study. In addition to surface fluxes we measured CO2 concentration and isotopic signature of depth profiles along the chronosequence. Radiocarbon signatures in the mineral soil differed significantly from the isotopic signature of surface CO2 fluxes, indicating that the majority of the soil respiration flux is derived from near surface layers.

B22B-04 1440h

Dependency of Ecosystem Respiration in a Cool Temperate Bog on Peat Temperature and Water Table

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We measured ecosystem respiration (ER) from nighttime net ecosystem exchange of carbon dioxide determined from an eddy covariance tower located in a large ombrotrophic bog near Ottawa, Canada. Measurements were made from May to October over 5 years, 1998 to 2002. Ecosystem respiration ranged from <0.05 mg CO2/m2/s in spring (May) and late fall (late October) to 0.10-0.15 mg CO2/m2/s during the summer (July-August). As anticipated, there was a strong relationship between ER and peat temperatures, such as at a depth of 5 cm ($r2 = 0.63$). Q10 over 5° to 15°C varied from 2.2 to 4.2 depending upon the choice of temperature level and location within a hummock or hollow. Unexpected for a wetland ecosystem, there was only a weak relationship between ER and water table position ($r2 = 0.11$). Comparison of ER in early and late summer, 2002 with similar surface temperature revealed no significant difference in ER. A laboratory incubation of peat cores at different moisture contents showed that CO2 production was reduced by drying in the surface samples, but there was little decrease in samples from below a depth of 30 cm. We believe that the lack of correlation between ER and water table position in this ecosystem results from an increase in CO2 production at depth compensating a decrease in production of CO2 by heterotrophic respiration in the near surface layers and autotrophic respiration in the moss community.

B22B-05 1455h

Physical Evidence for Deep Ebullition Fluxes in Northern Peatlands

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Recent field studies from northern Minnesota indicate that deep ebullition fluxes may be a major component of the methane cycle in large peat basins. Zones of overpressure were discovered under raised bogs across the Glacial Lake Agassiz peatlands in which biogenic gas bubbles accumulate in semi-elastic compartments confined by dense wood layers. Instrument stations at the Red Lake bog indicate that overpressures persist for long periods, although short depressuring cycles are triggered by a combination of droughts and/or sharp declines in atmospheric pressure. These depressuring cycles occur synchronously with large surface deformations that exceed 20-30 cm in 2 to 6 hours indicating the release of large volumes of gas from deep overpressured compartments. We calculate that the 3 largest surface deformations in August 1997 alone were associated with the release of 136 g CH4 m-2 which exceeds by an order of magnitude the annual average chamber fluxes measured at this same site. Similar large changes in gas volume at depth were obtained using 2 different independent methods based on 1) the degree of overpressuring in the deeper peat and 2) relating the barometric efficiency of the piezometers to specific yield of the shallow peat. Further evidence for large volumes of gas in the deeper peat was also detected by imaging peat cores with Magnetic Resonance Imaging. These studies indicate that the dynamics of free-phase gas plays an important role in the carbon cycle of large peatlands.

B22B-06 1510h

The significance of methane ebullition

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Ebullition is often the dominant pathway of methane release from aquatic ecosystems, yet it has seldom been carefully measured, due to heterogeneity in the spatial distribution and episodic release of gas bubbles. This likely results in an underestimation of total methane emission. We took advantage of ice formation over lake surfaces in NE Siberia to map patterns of ebullition. As ice forms in autumn, bubbles released from lake sediments are continually trapped under the ice at the water surface resulting in stacks of bubbles separated by thin films of ice called koshkas'. Mapping the distribution of koshkas enabled us to identify background' patterns of ebullition. In addition, we located hot-spot' ebullition sites that remain permanently open throughout winter due to exceptionally high rates of methane bubbling. We used random and selective placement of underwater/ under-ice chambers to measure background' and hot-spot' fluxes annually. The combination of mapping and chamber measurements among different types of lakes and along lake margins varying in intensity of thermokarst erosion or aquatic plant growth enabled us to 1) improve estimates of total methane emissions from NE Siberian lakes, and to 2) identify landscape processes (thermokarst erosion vs. wetland mat formation) that enhance methane production and emission. Ignoring the contribution from hotspots, background ebullition comprised more than 75% of total methane emissions from lakes. From hotspot sites we measured up to 10-L m-2 of methane per day in early summer. Although hotspots comprised roughly 0.05% of the area along thermokarst margins, where they were most common, ebullition from hotspots contributed approximately 69% of the total ebullition flux. Including the flux from hotspots could increase estimates of CH4 ebullition from thermokarst margins 300%! Thermokarst lakes in Russia comprise a large proportion of the world's high latitude lakes; yet they are understudied. North Siberian lakes differ from most lakes in Alaska and Canada because they are surrounded by ice-rich (50-90% ice) permafrost that facilitates intense thermokarst erosion along lake margins. In turn, organic-rich (2%) mineral soil subsides into anaerobic lake bottoms, providing a fresh, labile substrate for methanogenesis. Increased thermokarst erosion with climate warming would provide a positive feedback to methane production and emission from lakes. Although thermokarst activity likely results in higher emissions of methane via ebullition from North Siberian lakes than from other northern lakes, results from this study suggest ebullition may be a more important pathway of methane emission than what has been reported to date.

