# Simple tropospheric ozone retrieval from TOMS and OMI

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**ABSTRACT:**

When the background tropospheric ozone column over the Pacific Ocean is subtracted from the latitudinal total ozone distribution, the results show remarkable agreement with the latitudinal stratospheric ozone distribution using the CCD. The latitudinal tropospheric ozone distribution using the CCD method, with a persistent maximum over the southern tropical Atlantic, is also seen in the latitudinal tropospheric ozone distribution using the T-P method. It suggests that the CCD method can be replaced by the simple T-P method. However, the tropical Atlantic paradox exists in the results of both the CCD and T-P methods during the northern burning season. In order to investigate this paradox, we compare the latitudinal ozone distributions using the CCD and T-P methods by using the SAGE measurements (e.g. T-SA method) and the SHADOZ ozonesoundings (e.g. T-S method) assuming zonally invariant stratospheric ozone, which is the same assumption as of the CCD method. During the northern burning season, the latitudinal distributions in the tropospheric ozone derived from the T-SA and T-S methods show higher tropospheric ozone over the northern tropical Atlantic than the southern Atlantic due to a stronger gradient in stratospheric ozone relative to that from the CCD and T-P methods. This indicates that the latitudinal tropospheric ozone distribution can be changed depending on the data that is used to determine the latitudinal stratospheric ozone distribution. Therefore, there is a possibility that the north-south gradient in stratospheric ozone over the Atlantic can be a solution of the paradox.

**KEY WORDS:** Tropospheric ozone, Residual-type method, Biomass burning, Atlantic paradox

## 1. Introduction

The residual-type methods always show a maximum over the southern tropical regions assuming zonally invariant stratospheric ozone. However, CO from MOPITT sensor shows a maximum over southern Atlantic during austral dry season and northern Atlantic during boreal dry season. This discrepancy is called the tropical Atlantic paradox. In order to explore the paradox, most of studies have tried to interpret in-situ measurements and adjust the model to fit to the ozone distribution from the residual-type methods. However, no one has ever investigated how a small deviation in the zonally-flat stratospheric ozone influences the latitudinal stratospheric and tropospheric ozone distribution over the Atlantic. The purpose of this paper is to investigate how the latitudinal stratospheric ozone distribution influences the latitudinal tropospheric ozone distribution over the Atlantic.

## 2. Methodology

### 2.1 Convective Cloud Differential Method

The CCD method requires preliminary work in order to determine the latitudinal distribution of stratospheric ozone. After examining the high convective regions using ISCCP cloud top pressures and a sophisticated statistical scheme, the latitudinal stratospheric column ozone is derived by averaging total ozone measured over the tropical Pacific between 120°E and 180°E. Then, the CCD method determines the tropospheric ozone by subtracting the zonally invariant stratospheric ozone from TOMS total ozone when the skies are clear. This implies that if any method measures the climatological latitudinal stratospheric ozone distribution for a single longitude band, the entire amount of tropical stratospheric ozone can be determined because of the zonal mean assumption.

### 2.2 TOMS-Pacific Method

We have selected two regions: the Pacific (120°E-180°E) with clean air and the Atlantic (15°W-15°E) with elevated tropospheric ozone from biomass burning. The latitudinal stratospheric ozone distribution from the CCD is quite different from that over the Atlantic because of the strong variability in the latitudinal tropospheric ozone distribution. On the contrary, the latitudinal total ozone distribution subtracted by 26 DU over the Pacific (T-P method) agrees remarkably well with the latitudinal stratospheric ozone distribution from the CCD.

### 2.3 TOMS-SAGE method

We have used the improved SAGE-II V6.1 measurements based on the assumption of zonally invariant stratospheric ozone. Tropospheric ozone is derived by subtracting averaged stratospheric ozone measured by SAGE from total ozone measured by TOMS (T-SA method).

### 2.4 TOMS-Sonde method

Tropospheric column ozone was determined from the soundings and then subtracting it from the total amount of ozone measured by TOMS at each station to determine the stratospheric column ozone (T-S method).

### 2.5 Zonal anomaly method

This study calculated zonal anomaly using total ozone and reflectivity data from TOMS. TOMS total ozone data in this study was screened for cloudy scenes by rejecting ozone measurements where TOMS reflectivity is greater than 0.3. And then, the screened total ozone was averaged as latitude by each 1 degree. Zonal anomaly was calculated by subtracting zonally averaged ozone from total ozone (ZA method).

## 3. Results

In figure 1, the latitudinal tropospheric ozone derived from the CCD and the T-P during the DJF period presents a peak over the southern tropics. On the other hand, the latitudinal tropospheric ozone distributions from the T-SA and the T-S exhibit a maximum over the northern tropical Atlantic.

The T-S attributes the latitudinal total ozone variation during the MAM period over the Atlantic mostly to tropospheric ozone, but the CCD, the T-P, and the T-SA attribute the variation mostly to stratospheric ozone.

The latitudinal stratospheric ozone distribution from the CCD perfectly matches the distribution from the T-P in tendency and magnitude for the JJA period. The latitudinal stratospheric ozone distribution from the T-SA and the T-S follows the same tendency as the CCD and the T-P. For SON, all methods show a southern maximum and northern minimum due to a strong north-south gradient in total ozone over the Atlantic.

The CCD corrected for the TOMS error associated with clouds intensifies the southern tropospheric enhancement during the southern burning season. The tropospheric ozone from the corrected CCD shows the peak moving northward during the northern burning season.

The ZA results presented 1-wave pattern with maximum values in the tropical Atlantic and minimum values in the tropical Pacific for all 4 seasons. This feature is comparable to CCD method in the region of tropic.

