

Air quality offset calculations for Kwazamokuhle

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Baseline scenario

Baseline emissions

Household emission sources

Kwazamokuhle is characterised by a high proportion of household who use coal for domestic cooking and heating. The importance of coal is visible in the results on the question on the main energy carrier for heating from the 2011 Census are shown in the Table 1.

Table 1: Main energy carrier for heating from the 2011 Census

SP_Name	Electricity	Gas	Paraffin	Wood	Coal	Animal.dung	None
Mafred	436	6	3	4	92	NA	5
Emaskopasini	436	4	NA	3	193	NA	112
Tycoon	553	15	NA	3	295	NA	62
Mapehla	139	7	3	NA	109	NA	23
Kwazamokuhle SP	1645	38	24	31	1309	3	319

It is clear that there are far fewer users of wood and dung than of coal. Because there are very few households who use wood that do not on occasion use coal as well, the responses for coal on the question “Mark ALL the energy carriers that you use for heating?” are used as an estimate for domestic solid fuel use. A summary is provided in Table 2.

Table 2: Solid fuel use for heating from the 2011 Census

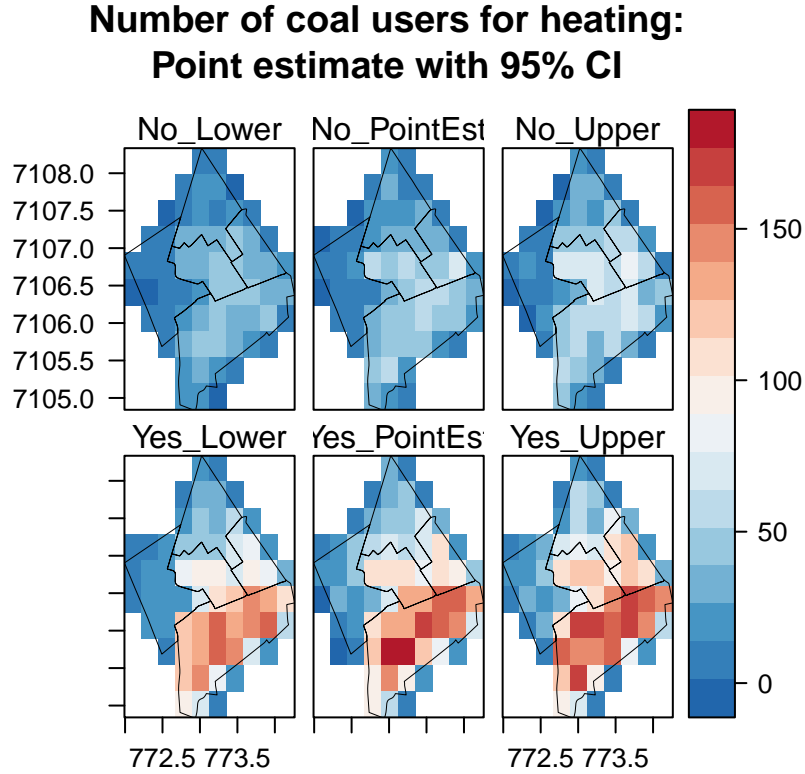
SP_NAME	Fuel	No_fuel
Mafred	96	450
Emaskopasini	196	552
Tycoon	298	630
Mapehla	109	172
Kwazamokuhle SP	1343	2026

It is known however that because the Census asks only a question about the *main* energy carrier, the number of solid fuel users are underestimated. The results of the survey leads to a substantially higher estimate compared to the census. The estimates of coal using households per sub-place derived from the household survey is shown in Table 3. It is clear that the number of coal using households derived from the survey results are substantially higher.

Table 3: Estimated number of coal using households per subplace with upper and lower bound of the 95% confidence interval

place	sol.energy.heating.all.coal	PointEst	Lower	Upper
emaskopasini	No	262	192	343
	Yes	532	451	602
kwazamokuhle.sp	No	816	675	975
	Yes	2765	2606	2906
mafred	No	193	134	263
	Yes	387	317	446
mapehla	No	71	40	115
	Yes	227	183	258
tycoon	No	337	257	428
	Yes	648	557	728

The approximate spatial distribution of the households by coal use are shown below. The high concentration of coal users in the southern and eastern parts of Kwazamokuhle is clear.



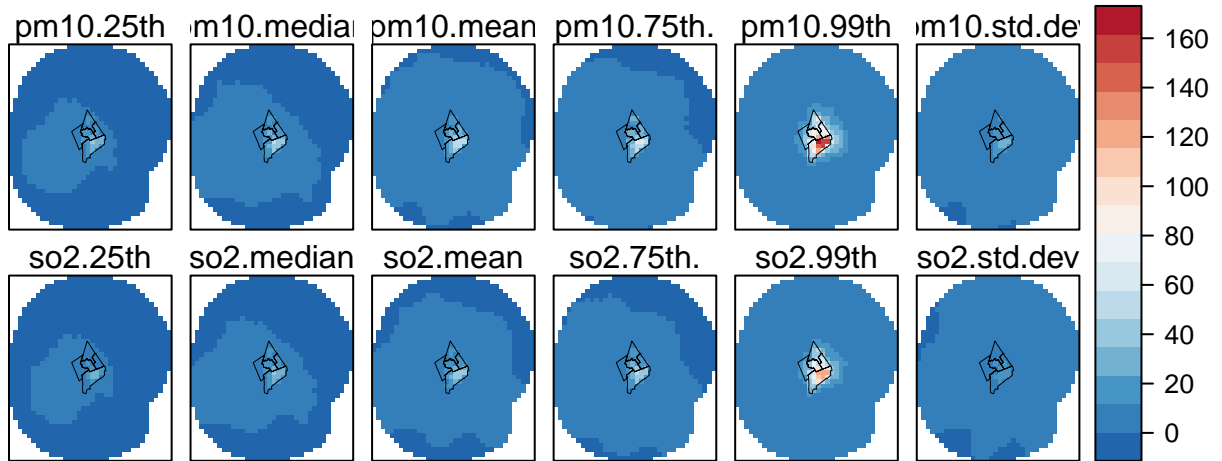
Baseline emission are calculated from the results of a domestic fuel use survey. The estimates for fuel consumption based on the household survey are shown in Table 4. Winter coal consumption is understandably highest than summer consumption. Once again Kwazamokuhle SP has the highest consumption.

