ASSESSMENT OF THE HUMAN HEALTH RISK DUE TO THE EXPOSURE TO AIR POLLUTION USING AIR QUALITY ENSEMBLE MODELLING DATA

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Introduction to the concept of Relative Risk

RR : Relative Risk

- Is a measure to estimate the **influence** of a **factor (*i*)** on the exacerbation of a certain **Health Outcome (*HO*)**
- Derived from epidemiological studies
- *RR_i =RR_i (level of exposure, health outcome, age, sex)*

$$RR_i = \frac{Risk\ of\ HO\ with\ exposure}{Risk\ of\ HO\ without\ exposure} \begin{cases} > 1 : negative\ effect\ on\ health \\ = 1 : no\ effect\ on\ health \\ < 1 : beneficial\ effect\ on\ health \end{cases}$$

In case of Air pollution RR_i are provided by WHO for NO_2,SO_2,O_3, PM_{10}, $PM_{2.5}$, per each increment of 10 μg/m^3 of the pollutant's concentration

Example:

Health Outcome (HO) = mortality due to all causes
Triggering factor = $PM_{2.5}$
Exposure = mean concentration over 24 hours

$$RR_{PM2.5} = \frac{Risk\ of\ mortality\ with\ exposure\ to\ 10\ \frac{\mu g}{m^3 * d}\ of\ PM_{2.5}}{Risk\ of mortality\ without\ exposure} = 1.015\ [1.007, 1.022]$$

The relative risk of mortality increases of 1.5% per each increment of 10 μg/m^3 of the $PM_{2.5}$ daily average concentration!

