Phytotoxic Assessment of O_3 and SO_2 on Four Major Crops in Mpumalanga, South Africa

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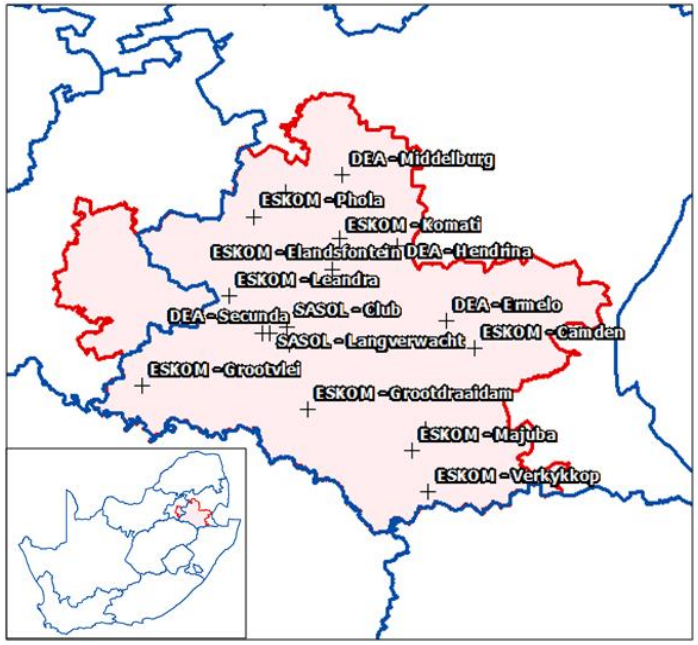
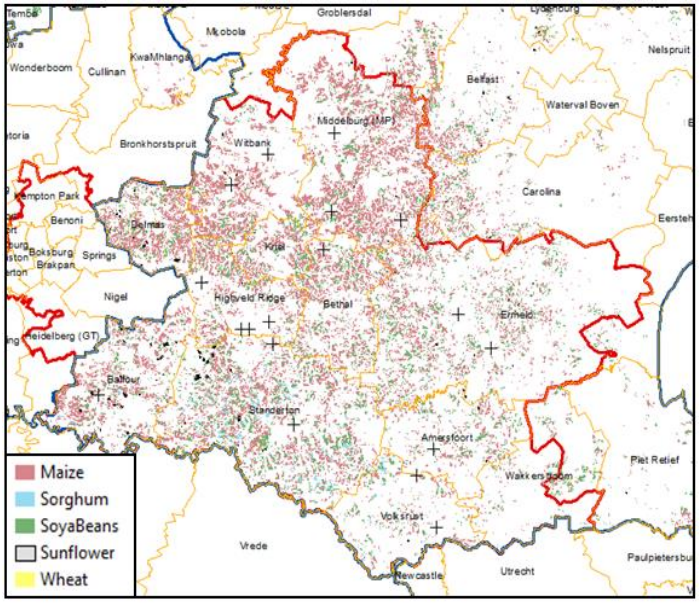
The Highveld Priority Area





Network	Station Name	Coordinates	Location details
DEA	Secunda	26.548578°S 29.080055°E	In a township
DEA	Witbank	25.877812°S 29.188664°E	In a township
DEA	Hendrina	26.150947°S 29.716789°E	Rural community
DEA	Middelburg	25.796061°S 29.463623°E	Middle class community
DEA	Ermelo	26.493372°S 29.968056°E	In a township
SASOL	Club	26.519579°S 29.194118°E	Upper class club
SASOL	L/Embelenhle	26.551389°S 29.1125°E	Middle class near mines
ESKOM	Amersfoort	27.010167°S 29.867833°E	-
ESKOM	Camden	26.622608°S 30.108976°E	Rural near power station
ESKOM	Phola	25.995670°S 29.038173°E	In a townswhip
ESKOM	Majuba	27.112809°S 29.800300°E	Rural. No population
ESKOM	Verkykkop	26.309091°S 29.881436°E	Rural. No population
ESKOM	Leandra	26.371822°S 28.917127°E	Middle class & township
ESKOM	Elandsfontein	26.245487°S 29.417382°E	Rural. No population
ESKOM	Komati	26.098178°S 29.450542°E	Rural near power station
ESKOM	Grootdraaidam	26.891813°S 29.307802°E	Rural. No population
ESKOM	Grootvlei	26.764677°S 28.480087°E	Rural community
ESKOM	Bossiespruit	26.605833°S 29.210833°E	Rural. No Population

http://www.timeslive.co.za/sundaytimes/businesstimes/2016/12/04/Success-in-silicosis-case-raises-workers-hopes-of-more-actions

http://www.kasipedia.com/2017/01/30/daveyton-shoot-by-neo-sefatsa/

http://abahlali.org/node/date/2015/09/

http://communitymonitors.net/wp-content/uploads/2016/07/SusanUmzobenzi-20160722-3.jpg

