# Uvsq-Sat NG, un satellite dédié à l'observation des gaz à effet de serre




*27 January 2025*
*A.-J. Vieau, M. Meftah et al.*

# Uvsq-Sat NG

**Uvsq-Sat NG** aims:

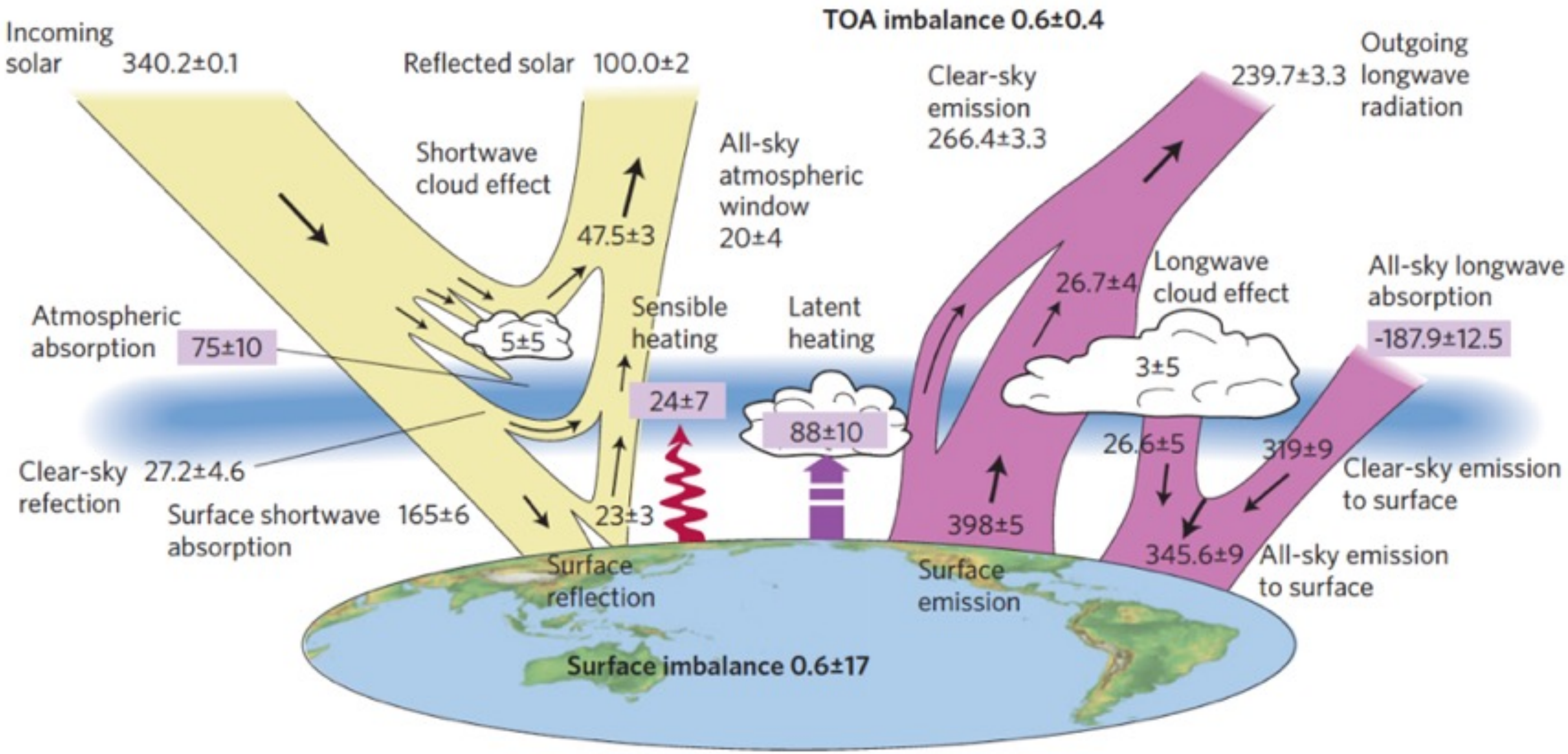
- To continue the **Earth Radiation Budget** (**ERB**) research initiated by Uvsq-Sat and Inspire-Sat satellites. It intends to achieve broadband ERB measurements using advanced yet simple technologies.
- To monitor **atmospheric gas concentrations** (**$CO_2$** and **$CH_4$**) on a global scale and explore their correlation with Earth's Outgoing Longwave Radiation (**OLR**).

→ Uvsq-Sat NG carries multiple payloads, including Earth Radiative Sensors (ERSs) for tracking solar and terrestrial radiation, a Near-Infrared (NIR) Spectrometer for assessing greenhouse gases (GHGs) concentrations, and a high-definition camera (NanoCam) for Earth imaging. The NanoCam helps with geolocating observed scenes and provides an opportunity to estimate the **vertical temperature profile of the atmosphere** by observing the Earth's limb.

→ We will also endeavor to capture images of the aurora between 60 and 80 geomagnetic latitude both above North and South oval. Nadir pointing or close Nadir pointing is convenient but limb geometry could also be very interesting. The goal is to conduct a study on **auroral structures**, with a specific emphasis on the less commonly observed sub-auroral features.

# Earth Energy Imbalance

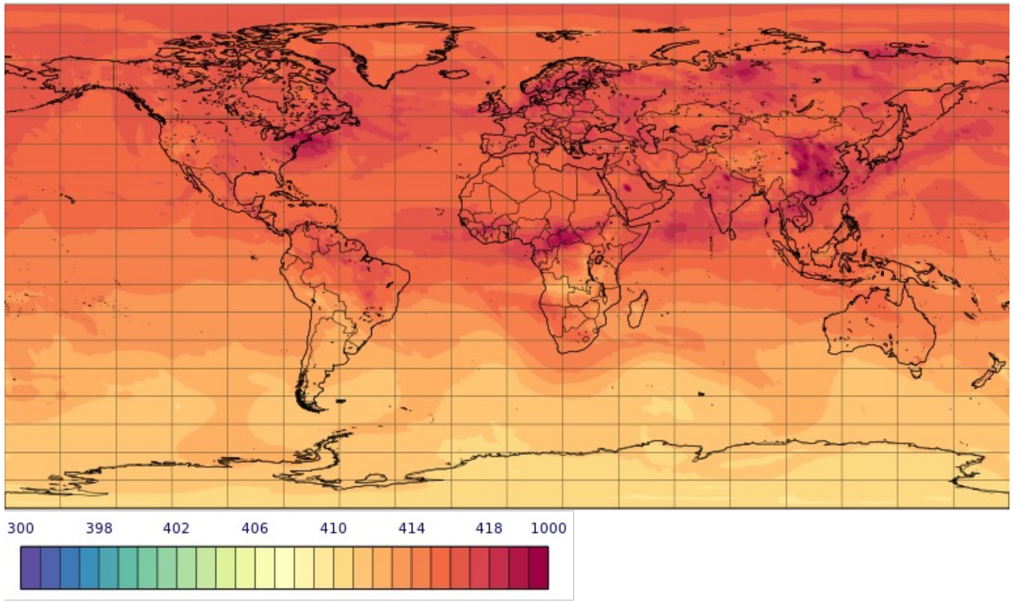
❑ **Importance of the key components of the Earth energy budget**



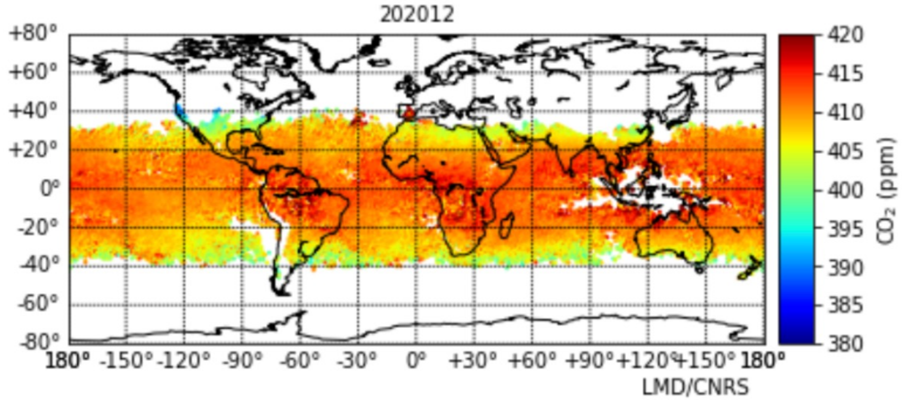

**Earth Energy Imbalance = Incoming solar –**
**[ Reflected solar (OSR) + Outgoing longwave radiation (OLR) ]**

# GHG observations

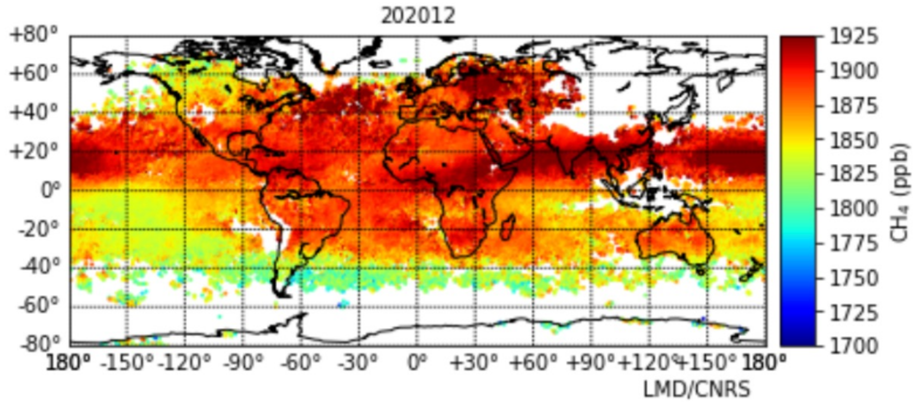
## ❑ Importance of GHG and role in Earth enegy budget




*Total column of carbon dioxide [ppmv] for Thursday 28 November 2019. (Credit: Copernicus Atmosphere Monitoring Service, ECMWF)*



