Tropical Economics

By Solomon M. Hsiang and Kyle C. Meng*

Many economists have observed that wealth is systematically lower in the tropics than elsewhere (Sala-i Martin, 1997; Nordhaus, 2006). Determining why this is remains a major puzzle. Leading hypotheses include, inter alia, the tropics's disease burden (Gallup, Sachs and Mellinger, 1999), biota available for domestication (Diamond, 1997), distance from trading partners (Frankel and Romer, 1999), colonial (Acemoglu, Johnson and Robinson, 2001) and other institutions (Easterly and Levine, 2003), average temperature (Nordhaus, 2006), distance from sources of technology (McCord and Sachs, 2013), and frequency of natural disasters (Hsiang and Jina, 2014). In fact, so many factors set the tropics apart that it is now common in cross-sectional analyses to use a country's latitude as a proxy for unobserved tropical determinants, although latitude is never itself considered to have fundamental importance as a "deep parameter".

We point out that latitude may have fundamental economic consequence because it plays a key role in how countries experience geophysical processes that have economic implications. Because the earth is spherical and spins rapidly on its axis, irregular variations of Pacific ocean temperatures, known as the El Niño-Southern Oscillation (ENSO), have distinctive environmental consequences throughout the tropics. ENSO drives large annual fluctuations in local temperature and rainfall throughout the tropics—which are known to have significant influence on various economic outcomes (Dell, Jones and Olken, 2014; Burke, Hsiang and Miguel, forthcoming)—but it is less influential for other countries because of physical constraints on the atmosphere. The relatively larger environmental volatility caused by ENSO in the tropics has the potential to generate unique costs. Here we demonstrate that ENSO drives year-to-year variations in local weather and agricultural economic activity in the tropics. Crucially, we estimate effects of ENSO while controlling for unobserved time-invariant and trending differences between countries, such that our results explicitly isolate an average within-country effect of ENSO on economic activity using only time-series variation.

* Hsiang: University of California, Berkeley, 2607 Hearst Ave. Berkeley, CA 94720, shsiang@berkeley.edu. Meng: University of California, Santa Barbara, 4416 Bren Hall. Santa Barbara, CA 93106-3151, kmeng@bren.ucsb.edu. We thank Marshall Burke, Mark Cane, and Jonathan Dingel for comments and discussions.

I. Why Latitude Matters

A profound linkage between "tropicalness" and exposure to economically meaningful climate variability results from a difference in how tropical and high-latitude locations (hereafter "temperate,") are affected by the planet's rotation. Figure 1 illustrates the central idea. Imagine drawing two dots on a piece of paper and laying it on the ground at a latitude $L_{tropical}$ near the equator. Place an identical piece of paper on the ground nearer the pole at latitude $L_{temperate}$. To a viewer not on the surface of the earth but fixed in space above the planet (who has the perspective of Figure 1), the dots at $L_{tropical}$ will appear to move in parallel with one another as they complete a full rotation once a day. In contrast, the dots at $L_{temperate}$ appear to rotate around one another once per day such that whichever dot is nearest the viewer is furthest from the viewer twelve hours later.

[Figure 1 here]

The relative rotation of dots at $L_{temperate}$ is similarly exhibited by the atmosphere overlying this location, affecting how it behaves at this latitude because its angular momentum must be conserved locally. This imposes an additional constraint on atmospheric motions in temperate regions similar to the way in which the angular momentum of a spinning bicycle wheel constrains its motion and keeps the bicycle upright. Because of this additional constraint, weather patterns at temperate latitudes exhibit organized swirling structures that are experienced on the surface as cold fronts, warm fronts, and distinct high and low pressure systems.

In contrast, the absence of angular momentum at $L_{tropical}$ allows the tropical atmosphere to behave more or less like a bathtub. Similar to when hot water is added to a cold bathtub and mixes quickly, disturbances in the tropical atmosphere are weakly constrained and spread throughout the tropics relatively rapidly. This causes greater uniformity in weather patterns across the tropics. It also implies that large climatological events in one location may systematically affect weather in distant locations. Such is the case in an El Niño event.

