```
!         path:           $Source$
!         author:       $Author: miacono $
!         revision:    $Revision: 32234 $
!         created:      $Date: 2018-02-08 15:00:23 -0500 (Thu, 08 Feb 2018) $
!----------------------------------------------------------------------
!
!--------------------------------------------------------------------------
```


USER INSTRUCTIONS FOR RRTMG_SW

Contents:

INPUT_RRTM Instructions

RECORD 1.1

CXID: 80 characters of user identification (80A1)

CXID(1) is the flag which determines program initialization and termination. The actual input data stream for RRTM commences with the record containing a '$' in CXID(1). Any records that are read prior to a record containing a '$' in CXID(1) are ignored.

RECORD 1.2

```
IAER,   IATM,   ISCAT,  ISTRM,   IOUT,    IMCA, ICLD,  IDELM, ICOS

  20,     50,      83,      85,  88-90,      94,    95,     99,  100

18x, I2, 29X, I1, 32X, I1, 1X, I1, 2X, I3, 3X, I1,   I1, 3X, I1,   I1
```

IAER (0,10) flag for aerosols

= 0 no layers contain aerosols

= 6 uses ECMWF global mean aerosol properties for one or all of six aerosol types. Aerosol optical thickness at 0.55 micron, ECAER, must be set manually in the main source module, rrtmg_sw.1col.f90, to activate the aerosols with this option.

= 10 one or more layers contain aerosols (requires the presence of file IN_AER_RRTM)

IATM (0,1) flag for RRTATM 1 = yes

ISCAT (0,1) switch for DISORT or simple two-stream scattering

= 0 DISORT (unavailable)

= 1 two-stream (default)

ISTRM flag for number of streams used in DISORT (when ISCAT equal to 0)

= 0 - 4 streams (unavailable)

= 1 - 8 streams (unavailable)

= 2 - 16 streams (unavailable)

IOUT = -1 if no output is to be printed out.

= 0 if the only output is for 820-50000 cm-1.

= n (n = 16-29) if the only output is from band n.
For the wavenumbers for each band, see Table I.
= 98 if output is generated for 15 spectral intervals, one
for the full shortwave spectrum (820-50000 cm-1), and one
for each of the 14 bands.

IMCA (0,1) flag for McICA (Monte Carlo Independent Column Approximation)
for statistical representation of sub-grid cloud fraction
and cloud overlap
= 0 standard forward calculation; do not use McICA (valid for
clear or overcast conditions only)
= 1 use McICA (will perform statistical sample of 200 forward
calculations and output average flux and heating rates)

ICLD (0,1,2,3) flag for clouds
= 0 no cloudy layers in atmosphere
= 1 one or more cloudy layers present in atmosphere. Cloud layers
are treated as overcast only for IMCA = 0, or they are treated
using a RANDOM overlap assumption for IMCA = 1.
(requires the presence of file IN_CLD_RRTM for column model)
(available for IMCA = 0 or 1)
= 2 one or more cloudy layers present in atmosphere. Cloud layers
are treated using a MAXIMUM/RANDOM overlap assmption.
(requires the presence of file IN_CLD_RRTM for column model)
(available only for IMCA = 1)
= 3 one or more cloudy layers present in atmosphere. Cloud layers
are treated using a MAXIMUM overlap assmption.
(requires the presence of file IN_CLD_RRTM for column model)
(available only for IMCA = 1)

Measurement comparison flags:
IDELM (0,1) flag for outputting downwelling fluxes computed using the delta-M scaling approximation
= 0 output "true" direct and diffuse downwelling fluxes (default)
= 1 output direct and diffuse downwelling fluxes computed with delta-M approximation
(Note: The delta-M approximation is always used internally in RRTMG_SW to compute the total downwelling flux at each level. What the IDELM flag determines is whether the components of the downwelling flux, the direct and diffuse fluxes, that are output are the actual direct and diffuse fluxes (IDELM = 0) or are those computed using the delta-M approximation (IDELM = 1).

