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// Stan model for budburst/leafout experiment from January 2015
// Includes chilling levels (3 levels, as dummy variables for each level)
// Including species as intercept
// Budburst/leafout day as a function of species as modeled group level factors, and site, temperature, photoperiod, and chilling as unmodeled factors (experimental manipulation)
// Includes non-centered parameterization (NCP or ncp) //

data {
  int N;
  int n_sp;
  int n_site;
  int sp[N];
  vector[N] lday;
  vector[N] warm;
  vector[N] photo;
  vector[N] chill1;
  vector[N] chill2;
  vector[N] site;
}

transformed data {
  // 9 interaction terms
  vector[N] inter_wp;
  vector[N] inter_ws;
  vector[N] inter_ps;
  vector[N] inter_wc1;
  vector[N] inter_wc2;
  vector[N] inter_pc1;
  vector[N] inter_pc2;
  vector[N] inter_sc1;
  vector[N] inter_sc2;

  inter_wp = warm .* photo;
  inter_ws = warm .* site;
  inter_ps = photo .* site;
  inter_wc1 = warm .* chill1;
  inter_wc2 = warm .* chill2;
  inter_pc1 = photo .* chill1;
  inter_pc2 = photo .* chill2;
  inter_sc1 = site .* chill1;
  inter_sc2 = site .* chill2;
}

parameters {
  vector[n_sp] a_sp;
  vector[n_sp] b_warm;
  vector[n_sp] b_photo;
  vector[n_sp] b_chill1;
  vector[n_sp] b_chill2;
  vector[n_sp] b_site;

  vector[n_sp] b_inter_wp_ncp;
  vector[n_sp] b_inter_ws_ncp;
  vector[n_sp] b_inter_ps_ncp;
  vector[n_sp] b_inter_wc1_ncp;
  vector[n_sp] b_inter_wc2_ncp;
  vector[n_sp] b_inter_pc1_ncp;
  vector[n_sp] b_inter_pc2_ncp;
  vector[n_sp] b_inter_sc1_ncp;
  vector[n_sp] b_inter_sc2_ncp;

  real mu_a;
  real mu_b_warm;
  real mu_b_chill1;
  real mu_b_chill2;
  real mu_b_photo;
  real mu_b_site;

  real mu_b_inter_wp;
  real mu_b_inter_ws;
  real mu_b_inter_ps;
  real mu_b_inter_wc1;
  real mu_b_inter_wc2;
  real mu_b_inter_pc1;
  real mu_b_inter_pc2;
  real mu_b_inter_sc1;
  real mu_b_inter_sc2;

  real sigma_b_warm;
  real sigma_b_photo;
  real sigma_b_chill1;
  real sigma_b_chill2;
  real sigma_b_site;

  real sigma_a;

  real sigma_b_inter_wp;
  real sigma_b_inter_ws;
  real sigma_b_inter_ps;
  real sigma_b_inter_wc1;
  real sigma_b_inter_wc2;
  real sigma_b_inter_pc1;
  real sigma_b_inter_pc2;
  real sigma_b_inter_sc1;
  real sigma_b_inter_sc2;

  real sigma_y;
}

transformed parameters {
  vector[n_sp] b_inter_wp;
  vector[n_sp] b_inter_ws;
  vector[n_sp] b_inter_ps;
  vector[n_sp] b_inter_wc1;
  vector[n_sp] b_inter_wc2;
  vector[n_sp] b_inter_pc1;
  vector[n_sp] b_inter_pc2;
  vector[n_sp] b_inter_sc1;
  vector[n_sp] b_inter_sc2;
  vector[N] y_hat;

  b_inter_wp = mu_b_inter_wp + sigma_b_inter_wp*b_inter_wp_ncp;
  b_inter_ws = mu_b_inter_ws + sigma_b_inter_ws*b_inter_ws_ncp;
  b_inter_ps = mu_b_inter_ps + sigma_b_inter_ps*b_inter_ps_ncp;
  b_inter_wc1 = mu_b_inter_wc1 + sigma_b_inter_wc1*b_inter_wc1_ncp;
  b_inter_wc2 = mu_b_inter_wc2 + sigma_b_inter_wc2*b_inter_wc2_ncp;
  b_inter_pc1 = mu_b_inter_pc1 + sigma_b_inter_pc1*b_inter_pc1_ncp;
  b_inter_pc2 = mu_b_inter_pc2 + sigma_b_inter_pc2*b_inter_pc2_ncp;
  b_inter_sc1 = mu_b_inter_sc1 + sigma_b_inter_sc1*b_inter_sc1_ncp;
  b_inter_sc2 = mu_b_inter_sc2 + sigma_b_inter_sc2*b_inter_sc2_ncp;

  for (i in 1:N) {
    y_hat[i] = a_sp[sp[i]] +
      b_site[sp[i]] * site[i] +
      b_warm[sp[i]] * warm[i] +
      b_photo[sp[i]] * photo[i] +
      b_chill1[sp[i]] * chill1[i] +
      b_chill2[sp[i]] * chill2[i] +
      b_inter_wp[sp[i]] * inter_wp[i] +
      b_inter_ws[sp[i]] * inter_ws[i] +

