

# Satellite Coastal & Oceanic Atmospheric Pollution Experiment (SCOAPE): A Feasibility Study on Using Satellite-based Data for Offshore Air Quality Monitoring

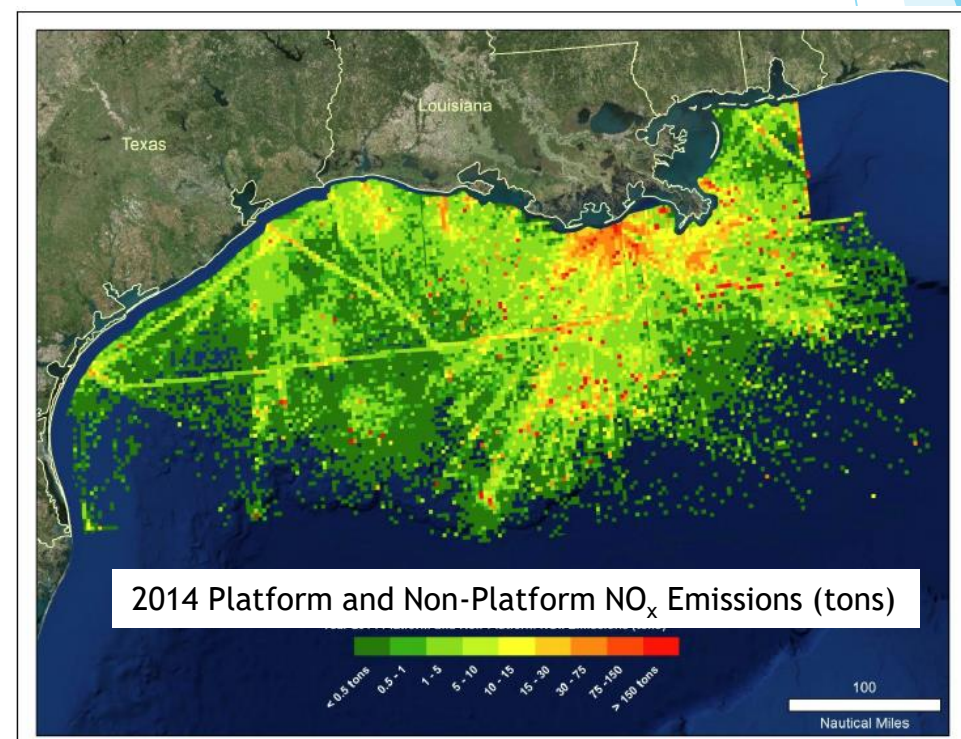
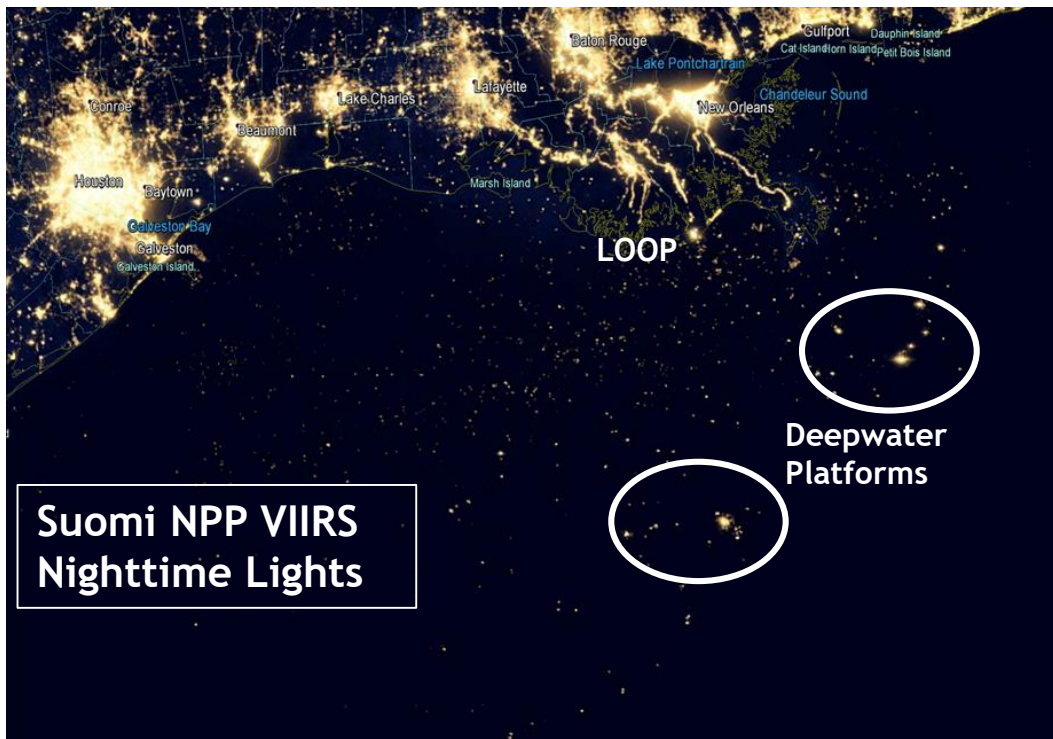
**NASA/GSFC:** Bryan Duncan (PI), Anne Thompson (Cruise Chief Scientist), and Debra Kollonige (Project Manager)

**BOEM:** Holli Ensz (Contract Office Representative ), Walter Johnson (Chief, Branch of Physical and Chemical Sciences)

**BSEE:** Joanne Murphy

# SCOAPE MISSION: NASA GSFC in Support of BOEM

- ▶ The Outer Continental Shelf Lands Act (OCSLA) requires BOEM to ensure OCS oil and natural gas (ONG) exploration, development, & production do not significantly impact the air quality (AQ) of any state.
- ▶ NASA GSFC, supported by BOEM, are evaluating the potential for using satellite data to monitor offshore AQ with a focus on Gulf of Mexico (GOM), where BOEM has AQ jurisdiction and expects ONG lease expansion through 2022.

