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NACP MCI: Cropland Productivity and Biophysical Properties, Nebraska, USA, 2001-2008

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Revision Date: May 22, 2014

Summary:

This data set provides an integrated collection of (1) ground-based meteorological, radiometric, and vegetation measurements, (2) flux-based estimates of gross primary production (GPP), and (3) numerous vegetation indices derived from satellite imagery for three eddy covariance flux tower locations near Lincoln, Nebraska, USA. Land use surrounding the towers is cropland with corn and soybeans. Data are reported for selected days during the growing seasons of 2001 through 2008 only when ground-based crop canopy reflectance was measured. Algorithms developed to relate ground-based and satellite spectral information to GPP of the cropland adjacent to the towers are provided.

- AmeriFlux tower-based Level 2 measurements included photosynthetically active radiation (PAR), heat flux, and GPP estimates; see Section 2 for specific towers.
- Ground-based measurements on the corn and soybean vegetation surrounding the towers included total chlorophyll content (Chl) and leaf area index (LAI).
- Ground-based crop canopy reflectance was measured at 5.4 m above the corn and soybean canopy using hyperspectral radiometers (range 400 to 1100 nm) during the growing season from May to October in eight different years (2001-2008). This resulted in 173 measurement campaigns (18 in 2001, 31 in 2002, 34 in 2003, 31 in 2004, 21 in 2005, 15 in 2006, 14 in 2007, and 9 in 2008).
- Spectral bands from Landsat TM and ETM+, MERIS, and MODIS instruments were used to calculate vegetation indices. Vegetation indices related to chlorophyll can be used as a proxy for GPP because of the observed close relationship between GPP and Chl content in crops. Algorithms developed to relate spectral information to the GPP of the cropland adjacent to the towers are provided as companion files.

The study was undertaken as part of the North American Carbon Program (NACP) Mid-Continent Intensive (MCI) campaign.

There is one comma-delimited data file (.csv) with this data set. The equations used for calculated variables and the algorithms developed to relate spectral information to GPP are included as companion files.

Data and Documentation Access:

Get Data: http://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1217

Description and Links to Additional Supplemental Information:

- [Table_of_Algorithms.pdf](#): The algorithms produced (based on these data) relating GPP and reflectance
- [Equations_for_calculated_variables.pdf](#): The equations used for calculated variables (biophysical characteristics and vegetation indices)

Data Citation:

Cite this data set as follows:

Gitelson, A.A. 2014. NACP MCI: Cropland Productivity and Biophysical Properties, Nebraska, USA, 2001-2008. Data set. Available on-line

[<http://daac.ornl.gov>] from ORNL DAAC, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1217>

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1. Data Set Overview:

Project: North American Carbon Program

The North American Carbon Program (NACP) (Denning et al., 2005; Wofsy and Harris, 2002) is a multidisciplinary research program to obtain scientific understanding of North America's carbon sources and sinks and of changes in carbon stocks needed to meet societal concerns and to provide tools for decision makers. Successful execution of the NACP has required an unprecedented level of coordination among observational, experimental, and modeling efforts regarding terrestrial, oceanic, atmospheric, and human components. The project has relied upon a rich and diverse array of existing observational networks, monitoring sites, and experimental field studies in North America and its adjacent oceans. It is supported by a number of different federal agencies through a variety of intramural and extramural funding mechanisms and award instruments.

This data set was collected as part of the North American Carbon Program (NACP) Mid-Continent Intensive (MCI) campaign.

This data set provides an integrated collection of (1) ground-based meteorological, radiometric, and vegetation measurements, (2) flux-based estimates of gross primary production (GPP), and (3) numerous vegetation indices derived from satellite imagery for three AmeriFlux tower locations near Lincoln, Nebraska, USA. Land use surrounding the towers is cropland with corn and soybeans. Algorithms developed to relate spectral information to the GPP of the cropland adjacent to the towers are provided as companion files.

2. Data Characteristics:

2.1. Spatial Coverage

Site: AmeriFlux towers, Lincoln, Nebraska, USA

Site boundaries: (All latitude and longitude given in degrees and fractions)

Site (Name)	Site Code	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Mead - irrigated continuous maize site	US-Ne1	-96.4766	-96.4766	41.1651	41.1651
Mead - irrigated maize-soybean rotation site	US-Ne2	-96.4701	-96.4701	41.1649	41.1649
Mead - rainfed maize-soybean rotation site	US-Ne3	-96.4397	-96.4397	41.1797	41.1797

2.2. Temporal Coverage

The data set covers the period 2001/06/12 to 2008/08/15.

