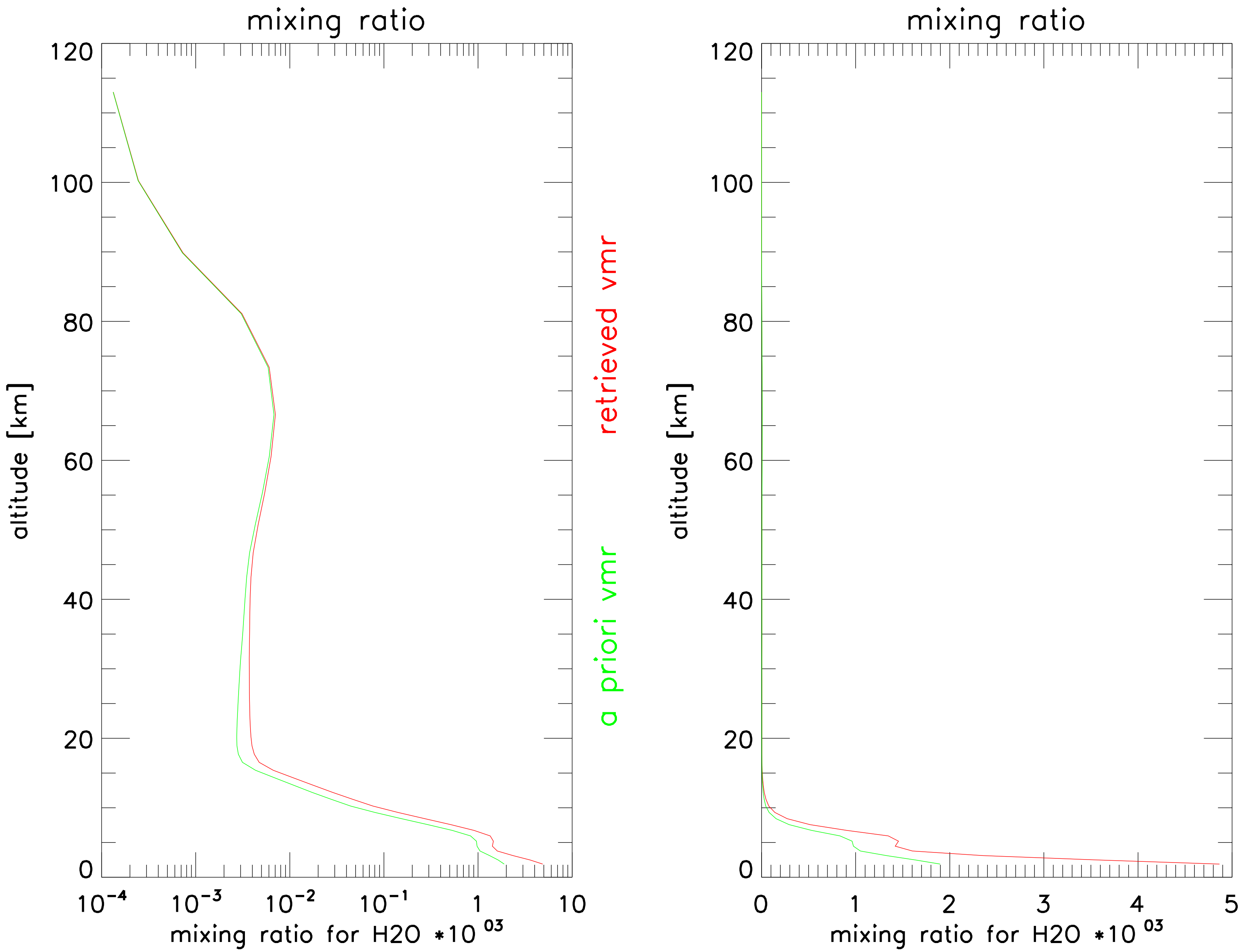
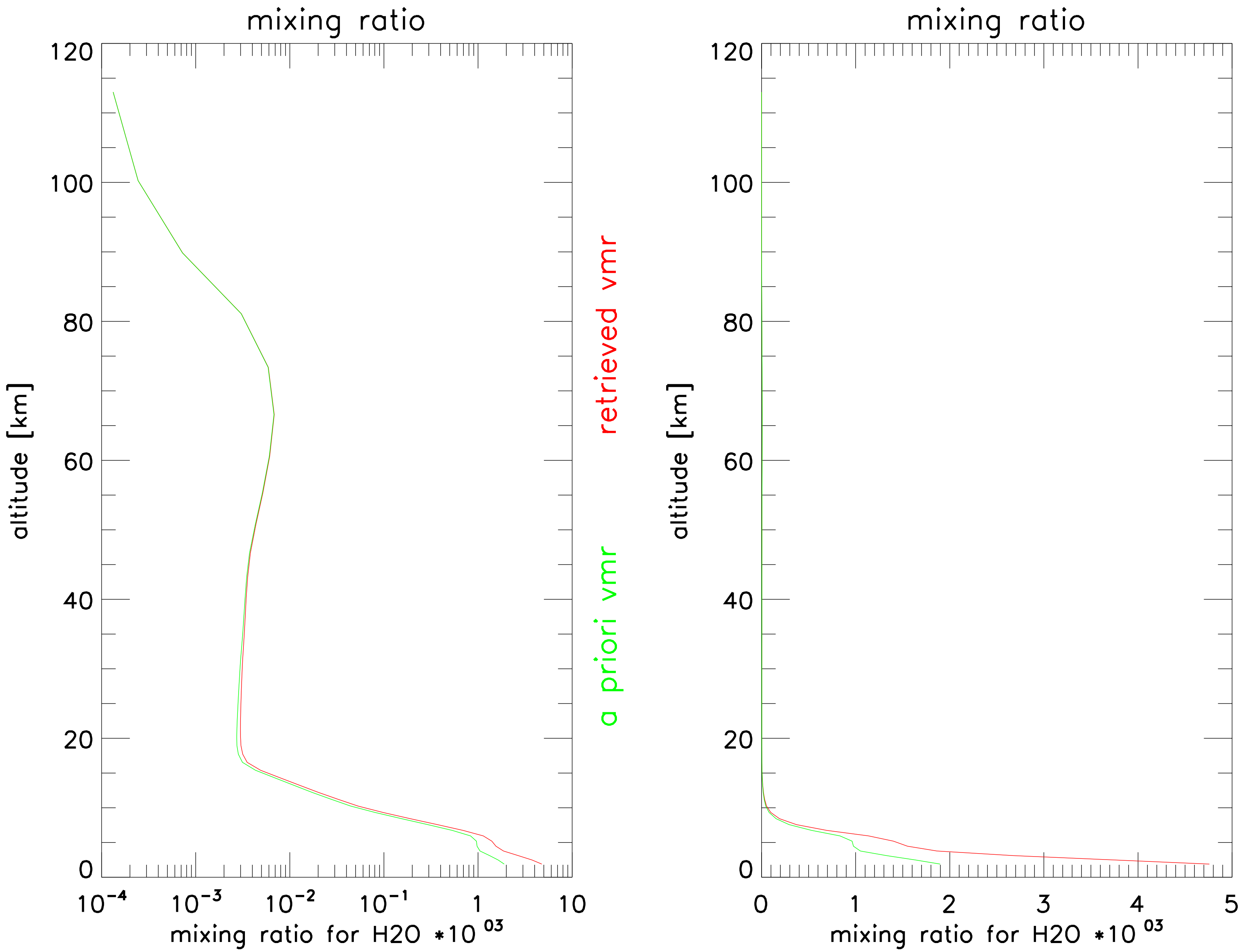
