Greenness Trends and Carbon Stocks of Mangrove Forests Across Mexico, 2001-2015

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Dataset Version: 1

Summary

This dataset provides estimates of greenness trends, above- and belowground carbon stocks, and climate variables of the persistent mangrove forests on the coasts of Mexico (PMFM) at a 1 km resolution from 2001 through 2015. Data are available as one-time estimates or across the temporal range; typically as monthly summaries. One-time estimates of aboveground carbon and soil organic carbon stocks for the PMFM derived from existing sources are provided. Also included are the monthly mean normalized difference vegetation index (NDVI) from MOD13A3 used to derive greenness trends, monthly mean air temperature, and total monthly precipitation from Daymet for 2001-2015 across the PMFM. Other files include the distribution and coverage of PMFM across Mexico. Distributions are provided as four categories of PMFM: (1) Arid mangroves with Surface Water as main input, along the Gulf of California and Pacific Coast (ARsw); (2) humid mangroves with surface water input along the Pacific Coast (HUsw-Pa); (3) humid mangroves with surface water input along the coast of the Gulf of Mexico (HUsw-Gf); (4) humid mangroves with groundwater input along the Gulf of Mexico and Caribbean Sea (HUgw). These data provide a baseline for national monitoring programs, carbon accounting models, and greenness trends in coastal wetlands.

There are 28 data files in GeoTIFF (*.tif) format and four shapefiles bundles in compressed (*.zip) format, included in this dataset.

