Supplementary Materials

The Fig. S1- S5 show the validation results of the supplementary model (SR0002), which removed the CAMS, CHLEVI variable and was used for global XCO_2 mapping from 2000 to 2002.

The Table S1, Fig. S6 show the validation results of the main model (SR0320), which used all variables and was used for global XCO2 mapping from 2003 to 2020.

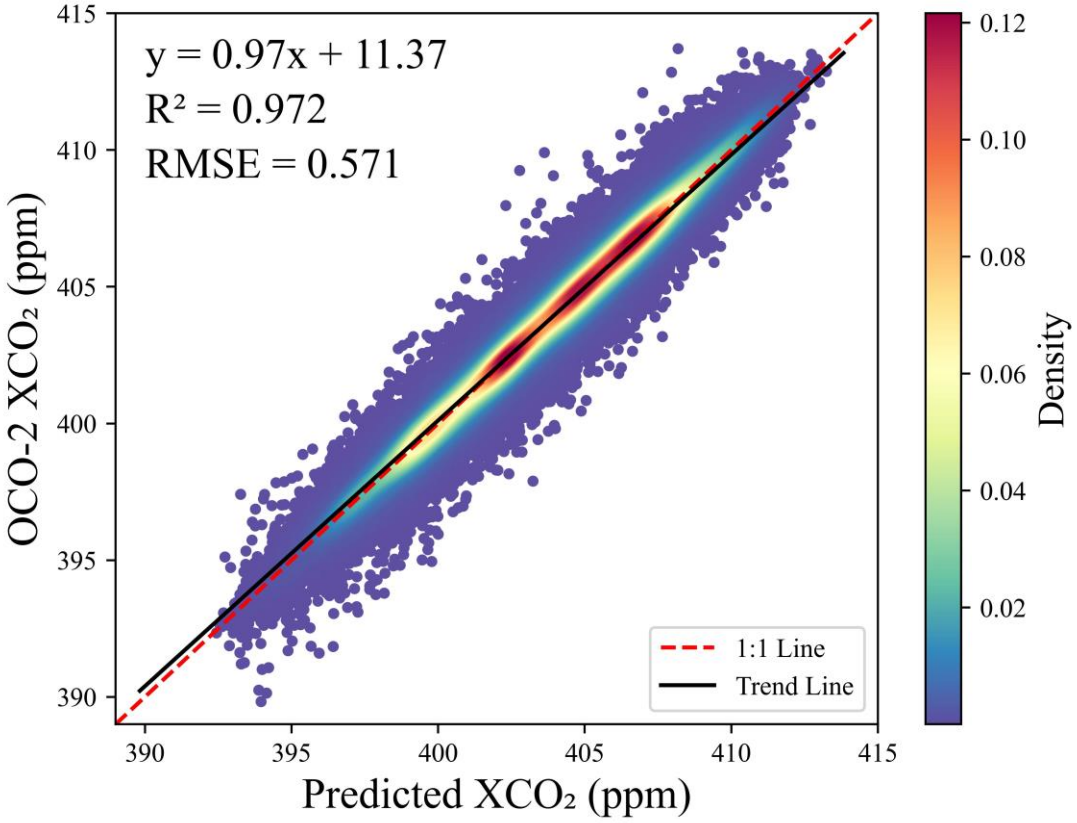


Fig. S1 The overall results of ten-fold cross validation of model SR0002.

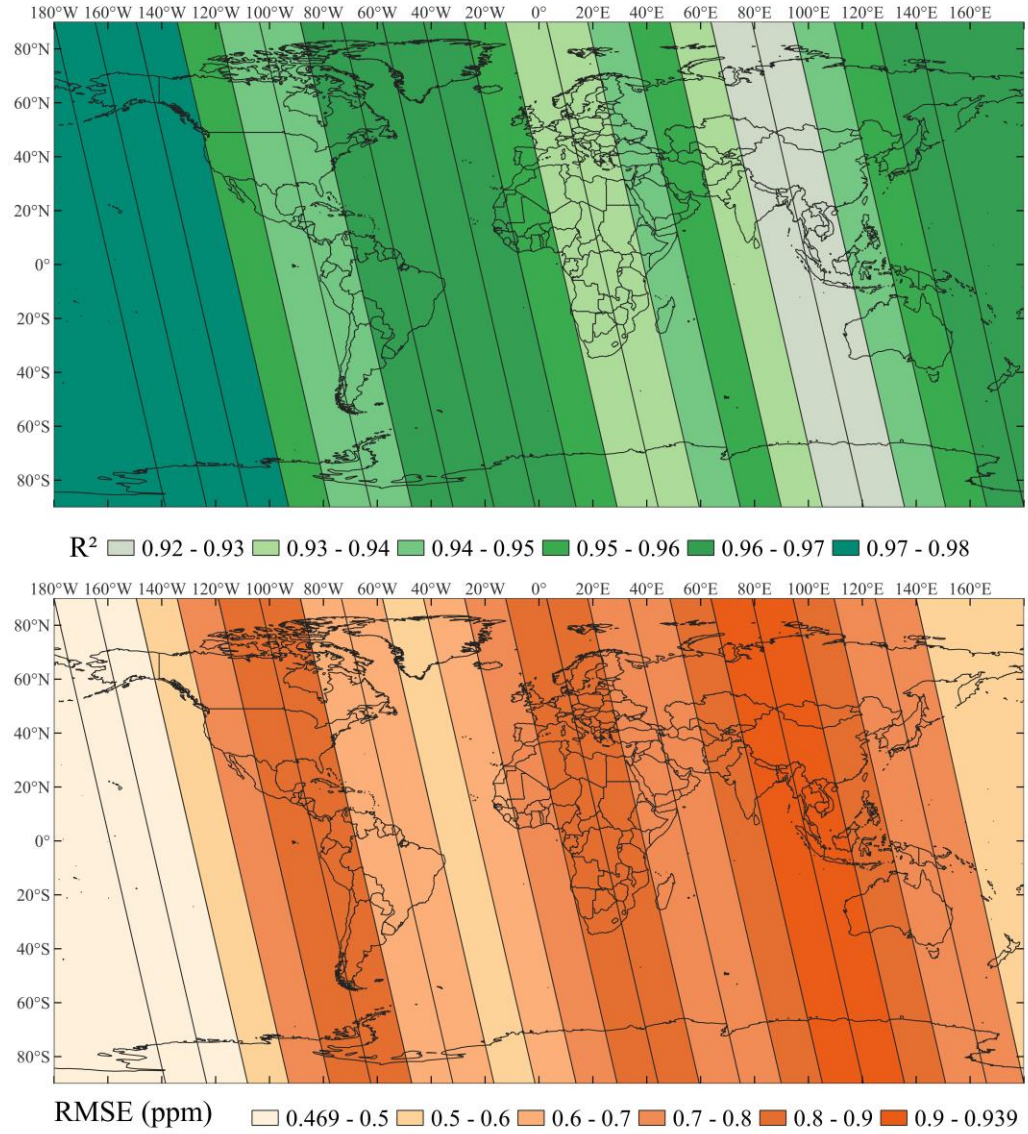


Fig. S2 The results of spatial expansibility validation of model SR0002.

