FTIR participation during PEGASOS at Cabauw.

Acronym: FTIRPEG.

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Introduction and motivation.

This project's general objective is to perform column measurements of CO, CH_4, and N_2O with a Fourier Transform Infrared (FTIR) spectrometer at Cabauw. Wherever feasible, information about the vertical distribution will also be retrieved from the spectra. The target species are relevant for air quality and climate studies.

Scientific objectives.

The more specific objectives of the project are:

- To perform the FTIR measurements in a period that includes the period when the PEGASOS (Pan-European Gas-AeroSOls-climate interaction Study, http://pegasos.iceht.forth.gr) zeppelin flies over the Cabauw site (May-June 2012), and to perform measurements in support of the PEGASOS and ACTRIS scientific objectives: partial and total columns of CH_4, CO, N_2O, and if possible also of CO_2 and NO_2.
- To make the observations with the FTIR instrument alongside with in-situ measurements on the ground and on the tall tower of Cabauw of the same target species plus NOx.

Therefore, the combination of the various observations should enable the study of the diurnal variation of local and regional sources and sinks. In the end, it is hoped to propose an optimization of the use of emission inventories in local and regional models.

Reason for choosing the Cabauw station.

The station hosted two relevant campaigns during the visiting period.
The first was the PEGASOS campaign (Pan-European Gas-AeroSOls-climate interaction Study) in May, and the second was the INGOS (Integrated Non-CO_2 Greenhouse gas Observing System) CH4 Flux campaign.

Because of these campaigns, many other instruments were present in Cabauw, measuring a variety of relevant atmospheric parameters.
Cabauw is situated in one of the most polluted regions of Europe, and is at the same time relatively far from local emission sources, so that the measurements at this site are representative for background pollution.

Method and experimental set-up.

The experimental set-up is the same as the one that we used during the 2004 and 2007 observations campaigns and for the continuous measurements since 2009 at La Réunion Island in the frame of the Network for the Detection of Atmospheric Composition Change (NDACC). It consists of an automatic and remote control system for solar absorption observations of the atmospheric composition with a Fourier transform Infrared Interferometer (FTIR) (Bruker IFS120M), the so-called BARCOS system. A complete description of BARCOS is given in Neefs et al. (2007).
Besides the FTIR instrument (Bruker 120M), the system also includes a solar tracker (ST), a meteorological station, an automatic liquid nitrogen filling system for cooling the detectors, and a data logger unit.
This setup enables completely automatic operation of the experiment; it enables also remote control from Brussels via Internet (a VNC connection) .

A more complete description of the experimental setup at La Réunion can be found in Senten et al. (2008) and, Vigouroux et al. (2009; 2012).

Preliminary results and conclusions.

The PEGASOS Zeppelin flew over the CESAR site in Cabauw on five days between 19 and 27 May. There were in-situ measurements of a.o. CO, NO_2, CO_2, CH_4, and N_2O. During the INGOS campaign between 4 and 27 June, there were several instruments measuring CH_4, CO_2 and N_2O. Two air-quality models have been run for this time period: the Dutch Lotos-Euros model and the EURAD model from the University of Cologne. The data is currently being collected from the participating institutes.
The weather during June and July was unfortunately less sunny than normal, but in May we had a reasonable amount of clear sky hours, which is a prerequisite for obtaining good FTIR measurements.
Despite the bad weather, we got nearly 1000 FTIR spectra during the measurement campaign. The following table shows the number of raw spectra per day which we have obtained during this campaign (the letters ch, cl, … correspond to different optical filters that we use to limit the spectral range of the light incident on the detectors. The different spectral ranges are listed and described in Senten et al. (2008).)
The analyses of the FTIR data obtained during this campaign are currently ongoing in collaboration between the participating teams of KNMI (Ankie Piters) and BIRA (M. De Mazière and Bavo Langerock, et al.) At start, BIRA will do the retrievals of the target species from the

FTIR spectra, and provide the retrieval results (i.e., the vertical profiles and total columns of the target species, and the associated averaging kernels and error budgets) to KNMI. The retrieval is performed with the latest version of SFIT2 (v3.94), which is the standard retrieval code in the NDACC Infrared Working Group. It is a line-by-line radiative transfer code, coupled with an inversion module based on the Optimal Estimation Method. The error evaluation algorithm was developed at BIRA for our NDACC retrievals at Réunion Island. Then the retrieved data will be exploited in synergy with the other data gathered at the site, by KNMI together with the other participating institutes..
As an example of retrieval results, Figure 1, left-hand side, shows parts of the solar absorption spectrum observed on May 24 in the 3micro windows, that are used to retrieve the CO vertical profile and total column. The retrieved profile, together with the a priori profile, is shown in the right-hand side of Figure 1. We have approximately 2 Degrees of Freedom for Signal in the CO vertical profile.

