Cloud top pressure retrieval from O_2 A-band

& potential of multi-layer detection using water vapour channels

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I – Summary

We describe our algorithm for the retrieval of **cloud top pressure** (CTP) from **O_2 A-band** based on **optimal estimate method**. It applies for mono-layer clouds and makes use of CloudSat/Calipso climatology in order to vary the vertical structure (either extinction profile and cloud geometrical thickness) of the cloud as a function of the optical thickness and cloud top pressure.

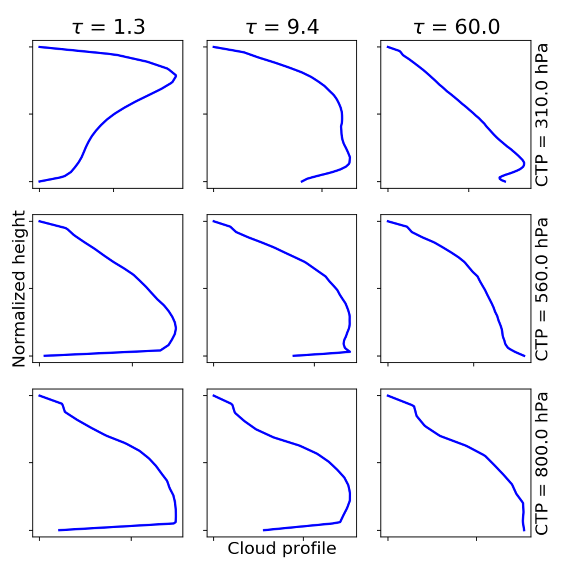
Departure of actual cloud vertical structure regarding our model is an major source of error for the retrieved CTP. In that regard multi-layer situation is particularly problematic. We intend to exploit short wave infrared water vapour absorption channel(s) in addition to the O_2 A-band channel in our algorithm to **detect multi-layer situations.**

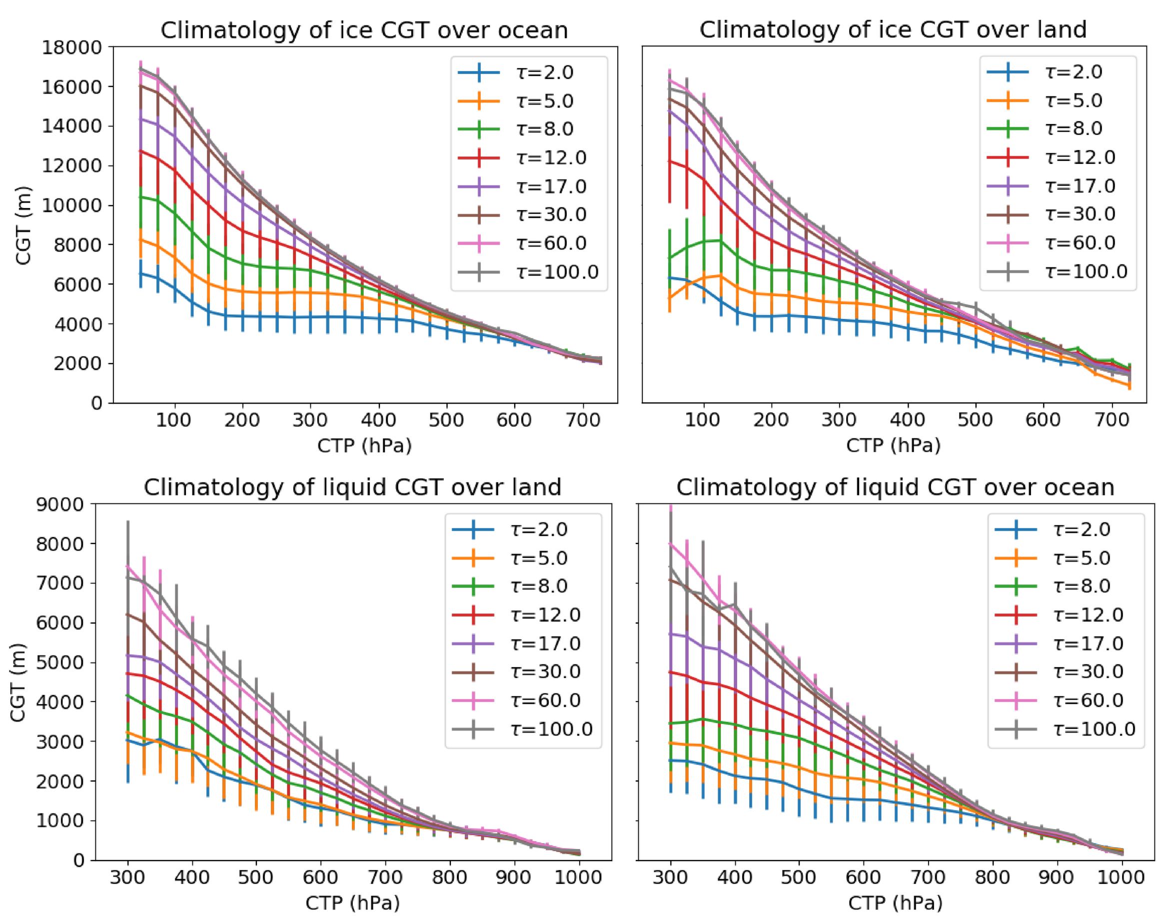
The algorithm is primarily developed for the future **EPS-SG/METimage** instrument. It can be adapted to instruments with similar spectral characteristics (e.g. MERIS, PARASOL/POLDER, Sentinel3/OLCI, 3MI).

