

Source apportionment using the brute force method to estimate sector impacts on air pollution episodes in Spain

Mark R. Theobald, Marta García Vivanco, Victoria Gil, Juan Luis Garrido and Coralina Hernández



Atmospheric Modelling Unit: CIEMAT. Madrid, Spain

HARMO22

Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Pärnu, Estonia, 10-13 June 2024

Outline

- 1. Identification of pollution episodes
- 2. Brute force source apportionment method
- 3. Model evaluation
- 4. Impacts:
 - Boundary concentrations
 - Transboundary
 - Biogenic emissions
- 5. Impacts of Spanish source sectors
- 6. Episode analysis
- 7. Conclusions





Methods – Identification of pollution episodes

Criteria used :

- Exceedance of the daily limit/target value
- At >1 background monitoring site
- During >1 day

O₃: Maximum daily 8-hour mean (MDA8): 120 μg m⁻³ **NO**₂: Daily mean: 50 μg m⁻³ **PM**_{2.5}: Daily mean: 25 μg m⁻³ (New AAQD) **PM**₁₀: Daily mean: 45 μg m⁻³



Pollution Episodes (2021)

O₃: Maximum Daily 8-hour mean (MDA8)

January-2021	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	Sep. mber-2021	October-2021	November-2021	December-2021
26 27 28 29 30 31 1	30 31 1 2 3 4 5	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 3 30	29 30 31 1 2 3 4	26 27 28 29 30 1 2	31 1 2 3 4 5 6	28 29 30 1 2 3	25 26 27 28 29 30 1	30 31 1 2 3 4 5	27 28 29 30 1 2 3
2 3 4 5 6 7 8	6 7 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 6 7	5 6 7 8 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8	6 7 8 9 10 11 12	4 5 6 7 8 9 10
9 10 11 12 13 14 15	13 14 15 16 17 18 19	13 14 15 16 17 18 19	10 11 12 13 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	14 15 16 17 18 19 20	11 12 13 14 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 17
16 17 18 19 20 21 22	20 21 22 23 24 25 26	20 21 22 23 24 25 26	17 18 19 20 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	21 22 23 24 25 26 27	18 19 20 21 2 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24
23 24 25 26 27 28 29	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	22 23 24 25 26 27 28	26 27 28 29 30 1 2	24 25 26 27 28 29 30	28 29 30 31 1 2 3	25 26 27 28 30 1	23 24 25 26 27 28 29	27 28 29 30 1 2 3	25 26 27 28 29 30 31
30 31 1 2 3 4 5	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	29 30 31 1 3 4	3 4 5 6 7 8 9	31 1 2 3 4 5 6	4 5 6 7 8 9 10	2 3 4 5 6 7 8	30 31 1 2 3 4 5	4 5 6 7 8 9 10	1 2 3 4 5 6 7
SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWFF	SSMTWTF	SSMTWTF	SSMTWTF	SSMIWTF	SSMTWTF	SSMTWTF	SSMTWTF

NO₂: Daily mean

1 m / 1 m	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	September-2021	October-2021	November-2021	December-2021
26 27 28 29 30 31	1 31 1 2 3 4 5	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	29 30 31 1 2 3 4	26 27 28 29 30 1 2	31 1 2 3 4 5 6	28 29 30 31 1 2 3	25 26 27 28 29 7 1	30 31 1 2 3 4 5	27 28 29 30 1 2 3
2 3 4 5 6 7	8 6 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	5 6 7 8 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 9 7 8	6 7 8 9 10 11 12	4 5 6 7 8 9 10
9 10 11 12 13 14	15 13 14 5 16 17 18 19	13 14 15 16 17 18 19	10 11 12 13 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 3 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 17
16 17 18 19 20 21 2	22 20 21 2 23 24 25 26	20 21 22 23 24 25 26	17 18 19 20 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 0 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24
23 24 25 26 27 28	29 27 2/ 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	22 23 24 25 26 27 28	26 27 28 29 30 1 2	24 25 26 27 28 29 30	28 29 30 31 1 2 3	25 26 27 28 29 30 1	23 24 25 26 2, 28 29	27 28 29 30 1 2 3	25 26 27 28 29 30 31
30 31 1 2 3 4	5 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	29 30 31 1 2 3 4	3 4 5 6 7 8 9	31 1 2 3 4 5 6	4 5 6 7 8 9 10	2 3 4 5 6 7 8	30 31 1 2 3 4 5	4 5 6 7 8 9 10	1 2 3 4 5 6 7
5	F S S M T W T F	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SMTWTF	SSMTWTF

