Status of Modtran/LibRadTran simulation and Comparison in december 2016

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Overview

Data points of the grid

Altitude

$h = 2.75$ km.

Wavelength range

$\lambda \in [250, 1200]$ nm, $\Delta\lambda = 1$ nm

Airmass range

z computed for 31 points in steps of 0.1 : $z \in [1, 3]$

The Atmospheric Profile

Compare predictions for 2 realistic atmospheric models.

- US standard atmosphere $\rightarrow$ probably good for LSST, but perhaps a little too wet
- Subarctic winter $\rightarrow$ very dry air, probably well suited for LSST site

The above atmospheric models are both available in Modtran(Data Card : Card1.MODEL) and LibRadTran (Data Card : atmosphere_file.)

Main absorption models used in LibRadTran

- **Representative wavelengths parameterization (REPTRAN)**,
- **Pseudo-spectral calculation adapted from LOWTRAN**.
- **CRS: switching off spectral parameterization**.

Absorption models in LibRadTran :

1) REPTRAN, 2) LOWTRAN, 3) CRS,

The absorption models in Modtran

- **Band models methods**, The Modtran or Lowtran models,
- **The correlated-k method**, The Modtran and Lowtran either in slow or medium modes.

Absorption models in Modtran :

1) MODTRAN band Model, 2) LOWTRAN Band Model , 3) MODTRAN correlated-k and slow speed, 4) MODTRAN correlated-k and slow speed, 5) MODTRAN correlated-k and medium speed

The Data card for specifying the absorption model in Modtran is *CARD1 MODTRN* . One should provides the values *T,M,C,K,F,L* and *CARD1 SPEED* is *S* or blank.

Different modes : Selected interaction processes

- Simulate with only molecular scattering (Rayleigh scattering) (code name *sc*).
- **Simulate pure molecular absorption (code name *ab*).**

Variation of Precipitable Pressure Water *PWV*

absorption profiles for 31 points $pwv \in [0\ \mathrm{mm}, 15\ \mathrm{mm}]$ **in steps of 0.5 mm**

Variation of Ozone O_3

absorption profiles for 21 points $O_3 \in [200\ \mathrm{Dobson}, 600\ \mathrm{Dobson}]$.

- **Simulate the combination of molecular scattering and molecular absorption (code name *sa*).**
  - **perform similar variations in *PWV* and O_3**

File naming : Part 1

filename

$P\_O\_\{rte\}\_\{atm\}\_\{proc\}\_\{mod\}\_zXX\_wvXX\_ozXX.extension$

P : **RT** or **MT** for LibRadtran or Modtran,

O : Observatory site **LS** or **HP** or **GM** or **MK** for LSST, OHP, Gemini South, Mauna Kea,...

{rte} : **pp** or **ps**,

{atm} : **us** or **sw**,

{proc} : **sc** for pure molecular scattering, **ab** for pure molecular absorption, **sa** for the combination of molecular scattering and absorption,

{mod} : in LibRadTran : **rt** for Reptran model, **lt** for Lowtran model, **cr** for CRS model, **fu** for the Fu and Liou model, **k2** for Kato2 model, and **kt** for Kato model.

{mod} : in ModTran : **mt** for Modtran band model), **mk** for Modtran correlated-k model, **lt** for Lowtran model.

zXX : Airmass z, where XX is the value of the airmass on 2 digit $XX = 2 \times z$,

wvXX : Precipitable water vapour pwv, where XX is the value of the pwv on 3 digit $XXX = 10 \times pwv$, pwv in mm unit,

ozXX : Ozone oz, where XX is the value of the oz on 2 d igit $XX = oz/10$, oz is Dobson unit.

For example a filename for LibRadtran, for LSST could be :

$$RT\_LS\_pp\_us\_sa\_rt\_z15\_wv030\_oz30.txt$$

where $pwv = 3$ mm and $oz = 300$ Dobson unit and $z = 1.5$.

