

# The ASI contribution to the monitoring of GHGs from space

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2021  
CLIMATE

# ASI Earth Observation at glance:

*for our planet, for our future...*

*...ensure the understanding, monitoring and protection of our planet guaranteeing the maximum benefit for science, applications, society and economic growth of Italy...*

*ASI implements this vision through its Earth observation programs developed in Italy, in Europe (ESA, EU, EUMETSAT) and within the widest international framework.*

*ASI plays an architect role in the definition, development, procurement, exploitation and evolution of the space assets through its National industry and science and application community, contributing actively to the major European infrastructures.*

## Our 8 major objectives in Earth Observation

*Sustain the Future of Synthetic Aperture Radar*

- New instruments and constellations (X/L/P Bands)
- Developments for large reflectors/deployable antennas
- SAR Technology Roadmap

*Secure the leadership in Hyperspectral payload*

- Hyperspectral Next Generation
- Miniaturized Hyperspectral Mission (PLATiNO)
- Hyperspectral Technology Roadmap

*Strengthen developments in Thermal Infrared*

- TIR Mission based on minisatellite (PLT-2)
- ASI-NASA TIR mission
- TIR Technology Roadmap

*Achieve autonomy in HR systems*

- HR Mission based on minisatellite (Feasibility study)
- Optical Technology Roadmap

*Consolidating the Lidar capability*

- Lidar mission (Feasibility study)
- Lidar Technology Roadmap

*Sustain development of new instruments*

- Radiometers, Quantum Gravimetry, etc
- Technology roadmap

*Strengthen Earth science and applications*

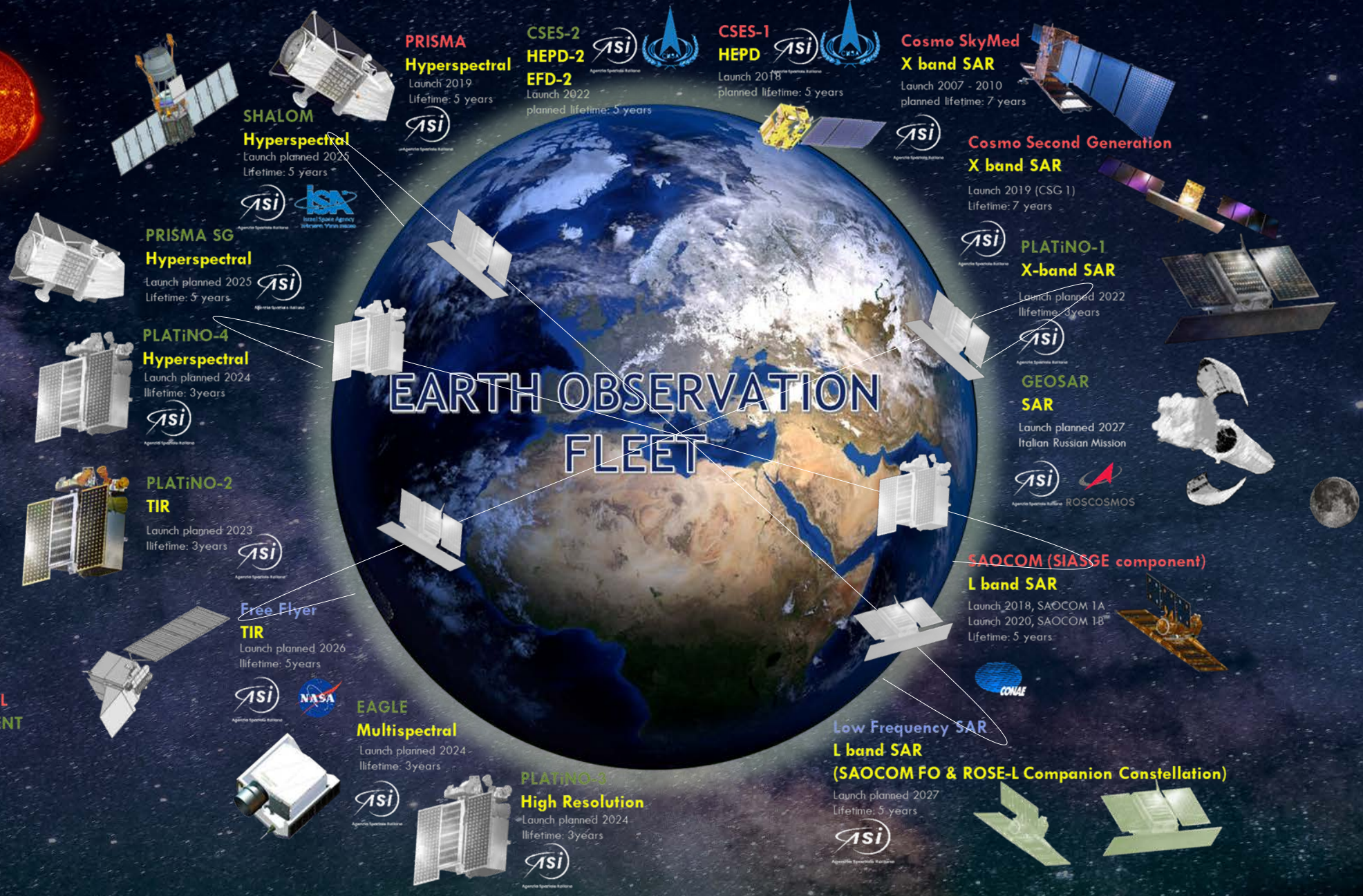
- Scientific and application projects 1) to understand earth system and interaction between process and 2) to deliver information to enhance quality of life and strengthen our economy