PM_{2.5}: Daily mean

Jan	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	September-2021	October-2021	November-2021	D
26 27 28 29 30 31 1	31 1 2 3 4 5	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	29 30 31 1 2 3 4	26 27 28 29 30 1 2	31 1 2 3 4 5 6	28 29 30 31 1 2 3	25 26 27 28 29 30 1	30 31 1 2 3 4 5	27 28 29 30 1 2 3 60
2 3 4 5 6 7 8	6 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	5 6 7 8 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8	6 7 8 9 10 / 12	4 5 6 7 8 9 10
9 10 11 12 13 14 15	13 14 15 16 17 18 19	13 14 15 16 17 18 19	10 11 12 13 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 17 45
16 17 18 19 20 21 22	20 21 22 23 24 25 26	20 21 22 23 24 25 26	17 18 19 20 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24 40
23 24 25 26 27 28 29	27 1 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	22 23 24 25 26 27 28	26 27 28 29 30 1 2	24 25 26 27 28 29 30	28 29 30 31 1 2 3	25 26 27 28 29 30 1	23 24 25 26 27 28 29	27 28 29 30 1 3	25 26 27 28 29 30 31 35
30 31 1 2 3 4 5	7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	29 30 31 1 2 3 4	3 4 5 6 7 8 9	31 1 2 3 4 5 6	4 5 6 7 8 9 10	2 3 4 5 6 7 8	30 31 1 2 3 4 5	4 5 6 7 8 9	1 2 3 4 5 6 7
o ser o ser o se	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	5 0 11 7 111 25

PM₁₀: Daily mean

January-2021	February-2021	March-2021	April-2021	May-2021	June-2021	July 201	August-2021	September-2021	October-2021	November-2021	December-2021
27 28 29 2 11 1	00 01 1 2 3 4 5	27 28 1 2 3 5	27 27 29 30 31 1 2	24 25 26 27 28 29 30	29 30 31 1 3 4	26 27 28 29 20 1 2	01 1 2 3 4 5 6	28 29 30 31 1 2 3	25 26 27 28 29 30 1	00 01 1 2 3 4 5	27 28 29 30 1 2 3
3 4 5 6 7 8	7 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	5 6 7 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8	6 7 8 9 10 11 12	4 5 6 7 8 9 10
10 11 1 13 14 15	13 14 15 16 17 18 19	13 14 15 16 17 18 19	10 11 12 8 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 13
17 18 1 20 21 22	20 21 22 23 24 25 26	20 21 22 23 24 25 26	17 18 19 0 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	1 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24
24 25 26 7 28 29	27 28 1 2 0 4 5	27 28 29 30 31 1 2	24 25 / 27 28 29 30	22 23 24 25 26 27 28	26 27 28 2 30 1 2	24 25 26 27 28 29 30	28 29 30 31 1 2 3	25 26 27 28 29 30 1	23 24 25 26 27 28 29	27 28 29 30 1 2 3	25 26 27 28 29 30 31
31 1 2 3 5	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 3 4 5 6 7	29 30 31 1 2 0 4	3 4 5 6 7 0	31 1 2 3 4 4	4 5 6 7 8 9 10	2 3 4 5 6 7 8	30 31 1 2 3 4 5	4 5 5 7 8 9 10	1 2 3 4 5 6 7
SMTWTF	SMTWTF	SSMTWT	SSMTWTF	SSMTWTF	SSMTWTF	SSMIWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF



Brute Force Source Apportionment

Base scenario (BS)



Reduction scenario (RS)



S₃: Una reducción de X%

Potential impact of S_3 = (BS-RS) × (100/X) =

Contribution of S₃ <u>for linear</u> <u>species</u>

(But not for non-linear species such as O₃ and secondary PM)



Method application in this study

Three levels of detail

European simulations



Reductions applied to:

- Spain
- Neighbouring countries (FR, PT)
- Resto of SW Europe
- International shipping
- Biogenic emissions
- Boundary concentrations (O₃ / non O₃)

Spanish simulations (nested within European Base Case)



Episode runs (1-2 months):

With reductions for:

- Source sectors in Spain and emitted species (e.g. NOx from SNAP7)
- All other anthropogenic emissions

Annual runs:

With reductions for:

- Source sectors in Spain (SNAP 1-10)
- Rest of SW Europe
- International shipping
- Biogenic emissions (VOC, NOx, PM)
- Boundary concentrations (O₃ / non O₃)

