

# living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE  
OF OUR PLANET FROM SPACE



## The Copernicus Hyperspectral Imaging Mission For The Environment (CHIME)

Marco Celesti, Michael Rast, Jennifer Adams, Ferran Gascon,  
Jens Nieke

26/05/2022



**Jens Nieke, Marco Celesti, Michael Rast\*, Jennifer Adams\*\*, Gianluigi di Cosimo, Antonio Gabriele, Claudia Isola, Heidrun Weber, Helene Strese, Ferran Gascon, Valentina Boccia, Claudia Wildner (and many others)**  
**European Space Agency**

**Ivan Konaktchiev, Peter Strobl, Cristina Ananasso\*\*\***  
**European Commission**

**Andrew Skidmore, Heike Bach, Eyal Ben-Dor, Sabine Chabrillat, Cindy Ong, Claudia Giardino, Giovanni Rum, Jean-Baptiste Feret, Luis Guanter, Martin Schlerf, Martin Schodlok, Matthew Williams, Michael Schaepman, Robert O. Green, Roberto Colombo, Stuart Marsh, Tobias Storch**  
**Members of the CHIME MAG**

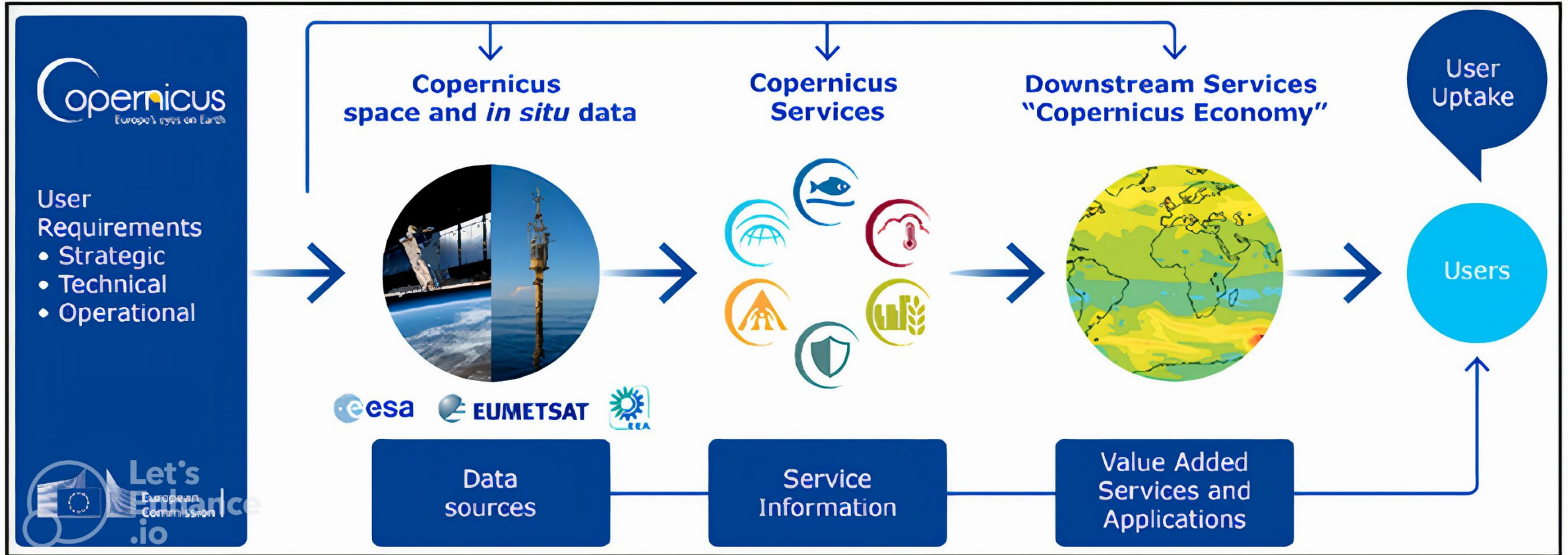
**CHIME**  
Copernicus Hyperspectral Imaging  
Mission for the Environment