*Pull users towards our applications and services layers*

- Demonstrators
- Application Services Start-Up

# EARTH OBSERVATION FLEET

OPERATIONAL  
IN DEVELOPMENT  
PLANNED



- Monitoring of GHGs from space is one of the challenges of the Earth Observations infrastructures, considering spatial, spectral, and temporal resolutions.
- Still, significant uncertainties on the sources of the main greenhouse gases: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O).
- The only way to attenuate climate change is to monitor and reduce anthropogenic emissions of CO<sub>2</sub> and CH<sub>4</sub>.



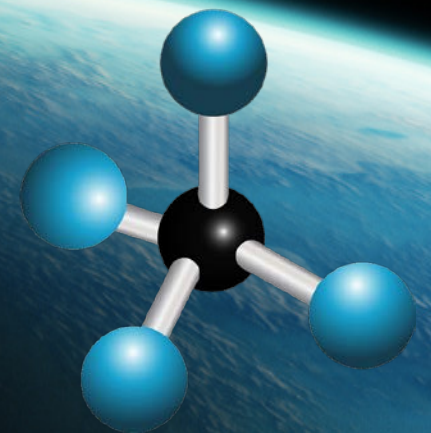
*Steel plant, Taranto (Italy)*

# CH<sub>4</sub> MAPPING FROM SPACE

- Industrial methane emissions play a major role in the methane budget
- Emitters are typically “point sources”: strong emissions as plumes from small surface elements
- Typically a small number of emitters account for a large fraction of the total emissions



- **High spatial resolution measurements are needed.**
- **The capability of imaging spectroscopy for methane mapping has been demonstrated since 2010 with JPL's AVIRIS (Airborne Visible / Infrared Imaging Spectrometer).**



METHANE



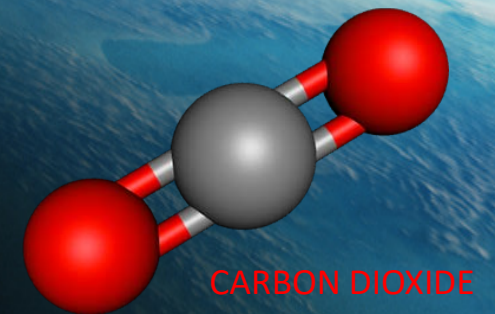
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# CO<sub>2</sub> MAPPING FROM SPACE

- Carbon dioxide (CO<sub>2</sub>) emissions from power plants represent one of the largest sources of anthropogenic greenhouse gases;
- Strong point sources dominate carbon dioxide emissions;
- CO<sub>2</sub> estimations often lack atmospheric measurements and instead rely on fuel consumption, population dynamics, and other data.



