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FOREWORD

The EUROSIBERIAN CARBONFLUX project

This special issue of Tellus contains the collected scientific contributions from the first phase of the EUROSIBERIAN CARBONFLUX project.

About a decade ago a significant sink of atmospheric carbon dioxide was inferred in the northern extra tropics of which a significant fraction must be attributed to the terrestrial biosphere in Eurasia and North America (Keeling et al., 1989; Tans et al., 1990). This discovery has since been confirmed by many subsequent analyses [see e.g. the summary given by Prentice et al., 2002 and references therein]. However, this finding at once gives rise to a series of further scientific questions: Where exactly is this sink located? What is its magnitude? How does it vary with time? What are its underlying processes and how permanent are these? Answering these questions necessitates the development of monitoring systems for the determination of the carbon balance of large-scale continental areas. Later in the 1990's a second motivation for the accurate determination of the carbon balance on continental and regional scales emerged with the Kyoto protocol that specifically allows the possibility to partially discount fossil fuel CO_2 emissions on a national level with natural biospheric sinks.

Unfortunately, the determination of the carbon balance of large-scale regional (10^6 km) and continental scales is not trivial. Traditionally two lines of attack have been pursued. By means of the *top-down* approach on tries to estimate the surface sources and sinks from their spatio-temporal signatures reflected in the atmospheric CO_2 concentration field by means of inverse modeling. On the regional scale, this method suffers, however, from a lack of atmospheric measurements particularly in the interior of the continents, and the fact that the pertinent atmospheric signals are very small and superimposed on relatively large day-to-day concentration variations, which are difficult to represent in atmospheric models. Alternatively, it has become possible to measure directly the exchange flux of CO_2 *in situ* over the canopy with relatively high accuracy using micrometeorological techniques. Using the *bottom-up* approach one may then try to scale the point measurements up to regional and continental ecosystems. In selected areas of the world it is also possible to estimate regional carbon balances at least for forested areas from detailed forest inventory statistics. Finally, there exist new approaches based on remote sensing of the surface reflectance in various wavebands, which may be related to properties of the vegetation (e.g. above ground biomass) and their temporal changes. However, a part from specific methodological problems with the measurements themselves, all of these bottom-up extrapolations on its own rely on scaling assumptions, which are not easy to justify. Obviously, an integrated approach has to be developed, in which the bottom-up and top-down strategies are merged in a rational way.

The EUROSIBERIAN CARBONFLUX project was conceived to initiate such an integrated approach for the monitoring of the European and western Siberian boreal forest ecosystem. Seven research groups from Western Europe together with a joint Russian group from Moscow and Krasnojarsk[1] designed and executed the project during 1998–2000 with

[1]Max-Planck-Institute for Meteorology, Hamburg, Germany, Max-Planck-Institute for Biogeochemistry, Jena, Germany, Institut für Umweltphysik, Ruprecht-Karls-Universität, Heidelberg, Germany, Laboratoire des Sciences du Climat et de l'Environnement, Saclay, France, Université Paul Sabatier/Centre d'Études Spatiales de la Biosphère (CESBIO), Toulouse, France, Centrum voor Isotopen Onderzoek, Faculty of Mathematics and Natural Sciences, Rijksuniversiteit Groningen, The Netherlands, Department of Meteorology, Arrhenius Laboratory, Stockholm University, Sweden, Institute of Evolution and Ecology Problems, Russian Academy of Sciences, V. N. Sukatschev's Laboratory of Biogeocenology, Moscow, Federal Republic of Russia, V. N. Sukachev Institute of Forest, Siberian Division, Russian Academy of Sciences, Academgorodok, Krasnoyarsk, Federal Republic of Russia.

financial support from the European Union under its 4th framework programme. The chosen main focus area of Siberia was motivated for several reasons. Siberia (defined here as the forested areas of Russia east of the Ural mountains) clearly constitutes a major component of the global terrestrial carbon cycle, comprising about 90 PgC or ∼4% of the global amount of carbon stored in vegetation and soils and contributing about 2.4 $PgCa^{-1}$ equivalent to ∼4% to the global annual net primary production. Climate change projections for this century indicate substantially larger than average warming in continental Siberia while almost 65% of the Siberian forests lie on permafrost. Monitoring the fate of this important carbon cycle component over the years to come clearly constitutes a scientific necessity.

The Siberian environment also offers distinct scientific advantages for observations. The climate of the interior of the Eurasian continent is dominated by large interannual variability, providing a natural laboratory for the investigation of longer-term climate impacts on terrestrial ecosystems. In particular western Siberia consists of a large flat and relatively homogenous ecosystem mosaic of forests and wetlands, a distinct benefit for scaling studies by integrated observations and models. Compared to Europe the Siberian environment is only modestly affected by anthropogenic impacts: most of the vast boreal forest ecosystem is still dominated by natural processes while the atmospheric composition in the planetary boundary layer mostly reflects natural terrestrial sources.

