Requirements for accurate radiative transfer simulation to support vicarious calibration

Yves Govaerts and Vincent Leroy Rayference

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This work is founded by the MetEOC-3 project
Radiative transfer models play a critical role for vicarious calibration;

Instruments like S2/MSI have proven to have a radiometric accuracy close to 2-3%;

What is expected simulation accuracy with current RTMs over CEOS calibration sites: 1%, 3% or 5%?
Experimental Setup

- Acquisition of TOA BRF over Libya-4 acquired by (PICSCAR)
  - Envisat/MERIS
  - AQUA/MODIS
  - S2A/MSI
  - L8/OLI

- Simulation of these TOA BRF with 3 different RTM fed with the same surface and aerosol properties (Govaerts et al., 2004, 2013)

<table>
<thead>
<tr>
<th>Code</th>
<th>RTE solver</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>6S-V</td>
<td>Successive order</td>
<td>Hitran96</td>
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<tr>
<td>LibradtranV2</td>
<td>Monte Carlo</td>
<td>Hitran2012</td>
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<td>RTMOM</td>
<td>Matrix Operator</td>
<td>Hitran96</td>
</tr>
</tbody>
</table>
Libya4 : S2A_MSI SZA : 0 – 30

100(OBS - SIM)/SIM

Wavelength (μm)

siksV1_1
libradtran2
rtmom

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AQUA/MODIS

Libya4 : MODISA

100(OBS - SIM)/SIM

Wavelength (µm)

sixsV1_1
libradtran2
rtmom
Envisat/MERIS

Libya4 : MERIS

REL STD DEV (%)

Wavelength (μm)

sixsV1_1
libradtran2
rtmom
ZSA < 30

MERIS 412 band

SIXS-V
Libradtran
RTMOM
MERIS 885 band

ZSA < 30

SIXS-V
Libradtran
RTMOM
BACKGROUND

- Radiation transfer models (RTM) is the only way to understand EO observations;
- There is a need to have an accurate consistency between ground observations (GO), RTM and EO data.
TOWARD A 1% RTM ACCURACY

- Surface BRF: accounting for topography (e.g., oriented sand dune);
- Molecular absorption: account for species like O4;
- Rigorous calculation of the coupling between:
  - Surface reflectance and atmosphere scattering;
  - Aerosol scattering and molecular absorption;
- Polarization, non flat earth for large zenith angles;
- Improvement of the surface and atmospheric property characterization;
NEW 3D RTM

- In the Framework of the MetEOC-3 project, Rayference will initiate the design of a new open-source community 3D RTM to support CalVal activities;

- This new 3D RTM will include the following main features:
  - Simulation of satellite observations in the VIS, NIR and thermal IR spectral regions;
  - Simulation of ground observations;
  - Simulation of laboratory experiments.
GENERAL CONCEPT

- Based on the recycling of a state-of-the art Monte Carlo Ray Tracer;
- Open source, community model;
- Includes best features of existing 1D and 3D RTMs;
- Includes standard scenes and 3D scene generators;
- Includes water, atmosphere, snow, ice, …;
- Extensively evaluated with rigorous protocols.
PHYSICAL PROCESSES

Possible new features might include

- Polarization;
- Thermal emission;
- Propagation of the phase (coherent back scattering);
- Inelastic scattering (fluorescence, Raman scattering);
- Specific instruments (not BRF at the infinity);
- ....
REQUIREMENTS

- Physical processes to be simulated;
- Scene types (atmosphere, surface, water, ice, ...);
- MMI (levels according to applications and users);
- Interface with existing models, data-base.
- Measurement types;
- Expected accuracy;
- Validation protocol.

If interested, please contact vincent.leroy@rayference.eu
MILESTONES

• A first beta version of this new 3D RTM is expected to be released in 2020 with the core functionalities implemented;

• A limited series of test/demonstration cases (targets) will be developed during that phase;

• The code will be available for contribution in 2021;

• Expected to be fully developed, documented and validated in early 2022.
CONCLUDING REMARKS

- Feedback from this community for the requirements is welcome (vincent.leroy@rayference.eu);
- There is an opportunity to include a 3D characterization of a CEOS PICS or RadCalNet target;
- Targeted accuracy around 1%.