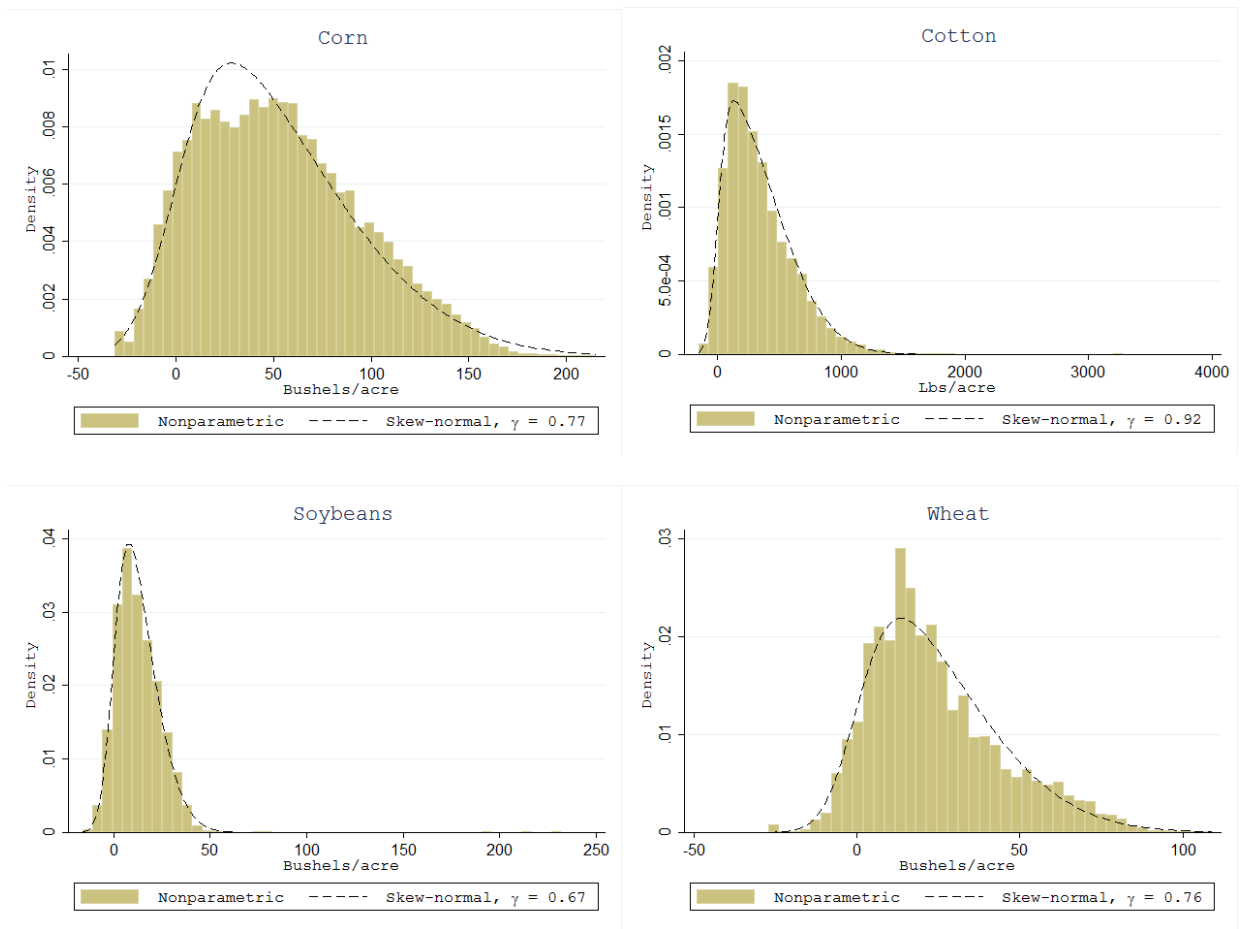
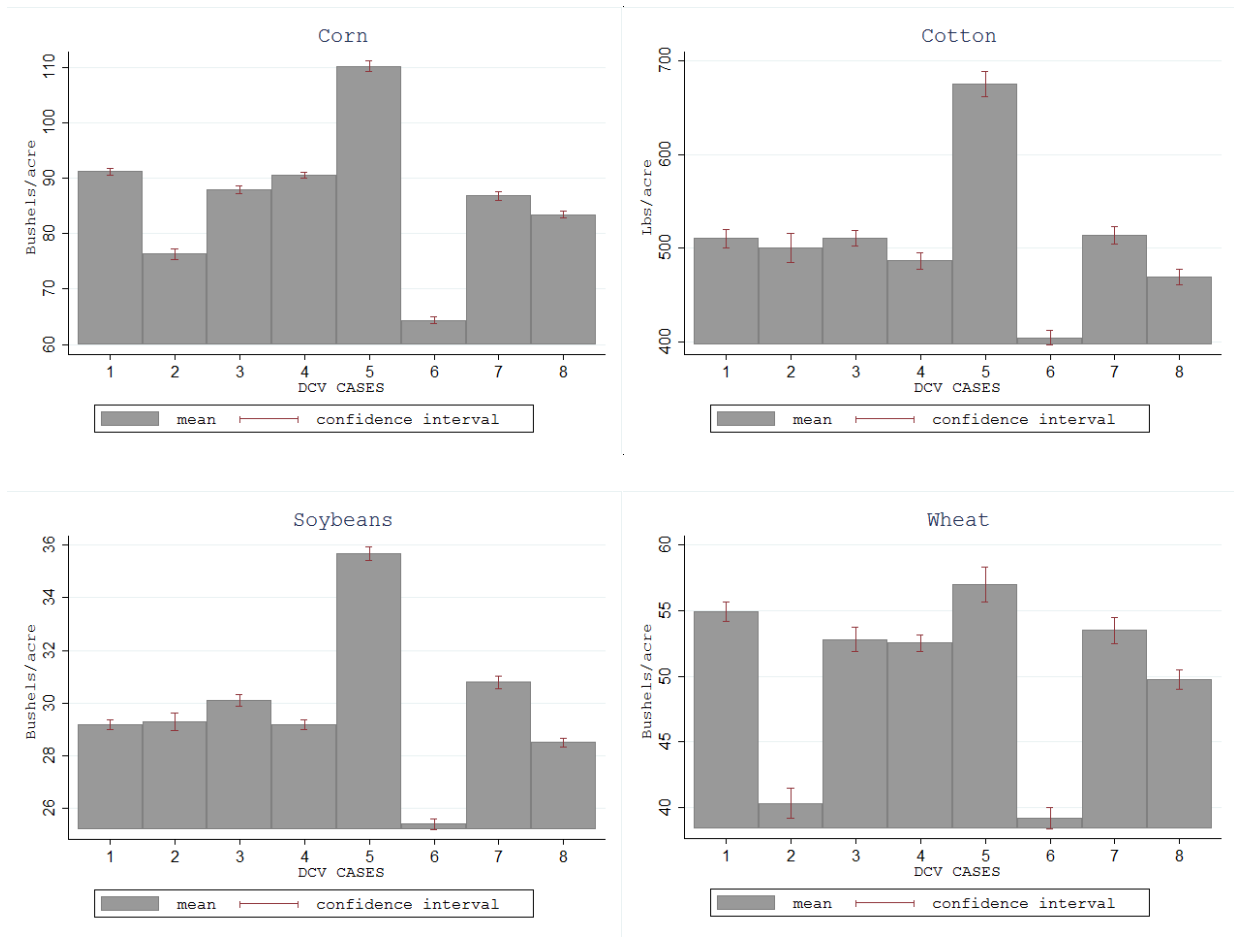