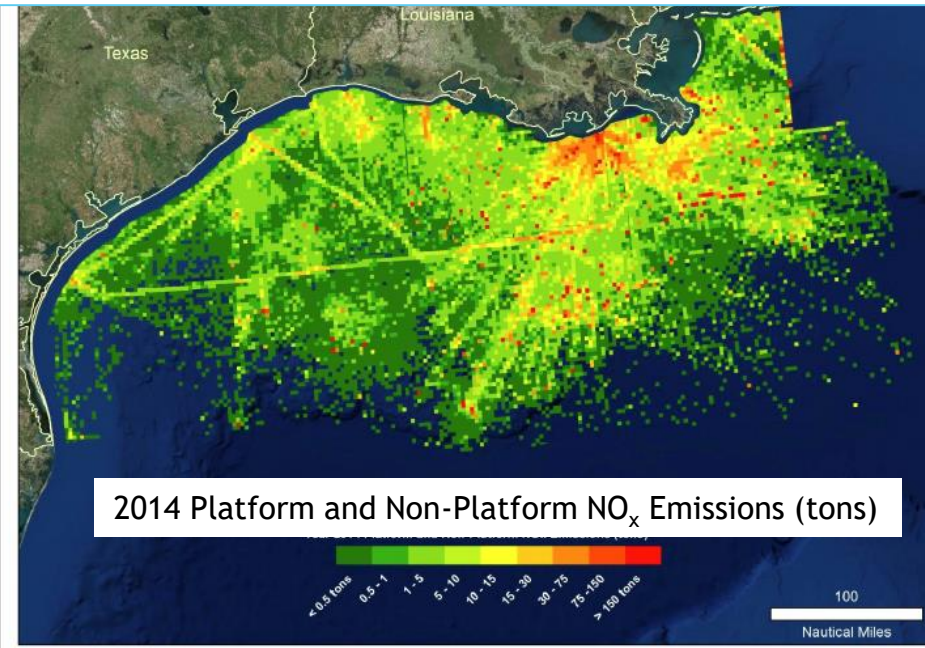
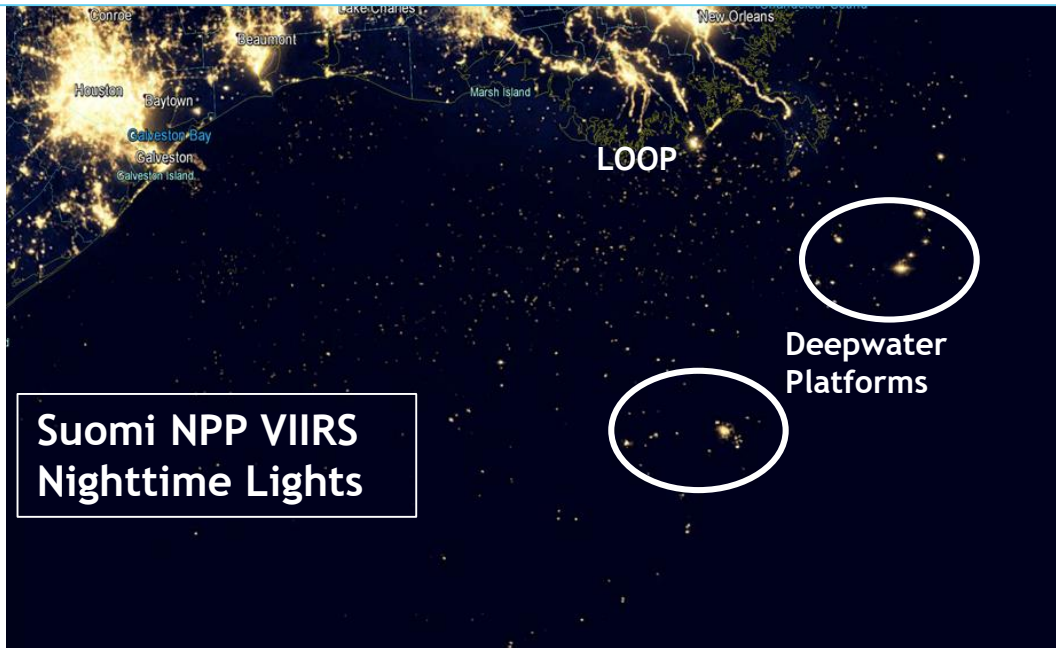


Left: Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) 2012 Earth at Night from <https://worldview.earthdata.nasa.gov/>. Right: Cover image from BOEM OCS Study 2017-044. GOM Platform and Non-Platform NO<sub>x</sub> emissions in 2014.

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## Scientific Goal: Can BOEM use satellite products to monitor offshore emissions?

