Cloud Top Pressure retrieval from O_2 A-band with METimage

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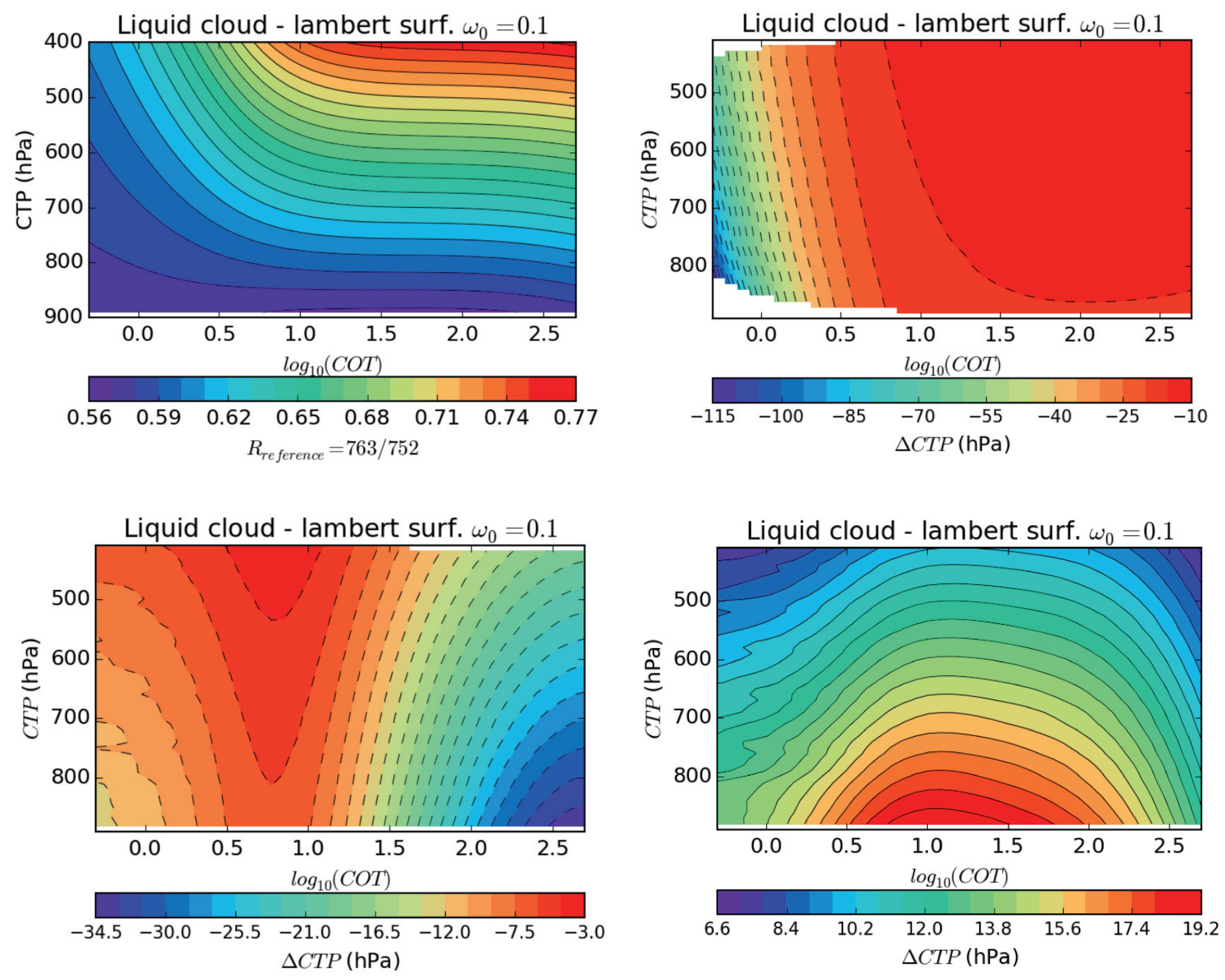
Summary

METimage is a cross-purpose medium resolution, multi-spectral optical imager/radiometer that will flight on board EPS-SG. It is intended to provide high quality imagery data for global and regional numerical weather prediction and now-casting, and to support the sounding instruments on EPS-SG. Taking advantage of its large spectral range (0.44-13.5 microns), METimage will provide, among others, Cloud Top Pressure (CTP) products based on the use of visible imaging in the oxygen A-band. EUMETSAT currently is considering implementing a retrieval method based on Optimal Estimate (OE) and Look-Up Tables as the forward model. We present a study on prototyping the corresponding algorithm. We first present selected results of a sensitivity study. Then we present a prototype version of the algorithm that was tested on synthetic data.