2.3. Data File information

The GPP and reflectance data are presented in one csv file: **NACP_Crop_GPP_Reflectance_2001_2008.csv**.

The algorithms produced based on these data relating GPP and reflectance are provided in the file [Table_of_Algorithms.pdf](#) and equations used for calculated variables (biophysical characteristics and vegetation indices) are provided in the file [Equations_for_calculated_variables.pdf](#).

Column	Column heading	Units/Format	Description
1	Year	YYYY	Year in which measurements were made
2	Date	YYYYMMDD	Date on which measurements were made
3	Field		Field identification: Sites 1, 2, or 3
4	Field Type		Field type: either Dryland or Irrigated
5	Crop		Crop growing at the time of measurement: Bt Corn; Corn or Soybean

6	DOY		Day of the year on which measurements were made, with Jan 1= 1 and Dec 31= 365. Data are reported for selected days during the growing season -- ranging from 139 to 282. These are the days ground-based crop reflectance was measured.
7	GPP_Day	umol per m2 per s	Daytime GPP derived by averaging hourly GPP values when incoming photosynthetically active radiation [PARin] exceeded 1 umol m-2 s-1
8	PARin_Day	umol per m2 per s	Daytime incoming photosynthetically active radiation (PAR) (wavelength from 400 to 700 nm) derived by averaging hourly PARin measurements when PARin exceeded 1 umol m-2 s-1
9	fAPAR_Day	unitless	Absorbed fraction of PAR derived by averaging hourly fAPAR when PARin exceeded 1 umol m-2 s-1
10	LE_Day	W per m2	Daytime Latent heat flux derived by averaging hourly measurements when PARin exceeded 1 umol m-2 s-1
11	GPP_MDay	umol per m2 per s	Midday GPP derived by averaging hourly GPP values for the period between 10:30 and 15:30 local time (CDT)
12	PARin_MDay	umol per m2 per s	Midday PARin derived by averaging hourly measurements for the period between 10:30 and 15:30 local time (CDT)
13	fAPAR_MDay	unitless	Absorbed fraction of PAR derived by averaging hourly fAPAR for the period between 10:30 and 15:30 local time (CDT)
14	LE_MDay	W per m2	Midday Latent heat flux derived by averaging hourly measurements for the period between 10:30 and 15:30 local time (CDT)
15	canopy_Ch1	g per m2	Canopy chlorophyll content calculated as leaf chlorophyll content times LAI
16	LAI	m2 per m2	LAI determined destructively
17	LAIgreen	m2 per m2	LAI for green leaf material, the photosynthetically functional component of LAI
18	VF	%	Vegetation fraction (percent vegetation ground cover)
19	TM_NDVI	unitless	Normalized difference vegetation index calculated from Landsat TM and ETM+
20	TM_EVI2	unitless	Enhanced vegetation index calculated from Landsat TM and ETM+
21	TM_WDRVI_05	unitless	Wide dynamic range vegetation index with alpha equal to 0.05 from Landsat TM and ETM+
22	TM_WDRVI_1	unitless	Wide dynamic range vegetation index with alpha equal to 0.1 from Landsat TM and ETM+
23	TM_Green NDVI	unitless	Green vegetation index calculated from Landsat TM and ETM+
24	TM_VARI	unitless	Visible atmospherically resistant indices calculated from Landsat TM and ETM+
25	TM_Clgreen	unitless	Chlorophyll index green from Landsat TM and ETM+
26	MODIS_Clgreen	unitless	Chlorophyll index green calculated from MODIS
27	MERIS_Clre	unitless	Chlorophyll index red edge calculated from MERIS
28	R_TM_blue	%	Reflectance for the blue portion of the spectrum (wavelengths of 450 to 520 nm) calculated from simulated TM reported in percent
29	R_TM_green	%	Reflectance for the green portion of the spectrum (wavelengths of 520 to 600 nm) calculated from simulated TM reported in percent
30	R_TM_red	%	Reflectance for the red portion of the spectrum (wavelengths of 630 to 690 nm) calculated from simulated TM reported in percent
31	R_TM_IR	%	Reflectance for the near infrared (NIR) portion of the spectrum (wavelengths of 760 to 900 nm) calculated from simulated TM reported in percent
32	R_MODIS _green	%	Reflectance for the green portion of the spectrum (wavelengths of 545 to 565 nm) calculated from MODIS reported in percent

