Combined $^{14}$CO$_2$ and CO observations, a key to high-resolution fossil fuel CO$_2$ records?

Ingeborg Levin(1), Ute Karstens (2)

(1) Institut für Umweltphysik, University of Heidelberg, Im Neuenheimer Feld 229, 69120 Heidelberg, Germany
Max Planck Institute for Biogeochemistry, P.O. Box 100164, 07701 Jena, Germany
Ingeborg.Levin@iup.uni-heidelberg.de

Abstract

The greenhouse gases budget over Europe and other highly populated regions is largely influenced by anthropogenic emissions. Even in remote areas of e.g. Europe, about 30% to 50% of the continental CO$_2$ signal is originating from fossil fuel (i.e. coal, oil and natural gas) burning. Separating the fossil fuel from the natural biogenic signal in the atmosphere is, therefore, a crucial task for quantifying exchange fluxes of the continental biosphere from atmospheric observations and inverse modelling.

An uncertainty estimate of a purely observational approach to derive hourly regional fossil fuel CO$_2$ offsets ($\Delta$CO$_2$(foss)) at continental CO$_2$ monitoring sites is presented. Weekly mean $^{14}$C-based fossil fuel CO$_2$ mixing ratios and corresponding regional CO offsets ($\Delta$CO) are proposed to determine weekly mean $\Delta$CO/$\Delta$CO$_2$(foss) ratios in order to derive hourly $\Delta$CO$_2$(foss) mixing ratios from hourly $\Delta$CO measurements. Respective regional model estimates of CO and CO$_2$(foss) are applied to test this approach and obtain RMS errors of the correspondingly determined regional hourly fossil fuel CO$_2$ component. The uncertainty of this method turns out to increase with decreasing fossil fuel CO$_2$ fraction ranging from about 15% up to 40% for European CO$_2$ observational sites. Together with the uncertainty of the $\Delta$CO/$\Delta$CO$_2$(foss) ratio which is dominated by the precision of the $^{14}$CO$_2$ measurement, this method is still more accurate than any model-based approach.
Quantifying the decrease in methane emissions from fossil fuel production in Europe and Siberia using modeling and atmospheric measurements of carbon dioxide and methane from Alert, Canada

D. Worthy1, E. Chan1, M. Ishizawa1, D. Chan1, P. Bergamaschi2 and I. Levin3
1) Environment Canada, 4905 Dufferin Street, Toronto, Canada
2) Climate Change Unit Institute for Environment and Sustainability (IES) Joint Research Centre European Commission TP 280 I-21020 Ispra (Va) Italy
3) Institut für Umweltphysik, University of Heidelberg (UHEI-IUP), Heidelberg, Germany
1) 4905 Dufferin Street, Toronto, Canada
2) TP 280 I-21020 Ispra (Va) Italy
3) Heidelberg, Germany
Doug.worthy@ec.gc.ca

Keywords
Methane, Emissions, Alert, Europe

Abstract
Continuous measurements of CO₂ and CH₄ have been made at the Canadian Baseline Observatory at Alert since 1987. The time series of CO₂ and CH₄ are frequently highly correlated in winter during well-defined episodes lasting anywhere from 2 to 5 days. This is primarily due to synoptic meteorology, weak vertical mixing and rapid air mass transport of cohesive plumes of pollutants originating mainly from Siberian and/or European source regions. Ratios of CH₄/CO₂ during these well defined episodes consistently dropped (1988 to 2004) from ~20 ppb CH₄ per 1 ppm of CO₂ to ~12 ppb CH₄ per 1 ppm of CO₂, a decrease of 40%. To estimate the spatial and temporal change in the source emissions necessary to produce these observations, the atmospheric CO₂ and CH₄ concentrations at Alert were simulated using the NIES atmospheric transport model and NCEP reanalysis meteorology, along with CO₂ sources (biospheric, oceanic and fossil fuel fluxes) and eleven individual CH₄ sources, including gas and coal production. Land source regions are divided into Europe, Western Siberia, Eastern Siberia, Boreal and Temperate North America with the remainder being grouped together into one region. Partitioning the simulated CH₄ synoptic events at Alert in winter into contributions by source clearly shows that gas and coal account for more than 90% of the total signal. Partitioning the simulated CH₄ events into contributions by region shows on average that fossil fuel emissions from Europe account for more than 50% of the signal, with Western Siberia, Eastern Siberia and Temperate North America accounting for ~20%, 15% and 5% respectively. In the absence of a change in the emissions of CH₄, modelled ratios of CH₄/CO₂ showed no change. To reproduce the trend in the ratio of CH₄/CO₂ observed in the data requires a reduction in emissions of CH₄ on the order of 15 to 20 Tg per year which would be in accordance to observed decreasing growth rates of CH₄ in the last decade.
Carbon sequestration due to the abandonment of croplands in the former USSR since 1990