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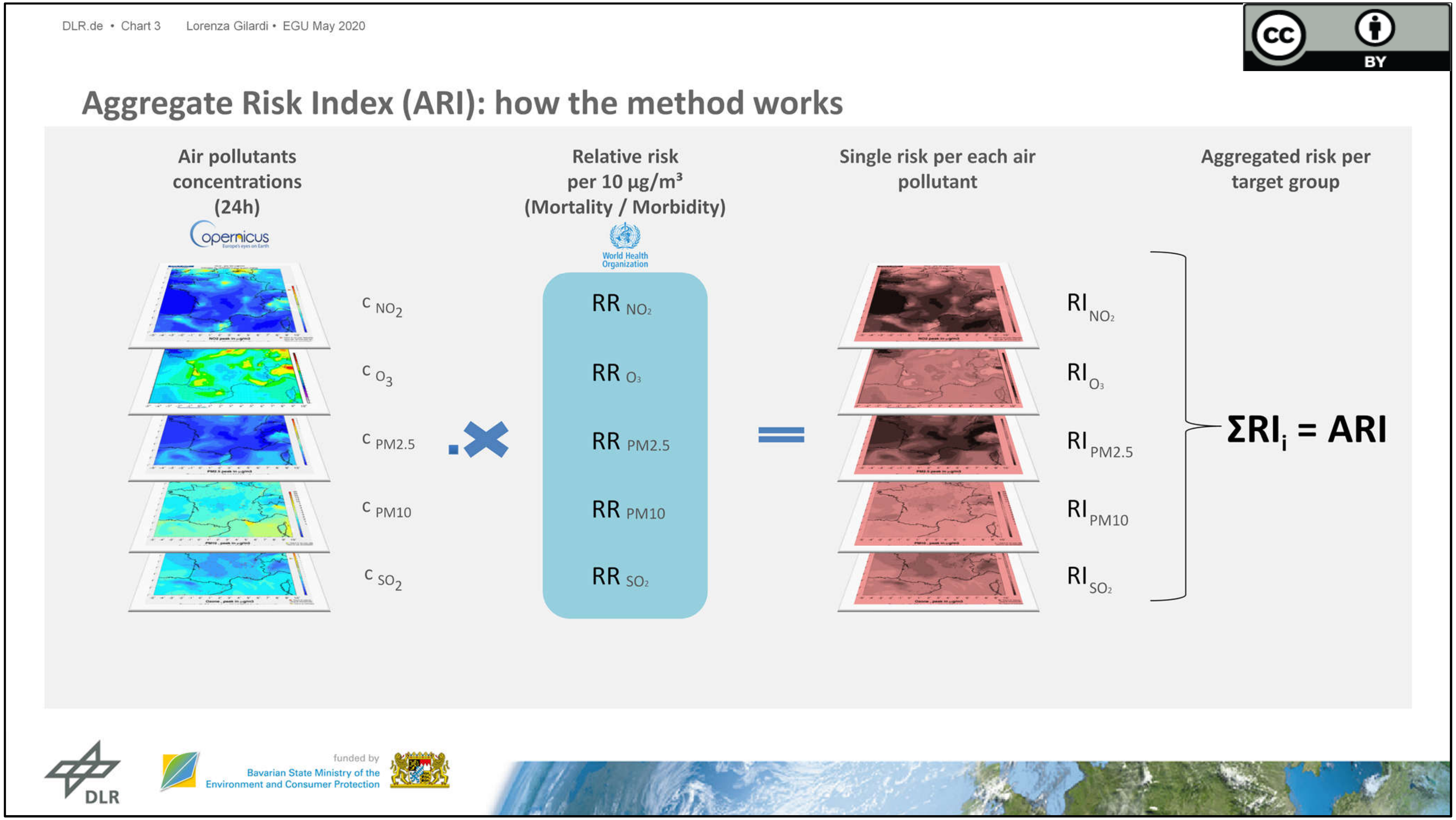
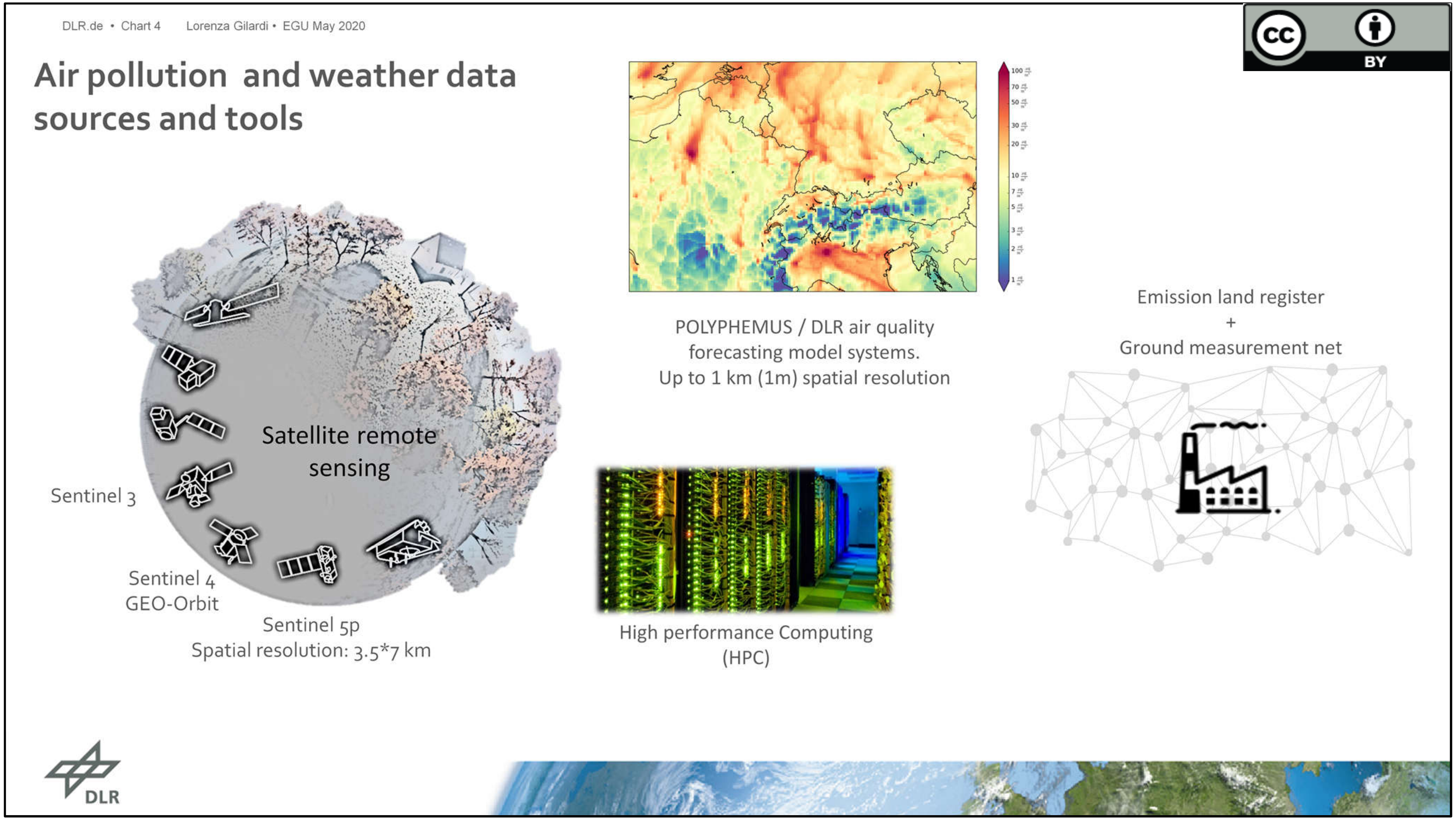
- The Relative Risk (RR) concept it is widely used in medical science. In this slide it is explained the logic behind its formulation.
- Please note that RR can also assume positive values. A good example is vaccination: a vaccinated person is less likely to be infected with respect to a non-vaccinated one.
- Please note that a relative risk of 1.015 means an increase of mortality of 1.5%. This is **not** an absolute increase. If the mortality (for example due to pulmonary diseases) is x%, and the relative risk due to smoking is 1.015, this means that the mortality rises to x*1.015%.



