Notes on air quality offset calculations

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Simulated example

A simple simulated example is used to illuminate key aspects of the air quality offset problem related to industrial sources that is offset by domestic air pollution and to test the calculation functions. The main computational challenge in air quality offsetting is spatial and temporal resolution at which the calculation takes place. This is an issue that has to be taken into account in the calculations but also in reporting and representation. The calculation tools developed for the offset methodology maintain the spatial of the original dispersion model and aggregates the data from the original dispersion model to 24 hours as this is the default averaging period relevant to acute expose in the methodology.

Setup

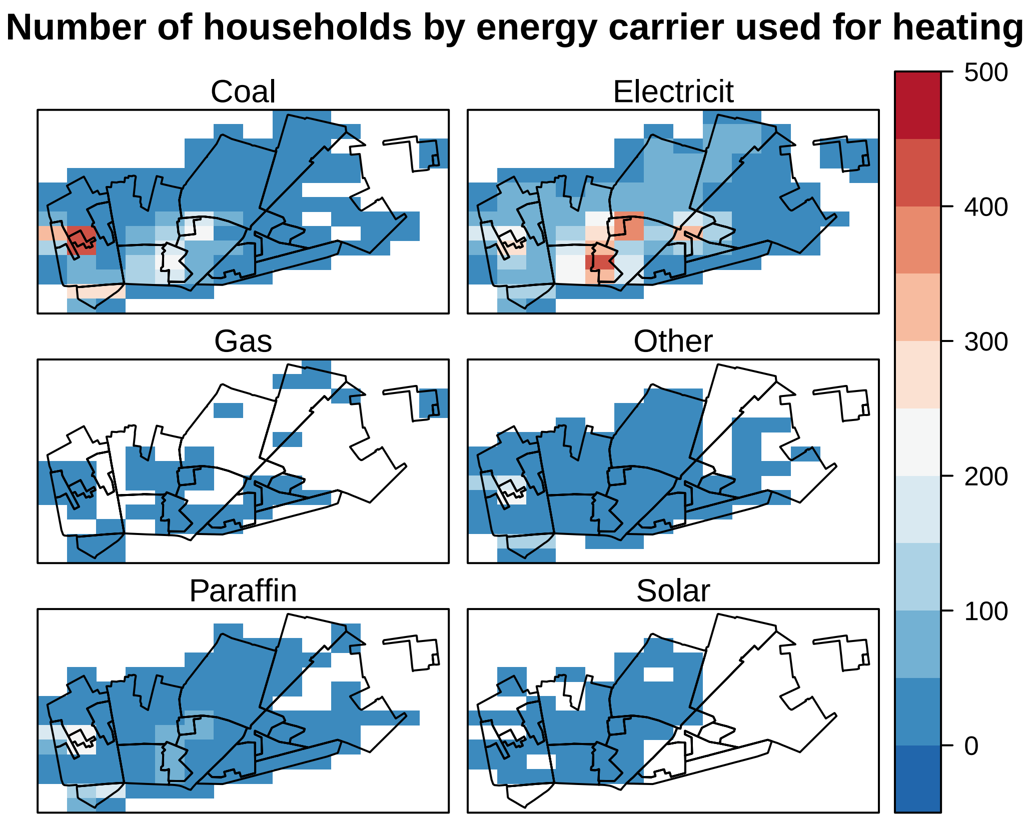
For the purpose of this simulated the following assumptions apply:

- Population
  - Assume a town with a number of suburbs
  - Different distribution of energy carriers in each suburb
- Pollution sources
  - One large source of SO2 relatively far from the town
  - A smaller source of PM10 closer to town
  - Distributed household PM10 sources within the town
- Offset scenario
  - Reduce household emissions of x% of households by z%
  - Baseline for the large SO2 source is at 80% of its current emissions
  - Calculation is done for a period of one year
  - A number of offset calculation methods are demonstrated

Pollution sources

Household sources

To calculate the potential of a household-based air quality offset intervention, one needs to know the distribution of households and their energy use patterns. The figure below shows the distribution of households by energy carrier used for heating in the example data set.



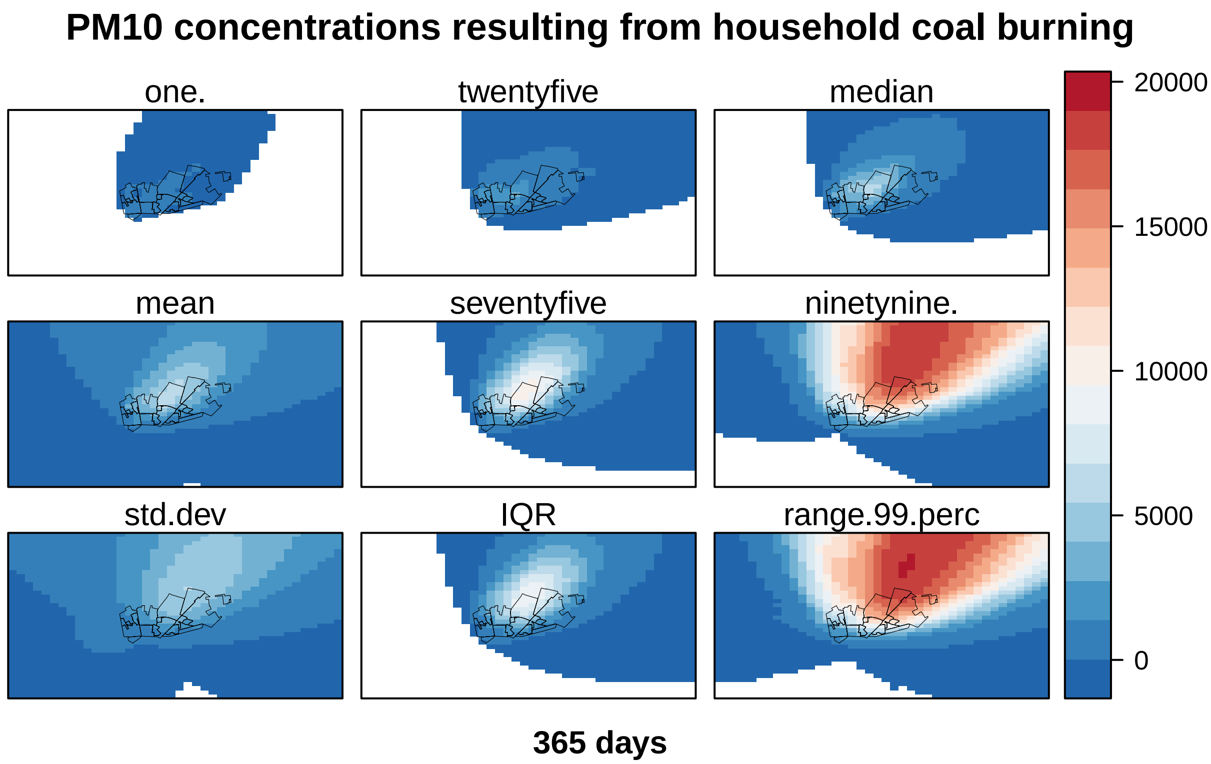
Baseline scenario

The baseline scenario is that domestic coal use would continue unabated.

Household emissions and atmospheric impact

Each energy carrier type is associated with an expected emission rate that may vary daily or seasonally. For the sake of an offset calculation is not needed to estimate all emissions from households in a specific area but only those emissions that are addressed by the interventions (i.e. that differ in the baseline and the project scenario).

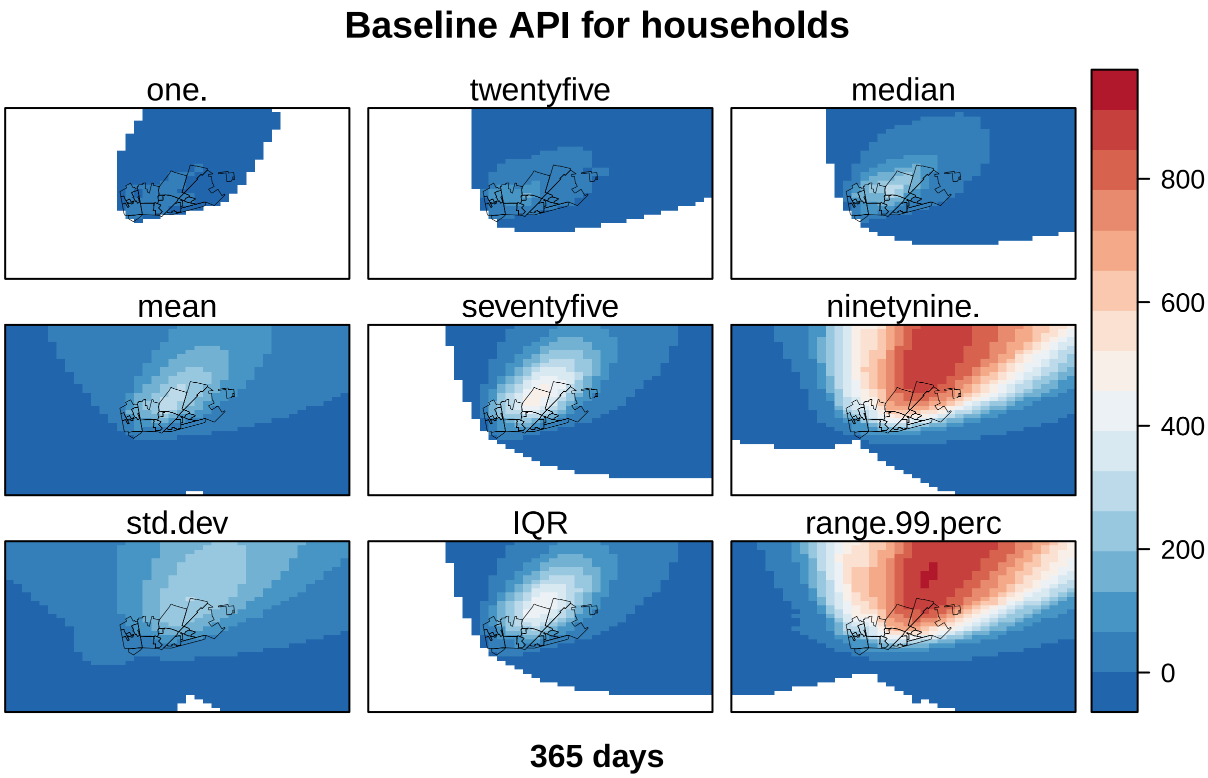
PM10 emission must be modeled for household coal use because the target pollutant in the example case is PM10 and the target emission source in domestic coal burning. A summary of 365 days of PM10 concentrations resulting from household coal burning is shown below for the simulated dataset (the panels represent [left to right, top to bottom], the first, 25th, 50th percentiles, the mean, the 75th and 99th percentiles as well as the standard deviation, inter-quartile range and 99% range).



