Preliminary AURIC & libRADtran background simulation for EUSO-Balloon flight

M. Putiš, P. Bobík, Š. Mackovjak
(IEP SAS)

Torino
January 2015

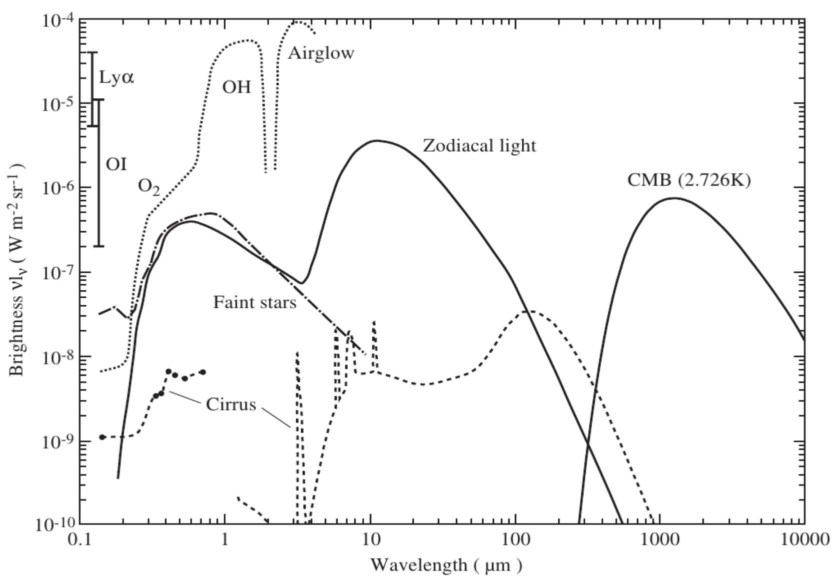
Part I: Sources of background for balloon

- To simulate situation for EUSO-balloon we extract:
  - Zodiacal light spectrum from Leinert [1]
  - Star light spectrum from Leinert [1]
  - Airglow spectrum from AURIC model [2]
- These spectra was propagate through atmosphere by libRADtran to simulate balloon measurement at 40 km. [3]
- Surface mixed forest – albedo 0.028 (water albedo doesn't change situation see my Moscow presentation)
- No moon, no city lights, no aurora, cloudless
- Preliminary value of background from EUSO-balloon data for cloudless condition at ~ 5:30 UT is ~ 276 ph/(m2 ns sr) SEE SIMON MACKOVJAK presentation
- Remember that situation is different for other positions – background could by higher.

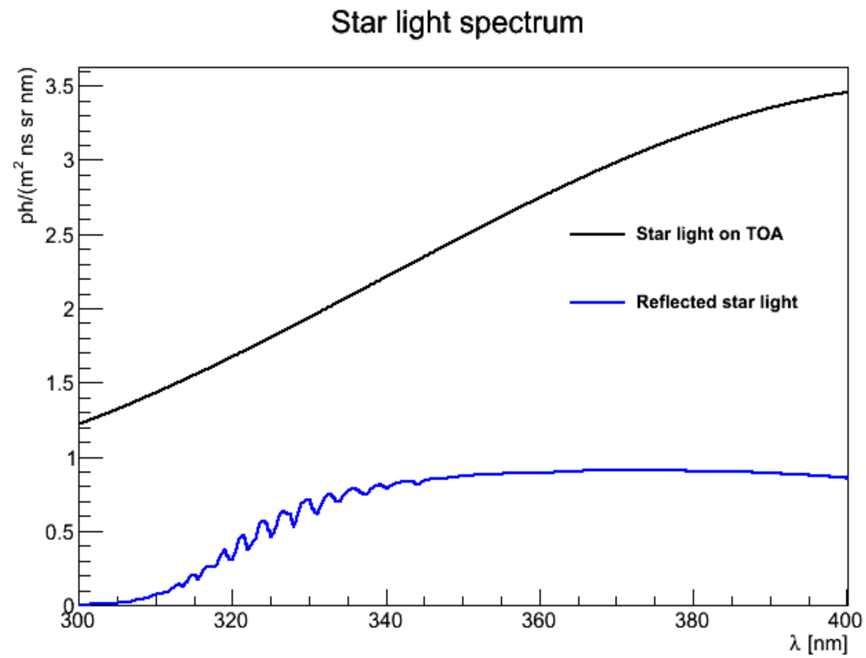
- [1] Ch. Leinert et al, Astron. Astrophys. Suppl. Ser. 127, 1-99 (1998)
- [2] D. J. Strickland et al, J. Quant. Spect. Rad. Transfer, 62, 689, 1999.
- [3] B. Mayer and A. Kylling, Technical note: The libRadtran software package for radiative transfer calculations - description and examples of use, doi:10.5194/acp-5-1855-2005

