HIRLAM-B Radiation Physics 2012

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Harmonie radiation experiments

The default radiation scheme in the HARMONIE model is ECMWF's IFS scheme which is computationally intensive and therefore only called every 15 time steps. In this work, the simpler HIRLAM radiation scheme was included in AROME physical parameterisations. Running it at every time step takes as much CPU time as running the ECMWF scheme every 15 steps. It is hoped that also the ALARO radiation scheme will be included so that the user will have the choice of three schemes of different level of complexity. Schemes can be compared consistently when called from a common physics platform - AROME or ALARO/ARPEGE.

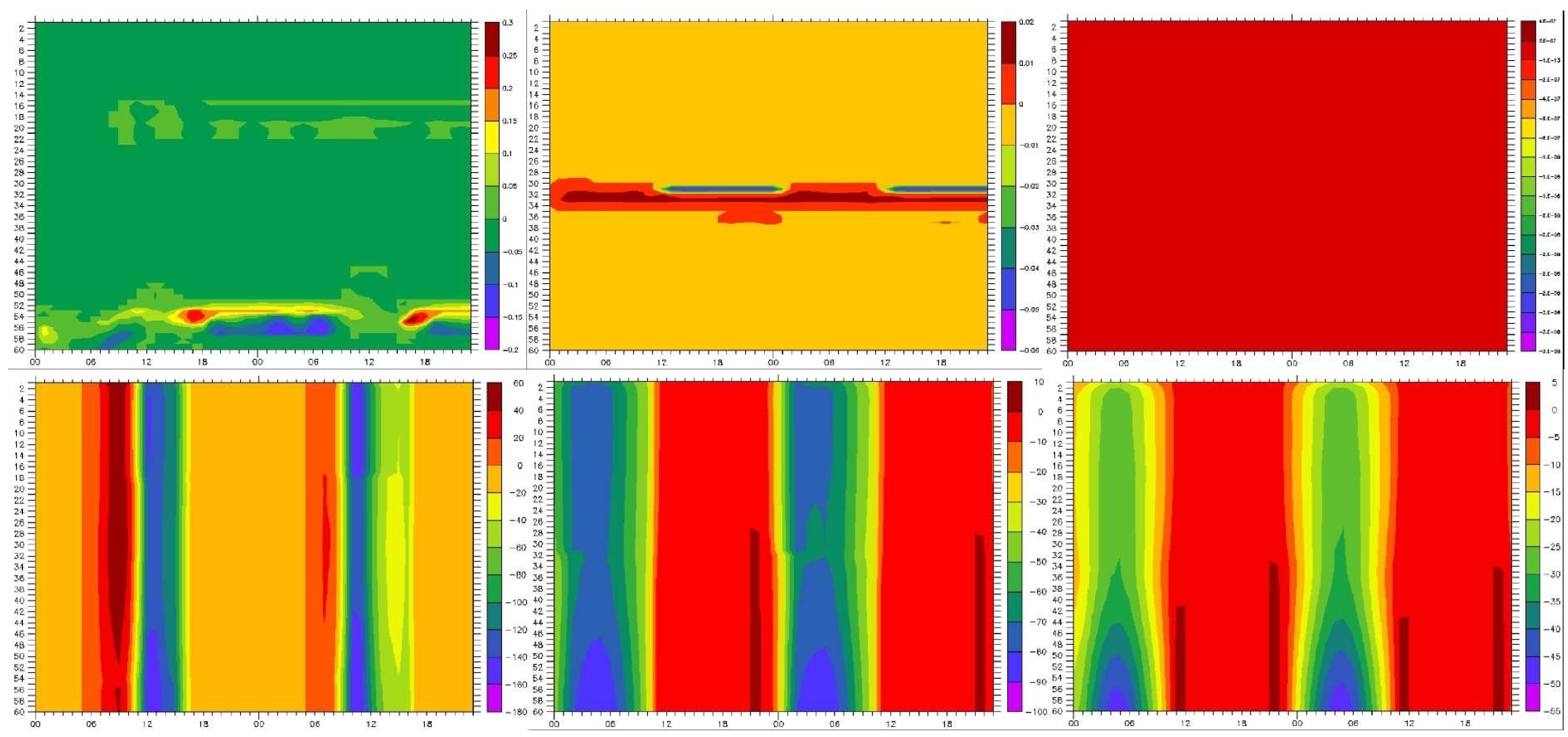

Figure 1: Three examples of difference plots of MUSC with the IFS and the HLRADIA radiation scheme, respectively. The first column shows an example with liquid water clouds, the second column an example with ice clouds, and the third example is without clouds. The top row shows differences in cloud condensate (unit: g/kg), while the bottom row shows differences in SW radiation (unit: W/m^2). Differences in LW radiation were minor and not shown here.

