

Expanding the Geostationary Atmospheric Composition Satellite Constellation Towards Global Coverage ...

Orbits for High Latitude Observations

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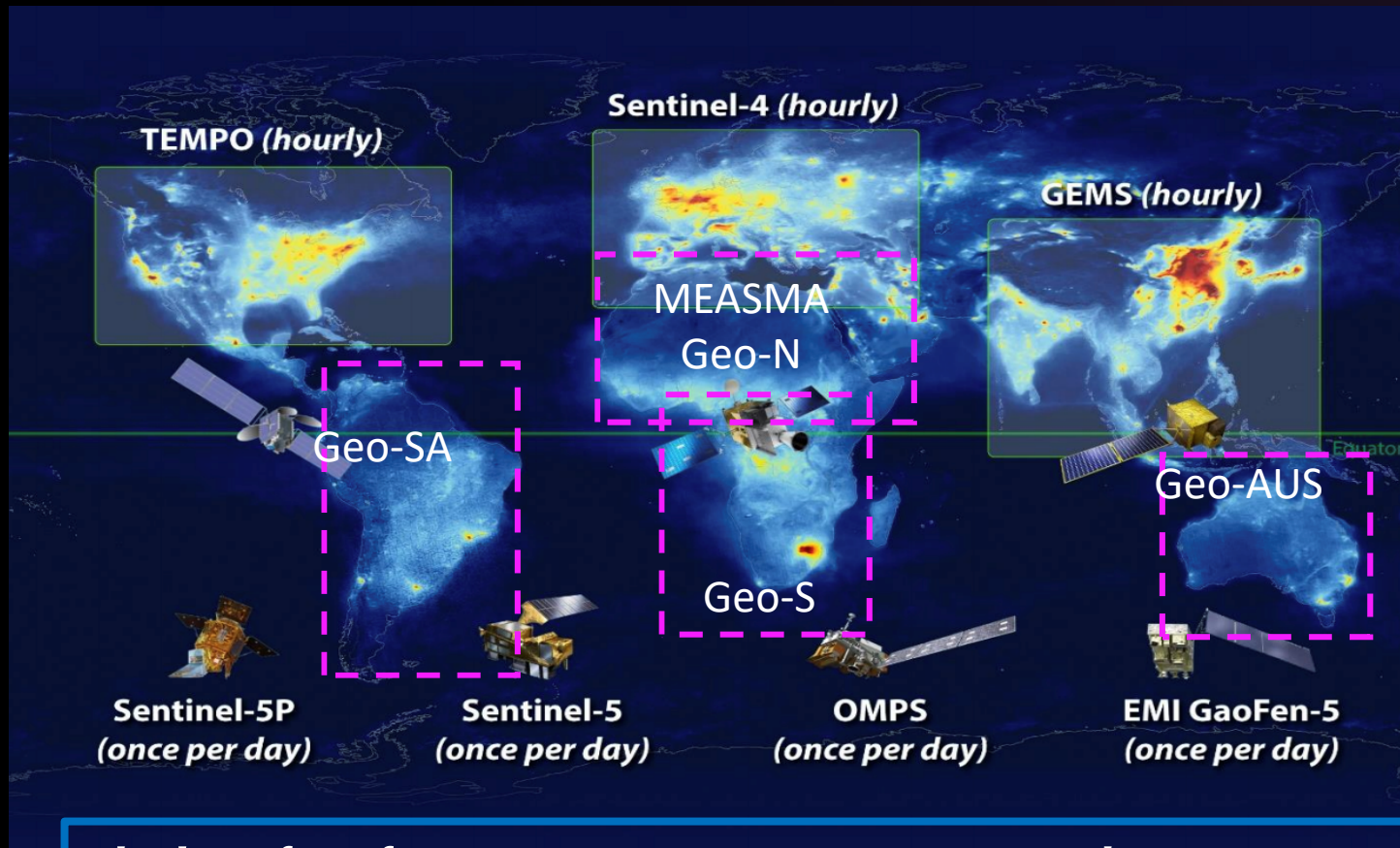
CEOS AC-VC

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Closing the Gap: The Global Geostationary Satellite Solution (hourly)



- Four new **geostationary satellites** in the next decade
- Continuous, wide-area coverage over the Global South.
- Complementing and enhancing existing constellation.
- Identifying pollution hotspots and tracking transboundary pollution to and from the Global South.
- Significant ownership and participation at the regional level to build capacity.

