Predicted Greenness:

Refining the econometrics of global drought measurement

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Introduction

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  2. Identifying self-reported droughts.
  3. Estimating the effect on economic activity.

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- Drought is probably the most devastating type of natural hazard. Population growth and global warming might lead to more drought disasters in near future.
- In order to study the consequences of drought, it is important to minimize measurement error and potential endogeneity.

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- **Hydrological** drought: Lack of surface water resulting from lack of rainfall.
- **Agricultural** drought: Links dryness with agricultural impacts. Takes into account precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, etc.

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  - Normalized Difference Vegetation Index (NDVI) anomalies.

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- There might be very far between weather stations.
- The distance to the nearest weather station is probably correlated with income levels and population density.

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- Urban development
- Changes in cultivation and irrigation patterns.

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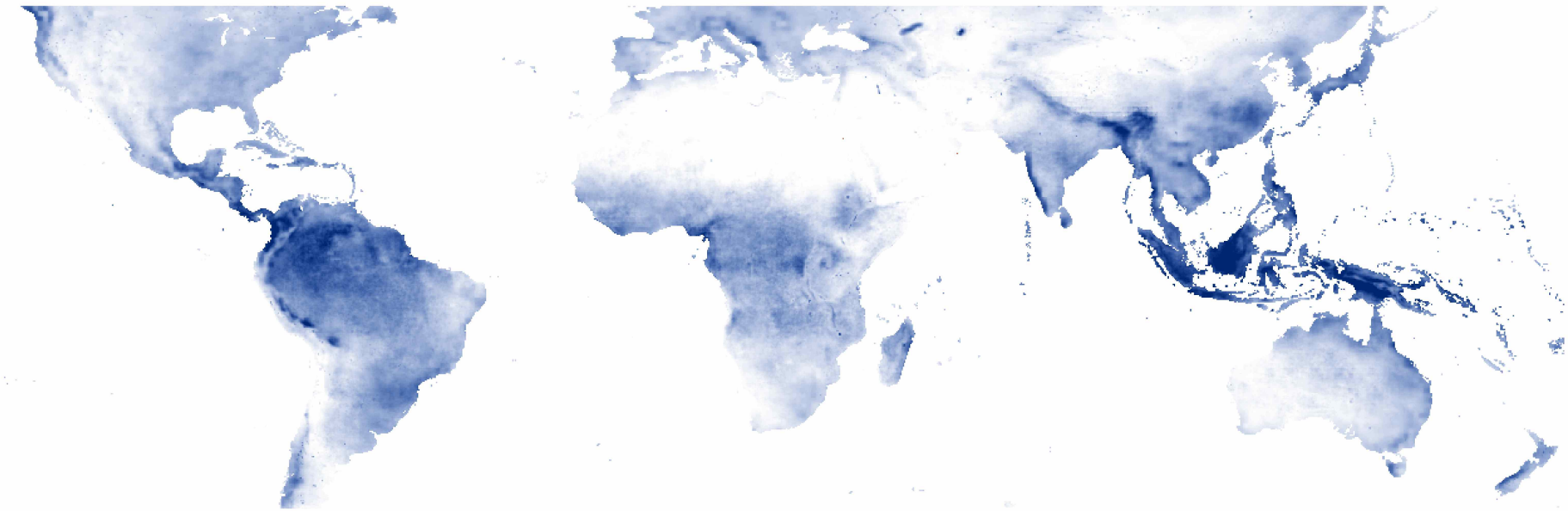
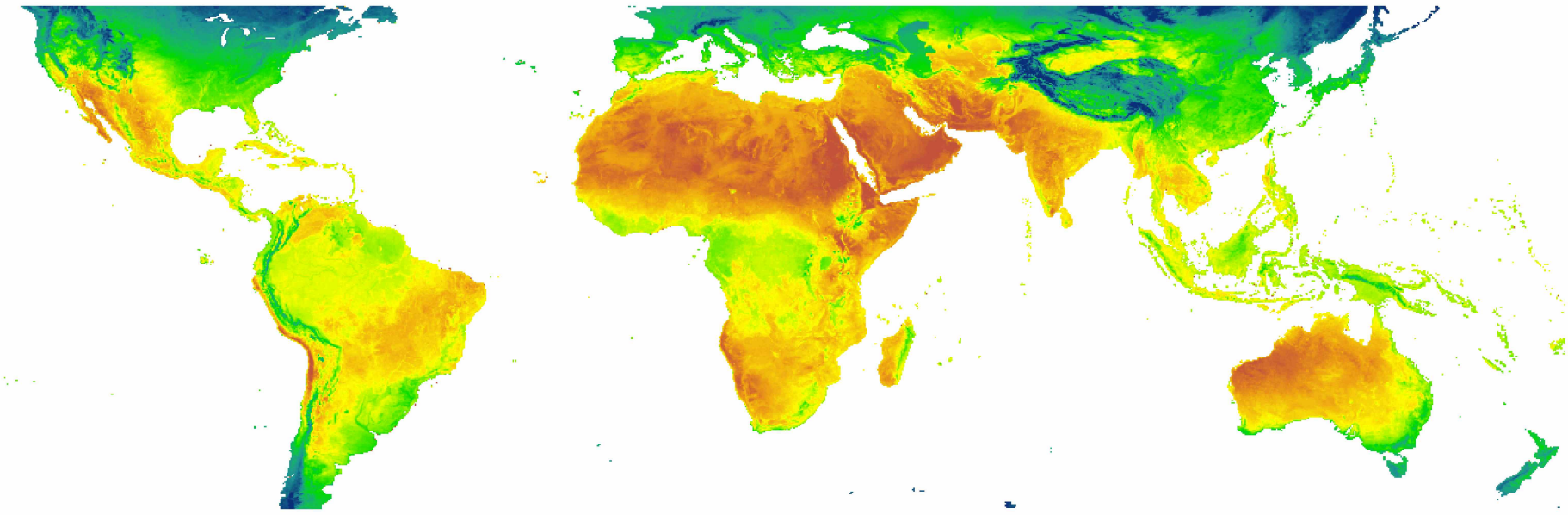
- This allows for the estimation of predicted greenness anomalies where anomalies in rainfall and temperatures (with up to 6 lags) are used to predict greenness anomalies.
- The result is an agricultural drought index that takes into account both input variables and observed greenness anomalies while filtering out all anthropogenic causes of changes in greenness.