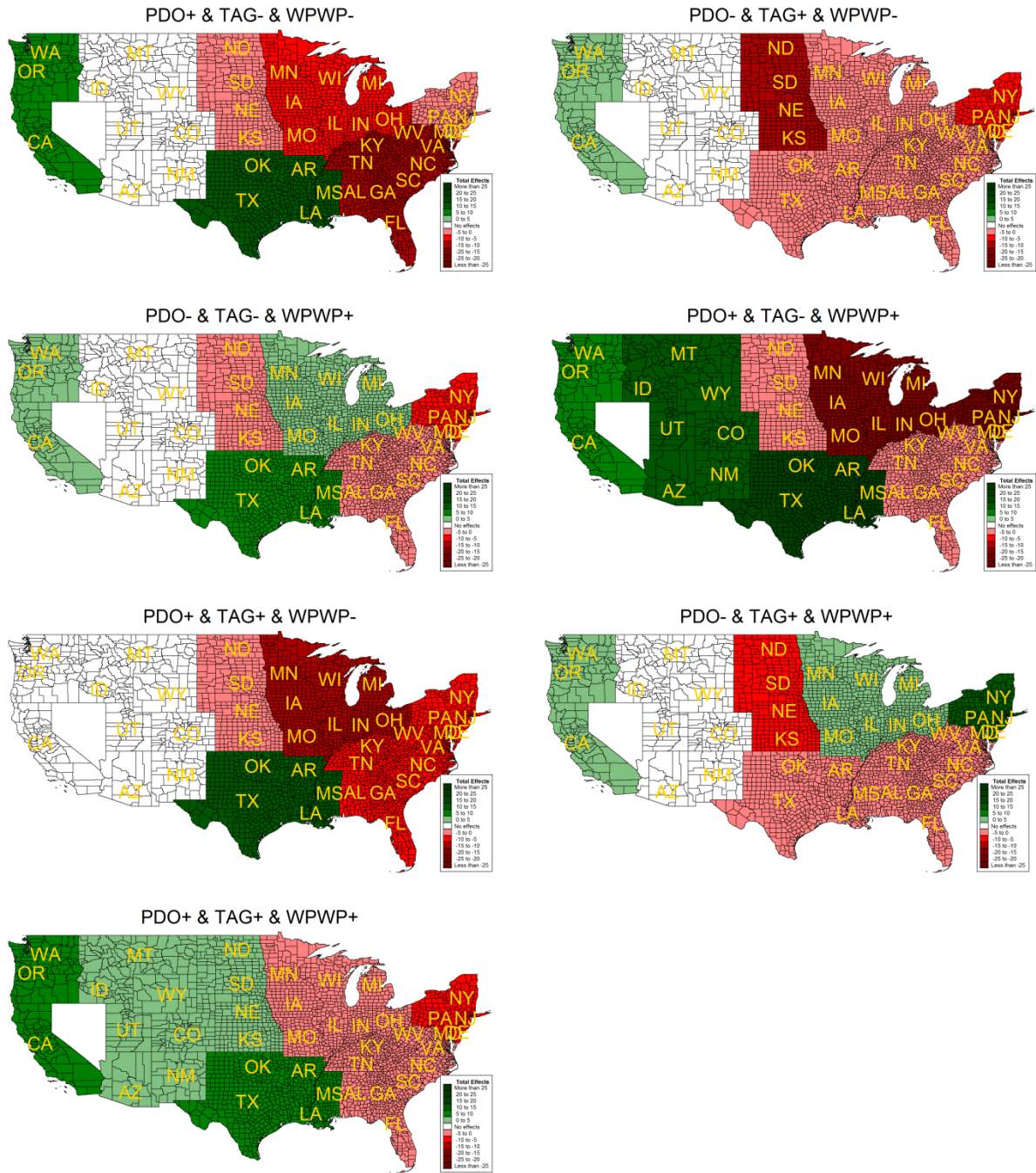
## Supplementary Material Appendix



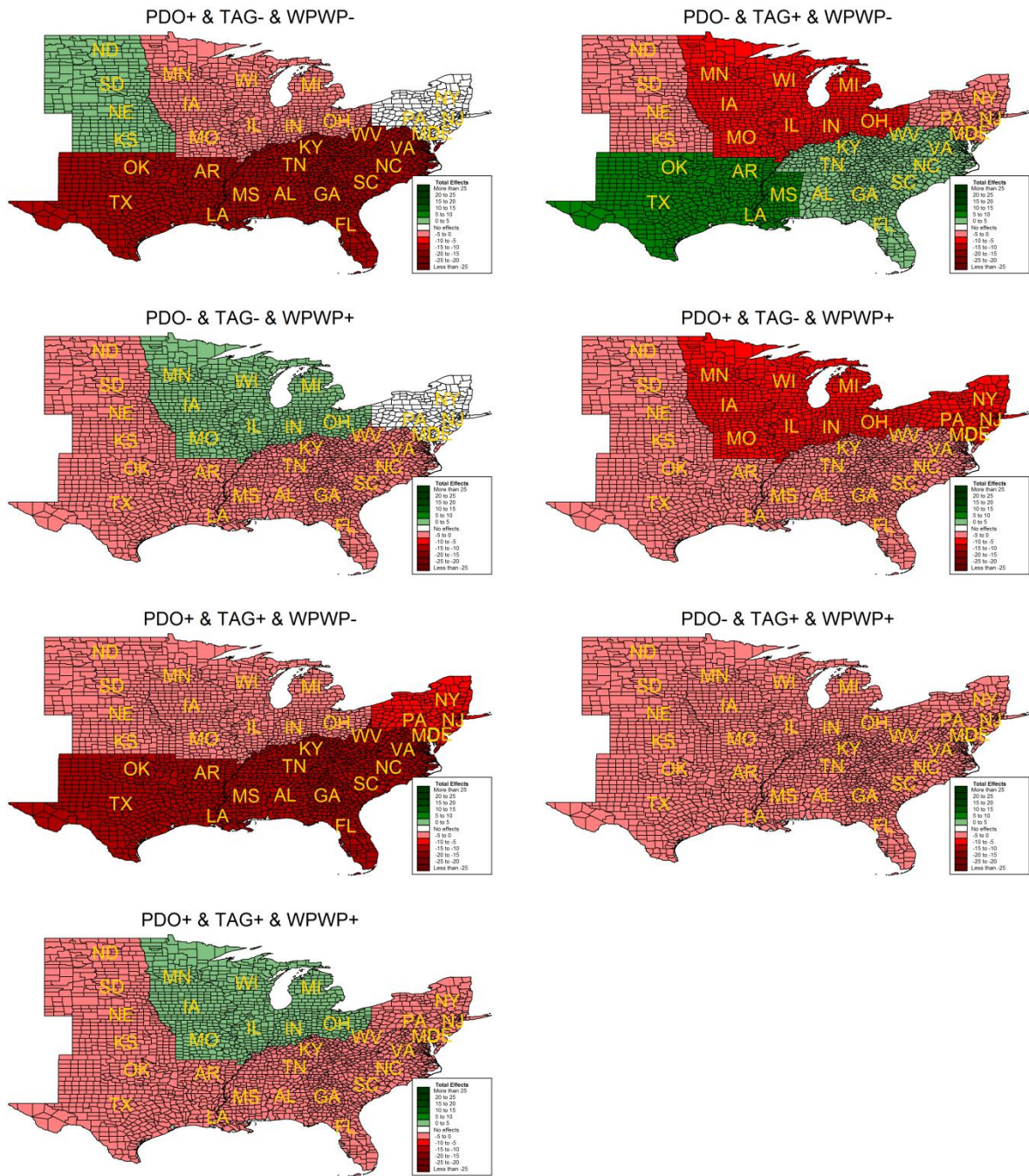
**Figure A1.** Histogram and Skew-normal Density Estimates of Crop Yields: using the raw county-level data for the years between 1950 and 2015.



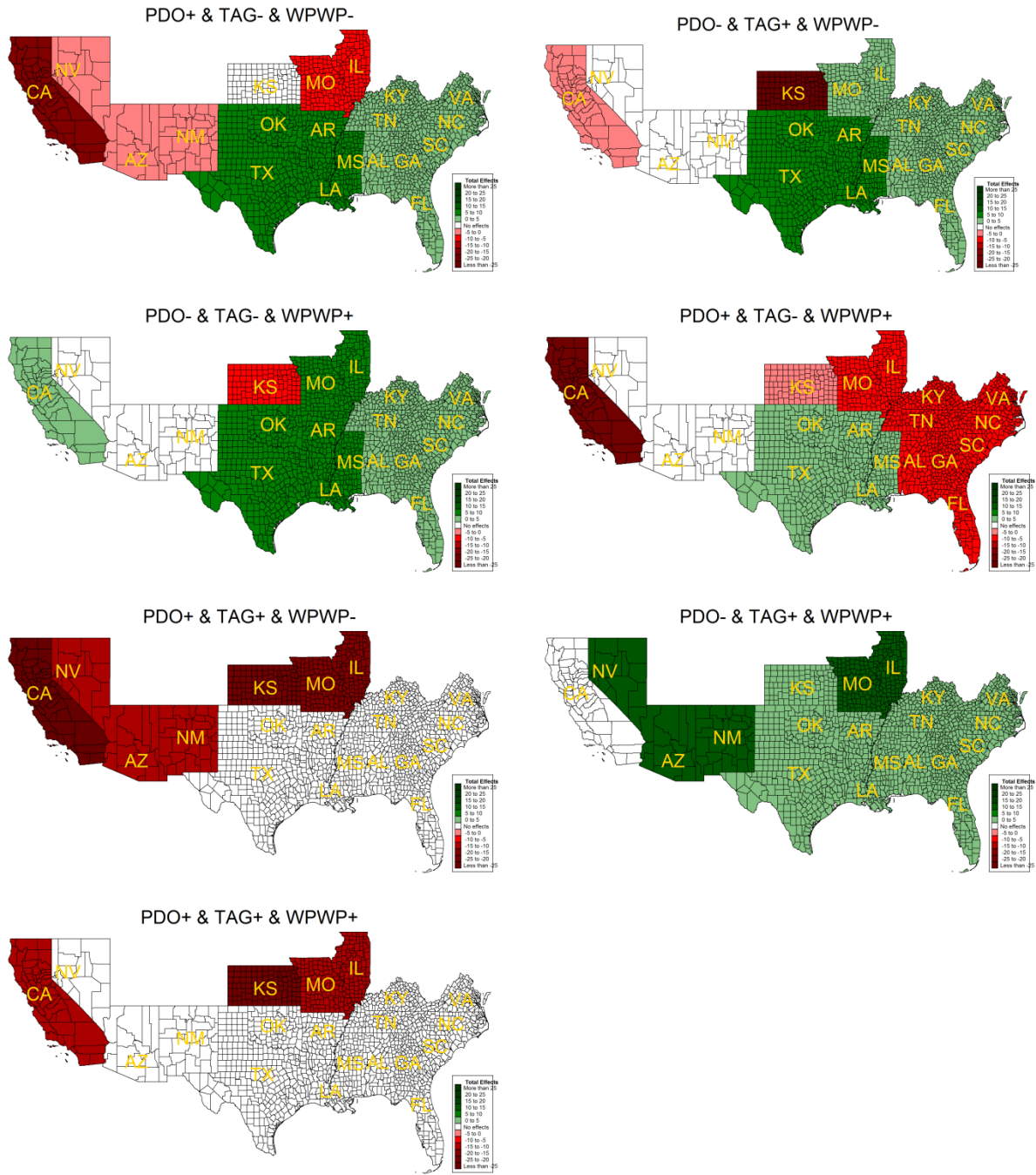
**Figure A2.** Mean with 95% Confidence Interval of Crop Yields for 8 DCV Phase Combinations: (PDO+,TAG-,WPWP-), (PDO-,TAG+,WPWP-), (PDO-,TAG-,WPWP+), (PDO+,TAG-,WPWP+), (PDO+,TAG+,WPWP-), (PDO-,TAG+,WPWP+), (PDO+,TAG+,WPWP+), and (PDO-,TAG-,WPWP-) using the raw county-level data for the years between 1950 and 2015.



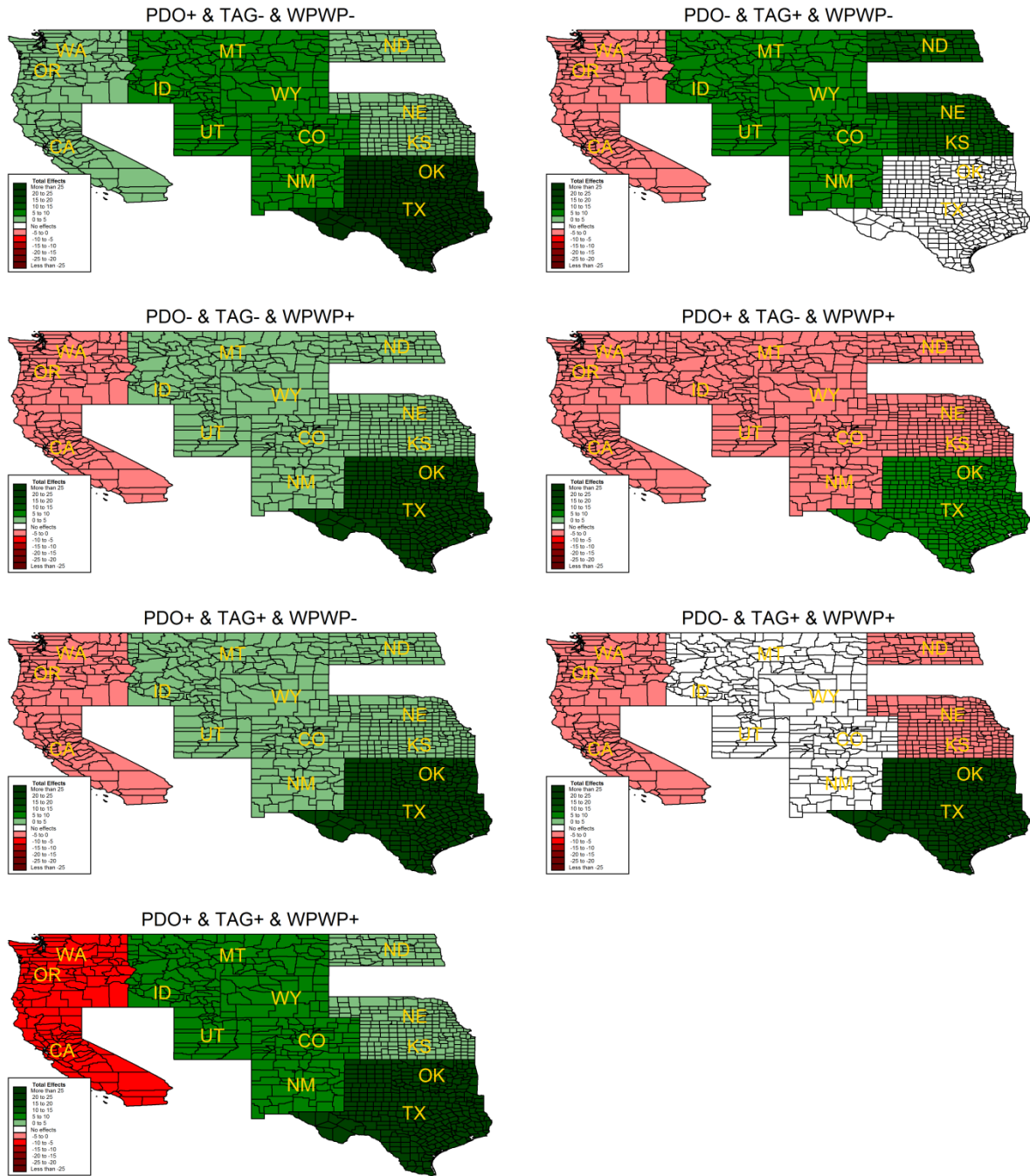
**Figure A3.** DCV Impacts on Corn Yields by Region. Estimated total DCV impacts compared with the null-DCV phase or (PDO-, TAG-, WPWP-) in every five bushel/acre are only those with the cluster-robust  $p$ -value < 0.05. The red (green) colors illustrate decreases (increases) in corn yields.



**Figure A4.** DCV Impacts on Soybean Yields by Region. Estimated total DCV impacts compared with the null-DCV phase or (PDO-, TAG-, WPWP-) in every five bushel/acre are only those with the cluster-robust  $p$ -value $<0.05$ . The red (green) colors illustrate decreases (increases) in soybean yields.



**Figure A5.** DCV Impacts on Cotton Yields by Region. Estimated total DCV impacts compared with the null-DCV phase or (PDO-, TAG-, WPWP-) in every five bushel/acre are only those with the cluster-robust  $p$ -value $<0.05$ . The red (green) colors illustrate decreases (increases) in cotton yields.



**Figure A6.** DCV Impacts on Non-irrigated Wheat Yields by Region. Estimated total DCV impacts compared with the null-DCV phase or (PDO-, TAG-, WPWP-) in every five bushel/acre are only those with the cluster-robust  $p$ -value  $< 0.05$ . The red (green) colors illustrate decreases (increases) in wheat yields.

