Aerosol effects on the physical weather in the HARMONIE model

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Motivation

Modern numerical weather prediction (NWP) models are able to represent a wide spectrum of atmospheric processes and transformations in explicit manner. Chemical transport models (CTM) explore physical atmospheric fields as drivers for simulating numerous chemical reactions and conversions on temporal scales from seconds to years with appropriate accuracy. The high resolution limited area HARMONIE model allows to consider feedbacks from chemical and aerosol effects to physical variables. To highlight the impact of aerosols on atmospheric conditions, sensitivity experiments were performed with modified concentrations in set of aerosol types.

HARMONIE model (general info)

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

Case study: 08-11 August 2010, the Denmark domain, horizontal resolution – 2.5 km. The model outputs of 1 hour obtained with different aerosol concentrations were compared to each other. The climatological distributions of ozone and aerosols are involved in the radiation scheme and microphysic package. The influence of aerosols is highlighted via replacing the available climatological aerosol information by manually changed values.

IC & BC are generated on the base of the global ECMWF model (interval 3 hours).

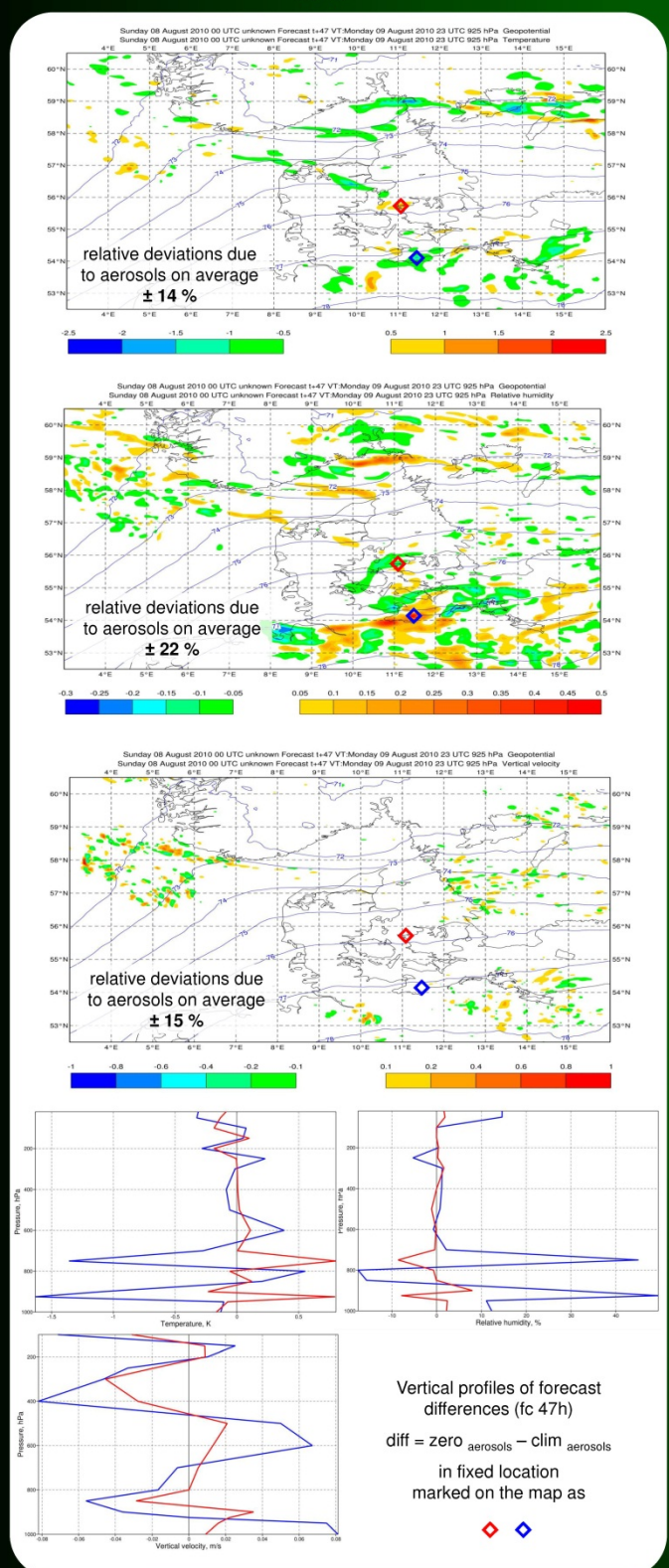
Aerosol controls in model code description

The aerosol initialization within the model code is handled in the …/src/arp/setup/sugrida.F90 subroutine in the setup block. These are the six aerosol types: Sea, Land, Soot/Urban, Desert Dust, Stratospheric Sulphate background and Volcano. The four earlier types must be initialize in one set if only aerosol simulations are performed, while the latter two aerosols are optional.

