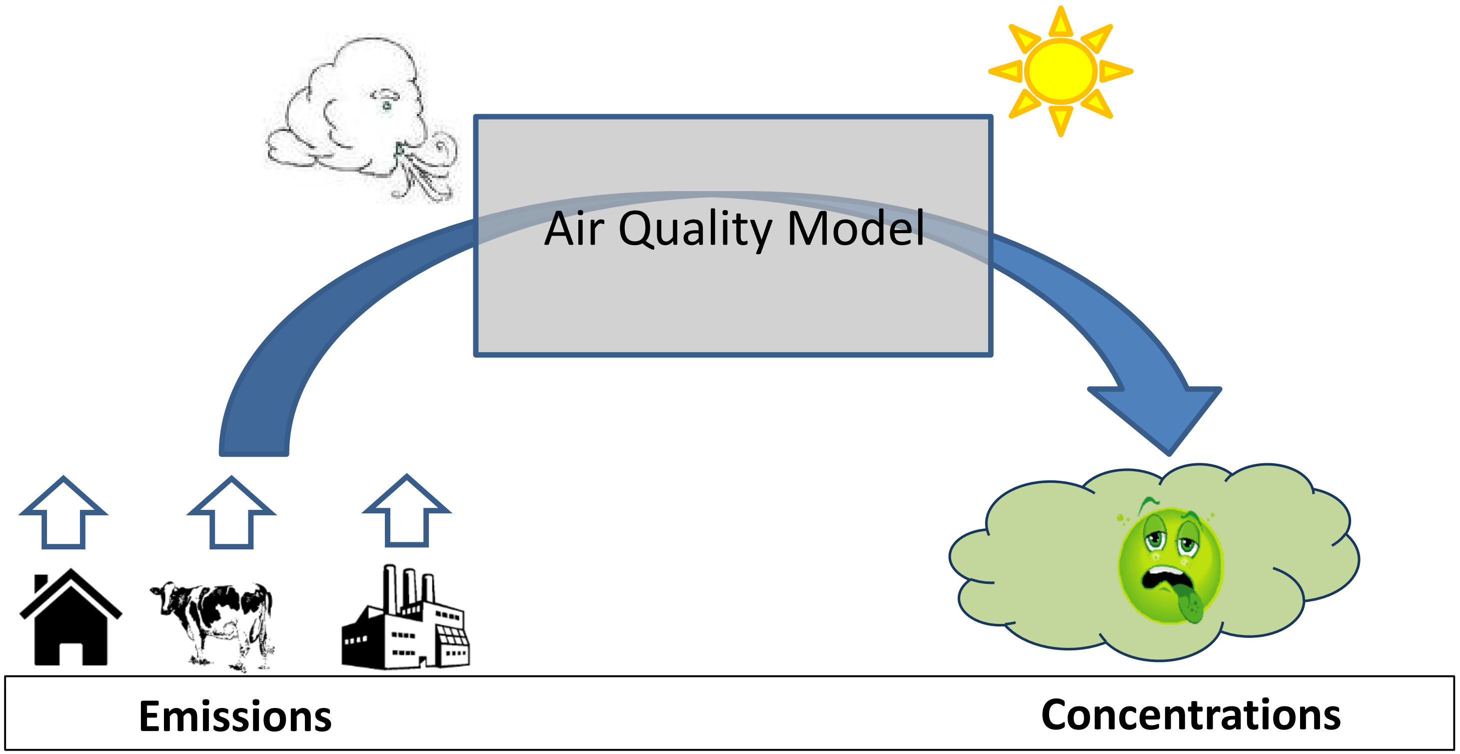
Source Apportionment and Planning: What & when is it fit for purpose?

