Meteorologisk institutt

Norwegian Meteorological Institute

An example of EMEP model policy applications: Source-receptor calculations (SR)

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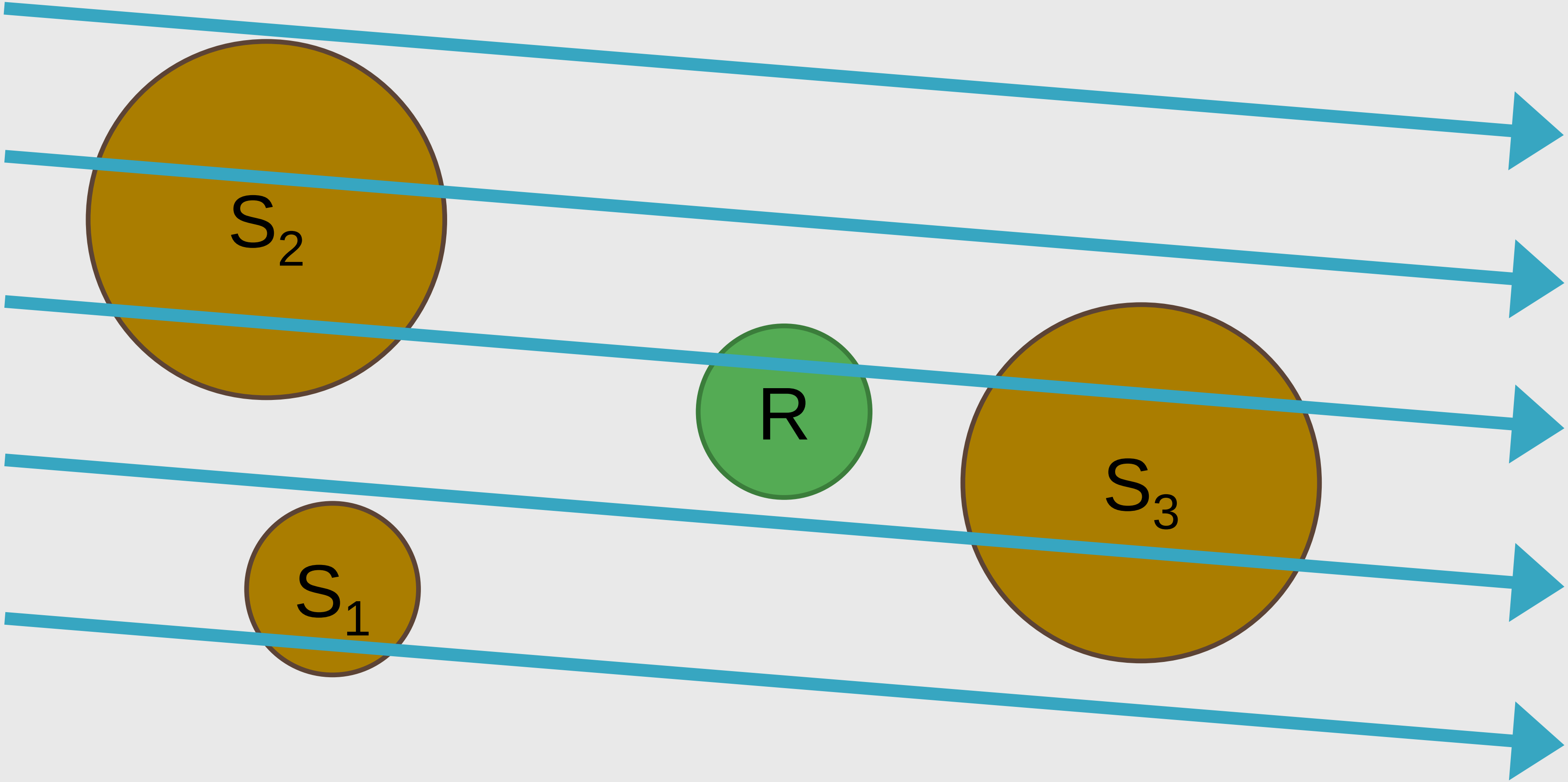
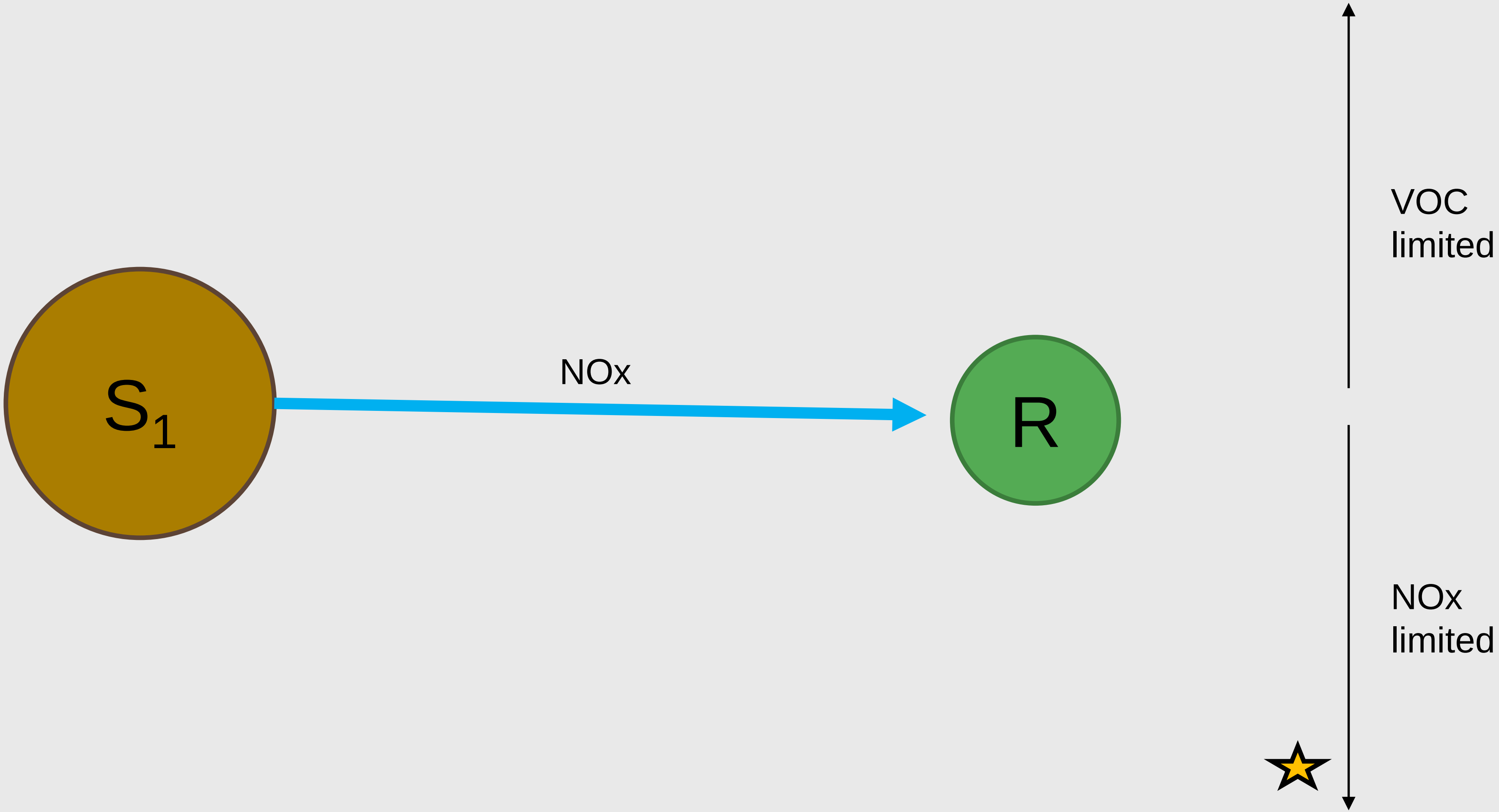
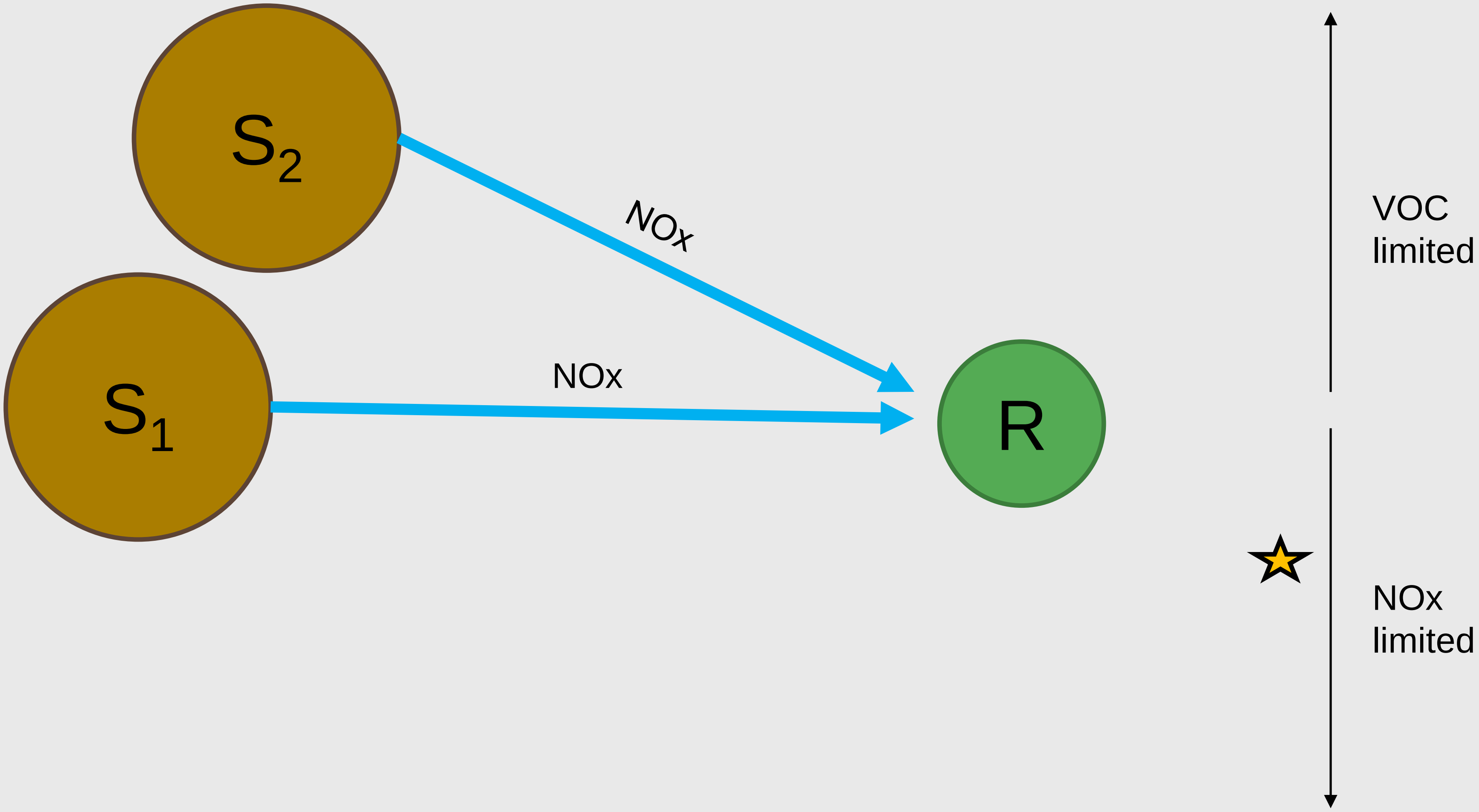
EMEP modelling course, Oslo, 29-30 April 2019



