

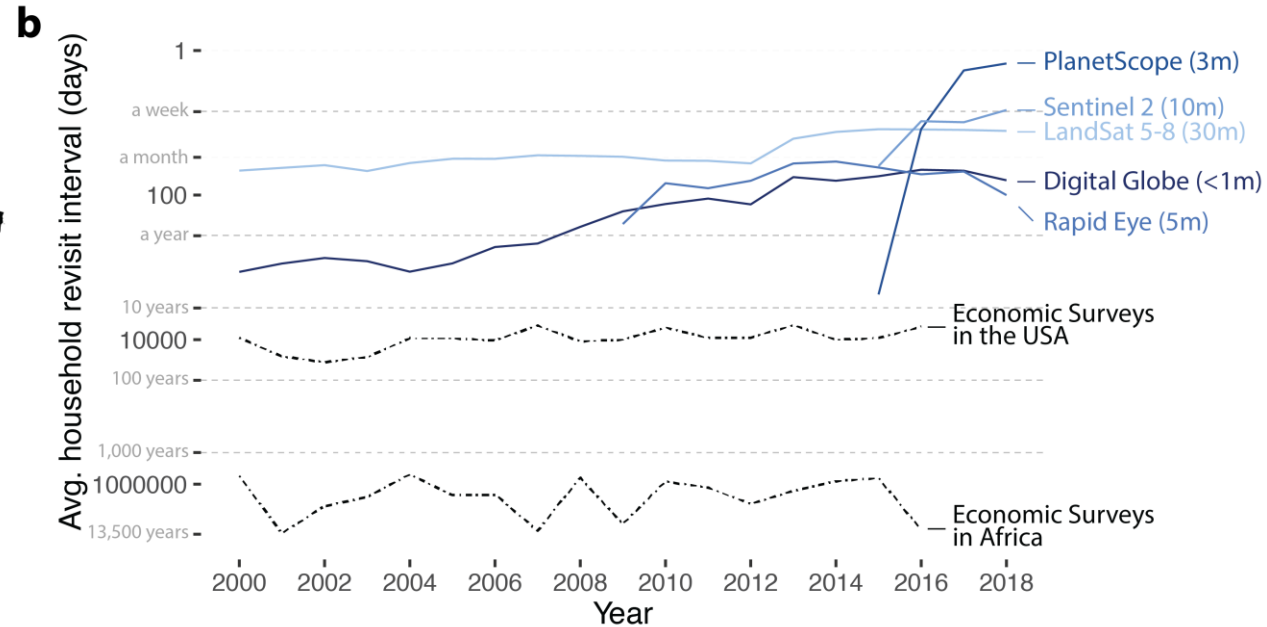
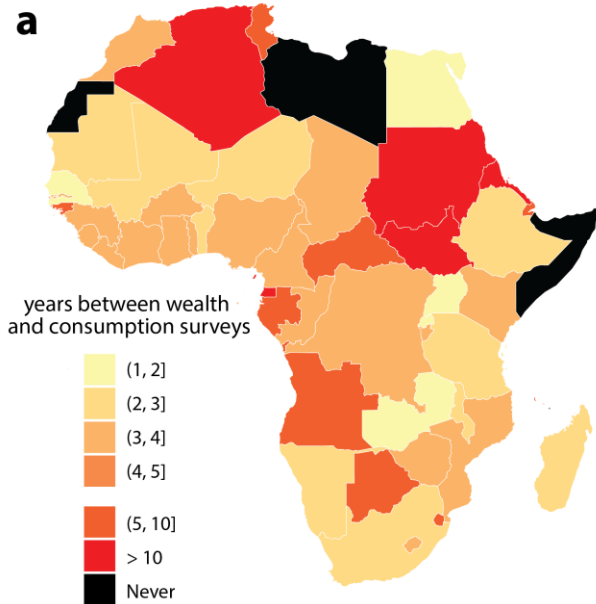
A satellite night view of Earth, showing the continents of North and South America. The landmasses are illuminated by a dense network of yellow and white lights, representing city lights and urban areas. The oceans are dark blue, with some lighter blue areas indicating cloud cover or water temperature variations. The overall scene is a high-contrast, high-resolution image of the planet's surface at night.

