DEFENCE R&D DÉFENSE

Computation of atmospheric transmittance and radiance using wideband CK

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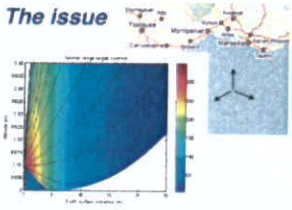
Outline

- The issue
- The Wide-band correlated-k approach
- Example of performance
- SMART– a new computational module
- Summary/Conclusion

The issue

Requirements

- Computation in a 2D plane (e.g. Contrast/Prob detection calculation)
- Computation in 3D space (e.g. scene generation)

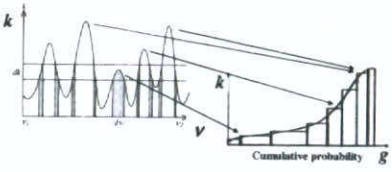


Problems

- Running the model at every point on a tight grid is **slow**
- Interpolating on a coarse grid is **inaccurate**

The Correlated-k Approach

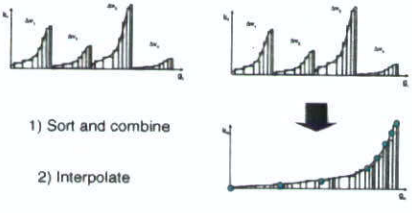
Transformation to Correlated-K space



$$\tau = \sum_i \Delta g_i \exp(-k_i \cdot l)$$

Wideband correlated-k's

Converting MODTRAN4™ CK extinctions to wideband CK



1) Sort and combine

2) Interpolate

All other spectral quantities must be aligned with the wide CK distribution

Computation performance in MWIR (3.0 to 5.0 μm, resolution = 5 cm^{-1})

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

Accuracy	Single Scattering	2-Stream MS	16-Stream DISORT
R (% from MOD4)	2.3%	1.5%	1.8%
T (% from MOD4)	3.0%		

Speed	WB-CK	WB-CK (16 Str)
Time	0.00124 sec	0.19 sec

WB-CK vs MODTRAN 4

	MOD4	MOD4 (2-Str)	MOD4 (16-Str)
MOD5 Time	1 sec	3 sec	1586 sec
WB-CK / MOD	847	1316	8347

The SMART Module

The wideband CK method is part of

SMART

ultiresolution

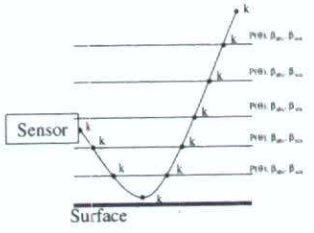
tmospheric

adiative

ransmission

The SMART Module (cont'd)

Performs radiative transfer calculations in layered atmospheres

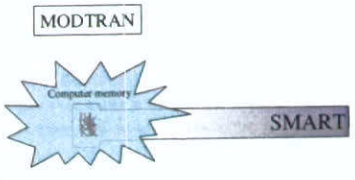


SMART Module
Main features

- Spectral and wideband CK transmittance & radiance
- MODTRAN molecular extinctions (CK)
  - Seamless integration of MOD4v3r1
- MODTRAN and DRDC aerosol models
- 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

Interaction with MODTRAN

- No modifications to MODTRAN source is necessary
- Compatible with the official MODTRAN4 executable



Conclusion

- **Accurate and fast radiative transmission is possible with the wideband CK method**
- **Discrepancies with MODTRAN are well below 5% for most visible and IR bands**
- **Allow computations of radiance and transmittance at a rate of ~1000 lines of sight per second**
- **SMART will be used in EO-TDA development programs**

Wideband correlated-k's

- Variation between minimum and maximum absorption is much larger for wide bands
- and even within sub-bins
- We need a better integration scheme

Computation performance in the visible (0.4 to 0.7 μm, resolution = 5 cm^{-1})

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

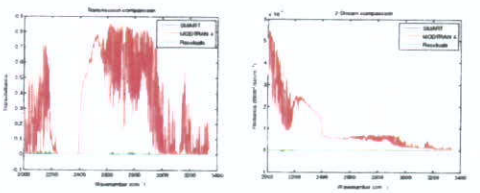
Accuracy	Single Scattering	2-Stream MS	16-Stream DISORT
R (% from MOD5)	0.4%	0.8%	0.8%
T (% from MOD5)	0.4%		

Speed	WB-CK	WB-CK (16 Str)
Time	0.0013 sec	0.21 sec

WB-CK vs MODTRAN 5

	MOD5	MOD5 (2-Str)	MOD5 (16-Str)
MOD5 Time	3.0 sec	4.5 sec	1164 sec
WB-CK / MOD	2308	3461	5543

Results – Spectral (3.0 to 5.0 μm)



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

Computational aim

- Accuracy
  - Radiance results within 5% of full MODTRAN 4 calculations
  - Capable of multiple scattering
  - No need for spectral information (wideband)
- Speed
  - At least 100 lines of sight per second (excluding initialization)
  - No significant slowdown in 2 stream multiple-scattering