**Table A1.** Descriptive Statistics of Crop Yields

	<b>Mean</b>	<b>Std. Dev.</b>	<b>Minimum</b>	<b>Maximum</b>	<b>N</b>
Corn (Bushels/Acre)	84.4	41.6	0.3	246.0	102,501
Soybeans (Bushels/Acre)	29.4	10.8	0.7	249.0	75,036
Wheat (Bushels/Acre)	51.2	20.2	4.0	136.0	16,173
Cotton (Pounds/Acre)	490.4	270.8	8.0	3433.0	23,752

Source: County-level data for the years between 1950 and 2015 from United States Department of Agriculture's National Agricultural Statistics Service Quick Stats database (USDA NASS)

**Table A2.** Frequencies of DCV Phase Combinations

<b>DCV Phase Combinations</b>	<b>Year</b>
PDO+, TAG-, WPWP-	1977, 1984, 1985, 1986, 1987, 1993
PDO-, TAG+, WPWP-	1955, 1966, 1967, 2011, 2012
PDO-, TAG-, WPWP+	1959, 1963, 1968, 1973, 1990, 1999, 2000, 2001, 2009
PDO+, TAG-, WPWP+	1976, 1978, 1979, 1980, 1982, 1983, 1992, 1997, 2006
PDO+, TAG+, WPWP-	1988, 1996, 2002, 2003, 2014, 2015
PDO-, TAG+, WPWP+	1950, 1951, 1952, 1953, 1954, 1956, 1961, 1962, 1964, 1969, 1970, 2007, 2010, 2013
PDO+, TAG+, WPWP+	1957, 1958, 1960, 1981, 1995, 1998, 2004, 2005
PDO-, TAG-, WPWP-	1965, 1971, 1972, 1974, 1975, 1989, 1991, 1994, 2008



**Table A3. Regression Estimates for Weather Variables**

	<b>GDD</b>	<b>GDD<sup>2</sup></b>	<b>Precip</b>	<b>Precip<sup>2</sup></b>	<b>PDSI</b>	<b>PDSI<sup>2</sup></b>	<b>Log of Temp Intensity</b>	<b>Log of Precip Intensity</b>
Trend	-0.00681 (0.831)	-7.138 (0.269)	-0.0321 (0.226)	-2.492 (0.343)	0.0188 (0.398)	0.111 (0.233)	-0.00593*** (0.000)	-0.00518*** (0.000)
Trend <sup>2</sup>	0.000490 (0.338)	0.191 (0.067)	0.00125** (0.002)	0.0861* (0.032)	-0.000193 (0.555)	-0.00117 (0.400)	0.0000650*** (0.000)	0.000101*** (0.000)
El Niño x CT	0.0414 (0.830)	32.49 (0.275)	0.657* (0.028)	45.55* (0.028)	0.0821 (0.563)	0.713 (0.105)	0.0252* (0.012)	0.0206*** (0.000)
El Niño x MT	-0.847** (0.002)	-123.5** (0.003)	0.910*** (0.000)	27.82*** (0.000)	0.486** (0.005)	1.597* (0.048)	-0.104*** (0.000)	0.0425*** (0.000)
El Niño x NE	-0.353 (0.199)	-30.94 (0.366)	-0.873*** (0.000)	-43.30** (0.002)	-0.545*** (0.000)	-1.280*** (0.000)	0.218*** (0.000)	-0.0108** (0.009)
El Niño x NP	-0.745*** (0.000)	-109.0*** (0.000)	1.724*** (0.000)	97.75*** (0.000)	0.496*** (0.000)	1.869** (0.002)	-0.0917*** (0.000)	0.0544*** (0.000)
El Niño x P	0.430 (0.662)	28.87 (0.826)	-0.237 (0.475)	2.272 (0.890)	0.177 (0.063)	1.741** (0.006)	-0.0832** (0.001)	-0.0335** (0.003)
El Niño x SE	1.245*** (0.000)	257.8*** (0.000)	-1.564*** (0.000)	-148.9*** (0.000)	-0.281** (0.003)	-0.332 (0.195)	0.0505*** (0.000)	0.000330 (0.920)
El Niño x SP	0.349 (0.493)	97.06 (0.395)	2.431*** (0.000)	170.5*** (0.000)	1.194* (0.012)	4.695* (0.019)	-0.0348*** (0.000)	0.0692*** (0.000)
La Niña x CT	1.627*** (0.000)	235.4*** (0.000)	0.686 (0.252)	124.0 (0.082)	0.113 (0.631)	0.826 (0.335)	0.0934*** (0.000)	0.00286 (0.289)
La Niña x MT	-1.597*** (0.000)	-214.9*** (0.000)	0.403*** (0.000)	2.822 (0.529)	0.793* (0.014)	3.341* (0.014)	-0.00775 (0.635)	0.0403*** (0.000)
La Niña x NE	1.131*** (0.000)	150.3*** (0.000)	0.397*** (0.001)	39.50** (0.003)	0.118* (0.034)	0.885** (0.001)	0.193*** (0.000)	-0.00820* (0.049)
La Niña x NP	0.388 (0.440)	46.47 (0.553)	0.186 (0.381)	10.03 (0.383)	0.636*** (0.000)	3.833*** (0.000)	0.0467*** (0.000)	0.000773 (0.863)
La Niña x P	-2.599*** (0.000)	-323.2*** (0.000)	-0.294*** (0.000)	-3.651 (0.633)	0.313 (0.219)	1.781 (0.137)	-0.0390 (0.137)	0.0274* (0.019)
La Niña x SE	1.332*** (0.000)	277.3*** (0.000)	-1.235 (0.055)	-107.1 (0.121)	-0.573*** (0.000)	-1.714** (0.002)	0.116*** (0.000)	-0.0250*** (0.000)
La Niña x SP	0.525 (0.214)	157.0 (0.103)	0.873 (0.078)	83.74* (0.018)	0.615* (0.045)	2.395* (0.017)	0.0109* (0.023)	0.0134** (0.002)
C1 x CT	3.668*** (0.000)	603.1*** (0.000)	2.196** (0.005)	172.8** (0.001)	-0.223 (0.275)	-0.223 (0.766)	0.161*** (0.000)	0.0470*** (0.000)
C2 x CT	3.982*** (0.000)	605.6*** (0.000)	-1.593*** (0.001)	-53.24 (0.312)	-0.889*** (0.000)	-1.715* (0.043)	0.466*** (0.000)	-0.0633*** (0.000)
C3 x CT	1.447*** (0.000)	192.4*** (0.000)	1.887*** (0.000)	138.4*** (0.000)	0.0190 (0.914)	0.702 (0.246)	0.0481*** (0.000)	0.0163*** (0.000)
C4 x CT	-0.729 (0.200)	-124.7 (0.217)	0.181 (0.784)	52.27 (0.378)	0.0827 (0.603)	0.352 (0.543)	0.182*** (0.000)	0.00812* (0.050)

	<b>GDD</b>	<b>GDD<sup>2</sup></b>	<b>Precip</b>	<b>Precip<sup>2</sup></b>	<b>PDSI</b>	<b>PDSI<sup>2</sup></b>	<b>Log of Temp Intensity</b>	<b>Log of Precip Intensity</b>
C5 x CT	0.288 (0.568)	-33.87 (0.686)	0.229 (0.786)	191.8 (0.308)	-0.406 (0.158)	-1.891* (0.047)	0.226*** (0.000)	-0.0508*** (0.000)
C6 x CT	1.785*** (0.000)	257.1*** (0.000)	1.051* (0.033)	76.52* (0.042)	-0.311 (0.119)	-1.171 (0.192)	0.200*** (0.000)	-0.0131*** (0.000)
C7 x CT	1.376** (0.002)	168.7* (0.011)	2.223* (0.020)	188.7** (0.006)	-0.0856 (0.720)	-0.280 (0.574)	-0.0189 (0.180)	0.0190*** (0.000)
C1 x MT	0.365 (0.518)	99.88 (0.216)	1.879*** (0.000)	54.05*** (0.000)	1.100 (0.291)	5.407 (0.154)	-0.0490 (0.100)	0.143*** (0.000)
C2 x MT	0.793 (0.149)	79.92 (0.333)	-0.597 (0.151)	-33.68 (0.146)	-0.340 (0.288)	-1.307 (0.414)	0.0469 (0.110)	-0.0213 (0.121)
C3 x MT	-0.480* (0.045)	-86.81* (0.035)	0.0381 (0.945)	-14.70 (0.392)	-0.418 (0.314)	-1.840 (0.290)	-0.0140 (0.574)	0.0287* (0.010)
C4 x MT	-1.161 (0.073)	-166.9 (0.076)	1.079* (0.013)	25.75 (0.087)	1.427* (0.016)	5.702** (0.006)	-0.0576* (0.032)	0.0995*** (0.000)
C5 x MT	0.614 (0.122)	34.29 (0.611)	-1.089** (0.004)	-81.43*** (0.000)	-1.536** (0.001)	-7.753*** (0.000)	0.101*** (0.000)	0.0302* (0.017)
C6 x MT	0.736* (0.016)	39.97 (0.449)	-0.536 (0.053)	-18.33 (0.344)	-0.297 (0.191)	-1.830 (0.079)	0.0352 (0.114)	-0.0767*** (0.000)
C7 x MT	-1.462** (0.003)	-213.8** (0.004)	1.256** (0.004)	26.93 (0.108)	0.563 (0.460)	2.215 (0.406)	0.0180 (0.481)	0.0928*** (0.000)
C1 x NE	1.771*** (0.000)	295.3*** (0.001)	-0.964 (0.232)	-67.24 (0.199)	-0.324 (0.053)	0.335 (0.615)	0.324*** (0.000)	-0.0455*** (0.000)
C2 x NE	3.156*** (0.000)	412.1*** (0.000)	-0.221 (0.604)	46.33 (0.209)	-1.038*** (0.000)	-1.688 (0.125)	0.536*** (0.000)	-0.0359*** (0.000)
C3 x NE	1.094*** (0.000)	132.7** (0.008)	-1.672*** (0.000)	-113.2*** (0.001)	-0.483* (0.027)	-0.0747 (0.922)	0.331*** (0.000)	-0.0221*** (0.001)
C4 x NE	-0.913*** (0.000)	-128.2*** (0.000)	-0.0127 (0.979)	4.772 (0.892)	0.428*** (0.000)	2.134** (0.001)	0.157*** (0.000)	-0.0391*** (0.000)
C5 x NE	0.552 (0.094)	-14.63 (0.817)	-0.756 (0.131)	-65.86 (0.056)	-0.122 (0.399)	0.383 (0.626)	0.476*** (0.000)	-0.0380*** (0.000)
C6 x NE	0.423 (0.282)	26.73 (0.657)	-1.455** (0.004)	-111.6** (0.002)	-0.0694 (0.710)	1.080 (0.165)	0.182*** (0.000)	-0.0362*** (0.000)
C7 x NE	1.712*** (0.000)	216.3*** (0.000)	-2.252*** (0.000)	-130.5*** (0.000)	-0.0389 (0.682)	1.028* (0.012)	0.163*** (0.000)	-0.0442*** (0.000)
C1 x NP	0.789 (0.074)	142.5* (0.017)	5.396*** (0.000)	323.3*** (0.000)	1.872** (0.003)	8.551*** (0.000)	-0.0152 (0.294)	0.116*** (0.000)
C2 x NP	2.632*** (0.000)	438.3*** (0.000)	-1.594 (0.087)	-60.70 (0.273)	-0.610 (0.479)	1.728 (0.700)	0.191*** (0.000)	-0.0759*** (0.000)
C3 x NP	-0.129 (0.776)	-51.96 (0.490)	1.168* (0.015)	61.25* (0.048)	0.957*** (0.000)	4.748*** (0.000)	0.106*** (0.000)	0.0340*** (0.000)
C4 x NP	-0.967 (0.357)	-186.4 (0.303)	-0.312 (0.556)	12.42 (0.561)	0.639* (0.041)	3.788 (0.069)	0.150*** (0.000)	-0.00795 (0.238)