O3 in the HPA

In 2016, the new 2015 8-hour ozone NAAQS was exceeded in the **LA Basin on 132 days**

(AQMD)

SA standards were exceeded on **20-245 days in 2016 in the HPA**

(DEA)

0.061 ppm SA DEA
0.070 ppm US EPA

AOT40

- An excess indicator for the protection of vegetation defined by the European Union
- An accumulated ozone exposure over a threshold of 40 ppb (80 µg/m³).
- Calculated over 3 months and during daylight hours: 6 am to 6 pm when plant stomata is open
- Only years with 80 % data availability

$$data\ completeness = \frac{number\ of\ valid\ data\ points\ obtained}{total\ number\ of\ data\ points\ in\ the\ averaging}$$

$$\mathrm{AOT40} = \sum_{i=1}^{n}([c_{O_3}] - 40ppb)$$

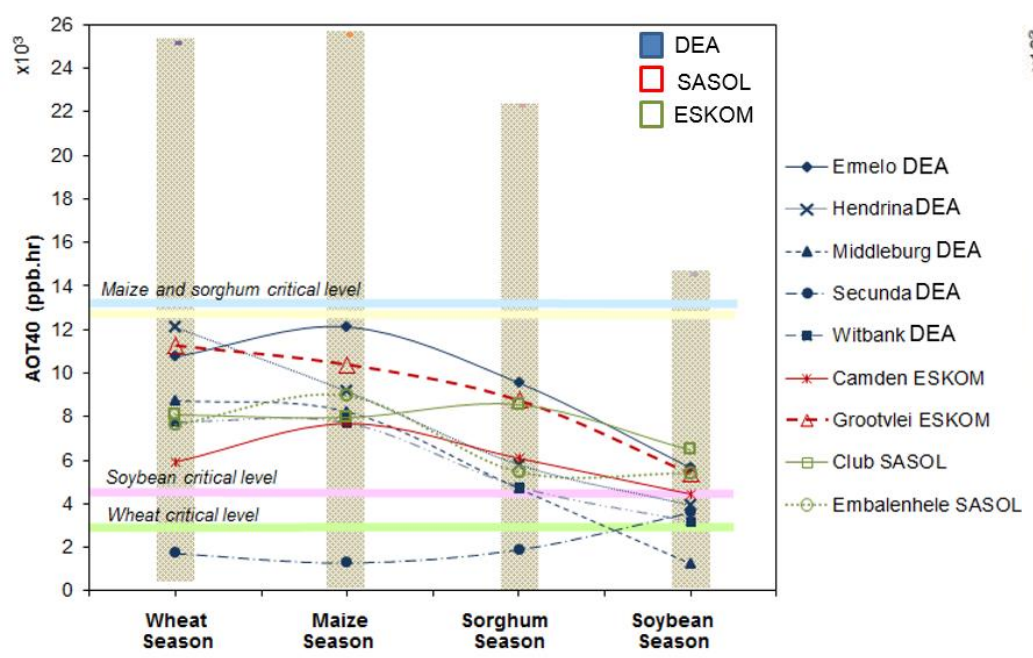
Wheat
(August-October)