Table 4: Baseline coal use by Suburb

subplace	no coal %	coal %	#HH	winter kg/m	summer kg/m	ave(W) users	ave(S) users	ave(W) users	ave(S) users
emaskopasini	32.97	67.03	794	114218	62135	143.9	78.26	214.6	116.7
kwazamokuhle	22.77	77.23	3581	726929	376067	203	105	262.8	136
sp									
mafred	33.33	66.67	580	111204	61041	191.7	105.2	287.6	157.9
mapehla	23.81	76.19	298	78051	39232	261.9	131.7	343.8	172.8
tycoon	34.23	65.77	985	169136	97482	171.7	98.97	261.1	150.5

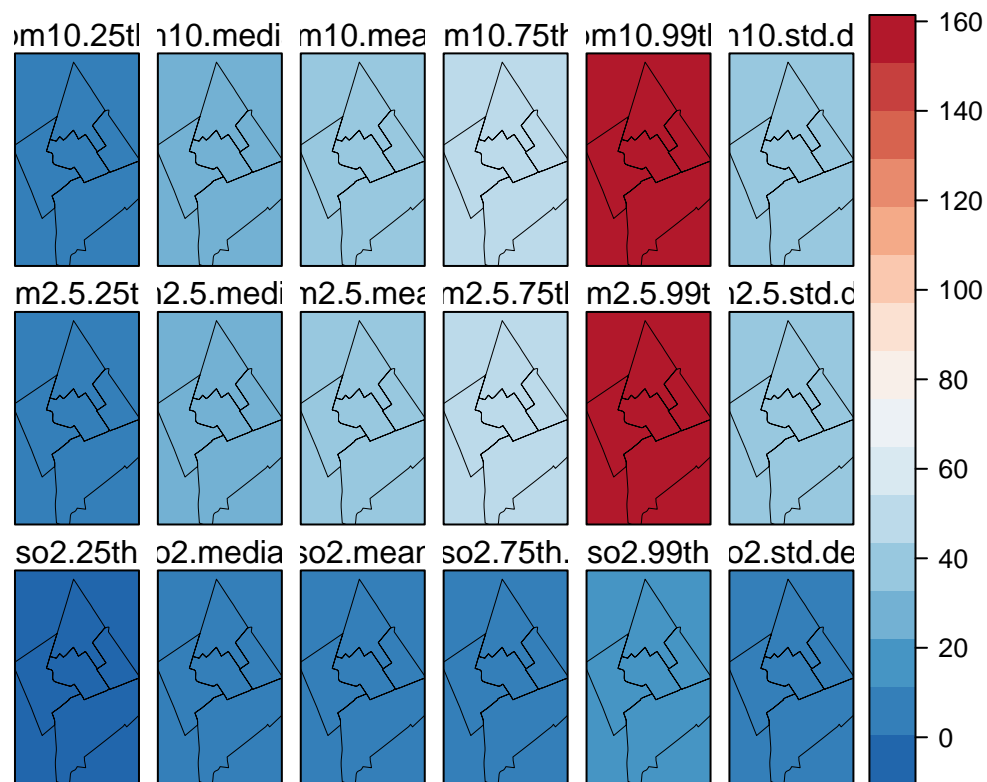
Baseline states

The modelled baseline PM10 and SO2 resulting from household emissions in Kwazamokuhle is shown below. The baseline emission from household coal use is summarised below. The tiles represent the 25%, 50% percentiles, the mean and the 75% and 99% percentile. The last tile in each row represent the standard deviation.

