Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management

FRESCO-S: A fast retrieval scheme for clouds from the oxygen absorptions for Sentinels (S5P/S5)

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FRESCO has been developed to retrieve cloud parameters from satellite spectrometers. FRESCO data are mainly used to correct cloud effects on trace gas retrievals, and to filter clouds in trace gas and aerosol retrievals. The latest development is the FRESCO for Sentinels (FRESCO-S). FRESCO-S products include effective cloud fraction, cloud height (cloud pressure), scene albedo, scene pressure. These parameters can be retrieved from the O_2 A and B bands, with only the O_2 A-band currently used for TROPOMI. Recently we also tested FRESCO-S using the Directional Lambertian Equivalent Reflectance derived from TROPOMI.

1. FRESCO-S for TROPOMI

The Tropospheric Monitoring Instrument (TROPOMI) is a spectrometer operating from the ultraviolet to the shortwave infrared. TROPOMI is dedicated to measurements of tropospheric composition, especially air quality and climate relevant gases. The geophysical (Level-2) products of TROPOMI include trace gases, clouds, and aerosols.
In KNMI, the FRESCO-S cloud pressure product is used in NO_2 retrievals. Figure 1 shows an O_2 A-band reflectance spectrum measured by TROPOMI.

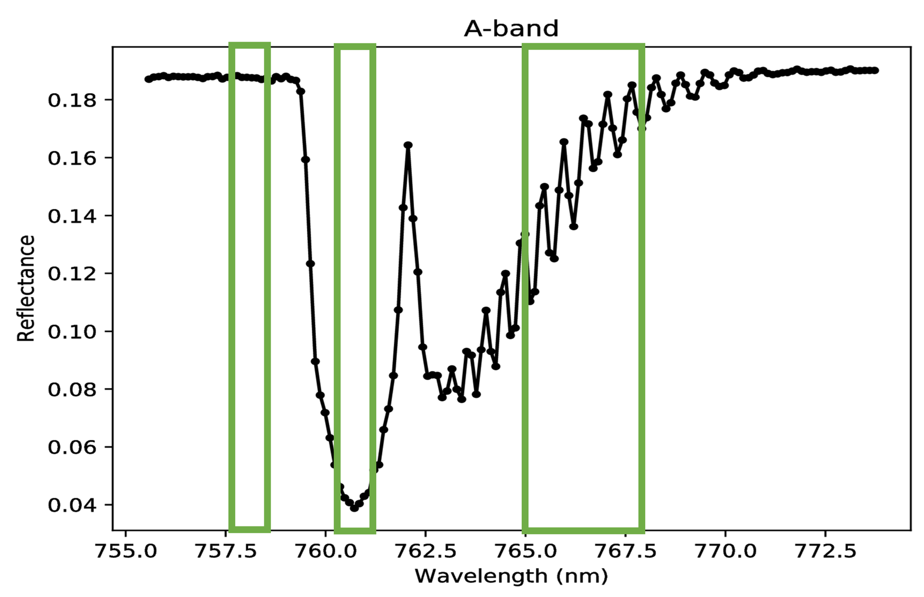

Figure 1. *An O_2 A band reflectance spectrum measured by TROPOMI. The boxes indicate fitting windows used in FRESCO-S.*

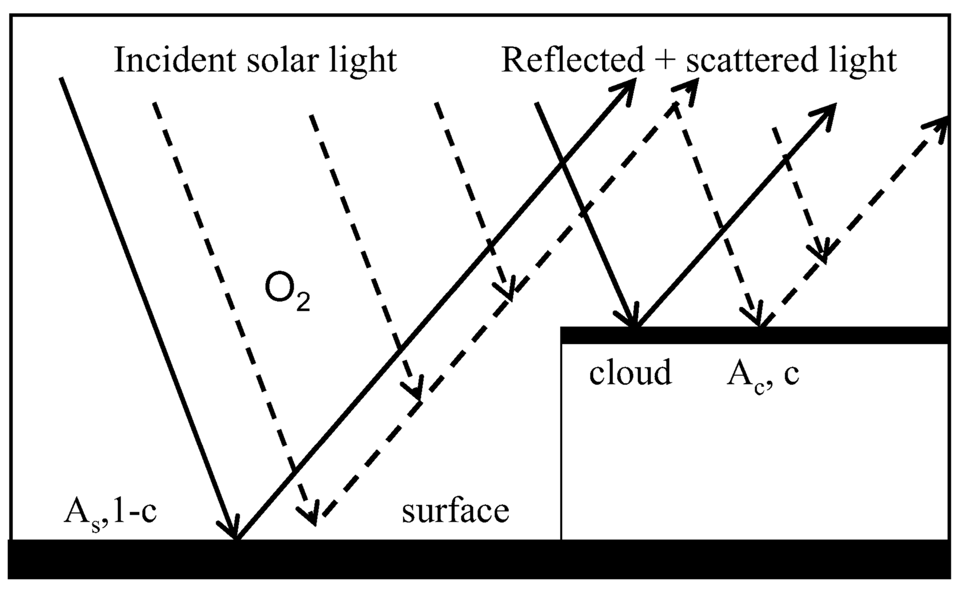

Figure 2. *Principle of the FRESCO cloud algorithm to retrieve effective cloud fraction and cloud pressure*

