

## Appendix S1: Supplementary Results

### Landcover map bias

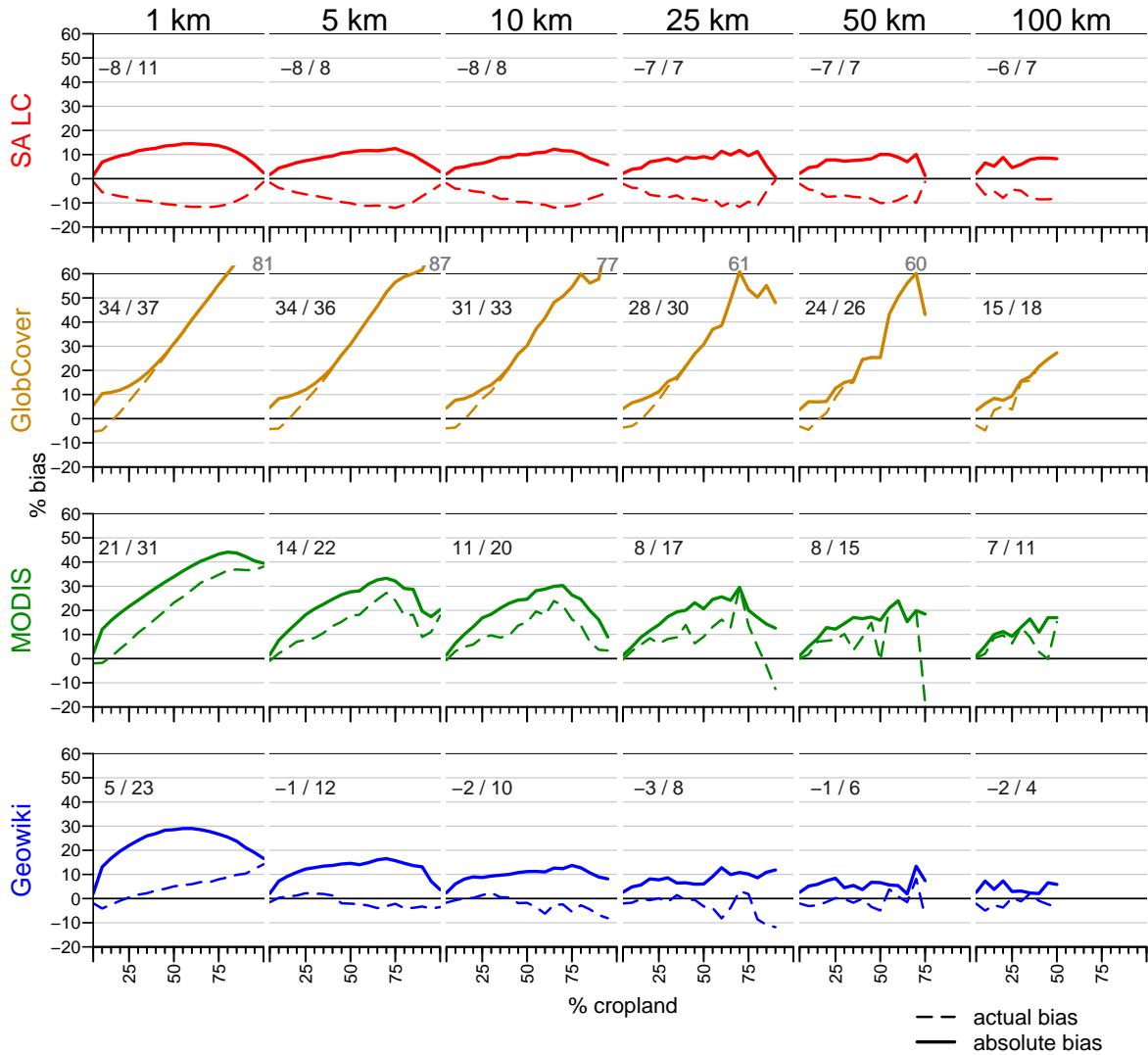


Figure 1: Mean biases for each of the landcover maps as a function of cropland density (calculated using the 2011 reference maps) and aggregation scales. Rows present biases by map product, columns by aggregation scale. Dash lines indicate mean actual bias at each level of cropland density, calculated in bins spanning 5% of density (e.g. 0-5% cropland cover, 5-10%, etc.), while solid lines indicate the mean absolute bias. The black numbers in each plot area present the overall means of actual and absolute bias for each sensor-scale combination (actual/absolute).

