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1. TITLE

1.1 Data Set Identification

ISLSCP II FASIR-adjusted NDVI Biophysical Parameter Fields, 1982-1998

1.2 File Name(s)

The files in this data set are named using the following naming convention:

fasir_*descriptor*413_xx_YYYYmm.asc

where:

fasir_*descriptor*413	identifies the data set and the version number (4.13).
descriptor	identifies the particular biophysical field (See Section 3.2).
xx	identifies the spatial resolution of the data set where **1d**, **hd**, and **qd** stand for a spatial resolution of 1, 1/2 and 1/4 degrees in both latitude and longitude, respectively.
YYYY	is the four-digit year from 1982 to 1998.
mm	is the two-digit month from 01 to 12.

In addition to the monthly biophysical fields, there are three individual files called **fasir_vcover413_xx_1982-1998.asc** that contain the vegetation cover for the entire period from 1982 to 1998 (i.e. fixed fields). For these files **xx** is as above.

1.3 Revision Date of this Document

March 31, 2010

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

Dr. Sietse O. Los,
NERC Climate and Land-Surface Systems Interaction Centre,
Department of Geography,
University of Wales Swansea, Wales, United Kingdom
Adran Ddaearyddiaeth,
Prifysgol Cymru Abertawe, Cymru, D.U.

2.2 Title of Investigation

Monitoring Seasonal and interannual variations in Land-Surface Vegetation from 1982-1998 using FASIR-adjusted NDVI.

2.3 Contacts (For Data Production Information)

	Contact 1	Contact 1 (Welsh)
2.3.1 Name	Dr. Sietse O. Los	Dr. Sietse O. Los
2.3.2 Address	Department of Geography University of Wales Swansea Singleton Park	Adran Ddaearyddiaeth Prifysgol Cymru Abertawe Parc Singleton
City/St.	Swansea SA2 8PP	Abertawe SA2 8PP
Zip Code		
Country	Wales, United Kingdom	Cymru, D.U.
2.3.3 Tel. No.	44 (0) 1792 295144	44 (0) 1792 295144
Fax No.	44 (0) 1792 295955	44 (0) 1792 295955
2.3.4 E-mail	s.o.los@swan.ac.uk	s.o.los@swan.ac.uk

	Contact 2 (ISLSCP II)
2.3.1 Name	Dr. Eric Brown de Colstoun
2.3.2 Address	NASA/GSFC Code 614.4
City/St.	Greenbelt, MD
Zip Code	20771
Country	USA
2.3.3 Tel. No.	(301) 614-6597
Fax No.	(301) 614-6695
2.3.4 E-mail	eric.c.browndecolsto@nasa.gov

* Providing information on these data is not part of our daily routine; Please read this document and descriptions first and/or refer to the publications listed below. Allow for some delay in our response. For general questions regarding the data contact the NASA Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC) first (see Section 13).

2.4 Data Set Citation

Sietse, O.L. 2010. ISLSCP II FASIR-adjusted NDVI Biophysical Parameter Fields, 1982-1998. In Hall, Forrest G., G. Collatz, B. Meeson, S. Los, E. Brown de Colstoun, and D. Landis (eds.). ISLSCP Initiative II Collection. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/970

2.5 Requested Form of Acknowledgment

Users of the International Satellite Land Surface Climatology (ISLSCP) Initiative II data collection are requested to cite the collection as a whole (Hall et al. 2006) as well as the individual data sets. Please cite the following publications when these data are used:

Hall, F.G., E. Brown de Colstoun, G. J. Collatz, D. Landis, P. Dirmeyer, A. Betts, G. Huffman, L. Bounoua, and B. Meeson, The ISLSCP Initiative II Global Data sets: Surface Boundary Conditions and Atmospheric Forcings for Land-Atmosphere Studies, *J. Geophys. Res.*, 111, doi:10.1029/2006JD007366, 2006.

Los, S.O., G.J. Collatz, P.J. Sellers, C.M. Malmström, N.H. Pollack, R.S. DeFries, L. Bounoua, M.T. Parris, C.J. Tucker, and D.A. Dazlich, 2000, A global 9-year biophysical land-surface data set from NOAA AVHRR data. *J Hydrometeor*., 1, 183-199.

Los, S.O., G.J. Collatz, P.R.J. North, D.A. Dazlich and P.J. Sellers, in preparation, A global 17-year biophysical land-surface data set from NOAA AVHRR data.

Special Acknowledgments

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Climatology Project (ISLSCP) Initiative II Data Collection. The Department of Geography at the University of Wales Swansea (United Kingdom) provided additional resources. Scott Denning's group at the Department of Atmospheric Sciences at Colorado State University provided an updated version of SiBx to calculate the roughness length and zero plane displacement. We would like to thank all supporters of ISLSCP Initiative II, their encouragement was instrumental to this project.