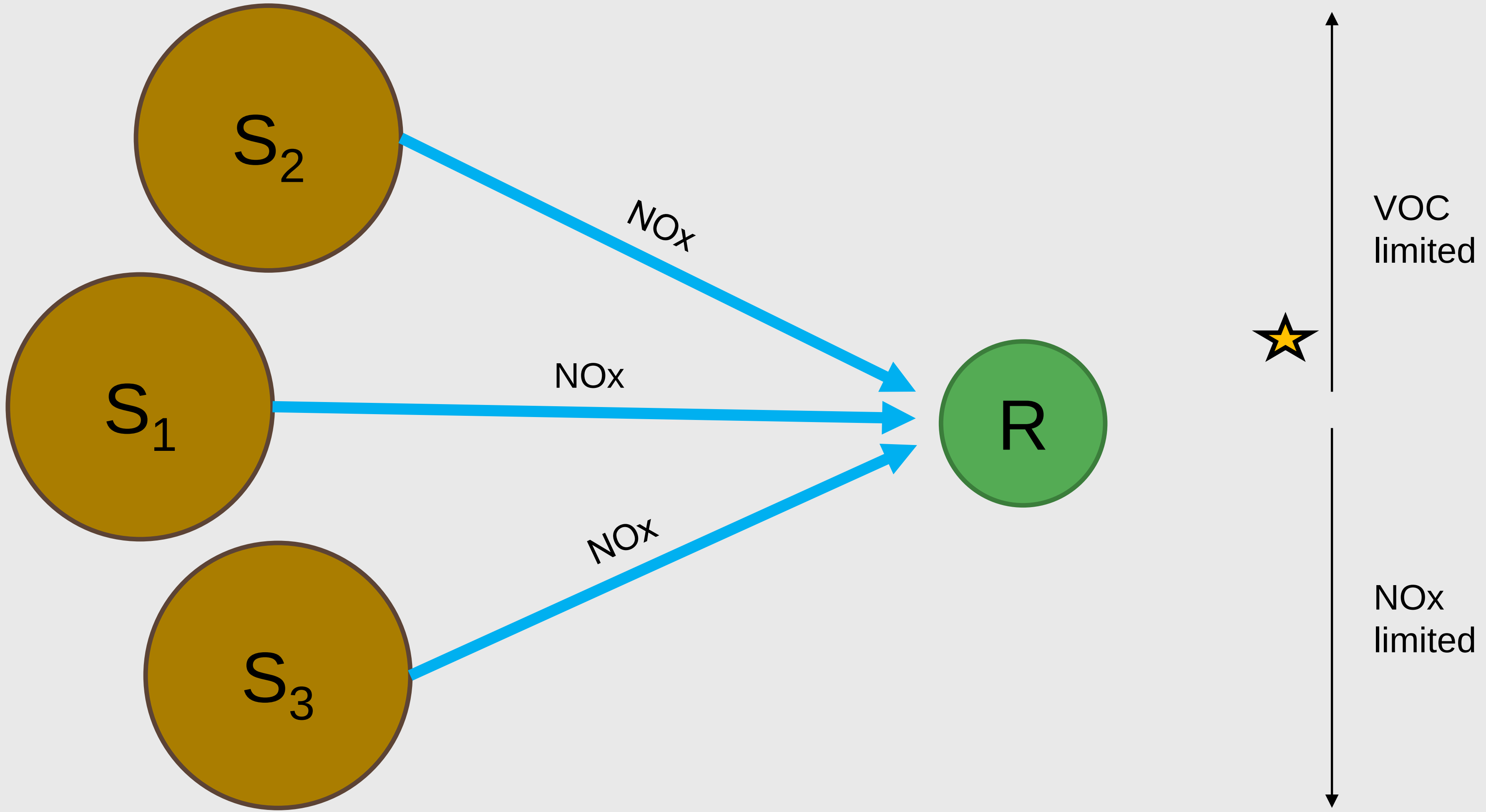
S_2
R
S_3
S_1



S_1
NOx
R
VOC limited
NOx limited



S2
NOx
S1
NOx
R
VOC
limited
NOx
limited


S2
S1
S3
NOx
NOx
NOx
R
VOC limited
NOx limited

SR relationships depend on …

- Distance, wind speed/direction, and other meteorological conditions
- Emissions, and distribution of emissions within the sources/receptors
- Emissions from other sources
- Size of the receptor area
- … and a lot more.

SR - policy questions

- What are the causes of air pollution?
  - which industrial sectors, which countries or areas, …
- Natural vs. antropogenic contributions
- Indigenous vs. long-range transported contributions
- What can we do about it?
  - short-term measures, quick response
  - long-term measures

EMEP SR products

- Country-to-country blame matrices (traditional)
  - Every year: 250 annual model runs (5 species × 50 countries/regions)
  - For EMEP status reports, OSPAR and HELCOM reports, input to GAINS model, Gothenburg protocol
- Sector-specific source attribution
  - Every five to ten years or so: ~1000 annual model runs
- SR forecasts for selected cities (since ~2010)
  - Daily pre-operational service: ~50 five-day model runs
  - Copernicus Atmosphere Monitoring Service, website
- “Local fraction” per grid (since ~2017)
  - Calculates fluxes across grid cell boundaries
  - uEMEP / research

Source-receptor relationships

Calculation of the ‘blame matrix’ B

$$B_{ij} = \frac{\Delta C_j}{\Delta E_i}$$

where

B_{ij} is the transfer coefficient from source i to receptor j

ΔE_i = emission change in emissions from source i

ΔC_j = change in concentration in receptor j

EMEP MSC-W reports

- https://www.emep.int
- https://www.emep.int/mscw
- https://www.emep.int/mscw/mscw_publications.html

- https://emep.int/publ/reports/2018/EMEP_Status_Report_1_2018.pdf

Table C.1: 2016 country-to-country blame matrices for **oxidised sulphur** deposition.
Units: 100 Mg of S. **Emitters →, Receptors ↓.**

	AL	AM	AT	AZ	BA	BE	BG	BY	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GE	GR	HR	HU	IE	IS	IT	KG	KZ	LT	LU	LV	MD	ME	
AL	34	0	0	0	5	0	1	0	0	0	0	0	0	0	1	0	0	0	0	4	0	0	0	0	5	0	0	0	0	0	0	4	AL
AM	0	68	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	-0	0	0	0	AM
AT	0	0	31	0	7	1	1	0	1	0	18	37	0	0	1	0	3	1	0	0	1	1	0	0	3	0	0	0	0	0	0	1	AT
AZ	0	21	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	AZ
BA	1	0	1	0	302	0	2	0	0	0	4	3	0	0	2	0	1	0	0	1	3	2	0	0	5	0	0	0	0	0	0	15	BA
BE	0	-0	0	-0	0	50	0	0	0	-0	0	17	0	0	1	0	15	6	-0	0	0	0	0	0	0	-0	0	0	0	0	0	0	BE
BG	2	0	0	0	11	0	181	1	0	0	2	2	0	0	1	0	0	0	0	18	0	1	0	0	2	0	1	0	0	0	1	6	BG
BY	0	0	1	0	9	1	5	103	0	0	11	22	1	3	1	2	2	3	0	1	0	1	0	0	1	0	3	6	0	1	1	3	BY
CH	0	0	0	0	0	0	0	0	14	0	1	7	0	0	2	0	8	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	CH
CY	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	CY
CZ	0	0	3	0	6	1	1	0	0	0	158	48	0	0	1	0	3	2	0	0	1	2	0	0	1	0	0	0	0	0	0	1	CZ
DE	0	0	6	0	4	32	0	1	5	0	56	702	1	1	7	0	48	28	0	0	0	1	1	0	2	0	0	1	1	0	0	0	DE
DK	0	0	0	0	0	2	0	0	0	0	2	18	9	0	1	0	2	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DK
EE	0	0	0	0	1	0	0	2	0	0	1	4	0	14	0	4	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	EE
ES	0	0	0	0	1	1	0	0	0	0	1	4	0	0	371	0	7	2	-0	0	0	0	0	0	2	0	0	0	0	0	0	0	ES
FI	0	0	0	0	2	1	1	3	0	0	5	13	1	13	1	68	1	3	0	0	0	0	0	0	0	0	1	2	0	0	0	0	FI
FR	0	0	1	0	2	16	0	0	3	0	6	59	0	0	87	0	308	31	0	0	1	0	1	0	9	0	0	0	1	0	0	0	FR
GB	0	0	0	-0	0	4	0	0	0	0	2	17	0	0	7	0	12	286	-0	0	0	0	7	1	0	0	0	0	0	0	0	0	GB
GE	0	14	0	5	1	0	1	0	-0	1	0	0	0	0	0	0	0	0	34	1	0	0	0	0	0	0	2	0	0	0	0	0	GE

Table C.1 Cont.: 2016 country-to-country blame matrices for **oxidised sulphur** deposition.
Units: 100 Mg of S. **Emitters** →, **Receptors** ↓.