ICOS = 0 there is no need to account for instrumental cosine response (default)

= 1 to account for instrumental cosine response in the computation of the direct and diffuse fluxes

(unavailable)

= 2 to account for instrumental cosine response in the computation of the diffuse fluxes only

(unavailable)

(Note: ICOS = 1 and ICOS = 2 requires the presence of the file COSINE_RESPONSE, which should consist of lines containing pairs of numbers (ANG, COSFAC), where COSFAC is the instrumental cosine response at the angle ANG.)

RECORD 1.2.1

JULDAT, SZA, ISOLVAR, SCON, SOLCYCFRAC, (SOLVAR(IB),IB=16,29)

13-15, 19-25, 29-30, 31-40, 41-50, 51-190

12X, I3, 3X, F7.4, 3X, I2, F10.4, F10.5, 14F10.5

JULDAT Julian day associated with calculation (1-365/366 starting January 1).

Used to calculate Earth distance from sun. A value of 0 (default) indicates no scaling of solar source function using earth-sun distance.

SZA Solar zenith angle in degrees (0 degrees is overhead).

ISOLVAR Solar variability option [-1,0,1,2,3]

=-1 (when SCON .EQ. 0.0): no solar variability; each band uses the Kurucz extraterrestrial solar irradiance, corresponding to a spectrally integrated solar constant of 1368.22 Wm-2 (method used in rrtmg_sw_v3.91 and earlier)

=-1 (when SCON .NE. 0.0): solar variability active; baseline solar irradiance of 1368.22 Wm-2 is scaled to SCON, solar variability is determined (optional) by non-zero scale factors for each band defined by SOLVAR

= 0 (when SCON .EQ. 0.0): no solar variability; each band uses the solar constant from the NRLSSI2 model of 1360.85 Wm-2 (for the spectral range 100-50000 cm-1) with quiet sun, facular and sunspot contributions fixed to the mean of Solar Cycles 13-24 and averaged over the mean solar cycle

= 0 (when SCON .NE. 0.0): no solar variability; baseline solar irradiance of 1360.85 Wm-2 (for the spectral range 100-50000 cm-1) is scaled to SCON

= 1 solar variability active; solar cycle contribution determined by input of SOLCYCFRAC, a fraction representing the phase of the solar

cycle, with
facular brightening and sunspot blocking effects varying in time with this
fraction through their mean variations over the average of Solar Cycles 13-24
(corresponding to a solar constant of 1360.85 Wm-2); two amplitude scale
factors provided in SOLVAR allow independent adjustment of facular and sunspot
effects from their mean solar cycle amplitudes

= 2 solar variability active; solar cycle contribution determined by direct
specification of Mg (facular) and SB (sunspot) indices consistent with the
NRLSSI2 solar model; these are provided in SOLVAR and are used to model the
solar variability at a specific time for a specific solar cycle
(SCON = 0.0 only; solar constant depends on Mg and SB indices provided)
Further information on setting the Mg and SB indices for this option can
be found at the NRLSSI model github site: https://github.com/lasp/nrlssi.

= 3 (when SCON .EQ. 0.0): no solar variability; each band uses the NRLSSI2
extraterrestrial solar irradiance, corresponding to a spectrally integrated
solar constant of 1360.85 Wm-2 with quiet sun, facular and sunspot
contributions averaged over the mean of Solar Cycles 13-24
= 3 (when SCON .NE. 0.0): solar variability active; baseline solar irradiance
of 1360.85 Wm-2 is scaled to SCON, solar variability is determined (optional)
by non-zero scale factors for each band defined by SOLVAR and applied to SCON

SCON For ISOLVAR = -1 or 0:
Total solar irradiance (if SCON > 0, internal solar irradiance is scaled
to this value)
For ISOLVAR = 1:
Solar constant; integral of total solar irradiance averaged over solar cycle
(if SCON > 0, internal solar irradiance is scaled to this value)

For ISOLVAR = 2:
SCON must be 0.0, since total solar irradiance is defined by the Mg and SB indices provided in SOLVAR
For ISOLVAR = 3:
Total solar irradiance before individual band scale factors are applied
(if SCON > 0 internal solar irradiance is scaled to this value)
Set SCON = 0.0 to use internal solar irradiance, which depends on ISOLVAR

SOLCYCFRAC Solar cycle fraction (0-1); fraction of the way through the mean 11-year cycle with 0.0 defined as the first day of year 1 and 1.0 defined as the last day of year 11 (ISOLVAR=1 only). Note that for the combined effect of the solar constant of 1360.85, and the mean facular brightening and sunspot dimming components (without scaling), the minimum total solar irradiance of 1360.49 occurs at SOLCYCFRAC = 0.0265, and the maximum total solar irradiance of 1361.34 occurs at SOLCYCFRAC = 0.3826.