This work is done under EUMETSAT contract.



Sensitivity of the signal ratio

The CTP is constrained by the ratio of R=VII-5(763nm)/VII-4(752nm). This ratio is mainly sensitive to the CTP and cloud optical thickness (COT) (see Fig.1) but is also affected by several other parameters. Among those are the (i) Cloud geometrical thickness (CGT) and vertical profile (see Fig.1), (ii) Surface properties, (iii) Cloud micro-physics, (iv) Cloud fraction, (v) Aerosol, (vi) Temperature vertical profile and (vii) geometry. The cloud vertical profile and CGT are of particular importance cause they have a significant impact on R for lower level thick clouds.

Figure 1: (**Upper left panel**) The signal ratio variation as a function of CTP and COT. (**Upper right panel**) CTP variation equivalent to the R deviation due to noise (for SNR=500). (**Lower left panel**) CTP variation equivalent to a variation from a Stratocumulus to homogeneous vertical profile (CGT=1.0 km). (**Lower right**) CTP variation equivalent to a variation of the CGT of ±10% regarding 1km. These are all for liquid cloud over with a lambertian surface w_a=0.1.

Synthetic data simulator

A METimage (and 3MI) synthetic data simulator was developped under a previous EUMETSAT contract. This is a valuable tool for level 2 algorithm testing since any parameter driving the measured radiance is known and controlled.

In the simulator, full orbit propagation is performed derived from EPS orbital parameters. Observation geometries (sensor reference frame) for METimage is simulated based on instrument sampling characteristics. Geolocation and sampling geometries are used to model the radiative transfer in which surface and atmosphere (clouds, aerosols, gas) have been realistically described based on ancillary information obtained for dates and time of required simulation (among which AVHRR products for clouds, MACC reanalysis for aerosols, ECMWF reanalysis for atmospheric state, MODIS BRDF parameters climatology for land properties). The simulated TOA radiances have been generated at level 1b (see Fig. 2), equivalent to the calibrated and geolocated measurements.