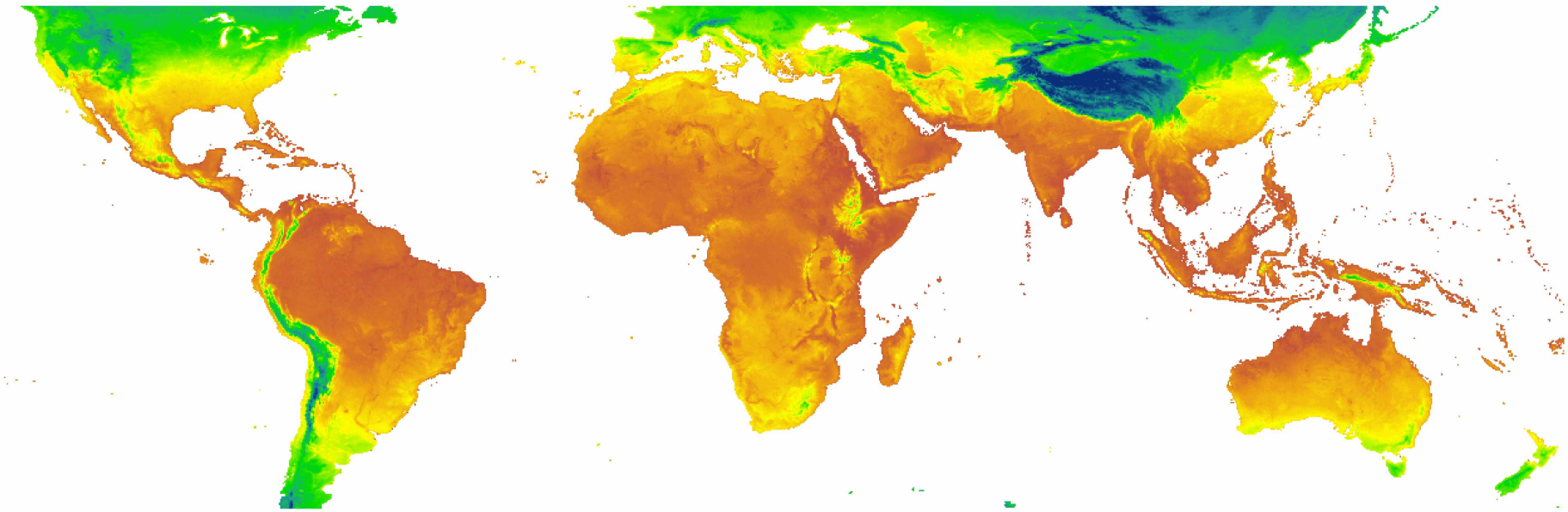
Data: Rainfall



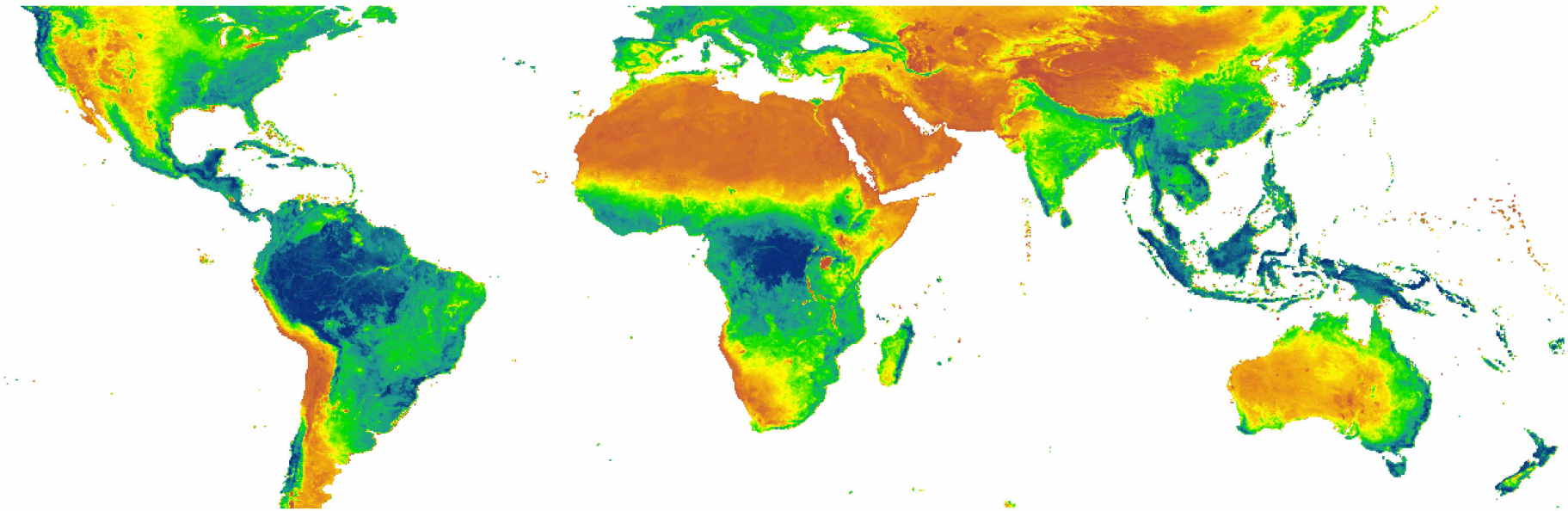
Data: Daytime temperatures



Data: Temperatures at night



Data: NDVI



How is the data combined?

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1: OLS:

$$N\ddot{D}VI_{itm,OLS} = \gamma_0 + \sum_{n=0}^{6} \left(\gamma_{1n} \ddot{P}_{it,m-n} + \gamma_{2n} \ddot{T}_{hit,m-n} \right) + \delta_t + \epsilon_{itm} \qquad (3)$$

