

Appendix S1: Supplementary Results

Landcover map bias

Table 1: Biases and mean absolute errors (MAE) in cropland maps relative to the 2011 reference map for each aggregation scale calculated over the entire country, for the union of agricultural regions ($\text{cropland} > 0$), and as density independent means, wherein the mean bias/MAE values for each of 20 cropland cover classes (representing 5% increments of cover 0% to 100% defined by the reference map) were calculated and then averaged.

Region	Metric	Map	1 km	5 km	10 km	25 km	50 km	100 km
Country	Bias	SA-LC	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5
Country	Bias	GlobCover	2.0	2.0	2.0	2.0	2.0	2.0
Country	Bias	MODIS	2.5	2.5	2.5	2.5	2.5	2.5
Country	Bias	GeoWiki	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
Country	MAE	SA-LC	3.3	2.9	2.8	2.7	2.6	2.6
Country	MAE	GlobCover	11.3	9.4	8.8	8.2	7.6	7.2
Country	MAE	MODIS	7.8	6.5	6.1	5.6	5.0	4.6
Country	MAE	GeoWiki	6.3	4.5	3.9	3.2	2.6	2.2
Agricultural	Bias	SA-LC	-9.1	-4.4	-3.3	-2.9	-2.7	-2.6
Agricultural	Bias	GlobCover	3.7	2.8	2.5	2.2	2.1	2.1
Agricultural	Bias	MODIS	7.1	4.1	3.4	2.9	2.7	2.6
Agricultural	Bias	GeoWiki	-2.0	-1.0	-0.8	-0.7	-0.6	-0.6
Agricultural	MAE	SA-LC	11.1	5.0	3.7	3.0	2.8	2.6
Agricultural	MAE	GlobCover	20.5	12.8	10.7	9.0	8.1	7.3
Agricultural	MAE	MODIS	22.7	10.8	8.2	6.3	5.4	4.7
Agricultural	MAE	GeoWiki	19.2	7.8	5.3	3.7	2.9	2.3
Density independent	Bias	SA-LC	-8.6	-7.6	-7.7	-7.0	-6.5	-5.6
Density independent	Bias	GlobCover	33.6	33.5	30.9	27.9	23.8	14.4
Density independent	Bias	MODIS	20.9	13.9	11.0	8.1	7.7	7.1
Density independent	Bias	GeoWiki	4.3	-1.1	-1.8	-2.3	-0.1	-0.6
Density independent	MAE	SA-LC	11.4	8.4	8.1	7.2	6.6	5.6
Density independent	MAE	GlobCover	37.1	35.8	32.9	29.7	25.8	16.9
Density independent	MAE	MODIS	31.5	22.3	19.4	16.9	14.7	11.2
Density independent	MAE	GeoWiki	23.2	12.1	9.9	8.1	6.2	3.8

Table 2: Biases and mean absolute errors (MAE) in cropland maps relative to the 2007 reference map for each aggregation scale calculated over the entire country, for the union of agricultural regions, and as density independent means, wherein the mean bias/MAE values for each of 20 cropland cover classes (representing 5% increments of cover 0% to 100% defined by the reference map) were calculated and then averaged.

Region	Metric	Map	1 km	5 km	10 km	25 km	50 km	100 km
Country	Bias	SA-LC	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9
Country	Bias	GlobCover	1.7	1.7	1.7	1.7	1.7	1.7
Country	Bias	MODIS	2.2	2.2	2.2	2.2	2.2	2.2
Country	Bias	GeoWiki	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Country	MAE	SA-LC	3.0	2.9	2.9	2.9	2.9	2.9
Country	MAE	GlobCover	11.3	9.4	8.9	8.2	7.7	7.2
Country	MAE	MODIS	7.7	6.4	6.0	5.5	5.0	4.6
Country	MAE	GeoWiki	6.2	4.4	3.8	3.1	2.6	2.2
Agricultural	Bias	SA-LC	-9.9	-4.9	-3.8	-3.3	-3.1	-2.9
Agricultural	Bias	GlobCover	3.1	2.3	2.0	1.9	1.8	1.7
Agricultural	Bias	MODIS	6.4	3.6	2.9	2.5	2.3	2.2
Agricultural	Bias	GeoWiki	-2.8	-1.6	-1.2	-1.0	-1.0	-0.9
Agricultural	MAE	SA-LC	10.4	5.0	3.9	3.3	3.1	3.0
Agricultural	MAE	GlobCover	20.6	12.8	10.7	9.1	8.1	7.4
Agricultural	MAE	MODIS	22.6	10.6	8.0	6.2	5.3	4.7
Agricultural	MAE	GeoWiki	19.2	7.7	5.2	3.6	2.8	2.2
Density independent	Bias	SA-LC	-9.9	-8.5	-8.4	-7.4	-7.0	-6.6
Density independent	Bias	GlobCover	33.8	33.8	31.2	27.4	21.6	14.8
Density independent	Bias	MODIS	20.8	13.3	10.5	6.9	6.9	7.0
Density independent	Bias	GeoWiki	3.8	-1.8	-2.5	-2.9	-0.9	-1.5
Density independent	MAE	SA-LC	10.5	8.6	8.4	7.5	7.0	6.6
Density independent	MAE	GlobCover	37.4	36.1	33.2	29.3	24.0	17.4
Density independent	MAE	MODIS	31.7	22.2	19.5	17.2	14.5	11.6
Density independent	MAE	GeoWiki	23.3	12.0	9.8	8.2	5.9	4.0

