Testing new aerosol parametrizations in ACRANEB2 scheme

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- **Time:** 30/11/2022 - 16/12/2022
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1 Introduction

Having the new and different approaches for implementing near real-time aerosols into the model, one of the appropriate ways to test and compare them is using a single column model MUSC. All experiments so far were done in HARMONIE-AROME environment (cy46h1 branch) with the plan to make MUSC experiments also in AROME and ALARO.
Experiments were set in the new Atos HPC from the ECMWF. Besides of setting the MUSC experiment, Harmonie environment for 3D experiments has also been set and explained with all the tools.

2 Harmonie environment

Harmonie experiment is set up by executing two scripts. First it is useful to create a variable `$reflib` which is a path to the main code. Script `Harmonie` creates all the necessary folders and `Env_system` is setting up the environment.
Once the environment is set, the experiment can be run by adjusting `config_exp.h` - from `$reflib/ecf` which contains all the necessary definitions such as model geometry, climate files, physics switches (choosing between AROME and ALARO physics), assimilation etc.

`config_exp.h` definitions convert to namelist variables via two additional files, which may be manually edited if needed:

- `harmonie_namelist.pm` - from `$reflib/nam`
- `forecast_model_settings.sh` - from `$reflib/scr`

The experiment is then run by executing:

```
Harmonie start DTG=2021041900 DTGEND=2021042100
```

For running Harmonie 3D and MUSC experiments the same forecast model and tools are used. MUSC experiment can be made from the 3D one by adjusting the namelist to run the model only for one column (4 gridpoints). In the namelist LMUSCLFA should be set to True. Namelist NAMLSFORC, which will be read only if LSFORC is True, can be adjusted for different forcings.
The detailed description of the whole Harmonie system can be found on Hirlam wiki page in github:
https://hirlam.github.io/HarmonieSystemDocumentation/dev/

3 Testing different aerosol parametrizations in radiation

Treating aerosols for the radiation includes several steps:

1. having the inherent optical properties of the aerosols
2. spectral averaging of these properties
3. averaging over the aerosol mixture with the respect of humidity (hydrophilic aerosols have different properties depending on the relative humidity)

In the Harmonie side, there are already existing tools and scripts, while the new modset based on cy46t1 was made by Ján Mašek (details about it can be found in the report from my stay in Prague). In Table 1 there are enlisted different sources and scripts for the three steps mentioned above.

Table 1: Names of the scripts and tools used in Harmonie side and in the new modset made by Ján Mašek for the aerosol optical properties (1.), spectral averaging (2.) and averaging over aerosol species (3.)

	HARMONIE	**NEW MODSET**
1.	ASCII file RADAIOP	netcdf file
2.	SUAIOP	SUAERO
3.	AEROPT	RAD_AER_MMR

New modset contains also new module (YOMAERO) and new namelist (NAMAERO) through which it is possible to choose which aerosols from the netcdf file to use (variable MAP_AERO_GFL).
To compare only averaging routines, changes were made in SUECRAD (calling SUAERO instead of SUAIOP) and in APL_AROME to use in ACRANEB2 results from RAD_AER_MMR instead of AEROPT. MMRs used for averaging in RAD_AER_MMR were GFL fields containing MMRs already existing in Harmonie.
Testing was made for two cases:

- 23^{rd} of February which represents Saharan dust intrusion,
- 19^{th} of April which is a clear-sky case.

For each of the cases, four experiments with different aerosol treatment were performed:

- az - zero aerosols,
- at - Tegen aerosols,
- am - climatological MMRs,
- an - near real-time MMRs.

The reference was Harmonie run using RADAIOP ASCII file with properties, subroutines SUAIOP and AEROPT for spectral and averaging over aerosol types. Eleven aerosols are used both in radiation and in microphysics (Table 2). In all the figures with results, variable shown is shortwave radiation at the surface. In Figure 1 there are eight lines shown, the upper four are for April clear-sky case and the lower four are for February dust intrusion case. It is obvious that clear-sky case has more shortwave radiation at the surface. From the four aerosol treatment experiments, zero aerosols has the most shortwave radiation passing through the atmosphere while Tegen aerosol experiment has the least. For the February case Tegen has also the least, but near real-time has the most.

