



National Aeronautics and Space
Administration

NASA Carbon Monitoring System



The NASA Carbon Monitoring System (CMS): Applications Efforts & Communities of Practice

Edil A. Sepúlveda Carlo
CMS Applications Coordinator
NASA GSFC / SSAI

**Applied Earth Observations Innovation Partnership Spring 2022 Workshop:
Integrating Remote Sensing Data for Land Management Decision-Making**
Wednesday, March 23, 2022





National Aeronautics and Space Administration

NASA Carbon Monitoring System

- Initiated in 2010 by Congressional direction
- 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.



George Hurtt, U Maryland
Science Team Leader

CMS Applications Team:
Edil Sepulveda Carlo, Lead
Peter Griffith, NASA GSFC
Ben Poulter, NASA GSFC
Sabrina Delgado, NASA GSFC
Molly Brown, Univ. of Maryland

NASA Carbon Monitoring System

For more info, please visit:
<http://www.carbon.nasa.gov>



Objectives of the Carbon Monitoring System Initiative

- Use the full range of NASA satellite observations, modeling/analysis capabilities, and commercial off-the-shelf technologies to establish the accuracy, quantitative uncertainties, and utility of products for supporting national and international policy, regulatory, and management activities.
- Prototype the development of carbon MRV systems which can provide transparent data products achieving levels of precision and accuracy required by current carbon trading protocols.
- Harness unique capabilities of NASA centers and the NASA-funded investigator community, making use of competitive peer review wherever possible.
- **Rapidly initiate generation and distribution of products, both for evaluation and to inform near-term policy development and planning.**
- **Engage with, and contribute to, related U.S. and international stakeholders and agencies.**



National Aeronautics and Space Administration

NASA Carbon Monitoring System



CMS Applications Program Framework

Policy Speaker Series

Brings stakeholders to NASA to explain how carbon science data are applied to specific policies. Informs CMS science community of specific stakeholders data needs and collaboration opportunities.

Applications Workshops

Annual event with CMS Science Team and end users for a better understanding of stakeholder uses, needs and challenges for carbon monitoring and MRV as well as lessons learned.

Data Products Fact Sheet

Collection of CMS metadata and policy data for each product (e.g. spatial extent, resolution, uncertainty, application areas, relevant policies), Integrated into CMS website database.

Application Readiness Levels (ARLs)

Provide transparency to HQ and user community on the maturity of each CMS product. Used as a communication tool for stakeholders to assess product maturity.

Surveys & Community Assessments

Evaluate thematic user challenges within the CMS. Assess impact of CMS data products for end user organizations.

Socioeconomic Studies

Development of socioeconomic case study addressing the social value of CMS Lidar in MD DNR policy, and an ongoing assessment of the contribution of CMS flux products to the reduction of uncertainty in the carbon cycle.

Feedback to CMS Science Community and NASA HQ ESD



CMS Applications Efforts Examples. 2019 CMS Applications Workshop in La Jolla, CA: CMS Application workshops and tutorials provide an opportunity for CMS Science Team members and stakeholders to engage on thematically detail objectives that help advance CMS science into appropriately scaled policy arenas.



Overview of CMS Data Products

• Where can CMS datasets be found?

DMAC Home > Get Data > NASA Projects > Carbon Monitoring System (CMS)

Carbon Monitoring System (CMS)

Overview

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.