Sources of background for balloon - Integrated star light

- Star light spectrum – fit of spectrum from [1]



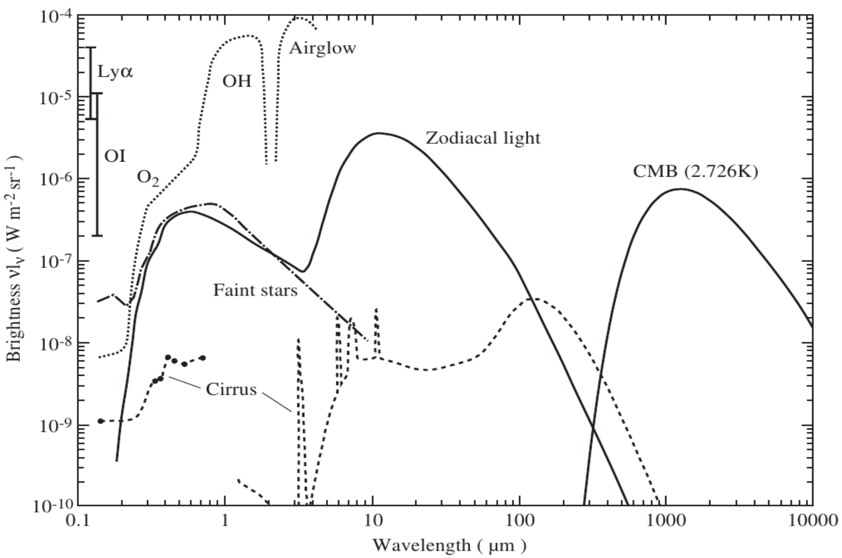
[1] Ch. Leinert et al, Astron. Astrophys. Suppl. Ser. 127, 1-99 (1998)

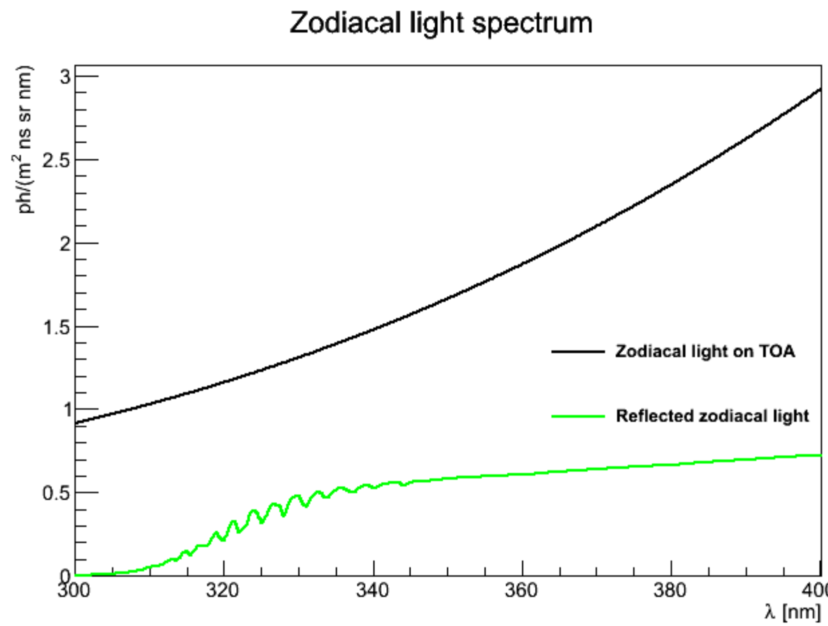


- Integral of TOA spectrum = 243 ph/(m2 ns sr)
- Integral of reflected spectrum at altitde 40 km = 68 ph/(m2 ns sr)

Sources of background for balloon - Zodiacal light

- Zodiacal light spectrum – fit of spectrum from [1]



