INTER-COMPARISON OF TOTAL COLOMN OZONE OBTAINED BY IASI/METOP OBSERVATION WITH GROUND BASED AND SATELLITE OBSERVATION IN THE SOUTHERN TROPIC AND SUBTROPIC

Mohamed Toihir ABDOULWAHAB

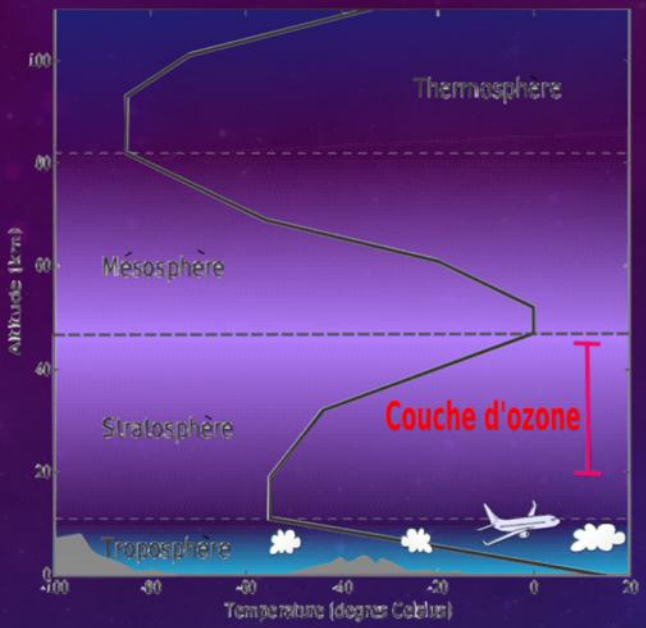
PhD student 2nd year

Laboratoire de l'Atmosphère et des Cyclones (LACy) UMR 8105 , Université de la Réunion, La Reunion France
School of Chemistry and Physics , Physique department , University of KwaZulu Natal , Durban South Africa

Title of thesis : **Variability and transport of stratospheric ozone over Southern Africa and Indian Ocean**

Supervisor : Prof H. Bencherif

Co-supervisor : Prof V. Sivakumar



Variation of Ozone concentration depends:

- Ozone Depleting Substance ($C_xF_yCl_z$, C_xF_yBr, $C_xH_xCl_z$, …)
- Green house gases (CH4 , CO2 , CO …)
- natural variability and anthropogenic activities

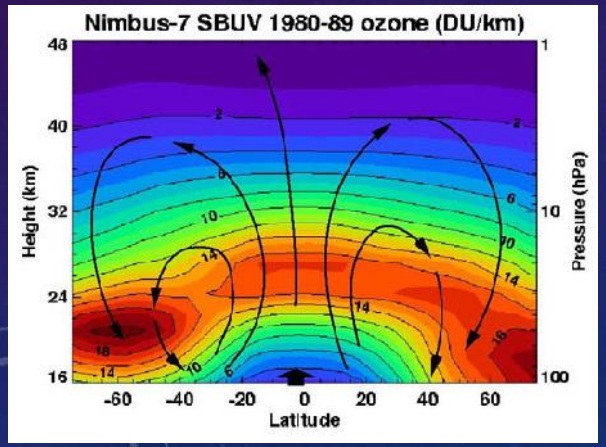
Ozone formation:

sunlight reaction especially in the tropic

- Ozone hole discovery 1985 by Farman ozone is under high surveillance

- Montreal protocol on substances that deplete the ozone layer 1987, we are waiting for an increase of Ozone this last time !

INTRODUCTION



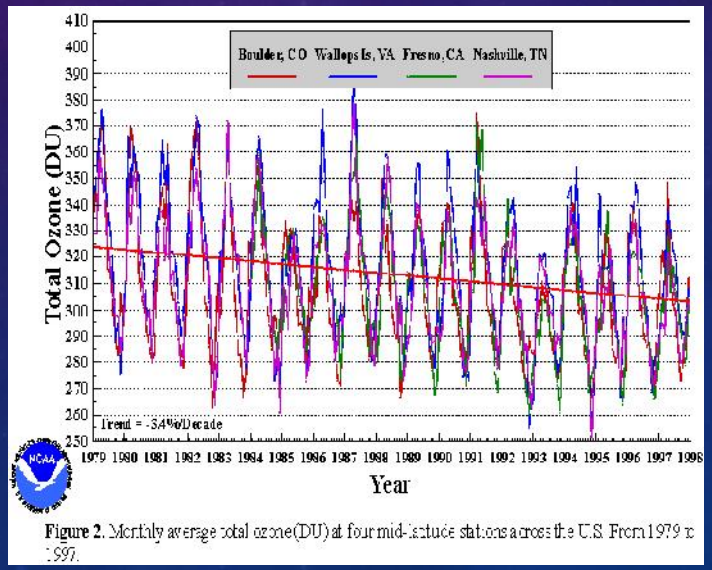
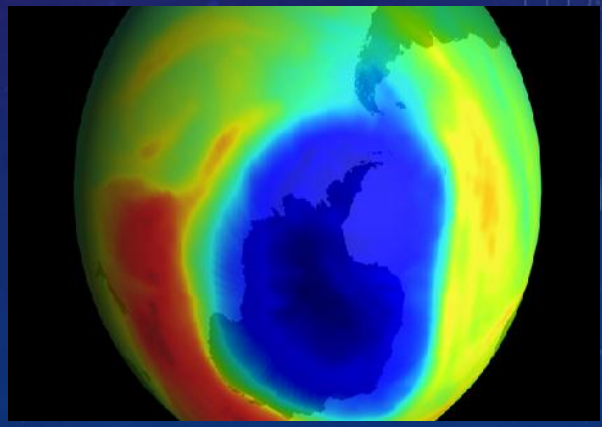
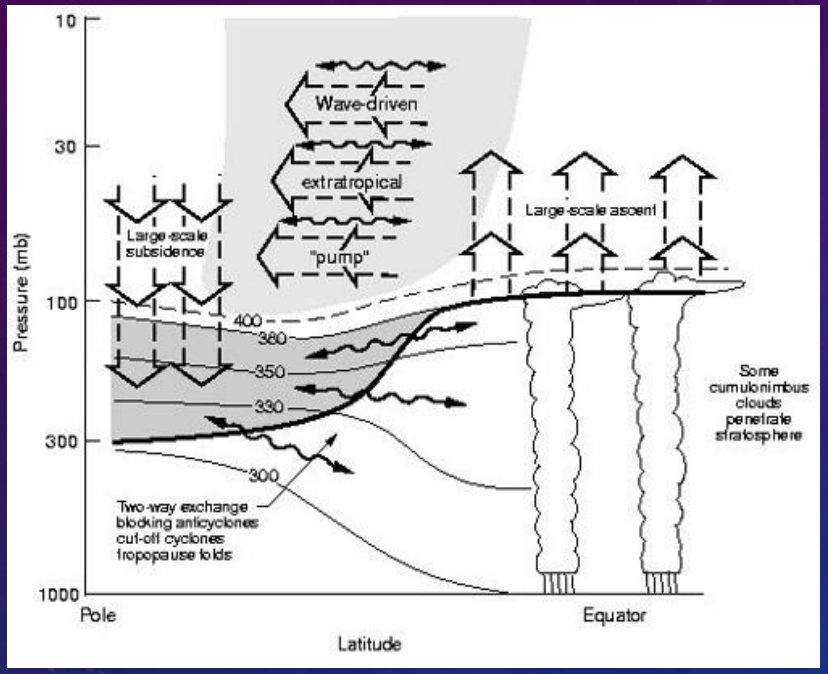
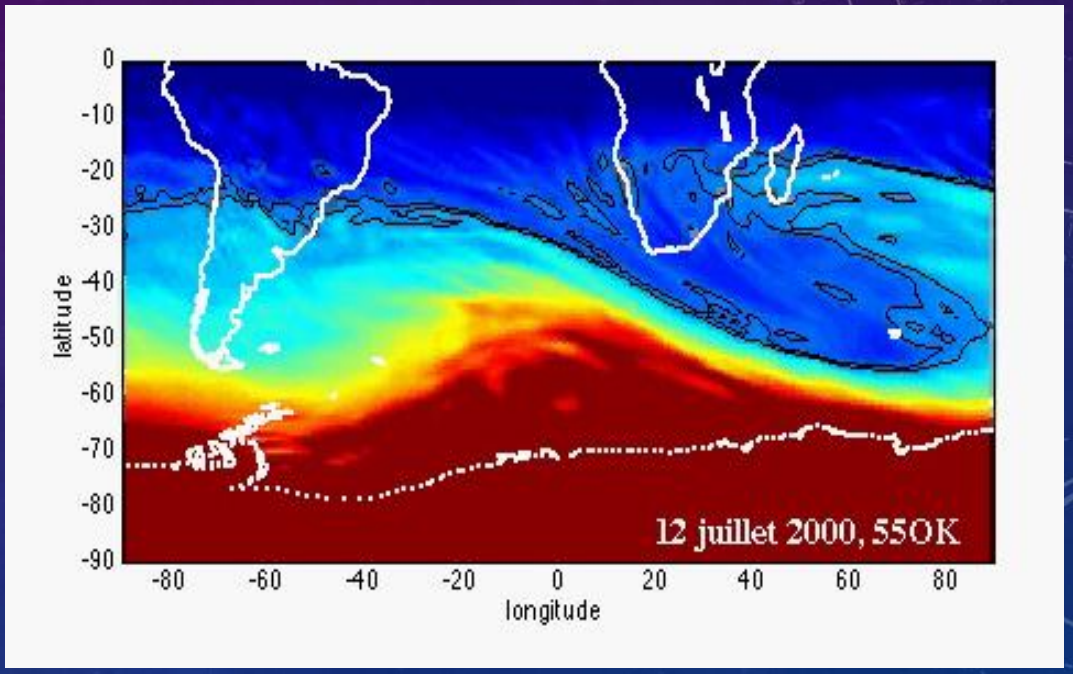