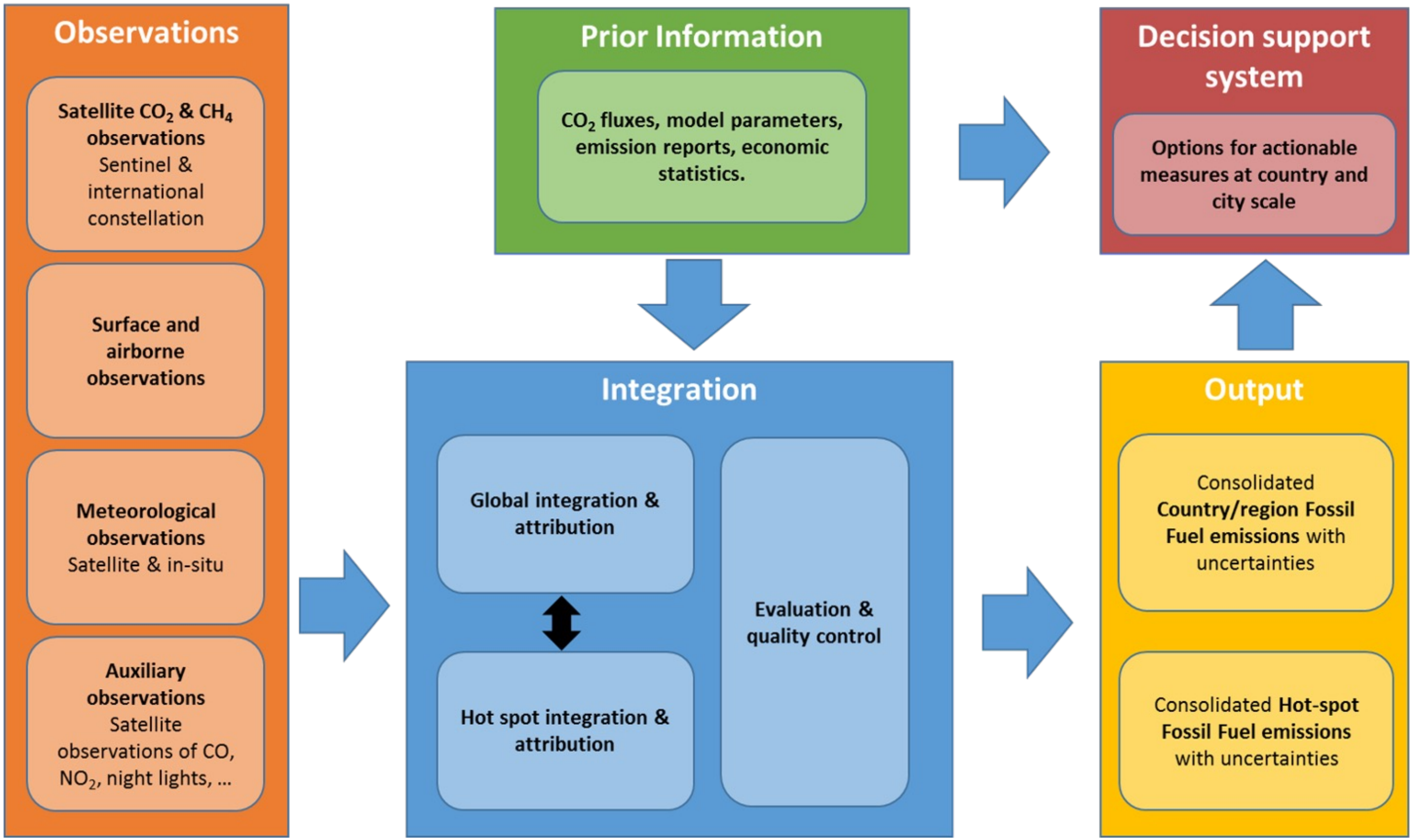

*Carte de Colonne de $CO_2$ (IASI/Metop-B) mois de décembre 2020*




*Carte de Colonne de $CH_4$ (IASI/Metop-B) mois de décembre 2020*

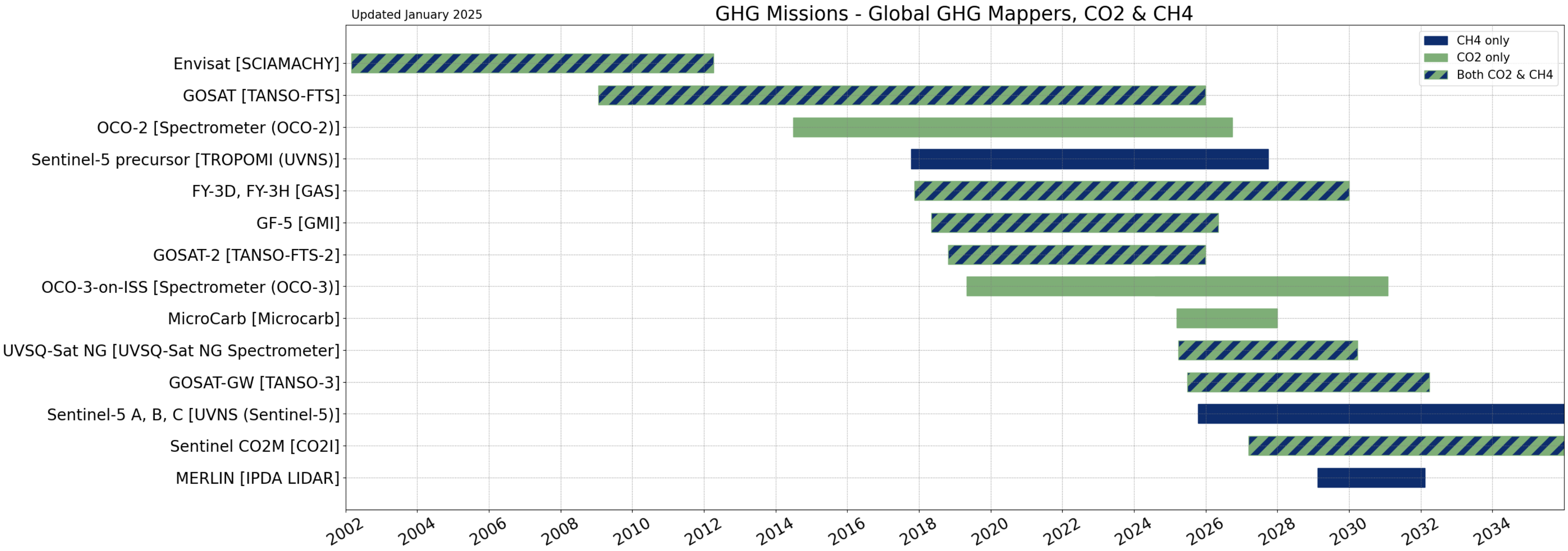
# GHG observations

❑ **System functional overview an atmospheric CO2 and CH4 monitoring system**

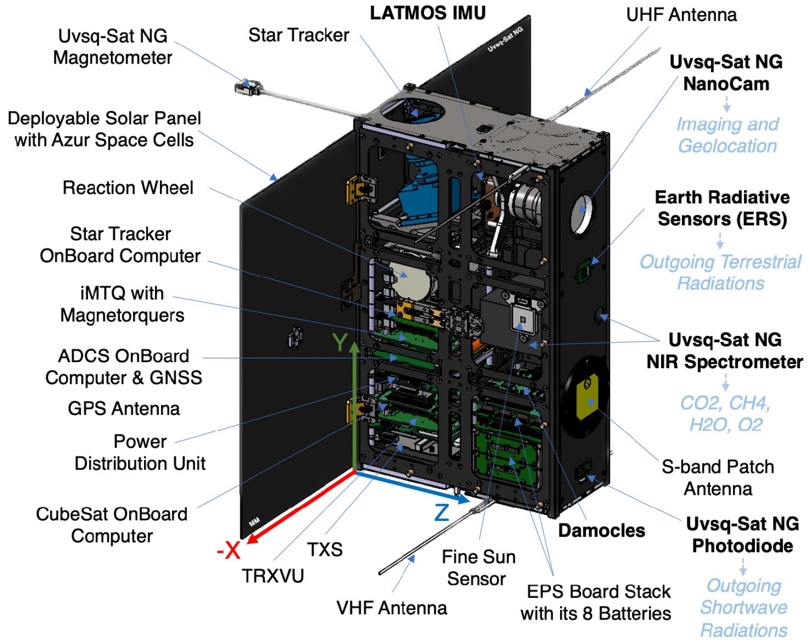


# GHG observations

## ❑ GHG Mission Timelines



# Uvsq-Sat NG a satellite for observing Earth


| Properties | Value | Comments |
|---|---|---|
| Orbit | Sun-Synchronous Orbit (SSO) | Maximum altitude of 600 km, LTAN of 06:30 |
| Design life time | Minimum of 2 years in LEO | 3 years desired |
| Launch date | Between Q2 2025 and Q1 2026 | Launch vehicle: Falcon 9, Vega-C or Zéphyr |
| Launch adapter | QuadPack or EXOpod deployer | Payload mass up to 12 kg |
| CubeSat type | 6U XL | Easy-to-assemble modular design |
| Launch mass | 10.0 kg [1] | Maximum with margins |
| Dimensions | 10.0 cm × 36.6 cm × 22.6 cm | Stowed along X, Y, and Z axes |
| | 111.3 cm × 36.6 cm × 38.8 cm | Unstowed including all deployable elements |

**Uvsq-Sat NG, a new satellite to envision the space of tomorrow. An In-Orbit Demonstrator to prepare the SmallSats constellations of the future.**

