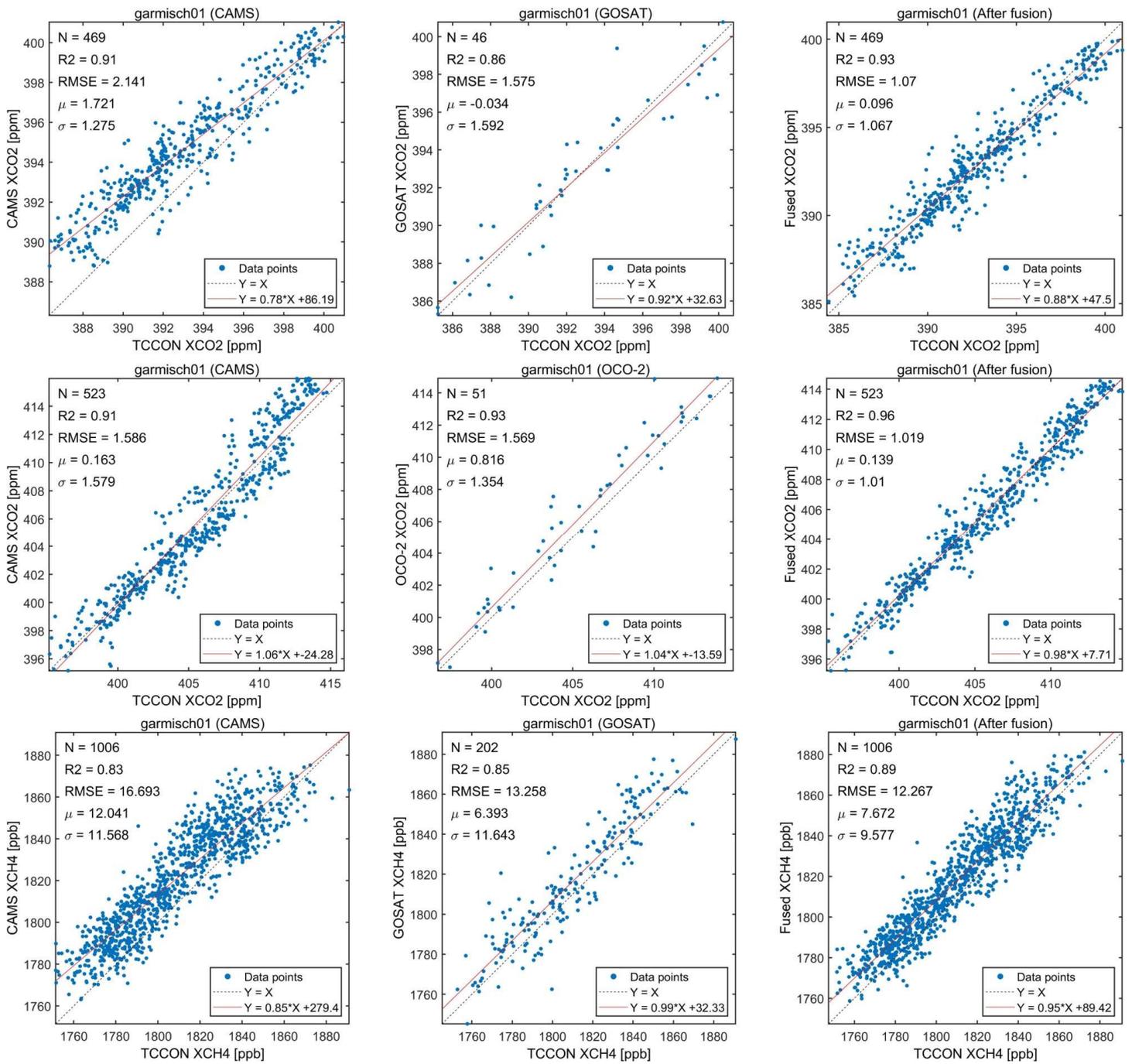


Figure S6. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on garmisch01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

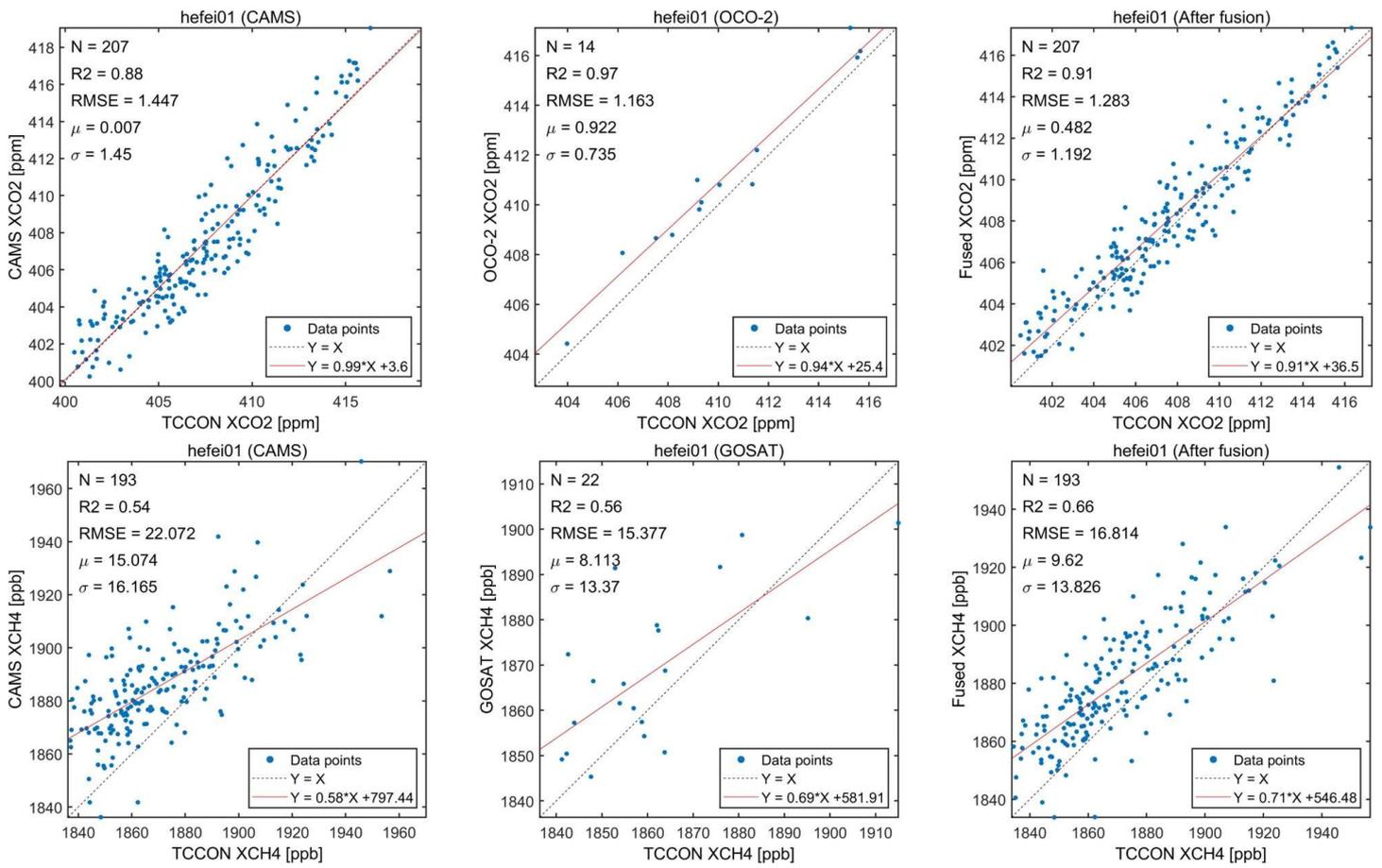


Figure S7. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on hefei01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

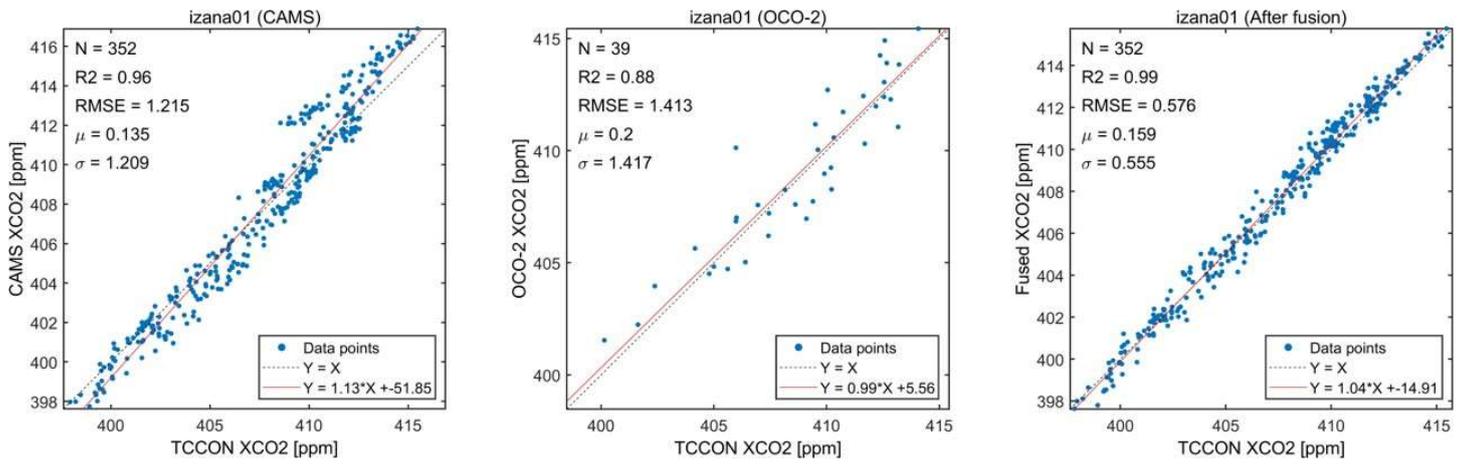


Figure S8. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), OCO-2 (middle), and fused results (right) on izana01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON XCO₂; Y: CAMS-EGG4/OCO-2/fused XCO₂. Unit: ppm to XCO₂ for RMSE, μ , and σ .

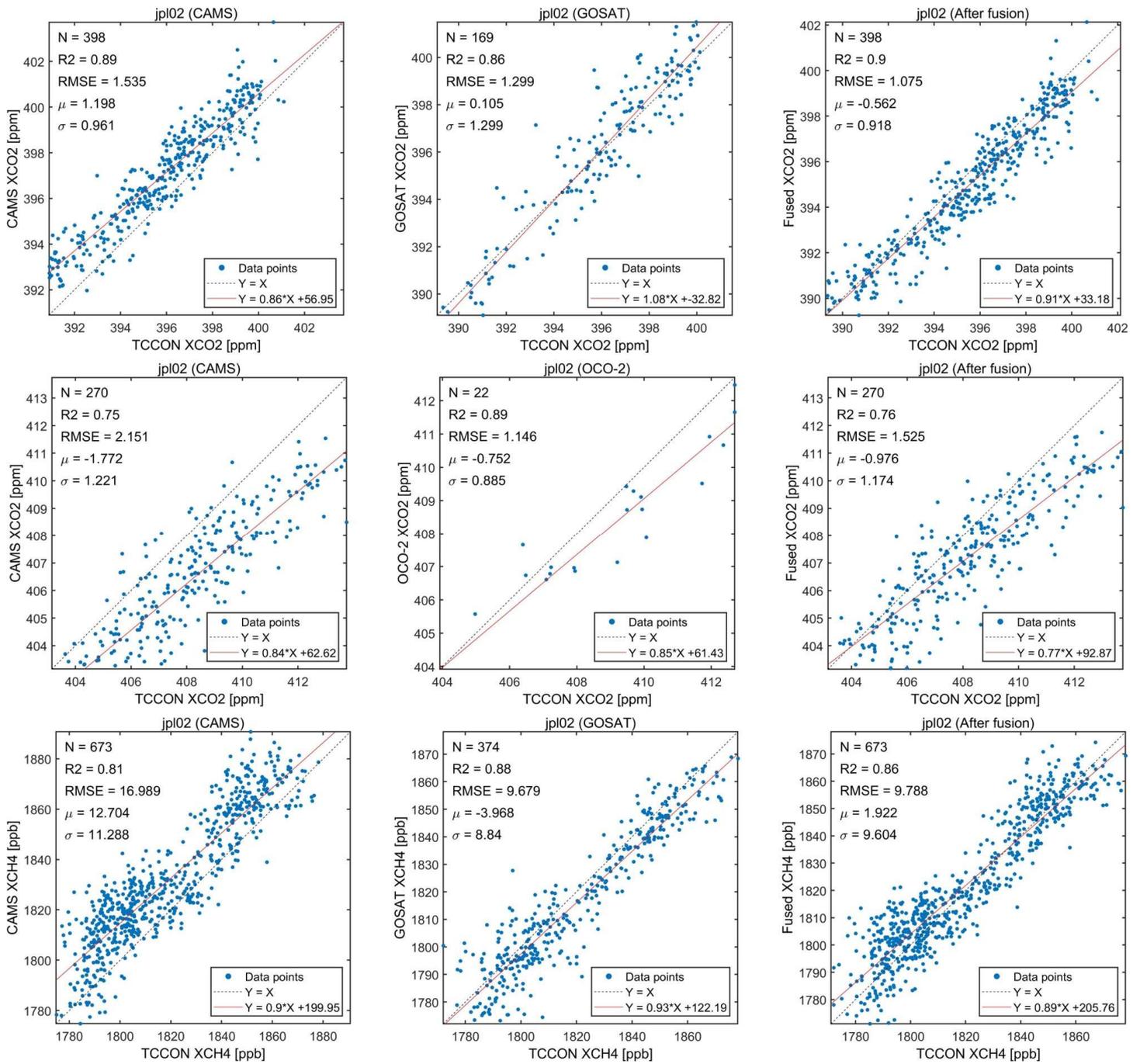


Figure S9. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on jpl02. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

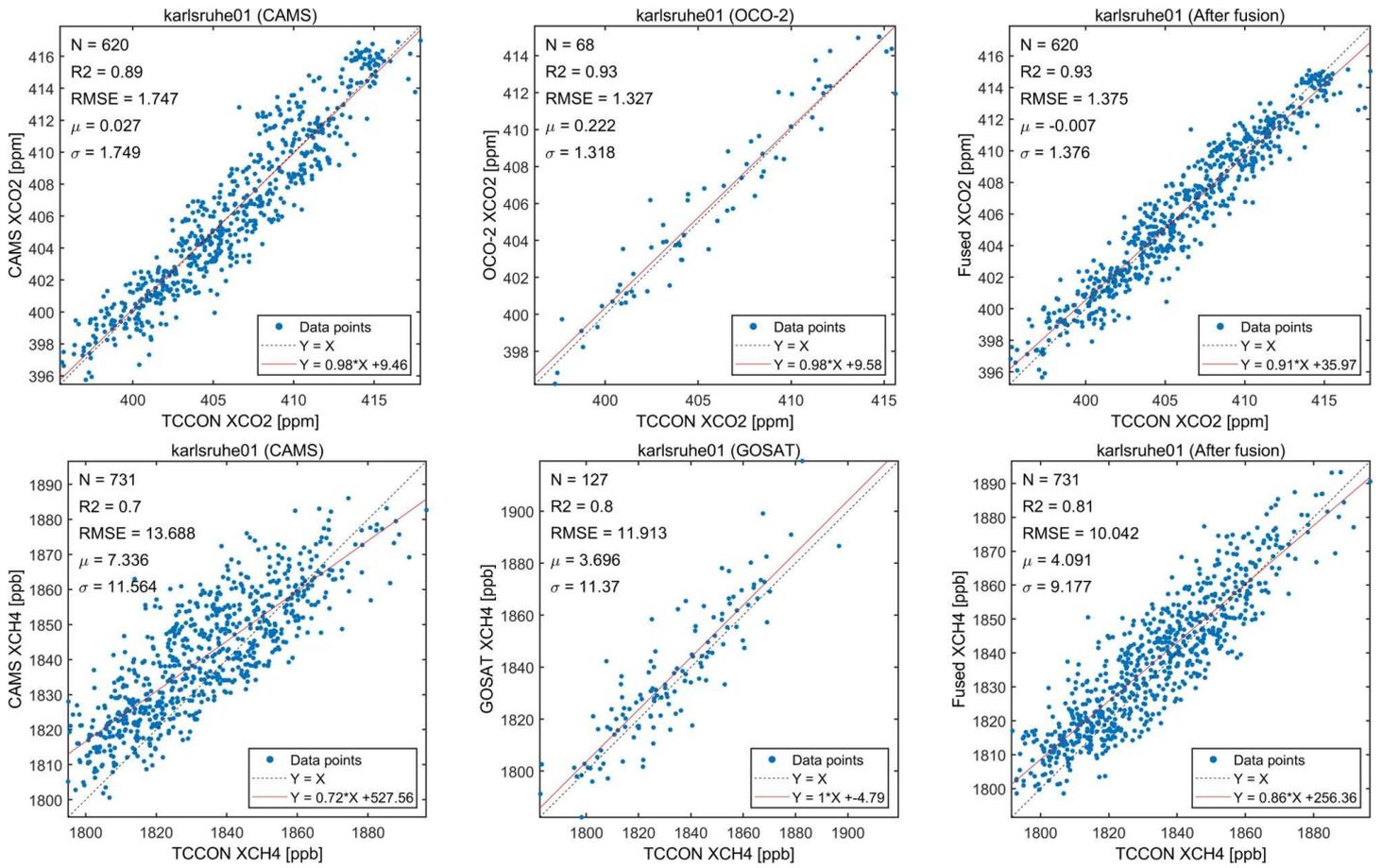


Figure S10. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on karlsruhe01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

