Weather sensitivity to aerosol influence over the Baltic countries

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Motivation

An important goal in operational weather forecasting is an accurate prediction of precipitation on meso-scales. This demands, among the others, detailed representation of aerosol impact on the troposphere. Various direct, semi-direct and indirect effects of aerosols lead to significant changes in amount and distribution of precipitation, especially for weak patterns. Features of the atmosphere sensitivity to aerosols is studied employing the HARMONIE (Hirlam Aladin Regional/Meso-scale Operational NWP In Europe) model. The focus of the study is the life-time of convective cells in the smoke environment associated with wild fires. In particular, how soot aerosol particles influence on meteorological parameters and physical-dynamical mechanisms responsible for precipitation formation.

HARMONIE model

A Harmonie modelling system is the result of collective development and implementation work of HIRLAM-B programme under the cooperation context of HARMONIE, with major scientific and technical contribution from partners in ECMWF, Meteo France and members of ALADIN consortia. At its default, HARMONIE features belong to a meso-scale forecast system with convection-permitting AROME physics, 3D-VAR upper air assimilation, and an optimal interpolation-based surface analysis, on a model grid up to 1 km in horizontal and 65 vertical levels.

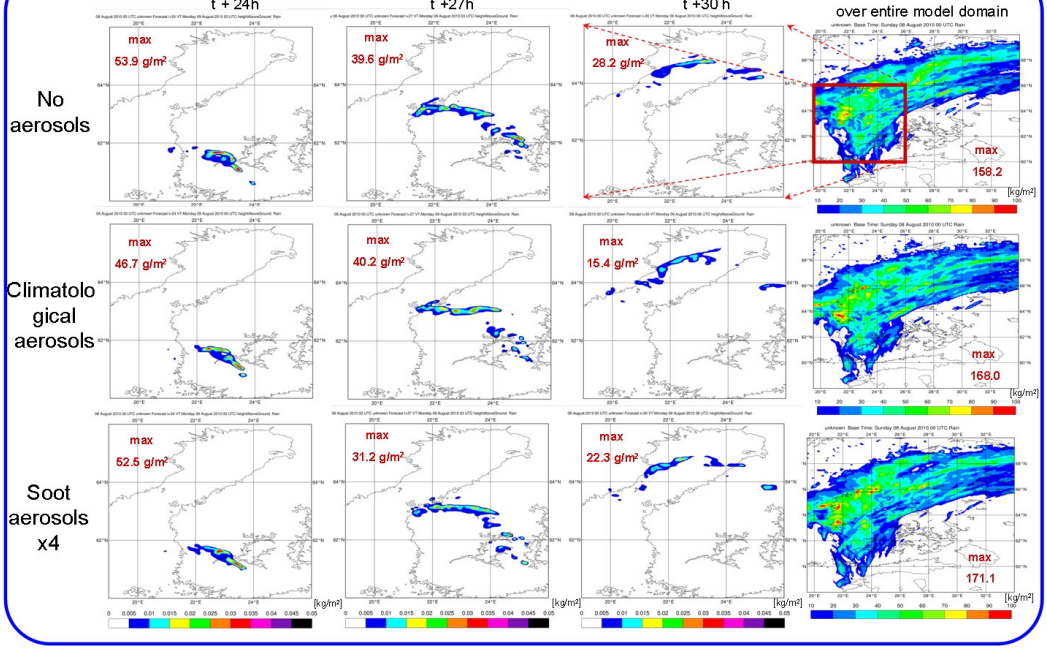
Experiment setup

Main tool (NWP model)	→	Harmonie-38h1.1
Vertical levels	→	65 (model levels)
Dynamics	→	non-hydrostatic
Physics	→	AROME
Suface scheme	→	SURFEX
Boundaries and initial conditions	→	ECMWF-IFS (boundary interval 3h)

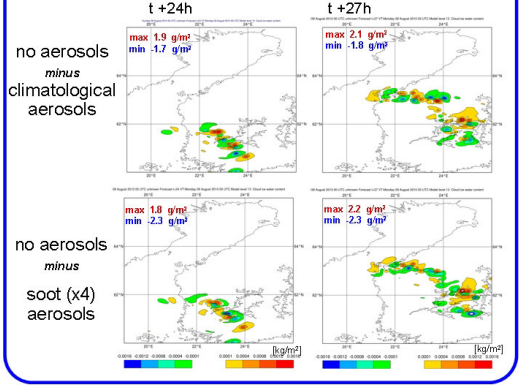
(i) Climatological distribution of aerosols -> SOOT, LAND, SEA AEROSOLS
(ii) Extreme concentration of SOOT aerosols(4 times higher)
(unit is the aerosol optical depth per model level at a wavelength of 550 nm)