3. INTRODUCTION

3.1 Objective/Purpose

The Fourier-Adjusted, Sensor and Solar zenith angle corrected, Interpolated, Reconstructed (FASIR) adjusted Normalized Difference Vegetation Index (NDVI) data set and derived biophysical parameter fields were generated to provide a 17-year, satellite record of monthly changes in the photosynthetic activity of terrestrial vegetation. This multiple resolution (1/4, 1/2 and 1 degree in latitude and longitude) biophysical parameter data set contains essential variables for the calculation of photosynthesis, and the energy and water exchange between the Earth's surface (in particular of vegetation) and the lower boundary layer of the atmosphere. The Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) is related to the light absorption and the photosynthetic capacity of vegetation. It also serves as an intermediate variable to calculate vegetation cover fraction (Vcover), total Leaf Area Index (LAI_T), green leaf area index (LAI_G), roughness length (z0), zero plane displacement (d),and snow-free albedo (Sellers et al 1996, Los et al 2000). The biophysical parameters were derived assuming one canopy layer.

3.2 Summary of Parameters

The biophysical parameters were derived from the monthly ISLSCP II FASIR NDVI (version 4.13) data set covering the period from 1982 to 1998. FASIR NDVI data were calculated from Pathfinder Advanced Very High Resolution Radiometer (AVHRR) Land (PAL) channel 1 and 2 data, and were corrected for Bidirectional Reflectance Distribution Function (BRDF) effects, volcanic aerosols, cloud and atmospheric effects and missing data (see FASIR NDVI documentation in this collection). The biophysical parameters fields included in this data set and their respective field *descriptor* used in the file names (see Section 1.3) are:

- *fapar*: Fraction of photosynthetically active radiation absorbed by the green fraction of the vegetation canopy. This parameter is an indication of the photosynthetic capacity of vegetation and is closely related to the NDVI (Monthly).
- *tlai*: Total leaf area index (LAI_T) - The one-sided surface area of all leaves (dead and live) and stem area divided by the ground surface area (Monthly).
- *glai*: Green leaf area index (LAI_G) - The one-sided surface area of all live leaves divided by the ground surface area. The LAI_G replaces the greenness fraction (the ratio of green leaf area index to total leaf area index) that was part of the ISLSCP 1 data collection. Greenness fraction was frequently confused with vegetation cover fraction, this ambiguity is now removed (Monthly).

- *rough*: Aerodynamic Roughness length (z0)- This parameter represents the height above the ground surface to which the wind can penetrate. It is used to calculate the turbulent transfer between the land surface and the atmosphere (Monthly).
- *0plane*: Zero plane displacement (d). This parameter is used in combination with z0.
- *vcover*: Vegetation Cover Fraction - The fraction of ground surface covered by the maximum extent of the vegetation canopy (varies between 0 and 1). This is a fixed field representing the entire period 1982-1998.

3.3 Discussion

The spatial distribution and temporal variation of vegetation is important for the exchanges of water, energy and carbon between the land surface and the atmosphere. Biogeochemical models and land-surface parameterizations coupled to general circulation models of the atmosphere use vegetation parameters to calculate energy, water and carbon fluxes. Satellite data provide a means to obtain global vegetation parameters as input to these models. The biophysical parameters discussed in this document are used in the following ways:

FAPAR is used to calculate the maximum photosynthetic capacity. Photosynthesis is calculated from the photosynthetic capacity and environmental parameters such as drought stress and temperature stress. FAPAR is an intermediate in the calculation of LAI and VCOVER. The grid-cell values represent the FAPAR of all vegetation (tall and short) in the grid cell.

LAI_T and LAI_G are used to calculate the interception of precipitation by leaves and the albedo of the land surface. The albedo affects the amount of solar radiation that is absorbed by the land surface, in general more vegetation leads to a darker land surface and to more absorption of solar radiation. The distinction between LAI_T and LAI_G is necessary for the calculation of albedo, since dead leaves and live leaves have different optical properties and reflect different amounts of solar radiation. The grid-cell values represent the leaf area index of all vegetation in a grid cell (tall and short).

Vcover is used in the calculation of LAI from FAPAR and in the calculation of roughness length to account for non-linearities. Vcover is also used in the calculation of rainfall interception by the vegetation canopy. The grid-cell values represent the fraction of the surface covered by all vegetation (tall and short) during maximum vegetation development.

z0 represents the height above the ground surface to which the wind can penetrate. It is used to calculate the turbulent transfer of heat and momentum between the land surface and the atmosphere.

d is a scale height used to correct the wind profile for variations in the aerodynamic properties of the land surface.

4. THEORY OF MEASUREMENTS

FAPAR: Calculation of FAPAR depends on a near-linear relationship with NDVI that was found in theoretical studies by Sellers (1985), among others. The relationship varies with soil background reflectance: over bright soils the FAPAR tends to be close to linear with NDVI, whereas over dark soil backgrounds the FAPAR tends to be linear with the Simple Ratio (SR=nir/red), a transform of the NDVI. Data from multiple field experiments (FIFE, BOREAS, OTTER and HAPEX-Sahel) indicate that an intermediate relationship was most appropriate if *a priori* information on soil background reflectance was missing (Los et al 2000, see also Sellers 1985, Hall et al 1992, Sellers et al 1994, 1995).