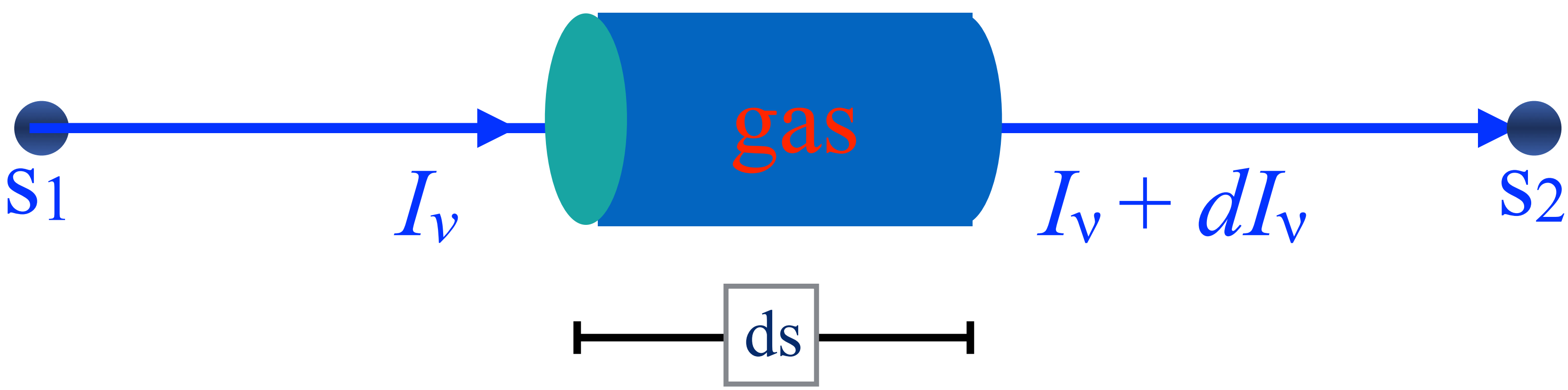