Household Impact

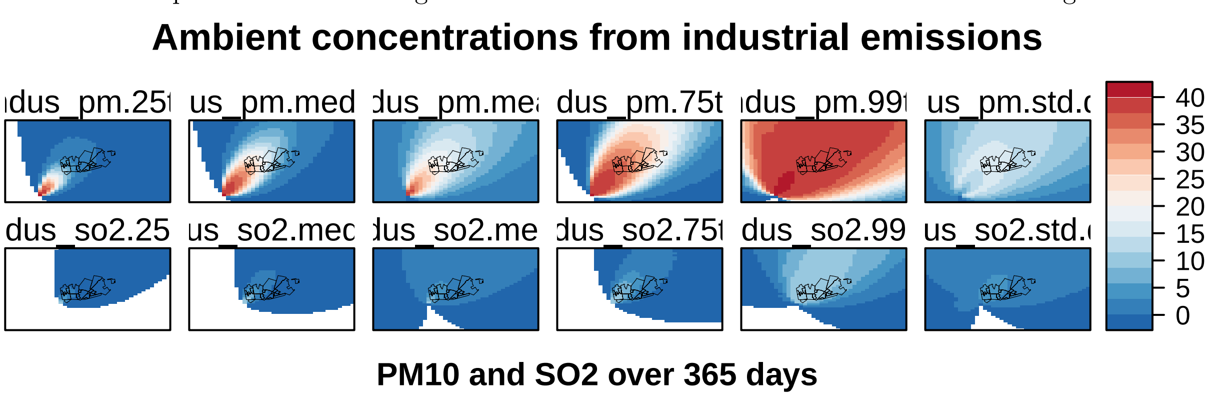
The health risk posed to a single susceptible individual is used as the impact metric. This is the simplest of the impact metrics allowed by the the methodology. Only PM10 from households is qualified. This is a conservative since the project will also lead to the reduction in other emissions such as SO2. The project impact is therefore likely higher that what is expressed here but any additional benefits are discounted i the interest of a conservative estimate of the impact of the project activity.

A summary of the API score for PM10 and SO2 from households are shown below

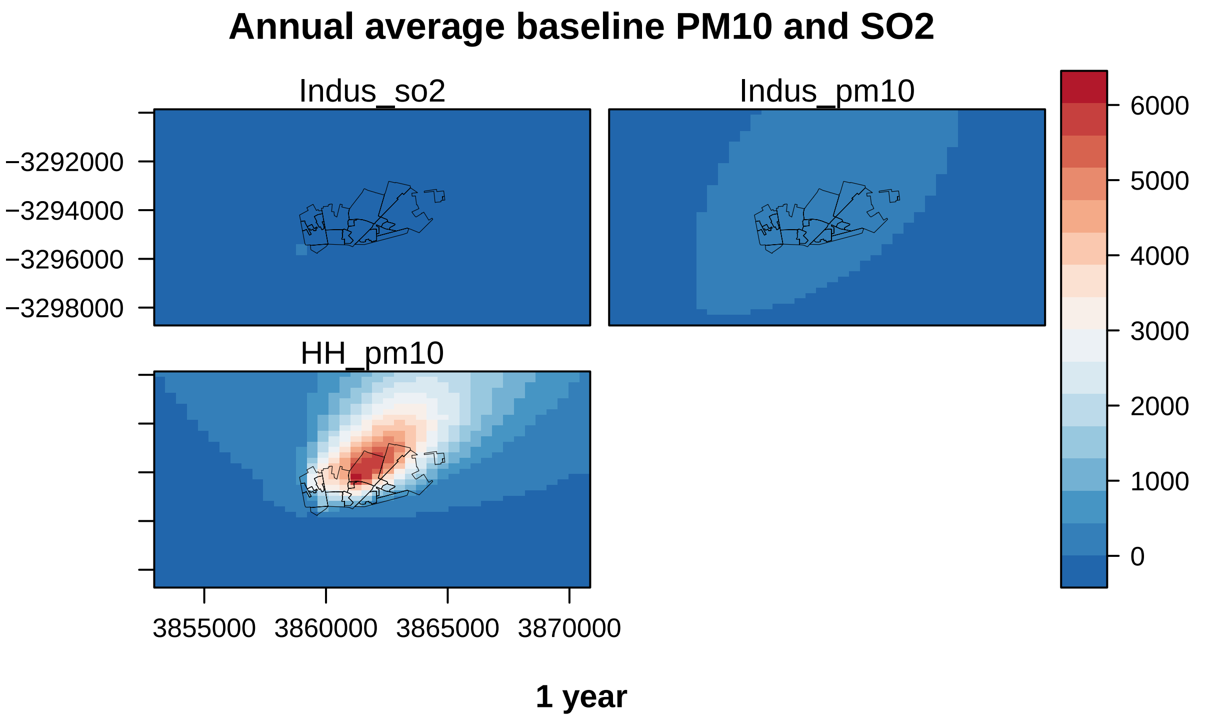


Industrial sources

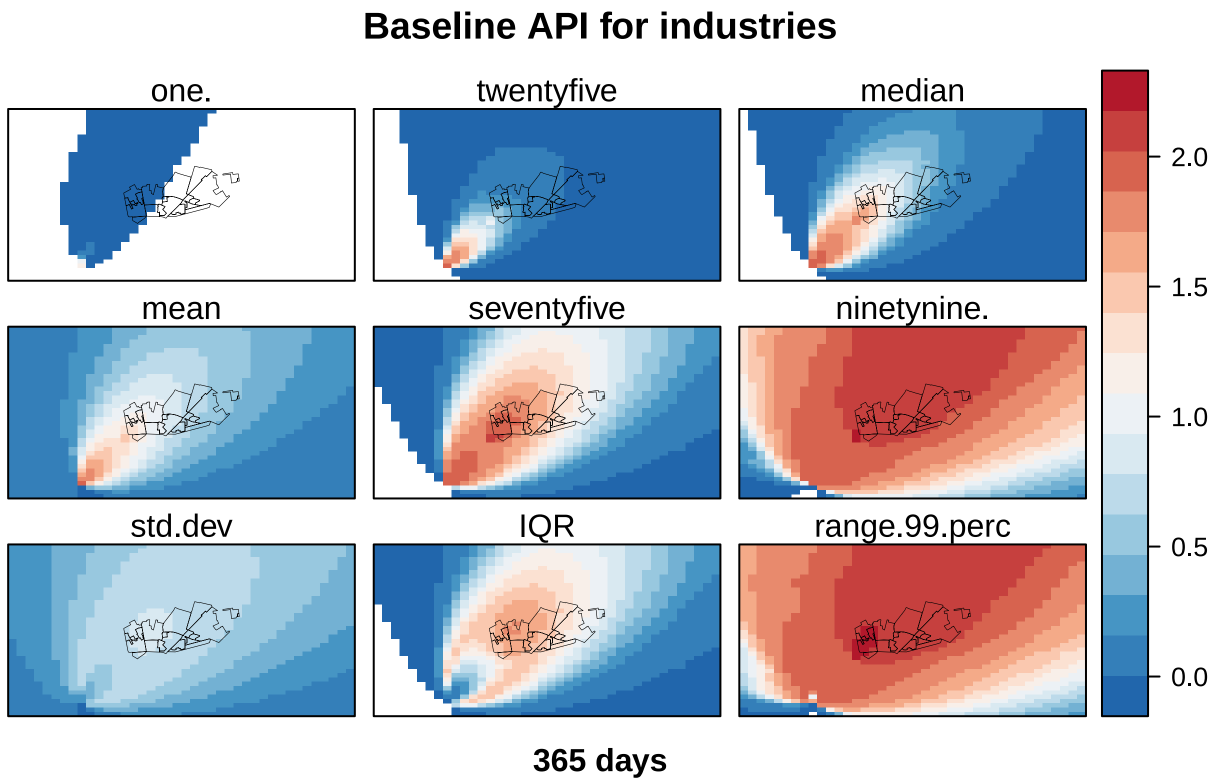
The typical offset scenario will be that a large industrial point source will be situated some distance away from densely inhabited areas but that inhabited areas may be affected from time to time. A summary of the baseline atmospheric states resulting from the industrial source in the simulated dataset is given below.



Not only short term exposure is important, but also long term exposure because the largest effect of air pollution is likely to be the loss of life years due to chronic exposure to air pollution. The annual averaging period must therefore also be accounted for. The annual average PM10 and SO2 concentrations resulting from the simulated industrial source are given below.