- **Remote sensing with imaging spectrometer instruments offers a new capability to do top-down monitoring**
- **PRISMA hyperspectral mission provides 30 m spatial resolution and allows quantification of CO<sub>2</sub> emissions at the facility scale**



# PRISMA

*PRISMA, fully funded by the Italian Space Agency (ASI), is an in-orbit Earth Observation system with an innovative, electro-optical instrumentation that simultaneously combines data of a hyperspectral sensor and a panchromatic camera from the same scene.*

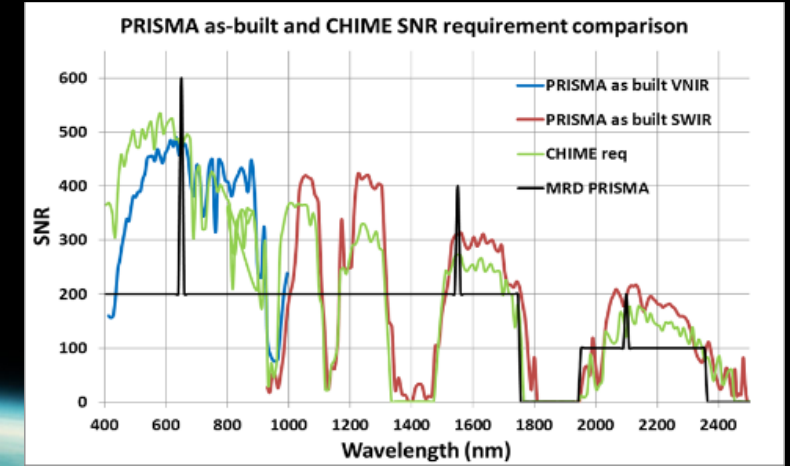
## SPECS

240 total bands in VNIR (#66, 400–1010 nm) & SWIR (#174, 920–2505 nm) at a spatial resolution of 30 m on a swath of 30 km

Mean spectral resolution of 10 nm in a spectral range of 400-2500 nm

Pan (Panchromatic) imagery is provided at a spatial resolution of 5 m

Simultaneous acquisition of images in the VNIR, SWIR and PAN on the same scene!

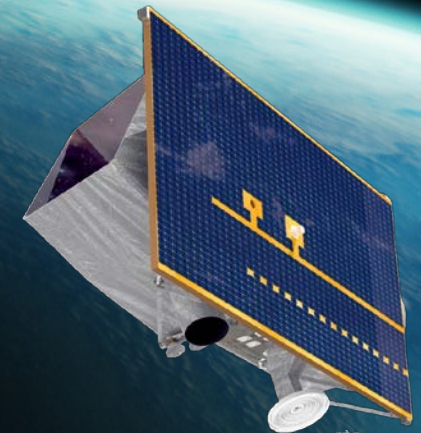


## Mission

Providing global observation capability for monitoring of natural resources and atmospheric characteristics

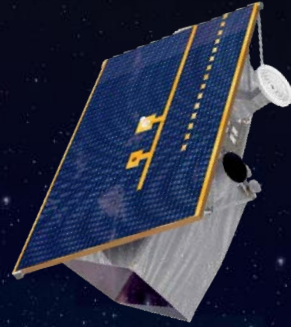
## Mission Topics

- Land Cover
- Pollution and water quality
- Carbon Cycle
- Soil Moisture



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# Hyperspectral remote sensing: how PRISMA works

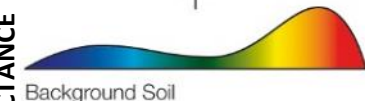
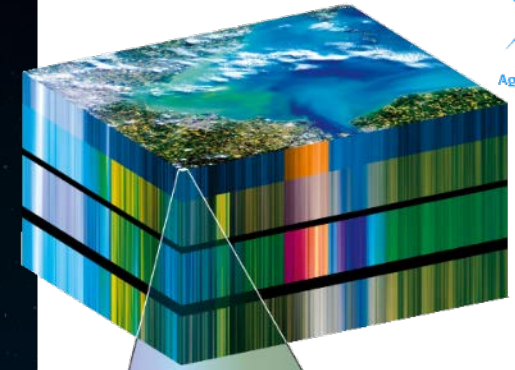


VISIBLE REFLECTED ENERGY

PRISMA's visible channels capture sunlight reflected off Earth and only see during the daytime.

PRISMA's infrared channels detect energy that is not visible to the human eye. They collect energy that is emitted by objects such as the surface of Earth and clouds. It can detect infrared energy day or night.