Carbon Monitoring System Datasets List

Sign in to download CMS datasets.
92 CMS datasets
Show All entries

Q#	CMS dataset	Updated	Published	User Guide
1	Global Mangrove Loss Extent, Land Cover Change, and Loss Drivers, 2009-2019	2022-03-17	2022-03-17	
2	Methane and Ethane Observations for Boston, MA, 2012-2020	2022-03-15	2022-03-15	
3	CMS Daily Gross Primary Productivity over CONUS from TROPOMI SIF, 2018-2020	2022-02-22	2022-02-22	
4	Carbon Pools across CONUS using the MaxEnt Model, 2005, 2010, 2015, 2016, and 2017	2021-12-21	2021-12-21	
5	Global Gridded 1-km Soil and Soil Heterotrophic Respiration Derived from SRDB v5	2021-12-08	2021-12-08	
6	Resilience of Coastal Wetlands to Sea Level Rise, CONUS, 1998-2100	2021-11-30	2021-11-30	
7	MODIS-based GPP PAR, fC4, and SANIRV estimates from SLOPE for CONUS, 2000-2019	2021-11-13	2021-12-03	
8	Global Gas Flare Survey by Infrared Imaging, VIRRS Nightfire, 2012-2019	2021-10-29	2021-10-29	
9	CMS Forest Aboveground Biomass from FIA Plots across the Conterminous USA, 2009-2019	2021-09-23	2021-09-23	
10	CMS Global 0.5-deg Wetland Methane Emissions and Uncertainty (WEMCHANS v1.3.1)	2021-09-23	2021-09-23	
11	CLMS-DART Regional Carbon Fluxes and Stocks over the Western US, 1998-2010	2021-07-21	2021-07-21	
12	CMS Terrestrial Carbon Stocks, Emissions, and Fluxes for Conterminous US, 2001-2016	2021-06-28	2021-06-28	
13	Greenness Trends and Carbon Stocks of Mangrove Forests Across Mexico, 2001-2015	2021-06-25	2021-06-24	
14	LiDAR Derived Biomass, Canopy Height, and Cover for New England Region, USA, 2015	2021-06-16	2021-06-16	
15	Relative Tidal Marsh Elevation Maps with Uncertainty for Conterminous USA, 2010	2021-06-14	2021-06-14	
16	Forest Carbon Stocks and Fluxes from the NFMCS, Conterminous USA, 1990-2010	2021-05-24	2021-05-18	
17	Global Mangrove Distribution, Aboveground Biomass, and Canopy Height	2021-04-29	2019-05-02	

EARTHDATA Find a DAAC

GES DISC Data Collections

MERRA-2 reprocessed Sept

NASA Carbon Monitoring System

Data Collections Showing

Refine By

Subject Sort

- Atmospheric Chemistry (24)
- Ecological Dynamics (6)
- Ocean Chemistry (18)

Measurement Sort

- Alkalinity (1)
- Biogeochemical Cycles (1)
- Carbon (1)
- Carbon Dioxide (38)
- Dissolved Gases (1)

Source Sort

- Aqua MODIS (6)
- GOSAT TANSO-FTS (2)
- Models/Analyses BLING (1)
- Models/Analyses CASA-GFED3-V2 (5)
- Models/Analyses CASA-GFED3-V3 (3)

Processing Level Sort

- 4 (31)

Project Sort

- CMS (31)

Temporal Resolution Sort

- 3 hours (2)
- 1 day (3)
- 1 month (21)
- 1 year (5)

NASA Carbon Monitoring System

Project: Poultier (CMS 2020): Blue Carbon Prototype Products for Mangrove Methane and Carbon Dioxide Fluxes (BLUEFLUX)

Info Abstract Participants Keywords

Science Team Members

Benjamin (Ben) Poultier, NASA GSFC
Temilola (Lola) Fatoyinbo, NASA GSFC
Reem Hannun, University of Pittsburgh
David Lagomasino, East Carolina University
Judith Rosentreter, Yale University
Glenn Wolfe, NASA GSFC

Project Funding

2021 - 2024 | NASA (agency representative: Laura Lorenzoni)

Solicitation

2020 NASA: Carbon Monitoring System

Other Programs

ORB | CCE

Internal ID

4317

Products

Airborne Fluxes for Southern Florida	Planned
Airborne Fluxes for the Caribbean	Planned