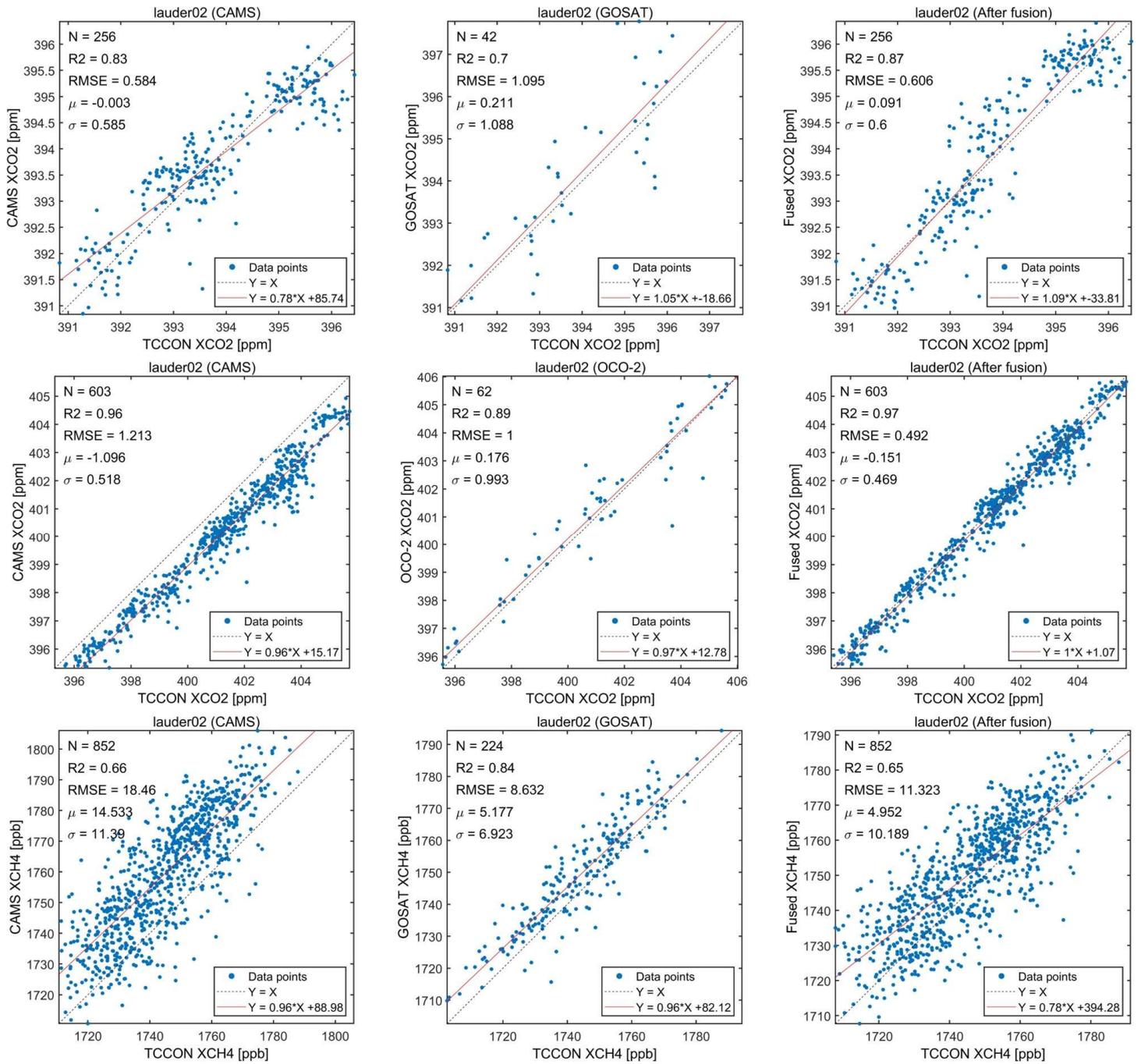


Figure S11. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on lauder02. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

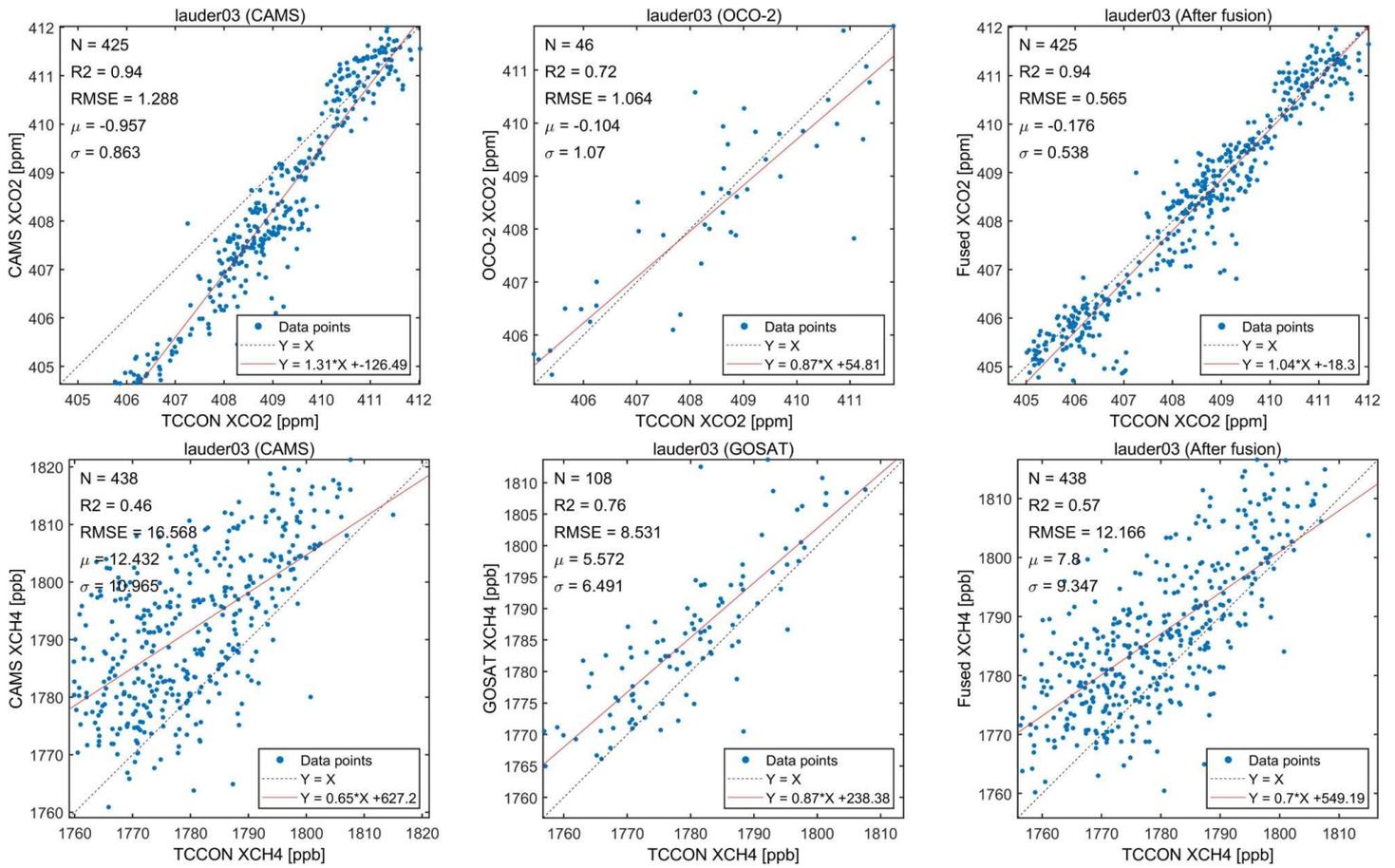


Figure S12. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on lauder03. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

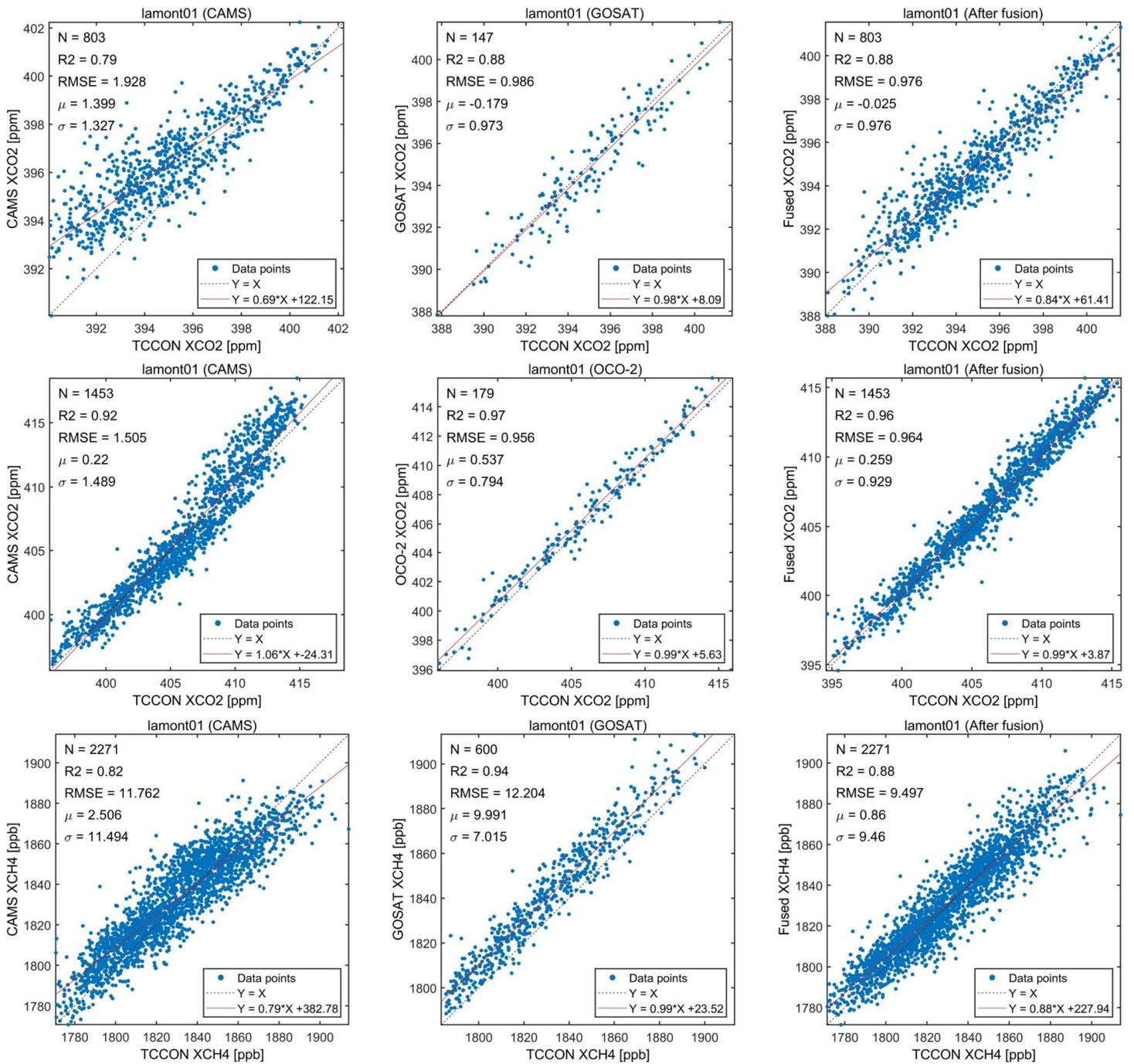


Figure S13. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on lamont01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

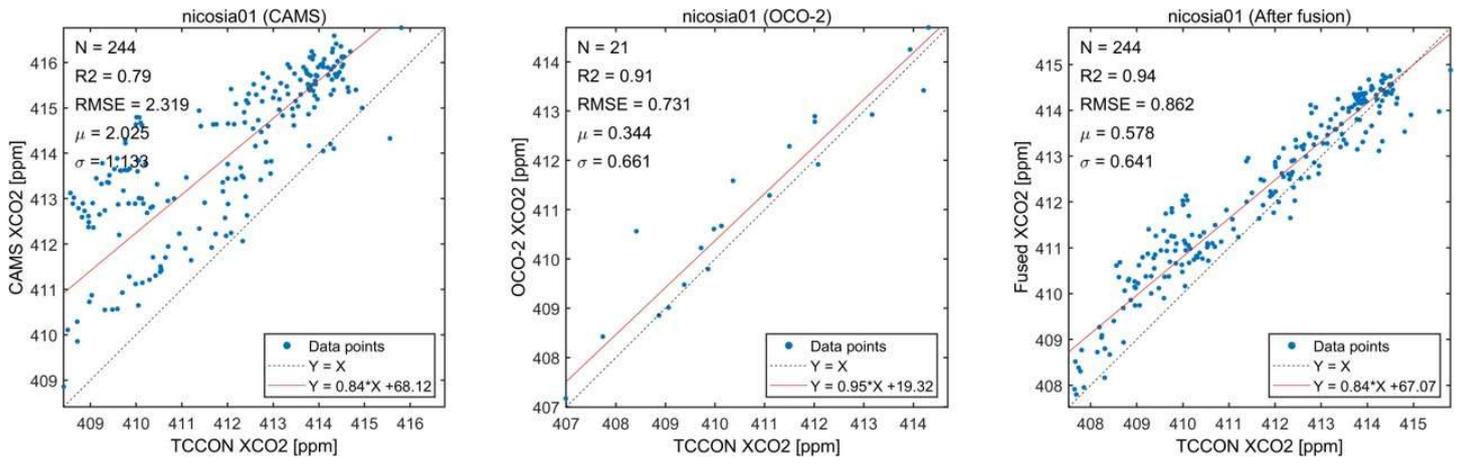


Figure S14. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), OCO-2 (middle), and fused results (right) on nicosia01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON XCO₂; Y: CAMS-EGG4/OCO-2/fused XCO₂. Unit: ppm to XCO₂ for RMSE, μ , and σ .

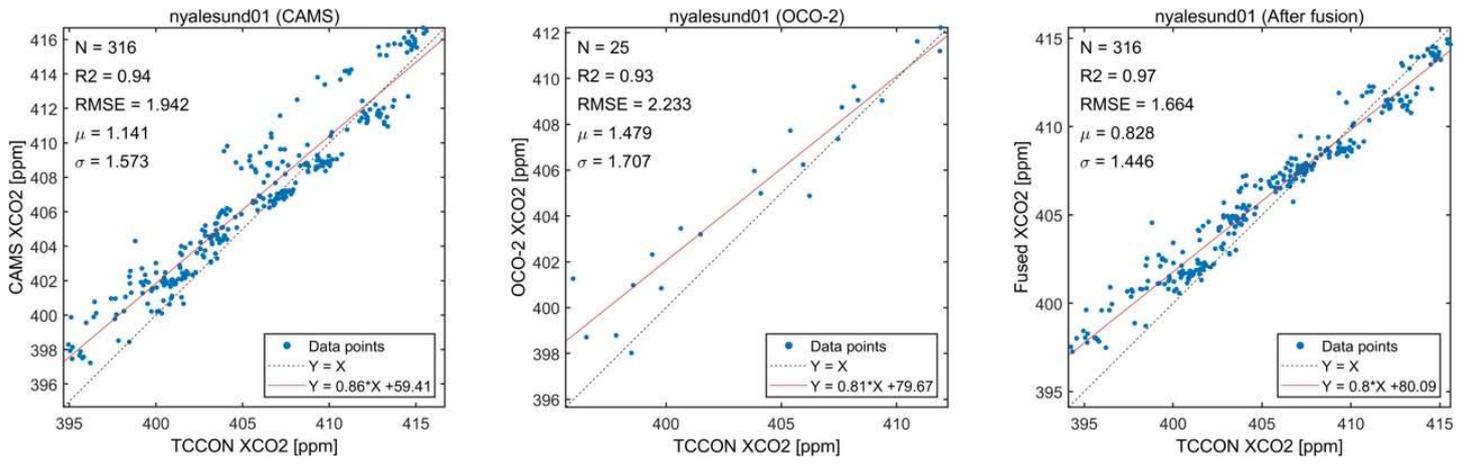


Figure S15. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), OCO-2 (middle), and fused results (right) on nyalesund01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON XCO₂; Y: CAMS-EGG4/OCO-2/fused XCO₂. Unit: ppm to XCO₂ for RMSE, μ , and σ .

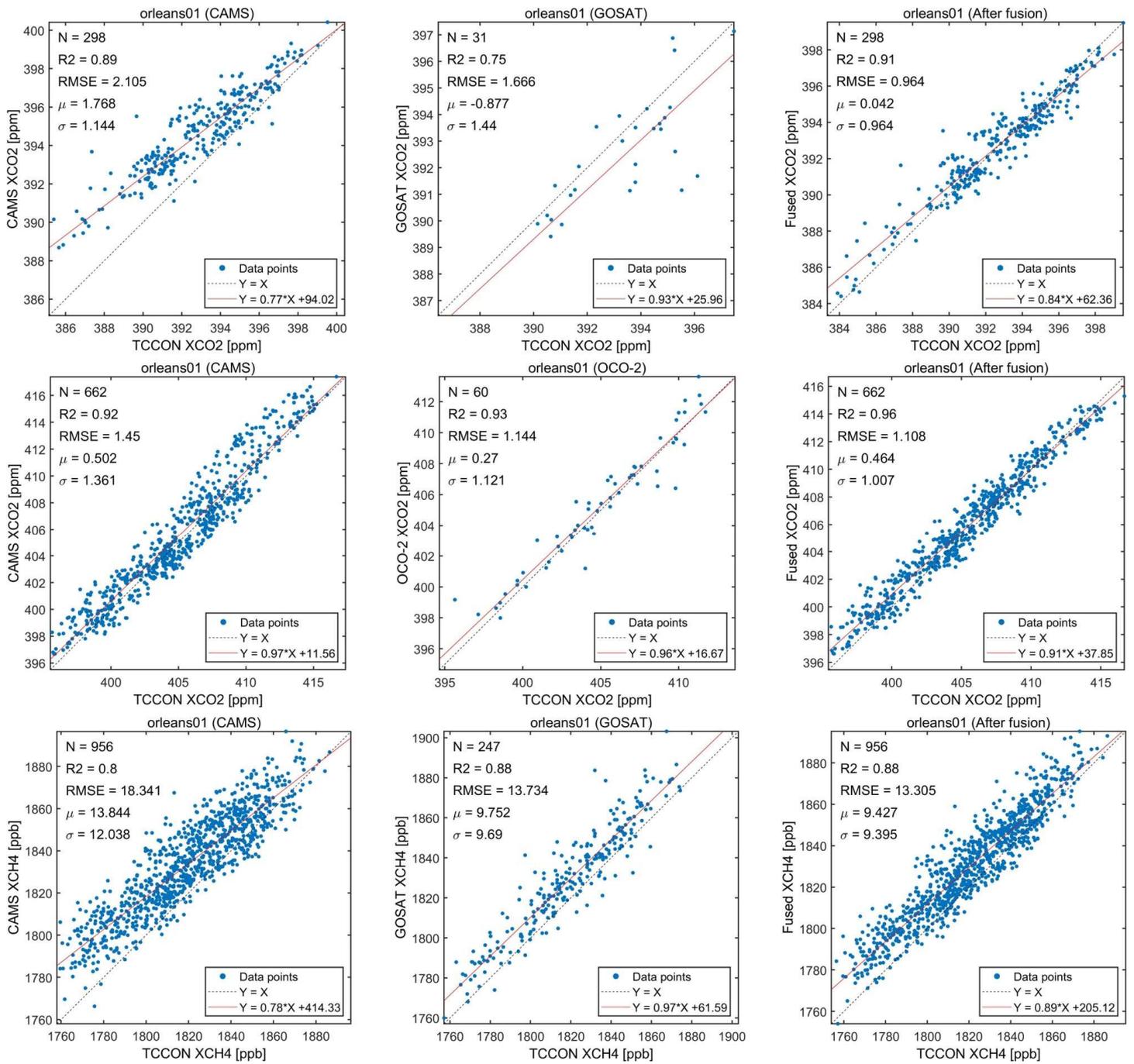


Figure S16. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on orleans01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