The benefits of investing in geostationary atmospheric composition monitoring extend far beyond the scientific realm. By improving our ability to predict and respond to environmental challenges, we can realize significant economic savings in areas such as healthcare, agriculture, resource management, and reducing the economic impact of disasters and extreme weather.

AOM

ARCTIC OBSERVING MISSION

Proposed Canadian-led international satellite mission to provide improved environmental monitoring and situational awareness in the Arctic region

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

Extent of coverage

Two satellites in a highly
elliptical orbit (HEO)
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



SPACE WEATHER

Improve space weather forecasts
and protect satellites and
ground-based infrastructures



A HEO UV-vis spectrometer
is no longer under
consideration, but
AOD/PM_{2.5} data from a
meteorological imager and
CO, O₃, NH₃ and some
organics from a NIR-LWIR
sounder



Canadian Space
Agency

Agence spatiale
canadienne



Environment and
Climate Change Canada

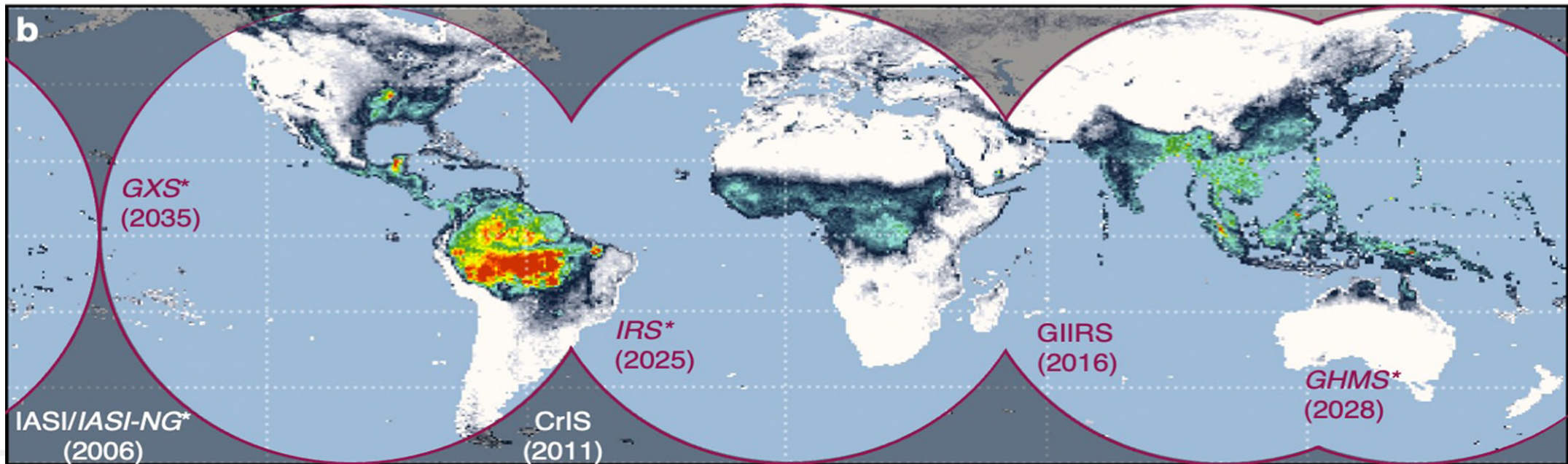
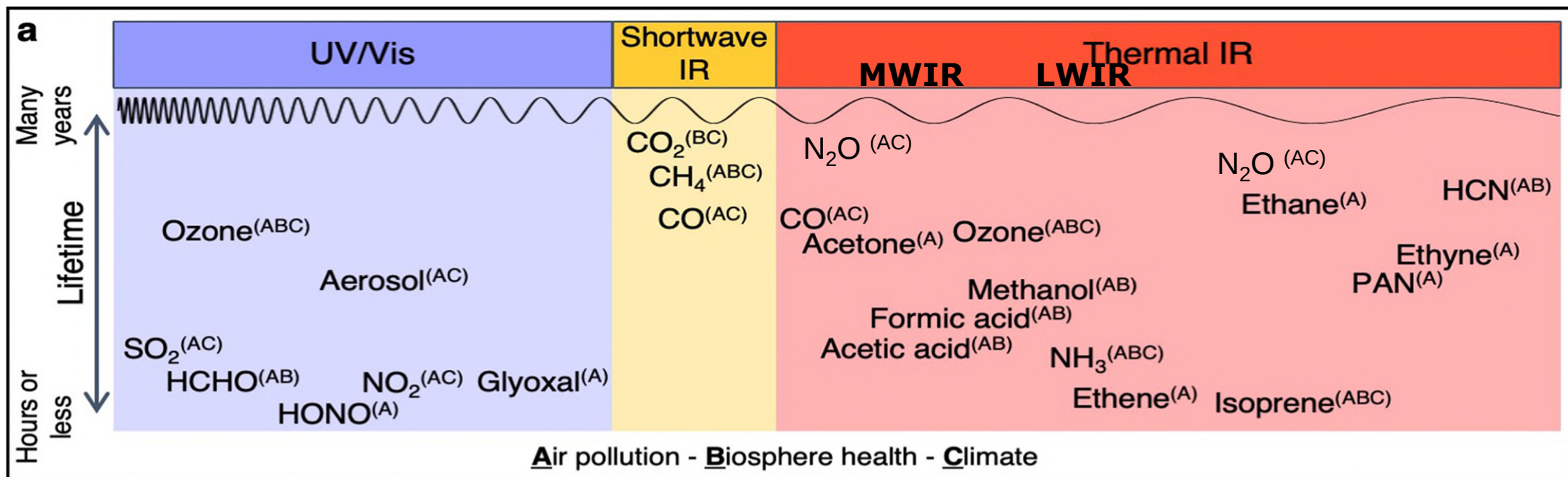
Environnement et
Changement climatique Canada



