

Radiation Experiments using the ALADIN-HIRLAM system

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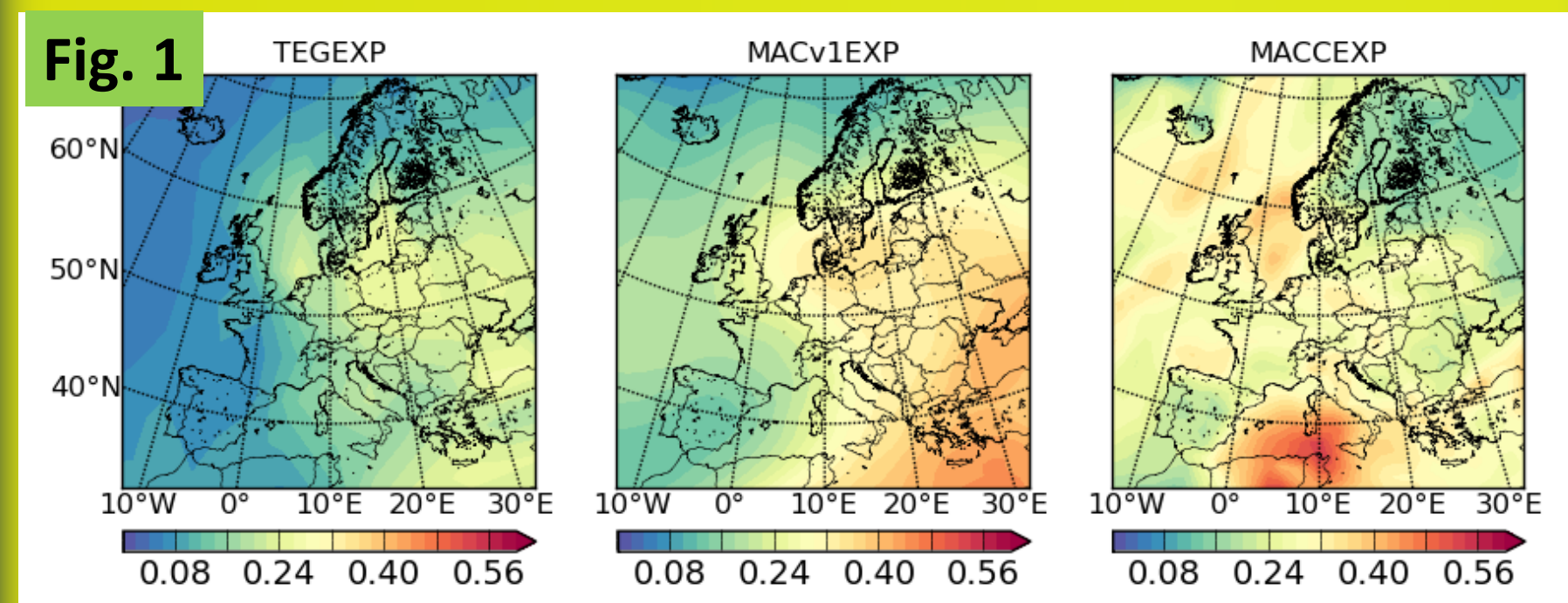
Introduction

- We have 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 over the past year.

