Supplementary Material

Water uptake and gas-particle partitioning of inorganic nitrate aerosols

H. D. Do, Y. B. Lim, and Y. P. Kim

S1. Linear regression for constructing $AN_{ISO\_CORRECTION}$ and $AN_{EAIM\text{-}CORRECTION}$

The concentrations of nitrates and ammoniums at RH 10% were assumed to be the same as the stable-mode simulations. Then, ALWC, nitrates and ammoniums increased with RH as much as what the metastable mode predicted. To perform a linear regression properly above RH 10%, simulations by the metastable-mode E-AIM in the entire range of RH were considered, but simulations by the metastable-mode ISORROPIA-II in the range of RH 30-90% were considered because in the range of RH 10-30%, GF (ISORROPIA-II Metastable (II)) and the total sum of ALW, ammoniums, and nitrates decreased as RH increased (Fig. S3D and F). At RH 10%, 22 $\mu g/m^3$ of ALWC, which was 28% of total aerosols, was calculated based on a 250 nm diameter of aerosols. $AN_{ISO\_CORRECTION}$ in Fig. 1 illustrates the revised GF of AN aerosols curve based on ISORROPIA-II simulations. So does $AN_{E\text{-}AIM\_CORRECTION}$ in Fig. S5 based on E-AIM simulations. In $AN_{E\text{-}AIM\_CORRECTION}$, the concentrations of nitrates and ammoniums in the stable mode were used at RH 10% and those in the metastable mode were used above RH 10%.

Table S1. Concentrations of inorganic and organic species in thermodynamic model input for aerosol types

Aerosol Type	Sulfate ($\mu g/m^3$)	Ammonium ($\mu g/m^3$)	Nitrate ($\mu g/m^3$)	Glyoxal ($\mu g/m^3$)
AS Aerosol	37.76	14.16	0.00	0.00
AN Aerosol	0.00	11.68	40.24	0.00
AS: AN (80:20)*	32.29	14.61	8.60	0.00
AS: AN (50:50)*	17.08	12.80	22.04	0.00
AS: AN (20:80)*	8.07	13.02	34.41	0.00
Glyoxal Aerosol	0.00	0.00	0.00	51.92
AS: Glyoxal (70:30)**	26.24	9.84	0.00	15.85
AS: Glyoxal (50:50)**	18.88	7.08	0.00	25.96
AN: Glyoxal (5:5)***	0.00	5.84	20.12	25.96
AS: AN: Glyoxal (50:50:20)****	14.25	10.68	18.39	8.60

* : Mixture of AS and AN Aerosol

** : Mixture of AS and Glyoxal Aerosol

*** : Mixture of AN and Glyoxal Aerosol

**** : Mixture of AS, AN, and Glyoxal Aerosol

(x:y) : mass-based ratio of x to y

Table S2. Simulated ALWC output for AS Aerosols (input: $[NH_4^+]$ = 14.16 μg/m^3 and $[SO_4^{2-}]$ = 37.76 μg/m^3) (Original vs. Revised)

RH (%)	ISORROPIA-II Stable Mode		E-AIM Stable Mode	
	Original (μg/m^3)	Revised (μg/m^3)	Original (μg/m^3)	Revised (μg/m^3)
10	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00
55	0.00	28.64	0.00	27.24
60	0.00	33.05	0.00	31.88
65	0.00	38.34	0.00	37.44
70	0.00	45.00	0.69	44.35
75	0.00	53.71	3.26	53.41
80	66.09	66.09	66.23	66.23
85	86.20	86.20	86.65	86.65
90	126.33	126.33	126.89	126.89

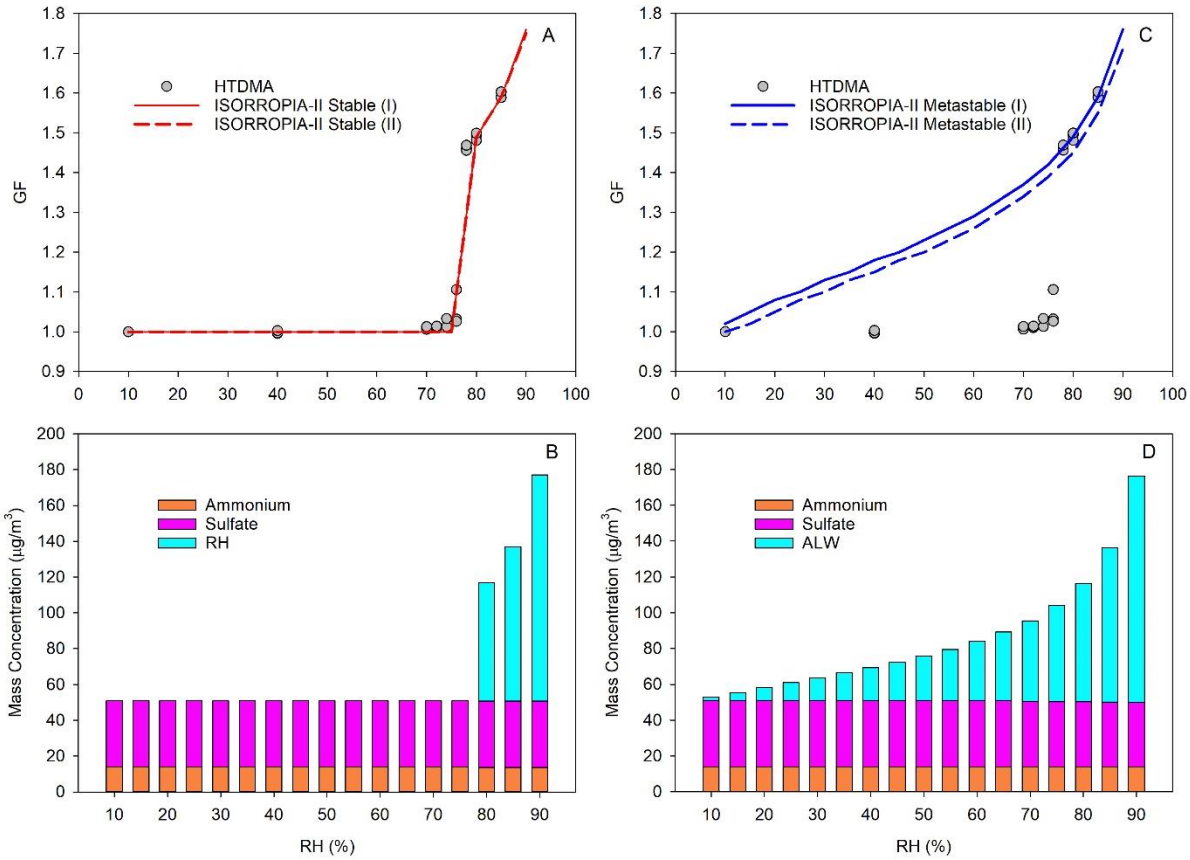


Figure S1. Hygroscopic Growth Factor (GF) vs. RH plots for AS aerosols (A) and (C). HTDMA indicates measurements by HTDMA. ISORROPIA-II Stable and Metastable indicate simulation results by ISORROPIA-II with the stable and metastable mode, respectively. As we mentioned in method section, ISORROPIA-II (I) indicates that the growth factor has been determined by the water-removed aerosol (i.e., $GF(I) = D_i/D_{dry,i}$). ISORROPIA-II (II) indicates that the growth factor has been determined by the aerosol size at RH 10% (i.e., $GF(II) = D_i/D_{10\%}$). Mass concentrations of the sum of ammoniums, sulfates and ALWC vs. RH in the stable mode (B) and in the metastable mode (D).