\* now at ISSI Bern

\*\* now at University of Zurich

\*\*\* now at ECMWF

# Sentinels: a key element in Copernicus



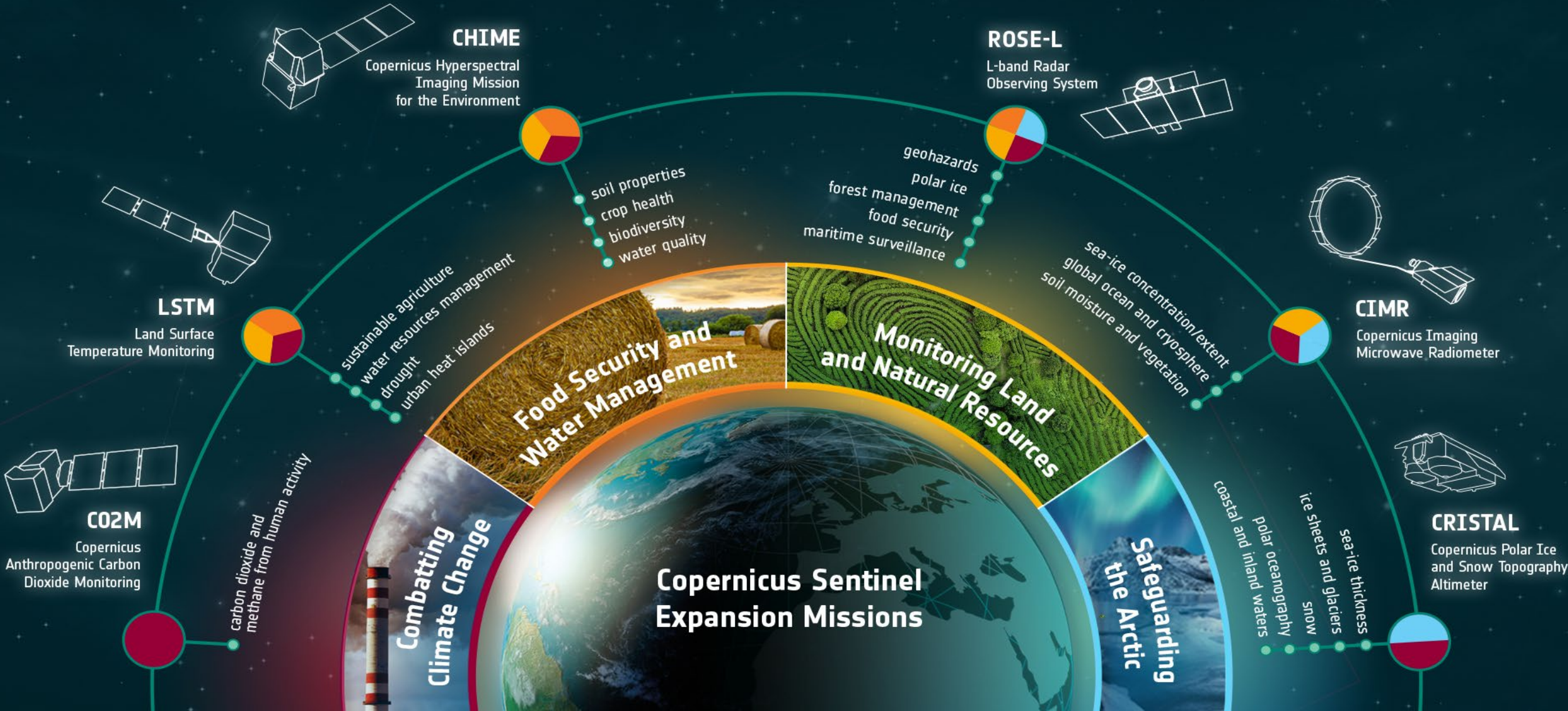
## Copernicus Users Uptake Strategy



PROGRAMME OF THE  
EUROPEAN UNION



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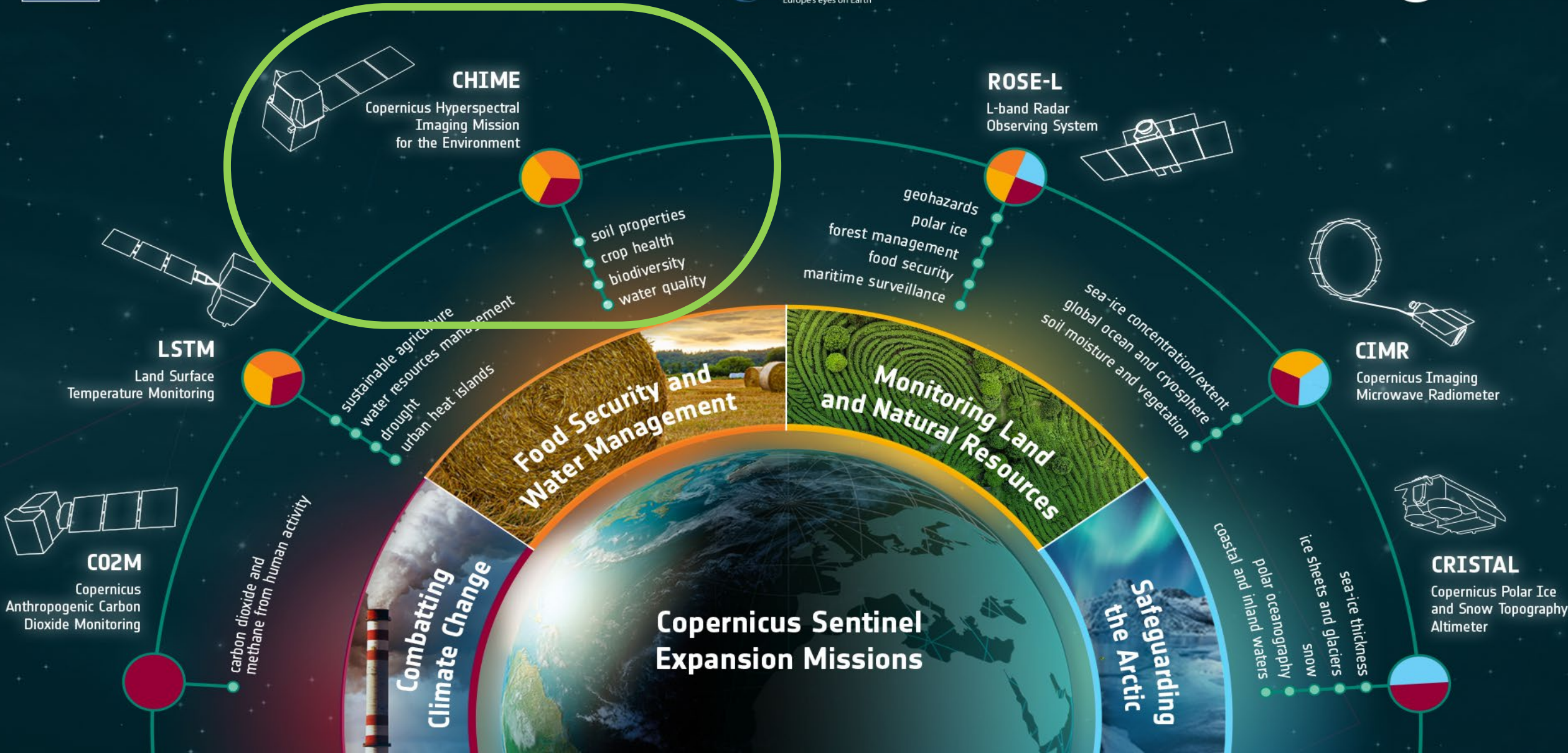