II. The El Niño-Southern Oscillation

Roughly every 3-7 years, an "El Niño" event occurs when normal, mutually-reinforcing circulation patterns of the Pacific atmosphere and ocean collapse. This breakdown allows very warm ocean waters that are usually maintained around Indonesia to slosh eastward across the Pacific Ocean, causing the east equatorial Pacific to become substantially warmer than usual and releasing substantial thermal energy into the equatorial atmosphere (Cane and Zebiak, 1985). Because the tropical atmosphere is not constrained by relative rotation, the warming of air initiated above the east Pacific is propagated throughout the tropics by a wave in the atmosphere which sweeps the globe, altering climatological conditions throughout the tropics (Chiang and Sobel, 2002). An El Niño event typically begins with a warming of the tropical Pacific Ocean during May, which causes warming throughout the entire tropics for roughly a year. In this way, conditions in the tropical Pacific Ocean synchronize annual climatic conditions throughout the tropics, with weaker, and on average opposite, impacts at temperate latitudes. Figure 2 displays an example characteristic pattern of warming experienced around the globe several months after tropical Pacific surface temperatures have peaked.

[Figure 2 here]

The irregular switching between hotter and drier "El Niño" conditions and cooler and wetter "La Niña" conditions, with "neutral" conditions somewhere in the middle, is known as the El Niño-Southern Oscillation (ENSO). On annual frequencies, ENSO is a major mode of the global climate system and it is recovered from data as the first principle component of either the atmosphere or ocean. Because of this property, a scalar index of ENSO is considered an important state variable describing the condition of the global climate system at any moment in time. For physical reasons, such an index is well approximated (or defined) by average surface temperatures of equatorial waters in the east Pacific Ocean. For this analysis, we employ the widely used index NINO3.4, defined as average sea surface temperatures in a rectangle defined by 5°N-5°S, 170°W-120°W (Appendix Fig. 1).

III. Tropical Economic Variability Induced by ENSO

It has been previously demonstrated in numerous contexts that local, idiosyncratic temperature and rainfall variations may induce substantial economic fluctuations (Dell, Jones and Olken, 2014). If ENSO causes large, systematic disturbances in these variables throughout the tropics, it is plausible that this is an important driver of economic volatility in the tropics.

There are spatial and temporal considerations in our country-level panel model. First, we follow the approach developed in Hsiang, Meng and Cane (2011) to identify the tropical countries whose local temperatures are strongly linked to ENSO and the temperate countries whose local temperatures are weakly affected by ENSO (Appendix Fig. 1 and Appendix Table 1). Second, also following Hsiang, Meng and Cane (2011), we measure the dominant state of ENSO in each calendar year by averaging the monthly NINO3.4 index May-December to construct an annual index $ENSO_t$ that can be matched to economic data. Then for outcome Y_{it} in country i, we exploit exogenous year-to-year variation in ENSO to estimate

$$(1) \quad Y_{it} = \beta_1 ENSO_t + \beta_2 ENSO_{t-1} + \theta_i t + \mu_i + \epsilon_{it}.$$

θ_i are country-specific trends and μ_i are country fixed effects. β_1 and β_2 capture the contemporaneous and lagged effect of ENSO respectively. Eq. 1 is estimated separately for tropical and temperate countries. Because ENSO events span more than a calendar year and, furthermore, could potentially induce temporal displacement of effects, our parameter of interest is $\beta = \beta_1 + \beta_2$. We display β in Table 1 for four outcomes in each tropical and temperate subsample (we report β_1 and β_2 separately in Appendix Table 2). Finally, we adjust standard errors to account for the potential that disturbances ϵ_{it} have spatial autocorrelation of arbitrary form within 2000 km and serial correlation over 5 years (Conley, 1999; Hsiang, 2010) (we report results varying these cutoffs in Appendix Table 3). We also confirm that our linear model provides a reasonable approximation of the data in Appendix Table 4.