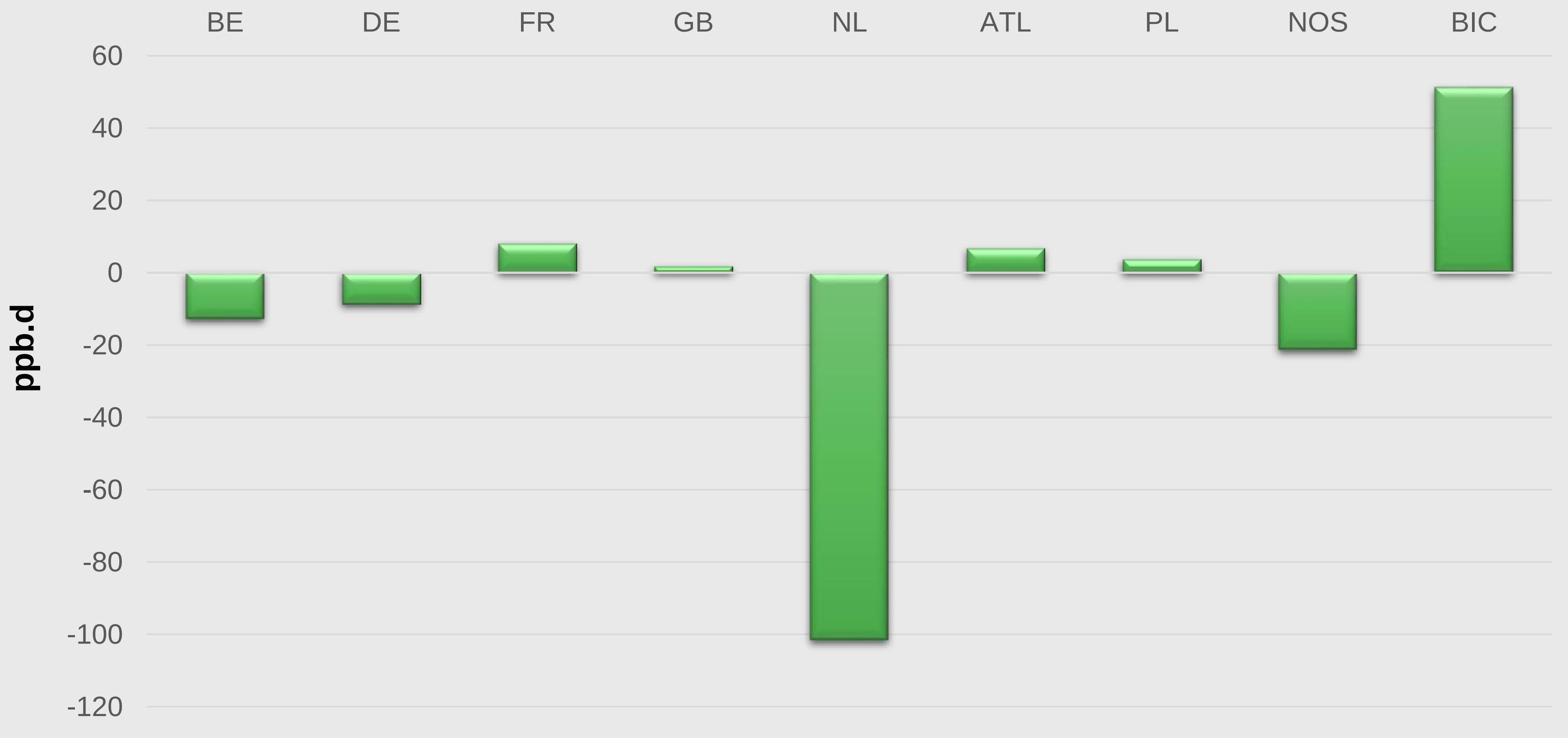
	MK	MT	NL	NO	PL	PT	RO	RS	RU	SE	SI	SK	TJ	TM	TR	UA	UZ	ATL	BAS	BLS	MED	NOS	AST	NOA	BIC	DMS	VOL	SUM	EXC	EU	
AL	11	0	0	0	1	0	0	14	0	0	0	0	0	0	6	2	0	0	0	0	9	0	0	12	7	3	50	172	90	15	AL
AM	0	0	0	0	0	0	0	0	1	0	0	0	0	0	44	0	0	0	0	0	1	0	90	3	14	0	5	231	118	1	AM
AT	0	0	0	0	23	0	1	19	1	0	2	2	0	0	2	2	0	0	0	0	2	0	0	3	6	1	5	181	163	128	AT
AZ	0	0	0	0	0	0	0	0	8	0	0	0	0	0	48	5	0	0	0	0	1	0	195	4	25	1	8	356	122	2	AZ
BA	1	0	0	0	10	0	3	109	1	0	0	2	0	0	4	5	0	0	-0	0	6	0	0	12	8	2	20	528	479	40	BA
BE	0	0	5	0	1	0	0	0	0	0	0	0	-0	-0	0	0	-0	1	0	0	0	2	0	1	2	3	0	106	98	97	BE
BG	20	0	0	0	9	0	25	63	8	0	0	1	0	0	82	30	0	0	0	3	10	0	3	14	17	2	43	560	468	244	BG
BY	2	0	1	0	140	0	9	25	68	1	0	3	0	0	46	106	-0	1	1	1	2	1	2	5	11	3	14	623	582	216	BY
CH	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	3	1	1	50	40	24	CH
CY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	1	0	4	2	2	1	2	32	19	4	CY
CZ	0	0	1	0	66	0	2	20	1	0	1	4	0	0	1	3	0	0	0	0	1	0	0	2	5	1	2	339	328	294	CZ
DE	0	0	22	0	89	1	1	11	4	0	0	2	0	0	1	4	-0	6	1	0	3	6	0	6	19	16	3	1096	1034	1005	DE
DK	0	0	2	0	12	0	0	1	2	0	0	0	0	0	0	1	-0	1	1	0	0	1	0	0	2	6	0	73	61	56	DK
EE	0	0	0	0	13	0	0	2	12	1	0	0	-0	0	1	4	-0	0	1	0	0	0	0	0	2	2	0	70	64	42	EE
ES	0	0	0	0	2	19	0	1	0	0	0	0	-0	-0	0	0	-0	41	0	0	62	0	0	79	54	28	4	683	415	412	ES
FI	0	0	1	2	31	0	1	5	87	9	0	1	0	0	5	12	-0	2	2	0	0	1	0	1	9	14	2	301	269	151	FI
FR	0	0	6	0	13	4	0	6	2	0	0	1	0	0	2	1	0	37	0	0	41	7	0	49	47	44	14	802	563	545	FR
GB	0	0	4	0	6	1	0	0	2	0	0	0	0	0	0	1	-0	28	0	0	1	5	0	1	19	37	0	445	353	348	GB
GE	0	0	0	0	1	0	1	2	7	0	0	0	0	0	121	8	0	0	0	2	2	0	89	5	20	1	12	329	198	4	GE