Vuichard Nicolas (1), Belelli Marchesini Luca (1), Ciais Philippe (2) and Valentini Riccardo (1)

(1) Department of Forest Ecology, University of Tuscia
(2) Laboratoire des Sciences du Climat et de l'Environnement, IPSL, CNRS/CEA/UVSQ

(1) Via S. Camillo de Lellis - 01100 Viterbo, ITALY
(2) CE L'Orme des Merisiers, Bâtiment 701 - Point Courrier 129 91191 Gif-sur-Yvette Cedex FRANCE

vuichard@unitus.it

Keywords
land-use change, carbon sequestration, eddy covariance, ecosystem modelling, Kyoto protocol

Abstract
Since the 90's, the economic recession in the former USSR (current Commonwealth of Independent States, CIS) has induced an abandonment of cultivated lands. Overall the CIS, it is more than 20 millions of hectares of arable lands that have been abandoned from 1992 to 2002 (FAO, 2002), leading to a probable important carbon uptake by soils. Our study tends to quantify the C sink due to this land-use change from plot to regional scale.

In the region of Hakasia (90°E 54.5°N), NEE was monitored by eddy covariance technique from 2002 to 2004 over three nearby sites (Hak1, Hak2 and Hak3) with different land use history (natural steppe, recovered steppe since 10 years and 5 years, respectively). Thanks to this experiment, we may infer the temporal dynamic of the C balance after land conversion. All sites were sinks of carbon diminishing with the time since land conversion: 107, 76 and 22 gC m⁻² y⁻¹ for Hak3, Hak2 and Hak1, respectively.

Based on this field study, regional estimates of the C uptake have been calculated using (1) simple up-scaling rules and (2) an ecosystem model (ORCHIDEE model, Krinner, 2005). Meteorological data used for ORCHIDEE simulations are derived from a 0.5-degree climatology from 1916 to 2003. For the timing of the land conversion and its spatial distribution, we use the land-use map developed by Hurtt et al. (2006).

Both approaches lead to a significant sink of carbon which can have a considerable impact on Kyoto implementation policies. Member states should select relevant actions related to the LULUCF sector within the end of 2006, among which cropland and grazing land management. According to our study, the CIS should envisage the abandonment of cropland during the 90's as a pertinent LULUCF action.
Management effects on the annual carbon balance of forests: an analysis of a global database

Denis Loustau (1), John Grace (2), André Granier (3), Ilaria Inglima (4), Ivan Janssens (5), Fredrik Lagergren (6), Anders Lindroth (6), Sebastiaan Luyssaert (5), Giorgio Matteucci (7), Maurizio Mencuccini (2), Eero Nikinmaa (8), Jianwu Tang (9), Lisa Wingate (2).

(1) INRA, UR 1263 EPHYSE
(2) University of Edinburgh, Institute of Atmospheric and Environmental Science
(3) INRA, UMR Ecologie et Ecophysiologie Forestières
(4) Facoltà di Scienze Ambientali, II° Università degli Studi di Napoli,
(5) Universiteit Antwerpen, Dept. Biologiebedrijfsadres,
(6) University of Lund, Department of Physical Geography and Ecosystems Analysis
(7) Dipartimento Scienze Ambiente Forestale e sue Risorse, Università degli Studi della Tuscia
(8) Department of Forest Ecology, University of Helsinki,
(9) Department of Forest Resources, University of Minnesota

(1) INRA, UR 1263 EPHYSE, 71 avenue Edouard Bourlaux, 33883, Villenave d'Ornon, France.
(2) University of Edinburgh, Institute of Atmospheric and Environmental Science, Crew Building, The King's Buildings, West Mains Road, Edinburgh EH9 3JN, United Kingdom.
(3) INRA, UMR Ecologie et Ecophysiologie Forestières, 54280, Champenoux, France.
(4) Facoltà di Scienze Ambientali, II° Università degli Studi di Napoli, v. Arena, 22, 81100, Caserta (CE), Italy.
(5) Universiteit Antwerpen, Dept. Biologiebedrijfsadres, Campus Drie Eiken, D C16, Universiteitsplein 1, 2610 Wilrijk, Belgium.
(6) University of Lund, Department of Physical Geography and Ecosystems Analysis, Sölvegatan 12, 223 62 Lund, Sweden.
(7) Dipartimento Scienze Ambiente Forestale e sue Risorse, Università degli Studi della Tuscia, via S. Camillo De Lellis, 01100, Viterbo (VT), Italy.
(8) University of Helsinki, Dept of Forest Ecology, Latokartanonkaari 7, (P.O. BOX 27), FIN-00014, University of Helsinki, Finland.
(9) Department of Forest Resources, University of Minnesota, 1530 Cleveland Ave N, St Paul, MN 55108, USA.

loustau@pierroton.inra.fr

Keywords
Forest, carbon balance, management, primary production, respiration.