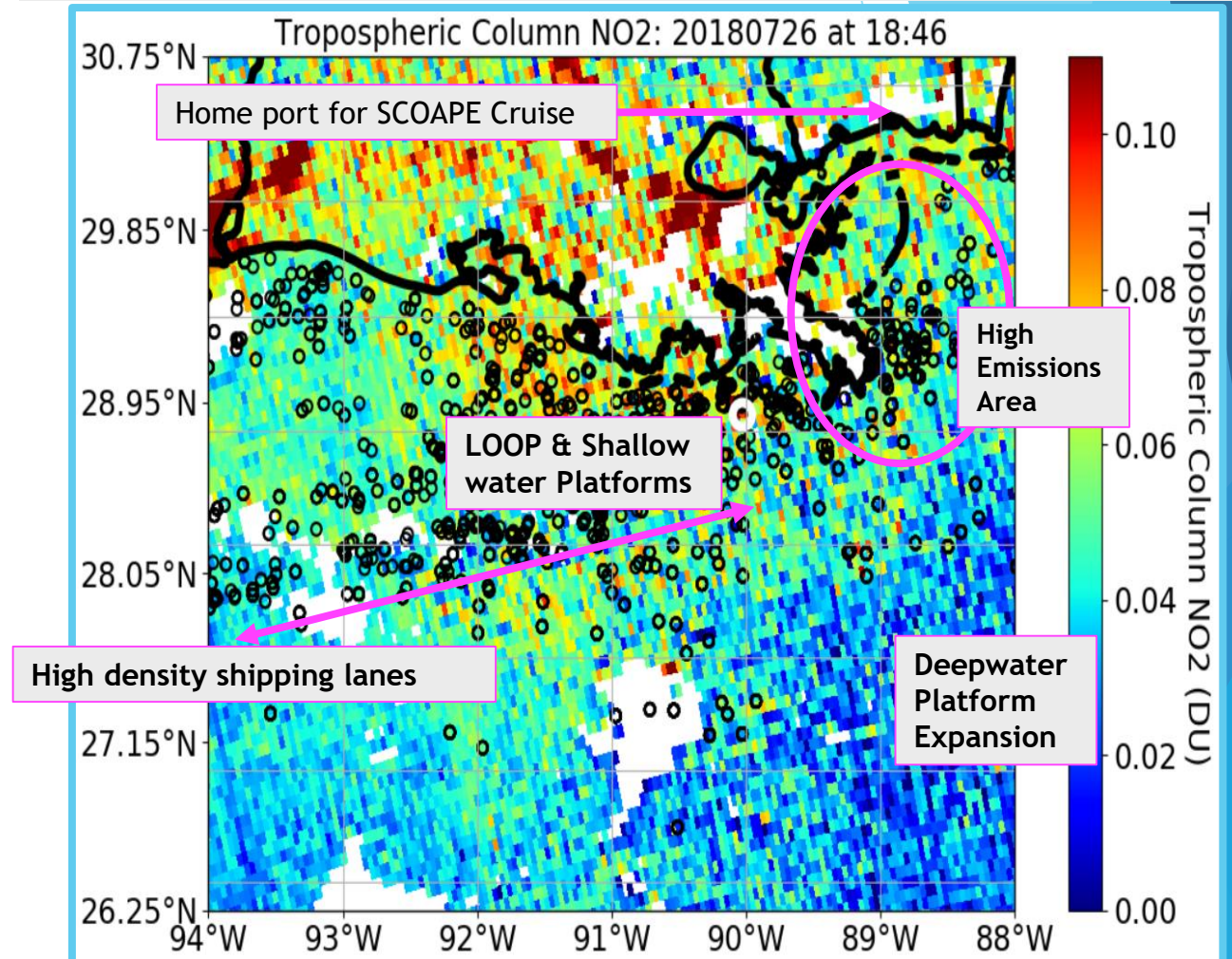


Left: Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) 2012 Earth at Night from <https://worldview.earthdata.nasa.gov/>.  
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# WHAT is SCOAPE?: Two-Phase Project & Deliverables

- ▶ (1) Feasibility report on use of satellite data over ONG activity & coastal environments:
  - ▶ Evaluate satellite  $\text{NO}_2$  in recent coastal campaigns.
  - ▶ Observations of pollutants & their spatial gradients around GOM (with a focus on OMI & TROPOMI products).
- ▶ (2) Conduct GOM shipboard feasibility survey, **SCOAPE Cruise**, with remote and in-situ sensors to validate satellite  $\text{NO}_2$  and other products.

