Radiation Experiments and Developments

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Summary

What's new since the ASM in Lisbon?

- MarcoPolo aerosol experiments (FP7) **[1]**
- CIRC comparisons of radiation schemes
- Comparison of Tegen vs CAMS aerosols
- Working version of MUSC cycle 43
- Calling radiation subroutines intermittently vs calling them every time step
- Validation of HLRADIA using FMI archived operational data **[2]**

1. MarcoPolo Experiments

- As part of the FP7 project **[1]**: "MarcoPolo" aerosol experiments were run for a domain over China around Shanghai
- **Experiment 1:** HARMONIE-AROME cy40h1 default version
- **Experiment 2:** As above + MACC reanalysis aerosols converted to IFS aerosol categories
- **Experiment 3:** As above + Menon et al.. aerosol CCN/$r_{e,\,liq.}$ indirect effect
- **Strong impacts on convective events seen in experiments 2 & 3.** This is mainly due to the strong increase in urban aerosols which affects the temperatures (Fig. 1 & 2)

Fig. 1

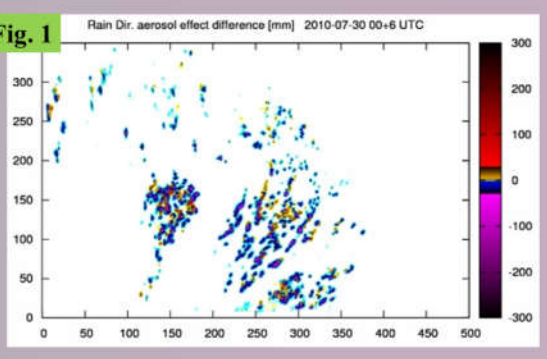


Figure 1: Changes (Exp. 2 - Exp. 1) in liquid precipitation due to the direct aerosol effect of MACC reanalysis aerosols.

Fig. 2

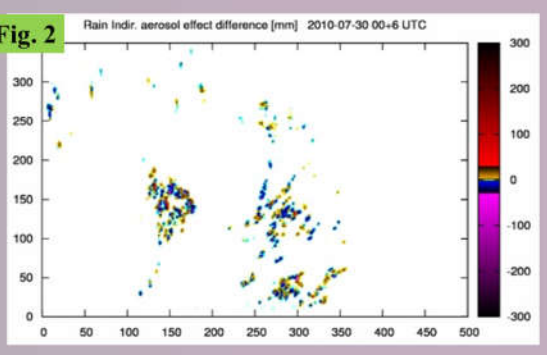


Figure 2: Changes (Exp. 3 - Exp. 2) in precipitation due to the indirect CCN effect of MACC reanalysis aerosols.

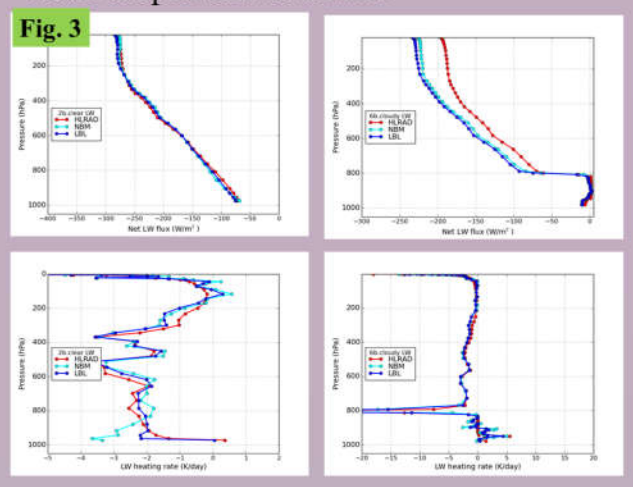
2. CIRC Experiments

- 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 HLRADIA, NBM (narrow band model) and LBL (line by line model, CHARTS) **[2]**

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 SW flux** is overestimated by HLRADIA at the surface and TOA (6-19 W/m^2) and atmospheric absorption is underestimated
- **Cloudy-sky SW flux** at TOA overestimated by HLRADIA (~20 W/m^2) – sensitive to how cloud droplet size is treated

Fig. 3

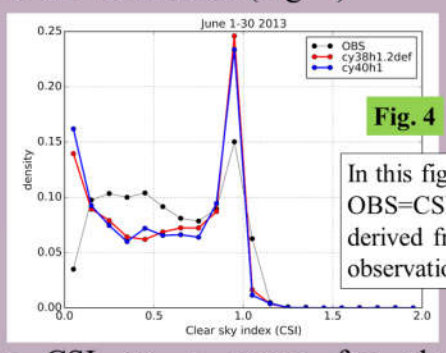


- **Clear-sky LW flux** errors are small at the surface (within 7 W/m^2). **Cloudy-sky LW flux** errors are small and positive (tuning needs investigation)
- HLRADIA strongly **overestimates the cloud LW radiative effect** at TOA
- Clouds with separate cloud layers – HLRADIA ok for SW but problems in the LW as the scheme accounts for clouds as a single layer but in reality there are strong exchanges between cold high clouds and warm low clouds

