Greenhouse Gas Observations from the Arctic Observing Mission (AOM)

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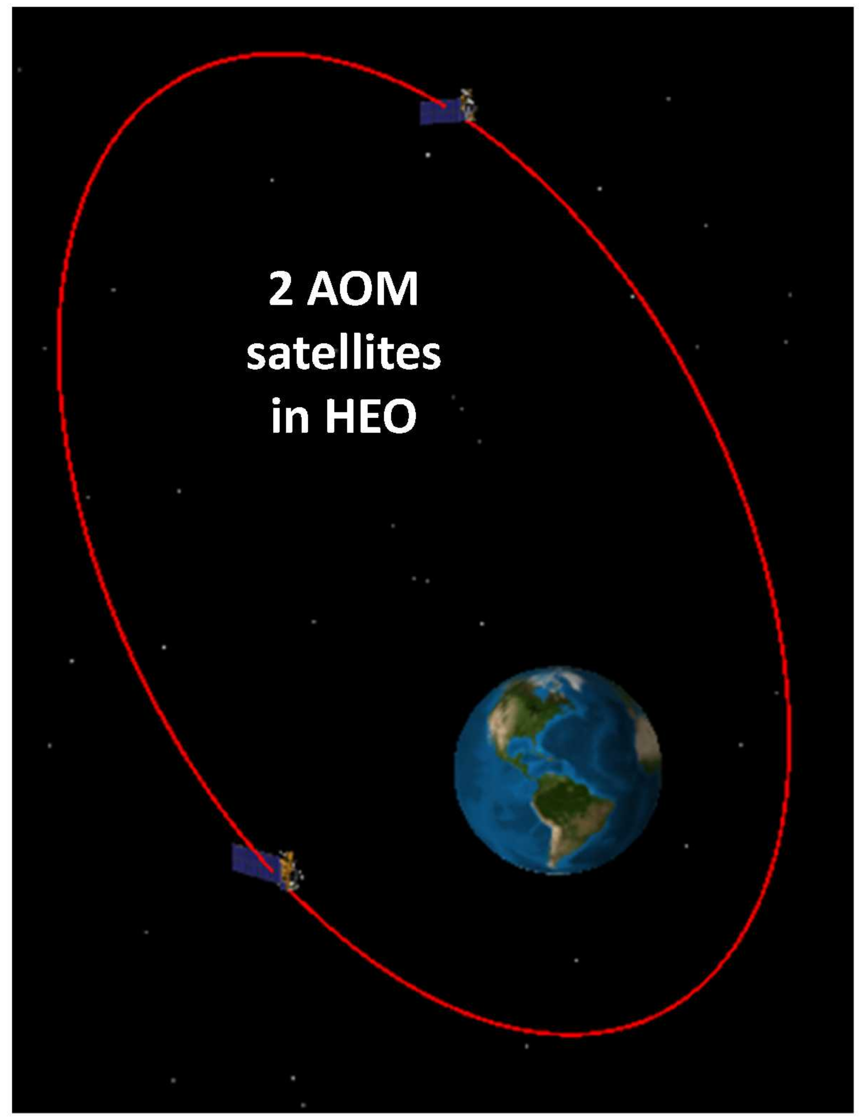
Available for Discussion:
July 12, 1:00-2:00 UTC
July 13, 1:00-2:00 UTC
July 14, 1:00-2:00 UTC