The first experiments showed unexpectedly large sensitivity of the cloud droplet and crystal distribution to changes in radiation parameterisations. Further studies are needed to understand these results. More MUSC and full HARMONIE experiments will be carried out with the aim of developing optimal radiation parameterisations for the HARMONIE mesoscale NWP model.

Aerosols

A fast algorithm accounting for shortwave and longwave radiative effects of aerosols in the HLRADIA scheme has been developed. This is made to be used in an operational NWP-model. Monthly mean black carbon and water soluble organic carbon aerosols + sulphate profiles typical for Sodankylä (Koch 2001, JGR 106,20311) are shown in Figure 2 (left). Aerosol forcing was extracted from these profiles for a sensitivity study using July atmospheric conditions. Sensitivity experiments were performed using the single-column HIRLAM, which included HLRADIA with the new aerosol algorithm. A response of up to 28 W/m^2 for longwave radiation and up to -80 W/m^2 for shortwave radiation was found when the aerosol load was increased by a factor of 30.

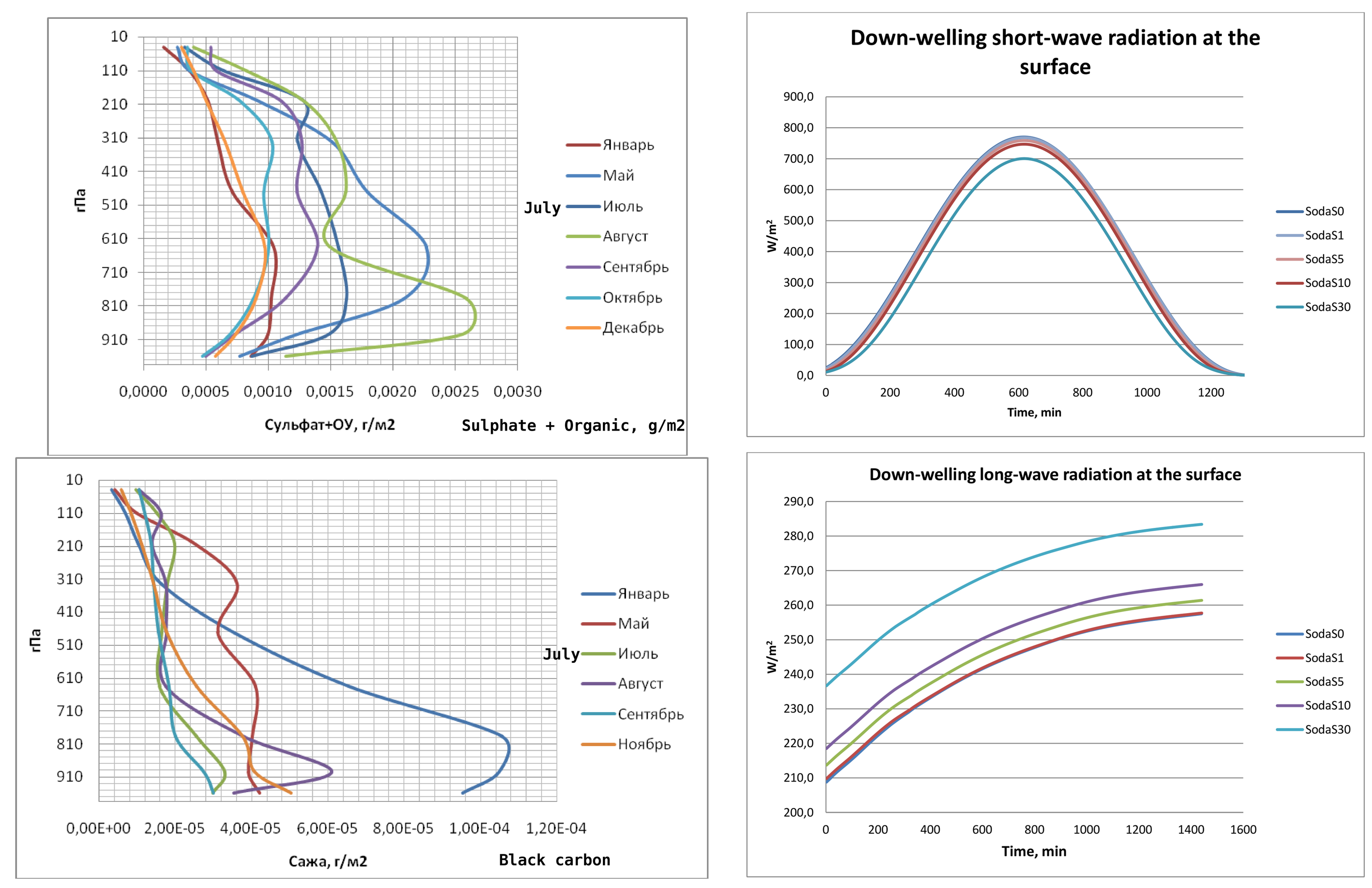

Figure 2: Aerosol profiles for Sodankylä (left panel): vertical axis pressure (hPa), horizontal axis concentration (g/m2), and the different coloured curves represent different months. Surface downward SW (top right) and LW (bottom right) irradiances, calculated for five assumed aerosol profiles. The x-axis shows the forecast length in minutes, y-axis the irradiance (W/m2). The basic July aerosol profiles were multiplied by factors of 0 (SodaS0, no aerosol), 1 (SodaS1, organic and black carbon + sulfate as given by the observed profiles), 5 (SodaS5), 10 (SodaS10) and 30 (SodaS30).