Using satellites to amplify the power of household surveys

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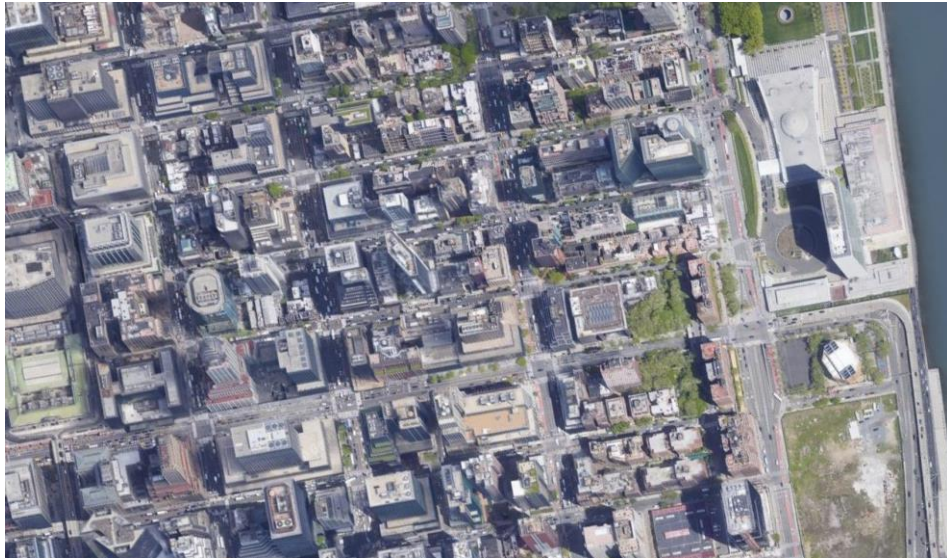
Our benchmark measurement technology: expensive, infrequent



Result: hard to target development interventions, understand their effectiveness

Why might satellites help here?

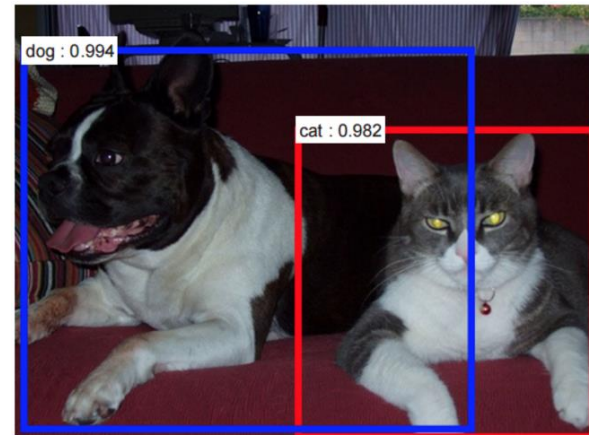
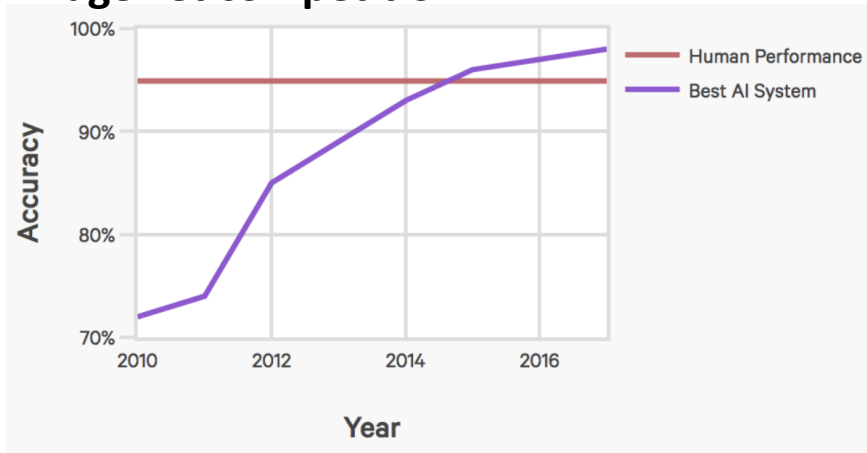
1. Humans can distinguish income levels in imagery



Why might satellites help here?