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2: OLS with climate zone interaction:

$$N\ddot{D}VI_{itm,i} = \gamma_0 + \sum_{n=0}^{6}\Big(\gamma_{1n}\ddot{P}_{it,m-n} + \gamma_{2n}\ddot{T}_{hit,m-n} + \gamma_{3n}\ddot{P}_{it,m-n} * C_i + \gamma_{4n}\ddot{T}_{hit,m-n} * C_i\Big) + \delta_t + \epsilon_{itm} \quad (4)$$

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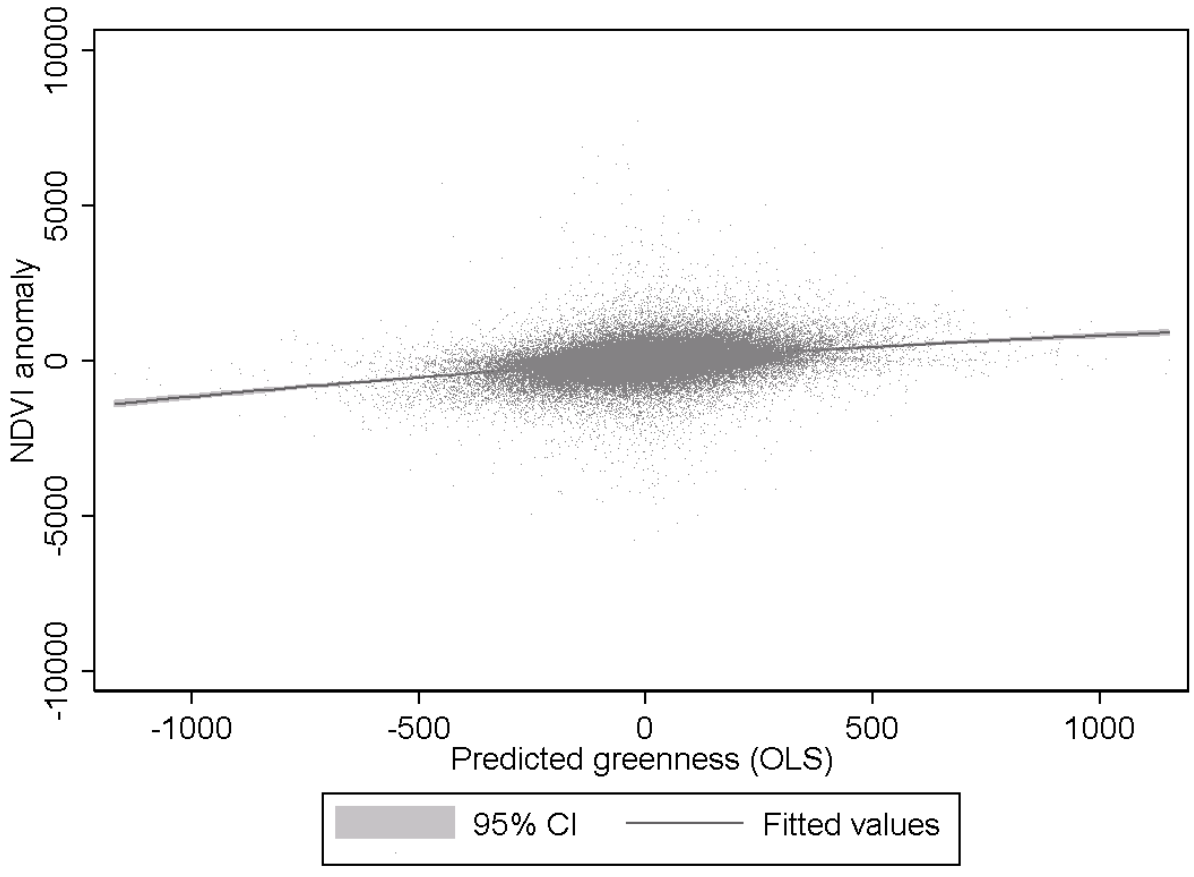
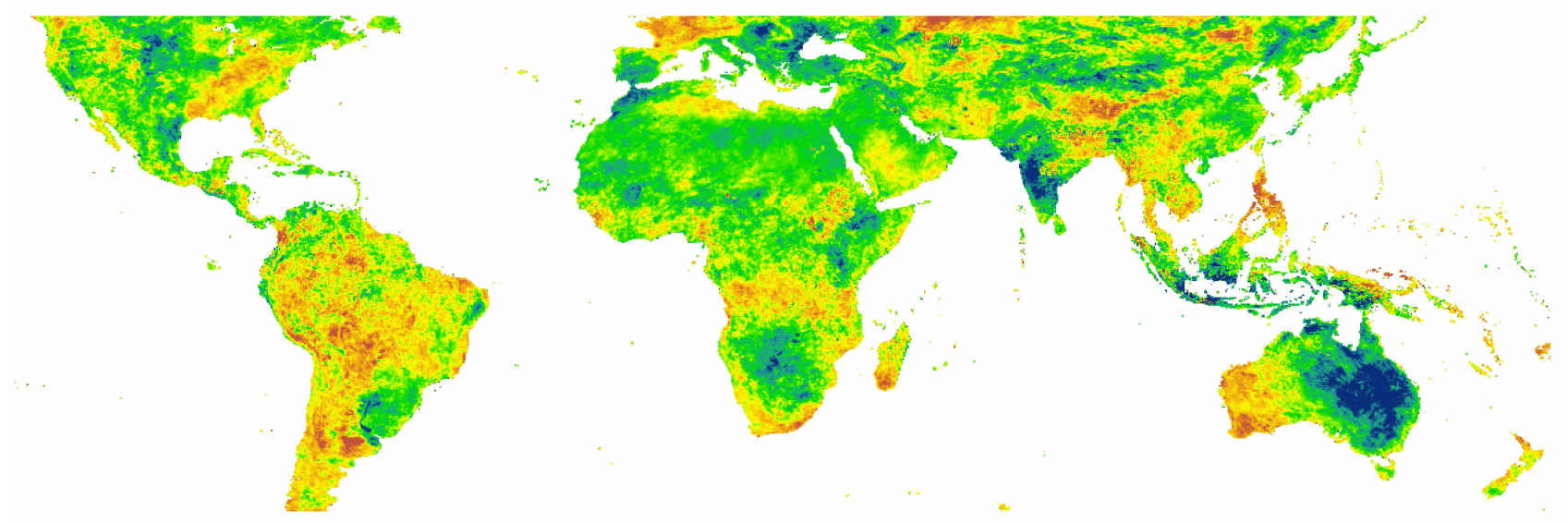
3: Random forest