Metadata Fields	Explanation
Award Year	The year the funding was granted
Project ID	Principal Investigator's last name and project #
Objectives	Goals that the project seeks to attain by developing data and products
Science Theme	Type of data and products, according to components of carbon cycle research that are most relevant: Global Flux, Ocean-Atmosphere Flux, Land-Atmosphere Flux, Land-Ocean Flux, Land Biomass, Ocean Biomass, Lake Biomass, MRV, and Decision Support
Products Keywords	Keywords that will help stakeholders identify data and products appropriate to their needs. See below for a table that explains each product keyword.
Data Products	A description of output data and products that will be publicly available upon completion of the project
Spatial Extent	The geographical area that the data and products cover
Coordinates	Coordinates can be approximate. They can be the center of Spatial Extent or study sites. Shape files are welcome.
Time Period	The time period that the data and products cover
Spatial Resolution	Finest spatial resolution of data and products
Temporal Frequency	Time intervals of data products
Input Data Products	Any satellite, airborne, field, and modeled data products used. If airborne Lidar data was used, please indicate where, when, which instruments, and how much data (area, dimensions, or number and length of lines).
Algorithm/Models Used	Any algorithm or models used to develop data and products
Evaluation	Any efforts to evaluate the accuracy, robustness, and/or performance of data and products
Intercomparison Efforts/Gaps	Any key intercomparison effort(s) that have been undertaken or gaps where future intercomparison efforts are warranted
Uncertainty Estimates	Plans to quantify data uncertainty, if any
Uncertainty Categories	1. Ensemble (e.g. stochastic), 2. Deterministic, 3. Model-Data Comparison, 4. Model-Model Comparison, and/or 5. Data-Data Comparison
Application Areas	Areas with policy or societally relevant decision processes, which may benefit from the usage of data and products
Potential Users	Possible end users of data and products once fully developed
Stakeholders	End users engaged with CMS PIs who are using or plan to use data and products in the future
Application Readiness Level (ARL)	The NASA index that assesses applications potential of data and products in operational settings. Detailed explanation . Principal Investigators specified the ARLs of their own projects
Future Developments	Future plans to engage stakeholders, share data and products, and raise awareness of the product development efforts
Limitations	Any shortcoming of data and products that users must be aware of
Date When Data/Product Available	The date (MM/DD/YY - if possible) on which data and products will be made publicly available
Data Server URL	The URL address where a user may access data and products
Metadata URL	The URL address where a user may access metadata

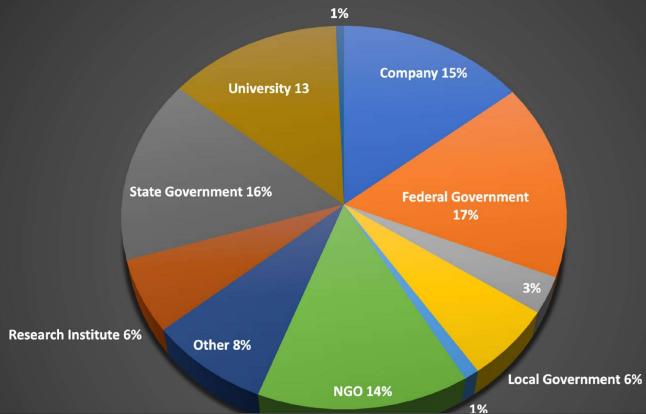


CMS and End Users

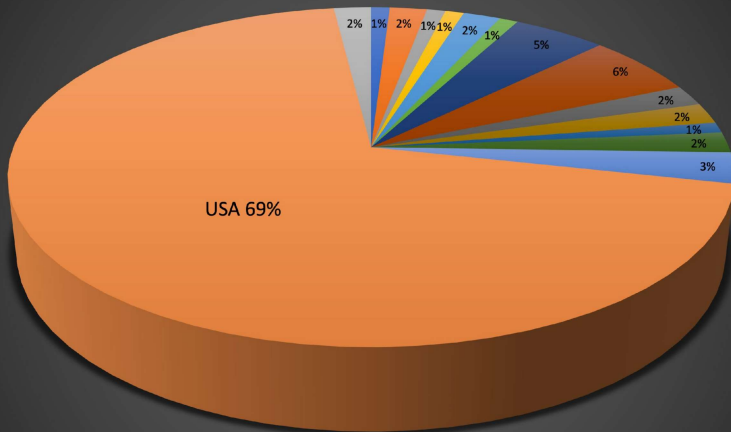
- CMS was implemented with “End Users” in mind. We were directed in appropriations language to design a prototype “System” for monitoring “Carbon”.
- Co-development of science data products is essential .
- Engaged, two-way relationships between scientists and stakeholders are emphasized as critical in the process of producing science that is relevant to the context in which it could be used by decision makers.
- These studies report that *users’ perceptions of scientific information are highly influenced by their relationship with scientists that produce it.*
- **Engagement with end users early, often, and throughout the product development process is the key to success.**