Figure 2. Monthly average total ozone (DU) at four mid-latitude stations across the U.S. From 1979 to 1997.



Recent observations and studies have shown that in subtropics dynamical processes such as vertical and isentropic exchanges through the stratospheric dynamical barriers occur and contribute also on transport and variability of ozone

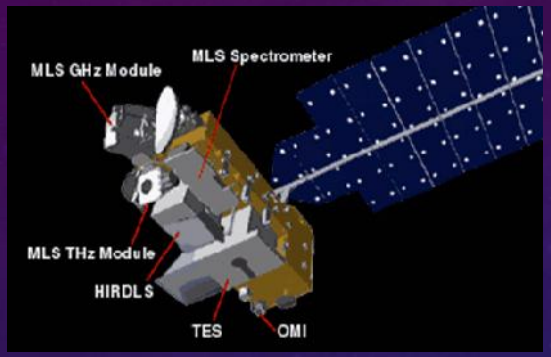


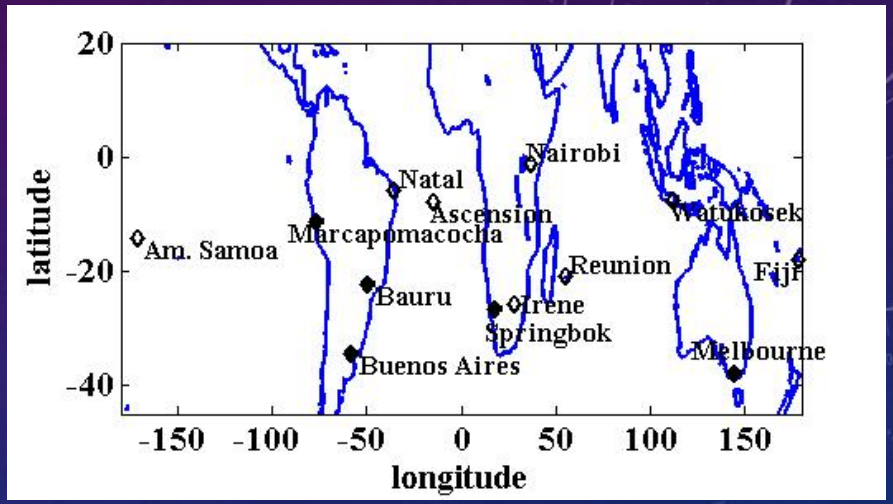


That is among the reason we have focused our study on variability and transport of ozone in this region.

Quantify and validate ozone measurement over the tropic and subtropics region

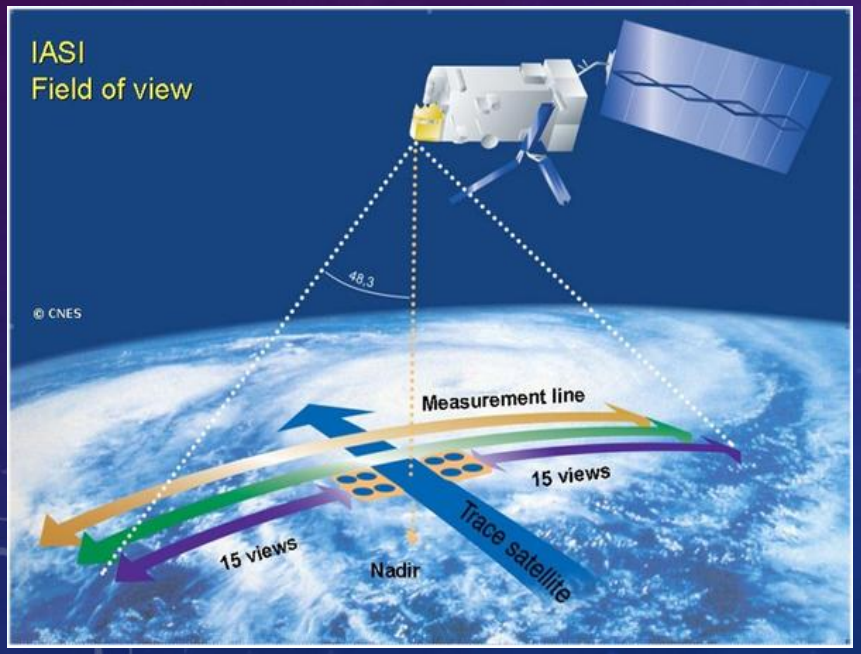
Validation of TCO measurements obtained by IASI observation achieved between July 2008 and December 2012 overpass over 13 tropical and subtropical sites by comparing with TCO from other instruments :





INSTRUMENTS

What is the Infrared Atmospheric Sounding interferometer IASI instrument ?