	<b>GDD</b>	<b>GDD<sup>2</sup></b>	<b>Precip</b>	<b>Precip<sup>2</sup></b>	<b>PDSI</b>	<b>PDSI<sup>2</sup></b>	<b>Log of Temp Intensity</b>	<b>Log of Precip Intensity</b>
C5 x NP	0.191 (0.822)	-66.65 (0.605)	-1.501** (0.001)	-70.40* (0.027)	-0.555 (0.087)	0.121 (0.944)	0.121*** (0.000)	-0.0645*** (0.000)
C6 x NP	-0.520* (0.026)	-102.7* (0.028)	1.650*** (0.000)	109.1*** (0.000)	0.0945 (0.777)	0.504 (0.792)	0.0686*** (0.000)	0.00771 (0.197)
C7 x NP	-1.911* (0.019)	-363.6* (0.016)	2.816** (0.002)	151.0** (0.009)	1.014** (0.001)	4.833*** (0.000)	-0.0213 (0.092)	0.0590*** (0.000)
C1 x P	1.825*** (0.000)	261.2** (0.002)	-0.568 (0.490)	-12.91 (0.746)	-0.489 (0.069)	-0.647 (0.478)	0.0416 (0.367)	0.0460* (0.021)
C2 x P	-2.098*** (0.000)	-296.0*** (0.000)	0.974* (0.010)	45.78* (0.012)	0.980* (0.017)	4.262* (0.012)	0.0151 (0.752)	0.0108 (0.592)
C3 x P	0.427 (0.058)	43.77 (0.337)	-2.140*** (0.000)	-87.43*** (0.000)	-0.637* (0.047)	-1.147 (0.219)	-0.00378 (0.927)	-0.0343 (0.061)
C4 x P	-0.182 (0.324)	-23.82 (0.305)	1.014 (0.121)	39.97 (0.055)	1.100 (0.061)	4.877 (0.075)	-0.0456 (0.286)	0.105*** (0.000)
C5 x P	2.578** (0.010)	304.1 (0.109)	-2.125*** (0.001)	-110.0** (0.005)	-1.067*** (0.000)	-4.598** (0.002)	0.103* (0.018)	-0.0685*** (0.000)
C6 x P	0.611 (0.057)	36.58 (0.465)	-2.000*** (0.000)	-83.17*** (0.000)	0.280 (0.353)	1.836 (0.157)	-0.00961 (0.795)	-0.0939*** (0.000)
C7 x P	1.047 (0.062)	100.5 (0.092)	1.440 (0.089)	32.73 (0.375)	1.241 (0.190)	6.003 (0.200)	0.0637 (0.121)	0.0824*** (0.000)
C1 x SE	3.398*** (0.000)	688.6*** (0.000)	-7.139*** (0.000)	-536.4*** (0.000)	-2.081*** (0.000)	-5.033*** (0.000)	0.497*** (0.000)	-0.128*** (0.000)
C2 x SE	4.064*** (0.000)	794.6*** (0.000)	-3.861*** (0.000)	-315.4*** (0.001)	-1.888*** (0.000)	-4.874*** (0.000)	0.349*** (0.000)	-0.0719*** (0.000)
C3 x SE	1.513*** (0.000)	276.3*** (0.000)	-4.481*** (0.000)	-346.1*** (0.000)	-1.368*** (0.000)	-3.216*** (0.000)	0.270*** (0.000)	-0.0673*** (0.000)
C4 x SE	-1.080*** (0.000)	-199.3*** (0.000)	-3.497*** (0.000)	-254.8*** (0.000)	-0.672*** (0.000)	-1.825*** (0.000)	0.280*** (0.000)	-0.0878*** (0.000)
C5 x SE	1.148** (0.002)	203.7* (0.014)	-2.396* (0.010)	19.52 (0.907)	-0.924*** (0.000)	-3.000*** (0.001)	0.313*** (0.000)	-0.0592*** (0.000)
C6 x SE	1.750*** (0.000)	303.4*** (0.000)	-4.308*** (0.000)	-314.4*** (0.000)	-1.205*** (0.000)	-2.463** (0.003)	0.404*** (0.000)	-0.0730*** (0.000)
C7 x SE	1.795*** (0.000)	324.8*** (0.000)	-3.412*** (0.000)	-254.9*** (0.000)	-0.784*** (0.000)	-1.805** (0.001)	0.343*** (0.000)	-0.0666*** (0.000)
C1 x SP	0.149 (0.808)	64.21 (0.654)	-2.205 (0.102)	-199.7 (0.100)	0.988 (0.325)	3.382 (0.254)	0.112*** (0.000)	-0.0339*** (0.000)
C2 x SP	5.053*** (0.000)	1241.8*** (0.000)	-3.705*** (0.000)	-205.3*** (0.001)	-2.278*** (0.000)	-10.16*** (0.000)	0.140*** (0.000)	-0.143*** (0.000)
C3 x SP	0.151 (0.788)	64.73 (0.603)	-0.0886 (0.943)	11.85 (0.921)	0.0972 (0.871)	-1.136 (0.432)	0.0741*** (0.000)	0.00424 (0.498)
C4 x SP	-2.270*** (0.000)	-489.7*** (0.000)	-0.274 (0.668)	-4.419 (0.946)	0.442 (0.453)	0.924 (0.599)	0.0697*** (0.000)	-0.0296*** (0.000)

	<b>GDD</b>	<b>GDD<sup>2</sup></b>	<b>Precip</b>	<b>Precip<sup>2</sup></b>	<b>PDSI</b>	<b>PDSI<sup>2</sup></b>	<b>Log of Temp Intensity</b>	<b>Log of Precip Intensity</b>
C5 x SP	-0.858* (0.048)	-193.7* (0.047)	-1.652* (0.034)	-96.28 (0.228)	-0.329 (0.351)	-1.202 (0.360)	0.0455*** (0.000)	-0.0255*** (0.000)
C6 x SP	0.0539 (0.900)	-13.30 (0.885)	-2.933** (0.005)	-202.9 (0.069)	-0.607 (0.321)	-3.321** (0.005)	0.103*** (0.000)	-0.0685*** (0.000)
C7 x SP	-1.446 (0.066)	-332.0 (0.069)	-0.00492 (0.997)	-15.71 (0.883)	0.919 (0.326)	2.017 (0.392)	0.0944*** (0.000)	-0.00497 (0.443)
Constant	111.6*** (0.000)	12694.4*** (0.000)	43.58*** (0.000)	1985.8*** (0.000)	0.783* (0.019)	0.729 (0.592)	3.622*** (0.000)	4.297*** (0.000)
<i>N</i>	154,013	154,013	154,013	154,013	154,013	154,013	154,013	154,013
R Squared	0.8003	0.8010	0.4822	0.0603	0.1331	0.1393		
Wald $\chi^2$ ( <i>d.f.</i> =112)							256,154.55 (<0.000)	86,116.40 (<0.000)

Note: 1) Dependent variables are annual growing degree day, amount of precipitation, PDSI (Palmer Drought Severity Index), hot days, and wet days. Independent variables are time trend, interactions of ENSO and regional dummies, interactions of DCV and regional dummies, and U.S. state dummies.

2) All equations are random effects linear panel data models except log of hot days which is zero-inflated Poisson random effects model and log of wet days which is Poisson random effects model.

3) Regional Dummies are CT for Central(IA, IL, IN, MI, MN, MO, OH, WI); MT for Mountains(AZ, CO, ID, MT, NM, NV, UT, WY); NE for Northeast(CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT); NP for Northern Plains(KS, ND, NE, SD); P for Pacific(CA, OR, WA); SE for Southeast(AL, FL, GA, KY, NC, SC, TN, VA, WV); SP for Southern Plains(AR, LA, MS, OK, TX).

4) DCV (PDO, TAG, WPWP) dummy variables identify 7 different DCV phase combinations. C1 for (PDO+,TAG-,WPWP-); C2 for (PDO-,TAG+,WPWP-); C3 for (PDO-,TAG-,WPWP+); C4 for (PDO+,TAG+,WPWP-); C5 for (PDO+,TAG-,WPWP+); C6 for (PDO-,TAG+,WPWP+); and C7 for (PDO+,TAG+,WPWP+); where C8 for (PDO-,TAG-,WPWP-) is excluded from co-linearity.

5) Estimated coefficients with the cluster-robust *p*-values in parentheses (\* *p*<0.05, \*\* *p*<0.01, \*\*\* *p*<0.001).

6) The dummy coefficients of U.S. states are not shown.

**Table A4. Skew-normal Regression on Crop Yields**

	<b>Corn</b>	<b>Cotton</b>	<b>Soybeans</b>	<b>Wheat</b>
Trend	0.0380*** (0.000)	0.0109** (0.002)	0.0149*** (0.000)	0.0288*** (0.000)
Trend <sup>^2</sup>	-0.000242*** (0.000)	0.000102 (0.076)	-0.0000291 (0.290)	-0.000228*** (0.000)
Harvested Acreage	0.00000181*** (0.000)	0.00000131* (0.014)	0.000000764*** (0.000)	0.00000306*** (0.000)
GDD	0.113** (0.003)	-0.134 (0.557)	0.0971*** (0.001)	-0.0134 (0.690)
GDD <sup>^2</sup>	-0.00621* (0.033)	0.00540 (0.420)	-0.00465** (0.002)	0.000376 (0.760)
PDSI	0.0108 (0.124)	0.00952 (0.375)	0.00252 (0.551)	0.0133* (0.022)
PDSI <sup>^2</sup>	-0.000175 (0.917)	0.000395 (0.871)	0.00191 (0.160)	-0.00185 (0.144)
Precipitation	-0.0146 (0.204)	-0.0757* (0.016)	0.00353 (0.688)	-0.0599* (0.031)
Precipitation <sup>^2</sup>	0.000326 (0.391)	0.00259 (0.152)	-0.0000556 (0.676)	0.00376 (0.195)
Day Temp>90° F	-0.0376*** (0.000)	-0.00761 (0.054)	-0.0343*** (0.000)	0.00884* (0.017)
Day Precip>1 inch	-0.00414 (0.343)	0.0122 (0.241)	0.000317 (0.926)	0.00997* (0.029)
El Niño x CT	0.0328*** (0.000)	0.0726*** (0.000)	0.0112 (0.156)	
El Niño x MT	-0.0182 (0.528)	0.0372 (0.333)		0.0458** (0.002)
El Niño x NE	-0.0497*** (0.000)		-0.0307* (0.011)	
El Niño x NP	0.00103 (0.934)	-0.133*** (0.000)	-0.00355 (0.239)	0.0381 (0.103)
El Niño x P	0.0175 (0.325)	0.0711*** (0.000)		0.0150 (0.329)
El Niño x SE	0.00538 (0.664)	0.0299 (0.214)	-0.0323*** (0.000)	
El Niño x SP	-0.0173 (0.081)	0.0722*** (0.000)	-0.00307 (0.850)	0.0768*** (0.000)
La Niña x CT	-0.0773*** (0.000)	-0.0756*** (0.000)	-0.0329*** (0.000)	

	<b>Corn</b>	<b>Cotton</b>	<b>Soybeans</b>	<b>Wheat</b>
La Niña x MT	0.0138 (0.218)	-0.0413** (0.005)		0.00953 (0.395)
La Niña x NE	-0.0976*** (0.001)		-0.0426*** (0.000)	
La Niña x NP	-0.00414 (0.652)	-0.122*** (0.000)	-0.0267* (0.039)	0.0569** (0.005)
La Niña x P	0.00334 (0.714)	-0.0916*** (0.000)		0.0359 (0.057)
La Niña x SE	-0.0397** (0.002)	0.0159 (0.486)	-0.0732*** (0.000)	
La Niña x SP	0.0648* (0.022)	0.00406 (0.801)	-0.0657*** (0.000)	0.0610*** (0.000)
C1 x CT	-0.0498** (0.005)	-0.0486*** (0.000)	0.0268 (0.088)	
C2 x CT	0.0134 (0.613)	0.0394* (0.031)	-0.0405** (0.009)	
C3 x CT	0.0176 (0.136)	0.0729*** (0.000)	0.00448 (0.641)	
C4 x CT	-0.0913*** (0.000)	-0.161*** (0.000)	-0.00393 (0.833)	
C5 x CT	-0.151*** (0.000)	-0.0317* (0.018)	-0.0730*** (0.000)	
C6 x CT	0.0659* (0.033)	0.0949*** (0.000)	-0.00423 (0.835)	
C7 x CT	-0.0468** (0.009)	-0.106*** (0.000)	0.00345 (0.744)	
C1 x MT	0.0740 (0.071)	-0.0189 (0.713)		0.0566*** (0.001)
C2 x MT	-0.0420 (0.193)	0.0966 (0.065)		0.0572* (0.013)
C3 x MT	0.0639 (0.078)	0.00638 (0.762)		0.0430** (0.002)
C4 x MT	0.0501 (0.098)	-0.129* (0.015)		0.0371* (0.042)
C5 x MT	0.150** (0.006)	-0.0786 (0.498)		0.0310 (0.232)
C6 x MT	-0.0806 (0.127)	0.125** (0.003)		0.0184 (0.480)
C7 x MT	0.0422 (0.289)	-0.0326 (0.432)		0.0749*** (0.000)

	Corn	Cotton	Soybeans	Wheat
C1 x NE	-0.0389 (0.091)		-0.0103 (0.637)	
C2 x NE	-0.0498 (0.067)		-0.0141 (0.552)	
C3 x NE	-0.0462** (0.004)		-0.0136 (0.426)	
C4 x NE	-0.0664* (0.012)		-0.0550* (0.050)	
C5 x NE	-0.188*** (0.000)		-0.0653*** (0.000)	
C6 x NE	0.115*** (0.000)		-0.0282 (0.272)	
C7 x NE	-0.0541** (0.001)		-0.0454*** (0.001)	
C1 x NP	0.0330 (0.154)		0.0476*** (0.001)	0.0105 (0.683)
C2 x NP	-0.0975*** (0.000)	-0.447*** (0.000)	-0.120 (0.111)	0.0983*** (0.000)
C3 x NP	-0.00483 (0.864)	-0.114*** (0.000)	-0.00599 (0.855)	0.0132 (0.506)
C4 x NP	-0.00458 (0.864)	-0.336*** (0.000)	-0.00128 (0.968)	0.0379*** (0.001)
C5 x NP	-0.0313 (0.300)	-0.0972** (0.002)	-0.0108 (0.764)	-0.0689 (0.062)
C6 x NP	-0.0946*** (0.000)	-0.0678 (0.074)	-0.0992 (0.154)	-0.0498 (0.123)
C7 x NP	-0.0459 (0.083)	-0.296*** (0.000)	0.0274 (0.105)	0.0149 (0.858)
C1 x P	0.0985*** (0.000)	-0.158*** (0.000)		0.0221* (0.030)
C2 x P	0.0336* (0.018)	-0.0236 (0.530)		-0.00247 (0.876)
C3 x P	0.0389* (0.033)	0.0381* (0.014)		-0.00155 (0.931)
C4 x P	0.00637 (0.796)	-0.250*** (0.000)		-0.0127 (0.357)
C5 x P	0.0820*** (0.000)	-0.215*** (0.000)		-0.00776 (0.883)
C6 x P	0.00684 (0.829)	-0.00660 (0.875)		-0.0319 (0.122)

