Supplement

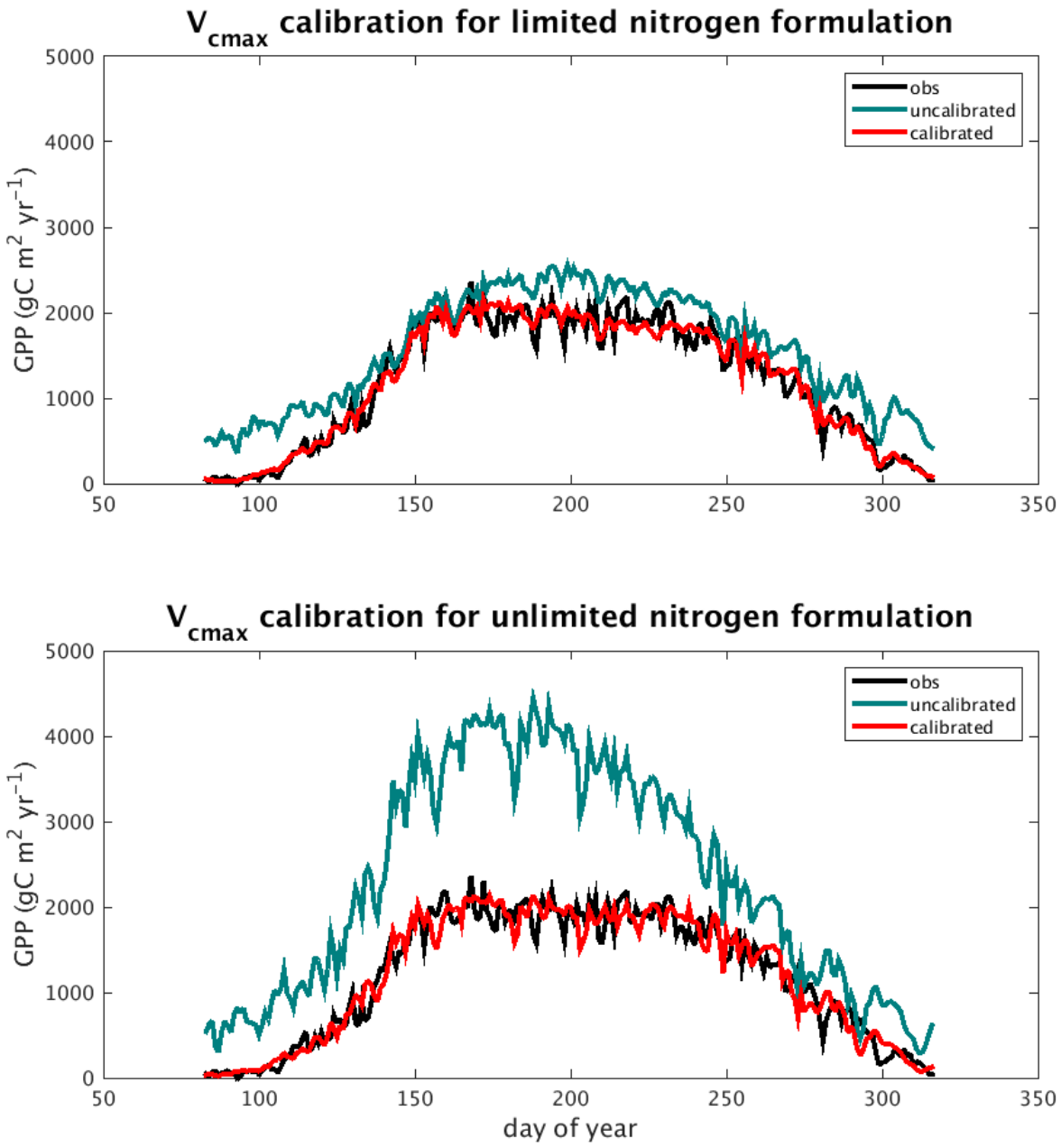

Figure S1. Calibrated and uncalibrated simulations for the *limited nitrogen* formulation (top panel) and *unlimited nitrogen* formulation (bottom panel). The *limited nitrogen* calibrated run used the V_{cmax25} calibration parameter: (equation (A1)) $f_{df} = (1.09 * 10^{-12})x^6 - (1.351 * 10^{-9})x^5 + (6.722 * 10^{-7})x^4 - (1.709 * 10^{-4})x^3 + (2.324 * 10^{-2})x^2 - (1.584)x + 42.31$, where x represents the day of the year. The *unlimited nitrogen* calibrated run used the V_{cmax25} calibration parameter: (equation (A2)) $f_{df} = (5.01 * 10^{-13})x^6 - (6.258 * 10^{-10})x^5 + (3.105 * 10^{-7})x^4 - (7.803 * 10^{-5})x^3 + (1.041 * 10^{-2})x^2 - (0.690)x + 17.93$.