PROGRAMME OF THE  
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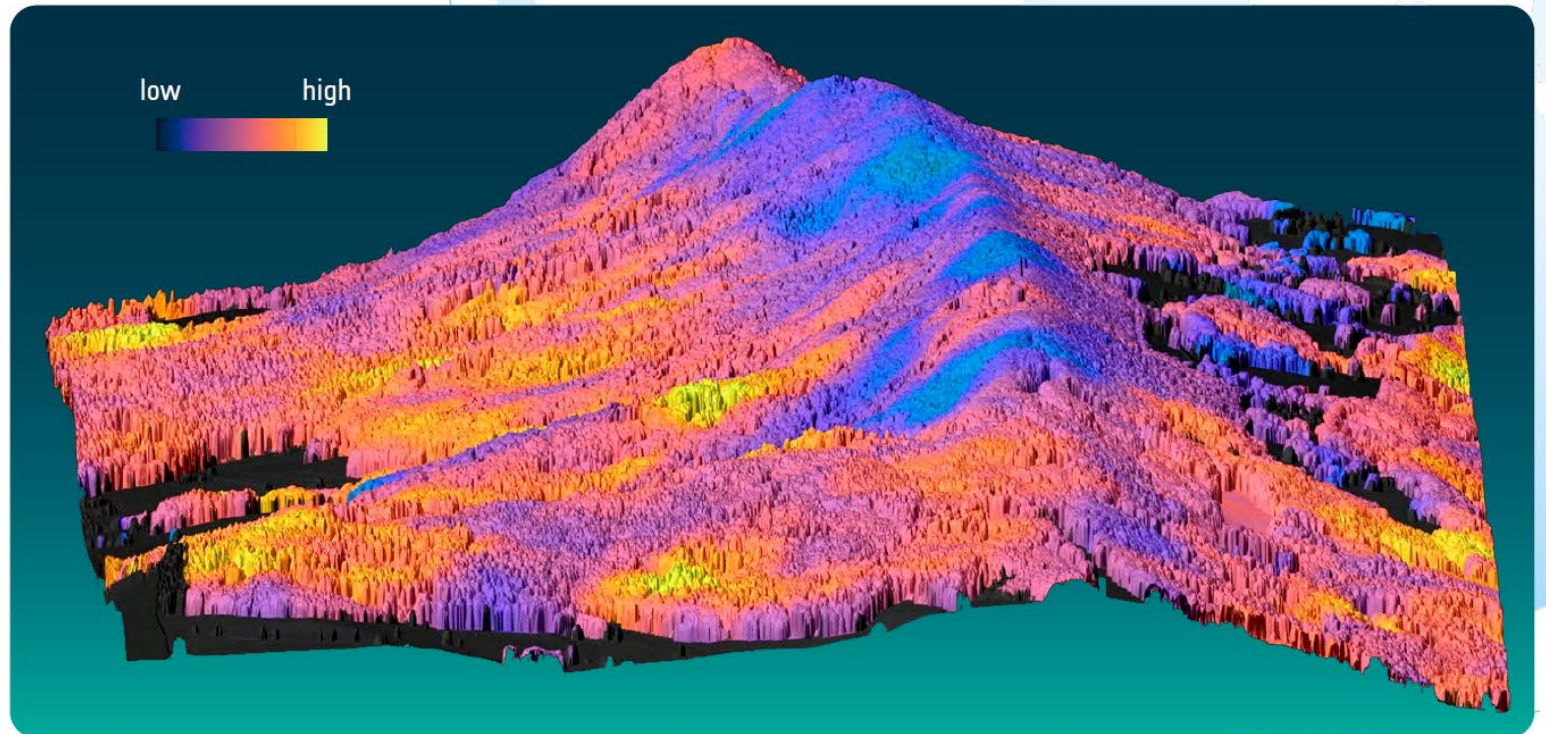
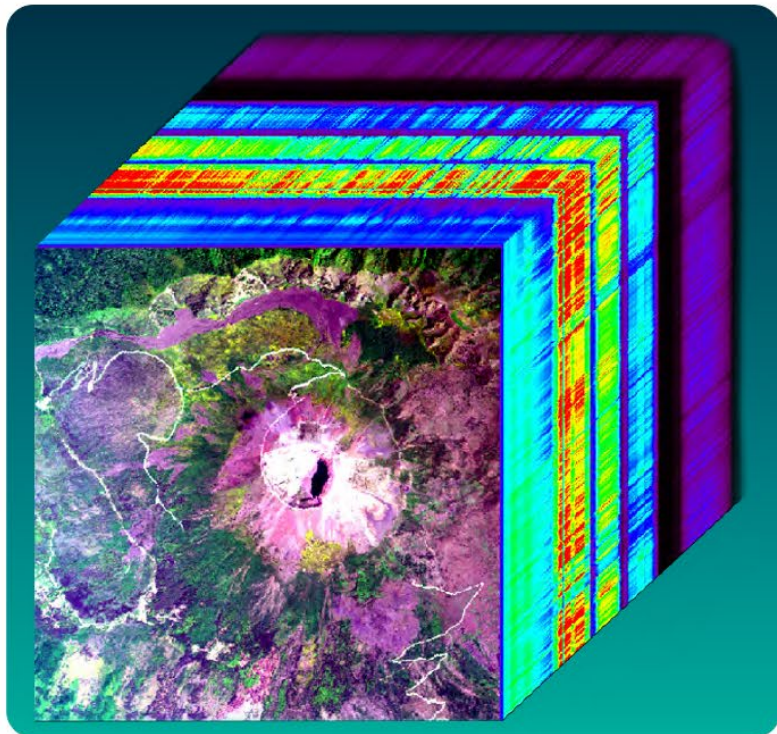


