

Ground-based FTIR measurements at Ile de La Réunion: Observations, error analysis and comparisons with satellite data

C. Senten¹, M. De Mazière¹, C. Hermans¹, B. Dils¹, M. Kruglanski¹, A. Merlaud¹, E. Neefs¹, F. Scolas¹, A.C. Vandaele¹, C. Vigouroux¹, K. Janssens^{1a}, B. Barret², M. Carleer², P.F. Coheur², S. Fally², J.L. Baray³, J.M. Metzger³, J. Leveau³, E. Mahieu⁴

¹ Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium, ^{1a} formerly at BIRA-IASB, ^{1b} formerly at BIRA-IASB and SCQP/ULB, now at the Laboratoire d'Aérodologie, Toulouse, France, ² Service de Chimie Quantique et Photophysique (SCQP), Université Libre de Bruxelles (ULB), Brussels, Belgium, ³ Laboratoire de l'Atmosphère et des Cyclones (LACY), Université de La Réunion, Ile de La Réunion, ⁴ Institute of Astrophysics and Geophysics of the University of Liège, Liège, Belgium

Contact: cindy.senten@aeronomie.be

Introduction:

→ The Belgian Institute for Space Aeronomy contributes to the **Network for the Detection of Atmospheric Composition Change (NDACC)**, for the continued worldwide monitoring of the atmospheric composition and its changes.

→ One of the observation methods used is **Fourier transform infrared (FTIR) spectrometry**. In collaboration with the ULB and the Université de La Réunion, BIRA-IASB has performed two short-term FTIR measurement campaigns at the complementary NDACC site **Ile de La Réunion** – a tropical island in the Indian Ocean – in **2002 and 2004**.

→ All recorded spectra have been analysed using the **inversion algorithm SFIT2**, which is based on the **Optimal Estimation Method** of Rodgers. This gives us the opportunity to obtain information on the **total column amounts** and even on the **vertical distribution** of several important **trace gases** in the atmosphere.

Campaign specifications:

First campaign:

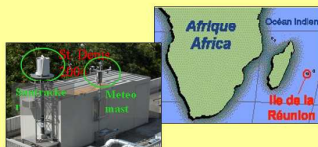
Period: **October 2002**
 Location A: **Piton du Maito**
 Altitude: **2203 m**
 Latitude: **21°04' S**
 Longitude: **55°23' E**

&

Location B: **Saint Denis**
 Altitude: **50 m**
 Latitude: **20°54' S**
 Longitude: **55°29' E**

Second campaign:

Period: **August - October 2004**
 Location: **Saint Denis**



During both campaigns **Bruker 120M FT Spectrometers** have been operated in **solar absorption mode**, allowing a **maximum optical path difference of 250 cm**, providing a **best spectral resolution of 0.0036 cm⁻¹**. The **Bruker Automation and Remote Control System (BARCOS)** by E. Neefs et al. [1] has been used successfully.

Campaign objectives:

- Obtain total / partial columns of atmospheric trace gases, such as **CH₄, C₂H₆, CO, HCl, HCN, HF, HNO₃, O₃ and N₂O**.
- Prepare for **continuous FTIR observations** at Ile de La Réunion from **2009 onward**.
- **Validate satellite data**, in particular from **ACE** in 2004.

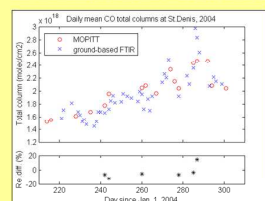
Retrieval results at Ile de La Réunion:

Retrieval approach, information content and error budgets (%) on the total columns at Maito / St. Denis:

