

# Planning Indicators & $\Delta$ tool

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## Introduction

In this note, indicators are proposed for the dynamic evaluation of model results, i.e. for model run in scenario mode (emission reductions). Although dynamic indicators have been already implemented in the planning tool, we here propose a simplified template, directly implemented in the Delta tool. The main objective is to offer a common standardized template to facilitate the screening and comparison of model results.

## Brief overview of the indicators

In the following the concentration fields are intended as grid-cell values, whereas emissions are representative of an area (region, country, city...) over which emission are reduced in the model scenarios. The delta tool contains the three following indicators.

**Absolute potency (P):** The absolute potency is defined as the derivative of the concentration with respect to the emissions (or in other words the speed with which concentrations (C) will change as a result of an emission (E) change). Since instantaneous derivatives are not a model output, derivatives are approximated by their finite difference version, i.e.:

$$P = -\frac{dC}{dE} \approx -\frac{\Delta C}{\Delta E} = -\frac{C_{E_\alpha} - C_{E_{0\%}}}{E_\alpha - E_{0\%}}$$

where  $\alpha$  is the percentage emission reduction. P provides insight on the intensity or strength of the process. P is expressed in  $(\mu\text{g}/\text{m}^3)/(\text{kT}/\text{km}^2)$ . If the relation between concentrations and emissions is linear, P is constant and does not depend on the percentage emission reduction. This indicator is therefore useful to understand the model behavior (e.g. dispersion, chemistry, spatial distribution of the emissions) and compare different models among each other.

**Absolute Potential ( $\Pi$ ):** The absolute potential is defined as the concentration change resulting from an abatement of all the emissions:

$$\Pi = C_{E_{100\%}} - C_{E_{0\%}} \approx \frac{C_{E_\alpha} - C_{E_{0\%}}}{\alpha}$$

$E_{0\%}$  are the emissions reduced of 0%,  $E_{0\%}=E$ .

$E_{\alpha}$  are the emissions reduced of 0%,  $E_{0\%}=E$ ,  $E_{100\%}$  are the emission reduced of 100%,  $E_{100\%}=0$ .

The absolute potential is also related to the absolute potency. Indeed the absolute potency can be written as follow:

$dC = -P.dE$  which can be integrated over the whole range of available emissions:

$$\int_{C_{E_{0\%}}}^{C_{E_{100\%}}} dC = - \int_{E_{100\%}}^{E_{0\%}} P dE = C_{E_{100\%}} - C_{E_{0\%}} = \Pi$$

$\Pi$  is expressed in  $\mu\text{g}/\text{m}^3$  and represents the total emission change one would get when reducing emissions to zero.  $\Pi$  is therefore useful to policymakers but less to model developers since it does not allow distinguishing inconsistencies in potencies from those in emissions. It is however useful as first screening indicator.

**Relative Potential ( $\pi$ ):** The relative potential is defined as the ratio between the absolute potential  $\Pi$  and concentration, i.e.:

$$\pi = \frac{\Pi}{C_{E_{0\%}}} = \frac{C_{E_{100\%}} - C_{E_{0\%}}}{C_{E_{0\%}}} \approx \frac{C_{E_{\alpha}} - C_{E_{0\%}}}{\alpha C_{E_{0\%}}}$$

$\pi$  provides complementary information to  $\Pi$ .

In the table below we illustrate the complementary character of the three indicators with simple fictitious numbers. Each indicator provides a specific information and it is important to look at all three of them. We assume that 100% of the available emissions are reduced to calculate the potencies and potentials, i.e.  $\Delta E = E$ .

REF	C	$\Delta C$	E	Absolute Potency	Absolute Potential	Relative Potential
1	100	-10	50	0.2	10	0.1
2	100	-10	10	1	10	0.1
3	20	-10	50	0.2	10	0.5

Case 1 is the reference. We see the following:

- A high absolute potency can result in small potentials if the amount of available emissions is limited (case 2), and vice versa.
- A high relative potential does not imply a high absolute potential (case 3) and vice versa.