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# CHIME Mission Objectives

- Provide routine hyperspectral measurements in support of EU- and related policies for the management of natural resources & assets
- Support food security, agriculture and raw materials, soil properties
- Secondary Applications: biodiversity and ecosystem sustainability, forestry management, environmental degradation, lake/coastal ecosystems and water quality, snow grain size/albedo, snow impurities]



Physiological diversity of a temperate forest (Airborne imaging spectroscopy APEX data - Schaepman, Jehle et al. 2015)

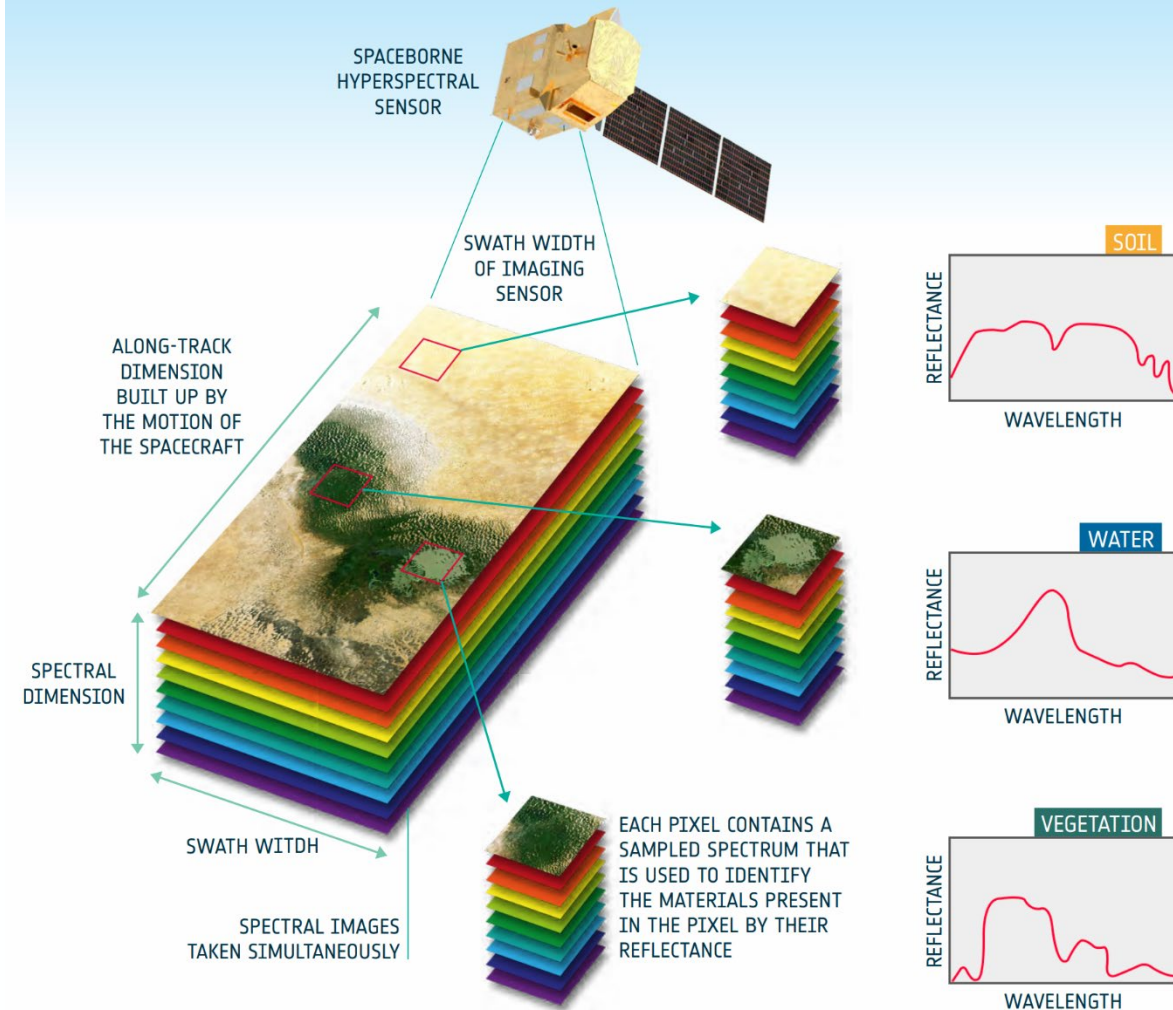
# CHIME Key Mission Requirements

- Operational hyperspectral observations of land and coastal areas
- Spectral range: 400 – 2500 nm
- Spectral bandwidth and SSI  $\leq 10\text{nm}$
- Ground Resolution: 30 m
- Revisit 12.5 days (2 satellites)
- High radiometric accuracy, low spectral/spatial mis-registration
- High SNR

→ Matching performance of parallel IS missions (e.g. EnMAP, PRISMA, SBG)




## Core data products:

- L1-B Top-of-atmosphere (TOA) radiance
- L1-C Ortho-rectified TOA reflectance
- **L2-A Ortho-rectified bottom-of-atmosphere (surface) reflectance**






# CHIME High Priority Prototype L2-B Products



DOMAIN	THEMATIC AREA	VARIABLES CHPPP	CHIME Candidate Algorithms
AGRICULTURE / FOOD SECURITY	 <p>Assessment of biophysical and biochemical variables related to the crops and of agronomic interest</p>	Leaf/Canopy Pigment Content	<p>Semi-empirical modelling based on narrow-band vegetation indices; Hybrid methods based on ANN/LUT or other machine learning algorithms applied to vegetation canopy radiative transfer models outputs (e.g. PROSAIL).