

Environmental Studies Program: Ongoing Study

Field	Study Information
Title	Offshore Air Quality (AQ) from NASA's Satellites and Related Experiments (NT-22-02)
Administered by	Office of Environmental Programs
BOEM Contact(s)	Holli Wecht (holli.wecht@boem.gov)
Procurement Type(s)	Interagency Agreement
Conducting Organization(s)	NASA Goddard Space Flight Center
Total BOEM Cost	\$1,043,020
Performance Period	FY 2022–2026
Final Report Due	September 2027
Date Revised	November 4, 2024
Problem	No air quality (AQ) monitors exist in the offshore areas of the Gulf of Mexico (GOM), Atlantic, or Pacific Regions to aid BOEM in the management of AQ impacts as required under the Outer Continental Shelf Lands Act (OCSLA) and/or the National Environmental Policy Act (NEPA).
Intervention	NASA's measurements from SCOAPE-I & TROPOMI with TRACER-AQ Experiment data will support TEMPO satellite algorithm development. NASA will also provide nitrogen dioxide (NO ₂) pollutant validation post-launch (SCOAPE-II). These estimates will allow BOEM to potentially monitor and track offshore pollutants using the TEMPO satellite leading to better management of impacts in the future.
Comparison	NASA will compare NO ₂ data in GOM during TRACER-AQ with TROPOMI & SCOAPE-I, followed by TEMPO validation to ensure accuracy of TEMPO data.
Outcome	NASA will provide BOEM a Standard Operating Procedure for use of OMI/TROPOMI and TEMPO data in their management of air quality pollutants.
Context	Development measurements are provided by SCOAPE-I and TRACER-AQ measurements using OMI and TROPOMI with prototype over the GOM. All satellite data will also be available in the Pacific and Atlantic Regions.

BOEM Information Need(s): BOEM has no air quality (AQ) monitors over the waters in the Gulf of Mexico (GOM), Atlantic, and Pacific Regions, making it difficult to measure and track pollutants, which may impact the air quality of states. Two of BOEM's responsibilities under the Outer Continental Shelf Lands Act (OCSLA 1334(a)(8)) is to ensure activities authorized do not significantly impact the state's air quality compliance with the National Ambient Air Quality Standards (NAAQS) in the GOM and to draft National Environmental Policy Act (NEPA) documents in the Atlantic and Pacific Regions assessing impacts from our authorized activities. Using NASA's 2021 TRACER-AQ field measurements and the TEMPO (Tropospheric Emissions: Monitoring of Pollution) satellite mission's hourly, high resolution pollutant data offshore, will allow BOEM to better manage air quality from energy resources, including oil and gas, renewables, and sand/gravel projects. This study will build on the previous NASA's Satellite

Coastal Oceanic and Atmospheric Pollution Experiment (SCOAPE) in 2019 in the GOM (Thompson 2020). In addition, this SCOAPE-II campaign includes two NASA IAAs: NT-22-02 is the vessel measurement (this profile) and NT-23-02 is the aircraft measurement tasks.

Background: A past IAA between BOEM and NASA's Goddard Space Flight Center successfully addressed two questions:

1. Can satellite data be used to inform BOEM about AQ over the OCS (Outer Continental Shelf)?
Yes, NASA provided examples of pollutants over GOM, including TROPOMI satellite NO_2 .
2. How accurate are the NO_2 satellite data over the GOM and Atlantic Regions? TROPOMI Total Column (TC) NO_2 satellite data agreed with both coastal and shipboard Pandora spectrometers that provided independent ground-truth. Under clean air conditions, satellite-Pandora agreement was 2-3%; for more polluted conditions, agreement was 15-20%.

Objectives: The objectives of this IAA order are to gather offshore air pollutant measurements via airflights, cruises, and other methodology for validation of satellite data and emissions inventories, which will improve impact assessments, and to develop Standard Operating Procedures (SOPs) using satellite data for BOEM's air quality management from its authorized sources.

Methods:

1. The NO_2 impact of offshore oil and natural gas emissions was studied in TRACER-AQ. Because the current GV aircraft sampling in the TRACER-AQ study does not extend to the central GOM, NASA augmented the 2021 TRACER-AQ field measurements with several offshore flights under NT-23-02 (Figure 1).



Figure 1. GV aircraft flight plan (yellow lines) over the GOM during TRACER-AQ to measure TROPIC NO_2 with GCAS, and ozone and aerosol profiles with HSRL2.

