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 households 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; these results 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

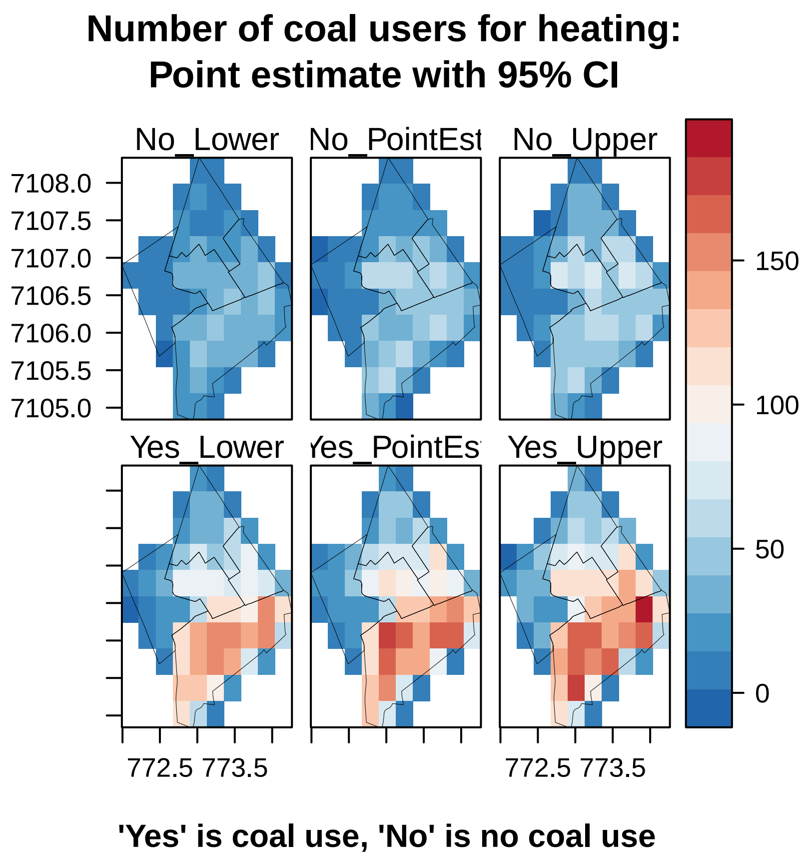
SP_NAME	Fuel	No_fuel
Mafred	96	450
Emaskopasini	196	552
Tycoon	298	630
Mapehla	109	172
Kwazamokuhle SP	1343	2026

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 lead to a substantially higher estimate compared to the census. The estimates of coal using households per sub-place derived from the household survey are shown in Table 3. It is clear that the number of coal using households derived from the survey results is 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.



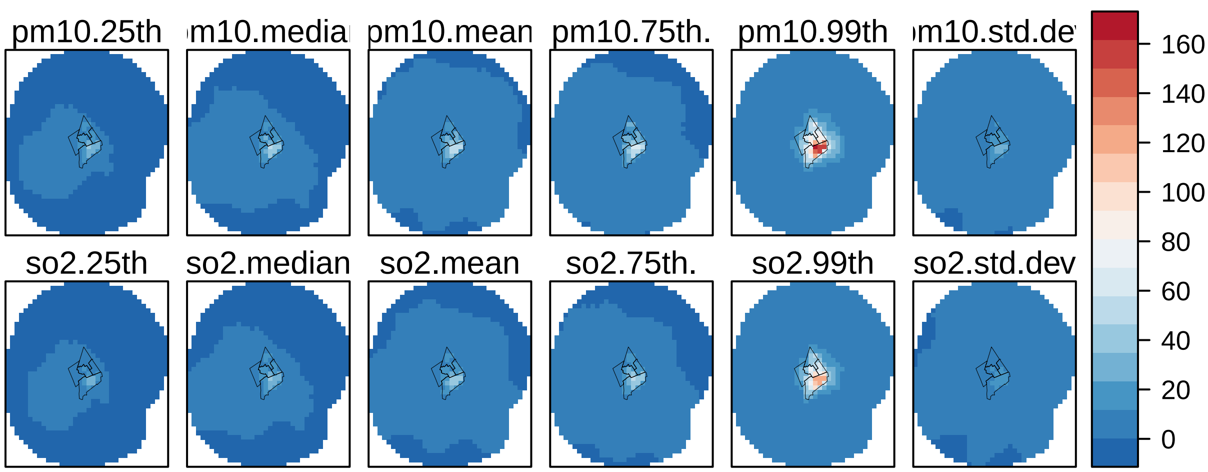
Baseline emissions are calculated from the results of a domestic fuel use survey. The estimates for fuel consumption based on the household survey are shown in Table 4. Winter coal consumption is understandably higher than summer consumption. Once again KwaZamokuhle SP has the highest consumption.

Table 4: Baseline coal use by Suburb

subplace	no coal %	coal %	#HH	winter kg/m	summer kg/m	ave(W)	ave(S)	ave(W) users	ave(S) users
emaskopasini	32.97	67.03	794	114218	62135	143.9	78.26	214.6	116.7
kwazamokuhle sp	22.77	77.23	3581	726929	376067	203	105	262.8	136
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

