universidade de aveiro

FAIRMODE Forum for air quality modelling in Europe

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Last findings of the study for intercomparison of LV exceedance spatial representativeness areas Antwerp Case

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WG4 MICROSCALE ASSESSMENT

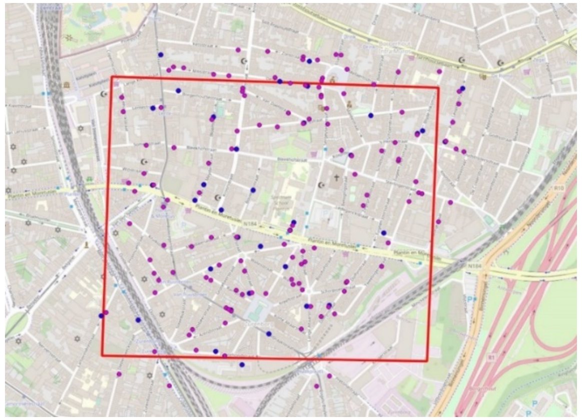
FAIRMODE Plenary Meeting.

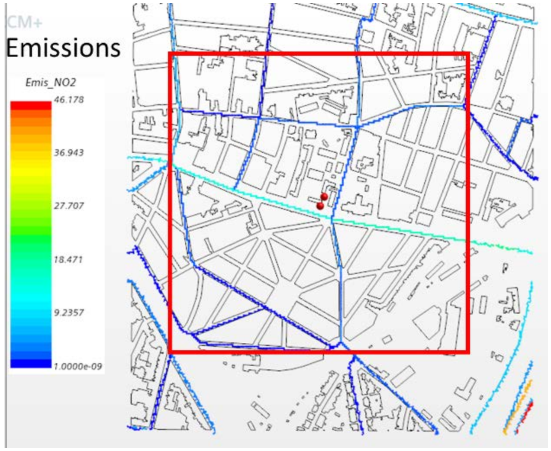
Paris, February, 2023

WG4 Intercomparison exercise

Domain and data

- Urban district (800x800 m) of Antwerp (Belgium). NO_2.
- Measurements from two AQ stations and 72 samplers.
- Emission data for traffic.

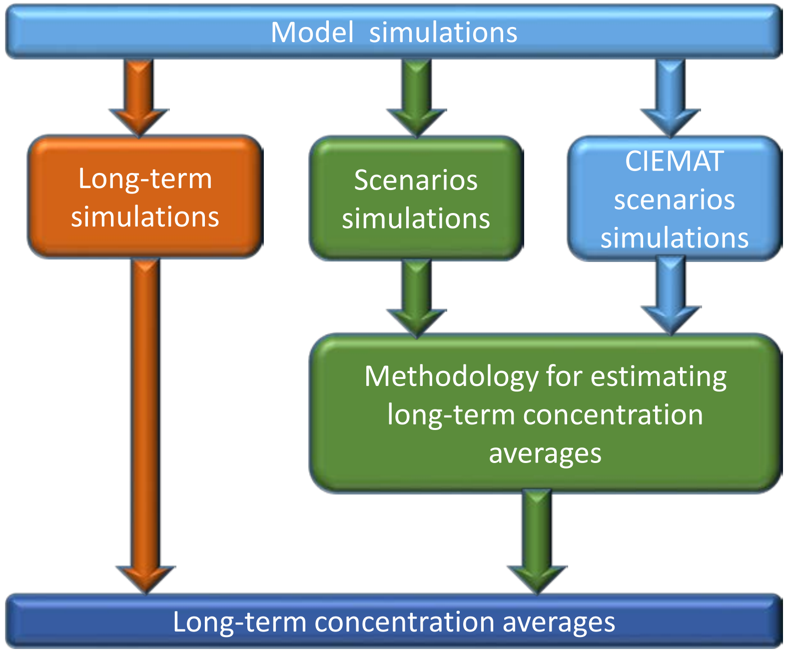




Models and methodologies

- **CFD models (RANS mostly), Gaussian, Lagrangian, AI.**
- Different methods for computing annual indicators of pollutant concentrations.
  - **Methods based on simulating a set of selected scenarios** (wind scenarios and/or emission scenarios) **and then a postprocessing** (PDF of scenarios, rebuilding a entire year, etc) of model results for retrieving annual indicators.
  - **Simulating the full-year**, (mostly for No CFD models but one of them run CFD models a complete year).

Ways of participating in the exercise:



WG4 Intercomparison exercise

Type of evaluations and comparisons

1. ***Hourly time series for <u>one day</u> with high pollution.***
   - ***May 6th, 2016 selected to simulate.***
   - ***The model results compared with <u>two AQ stations data</u>***

