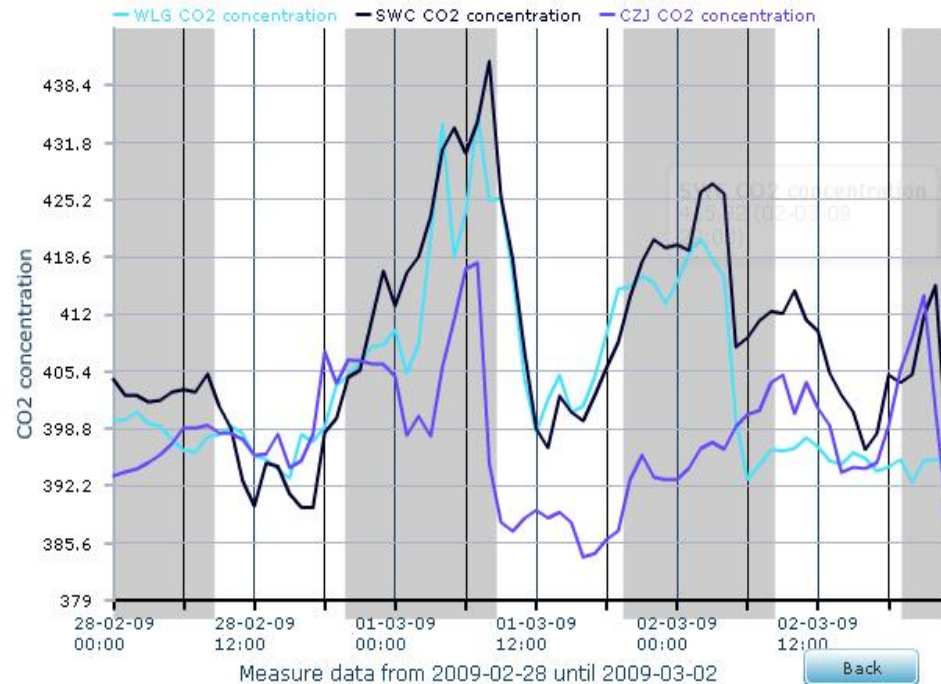
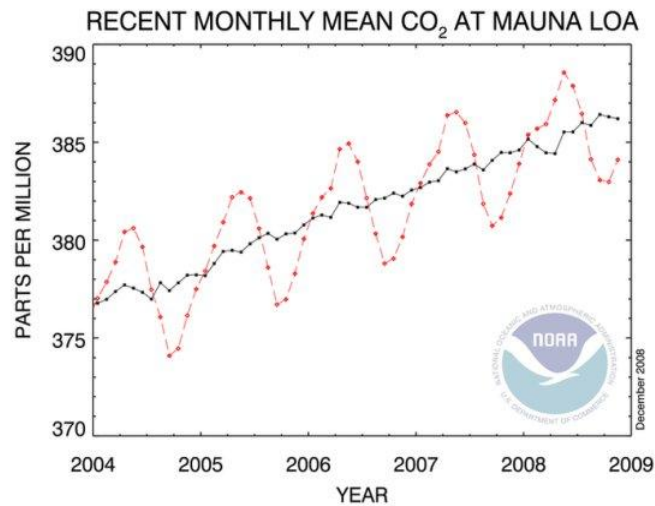