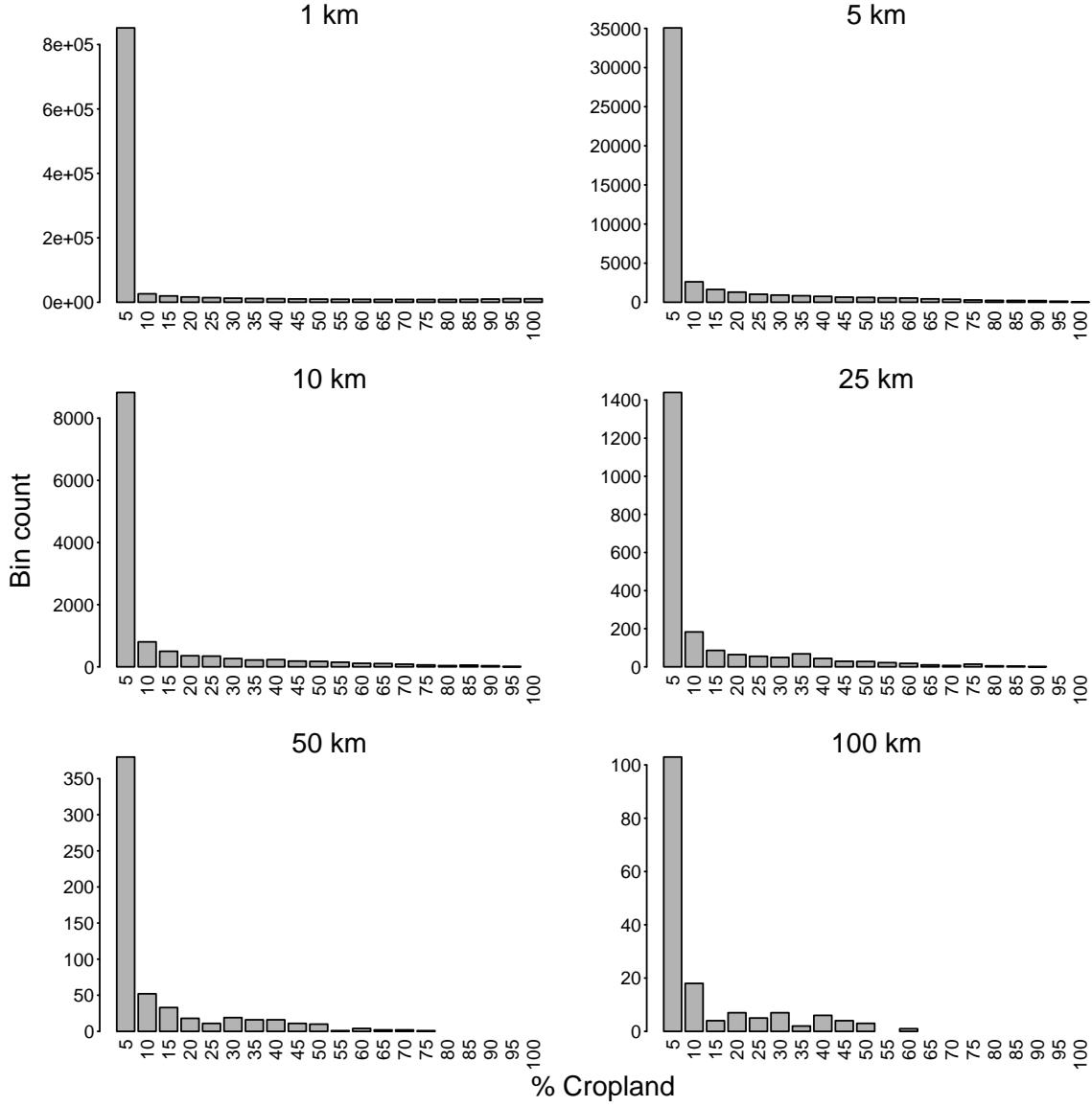


Figure 1: Number of cells within each cropland density bin at each scale of aggregation, where bins represent 5% increment of cropland cover from 0 to 100% (values on x-axis provide the upper limit of each bin).