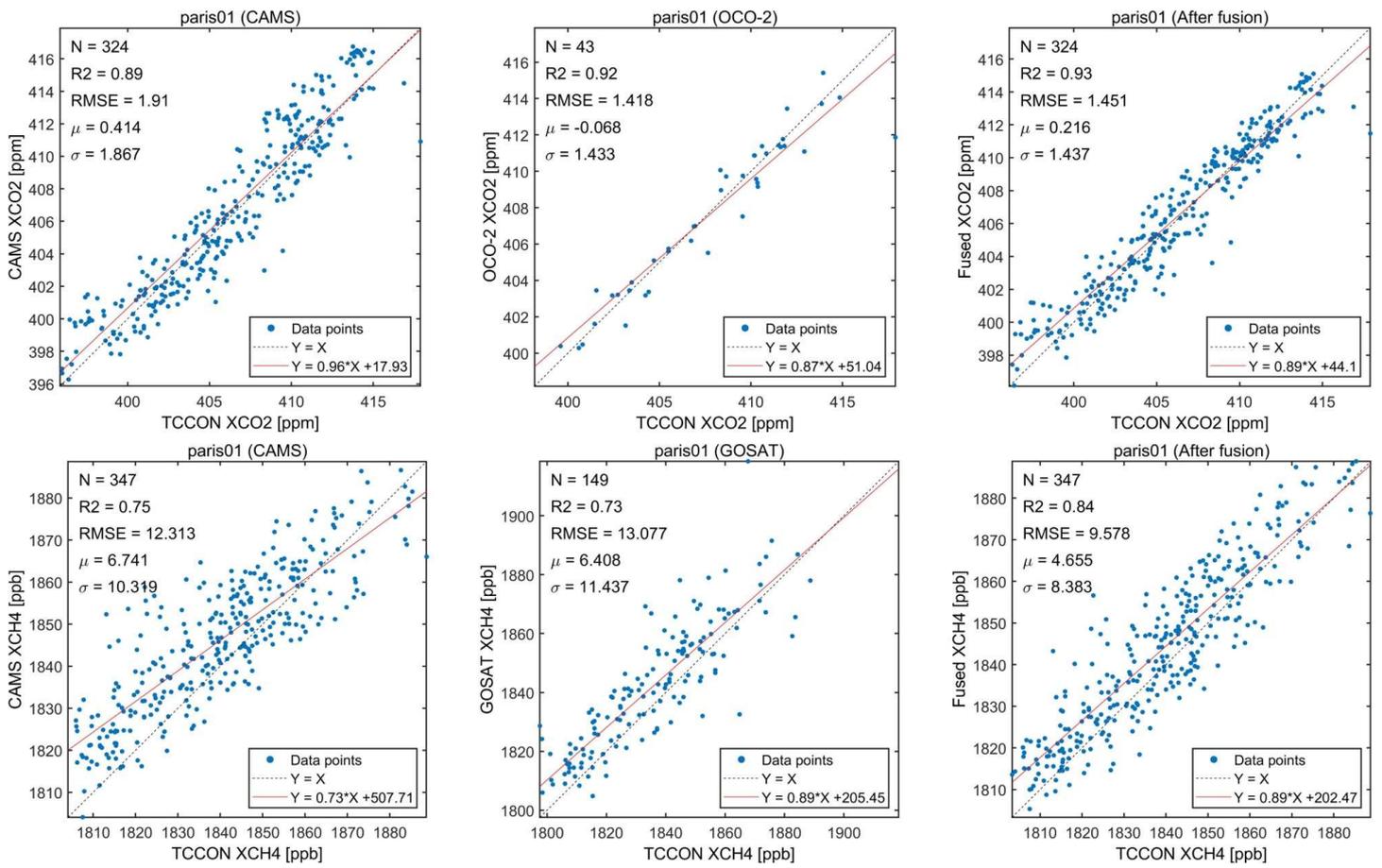


Figure S17. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on paris01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

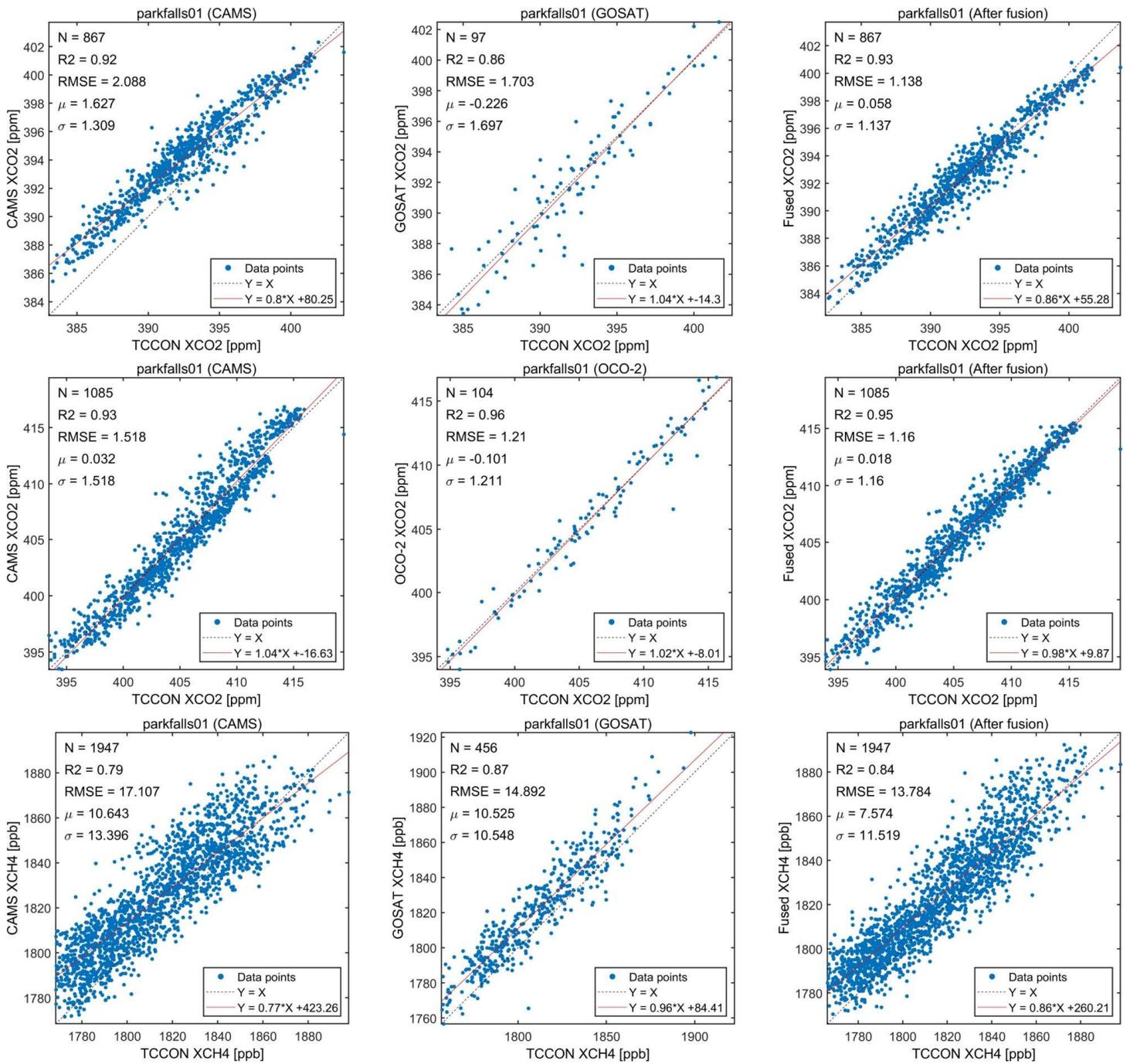


Figure S18. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on parkfalls01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

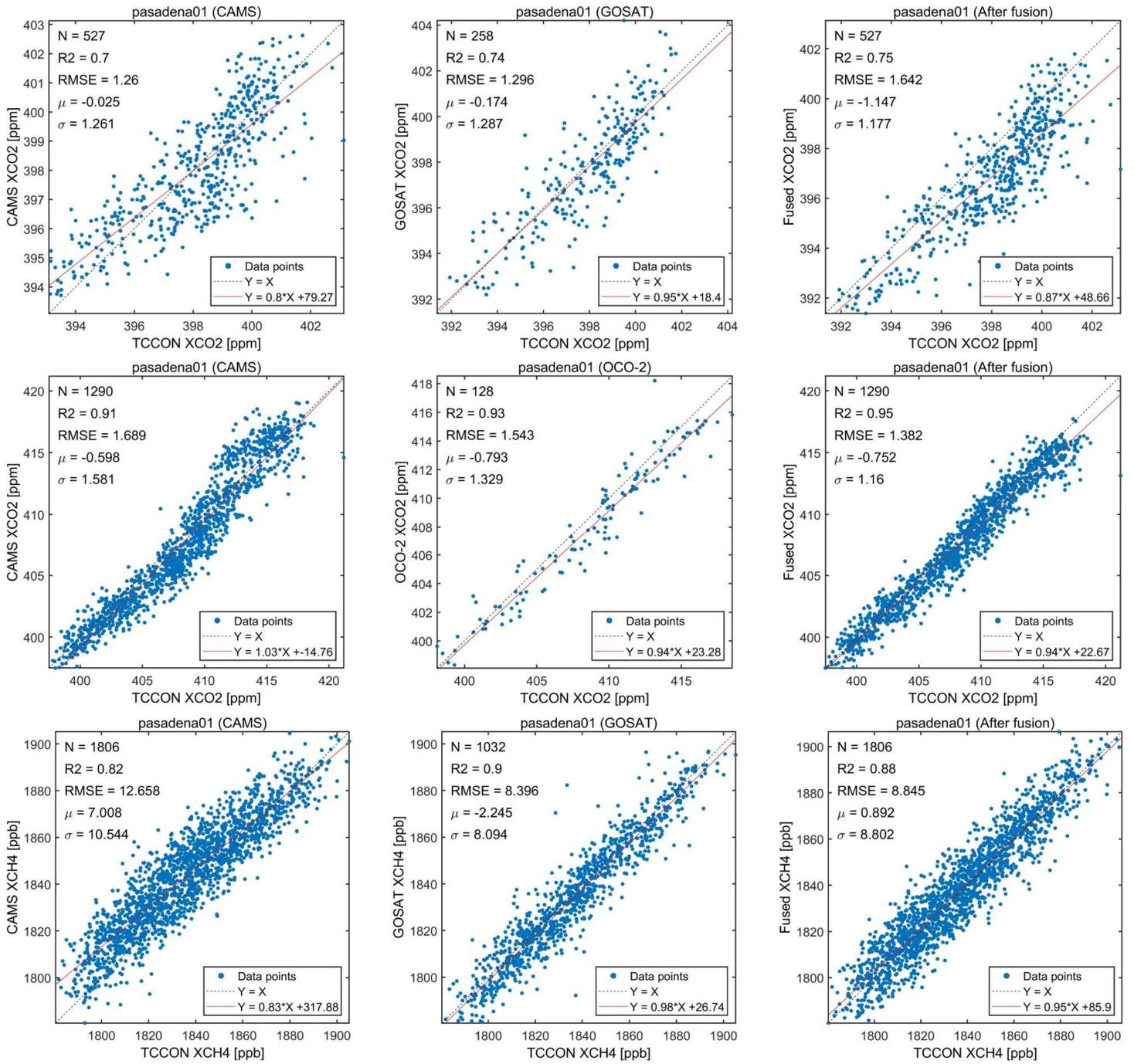


Figure S19. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on pasadena01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

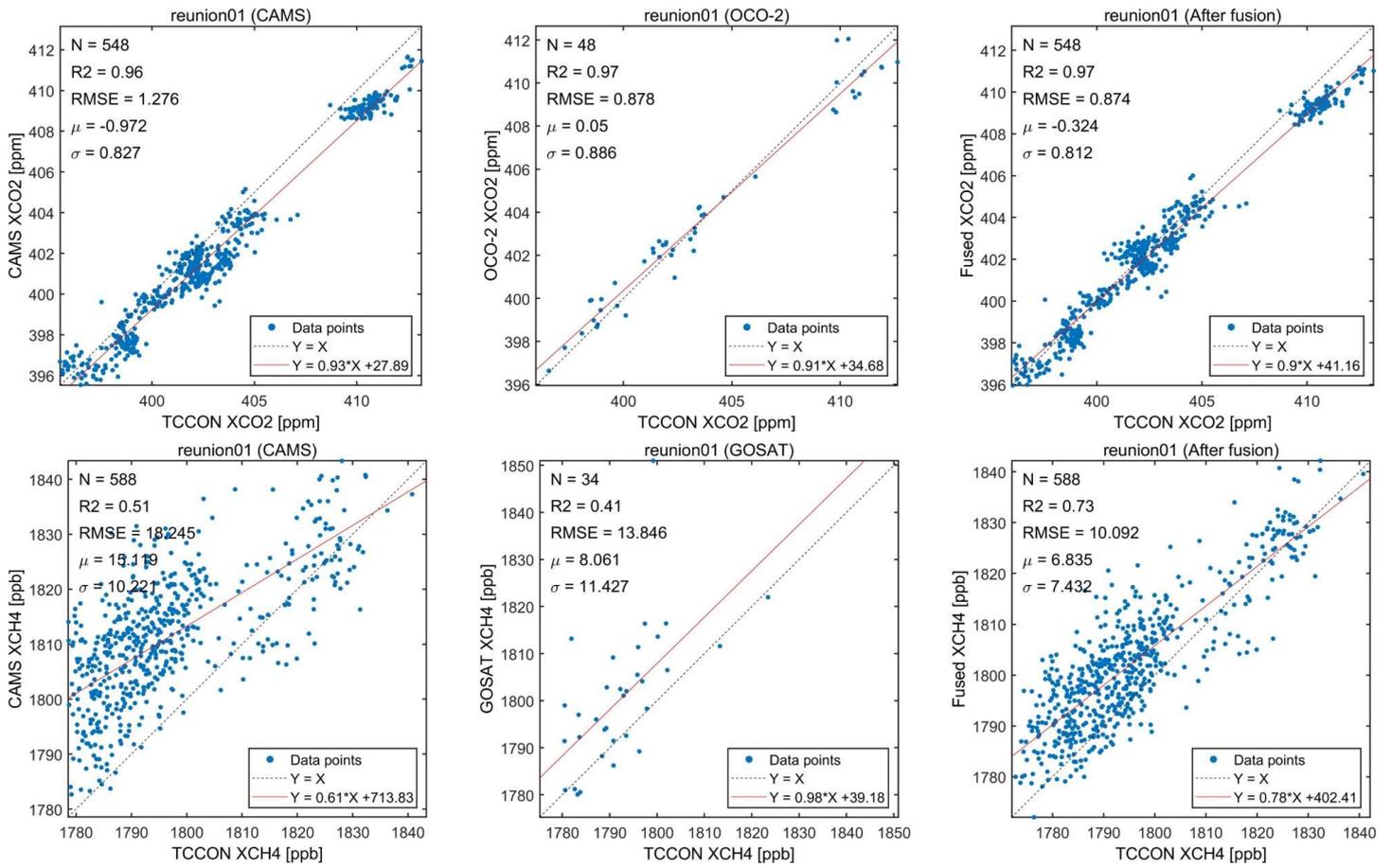


Figure S20. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on reunion01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

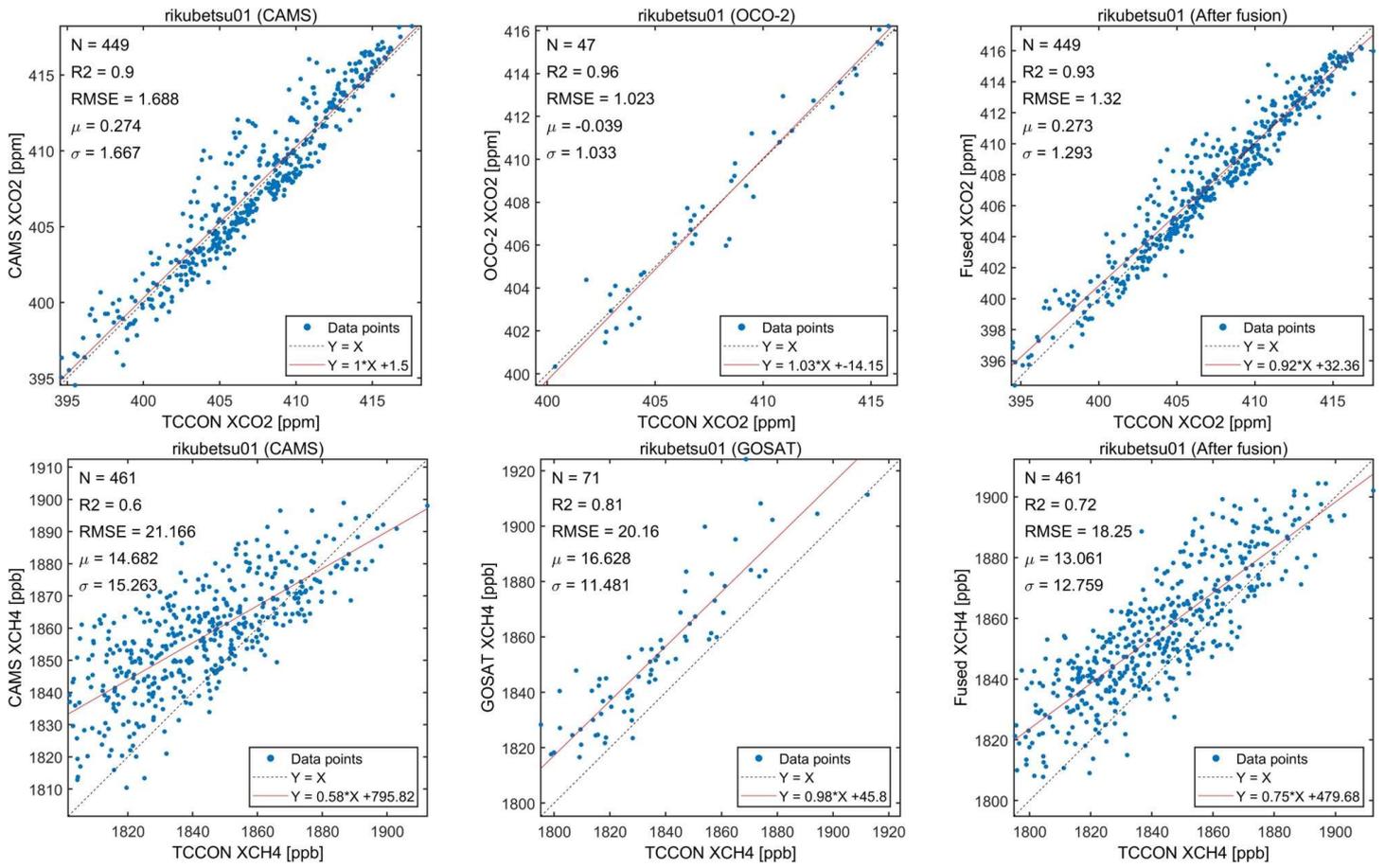


Figure S21. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on rikubetsu01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