II - METimage algorithm description

The retrieval in based on optimal estimate with Look-Up Tables as forward model, **F(X)**. We have $\mathbf{y}_{\mathbf{land}}$= ($I_{670}$, I_{763}/I_{752}), $\mathbf{y}_{\mathbf{ocean}}$=($I_{865}$, I_{763}/I_{752}) and **x** = (COT, CTP). Non retrieved parameters are $\mathbf{b}_{\mathbf{land}}$=(SZA, VZA, RAA, WSA_{land}, $P_{surface}$) or $\mathbf{b}_{\mathbf{ocean}}$=(SZA, VZA, RAA, $Wind_{SPD}$, $P_{surface}$). The ocean and six different land biomes are considered to reproduce a BRDF variability.

In **F(X)**, clouds (either ice or liquid) are mono-layer with a varying vertical structure following Calipso and CPR climatologies (see below).



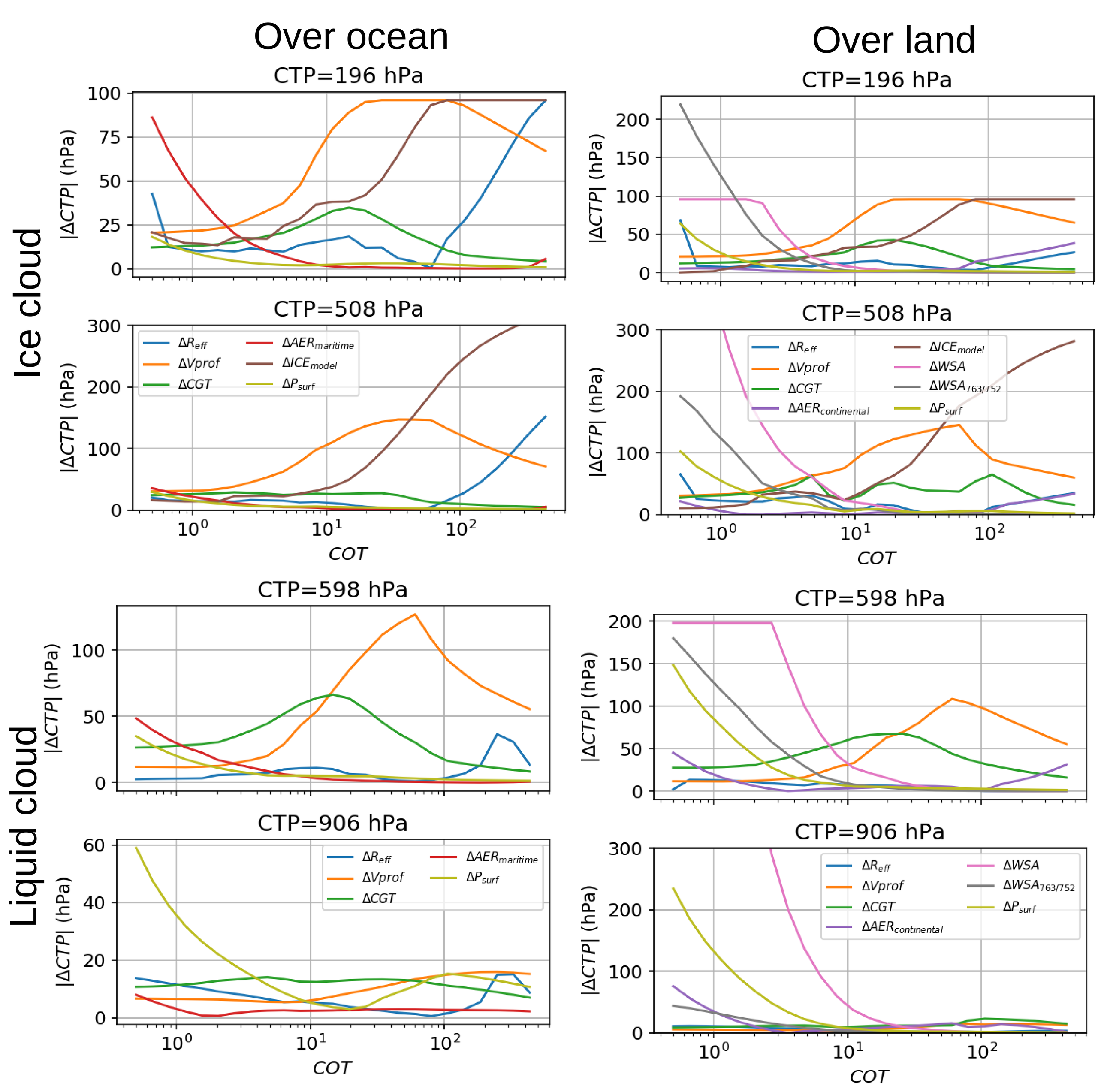


(Right panel) Climatology of Cloud Geometrical Thickness, CGT = f(COT, CTP), from CloudSat/Caliop measurements (product : 2B_GEOPROF_LIDAR, year : 2008).

(Left panel) Average cloud vertical extinction profiles as a function of (COT, CTP) from CPR climatology. Source: Carbajal Henken et al. [2014]