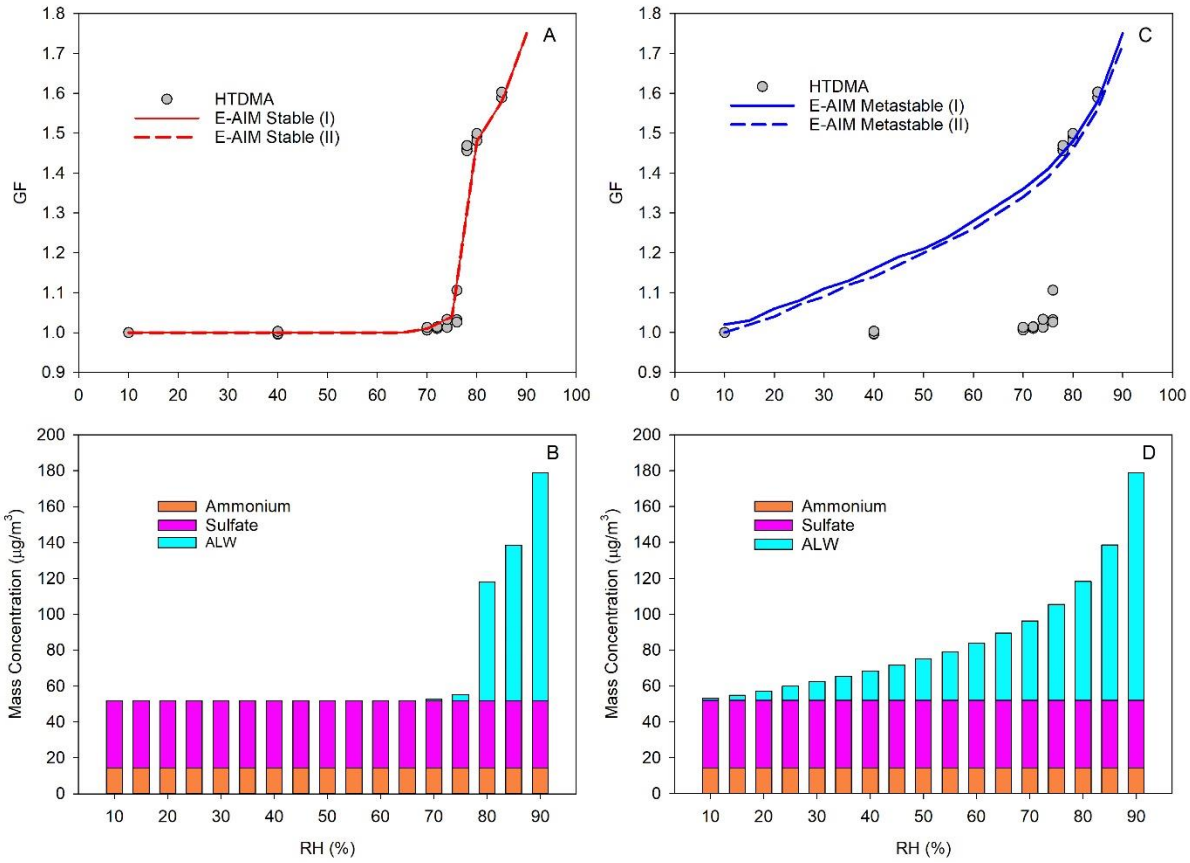


Figure S2. GF vs. RH plots for AS aerosols in the stable mode (A) and in the metastable mode (C). HTDMA indicates measurements by HTDMA. E-AIM Stable and Metastable indicate simulation results by E-AIM with the stable and metastable mode, respectively. E-AIM (I) indicates that the growth factor has been determined by the water-removed aerosol (i.e., GF(I) = $D_i/D_{dry,i}$). E-AIM (II) indicates that the growth factor has been determined by the aerosol size at RH 10% (i.e., GF(II) = $D_i/D_{10\%}$). Mass concentrations of the sum of ammoniums, sulfates and ALWC vs. RH in the stable mode (B) and in the metastable mode (D)

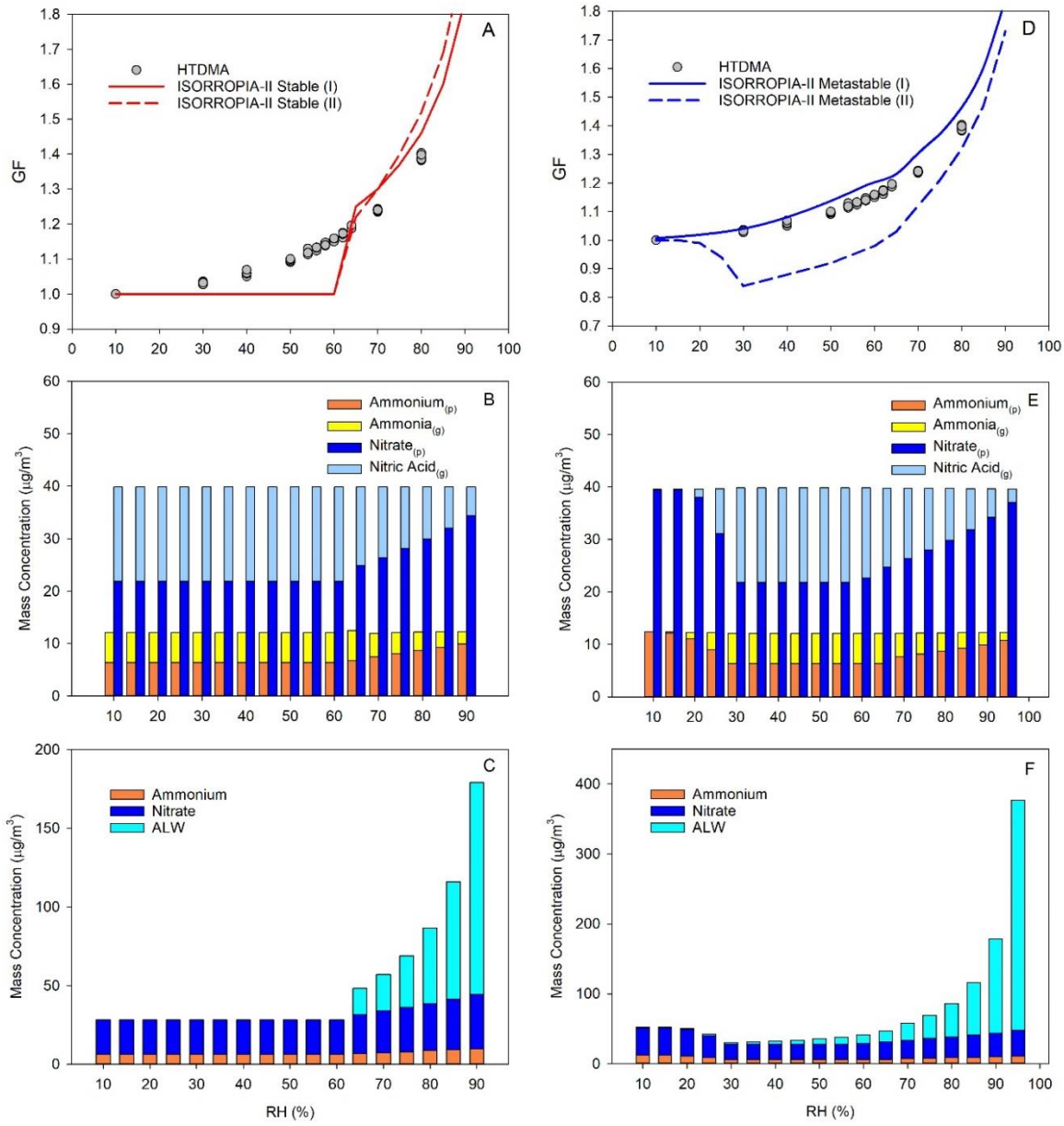


Figure S3. GF vs. RH plots for AN aerosols in the stable mode (A) and in the metastable mode (D). HTDMA indicates measurements by HTDMA. ISORROPIA-II Stable and Metastable indicate simulation results by ISORROPIA-II with the stable and metastable mode, respectively. ISORROPIA-II (I) indicates that the growth factor has been determined by the water-removed aerosol (i.e., $GF(I) = D_i/D_{dry,i}$). ISORROPIA-II (II) indicates that the growth factor has been determined by the aerosol size at RH 10% (i.e., $GF(II) = D_i/D_{10\%}$). The gas-particle partitioning of ammonium-ammonia and nitrate-nitric acid vs. RH in the stable mode (B) and in the metastable mode (E). Mass concentrations of the sum of ammoniums, nitrates and ALWC vs. RH in the stable mode (C) and in the metastable mode (F). Ammonium, Sulfate, Nitrate, and ALW are in the particle phase. Ammonia and Nitric Acid are in the gas phase.

