Motivations

1. Current climate models and numeric weather predictions (NWP) assume blackbody surface ($ε = 1$) in the longwave radiation schemes.
2. In reality, the surface spectral emissivity, which is a function of both zenith angle $θ$ and wavenumber $v$, has non-negligible impact on the radiation budget, especially in Polar regions (Chen et al. 2014).
3. Quantify the errors due to the representation of surface emissivity in mainstream radiation schemes.

Emissivity

Different ways of the representations of the spectral emissivity for two types of surface.

LBLRTM and RRTMG_LW

1. A line-by-line radiative transfer model (LBLRTM) version 12.2 is used as benchmark.
2. The RRTMG_LW model utilizes the correlated-k approach to calculate fluxes and the radiative cooling rates.
3. The RRTMG_LW is one of the most widely used longwave radiation scheme in current weather and climate models.

Possible error sources of the RRTMG_LW

1. Ignoring the angular dependence of surface emissivity.
2. Approximating spectrally varying surface emissivity with band-averaged surface emissivity.
3. Approximate method for solving the radiative transfer equation.

Methodology

1. Compare the radiative cooling rates calculated by the LBLRTM using different representations of surface emissivity.
2. Compare the radiative cooling rates calculated by the RRTMG_LW and by the LBLRTM.
3. Four atmospheric profiles are used: mid-latitude summer (MLS), subarctic winter (SAW), tropical (TROP) and Sahara desert (SAHARA) profiles.
4. Two types of surface are applied: ocean and desert.

Case definitions

<table>
<thead>
<tr>
<th>LBLRTM</th>
<th>Case0</th>
<th>Case1</th>
<th>Case2</th>
<th>Case3</th>
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</thead>
<tbody>
<tr>
<td>RRTMG_LW</td>
<td>N/A</td>
<td>N/A</td>
<td>Case1</td>
<td>Case3</td>
</tr>
</tbody>
</table>

Three atmospheric profiles are used: mid-latitude summer (MLS), subarctic winter (SAW), tropical (TROP) and Sahara desert (SAHARA) profiles.

Qualifications Of The Errors Associated With The Representation Of Surface Emissivity In The RRTMG_LW

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