## Implementation in the delta tool

**Preparation of datasets and naming convention:** For each emission scenarios, the model results must be processed in a similar way to the base case (i.e. use of the same startup.ini file to create the netcdf files). For the scenarios, the base case naming convention: “year\_modelName\_Time.cdf” (e.g. 2012\_CHIM\_Time.cdf) must be changed to the following “POL%%\_modelName\_Time.cdf” (e.g. NOx25\_CHIM\_time.cdf) where the three first letters (POL) are used to name the pollutant/sector reduced (e.g. NOx, TRA, RES...) and the two next positions (%%) are used to specify the percentage of reduction (from 01 to 99). A maximum of 5 POL can be used with for each of them up to 2 reduction percentages. Measurements can be prepared but DO NOT need to be present since only model results can be used in this analysis.

**Scenarios and emission reduction levels:** A maximum of 5 different scenarios (e.g. NOx, VOC, TRA...) can be managed by Delta, with for each up to two emission reduction levels (e.g. 15 and 30%). A specific scenario in which all sectors/pollutants analyzed are reduced contemporarily can also be included (naming: POL=“ALL”). If the “ALL” scenario is used, it is important that it is calculated with a reduction that is similar to the one used for all the individual scenarios (e.g. NOx, VOC). This “ALL” scenario can be produced for two different level of emission reduction percentages.

**Configuration files:** In the init.ini file (resource directory), comment the line “standard user” and uncomment the “advanced user” line.

**Data Selection widget:** Tick the boxes “MOD without OBS” and “all available scenarios” to see all scenarios and allow the results to be produced for any stations regardless measurement availability. Any number of scenarios can be selected but the base case is always requested. If shown available in the list, the “ALL” scenario cannot be used for absolute potency. The user should unselect it if shown marked.

**Analysis widget:** Select the Diagram “dynamic evaluation”. Among the six available options, three refer to the three indicators described above: absolute potency, absolute potential and relative potential. For the absolute potency option, the user needs to introduce emissions (in the threshold field). The number of values to introduce corresponds to the number of pollutants reduced. The numbers should be introduced in alphabetical order and in T/km<sup>2</sup>. If we take the example of Belgium with a total NOx emitted of 300kT for an area of 30000 km<sup>2</sup>, this would lead to a value of 10 to be entered for NOx.

**Group/single observation mode:** For potentials (both absolute and relative) it is possible to select group of stations. It is not possible to mix single stations and groups in the same diagram. For the absolute potency, no group can be selected.

**Threshold values for the absolute potency:** If the user changes the number of pollutant scenarios in the data selection widget, emission values should be introduced again in the analysis widget before execution of the diagram. The number of threshold values (emission densities) should indeed be consistent with the number of pollutants reduced.

## Examples

We provide here one example for each indicator previously described. Finally one example with groups of stations is also included.

### **Absolute potency (Figure 1)**

An absolute potency is calculated for the annual average concentration for each selected station and for each precursor. These are represented by the (dark and light) blue bars which extension ranges from the minimum potency value (among the available stations) to the maximum value. The circle represents the average value. Potencies are calculated for two reduction levels (if available) which are overlaid on the diagram. Differences between the dark and light blue lines indicate the level of non-linearity.

A similar potency calculation is performed on the 95<sup>th</sup> percentile (orange and red lines). For each station, only a subset of concentration values (the 5% highest concentration days/hours) is used for the calculations.

Note that the unit is ng/m<sup>3</sup> per kt/km<sup>2</sup> for convenience. The abscissa should then be divided by 1000 to get back to the usual ug/m<sup>3</sup> units.