33	R_MERIS_RE	%	Reflectance for the red edge (RE) portion of the spectrum (wavelengths of 703 to 712 nm) calculated from MERIS reported in percent
34 through 84	R_XXX	%	For the remaining columns the values are ground-based measurements of crop canopy reflectance centered on the specific wavelengths in nanometers named in the column heading and reported in percent. Percent reflectance equation provided in Section 5
Missing data represented by -9999			

Sample data

<p>Year,Date,Field,Field Type,Crop,DOY,GPP_Day,PARin_Day,fAPAR_Day,LE_Day, GPP_MDay,PARin_MDay,fAPAR_MDay,LE_MDay,canopy_ChI,LAI,LAIgreen,VF,TM_NDVI,TM_EVI2, TM_WDRVI_05,TM_WDRVI_1,TM_GreenNDVI,TM_VARI,TM_Clgreen,MODIS_Clgreen, MERIS_CIre, R_TM_blue,R_TM_green,R_TM_red,R_TM_IR,R_MODIS_green,R_MERIS_RE,R_400,R_410,R_420,R_430, R_440,R_450,R_460,R_470,R_480,R_490,R_500,R_510,R_520,R_530,R_540,R_550,R_560,R_570,R_580, R_590,R_600,R_610,R_620,R_630,R_640,R_650,R_660,R_670,R_680,R_690,R_700,R_710,R_720,R_730, R_740,R_750,R_760,R_770,R_780,R_790,R_800,R_810,R_820,R_830,R_840,R_850,R_860,R_870,R_880, R_890,R_900</p> <p>2001,20010612,1,Irrigated,Corn,163,0.545,693.748,0.12,-108.48,0.823,1314.533,0.094,-172.517,-9999,0.355, 0.346,5.963,0.207,0.108,-0.859,-0.736,0.334,-0.136,1.002,1.07,0.337,7.057,9.302,12.241,18.625,8.996, 13.93, 4.963,5.199,5.426,5.706,5.956,6.243,6.482,6.683,6.918,7.126,7.385,7.645,7.977,8.313,8.653,9.003, 9.332,9.647,9.947,10.312,10.53,10.748,11.033,11.322,11.614,11.932,12.192,12.566,12.851,13.21,13.684, 14.177,14.767,15.22,15.616,16.105,16.463,16.915,17.306,17.711,17.961,18.56,18.573,19.044,19.334,19.393, 19.574,20.157,19.74,19.856,18.793</p> <p>2001,20010621,1,Irrigated,Corn,172,0.701,829.099,0.369,-149.851,1.044,1407.15,0.29,-238.067,-9999,1.294, 1.291,57.786,0.787,0.582,-0.409,-0.088,0.707,0.181,4.815,3.986,3.195,3.81,6.891,4.781,40.068,8.036,9.552, 2.197,2.412,2.654,2.862,2.958,3.097,3.178,3.241,3.349,3.593,3.935,4.47,5.615,6.962,7.819,8.244,8.045,7.259, 6.463,5.894,5.717,5.476,5.159,5.069,4.968,4.728,4.549,4.441,4.554,5.159,7.509,11.596,17.394,25.301,32.966, 37.794,38.273,40.949,41.193,41.38,41.351,41.039,39.311,39.934,40.97,41.18,41.08,40.483,39.997,38.642, 35.236</p>

Companion Files:

- Equations used for calculated variables (biophysical characteristics and vegetation indices) are provided in the companion file [Equations_for_calculated_variables.pdf](#).
- The algorithms produced based on these data relating GPP and reflectance are provided in the companion file [Table_of_Algorithms.pdf](#).

3. Data Application and Derivation:

These data allowed for the development of algorithms which accurately estimate GPP from satellite-based reflectance data and chlorophyll related indices for irrigated and rainfed fields of the dominant crops in the state of Nebraska. The algorithms are provided in the companion file [Table_of_Algorithms.pdf](#) along with literature citations for more information.

4. Quality Assessment:

Accuracy of the individual algorithms for each vegetation index was assessed and reported with the algorithms in terms of root mean square error (RMSE) in the companion file [Table_of_Algorithms.pdf](#).

