Simulation of carbon exchange using a regional model

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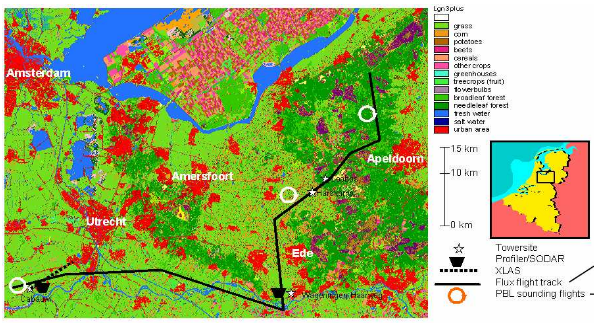
Introduction

Land surface affects the atmosphere primarily through the interaction of the one-dimensional fluxes of heat, water, momentum and CO_2. These fluxes are controlled by processes that are related to surface properties exhibiting local variation, such as soils, vegetation / land use type, and in the case of CO_2 anthropogenic emissions.

To assess the influence of different land use types on the atmospheric CO2 concentration, local fluxes of heat, energy and CO2 and local meteorological conditions two models have been coupled with each other: RAMS and SWAPS-C (land surface model).

Objective of this study

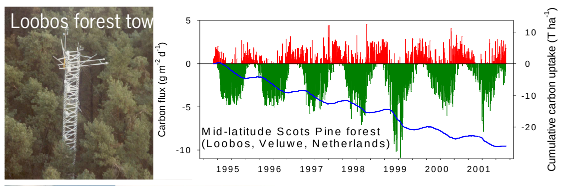
To understand the main controlling factors determining carbon dioxide content in the atmospheric boundary layer for selected areas in Europe, using a combination of experimental and forward modeling tools. Here we focus on central Netherlands



Description of experiment

Results are shown for a simulation performed by the RAMS/SWAPS-C coupled model for summer 2002 for an area comprising the center of The Netherlands. The results will be validated using observations taken during the 2002 summer campaign (from 15 July to 29 July). This campaign was part of the EU-FP5 funded RECAB project.

Observations are available from a number of flux towers over forest (1), grass (2) and maize fields (1) allowing parameterization of the LSM. Aircraft observations of turbulent and radiative fluxes at low flying altitudes further help to assess surface flux heterogeneity. Aircraft profiles of trace gas concentrations allow characterization of trace gas dynamics in the ABL



Surface and CBL Fluxes,
Continuous: H, λE, u*, PAR, Q_n

CBL profiles,
Continuous: T, q, CO_2
Flasks: CO_2, CH_4, N_2O, $\delta^{18}O$ and $\delta^{13}C$

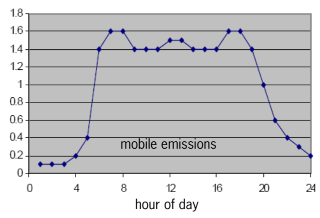
Model configuration

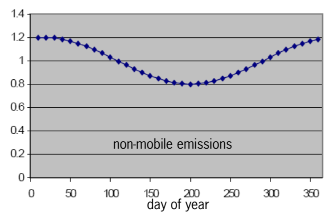
A nested model configuration has been used, laterally forced by ECMWF analysis. Analysis focused on the highest resolution domain. Larger domains guarantee realistic lateral CO2 fluxes for bottom (ABL) part of smaller domains.

grids	1	2	3
δx, δy	48 km (83x83)	16 km (41x38)	4 km (42x42)
δt	50 s	16.7 s	16.7 s
δz		25 - 1000 m (35)	
radiation		Harrington (1996)	
land surface		SWAPS-C (Ashby (1998), Hanan (2000))	
diffusion		Mellor/Yamada (1982)	
convection		Full microphysics package (Flatau, '89)	
forcing		ECMWF	
forcing time scale		lateral 1800 s	

Model coupling

We coupled RAMS to SWAPS-C, a two layer land surface scheme including CO_2 fluxes from assimilation and respiration. For anthropogenic CO2 fluxes we implemented the EDGAR 3.2 emission inventory database (Olivier and Berdowski, 2001). The data were downscaled from original 1 by 1 degree to model grid sizes attributing emissions to urban pixels only, and from annual totals to model time steps assuming for mobile emissions a diurnal cycle with no seasonal cycle and for non-mobile emissions a seasonal cycle with no diurnal cycle. Marine CO_2 fluxes are modeled based on global δpCO_2 maps compiled by Takahashi