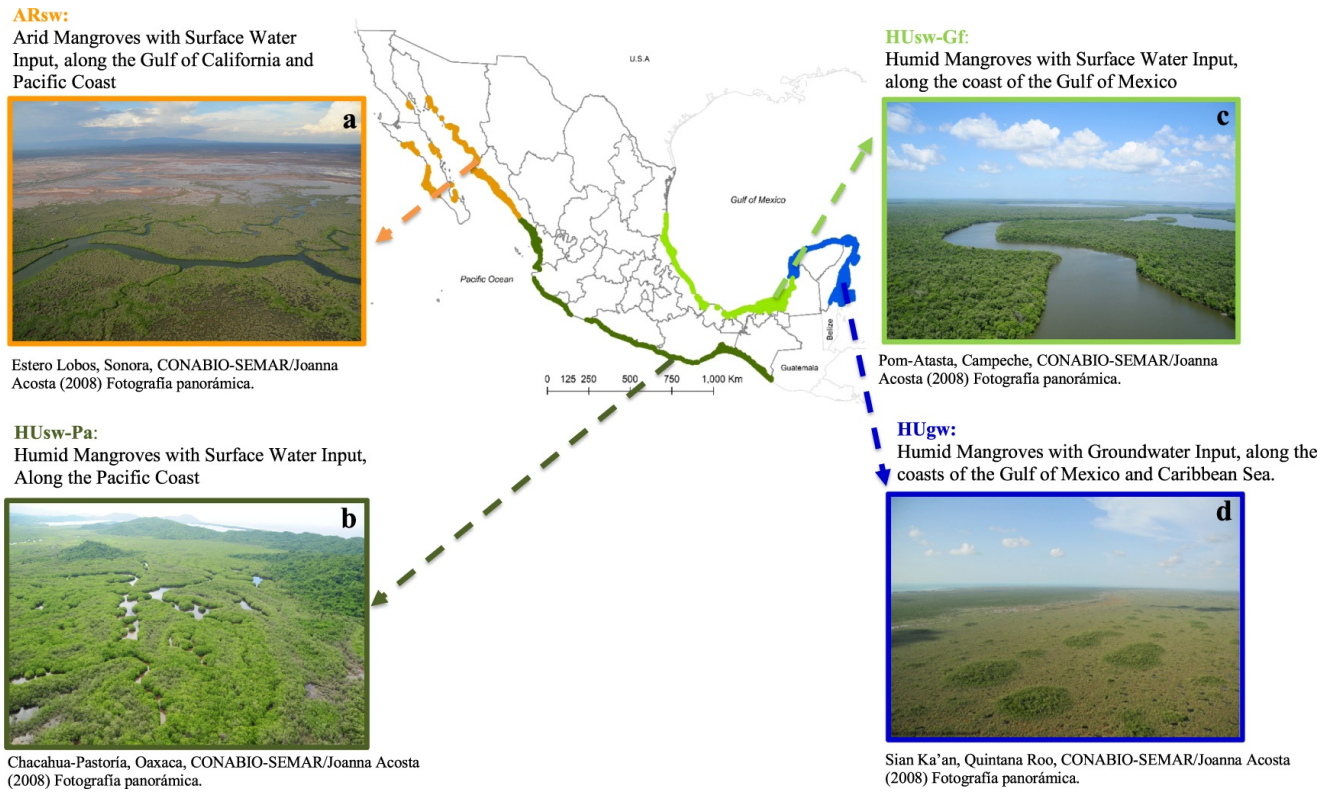

Figure 1. Categories of persistent mangrove forests on the coasts of Mexico. Source: Vázquez-Lule et al. (2019)

Citation

Vázquez-Lule, A., R. Colditz, J. Herrera-silveira, M. Guevara, M.G. Rodríguez-Zúñiga, I. Cruz, R. Ressl, and R. Vargas. 2021. Greenness Trends and Carbon Stocks of Mangrove Forests Across Mexico, 2001-2015. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1853 https://doi.org/10.3334/ORNLDAAC/1853

Table of Contents

1. Dataset Overview

This dataset provides estimates of greenness trends, above- and belowground carbon stocks, and climate variables of the persistent mangrove forests on the coasts of Mexico (PMFM) at a 1 km resolution from 2001 through 2015. Data are available as one-time estimates or across the temporal range; typically as monthly summaries. One-time estimates of aboveground carbon and soil organic carbon stocks for the PMFM derived from existing sources are provided. Also included are the monthly mean normalized difference vegetation index (NDVI) from MOD13A3 used to derive greenness trends, monthly mean air temperature, and total monthly precipitation from Daymet for 2001–2015 across the PMFM. Other files include the distribution and coverage of PMFM across Mexico. Distributions are provided as four categories of PMFM: (1) Arid mangroves with Surface Water as main input, along the Gulf of California and Pacific Coast (ARsw); (2) humid mangroves with surface water input along the Pacific Coast (HUsw-Pa); (3) humid mangroves with surface water input along the coast of the Gulf of Mexico (HUsw-Gf); (4) humid mangroves with groundwater input along the Gulf of Mexico and Caribbean Sea (HUgw). These data provide a baseline for national monitoring programs, carbon accounting models, and greenness trends in coastal wetlands.

Project: Carbon Monitoring System

The NASA Carbon Monitoring System (CMS) program is designed to make significant contributions in characterizing, quantifying, understanding, and predicting the evolution of global carbon sources and sinks through improved monitoring of carbon stocks and fluxes. The System uses NASA satellite observations and modeling/analysis capabilities to establish the accuracy, quantitative uncertainties, and utility of products for supporting national and international policy, regulatory, and management activities. CMS data products are designed to inform near-term policy development and planning.

Related Publications

Vázquez-Lule, A., R. Colditz, J. Herrera-Silveira, M. Guevara, M.T. Rodríguez-Zúñiga, I. Cruz, R. Ressl and R. Vargas. 2019. Greenness trends and carbon stocks of mangroves across Mexico. Environmental Research Letters 14:075010. https://doi.org/10.1088/1748-9326/ab246e

Related Datasets

Cartus, O., J. Kellndorfer, W. Walker, C. Franco, J. Bishop, L. Santos, and J.M.M. Fuentes. 2014. A national, detailed map of forest aboveground carbon stocks in Mexico. Remote Sensing 6:5559-5588. https://doi.org/10.3390/rs6065559

Didan, K. 2015. MOD13A3 MODIS/Terra vegetation Indices Monthly L3 Global 1km SIN Grid V006 [Data set]. NASA EOSDIS Land Processes DAAC. https://doi.org/10.5067/MODIS/MOD13A3.006

Guevara M, Arroyo-Cruz C E, Brunsell N, et al. 2020. Soil organic carbon estimates for 30-cm depth, Mexico and Conterminous USA, 1991-2011. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1737

Thornton, P.E., M.M. Thornton, B.W. Mayer, Y. Wei, R. Devarakonda, R.S. Vose, and R.B. Cook. 2016. Daymet: Daily surface weather data on a 1-km grid for North America, Version 3. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1328

Acknowledgments

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2. Data Characteristics

Spatial Coverage: Terrestrial Coastline of Mexico

Spatial Resolution: 1 km

Temporal Coverage: 2001-01-01 to 2015-12-31

Temporal Resolution: One-time estimates of Greenness Trends over the temporal range and Carbon stocks. Monthly means or totals of climate variables and NDVI from 2001 to 2015.