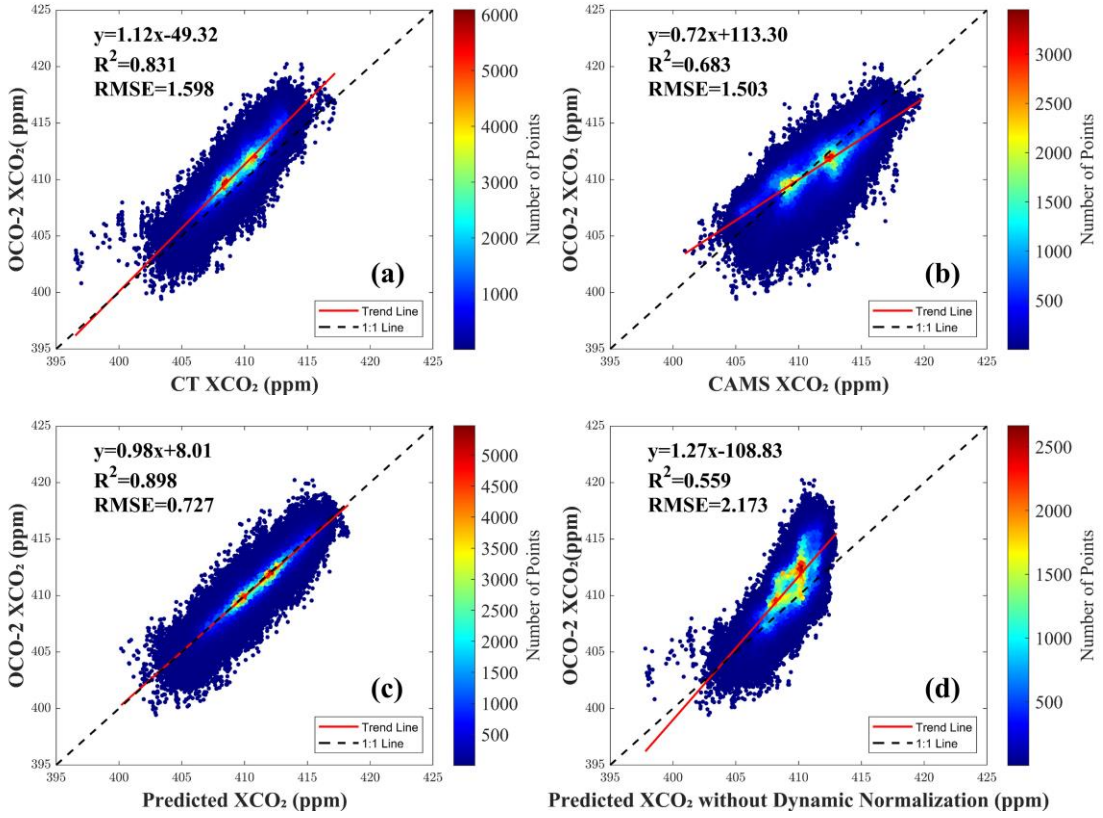


Fig. S3. Comparison of XCO2 from different sources between 2019 to 2020 for model SR0002: (a) CT vs OCO-2, (b) CAMS vs OCO-2, (c) XCO2 predicted by model SR0002 using dynamic normalization vs OCO-2, (d) XCO2 predicted by model SR0002 without using dynamic normalization vs OCO-2.