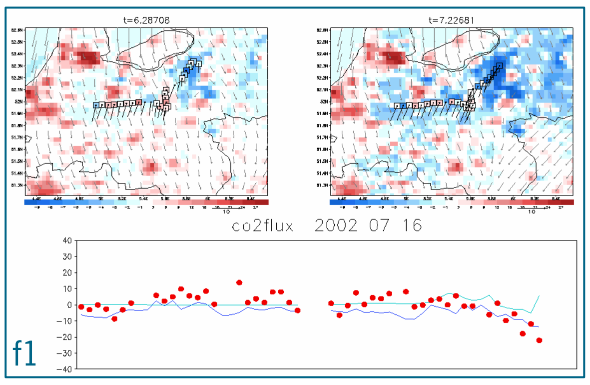


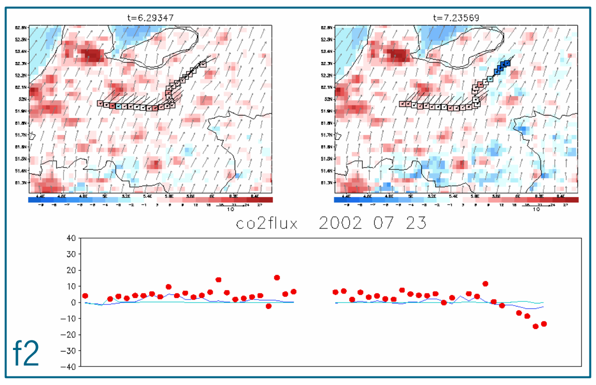


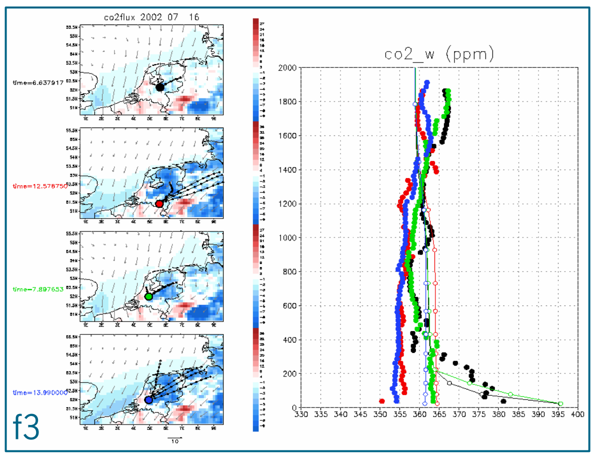
Comparing simulated & observed fluxes and scalars

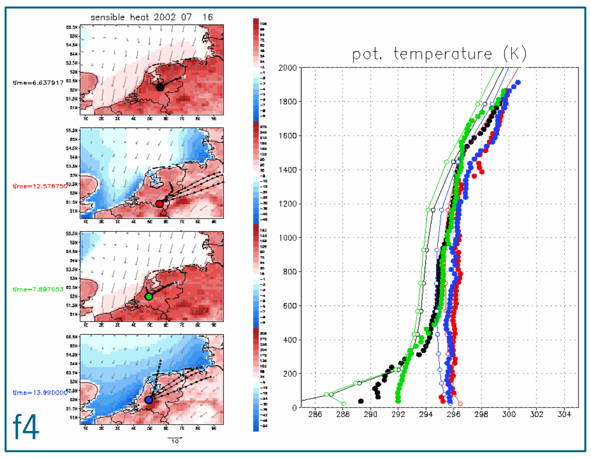
Graphs f1 and f2 at right simulated and aircraft observed CO_2 fluxes are compared for two contrasting days. Top figures show simulated surface flux maps and wind vectors, plus observed fluxes along flight track in same colour coding. Bottom shows same: dots observed fluxes, dark blue line simulated surface fluxes, light blue simulated flux at flying altitude.

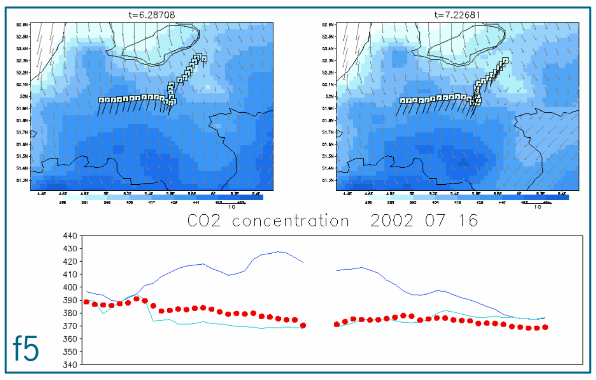
Graphs f3 - f5 below compare simulated and aircraft observed scalar concentrations: f3 and f4 vertical profiles of CO_2 and pot temperature, f5 horizontal transect of CO_2











Left hand side of f3 and f4: location of respective profiles plotted on simulated surface flux map together with backward trajectories at 4 heights in profile. Right hand side: observed (filled dots) and simulated (open dots+lines) profiles.

Conclusions 1

General dynamics and spatial patterns of surface fluxes compare well with aircraft observed fluxes, but vertical flux divergence hampers interpretation. At site level (not shown) simulated fluxes compared well against tower observations

Conclusions 2

General dynamics and spatial patternsof scalar profiles qualitatively compare reasonable with aircraft observed profiles and transects, but e.g. qualitatively night time CO_2 build up is more problematic.

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