A. Clappier, D. Pernigotti, C. Belis, P. Thunis

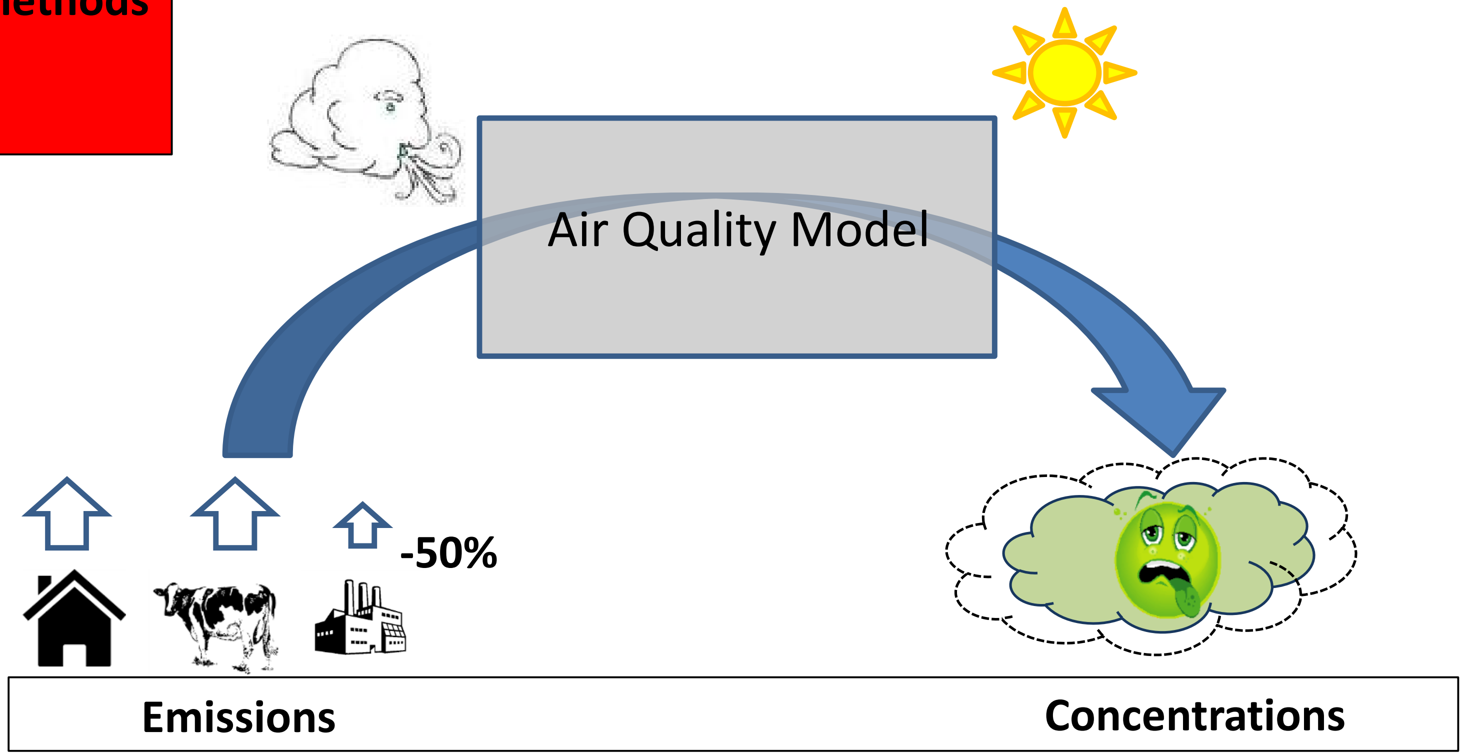
Air Quality Models



Planning

Brut Force methods

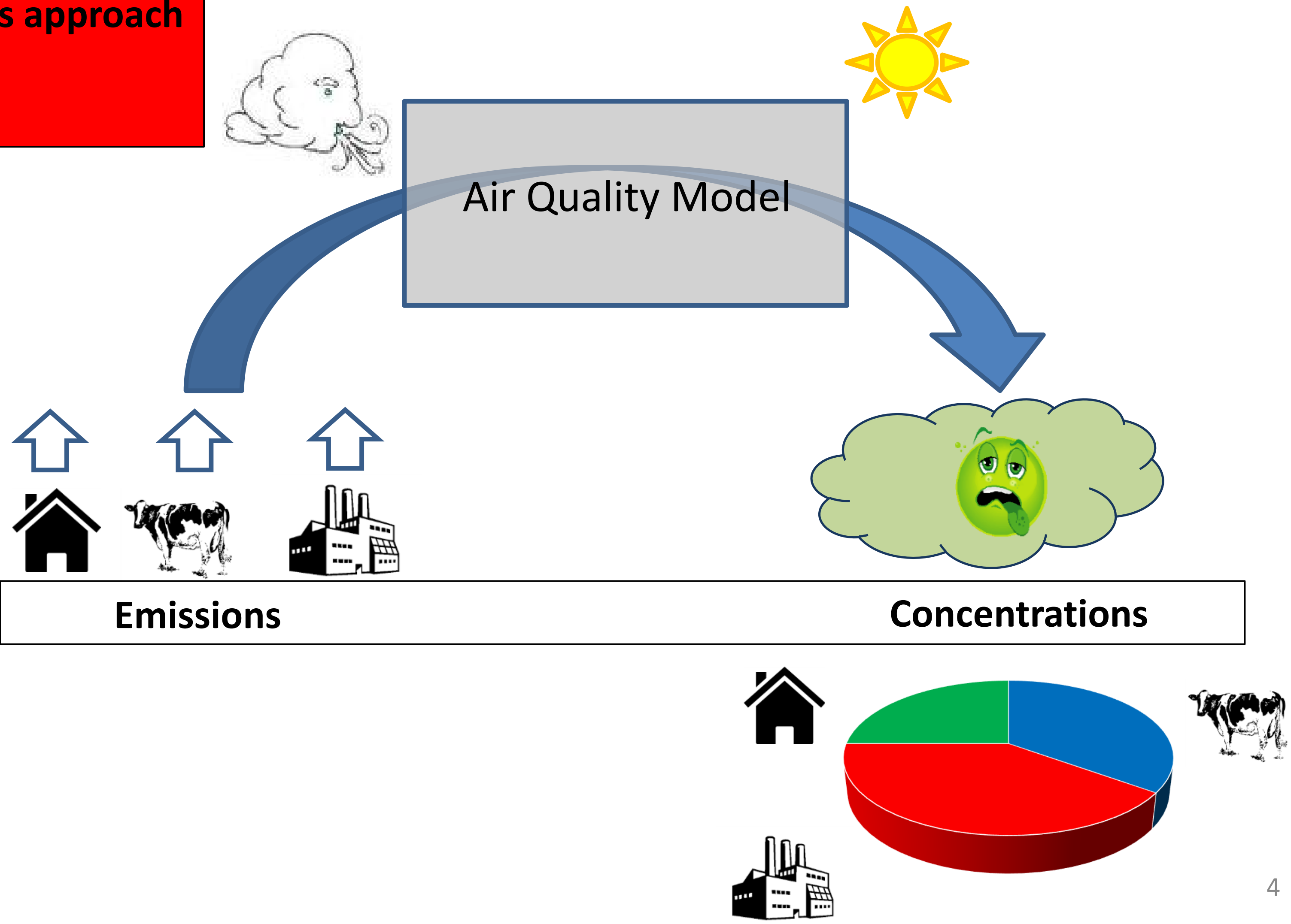
DDM



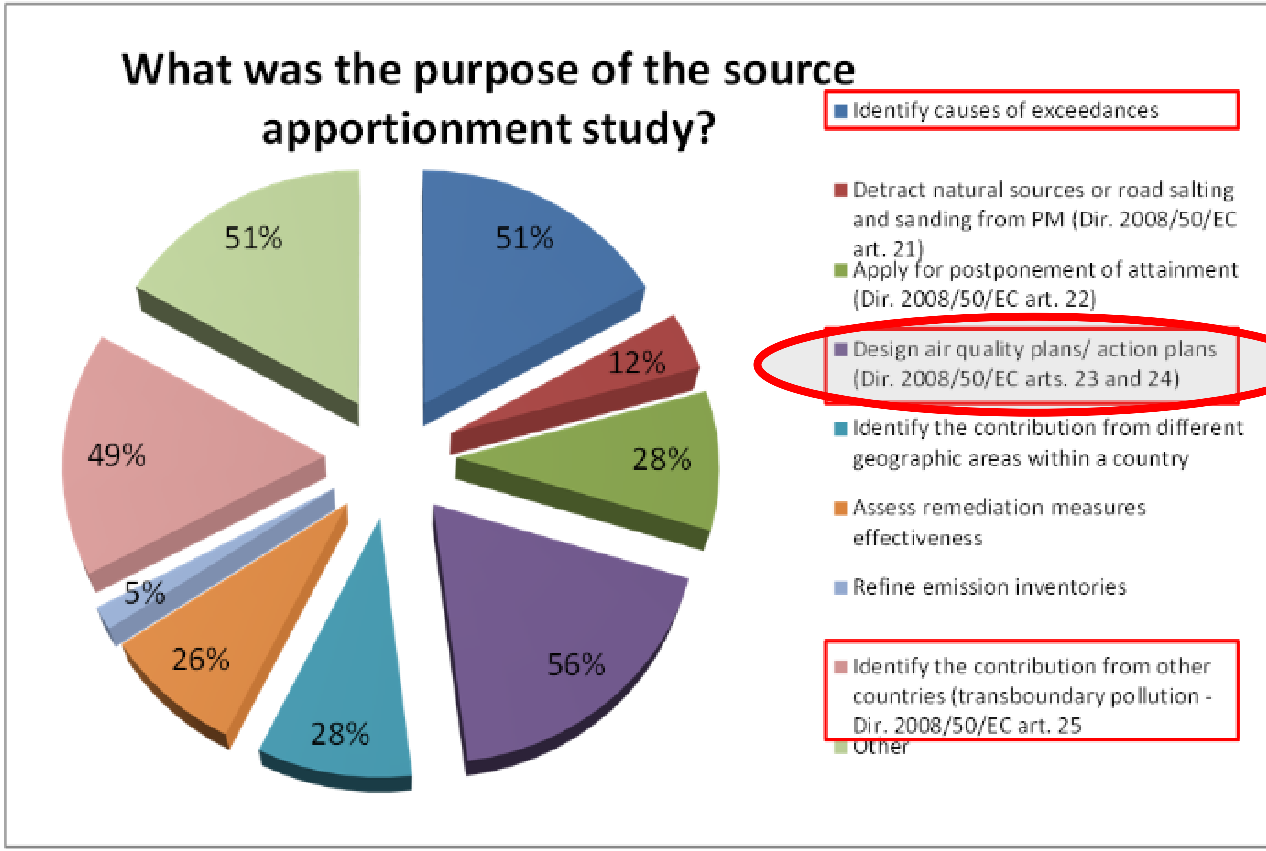
Source apportionment

Tagged species approach

PSAT



Source apportionment in integrated assessment studies



The main reasons are associated to obligations deriving from the AQD:

- to design air quality plans or action plans,
- to identify the causes of exceedances, and
- to identify transboundary pollution