Natural Resources
Canada

Ressources naturelles
Canada

Canada

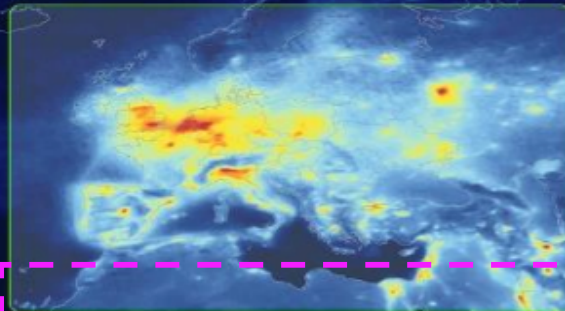


Background is isoprene from CrIS adapted from Dylan Millet et al. (2024) Coordinated Geostationary, Multispectral Satellite Observations are critical for Climate and Air Quality Progress, AGU Advances, <https://doi.org/10.1029/2024AV001322>.

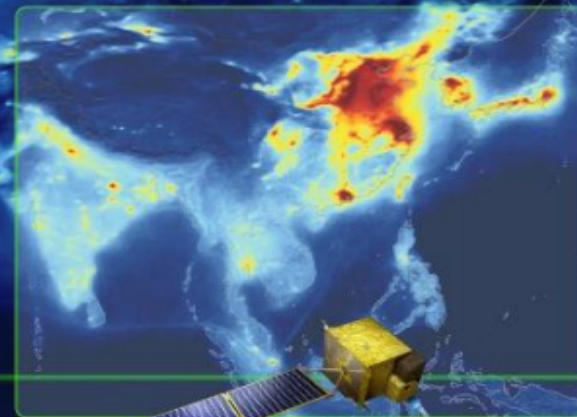
TEMPO (hourly)