Paper under review in STOTEN

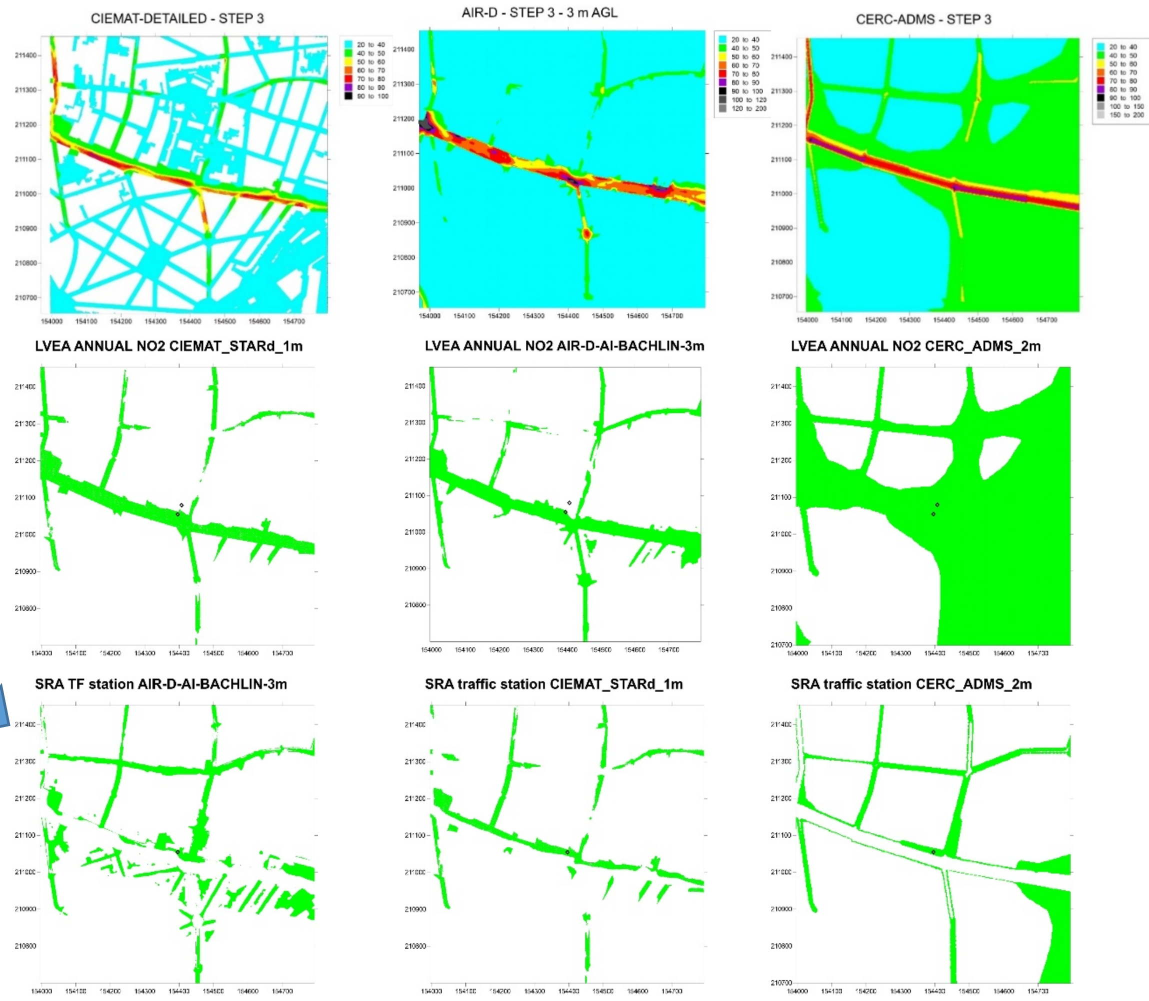
2. ***Monthly averaged concentration map for the <u>campaign period</u> (April 29 - May 28).***
   - ***Comparison with <u>passive samplers' data</u>***
   - ***Intercomparison among models results (2D maps).***

3. ***Annual concentration map for <u>2016 year</u> .***
   - ***Intercomparison of results from every methodology (2D maps).***

4. ***To compute LV exceedance and spatial representativeness areas of AQ stations.***
   - ***Intercomparison of results from every methodology (2D maps).***

Intercomparison of spatial representativeness/exceedances areas

- Using the results of annual average of NO_2 computed by the different models/methodologies for Antwerp domain.
- Intercomparison of:
  - NO_2 anual limit value (40 µg/m^3) exceedance areas (LVEA) in the Antwerp district domain.
  - **Spatial representativeness areas (SRA) of the two air quality stations (background and traffic types)**
- Two key questions:
  - How different are the LV exceedance areas?
  - **How different are the spatial representativeness areas?**
- Discussion about areas computed discarding the area covered by buildings

