Supplementary Material: Sensitivity analysis of an updated bidirectional air-surface exchange model for mercury vapor

Xun Wang[1,2], Che-Jen Lin[1,3,4], Xinbin Feng[1]

[1] State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang, China

[2] University of Chinese Academy of Sciences, Beijing, China

[3] Department of Civil Engineering, Lamar University, Beaumont, TX, USA

[4] College of Environment and Energy, South China University of Technology, Guangzhou, China

Correspondence to: C.-J. Lin (jerry.lin@lamar.edu); X. Feng (fengxinbin@vip.skleg.cn)

1 Initial parameter screening for bare lands

Normal plot of the standardized effects of 2^{11-6} (Figure s1) suggests significant effect from fraction of organic carbon, friction velocity, soil Hg content at 95% confidence level. The P-value of main effects from air temperature at 2 meters and scaling factor for reactivity of mercury on ozone (β_{Hg^0}) were close to 0.05 (0.069 and 0.073, respectively). For the second order interactions, air temperature and β_{Hg^0} are important. Therefore fraction of organic carbon, friction velocity, soil Hg concentration, air temperature, β_{Hg^0}, were chosen for the final 2^5 full factorial design.

2 Initial parameter screening for canopy system

The alias structure of the 2^{15-9} fractional design is complex (Figure s2). To ensure that the most significant factors are selected for the final full factorial design, all parameters confounded in alias system were chosen to run 2^{11-6} experiment except for air Hg^0 concentration because its weak significance (P = 0.437). From the results of the 2^{11-6} fractional design (Figure s3) result, the fraction of organic carbon, friction velocity, soil

Hg concentration, β_{Hg^0}, soil moisture condition are significant. The P-value of main effects from Hg previously deposited to leaf stomata and air temperature were close to 0.05 (0.069 and 0.136, respectively). Therefore, fraction of organic carbon, friction velocity, soil Hg concentration, β_{Hg^0}, soil under moisture condition, Hg previously deposited to leaf stomata and air temperature were chosen to for another 2^{7-1} fractional experiments. Based on the results (Figure s7), the main effects from fraction of organic carbon, friction velocity, soil Hg concentration are significant. To get the full design, Hg previously deposited to leaf stomata and β_{Hg^0} were eliminated because of the relatively weaker significance.