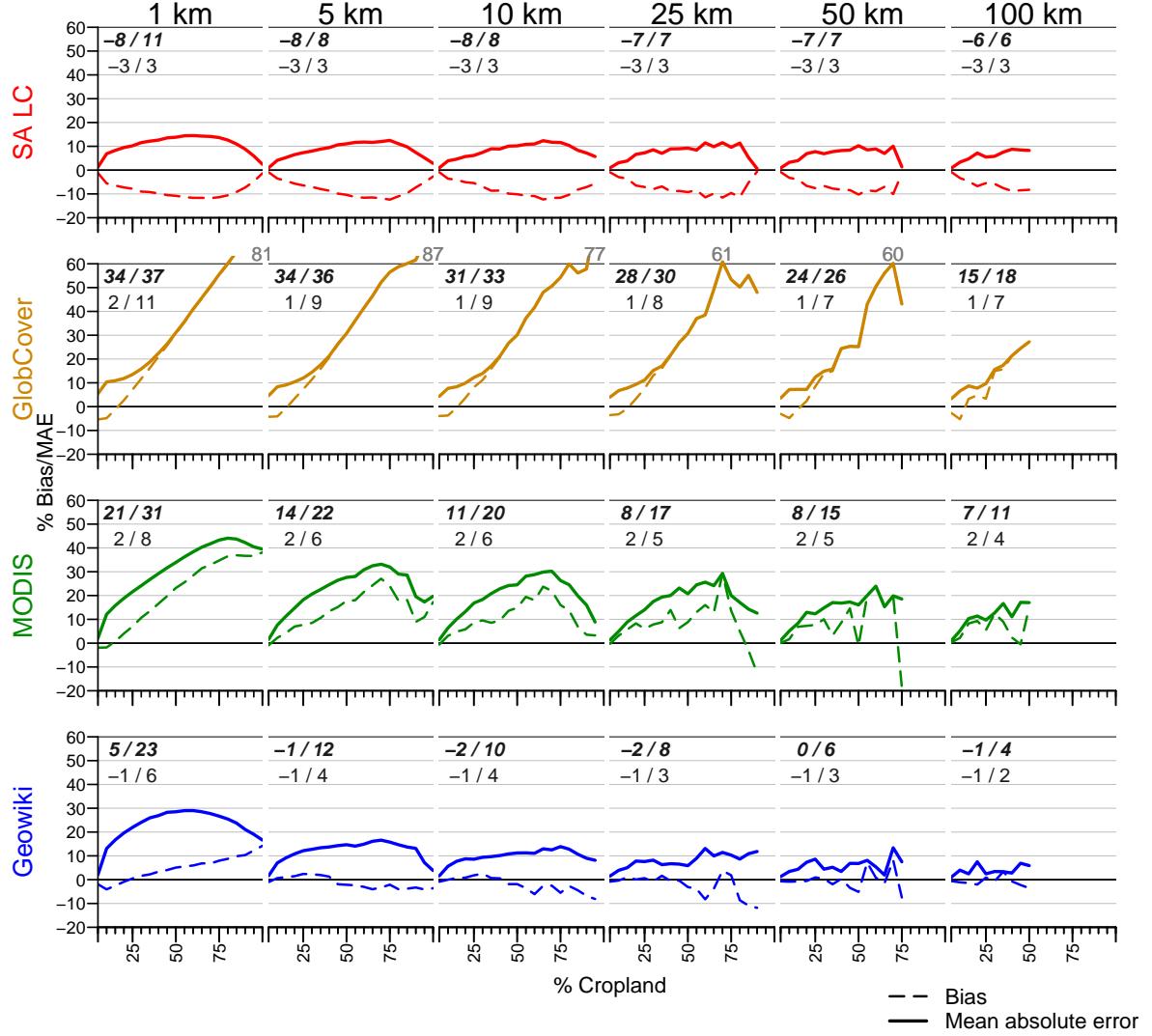


Figure 2: Biases and mean absolute errors (MAE) for each of the cropland maps as a function of cropland density (calculated using the 2011 reference maps) and aggregation scales. Rows present biases by map product, columns by aggregation scale. Dash lines indicate bias at each level of cropland density, calculated in bins spanning 5% of density (e.g. 0-5% cropland cover, 5-10%, etc.), while solid lines indicate the mean absolute error. The black numbers in each plot area present the overall means of bias/MAE for each sensor-scale combination. The bin-wise and overall mean statistics were calculated from pooled map errors calculated from differences between the 2007 reference map and each cropland map (including all three variants—high, medium, and low—of the MODIS and GlobCover-derived cropland maps), and the 2011 reference map and each cropland map.

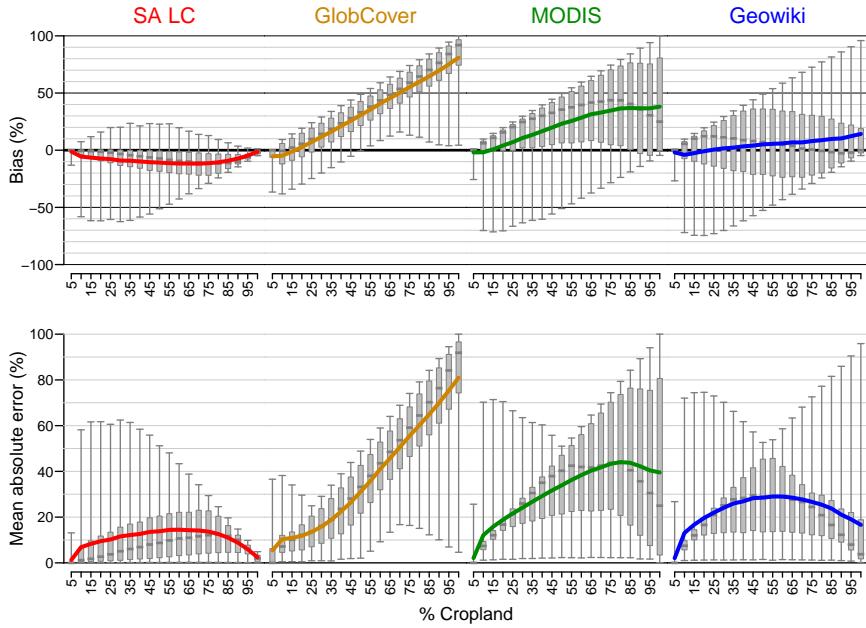


Figure 3: Biases and mean absolute errors (MAE) for each of the cropland maps at 1 km resolution, as a function of cropland density. Colored lines (color-coded to map product name) show the bias/MAE at each level of cropland density, calculated in bins spanning 5% (e.g. 0-5% cropland cover, 5-10%, etc.). Box plots show the variability of bias in each bin (whiskers = 2.5 and 97.5 percentiles, box the inter-quartile, and grey bar in box the median). Biases are presented in the top row, and MAEs in the bottom row. Statistics were calculated from pooled map errors calculated from differences between the 2007 reference map and each cropland map (including all three variants—high, medium, and low—of the MODIS and GlobCover-derived cropland maps), and the 2011 reference map and each cropland map.