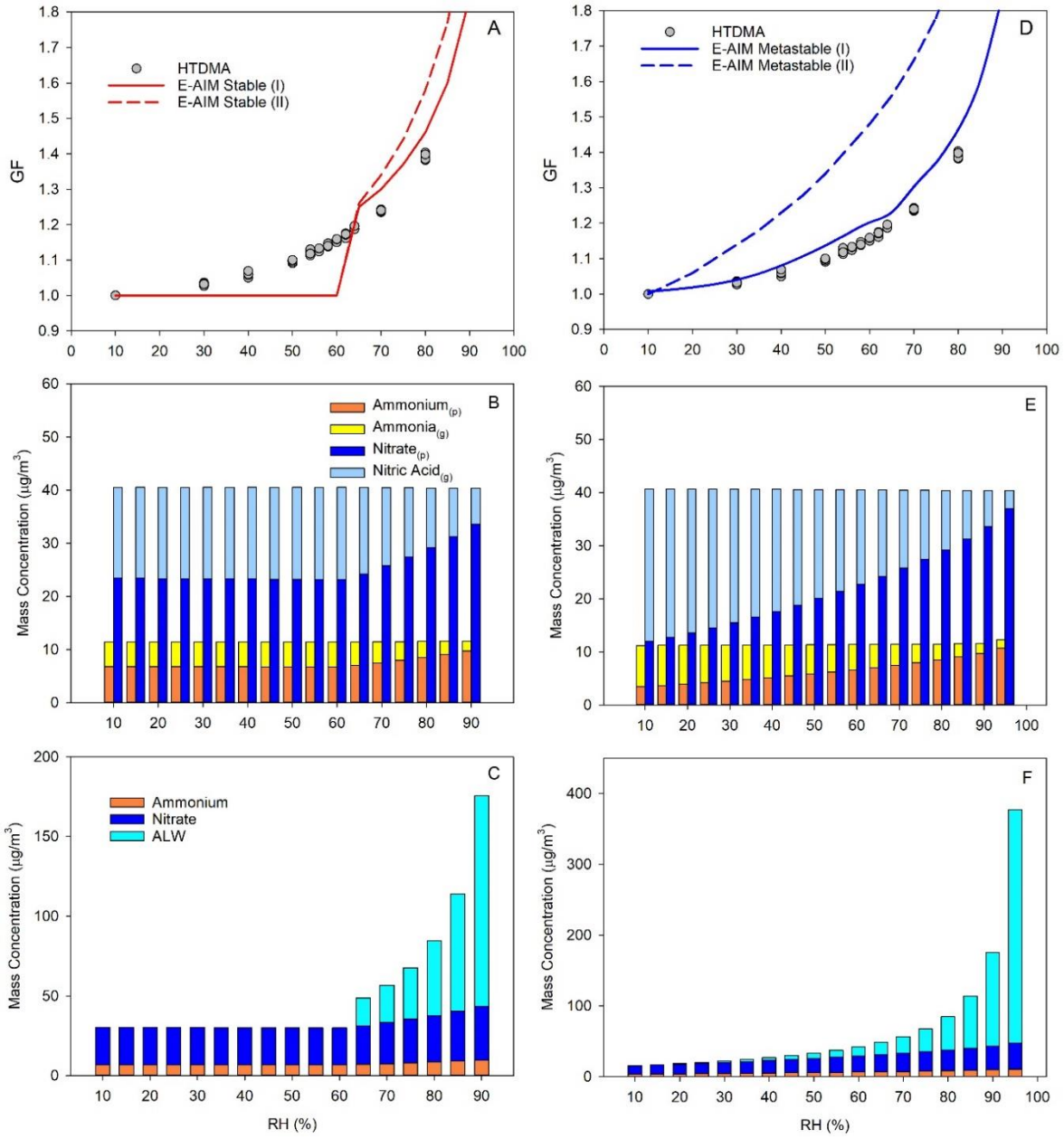
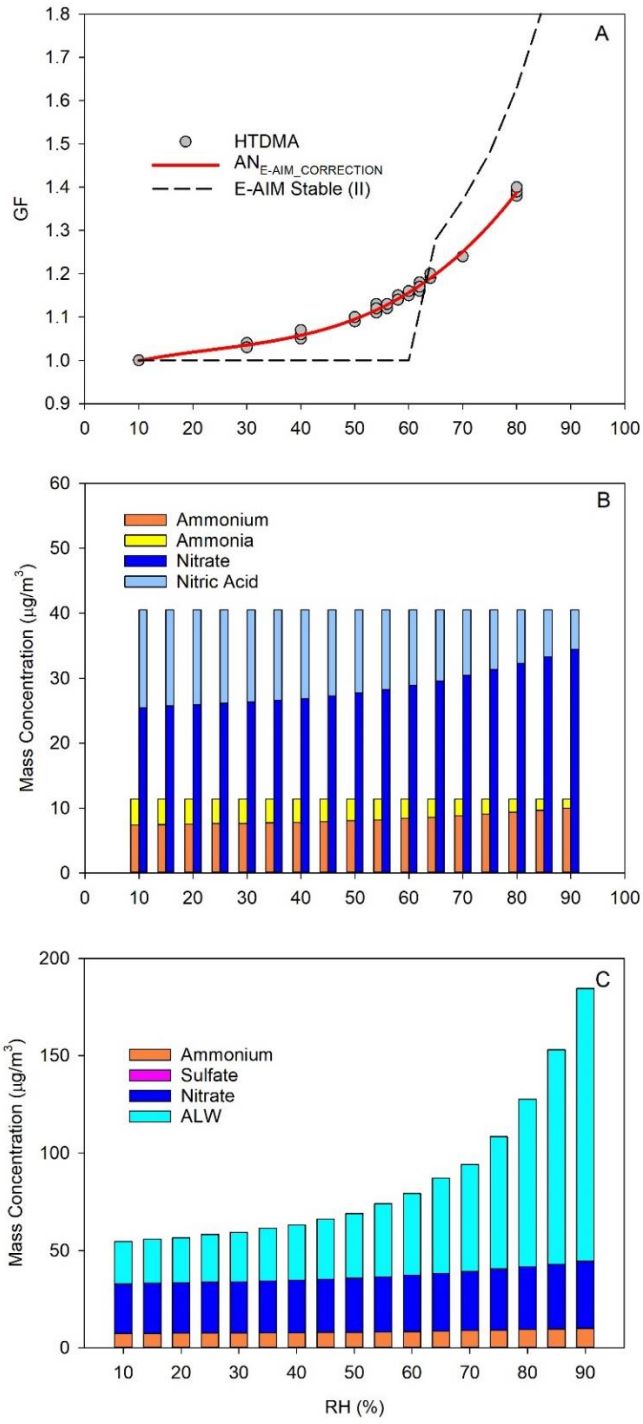


Figure S4 GF vs. RH plots for AN aerosols in the stable mode (A) and in the metastable mode (D). HTDMA indicates measurements by HTDMA. E-AIM Stable and Metastable indicate simulation results by E-AIM with the stable and metastable mode, respectively. E-AIM (I) indicates that the growth factor has been determined by the water-removed aerosol (i.e., GF(I) = $D_i/D_{dry,i}$). E-AIM (II) indicates that the growth factor has been determined by the aerosol size at RH 10% (i.e., GF(II) = $D_i/D_{10\%}$). The gas-particle partitioning of ammonium-ammonia and nitrate-nitric acid vs. RH in the stable mode (B) and in the metastable mode (E). Mass concentrations of the sum of ammoniums, nitrates and ALWC vs. RH in the stable mode (C) and in the metastable mode (F)



Figures S5. GF vs. RH plots for AN aerosols. HTDMA indicates measurements by HTDMA. $AN_{E\text{-}AIM\_CORRECTION}$ indicates GF of AN aerosols obtained by the linear regression (S1 Text). Ammonium, Sulfate, Nitrate, and ALW are in the gas phase. Ammonia and Nitric Acid are in the gas phase. Their simulation results based on $AN_{E\text{-}AIM\_CORRECTION}$ are plotted with RH in (B) and (C).

