Precomputed Atmospheric Scattering in Radiance

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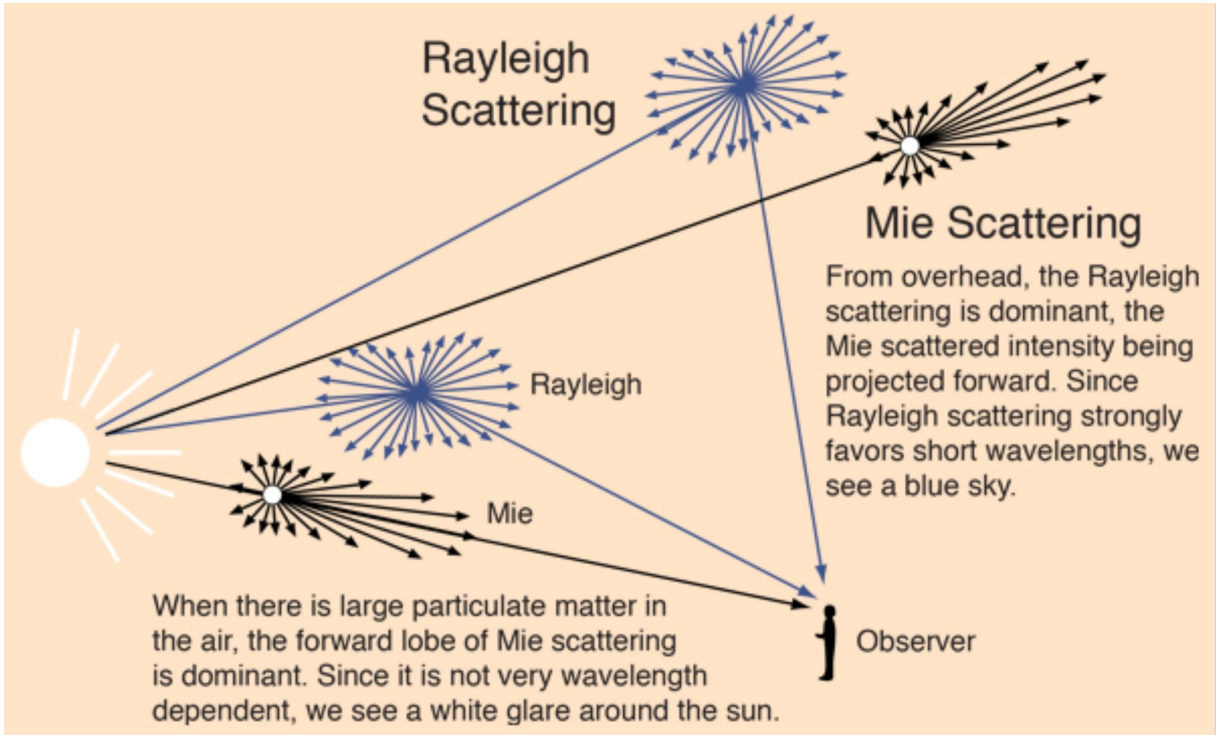
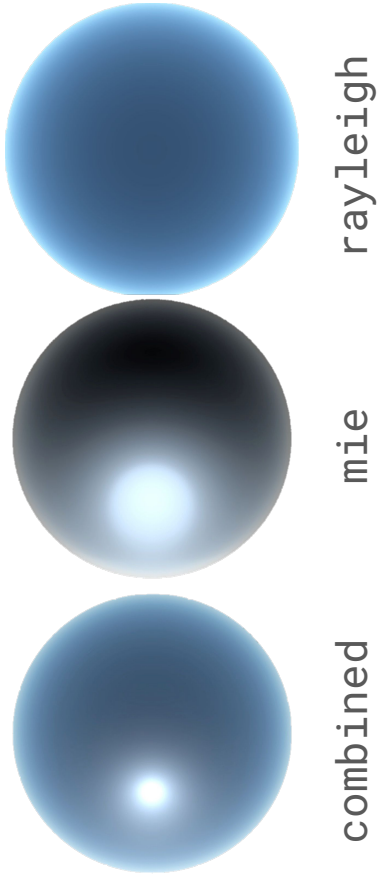
Why

