Carbon Flux Using Eddy Covariance Methodology in Arctic Coastal Wet Sedge Tundra

WALTER C. OECHEL, ROMMEL ZULUETA, AND HYOJUNG KWON
Global Change Research Group, San Diego State University, California 92182

INTRODUCTION

Tower-based eddy covariance measurements provided a near continuous temporal record of mass and energy over hectare spatial-scales. However, in a regional context, these measurements still represent a "point" measurement [*Baldocchi et al.*, 1996; *Vourlitis and Oechel*, 1997, 1999]. Aircraft-based measurements provide a relatively detailed measure of the large-scale (e.g., km^2) spatial variance in mass and energy exchange, but because of safety reasons, are temporally restricted to daytime periods and favorable weather conditions [*Crawford et al.*, 1996; *Desjardins et al.*, 1997]. The information gained from each technique is complimentary and essential for understanding spatial and temporal patterns in fluxes [*Desjardins et al.*, 1997].

Two of the primary objectives of the National Science Foundation Arctic Transitions in the Land-Atmosphere System (ATLAS) flux program are to quantify the plot (0.5 m^2), landscape (0.5-4 ha), and regional (e.g., 3 km^2) net ecosystem exchange (NEE) over several growing seasons and to develop methods for scaling point-measurements of mass and energy flux over varying spatial and temporal scales [*Weller et al.*, 1995]. As a preliminary exercise to fulfill these objectives, it is important to quantify the interrelationships between the mass and energy fluxes measured from different sampling techniques. The data presented here provide a baseline for comparison with future aircraft flux measurements.

METHODS

Fluctuations in wind speed, temperature, CO_2, and H_2O vapor were measured at 2.5 m above ground level. Vertical wind speed and temperature fluctuations were measured at 10 Hz using a three-dimensional sonic anemometer-thermometer (SWS-211/3K, Applied Technologies Inc., Boulder, Colorado) aligned into the mean wind. Carbon dioxide and H_2O vapor fluctuations were measured at 10 Hz with a fast response open-path infrared gas analyzer. The CO_2 and H_2O vapor channels of both sensors were calibrated at a minimum of every other week with 300 and 400 ppm standard gases and a portable dewpoint generator (LI-610, LI-COR Inc., Lincoln, Nebraska), respectively. For detailed information on methodology see *Vourlitis and Oechel* [1997, 1999].

Barrow and Atqasuk are the northern and southern anchor points, respectively, for the aircraft transect. The Barrow site (71°19'N, 156°36'W) is located in the Barrow Environmental Observatory (BEO) that covers several square kilometers dedicated to long-term arctic research and includes several different representative wet-moist coastal sedge tundra types. It is located 2 km south of the Arctic Ocean and comprised of low- and high-centered polygon ice wedges (polygon troughs) and drained lake tundra land forms [*Brown et al*., 1980]. The Atqasuk site [70°29'N, 157°25'W] is located 100 km south of Barrow, Alaska. Soils are developed on aeolian sands of Quaternary age [*Everett*, 1980]. The site is comprised of a variety of moist-wet coastal sedge tundra and moist-tussock tundra surfaces in the more well-drained upland areas [*Batzli*, 1980]. Vegetation that dominate the area include the tussock-forming sedge, *Eriophorum vaginatum*, as well as other evergreen and deciduous forbs and shrubs [*Komarkova* and *Webber*, 1980; *Walker et al.*, 1989]. This site is also an intensive site for year-round measurements of net CO_2 flux and energy balance. Atqasuk's more continental climate and sandy substrate make a useful contrast with conditions at Barrow.

RESULTS

Net sink activity increased up to 4.0 gC m^{-2} d^{-1}, thaw depth (active layer depth) was –32 cm, and soil moisture content was 66% between mid-July and late July 1999 at the Barrow site (Figure 1). As thaw depth increased and soil moisture content decreased (to 63% in early August) sink strength of CO_2 flux decreased because of the soil respiration caused by microbial activation in the soil. After a precipitation event in mid-August, soil moisture content increased up to 71%, and there was rapid