[Table 1 here]

In the first two rows of Table 1, we show that ENSO systematically affects country-level *temperature* and *rainfall* in the tropics (see Data Appendix). A rise in the ENSO index by +1°C increases local temperatures in the tropics by +0.27°C and lowers rainfall by −4.6 cm on average (combined over two years). For temperate countries, temperatures actually fall due largely to changes in atmospheric and ocean circulations, but only by half as much, and there is a small but insignificant positive effect on rainfall.

We next examine how *log cereal yields*, *log cereal production*, and *log agricultural value added* respond to ENSO—we presume these affects result mainly from the above temperature and rainfall changes, but there may be additional pathways. A +1°C increase in the ENSO index lowers cereal yields −2%, total cereal production −3.5%, and agricultural income −1.8% on average across the tropics. These effects are highly statistically significant and suggest that rises in prices do not fully compensate countries for declines in agricultural output. For a sense of magnitudes, the ENSO index used ranges from roughly −1.5°C to +2°C, with a standard deviation of 0.8°C. These results suggest that substantial and spatially-coherent fluctuations in agricultural output across the tropics are likely driven by ENSO.

We repeat a similar analysis for yields and agricultural income in temperate countries. Consistent with temperature and rainfall changes that are opposite in sign, lower in magnitude, and less statistically significant than corresponding changes in the tropics, we see that crop yields increase in temperate countries when the tropical Pacific warms, albeit with a smaller magnitude that is less significant. Agricultural value added rises and is highly significant, although it is possible that some of this response is linked to general equilibrium price changes, perhaps driven by food shortages in the tropics.

IV. Discussion

We find that agricultural economic activity in the tropics is tightly coupled to the state of ENSO. The absence of relative rotation in the tropical atmosphere allow erratic fluctuations in the Pacific Ocean to increase volatility in the local weather and economies of distant tropical locations. Agricultural economic activity in temperate locations exhibit a reversed response, although the physical linkage is different and the effect is smaller and less statistically significant. If volatility in agricultural production impedes economic growth, the relatively stronger influence of ENSO on the tropics may offer yet another partial explanation for slower historical growth in the tropics.

Our finding have two clear policy implications. First, due to advances in climate modeling, strong ENSO events are now generally predictable up to 2 years in advance (Chen et al., 2004). Such forecasts offers the potential for improved economic planning in the tropics. Second, despite these advances in prediction, components of ENSO variation remain stochastic, especially for time-horizons longer than 24 months. The asymmetric effects of ENSO on tropical and temperate countries suggests the potential for global risk sharing. In Dingel, Hsiang and Meng (2015), we explore the extent to which global trade spreads the economic risk generated by ENSO.

REFERENCES

Acemoglu, D., S. Johnson, and J. A. Robinson. 2001. "The Colonial Origins of Comparative Development: An Empirical Investigation." *Amer. Econ. Rev.*, 91(5): 1369–1401.

Burke, Marshall, Solomon M Hsiang, and Edward Miguel. forthcoming. "Climate and Conflict." *Annual Review of Economics.*

Cane, Mark A, and Stephen E Zebiak. 1985. "A theory for El Niño and the Southern Oscillation." *Science*, 228(4703): 1085–1087.

Chen, Dake, Mark A. Cane, Alexey Kaplan, Stephen E. Zebiak, and Daji Huang. 2004. "Predictability of El Nino over the past 148 years." *Nature*, 428(6984): 733–736.

Chiang, John CH, and Adam H Sobel. 2002. "Tropical Tropospheric Temperature Variations Caused by ENSO and Their Influence on the Remote Tropical Climate*." *Journal of Climate*, 15(18): 2616–2631.

Conley, Timothy. 1999. "GMM Estimation with Cross Sectional Dependence." *Journal of Econometrics*, 92(1): 1–45.

Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken. 2014. "What Do We Learn from the Weather? The New Climate-Economy Literature." *Journal of Economic Literature*, 52(3): 740–98.

Diamond, Jared. 1997. *Guns, Germs and Steel: the Fates of Human Societies.* W. W. Norton and Co.

Dingel, Jonathan I., Solomon M. Hsiang, and Kyle C. Meng. 2015. "Global Trade and Risk Sharing in a Spatially Correlated Climate." *Mimeo.*

Easterly, William, and Ross Levine. 2003. "Tropics, germs, and crops: how endowments influence economic development." *Journal of Monetary Economics*, 50(1): 3 – 39.

