Radiation Experiments using the ALADIN-HIRLAM system

Emily Gleeson[1], Laura Rontu[2], Velle Toll[3,4], Kristian Pagh Nielsen[5], Jan Mašek[6], Markku Kangas[2]

[1] Met Éireann, Ireland, [2] FMI, Finland, [3] University of Tartu, Estonia, [4] EMHI, Estonia, [5] DMI, Denmark, [6] CMHI, Czech Republic

Introduction

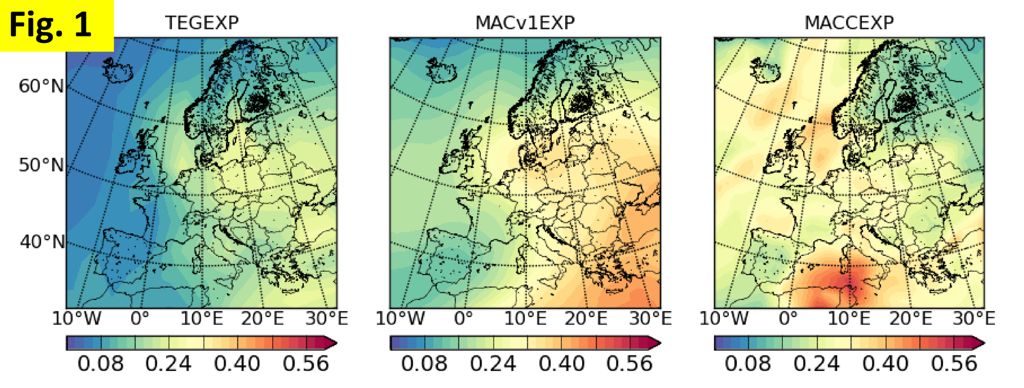
- The radiation team has been developing and testing the radiation parametrizations in HARMONIE-AROME since 2011.
- The group creates and maintains the HARMONIE-AROME radiation branch and HARMONIE-MUSC experiments.
- This poster summarises some of our work published during the past year.

HARMONIE-ALARO aerosol experiments

(*Toll et al., 2016*)

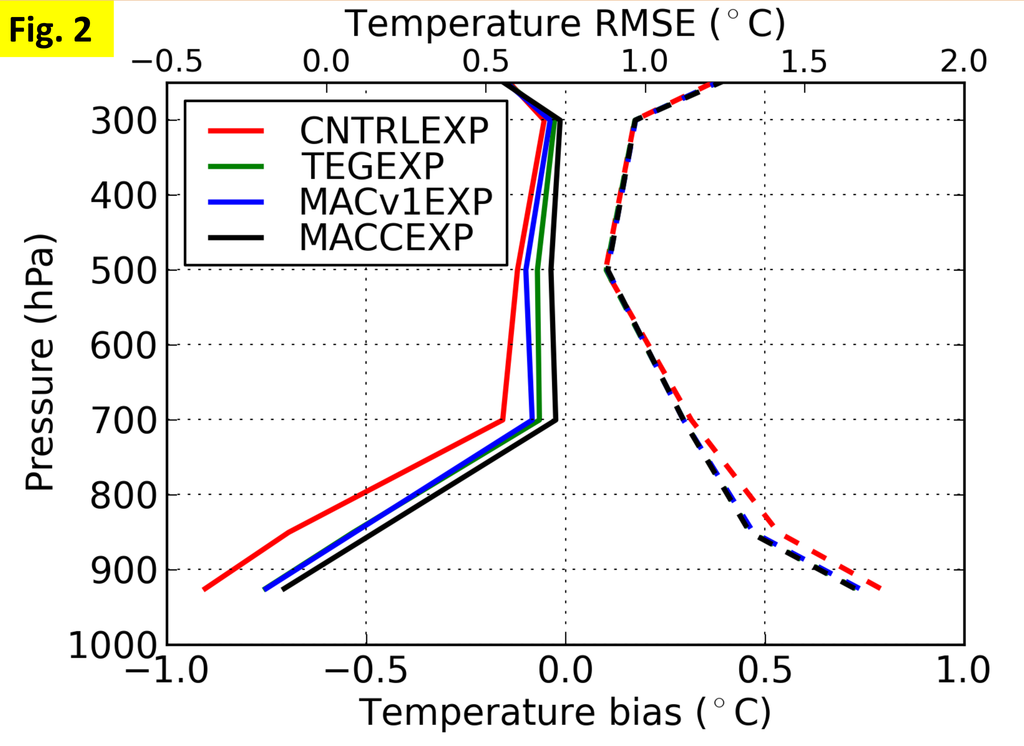
- ALARO-0 physical parametrizations were used except for radiation (*IFS cycle 25r1*) and surface (*SURFEX*).
- By default *Tegen et al. 1997* aerosol optical depths (AOD) at 550 nm (AOD550), *Hess et al. 1998* aerosol inherent optical properties (IOPs) and *Tanre et al. 1984* aerosol vertical profiles are used.
- We ran a series of 96-hour forecasts over Europe for the period April 16-30th 2011 on a 15 km grid with 60 vertical levels.
- 4 aerosols scenarios were considered: 1) aerosol-free, 2) Tegen monthly climatology (default), 3) MACv1 monthly aerosol climatology and 4) time-varying aerosols from the MACC reanalysis (see **Figure 1** for AOD550 comparison).