1. Humans can distinguish income levels in imagery
2. Computers are getting really good at image recognition tasks

ImageNet competition



Why might satellites help here?

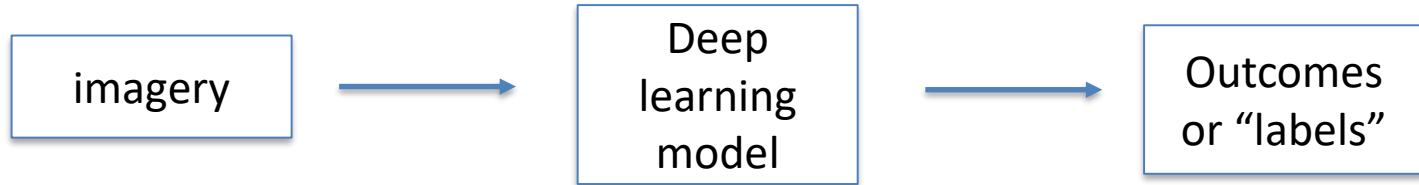
1. Humans can distinguish income levels in imagery
2. Computers are getting really good at image recognition tasks
3. **There is a lot of new imagery to play with**

New sources of satellite data

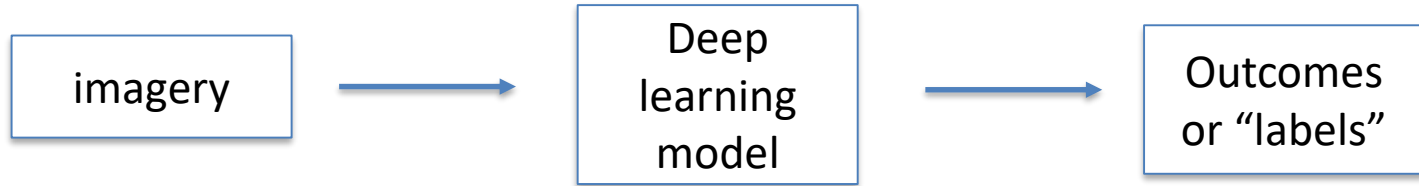


Sensor	Wavelengths	Spatial Resolution	Revisit frequency	Launch year
Sentinel-1	C-band radar	20m	6 day	2014, 2016
Sentinel-2	Optical	10m	5 day	2015, 2017
Skysat	Optical	1m	~weekly	2013-present
Planet	Optical	3-5m	~daily	2014-present

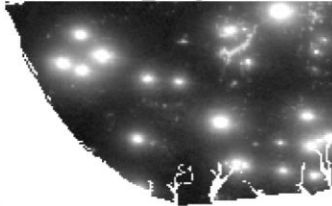
Can satellites help fill in temporal + spatial gaps between surveys?



Can satellites help fill in temporal + spatial gaps between surveys?



b - NL imagery



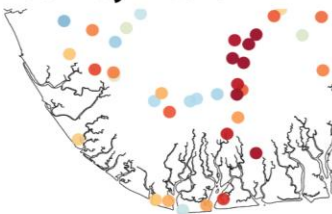
Input: Nighttime lights (500m)

d - MS imagery



Input: Multispectral optical imagery (Landsat, 30m)