# Uvsq-Sat NG a satellite for observing Earth

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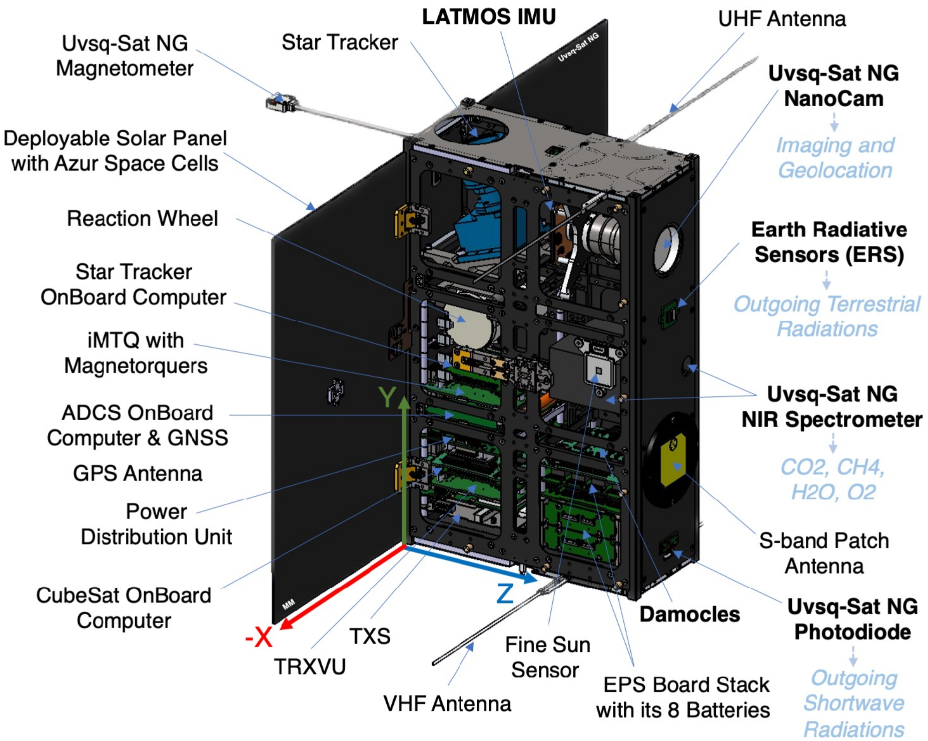
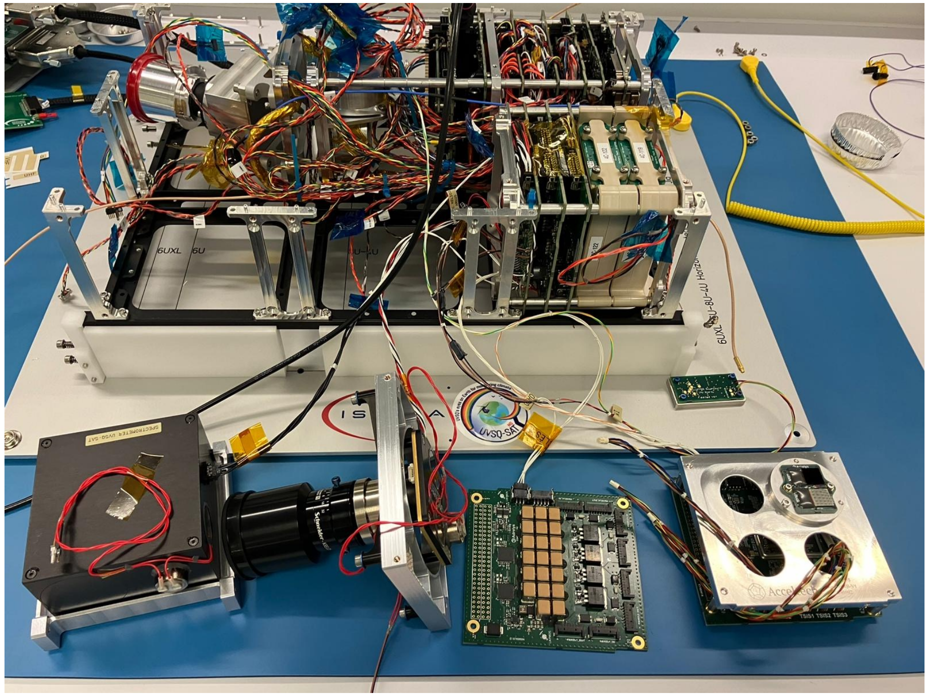
Uvsq-Sat NG carries multiple payloads, including Earth Radiative Sensors (ERSs) for tracking solar and terrestrial radiation, a Near-Infrared (NIR) Spectrometer for assessing greenhouse gases (GHGs) concentrations, and a high-definition camera (NanoCam) for Earth imaging. The NanoCam helps with geolocating observed scenes.



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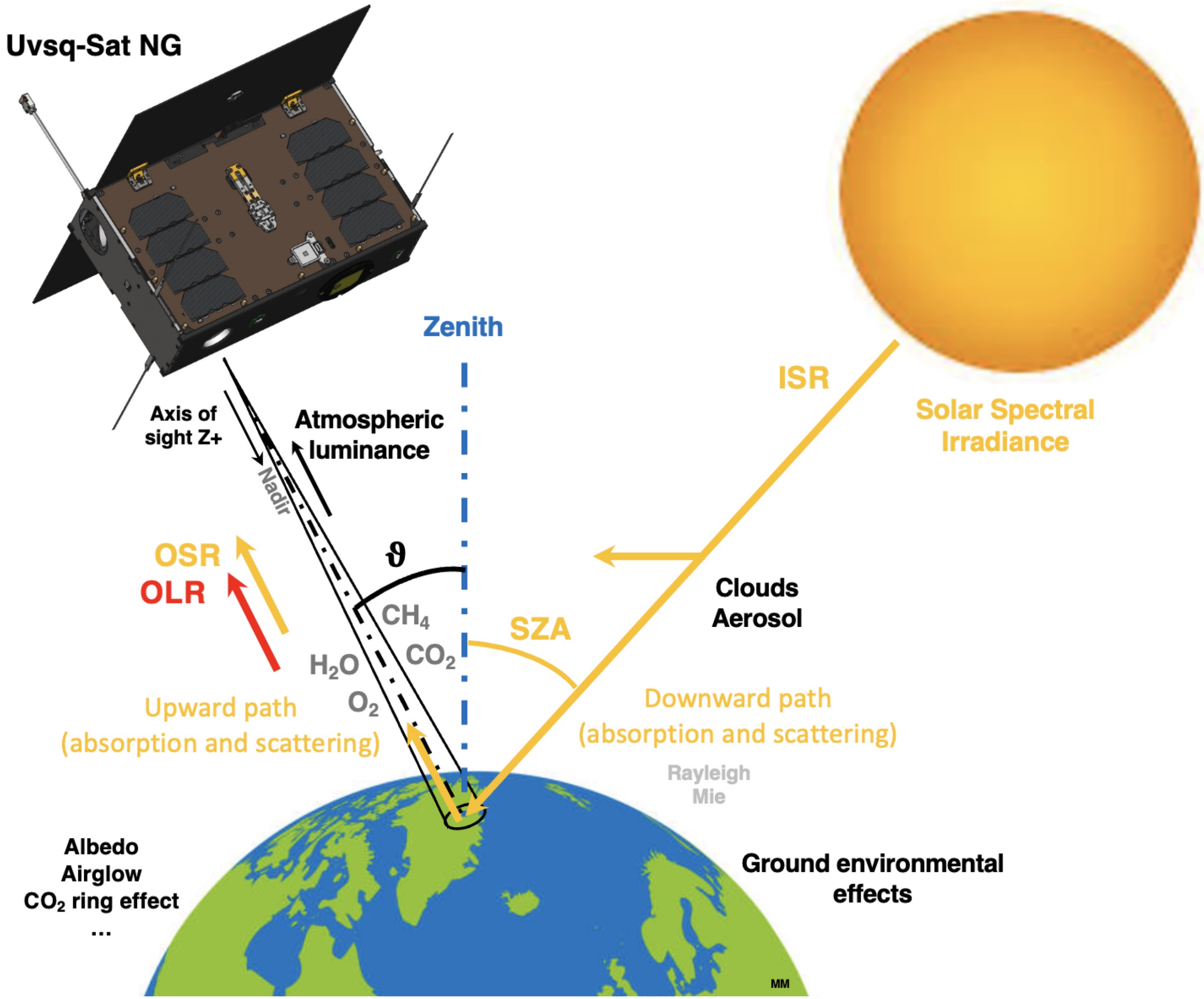

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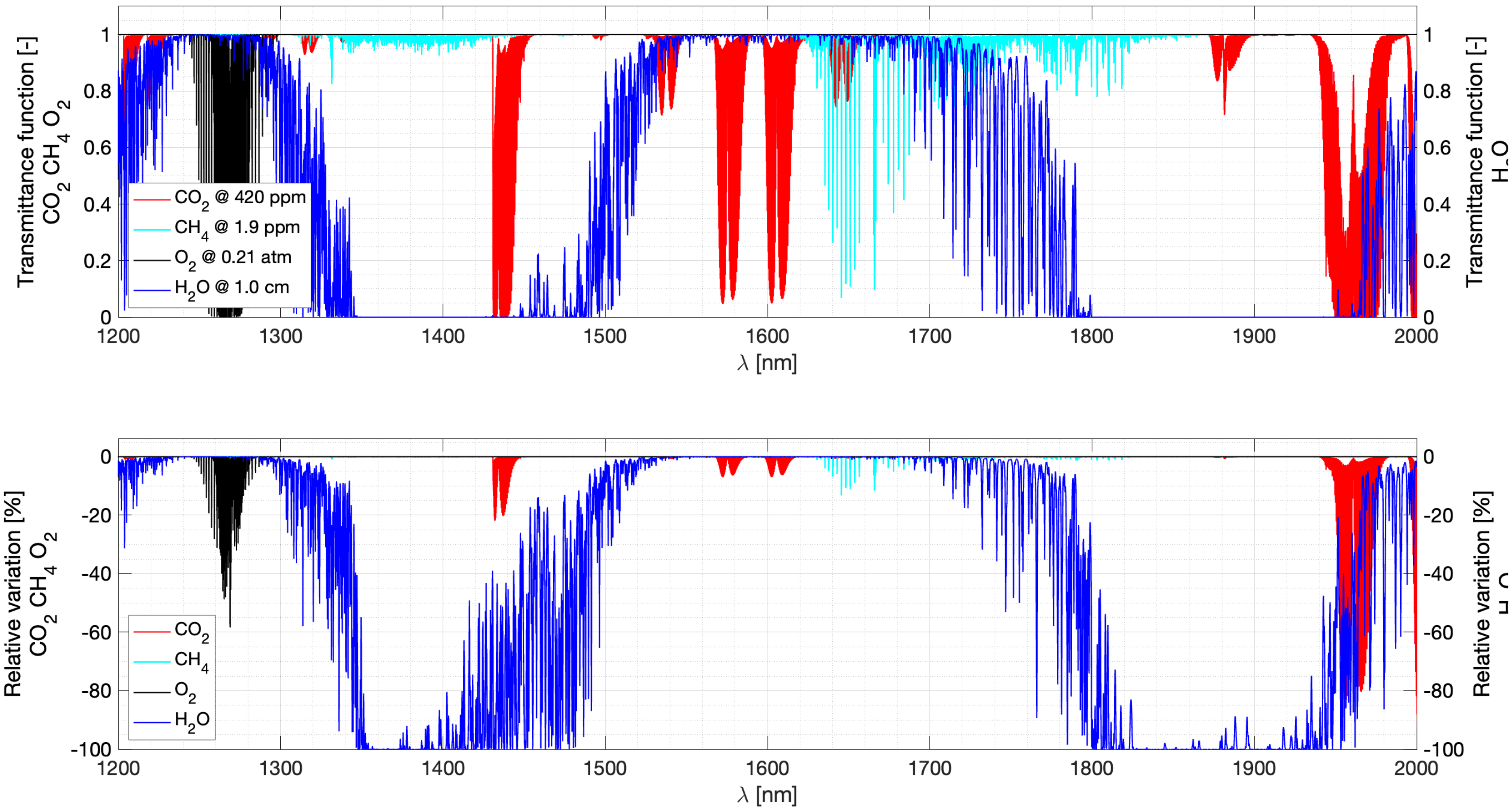

