*UNEP/GRID Documentation Summary for Data Set:*

# NOAA Global Vegetation Index (GVI)

The NOAA Global Vegetation Index (hereafter, NOAA/GVI) archive held by GRID is a series of weekly, monthly, seasonal and annual data files as produced by GRID-Geneva from the original NOAA/GVI data set, the source of which is the U.S. NOAA/NESDIS/NCDC/SDSD.* The time period covered by these data as held by GRID is 12 April 1982 through 31 December 1990.

The GVI is derived from NOAA/AVHRR Global Area Coverage (GAC) data which are obtained on a daily basis. For any given week, the highest daily value of the so-called Normalized Difference Vegetation Index (NDVI) is sampled to produce a Weekly GVI data file. The NDVI is calculated from channels one (visible red light) and two (nearinfrared light) values imaged by the AVHRR sensor, as follows:

$$NDVI = (ch.\ 2 - ch.\ 1)/(ch.\ 2 + ch.\ 1)$$

The NDVI has been correlated with such physical measurements as total standing biomass, green leaf-area index (LAI) and per cent vegetation cover, but is probably best described as a relative measure of vegetation vigor and photosynthetic activity. It is most often used among other applications as a tool for monitoring temporal changes in vegetation.

An additional variable has been provided by NOAA since the beginning of July 1990, the calibrated vegetation index or CVI, and is based on the albedo rather than raw channel reflectance values, as follows:

$$CVI = (A2 - A1)/(A2 + A1);$$

where A1 and A2 are albedos calculated from weekly composites of channels 1 and 2.

The NOAA/GVI data files held by GRID-Geneva cover both the so-called First Generation and Second Generation NOAA products. They are all held in the Plate Carree or Simple Cylindrical Projection used as a standard by GRID, which is a particular form of the Equirectangular. As NOAA only offers pre-April 1985 weekly GVI data in the Polar Stereographic projection (two hemispherical halves), all April 1982 through March 1985 data files have been converted to Plate Carree using a modified algorithm from Singh et al. (University of Reading, U.K.). Also, monthly, seasonal and annual maximum vegetation index (MVI) values have been calculated

for all months/seasons/years of data which are archived (i.e., April 1982 through December 1990), and their equivalent data files are stored and distributed.

The NOAA/GVI data files are all raster arrays consisting of 904 lines by 2500 elements. Their origin point (northwest or upper-left corner) is 75 degrees North latitude and 180 degrees West longitude, and they extend to 55 degrees South latitude and 180 degrees East longitude at their terminal point (southeast or lower-right corner). The nominal spatial resolution of the data (pixel size) is 16 km. at the equator, and each data file comprises 2.26 Mb.

The best reference for these products is the NOAA "Global Vegetation Index Users' Guide (rev. Oct. 1990)", compiled and edited by Katherine B. Kidwell and available from the U.S. Department of Commerce, NOAA / NESDIS / NCDC / Satellite Data Services Division, Princeton Executive Square, Wash. D.C. 20233 USA. Also available is a document which describes GRID processing of these data sets, their availability and archive formats.

* - U.S. National Oceanic and Atmospheric Administration / National Environmental Satellite Data and Information Service / National Climate Data Center / Satellite Data Services Division