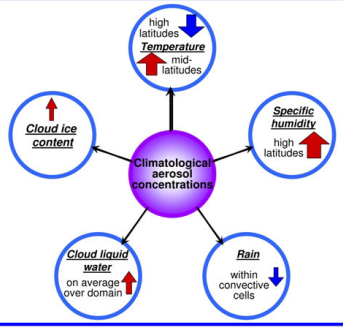
Geographical region	->	FINLAND
Forecast period	->	8-10 August 2010
Grid size resolution	->	2,5 x 2,5 km
Forecast length	->	48 hours

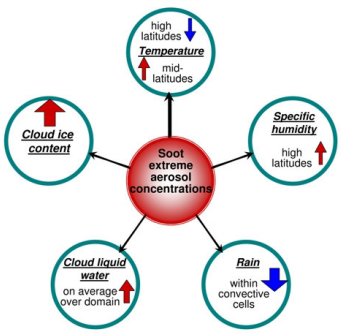
Rain forecast near the surface with different aerosol concentrations



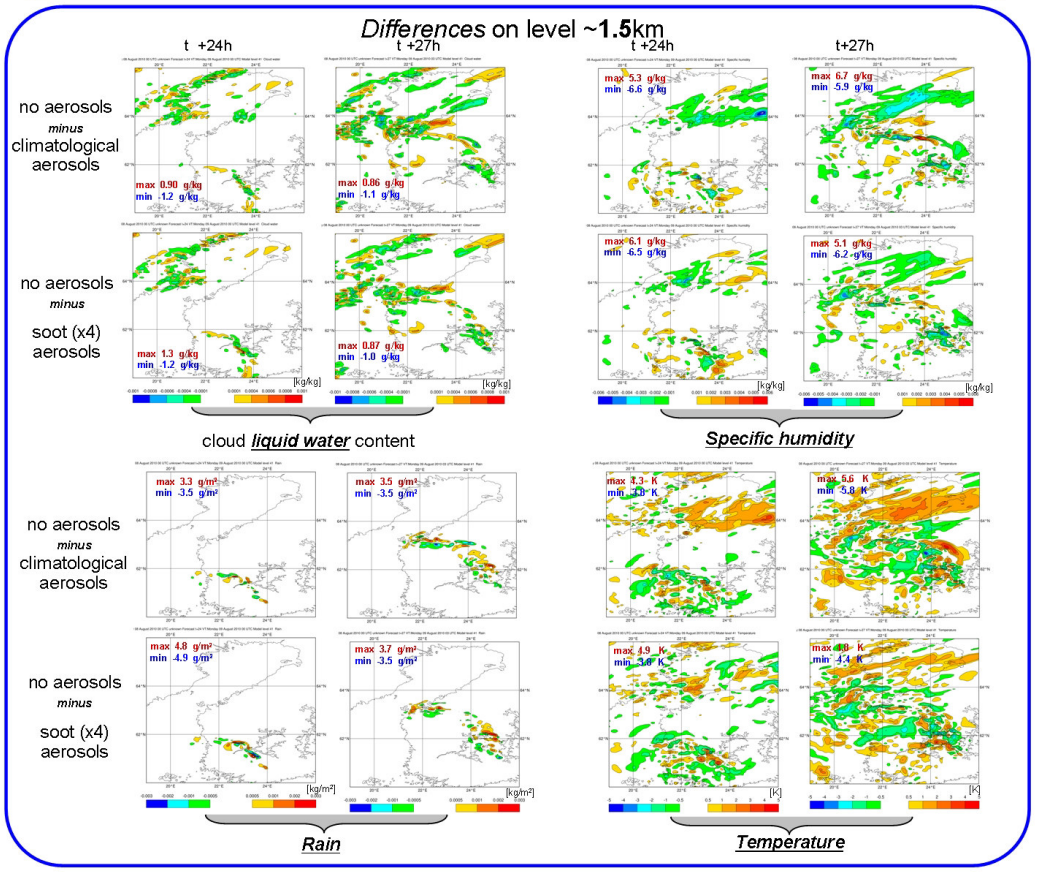
Differences of cloud ***ice*** water content on level ~**10**km







Differences on level ~**1.5**km



CONCLUDING REMARKS

Numerical experiments with the HARMONIE model have shown:
- aerosols impact as a trigger in a complex chain of interactions between physical atmospheric variables such as the air temperature, humidity, stratification, cloudiness, and finally precipitation;
- perturbations in atmospheric fields appear in a form of mesoscale cells of opposite signs following each other;
- major changes occur within the planetary boundary layer and reach up to ±6 K for temperature, ±7 g/kg for specific humidity, ±1.5 g/kg for cloud liquid water content, ±5 g/m^2 for rain water in the atmosphere;
- accumulated precipitation for 48 hours are not sensitive to aerosols (~ ±6-8%), while variations within individual mesoscale cells reach up to 60%;
- due to microphysical properties, extreme soot concentrations weaker affect the temperature and specific humidity fields comparing climatological concentrations of other aerosol types;
- the cloud ice formation appears more active in case of substantial increasing of soot aerosols.

Future plan includes investigation of the life-time of a single precipitation cell on higher spatial and temporal resolution, and verification model results against high resolution radar data.

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