	<b>Corn</b>	<b>Cotton</b>	<b>Soybeans</b>	<b>Wheat</b>
C7 x P	0.0858* (0.036)	-0.124*** (0.000)		-0.0566* (0.011)
C1 x SE	-0.0729* (0.017)	-0.00771 (0.833)	-0.0619* (0.016)	
C2 x SE	0.0137 (0.572)	-0.0469 (0.245)	0.0785* (0.027)	
C3 x SE	-0.0116 (0.427)	-0.0291 (0.630)	-0.0245 (0.178)	
C4 x SE	-0.0489** (0.006)	-0.0434 (0.180)	-0.0785*** (0.000)	
C5 x SE	-0.0502 (0.235)	-0.0770* (0.018)	-0.00391 (0.845)	
C6 x SE	-0.0213 (0.462)	-0.0524 (0.158)	0.00101 (0.980)	
C7 x SE	-0.0288 (0.078)	0.0125 (0.718)	-0.00806 (0.642)	
C1 x SP	0.152** (0.005)	0.0770*** (0.000)	-0.0881*** (0.000)	0.250*** (0.000)
C2 x SP	0.0555 (0.296)	0.0906* (0.018)	0.0972* (0.040)	
C3 x SP	0.0761* (0.045)	0.0824** (0.002)	-0.0340 (0.449)	0.159*** (0.000)
C4 x SP	0.124* (0.015)	-0.0178 (0.181)	-0.0875* (0.013)	0.151*** (0.000)
C5 x SP	0.185* (0.035)	0.0418* (0.045)	-0.0114 (0.811)	0.0674*** (0.001)
C6 x SP	-0.0489 (0.380)	-0.0382 (0.332)	0.0433 (0.138)	0.143* (0.049)
C7 x SP	0.0883* (0.039)	0.0315 (0.442)	-0.0131 (0.825)	0.154*** (0.000)
Constant	2.768*** (0.000)	6.513*** (0.001)	2.368*** (0.000)	3.507*** (0.000)
Gamma	-0.674*** (0.000)	-0.501*** (0.000)	-0.629*** (0.000)	-0.572*** (0.000)
ln(Sigma)	-1.209*** (0.000)	-0.952*** (0.000)	-1.457*** (0.000)	-1.445*** (0.000)
N	102,501	23,751	75,035	16,172
Wald $\chi^2$ (d.f.)	261208.3 (114) (<0.000)	25779.0 (83) (<0.000)	137698.7 (86) (<0.000)	33113.7 (59) (<0.000)
Normality $\chi^2$ (d.f.)	10524.9 (1) (<0.000)	1278.1 (1) (<0.000)	7059.8 (1) (<0.000)	1277.2 (1) (<0.000)

Note: 1) Dependent variables are yearly average crop yield per harvested acre by county. Independent variables are crop acreage, time



trend, growing degree day, amount of precipitation, PDSI (Palmer Drought Severity Index), hot days, wet days, interactions of ENSO and regional dummies, interactions of DCV and regional dummies, and U.S. state dummies

2) Regional Dummies. CT=Central(IA, IL, IN, MI, MN, MO, OH, WI); MT=Mountains(AZ, CO, ID, MT, NM, NV, UT, WY); NE=Northeast(CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT); NP=Northern Plains(KS, ND, NE, SD); P=Pacific(CA, OR, WA); SE=Southeast(AL, FL, GA, KY, NC, SC, TN, VA, WV); SP=Southern Plains(AR, LA, MS, OK, TX).

3) DCV dummy variables cover 7 different DCV phase combinations. C1=(PDO+,TAG-,WPWP-); C2=(PDO-,TAG+,WPWP-); C3=(PDO-,TAG-,WPWP+); C4=(PDO+,TAG-,WPWP+); C5=(PDO+,TAG+,WPWP-); C6=(PDO-,TAG+,WPWP+); and C7=(PDO+,TAG+,WPWP+); where C8=(PDO-,TAG-,WPWP-)is excluded and is in the intercept.

4) Estimated coefficients with the cluster-robust  $p$ -values in parentheses (\*  $p<0.05$ , \*\*  $p<0.01$ , \*\*\*  $p<0.001$ ).

5) The dummy coefficients of U.S. states are not shown.

**Table A5.** Direct and Indirect DCV Impacts on Crop Yields by Region

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
<b>CORN</b>								
(bushels/acre)								
Central	Direct	-0.05** (0.006)			-0.092*** (<0.001)	-0.152*** (<0.001)	0.066* (0.033)	-0.047** (0.01)
	Indirect	-0.012** (0.006)	-0.043*** (<0.001)	0.005*** (<0.001)	-0.016*** (<0.001)	-0.035*** (<0.001)	-0.017*** (<0.001)	0.012*** (<0.001)
Mountains	Direct					0.151** (0.007)		
	Indirect					-0.024*** (<0.001)		0.016* (0.033)
Northeast	Direct			-0.047** (0.005)	-0.067* (0.012)	-0.189*** (<0.001)	0.115*** (<0.001)	-0.055** (0.002)
	Indirect	-0.034*** (<0.001)	-0.054*** (<0.001)	-0.033*** (<0.001)	-0.005*** (<0.001)	-0.059*** (<0.001)		-0.005* (0.036)
Northern Plains	Direct		-0.098*** (<0.001)				-0.095*** (<0.001)	
	Indirect	-0.01* (0.033)	-0.018*** (<0.001)	-0.014*** (<0.001)	-0.018*** (<0.001)	-0.019*** (<0.001)		
Pacific	Direct	0.099*** (<0.001)	0.034* (0.019)	0.039* (0.033)		0.082*** (<0.001)		0.086* (0.036)
	Indirect	-0.011*** (<0.001)				-0.011*** (<0.001)	0.006*** (<0.001)	
Southeast	Direct	-0.073* (0.017)			-0.049** (0.006)			
	Indirect	-0.064*** (<0.001)	-0.039*** (<0.001)	-0.035*** (<0.001)	-0.034*** (<0.001)	-0.041*** (<0.001)	-0.045*** (<0.001)	-0.041*** (<0.001)
Southern Plains	Direct	0.152** (0.005)		0.077* (0.045)	0.124* (0.016)	0.186* (0.035)		0.089* (0.04)
	Indirect	-0.016*** (<0.001)	-0.023* (0.05)	-0.01*** (<0.001)			-0.016*** (<0.001)	-0.015*** (<0.001)
<b>COTTON</b>								
(lbs/acre)								
Central	Direct	-0.049*** (<0.001)	0.04* (0.032)	0.073*** (<0.001)	-0.161*** (<0.001)	-0.032* (0.018)	0.095*** (<0.001)	-0.107*** (<0.001)
	Indirect	-0.02* (0.017)	-0.027* (0.017)	-0.003* (0.017)		-0.028* (0.017)	0.015* (0.017)	-0.035* (0.017)

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
Mountains	Direct				-0.129* (0.015)		0.125** (0.004)	
	Indirect	-0.01* (0.017)						
Northeast	Direct							
	Indirect							
Northern Plains	Direct		-0.447*** (<0.001)	-0.114*** (<0.001)	-0.336*** (<0.001)	-0.098** (0.002)		-0.296*** (<0.001)
	Indirect		0.15* (0.017)	0.024* (0.017)	0.09* (0.017)	0.078* (0.017)	0.036* (0.017)	0.074* (0.017)
Pacific	Direct	-0.159*** (<0.001)		0.039* (0.015)	-0.25*** (<0.001)	-0.215*** (<0.001)		-0.124*** (<0.001)
	Indirect	0.003* (0.017)	-0.006* (0.017)		-0.006* (0.017)			-0.009* (0.017)
Southeast	Direct					-0.077* (0.018)		
	Indirect	0.036* (0.017)	0.009* (0.017)	0.029* (0.017)		-0.02* (0.017)	0.026* (0.017)	
Southern Plains	Direct	0.078*** (<0.001)	0.091* (0.019)	0.083** (0.003)		0.042* (0.046)		
	Indirect						0.027* (0.017)	
<b>SOYBEANS</b> (bushels/acre)								
Central	Direct		-0.041** (0.01)			-0.073*** (<0.001)		
	Indirect		-0.039*** (<0.001)	0.005** (0.004)	-0.014*** (<0.001)	-0.024*** (<0.001)	-0.018*** (<0.001)	0.01*** (<0.001)
Mountains	Direct							
	Indirect							
Northeast	Direct				-0.056* (0.05)	-0.066*** (<0.001)		-0.046*** (<0.001)
	Indirect		-0.038*** (<0.001)		-0.007* (0.012)	-0.032*** (<0.001)	-0.019*** (<0.001)	0.005* (0.03)

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
Northern Plains	Direct	0.048*** ( $<0.001$ )						
	Indirect		-0.016*** ( $<0.001$ )	-0.013*** ( $<0.001$ )	-0.016*** ( $<0.001$ )	-0.017*** ( $<0.001$ )	-0.009*** ( $<0.001$ )	
Pacific	Direct	-0.062* (0.017)	0.079* (0.028)		-0.079*** ( $<0.001$ )			
	Indirect	-0.047*** ( $<0.001$ )	-0.045*** ( $<0.001$ )	-0.028*** ( $<0.001$ )	-0.026*** ( $<0.001$ )	-0.035*** ( $<0.001$ )	-0.046*** ( $<0.001$ )	-0.037*** ( $<0.001$ )
Southeast	Direct							
	Indirect							
Southern Plains	Direct	-0.089*** ( $<0.001$ )	0.098* (0.041)		-0.088* (0.014)			
	Indirect	-0.022*** ( $<0.001$ )	-0.017*** ( $<0.001$ )	-0.015*** ( $<0.001$ )	-0.015*** ( $<0.001$ )	-0.011*** ( $<0.001$ )	-0.021*** ( $<0.001$ )	-0.021*** ( $<0.001$ )
<b>WHEAT</b> (bushels/acre)								
Central	Direct							
	Indirect							
Mountains	Direct	0.057*** ( $<0.001$ )	0.058* (0.014)	0.044** (0.003)	0.038* (0.043)			0.075*** ( $<0.001$ )
	Indirect							0.004* (0.018)
Northeast	Direct							
	Indirect							
Northern Plains	Direct		0.099*** ( $<0.001$ )		0.038*** ( $<0.001$ )			
	Indirect			0.025** (0.007)		-0.006* (0.03)		
Pacific	Direct	0.023* (0.03)						-0.057* (0.011)
	Indirect			-0.015* (0.023)		-0.005* (0.03)		

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
Southeast	Direct							
	Indirect							
Southern Plains	Direct	0.251*** ( $<0.001$ )		0.159*** ( $<0.001$ )	0.152*** ( $<0.001$ )	0.068*** ( $<0.001$ )	0.144* (0.049)	0.154*** ( $<0.001$ )
	Indirect	0.014*** ( $<0.001$ )		0.02* (0.032)		-0.016* (0.043)		0.005* (0.018)

- Note: 1) Yields of all crops are in bushels/ harvested acre, except for cotton yield which is in lbs/ harvested acre.  
2) Coefficients estimated by Delta method with the cluster-robust  $p$ -values in parentheses (\*  $p<0.05$ , \*\*  $p<0.01$ , \*\*\*  $p<0.001$ ).  
3) Blanks in some regions imply no significant impacts at 95% statistical confidence.

**Table A6.** Generalized-least Square Regression on Yield Variance ( $\hat{u}^2$ )

	Corn	Cotton	Soybeans	Wheat
Trend	-0.00459*** (0.000)	-0.00487*** (0.000)	-0.00220*** (0.000)	-0.00356*** (0.000)
Trend <sup>^2</sup>	0.0000639*** (0.000)	0.0000344* (0.029)	0.0000362*** (0.000)	0.0000583*** (0.000)
Harvested Acreage	-0.000000572*** (0.000)	-0.00000118*** (0.000)	-0.000000298*** (0.000)	-0.000000785*** (0.000)
GDD	-0.0398*** (0.000)	-0.00402 (0.914)	-0.0629*** (0.000)	0.000432 (0.933)
GDD <sup>^2</sup>	0.000603* (0.027)	-0.0000473 (0.967)	0.00261*** (0.000)	-0.000261 (0.245)
PDSI	0.00606*** (0.000)	0.0172*** (0.000)	0.00737*** (0.000)	-0.00144 (0.509)
PDSI <sup>^2</sup>	-0.00578*** (0.000)	-0.00625*** (0.000)	-0.00454*** (0.000)	-0.000745 (0.159)
Precipitation	-0.0123*** (0.000)	-0.0135* (0.036)	-0.00365** (0.008)	-0.0128* (0.031)
Precipitation <sup>^2</sup>	0.000442*** (0.000)	0.00159*** (0.000)	0.000121* (0.022)	0.00173* (0.031)
Day Temp>90°	0.0276*** (0.000)	-0.000114 (0.952)	0.0222*** (0.000)	-0.00156 (0.282)
Day Precip>90	-0.00332*** (0.001)	0.00211 (0.420)	-0.00182** (0.008)	-0.000433 (0.750)
El Niño x CT	-0.0236*** (0.000)	-0.0282 (0.669)	-0.00383 (0.224)	
El Niño x MT	0.0564*** (0.000)	0.0403 (0.377)		-0.00718 (0.295)
El Niño x NE	0.0243 (0.051)		0.0164 (0.130)	
El Niño x NP	-0.0250** (0.001)	-0.0274 (0.880)	-0.000862 (0.874)	0.00520 (0.553)
El Niño x P	0.0341 (0.105)	-0.0391 (0.512)		-0.0173 (0.145)
El Niño x SE	-0.00752 (0.249)	-0.0135 (0.356)	0.00328 (0.493)	
El Niño x SP	-0.0602*** (0.000)	-0.0416*** (0.000)	-0.00297 (0.601)	0.00950 (0.418)
La Niña x CT	-0.0176*** (0.001)	0.0336 (0.625)	-0.0000451 (0.989)	