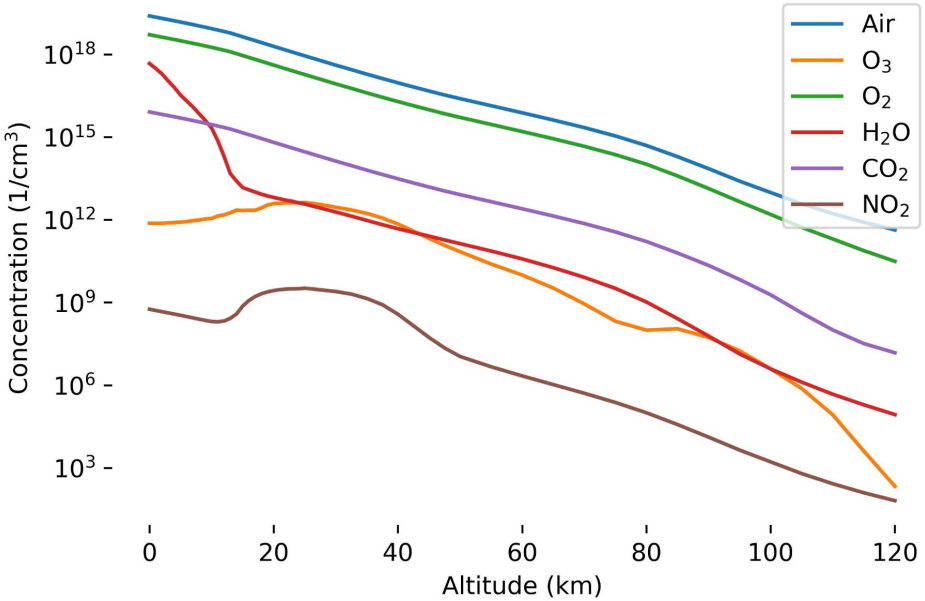
- (Hyper)spectral Simulation
  - Better accuracy
  - Non-visual application
- Spectral Material Data
  - Opaque surface: ✅ Spectral Materials Database (spectraldb.com)
  - Specular transparent surface (glass): ✅ IGDB (igsdb.lbl.gov)
  - Scattering material (BSDF) ❌
- Spectral Light Source
  - Daylight ❌
  - Artificial light ✅