</p> <p>Narrow-band vegetation indices; Hybrid methods based on ANN/LUT or other machine learning algorithms e.g. GPR methods applied to vegetation canopy reflectance models (e.g. PROSAIL).</p>
		Leaf/Canopy Nitrogen Content	
		LAI	
		Canopy Water Content	
		Leaf/Canopy Pigment Content	
		Leaf Mass/Area	
	 <p>Topsoil properties</p>	Soil organic carbon content	<p>Chemometrics modelling (e.g. PLSR); Spectral analysis; Spectral indices; Machine learning (e.g. Random Forest)</p>
		Soil texture (clay, silt, sand)	
GEOLOGY & MINERALS	 <p>Raw material detection</p>	Mineral identification / classification (Kaolinite, Smectite, Jarosite, Dolomite)	<p>Sub-pixel linear unmixing Tetracorder type (EnGeoMap/PRISM)</p>
		Hematite – Goethite distribution	
		Ferric oxide content	
		Kaolin Crystallinity	



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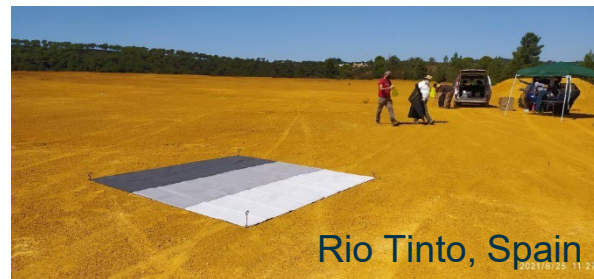
# CHIME “Hypersense” Campaigns

2018 – Ground / Airborne

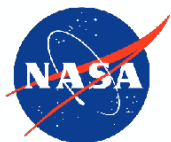
2020 – Ground / ~~Airborne~~ / Spaceborne

**2021 – Ground / Airborne / Spaceborne**

- 17 fully successful sites (+1) across Europe
- Exceptional coordination between all teams (including PRISMA and DESIS)
- Concurrent Ground / Airborne / Spaceborne acquisitions over 8 sites
- **Direct input to RCS, E2E and L2 studies**
- Open data policy fostering community exploitation



AVIRIS-NG Surface Reflectance (RGB)  
22<sup>nd</sup> June 2021 - Jolanda di Savoia (IT)