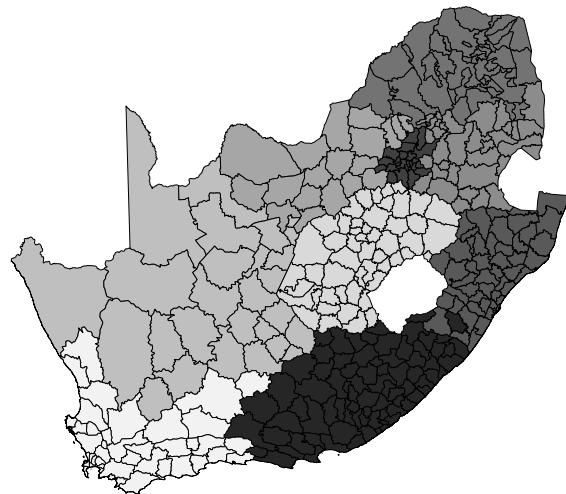


Figure 4: South Africa's magisterial districts.

Carbon bias

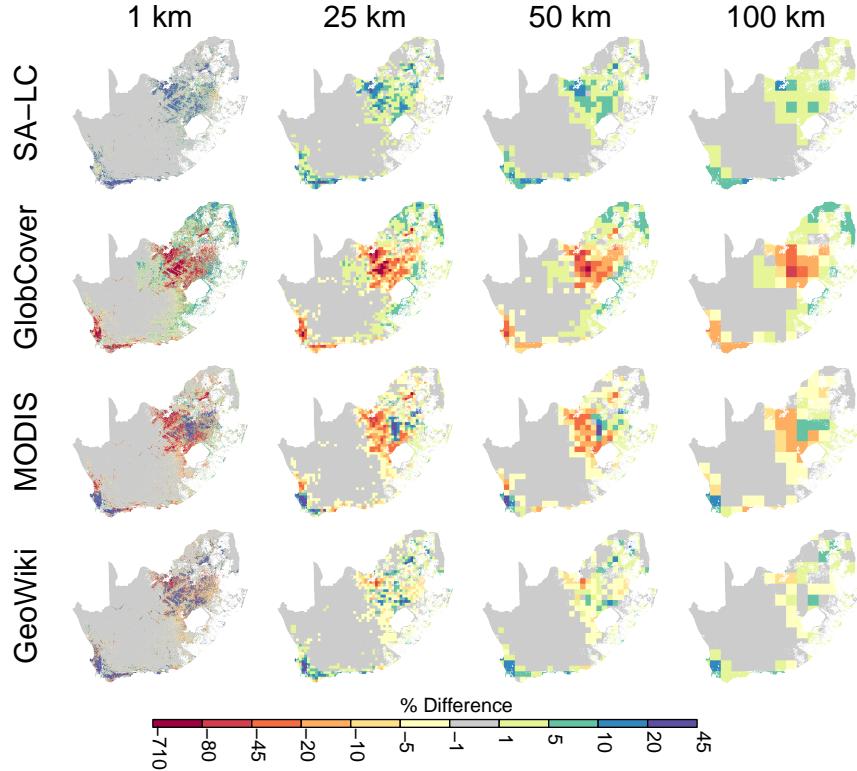


Figure 5: Spatial patterns of error (averaged across four different possible cover types adjacent to cropland) in carbon stock estimates.

Table 3: Percent differences in total carbon stock estimates calculated from the reference maps and from each of the four cropland maps. Differences are evaluated for total carbon estimates either at the country scale or over just the agricultural regions (cropland >0.05%), using the carbon densities of 5 different cover types to provide the values for the non-agricultural portions of each pixel (cover types indicated by column names).

Region	Map	Forest	Secondary	Shrubland	Grassland	Sparse
Country	SA-LC	2.6	2.5	2.5	0.1	-2.1
Country	GlobCover	-2.1	-2.0	-2.0	-0.1	1.7
Country	MODIS	-2.6	-2.5	-2.5	-0.1	2.1
Country	GeoWiki	0.6	0.5	0.5	0.0	-0.5
Agricultural	SA-LC	-2.0	-2.7	-2.8	-10.6	-14.9
Agricultural	GlobCover	-161.9	-156.3	-155.5	-95.9	-63.6
Agricultural	MODIS	-1.6	-0.8	-0.7	8.4	13.3
Agricultural	GeoWiki	7.7	7.3	7.2	2.9	0.5

Table 4: Biases and mean absolute errors for each of the cropland maps across aggregation scales and each possible landcover type sharing the pixel with cropland. Metrics were calculated across the union of agricultural areas (cropland >0.05%) identified by the reference map and the cropland map to which it was being compared