### **Absolute and relative potential (Figure 2)**

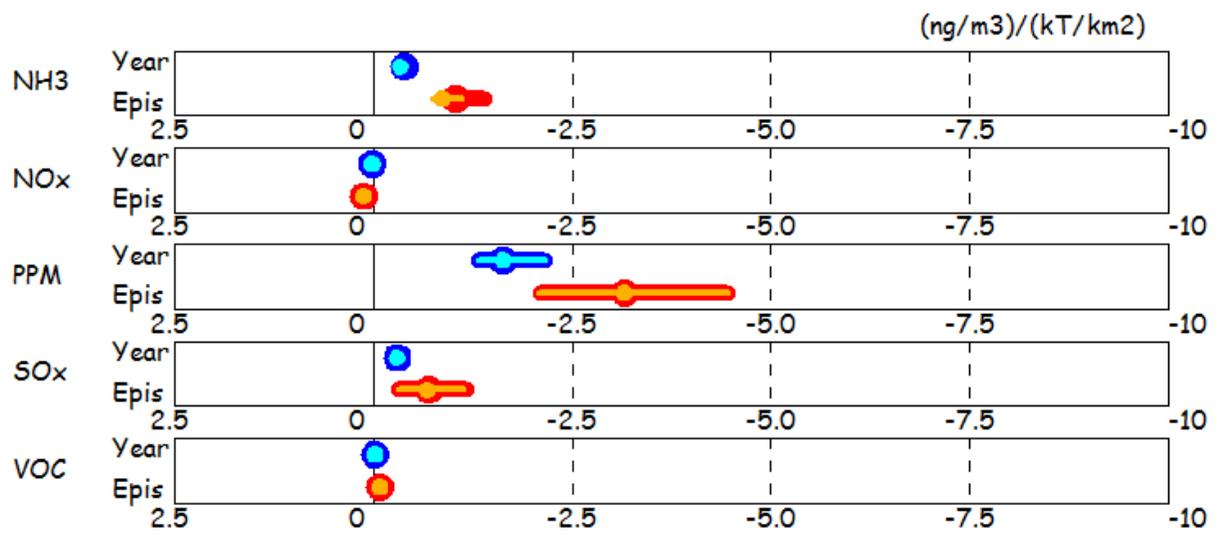
Similar calculations are performed for the potentials (absolute and relative). In the case of potentials, however, it is possible to include an “ALL” scenario, i.e. one where all analysed precursors are reduced contemporarily. A new line of analysis “INT” will then automatically be created. It represents the non-linear interaction, i.e. the difference between the “ALL” scenario response and the sum of all individual scenario responses. In the case shown, it would be:

ALL: Scenario in which NO<sub>x</sub>, SO<sub>2</sub>, VOC, PPM and NH<sub>3</sub> emissions are all reduced by a percentage reduction, similar for all precursors. “INT” is then calculated as:

$$\Delta C_{INT} = \Delta C_{ALL} - \{ \Delta C_{IPPM} + \Delta C_{SO2} + \Delta C_{NH3} + \Delta C_{VOC} + \Delta C_{NOx} \}$$

