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A Year of Radiation Measurements at the North Slope of Alaska

Second Quarter 2009
ARM and Climate Change Prediction Program Metric Report

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1. Introduction

In 2009, the Atmospheric Radiation Measurement (ARM) Program and the Climate Change Prediction Program (CCPP) have been asked to produce joint science metrics. For CCPP, the second quarter metrics are reported in *Evaluation of Simulated Precipitation in CCSM3: Annual Cycle Performance Metrics at Watershed Scales*. For ARM, the metrics will produce and make available new continuous time series of radiative fluxes based on one year of observations from Barrow, Alaska, during the International Polar Year and report on comparisons of observations with baseline simulations of the Community Climate System Model (CCSM).

2. NSA Radiation Data

2.1 Methodology

Observations from a suite of radiometers including Precision Spectral Pyranometers (PSPs), Precision Infrared Radiometers (PIRs), and a Normal Incident Pyrheliometer (NIP) are combined with surface meteorological instruments using the Quality Control of Radiation (QCRad) Value Added Product (VAP; Long and Shi 2006; Long and Shi 2008) to assess data quality and produce a continuous time series of broadband radiative flux measurements for 2008 at Barrow (C1) and Atqasuk (C2), Alaska. The QCRad methodology uses climatological analyses of the surface radiation measurements to define reasonable limits for testing the data for unusual data values and produces best estimates of observed radiative fluxes. The methodology not only sets standard maximum and minimum value limits, but includes many cross-comparisons based on what the ARM Program has learned about how these instruments behave in the field. In addition, the unshaded pyranometer measurements are corrected for thermal offsets using historical correction coefficients at the North Slope of Alaska (NSA) site.

The temporal resolution of the resulting datastream is 1 minute. Two netCDF files are produced daily at each site for the QCRad VAP. The first file is a c1 level file, which contains radiation measurement fields and the bit-backed quality control (QC) information associated with each field. The summary netcdf file (.s1) contains the same radiation measurement fields with simplified QC information and is the recommended ARM surface radiation file for the general user. In addition, a time series of daily (24-hour average) upwelling and downwelling shortwave and longwave fluxes has been produced for the 2008 data at Barrow and Atqasuk for model evaluation.

2.2 Features of Measured Fluxes

Atqasuk is located 70 miles south of Barrow and has a much more continental climate. The broad features of the radiation measurements at Barrow and Atqasuk are similar, but there is significant day-to-day variability between the two sites. Time series of the 24-hour averaged downwelling and upwelling broadband shortwave (SW) fluxes at Barrow and Atqasuk in 2008 are illustrated in Figures 1 and 2. The seasonal cycle of solar insulation in the Arctic is readily apparent in the total and diffuse downwelling SW plots. The variability in downwelling SW associated with variability in cloud amount and properties also can be seen, and is largest in the direct beam measurements. The upwelling SW (Figures 1d, 2d) is measured by a pyranometer located on the 10-m tower. In Arctic winter, there is no upwelling SW, because there is no downwelling SW to be reflected by the surface. The upwelling SW increases rapidly through the spring, as the amount of downwelling SW flux increases. The abrupt transition from high upwelling SW values to low upwelling values corresponds to a change in surface conditions associated with the melting of snow (which has high albedo) under the tower. The transition occurs later at Barrow than at Atqasuk, due to different environmental conditions at the two sites.