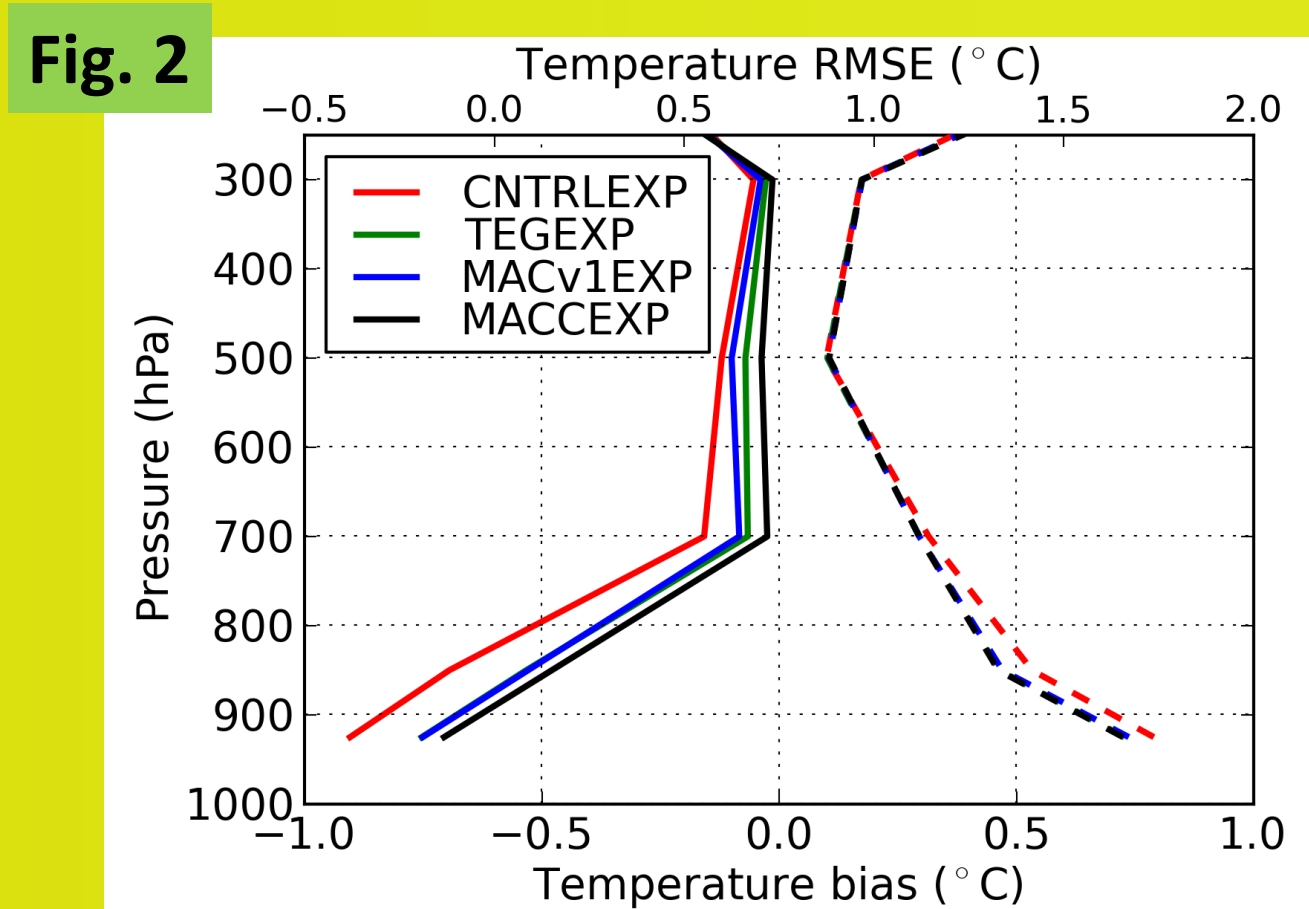
HARMONIE-ALARO aerosol experiments

(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 climatology (default), 3) MACv1 aerosol climatology and 4) aerosols from the MACC reanalysis (see Figure 1 for AOD @ 550 nm comparison).



- Using the more realistic MACC dataset, 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 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).