Metric	Cover	Map	1 km	5 km	10 km	25 km	50 km	100 km
Bias	All	GeoWiki	-5.6	0.8	0.8	0.5	0.4	0.4
Bias	All	GlobCover	-23.9	-8.5	-6.5	-4.7	-3.6	-2.7
Bias	All	MODIS	-22.1	-5.3	-3.9	-2.9	-2.4	-1.9
Bias	All	SA-LC	7.2	4.0	3.2	2.6	2.2	1.9
Bias	Forest	GeoWiki	-11.9	1.9	1.7	1.2	0.9	0.8
Bias	Forest	GlobCover	-51.9	-16.6	-12.5	-9.0	-6.9	-5.3
Bias	Forest	MODIS	-47.8	-10.9	-7.9	-6.0	-5.1	-4.2
Bias	Forest	SA-LC	15.6	8.6	7.0	5.5	4.8	4.2
Bias	Grassland	GeoWiki	0.1	0.1	0.0	0.0	0.0	0.0
Bias	Grassland	GlobCover	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1
Bias	Grassland	MODIS	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1
Bias	Grassland	SA-LC	0.3	0.2	0.2	0.1	0.1	0.1
Bias	Secondary	GeoWiki	-6.9	1.6	1.5	1.1	0.8	0.8
Bias	Secondary	GlobCover	-34.2	-13.2	-10.3	-7.8	-6.1	-4.7
Bias	Secondary	MODIS	-33.3	-9.4	-7.0	-5.5	-4.7	-3.9
Bias	Secondary	SA-LC	13.5	7.6	6.2	5.0	4.4	3.9
Bias	Shrubland	GeoWiki	-6.5	1.6	1.4	1.1	0.8	0.8
Bias	Shrubland	GlobCover	-32.6	-12.8	-10.0	-7.6	-6.0	-4.7
Bias	Shrubland	MODIS	-31.9	-9.2	-6.9	-5.4	-4.7	-3.9
Bias	Shrubland	SA-LC	13.2	7.5	6.1	5.0	4.4	3.8
Bias	Sparse	GeoWiki	-2.8	-1.0	-0.8	-0.8	-0.7	-0.6
Bias	Sparse	GlobCover	-0.7	0.4	0.6	0.9	1.0	1.1
Bias	Sparse	MODIS	2.9	2.9	2.8	2.7	2.6	2.5
Bias	Sparse	SA-LC	-6.7	-3.8	-3.3	-2.9	-2.8	-2.5
MAE	All	GeoWiki	26.8	9.4	6.5	4.5	3.4	2.4
MAE	All	GlobCover	36.7	17.0	14.0	11.5	9.6	8.0
MAE	All	MODIS	37.8	13.8	10.8	8.4	6.7	5.5
MAE	All	SA-LC	13.6	6.3	4.9	3.9	3.4	3.0
MAE	Forest	GeoWiki	45.9	14.3	9.8	6.6	4.8	3.4
MAE	Forest	GlobCover	68.8	27.5	22.0	17.4	14.2	11.6
MAE	Forest	MODIS	69.1	21.7	16.6	12.6	9.9	7.9
MAE	Forest	SA-LC	22.1	9.6	7.5	5.8	4.9	4.3
MAE	Grassland	GeoWiki	0.8	0.3	0.3	0.2	0.1	0.1
MAE	Grassland	GlobCover	0.8	0.6	0.5	0.4	0.4	0.3
MAE	Grassland	MODIS	0.9	0.5	0.4	0.3	0.3	0.2
MAE	Grassland	SA-LC	0.5	0.2	0.2	0.2	0.1	0.1

MAE	Secondary	GeoWiki	36.8	12.8	8.8	6.0	4.4	3.2
MAE	Secondary	GlobCover	50.2	23.5	19.3	15.6	13.0	10.7
MAE	Secondary	MODIS	52.3	19.1	14.9	11.4	9.1	7.3
MAE	Secondary	SA-LC	18.7	8.6	6.7	5.3	4.5	4.0
MAE	Shrubland	GeoWiki	35.8	12.6	8.7	6.0	4.4	3.2
MAE	Shrubland	GlobCover	48.5	23.0	19.0	15.4	12.8	10.6
MAE	Shrubland	MODIS	50.7	18.8	14.7	11.3	9.0	7.2
MAE	Shrubland	SA-LC	18.3	8.4	6.6	5.2	4.5	3.9
MAE	Sparse	GeoWiki	14.7	6.9	5.2	3.8	3.0	2.3
MAE	Sparse	GlobCover	15.3	10.5	9.4	8.5	7.7	6.8
MAE	Sparse	MODIS	16.2	9.0	7.6	6.3	5.4	4.6
MAE	Sparse	SA-LC	8.6	4.4	3.7	3.1	2.9	2.6

Table 5: Biases and mean absolute errors for each of the cropland maps across aggregation scales and each possible landcover type sharing the pixel with cropland. Means were calculated across the entire country.

Metric	Map	Cover	1 km	5 km	10 km	25 km	50 km	100 km
Bias	GeoWiki	All	-1.7	0.4	0.4	0.3	0.2	0.3
Bias	GlobCover	All	-12.6	-5.6	-4.5	-3.4	-2.7	-2.2
Bias	MODIS	All	-7.3	-2.8	-2.3	-1.9	-1.7	-1.5
Bias	SA-LC	All	2.1	2.0	1.8	1.7	1.5	1.5
Bias	GeoWiki	Forest	-3.7	0.9	0.9	0.8	0.6	0.6
Bias	GlobCover	Forest	-27.3	-10.9	-8.7	-6.5	-5.2	-4.3
Bias	MODIS	Forest	-15.8	-5.7	-4.6	-4.0	-3.6	-3.2
Bias	SA-LC	Forest	4.5	4.2	3.9	3.6	3.3	3.2
Bias	GeoWiki	Grassland	0.0	0.0	0.0	0.0	0.0	0.0
Bias	GlobCover	Grassland	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Bias	MODIS	Grassland	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Bias	SA-LC	Grassland	0.1	0.1	0.1	0.1	0.1	0.1
Bias	GeoWiki	Secondary	-2.1	0.8	0.8	0.7	0.5	0.6
Bias	GlobCover	Secondary	-18.0	-8.7	-7.1	-5.6	-4.6	-3.8
Bias	MODIS	Secondary	-11.0	-4.9	-4.1	-3.6	-3.3	-3.0
Bias	SA-LC	Secondary	3.9	3.7	3.5	3.3	3.1	3.0
Bias	GeoWiki	Shrubland	-2.0	0.8	0.8	0.7	0.5	0.6
Bias	GlobCover	Shrubland	-17.1	-8.4	-7.0	-5.5	-4.5	-3.8
Bias	MODIS	Shrubland	-10.6	-4.8	-4.1	-3.5	-3.2	-2.9
Bias	SA-LC	Shrubland	3.8	3.6	3.5	3.2	3.0	2.9
Bias	GeoWiki	Sparse	-0.9	-0.5	-0.5	-0.5	-0.5	-0.5
Bias	GlobCover	Sparse	-0.4	0.3	0.4	0.6	0.8	0.9
Bias	MODIS	Sparse	0.9	1.5	1.6	1.8	1.8	1.9
Bias	SA-LC	Sparse	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9