Site Boundaries: Latitude and longitude are given in decimal degrees.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Mexico	-114.0553	-86.5301	29.7262	14.4292

Data File Information

There are 28 data files in GeoTIFF (*.tif) format and four shapefiles bundles in compressed (*.zip) format, included in this dataset.

The distribution maps for mangrove types follow the file naming convention **<mangrove type>_PMFM_<year(s)>.tif** or **<mangrove type>_<category>.zip**

For files containing greenness trend and NDVI, carbon stock variables, and climate variables, the naming convention is **<variable>_<mangrove type>_<year(s)>.tif**

Table 1. File names and descriptions.

File Name	Columns	Rows	Bands	Units	Description
Distribution Maps for Mangrove Types					
ARsw_PMFM_2001_2015.tif	721	710	1		Detailed distribution of arid mangroves with surface water input, 2001–2015 (1=present)
HUgw_PMFM_2001_2015.tif	430	406	1		Detailed distribution of humid mangroves with groundwater input, 2001–2015 (1=present)
HUsw-Gf_PMFM_2001_2015.tif	814	612	1		Detailed distribution of humid mangroves with surface water input, Gulf of Mexico, 2001–2015 (1=present)

HUsw-Pa_PMFM_2001_2015.tif	1552	964	1		Detailed distribution of humid mangroves with surface water input, Pacific Coast, 2001–2015 (1=present)
ARsw_category.zip					General range of arid mangroves with surface water input, 2001–2015
HUgw_category.zip					General range of humid mangroves with groundwater input, 2001–2015
HUsw-Gf_category.zip					General range of humid mangroves with surface water input, Gulf of Mexico, 2001–2015
HUsw-Pa_category.zip					General range of humid mangroves with surface water input, Pacific Coast, 2001–2015
Greenness Trend and NDVI by Mangrove Type					
GreenTrend_ARsw_2001_2015.tif	622	616	3		Greenness trend for arid mangroves with surface water input, 2001–2015. Bands; 1: # years used, 2: slope of greenness trend, 3: significance of trend (P)
GreenTrend_HUgw_2001_2015.tif	375	379	3		Greenness trend for humid mangroves with groundwater input, 2001–2015. Bands; 1: # years used, 2: slope of greenness trend, 3: significance of trend (P)
GreenTrend_HUsw-Gf_2001_2015.tif	772	448	3		Greenness trend for humid mangroves with surface water input, Gulf of Mexico, 2001–2015. Bands; 1: # years used, 2: slope of greenness trend, 3: significance of trend (P)
GreenTrend_HUsw-Pa_2001_2015.tif	1497	920	3		Greenness trend for humid mangroves with surface water input, Pacific Coast, 2001–2015. Bands; 1: # years used, 2: slope of greenness trend, 3: significance of trend (P)
NDVI_ARsw_2001_2015.tif	705	695	180		Monthly mean normalized difference vegetation index for arid mangroves with surface water input, 2001–2015
NDVI_HUgw_2001_2015.tif	420	398	180		Monthly mean normalized difference vegetation index for humid mangroves with groundwater input, 2001–2015
NDVI_HUsw-Gf_2001_2015.tif	797	599	180		Monthly mean normalized difference vegetation index for humid mangroves with surface water input, Gulf of Mexico, 2001–2015
NDVI_HUsw-Pa_2001_2015.tif	1520	944	180		Monthly mean normalized difference vegetation index for humid mangroves with surface water input, Pacific coast, 2001–2015
Carbon Stock Variables by Mangrove Type					
AGC_ARsw_2007.tif	721	710	1	Mg ha^{-1}	Aboveground carbon for arid mangroves with surface water input, 2007
AGC_HUgw_2007.tif	430	406	1	Mg ha^{-1}	Aboveground carbon for humid mangroves with groundwater input, 2007
AGC_HUsw-Gf_2007.tif	814	612	1	Mg ha^{-1}	Aboveground carbon for humid mangroves with surface water input, Gulf of Mexico, 2007
AGC_HUsw-Pa_2007.tif	1552	964	1	Mg ha^{-1}	Aboveground carbon for humid mangroves with surface water input, Pacific Coast, 2007
SOCD_ARsw_2010.tif	716	701	1	Mg ha^{-1}	Soil organic carbon for arid mangroves with surface water input, 2007
SOCD_HUgw_2010.tif	426	404	1	Mg ha^{-1}	Soil organic carbon for humid mangroves with groundwater input, 2007
SOCD_HUsw-Gf_2010.tif	809	609	1	Mg ha^{-1}	Soil organic carbon for humid mangroves with surface water input, Gulf of Mexico, 2007
SOCD_HUsw-Pa_2010.tif	1539	950	1	Mg ha^{-1}	Soil organic carbon for humid mangroves with surface water input, Pacific Coast, 2007
Climate Variables by Mangrove Type					
MTemp_ARsw_2001_2015.tif	705	695	180	°C	Monthly mean air temperature for arid mangroves with surface water input, 2001–2015
MTemp_HUgw_2001_2015.tif	420	398	180	°C	Monthly mean air temperature for humid mangroves with groundwater input, 2001–2015
MTemp_HUsw-Gf_2001_2015.tif	797	599	180	°C	Monthly mean air temperature for humid mangroves with surface water input, Gulf of Mexico, 2001–2015
MTemp_HUsw-Pa_2001_2015.tif	1520	944	180	°C	Monthly mean air temperature for humid mangroves with surface water input, Pacific coast, 2001–2015
TotPrcp_ARsw_2001_2015.tif	705	695	180	mm	Monthly mean total precipitation for arid mangroves with surface water input, 2001–2015
TotPrcp_HUgw_2001_2015.tif	420	398	180	mm	Monthly mean total precipitation for humid mangroves with groundwater input, 2001–2015

