RTTOV-7/8 coefficient files format

Pascal Brunel
MétéoFrance

This documentation was developed within the context of the EUMETSAT Satellite Application Facility on Numerical Weather Prediction (NWP SAF), under the Cooperation Agreement dated 25 November 1998, between EUMETSAT and the Met Office, UK, by one or more partners within the NWP SAF. The partners in the NWP SAF are the Met Office, ECMWF, KNMI and Météo France.

Change record			
Version	Date	Author / changed by	Remarks
1.0	18/04/01	P. Brunel	Initial
1.1	12/02/03	P. Brunel	Update for RTTOV7 v2.4 release
1.2	19/02/03	R. Saunders	Additions/corrections
1.3	25/05/04	P. Brunel	Update for RTTOV8
1.4	25/10/04	B. Conway	Doc ID and standard running header introduced
1.5	23/11/04	R. Saunders	Corrected MTSAT id number

Introduction

This document documents the format of the RT coefficient files used with the RTTOV fast model. It is applicable to RTTOV-7 and RTTOV-8 coefficient files. Note RTTOV-8 can be run with RTTOV-7 files but not the opposite.

The file format is able to serve all the kinds of instruments supported by RTTOV , infrared (IR), microwave (MW) or high resolution IR sounder (Hi) and is easy to update for new options. The format relies on "sections" which are starting by a key word, the order of the sections is important for 'identification' and 'fast_variable' as they are defining the other sections. The structure/rules are defined as follows:

<section name>
Starting in any column, capital letters, no space, no comment on the line, section "END" will logically close the file
! <comment>
Any line starting by a '!' in any column. Comment lines can be put before or after a section name but NOT inside a section data area
i1 r2 i3 ! <comment>
Integer or real data can be followed by a comment (a space should precede the!) only when they are not part of an array described on several lines.
string ! <comment>
String can be followed by a comment, so a string cannot contain a "!" character. The default size of string variables is 32 characters, otherwise specified. Strings will be internally left justified.
<empty line>
Empty lines are not allowed

integer missing value is -9999

Sections:

The actual list of sections is:

- IDENTIFICATION
- LINE-BY-LINE
- FAST_MODEL_VARIABLES
- FILTER_FUNCTIONS
- FUNDAMENTAL_CONSTANTS
- FASTEM
- SSIREM
- GAZ_UNITS
- REFERENCE_PROFILE
- PROFILE_LIMITS
- FAST_COEFFICIENTS
- COEF_SUB_FILES
- END

A section is generally preceded and followed by comment lines providing information on how it was created.
The data information contained in one section is described line by line. In this group of lines, comment lines are not allowed, but comments can be added at the end of the values. All lines between the end of a section and the beginning of another section are ignored, so adding a new section in a file will not return an error if the reading subroutine is not updated. For each section we will indicate the variable name and type used in the reading subroutine and a short description.

Arrays (RTTOV7 only)

RTTOV-7 only:

The sizes of the arrays are given relatively to the defined RTTOV parameters.

```
fmv_chn_max     = jpch      maximum number of channels
fmv_lvl_max     = jplev     maximum number of levels
fmv_var_max     = jpcofm    max number of variables,  Mixed Gases
```

New parameters introduced:

```
fmv_gas_max     =  jpgas = 3      maximum number of gases
lbl_dataset_max = 2   maximum number of line/line datasets
```

fastem_coef_max = 140 maximum number of FASTEM coefficients

Note that all arrays are stored in the coefficient file according to their real used dimensions and NOT the dimensions of the declarations. For example the maximum number of channels is 47 in RTTOV6 and the number of channels stored for a METEOSAT file is 2.

There are no limits for the RTTOV7 v2.4 and following versions which are using dynamic memory allocation. So for these versions of the code, the maximum value shall be replaced by the actual value contained by the file. For example the reference to **fmv_chn_max** shall be replaced by the real number **fmv_chn**.

