Reference computations for solar and thermal radiation

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Background: The ESCAPE-2 project

ESCAPE-2 will develop world-class, extreme-scale computing capabilities for European operational numerical weather and climate prediction systems

Partners include: ECMWF, the Belgian RMI and the French CEA

Uncertainty quantification (UQ) is essential for code optimization, e.g. how is the UQ of radiation parametrizations compared to single precision computations?

In order to quantify the uncertainty of radiation computations a reference is needed.

Radiation reference model: DISORT

- **50 test profiles from around the world are used**
- **Specifically the 47 layer CKD-MIP profiles from Hogan (2020)**
- **For thermal (LW) radiation 6 CO_2 scenarios for each profile are used: 140, 280, 415 (current), 560, 1120 and 2240 ppm.**
- **Current values are used for the other greenhouse gases:** 1921 ppb CH_4, 332 ppb N_2O, 495 ppt CFC-12 and 861 ppt CFC-11 (Hogan & Matricardi 2019). The 861 ppt of CFC-11+ include equivalents of all other greenhouse gases. These "other greenhouse" gases are mostly not modelled explicitly in current weather and climate models.
- **DISORT is run with 30 streams spanning the zenith angles, and 4326 solar (SW) spectral bands, and 648 LW spectral bands.**
- **Liquid and ice cloud water and effective radii are included.**
- **Aerosols are not included in these reference computations, but this could be done if needed.**
- **Solar constant: 1365 W/m^2 – to be consistent with ACRANEB2.**

More about the CKD-MIP profiles

- **The 50 profiles are distributed across the world from Antarctica to the Tropics.**
- **They are picked to be representative also for extreme atmospheric conditions that may occur.**
- **The skin temperatures range from 201 K to 318 K.**
- **The surface pressures range from 586 hPa to 1033 hPa.**

Results and discussion

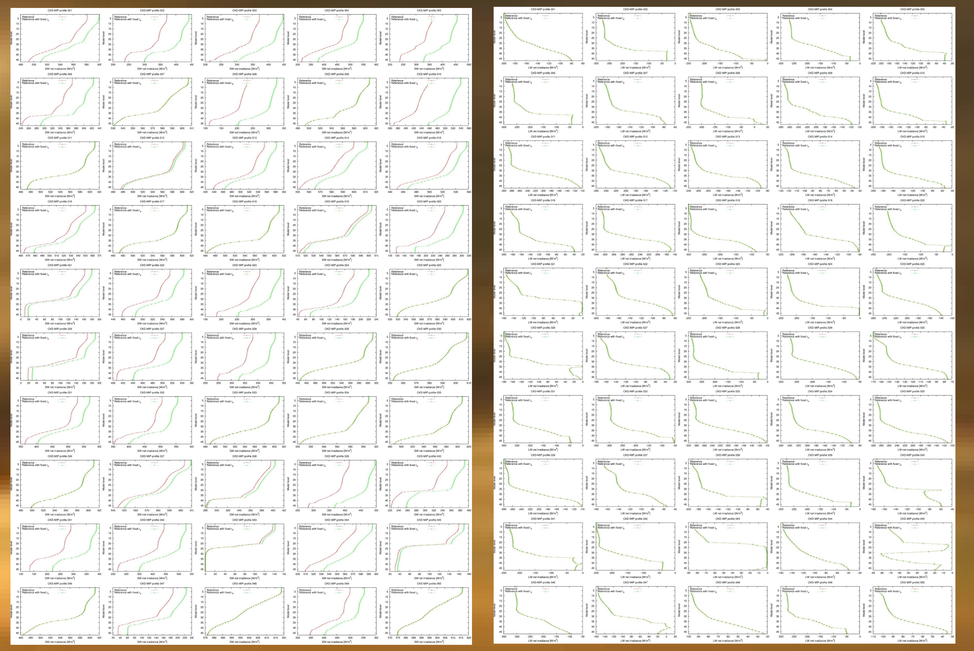

Figure 1. **Left**: The 50 SW (solar) CKD-MIP reference profiles. The SW Net flux profiles are shown as a function of the model levels, which are on the y-axis.
Right: The 50 LW (thermal) CKD-MIP reference profiles for the "current" CO_2 concentration of 415 ppm. The LW Net flux profiles are shown as a function of the model levels, which are on the y-axis.
The red curves in the plots show the reference computations when the cloud liquid efficient and cloud ice equivalent radii are accounted for.
The green curves in the plots show the reference computations when the cloud liquid efficient radius is fixed at 10 µm, and the cloud ice equivalent radius is fixed at 50 µm.

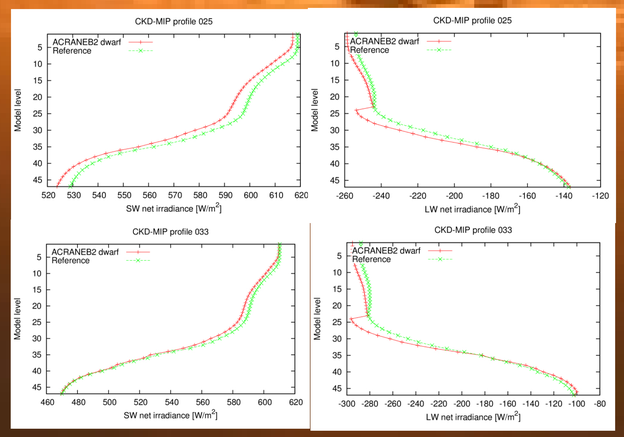

Figure 2. Enhanced comparisons of the reference flux profiles (green curves) with ACRANEB2 computations (red curves) for 2 selected clear sky profiles.
Top: Profile 25. **Bottom**: Profile 33.
Left: SW net fluxes. **Right**: LW net fluxes.

In figures 1 and 2 the fifty test profile computations and a comparison with ACRANEB2 for two of these can be seen. In figure 1 computations for fixed cloud droplet effective radii are added. These show differences of up to almost 50% relative to the main reference computations in cloudy cases.

In figure 2, two preliminary comparisons to ACRANEB2 SW and LW computations are shown. These are for clear sky conditions in Europe. The SW net flux differences are less than 1% for these cases. For the more extreme profiles, the differences are larger. The jump in the ACRANEB2 LW results at level 25 (approx. 200 hPa) needs to be checked further.

Data availability

These radiation flux reference data are available to anyone interested.
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