Fig. 1



- Using near real-time aerosol data from the MACC reanalysis, which includes assimilated AOD measurements, results in improved forecasts of shortwave (SW) radiation and temperature (**Figure 2**) and humidity in the lower troposphere.
- Overall the improvements resulting from using real-time data instead of climatological aerosols are small when the aerosol distribution is close to average but can be considerable when pollution is heavy (see next section and Toll et al., 2015).

Fig. 2

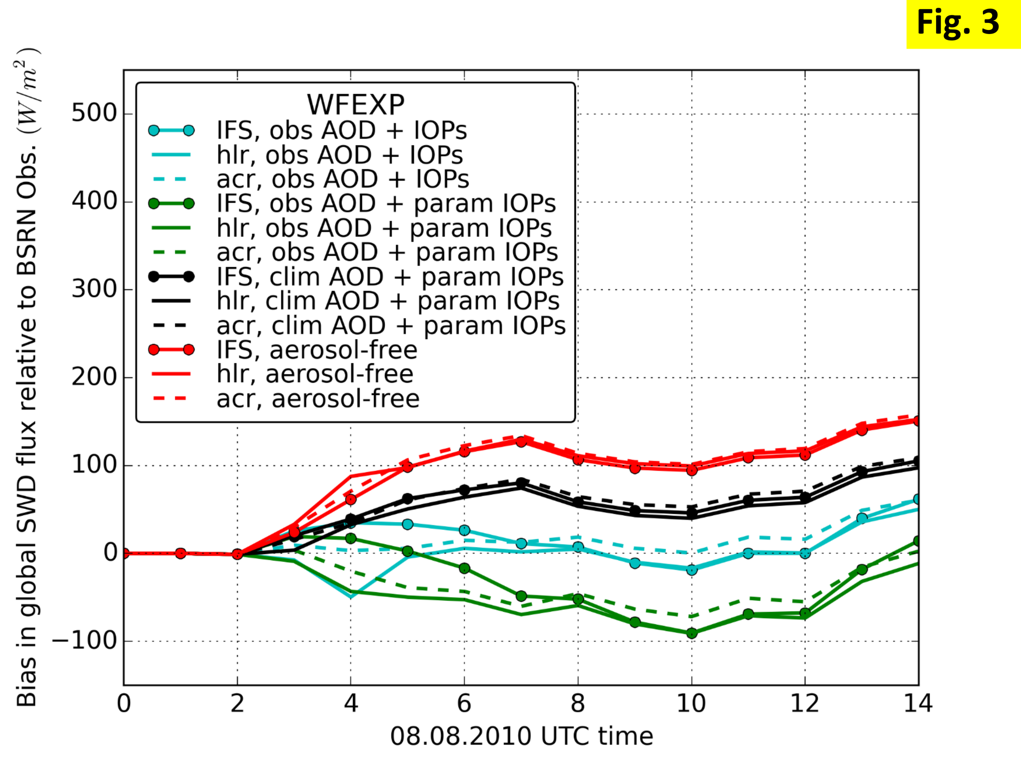


MUSC aerosol & radiation scheme experiments

(*Gleeson et al., 2015*)

- **Figure 3** shows a time-series of bias in global downwelling SW (SWD) irradiance (W/m^2) simulated using MUSC relative to BSRN observations for Tõravere, Estonia on August 8th 2010 (when major wildfires affected the region).
- 4 aerosol scenarios (red: *aerosol free*; black: *climatological AOD550 and parametrized IOPs*; green: *observed AOD550 and parametrized IOPs*; cyan: *observed AOD550 and IOPs*) and 3 radiation schemes are considered (IFS, hlradia (hlr) and acraneb2 (acr).
- Correct AOD and IOPs (single scattering albedo, asymmetry factor and AOD spectral scaling) matter more than the choice of radiation scheme.
- Broadband schemes (hlradia, acraneb2) perform well when the broadband AOD is used instead of AOD550.