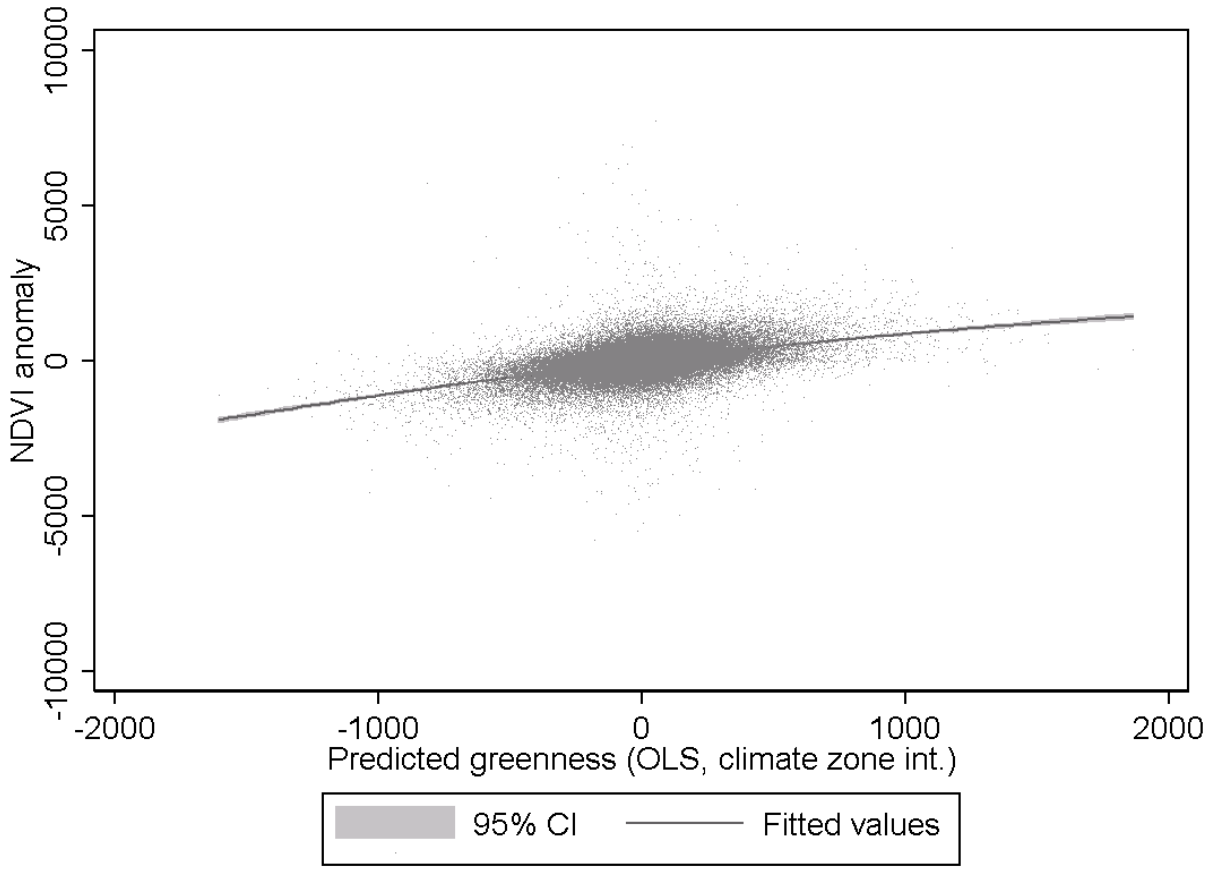
Predicted greenness anomalies - Ordinary Least Squares