For the calculation we take the average FAPAR from a linear relationship between SR and FAPAR and from a linear relationship between NDVI and FAPAR (see section 9.2.1). We further assume that the 98 percentile of the NDVI distribution of a vegetation type reflects fully "green" conditions, and an FAPAR value close to maximum (0.95). This assumption that fully green conditions exists is reasonable for tall vegetation types where maximum NDVI indicates a sufficient supply of moisture, light, warmth and nutrients for maximum vegetation development. For other vegetation types this assumption that fully green conditions occur is not reasonable, for example in deserts vegetation growth is severely limited by drought and excessive heat. For desert classes we do not expect that the 98 % of the NDVI distribution represents fully green conditions. A similar situation exists with respect to the occurrence of bare soils: deserts are likely to be bare at the low end of the NDVI distribution; hence the 2 % value of the distribution of deserts is likely to represent bare soil conditions. Tropical forests will contain vegetation even at the low end of the distribution, hence the 2 % of the NDVI distribution of tropical forest does not represent bare soil conditions. In order to obtain reasonable estimates of FAPAR, maxima and minima of particular vegetation classes were used to represent maximum and minimum conditions of other vegetation types (see table 1). The minimum and maximum FASIR NDVI values corresponding to minimum and maximum FAPAR are presented in table 2 (Section 9.2.1).

VCOVER: represents the maximum vegetation cover fraction over the year. It is the fraction of ground area covered by the maximum extent of the vegetation canopy. Maximum vegetation cover fraction in each grid cell was assumed invariant over 1982-1998; this simplification allowed VCOVER to be calculated from the maximum FAPAR that occurred in each gridcell over 1982-1998. Vegetation is assumed homogeneous within the area covered with vegetation. No distinction is made between tall and short vegetation cover fractions (See section 9.2.1 for computational algorithm). In the ISLSCP I data set, the vegetation cover fraction was assumed 1 and the leaf area assumed a homogenous layer over the grid cell. The calculation of a spatially varying value of VCOVER divides the grid cell in a homogeneous layer with evenly spread LAI and a fraction with bare soil. The maximum vegetation cover fraction can be calculated for each year, however, the constant value over multiple years led to better results in an offline version of the simple biosphere model (Schaefer, personal communication). It is at present not possible to calculate a seasonally varying vegetation cover fraction, because this variation is confounded with variations in LAI. Without further information, we can calculate from the NDVI either seasonally varying LAI assuming VCOVER constant or seasonally varying vegetation cover fraction assuming LAI constant, but not both. The former option is more realistic and is therefore preferred. To accurately determin the vegetation cover fraction one should use high resolution remote sensing data (e.g. LANDSAT Thematic Mapper (TM) or Système Probatoire pour l'Observation de la Terre (SPOT))

LAI: The FAPAR - LAI relationship is assumed exponential for vegetation evenly distributed over a surface (Monteith, 1973). We assumed that the maximum LAI changes linearly with the vegetation canopy fraction, this behavior was observed for vegetation concentrated in clusters by Huemmrich and Goward (1992), see also Los et al (2000). Within the fraction covered with vegetation we tied the relationship between FAPAR and LAI to two points: an FAPAR of 0.95 is equivalent to the maximum LAI for a particular class, and an FAPAR of 0.001 is equivalent to a minimum LAI. The minimum and maximum LAI values are presented in table 2 (Section 9.2.1).

z0, d: The first-order closure model of Sellers et al. (1989, 1995a) is applied repeatedly to the vegetation properties subset of morphological parameters, e.g., vegetation height, leaf morphology (length, width and leaf angle distribution obtained from biome dependent look-up tables) vegetation cover fraction, estimated canopy parameters and the EDC land cover map, to create a relationship between LAI and roughness length, z0, and zero plane displacement, d, for each grid cell. The model is cycled to produce values of either z0 or d for each grid cell for leaf area indices ranging from [0] to [8.0] in [0.5] increments. This relationship for each grid-cell is combined with the LAI fields,to produce the monthly fields of z0 and d. Linear interpolation is used for intermediate LAI values.

Vegetation class		Description	98 % from class	2 % from class
Tall	1	Broad leaf evergreen	6	9 and 11
	2	Broad leaf deciduous	2	9 and 11
	3	Mixed broad leaf and needle leaf	3	9 and 11
	4	Needle leaf evergreen	4	9 and 11
	5	Needle leaf deciduous	5	9 and 11
	6	Broadleaf drought deciduous and grass	6	9 and 11
Short	7	Ground cover or grass land	6	9 and 11
	8	Shrubs and ground cover	6	9 and 11
	9	Shrubs and bare soil	6	9 and 11
	10	Tundra	6	9 and 11
	11	Bare soil	6	9 and 11
	12	Agriculture	6	9 and 11

Table 1: *Assignment of representative NDVIs representing maximum green vegetation conditions and minimum bare soil conditions. Some classes are unlikely to have NDVIs from either maximum green conditions or bare soil conditions; for these classes 98 % and 2 % values need to be derived from a different class. Classes correspond to the SiB1 classification of the EROS Data Center (EDC) global land cover classification product, also included in this ISLSCP II data collection.*

5. EQUIPMENT

5.1 Instrument Description.

The Advanced Very High Resolution Radiometer (AVHRR) acquired data in 5 spectral bands; one visible, one near infrared and three thermal bands with 1024 quantizing levels. The thermal bands are not used in FASIR. AVHRR has the capability to transmit data to the ground at spatial resolutions of 1.1 and 4 km. The 4-km product or global area coverage (GAC) product is derived from the 1-km product by onboard sampling. The 4-km product is available globally from August 1981 until the present. The 1-km record is not continuous. Its availability depends upon prior arrangements made by NOAA, or on the proximity of a local receiving station that can capture the data directly from the satellite.

