Supplementary

Table S1: Oceanic indices used in this study and their definitions and source

Index	Definition	Source
Niño1+2	The averaged SSTA in the region (0°-10° S, 90°-80° W)	https://psl.noaa.gov/data/correlation/nina1.anom.data
Niño3.4	The averaged SSTA in the region (5° N-5° S, 150°-90° W)	https://psl.noaa.gov/data/correlation/nina34.anom.data
Niño3	The averaged SSTA in the region (5° N-5° S, 170°-120° W)	https://psl.noaa.gov/data/correlation/nina3.anom.data
Niño4	The averaged SSTA in the region (5° N-5° S, 160° E-150° W)	https://psl.noaa.gov/data/correlation/nina4.anom.data
SOI	A measure based on the difference in SLP anomalies between Tahiti and Darwin, Australia	https://psl.noaa.gov/data/correlation/soi.data
PDO	The leading principal component of monthly SSTA in the North Pacific Ocean	https://psl.noaa.gov/data/correlation/pdo.data
NPI	The area-weighted SLP over the region (30° N-65° N, 160° E-140° W)	https://psl.noaa.gov/data/correlation/np.data
TSA	The averaged SSTA in the region (0°-20° S, 10° E-30° W)	https://psl.noaa.gov/data/correlation/tsa.data
TNA	The averaged SSTA in the region (5.5°N-23.5°N, 15°-57.5°W)	https://psl.noaa.gov/data/correlation/tna.data
AMO	The averaged SSTA in the North Atlantic Ocean (0°-70° N)	https://psl.noaa.gov/data/correlation/amon.us.data
IOD	The difference in SSTA between the western equatorial Indian Ocean (50°-70° E, 10° S-10° N) and the southeastern equatorial Indian Ocean (90°-110° E, 10° S-0°)	calculated
IOB	The averaged SSTA in the region (20° S-20° N, 40° -110° E)	calculated

Table S2: Regression coefficients of various meteorological factors in ridge regression

