Recent Upgrades to MODTRAN - New Solar Irradiance and Instrument Scanning Functions


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Recent upgrades are intended to make MODTRAN a more accurate, convenient and versatile atmospheric modeling tool. The current default solar irradiance database due to Kurucz was corrected in the 310-340 nm region using measured data. Several other data sets are also made available to the user. The user can also use his/her own data residing in a file. Examination confirms that the corrected Kurucz data is still the best overall among all currently available data sets. MODTRAN can now be run using frequency inputs which are in wavenumber, nm or micron. Additionally, there is now the capability of obtaining radiance and transmittance which are convolved with an appropriate instrument scanning function. Several choices of scanning functions are available including a user-defined option. This upgrade is helpful to users who would like to model satellite data which are gathered as a function of wavelength and have undergone instrument degradation. All upgrades are accomplished while maintaining strict compatibility of TAPE5 with earlier versions of the code. Work is currently in progress to incorporate NOVAM (Navy Oceanic Vertical Aerosol Models) into MODTRAN.
ABSTRACT

RECENT UPGRADES TO MODTRAN - NEW SOLAR IRRADIANCE AND INSTRUMENT SCANNING FUNCTIONS

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Hanscom AFB, MA 01731

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THE 20TH ANNUAL DOD CONFERENCE ON ATMOSPHERIC TRANSMISSION MODELS (10-12 JUNE, 1997)
OUTLINE

• SOLAR IRRADIANCE UPGRADES
  - MOTIVATION
  - DESCRIPTION OF DATA SETS

• GENERALIZED FREQUENCY INPUT SCHEME
  - NEW UNITS FOR FREQUENCY INPUTS

• INSTRUMENT SCANNING OR FILTER FUNCTION CAPABILITY
  - DESCRIPTION OF SCANNING FUNCTIONS

• SUMMARY
MOTIVATION

• MODTRAN REQUIRES ACCURATE TOA SOLAR IRRADIANCE ($I_0$)

• CURRENTLY CALCULATIONS DUE TO KURUCZ ARE USED
  - EXTENSIVE LBL CALCULATIONS BASED ON SOLAR TEMPERATURE PROFILE, SOLAR ABUNDANCES AND VOIGT LINE PROFILE
  - STANDS UP WELL AGAINST MEASUREMENTS

• NEW MEASUREMENTS ARE AVAILABLE INCLUDING THOSE AT TOA
  - MEASUREMENTS AT KITT-PEAK (USED BY THE GOME COMMUNITY)
  - TOA SOLAR UV MEASUREMENTS (ATLAS SSBUV)
  - TOA MEASUREMENTS BY FRENCH SCIENTISTS (SOLSPEC)

• NEED TO ACCOMMODATE USER-SUPPLIED $I_0$
  - HAS APPLICATIONS, FOR EXAMPLE, IN O$_3$ RETRIEVAL
NEW CHOICES OF BUILT-IN $I_0$ FILES

- CARD 1A, COLUMNS 61-80, TRIGGERS CHOICE OF $I_0$

- FOUR BUILTIN SOLAR $I_0$ FILES
  - NEWKUR.DAT (CORRECTED KURUCZ); INPUT 1 OR BLANK
  - OLDKUR.DAT (KURUCZ); INPUT 2
  - CHKUR.DAT (KITT-PEAK, COURTESY OF K. CHANCE); INPUT 3
  - CEBCHKUR.DAT (ATLAS SSBUV, COURTESY OF R. CEBULA); INPUT 4
  - THKUR.DAT (SOLSPEC, COURTESY OF G. THUILLIER); INPUT 5

- CORRECTED KURUCZ IS DEFAULT (BLANKS IN COLS 61-80)

- ALL ARE FROM 50-50000 CM$^{-1}$; NON-KURUCZ HAVE MULTIPLE SOURCES
  - IRRADIANCES IN (W/CM$^2$)/CM$^{-1}$ VERSUS CM$^{-1}$

- USER-SUPPLIED DATA CAN BE USED (FILENAME IN COLS 61-80)
<table>
<thead>
<tr>
<th>STRUCTURE OF USER-SUPPLIED $I_0$ FILE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FILE CONTENT</strong></td>
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<tr>
<td><strong>FREQUENCY UNIT DESIGNATOR</strong></td>
</tr>
<tr>
<td><strong>FREQUENCY 1</strong></td>
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<tr>
<td><strong>FREQUENCY 2</strong></td>
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<td><strong>...</strong></td>
</tr>
<tr>
<td><strong>UNIT DESIGNATORS</strong></td>
</tr>
<tr>
<td><strong>FREQUENCY IN CM$^{-1}$</strong></td>
</tr>
<tr>
<td><strong>1</strong></td>
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<tr>
<td><strong>FREQUENCY IN NM</strong></td>
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<td><strong>2</strong></td>
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<tr>
<td><strong>FREQUENCY IN MM</strong></td>
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<tr>
<td><strong>3</strong></td>
</tr>
<tr>
<td><strong>$I_0$ AT INTEGRAL CM$^{-1}$, ARE OBTAINED BY</strong></td>
</tr>
<tr>
<td><strong>INTEGRATION/INTERPOLATION</strong></td>
</tr>
<tr>
<td><strong>PADDED BY DATA FROM DEFAULT BUILTIN FILE</strong></td>
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</tbody>
</table>
UPPER ATMOSPHERIC (SHUTTLE EXPT) DATA