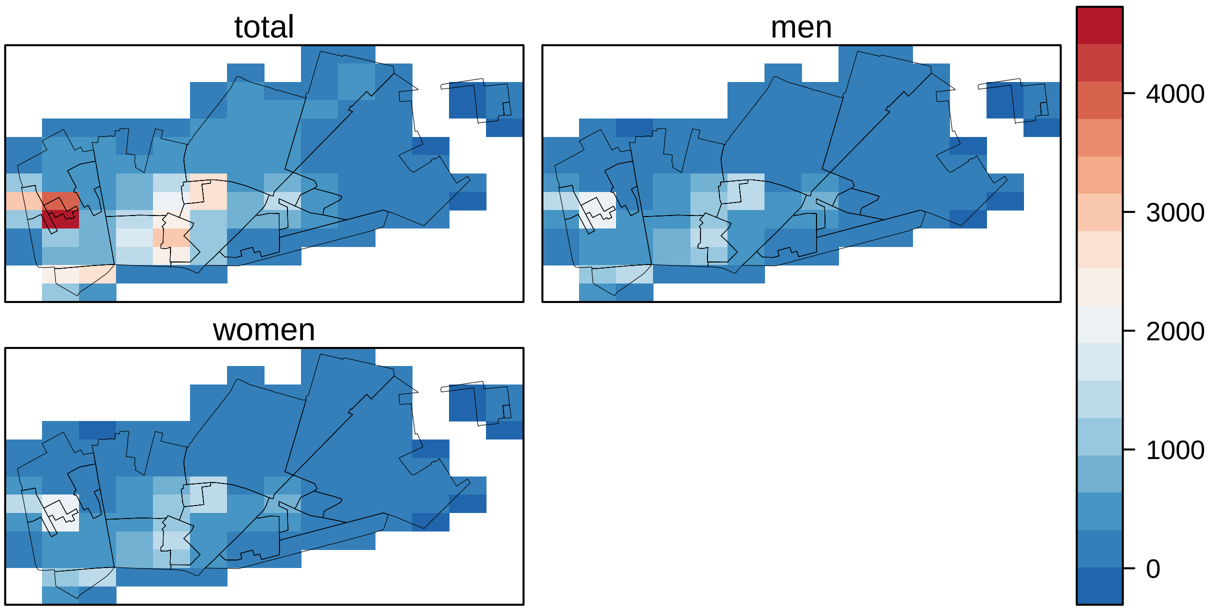


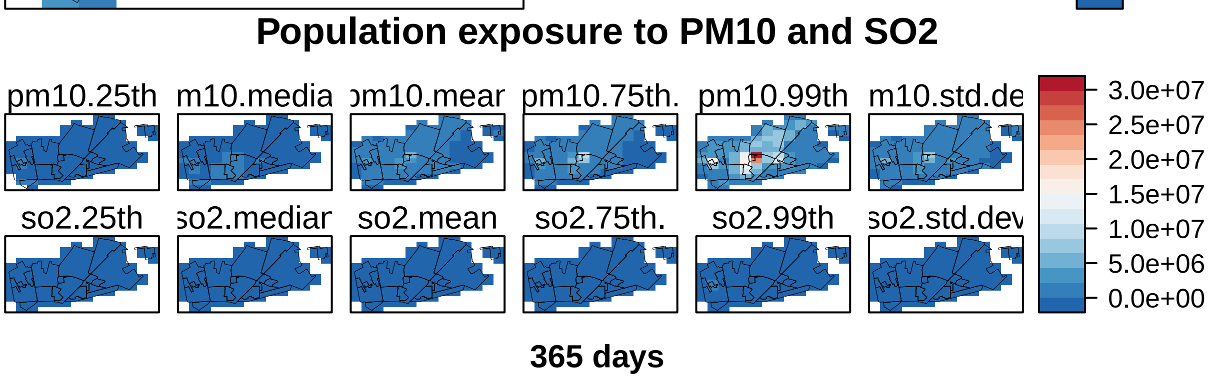
In the same way as with households, the impact of industrial sources can be expressed in terms of health risk with an air pollution index score for each 24 hour period. This is shown below.



Population

Not all calculation approaches require population characteristics. Methods making use of exposure, intake or aggregated health outcomes must make use of basic population characteristics. Such data can be stored as counts of men and women (possible differentiated into age categories) in each cell. Exposure in each time period is expressed as the product of people and ambient concentrations.





In the example above it is obvious that the bulk of the impact, as expressed in population exposure, is located in a small. The exposures shown above multiplied by an breathing rate yields the intake used in the standards weighted intake approach.

Incidence rates

Very often incidence rates for health outcomes are not available at the same resolution as the exposure data and one must assume regional or national incidence rates to apply to the target area.

Offset scenatio

In the example dataset the following scenarios are assumed. It is assumed that in the baseline scenario the industrial source would reduce SO2 emissions by 20% and households would continue coal at baseline rates.

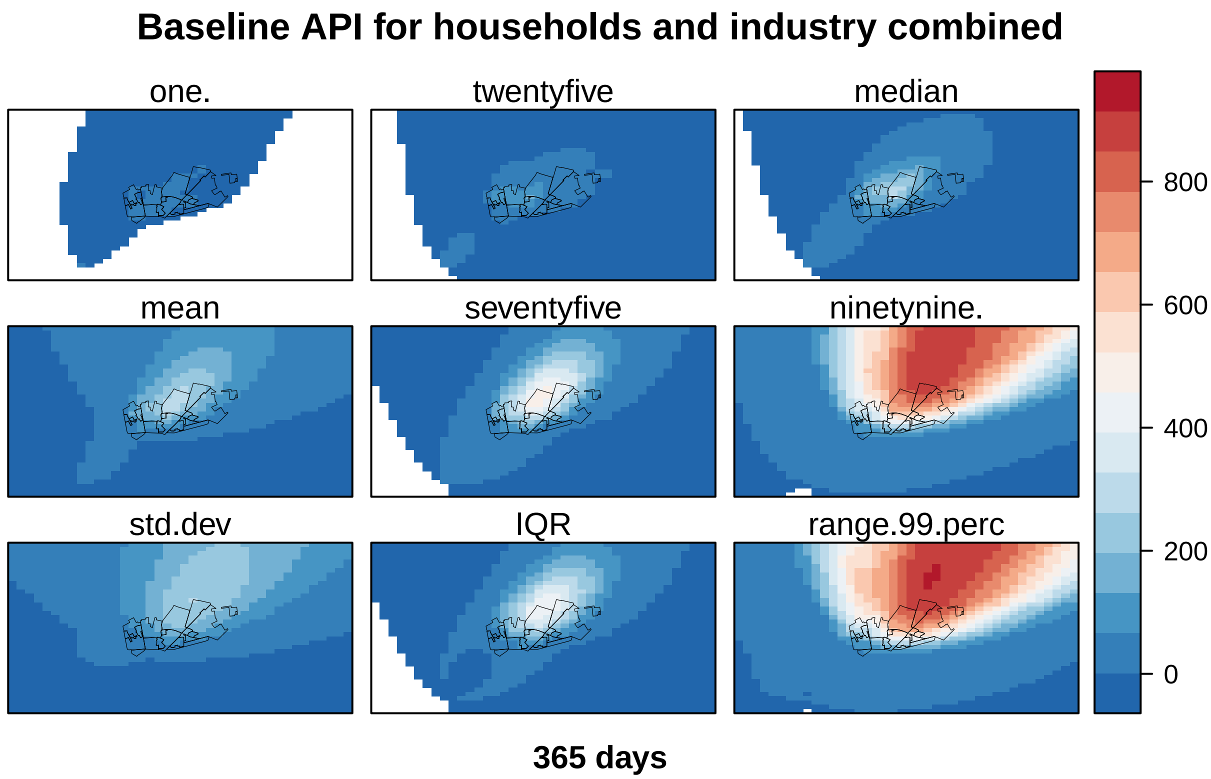
In the project scenario the industrial source would not curtail SO2 emissions but that an intervention would be implemented that reduces emissions by 80% on 50% of coal using households.

To calculate the project impact using the health risk approach the baseline and project atmospheric state is calculated first. In this case the pollutants under consideration are PM10 and SO2 from industrial sources and PM10 from domestic sources. Because acute and chronic exposure are both important the impact is shown both at the 24h and the annual averaging period.

Baseline impact

Acute imact

The baseline impact of acute exposure to pollutants from households and industrial sources over a 24 hour period has already been shown above. Since the API used is by design additive for all pollutants, the baseline impact is the sum of the household and project impact for each day of the year



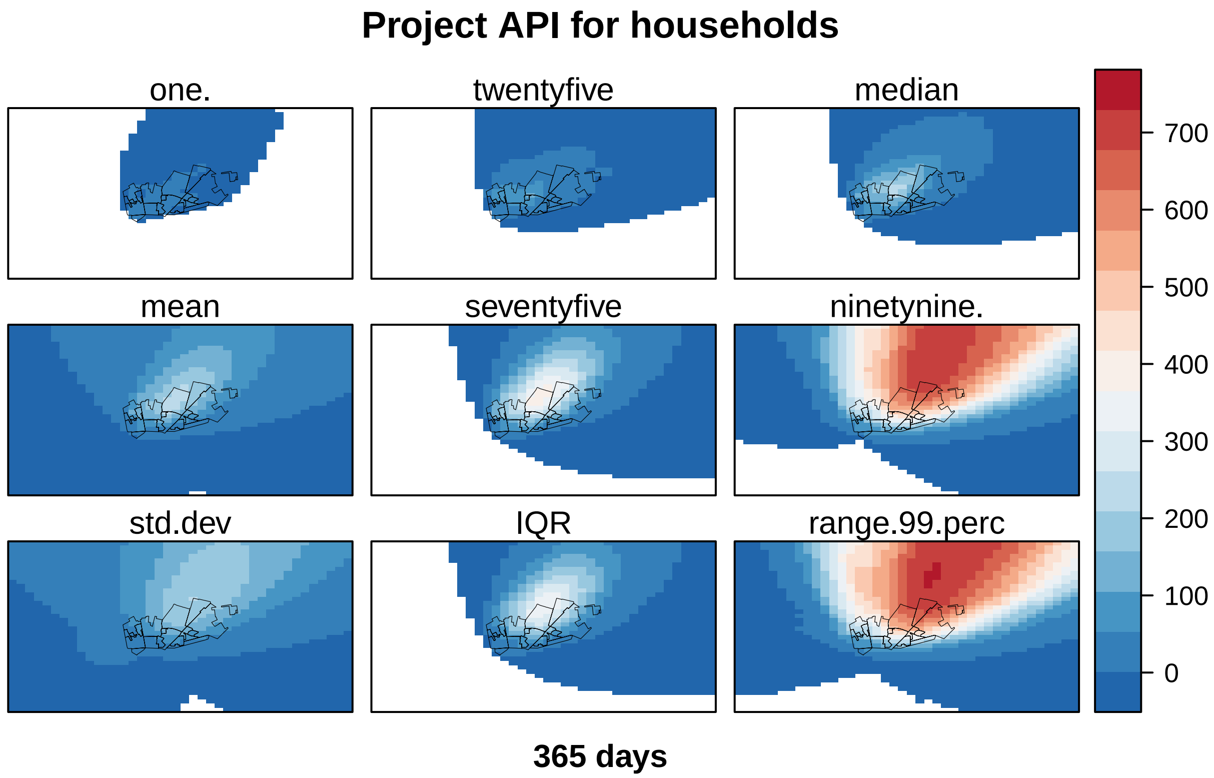
Chronic impact

The chronic impact is a function of the annual average for the baseline scenario that was given above.