Variable	Coefficient
DTR	-0.66735
SMroot	0.627568
Tmx	-0.527428
Tmp	-0.446923
Pre	-0.402184
Tmn	-0.030895
Cld	0.328608
Wet	-0.108994
VPD	-0.106505
DSRF	0.089041
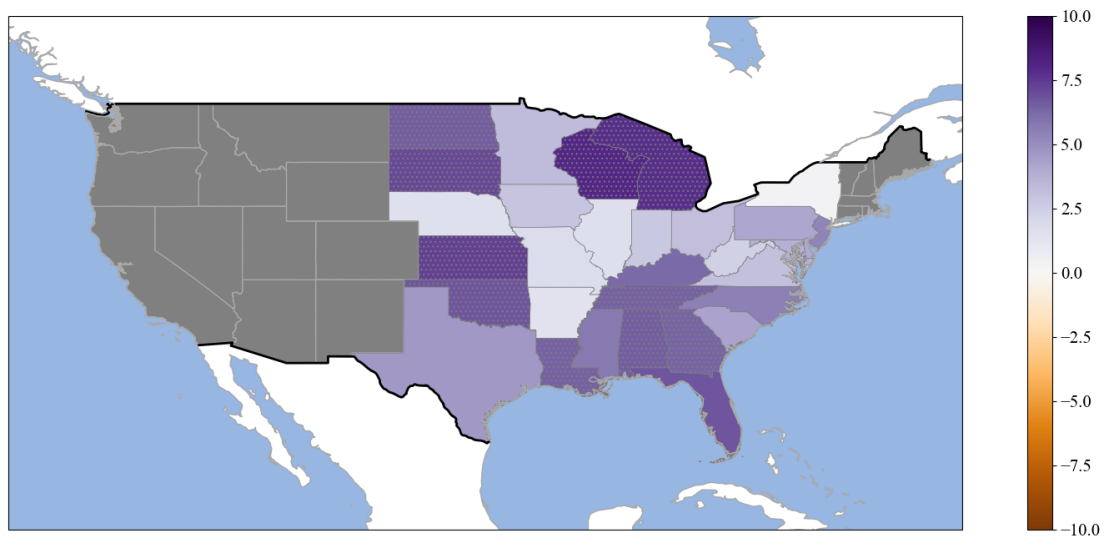
Figure S1: Spatial distribution of the sensitivity of soybean yield anomalies to the standardized Niño3.4 index during MJJ (May–July) from 1980 to 2017. The values represent the change in the percent yield anomaly per one standard deviation (1σ) increase in the standardized Niño3.4 index. Dots indicate statistically significant correlations at the 90% confidence level (t-test).
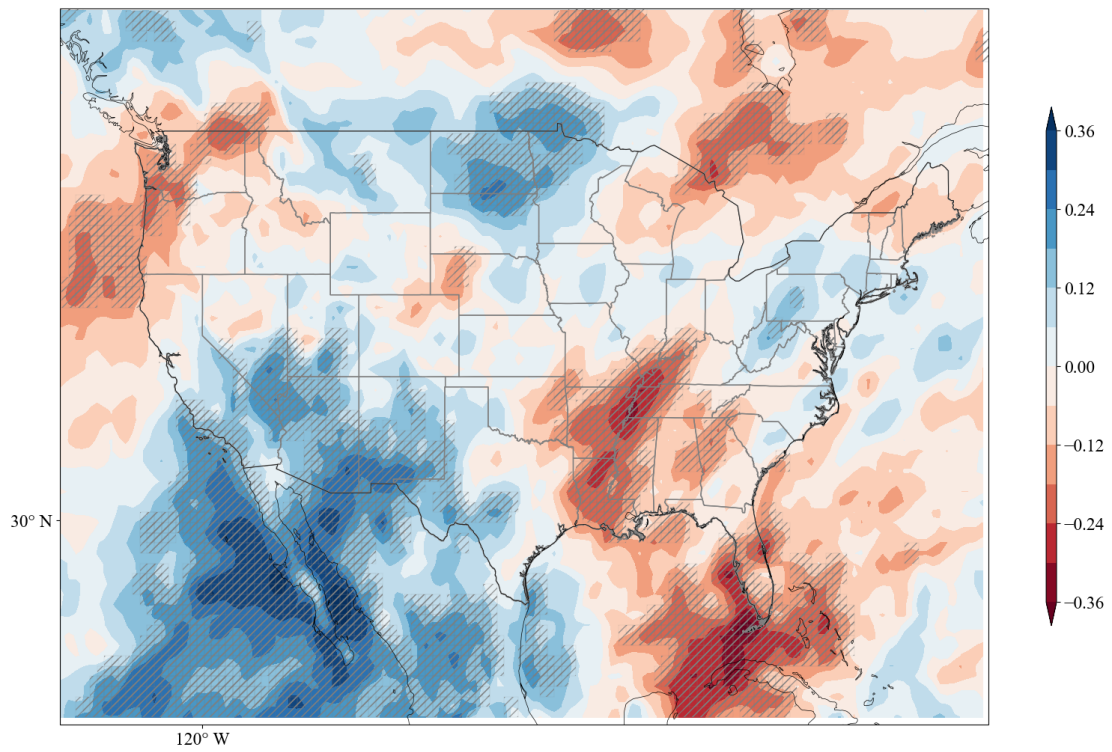
Figure S2: Responses of vertically integrated moisture divergence (kg·m⁻²) to the standardized IOB index during ND(–1)J. The variable was standardized before analysis. Values indicate the standardized change (in σ units) in vertically integrated moisture divergence per 1σ increase in the standardized IOB index. Shaded areas with diagonal hatching indicate regions where the response is statistically significant at the 90% confidence level (t-test).