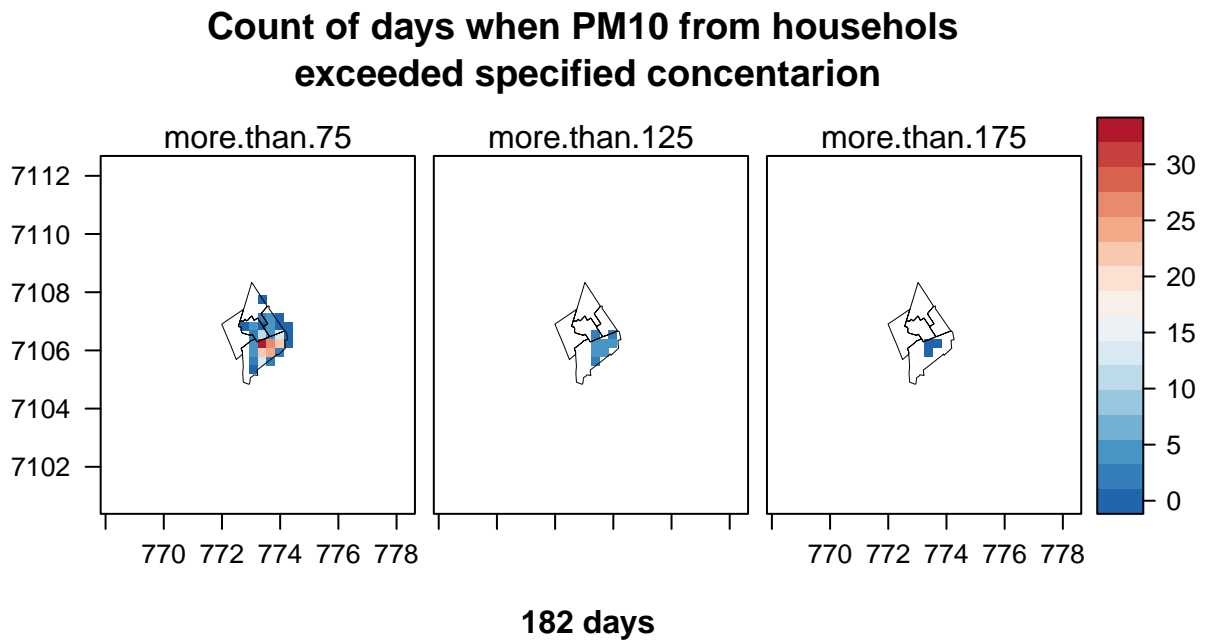


The distribution of the PM10 and SO2 is fairly similar but the concentration of PM10 is modelled to be higher. It is also clear that the concentration of both PM10 and SO2 decreases rapidly with distance from the household sources.

The modelled baseline PM2.5, PM10 and SO2 from the industrial point source is shown below.

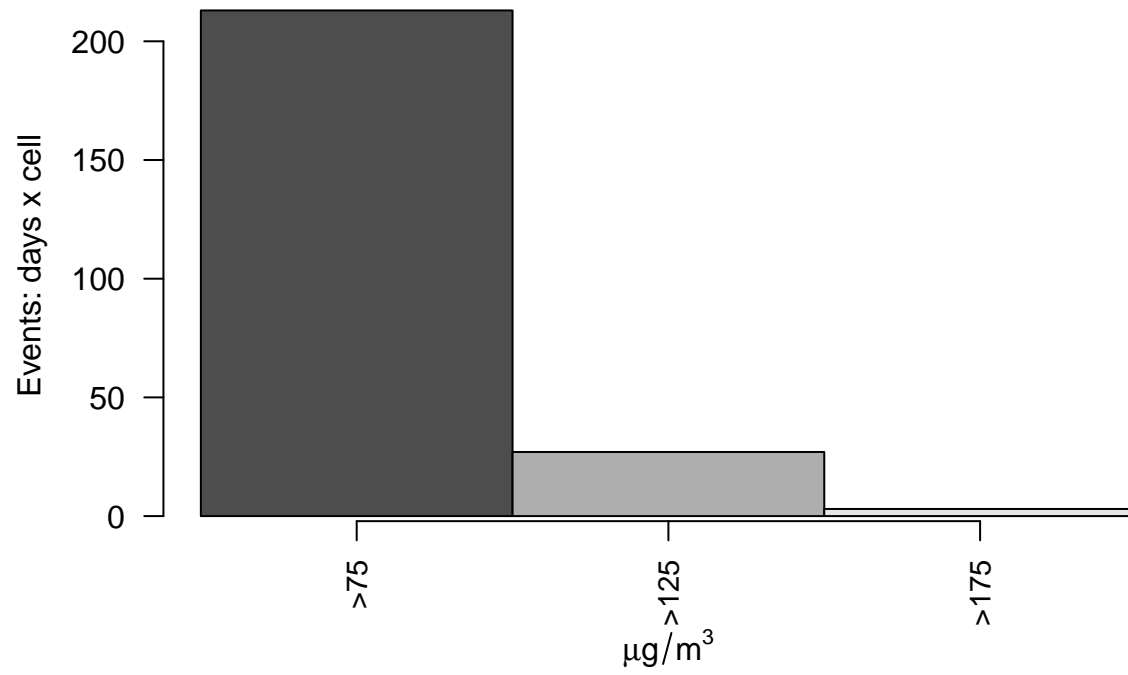


The count of days where the PM10 concentrations that resulted from household emissions and the industrial point source are modelled to exceed a specified level and the is shown below for the baseline scenario.