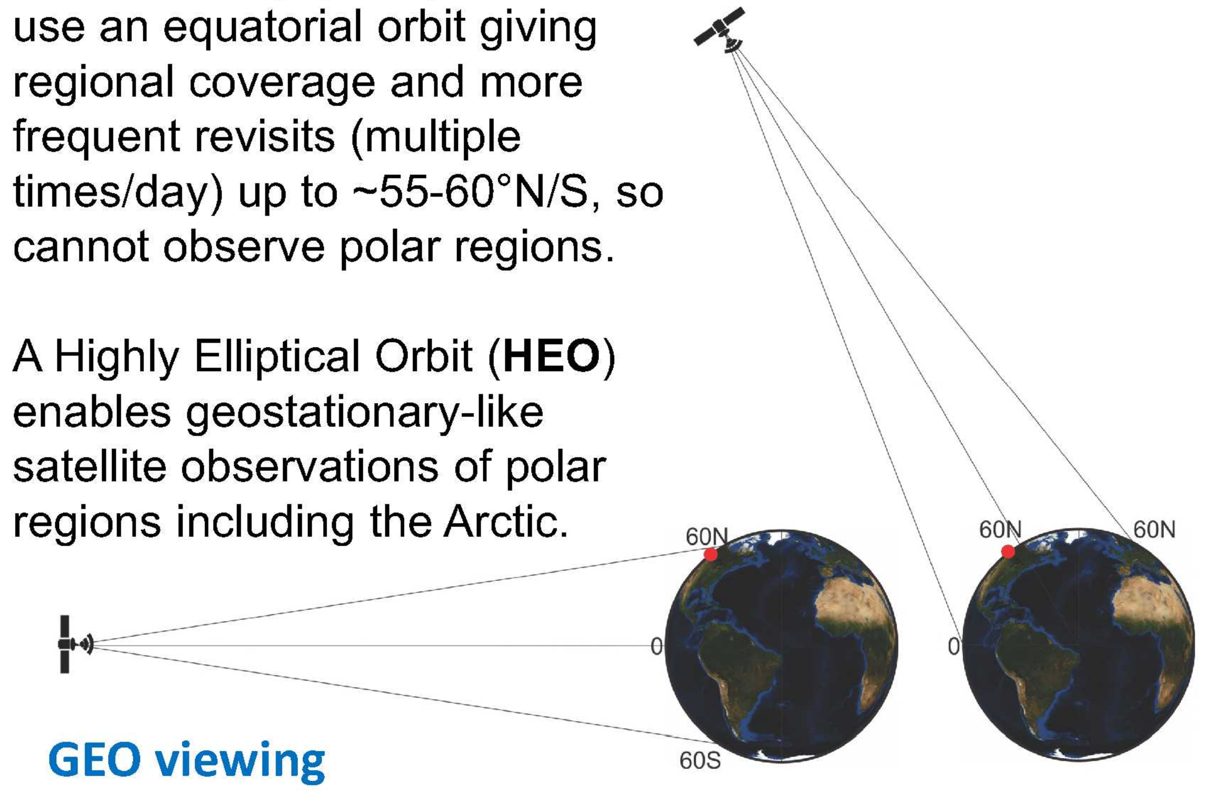
What is the Arctic Observing Mission (AOM)?

- AOM is a proposed mission consisting of 2 satellites in a highly elliptical orbit (HEO) to provide observations of unprecedented frequency and density for greenhouse gases (GHGs), air quality (AQ), meteorology and space weather over northern regions: ~45-90°N.
- AOM is in undergoing a pre-formulation study (Phase 0), jointly led by the Canadian Space Agency (CSA) and Environment and Climate Change Canada (ECCC).
- Discussions are ongoing with some international agencies (NOAA, NASA, EUMETSAT, ESA and others) about potential partnership in AOM, which will be vital to the mission.



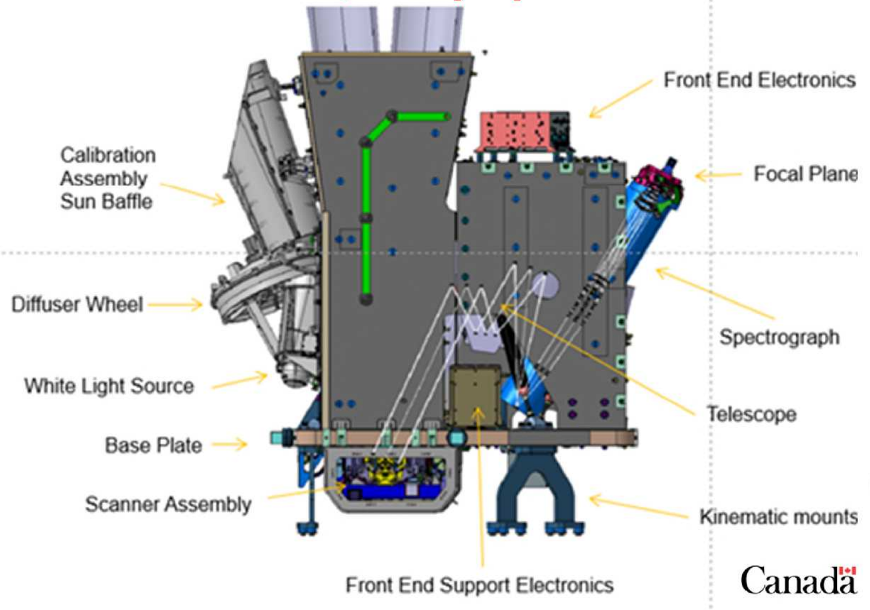
- Low Earth Orbit (**LEO**) satellites observe globally, but with infrequent revisits.
- Geostationary (**GEO**) satellites use an equatorial orbit giving regional coverage and more frequent revisits (multiple times/day) up to ~55-60°N/S, so cannot observe polar regions.
- A Highly Elliptical Orbit (**HEO**) enables geostationary-like satellite observations of polar regions including the Arctic.