MAE	GeoWiki	All	8.3	4.6	3.7	3.0	2.3	1.9
MAE	GlobCover	All	19.3	11.2	9.8	8.3	7.2	6.5
MAE	MODIS	All	12.5	7.2	6.4	5.5	4.7	4.1
MAE	SA-LC	All	3.9	3.0	2.8	2.5	2.4	2.3
MAE	GeoWiki	Forest	14.3	7.0	5.6	4.3	3.3	2.6
MAE	GlobCover	Forest	36.2	18.1	15.3	12.6	10.7	9.3
MAE	MODIS	Forest	22.9	11.4	9.8	8.2	6.9	5.9
MAE	SA-LC	Forest	6.3	4.7	4.2	3.8	3.4	3.3
MAE	GeoWiki	Grassland	0.2	0.2	0.1	0.1	0.1	0.1
MAE	GlobCover	Grassland	0.4	0.4	0.3	0.3	0.3	0.3
MAE	MODIS	Grassland	0.3	0.2	0.2	0.2	0.2	0.2
MAE	SA-LC	Grassland	0.1	0.1	0.1	0.1	0.1	0.1
MAE	GeoWiki	Secondary	11.5	6.3	5.0	3.9	3.1	2.4
MAE	GlobCover	Secondary	26.4	15.5	13.4	11.3	9.8	8.6
MAE	MODIS	Secondary	17.3	10.0	8.7	7.4	6.3	5.5
MAE	SA-LC	Secondary	5.3	4.2	3.8	3.4	3.2	3.0
MAE	GeoWiki	Shrubland	11.2	6.2	5.0	3.9	3.0	2.4
MAE	GlobCover	Shrubland	25.5	15.2	13.2	11.2	9.7	8.5
MAE	MODIS	Shrubland	16.8	9.8	8.6	7.3	6.2	5.4
MAE	SA-LC	Shrubland	5.2	4.1	3.8	3.4	3.1	3.0
MAE	GeoWiki	Sparse	4.6	3.4	3.0	2.5	2.1	1.7
MAE	GlobCover	Sparse	8.0	6.9	6.6	6.2	5.8	5.5
MAE	MODIS	Sparse	5.4	4.7	4.5	4.1	3.8	3.5
MAE	SA-LC	Sparse	2.5	2.2	2.1	2.0	2.0	2.0

Yield and Harvested Area Bias

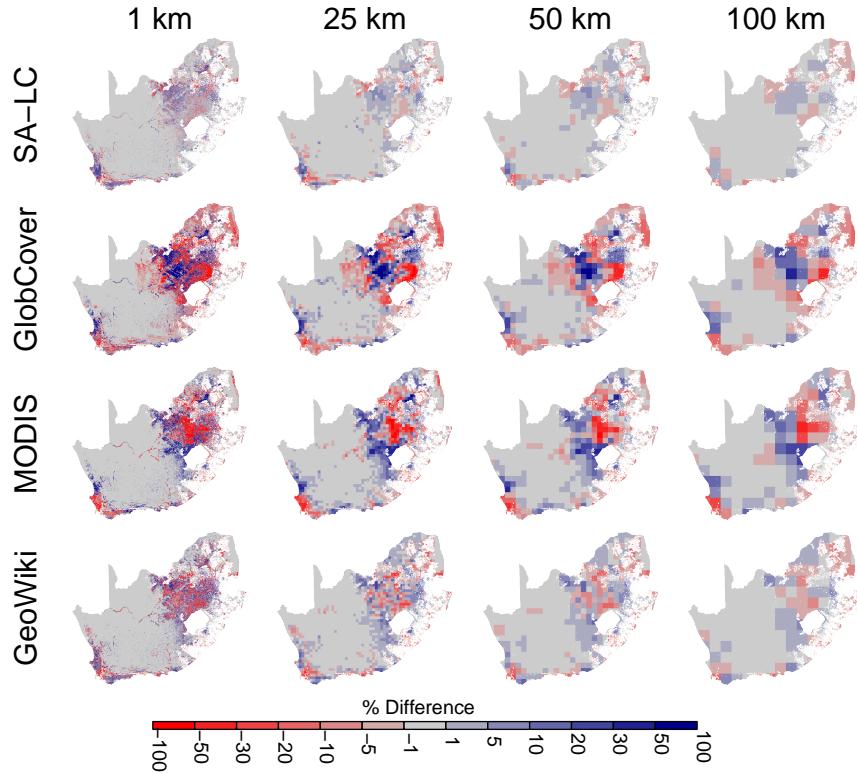


Figure 6: Errors in cropland maps adjusted using provincial cropland area statistics.

