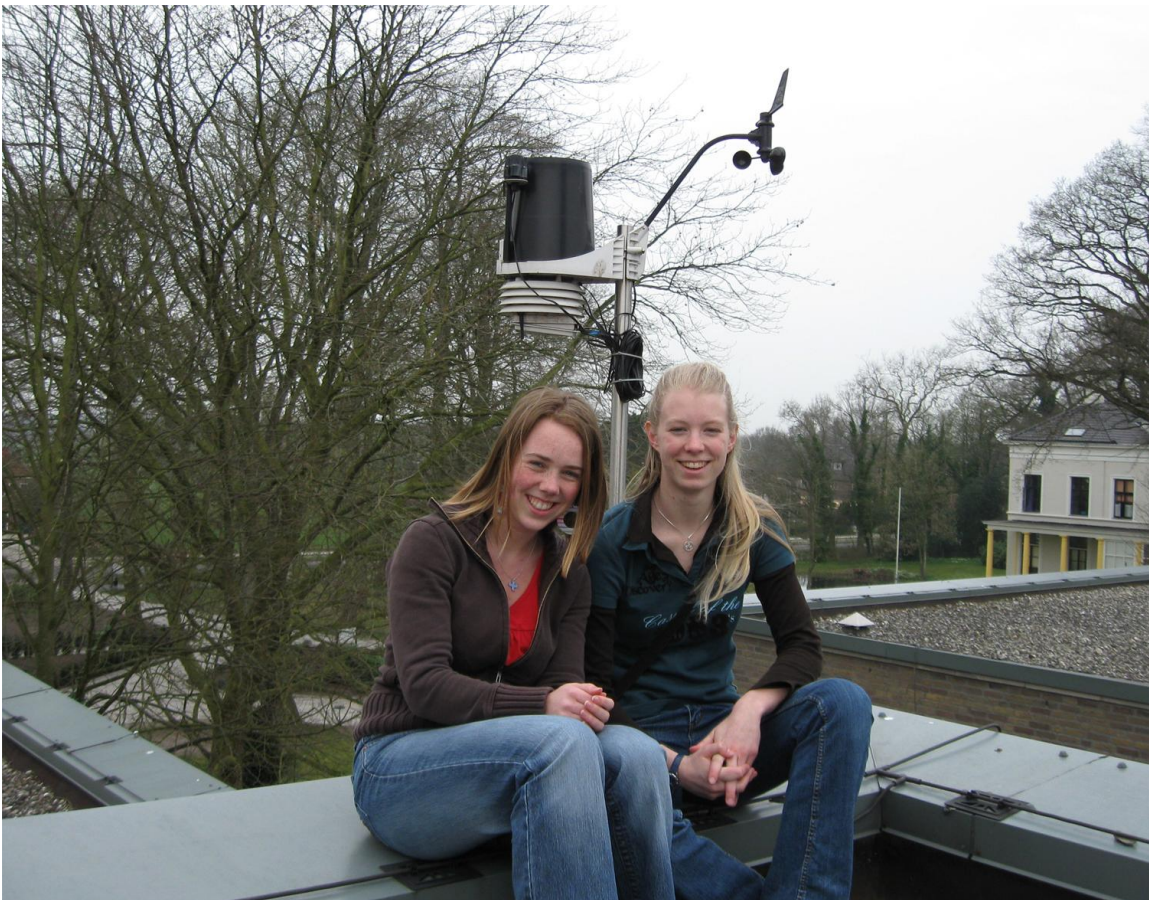


# The influence of external factors on the levels of CO<sub>2</sub> in the air

Students, teachers and scientists in interaction



Teacher-scientist partnerships:  
a tool for professional development  
Socrates Programme - Comenius 2.1  
129289-CP-1-2006-1-DE-COMENIUS-C21

# Content

Preface.....	3
Description of the project.....	4
Evaluation.....	6
Annex 1.....	7

