# Oechel *et al*. San Diego State University (SDSU)
# 2001 Summer Field Activity Report

## General Field Conditions

**Atqasuk, North Slope, Alaska –**

The 2001 summer season (June-September) in the Atqasuk area was colder and drier than in 2000. Average air temperature between June-September was 4.2°C. Average monthly temperatures were 4.3°C, 7.6°C, 4.3°C, and 0.7°C for June, July, August, and September respectively. Soil surface temperatures were close to freezing in early June, increasing through July to a maximum recorded temperature of 18.6°C. Total summer precipitation for this time period was 88.9 mm, considerably lower than the 120.6 mm recorded for the previous summer. Monthly precipitation values were 10.2 mm, 35.7 mm, 33.2 mm, and 9.8 mm for June, July, August, and September respectively. The maximum recorded active layer depth in late-August was -39 cm. Winds were predominately from the NW to NE with an average summer wind speed of 4.4 m $s^{-1}$.

**Barrow, North Slope, Alaska –**

The 2001 summer season (June-September) on the Barrow coastal plain was also colder and drier than in 2000. Weather conditions in early-June were cold with periods of light snow and an average air and soil surface temperature of 0°C and -3°C respectively. Complete snow melt occurred in mid-June. Maximum recorded air and soil surface temperature was in August with 10.2°C and 5.2°C respectively. Total precipitation was 84.6 mm. Predominant wind directions were from the NW to NE with wind speeds averaging 4.9 m $s^{-1}$ and varying from 1.8 m $s^{-1}$ to 8.7 m $s^{-1}$. Maximum active layer depth was measured in late-August at -33.3 cm.

**Prudhoe Bay, North Slope, Alaska –**

The average air temperature for July-September in Prudhoe Bay was 9.2°C with a maximum recorded air temperature of 14.4°C. Mean surface soil temperature was 7.2°C. Total precipitation was 147.1 mm with intensive rain events occurring between mid-July to mid-August. Total monthly precipitation was 30.0 mm, 116.8 mm, and 0.3 mm for July, August, and September respectively. Average wind speed was 4.9 m $s^{-1}$ with the predominant wind direction from the NW to NE.

**Quartz Creek, Seward Peninsula, Alaska –**

The Quartz Creek area was on average cooler (9.5°C) in 2001 compared to the 8-year mean (1992-2000: 10.7°C). This was mainly due to the lower average air temperatures in June (8.6°C) and July (10.6°C). The only summer snowfall event was on June 14$^{th}$. The last night of frost in the spring was on June 17$^{th}$ and the first fall frost being on August 21$^{st}$. There were 26 days with rain events and a total precipitation of 94.5 mm. This is close to the 8-year average (1992-2000: 98.7 mm). The average wind speed was 3.7 m $s^{-1}$ coming predominately from the S, SW and W. Thaw started after the completion of snow melt (estimated at June 1) with the maximum active layer depth measured at -53 cm (-44 cm in the intertussocks).

**Lavrentiya, Chukotka Peninsula, Russia –**

The summer was characterized by a cold June, a sunny and warm July, with August and September being quite typical for the region. Average air temperature for the last third of July was higher (11.9°C) than the same time in 2000 (5.7°C). Mean August temperatures for 2000 and 2001 were about the same, at 6.5°C and 6.4°C respectively. September was on average slightly higher in 2001 (3.7°C) than in 2000 (2.4°C). Average wind speeds (3m height) were 3.8 m $s^{-1}$, 4.8 m $s^{-1}$, and 5.7 m $s^{-1}$ for July, August, and September respectively. Thaw depth dynamics were similar in both 2000 and 2001 with measured maximum active layer depth in September being -66.7 cm and -67.7 cm respectively. However, the mean water table depth (from soil surface) was much deeper in 2001 (-20.4 cm) as compared to 2000 (-11.0 cm). Water table depths were greatest beginning in August.

## Measurements

**Tower Based Eddy Covariance**

Measurements of mass ($CO_2$ and $H_2O$), momentum and energy are recorded year-round at Prudhoe Bay, Barrow and Atqasuk, Alaska using the eddy covariance technique. Establishment of the year-round towers was in 1994, 1997, and 1998 for Prudhoe Bay, Barrow, and Atqasuk respectively and have been running nearly continuously since then. An additional year-round eddy covariance tower was established in the Central Marsh of Barrow in the spring of 1999, and includes continuous measurements of methane and ozone using a modified aerodynamic gradient technique.