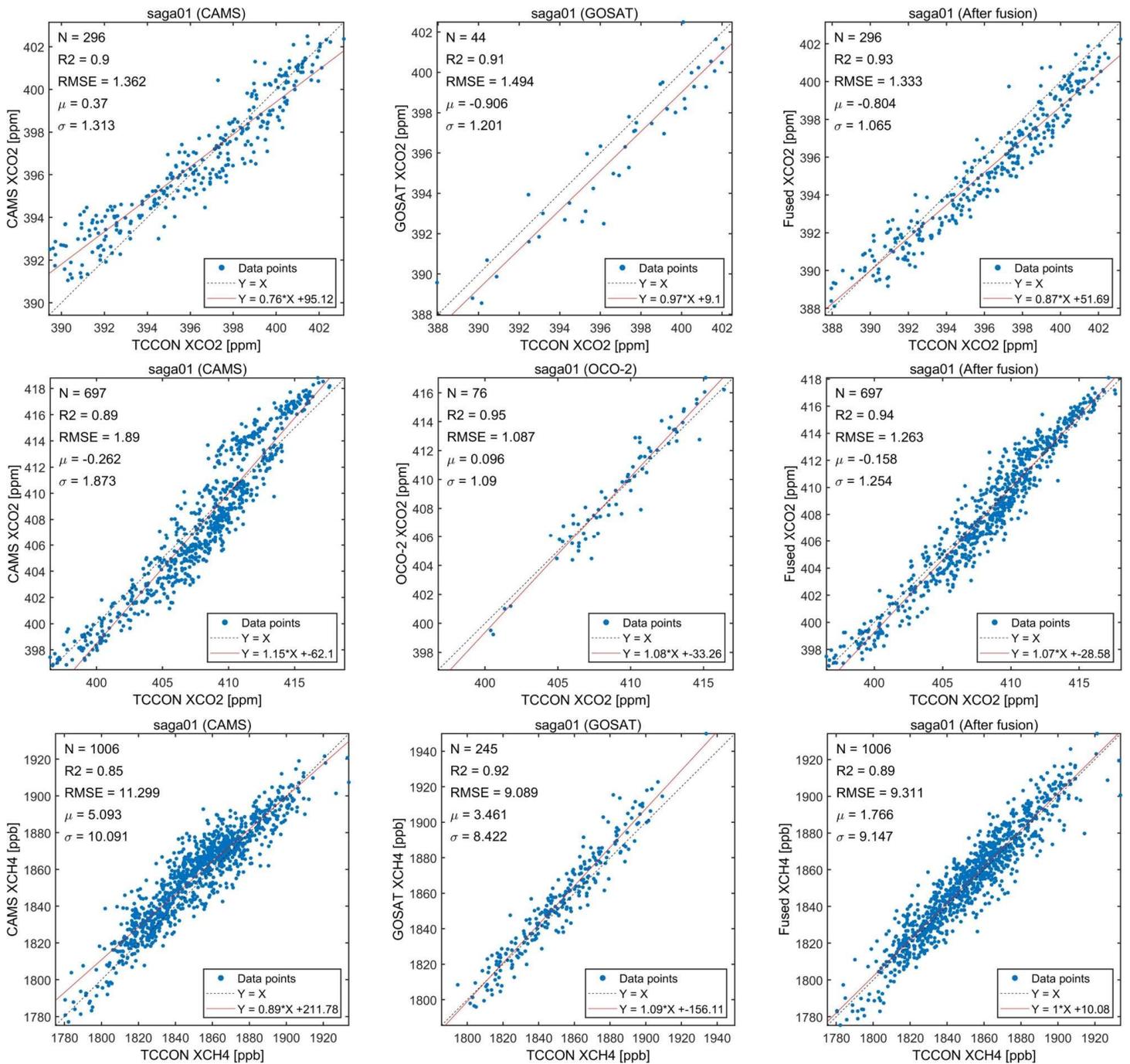


Figure S22. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on saga01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

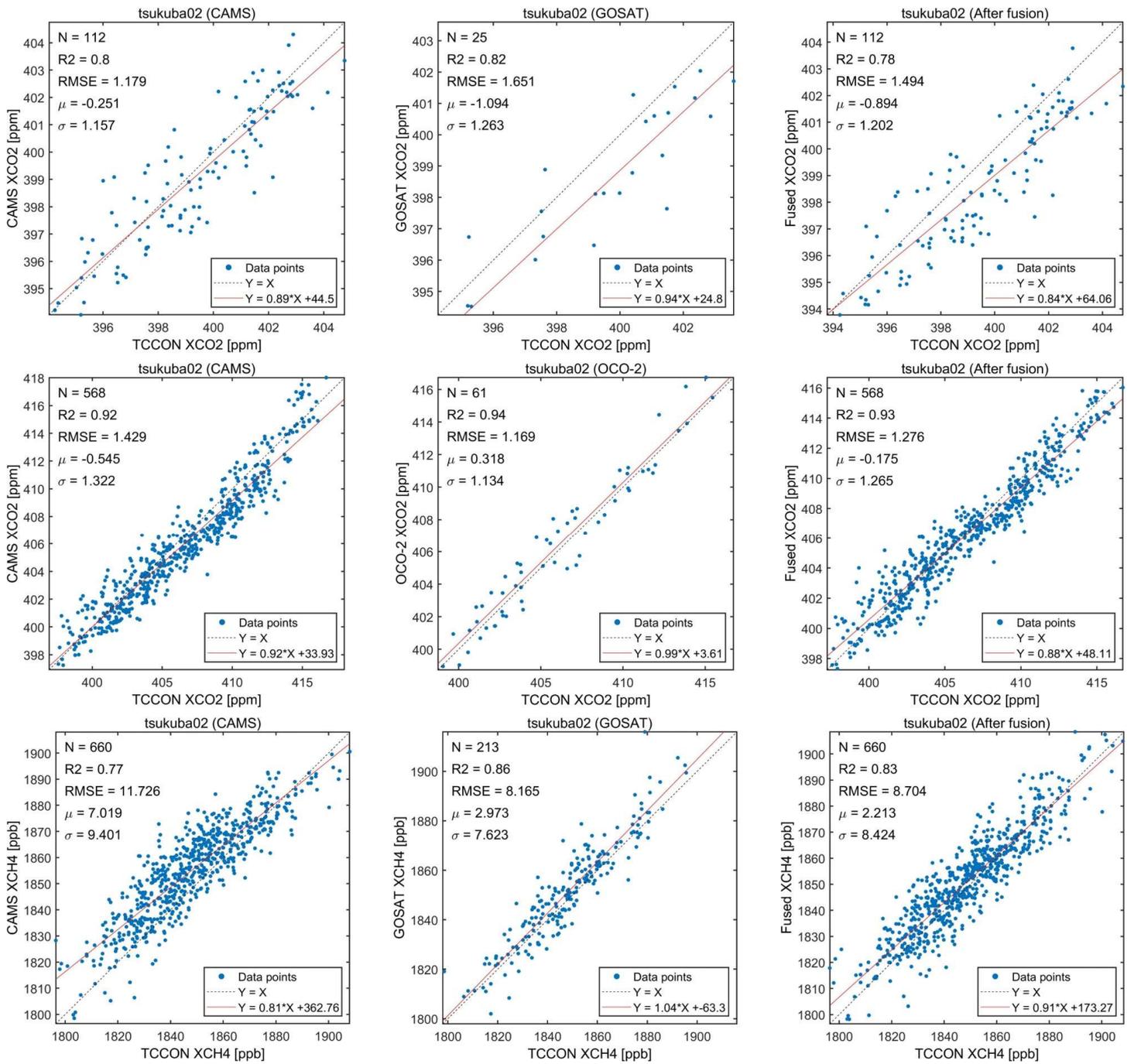


Figure S23. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on tsukuba02. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

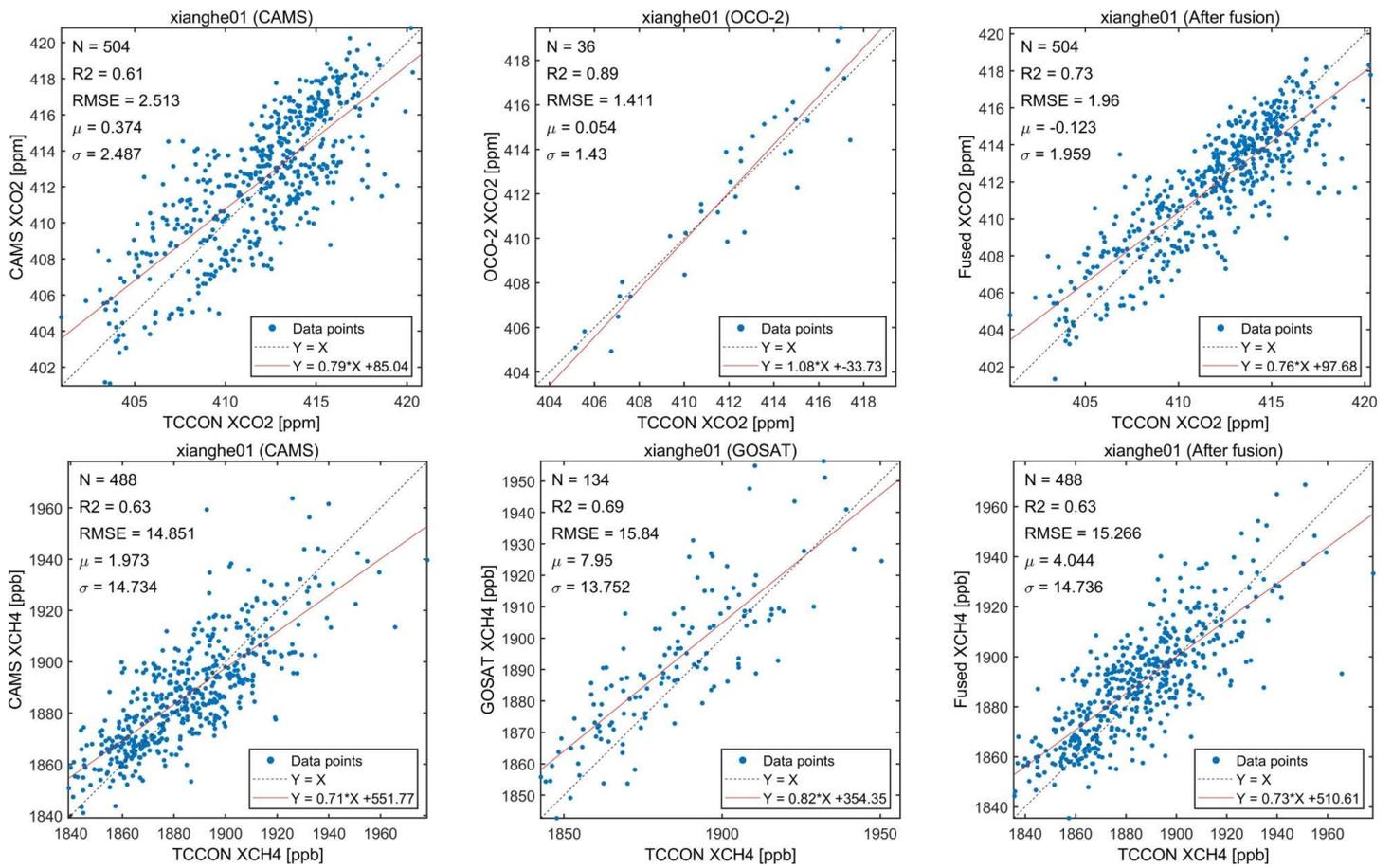


Figure S24. Scatter-plots of the in-situ validation results for CAMS-EGG4 (left), GOSAT/OCO-2 (middle), and fused results (right) on xianghe01. Black dotted and red full lines stand for the 1:1 and fitted lines, respectively. X: TCCON data; Y: CAMS-EGG4/GOSAT/OCO-2/fused data. Unit: ppm/ppb to XCO₂/XCH₄ for RMSE, μ , and σ .

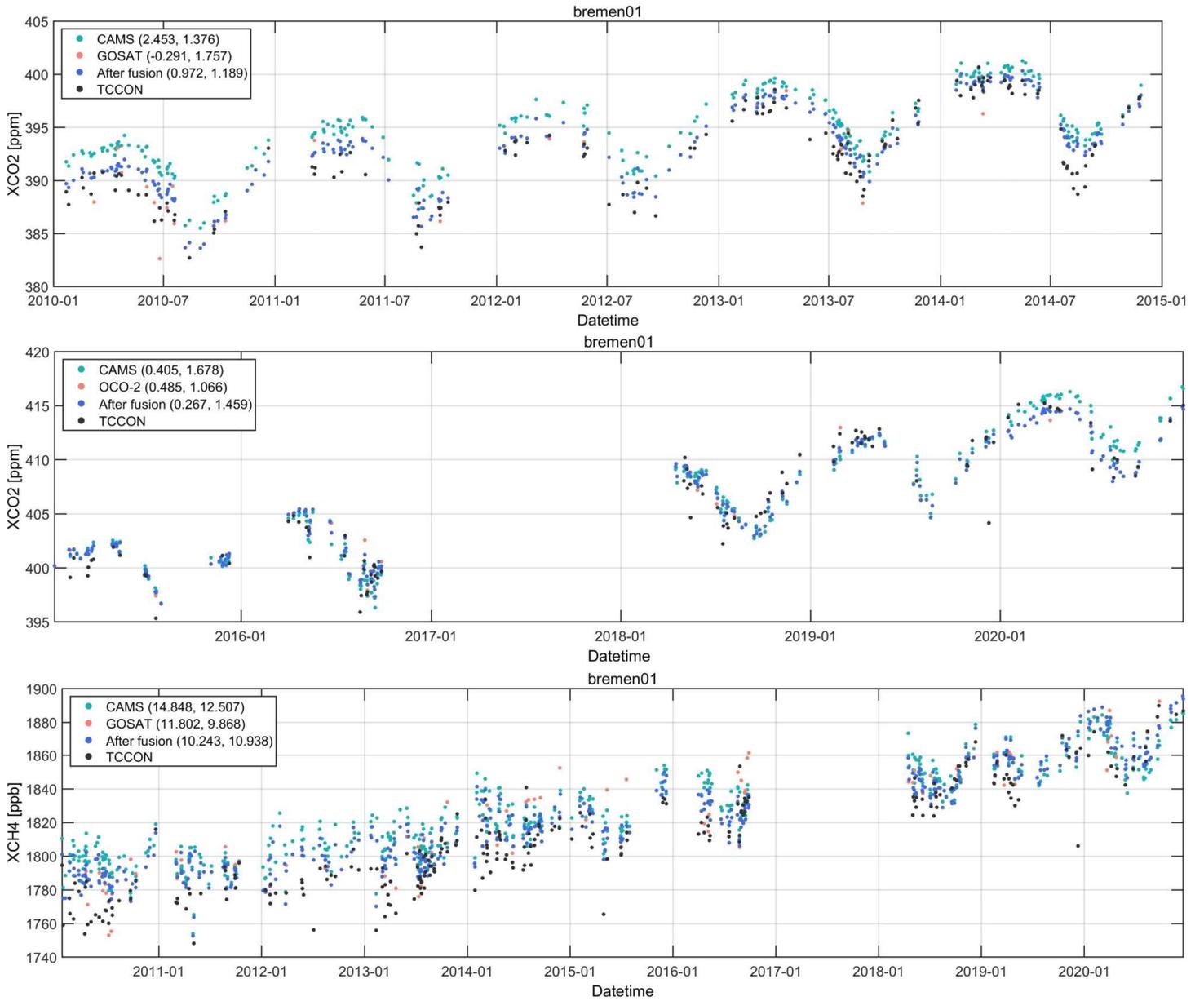


Figure S25. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on bremen01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

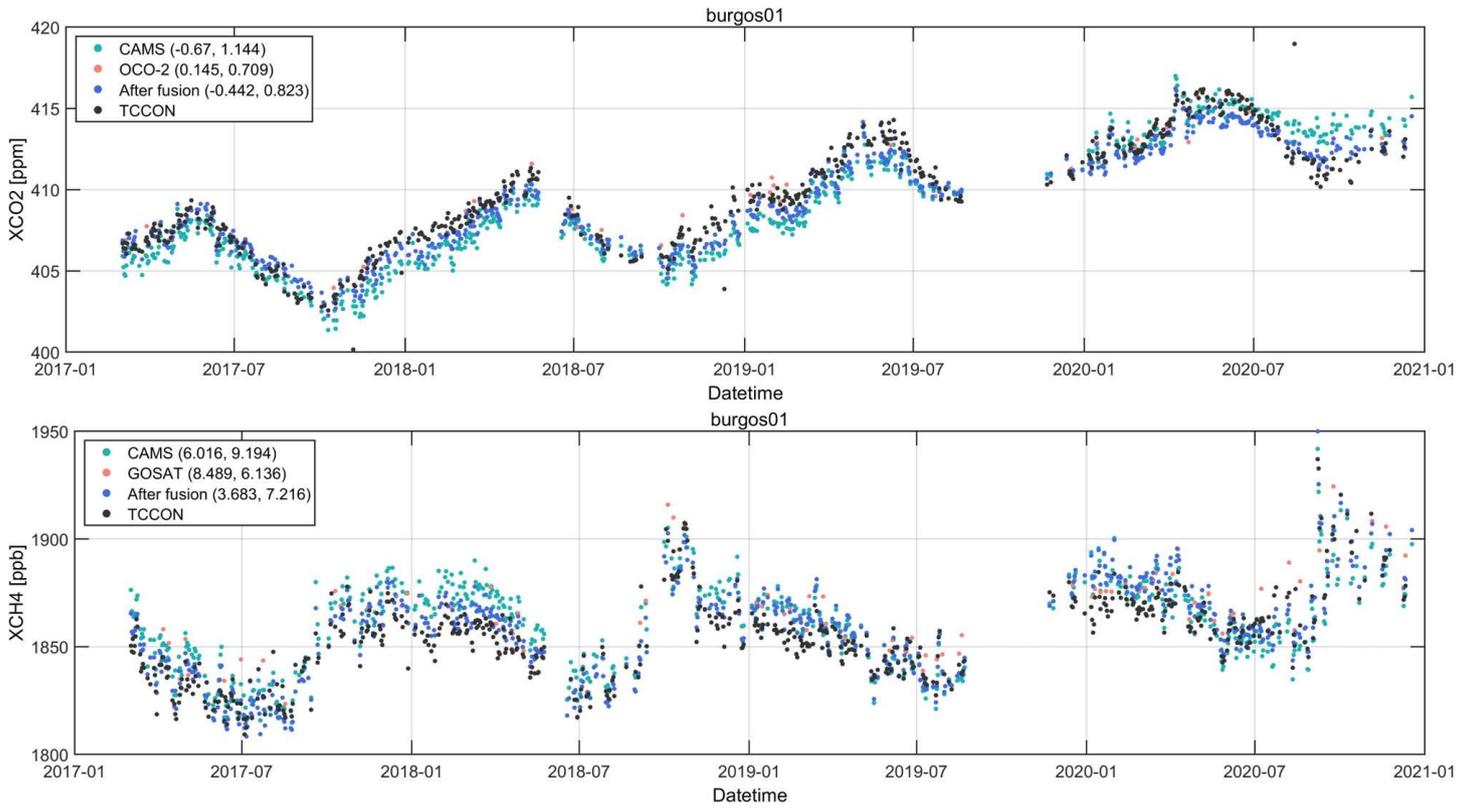


Figure S26. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on burgos01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

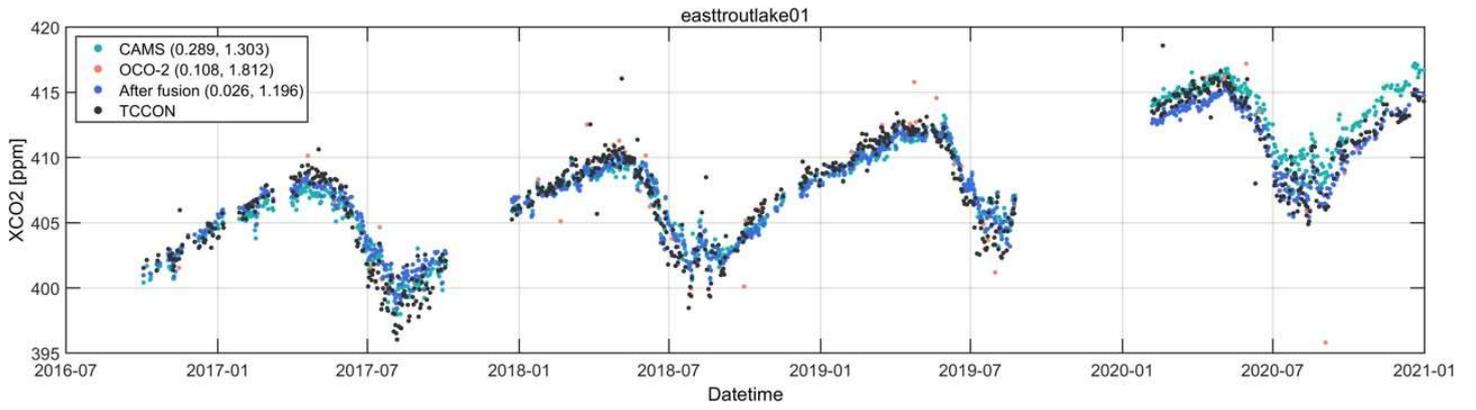


Figure S27. Scatter-plots of the time series for daily CAMS-EGG4, OCO-2, fused, and TCCON XCO₂ on easttroutlake01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm to XCO₂ for μ and σ .