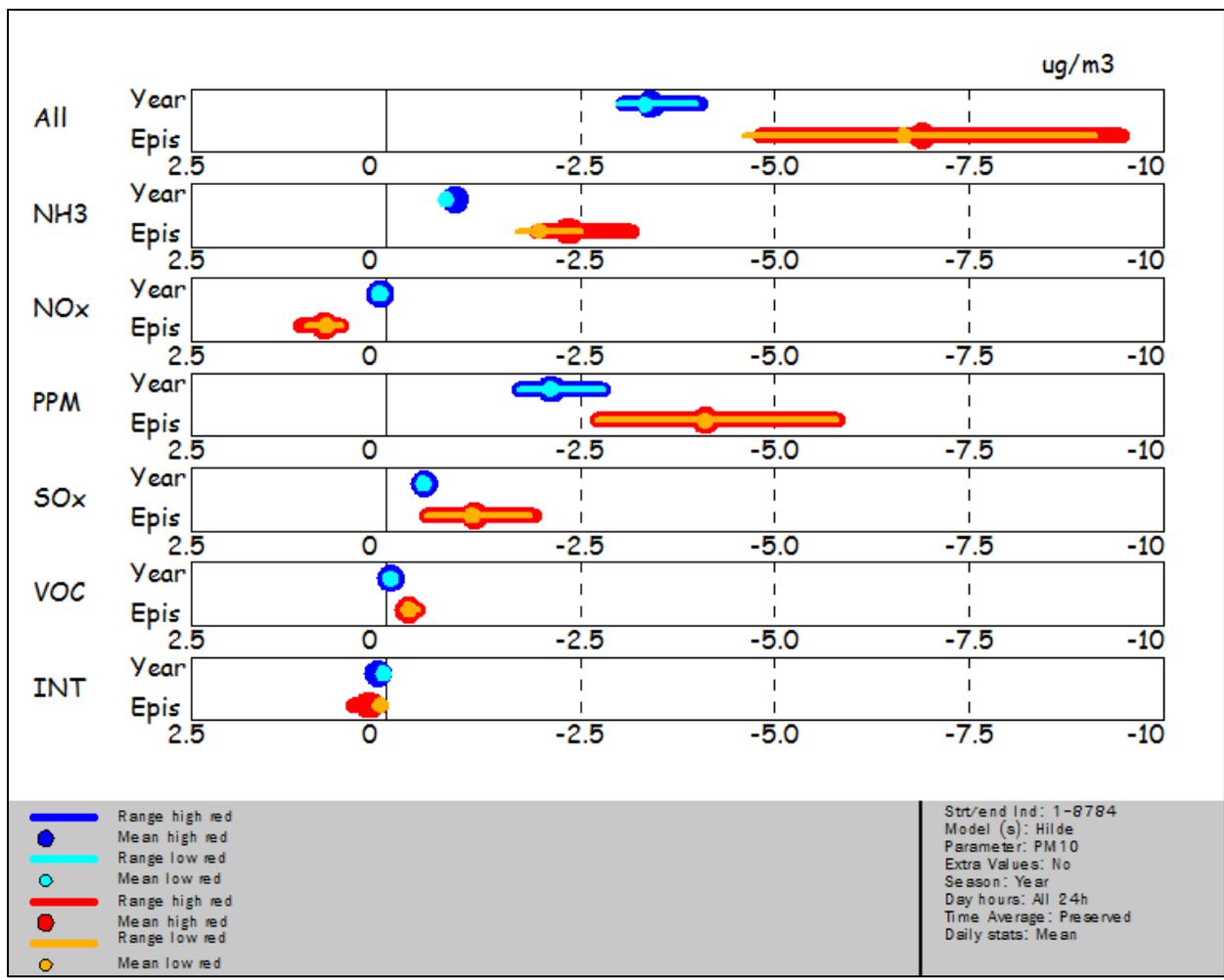
### **Group mode for potentials (Figure 3)**

In this configuration, only the average group potentials will be shown (not the line joining the minimum and maximum value) for display reasons



<ul style="list-style-type: none"> <li><span style="color: blue;">—</span> Range high red</li> <li><span style="color: blue;">●</span> Mean high red</li> <li><span style="color: cyan;">—</span> Range low red</li> <li><span style="color: cyan;">●</span> Mean low red</li> <li><span style="color: red;">—</span> Range high red</li> <li><span style="color: red;">●</span> Mean high red</li> <li><span style="color: orange;">—</span> Range low red</li> <li><span style="color: orange;">●</span> Mean low red</li> </ul>	<p>Str/end Ind: 1-8784          Model (s): Hilde          Parameter: PM10          Extra Values: 2.2/6.5/1.3/1.6/3.4          Season: Year          Day hours: All 24h          Time Average: Preserved          Daily stats: Mean</p>
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Figure 1: Absolute potencies for PM10