Sentinel-4 (hourly)



GEMS (hourly)



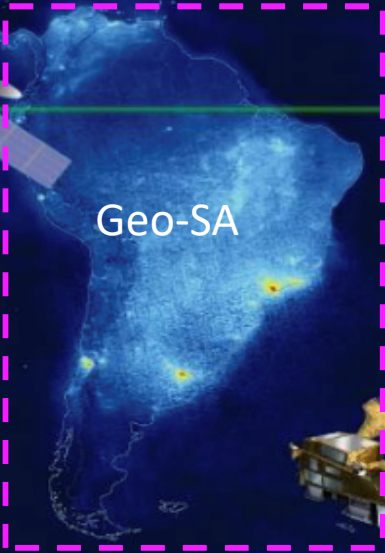
MEASMA
Geo-N



Geo-S



Geo-SA



Geo-AUS



Equator

**Sentinel-5P
(once per day)**



**Sentinel-5
(once per day)**



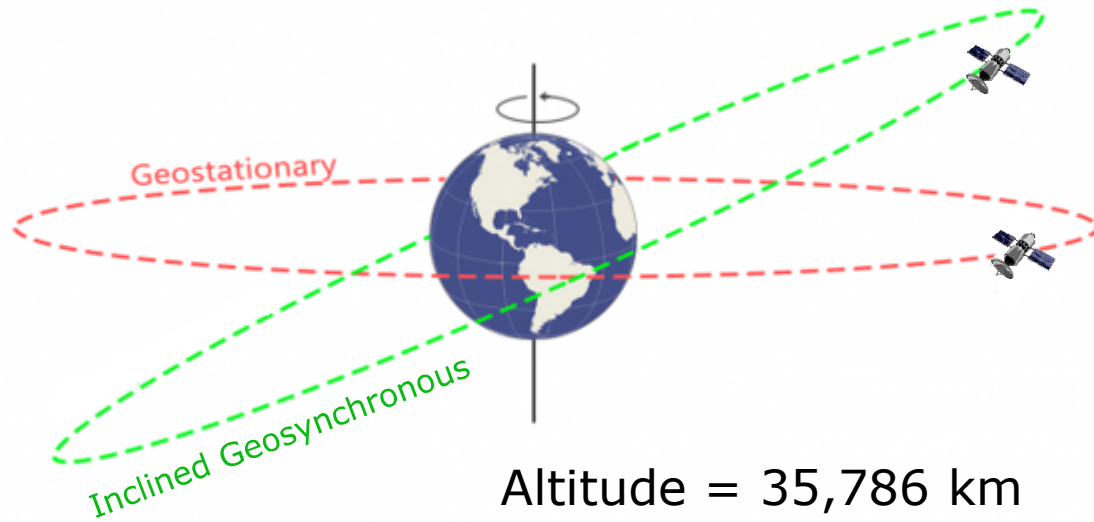
**OMPS
(once per day)**



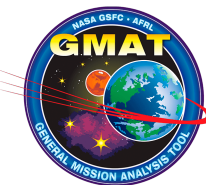
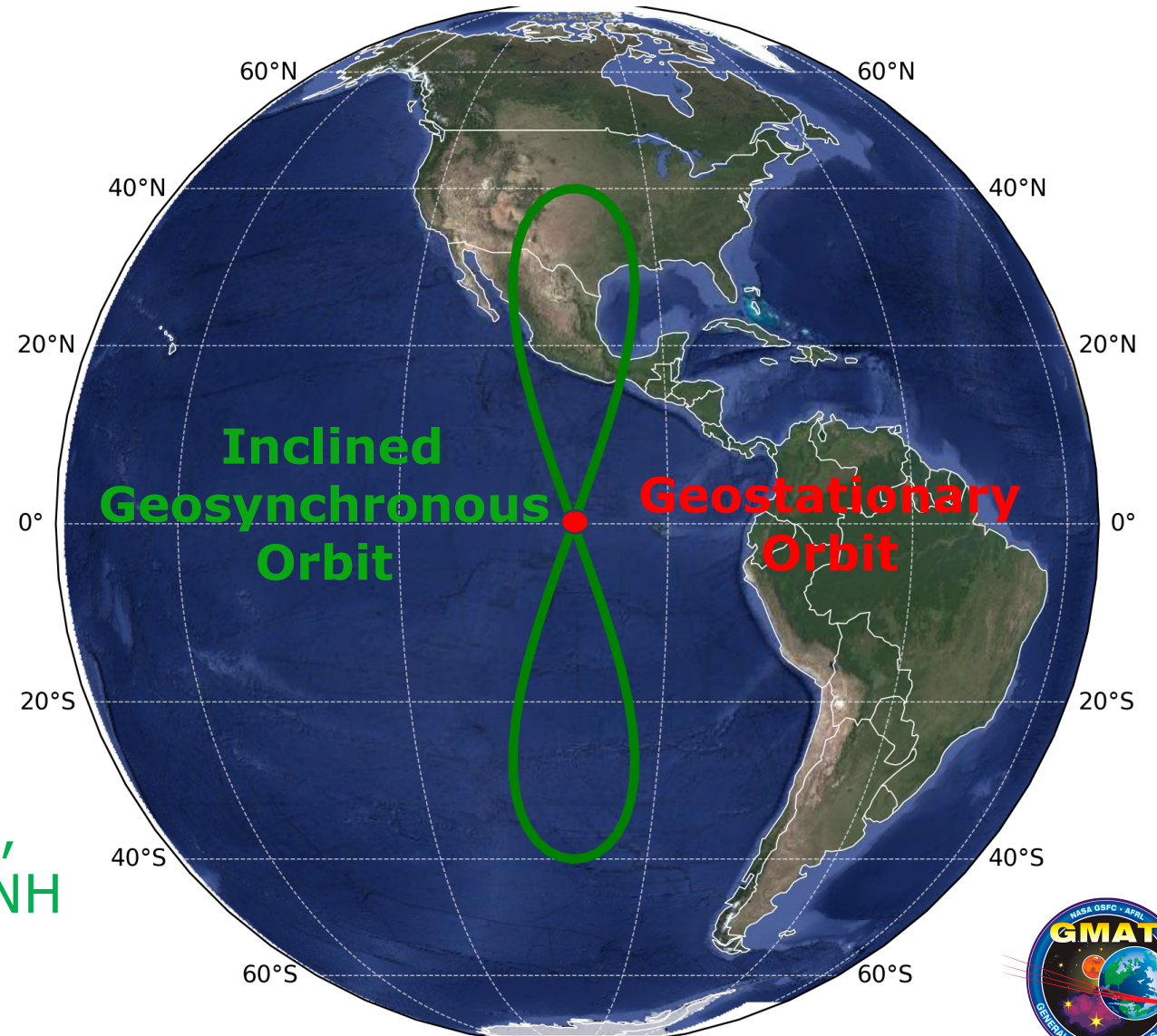
**EMI GaoFen-5
(once per day)**