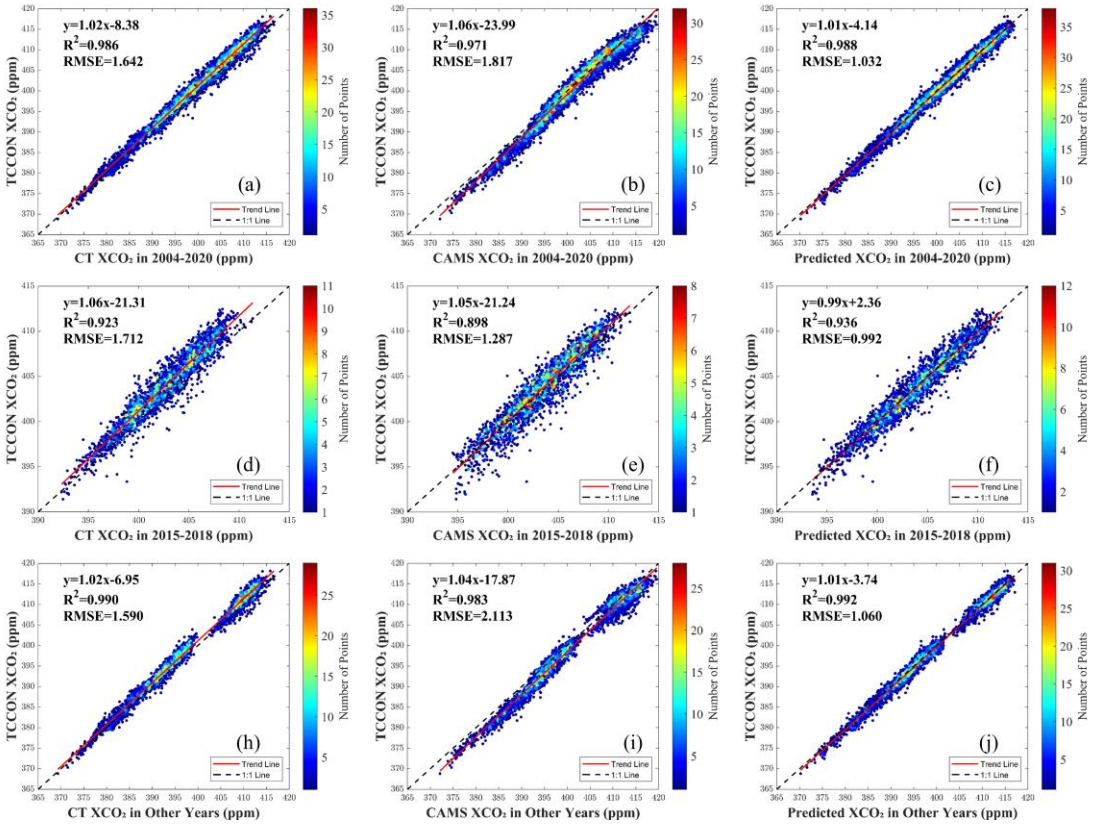
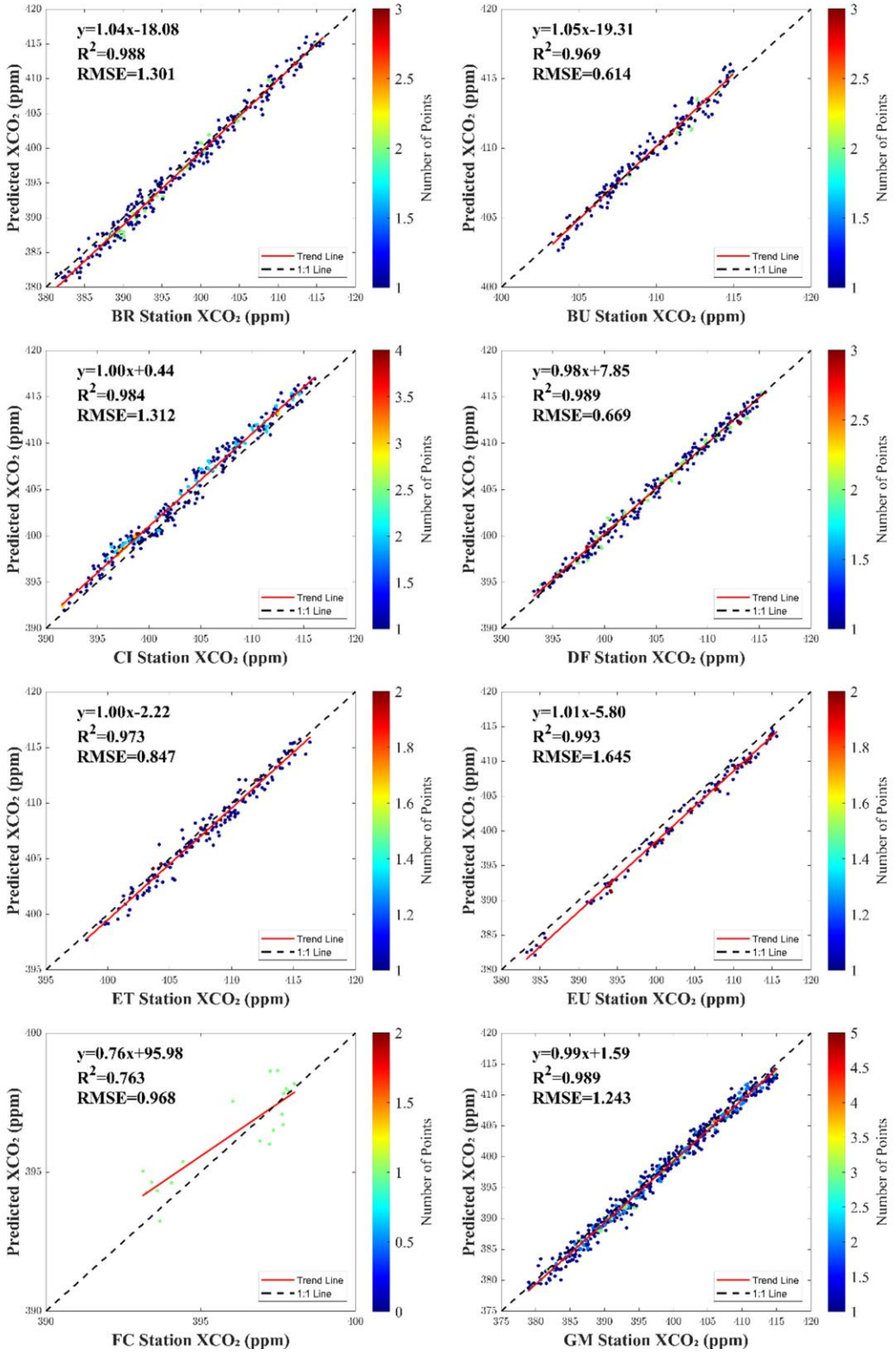