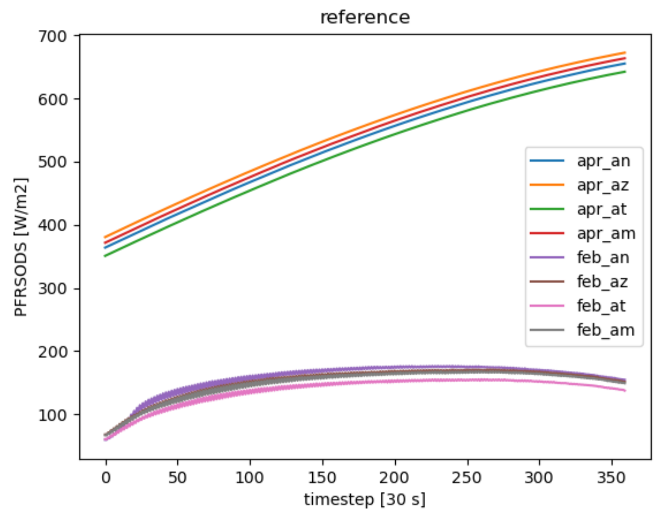

Figure 1: April and February cases for the reference run

First step in the comparison was to run the new modset, choosing zero aerosol in the NAMAERO namelist (Figure 2).

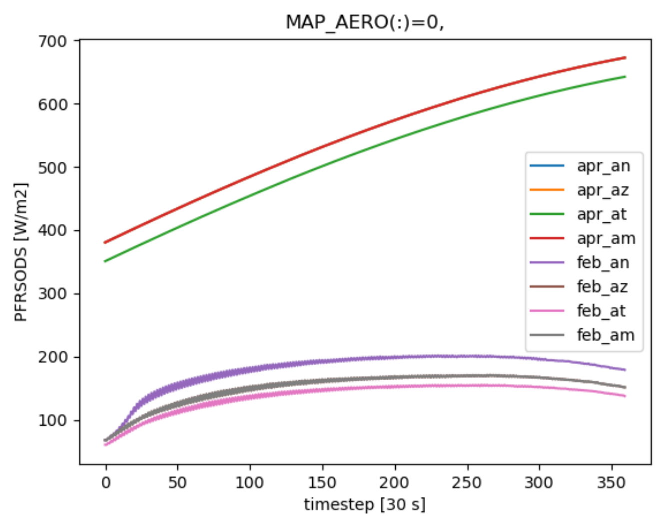

Figure 2: April and February cases for the new modset choosing to use zero aerosols in radiation

Comparing the results when not using MMRs (zero and Tegen), they are the same as for the reference run. Climatological MMRs experiment, am, for both February and April cases corresponds to the zero aerosol experiment because we set in the namelist not to use any aerosols (MAP_AERO_GFL=0). This is not valid for the near real-time experiment in the February case. When using near real-time aerosols, they are also used in microphysics even if we are not using them in the radiation scheme. This is the reason for different values of shortwave radiation between the experiments zero and near real-time aerosols. Confirmation that the difference comes from the microphysics is that for the clear-sky case az, an and am have all the same values of the shortwave radiation.

Next step was choosing the same aerosol types as used in the reference run. For the same 11 aerosol types (Table 2), optical properties will be taken from the netcdf file, while in the reference run they were taken from the ASCII RADAIOP file. MMR fields are the same as in the reference run.

Table 2: connecting aerosols to aerosol_ifs_rrtm_46R1_with_NI_AM.nc via mapping

GFL name	description	netcdf file number
SS1	sea salt (0.03 - 0.5 μm)	-1
SS2	sea salt (0.5 - 5 μm)	-2
SS3	sea salt (5 - 20 μm)	-3
DD1	dust (0.03 - 0.55 μm)	1
DD2	dust (0.55 - 0.9 μm)	2
DD3	dust (0.9 - 20 μm)	3
OM1	hydrophilic organic matter	-4
OM2	hydrophobic organic matter	10
BC1	hydrophilic black carbon	11
BC2	hydrophobic black carbon	11
SU	sulphate	-8

In Figure 3 are shown results after running experiments with MAP_AERO_GFL set according to Table 2.