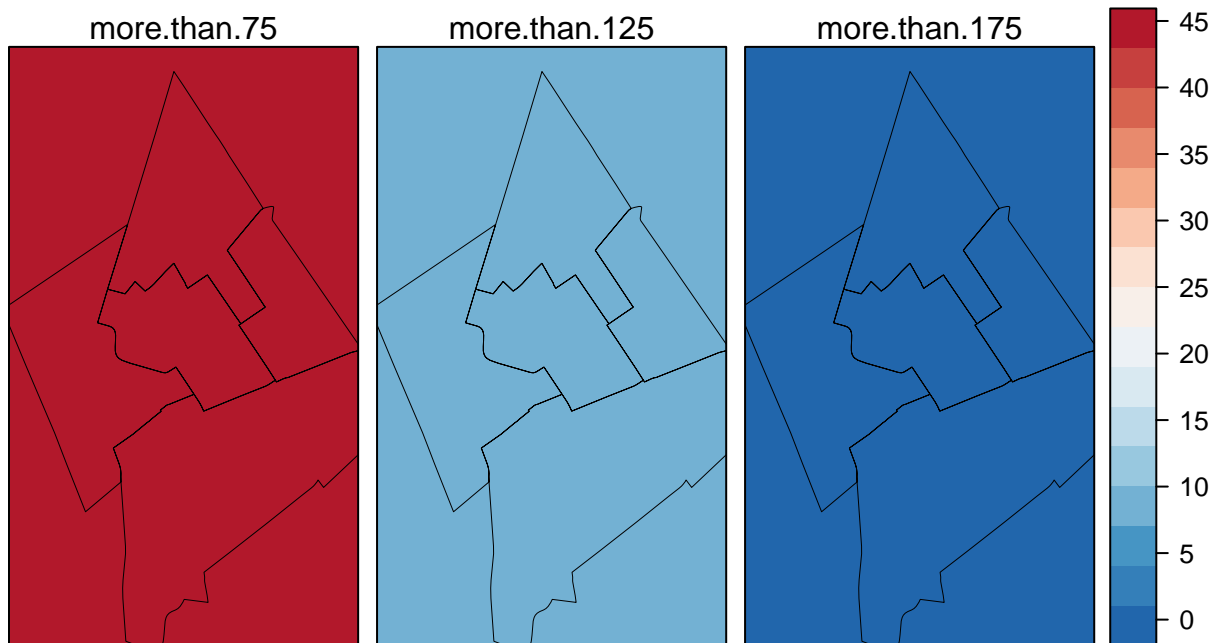


The exceedances of daily PM10 standard related to household emissions occur over the southern and eastern side of Kwazamokuhle with the highest exceedance count at every level occurring in Kwazamokuhle SP.