Predicted greenness anomalies in 2010 - Ordinary Least Squares



Predicted greenness anomalies - OLS with climate zones



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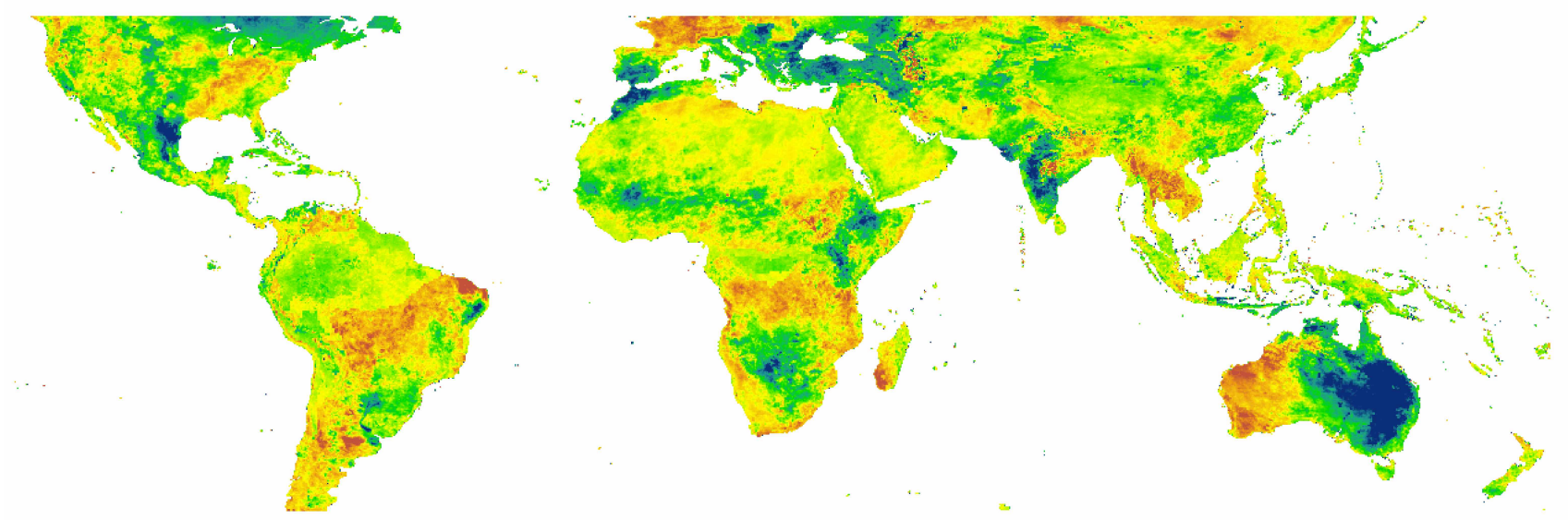

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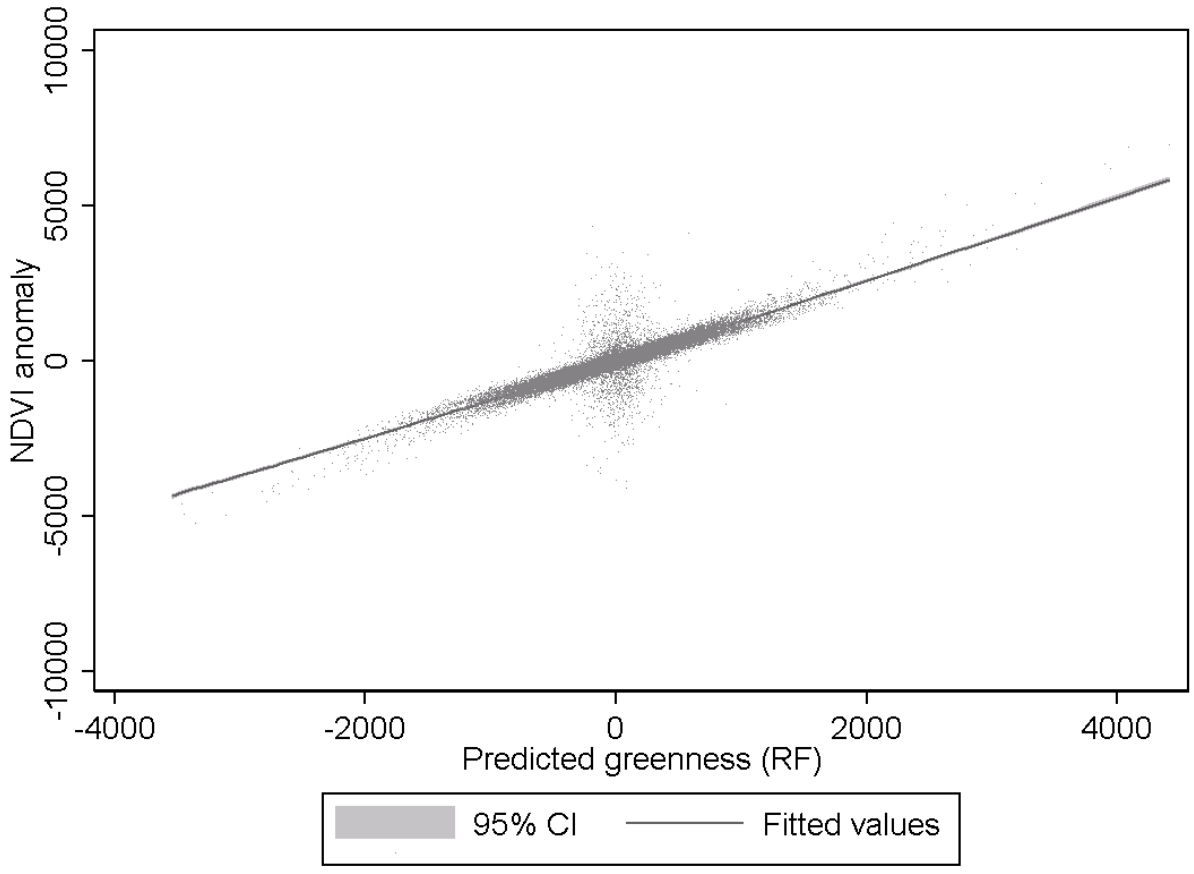

