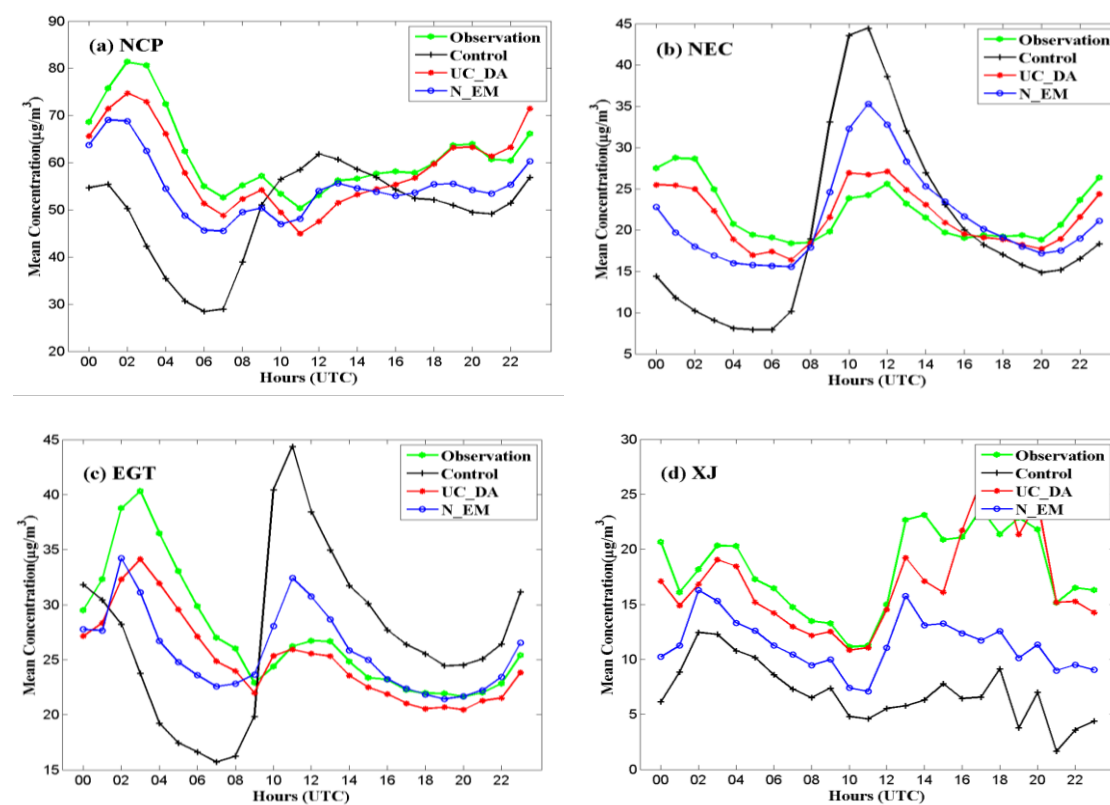


Figure S1 (a) The "real" emissions (EM_obs) and (b) the background emission EM_50. Units are $\text{mol km}^{-2} \text{hr}^{-1}$.