**Aggregated # of days when PM10 from households
exceeded specified concentrarion**

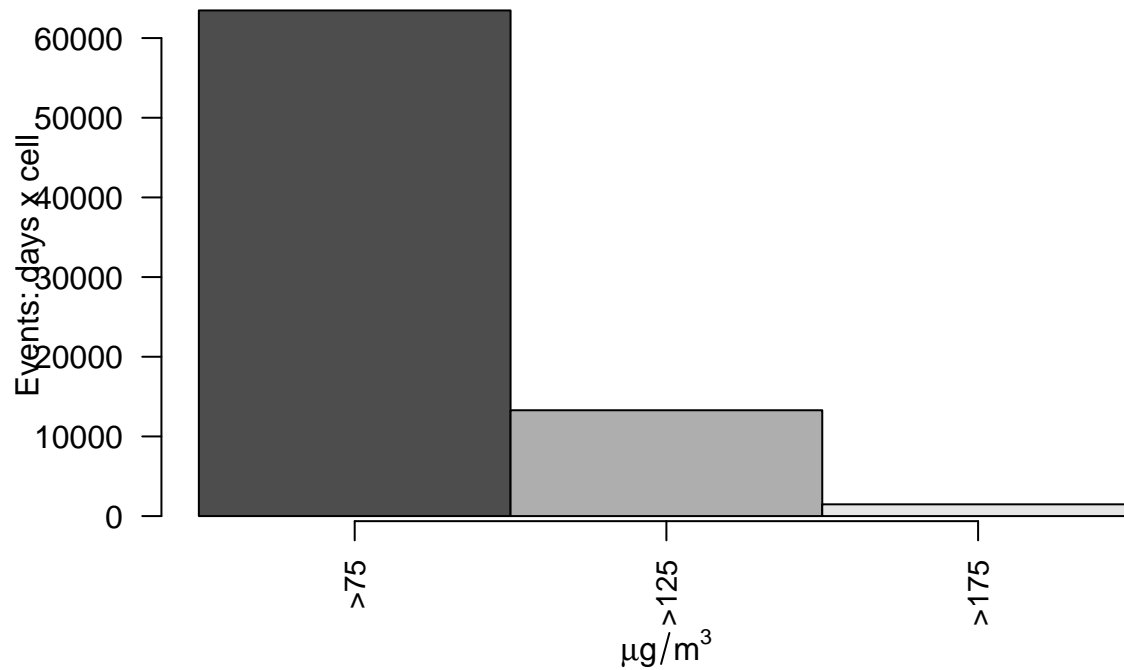


Count of days when PM10 from Eskom exceeded specified concentration



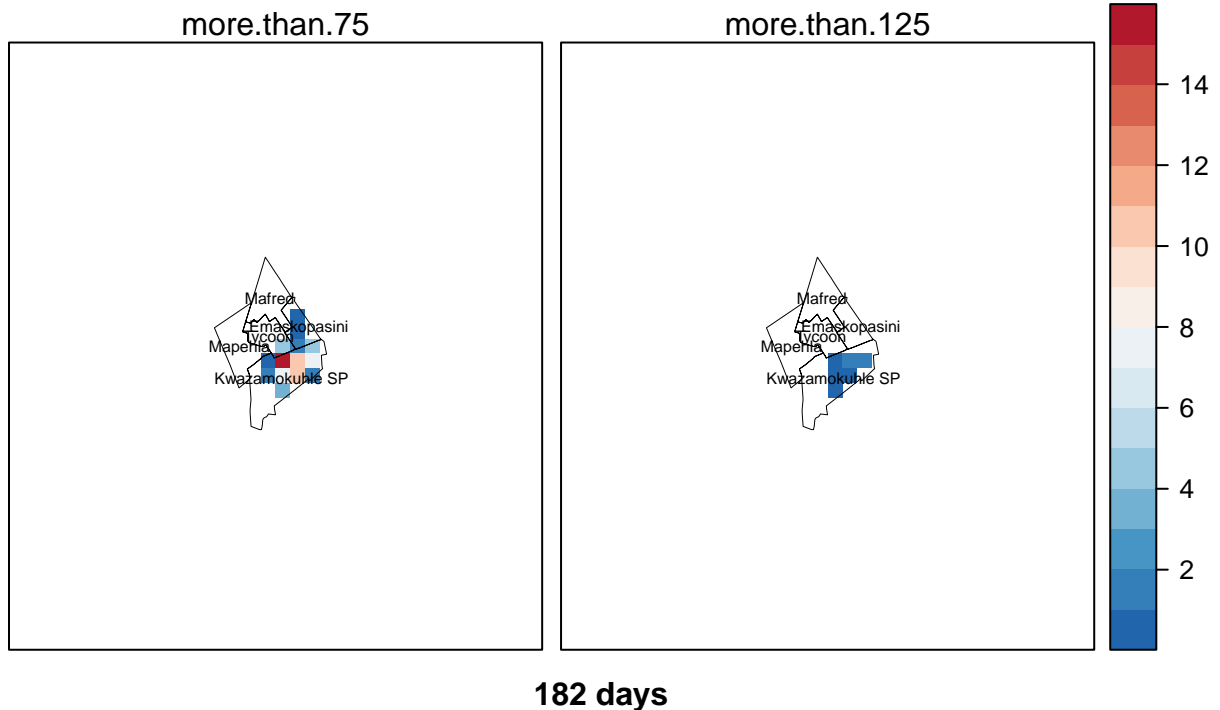
365 days

Aggregated of days when PM10 from Eskom exceeded specified concentration

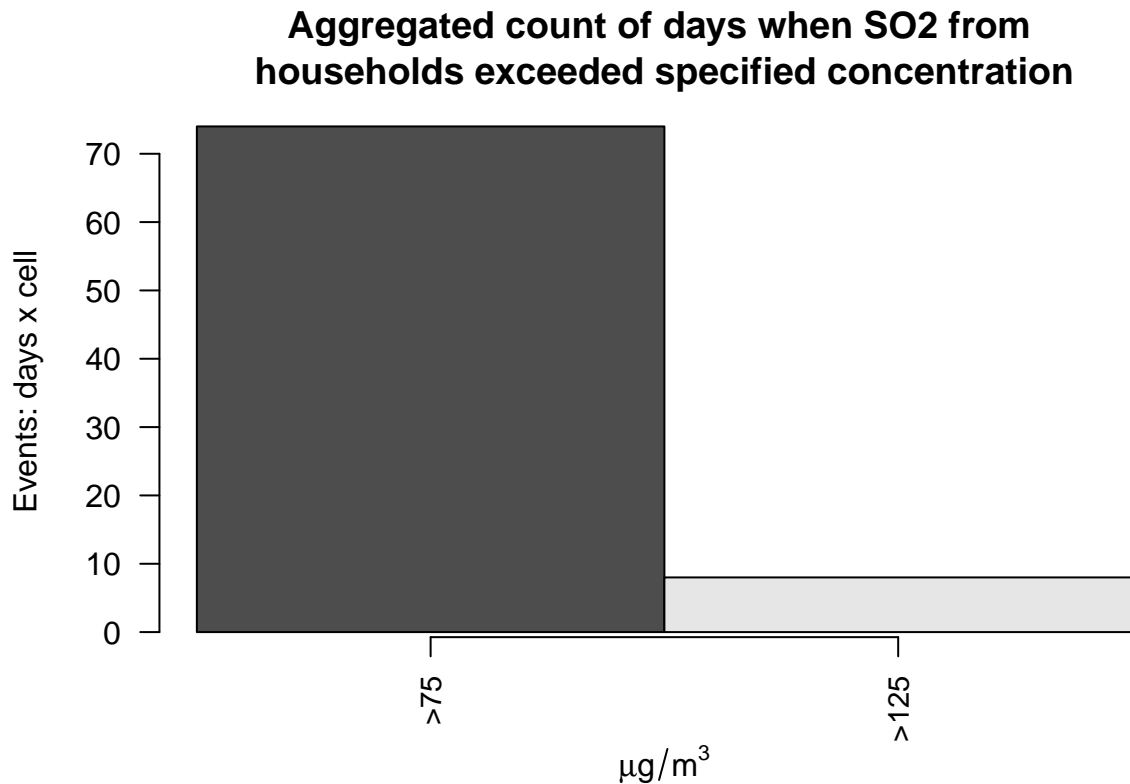


The count of days where SO2 concentration that resulted from household emissions is modelled to exceed a specified level is shown below for the baseline scenario.

Count of days when SO2 from households exceeded specified concentration



Occurrences of exceedances of the daily SO₂ standard related to coal combustion from households are less common than that for PM₁₀. The area over which such occurrences are smaller than that of PM₁₀ for every level and the count of exceedances for each level is also less. Once again most exceedances occur in Kwazamokuhle SP.



The count of days where SO2 from the industrial point source exceeded specified level for the baseline scenario is shown not in the same because all values are below the minimum level in the previous plot.