CO₂-concentration close to earth's surface fluctuates heavily

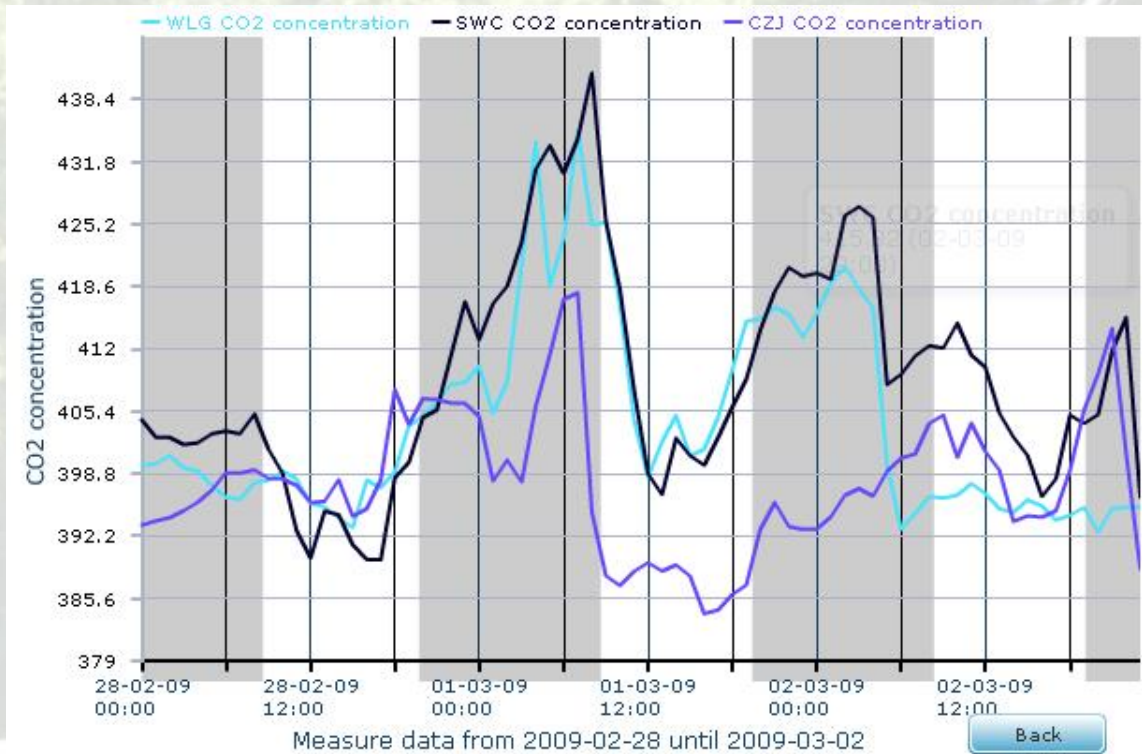


- High in the atmosphere, the air is well mixed
- Close to the earth the CO₂-levels display a whimsical course