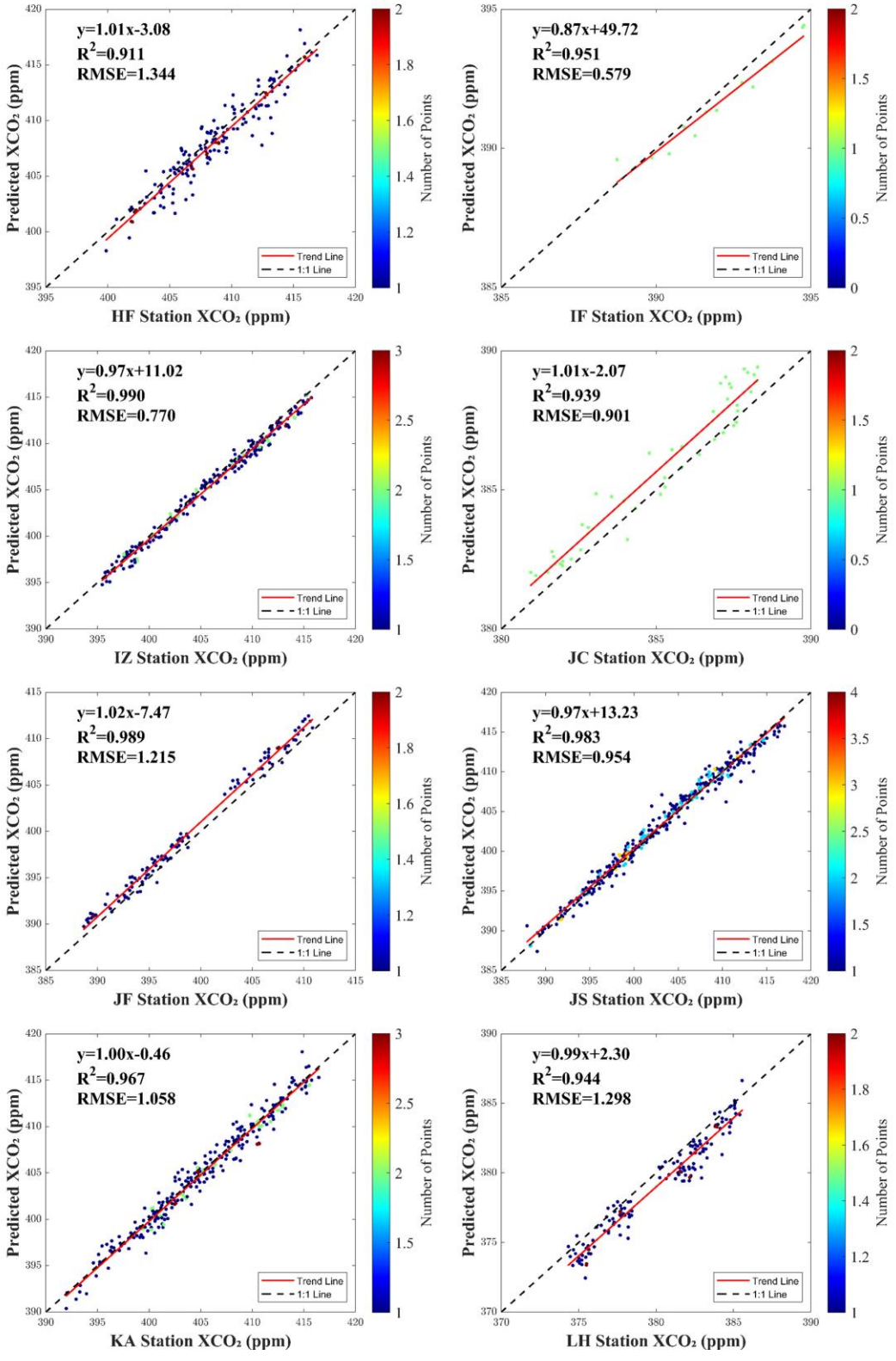
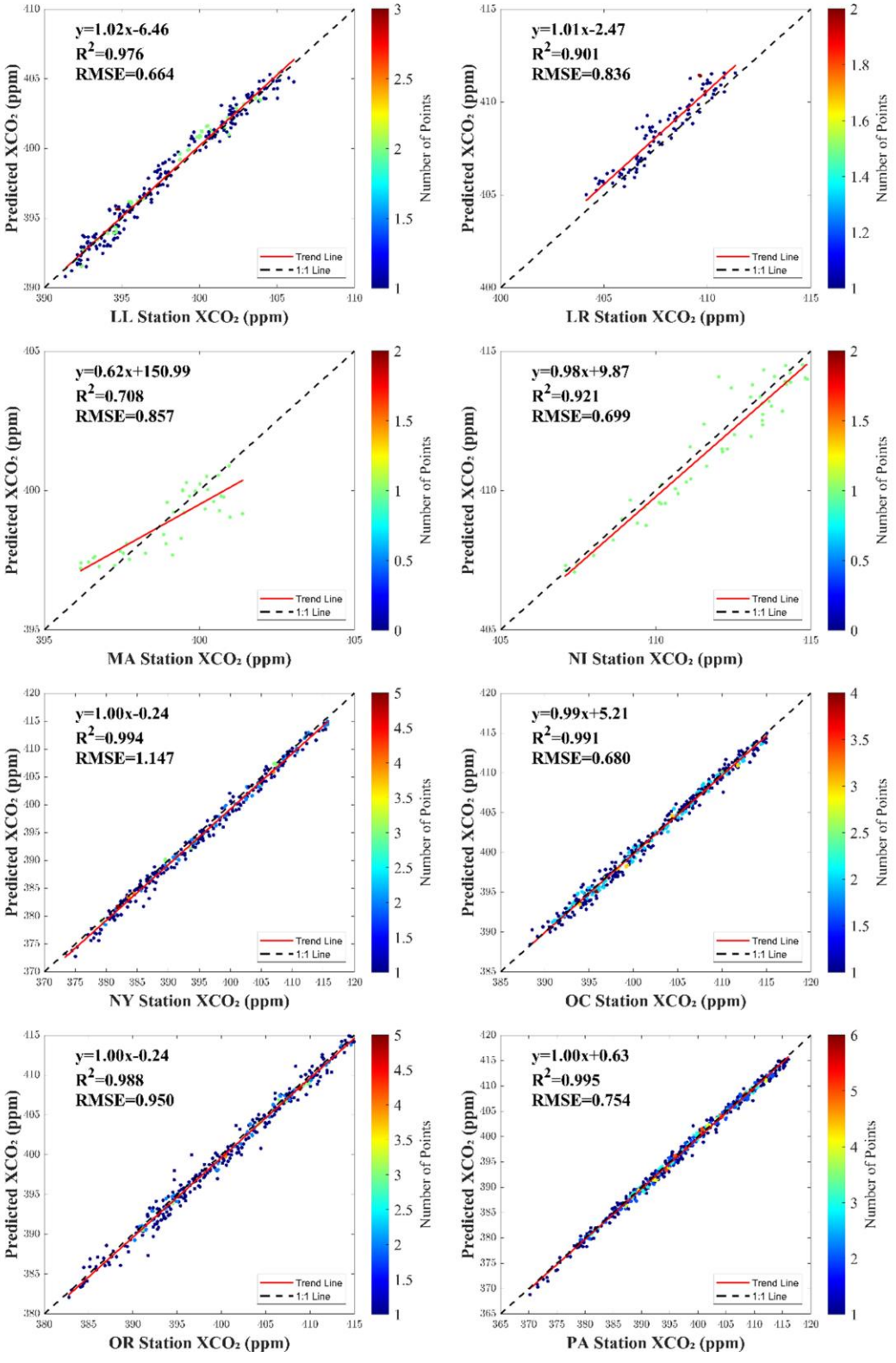


