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SMARTI, a Suite for Multi-resolution Atmospheric Radiative Transmission Interface library developed at DRDC-Valcartier

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- Conclusion

The SMART library

SMART

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The SMART library

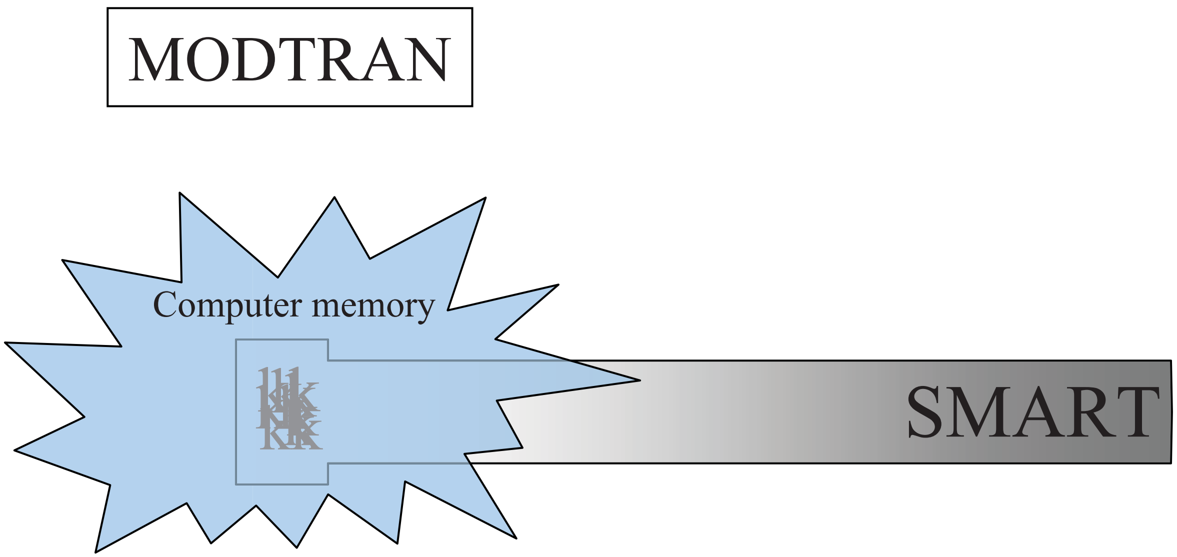
- SMART (0.1 beta) features
  - Spectral and wideband CK transmittance & radiance
  - MODTRAN molecular extinctions (CK)
    - Seamless integration of MOD4v3r1
  - MODTRAN and DRDC aerosol models
  - Falling snow model (DRDC)
  - DRDC accurate refracted path calculation
  - 2-stream (flux) and DISORT (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

- High language portability (SMARTI)
  - C++ (native)
  - Java
  - Matlab (trough Java)
  - Python
- Other language wrappers are possible/planned
  - C#, Lisp, Lua, Octave, Pearl, PHP, Pike, TCL, R, Ruby, and more…