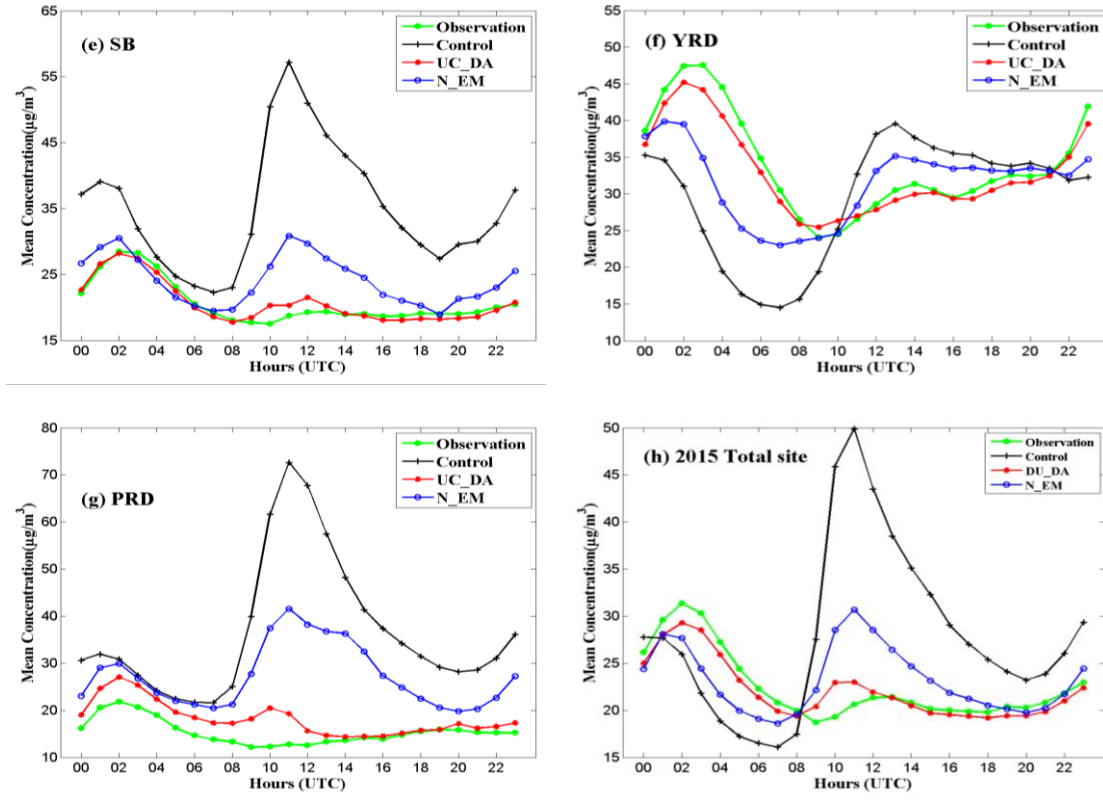
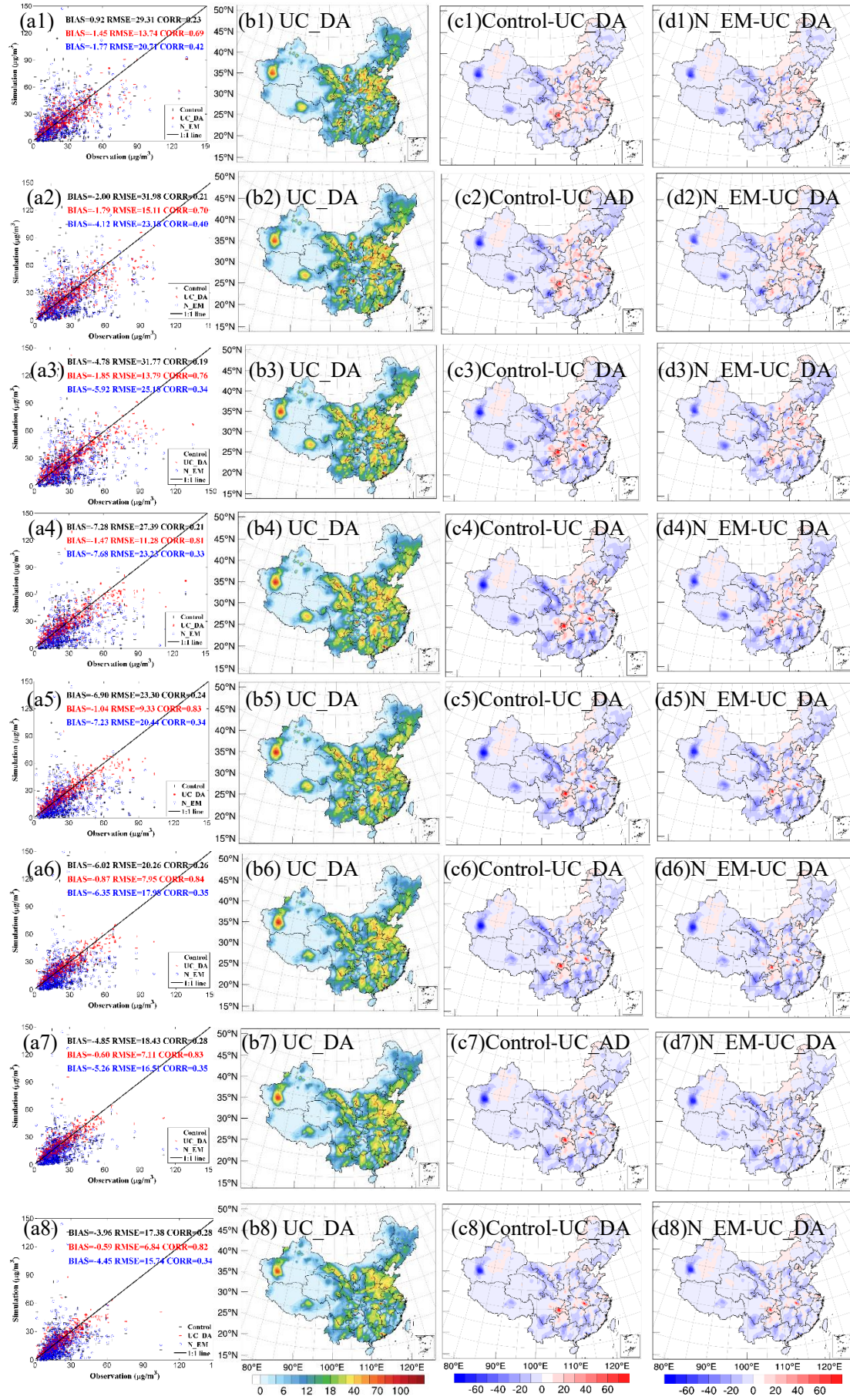
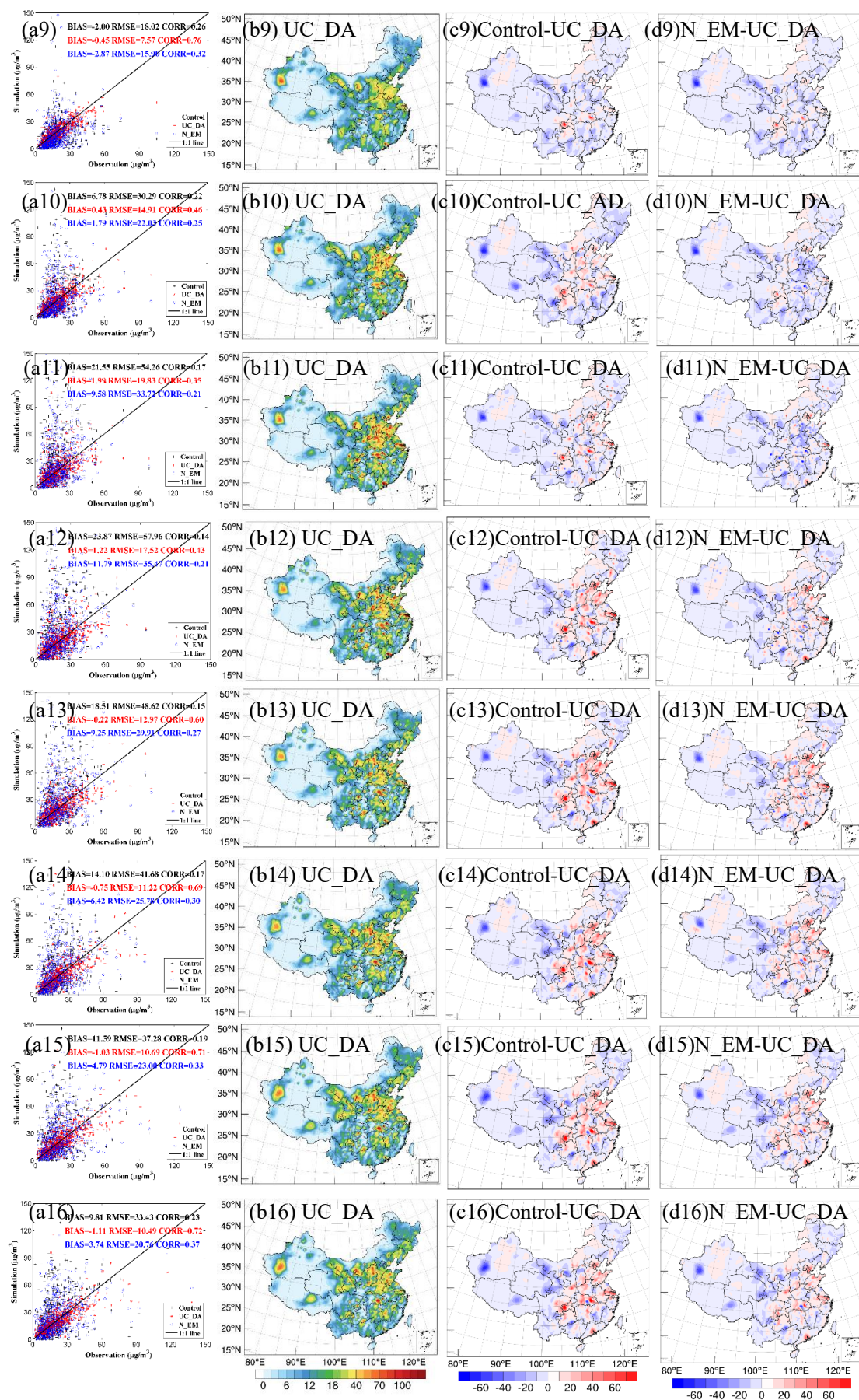


Figure S2. Diurnal pattern of selected sites (in condition of static wind) averaged SO_2 concentration in October 2015: (a) NCP, (b) NEC, (c) EGT, (d) XJ, (e) SB, (f) YRD, (g) PRD, (h) China. Units: $\mu\text{g m}^{-3}$. UC_DA: Updata Cycle Data Assimilation; N_EM: New Emission.





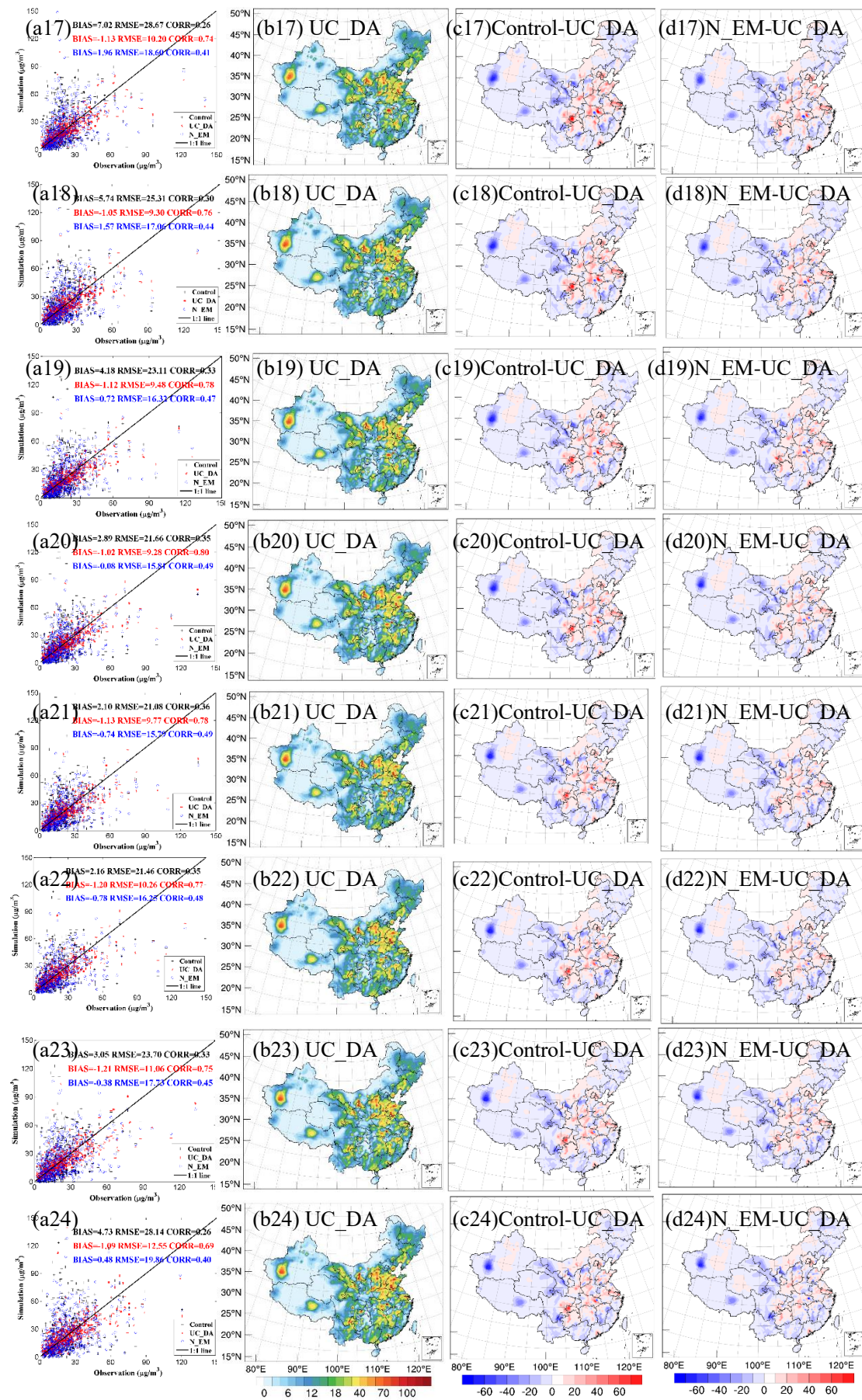
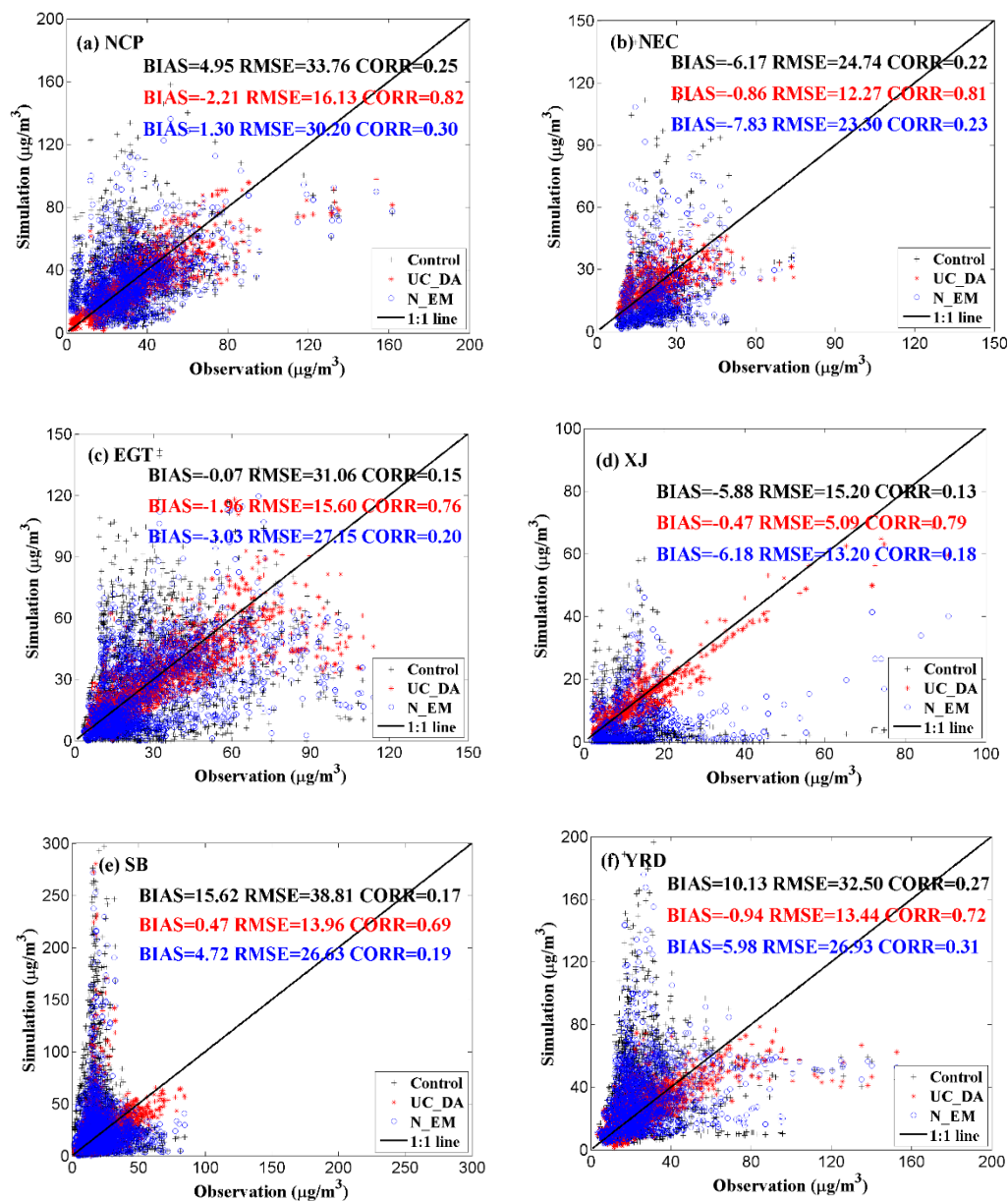