smroot_NDJ1_year0_JAS
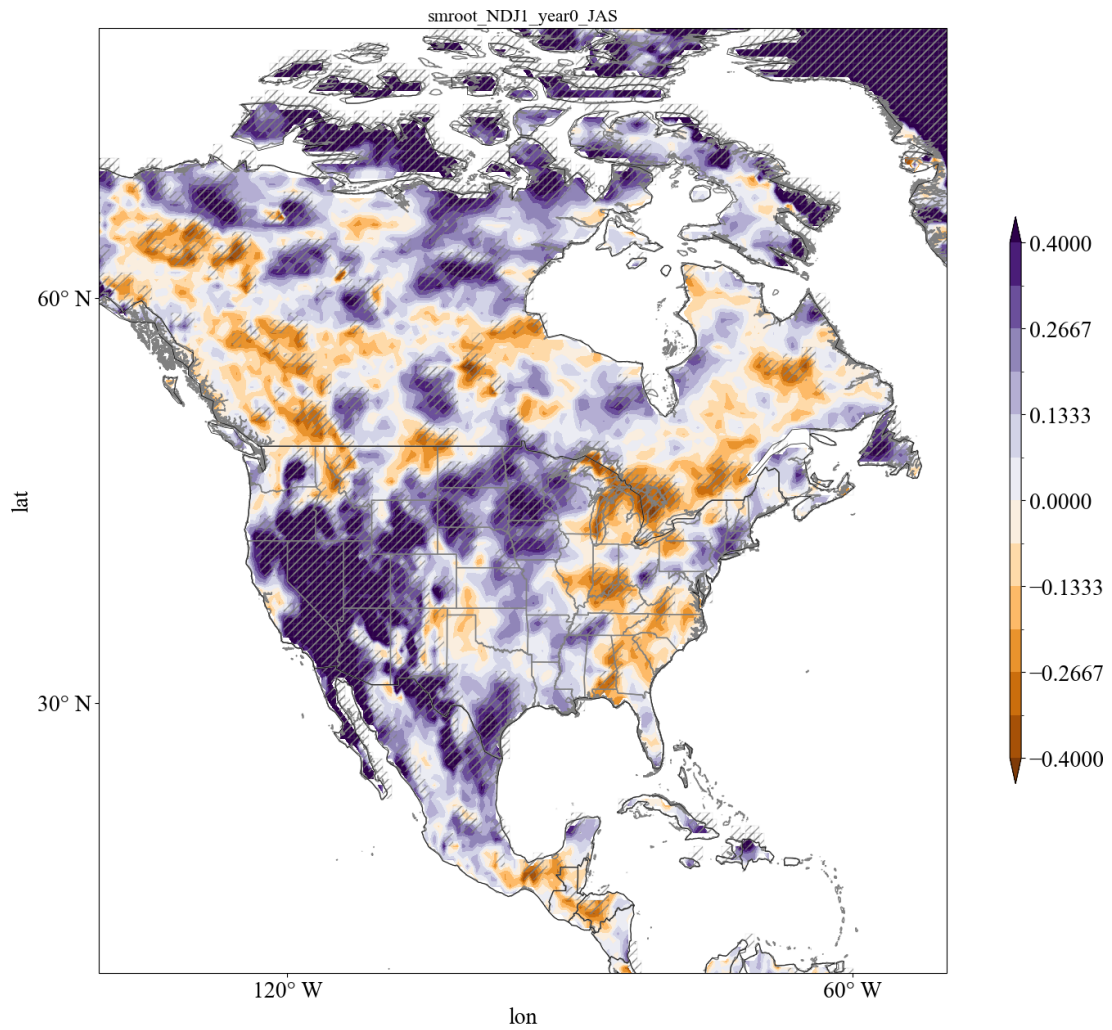
Figure S3: The correlation between SMroot during ND(-1)J and during JAS. Shaded areas with diagonal hatching indicate regions where the response is statistically significant at the 90% confidence level (t-test).
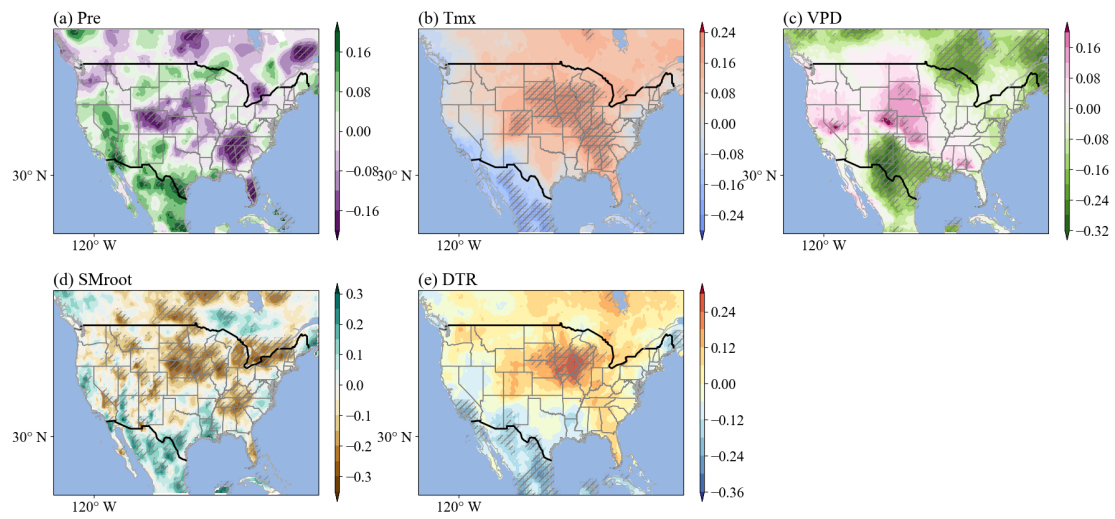
Figure S4: Responses of (a) precipitation (Pre, mm·d−1), (b) maximum temperature (Tmx, °C), (c) vapor pressure deficit (VPD, hPa), (d) root zone soil moisture (SMroot, m3·m-3), and (e) diurnal temperature range (DTR, °C) during JAS to the standardized IOB index during ND(–1)J. All variables were standardized before analysis. Values represent standardized changes (in σ units) in each variable per 1σ increase in the standardized IOB index. Shaded areas with diagonal hatching indicate regions where the response is statistically significant at the 90% confidence level (t-test).