University of Zurich  
UZH



European Space Agency



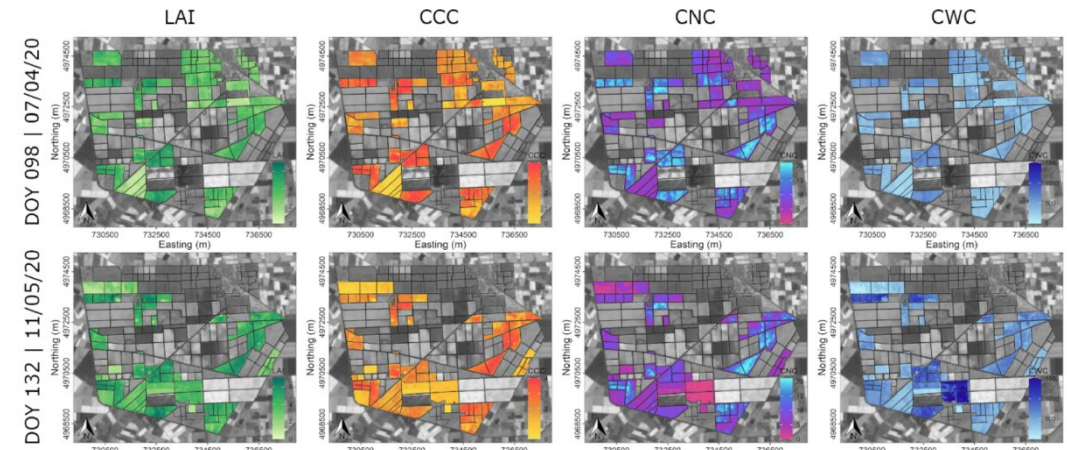
Agenzia Spaziale Italiana



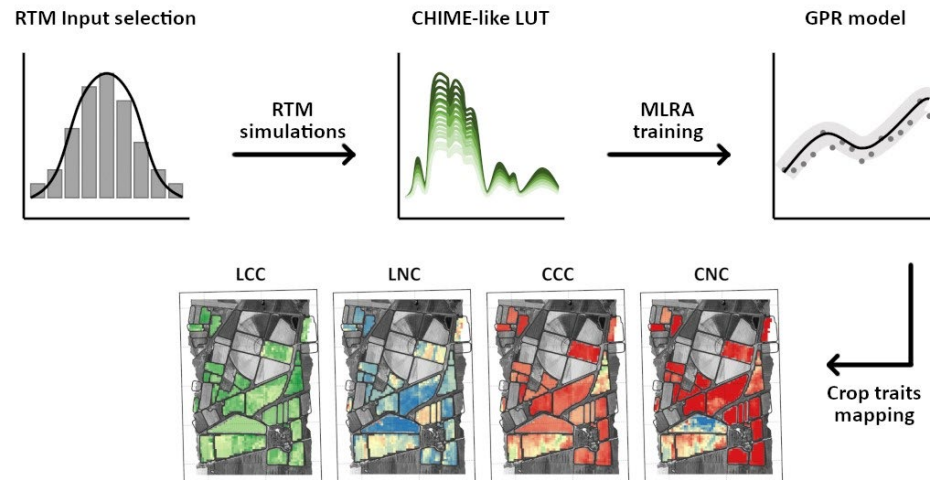
[ESA - Going hyperspectral for CHIME](#)

# Retrieval of Leaf and Canopy Nitrogen Content

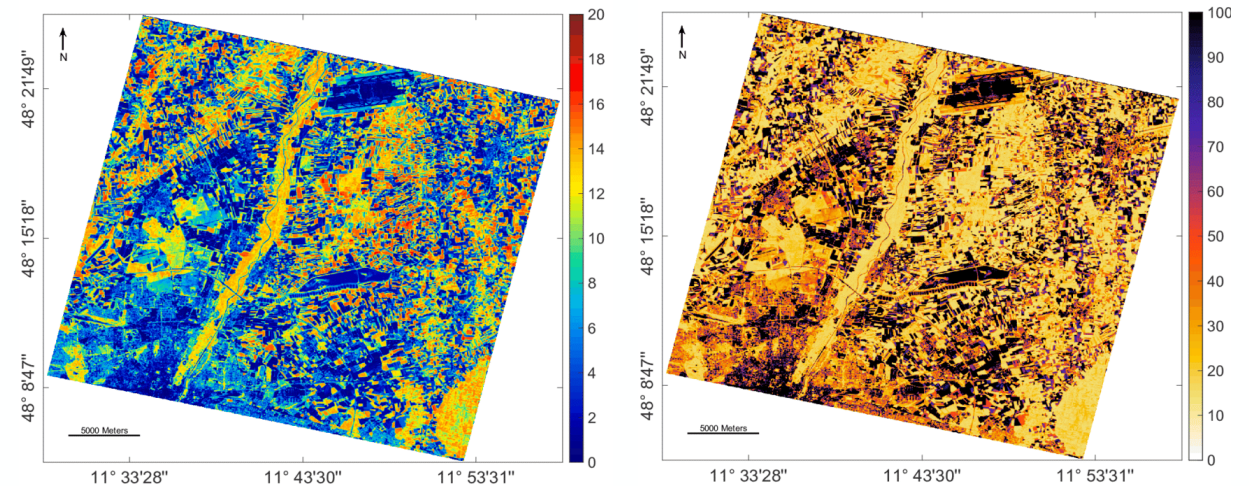
- **Nitrogen (N)** is one of the most important plant macro-nutrients
  - a proper management of N is a key factor for effective agricultural practices
- CHIME will provide Leaf and Canopy N Content maps to support precision farming



