"Assessing combusted biomass from grassland savanna fires using SEVIRI geostationary imagery. Comparison with the pre-burn biomass availability derived from the SPOT VGT NPP product."

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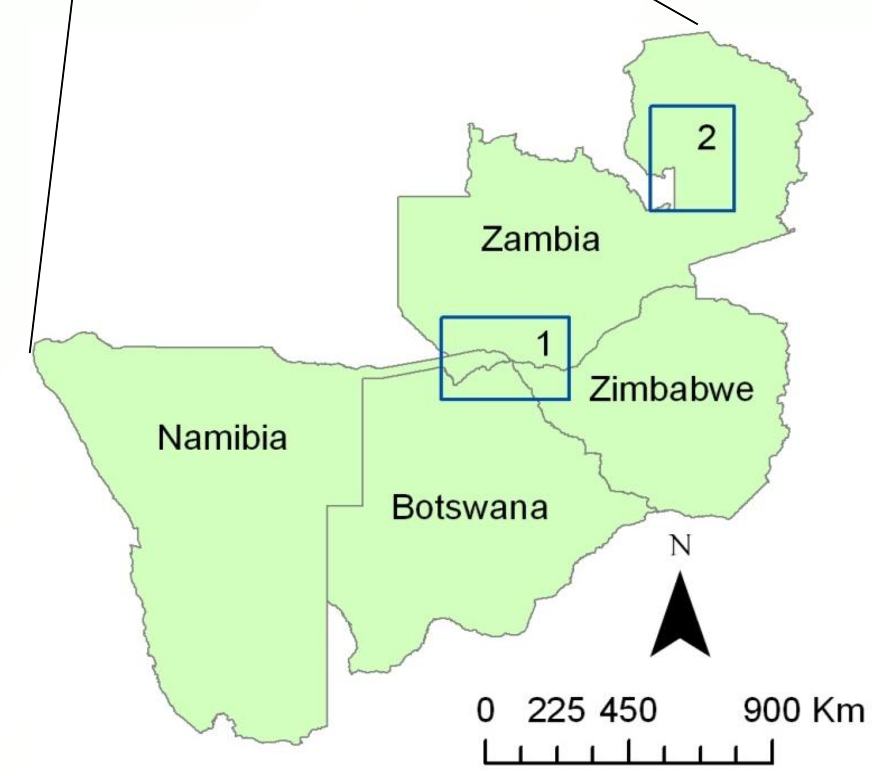
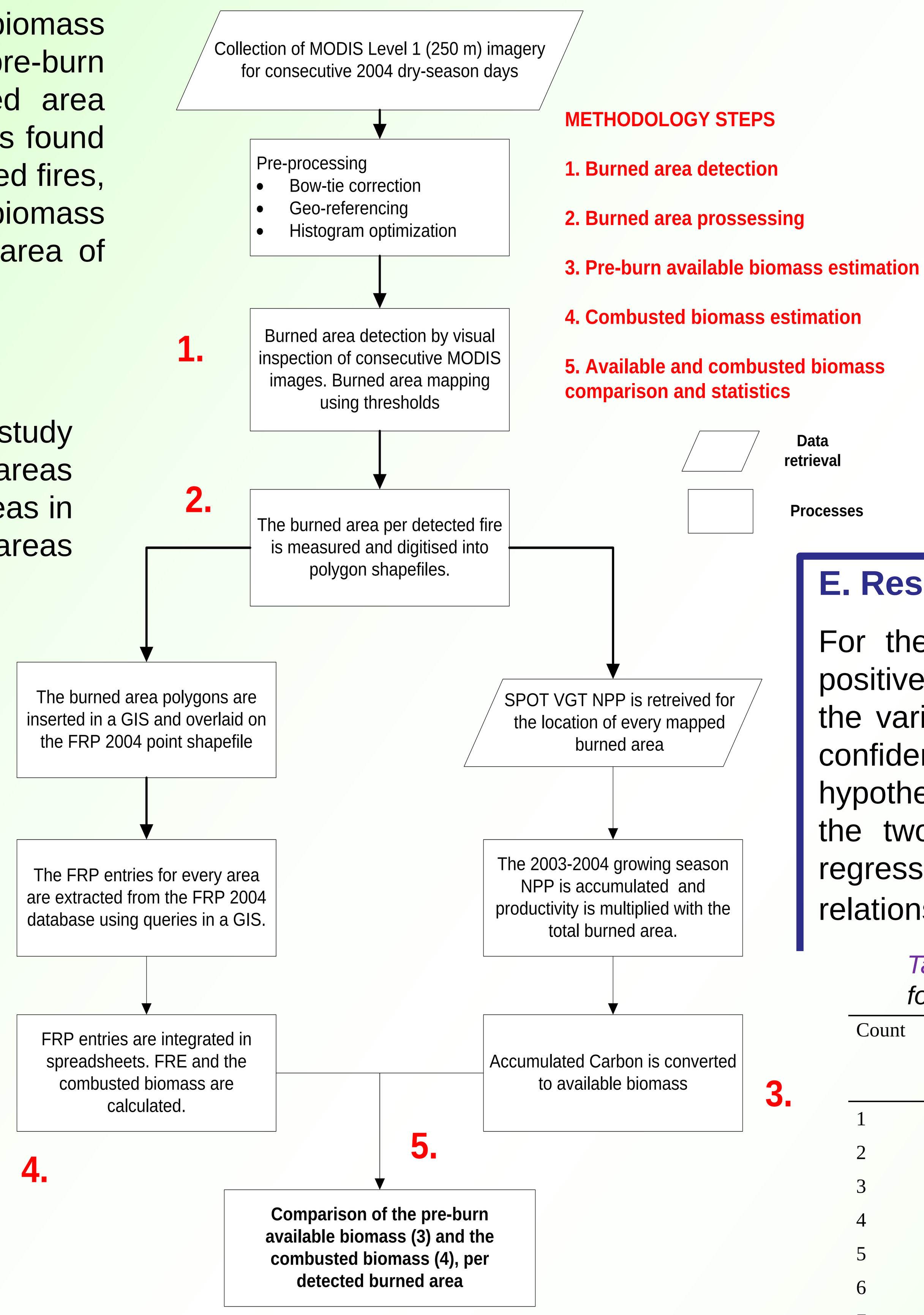