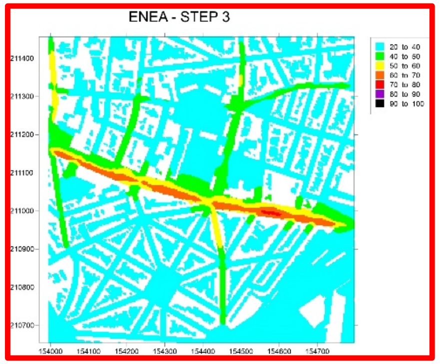


Summary of former results for annual NO_2 maps

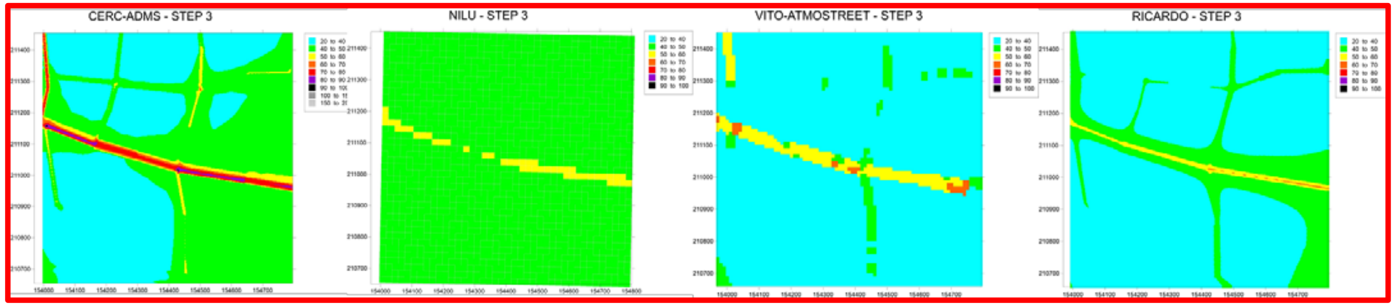
- Comparison grouping by model types

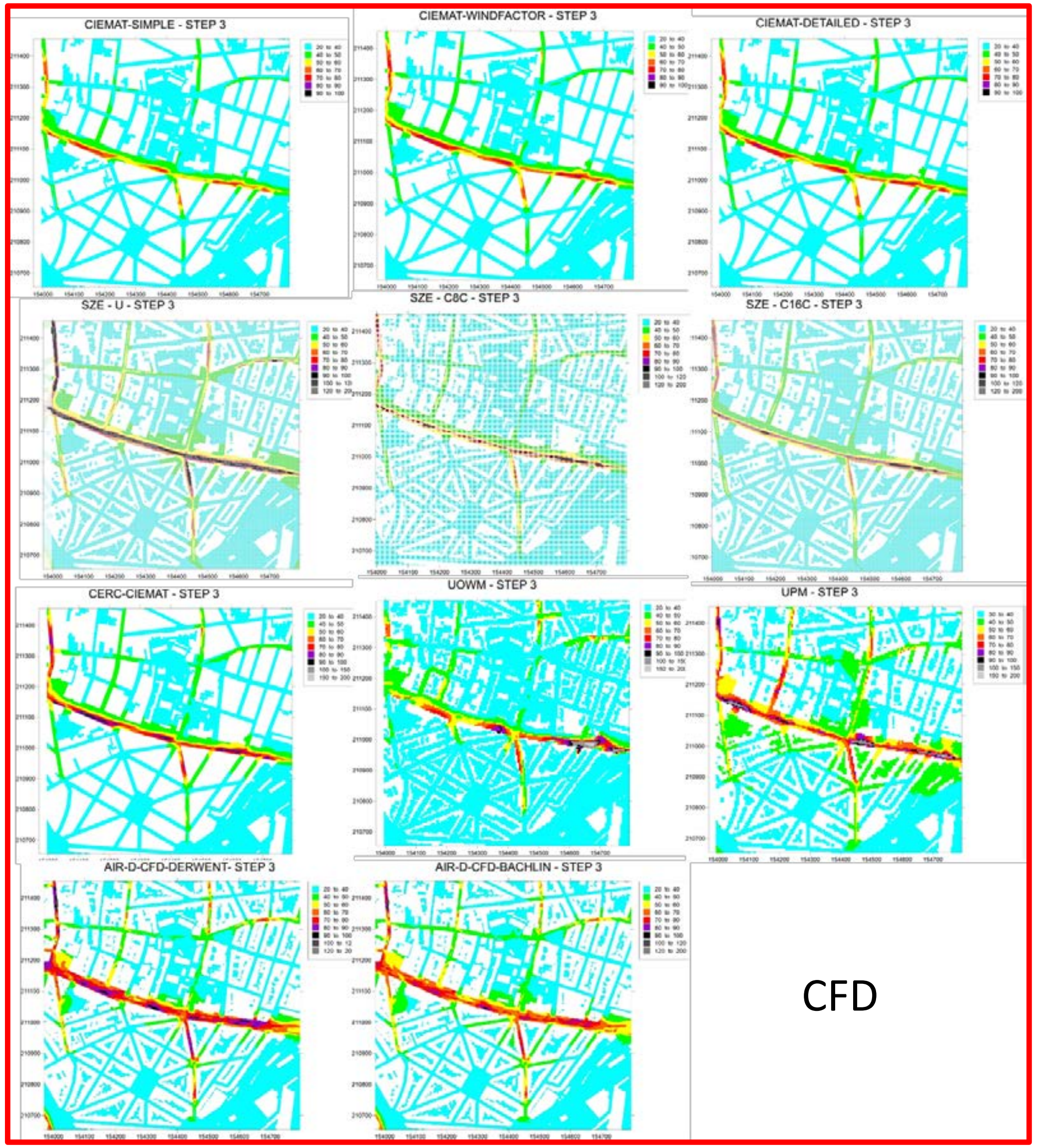
AI

LAGRANGIAN



GAUSSIAN

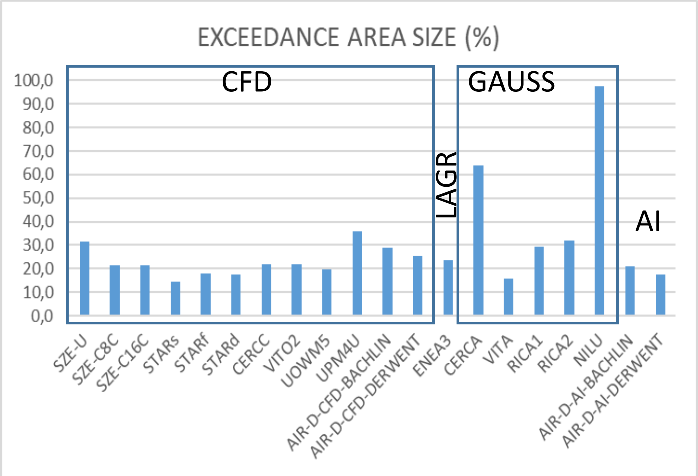


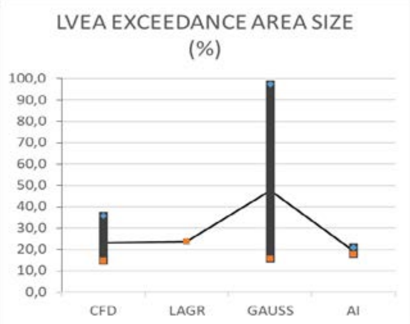


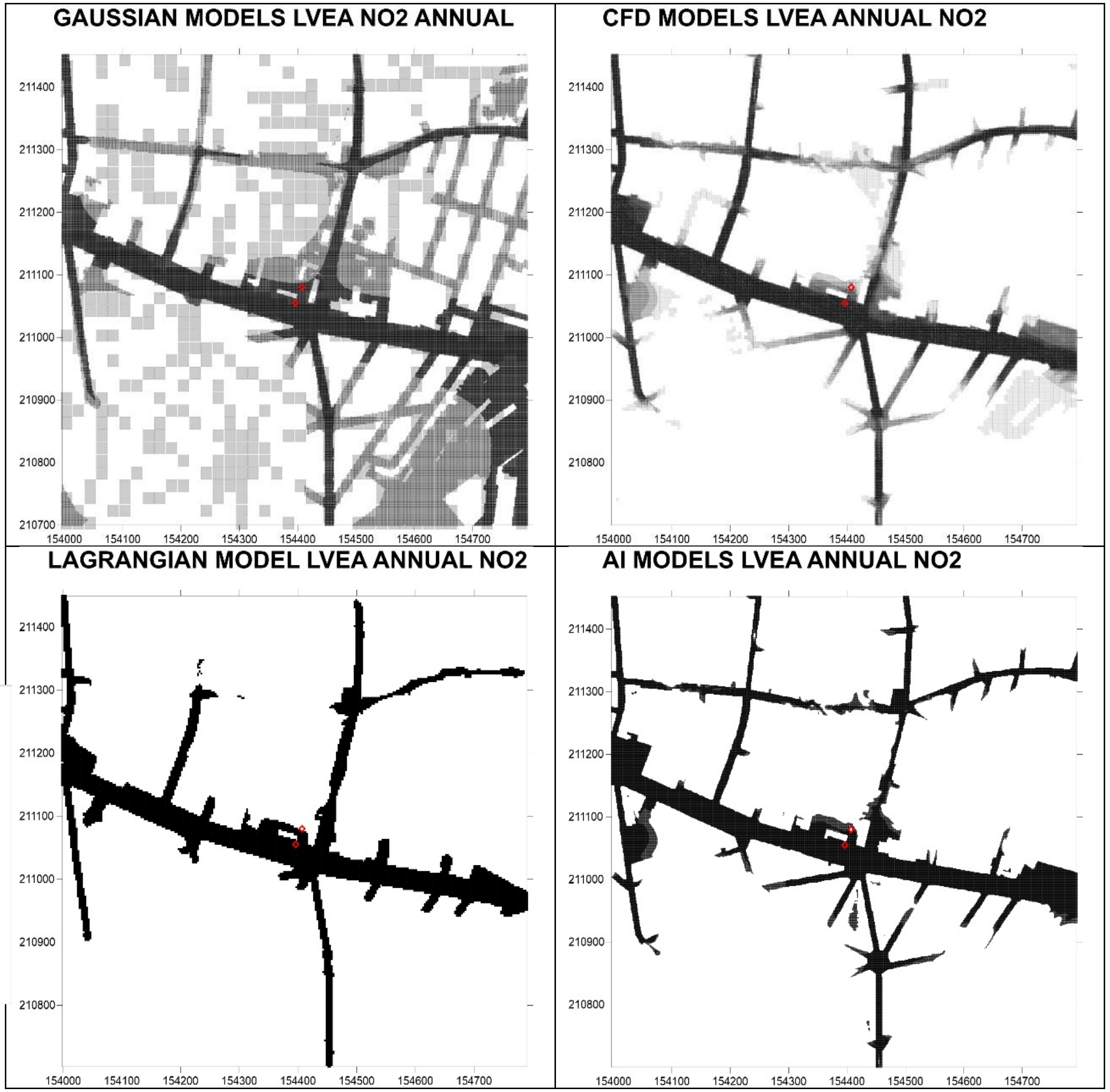
CFD

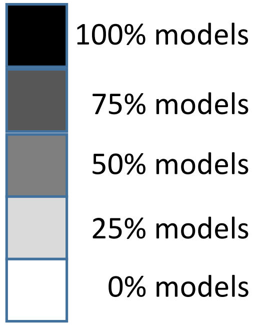
Summary of former results for LVEA

- *All models coincide, exceeding LV on main streets, but there are significant differences in shape and size of LVEA.*
- *Larger LVEA for most of Gaussian models, but strong variability.*
- *Size and shape of LVEA for CFD, Lagrangian and AI models rather similar, but some variability for CFD.*
