TALL TOWER OBSERVATIONS OF GREENHOUSE GASES IN EUROPE: POSSIBILITIES FOR EMISSION VERIFICATION

A.T. Vermeulen[1], the CHIOTTO Team, and G. Pieterse[1]

[1]*Air Quality & Climate Change, ECN, Westerduinweg 1, Petten, The Netherlands*
a.vermeulen@ecn.nl

ABSTRACT
In the CHIOTTO project (http://www.chiotto.org) as part of the CarboEurope cluster of projects (http://www.carboeurope.org) a network of 8 tall tower stations has been set up in Europe. Most towers are equipped for continuous high precision measurements of ambient CO_2, CH_4, CO and SF_6. Some stations are also equipped for continuous measurement of ^{222}Rn and flask sampling. First measurement results are presented and evaluated using forward and inverse model calculations.

INTRODUCTION
If we are to infer greenhouse gas fluxes at the regional level, it is necessary to sample concentrations close to the earth surface and on a continuous basis to capture the signal of greenhouse gas exchange fluxes. This calls for measurements in the boundary layer. Here the variability in concentrations (diurnal cycles) is huge, because the air is to a large extent influenced by local sources. In order to separate the effect of local (few tens of km) variability from the regional signal, one needs to continuously monitor concentrations above the surface layer (100 meters), complemented for CO_2 by eddy flux towers to characterize the contribution of "local" biospheric exchange. If the gases are measured at sufficient height above ground (ideally a few hundred meters), then a fairly homogeneous signal that integrates fluxes over a footprint on the order of a circle of 500 to 1000 km is obtained [*Gloor et al*, 2001].

In the CHIOTTO project we sample on tall towers continuously CO_2 and other greenhouse gases together with tracers that help validate the realism of transport simulation with atmospheric models like ^{222}Rn. The 8 tall tower locations are shown in Table 1 and Fig. 1. The footprints of these towers, also shown in Fig. 1, cover NW-Europe fairly well. In CHIOTTO we try to ensure high data quality and a high standard of calibration and inter-comparison. The tower-based observations will also be useful and important as ground-truthing data for calibration and verification of future remote-sensing (satellite) data.

Table 1 Tall tower data summary

		Height	Position		Concentration measurement (levels)							Flux meas	
Name		(m)	Lon	Lat	CO_2	CH_4	N_2O	SF_6	CO	^{222}Rn	Flasks	CO_2	CH_4
Cabauw	NL	200	04°56’	51°58’	4	4	4	4	4	1	✓	2	
Griffin	UK	232	-2°59'	56°33’	1	1	1	1		1			
Hegyhatsal	H	117	16°39’	46°57'	4	1	1	1	1		✓	2	
Orleans	F	203	2°07’	46°58’	3	3	3	3	3	1	✓		
Norunda	S	102	17°28’	60°05’	4	2						2	2
Florence	I	245	11°16’	43°49’	1	1	1	1	1				
Ochsenkopf	D	163	11°49’	50°03’	3	3	3	3			✓		
Bialystok	PL	300	22°45’	52°15’	5	5	5	5	5		✓		

RESULTS
Most of the towers got their equipment up and running in the first half of 2005. We will therefore concentrate here on older data from Cabauw tower to illustrate the use of the tall tower data.

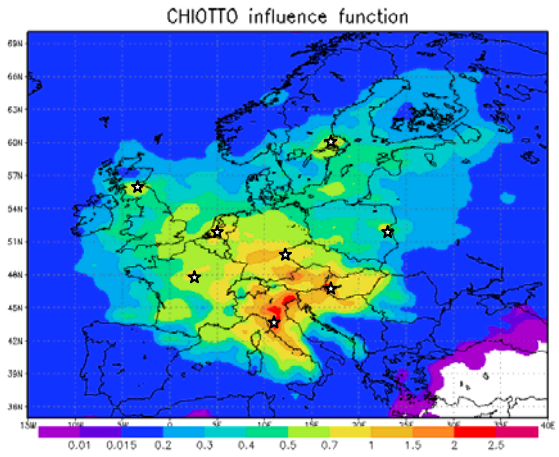

Fig. 1 CHIOTTO Tall tower positions and footprint

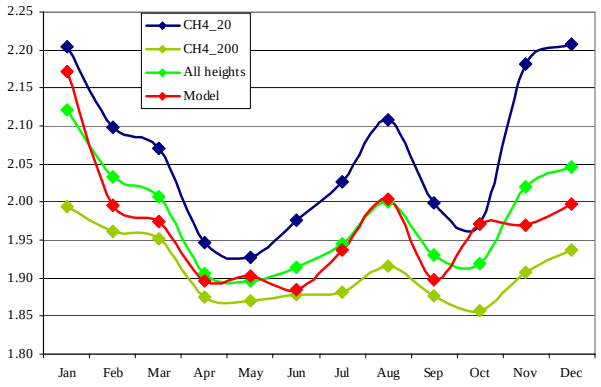

Fig. 3 Observed vs modeled seasonal trend of CH_4

Measurements

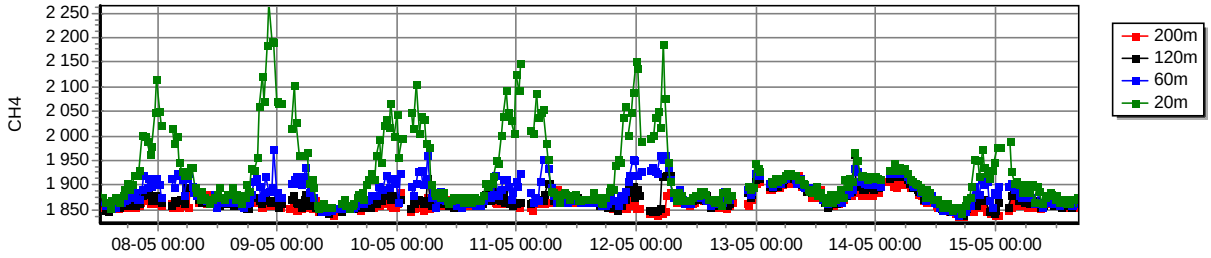

Fig. 2 CH4 concentration profile [ppb] for four vertical levels (AGL=ASL) at Cabauw, May 2005

In Fig. 2 an example one week time series for methane at four vertical levels is displayed. Nighttime accumulation like in the first half of the shown period is observed frequently. Synoptical scale variation like in the second half is observed more in winter time.

Forward model predictions

In Fig. 3 the seasonal trend of CH_4 in 2002 is shown as measured at measurement levels of 20 m and 200 m. Also shown is the concentration in the tropospheric mixed layer, calculated from the observed vertical profile and the modeled mixing layer height. The mixed layer concentration predicted by the simple two-layer trajectory model COMET matches quite well with the observation. The correlation coefficient between observed and modeled CH_4 mixed layer concentration for 2002 at 1 hr interval is 0.816 with a RMSE of 2 ppb. The more sophisticated Flexpart LPDM performs less when predicted concentrations are compared with observations, r=0.60.

Inverse model predictions

The COMET model can be used to calculate a Source-Receptor Matrix (SRM) that can be inverted using Truncated Singular Value Decomposition (TSVD). The emissions calculated for Cabauw show quite robust emission estimates for country-wise yearly average fluxes.

REFERENCE

Gloor, M., Bakwin, P., Hurst, D., Lock, L., Draxler, R. and Tans, P., (2001). What is the concentration footprint of a tall tower? *J. Geophys. Res.*, *106*, 17831-17840.