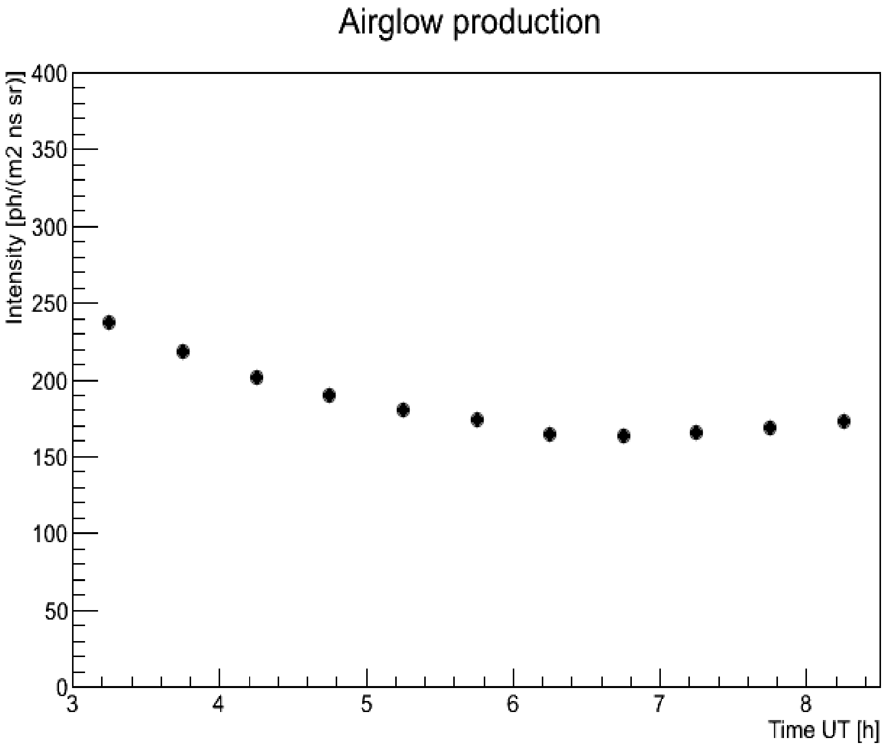


[1] Ch. Leinert et al, Astron. Astrophys. Suppl. Ser. 127, 1-99 (1998)

- Integral of TOA spectrum = 175 ph/(m2 ns sr)
- Integral of reflected spectrum at altitude 40 km = 48 ph/(m2 ns sr)

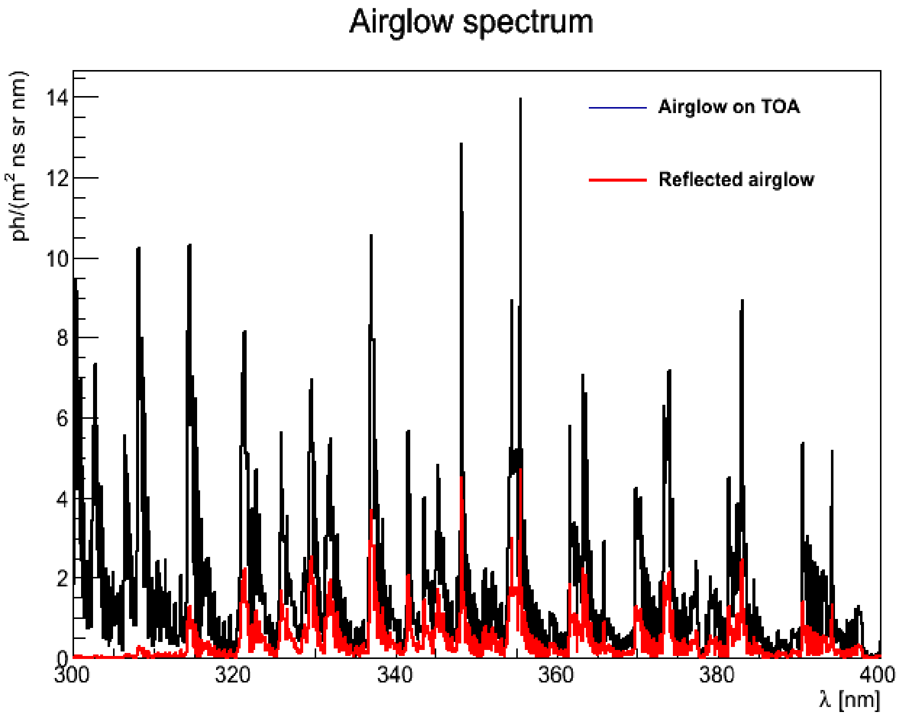
Sources of background for balloon -Airglow

- Provided by AURIC model [1]



- [1] D. J. Strickland et al, J. Quant. Spect. Rad. Transfer, 62, 689, 1999.