B22B-07 1525h

Use of Stable Isotopes and Incubation Studies to Characterize Methane Production Mechanism in Northern Wetlands

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Arctic and boreal ecosystems are important since they occupy greater than 1/5 of the Earth's terrestrial surface, they are sensitive to subtle climate changes, and they have significant effects on the atmosphere. Methanogenesis is dominated by two major pathways, acetotrophic (i.e., acetoclastic) methanogenesis in which acetate is the immediate precursor of CH4 (and CO2), and H2/CO2 methanogenesis in which CH4 is a product of H2 oxidation coupled with CO2 reduction. Recent studies suggest that acetotrophic methanogenesis does not occur widely in the northern wetlands and acetate can accumulate to high levels (Duddleston et al., 2002; Hines et al., 2001a). Methanogenesis at these sites is dominated by the H2/CO2 pathway and the importance of acetate as a precursor of CH4 seems to decrease with decreasing temperature and increasing oligotrophy. We surveyed a transect across Alaska from Deadhorse to Anchorage and used stable isotope distributions of DIC, CH4 and H2O to discern the relative importance of differing methane production mechanisms. These results compared favorably to incubation studies. Vegetation type was found to be a strong indicator of methane production mechanism, with Carex indicating acetotrophic methaneogenesis and sphagnum being an indicator of a lack of acetate methaneogenesis. The effects of production pathway variation on the dD of methane will also be presented.

B22C MCC: 3002 Tuesday 1340h

Validation and Application of Land Surface Products From the MODIS Sensor II *(joint with H, GC)*

Presiding: **S W Running,** University of Montana**; R Nemani,** NASA Ames Research Center

B22C-01 1345h

Terrestrial Carbon Sinks Predicted From MODIS Satellite Data and Ecosystem Modeling

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A simulation model (NASA-CASA) based on satellite observations of monthly vegetation cover from the moderate resolution imaging spectroradiometer (MODIS) was used to estimate monthly carbon fluxes in terrestrial ecosystems during 2001. For the terrestrial biosphere, predicted net ecosystem production (NEP) flux for atmospheric carbon dioxide was estimated as annual net sink of 3.6 Pg C. Our NASA-CASA model results for NEP in 2001 reflect observed climate patterns between and within major continental areas of the terrestrial biosphere. Above average temperatures were strongly associated with positive NEP (net sink fluxes) across the high latitude zones of eastern Canada and Eurasia. Positive NEP fluxes were also associated with the heavy rainfall reported in eastern Europe, Siberia, Australia, West Africa, and southern Africa. Negative NEP (net source fluxes) were associated with severe droughts reported in south Asia, eastern Africa, northern China, and northern and eastern coastal South America.

