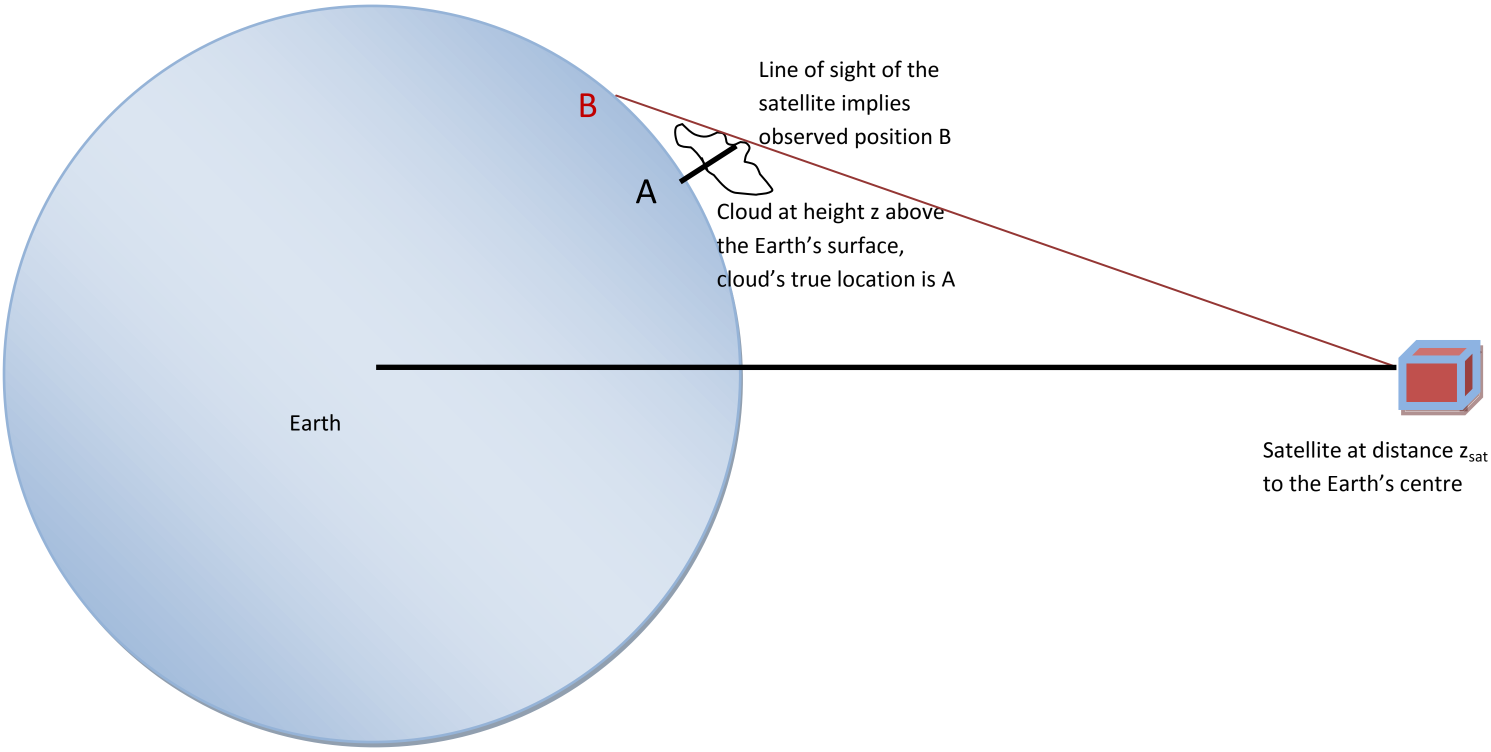
Description of the parallax correction functionality

A parallax correction to any height (e.g. cloud top height) information is necessary, as the object at height h_{cloud}, observed by a satellite at height h_{sat} above the Earth's centre, will actually be in a slightly different position than the position recorded by the satellite. The figure below illustrates the concept (not to scale!):



The parallax correction functionality needs the following input:

Satellite height above the Earth's centre (in km):	h_{sat}
Latitude of subsatellite point:	φ_{sat}
Longitude of subsatellite point:	λ_{sat}
Height of the observed (cloud) object (in km):	h_{cloud}
Assigned latitude of the object (point B in figure):	φ_{cloud}
Assigned longitude of the object (point B in figure):	λ_{cloud}

The parallax correction functionality produces as output:

Parallax corrected latitude of the object (point A in figure):	$\varphi_{cloud,corr}$
Parallax corrected longitude of the object (point B in figure):	$\lambda_{cloud,corr}$

The following static data are needed:

Earth radius, equator (in km):	R_{equ}
Earth radius, pole (in km):	R_{pole}
Mean Earth radius (in km):	$R_{mean} = 0.5\ (R_{equ} + R_{pole})$
Radius ratio:	$R_{ratio} = R_{equ} / R_{pole}$

Note: Latitude φ is defined between -90° and +90° (resp. between -π/2 and +π/2 if expressed in radians), latitudes North are positive. Longitude λ is defined between -180° and +180° (resp. between -π and +π if expressed in radians), longitudes East are positive.

