A fast cloud retrieval algorithm from the oxygen B-band for GOME-2 measurements

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Outline

• Introduction on FRESCO

• Why using FRESCO in the oxygen B-band?

• Comparisons between FRESCO-A and FRESCO-B

• Directional dependence of surface LER climatology

• Conclusions - perspectives
Intro : Fast REtrieval Scheme for Cloud from the Oxygen A-band

• Retrieving cloud altitude from $O_2$ absorption (Vanbauce 1998, Preusker 2007, Lelli 2012…)
  – Depends weakly on temperature profile,
  – Sensitive to low clouds,
  – Retrieve cloud optical mid-level altitude

• FRESCO : (Koeleimeijer 2001, Wang 2008)
  • Retrieves cloud properties from reflectances measured in the 02 A-band
    – cloud effective fraction + cloud pressure
  • Used operationnally (http://www.temis.nl/fresco/)
    – input for in trace gas and aerosols retrievals
Fast REtrieval Scheme for Cloud from the Oxygen A-band

- Hyp: Cloud and surface are lambertian
- $A_c, A_s$: Albedos of cloud and surface, $A_c = 0.8$
- $C_{\text{eff}}$: Effective cloud fraction
- $T_s, T_c$: Two-ways O2 transmissions
- $R_c, R_s$: Single Rayleigh scattering reflectances

$$R_{\text{sim}} = c_{\text{eff}} T_c A_c + (1 - c_{\text{eff}}) T_s A_s + c_{\text{eff}} R_c + (1 - c_{\text{eff}}) R_s$$

Minimizing the difference between simulated and measured reflectances (Levenberg-Marquardt nonlinear least-square method)
Why using FRESCO in the oxygen B-band?

- The O2 B-band (686-690 nm) is less deep than the O2 A–band (758-772nm)
Why using FRESCO in the oxygen B-band?

- The $O_2$ B-band (686-690 nm) is less deep than the $O_2$ A–band (758-772 nm).

**GOME-2**
- Spectrometer on board MetOp A/B
- Measurement in UV-VIS-NIR (240-800 nm) to monitor atmospheric composition

The difference of pressure retrieved with $O_2$ A and B bands can provide information on cloud vertical structure.
Why using FRESCO in the oxygen B-band?

- The O2 B-band (686-690 nm) is less deep than the O2 A-band (758-772 nm).
- Vegetation albedo is lower in the O2 B-band.
- The difference of pressure retrieved with O2 A and B bands can provide information on cloud vertical structure.
- Vegetation cover: Retrievals in the B-band might be more accurate than in the A-band.
First results of FRESCO-B

Effective cloud fraction

July 2014
4 208 125 pi.

\[ \bar{c}_{\text{eff}} = 0.389 \pm 0.304 \]

Cloud pressure

\[ \bar{P} = 736 \pm 195 \text{ HPa} \]
Comparison between FRESCO-A and FRESCO-B cloud effective fractions

$C_{\text{eff,FRESCO-B}} - C_{\text{eff,FRESCO-A}}$

Mean effective cloud fraction:
- very similar with both methods,
- whatever the underlying surface is

<table>
<thead>
<tr>
<th></th>
<th>All surfaces</th>
<th>Ocean</th>
<th>Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-band</td>
<td>0.387±0.297</td>
<td>0.388±0.294</td>
<td>0.390±0.310</td>
</tr>
<tr>
<td>B-band</td>
<td>0.389±0.304</td>
<td>0.395±0.298</td>
<td>0.380±0.320</td>
</tr>
</tbody>
</table>
Comparison between FRESKO-A and FRESKO-B cloud pressures

Over Ocean, differences between $P_{\text{FRESKO-A}}$ and $P_{\text{FRESKO-B}}$ are only due to a difference of transmission.

$P_{\text{FRESKO-A}}$ and $P_{\text{FRESKO-B}}$ indicate 2 different altitudes in the cloud layer.

Over Ocean

$2032709\text{ pi.}$

$\bar{P}_{\text{FRESKO-A}} = 749 \pm 199$

$\bar{P}_{\text{FRESKO-B}} = 763 \pm 179$

$\Delta P = 13.9 \pm 42.1$
Comparison between FRESCO-A and FRESCO-B cloud pressures

\[ A_{685} - A_{758} \]

\[ P_{FRESCO-B} - P_{FRESCO-A} \]

- Difference is more complex
- The difference of pressure can be due to difference of transmission or difference of surface albedo

Over Vegetation

\[ 651 \, 903 \, \text{pi.} \]

\[ \bar{P}_{FRESCO-A} = 681 \pm 174 \]

\[ \bar{P}_{FRESCO-B} = 689 \pm 157 \]

\[ \Delta P = 8.52 \pm 50.2 \]
Directional dependence of surface LER climatology

- Stronger over vegetation
- Stronger in the A-band
- Overestimated LER and consequences on cloud products

(Lorente et al., 2018)
Bias in the retrieval of cloud properties (Western pixels) due to BRDF effect

- Ceff: Difference we don’t expect between FRESCO-A and FRESCO-B
- Cloud pressure: Smaller difference

Necessity to correct this effect with a directional LER dataset
Conclusions - Perspectives

• Fast cloud retrieval algorithm from the oxygen B-band for GOME-2 measurements
  – Good performances compared to FRESCO
  – More accurate cloud pressure over vegetation cover
    – Next step: Combine pressures obtained in A and B-bands

• Will be applied to TROPOMI on-board Sentinel-5P
  – UV-VIS-NIR-SWIR spectrometer
  – Smaller spatial resolution than GOME-2 (40*80 km² -> 3.5*7 km²)
    – Validation through campaign based comparisons