The Blue Marble Next Generation - A true color earth dataset including seasonal dynamics from MODIS

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1 Dataset User's manual

1.1 Map projection

The BMNG dataset [Stöckli et al., 2006] is gridded at the following spatial resolutions: 15, 60 and 240 arc-seconds (500m, 2km, and 8km approximate spacing at the equator). It uses a geographic (Plate Carrée) projection, which is based on an equal latitude-longitude grid spacing (not an equal area projection!). The projection datum is WGS84.

1.2 Data format

All data are available as monthly global composite images. The highest resolution at 500m is furthermore split into 8 global tiles according to Figure 1 to facilitate their handling on less powerful computer systems.

In Table 1 the file and directory structure of the BMNG dataset is outlined. The geographical extent of each global composite or tile is specified in the columns showing the upper left and the lower right edges. File suffix [Y] shows the file format: *png* (lossless compression) or *jpg* (lossy compression with quality setting of 75%) [1]. The NDVI data is processed but not yet stitched on global scale.

1.3 GIS users

Geographic information is needed by GIS software to geolocate BMNG images. We cannot provide this information for every software package, but we have created sample world files (for use within ESRI ArcView, ArcGis), which can go along

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[1]the global 500m composites stored in the *world_big* directory are raw binary files with the dimensions 3 x 86400 x 43200 (channels x columns x rows); data type is unsigned byte, with no header. They can be used for direct file access by data processing software (e.g. for subsetting, web-streaming etc.)

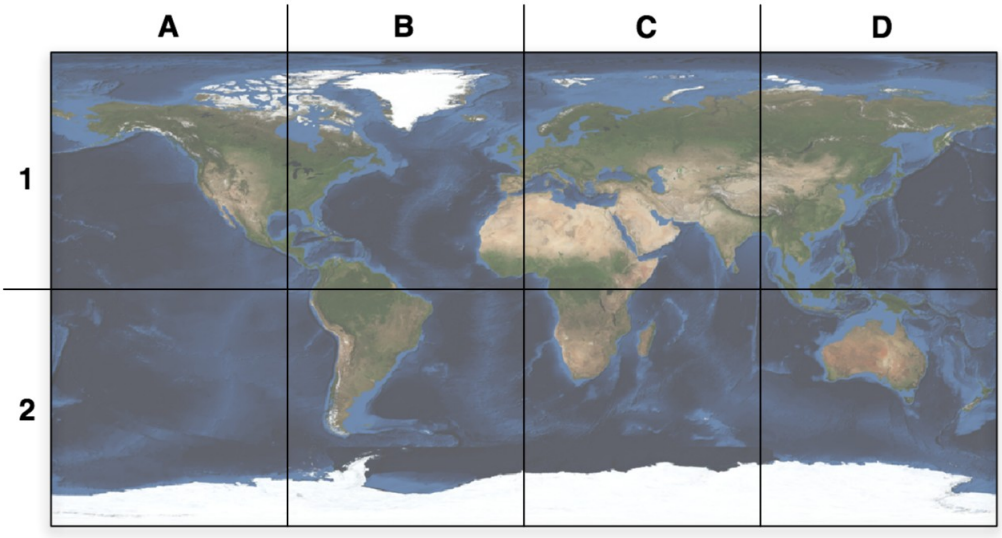

Figure 1: Sub-domains of the 500m BMNG files

Table 1: Geographic extents of the BMNG files

Directory	Filename	Upper left	Lower right	Resol. [pixels/°]
world_500m	[X].3x21600x21600.A1.[Y]	90N 180W	0N 90W	240
	[X].3x21600x21600.B1.[Y]	90N 90W	0N 0W	240
	[X].3x21600x21600.C1.[Y]	90N 0W	0N 90E	240
	[X].3x21600x21600.D1.[Y]	90N 90E	0N 180E	240
	[X].3x21600x21600.A2.[Y]	0N 180W	90S 90W	240
	[X].3x21600x21600.B2.[Y]	0N 90W	90S 0W	240
	[X].3x21600x21600.C2.[Y]	0N 0W	90S 90E	240
	[X].3x21600x21600.D2.[Y]	0N 90E	90S 180E	240
world_big	[X].3x86400x43200.bin.gz	180W 90N	180E 90S	240
world_2km	[X].3x21600x10800.[Y]	180W 90N	180E 90S	60
world_8km	[X].3x5400x2700.[Y]	180W 90N	180E 90S	15

with the BMNG images (e.g. *.jpgw or *.tifw files):

http://www.iac.ethz.ch/staff/stockli/bmng/bmng_arcview/
Important:

- Some software requires no more than one period"." inside the filename. You may need to replace the periods in the BMNG files with underscores"_", except for the file name suffix (e.g. .jpg or .png)
- Name the world file the same way as you name the image file, but add e.g. ".jpgw" (UNIX) or ".jpw" (Windows).