URL: http://geo.arc.nasa.gov/sge/casa/

B22C-02 1400h INVITED

Accuracy of the MODIS Snow-Cover Maps in Forest and Mixed Agriculture and Forest Land-Cover types

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Snow-cover maps have been produced globally since March of 2000 from the Moderate-Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. Other snow products such as fractional-snow cover and snow albedo have also been developed and will be available soon. The 500-m resolution snow maps have been validated in different land covers. It has long been known that it is difficult to map snow in dense forests, and thus the snow-mapping accuracy is lowest in forested land covers because trees, particularly dense forests, block the view of the ground where the snow accumulates. Accuracy of mapping snow cover at the global scale varies by month, mainly because the percentage of snow-covered forest varies as snow accumulates and melts during the year. Errors are greatest between the months of November and April in North America (9%) and Eurasia (9-10%) when the snow completely covers the boreal forest, and the least in the months of July through September. Using a 1-km resolution MODIS 17-class land-cover map product, developed at Boston University, we classify the Northern Hemisphere into 7 land-cover types (plus water): forest, mixed agriculture and forest, barren/sparsely vegetated, tundra, grasslands/shrublands, wetlands, and permanent snow and ice. Under a complete snow cover, snow-mapping errors are generally <5% in all of the classes except forest and mixed agriculture and forest, where errors can be as high as 10% in the spring and fall transition seasons. In this paper we study in detail the accuracy of the 500-m resolution MODIS Version 4 snow maps in these regions using Landsat ETM+ data used as "ground truth." For example, in the mixed agriculture and forest land cover type in south-central Nebraska and northern Kansas, comparison of a Landsat-derived snow map (used herein as "ground truth") with a MODIS snow map on 14 December 2000 showed that 96% of the pixels were correctly identified as snow (after cloud masking). We also use the MODIS vegetation continuous fields (VCF) product to determine percent tree cover for use in further validating the snow maps in the forest land-cover type. Limitations of this method of snow mapping include the presence of cloud cover.

URL: http://modis-snow-ice.gsfc.nasa.gov

B22C-03 1415h

Global Retrieval of Roughness Length from EOS-Terra Satellite Products and Limited Field Study Data

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Global and regional retrievals, which illustrate the seasonality, of roughness length will be presented. Roughness length is a key factor in estimating the sensible and latent heat fluxes in climate models. In the past the lack of observations made it necessary for most climate models to use relatively crude estimates for roughness length. Typically the roughness length was assigned a constant value for each of the land cover classifications. In reality roughness length depends upon the average height, shape, density and Leaf Area Index (LAI) of the vegetation present. The retrievals presented here depend on these four variables, and they represent a significant improvement over past approaches. The parameterization of roughness length in terms of the four variables (average height, shape, density and LAI) is based on the work of Raupach and Lindroth. The roughness length is formulated in such a way that roughness length can be found either by remote sensing or by variables used in climate models with interactive canopies. The EOS-Terra satellite products used are the overstory plant density and LAI for the seven treed IGBP land cover classes (evergreen and deciduous needle-leaf, evergreen and deciduous broad-leaf and mixed forests, savannah and woody savannah). The tree crown shape (the canopy height-to-width ratio) is based on field studies; it depends on the tree's basic shape (conical or elliptical) and on latitude. At present, the height is of all the vegetation is the average height for the various land cover classifications found in numerous field studies. Limitations of the current retrieval and future improvements will be discussed.

B22C-04 1430h

Integrating Aircraft, Tower fluxes, MODIS and Biome-BGC to Study Carbon Dioxide and Water Vapor Fluxes over Arctic Alaska

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To understand carbon and water dynamics of susceptible Arctic Tundra ecosystem, intensive and integrated methods are implemented on the North Slope of Artic Alaska, including eddy covariance, remote sensing and ecosystem models. Tower-based eddy covariance instruments have strongly ability to measure long-term temporal trend, and aircraft-based flux measurements is able to assess spatial variations efficiently. Both of complemental measurements have been used on this region for several years. The Aircraft (Sky Arrow ERA 650) with eddy covariance and remote sensors flied at 100 km scale over 115 hours in 2001. The aircraft fluxes are compared to tower fluxes at Barrow, Atqasuk and potable tower. The correlation of aircraft fluxes and MODIS NDVI, EVI and LAI are addressed. MODIS GPP, PSN, NPP are validated by tower measurement at long-term temporal scale and by aircraft measurement at larger spatial scale. The process-based ecosystem model, Biome-BGC, is run at five sites: Barrow, Atqasuk, Ivotuk, Toolik Lake, Prudhoe Bay. While the model can computer components of CO2 flux that cannot be directly monitored, the comparisons of model outputs and aircraft, tower measurements are used to help improve the model estimate ability. The intercomparison of model and MODIS is also discussed in this paper. Key words: Arctic tundra, trace-gas flux, aircraft-based, eddy covariance, MODIS, Biome-BGC

B22C-05 1445h

Intercomparison of Land Surface Remote Sensing Products From Various Sensors.