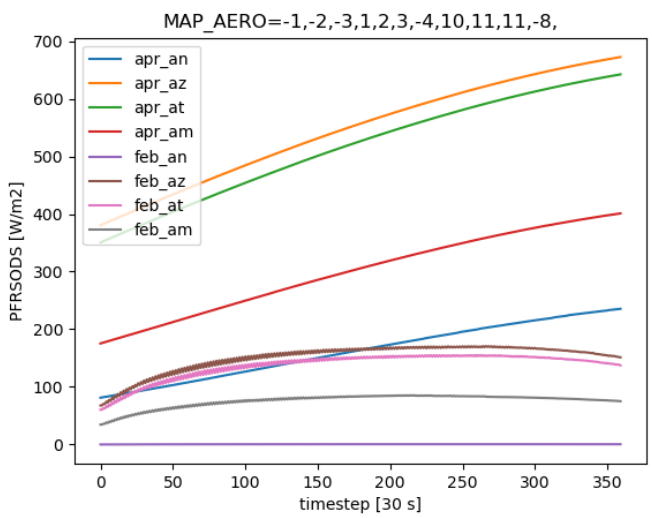

Figure 3: April and February cases for the new modset choosing to use the same aerosols like in the reference run

Results from Figure 3 for experiments when using MMRs (an and am) are unphysical. Too little shortwave radiation is reaching the surface. For near real-time aerosols (an) February case, shortwave radiation is close to 0.

To see the impact of choosing different aerosols, a few additional choices were made. One of them, using only three hydrophilic aerosols (sea salt for three size bins), is shown in Figure 4.

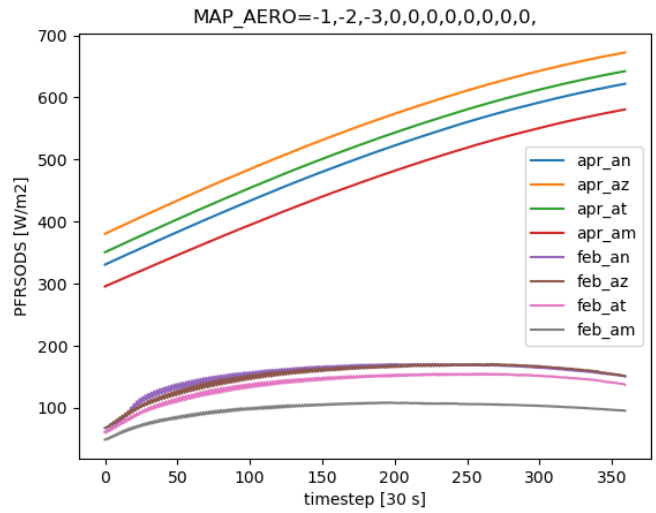

Figure 4: April and February cases for the new modset choosing to use only sea salt aerosols

Similar results with too little shortwave radiation reaching surface are obtained even from choosing only one aerosol type when there is no averaging.
Based on the investigated results, one of the problems might be in the usage of the inherent optical properties. They should be compared with the ones from the ASCII file, vertical profiles of the properties can be plotted.

4 Conclusion

The new modset and already existing subroutines for spectral and averaging to get aerosol mixture have been compared. Aerosol inherent optical properties are taken from the netcdf file and not from the already used ASCII file. Results show big difference and non-physical behaviour for the new modset. Regarding the results, problem might arise from the difference or wrong usage of the optical properties. There should be further investigation focused on comparing and analyzing inherent optical properties.
One part of the stay was dedicated for more technical topics. Harmonie environment on the ECMWF HPC has been set up. It will be useful to be able to run Harmonie 3D experiments for comparing the results and test new developments in different canonical model configurations.

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