4. Topics in the classroom

Background on the SchoolCO2web dataset and its use at schools
As the SchoolCO2web-project proceeds, the database expands. This provides the participating schools with a large collection of CO_2-measurements from a variety of European locations, which can be used for studies by pupils. At the moment, it is already possible to study daily and seasonal oscillations of the CO_2-levels and maybe before the end of the project, the first results of annual effects will become visible. In order to enable an optimal use of the large datasets, this chapter will list and explain several possible study topics. In general, two types of studies can be distinguished:

1. technical studies, relating to 'the art of measuring'. Pupils will learn what is required to make correct use of the (calibrated!) CO_2-meters, what the right conditions are to measure, how many datapoints are required and which statistics should be implied.
2. scientific studies, making use of the obtained data. By interpreting these data, pupils can for example try to find seasonal influences, inversions or regional variations due to specific local situations.

Of course, technical and scientific studies are not two separate worlds and it is important for pupils to realise this. So although the classroom topics will be listed either under 'technical studies' or under 'scientific studies', the teacher should show the crosstalk between these types of studies. In the framework of the SchoolCO2web, pupils will be taught the lessons of good measurement in the technical studies and should become aware that these are a prerequisite to ever perform scientific studies. In addition, they will be acquainted with the fact that scientific studies are not just about obtaining new insights. Only if the included controls validate the results and the researcher can trace back known or expected phenomena in the data, he or she will be able to trust the acquired datasets.
Finally, in addition to working with the SchoolCO2web datasets themselves, classroom topics can also aim at creating general awareness among the pupils about for example CO_2-emission and climate change. An example of this is the DoMUS model, which will be explained in a separate section in this chapter.
For each described classroom topic, the following aspects will be adressed:

a. Background information
b. Learning aim for the pupils
c. Form of the activities and extent of the pupils' participation
d. Required time
e. Suggestions for reporting – present results to associated university/research institute, compare with other participating schools/pupils. For information on reporting to the SchoolCO2web, see appendix 2.

Technical studies
1. Accurate measurements
Background: In Figure 7, a structural difference of about 12 ppm could be observed between the CO_2-levels measured at the Maartenscollege in Haren and the Carl-Zeiss-Gymnasium in Jena. One could be tempted to conclude that the CO_2-concentration at the latter location is thus higher. However, pupils should be aware that a number is nothing more than just a number, unless the meter is properly calibrated. In the described situation for instance, the difference has not been caused by natural effects, but is a result of inaccuracy of one or both of the meters. As a consequence, the data cannot be compared with each other or with data from other sources. It is still possible to compare the data obtained by the same meter over a (limited) time, although this is not good scientific practice and should thus preferably not be taught to the pupils. In contrast, pupils should become familiar with the principles of calibration. When well calibrated, the meters of the SchoolCO2web can reach an accuracy of 1 ppm.
Aim: Familiarize pupils with the principles of calibration and make them aware of the famous expression "never trust a meter". In addition to this 'technical' aim, pupils should also learn that small differences can be very important in scientific measurements, especially in the field of atmospheric CO_2 research, so although performing accurate measurements and calibrations is one of the more difficult and time consuming tasks, it is a prerequisite for relevant scientific research.
Activities:
The calibration itself, with a calibration gas, is normally done by a technician, preferably a few times per year. The pupils can likely not participate in the actual calibration, but they can be made aware of the effect it has. Next, some examples of activities are listed:

- To involve the students in the calibration event, they could compare several measurements: two subsequent measurements taken before calibration, two subsequent measurement taken after calibration and two subsequent measurements with the calibration in between. If the meter was already well calibrated, there should not be too much difference, but on the schools this might actually be disappointing. In this case, the outcome will probably be that there is not much difference between two subsequent measurements, as long as they are taken at the same side of the calibration event. For comparison, they could also look at the data obtained by the professional measuring tower of the Centre of Isotope Research at Lutjewad. This meter has an accuracy of at least 0.1 ppm. To realise this accuracy, the meter automatically calibrates itself directly after each measurement, so that every measurement is taken with the highest possible accuracy. In this case, the observed difference between any two subsequently taken measurement should be very small if not almost absent.