Fig. 3

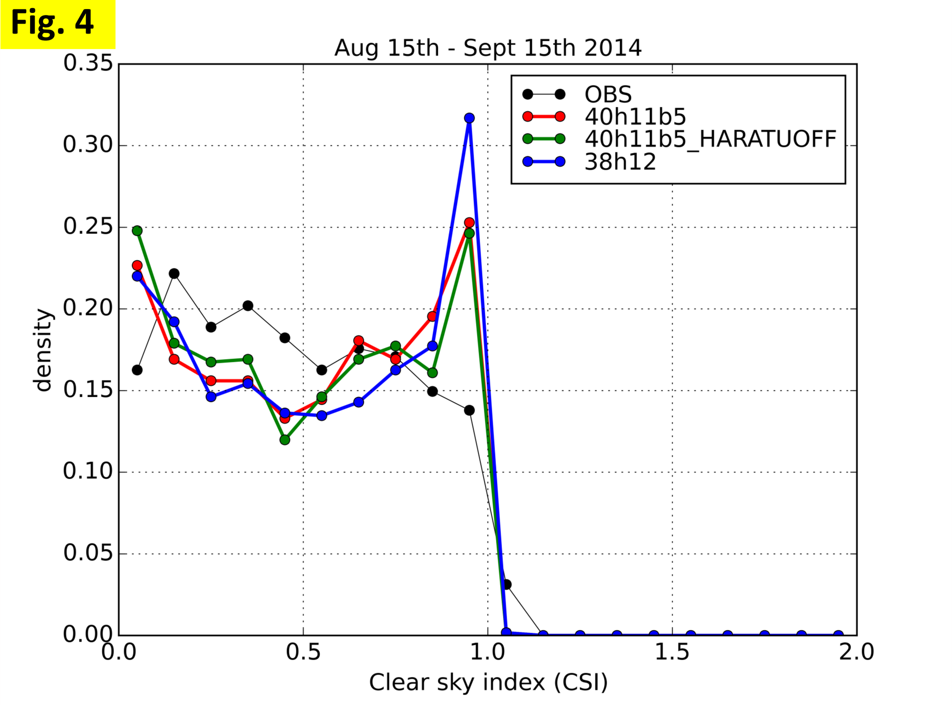


Radiation verification: CSI

(*Gleeson et al., 2015*)

- Using measured SW fluxes to verify modelled clouds is an improved method of verification compared to the traditional method of using synoptic surface observations, where only the cloud cover, and not cloud water loads, is verified.
- We used the clear sky index (CSI) as a means of SW flux and cloud verification where CSI is the global SWD radiation normalised by the clear sky SWD radiation.

Fig. 4



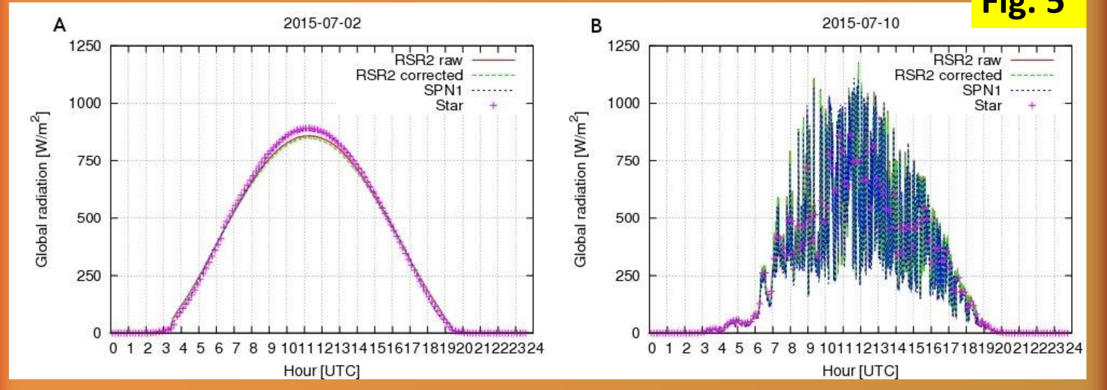
- Using CSI as a proxy for cloudiness highlights the binary (on/off) cloud cover in HARMONIE-AROME. This is evident in **Figure 4** which shows the CSI calculated for Irish stations in August/September 2014 using observations and 3 configurations of HARMONIE-AROME: 1) cycle 38h1.2, 2) cycle 40h11b2 (using the Nielsen SW cloud liquid optical property scheme, a cloud inhomogeneity of 1.0 and HARATU), 3) same as 2) but without HARATU.