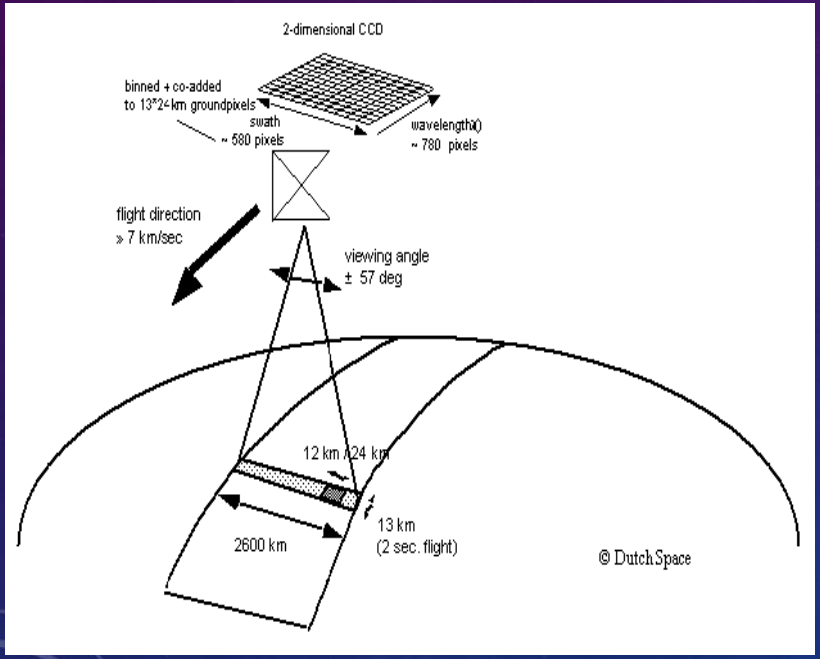
IASI is a nadir Fourier Transform spectrometer onboard MetOP launched in October 2006 designed to measure the spectrum emitted by the Earth Atmosphere system with a spectral resolution between 0.3 and 0.5cm^{-1} in the spectral range from 645 to 2760 cm^{-1}

Characteristics :

- Angle of view : nadir viewing with an angle of 48.3°
- swath-width around 2200 km
- field-of view : (50 km×50 km) composed by a matrix of 2 ×2 circular pixels, with 12 km diameter
- observation: twice per day .

Ozone information is retrieved from the 9.6µm absorption band; here the instrumental radiometric noise is evaluate to be better than 0.2K at 280K

What is the Ozone Monitoring Instrument OMI Aura satellite ?



OMI is a nadir hyper spectral imaging spectrometer onboard Aura satellite lunched in July 2004 designed to provide global ozone information by measuring the solar backscatter radiation in the UV(UV1:270-310nm , UV2: 310-365nm) and visible(350-500nm) with a spectral resolution of 0.5nm .

Characteristics :

- Angle of view : nadir viewing with an angle of ±57.3°
- swath-width around 2600 km
- field-of view : 13x24 km^2 (UV2 and visible) and 13x 48 km^2 (UV1)
- observation: daily global observation .

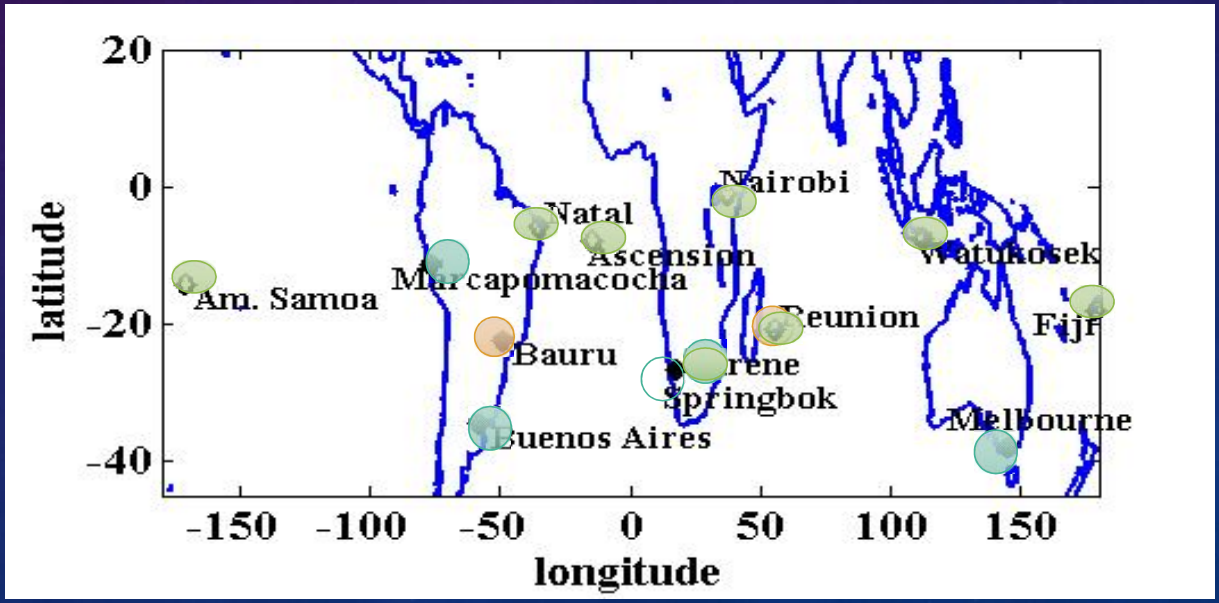
OMITO3 used here are retrieved using 2 wavelengths (317.5 nm, 331.2 nm) under most conditions and(331.2 nm and 360nm) under high ozone and high solar zenith angle). The precision of OMTO3 is evaluated at 3%

Dobson , SAOZ ground based spectrometer and SHADOZ

Total ozone observations are made with the Dobson spectrophotometer by measuring the relative intensities of selected pairs of ultraviolet wavelengths. The most used are the double pair (305.5/325.5 nm and 317.6/339.8 nm) and (311.45/332.4 nm and 316.6/339.8 nm) emanating from the sun, moon or zenith sky

SAOZ operates in the visible and ultraviolet spectral bands in which measures the sunlight scattered from the zenith sky in the wavelength range between 300 nm and 600 nm. The spectral resolution value is evaluated to 0.8 nm

SHADOZ stations are used in this work. Equipped with radiosondes for temperature, humidity and pressure, this device provide vertical profiles with vertical resolution between 50 and 100m from ground to balloon burst; generally below an altitude that exceeds rarely 32 km