Example of US standard atmosphere, with Reptran, for airmass $z = 1$ and $z = 2$, when varying PWV :

See repository at :
https://github.com/LSSTDESC/PC5AtmosphericExtinction/tree/master/Lib

ls PC5AtmosphericExtinction/LibRadTran/simulations/RT/2.0/LS/pp/us

```
RT_LS_pp_us_ab_rt_z10_wv0.OUT RT_LS_pp_us_ab_rt_z20_wv30.OUT
RT_LS_pp_us_ab_rt_z10_wv10.OUT RT_LS_pp_us_ab_rt_z20_wv35.OUT
RT_LS_pp_us_ab_rt_z10_wv100.OUT RT_LS_pp_us_ab_rt_z20_wv40.OUT
RT_LS_pp_us_ab_rt_z10_wv105.OUT RT_LS_pp_us_ab_rt_z20_wv45.OUT
RT_LS_pp_us_ab_rt_z10_wv110.OUT RT_LS_pp_us_ab_rt_z20_wv5.OUT
RT_LS_pp_us_ab_rt_z10_wv115.OUT RT_LS_pp_us_ab_rt_z20_wv50.OUT
RT_LS_pp_us_ab_rt_z10_wv120.OUT RT_LS_pp_us_ab_rt_z20_wv55.OUT
RT_LS_pp_us_ab_rt_z10_wv125.OUT RT_LS_pp_us_ab_rt_z20_wv60.OUT
RT_LS_pp_us_ab_rt_z10_wv130.OUT RT_LS_pp_us_ab_rt_z20_wv65.OUT
RT_LS_pp_us_ab_rt_z10_wv135.OUT RT_LS_pp_us_ab_rt_z20_wv70.OUT
RT_LS_pp_us_ab_rt_z10_wv140.OUT RT_LS_pp_us_ab_rt_z20_wv75.OUT
```

File naming : Part 2

Naming absorption models for Modtran

filename

P_O_{rte}_{atm}_{proc}_{mod}_zXX_wvXX_ozXX.extension

{mod} :

- **mt** for Modtran band model (CARD1.MODTRN='T'),
- **mm** for Modtran band model (CARD1.MODTRN='M'),,
- **lt** for Lowtran band model (CARD1.MODTRN='L' or 'F'),
- **mks** for Modtran correlate-k in slow mode (speed), (CARD1.MODTRN='K' or 'C and CARD1.SEED='S'),
- **mkm** for Modtran correlate-k in medium mode (speed), (CARD1.MODTRN='K' or 'C and CARD1.SEED='M'),

For example a filename for Modtran, for LSST could be :

$$MT\_LS\_pp\_us\_sa\_mt\_z15\_wv030\_oz30.txt$$

where $pwv = 3$ mm and $oz = 300$ Dobson unit.

Example of Hierarchy of directories

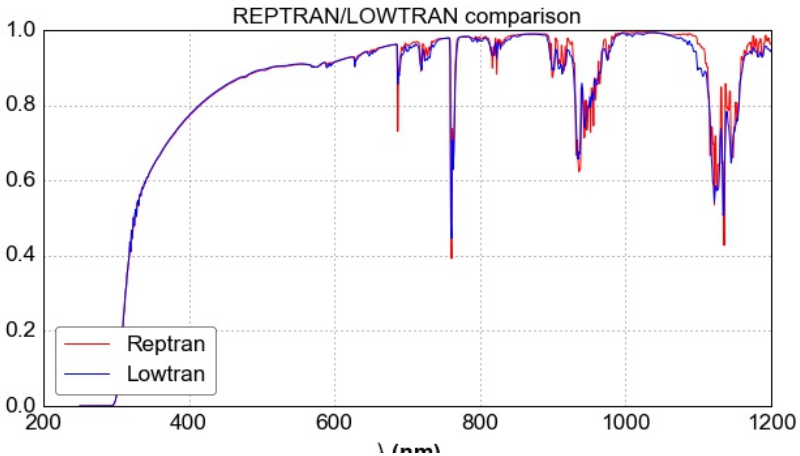
rootdir	top directory
rootdir/RT/VXX/LS/pp/us/sc/	pure molecular scattering
rootdir/RT/VXX/LS/pp/us/ab/rt/wv/	pure molecular absorption for varying *pwv*
rootdir/RT/VXX/LS/pp/us/ab/rt/oz/	pure molecular absorption for varying *oz*
rootdir/RT/VXX/LS/pp/us/sa/rt/wv/	molecular absorption and scattering for varying *pwv*
rootdir/RT/VXX/LS/pp/us/sa/rt/oz/	molecular absorption scattering for varying *oz*
rootdir/RT/VXX/LS/pp/us/sc/ae/	pure molecular scattering and default aerosols scattering
rootdir/RT/VXX/LS/pp/us/sa/rt/ae/	molecular absorption scattering and default aerosols scattering
rootdir/RT/VXX/LS/pp/us/sc/as/	pure molecular scattering and special aerosols scattering
rootdir/RT/VXX/LS/pp/us/sa/rt/as/	molecular absorption scattering and special aerosols scattering