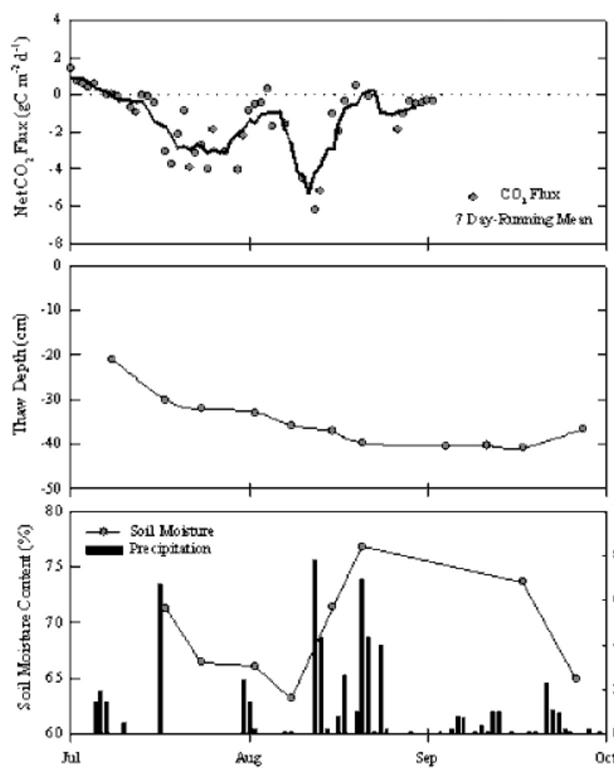

Fig. 1. Seasonal trend of daily integrated net CO_2 flux with thaw depth, soil moisture content, and precipitation at Barrow in 1999.

increase of sink activity (to 6.2 gC m^{-2} d^{-1}) even though thaw depth was -37 cm deep. It is assumed that soil moisture affected soil temperature, which in turn affected soil respiration, and there was a decrease of soil respiration resulting in a strong sink activity of net CO_2 flux. In late August net sink activity was small; thaw depth increased up to –41 cm; and soil moisture was 76%.

Acknowledgment. The authors thank Dan Endres, Station Chief at the CMDL Barrow station, for providing facilities, help in maintaining the tower, and periodic assistance with instrumentation and data acquisition computers.

REFERENCES

Baldocchi, D.D., R. Valentini, S. Running, W. Oechel, and R. Dahlman, Strategies for measuring and modeling carbon dioxide and water vapor fluxes over terrestrial ecosystems, *Global Change Biol., 2*, 159-168, 1996.

Batzli, G.O., Patterns of vegetation and herbivory in arctic tundra: Results from the Research on Arctic Tundra Environment (RATE) program, *Arct. Alp. Res., 12*, 401-578, 1980.

Brown, J, P.C. Miller, L.L. Tieszen, and F.L. Bunnell, *An Arctic Ecosystem: The Coastal Tundra at Barrow, Alaska*, 571 pp., Dowden, Hutchinson, and Ross, Stroudsburg, PA, 1980.

Crawford, T.L., R.J. Dobosy, R.T. McMillen, C.A. Vogel, and B.B. Hicks, Air-surface exchange measurement in heterogeneous regions: Extending tower observations with spatial structure observed from small aircraft, *Global Change Biol.*, *2*, 275-285, 1996.

Desjardins, R.L., J.I. MacPherson, L. Mahrt, P. Schuepp, E. Pattey, H. Neumann, D. Baldocchi, S. Wofsy, D. Fitzjarrald, H. McCaughey, and D. W. Joiner, Scaling up flux measurements for the boreal forest using aircraft-tower combinations, *J. Geophys. Res., 102*, 29,125-29,133, 1997.

Everett, K.R., Distribution and variability of soils near Atkasook, Alaska, *Arc. Alp. Res.*, *12*, 433-446, 1980.

Komarkova, V., and P.J. Webber, Two low arctic vegetation maps near Atkasook, Alaska, *Arc. Alp. Res.*, *12*, 447-472, 1980.

Vourlitis, G.L., and W.C. Oechel, Landscape-scale CO_2, water vapor, and energy flux of moist-wet coastal tundra ecosystems over two growing seasons, *J. Ecol., 85*, 575-590, 1997.

Vourlitis G.L., and W.C. Oechel, Eddy covariance measurements of net CO_2 flux and energy balance of an Alaskan moist-tussock tundra ecosystem, *J. Ecol.*, *80*, 686-701, 1999.

Walker, D. A., E. Binnian, B.M. Evans, N.D. Lederer, E. Nordstrand, and P.J. Webber, Terrain, vegetation, and landscape evolution of the R4D research site, Brooks Range Foothills, Alaska, *Holarct. Ecol.*, *12*, 238-261, 1989.

Weller, G., F.S. Chapin III, K.R. Everett, J.E. Hobbie, D. Kane, W.C. Oechel, C.L. Ping, W.S. Reeburgh, D. Walker, and J. Walsh, The arctic flux study: A regional view of trace gas release, *J. Biogeogr.*, *22*, 365-374, 1995.