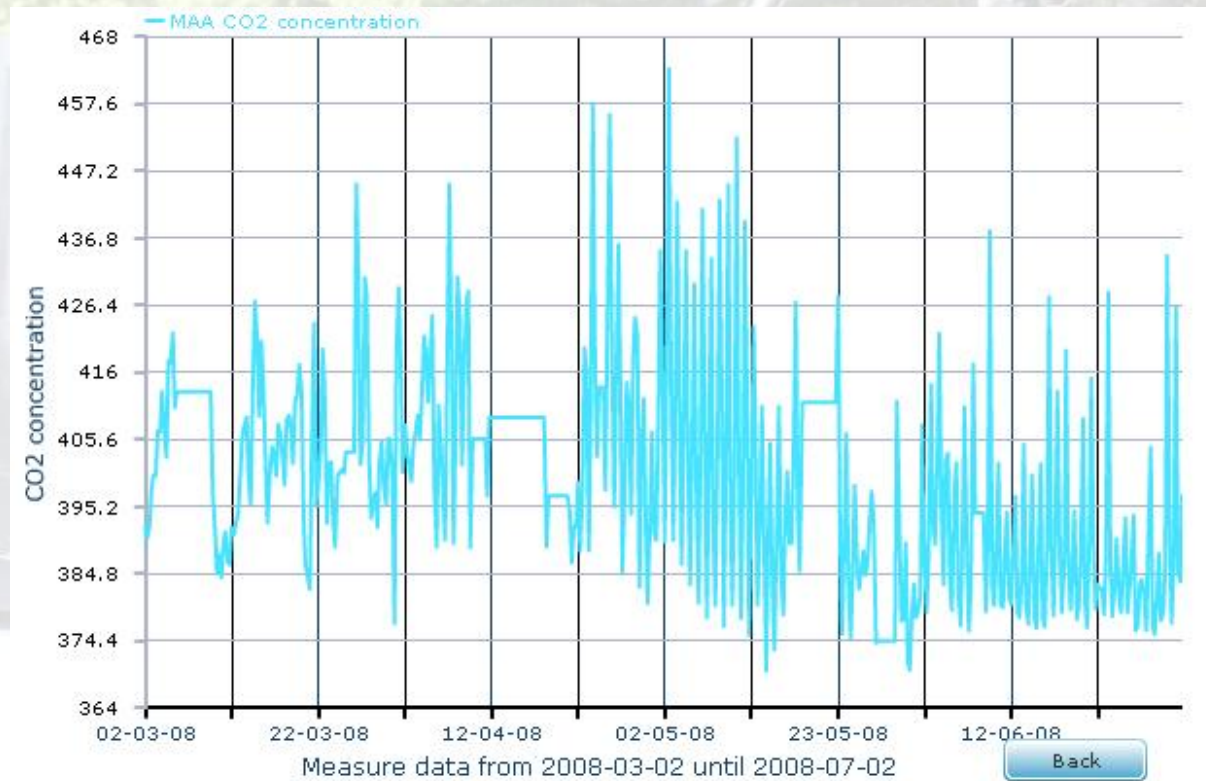
Variation due to day-night rhythm

- Inversion: During the night, the CO₂- concentration often increases



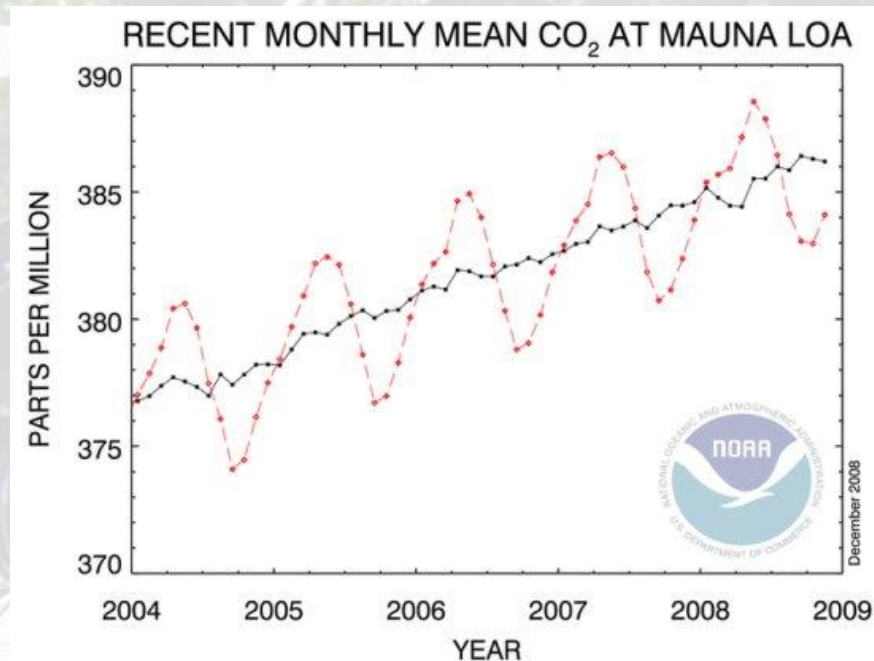
Variation due to the seasonal cycle

- In the growing season plants take up more CO₂



Research to CO₂ in the past

- Emphasis on measuring the average course of the atmospheric CO₂-concentration
- Goal was to demonstrate that the CO₂-levels are increasing



Current research to CO₂

- Closely map the carbon cycle
- Goals are to gain insight into the sources and sinks of CO₂ and to be able to make predictions about the carbon cycle
- Hundreds of scientists in Europe work together on these goals within CarboEurope and CarboOcean project





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Results of 5 years of research of CarboEurope

- Nitrogen, derived from fertilizers, has spread via the rain. As a result, the growth of forests has increased and so has the uptake of CO₂
- Peatlands that are converted into agricultural fields cast out a lot of CO₂. Although peatlands cover only 3% of Europe's surface, they expel as much CO₂ as taken up by 25% of all the European forests