Tagliabue *et al.* (2022) <https://doi.org/10.1016/j.isprsjprs.2022.03.014>



Candiani *et al.* (2022) <https://doi.org/10.3390/rs14081792>



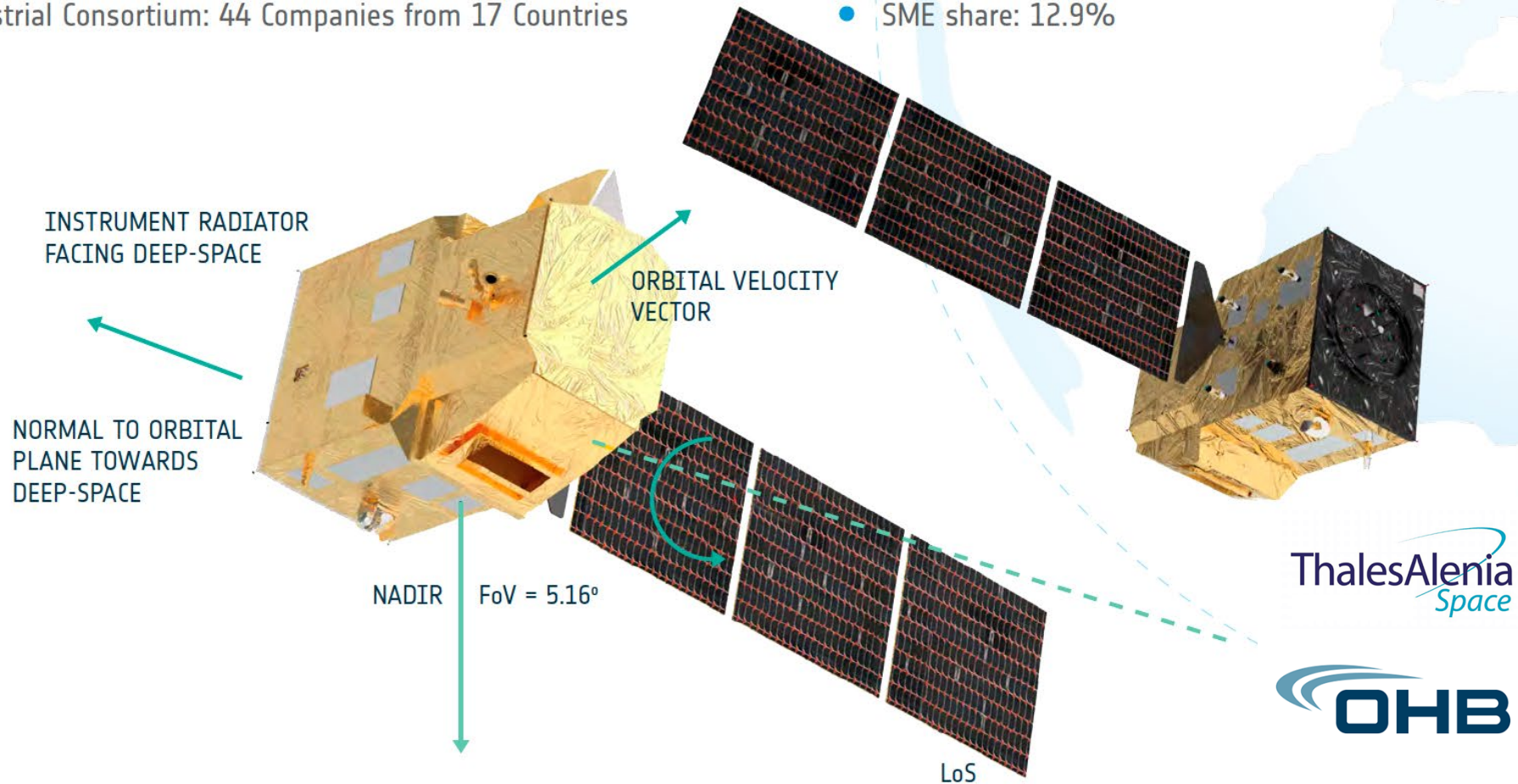
Verrelst *et al.* (2021) <https://doi.org/10.1016/j.isprsjprs.2021.06.017>

