



Greenhouse Gas Observations from the proposed Arctic Observing Mission (AOM)

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ARCTIC OBSERVING MISSION

Proposed Canadian-led international satellite mission to provide a better understanding of the effects of climate change in the North

Observations
north of $\sim 40-45^{\circ}\text{N}$

Extent of coverage

Two satellites in a highly
elliptical orbit

Continuous observations over
northern regions

METEOROLOGY

Support weather and
environmental predictions
for the North



GREENHOUSE GASES

Detect and monitor greenhouse
gas emissions from natural and
human activity



AIR QUALITY

Monitor air pollutant
emissions and improve air
quality forecasts



Canadian Space
Agency

Agence spatiale
canadienne



Environment and
Climate Change Canada

Environnement et
Changement climatique Canada



Natural Resources
Canada

Ressources naturelles
Canada

Canada

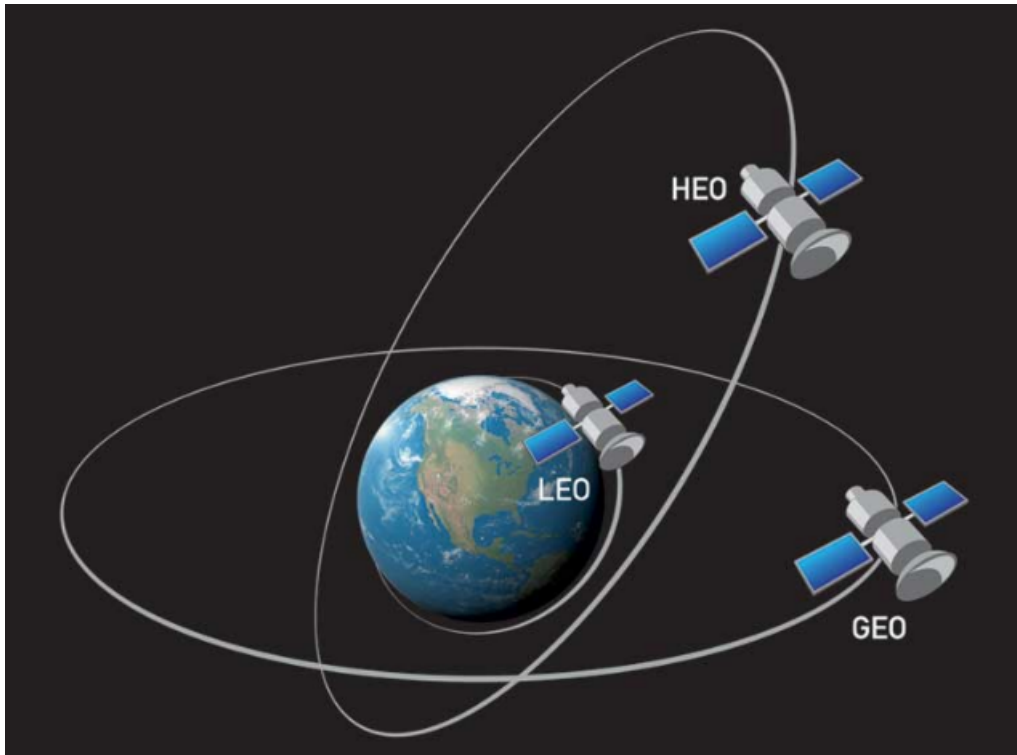


A CONSTELLATION ARCHITECTURE FOR MONITORING CARBON DIOXIDE AND METHANE FROM SPACE

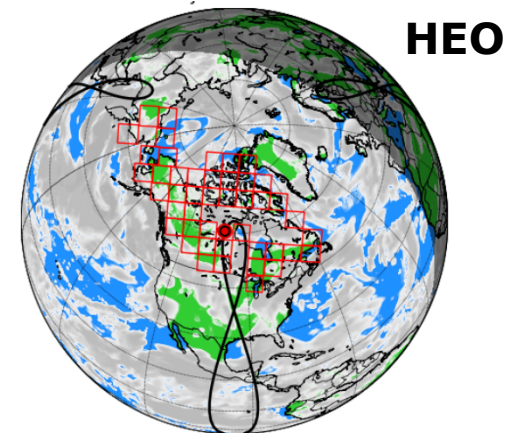
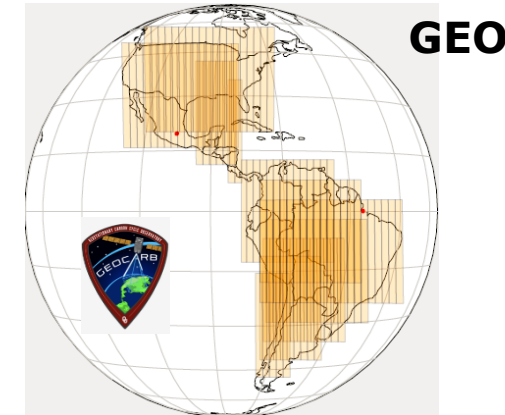
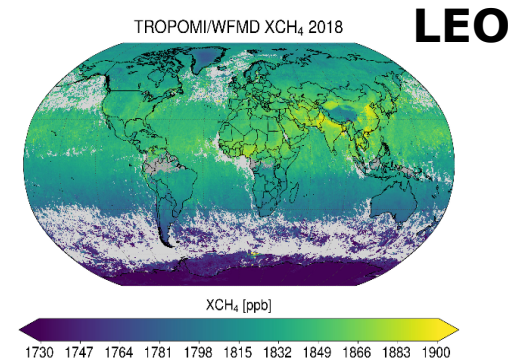
[Crisp et al. \(2018\) CEOS White Paper](#)

6.1 A CO₂/CH₄ constellation architecture with LEO, GEO and HEO elements

A constellation of CO₂/CH₄ satellites that fully exploits the assets of the LEO, GEO, and HEO vantage points will be needed to meet the demanding GCOS requirements for precision, accuracy, spatial and temporal resolution and coverage summarized in Table 6.1.



- **Low Earth Orbit (LEO):** Near polar-orbit, global sampling, but low temporal revisit rates
- **Geostationary Orbit (GEO):** Equatorial orbit, rapid revisit rates, but limited to ~60°S-60°N
- **Highly Elliptical Orbit (HEO):** Can be oriented to give quasi-geostationary observations over polar regions



CEOS-CGMS Roadmap, Issue #2 (2024) is the latest coordination effort to implement this vision.

Intelligent Pointing increases the fraction of cloud-free CO₂ and CH₄ observations from space