IDENTIFICATION

id_platform, id_sat, id_inst
3 integers
RTTOV_ids (see Annex A)

id_common_name
32 characters string
Common name of the satellite/instrument ex: Noaa16 AMSU-A

id_sensor
2 characters string
Type of sensor: micro-wave, infra-red, interferometer
Value should be one of those [’MW’ , ‘IR’, ‘Hi’] (ignore case of letters)

id_comp_lvl
integer
coefficient file version number for compatibility

id_creation
80 characters string
Any comment giving information on who or where was created this coefficient file
information only

id_creation_year, id_creation_month, id_creation_day
3 integers
Date of creation of the coefficient file (year month day). *information only*

LINE-BY-LINE

This section is for information only, none of its data is used in RTTOV

lbl_id
characters string
Name of LbL code including version number.

lbl_database
characters string
Name of the spectroscopic database

lbl_h2o_cntnm
characters string
Name of the H2O continuum

lbl_dataset_nb
integer
Number of profile datasets used (actually 2 TIGR43 for T,WV and NESDIS 34 for O3)

Each dataset of lbl_dataset_nb is described by 2 data lines

Line n+1 lbl_dataset_name
characters string, stored in an array of size lbl_dataset_max
Profile dataset name followed by any comment.

Line n+2 lbl_dataset_prf, lbl_dataset_const, lbl_dataset_lvl, lbl_dataset_sec
4 integers, stored in arrays of size lbl_dataset_max
Number of profiles
Number of constituents
Number of levels
Number of secant angles

FAST_MODEL_VARIABLES

fmv_model_def
characters string
Fast model variables definition (RTTOV6, RTTOV7, RTTOV8, OPTRAN)

fmv_model_ver
integer
Version number of the predictors of the fast model.
this line is not present for all RTTOV7 coefficient files, in that case version 7 is assumed.

fmv_chn
integer
Number of channels stored in this coefficient file, can be different from the usual instrument channel number.

fmv_gas
integer
Number of different gases described in the file

Each gas of fmv_gas is described by 2 data lines:

Line n+1 fmv_gas_id
characters string stored in an array of size fmv_gas_max
The identification of the absorber gaz, should be one of: [Mixed_Gases, Water_vapour, Ozone, WV_Continuum, CO2, N2O, CO, CH4]

Line n+2 fmv_var, fmv_lvl
2 integers, stored in arrays of size fmv_gas_max
Number of variables/predictors
Number of levels (pressure or absorber space)

FILTER_FUNCTIONS
One line for each channel (fmv_chn)

ff_ori_chn, ff_val_chn, ff_cwn, ff_bco, ff_bcs, ff_gam
2 integers, 4 reals arrays of size fmv_chn_max
Original channel number for the instrument
Validity of the channel (if 1 channel is valid)
Central wave number (cm^{-1})
Band correction offset (K)
Band correction slope (K/K)
Gamma factor transmittance corrections (not used currently so set to 1)

FUNDAMENTAL_CONSTANTS
Values used for generate the coefficients, controlled internally RTTOV for consistency.

fc_speedl
real
Speed of light (cm/s)

fc_planck_c1, fc_planck_c2
real
Planck constants
First radiation constant for spectral radiance (mW/(m2.sr.cm-4))
Second radiation constant for spectral radiance (cm.K)

fc_sat_height
real
Satellite nominal height (km)

FASTEM (mandatory for id_sensor MW)

fastem_ver
integer
Emissivity model version number

fastem_coef_nb
integer
Number of coefficients (140 for Fastem 1 and 2)
fastem_coef
real, array of size fastem_coef_max
Array of fastem coefficients, real size of stored array is fastem_coef_nb
fastem_polar
integer (free format) array of size fmv_chn_max
Array of polarisation (each channel)

MPOL = 0 : 0.5*(V+H)
MPOL = 1 : polarisation angle=90-incidence angle
MPOL = 2 : polarisation angle=incidence angle
MPOL = 3 : vertical polarisation
MPOL = 4 : horizontal polarisation

SSIREM (mandatory for id_sensor IR and Hi)
ssirem_ver
integer
Emissivity model version number

One line per channel (fmv_chn_nb)
ssirem_chn, ssirem_a0, ssirem_a1, ssirem_a2, ssirem_xzn1, ssirem_xzn2
integer, 5 reals arrays of size fmv_chn_max
Original channel number for the instrument (for verification only)
5 coefficients for emissivity model ssirem
GAZ_UNITS
Optional section. Only for version 7 v2.4 and higher.
One line for each gaz (fmv_gas)
Gaz_concentration units
Integer
Gaz unit number. Refers to the unit for gaz amount used in reference and limit profiles
Allowed units are:
1 specific concentration (kg/kg)
2 volume mixing ratio (ppmv)
If this section is not present (or for RTTOV7) specific concentration is assumed.
REFERENCE_PROFILE
The number of levels is the one of the first gas defined in FAST_MODEL section (fmv_lvl(1))
The number of gases is defined in the FAST_MODEL section by fmv_gas