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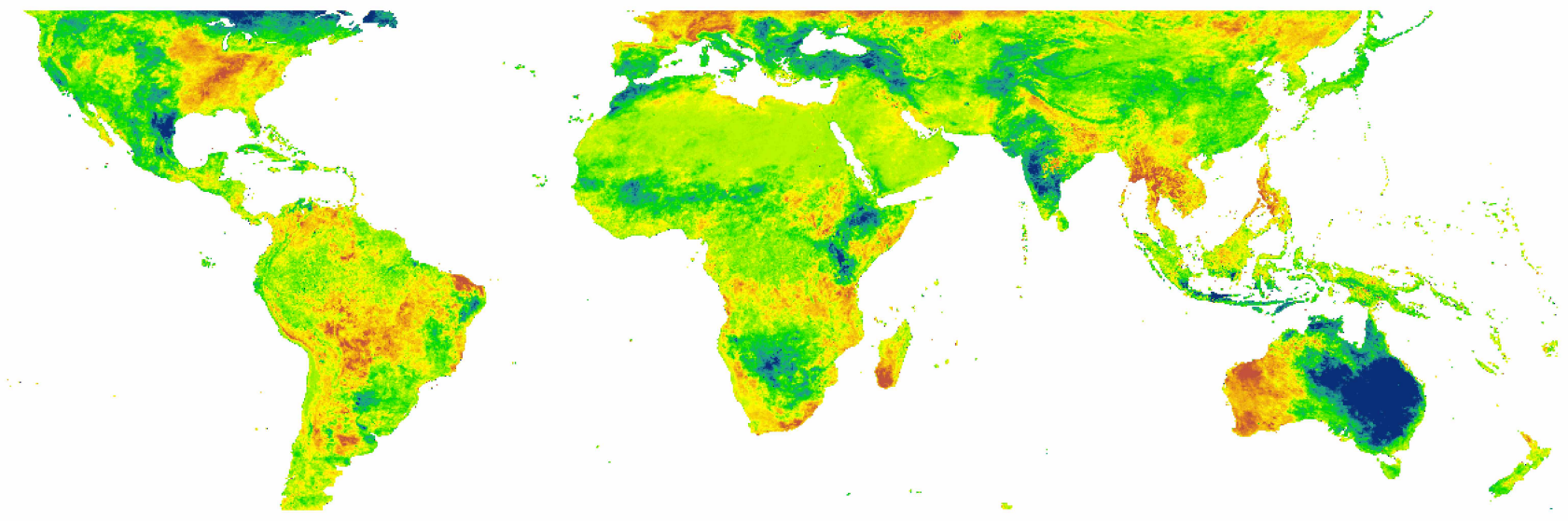
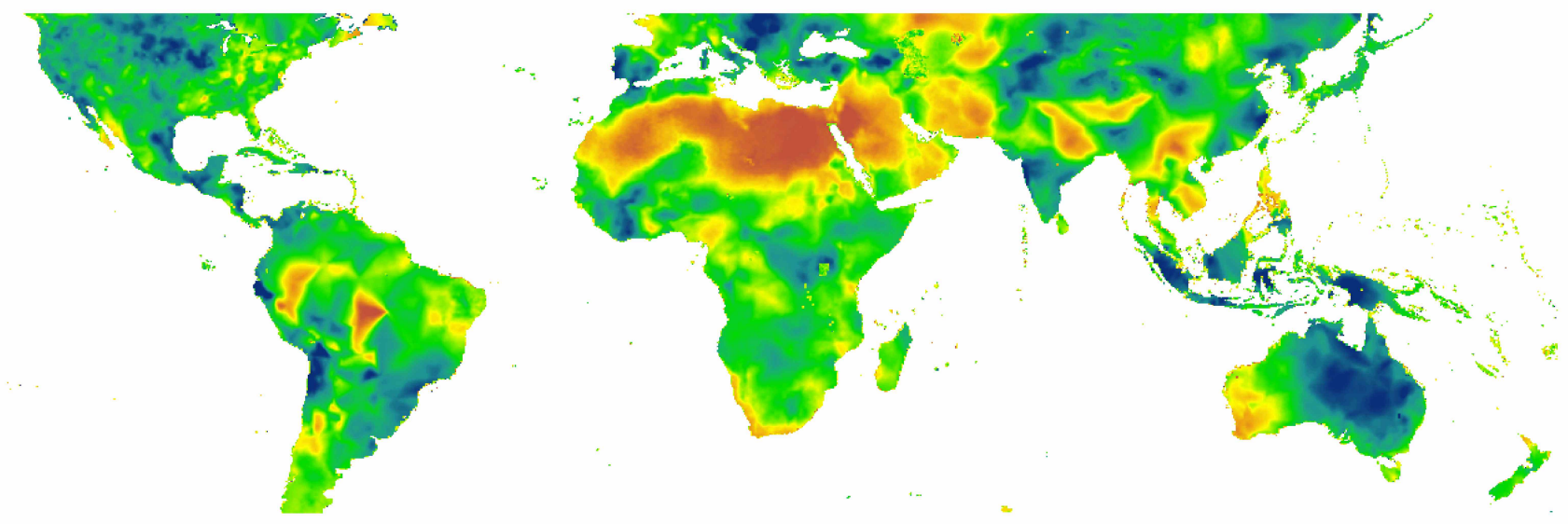