Fig. S4. All TCCON station observations vs CT , CAMS and model SR0002 prediction results from 2004 to 2020. The data for (a), (b), (c) are from 2004 to 2020. The data for (d), (e), (f) are from 2015 to 2018, which is the period for model training. The data for (h), (i), (j) are from other years, which is the period for model extrapolation.


y=1.04x-18.08
R²=0.988
RMSE=1.301
Predicted XCO₂ (ppm)
BR Station XCO₂ (ppm)
Number of Points
Trend Line
1:1 Line
y=1.05x-19.31
R²=0.969
RMSE=0.614
BU Station XCO₂ (ppm)
y=1.00x+0.44
R²=0.984
RMSE=1.312
CI Station XCO₂ (ppm)
y=0.98x+7.85
R²=0.989
RMSE=0.669
DF Station XCO₂ (ppm)
y=1.00x-2.22
R²=0.973
RMSE=0.847
ET Station XCO₂ (ppm)
y=1.01x-5.80
R²=0.993
RMSE=1.645
EU Station XCO₂ (ppm)
y=0.76x+95.98
R²=0.763
RMSE=0.968
FC Station XCO₂ (ppm)
y=0.99x+1.59
R²=0.989
RMSE=1.243
GM Station XCO₂ (ppm)


y=1.01x-3.08
R²=0.911
RMSE=1.344
Trend Line
1:1 Line
Predicted XCO₂ (ppm)
HF Station XCO₂ (ppm)
Number of Points
y=0.87x+49.72
R²=0.951
RMSE=0.579
IF Station XCO₂ (ppm)
y=0.97x+11.02
R²=0.990
RMSE=0.770
IZ Station XCO₂ (ppm)
y=1.01x-2.07
R²=0.939
RMSE=0.901
JC Station XCO₂ (ppm)
y=1.02x-7.47
R²=0.989
RMSE=1.215
JF Station XCO₂ (ppm)
y=0.97x+13.23
R²=0.983
RMSE=0.954
JS Station XCO₂ (ppm)
y=1.00x-0.46
R²=0.967
RMSE=1.058
KA Station XCO₂ (ppm)
y=0.99x+2.30
R²=0.944
RMSE=1.298
LH Station XCO₂ (ppm)


y=1.02x-6.46
R²=0.976
RMSE=0.664
Trend Line
1:1 Line
Predicted XCO₂ (ppm)
LL Station XCO₂ (ppm)
Number of Points
y=1.01x-2.47
R²=0.901
RMSE=0.836
LR Station XCO₂ (ppm)
y=0.62x+150.99
R²=0.708
RMSE=0.857
MA Station XCO₂ (ppm)
y=0.98x+9.87
R²=0.921
RMSE=0.699
NI Station XCO₂ (ppm)
y=1.00x-0.24
R²=0.994
RMSE=1.147
NY Station XCO₂ (ppm)
y=0.99x+5.21
R²=0.991
RMSE=0.680
OC Station XCO₂ (ppm)
y=1.00x-0.24
R²=0.988
RMSE=0.950
OR Station XCO₂ (ppm)
y=1.00x+0.63
R²=0.995
RMSE=0.754
PA Station XCO₂ (ppm)