# NOAA Global Vegetation Index (GVI) Archive at GRID-Geneva


## Summary

The NOAA Global Vegetation Index (hereafter, NOAA/GVI) archive held at GRID is a series of weekly data sets produced by the U.S. NOAA / NESDIS / NCDC / SDSD (see below) covering the time period 12 April 1982 to present. This brief document is intended to describe how these data have been processed and archived at GRID-Geneva; for a more technical description of what the data sets are and how they are produced by NOAA, the reader is referred to the "Global Vegetation Index Users' Guide" published in May 1986 and last updated in October 1990. The NOAA/GVI archive held at GRID currently consists of nearly ten years of data, extending from April 1982 through December 1991. Although the original NOAA tapes contain the raw weekly AVHRR-GAC resampled individual data channels (1,2,4,5) and ancillary information (solar zenith angle and scan angle), only the NOAA calculated normalized vegetation index and, since July 1991, the calibrated vegetation index (CVI) weekly files have been reformatted and archived by GRID. The other raw and ancillary data channels would still have to be recovered from tape if they are needed. All of the reformatted NOAA/GVI files are held on cartridge tape each as a 904 line by 2500 element array. The nominal pixel resolution of these data sets is 16 km. (square) at the equator; each array covers an area from 75 degrees north to 55 degrees south latitude, and all 360 degrees of longitude. All NOAA/GVI files are stored in the standard GRID Plate Carree or Simple Cylindrical projection, a particular form of the Ecquirectangular projection. As NOAA only offers pre-April 1985 weekly GVI data in the Polar Stereographic projection (two hemispherical halves), all April 1982 through March 1985 files have been converted to Plate Carree using an algorithm modified from Singh et al. (Univ. of Reading). Also, monthly maximum vegetation index values as well as seasonal and annual maxima have been calculated for all months/seasons/years archived (i.e., to end of 1991).


NOAA: National Oceanic and Atmospheric Administration;
NESDIS: National Environmental Satellite Data and Information Service;
NCDC: National Climate Data Center;
SDSD: Satellite Data Services Division

## 1. Format of Original NOAA Tapes

There are two sets of NOAA/ GVI tapes which have been processed thus far at GRID-Geneva and, while the procedures for handling both have been similar, they were done on two different computer systems and for the one set an extra processing step was necessary (conversion from Polar Stereo to Plate Carree

projection). The first set of tapes processed was the earlier data or so called 'First Generation' Vegetation Index product assembled by NOAA. In its early stages this product was considered experimental, and underwent several changes in sampling method to compute the daily arrays which serve as input to the weekly product. These data tapes only contain an initial documentation file plus four weekly data arrays channel two, scaled simple veg. index, scaled normalized veg. index, channel one; thus only file four (scaled NVI) was processed for each week available. Covering the time period 12 April 1982 through 8 April 1985, this set of 13 original tapes consisted of Polar Stereographic projection arrays in 2048 line by 1024 element file size (with northern hemisphere in upper 1024 x 1024 pixels and southern hemisphere in lower 1024 x 1024 pixels). These were all processed on the IBM 4381 computer system, using four basic steps: data ingest, conversion from Polar Stereo to Plate Carree projection, verification of data sets and calculation of monthly maxima using IAX software, and archival of final products.

The second set of tapes was processed partly on the VAX 3600 using a combination of system-level and ELAS functions, and partly on the IBM 4381 computer. These tapes were of the so-called 'Second Generation' Vegetation Index product, and contain seven basic composite arrays for each week in the Plate Carree projection: channels one, two, four and five, solar zenith angle, scan angle, and the normalized vegetation Index (the NVI, or over one week the composite NVI). Because there is a documentation file preceding each weekly set of seven arrays, it is actually file eight that contains the NVI data (and since July 1990, file nine the CVI data) processed at Grid-Geneva. This tape format applies to all NOAA/GVI data processed at Grid-Geneva starting on 9 April 1985 but not before this date. Beginning with this date NOAA distributes the weekly products in Plate Carree, Polar Stereographic, and Mercator projections. Thus for this period GRID has purchased and will continue to purchase the Plate Carree arrays only, as they are immediately compatible with the existing GRID database and the latitude/longitude coordinate system. Beginning with year 1988, NOAA/GVI data tapes have been processed on the IBM 4381, where all NOAA/GVI data (April 1982 to present) are being stored.

## 2. NOAA/GVI Data Processing Procedures at GRID

### 2.1 Data Ingest

#### 2.1a 'First Generation' Product

All 'First Generation' weekly vegetation index files were entered to the IBM 4381 computer using the CMS command MOVEFILE. This command allows for the "restructuring" of data records as files are ingested, which was necessary in the case of both the First and Second Generation GVI files. On the original tapes, four

logical data records (lines of data) are contained in each physical record for all files read from tape, in order to assemble a proper output image/data file. This was easily accomplished using MOVEFILE, while on the VAX 3600 other means were used for the Second Generation files entered there (see below). One original tape was ingested at a time (i.e., all normalized veg. index files; meaning every fifth file and usually 12 per tape), before proceeding on to the additional steps 2.2, 2.3a, 2.4a.