HEO gives better view angles for high latitudes



Proposed AOM Instruments

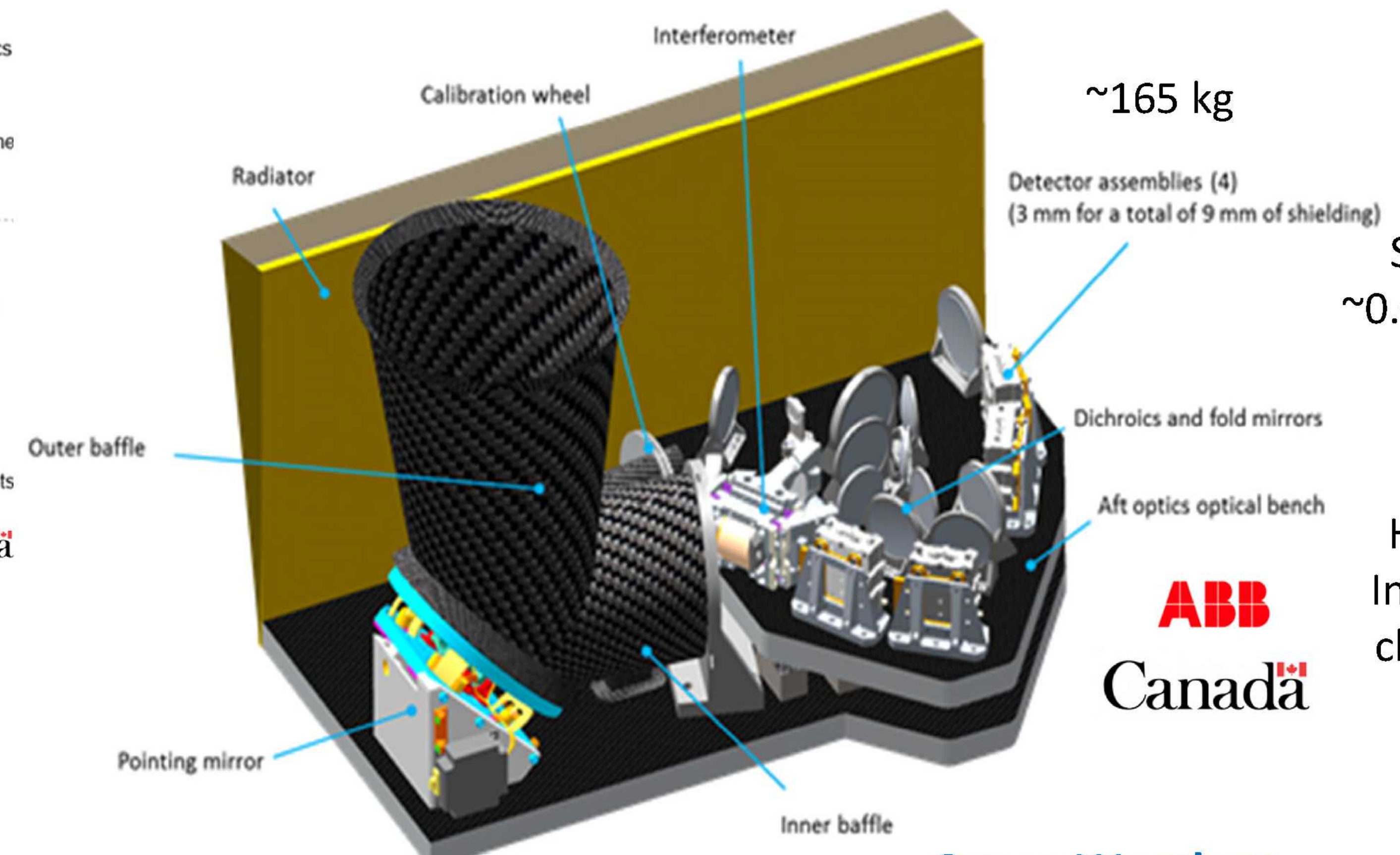
UV-Vis Air Quality Spectrometer



Meteorological Imager

Advanced Baseline Imager (ABI)
~350 kg, 16 channels

NIR-SWIR GHG Imaging Fourier Transform Spectrometer (IFTS)



~165 kg

ABB
Canada

IFTS Bands:
0.76, 1.61, 2.06, 2.34 μm

Spectral sampling (0.25 cm^{-1}):
~0.017, ~0.078, ~0.127, ~0.167 nm

Pixels: ~4x4 km^2

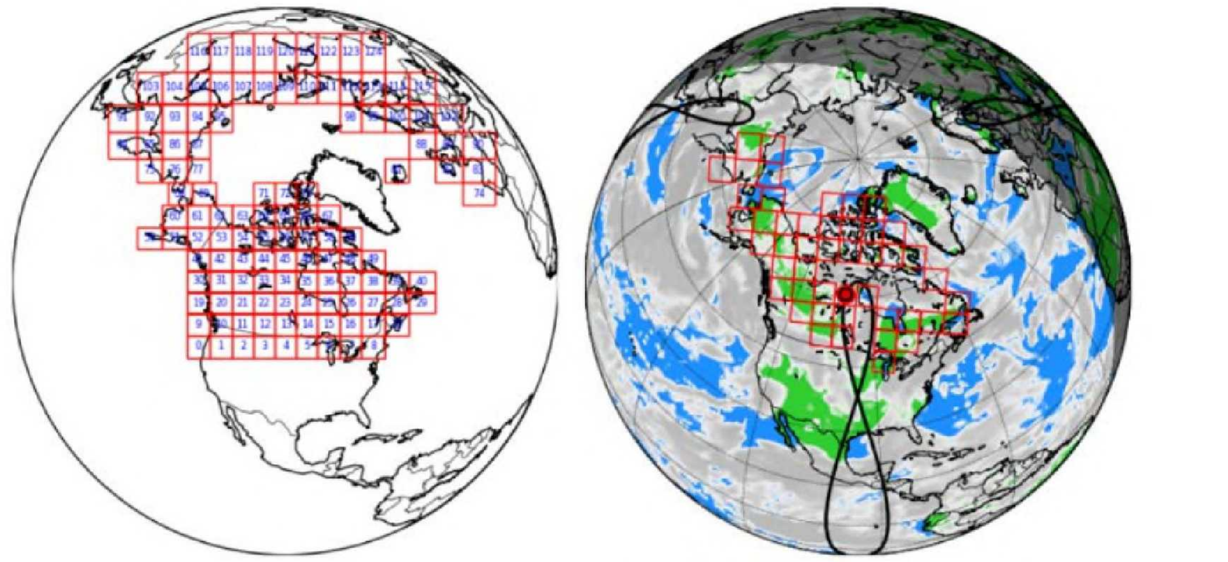
Hourly CO_2, CH_4, CO and Solar Induced Fluorescence (SIF) over cloud-free, Arctic & Boreal land during daylight

Space Weather:
In situ instruments and UV Auroral Imaging

Greenhouse Gas Observing Strategy and Applications

- The Near Infrared (NIR) - Shortwave Infrared (SWIR) GHG Imaging Fourier Transform Spectrometer (IFTS) can simultaneously image 2 spatial dimensions (128x128 pixels) with "step-&-stare" approach.
- Intelligent Pointing: Cloud data from the met imager will inform the GHG instrument pointing strategy to spend time pointing at the least cloudy areas, greatly increasing the yield of cloud-free observations.
- Expected retrieval precision (forest albedo, SZA=45°, low aerosol):