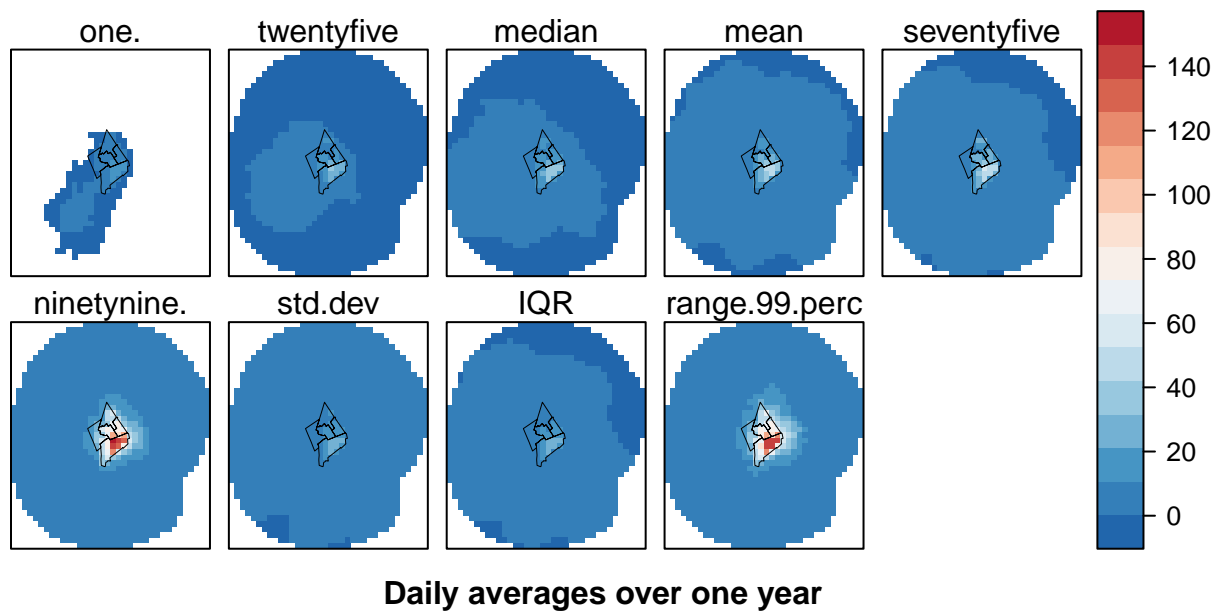
Project boundary

The spatial extent of the project boundary is the overlapping extent of the ambient contribution of the baseline emissions above 2 $\mu\text{g}/\text{m}^3$ per year or 19 $\mu\text{g}/\text{m}^3$ per day in PM10 or SO2 and the same for project emissions from the managed activity. Project emissions from the managed activity are the emissions from Eskom in the business-as-usual scenario. Baseline emissions from households are the emissions from households before implementation of the intervention.

Application of thresholds to determine project boundary

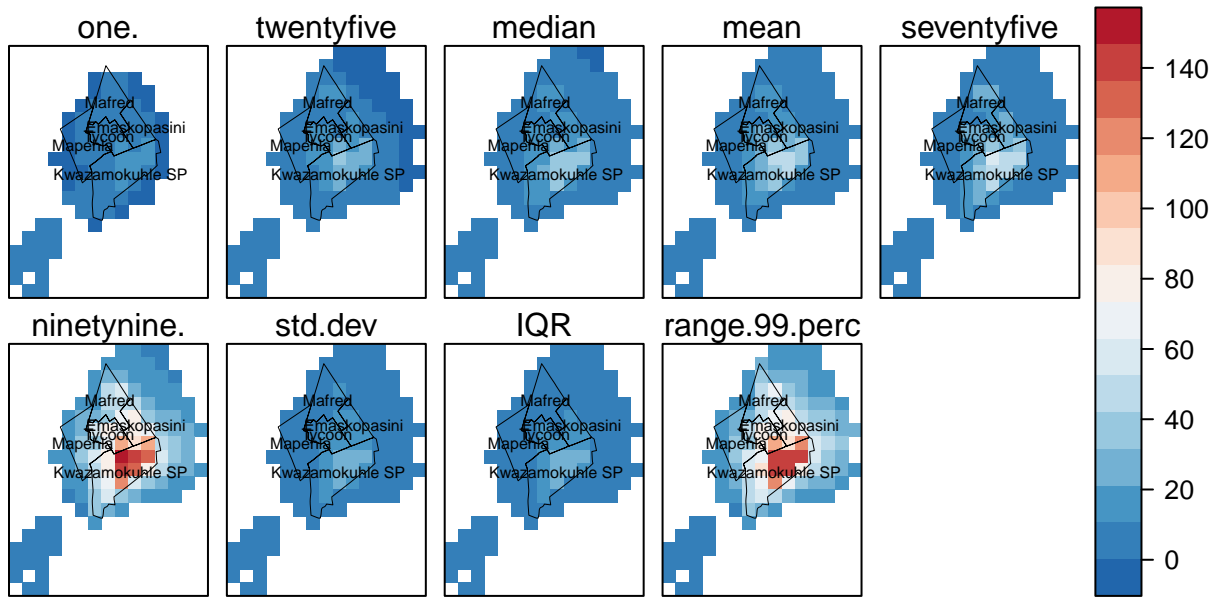
The baseline emission from household coal use is summarised below. The tiles represent the 1%, 25%, 50% percentiles, the mean and the 75% and 99% percentile. The last three tiles represent the standard deviation, inter-quartile range and 99% range of the data.

Summary of modelled PM10 concentrations from household coal burning in Kwazamokuhle



The extent of the impact of household emissions in the baseline scenario above an annual average of $2\mu\text{g}/\text{m}^3$ or an daily average of $19\mu\text{g}/\text{m}^3$ is shown below. Blank cells are outside of the project boundary

Definition of the project boundary



Non-blank areas are where daily or annual PM10 exceed the threshold (182 days)

It is clear from the application of the threshold that, if the modelling is correct, the impact of domestic burning is localised in close proximity to the emissions. The project boundary includes the whole of the main place Kwazamokuhle. Of all the sub-places that make up the main place Kwazamokuhle, the highest mean and maximum concentrations are found in Kwazamokuhle SP.

