Applications of SMART: a DRDC atmospheric radiative transfer library optimized for wide band computations

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**Applications of SMART: a DRDC atmospheric radiative transfer library optimized for wide band computations**

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• Conclusion
The SMART library

SMART Suite

for ultimate resolution

tmospheric

adiative

transmission

Interface
The SMART library

• SMART (1.0 beta) features
  – Spectral and wideband CK transmittance & radiance
  – MODTRAN molecular extinctions (CK)
    • Seamless integration of MOD4v3r1
  – MODTRAN and DRDC aerosol models
  – Falling snow model (DRDC)
  – DRDC accurate refracted path calculation
  – 2-stream (flux) and DISORT (N-stream) MS calculations
  – Lambert and sea surface (DRDC analytical model) BRDF. Others to come.
  – Optimized by using advanced C++ programming methods
    • Intuitive like C++, fast like Fortran/C
The SMART library

• No modifications to the MODTRAN source code is necessary
  – Works with the official MODTRAN4 executable
  – Plans to support MODTRAN 5 in the near future
The SMART library

• High language portability (SMARTI)
  – C++ (native)
  – Java
  – Matlab (through Java)

• Other language wrappers are possible/planned
  – Python, C#, Lisp, Lua, Octave, Pearl, PHP, Pike, TCL, R, Ruby, and more…
The correlated-k theory

- Transformation to Correlated-K space

\[ T = \sum_{i} \exp \left( -k_i (g) \cdot s \right) \Delta g_i \]
Wideband correlated-ks

- Converting MODTRAN4™ CK extinctions to wideband CK

1) Sort

2) Interpolate
Wideband correlated-ks

- Converting other quantities to wideband CK space
Benefits

• **Speed (wideband)**
  
  – Over 1000 lines of sight per second (excluding initialization) in single and 2-flux multiple scattering
  
  – 50 lines of sight per second with 16 stream DISORT.

<table>
<thead>
<tr>
<th></th>
<th>Wide band CK</th>
<th>MODTRAN 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single (17 ck)</td>
<td>2 Str MS</td>
</tr>
<tr>
<td>Visible</td>
<td>0.00078 s</td>
<td>0.00125 s</td>
</tr>
<tr>
<td>3-5 μm</td>
<td>0.00124 s</td>
<td>0.00234 s</td>
</tr>
</tbody>
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(Excluding initializing phase)
Benefits

- **Accuracy**
  - Spectral results are almost identical to MODTRAN 4.
  - Wideband radiance results are within 5% of full MODTRAN 4 calculations
Applications

• Scene modeling:
  – Simulators
  – Assessing target
detection/tracking algorithms.
  – Training

• EOTDA applications:
  – Contrast maps
  – Detection probability
  – “What if” scenarios
    • (requires especially optimized
      RT codes)

• Modeling for multi-spectral
detectors.
Current projects: KARMA simulation framework

IR scene Generation:
• IR scene = Input to the seeker models
• SMART atmosphere model
  – Dynamic atmospheric properties
  – Wideband-CK computations
Current projects: MPIR (PSAD)

- PSAD-MPIR on the French FREMM (Multi Mission European FRigate) for DCNS

Thermal ship image courtesy of Fabian Lapierre, Royal Naval Academy of Belgium.
(Computed using OSMOSIS)
Conclusion

- SMART(I) v1.0 beta is now ready.
- SMARTI is already in use in Canadian/International collaborative projects.
- Interested beta users are welcome (vross@aerex.ca).
- Imaging, multispectral and EOTDA applications would benefit.
- Divergence from MODTRAN 4 in radiance and transmittance are below 5% for most visible and IR bands in wide CK mode.