TotPrcp_HUsw-Gf_2001_2015.tif	797	599	180	mm	Monthly mean total precipitation for humid mangroves with surface water input, Gulf of Mexico, 2001–2015
TotPrcp_HUsw-Pa_2001_2015.tif	1520	944	180	mm	Monthly mean total precipitation for humid mangroves with surface water input, Pacific coast, 2001–2015

Data File Details

- All files are projected in Mexico Lambert Conic Conformal (EPSG:6361).
- All GeoTIFF files have a resolution of 1 km grid cells and the no data value is -9999.

Table 2. Abbreviations of mangrove types and variables.

Abbreviation	Description
AGC	Aboveground carbon in Mg ha^{-1}
ARsw	Arid mangroves with surface water as main input, along the Gulf of California and Pacific Coast
GreenTrend	Statistical trend in greenness (regression slope)
HUgw	Humid mangroves with groundwater input along the Gulf of Mexico and the Caribbean Sea
HUsw-Gf	Humid mangroves with surface water input along the Gulf of Mexico
HUsw-Pa	Humid mangroves with surface water input along the Pacific Coast
Mtemp	Monthly mean air temperature in °C
NDVI	Normalized difference vegetation index
PMFM	Persistent mangrove forest of Mexico
SOCD	Soil organic carbon density in first 30 cm of depth in Mg ha^{-1}
TotPrcp	Monthly mean total precipitation in mm

3. Application and Derivation

Mangrove forests cover less than 0.1% of the earth's surface but are one of the most productive ecosystems. Their carbon stocks vary with geography and mangrove type. In Mexico, there are four types of persistent mangrove forests (PMFM) classified by geomorphic features along Mexico's coast. This project investigated relationships in the spatial patterns of greenness trends, carbon stocks (i.e., aboveground carbon, soil organic carbon density), air temperature, and precipitation between 2001–2015. It built upon previous analyses and field data (Cartus et al., 2014, Guevara et al., 2017, Herrera-Silveira et al., 2016). These results provide a baseline for national monitoring programs, carbon accounting models, and greenness trends in coastal wetlands.

Greenness trends varied among mangrove types during the study period. Significant positive trends were observed among arid mangroves with surface water input (ARsw) and humid mangroves with surface water input along the Pacific Coast (HUsw-Pa). ARsw and HUsw-Pa were dominated by the black mangrove (*Avicennia germinans*). Negative, but non-statistically significant, trends were observed among humid mangroves with surface water input (HUsw-Gf) and with groundwater input (HUgw) along the Gulf of Mexico (Vázquez-Lule et al., 2019).