3. Radiation verification: CSI

- Using measured SW fluxes to verify modelled clouds is an improved method of verification compared to using synoptic surface observations
- In the latter only cloud cover is verified, whereas downwelling SW fluxes are an indirect measure of cloud water load and cloud microphysical properties
- We used the clear sky index (CSI) as a metric for SW flux and cloud verification (CSI is the global SWD radiation normalised by the estimated clear sky downwelling SW radiation) **[3]**
- Observations from 7 stations in Ireland were used in the verification (Fig. 4)

Fig. 4



In this figure OBS=CSI derived from observations

- Using CSI as a proxy for cloudiness highlights the binary (on/off) cloud cover in HARMONIE-AROME (Fig. 4)
- From a radiation view-point the differences between cycle 38 and 40 include:
  - Inhomogeneity factor (0.7 vs 1.0)
  - Nielsen cloud liquid optical properties
  - HARATU

4. CAMS Aerosols

- There are now 2 aerosol climatologies available in HARMONIE-AROME: Tegen (default **[4]**) and CAMS (Copernicus Atmosphere Monitoring Service)
- CAMS: AOD at 550 nm was derived using data from 2003-2011
- Relative to Tegen, CAMS land aerosols have a lower AOD over Northern Europe; the sea aerosols have a higher AOD (Fig. 5)

Fig. 5

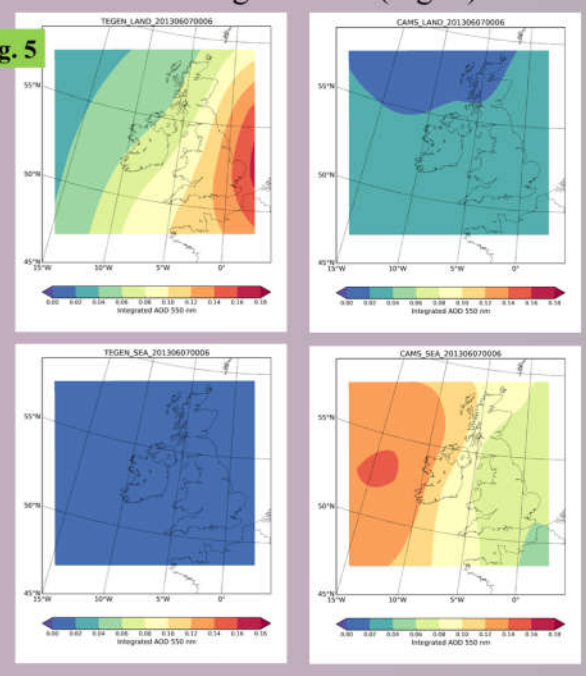
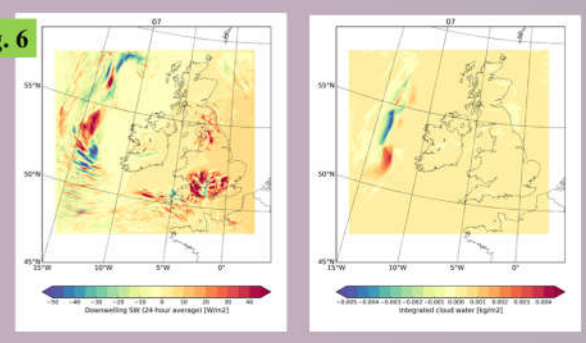


Fig. 6 shows the difference in global radiation and integrated cloud water when Tegen is replaced by CAMS aerosols

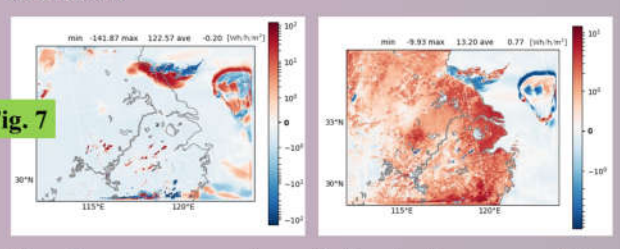
Fig. 6



5. Frequency of call to radiation physics routines

- 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

Fig. 7



- Fig 7: an example of the influence of the frequency of calling the IFS radiation scheme in a HARMONIE-AROME experiment
- Differences in average SW (left) and LW (right) downward surface fluxes over 1 hour from 0 to 1 UTC (8-9 am local time) on the 30th of July 2010 are shown
- Flux differences: radiation call every 15th time-step (default) minus radiation call every time-step

References: **[1]** Nielsen et al., "Relationship between air pollution and meteorology", Public report from the MarcoPolo FP7 project, 2017. **[2]** Rontu et al., ASR, 2017. **[3]** Gleeson et al., ALADIN-HIRLAM NL5, 2015. **[4]** Tegen et al., J. Geophys. Res. Atmos., 1997.