Contributions to SOMO35 in Germany

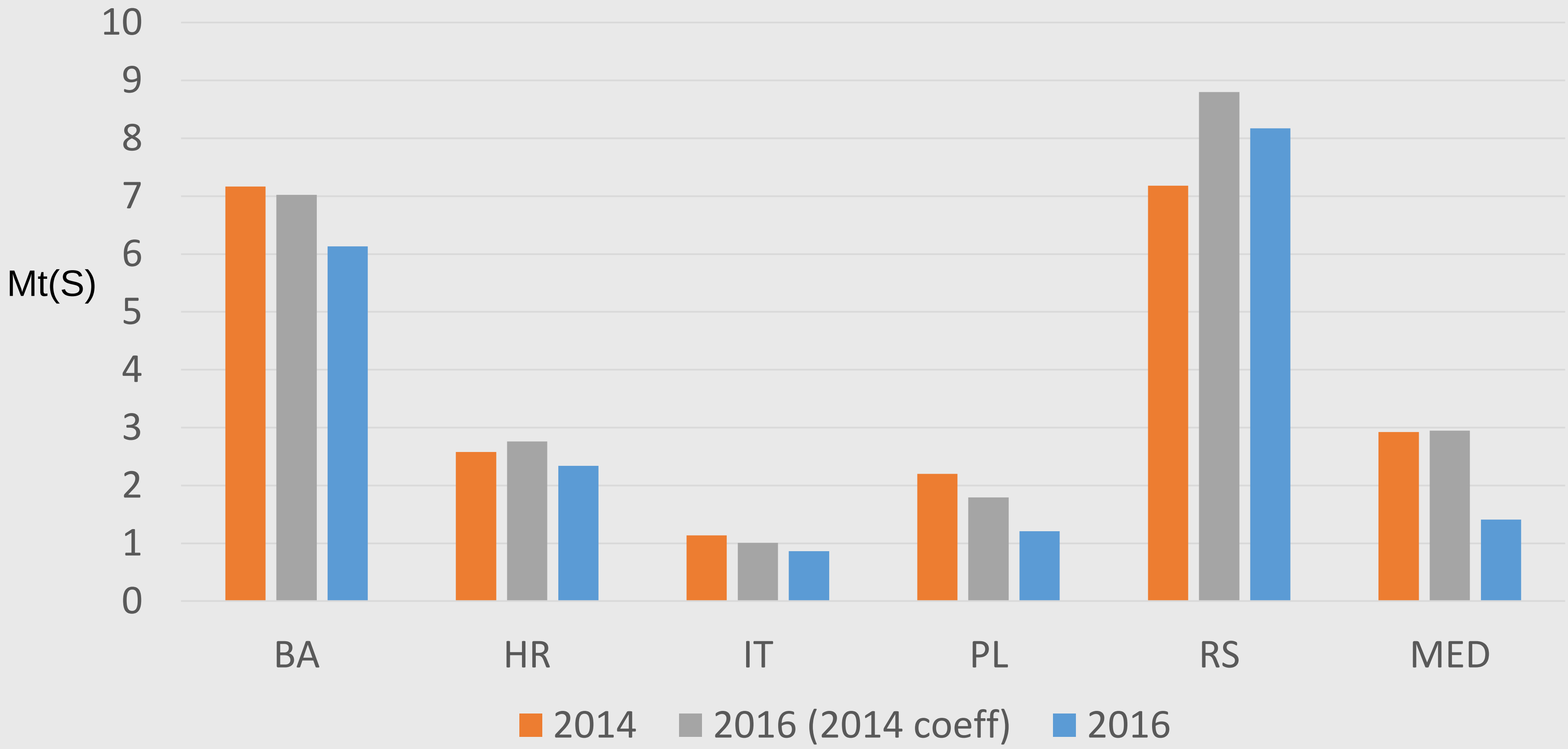
… in 2016 due to NOx emissions

Contributions to SOMO35 in the Netherlands

… in 2016 due to NOx emissions in 2016



Sources of S deposition to Croatia



Inter-annual variability in B

... is mainly due to:

- changes in meteorology and emissions
- updates to the model code / emissions

→ Calculation of 'weather-normalized' changes:

$$\Delta C_j(y_m) = \Delta E_i * B_{ij}(y_m) + BIC(y_m) \qquad e.g.\ \ y_m = 1995 \ldots 2014$$

Copernicus Atmosphere Monitoring Service

Atmosphere Monitoring

- **Copernicus** is the European Union's Earth Observation Programme, divided into six thematic streams, including *'Atmosphere' (CAMS)*

- **CAMS** products are available free of charge

- **CAMS** products cover the global and regional scales (not local)

