Minutes: ITT 5433/07/NL/HE – Towards a Generic Radiative Transfer Model for the earth's Surface – Atmosphere System: ESAS light

Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Minutes-Nr.	Meeting	Organisations.	Date	Meeting place
02	ESAS light	ESA, DLR	09.06.2008	Oberpfaffenhofen Germany

Arbeitssitzung/Besprechungsthema

Minutes of the 1st progress meeting of ESAS light

Start: 10:15

End: 17:45

Meeting leader	Telefon-Nr.	Minute taker	Telefon-Nr.	Invitation and Agenda from
		Ulrich Hamann	+49 08153 28 1797	02.06.2008

Meeting participants — absent with valid excuse — Additional distribution list

Marc Bouvet (MB), ESA
Bernhard Mayer (BM), DLR
Claudia Emde (CE), DLR
Ulrich Hamann (UH), DLR
Arve Kylling (AK)

Agenda

1. Introduction
2. Review of the actions from negotiation meeting and telecons
3. WP1100 Literature review
4. WP1200 Survey of ESA missions
5. WP1300 Requirements for libRadtran
6. WP1400 Requirements for future evolution of libRadtran
7. Discussion of libRadtran requirements
8. Miscellaneous
9. Action items

0. Preliminaries

1. Acceptance of the last minute

The last minute was already accepted before this meeting.

2. Minutes

Introduction by BM

BM briefly introduced the structure and objectives of the Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), in particular of the Institut fuer Physik der Atmosphaere (IPA).

Review of the actions from negotiation meeting and telecons

All points were closed, except providing a table of which solver shall be able to simulate which feature, which was discussed during this meeting.

WP1100 Literature review

CE gave an overview over existing radiative transfer models. A list of the models is provided at the project page of ESAS light (http://esaslight.libradtran.org/internal/Wiki/doku.php). Raman-scattering and polarisation are simulated only by a few models. libRadtran, including the intended changes, fulfills the demands of the ESAS light project.

Comment by BM:
There will be a future radiative transfer code intercomparison: CIRC (Continual Intercomparison of Radiation Codes, http://climate.gsfc.nasa.gov/CIRC/) where libRadtran will participate.

Comment by MB:
Hydrolight (http://www.sequoiasci.com/products/rad_Hydrolight.aspx) is regarded as a standard in the ocean color community, which provides optical data for ocean constituents.

Comment by AK:
COART is a coupled atmosphere-ocean radiative transfer model, which, according to information on its web-side (http://snowdog.larc.nasa.gov/jin/rtnote.html), is planed to become freely available.

Discussion concerning *line-by-line* models:
Clarification: In order to do line-by-line simulations with libRadtran, the absorption cross-sections have to be provided to libRadtran. There are sophisticated and freely available programs like RFM, MIRART, and ARTS, which convert spectral data bases like HITRAN or GEISA (both constantly updated) to absorption cross-section spectra. Currently libradtran uses genln2 for this purpose. However, genln2 is not updated any more and is not very user friendly. During this project a more convenient program shall be chosen in order to provide these input data to libRadtran. Requirements to the line-by-line model are accuracy, user friendliness and that is open source. The computational speed should be faster than the solution of the radiative transfer equation. The decision which line-by-line model to be used, will be made before the next meeting.

CE gave an overview of input data bases usable by libRadtran
The parametrisation of *clouds* in libRadtran is already state of the art. For water clouds Mie theory can be applied. For ice clouds Key, Baum, and Fu parameterisations are implemented. The Baum parameterisation is the most sophisticated one, as it provides phase functions as well as uses a realistic mixtures of ice crystal habits.

Aerosol data bases are GADS and OPAC. Using Mie theory and the wavelength dependent complex refractive index a data base of optical properties will be generated.

Surface data bases
It is already possible to use spectral albedo as input data in libRadtran; several data bases can already be included. Several BRDF parameterizations are already available in libRadtran, including RPV (land surfaces), AMBRALS (land surfaces, used by MODIS), Cox and Munk. Further angular models will be included, in particular those which are required for operational products like MODIS and POLDER for land surface. For ocean surfaces the BRDF models of Ebuchi will be implemented.

Comment by MB:
The RAdiation transfer Model Intercomparison (RAMI, http://rami-benchmark.jrc.it/HTML/Home.php) is an intercomparison of explicit modeling of BRDFs. The scales used in this intercomparison are usually smaller than these used by libRadtran, but the output of the RAMI codes may be used as input to libRadtran.

Solar spectrum
It is possible to use different solar spectra in libRadtran. A default spectrum shall be provided for the complete solar spectral range (0.2 micron to 5 micron) which is composed of different spectra, following recommendations in the literature. The spectrum by Thullier is used in several ESA missions, and shall therefore also be included.

A detailed overview of these points is provided in the WP1100 report and the ESASLight Wiki.

WP1200 Survey of ESA missions

CE gave an overview over ESA's current and future missions. Requirements of forward modeling are:

Simulation of passive instruments: imagers and spectrometers.
Most important developments of libRadtran are polarisation, Raman scattering, surface BRDFs, line-by-line simulations, and consideration of spherical geometry.