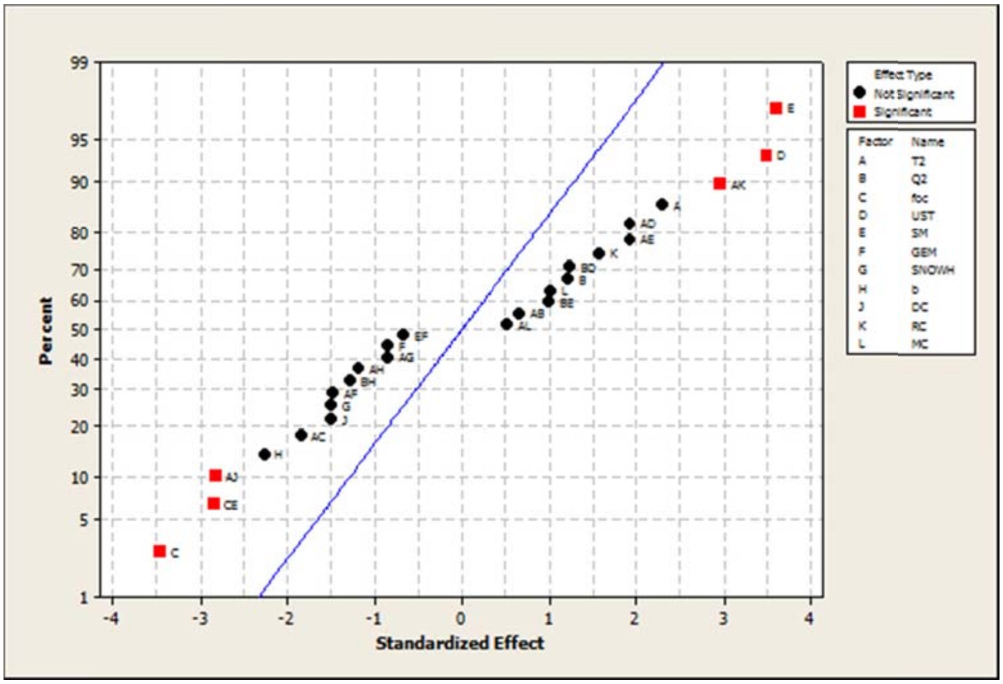

Figure s1: Results of 2^{11-6} fractional design for bare lands. Significance at $P<0.05$. T denotes air temperature at 2 meters, Q2 denotes water vapor mixing ratio, foc denotes fraction of organic carbon in surface soil, UST denotes friction velocity, SM denotes soil total Hg concentration, GEM denotes air Hg(0) concentration, SNOWH denotes snow depth, b denotes scaling factor of reactivity Hg, DC denotes dew condition, RC denotes rain condition, MC denotes moist soil condition. Alias information for significant terms: T*DC + Q2*SNOWH + foc*UST + SM*b, T*RC + Q2*MC+ foc*b + UST*SM, foc*SM + UST*b + SNOWH*MC + DC*RC.

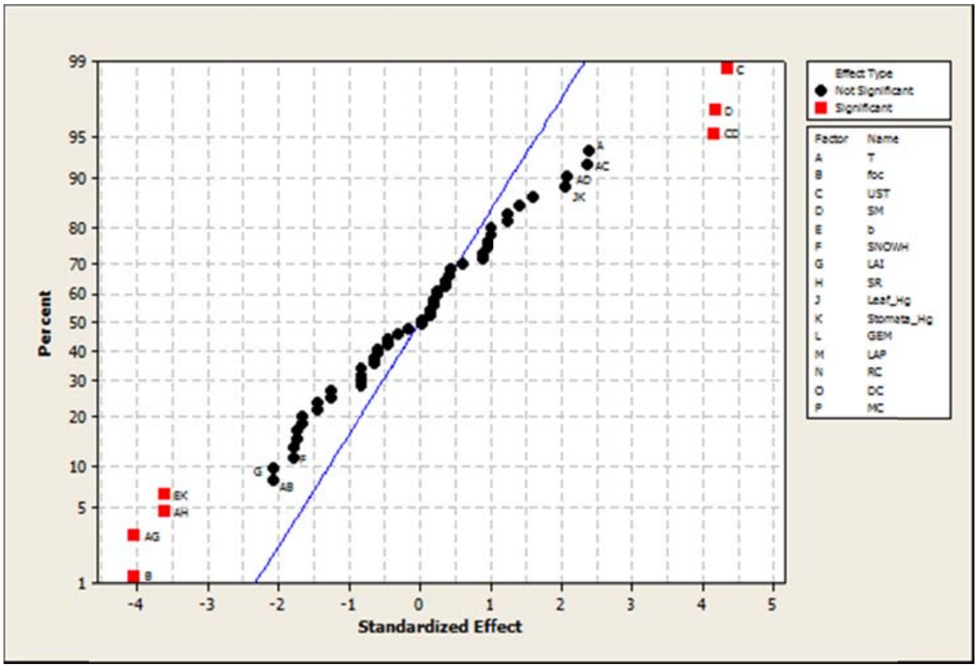

Figure s2: Results of 2^{15-9} fractional design for canopy system. Significance at $P<0.05$. T denotes air temperature at 2 meters, foc denotes fraction of organic carbon in surface soil, UST denotes friction velocity, SM denotes soil total Hg concentration, b denotes scaling factor of reactivity Hg, SNOWH denotes snow depth, LAI denotes Leaf area index , SR denotes solar irradiation, Leaf_Hg denotes Hg concentration in leaf rinse, Stomata_Hg denotes Hg previously deposited to leaf stomata, GEM denotes air Hg(0) concentration, LAP denotes leaf-air partitioning coefficient, DC denotes dew condition, RC denotes rain condition, MC denotes moist soil condition. Alias information for significant terms: T*LAI + foc*UST, T*SR + foc*SM, UST*SM + LAI*SR + GEM*LAP, b*Stomata_Hg + RC*MC.