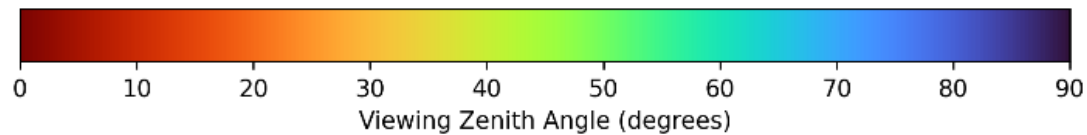
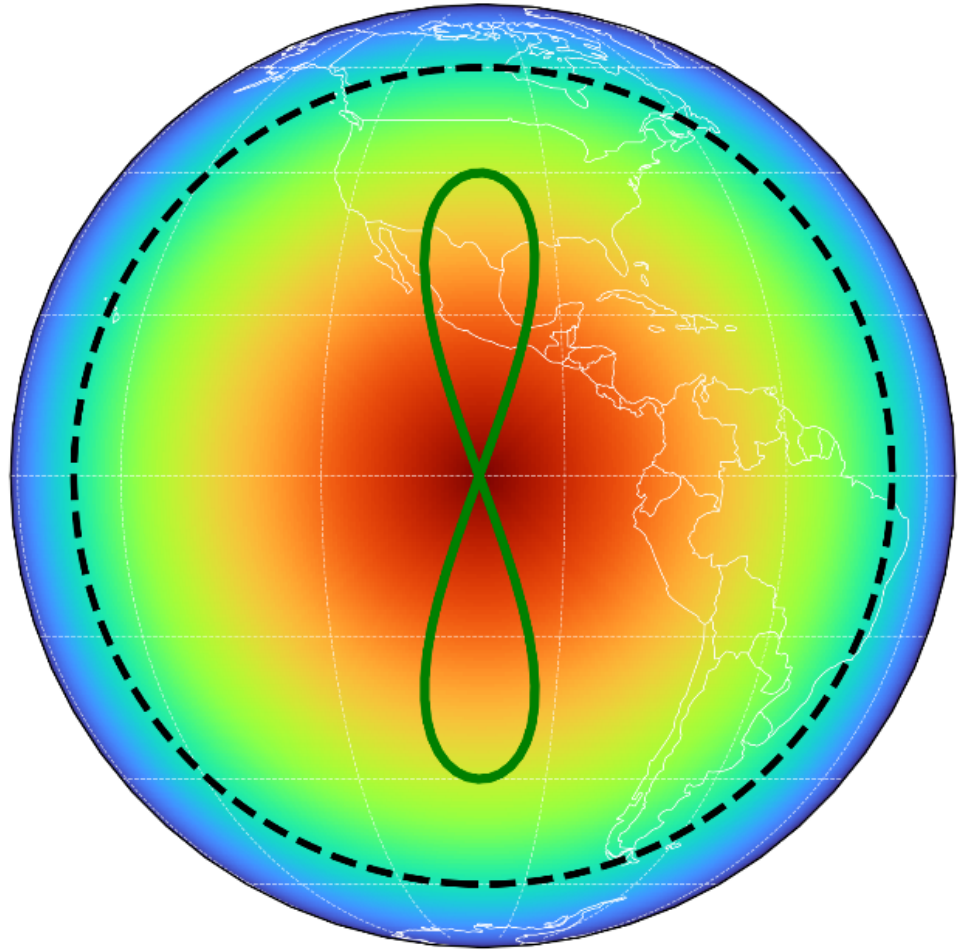
Inclined Geosynchronous Orbit (IGSO)