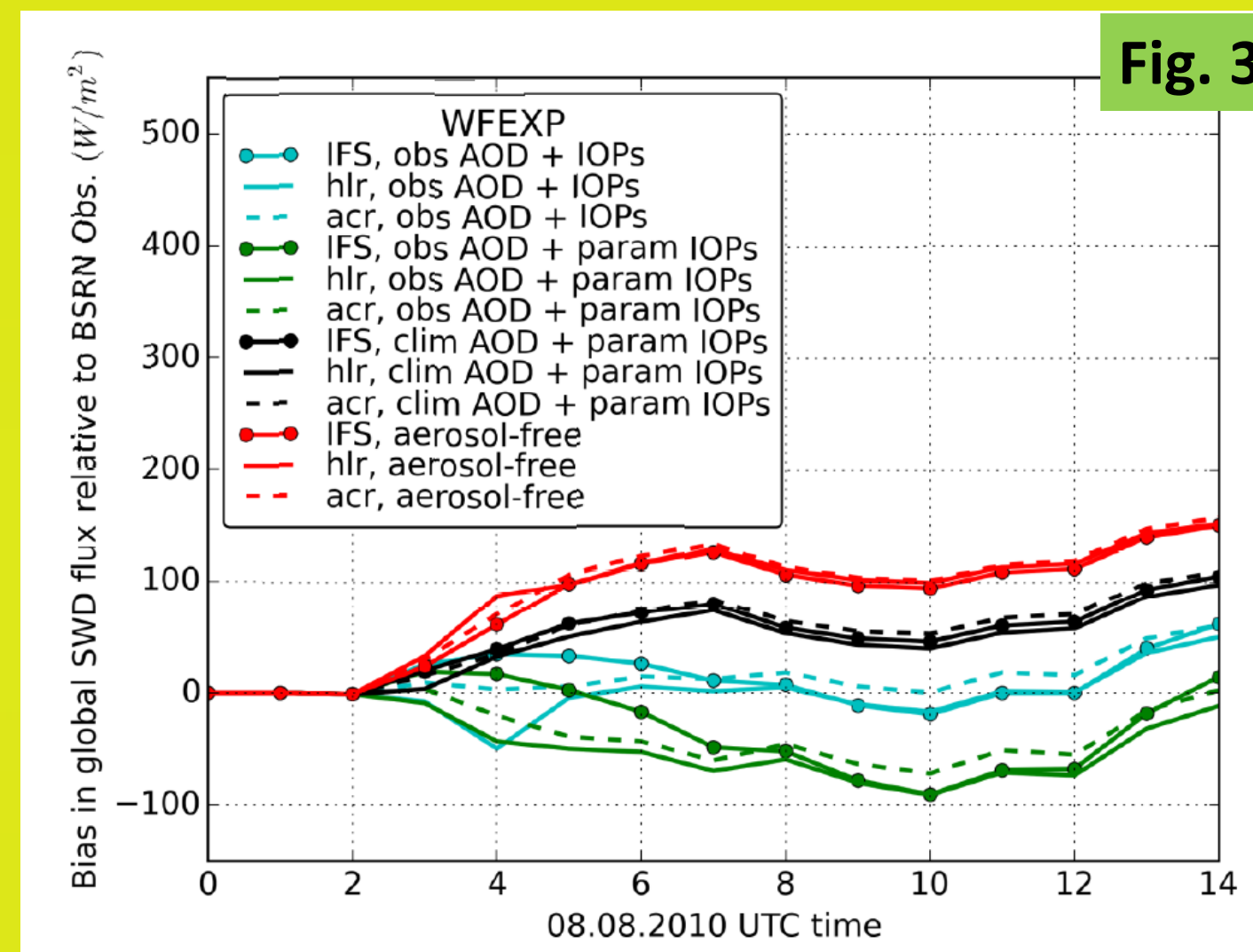


MUSC aerosol & radiation scheme experiments

(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.

