SMEX02 Vegetation Water Content, Iowa Regional and Walnut Creek Watershed, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Jackson, T. and M. Cosh. 2003. *SMEX02 Vegetation Water Content, Iowa Regional and Walnut Creek Watershed, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/0X2GRYXDM3EA. [Date Accessed].

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National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

1.1 Format

Files are in flat binary format with no header. Data are in PC byte order (little endian). SGI and Sun users will need to byte-swap these data before using them.

Regional files for VWC are 1851 columns by 3831 rows.

Watershed files for VWC are 1216 columns by 611 rows.

1.2 File and Directory Structure

There are two main directories, regional and watershed.

Individual data values must be divided by 25.5 to obtain the actual VWC in kg/m3.

1.3 File Naming Convention

File names begin with the Julian date, followed by the data type, VWC. Regional files have no other designation. For example, "198_VWC.bil." Walnut Creek watershed files include "WC" before the data type. For example, "198_WC_VWC.bil."

The following table shows the day, month, and year for the Julian dates used in the file names.

Table 1. Julian Dates of Files

Regional Files	Watershed Files	Date
174_VWC.bin		25-Jun-2002
175_VWC.bin	175_WC_VWC.bil	25-Jun-2002
176_VWC.bin	176_WC_VWC.bil	26-Jun-2002
177_VWC.bin	177_WC_VWC.bil	27-Jun-2002
178_VWC.bin	178_WC_VWC.bil	28-Jun-2002
179_VWC.bin	179_WC_VWC.bil	29-Jun-2002
180_VWC.bin	180_WC_VWC.bil	30-Jun-2002
181_VWC.bin	181_WC_VWC.bil	1-Jul-2002
182_VWC.bin	182_WC_VWC.bil	2-Jul-2002
183_VWC.bin	183_WC_VWC.bil	3-Jul-2002
184_VWC.bin	184_WC_VWC.bil	4-Jul-2002
185_VWC.bin	185_WC_VWC.bil	5-Jul-2002

Regional Files	Watershed Files	Date
186_VWC.bin	186_WC_VWC.bil	6-Jul-2002
187_VWC.bin	187_WC_VWC.bil	7-Jul-2002
188_VWC.bin	188_WC_VWC.bil	8-Jul-2002
189_VWC.bin	189_WC_VWC.bil	9-Jul-2002
190_VWC.bin	190_WC_VWC.bil	10-Jul-2002
191_VWC.bin	191_WC_VWC.bil	11-Jul-2002
192_VWC.bin	192_WC_VWC.bil	12-Jul-2002
193_VWC.bin	193_WC_VWC.bil	13-Jul-2002
194_VWC.bin	194_WC_VWC.bil	14-Jul-2002
195_VWC.bin	195_WC_VWC.bil	15-Jul-2002
196_VWC.bin	196_WC_VWC.bil	16-Jul-2002
197_VWC.bin	197_WC_VWC.bil	17-Jul-2002
198_VWC.bin	198_WC_VWC.bil	18-Jul-2002

1.4 File Size

Files in the regional directory are 6.76 MB each. Files in the watershed directory are 725 KB each.

1.5 Volume

Total volume of all images is 186 MB.

1.6 Spatial Coverage

The coordinates for both areas given below are in latitude and longitude and in Universe Transverse Mercator (UTM) Zone 15. The coordinates represent the pixel centers of each corner pixel.

Table 2. Regional Area

Location	Latitude	Longitude	Easting	Northing
Upper Left	42.729 N	93.841 W	431100.000 E	4731100.000 N
Upper Right	42.732 N	93.163 W	486600.000 E	4731100.000 N
Lower Left	41.694 N	93.827 W	431100.000 E	4616200.000 N
Lower Right	41.697 N	93.161 W	486600.000 E	4616200.000 N

Table 3. Watershed Area

Location	Latitude	Longitude	Easting	Northing
Upper Left	42.037 N	93.832 W	431100.000 E	4654300.000 N
Upper Right	42.040 N	93.392 W	467550.000 E	4654300.000 N
Lower Left	41.872 N	93.830 W	431100.000 E	4636000.000 N
Lower Right	41.875 N	93.391 W	467550.000 E	4636000.000 N

1.6.1 Spatial Resolution

The Landsat TM and ETM+ data were used to produce high-resolution (30 m) NDWI and VWC data.