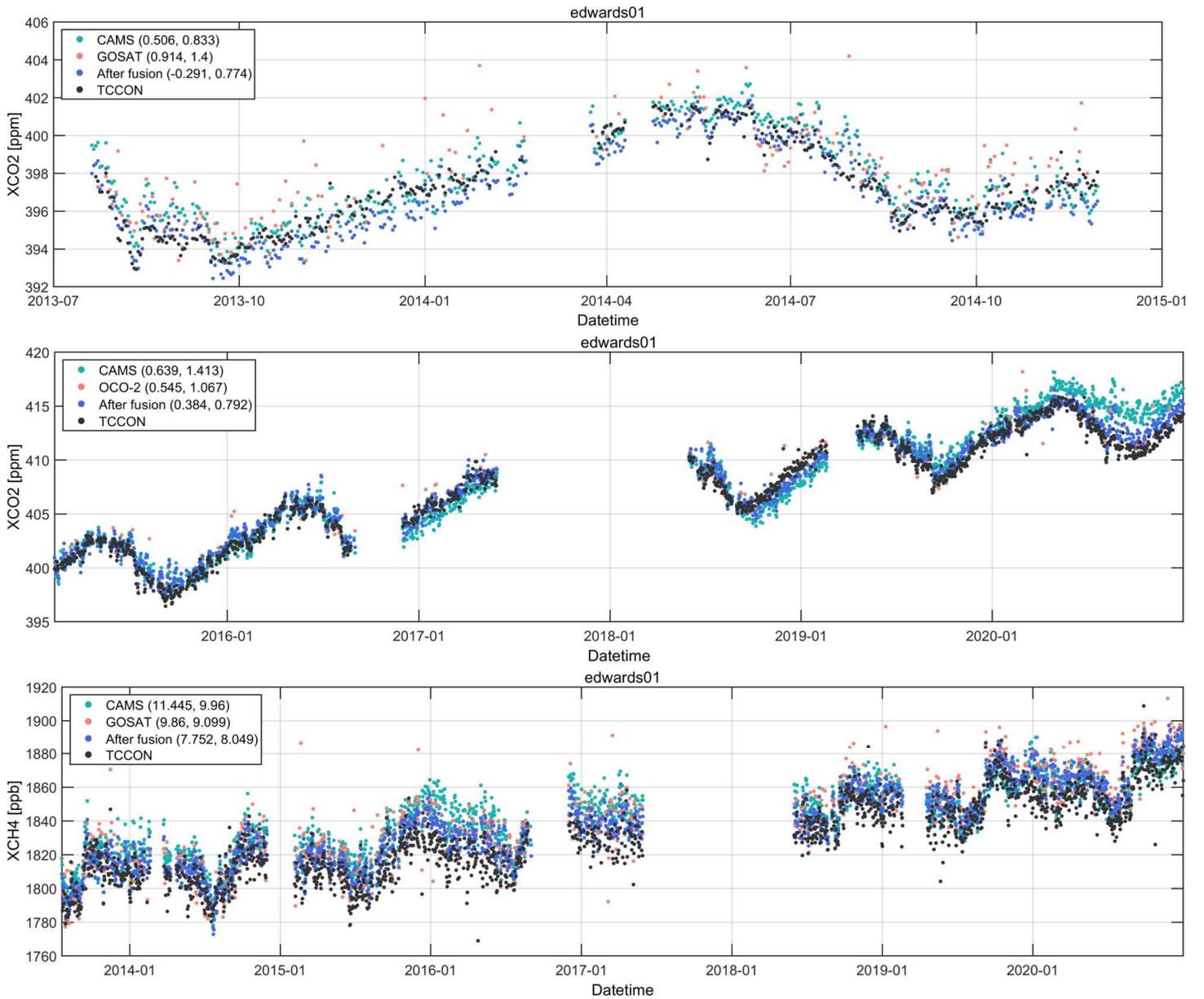


Figure S28. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on edwards01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

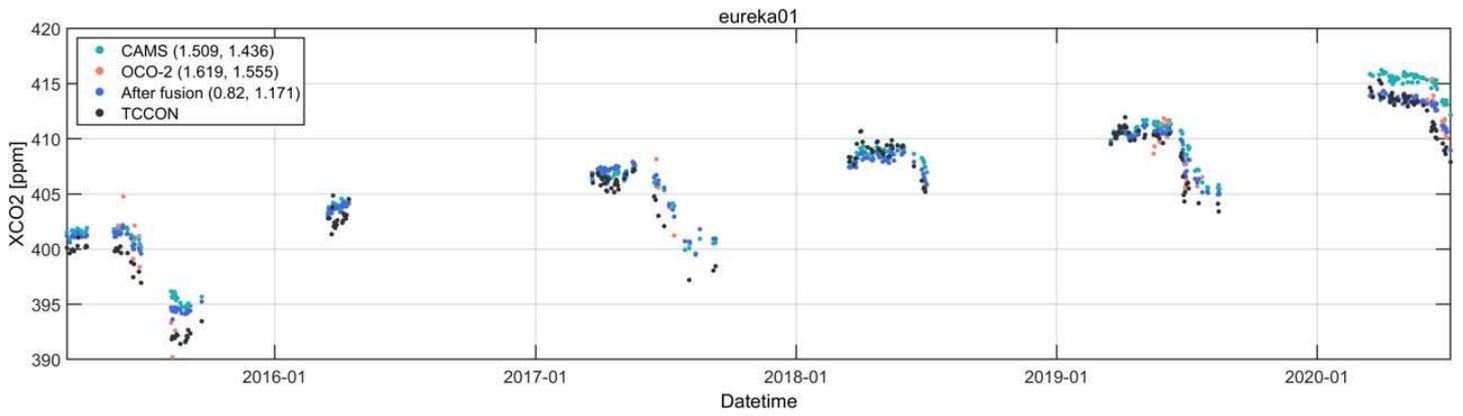


Figure S29. Scatter-plots of the time series for daily CAMS-EGG4, OCO-2, fused, and TCCON XCO₂ on eureka01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm to XCO₂ for μ and σ .

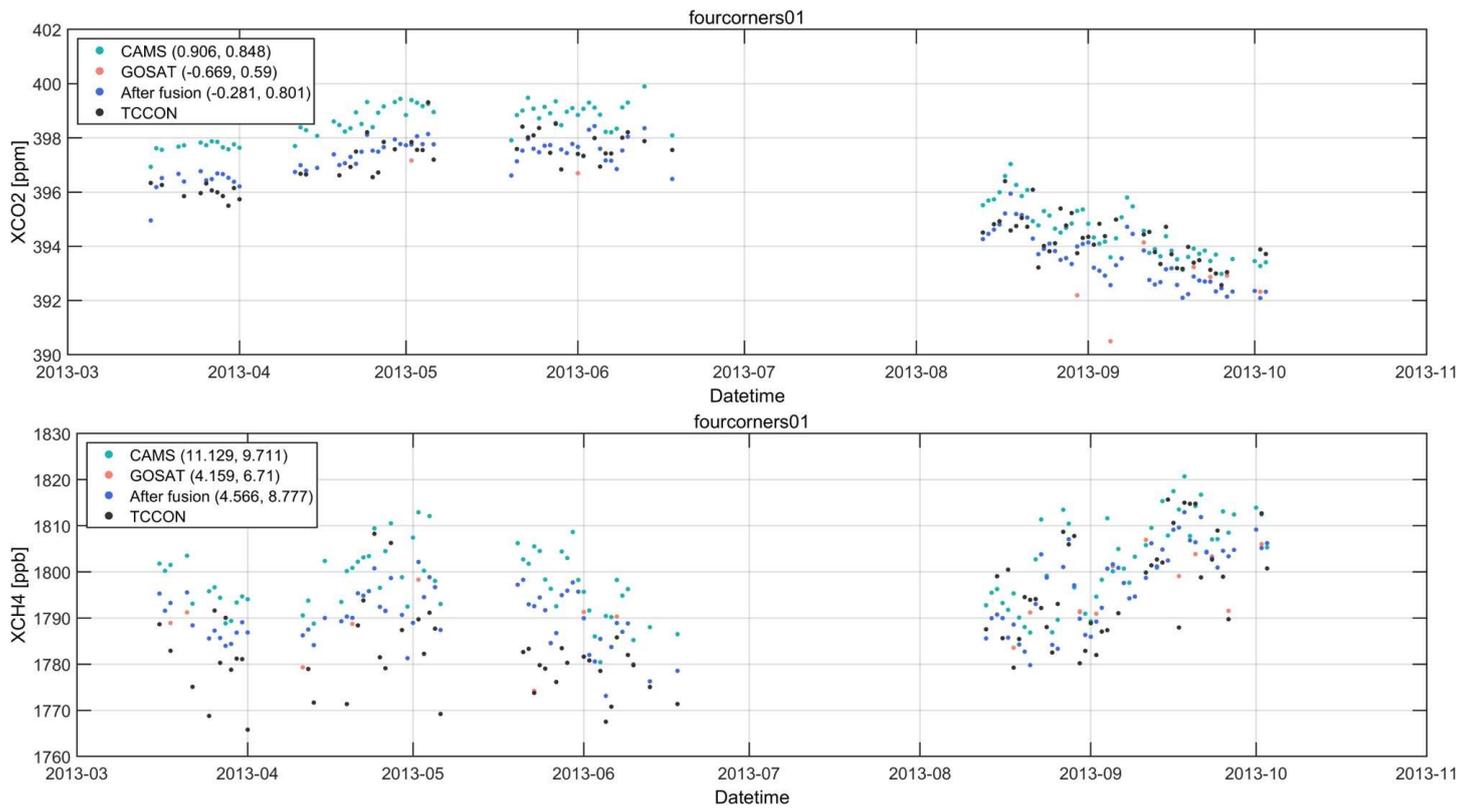


Figure S30. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT, fused, and TCCON data on fourcorners01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

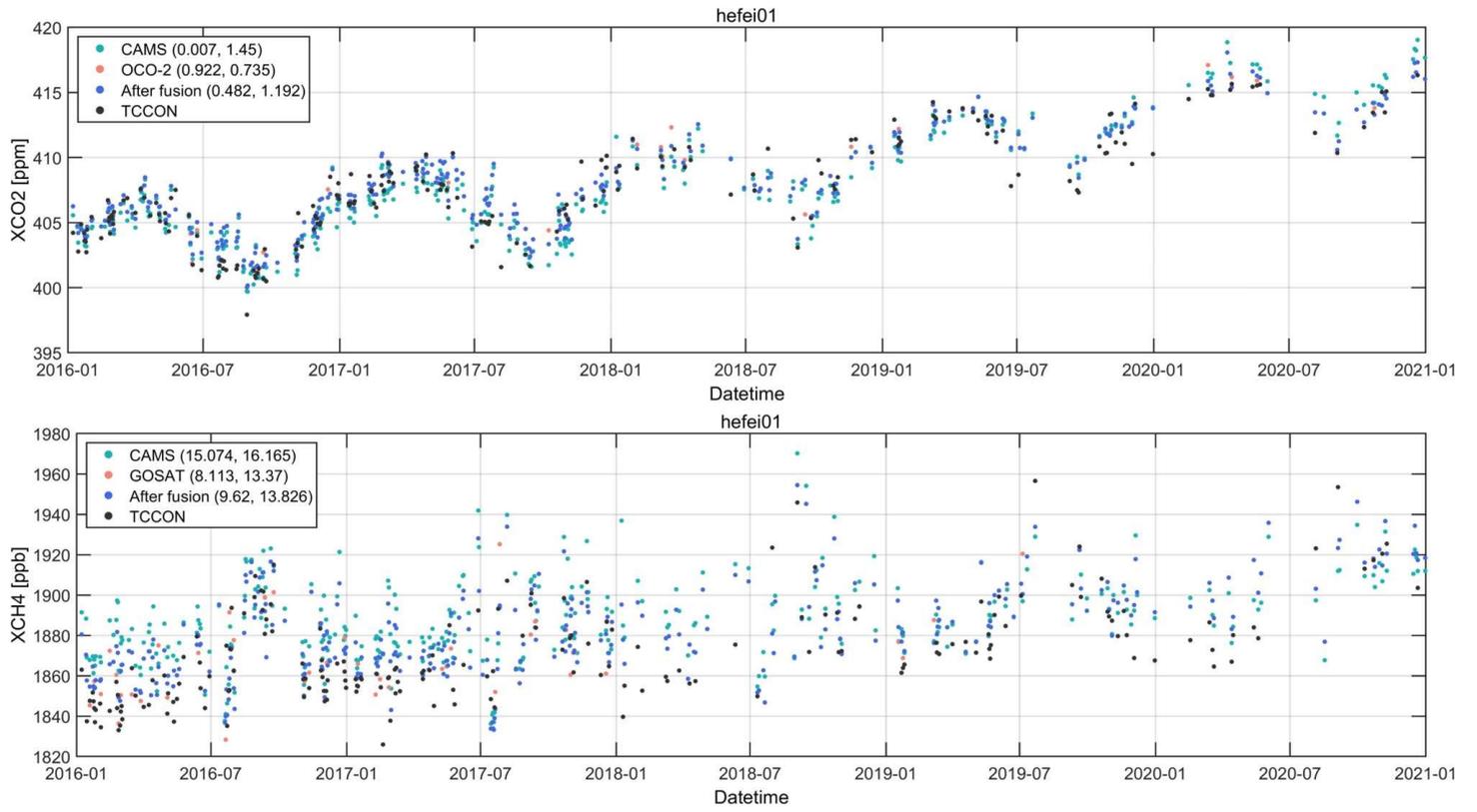


Figure S31. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on hefei01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

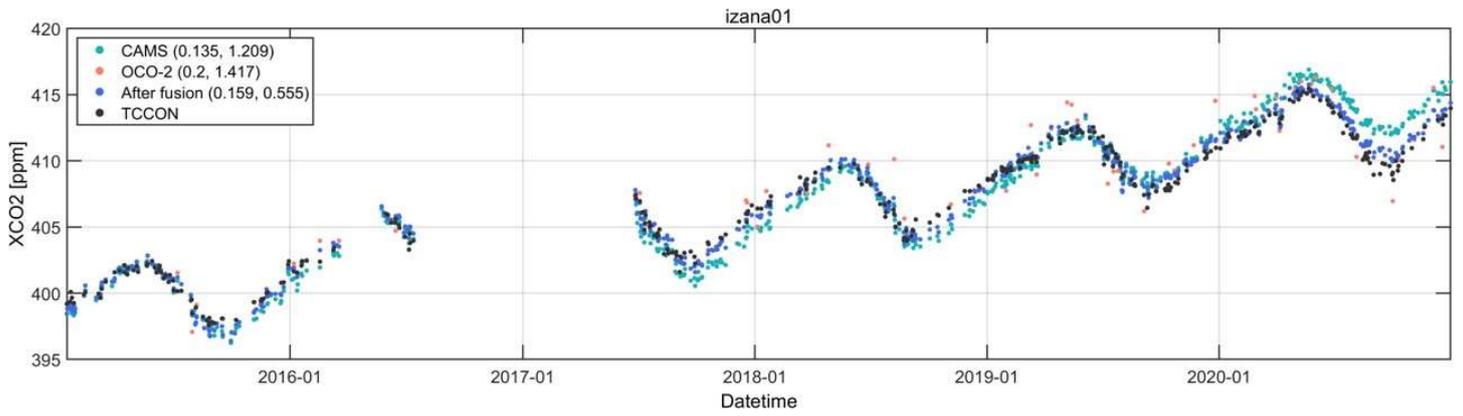


Figure S32. Scatter-plots of the time series for daily CAMS-EGG4, OCO-2, fused, and TCCON XCO₂ on izana01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm to XCO₂ for μ and σ .