2.1b 'Second Generation' Product

All 'Second Generation' weekly vegetation index data files between April 1985 and December 1987 were entered to the VAX 3600 computer using the ELAS function RFRIBS, which reads band sequential data files from tape. The data files were then "restructured" as described in 2.1a (four data lines per physical record) using ELAS functions ECOPY and RFRIBS again, to create correct output images/data files. Normally, one month of data (i.e. four or five weekly files) were processed at a time, before proceeding with steps 2.3b and 2.4b. All NOAA/GVI 'Second Generation' data files since January 1988 have been entered on the IBM 4381 computer, with CMS MOVEFILE and FILEDEF used to "restructure" the data from two data lines per one phys cal record, to one.

2.2 Conversion from Polar Stereographic to Plate Carree Projection (First Generation Product only)

After each original tape was entered to the IBM 4381 computer, the data files existing on disk were in the Polar Stereographic projection, with two adjoining hemispherical halves as described in part 1 above. For these 'First Generation' (April 1982 through March 1985) data sets to match the 'Second Generation' products and other GRID data sets, it was necessary to convert them to the Plate Carree (Simple Cylindrical) projection. This was accomplished using an algorithm named GVICO written by Sadhu Singh, A. S. Narracott and J. R. Hardy at the University of Reading (U.K.). GVICO uses a nearest neighbor resampling technique to reformat the Polar Stereographic GVI files into the Plate Carree projection. Two transformations, resulting in two different output file sizes/resolutions, are possible. The socalled "Hardy-Singh-Narracott (HSN)" transformation yields an output file size of 1024 lines by 2048 elements with a spatial resolution of 19.5 km. at the equator; while the NOAA transform yields an output file size of 904 lines by 2500 elements, with a spatial resolution of 16 km. at the equator. As the latter is identical to NOAA's 'Second Generation' GVI product, it was selected in order to match the later data sets. Also, small but computationally important changes were made to the constants defining the center (polar) points of the northern and southern hemisphere arrays in the original (input) NOAA/GVI data sets. These are slightly offset from the actual center points of the $1024^2$ data arrays for both northern and southern hemispheres, and if not properly corrected results in a small (anywhere from one to

three lines) gap at the equator in the output data sets. After adjustment, these four constants were kept uniform for all runs of GVICO.

All outputs of GVICO were thoroughly examined using the display capabilities of IBM/IAX on a 5080 graphics screen, as were the results of the VAX/ELAS "restructuring" procedure. This was done to verify that each image/data set was in the proper format, before proceeding to steps 2.3 and 2.4.

## 2.3 Calculation of NOAA/GVI Monthly Maxima, Seasonal Maxima, and Annual Maximum

A monthly maximum normalized vegetation index data set is calculated for every month of 1982 through the most recent time period for which two or more input weeks were available; i.e., April 1982 through December 1991. Each monthly maximum veg. index (hereafter MVI) data set is calculated from a maximum of five weekly data sets. Four are typically used, but in cases where a Julian calendar indicated that the majority of days of a fifth week fell within a particular month, five are used. With 52 weeks per year, this latter case happens four months/times annually. Also, in rare cases where one or more weeks of input NOAA/GVI data were missing (i.e. do not exist), the monthly MVI is still calculated with two, three, or four input weeks. Due to an inverse scaling of the raw vegetation index values done by NOAA (see GVI Users Guide, p. 10), the MVI data sets calculated are in fact the minimum digital number (d.n.) values from the input weekly data sets.