### Carbon bias

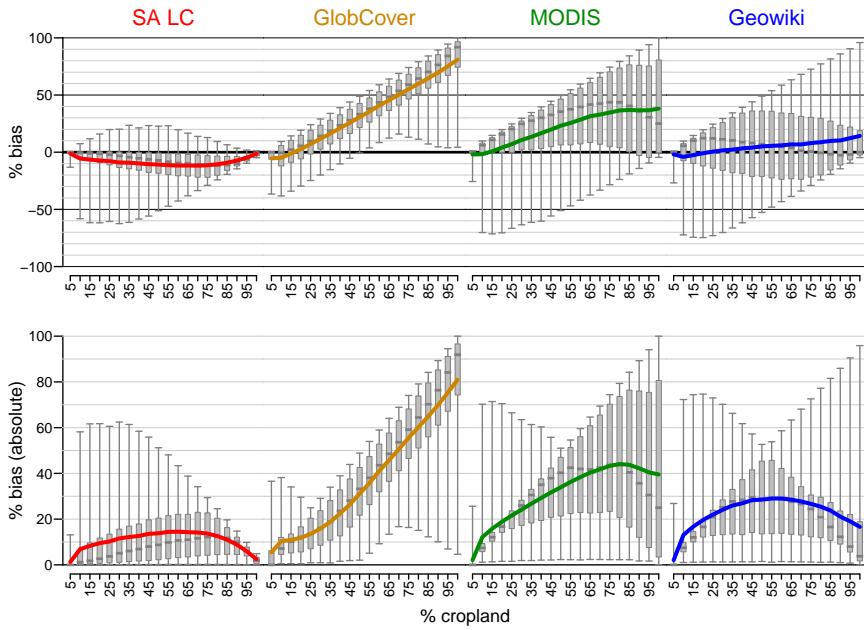


Figure 2: Mean biases for each of the landcover maps at 1 km resolution, as a function of cropland density. Colored lines (color-coded to map product name) show the mean bias at each level of cropland density, calculated in bins spanning 5% (e.g. 0-5% cropland cover, 5-10%, etc.). Box plots show the variability of bias in each bin (whiskers = 2.5 and 97.5 percentiles, box the inter-quartile, and grey bar in box the median). Actual biases are presented in the top row, and absolute biases in the bottom row.

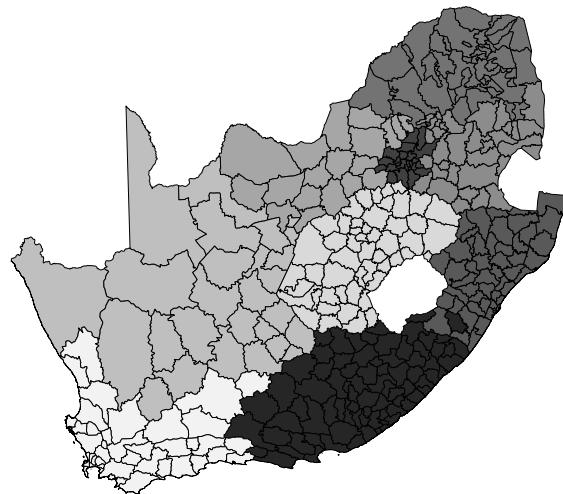


Figure 3: South Africa's magisterial districts.