Project impact

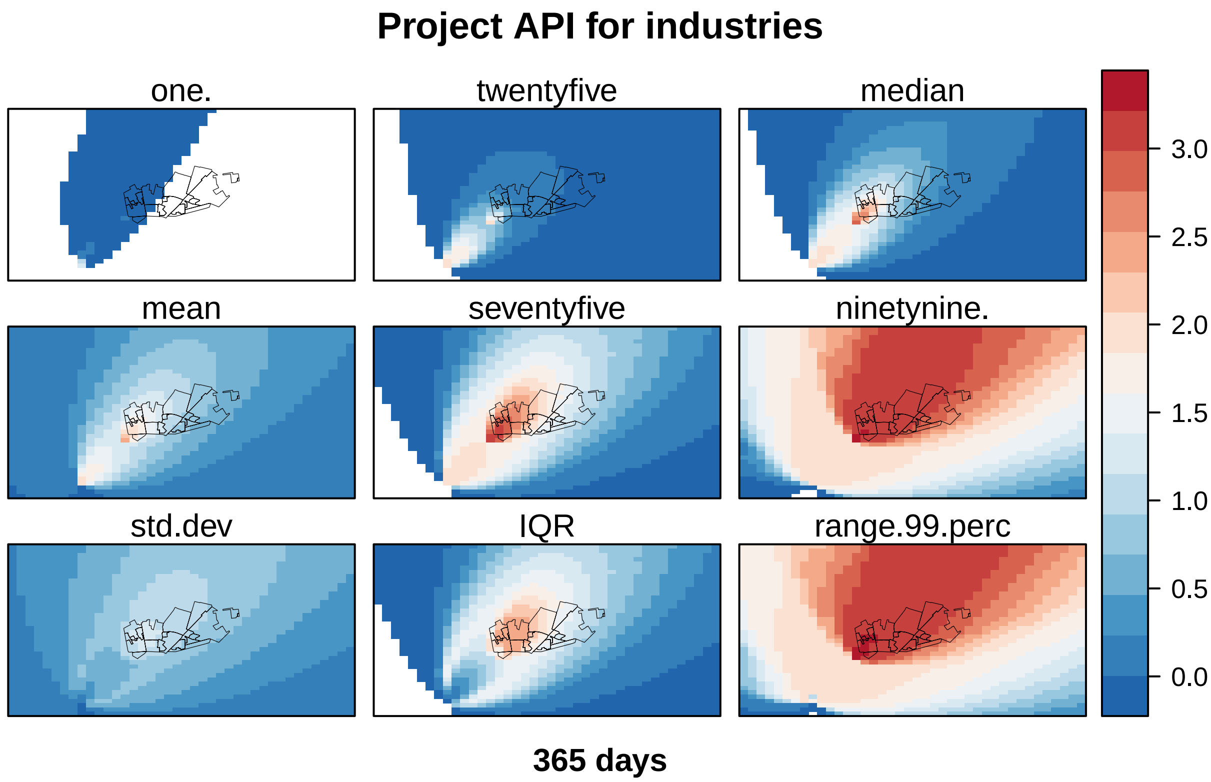
Acute impact of households in the project scenario

The impact, expressed as and 24-hour API score of households in the project scenario is shown below.



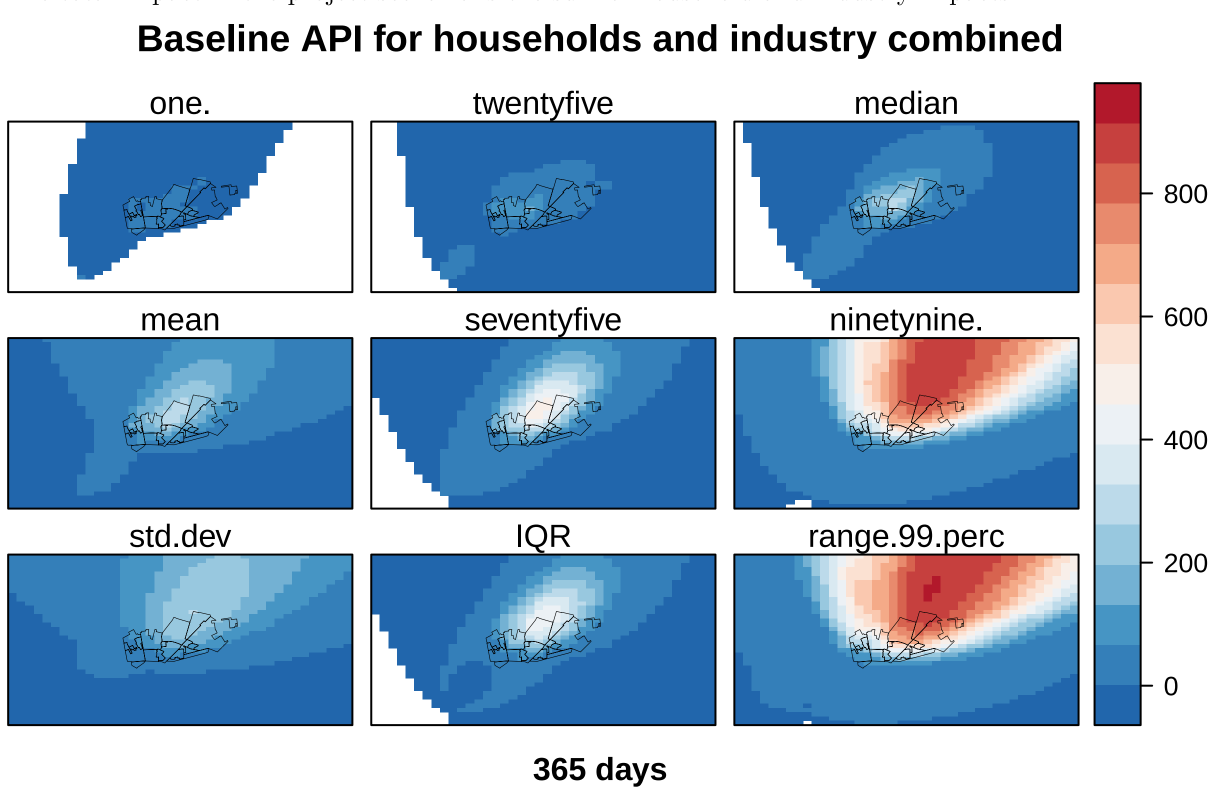
Acute impact of the industrial source in the project scenario

The impact, expressed as and 24-hour API score for the industrial source in the project scenario is shown below.



Consolidated project impact

The total impact in the project scenario is the sum of household and industry impacts.