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b_inter_ps[sp[i]] * inter_ps[i] +
b_inter_wc1[sp[i]] * inter_wc1[i] +
b_inter_wc2[sp[i]] * inter_wc2[i] +
b_inter_pc1[sp[i]] * inter_pc1[i] +
b_inter_pc2[sp[i]] * inter_pc2[i] +
b_inter_sc1[sp[i]] * inter_sc1[i] +
b_inter_sc2[sp[i]] * inter_sc2[i]
;

}

}

model {
  // Priors //
  mu_b_warm ~ normal(0, 35);
  mu_b_photo ~ normal(0, 35);
  mu_b_chill1 ~ normal(0, 35);
  mu_b_chill2 ~ normal(0, 35);
  mu_b_site ~ normal(0, 35);

  /* mu_b_inter_wp ~ normal(0, 35); // Delete because all in NCP now
  mu_b_inter_ws ~ normal(0, 35);
  mu_b_inter_ps ~ normal(0, 35);
  mu_b_inter_wc1 ~ normal(0, 35);
  mu_b_inter_wc2 ~ normal(0, 35);
  mu_b_inter_pc1 ~ normal(0, 35);
  mu_b_inter_pc2 ~ normal(0, 35);
  mu_b_inter_sc1 ~ normal(0, 35);
  mu_b_inter_sc2 ~ normal(0, 35); */

  sigma_b_warm ~ normal(0, 10);
  sigma_b_photo ~ normal(0, 10);
  sigma_b_chill1 ~ normal(0, 10);
  sigma_b_chill2 ~ normal(0, 10);
  sigma_b_site ~ normal(0, 10);

  sigma_b_inter_wp ~ normal(0, 10);
  sigma_b_inter_ws ~ normal(0, 10);
  sigma_b_inter_ps ~ normal(0, 10);
  sigma_b_inter_wc1 ~ normal(0, 10);
  sigma_b_inter_wc2 ~ normal(0, 10);
  sigma_b_inter_pc1 ~ normal(0, 10);
  sigma_b_inter_pc2 ~ normal(0, 10);
  sigma_b_inter_sc1 ~ normal(0, 10);
  sigma_b_inter_sc2 ~ normal(0, 10);

  a_sp ~ normal(mu_a, sigma_a);

  b_warm ~ normal(mu_b_warm, sigma_b_warm);
  b_photo ~ normal(mu_b_photo, sigma_b_photo);
  b_chill1 ~ normal(mu_b_chill1, sigma_b_chill1);
  b_chill2 ~ normal(mu_b_chill2, sigma_b_chill2);
  b_site ~ normal(mu_b_site, sigma_b_site);

  /* b_inter_wp ~ normal(mu_b_inter_wp, sigma_b_inter_wp); // Delete because all in NCP now
  b_inter_ws ~ normal(mu_b_inter_ws, sigma_b_inter_ws);
  b_inter_ps ~ normal(mu_b_inter_ps, sigma_b_inter_ps);
  b_inter_wc1 ~ normal(mu_b_inter_wc1, sigma_b_inter_wc1);
  b_inter_wc2 ~ normal(mu_b_inter_wc2, sigma_b_inter_wc2);
  b_inter_pc1 ~ normal(mu_b_inter_pc1, sigma_b_inter_pc1);
  b_inter_pc2 ~ normal(mu_b_inter_pc2, sigma_b_inter_pc2);
  b_inter_sc1 ~ normal(mu_b_inter_sc1, sigma_b_inter_sc1);
  b_inter_sc2 ~ normal(mu_b_inter_sc2, sigma_b_inter_sc2); */
  b_inter_wp_ncp ~ normal(0, 35);
  b_inter_ws_ncp ~ normal(0, 35);
  b_inter_ps_ncp ~ normal(0, 35);
  b_inter_wc1_ncp ~ normal(0, 35);
  b_inter_wc2_ncp ~ normal(0, 35);
  b_inter_pc1_ncp ~ normal(0, 35);
  b_inter_pc2_ncp ~ normal(0, 35);
  b_inter_sc1_ncp ~ normal(0, 35);
  b_inter_sc2_ncp ~ normal(0, 35);

  lday ~ normal(y_hat, sigma_y);
}

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