III – CTP error budget

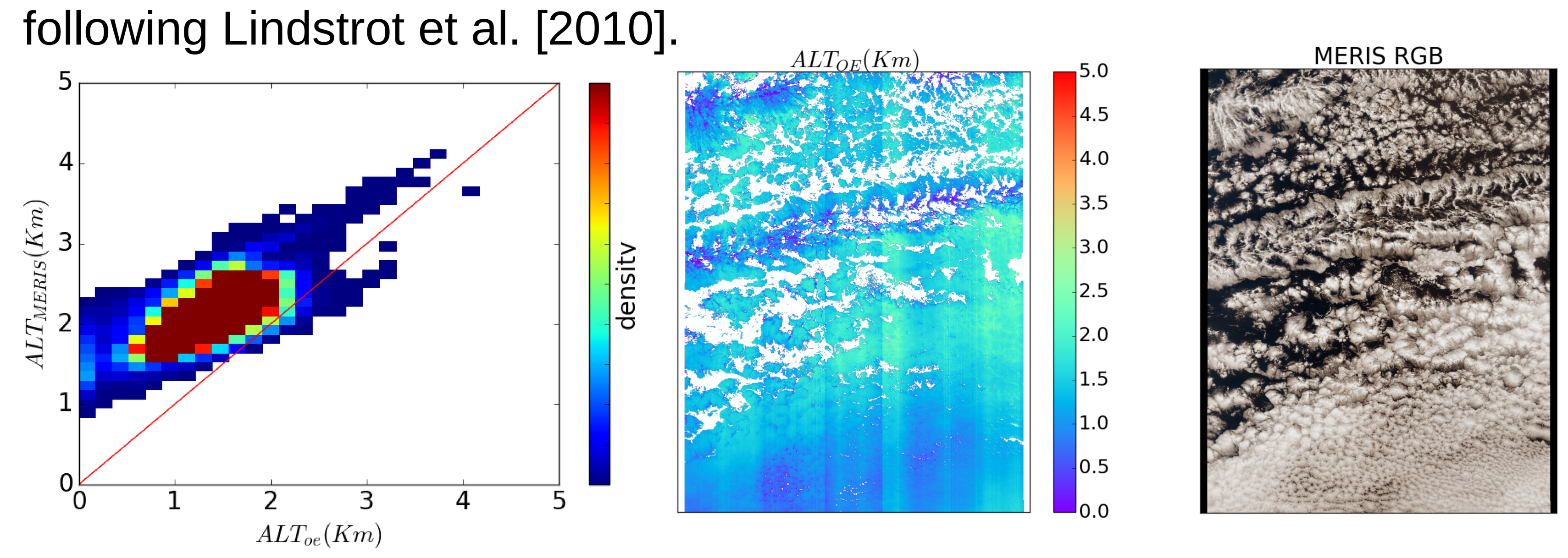
The retrieval is applied on synthetic radiances for scenes with "wrong" parameters in order to assess the error (ΔCTP) committed when such parameters are not well constrained in **F(X).**



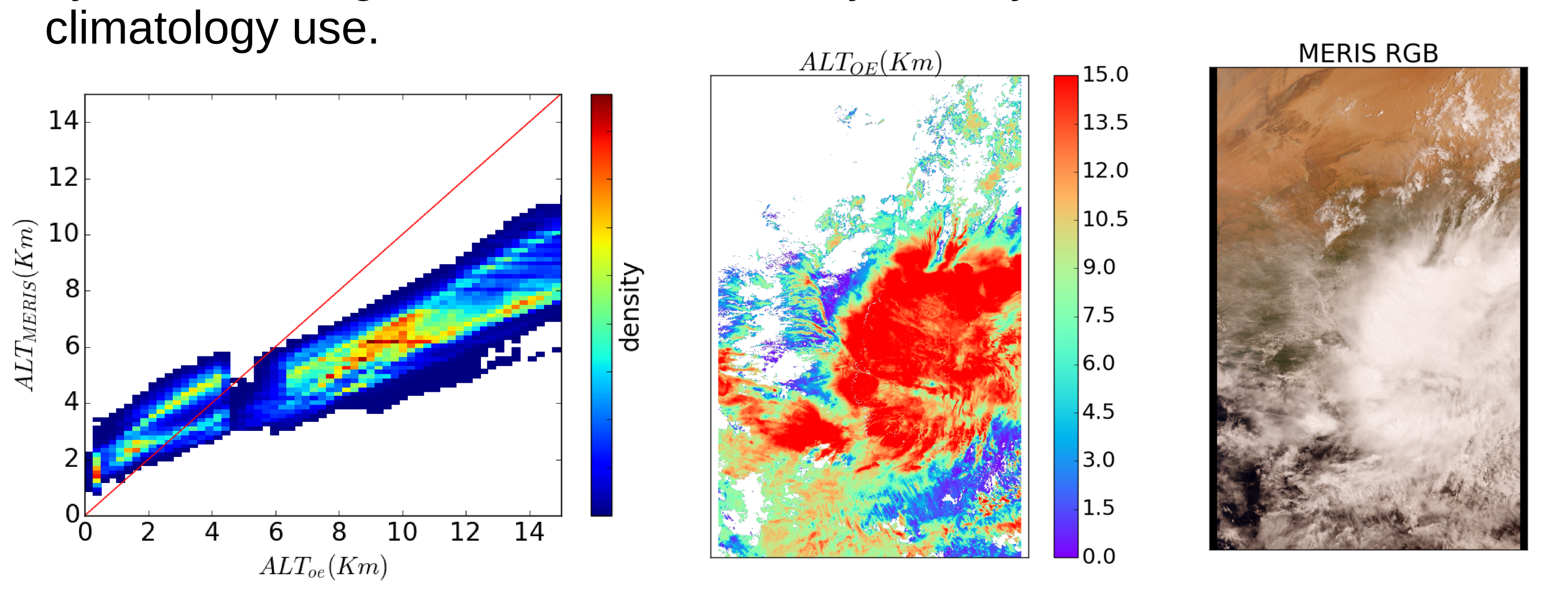
Parameter	Perturbation
ΔR_{eff}	8 µm (instead 14) for liquid and 60 µm (instead 25) for ice
ΔV_{prof}	Raise ext. prof. +σ top, lower it -σ bottom (σ from climato)
ΔCGT	CGT + σCGT/2.0 (σ from climato)
$\Delta AER_{maritime}$	Add maritime aer. with OPD=0.1
$\Delta AER_{cont.}$	Add cont. aer. with OPD=0.1
ΔICE_{model}	Change ice model GHM (Baum et al.) to RHM (Parasol/Polder)
ΔWSA	all channels WSA=0.12 (instead 0.1)
$\Delta WSA_{763/752}$	763 nm WSA=0.12 (instead 0.1)
ΔP_{surf}	P_{surf} = 973hPa (instead of 1013hPa)