The month of August included flux measurements with a portable eddy covariance tower. This tower was deployed at two different locations along the airplane flux flightline. One of the locations was at the southern end of the North-South (N-S) flightline. The other location was at the intersection of the North-South and East-West (E-W) flightline transects. We've also placed the portable tower at a location several kilometers to the south of the eddy covariance tower at Atqasuk as a cross-comparison of the current eddy system and to asses the representative-ness of the tower footprint area.

**Atqasuk, Alaska**

The area ecosystem was a slight net sink of carbon for July and August with maximum mid-day uptake rates of -0.8 gC $m^{-2}$ $hr^{-1}$ and -0.3 gC $m^{-2}$ $hr^{-1}$ respectively. Maximum recorded daily fluxes occurred in late June at -1.2 gC $m^{-2}$ $d^{-1}$. Diurnal amplitudes of $CO_2$ flux varied markedly in July while in August the diurnal pattern was relatively constant.

**Barrow, Alaska**

Preliminary results from the eddy covariance tower showed that the Barrow area was a net sink of carbon over the growing season (June-August). The daily $CO_2$ flux was a slight source following the snowmelt in early June with average daily fluxes of +0.18 gC $m^{-2}$ $hr^{-1}$. The seasonal pattern of carbon sequestration this summer appears to have two peaks. Net ecosystem sink activity began in late June, decreasing in early July. Then in

mid-July there was an increase in net sink activity that remained into late August. The mid-day uptake increased from -0.01 gC $m^{-2}$ $hr^{-1}$ in June to -0.15 gC $m^{-2}$ $hr^{-1}$ in August with the strongest net sink of -2.4 gC $m^{-2}$ $d^{-1}$ occurring in late August. Diurnal $CO_2$ flux patterns show that net sink activity peaked between 10am and 3pm with times of net source activity strongest between 10pm and 4am.

**Barrow (Central Marsh), Alaska – Aerodynamic $CH_4$ Measurements**

This is the third season of $CH_4$ flux measurements at Central Marsh. Measurements of $CH_4$ have continued into the winter months and preliminary results from those data are still pending further analysis. Methane flux measurements were done using a modified aerodynamic gradient method using a specialized flame ionization detector (FID). The aerodynamic parameters were corrected with measurements made simultaneously from a co-located eddy covariance system measuring $CO_2$, $H_2O$ and energy exchange. This tower is a collaborative effort between SDSU and scientists from Japan directed by Dr. Yoshinobu Harazono.

Preliminary processing of the 2001 growing season $CH_4$ data show that $CH_4$ fluxes was higher in June and July when compared to 2000. The daily maximum $CH_4$ flux reached +110 mg $CH_4$ $m^{-2}$ $day^{-1}$ compared to +70 mg $CH_4$ $m^{-2}$ $day^{-1}$ in 2000. In September and early October there was very little snow in the Barrow area, so daily $CH_4$ fluxes was still relatively high, +10 mg $CH_4$ $m^{-2}$ $day^{-1}$. The seasonal $CH_4$ fluxes are calculated as a net source to the atmosphere of +6.6 g$CH_4$ $m^{-2}$ for 1999, +3.3 g$CH_4$ $m^{-2}$ for 2000 but was less than +5 g$CH_4$ $m^{-2}$ in 2001.

**Prudhoe Bay, Alaska**

Carbon exchange at the U-Pad (Betty Pingo) site in Prudhoe Bay showed a relatively weak net sink in July and August. Average daily fluxes was +0.03 gC $m^{-2}$ $d^{-1}$ in July and -0.35 gC $m^{-2}$ $d^{-1}$ in August. Mid-day carbon uptake in July was -0.3 gC $m^{-2}$ $hr^{-1}$ with a maximum mid-day uptake in August of -0.6 gC $m^{-2}$ $hr^{-1}$.

**Quartz Creek, Seward Peninsula, Alaska**

Last season, this same site was measured between August 2-7, 2000. This year the tower was established on June 5 and continued measurements until August 25.

During the 2001 summer months, tussock tundra ecosystems at the Quartz Creek research site demonstrated strong sink activity to the ecosystem. At the beginning of June, ecosystems within the footprint area were acting as a carbon source to the atmosphere, however for the entire measurement the net exchange was a sink to the ecosystem. Beginning on June 10$^{th}$ to end of the measurement period (August 25$^{th}$) they were mainly functioning as a carbon sink with only few days as a source. The total seasonal net carbon exchange (June 5-August 25) was a net sink of -170 gC $m^{-2}$. The net carbon exchange in June was -47 gC $m^{-2}$ with average daily rates of -1.82 ± 0.35 gC $m^{-2}$ $day^{-1}$, July was -83.1 gC $m^{-2}$ with average daily rates of -2.77 ± 0.28 gC $m^{-2}$ $day^{-1}$ and August was -38.5 gC $m^{-2}$ with average daily rates of -1.54 ± 0.14 gC $m^{-2}$ $day^{-1}$.