http://hyperphysics.phy-astr.gsu.edu/hbase/atmos/blusky.html



Rayleigh scattering: exponential

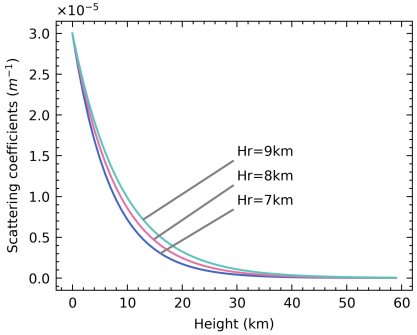


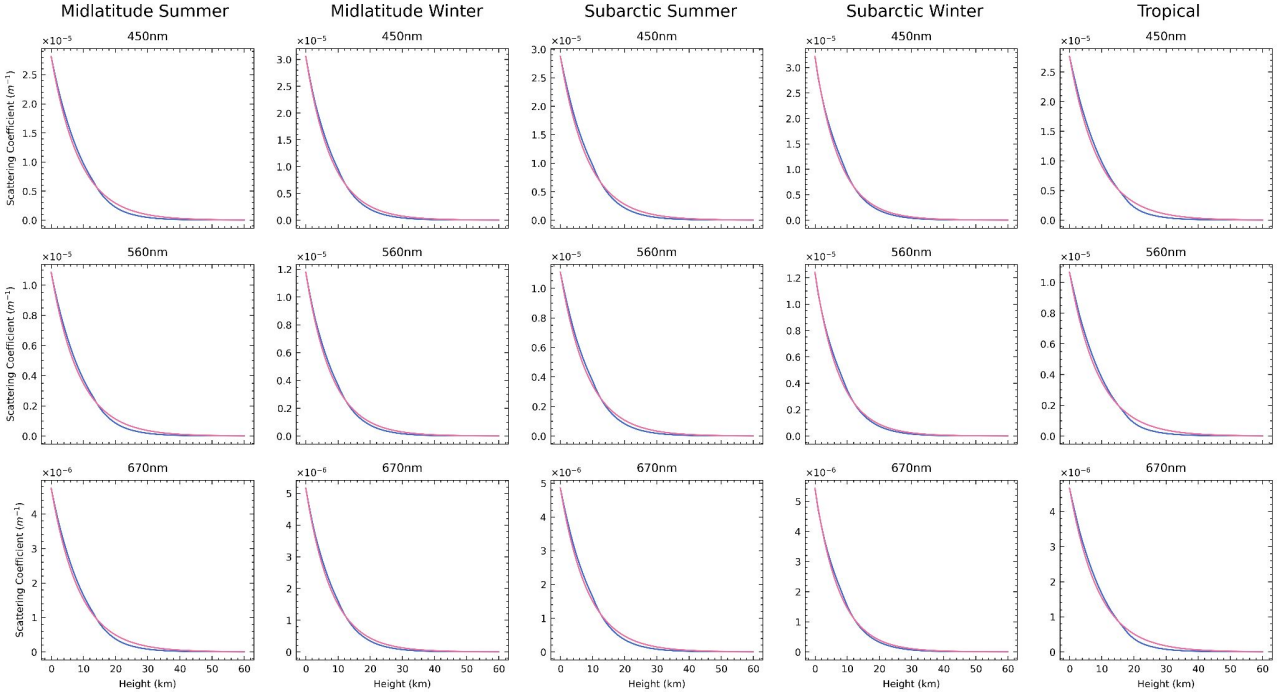
$$\beta_R = \beta_0 e^{-h/H_r}$$

β_0: scattering coefficient at sea level

H_r: Scale height

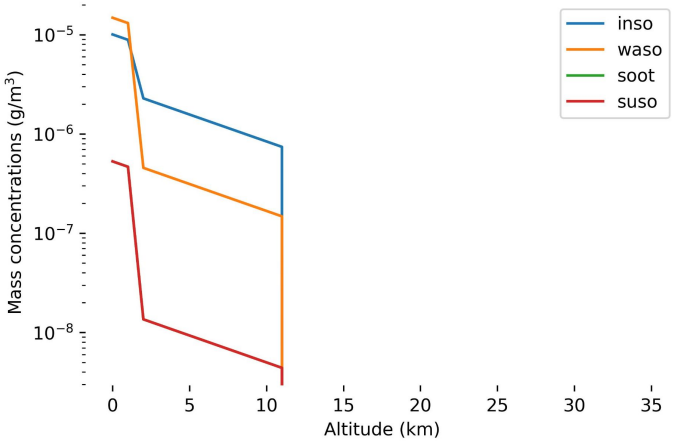
Rayleigh scattering: exponential

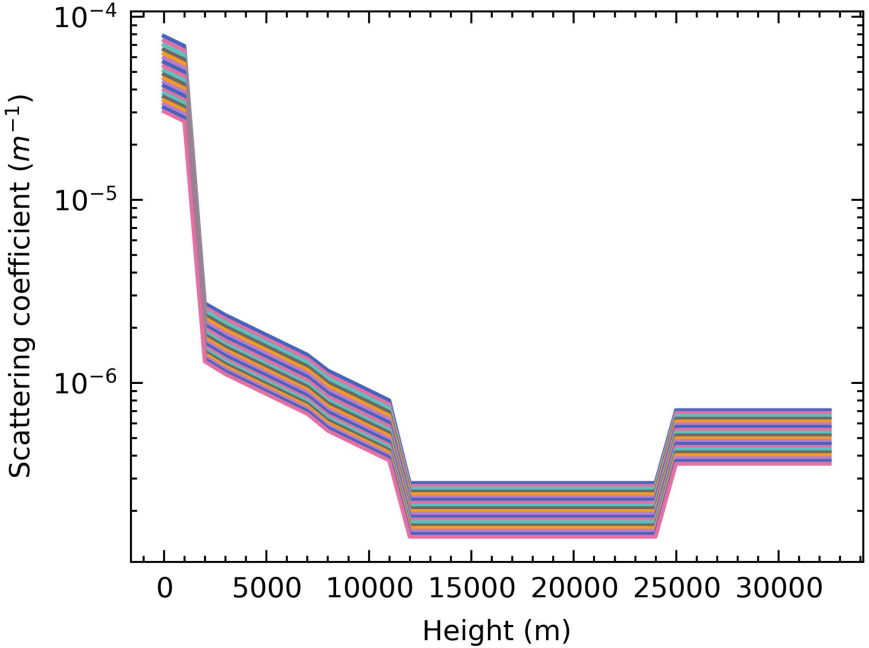




Tuning scale height for each category to minimize “area under curve” different between computed and fitted curve