SOLVAR Solar variability scaling factors or indices (ISOLVAR=-1,1,2,3 only)
For ISOLVAR = 1:
SOLVAR(1) Facular (Mg) index amplitude scale factor
SOLVAR(2) Sunspot (SB) index amplitude scale factor

For ISOLVAR = 2:
SOLVAR(1) Facular (Mg) index as defined in the NRLSSI2 model; used for modeling time-specific solar activity
SOLVAR(2) Sunspot (SB) index as defined in the NRLSSI2 model; used for modeling time-specific solar activity

For ISOLVAR = -1 or 3:
SOLVAR(1:14) Band scale factors for modeling spectral variation of averaged solar cycle in each shortwave band

RECORD 1.4

IEMIS, IREFLECT, (SEMISS(IB),IB=16,29)

12, 15, 16-85

11X, I1, 2X, I1, 14F5.3

(Note: surface reflectance = 1 - surface emissivity)

IEMIS = 0 each band has surface emissivity equal to 1.0
= 1 each band has the same surface emissivity (equal to SEMISS(16))
= 2 each band has different surface emissivity (for band IB, equal to SEMISS(IB))

IREFLECT = 0 for Lambertian reflection at surface, i.e. reflected radiance is equal at all angles
= 1 for specular reflection at surface, i.e. reflected radiance at angle is equal to downward surface radiance at same angle multiplied by the reflectance. THIS OPTION CURRENTLY NOT IMPLEMENTED.

SEMISS the surface emissivity for each band (see Table I). All values must be greater than 0 and less than or equal to 1. If IEMIS = 1, only the first value of SEMISS (SEMISS(16)) is considered. If IEMIS = 2 and no surface emissivity value is given for SEMISS(IB), a value of 1.0 is used for band IB.

****
******   these records applicable only if RRTATM not selected (IATM=0)   ******

LAYER INPUT   (MOLECULES ONLY)

RECORD 2.1

IFORM, NLAYRS, NMOL

2   3-5,   6-10

1X,I1   I3,   I5

IFORM   (0,1) column amount format flag
= 0   read PAVE, WKL(M,L), WBROADL(L) in F10.4, E10.3, E10.3 formats (default)
= 1   read PAVE, WKL(M,L), WBROADL(L) in E15.7 format

NLAYRS   number of layers (maximum of 200)

NMOL   value of highest molecule number used (default = 7; maximum of 35)
See Table II for molecule numbers.

RECORD 2.1.1

PAVE,   TAVE,   PZ(L-1),   TZ(L-1),   PZ(L),   TZ(L)

1-10, 11-20,   44-51,   52-58,   66-73,   74-80

F10.4, F10.4, 23X, F8.3,   F7.2,   7X, F8.3,   F7.2

PAVE   average pressure of layer (millibars) (**If IFORM=1, then PAVE in E15.7 format**)

TAVE   average temperature of layer (K)

PZ(L-1)   pressure at bottom of layer L

TZ(L-1)   temperature at bottom of layer L - used by RRTM for Planck

Function Calculation

** NOTE ** PZ(L-1) and TZ(L-1) are only required for the first layer. RRTM assumes that these quantites are equal to the top of the previous layer for L > 1.

