# TORMS: TOTAL OZONE RETRIEVAL FROM MERIS IN VIEW OF APPLICATION TO SENTINEL-3

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## Abstract

An algorithm has been developed to retrieve total column of ozone (TCO) using MERIS TOA reflectances, which include the ozone Chappuis bands.
It has been applied to the full MERIS archive and MERIS TCOs have been compared to those retrieved more classically from the UV nadir sensor GOME-2A. The method is valid over bright and spectrally white surface such as snow/ice surfaces and optically thick clouds. The TCOs from MERIS and GOME-2A agree generally well over Antarctica, while MERIS tends to underestimate TCOs elsewhere. MERIS TCOs have also been compared to ground measurements and show a good correlation (bias and root mean square error of about 4 and 20 DU, respectively).

## Domain of applicability

**Identification of key parameters** (Fig. 3)
SIG_RESIDU: chi-square difference between TOA reflectances measured in bands 1,2 ,3,4,5,7,8,10,12,13 and a 3-rd order polynomial fitted through them. Contrast indicator - Low values: no sensitivity to O3 absorption; high values: O3 absorption leads to some deviation from the free-absorption spectrum, TCO may be retrieved.

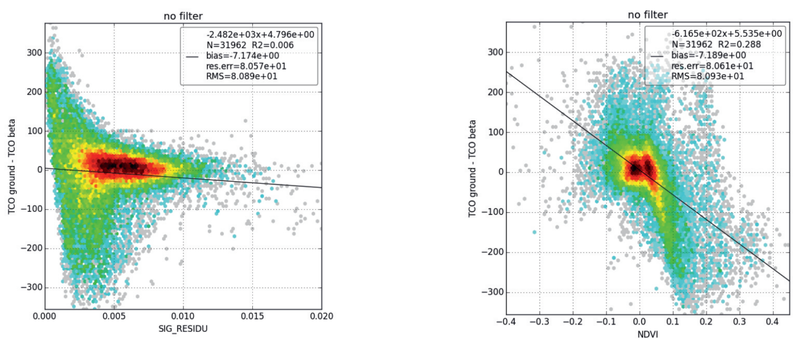
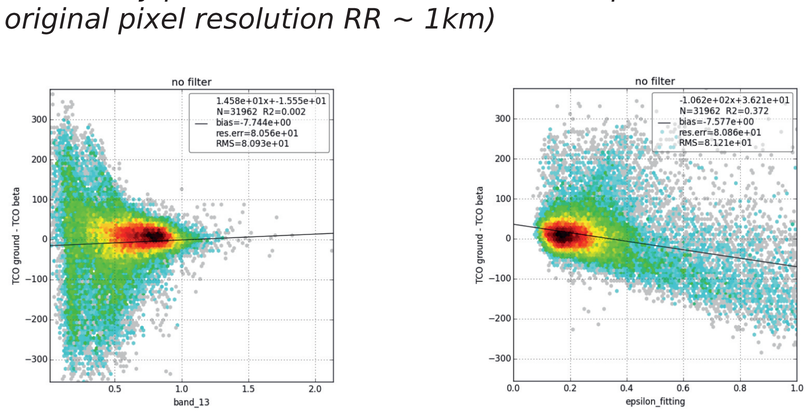



*Fig. 3: Differences between MERIS TCO and ground TCO versus key parameters. (MERIS retrieval is performed at original pixel resolution RR ~ 1km)*




NDVI: high values indicate vegetation spectral signature making difficult the fit of a polynomial to determine the free-absorption spectrum.
Reflectance at 865 nm (band 13): signal-to-noise indicator.
epsilon_fitting: chi-square difference from the minimization procedure. Low values are expected for reliable retrievals.

**Retrieval preformed over bright surfaces and optically thick clouds**

## Validation versus ground

28 stations (WOUDC and NDACC) have been selected to cover a large representative range of latitudes, geographical and geophysical conditions. Algorithm has been applied to the pixel over these stations for the entire MERIS mission: 2002-2012. Following thresholds have been applied on key diagnostic parameters: sig_residu>0.003, NDVI<0.02, band_13>0.8 and epsilon_fitting<0.25 (see Fig. 4).