**Author:** Menno Keij

**Date:** 29<sup>th</sup> of July 2009

**Institute:** University of Groningen, Faculty of Natural Sciences and Mathematics, Department of Education

## Preface

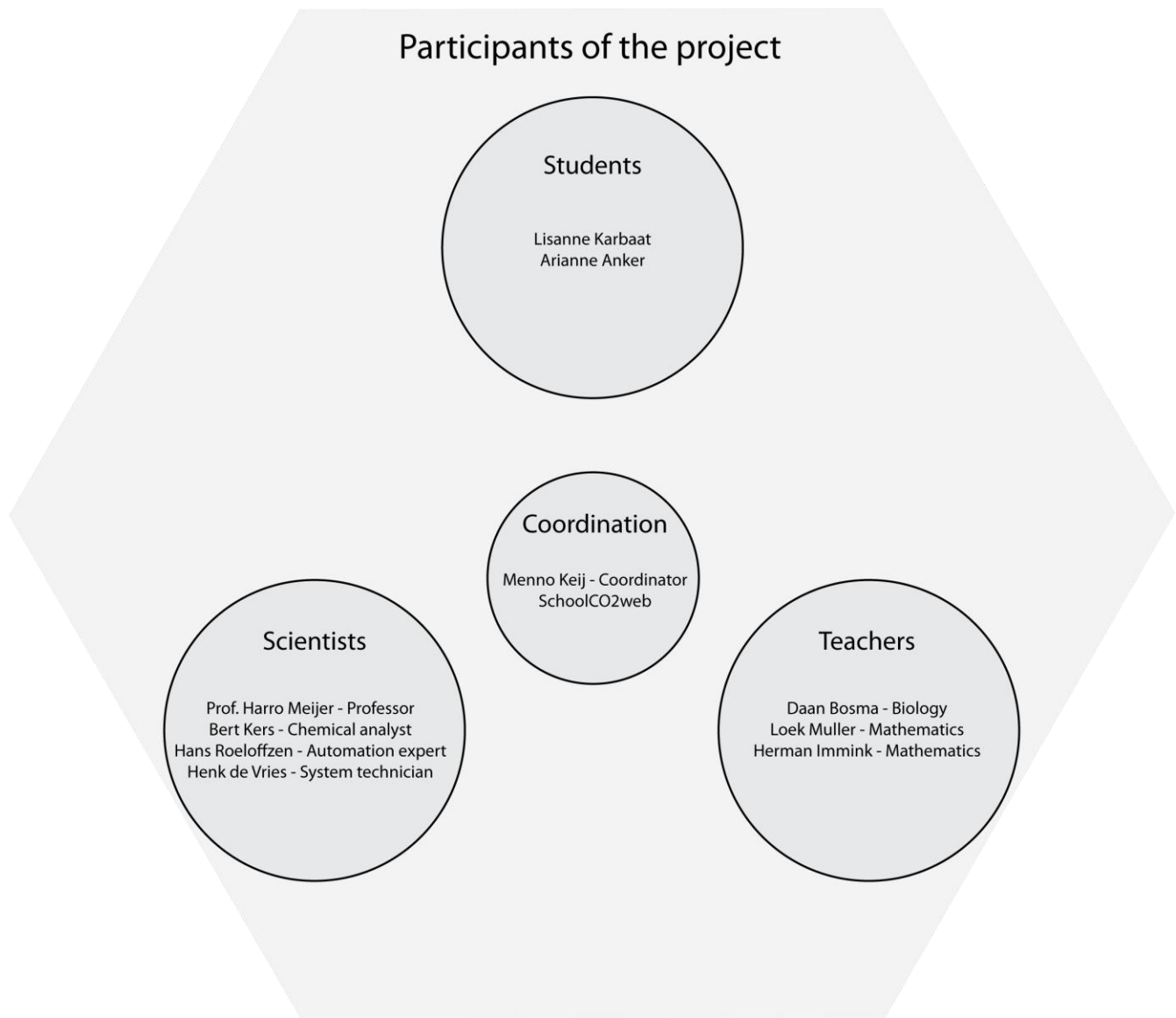
This document describes the experiences with a project in which high school students and their teachers worked together with scientists. The students investigated the influence of local sinks and sources around their school on the local atmospheric CO<sub>2</sub> levels. To achieve this, they made use of the measurements of CO<sub>2</sub> and weather variables of the meters on the roof of their school, the Maartenscollege. The Maartenscollege participates in the SchoolCO<sub>2</sub>web. The SchoolCO<sub>2</sub>web has been set up by the Center of Isotope Research (CIO) and the Department of Education (IDO) of the University of Groningen in cooperation with several high schools. The schools send their atmospheric measurements automatically to a central database of the University. By means of a simple online tool, teachers and pupils can download the data and use them for lessons and projects around CO<sub>2</sub> ([www.carboschools.org](http://www.carboschools.org)). Currently, the network has expanded from three regional schools two years ago to eleven schools throughout Europe today.