DATASET COVERAGE

Stations	latitude	longitude	Dobson/SAOZ	OMI & MLS	SHADOZ	IASI
Baur	-22.34	-49.03	Nov.1995-dec.2012	Oct.2004-dec.2012		Jun2008-dec.2012
Buen	-34.58	-58.48	Jan.1983-dec.2012	Oct.2004-dec.2012		Jun2008-dec.2012
Irène	-25.91	28.21	Juil.1990-dec.2012	Oct.2004-dec.2012	1998-2012	Jun2008-dec.2012
Marc	-11.40	-76.32	fév.2000-dec.2012	Oct.2004-dec.2012		Jun2008-dec.2012
Melb	-37.80	144.97	Jan.1983-dec.2012	Oct.2004-dec.2012		Jun2008-dec.2012
Nata	-5.87	-35.2	Jan.1983-sep.2006	Oct.2004-dec.2012	1998-2010	Jun2008-dec.2012
Réun	-20.90	55.48	Aug.1993-dec.2012	Oct.2004-dec.2012	1998-2012	Jun2008-dec.2012
Spri	-26.7	17.9	Mar.1995-dec.2012	Oct.2004-dec.2012		Jun2008-dec.2012
Asc	-7.98	-14.42		Oct.2004-dec.2012	1998-2010	Jun2008-dec.2012
Nair	-1.27	36.8		Oct.2004-dec.2012	1998-2012	Jun2008-dec.2012
Samo	-14.23	-170.56		Oct.2004-dec.2012	1998-2012	Jun2008-dec.2012
Fiji	-18.13	178.40		Oct.2004-dec.2012	1998-2011	Jun2008-dec.2012
Java	-7.65	112.65		Oct.2004-dec.2012	1998-2012	Jun2008-dec.2012

Only data from January 2008 to December 2012 have used for this inter-comparison study

METHODS

monthly average Total Column Ozone data recorded on IASI have been compared with that of :

- OMI
- DOBSON
- SAOZ
- Integrated ozonesonde data

Statistical index used are :

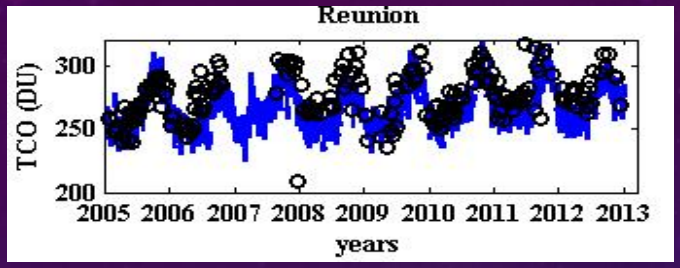
- Correlation coefficient
- Absolute and relative RMS (Root Mean Square)
- bias

$$\%RD = 100x(IASI_{TCO} - I_{TCO})/I_{TCO}$$

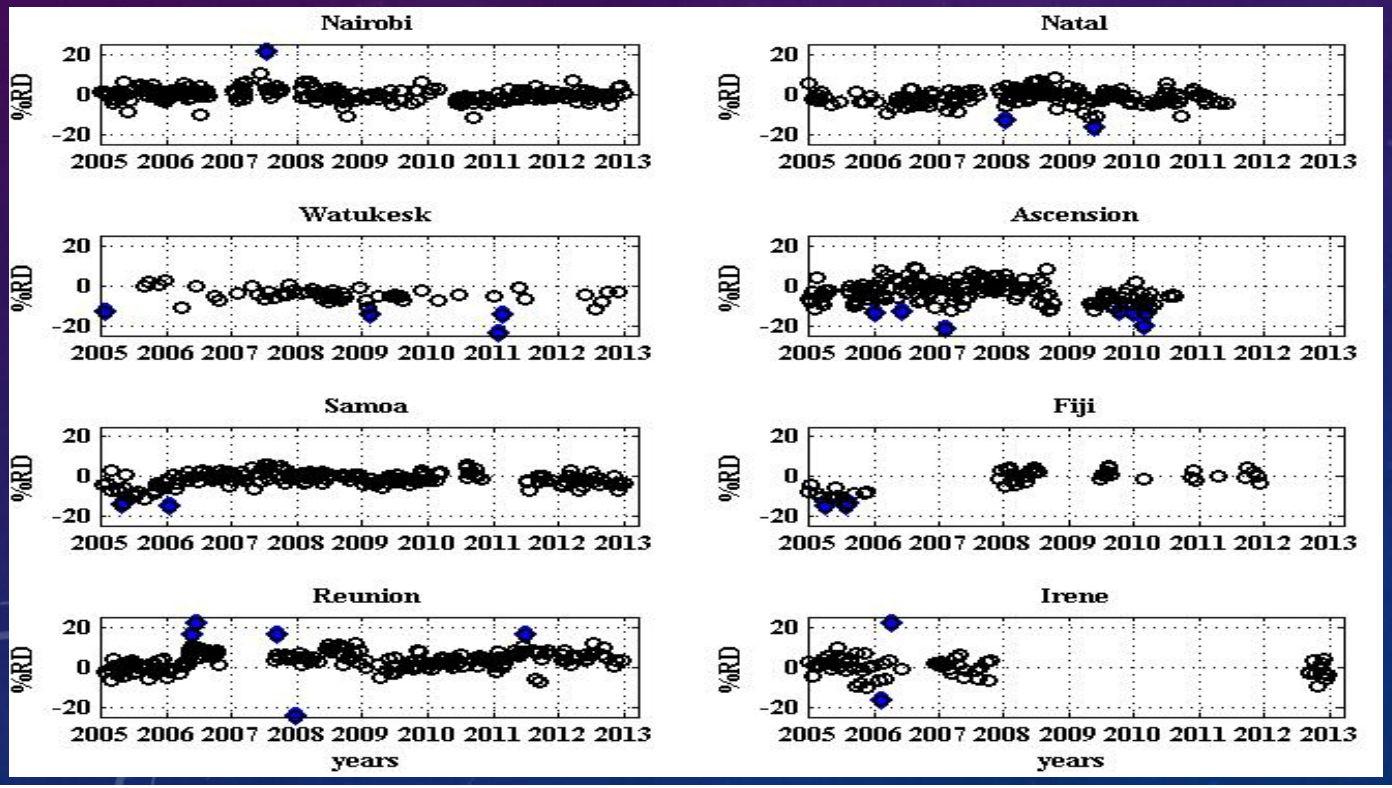
TCO from radiosondes have been calculated using McPeters , 1997.
The principal is to integrate the profile amount from ground to balloon burst , Then added from this altitude the corresponding SBUV satellite monthly climatological (1979 - 1990) value to calculate the profile TCO

stations	Nair	Nata	Asca	Java	Samo	Fiji	Reun	Iren
N0 : nombre de profile Totale	307	213	232	93	242	86	258	69
N2 : nombre de profile > 12hPa	261	177	186	65	208	59	219	63

Criterion used to validate TCO obtained by integrated ozonesondes



Suspect profiles : %RD<-13% || > +13%
Confrontation with :
- Ozonesondes monthly mean climatology ± 2σ (sdt)
- Coincidence daily Microwave Limb Sounder , MLS profile ± 2σ (sdt)