**Lavrentiya, Chukotka Peninsula, Russia**

This is the second season of eddy covariance flux measurements for this site. A portable tower in 2000 was used between July 22-October 16, 2000. This season the tower

was re-established at the same location on June 18, 2001 and is now a year-round eddy covariance measurement site.

The start of the vegetative growing season for the Lavrentiya area was between June 19-28 with the peak season occurring between July 9-29. The fall senescence began around mid-August with the onset of winter around the last week in October. The Lavrentiya tundra ecosystem acted as a net carbon sink between June 19-August 28 with an average uptake rate of -0.81 gC $m^{-2}$ $day^{-1}$. Following August 28, the ecosystem became a net source of carbon to the atmosphere and between August 28-October 27, the ecosystem was a net carbon source of +0.78 gC $m^{-2}$ $day^{-1}$. A net sink of -57.8 gC $m^{-2}$ occurred during the vegetative season (June 19-August 28) and there was a net loss of +22.3 gC $m^{-2}$ during the fall to winter (August 29-October 27). The seasonal net ecosystem carbon exchange for 2001 (June 19-October 27) was -35 gC $m^{-2}$ $season^{-1}$.

**Airplane Based Eddy Covariance –**

This is the third year, that the Sky Arrow 650TCN Environmental Research Aircraft (ERA) has been in the Barrow area making large scale measurements of mass ($CO_2$, $H_2O$), momentum (three-dimensional turbulent winds) and energy. The Sky Arrow arrived in Prudhoe Bay, Alaska on June 13 where it was assembled and went through initial flight tests on June 20th. The aircraft was then flown to Barrow on June 21st and aircraft instrument flight calibrations and tests were done between June 22-24 over the Arctic Ocean. The first aircraft flux flight was on June 25th along the North-South transect. This season (June 21-September 8) we flew a total of 162.6 flight hours. The flights consisted of flux flights (131.4 hours), in-flight instrument calibrations (8.4 hours), general flight tests (2.7 hours), aerial photography (3.8 hours) and air tours of research sites (5.7 hours). The last flux flight was on September 8. The Sky Arrow was then flown from Barrow to Prudhoe Bay on September 10, disassembled and packed for shipment on September 12.

Measurements of NDVI along the flightline transects were recorded and provide a spatial representation of the NDVI along each transect as well as surface features like tundra vegetation and water bodies. Simultaneous measurements of net flux and NDVI from the Sky Arrow provide the basis for a spatial relationship between the fluxes and NDVI. A temporal relationship with fluxes and NDVI is also established as multiple flights throughout the Arctic growing season were conducted. These data will then be used in tower-aircraft comparisons as well as aircraft-satellite remote sensing comparisons. Relationships between net flux and NDVI along the flightline transects can be dynamic and variable. Though the NDVI does not change dramatically during the duration of a flight, weather conditions can greatly affect the flux signal. The North Slope of Alaska has variable and ever changing weather and it is common for parts of the flightline transects to be in different conditions. We have found that under high light conditions (sunny), total photosynthetic production (characterized by NDVI) becomes the limiting factor for the fluxes, while under low light conditions (overcast) other factors become limiting (e.g. temperature).

**Airplane Based Spectral Reflectance –**

This effort is in collaboration with Dr. John Gamon of the California State University Los Angeles (CSULA). Measurements of aircraft based hyperspectral reflectance were taken simultaneously with the aircraft flux measurements along the flux flightlines; this season 9 hyperspectral/flux flights were conducted between June 28 – September 8. The PP Systems' Unispec measures between 350-1150 nm, that can resolve absorption features of individual chemical compounds (e.g. pigments or water) and can be used to identify and characterize the

functional state of objects (e.g. plants). Typical indices include the Normalized Difference Vegetation Index (NDVI), the Photochemical Reflectance Index (PRI), and the Water Band Index (WBI).

**Airplane Based Aerial Photography –**

The Sky Arrow was used to make several flights over various research areas for film based aerial photography. Besides the SDSU research sites (towers and tundra manipulation plots) in the Barrow and Atqausk areas, aerial photographs were taken of the research sites of Webber *et al.* (Michigan State University) in Barrow. Aerial photographs of the CSULA hyperspectral tram system in Barrow were also taken. Additional aerial photos and digital video was taken for the science division of the Ukpeagvik Inupiat Corporation (UIC) of an Inupiat archaeological site off of Point Franklin.