A seasonal maximum normalized vegetation index data set is calculated for every threemonth seasonal period between April 1982 and November 1991. There are three inputs per derived data set,*- as follows: (seasons according to Northern Hemisphere):

| | | |
|---|---|---|
| Winter for a given year | = | December (previous year), January, February monthly maxima; |
| Spring for a given year | = | March, April, May monthly maxima; |
| Summer for a given year | = | June, July, August monthly maxima; |
| Autumn for a given year | = | September, October, November monthly maxima. |

An annual maximum normalized vegetation index data set is calculated for each yearly (12month) period from 1982 to 1991. This is done using the 12 monthly maxima data sets as inputs from within each calendar year (that is, January through December of a given year).+

* - except for Spring of 1982, which was derived from April and May inputs only.
\+ - except for 1982, which uses only months April through December.

2.3a 'First & Second Generation' Products on IBM 4381

Here the monthly, seasonal and annual MVI data sets were calculated using the IAX function 'MIN', which extracts the minimum value from pair(s) of input data sets, and saves the result as an output variable. This variable can then be stored on disk as an image/data set. Because nested pairs are allowed, this was a very quick and easy method for calculating most monthly MVI data sets; e.g.

$$MVI = \min(\min(WK1, WK2), \min(WK3, WK4))$$

The monthly, seasonal, and annual MVI results were carefully examined on the IBM 5080 graphics screen to assure that the calculations were correctly derived from the two to five weekly, or three (or 12) monthly, input data sets in each case.

2.3b 'Second Generation' Product on VAX 3600

Here the monthly, seasonal, and annual GVI data sets were calculated using the ELAS function 'DBAS', which allows interactive coding in the BASIC programming language for up to 20 input data sets. Since DBAS contains 'MIN' and 'MAX' functions, it was again straightforward to extract the minimum weekly value (d.n.), representing maximum MVI, from up to five data sets with a short program. DBAS automatically creates an output image/ data file if the run is successful. These, too, were carefully checked for correctness.

2.4 Data Archival of Derived Products

The archival medium for all NOAA/GVI data sets held by GRID is IBM 3480 tape cartridge. In addition, there are 13 original tapes of the NOAA 'First Generation' product, and the 65 original tapes of the NOAA 'Second Generation' product also held by GRID. It is worth bearing in mind that only the normalized vegetation index (and, since 9 July 1990, the calibrated vegetation index) data files have been processed from all of these tapes.

Each year of NOAA/GVI data is backed up on IBM 3480 tape cartridges, with one 180megabyte cartridge used per year for a total of ten cartridges, plus one per year for CVI data files. From 1990 onward, this is the sole form of backup being used due to consideration of space. Thus, each cartridge holds (approx.) 52 weeks; plus 12 months, four seasons and one annual maximum NOAA/GVI data set. These cartridges were written using the IBM VM/CMS 'TAPE DUMP' command. This means that non-IBM systems could not easily read or restore ('LOAD') the files in question from this particular backup format.

## 2.5 IBM/SQL Meta-Database Entry

All of the above-mentioned weekly, monthly, seasonal and annual NOAA/GVI data files derived from the original NOAA/GVI first and second generation products have already been entered to the GRID meta-database on the IBM 4381. That is, they exist as catalog entries fully described by approximately 30 fields and a date (i.e. the year, month and/or week) which distinguishes the data file; thus, it is important to understand the file naming conventions used. For a given weekly data file, the file name is written as follows:

VI yr WK wk
where: yr = year (currently, 82 through 91)
and : wk = week of the year (from 01 through 52)

The monthly MVI data files are named as follows:

MVI yr mon
where: yr= year
and : mon = month abbreviated

The seasonal MVI data files are as follows:

MVI yr ssn
where: yr = year
and : ssn = season of year

The annual MVI data files are as follows:

MVI yr ANN
where: yr=year

From July 1990 onward, the file naming conventions for the calibrated vegetation index (CVI) files are the same as indicated above, except that 'CVI' is inserted in place of 'MVI'. This allows a clear and unique file name for each data file. All files have a four-letter extension (filemode) of 'IAXI' for consistency, although they may have been created on the VAX under ELAS.