Frankel, Jeffrey A, and David Romer. 1999. "Does trade cause growth?" *American economic review*, 379–399.

Gallup, John Luke, Jeffrey D Sachs, and Andrew D Mellinger. 1999. "Geography and economic development." *International regional science review*, 22(2): 179–232.

Hsiang, Solomon M. 2010. "Temperatures and Cyclones strongly associated with economic production in the Caribbean and Central America." *Proceedings of the National Academy of Sciences*, 107(35): 15367–15372.

Hsiang, Solomon M, and Amir S Jina. 2014. "The causal effect of environmental catastrophe on long-run economic growth: evidence from 6,700 cyclones." National Bureau of Economic Research.

Hsiang, Solomon M., Kyle C. Meng, and Mark A. Cane. 2011. "Civil conflicts are associated with the global climate." *Nature*, 476(7361): 438–441.

McCord, Gordon C, and Jeffrey D Sachs. 2013. "Development, Structure, and Transformation: Some Evidence on Comparative Economic Growth." National Bureau of Economic Research.

Nordhaus, W. D. 2006. “Geography and macroeconomics: New Data and new findings.” *Proceedings of the National Academy of Sciences*, 103(10).

Sala-i Martin, Xavier X. 1997. “I just ran two million regressions.” *The American Economic Review*, 178–183.

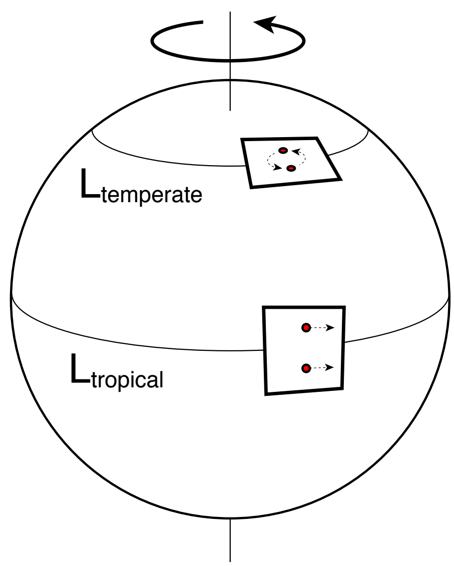


Figure 1. Tropical latitudes experience the Earth's rotation differently from temperate latitudes.

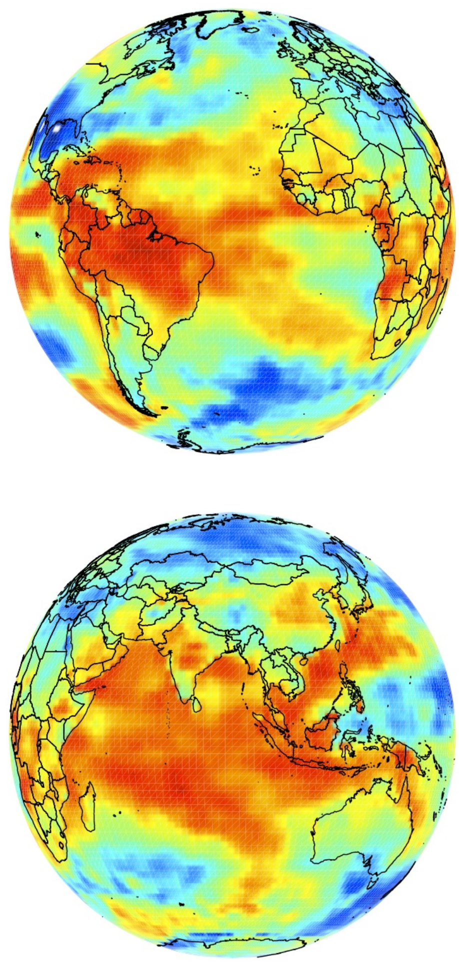


Figure 2. Correlation between December sea surface temperature in the tropical west Pacific Ocean and temperatures at each location 5 months later.