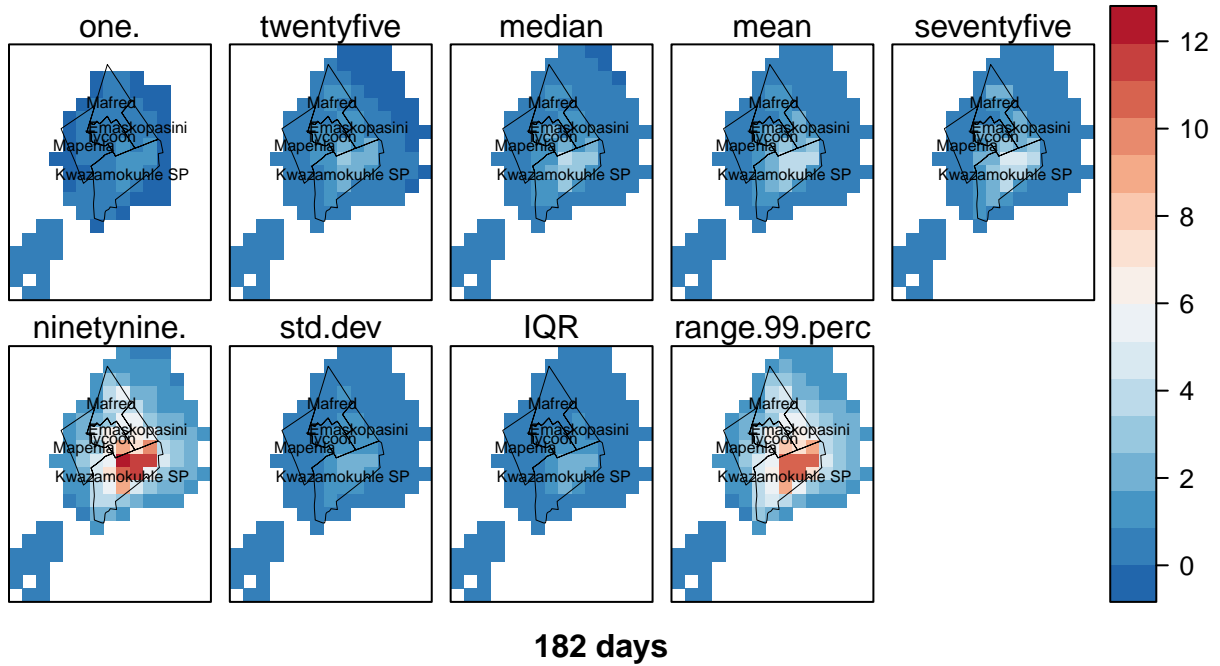
Baseline impact

Baseline impact can be determined using different calculation approaches. Four approaches will be demonstrated. These are: 1. Health risk approach 2. Particle equivalence approach 3. Standards weighted intake 4. Burden of disease approach

Health risk approach

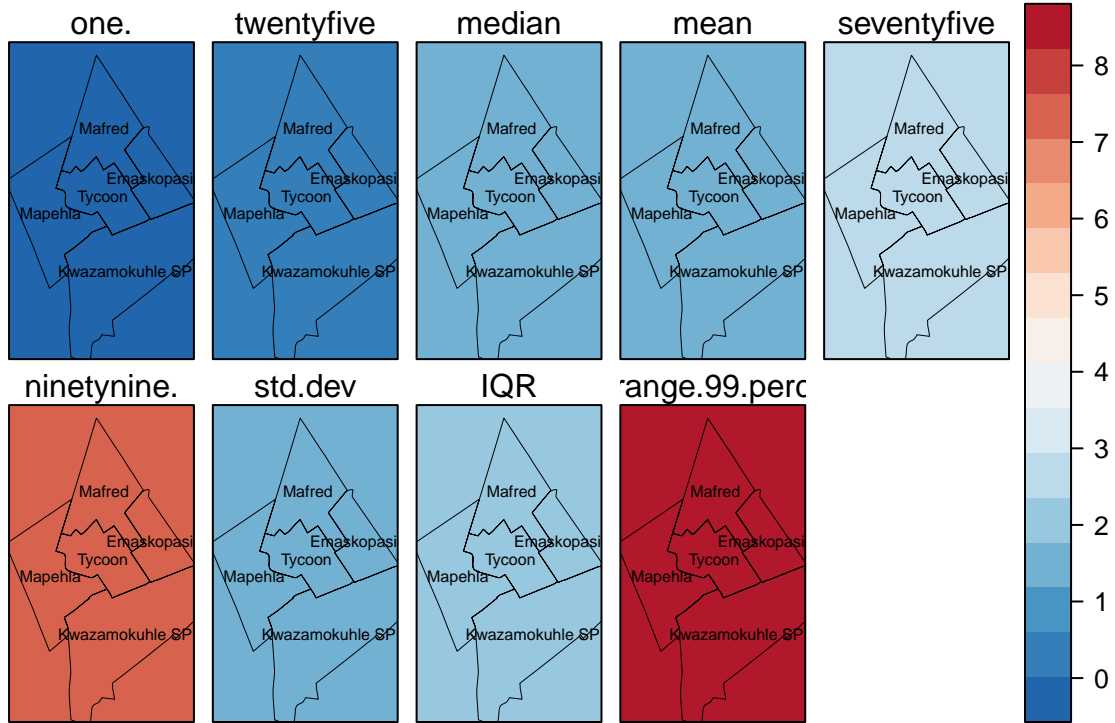
The health risk approach uses an air quality index based on the relative risk of short term mortality of every pollutant. Here the pollutants are PM10 and SO2 but O3 and NO2 can potentially be added. The baseline impact represents the combined impact of all pollutants. A summary of the daily API resulting from households are given below.