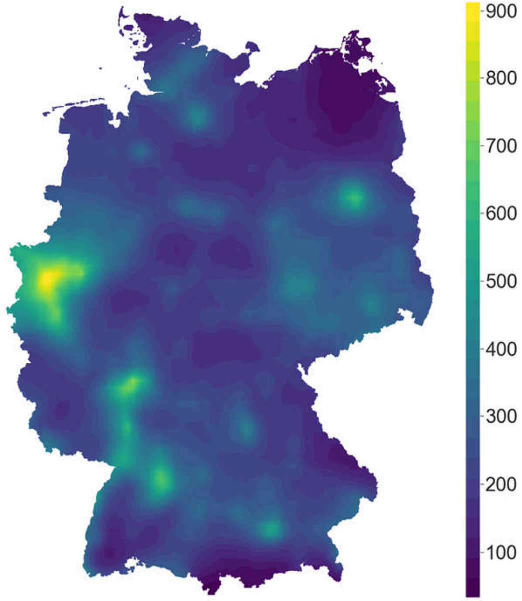
- The slide shows the calculation of the Aggregate Risk Index (ARI) following the method developed by Sicard et al, 2012
- It is based on a linear addition of the single effects attributable to each pollutant.



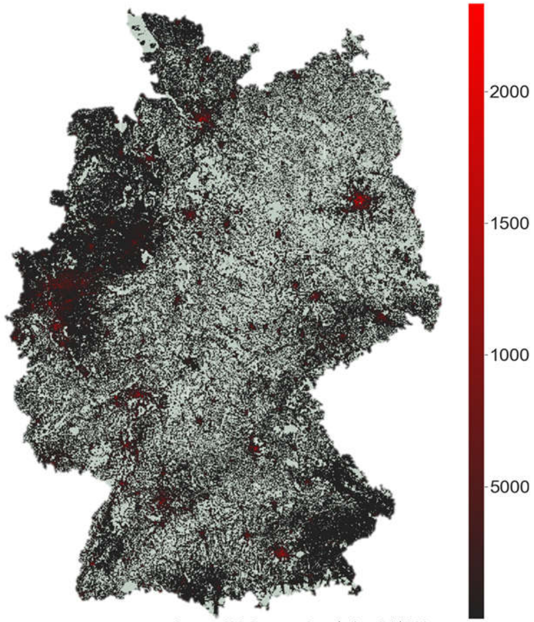
- This approach can be used to produce a risk map, using as input concentration data derived from satellite remote sensing, air quality models or in situ data.
- The application of the method described in the previous slide allows getting a risk map out of air pollution maps.
- For the sake of this study, air pollution data from the multi-year reanalysis of the Copernicus Atmospheric Monitoring Service (CAMS) were used.