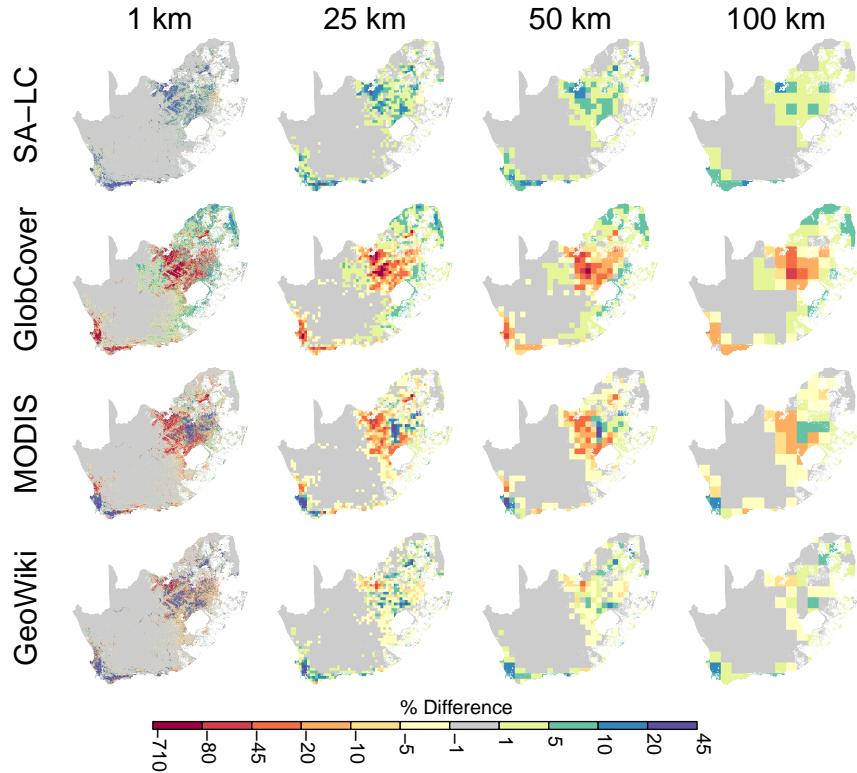


Figure 4: Spatial patterns of mean bias (across four different possible cover types adjacent to cropland) in carbon stock estimates.

Table 1: 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 2: Mean actual and absolute biases for each of the cropland maps across aggregation scales and each possible landcover type sharing the pixel with cropland. Means 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

Bias	Cover	Map	1 km	5 km	10 km	25 km	50 km	100 km
Actual	Forest	SA-LC	15.6	8.6	7.0	5.6	4.8	4.2
Actual	Forest	GlobCover	-51.9	-16.6	-12.5	-9.0	-6.9	-5.3
Actual	Forest	MODIS	-47.8	-10.9	-7.9	-6.0	-5.1	-4.2
Actual	Forest	geow	-11.9	1.9	1.7	1.2	0.9	0.8
Actual	Secondary	SA-LC	13.5	7.6	6.2	5.1	4.5	3.9
Actual	Secondary	GlobCover	-34.2	-13.2	-10.3	-7.8	-6.1	-4.7
Actual	Secondary	MODIS	-33.3	-9.4	-7.0	-5.5	-4.7	-3.9
Actual	Secondary	geow	-6.9	1.6	1.5	1.1	0.8	0.8
Actual	Shrubland	SA-LC	13.2	7.5	6.1	5.0	4.4	3.9
Actual	Shrubland	GlobCover	-32.6	-12.8	-10.0	-7.6	-6.0	-4.7
Actual	Shrubland	MODIS	-31.9	-9.2	-6.9	-5.4	-4.6	-3.9
Actual	Shrubland	geow	-6.5	1.6	1.4	1.1	0.8	0.8
Actual	Grassland	SA-LC	0.3	0.2	0.2	0.1	0.1	0.1
Actual	Grassland	GlobCover	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1
Actual	Grassland	MODIS	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1
Actual	Grassland	geow	0.1	0.1	0.0	0.0	0.0	0.0
Actual	Sparse	SA-LC	-6.7	-3.8	-3.3	-2.9	-2.8	-2.5
Actual	Sparse	GlobCover	-0.7	0.4	0.6	0.8	1.0	1.1
Actual	Sparse	MODIS	2.9	2.9	2.8	2.7	2.6	2.5
Actual	Sparse	geow	-2.8	-1.0	-0.8	-0.8	-0.7	-0.7
Actual	All	SA-LC	7.2	4.0	3.2	2.6	2.2	1.9
Actual	All	GlobCover	-23.9	-8.5	-6.5	-4.7	-3.6	-2.7
Actual	All	MODIS	-22.1	-5.3	-3.9	-2.9	-2.4	-1.9
Actual	All	geow	-5.6	0.8	0.8	0.5	0.4	0.4
Absolute	Forest	SA-LC	22.1	9.6	7.5	5.8	5.0	4.3
Absolute	Forest	GlobCover	68.8	27.5	22.0	17.3	14.2	11.6
Absolute	Forest	MODIS	69.1	21.7	16.6	12.6	9.9	7.9
Absolute	Forest	geow	45.9	14.3	9.8	6.6	4.8	3.4
Absolute	Secondary	SA-LC	18.7	8.6	6.7	5.3	4.6	4.0
Absolute	Secondary	GlobCover	50.2	23.5	19.3	15.6	13.0	10.7
Absolute	Secondary	MODIS	52.3	19.1	14.9	11.4	9.1	7.3
Absolute	Secondary	geow	36.8	12.8	8.8	6.0	4.4	3.2
Absolute	Shrubland	SA-LC	18.3	8.4	6.6	5.2	4.5	3.9
Absolute	Shrubland	GlobCover	48.5	23.0	19.0	15.4	12.8	10.5
Absolute	Shrubland	MODIS	50.7	18.7	14.7	11.3	9.0	7.2
Absolute	Shrubland	geow	35.8	12.6	8.7	6.0	4.4	3.2