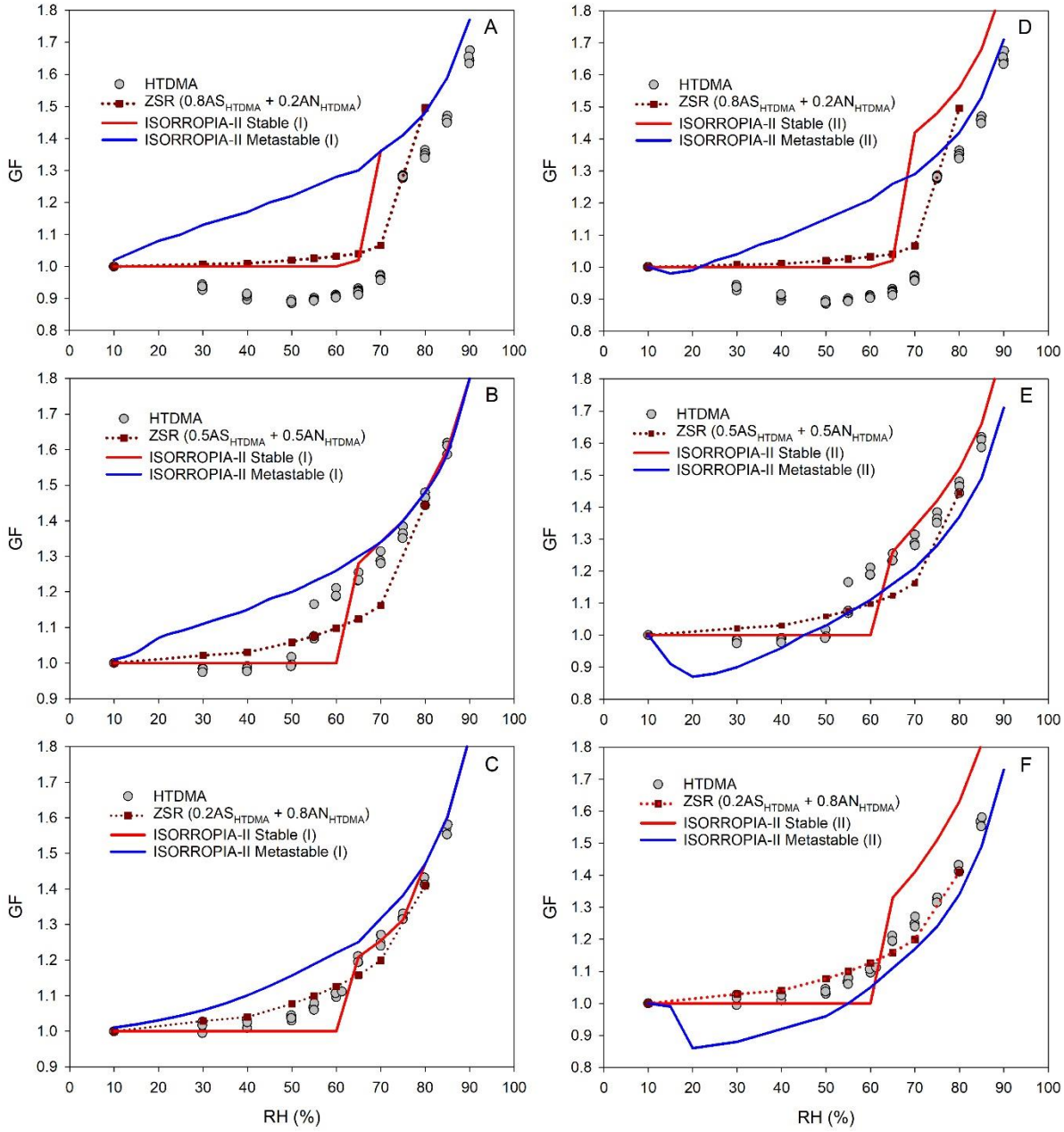


Figure S6. GF vs. RH plots for the mixture aerosols: the mass-based ratios of ammonium sulfates and ammonium nitrates are 4: 1 for (A and D), 1: 1 for (B and E), and 1: 4 for (C and F). HTDMA indicates measurements by HTDMA, ZSR(HTDMA) indicates ZSR estimation for individual HTDMA measurements for ammonium sulfates and ammonium nitrates, separately. ISORROPIA-II Stable and Metastable indicate simulation results by ISORROPIA-II with the stable and metastable mode, respectively. ISORROPIA-II Stable (I) and Metastable (I) are Type (1) simulations (A, B, and C). ISORROPIA-II Stable (II) and Metastable (II) are Type (II) simulations (D, E, and F)