- To see what the effect of calibration is on the long term, pupils could make graphs of measured CO_2-concentrations at the school of the period of for example one month before and one month after a calibration event. Do they observe a clear break in the CO_2-level trend, as was described in section 2.4 for the example of US and UK seawater temperature measurements? Now the pupils know that the meter has been calibrated, but let them speculate on what they would have concluded if they would not have known that.
- Depending on the equipment a school has, pupils could work in smaller groups, each equiped with a CO_2-meter, and per group measure CO_2-levels at several, specified locations in and around their school. In this case, one of the meters should be properly calibrated, while the others could be uncalibrated. The pupils could collect their data (for example the average of three measurements at each location) and compare their results with those of other group and with the results obtained by the calibrated meter. This could give them a good indication of spreading in datapoints as a results of calibration defects.

<u>Required time:</u>
This topic is more of an introduction to good measurement than a complete series of lessons, as is for example the module "measuring and interpreting" (see next section). The activities described above should be regarded as a nice starting point for pupils to get acquainted with measuring techniques and their pitfalls. The required time can therefore be limited to one lesson, embedded in the series of lessons connected to the module.

<u>Suggestions for reporting:</u>
Due to its introductory and technical nature, this topic is not very suitable for comparisons or interactions with other schools, except for merely noticing the difference in absolute CO_2-concentrations as mentioned above. The output expected from pupils could be graphs of their own acquired data supplemented with a short overview of the main observations.

2. Module "Measuring and Interpreting"

<u>Background:</u>
Within the Dutch NLT-platform (Nature, Life and Technology), a 40-hours module entitled "Measuring and interpreting" has been developed and certified for use at the national level in the two final years of highschool. Instead of focussing on climate change itself, the module aims at understanding the CO_2-measurements underlying climate change research. Even researchers themselves often feel uncertain about error-analysis and statistics of their data. In addition, climate change research is complicated by the fact that CO_2-concentrations vary as a result of human activities, weather conditions and CO_2-fixation by plants during the growth season, while margins are small and minor differences can be meaningful. The main question is therefore: How to measure properly and how to interpret the data in a correct way? For this purpose, the data of the SchoolCO2web are used. Currently, the module manual is only available in Dutch. However, in Appendix 3 an overview of the module is listed, enabling non-Dutch teachers to imply the main topics in their lessons.

<u>Aim:</u>
After finishing the module, pupils should be capable of using different types of measuring devices, be aware of inaccuracies and errors in their measurements and know how to account for these during dataprocessing and be able to interpret and, if necessary, filter their data in a correct way. Furthermore, at the end of the module, pupils will perform their own small research project, for which they should develop a proper experimental setup, using the knowledge they have acquired.

<u>Activities:</u>
The module starts with a booklet with theoretical information and questions, which the pupils should study. Halfway during the module, they will actively participate in practicals, centred around the theme of measuring inaccuracies. The last stage of the module consists of a small research project, which they will perform in couples. This part of the module is meant as a scientific study rather than a technical. The pupils should develop an experimental setup, making use of CO_2-data downloaded from the SchoolCO2web. They should identify, represent and interpret interesting dataseries on a chosen topic (*e.g.* seasonal effects, day-night rhythm, etc.).

<u>Required time:</u>
The module is established for 40 study-hours (50% classroom activities, 20% independent learning/working and 30% own research project). A short version, the minimodule "Measuring and Knowing" is also available, addressing more or less the same topics. This module is estimated on three lessons.

Suggestions for reporting:
The results obtained when working with the textbook should be documented in a portfolio. The results of their own research project should be shared with a broader public. They can write a report for their teacher, present their results in a poster presentation for their classmates and could report their project to the SchoolCO2web. Since the research project is an example of a scientific study, pupils should aim at reporting in a scientific way, so, for example, write their report in 'article-style' and use proper, scientifically acceptable figures, graphs, diagrams and legends.