Absolute	Grassland	SA-LC	0.5	0.2	0.2	0.2	0.1	0.1
Absolute	Grassland	GlobCover	0.8	0.6	0.5	0.4	0.4	0.3
Absolute	Grassland	MODIS	0.9	0.5	0.4	0.3	0.3	0.2
Absolute	Grassland	geow	0.8	0.3	0.3	0.2	0.1	0.1
Absolute	Sparse	SA-LC	8.6	4.4	3.7	3.1	2.9	2.6
Absolute	Sparse	GlobCover	15.3	10.5	9.4	8.5	7.7	6.8
Absolute	Sparse	MODIS	16.2	9.0	7.6	6.3	5.4	4.6
Absolute	Sparse	geow	14.7	6.9	5.2	3.8	3.0	2.3
Absolute	All	SA-LC	13.6	6.3	4.9	3.9	3.4	3.0
Absolute	All	GlobCover	36.7	17.0	14.0	11.4	9.6	8.0
Absolute	All	MODIS	37.8	13.8	10.8	8.4	6.7	5.4
Absolute	All	geow	26.8	9.4	6.5	4.5	3.4	2.4

Table 3: Mean actual and absolute biases for each of the cropland maps across aggregation scales and each possible landcover type sharing the pixel with cropland. Means 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

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

Actual	geow	All	-1.7	0.4	0.4	0.3	0.2	0.3
Absolute	SA-LC	Forest	6.3	4.7	4.2	3.8	3.5	3.3
Absolute	GlobCover	Forest	36.2	18.1	15.3	12.6	10.7	9.3
Absolute	MODIS	Forest	22.9	11.4	9.8	8.2	6.8	5.9
Absolute	geow	Forest	14.3	7.0	5.6	4.3	3.3	2.6
Absolute	SA-LC	Secondary	5.3	4.2	3.8	3.5	3.2	3.0
Absolute	GlobCover	Secondary	26.4	15.5	13.4	11.3	9.8	8.6
Absolute	MODIS	Secondary	17.3	10.0	8.7	7.4	6.3	5.5
Absolute	geow	Secondary	11.5	6.3	5.0	3.9	3.1	2.4
Absolute	SA-LC	Shrubland	5.2	4.1	3.8	3.4	3.1	3.0
Absolute	GlobCover	Shrubland	25.5	15.2	13.2	11.1	9.6	8.5
Absolute	MODIS	Shrubland	16.8	9.8	8.6	7.3	6.2	5.4
Absolute	geow	Shrubland	11.2	6.2	5.0	3.9	3.0	2.4
Absolute	SA-LC	Grassland	0.1	0.1	0.1	0.1	0.1	0.1
Absolute	GlobCover	Grassland	0.4	0.4	0.3	0.3	0.3	0.3
Absolute	MODIS	Grassland	0.3	0.2	0.2	0.2	0.2	0.2
Absolute	geow	Grassland	0.2	0.2	0.1	0.1	0.1	0.1
Absolute	SA-LC	Sparse	2.5	2.2	2.1	2.0	2.0	2.0
Absolute	GlobCover	Sparse	8.0	6.9	6.6	6.2	5.8	5.5
Absolute	MODIS	Sparse	5.4	4.7	4.5	4.1	3.8	3.5
Absolute	geow	Sparse	4.6	3.4	3.0	2.5	2.1	1.7
Absolute	SA-LC	All	3.9	3.1	2.8	2.5	2.4	2.3
Absolute	GlobCover	All	19.3	11.2	9.8	8.3	7.2	6.5
Absolute	MODIS	All	12.5	7.2	6.4	5.5	4.7	4.1
Absolute	geow	All	8.3	4.6	3.7	3.0	2.3	1.9