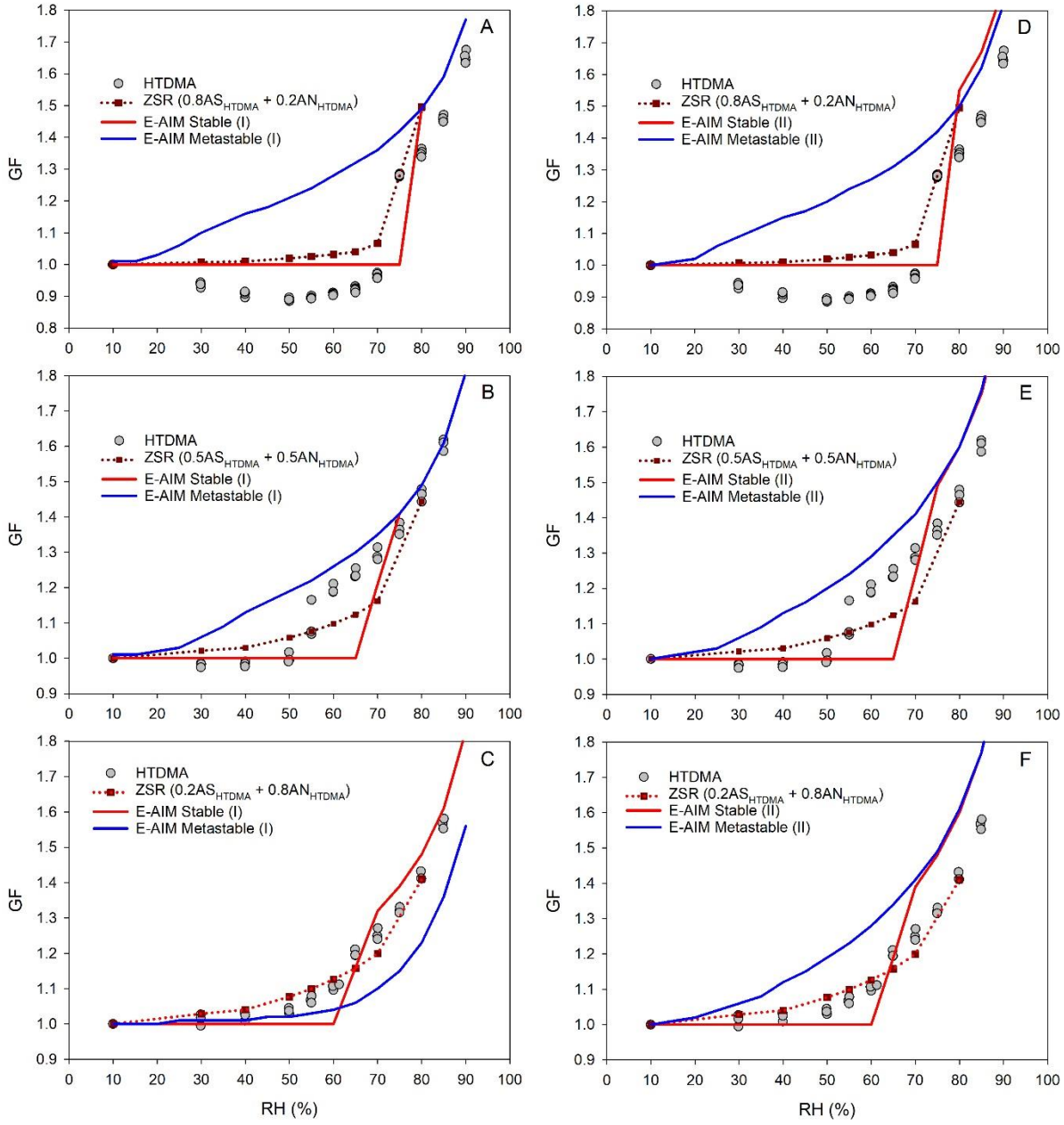


Figure S7. GF vs. RH plots for the mixture aerosols: the mass-based ratios of ammonium sulfates and ammonium nitrates are 4: 1 for (A and D), 1: 1 for (B and E), and 1: 4 for (C and F). HTDMA indicates measurements by HTDMA, ZSR(HTDMA) indicates ZSR estimation for individual HTDMA measurements for ammonium sulfates and ammonium nitrates, separately. E-AIM Stable and Metastable indicate simulation results by E-AIM with the stable and metastable mode, respectively. E-AIM Stable (I) and Metastable (I) are Type (1) simulations (A, B, and C). E-AIM Stable (II) and Metastable (II) are Type (II) simulations (D, E, and F)

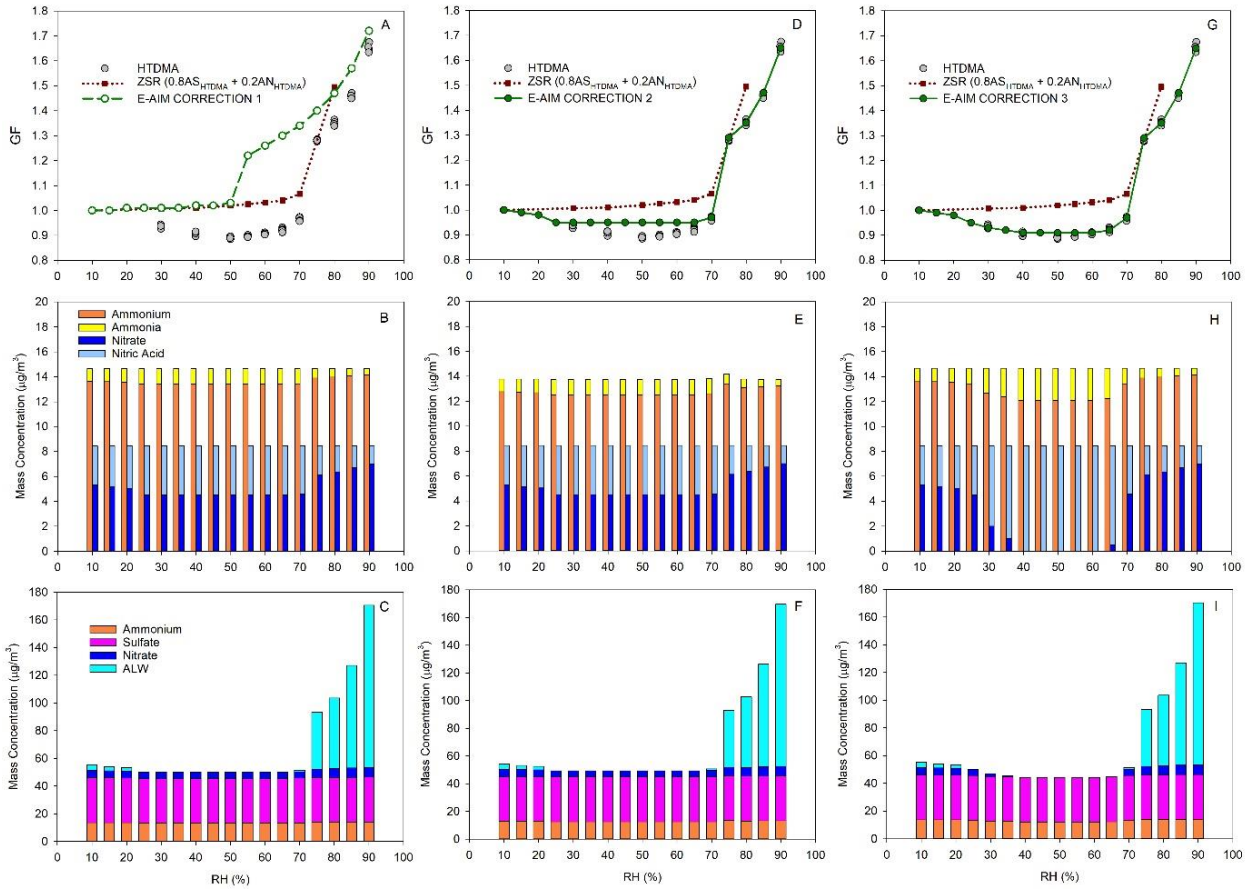


Figure S8. GF vs. RH plots for the mixture aerosols with the mass-based ratios of ammonium sulfates and ammonium nitrates to be 80 : 20 (A, D, and G). ZSR($0.8AS_{HTDMA} + 0.2AN_{HTDMA}$) indicates the sum of HTDMA measurements for individual AS aerosols and AN aerosols with ZSR method (AS : AN = 80 : 20). The gas-particle partitioning of ammonium$_{(p)}$-ammonia$_{(g)}$ and nitrate$_{(p)}$-nitric acid$_{(g)}$ (B, E, and G). The mass concentrations of ammoniums, sulfates, nitrates and ALW in the mixture aerosols vs. RH (C, F, I).