## Chamber Based Ecosystem Flux Measurements

Whole ecosystems carbon flux measurements were also conducted at Barrow and Quartz Creek using chamber-based techniques. The chamber-based measurements at Quartz Creek were used as a check of the eddy covariance tower located at the same site.

### Quartz Creek, Seward Peninsula, Alaska

Net ecosystem $CO_2$ fluxes were measured using eight square bases (40x40 cm) and a transparent cuvette top. The bases were installed on June 12. Three chambers represented tussocks, four were intertussock plant associations, and one was located in a moss/dwarf shrub ecosystem. Chamber data were used to estimate net carbon fluxes as a reference for the tower based eddy covariance estimates. They are also used to estimate the rate of soil carbon emission. After July 18, two more bases were added: one for estimation of soil carbon emission with above-ground vegetation removed, and another with both vegetation and litter removed.

The best significant correlation between eddy-based flux data and chamber-based data during the entire summer season was +0.78 ($p<0.05$) at hourly scale, with much better correlation during the period of the most intensive plant growth ($25^{th}$ of June - $25^{th}$ of July: +0.9), but +0.66 only during the end of vegetative period and start of senescence and yellowing ($25^{th}$ of July - $20^{th}$ of August). Nevertheless the average hourly carbon flux rates (gC $m^{-2}$ $hour^{-1}$) estimated by these independent methods were significantly different. In all cases, when measured simultaneously (N=50), eddy-based average hourly rates of net carbon exchange (sink) were much greater than chamber-based ones (-0.18 ± 0.017 < -0.05± 0.008 gC m-2 hr-1, P < 0.0001). This difference was even more pronounced during the period of intensive plant growth ($25^{th}$ of June - $25^{th}$ of July), but much less during the second period ($26^{th}$ of July - 20 August). Thus during this period the maximal hourly rates estimated by eddy-covariance method and minimal rates by chamber-based method were not significantly different (-0.14± 0.013 and -0.15 gC m-2 hr-1, P=0.323) during the periods of simultaneous measurements. During the chamber measurements the minimal carbon net flux rates (maximal carbon sink activity) were demonstrated by tussock microhabitats.

## Tundra Manipulations Experiment – Barrow, Alaska

The full factorial water table and soil heating manipulation experiment was continued at Barrow, Alaska for its third and final year. The site was established in the fall of 1998 and this year was the third full season of measurements. The experiment continued to be very effective in manipulation of tundra soil temperatures as well as a decreased and increased water table depth within the manipulation plots. Carbon fluxes in the control plots continue to compare favorably with the eddy covariance tower located several hundred meters away and the manipulated treatments continued to show differences in carbon flux from the control plots similar to previous seasons.

Preliminary results of the three years (1999-2001) indicate that with increased soil temperatures (+3°C above ambient), there is enhanced $CO_2$ uptake. Water table manipulation shows an additive effect on uptake, but appears to have a much weaker effect on fluxes alone and smaller in magnitude than that of increases in soil temperature. This trend continued into the third year of manipulation. Conditions in Barrow were cooler and drier this year than the 2000 season, but similar trends in uptake continued to be present. Whole ecosystem respiration values continued to be higher for elevated temperature treatments and there was a slight increase in $CO_2$ uptake under conditions of elevated temperature. Further data analysis will reveal if there have been significant changes between the three years and will determine trajectories of simulated climate change on this ecosystem.

The experiment concluded at the end of this season with complete equipment and boardwalk removal between August 30-September 4. Whole ecosystem biomass collections were done along with several soil cores between August 22-29. These biomass samples and soil cores will be analyzed for total productivity and nutrients that will look directly at changes in mineralization and nutrient status of the ecosystem.

# Research Participants

SDSU Investigators –

| Name | Organization | Dates |
|---|---|---|
| Walter C. Oechel | Department of Biology<br>San Diego State University | Jul. 28 – Aug. 1 |
| Rommel C. Zulueta | San Diego State University<br>University of California Davis | Jun. 1 – Jun. 6<br>Jun. 19 – Sep.14 |
| Hyojung Kwon | San Diego State University<br>University of California Davis | Jun. 1 – Jun. 6<br>Jun. 19 – Sep. 16<br>Oct.8 – Oct. 17 |
| Joseph G. Verfaillie | Department of Biology<br>San Diego State University | Jun. 14 – Sep. 13 |
| Glen Y. Kinoshita | Department of Biology<br>San Diego State University | Jun. 2 – Sep. 10 |
| Michelle Perl | San Diego State University | Jun. 15 – Aug. 14 |
| Leticia Sanchez | San Diego State University | Jun. 26 – Aug. 24 |
| Spring Strahn | San Diego State University | Jun. 2 – Aug. 14 |