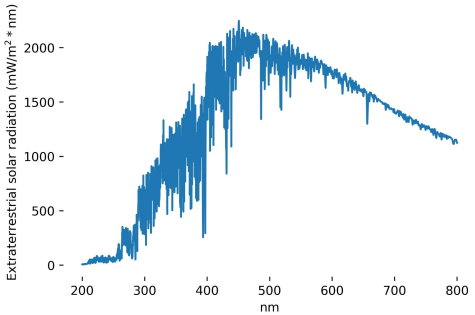
Mie scattering: direct interpolation



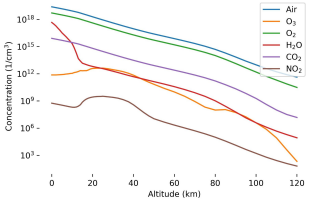


Data flow and mechanism

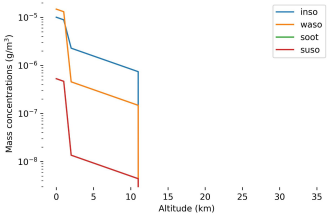
Extraterrestrial Solar Radiation



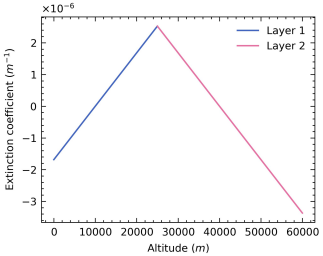
Air molecules