PZ(L) pressure at top of layer L

TZ(L) temperature at top of layer L - used by RRTM for Planck Function Calculation

RECORD 2.1.2

(WKL(M,L), M=1, 7), WBROADL(L)

(8E10.3)

WKL(M,L) column densities or mixing ratios for 7 molecular species (molecules/cm**2)

WBROADL(L) column density for broadening gases (molecules/cm**2)

NOTE If IFORM=1, then WKL(M,L) and WBROADL(L) are in 8E15.7 format

RECORD 2.1.3 only if (NMOL .GT . 7) # records depends on NMOL

(WKL(M,L), M=8, NMOL)

(8E10.3)

NMOL is set from LINFIL (TAPE3)

(NMOL limited to 35 in RRTM) **NOTE: If IFORM=1 then WKL(M,L) in 8E15.7 format**

REPEAT RECORDS 2.1.1 through 2.1.3 for the remaining layers (up to NLAYRS)

****

******** these records applicable if RRTATM selected (IATM=1) ********

RECORD 3.1

MODEL, IBMAX, NOPRNT, NMOL, IPUNCH, MUNITS, RE, CO2MX, REF_LAT

5, 15, 25, 30, 35, 39-40, 41-50, 71-80, 81-90

I5, 5X, I5, 5X, I5, I5, I5, 3X, I2, F10.3, 20X, F10.3, F10.3

MODEL selects atmospheric profile

= 0 user supplied atmospheric profile
= 1 tropical model
= 2 midlatitude summer model
= 3 midlatitude winter model
= 4 subarctic summer model
= 5 subarctic winter model
= 6 U.S. standard 1976

IBMAX selects layering for RRTM

= 0 RRTM layers are generated internally (default)
> 0 IBMAX is the number of layer boundaries read in on Record 3.3B which are used to define the layers used in RRTM calculation

NOPRNT = 0 full printout
= 1 selects short printout

NMOL number of molecular species (default = 7; maximum value is 35)

IPUNCH = 0 layer data not written (default)
= 1 layer data written to unit IPU (TAPE7)

MUNITS = 0 write molecular column amounts to TAPE7 (if IPUNCH = 1, default)
= 1 write molecular mixing ratios to TAPE7 (if IPUNCH = 1)

RE radius of earth (km)

defaults for RE=0:

a) MODEL 0,2,3,6 RE = 6371.23 km

b) 1 RE = 6378.39 km

c) 4,5 RE = 6356.91 km

CO2MX mixing ratio for CO_2 (ppm). Default is 330 ppm.

REF_LAT latitude of location of calculation (degrees)

defaults for REF_LAT = 0:

a) MODEL 0,2,3,6 REF_LAT = 45.0 degrees

b) MODEL 1 REF_LAT = 15.0

c) MODEL 4,5 REF_LAT = 60.0

RECORD 3.2

HBOUND, HTOA

1-10, 11-20

F10.3, F10.3

HBOUND altitude of the surface (km)

HTOA altitude of the top of the atmosphere (km)

RECORD 3.3 options

RECORD 3.3A For IBMAX = 0 (from RECORD 3.1)

AVTRAT, TDIFF1, TDIFF2, ALTD1, ALTD2

1-10, 11-20, 21-30, 31-40, 41-50

F10.3, F10.3, F10.3, F10.3, F10.3

AVTRAT maximum Voigt width ratio across a layer
(if zero, default = 1.5)

TDIFF1 maximum layer temperature difference at
ALTD1 (if zero, default = 5 K)

TDIFF2 maximum layer temperature difference at
ALTD2 (if zero, default = 8 K)

ALTD1 altitude of TDIFF1 (if zero, default = 0 Km)

ALTD2 altitude of TDIFF2 (if zero, default = 100 Km)

RECORD 3.3B For IBMAX > 0 (from RECORD 3.1)

ZBND(I), I=1, IBMAX altitudes of RRTM layer boundaries

(8F10.3)

If IBMAX < 0

PBND(I), I=1, ABS(IBMAX) pressures of LBLRTM layer boundaries

(8F10.3)

--

User Defined Atmospheric Profile

------------------------------- (MODEL = 0) -------------------------------

RECORD 3.4

IMMAX, HMOD

5, 6-29

I5, 3A8

IMMAX number of atmospheric profile boundaries

If IMMAX is set to a negative value, the level boundaries are specified in PRESSURE (mbars).

