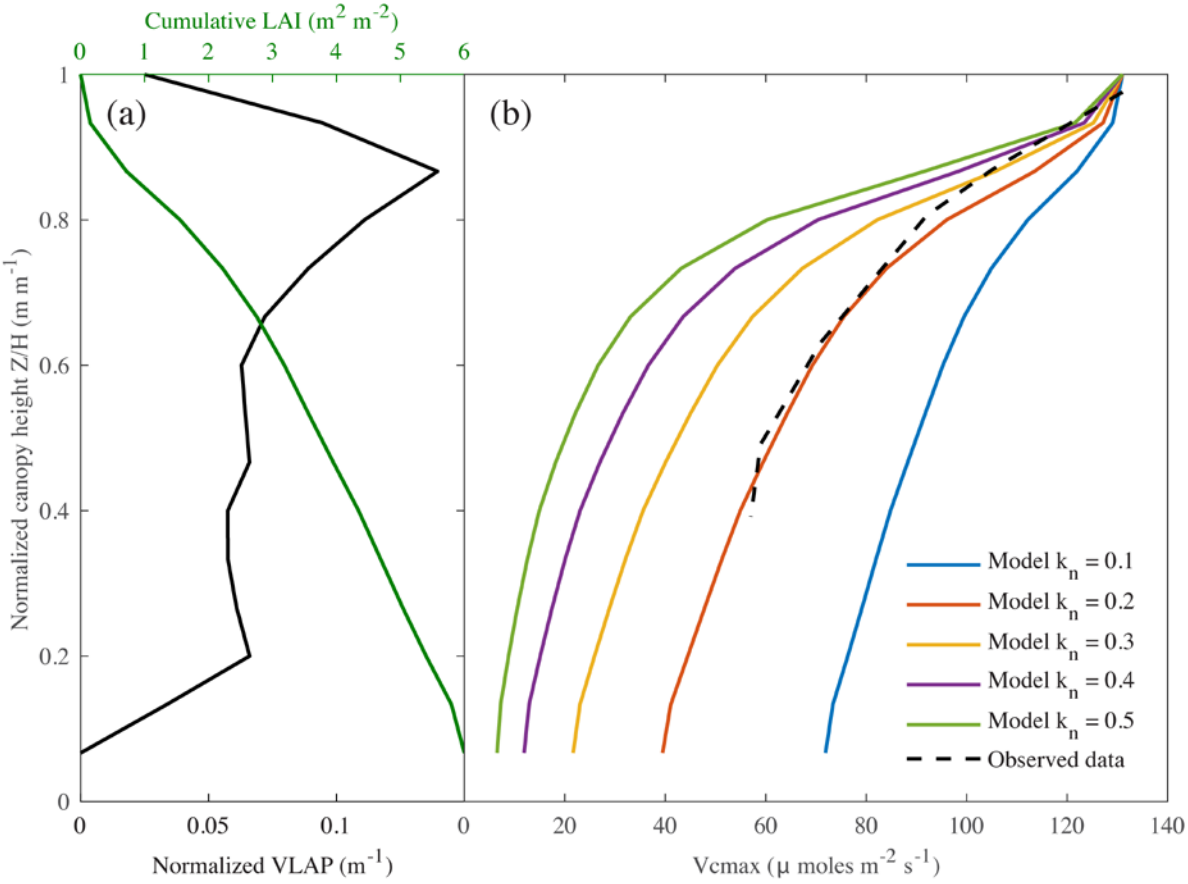
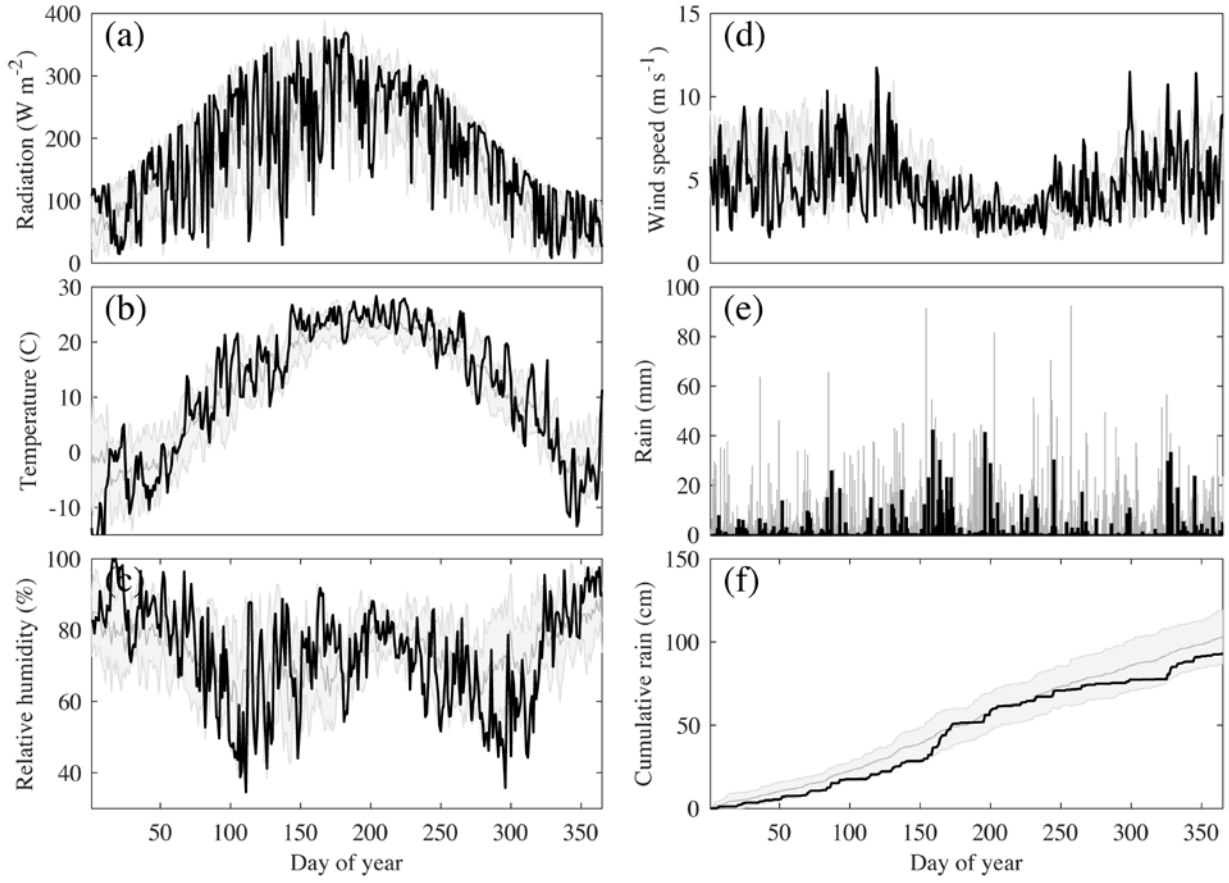
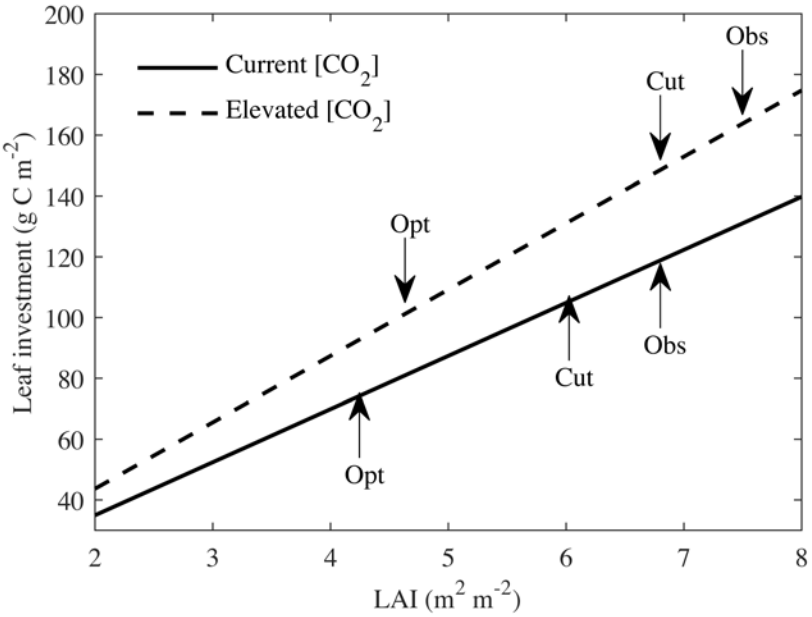
Supporting information:



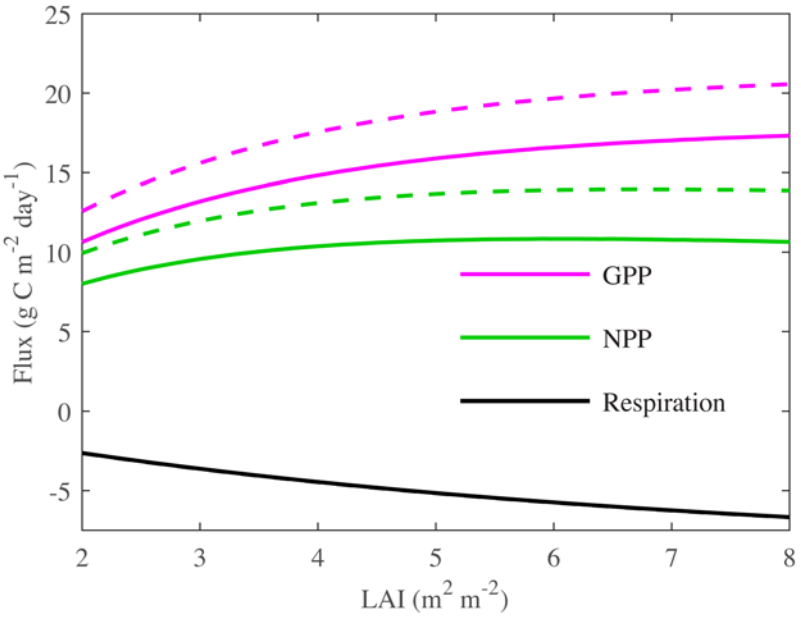
Supplementary Figure S1: Vertical distribution of leaf nitrogen (and hence $V_{cmax,25}$) in soybean canopies. Z/H is the ratio of the height Z to that of the canopy H, and represents normalized canopy height. Thus Z/H=1 means top of the canopy and Z/H=0 means bottom of the canopy. (a) Variation of normalized vertical leaf area profile (VLAP) (green line) and cumulative LAI (black line) as a function of normalized canopy height. The Normalized VLAP is computed by dividing the LAI at a given canopy height with the total LAI and has the units m^{-1}. (b) Variation of model predicted and observed $V_{cmax,25}$ as a function of canopy depth. A leaf nitrogen extinction coefficient of 0.2 fits the data well.