Percentage of CMS Stakeholders by Organization Type



Percentage of CMS Stakeholder Organizations by Country

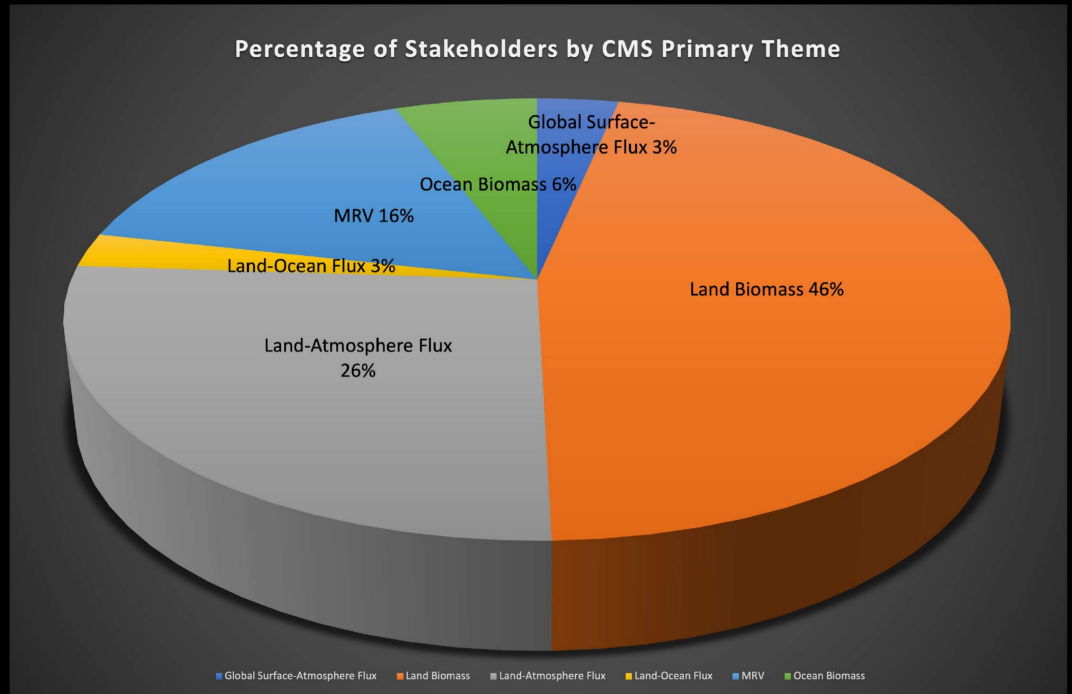


- Australia
- Canada
- Colombia
- Ethiopia
- Germany
- India
- Indonesia
- Mexico
- Mozambique
- Norway
- South Africa
- Tanzania
- United Kingdom
- USA
- Zambia

CMS Stakeholder Survey for Science Team

Who are our stakeholders?

