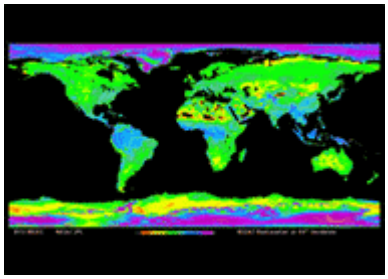
Notice to Data Users:
The documentation for this data set was provided solely by the Principal Investigator(s) and was not further developed, thoroughly reviewed, or edited by NSIDC. Thus, support for this data set may be limited.

SMEX05 QuikSCAT/SeaWinds Backscatter Data: Iowa



Summary

This data set includes radar backscatter data collected over the Soil Moisture Experiment 2005 (SMEX05) area of Iowa, USA from 01 May 2005 through 31 July 2005. The SeaWinds scatterometer on the NASA Quick Scatterometer (QuikSCAT) satellite collected backscatter data. The total volume of this data set is approximately 18 megabytes. Data are provided in gzip compressed Brigham Young University - Microwave Earth Remote Sensing (BYU-MERS) Scatterometer Image Reconstruction (SIR) images and Graphics Interchange Format (GIF) images, and are available via FTP.

The Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) is a mission instrument launched aboard NASA's Aqua satellite on 04 May 2002. AMSR-E validation studies linked to SMEX are designed to evaluate the accuracy of AMSR-E soil moisture data. Specific validation objectives include: assessing and refining soil moisture algorithm performance; verifying soil moisture estimation accuracy; investigating the effects of vegetation, surface temperature, topography, and soil texture on soil moisture accuracy; and determining the regions that are useful for AMSR-E soil moisture measurements.

Citing These Data:

Long, David G. 2010. *SMEX05 QuikSCAT/SeaWinds Backscatter Data: Iowa.* Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

Overview Table

Category	Description
Data format	gzip compressed SIR GIF
Spatial coverage	41.5º to 42.5º N, 93º to 95º W
Temporal coverage	01 May 2005 to 31 July 2005
File naming convention	queh-a-NAm05-121-124.sir.SME.gz queh-a-NAm05-121-124.sir.SM.gif
File size	.gz files range in size from 7 to 32 KB .gif files range in size from 3 KB to 14 KB
Procedures for obtaining data	Data are available via FTP.

Table of Contents

1. Contacts and Acknowledgments:

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Acknowledgements:

This work was supported by the NASA Aqua AMSR-E, Terrestrial Hydrology, Global Water Cycle Programs, Ocean Vector Winds, and Pathfinder programs. QuikSCAT data was obtained through the Jet Propulsion Laboratory Physical Oceanography Distributed Active Archive Center.

2. Detailed Data Description:

Format:

The data files are gzip compressed BYU SIR format image files of backscatter values. The file header contains map projection information and information required to convert the values stored in the file to floating point backscatter values.

Also included are GIF files for quick-look purposes. The grayscale for each GIF file is -30 to 0 dB, black to white. The text in the lower left of the GIF image shows the year and day range of the data. The bright spots are urban areas.

The BYU SIR image format was developed by the Brigham Young University Microwave Earth Remote Sensing research group to store images of the earth along with the information required to easily earth-locate the image pixels.

A SIR file consists of one or more 512 byte headers containing the information required to read the file contents. Headers also include the map projection information required to map pixels to latitude and longitude (lat/lon) on the Earth surface. Pixel values are generally stored as 2-byte (high order byte first) integers, though they also can be stored as bytes or as Institute of Electrical and Electronics Engineers (IEEE) floating point. The IEEE format is not portable to all machines, so is not recommended. Scale factors to convert the integer or byte pixel values to native floating point units are stored in the file header. The origin of each image is displayed in the lower left corner. The Earth location of a pixel is identified by the lower-left corner.