Japanese Investigators –

| Name | Organization | Dates |
|---|---|---|
| Yoshinobu Harazono | • Ecosystem Gas Exchange Team, National Institute of Agro-Environmental Sciences, Japan<br>• International Arctic Research Center (Invited Scientist) | Jun. 10 – Jun. 20<br>Jul. 18 – Jul. 30<br>Oct. 12 – Oct. 17<br>Nov. 20 – Nov. 24 |
| Akira Miyata | Ecosystem Gas Exchange Team, National Institute of Agro-Environmental Sciences, Japan | Feb. 1 – Feb. 6<br>Mar. 21 – Mar. 29<br>Jun. 3 – Jun. 12<br>Oct. 12 – Oct. 17 |
| Masayoshi Mano | Chiba University,<br>Japan | Feb. 1 – Feb. 6<br>Mar. 4 – Jun. 14<br>Jul. 9 – Sep. 15<br>Oct. 7 – Oct. 17 |
| Atushi Nojiri | Okayama University,<br>Japan | Jun. 1 – Jul. 11 |
| Katsuo Abe | Ecosystem Gas Exchange Team, National Institute of Agro-Environmental Sciences, Japan | Feb. 1 – Feb. 5 |
| Keisuke Ono | Ecosystem Gas Exchange Team, National Institute of Agro-Environmental Sciences, Japan | Jul. 18 – Jul. 23<br>Nov. 20 – Nov. 26 |
| Md. Abdul Baten | Ecosystem Gas Exchange Team, National Institute of Agro-Environmental Sciences, Japan (Invited Scientist) | Sep. 5 – Sep. 14 |
| Tatsuo Hosono | Ecosystem Gas Exchange Team, National Institute of Agro-Environmental Sciences, Japan | Mar. 21 – Mar. 29 |

Russian Investigators –

| Name | Organization | Dates |
|---|---|---|
| Andrei Ivaschenko | Biology Department<br>Moscow State University | Jun. 10 – Aug. 1<br>Dec. 2-Dec. 31 |
| Oleg Tomilin | Forest Ecology and Production Center<br>Russian Academy of Sciences | Jun. 10 – Oct. 3 |
| Dmitri Zamolodchikov | Forest Ecology and Production Center<br>Russian Academy of Sciences | Jul. 8 – Sep. 14 |
| Andrei Gladkov | Russian Institute of Land Resources<br>Russian Federal Land Service | Jul. 31 – Nov. 2 |

# Student Involvement

## Highschool

Steven Andrews –

Steven is a junior from Valhalla High School located in the Grossmont High School District in San Diego County. He participated in field activities from July 14 – August 14, 2001. His participation in fieldwork included chamber based flux measurements, measurements of active layer depth and soil moisture contents within the eddy covariance tower footprint areas. He also helped in instrument calibrations and primary data processing.

## Undergraduate

Michelle Perl (SDSU) –

Michelle participated in our research field season as part of the NSF Undergraduate Mentoring in Environmental Biology (UMEB) program. Michelle's research project looked at ectomychorrizal infection rates on two *Salix* species in the area adjacent the eddy covariance flux tower and tundra manipulations site. Besides her own research project, she also aided in chamber based flux measurements on the tundra manipulation plots as well as determination of active layer depth and soil moisture contents within the tower footprint areas.

Leticia Sanchez (SDSU) –

Leticia also participated in our research field season as part of the NSF Undergraduate Mentoring in Environmental Biology (UMEB) program. Leticia's research project included the use of small ecosystem chambers to study soil respiration over a range of micro-topographical features surrounding the eddy covariance flux tower and tundra manipulations site. Besides her own research project, she also aided in chamber based measurements on the tundra manipulation plots as well as determination of active layer depth and soil moisture contents within the tower footprint areas.

Spring Strahm (SDSU) –

Participated in our field season as a undergraduate field assistant in the maintenance of the two eddy covariance in Atqasuk and Barrow, Alaska. Spring's main field duties included daily maintenance checks of the eddy covariance systems and time domain reflectometry (TDR) soil moisture systems. Additional responsibilities included data download and initial processing, as well as measurements of active layer depth, soil moisture, and biomass sampling and assessment. Spring also aided in the setup and maintenance of the three portable tower locations this summer.

## Graduate

Glen Kinoshita (Masters, SDSU) –

This is Glen's fourth and final field season overseeing and running the tundra manipulations site. Glen is also part of the PISCES project and UMEB programs. Besides maintaining the tundra manipulations site, he provided guidance to the two UMEB students as well as the teacher participating in the TEA program.