Cloud physical properties

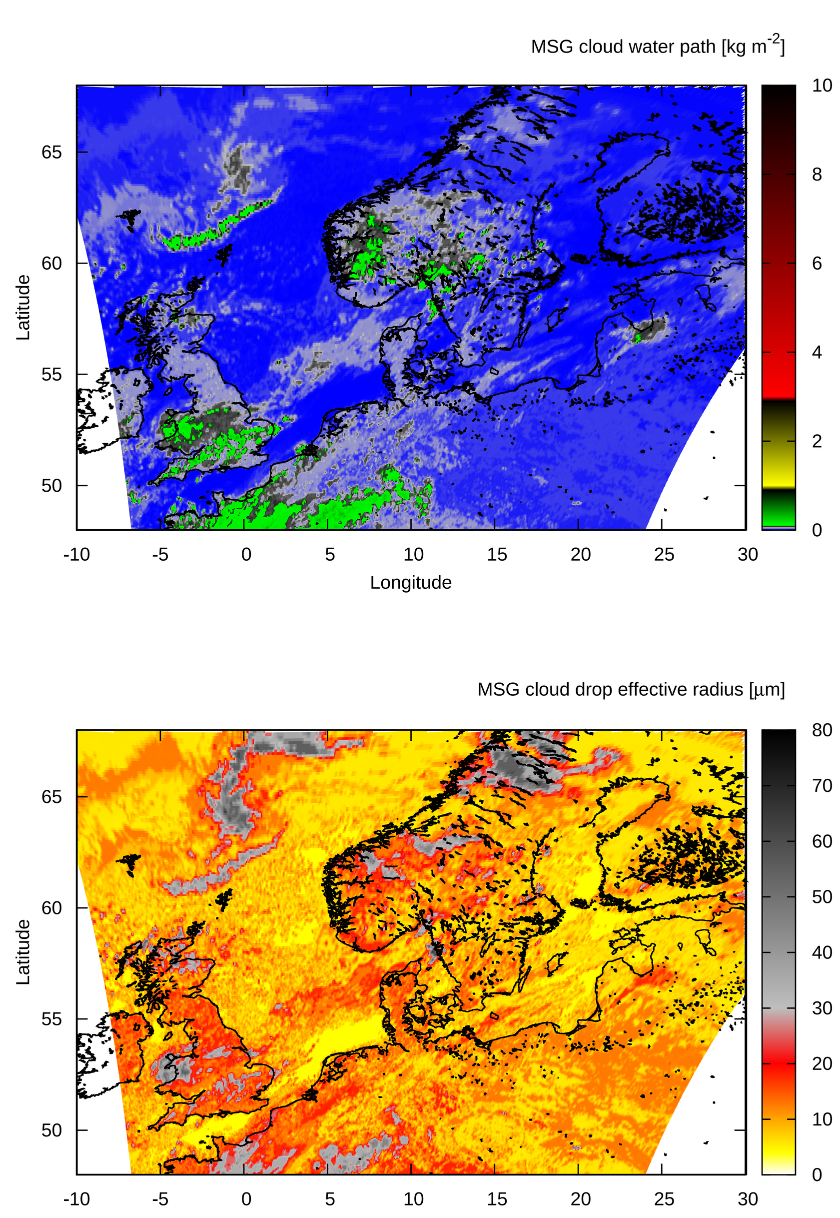

Figure 3: An example of cloud condensate (CC) and cloud effective radius (REFF) over NW-Europe.

In Fig. 3 cloud physical properties derived from calibrated Meteosat SG SEVIRI radiance images are shown. The derivation is made from a look-up table calculated by the DISORT model. In this the variations in solar zenith angle, observation zenith angle, relative azimuth angle, wavelength, integrated cloud condensate, and cloud effective radius are all accounted for. Additionally, if a-priori knowledge of the surface albedo is available, this can be used to adjust the radiance values in the look-up table.

CC and REFF over NW-Europe are presently derived in near real-time at DMI. Introduction of these data into the data assimilation is considered.

3-D radiation parameterisation

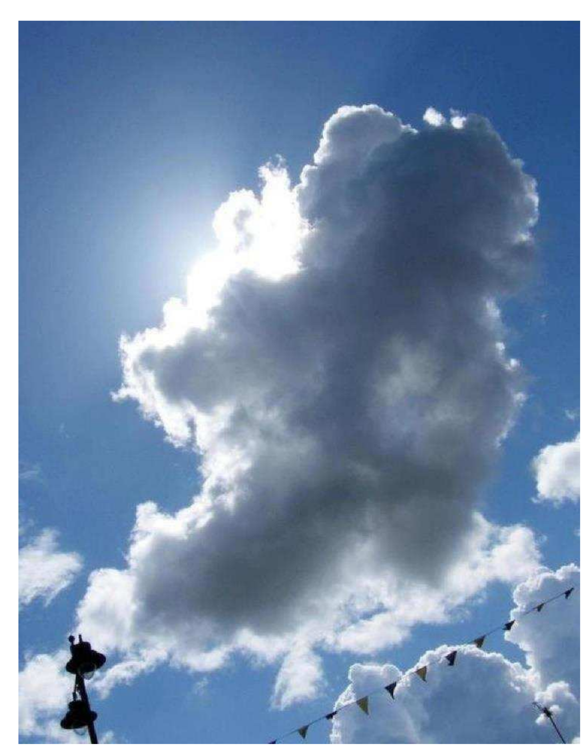

Figure 4: Clouds often have complex 3-dimensional shapes that must be parameterised into the NWP-model grid-boxes.