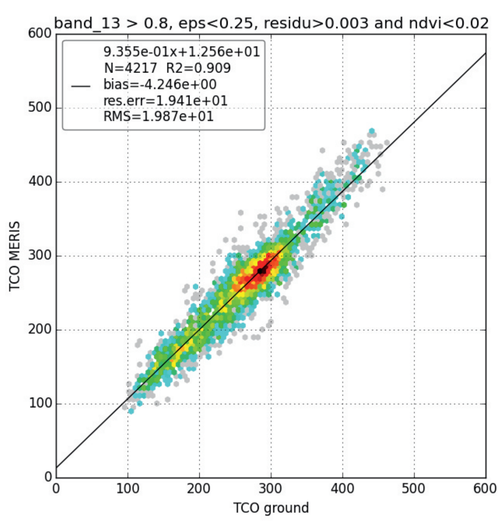



*Fig. 4: MERIS TCO versus ground TCO for 28 stations and the whole MERIS mission.*

**Bias=-4.2 DU**
**RMS=19.9 DU**
**$R^2$=0.91**

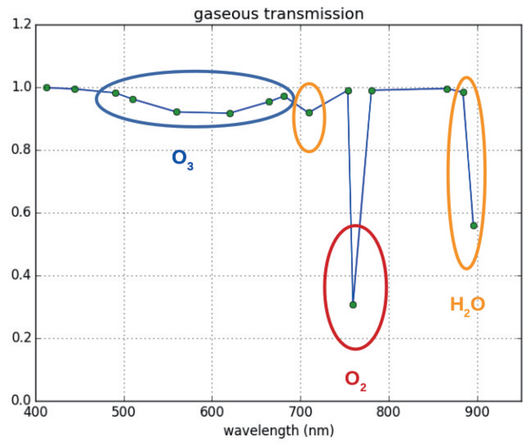



*Fig. 1*

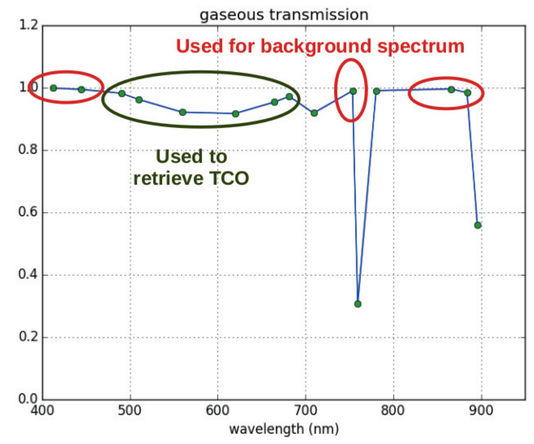



*Fig. 2*

## Theoretical Background: absorption and ozone signature

The method assumes that the TOA reflectance spectrum in the absence of gaseous absorption can be modelled by a third order polynomial. TCO is then retrieved by making use of the difference between this polynomial calculated from bands number 1, 2, 10, 12 and 13, and the measured reflectance in band number 3, 4, 5, 6, 7 and 8 where ozone absorbs (Fig. 1).

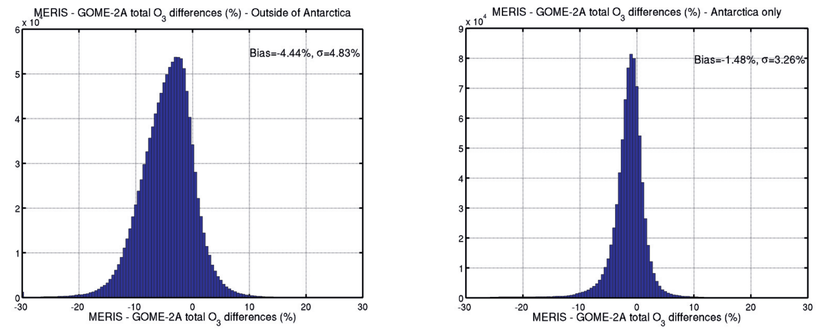
## Method

Differential approach (Fig. 2): a free absorption spectrum results from the fit of a 3rd order polynomial through signals from channels 1, 2, 10, 12 and 13. Residual O3 absorption is corrected for with a simple formulation assuming two single layers.
Look-up tables of $O_3$ transmittances in channels 3-8 have been calculated using accurate RT simulations in a spherical shell atmosphere for total O3 columns from 25 to 600 DU and taking into account scattering/absorption coupling. The TCO is retrieved using a non-linear least squares procedure minimizing the differences between the free-absorption spectrum and transmittances measured in channels 3-8 and corrected for O3 absorption. This correction is extracted from the look-up tables and depends on TCO.