- *LVEA size seems to not significantly depend on grid resolution.*





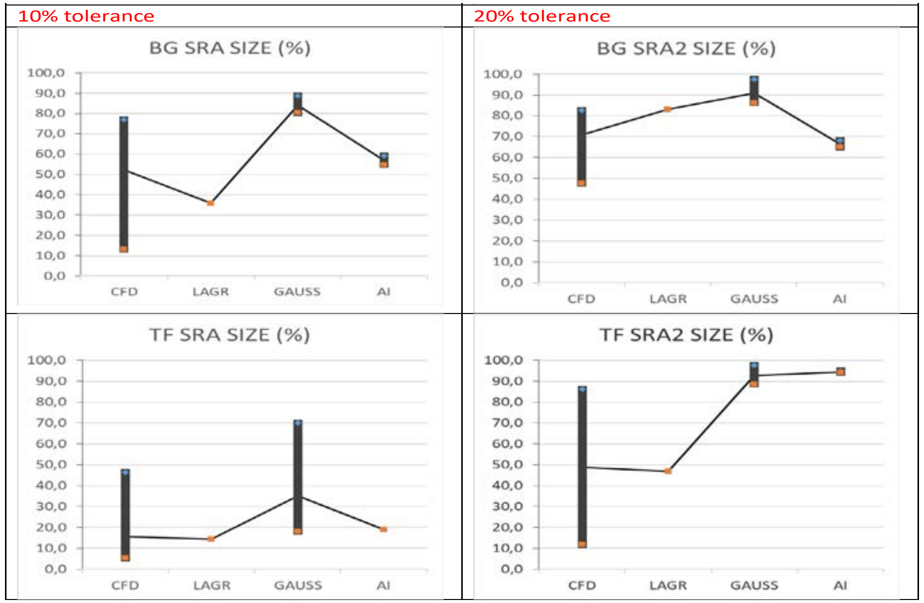




20 models
5 Gaussian
12 CFD
1 Lagrangian
2 AI

Summary of former results for SRA

- *SRA are larger for the background (BG) station than for the traffic (TF) one.*
- *20% tolerance SRA (SRA2) >> 10% tolerance SRA (SRA) especially for TF station*
- *Gaussian models estimate larger SRA than of other model types.*
- *Significant variability in CFD and Gaussian results.*
- *Except for one Gaussian model (EPISODE), SRAs of both stations exclude most part of the main street.*
- *Some relation between SRA size and grid resolution or concentration*



