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Overview of bias correction practices for AQ planning in Italy

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New AQD: Ambient air quality and cleaner air for Europe

text adopted 24 April 2024

Article 19
Air quality plans ***and air quality roadmaps***

"Member States shall establish air quality plans for those zones ***that set out appropriate measures to achieve the limit value or target value concerned and to keep the exceedance period as short as possible, and in any case no longer than 4 years from the end of the calendar year in which the first exceedance was recorded. Those air quality plans shall be established*** as soon as possible and no later than 2 years after the calendar year during which that exceedance of any limit value or target value was recorded."

Table 1 – Limit values for the protection of human health to be attained by 1 January 2030

Averaging period	**Limit value**	
$PM_{2,5}$		
1 day	25 µg/m³	not to be exceeded more than 18 times per calendar year
Calendar year	10 µg/m³	
PM_{10}		
1 day	45 µg/m³	not to be exceeded more than 18 times per calendar year
Calendar year	20 µg/m³	
Nitrogen dioxide (NO_2)		
1 hour	200 µg/m³	not to be exceeded more than ***3 times*** per calendar year
1 day	50 µg/m³	not to be exceeded more than 18 times per calendar year
Calendar year	20 µg/m³	

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Gridded model data versus Point measurements

-bias correction premises-

1) how to express the bias between model and measurement in a point

2) how to distribute the punctual bias over model grid

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How to express the bias between model and measurement in a point

Bias correction (B) definition for base year:

Absolute: $B_A=M_{ref}-O$

Relative: $B_R=(M_{ref}-O)/O$

Fraction: $B_F=O/M_{ref}$

Where:

M_{ref}=modelled value for reference simulation (base year)

O=observation

B definition for base year	use of B	area of application
B_F	Model concentration at scenario year is multiplied by **B_F**	national, Lombardia
B_F	Model concentration at scenario year is multiplied by **B_F**	Po Valley (Life PREPAIR), Emilia-Romagna, Umbria
B_A	**B_A** to obtain adjusted base year simulation	Piemonte

Note: **B_A** tested and discarded at national scale

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How to distribute the punctual bias over model grid

B definition for base year	use of B	distribute B over grid	area of application
$\mathbf{B_F}$	both base year and scenario year are multiplied by $\mathbf{B_F}$	none, used at measurement points	national, Lombardia
$\mathbf{B_F}$	both base year and scenario year are multiplied by $\mathbf{B_F}$	adjustment factor map obtained from $\mathbf{B_F}$ spatialized with kriging	Po Valley (Life PREPAIR), Emilia-Romagna, Umbria
$\mathbf{B_A}$ $\mathbf{B_F}$	$\mathbf{B_A}$ to obtain adjusted base year simulation	adjustment factor map for base year obtained from $\mathbf{B_A}$ spatialized with kriging scenario year adjusted using $\mathbf{B_F}$ calculated between adjusted and non-adjusted base year simulation	Piemonte

National Air Pollution Control Plan

(ENEA for Min. Env.)

Request: Table of projected number of non-compliant and compliant zones for each AAQD pollutants

- Starting point: measured concentrations at background stations
- Target: projected concentrations at background stations

= bias correction only at **stations**, testing both B_A and B_F

	Number of non-compliant air quality zones			
	Specify baseline year	2020	2025	2030
$PM_{2.5}$ (1 yr)				
NO_2 (1 hr)				
NO_2 (1 yr)				
PM_{10} (24 hrs)				
PM_{10} (1 yr)				
O_3 (max 8 hr mean)				
Other (please specify)				

B_A vs B_F

WM		B_A number of non-compliant and compliant zones - B_A			B_F number of non-compliant and compliant zones - B_F		
		2010	2020	2030	2010	2020	2030
NO_2	year	38	34	25	38	21	3
NO_2	hour	3	3	3	3	2	0
PM10	year	13	8	5	13	1	0
PM10	day	38	38	37	38	28	19
PM2.5	year	9	4	1	9	1	0
O_3	Daily max of 8h avgs	46	39	29	46	34	28

- NO_2 and PM, B_F follow better the decrease of emissions
- O_3 is less sensitive to the method probably due to the statistical indicator used and better model performances

ARPAE: model adjustment BF

$f_i = O_i / M_i$

O_i observation; M_i model value for each station location i

Kriging with external drift → KED

fk,j correction matrix over model grid: cell (k, j)