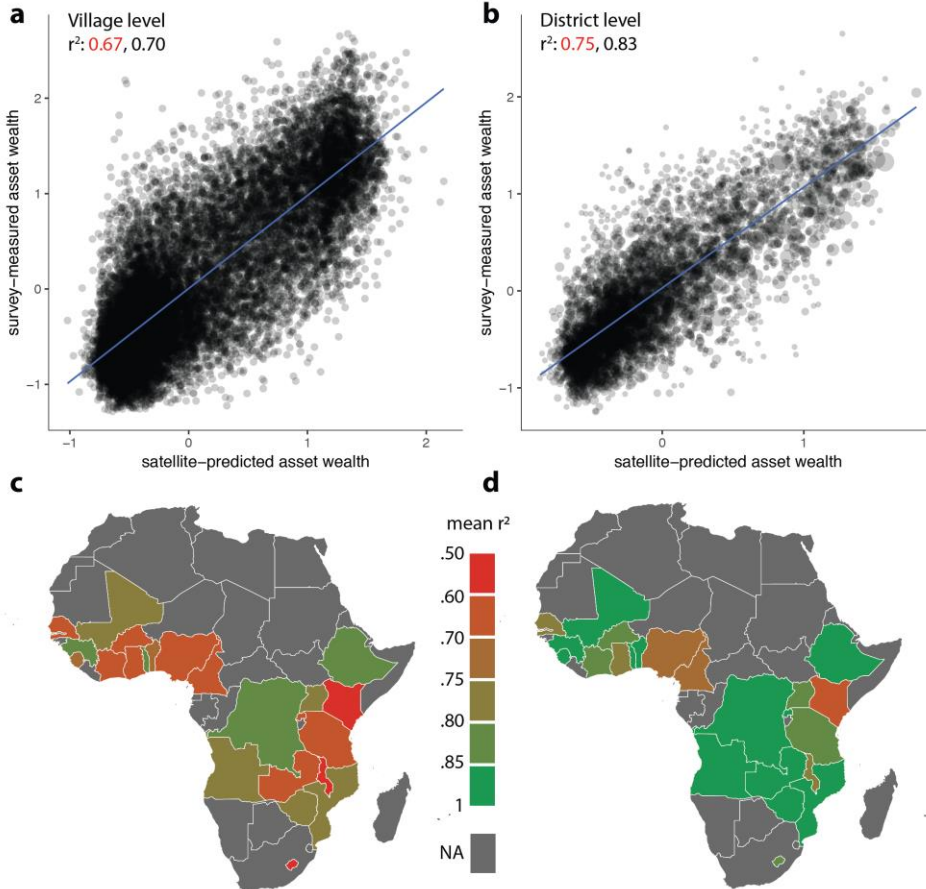
f - Survey wealth



Labels: village-level wealth estimates from 500k households, 20k villages from Demographic and Health surveys

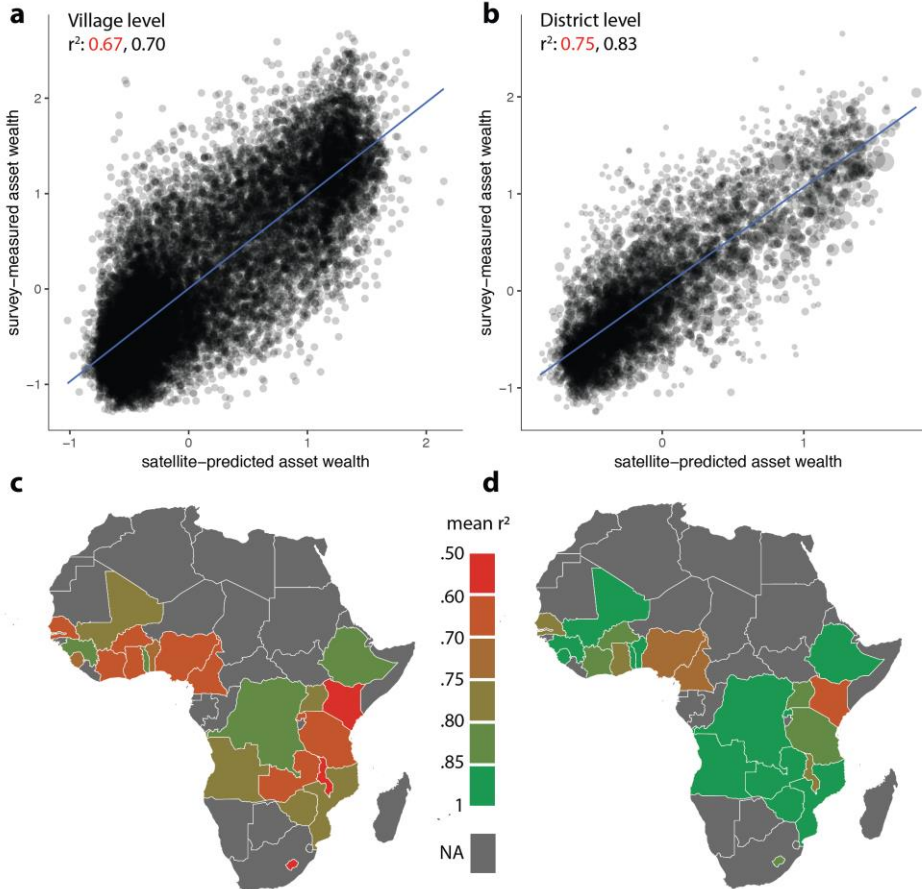
Satellites do a good job in predicting well-being in cross-section