Radiation verification: Temporal variability of solar irradiances

- Information on the variability of solar irradiance and forecast global irradiance is not obtained from standard RMSE/STDEV/BIAS statistics
- Stein et al. (2012) and Lorenz et al. (2016) have suggested two methods to quantify measured and forecast global irradiance variability.
- Lorenz et al. (2016) show that LAMs are much better at forecasting variability than the global IFS model despite having significantly higher RMSEs.

- **Figure 5** shows global SWD irradiances for a clear day (A) and a day with high variability (B) measured using 3 instrument types (Star Type 8101, RSR2, SPN1 sunshine pyranometer).

Fig. 5

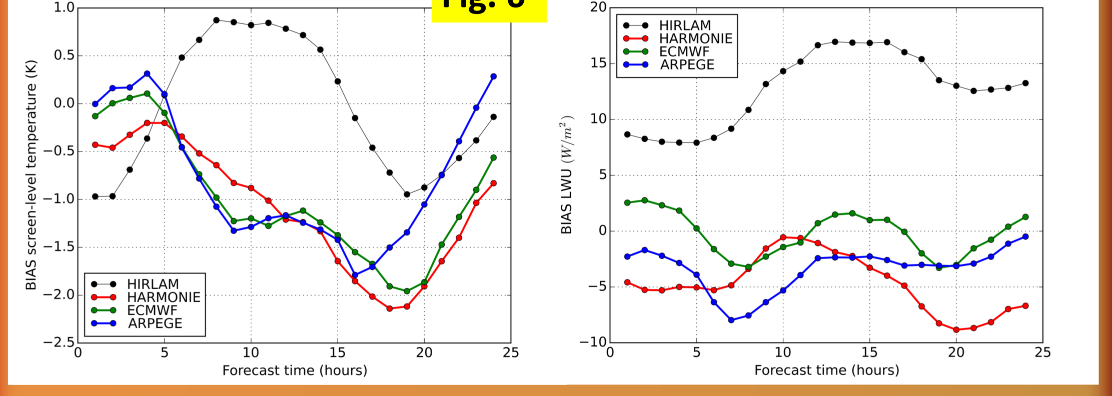


Radiation verification: Sodankylä

(*Kangas et al., 2016*)

- In NWP models, screen-level temperature (T_{2m}) is diagnosed from the grid-average surface temperature and the lowest model-level temperature. On the other hand observed T_{2m} represents local conditions. Thus, standard observation validation compares variables which are not directly comparable.
- Comparison of measured and simulated upwelling longwave radiation (LWU) can complement validation of near-surface temperatures because LWU directly represents the surface temperature.
- **Figure 6** shows biases in T_{2m} and LWU at Sodankylä for March to May 2014 where HIRLAM (FMI), HARMONIE-AROME (FMI), IFS (ECMWF) and Arpege (Metéo France) +1,+2…+24h forecasts are compared to observations.

Fig. 6



- During this period, HIRLAM systematically overestimates daytime LWU and T_{2m} whereas HARMONIE and Arpege slightly underestimate these parameters. The correspondence between LWU and T_{2m} is less clear for HIRLAM at night and IFS.
- Measured LWU represents cold conditions at a snow-covered point on open land whereas the model grid-squares cover up to 50 km^2 of pine forest. The grid-average (forest) T_{2m} from the models was compared to T_{3m} measured in the forest.

References: Gleeson et al., *ACPD*, 2015; Gleeson et al., *ALADIN-HIRLAM Newsletter 5*, 2015; Hess et al., *Am. Meteorol. Soc.*, 1998; Kangas et al., *Geosci. Instrum. Method Data Syst. Discuss*., 2016; Lorenz et al., *Progress in Photovoltaics: Research & Applications*, 2016; Stein et al., *Proceedings of the World Renewable Energy Forum*, 2012; Tanre et al., *Aerosols and their climatic effects*, 1984; Tegen et al., *J. Geophys. Res.*, 1997; Toll and Männik, *Atmospheric Research*, 2015; Toll et al., *Atmospheric Research*, 2015; Toll et al., *Atmospheric Environment*, 2015; Toll et al., *Atmospheric Research*, 2016;