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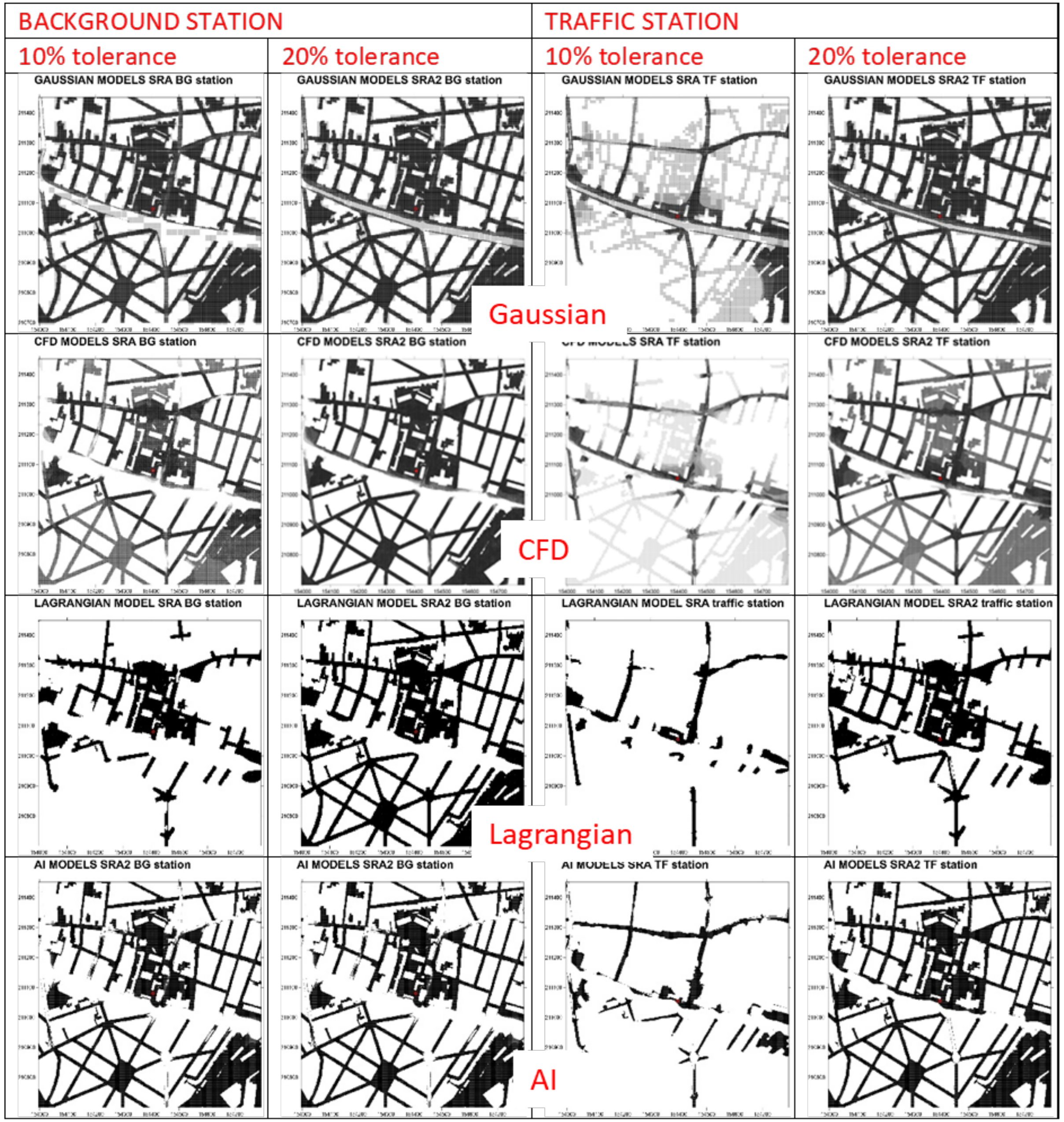
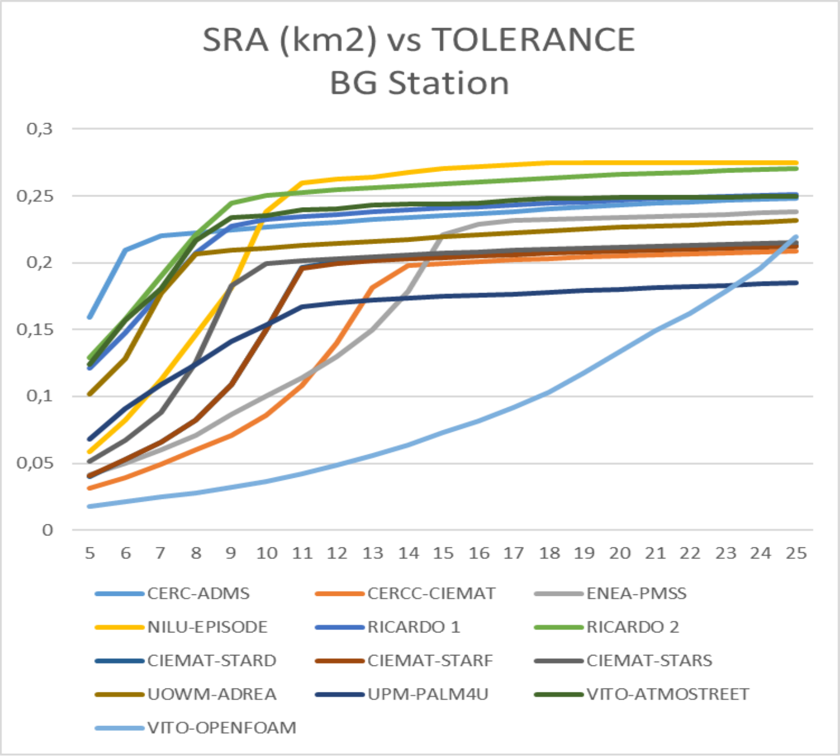
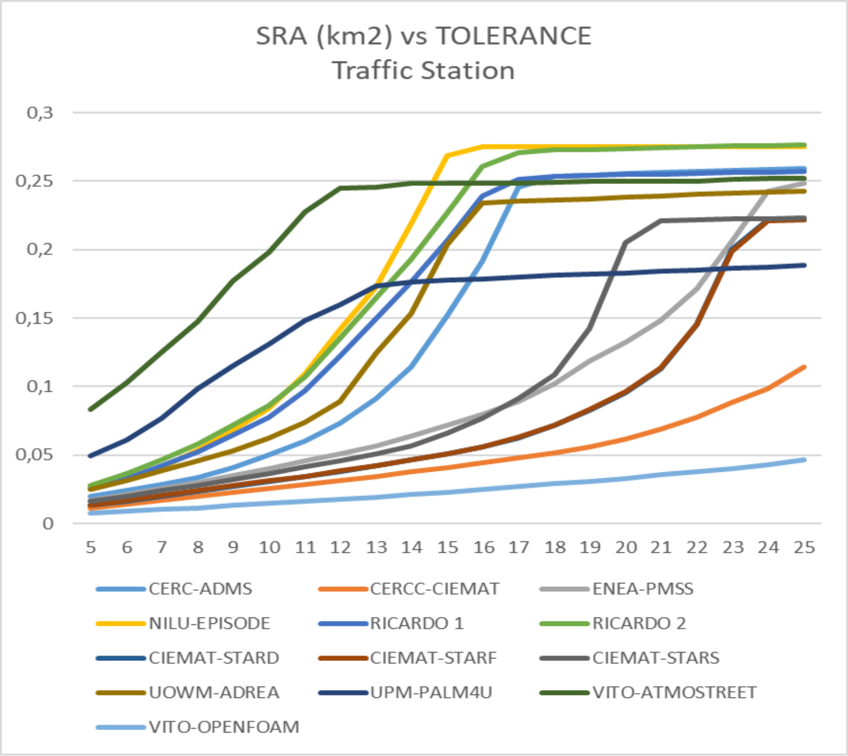


How different are SRA depending percentage of tolerance?