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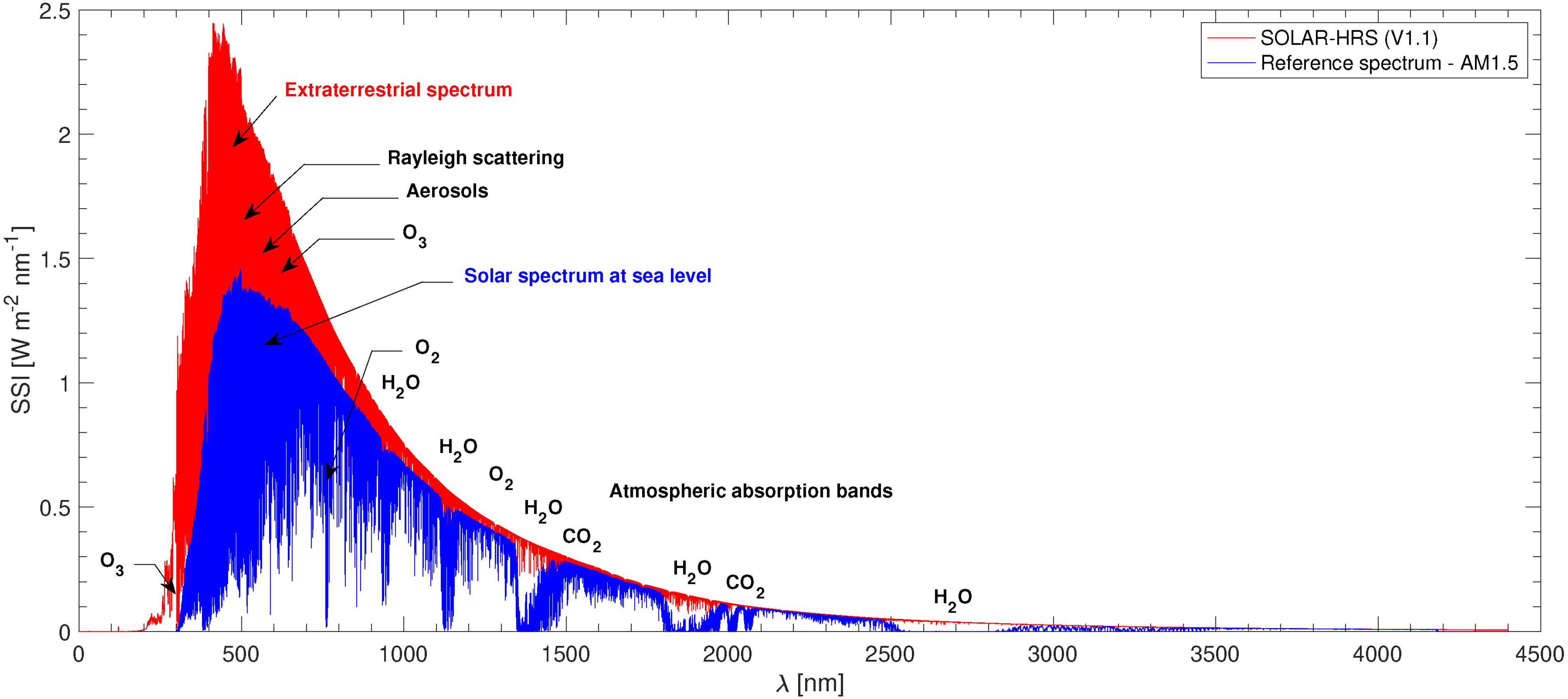

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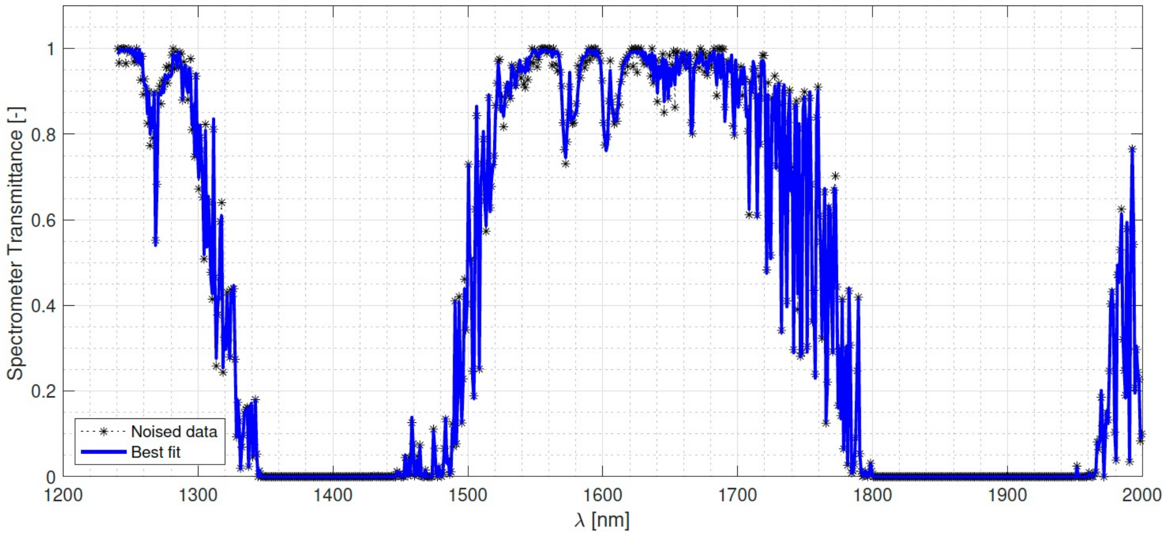


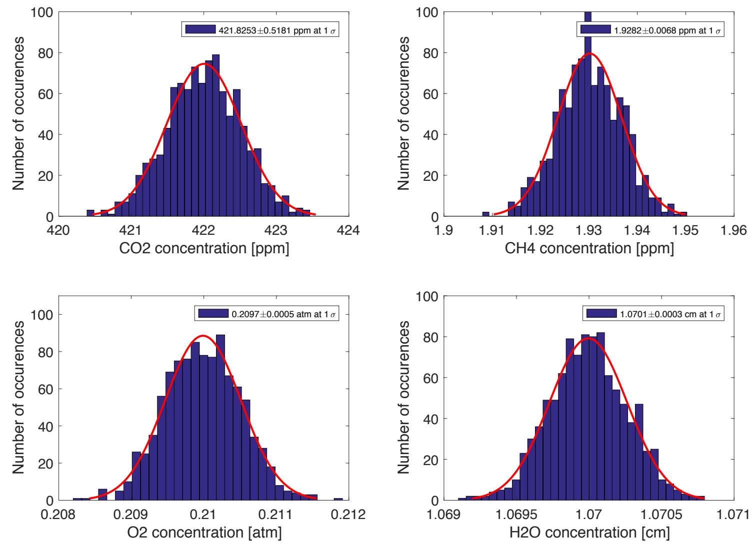

The Levenberg-Marquardt algorithm is used to fit a model that relates the observed dimensionless transmittance functions to the concentrations of the atmospheric gases.

The Monte Carlo method is used to perform multiple simulations with randomized inputs within specified uncertainty bounds. This helps to estimate the range of gases concentrations ($CO_2$, CH4, $O_2$, $H_2O$) and their associated uncertainties.

**Table 5.** Uncertainties of atmospheric gas concentrations (1–Sigma) for various data retrievals based on different instrumental characteristics.

| **Resolution: 1 nm** | | | | | | |
|---|---|---|---|---|---|---|
| SNR | 50 | 100 | 250 | 500 | 1,000 | 2,000 |
| $CO_2$ [ppm] | 10.998 | 5.602 | 2.204 | 1.130 | 0.575 | 0.277 |
| $CH_4$ [ppb] | 125.028 | 66.209 | 25.245 | 12.302 | 6.625 | 3.108 |
| $O_2$ [Ratio] | 11.024E-3 | 5.921E-3 | 2.433E-3 | 1.165E-3 | 0.636E-3 | 0.299E-3 |
| $H_2O$ [cm] | 4.746E-3 | 2.271E-3 | 0.877E-3 | 0.441E-3 | 0.207E-3 | 0.114E-3 |

| **Resolution: 6 nm** | | | | | | |
|---|---|---|---|---|---|---|
| SNR | 50 | 100 | 250 | 500 | 1,000 | 2,000 |
| $CO_2$ [ppm] | 33.974 | 16.720 | 6.426 | 3.154 | 1.674 | 0.808 |
| $CH_4$ [ppb] | 431.491 | 198.877 | 88.926 | 40.973 | 21.593 | 11.317 |
| $O_2$ [Ratio] | 33.139E-3 | 16.209E-3 | 5.657E-3 | 3.169E-3 | 1.588E-3 | 0.850E-3 |
| $H_2O$ [cm] | 12.474E-3 | 5.933E-3 | 2.518E-3 | 1.236E-3 | 0.609E-3 | 0.284E-3 |



# Uvsq-Sat NG a satellite for observing Earth

**Uvsq-Sat NG instrument spectral resolution: 1 nm**

| Aerosols \ Surface | Pine forest (a) | Deciduous forest (b) | Ocean (c) | Homogeneous snow (d) |
|---|---|---|---|---|
| Continental | 0.5 ppm | 0.4 ppm | 77.6 ppm | 0.3 ppm |
| Desert | 0.5 ppm | 0.3 ppm | 82.8 ppm | 0.3 ppm |
| Maritime | 0.6 ppm | 0.4 ppm | 81.4 ppm | 0.3 ppm |
| Urban | 0.5 ppm | 0.4 ppm | 78.4 ppm | 0.3 ppm |

**Uvsq-Sat NG instrument spectral resolution: 5 nm**

| Aerosols \ Surface | Pine forest (a) | Deciduous forest (b) | Ocean (c) | Homogeneous snow (d) |
|---|---|---|---|---|
| Continental | 1.3 ppm | 0.9 ppm | 234.5 ppm | 0.7 ppm |
| Desert | 1.7 ppm | 0.8 ppm | 225.8 ppm | 0.6 ppm |
| Maritime | 1.4 ppm | 1.1 ppm | 228.6 ppm | 0.8 ppm |
| Urban | 1.3 ppm | 0.9 ppm | 233.2 ppm | 0.7 ppm |

$CO_2$ uncertainties (at 1σ) determination according to the various simulation cases (requirements: 1 ppm).