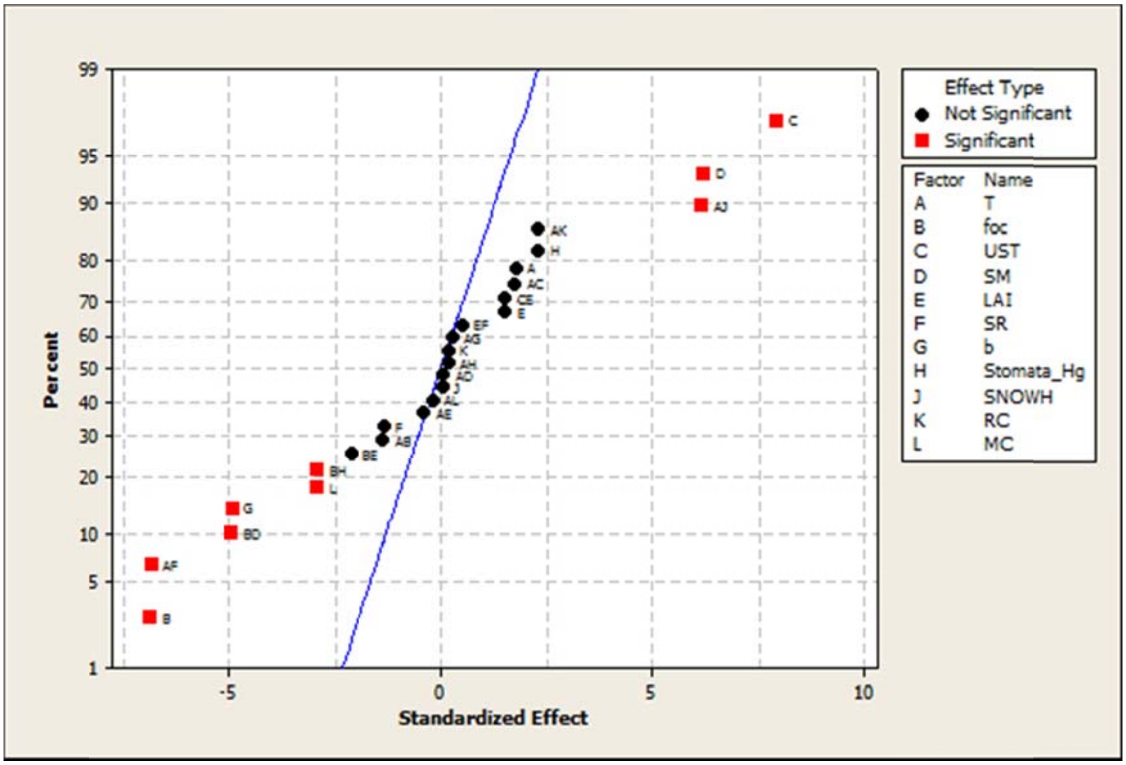

Figure s3: Results of 2^{11-6} fractional design for canopy system. Significance at $P<0.05$. T denotes air temperature at 2 meters, foc denotes fraction of organic carbon in surface soil, UST denotes friction velocity, SM denotes soil total Hg concentration, LAI denotes leaf area index, SR denotes solar irradiation, b denotes scaling factor of reactivity Hg, Stomata_Hg denotes Hg previously deposited to leaf stomata, SNOWH denotes snow depth, RC denotes rain condition, MC denotes moist soil condition. Alias information for significant terms: T*SR + foc*UST + SM*b + Stomata_Hg*MC, T*SNOWH + foc*b + UST*SM + LAI*Stomata_Hg, foc*LAI + SM*MC + b*Stomata_Hg, foc*Stomata_Hg + UST*MC + LAI*b + SR*RC.

