CO_2 balance measurements and modelling for Danish terrestrial areas

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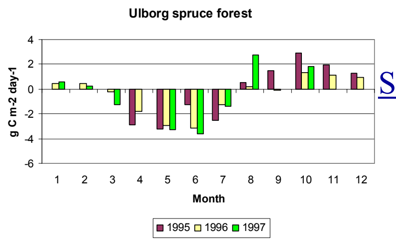
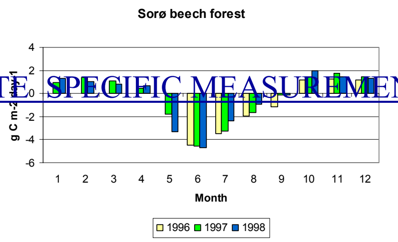
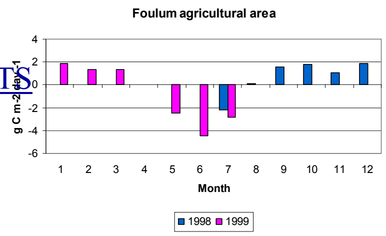
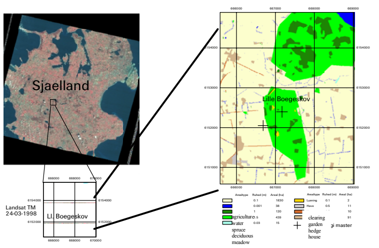
SITE SPECIFIC MEASUREMENTS



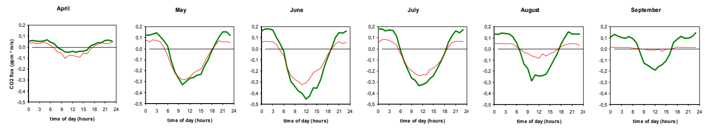




Values of monthly CO_2 balances show that there is a net uptake of carbon during summer and a net loss during winter. Please note the relatively large difference between the individual years. Also note the sign convention: a negative flux is towards the surface (CO_2 is lost from the atmosphere) thus carbon is taken up by the vegetation.



- Ulborg: The site is dominated by Norway spruce (*Picea abies*) but other sorts of trees are present. The trees are planted. They are 40 years old and about 12 m tall. The net uptake starts as early as March but ends already in July, possibly due to water stress.
- Sorø: The site is dominated by beech (*Fagus sylvatica*). The trees are about 80 years old and 25 m tall. The net uptake starts in May after leaf-out and ends in September.
- Foulum: This is an agricultural area. The fields are dominated by barley, wheat and grass.The net uptake is in the period May to July.



In Sorø there is an additional flux station outside the forest. The half-hourly mean values of the net flux, measured by eddy correlation, is shown as ensemble averaged days for the months of April through September 1998. (green curves: forest, red curves: agricultural land).

The forest has the largest uptake through photosynthesis during the months of June to September. On the other hand the carbon loss during night time (due to respiration) is the larger. The daily carbon net balance for the month in question is the integral over the curves.

The two meteorological masts were placed approximately 500 m apart as shown on the map to the left.

REGIONAL MAPPING

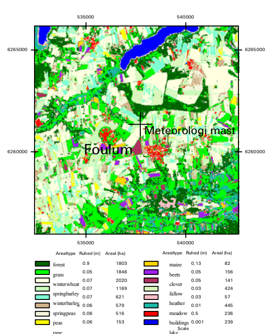
OBJECTIVES

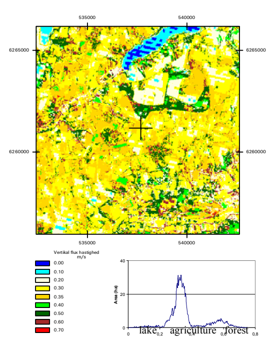
- To calculate the total contribution of CO_2 (source or sink) from vegetated surfaces in Denmark.
- To calculate the load of depositing air pollutants to selected points (particular biotopes) in Denmark.

REGIONAL EXAMPLE

As an example we have determined the land-use pattern for a 10 × 10 km area in Foulum using Landsat TM (20 × 20 m pixels). This classification has been translated into surface roughness categories (figure to the left below) and from this the pattern of surface friction velocity $u_*(x,y)$ has been calculated (figure to the right) using the non-linear aggregation method described adjacent to this text.

Values for C_* (see adjacent text for the definition) will be calculated for the relevant land-use types and maps of the CO_2 flux will then be determined.





METHOD

The basis for the method is the equation

$$CO_2\ flux = -u_*(x,y)\,C_*(x,y)$$

where $u_*(x,y)$ is the vertical flux velocity (friction velocity) in the point x,y in the landscape and C_* is a similar turbulent quantity for the fluctuations in concentration. For the determination of u_* and C_* we use the following surface layer similarity relationships

$$u_* = \frac{\kappa\ u(z)}{\ln\left(\frac{z}{z_0}\right) - \psi_m\left(\frac{z}{L}\right)}, \quad C_* = \frac{\kappa\,[C_a(z) - C_0]}{\ln\left(\frac{z}{z_{0t}}\right) - \psi_s\left(\frac{z}{L}\right)}, \quad L = \frac{-\overline{\theta}\,u_*^3}{\kappa g\,\overline{w_{0'}\theta_{0'}}}, \quad \overline{w'\theta_{0'}} = -\theta_* u_*, \quad \theta_* = \frac{\kappa\,[\theta(z) - \theta_0]}{\ln\left(\frac{z}{z_{0t}}\right) - \psi_s\left(\frac{z}{L}\right)},$$

In these equations there is a correction for the stratification of the air temperature as well as the upstream surface roughness conditions through a separate flow model for the calculation of $u(z)$ as a function of x,y (see Hasager and Jensen, 1999, Surface flux aggregation in heterogeneous terrain. *Quart.J.Royal.Met.Soc.*, **125**, 2075-2102).

DATA

The surface temperature, $\theta_0(x,y)$ is measured from satellite. The surface roughness $z_0(x,y)$ is also determined from satellite images through land cover classification, using databases for typical roughnesses of the different types of vegetation.

The background wind speed, direction, air temperature and CO_2 concentration is measured from a tall meteorological tower.

The surface concentration of CO_2 ($C_0(x,y)$) is a function of plant bio-geochemistry, climate parameters and soil humidity and is modelled separately from a photosynthesis module.

APPLICATIONS

Surface fluxes of for example CO_2, nitrogen compounds, ozone or particles can be determined as:

- regional and national average (aggregated) values
- local values to particular biotopes in the region (critical load)
- scenario values for assumed changes in the land-use pattern

Ackknowledgements

Field experiments were funded by Det Strategisk Miljøforskningsprogram, Skov- og Naturstyrelsen and ESA-research funding from the Danish Research Agency. Thanks goes to the following persons for their contributions to the project: Poul Hummelshøj, Helge Ro-Poulsen, Svend Danbæk, Viggo Madsen, John E.Hansen, Lars Christensen, Gunnar Jensen, Jørgen Bille Hansen og Eva Bøgh.