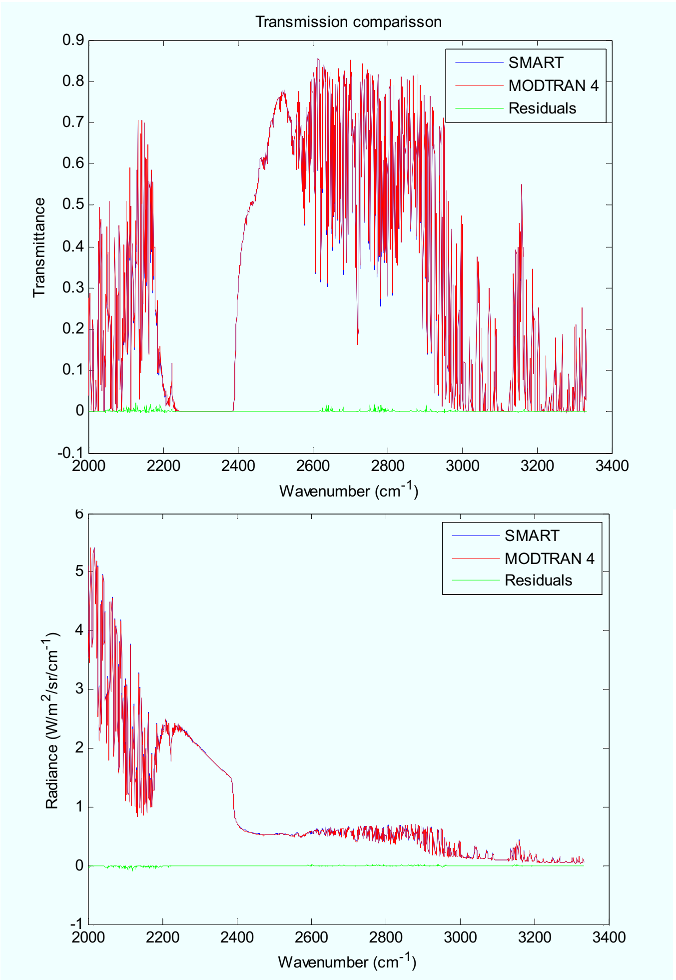
The SMART library

- No modifications to the MODTRAN source code is necessary
  - Works with the official MODTRAN4 executable
  - Plans to support MODTRAN 5 in the near future



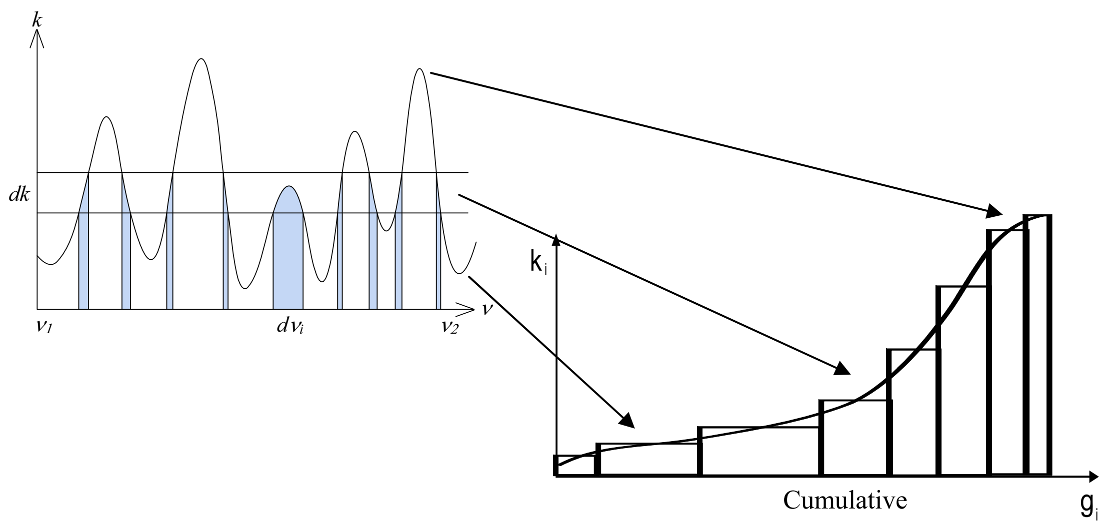
Benefits

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



A correlated-k refresher

- Transformation to Correlated-K space



- Monotonic function need much fewer points to be represented accurately

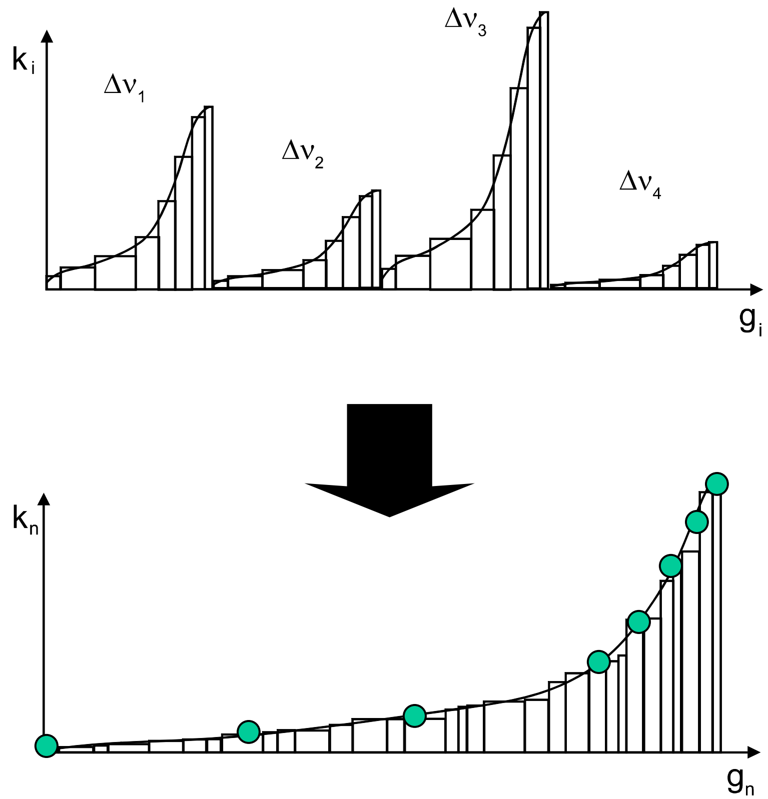
$$T = \sum_i \exp\left(-k_i(g) \cdot s\right) \Delta g_i$$