Figure S3. Model simulated and observed SO₂ concentrations for October 2015 in China from 00UTC to 23UTC (top-down). a: Scatter plots, b: the hourly average simulated by UC_DA experiment, c: differences of the hourly average between Control experiment and UC_DA experiment, and d: differences of the hourly average between N_EM experiment and UC_DA experiment. Units: $\mu\text{g m}^{-3}$. UC_DA: Udata Cycle Data Assimilation; N_EM: New Emission.



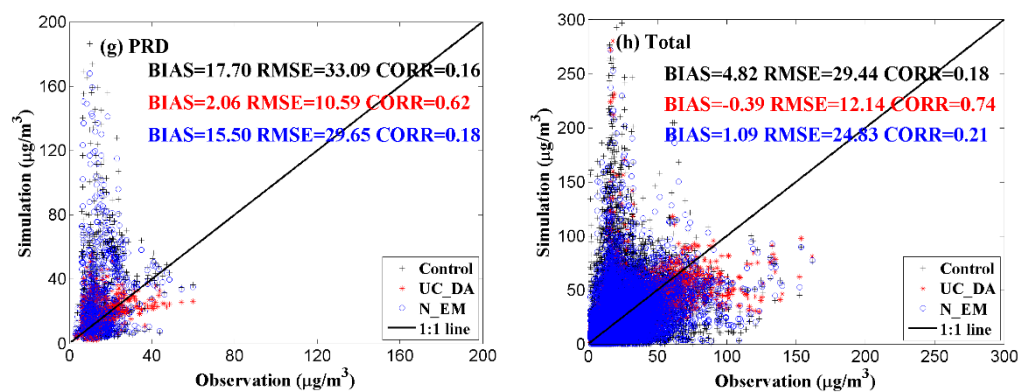


Figure S4. Scatter point between observation and model simulations for October 2015: **(a)** NCP, **(b)** NEC, **(c)** EGT, **(d)** XJ, **(e)** SB, **(f)** YRD, **(g)** PRD, **(h)** China. Units: $\mu\text{g m}^{-3}$. UC_DA: Updata Cycle Data Assimilation; N_EM: New Emission.