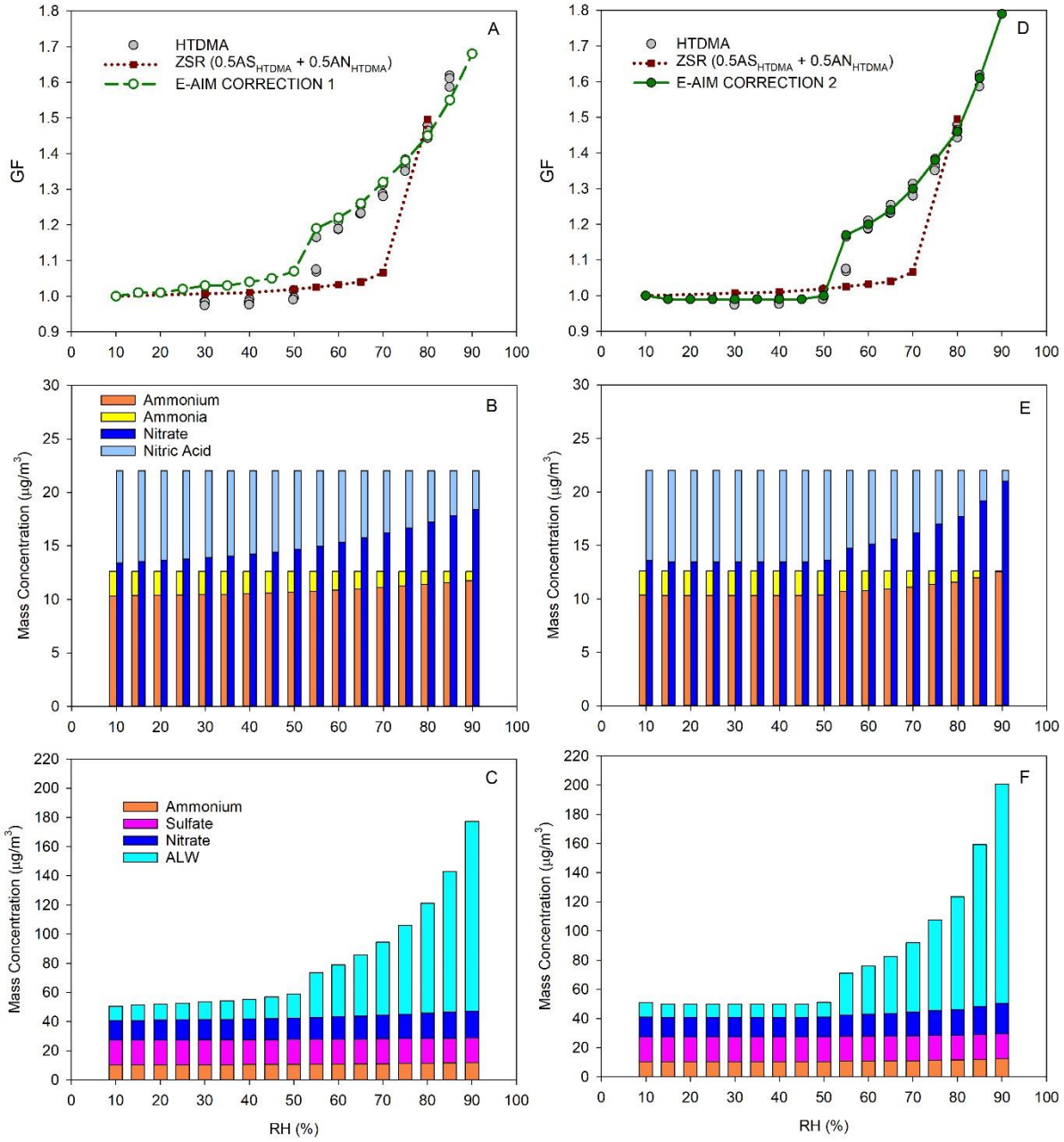


Figure S9. GF vs. RH plots for the mixture aerosols with the mass-based ratios of ammonium sulfates and ammonium nitrates to be 50 : 50 (A, and D). The gas-particle partitioning of ammonium$_{(p)}$-ammonia$_{(g)}$ and nitrate$_{(p)}$-nitric acid$_{(g)}$ (B and E). The mass concentrations of ammoniums, sulfates, nitrates and ALW in the mixture aerosols vs. RH (C and F).

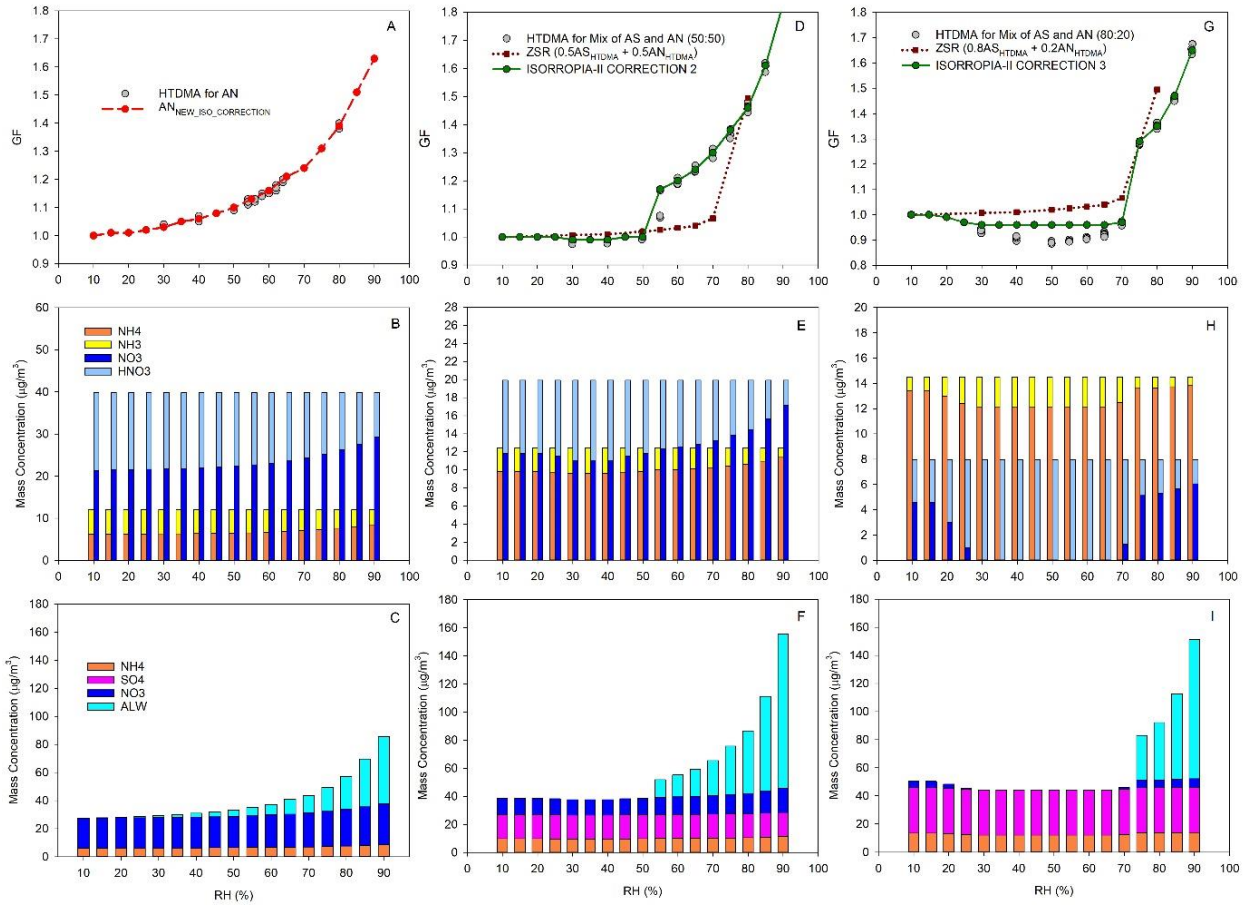


Figure S10. GF vs. RH plots for AN aerosols (A), which are adjusted to have no ALWC at RH 10% (C) and follow the metastable simulations as RH increases (B and C). Hygroscopic growth factor (GF) vs. RH plots for the mixture of AS and AN aerosols with the ratio of 50 : 50 (D) and 80 : 20 (G). Mass concentrations of components for AS: AN (50: 50) vs RH plots (E and F). Mass concentrations of components for AS: AN (80 : 20) vs RH plots (H and I)

