Evaluation and Application of Low-cost, Medium-high-accuracy CO_2 Measurements on Western-European Flux Towers

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Rationale

High-accuracy CO_2 measurement (better than 0.1 ppm) at sufficient height in the atmosphere (mixed layer or troposphere) is prerequisite to estimate regional atmospheric CO2 budgets from model inversions.

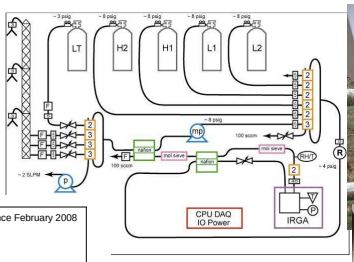
- Continuous monitoring at such heights is expensive and still not achieved at many sites.
- If the density of measurement sites would be much higher, the criteria for accuracy and measurement height might be relaxed, and costs reduced.

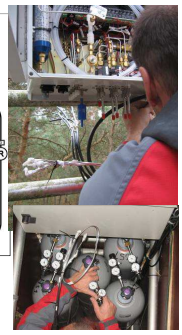
Objectives

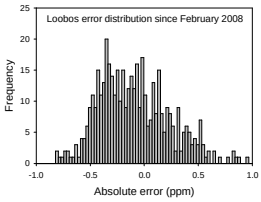
- We tested a small network of medium-accuracy CO_2 monitors above canopies on flux towers.
- Apart from providing high-resolution patterns of $[CO_2]$, we expect that combining these with local fluxes helps to extrapolate them to regional values.

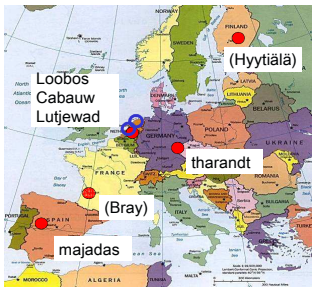
Technique

- Low-cost CO2 measuring equipment (AIRCOA, Stephens et al, NCAR).
- Simple IRGA (LiCor 820), an elaborate gas drying and pressure-control system, and frequent on-site calibration (4-hourly).
- Adapted to installation at remote sites, relying on solar and wind power and low-speed telephone internet (GPRS) connections.
- Automatic error monitoring using an additional control cylinder. RMS is about 0.3 ppm



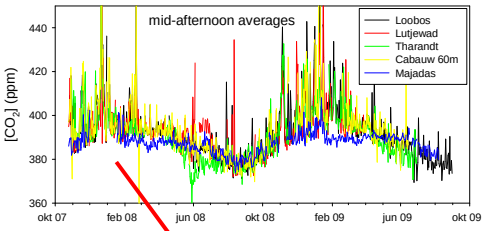






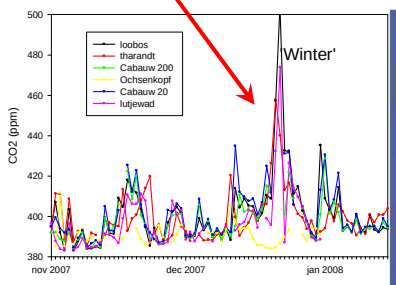
Sites

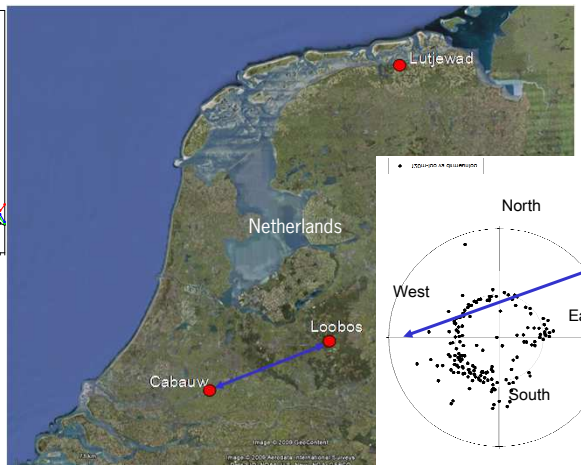
- Within CarboEurope consortium
- Installed at five flux tower site.
- We analyse three of them and compare to high-accuracy data from Cabauw (NL) and Lutjewad (NL).

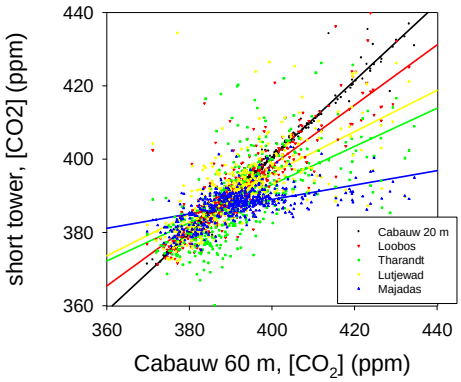


Time series consistent

- High consistency across sites
- NW Europe winters show regionally consistent signals, strong ' pollution' peaks.
- Mediterranean data show earlier onset of uptake
- Marine site poorly correlated







Spatial correlation decreases with distance

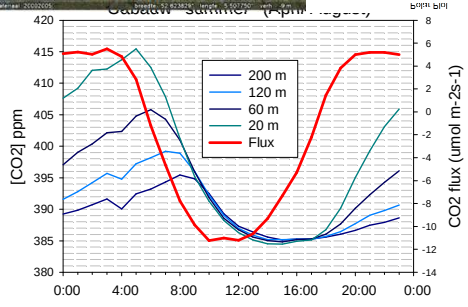
- Lutjewad (marine) poorly correlated
- Netherlands in winter is more polluted than E. Germany and Spain

Spatial trends?

- Spatial trends between Cabauw and Loobos, along main wind direction (SW) larger than with perpendicular wind
- This suggests signal of fluxes in between (100km)
- Calls for more sophisticated regional inversion study

Extrapolate to greater height?

- Davis et al suggest extrapolating surface $[CO_2]$ to CBL heights using the ' Virtual Tall Tower' (VTT) technique
- This involves empirical flux-gradient relationships
- Data from Cabauw tall tower show concentrations lagging behind fluxes
- This suggests VTT methods are not straightforward here
- Better to extrapolate using meso-scale models?



Conclusions

- The systems have functioned satisfactorily. Errors should be reduced further.
- Signals are clearly comparable and useful inferences of concentration gradients and regional carbon exchange can be made already from basic data analysis.
- These data should be used in regional assimilation of $[CO_2]$, fluxes and models.

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