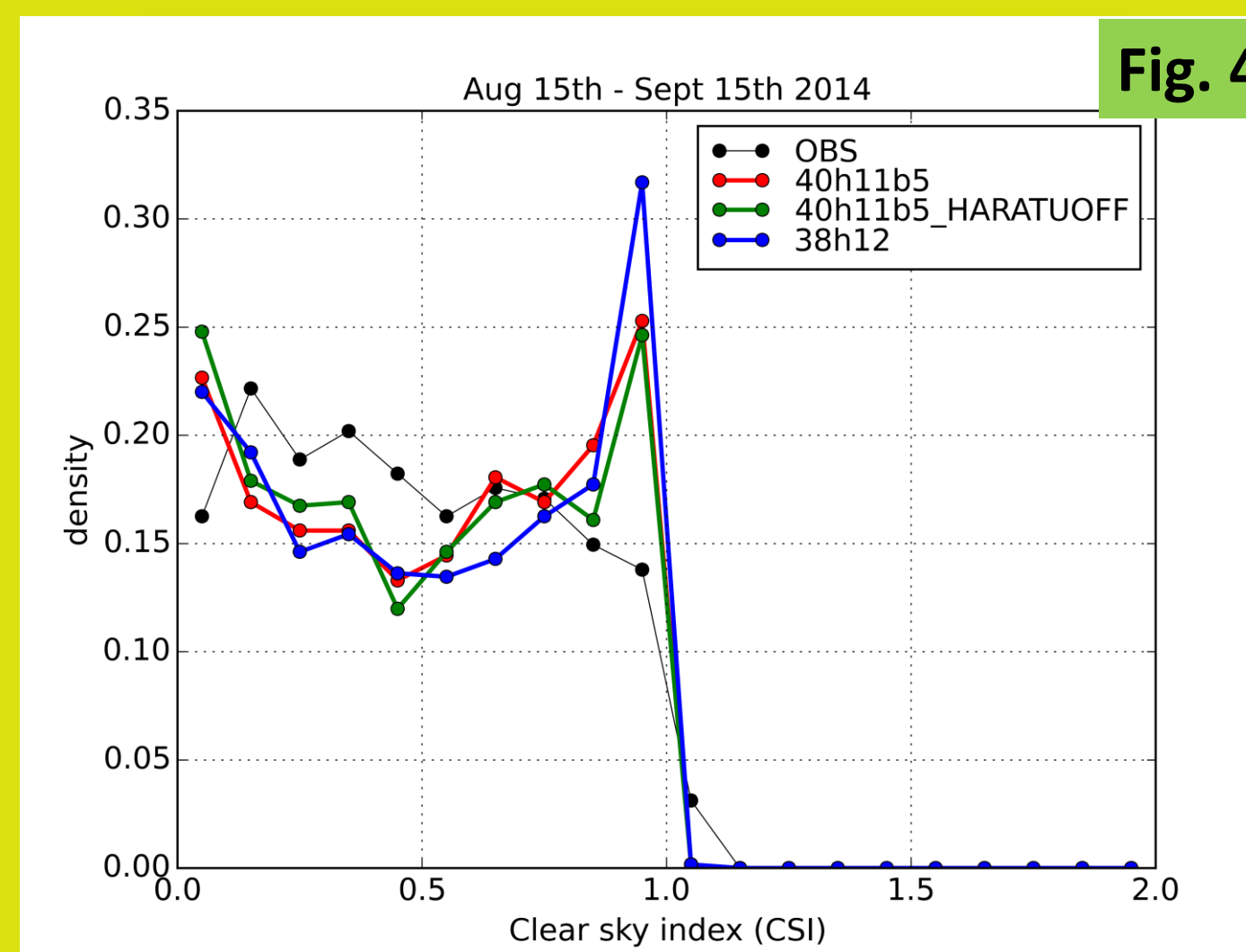
- Broadband schemes (HLRADIA, ACRANEB2) perform well when the broadband AOD is used instead of AOD550).