INFRARED EMITTED ENERGY



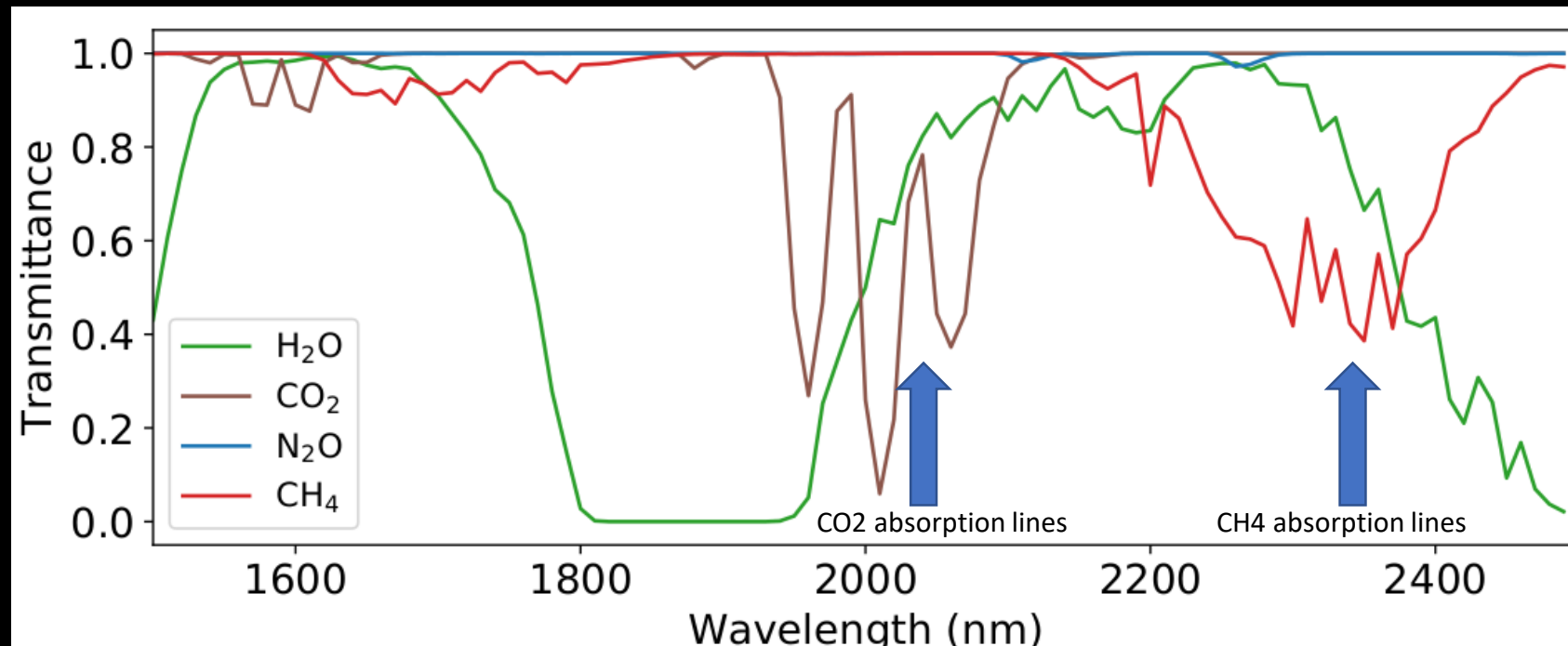
REFLECTANCE

0.4  $\mu\text{m}$

2.5  $\mu\text{m}$

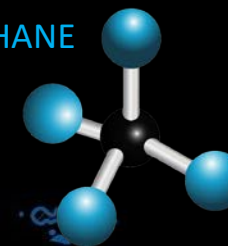
# PRISMA CH<sub>4</sub> and CO<sub>2</sub> MAPPING FROM SPACE

- Imaging spectrometers like PRISMA measures solar radiance reflected off the Earth's surface, producing an image where each pixel has a detailed spectrum containing information on surface and atmospheric properties.
- Imaging spectrometers measure narrow spectral bands (e.g. 10 nm for PRISMA) in the shortwave infrared, capturing **absorption features** between 2 and 2.5  $\mu\text{m}$  wavelength caused by atmospheric CO<sub>2</sub> and CH<sub>4</sub>
- Increased CO<sub>2</sub>/CH<sub>4</sub> concentration within a pixel's spatial resolution produces stronger absorption