6-month SPEI in 2010



Evaluating predicted greenness anomalies

Are predicted greenness anomalies better than existing drought measures?

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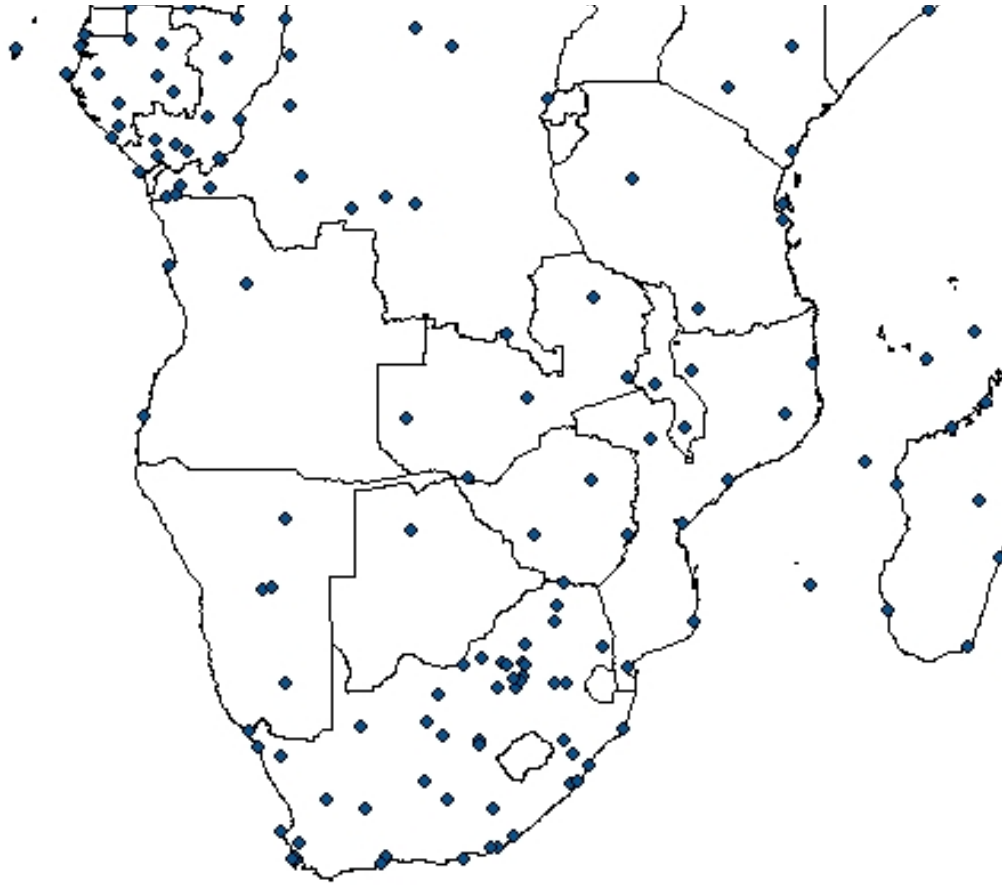
- Testing for weather station bias
- Identifying self-reported droughts
- Assessing the effect on economic activity