The standard SIR format supports a variety of image projections including:

- rectangular array (no projection)
- a rectangular latitude/longitude array
- two different types of Lambert equal-area projections which can be used in both non-polar and polar projections
- polar stereographic projections
- Equal-Area Scalable Earth (EASE-grid) polar projection with various resolutions
- EASE global projection with various resolutions

In general, SIR image data files have been generated using the SIR resolution enhancement algorithm or one of its variants for radiometer processing. The multivariate SIR algorithm is a non-linear resolution enhancement algorithm based on modified algebraic reconstruction and maximum entropy techniques (Long, Hardin, and Whiting, 1993). The single variate SIR algorithm was developed originally for radiometers (Long and Daum, 1997) but also was used for SeaWinds (Early and Long, 2001). The SIR with modified median filtering (SIRF) algorithm has been successfully applied to SEASAT-A Scatterometer System (SASS) and NASA Scatterometer (NSCAT) measurements to study tropical vegetation and glacial ice (e.g. Long and Drinkwater, 1999). Variants of SIR have been successfully applied to European Remote Sensing Satellite-1 (ERS-1) and European Remote Sensing Satellite-2 (ERS-2) scatterometer and various radiometers including the Special Sensor Microwave/Imager (SSM/I) and the Scanning Multichannel Microwave Radiometer (SMMR). SIRF is used for SASS, NSCAT, and SeaWinds slice data processing. SIR is used for ERS-1 & 2 and SeaWinds egg data. SIRF is not used with ERS-1 & 2 data and SeaWinds egg data.

File Naming Convention:

Files are named according to the following convention and are further described in Table 1:

```
nnnn-a-NAm05-ddd-ddd.sir.SME.gz
nnnn-a-NAm05-ddd-ddd.sir.SM.gif
```

Table 1. Description of File Name Variables

Variable	Description
nnnn	Sensor and polarization name: queh = QuikScat egg inner beam (h-pol) quev = QuikScat egg outer beam (v-pol) qush = QuikScat slice inner beam (h-pol) qusv = QuikScat slice outer beam (v-pol)
a	ascending (north-bound) orbit passes
NAm05	North America
ddd-ddd	For images that are composites of two or more images, ddd- is Start day (Day of year) of data used in the image, and -ddd is End day of data used to make image, e.g. queh-a-NAm05-121-124.sir.SM.gif.

	For single-day images, file names use the same Day of year number in each ddd-ddd, e.g. queh-a-NAm05-130-130.sir.SME.gz.
`sir`	SIR image
`SME (or SM)`	SMEX05 box extracted from the NAm region
`.gz`	gzip compressed file
`.gif`	Graphics Interchange Format

File Size:

The .gz compressed files range in size from 7 to 32 kilobytes.

The GIF files range in size from 3 to 14 kilobytes.

Spatial Coverage:

Northernmost Latitude: 42.5º N
Southernmost Latitude: 41.5º N
Westernmost Longitude: 95º W
Easternmost Longitude: 93º W

Temporal Coverage:

Data span 01 May 2005 to 31 July 2005.

Parameter or Variable:

Backscatter values

3. Data Access and Tools:

Data Access:

Data are available via FTP at:
ftp://sidads.colorado.edu/pub/DATASETS/AVDM/data/soil_moisture/SMEX05/satellite/QUIKSCAT

Software and Tools:

Software to read SIR format files are available in C, Fortran, Matlab, and IDL/PV-WAVE from the BYU MERS Web site (http://www.mers.byu.edu/software.html), or from the NASA Scatterometer Climate Record Pathfinder Web site (http://www.scp.byu.edu/downloads.html). Details of the header byte format are documented in the various file readers. Available utilities include a modified xv program to directly view SIR files, and programs to convert SIR files into .gif, .bmp, .tiff, and geotiff files.

Related Data Collections:

For related data collections, please see AMSR-E Validation:
http://nsidc.org/data/amsr_validation/

4. Data Acquisition and Processing:

SeaWinds is a radar scatterometer on QuikSCAT and on Advanced Earth Observation Satellite-II (ADEOS-II). The first SeaWinds was launched in 1999 and was designed to measure near-surface wind speed over the Earth's oceans. SeaWinds uses a rotating dish antenna with two spot beams that sweep in a circular pattern. The antenna spins at a rate of 18 rpm, scanning two pencil-beam footprint paths at incidence angles of 46 degrees horizontal polarization (H-pol) and 54 degrees vertical polarization (V-pol). The antenna radiates microwave pulses at a frequency of 13.4 GHz across broad regions on Earth's surface with an 1800 km swath.