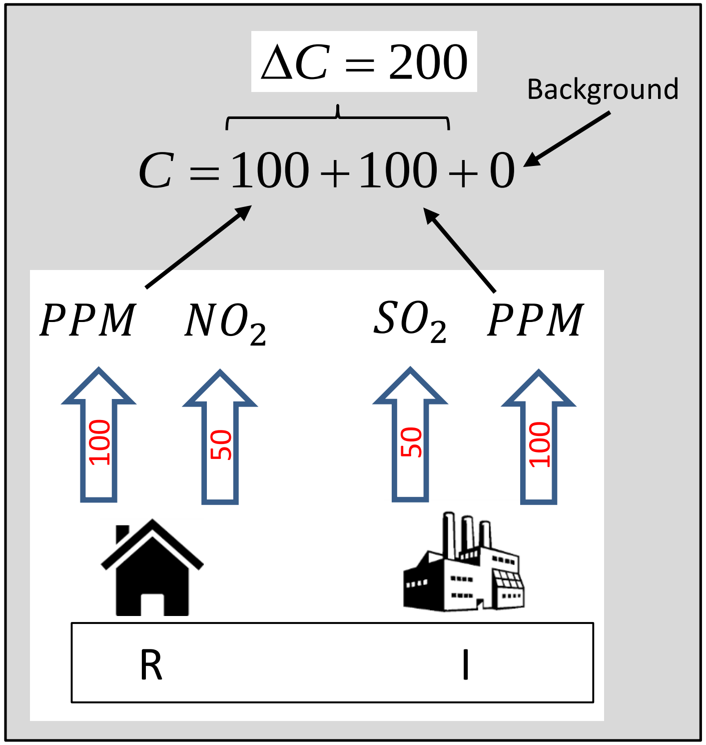
Source: Appraisal deliverable 2.6 - http://www.appraisal-fp7.eu

Appraisal project

Question

Can we use source apportionment to design air quality plans ?

Example: linear case



$$PPM \rightarrow PM[PPM]$$

$$NO_2 + NH_3 \rightarrow PM[NH_4NO_3]$$

$$SO_2 + 2NH_3 \rightarrow PM[(NH_4)_2SO_4]$$

***Source apportionment** estimates **contributions** of the different sources:*

$$\delta C_R = 100$$

$$\delta C_I = 100$$

$$\delta C_R + \delta C_I = 200 = \Delta C$$

***Planning** estimates **impacts** of the different sources:*

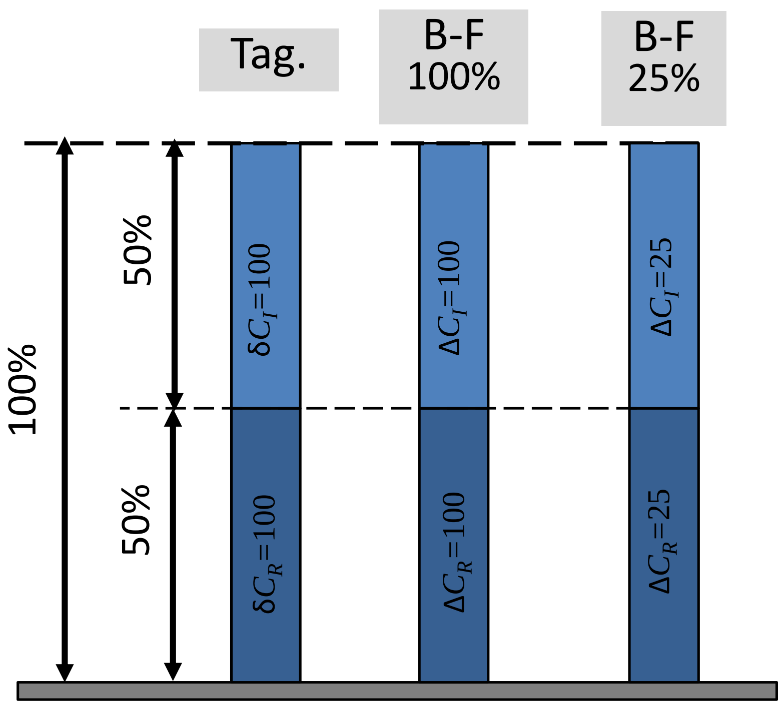
100% reduction:	$\Delta C_R = 100$	$\Delta C_I = 100$	$\Delta C_R + \Delta C_I = 200 = \Delta C$
25% reduction:	$\Delta C_R = 25$	$\Delta C_I = 25$	$\Delta C_R + \Delta C_I = 50 = \Delta C$