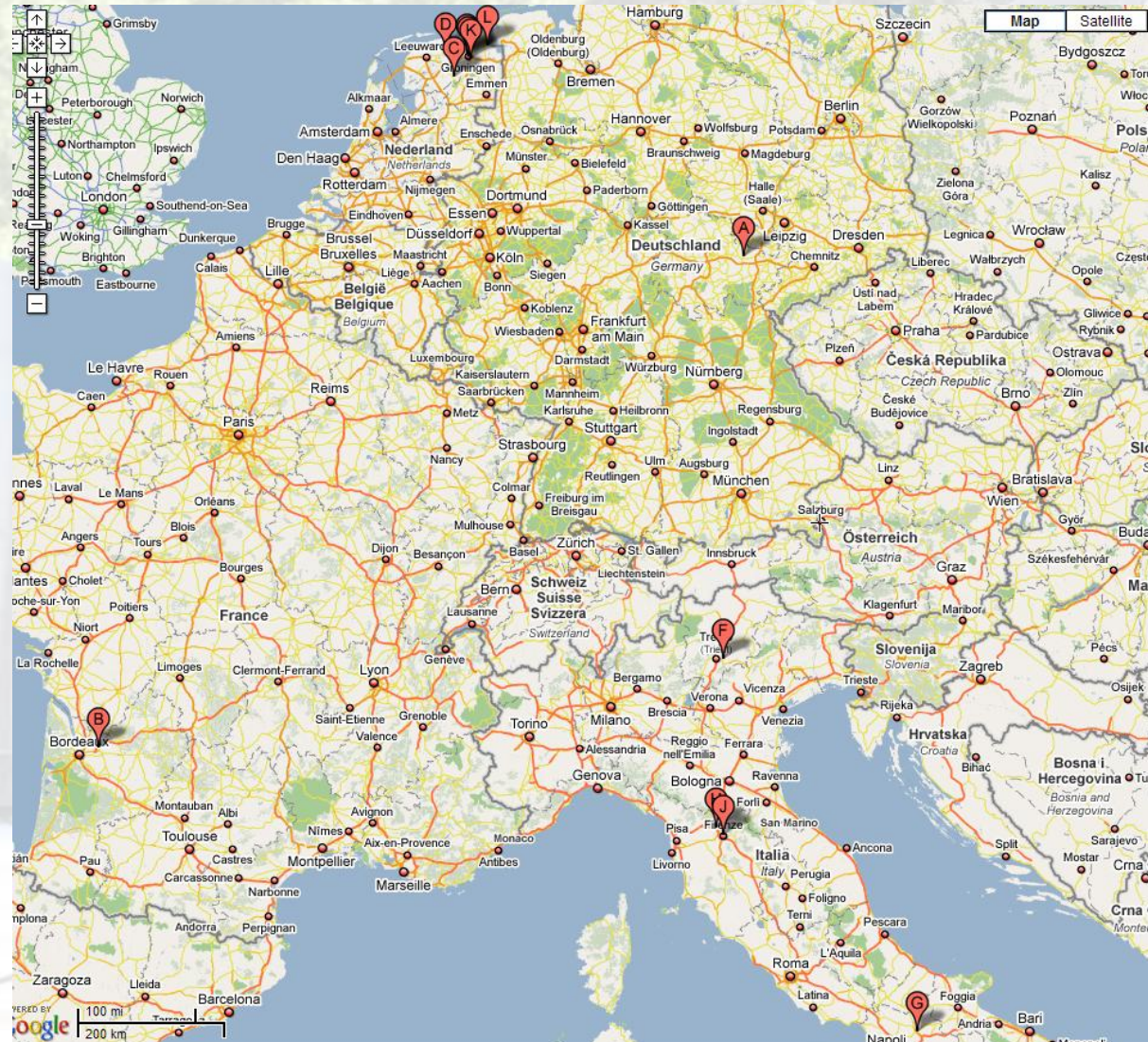


Results of 5 years of research of CarboEurope (2)

- Forests and grasslands are a sink for CO₂
- Agricultural fields are sometimes a small sink for CO₂, sometimes they are neutral
- Because of the increasing temperature, the vegetation has a higher uptake of CO₂ in spring, but during the fall the vegetation exhausts more CO₂



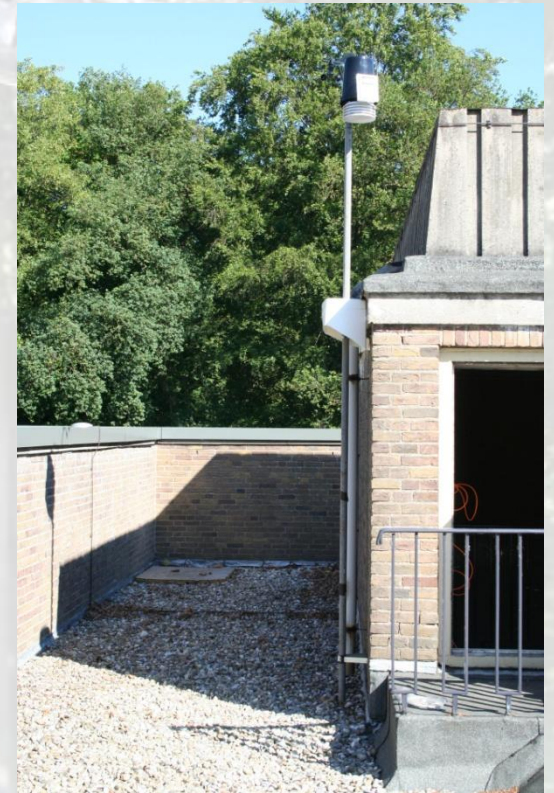
European network of measuring schools: SchoolCO2web