Table 6: Mean absolute errors (MAE) in statistically constrained cropland maps, calculated over the entire country, and for the union of agricultural regions ($\text{cropland} > 0$) defined by the reference and corresponding adjusted cropland maps

Region	Map	1 km	5 km	10 km	25 km	50 km	100 km
Country	SA-LC	2.8	2.0	1.7	1.4	1.2	0.9
Country	GlobCover	10.9	8.5	7.7	6.6	5.7	4.6
Country	MODIS	8.7	7.0	6.5	5.7	5.0	4.4
Country	GeoWiki	6.1	4.2	3.5	2.9	2.3	1.7
Agricultural	SA-LC	9.6	3.3	2.2	1.6	1.3	1.0
Agricultural	GlobCover	19.9	11.5	9.2	7.3	6.0	4.7
Agricultural	MODIS	25.3	11.6	8.6	6.5	5.3	4.5
Agricultural	GeoWiki	18.4	7.2	4.8	3.3	2.5	1.8

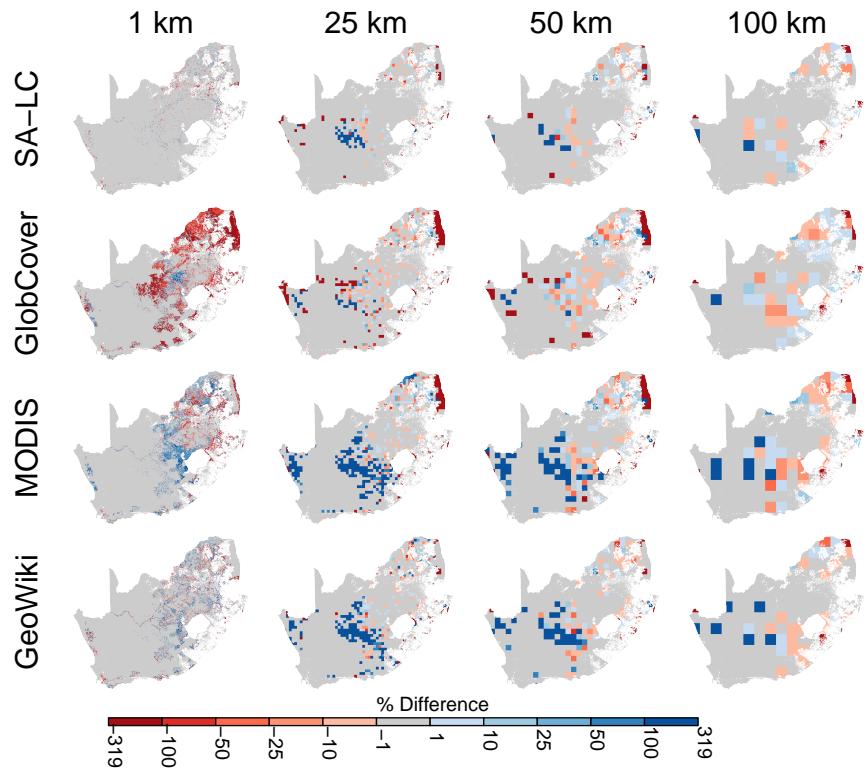


Figure 7: Errors (normalized to the reference-derived country mean) in disaggregated maize yield estimates.

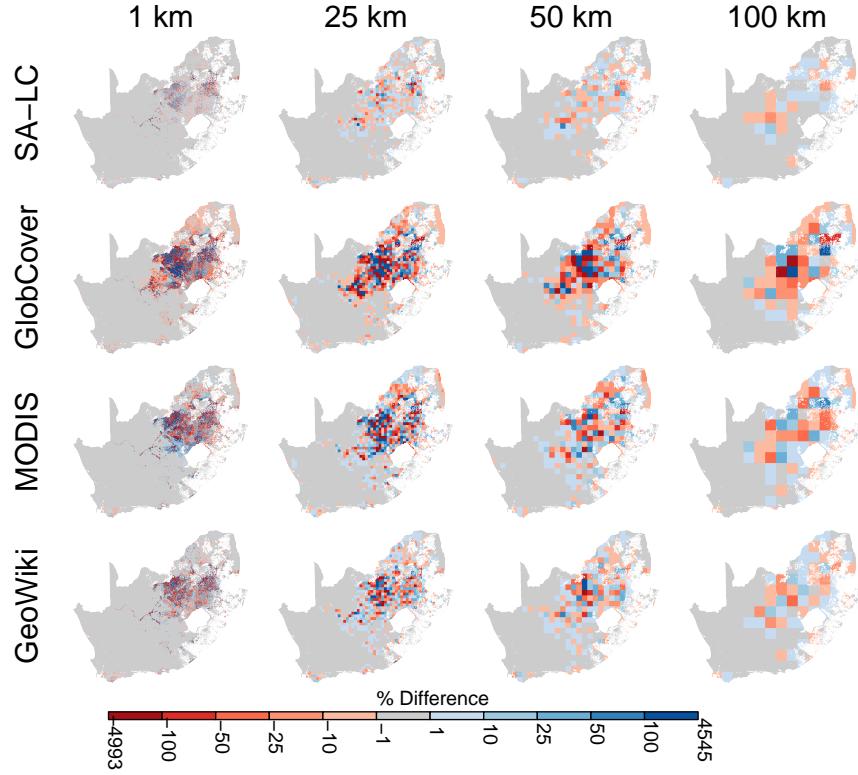


Figure 8: Errors (normalized to reference-derived country mean) production estimates calculated from disaggregated maize yield and harvested area estimates.