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

The NOAA AVHRR satellite series 6,7,9, 11 and 14 used to compile the NDVI record flew in sun-synchronous polar orbits with a nominal 1:30 PM local overpass time at launch. However, the overpass times drifted by as much as 4 1/2 hours later in the day creating variable illumination and view angles over the period of record. The 55-degree sensor swath width permitted a daily view of each pixel on Earth although at different illumination and view angles during the 9-day repeat cycle. Maximum value NDVI data compositing tends to select pixels acquired in a near-nadir mode with minimum atmospheric effects. Even so, view, illumination and atmospheric effects remain. Reducing these effects is the aim of FASIR processing.

5.1.2 Mission Objectives

The NOAA AVHRR satellite sensor series was originally designed as weather satellites. However from the early 1980s, AVHRR data have been used increasingly to monitor the type and condition of land vegetation. AVHRR vegetation data archives extend back to August 1981.

5.1.3 Key Variables

The AVHRR measures top of the atmosphere radiance in 5 spectral bands. Band 1 covers the 500 to 700 nm region, band 2 the 700 to 1100 nm region, with three thermal bands one covering the middle infrared region around 3 microns and two thermal infrared bands in the 10 to 11 micron region. The FASIR NDVI product uses as input, radiance in bands 1 and 2 provided by the Pathfinder AVHRR Land (PAL) effort (James and Kalluri, 1994).

5.1.4 Principles of Operation

The NOAA satellite series, NOAA 6, 7, 9, 11 and 14 were in polar, sun-synchronous orbits with nadir afternoon overpass times. NOAA 6 data span the years 1980,1981, NOAA 7, 1982 -1985, NOAA 9, 1986-1989, NOAA 11, 1989-1995, NOAA 14, 1995-2000. Gaps in the AVHRR record exist from September 1994 until December 1994 when NOAA 11 started to malfunction and its replacement, NOAA 13, failed shortly after launch. Each AVHRR sensor has different and variable calibration and overpass time.

5.1.5 Instrument Measurement Geometry

The AVHRR is a scanning, imaging radiometer, scanning ± 55 degrees, providing a 2800 km swath width. The orbital configuration permits daily coverage at a maximum spatial resolution of 1 km of each point on earth, although at different viewing and illumination geometries on subsequent days. The orbit repeats its ground track each 9 days.

5.1.6 Manufacturer of Instrument

ITT.

5.2 Calibration

NOAA provides preflight calibration coefficients that relate the digital counts measured by the satellite to reflectances. The preflight calibration coefficients for the visible and near infrared channel are of the form:

reflectance = gain*(digital counts - offset) (1)

The gain and the offset are determined on the ground prior to launch of the satellite; The gain and offset are referred to as preflight calibration coefficients. The preflight calibration coefficients change for each satellite. In some cases preflight coefficients were updated during the time of operation of a satellite.

Preflight calibration coefficients do not take into account the degradation of the AVHRR sensor during its time of operation. Several techniques exist to correct for the change in sensitivity of the AVHRR. For the Pathfinder data, the coefficients by Rao and Chen (1994) are used to correct the visible and near infrared reflectances for in-flight sensor degradation. The Rao and Chen calibration reduces the relative error in the gain as a result of sensor degradation to about 5 %. In the FASIR NDVI data the relative degradation error in the gain is further reduced to below 1 %. See section 9.2.1 of FASIR NDVI documentation for details.

5.2.1 Specifications

5.2.1.1 Tolerance

See Rao and Chen (1994) and FASIR NDVI documentation for more details.

5.2.2 Frequency of Calibration

See Rao and Chen (1994) and FASIR NDVI documentation for more details.

5.2.3 Other Calibration Information

See James and Kalluri (1994), See Rao and Chen (1994) and FASIR NDVI documentation.

6. PROCEDURE

6.1 Data Acquisition Methods

These data were derived entirely from the FASIR NDVI data set included in this ISLSCP II data collection. The 1, 0.5, and 0.25 degree biophysical parameter (FAPAR, LAI_T, LAI_G, VCOVER, Z0, d) data set is calculated from 1, 0.5 and 0.25 degree global FASIR - NDVI data set and the EDC SiB1 land cover data set, also in this collection. The FASIR NDVI data are derived from the Pathfinder AVHRR Land (PAL) 8 km data set (Channel 1 and 2, solar zenith angle, scan angle and relative azimuth angle). The Pathfinder data were corrected for residual intercalibration differences and sensor degradation, BRDF (solar zenith angle and view zenith angle) effects, clouds over tropical forests, volcanic aerosol effects, missing data (snow, sza > 80 degrees, data gap in Sept 1994-Dec1994) and short-term (< 3 months) atmospheric and cloud effects. The resulting data set is referred to as FASIR NDVI version 4.13 and is described in the FASIR NDVI documentation.