Wealth predictions on held-out countries



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Wealth predictions on held-out countries



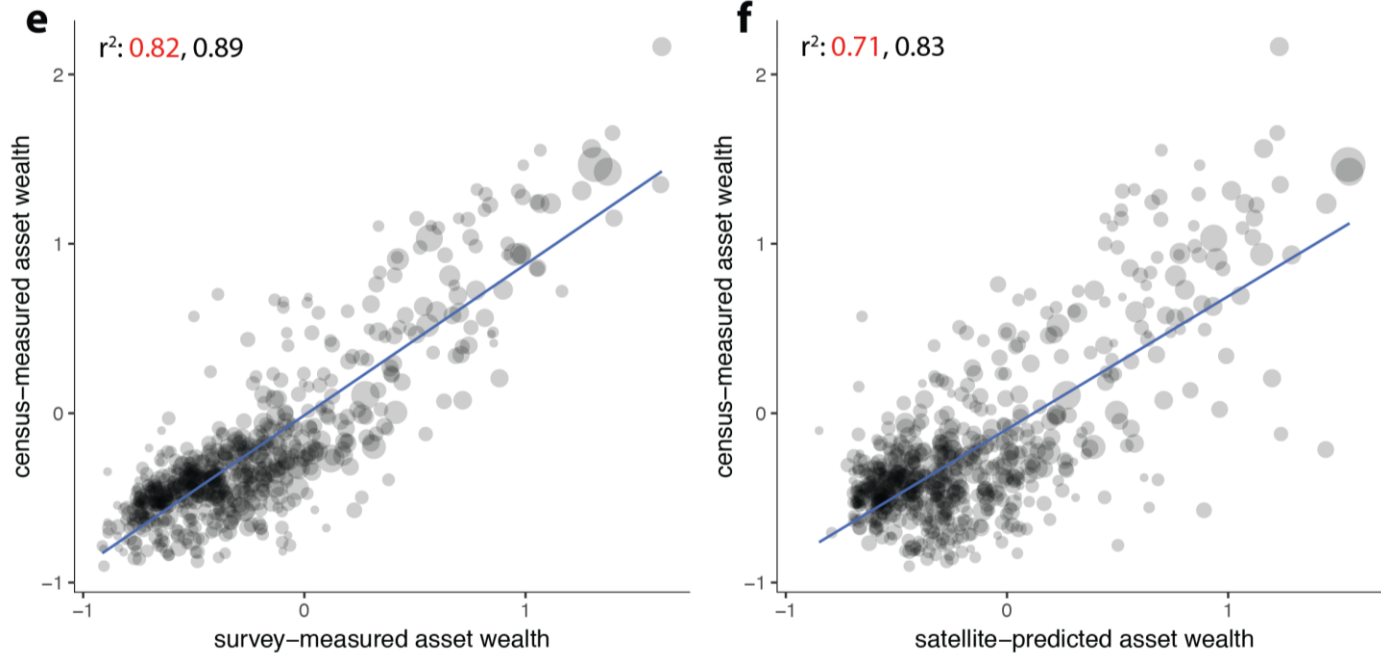
At least 2 challenges for applied work:

1. **Diagnosis:** where are errors coming from?
2. **Interpretability:** what is the model doing?