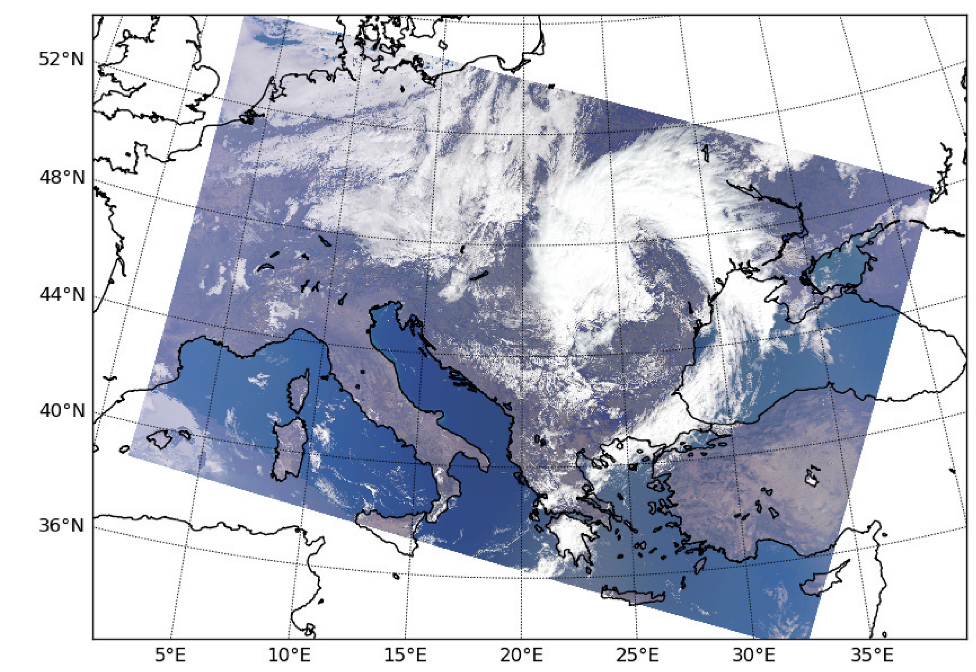
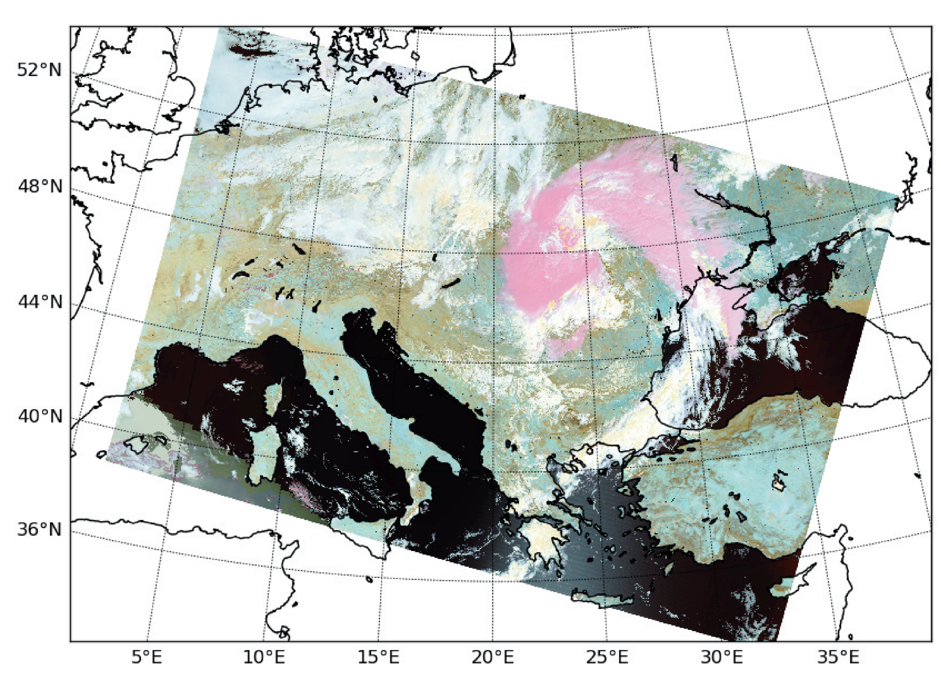