4. Quality Assessment

Distribution maps of mangrove forests were developed from existing maps of mangrove occurrence. These maps had resolutions of 10-30 m for years 2000, 2005, 2010, and 2015 (Giri et al., 2011; Mexican Mangrove Monitoring System; Valderrama-Landeros et al., 2017). Interactive maps and data of mangrove distribution (Cartus et al., 2014) can be viewed and downloaded from the Conabio Geoinformation Portal 2021:National Biodiversity Information System (SNIP) at http://www.conabio.gob.mx/informacion/gis/ . The following raster files are available:

- CONABIO. 2013. Distribución de los manglares de México en 1970-1981
- CONABIO. 2013. Distribución de los manglares de México en 2005
- CONABIO. 2013. Distribución de los manglares de México en 2010
- CONABIO. 2016. Distribución de los manglares de México en 2015

All maps were resampled to 30 m resolution. Each 1 km cell in the final map products was coded as mangroves present (1) if >65% of the co-registered 30 m cells contained mangroves. The >65% threshold captured >50% of persistent mangrove forests in Mexico over the study period (2001–2015).

Greenness was measured from 180 monthly composites of nine MODIS tiles covering Mexico. The composites were resampled and mosaicked using the MODIS Reprojection Tool, available at the time of processing through the Land Processes Distributed Active Archive Center, to provide a time series of NDVI measurements. The quality and reliability of the NDVI composites were assessed by using the Time-series Generator Software (TiSeG; Colditz et al 2008). Invalid pixels were identified, and gaps in coverage were filled by linear interpolation.

Corrections factors were applied to carbon stock estimates because Cartus et al. (2014) may have underestimated the aboveground carbon, and Guevara et al. (2017) product may have overestimated the soil organic carbon in mangroves. See Vázquez-Lule et al. (2019) for details.

5. Data Acquisition, Materials, and Methods

Mangrove forests across Mexico are distributed between latitudes 27.83 to 14.50 degrees North. Four categories of mangroves were defined based on: latitudinal distribution, mean air temperature, main input of freshwater, and their location throughout the coast (i.e., the Gulf of California, Pacific Coast, Gulf of Mexico, Caribbean Sea). Categories include (a) arid mangroves with surface water input along the Gulf of California and Pacific Coast (ARsw); (b) humid mangroves with surface water input along the Pacific Coast (HUsw-Pa); (c) humid mangroves with surface water input along the coast of the Gulf of Mexico (HUsw-Gf); and (d) humid mangroves with groundwater input along the coast of the Gulf of Mexico and Caribbean Sea (HUgw). See Vázquez-Lule et al. (2019) for details of identification of PMFM.

The greenness of mangroves was derived from monthly composites of NDVI from 2001–2015 at 1 km spatial resolution from the MOD13A3 product (Didan, 2015). Investigators used 180 monthly composites from each of the nine tiles covering Mexico (h07v05, h07v06, h07v07, h08v05, h08v06, h08v07, h09v05, h09v06, j09v07). These composites were pre-processed (i.e., resampled and mosaicked) using the MODIS reprojection tool. Their quality assurance was done with the Time-series Generator Software (TiSeG; Colditz et al., 2008), and gaps due to invalid pixels were filled using linear interpolation. Greenness trends were analyzed from this time series for each mangrove category using non-parametric Theil-Sen Regression with deseasonalized data in the "openair" R package for trend detection analyses.

Climatic variables, mean air temperature, and precipitation were derived from Daymet products at 1 km of spatial resolution from 2001 to 2015 (Thornton et al., 2017). Mean monthly air temperature (°C) was the average of the maximum and minimum air temperature for each grid cell. Total monthly precipitation was in mm by grid cell.

Aboveground carbon (AGC) and soil organic carbon density (SOCD) were extracted from Cartus et al. (2014) and Guevara et al. (2017), respectively. SOCD included carbon at 30 cm of depth. Both products were one-time estimates, and they were standardized per mangrove category as per a previous synthesis study (Herrera-Silveira et al., 2016). See Vázquez-Lule et al. (2019) for more information on methods used to produce this dataset.

6. Data Access

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

Greenness Trends and Carbon Stocks of Mangrove Forests Across Mexico, 2001-2015

Contact for Data Center Access Information:

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

7. References

Cartus, O., J. Kellndorfer, W. Walker, C. Franco, J. Bishop, L. Santos, and J. M. M. Fuentes. 2014. A national, detailed map of forest aboveground carbon stocks in Mexico. Remote Sensing 6:5559-5588. https://doi.org/10.3390/rs6065559

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