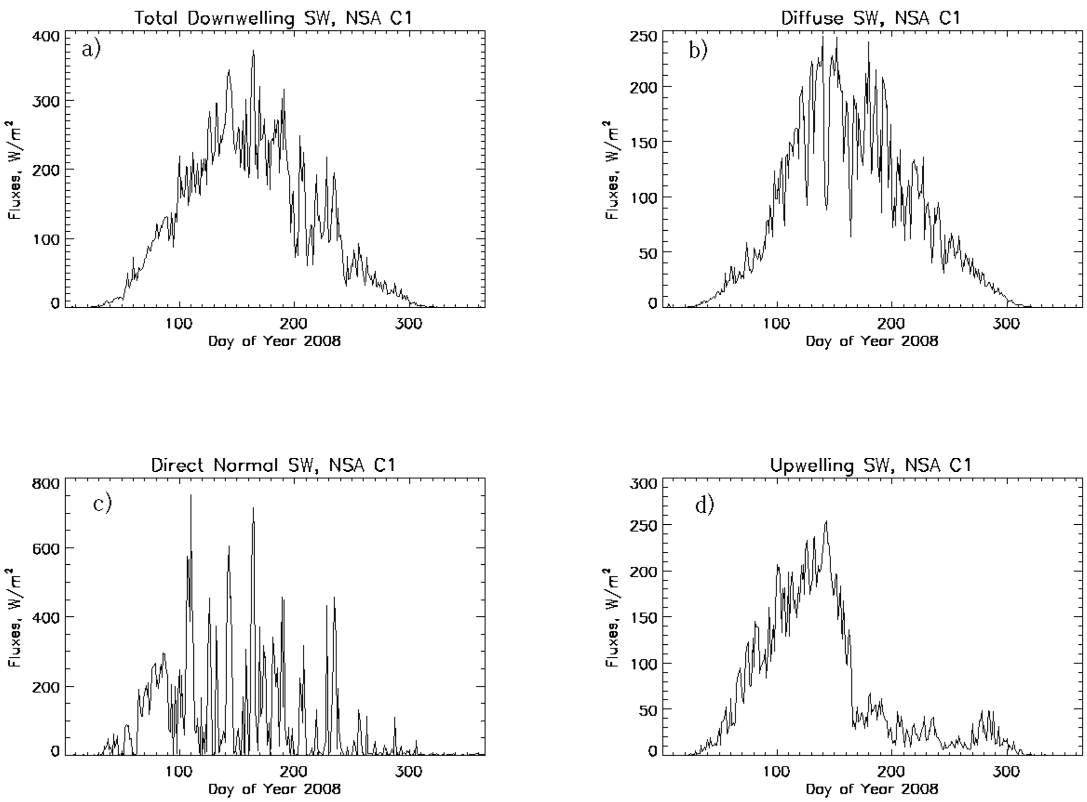

Figure 1. Time series of 24-hour average a) total downwelling shortwave, b) downwelling diffuse shortwave, c) downwelling direct normal, d) upwelling shortwave broadband fluxes during 2008 at the ARM Climate Research Facility (ACRF) Barrow, Alaska, site (NSA C1).

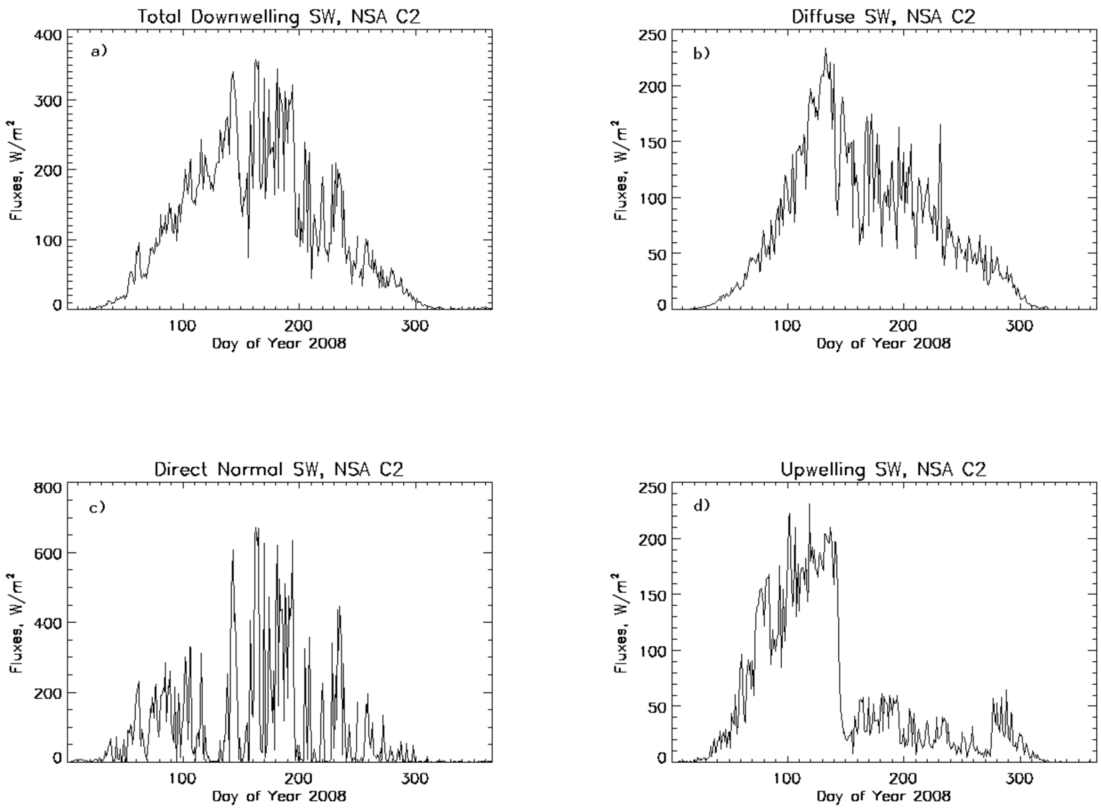

Figure 2. Time series of 24-hour average a) total downwelling shortwave, b) downwelling diffuse shortwave, c) downwelling direct normal, d) upwelling shortwave broadband fluxes during 2008 at the ACRF Atqasuk, Alaska site (NSA C2).