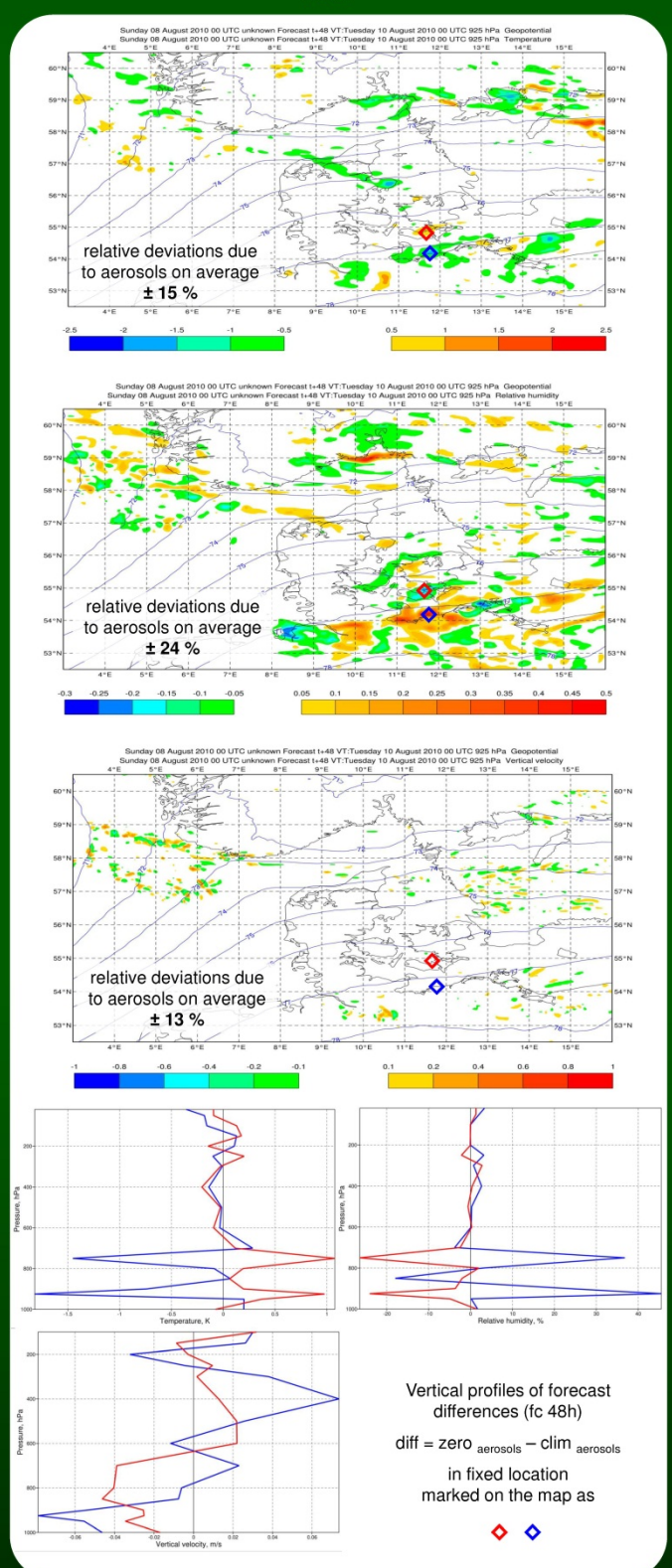
Aerosol vertical distribution is used (if LRAYFM is true) at radiation time steps in …/arp/phys_ec/radaer.F90. The unit is the aerosol optical depth per model level at a wavelength of 550 nm. The cloud cover for SW radiation calculations is set in the subroutine .../arp/phys_radi/swu.F90.