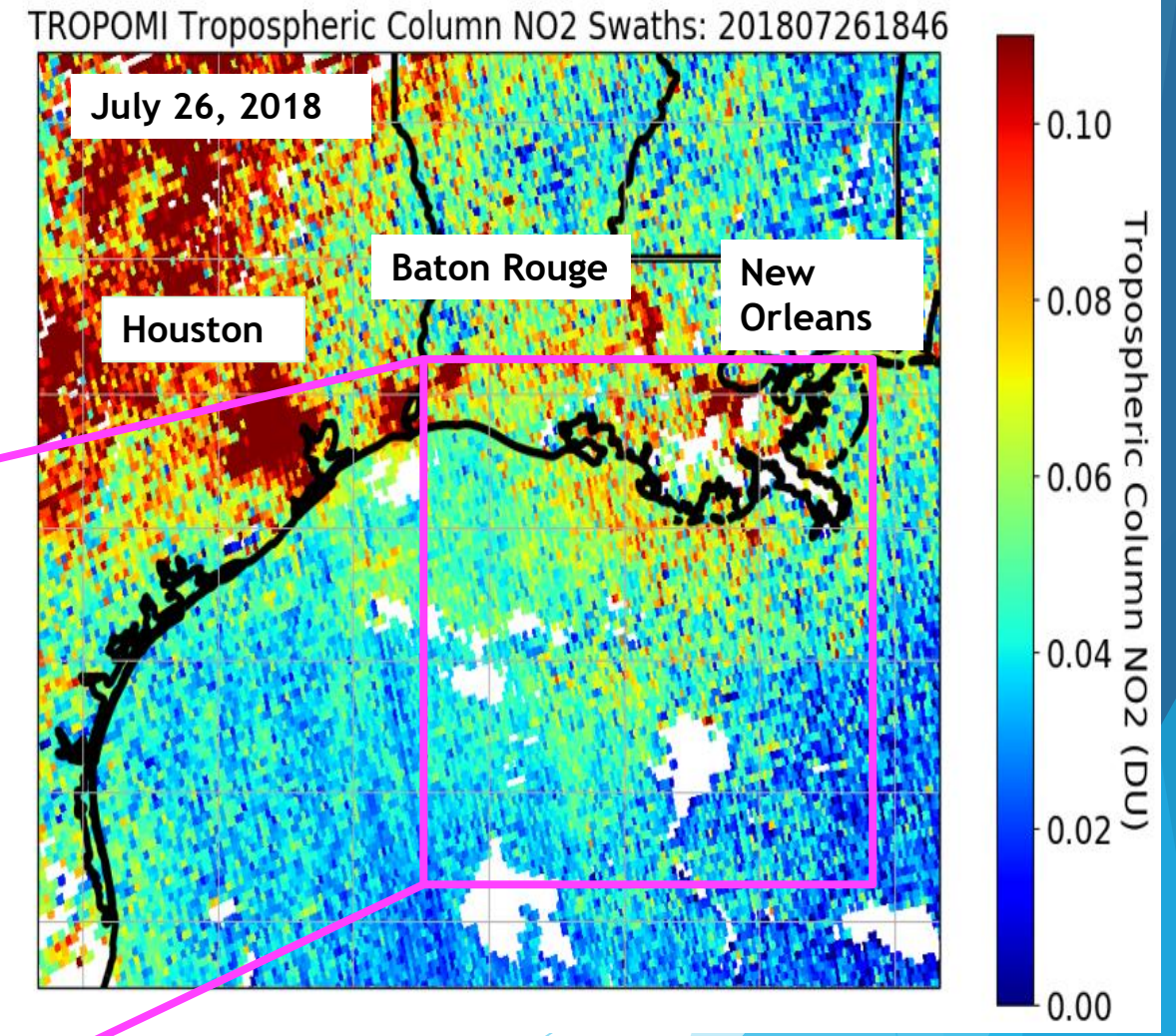
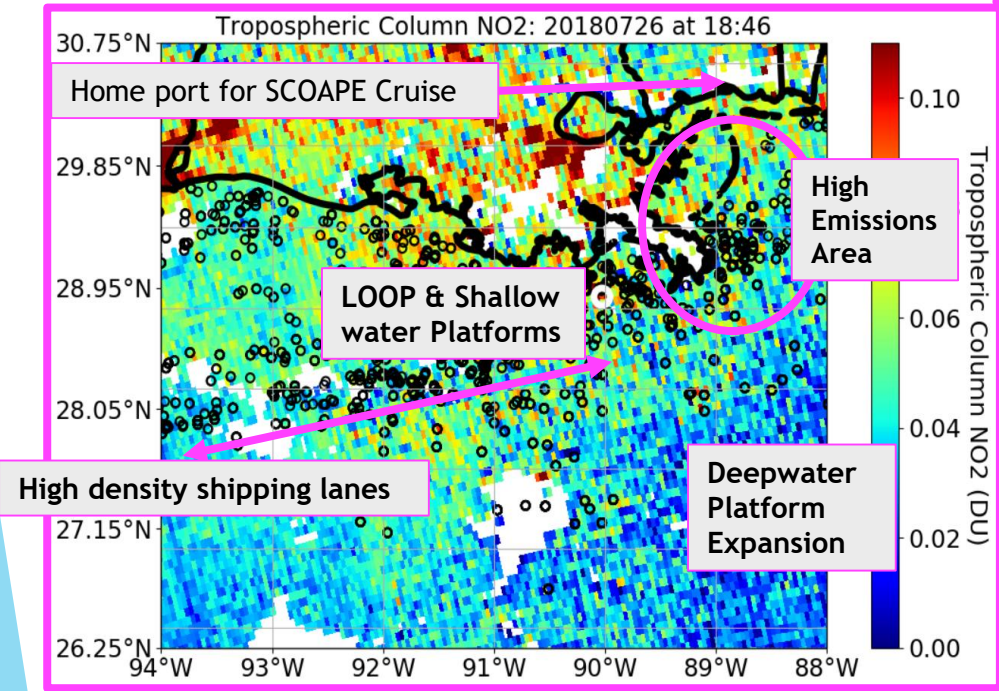
## TROPospheric Monitoring Instrument (TROPOMI) View



Above: TROPOMI  $\text{NO}_2$  on July 26 2018 w/ BOEM  $\text{NO}_x$ -emitting platforms (black circles). Image courtesy of A. Kaltenbaugh.

# Phase #1: Satellite Observations over Coasts & ONG Activity

- Copernicus **TROPOspheric Monitoring Instrument (TROPOMI)**, launched in Fall 2017 by ESA & NSO with *1x/day* 3.5 x 7 km<sup>2</sup> coverage for NO<sub>2</sub>.
- High spatial resolution of TROPOMI b/w land-water interface is very promising for SCOAPE Objectives.
- **Below:** TROPOMI NO<sub>2</sub> w/ BOEM NO<sub>x</sub>-emitting platforms (black circles).



**Above:** TROPOMI NO<sub>2</sub> data from 26 July 2018 over GOM (White represents cloud cover). Image Courtesy of A. Kaltenbaugh.