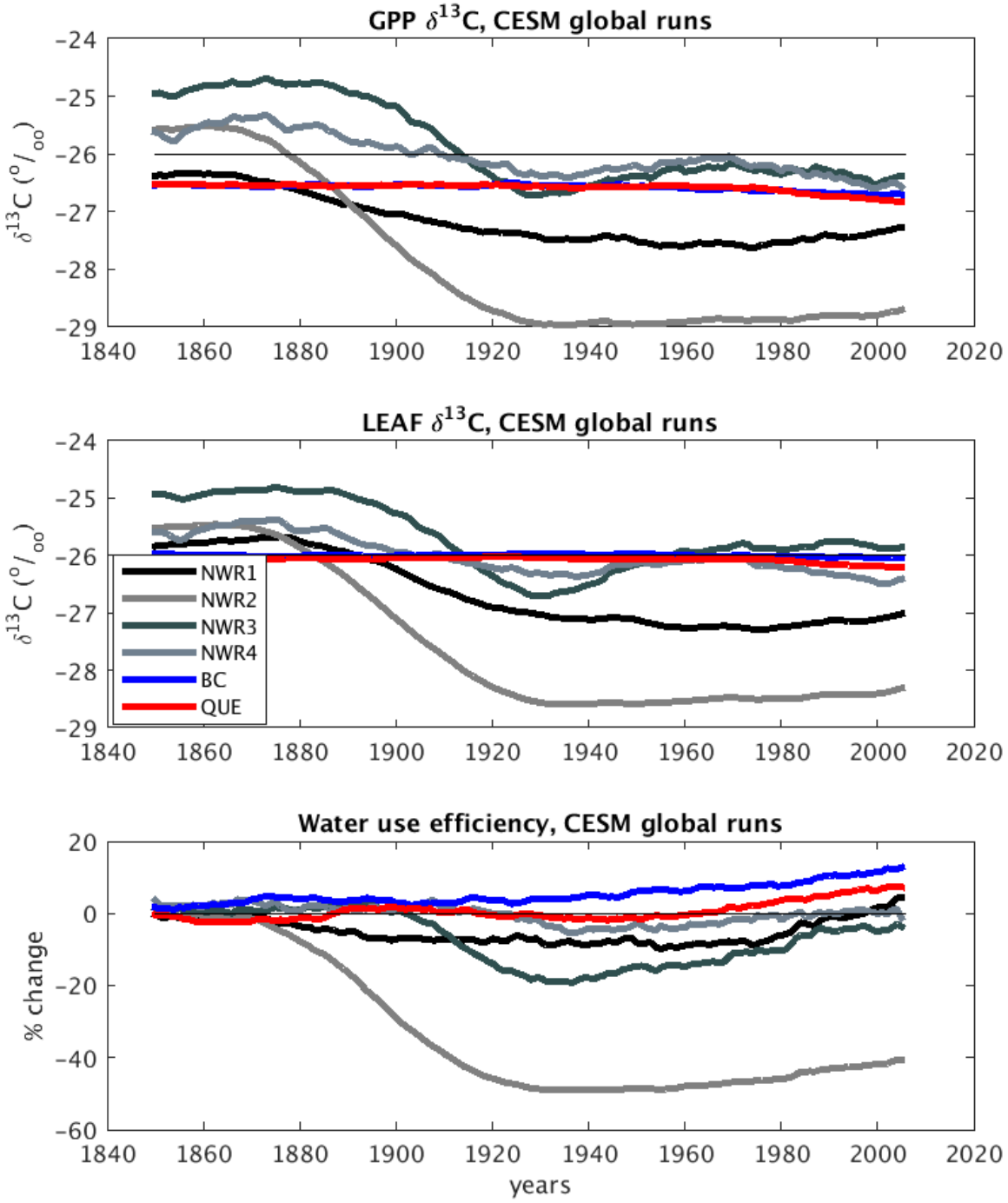

Figure S2. Global CESM simulation output based upon fully coupled isotope enabled experiment with CAM5 and CLM45BGC (courtesy Keith Lindsay, NCAR). NWR1 represents model output from a grid cell that is collocated with coordinates of the site Niwot Ridge (40.0329^o N, -105.5464^o W), NWR2, NWR3 and NWR4 represent grid cells adjacent to NWR1 and closest to the Niwot Ridge spatial coordinates. QUE and BC represent grid cells of coniferous forest located in Quebec (49.5^o N,-70.0^o W) and British Columbia (52.3^o N, -122.5^o W) respectively.