- ATLAS SSBUV DATA; 200.06-406.45 NM (49985-24603 CM$^{-1}$)
  - STEP SIZE 0.152-0.136 NM
  - UNCERTAINTY IN $\lambda$ $\pm$ 0.026 NM
  - 2$\sigma$ UNCERTAINTY 6% AT 200 NM, 2.8% AT 250 NM AND 2.6% 300-400 NM

- SSBUV WAS AUGMENTED BY KITT-PEAK DATA AND KURUCZ

- SOLSPEC INSTRUMENT; 199.12-876.86 NM (11404-50221 CM$^{-1}$)
  - STEP SIZE 0.36-0.9 NM

- SOLSPEC SET WAS BY AUGMENTED BY KURUCZ CALCULATION

- ATLAS SSBUV IS TAKEN TO BE THE BENCHMARK FOR THIS TASK
KITT-PEAK MEASUREMENTS DATA

- TWO SETS OF MEASUREMENTS MERGED (230-800 NM)
  - CALIBRATION IS \pm 0.002 NM, STEP SIZE IS 0.01

- DATA WAS NOT CORRECTED FOR O$_2$ ATMOSPHERIC BAND LINES
  - REPLACED O$_2$ LINES BY KURUCZ'S

- SOME ATMOSPHERIC EFFECTS STILL REMAIN
  - AROUND 720 NM ATMOSPHERIC H$_2$ MAY BE A PROBLEM
  - AROUND 320-330 NM THERE IS ALSO SOME PROBLEM
INTEGRATED BANDPASS RADIANCES (W/m²)

<table>
<thead>
<tr>
<th>406.45 nm</th>
<th>200.06 nm</th>
<th>199.12 nm</th>
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<tbody>
<tr>
<td>878.88 nm</td>
<td>800 nm</td>
<td>230 nm</td>
</tr>
<tr>
<td>200 nm</td>
<td>Corrected Kurucz Calculation</td>
<td></td>
</tr>
<tr>
<td>Corrected Chance Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cebula Data (Atlas SSBUV)</td>
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<tr>
<td>Thuillier Data (SOLSPEC)</td>
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</tbody>
</table>

877-800 nm 800-406 nm 406-230 nm 230-200 nm 800-230 nm
Interval 1 Interval 2 Interval 3 Interval 4 Interval 5

<table>
<thead>
<tr>
<th></th>
<th>Interval 1</th>
<th>Interval 2</th>
<th>Interval 3</th>
<th>Interval 4</th>
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<tr>
<td>KR 80</td>
<td>647</td>
<td>122</td>
<td>0.95</td>
<td>768</td>
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</tr>
<tr>
<td>CH</td>
<td>645</td>
<td>118</td>
<td>0.95</td>
<td>764</td>
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<tr>
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<td>654</td>
<td>121</td>
<td>1.02</td>
<td>778</td>
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<tr>
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<td>778</td>
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</tbody>
</table>

(KR = corrected Kurucz, CH = corrected Chance, CB = SSBUV, TH = SOLSPEC)
UPPER ATMOSPHERIC DATA COMPARED

- SSBUV AND SOLSPEC COMPARED AT "COMMON" RESOLUTION
- MAXIMUM DIFFERENCE IS 11% AT 263 NM
- AGREEMENT IS BETTER AT SHORTER WAVELENGTHS
KITT-Peak and Corrected Kurucz (310-340 NM)

Irradiance (mW/m²/nm)

Wavelength (nm)
KITT-PEAK AND CORRECTED KURUCZ (200-400 NM)
KITT-PEAK AND CORRECTED KURUCZ (400-800 NM)
KITT-PEAK AND CORRECTED KURUCZ (200-400 NM)
GENERALIZED UNITS FOR CARD 4 INPUTS

CARD 4: V1, V2, DV, FWHM, YFLAG, XFALG, DLIMIT, FLAGS
FORMAT(4F10.0, 2A1, A8, A4)

- FREQUENCY INPUTS CAN NOW BE IN μM, NM AND CM⁻¹
- UNIT IS INDICATED BY FLAGS(1:1) WHICH IS W, M, N OR BLANK
- DEFAULT (FLAGS(1:1) IS BLANK) IS CM⁻¹
- OLD TAPE5's WORK JUST FINE WITH THE NEW CODE
INSTRUMENT SCANNING FUNCTION

• CHOICE IS INDICATED BY FLAGS(2:2)
  1 TRIANGULAR  2 SQUARE  3 GAUSSIAN
  4 SINC  5 SINC²  6 HAMMING
  7 USER-SUPPLIED

• DEFAULT (BLANK) IS TRIANGULAR; OLD TAPE5’s ARE FINE

• FLAGS(3:3) INDICATES IF FWHM IS RELATIVE
  - RELATIVE % FWHM CAN HELP MODEL, E.G., CVFs

• CAN ONLY DEGRADE TOTAL TRANS AND RAD TO SAVE TIME
  - MUST SET FLAGS(4:4) TO BLANK

• IF FWHM IS TOO FINE ERROR MSG IS PRINTED AT THE OUTSET
SUMMARY OF MODTRAN UPGRADES

• SEVERAL CHOICES OF SOLAR $I_0$ DATA IS AVAILABLE

• THE KURUCZ SPECTRUM (CORRECTED IN 310-340 NM) IS STILL THE BEST (DEFAULT)

• USER-DEFINED $I_0$ FILE WITH FLEXIBLE UNITS CAN BE INPUT

• CARD 4 INPUTS CAN BE IN $\mu$M, NM OR CM$^{-1}$

• SEVERAL SCANNING FUNCTIONS (INCLUDING USER-DEFINED FUNCTION) ARE NOW AVAILABLE