Example: linear case

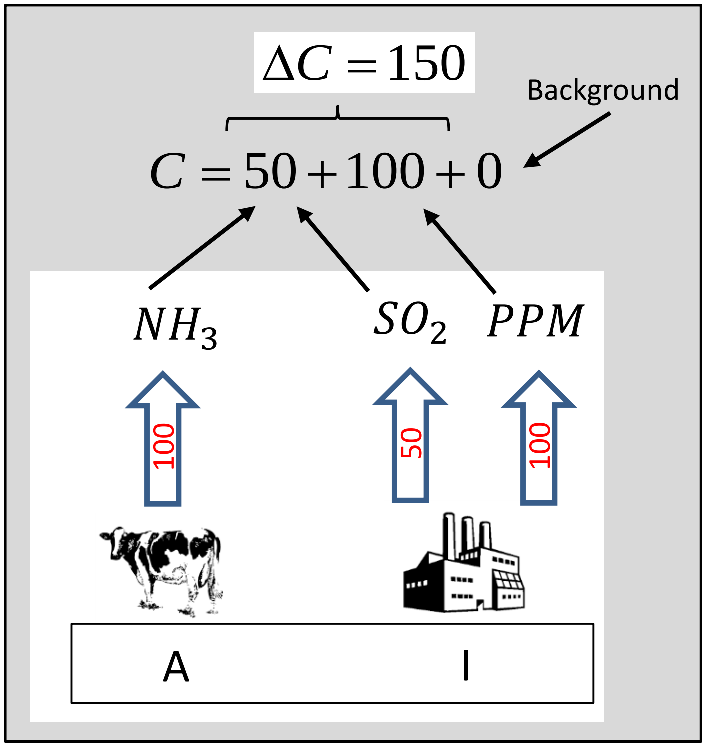
Source apportionment $\Delta C = 200$ $\delta C_R = 100$ $\delta C_I = 100$

Planning 100% red. $\Delta C = 200$ $\Delta C_R = 100$ $\Delta C_I = 100$

Planning 25% red. $\Delta C = 50$ $\Delta C_R = 25$ $\Delta C_I = 25$



Example: non linear case



$$PPM \rightarrow PM[PPM]$$

$$NO_2 + NH_3 \rightarrow PM[NH_4NO_3]$$

$$SO_2 + 2NH_3 \rightarrow PM[(NH_4)_2SO_4]$$

Source apportionment *estimates* ***contributions*** *of the different sources:*

$$\delta C_A = 50 \times (1 - 0.73) = 13.5$$

$$\delta C_I = 50 \times 0.73 + 100 = 136.5$$

$$\delta C_A + \delta C_I = 150 = \Delta C$$

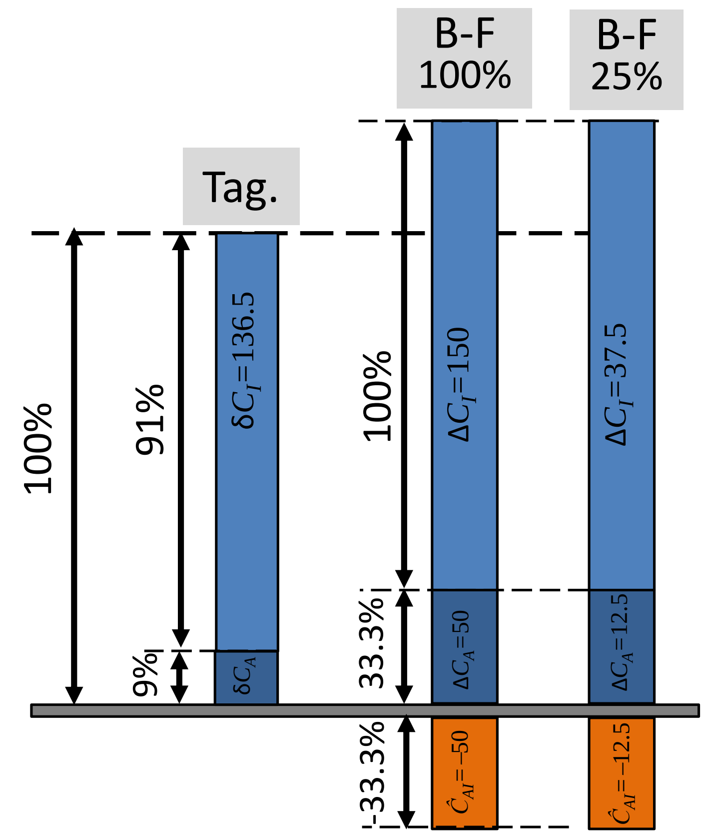
Planning *estimates* ***impacts*** *of the different sources:*

100% reduction: $\Delta C_A = 50$ $\Delta C_I = 150$ $\Delta C_A + \Delta C_I = 200 \neq \Delta C$

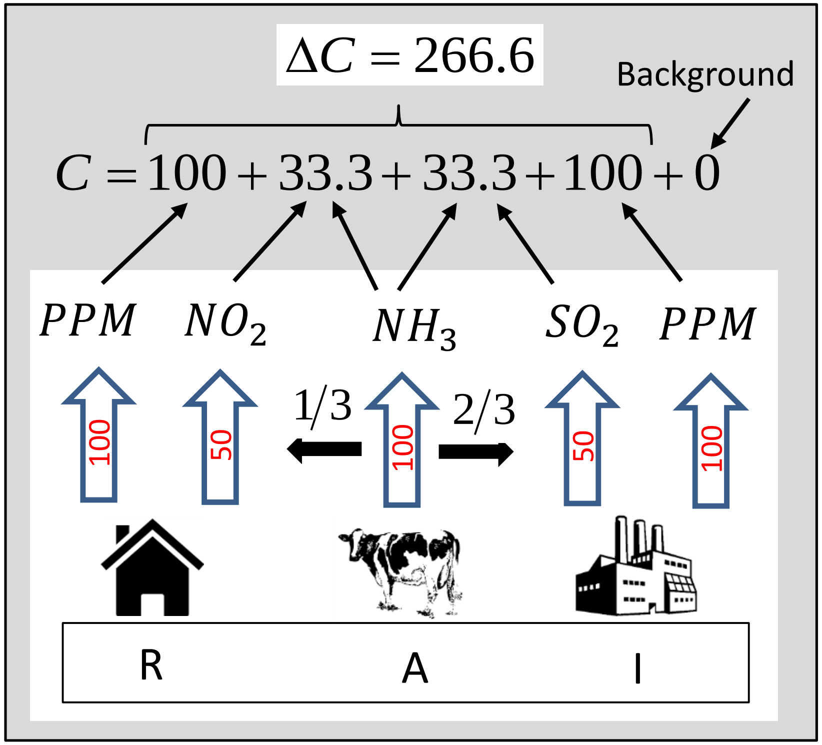
$$\Delta C = \Delta C_A + \Delta C_I + \hat{C}_{AI} \qquad \hat{C}_{AI} = -50$$