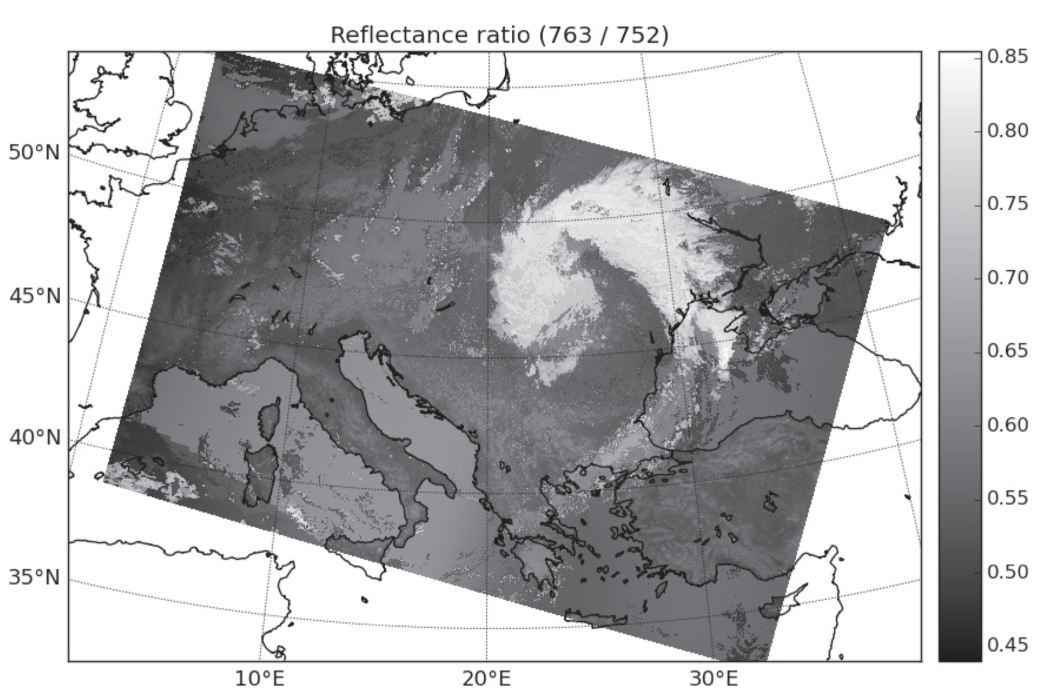