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The biophysical activities on land surfaces are documented from spectral measurements made in space. Advances in the understanding of radiation transfer and availability of higher performance instruments have lead to the development of a new generation of geophysical products able to provide reliable, accurate information on the state and evolution of terrestrial environments. Specifically, a series of optimized algorithms have been developed to estimate the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) for various instruments. Such an approach allows the synergistic use of FAPAR products derived from different sensors and the construction of global FAPAR time series independent from the life time of these specific sensors. The outline of the methodology will be summarized and the preliminary results of an inter-comparison exercise conducted with SeaWiFS, MERIS(ENVISAT), MISR(Terra) and MODIS(Terra) products will be presented.

B22C-06 1500h INVITED

MODIS LAI and FPAR Product on Global, Regional and Local Scales

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An algorithm based on physics of radiative transfer in vegetation canopies for the retrieval of vegetation green leaf area index (LAI) and fraction of absorbed photosynthetically active radiation (FPAR) from MODIS surface reflectance data was developed, prototyped and is in operational production at NASA computing facilities since June 2000. This presentation is focused on the analysis of the of the LAI and FPAR retrievals as a function of time and spatial scale as detailed below. First theme covers analysis of the global MODIS LAI and FPAR products from July 2000 to December 2002, collections 1 and 3. About 70% of the total retrievals are obtained with the main radiative transfer based algorithm. Temporal compositing from 8-day to monthly further increases the frequency of main algorithm retrievals. The retrieved LAI and FPAR fields display expected features when analyzed by biomes and latitudes. The main algorithm fails as expected when input surface reflectance data have high uncertainties, especially under snow and cloud conditions. The analysis presented here reinforces the need for examining product quality flags accompanying the LAI and FPAR product before using these products in application studies. Second theme covers analysis of the LAI product at regional and local scales. We highlight the statistical nature of MODIS LAI and FPAR products arising from the relation between uncertainties in algorithm inputs and outputs, using Collection 3 MODIS LAI product. Two random variables impact the quality of retrieved LAI and FPAR fields at local scale- uncertainties in biome classification and surface reflectance measurements. To decrease impact of input uncertainties, averaging of LAI and FPAR product over an extended area is required to accumulate a sufficient number of pixels with high quality input. Further improvements in LAI and FPAR retrieval coverage and quality will require a better consistency between observed and simulated reflectances in spectral space.

B22C-07 1515h

Using Vegetation Continuous Fields to Monitor Change in Forest Cover

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Using continous fields of percent forest cover from MODIS data, an approach to monitor change has been developed. The algorithm utilizes a regression tree to automatically generate annual global estimates of forest cover. The 500 meter MODIS data represent an intermediate resolution appropriate for monitoring many types of human-induced land cover change. Three years of MODIS data have been processed and initial results show that deforestation events can be detected on an annual basis. Results from Brazil highlight clearing for agroindustrial purposes, particularly in Mato Grosso state. Field work in this region has been performed and reveals a good correspondence between MODIS-estimated percent forest cover and in situ forest cover measurements. These initial results point the way of operational change detection mapping of global forest cover and other biophysical parameters.

B22C-08 1530h INVITED

The MODIS Rapid Response Project: Near-Real-Time Processing for Fire Monitoring and Other Applications