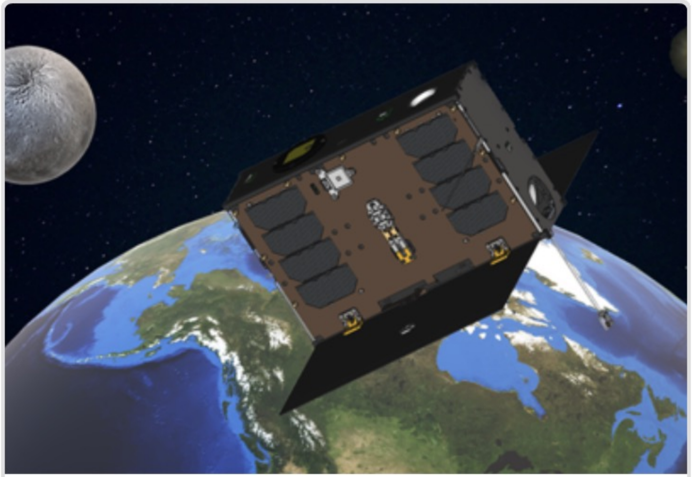
**Uvsq-Sat NG instrument spectral resolution: 1 nm**

| Aerosols \ Surface | Pine forest (a) | Deciduous forest (b) | Ocean (c) | Homogeneous snow (d) |
|---|---|---|---|---|
| Continental | 4.9 ppb | 3.7 ppb | 194.1 ppb | 2.5 ppb |
| Desert | 4.4 ppb | 3.2 ppb | 184.8 ppb | 2.4 ppb |
| Maritime | 5.8 ppb | 4.2 ppb | 202.2 ppb | 3.2 ppb |
| Urban | 4.7 ppb | 3.4 ppb | 193.4 ppb | 2.8 ppb |

**Uvsq-Sat NG instrument spectral resolution: 5 nm**

| Aerosols \ Surface | Pine forest (a) | Deciduous forest (b) | Ocean (c) | Homogeneous snow (d) |
|---|---|---|---|---|
| Continental | 12.2 ppb | 10.2 ppb | 735.6 ppb | 7.8 ppb |
| Desert | 10.5 ppb | 8.5 ppb | 710.8 ppb | 7.0 ppb |
| Maritime | 15.5 ppb | 12.7 ppb | 763.2 ppb | 8.8 ppb |
| Urban | 12.2 ppb | 10.3 ppb | 730.5 ppb | 7.1 ppb |

$CH_4$ uncertainties (at 1σ) determination according to the various simulation cases (requirements: 10 ppb).



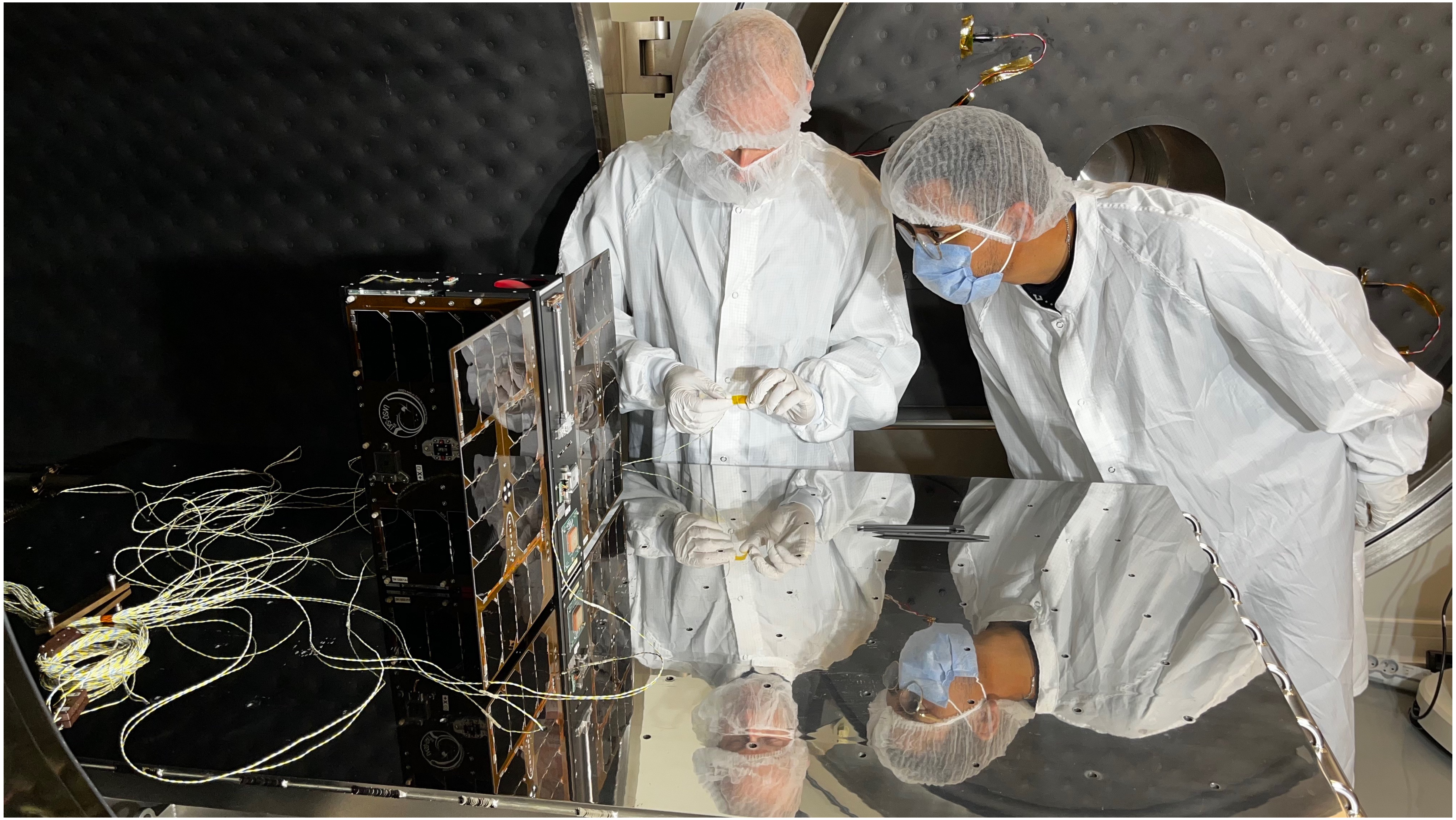
## UVSQ-Sat NG

$CO_2$ $CH_4$ NGO Limited

UVSQ-Sat NG objectives include ensuring continuity of the Earth Radiation Budget (ERB) initiated via the UVSQ-Sat and Inspire-Sat satellites, achieving broadband ERB measurements, and conducting precise and comprehensive monitoring of atmospheric gas concentrations ($CH_4$, $CO_2$) on a global scale. More...

Clavier et al., 2024

# Uvsq-Sat NG a satellite for observing Earth



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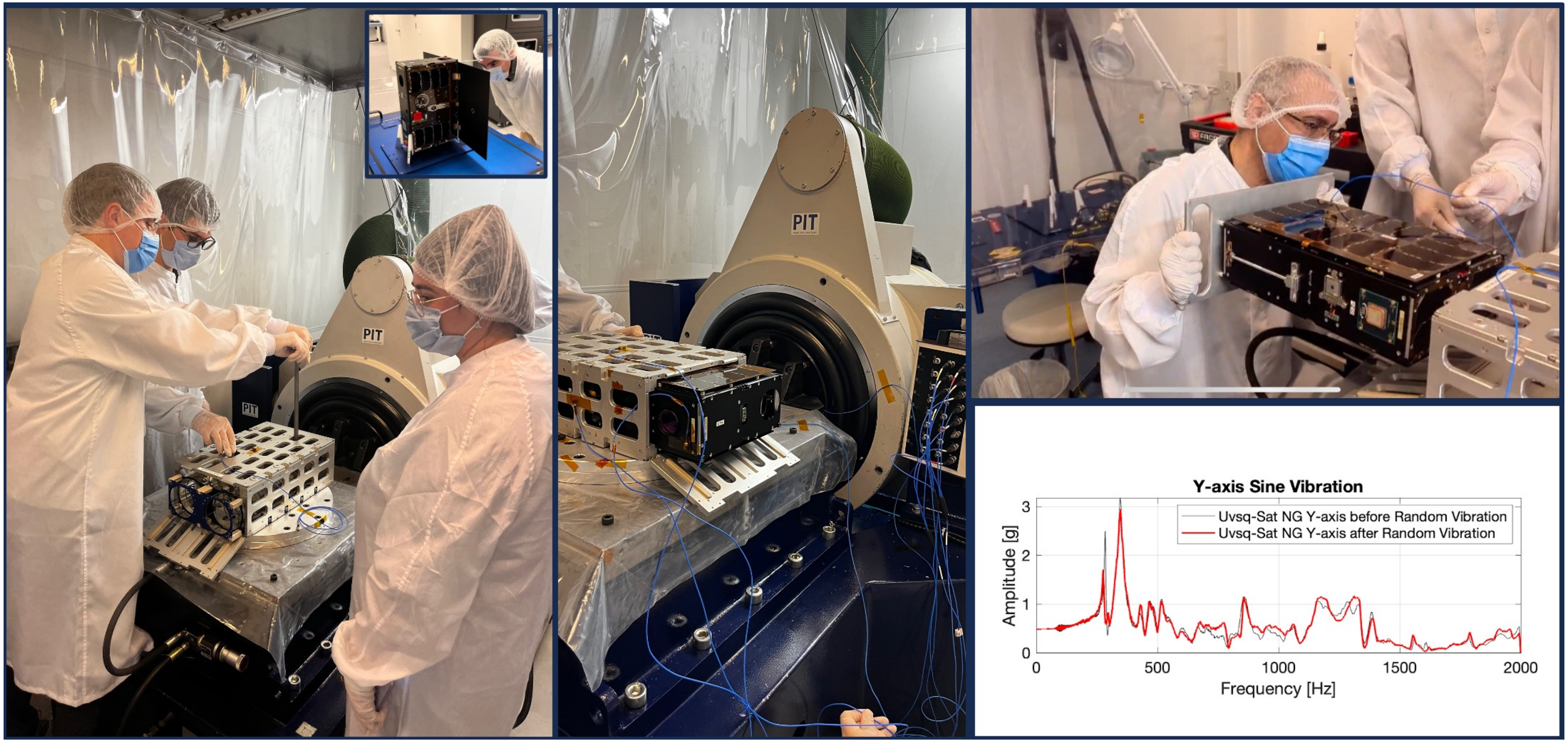