Figure 2: TOA synthetic METimage radiances. (**Upper panel**) RGB (I_{670}, I_{555}, I_{443}). (**Middle panel**) RGB (I_{865}, I_{1630}, I_{2250}). (**Lower panel**) R = I_{763} / I_{752}





Cloud Top Pressure retrieval ATBD

The state vector is (COT, CTP). The measure vector is (I, R) with R=I_{763}/I_{752} and I being the I_{865} reflectance over water surface and I_{670} reflectance over land.

LUT (forward model) entries are (i) COT, (ii) CTP, for the state vector and (iii) SZA, (iv) VZA, (v) RAA, (vi) wind speed over ocean, white sky albedo over land and (vii) surface pressure for non-retrieved parameters.

Eight different land types are considered to reproduce a directionnality variability (one LUT per type). The cloud particles effective radius R_{eff} is fixed for each phase (one LUT per phase).

The CGT and vertical profile are varied as a function of (COT,CTP) following Calipso and CPR climatologies (Fig.3)

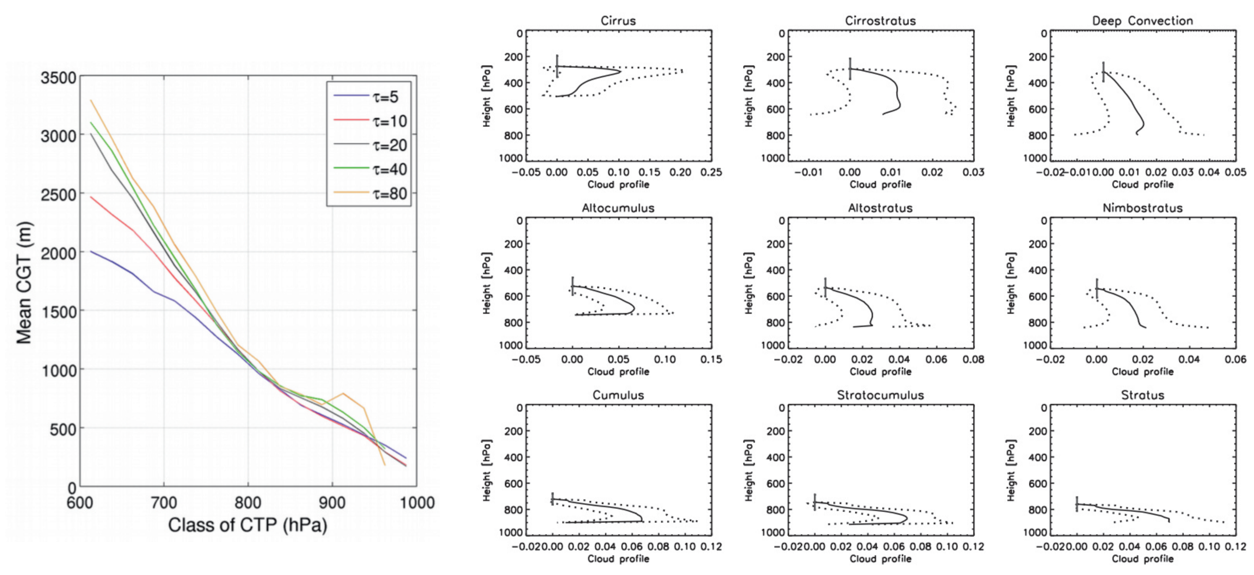
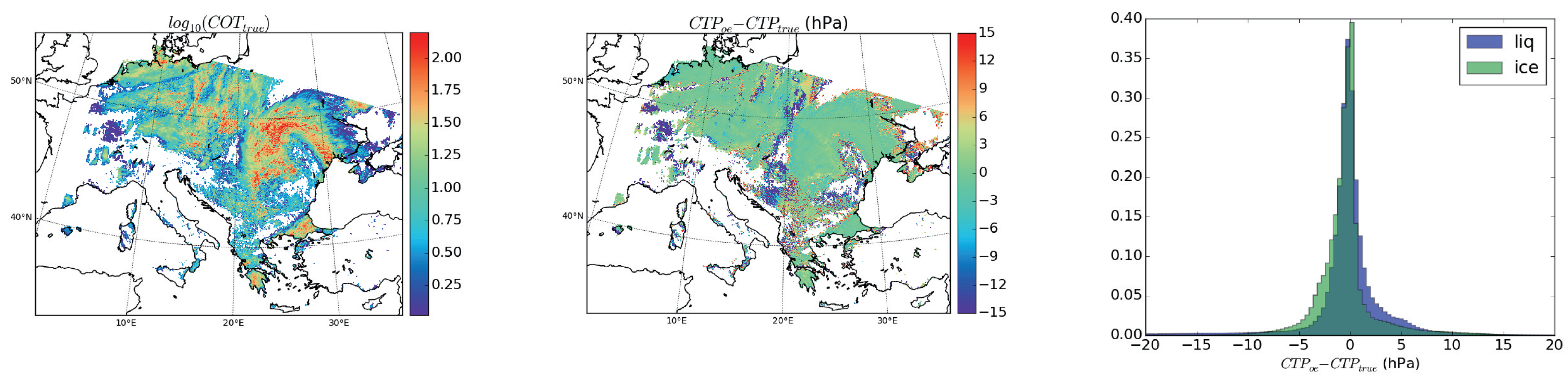