Note: Red indicates strong positive correlation, blue is strong negative correlation.
Source: See Hsiang, Meng and Cane (2011) for method.

Table 1—ENSO effects by region

Outcome	Tropical	Temperate
Temperature (°C)	0.274 [0.017]***	-0.132 [0.054]**
Precipitation (cm)	-4.636 [0.720]***	0.627 [0.579]
Log cereal yield	-0.020 [0.008]***	0.017 [0.010]*
Log cereal production	-0.035 [0.012]***	0.024 [0.013]*
Log agriculture value added	-0.018 [0.005]***	0.016 [0.006]***
Observations	2,756	2,043
No. countries	78	69

Note: Each coefficient estimated from a separate country-level panel data model with country fixed effects and country-specific trends. Coefficients are β, the combined linear effect of $ENSO_t$ on outcome in year t and in year $t+1$. Sample period is 1961-2009 for all models. Standard errors in brackets are adjusted for spatial (2000km) and serial (5-years) correlation. *** p<0.01, ** p<0.05, * p<0.1.

Appendix to *Tropical Economics*

American Economic Review, Papers and Proceedings

Solomon M. Hsiang and Kyle C. Meng*

Appendix A Data

ENSO index ENSO variations can be detected using different indices, with the most commonly used being equatorial Pacific sea surface temperature (SST) anomalies. We utilize monthly values of the Kaplan NINO3.4 index which averages SST over the area 5°N - 5°S, 170°W - 120°W (Kaplan et al., 1998). Following Hsiang, Meng and Cane (2011) we construct an annual winter index by averaging months from May to December to capture the months in which ENSO is typically most active.

Global gridded temperature and precipitation data Temperature (in degrees centigrade) and precipitation (in cm per year) variables constructed from monthly gridded global weather data at a 0.5° latitude by 0.5° degree longitude resolution from the Center for Climatic Research at the University of Delaware (Legates and Willmott, 1990*a*,*b*). Monthly data was first spatially aggregated from pixel to country-level using cross-sectional crop area weights from Ramankutty et al. (2008). Annual measures constructed by averaging January-December monthly values.

Agricultural outcome variables Country-level cereal yield (in kg/hectare), cereal output (in metric ton) and agricultural-value added (in 2000 USD) was obtained from the World Bank World Development indicators.

References

Hsiang, Solomon M., Kyle C. Meng, and Mark A. Cane. 2011. "Civil conflicts are associated with the global climate." *Nature*, 476(7361): 438–441.

Kaplan, A., M. Cane, Y. Kushnir, A. Clement, M. Blumenthal, and B. Rajagopalan. 1998. "Analyses of global sea surface temperature 1856-1991." *Journal of Geophysical Research*, 103: 18,567–18,589.

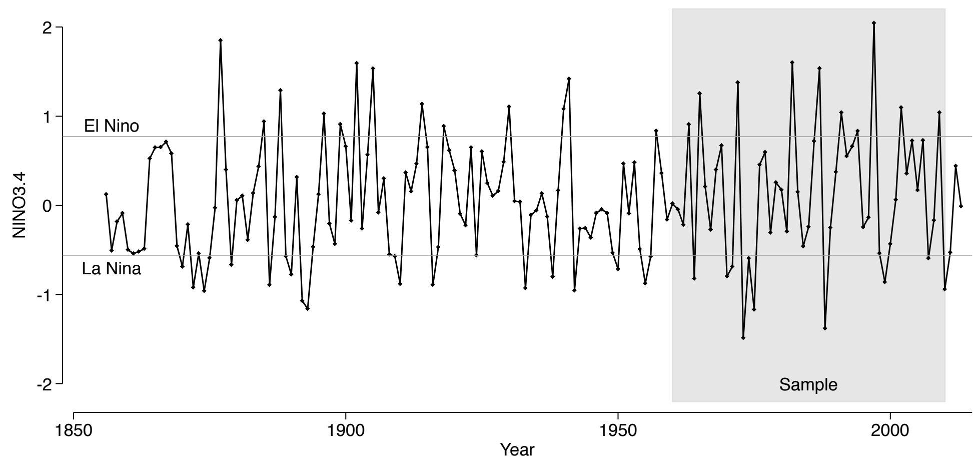
Legates, D. R., and C. J. Willmott. 1990*a*. "Mean Seasonal and Spatial Variability Global Surface Air Temperature." *Theoretical and Applied Climatology*, 41: 11–21.