Atushi Nojiri (Masters, Okayama University) –

This is Atushi's first season in Barrow, Alaska. He is working in collaboration with the NIAES to measure carbon ($CO_2$ and $CH_4$) fluxes in Arctic tundra ecosystems using eddy covariance modified aerodynamic techniques.

Hyojung Kwon (Doctoral, SDSU/UCD) –

This is Hyojung's third field season in Alaska. Her work involves the measurement of trace gases and energy from tower based eddy covariance towers at Prudhoe Bay, Barrow, Atqasuk, and the Seward Peninsula. She continues to maintain the three permanent eddy covariance towers located at Atqasuk, Barrow and Prudhoe Bay, as well as operating and maintaining the portable tower along the Sky Arrow flightline transect. She was on the Seward Peninsula to help establish the portable eddy covariance tower and base camp there at Quartz Creek as well as in the end to help close the site and base camp. Hyojung also makes week long maintenance trips to the three main tower sites throughout the winter months.

Masayoshi Mano (Doctoral, Chiba University) –

This is Masa's second season in Barrow measuring carbon ($CO_2$ and $CH_4$) fluxes of Arctic tundra ecosystems in collaboration with the NIAES. His work involves both the eddy covariance and modified aerodynamic techniques to measure surface exchanges of mass and energy. Masa received his Masters degree from Chiba University doing work as a collaboration with SDSU on the LAII project in the Kuparuk Basin between 1995 and 1996.

Rommel Zulueta (Doctoral, SDSU/UCD) –

Returning for another full field season in Alaska and once again managing the summer field season for SDSU. His work involves regional-scale measurements of net ecosystem exchange of mass, momentum and energy using aircraft based eddy covariance and low level remote sensing. Rommel is the pilot of the Sky Arrow and concentrated his time and efforts this season on the aircraft operations and aircraft based flux measurements. Rommel has over 518 total flight hours and over the past three field seasons has accumulated over 280 flight hours flying the Alaska flux transects alone.

## Teacher Involvement

Chris Donovan –

Chris is a high school teacher from Desert View High School in Tucson, Arizona and participated in our field season as a part of the NSF Teachers Experiencing the Arctic and Antarctic (TEA) program. She participated in our Alaska field activities in both Barrow and Atqasuk between June 4 – July 22. Chris' participation with our research included chamber based diurnal measurements on the tundra manipulation plots, determination of active layer depth and soil moisture contents within the tower footprint areas, occasional daily maintenance checks of the eddy covariance systems, as well as data download and initial data processing. Chris selected a personal project for herself and surveyed the major vegetation types within the Barrow eddy covariance tower footprint along our soil moisture and active layer depth transects. Her interest was to use a vegetation survey of the tower footprint area done by Skip Walker in 1998 in an attempt to see if there was a vegetation change over the years. Her experience in Alaska not only included field research but also had a large cultural component. She visited the Barrow high

school, attended two nalukatuqs (traditional native whaling celebration), and participated in an archeological excavation at Point Barrow. She also had exposure to other researchers in the Barrow area as well as interactions with the local native community. As part of the TEA requirements, Chris kept an internet accessible journal of her experience in the Arctic and our research group at http://tea.rice.edu/tea_donovanfrontpage.html.

## Linkages to Other Projects

***UMEB*** – ***U****ndergraduate* ***M****entoring in* ***E****nvironmental* ***B****iology*

This National Science Foundation funded program is designed to provide undergraduate students the opportunity to gain research experience in environmental biology. Each student involved is responsible for their own individual research project. Their research projects include an exploration of the primary literature, identifying research questions, development and implementation of their research in the field, data analysis, and ultimately presentation.

We had two undergraduate students as part of our Arctic field season, Leticia Sanchez and Michelle Perl. They each had their own research projects as well helping with other field research activities (see *Student Involvement* section). Glen Kinoshita was their field research guide for their summer work.

***TEA*** – ***T****eachers* ***E****xperiencing the* ***A****ntarctic and the Arctic*

This is a National Science Foundation funded program (linked to OPP #9732105) created to provide elementary and secondary school teachers the opportunity participate in ongoing field research with NSF-funded scientists. The goal of this program is to enrich the scientific scope of the school teacher so they may then bring back what they have learned to share with students and other teachers.