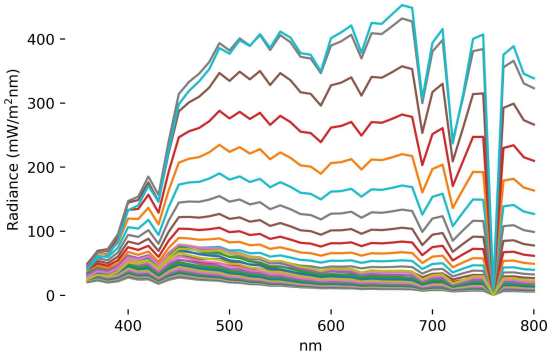


Aerosol



Ozone absorption





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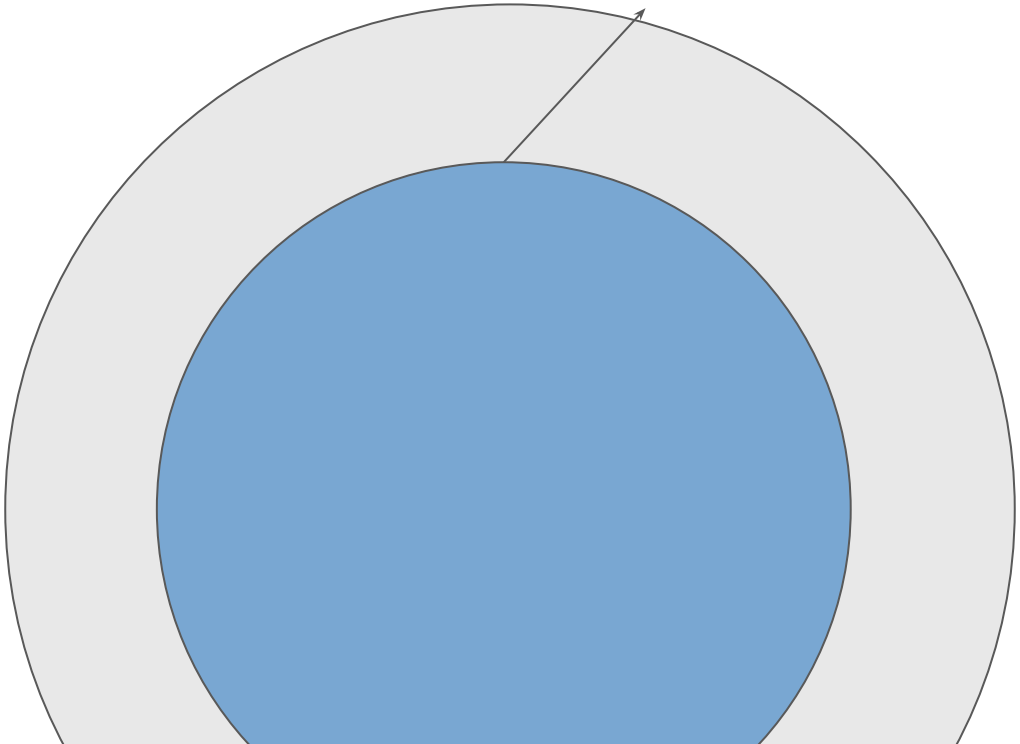
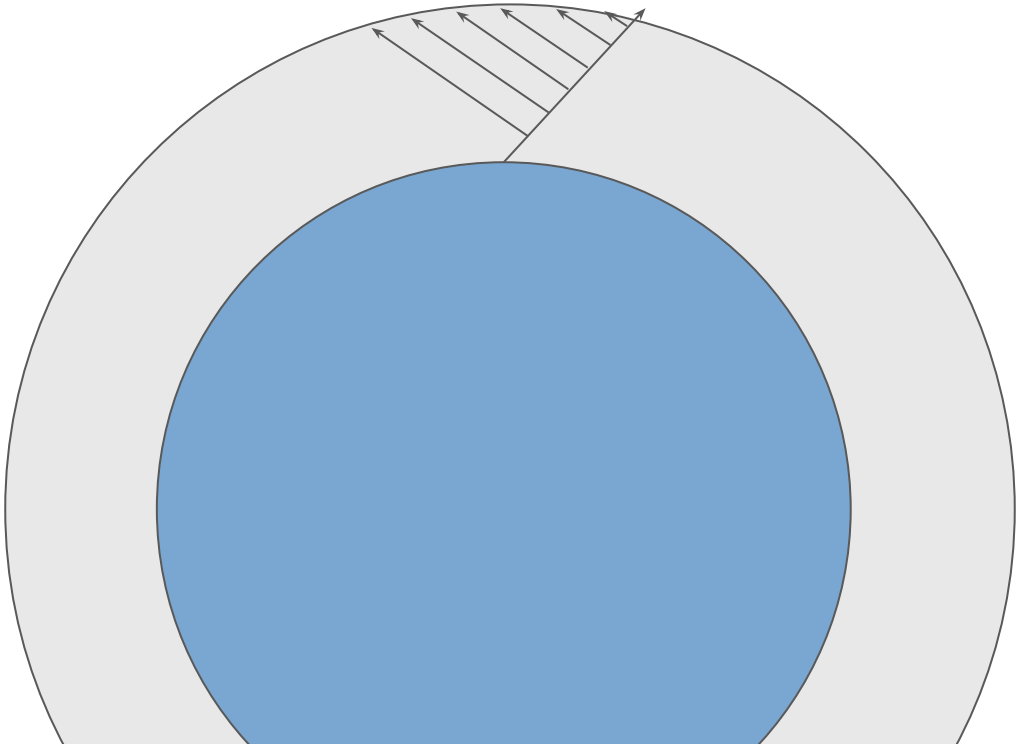
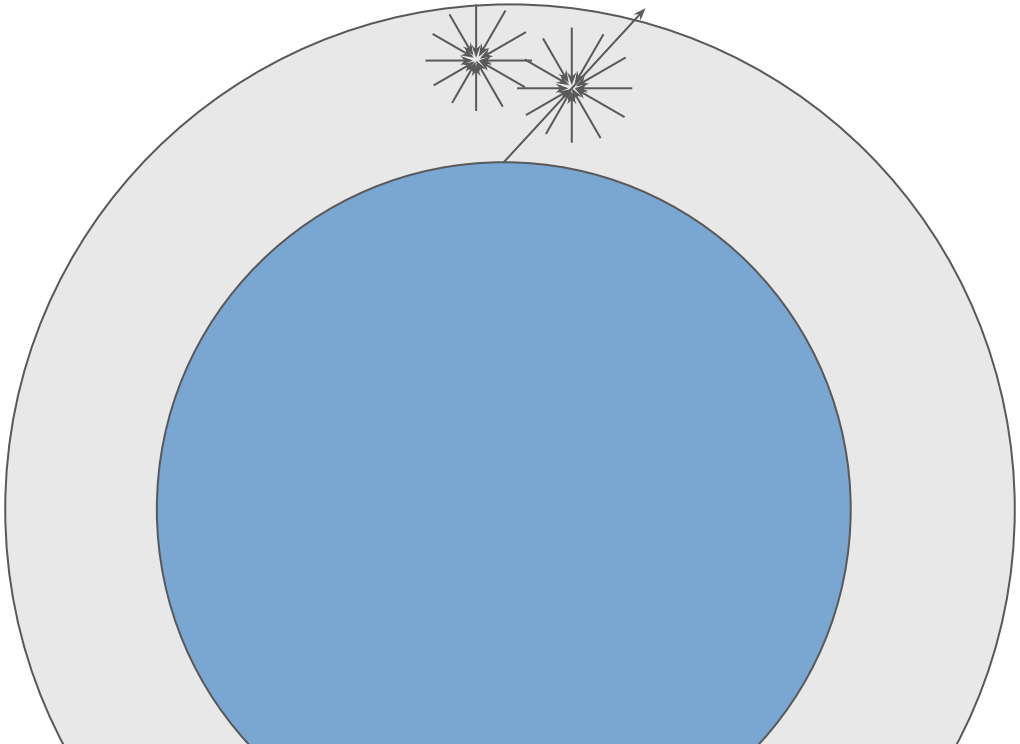
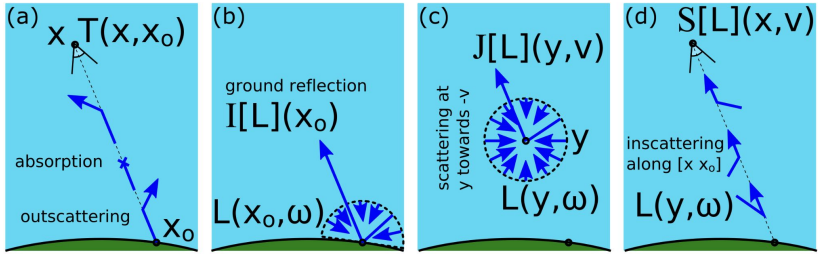