3. Measuring CO_2 by hand
Background:
For the SchoolCO2web, measurements of the atmospheric CO_2-concentrations are taken by the Vaisala CO_2-meter that is positioned at the roof of the school. The advantage of this location is that it is likely the most optimal for each school and measurements are fully automated, guaranteeing a constant supply of data to the database. The disadvantage of this location is that the pupils are not actively involved in taking measurements. It would therefore be nice to equip them with a CO_2-meter and enable them to perform measurements themselves. For this purpose, there are two options. The first option is to remove the Vaisala meter, which actually is quite small, from the roof and let the pupils use this to measure CO_2-concentrations at different test locations. The second option is to use additional, special small hand CO_2-meters. Which option is preferred, depends on the objective of the measurements. The small hand meters are far less accurate than the Vaisala-meter (25-50 ppm versus 1 ppm accuracy), but are usually good enough for measuring large differences as, for example, in the classroom and, also important, do not lead to an interruption in the data collected for the SchoolCO2web. However, when higher accuracy is required, for example when pupils would like to perform measurements on photosynthesis, the Vaisala should be used.
Aim:
Involve pupils actively in taking CO_2-measurements and let them argue on the choice of the correct measuring device, given the aim of the measurements they are going to take.
Activities:
Pupils can measure CO_2-concentrations either indoors or outdoors. The activities can either be class-activities or individual activities. In the class activities, groups of pupils can measure the CO_2-concentration at specified locations, according to a protocol provided by their teacher and generally with a focus on technical aspects of the measurements. Afterwards, they can compare their data with those of their classmates. The individual activities could be incorporated in a research project, making it a more scientific study. In this case, pupils should also design their own experiments. Some examples of activities are listed below:

- Pupils can measure the effect of respiration by humans on the indoor CO_2-concentration. In classrooms with many students and often only little ventilation, CO_2-levels can rise quickly. The rate of CO_2-generation depends on the number of people in the room, their size and their physical activity. By ventilation, CO_2-concentrations can be decreased. The average adult's breath contains about 35,000 to 50,000 ppm of CO_2 (100x higher than outdoor air). Pupils can make estimations of the expected CO_2-concentration in their classroom based on the conditions (amount of people, size of the room, degree of ventilation) and can perform CO_2-measurements. They can compare their actual results with their estimations and can try to explain any observed differences or similarities.
- Pupils can measure the CO_2-levels in their classroom as an indication for the indoor air quality. Research has shown that CO_2-levels are most of the time too high. The CO_2 itself is not a health concern, but conditions with high CO_2-concentrations lead however to lower learning performances and absence through illness. Pupils can measure the indoor CO_2-concentration under different circumstances, for example time (first hour of the day compared to final hour), physical activity (pupils listening to the teacher compared to pupils working on a test), length of the pupils (first grade compared to final grade), classroom type (chemistry room, gymnastics room, computer room), etcetera. An option to extend this research is to also measure other paramenters and study if there is a correlation between for example CO_2-concentration, temperature and humidity.
- Pupils can measure outdoor CO_2-concentrations directly in the open air. For this purpose, they can study their environment by Google Earth and identify possible sinks and sources of CO_2 (discussed in more detail in the section 'scientific studies'). In addition they should consider possible effects of wind speed and direction. With this information, the pupils can make a list of interesting measuring locations, times and weather conditions and decribe their expectations for each situation. After performing the measurements, they can interpret the data and compare them with their expectations.
- A nice example of CO_2-measurements has been performed by the SchoolCO2web partners in Barcelona, Spain. Pupils there have measured CO_2-concentrations at different altitudes. Of course, these type of measurements can only be done if the local terrain permits.

- Pupils can measure CO_2-concentrations in a CO_2-box to mimic the natural situation on the ground. As illustrated in Figure 8, test conditions can be created in agreement with the research question. For example CO_2-uptake by photosynthetic effects can be studied when a plant is being grown in the box, while CO_2-emission by respiration can be studied in the presence of animals. Also, both animals and plants can be present in the box, thus showing a scenario of co-existence and its effects. A manual is available explaining these and other test situations.
- Required time:

Depending on the chosen activity, the required time can be just one lesson, but also a few hours to a (short) project which the pupils perform partially as homework. If the activities are done in the framework of technical studies, maximally a few hours is enough to focus on technical aspects of the measurements. If the pupils are more actively involved in setting up the experimental procedure, it will most likely become a more scientific study, which is very suitable for a short research or examination project.