# CH4 POINT EMISSION FROM PRISMA

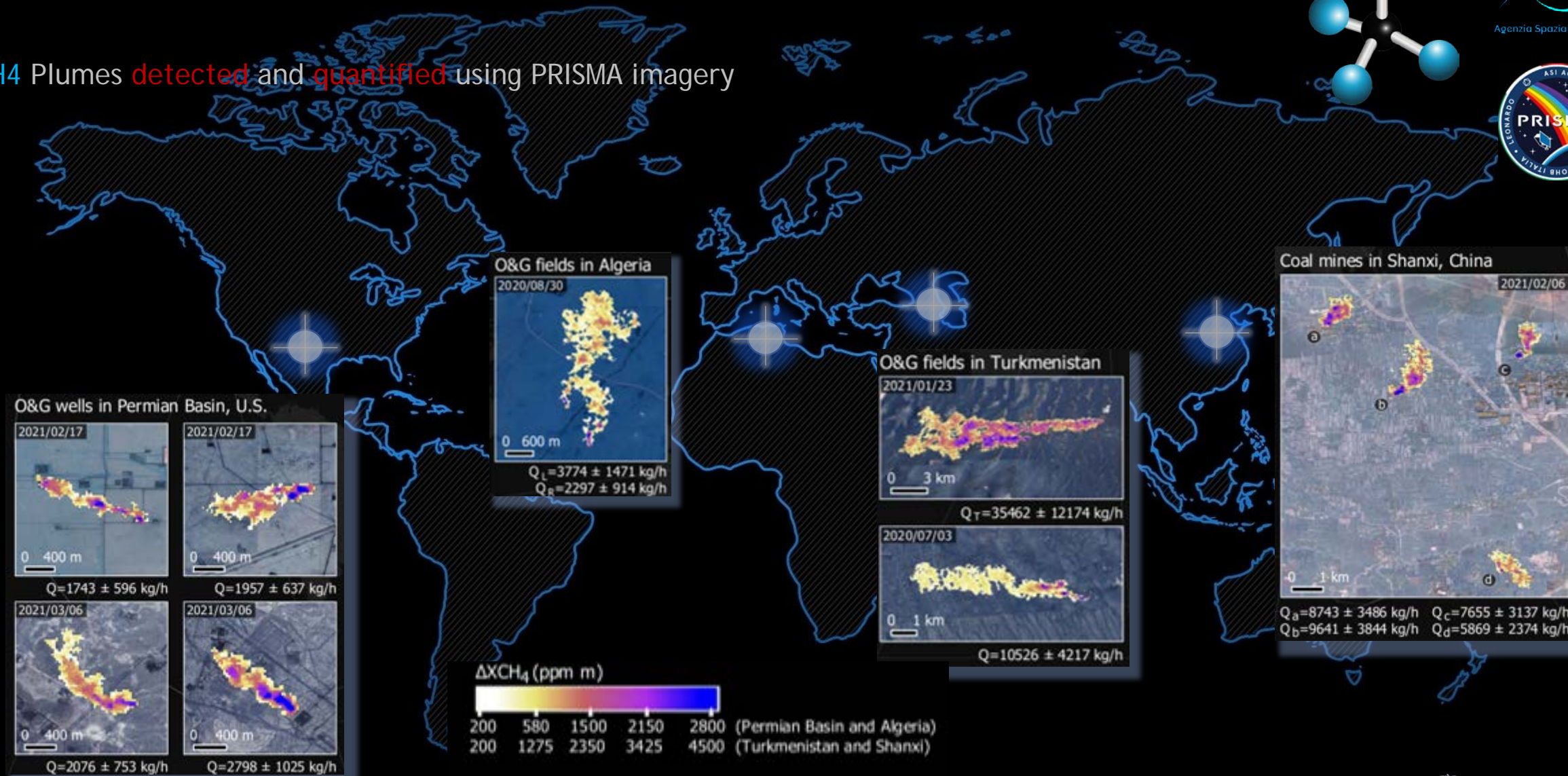
METHANE



Agenzia Spaziale Italiana



CH4 Plumes detected and quantified using PRISMA imagery



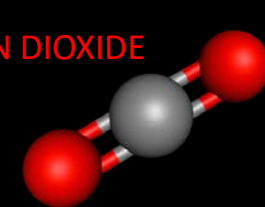
Information generated by Guanter L. et al. presented at ASI Hyperspectral Remote Sensing Workshop 2021, under an ASI License to Use; Original PRISMA Product - © ASI - (2020-2021)."