Percentage of Stakeholders by CMS Primary Theme

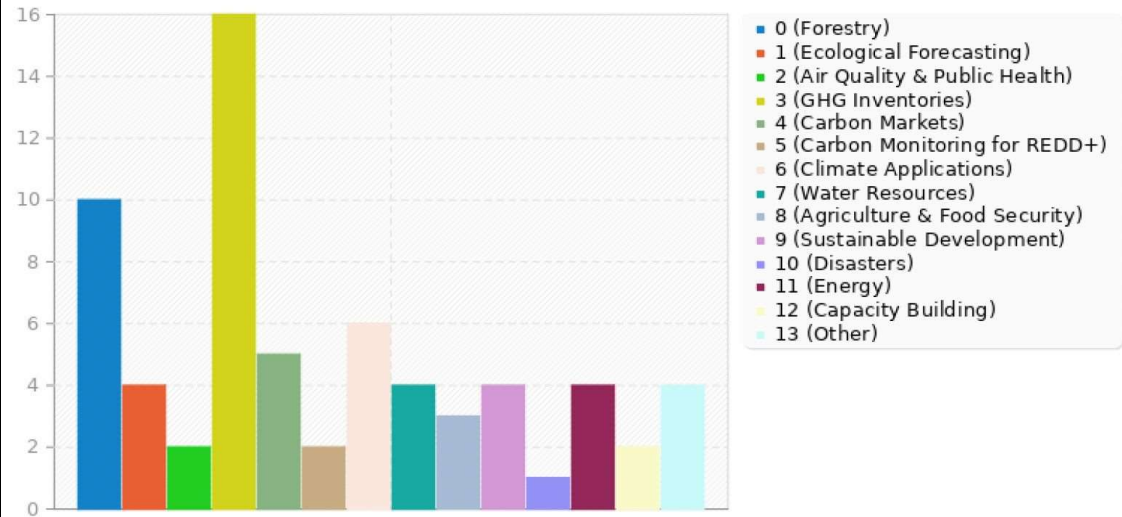


- Global Surface-Atmosphere Flux
- Land Biomass
- Land-Atmosphere Flux
- Land-Ocean Flux
- MRV
- Ocean Biomass



Stakeholder Feedback

What are some of the applications you address with the CMS data products?



Principal Applications

GHG Inventories

Forestry

Climate Applications

Carbon Markets



CMS Success Stories: High Resolution Forest Carbon Monitoring & Modeling in RGGI+ Region

- ❖ Continued funded project
 - ❖ 2011: Maryland
 - ❖ 2014: MD, DE, PA
 - ❖ 2016: New England (RGGI)
 - ❖ 2020: National & Global Scales
- ❖ Stakeholder Multi-State Working Group created with participation of climate change & forestry state agencies – recent publication in ERL
- ❖ LiDAR-derived Aboveground Biomass, Canopy Height and Cover product used extensively by Maryland DNR and other organizations – recent press release

ENVIRONMENTAL RESEARCH LETTERS

TOPICAL REVIEW

Context and future directions for integrating forest carbon into sub-national climate mitigation planning in the RGGI region of the U.S.

Rachel L. Lamb^{1,2}, George C. Hurtt³, Te Jay Boudreau⁴, Elliott Campbell⁵, Edil A. Sepúlveda Carlo⁶, Hong-Hanh Chu⁷, Jennifer de Moor⁸, Ralph O. Dubayah⁹, Dena Goncalves¹⁰, Madeline Guy¹¹, Nathan E. Hultman¹², Shawn Lehman¹³, Bennet Leon¹⁴, Andrew J. Lister¹⁵, Cary Lynch¹⁶, Lei Ma¹⁷, Christopher Martin¹⁸, Nathan Robbins¹⁹, Alexander Rudek²⁰, Carlos E. Silva²¹, Christopher Skoglund²² and Hao Tang²³

Keywords: forest carbon, climate action plans, greenhouse gas, policy, mitigation, climate change, carbon sequestration

Supplementary material for this article is available online

Abstract

International frameworks for climate mitigation that build from national actions have been developed under the United Nations Framework Convention on Climate Change and advanced most recently through the Paris Climate Agreement. In parallel, sub-national actors have set greenhouse gas (GHG) reduction goals and developed corresponding climate mitigation plans. Within the U.S., multi-state coalitions have formed to facilitate coordination of related science and policy. Here, utilizing the form of the NASA Carbon Monitoring System's Multi-State Working Group, we collected and reviewed climate mitigation plans for 11 states in the Regional Greenhouse Gas Initiative region of the Eastern U.S. For each state we reviewed the (a) policy framework for climate mitigation, (b) GHG reduction goals, (c) inclusion of forest activities in the state's climate action plan, (d) existing science used to quantify forest carbon estimates, and (e) stated needs for forest carbon monitoring science. Across the region, we found important differences across all categories. While all states have GHG reduction goals and framework documents, nearly three-quarters of all states do not account for forest carbon when planning GHG reductions; those that do account for forest carbon use a variety of scientific methods with various levels of planning detail and guidance. We suggest that a common, efficient, standardized forest carbon monitoring system would provide important benefits to states and the geographic region as a whole. In addition, such a system would allow for more effective transparency and progress tracking to support state, national, and international efforts to increase ambition and implementation of climate goals.

Department of the Environment

Md. Environment Sec. Grumbles to Attend Key Global Climate Conference in Scotland

BALTIMORE (November 4, 2021) — Maryland Department of the Environment Secretary Ben Grumbles will attend and participate in key events of the annual global summit on climate change, known as COP26 (Conference of the Parties for the 26th year) in Glasgow, Scotland, November 7-10.