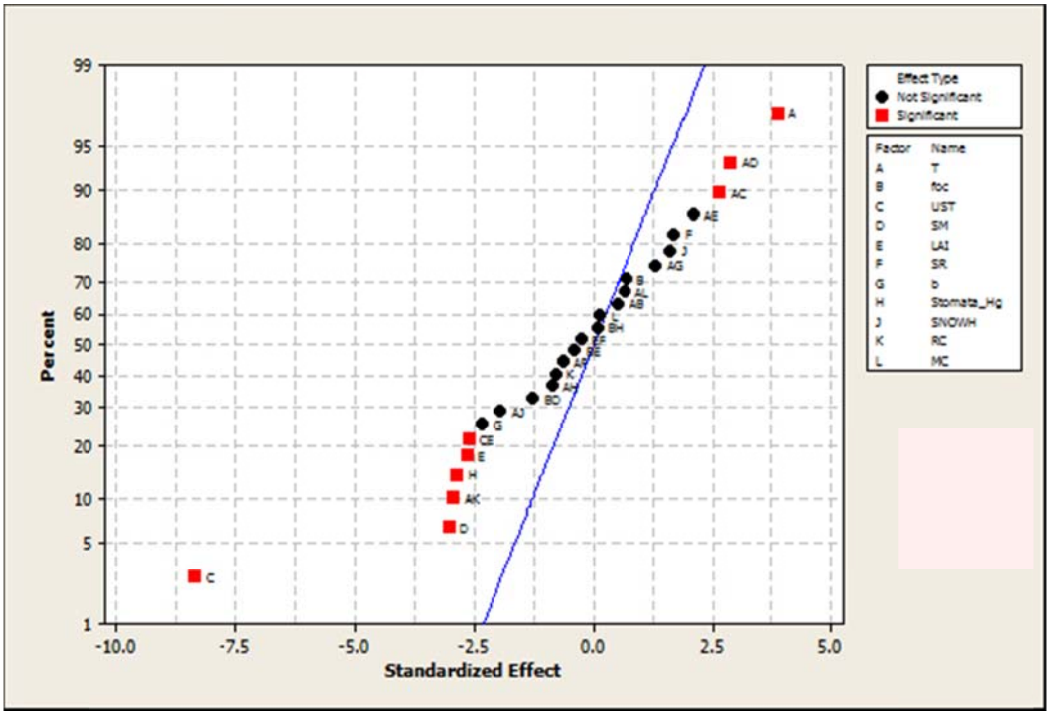

Figure s4: Results of 2^{11-6} fractional design for foliage. Significance at $P<0.05$. T denotes air temperature at 2 meters, foc denotes fraction of organic carbon in surface soil, UST denotes friction velocity, SM denotes soil total Hg concentration, LAI denotes leaf area index, SR denotes solar irradiation, b denotes scaling factor of reactivity Hg, Stomata_Hg denotes Hg previously deposited to leaf stomata, SNOWH denotes snow depth, RC denotes rain condition, MC denotes moist soil condition. Alias information for significant terms: T*SR + foc*UST + SM*b + Stomata_Hg*MC, T*SNOWH + foc*b + UST*SM + LAI*Stomata_Hg, foc*LAI + SM*MC + b*Stomata_Hg, foc*Stomata_Hg + UST*MC + LAI*b + SR*RC.