$M^{BASE}_{j,k}$: direct model output base case

$M^{*\,BASE}_{j,k} = M^{BASE}_{j,k} \times f_{j,k}$: adjusted model base case

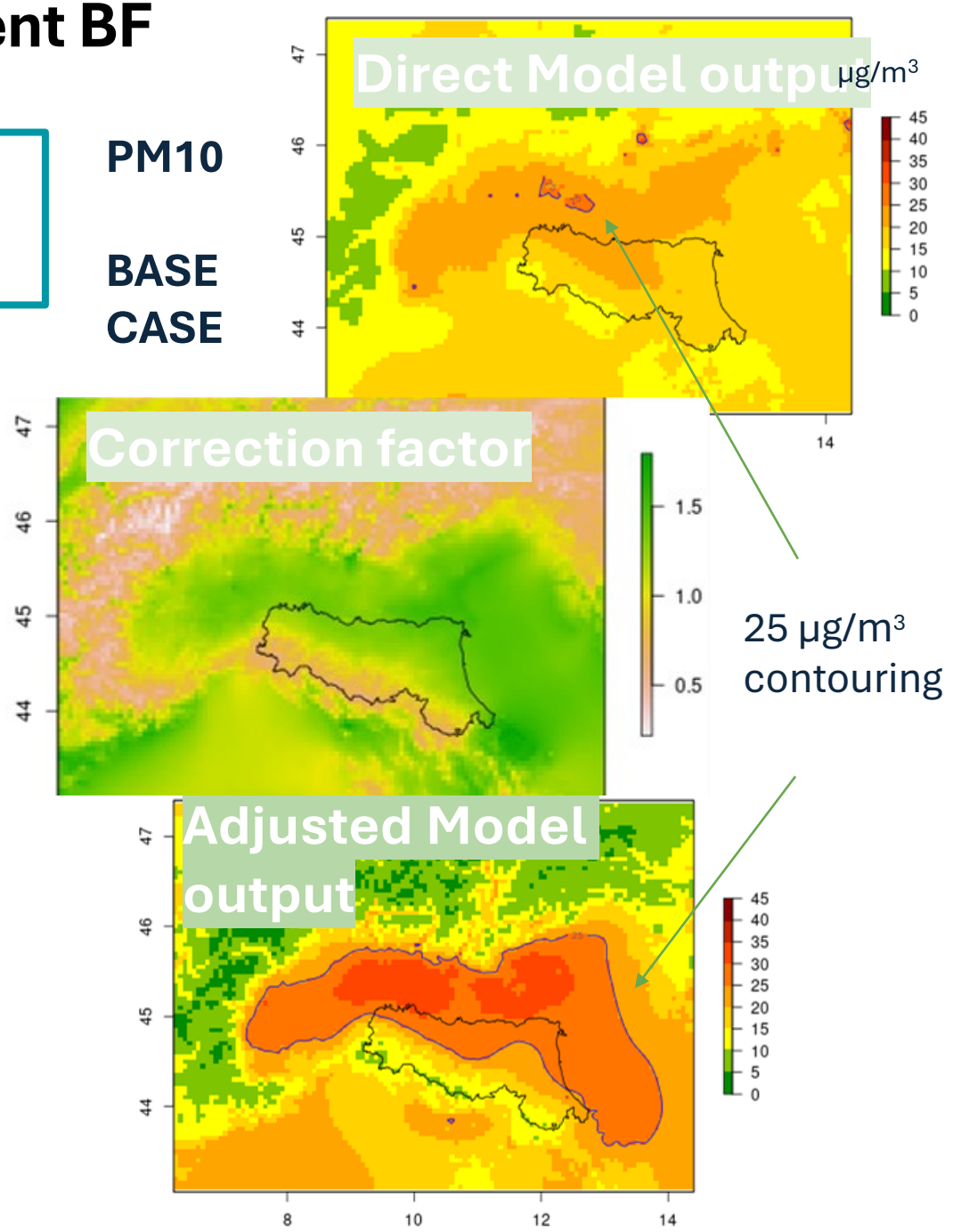
For each scenario

$M^{SCENARIO}_{j,k}$: direct model output

$M^{*\,SCENARIO}_{j,k} = M^{SCENARIO}_{j,k} \times f_{j,k}$: adjusted model output

PM10

BASE CASE



ARPAE applications

Key issue: **How spatialize f factor over model grid?**

Kriging is a possible choice, but **which parameters?**

exponential variogram is set, 3 possible type of external trend examined:

