Supplement to 'EMPOL 1.0: A new parameterization of pollen emission in numerical weather prediction models'

EMPOL is an integral part of the NWP model system COSMO-ART. It is written in Fortran. The NWP model system is distributed in two parts: COSMO can be obtained from the German Weather Service (DWD). The ART part (containing EMPOL) can be obtained from the Institute for Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT), Dr. Bernhard Vogel.

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Table 1 gives an overview about the necessary input and model fields that have to be provided when implementing the emission parameterization EMPOL into a different NWP model system.

Table 2 gives an overview about the differences of the emission parameterizations described in the publication.

The different steps of the pollen emission parameterization EMPOL are displayed in Figure 1.

Table 1: Parameters and their units used in the emission parameterization EMPOL. The third column indicates the role of the parameters: 'I' - parameter provided as input field, 'M' - parameter taken from the NWP model (at best from the model level that corresponds to the emission height), 'T' - tuning parameter, 'C' - parameter calculated within EMPOL.

Parameter	Unit	Info	Description
$Q_{pollen,day}$	m^{-2}	T	total amount of pollen that can be released per day under perfect conditions
$Q_{pollen,\Delta t}$	m^{-2}	T	amount of pollen that can be released per time step under perfect conditions
R_{pollen}	m^{-2}	C	content of the pollen reservoir, current time step
$R_{pollen,old}$	m^{-2}	C	content of the pollen reservoir, previous time step
$R_{pollen,sum}$	m^{-2}	C	total amount of released pollen since midnight
ΔR_{pollen}	m^{-2}	C	pollen released during the current time step
$F_{E,pollen}$	$m^{-2}\ s^{-1}$	C	emission flux of pollen grains
C_{pollen}	m^{-3}	C	pollen concentration
Ψ_{random}	-	T	loss of pollen from the reservoir due to random processes
Ψ_{precip}	-	T	loss of pollen from the reservoir due to precipitation
Φ_{plant}	-	C	plant-dependent influences on pollen emission
Φ_{met}	-	C	meteorological influences on pollen emission
Φ_{biol}	-	C	biological influences on pollen emission
$f_{R,T}$	-	T	fraction of open flowers as a function of temperature
$f_{R,RH}$	-	T	fraction of open flowers as a function of relative humidity
$f_{E,TKE}$	-	T	fraction of emitted pollen as a function of turbulent kinetic energy
$f_{E,RH}$	-	T	fraction of emitted pollen as a function of relative humidity
$f_{Q,cov}$	-	I	fraction of the grid box covered with the specific plant
$f_{Q,seas}$	-	I	mathematical description of the course of the pollen season
$f_{Q,alt}$	-	I	productiviy of the plants as a function of altitude
T	K	M	temperature at the lowest model level
rh	%	M	relative humidity at the lowest model level
TKE	$m^2\ s^{-2}$	M	turbulent kinetic energy at the lowest model level
Δt	s	M	time step of the simulation
p	$kg\, m^{-2}\ s^{-1}$	M	sum of convective and grid-scale precipitation

Table 2: Differences between the four parameterizations of pollen emission (see text) that are mentioned in the publication.

Feature	H_{orig}	H_{opt}	S13	EMPOL
Description of the pollen season	Invariable formulation: the pollen season has the shape of a parabola and a fixed length of 30 days.	Use of an external model that describes start, end and course of the pollen season as functions of temperature sums.	Start and course of the pollen season are variable and depend on temperature sums. The end of the season is determined via a pollen reservoir.	Use of an external model that describes start, end and course of the pollen season as functions of temperature sums.
Influence of meteorological parameters on pollen release and entrainment of the pollen into the atmosphere	Pollen release and entrainment are combined: - friction velocity - wind speed - temperature - relative humidity	Pollen release and entrainment are combined: - friction velocity - wind speed - temperature - relative humidity	Pollen release and entrainment are combined: - 10 m wind speed - convective velocity scale - relative humidity - precipitation	Pollen release and pollen reservoir: - temperature - relative humidity - precipitation - random losses Entrainment: - turbulent kinetic energy - relative humidity
Upper limit for emission with high wind speeds?	no	yes	yes	yes
Additional aspects/factors included in the parameterization	- leaf area index - height of the plants - resuspension - maximum value for the sum of emitted pollen grains	- leaf area index - height of the plants - reducing factor for altitude	- maximum value for the sum of emitted pollen grains	- reducing factor for altitude - pollen reservoir - cut-off of the release of pollen if a daily maximum value is reached