ARI- long term analysis vs population density

Number of days with an increased relative risk of mortality of 16% due to all causes in the time span between 2010-2016 due to the exposure to air pollution



Population density for the year 2011 [inhabitant/ km^2]



Source: JRC, Eurostat Population Grid 211

↑ Heath risk

↑ Air pollution sources

↑ Population density

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- On the left, it is possible to see a long term analysis conducted using CAMS air pollution data over Germany between 2010 and 2016. Particularly, the image shows the total number of days where the relative risk of mortality due to all causes was potentially increased by 16% (RR =1.016).
- 16% is the threshold assumed by WHO to discriminate between low and moderate risk levels.
- The risk map visibly mirrors the population density map (right image) of Germany. Higher population often means high air pollution levels but also a higher number of people exposed to it.

Potential Years of Life Lost (PYLL): a first comparison approach with health data

PYLL = „ *Potential Years of Life Lost is a summary* ***measure of premature mortality*** *which provides an explicit way of weighting* ***deaths*** *occurring at younger ages, which might be, a priori,* ***preventable****." (Source EUROSTAT)*

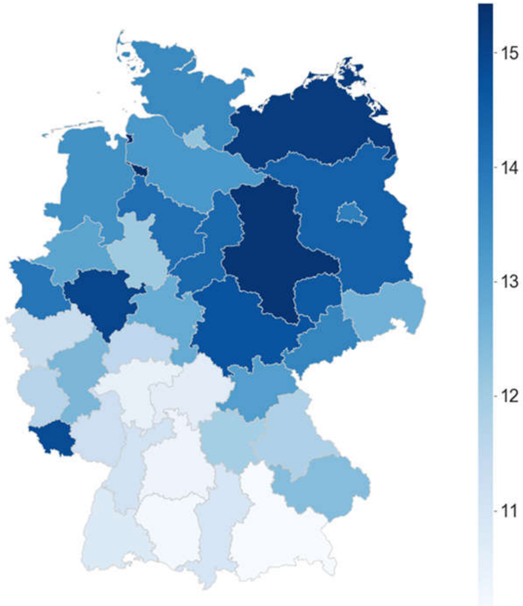
EUROSTAT database provides with yearly PYLL data for the NUTS2 region in Europe

$$\sum_{i=1}^{n} (life\ expentancy\ - age\ at\ death_i)$$

Where:

$n = number\ of\ preventable\ death\ per\ year$
$life\ expentancy = 70\ years$

Sum of the PDLL for each NUTS2 region in Germany for the year 2016. [days/(inhabitant*year)]
Source: Eurostat Causes of death (hlth_cdeath)



