Background correction for EOG VIIRS-DNB monthly composites (data and scripts)
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1. Licence

2. Citation

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3. Data Description

The datasets contain low resolution image data (Coesfeld et al., 2020) that can be used to approximately remove natural light from the monthly composite nighttime images produced by the Earth Observation Group (EOG) using the Visible Infrared Imaging Radiometer Suite (VIIRS) Day-Night Band (DNB) (Earth Observation Group, 2015). Natural light includes airglow and reflected light from stars, as well as polar light at high latitudes.

The low-resolution images can be expanded and then subtracted from the EOG monthly composites, using python scripts included in this data publication (Coesfeld et al., 2020).

3.1. Input Data

The background correction is based on the **VIIRS-DNB monthly composites data** from April 2012 to December 2019 without stray light correction produced by the EOG, and the associated file containing the number of cloud-free observations (Earth Observation Group, 2015).

Locations away from human settlements and artificial lights were selected using the **Global Human Settlement Layer (GHSL) population density map from 2015** [3] and the **VIIRS-DNB 2015 vcm-orm annual composite** by the EOG (Earth Observation Group, 2015).

3.2. Python scripts

3.2.1. Selecting locations

The python script we used in Coesfeld et al. (2020) to select locations on an equally spaced grid over the global DNB extent (from 75N to 65S) is included. The six images of the EOG composite are processed separately. This code identifies locations on a 72x28 grid (2016 locations total). In order to optimize the location of the specified grid points, the Global Human Settlement Layer (GHSL) population density and VIIRS-DNB annual composite of 2015 are consulted. For each of the 2016 grid locations, a 500 x 500 pixels (2.083° by 2.083°) subset centred on the corresponding point is inspected for both data sources. The GHSL subset is converted to a binary format with 0 indicating no population and 1 indicating the presence of population. For the annual radiance subset a maximum value of 10 $nWcm^{-2}sr^{-1}$ is defined and all values above are artificially set to 10 $nWcm^{-2}sr^{-1}$. The value in all cells is divided by 5 in order to set the range to [0,2].

In cases where the GHSL had no population in the entire 500 x 500 pixel area, we keep the initial grid location. For all other locations, the position is slightly shifted to a location within the 500 x 500 subset, which is least affected by human activity. For both data sets, we artificially define a 10 pixel wide frame with a value of 1 for GHSL and 2 for the DNB annual radiance at the edge of each subset in order to push the new point location towards the centre. In order to generate smeared images, a Gaussian filter is applied to the subsets using three different standards deviations (σ = 4, 20 and 100 pixels) for the GSHL subset and one standard deviation (σ = 20) for the DNB subset thus creating a total of four GHSL and two DNB maps. All six maps are summed together, producing an image with values ranging from [0-8]. In order to find the location which is least affected by humans, the smallest value in this image is located and defined as new location. The table storing all 2016 equally spaced grid points as well as their updated locations is provided in csv format (2020-003_Coesfeld-et-al_grid_locations.csv).

3.2.2. Background correction data

After generating the list of specified correction sites, we assign monthly radiance values with monthly DNB composites data to these locations. The median of a 5 x 5 pixel neighbourhood area is calculated for each site with all monthly composite pixels that have a minimum of two cloud free observations. The table storing all 2016 locations and their monthly radiance values from 2012 to 2019 is provided in csv format (2020-003_Coesfeld-et-al_grid_locations_median_monthly_values_2019.csv). To remove temporal outliers (e.g. forest fires, volcanoes), a time series from April 2012 to December 2019 is created for each location. For all data taken in 2017 or later, we subtract 0.15 $nWcm^{-2}sr^{-1}$ to roughly account for the shift in the zero value from NASA's change in processing. For each time series, we find the 15.9th and the 84.1th percentile and define half of the difference between them as 1σ. The outlier threshold is set to either 1 $nWcm^{-2}sr^{-1}$ or 4σ added to the median value (whichever is larger). The table of thresholds is provided in csv format (2020-003_Coesfeld-et-al_pixel_thresholds.csv). Pixels with no data (due to clouds) are also flagged as outliers. For each monthly outlier, the median value of a neighbourhood area with 17-pixel longitude and 3-pixel latitude is calculated if at least 18 of the 51 values are not flagged as outliers. In a final step to smooth the data, a low-pass filter is applied within latitude bands: $L_{i,j,smoothed} = 1/4\ (L_{i-1,j} + 2L_{i,j} + L_{i+1,j})$, where longitude is represented by *i* and latitude by *j*. The monthly correction files are provided in csv format (2020-003_Coesfeld-et-al_zero_correction_csv.zip).

3.2.3. Background light correction routine for DNB tiles

The background correction data can be used to correct an original monthly DNB composite data tile. The grid area of the DNB tile of interest is selected from the background correction data and resampled using the OpenCV-Python routine cv2.resize and cropped to match the monthly DNB composite spatial resolution and extent. Once matched, the background correction values can be simply subtracted from the monthly DNB composite data giving unlit areas a value of 0. The provided python script (2020-003_Coesfeld-et-al_correction-function.py) defines a function to automatically apply this routine to any DNB input for which the corresponding correction image exists, and illustrates the usage with a simple example.