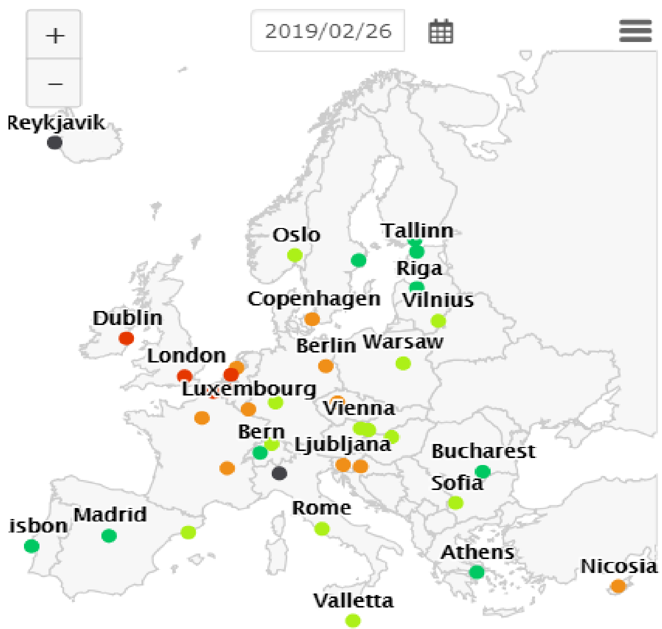
https://atmosphere.copernicus.eu/

ECMWF Copernicus Europe's eyes on Earth European Commission

CAMS – Daily Source allocation

Atmosphere Monitoring

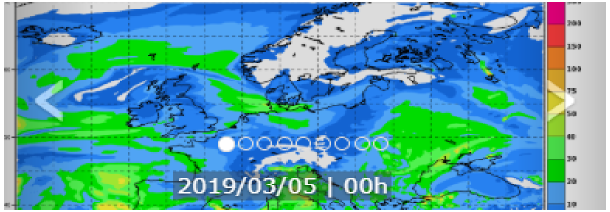
Daily Forecast | Country Attribution | Chemical Species



City – Paris

Pollutant – PM10

Model – EMEP



Attribution to External/Local PM10 sources

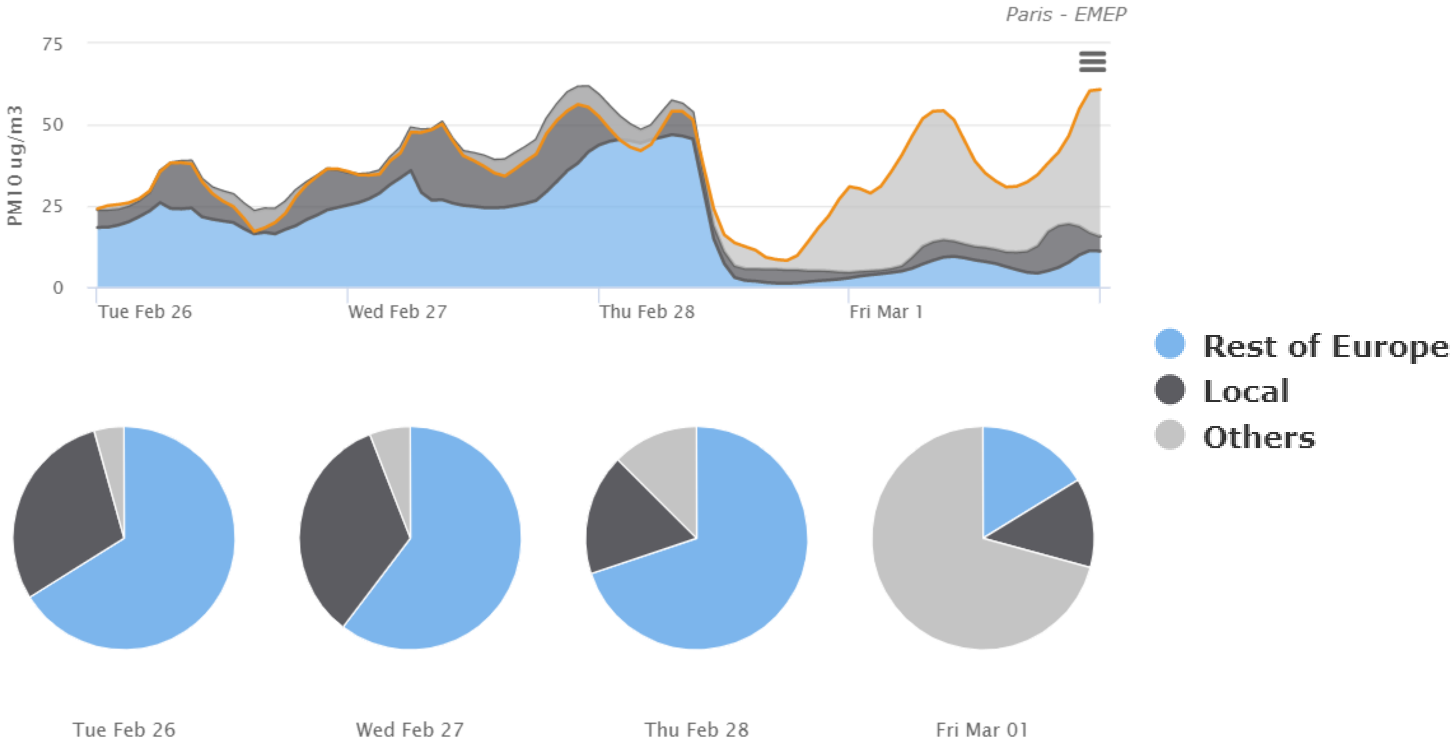
Tool developed and maintained by:

Norwegian Meteorological Institute

https://policy.atmosphere.copernicus.eu/DailySourceAllocation.html

ECMWF Copernicus Europe's eyes on Earth European Commission

CAMS – Daily Source allocation

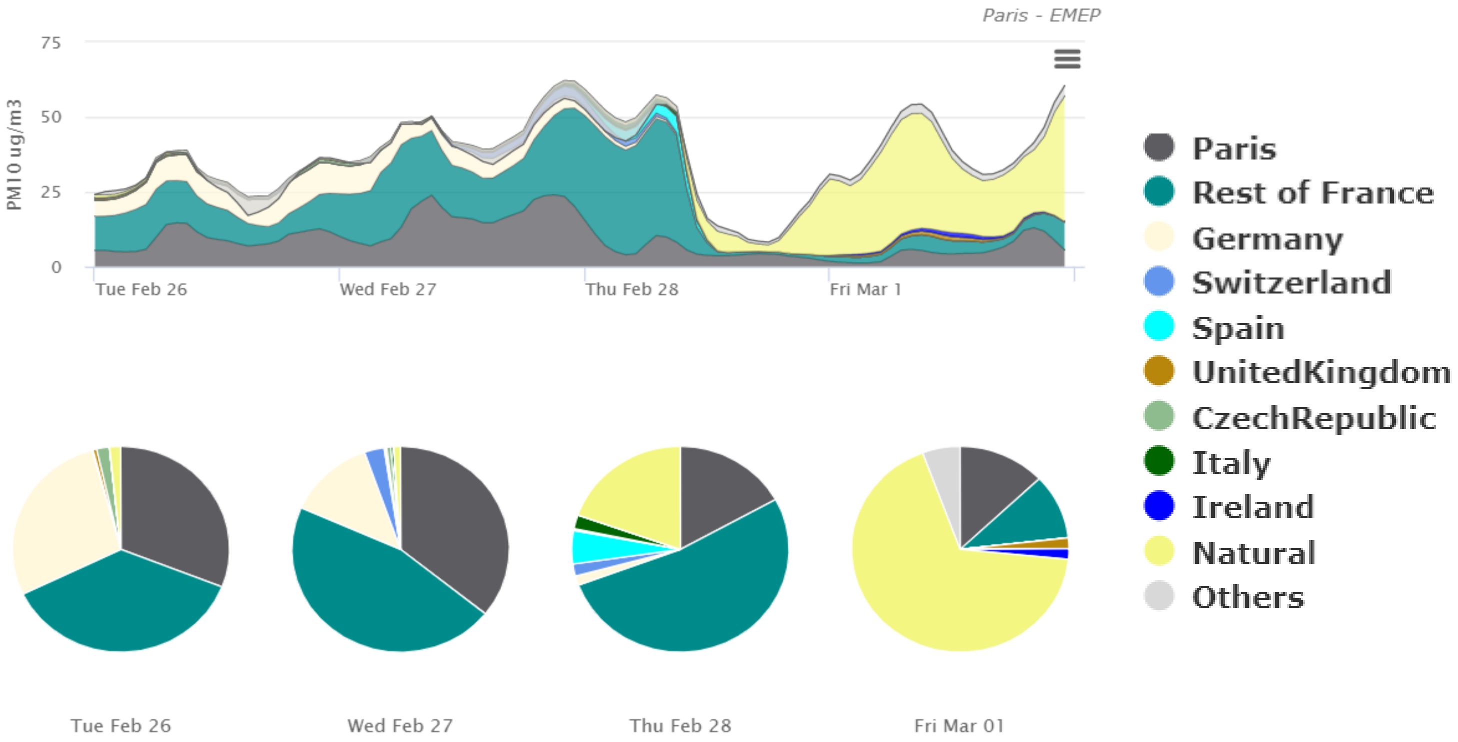


Atmosphere Monitoring

Norwegian Meteorological Institute

ECMWF Copernicus Europe's eyes on Earth European Commission

Atmosphere Monitoring



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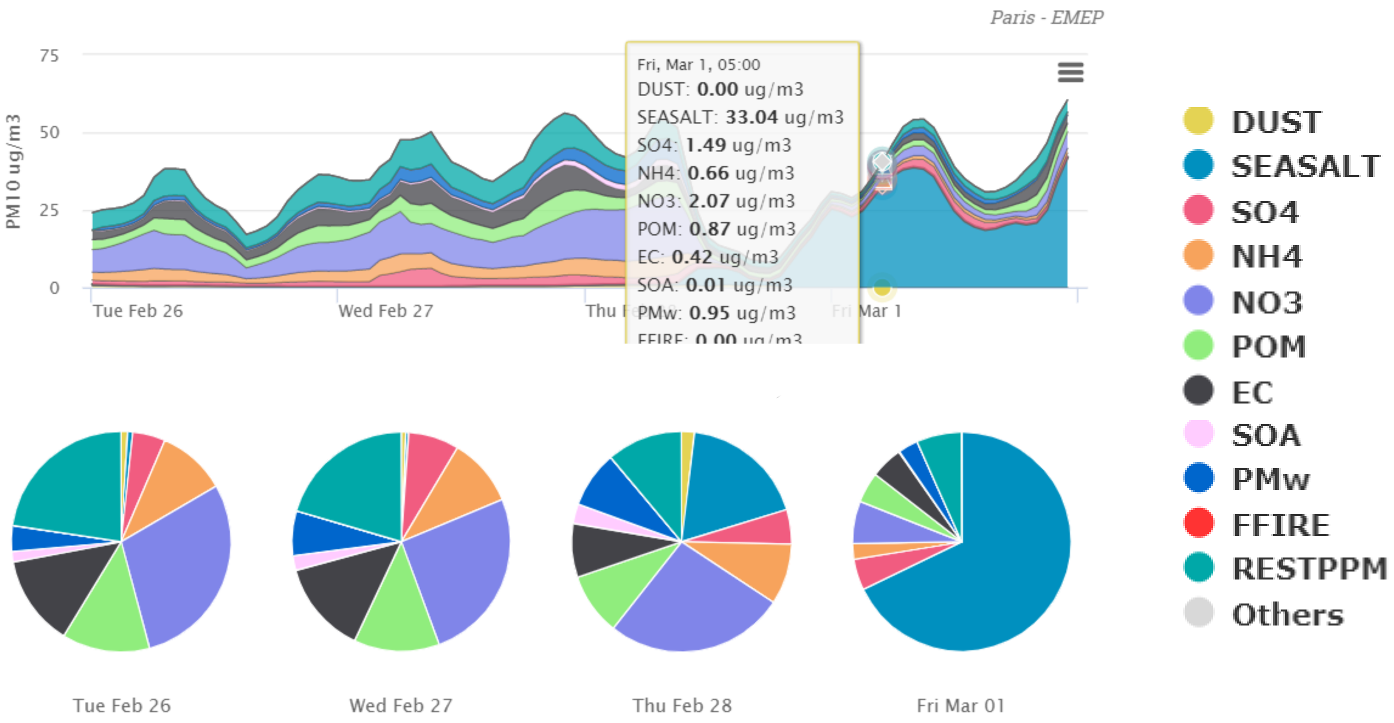
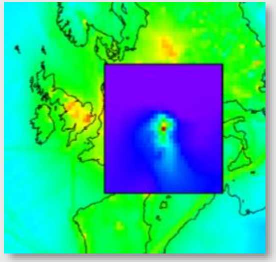
CAMS – Daily Source allocation

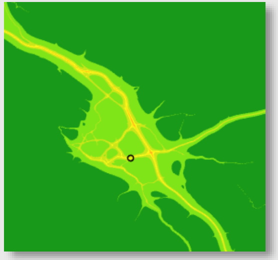


A new feature of EMEP: *u*EMEP

*u*EMEP (urban EMEP) consists of two parts



- A method for calculating the local contribution of emission sources to the gridded concentrations, known as **local fraction**

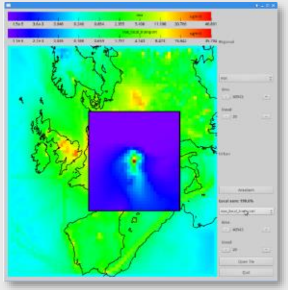


- A method for **downscaling** the local fraction contribution from EMEP to high resolution sub-grids of ~50 m. Achieved by **redistribution** or **replacement** of emissions and Gaussian dispersion modelling

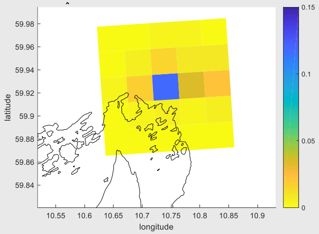
.. can be applied on both hourly and annual data and at all EMEP resolutions

Local fractions in EMEP (*LF*-EMEP)

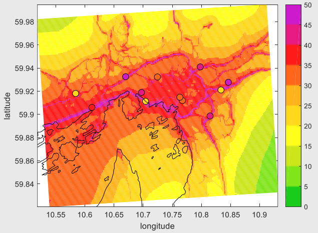
- Built into the EMEP model, fluxes are followed through the model domain to the surrounding grids (i.e. not parameterized, but calculated at each timestep: emis., adv., diff., dep., chem.)