Since April 2007 the SchoolCO<sub>2</sub>web participates in the Teacher Scientist Partnerships (TSP) project, which is an EU funded Comenius 2.1 project (Training of School Education Staff). This document is an output of the TSP project. The goal of the TSP project is to build partnerships between teachers and scientists, and to integrate both teachers and students in authentic research institutes all over Europe, working on carbon dioxide and climate change. The idea behind the partnerships is that factual knowledge is not sufficient enough for students to understand science and to be able to cope with a fast changing world. Instead, students and teachers will be involved in authentic learning outside the classroom, in a research environment, and have a chance to develop their understanding of science by getting involved in real science.



# Description of the project

## Scientists, teachers and students involved



### **Place of the project into the school curriculum**

In the Netherlands, high school students choose a profile when they are around 15 years old. A profile is a set of coherent high school subjects. During the last year of high school, students have to carry out a practical assignment of 80 hours, which is called a profile project. The students have to design and carry out their experiment, write a paper and present the outcomes. At least two of the subjects of their profile should be involved within the project, which gives it a multi disciplinary character.

## Course of the project

In May 2008 biology teacher Daan Bosma demonstrated an experiment with a CO<sub>2</sub> box in the classroom. He told the students about the participation of the Maartenscollege in the SchoolCO<sub>2</sub>web and that students could use the data for their profile project. Two students, Lisanne Karbaat and Arianne Anker seized this opportunity.

In August the students searched for resources, started to read about correlations, defined research questions and made an appointment with prof. Harro Meijer. Prof. Harro Meijer and Menno Keij visited the school to give the students expert information on atmospheric CO<sub>2</sub> levels. During this conversation, the possibilities became clearer for the students and enabled them to better define their research aims.

In September the students and Daan Bosma went to the Center of Isotope Research (CIO) to calibrate the meter of their school. Chemical analyst Bert Kers assisted them during the calibration. The students started to work on the first chapter of their paper. Meanwhile, they asked questions by e-mail to prof. Harro Meijer and technical assistant Henk de Vries. They received answers on their emails.

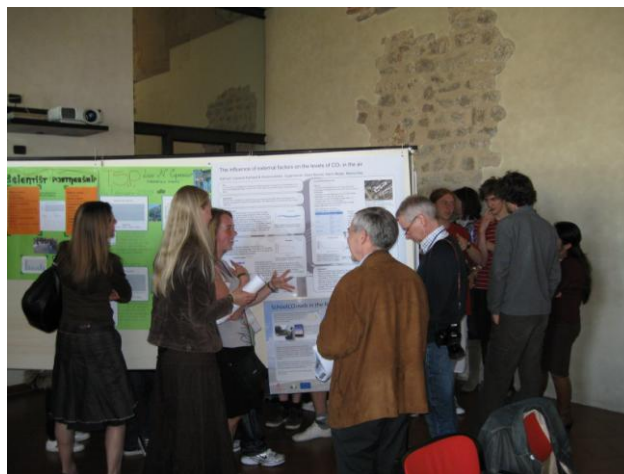
In October the students learned about correlation with help of mathematics teacher Loek Muller and a learning book. Because the on-line tool to download data of the SchoolCO<sub>2</sub>web didn't work correctly during this time, the students made a direct request for data to automation expert Hans Roeloffzen of the CIO. They received the weather and CO<sub>2</sub> data of their school.