The time series of upwelling and downwelling longwave (LW) fluxes (Figures 3 and 4) shows the strong seasonal cycle associated with changes in water vapor and temperature during the year. In winter, the NSA is very cold and very dry, and clear sky downwelling and upwelling longwave fluxes are on the order of 150 W/m2 and 180 W/m2, respectively. In these conditions, the absorption and emission associated with clouds has a very strong impact on the downwelling LW fluxes. The increase in downwelling LW associated with cloudy conditions in winter warms the surface, and leads to a corresponding (although smaller) increase in upwelling LW. During warmer and moister conditions in the summer, clouds still drive most of the variability in the LW fluxes, but do not have as large an impact relative to clear sky fluxes as they do in the winter.

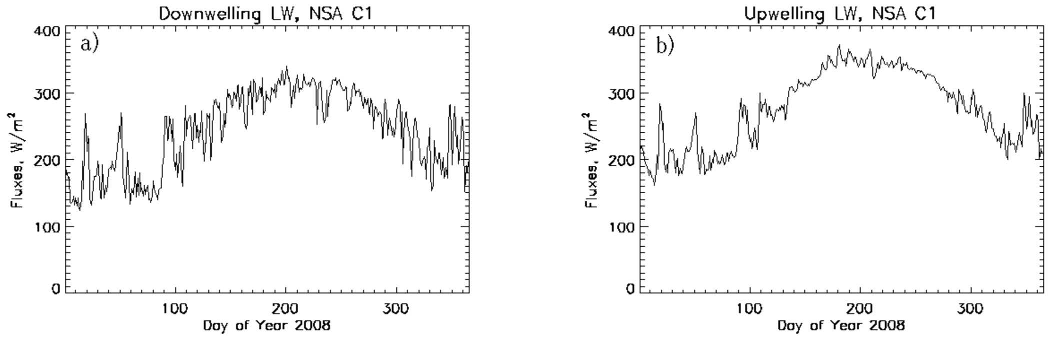

Figure 3. Time series of 24-hour average broadband a) downwelling longwave, b) upwelling longwave fluxes at Barrow, Alaska (NSA C1).

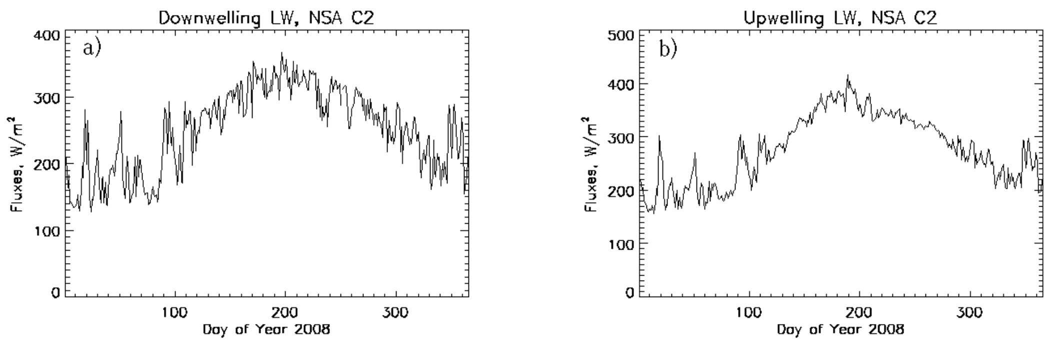

Figure 4. Time series of 24-hour average broadband a) downwelling longwave, b) upwelling longwave fluxes at Atqasuk, Alaska (NSA C2).

3. References

Long, CN, and Y Shi. 2006. "The QCRad Value Added Product: Surface radiation measurement quality control testing, including climatologically configurable limits." U.S. Department of Energy, ARM TR-074, 69 pp. Available via http://www.arm.gov/publications/tech_reports/arm-tr-074.pdf.

Long, CN, and Y Shi. 2008. "An automated quality assessment and control algorithm for surface radiation measurements." *The Open Atmospheric Science Journal* 2: 23-37, doi: 10.2174/1874282300802010023.