Correct parameterisation of complex cloud fields is a challenge in NWP-modeling. Mostly, this is done by having a cloudy and a cloud-free fraction in a given model grid box. Also, assumptions about how the clouds overlap at different levels are made.

Here we suggest that when models go to resolutions of 2-3 km and time-steps of 1-2 minutes, which is often the case today, it is necessary also to account for multiple reflections from the cloudy fraction in the cloud-free fraction of the grid box. This is in particularly needed for correctly modeling short term variations in the shortwave irradiance at the surface $S^{-}(sfc)$,

$$S^{-}(sfc) = ((1 - f_{cl})S^{-}(sfc, \text{cloudfree}) + f_{cl}S^{-}(toc)\mathcal{T}_{cl})/(1 - A(1 - \mathcal{T}_{cl})f_{cl}). \quad (1)$$

Here f_{cl} is the cloud fraction, A is the surface albedo, $S^{-}(sfc, \text{cloudfree})$ is the downward shortwave irradiance at the surface under clear sky conditions, $S^{-}(toc)$ is downward shortwave irradiance at the top of the cloud, and $\mathcal{T}_{cl}$ is cloud transmittance.

The effect of the parameterisation in Eq. (1) is an enhancement of the local shortwave irradiance, when fractional cloud cover occurs, compared to previously used parameterisation.