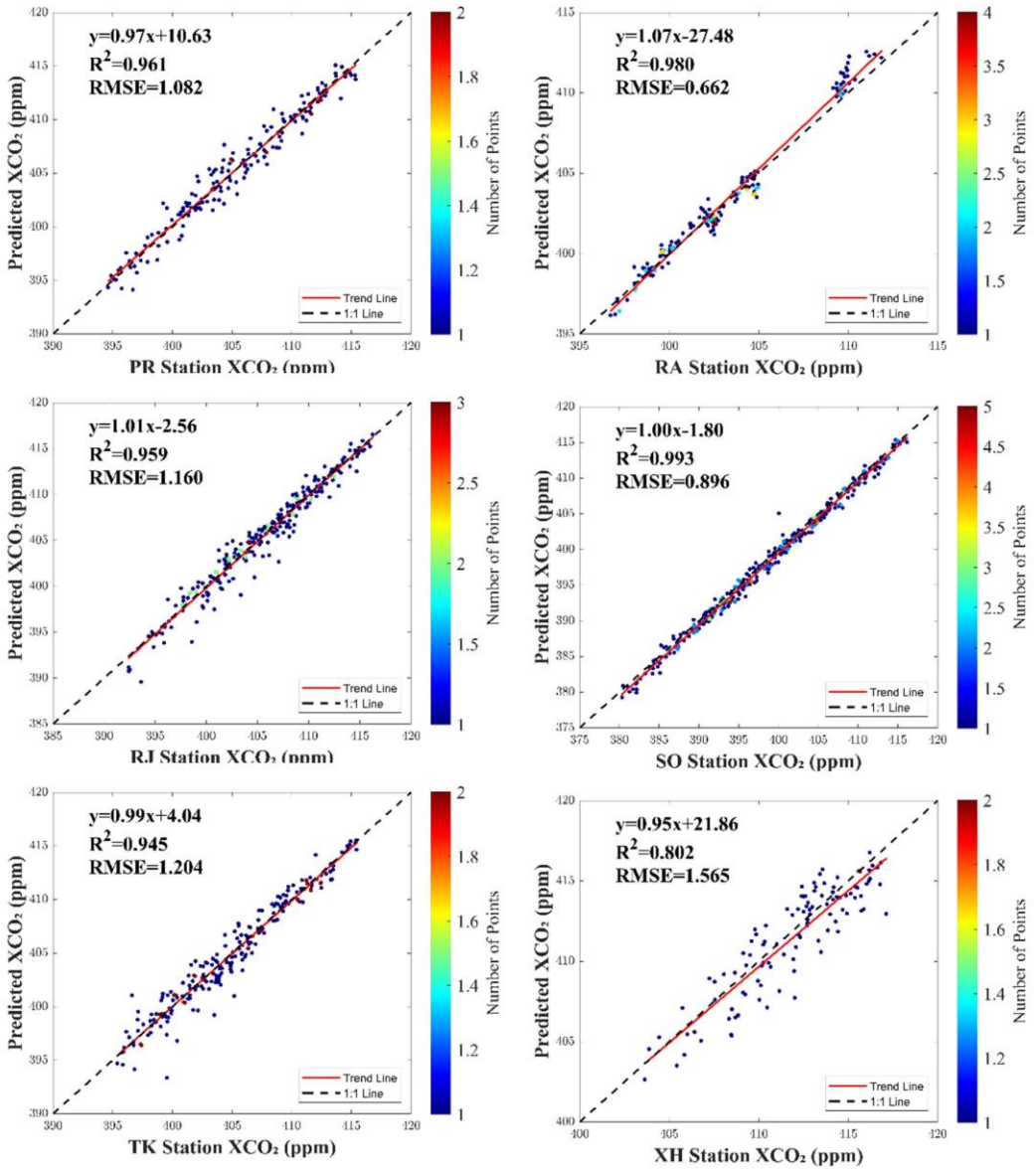
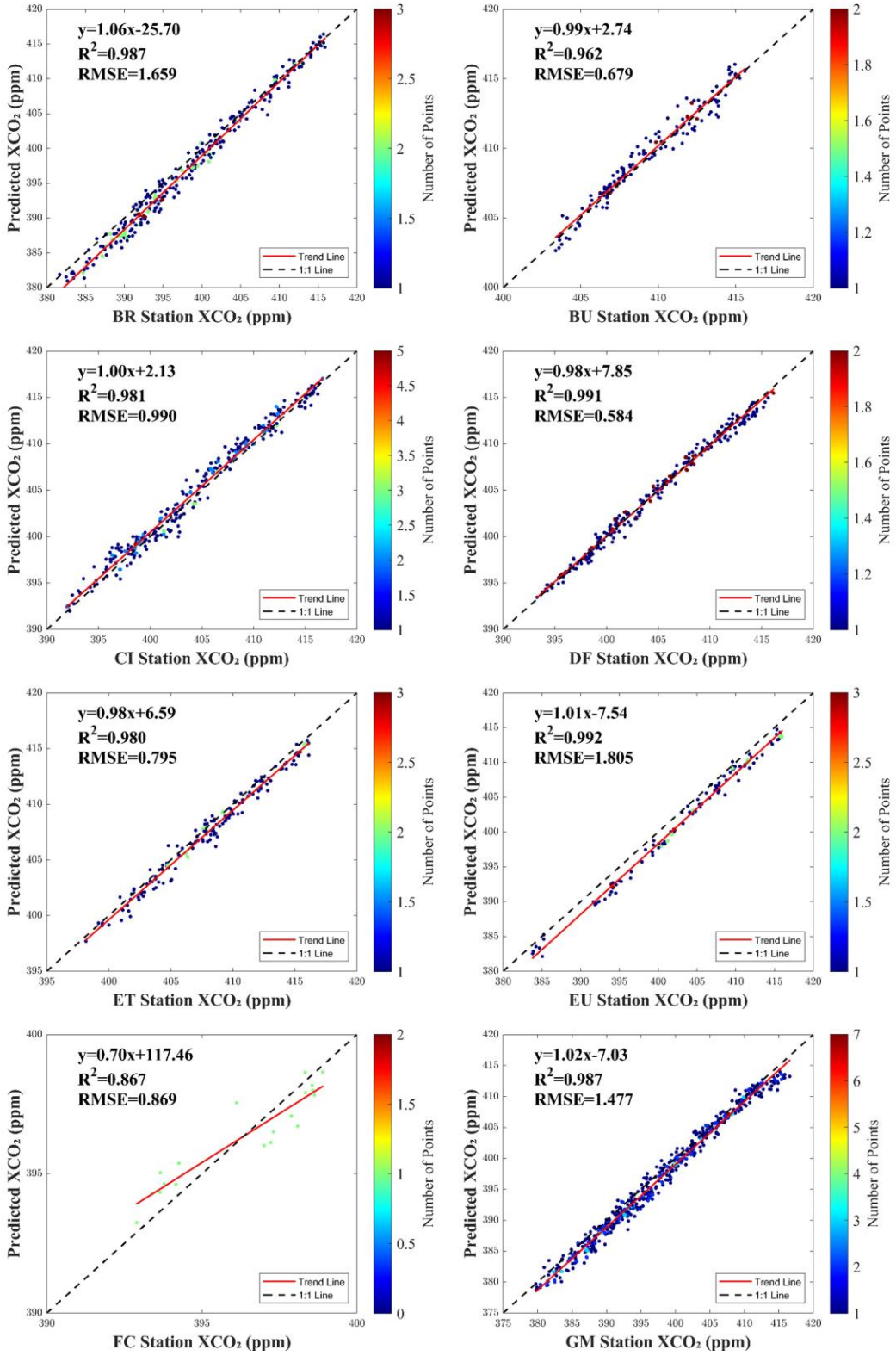
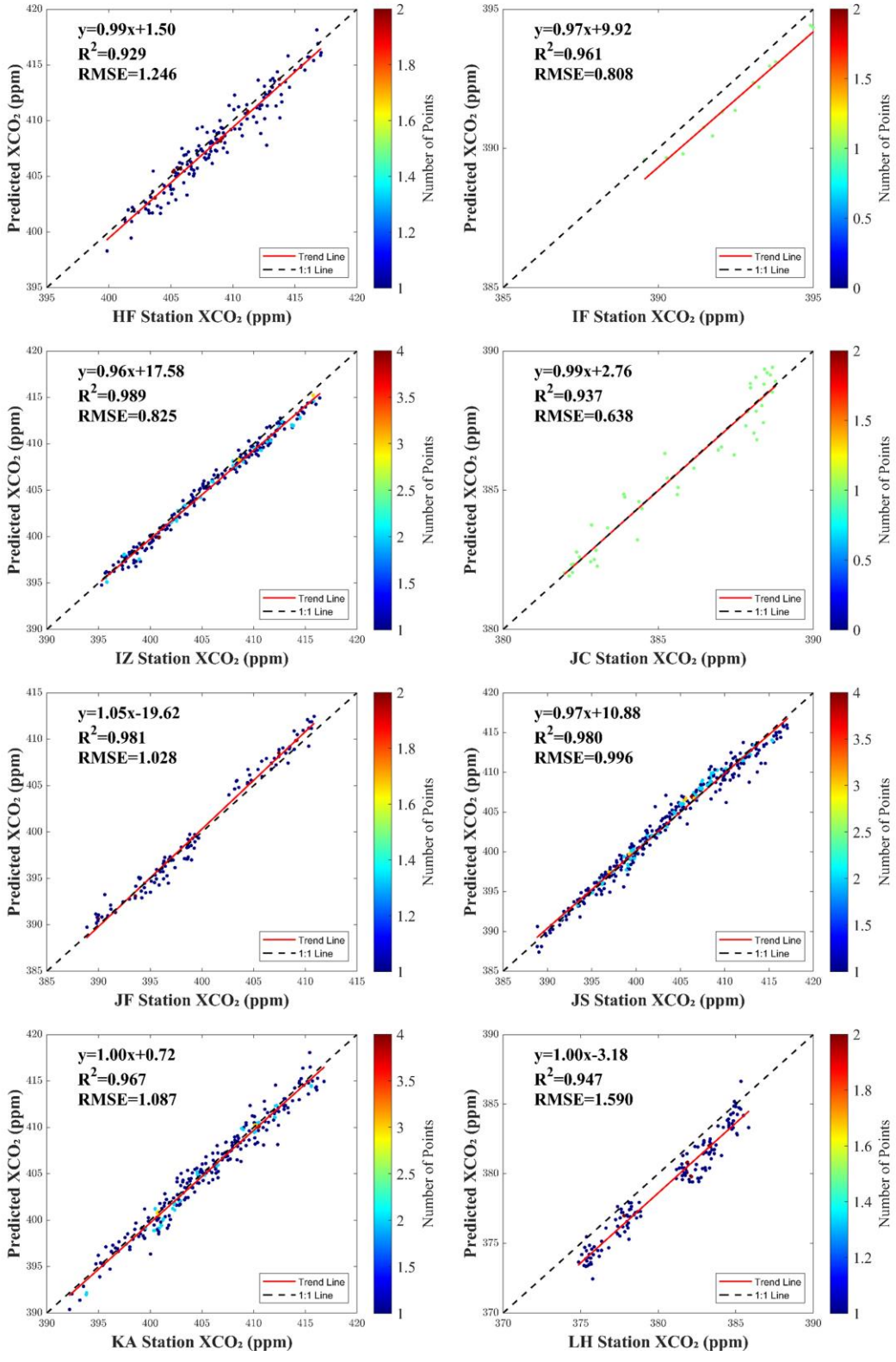


