Which yield yields the true yield? Investigating the accuracy of yield estimates

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In 2023, an estimated 28.9 percent of the global population – **2.33 billion people** – were moderately or severely food insecure.

FAO, IFAD, UNICEF, WFP and WHO (2024)



How weather determines yields is one of the oldest scientific questions...

TOY EPTA KAI EPAI. ערמו אוס ווושטי מטול אוסו אאב ovotice. שלוד לי קוייו דוד סקודeou marie vuveroau, Ovre da Beoli andres ouns άφατοί τι φατοί τι, האדוי דב (אוטה עביע אסום באאלב) ET iduves ono hop nou ay luopa napos itilpenierns, os twierara divuala vais. ide iday aimy re, dina d'idure depusas עטא, ציוש לוב אב דבפסא בדאידעעם עטלאסמיעוש. shapa usvoy the reid wy ysig, an un rain Eioi d'un, This uli new ETT alvhoser vonotes, H & ביאועטעאדא, אל א מיליגע טעטע באצסיע. Exertin, STIS Thurs quite Georos, all' va avay Abavaray Bornory Ley Unaor Bageran. (ANS A SETEPHU (TOTEPHU MEREURO VUE EPECONNI)

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How weather determines yields is one of the oldest scientific questions...

... and the answer varies depending on which data you use.



Census yields (Food and Agriculture Organization)

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Census yields (Food and Agriculture Organization)

vs.

Remote-sensed yields (Contiguous Solar Induced Fluorescence)

How weather determines yields is one of the oldest scientific questions...

... and the answer varies depending on which data you use.

Year-to-year yield variability explained by weather, when using...



 $\log(C_{ij})' = c + \alpha_1 T'_{ij} + \alpha_2 T'^2_{ij} + \beta_1 S M'_{ij} + \beta_2 S M'^2_{ij} + \epsilon_{ij}$

Year-to-year yield variability explained by weather, when using...



 $\log(C_{ij})' = c + \alpha_1 T'_{ij} + \alpha_2 T'^2_{ij} + \beta_1 S M'_{ij} + \beta_2 S M'^2_{ij} + \epsilon_{ij}$



Year-to-year yield variability explained by weather, when using...







Census yield variability attributable to weather remains constant across class.



Remote-sensed (but not **census**) yield variability attributable to weather follows an income gradient.



Depending on which yield you use, you will get **two very different stories** about how climate change will impact future food security.



What explains the discrepancy between the **census** yields and the **remote sensed** yields?

In wealthier countries, census and remote-sensed yields match better.



Global All-crop Bayesian Mixed Model (beta distribution)

Correlation coefficient ²		oefficient ²
Predictors	Estimates	CI (95%)
Intercept (Class: High income)	0.18	0.16 – 0.21
Class: Low income	0.76	0.61 – 0.93
Class: Lower middle income	0.77	0.65 – 0.92
Class: Upper middle income	0.81	0.68 – 0.96
Time offset: lag	0.66	0.58 – 0.75
Time offset: lead	0.68	0.60 – 0.77
FAO flagged percentage	0.91	0.85 – 0.96
Total harvested area	1.09	1.04 – 1.15
Average harvested area	1.06	1.00 – 1.13
Cropland fraction	1.11 ***	1.03 – 1.18
Average CSIF	0.92	0.86 – 0.98

Random Effects

σ^2	1.00
τ 00 country	0.06
τ 00 crop	0.03
ICC	0.08
N сгор	19
N country	160
Observations	1568
Marginal R^2 / Conditional R^2	0.092 / 0.153

Global All-crop Bayesian Mixed Model (beta distribution)

Higher income, fewer data flags, and larger cropland area are all associated with a higher correlation between **census** yields and the **remote sensed** yields.

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