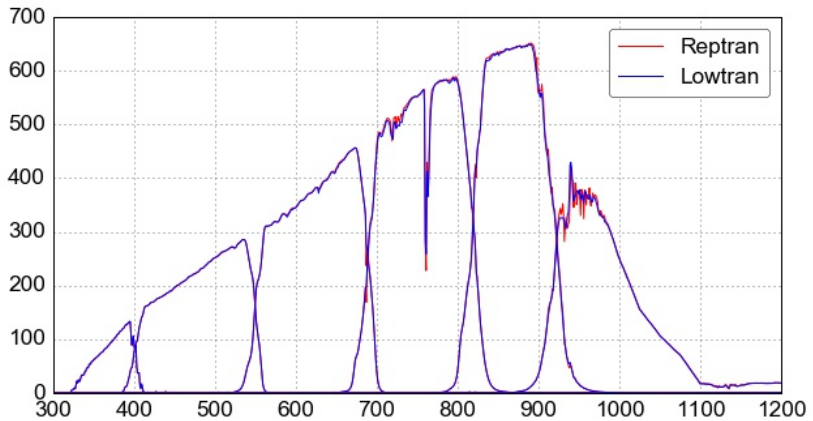
- *RT* means LibRadTran
- *VXX* = 2.0 is the version number of Radtran or Modtran.
- *LS* means LSST site,
- *pp* means geometry of parallel planes for the atmosphere

Example of comparison inside LibRadTran : REPTRAN vs LOWTRAN

Magnitude calculation

$$F_{\Delta\lambda}^{ADU} = \frac{\pi D^2}{4 g_{el} hc} \int_{\Delta\lambda} T^{atm}(\lambda) T^{filt}(\lambda) \epsilon_{CCD}(\lambda) S_{\lambda}^{E}(\lambda) \lambda d\lambda$$





Example

For a flat SED $S_{\lambda}^{E}(\lambda) = cte$, with $z = 1$:

filter	mag-shift (mmag)	filter	mag-shift (mmag)	filter	mag-shift (mmag)
U	- 3.0	I	+ 8.9	G	-2.6
Z	7.3	R	+ 1.5	Y4	4.5

Status of the work

- GitHub Repository created by Nicolas at
  https://github.com/DarkEnergyScienceCollaboration/PC5AtmosphericExtinction
- Prescription note written to proceed with air transparency simulations and posted at
  https://github.com/DarkEnergyScienceCollaboration/PC5AtmosphericExtinction/tree/master/doc/Prescriptions
- Simulation with LibRadTran **done** and at posted at (see README)
  https://github.com/DarkEnergyScienceCollaboration/PC5AtmosphericExtinction/tree/master/LibRadTran/simulations
- Simulation with Modtran **soon performed** and at posted at (see README)
  https://github.com/DarkEnergyScienceCollaboration/PC5AtmosphericExtinction/tree/master/ModTran

- Ready for Atmospheric properties Analysis,
- Almost ready for comparison, at least comparing the different models inside LibRadTran.

The End