6.2 Spatial Characteristics

6.2.1 Spatial Coverage

The spatial coverage is global for all land areas except Antarctica, Greenland and small islands. Data in files are ordered from North to South and from West to East beginning at 180 degrees West and 90 degrees North.

6.2.2 Spatial Resolution

The data are given in an equal-angle latitude longitude grid at three different spatial resolutions of 1, 1/2 and 1/4 degrees in both latitude and longitude.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

The data set spans the period from January 1982 through December 1998. Gaps in the AVHRR record do exist from September 1994 until December 1994 because NOAA 11 started to malfunction and its replacement, NOAA 13, failed shortly after launch. NDVI data for this period have been interpolated using a climatological mean and the Fourier Adjustment (see Section 9.0 of FASIR NDVI documentation).

6.3.2 Temporal Resolution

Monthly temporal resolution for all fields with the exception of the VCOVER data which are static over the period 1982-1998.

7. OBSERVATIONS

7.1 Field Notes

Not applicable to this data set.

8. DATA DESCRIPTION

8.1 Table Definition

Not applicable to this data set.

8.2 Type of Data

8.2.1 Parameter/	8.2.2 Parameter/ Variable	8.2.3 Data	8.2.4 Units of	8.2.5 Data

Variable Name	Description	Range[1]	Measurement	Source
fapar	Fraction of PAR absorbed by green parts vegetation in each cell.	0.001 to 0.95 Permanent Ice = -77 No data over land = -88 Water = -99	Unitless	FASIR NDVI and EDC SiB1 Land cover
vcover	Vegetation cover fraction for each cell.	0 to 1 Permanent Ice = -77 No data over land = -88 Water = -99	Unitless	
tlai (lai_t)	Total leaf area index for each cell.	0.01 to 8.08 Permanent Ice = -77 No data over land = -88 Water = -99	m/m	
glai (lai_g)	Green leaf area index for each cell.	0.001 to 8 Permanent Ice = -77 No data over land = -88 Water = -99	m/m	
rough (z0)	Aerodynamic roughness length for each cell.	0 to 2.497 Permanent Ice = -77 No data over land = -88 Water = -99	m	Same as above and SiBx
0plane (d)	Zero plane displacement for each cell.	0 to 33 Permanent Ice = -77 No data over land = -88 Water = -99	m	

8.3 Sample Data Record

Not applicable to this data set.

8.4 Data Format

All of the files in the ISLSCP Initiative II data collection are in the standard ArcGIS ASCII Grid format. The file format consists of six lines of header information followed by numerical fields of varying length, which are delimited by a single space and arranged in columns and rows.

The files at different spatial resolutions each contain the following numbers of columns and rows:

1 degree: 360 columns by 180 rows
1/2 degree: 720 columns by 360 rows
1/4 degree: 1440 columns by 720 rows

All files are gridded to a common equal-angle lat/long grid, where the coordinates of the upper left corner of the files are located at 180 degrees W, 90 degrees N and the lower right corner coordinates are located at 180 degrees E, 90 degrees S. Data in the files are ordered from North to South and from West to East beginning at 180 degrees West and 90 degrees North. All values in these files are written as real numbers. Water bodies are assigned the value of -99, missing data over land are assigned the value of -88, and permanent ice is listed as -77.

8.5 Related Data Sets

This data set is based on the FASIR NDVI data set included in this data collection, which in turn is based on data from the 8 km Pathfinder AVHRR Land (PAL) data set (James and Kalluri, 1994), available at the GSFC DAAC (see FASIR NDVI documentation for more information). In addition, this data set was used to produce a 1-degree global monthly snow free Surface Albedo data set,"ISLSCP II Monthly Snow-Free Albedo, 1982-1998, and Background Soil Reflectance", also in this collection. Related data sets can also be obtained at http://daac.ornl.gov/ISLSCP_II/islscpii.html .

The EROS Data Center (EDC) global land cover classification product using the Simple Biosphere (SiB) legend was used in the production of this data set (see Section 9.0).

9. DATA MANIPULATIONS

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

See Section 9.2.1

9.2 Data Processing Sequence

The processing sequence is updated from the one used in ISLSCP Initiative I and follows closely the description given in Los et al (2000). The biophysical parameters are calculated from the FASIR NDVI data at 0.25 degree (version 4.13; see FASIR NDVI documentation) and resampled to 0.5 and 1 degree resolution.

9.2.1 Processing Steps and Data Sets

Two data sets are used for the calculation of biophysical parameters.

1. 0.25 by 0.25 degree FASIR- NDVI data set (see FASIR NDVI documentation)
2. The EDC SiB 1 land cover classification classes; wetlands in the EDC classification are treated as grass biomes, dry coastal complexes as broadleaf shrubs and bare soil.