***PISCES*** – ***P****artnerships* ***I****nvolving the* ***S****cientific* ***C****ommunity In* ***E****lementary* ***S****chools*

This National Science Foundation funded project (DGE #997941) is designed to bring science education to K-6 classrooms as well as professional development for K-6 teachers by bringing scientists and scientific educators into the classroom. The SDSU PISCES program has an Arctic component which includes collaborative science education programs with classes at Barrow's Ipalook Elementary School. Alejandra Rios and Maggie Reinbold are two SDSU undergraduate students participating in the PISCES program and made several trips to Barrow, Alaska in 2001.

***CSULA*** – ***C****alifornia* ***S****tate* ***U****niversity* ***L****os* ***A****ngeles*

Collaborative work with Dr. John Gamon from CSULA and Fred Huemmrich of JCET, University of Maryland Baltimore County on the linkage between hyperspectral reflectances and physiological properties of the ecosystem continued. Their work includes linkages between hyperspectral reflectances and fluxes at the tundra manipulation plots, eddy covariance tower footprints, as well as the aircraft based fluxes. Gamon *et al.* has established sites adjacent our eddy covariance flux footprint area and had a hyperspectral tram system along a 100 meter transect adjacent the tundra manipulation plots. This hyperspectral instrumentation was also installed on the SDSU Sky Arrow for simultaneous measurements with airplane-based measurements.

***NIAES*** *– **N**ational **I**nstitute of **A**gro-**E**nvironmental **S**ciences*

Collaborative work with Dr. Yoshinobu Harazono and Dr. Akira Miyata on year-round carbon ($CO_2$ and $CH_4$) fluxes. This is their third season of year-round methane and carbon fluxes from the Central Marsh of Barrow, but the eighth year of collaboration with this group. The NIAES also collaborates with Japanese universities and has brought a few masters and doctoral students to do research on the North Slope of Alaska as part of the LAII and ATLAS projects.

***MODIS*** *– **Mod**erate Resolution **I**maging **S**pectroradiometer*

The MODIS program is headed by Dr. Steve Running **(**School of Forestry, University of Montana) and provides many satellite derived products such as global Gross Primary Production (GPP). As part of the AmeriFlux network, the Barrow and Atqasuk towers input parameter data into MODIS for comparisons of the MODIS output and the measured tower fluxes for the Arctic ecosystem regions.

***MSU*** *– **M**ichigan **S**tate **U**niversity*

This season Dr. Patrick Webber and Dr. Craig Tweetie of MSU developed a vegetation map of the Barrow area. Collaborative efforts between MSU, Dr. Steve Oberbauer of Florida International University (FIU), CSULA, and SDSU are underway to develop a flux-vegetation map. This map will link the vegetation map with satellite IKONOS imagery and ground based chamber measurements. Validation of the flux-vegetation map will be done with comparisons of the tower based eddy covariance measurements and ultimately the aircraft fluxes.

***UAF*** *– **U**niversity of **A**laska **F**airbanks*

Dr. Chien-Lu Ping and Dr. Gary Michaelson came to the Barrow and Atqasuk eddy covariance tower areas to do work on soil profiling and soil horizon analysis.

Dr. Douglas Kane and Dr. Larry Hinzman have two permanent hydrological stations that are co-located with our eddy covariance towers. These towers are located at the U-Pad (Betty Pingo) site on Prudhoe Bay, as well as in the Seward Peninsula.

***UIC*** *– **U**kpeagvik **I**nupiat **C**orporation*

This past season we worked one day with the Science Division of UIC and took some aerial digital video and photos of an Inupiat archaeological site off of Pt. Franklin.

**BigFoot** – Linking In Situ Measurements, Remote Sensing, and Models to Validate MODIS Products Related to the Terrestrial Carbon Cycle

The Barrow eddy covariance tower has become a MODIS product validation site. As part of the validation program, Dr. Warren B. Cohen (Pacific Northwest Research Station, USDA Forest Service), Dr. Stith Tom Gower (Department of Forest Ecology and Management, University of Wisconsin), Dr. David P. Turner (Forest Science Department, Oregon State University), and Dr. Steven W. Running (School of Forestry, University of Montana) have visited the Barrow area to establish the MODIS validation grid that will be measured intensively beginning next year.