For each gas, fmv_lvl(1) lines (one per level) containing:
ref_prfl_p, ref_prfl_t, ref_prfl_mr for (level,gas)

reals
Reference profile pressure (hPa) (same for all gases), array of size fmv_lvl_max
For each gas (fmv_gas), arrays of size (fmv_lvl_max, fmv_gas_max)
temperature (K) gaz amount (Kg/Kg or ppmv, see gaz_units)

Note: For Mixed Gases the mixing ratio shall be set to the "missing" value
PROFILE_LIMITS
The number of levels is the one of the first gas defined in FAST_MODEL section (fmv_lvl(1))
The number of gases is defined in the FAST_MODEL section by fmv_gas
One line per level fmv_lvl(1):
lim_prfl_p, lim_prfl_tmax, lim_prfl_tmin
reals
Reference profile pressure (same for all gases) array of size fmv_lvl_max

Maximum temperature at level (K) array of size fmv_lvl_max Minimum temperature at level (K) array of size fmv_lvl_max For each gas (fmv_gas)

For each gas, fmv_lvl(1) lines (one per level) containing:

lim_prfl_p, lim_prfl_gmax, lim_prfl_gmin for (level, gas)

reals
Reference profile pressure (hPa) (same for all gases) array of size fmv_lvl_max
Maximum gaz amount (Kg/Kg or ppmv, see gaz_units) array of size fmv_lvl_max, fmv_gas_max
Minimum gaz amount (Kg/Kg or ppmv, see gaz_units) array of size fmv_lvl_max, fmv_gas_max
Note: For Mixed Gases the mixing ratio shall be set to the "missing" value

FAST_COEFFICIENTS
This section is using the values defined in the FAST_MODEL_VARIABLES section.
For each gas, in the same order as the FAST_MODEL_VARIABLES section:

fc_gas_id
characters string
Gas identification, for comparison with section FAST_MODEL_VARIABLES, same name.

fc_coef
real, array (fmv_lvl fmv_chn, fmv_var)
Fast model coefficients the array for gas fc_gas_id.

COEF_SUB_FILES
Only for version 7 v2.4 and higher.
This section is using the values defined in the FAST_MODEL_VARIABLES section.
This section indicates that the fast coefficients are stored in separate files, one for each gaz. Each "sub" file contains an array fc_coef(fmv_lvl, fmv_chn, fmv_var) and may have comment header lines.
For each gas, in the same order as the FAST_MODEL_VARIABLES section:

sub_file
characters string
File name which contains the fast model coefficients

END
The program will ignore all information beyond this line

BINARY FORMAT
With release RTTOV7 v2.4 it is now possible to convert the ASCII files to a binary format. The file access is sequential and contains all sections present in the internal coefficient derived type. The first record contains a reference string and a reference real number.

- Reference string: "%RTTOV_COEFF " (16 characters left aligned)
- Reference real number: 1.2345E12

The reference number is used to check the accordance between the file and the library for little/big endian and real word size.

Annex A: File names

Coefficient file names have the following syntax:

rtcoef_*platform_satid_instrument.ext*

Where:

- Platform is the platform name of the satellite
- Satid is the satellite number
- Instrument is the instrument name
- Ext is the extension of the file name [dat, bin] dat is used for the ASCII files and bin for the binary files

Platforms and instruments supported at date of writing:

Platform	RTTOV id	Sat id range
NOAA	1	1 to 17
DMSP	2	8 to 16
Meteosat	3	5 to 7
GOES	4	8 to 12
GMS	5	5
FY-2	6	2
TRMM	7	1
ERS	8	1 to 2
EOS	9	1 to 3
METOP	10	1 to 3
ENVISAT	11	1
MSG	12	1
FY-1	13	3 to 4
ADEOS	14	2
MTSAT	15	1
CORIOLIS	16	1
NPOESS	17	
GIFTS	18	