mixing ratio
altitude [km]
120
100
80
60
40
20
0
10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10
mixing ratio for H2O *10 03
retrieved vmr
a priori vmr
mixing ratio
altitude [km]
0 1 2 3 4 5
mixing ratio for H2O *10 03

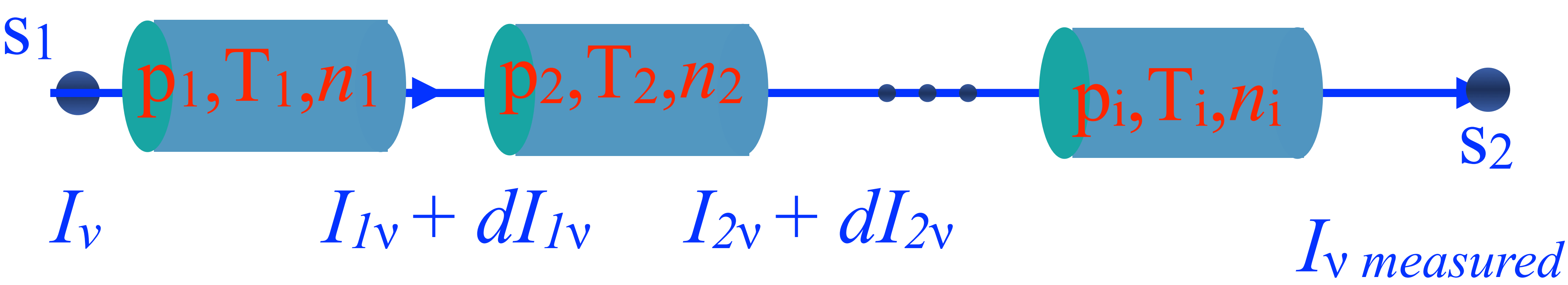

mixing ratio
120
100
80
60
40
20
0
altitude [km]
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
mixing ratio for H2O *10 03
retrieved vmr
a priori vmr
mixing ratio
120
100
80
60
40
20
0
altitude [km]
0
1
2
3
4
5
mixing ratio for H2O *10 03

Generally only in a laboratory do we have a situation where p, T, and n are constant.