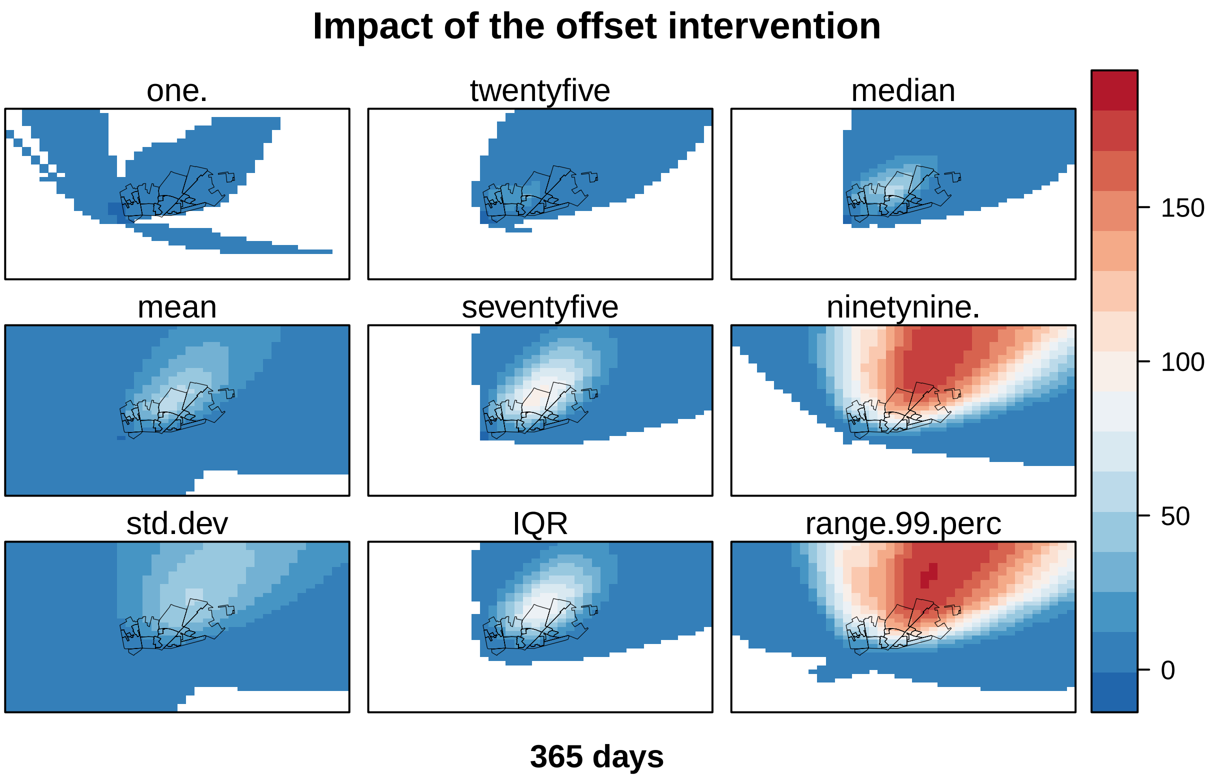


Chronic

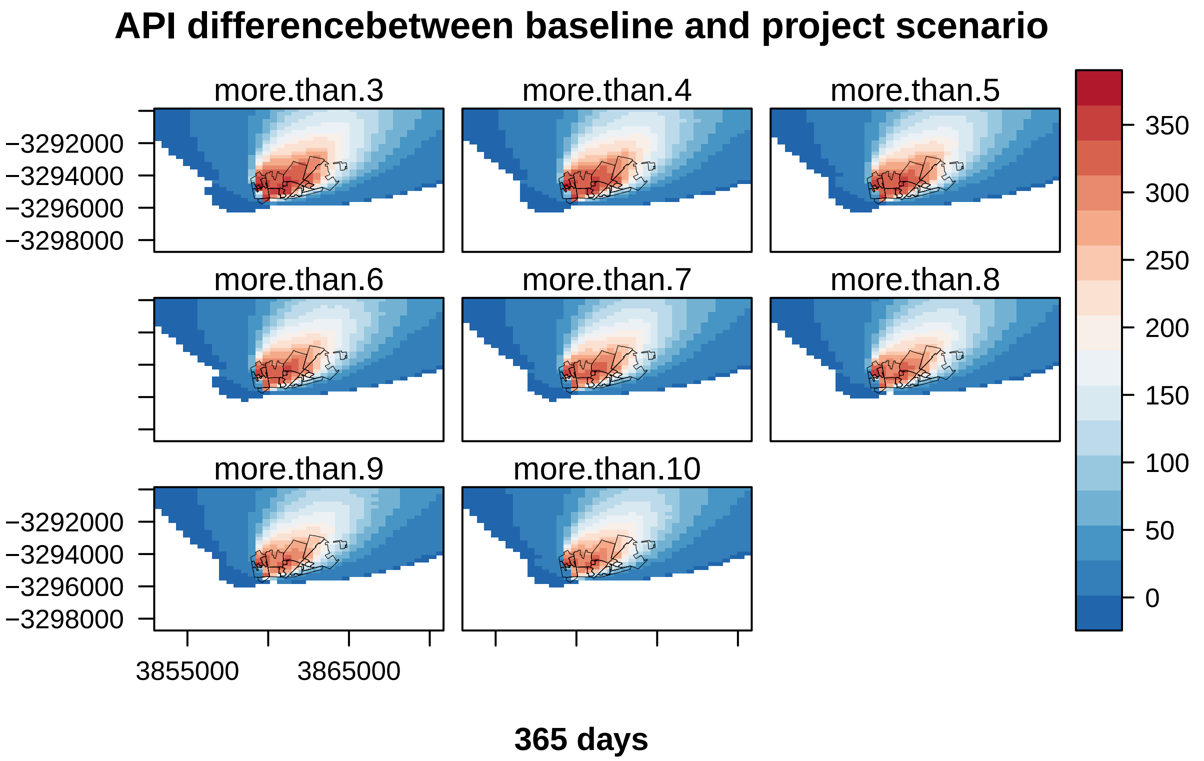
The chronic impact is calculated in the same way as the acute impact but is based on annual averages

Offset impact

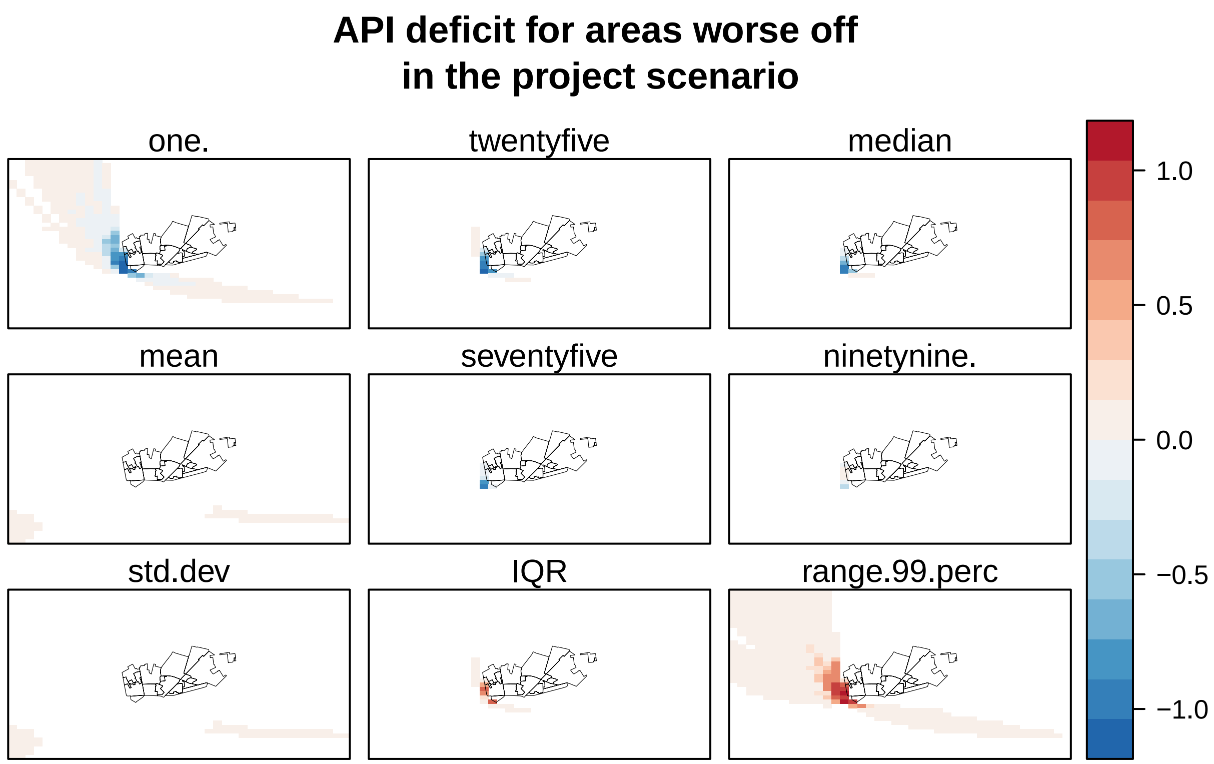
The impact of the offset intervention is the difference between baseline and project impact.



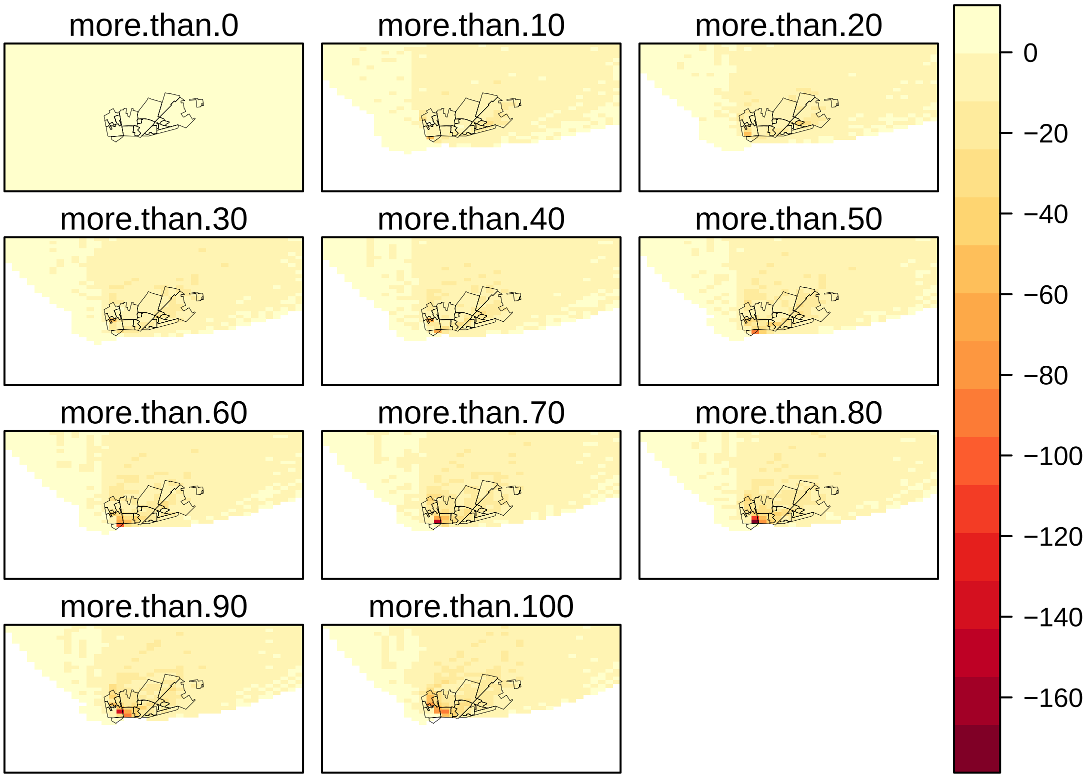
The counts of API difference is important because one has to ascertain if there are areas that are worse off because of the offset.



On the whole it does not seem like the there are large areas that are worse off because of the simulated offset scenario. There are however small areas where the situation is worse on some days in the project scenario compared to the baseline scenario. As is shown below, these areas are situated downwind from the industrial source but mostly upwind from the household sources. The API deficit, however is very small.



The same phenomenon is also visible when the counts of exceedences of specific API levels are compared.



Method applied to Kwazamokuhle with availible data

Project boundary

Extent of the impact of the managed activity

The spatial extent of the project boundary is the extent of the ambient contribution of the managed facility above 2 ug/m3 per year or 19 ug/m3 per day in PM10 or SO2.

Extent of the impact of household emissions

Baseline scenario

Baseline emissions

Baseline emission are calculated from the results of a domestic fuel use survey.