## Yield and Harvested Area Bias

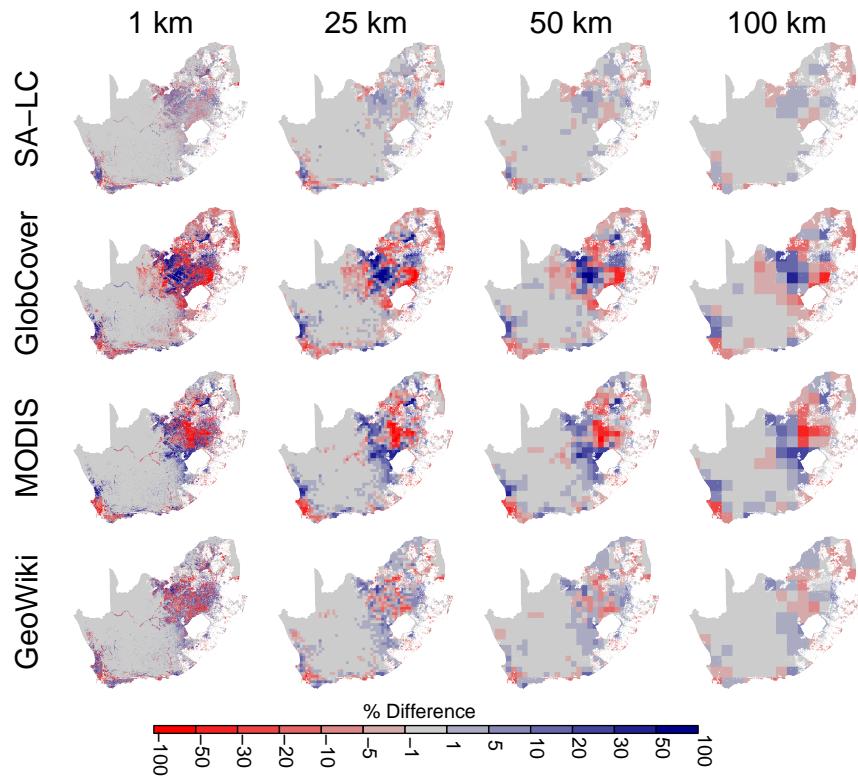


Figure 5: Biases in cropland maps adjusted using provincial level cropland area estimates.

