SILAM Fact sheet

1.1 Assimilation and forecast system: synthesis of the main characteristics

Discretisation	Horizontal resolution	0.1° x 0.1° regular lat-lon
	Number of vertical levels	10
	Top altitude	8700m
	Depth of lower most layer	25m
	Number of lower layers	5 below 1km
Initial & boundary conditions & meteorology	Meteorological driver	D-1 12:00 UTC IFS, 1hrly
	Boundary values	CAMS-Global IFS
	Initial values	Previous forecast
Emissions: natural & biogenic	In-domain soil and road dust emissions	SILAM dust source, SILAM sea salt source, Silam BIO-VOC source
	In-domain sea-salt emissions	Sofiev et al (2011)
	Birch, Grass, Olive, Ragweed, Alder, Mugwort Pollen provided by FMI	yes
	Biogenic emissions	Dynamic biogenic, Poupkou et al. (2010)
	Soil NOx	none
	Wildfiles emissions	Hourly emissions from D-2 cycled for AN (D-1) and FC (D+0 and D+1, zero for the remaining days)
Chemistry/ Physics	Gas phase chemistry	CBM-IV
	Heterogeneous chemistry	Sofiev (2000)
	Aerosol size distribution	2 bins, except for dust (4 bins from 10nm to 30µm) and sea salt (5 bins from 10nm to 30µm)
	Inorganic aerosols	Sofiev (2000)
	Secondary organic aerosols	VBS
	Aqueous phase chemistry	SO2 oxidation, nitrate formation (Sofiev, 2000), heterogeneous nitrate formation on sea salt particles
	Dry deposition: gases	resistance approach (Wesely, 1989)
	Dry deposition: aerosols	(Kouznetsov & Sofiev, 2012)
	Wet deposition	SILAM
Assimilation	Assimilation method	Intermittent 3d-var
	Assimilated surface pollutants	NO2, O3, CO, SO2, PM2.5, PM10
	assimilated satellite	
	Frequency of assimilation	Hourly

1.2 Model Overview

The System for Integrated modeLling of Atmospheric coMposition SILAM v.5.6 (Sofiev et al, 2015) is a Eulerian chemical transport model with the transport module based on advection scheme of Galperin (2000) refined by Sofiev et al (2015) and adaptive vertical diffusion algorithm of Sofiev (2002). Apart from the transport and physico-chemical cores described below, SILAM includes a set of supplementary tools including a meteorological pre-processor, input-output converters, reprojection and interpolation routines, etc. In the operational forecasts, these enabled direct forcing of the model by the ECMWF IFS meteorological fields. A system outlook can also be found at http://silam.fmi.fi.

1.3 Model geometry

The modelling domain covers 25.05°W to 44.95°E and 30.05°N to 71.95°N on a regular latitude longitude grid of 0.1°resolution. Following Sofiev (2002), SILAM uses a multi-vertical approach with the meteorology-resolving grid corresponding to the tropospheric part of the IFS vertical: hybrid levels from 69 to 137. The chemical transformations and vertical fluxes are computed based on 10 thick staggered layers, with the thickness increasing from 25 m for the lowest layer to 1000-2000 m in the free troposphere. The exact layer tops are located at 25,75,175,375,775,1500,2700,4700,6700 and 8700m above surface. Within the thick layers, the sub-grid information is used to evaluate the weighted averages of the high-resolution meteorological parameters and effective diffusion coefficients.

1.4 Forcing Meteorology

Meteorological forcing is the ECMWF IFS operational forecasts taken from the 12:00UTC forecast of the previous day extracted at a resolution of 0.1°

1.5 Chemical initial and boundary conditions

Boundary conditions are taken from the C-IFS (see Table 2). The full fields are imported every 3 hours; in-between, the linear interpolation is applied. For the time being, the sea-salt boundary conditions are taken from SILAM own global forecasts. The forecasts are initialised with the SILAM forecast of the previous day.

1.6 Emissions

The common annual anthropogenic emissions CAMS-REG are implemented as explained in Section 3.2. The PM2.5 emissions are split into EC, OC and mineral components, and OC is mapped to the volatility bins according to Shrivastava et al. (2011). Emissions of biogenic VOCs and sea salt are computed in the corresponding SILAM dynamic modules, which are described below. GFAS hourly emissions from wild-land fires are replicated from D-2 to D+1 for forecast and shut down after, for analysis mode it is used as is.

1.7 Solver, advection and mixing

The SILAM Eulerian transport core (Sofiev et al, 2015) is based on the coupled developments: refined advection scheme of Galperin (2000) and vertical diffusion algorithm of Sofiev (2002) and Kouznetsov & Sofiev (2012). The methods are compatible, in a sense that both use the same set of variables to determine the sub-grid distribution of tracer mass. The approach, in particular, allows computing correct vertical exchange using high-resolution input data but low-resolution chemistry and diffusion grids. The later feature is used in the vertical setup with 9 thick layers.

Diffusion is parameterised following the first-order K-theory based closure. Horizontal diffusion is embedded into the advection routine, which itself has zero numerical viscosity, thus allowing full control over the diffusion fluxes. The vertical diffusivity parameterisation follows the approach suggested by Genikhovich et al. (2004), as described in Sofiev et al (2010). The procedure diagnoses all the similarity theory parameters using the profiles of the basic meteorological quantities: wind, temperature and humidity. Output includes the value of eddy diffusivity for scalars at some reference height (taken to be 1m).

1.8 Deposition

Dry deposition parameterisation follows the resistive analogy of Wesely (1989). Deposition velocity for aerosols are evaluated using the original (Kouznetsov & Sofiev, 2012) algorithm. Wet deposition parameterisation is based on the scavenging coefficient after Sofiev (2000) for gas species and a new deposition scheme for aerosols following the generalised formulations of (Kouznetsov & Sofiev, 2012).

1.9 Chemistry and aerosols

The main gas-phase chemical mechanism is CBM-4. The heterogeneous scheme is an updated version of the DMAT model scheme (Sofiev, 2000). It incorporates the formation pathways of secondary inorganic aerosols.
Emission of 2 sets of compounds is embedded into the simulations: biogenic VOC, sea salt, and desert dust. The bio-VOC computations follow the Poupkou et al. (2010) model and provide isoprene and mono-terpene emissions (currently, only isoprene emission is used in the CB-4 mechanism). The sea salt emission parameterisation is the original development generally based on Sofiev et al (2011), with refinements and spume formation mechanism.

1.10 Assimilation system

The embedded data assimilation is based on the 3d- and 4d-dimensional variational approach (Vira & Sofiev, 2012, 2015). The adjoint formulations exist for all dynamic modules, linearized transformation scheme of sulphur oxide and for aerosol particles. The assimilation procedure has been tested for both initialising the concentration fields and for refinement of the emission coefficients. The observation operators exist for in-situ observations and for the vertically integrated columns observed by the nadir-looking satellites. For the near-real time operational analyses in CAMS, the previous-day observations are used in a 3D-VAR data assimilation suite. The assimilated observations are in situ NO2, O3 and PM2.5, PM10, SO2 and CO.