Radiation verification: CSI

(Gleeson et al., 2015)

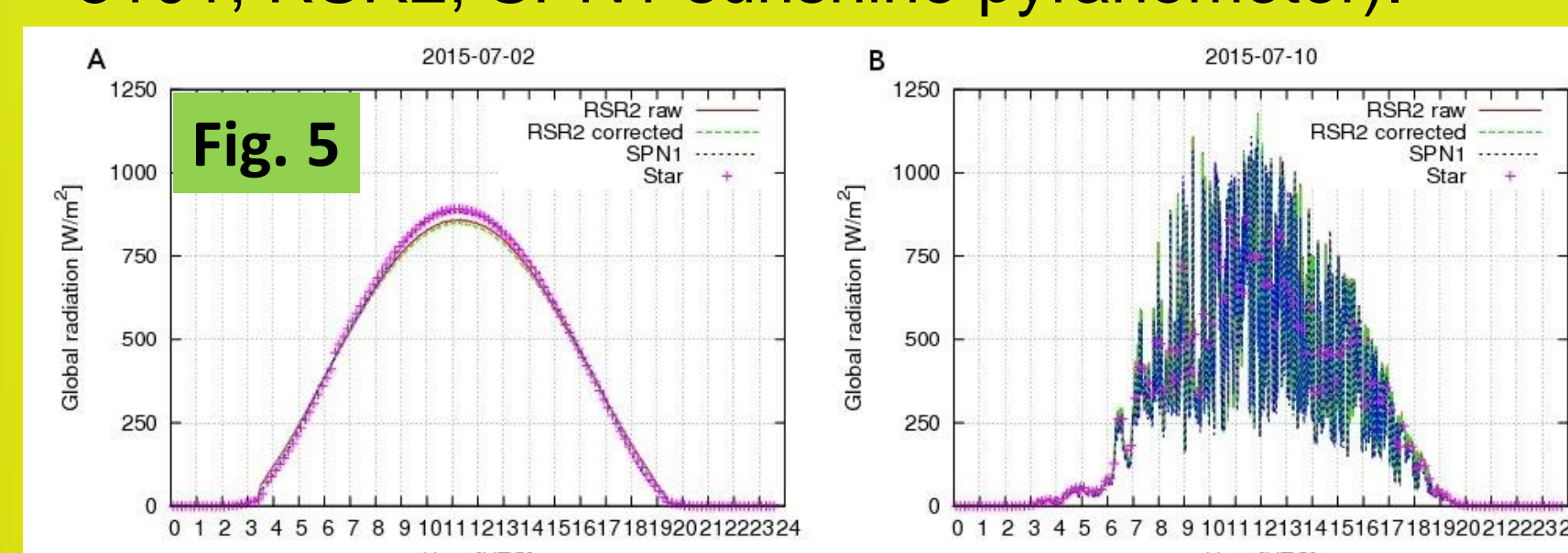
- Using measured SW fluxes to verify modelled clouds is an improved method of verification compared to the traditional method of using synoptic surface observations, where only the cloud cover, and not cloud water loads, is verified.
- We used the clear sky index (CSI) as a means of SW flux and cloud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



- Using CSI as a proxy for cloudiness highlights the binary (on/off) cloud cover in HARMONIE. This is evident in the 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