Legates, D. R., and C. J. Willmott. 1990*b*. "Mean Seasonal and Spatial Variability in Gauge-Corrected, Global Precipitation." *International Journal of Climatology*, 10: 111–127.

Ramankutty, Navin, Amato T. Evan, Chad Monfreda, and Jonathan A. Foley. 2008. "Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000." *Global Biogeochemical Cycles*, 22(1).

*Hsiang: University of California, Berkeley, 2607 Hearst Ave. Berkeley, CA 94720, shsiang@berkeley.edu. Meng: University of California, Santa Barbara, 4416 Bren Hall. Santa Barbara, CA 93106-3151, kmeng@bren.ucsb.edu.

Appendix B Figures



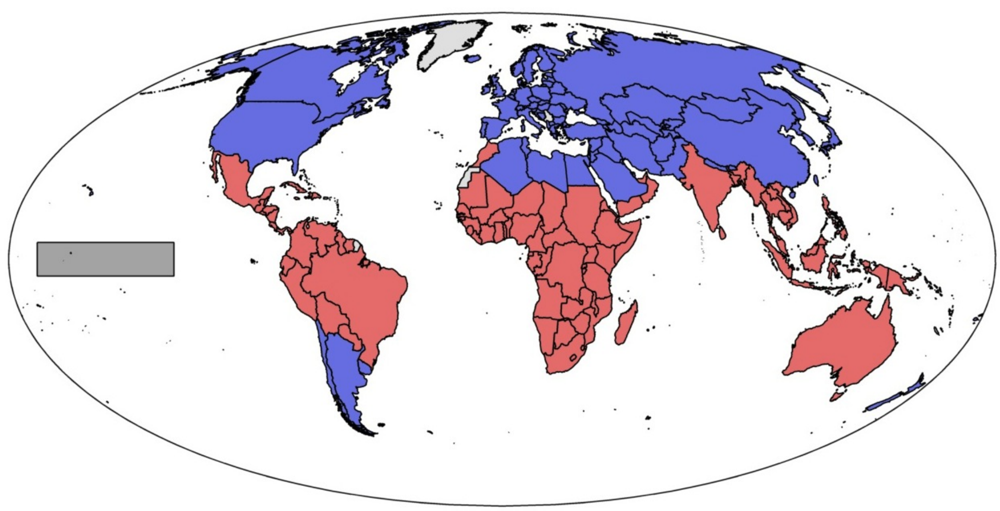


Figure 1: Top: Annual averaged May-December NINO3.4 index. La Niña years are often defined as ENSO index in 1st quintile. El Niño year are often defined as ENSO index in 5th quintile. Data sample period in shaded area. Bottom: Tropical countries strongly affected by ENSO in “Tropical” sample are red. “Temperate” sample countries are blue. See Hsiang, Meng and Cane (2011) for the method used to identify these two samples. Light gray countries have no population data, which is needed for sample assignment. Dark grey rectangle spanning 5°N-5°S and 170°W-120°W is the NINO3.4 region over which sea surface temperatures are averaged to compute the NINO3.4 index.