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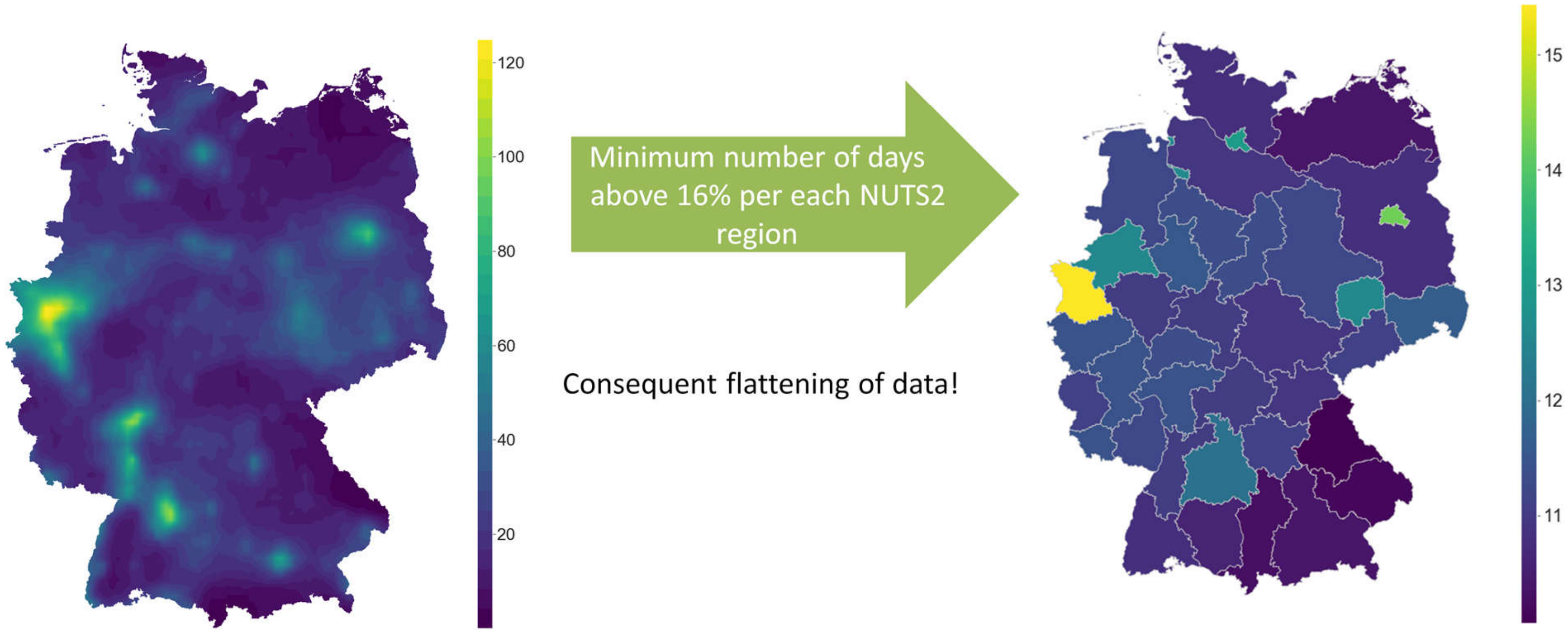
- The Potential Years of Life Lost (PYLL) is used in statistical demography as index that takes into account the age of the death's occurrence.
- Data of PYLL are freely accessible through the EUROSTAT portal. They are provided at a coarse spatial aggregation level (NUTS2 regions).
- On the right it is possible to see the PYLL index for Germany for the year 2016. Please note that the values are converted into days.

PYLL vs ARI: a first comparison approach with health data -1



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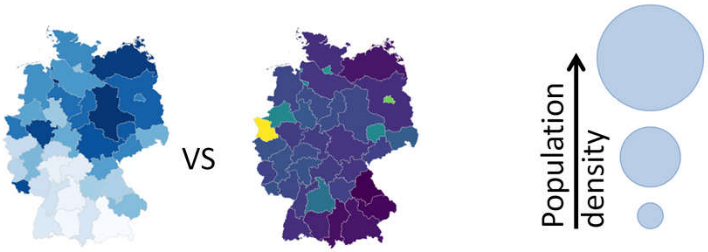
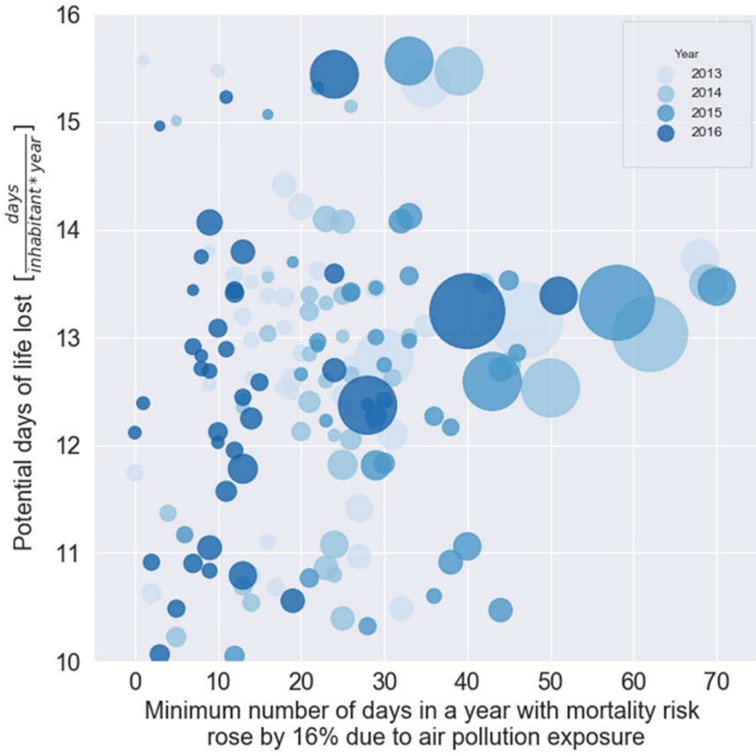
- In order to perform a first comparison with the health data statistics from EUROSTAT, the calculated aggregate risk must be represented at the same level of spatial aggregation (NUTS 2 regions) per each examined year.
- As representative statistic for the aggregate risk, the **minimum** value registered in the region it is taken into account. This means the minimum number of days with ARI > 16% for each region, per year.
- The minimum is used because epidemiological studies often show that visible effects on health occur above a minimum threshold of exposure.
- The aggregation of the data implies a loss of information.