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European network of measuring schools: SchoolCO2web

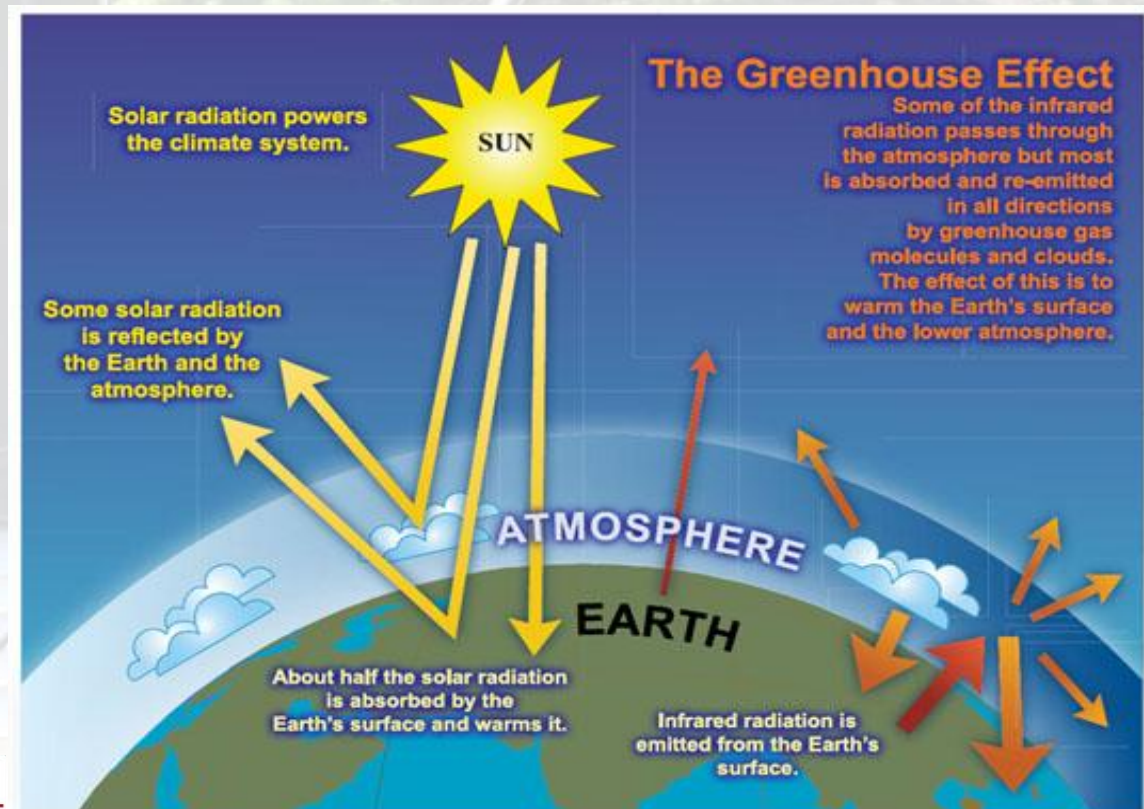


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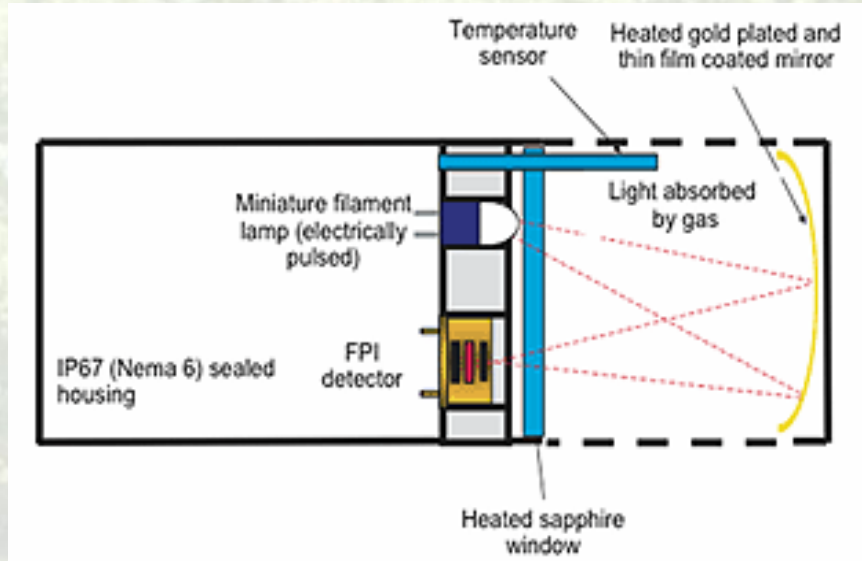


Greenhouse effect

- Caused by absorption of infrared radiation by greenhouse gases, like water vapor, carbon dioxide and methane



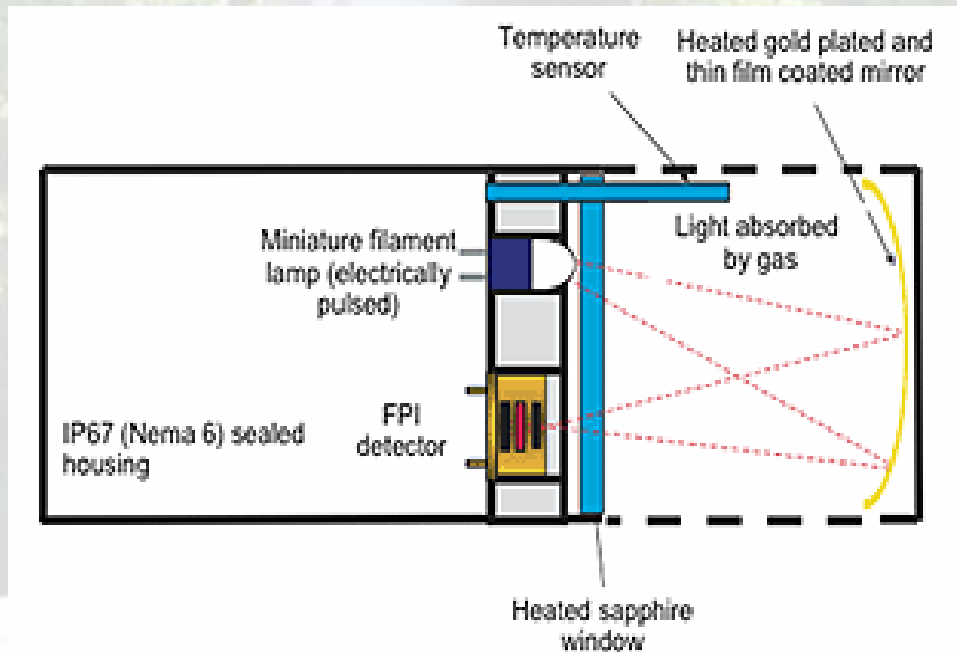
Greenhouse effect in the CO₂-meter



- Lamp emits infrared light
- Reflexion against mirror
- Detection light intensity by Fabry-Perot meter
- The CO₂-concentration is determined on the basis of the difference between the emitted light and the reference

Greenhouse effect in the CO₂-meter

- Measurement is proportional to the number of CO₂-molecules



Problem 1: number of molecules is being influenced by the temperature and the air pressure

- Temperature & air pressure
- General gas law $pV = nRT$
 - p = pressure (N/m^2)
 - V = volume (m^3)
 - n = amount of gas (mol)
 - R = gas constant
 - T = temperature



Problem 2: measurements influenced by the humidity of the air

- Air humidity is a measure for the amount of water vapor in the air
- Water vapor is also a greenhouse gas and thus absorbs infrared light