Simulation of active instruments: lidar.
For this purpose a single scattering lidar simulator shall be added to libRadtran. The development of a general lidar simulator is beyond the scope of ESAS Light, but DLR has a strong interest in developing such a tool.

A detailed overview of these points is provided in the WP1200 report and the ESASLight Wiki.

WP1300 Requirements for libRadtran

The Monte Carlo code *MYSTIC shall be made freely available* at the end of the project, including all developments in the framework of ESASLight. In particular, the freely available version of MYSTIC shall allow

- 3D simulations in a plane-parallel atmosphere, with
- horizontal variations of water and ice clouds, including polarization
- simulations in a spherical shell atmosphere, with the atmosphere
- varying in the radial direction

A demo version of MYSTIC shall be made available for ESA together with the demo version of the toolbox.

Clarification: Calculation of transmission and reflectivities is already possible in libRadtran, in addition to irradiance and radiance.

MB strongly emphasises ESA's wish for a *GUI*. LibRadtran contains more than 200 input options which interact with each other. Thus, the design of a GUI including all input possibilities requires considerable work. Therefore the first version of the GUI shall contain only a limited set of input options which will help new users to get started with libRadtran. It was agreed that one of the main benefits of such a GUI would be to help the user set up the input file for a specific problem, and then use this a basis for further calculations. CE presented some software tools suitable for the design of a GUI. A strong requirement for the selection of the design software is the availability of a plotting package to allow visualization of input and output. Also, the tools need to be available at least under Linux, Windows, and Mac. A more detailed concept of the GUI development including a recommendation for the software environment shall be presented at the next progress meeting.

A detailed overview of the requirements is provided in the WP1300 report and the ESASLight Wiki.

WP1400 Requirements for future evolution of libRadtran

The *BRDFs* implemented in this study do consider wind speed, salinity, and chlorophyll. In order to simulate ocean color even more input parameters like sediments would be desirable. Within the scope of ESAS Light, the water surface shall be considered as the lower boundary of the model domain and shall be described by a BRDF. Radiative transfer into water bodies is very important but also very challenging and was put on the list of future requirements.

In this study, a *single scattering lidar simulator* shall be developed. In future, a lidar simulator which also account for higher orders of scattering should be developed.

Radiative simulations on Mars and Titan have already been made with libRadtran. Up to now such simulations require the user to provide the description of the atmosphere manually, e.g. by means of providing an explicit Rayleigh scattering cross section because libRadtran by default assumes "air" as scattering molecules and the Rayleigh cross section of the CO2 which makes up the Martian atmosphere is quite different. Future development may include *more user friendliness for simulations on other celestial bodies*, in particular Mars and Venus.

The calculations of *Jacobians* is currently not supported. In principle, those may be calculated with several calls to libRadtran but numerical noise of the solver (disort, and in particular Monte Carlo) may prevent this approach. In future, a solver which can calculate Jacobians is desirable.

A detailed overview of future requirements is provided in the WP1400 report and the ESASLight Wiki.

Discussion of libRadtran requirements

Cleaning and restructuring
The self test of libRadtran will be split in a user test, a more detailed developer test, and a very extended permanently looping consistency test. As libRadtran is under constant development, also cleaning and structuring of the code are continuous tasks. This work package will contain homogenisation of the code, the description of functions, and some changes in order to reduce the demand concerning memory which is still a critical issue e.g. for spectral calculations involving Mie phase functions for clouds.

In oder to improve the *user friendliness* the verbose output shall be improved.
The installation of libRadtran is already very user friendly on Linux and Unix machines, that is, downloading, configuration to your system, compiling the code, and checking the installation, which can be done with a few commands. The provision of binaries would be very laborious because binaries for many different operating systems would be required (Windows XP and Vista, Macintosh, and many flavours of Unix and Linux). It is therefore not intended to provide binaries but rather to improve the installation documentation.

A *Wiki page for users* shall be installed where users may discuss problems and contribute knowledge. This might also contain an installation guide for libRadtran on a number of computer systems, where users may contribute.

AK gave a introduction to *Raman scattering* and described how it will be implemented in libRadtran by an iterative process.

There is no need to adapt the contract between ESA and the DLR because the developments during ESASLight will be Open Source at the end of the project.

Miscellaneous

MB suggested that the libRadtran home page might be ripe for an overhaul. The libRadtran developers had no objections to that and welcomed the suggestion. The design and look of a new libRadtran home page will be discussed at the next meeting.

Action items:

- UH provides the minutes for this meeting.
- CE updates the reports considering the comments of this meeting.
- CE creates tables in matrix style of:
  - RTE solvers of libRadtran against applicable options
  - EOS missions against requirements
- CE and BM install a Wiki for libRadtran users.

Additionally the implementation plan of the GUI and the coupling with the line-by-line model was mentioned, but this is already contained in the next working packages.

Next meeting

The next meeting will be 18th of September 2008 at DLR Oberpfaffenhofen.

Bernhard Mayer Claudia Emde Arve Kylling Ulrich Hamann