Example: non linear case

Source apportionment	$\Delta C = 150$	$\delta C_A = 13.5$	$\delta C_I = 136.5$	
Planning 100% red.	$\Delta C = 150$	$\Delta C_A = 50$	$\Delta C_I = 150$	$\hat{C}_{AI} = -50$
Planning 25% red.	$\Delta C = 37.5$	$\Delta C_A = 12.5$	$\Delta C_I = 37.5$	$\hat{C}_{AI} = -12.5$



Example: non linear case



$$\mathrm{PPM} \rightarrow \mathrm{PM}[\mathrm{PPM}]$$
$$\mathrm{NO_2} + \mathrm{NH_3} \rightarrow \mathrm{PM}[\mathrm{NH_4NO_3}]$$
$$\mathrm{SO_2} + 2\mathrm{NH_3} \rightarrow \mathrm{PM}[(\mathrm{NH_4})_2\mathrm{SO_4}]$$

Source apportionment *estimates* ***contributions*** *of the different sources:*

$$\delta C_R = 100 + 33.3 \times 0.78 = 125.8$$

$$\delta C_A = 33.3 \times (1 - 0.78) + 33.3 \times (1 - 0.73) = 16.6$$

$$\delta C_I = 100 + 33.3 \times 0.73 = 124.2$$

$$\delta C_R + \delta C_I + \delta C_A = \Delta C$$

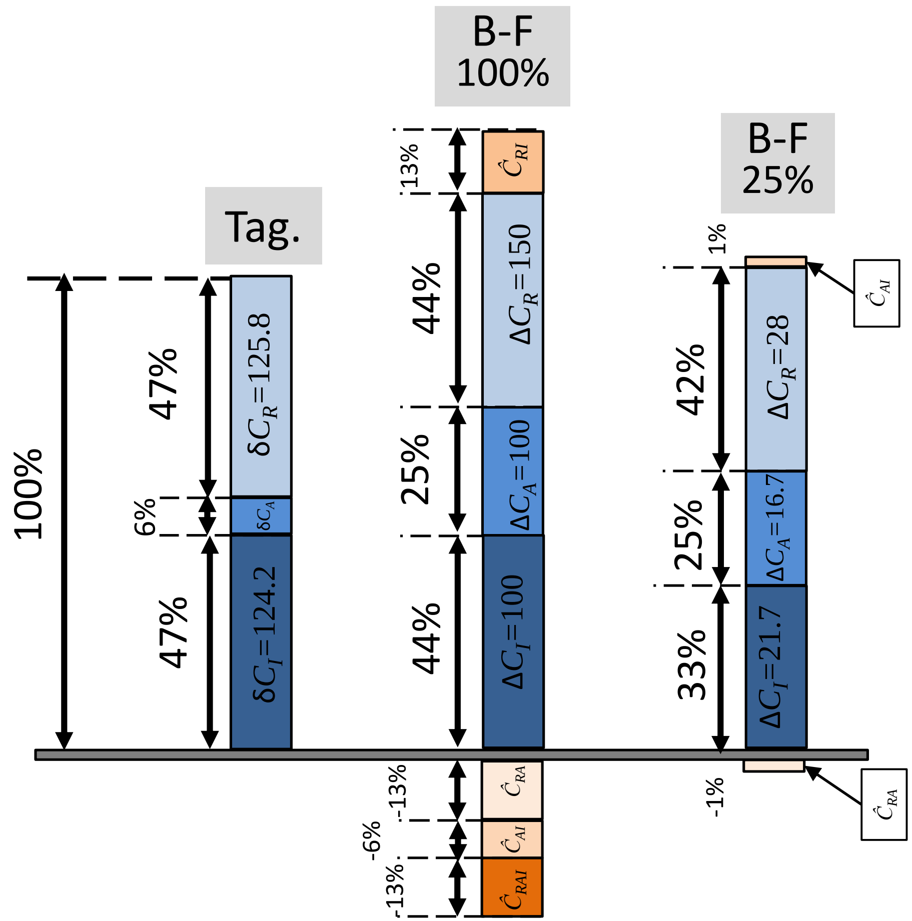
Planning *estimates* ***impacts*** *of the different sources:*

$$\Delta C_R = 116.7 \quad \Delta C_A = 67.6 \quad \Delta C_I = 116.7 \qquad \Delta C_R + \Delta C_A + \Delta C_I = 300 \neq \Delta C$$

$$\Delta C = \Delta C_R + \Delta C_A + \Delta C_I + \hat{C}^{int} \qquad \hat{C}^{int} = -33.3 = \hat{C}_{RA} + \hat{C}_{RI} + \hat{C}_{AI} + \hat{C}_{RAI}$$