Sensor	RTTOV id	Channels
HIRS	0	1 to 19
MSU	1	1 to 4
SSU	2	1 to 3
AMSU-A	3	1 to 15
AMSU-B	4	1 to 5
AVHRR	5	1 to 3
SSMI	6	1 to 7
VTPR1	7	1 to 8
VTPR2	8	1 to 8
TMI	9	1 to 9
SSMIS	10	1 to 24
AIRS	11	1 to 2378
HSB	12	1 to 4
MODIS	13	1 to 17
ATSR	14	1 to 3
MHS	15	1 to 5
IASI	16	1 to 8461
AMSR	17	1 to 14
spare		
ATMS	19	TBD
MVIRI	20	1 to 2
SEVIRI	21	1 to 8
GOES-Imager	22	1 to 4
GOES-Sounder	23	1 to 18
GMS/MTSAT imager	24	1 to 4
FY2-VISSR	25	1 to 2
FY1-MVISR	26	1 to 3
CRIS	27	TBD
CMIS	28	TBD
VIIRS	29	TBD
WINDSAT	30	TBD
GIFTS	31	TBD

Annex B: Example of coefficient file for NOAA14 AVHRR

```
! RTTOV coefficient file noaa-14   avhrr
 ! -----------------------------------------------------
IDENTIFICATION
 !
  1 14  5          ! platform sat_id instrument
 noaa-14   avhrr
 ir               ! sensor type [ir,mw,hi]
  7               ! RTTOV compatibility version
 copy from original RTTOV6 coefficient file
 2001 03 21       ! creation date
 ! -----------------------------------------------------
LINE-BY-LINE
 !
 GENLN2           ! line-by-line
 HITRAN96         ! spectroscopic database
 CKD2.1           ! Water Vapour continuum
 2                ! Profile datasets
 TIGR-43          ! dataset name
 43 2 43 6        ! profiles gases levels secants
 NESDIS-34        ! dataset name
 34 2 43 6        ! profiles gases levels secants
 ! -----------------------------------------------------
FAST_MODEL_VARIABLES
 !
 !Predictors MG EYRE; WV RAYER+SAUNDERS+DEBLONDE; Ozone RAYER
 RTTOV6           ! fast model name
    3             ! Number of channels described in the coef file
    3             ! Number of gases described in the coef file
 Mixed_gases      ! gas identification
   10  43         ! variables/predictors  levels (pressure/absorber)
 Water_vapour     ! gas identification
   10  43         ! variables/predictors  levels (pressure/absorber)
 Ozone            ! gas identification
   10  43         ! variables/predictors  levels (pressure/absorber)
 ! -----------------------------------------------------
FILTER_FUNCTIONS
 !
 ! Channel Number (from instrument original description)
 ! Channel status
 ! Central Wavenumber
 ! Band Correction coefficients(Offset,Slope)
 ! Gamma correction factor
    3    1   0.2659474121E+04   0.1982606173E+01   0.9973250031E+00   0.1000000000E+01
    4    1   0.9293596802E+03   0.4373422563E+00   0.9984871149E+00   0.1000000000E+01
    5    1   0.8346019897E+03   0.2458697110E+00   0.9990643263E+00   0.1000000000E+01
 ! -----------------------------------------------------
FUNDAMENTAL_CONSTANTS
 !
 ! units of constants for spectral radiance
 ! first radiation constant(mW/(m2.sr.cm-4))
 ! second radiation constant (cm.K)
  29979246592.0              ! speed of light (cm/s)
  0.1191066E-04  1.438833    ! Planck constants
    870.0                    ! nominal satellite height (km)
 ! -----------------------------------------------------
SSIREM
 !
 ! Channel Number (from instrument original description)
 ! 5 coefficients for emissivity model ssirem
  1   ! version number
    3   0.9757100   0.0186299   0.0240611 4.0 8.0
    4   0.9917680   0.0078884   0.0187878 4.0 8.0
    5   0.9883230   0.0134569   0.0253074 4.0 8.0
 ! -----------------------------------------------------
REFERENCE_PROFILE
```