PYLL vs ARI: a first comparison approach with health data -2





- Each point represents a NUTS2 region in Germany.
- The size is proportional with the average population density between 2013 and 2016

Scarce correlation between data

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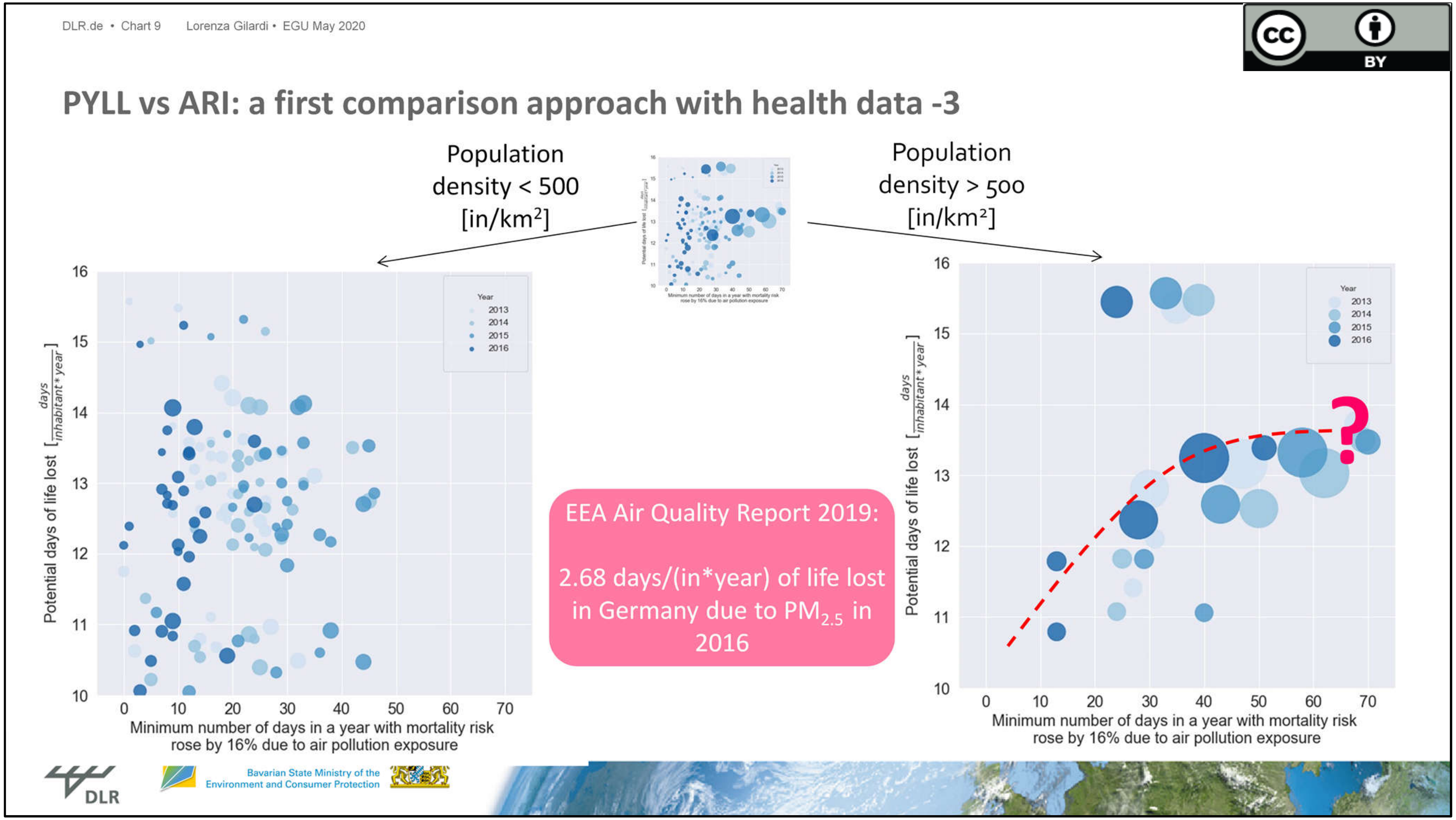
- Data from different years are plotted on the same graph to increase the examined sample size.
- The first comparison between data doesn't show any promising correlation.