2023

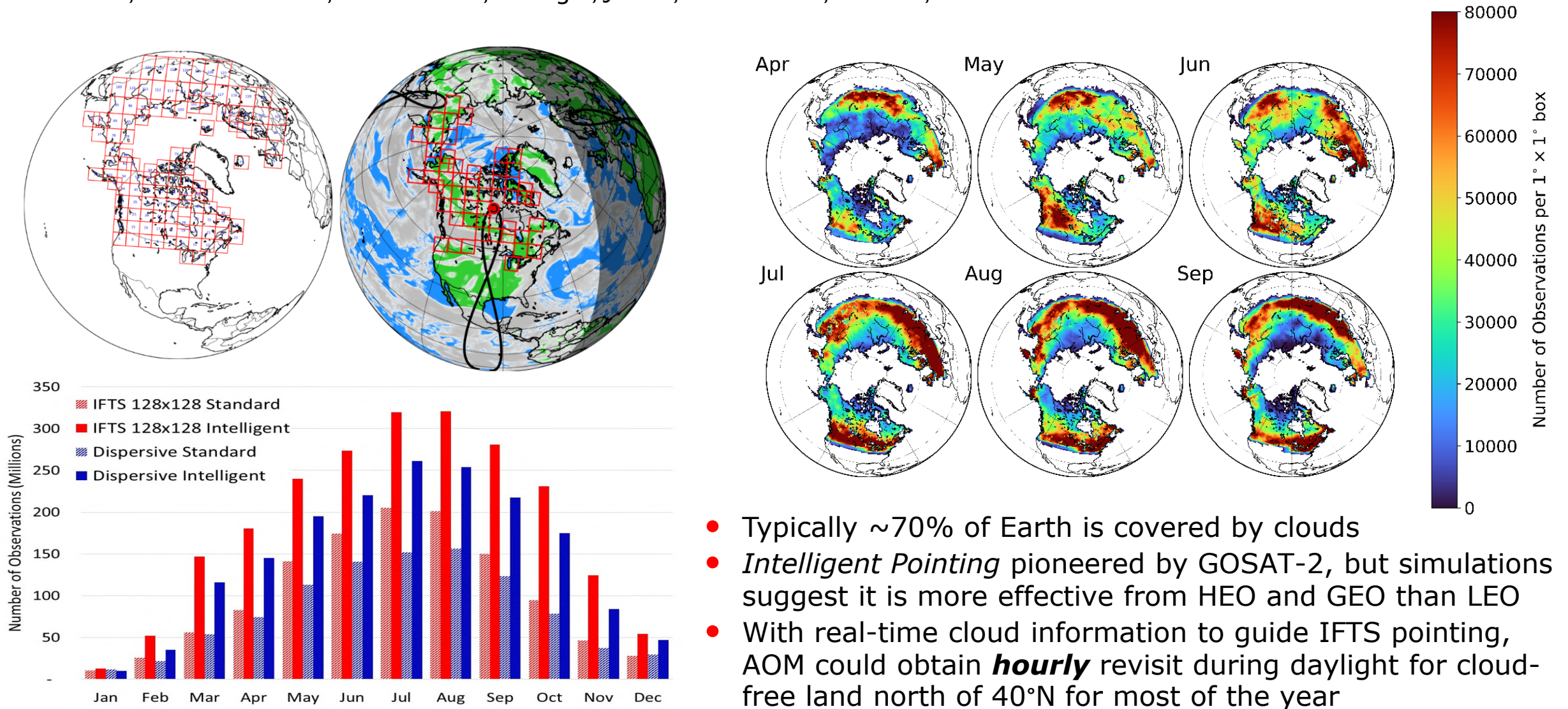


frontiers

Frontiers in Remote Sensing

R. Nassar, C.G. MacDonald, B. Kuwahara, A. Fogal, J. Issa, A. Girmenia, S. Khan, C. Sioris

<https://doi.org/10.3389/frsen.2023.1233803>



Canada's Strategy for Satellite Earth Observation

RESOURCEFUL
RESILIENT
READY

Canada's Strategy
for Satellite Earth
Observation



High-altitude balloon prior to launch.
Credit: ECCC-CSA

SATELLITE EO IN ACTION: Testing New Technology for Monitoring Greenhouse Gases from Space

Canadian industry leads the world in Fourier Transform Spectrometer (FTS) technology and is currently advancing it to better observe atmospheric gases from space. FTS enables satellite imaging of critical gases such as carbon dioxide (CO_2) and methane (CH_4) that are leading causes of climate change. The technology also supports the surveillance of other important greenhouse gas emissions from sources such as permafrost thaw and forest fires in a warming climate. Canada is targeting application of this new technology as part of future missions, particularly to monitor the Arctic more closely. In preparation, the GC, along with industry and academia, are working together to test prototypes using high-altitude balloons. These high-altitude balloon experiments allow scientists to test how the instrument operates in the cold, low-pressure environment of the stratosphere, a precursor to the instrument one day operating in space.

IFTS Balloon Demo Flight

- Imaging FTS CO_2 & CH_4 balloon measurements over boreal forest, launched from CSA-CNES facility (Timmins, ON) made August 22, 2022 to demonstrate IFTS technology for AOM
- Nadir viewing from 37 km altitude during 13-hour flight (daylight & night), with 4 h of adequate SZA
- 0.76 micron, filter wheel for 1.6 micron band options
- InGaAs detector observing 56x56 array of 8.5x8.5 m² pixels, 100 s integration time
- 2 Bruker EM27/Sun ground-based FTSs (Felix Vogel, ECCC) to validate the IFTS observations
- Demo was very informative on indirect observing factors that affect data quality