2. Prepare for TEMPO by developing a Standard Operating Procedure (SOP) for BOEM air subject matter experts to use for air management using OMI/TROPOMI satellite TROPIC NO₂ routinely over GOM OCS (publicly available data), then extending to Atlantic and Pacific coasts.
3. Post-TEMPO launch. Conduct a SCOAPE-II in central GOM, revisiting SCOAPE-I region with a dedicated oceanographic cruise during NASA aircraft operations to be conducted, as TRACER-AQ with GV and GCAS, possibly other platforms, e.g., NASA's P-3B aircraft?
4. Add TEMPO sampling SOP for BOEM to TROPOMI SOP to monitor future air quality impacts of ONG.

Specific Research Question(s):

1. Although SCOAPE-I gave a snapshot of OCS AQ in May 2019, what is the distribution of TC NO₂ and tropospheric column (TROPIC) NO₂ over the GOM year-round? NASA will develop a climatology for BOEM that discriminates land and ONG sources using TROPOMI and TEMPO satellite data.
2. How do TROPOMI and Pandora TC NO₂ measurements during NASA's 2021 TRACER-AQ aircraft and ground campaign in the Houston area and western GOM compare to SCOAPE-I measurements? BOEM will derive the answer from NASA's Gulfstream V (GV) aircraft operating a TROPIC NO₂ instrument "GCAS" (GEOstationary Coastal and Air Pollution Events (GEO-CAPE) Airborne Simulator) during TRACER-AQ over ONG platforms near Houston and Galveston. GCAS will also evaluate TROPOMI and fly over a Pandora and in-situ NO₂ analyzer network operating in TRACER-AQ. A second remote sensor on the GV, the UV-Differential Absorption Lidar (UV-DIAL) will provide vertical profiles of ozone and aerosols to track plumes that are transported downwind from emissions sources.
3. How can SCOAPE-I and TRACER-AQ be linked when they are not in the same part of GOM? BOEM will support collection of NASA's GCAS TROPIC NO₂ and UV-DIAL data over the central GOM (off Louisiana) by augmenting NASA/LaRC B200 flights, re-sampling the SCOAPE-I region, thus connecting SCOAPE-I measurements to TRACER-AQ. This requires Pandora(s) along the Louisiana coast to further connect TRACER-AQ and SCOAPE-I and to prepare for the hourly air quality measurements from TEMPO.

Current Status: Post award meeting was held on November 9, 2022 (Task 1). A draft OMI/TROPOMI SOP was prepared (Task 3). There are two NASA IAAs for the SCOAPE-II effort (NT-22-02 is the vessel measurements and NT-23-02 is the aircraft measurements), so several coordination meetings were held between all the NASA centers (Goddard, Johnson Space Center, Jet Propulsion Lab, and Langley) before the campaign. In June 2024, the SCOAPE-II campaign was conducted in the GOM including the use of the Research Vessel Point Sur for air measurements and the AVIRIS-3 methane instrument via B200 aircraft (Task 4). All instruments performed exceptionally well. In June 2024, the GCAS instrument measured NO₂ over the GOM under IAA NT-23-02. All data is being archived on NASA's website.

Publications Completed:

Fedkin NM, Stauffer RM, Thompson AM, Kollonige DE, Wecht HD, Elguindi N. 2024. Satellite NO₂ trends and hotspots over offshore oil and gas operations in the Gulf of Mexico. *Earth and Space Science*. 11:e2023EA003165. <https://doi.org/10.1029/2023EA003165>

Thompson AM, Kollonige DE, Stauffer RM, Abuhassan N, Kotsakis AE, Swap RJ, Wecht HD. 2020. Satellite and shipboard views of air quality along the Louisiana coast: The 2019 SCOAPE (Satellite Coastal and Oceanic Atmospheric Pollution Experiment) cruise. EM Magazine (Air and Waste Management Assn). Oct 2020.

Thompson AM, Kollonige DE, Stauffer RM, Kotsakis AE, Abuhassan N, Lamsal LN, Swap RJ, Blake DR, Townsend-Small A, Wecht HD. 2023. Two air quality regimes in total column NO₂ over the Gulf of Mexico in May 2019: Shipboard and satellite views. Earth and Space Science. 10:e2022EA002473. <https://doi.org/10.1029/2022EA002473>

Affiliated WWW Sites:

TRACER-AQ Mission Page: <https://www-air.larc.nasa.gov/missions/tracer-aq/index.html>

SCOAPE and SCOAPE-II Mission Page: <https://www-air.larc.nasa.gov/missions/scoape/index.html>

NASA SCOAPE Technical Report: <https://ntrs.nasa.gov/citations/20205008618>

BOEM OCS Study 2019-072: https://espis.boem.gov/final%20reports/BOEM_2019-072.pdf

References:

Thompson AM. 2020. Evaluation of NASA's remote-sensing capabilities in coastal environments. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 33 p. Report No.: OCS Study BOEM 2020-047.