Appendix C Tables

Table 1: ENSO country assignment

ENSO TELECONNECTED TROPICAL COUNTRIES	Angola, Australia, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Brunei Darussalam, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Colombia, Congo, Rep., Costa Rica, Cote d'Ivoire, Cuba, Djibouti, Dominican Republic, Ecuador, El Salvador, Eritrea, Ethiopia, Gabon, Gambia, The, Ghana, Guatemala, Guinea, Guinea-Bissau, Guyana, Honduras, India, Indonesia, Jamaica, Kenya, Lao PDR, Lesotho, Liberia, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mexico, Morocco, Mozambique, Namibia, Nicaragua, Niger, Oman, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Rwanda, Senegal, Sierra Leone, South Africa, Sri Lanka, Sudan, Suriname, Swaziland, Tanzania, Thailand, Timor-Leste, Togo, Trinidad and Tobago, Uganda, United Arab Emirates, Venezuela, RB, Vietnam, Yemen, Rep., Zambia, Zimbabwe
ENSO WEAKLY AFFECTED TEMPERATE COUNTRIES	Albania, Algeria, Argentina, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bhutan, Bosnia and Herzegovina, Bulgaria, Canada, Chile, China, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Arab Rep., Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iran, Islamic Rep., Iraq, Ireland, Italy, Japan, Jordan, Kazakhstan, Korea, Rep., Kuwait, Kyrgyz Republic, Latvia, Lebanon, Lithuania, Luxembourg, Macedonia, FYR, Moldova, Mongolia, Nepal, Netherlands, New Zealand, Norway, Pakistan, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Slovak Republic, Slovenia, Solomon Islands, Spain, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tunisia, Turkey, Turkmenistan, Ukraine, United Kingdom, United States, Uruguay, Uzbekistan.

Notes: ENSO country partition using method based on correlation between local temperature and ENSO index. See Hsiang, Meng, and Cane (2011) for details.

Table 2: ENSO effects by region: contempt and lagged effects

Outcome	Temp		Precip		log yield		log output		log ag value added	
Sample	Tropics	Temperate	Tropics	Temperate	Tropics	Temperate	Tropics	Temperate	Tropics	Temperate
$ENSO_t$	0.088	-0.094	-3.864	0.405	-0.008	0.014	-0.016	0.022	-0.007	0.01
	[0.011]***	[0.032]***	[0.500]***	[0.376]	[0.005]*	[0.006]**	[0.007]**	[0.008]***	[0.003]**	[0.004]**
$ENSO_{t-1}$	0.186	-0.038	-0.772	0.222	-0.012	0.003	-0.019	0.002	-0.011	0.007
	[0.011]***	[0.032]	[0.467]*	[0.405]	[0.005]**	[0.006]	[0.008]**	[0.008]	[0.003]***	[0.004]*
$ENSO_t + ENSO_{t-1}$	0.274	-0.132	-4.636	0.627	-0.020	0.017	-0.035	0.024	-0.018	0.016
	[0.017]***	[0.054]**	[0.720]***	[0.579]	[0.008]***	[0.010]*	[0.012]***	[0.013]*	[0.005]***	[0.006]***
Observations	2769	2,043	2,756	2,043	2,756	2,043	2756	2043	2756	2043
No. of countries	78	69	78	69	78	69	78	69	78	69

Notes: Each column estimated from a separate country-level panel data model with country fixed effects and country-specific trends. Sample period is 1961-2009 for all models. Standard errors in brackets are adjusted for spatial (2000km) and serial (5-years) correlation. *** p<0.01, ** p<0.05, * p<0.1

Table 3: ENSO effects by region: standard errors

Outcome		Std. err.	Tropics	Temperate
Temperature (in C, crop weighted)			0.274	-0.132
	Spatial HAC	Dist=2000 Year=5	[0.017]***	[0.054]**
		Dist=2000 Year=10	[0.016]***	[0.054]**
		Dist=4000 Year=5	[0.020]***	[0.063]**
		Dist=4000 Year=10	[0.020]***	[0.063]**
	Clustering	country	[0.018]***	[0.031]***
		year	[0.032]***	[0.073]*
Precipitation (in cm, crop weighted)			-4.636	0.627
	Spatial HAC	Dist=2000 Year=5	[0.720]***	[0.579]
		Dist=2000 Year=10	[0.679]***	[0.556]
		Dist=4000 Year=5	[0.827]***	[0.581]
		Dist=4000 Year=10	[0.791]***	[0.558]
	Clustering	country	[1.018]***	[0.551]
		year	[0.946]***	[0.491]
log cereal yield (in kg/hectare)			-0.020	0.017
	Spatial HAC	Dist=2000 Year=5	[0.008]***	[0.010]*
		Dist=2000 Year=10	[0.008]***	[0.010]*
		Dist=4000 Year=5	[0.008]***	[0.010]*
		Dist=4000 Year=10	[0.008]***	[0.010]*
	Clustering	country	[0.008]***	[0.009]**
		year	[0.007]***	[0.010]*
log cereal output (in metric tons)			-0.035	0.024
	Spatial HAC	Dist=2000 Year=5	[0.012]***	[0.013]*
		Dist=2000 Year=10	[0.011]***	[0.012]**
		Dist=4000 Year=5	[0.012]***	[0.014]*
		Dist=4000 Year=10	[0.012]***	[0.013]*
	Clustering	country	[0.010]***	[0.013]*
		year	[0.013]**	[0.015]
log ag value added (in 2000 USD)			-0.018	0.016
	Spatial HAC	Dist=2000 Year=5	[0.005]***	[0.006]***
		Dist=2000 Year=10	[0.005]***	[0.006]***
		Dist=4000 Year=5	[0.005]***	[0.007]**
		Dist=4000 Year=10	[0.005]***	[0.007]**
	Clustering	country	[0.004]***	[0.006]**
		year	[0.005]***	[0.009]*
Number of countries			78	69