	Corn	Cotton	Soybeans	Wheat
La Niña x MT	-0.0321* (0.042)	-0.0274 (0.557)		0.0143* (0.045)
La Niña x NE	0.0337** (0.006)		0.00672 (0.523)	
La Niña x NP	-0.00842 (0.284)	-0.254 (0.457)	-0.00296 (0.584)	0.00229 (0.808)
La Niña x P	0.0125 (0.557)	0.00626 (0.920)		-0.00477 (0.706)
La Niña x SE	0.0131* (0.047)	0.0435** (0.003)	0.0283*** (0.000)	
La Niña x SP	0.0589*** (0.000)	0.0640*** (0.000)	0.0172** (0.003)	0.00727 (0.577)
C1 x CT	0.0247** (0.005)	0.00809 (0.942)	0.000704 (0.897)	
C2 x CT	0.00213 (0.826)	0.0343 (0.788)	-0.0370*** (0.000)	
C3 x CT	-0.0365*** (0.000)	0.0148 (0.884)	-0.0225*** (0.000)	
C4 x CT	0.0116 (0.152)	0.0486 (0.632)	-0.0114* (0.022)	
C5 x CT	-0.0336*** (0.000)	0.0103 (0.935)	-0.0316*** (0.000)	
C6 x CT	-0.0251** (0.001)	-0.0240 (0.794)	-0.0210*** (0.000)	
C7 x CT	-0.0414*** (0.000)	0.0518 (0.622)	-0.0177*** (0.000)	
C1 x MT	-0.0359 (0.122)	-0.0789 (0.256)		-0.00292 (0.788)
C2 x MT	0.116*** (0.000)	-0.0944 (0.332)		-0.0420** (0.004)
C3 x MT	0.0241 (0.277)	-0.0789 (0.230)		-0.0111 (0.284)
C4 x MT	-0.0419 (0.053)	-0.0697 (0.281)		0.00732 (0.470)
C5 x MT	-0.174*** (0.000)	-0.141 (0.057)		0.0159 (0.239)
C6 x MT	0.105*** (0.000)	-0.0890 (0.200)		-0.0271* (0.018)
C7 x MT	-0.0228 (0.316)	-0.136 (0.051)		-0.0111 (0.313)

	Corn	Cotton	Soybeans	Wheat
C1 x NE	0.0318 (0.097)		-0.00637 (0.706)	
C2 x NE	0.0327 (0.148)		-0.00798 (0.696)	
C3 x NE	0.0496** (0.005)		-0.00135 (0.935)	
C4 x NE	0.0256 (0.147)		-0.00169 (0.919)	
C5 x NE	0.0444* (0.032)		-0.00181 (0.913)	
C6 x NE	-0.00720 (0.681)		0.00193 (0.910)	
C7 x NE	0.0398* (0.037)		0.0145 (0.392)	
C1 x NP	-0.0209 (0.112)		0.0526*** (0.000)	-0.0171 (0.176)
C2 x NP	0.0587*** (0.000)	0.313 (0.357)	0.0927*** (0.000)	0.0339 (0.273)
C3 x NP	-0.0395*** (0.001)	-0.290 (0.608)	0.0170* (0.036)	-0.0202 (0.139)
C4 x NP	-0.0311** (0.010)	-0.241 (0.621)	0.0324*** (0.000)	-0.0167 (0.171)
C5 x NP	-0.0474*** (0.001)	-0.231 (0.613)	0.0343*** (0.000)	0.00946 (0.534)
C6 x NP	-0.0508*** (0.000)	-0.0194 (0.952)	0.0691*** (0.000)	0.0583*** (0.000)
C7 x NP	-0.0653*** (0.000)	-0.212 (0.645)	0.0185* (0.031)	0.0305* (0.025)
C1 x P	0.0226 (0.515)	0.0179 (0.880)		0.00229 (0.891)
C2 x P	0.0133 (0.733)	-0.0742 (0.519)		0.0220 (0.551)
C3 x P	0.0151 (0.619)	-0.00547 (0.954)		-0.0351* (0.044)
C4 x P	0.0422 (0.189)	0.0808 (0.433)		0.0265 (0.096)
C5 x P	-0.00217 (0.956)	-0.0472 (0.682)		-0.0272 (0.160)
C6 x P	0.0555 (0.050)	0.00350 (0.968)		-0.00391 (0.860)



	Corn	Cotton	Soybeans	Wheat
C7 x P	0.0461 (0.160)	0.0902 (0.348)		-0.0210 (0.247)
C1 x SE	0.0659*** (0.000)	0.110*** (0.000)	0.00116 (0.878)	
C2 x SE	0.000749 (0.950)	0.0124 (0.649)	-0.0507*** (0.000)	
C3 x SE	-0.00995 (0.308)	-0.0572* (0.011)	0.0262*** (0.000)	
C4 x SE	0.0420*** (0.000)	0.0214 (0.364)	0.0300*** (0.000)	
C5 x SE	0.0121 (0.321)	-0.0147 (0.585)	-0.0254** (0.001)	
C6 x SE	-0.00114 (0.903)	-0.0908*** (0.000)	0.0171* (0.021)	
C7 x SE	-0.0197 (0.054)	-0.0966*** (0.000)	-0.00223 (0.767)	
C1 x SP	-0.0740*** (0.000)	-0.0141 (0.479)	-0.0106 (0.237)	-0.0232 (0.173)
C2 x SP	0.0165 (0.317)	-0.0553* (0.014)	0.0196 (0.072)	
C3 x SP	-0.0353** (0.004)	-0.00200 (0.908)	0.0174* (0.032)	-0.0444** (0.009)
C4 x SP	0.0237 (0.062)	0.0541** (0.002)	0.0267** (0.001)	-0.0111 (0.501)
C5 x SP	-0.0149 (0.328)	-0.000101 (0.996)	-0.0141 (0.141)	0.0118 (0.549)
C6 x SP	0.0185 (0.121)	0.0191 (0.265)	-0.0324*** (0.000)	-0.0329 (0.365)
C7 x SP	-0.0477*** (0.000)	0.0213 (0.248)	0.0311*** (0.001)	-0.0329 (0.070)
Constant	0.595*** (0.000)	0.470 (0.129)	0.436*** (0.000)	0.262*** (0.000)
<i>N</i>	102,501	23,751	75,035	16,172
Wald $\chi^2$ (d.f.)	12179.6 (114) (<0.000)	1184.1 (83) (<0.000)	7521.3 (86) (<0.000)	848.6 (59) (<0.000)

Note: 1) Dependent variable = estimated yield variance. Independent variables = time trend, crop acreage, growing degree day, amount of precipitation, PDSI (Palmer Drought Severity Index), hot days, wet days, interactions of ENSO and regional dummies, interactions of DCV and regional dummies, and U.S. state dummies

2) Regional Dummies. CT=Central(IA, IL, IN, MI, MN, MO, OH, WI); MT=Mountains(AZ, CO, ID, MT, NM, NV, UT, WY); NE=Northeast(CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT); NP=Northern Plains(KS, ND, NE, SD); P=Pacific(CA, OR, WA); SE=Southeast(AL, FL, GA, KY, NC, SC, TN, VA, WV); SP=Southern Plains(AR, LA, MS, OK, TX).

- 3) DCV dummy variables for different DCV phase combinations. C1=(PDO+,TAG-,WPWP-); C2=(PDO-,TAG+,WPWP-); C3=(PDO-,TAG-,WPWP+); C4=(PDO+,TAG-,WPWP+); C5=(PDO+,TAG+,WPWP-); C6=(PDO-,TAG+,WPWP+); and C7=(PDO+,TAG+,WPWP+); where C8=(PDO-,TAG-,WPWP-)is excluded and is in the intercept.
- 4) Estimated coefficients with the cluster-robust  $p$ -values in parentheses (\*  $p<0.05$ , \*\*  $p<0.01$ , \*\*\*  $p<0.001$ ).
- 5) The dummy coefficients of U.S. states are not shown.

**Table A7.** Total DCV Impacts on Yield Variance ( $\hat{u}^2$ )

	(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
<b>CORN</b>							
Central	0.023* (0.013)	0.034*** (<0.001)	-0.044*** (<0.001)	0.012*** (<0.001)			-0.054*** (<0.001)
Mountains	-0.006*** (<0.001)	0.116*** (<0.001)		-0.035*** (<0.001)	-0.122*** (<0.001)	0.105*** (<0.001)	-0.006*** (<0.001)
Northeast	0.017*** (<0.001)	0.051*** (<0.001)	0.083*** (<0.001)		0.094*** (<0.001)	0.008*** (<0.001)	0.045* (0.019)
Northern Plains	-0.046*** (<0.001)	0.068*** (<0.001)	-0.05*** (<0.001)		-0.037** (0.01)	-0.051*** (<0.001)	-0.082*** (<0.001)
Pacific	0.01*** (<0.001)		0.003*** (<0.001)	0.005* (0.012)	0.01*** (<0.001)	-0.013*** (<0.001)	-0.005*** (<0.001)
Southeast	0.127*** (<0.001)	0.043*** (<0.001)	0.038*** (<0.001)	0.082*** (<0.001)	0.054*** (<0.001)	0.045*** (<0.001)	0.04*** (<0.001)
Southern Plains	-0.059*** (<0.001)	0.037*** (<0.001)	-0.029* (0.022)	0.014*** (<0.001)	0.03*** (<0.001)	0.016*** (<0.001)	-0.038** (0.006)
<b>COTTON</b>							
Central				0.004*** (<0.001)		0.03*** (<0.001)	
Mountains	-0.035*** (<0.001)		-0.01** (0.003)	-0.022*** (<0.001)	-0.001*** (<0.001)		
Northeast							
Northern Plains			-0.028*** (<0.001)			-0.011** (0.002)	
Pacific		-0.015*** (<0.001)	-0.007*** (<0.001)	-0.024*** (<0.001)	-0.005*** (<0.001)	-0.011*** (<0.001)	-0.045*** (<0.001)
Southeast	0.105*** (<0.001)		-0.064** (0.005)		-0.018*** (<0.001)	-0.106*** (<0.001)	-0.107*** (<0.001)
Southern Plains		-0.047* (0.036)		0.055** (0.003)	-0.002*** (<0.001)		0.024*** (<0.001)

	(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
<b>SOYBEANS</b>							
Central			-0.028*** (<0.001)				-0.026*** (<0.001)
Mountains							
Northeast	-0.005*** (<0.001)	0.027*** (<0.001)	0.01*** (<0.001)	0.007*** (<0.001)	0.029*** (<0.001)	0.019*** (<0.001)	-0.002*** (<0.001)
Northern Plains	0.02* (0.033)	0.102*** (<0.001)		0.05*** (<0.001)	0.04*** (<0.001)	0.074*** (<0.001)	
Pacific							
Southeast	0.039*** (<0.001)		0.052*** (<0.001)	0.053*** (<0.001)		0.055*** (<0.001)	0.031*** (<0.001)
Southern Plains	0.015*** (<0.001)	0.025*** (<0.001)	0.039*** (<0.001)	0.039*** (<0.001)	0.021*** (<0.001)		0.053*** (<0.001)
<b>WHEAT</b>							
Central							
Mountains		-0.043** (0.005)				-0.028* (0.019)	
Northeast							
Northern Plains						0.058*** (<0.001)	0.029* (0.034)
Pacific			-0.036* (0.045)				-0.002* (0.031)
Southeast							
Southern Plains			-0.043* (0.013)	0.001* (0.044)	0.002* (0.031)		

Note: 1) Coefficients estimated by Delta method with the cluster-robust  $p$ -values in parentheses (\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ ).

2) Blanks in some regions imply no significant impacts at 95% statistical confidence.