Wideband correlated-ks

- Converting MODTRAN4™ CK extinctions to wideband CK

1) Sort

2) Interpolate

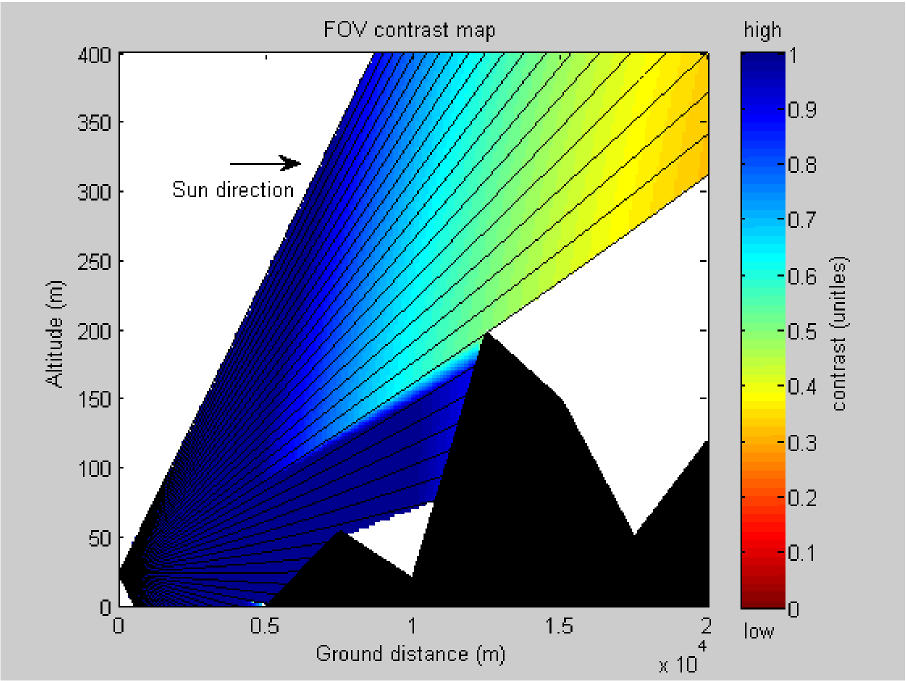


Applications

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

Applications

- EOTDA applications:
  - Contrast maps
  - Detection probability
  - "What if" scenarios
    - (requires especially optimized RT codes)



- Modeling for multi-spectral detectors.

Current projects: KARMA simulation framework

Environment
- Atmospheric transmittance
- EO/IR scene

Expendable (flare)
- Dynamics
- EO/IR signature

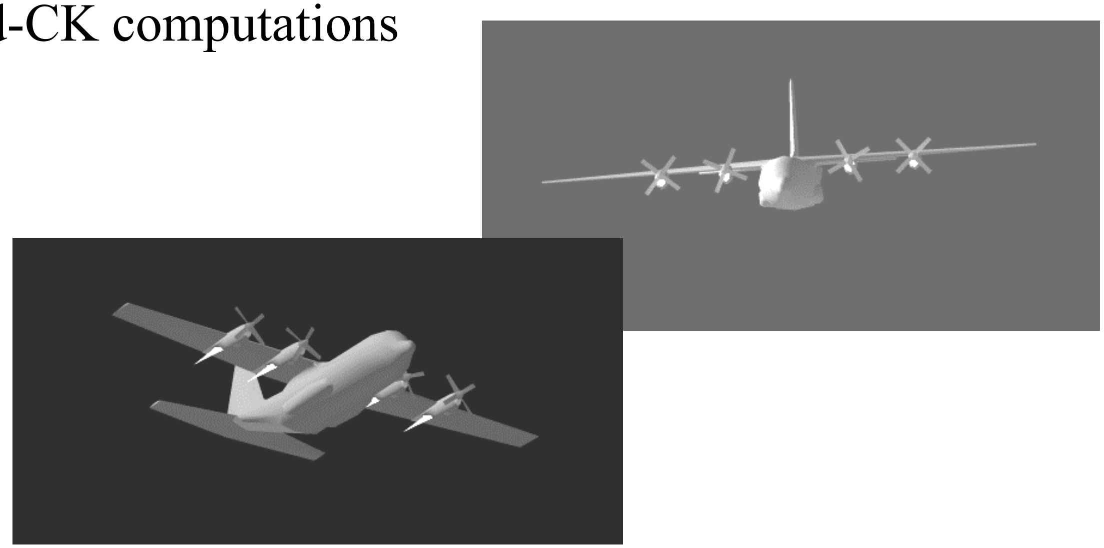
Munition
- Dynamics
- Guidance
- Control
- Autopilot
- Propulsion
- Fuze
- EO/IR seeker
- EO/IR signature