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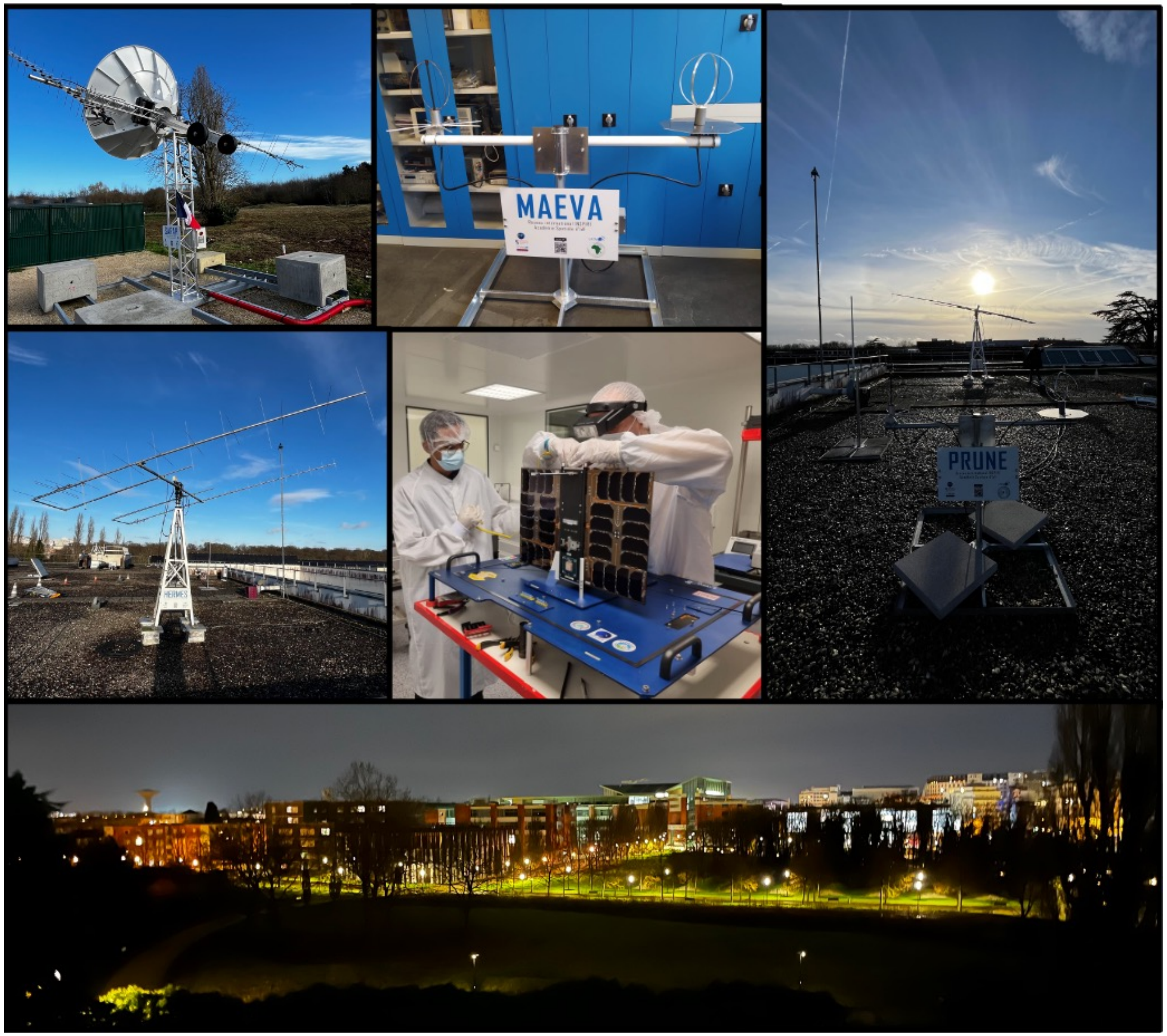


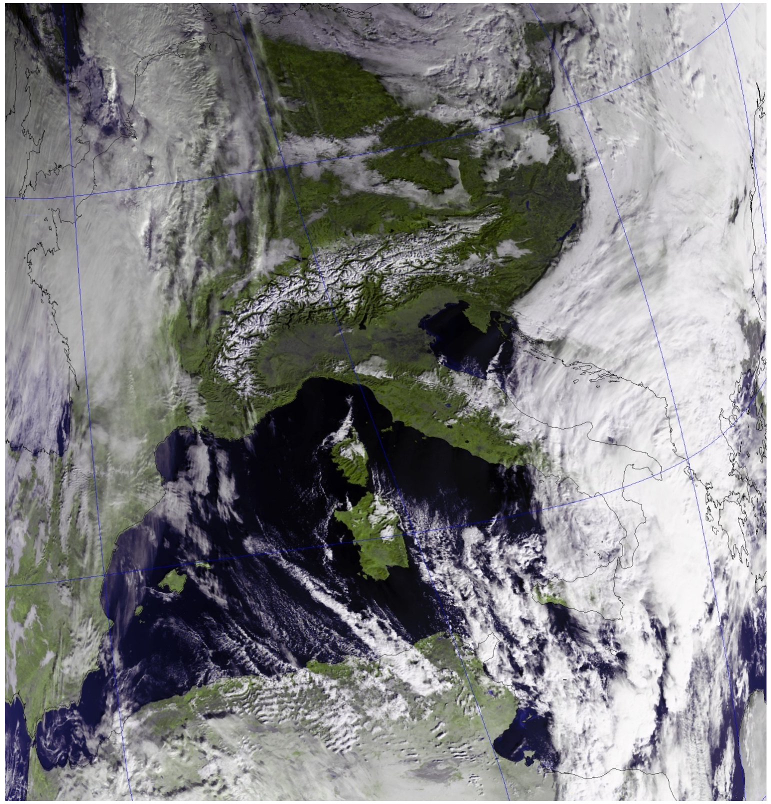

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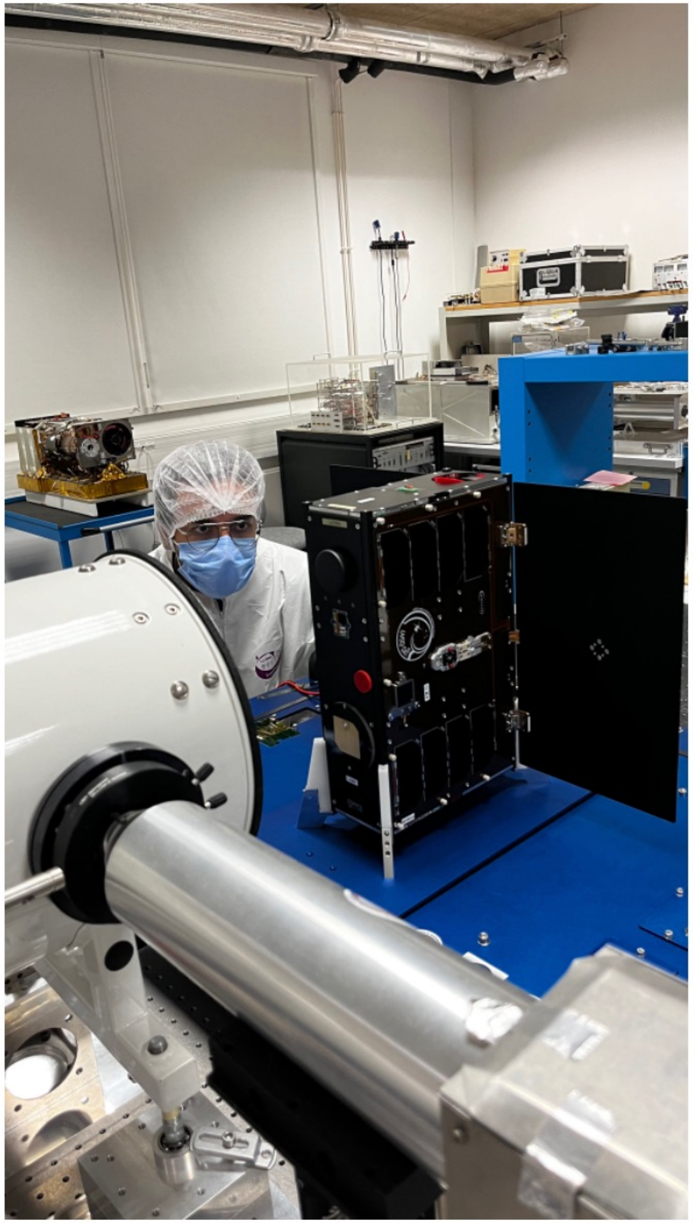