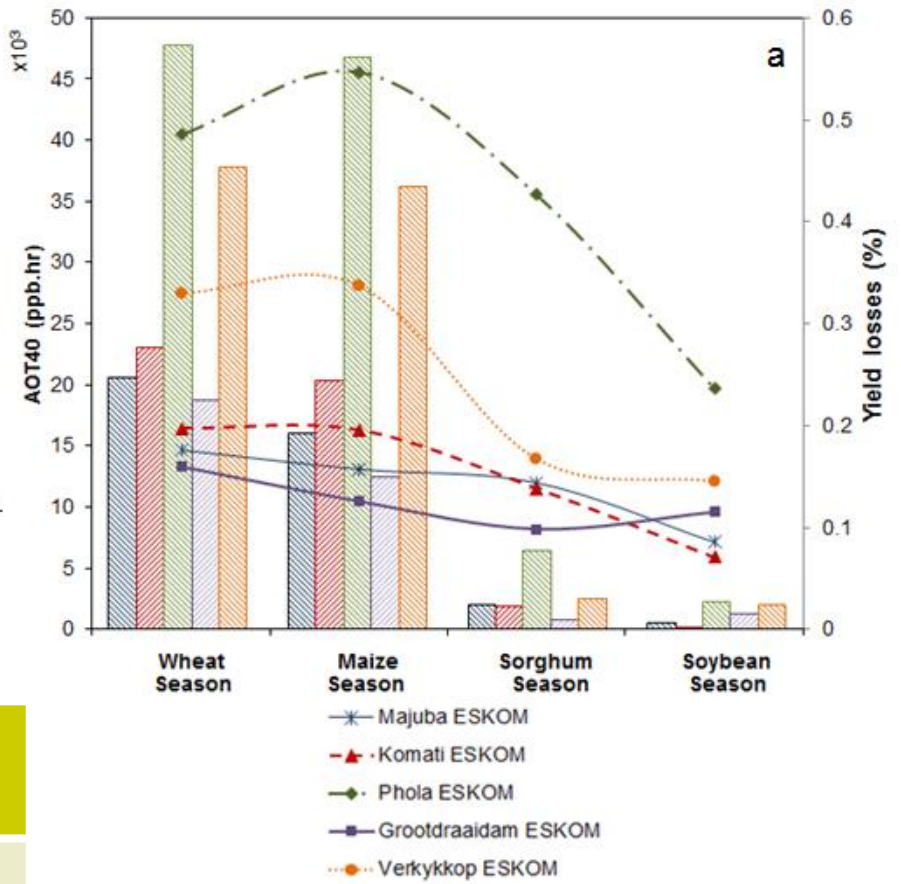
4 major crops

Maize
(September-November)

Sorghum
(October-December)

Soybean
(November-January)