A. Abstract

We examined the relationship between the combusted biomass and the pre-burn biomass availability for 18 burned grassland savanna areas in Southern Africa. We used SEVIRI Fire Radiative Power (FRP) data to assess the combusted biomass and the SPOT VGT Net Primary Production (NPP) product to estimate the pre-burn biomass availability. MODIS Level 1b imagery was used for the burned area detection and mapping. A strong linear and highly significant relationship was found ($r2 = 0.94$, $n = 14$, $p < 0.0001$) between the two variables. For the 18 processed fires, FRE ranged from 0.04 to 23.2 Tjoules combusting 15.5 and 8531.3 tones of biomass respectively. All the fires combusted a total of 38240 tones in a burned area of 270.06 km2.

B. Area and Data

18 savanna/ grasslands fires were detected and processed in the 2 areas of study which are shown in the upper right figure. In the first area of study , 6 burned areas were detected in North-eastern Namibia, 6 areas in Western Zimbabwe, 2 areas in Northern Botswana and 1 in southern Zambia. In the second area of study, 3 areas were detected in Northern Zambia.



C. Burned area detection and measurement

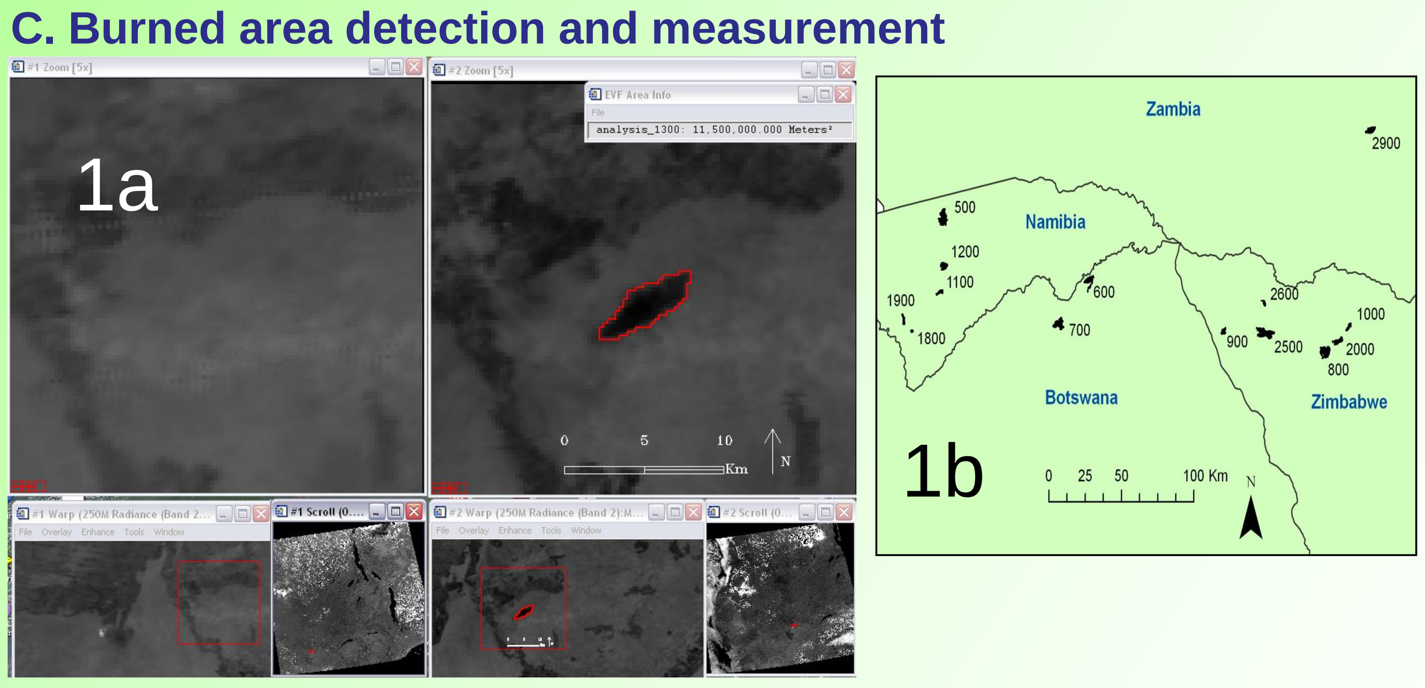


Figure 1a. Detection and quantification of an example burned area. On the left display: MODIS band 2 image depicting a burned area on 26/8/2004 just before the fire. On the right display the same area, burned, just after the fire on the 29/8/2004. 1b The detected and processed areas of the first region of study.

D1. Pre-burn available biomass calculation

For all the 18 detected burned areas, 10-day mean NPP (mgC m^{-2}) values were retrieved from the VITO-GeoSuccess website. For every detected area, the NPP that was retrieved covers the period between August 2004 and the time that the same areas were previously burned. The GLOBCARBON Burned Area Estimate (BAE) product (VITO, 2007) was retrieved in order to verify the time of the preceding fires for the detected areas (figure 5a). Given the fact that the combustion completeness typically reaches 83 - 98% at the end of the dry-season (Scholes et al., 1996), we assume that the available amount of biomass that is finally combusted, starts to accumulate from the beginning of the growing season (01/10) just after the first fires till the time prior to the fires of August 2004 (21/07) (figure 5b).