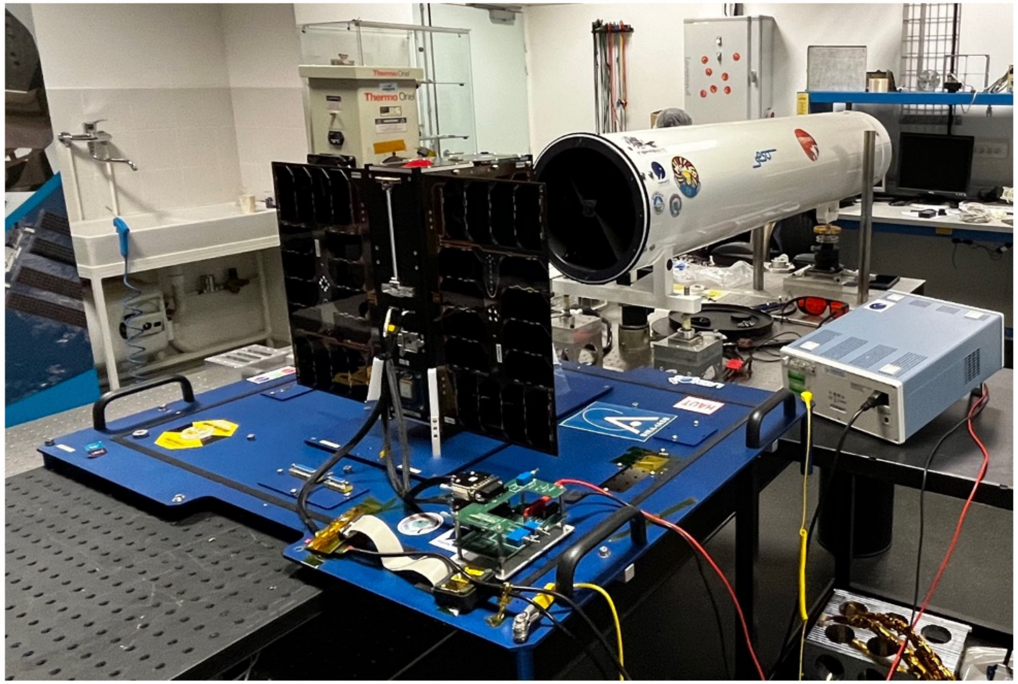

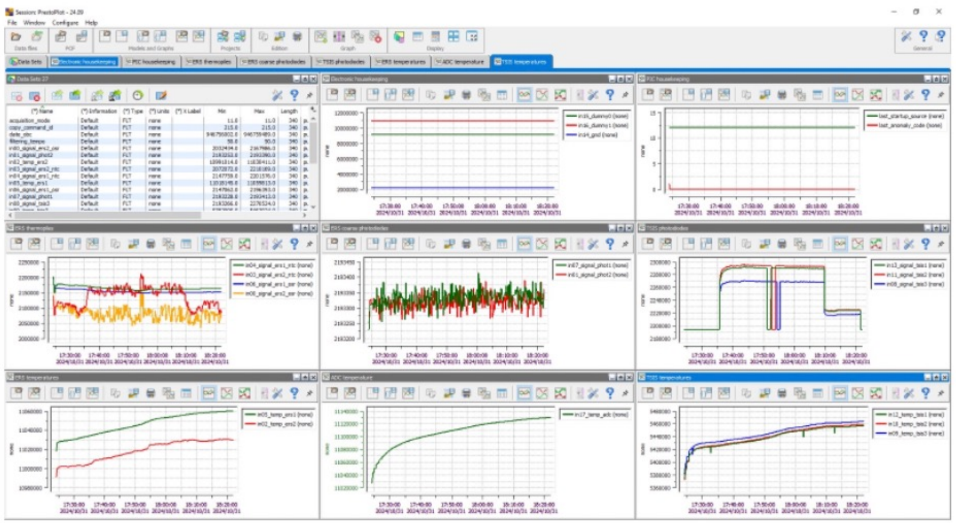

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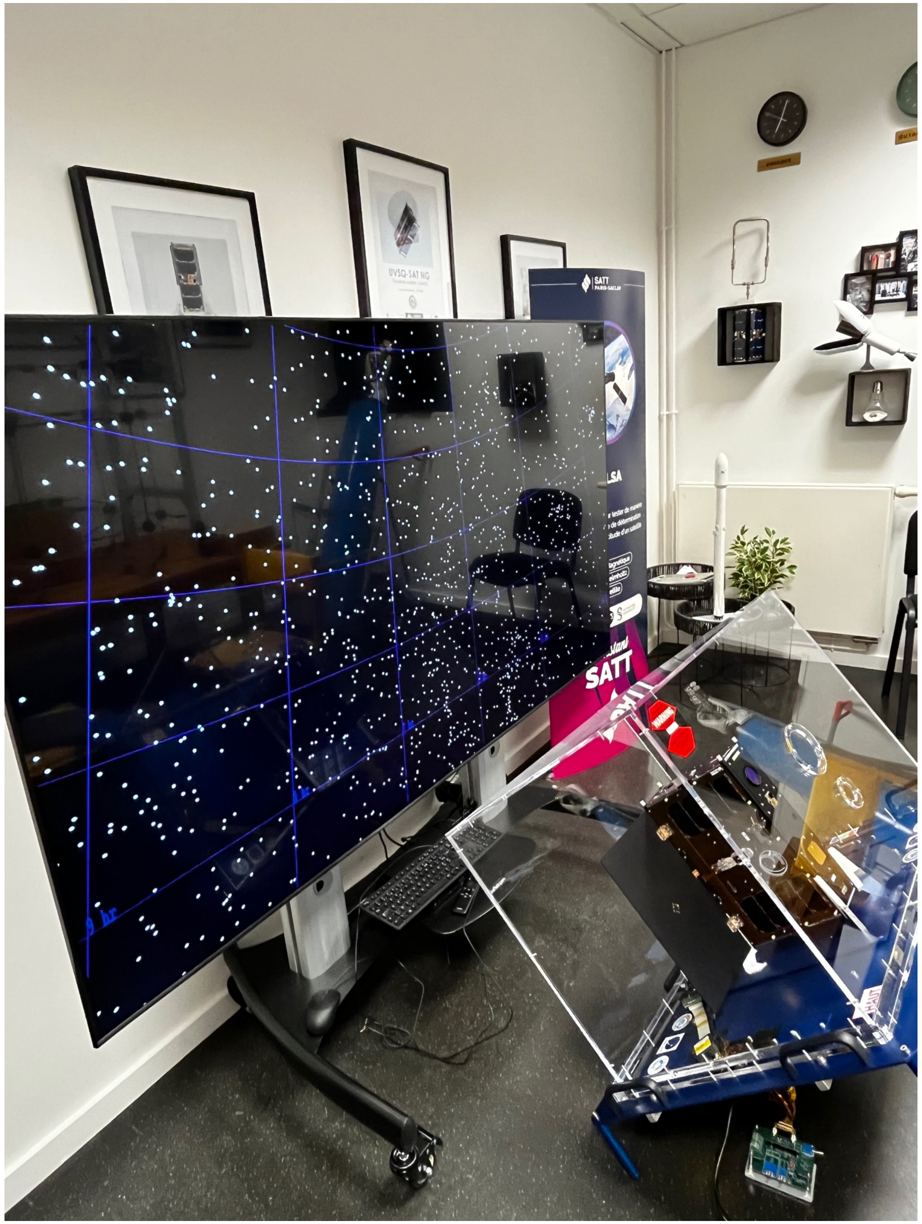


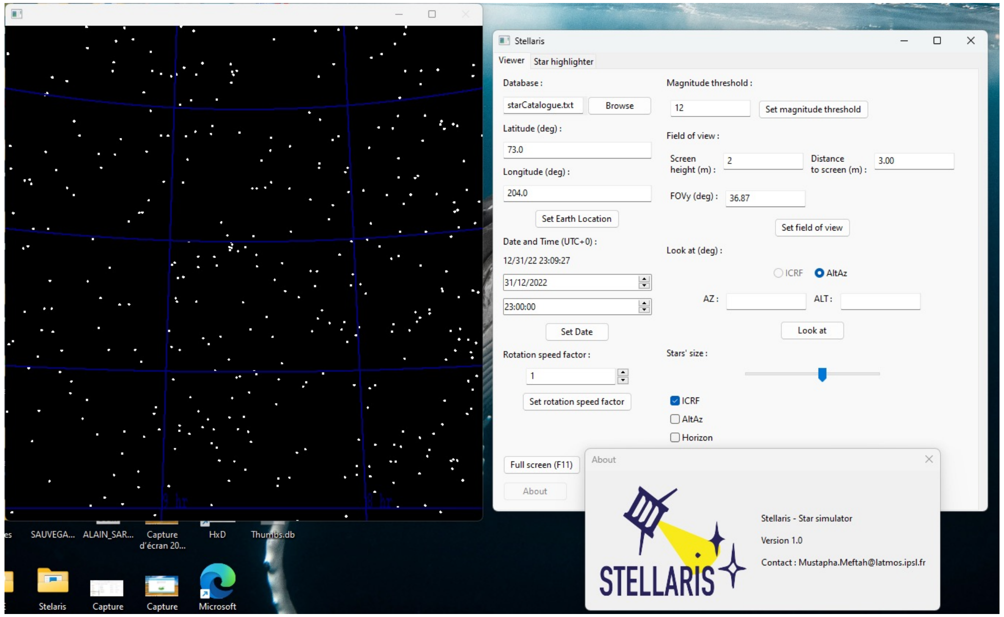

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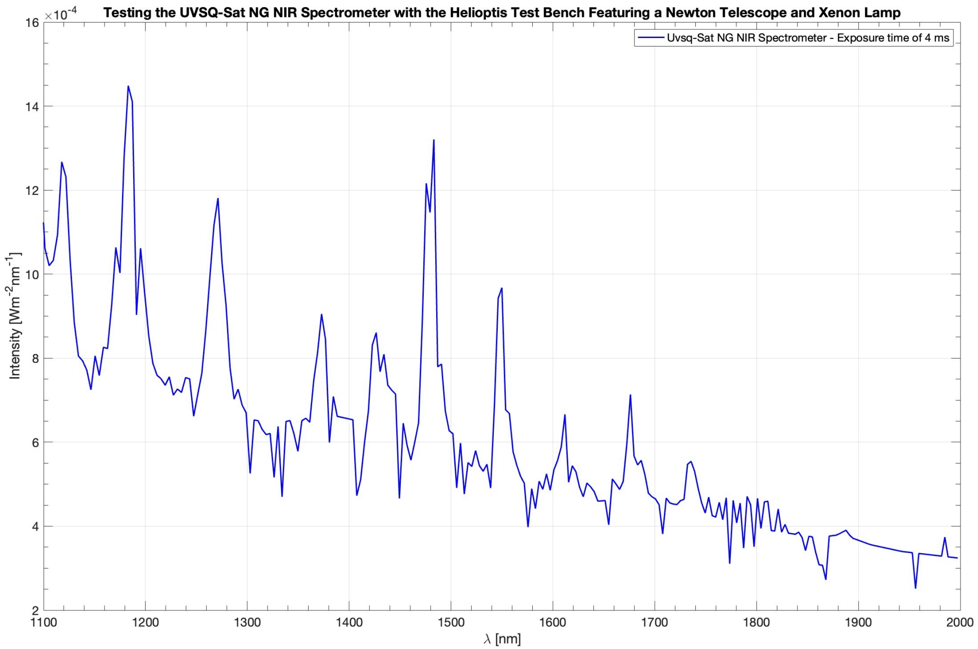


