3DRT - Clouds (I3RC) and Vegetation (RAMI)
Status and perspectives

R. Cahalan, F. Evans, A. Marshak, B. Mayer, L. Oreopoulos,
R. Pincus, T. Varnai, B. Pinty, J-L. Widlowski,
& the I3RC & RAMI Groups

IRC @ IRS2008, Iguaçu, Brasil
I3RC = Int’l Intercomparison of 3D Radiation Codes
Initiated at 1998 GRP meeting in St Andrews
Activity of 3DWG of Int’l Radiation Commission
Now 7 “Cases” with many “Experiments"
Phase 3 Intercomparisons (12 models participated)

Solar reflectance

Overhead view (simulated by JAMS model)

Reflectance

Distance (km)

Logarithm of reflectance

Scene average reflectance

Oblique view
Forward scattering, Viewing zenith = 60°

DZLR1 DZLR2 DZLR3 JAMS1 MIUB1 MIUB2 UMBC6

Lidar multiple scattering

DZLR (Monte Carlo method) URDG (TDTS method)

Time delay of return signal (100 nsec)

Radial distance (*10 m)

Logarithm of reflectance

Radial distance (*10 m)
Simulation of 3D photon transport

- Animation of scalar flux \((I^+ + I^-)\)
  - Colour scale is logarithmic
  - Represents 5 orders of magnitude
- Domain properties:
  - 500-m thick
  - 2-km wide
  - Optical depth of 20
  - No absorption
- In this simulation the lateral distribution is Gaussian at each height and each time
I3RC Status and Plans

I3RC community code for 3D radiative transfer
• Release 1: July 2005, Release 2: July 2006 – vs SHDOM, more flexible & faster for many problems
• Over 40 downloads in 2007 (since we started keeping track)
• Radiative fluxes, heating rates, and radiances for any view direction
• Scene-average values and complete fields
• Single wavelength, but k-distribution for gaseous absorption in preparation
• Release 3 due Oct 2007: arbitrary surface BRDFs, Iwabuchi Russian roulette for speedy intensities, and MPI driver
• Open Source Licensing to encourage further development and widest usage

Information on 3D radiative transfer codes (including I3RC community code)
• I3RC Programmer Guide & Primer now available
• I3RC website: http://i3rc.gsfc.nasa.gov/ (also includes other resources such as 3D-related publications)

Plans
• Easy-to-use community model of 3D radiative transfer: online 3D simulator, executables
• Automated code verification - online system like RAMI’s
• Illustrative archive of 3D radiative effects
3DRT application: \textbf{Ice \& Snow Thickness from THOR}

Figure 1. Schematic diagram of airborne sea ice measurements using offbeam lidars.

Figure 2. Simulated offbeam lidar signals for various snow and sea ice conditions. The figure was created through a 3-D Monte Carlo radiative transfer model.

Figure 3. Simulated THOR4Ice data for 2 m thick ice covered by 15 cm snow. The legend indicates the outer radius (in cm) of each annular field-of-view.

Figure 4. Retrieval uncertainties caused by observational noise. Each curve is for a different horizontal resolution. The calculations are for 30° solar elevation and old snow. The error bars indicate the uncertainty in retrieval uncertainty estimates that arise from the random nature of simulated observational noise.
3DRT application: WRF Convective Lifecycles

Periodic boundary

domain average condensate
(liquid, ice, snow, graupel, rain)

cloud fraction
(liquid, ice)

height (km)

0 - 80 min   0 - 240 min
3D          3D
ICA         ICA

height (km)

fraction

0 - 240 min
3D          3D
ICA         ICA

0 - 240 min
3D          3D
ICA         ICA

height (km)

fraction

0 - 240 min
3D          3D
ICA         ICA
3DRT application: WRF Convective Lifecycles

ICA

14:40

3D

cloud condensate

SW heating rate

4.1 g/kg

1.2 K/hour

vertical velocity

+11 m/s

-19 m/s

km

100

SW heating rate

6 g/kg

2.4 K/hour

vertical velocity

+20 m/s

-20 m/s

km

100
Purpose:
- Common platform.
- Document uncertainties and errors among models.
- Establish protocol.
- Foster debate.

Organisation:
- Led by JRC in Italy
- Steering committee (RAB)
- Triennial phases
RAMI Topics

- directionally-varying and hemispherically-integrated quantities (BRFs & fluxes)

- domain-averaged and local (resolved) quantities.