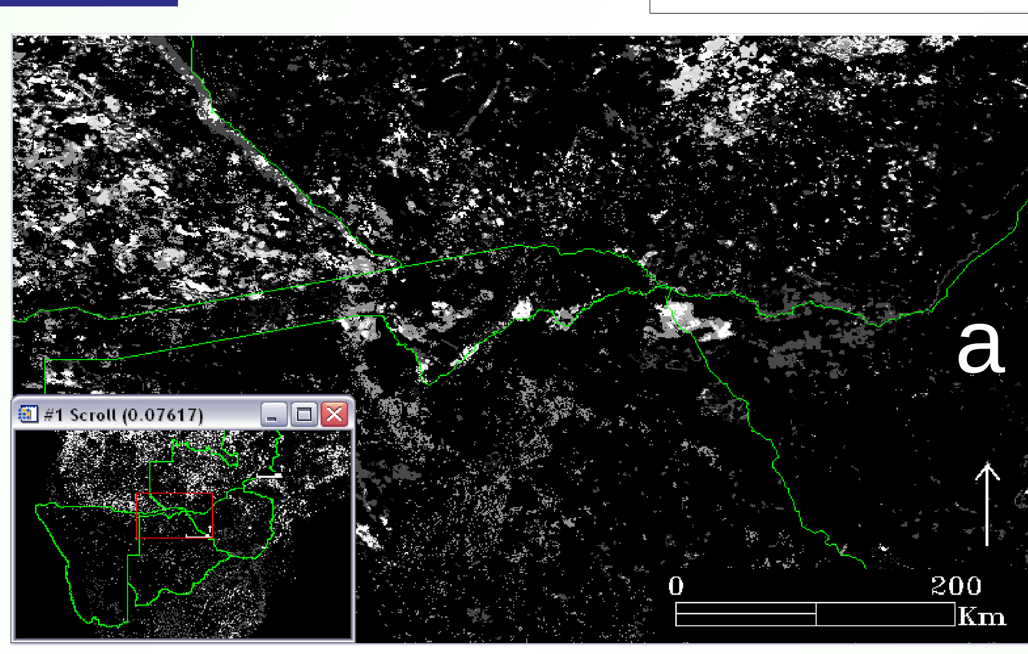
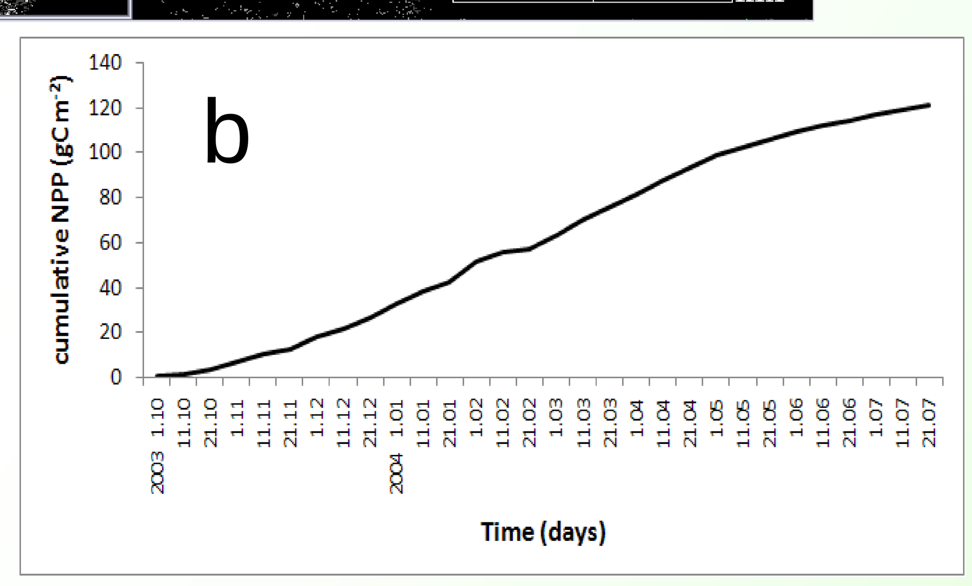


Figure 5a,b. a) Veification of the time of previous burn with the BAE product. b) Cumulative NPP (gC m-2) for the 2003-2004 growing season.



D2. combusted biomass calculation

The 2004 SEVIRI FRP database, developed at King's College London, was imported in a GIS and it was clipped on the boundaries of the studied areas. Following, the digitized polygons of the detected burned areas were imported in the GIS, and the two layers were overlaid. Using logical queries on the FRP 2004 geo-database, the corresponding to polygons FRP 2004 entries, were extracted (figure 2). The extracts were imported in a spreadsheet and for every component (1km x 1km pixels) of every detected event, they were integrated. By integrating all the corresponding FRP entries of a detected burned area, one can examine the temporal evolution of the fire in 15 min resolution and estimate the Fire Radiative Energy (FRE) which, according to Wooster et al. (2004; 2005), is directly related to the amount of biomass that was combusted. The temporal evolution of a fire is given in figure 3.