XCO_2	XCH_4	XCO
0.42%	0.62%	8.6%

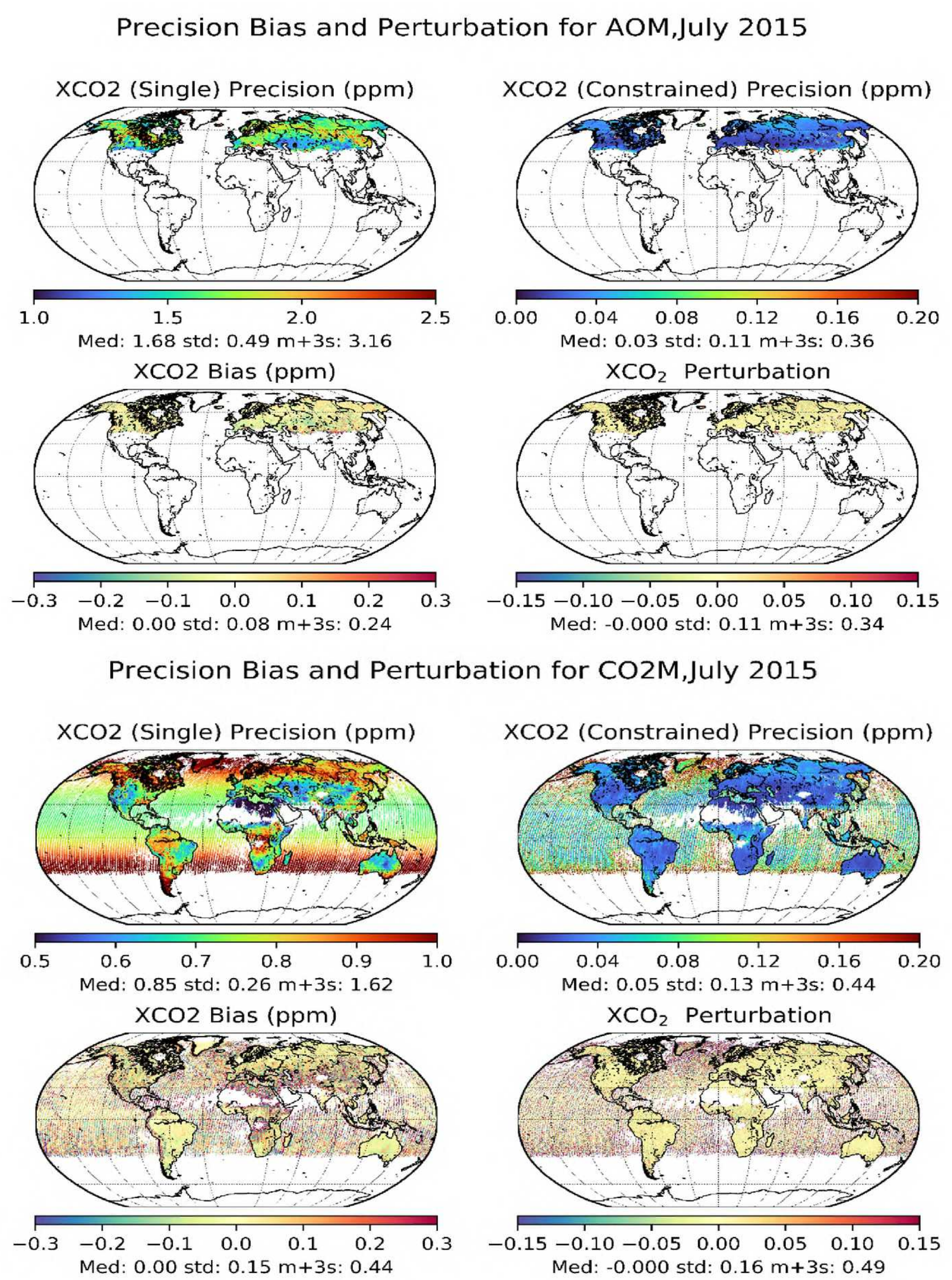


Left: Red boxes show 125 possible positions for 128x128 ~4x4 km^2 pixel field-of-view (FOV) from apogee at 95°W, accounting for pixel growth with larger viewing angles.
Right: Example AOM GHG FOV locations in a ~60-min period based on cloud coverage (NASA MERRA2 0.5°x0.67° cloud fractions >0.1), solar illumination and viewing angles. Satellite position (red circle) and orbit tracks (black lines) also shown.