HMOD 24 character description of profile

RECORD 3.5

ZM, PM, TM, JCHARP, JCHART, (JCHAR(K),K =1,28)

1-10, 11-20, 21-30, 36, 37, 41 through 68

E10.3, E10.3, E10.3, 5x, A1, A1, 3X, 28A1

ZM boundary altitude (km). If IMMAX < 0, altitude levels are computed from pressure levels PM. If any altitude levels are provided, they are ignored if IMMAX < 0 (exception: The first input level must have an accompanying ZM for input into the hydrostatic equation)

PM pressure (units and input options set by JCHARP)

TM temperature (units and input options set by JCHART)

JCHARP flag for units and input options for pressure (see Table II)

JCHART flag for units and input options for temperature (see Table II)

JCHAR(K) flag for units and input options for the K'th molecule (see Table II)

RECORD 3.6.1 ... 3.6.N

VMOL(K), K=1, NMOL

8E10.3

VMOL(K) density of the K'th molecule in units set by JCHAR(K)

REPEAT records 3.5 and 3.6.1 to 3.6.N for each of the remaining IMMAX boundaries

---

User Defined Atmospheric Profile

------------------------------- (IPRFL = 0) -------------------------------

RECORD 3.8

LAYX, IZORP, XTITLE

5, 10, 11-60

I5, I5 A50

LAYX number of atmospheric profile boundaries

IZORP (0,1) flag which determines value of ZORP on Record 3.8.1

= 0 ZORP is an altitude in KM
= 1 ZORP is a pressure in millibars

XTITLE 50 character description of profile

RECORD 3.8.1

ZORP, (JCHAR(K),K =1,28)

1-10, 16 through 50

F10.3, 5X, 35A1

ZORP boundary altitude (km) or pressure (millibars) as determined by IZORP on Record 3.8

JCHAR(K) flag for units and input options for the K'th cross-section

JCHAR = 1-1 - default to value for specified model atmosphere

= " ",A - volume mixing ratio (ppmv)

RECORD 3.8.2 ... 3.8.N

DENX(K), K=1, IXMOLS

8E10.3

DENX(K) density of the K'th cross-section in units set by JCHAR(K)

REPEAT records 3.8.1 to 3.8.N for each of the remaining LAYX boundaries

----

TABLE I. RRTM Bands and Included Species

Band #	Wavenumber Range (cm-1)	1050 - 96 mb	96 - 0.01 mb
16	2600-3250	H2O,CH4	CH4
17	3250-4000	H2O,CO2	H2O,CO2
18	4000-4650	H2O,CH4	CH4
18	4650-5150	H2O,CO2	CO2
20	5150-6150	H2O,CH4*	H2O,CH4*
21	6150-7700	H2O,CO2	H2O,CO2
22	7700-8050	H2O,O2	O2
23	8050-12850	H2O	nothing
24	12850-16000	H2O,O2,O3*	O2,O3*
25	16000-22650	H2O,O3*	O3*
26	22650-29000	nothing	nothing
20	29000-38000	O3	O3
28	38000-50000	O3,O2	O3,O2
29	820-2600	H2O	CO2

* Included as minor species.

TABLE II. Units and input options for the K'th molecule

TABLE II

USER OPTIONS FOR PRESSURE, TEMPERATURE, AND MOLECULAR DENSITY

JCHARP

PRESSURE	1-6	default to value for specified model atmosphere
(JCHARP)	" ",A	pressure in (mb)
	B	" " (atm)
	C	" " (torr)

JCHART

TEMPERATURE	1-6	default to value for specified model atmosphere
(JCHART)	" ",A	ambient temperature in deg (K)
	B	" " " " " " (C)

JCHAR(M)

(M): AVAILABLE (1) H2O (2) CO2 (3) O3 (4) N2O (5) CO (6) CH4 (7) O2
MOLECULAR SPECIES (8) NO (9) SO2 (10) NO2 (11) NH3 (12) HNO3 (13) OH (14) HF
(15) HCL (16) HBR (17) HI (18) CLO (19) OCS (20) H2CO (21) HOCL
(22) N2 (23) HCN (24) CH3CL (25) H2O2 (26) C2H2 (27) C2H6 (28) PH3
(29) COF2 (30) SF6 (31) H2S (32) HCOOH (33) EMPTY (34) EMPTY (35) EMPTY

potential choice of units for above species:

JCHAR	= 1-6	- default to value for specified model atmosphere
	= " ",A	- volume mixing ratio (ppmv)
	= B	- number density (cm-3)
	= C	- mass mixing ratio (gm/kg)
	= D	- mass density (gm m-3)
	= E	- partial pressure (mb)
	= F	- dew point temp (K) *H2O only*
	= G	- dew point temp (C) *H2O only*
	= H	- relative humidity (percent) *H2O only*
	= I	- available for user definition

JCHAR must be less than "J"

****

IN_CLD_RRTM Instructions (this file required if ICLD = 1 in Record 1.2 of INPUT_RRTM)

RECORD C1.1

INFLAG, ICEFLAG, LIQFLAG

5 10 15

4X, I1, 4X, I1, 4X, I1

Note: ICEFLAG and LIQFLAG are required only if INFLAG = 2.

INFLAG = 0 direct specification of optical depths of clouds;
cloud fraction and cloud optical depth (gray), single scattering albedo,
and N-str moments of the phase function

= 2 calculation of separate ice and liquid cloud optical depths, with
parameterizations determined by values of ICEFLAG and LIQFLAG.
Cloud fraction, cloud water path, cloud ice fraction, and
effective ice radius are input for each cloudy layer for all
parameterizations. If LIQFLAG = 1, effective liquid droplet radius
is also needed. If ICEFLAG = 1, generalized effective size is
is also needed.

ICEFLAG = 0 inactive
= 1 the optical depths (non-gray) due to ice clouds are computed as closely as
possible to the method in E.E. Ebert and J.A. Curry, JGR, 97, 3831-3836 (1992).
= 2 the optical properties are computed by a method based on the parameterization
of spherical ice particles in the RT code, STREAMER v3.0 (Reference:
Key. J., Streamer User's Guide, Cooperative Institute for
Meteorological Satellite Studies, 2001, 96 pp.).
= 3 the optical depths are computed by a method based on the parameterization
of ice clouds due to Q. Fu, J. Clim., 9, 2058 (1996).

LIQFLAG = 0 inactive

= 1 the optical depths (non-gray) due to water clouds are computed by a method based on the parameterization of water clouds due to Y.X. Hu and K. Stamnes, J. Clim., 6, 728-742 (1993).

These methods are further detailed in the comments in the file 'rrtmg_sw_cldprop.F90' and the module 'rrtmg_sw_susrtop.F90'.

RECORD C1.2 (one record for each cloudy layer, if INFLAG = 0)

TESTCHAR,	LAY,	CLDFRAC,	TAUCLD or CWP,	SINGLE-SCAT, ALBEDO	PMOM(0:NSTR)
1,	3-5,	6-15,	16-25,	26-35,	36-196
A1, 1X,	I3,	E10.5,	E10.5,	E10.5,	16E10.5

TESTCHAR control character -- if equal to '%', cloud input processing is terminated

LAY layer number of cloudy layer. The layer numbering refers to the ordering for the upward radiative transfer, i.e. botton to top. For IATM = 0 (Record 1.2), each layer's number is equal to the position of its Record 2.1.1 in the grouping of these records. For example, the second Record 2.1.1 occurring after Record 2.1 corresponds to the second layer. For IATM = 1 (Record 1.2) and IBMAX > 0 (Record 3.1), layer n corresponds to the region between altitudes n and n+1 in the list of layer boundaries in Record 3.3B. For IATM = 1 (Record 1.2) and IBMAX = 0 (Record 3.1), the layer numbers can be determined by running RRTM for the cloudless case and examining the TAPE6 output from this run.