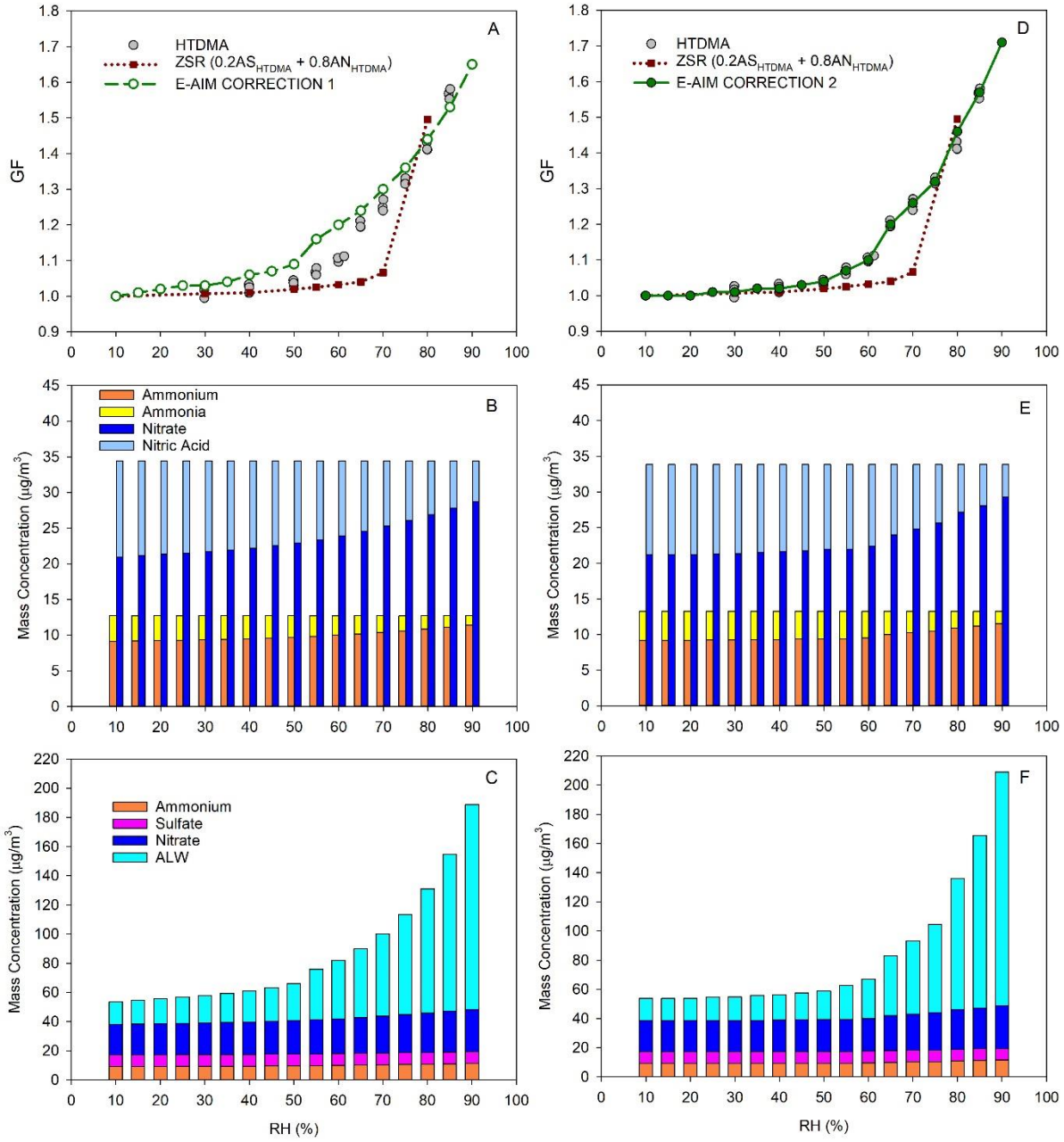


Figure S11. GF vs. RH plots for the mixture aerosols with the mass-based ratios of ammonium sulfates and ammonium nitrates to be 20 : 80 (A, and D). The gas-particle partitioning of ammonium$_{(p)}$-ammonia$_{(g)}$ and nitrate$_{(p)}$-nitric acid$_{(g)}$ (B and E). The mass concentrations of ammoniums, sulfates, nitrates and ALW in the mixture aerosols vs. RH (C and F).

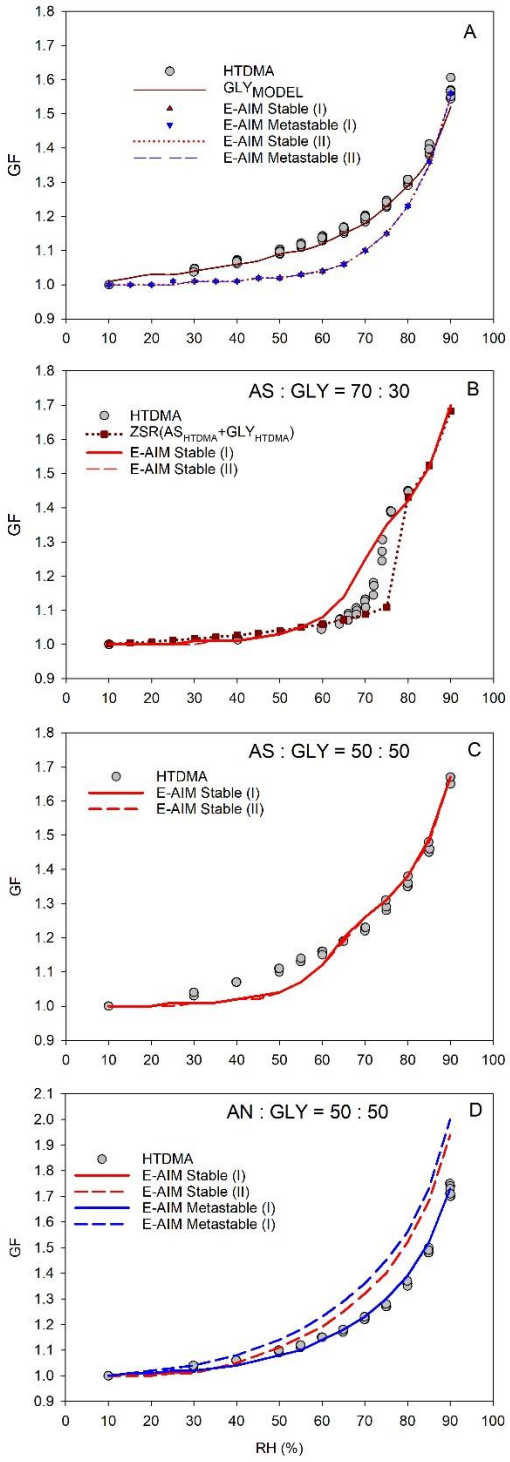


Figure S12. GF vs. RH plots for glyoxal (A), the mixture of AS and glyoxal aerosols (70 : 30) (B), the mixture of AS and glyoxal aerosols (50 : 50) (C) and the mixture of AN and glyoxal aerosols (50 : 50) (D). HTDMA indicates HTDMA measurements. GLY_{MODEL} indicates a model fit. E-AIM (I) and E-AIM (II) were performed in the stable/metastable mode.