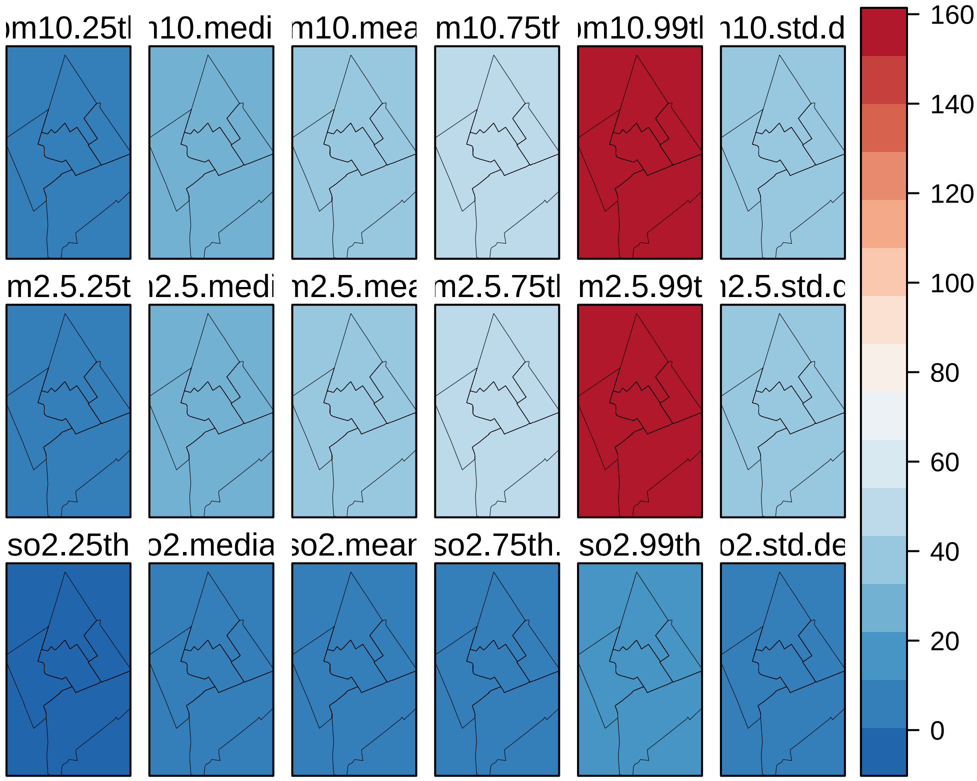
Baseline states

The modelled baseline PM10 and SO_2 resulting from household emissions in KwaZamokuhle is shown below. The baseline emissions from household coal use are summarised below. The tiles represent the 25th and 50th percentiles, the mean and the 75th and 99th percentiles. The last tile in each row represent the standard deviation.

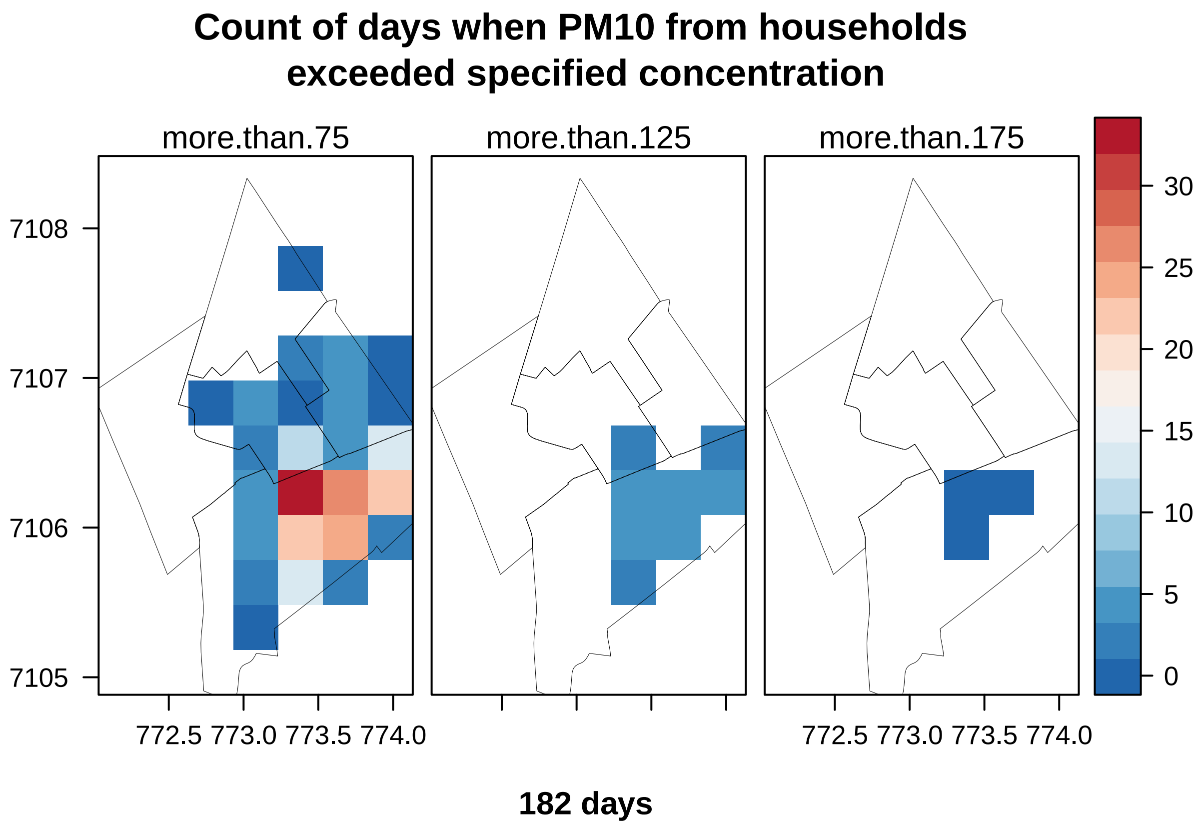


The distributions of the PM10 and SO_2 are fairly similar but the concentration of PM10 is modelled to be higher. It is also clear that the concentration of both PM10 and SO_2 decreases rapidly with distance from the household sources.

The modelled baseline PM2.5, PM10 and SO_2 resulting from the industrial point source is shown below.