Figure 3 (**Right Panel**) Climatology of CPR profile from Carbajal-Henken et al. [2013]. (**Left panel**) CLOUDSAT/CALIPSO CGT climatology for liquid clouds.

CTP retrieval testing on METimage synthetic data

The optimal estimate retrieval is tested with the synthetic data. Here, in order to focus on the effect of LUT sampling the forward model setting is the exact same in LUT building and synthetic data production. In the present case, the maximum interpolation error due to the LUT sampling is ~4% for I and 0.5% for R. Fig. 4 and 5 show the resulting error on CTP retrieval.



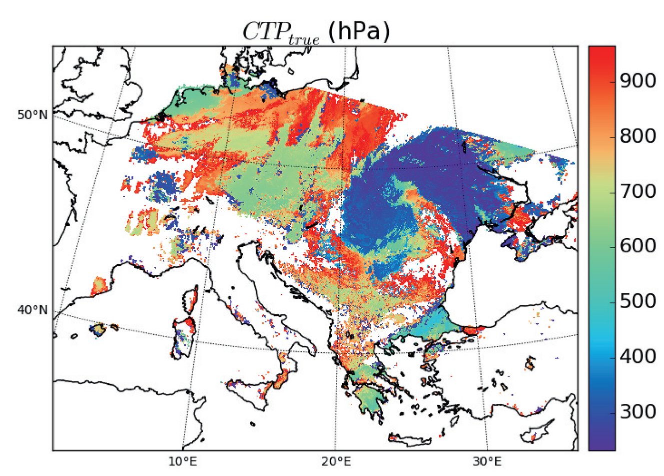
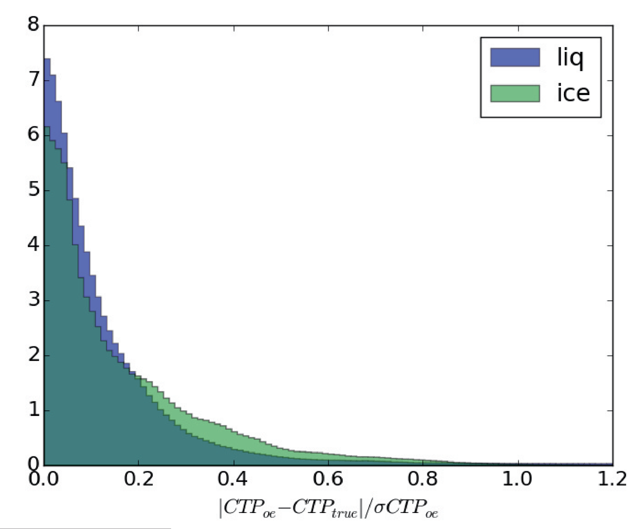
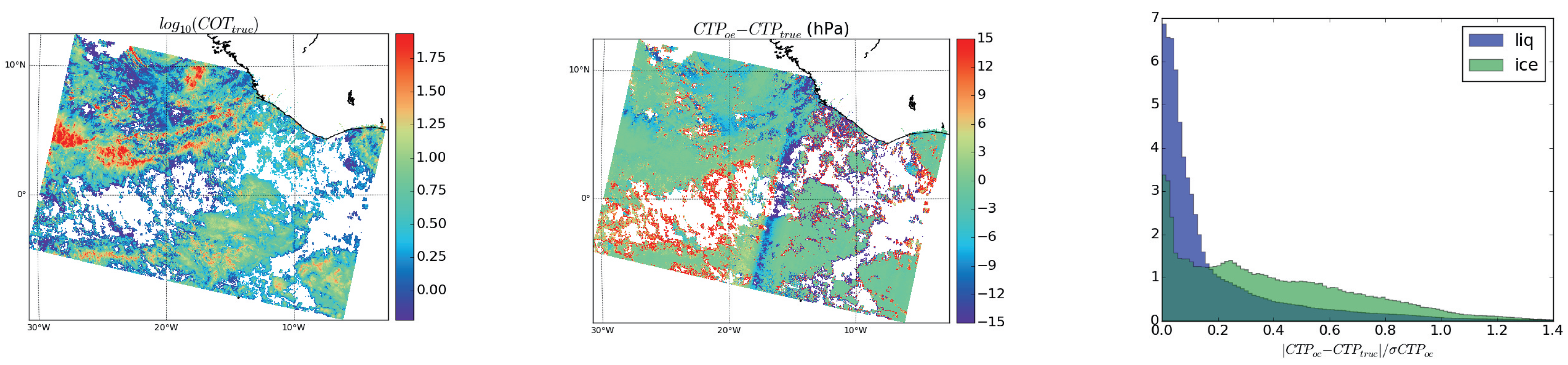


Figure 4: Results of OE retrieval for a METimage synthetic data granule over land (Mid-September). Maps show the true COT (upper left), the true CTP (lower left) and the error on CTP (i.e CTP retrieved - true CTP). Plots on the right side show the histogram of the CTP error (upper right) and the error normalised by the OE CTP uncertainty.





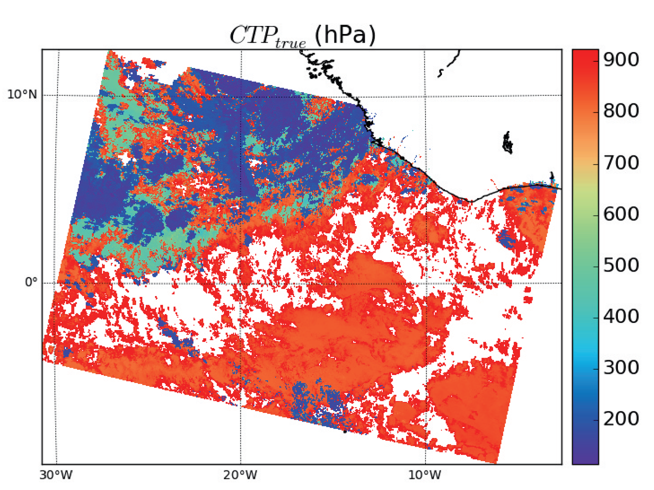


Figure 5: Results of OE retrieval for a METimage synthetic data granule over ocean. Maps and plots description are the same as for Fig 4.