# CHIME Space Segment

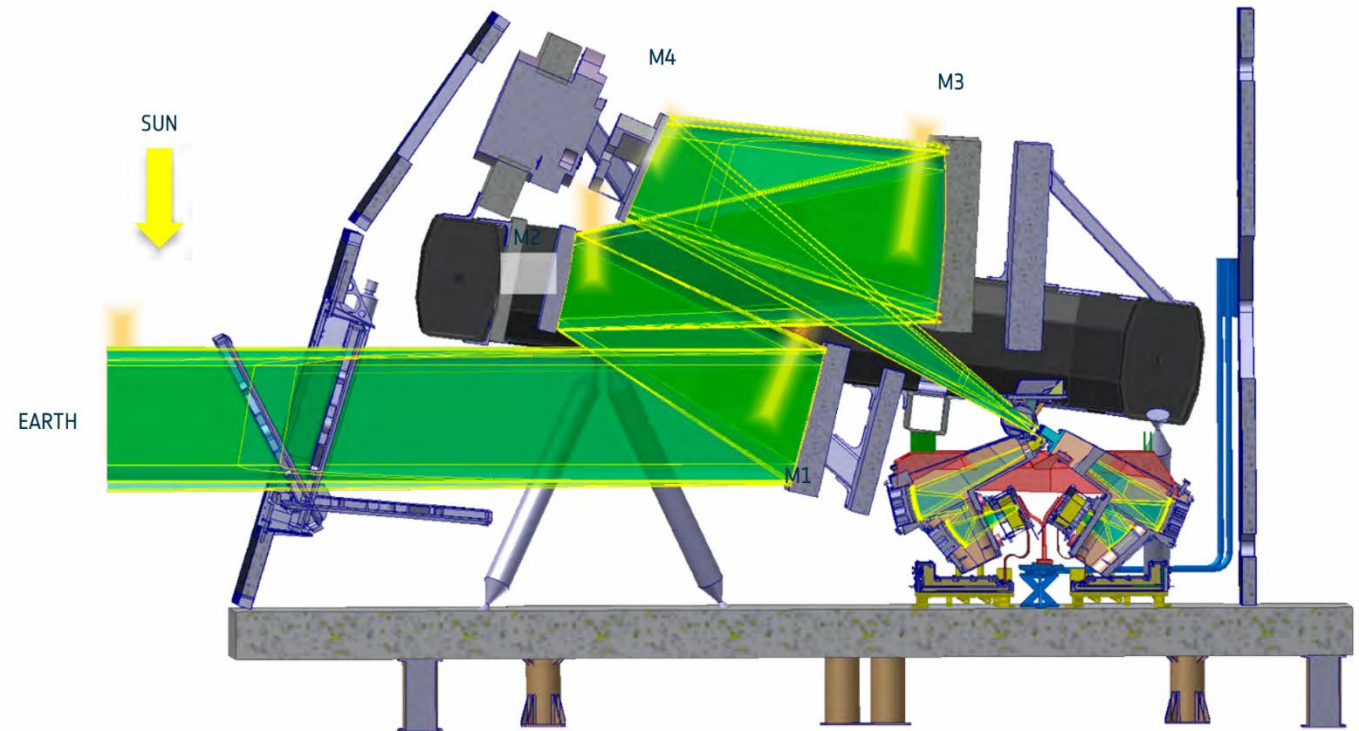
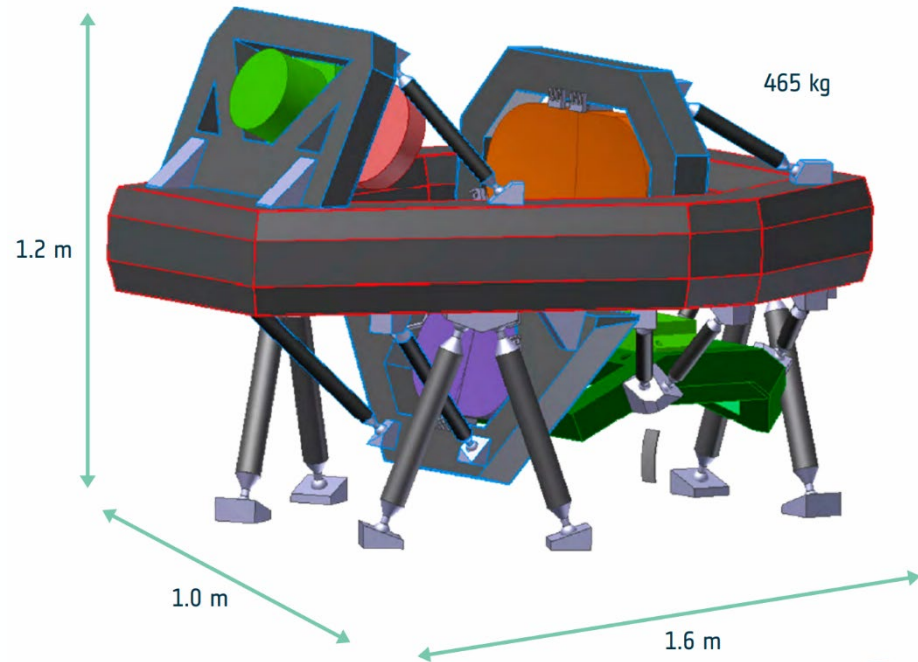
Full Consortium Established for Space segment Development B2/CD (for PFM + FM2)

- Prime Contractor: Thales Alenia Space France (TAS-F)
- Industrial Consortium: 44 Companies from 17 Countries

- Instrument Prime: OHB (DE) with
  - LEONARDO (IT) for Focal Planes & E2E Calibration
  - AMOS (BE) for 3 x spectrometer, gratings and slits
- SME share: 12.9%



- System PDR started 25<sup>th</sup> May 2022
- Instrument HSI PDR procedure finalized
- PDR Closeout expected in October 2022
- Start of Phase C/D expected in Q4 2022



Conceptual design for the optical accommodation of telescope and spectrometers for the staggered slit design



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## PRISMA

- CHIME Campaign
- advancement of algorithm development
- new retrieval techniques such as AI and machine learning are examined



## EnMAP and DESIS

- End to end simulator combined usage
- Exchange of ATBDs at different product levels
  - Cooperation on retrieval toolbox and operational processors



## US decadal plan priority Mission SBG (Surface Biology Geology)

- established Joint Working Groups consolidating an End-Product harmonisation, Retrieval Simulations and Orbit definitions and CalVal



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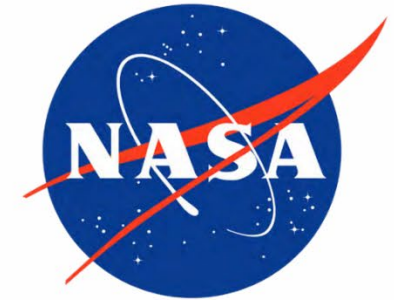
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**2<sup>nd</sup> Workshop on International Cooperation in Spaceborne Imaging Spectroscopy**  
**17-21 October 2022 @ESTEC/ESRIN**

# Thank you for you attention!



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