Calculation of FAPAR from FASIR data

- FAPAR_SR = (0.95-0.001)(SR - SR02)/(SR98 - SR02) + 0.001
- FAPAR_NDVI = (0.95-0.001)(NDVI - NDVI02)/(NDVI98 - NDVI02) + 0.001
- FAPAR = (FAPAR_SR) + (FAPAR_NDVI)/2

We truncate such that 0.001 <= FAPAR <= 0.950. SR = (1+NDVI)/(1-NDVI) is the simple ratio. NDVI is FASIR NDVI. SR98 is the 98 % of the SR distribution of a particular land cover class. SR02 is the 2 % of the SR distribution of a the desert class. SR98 and SR02 values are calculated from NDVI 98% and 02% in table 2.

Calculation of Vcover

vcover = ((FAPAR_max-0.001)/(0.95-0.001)); where FAPAR_max is the maximum fapar over 17 years of data for a particular grid cell.

Calculation of Leaf Area Index

bark[ii] = -1.0/laimax[ii]*log(0.05); where laimax depends on vegetation type ii

zlt1 = -1.0/bark[ii]*log(1-FAPAR1); where zlt1(= green leaf area index) and FAPAR1 refer to current month.

zlt0 = -1.0/bark[ii]*log(1-FAPAR0); zlt0 and FAPAR0 refer to previous month
if (zlt0 < zlt1){dead = 0.0001 + stem[ii];} dead is dead lai; stem is stem lai
else {dead = vcover*(zlt0 - zlt1) + stem[ii];}
zlt1 = (zlt1 * vcover) + dead; convert green to total lai

Calculation of z0 and d; input of parameters to SiBx

Pseudo-computer code is given below:

```
/*sibx expects the following variables */ ZWIND = 100.0; ZMET =
 100.0; ZS = 0.05; G1 = 1.449; ZTZ0 = 11.785; IGCM = 0;
/* regression coefficients to calculate z2, z1 anc zc equivalent so that
 mean per biome type roughly corresponds to Sellers et al 1996 */
 z2_coef = 43.0; zc_coef = 1.33; z1_coef0 = -0.80944; z1_coef1
 = 1.13695; z1_coef2 = -0.03082;
if (mask == 12) /* agriculture */
{ z2 = 1.0;z1 = 0.1;zc = 0.55;} /* z2 is tree height, z1 is height
 bottom canopy, zc is canopy inflection point */
 else /* for other biome types */
{
z2 = (double) z2_coef * FAPAR_sum / (n_elem-16);
z1 = (double) z1_coef0 + z1_coef1 * z2 + z1_coef2 * z2 * z2;
z1 = (z1 < 0.1) ? 0.1 : z1;
zc =1.0/zc_coef * z2;
}
if (vcover > 0.05)
{
z0_int[0] = 0.0;
for (ii = 1; ii < 19; ii++)
{
Z2 = z2;
ZC = zc;
Z1 = z1;
ZLT = (double) ii/2.0;
VCOV1 = vcover;
```

```
ZLEN = zlen[mask];
ZLW = zlw[mask];
CHIL = chil[mask];
sibx_( &ZWIND, &ZMET, &Z2, &ZC, &Z1, &ZS, &ZLT, &VCOV1,
 &ZLEN, &ZLW, &CHIL, &RBC, &RDC,
&Z0, &D, &Z0Z2, &DZ2, &HA, &HAZ2, &G1, &G2, &G3, &ZTZ0,
 &CORB1, &CORB2, &USTARU); /*call sibx */
printf("\nOutput from sibx\n\n");
printf("REF. HGT WIND SPEED (ZWIND) %lf\n", ZWIND);
printf("REF. HGT TEMPERATURES (ZMET) %lf\n", ZMET);
printf("CANOPY HEIGHTS (Z2, ZC, Z1) %lf %lf %lf\n", Z2, ZC, Z1);
printf("LEAF DIMENSIONS (ZLEN, ZLW) %lf %lf\n", ZLEN, ZLW);
printf("ROSS-GOUDRIAAN FUNCTION (CHIL) %lf\n", CHIL);
printf("VEGETATION PAR. (VCOV1, ZLT) %lf %lf\n", VCOV1, ZLT);
printf("GROUND ROUGHNESS (ZS) %lf\n", ZS);
printf("ROUGHNESS LENGTH (Z0) %lf %lf\n", Z0, Z0Z2);
printf("ZERO PLANE DISP. (D) %lf %lf\n", D, DZ2 );
printf("SOURCE HEIGHT (HA) %lf %lf\n", HA, HAZ2);
printf("BOUND. LAYER R (RBC OR C1) %lf\n", RBC);
printf("SOIL TO HA R (RDC OR C2) %lf\n", RDC);
printf("AERO-COEFF (G1) %lf\n", G1);
printf("AERO-COEFF-M (G2) %lf\n", G2);
printf("AERO-COEFF-H,V (G3) %lf\n", G3);
printf("AERO-COEFF (ZTZ0) %lf\n", ZTZ0);
printf("NON-NEUTRAL COEFF (CORB1) %lf\n", CORB1);
printf("NON-NEUTRAL COEFF (CORB2) %lf\n", CORB2);
printf("U* /U AT REF HEIGHT %lf\n", USTARU);
/* sibx returns z0 and d (among other parameters */
}
```