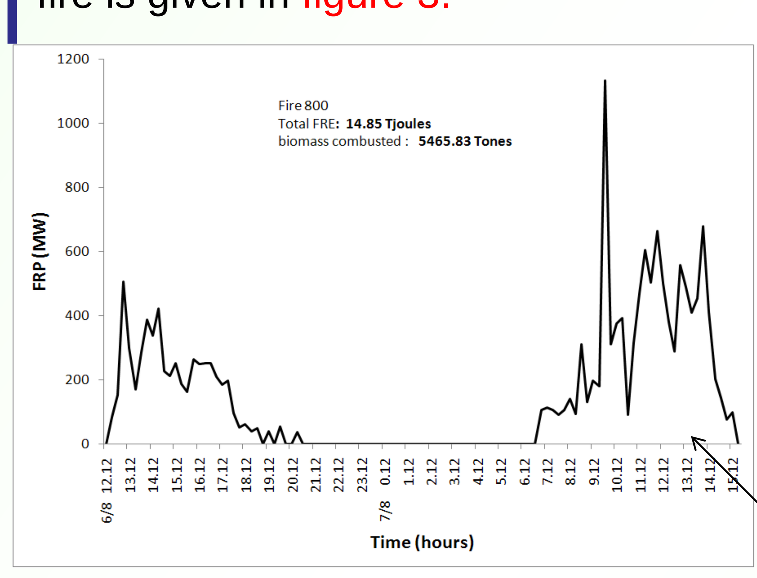
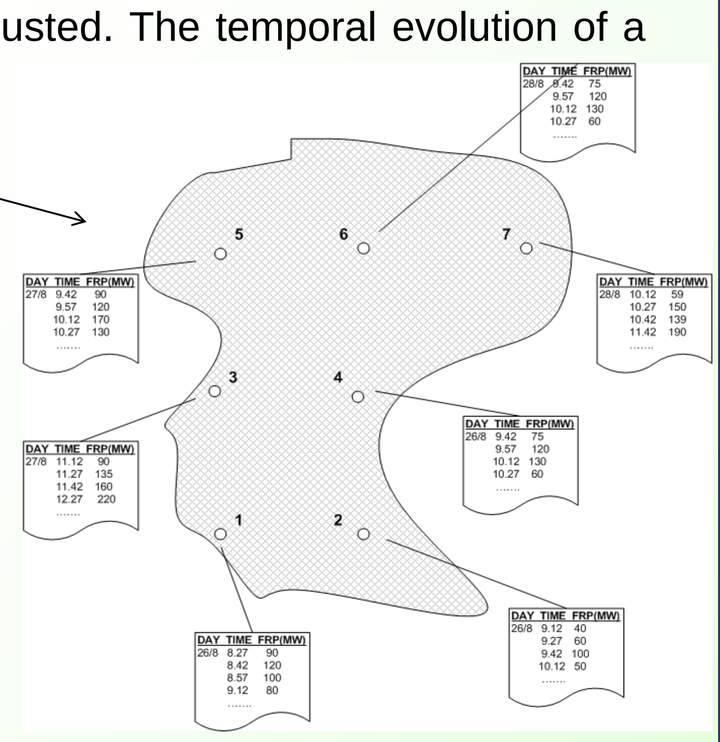


Figure 2. The burned area is shown in grey pattern and the corresponding components of the FRP geo-database are depicted in small circles.

Figure 3. FRP time series for a processed fire.