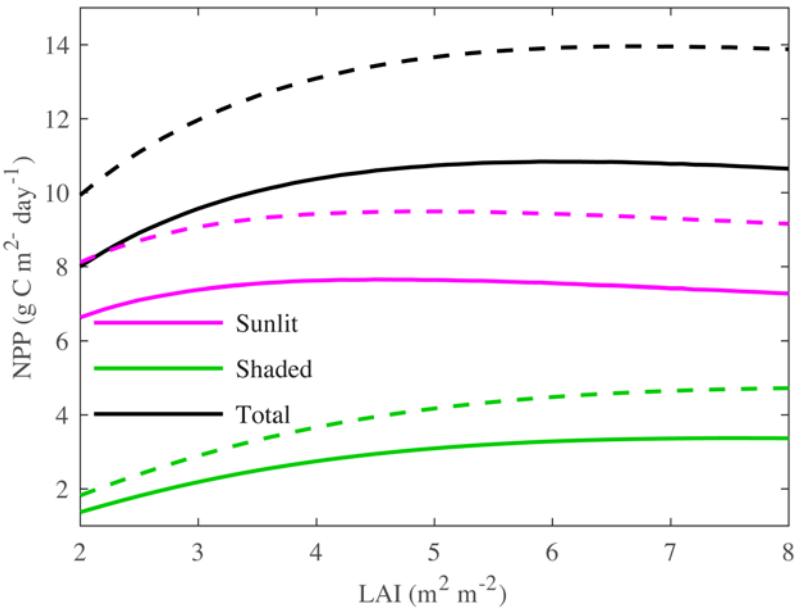
Supplementary Figure S2: SoyFACE weather data for year 2010 (black line) with average (grey line) and ± 1 s.e. (shaded grey region) across 9 years (2002-2010). (a) daily incoming shortwave radiation, (b) daily temperature, (c) daily relative humidity, (d) daily wind speed, (e) daily precipitation, and f cumulative daily total precipitation.



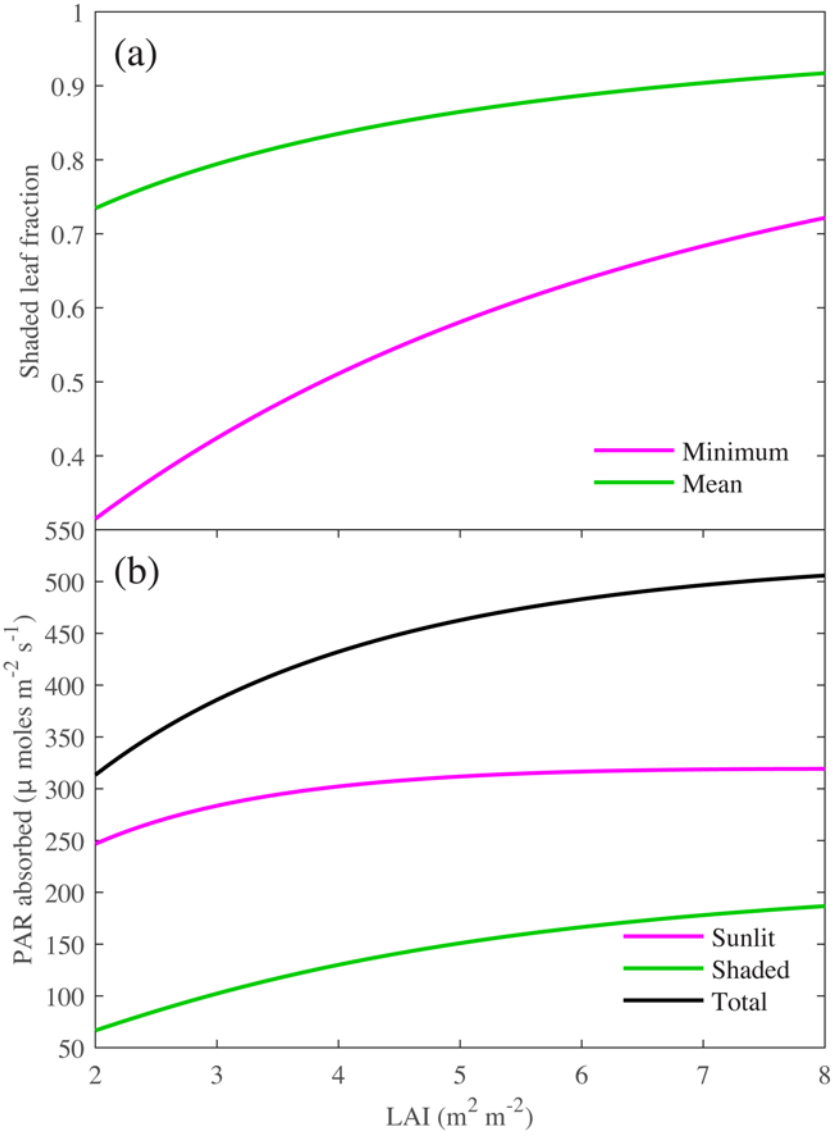
Supplementary Figure S3: Estimated leaf tissue construction carbon costs, as a function of LAI in soybean plant canopies under current and elevated [CO_2] (550 ppm). At optimal LAI, leaf construction cost is lowered by 38% and 39% under current and elevated [CO_2] respectively. Experimentally decreased peak LAI, resulted in a decrease in leaf construction cost by 12% and 9% under current and elevated [CO_2] respectively. The higher cost under elevated [CO_2] results from a higher mass per unit leaf area, based on measurement made at dawn when starch content was negligible in both [CO_2] treatments (Rogers et al. 2006).