Diagnosis: compare both predictions and ground truth against a third independent variable

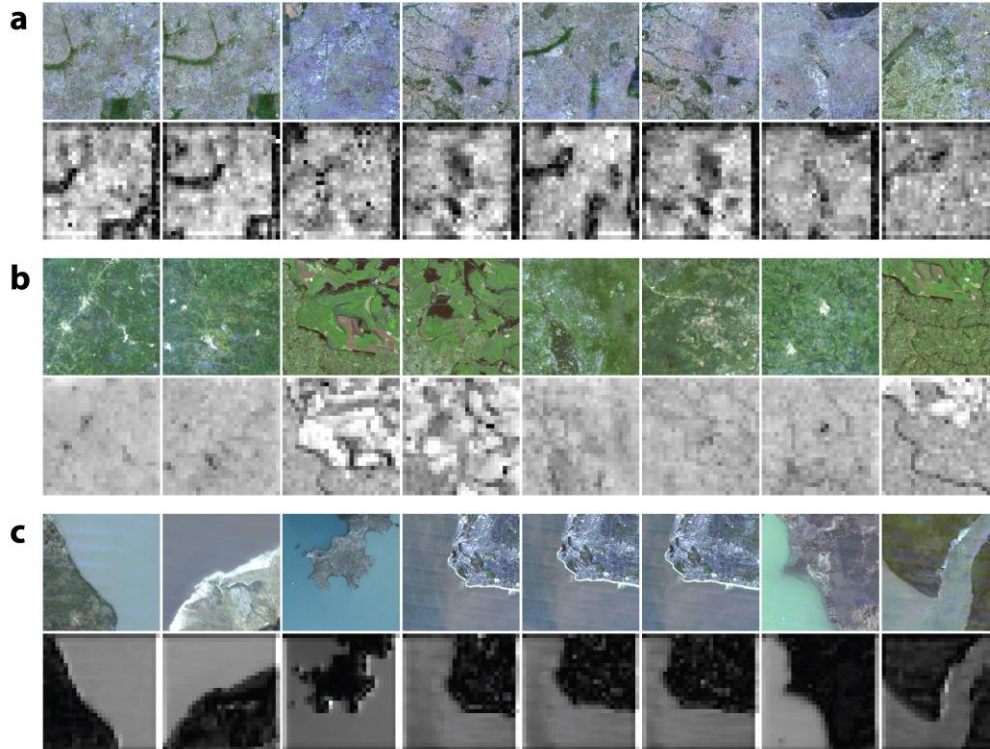
Diagnosis: compare both predictions and ground truth against a third independent variable

We assemble independent wealth measures from censuses in 9 countries (district level)

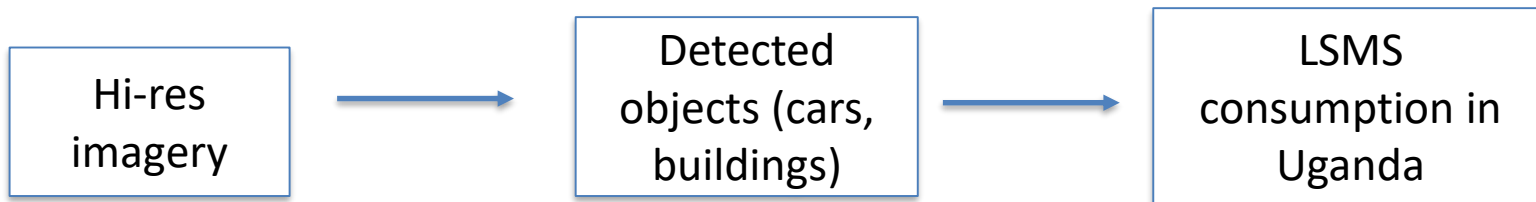


Diagnosis: at least some of error due to noise in ground data
i.e. *ground truth is not absolute truth*