1.6.2 Projection Description

Universal Transverse Mercator (UTM) Zone 15.

1.7 Temporal Coverage

1.7.1 Temporal Resolution

Daily coverage for the dates 25 June through 18 July 2002.

1.8 Parameter or Variable

1.8.1 Parameter Description

The parameter measured in this data set is VWC, derived from NDWI. NDWI is the difference between the visible (red) and near-infrared (NIR) bands over their sum. NDWI divides the difference between reflected green-light and reflected near-infrared by the sum of those two bands. NDWI gives an estimate of the soil moisture.

1.8.2 Parameter Source

TM scenes from Landsat 5 and Landsat 7 were acquired during the primary study period. These data were used to produce high-resolution (30 m) NDVI and NDWI data sets. The following table details the Landsat coverage for the dates of the study.

Table 4. Landsat Coverage

Date	Landsat Number	Path	Row
June 6	7	27	31
June 23	5	26	31
July 1	7	26	31
July 8	7	27	31
July 17	7	26	31

1.8.3 Sample Data Record

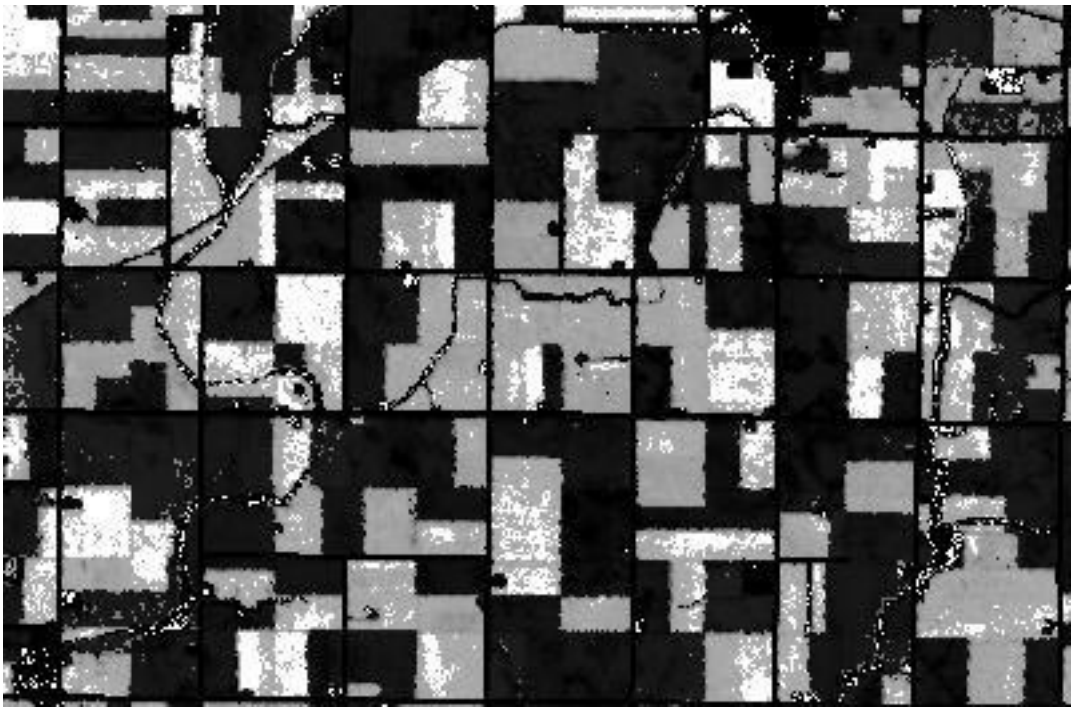

Figure 1. A screen shot of a portion of the image file “198_VWC.bin.”