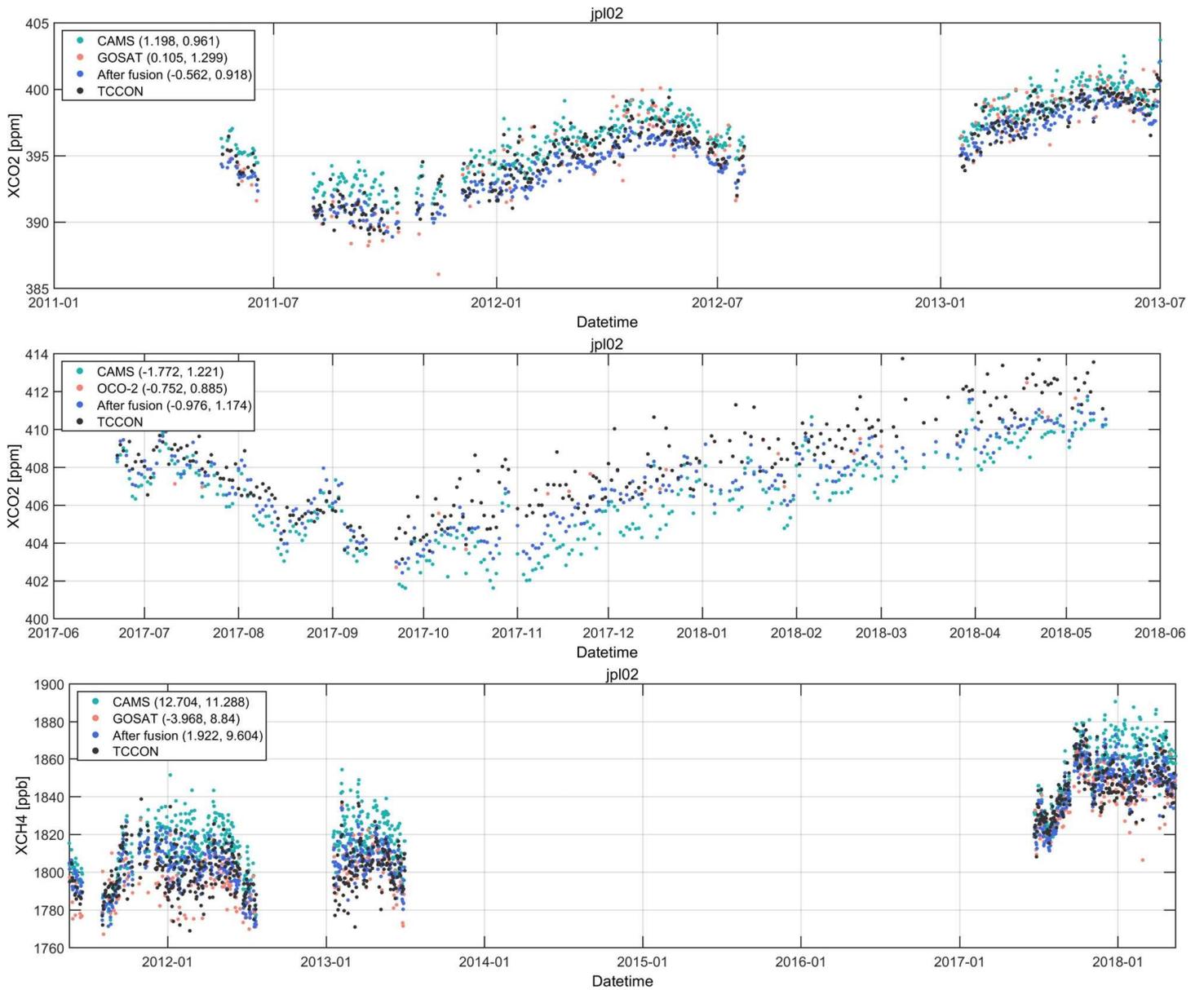


Figure S33. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on jpl02. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

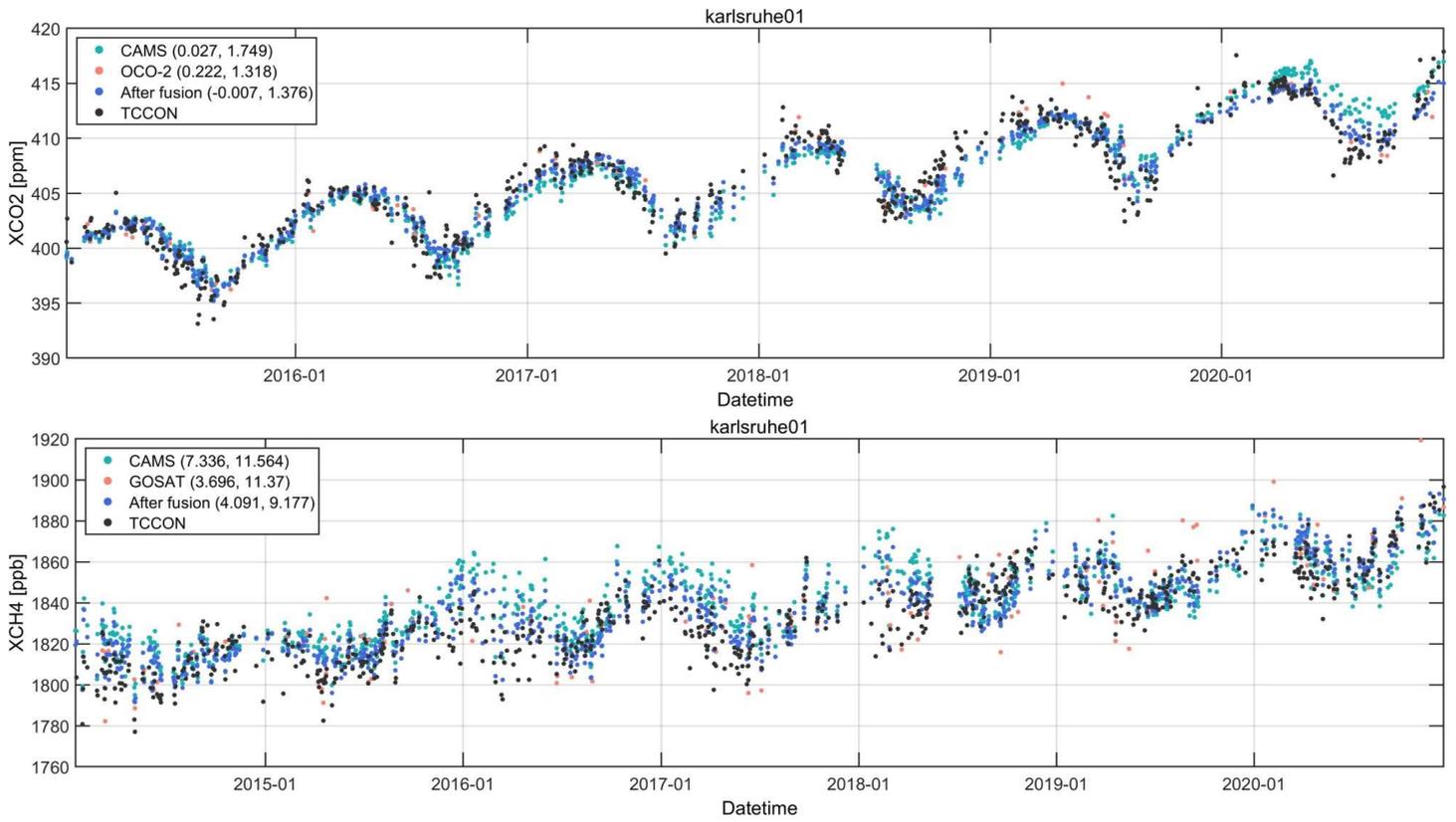


Figure S34. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on karlsruhe01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

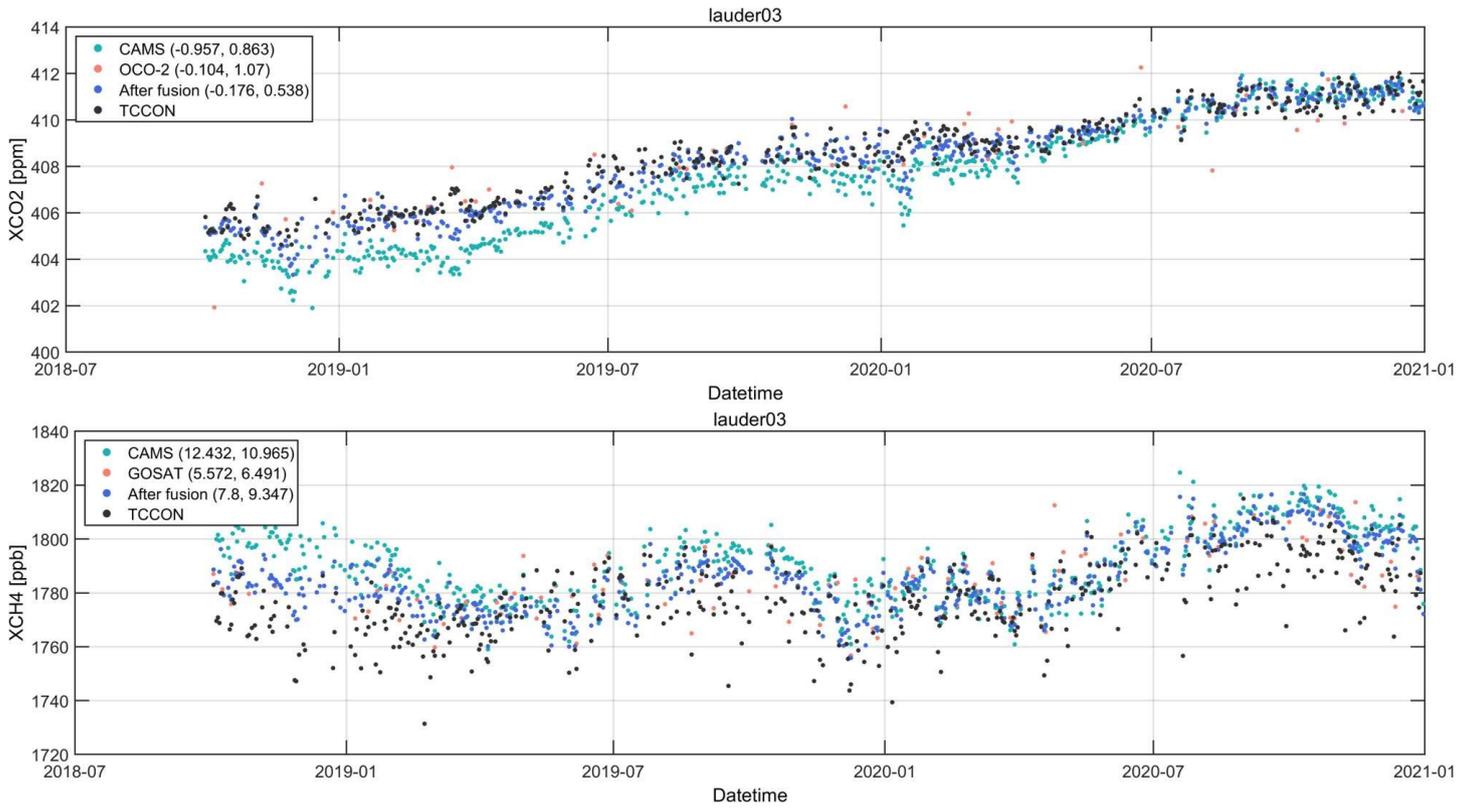


Figure S35. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on lauder03. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

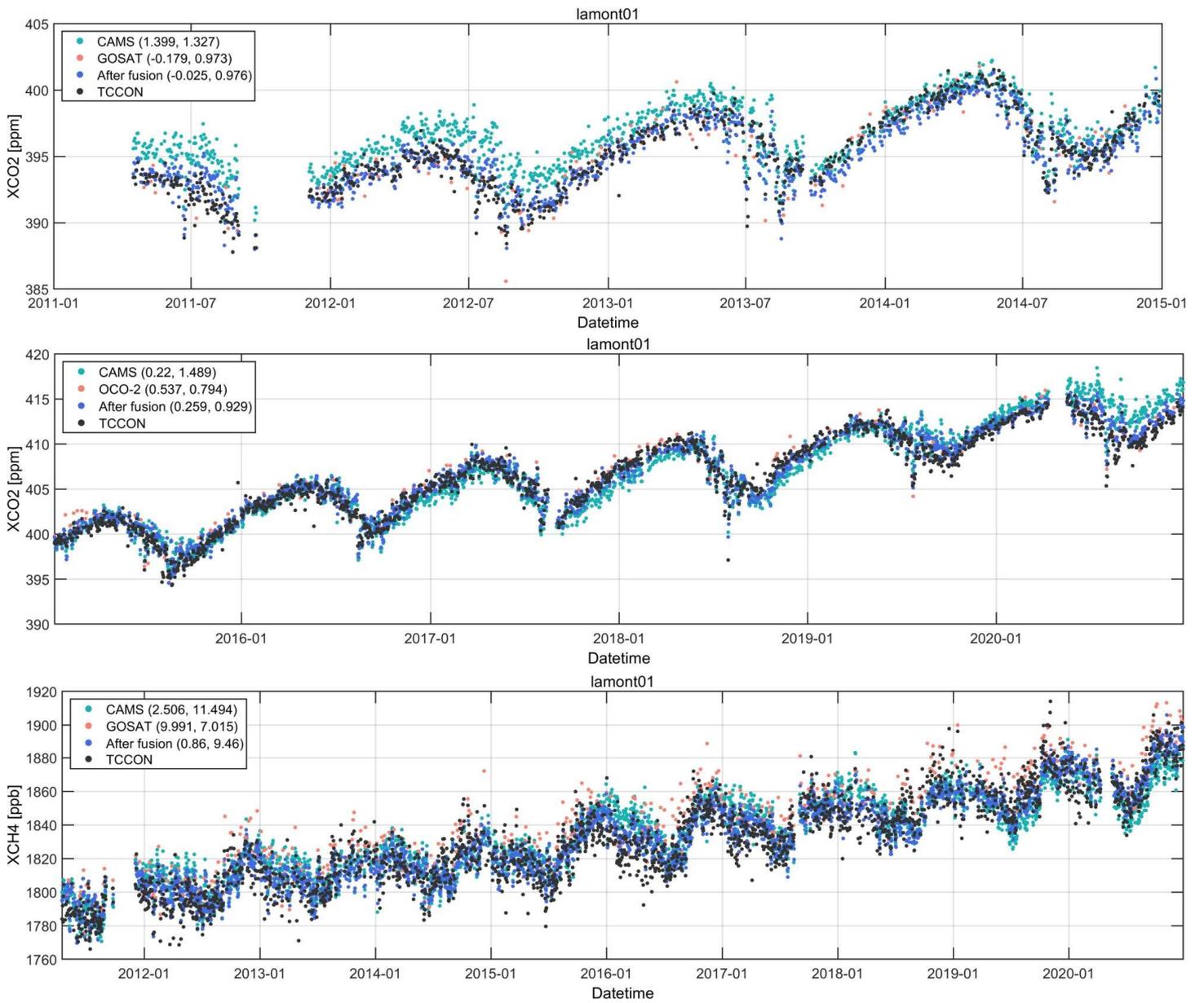


Figure S36. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on lamont01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

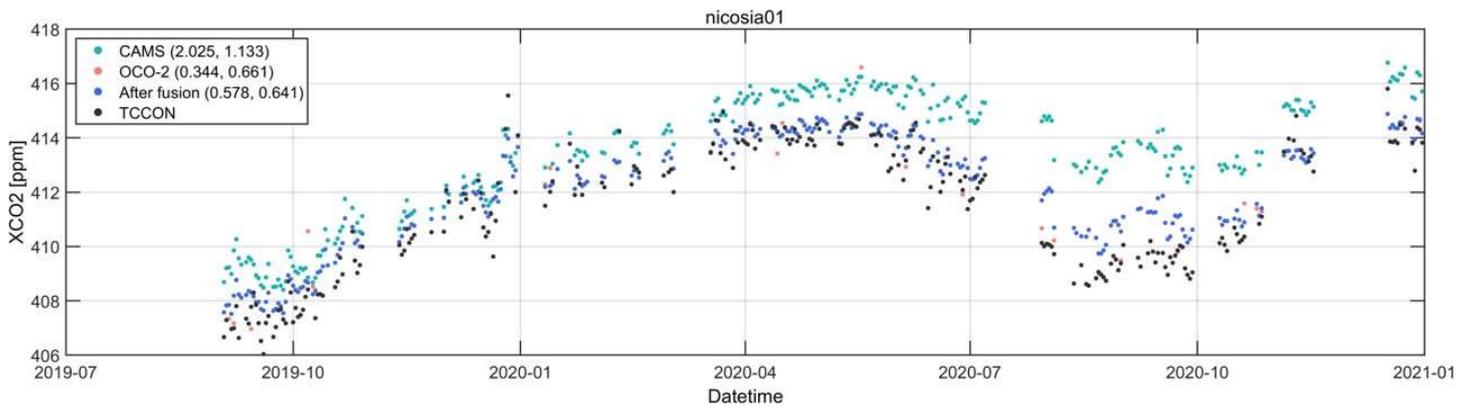


Figure S37. Scatter-plots of the time series for daily CAMS-EGG4, OCO-2, fused, and TCCON XCO₂ on nicosia01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm to XCO₂ for μ and σ .

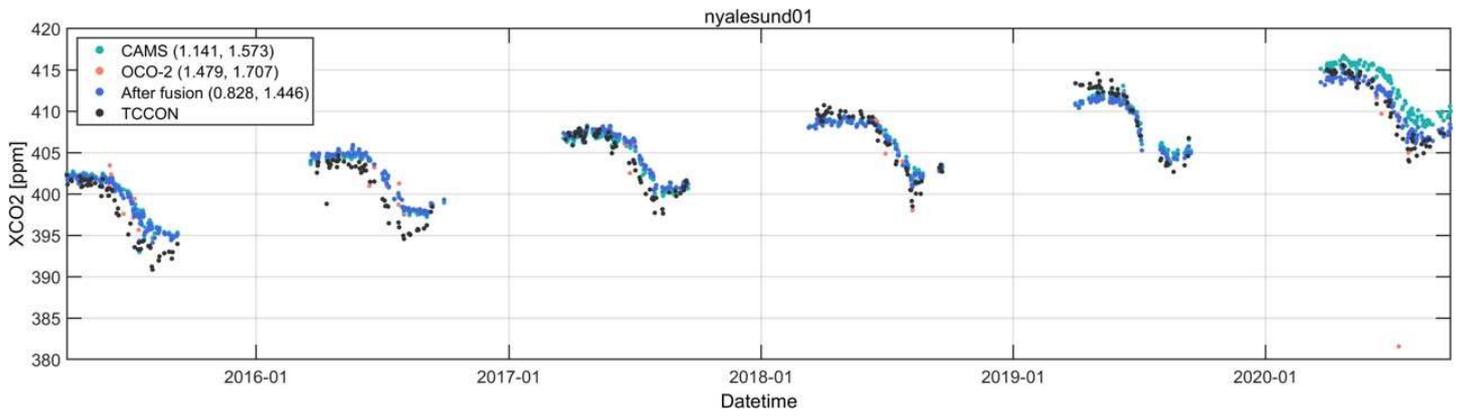


Figure S38. Scatter-plots of the time series for daily CAMS-EGG4, OCO-2, fused, and TCCON XCO₂ on nyalesund01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm to XCO₂ for μ and σ .