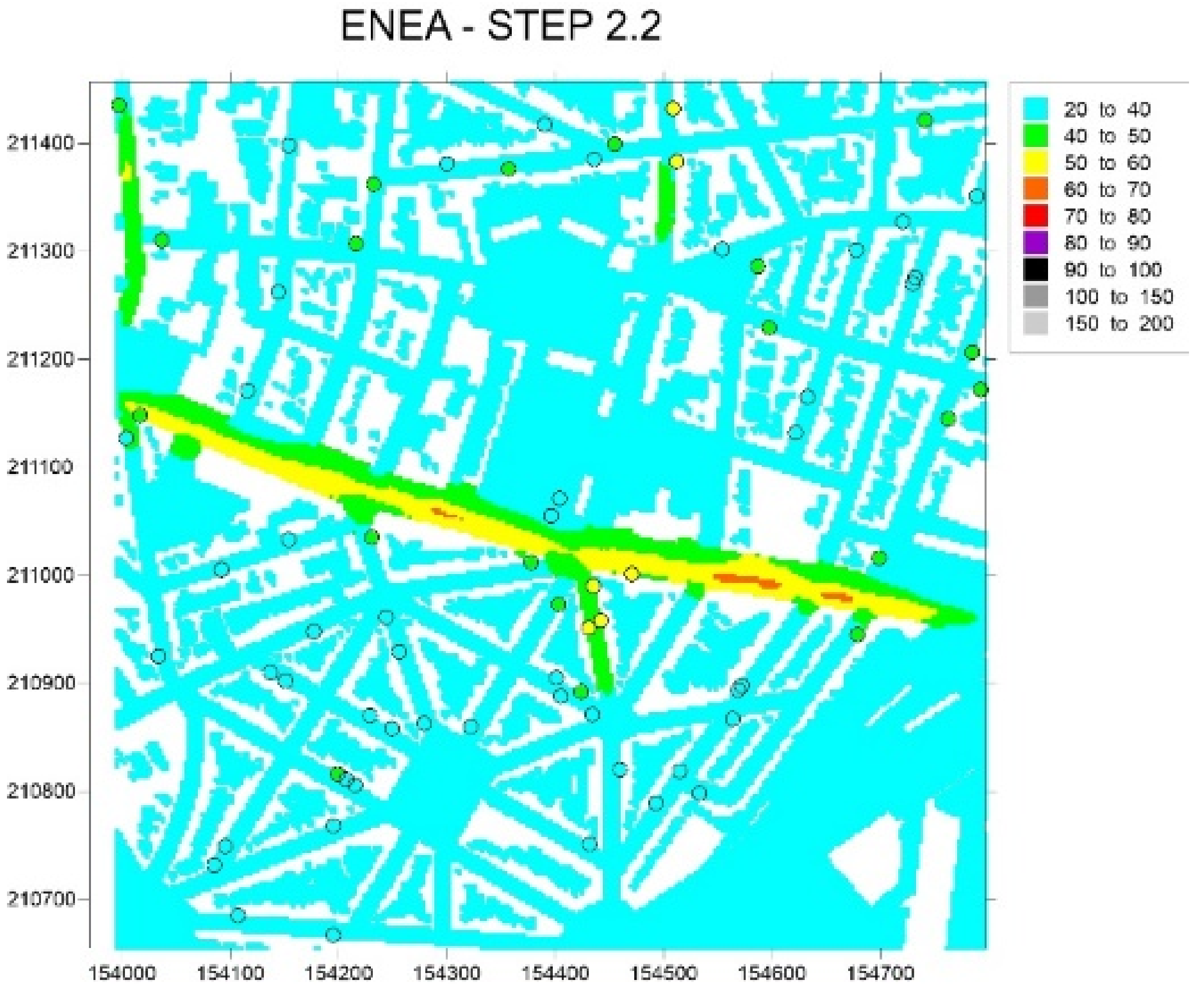
SRA sizes increase strongly as tolerance increase but up to some critical tolerance and then, the increasing is very low.
Critical tolerance is different for each station (higher for the traffic station).
Critical tolerance is different for each model.
Is it a limit for tolerance? If tolerance is too high the SRA covers almost the entire domain





How good are the models computing LVEA and SRA?

- **Compute LVEA and SRA with monthly model data and compare with observed LVEA and SRA**
- NO_2 concentration from 72 samplers campaign (May 2016).
- For LVEA:
  - Compute what samplers are inside the LVEA (LV = 40 µg/m^3) ("observed" LVEA).
- For SRA:
  - Compute what samplers are inside the tolerance interval (10%, 15%, 20%) respect the concentration at 2 AQ stations ("observed" SRA).
- Compare with the estimated LVEA and SRA by the modelling applications.



How good are the models computing LVEA and SRA?

- Model validation
- Several categorical indexes were computed, for example:
  - **Accuracy index**. How good are the models predictting the samplers in and out the LVEA or SRA?
  - **False Alarm Rate (FAR)**. What is rate of prediction of samplers inside the LVEA or SRA, when actually are out of them?
  - **BIAS**. Are the models under or overpredicting the LVEA or SRA?
- Separated analysis for LVEA and SRA.
- Observed data are monthly averages of NO_2 concentration from the 72 samplers
- Model data are monthly averages of NO_2 concentration at samplers sites:
  - Original
  - Bias corrected
  - Normalized with observation at two (BG and TF) stations
- The work is ongoing yet but is very advanced

Model validation for LVEA

How good are the models results predicting the LVEA?

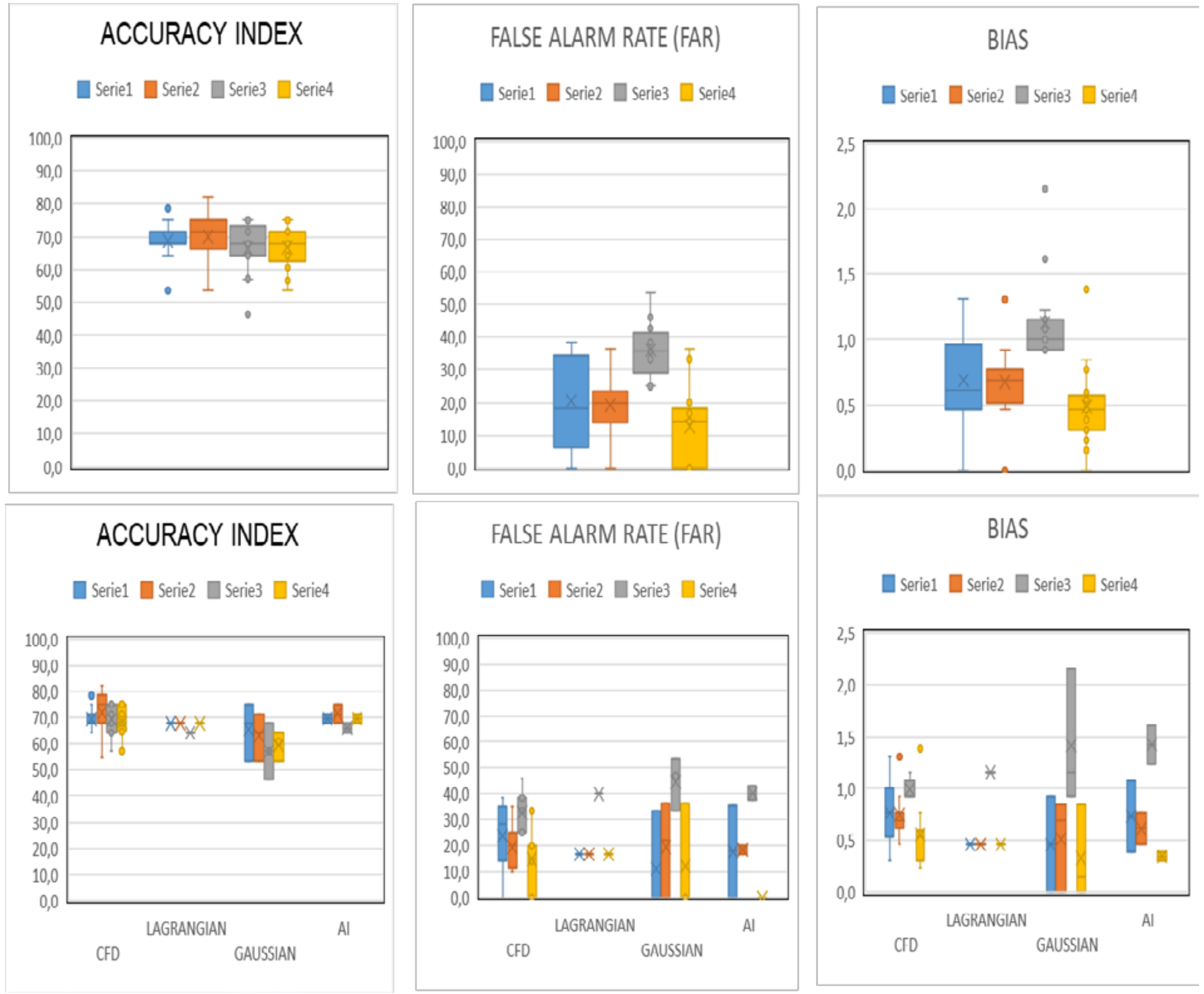
- *The models predicts better the no-exceedance areas (80% of hits) than the exceedances ones (less than 60%).*
- *Accuracy index is quite good on average close to 70%, with false alarm rates below 25%, but generally underpredicting LVEA*