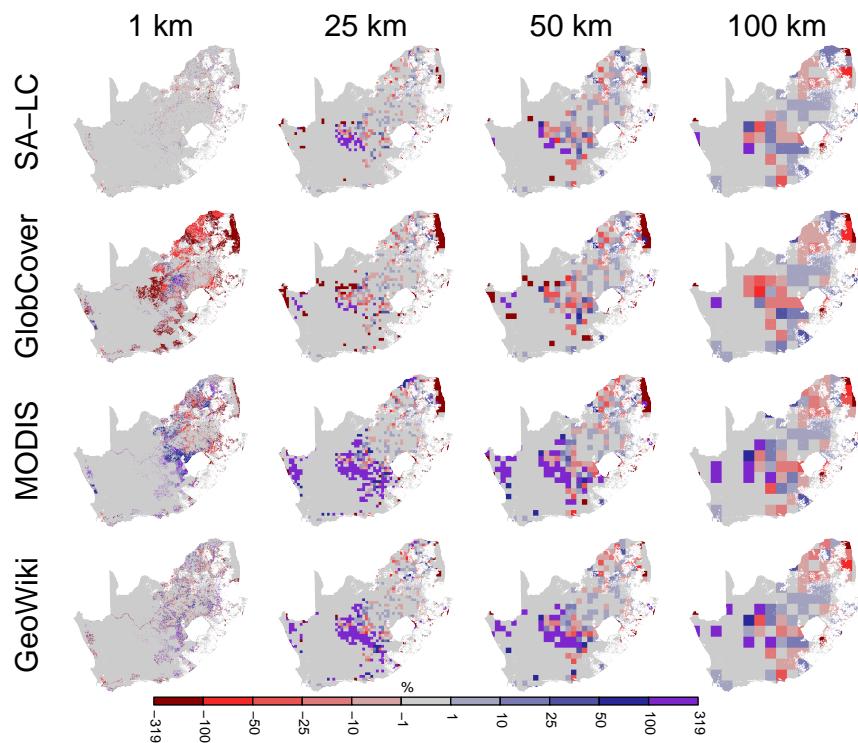


Figure 6: Biases in disaggregated maize yield estimates.

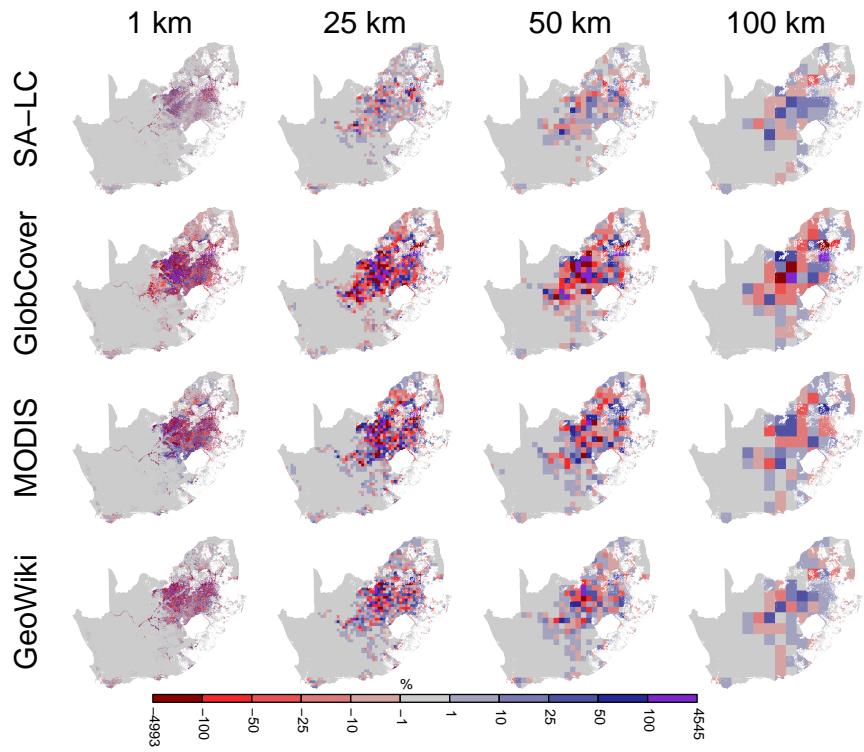


Figure 7: Biases in production estimates calculated from disaggregated maize yield and harvested area estimates.

Table 4: Mean actual and absolute biases for yield and production estimates disaggregated from magisterial district level farm census data onto adjusted cropland maps. Biases were calculated as percent differences relative to the mean value calculated from the reference map.