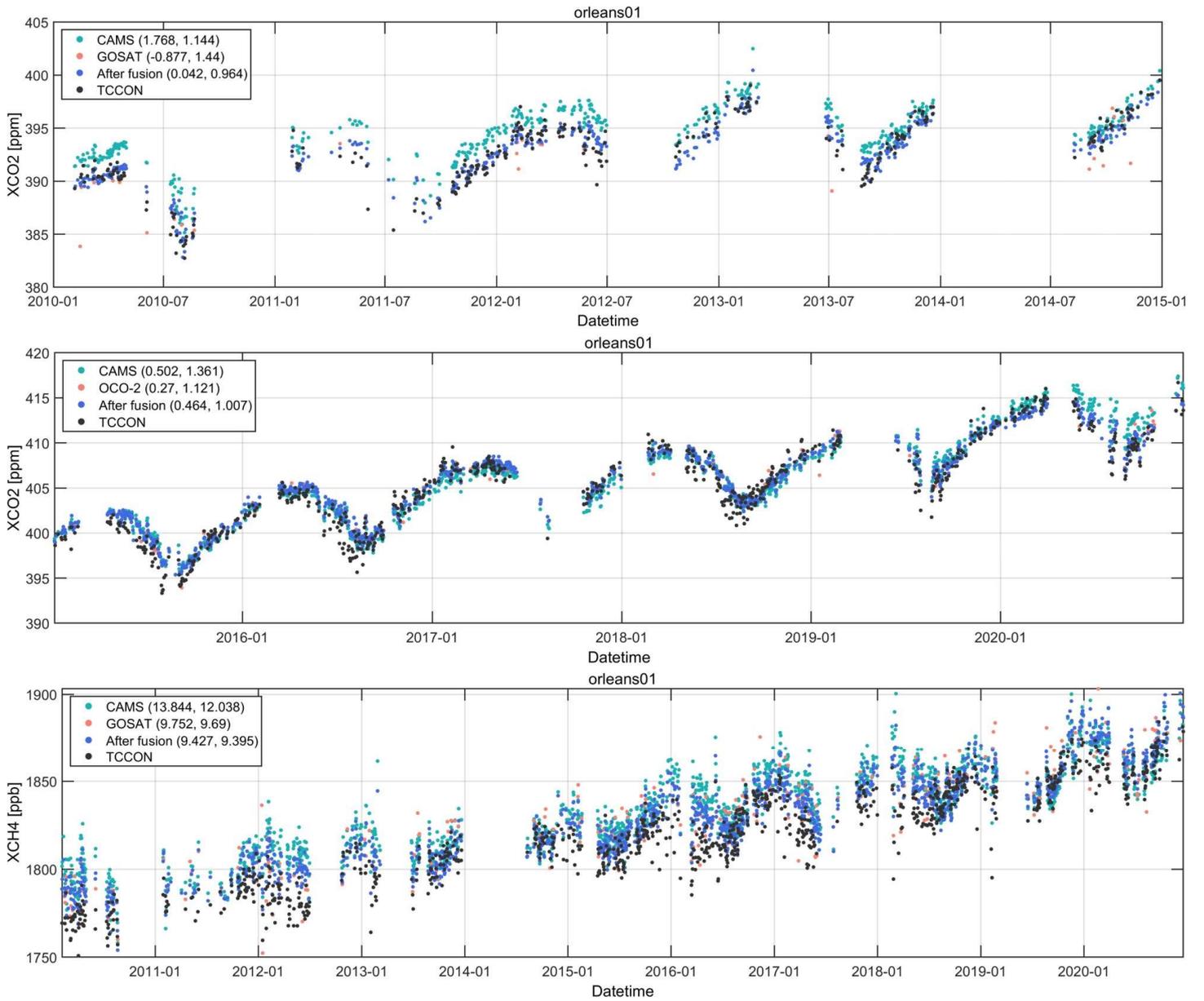


Figure S39. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on orleans01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

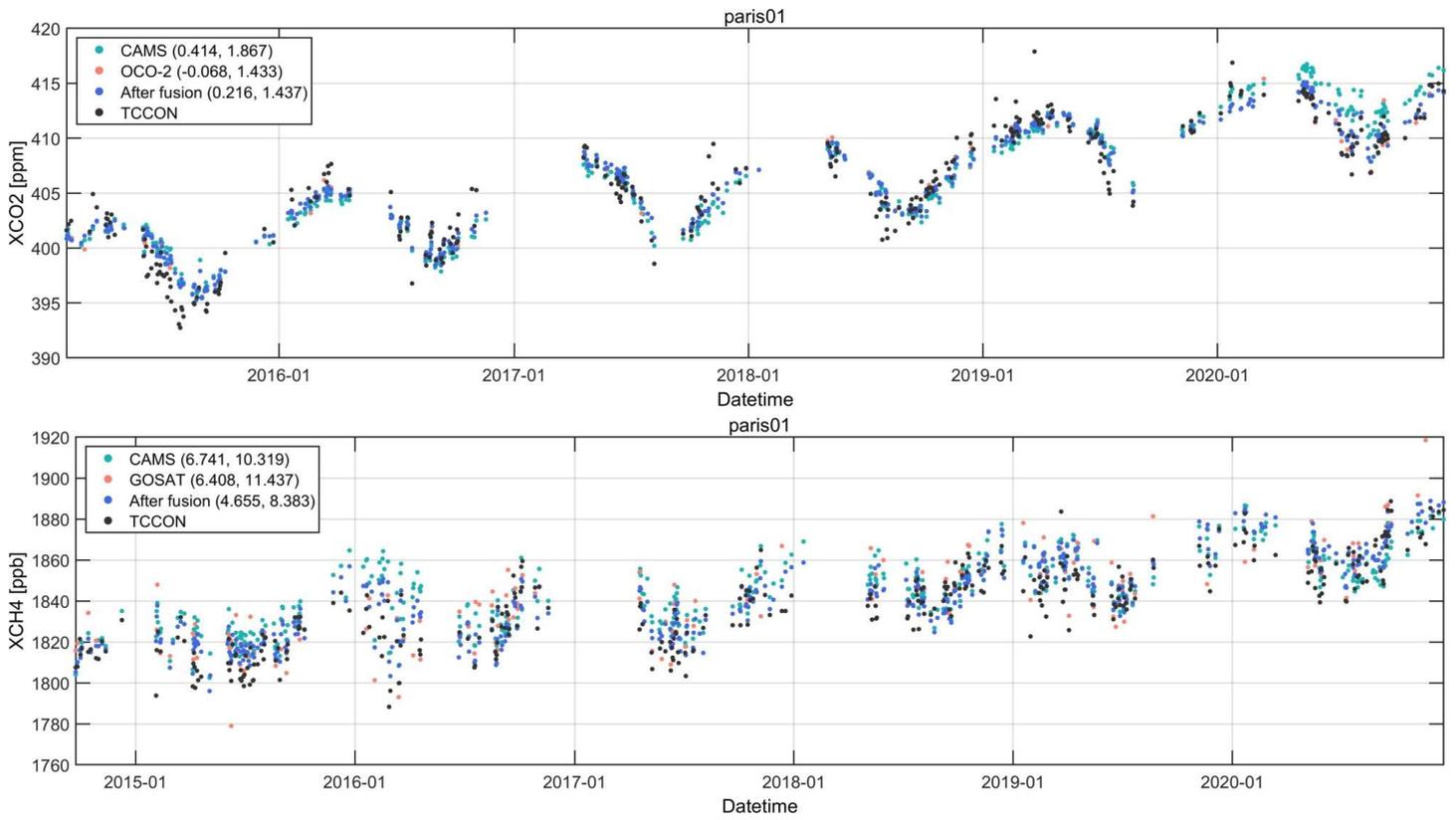


Figure S40. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on paris01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

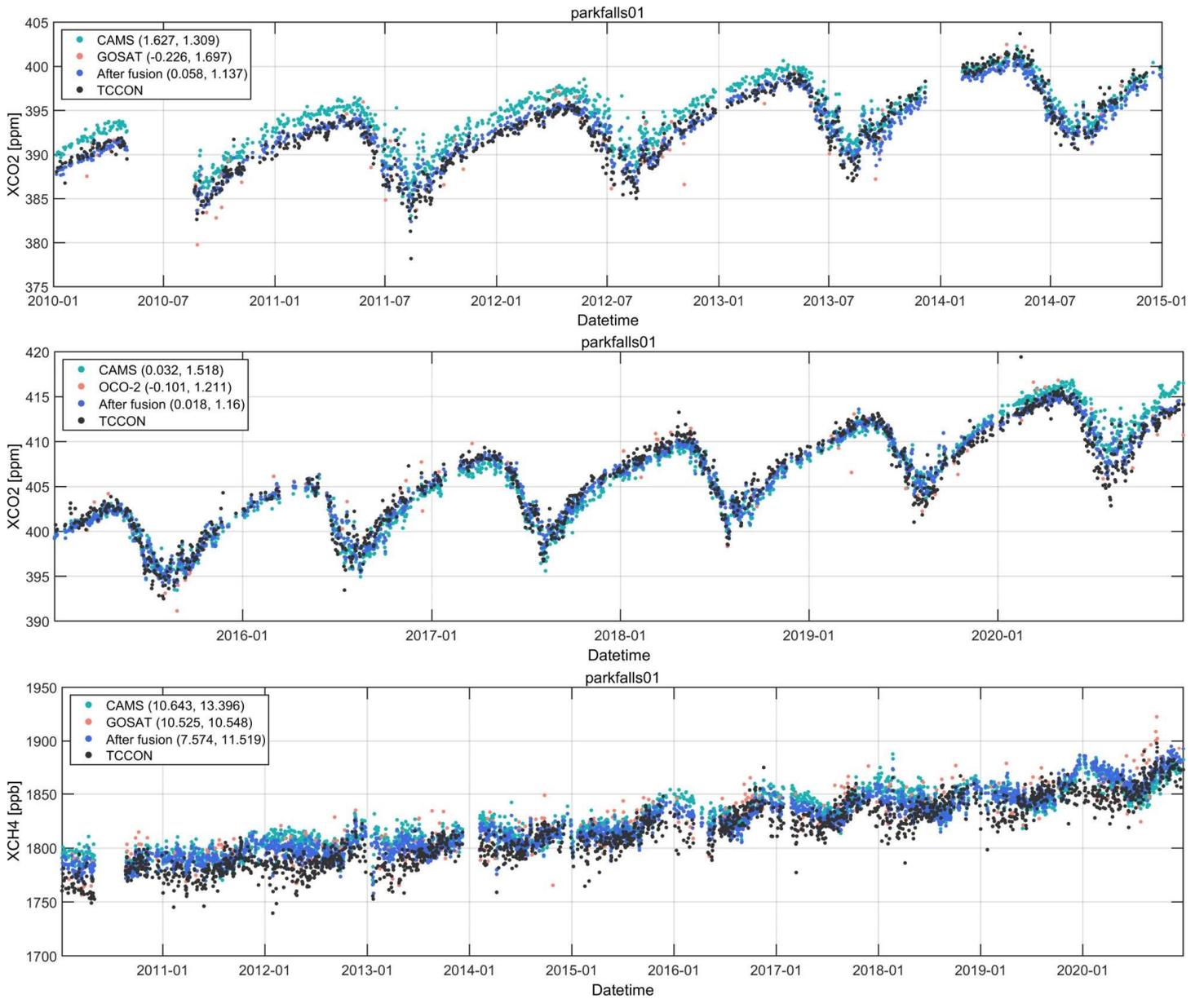


Figure S41. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on parkfalls01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

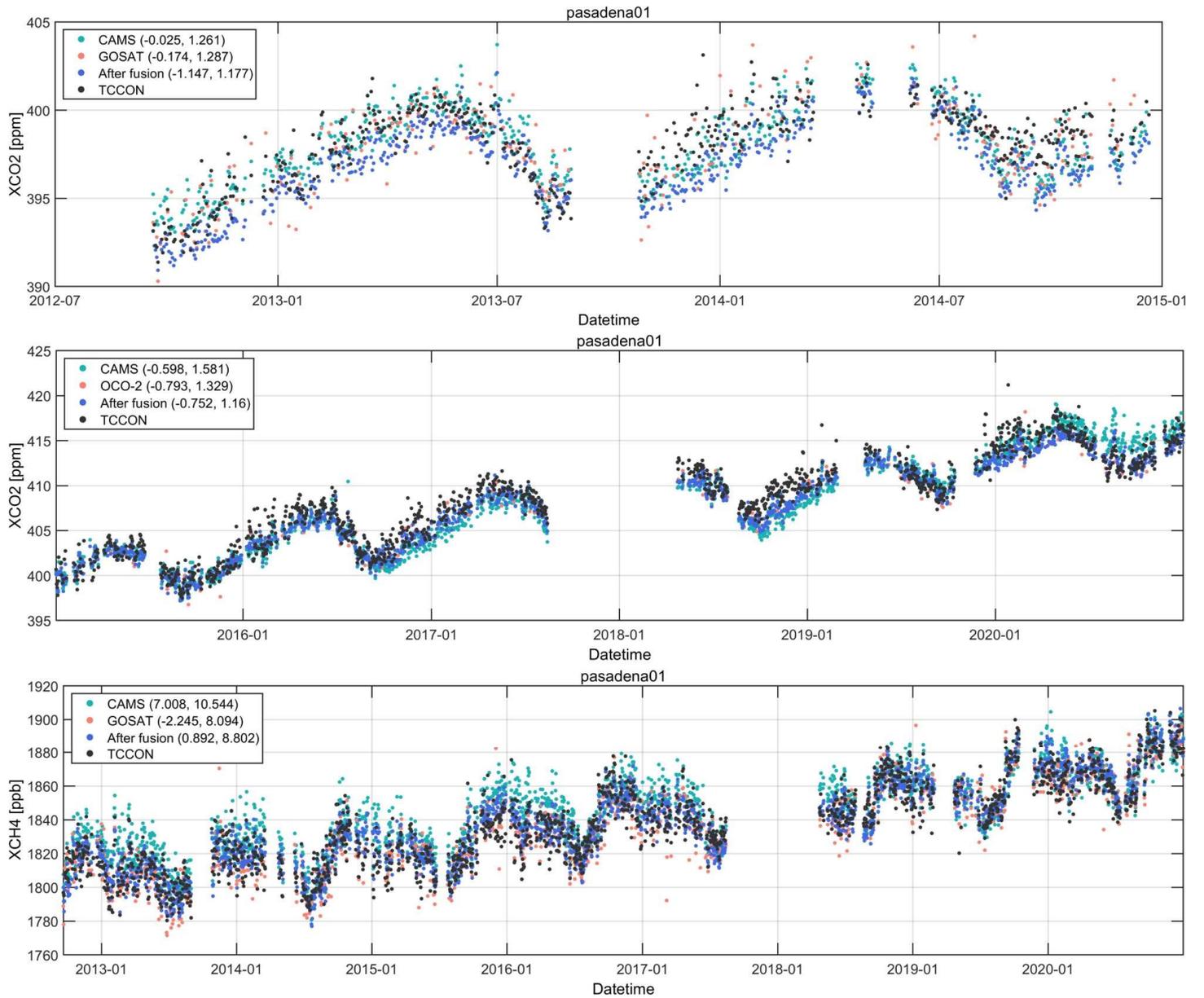


Figure S42. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on pasadena01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

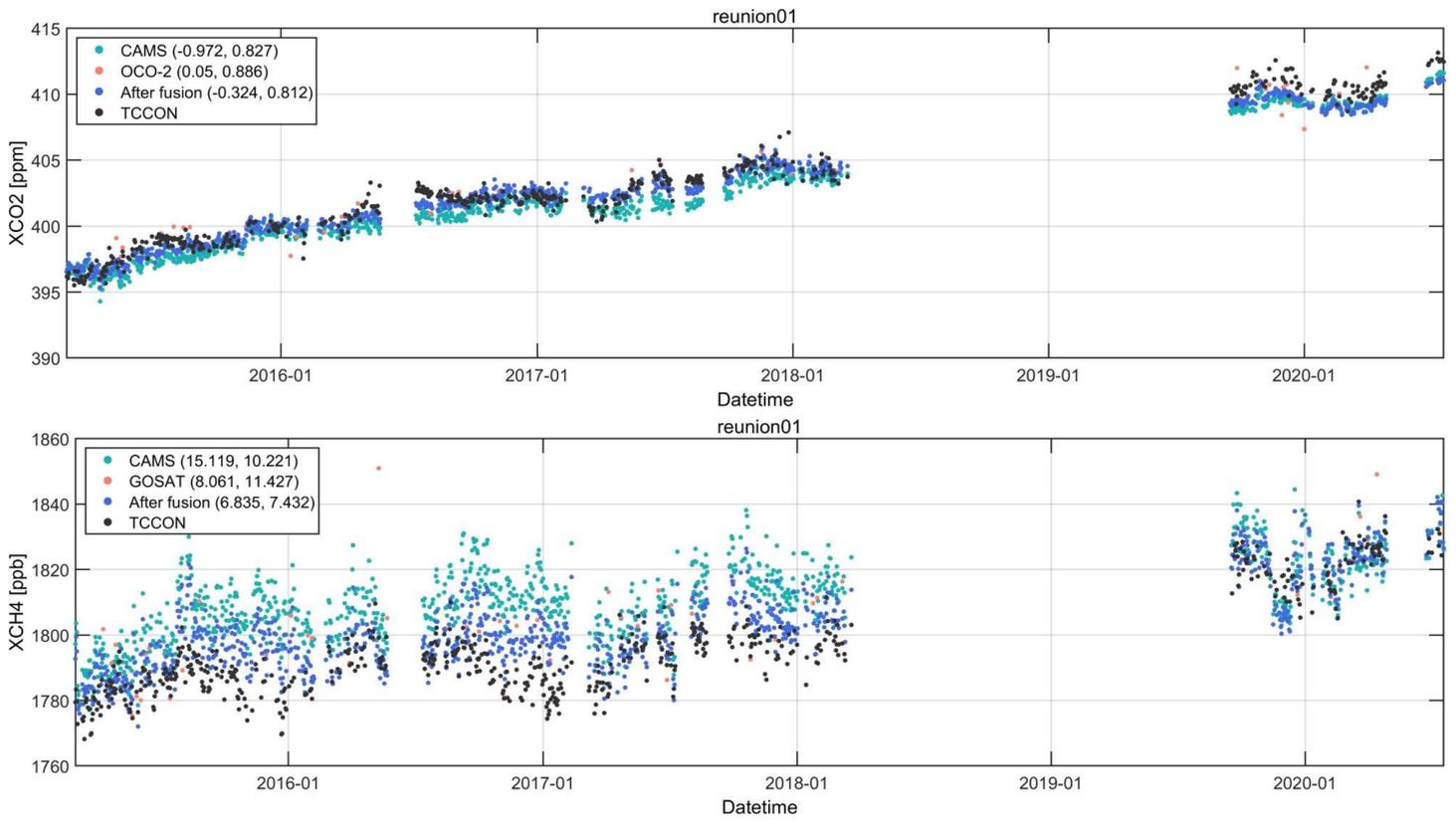


Figure S43. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on reunion01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