In the FRESCO algorithm, cloud is assumed to be a Lambertian reflector having an albedo of 0.8. Surface albedo is needed for the cloud free part of a pixel. The O_2 absorption and single Rayleigh scattering are taken into account in the cloud model. Figure 2 illustrates the principle of FRESCO for retrieving the effective cloud fraction and cloud pressure.
In the scene albedo and scene pressure retrievals, the pixel is assumed to be fully cloudy and the surface albedo is not needed.
In FRESCO-S, optimal estimation is used to find the best fit between measured and simulated spectra.

2. Effective cloud fraction and cloud pressure

TROPOMI effective cloud fraction and cloud pressure show detailed cloud structure. The effective cloud fraction is smaller than the geometric cloud fraction. The cloud pressure is approximately an optical middle pressure of the clouds (see Fig. 3).

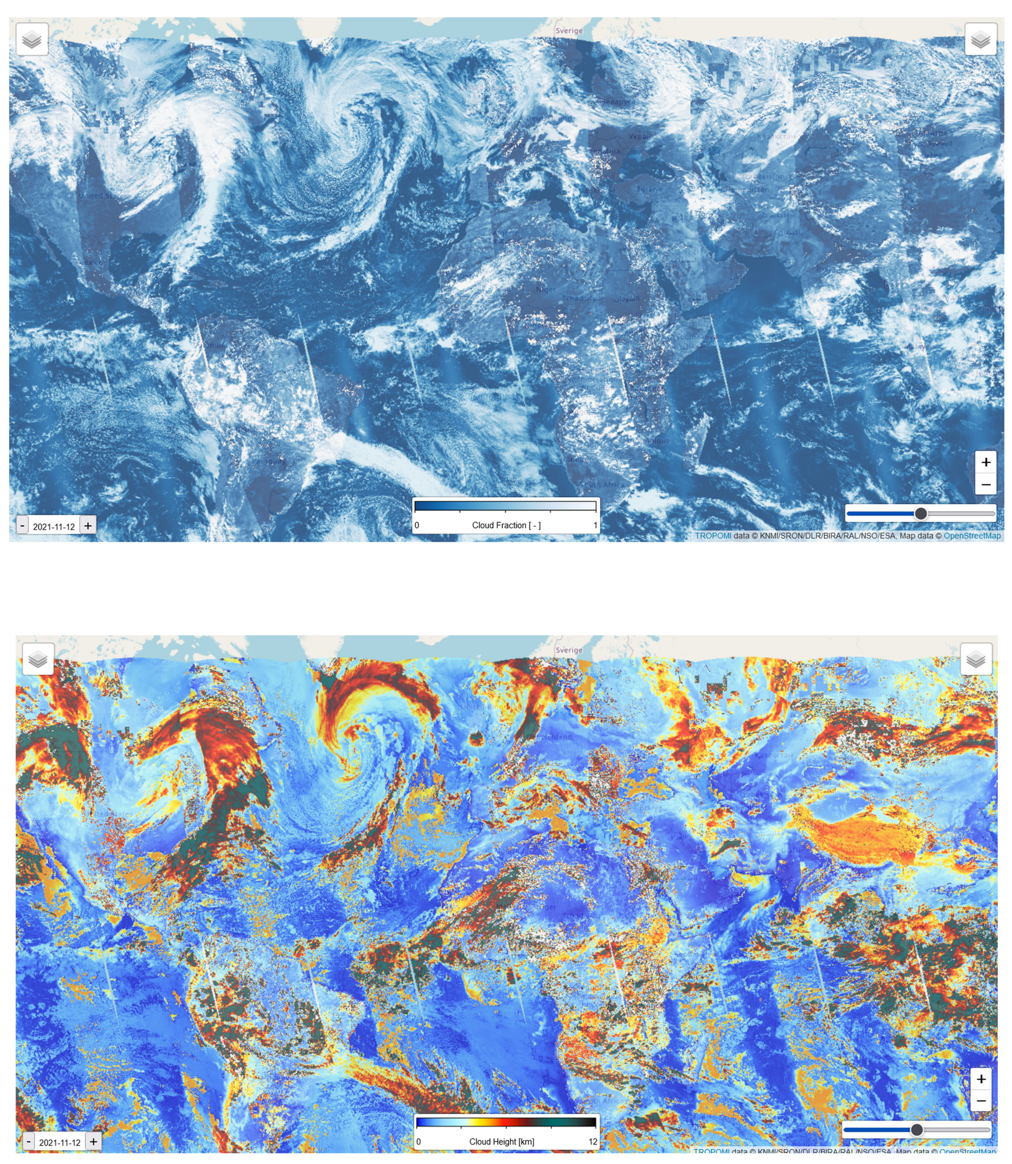

Figure 3. *FRESCO effective cloud fraction (upper) and cloud height (lower) on 12 November 2021.*

3. FRESCO-S using TROPOMI DLER

The quality of the FRESCO-S product depends on the surface albedo database. Currently FRESCO-S uses GOME-2 LER because GOME-2 LER was the best choice before the launch of TROPOMI. Figure 4 shows the effective cloud fraction retrieved using GOME-2 LER, TROPOMI LER and DLER respectively. The area is over the Sahara desert, only south part of the image has some clouds.

GOME-2 FRESCO product has already used the GOME-2 DLER. FRESCO effective cloud fraction and cloud pressure retrieved using the DLER have less view zenith angle dependence than those using LER (see Fig. 5). We expect TROPOMI FRESCO-S using DLER will have similar improvement to GOME-2 FRESCO.