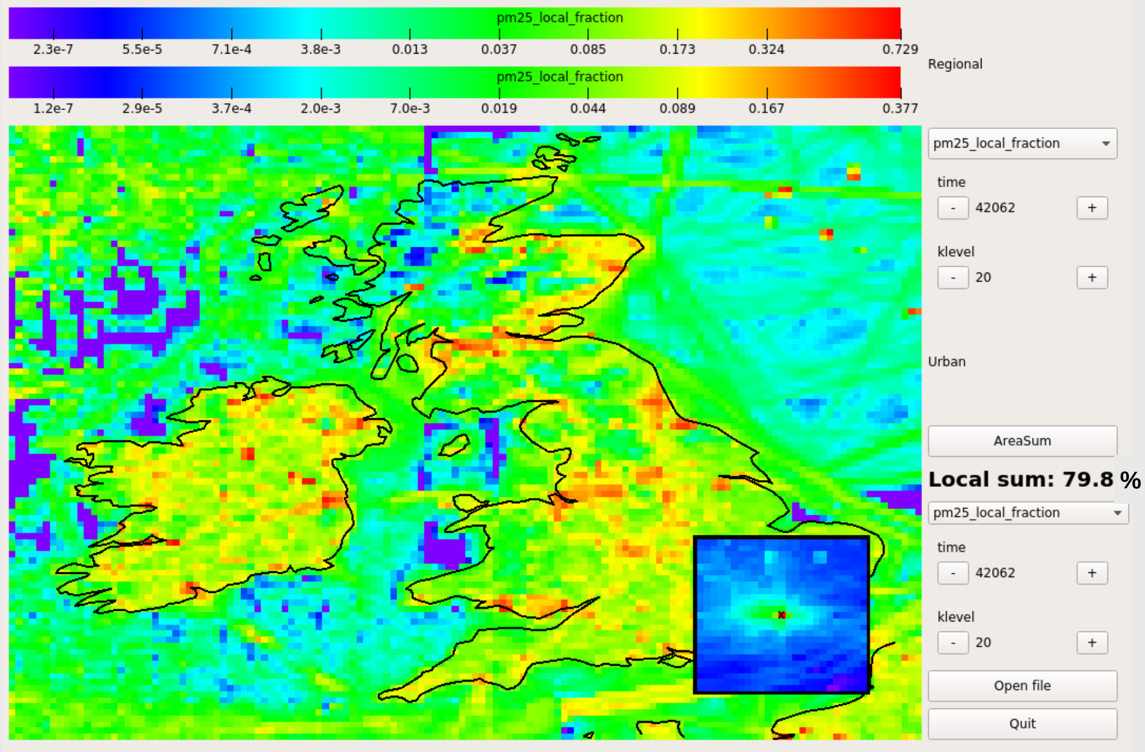
- With this we know the fractional contribution to each grid from all the neighbouring grids ('local region'), e.g. 5 x 5 or 20 x 20 surrounding grids



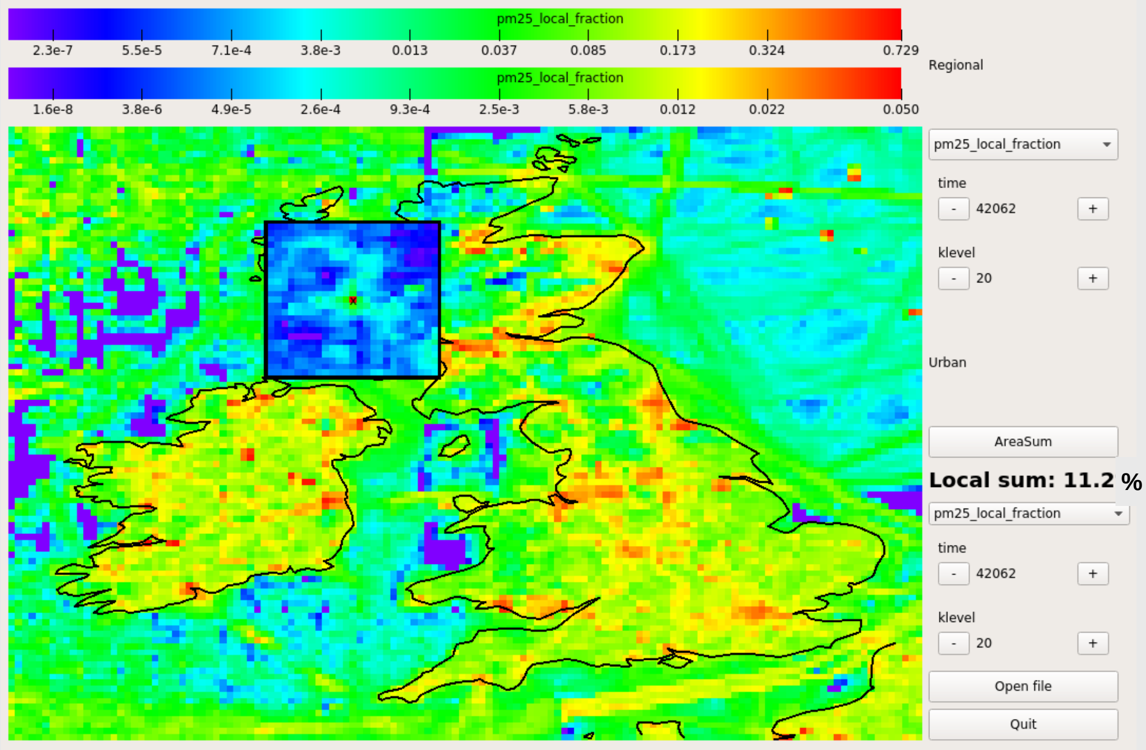
- Knowing this we can calculate source contributions to or from the 'local region', and/or use this information to downscale only this local source contribution within an EMEP grid



The local fractions visualization tool



The local fractions visualization tool



Conclusions

- Annual source-receptor calculations have for decades been one of the main products from EMEP to the UN LRTAP Convention (in addition to status and trends)
- During the last 10 to 15 years more products have been developed, both for research (HTAP) and for policy applications and public users (CAMS, uEMEP)
- The computational efficiency of the EMEP model is key to the success of these applications