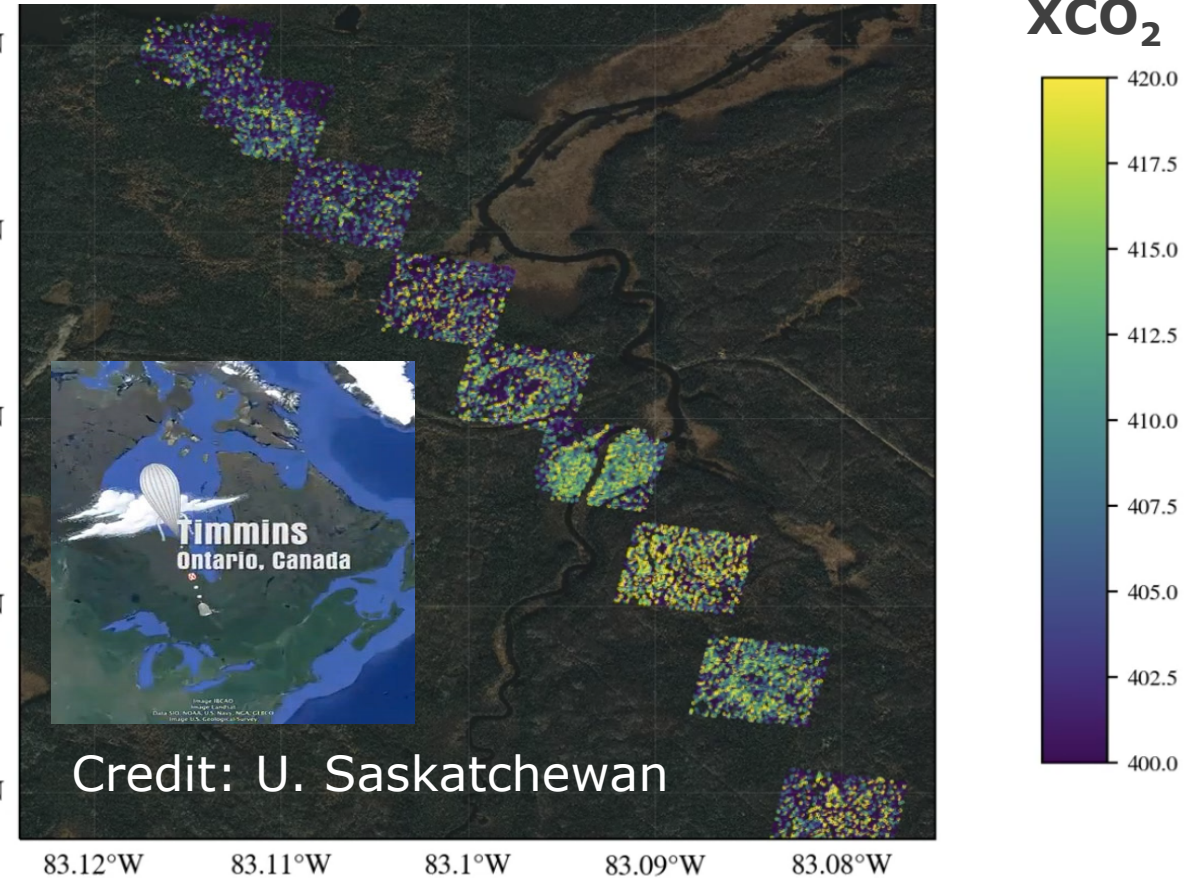
49.03°N

49.02°N

49.01°N

49°N

48.99°N



Qian et al (2024, SPIE) <https://doi.org/10.1117/12.3030957>



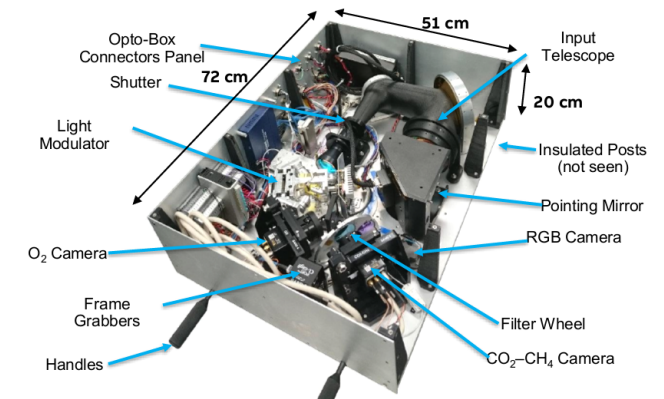
Environnement et
Climate Change Canada

Environnement et
Changement climatique Canada



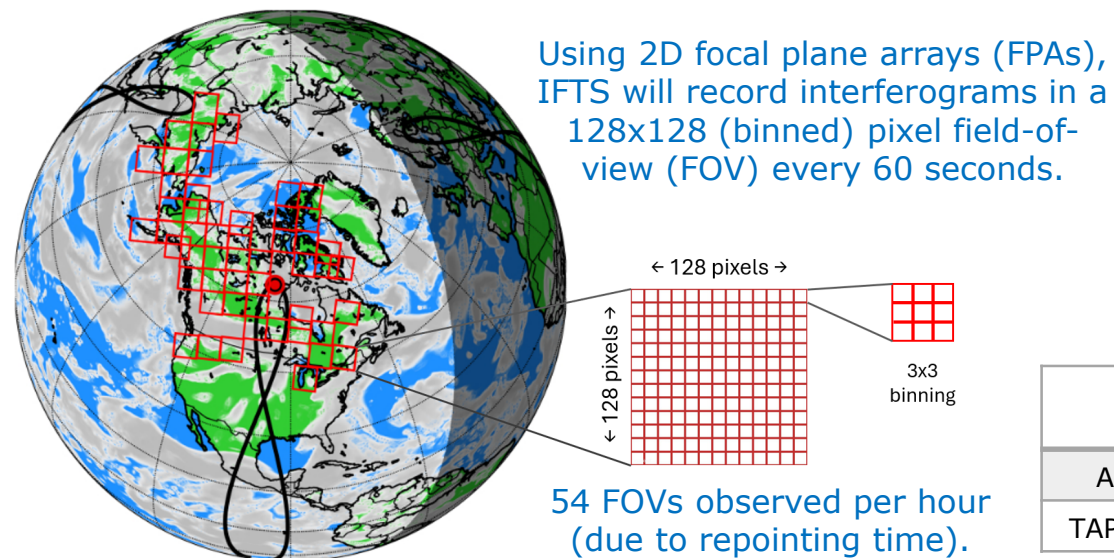
EM 27/SUN Series

• For Atmospheric Measurements



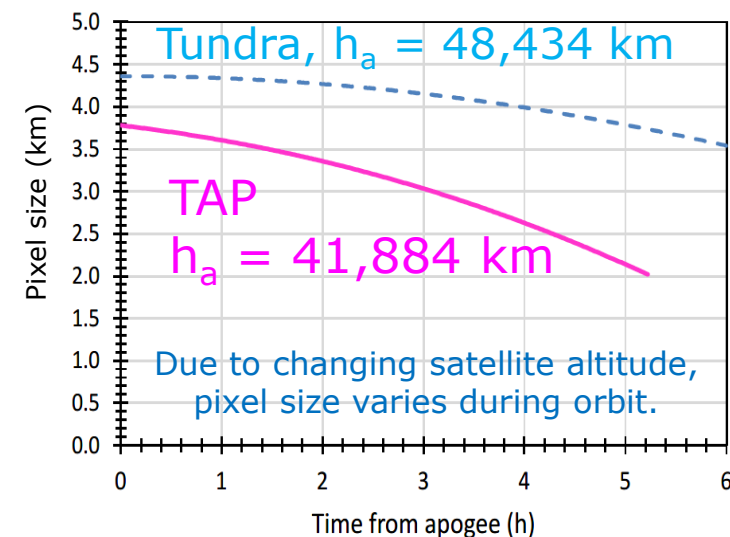
AOM Greenhouse Gas Data Plan Outline

By observing mainly clear sky areas using a cloud mask from the Met imager, the IFTS can obtain hourly column-averaged CO₂, CH₄ and CO observations and solar induced fluorescence (SIF) observations over cloud-free land north of 40°N during daylight. CO₂ and CH₄ will be assimilated in a model to obtain surface fluxes.



Each binned pixel is made up of 9 'unbinned' pixels, which can potentially be available for applications that favor spatial resolution over precision (if pointing stability goal can be achieved and increased data rate can be accommodated).