What type of models provides better predictions of the LVEA?

- *CFD models provides more consistent results with better scores for many statistics and being less sensitive to the different types of data correction or normalization. Unsteady full month CFD simulations does not seem to provide better results than the scenario CFD simulation methodologies.*
- *AI and Lagrangian (in this order) also give quite good results.*
- *Gaussian seem to obtain the lowest values of accuracy and Bias (strong underprediction), but lowest false alarm rate.*
- *Gaussian models with street-canyon parametrizations provides much better results than the simplest Gaussian models. The results of the former ones are relatively close to those of the other models.*

What type of model results' corrections (BC, BG, TF) are more suitable?

- *Not clear. Perhaps, overall BG normalization provides slightly better results. However, TF normalization seems to worsen the quality of exceedances predictions*



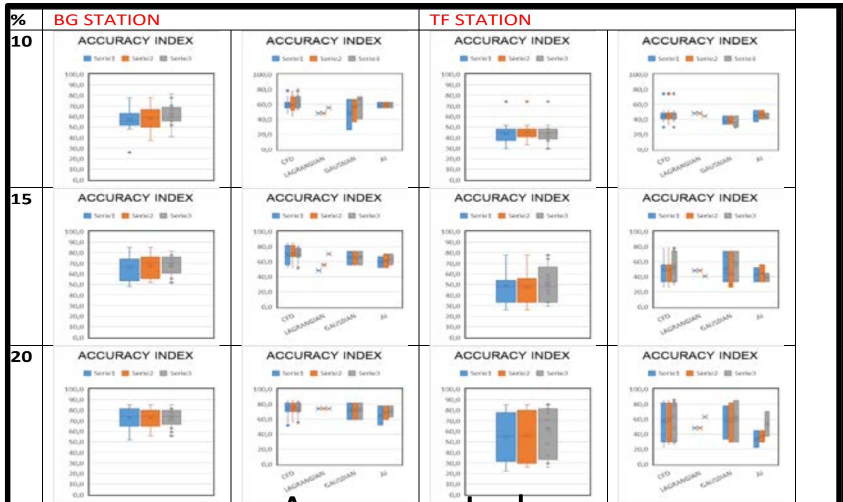
Series 1 = original, Series 2 = Normalized BG station, Series 3 = Bias corrected, Series 4 = Normalized TF station

Model validation for SRA?

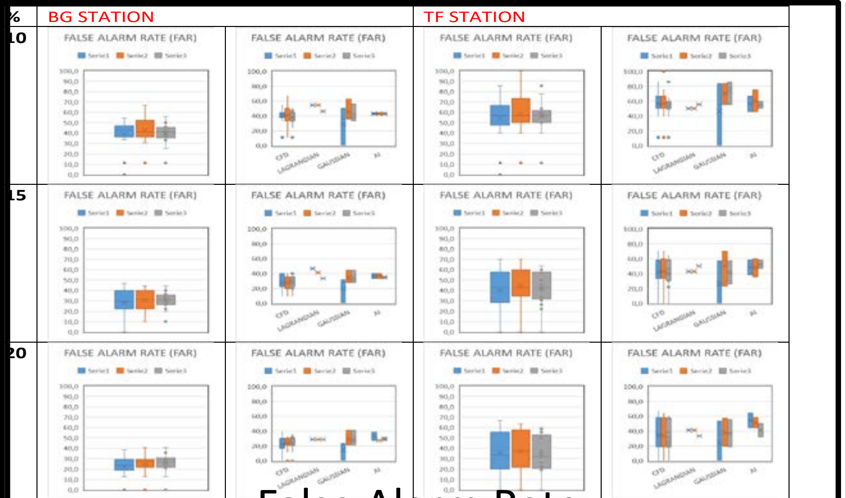
How good are the models results predicting the SRA?

- *SRA for low tolerances are more difficult to predict than SRA for larger tolerances. It is more evident for TF station.*
- *Higher improvement when passing from 10% tolerance to 15% tolerance than from 15% to 20% for BG station. For TF station, the improvement rate with increasing tolerance is more regular.*

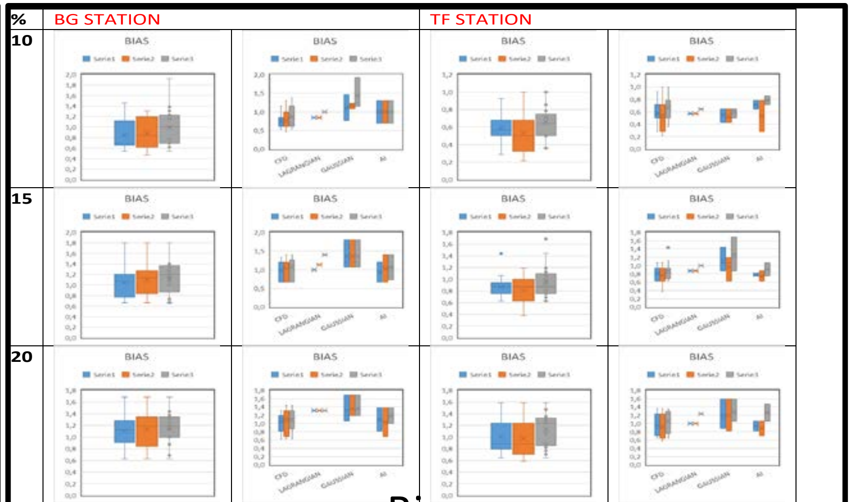
Series 1 = original, Series 2 = station normalized, Series 3 = Bias corrected