In November the students imported the data into Excel. They tried to find correlations and made graphs. Daan Bosma assisted them with this work. They also investigated whether the trees in the vicinity of the meter could have an influence on the measured CO<sub>2</sub> data. They counted the trees around the school and estimated their influence according to resources on the CO<sub>2</sub> uptake by trees (source: Edinburgh Centre for Carbon Management).

In December the students continued and finished their paper.

In February they adjusted their paper and sent it to coordinator Menno Keij in order to participate in a competition for the best paper on CO<sub>2</sub> measurements. They won the competition and were given the opportunity to join the Carboschools meeting in Italy at the end of April. They took the opportunity.

In April the students and Menno Keij made a poster (in English) to present their work to other students during the Carboschools conference. During the conference in Pistoia (Italy) the students presented their work to teachers and students from different countries.



## Outputs of the project

The students wrote a paper and made a poster. The poster is in English and summarizes well the findings of the students (see Annex 1).

# Evaluation

## Students

We used a questionnaire to evaluate the project. This questionnaire is the Carboschools Project Evaluation Questionnaire.

The students said they learned a lot during this project, mainly how to work with Excel and how inversion layers work. They learned from the scientists how to calibrate a meter and how CO<sub>2</sub> levels are influenced in the atmosphere. They liked to learn about science by doing this practical projects and they would like to do these kind of projects more often in the future. Generally, they were positive about the project.

The students were not positive about the organization and the first explanation of the project. More professional assistance and more structure could definitely improve these kind of projects. They also didn't like that the project took a lot of time.

## Teacher

In an open interview, I asked Daan Bosma about his opinion on the project.

"In may 2008 I gave a demonstration with the CO<sub>2</sub> box in the classroom to students of 16 – 17 years old. I also went with the students to the roof of the school to see the CO<sub>2</sub> meter and the weather station. The idea was to make students enthusiastic for doing their profile project on the CO<sub>2</sub> measurements of out school. I was slightly disappointed that just two students chose the subject in the end. The reason for this could be that most students feel not appealed to data analysis.

The students who did the project asked a lot in the beginning, but not that much later on in the project. They worked at a steady pace. They gave me a preliminary version of their work, I've read this thoroughly. Some calculations were not correct, especially the ones about the respiration of trees. I gave them hints for improvement.

The students had the possibility to contact prof. Harro Meijer by e-mail, but they didn't make much use of this possibility. I had the idea that they looked up at Harro and that they were scared that their questions might look stupid. This surprised me, because they had a very open conversation with Harro on our school at the start of the project. This fear of being dumb in the presence of people who already made an academic career decreased during the journey in Pistoia (the TSP final conference), probably because they spoke with a lot of teachers and scientists in an informal way.

I went with the students to the lab of the Center of Isotope Research (CIO) to calibrate the CO<sub>2</sub> sensor of our school. They were assisted by chemist Bert Kers. He was very enthusiastic. A side effect was that the visit took more time than we thought. As a consequence, the parents of one of the students got worried.

I liked to do this project, but it was not so much related to biology. I think that it was too much focused on data analysis, and too little on collecting data. Students generally like to collect data, and not just to work with a data set."



# The influence of external factors on the levels of CO<sub>2</sub> in the air

Authors: Lisanne Karbaat & Arianne Anker. Supervisors: Daan Bosma, Harro Meijer, Menno Keij.

## Aim

Our aim was to investigate the influence of external factors on the amount of atmospheric CO<sub>2</sub> around the Maartenscollege in Haren (NL). These factors are weather factors and sources and sinks.

## Equipment

With the Davis Vantage Pro weather station we measured amongst others wind speed, wind direction, atmospheric pressure and temperature. We measured the CO<sub>2</sub> levels with the Vaisala GMP-343.