## Acknowledgements

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# Site Locations and Descriptions

## Barrow

This research site is approximately two kilometers south of the Elson Lagoon and located adjacent the National Oceanic and Atmospheric Administration's Climate Monitoring and Diagnostics Laboratory (NOAA-CMDL), the Department of Energy's Atmospheric Radiation Measurements (DOE-ARM), and the United States Geological Survey (USGS) magnetometer monitoring site comprised of low- and high-centered polygons, ice wedges and drained lake tundra land forms

SDSU Eddy covariance tower:
71° 21' 00.00" N : 156° 37' 18.53" W
*Measured: Year round*

SDSU Tundra manipulations:
71° 19' 18.36" N : 156° 37' 06.35" W

SDSU Demography transect:
Six Barrow sites:
71° 18' (between 43.7" and 58.9") N : 156° 35' (between 31.6 and 40.7") W

NIAES Eddy covariance and CH4 flux tower:
71° 19' 16.86" N : 156° 37' 18.53" W

CSULA Hyperspectral transect:
71° 19' 21.24" N : 156° 36' 24.15" W

## Atqasuk

This research site is in the well-drained, upland moist tussock tundra dominated by *Eriophorum vaginatum* as well as evergreen and deciduous forbs and shrubs. This site is adjacent the native village of Atqasuk.

SDSU Eddy covariance tower:
70° 28' 10.6" N : 157° 24' 32.2" W
*Measured: Year round*

SDSU Eddy covariance cross-comparison tower:
70° 27' 53" N: 157° 24' 56" W
*Measured: August 10-22, 2001*

SDSU Demography transect:
Two sites at Atqasuk, each with three transects.
70° 27' 1.9" N : 157° 24' 25.4" W
70° 26' 47.3" N : 157° 24' 12.9" W

**Prudhoe Bay**

This research site is located on West Operations Area of the Prudhoe Bay oil field and has previously been referred to as U-Pad or Betty Pingo. The area is dominated by the herbaceous sedges *Carex aquatilis* and *Eriophorum schuechzeri* and is characterized by inundated drained lakes, low- and high-centered polygons, as well as ice wedges.

SDSU Eddy covariance tower:
70° 16' 53.5" N : 148° 53' 05.4" W
*Measured: Year round*

**Seward Peninsula**

The site was selected 80 m to the South of the permanent 10 m meteorological tower operated by Hinzman *et al.* (site K2). The tower was installed on a poorly drained S/W slope 0.057m/m (about 5%). The site is located on a broad alluvial fan above the Kougarok river. The area appears to be representative of a large portion of interior regions of the Seward Peninsula and mainly is a well-developed tussock (*Eriophorum vaginatum*) dominated community with a few tall 1-2 m *Salix spp*. and *Betula nana* shrubs along the streams and in wind-protected locations.

SDSU Eddy covariance tower:
65° 25' 44.4" N : 164° 38' 45.3" W
*Measured: June 2 – August 25, 2001*

**Airplane Flightline Transects**

Three flightline transects were flown repeatedly throughout each measurement campaign. The three transects consisted of a 185 km North-South, a 95 km East-West, and a 16 km lake transect.

There is a latitudinal gradient in vegetation, precipitation, temperature and elevation from the Arctic coastal plain to the foothills of the Brooks Range. The North-South transect was established to study the latitudinal relationship between surface features, vegetation and temperature on net ecosystem flux. Along the route of the North-South transect are three permanent eddy covariance towers. Two are at the beginning of the transect close to Barrow, and the other is located adjacent the native village of Atqasuk, 100 km to the South of Barrow. These permanent towers allow us to do comparisons between aircraft and tower based eddy covariance measurements. A flightline spanning East and West was established as well as one over a large freshwater lake. The Arctic coastal plain is scattered with numerous ponds and lakes so the measurement of Lake Tusivoak was established to assess the contribution of these bodies of water on the surface fluxes.

Barrow North-South transect:
North end: 71° 30' 00.0" N : 156° 27' 00.0" W
South end: 70° 00' 00.0" N : 157° 45' 00.0" W

Barrow East-West transect:
East end: 70° 50' 00.0" N : 155° 55' 00.0" W
West end: 70° 50' 00.0" N : 158° 05' 00.0" W

Tusivoak Lake transect:
North end: 71° 08' 40.00" N : 156° 13' 00.0" W
South end: 71° 00' 30.00" N : 156° 03' 00.0" W

**Portable Eddy Covariance Tower**

The portable eddy covariance tower was used at two points along the aircraft flightline transect. One was at the end of the North-South transect the other at the North-South and East-West intersection. The end of the North-South transect is mainly tussock tundra with the dominant shrub being *Betula spp*. The intersection of the transects is characterized as coastal plain wet sedge tundra.

Center of E-W and N-S flightline transects:
70° 49.711' N: 157° 01.612' W
*Measured: August 7-10, 2001*

Southern end of N-S flightline transect:
70° 00.020' N : 157° 45.025' W
*Measured: August 1-7, 2001*

SDSU Eddy covariance cross-comparison tower:
70° 27' 53" N: 157° 24' 56" W
*Measured: August 10-22, 2001*