Platform (target, launcher)
- Dynamics
- Self-defence system
  - Expendable dispensor
  - DIRCM
  - MAWS
- Weapon system
  - Designator
  - Launch rail
- EO/IR signature

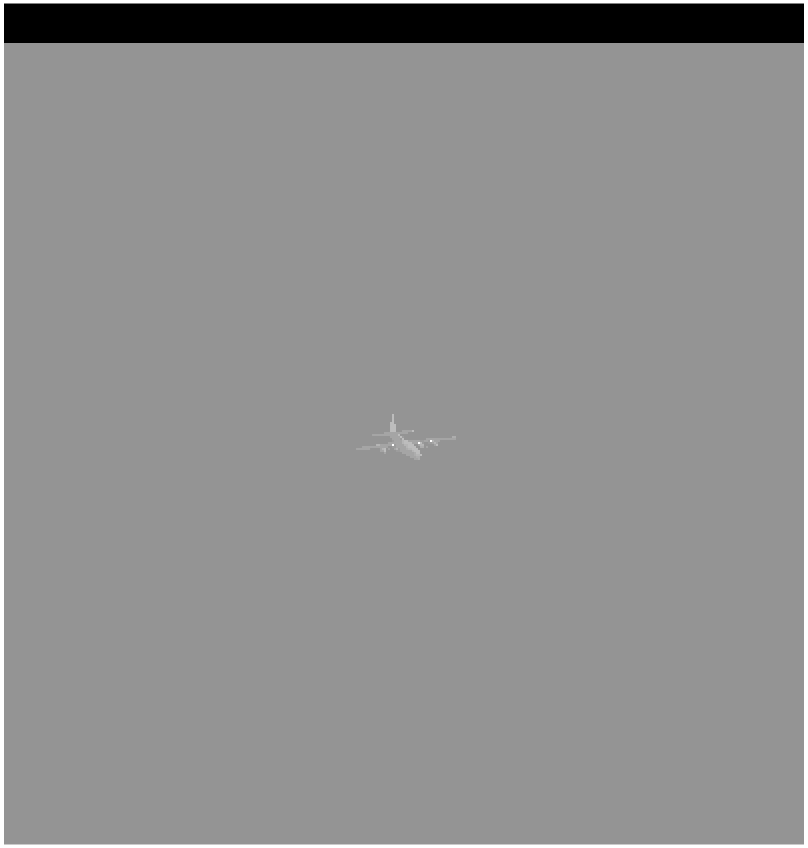
Current projects: KARMA simulation framework

IR scene Generation:

- IR scene = Input to the seeker models
- SMART atmosphere model
  - Dynamic atmospheric properties
  - Wideband-CK computations



Example KARMA Video



Current projects: MPIR (PSAD)