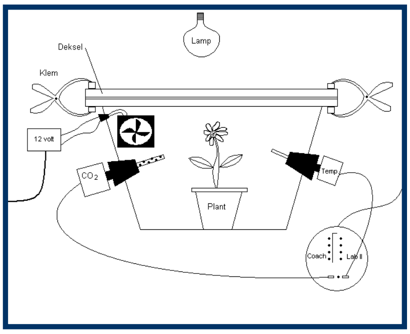

Figure 8. Example of a test situation created in the CO_2-box, in this case a growing plant to measure the effect of photosynthesis on CO_2-levels.

Suggestions for reporting:

Again, this depends on the nature of the chosen activity. When a class is divided into groups, which measure at different test locations or under different test conditions, a way to report would be via short presentations to the rest of class. The presentation session could be concluded by a classroom discussion on what is underlying the observed differences in the obtained data. Pupils could be stimulated to come up with suggestions for improvement of the measurements and suggestions for further research.

When the activities are performed in a (short) research project by individual pupils or couples of pupils, they could write a (article-style) report and/or give a powerpoint presentation on their results. Pupils could also give a demonstration of a short CO_2-box experiment as an outreach activity, for example on an information and orientation day for prospective pupils at their school.

Scientific studies

1. Atmospheric CO_2 cycles

Background:

As mentioned in chapter 3, atmospheric CO_2-concentrations vary due to different reasons. The first impulse of someone not familiar with CO_2-research might be to immediately draw conclusions from these fluctuations. However, first one should know the underlying causes for the observed variations in CO_2-levels. For example, normal seasonal variations occur through an increased CO_2-fixation in the growth season, leading to a drop in the CO_2-concentration. There are, however, also more accidental fluctuations, like inversions caused by the absence of wind and therefore an incomplete mixing of the measured air. These fluctuations have nothing to do with rising or dropping CO_2-levels, but rather just reflect the local situation at that particular day, time and condition. Important questions to deal with are therefore: How is it possible to discriminate between the different types of fluctuations? Which fluctuations reflect a relevant underlying reason? Which fluctuations are nothing more than just a disturbance in the CO_2-levels? When can trends in CO_2-concentrations be discerned? By involving pupils in scientific studies on atmospheric CO_2-concentrations, they learn how the CO_2-data should be studied, what can be concluded (and what not) and what could be tested in further research. With the data of the SchoolCO2web at their disposal, Carboschools-pupils could study a wide variety of research questions.

Aim:

Active participation of pupils in scientific studies. Pupils should get acquainted with climate research and CO_2-concentration measurements. They should learn that, although CO_2-levels fluctuate, relevant trends and oscillations can be found. Based on this knowledge they can formulate a research question, design a research plan and use existing dataseries on the SchoolCO2web for a (small) research project.

Activities:

Pupils should set up an experimental design to discover relevant trends and oscillations in existing dataseries. For this purpose, they could use dataseries of their own school, but also of other SchoolCO2web-partners. In their research plan, they should identify the right time and conditions to uncover the trend or oscillation that is the subject of their project. By doing so, they can try to answer any of the below listed questions. Appendix 4 discusses a number of concrete examples on these topics:

- Is there a difference in day-night cycle between a summer and a winter day? Would any potential effect be caused by different day lengths, increased or decreased photosynthesis, higher or lower temperature, etcetera. Or a combination of different factors.
- Are there differences in patterns between a relatively warm and a very cold day in winter? If so, how do these

differences relate to differences between a typical summer day and a typical winter day?

- Is there a correlation between temperature and CO_2-concentrations? If so, is this a positive or a negative correlation and can the correlation be used to predict future developments?
- Under which conditions does inversion occur? Correlations with wind speed have been established, but pupils can try to find more examples of inversion through low wind speed in the existing dataseries. In addition, they could debate the effect other weather conditions/local situations might have on inversion. Which factors would promote inversion? Which factors would inhibit inversion? When would these factors be optimal for inversion to occur? Can they then indeed find inversion patterns in the dataseries under these conditions? And can they demonstrate a correlation between these factors and CO_2-concentrations?
- Is there a difference in length or start of the growing season between different schools' environments? How do you observe the start of the growing season in the dataseries? When does the growing season start in for example the German schools' environment? And in The Netherlands? Or Italy? What can be seen when comparing the growing season out of the dataseries of two Dutch schools?
- Is it already possible to see any annual effects? For this it is important to do correct filtering, so this project might be a little more complicated to do in the classroom. It is however possible to approach a scientist for help. In that case, pupils could work on this in an examination project under supervision of a CO_2-researcher at the supporting University or Research Institute.

