Daily Report – Thursday, 5th September 2013

Depature 8.05 from Tartu

On the Way to Järvselja Mr. Miguel Portillo Estrada repeated some information about Estonia and told us some facts about Järvselja forest or measurements like gas exchange in ecosystems and soil respiration.

Arrival 9.25 in Järvselja

We started a half day excursion to Järvselja to visit the ICOS (Integrated Carbon Observation System) project on European soil. The main topic of this excursion was the eddy covariance method. The project at this station began in 2008. With the eddy covariance method you can measure the vertical turbulent fluxes between the surface boundary layer and the atmosphere. We learned something about the measurement of wind speed, gas concentration, especially of carbon dioxide, temperature, humidity and the pressure, which are measured on many points of the tower. Through the wind speed and the concentration of particles in the air, it is possible to reconstruct the place of origin. The aim why measurements are taken is to find out the boundary layer resistance. At night there is much carbon dioxide respiration in the soil which the plants can use for photosynthesis and growing. During the day the plants need water to transpire oxygen.

The measure system of an eddy-tower is composed of a 3D Sonic Anemometer, which measures the wind speed, a portable photosynthesis measurement and a thermometer.

Beside the wind speed measured by the 3D Sonic Anemometer the Porometer measures the gas exchange on leave level of carbon dioxide and water vapour.

At this place there are many interesting plants like *Anemone hepatica*, *Asarum europaeum*, *Oxalis*, *Paris quadrifolia* and *Filipendula ulmaria*. Especially the plants *Aegopodium podagraria*, *Crepis paludosa* and *Lamium galeobdolon* are indicators for nitrogen and humus-rich soil, and *Climacium dendroides* is an indicator of eutrophic and wet soil.

After a short trip we arrived at the second place. We walked to the next stop; there we saw the new station with a tower of 130 m in height. The tower that has a foundation of 4-5 tons was built during the last winter because the soil was frozen. This took only about 6 weeks. This new building will accomodate automatic devices for climate variables and gas concentrations.

After that we saw a Primary Forest, this is a forest which hasn´t been touched by silviculture for almost 100 years. The tallest tree is the Picea abies with a height of 43.1 m and a diameter of 71.7 cm and an age of 250 years.

We drive back to Tartu at 12.35.

Arrival at Tartu 13.30

At 14.35 Marian Kazda began the lecture on the topic "Plant growth in wetlands". He spoke on plant stress under flooding and also under hypoxia. He told us that most growing processes stop when plants are under stress. The plant stress under flooding has three big negative effects: oxygen shortage (hypoxia and anoxia), chemical changes of soil properties and post-anoxic oxidative stress.

Mr. Kazda showed us an example of a tomato plant under hypoxia and a tomato plant without hypoxia. The normal plant had normal gibberellic acid and cytokine concentrations while the concentrations in the plant under hypoxia were reduced. In contrast, the abscisic acid concentration in the tomato plant under hypoxia is increased which results in stomata closing the stomata. In the normal tomato plant the abscisic acid concentration is low and the stomata are open. Also the ethylene concentration in the plant under hypoxia is increased in comparison to the normal plant. Moreover the leaves of the tomato plant under hypoxia are curved.

We also learned that the consequence of a low oxygen supply is a shortage of energy. To understand how serious the consequence of a low oxygen supply is, Mr. Kazda gave us an example: a plant under normal conditions makes 38 ATP, a plant with a low oxygen supply makes only 2-3 ATP, because of the different ways of energy-production. Another effect of a low oxygen supply is a low root growth.

Later he told us some effects of hypoxia and anoxia on soil properties like that redox potential falls and that there are more reduced cations in the soil solution such as Fe^{2+} and Mn^{2+}. After that we learned what plants can do to protect themselves. Plants can cover root issues to protect themselves of ions. He explained us that plants can release oxygen out of the roots that there is a tiny oxygenic space around the roots which microorganisms which can use oxygen to transform reduced ions. Then Marian Kazda explained us how plants adapt to low oxygen levels in the substrate. Plants can guide oxygen through plant aerenchyma due to processes humidity-induced pressurisation, thermoosmotic ventilation and Venturi-effects. We learned that the gas diffusion of oxygen is possible through porous-membrane within the leaf, enabling gas diffusion but preventing the mass flow.

After that we got some information on radial oxygen loss and the carbon cycle. The roots release oxygen and organic carbons, through aerobic respiration of microorganism the organic carbons transfers to carbon dioxide which the soil respires in the atmosphere. Roots are associated with methane-oxidation bacteria to oxidize methane to carbon dioxide, which they can use for photosynthesis. He explained us that in wetland plants the supply of the rhizosphere with oxygen is highly important for methane oxidation.

At the end of his presentation he gave us a short summary. He repeated that the supply of the rhizosphere with oxygen by wetland plants is highly important for methane oxidation and the methanotrophic methane-oxidation provides carbon dioxide for plant photosynthesis. He also repeated that the fluctuation in internal oxygen concentrations indicates complex interactions between aeration and oxygen consumption.