What do we do when the path is going through atmospheres?

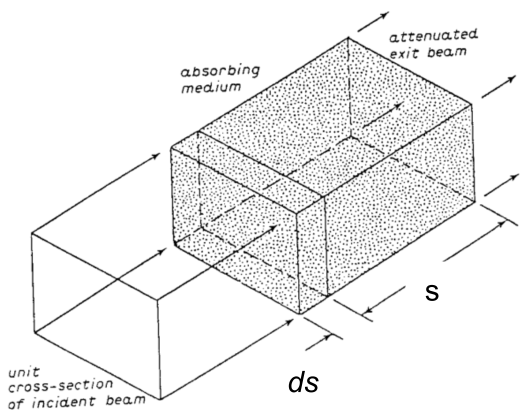
Break the path into layers where p, T, and *n* are roughly constant.



called Radiative Transfer

Transmittance and optical depth

The process of extinction is governed by the Beer-Bouguer-Lambert law. It states that extinction is linear in the amount of matter and in the intensity of radiation.



The attenuation of intensity along a path *ds* is thus:

$$dL_\nu = -L_\nu k_\nu^e \rho(s) ds \qquad (7)$$

Mass extinction coefficient [m^2Kg^{-1}]

Density of the medium [$Kg\ m^{-3}$]

The quantity $\beta_\nu^e = k_\nu^e \rho(s)$ is known as volume extinction coefficient [m^{-1}].

In general, the extinction coefficient is written as the sum of the absorption coefficient, k_ν^a and the scattering coefficient, k_ν^s: $k_\nu^e = k_\nu^a + k_\nu^s$

Matricardi, ECMWF

Transmittance and opical depth

The integration of Eq. (7) between points s_1 and $s_2=s_1+s$ yields :

$$L_\nu(s_2) = L_\nu(s_1)\exp(-\int_{s_1}^{s_2} k_\nu^e \rho(s) ds \qquad (8)$$

The optical depth of the medium between points s_1 and s_2 is defined as:

$$\tau_\nu = \int_{s_1}^{s_2} k_\nu^e \rho(s) ds \qquad (9)$$

The transmittance of the medium between points s_1 and s_2 is defined as:

$$\Gamma_\nu = \exp(-\int_{s_1}^{s_2} k_\nu^e \rho(s) ds \qquad (10)$$

The equation of radiative transfer

The change of intensity resulting from the interaction between radiation and matter is the sum of the contribution due to extinction and emission of radiation.

If we assume that the emission process is linear in the amount of matter, the change of intensity can be written as:

$$dL_\nu(\mathbf{s}) = -L_\nu(\mathbf{s})\, k_\nu^e\, \rho\, ds + J_\nu(\mathbf{s})\, k_\nu^e\, \rho\, ds \qquad (11)$$