	Binned Pixel	Unbinned Pixel
At 40,000 km	3.6 km	1.2 km
TAP orbit average	~ 3.0 km	~ 1.0 km



Level 0

Interferograms, later transformed to spectra

*Only binned pixels meet threshold precision & accuracy

Level 1

Baseline spectral sampling interval 0.30 cm⁻¹

Band	Wavelength (μm)	Wavenumber (cm ⁻¹)	SNR Goal & Threshold	Expected SNR
1) O ₂ A	0.758 – 0.772	12953–13192	54 / 18	20
2) CO ₂ – 1	1.598 – 1.618	6180–6258	119 / 40	91
3) CO ₂ – 2	2.042 – 2.079	4810–4897	116 / 40	99
4) CH ₄ , CO	2.301 – 2.380	4195–4345	140 / 50	87

Level 2

Expected precision (1σ) for binned pixel	
XCO ₂	~2 ppm (~0.5%)
XCH ₄	~18 ppb (~1.0%)
XCO	~ 5 %
SIF	~1.5 Wm ⁻² sr ⁻¹ μm ⁻¹

Level 3

Hourly 3D CO₂ and CH₄ fields (1°x1°)

Level 4

Monthly CO₂ and CH₄ surface fluxes (1°x1°)

L3/L4 latency will meet requirements of G3W

IFTS+:

Adding LWIR and MWIR bands could yield additional GHG and related data products

Adding a 5th IFTS band

- Baseline AOM IFTS has 4 NIR-SWIR bands.
- Conducted an industry study on adding a LWIR band $\sim 7.4\text{-}14.7\ \mu\text{m}$ ($\sim 680\text{-}1350\ \text{cm}^{-1}$), similar to LEO sounders (e.g. IASI, CrIS) & GEO of 2030s (GXS, MTG-IRS, GIIRS, Himawari Sounder).
- Gives temperature, water vapor, O_3 , NH_3 , SO_2 , HNO_3 , isoprene, mid-tropospheric CO_2 , and N_2O and mid-tropospheric CH_4 with widest version of band.
- Unlike XCO_2 and XCH_4 , CO_2 and CH_4 profiles with mid-tropospheric sensitivity could be observed over land/water, day/night and summer/winter.