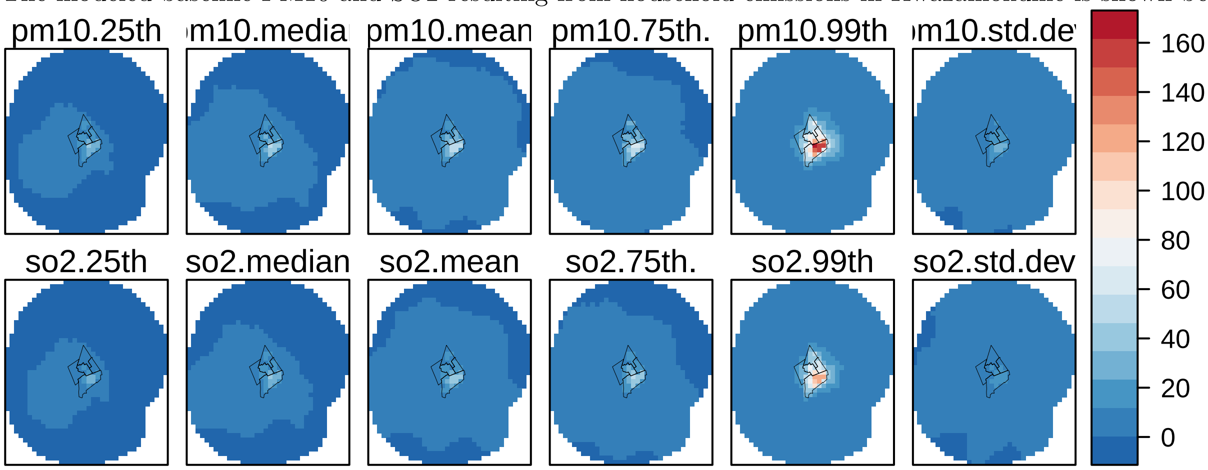
Number of fuel using households

Average seasonal fuel use

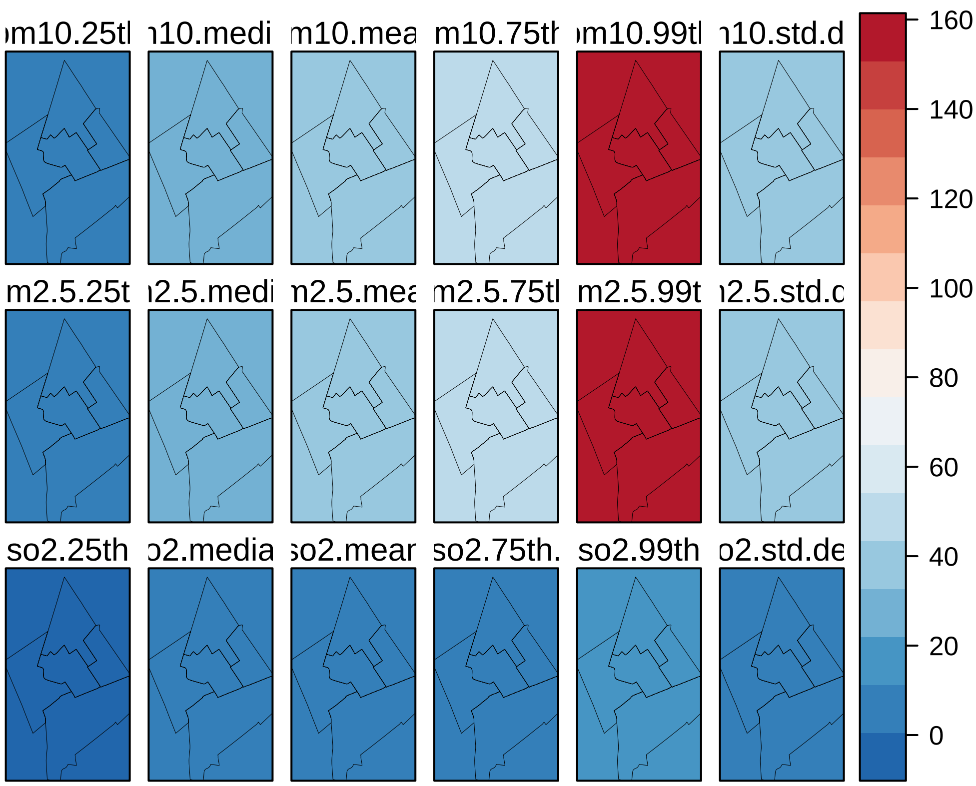
Average and total monthly emissions per season

Baseline states

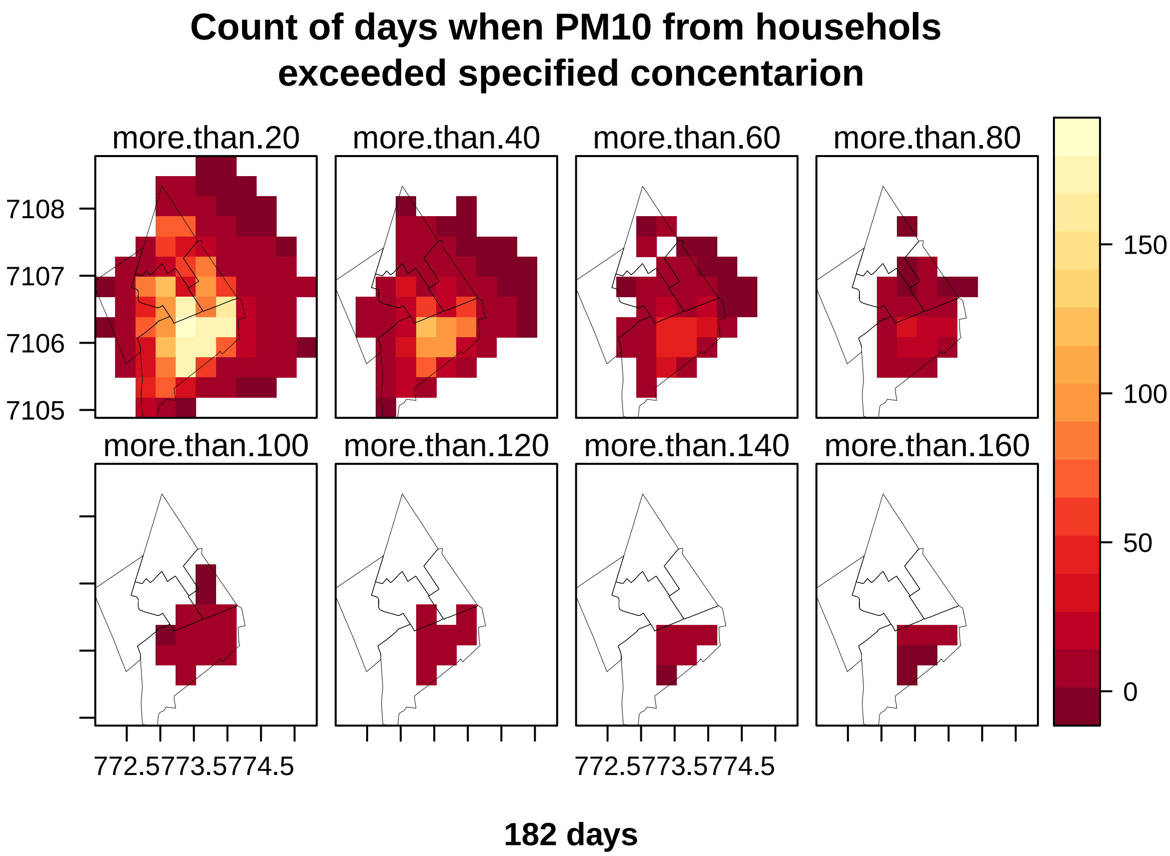
The modeled baseline PM10 and SO2 resulting from household emissions in Kwazamokuhle is shown below.