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The Moderate-resolution Imaging Spectroradiometer (MODIS) instrument on board the Terra and Aqua satellites offers an unprecedented combination of daily spatial coverage, spatial resolution, and spectral characteristics. These capabilities make MODIS ideal to observe a variety of rapid events: active fires, floods, smoke transport, dust storms, severe storms, iceberg calving, and volcanic eruptions. The MODIS Rapid Response System (http://rapidfire.sci.gsfc.nasa.gov) was developed at NASA's Goddard Space Flight Center to provide a rapid response to those events, with initial emphasis on active fire detection and 250m-resolution imagery. MODIS data for most of the Earth's land surface is processed just a few hours after data acquisition. A collaboration between NASA, the University of Maryland and the U.S.D.A. Forest Service has been developed to provide fire information derived from MODIS to federal fire managers. Active fire locations in the conterminous United States are produced by the MODIS Rapid Response System and communicated to the Forest Service within a few minutes of production. The MODIS Rapid Response processing was also adapted to Direct Broadcast to reduce the product turn-around to just minutes after data acquisition regionally. MODIS active fire locations are used by the Forest Service to generate regional fire maps over the United States, updated twice daily and provided to the fire managers to help them allocate firefighting resources. Active fire locations are also distributed in near-real-time to the Global Observation of Forest Cover (G.O.F.C.) user community through a web interface integrating MODIS active fire locations and Geographic Information System (G.I.S.) datasets. The suite of MODIS rapid fire products is currently being complemented with a Smoke Index product and a Burned Area product that will represent two new key tools available to the fire community. Finally a new collaboration with the U.S.D.A. Foreign Agricultural Service was recently developed to generate near-real-time MODIS data for crop monitoring and forecasting applications. A rapid Vegetation Index product was created to that effect.

B22D MCC: 3014 Tuesday 1600h

Carbon Cycling in Northern Soils and Surface Waters II *(joint with H)*

Presiding: **J J Carrasco,** U.S. Geological Survey**; R G Striegl,** U.S. Geological Survey**; K P Wickland,** U.S. Geological Survey

B22D-01 1605h INVITED

The role of dissolved organic carbon in northern wetland landscapes

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Wetlands play a large role in the cycling of DOC in northern landscapes from the land surface to aquatic ecosystems and there is a strong relationship between stream DOC export or concentration and proportion of the watershed occupied by peatland. These relationships have developed through the production potential for DOC from plant tissues and peat, the hydrologic transport mechanisms and the general lack of strong retention mechanisms in peatlands and other wetlands. I examine our knowledge of the atmospheric import, internal production, adsorption by mineral soils and export of DOC in northern peatland/upland systems from Ontario, Michigan and Finland and northern Manitoba.

B22D-02 1630h INVITED

Methane Emission and Net Ecosystem Exchange in Melt and Permafrost-Plateau Bog Features Within the Discontinuous Permafrost Zone of Northern Alberta, Canada

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Recent evidence indicates northern latitude permafrost is degrading in response to changing climate conditions (elevated temperatures and changing moisture input) which may significantly alter the processing of peatland carbon. As the permafrost melts, the bog surface subsides to the level of the surrounding water table creating a collapse scar with saturated surface conditions. Previously frozen peat is now available for decomposition and may become part of methanogenic processes elevating methane pools and emissions. Increased primary production in the collapse scar provides a sink for carbon dioxide and may counterbalance the greenhouse effect of a greater methane emission from these sites. However, increased primary production may stimulate methanogenesis and provide a positive feedback to even greater methane emissions. It is this balance of methane (CH_4) and CO_2 exchange that was examined within 7 melt features in northwestern Alberta during the growing season of 2002 (May to October). To measure CH_4 and CO_2 exchange, clear phytochambers (0.28 m^3) were placed on sampling frames (0.43m^2) inserted into the peat surface. Each site had 4 sampling frames (plots) in the melt feature and 4 plots in the permafrost plateau. Methane emission was measured by headspace grab samples analyzed on a FID-GC and net ecosystem CO_2 exchange (NEE) was estimated utilizing a LiCor 6200 portable photosynthesis system. During peak methane emission in late August, melt scars ranged between 2 to 10 mg CH_4 $m^{-2}h^{-1}$ as compared to the highly variable (near zero) permafrost plateau maximum exchange of 0.15 (emitted) to -0.15 (oxidized) mg CH_4 $m^{-2}h^{-1}$. Along a transect within the melt at two sites, methane emission and NEE peaked 2 meters from the permafrost plateau edge as compared to plots adjacent to the edge or near the middle of the melt feature (20m from the permafrost plateau). During late August, NEE during full sunlight ranged from a low uptake of 80 mg CO_2 $m^{-2}h^{-1}$ in permafrost plateau plots to a high of 1000 mg CO_2 $m^{-2}h^{-1}$ in melt plots near the permafrost edge. Highly productive sites for both NEE and CH_4 emission were related to the amount of vascular plants present.