- Spectrum at 5:30 UT



- Integral of TOA spectrum = 175 ph/(m2 ns sr)
- Integral of reflected spectrum = 43 ph/(m2 ns sr)

Overall background

Model (5:30 UT):

- Overall downward intensity:
  - Stars = 243 ph/(m2 ns sr)
  - Zodiacal = 175 ph/(m2 ns sr)
  - Airglow spectrum = 175 ph/(m2 ns sr)
  - Overall = 593 ph/(m2 ns sr)
- Overall reflected intensity (40km):
  - Stars = 68 ph/(m2 ns sr)
  - Zodiacal = 48 ph/(m2 ns sr)
  - Airglow = 43 ph/(m2 ns sr)
  - Overall = 159 ph/(m2 ns sr)

Data:

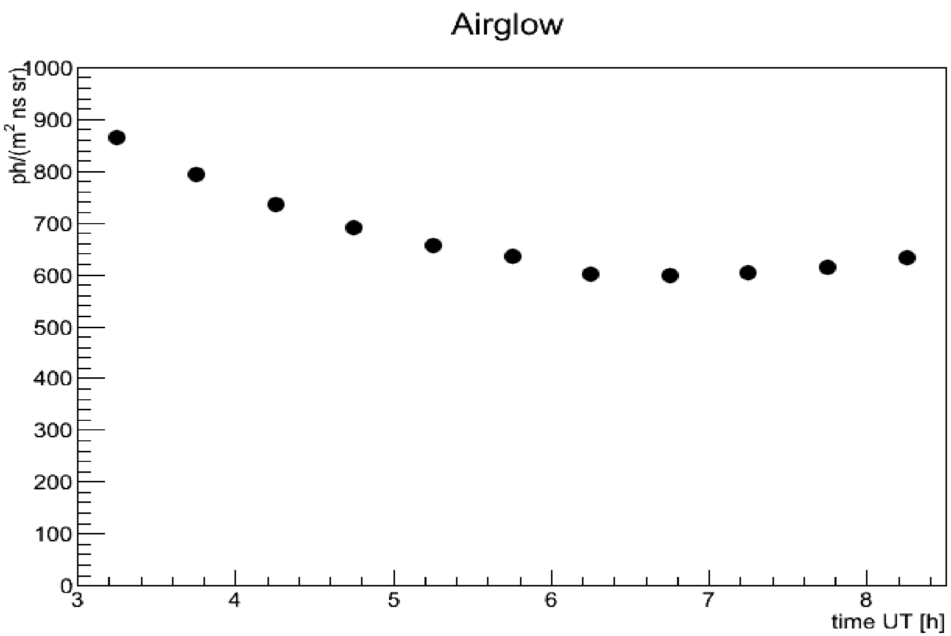
- Preliminary value of background from EUSO-balloon data for no cloud condition at ~ 5:30 UT is ~ 276 ph/(m2 ns sr) SEE SIMON MACKOVJAK presentation
- For conversion of intensity units:

$$1[pe\,px^{-1}GTU^{-1}]*(\frac{N_p}{QE\,OE\,A\,t})=437.64[ph\,m^{-2}sr^{-1}ns^{-1}]$$

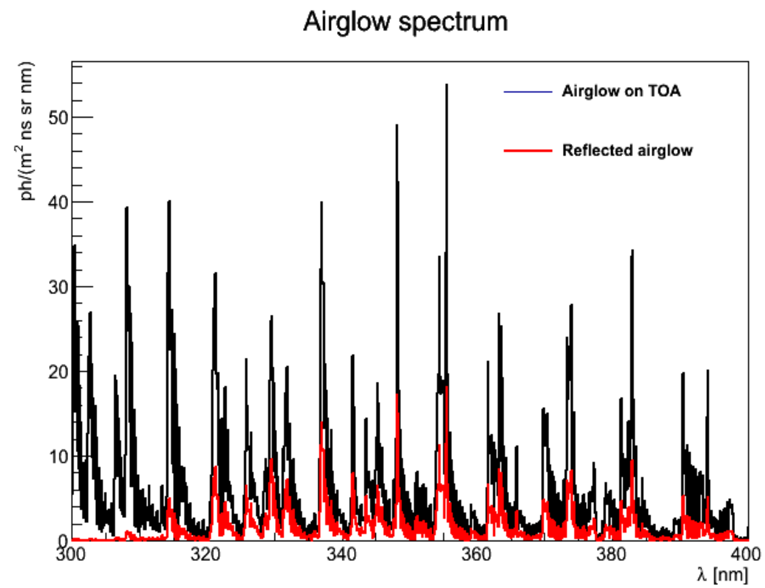
- QE = 0.2
- OE = 0.24
- Np = 2304
- t = 2500 ns
- A = 144/3282 m2 sr

Corrected airglow

- Main parameter of airglow production is atomic oxygen density vertical distribution.
- If we increase it by 100%, we reach agreement with data
- It is too much, something is wrong on model or data side.