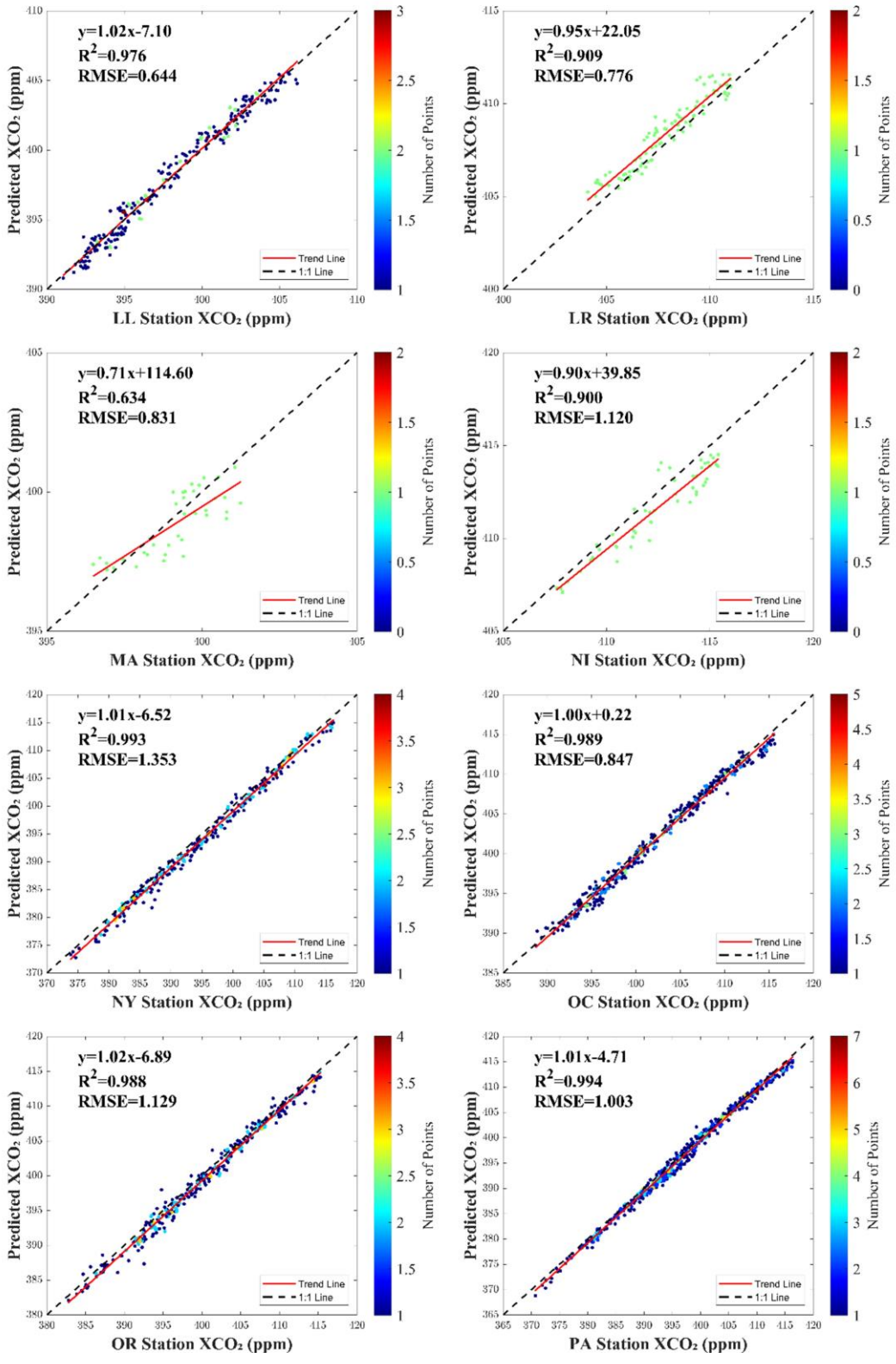
Fig. S5. The validation results for each TCCON station of model SR0002.

Table S1 Each result of ten-fold cross validation results for model SR0320 (R^2, RMSE and MAE).