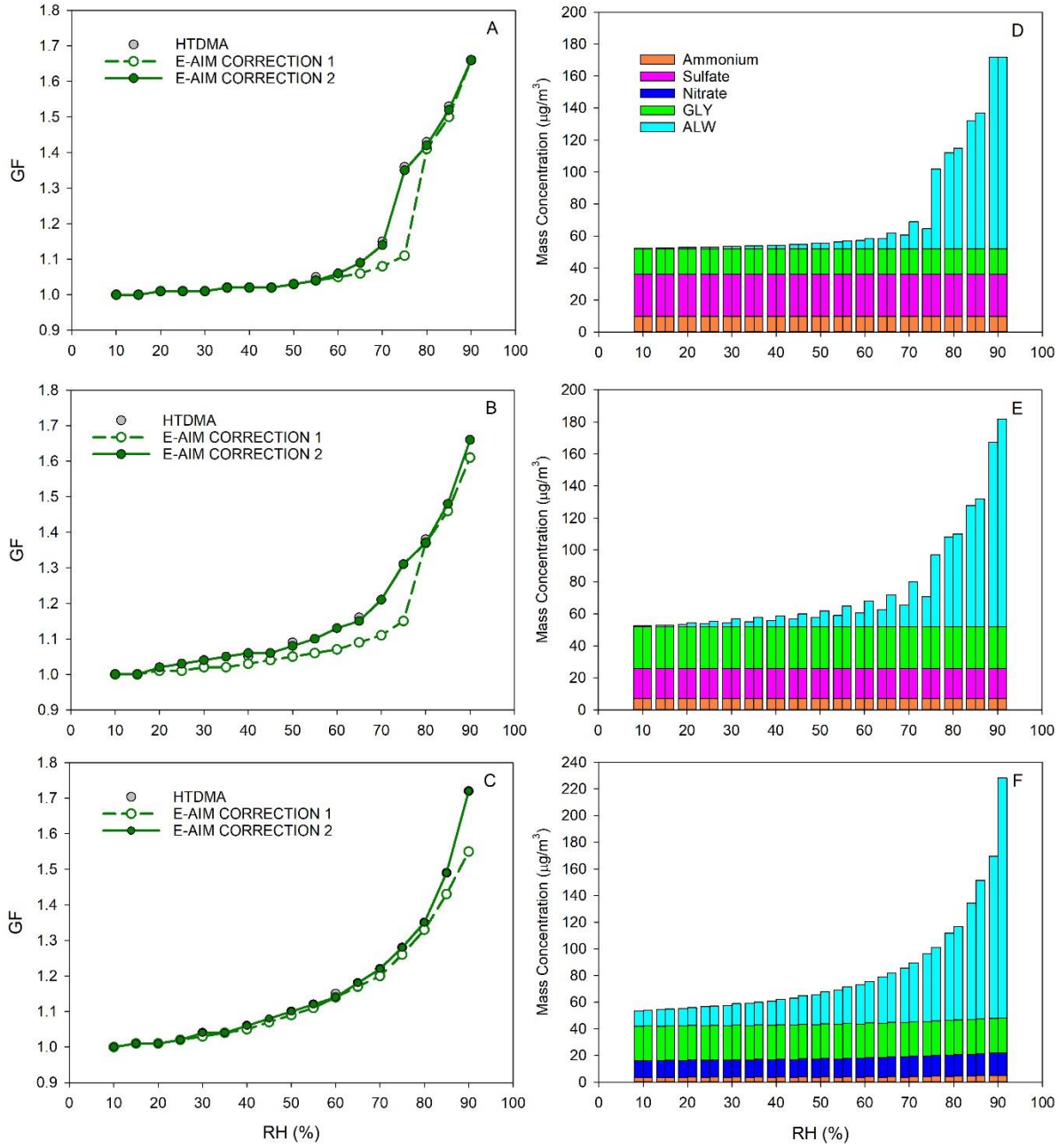


Figure S13. GF vs. RH plots for the mixture of AS and glyoxal aerosols (70 : 30) (A), the mixture of AS and glyoxal aerosols (50 : 50) (B) and the mixture of AN and glyoxal aerosols (50 : 50) (C). HTDMA indicates HTDMA measurements. Mass concentrations of aerosol components vs. RH plots (D) for (A), (E) for (B), and (F) for (C). The left stacked bar indicates ISORROPIA-II CORRECTION 1 (green open circle), and the right stacked bar indicates ISORROPIA-II CORRECTION 2 (green solid dot).

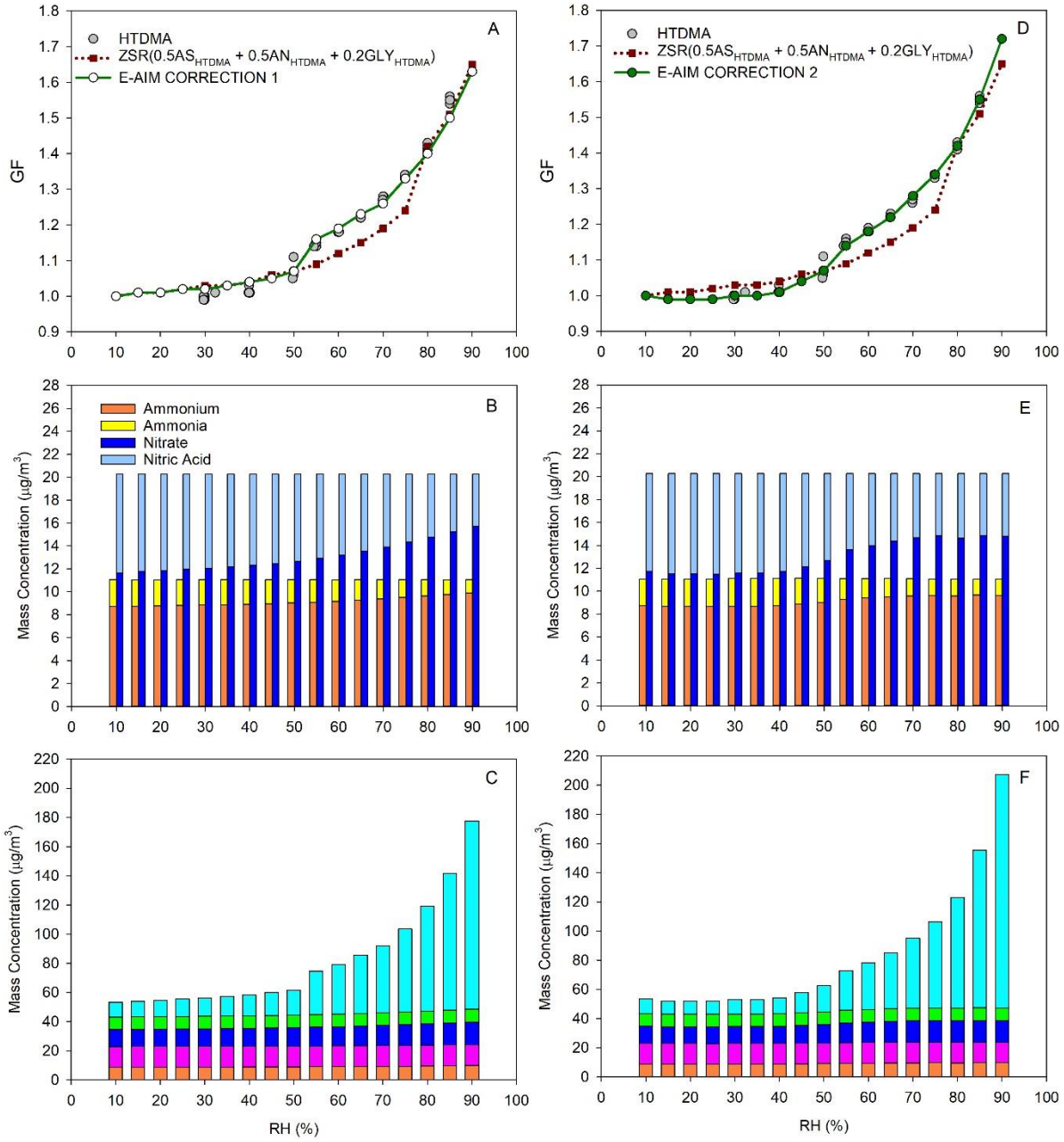


Figure S14. GF vs. RH plots for the mixture of AS, AN and glyoxal aerosols (50 : 50 : 20) (A and D). HTDMA indicates HTDMA measurements. ZSR(mAS$_{HTDMA}$ + nAN$_{HTDMA}$ + l GLY$_{HTDMA}$) indicates that the sum of HTDMA measurements for AS, AN, and glyoxal with ZSR method and the ratio (AS : AN : GLY = m : n : l). Mass concentrations of aerosol components vs. RH plots (B and C) for (A) and (E and F) for (D).