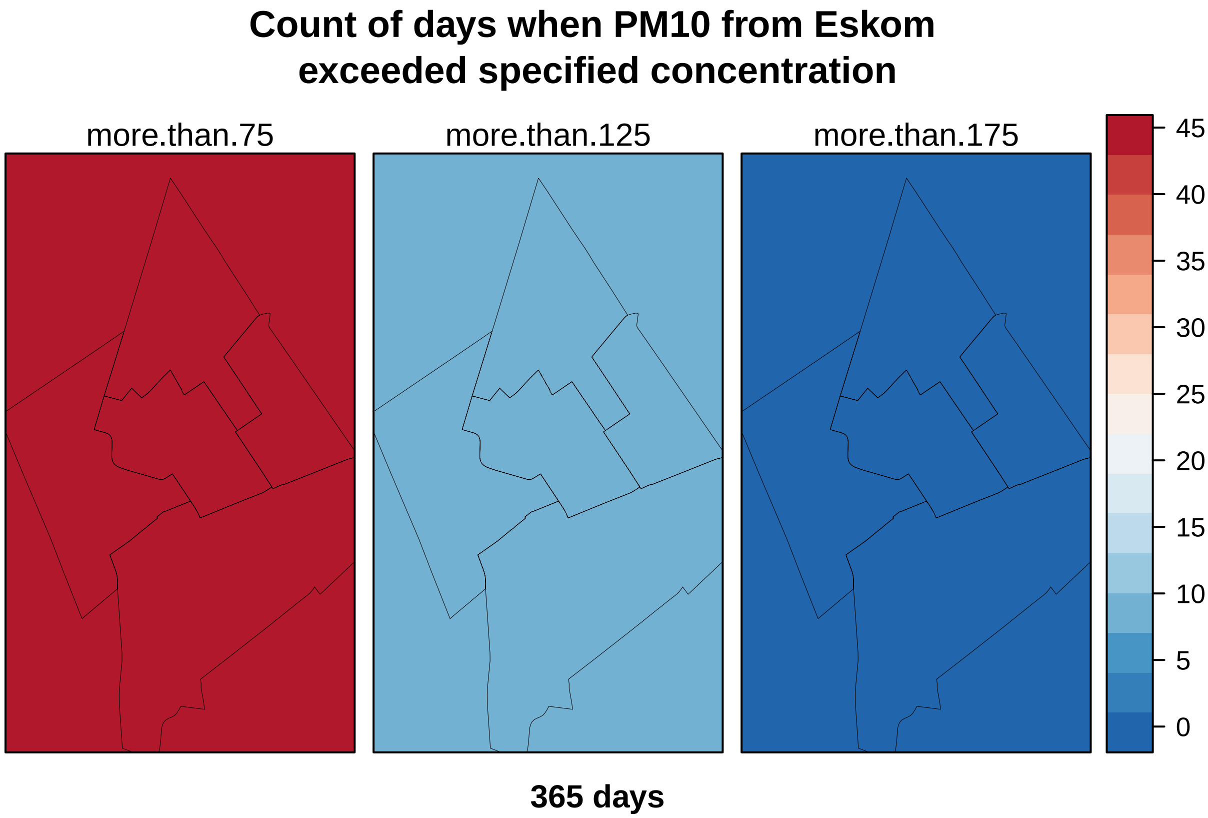


The count of days where the PM10 concentrations that resulted from household emissions and the industrial point source is modelled to exceed a specified level, is shown below for the baseline scenario.



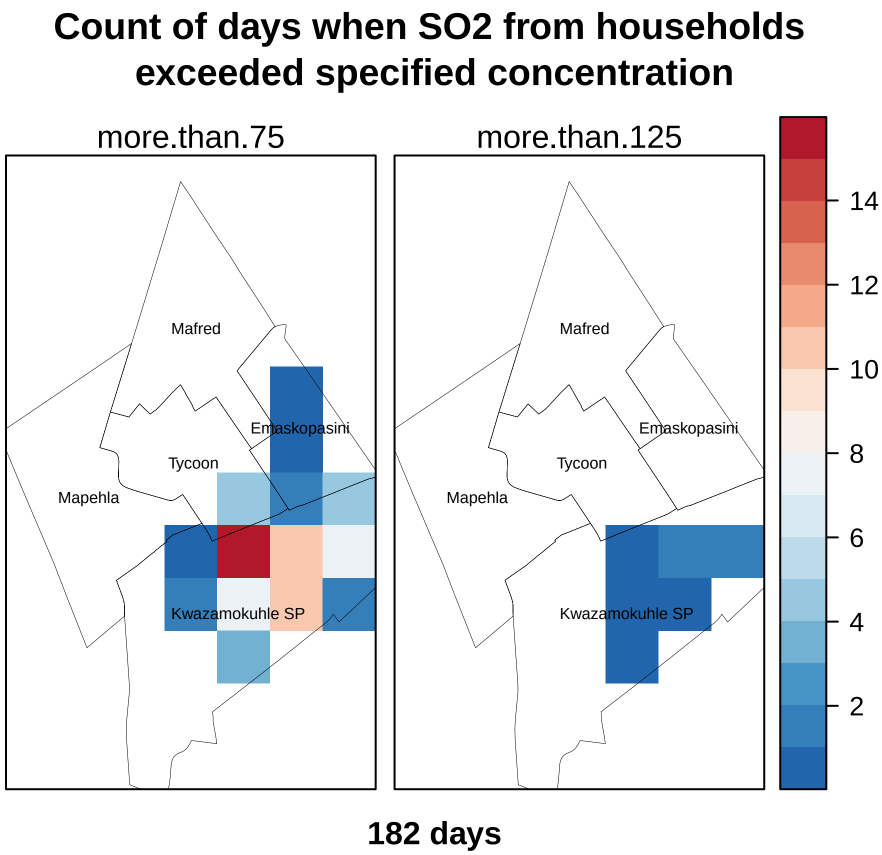
The exceedances of the daily PM10 standard related to household emissions occur over the southern and eastern side of KwaZamokuhle with the highest exceedance count at every level occurring in KwaZamokuhle SP.

concentration	%_days_in_exceedance
more.than.75	0.0481030
more.than.125	0.0060976
more.than.175	0.0006775



concentration	%_days_in_exceedance
more.than.75	14.3333333
more.than.125	3.0000000
more.than.175	0.3333333

The count of days where SO_2 concentration that resulted from household emissions is modelled to exceed a specified level, is shown below for the baseline scenario.