Interpretability: can visualize features that model is using



Interpretability: an alternate approach uses detected objects as features

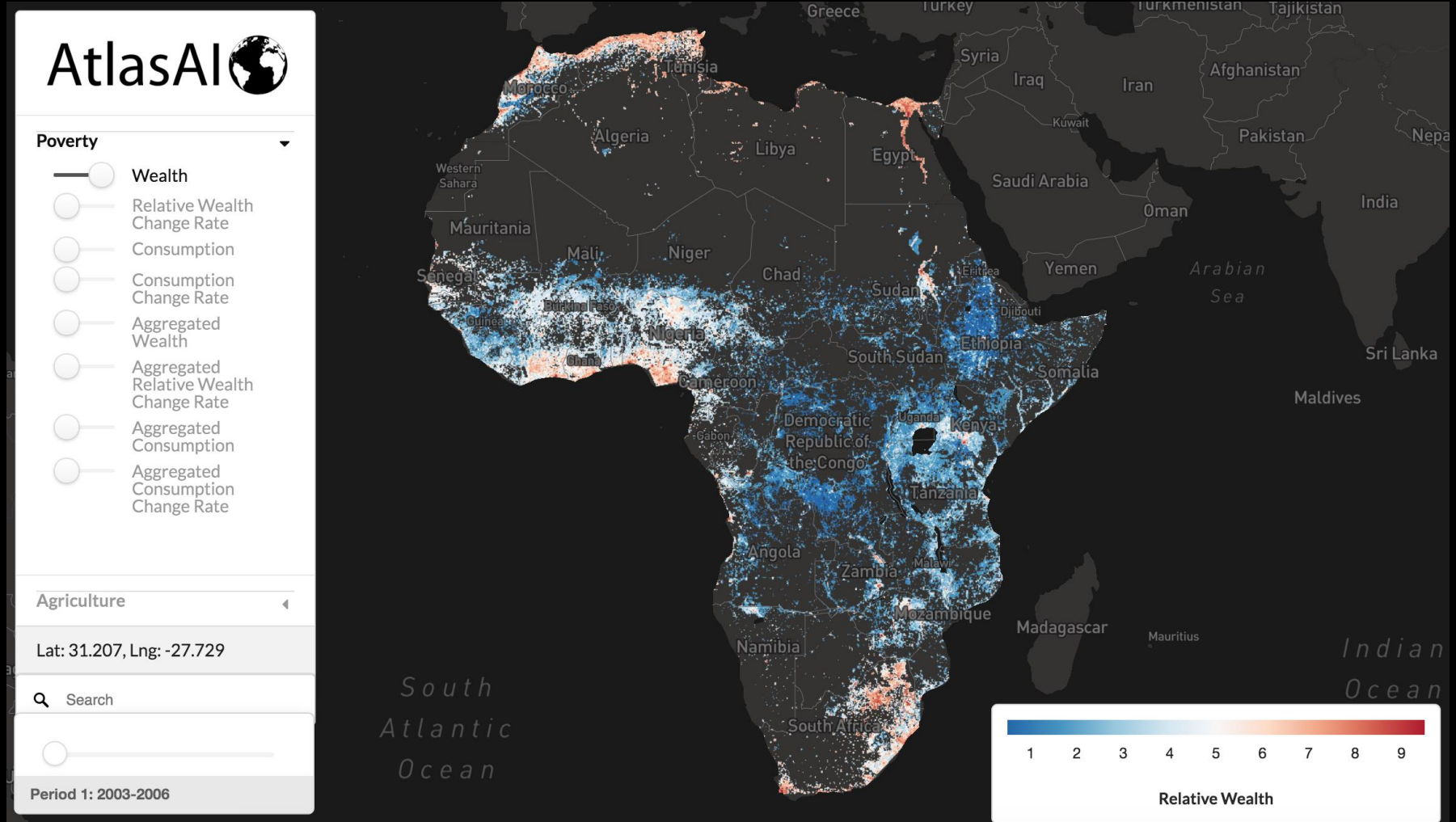


Method	RGB-CNN	NL-CNN [5]	Ours
r^2	0.04	0.39	0.41

Table 4: Comparison with baseline and state-of-the-art methods.

Figure 2: Sample detection results from Uganda. Zoom-in is recommended to visualize the bounding box classes. See **appendix** for more examples.

Estimates can be scaled



A satellite night view of Earth, showing the dark blue oceans and the glowing yellow and white lights of cities and urban areas. The lights are concentrated in the Northern Hemisphere, particularly in North America and Europe. The background is a deep, dark blue, suggesting the night sky.

Satellite imagery + deep learning can amplify
the power of existing surveys, helping to fill in
the gaps

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