Annex B

Description of the TM5-FASST model

TM5-FASST is a global air quality source-receptor model (AQ-SRM), developed by the European Commission's Joint Research Centre in order to address the need for swift and easy evaluation of global and regional air pollution emission scenarios and their impacts on human health and ecosystems. In general, AQ-SRMs link emissions of pollutants in a given source region with downwind impacts, using knowledge of meteorology and atmospheric chemical and physical processes which transform the emitted pollutant precursors. The source region is any point or area from which emissions are considered; the receptor is any point or area at which the pollutant concentration and impact is to be evaluated. An AQ-SRM will then include a functional relation between each emitted precursor and each end product for each source region and each receptor region.

The TM5-FASST model is a reduced-form SRM: the relation between the emissions of compound i from source x and resulting pollutant j concentration (where $j = i$ in case of a primary component) at receptor y is expressed by a simple functional relation, which mimics the underlying meteorological and chemical processes. In the current version of TM5-FASST, the function is a simple linear relation:

$$C_{ij}(x,y) = C_j^0(y) + A_{ij}(x,y) \cdot E_i(x)$$

where $C_{ij}(x, y)$ is the concentration of species j at receptor y formed from precursor i emitted at source x, $E_i(x)$ is the emission rate (kg/yr) of precursor i at source x, $A_{ij}(x, y)$ is the so-called source-receptor coefficient (SRC) between source location x and receptor location y for emitted precursor i leading to end product j, and $C_j^0(y)$ is a constant for pollutant j and location y.

The SRCs have been derived from a set of runs with the full chemical transport model TM5-CTM (Krol et al., 2005) by applying emission perturbations for each of a defined set of source regions and precursor components. TM5-CTM explicitly solves the mass balance equations of the species using detailed meteorological fields and sophisticated physical and chemical process schemes. TM5-CTM covers the global domain with a resolution of 1°×1°. More in particular, the applied procedure to calculate the SRCs was based on 56 source regions covering the global continents.

A base run with a reference global emission dataset for all relevant pollutants and pollutants precursors for the year 2000 was performed, including SO_2, NO_x, BC, OC, NMVOC, and NH_3. This run is based on the IPCC AR5 RCP reference scenario for the year 2000 (Van Vuuren et al., 2012). The base run produces the resulting base concentrations of all relevant pollutants at a global 1°×1° resolution.

A series of perturbation runs was performed, where sequentially in each of the defined 56 source regions, the emission of each of the pollutant precursors was reduced over the entire source region by 20% relative to the base run, and the resulting concentration of all affected pollutant species was calculated, in the same way as it was done for the base run. Hence, in principle, the number of perturbation runs is 56×n, with n the number of emitted compounds considered to be relevant. In practice, in order to reduce the number of runs, some non-interacting compounds were grouped into one perturbation simulation. For CO which is a longer-lived species perturbations were made at the aggregation level of continents. For CH_4 a single global perturbation run with TM5-CTM from the HTAP1 modelling experiment was used to evaluate the response on background ozone per kg emitted CH_4 (Fiore et al., 2009). The difference between the concentration field for a specific compound from each perturbation run and the base run is a global 360×180 concentration field (1°×1° resolution), the so-called delta-field.

For each receptor point (each grid cell), the resulting delta concentration between base and perturbation run, leads to the calculation of a unique SRC, expressing the concentration response in each grid cell upon an emission change in source region x as in the following equation, where $\Delta E_i(x) = 0.2 \times E_i^0(x)$ with $E_i^0(x)$ the base run emission.

$$A_{ij}\left(x,y\right)=\frac{\Delta C_j\left(y\right)}{\Delta E_i\left(x\right)}$$

Hence, the total concentration of component *j* in receptor region *y*, resulting from arbitrary emissions of all its precursors *i* at all source regions *x* is obtained by scaling the respective SRCs with the actual emission changes:

$$C_{ij}\left(x,y\right)=C_j^0\left(y\right)+\sum_x\sum_i A_{ij}\left(x,y\right)\left[E_i\left(x\right)-E_i^0\left(x\right)\right]$$

For example, in the case of *j*=ozone, the *i* precursors would comprise NO_x, NMVOC, CO and CH_4. An overview of all considered precursor-pollutant combinations is given in Table B.1. This set of linear equations for all components and all source and receptor regions emulates the full-fledged TM5-CTM, and constitutes the "kernel" of TM5-FASST.

Table B.1. **Relevant emitted precursor-pollutant pairs in TM5-FASST**

Pollutant → / Precursor ↓	SO_2 gas	NO_x gas	NH_3 gas	O_3 gas	CH_4 gas	SO_4 PM	NO_3 PM	NH_4 PM	BC PM	POM PM	SO_x dep	NOY dep	BC dep
SO_2 (g)	xxx	x	xx	x	x	xxx	xx	xx			xxx		
NO_x (g)	x	xxx	xx	xxx	xx	xx	xxx	xx			x	xxx	
NH_3 (g)	x	x	xxx	x	x	xx	xx	xxx			x		
BC (g)									xxx				xxx
POM (g)										xxx			
NMVOC (g)	x	x	x	xxx	xx	x	x	x			x		
CO (g)				xxx	xx								
CH_4 (g)	x	x	x	xxx	xxx	x	x	x			x		

Note: The number of x's gives a qualitative indication of the most influential precursors (xxx: highest influence). Influences indicated by a single x are due to feedback mechanisms affecting the level of oxidants, and hence the lifetime of hydroxyl radical (OH), in the atmosphere, which in turn affects the oxidation rate of the precursors. The (g) refers to gaseous component; PM = particulate matter; dep = deposited component. POM = polycyclic organic matter; NO_Y: fixed nitrogen.

Source: TM5-FASST model.

The resulting global concentration maps for different emission scenarios obtained by applying the source-receptor coefficients provide the required information to further assess the impact of emissions changes in terms of effects on human health, vegetation and ecosystems in general.

A full description of the TM5-FASST model methodology and validation against the full TM5 model is given by Van Dingenen and Dentener (forthcoming).

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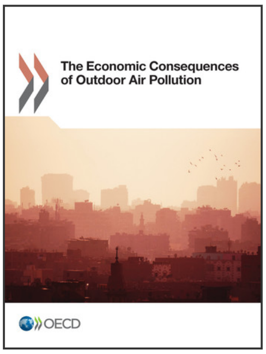

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