GeoCarb Mission Status Update – Summer

Berrien Moore, Principal Investigator Sean Crowell, Deputy PI/Project Scientist Peter Somkuti, Deputy Project Scientist



GeoCarb Mission: Overview & Goal

The GeoCarb Mission is designed to collect observations of the column averaged concentrations of carbon dioxide, methane, and carbon monoxide, and Solar Induced Fluorescence from geostationary orbit at a spatial resolution of 5-10 km over the Americas between 50°N and 50°S.

Level 1 Measurement Requirements:

- Provide high precision daily measurements of X_{CO2} (0.3%), X_{CH4} (0.6%), X_{CO} (10% or 12ppb) over sunlit, cloud free terrestrial regions at spatial scales of 5-10 km

- Study vegetation health (e.g., photosynthesis, ecosystem respiration) by measuring SIF and working with end users to develop useful products (e.g. indicators of plant stress)

The Goal of the GeoCarb Mission is to provide observations and demonstrate methods to realize a transformational advance in our scientific understanding of the global carbon cycle.



Science Hypotheses

- The ratio of CO₂ fossil source to biotic sink for CONUS is ~4:1
- 2. Variation in productivity controls spatial patterns of terrestrial sinks
- 3. Amazonian ecosystems are a large (~0.5-1.0 GtC/y) net sink for CO₂
- 4. Larger cities emit less CO₂ emission per capita than smaller ones
- 5. Amazonian ecosystems are a large (~50-100 MtC) net source for CH₄
- 6. The CONUS methane emissions are a factor of 1.6 \pm 0.3 larger than in EDGAR and EPA databases



GeoCarb Sampling





GeoCarb Mission Phasing



GeoCarb Mission Status – January 2022



Instrument Progress

- All optics have been bonded
- Spectrograph subassembly has been integrated scheduled for thermal vacuum testing to start in August
 - Alignment was extremely challenging, but we have gotten to the finish line at last!
 - We will test the spectrograph assembly on its own to assess the performance and rule out any serious issues
- Flight software is maturing
- Flight electronics are undergoing environmental test
- Fore-optics are bonded and being integrated into telescope and scan box
- Primary structure (main bench) is undergoing environmental test



Instrument is coming together!



GeoCarb Mission Status – January 2022



Science Algorithm Development

- ACOS: Full Physics
 - Simultaneous 4 band retrieval (heritage from OCO)
 - Demonstrated on real data ready to go!
- GASBAG: Single band DOAS-style retrieval
 - Used to retrieve SIF and screen for clouds
 - Very fast retrieval of CO and CH4
 - Demonstrated ability to reproduce some of the TROPOMI "albedo bias" – interaction of dark scenes with low to moderate aerosols (right images)
- Artificial intelligence approaches are also being actively explored in conjunction with AI2ES at OU, CSU, and JPL/Caltech





Challenges on the Horizon

- Keystone leads to a significant error as spatial samples cross multiple detector rows – simple resampling techniques have large residuals
 - Created end-to-end simulator to test out potential solutions to this issue (top images)
- Detector residual image effects have been reduced, but will still be present
 - Running ~20K colder FPAs than originally planned
 - Dropping a frame in between science coadds removes the worst effects
- Slit homogenizer was descoped due to extreme induced polarization sensitivity – nonuniform illumination will remain a challenge
 - Much narrower ISRF in V polarization as compared to H polarization (bottom image)
 - Polarization of incoming light will be unknown and highly variable
 - Trade: ISRF distortions from brightness or polarization?



Images of Slit Homogenizer with three different devices under different polarized inputs – data taken by ITO



- With multiple daily revisits, GeoCarb will constrain terrestrial emissions of CO2, CH4, and CO at city to continental scales
- The GeoCarb instrument is making great progress towards delivery in time for IWGGMS 2023!
- A dedicated launch vehicle and bus will support GeoCarb science objectives even more smoothly than the original hosted payload approach
- The science segments will be ready to support operations with high quality algorithms, data processing, and validation through exercise early and often with real instrument data
- Despite the upcoming challenges, GeoCarb will still enable a step change in our understanding of the carbon cycle.



Backup

GeoCarb Mission Science



- NASA HQ assigned procurement of spacecraft and launch vehicle to GSFC in late 2021
 - Project Manager: Elizabeth Park (GSFC)
- Currently refreshing interface requirements documents in preparation for RFP release
- Timeline for launch is late 2023-summer 2024