1.4 Relief shading and Topography

The file prefix [X] is either *world* for non-shaded data, *world.topo* for a relief shading based on land topography or *world.topo.bathy* when a relief shading of

land topography and ocean bathymetry was applied. The following topographic datasets were used for relief shading:

1. 3 arc-second SRTM dataset (Shuttle Radar Topography Mission, [JPL, 2005]) from 60S-60N
2. 30 arc-second GTOPO30 dataset [USGS, 1996], from 60N-90N, and to fill small voids in the SRTM dataset, using bi-cubic interpolation (David Gil, personal communication)
3. RAMP II dataset (Radarsat Antarctic Mapping Project Digital Elevation Model Version 2, [Liu et al., 2001]) from 90S-60S
4. 1 arc-minute GEBCO (General Bathymetric Chart of the Oceans [IOC et al., 2003]) dataset

To create your own topographic shading please use the above described interpolated topography dataset which can be found in the "topography/" folder. Two files are available. The data is in units [m] and is stored as 2-byte signed integer, big-endian (Motorola):

1. Land topography: srtm_ramp2.world.86400x43200.bin.gz uses the same spatial resolution as BMNG
2. Ocean bathymetry: gebco_bathy.21601x10801.bin.gz uses 2km spatial resolution

1.5 Landmask

A *watermask* and an *oceanmask* is provided in the directory "landmask/". Both masks use the MODIS land product internal mask, but show different features: the watermask differentiates all water bodies (including rivers, lakes and oceans) from land areas where the oceanmask only separates ocean from the mainland (including inland lakes and rivers etc.).

File format: The same geographical projection parameters as for the BMNG files in Table 1 apply. The mask is time-invariant and its data type is unsigned 8-bit integer (byte) and the raw binary files have dimensions 86400 x 43200 (columns x rows). Land has values of 255 and water has 0. Subsampled files and tiles of dimensions 21600x21600 according to Figure 1 are provided as *png* files.

1.6 NDVI

A monthly Normalized Difference Vegetation Index (NDVI) was calculated from the fourier-adjusted red (R) and near-infrared (N) channels in the BMNG dataset: NDVI = (N−R)/(N+R). It can be found in the "ndvi/" directory. NDVI is used for global vegetation monitoring and in climate modeling research and exploits the spectral properties of plants. It has high values around $0.1 - 0.7$ for active vegetation (doing photosynthesis) and rather low values of $0.0 - 0.1$ for dormant vegetation. Rocks, snow, water and glaciers get negative values. In the dataset all water bodies have been assigned a value of -1.0. The NDVI was calculated from the snow-free fourier-adjusted reflectances to avoid snow contamination in the seasonal course of vegetation state. Areas with a permanent snow cover are however included.

File format: The same geographical projection parameters as for the BMNG files in Table 1 apply. There are 12 monthly NDVI file sets available for 2004. The NDVI data type is unsigned 8-bit integer (byte) and the raw binary files have dimensions 86400 x 43200 (columns x rows). NDVI values can be calculated from the 8-bit data [DN]: NDVI = (DN−127)/128. Subsampled files and tiles of dimensions 21600x21600 according to Figure 1 are provided as *png* files.

1.7 Caveats

As with digital satellite remote sensing datasets, users of the BMNG must be aware that certain characteristics of the data and artifacts of the used processing methodology may render it unsuitable for certain applications. A number of problems may be encountered by using the data:

- **Spatial accuracy:** The used MOD09A1 product is derived by reprojecting satellite swath L1b granules into the sinusoidal projection. The BMNG is then reprojected into the geographic projection. The two involved reprojection steps may introduce small inaccuracies, and the chosen geographic projection of the final images results in distorted (smeared) appearance of higher latitude areas, since it is not an equal-area projection.

- **Spatial availability:** MOD09A1 is not available north of 80N and south of 60S. For arctic areas a landmask-based snow color fill routine was applied homogeneously over all land areas. For the Antarctic the MODIS Mosaic of Antarctica (MOA; Haran et al. [2005]) was colorized and reprojected to the regular lat/lon BMNG grid. MOA is a freely available data product distributed by NSIDC. It can be downloaded at: http://nsidc.org/data/moa/index.html.

- **Temporal accuracy:** Water areas don't currently show any seasonal variation. This may be changed in future versions of the BMNG. Seasonal variations may be suppressed where heavy cloud cover does not provide sufficient temporal information. Agricultural landscapes do not necessarily follow the the continuous seasonal variations, on which our methodology is based. Apart from the climate, humans are an important driver of the plant phenology in such areas.

- **Processing artifacts:** As described in the Methods section, incomplete cloud or snow masking and problems in the atmospheric corrections in the MOD09A1 data presents a significant challenge to the extraction of monthly cloud-free land surface reflectances. The use of discrete Fourier series can remove most of these effects, but it can fail in some areas. These are especially areas with short term changes in snow cover and water, where sunglint, aerosols and other effects do not allow a good atmospheric correction of satellite reflectances.

1.8 Citation of the BMNG

Stöckli, R., Vermote, E., Saleous, N., Simmon, R., and Herring, D. (2006). True color earth data set includes seasonal dynamics. EOS, 87(5):49, 55. Corresponding author: rstockli@climate.gsfc.nasa.gov

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