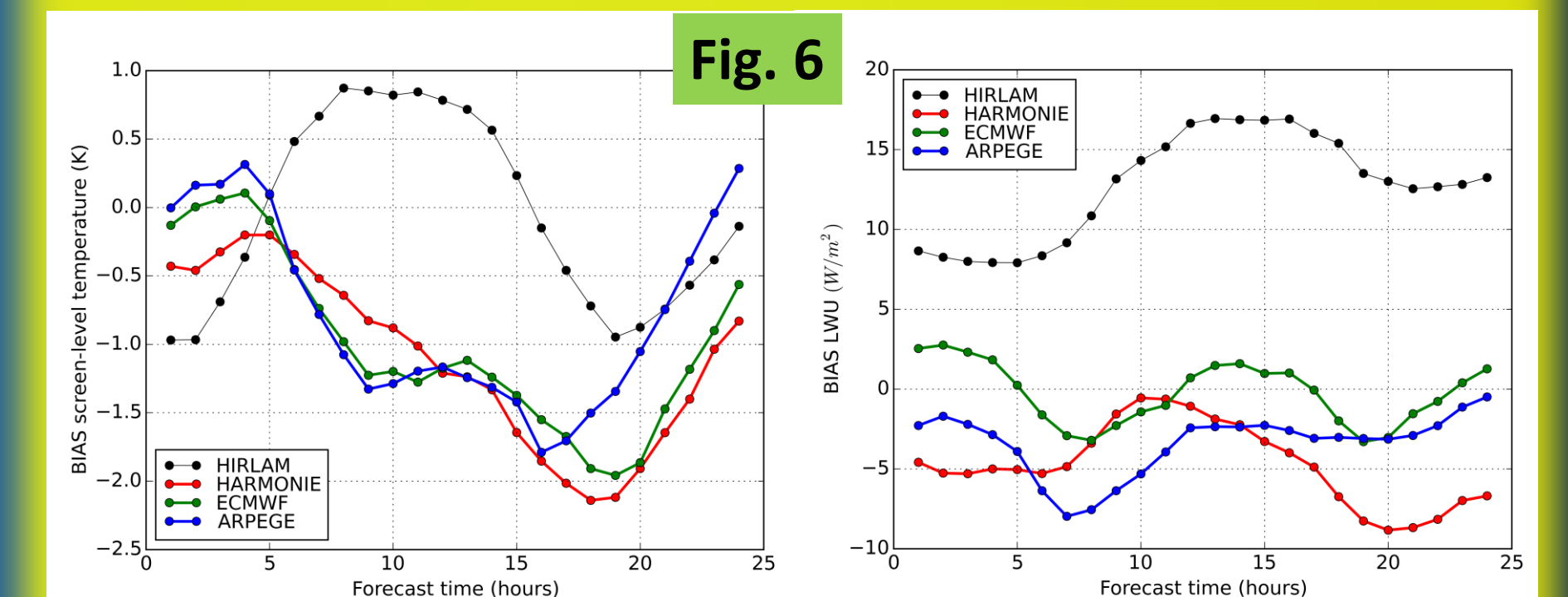
- Information on the variability of solar irradiance and illuminance is not obtained from standard RMSE/BIAS statistics.
- Stein et al. (2012) and Lorenz et al. (2016) have suggested two methods to quantify measured and forecast global irradiance variability.
- Lorenz et al. (2016) show that LAM models 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).



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 (Météo France) +1,+2,...,+24h forecasts are compared to observations.