Note: The earth radii R_{equ} and R_{pole} should have the same values as used elsewhere in the L1/L2 processing

Step 1: Express satellite position in Cartesian coordinates

$$x_{sat} = h_{sat} \cos(\varphi_{sat,geod}) \sin(\lambda_{sat})$$

$$y_{sat} = h_{sat} \sin(\lambda_{sat})$$

$$z_{sat} = h_{sat} \cos(\varphi_{sat,geod}) \cos(\lambda_{sat})$$

where $\varphi_{sat,geod}$ is the geodetic latitude of the subsatellite point, defined as

$$\varphi_{sat,geod} = \arctan\left[\tan(\varphi_{sat})\, R_{ratio}^2\right]$$

sin, cos, tan, arctan are the trigonometric sine, cosine, tangent and inverse tangent functions.

Step 2: Express the surface position of point B in Cartesian coordinates

$$x_{cloud} = R_{local} \cos(\varphi_{cloudgeod}) \sin(\lambda_{cloud})$$

$$y_{cloud} = R_{local} \sin(\lambda_{cloud})$$

$$z_{cloud} = R_{local} \cos(\varphi_{cloudgeod}) \cos(\lambda_{cloud})$$

where R_{local} is the Earth's radius at point B, and $\varphi_{cloud,geod}$ is the geodetic latitude of point B, according to

$$R_{local} = \frac{R_{eq}}{\sqrt{\cos^2(\varphi_{cloudgeod}) + R_{ratio}^2 \sin^2(\varphi_{cloudgeod})}}$$

$$\varphi_{cloudgeod} = \arctan\left[\tan(\varphi_{cloud})\, R_{ratio}^2\right]$$

Step 3: Compute local ratio of Earth radii, corrected for cloud top height (squared)

$$R_{ratio,local} = \left(\frac{R_{equ} + h_{cloud}}{R_{pole} + h_{cloud}} \right)^2$$

Step 4: Compute the difference vector between the satellite and the cloud (point B) position

$$x_{diff} = x_{sat} - x_{cloud}$$

$$y_{diff} = y_{sat} - y_{cloud}$$

$$z_{diff} = z_{sat} - z_{cloud}$$

Step 5: Compute the correction for the line of sight at the cloud top height h_{cloud}

$$c = \frac{\sqrt{e_2^2 - 4e_1 e_3} - e_2}{2e_1}$$

with

$$e_1 = x_{diff}^2 + R_{ratio,local}\, y_{diff}^2 + z_{diff}^2$$

$$e_2 = 2\left(x_{cloud}\, x_{diff} + R_{ratio,local}\, y_{cloud}\, y_{diff} + z_{cloud}\, z_{diff}\right)$$

$$e_3 = x_{cloud}^2 + R_{ratio,local}\, y_{cloud}^2 + z_{cloud}^2 - \left(R_{equ} + h_{cloud}\right)^2$$

Step 6: Apply correction to Cartesian coordinates of cloud position (point B)

$$x_{corr} = x_{cloud} + c\, x_{diff}$$

$$y_{corr} = y_{cloud} + c\, y_{diff}$$

$$z_{corr} = z_{cloud} + c\, z_{diff}$$

x_{corr}, y_{corr} and z_{corr} are now the Cartesian coordinates of the parallax corrected location (point A in figure).

Step 7: Convert corrected Cartesian coordinates back to latitude and longitude (of point A)

$$\varphi_{cloud,corr} = \arctan\left[\frac{\tan\left(\arctan\frac{y_{corr}}{\sqrt{x_{corr}^2 + z_{corr}^2}}\right)}{R_{ratio}^2}\right]$$

$$\tan(\lambda_{cloud,corr}) = \frac{x_{corr}}{z_{corr}}$$

The corrected longitude $\lambda_{cloud,corr}$ can then in principle derived through the inverse tangent function, but care has to be given as to the actual quadrant of the 360° circle. In any modern computer language, this is easily achieved by the ATAN2 function, which is given two arguments:

$$\lambda_{cloud,corr} = \mathrm{ATAN2}(x_{corr}, y_{corr})$$

Example removed.