## Phase #2: SCOAPE Validation Cruise in GOM

- ▶ R/V Point Sur (USM-owned, LUMCON-operated) will sail 10-18 May 2019 (9 days) for onshore flow & to maximize satellite view (need clear skies).
- ▶ Supersite of land measurements @ LUMCON to capture land-water gradients.
- ▶ Coastal deployment of two Pandoras, one @ LUMCON, one site TBD (more urban).
- ▶ Using BOEM Emissions estimates (2014 & 2017) & TROPOMI for guidance.
- ▶ **Goals:** (1) Capture regions where maximum & minimum NO<sub>2</sub> (plus CO, VOCs, SO<sub>2</sub>, CH<sub>4</sub>) expected. (2) Validate gradients.
- ▶ For QA/QC, instruments are being tested & vetted at NASA GSFC, including Pandora spectrometers for NO<sub>2</sub>.



Species	Instrument	Collaborator
NO <sub>2</sub> (and calibrator)	In situ	NASA GSFC
Column NO <sub>2</sub>	Pandora	NASA GSFC (Swap)
O <sub>3</sub>	In situ	NASA GSFC
	Ozonesondes	NASA GSFC
Temperature, RH, etc.	Met system	NASA GSFC
Aerosol (AOD) & O <sub>3</sub> columns	Microtops Columns	NASA GSFC
VOCs (plus CH <sub>4</sub> )	In-situ flasks	UCI (Blake)
CO	In-situ	NASA GSFC
HCHO	In-situ	NASA GSFC (Hanisco)
PBL height	Ceillometer	UMBC

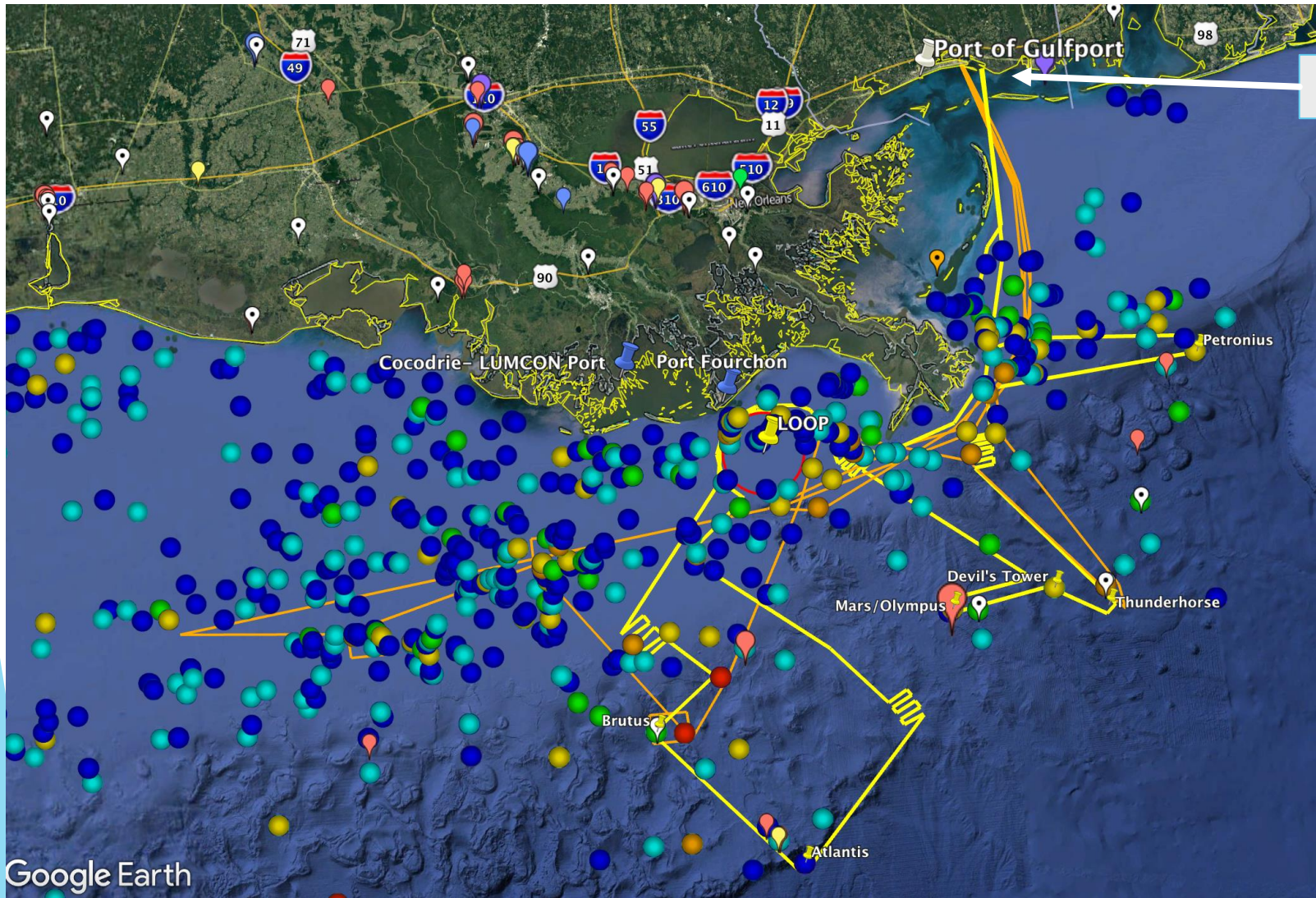
# Phase #2: SCOAPE Land Measurements During Cruise