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

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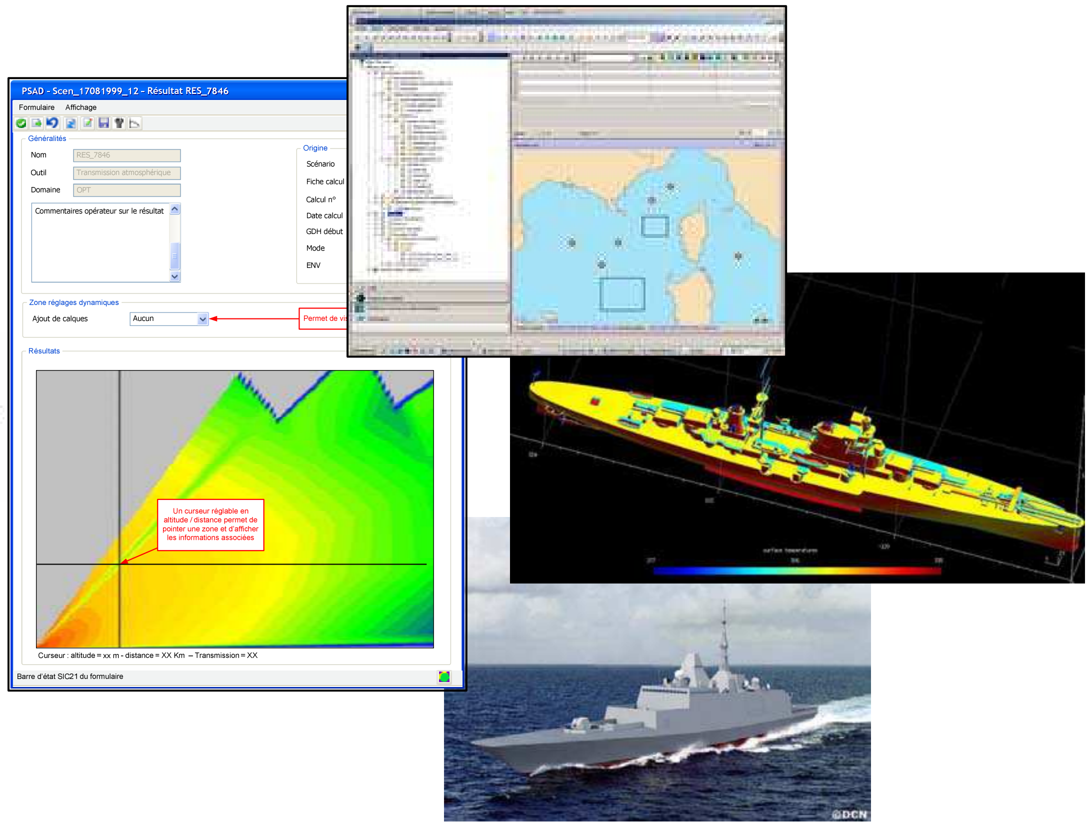

Thermal ship image courtesy of Fabian Lapierre, Royal Naval Academy of Belgium. (Computed using OSMOSIS)

Conclusion

- SMART(I) v1.0 beta is now ready.
- SMARTI is already in use in Canadian/International collaborative projects
- Interested beta users are welcome.
- 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

Conclusion

Thank you!

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Results - 0.4 to 0.7 μm

- Accuracy

	Single	2 Str MS	16 Str DISORT
R (% from MOD4)	0.41%	0.44%	0.18%
T (% from MOD4)	0.32%		

- Speed

	W-CK (17 ck)	W-CK (2 Str)	W-CK (16 Str)	MOD4 (5 cm^{-1})	MOD4 (2 Str)	MOD4 (16 Str)
Time (s)	0.00078 s	0.00125 s	0.166 s	0.83 s	2.86 s	3061 s
Ratio to W-CK	-	-	-	1064	2288	18439

(45° slant path from ground to space in a maritime environment, sun at 57° from zenith)

Results - 3.0 to 5.0 μm

- Accuracy

	Single	2 Str MS	16 Str DISORT
R (% from MOD4)	2.3%	1.5%	1.8%
T (% from MOD4)	3.0%		

- Speed

	W-CK (17 ck)	W-CK (2 Str)	W-CK (16 Str)	MOD4 (1 cm^{-1})	MOD4 (2 Str)	MOD4 (16 Str)
Time (s)	0.00124 s	0.00234	0.19 s	1.05 s	3.08 s	1586
Ratio to W-CK	-	-	-	847	1316	8347

(45^{o} slant path from ground to space in a maritime environment, sun at 57^{o} from zenith)

Results - 8.0 to 12.0 µm

- Accuracy

	Single	2 Str MS	16 Str DISORT
R (% from MOD4)	0.61%	0.75%	0.87%
T (% from MOD4)	10.2%		

- Speed

	W-CK (17 ck)	W-CK (2 Str)	W-CK (16 Str)	MOD4 (1 cm^{-1})	MOD4 (2 Str)	MOD4 (16 Str)
Time (s)	0.00031 s	0.00078	0.020 s	0.41 s	1.03 s	63.7 s
Ratio to W-CK	-	-	-	1323	1321	3185

(45° slant path from ground to space in a maritime environment, sun at 57° from zenith)

Results – 10.0 to 12.0 μm

- Accuracy

	Single	2 Str MS	16 Str DISORT
R (% from MOD4)	0.77%	0.82%	0.72%
T (% from MOD4)	1.25%		

O_3 Band?