Accuracy Index



False Alarm Rate



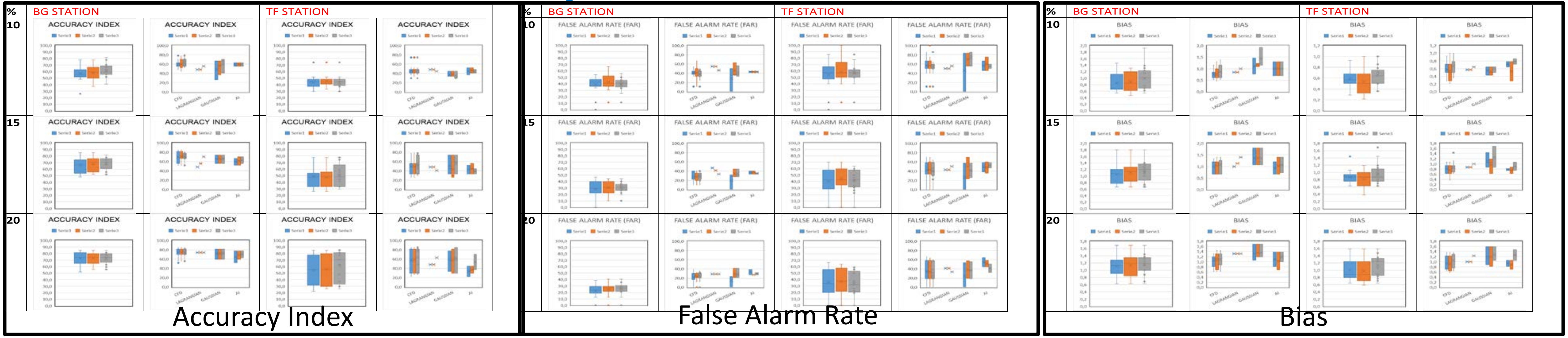
Bias

Model validation for SRA?

What type of models provides better predictions of SRA?

- *CFD models provides more consistent results with better scores for many statistics and being less sensitive to the bias correction or station normalization.*
- *Many cases of scenario CFD simulation methodologies provides results as good as the unsteady full month CFD simulations.*
- *Other model types have also generally quite good results but with some shortcomings.*
- *Gaussian models with street-canyon parametrizations (Gaussian SC) provides better results than the simplest Gaussian models for the SRA of BG stations being closer to the results of other model as CFD. However, the improvement is no evident for the SRA of TF station (not shown here)*

Series 1 = original, Series 2 = station normalized, Series 3 = Bias corrected

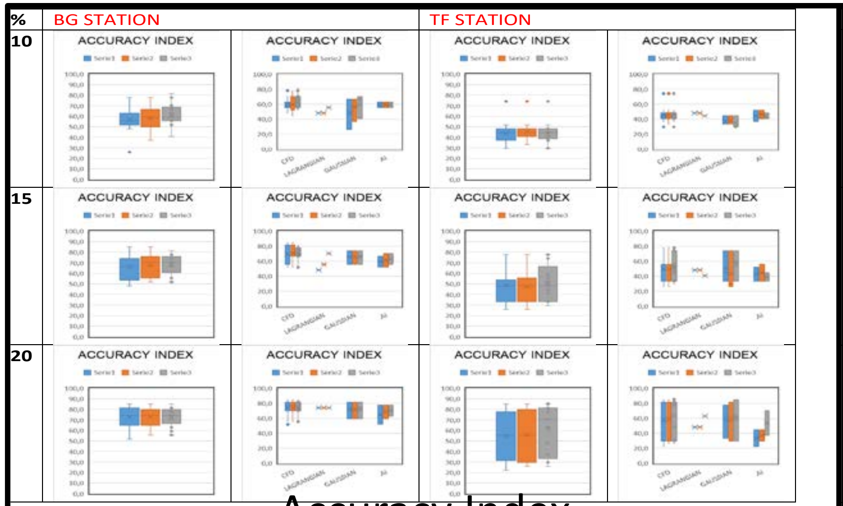


Model validation for SRA?

What type of model results' corrections (BC, BG, TF) are more suitable?

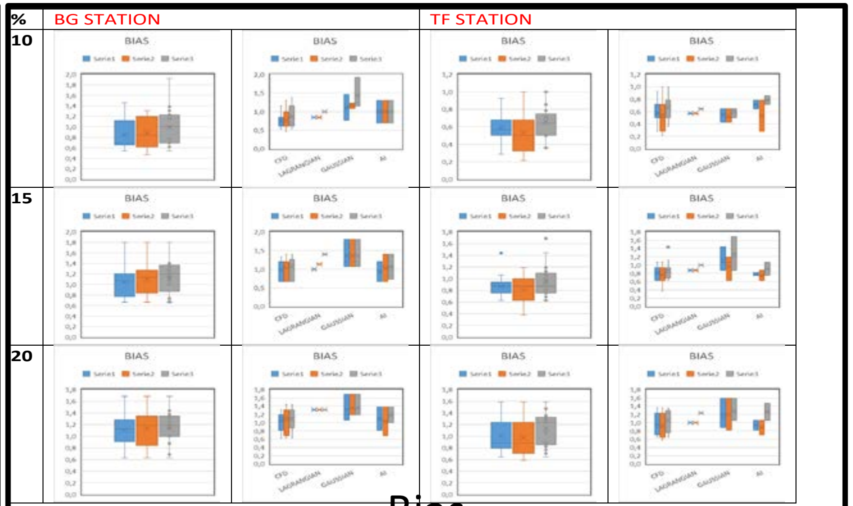
- *On average of all models, few differences between SRA computed from original, bias corrected and station normalized.*
- *Maybe, bias corrected data provides in some cases slightly better accuracy indexes in some cases and lower false alarm rates, while BIAS index seems to be higher (reducing the underprediction) than BIAS for original data giving rise to some overprediction for high tolerances.*

Series 1 = original, Series 2 = station normalized, Series 3 = Bias corrected



Accuracy Index

False Alarm Rate



Bias