Reductions of 10% and 25%



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Method application in this study

Three levels of detail

European simulations



Reductions applied to:

- Spain
- Neiahbourina countries (FR. PT)
- 19 simulations
- Biogenic emissions
- Boundary concentrations (O₃ / non O₃)

Spanish simulations (nested within European Base Case)



Episode runs (1-2 months):

With reductions for:



• Alrother unthropogenic emissions

Annual runs:

With reductions for:

Source sectors in Spain (SNAP 1-10)

35 simulations

- Biogenic emissions (VOC, NOx, PM)
- Boundary concentrations (O₃ / non O₃)

Reductions of 10% and 25%



Model set-up

- Chemistry and Transport Model:
 - CHIMERE (v2013)
- Spatial Resolutions:
 - 0.15° x 0.15° (SW Europe; SWEU)
 - 0.1° x 0.1° (Iberian Peninsula; IP)
- Emissions (2021):
 - Spain: National Emission Inventory
 - Rest of Europe: EMEP
- Meteorology: ECMWF IFS 2021
- Boundary conditions: LMDZ-INCA and GOCART (climatological)
- Biogenic emissions: MEGAN



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Simulation of episodes (at background station locations)

O₃: Maximum Daily 8-hour mean (MDA8)

	January-2021	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	September-2021	October-2021	November-2021	December-2021	170
	26 27 28 29 30 31 1	30 31 1 2 3 4 5	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	29 30 31 1 2 3 4	26 27 28 29 30 1 2	31 1 2 3 4 5 6	28 29 30 31 1 2 3	25 26 27 28 29 30 1	30 31 1 2 3 4 5	27 28 29 30 1 2 3	160
	2 3 4 5 6 7 8	6 7 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	5 6 7 8 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8	6 7 8 9 10 11 12	4 5 6 7 8 9 10	150
	9 10 11 12 13 14 15	13 14 15 16 17 18 19	13 14 15 16 17 18 19	10 11 12 13 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 17	150
ORS	16 17 18 19 20 21 22	20 21 22 23 24 25 26	20 21 22 23 24 25 26	17 18 19 20 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24	140
005	23 24 25 26 27 28 29	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	22 23 24 25 26 27 28	26 27 28 29 30 1 2	24 25 26 27 28 29 30	28 29 30 31 1 2 3	25 26 27 28 29 30 1	23 24 25 26 27 28 29	27 28 29 30 1 2 3	25 26 27 28 29 30 31	130
	30 31 1 2 3 4 5	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	29 30 31 1 2 3 4	3 4 5 6 7 8 9	31 1 2 3 4 5 6	4 5 6 7 8 9 10	2 3 4 5 6 7 8	30 31 1 2 3 4 5	4 5 6 7 8 9 10	1 2 3 4 5 6 7	100
	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	120
	January-2021	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	September-2021	October-2021	November-2021	December-2021	
	26 27 28 29 30 31 1	30 31 1 2 3 4 5	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	29 30 31 1 2 3 4	26 27 28 29 20 1 2	31 1 2 3 4 5 6	28 29 30 31 1 2 3	25 26 27 28 29 30 1	30 31 1 2 3 4 5	27 28 29 30 1 2 3	140
	2 3 4 5 6 7 8	6 7 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	5 6 7 8 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8	6 7 8 9 10 11 12	4 5 6 7 8 9 10	135
1100	9 10 11 12 13 14 15	13 14 15 16 17 18 19	13 14 15 16 17 18 19	10 11 12 13 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 17	
NUD	16 17 18 19 20 21 22	20 21 22 23 24 25 26	20 21 22 23 24 25 26	17 18 19 20 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24	130
	23 24 25 26 27 28 29	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	22 23 24 25 26 27 28	26 27 28 29 30 1 2	24 25 26 27 28 29 30	28 29 30 31 1 2 3	25 26 27 28 29 30 1	23 24 25 26 27 28 29	27 28 29 30 1 2 1	25 26 27 28 29 30 31	125
	30 31 1 2 3 4 5	6 7 6 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	29 30 31 1 2 3 4	3 4 5 6 7 8 9	31 1 2 3 4 5 6	4 5 6 7 8 9 10	2 1 4 5 6 7 1	30 31 1 2 3 4 5	4 5 6 7 8 0 10	1 2 3 4 5 6 7	100
	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	120