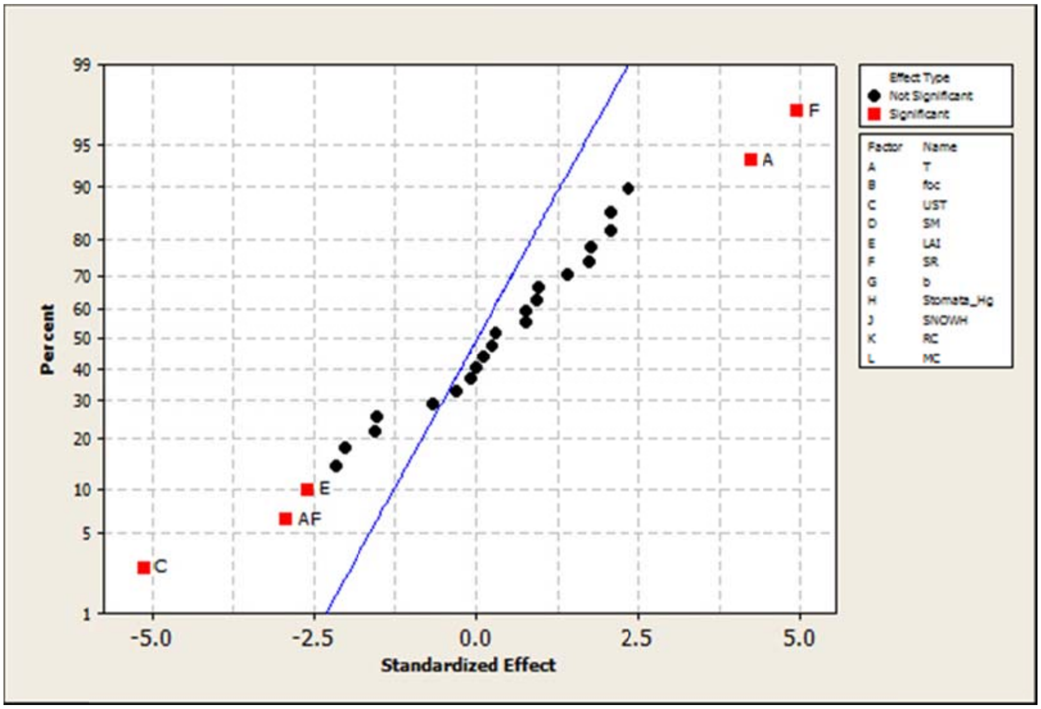

Figure s5: Results of 2^{11-6} fractional design for stomata. Significance at $P<0.05$. T denotes air temperature at 2 meters, foc denotes fraction of organic carbon in surface soil, UST denotes friction velocity, SM denotes soil total Hg concentration, LAI denotes leaf area index, SR denotes solar irradiation, b denotes scaling factor of reactivity Hg, Stomata_Hg denotes Hg previously deposited to leaf stomata, SNOWH denotes snow depth, RC denotes rain condition, MC denotes moist soil condition. Alias information for significant terms: T*SR + foc*UST + SM*b + Stomata_Hg*MC, T*SNOWH + foc*b + UST*SM + LAI*Stomata_Hg, foc*LAI + SM*MC + b*Stomata_Hg, foc*Stomata_Hg + UST*MC + LAI*b + SR*RC.