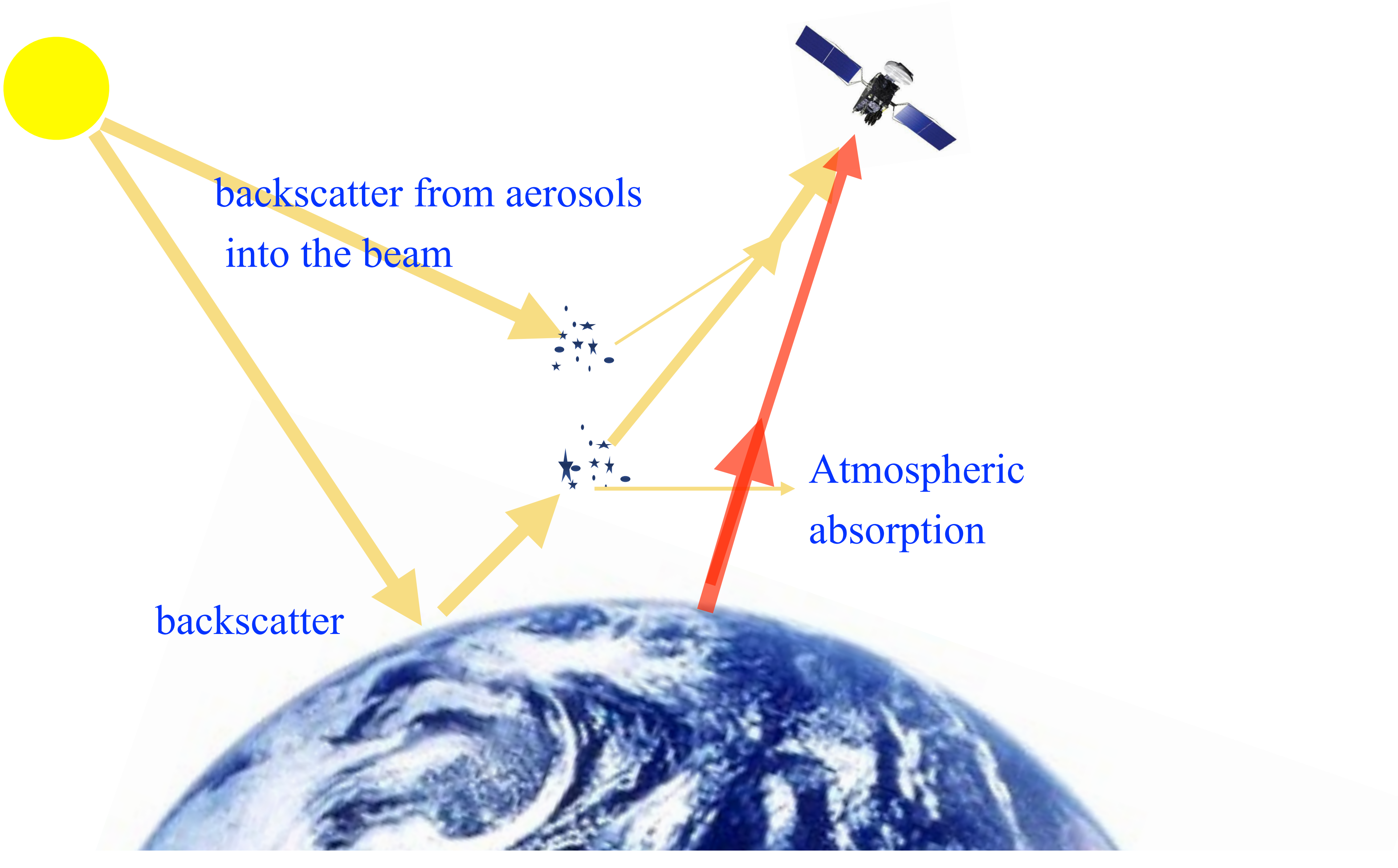
Eq. (11) is known as the Schwarzchild's equation.