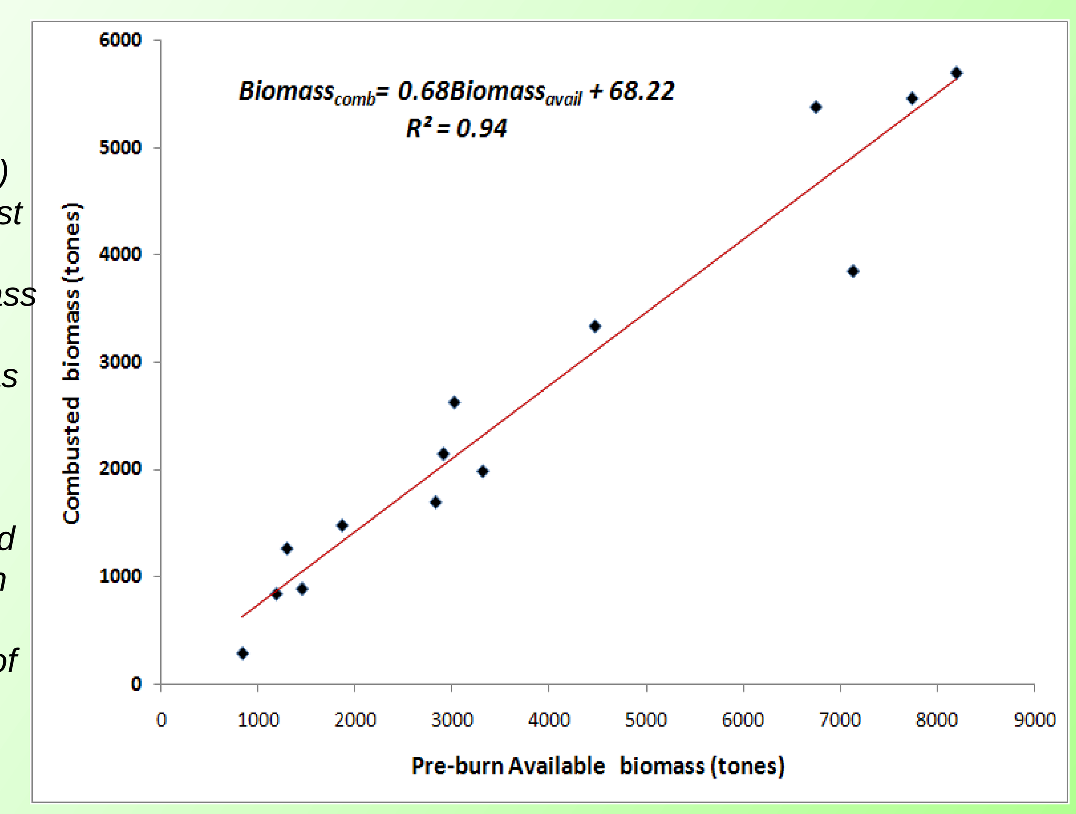
E. Results

For the 18 detected areas (n=18) (table 1), a strong positive linear correlation was found ($r = 0.93$) between the variables. The significance test for (r) at the 99.99% confidence level showed that we had to reject the null hypothesis that there is no significant correlation between the two variables ($r=0$) and accept the alternative. A regression analysis was performed to describe the relationship between the variables (figure 6).

Table 1. List of pre-burn available and combusted biomass for the 18 detected burned areas that were processed.

Count	Burned area code	Available Biomass (Tones)	Combusted Biomass (Tones)	Proportion combusted (%)
1	500	8193.92	5703.20	69.60
2	600	4465.80	3337.59	74.74
3	700	3308.36	1982.02	59.91
4	800	7736.45	5465.83	70.65
5	900	1858.41	1477.63	79.51
6	1000	1445.20	884.70	61.22
7	1100	1289.14	1261.37	97.85
8	1200	3015.36	2626.15	87.09
9	1800	336.96	15.49	4.60
10	1900	1179.24	837.33	71.00
11	2000	3388.48	431.26	12.73
12	2100	2902.55	2145.26	73.91
13	2200	2822.31	1694.83	60.05
14	2300	2841.02	629.92	22.17
15	2400	1393.06	228.38	16.39
16	2500	7126.60	3852.52	54.10
17	2600	832.21	282.56	34.00
18	2900	6744.41	5384.15	79.80

Figure 6. Combusted biomass (tones) is plotted against pre-burn available biomass (tones) for 14 processed areas excluding the outliers. The regression trendline is fitted and its equation is presented in the upper part of the graph.



F. Discussion/ Limitations

- **The** results indicate that there is a linear and highly significant relationship between the pre-burn available biomass and the amount that is actually combusted from southern Africa savanna fires ($r^2 = 0.94$, $n = 14$, $p < 0.001$).

- **Different** products from different sensors were used successfully in order to answer the existing hypothesis.

- **If** one knows the size of the area that was burned, one can easily estimate the pre-burn available biomass (using the SPOT VGT NPP product) and use the proposed model (figure 4) to estimate the amount of biomass that was combusted.

- **Knowing** the amount of biomass that was combusted, one can estimate the amount of carbon that was released in the atmosphere.
- **The** SPOT VGT NPP product was validated and compared with the GFED version 2 and several other relevant studies and good agreement was found in terms of carbon and biomass productivity in the areas of study.

- **The** sample size of this study could, however, be a limitation. Although we came up with a very strong significant correlation ($r = 0.97$) and a good model ($r^2 = 0.94$), a bigger sample would increase our confidence in making any assumption.

- **Most** of the uncertainties in this work come from the combusted biomass estimates and the SEVIRI FRP database

- **SEVIRI** underestimates fires outside the range of 665 – 1365 K (Roberts et al., 2005) leads to the assumption that the temporal evolution of some and especially small scale fires isn't accurately recorded

F. References Cited

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