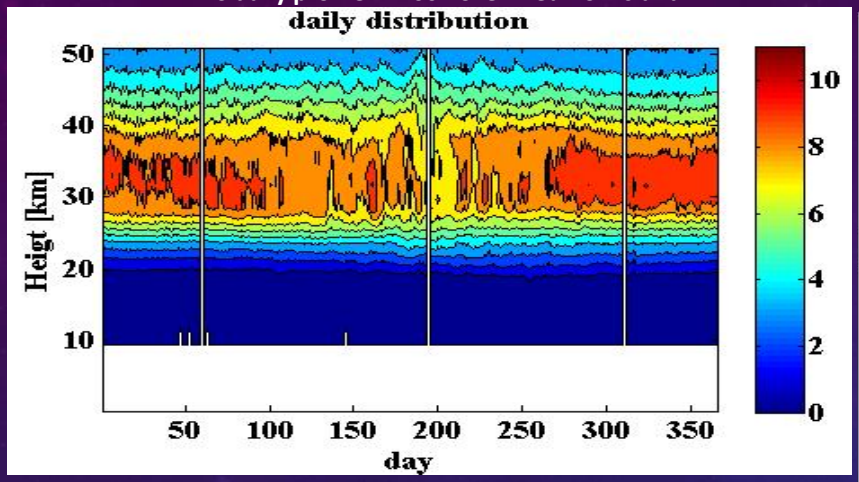
Suspect profile

1 Nairobi
2 Natal
5 Java
7 Ascension Island,
3 Samoa
4 Fiji
5 la Reunion
2 Irene.

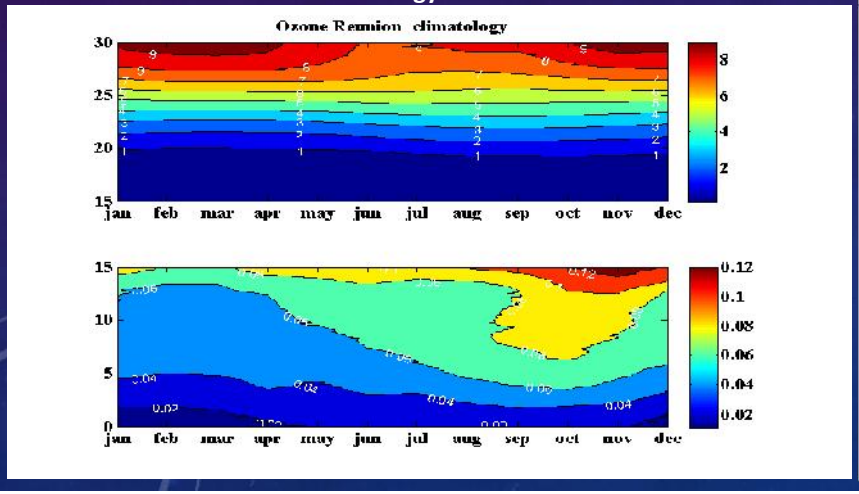
Criterion used to validate TCO obtained by integrated ozonesondes

Example of Reunion for 2007

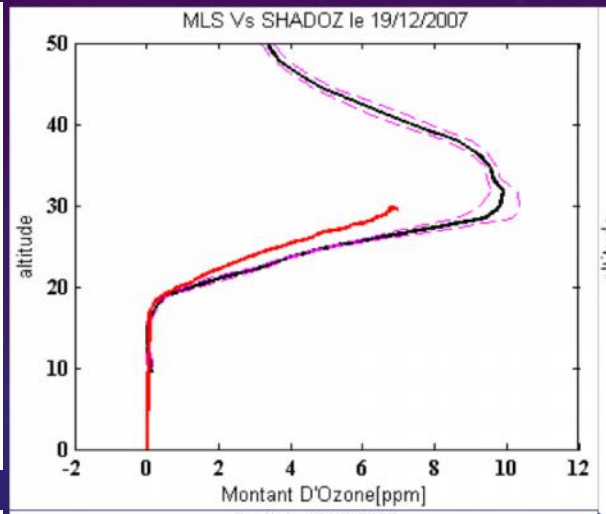
MLS daily profile in 2007 over Reunion island

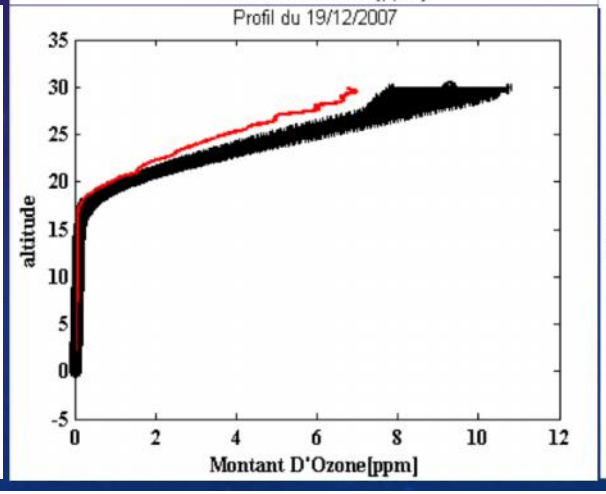


Ozonesondes climatology 1998-2012 over Reunion

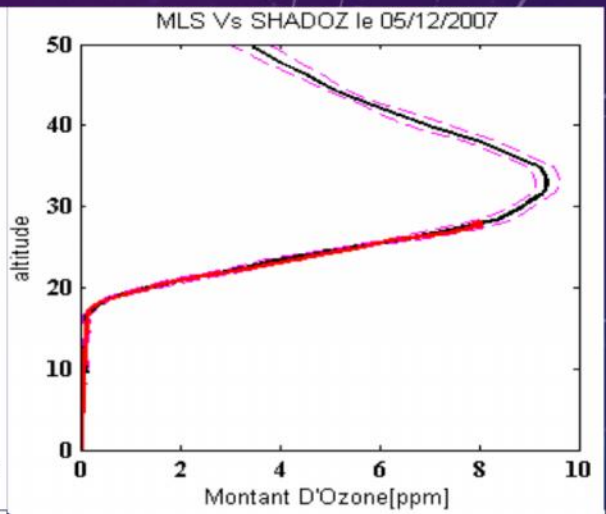


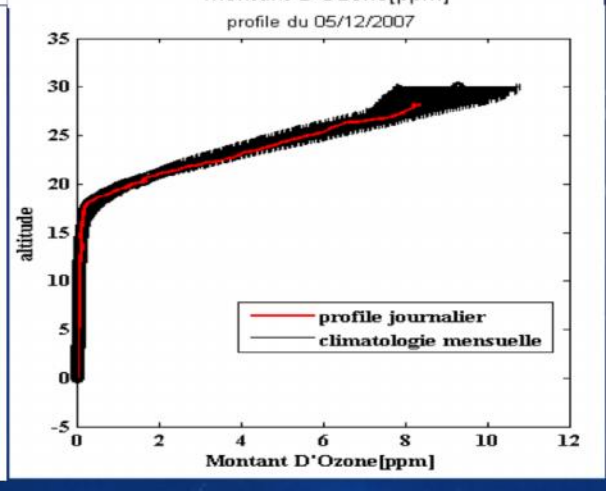
Suspect profile recorded the 19/12/2007 over Reunion