RESULTS: diff = [$NO_{aerosols}$ – $CLIM_{aerosols}$], Lev 925 hPa

47h



48h



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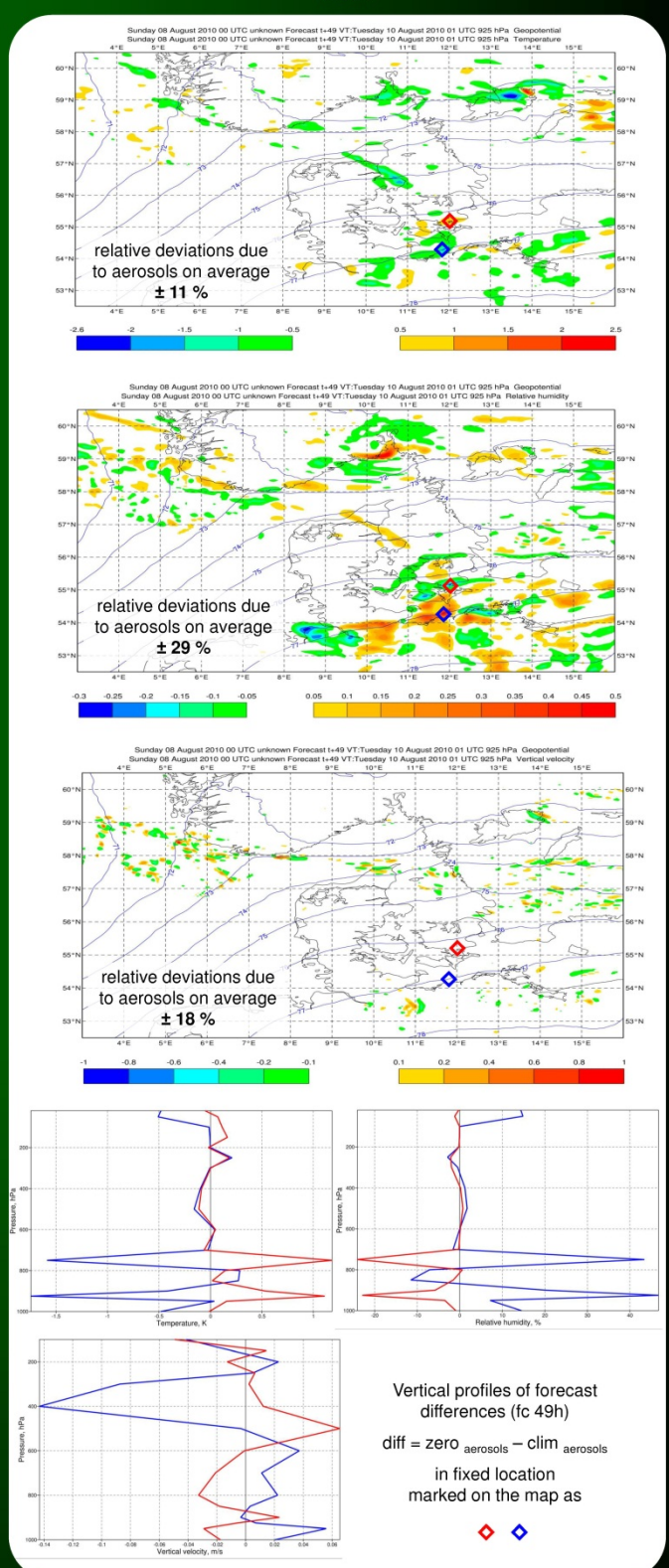
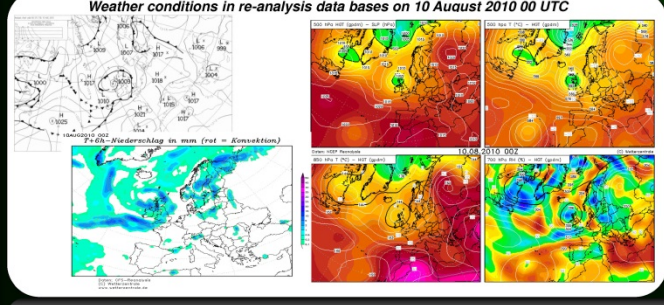


Weather conditions in re-analysis data bases on 10 August 2010 00 UTC



CONCLUDING REMARKS

Numerical experiments with the HARMONIE model have shown:

- the aerosol impact on physical atmospheric variables occurs through a complex chain of interactions between the radiation, air temperature, humidity, stratification, vertical motions, cloudiness, and finally precipitation. In the chain aerosols play a role of a trigger;
- perturbations in atmospheric fields appear in a form of mesoscale cells of opposite signs following each other and growing with the leading time, while domain averaged deviations are oscillating around zero values;
- major changes occur within the planetary boundary layer and along frontal zones of high gradients at all levels;
- maximum deviations reach up to approximately 2.5 K for temperature, 35 % for relative humidity, ± $2*10^6$ W/m^2 for net short wave radiation fluxes at the top of the atmosphere and up to + $5*10^6$ W/m^2 near the surface, 1 m/s for vertical velocity.

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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