**FRESCO version changes history**

Changes in sc-v5.2 (03-04-2008)

The following header information has been added:

Version number of FRESCO
Creation date and time of the FRESCO level 2 file
Version number of the level 1 processor
The level 1 filename
For each state in the orbit: state ID, integration time, number of observations

The header lines start with #


Changes in sc-v5.1 (10-12-2007)

1. IN FRESCO version sc-v5.1 the geometric sunglint flag is added.

2. If the retrieved cloud height is negative, the cloud height is set to surface height of this pixel. In the pervious versions, the negative cloud height is set to 0.

3. In the fit allow negative cloud fraction until -0.05 and cloud fraction less than 1.2. In the output the negative cloud fraction and cloud fraction larger than 1 are set to 0 and 1, which improve the fit, and the cloud pressure retrievals.

4. Data format change (F90 format)
Old:
 write(39,'(a8,a11,i2,4f8.3,f9.4,4f9.3,f10.4,3f8.3,7f8.4,e10.3,**i2**,3f9.3)') …

New:
 write(39,'(a8,a11,i2,4f8.3,f9.4,4f9.3,f10.4,3f8.3,7f8.4,e10.3,**i3**,3f9.3)') …


**Flag definition in FRESCO sc-v5.1**

The flag in FRESCO versions sc-v5.1 are 0-5 and 10-15.
   0: normal pixel, retrieve cloud fraction, cloud pressure (cloud albedo =0.8)
   1: snow/ice pixel, retrieve cloud albedo, cloud pressure  (cloud fraction =1.0)
   2: reflectance less than 0 or reflectance larger than limit (rmax)
   3: viewing zenith angle larger than the viewing zenith angle in the transmission
      database (extrapolation are used here)
   4: solar zenith angle larger than solar zenith angle in the transmission database
   5: fit error,  (gaussjf: ERROR singular matrix)
   Flag=10-15: geometric sunglint flag over ocean, sunglint might occur.

Flag 0-5 are the same as in the previous version of FRESCO. The geometric sunglint flag is the original flag (0-5) plus 10, so the sunglint flags can be 10, 11, 12, 13, 14, 15. The flag 10-15 have the same meaning as 0-5 but the sunglint might occur according to the geometry.

**How to use the sunglint flags**

If using FRESCO effective cloud fraction and cloud height for cloud corrections in trace gas retrievals the pixels with sunglint can be used the same as cloudy pixels. For example if one selects effective cloud fraction with flag 0, one should also include the cloud fractions with flag 10.

The sunglint flags are important for the users who use FRESCO(+) cloud products for cloud trend or model comparison. In this case the sunglint should be excluded from real clouds. However, the intensity and pattern of sunglint is linked to the wind speed and wind direction and geometry. It is not possible to flag sunglint exactly in FRESCO(+) algorithm because of lacking wind information. It is also difficult to separate sunglint from clouds. For the pixels with sunglint flags more analysis are needed. The reflectance of typical sunglint is 0.2, in FRESCO(+) the effective cloud fraction is roughly 0.1-0.3 over sunglint pixels (see Fig. 1). The cloud pressure should be sea surface, 1013 hPa or 0 km. Using this empirical criteria some sunglint can be separate from clouds.

**The calculation of sunglint in FRESCO sc-v5.1**

Sunglint is a major contribution to reflectance over oceans, because the sea surface is a near-perfect specular reflector. If there are no clouds the sunlight can be reflected to the satellite instrument directly. The intensity of reflectance and pattern depends on the wind speed, wind direction and the geometry. The typical reflectance of sunglint is 0.2, which is smaller than bright clouds.

The sunglint angle ($\Delta\Omega_{gl\,\mathrm{int}}$) is defined as the angle for which the sun glint would occur if ocean is a perfect mirror. The deviation from this angle is defined as

$$\cos(\Delta\Omega_{gl\,\mathrm{int}}) = \cos\theta_0 \cos\theta + \sin\theta_0 \sin\theta \cos(\varphi - \varphi_0)$$

Where $\theta_0$ is solar zenith angle, $\theta$ is the viewing zenith angle, $\varphi_0$ is the solar azimuth, $\varphi$ is the viewing azimuth. In FRESCO $\theta$ is positive, the relative azimuth angle is used as abs($\varphi$ - $\varphi_0$) between [0, 180°]. If ($\varphi$ - $\varphi_0$) > 180, ($\varphi$ - $\varphi_0$)=360-($\varphi$ - $\varphi_0$) . The definition of the angles might be different for other instruments.
The sunglint angle is set to 18° according to statistic of SCIAMACHY data. Same angles are used in AAI product for SCIAMACHY. The sunglint depends on wind speed and direction and scattering angle, therefore sunglint angle can be larger or smaller than 18°. More accurate sunglint calculations can be founded in the paper by Breon et al. (2006).

It is also possible to distinguish sunglint and cloud from polarization measurement because sunglint is polarized and clouds are not.

Reference

M. de Graaf, P. Stammes,  2005, ACP 5
F. M. Breon and N. Henriot, Spaceborne