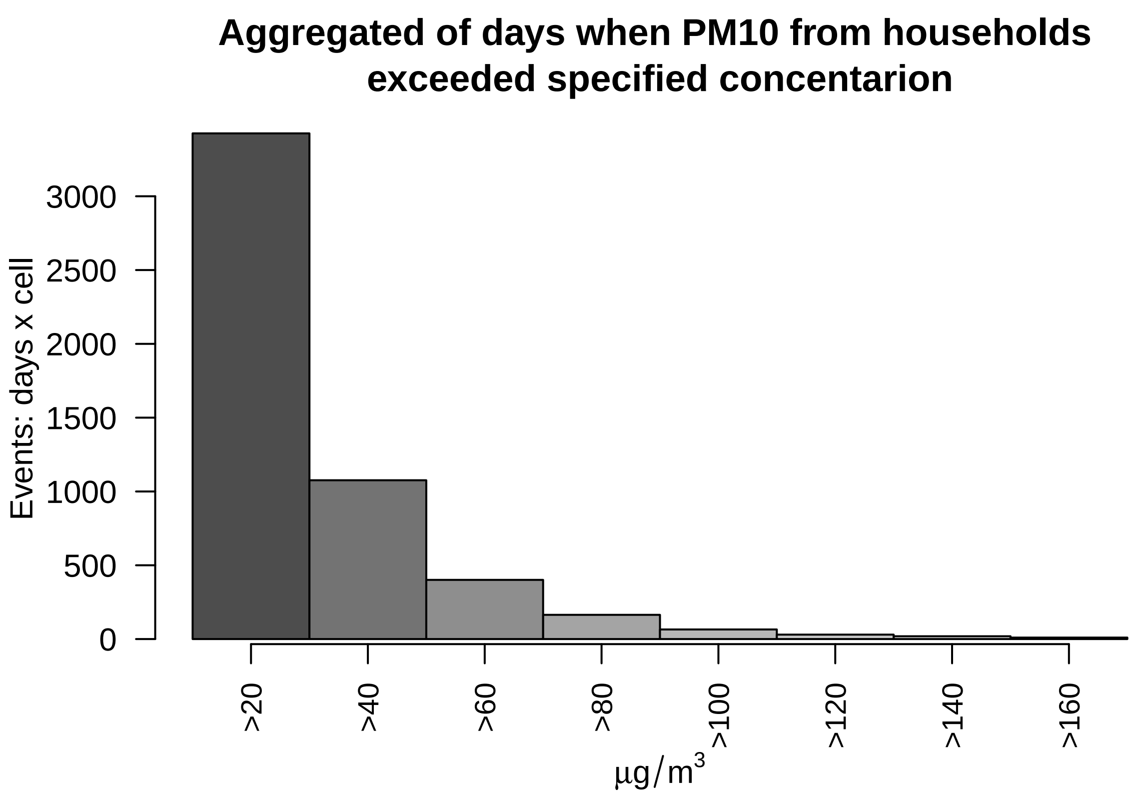


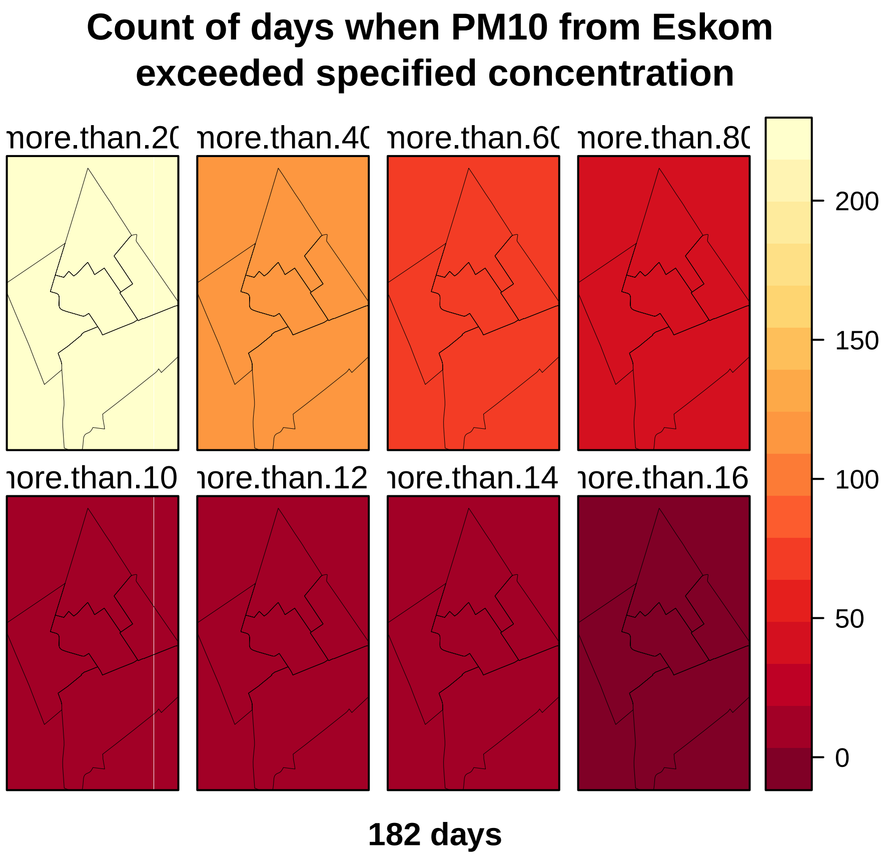
The modeled baseline PM2.5, PM10 and SO2 from the industrial point source is shown below.

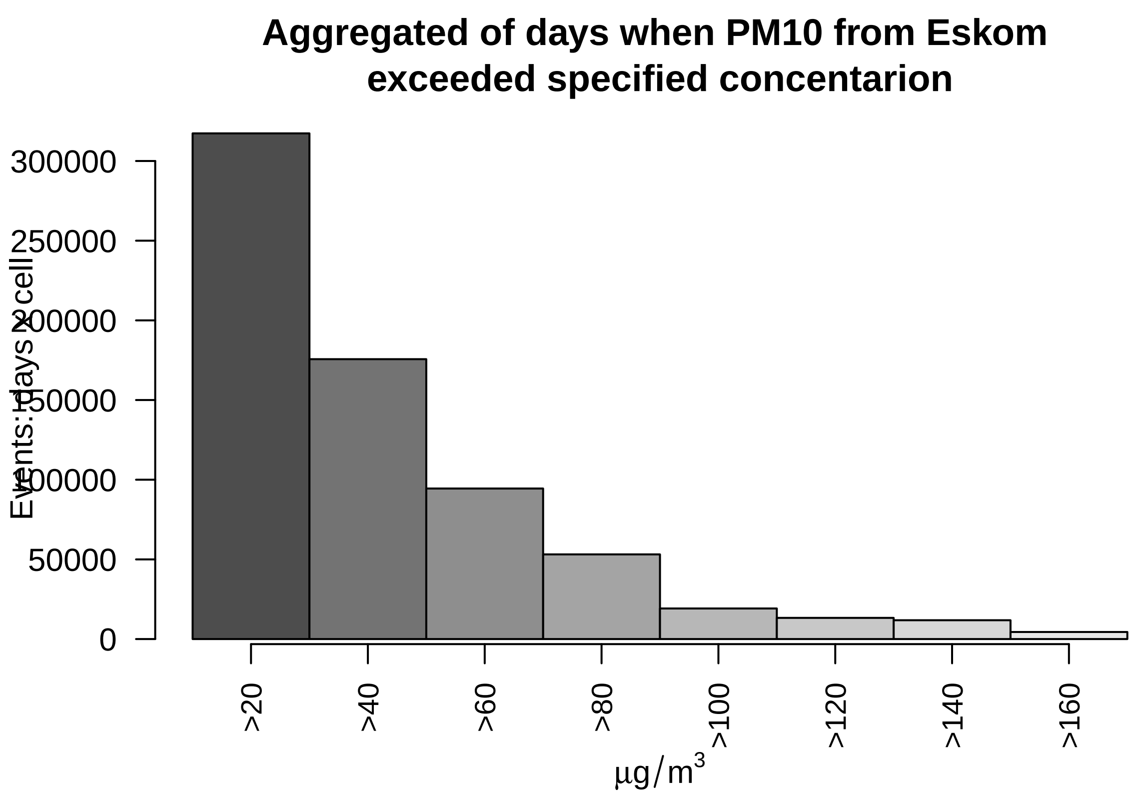


The count of days where the PM10 concentrations that resulted from household emissions and the industrial point source are modeled to exceed a specified level and the is shown below for the baseline scenario.

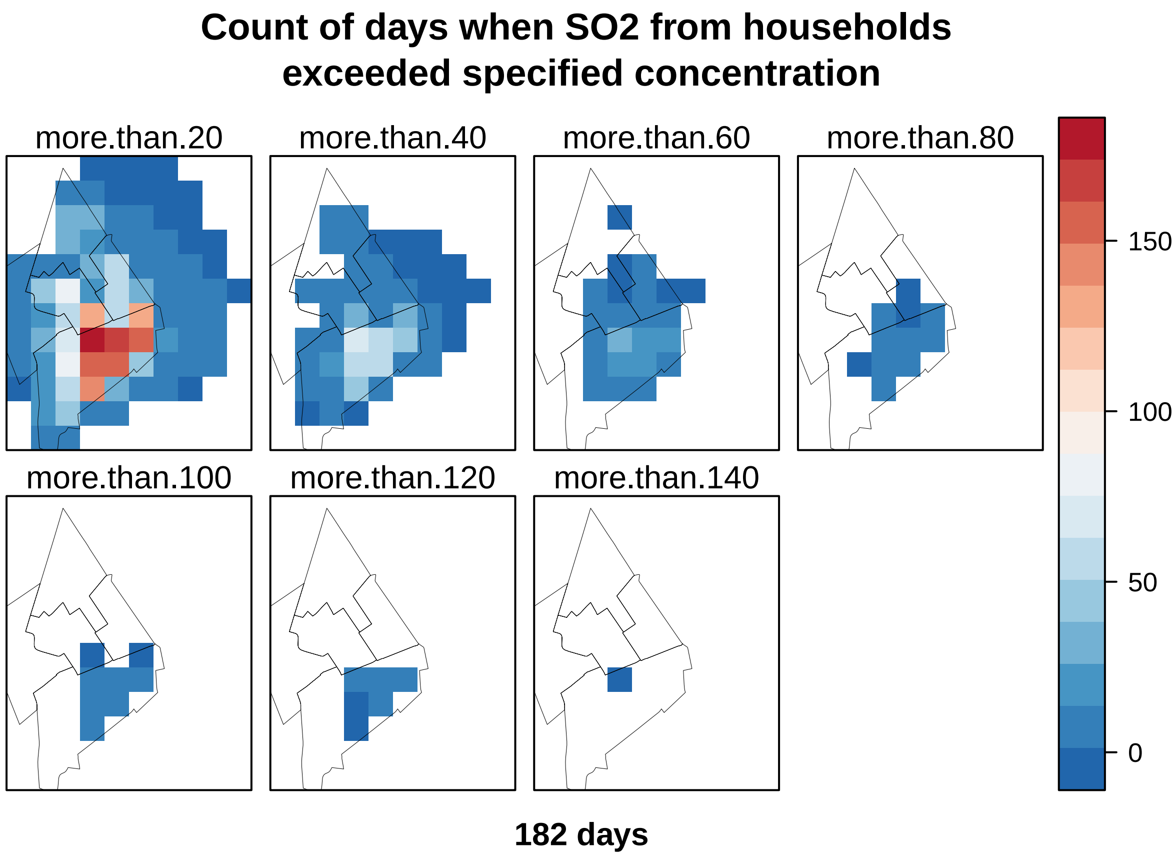

Count of days when PM10 from househols
exceeded specified concentarion
more.than.20
more.than.40
more.than.60
more.than.80
more.than.100
more.than.120
more.than.140
more.than.160
7108
7107
7106
7105
772.5773.5774.5
772.5773.5774.5
150
100
50
0
182 days

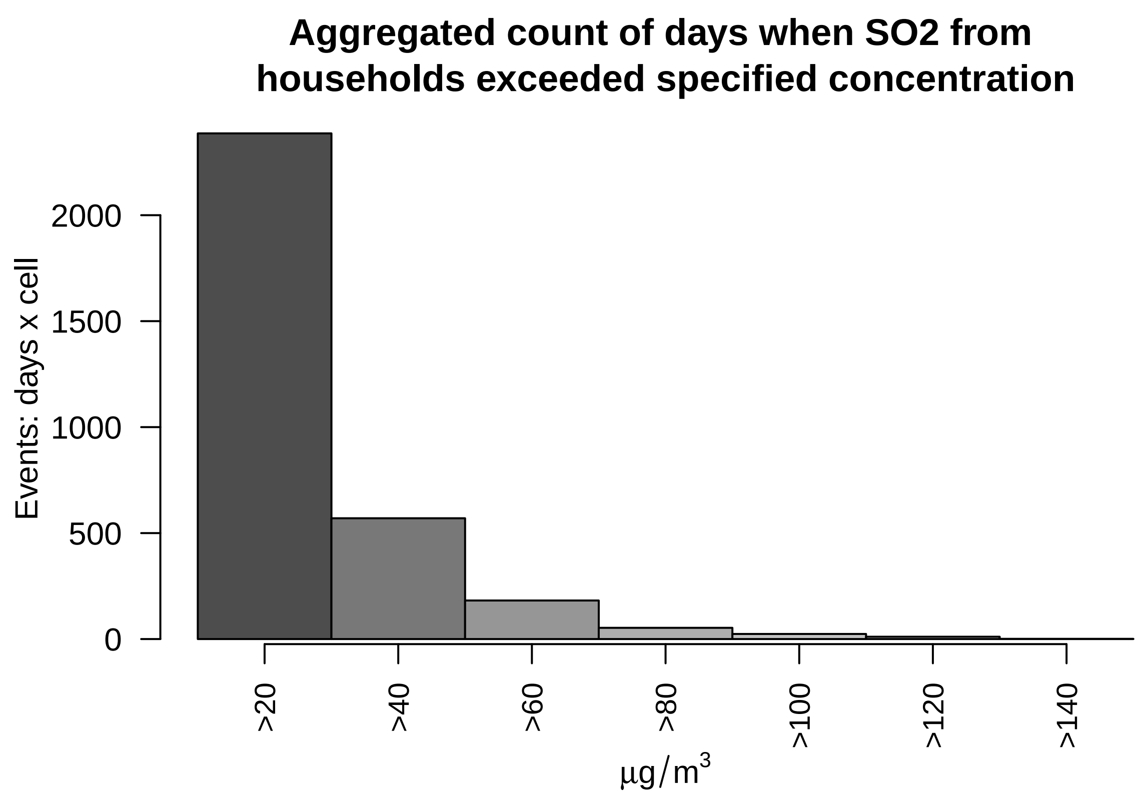

Aggregated of days when PM10 from households
exceeded specified concentarion
Events: days x cell
3000
2500
2000
1500
1000
500
0
>20
>40
>60
>80
>100
>120
>140
>160
µg/m3