Solution: Davis Vantage Pro weather station



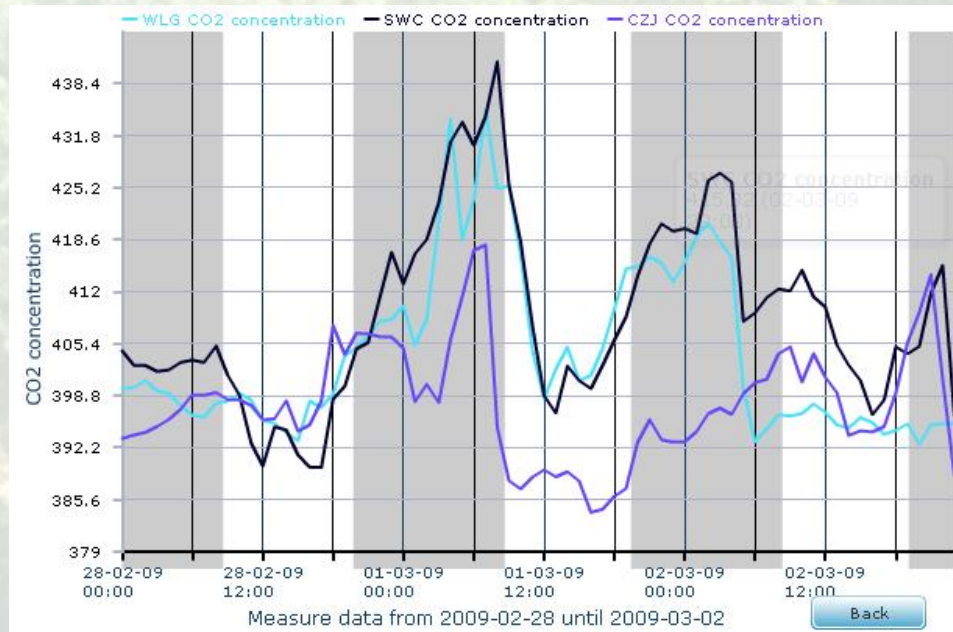
- Temperature
- Air pressure
- Air humidity
- Precipitation
- Wind speed
- Wind direction

CO₂-measurements compensated by measurements of the weather station

- Temperature
- Air pressure
- Air humidity



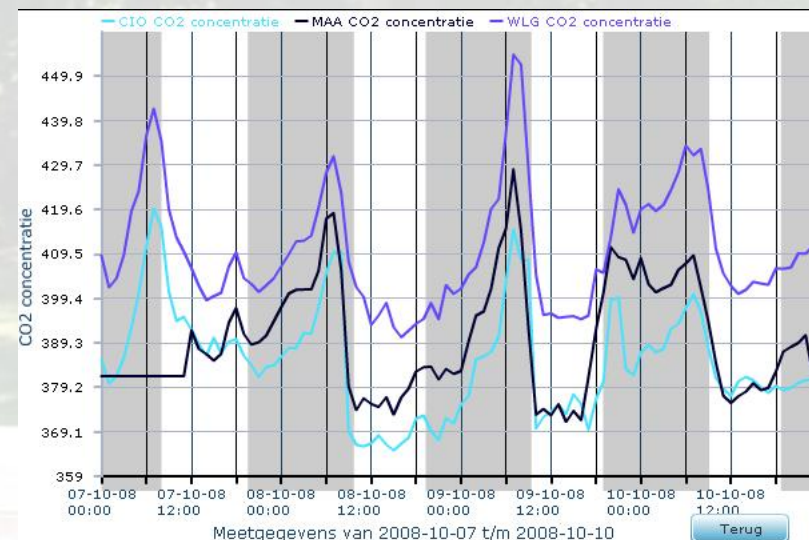
Measuring accuracy is very important



- Local differences are small, just a few ppm
- Nevertheless, to distinguish sources and sinks, meters have to be very accurate

Measurement accuracy through calibration

- To assure that the meters run equal and are accurate they need to be calibrated regularly
- Calibration of meters is for CarboEurope as well as for the SchoolCO2web 1 of the most difficult things
- Accuracy:
 - CarboEurope: 0,05 ppm
 - SchoolCO2web: 1 ppm
 - Coach meters: 50 ppm



Calibration on the Center of Isotope Research (NL)



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Download tool (sheet for presentator)

- Windspeed and CO₂
 - Willem Lodewijk Gymnasium 02-01-2009 tot 07-01-2009
- Correlation windspeed and CO₂
 - Maartenscollege 7-10-2008 – 28-10-2008
 - Download data and show operations in Excel