Algorithm: Precomputed atmospheric scattering

- Storing precomputed atmospheric scattering in a look-up table (Bruneton & Neyret)
  - Transmittance (tau*.dat)
  - Irradiance (irrad*.dat)
  - Single scattering Mie (scat1m*.dat)
  - Multi-scattering Mie (scat*.dat)

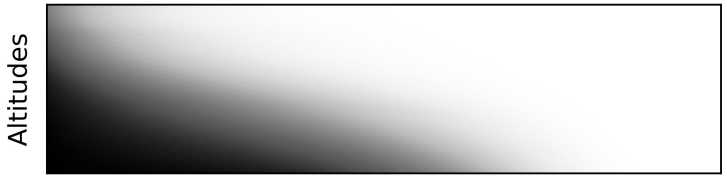


(Bruneton & Neyret)

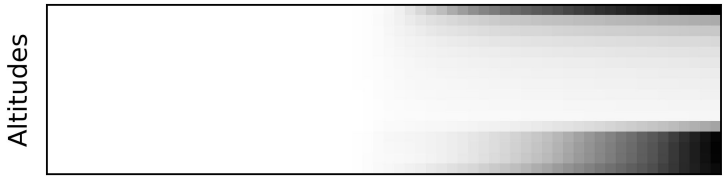
- Sample a two and four dimensional grid over the skydome
- Standard air profile for Rayleigh scattering, including tropical, mid-latitude, subarctic, summer and winter. Auto-picked based on input lat&lon and date-time
- OPAC continental_average aerosol profile with broadband AOD scaling