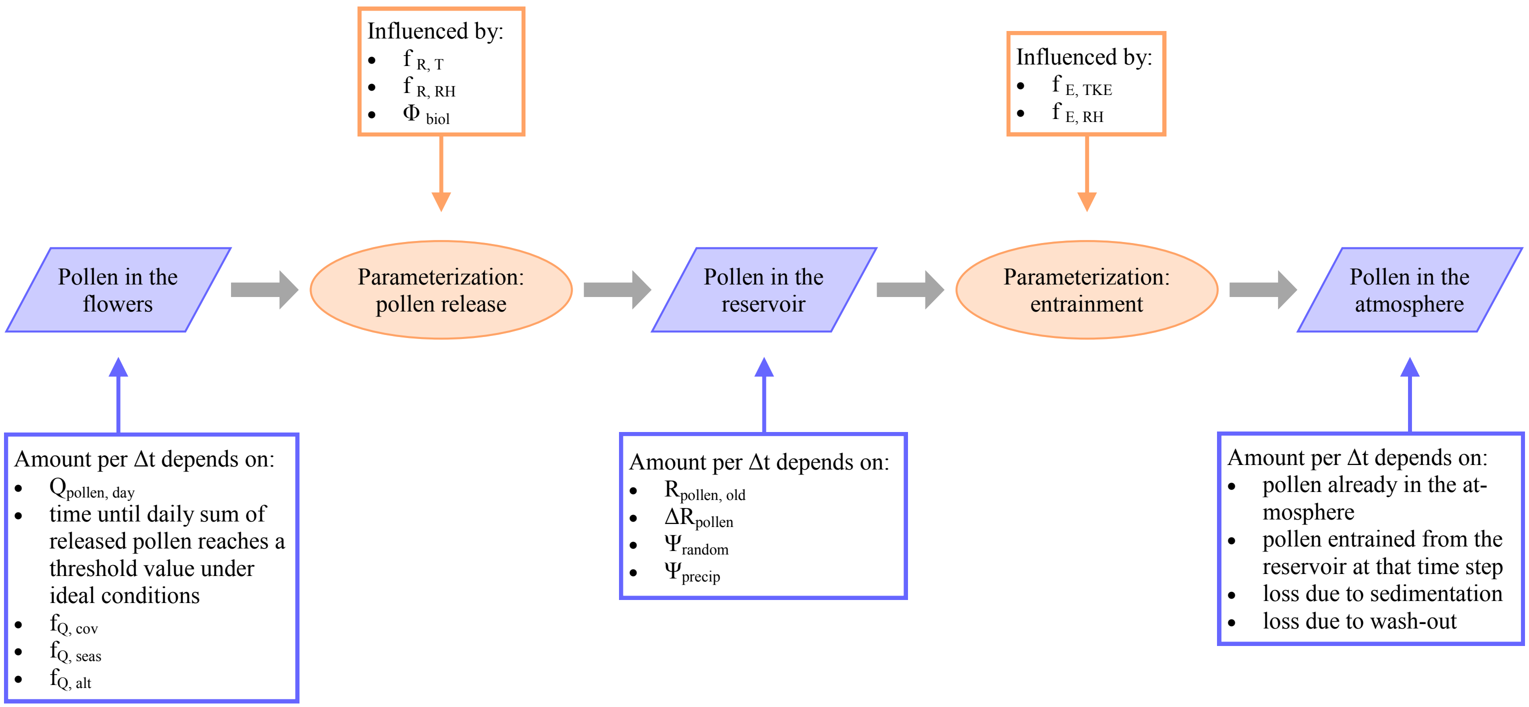

Figure 1: Flowchart displaying the different steps and influencing parameters of the emission parameterization EMPOL.