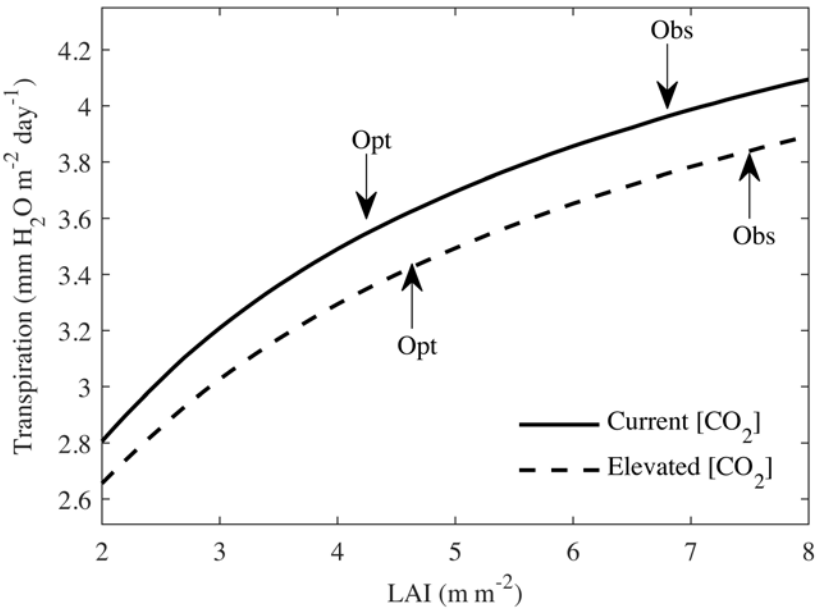
Supplementary Figure S4: Predicted variation in total photosynthetic canopy uptake of CO_2 (GPP), respiratory efflux (Respiration) and the net of these (NPP) as a function of LAI in current (solid lines) and elevated (dashed lines) [CO_2]. MLCan models leaf respiration as a function of leaf nitrogen and this is lower under elevated [CO_2]. MLCan does not take into account the differences in leaf thickness between ambient and elevated [CO_2]. While there are differences in in leaf respiration between ambient and elevated [CO_2], they are minor < 1% and are not apparent at this scale.



Supplementary figure S5: Individual and combined predicted contributions of average sunlit and shaded leaves to canopy NPP over a 24 h period as a function of LAI. Solid lines represent current [CO_2] and dashed lines represent elevated [CO_2].



Supplementary Figure S6: Shading in soybean canopies. (a) Predicted variation of the mean (24 h average) and minimum (solar noon) shaded leaf fraction as a function of LAI. (b) Predicted separate and combined contributions of average sunlit and shaded leaves to PAR absorbed over a 24 h period as a function of LAI.



Supplementary Figure S7: Predicted total crop transpiration as a function of LAI. Solid lines represent current [CO_2] and dashed lines represent elevated [CO_2].