- ▶ LUMCON site instrumentation:
  - ▶ NO<sub>2</sub>: In-situ analyzer, Pandora, NO<sub>2</sub> sondes (drone option)
  - ▶ Ceilometer for boundary layer heights
  - ▶ Ozone monitor, VOC canisters
- ▶ Urban location (TBD) Instrumentation:
  - ▶ NO<sub>2</sub>: Analyzer & Pandora
  - ▶ Other TBD: Ozone, CO desirable



# SCOAPE Cruise Strategy: Strawman Targets for Sampling

- Using BOEM 2014 & 2017 Preliminary Platform Emissions for Guidance.
- Based on VIIRS satellite flaring product, there are deepwater platforms that are observed frequently.
- How much time should be spent near **Shallow vs deepwater platforms?**

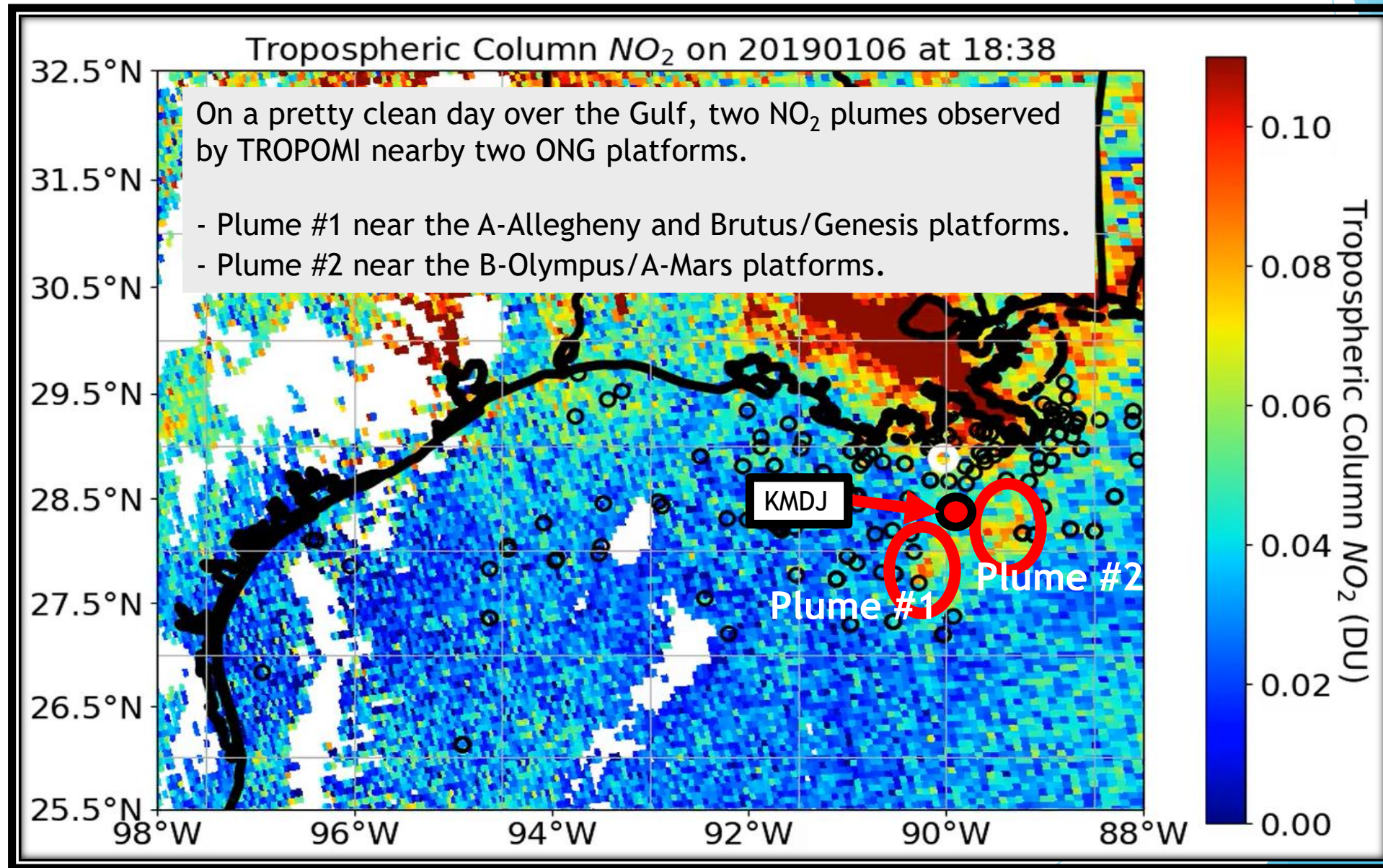


Home port for USM R/V Point Sur

- Google map: Filled circles ranging from low (blue) to high (red) NOx emissions for May from 2014 BOEM Database for platform sources.
- Areas to target during sampling days:
  - Shallow platforms
  - Deepwater platforms
  - Clean background
  - LOOP
  - Shipping lanes