Notes: Each coefficient estimated from a separate country-level panel data model with country fixed effects and country-specific trends. Coefficients captures β in Eq. 1, the combined linear effect of ENSO_t on outcome in year t and in year $t+1$. Sample period is 1961-2009 for all models. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 4: ENSO effects by region: nonlinearity

Outcome	Temp		Precip		log yield		log output		log ag value added	
Sample	Tropics	Temperate	Tropics	Temperate	Tropics	Temperate	Tropics	Temperate	Tropics	Temperate
$\text{ENSO}_t \in [-1.5, -.75)$	-0.314	0.496	4.949	-1.944	-0.021	-0.037	0.028	-0.055	0.036	-0.0078
	[0.044]***	[0.124]***	[2.076]**	[1.682]	[0.022]	[0.030]	[0.032]	[0.038]	[0.015]**	[0.019]
$\text{ENSO}_t \in [-.75, -.25)$	-0.095	0.592	1.035	2.200	-0.018	-0.016	-0.010	-0.018	0.04	0.0087
	[0.048]**	[0.152]***	[1.948]	[1.562]	[0.021]	[0.027]	[0.033]	[0.034]	[0.014]***	[0.017]
$\text{ENSO}_t \in [-.25, -.25)$	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-	-	-	-	-	-
$\text{ENSO}_t \in [25, .75)$	0.152	0.144	-2.606	1.343	-0.045	0.012	-0.032	0.026	0.022	0.041
	[0.035]***	[0.118]	[1.584]*	[1.181]	[0.017]***	[0.021]	[0.028]	[0.027]	[0.010]**	[0.013]***
$\text{ENSO}_t \in [.75, 1.25)$	0.140	0.522	-6.648	0.711	-0.062	-0.0005	-0.046	-0.019	-0.021	0.043
	[0.063]**	[0.187]***	[2.555]***	[2.059]	[0.029]**	[0.033]	[0.046]	[0.045]	[0.017]	[0.023]*
$\text{ENSO}_t \in [1.25, 2.0]$	0.535	0.230	-8.356	1.191	-0.062	0.014	-0.070	0.033	0.007	0.016
	[0.056]***	[0.169]	[2.226]***	[1.830]	[0.026]**	[0.029]	[0.038]*	[0.038]	[0.016]	[0.020]
Observations	2769	2,043	2,756	2,043	2,756	2,043	2756	2043	2756	2043
No. of countries	78	69	78	69	78	69	78	69	78	69

Notes: Each column estimated from a separate country-level panel data model with country fixed effects and country-specific trends. Coefficients captures β in Eq. 1, the combined linear effect of ENSO_t in each bin on outcome in year t and in year $t+1$ relative to years when ENSO is in neutral state, $\text{ENSO}_t \in [-.25, .25)$. Sample period is 1961-2009 for all models. Standard errors in brackets are adjusted for spatial (2000km) and serial (5-years) correlation. *** p<0.01, ** p<0.05, * p<0.1