R^2	RMSE (ppm)	MAE (ppm)
0.974	0.551	0.380
0.974	0.544	0.379
0.973	0.551	0.381
0.974	0.549	0.378
0.973	0.558	0.386
0.973	0.551	0.379
0.973	0.556	0.383
0.975	0.544	0.378
0.973	0.557	0.383
0.974	0.552	0.383


y=1.06x-25.70
R²=0.987
RMSE=1.659
Trend Line
1:1 Line
Predicted XCO₂ (ppm)
BR Station XCO₂ (ppm)
Number of Points
y=0.99x+2.74
R²=0.962
RMSE=0.679
BU Station XCO₂ (ppm)
y=1.00x+2.13
R²=0.981
RMSE=0.990
CI Station XCO₂ (ppm)
y=0.98x+7.85
R²=0.991
RMSE=0.584
DF Station XCO₂ (ppm)
y=0.98x+6.59
R²=0.980
RMSE=0.795
ET Station XCO₂ (ppm)
y=1.01x-7.54
R²=0.992
RMSE=1.805
EU Station XCO₂ (ppm)
y=0.70x+117.46
R²=0.867
RMSE=0.869
FC Station XCO₂ (ppm)
y=1.02x-7.03
R²=0.987
RMSE=1.477
GM Station XCO₂ (ppm)


y=0.99x+1.50
R²=0.929
RMSE=1.246
HF Station XCO₂ (ppm)
y=0.97x+9.92
R²=0.961
RMSE=0.808
IF Station XCO₂ (ppm)
y=0.96x+17.58
R²=0.989
RMSE=0.825
IZ Station XCO₂ (ppm)
y=0.99x+2.76
R²=0.937
RMSE=0.638
JC Station XCO₂ (ppm)
y=1.05x-19.62
R²=0.981
RMSE=1.028
JF Station XCO₂ (ppm)
y=0.97x+10.88
R²=0.980
RMSE=0.996
JS Station XCO₂ (ppm)
y=1.00x+0.72
R²=0.967
RMSE=1.087
KA Station XCO₂ (ppm)
y=1.00x-3.18
R²=0.947
RMSE=1.590
LH Station XCO₂ (ppm)
Predicted XCO₂ (ppm)
Number of Points
Trend Line
1:1 Line


y=1.02x-7.10
R²=0.976
RMSE=0.644
Trend Line
1:1 Line
Predicted XCO₂ (ppm)
LL Station XCO₂ (ppm)
Number of Points
y=0.95x+22.05
R²=0.909
RMSE=0.776
LR Station XCO₂ (ppm)
y=0.71x+114.60
R²=0.634
RMSE=0.831
MA Station XCO₂ (ppm)
y=0.90x+39.85
R²=0.900
RMSE=1.120
NI Station XCO₂ (ppm)
y=1.01x-6.52
R²=0.993
RMSE=1.353
NY Station XCO₂ (ppm)
y=1.00x+0.22
R²=0.989
RMSE=0.847
OC Station XCO₂ (ppm)
y=1.02x-6.89
R²=0.988
RMSE=1.129
OR Station XCO₂ (ppm)
y=1.01x-4.71
R²=0.994
RMSE=1.003
PA Station XCO₂ (ppm)

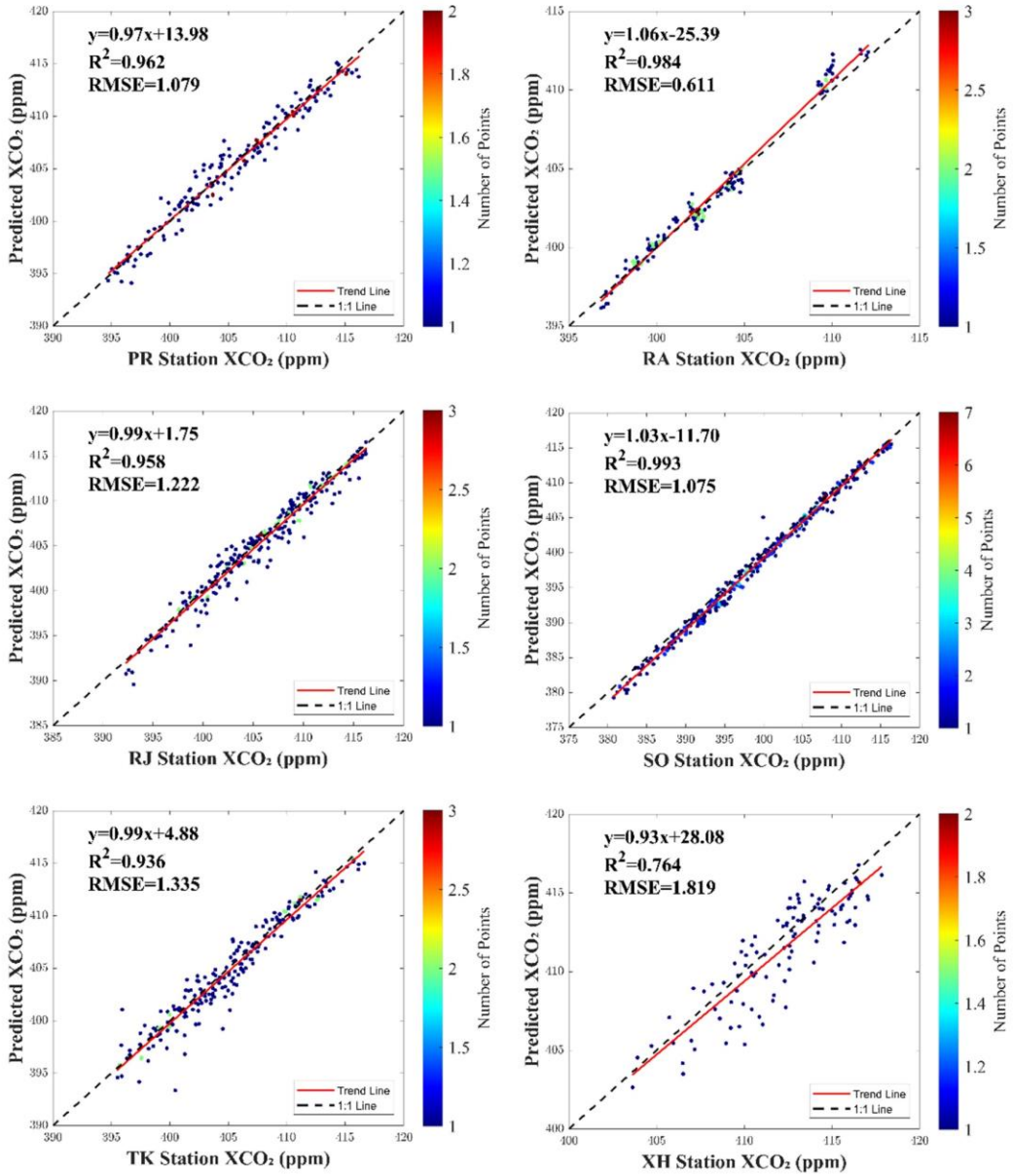


Fig. S6. The validation results for each TCCON station of model SR0320.