Table 7: Biases and mean absolute errors (MAE) in disaggregated maize yield and production (calculated from disaggregated yield and harvested area estimates) maps. Bias and MAE were normalized to their respective mean values calculated from reference maps.

Metric	Map	Variable	1 km	5 km	10 km	25 km	50 km	100 km
Bias	SA-LC	Yield	-5.1	-0.3	2.9	3.5	3.5	1.5
Bias	GlobCover	Yield	-58.0	-35.5	-21.9	-11.7	-8.8	-1.5
Bias	MODIS	Yield	5.1	21.1	28.7	26.4	20.2	11.4
Bias	GeoWiki	Yield	2.4	24.1	29.0	24.9	21.1	9.6
Bias	SA-LC	Production	0.0	-0.1	-0.1	-0.1	-0.0	0.0
Bias	GlobCover	Production	0.0	-0.1	0.0	0.1	0.3	0.3
Bias	MODIS	Production	0.0	-0.1	-0.1	-0.1	0.0	-0.1
Bias	GeoWiki	Production	0.0	0.1	0.0	0.0	0.1	0.1
MAE	SA-LC	Yield	15.5	16.4	19.6	15.5	12.0	6.7
MAE	GlobCover	Yield	71.7	47.6	37.4	23.1	17.0	6.1
MAE	MODIS	Yield	55.9	50.5	50.0	44.2	37.8	20.4
MAE	GeoWiki	Yield	41.1	40.5	39.8	34.5	28.1	14.3
MAE	SA-LC	Production	19.7	11.3	8.6	5.5	3.3	1.9
MAE	GlobCover	Production	55.7	55.5	52.5	42.2	28.1	17.3

MAE	MODIS	Production	56.0	41.3	35.6	24.9	14.1	8.4
MAE	GeoWiki	Production	43.7	30.2	23.5	15.3	9.3	4.0

Evapotranspiration bias

Table 8: Biases and mean absolute errors (as %) for evapotranspiration variables derived from a 29-year time series calculated by the VIC model, including the average total ET for the 3 months of the year when ET is highest, the annual mean and the minimum and maximum annual ETs in the time series.

Variable	Map	Bias	Abs Bias
Peak	GeoWiki	0.2	0.8
Annual Mean	GeoWiki	0.3	0.7
29-year Min	GeoWiki	0.3	0.6
29-year Max	GeoWiki	0.3	0.8
Peak	GlobCover	0.1	1.2
Annual Mean	GlobCover	-0.1	1.0
29-year Min	GlobCover	-0.2	0.9
29-year Max	GlobCover	0.2	1.2
Peak	MODIS	-0.5	0.9
Annual Mean	MODIS	-0.6	0.8
29-year Min	MODIS	-0.6	0.7
29-year Max	MODIS	-0.5	0.8
Peak	SA-LC	0.3	0.7
Annual Mean	SA-LC	0.5	0.6
29-year Min	SA-LC	0.4	0.5
29-year Max	SA-LC	0.4	0.6

Agent allocation bias

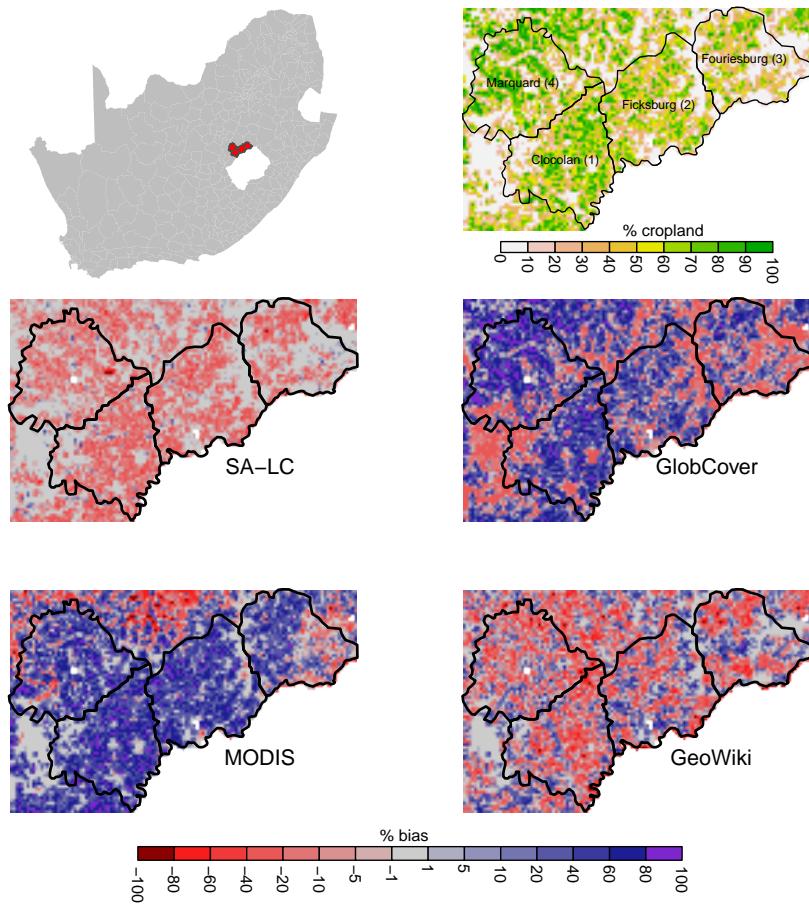


Figure 9: The location of the four selected magisterial districts (top left) used in evaluating agent allocation bias, the reference levels of cropland cover within those districts (top right), and the difference in cropland percentage between the reference and each of the four cropland maps (lower four panels).

References