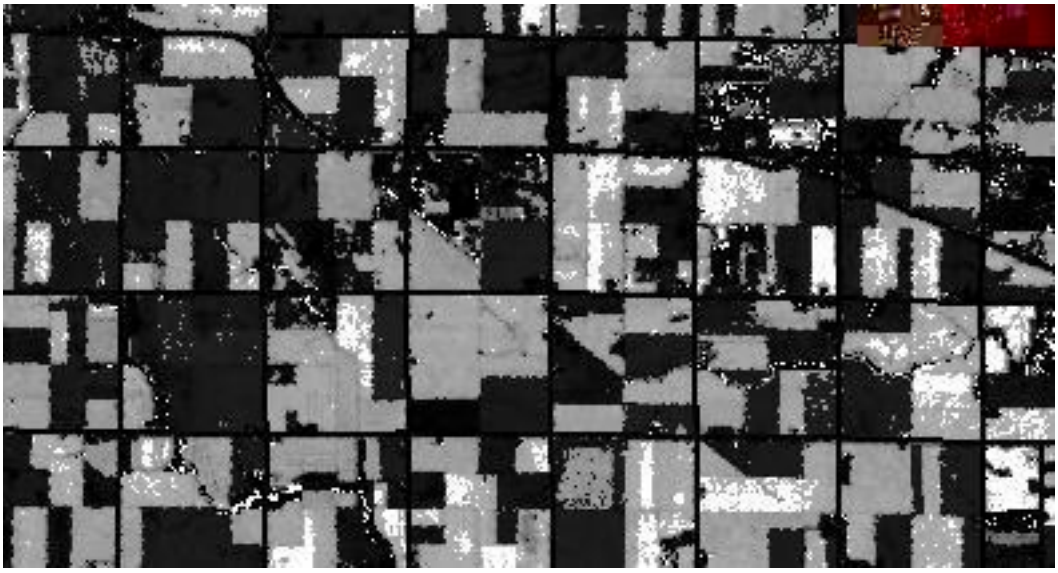

Figure 2. A screen shot of a portion of the image file "198_WC_VWC.bil."

2 SOFTWARE AND TOOLS

Open these files in an appropriate image processing or image viewing application.

3 DATA ACQUISITION AND PROCESSING

3.1 Derivation Techniques and Algorithms

3.1.1 Normalized Difference Water Index (NDWI)

Radiance from a satellite platform is strongly affected by the presence of the atmosphere. Atmospheric correction for NDWI was made to convert satellite-based radiance to an estimate of ground reflectance. Please see the SMEX Iowa Satellite Vegetation and Water Index (NDVI and NDWI) Data documentation for information about the atmospheric correction made for NDWI.

3.1.2 Watershed Calibration

VWC was derived from the NDWI, which is a ratio of bands available from the Landsat 5 TM and Landsat 7 ETM+. The ratio is defined as:

$$NDWI = (Band\ 4 - Band\ 5)/(Band\ 4 + Band\ 5)$$

Five scenes were used to estimate VWC for the entire watershed. The first step was to determine the trend of VWC versus day of year (DOY) and compare it to the trend of NDWI versus DOY. Vegetation sampling was conducted before and during the SMEX02 to support this endeavor. 31 watershed fields were sampled between 2 and 4 times during June and July 2002 to provide an

estimate of VWC per field. Within each field, locations were selected to represent a high, a low, and an average vegetation cover. The corners of each sampling site are the basis for data retrieval for the proceeding analysis.

Average VWC values were calculated for each field for each day of sampling. Some days were combined so that the VWC estimate is the average of five samples at three sampling sites for a total of 15 samples. An initial value of 0.05 kg/m2 for VWC was set on June 10, 2002 which is characteristic of the region. From these data points, VWC values were interpolated for the remaining dates for each field. Functions were then developed for both corn and soybean fields.