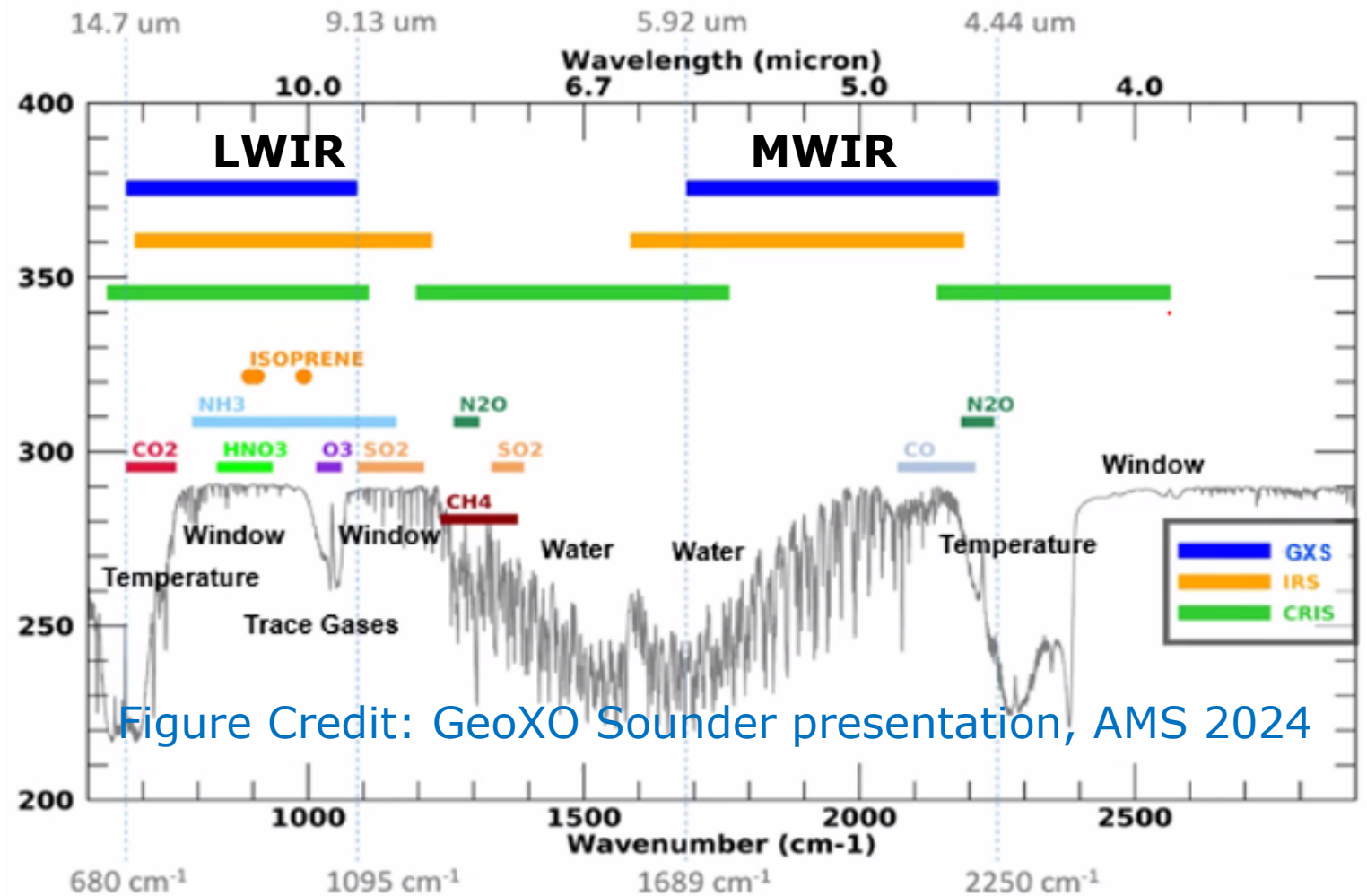
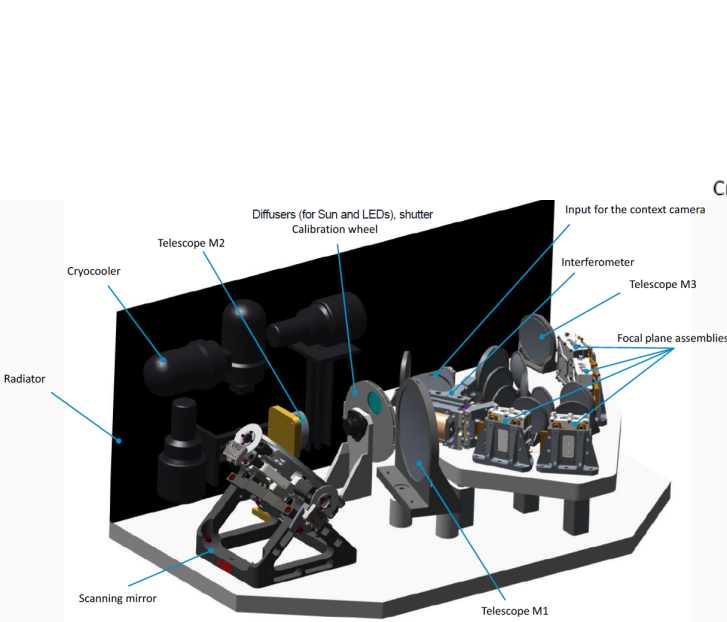