NO₂: Daily mean

	January-2021	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	September-2021	October-2021	November-2021	December-2021
	26 27 28 29 30 31 1	30 31 1 2 3 4 5	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	29 30 31 1 2 3 4	26 27 28 29 30 1 2	31 1 2 3 4 5 6	28 29 30 31 1 2 3	25 26 27 28 29 30 1	30 31 1 2 3 4 5	27 28 29 30 1 2 3
000	2 3 4 5 6 7 8	6 7 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	5 6 7 8 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8	6 7 8 9 10 11 12	4 5 6 7 8 9 10
	9 10 11 12 13 14 15	13 14 15 16 17 18 19	13 14 15 16 17 18 19	10 11 12 13 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 17
ORS	16 17 18 19 20 21 22	20 21 22 23 24 25 26	20 21 22 23 24 25 26	17 18 19 20 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24
005	23 24 25 26 27 28 29	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	22 23 24 25 26 27 28	26 27 28 29 30 1 2	24 25 26 27 28 29 30	28 29 30 31 1 2 3	25 26 27 28 29 30 1	23 24 25 26 27 28 29	27 28 29 30 1 2 3	25 26 27 28 29 30 31
	30 31 1 2 3 4 5	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	29 30 31 1 2 3 4	3 4 5 6 7 8 9	31 1 2 3 4 5 6	4 5 6 7 8 9 10	2 3 4 5 6 7 8	30 31 1 2 3 4 5	4 5 6 7 8 9 10	1 2 3 4 5 6 7
	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF
	January-2021	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	September-2021	October-2021	November-2021	December-2021
	26 27 28 29 30 31 1	30 31 1 2 3 4 5	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	29 30 31 1 2 3 4	26 27 28 29 30 1 2	31 1 2 3 4 5 6	28 29 30 31 1 2 3	25 26 27 28 29 30 1	30 31 1 2 3 4 5	27 28 29 30 1 2 3
	2 3 4 5 6 7 8	6 7 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	5 6 7 8 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8	6 7 8 9 10 11 12	4 5 6 7 8 9 10
	9 10 11 12 13 14 15	13 14 15 16 17 18 19	13 14 15 16 17 18 19	10 11 12 13 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 17
VI())	16 17 18 19 20 21 22	20 21 22 23 24 25 26	20 21 22 23 24 25 26	17 18 19 20 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24
	23 24 25 26 27 28 29	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	22 23 24 25 26 27 28	26 27 28 29 30 1 2	24 25 26 27 28 29 30	28 29 30 31 1 2 3	25 26 27 28 29 30	23 24 25 26 27 28 29	27 28 29 30 1 2 3	25 26 27 28 29 30 31
100	23 24 25 26 27 28 29 30 31 1 2 3 4 5	27 28 1 2 3 4 5 6 7 8 9 10 11 12	27 28 29 30 31 1 2 3 4 5 6 7 8 9	24 25 26 27 28 29 30 1 2 3 4 5 6 7	22 23 24 25 26 27 28 29 30 31 1 2 3 4	26 27 28 29 30 1 2 3 4 5 6 7 8 9	24 25 26 27 28 29 30 31 1 2 3 4 5 6	28 29 30 31 1 2 3 4 5 6 7 8 9 10	25 26 27 28 29 30 1 2 3 4 5 6 7 8	23 24 25 26 27 28 29 30 31 1 2 3 4 5	27 28 29 30 1 2 3 4 5 6 7 8 9 10	25 26 27 28 29 30 31 1 2 3 4 5 6 7