Zuzana Urbanova gave a summary of "wetland and carbon fluxes". She began with some attributes of wetlands: a transitional ecosystem between aquatic and terrestrial systems, which is permanently or periodically waterlogged or flooded, hydrotropic vegetation and the substrate is saturated with water. The definition of the Ramsar Convention is "... wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters." The Ramsar convention is of international importance, especially as a waterflow habitat. It is an international treaty for the conservation and sustainable utilization of wetlands, to stop loss of wetlands, to recognize the fundamental ecological functions of wetlands and their economic, cultural, scientific and recreational value.

Wetlands make only 6% of the earth surface. The ecological function of wetlands is complex; the wetlands are the most biologically productive and biologically diverse ecosystem, with living filters and element cycling (e.g.

accumulation, transformation and transport). Wetlands influence atmosphere and hydrosphere, further the flood control, shoreline stability and they host many species of plants and animals.

Later she presented us the main factors affecting wetlands: the hydrology and climate, the trophic status and oxic vs. anoxic conditions. Especially wetland biotopes are determined mostly by hydrology, e.g the source of water (precipitation, groundwater, surface water), the water depth and its fluctuation, the flow rate, the timing and duration of flooding and the hydrology influences of chemical and physical traits, e.g. soil anaerobiosis, nutrient cycles and their availability and organic matter accumulation, which influences plant species composition. Wetlands can be classified in marine and coastal wetlands, inland wetlands and human-made wetlands. Typical for the marine and coastal wetlands are shallow marine waters, coral reefs, rock and sandy shores, intertidal zones, salt marshes, lagoones and estuarine waters. The characteristic for the inland wetlands are riverine, like river deltas, rivers, creek, streams and floodplains, the lacustrine, e.g lakes (freshwater, salt periodic ...) and the palustrine like marshes, swamps, wet grasslands, fens, bogs, springs and oases. At last the human-made wetlands are classified through ponds, rice paddies, water reservoirs, sand and stone pits, constructed wetlands, ditches, canals and drains. Then we learned something about carbon in wetlands, particularly that carbon is the basic element of life forms. Carbon is needed for the photosynthesis and the respiration in the aerobic system. The major reservoir of carbon is not the atmosphere with 735 Pg but the soil with 2100-2500 Pg, especially the wetlands contributed with 450-700 Pg (Pg = 10^{15} g). She gave us some information about the carbon cycling in wetlands. The ecosystem absorbs carbon through photosynthesis and loses it through autotrophic respiration, heterotrophic respiration and leaching. Carbon accumulates when immobilisation in humus and/peat exceeds carbon losses. The result of the carbon cycling is the ecosystem carbon balance. Carbon accumulation exists in wetlands because of slower decomposition. The decomposition rate is controlled by the hydrological regime, the content of oxygen, the temperature, the quality and quantity of organic material, the microbial activity, the pH, nutrient content, water quality and so on. The result of carbon accumulation varies between wetland types and in time.

The variability of carbon fluxes was a short chapter in her lecture. Both, photosynthesis (GPP) and ecosystem respiration (Re) are controlled by many factors, which can change gradually: the climate (radiation, temperature, and precipitation), the plant species composition (quality and quantity of organic matter, root exudates ...) and the hydrology. These three points are all in interaction with each other. The carbon fluxes vary over the years.

The next topic is the wetlands as a methane source and the factors influencing methane production and emission are an important point of this topic. Wetlands are one of the largest natural sources of methane to the atmosphere. Particularly methane has a 25 times stronger global warming potential than carbon dioxide. As a result wetlands have dual impact on climate, the sink of carbon dioxide and the source of methane. Methane is an end product of anaerobic decomposition under the most reduced condition, when other electron acceptors (Oxygen, Nitrate, Iron, Manganese, Sulfate) are depleted. Methane is produced by methanorganic Archaea and they use as a substrate e.g. acetate, carbon dioxide and hydrogen or methyl compounds. The transport from the methane to the atmosphere happened via plants (aerenchym), diffusion and ebullition. Aerobic methanotrophic bacteria are responsible for the methane oxidation. The next point are the factors, which influence the methane production and emissions e.g. hydrology (aerobic/anaerobic conditions), the trophic status (nutrients, pH, substrate availability ...), the plant species composition (oxygen transport through aerenchyma, quality of organic matter, exudates ...) and the temperature. Analogical to the carbon accumulation, the methane production and emissions vary also in time and between wetland types.

At the end of her presentation she showed us something about the feedback mechanism of wetlands and climate. The carbon dioxide sequestration represents the cooling effect and the methane emissions the warming effect. Global warming potential (GWP) is a measure of the relative effect of a given substance compared to carbon dioxide. Methane has more effective thermal absorption and has increased in methane concentration over the last 200 years from 0.7 to 1.8 ppm.

The last question was: "What will be the impact of climate change to wetlands?" The sea level rises, especially at the coastal wetlands, the higher temperatures e.g. increase in photosynthesis, respiration, biomass production, decomposition, methane emissions, changes in plant composition and so on, and the changes in precipitation with hydrology, plant composition, biogeochemical process and so on. The climate change is projected to be the most severe at the high latitudes where most peatlands are situated, and the permafrost melting in the tundra.

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