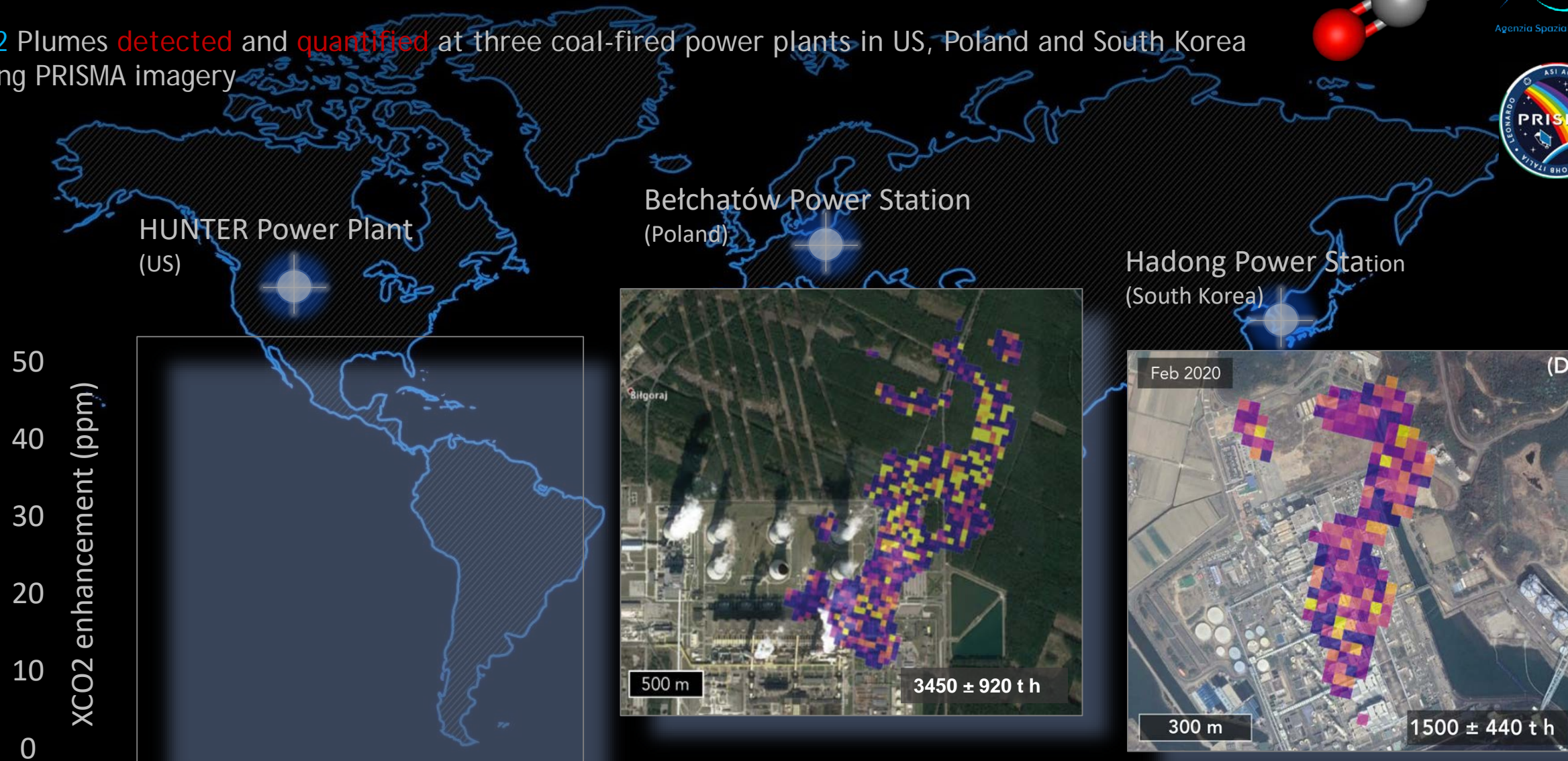
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# COAL AND GAS FIRED POWER PLANTS from PRISMA

CARBON DIOXIDE



Co<sub>2</sub> Plumes **detected** and **quantified** at three coal-fired power plants in US, Poland and South Korea using PRISMA imagery