Occurrences of exceedances of the daily SO_2 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.

concentration	%_days_in_exceedance
more.than.75	0.0250678
more.than.125	0.0027100

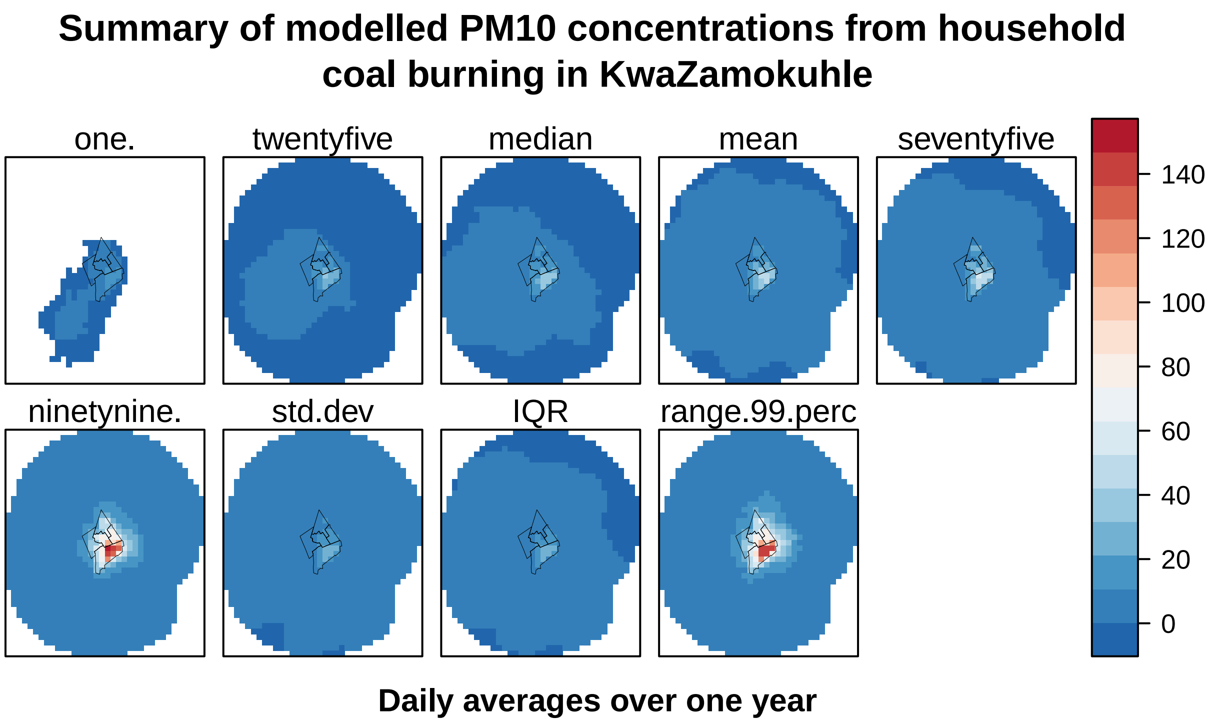
The count of days where SO_2 from the industrial point source exceeded the specified level for the baseline scenario is not shown in the previous plot because all values are below the minimum level.

Project boundary

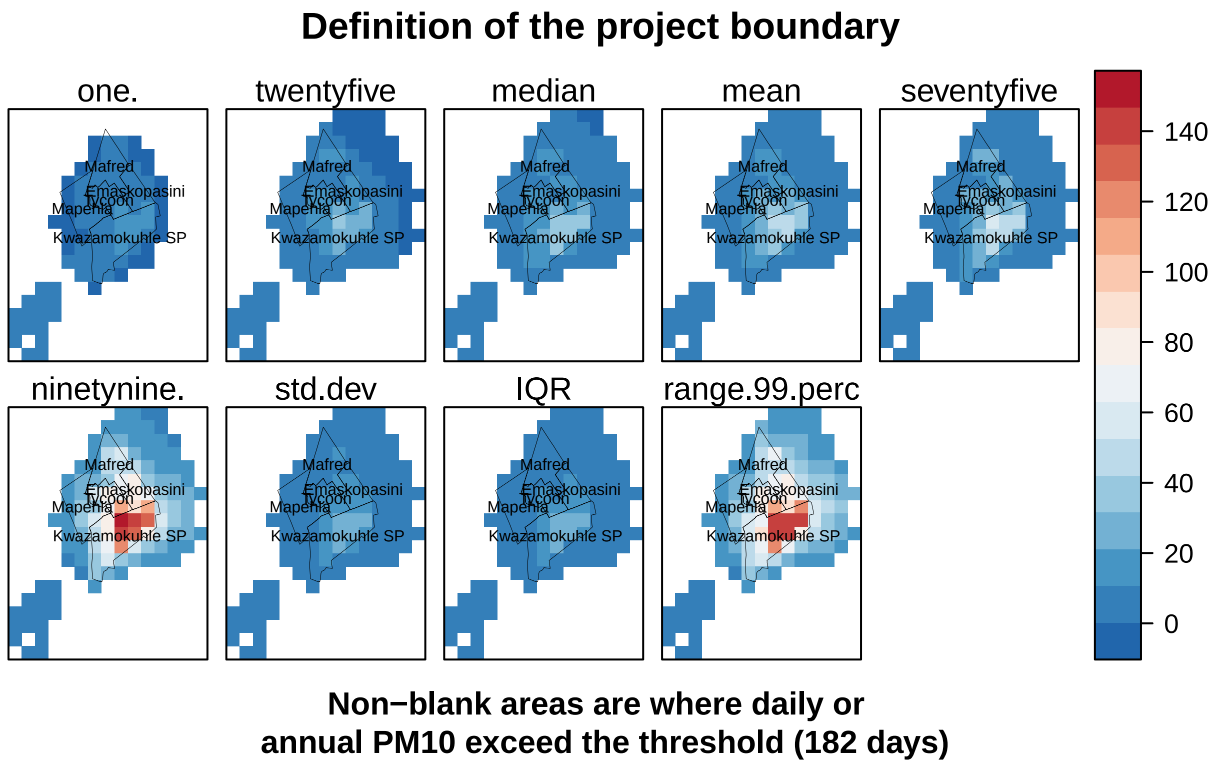
The spatial extent of the project boundary is the overlapping extent of the ambient contribution of the baseline emissions above 2 ug/m3 per year or 19 ug/m3 per day in PM10 or SO_2, and the same for project emissions from the managed activity. Project emissions from the managed activity are the emissions 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 emissions from household coal use are summarised below. The tiles represent the 1st, 25th and 50th percentiles, the mean and the 75th and 99th percentiles. The last three tiles represent the standard deviation, inter-quartile range and 99% range of the data.