molec.	μ -windows [cm ⁻¹]	interfering gases	DOF	temp. error	lin par. error	meas. error	smoot. error	total error
CH ₄	2613.70 - 2615.40	HDO, H ₂ O, CO ₂	3.2 / 3.3	0.27 / 0.34	0.06 / 0.06	0.46 / 0.31	0.28 / 0.15	0.61 / 0.49
	2650.60 - 2651.30							
	2845.50 - 2845.80							
	2903.60 - 2904.03							
	2921.00 - 2921.60							
C ₂ H ₆	2976.50 - 2977.20	H ₂ O, CH ₄ , O ₂	1.5 / 1.7	0.26 / 0.43	0.20 / 0.65	2.08 / 4.71	1.75 / 3.61	2.74 / 5.98
CO	2057.70 - 2057.91	O ₂ , OCS, CO ₂ , N ₂ O, H ₂ O, solar CO	2.6 / 2.8	0.37 / 0.43	0.20 / 0.22	0.84 / 1.10	0.49 / 0.55	1.06 / 1.32
	2069.55 - 2069.72							
	2157.40 - 2159.35							
HCl	2925.69 - 2926.21	H ₂ O, CH ₄ , NO ₂	1.0 / 1.1	0.46 / 0.14	0.81 / 0.83	3.82 / 3.27	1.83 / 3.76	4.34 / 5.05
HCN ^a	3268.18 - 3268.27	H ₂ O	1.5 / 1.4	...	...	...	...	...
3287.18 - 3287.32								
3299.46 - 3299.58								
HF	4038.70 - 4039.05	H ₂ O, CH ₄	1.4 / 1.4	0.40 / 0.22	0.35 / 0.43	1.18 / 1.31	1.76 / 2.50	2.19 / 2.87
HNO ₃	872.25 - 874.80	OCS, C ₂ H ₆ , H ₂ O	1.0 / 1.2	0.75 / 0.44	0.80 / 0.70	1.75 / 2.53	4.68 / 3.64	5.12 / 4.51
	2537.85 - 2538.80							
O ₃	1000.00 - 1005.00	H ₂ O	4.9 / 5.1	...	...	...	...	...
	2481.30 - 2482.60							
N ₂ O	2526.40 - 2528.20	CO ₂ , CH ₄ , O ₂ , H ₂ O, HDO	3.0 / 3.2	0.08 / 0.09	0.12 / 0.09	0.24 / 0.29	0.18 / 0.26	0.33 / 0.41
	2537.85 - 2538.80							
	2540.10 - 2540.70							

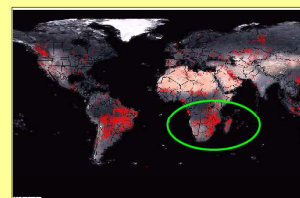
^a cf. poster EGU2007-A-07059 from E. Mahieu et al. [2]

CO total columns in 2004: FTIR versus MOPITT



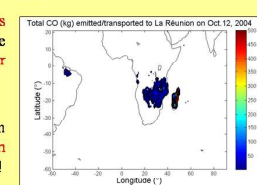
- **CO increase** by the end of October, due to its **seasonal cycle**.
- Additional enhancement on several days due to **biomass burning events** → confirmed by **FLEXPART** backtrajectories.
- **Similar enhancements** are visible in the **highly correlated C₂H₆ total columns**.

October 2004 fire map from ESA

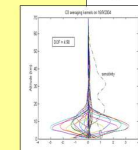
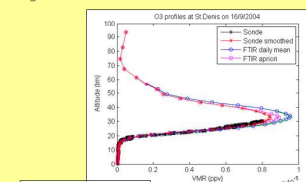


CO backtrajectories by FLEXPART:

- **Backward trajectories** for CO ending at Ile de La Réunion on **October 12, 2004**.
- **Clear impact** from forest fires in **southern Africa and Madagascar!**

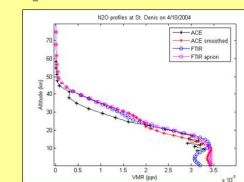


O₃ FTIR versus ozone sondes



The **relative difference** (FTIR-sonde/sonde) between the FTIR and smoothed space borne ACE partial column of O₃ is **8.5 %** in the sonde altitude range **0 to 30.5 km**.

N₂O FTIR versus ACE-FTS



The **relative difference** (FTIR-ACE/ACE) between the FTIR and smoothed space borne ACE partial column of N₂O is **5.4 %** in the altitude range **8.8 to 23.2 km**, where FTIR is **highly sensitive**.

Summary & conclusions:

- It has been demonstrated that it is fully **feasible to perform ground-based FTIR observations** at Ile de La Réunion, even at sea level altitude.
- This is the **first time** that **ground-based data** regarding the **abundances** of a large number of **atmospheric trace species** have been obtained at a **subtropical site in the Southern Hemisphere**. They are extremely useful for the **validation of satellite data and numerical models** of the atmosphere.
- The campaign data presented here are the **initial ones of a long-term series** that we intend to build at La Réunion once the infrastructure at Maito, dedicated to NDACC observations, will be available.
- A **third campaign at Ile de La Réunion** is planned in 2007, which will have as main goal the **validation of IASI**.

References: [1] Neefs E. et al., BARCOS, an automation and remote control system for atmospheric observations with a Bruker interferometer, Review of Scientific Instruments 78, 2007. [2] Mahieu E. et al., Retrieval of HCN from high-resolution FTIR solar spectra recorded at the Jungfraujoch station, EGU, 2007. Acknowledgements: Thanks for financial support are due to the EC project SCOUT-O3 and to the Belgian Federal Science Policy (national support to SCOUT-O3, Ministerial Order MO/03/020, and the SPSD/ESACII, SPSD/AGACC and PRODEX contracts).