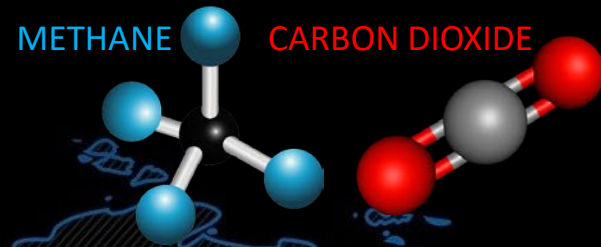
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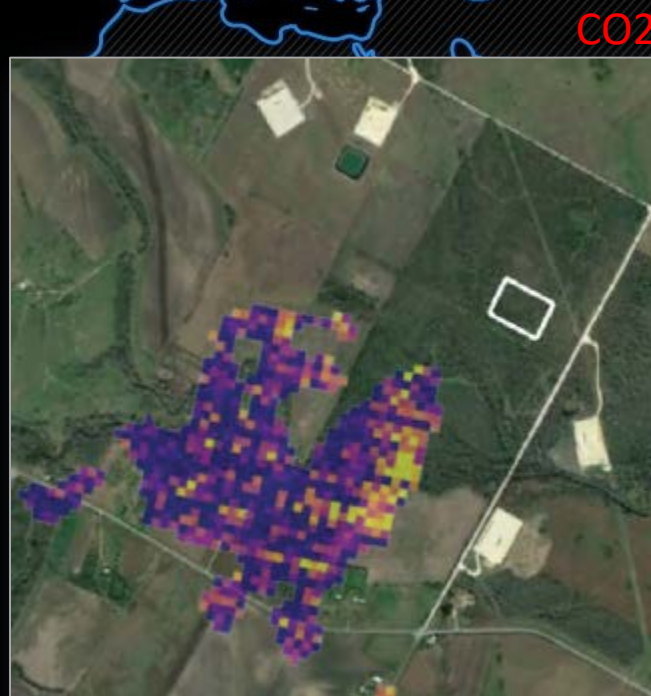
# COAL AND GAS FIRED POWER PLANTS from PRISMA

Simultaneously retrieving column averaged  $\text{CO}_2$  and  $\text{CH}_4$  concentrations with high spatial resolution

This capability has not been available or demonstrated with any single satellite instrument previously



Eagle Ford Share, Victoria, Texas (US)



Information generated by Cusworth D. et al. Geophysical Research Letters, 48(2), under an ASI License to Use; Original PRISMA Product - © ASI - (2020-2021)."

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*PRISMA Second Generation is the future Hyperspectral Italian Mission, to be launched in 2025.*

- *Entirely Funded by the Italian Space Agency*
- *Hyperspectral data continuity currently available by the PRISMA system.*

# PRISMA

## 2<sup>nd</sup> Generation

### SPECS

**SWATH and SNR:** on demand techniques of SWATH enlargement and SNR enhancement on a single pass, by the use of platform agility.

**Acquisition modes: STRIPMAP and SPOTLIGHT.**

- STRIPMAP image: VNIR/SWIR GSD  $\leq 30$  m and PAN GSD  $\leq 5$  m, swath  $\geq 30$  km and indefinite length with a Daily STRIPMAP Imaging Capacity (acquire, downlink and archive) more than 2.000.000 km<sup>2</sup>.
- SPOTLIGHT image (on-demand): VNIR/SWIR GSD  $\leq 10$  m and PAN GSD  $\leq 2,5$  m, swath  $\geq 30$  km and length up to 210 km with a Daily SPOTLIGHT Imaging Capacity (acquire, downlink and archive) more than 200.000 km<sup>2</sup>.

**Low revisit time (72 h with a maximum off-nadir angle of  $\pm 30^\circ$ )**

# CONCLUSIONS

- PRISMA has the capability of detecting and quantifying GHG such as CO<sub>2</sub> and CH<sub>4</sub> at high spatial resolution
- Joint CO<sub>2</sub>/CH<sub>4</sub> remote sensing capability allows for fuller GHG accounting at co-emitting facilities
- The majority of global power plant CO<sub>2</sub>/CH<sub>4</sub> emissions can be monitored with current and coming hyperspectral missions.
- Methods for the detection and quantification of strong methane point emissions with PRISMA can play an important role in the ongoing international effort to detect methane point emissions
- PRISMA Second Generation, with on-demand enhanced spatial resolution down to 10 meters, will enhance the monitoring of GHG emissions.

*Thank You for your attention*

*Register on ASI website to download products and request acquisitions of PRISMA:  
<https://www.asi.it/en/earth-science/prisma/>*