The extent of the impact of household emissions in the baseline scenario above an annual average of 2ug/m3 or an daily average of 19ug/m3 is shown below. Blank cells are outside of the project boundary.



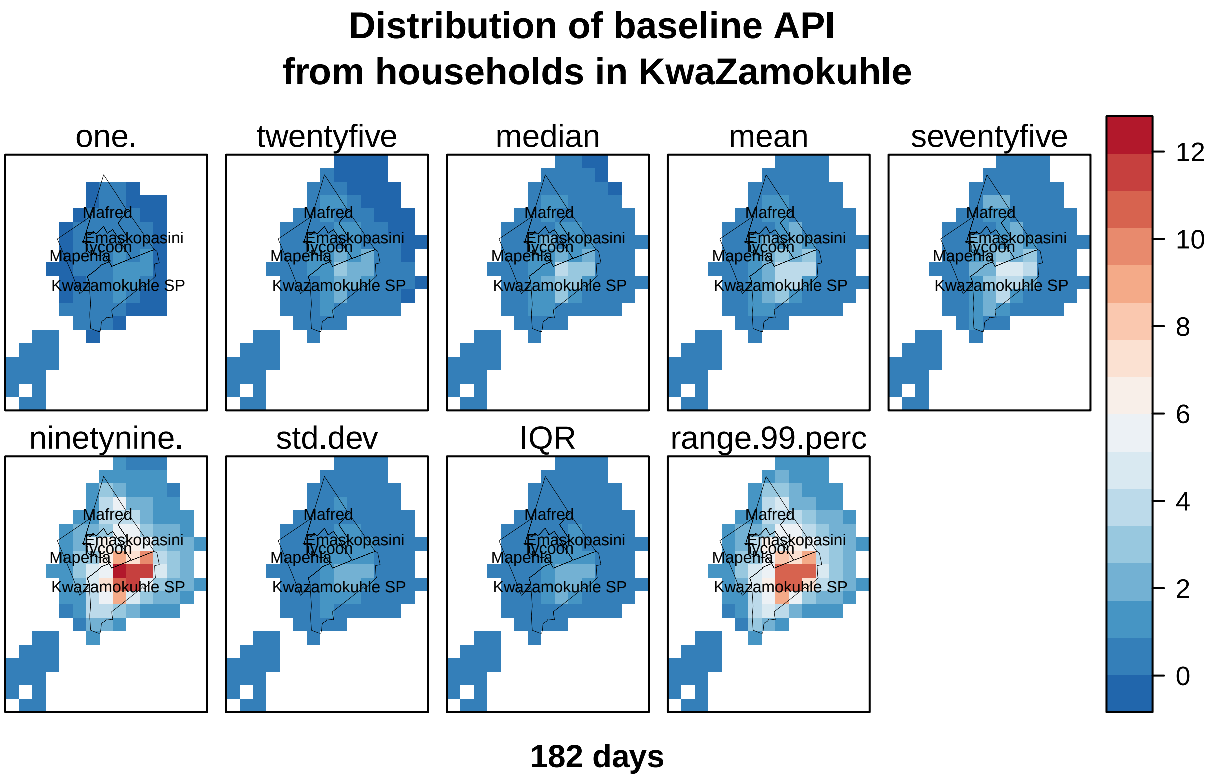
It is clear from the application of the threshold that, if the modelling is correct, the impact of domestic burning is localised in close proximity to the emissions. The project boundary includes the whole of the main place KwaZamokuhle. Of all the sub-places that make up the main place KwaZamokuhle,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