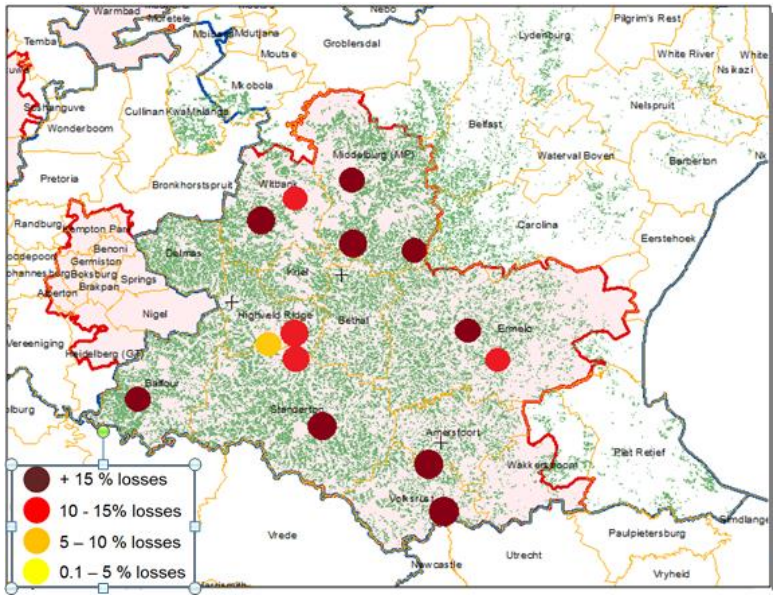




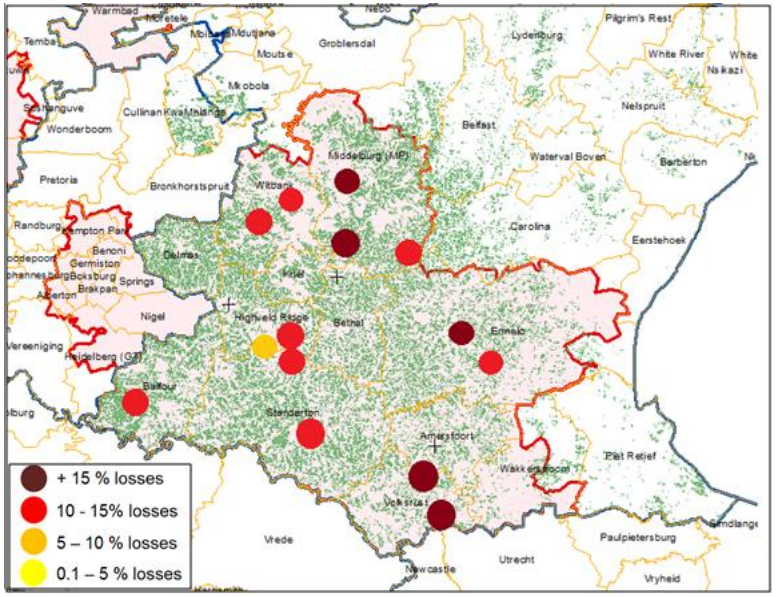
Crop	Function (y=relative yield x = AOT40 in ppm.hr)	Reference
Wheat (C3)	y=-0.0161x+0.99	Fuhrer et al. (1986a) Temple (1990b)
Maize (C4)	y= -0.0036x+1.02	Rudorff et al. (1996), Mulchi et al. (1995), Kress and Miller (1985)
Soghum (C4)	y= -0.0036x+1.02 (same as maize was used)	Rudorff et al. (1996), Mulchi et al. (1995), Kress and Miller (1985)
Soybean (C3)	y=-0.0116x+1.02	Heagle et al. (1988b), Heggestad et al. (1985, 1988), Mulchi et al. (1995) Heggestad and Lesser (1990), Heagle et al. (1987a, 1998), Fiscus et al. (1997)

- Previously developed **response functions** were utilized to calculate the **yield losses** for each crop
- No AOT40 equation has been developed for sorghum. The same equation as maize was used because both are C4 plants