Required time:

All listed activities are very suitable to use as topics for (small) research projects, typically examination projects.

Suggestions for reporting:

If indeed the topics are used in examination projects, pupils could report in a written report, article-style and perhaps also in a presentation. It would also be nice if they upload their report to the SchoolCO2web, so that other pupils could benefit from their achievements. Especially when the pupils work on an international topic, like the length of the growing season in different regions in Europe, they could contact pupils from a school in one of these regions and exchange their findings and comments and work on the project together. For this it would be nice if they could set up some kind of interface, like a networkgroup on internet, which could be used for communication and data transfer.

2. Module "World wide climate change"

Background:

An 8-lessons module about climate change has been developed in the framework of CarboEurope to enable teachers to include the SchoolCO2web data in the curriculum. The central theme in this project is the fluctuating atmospheric CO_2-concentration as mentioned above. The difference with the activities described in the previous section, is that this approach is more guided. The complete class of pupils will work on this theme, out of a preset module. The lessons will focus on the question on how these CO_2-fluctuations can be explained. To answer this question, pupils will first be thaught background knowledge on climate change, analyse the data of the SchoolCO2web and perform a practical study on the role of plant activity on CO_2-levels. One of the important things that the pupils will learn from this project is the scientific eye-opener that one, well-formulated hypothesis does not necessarily have to be fully accepted or fully rejected by the results of the experiment. Often, researchers will discover that it did not work as they initially thought and they have to think of alternative causes, formulate a new hypothesis and additional research questions. The manual to the module is available only in Dutch, but the main terms, aims and activities are outlined in Appendix 3.

Aim:

Pupils will learn to not only prove or reject a hypothesis, but also to adjust it. For this purpose, they use climate research as a framework. They should be aware of the fact that many more causes are possible for explaining the observed climate phenomena and not just the hypothesis that they have formulated. They will therefore also learn the importance of formulating well-defined and testable hypotheses, which is a delicate task in a field as complex as climate research. It is of no use stating something if it is not possible to test exactly the influence on, for example, the CO_2-concentration of the factor that is valued so high in the hypothesis.

Activities:

The project consists of different activities. In the first part, the pupils work with a textbook and assignments about climate change. The second part involves working with the data of the SchoolCO2web. The pupils are provided with different dataseries that they have to investigate with help of Microsoft Excel. A major learning aim in this phase of the project is also to improve their skills in working with Excel by performing practical tasks. The third part of the module consists of a practical about the influence of light on plants. They have to perform standard experiments and later on analyse and explain their data.

Required time:

The total time for the module is 8 lessons. It is also possible to do parts of the module.

Suggestions for reporting:

Pupils can hand in their answers to the questions in the theoretical part to their teacher. For the practical part, they can write a report, paying attention to a good representation of their results (graphs, diagrams). They can also present their results to each other, but since all pupils have followed the same practicals, it might be more useful to use a classroom discussion for this. Ask the pupils if they can come up with suggestions for improving their measurements or with suggestions for further research. Let them think critically about the requirements for good scientific research.

3. Sinks and sources

Background:

Normally, the atmospheric CO_2-concentrations in different regions do not differ too much. However, sometimes local differences are observed. Before ever continuing with the scientific interpretation of these differences, one should first of all be absolutely sure that the measurements have been carried out accurately and that the observed differences are statistically significant. When this is the case, the next point of action is to identify the cause(s) of these differences. In the past, the main aim of CO_2-research has been to determine the average global CO_2-levels and their trend. Recently, however, differences between regions are also taken into account. The current challenge of carbon research is to model the carbon cycle as accurately as possible. For this purpose, it is important to know what the effect of each region is on the atmospheric CO_2-level. Regions can function either as a source of CO_2 or as a sink for CO_2. A typical CO_2-sink, so a region that takes up more CO_2 than it emits, is a region with a lot of vegetation or water, for example large forests or oceans. CO_2-sources are characterized by a nett CO_2-emission over CO_2-uptake and, of this, two types can be distinguished: 1) natural sources, by respiration of animals and plants, release of CO_2 by oceans (depending on the conditions, water can act as sink or source), forest fires and vulcanic eruptions and 2) anthropogenic sources, caused by humans, which include burning of fossil fuels and deforestation. These sources can be very local, strong and often also time-dependent. One can think of the contribution of fossil fuels in traffic, industry and heating in winter. It is often not easy to detect local sources by measuring CO_2-concentrations, due to the mixing of the air. Usually, only nearby sources will be detected and even then, this depends on the wind direction.

