Representativeness of Ground Flux Sites to Regional Scale Airborne Fluxes

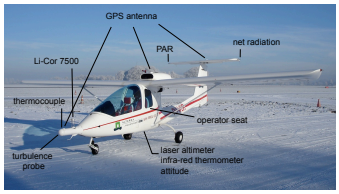
O.S. Vellinga[1,2], R.W.A. Hutjes[2,3], and J.A. Elbers[2,3]

(1) Wageningen University, Meteorology & Air-Quality Group, Wageningen, Netherlands
(2) Wageningen University, Earth-System Science & Climate Change Group, Wageningen, Netherlands
(3) Alterra, Wageningen UR, Wageningen, Netherlands

August 2009

Introduction

In 2007, we participated with our aircraft in the field experiment 'CarboEurope Regional Experiment Strategy' (CERES'07) in Southwest France. See website: http://carboregional.mediasfrance.org.



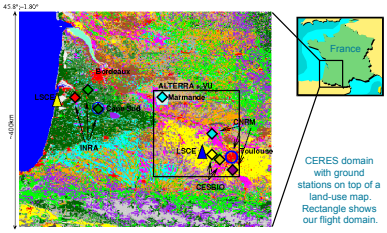
Our environmental research aircraft, a Sky Arrow ERA

Research Questions

- How to retrieve regional fluxes from the airborne data?
- Can we see meaningful spatial and temporal variations?
- How do they compare with CERES'07 ground data?

Field Experiment

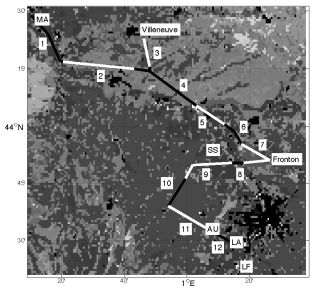
The experiment consisted of two intensive observation periods (IOPs): one in April and one in September. Both periods were dominated by sunny, warm and dry weather with light variable winds. Figure below shows the experimental domain with all ground stations and our flight domain.



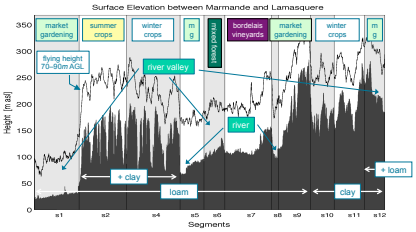
CERES domain with ground stations on top of a land-use map. Rectangle shows our flight domain.

Method

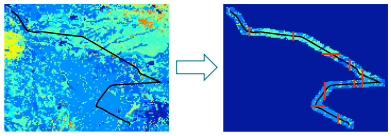
Flight paths were divided into segments based on terrain elevation, land use and soil type, using satellite imagery and digital maps. See next two figures for results!



Flight domain with five ground stations (2-char labels) and flight tracks divided into 12 segments (numbers)



An average footprint length was determined and was used to extract descriptive and quantitative data from a land-use map for the area directly influencing the measurements. See below!

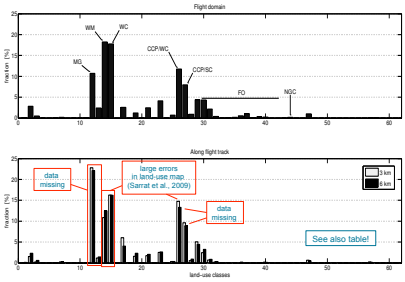


Flight domain with one flight track on top of a land-use map (*250m resolution*)

Extracted part of land-use map with *3km*-margin along flight track, incl. segment borders (red lines)

Up-Scaling Ground Data

Distributions of land-use fractions (for figures above) have been determined for the flight domain and for the area along the flight tracks. Figure below shows that the distribution for the whole flight domain is well represented by the distribution for the flight tracks.



Below, a table with average data for the period 1200–1400*h* local time (LT) from the five ground stations in the flight domain.

Station	Vegetation	Class	LAI	*fCO2*	*B*	E_t
IOP 1						
MA	maize	WM	0	3.3	2.88	0.26
SS	grass	multiple	3.9	-23.2	0.26	0.79
AU	sunflower	SC	0	0.3	0.78	0.56
LA	winter wheat	WC	4.3	-33.6	0.08	0.92
LF	fallow/grass	NGC	n/a	-15.6	0.26	0.79
IOP 2						
MA	maize	WM	4	-20.3	0.84	0.54
SS	grass	multiple	n/a	-1.6	1.68	0.37
AU	sunflower	SC	0	0.6	2.91	0.26
LA	winter wheat	WC	0	-0.2	3.83	0.21
LF	fallow/grass	NGC	n/a	-2.4	4.39	0.19

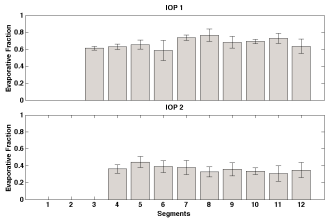
This shows that ground data cannot be up-scaled to regional scale due to the lack of data for large land-use classes (MG, CCP/SC and CCP/WC). In addition, Sarrat et al. (2009) found large errors in the land-use map for two other main classes winter crops (WC) and maize (WM).

Sarrat et al., Mesoscale Modelling of the CO2 Interactions Between the Surface and the Atmosphere Applied to the April 2007 CERES Field Experiment. Biogeosciences, 6(4):633–646, 2009.

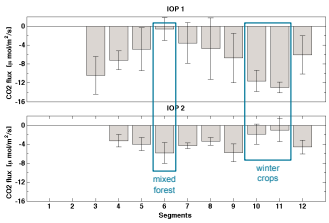
Airborne Fluxes

For segment averaged airborne fluxes, only flights between 1200*h* and 1400*h* LT were used to reduce diurnal effects. These averaged fluxes can be considered as regional fluxes.

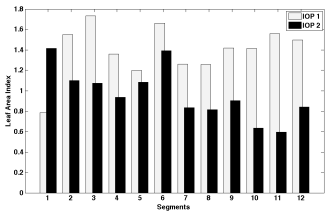
The evaporative fraction (= λE / [λE + H]) below shows that evapotranspiration during April (IOP 1) was larger than during September (IOP 2), which can be explained by the wet period before the start of IOP 1.



The segment averaged carbon uptake (CO_2 *flux*) shows clear seasonal changes for segments with winter crops and mixed forest.



In addition, carbon uptake correlates well with the leaf area index from MODIS satellite data, especially for September (IOP 2).



Conclusion

Even for a large field experiment like CERES'07, it was not possible to upscale ground data to the regional scale. The segment averaged fluxes clearly relate to the underlying terrain. Hence, airborne flux data is an essential tool for deriving regional fluxes.

Future Research

Extending a multiple regression model with a light-use efficiency model for photosynthesis, using detailed airborne footprint modelling. This study will be based on our airborne flux data-set of 47 flights (≈230 flight hours; covering a full seasonal cycle) obtained in the Netherlands during 2008. See website: www.me2.alterra.nl.

Acknowledgements
This study was implemented under the Dutch research programme 'Climate changes Spatial Planning' (www.ClimatechangesSpatialPlanning.nl) and was additionally funded by the Netherlands Organisation of Scientific Research (NWO). Many thanks go to A.A.M. Holtslag (Wageningen University) and P. Kabat (Wageningen University).

Corresponding Author:
olaf.vellinga@wur.nl

WAGENINGEN UR
For quality of life

CARBO EUROPE

climate changes spatial planning