Distribution of baseline API from households in Kwazamokuhle



The baseline impact of the industrial point source for the full year is shown below.

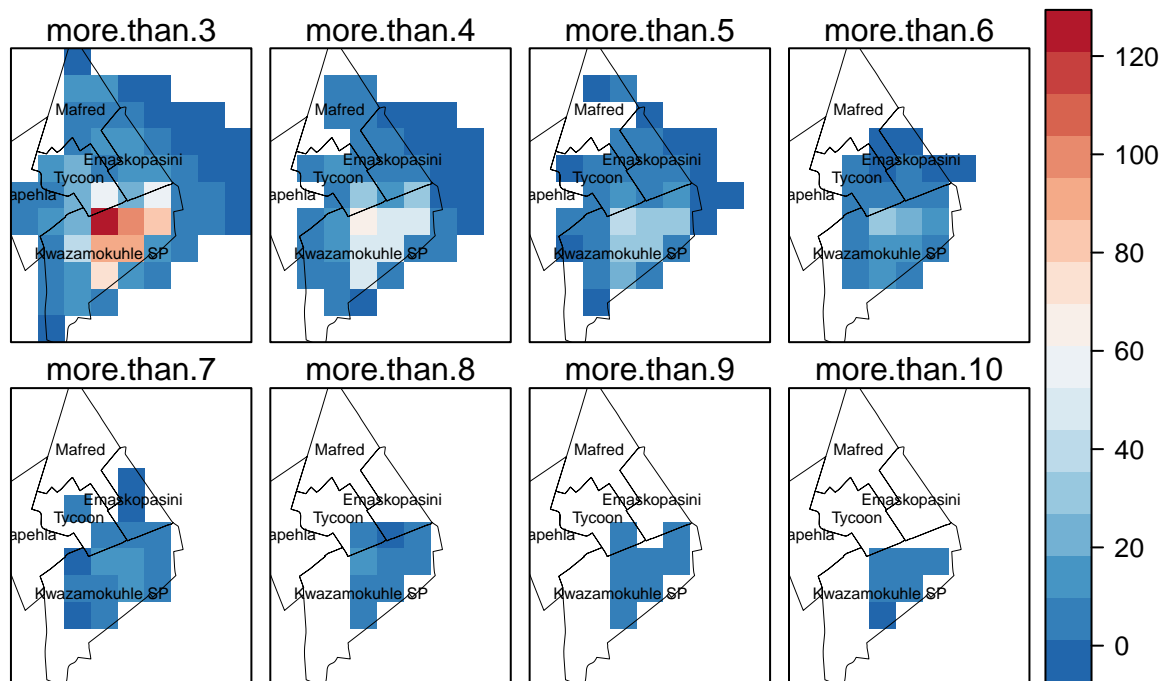
Kwazamokuhle baseline API from households



182 days

The count of days where the API that resulted from household emissions is modelled to exceed a specified level is shown below for the baseline scenario.

Days in Kwazamokuhle where API from households exceeded specified level



182 days

Kwazamokuhle SP has the highest health risk related to short term exposure

Particle equivalence approach

With sources that have a very localised dispersion, the particle equivalent impact (as PM10 equivalent) of that source is simply the concentration of the PM10 emitted by that source at every receptor. Therefore, for household emissions, the baseline impact is the same as the baseline state of PM10 shown above.

Standards weighted intake

The standards weighted intake approach roughly equivalent to a population weighted air pollution index with the index weights determined by the standard. In this way it is related to the health risk approach that also requires population data.

Burden of disease approach

Project scenario

The project scenario is the implementation on a stove exchange for full retrofit and LPG for all RDP houses who use coal.

The estimates for fuel users per house type are shown below.

	place	fuel house	PointEst	Lower	Upper
1	emaskopasini	NoFuel_NotRDP	35	14	85
2		NoFuel_RDP	209	146	288
3		Fuel_NotRDP	105	61	172
4		Fuel_RDP	445	364	522
6	kwazamokuhle.sp	NoFuel_NotRDP	103	58	182
7		NoFuel_RDP	619	495	766
8		Fuel_NotRDP	1191	1028	1365
9		Fuel_RDP	1669	1492	1848
11	mafred	NoFuel_NotRDP	18	5	60
12		NoFuel_RDP	141	90	208
13		Fuel_NotRDP	97	56	159
14		Fuel_RDP	325	256	391
16	mapehla	NoFuel_NotRDP	28	11	66
17		NoFuel_RDP	43	20	83
18		Fuel_NotRDP	57	30	99
19		Fuel_RDP	170	126	211
21	tycoon	NoFuel_NotRDP	195	133	278
22		NoFuel_RDP	133	82	208
23		Fuel_NotRDP	231	163	316
24		Fuel_RDP	426	339	517

The target for the project activity is therefore between 2577 and 3489 with a point estimate of 3035

Table 6: Implementation targets per sub-place

	place	fuel house	PointEst	Lower	Upper
4	emaskopasini	Fuel_RDP	445	364	522
9	kwazamokuhle.sp	Fuel_RDP	1669	1492	1848
14	mafred	Fuel_RDP	325	256	391
19	mapehla	Fuel_RDP	170	126	211
24	tycoon	Fuel_RDP	426	339	517

Project emissions

Improvement per household

LPG 100%

Kitchen King = $0.018 * \text{Union} * 1.4 * 2$ to be conservative $\sim 5\%$

Proportion of solid fuel using households reachable by the project

Project states

Project impacts