Bias	Map	Variable	1 km	5 km	10 km	25 km	50 km	100 km
Actual	SA-LC	Yield	-5.1	-0.3	2.9	3.5	3.5	1.5
Actual	GlobCover	Yield	-58.0	-35.5	-21.9	-11.7	-8.8	-1.5
Actual	MODIS	Yield	5.1	21.1	28.7	26.4	20.2	11.4
Actual	GeoWiki	Yield	2.4	24.1	29.0	24.9	21.1	9.6
Actual	SA-LC	Production	0.0	-0.1	-0.1	-0.1	-0.0	0.0
Actual	GlobCover	Production	0.0	-0.1	0.0	0.1	0.3	0.3
Actual	MODIS	Production	0.0	-0.1	-0.1	-0.1	0.0	-0.1
Actual	GeoWiki	Production	0.0	0.1	0.0	0.0	0.1	0.1
Absolute	SA-LC	Yield	15.5	16.4	19.6	15.5	12.0	6.7
Absolute	GlobCover	Yield	71.7	47.6	37.4	23.1	17.0	6.1
Absolute	MODIS	Yield	55.9	50.5	50.0	44.2	37.8	20.4
Absolute	GeoWiki	Yield	41.1	40.5	39.8	34.5	28.1	14.3
Absolute	SA-LC	Production	19.7	11.3	8.6	5.5	3.3	1.9
Absolute	GlobCover	Production	55.7	55.5	52.5	42.2	28.1	17.3
Absolute	MODIS	Production	56.0	41.3	35.6	24.9	14.1	8.4
Absolute	GeoWiki	Production	43.7	30.2	23.5	15.3	9.3	4.0

### Evapotranspiration bias

Table 5: Mean actual and absolute biases (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

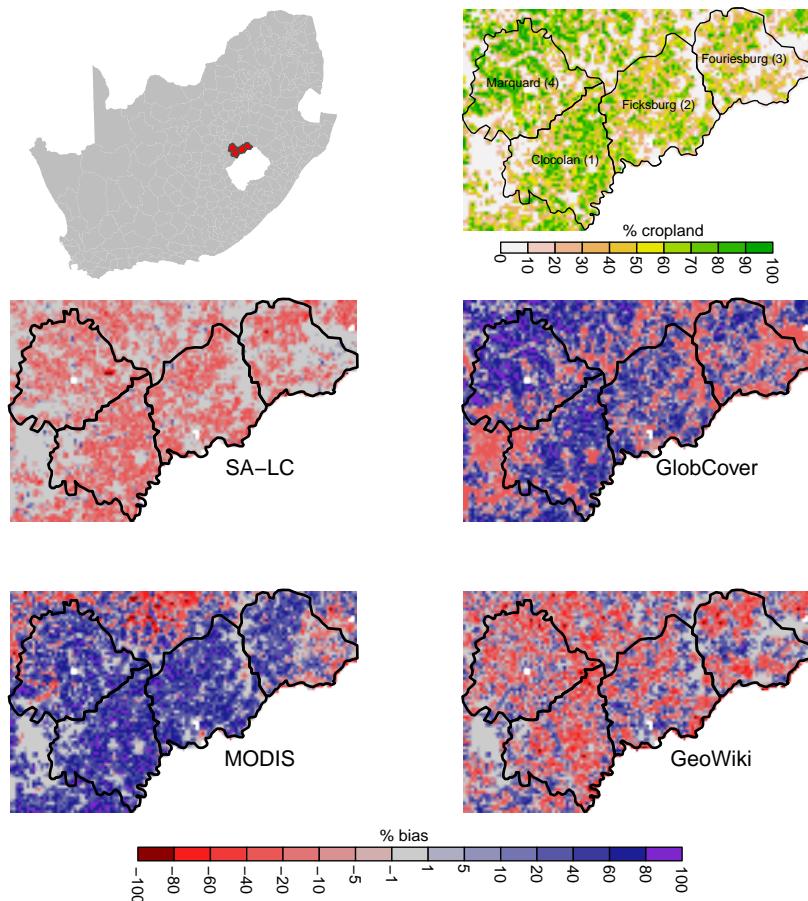


Figure 8: The location of the four selected magisterial districts (top left) used in evaluating agent allocation bias, the reference levels of cropland cover within those districts (top right), and the difference in cropland percentage between the reference and each of the four cropland maps (lower four panels).

### References