Baseline impact

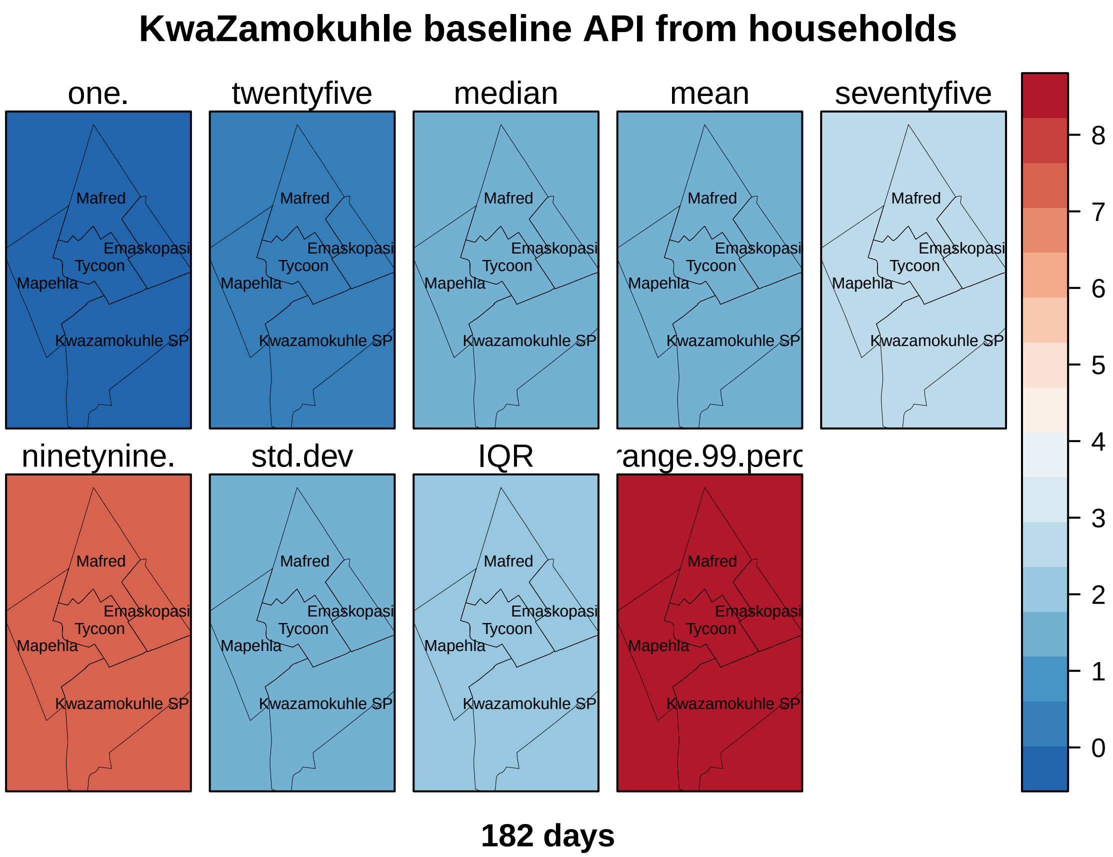
Baseline impact can be determined using different calculation approaches. Four approaches will be demonstrated. These are: 1. Health risk approach 2. Particle equivalence approach 3. Standards weighted intake 4. Burden of disease approach

Health risk approach

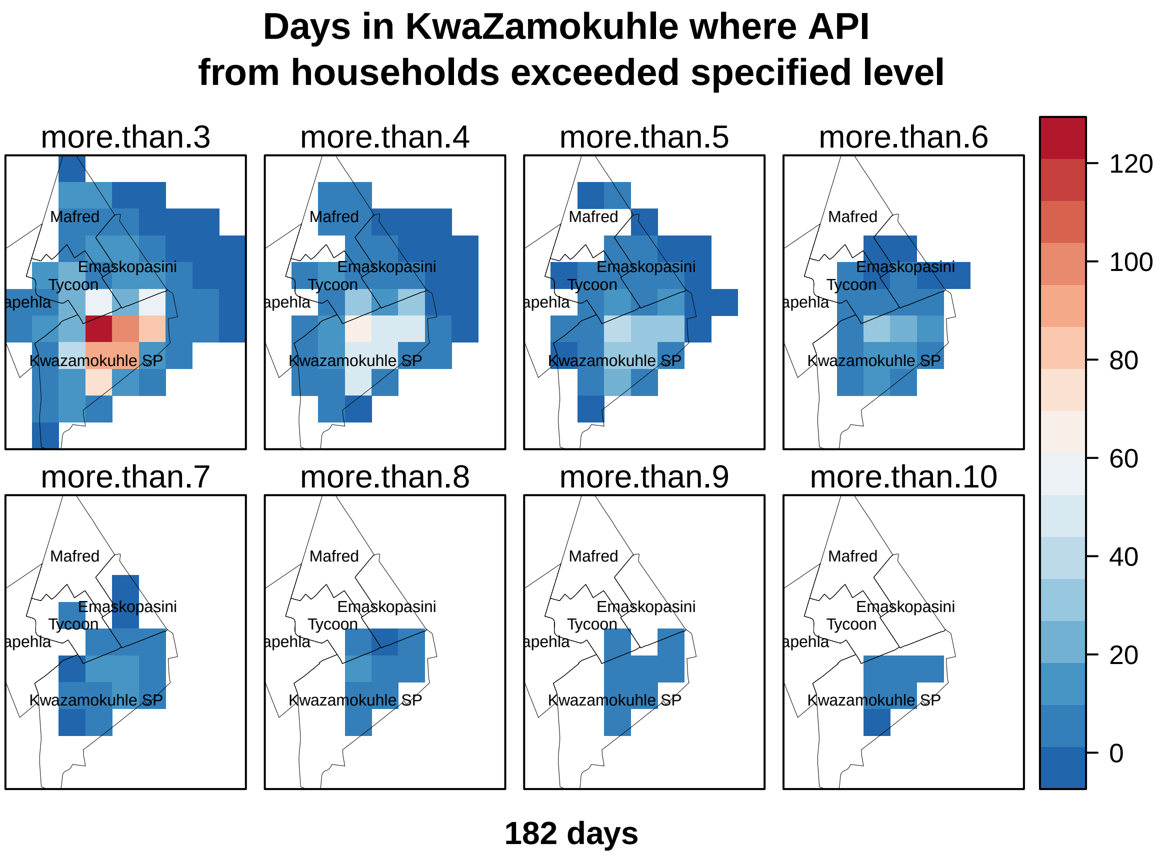
The health risk approach uses an air quality index based on the relative risk of short term mortality associated with every pollutant. Here the pollutants are PM10 and SO_2, but O_3 and NO_2 can potentially be added. The baseline impact represents the combined impact of all pollutants. A summary of the daily API resulting from households is given below.


Distribution of baseline API
from households in KwaZamokuhle
one.
twentyfive
median
mean
seventyfive
ninetynine.
std.dev
IQR
range.99.perc
Mafred
Emaskopasini
Tycoon
Mapehla
Kwazamokuhle SP
12
10
8
6
4
2
0
182 days

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



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.



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, in the case of household emissions, the baseline impact is the same as the baseline state of PM10 shown above.