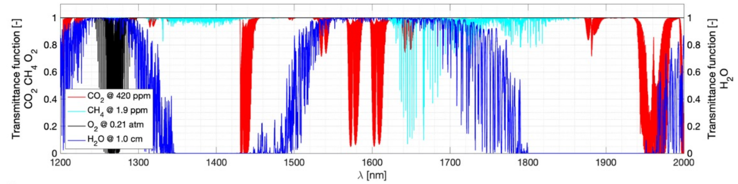


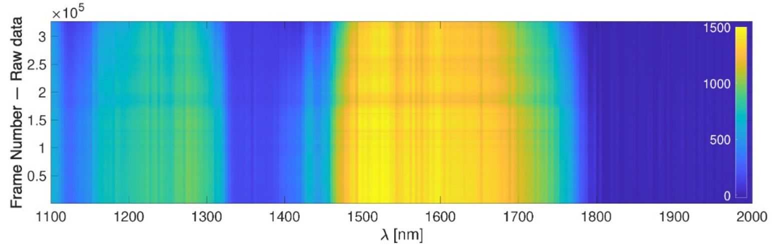


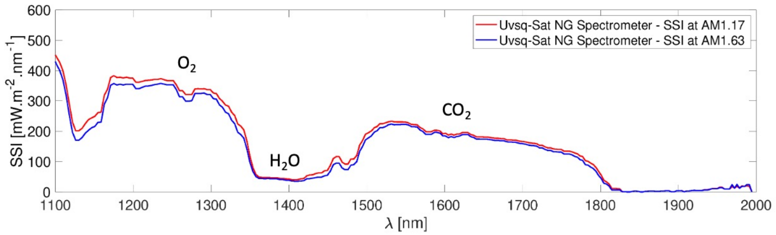


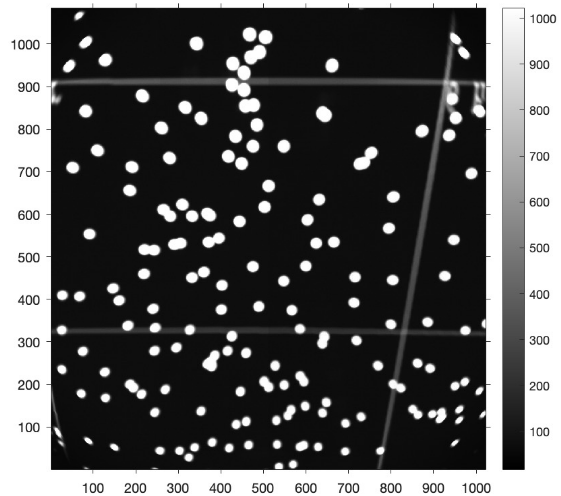

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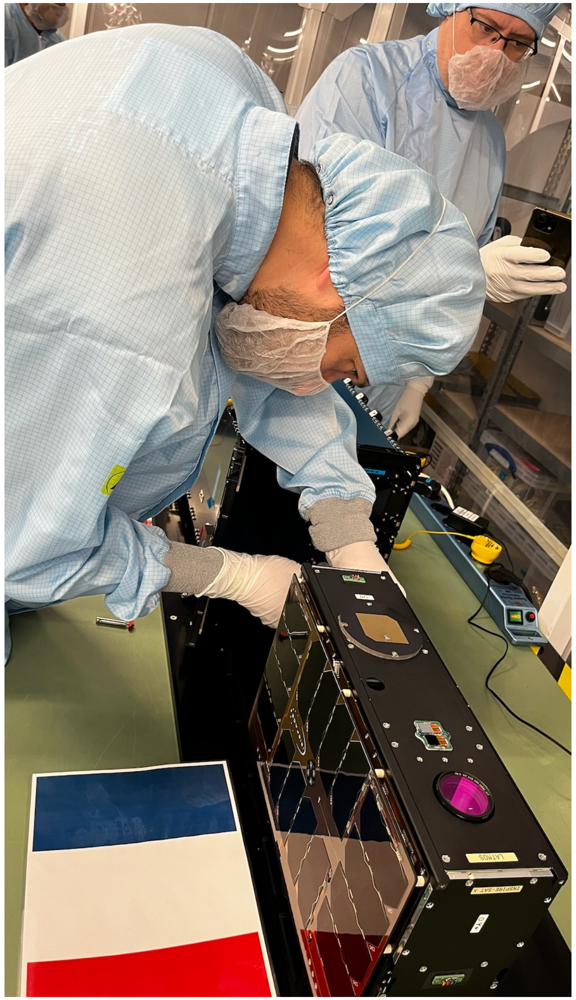

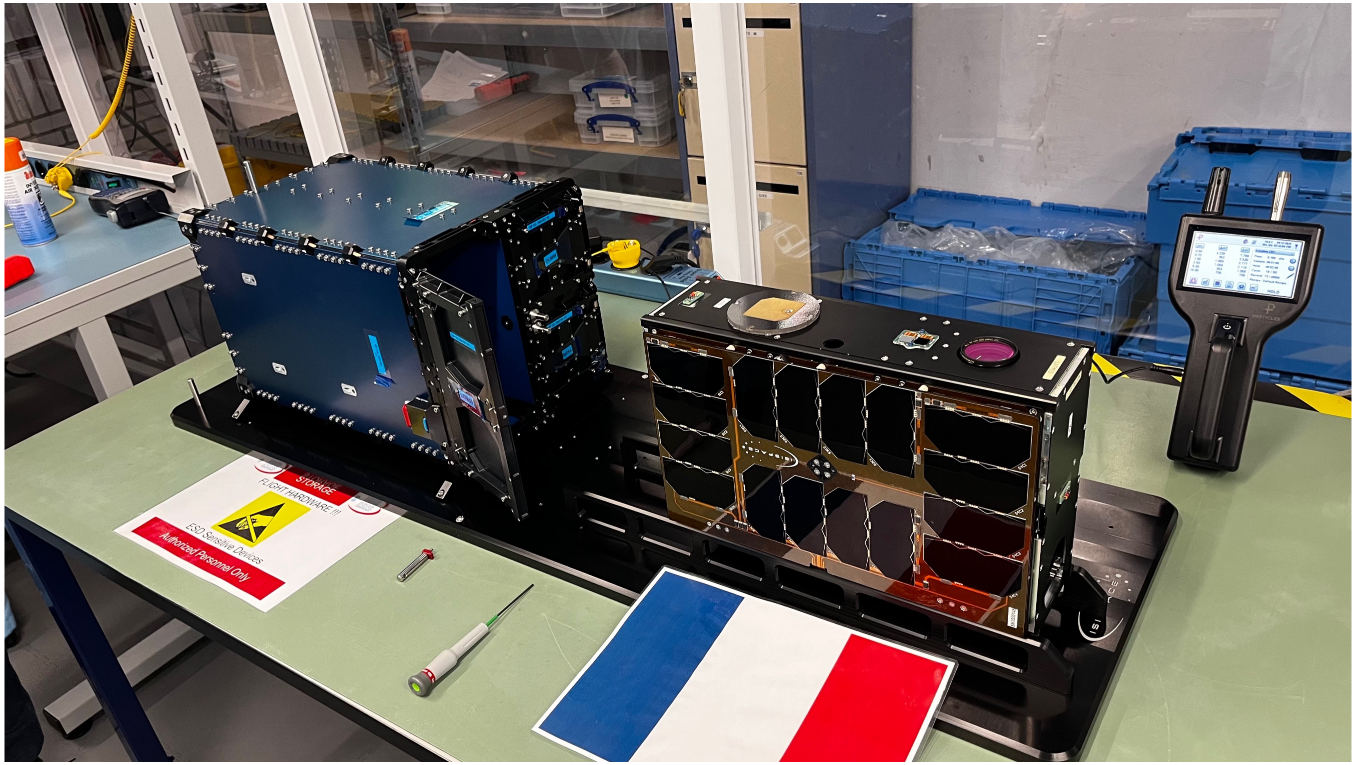

# Uvsq-Sat NG a satellite for observing Earth


**RÉPUBLIQUE FRANÇAISE**

Ministère de l'Éducation nationale,
de l'enseignement supérieur et de la recherche

Ministère de l'Économie, des finances
et de la souveraineté industrielle et numérique

**ARRÊTÉ du** 22 JAN. 2025

**portant autorisation à l'Université Versailles Saint-Quentin-en-Yvelines – Laboratoire atmosphères, milieux, observations spatiales (UVSQ-LATMOS) pour faire procéder au lancement par la société SpaceX depuis les États-Unis d'Amérique et assurer la mise en œuvre de l'opération de maîtrise dans l'espace extra-atmosphérique du satellite UVSQ-SAT NG**

**La Ministre de l'Éducation nationale, de l'enseignement supérieur et de la recherche et le Ministre de l'Économie, des finances et de la souveraineté industrielle et numérique,**

Vu la loi n°2008-518 du 3 juin 2008 modifiée relative aux opérations spatiales ;

Vu le décret n°2009-643 du 9 juin 2009 modifié relatif aux autorisations délivrées en application de la loi n°2008-518 du 3 juin 2008 relative aux opérations spatiales ;

Vu l'arrêté du 31 mars 2011 modifié relatif à la réglementation technique en application du décret n°2009-643 du 9 juin 2009 relatif aux autorisations délivrées en application de la loi n°2008-518 du 3 juin 2008 relative aux opérations spatiales ;

Vu la demande d'autorisation déposée par l'UVSQ-LATMOS enregistrée le 20 novembre 2024 ;

Vu l'avis du Président du Centre national d'études spatiales (CNES) par intérim en date du 14 janvier 2025 ;

Vu l'avis du Ministre des Armées en date du 17 janvier 2025 ;

# Conclusions

**Our main scientific goal is:**

**- To observe essential climate variables with a constellation of small satellites.**

**- To observe Auroras ...**

**The INSPIRE goals are:**

- To initiate a Space Program, and to teach courses related to Space.
- To have Laboratory facilities for hardware development and specialized personnel for teaching.
- To have facilities for building and testing CubeSat/small Instruments.
- To have ground stations for satellite operations.

**Our positions are:**

- To Design for simplicity and robustness:
  – Assume designs will fail and then prove they will work.
  – Design the satellite for easy assembly and disassembly.
  – Have respectable margins, robust safe modes, few deployables, graceful performance. degradation, and frequent preventative satellite resets.
- To Build an experienced team—it matters:
  – A successful team has veteran member(s) and frequent informal peer reviews (discussions) with proven subject matter experts.

Thank you for your attention