**Title:** HIRLAM and HARMONIE-AROME radiation comparisons

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# HIRLAM and HARMONIE-AROME radiation comparisons

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## 1 Introduction

The advantage of broadband, over spectral, radiation schemes is that they can be called more frequently within a NWP model, without compromising on computational efficiency. In mesoscale models fast interactions between clouds and radiation and the surface and radiation can be of greater importance than accounting for the spectral details of clear-sky radiation; thus calling the routines more frequently can be of greater benefit than the deterioration due to loss of spectral details. Fast but physically based radiation parametrizations are expected to be valuable for high-resolution ensemble forecasting, because as well as the speed of their execution, they may provide realistic physical perturbations.

We summarize validation of FMI operational HIRLAM NWP model results against Sodankylä and Jokioinen surface radiation measurements during 2006-2016. With this validation we wanted to learn

- How well does the HIRLAM radiation scheme HLRADIA, available for testing also in HARMONIE-AROME, behave in an operational NWP system?
- How to use radiation observations for NWP validation - can we evaluate model performance and detect changes?
- How to treat uncertainties in validation due to uncertainties of both the models and the observations?

We also show a HARMONIE example of how the radiation call frequency may influence results in a convective case.

## 2 Results

### 2.1 Ten-year validation of surface radiation fluxes at two stations

Finnish Meteorological Institute HIRLAM operational +3h and +6h forecasts were validated against Jokioinen (WMO station 02963, latitude 60.814°N, longitude 23.498°E, elevation 103 m.a.s.l.) and Sodankylä (02836, 67.362°N, 26.638°E, 179 m.a.s.l.) 3-hourly radiation observations, averaged from hourly means, between the 1st of April, 2006 and the 31st of March, 2016. During this period, practically unmodified version of the HLRADIA broadband radiation scheme was applied as documented by Rontu et al. (2017). The FMI operational HIRLAM model updates included introduction of the “newsnow” surface parametrizations and some minor changes, see Table 1 in Eerola (2013).

During 2006-2016 HIRLAM performed generally well compared to surface radiation measurements at two Finnish meteorological stations. Small systematic underestimation the SW absorption and overestimation of the LW absorption by the atmosphere was found. The SWDS bias of max. 20 $\mathrm{Wm}^{-2}$ may be due to the assumed inhomogeneity correction of 20% of the cloud condensate content. The LWDS bias of max. 5 Wm$^{-2}$ could be avoided by modifying an extra correction term of ca. +15 due to an assumed effect of "other greenhouse gases".

Radiation fluxes showed large variability due to cloud variations. Classifying the model and observation data according to cloudiness contains large uncertainties, especially for solar radiation when the solar elevation is low.

The reflected SW radiation (and consequently, albedo) shown by the model grid-average values and observed locally are not comparable due to the representativity error, especially over the snow-covered terrain. Upwelling LW flux, from which the grid-average surface temperature T$_{surf}$ can be derived, suffers less of this problem, thus LWUP observations might be used, to some extent, to measure the performance of model's T$_{surf}$.

## 2.2 Frequency of the radiation call

The sensitivity of the HARMONIE-AROME results to the calling frequency of the IFS radiation scheme is illustrated by the results of experiments that were run for a domain over China around Shanghai for a convective case at the 30th of July 2010. Figure 1 shows the difference in 1-hour global SW flux and downwelling LW flux when the IFS radiation scheme was called every time-step (EXP01) compared to the call every 15th time-step (EXP15), which is the default. Note that negative differences EXP01-EXP15 indicate a positive bias of the default intermittent experiment with respect to the experiment with full time-resolution and vice versa. Differences in cloud cover and precipitation were also found (not shown).

A day with few clouds was chosen for this example, which is taken from experiments done during the MarcoPolo FP7 project (Nielsen et al., 2017). In the left-hand panel of Figure 1 the differences in the SW irradiances are shown. Overall these are $<<$ 1 Wm$^{-2}$ and in average -0.2 Wm$^{-2}$. The larger differences are due to shifts in the cloud positions, which illustrates the high sensitivity of clouds to changes in the physics computations. In the right-hand panel of Figure 1 the differences in the LW irradiances are shown. Here significant overall differences are seen over land in the clear-sky parts of the domain. These differences go up to 13.2 Wm$^{-2}$. The explanation for this negative bias is that the integrated water vapour over land is increasing during the morning hours. Thus, more heat is gradually trapped. The intermittent setup fails to account for this effect.

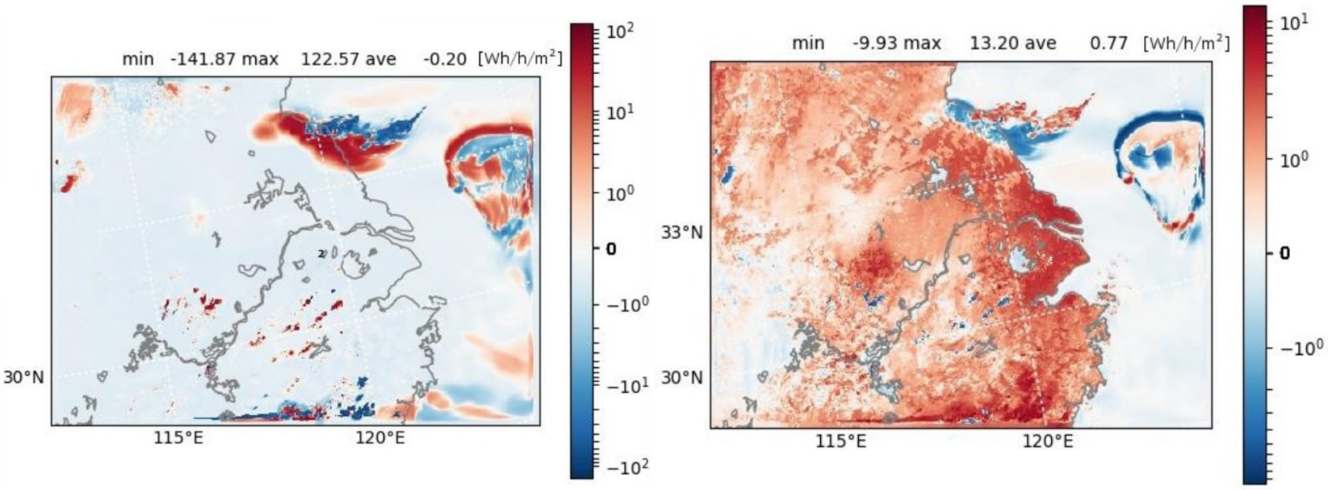

Figure 1: Difference EXP01-EXP15 in average irradiances: SW (left), LW (right), unit Wm$^{-2}$. The domain shown covers the Yangtze River Delta at the coast of China. The time interval is 1 hour from 0 to 1 UTC (8-9 AM local time) on the 30th of July 2010.

This example shows that the HARMONIE-AROME results can be quite sensitive to the calling frequency of radiation parametrizations. Further, more systematic studies are needed to understand the significance of such differences for weather forecasts and to validate the results against observed radiation fluxes and standard meteorological observations.

## Acknowledgements

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