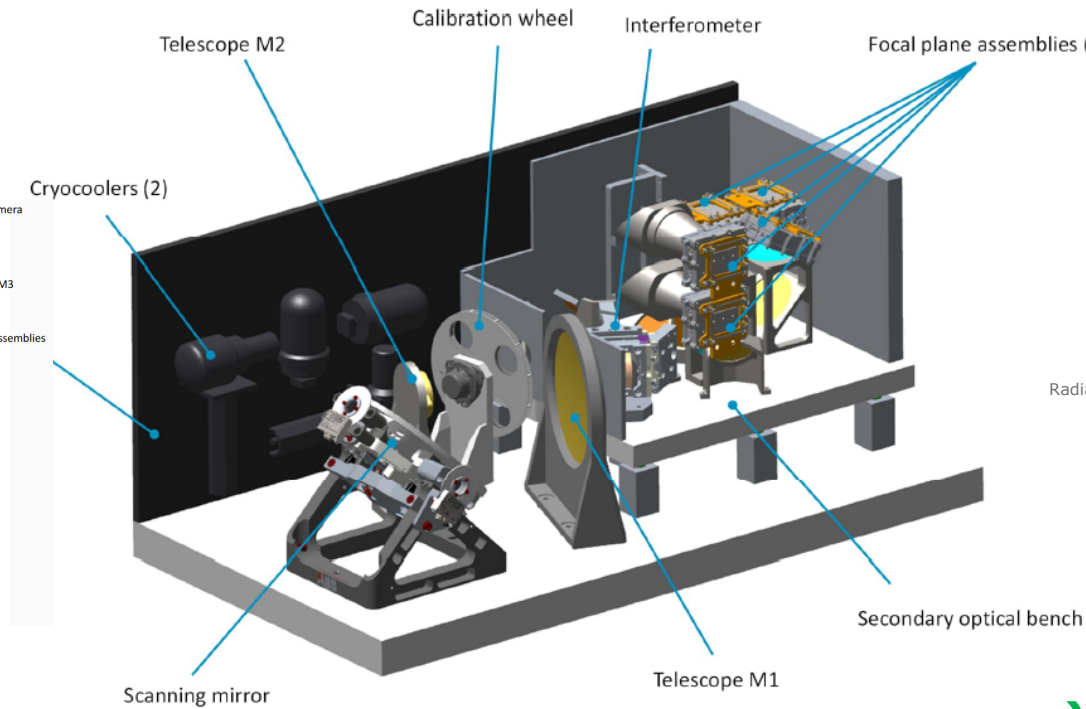
Figure Credit: GeoXO Sounder presentation, AMS 2024