Class	NDVI02	NDVI98	LAI_Gmax	Stem	zlen	zlw	chil
1	0.0295	0.712	7.0	0.08	0.1	0.05	0.10
2	0.0295	0.788	7.0	0.08	0.15	0.08	0.225
3	0.0295	0.800	7.5	0.08	0.1	0.04	0.125
4	0.0295	0.741	8.0	0.08	0.055	0.001	0.01
5	0.0295	0.765	8.0	0.08	0.04	0.001	0.01
6	0.0295	0.712	5.0	0.05	0.15	0.08	0.25
7	0.0295	0.712	5.0	0.05	0.6	0.01	-0.3
8	0.0295	0.712	5.0	0.05	0.03	0.003	0.01
9	0.0295	0.712	5.0	0.05	0.03	0.003	0.01
10	0.0295	0.712	5.0	0.05	0.03	0.004	0.2
11	0.0295	0.712	5.0	0.05	0.03	0.003	0.01
12	0.0295	0.712	5.0	0.05	0.15	0.08	-0.3

Table 2. *Typical Values used for calculation of biophysical parameter fields.*

9.2.2 Processing Changes

The following changes are made with respect to the ISLSCP Initiative I algorithms (Sellers et al 1996). Most of the changes (with the exception of the estimation of parameters for the calculation of z0 and d such as tree height, canopy inflection point) are documented in Los et al (2000).

- Use of the FASIR NDVI version 4.13, this version has updated corrections for:

  - BRDF effects; a correction estimating the BRDF with the LiSparse and Ross Thick kernels (Wanner et al 1995) replaced the solar zenith angle correction of Sellers et al (1996)
  - Volcanic aerosol effects: The aerosol fields of Sato et al (from 90 degrees South to 90 degrees North) replace the aerosol fields by Vermote et al (from 50 degrees South to 50 degrees North) because they extend further North. The magnitude of the NDVI corrections with these two data sets for latitudes below 50 degrees is similar.
  - Fourier Adjustment; anomalous high values are eliminated in addition to anomalous low values.
- Change in the calculation of FAPAR; ISLSCP I FAPAR was calculated as a linear function of the simple ratio. In the ISLSCP II data it is calculated as the intermediate of a linear function between FAPAR and NDVI and FAPAR and simple ratio (Los et al 2000). The modification is based on the results of intensive remote sensing campaigns (FIFE, BOREAS, HAPEX Sahel, OTTER; see Los et al 2000).
- Introduction of VCOVER in the calculation of LAI; VCOVER was assumed 1 in the ISLSCP 1 data (Los et al 2000).
- The greenness fraction (the ratio of green leaf area index to total leaf area index) is no longer included as a parameter and is replaced by green leaf area index (LAI_G). Greenness fraction was oftentimes confused with vegetation cover fraction, this ambiguity is now removed. If needed, greenness fraction can be calculated as the ratio between green leaf area and total leaf area.
- z0 and d are first order dependent on the seasonal sum of FAPAR, in the ISLSCP I data they were first order dependent on vegetation cover type. The vegetation cover fraction in the calculations of z0 varies for each grid cell. In ISLSCP I a value of VCOVER=1 was assumed.

9.2.3 Additional Processing by the ISLSCP II Staff

The ISLSCP II staff checked both the FASIR NDVI and biophysical fields data sets for consistency with the ISLSCP II land/water mask. Some inconsistencies between missing data flags were found and fixed in all data layers. Points in small islands (e.g. Hawaii) that were unclassified on the EDC land cover data set were set to -88, or missing data over land. There were many points over land with no NDVI values for the entire record (e.g. Greenland, Antarctica), and we needed to make a distinction between permanent ice points and points over land that were not seen by the AVHRR (typically small islands). Points in the permanent ice category (class 14) in the EDC land cover classification were set to the minimum value for each parameter (e.g. 0.001 for FAPAR). Points not in the ice category and with missing data for the entire record were set to -88 for all layers. Finally, some points had missing data over some months, typically winter, yet for other months the NDVI values and/or biophysical parameters were provided. For all these points, we assigned the minimum value found for the particular biophysical parameter (0.001 for FAPAR and LAI_G, 0.01 for LAI_T, and 0 for z0, d and VCOVER). For all data layers, the water values were then assigned the water flag of –99. The ISLSCP "permanent ice mask" (derived from the EDC land cover classification) was then imposed on each map, flagging permanent ice as -77.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None other than those described in Section 9.2 above.

9.4 Graphs and Plots

None given at this revision.

10. ERRORS

10.1 Sources of Error

Errors affecting all biophysical parameters:

1. Errors inherited from other data sets (see NDVI and FASIR - NDVI); especially data from September 1994-december 1994 (gap in the AVHRR record) and July- October 1991 (Some evidence of insufficient correction for volcanic aerosols) warrant close scrutiny.
2. Errors in the IGBP SiB 1 classification (see documentation on classification). These errors will have second order impact on the biophysical parameters because all biophysical parameters are first order dependent on the NDVI or a derived parameter. In the ISLSCP 1 data several parameters (z0, d) were first order dependent on vegetation class.
3. Assumption that 2% and 98% values for a vegetation type represent conditions with FAPAR of 0.001 and 0.95 or conditions with minimum and maximum leaf area index, respectively.
4. Assumptions about the FAPAR-NDVI relationship.
5. Assumptions underlying the calculation of VCOVER.

