Pollutants and non-GHG forcing agents - IMAGE

Air pollution emission sources included in IMAGE are listed in the table below. In approach and spatial detail, gaseous emissions are represented in IMAGE in four ways:

World number (W). The simplest way to estimate emissions in IMAGE is to use global estimates from the literature. This approach is used for natural sources that cannot be modelled explicitly.

Emission factor (EF). Past and future developments in anthropogenic emissions are estimated on the basis of projected changes in activity and emissions per unit of activity. The equation for this emission factor approach is:

$$\text{Emission} = \text{Activity}_{r,i} * \text{EF-base}_{r,i} * \text{AF}_{r,i}$$

where Emission is the emission of the specific gas or aerosol; Activity is the energy input or agricultural activity; r is the index for region; i is the index for further specification (sector, energy carrier); EF-base is the emission factor in the baseline; and AF is the abatement factor (reduction in the baseline emission factor as a result of climate policy). The emission factors are time-dependent, representing changes in technology and air pollution control and climate mitigation policies. The emission factor is used to calculate energy and industry emissions, and agriculture, waste and land-use related emissions. Following the equation, there is a direct relationship between level of economic activity and emission level. Shifts in economic activity (e.g., use of natural gas instead of coal) may influence total emissions. Finally, emissions can change as a result of changes in emission factors (EF) and climate policy (AF).

Gridded emission factor with spatial distribution (GEF) is a special case of the EF method, where the activity is grid-specific, resulting in grid-specific emissions. This is done for a number of sources, such as emissions from livestock.

Gridded model (GM). Land-use related emissions of NH3, N2O and NO are calculated with grid-specific models. The models included in IMAGE are simple regression models that generate an emission factor. For comparison with other models, IMAGE also includes the N2O methodology generally proposed by IPCC (IPCC, 2006).

Table 5.1: Atmospheric emissions calculated in IMAGE, by source and by method applied (from the IMAGE 3.0 documentation)

Source	Activity	CO_2	CH_4	N_2O	SO_2	NO_x	CO	NMVOC	F-gases	BC	OC	NH_3
a). Energy-related												
End-use energy use (industry, transport, residential, services and other)	Energy consumption rates	EF	EF	EF	EF	EF	EF	EF		EF	EF	
Energy sector (production of power, hydrogen, coal, oil, gas, bioenergy)	Energy production rates	EF	EF	EF	EF	EF	EF	EF		EF	EF	
Energy transport	Energy transport rates		EF									
Other energy conversion	Energy conversion rates	EF	EF	EF	EF	EF	EF	EF		EF		
b). Industry-related												
Emissions from industrial process	Industry value added (IVA)	EF	EF	EF	EF	EF	EF	EF	EF	EF		
Cement and Steel	Regional production	EF										
c). Agriculture-, waste- and land-use related												
Enteric fermentation, cattle	Feed type and amount		GM[a]									
Animal waste, all animal categories	Number of animals		GEF	GEF		GEF						GEF[b]
Landfills	Population		GEF									
Deforestation	Carbon burnt	GM	GEF	GEF	GEF	GEF	GEF	GEF		GEF	GEF	GEF
Agricultural waste burning	Carbon burnt	GM	GEF	GEF	GEF	GEF	GEF	GEF		GEF	GEF	GEF
Traditional biomass burning	Carbon burnt	GM	GEF	GEF	GEF	GEF	GEF	GEF		GEF	GEF	GEF
Savannah burning	Carbon burnt	GM	GEF	GEF	GEF	GEF	GEF	GEF		GEF	GEF	GEF
Domestic sewage treatment	Population, GDP		GEF	GEF								
Wetland rice fields	Area wetland rice		GEF									
Crops	N fertiliser and manure input, croptype			GM		GM						GM
Managed grassland	N fertiliser and manure input			GM		GM						GM

indirect emissions	N crops, fertiliser and manure input			GM								
Land-use change	Clearing forest areas			GM								
d). Natural sources												
Soils under natural vegetation	Net primary production			GM		GM						GEF
Natural vegetation	N/A							W	W			
Wildfires	N/A	W						W				
Oceans	N/A	W	W					W				W
Natural wetlands	N/A	W										
Termites	N/A	W										
Wild animals	N/A	W										
Methane hydrates	N/A	W										
Volcanoes	N/A	W			W							
Lightning	N/A			W		W						

Activity describes the activity level to which the emission factor is applied, or, if only GM method occurs, the main determinant for the gridded model.

Methods: W = Global emission; EF = Regional emission factor applied to the specified activity level; GEF = Grid-specific emission calculated from gridded activity level and (regional) emission factor; GM = Gridded, model-based emission (statistical or process-based model).

[a] *GM for dairy and non-dairy cattle, EF for other animal categories.*

[b] *EF for NH_3 emissions from animal houses, manure storage and grazing livestock; GM for NH_3 emissions from manure spreading.*

A brief overview is presented here, for more information see the IMAGE 3.0 web page.