Precomputed texture: transmittance and irradiance

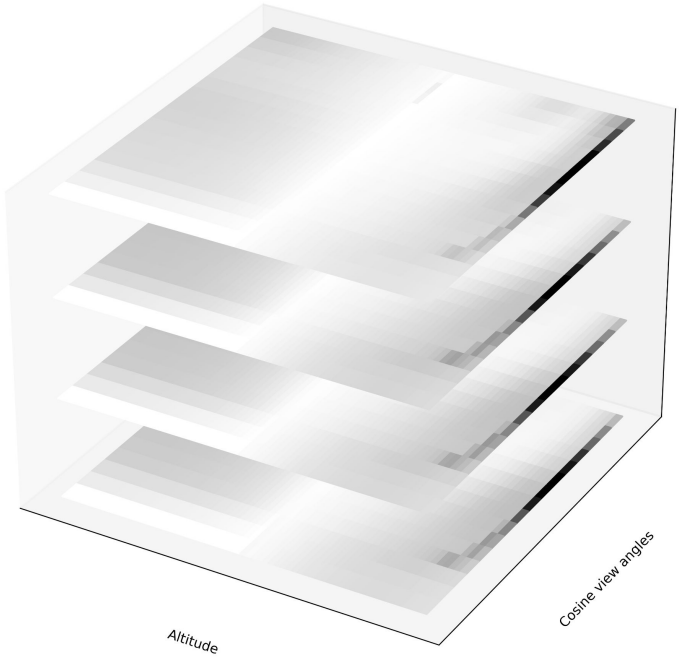
Transmittance texture at 550nm



Irradiance texture at 550nm



Scattering coefficient at a solar angle at 550nm



genssky

```
genssky month day hour [-a lat] [-o lon] [-m mer]
[-l file] [-d aod] [-c ccover] [-f name] [-g grefl]
[-p] [-r]

-c: total cloud cover 0-1, default=0, as weighted
average of a clear and overcast sky.
-d: broadband aerosol optical depth, default=0.115.
-f: output file prefix
-p: output file directory
-g: ground reflectance, default=0.2.
-r: sky hsr image X resolution, Y=X/2
```

genssky

-l: Mie scattering file path.
Defaults to using “mie_ca.dat” in RAYPATH:

```
# OPAC continental average aerosol profile.
# Mie scattering coefficients m-1
# Altitude 0 - 60km
# 380nm to 780nm at 20nm interval
# Computed using libradtrans
2
0 0 30 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000
16000 17000 18000 19000 20000 21000 22000 23000 24000 25000 27500 30000 32500 60000
0 19 20
7.8237e-05
7.3966e-05
6.9974e-05
6.6022e-05
6.2729e-05
5.9427e-05
5.6391e-05
5.3561e-05
```

gensdaymtx

```
gensdaymtx [-m div] [-u] [-r rot] [-p dir] [-o{a|f|d}]
[-n nproc]
-m: Reinhart subdivision
-u: daylight hours only
-r: sky rotation
-p: precomputed directory path
-o: output format, ascii, floats or double
-n: N processors for precomputation
```

gensdaymtx

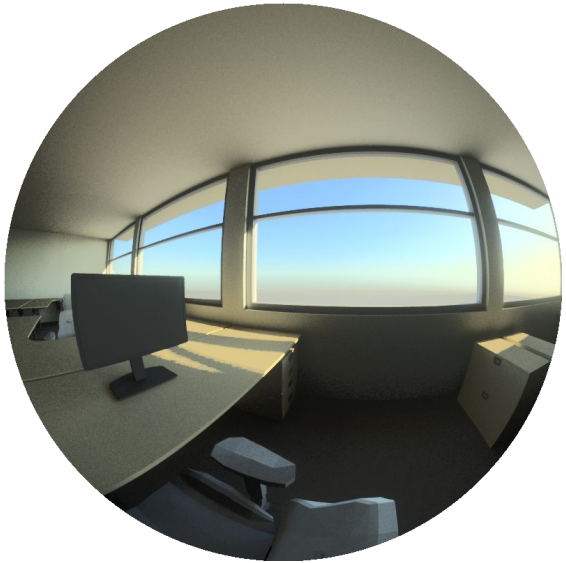
```
epw2wea [-a]
-a: output AOD and cloud cover on the fourth and fifth
column

Example:
epw2wea -a example.epw | gensdaymtx -m 4 -u > example.mtx
```

Renderings: solar altitude 50°, 10°, -4°

Renderings: cloud cover .0 .4 .8

Renderings: broadband AOD 0.05 0.1 0.2



Next step (in no particular order)

- Better cloud modeling
- Validation against measurement
- Normalize to broadband measurements (direct normal, global horizontal irradiance)
- Options to increase/decrease number of channels

genlrtsky

Using libradtran to generate hyperspectral sky image

```
genlrtsky month day hour minute [options]
```

See https://github.com/taoning/genlrtsky for details