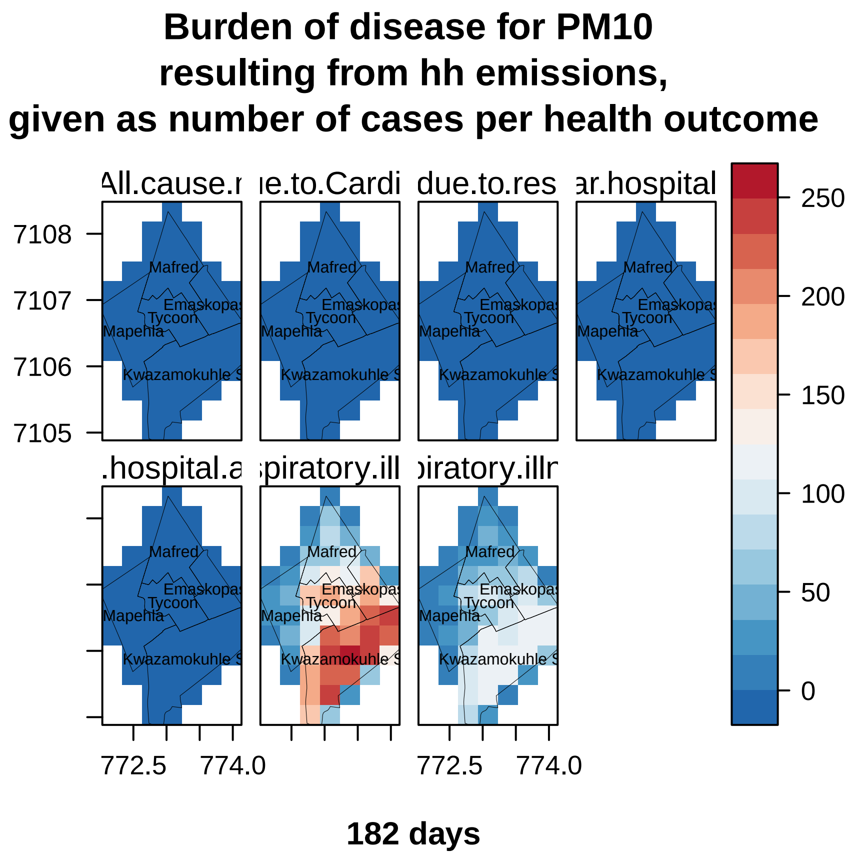
Standards weighted intake

The standards weighted intake approach is 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

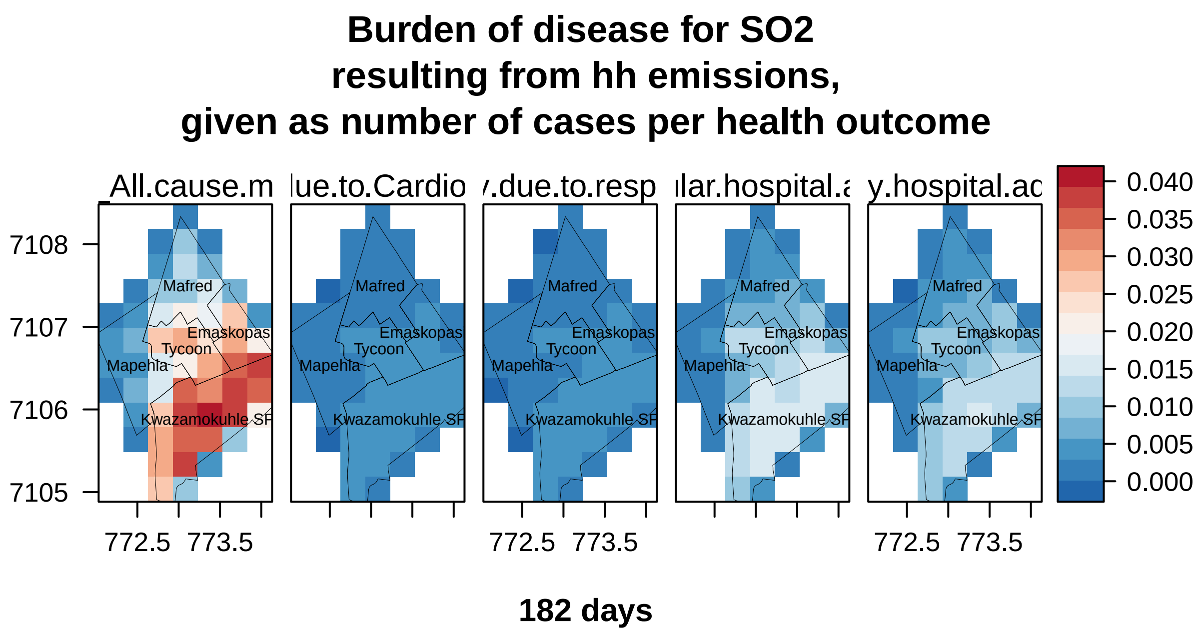
The burden of disease approach quantifies the actual or expected incidence of adverse health outcomes attributible to the exposure to ambient air pollution, and expresses the impact of the air pollution in terms of the proportion or number of cases of a specific outcome or as a weighted aggregate of such outcomes.

The baseline burden of disease impact for PM10 resulting from household emissions is shown below.