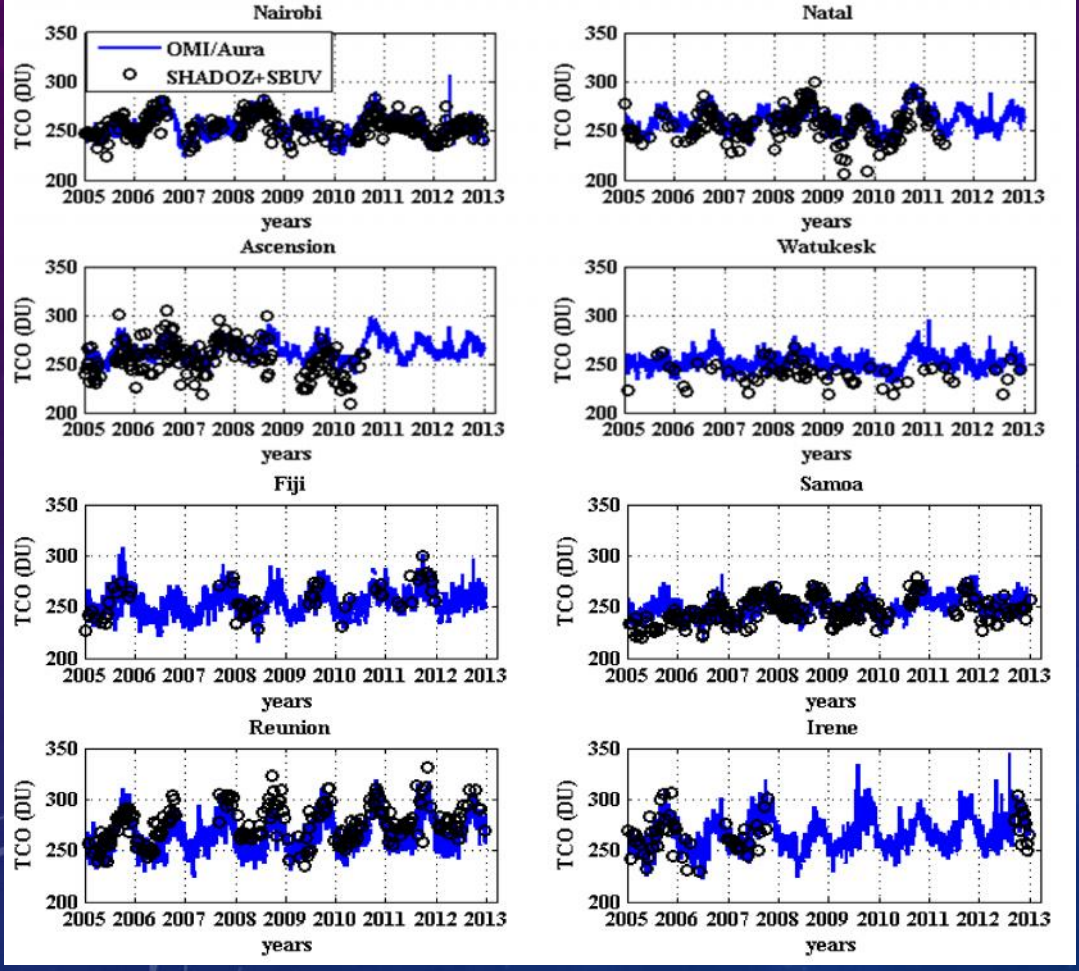


Normal profile recorded the 05/12/2007 over Reunion





validation TCO ozonesondes by comparison with OMI



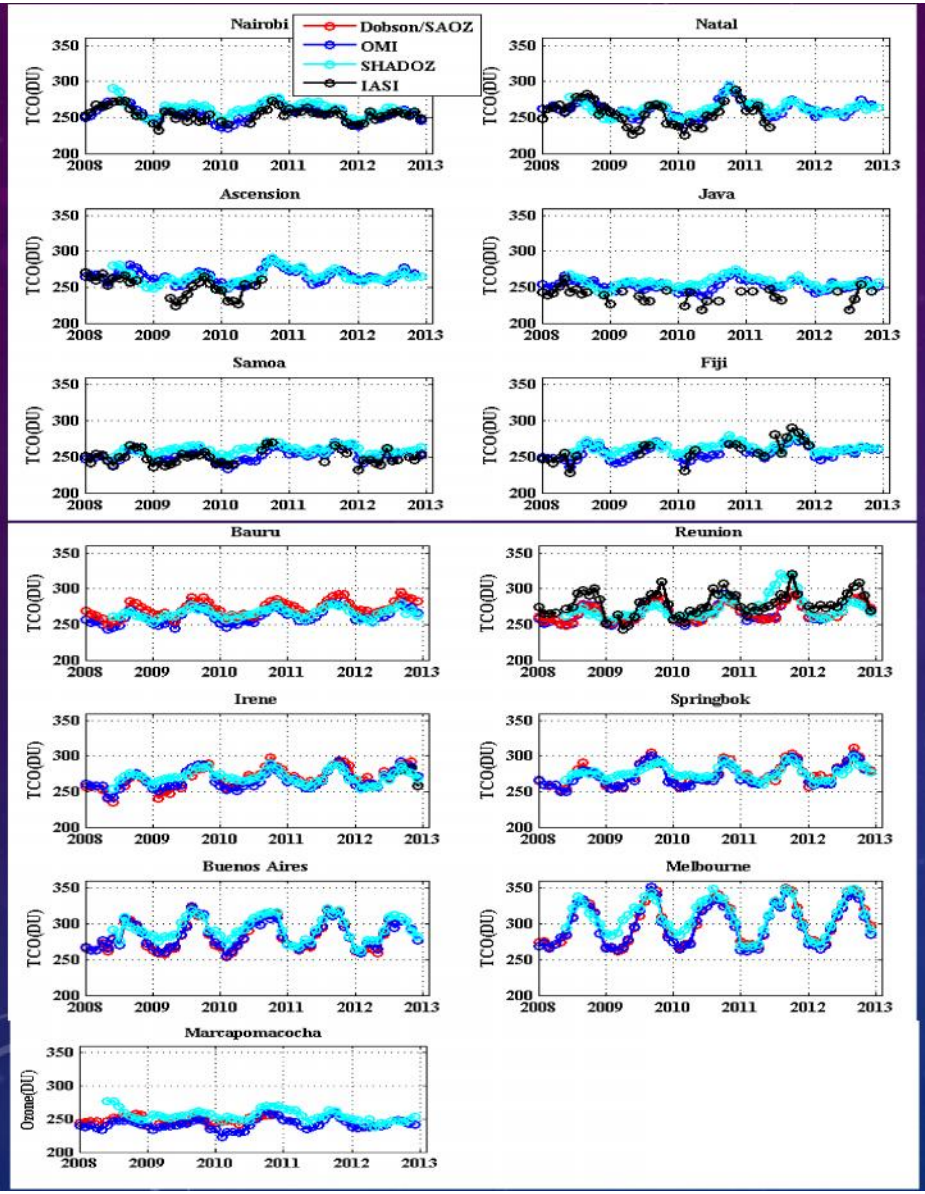
Ozonesondes dataset

stations	Nair	Nata	As. I	Java	Samo	Fiji	Reun	Iren
N2 : profile > 12hPa	261	177	186	65	208	59	219	63
suspect profile	1	2	7	4	3	3	5	2
N3: profile selected	260	175	180	61	205	58	214	61