Aim:

Make pupils aware of the effect local conditions can have on the CO_2-levels that are measured by the station. They learn what the characteristics of sinks and sources are and can try to identify them using for example Google Earth. Furthermore, pupils can learn about different dispersion models which predict the distribution of CO_2 in the environment.

Activities:

Pupils can use software like Google Earth to look for sinks and sources close to a measuring station, either that of their own school or of any of the other Carboschools. When looking for sources near their own school, they can use the handmeters or the dismantled Vaisala from the roof to perform measurements on local sinks and sources as described earlier in "Measuring CO_2 by hand" in the section on technical studies.

Alternatively, they can estimate the possibility that a local CO_2-source affects the CO_2-concentrations measured at a CO_2-station of one of the Carboschools partners. For this purpose, dispersion models can be used, which predict the distribution of CO_2 emitted from a certain source as dispersed by the wind. One of these models is the Gaussian Plume model. How to use this model is described in Appendix 5 - Tools. An excellent example of a CO_2-source is the one near the Maartenscollege in Haren, The Netherlands. This source has been identified by pupils from the Carl-Zeiss-Gymnasium in Jena, Germany by using the SchoolCO2web. More information on this example can be found in Appendix 4 – Examples of using the SchoolCO2web.

Required time:

Identifying a source or sink by help of Google Earth and using a Gaussian Plume model to trace back its effects in the data measured by the nearest CO_2-station is a topic that is suited very well for an examination project. It would be useful to approach a scientist of the local supporting university/research institute for assistance.

Suggestions for reporting:

Pupils could present their results in a written report and in a presentation for their classmates or for the research group of the supervising scientist. Especially when pupils examine a source or sink that is not near to their own school, but is located near to one of the other participants, they could contact pupils from the other school and start a collaboration, in which they work on the project together and report to and discuss with one another. This would clearly demonstrate the international nature of CO_2-research and would provide an international podium. Pupils could also upload their results to the SchoolCO2web, where it could function as demonstration material for pupils in other participating schools.

Creating awareness

1. DoMUS model and game and ecological footprints

Background:

Climate researchers keep telling us that the world is awaiting enormous disasters if we continue using our natural resources like we do. A drastic reduction in CO_2-emission is required to prevent the global temperature from increasing to a level at which irreversible effects are inevitable. An important role is played by politicians and climate advisors. At global conferences, like the climate conferences in Kyoto and, more recently, Copenhagen, agreements were to be made, obliging countries to maximally engage themselves to reduce CO_2-emissions. However, it turns out to be hard to achieve unconditional engagements of all partners. The interests of industries, governments, climate researchers, etcetera often point in different directions, complicating negotiations. But among the general publicum awareness increases that we cannot continue like this and many interest groups fight for the reduction of fossil fuels combustion, the increased usage of alternative energy sources like wind energy, solar energy and electric cars, the improvements of living conditions in developing countries or the protection of landscapes like glaciers and polar ice. In addition to these organized interest groups, individuals can also play a role in reducing CO_2-emission. The DoMUS model and DoMUS game have been developed to give people insight in the amount of energy they use and the amount of CO_2-emission this results in. By using their own household as scale, the consequences of personal conducts are directly reflected in terms of energy usage and CO_2-emission.

Aim:

Create awareness among pupils of the consequences of their daily behaviour on energy consumption and CO_2-emission and hopefully stimulate them to change their behaviour in order to reduce their energy requirements and, thus, CO_2-emission.