The EUROSIBERIAN CARBONFLUX project included four key activities: (1) regular (every 2–4 weeks) year-round measurements of the atmospheric composition (a.o. CO_2 concentration and its isotopic composition, O_2/N_2 ratio measurements, CH_4 and CO concentration) in the planetary boundary layer up to ∼3 km by means of light aircraft, (2) year-round

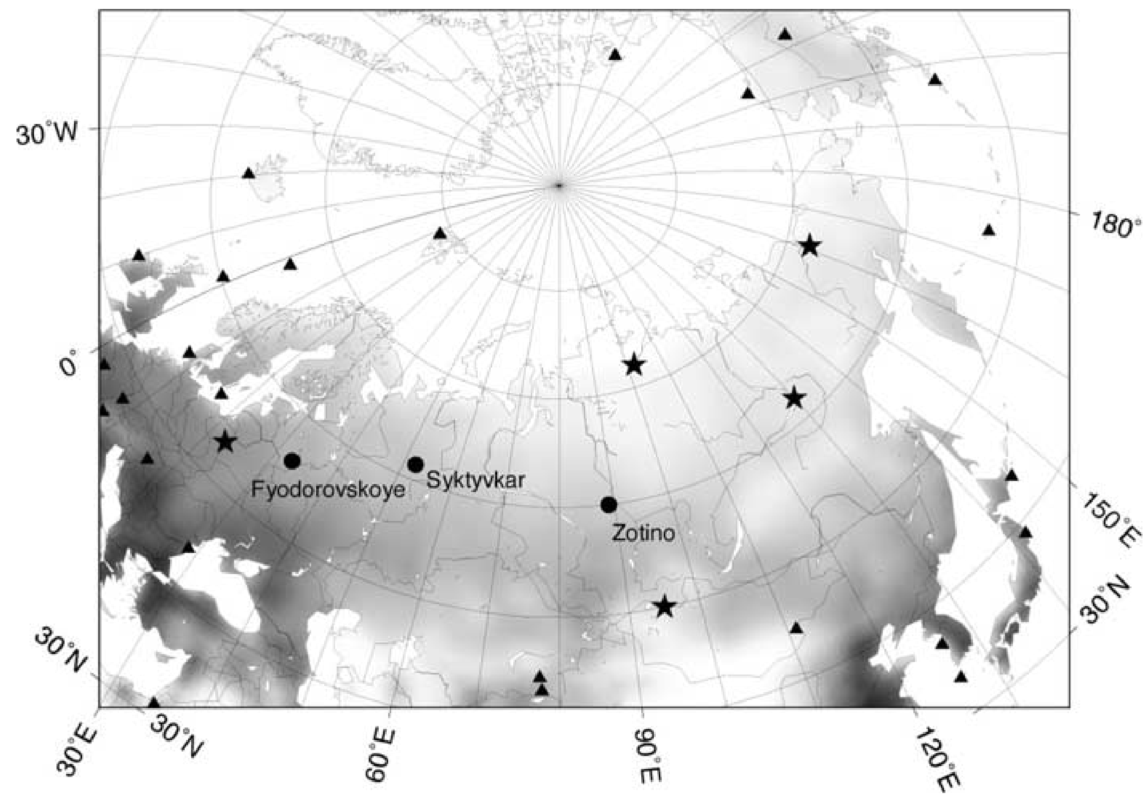

Fig. 1. EUROSIBERIAN CARBONFLUX project area. Circles: main project sites, stars: new project sites in follow-up project (TCOS-Siberia), triangles: surface and aircraft station network of partner agencies [GLOBALVIEW-CO_2, AEROCARB project]. Gray shading indicates net primary productivity for 1998 estimated from remote sensing data (Lafont et al., 2002).

continuous surface flux measurements by the eddy covariance technique over key forest and bog ecosystems, (3) *in situ* process studies on terrestrial carbon cycling and for scaling point measurements to the region by means of the atmospheric boundary layer budget technique, (4) development of a combined atmospheric-surface modelling system for the coherent synthesis of the measurements obtained on the various spatial and temporal scales during the project. The main surface and atmospheric observational programme was conducted along a west-east transect at approximately 60°N from western Russia to central Siberia with the three main stations Fyodorovskoye, Syktyvkar and Zotino (Figure 1, see Schulze et al., 2002, for an overview of the geographical region).

Many of the most important questions regarding the terrestrial carbon cycle require a long-term observation strategy. It was thus clear from the outset of EUROSIBERIAN CARBONFLUX, that a continuation beyond the nominal first three years of the project was necessary. Consequently, with support from the 5th framework programme from the EU a successor project "Terrestrial Carbon Observing Programme—Siberia (TCOS-Siberia)" has been launched for the time period 2002–2004. This new project also includes an expansion of the observation network with additional stations in eastern Siberia, the Arctic, the southern Siberian grasslands and at the western target region boundary in eastern Poland (Figure 1). With this extension it is hoped to cover the boreal ecosystems of Eurasia more completely and to significantly enhance the experience gained during EUROSIBERIAN CARBONFLUX.

Acknowledgements

Working in the interior of northern Eurasia is not always easy. The harsh climatic environmental conditions e.g. at Zotino in central Siberia with winter air temperatures dropping below −55°C and summer midday temperatures exceeding 30°C in conjunction with a frequent high mosquito density impose serious endurance and stamina requirements on field scientists and their technical equipment. Logistical and bureaucratical impediments also often pose challenges. Fortunately, the project profited immensely from the heartily support and cooperation with the ever helpful and friendly Russian colleagues, both from the partner institutes and from the local villages in the field. The scientific advances made today, as witnessed in this volume, would not have been possible without them. In the name of all western European participants, I very gratefully acknowledge their support. Special acknowledgements also go to Claus Brüning, project manager at the DG-XII, European Commission, for his diligent support of the project. EUROSIBERIAN CARBONFLUX was funded in the 4th framework programme of the European Union under project no. ENV4-CT97-0491.

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Martin Heimann
Max-Planck-Institute for Biogeochemistry
Postfach 100164
D-07701 Jena, Germany