B22D-03 1645h

A model of carbon flux and sedimentation in linked landscape-lake ecosystems

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North temperate lakes play an important role in processing organic carbon derived from the landscape as a whole. Lakes act both as conduits of inorganic carbon passing from lakes to the atmosphere and as mineralization sites for terrigenous organic carbon. The carbon load processed by lakes may partially offset estimates made for terrestrial net ecosystem exchange (NEE). The view of lakes as "hot spots" for carbon processing is tempered by uncertainties in the magnitude of the carbon load from terrestrial systems, the relative contributions of organic and inorganic carbon forms to that load, and in the influence of that load on key carbon cycling processes in lakes. The balance within the lake between sedimentation and flux to the atmosphere determines whether lakes are net sinks or net sources of atmospheric carbon. Here we develop a model to study carbon processing by lakes, and calibrate the model to a range of lake conditions found in northern Wisconsin. Our model indicated that lakes processed from 3-14 percent of terrestrial NEE, venting most of that carbon to the atmosphere. Most lakes were net heterotrophic and net sources of carbon to the atmosphere. When considering lakes over gradients of TP and DOC, only those lakes low in DOC and moderate to high in TP were net autotrophic and net sinks of carbon from the atmosphere. The model was especially sensitive to two parameters that may respond to drivers not included in the model: planktivory effects on algal biomass and pH changes due to acid deposition reductions.

B22D-04 1700h

Total Carbon Export from a Boreal Forested Catchment and the Relative Importance of Temperature and Flow

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For over a decade, streamwater dissolved organic carbon (DOC) has been sampled weekly to daily on one mire and two forested subcatchments within the boreal, 50 ha Svartberget catchment in Sweden. During the last year, DIC measurements have been added. This high resolution record of outputs from different landscape elements was analyzed to examine the role of climate on DOC flux and concentration, as well as to set the DIC export from headwaters in relation to the carbon budget for this region. Over the entire study period, export of total organic carbon (OC) averaged 7 g m-2 year-1 from the forested subcatchments, and 11 g m-2 from the mire subcatchment. The snowmelt exported ca. 45 % of all TOC, but the concentration-flow pattern indicated depletion of a soil source with time. Variation in summer TOC flux was four times larger than for the winter/spring flux. This large interannual variation in summer TOC export was related to the variability in both summer temperatures and flows, especially the latter. High flows during summer mobilized much more carbon than comparable winter/spring high flows.. The importance of sampling high flows when doing flux estimates was illustrated by the fact that 5 % of the highest flow events accounted for 40 % of the exported water but more than 50 % of the total organic carbon exported. Intensive snow melting followed by warm and exceptionally wet summers released around four times more TOC than during dry years. The headwater DIC export appears to be of the same order of magnitude as DOC export, but much of the DIC has left the stream via degassing within a few hours of leaving the soil, meaning that this DIC is not seen if the DIC budget is based on measurements further downstream.

B22D-05 1715h

Increased Concentrations of Dissolved Organic Carbon During the Spring Floods in the Sagavanirktok, Kuparuk and Colville Rivers in the Alaskan Arctic

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Arctic rivers discharge 40 to 80% of their annual water volume during the spring floods in May, June and July. During May and June 2001 and 2002, intensive sampling of the Sagavanirktok, Kuparuk and Colville rivers in the Alaskan Arctic was carried out to address questions related to the transport of dissolved and particulate organic carbon to the coastal Beaufort Sea. In June 2001, water flow increased by approximately 250% during peak discharge in the Sagavanirktok River, at the same time concentrations of dissolved organic carbon (DOC) increased from 167 to 742 micromolar. As water flow decreased in the 4 days following peak discharge, concentrations of DOC decreased to <300 micromolar. Similar results were found for the Kuparuk and Colville rivers. In May 2002, concentrations of DOC in the Kuparuk River increased from 670 to >1140 micromolar in 3 days and decreased with water discharge to 600 micromolar within 6 days of peak water discharge. In the Sagavanirktok River, concentrations of DOC increased from 420 to >600 micromolar during the first two days of water discharge in 2002.