CLDFRAC cloud fraction for the layer

TAUCLD (INFLAG = 0 only) total (ice and water) optical depth for the layer

SINGLE-SCATTERING ALBEDO SIngle-scattering albedo for cloudy layer (unitless)

PMOM Moments of the phase function, from 0 to NSTR. (unitless)

Note: The true optical depth,single-scattering albedo, and phase function moments must be input.
The Delta-M scaling, using the standard Henyey-Greenstein approach, is applied to the input cloud properties.

RECORD C1.3 (one record for each cloudy layer, INFLAG = 2)

TESTCHAR, LAY, CLDFRAC, TAUCLD or CWP, FRACICE, EFFSIZEICE, EFFSIZELIQ

1, 3-5, 6-15, 16-25, 26-35, 36-45, 46-55

A1, 1X, I3, E10.5, E10.5, E10.5, E10.5, E10.5

TESTCHAR control character -- if equal to '%', cloud input processing is terminated

LAY layer number of cloudy layer. The layer numbering refers to the ordering for the upward radiative transfer, i.e. botton to top. For IATM = 0 (Record 1.2), each layer's number is equal to the position of its Record 2.1.1 in the grouping of these records. For example, the second Record 2.1.1 occurring after Record 2.1 corresponds to the second layer. For IATM = 1 (Record 1.2) and IBMAX > 0 (Record 3.1), layer n corresponds to the region between altitudes n and n+1 in the list of layer boundaries in Record 3.3B. For IATM = 1 (Record 1.2) and IBMAX = 0 (Record 3.1), the layer numbers can be determined by running RRTM for the cloudless case and examining the TAPE6 output from this run.

CLDFRAC cloud fraction for the layer.

TAUCLD (INFLAG = 0 only) total (ice and water) optical depth for the layer
or CWP (INFLAG > 0) cloud water path for the layer (g/m2)

FRACICE (INFLAG = 2) fraction of the layer's cloud water path in the form of ice particles

EFFSIZEICE (INFLAG = 2 and ICEFLAG = 1) Effective radius of spherical ice crystals with equivalent projected area to hexagonal ice particles following Ebert and Curry (1992).
Valid sizes are 13.0 - 130.0 microns.

(INFLAG = 2 and ICEFLAG = 2) Effective radius of spherical ice crystals, re (see STREAMER manual for definition of this parameter)
Valid sizes are 5.0 - 131.0 microns.

(INFLAG = 2 and ICEFLAG = 3) Generalized effective size of hexagonal

ice crystals, dge (see Q. Fu, 1996, for definition of this parameter)
Valid sizes are 5.0 - 140.0 microns.

NOTE: The size descriptions for effective radius and generalized effective size are NOT equivalent. See the particular references for the appropriate definition.

EFFSIZELIQ (INFLAG = 2 and LIQFLAG = 1) Liquid droplet effective radius, re (microns)

Valid sizes are 2.5 - 60.0 microns.

IN_AER_RRTM Instructions (this file required if IAER = 1 in Record 1.2 of INPUT_RRTM)

RECORD A1.1

NAER

5

3X, I2

NAER number of different aerosol types (maximum of 99). An aerosol type is characterized by a specified
spectral dependence of aerosol optical depth, single-scattering albedo, and phase function; a change
to any of these quantities requires a new aerosol type. Each aerosol type requires the presence of
Records A2.1 - A2.3.

RECORD A2.1

NLAY, IAOD, ISSA, IPHA, (AERPAR(I),I=1,3)

5, 10, 15, 20, 21-44

3X, I2, 4X, I1, 4X, I1, 4X, I1, 3F8.2

NLAY number of layers containing the aerosol with the specified properties: spectral dependence of aerosol
optical depth (IAOD,AERPAR), single-scattering albedo (ISSA, SSA), and phase function (IPHA,PHASE).
Note that each layer can contain only one aerosol type.