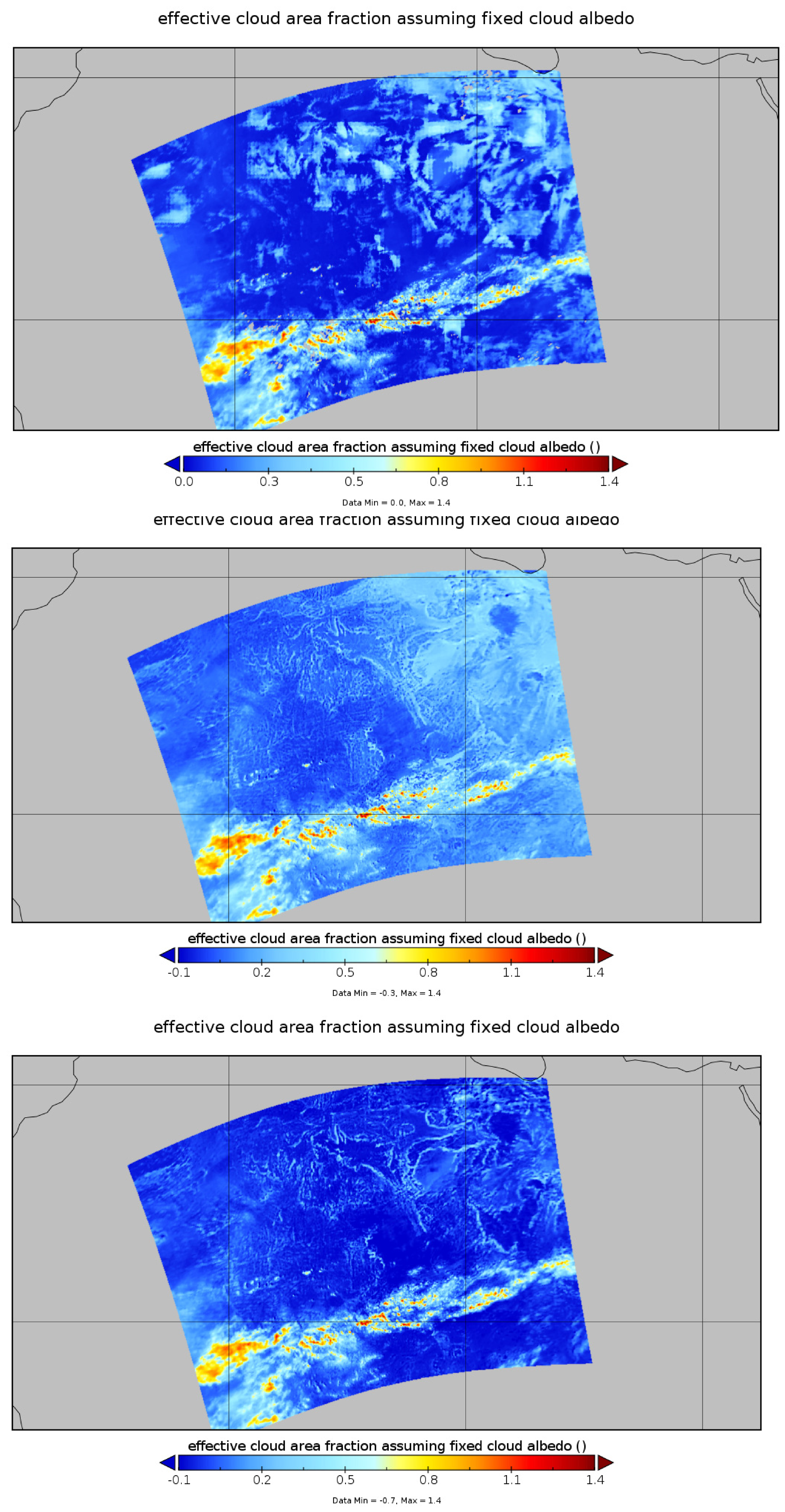

Figure 4. *FRESCO-S effective cloud fraction retrieved using GOME-2 LER (upper), TROPOMI LER (middle) and TROPOMI DLER (lower) for part of the orbit over Sahara desert on 17 March 2019.*

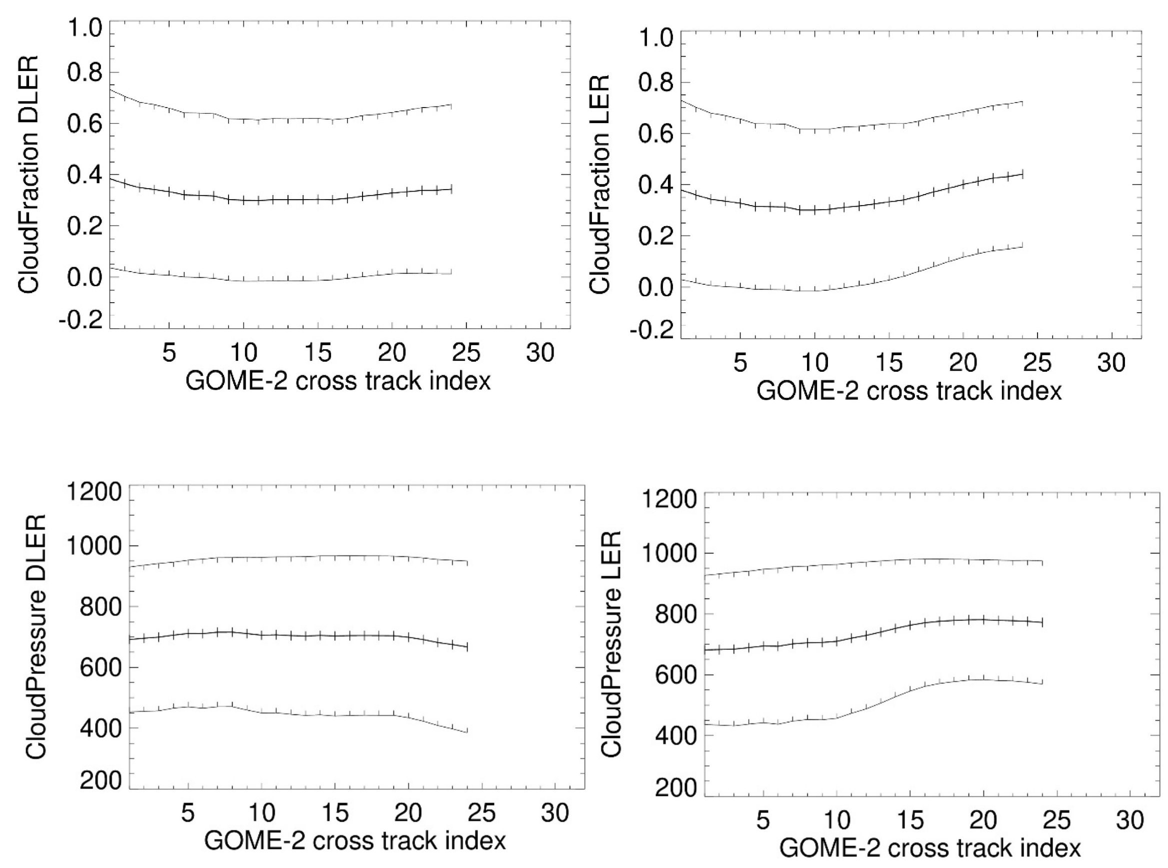

Figure 5. *Effective cloud fraction and cloud pressure (unit: hPa) as a function of cross track index over land for GOME-2A data in April 2010, left: DLER, right: LER.*

4. Summary

The FRESCO-S cloud algorithm is processed at near real-time in the TROPOMI processor as an auxiliary product for the air quality products. The improvement of FRESCO-S is ongoing. The tests of FRESCO-S using TROPOMI DLER show promising results. More analysis will be done after DLER is implemented in the operational algorithm.

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