QuikSCAT is in a sun-synchronous, 803-km, circular orbit with a local equator crossing time at the ascending node of 6:00 a.a. plus or minus 30 minutes. The SeaWinds antenna footprint is an ellipse approximately 25 km in azimuth by 37 km in the look (or range) direction. There is considerable overlap of these footprints, with approximately 8 to 20 of these ellipses with centers in a 25 by 25 km box on the surface. Signal processing provides commandable variable range resolution of approximately 2 to 10 kilometers. The nominal resolution is approximately 6 kilometers with an effective range gate of 0.5 msec. Additional information is available at http://podaac.jpl.nasa.gov/quikscat/qscat_doc.html.

The NASA Scatterometer Climate Record Pathfinder (SCP) is a NASA-sponsored collaborative project between investigators at Brigham Young University (BYU), the Jet Propulsion Laboratory (JPL), the European Space Agency (ESA), and the National Ice

Center (NIC) to develop accurately calibrated scatterometer-based data time series in support of climate-related studies of the Earth's cryosphere and biosphere. Originally developed to measure winds over the ocean from space, microwave radar scatterometers have proven to be applicable over a wide range of vegetation zones and moisture conditions including wet, dry and frozen. Because the scatterometer radar signal can penetrate the surface, a scatterometer can observe variability in subsurface/subcanopy climate-related features which are driven by diurnal, seasonal, and interannual forces. The 1978 launch of Seasat, carrying a Ku-band scatterometer (SASS), provided a baseline against which studies of global change can be measured. Other missions have followed SASS, including: the C-band ESA ERS-1 and ERS-2 missions beginning in 1992; the NASA Scatterometer (NSCAT) mission aboard the Japanese ADEOS satellite in 1996-97; SeaWinds on QuikSCAT beginning in 1999; and SeaWinds on ADEOS-II in 2003. With their rapid global coverage, day or night and all-weather operation, scatterometers offer a unique tool for long-term climate studies. The goal of the SCP is to provide scatterometer-based data sets to researchers involved in climate studies.

QuikSCAT collects vertically polarized backscatter measurements at approximately 54 degrees incidence and horizontally polarized measurements at approximately 46 degrees in two forms: eggs and slices. The resolution of egg measurements is approximately 35 km by 25 km, while slices are 25 km by 6 km. There are thus four versions of data, denoted by queh, quev, qush, and qusv representing egg-horizontal, egg-vertical, slice-horizontal, and slice-vertical respectively. The eggs measurements tend to be less noisy due to more averaging. Whereas ideally slices and eggs have the same mean, in practice there is some variation due to incidence angle effects.

Using the SIR algorithm which combines multiple passes to produce enhanced spatial resolution, we have generated backscatter images for each version (queh, quev, qush, and qusv). Daily images and four day average images were created. Due to the orbital geometry and swath width, some days do not completely cover the study area. The orbit has a four-day repeat, so the four-day images ensure full coverage of the study area and tend to reduce noise. The slice images are reported at a pixel resolution of 2.225 km/pixel while the egg images are reported at resolution of 4.45 km/pixel, though the effective resolution is somewhat less than this.

Small regions were extracted from the large standard SCP continental images such that the lat/lon bounds of the study region are contained within the study boxes. The map projection is a Lambert equal area projection so the box is not square in lat/lon. That is, lat/lon lines curve in the images.

Theory of Measurements:

The SCP datasets are based primarily on a time series of enhanced resolution images made from the scatterometer backscatter (sigma-0) measurements using the SIR and SIRF algorithms. For the highest possible spatial resolution (as well as to ensure full coverage over the images) multiple orbit passes are combined. There is thus a tradeoff

between temporal and spatial resolution. For SASS, NSCAT, and ERS, images are made of sigma-0 at 40 deg incidence angle (A) in dB and the slope of sigma-0 versus incidence angle (B) in dB/deg. For QuikSCAT and SeaWinds sigma-0 images at the nominal observation, incidence angles (46 deg H-pol and 54 deg V-pol) are made. In addition to these images, a number of ancillary images and derived products are generated including sea ice extent maps and sea ice motion data sets. From the time series of radar backscatter images and derived products, key climate-related parameters can be extracted for use in global climate change studies.

For scatterometers, the multivariate form of the SIR algorithm models the dependence of sigma-0 on incidence angle as sigma-0 (in dB) = A + B * (Inc Ang - 40 deg) over the incidence angle range of 15 to 60 degrees. The output of the SIR algorithm yields images of the A and B coefficients. This form is used for ERS, NSCAT, and SASS.