IAOD (0,1) flag for specifying the spectral dependence of aerosol optical depth
= 0 spectral dependence determined by Angstrom-like relationship (Molineaux et al.; see below)
with variables AERPAR(1), AERPAR(2), and AERPAR(3)
= 1 aerosol optical depths directly input for each layer and band in Record A2.1.1

ISSA (0,1) flag for gray or spectrally dependent single scattering albedo
= 0 gray SSA (equal to SSA(16))
= 1 spectrally dependent SSA (for band IB, equal to SSA(IB))

IPHA (0,1,2) phase function flag
= 0 spectrally gray phase function (equal to PHASE(16) in first and only Record 2.3); uses Henyey-Greenstein phase function
= 1 spectrally dependent phase function (for band IB, equal to PHASE(IB) in first and only Record 2.3); uses Henyey-Greenstein phase function
= 2 direct specification of moments of phase function. See Record 2.3.

AERPAR (only used if IAOD = 0) array of parameters for obtaining aerosol optical depth as a function of wavelength, as described below:

```
AOD = AOD1 * (AERPAR(2) + AERPAR(3) * (lambda/lambda1)) /
              ((AERPAR(2) + AERPAR(3) - 1) + (lambda/lambda1)**AERPAR(1))
    where
        lambda = wavelength in microns
        lambda1 = 1 micron
        AOD = aerosol optical depth at wavelength lambda
        AOD1 = aerosol optical depth at 1 micron (see Record A2.1.1).
```

This is a version of Eq. 13 from Molineaux et al, Appl. Optics, 1998. The default values of AERPAR(1), AERPAR(2), and AERPAR(3), which are 0, 1, and 0, respectively, yield an aerosol with spectrally grey extinction.

(Note: To obtain Angstrom relation, set AERPAR(2)=1., AERPAR(3)=0., and AERPAR(1) equal to Angstrom exponent.)

RECORD A2.1.1

(if IAOD = 0)
LAY, AOD1

5, 6-12

2X, I3, F7.4

(if IAOD = 1)
LAY, (AOD(IB),IB=16,29)

5, 6-103

2X, I3, 14F7.4

LAY layer number of aerosol layer. (The layer numbering refers to the ordering for the upward radiative transfer, i.e. bottom to top.
For IATM = 0 (Record 1.2), each layer's number is equal to the position of its Record 2.1.1 in the grouping of these records.
For example, the second Record 2.1.1 occurring after Record 2.1 corresponds to the second layer. For IATM = 1 (Record 1.2) and IBMAX > 0 (Record 3.1), layer n corresponds to the region between
altitudes n and n+1 in the list of layer boundaries in Record 3.3B.
For IATM = 1 (Record 1.2) and IBMAX = 0 (Record 3.1), the layer numbers can be determined by running RRTM for the cloudless case
and examining the TAPE6 output from this run.(

(if IAOD = 0)
AOD1 aerosol optical depth at 1 micron; can be used to scale the amount of aerosols in the
layer; see Record A2.1
(if IAOD = 1)
AOD aerosol optical depth for each band

REPEAT RECORD A2.1.1 for the remaining layers containing this aerosol type. There should be NLAY
records A2.1.1

RECORD A2.2

(SSA(IB),IB=16,29)

(1-70)

14F5.2

SSA Single scattering albedo for each band; must be equal to or greater than zero and
less than or equal to 1. If ISSA equals 0, then only the first value of SSA (SSA(16))
is considered.

RECORD A2.3

(PHASE(IB),IB=16,29)

(1-70)

14F5.2

PHASE Moments (starting with first moment) of the phase function for band IB. In this implementation,
the phase function P(u) for each band is defined as
P(u) = sum over streams l { (2l+1) (PHASE_l) (P_l(u)) }
where
u = cos(theta)
PHASE_l = the lth moment of the phase function
P_l(u) = lth Legendre polynomial,
and the number of streams to be used in DISORT (using the delta-M method) is determined
by the value of ISTRM in Record 1.2 of INPUT_RRTM.

For IPHA = 0 or IPHA = 1, the Henyey-Greenstein phase function is used and only the first
moment of the phase function needs to be specified, so only one Record A2.3 is read.
(Note: The first moment of the phase function is the asymmetry parameter.) If IPHA equals
0, then only the first value of PHASE (PHASE(16)) is considered.

For IPHA = 2, the number of A2.3 records should be equal to the number of streams.

REPEAT RECORDS A2.1 through A2.3 for the remaining aerosol types. There should be NAER sets (A2.1 through A2.3) of records.