**Figure 2: Absolute potentials for PM10**

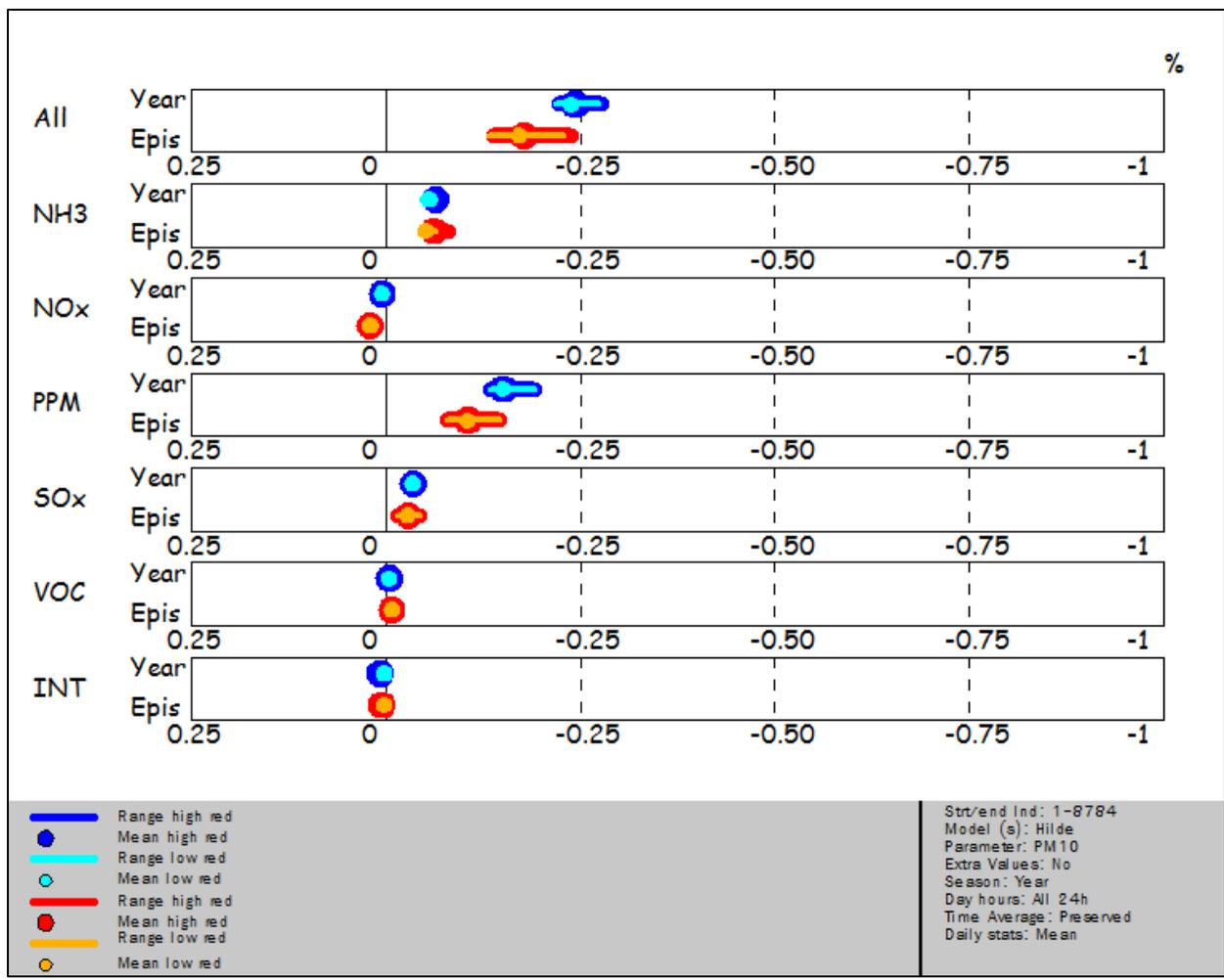


Figure 3: Relative