**Table A8:** Direct and Indirect DCV Impacts on Yield Variance ( $\hat{u}^2$ )

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
<b>CORN</b>								
Central	Direct	0.025** (0.006)		-0.037*** (<0.001)		-0.034*** (<0.001)	-0.026** (0.002)	-0.042*** (<0.001)
	Indirect	-0.003*** (<0.001)	0.034*** (<0.001)	-0.008*** (<0.001)	0.012*** (<0.001)	0.04*** (<0.001)	0.015*** (<0.001)	-0.012*** (<0.001)
Mountains	Direct		0.117*** (<0.001)			-0.175*** (<0.001)	0.105*** (<0.001)	
	Indirect	-0.006*** (<0.001)	-0.002*** (<0.001)		-0.035*** (<0.001)	0.053*** (<0.001)		-0.006*** (<0.001)
Northeast	Direct			0.05** (0.006)		0.045* (0.033)		0.04* (0.037)
	Indirect	0.017*** (<0.001)	0.051*** (<0.001)	0.034*** (<0.001)		0.049*** (<0.001)	0.008*** (<0.001)	0.005*** (<0.001)
Northern Plains	Direct		0.059*** (<0.001)	-0.04*** (<0.001)	-0.032** (0.01)	-0.048*** (<0.001)	-0.051*** (<0.001)	-0.066*** (<0.001)
	Indirect	-0.046*** (<0.001)	0.009*** (<0.001)	-0.01*** (<0.001)	0.017*** (<0.001)	0.012*** (<0.001)		-0.017*** (<0.001)
Pacific	Direct							
	Indirect	0.01*** (<0.001)		0.003*** (<0.001)	0.005* (0.012)	0.01*** (<0.001)	-0.013*** (<0.001)	-0.005*** (<0.001)
Southeast	Direct	0.066*** (<0.001)			0.043*** (<0.001)			
	Indirect	0.061*** (<0.001)	0.043*** (<0.001)	0.038*** (<0.001)	0.04*** (<0.001)	0.054*** (<0.001)	0.045*** (<0.001)	0.04*** (<0.001)
Southern Plains	Direct	-0.074*** (<0.001)		-0.036** (0.005)				-0.048*** (<0.001)
	Indirect	0.016*** (<0.001)	0.037*** (<0.001)	0.007*** (<0.001)	0.014*** (<0.001)	0.03*** (<0.001)	0.016*** (<0.001)	0.011*** (<0.001)
<b>COTTON</b>								
Central	Direct							

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
	Indirect				0.004*** (<0.001)		0.03*** (<0.001)	
Mountains	Direct							
	Indirect	-0.035*** (<0.001)		-0.01** (0.003)	-0.022*** (<0.001)	-0.001*** (<0.001)		
Northeast	Direct							
	Indirect							
Northern Plains	Direct							
	Indirect			-0.028*** (<0.001)			-0.011** (0.002)	
Pacific	Direct							
	Indirect		-0.015*** (<0.001)	-0.007*** (<0.001)	-0.024*** (<0.001)	-0.005*** (<0.001)	-0.011*** (<0.001)	-0.045*** (<0.001)
Southeast	Direct	0.11*** (<0.001)		-0.058* (0.012)			-0.091*** (<0.001)	-0.097*** (<0.001)
	Indirect					-0.018*** (<0.001)	-0.015*** (<0.001)	-0.011*** (<0.001)
Southern Plains	Direct		-0.056* (0.014)		0.055** (0.003)			
	Indirect		0.009** (0.002)			-0.002*** (<0.001)		0.024*** (<0.001)
<b>SOYBEANS</b>								
Central	Direct		-0.038*** (<0.001)	-0.023*** (<0.001)	-0.012* (0.022)	-0.032*** (<0.001)	-0.021*** (<0.001)	-0.018*** (<0.001)
	Indirect		0.027*** (<0.001)	-0.005*** (<0.001)	0.01*** (<0.001)	0.025*** (<0.001)	0.015*** (<0.001)	-0.008*** (<0.001)
Mountains	Direct							
	Indirect							
Northeast	Direct							

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
	Indirect	-0.005*** (<0.001)	0.027*** (<0.001)	0.01*** (<0.001)	0.007*** (<0.001)	0.029*** (<0.001)	0.019*** (<0.001)	-0.002*** (<0.001)
Northern Plains	Direct	0.053*** (<0.001)	0.093*** (<0.001)	0.017* (0.037)	0.033*** (<0.001)	0.035*** (<0.001)	0.07*** (<0.001)	0.019* (0.031)
	Indirect	-0.034*** (<0.001)	0.009*** (<0.001)	-0.007*** (<0.001)	0.017*** (<0.001)	0.006*** (<0.001)	0.005*** (<0.001)	-0.012*** (<0.001)
Pacific	Direct							
	Indirect							
Southeast	Direct		-0.051*** (<0.001)	0.027*** (<0.001)	0.03*** (<0.001)	-0.026** (0.002)	0.018* (0.022)	
	Indirect	0.039*** (<0.001)	0.04*** (<0.001)	0.026*** (<0.001)	0.023*** (<0.001)	0.036*** (<0.001)	0.038*** (<0.001)	0.031*** (<0.001)
Southern Plains	Direct			0.018* (0.033)	0.027** (0.002)		-0.033*** (<0.001)	0.032*** (<0.001)
	Indirect	0.015*** (<0.001)	0.025*** (<0.001)	0.021*** (<0.001)	0.012*** (<0.001)	0.021*** (<0.001)	0.024*** (<0.001)	0.022*** (<0.001)
<b>WHEAT</b>								
Central	Direct							
	Indirect							
Mountains	Direct		-0.043** (0.005)				-0.028* (0.019)	
	Indirect							
Northeast	Direct							
	Indirect							
Northern Plains	Direct						0.059*** (<0.001)	0.031* (0.026)
	Indirect			-0.036*				

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
Pacific	Direct			(0.045)				
	Indirect							-0.002* (0.031)
Southeast	Direct							
	Indirect							
Southern Plains	Direct			-0.045** (0.01)				
	Indirect				0.001* (0.044)	0.002* (0.031)		

Note: 1) Coefficients estimated by Delta method with the cluster-robust  $p$ -values in parentheses (\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ ).

2) Blanks in some regions imply no significant impacts at 95% statistical confidence.



**Table A9.** Generalized-least Square Regression on Yield Skewness ( $\hat{u}^3$ )

	<b>Corn</b>	<b>Cotton</b>	<b>Soybeans</b>	<b>Wheat</b>
Trend	0.00880*** (0.000)	0.0133*** (0.000)	0.00340*** (0.000)	0.00320* (0.013)
Trend <sup>2</sup>	-0.000122*** (0.000)	-0.000128*** (0.000)	-0.0000547*** (0.000)	-0.0000554** (0.003)
Harvested Acreage	0.000000772*** (0.000)	0.00000173*** (0.000)	0.000000272*** (0.000)	0.000000900*** (0.000)
GDD	0.0579*** (0.000)	0.0152 (0.838)	0.0661*** (0.000)	-0.00411 (0.628)
GDD <sup>2</sup>	-0.000938 (0.109)	-0.000688 (0.761)	-0.00281*** (0.000)	0.000406 (0.269)
PDSI	-0.0398*** (0.000)	-0.0222* (0.019)	-0.0144*** (0.000)	0.00134 (0.707)
PDSI <sup>2</sup>	0.0193*** (0.000)	0.0102*** (0.000)	0.00755*** (0.000)	0.00126 (0.145)
Precipitation	0.0193*** (0.000)	0.00358 (0.780)	0.00638** (0.005)	0.0107 (0.269)
Precipitation <sup>2</sup>	-0.000624** (0.001)	-0.00195* (0.023)	-0.000172 (0.053)	-0.00162 (0.218)
Day Temp>90°	-0.0373*** (0.000)	0.0115** (0.002)	-0.0238*** (0.000)	0.00279 (0.239)
Day Precip>90	0.00307 (0.143)	0.0000590 (0.991)	0.00118 (0.307)	0.000279 (0.900)
El Niño x CT	0.0630*** (0.000)	0.0382 (0.772)	0.00335 (0.526)	
El Niño x MT	-0.112*** (0.000)	-0.0939 (0.302)		0.00790 (0.482)
El Niño x NE	-0.0226 (0.396)		-0.00900 (0.620)	
El Niño x NP	0.0345* (0.040)	0.0470 (0.897)	0.00530 (0.561)	0.000671 (0.963)
El Niño x P	-0.0444 (0.325)	0.0651 (0.583)		-0.0143 (0.461)
El Niño x SE	0.0171 (0.223)	0.0530 (0.069)	0.0158* (0.048)	
El Niño x SP	0.0482** (0.010)	0.0797*** (0.001)	0.00490 (0.606)	-0.00268 (0.889)
La Niña x CT	0.0537*** (0.000)	-0.0540 (0.694)	-0.00193 (0.719)	

	<b>Corn</b>	<b>Cotton</b>	<b>Soybeans</b>	<b>Wheat</b>
La Niña x MT	0.0146 (0.666)	0.0318 (0.733)		-0.0166 (0.155)
La Niña x NE	-0.0585* (0.025)		-0.00773 (0.661)	
La Niña x NP	-0.0195 (0.248)	0.197 (0.772)	0.00163 (0.857)	-0.00599 (0.698)
La Niña x P	-0.0195 (0.669)	-0.0333 (0.788)		-0.000680 (0.974)
La Niña x SE	-0.0178 (0.209)	-0.0706* (0.017)	-0.0317*** (0.000)	
La Niña x SP	-0.0872*** (0.000)	-0.159*** (0.000)	-0.0204* (0.033)	-0.00778 (0.716)
C1 x CT	-0.0471* (0.014)	-0.0290 (0.895)	-0.0109 (0.234)	
C2 x CT	0.0111 (0.594)	0.0146 (0.954)	0.0469*** (0.000)	
C3 x CT	0.0495** (0.004)	-0.000968 (0.996)	0.0220** (0.006)	
C4 x CT	-0.0184 (0.290)	-0.0766 (0.705)	0.00169 (0.839)	
C5 x CT	0.0685*** (0.001)	-0.0404 (0.872)	0.0433*** (0.000)	
C6 x CT	0.0123 (0.457)	0.110 (0.551)	0.0259** (0.001)	
C7 x CT	0.0657*** (0.000)	-0.0182 (0.931)	0.0184* (0.029)	
C1 x MT	0.0432 (0.386)	0.101 (0.463)		0.0211 (0.235)
C2 x MT	-0.122 (0.061)	0.192 (0.322)		0.0619** (0.010)
C3 x MT	-0.0199 (0.676)	0.130 (0.320)		0.0225 (0.184)
C4 x MT	0.0467 (0.315)	0.118 (0.358)		-0.00368 (0.824)
C5 x MT	0.353*** (0.000)	0.224 (0.129)		0.000585 (0.979)
C6 x MT	-0.0450 (0.367)	0.213 (0.125)		0.0368 (0.050)
C7 x MT	0.104* (0.032)	0.226 (0.103)		0.0265 (0.143)

	<b>Corn</b>	<b>Cotton</b>	<b>Soybeans</b>	<b>Wheat</b>
C1 x NE	-0.0586 (0.154)		0.00175 (0.951)	
C2 x NE	0.00311 (0.949)		0.0173 (0.613)	
C3 x NE	-0.0658 (0.084)		0.0102 (0.712)	
C4 x NE	-0.0516 (0.174)		-0.00158 (0.955)	
C5 x NE	-0.0393 (0.376)		0.0134 (0.627)	
C6 x NE	0.0290 (0.440)		0.0124 (0.668)	
C7 x NE	-0.0415 (0.310)		-0.00910 (0.749)	
C1 x NP	-0.0119 (0.674)		-0.0838*** (0.000)	0.00678 (0.744)
C2 x NP	-0.138*** (0.000)	-0.488 (0.471)	-0.139*** (0.000)	-0.0270 (0.594)
C3 x NP	0.0161 (0.519)	0.225 (0.841)	-0.0452*** (0.001)	0.0151 (0.499)
C4 x NP	0.00446 (0.862)	0.162 (0.867)	-0.0567*** (0.000)	0.00573 (0.775)
C5 x NP	0.0204 (0.496)	0.173 (0.850)	-0.0546*** (0.000)	-0.0104 (0.675)
C6 x NP	0.103*** (0.000)	0.0290 (0.964)	-0.117*** (0.000)	-0.0678** (0.009)
C7 x NP	0.0817** (0.002)	0.167 (0.856)	-0.0311* (0.030)	-0.0393 (0.078)
C1 x P	-0.0303 (0.684)	-0.0831 (0.726)		-0.00610 (0.823)
C2 x P	-0.0127 (0.879)	0.117 (0.610)		-0.0343 (0.571)
C3 x P	-0.0126 (0.847)	0.0292 (0.877)		0.0253 (0.375)
C4 x P	-0.0789 (0.252)	-0.167 (0.415)		-0.0546* (0.036)
C5 x P	0.00893 (0.916)	0.000115 (1.000)		0.0354 (0.265)
C6 x P	-0.0500 (0.411)	0.0829 (0.629)		-0.00995 (0.784)