IV – Test CTP retrieval on MERIS data

We compare CTP retrieved with our algorithm to MERIS L2 product (Preusker et al., [2010]). The measurement vector is ($MERIS_{10}$, $MERIS_{11}/MERIS_{10}$). MERIS stray-light and smile effect are accounted for following Lindstrot et al. [2010].

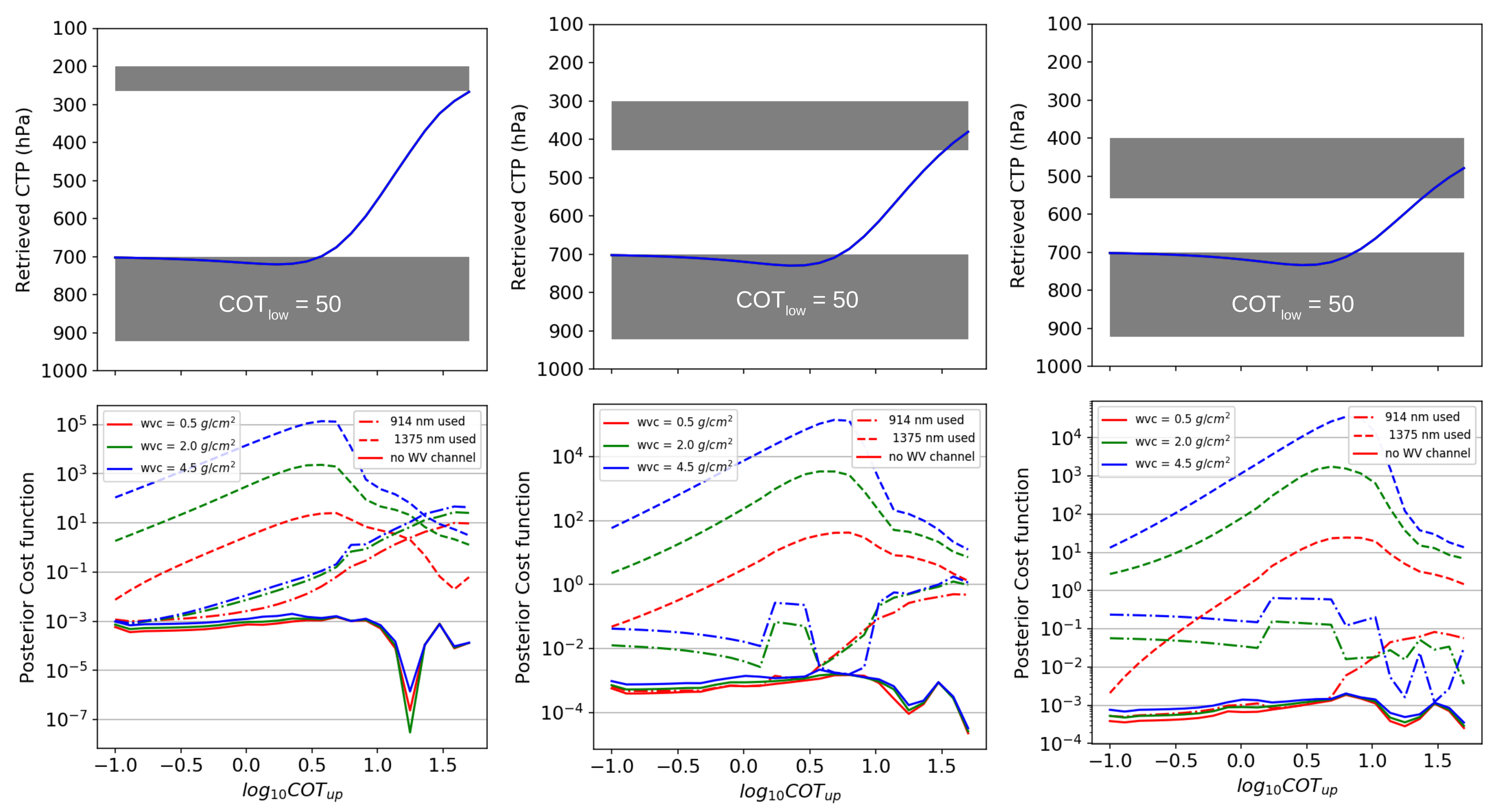


Both in stratocumulus scene (fig. above) and DCC scene (fig. below), our retrieval places low level clouds lower in the atmosphere and high level clouds higher in the atmosphere regarding MERIS L2. This larger dynamical range in our retrieval may mostly be related to the CGT climatology use.



V – Potential of multi-layers detection using water vapour channels

The current retrieval implementation is completely insensitive to multi-layer situation (although retrieved CTP is wrong in that case, see fig. below). Water vapour and oxygen have different vertical distribution. Comparing radiances in spectral bands affected by their absorption should then reveal additional information about the altitude where scattering occurs, i.e. the cloud vertical structure. In order to make the cost function sensitive to multi-layer, we compute it posterior to the retrieval, adding water vapour channel signal (914/865 and 1375/1240 nm) to the measurement vector.



A proper setting of errors in modelling 914 and 1375 nm channel radiances is crucial in order to properly estimate the cost function. We consider an uncertainty on water vapour content ΔWVC/WVC=10% (appearing in $\mathbf{S}_b$, the covariance of non retrieved parameters). We also compute a variance of the 914 and 1375 nm signal related to atmospheric profile variability, added to $\mathbf{S}_\varepsilon$, the covariance of measurement vector. Resulting retrieval and posterior cost function is shown on figure above for various multi-layer situations. Results are promising and further tests will be performed on real data (using PARASOL/MODIS and validation with CloudSat/Calipso).

Radiative transfer computation were performed using **ARTDECO** tool.

ARTDECO is freely available at
http://www.icare.univ-lille1.fr/projects/artdeco

EUMETSAT

This work is conducted under EUMETSAT contract.