Example: non linear case

Source apportionment	$\Delta C = 266.6$	$\delta C_R = 125.8$	$\delta C_A = 16.6$	$\delta C_I = 124.2$
Planning 100% red.	$\Delta C = 266.6$	$\Delta C_R = 116.7$	$\Delta C_A = 67.6$	$\Delta C_I = 116.7$
Planning 25% red.	$\Delta C = 66.7$	$\Delta C_R = 28$	$\Delta C_A = 16.7$	$\Delta C_I = 21.7$



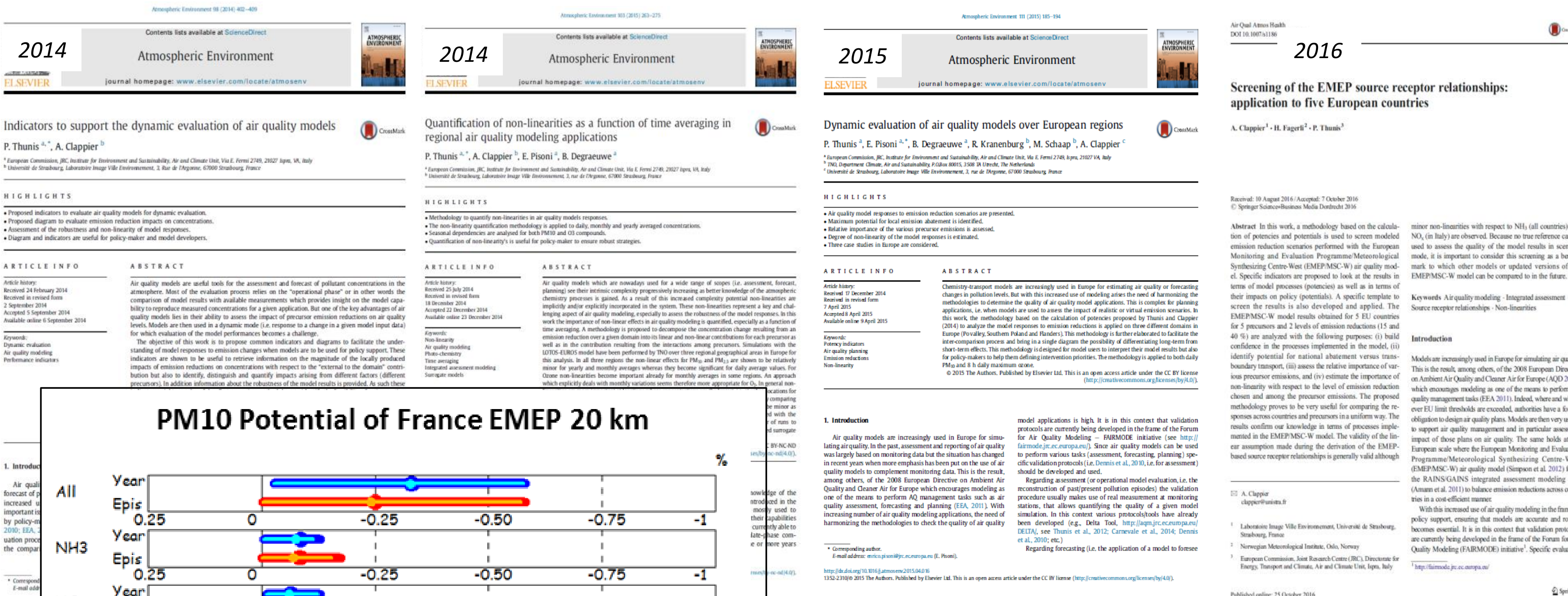
Answer

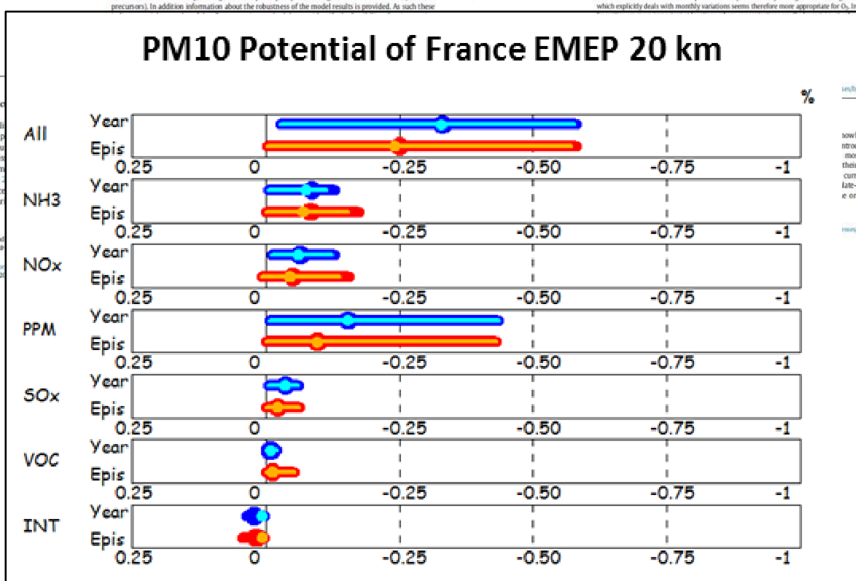
Can we use source apportionment to design air quality plans ?