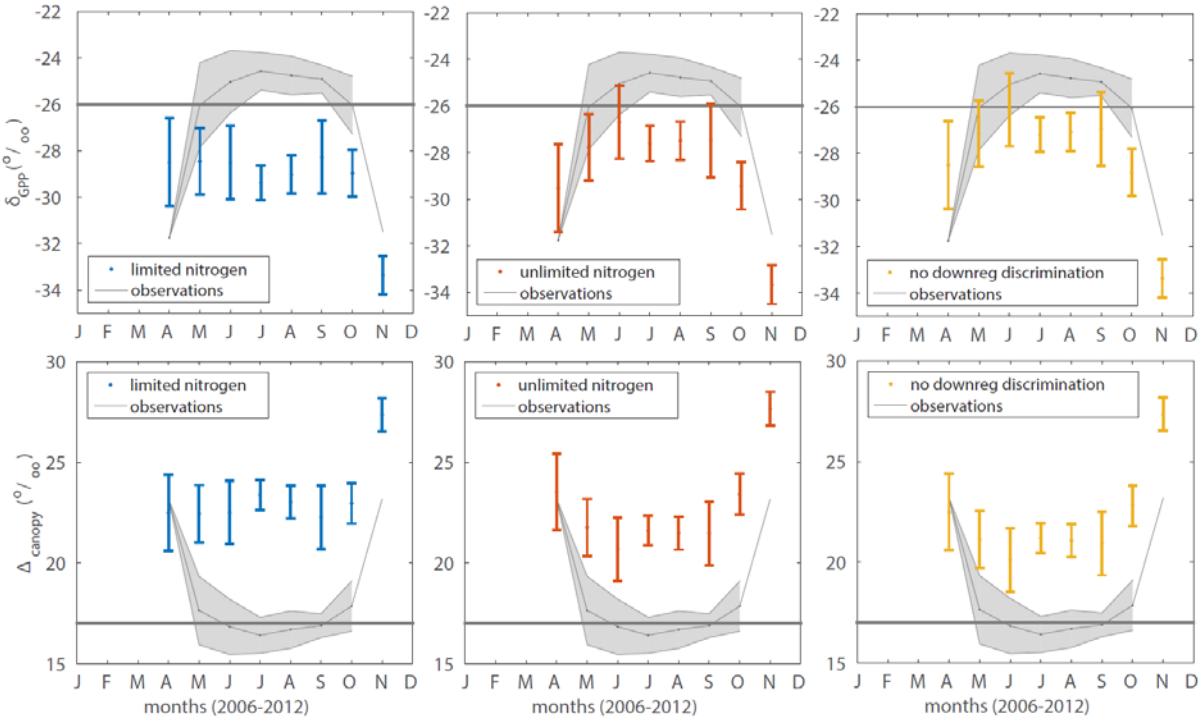

Figure S3. The seasonal photosynthetic discrimination pattern as shown through δ_{GPP} (top row) and Δ_{canopy} (bottom row). Colored uncertainty bars represent 95% confidence bounds of simulated monthly average values from 2006-2012. Gray-shaded observation bounds represent 95% confidence intervals of 'observed' monthly average values based upon isotopic mixing model using Lasslop et al., (2010) partitioning of net ecosystem exchange flux (Bowling et al. 2014). Horizontal lines represent $\delta^{13}C$ of -26 ‰ (top row) and 17 ‰ (bottom row) and are included for reference.