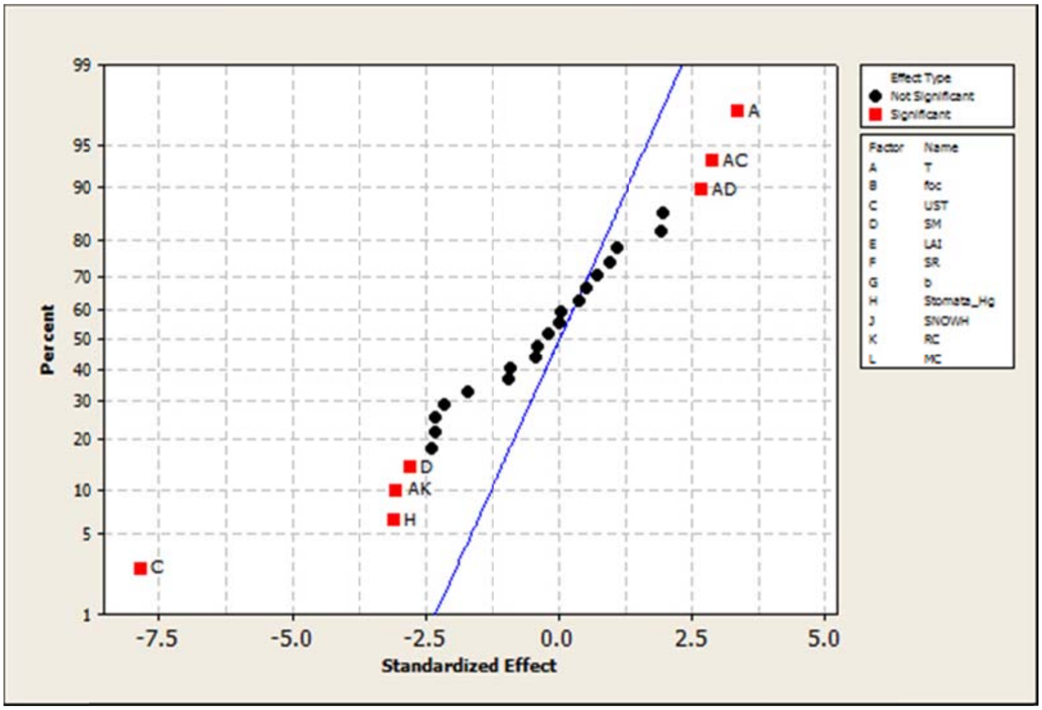

Figure s6: Results of 2^{11-6} fractional design for cuticle. Significance at P<0.05. T denotes air temperature at 2 meters, foc denotes fraction of organic carbon in surface soil, UST denotes friction velocity, SM denotes soil total Hg concentration, LAI denotes leaf area index, SR denotes solar irradiation, b denotes scaling factor of reactivity Hg, Stomata_Hg denotes Hg previously deposited to leaf stomata, SNOWH denotes snow depth, RC denotes rain condition, MC denotes moist soil condition. Alias information for significant terms: T*SR + foc*UST + SM*b + Stomata_Hg*MC, T*SNOWH + foc*b + UST*SM + LAI*Stomata_Hg, foc*LAI + SM*MC + b*Stomata_Hg, foc*Stomata_Hg + UST*MC + LAI*b + SR*RC.