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

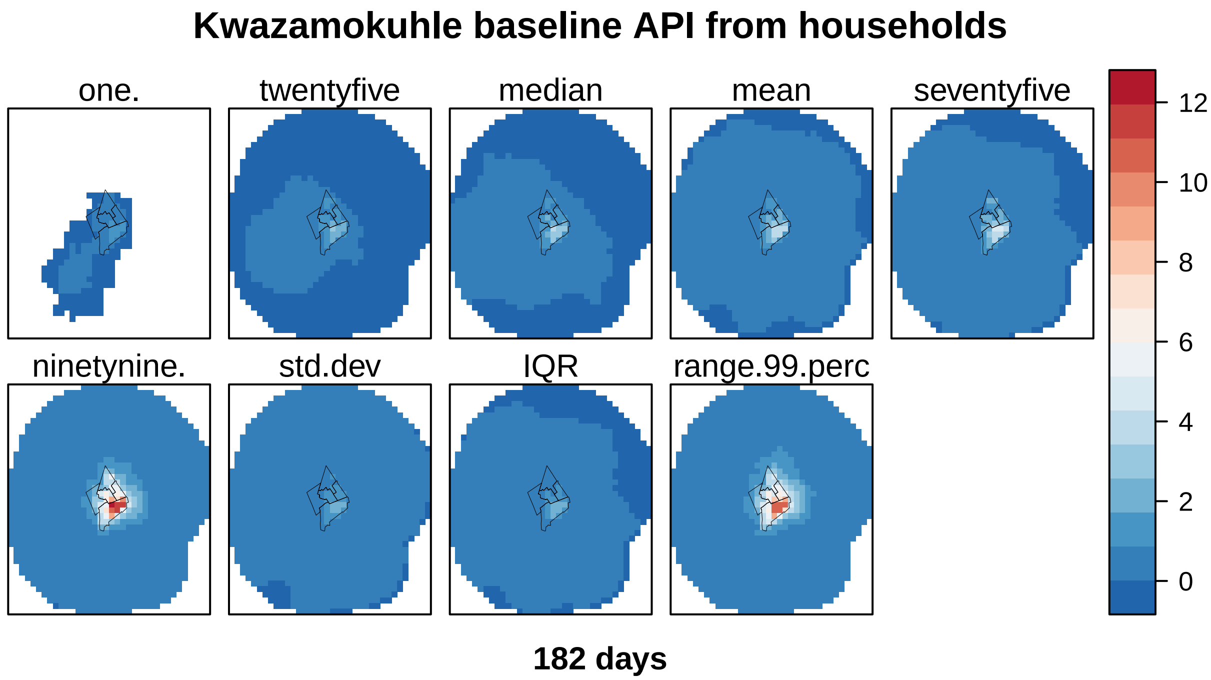




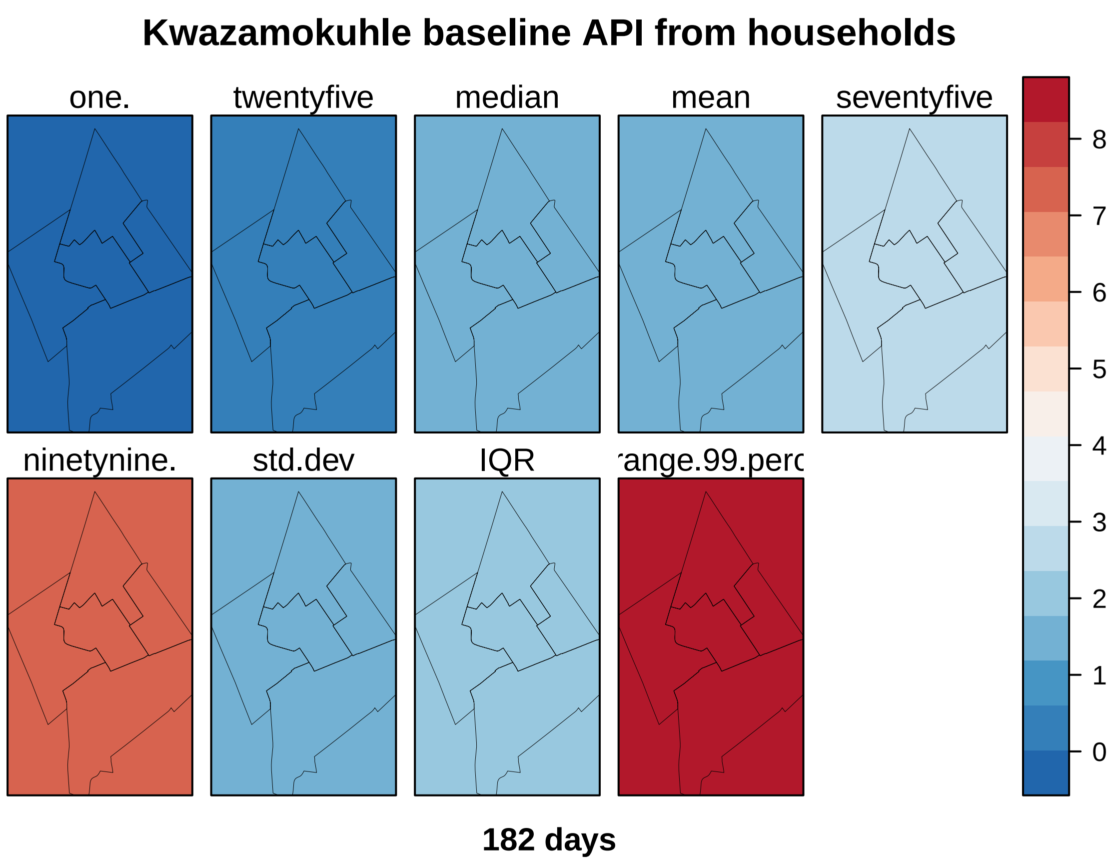
The count of days where SO2 from the industrial point source exceeded specified level for the baseline scenario is shown not in the same because all values are below the minimum level in the previous plot.

Baseline impact

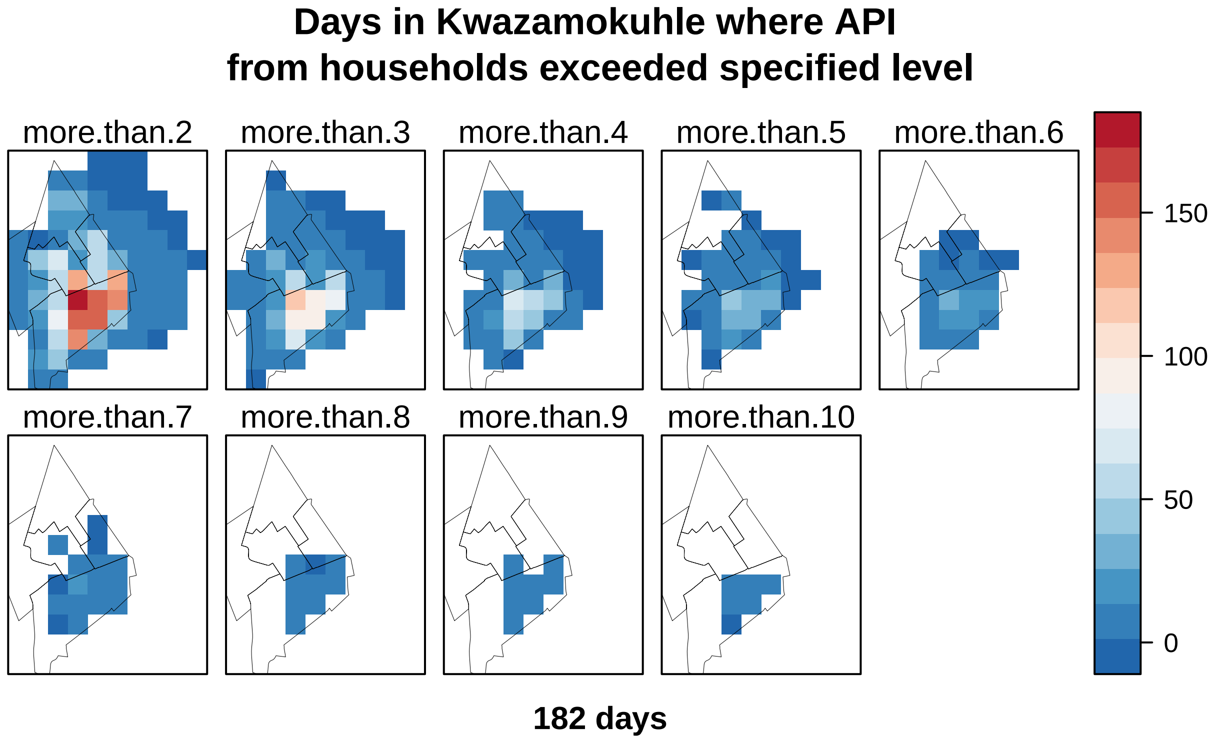
The baseline impact represents the combined impact of all pollutants. A summary of the daily API resulting from households are given below.



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 modeled to exceed a specified level is shown below for the baseline scenario.



Project scenario

Description of the project activity

Households qualifying for the intervention

Project fuel use

Project emissions

Project states

Annual average concentrations

Daily average concentrations

Project Exposures

Population exposed to ambient air pollution

Population exposed to indoor air pollution

Project impacts

Project API

Project BoD

Project SWI