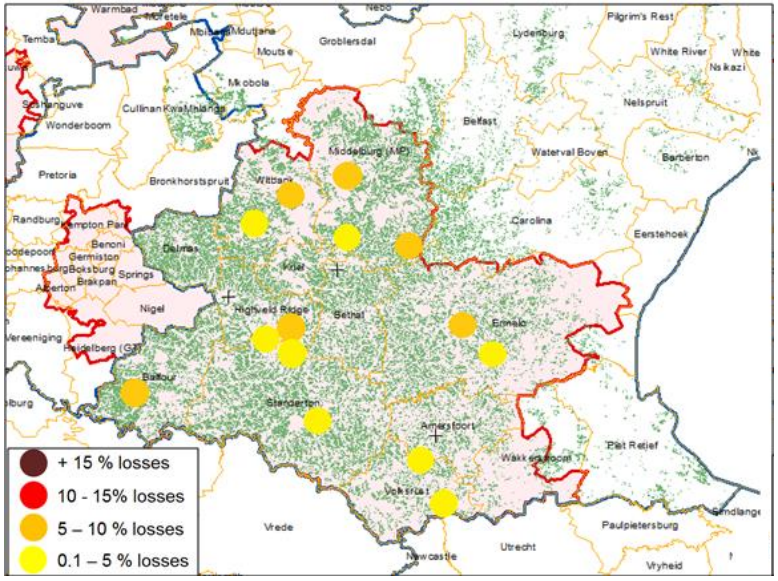
Wheat



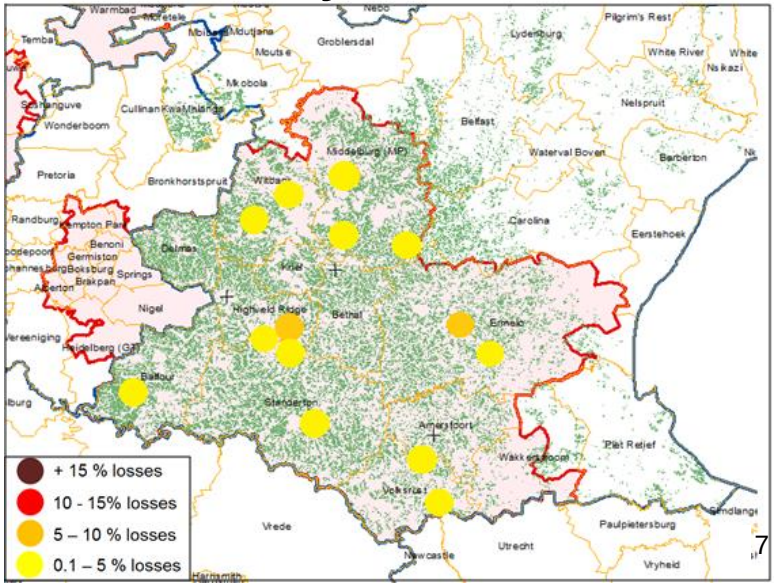
Maize



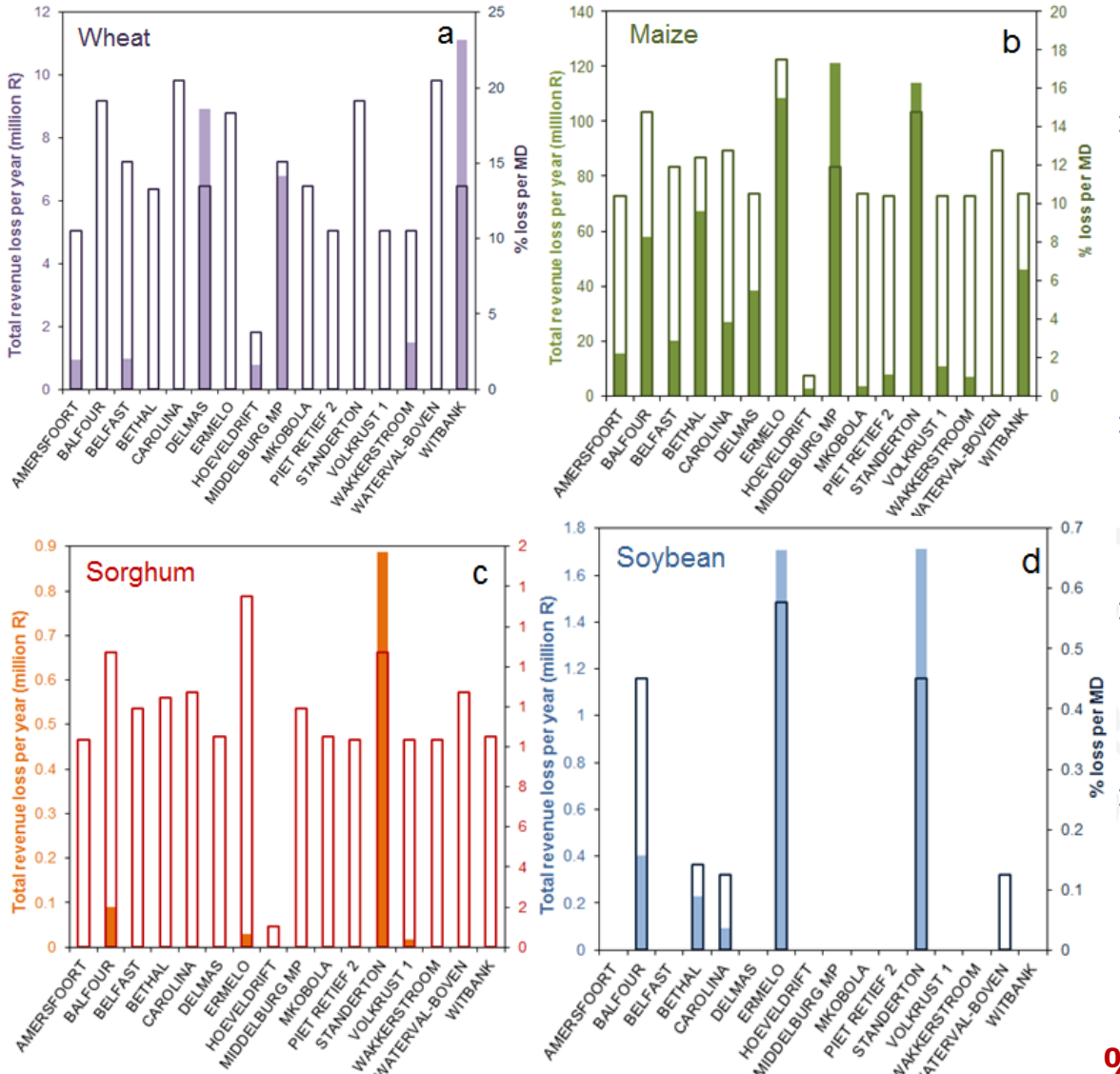
Sorghum



Soybean



Revenue loss due to ozone



Conclusions

- The most affected crop is **wheat** (multi-year average yield loss (AYL) of 14.21% and multi-year average total annual loss (TAL) of **$2.39 million** in the region)
- 2nd: **Maize** (AYL of 11.42% and TAL of **$49.9 million** in the region)
- 3rd: **Sorghum** (AYL of 0.55% and TAL of **$0.08 million** in the region)
- 4th: **Soybean** (AYL of 0.12% and TAL of **$0.32 million** in the region)

$ 52.69 million total loss
% of national GDP = 0.02%
% of GDP in Mpumalanga = 0.37%