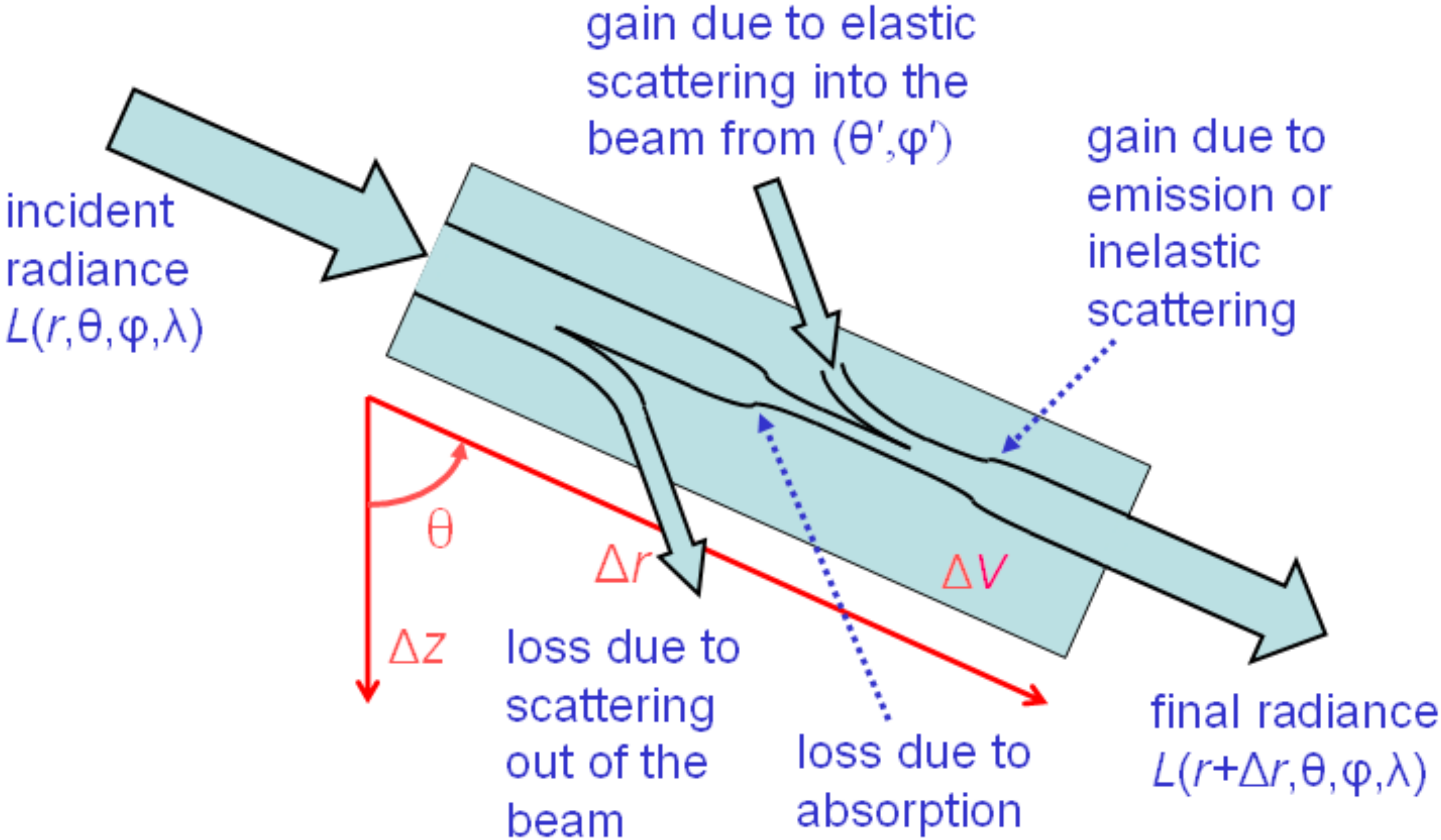
$J_\nu(\mathbf{s})$ is called the source function. It consists, in general, of two parts:

$$J_\nu(\mathbf{s}) = J_\nu(\mathbf{s})^{thermal} \frac{k_\nu^a}{k_\nu^e} + J_\nu(\mathbf{s})^{scattering} \frac{k_\nu^s}{k_\nu^e} \qquad (12)$$

Matricardi, ECMWF

Radiative transfer




gain due to elastic scattering into the beam from (θ′,φ′)
gain due to emission or inelastic scattering
incident radiance $L(r,\theta,\varphi,\lambda)$
θ
Δr
ΔV
Δz
loss due to scattering out of the beam
loss due to absorption
final radiance $L(r+\Delta r,\theta,\varphi,\lambda)$

Transmittance and optical depth

The process of extinction is governed by the Beer-Bouguer-Lambert law, which shows the extinction is linear in the amount of matter and the intensity of radiation.

The attenuation of intensity along a path ds is

$$dL_\nu = -L_\nu \, k_\nu^e \, \rho(s) \, ds$$