- Spectrum at 5:30 UT



- Integral of TOA spectrum = 636 ph/(m2 ns sr)
- Integral of reflected spectrum = 157 ph/(m2 ns sr)
- Overall intensity (airglow + star + zodiacal) = 273 ph/(m2 ns sr)

Possible sources of discrepancy

Model:

- Too many parameters in each model (AURIC, libRadtran)
- Wrong Integrated star and Zodiacal light spectrum
- We need to recheck it all.

Data:

- Are we sure that all factors are included?
- Is structure factor 0.76 included?

$$1[pe\, px^{-1} GTU^{-1}] * \left(\frac{N_p}{QE\, OE\, A\, t}\right) = 437.64 [ph\, m^{-2} sr^{-1} ns^{-1}]$$

Part II: Clouds

- Two cloud parameters in libRADtran
  - Effective droplet radius r_e or EDR [μm]
  - Liquid water content w or LWC [g/m3]

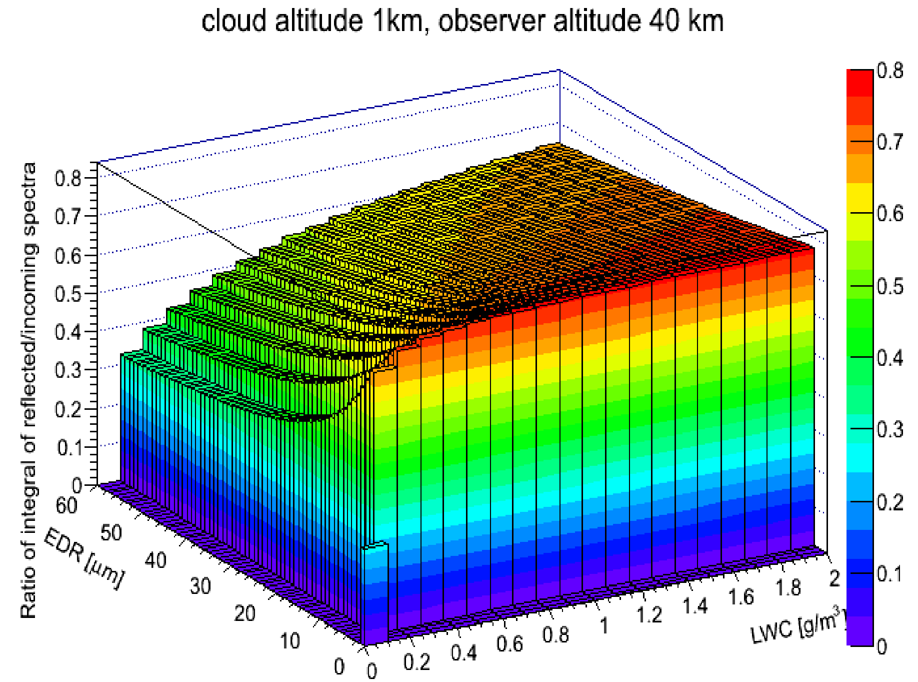
$$w = \int \frac{4}{3} \rho_w \pi r^3 n(r) dr,$$