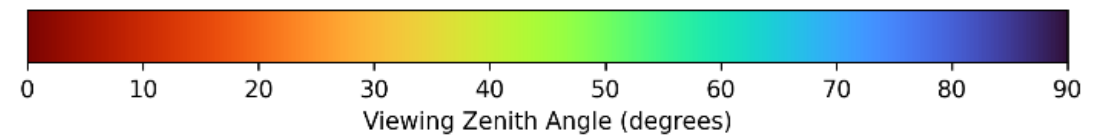
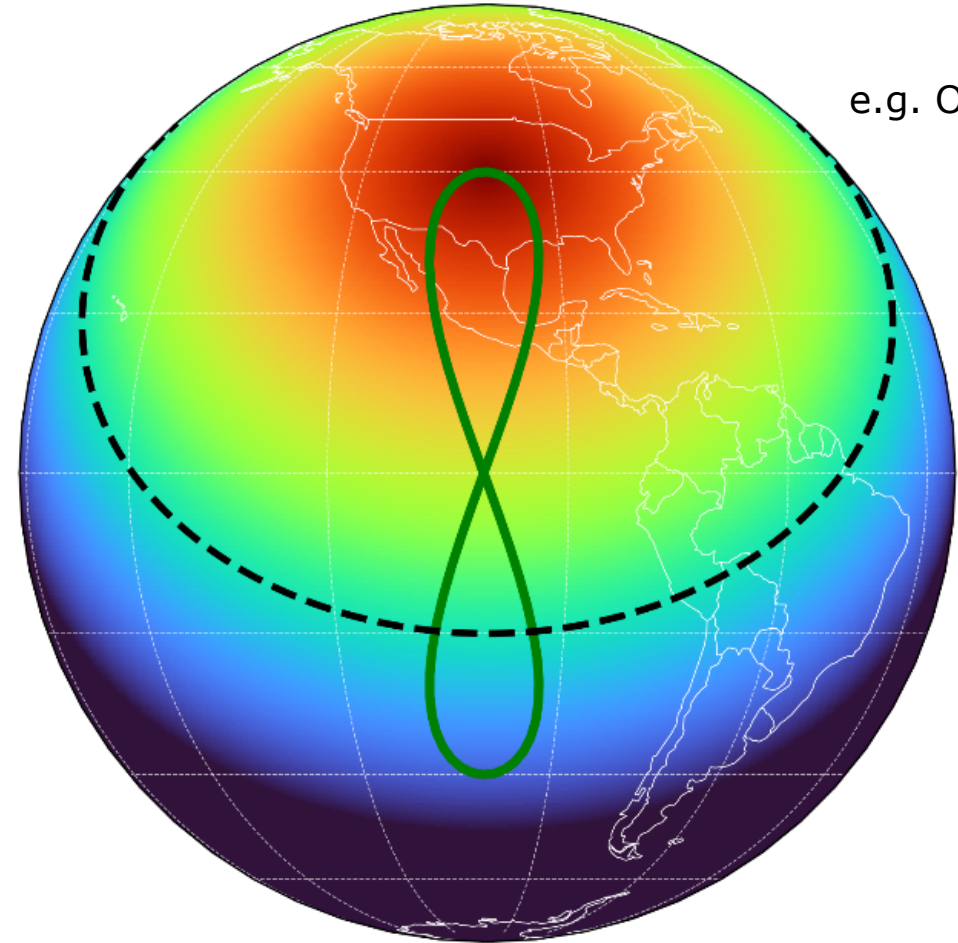
For an inclined geosynchronous orbit, the satellite spends 12 hours over the NH and 12 hours over the SH.



Key Advantage: Improved viewing angles



GEO or IGSO at 6:00 or 18:00 Local Time



IGSO at noon Local Time

e.g. One satellite
for U.S.,
Canada &
Mexico



Inclined Geosynchronous Orbits (IGSOs) for AQ

Comparison of IGSO to GEO:

- IGSOs work well for daytime observations (measuring reflected sunlight) focused in one hemisphere (North / South), but GEO is better for full disc observing or continuous 24 h coverage (as required for a meteorological imager or IR sounder).
- IGSO can give similar revisit rate as GEO (for similar area), but with better viewing angles if area of interest is not symmetrically centered on the equator.

Additional advantages of IGSO compared with HEO:

- Same altitude as GEO rather than varying altitude of HEO (apogee is typically higher than GEO, but large fraction of observations are made lower than GEO)
- Better radiation environment than from HEO (easily avoid van Allen belts)

Question: Why have I not heard of IGSOs before?

- IGSOs are used for communication satellites but are not standard for Earth observation.
- Some GEO satellites actually drift to low inclination IGSOs ($i < 5^\circ$) and are operated this way to reduce fuel use and extend their mission lifetime.
- GEO AQ missions have so far leveraged existing GEO meteorological programs (e.g. GEMS Sentinel-4 UVNS) or commercial hosting opportunities (e.g. TEMPO) rather than operate as stand-alone missions from an optimized orbit
- Within the last few years, costs for new micro-GEO buses may now allow stand-alone AQ inclined geosynchronous missions.
- In default IGSO configuration, timing of satellite position with solar illumination is not constant, but has an annual cycle. If satellite is at the maximum latitude at noon on a given day, it will be at the minimum latitude six months later. We are investigating tuning the orbital parameters to address this. Actively managing the satellite position in its orbital plane (true anomaly) is another alternative that requires further study.
- ***IGSO concept will appear in a dedicated section of AC-VC white paper as well as a draft manuscript for peer-review***