The incidence angle normalized sigma-0 (effectively the sigma-0 value at 40 degrees incidence angle) is represented by A measured in decibels (dB). Typically, $+2 < A < -45$ dB. However, in the SIR images A is typically clipped to a minimum -32 dB with values of $A < -32$ used to indicate missing data.

The B coefficient describes the incidence angle dependence of sigma-0 and has the units of dB/deg. A Ku-band global average of B is approximately -0.13 dB/deg. Typically, $-0.2 < B < -0.1$. B is clipped to a minimum value of -3 dB/deg. This value is used to denote missing data as well.

Single variable SIR or SIRF algorithms are used for radiometers and SeaWinds, producing only an A (in this case, the brightness temperature) image. Typically, this can range from 165 to 320. Single variable SIR and SIRF algorithms are used for SeaWinds egg and slice images, respectively. In both cases the A images are at the nominal measurement incidence angle for the sensor and in the sensor measurement units.

SIR images are stored in row-scanned (left to right) order from the lower left corner (the origin of the image) up through the upper right corner. By default, the location of a pixel is identified with its lower-left corner. The origin of pixel (1,1) is the lower left corner of the image. The array index n of the (i,j)th pixel where i is horizontal and j is vertical is given by $n=(j-1)*Nx+i$ where Nx is the horizontal dimension of the image.

5. References and Related Publications:

Please see the National Snow and Ice Data Center (NSIDC) SMEX05 Data Web site for more information and to access data:
http://nsidc.org/data/amsr_validation/soil_moisture/smex05/index.html

Backscatter observations from the NASA Scatterometer Climate Record Pathfinder (SCP): http://www.scp.byu.edu/

Early, D. S. and D. G. Long. 2001. Image Reconstruction and Enhanced Resolution Imaging From Irregular Samples. *IEEE Trans. Geosci. Remote Sens*. 39:2, 291-302.

Long, D. G. and D. Daum. 1997. Spatial Resolution Enhancement of SSM/I Data. *IEEE Trans. Geosci. Rem. Sens*. 36, 407-417.

Long, D. G. and M. R. Drinkwater. 1999. Cryosphere Applications of NSCAT Data. *IEEE Trans. Geosci. Remote Sens.* 37:3, 1671-1684.

Long, D. G., P. Hardin, and P. Whiting. 1993. Resolution Enhancement of Spaceborne Scatterometer Data. *IEEE Trans. Geosci. Remote Sens*. 31, 700-715.

NASA JPL SeaWinds on QuikSCAT:
http://podaac.jpl.nasa.gov/DATA_CATALOG/quikscatinfo.html

For additional references, visit the NASA SCP Web page Bibliography of Scatterometer Applications over Land and Ice:
http://www.scp.byu.edu/docs/bibliography.html

6. Document Information:

List of Acronyms& Abbreviations

The following acronyms and abbreviations are used in this document:

ADEOS-II - Advanced Earth Observation Satellite-II
bmp - bitmap file format
BYU-MERS – Brigham Young University - Microwave Earth Remote Sensing
DAAC - Distributed Active Archive Center
dB – decibel
EASE-grid - Equal-Area Scalable Earth
ERS-1 - European Remote Sensing Satellite-1
ERS-2 - European Remote Sensing Satellite-2
ESA - European Space Agency
FTP - File Transfer Protocol
geoTIFF - georeferenced TIFF file
GHz - gigahertz
GIF – Graphics Interchange Format
gz – gzip compressed file
H-pol – Horizontal polarization
IEEE – Institute of Electrical and Electronics Engineers
JPL – Jet Propulsion Laboratory

lat/lon - latitude and longitude
NASA - National Aeronautics and Space Administration
NIC - National Ice Center
NSIDC – National Snow and Ice Data Center
NSCAT - NASA Scatterometer
QuikSCAT – NASA Quick Scatterometer satellite
SASS – SEASAT-A Scatterometer System
SCP - NASA Scatterometer Climate Record Pathfinder
SIR – Scatterometer Image Reconstruction
SIRF - SIR with modified median filtering
SMEX05 – Soil Moisture Experiment 2005
SSM/I - Special Sensor Microwave/Imager
SSMR - Scanning Multichannel Microwave Radiometer
TIFF - Tag Image File Format
UTM - Universal Transverse Mercator
V-pol – Vertical polarization

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