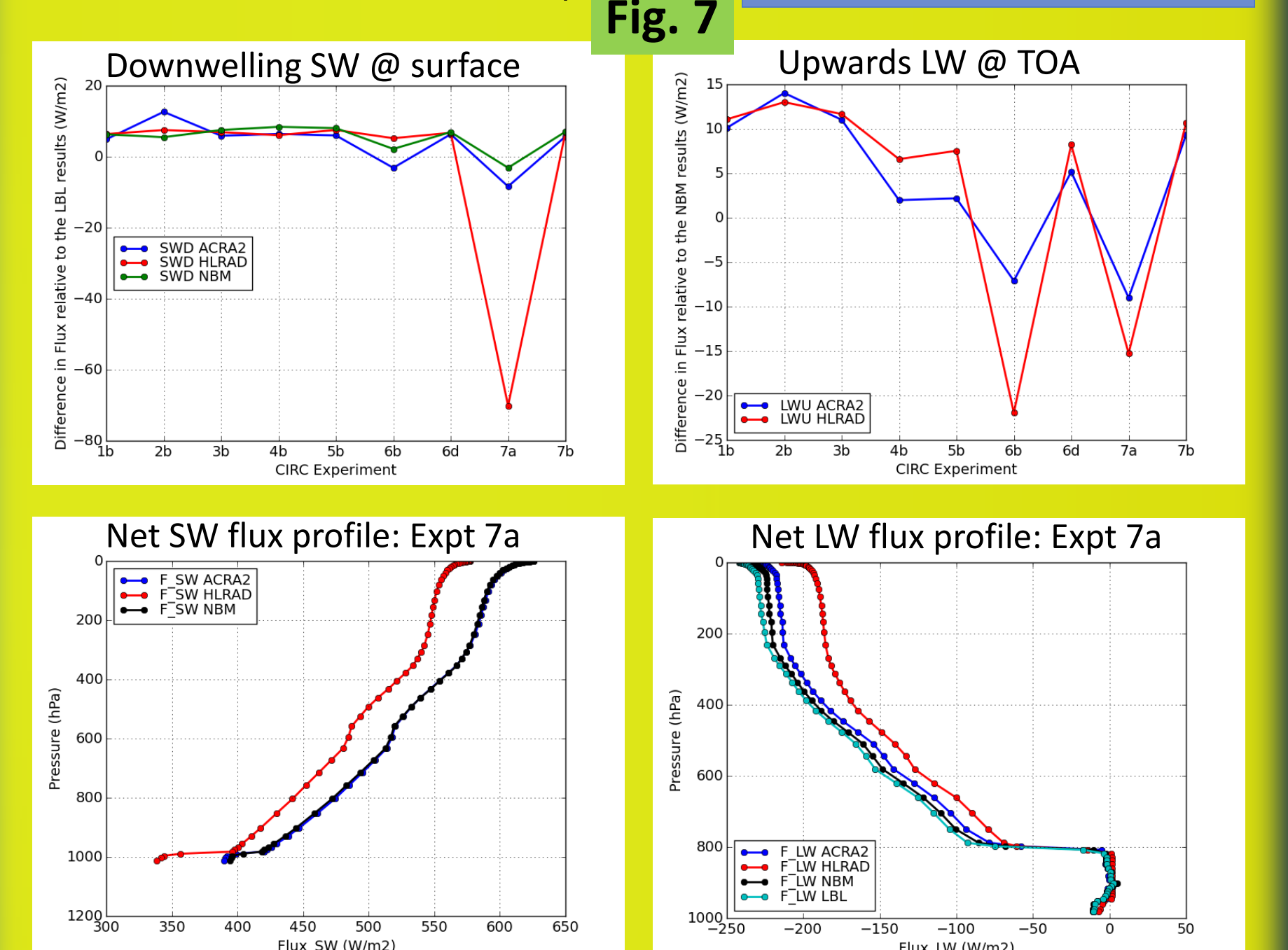


- During this period, HIRLAM systematically overestimates daytime LWU and T_{2m} whereas HARMONIE and Arpege slightly underestimate these parameters. The correspondence between LWU and T_{2m} is less clear for HIRLAM at night and IFS.
- Measured LWU represents cold conditions at a snow-covered point on open land whereas the model grid-squares cover up to 50 km² of pine forest. The grid-average (forest) T_{2m} from the models was compared to T_{3m} measured in the forest.

CIRC Experiments

- CIRC: Continual Intercomparison of Radiation Codes.
- <http://circ.gsfc.nasa.gov/>
- Considered the 9 CIRC test cases show in the table.
- Compared output from the following: HLRADIA, ACRANEB2, NBM (narrow band model), LBL (line by line model, CHARTS).

CIRC Experiment	
1b:	dry atmosphere, clear
2b:	very humid atmosphere, clear
3b:	humid atmosphere, clear
4b:	albedo=0.67, very dry atmosphere, clear
5b:	Same as 4b but with 2 x CO ₂
6b:	thick overcast liquid cloud, humid atmosphere
6d:	As 6b but clear sky.
7a:	moderately thin overcast liquid cloud, humid atmosphere
7b:	As 7a but clear sky



- Clear sky: HLRADIA competitive (SW & LW)
- Thick clouds (adjacent layers): HLRADIA is competitive with the other schemes.
- Thin clouds – large biases in HLRADIA fluxes/heating rates – cloud albedo related.
- Clouds with separate cloud layers – HLRADIA ok for SW but problems in the LW as HLRADIA accounts for cloud as a single layer but in reality there are strong exchanges between cold high clouds and warm low clouds.