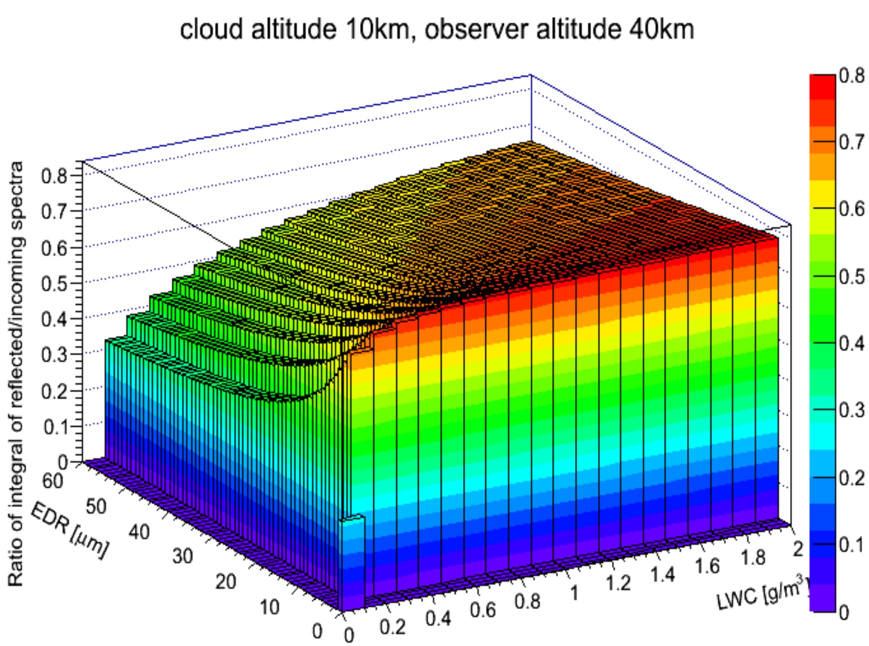
$$r_e = \frac{\int \pi r^3 n(r) dr}{\int \pi r^2 n(r) dr},$$

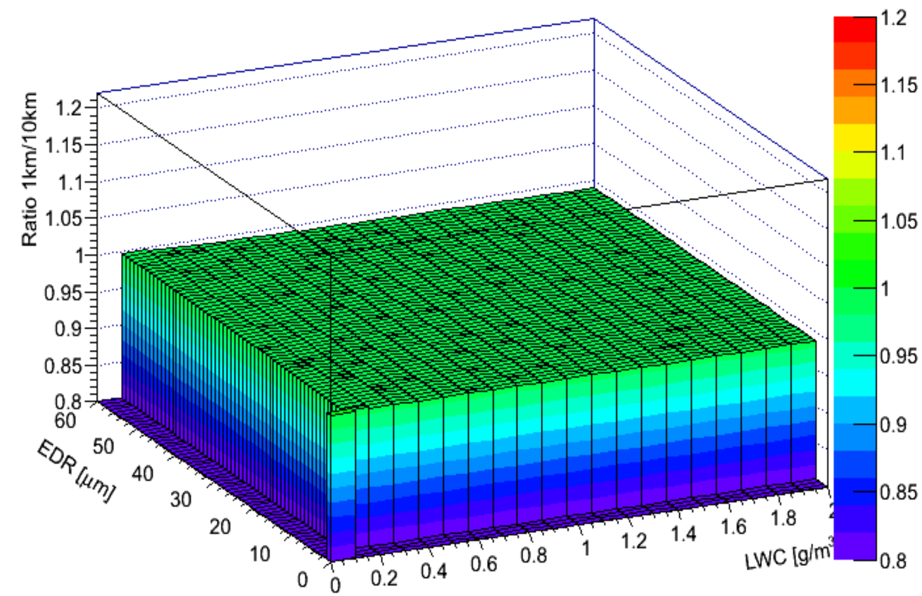
- r – droplet radius
- ρ_w – water density
- n(r) – droplet size distribution
- We simply try all combinations of EDR (in range 3 – 60 μm) and LWC (0.1 – 2) parameters to obtain first overlook
- Probably not all combinations are physical – we need to find some physical n(r) distributions

Clouds

- Observer altitude 40 km
- Surface albedo 0
- Cloud altitude 1km and 10km
- Cloud thickens 1km – uniform cloud
- Each bin contain ratio of integral of reflected and incoming spectra.
- Bin 0,0 – value for cloudless situation
- Hight LWC and small EDR have bigger reflection (~2.6 times) than low LWC and big EDR
- Altitude of cloud change situation in order of few percent







Conclusions

- Model predicted intensity:
  - Standard atomic oxygen density: 159 ph/(m2 ns sr)
  - Atomic oxygen density increase 100%: 273 ph/(m2 ns sr)
    - It is too much from model point of view, direct airglow radiation increase radically
- Data intensity: 276 ph/(m2 ns sr)
- Need some time to understand this

Clouds:

- Altitude of cloud doesn't play significant role (only few percent effect) for reflected intensity at given conditions
- We need to find which combinations of cloud parameters fit real cloud effects
  - In general hight LWC and small EDR have bigger (~2.6) reflection than low LWC and big EDR