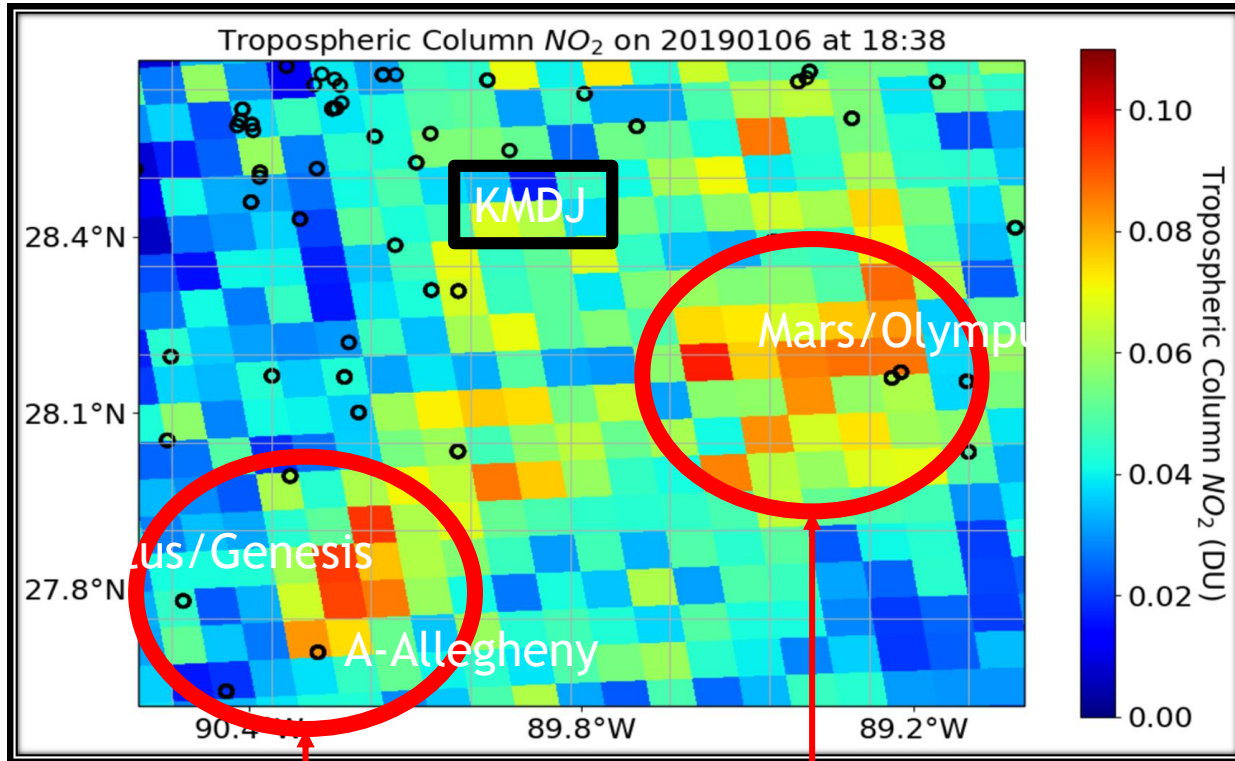


# Example of TROPOMI Observing Pollution Plume: January 2019



Data credit: Copernicus Sentinel data processed by ESA & KNMI (2018), Sentinel-5P TROPOMI, Accessed from GES DISC in February 2019, <https://doi.org/10.5270/S5P-s4ljg54>.

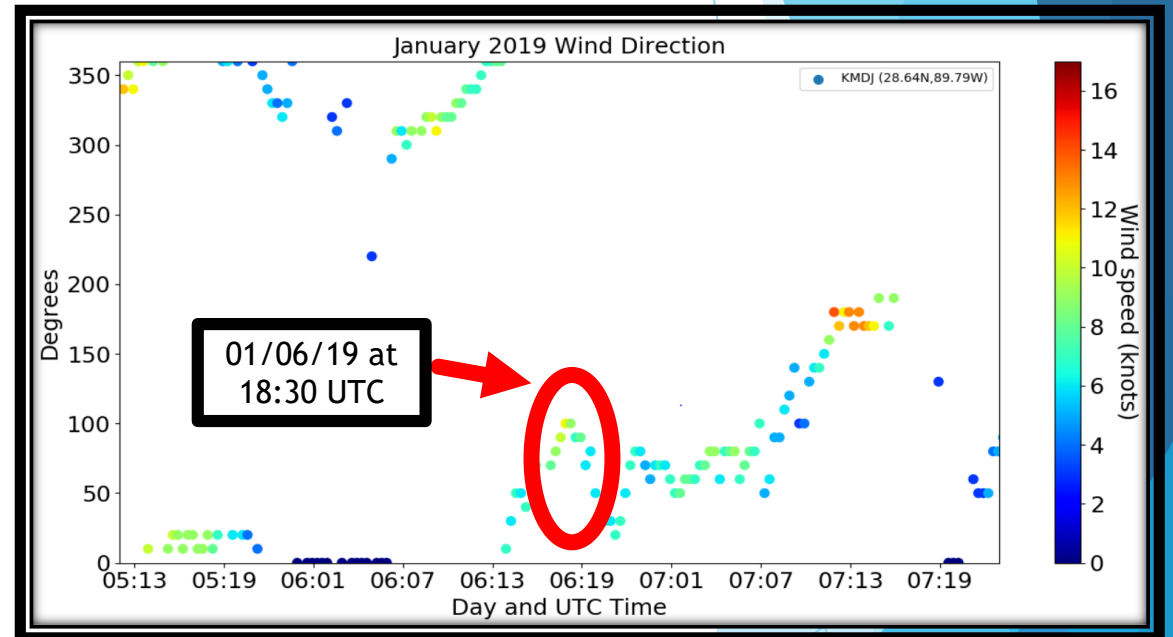
# TROPOMI NO<sub>2</sub>: Closer Looks on Jan 6, 2019