	<b>Corn</b>	<b>Cotton</b>	<b>Soybeans</b>	<b>Wheat</b>
C7 x P	-0.0792 (0.261)	-0.132 (0.490)		0.0213 (0.475)
C1 x SE	-0.0928*** (0.000)	-0.192*** (0.000)	-0.000893 (0.944)	
C2 x SE	0.0242 (0.342)	0.0835 (0.123)	0.0728*** (0.000)	
C3 x SE	0.0139 (0.508)	0.130** (0.004)	-0.00740 (0.537)	
C4 x SE	-0.0541* (0.011)	-0.0499 (0.288)	-0.0297* (0.010)	
C5 x SE	0.0123 (0.640)	0.0585 (0.274)	0.0370** (0.005)	
C6 x SE	0.0281 (0.160)	0.221*** (0.000)	0.0142 (0.250)	
C7 x SE	0.0337 (0.124)	0.183*** (0.000)	-0.0223 (0.076)	
C1 x SP	0.0653* (0.028)	0.0194 (0.625)	0.0141 (0.346)	0.0230 (0.408)
C2 x SP	-0.0418 (0.237)	0.171*** (0.000)	-0.0618*** (0.001)	
C3 x SP	0.0424 (0.110)	0.0277 (0.420)	-0.00868 (0.523)	0.0439 (0.117)
C4 x SP	-0.0481 (0.077)	-0.105** (0.003)	-0.0264 (0.054)	0.00680 (0.802)
C5 x SP	-0.0340 (0.298)	0.0341 (0.425)	0.0272 (0.091)	-0.00284 (0.930)
C6 x SP	-0.0145 (0.571)	-0.00773 (0.821)	0.0404** (0.003)	0.0384 (0.518)
C7 x SP	0.0473 (0.103)	-0.00921 (0.802)	-0.0205 (0.172)	0.0377 (0.205)
Constant	-0.747*** (0.000)	-0.628 (0.308)	-0.400*** (0.000)	-0.198** (0.002)
<i>N</i>	102,501	23,751	75,035	16,172
Wald $\chi^2$ (d.f.)	6217.7 (114) (<0.000)	773.9 (83) (<0.000)	3542.0 (86) (<0.000)	445.6 (59) (<0.000)

Note: 1) Dependent variable = estimated yield skewness. Independent variables = time trend, crop acreage, growing degree day, amount of precipitation, PDSI (Palmer Drought Severity Index), hot days, wet days, interactions of ENSO and regional dummies, interactions of DCV and regional dummies, and U.S. state dummies

2) Regional Dummies. CT=Central(IA, IL, IN, MI, MN, MO, OH, WI); MT=Mountains(AZ, CO, ID, MT, NM, NV, UT, WY); NE=Northeast(CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT); NP=Northern Plains(KS, ND, NE, SD); P=Pacific(CA, OR, WA); SE=Southeast(AL, FL, GA, KY, NC, SC, TN, VA, WV); SP=Southern Plains(AR, LA, MS, OK, TX).

3) DCV dummy variables for different DCV phase combinations. C1=(PDO+,TAG-,WPWP-); C2=(PDO-,TAG+,WPWP-);

C3=(PDO-,TAG-,WPWP+); C4=(PDO+,TAG-,WPWP+); C5=(PDO+,TAG+,WPWP-); C6=(PDO-,TAG+,WPWP+); and C7=(PDO+,TAG+,WPWP+); where C8=(PDO-,TAG-,WPWP-)is excluded and is in the intercept.

4) Estimated coefficients with the cluster-robust  $p$ -values in parentheses (\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ ).

5) The dummy coefficients of U.S. states are not shown.

**Table A10.** Total DCV Impacts on Yield Skewness ( $\hat{u}^3$ )

	(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
<b>CORN</b>							
Central	-0.039* (0.05)	-0.032*** (<0.001)	0.062*** (<0.001)	-0.016*** (<0.001)		-0.023*** (<0.001)	0.085*** (<0.001)
Mountains	0.004*** (<0.001)	0.002*** (<0.001)		0.073*** (<0.001)	0.237*** (<0.001)		0.108* (0.028)
Northeast		-0.06*** (<0.001)	-0.038*** (<0.001)	0.01*** (<0.001)	-0.066*** (<0.001)	0.012*** (<0.001)	
Northern Plains	0.1*** (<0.001)	-0.145*** (<0.001)	0.034*** (<0.001)	-0.046*** (<0.001)	0.021*** (<0.001)	0.102*** (<0.001)	0.121*** (<0.001)
Pacific	-0.007** (0.006)		-0.004*** (<0.001)	-0.041*** (<0.001)	-0.013*** (<0.001)	0.034*** (<0.001)	0.007*** (<0.001)
Southeast	-0.158*** (<0.001)	-0.048*** (<0.001)	-0.04*** (<0.001)	-0.109*** (<0.001)	-0.082*** (<0.001)	-0.049*** (<0.001)	-0.048*** (<0.001)
Southern Plains		-0.057*** (<0.001)	-0.01*** (<0.001)	-0.022*** (<0.001)	-0.049*** (<0.001)	-0.02*** (<0.001)	-0.015*** (<0.001)
<b>COTTON</b>							
Central	0.021** (0.005)	-0.023*** (<0.001)	0.014*** (<0.001)				
Mountains	0.078*** (<0.001)		0.025*** (<0.001)	0.053*** (<0.001)	0.01** (0.002)	0.014* (0.014)	0.02* (0.031)
Northeast							
Northern Plains		0.07** (0.005)	0.074*** (<0.001)	0.061** (0.004)	0.053*** (<0.001)	0.037*** (<0.001)	0.036*** (<0.001)
Pacific		0.018* (0.017)		0.047*** (<0.001)	0.012*** (<0.001)		0.079*** (<0.001)
Southeast	-0.151** (0.004)		0.16*** (<0.001)	0.021** (0.003)	0.034*** (<0.001)	0.276*** (<0.001)	0.223*** (<0.001)
Southern Plains	0.012** (0.003)	0.15*** (<0.001)		-0.099** (0.006)	0.002* (0.024)	0.014*** (<0.001)	

	(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
<b>SOYBEANS</b>							
Central			0.028*** (<0.001)	-0.01*** (<0.001)			0.028** (0.002)
Mountains							
Northeast	0.011*** (<0.001)	-0.028*** (<0.001)	-0.013*** (<0.001)	-0.007*** (<0.001)	-0.033*** (<0.001)	-0.021*** (<0.001)	
Northern Plains	-0.036* (0.02)	-0.149*** (<0.001)	-0.033* (0.015)	-0.081*** (<0.001)	-0.055*** (<0.001)	-0.122*** (<0.001)	
Pacific							
Southeast	-0.043*** (<0.001)		-0.028*** (<0.001)	-0.054*** (<0.001)		-0.042*** (<0.001)	-0.035*** (<0.001)
Southern Plains	-0.017*** (<0.001)	-0.092*** (<0.001)	-0.03*** (<0.001)	-0.012*** (<0.001)	-0.026*** (<0.001)		-0.025*** (<0.001)
<b>WHEAT</b>							
Central							
Mountains		0.062** (0.01)					
Northeast							
Northern Plains						-0.068** (0.009)	
Pacific				-0.055* (0.037)			
Southeast							
Southern Plains							

Note: 1) Coefficients estimated by Delta method with  $p$ -values in parentheses (\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ ).

2) Blanks in some regions imply no significant impacts at 95% statistical confidence.

**Table A11.** Direct and Indirect DCV Impacts on Yield Skewness ( $\hat{u}^3$ )

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
<b>CORN</b>								
Central	Direct	-0.048* (0.014)		0.05** (0.004)		0.069*** (<0.001)		0.066*** (<0.001)
	Indirect	0.009* (0.024)	-0.032*** (<0.001)	0.012*** (<0.001)	-0.016*** (<0.001)	-0.065*** (<0.001)	-0.023*** (<0.001)	0.019*** (<0.001)
Mountains	Direct					0.354*** (<0.001)		0.105* (0.033)
	Indirect	0.004*** (<0.001)	0.002*** (<0.001)		0.073*** (<0.001)	-0.117*** (<0.001)		0.004*** (<0.001)
Northeast	Direct							
	Indirect		-0.06*** (<0.001)	-0.038*** (<0.001)	0.01*** (<0.001)	-0.066*** (<0.001)	0.012*** (<0.001)	
Northern Plains	Direct		-0.139*** (<0.001)				0.103*** (<0.001)	0.082** (0.002)
	Indirect	0.1*** (<0.001)	-0.007* (0.018)	0.034*** (<0.001)	-0.046*** (<0.001)	0.021*** (<0.001)		0.039*** (<0.001)
Pacific	Direct							
	Indirect	-0.007** (0.006)		-0.004*** (<0.001)	-0.041*** (<0.001)	-0.013*** (<0.001)	0.034*** (<0.001)	0.007*** (<0.001)
Southeast	Direct	-0.093*** (<0.001)			-0.055* (0.012)			
	Indirect	-0.066*** (<0.001)	-0.048*** (<0.001)	-0.04*** (<0.001)	-0.054*** (<0.001)	-0.082*** (<0.001)	-0.049*** (<0.001)	-0.048*** (<0.001)
Southern Plains	Direct	0.066* (0.029)						
	Indirect	-0.02*** (<0.001)	-0.057*** (<0.001)	-0.01*** (<0.001)	-0.022*** (<0.001)	-0.049*** (<0.001)	-0.02*** (<0.001)	-0.015*** (<0.001)
<b>COTTON</b>								
Central	Direct							



		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
	Indirect	0.021** (0.005)	-0.023*** (<0.001)	0.014*** (<0.001)				
Mountains	Direct							
	Indirect	0.078*** (<0.001)		0.025*** (<0.001)	0.053*** (<0.001)	0.01** (0.002)	0.014* (0.014)	0.02* (0.031)
Northeast	Direct							
	Indirect							
Northern Plains	Direct							
	Indirect		0.07** (0.005)	0.074*** (<0.001)	0.061** (0.004)	0.053*** (<0.001)	0.037*** (<0.001)	0.036*** (<0.001)
Pacific	Direct							
	Indirect		0.018* (0.017)		0.047*** (<0.001)	0.012*** (<0.001)		0.079*** (<0.001)
Southeast	Direct	-0.193*** (<0.001)		0.131** (0.004)			0.221*** (<0.001)	0.184*** (<0.001)
	Indirect	0.042** (0.008)		0.03** (0.002)	0.021** (0.003)	0.034*** (<0.001)	0.055*** (<0.001)	0.039*** (<0.001)
Southern Plains	Direct		0.171*** (<0.001)		-0.106** (0.004)			
	Indirect	0.012** (0.003)	-0.022*** (<0.001)		0.007** (0.003)	0.002* (0.024)	0.014*** (<0.001)	
<b>SOYBEANS</b>								
Central	Direct		0.047*** (<0.001)	0.023** (0.007)		0.044*** (<0.001)	0.026** (0.002)	0.019* (0.03)
	Indirect		-0.029*** (<0.001)	0.006*** (<0.001)	-0.01*** (<0.001)	-0.03*** (<0.001)	-0.018*** (<0.001)	0.009*** (<0.001)
Mountains	Direct							
	Indirect							
Northeast	Direct							

		(PDO+, TAG-, WPWP-)	(PDO-, TAG+, WPWP-)	(PDO-, TAG-, WPWP+)	(PDO+, TAG-, WPWP+)	(PDO+, TAG+, WPWP-)	(PDO-, TAG+, WPWP+)	(PDO+, TAG+, WPWP+)
	Indirect	0.011*** (<0.001)	-0.028*** (<0.001)	-0.013*** (<0.001)	-0.007*** (<0.001)	-0.033*** (<0.001)	-0.021*** (<0.001)	
Northern Plains	Direct	-0.084*** (<0.001)	-0.14*** (<0.001)	-0.046*** (<0.001)	-0.057*** (<0.001)	-0.055*** (<0.001)	-0.117*** (<0.001)	-0.032* (0.03)
	Indirect	0.049*** (<0.001)	-0.009*** (<0.001)	0.013*** (<0.001)	-0.024*** (<0.001)		-0.005*** (<0.001)	0.018*** (<0.001)
Pacific	Direct							
	Indirect							
Southeast	Direct		0.073*** (<0.001)		-0.03* (0.011)	0.038** (0.005)		
	Indirect	-0.043*** (<0.001)	-0.045*** (<0.001)	-0.028*** (<0.001)	-0.024*** (<0.001)	-0.042*** (<0.001)	-0.042*** (<0.001)	-0.035*** (<0.001)
Southern Plains	Direct		-0.062*** (<0.001)				0.041** (0.004)	
	Indirect	-0.017*** (<0.001)	-0.03*** (<0.001)	-0.03*** (<0.001)	-0.012*** (<0.001)	-0.026*** (<0.001)	-0.028*** (<0.001)	-0.025*** (<0.001)
<b>WHEAT</b>								
Central	Direct							
	Indirect							
Mountains	Direct		0.062** (0.01)					
	Indirect							
Northeast	Direct							
	Indirect							
Northern Plains	Direct						-0.068** (0.009)	
	Indirect							

		<b>(PDO+, TAG-, WPWP-)</b>	<b>(PDO-, TAG+, WPWP-)</b>	<b>(PDO-, TAG-, WPWP+)</b>	<b>(PDO+, TAG-, WPWP+)</b>	<b>(PDO+, TAG+, WPWP-)</b>	<b>(PDO-, TAG+, WPWP+)</b>	<b>(PDO+, TAG+, WPWP+)</b>
Pacific	Direct				-0.055*			
	Indirect				(0.037)			
Southeast	Direct							
	Indirect							
Southern Plains	Direct							
	Indirect							

Note: 1) Coefficients estimated by Delta method with the cluster-robust  $p$ -values in parentheses (\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ ).

2) Blanks in some regions imply no significant impacts at 95% statistical confidence.