AOM IFTS Configurations



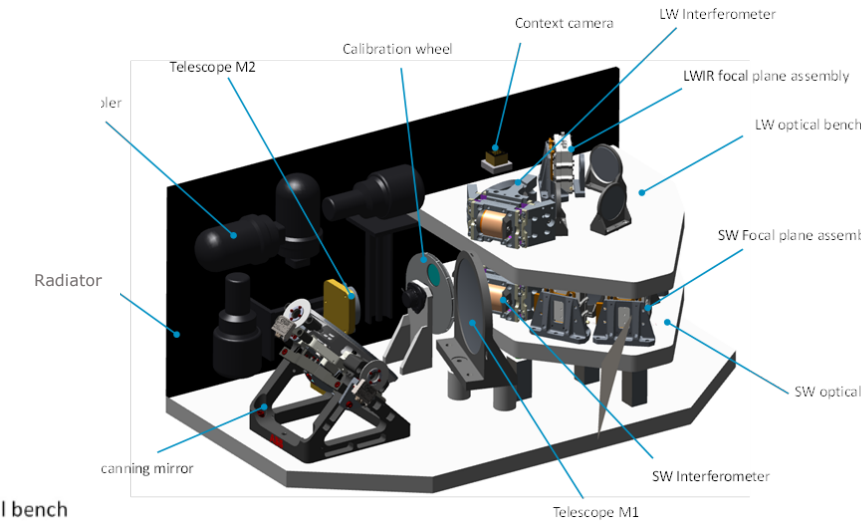
**a) 4-band IFTS:
176 kg**

4 FPAs in a single plane. Beamsplitter selected for NIR-SWIR and SNRs meet requirements.



**b) 5-band single-interferometer IFTS:
371 kg**

5th FPA is out of plane. 3D arrangement requires more rigidity beyond optical bench. One interferometer with an uncoated beamsplitter results in lost efficiency over wide spectral range (NIR-SWIR-LWIR). Maintain SNR by compensating with larger fore optics, but longer focal length means larger overall volume and casing.



c) 5-band dual-interferometer IFTS: 225 kg

Dual interferometer design adds <50 kg, no added volume. Each beamsplitter is optimized for its spectral region so SNR for NIR-SWIR is maintained. Interferometers can operate at different spectral sampling/resolution. Spacious 2nd level has room for possible 6th band (MWIR) for further benefits.

AOM Timeline and Next Steps

2022-2025 (Pre-formulation Studies – Phase 0)

- Completed IFTS sub-orbital demo (stratospheric balloon flight), NOAA-funded meteorological imager GEO to HEO adaptation study, a socio-economic benefits study (EuroConsult), published intelligent pointing paper and balloon IFTS proceedings, user consultation workshops,
- **AOM Mission Design Contract was completed March 2025**
- Outstanding technology study to acquire and test a large-format HgCdTe focal plane array for IFTS
- Planning ground segment: data reception, processing and applications plan
- Securing letters of support from partners: NOAA, EUMETSAT and others
- Preparing a funding request with hope for a possible decision in 2026

If successful ...

2027-2037 (Phases A-D)

- Detailed design, build, launch and on-orbit commissioning

2037-2047 (Phase E)

- AOM operations (10-year mission)