## Validation versus GOME-2A

GODFIT (BIRA - IASB algorithm for nadir UV sensors). This algorithm is used within the ESA O3_CCI project to generate multi-sensor consistent level-2 total ozone data sets (Lerot et al., 2014).

Differences between MERIS and GOME-2A TCO products for 18 days equally distributed during the year 2008 have been analysed: a globally good agreement is found but better results are obtained overt Antarctica.




*Out of Antarctica:*
*bias= -4.4%; sigma = 4.8%*

*Over Antarctica:*
*bias= -1.5%; sigma= 3.3%*

## L3 product

TORMS algorithm has been applied to the MERIS archive.

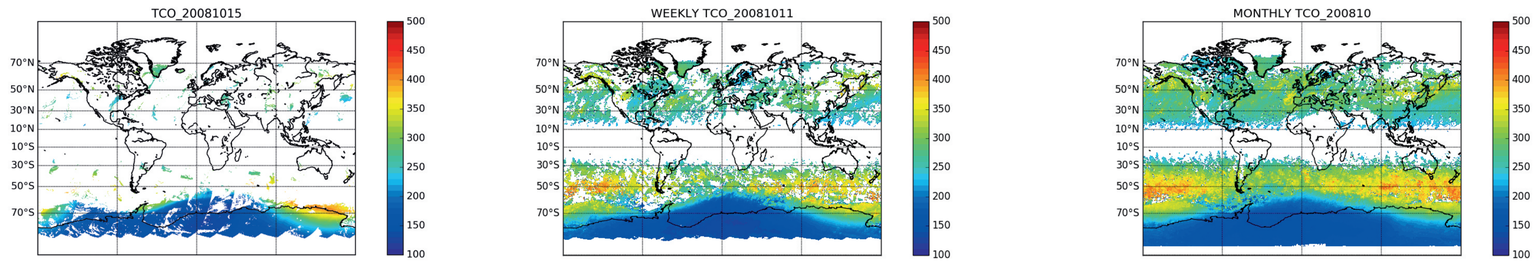
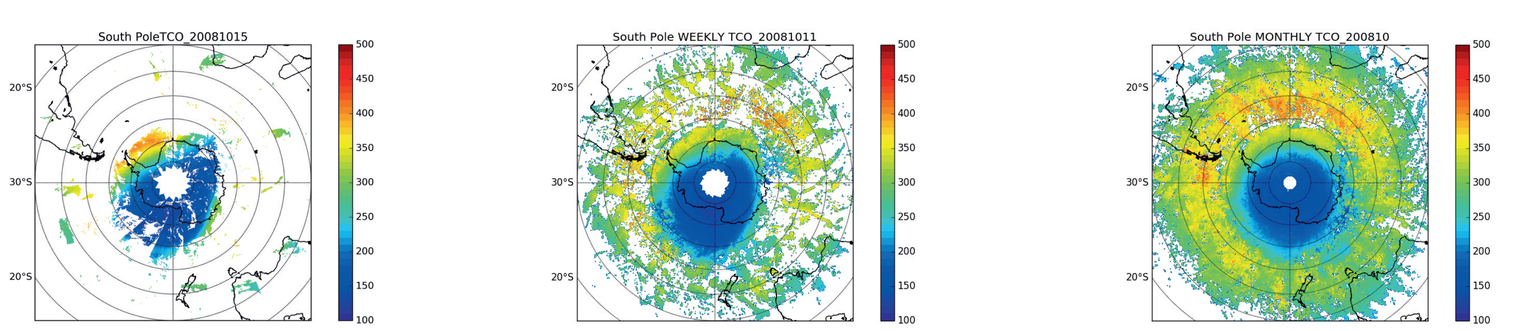



*Fig. 5: Daily (15th October 2008, left panel) weekly (11th-17th Oct. 2008, central panel) and monthly (Oct. 2008, right panel) composite of MERIS TCO. On bottom panel, projection is centered on South Pole.*




## Conclusion and future

An innovative algorithm has been developped for retrieving total column of ozone over bright surfaces (snow/ice) and optically thick clouds from MERIS observations. MERIS TCO are well correlated with ground based measurements (mean bias of -4.2 DU and RMS of 19.9 DU). Comparison with GOME-2 products shows that better results are obtained over Antarctica.
This algorithm can be applied to Sentinel-3/OLCI data because it has same bands as MERIS and one more channel in the Chappuis bands (673.5 nm). The 1020 nm channel can also be usedto better define background spectrum.

## Acknowledgements

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