## 4. Conclusions

Despite distinct differences in stratospheric ozone sampling, the latitudinal distribution of stratospheric ozone from the T-P method shows remarkable agreement with that from the CCD method that always observes higher tropospheric ozone over the southern tropical Atlantic than over the northern. Therefore, the sophisticated CCD method can be replaced by the simple T-P method. However, both the T-SA and the T-S exhibit a maximum over the northern tropical Atlantic during the northern burning season and over the southern tropical Atlantic during the southern burning season, which is consistent with the oscillation of burning. This latitudinal discrepancy is due to the difference in north-south gradient of stratospheric ozone. Therefore, the latitudinal tropospheric ozone distribution can be reversed depending on what data is used to determine the stratospheric component.

A correction for the effect of clouds on stratospheric ozone determined by CCD changes the latitudinal tropospheric ozone distribution. Uncertainty in the amount of stratospheric ozone over the Atlantic can be an important cause of the paradox. Therefore, the residual-type method using reliable stratospheric ozone data will resolve the paradox.

The ZA distribution in the low-latitude (30°S-30°N0 is very similar to CCD with wave 1 pattern. Therefore, ZA method can be a reliable technique for deriving tropospheric column ozone.

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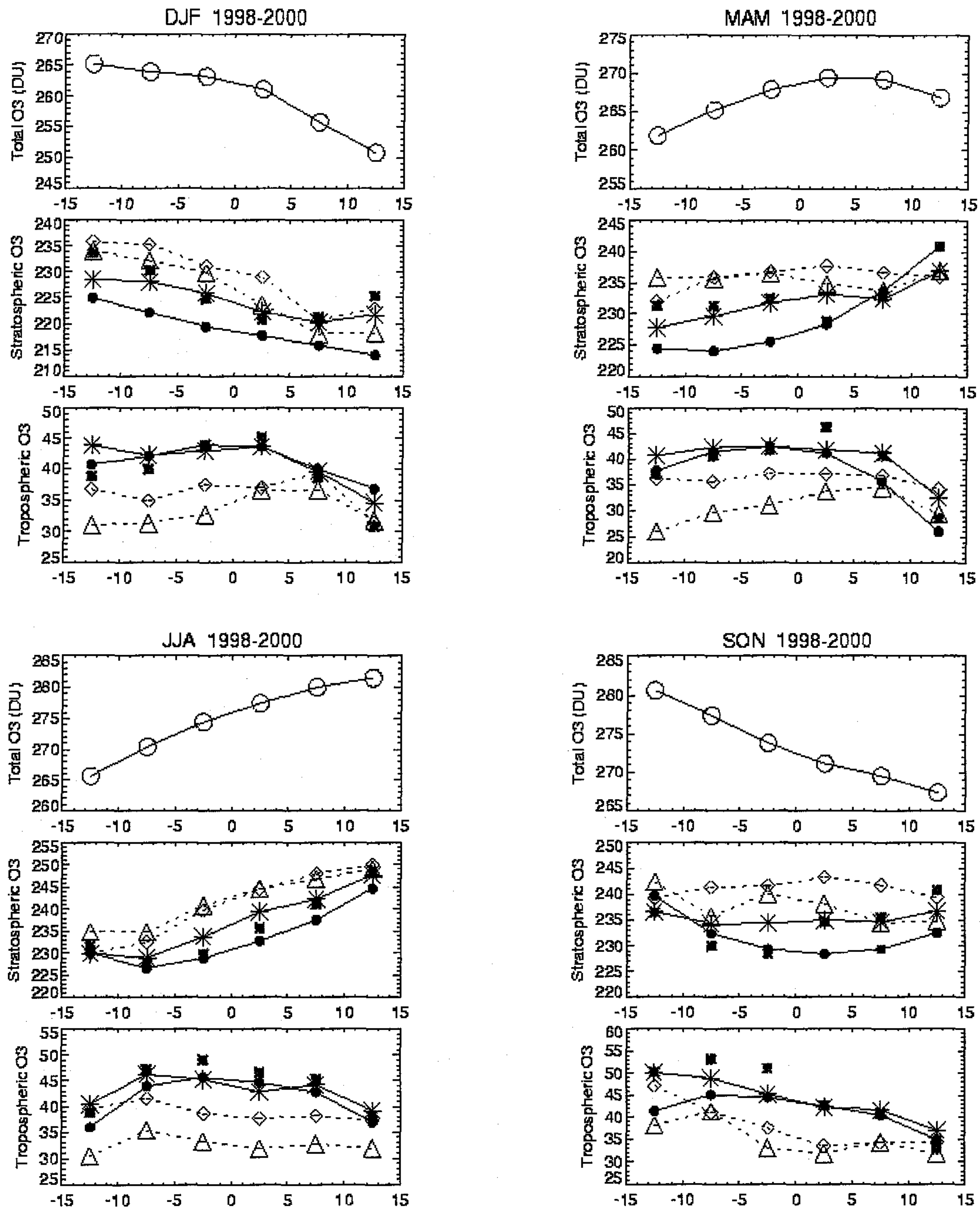


Figure 1. The latitudinal distribution of total ozone (top panel), stratospheric ozone (middle panel), and tropospheric ozone (bottom panel) from the TOMS-SAGE method (diamonds), the TOMS-Sonde method (triangle), the TOMS-Pacific method (closed circles), and the CCD method (asterisks) over the Atlantic (15W-15E) for 1998-2000. The thick asterisk marks indicate the corrected CCD products from cloud interference.