Distance to weather stations



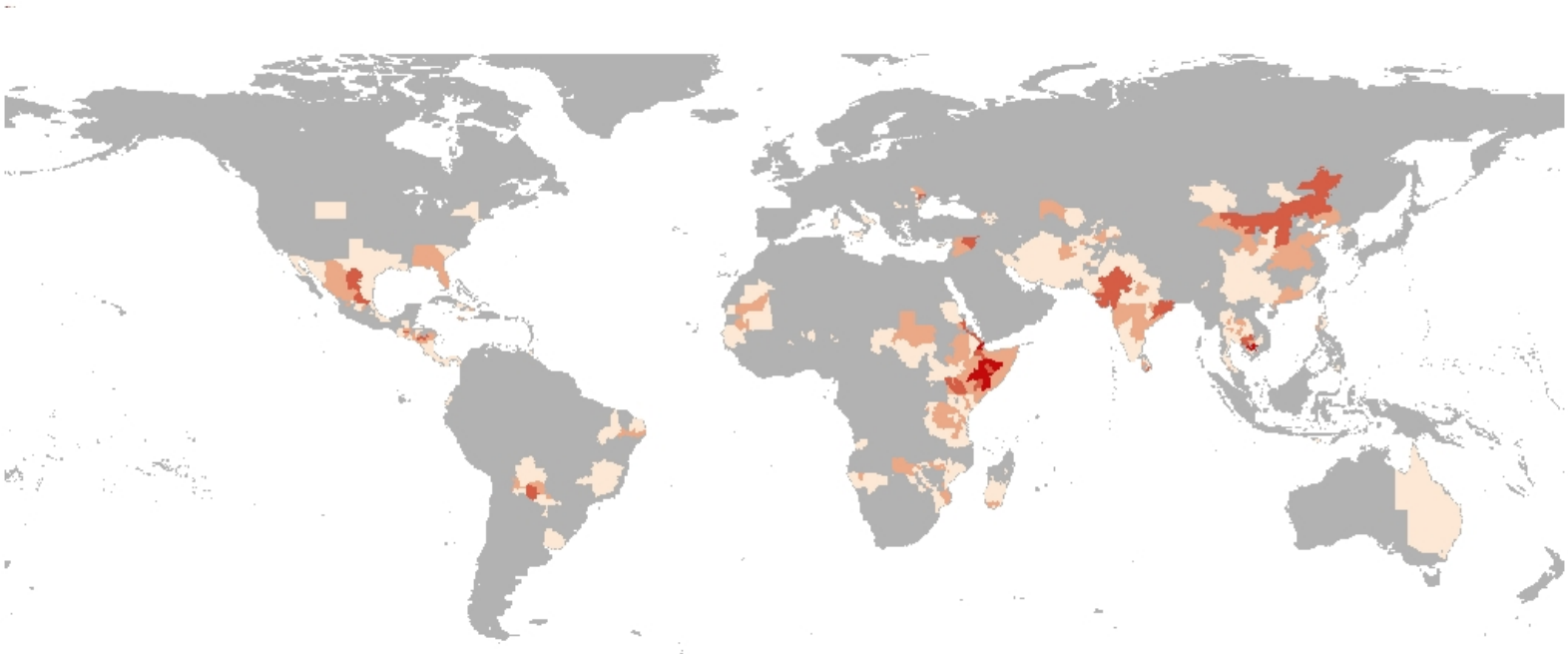
Weather station bias

Table 3: Correlations between 6-month SPEI and predicted greenness

	(1)	(2)	(3)	(4)
$\widehat{NDV\ddot{I} - ols_{itm}}$	0.414***			
	(0.000)			
$\widehat{NDV\ddot{I} - ols, c_{itm}}$		0.298***		
		(0.000)		
$\widehat{NDV\ddot{I} - RF_{itm}}$			0.274***	
			(0.000)	
$N\ddot{D}VI$				0.196***
				(0.000)
$Dist * \widehat{NDV\ddot{I} - ols_{itm}}$	-0.069***			
	(0.000)			
$Dist * \widehat{NDV\ddot{I} - ols, c_{itm}}$		-0.010***		
		(0.000)		
$Dist * \widehat{NDV\ddot{I} - RF_{itm}}$			-0.005***	
			(0.000)	
$Dist * N\ddot{D}VI$				-0.010***
				(0.000)
Observations	19,846,352	19,844,720	17,102,495	21,287,733
R-squared	0.117	0.085	0.072	0.026

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All drought indices are standardized to mean 0 and s.d. 1. Distance is measured in 100 kms.

Identifying self-reported droughts



Identifying self-reported droughts

Table 5: Correlation between drought indices and self-reported droughts

	Drought	$SPEI_{06}$	$\widehat{N\ddot{D}VI}_{OLS}$	$\widehat{N\ddot{D}VI}_{OLS,c}$	$\widehat{N\ddot{D}VI}_{RF}$
$SPEI_{06}$	-0.017	1			
$\widehat{N\ddot{D}VI}_{OLS}$	-0.024	0.359	1		
$\widehat{N\ddot{D}VI}_{OLS,c}$	-0.031	0.307	0.775	1	
$\widehat{N\ddot{D}VI}_{RF}$	-0.030	0.294	0.638	0.785	1
$N\ddot{D}VI$	-0.021	0.193	0.434	0.564	0.713

All drought indices are standardized to mean 0 and s.d. 1. For this analysis, the pixel-level data has been collapsed to second-level administrative units resulting in 3.3m observations (distrivt-months). In order to give larger weight to larger land areas, the correlation coefficients are weighted by the size of each unit.

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- Predicted greenness anomalies are aggregated to yearly averages and subsequently used to explain changes in artificial lights at night.

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Table 6: Changes in luminosity and predicted greenness

	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{N\ddot{D}VI}$	0.39***	-0.07***	-0.07***			
	(0.02)	(0.02)	(0.02)			
$W * \widehat{N\ddot{D}VI}$		0.79***	0.81***			
		(0.05)	(0.05)			
$SPEI_{06}$				0.07***	-0.06**	-0.08**
				(0.01)	(0.03)	(0.03)
$W * SPEI_{06}$					0.17***	0.23***
					(0.03)	(0.04)
Country dummies	No	No	Yes	No	No	Yes
Observations	1.83m	1.83m	1.83m	1.65m	1.65m	1.65m
R-squared	0.002	0.004	0.006	0.000	0.000	0.002

Dependent variable: year-on-year changes in luminosity as measured by the share of pixels lit within each unit of observation (in percent). Standard errors clustered at second sub-national level administrative units in parentheses.

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- An alternative - predicted greenness anomalies - has been introduced, which is unaffected by the distance to nearest weather station.
- Predicted greenness anomalies seem to outperform other global drought measures in predicting self-reported droughts as well as economic activity at the pixel level.