ID	description	formula
mo d	model and elevation	~ model + elevation
log	model log elevation	~ log(model)+ elev
1st	spatial	~X+Y

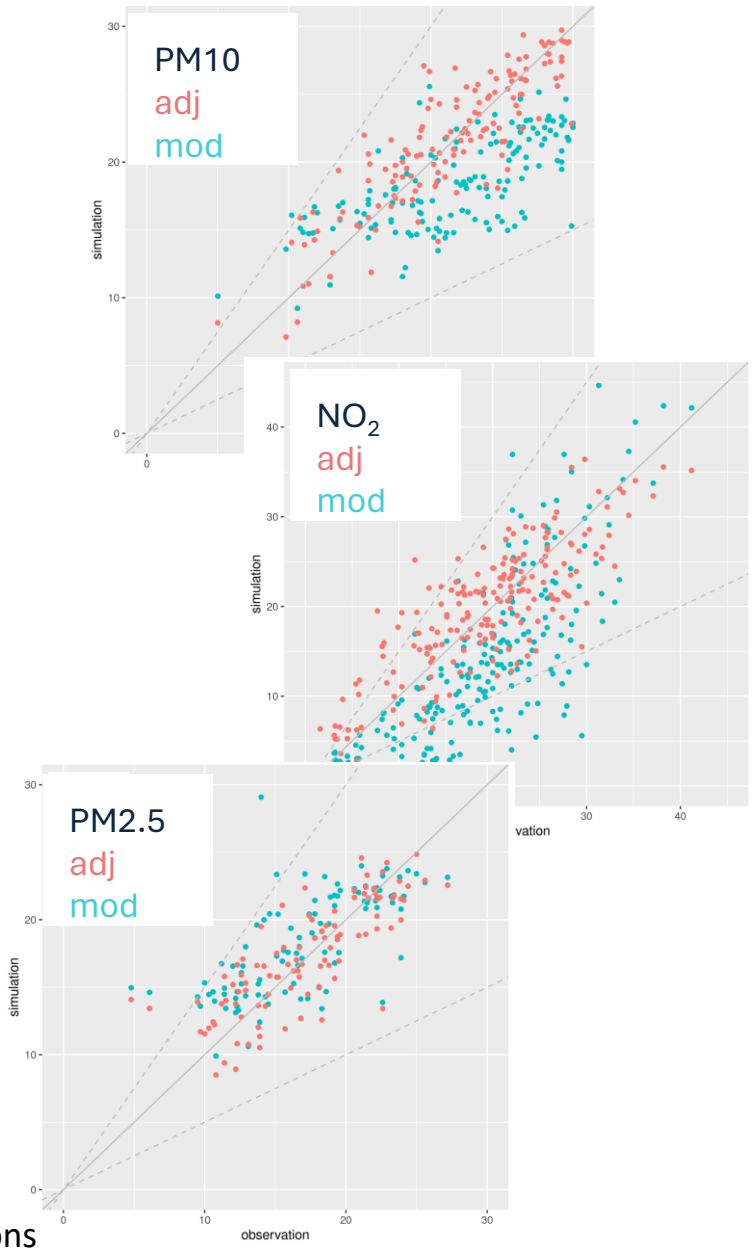
leave one out cross validation

Pollutant	Trend ID
PM10	log
PM2.5	mod
NO2	log

minimize standard error

Cross validation of base case

	PM10 bias	PM10 rmse	NO2 bias	NO2 rmse	PM2.5 bias	PM2.5 rmse
adjusted mod	0.06	2.76	0.24	4.54	0.14	2.81
direct mod	-4.16	6.09	-5.010	7.92	1.31	3.62



Evaluation of different scenarios: PREPAIR project
https://www.lifeprepair.eu/wp-content/uploads/2022/02/evaluation_scenarios_on_air_quality_inPovalley-1.pdf

Planning Emilia-Romagna actions
https://ambiente.regione.emilia-romagna.it/it/aria/temi/pair-2030

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Open questions

1) Which is the best way to express the bias between model and measurement in a point?

-pollutant type dependency, statistical indicator (mean or running mean), measurements representativity in relation to model spatial resolution, etc…

2) Which is the best way to propagate punctual model uncertainties due to model formulation, emissions and meteorology over the grid?

-pollutant type dependency, statistical indicator, measurements representativity in relation to model spatial resolution, etc…

3) Which is the best way to propagate base year model uncertainties due to model formulation, emissions and meteorology to scenario year?

-pollutant type dependency, statistical indicator, present or future meteorology, etc