Average NDWI values were retrieved from the five scenes for each of the WC fields sampled. Field averages were calculated by sampling the four corners of each sampling site for a total of 12 pixels per field. Some pixels were contaminated by nearby roadways or streams and these pixels were eliminated from the analysis. These field averages were then linearly extrapolated between the five days of record to provide an interpolated NDWI product for each field. A relationship was established for NDWI as a function of DOY for the two dominate crop types, corn and soybean.

The DOY functions for both VWC and NDWI were combined to produce new functions where VWC is predicted by NDWI. These functions are as follows:

Corn: VWC = 9.8166 * NDWI + 0.0522
Soybean: VWC= 1.468 * NDWI + 1.3615 * NDWI + 0.3394

In addition, areas determined to be forested were given a VWC of 10 kg/m2 and grassland were given a VWC of 0.5 kg/m2.

These functions were used to generate VWC maps for the five original TM/ETM+ scenes available. From the five available dates, VWC was determined for the length of the experiment by interpolating on a pixel-by-pixel basis from the five dates of VWC maps. Using a simple piecewise cubic Hermite interpolation for the five days, a time series was established from 6 June through 17 July 2002. This interpolation maintains the pattern for each day of record and interpolates between them for missing days. It was noted that for both NDVI and NDWI, the satellite sensors tended to saturate on or around 8 July 2002 for the very green vegetation. To compensate for this, the values for 17 July 2002 were adjusted in the case of VWC values equal to 5 kg/m3. If a pixel had a value of 5 kg/m2 (near saturation) the VWC was increased to 7 kg/m3. This value was used for interpolation.

To verify the accuracy of this method, the pixels relating to the vegetation ground sampling were retrieved for statistical analysis.

Corn: Bias: -0.0097 rmse: 0.5759

Soy: Bias: -0.0153 rmse: 0.1713
Total: Bias: -0.0118 rmse: 0.4695 R2: 0.9302

3.1.3 Regional Calibration

Preliminary regional VWC maps were generated similarly to the watershed, with some exceptions. Three sets of scenes were available for the Iowa region during the experiment, 23 June, 1 July, and 17 July. The two scenes for each day were mosaicked and regional maps of NDWI were generated. From the NDWI maps, VWC maps were generated using the same relationships that were developed in the Walnut Creek (WC) watershed region. From these three scenes, a linear interpolation was developed for the entire study period. To verify the accuracy of the preliminary interpolation method, the WC sampling sites were revisited and statistics were recalculated.

Corn: Bias: -0.2619 rmse: 0.6501
Soy: Bias: -0.0497 rmse: 0.1965
Total: Bias: -0.1883 rmse: 0.5381 R2: 0.9150

The high corn bias can be explained by the inability to interpolate during the later stages of the study period, when there was a precipitation event and rapid growth. This fact coupled with the tendency for NDWI to saturation at approximately 5 kg/m2 results in the poor fit of this data.

A primary reason for the preliminary nature of this data is the presence of clouds on 17 July 2002 which potentially influenced VWC readings for that area. Future datasets will provide a better remedy for this issue.

3.2 Sensor or Instrument Description

TM is a multispectral scanning radiometer carried on Landsat 4 and 5. The TM has seven spectral bands, with a spatial resolution of 30 m for most bands.

ETM+, an improved version of TM, is carried on Landsat 7. The ETM+ has eight spectral bands with a spatial resolution of 30 m for most bands. ETM+ calibration is good to within five percent.

4 REFERENCES AND RELATED PUBLICATIONS

Gao, B.C., 1996: NDWI - A normalized difference water index for remote sensing of vegetation liquid water from space. *Remote Sensing of Environment*, Vol. 58: 257-266

4.1 Related Websites

Landsat 7 Project information

Thematic Mapper (TM)

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

6.1 Publication Date

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6.2 Date Last Updated

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