- focus on science issues
  - horizontal fluxes
  - surface topography

Impact of horizontal radiation fluxes

Impact of surface topography
RAMI-3 results published

- Models evaluated both in relative & absolute terms
- Model agreement is better than during RAMI-2 (2004)

60-70% of all canopy RT models have participated in RAMI
RAMI On-line Model Checker (ROMC)

The ROMC’s *interactive mode* allows users to compare the performance of different versions of a single model, or else to evaluate multiple models. All ROMC graphs are available as .ps.

1. registered user selects test cases,
2. offline implementation & running of test cases using users model,
3. uploading of test case to ROMC and comparison with reference,
4. downloading of results graphs.

Reference data set covering all test cases from RAMI.

http://romc.jrc.it
Validation of existing remote sensing products (fAPAR, LAI)

Generate realistic representations of existing validation sites:

- use in-situ measurements and imagery.
- sample different biomes (SAFARI, BOREAS).
- ideal scene size 250x250 to 500x500 m$^2$.

- Apply typical in-situ measurements within these scenes:
  - reproduce measurements of existing field instruments (TRAC, LICOR, fisheye lens),
  - evaluate appropriateness of theory used in their interpretation (1-D medium),
  - provide optimal sampling strategies for correct up-scaling at known validation sites.
RAMI-4 and beyond (2)

Support to space agencies and policymakers (GMES)
- Evaluate inverse mode performance of RT models
- Introduce RT model certificates

Contribute to international programmes (GEWEX, CEOS)
- Develop optimal sampling strategies for the correct up-scaling of field measurements at existing validation sites
- Evaluate the radiative parameterisations of current land surface schemes (RAMI4PILPS project).
**Goal:**
Assess the accuracy and reliability of the shortwave radiation transfer schemes that are currently used in the parameterisation of land surfaces in SVATs, GCMs, and NWP models.

- Use the RAMI-3 MC reference models as ‘surrogate truth’

### proposed test cases

<table>
<thead>
<tr>
<th>1-D Canopies</th>
<th>3-D Canopies</th>
</tr>
</thead>
<tbody>
<tr>
<td>grasslands</td>
<td>shrublands</td>
</tr>
<tr>
<td>closed forest canopies</td>
<td>open forest canopies</td>
</tr>
</tbody>
</table>

Given detailed 1-D canopy descriptions, what are the values of the three fluxes $R$, $A$, and $T$? Given detailed 3-D canopy descriptions and $R$, how is the remaining energy split between $A$ and $T$?

**RAMI4PILPS starts April 2008**
Summary:

• RAMI benchmarking mechanism is in place
  - model participation increases and performances improve
  - benefits of large-scale intercomparison activity are harvested by RT model developers, their customers and the scientific community.

• RAMI Online Model Checker (ROMC) now available
  - allows debugging/validation of canopy RT models at any time.
  - uses RAMI “surrogate truth” derived form credible 3-D MC models.
  - facilitates participation of new models in future phases of RAMI.

The **ROMC** is an *indicative* model evaluator
RAMI aims at *comprehensive* model evaluation

• RAMI4PILPS soon to be launched
  - Assessment of the radiative surface flux parameterisation in SVATs & GCMs
Future 3DRT Group Activities

- Easy to use I3RC open source code
- Automated code validation
- Multi-angle instrument design/simulation
- Multi-instrument retrieval
- Test ICA and other \textit{parameterizations} for GCMs
- Test neural net & other “\textit{3D shortcuts}” for WRF
- Omnivorous Open Source: I3RC4Vegetarians?
- \textit{RadiationOpensourceCryoMeso\&SnowOceanClimateModels:}
  \rightarrow \textit{ROCM\&SOCMs}