potentials for PM10

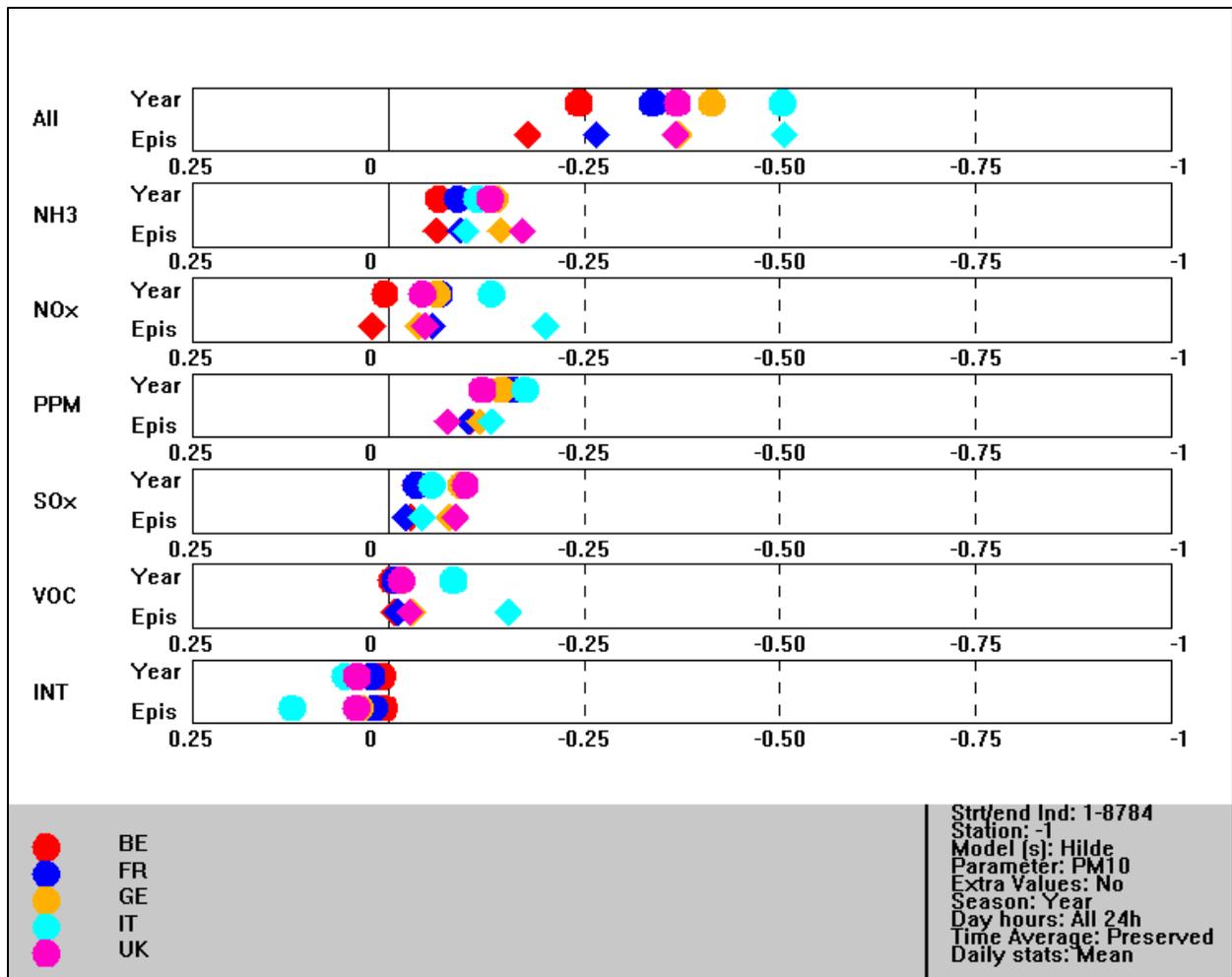


Figure 4: Relative potential (group mode) for PM10