BUT it must be "close enough" to linearity:

if not…

WG4 recommendation: Indicators





Use the indicators to quantify the non linearity.

WG4 recommendation: Indicators

Non linearity decreases with long time averaging

Non linearity increases with the area size

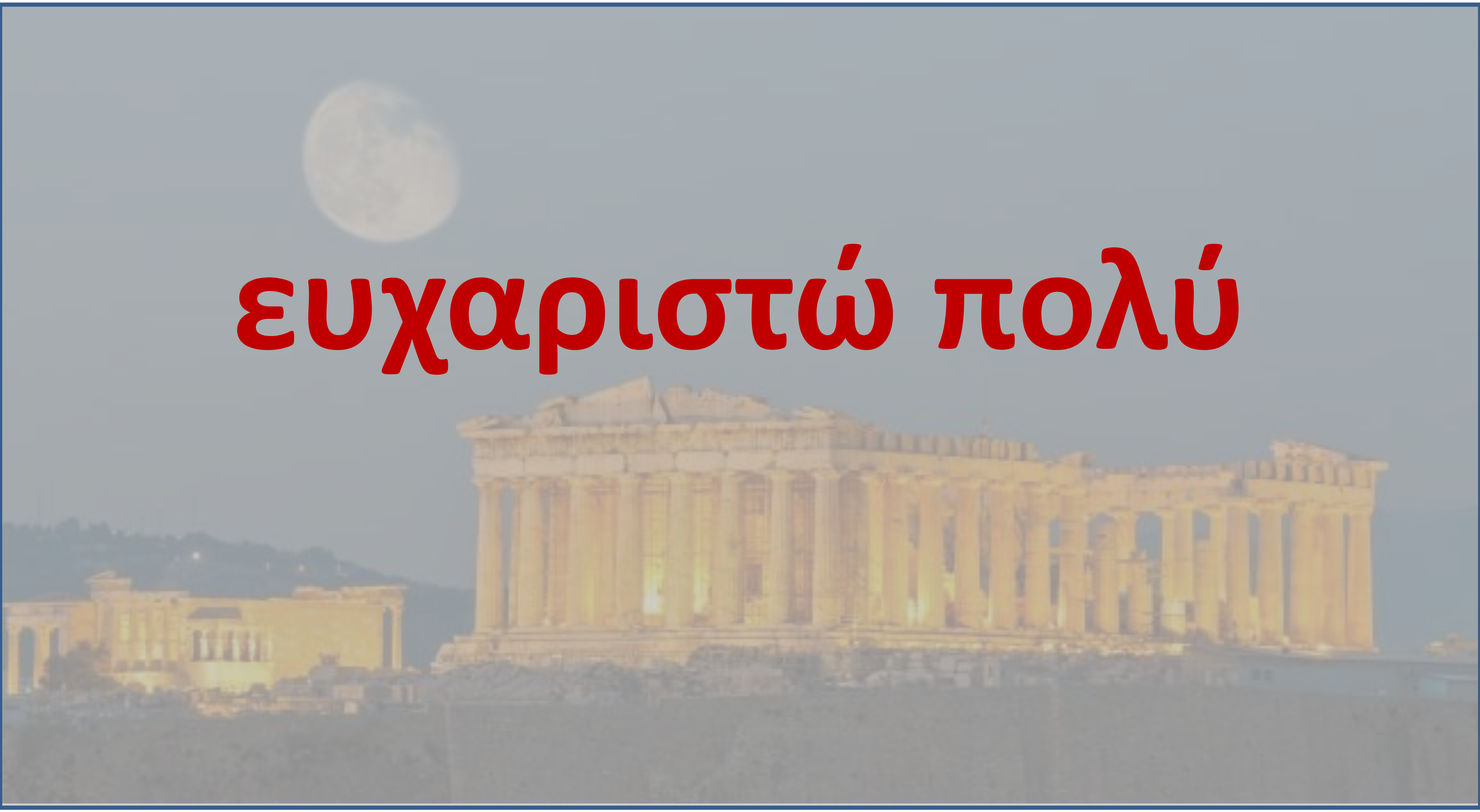
Non linearity is region and precursors dependent

Non linearity increases with the reduction percentage

Conclusion

Can we use source apportionment to design air quality plans ?

BUT **WG4 recommend a linearity check before usage**



ευχαριστώ πολύ