Abstract
Management of forest targets the production of wood and biomass. It is hypothesized that managed forests show a higher net primary production (NPP) and, among NPP components, wood NPP, than unmanaged forests. In addition, they may have a lower soil carbon content and heterotrophic respiration as a result of (1) site preparation practices such as drainage, fertilisation, ploughing, and (2) exportation of biomass.

This presentation provides an analysis about the effects of management on the annual carbon balance of forests at the stand level. It is based on the database used by the Forest Activity group of the CARBOEUROPE project which is composed of carbon annual flux and stocks.
covering 124 forest stands classified according to management intensity into four classes: fertilised or irrigated, managed, unmanaged and recently disturbed. Even if the database was not fully representative of management regime at this preliminary stage, we believe such an analysis may take benefit from the large number of sites inventoried to detect some emerging trends of management impacts on forest C balance at the global scale.

The management regime explains 48 and 35 % of the net ecosystem production (NEP) and NPP variances respectively. Indeed, the NPP of the wood compartment is highest in fertilised or irrigated stands, intermediate in managed forests and lowest in recently disturbed and unmanaged forests. Management effect on NPP is larger during juvenile stages and weaker beyond the age of 50. Similarly, the management regime affects NEP and to a lesser extent the gross primary production (GPP) with larger effects during younger stages. In summary, the forest management appears to shorten the lifetime of forest stands, to magnify the age effects on the annual carbon balance and to shift the allocation of the allocation of carbon toward the wood compartment.
Can climate benefits be reconciled with revenues for land management?

Annette Freibauer 1, Hannes Böttcher 1, Yvonne Scholz 2, Vincent Gitz 3, Philippe Ciais 4, Martina Mund 1, Thomas Wutzler 1, Ernst-Detlef Schulze 1

1 Max-Planck-Institute for Biogeochemistry
2 Institute of Energy Economics and the Rational Use of Energy
3 CIRED - CNRS/EHESS
4 Laboratoire des Sciences du Climat et de l’Environnement

1 P.O. Box 100164, 07701 Jena, Germany
2 University of Stuttgart, Germany
3 45 bis avenue de la Belle Gabrielle, 94736 Nogent s/ Marne, France
4 Laboratoire des Sciences du Climat et de l’Environnement, Unité Mixte de Recherche CEA-CNRS, CE Orme des Merisiers, 91191 Gif sur Yvette, Cedex, France

afreib@bgc-jena.mpg.de

Keywords
forestry, regional carbon management, land management, mitigation, Germany

Abstract
Management changes in forest and cropland offer significant potential for cost-efficient climate change mitigation. However, which type of land management will best serve the climate in a concrete natural and socio-economic environment, remains an issue of debate. This study demonstrates in a systematic and comprehensive manner, based on real-life region-specific data of Thuringia/Germany, a region representative for central-western European conditions, how forest and agricultural enterprises can reconcile their net revenue with competing demands for products, energy and climate change mitigation.

We compared management alternatives in forests: timber production, shift to shorter rotations for energy, and conservation for C sequestration. Cropland options were food cereals, use of straw for energy, whole cereal crops for energy, short rotation coppice of poplar for energy, and afforestation with slow growing oak for timber production.

We determined the climate benefits of land management options in relation to different system boundaries: 1) carbon stock changes in the ecosystem, 2) the sector perspective including carbon stored in products, and 3) the comprehensive systems perspective including also the fossil C displacement by substitution of fossil energy in power plants and of fossil energy embedded in products. We also calculated the net annual revenue per hectare and net present value in order to determine mitigation costs.

Cumulative climate benefits were defined as the sum of C stocks in ecosystems and products and cumulative C substitution. The cumulative climate benefit was similar among the forestry options while the agricultural options diverged in proportion to C substitution. Timber forestry was very climate friendly because of efficient product recycling for energy. Among the agricultural options, at all time horizons, C substitution resulted in higher climate benefits than C sequestration in all cases. Even under very productive conditions C losses from deforestation for short rotation plantations would not be compensated by fossil C substitution within a century.

We demonstrate that forestry already delivers significant carbon services without being financially rewarded, while agriculture leaves significant potential for climate change mitigation unexploited. Recycling of primary land use products is essential for effective
climate change mitigation in the land use sector and allows to accommodate competing pressures on the land resource.