5. Data Acquisition Materials and Methods:

Study site

Data were collected from three flux tower study sites located at the University of Nebraska Lincoln Agricultural Research and Development Center near Mead, NE, USA. Sites US-Ne1 and US-Ne2 are 65-hectare fields equipped with center pivot irrigation systems. US-Ne3 is of approximately the same size, but relies entirely on rainfall. Site US-Ne1 has continuous cultivation of maize, while sites US-Ne2 and US-Ne3 have maize-soybean rotations. Site US-Ne1 has been under no-till management until the harvest of 2005. Following the harvest in 2005, the conservation-plow tillage operation was initiated and followed from 2006 through 2008. Sites US-Ne2 and US-Ne3 have been under no-till management from 2001 until 2008. Soils of the study area are deep silty clay loam (Suyker et al., 2005).

The Level 2 micrometeorological eddy covariance data used in this study were collected each year from 2001 through 2008. The complete Level 2 data records for these three sites are available from AmeriFlux (<http://ameriflux.ornl.gov/>). To have sufficient upwind fetch (in all directions), eddy covariance sensors were mounted 3 m above the ground while the canopy was shorter than 1 m, and later moved to a height of 6.2 m until harvest (details are

given in Verma et al., 2005). The study sites represented approximately 90 to 95% of the flux footprint during daytime and 70- 90% during nighttime (e.g., Schuepp et al., 1990).

Calculation of NEE and GPP (See companion file: [Equations for calculated variables.pdf](#))

Daytime net ecosystem exchange (NEE) values were computed by integrating the hourly CO₂ fluxes collected by the eddy covariance tower during a day when PAR_{in} exceeded 1 mmol/g/m²/d. Daytime estimates of ecosystem respiration (R_e) were obtained from the night CO₂ exchange and temperature relationship (e.g., Falge et al., 2002). The daytime GPP was then obtained by subtracting daytime respiration from NEE. This approach has been widely used in the context of tower flux measurements and is considered to provide reasonable estimates at the landscape level. Daily GPP was expressed as the integral of the organic matter in grams of carbon produced by all the individual plants through photosynthesis per meter square during a day (gC/m²/d).

PAR measurements (See companion file: [Equations for calculated variables.pdf](#))

Incoming photosynthetically active radiation (PAR_{in}) was measured with point quantum sensors (LI-190, LI-COR Inc., Lincoln, NE) aimed upward, and placed 6 m above the surface. PAR reflected by the canopy and soil (PAR_{out}) was measured with Li-Cor point quantum sensors aimed downward, and placed at 6 m above the ground. PAR transmitted through the canopy (PAR_{transm}) was measured with Li-Cor line quantum sensors placed at about 2 cm above the ground, pointing upward; PAR reflected by the soil (PAR_{soil}) was measured with Li-Cor line quantum sensors placed about 12 cm above the ground, pointing downward. Absorbed PAR (APAR) was calculated as:

$$APAR = PAR_{in} - PAR_{out} - PAR_{transm} + PAR_{soil}$$

All the daytime radiation values were computed by integrating the hourly measurements during a day, and fAPAR was then calculated as APAR/PAR_{in}.

Estimation of Chl

Total chlorophyll content (Chl) was estimated as Chl= Chl_{leaf} x LAI, where Chl_{leaf} is the chlorophyll content of the collar or ear leaves in maize (Ciganda et al., 2009; Gitelson et al., 2005). Leaf chlorophyll content was retrieved from leaf reflectance measured by an Ocean Optics radiometer using a red edge chlorophyll index (details are in Gitelson et al., 2003a, 2006a; Ciganda et al., 2009).

LAI determination

Leaf area index (LAI) was determined destructively. Within each study site, six small intensive measurement zones (IMZ) were established to represent all major occurrences of soil and crop production. On each sampling date, plants from a 1m length of either of two rows were collected and the total number of plants recorded. Collection rows were alternated on successive dates to minimize edge effects on subsequent plant growth. Plants were kept on ice and transported to the laboratory. In the lab, plants were separated into green leaves, dead leaves, and litter components. Sample leaves were run through an area meter (Model LI-3100, Li-Cor, Inc., Lincoln NE) and the leaf area per plant was determined. For each IMZ, the leaf area per plant was multiplied by the plant population to obtain a total LAI. Total LAI for the six IMZs were then averaged to obtain a site-level value (details in Gitelson et al., 2003b).