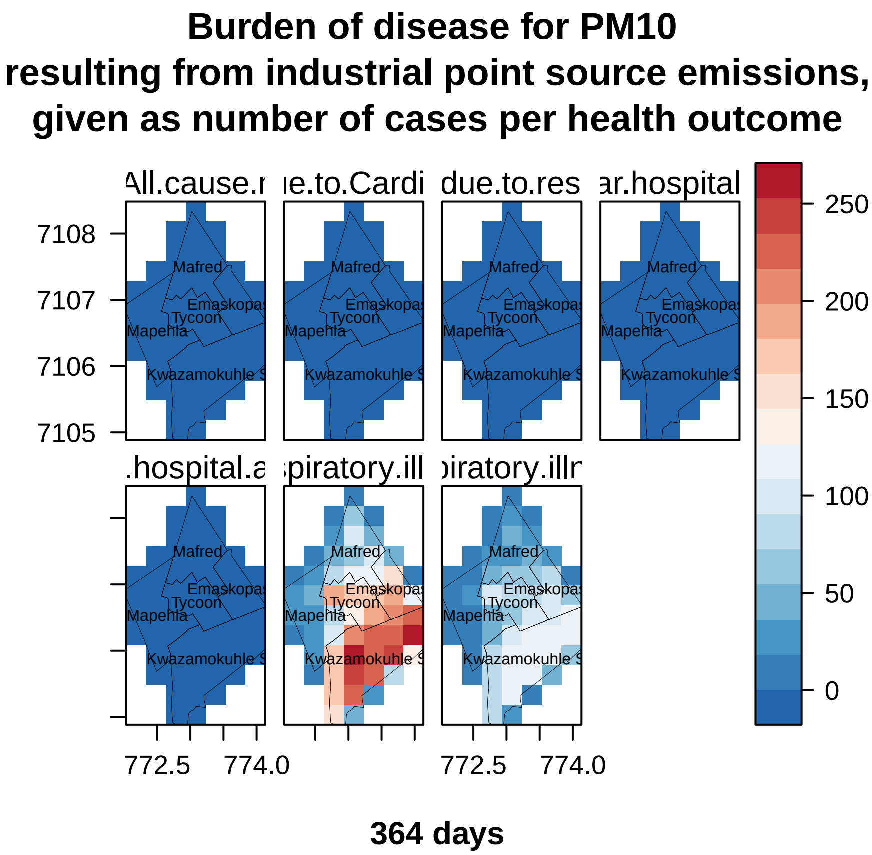
outcome	total_cases
all cause mortality	1.03
mortality due to cardiovascular diseases	0.15
mortality due to respiratory diseases	0.13
cardiovascular hospital admissions all ages	0.43
respiratory hospital admissions all ages	0.37
chronic respiratory illness among adults	6523.47
chronic respiratory illness among children	3261.74

The baseline burden of disease impact for SO_2 resulting from household emissions is shown below.



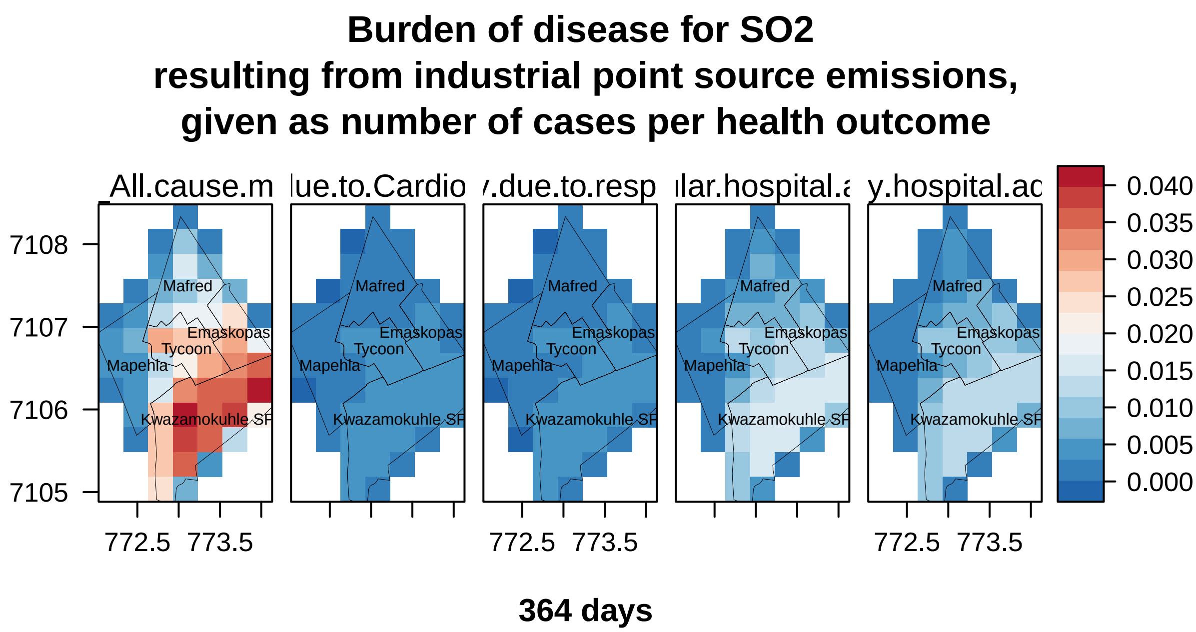
outcome	total_cases
all cause mortality	1.03
mortality due to cardiovascular diseases	0.15
mortality due to respiratory diseases	0.13
cardiovascular hospital admissions all ages	0.43
respiratory hospital admissions all ages	0.37

The baseline burden of disease impact for PM10 resulting from the industrial point source is shown below.



outcome	total_cases
all cause mortality	1.03
mortality due to cardiovascular diseases	0.15
mortality due to respiratory diseases	0.13
cardiovascular hospital admissions all ages	0.43
respiratory hospital admissions all ages	0.37
chronic respiratory illness among adults	6523.47
chronic respiratory illness among children	3261.74

The baseline burden of disease impact for SO2 resulting from the industrial point source is shown below.



outcome	total_cases
all cause mortality	1.03
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cardiovascular hospital admissions all ages	0.43
respiratory hospital admissions all ages	0.37

Project scenario

The project scenario is the implementation of a stove exchange for all RDP houses who use coal, where the households exchange their old coal stoves for a full retrofit and LPG.

The estimates of 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

	place	fuel house	PointEst	Lower	Upper
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 13: 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 * Union * 1.4 * 2 to be conservative ~ 5%

Proportion of solid fuel using households reachable by the project

Project states

Project impacts