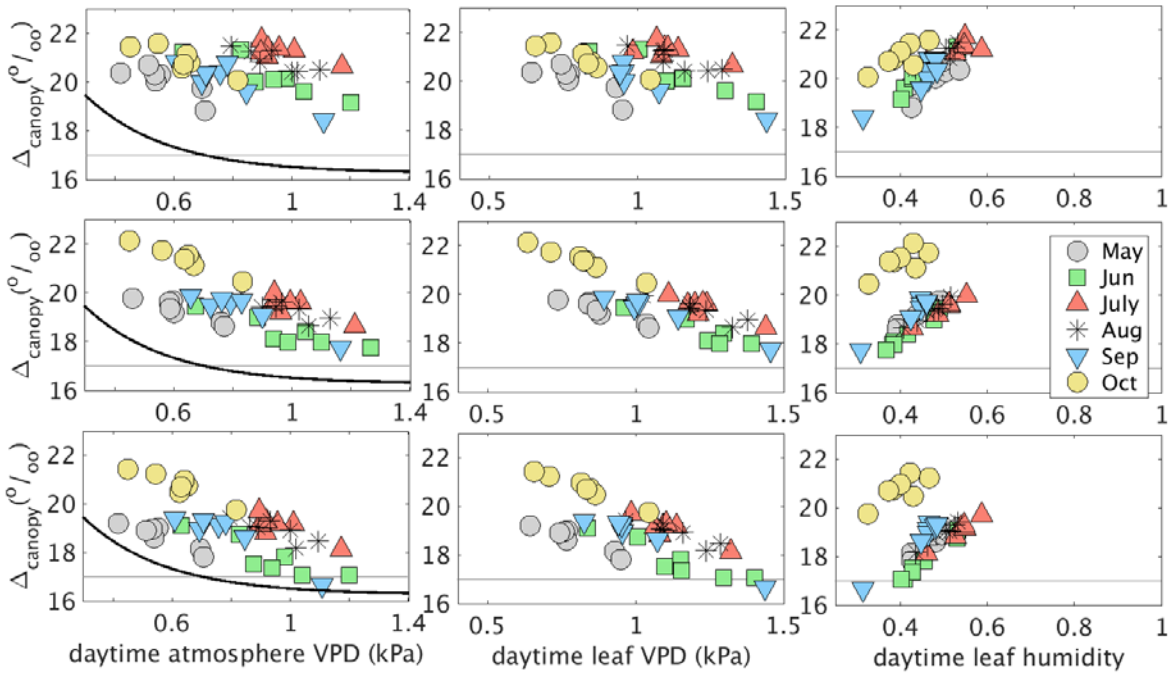

Figure S4. Relationship between monthly average photosynthetic discrimination and monthly average daytime atmosphere VPD (1st column), leaf VPD (2nd column) and leaf humidity (3rd column) from 2006-2012. The rows represent the *limited nitrogen* (row 1), *unlimited nitrogen* (row 2), and *no downregulation discrimination* (row 3) simulations. The black line in the 1st column is based on exponential fitted line from observed relationship at Niwot Ridge (Bowling et al. 2014). The horizontal lines represent $\delta^{13}C$ of 17 ‰ and are included for reference.

Supplement continued

Derivation of relationship between iWUE and c_i/c_a (discrimination)

Starting with Equation (9) and ending with Equation (17) from main text:

$$c_i^* = c_a - A_n\,(1 - f_{dreg})\,P_{atm}\,\frac{(1.4g_s)+(1.6g_b)}{g_b g_s}$$

Assume $f_{dreg} = 0$ for simplicity:

$$c_i^* = c_a - A_n\,P_{atm}\,\frac{(1.4g_s)+(1.6g_b)}{g_b g_s}$$

$$\frac{c_i^*}{P_{atm}} = \frac{c_a}{P_{atm}} - A_n\,\frac{(1.4g_s)+(1.6g_b)}{g_b g_s}$$

$$c_{i\,mole\,fraction}^* = c_{a\,mole\,fraction} - A_n\,\frac{(1.4g_s)+(1.6g_b)}{g_b g_s}$$

$$\frac{c_{i\,mole\,fraction}^*}{c_{a\,mole\,fraction}} = 1 - \frac{A_n}{c_{a\,mole\,fraction}}\,\frac{(1.4g_s)+(1.6g_b)}{g_b g_s}$$

Removing 'mole fraction' subscript for simplicity:

$$\frac{c_i^*}{c_a} = 1 - \frac{A_n}{c_a}\,\frac{(1.4g_s)+(1.6g_b)}{g_b g_s}$$

$$\frac{c_i^*}{c_a} = 1 - \frac{A_n}{c_a}\left(\frac{1.4}{g_b} + \frac{1.6}{g_s}\right)$$

Because $g_b \gg g_s$, therefore, $\frac{1.4}{g_b} \ll \frac{1.6}{g_s}$

$$\frac{c_i^*}{c_a} \cong 1 - \frac{A_n}{c_a}\left(\frac{1.6}{g_s}\right)$$

$$\frac{c_i^*}{c_a} \cong 1 - \frac{1.6}{c_a}\,iWUE$$