Statistical results

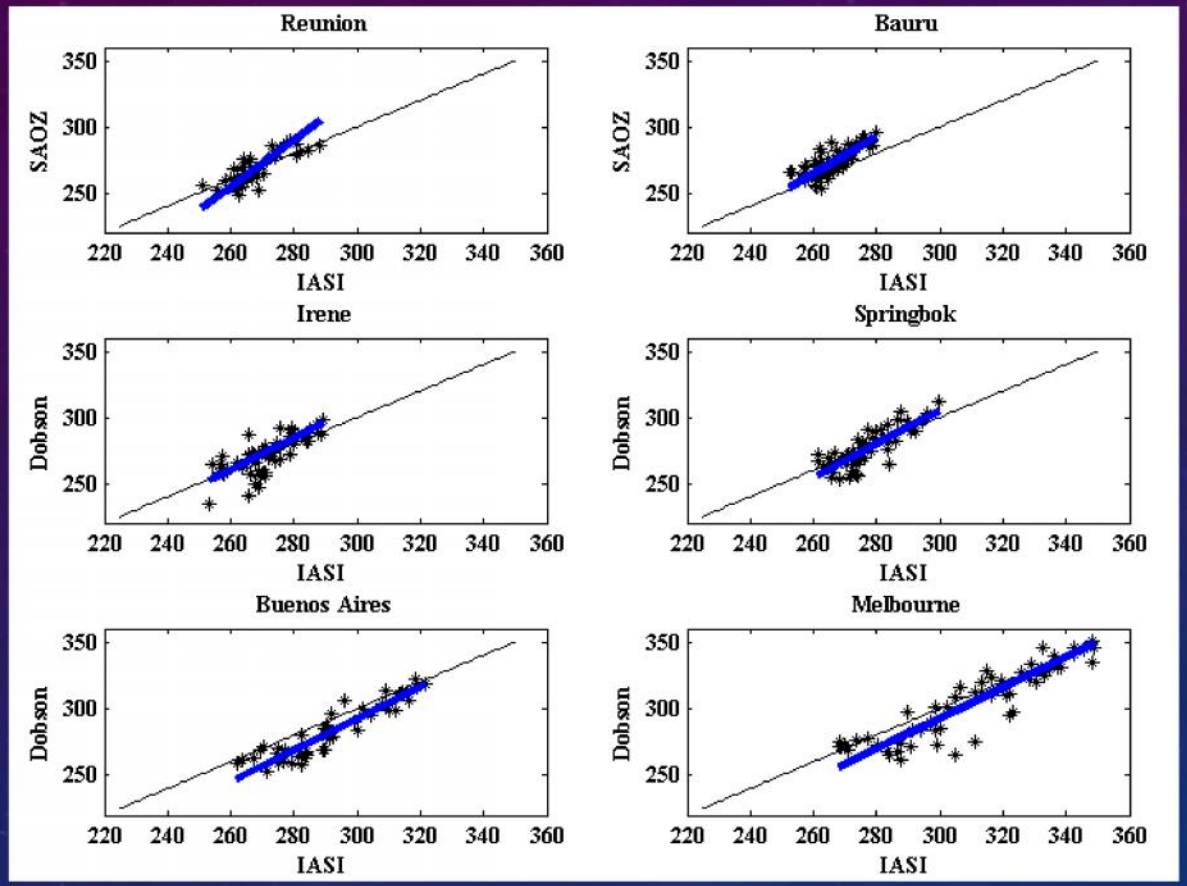
	Lat	Long	%Biais	% RMS	RMS (DU)	R
Irene	-25.25	28.22	-0.22	4.21	11.17	0.77
Reun	-21.06	55.48	3.28	5.11	13.55	0.82
Fiji	-18.13	178.40	-0.37	2.97	7.56	0.88
Samo	-14.23	-170.50	-1.35	3.48	8.69	0.73
As. Is	-7.98	-14.42	-3.16	5.86	15.47	0.58
Java	-7.57	112.65	-4.75	5.71	14.40	0.69
Natal	-5.42	-35.38	-1.65	3.82	9.98	0.79
Nair	-1.27	36.80	-0.38	2.92	7.43	0.77

RESULTS AND DISCUSSION ON TCO IASI COMPARISON



- Positive bias of 1.83% between IASI and OMI , R>0.83 from 15° southward . Boynard , 2009 : 3.3% between IASI and SAGE II .
- Positive bias 3±4% between IASI and ozonesonde with RMS of 4.72%(11.77DU). good than Thompson, 2003 (2-11%) TOMSV7
- Positive bias of 1.87% with Dobson and RMS 8.75 DU (3.24%) bias of 1.13% and 8.30 DU (3.00%) without Marcapomacocha
- Negative bias with SAOZ at Bauru(-2.65%)

Stations			IASI- OMI			IASI – Dobson/Saoz			IASI - SHADOZ		
	Lat	Long	RMS (DU)	%biais	R	RMS (DU)	%biais	R	RMS (DU)	%biais	R
Nair	-1.27	36.80	6.93	2.33	0.82				8.50	3.26	0.78
Nat	-5.87	-35.2	5.27	0.40	0.78				11.66	3.21	0.69
Java	-7.57	112.65	5.58	1.57	0.63				19.94	8.68	0.31
Asce	-7.98	-14.42	5.22	-0.12	0.75				14.46	6.01	0.65
Marc	-11.40	-76.32	12.12	4.99	0.57	9.93	3.43	0,41			
Samo	-14.23	-170.50	7.24	2.85	0.75				10.12	3.86	0.71
Fiji	-18.13	178.40	6.27	2.35	0.83				8.49	1.91	0.81
Reun	-20.90	55.48	6.13	0.25	0.84	5.66	0.19	0,82	14.51	-4.10	0.71
Baur	-22.34	-49.03	5.29	1.25	0.85	8.47	-2.65	0,75			
Iren	-25.91	28.21	5.78	1.16	0.86	7.13	0.26	0,74	6.47	1.02	0.73
Spri	-26.7	17.9	5.95	1,21	0.85	7.70	0,43	0,83			
Buen	-34.58	-58.48	7.74	2.48	0.93	9.35	3.12	0,93			
Melb	-37.80	144.97	10.16	3.09	0.94	9.66	2.15	0,91			