Grumbles will join top environmental officials from more than a dozen U.S. states for panel discussions and meetings to promote economy-wide deep decarbonization, adaptation and resiliency, highlighting Maryland's ambitious greenhouse gas reduction and nature-based restoration and protection strategies for the Chesapeake Bay and beyond and scientific initiatives on ocean acidification and carbon sequestration (involving forests, soils, and coastal wetlands also known as "blue carbon.") He will also meet with other countries, businesses and academic institutions to discuss public and private partnerships for a greener economy in Maryland and around the world.

"It's an honor to represent Maryland and Governor Larry Hogan's Administration at the global climate summit and to underscore the importance of bipartisan environmental leadership at home and abroad. We can and must find ways to dramatically slash greenhouse gases while growing the economy and increasing the resilience of communities and ecosystems," Secretary Grumbles said.

New agreements were made earlier in the summit to end deforestation and reduce methane emissions. Forests play a key role in absorbing carbon dioxide and slowing the rise in global temperatures.

Grumbles said the summit would also serve as a global platform for sharing a Maryland-based first of its kind technology for tracking the size and success of forests in pulling carbon pollution from the atmosphere. The carbon monitoring project resulted from a collaboration of the Maryland Department of the Environment, University of Maryland, Maryland Department of Natural Resources, Delaware Department of Natural Resources and Environmental Control, and the World Resources Institute.

Funded by NASA, the project pioneers the use of high-resolution Light Detection and Ranging (LiDAR) data, ecosystem modeling, and satellite imagery in measuring annual changes in forest carbon.

Forests already store the largest quantity of carbon in the state, removing about 10% of what is emitted annually. Maryland will be using results of this project in its greenhouse gas inventory and to help measure annual progress toward the state climate goals of 50% reduction in emissions by 2030 and net zero emissions by 2045.

Grumbles is chairman of the independent, bipartisan Maryland Commission on Climate Change, which adopted comprehensive recommendations on mitigation, adaptation, and resiliency actions on Nov. 1. He is also vice chair of the nation's first "tap and invest" program for the energy sector, the Regional Greenhouse Gas Initiative (RGGI) which has grown over the last two years to 11 states, and president of the Environmental Council of the States.

Numerous applications in land management decision-making!



National Aeronautics and Space Administration

NASA Carbon Monitoring System



CMS Active Stakeholder Organizations



UNITED STATES CLIMATE ALLIANCE

Unilever





CMS Applications Future Work

- CMS Policy Speaker Series 2022 Topics: COP26/COP27, Nature-Based Solutions to Climate Change, Methane Monitoring, Super-Emitters, Cities, Oceans, Blue Carbon, ???
- CMS Stakeholder Survey on Value & Societal Benefits of CMS Products
- Joint CMS Data Tutorials with DAACs including Hands-on Exercises
- NASA ARSET Trainings on Carbon Monitoring & Applications
- CMS Thematic Workshop on Fires
- Finish CMS Knowledge Flow Maps
- Publications on stakeholder needs in carbon monitoring, and relationships that drive carbon data product maturity within NASA Programs



ROSES CMS Call 2022 – Sept 30, 2022

NASA soliciting studies that address research needs to advance:

- (a) remote sensing-based approaches to quantifying forest degradation and forest regrowth;**
- (b) independent assessment of the accuracy of satellite or airborne remote sensing observations of biomass and carbon stocks;**
- (c) the use of satellite remote sensing as an alternative or a supplement to ground-based methods for quantifying net carbon emissions and/or storage;
- (d) Studies using remote sensing data that evaluate and enhance national reported carbon emissions inventories from bottom-up estimate; and
- (e) Studies that build upon and improve quantification of terrestrial-ocean carbon fluxes for accounting purposes (in particular, blue carbon ecosystem stocks and fluxes).

Priority given to proposals where stakeholders have in-kind contributions to ensure transfer of CMS activities into their own ongoing or future activity.

CONTACT INFORMATION

Edil Sepulveda Carlo, CMS Applications Coordinator

O: 301-614-6243 | C: 786-658-0607