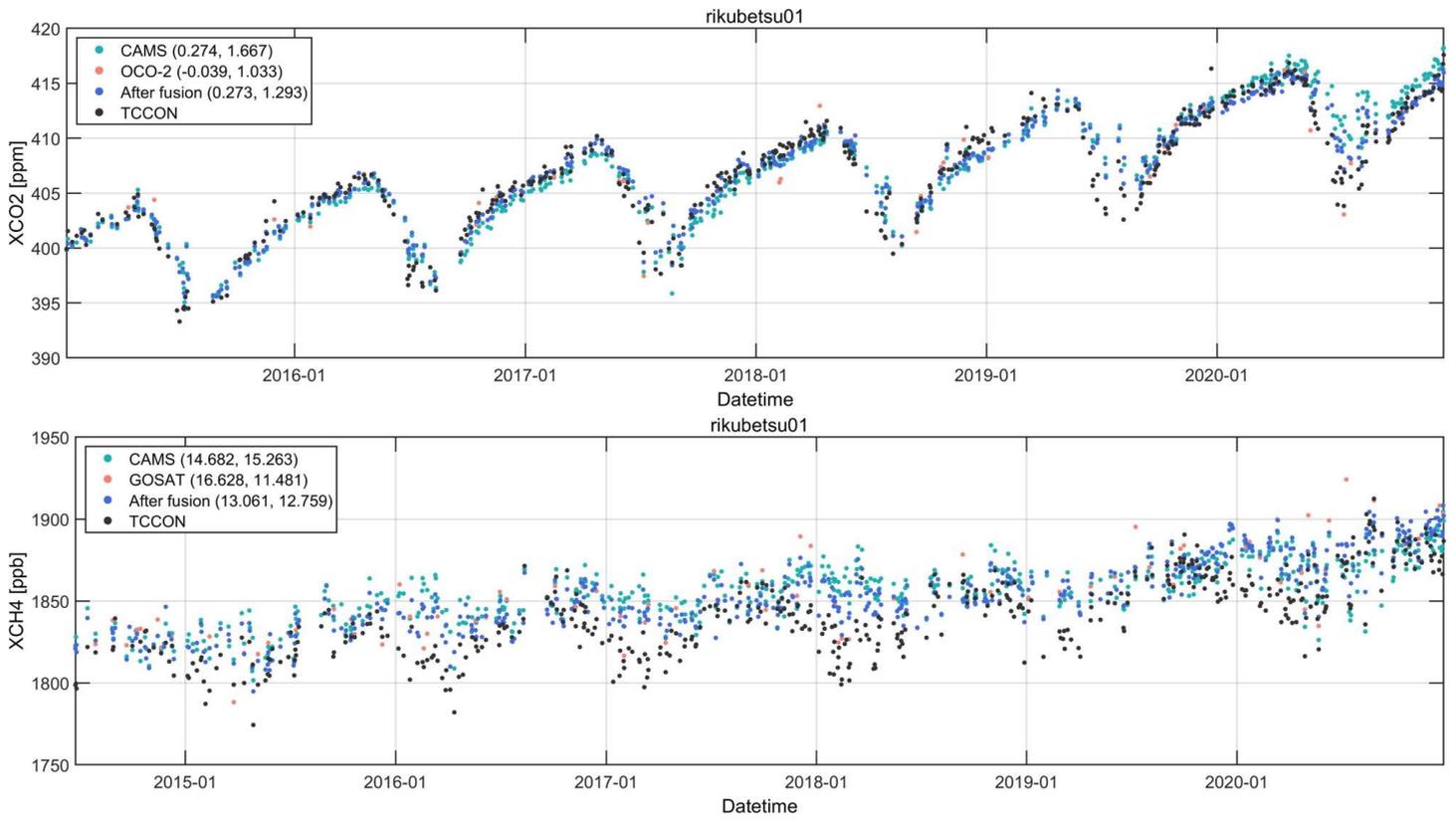


Figure S44. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on rikubetsu01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

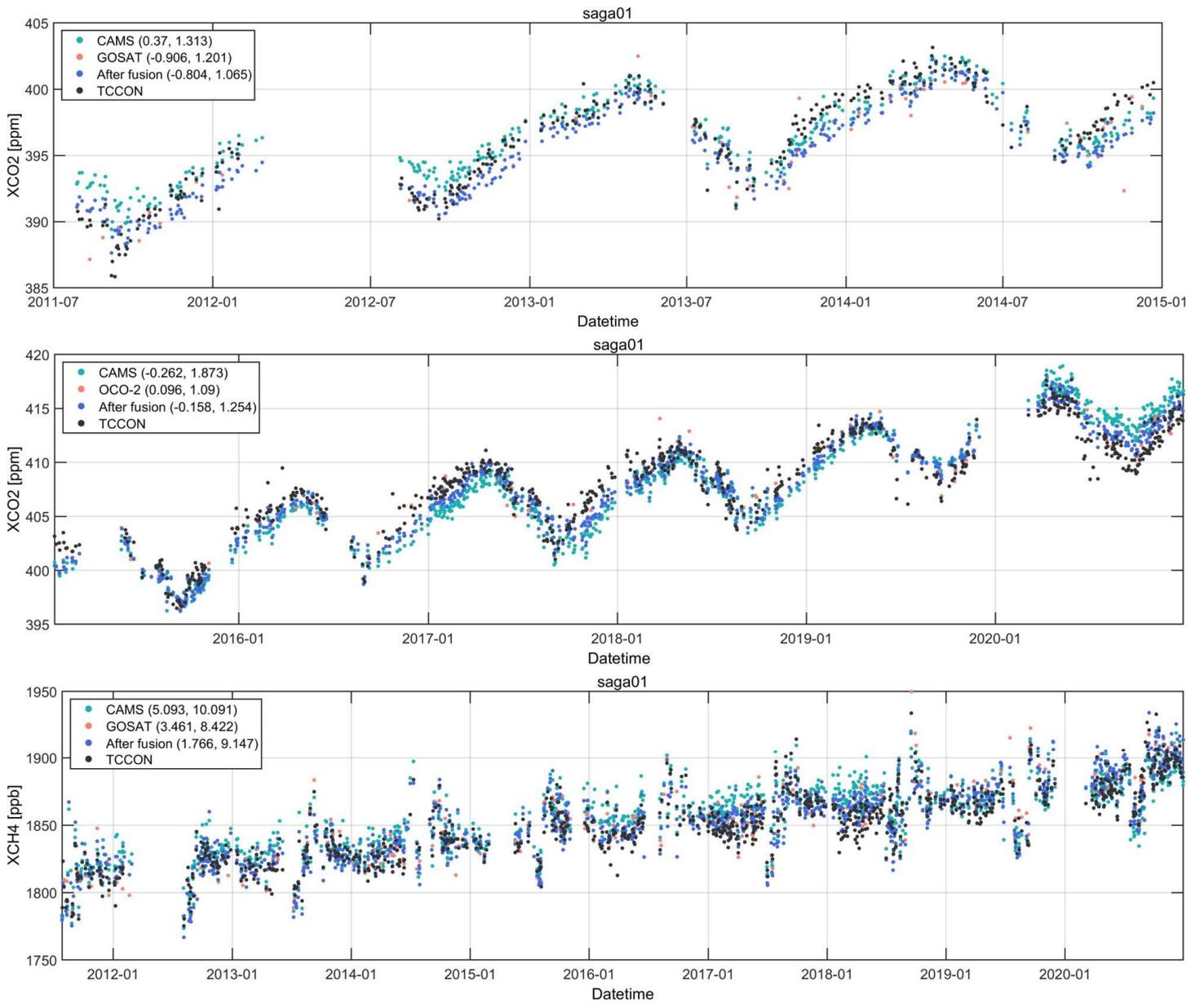


Figure S45. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on saga01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

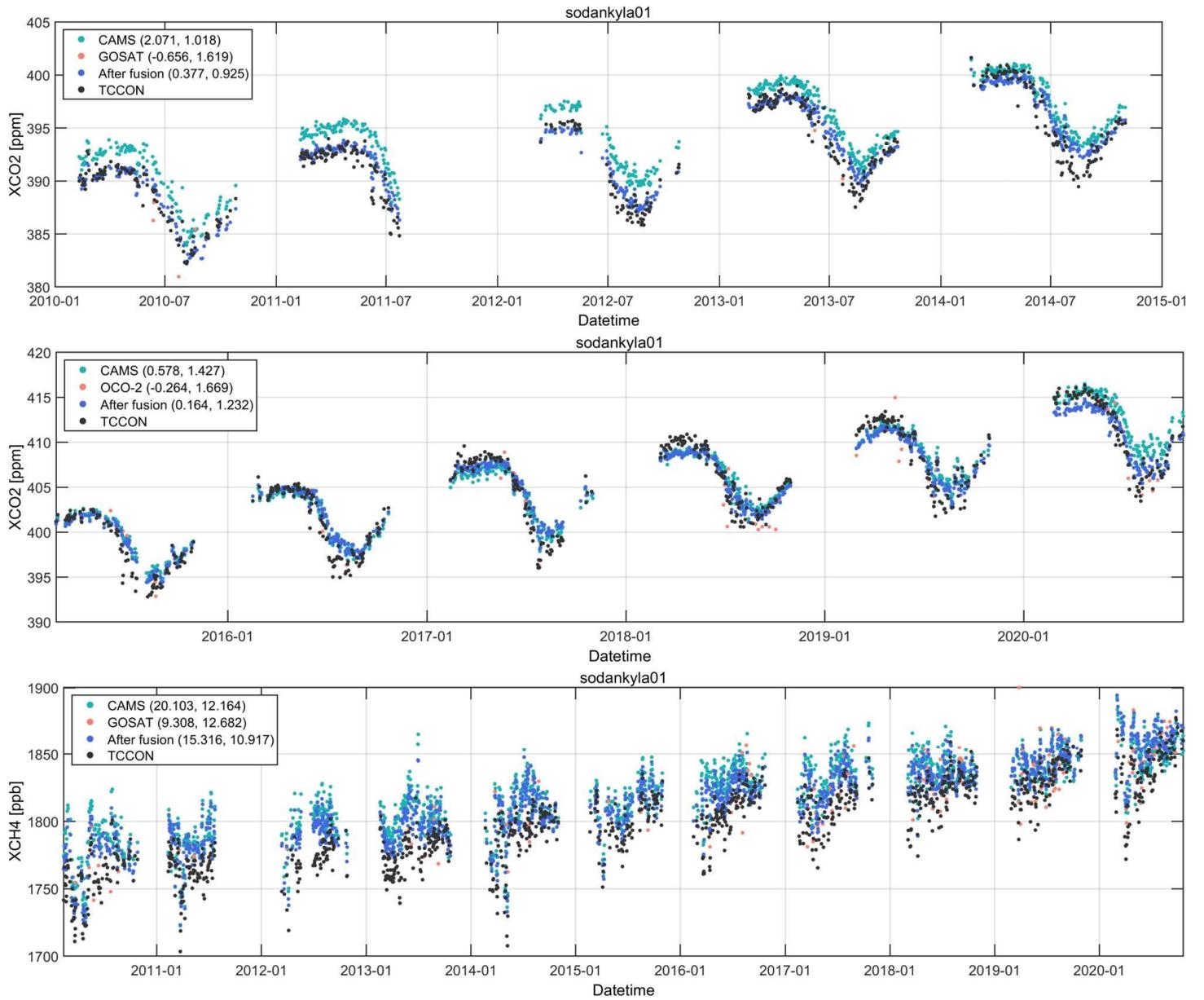


Figure S46. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on sodankyla01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

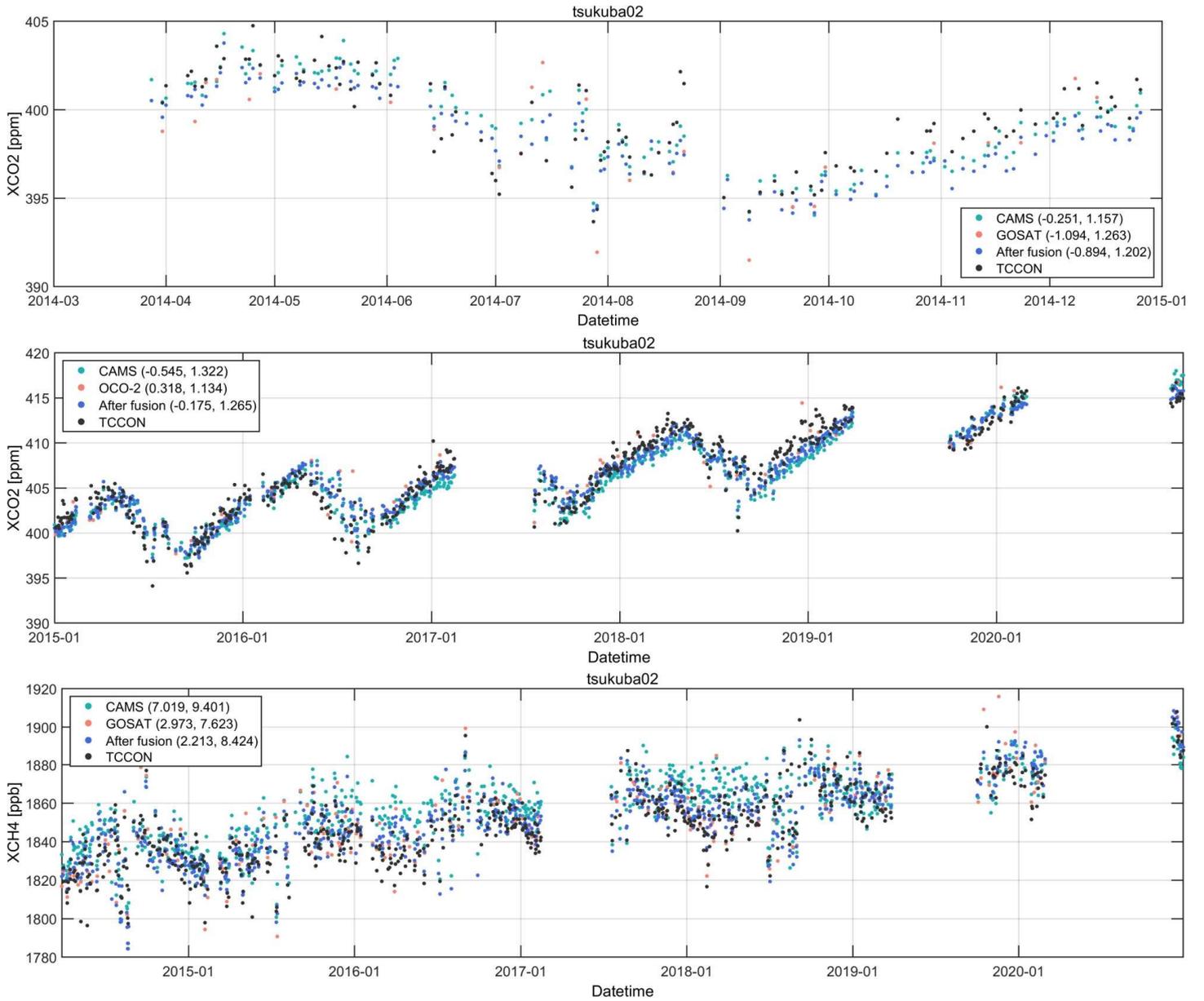


Figure S47. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on tsukuba02. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .

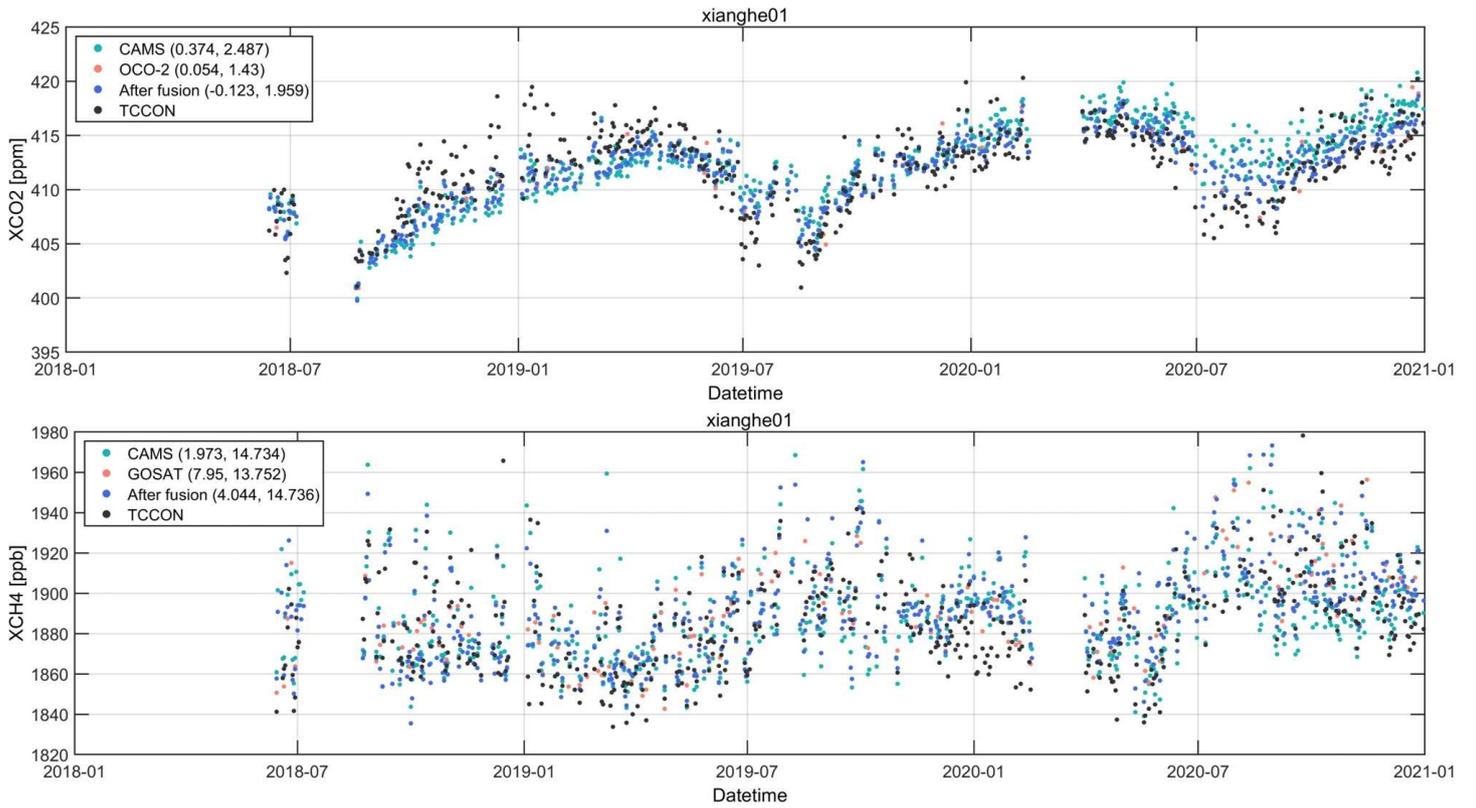


Figure S48. Scatter-plots of the time series for daily CAMS-EGG4, GOSAT/OCO-2, fused, and TCCON data on xianghe01. The first and second numbers in the bracket represent μ and σ , respectively. Unit: ppm/ppb to XCO₂/XCH₄ for μ and σ .