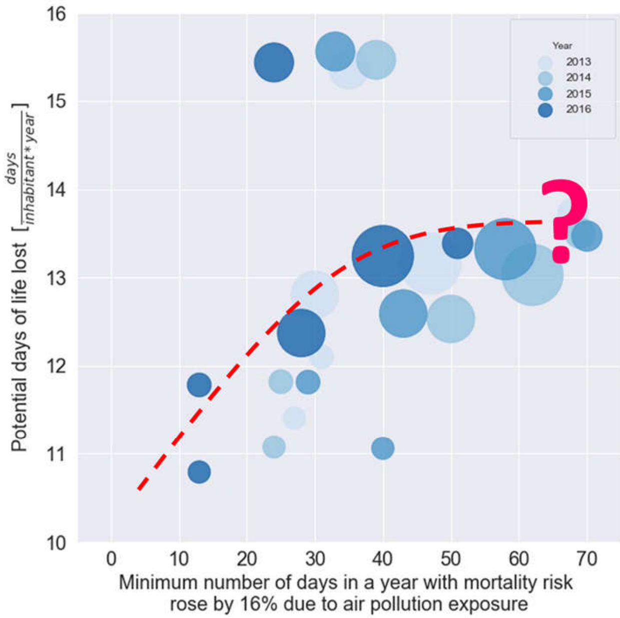


- Here the population density it is used as discriminating factor in order to separate the two graphs.
- One the left, for low population density, for every number of days with ARI >16% there is every possible combination of number of days of life lost. This likely means that the two variables are independent. For the specific case, air pollution it is probably not the main influencing factor for premature mortality.
- On the right, for high population density, it is possible to see a rough trend. This could mean that in highly populated areas (normally urban areas), air pollution might play a driving role in the occurrence of premature death.
- This is partially confirmed by EEA that attributes 2.68 days of life lost per citizens due to the only exposure to $PM_{2.5}$, that falls into the same order of magnitude.

PYLL vs ARI: a first comparison approach with health data -2

- Is air pollution the driving factor of premature death for highly densely populated areas?
- Other factors that might play a role? (socio-economical status, behavior, climate,..)

➢ Further studies needed



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It is not possible to exclude the presence of a high selection bias and the role of other cofactors.

Conclusion and future developments:

Summary:

- Long term analysis of ARI using CAMS data
- Comparison between ARI and population density → Higher values due to increased amount of air pollution sources
- First comparison with coarse health data on annual basis→ Air pollution might be a driving risk factor of premature death when highly present

Validation of the model:

- Comparison of **calculated ARI** with **highly spatial-temporal resolution health data** (death and hospitalization cases)

Improvement of the model:

- From simple additive approach to a more complex one with **non-linear** dependencies
  - *Use of **artificial intelligence (hybrid approach)***
  - *Development of a macroscopic **biophysical model***

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