Activities:

- In the DoMUS game pupils follow one or more setup characters during a week of his/her life. Every day, they have to make choices for this person, regarding dinner, sports, evening activities, destination for a daytrip, etcetera. All the choices affect the budget, the environment and the happiness of the person. At the end of the game, pupils will be informed on whether or not they reached the criteria. An outcome can be that their character was very happy, but has put a too large burden on the environment. By giving feedback, pupils realise what the consequences of different types of behaviour are and how they can live happily, without weighing down to much on the Earth. The game can also be played sequentially with different characters or scenarios, for example first playing with a high income character, then with a middle-income character and finally with a low-budget character. Pupils will then become aware of the fact that it is easier to cut down on CO_2-emission when one can afford more energy efficient appliances. However, the richer characters will most likely spend more money and energy on vacations and daytrips, thereby increasing their CO_2-emission.
- The DoMUS model is more complicated than the DoMUS game and is more difficult for pupils, since it requires knowledge about different aspects of their household that they probably do not have, like, for example, how much gas is used per year, what kind of insulation the house has and which type of heating. However, testing the model in a class of one of the SchoolCO2web-partners showed that pupils do like to enter their own household situation and look for improvements.
- As an alternative, numerous websites are available on which pupils can quickly determine how big their own (households') demand is. This so called ecological footprint is represented as the percentage of the Earth's surface is required to sustain their own or their own households' energy request. For every person in the world, 2.1 acres are available. The average footprint of a Dutch person is 4.1 acres. By filling in the details of their own household, pupils can asses how much Earth they require. The nice thing of these websites is that the entered number can be adapted to the personal situation, but that also averages are provided so the questionaire can be filled in even if one does not know exactly how the households' situation is. Example of sites on which the personal ecological footprint can be determined are:
    - www.epa.vic.gov.au/ecologicalfootprint (Australian, option for personal, school, etc footprint)
    - www.ecologicalfootprint.com (UK)
    - www.duurzaamheidinactie.nl (Dutch)
- Currently, there is a global initiative triggering people to reduce their own CO_2-emission with 10% per year, starting in 2010 (the 10:10 competition). Using DoMUS, pupils can get insight in the energy demand and CO_2-emission of their own household or even, by scaling up, of their school. This could form a nice starting point for setting up a plan to reduce their CO_2-emission in the framework of the 10:10 competition. More information on 10:10: www.1010global.org

Required time:

The DoMUS game can be used as an introduction for the DoMUS model, but can also be used independently. The game itself does probably take some 10 – 15 minutes per character/scenario. As a further introduction to the

DoMUS model, the websites on ecological footprints can be used. Usually, filling in the questionaire takes about 10 minutes.
The real DoMUS model requires more preparation time, in order to find all information about the status of the household concerning for example energy usage and insulation. As homework, pupils could collect the necessary data for their own household or in a project could try to find the data for their school.
Suggestions for reporting:
If pupils make a DoMUS model or an ecological footprint for their own situation, they could be stimulated to come up with suggestions for CO_2-emission reduction, which they could present in small notes that they report to an 'action board' in their classroom. The action board could either be a sheet of paper on the wall to which they stick memo's or an electronic interface to which they post their suggestions.
This topic is very suitable for competitions. Pupils could be asked to come up with suggestions to reduce the schools' CO_2-emission. The best idea or the highest reduction could be awarded with a prize and of course, the school should commit itself to actually follow up the suggestions, as long as these are feasible (things like switching off lights or computers rather than installing a complete new insulation system). In addition, pupils could take part in a 10:10-like competition, either individually or with their class or they could challenge pupils from other Carboschools to come up with a plan for CO_2-reduction.

Some additional aspects that might be addressed in the classroom
Working with meteorological data
Based on meteorological data, pupils can study phenological issues. They can investigate the relationship (if any) between factors such as temperature, rain fall and day length and for instance the return of migratory birds or the start of the blooming of plants. Pupils can look for informatin in books and on internet, but can also actively document data themselves and try to find a relationship. They can note observations on changes in nature in their own environment and can look up historical data on the internet. Many countries have phenological observation networks, which can provide a lot of information.

Pupils can also study weather patterns, both at their own school and in collaboration with other Carboschools. Data on temperature, air pressure, wind speed and direction are all available in the SchoolCO2web database. In addition pupils could note observation on the weather appearance, like number of sun hours, degree of coverage of the sky, etcetera. Combining these data, they could for example investigate whether there is a relation between the weather conditions and the coverage of the sky.