Plume #1

Plume #2

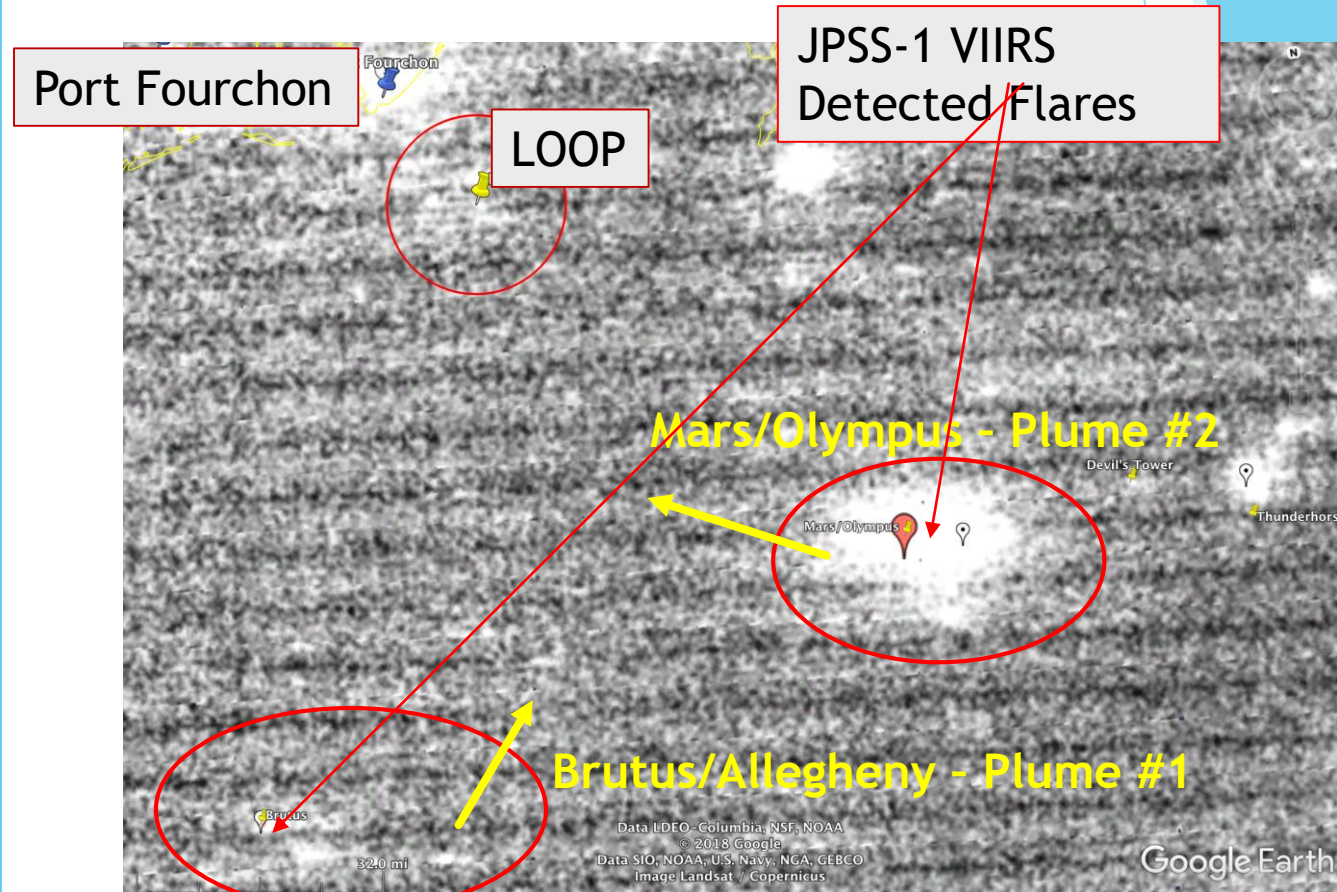
From location North of both platforms (KMDJ):  
Winds indicate southerly direction, which is inline with Plume #1 flow (at left).



# JPSS-1 Visible Infrared Imaging Radiometer Suite (VIIRS) Flare Detection in GOM

- On the Jan 5, 2019: Large hot flare detected by VIIRS Nightfire V3.0 (GRAVITE) product (from JPSS-1) at *Olympus/Mars platforms*.
- On Jan 6, 2019: VIIRS (same product) detected dim combustion sources at both *Olympus/Mars & Brutus/Genesis platforms*.
- These flaring events appear to be near sources of two NO<sub>2</sub> plumes detected by TROPOMI on Jan 6, 2019.
- Based on BOEM's 2014 (shown at right) & 2017 (preliminary) Emissions Inventories, these platforms are amongst the top-emitters of NO<sub>x</sub> (and other species) in GOM.

VIIRS Detected Flares from JPSS-1 & Day-Night Band from Suomi NPP



# WHO: NASA & BOEM Personnel on SCOAPE



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**SCOAPE Prin. Investigator**

**Dr. Anne Thompson - NASA**  
**Chief Scientist, SCOAPE Cruise**  
Adjunct Prof., PSU & UMCP AOSC



**Dr. Ryan Stauffer (NASA )**



**Holli Ensz (BOEM)**



**Nader Abuhassan (NASA)**



**Natasha Dacic (NASA)**

Others TBD:  
BOEM  
UMBC?

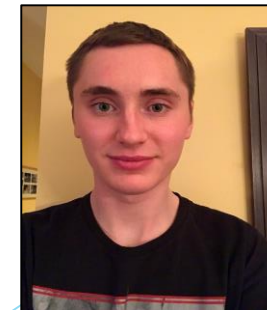
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**D. Kollonige, Lead**



**Dr. Lok Lamsal**  
NO<sub>2</sub> Satellite products



**Dr. Debra Kollonige**  
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