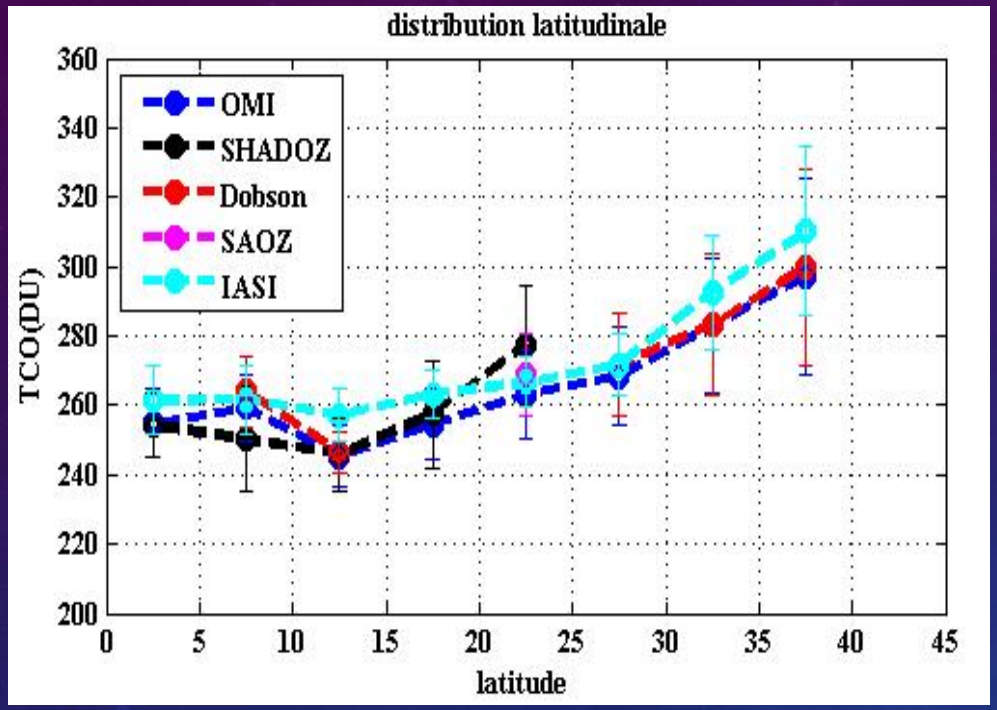


- Buenos Aires = 3.12 ± 2.91%
- Melbourne = 2.14 ± 4.21%
- springbok = 0.43 ± 3.23%
- Irene = 0.25 ± 3.64%

- 84% Bauru value are overestimate by SAOZ (-2.65%) . Similar result with

- Toihir et al, 2013: OMI vs SAOZ (-3.87) over Bauru
- Pastel, 2013 : merged satellite vs SAOZ (-2.04%) over Bauru

latitudinal distribution

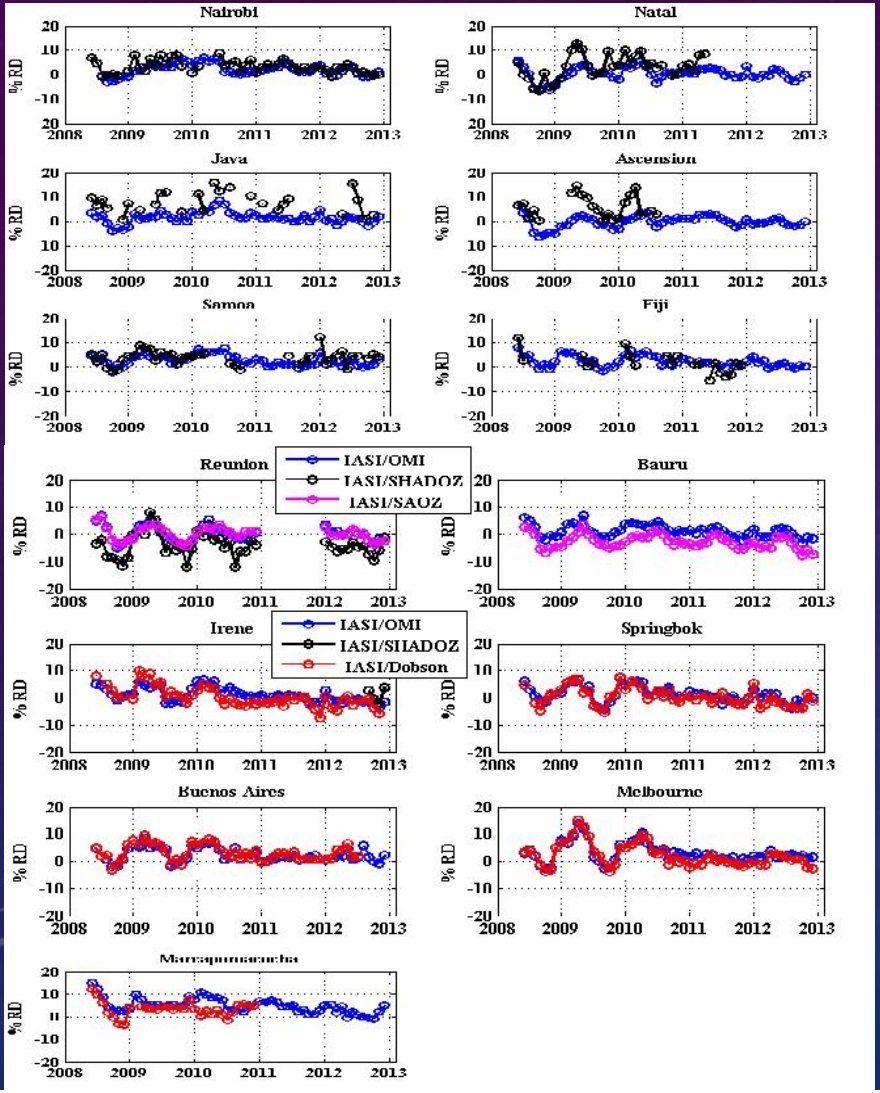


- IASI line is above the other lines except on the 20-25° where SAOZ and SHADOZ overestimate over Bauru and Reunion respectively

- R > 0.96 between IASI and the other instruments
- small variability of TCO over the tropic compared to that observed in the subtropical region
- Small variability of IASI TCO
- RMS of 6.48 DU (2.1%) with Dobson and 7.30DU (2.8%) with OMI Aura satellite

Station are grouped by 5° band , and 8 group of station are obtained from the Nairobi(1.27°S) to Melbourne (37.80°S).

seasonal dependence



- upward trend in autumn and a downward trend in the spring period especially between June 2008 and July 2010
- significant upward which can reach occasionally 9% and 14% in the tropical and subtropical sites respectively
- low downward spring which reach rarely 4%
- oscillation reducing within ±5% and ±4% with Dobson and OMI respectively after July 201O

Seasonal cycle of bias

	% bias OMI	% bias Dobson	% bias SAOZ	% bias SHADOZ
DJF	2.47	1.14	1.10	2.51
MAM	3.86	3.46	1.63	4.33
JJA	3.05	1.53	2.58	2.73
SON	0.66	-0.82	-2.38	0.22

SUMMARY

1- Good agreement is found between IASI and the other instruments

2- IASI slightly overestimate ozone except over Bauru and Reunion where SAOZ and SHADOZ TCO are high than IASI

3- IASI bias is lower than 2% with OMI , Dobson and SAOZ but less than 5% with ozonesondes

4- The best agreement is found over the subtropical region especially from 15° southward

5- High TCO variability is observed over the subtropics but anyway low on IASI than the other instruments

6- Correlation high than 0.96 is observed between IASI and the other instrument on latitudinal distribution

7- Seasonal dependence on IASI is observed with downward and upward trend in the spring and autumn respectively

8- From July 2010, the obtained RD reveal IASI low oscillation within ±4% and ±5% with respect to OMI and Dobson respectively

MERCI BEAUCOUP