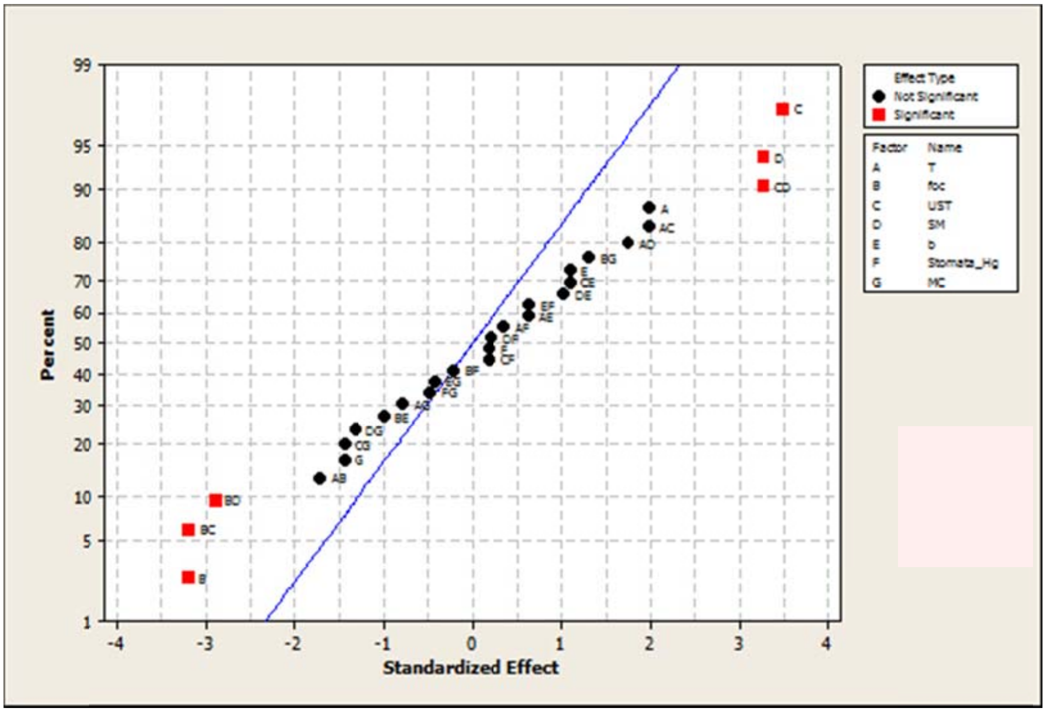

Figure s7: Results of 2^{7-1} fractional design for canopy system. Significance at $P<0.05$. T denotes air temperature at 2 meters, foc denotes fraction of organic carbon in surface soil, UST denotes friction velocity, SM denotes soil total Hg concentration, MC denotes moist soil condition. Alias information for significant terms: T*SR + foc*UST + SM*b + Stomata_Hg*MC, T*SNOWH + foc*b + UST*SM + LAI*Stomata_Hg, foc*LAI + SM*MC + b*Stomata_Hg, foc*Stomata_Hg + UST*MC + LAI*b + SR*RC.

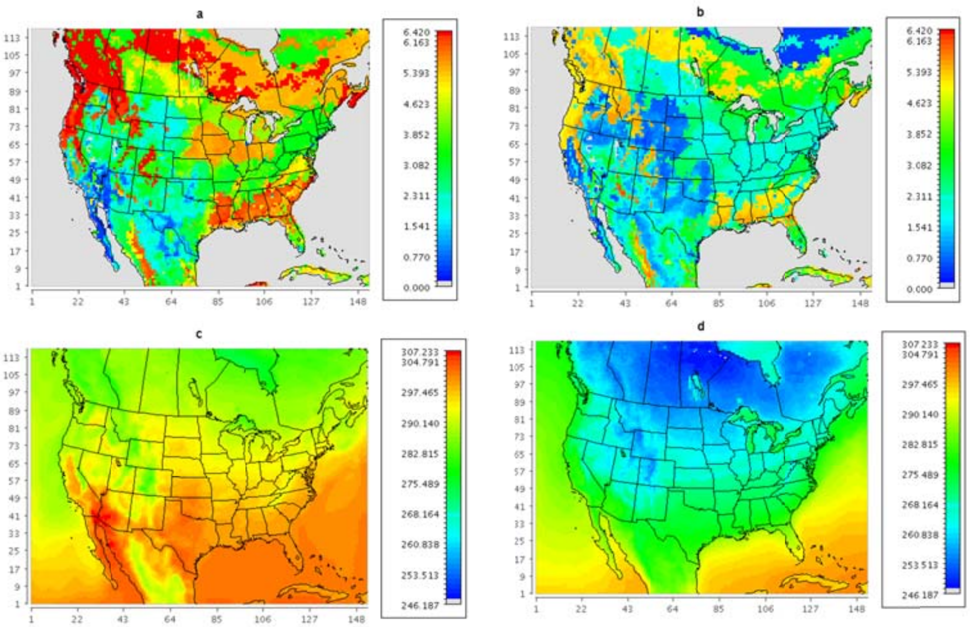

Figure s9: (a) the average spatial distribution of LAI (m^2 m^{-2}) in the summer month; (b) the average spatial distribution of LAI (m^2 m^{-2}) in the winter month; (c) the average spatial distribution of air temperature at 2 meters (K) in the summer month; (d) the average spatial distribution of air temperature at 2 meters (K) in the winter month

References

Ericksen, J. A., and Gustin, M. S.: Foliar exchange of mercury as a function of soil and air mercury concentrations, Science of the Total Environment, 324, 271-279, 10.1016/j.scitotenv.200310.034, 2004.

Graydon, J. A., St. Louis, V. L., Lindberg, S. E., Hintelmann, H., and Krabbenhoft, D. P.: Investigation of mercury exchange between forest canopy vegetation and the atmosphere using a new dynamic chamber, Environmental Science & Technology, 40, 10.1021/es0604616, 2006.

Gustin, M. S., Lindberg, S. E., and Weisberg, P. J.: An update on the natural sources and sinks of atmospheric mercury, Applied Geochemistry, 23, 10.1016/j.apgeochem.2007.12.010, 2008.

Millhollen, A. G., Gustin, M. S., and Obrist, D.: Foliar mercury accumulation and exchange for three tree species, Environmental Science & Technology, 40, 6001-6006, Doi 10.1021/Es0609194, 2006.