Outcome and future studies.

With the collected measurements, combined with the in-situ measurements of CO, CO_2, CH_4, N_2O, and NOx, we plan to study the diurnal variation in local and regional sources and sinks and possibly propose an optimization in the use of emission inventories in local and regional models.

References.

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Table 1. Number of FTIR spectra acquired during the campaign. The various columns indicate the type of spectra, according to the optical filters limiting the spectral bandwidth incident on the detectors.

Date	ch	cl	fo	hbr	hf	hh	hl	hv	nh	nl
10/05/2012	0	0	0	0	0	0	0	0	0	0
11/05/2012	1	0	0	0	0	4	0	0	1	0
13/05/2012	5	1	1	2	5	6	2	0	6	1
14/05/2012	11	0	2	2	10	6	1	2	9	1
15/05/2012	2	0	0	0	1	1	0	0	1	0
16/05/2012	6	2	0	2	10	8	1	0	9	1
17/05/2012	5	0	0	2	7	5	1	2	6	0
18/05/2012	4	0	0	2	2	4	0	0	4	0
19/05/2012	6	0	0	2	3	3	2	1	5	9
20/05/2012	0	0	0	0	0	0	0	0	0	0
24/05/2012	6	0	0	2	6	5	0	5	4	9
25/05/2012	10	4	1	2	11	10	3	2	10	2
27/05/2012	12	3	1	2	9	14	3	7	9	12
30/05/2012	11	0	1	2	7	12	0	6	8	11
31/05/2012	0	0	0	0	1	0	0	0	0	0
28/05/2012	9	2	3	2	10	14	3	7	10	11
29/05/2012	6	1	0	2	5	5	0	6	2	9
01/06/2012	0	1	0	0	0	1	0	0	1	1
02/06/2012	7	1	1	2	6	8	2	3	4	1
03/06/2012	0	0	0	0	0	0	0	0	0	0
04/06/2012	0	0	0	0	0	0	0	0	0	0
05/06/2012	4	2	0	2	3	3	2	1	3	1
08/06/2012	5	2	3	2	3	3	2	2	2	2
09/06/2012	0	0	0	0	0	0	0	0	0	0
13/06/2012	1	0	1	0	0	1	0	0	3	0
14/06/2012	10	1	0	2	5	11	2	3	8	2
18/06/2012	0	0	0	0	0	2	0	0	1	0
19/06/2012	10	2	2	2	7	8	2	2	9	1
20/06/2012	4	0	0	2	4	5	0	0	4	0
21/06/2012	2	0	1	0	1	0	0	0	1	0
22/06/2012	0	2	1	0	2	1	2	2	2	2
28/06/2012	3	0	0	0	1	2	1	0	2	0
29/06/2012	4	1	1	2	4	3	0	6	4	7
06/06/2012	3	0	0	0	3	5	0	0	4	0
10/06/2012	10	2	2	2	8	9	2	3	8	1
11/06/2012	0	0	0	0	0	0	0	0	0	0
12/06/2012	0	0	0	0	0	0	0	0	0	0
17/06/2012	0	0	0	1	0	0	0	0	0	0
02/07/2012	5	3	1	0	4	7	2	4	4	0
03/07/2012	2	0	0	2	4	4	0	0	7	0
04/07/2012	7	1	1	2	5	5	0	3	6	2
05/07/2012	2	2	1	2	8	2	0	0	6	2
06/07/2012	3	2	0	0	2	5	0	1	3	1
07/07/2012	11	1	0	2	6	8	3	2	6	1
08/07/2012	1	0	0	0	1	1	0	3	0	3
09/07/2012	0	0	0	0	3	0	0	0	1	0
10/07/2012	3	1	1	0	2	2	1	2	2	1
11/07/2012	3	0	1	0	3	2	0	0	6	0
13/07/2012	0	0	0	0	0	0	0	0	0	0
14/07/2012	0	0	0	0	0	0	0	0	0	0
15/07/2012	1	1	3	0	2	1	1	0	0	1
16/07/2012	1	1	0	0	0	0	2	0	0	0

12/07/2012	8	0	0	2	7	9	1	2	8	7
17/07/2012	1	0	0	2	0	1	0	0	2	0

Figure 1.
LHS: Solar absorption spectrum measured on May 24 at Cabauw. The three microwindows that are depicted are the ones selected for the retrieval of CO, shown in brown in the RHS of the figure; the a priori CO profile is shown in green. In the LHS, the observed spectrum is in blue, the simulated spectrum corresponding to the retrieved CO profile is in brown. The top figure shows the spectral residuals.