## Inversion layer

When the sun heats the earth, the air becomes turbulent, which results in a well mixed atmosphere. After sunset the surface and air right above the surface cools down. However, higher atmospheric layers are still warmer and function as a blanket, preventing the mixture of the atmosphere. As a result, CO<sub>2</sub> breathed out by organisms accumulates close to the surface. This inversion effect will be stronger as the difference in temperature between day and night increases. On the other hand, the effect will decrease when the wind speed increases.

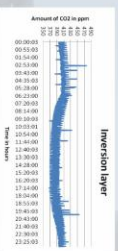


Figure 1 Yearly average amount of CO<sub>2</sub> during the day on the Maartenscollege

## Weather factors

### Wind speed

We found a negative correlation between the CO<sub>2</sub> concentration and the wind speed. The reason for this effect is that the wind mixes the air. The higher the wind speed, the less accumulation close to the surface.



Figure 3 Relation between atmospheric pressure and atmospheric CO<sub>2</sub> levels

### Wind speed

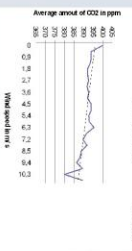


Figure 2 Relation between wind speed and atmospheric CO<sub>2</sub> levels

### Atmospheric pressure

A low atmospheric pressure means a low pressure area. Lower pressures go hand in hand with higher wind speeds, which means more mixing and thus less accumulation of CO<sub>2</sub> close to the surface. On the contrary, high atmospheric pressures are associated with low wind speeds, which means less mixing of the atmosphere.

## Local sinks and sources

### Method

- We have converted the amount of gas our school consumes in one year, to the amount of CO<sub>2</sub> our school discharges.
- We have calculated the amount of CO<sub>2</sub> the houses discharges with data from the ECCM.
- We have counted the number of trees within a hundred meter from our CO<sub>2</sub> probe.
- We have calculated the amount of CO<sub>2</sub> the trees absorb with data from the ECCM.



Figure 4 Satellite view of the Maartenscollege. We counted the trees and the sources within the circle (=100 m)

Table 1 The capacity and relative influence of different sources and sinks

Source / Sink	Amount CO <sub>2</sub>	Relative Influence
1500 trees	110,120 t CO <sub>2</sub> every year	1.00%
558 trees	26,53 t CO <sub>2</sub> every year	1.00%
Houses and school	211,4 t CO <sub>2</sub> every year	4.71%
Only the houses	1,6 t CO <sub>2</sub> every year	0.021%

## Results

- Trees don't have any influence on the CO<sub>2</sub> measurements.
- The school's central heating does have an influence: the central heating turns on and shuts down by means of negative feedback control. This is visible in the CO<sub>2</sub> data as an oscillating pattern.
- The influence of the central heating is especially visible as a peak when the wind direction is between 98° and 113°. Blowing CO<sub>2</sub> from the exhaust into the meter.
- The influence of the houses is only visible when the wind comes directly from their direction (220°).

### Wind direction

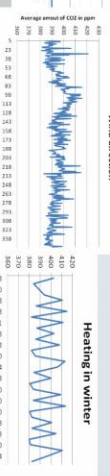


Figure 6 Relation between wind direction and atmospheric CO<sub>2</sub> levels

### Heating in winter

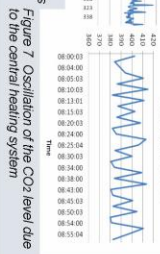


Figure 7 Oscillation of the CO<sub>2</sub> level due to the central heating system

## Discussion

- Because of the strong influence of the inversion effect, sorting data by day and night would improve analysis. After sorting, we would find different and stronger correlations between the CO<sub>2</sub> levels and weather factors.
- It's easier to measure sources than sinks: sinks (plants) are mostly active on sunny days when there is a lot of turbulence, sources (respirating organisms) are mostly active during the night when the inversion effect occurs.
- We grouped the CO<sub>2</sub> values at every value of the correlating weather factor and took the average. This reduced the variation of our data and changed the correlation coefficient we eventually found.