```
 !
 ! Ref.pressure (hPa)
 ! Ref.Temp (K) Ref.Mixing Ratio [Kg/Kg] for each gas
 ! Note for MxG that mixing ratio is "missing"
 !     Mixed_gases
    0.100  232.736 -.999900E+04
    0.290  247.984 -.999900E+04
    0.690  256.373 -.999900E+04
    1.420  254.918 -.999900E+04
    2.610  250.632 -.999900E+04
       …….
  985.880  268.795 -.999900E+04
 1005.430  268.892 -.999900E+04
 1013.250  268.942 -.999900E+04
 !     Water_vapour
    0.100  232.736 0.349555E-05
    0.290  247.984 0.376102E-05
    0.690  256.373 0.370316E-05
       …….
  985.880  268.795 0.281403E-02
 1005.430  268.892 0.277897E-02
 1013.250  268.942 0.276761E-02
 !     Ozone
    0.100  241.696 0.969339E-05
    0.290  256.761 0.100043E-04
    0.690  266.111 0.101194E-04
       ......

  985.880  283.993 0.443969E-07
 1005.430  284.845 0.419678E-07
 1013.250  285.188 0.409984E-07
 ! -------------------------------------------------------
PROFILE_LIMITS
 !
 ! Ref.pressure (hPa)
 ! Temp Max (K) Temp Min (K)
 ! Mixing Ratio Max and Min [Kg/Kg] for each gas
 ! Note for MxG that mixing ratio is "missing"
    0.100  335.50  162.00
       ................
  985.880  356.59  154.95
 1005.430  357.86  135.00
 1013.250  385.87  135.00
 !     Mixed_gases
    0.100    0.9999E+04 -0.9999E+04
    0.290    0.9999E+04 -0.9999E+04
    0.690    0.9999E+04 -0.9999E+04
    1.420    0.9999E+04 -0.9999E+04
       ............
 1005.430    0.9999E+04 -0.9999E+04
 1013.250    0.9999E+04 -0.9999E+04
 !     Water_vapour
    0.100    0.4379E-04  0.1200E-05
    0.290    0.4652E-04  0.1200E-05
    0.690    0.4609E-04  0.1200E-05
       ......
  985.880    0.2789E+00  0.6567E-04
 1005.430    0.2820E+00  0.6567E-04
 1013.250    0.2838E+00  0.6567E-04
 !     Ozone
    0.100    0.1631E-04  0.1014E-05
    0.290    0.1685E-04  0.1863E-05
       ...........
 1005.430    0.1619E-06  0.8100E-09
 1013.250    0.1615E-06  0.8100E-09
 ! -------------------------------------------------------
FAST_COEFFICIENTS
```

```
 !
 ! transmission coefficients
 ! Order of the gases:
 !     Mixed_gases
 !     Water_vapour
 !     Ozone
Mixed_gases
  0.00000000E+00  0.20232997E-08  0.10764080E-06  0.28016009E-07  0.20684205E-07
  0.26066479E-07  0.32925922E-07  0.23350742E-07 -0.12244456E-07 -0.58676970E-08
 -0.92317984E-08  0.30986072E-07  0.95044967E-07  0.11684996E-06  0.10500307E-06
       .....
 -0.63459395E-03 -0.66415878E-03 -0.68265415E-03 -0.68852189E-03 -0.67460578E-03
 -0.63684437E-03 -0.56977273E-03 -0.46719151E-03 -0.32133446E-03 -0.12839047E-03
Water_vapour
 -0.15355359E-04  0.24576575E-07  0.12117729E-07  0.70631865E-08  0.51983586E-08
  0.34577761E-08  0.11729411E-08  0.35222594E-08  0.28544962E-08  0.22689530E-08
       .....
 -0.83990989E-03 -0.10049873E-02 -0.11831783E-02 -0.13843434E-02 -0.15526412E-02
 -0.16152295E-02 -0.15763127E-02 -0.14355070E-02 -0.11775813E-02 -0.73866948E-03
Ozone
 -0.45034545E-06  0.33443484E-07  0.11146150E-07  0.12351772E-07  0.83291711E-08
  0.13916921E-07  0.11764262E-07  0.21004015E-07  0.27926324E-07  0.21376286E-07
       .....
 -0.12307930E-05 -0.75035092E-06 -0.10038976E-06  0.00000000E+00  0.00000000E+00
  0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00  0.00000000E+00
 ! ---------------------------------------------------
END
```