Reflectance measurements (See companion file [Equations for calculated variables.pdf](#))

Reflectance measurements were made using hyperspectral radiometers mounted on "Goliath", an all-terrain sensor platform (Rundquist et al., 2004). A dual-fiber optic system, with two intercalibrated Ocean Optics USB2000 radiometers, was used to collect radiometric data in the range 400 to 1100 nm with a spectral resolution of about 1.5 nm. Radiometer 1, equipped with a 25 degree field-of-view optical fiber was pointed downward to measure the upwelling radiance of the crop (L_{maize}). The position of the radiometer above the top of canopy was 5.4 m and kept constant throughout the growing season, yielding a sampling area with a diameter of around 2.4 m. Radiometer 2, equipped with an optical fiber and a cosine diffuser (yielding a hemispherical field of view), was pointed upward to simultaneously measure incident downwelling irradiance (E_{inc}). In order to match the transfer functions of both radiometers, inter-calibration was accomplished by measuring the upwelling radiance (L_{cal}) of a white Spectralon (Labshere, Inc., North Sutton, NH) reflectance standard simultaneously with incident downwelling irradiance (E_{cal}). Percent reflectance, ρ_λ, was computed as

$$\rho_{\lambda} = \left(\frac{L_{\lambda}^{maize}}{E_{\lambda}^{inc}} \right) \left(\frac{E_{\lambda}^{cal}}{L_{\lambda}^{cal}} \right) \times 100 \times \rho_{\lambda}^{cal}$$

where ρ_{λcal} is the reflectance of the Spectralon panel linearly interpolated to match the band centers of each radiometer. Note that 'maize' represents measurements over both corn and soybean crops.

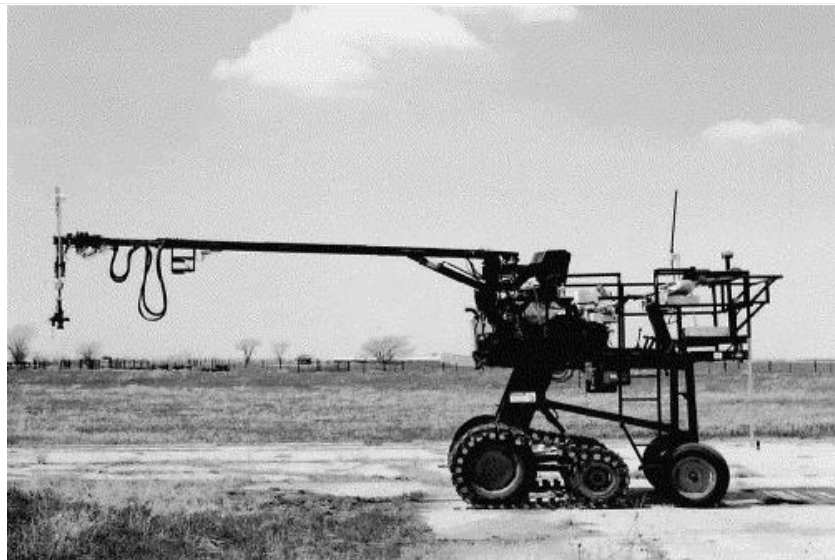


Figure 1. Reflectance measurements were made using hyperspectral radiometers mounted on "Goliath", an all-terrain sensor platform (Rundquist et al., 2004).

Radiometric data were collected close to solar noon (between 11:00 and 13:00 local time), when changes in solar zenith angle were minimal. For each measurement site, six randomly selected plots were established per field, each with six randomly selected sampling points. Thus, a total of 36 points within these areas were sampled per site at each data acquisition, and their median was used as the site reflectance. Measurements took about 5 min per plot and about 30 min per field. The two radiometers were inter-calibrated immediately before and immediately after measurement in each field. Reflectance measurements were carried out during the growing season from May to October over the eight-year period. This resulted in 173 measurement campaigns (18 in 2001, 31 in 2002, 34 in 2003, 31 in 2004, 21 in 2005, 15 in 2006, 14 in 2007, and 9 in 2008).

Resampled Reflectance Spectra

The collected reflectance spectra were resampled to the following spectral bands of Landsat: red (630 to 690 nm), green (520 to 600 nm), NIR (760 to 900 nm), and red edge band (703 to 713 nm) of MERIS (MEdium Resolution Imaging Spectrometer) using the spectral response functions of ETM Landsat and MERIS to calculate the above mentioned vegetation indices.

6. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Data Archive Center:

Contact for Data Center Access Information:

E-mail: uso@daac.ornl.gov

Telephone: +1 (865) 241-3952

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