3.2.4. Time series of selected locations

In order to illustrate the effect of the background light correction routine on monthly DNB radiance, we constructed a time series for a few specified locations and compare the difference between the corrected and the uncorrected values. For this, we assign monthly radiance values for the defined sites from April 2012 until December 2019. We only consider pixels with at least two cloud free observations during a month, and extract corrected and uncorrected DNB radiance. Here we consider both the radiance of the single pixel at the specified locations and median of the 5 x 5 pixel area surrounding that pixel. In order to show an example of an areal analysis for an entire country, we also extract the sum of the corrected and uncorrected radiance (of pixels with at least two cloud free observations) of North Korea. The provided python script (2020-003_Coesfeld-et-al_correction-timeseries.py) includes the code for assigning the described values and for visualizing them as a time series.

4. File description

Monthly DNB correction files from April 2012 to December 2019 are provided in comma-separated value (CSV) files in the provided zip file (2020-003_Coesfeld-et-al_zero_correction_csv.zip). They are on a 72x28 grid, with the top left corner at 72.5° N, 177.5° W. The longitude and latitude steps are 5 degrees.

4.1. File inventory

ZIP folder	Folder size	Filename	File format	Content
Scripts	18KB	2020-003_Coesfeld-et-al_location-selection	.py	Python script for selecting grid locations and exporting them to a csv file
		2020-003_Coesfeld-et-al_correction-extraction	.py	Python script for extracting VIIRS DNB radiance of specified grid locations, removing outliers, filling missing data and smoothing it. The final monthly correction maps are exported as csv files
		2020-003_Coesfeld-et-al_correction-function	.py	Python script for interpolating monthly correction images with simple example how to use it
		2020-003_Coesfeld-et-al_correction_timeseries	.py	Python script to generate time series of corrected and uncorrected DNB radiance for specified locations and its visualization
Data	2.37 MB	2020-003_Coesfeld-et-al_grid_locations	.csv	Table storing all 2016 correction sites
		2020-003_Coesfeld-et-al_grid_locations_median_monthly_values_2019	.csv	Table storing all 2016 correction sites and their corresponding monthly DNB radiance values from 2012 until 2019
		2020-003_Coesfeld-et-al_pixel_thresholds	.csv	Table storing thresholds for all 2016 correction sites used for removing outliers. The threshold values are on a 72x28 grid, with the top left corner at 72.5°N, 177.5°W
		2020-003_Coesfeld-et-al_zero_correction_csv	.zip	Zip folder storing all 93 monthly correction images in csv format. Each csv file is on a 72x28 grid, with the top left corner at 72.5°N, 177.5°W

4.2. Description of data tables

4.2.1. 2020-003_Coesfeld-et-al_grid_locations.csv

File 2020-003_Coesfeld-et-al_grid_locations contains locations for all 2016 correction sites

Column header	unit	Description
Index		Location Identifier
x matrix	Pixels	Matrix position on the x axis of the DNB raster
x matrix	Pixels	Matrix position on the y axis of the DNB raster
lon	DD.ddd	Longitude in WGS84 in decimal degrees of modified pixel location

lat	DD.ddd	Latitude in WGS84 in decimal degrees of modified pixel location
lon grid	DD.ddd	Longitude in WGS84 in decimal degrees of equally spaced grid
lat grid	DD.ddd	Latitude in WGS84 in decimal degrees of equally spaced grid
tile		VIIRS DNB tile of corresponding location

4.2.2. 2020-003_Coesfeld-et-al_grid_locations_median_monthly_values_2019

File 2020-003_Coesfeld-et-al_grid_locations_median_monthly_values_2019 contains locations for all 2016 correction sites and their corresponding monthly DNB radiance from 2012 until 2019

Column header	**unit**	**Description**
Index		Location Identifier
x matrix	Pixels	Matrix position on the x axis of the DNB raster
x matrix	Pixels	Matrix position on the y axis of the DNB raster
lon	DD.ddd	Longitude in WGS84 in decimal degrees of modified pixel location
lat	DD.ddd	Latitude in WGS84 in decimal degrees of modified pixel location
lon grid	DD.ddd	Longitude in WGS84 in decimal degrees of equally spaced grid
lat grid	DD.ddd	Latitude in WGS84 in decimal degrees of equally spaced grid
tile		VIIRS DNB tile of corresponding location (e.g. 75N180W, 75N060W, …)
2012-01	$nWcm^{-2}sr^{-1}$	Monthly DNB radiance of corresponding location of January 2012
2012-02	$nWcm^{-2}sr^{-1}$	Monthly DNB radiance of corresponding location of February 2012
…		
2019-11	$nWcm^{-2}sr^{-1}$	Monthly DNB radiance of corresponding location of November 2019
2019-12	$nWcm^{-2}sr^{-1}$	Monthly DNB radiance of corresponding location of November 2019

5. References

Coesfeld, J., Kuester,T., Kuechly,H. U., Kyba, C.C.M. (2020) Reducing variability and removing natural light from nighttime satellite imagery: a case study using the VIIRS DNB. Sensors, in press

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