Applications

Measurements of XCO_2 and XCH_4 for quantification of natural and anthropogenic CO_2 and CH_4 fluxes from forests, wetlands, permafrost, landfills, urban areas, large facilities, oil sands and other resource extraction. XCO for wildfire and anthropogenic emissions quantification. SIF provides information on start, end and intensity of growing season and vegetation productivity and stress.

CO_2 Observing System Simulation Experiment (OSSE)

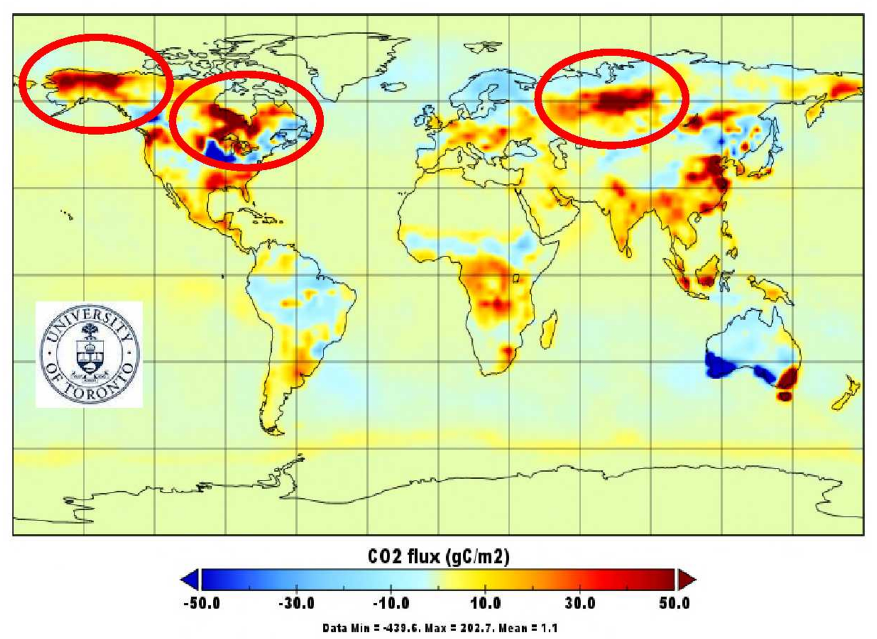


- Generated 18 months synthetic XCO_2 observations for 2 AOM satellites and 3 CO_2M satellites considering orbits, viewing strategies, instrument characteristics, geophysical factors and a 0.25° *nature run* with 0.9 PgC/yr permafrost CO_2 emissions.
- Assimilated each dataset in 2°x2.5° GEOS-Chem 4Dvar system to estimate 12 months of CO_2 surface fluxes in 14-day periods.
- Preliminary results show that AOM more easily detects the permafrost CO_2 emissions and more accurately quantifies northern high latitude biospheric CO_2 fluxes overall.

Left: Simulated AOM and CO_2M XCO_2 diagnostics.

Right: OSSE flux estimates from AOM for a 14-day period of late summer showing regions of permafrost CO_2 emission.

August 12-26



Status and Next Steps

- AOM Pre-formulation study (concluding in early 2024) will refine the mission concept and orbit, clarify roles of potential partners and provide cost estimates for implementation of a short list of mission configurations.
- A GHG IFTS will be tested in a sub-orbital environment using a stratospheric balloon to raise the instrument TRL (August 2022), with coincident ground-based validation (EM27/Suns) and possible aircraft validation.

- A funding request is planned for ~2025 and if successful, design and development will follow with the aim of a 2034 launch and ~10 years of operations.

Canada