PM_{2.5}: Daily mean

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	January-2021	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	September-2021	October-2021	November-2021	December-2021
	26 27 28 29 30 31 1	30 31 1 2 3 4 5	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	29 30 31 1 2 3 4	26 27 28 29 30 1 2	31 1 2 3 4 5 6	28 29 30 31 1 2 3	25 26 27 28 29 30 1	30 31 1 2 3 4 5	27 28 29 30 1 2 3
	2 3 4 5 6 7 8	6 7 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	5 6 7 8 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8	6 7 8 9 10 11 12	4 5 6 7 8 9 10
	9 10 11 12 13 14 15	13 14 15 16 17 18 19	13 14 15 16 17 18 19	10 11 12 13 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 17
ORS	16 17 18 19 20 21 22	20 21 22 23 24 25 26	20 21 22 23 24 25 26	17 18 19 20 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24
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	30 31 1 2 3 4 5	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	29 30 31 1 2 3 4	3 4 5 6 7 8 9	31 1 2 3 4 5 6	4 5 6 7 8 9 10	2 3 4 5 6 7 8	30 31 1 2 3 4 5	4 5 6 7 8 9 10	1 2 3 4 5 6 7
	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF	SSMTWTF
	January-2021	February-2021	March-2021	April-2021	May-2021	June-2021	July-2021	August-2021	September-2021	October-2021	November-2021	December-2021
	26 27 28 29 30 31 1	30 31 1 2 3 4 5	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	29 30 31 1 2 3 4	26 27 28 29 30 1 2	31 1 2 3 4 5 6	28 29 30 31 1 2 3	25 26 27 28 29 30 1	30 31 1 2 3 4 5	27 28 29 30 1 2 3
	2 3 4 5 6 7 8	6 7 8 9 10 11 12	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	5 6 7 8 9 10 11	3 4 5 6 7 8 9	7 8 9 10 11 12 13	4 5 6 7 8 9 10	2 3 4 5 6 7 8	6 7 8 9 10 11 12	4 5 6 7 8 9 10
100	9 10 11 12 13 14 15	13 14 15 16 17 18 19	13 14 15 16 17 18 19	10 11 12 13 14 15 16	8 9 10 11 12 13 14	12 13 14 15 16 17 18	10 11 12 13 14 15 16	14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19	11 12 13 14 15 16 17
VIUU	16 17 18 19 20 21 22	20 21 22 23 24 25 26	20 21 22 23 24 25 26	17 18 19 20 21 22 23	15 16 17 18 19 20 21	19 20 21 22 23 24 25	17 18 19 20 21 22 23	21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26	18 19 20 21 22 23 24
	23 24 25 26 27 28 29	27 28 1 2 3 4 5	27 28 29 30 31 1 2	24 25 26 27 28 29 30	22 23 24 25 26 27 28	26 27 28 29 30 1 2	24 25 26 27 28 29 30	28 29 30 31 1 2 3	25 26 27 28 29 30 1	23 24 25 26 27 28 29	27 28 29 30 1 2 3	25 26 27 28 29 30 31
	30 31 1 2 3 4 5	6 7 8 9 10 11 12	3 4 5 6 7 8 9	1 2 3 4 5 6 7	29 30 31 1 2 3 4	3 4 5 6 7 8 9	31 1 2 3 4 5 6	4 5 6 7 8 9 10	2 3 4 5 6 7 8	30 31 1 2 3 4 5	4 5 6 7 8 9 10	1 2 3 4 5 6 7



Potential Impact maps (SWEU)

Impact of Boundary Concentrations

PM_{2.5}: Annual mean

O₃ MDA8: 6 mth mean (Apr-Sep)

NO₂: Annual mean



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Potential Impact maps (IP) NO₂: Annual mean



HARMO 22, Pärnu, Estonia, 10-13 June 2024

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Potential Impact maps (IP) NO₂: Annual mean



Potential Impact maps (IP) PM_{2.5}: Annual mean



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Potential Impact maps (IP)

PM_{2.5}: Annual mean



Potential Impact maps (IP) O_3 MDA8: 6 mth mean (Apr-Sep)

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Potential Impact maps (IP) O_3 MDA8: 6 mth mean (Apr-Sep)



Detailed impact analyses of episodes: O₃ MDA8 (June-July)



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Detailed impact analyses of episodes: PM_{2.5} daily mean (January)





Detailed impact analyses of episodes: PM_{2.5} daily mean (January)





Conclusions

- 1. Brute force source apportionment is a useful tool for estimating source impacts at different temporal and spatial scales
- 2. Background O_3 not only has an impact on O_3 concentrations but also influences NO_2 and $PM_{2.5}$ concentrations
- 3. Biomass burning of agricultural waste can have an impact on O_3 concentrations
- 4. Mitigation strategies should take into account the spatial variability of source impacts



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Thanks!

- Thanks to the European Center for Medium-Range Weather Forecasts (ECMWF) for the provision of meteorological modelling data; with thanks also to AEMET for managing access to this information.
- Project TED2021-132431B-100 (TRANSAIRE: Transition to cleaner air in Spain) funded by MCIN/AEI/ 10.13039/501100011033 and by the European Union NextGenerationEU/PRTR



 We thank the Ministry for the Ecological Transition and Demographic Challenge (MITERD) for the provision of the emission inventory. We also acknowledge MITERD for providing data from air quality stations.



mark.theobald@ciemat.es