Errors affecting roughness length and zero plane displacement:

1. Assumed relationship between the annual sum of FAPAR and tree height.
2. Homogeneous vegetation cover fraction assumed.
3. Approximations in SiBx from the original second order closure model of Shaw and Perreira (See Sellers et al 1996).

10.2 Quality Assessment

10.2.1 Data Validation by Source

FASIR FAPAR and LAI data have been compared with measurements from BOREAS, FIFE, HAPEX-Sahel and OTTER. These comparisons indicate that errors in FAPAR are around 10%. Offline tests with SiB for the Wisconsin flux tower area indicate that the estimates of biophysical parameters are close to the values for optimum model performance (Denning pers. comm.). Errors in interannual variation in FASIR NDVI and related parameters are likely to be in the order of 20 to 30 % of the amplitude (Malmstrom et al 1998, Los et al 2000) Further verification of biophysical parameters has still to be done and will be subject of future studies (Sellers et al 1996, Malmstrom et al 1998, Los et al 2000). For several areas in temperate latitudes a close correspondence exists between temperature and NDVI (and related biophysical parameter) anomalies; for several areas in tropical latitudes there is a close correspondence between rainfall anomalies and NDVI (and related biophysical parameter) anomalies (Los et al 2001, Collatz personal communication).

10.2.2 Confidence Level/Accuracy Judgment

See the NDVI document, FASIR document and Section 10.2.1 in this document.

10.2.3 Measurement Error for Parameters and Variables

See Table 3 below.

10.2.4 Additional Quality Assessment Applied

None.

11. NOTES

11.1 Known Problems With The Data

- Related to products from which the biophysical parameters were derived (FASIR-NDVI, EDC land cover, NDVI) as well as to assumptions used for the calculation of FAPAR.
- Missing data during September 1994 until December 1994.
- Insufficient aerosol correction for July-September 1991.

11.2 Usage Guidance

- The biophysical parameters present generalized patterns which may result in poor representations of a specific locale.
- Users should interpret results from these data with care and give ample consideration to validation and verification.

11.3 Other Relevant Information

Not available at this revision.

Variable	Range	Estimated seasonal uncertainty (RSE)	Estimated interannual uncertainty (RSE)
FAPAR	0 to 0.95	0.1	0.03
LAI	0 to 8	1	0.3
Vcover	0 to 1	0.1*	NA
z0	0 to 2.5	30%	30%
d	0 to 33	30%	30%

Table 3. *Estimated errors for the biophysical fields. * for month with maximum vegetation; N/A otherwise.*

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation

See FASIR NDVI data set documentation.

12.2 Journal Articles and Study Reports

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13. DATA ACCESS

13.1 Data Access Information

The ISLSCP Initiative II data are archived and distributed through the Oak Ridge National Laboratory (ORNL) DAAC for Biogeochemical Dynamics at http://daac.ornl.gov.

13.2 Contacts for Archive

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

13.3 Archive/Status/Plans

The ISLSCP Initiative II data are archived at the ORNL DAAC. There are no plans to update these data.

14. GLOSSARY OF ACRONYMS

AVHRR	Advanced Very High Resolution Radiometer
BOREAS	BOReal Ecosystem-Atmosphere Study
BRDF	Bidirectional Reflectance Distribution Function
DAAC	Distributed Active Archive Center
DISC	Data and Information Service Center
DVD	Digital Video Disk
EDC	EROS Data Center
EOS	Earth Observing System
FASIR (NDVI)	Fourier Adjusted, Solar and view zenith angle correction, Interpolation, and Reconstruction of NDVI
FIFE	First ISLSCP Field Experiment
FAPAR/Fpar	Fraction of Absorbed Photosynthetically Active Radiation
GAC	Global Area Coverage
GCM	General Circulation Model
GES	Goddard Earth Sciences
GIMMS	Global Inventory Monitoring and Modeling Studies
GSFC	Goddard Space Flight Center
GVI	Global Vegetation Index
HAPEX-Sahel	Hydrologic and Atmopsheric Experiment in the Sahel
HEFCW	Higher Education Funding Council for Wales

IDS	Inter disciplinary Science
IFOV	Instantaneous Field Of View
ISLSCP	International Satellite Land Surface Climatology Project
LAC	Local Area Coverage
LAI	Leaf Area Index
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanographic and Atmospheric Administration
ORNL	Oak Ridge National Laboratory
OTTER	Oregon Transect Ecosystem Research Project
PAL	Pathfinder AVHRR Land
PAR	Photosynthetically Active Radiation
RMS	Root Mean Square Error
SiB	Simple Biosphere model
SPOT	Système Probatoire pour l'Observation de la Terre
SR	Simple Ratio
TM	Thematic Mapper