Copernicus Sentinel Expansion Missions

CO2M – Anthropogenic CO2
Causes of Climate Change

LST – Land Surface Temperature
Agriculture & Water Productivity

CRISTAL – Polar Ice & Snow
Effects of Climate Change

CHIME – Hyperspectral Imaging
Food Security, Soil, Minerals, Biodiversity

CIMR – Passive Microwave
Sea: Surface Temp. & Ice Concentration

ROSE-L – L-band SAR Mission
Vegetation & Ground Motion & Moisture

Causes of Climate Change
Food Security, Soil, Minerals, Biodiversity
Sea: Surface Temp. & Ice Concentration
Vegetation & Ground Motion & Moisture

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European Space Agency
Copernicus Hyperspectral Imaging Mission (CHIME)

- 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 - Schepman, Jehle et al. 2015)
Application Pillars Of Hyperspectral Imaging For Natural Resource Management

Natural Resources Management

Sustainable Agriculture and Food Security
- Food nutrition and nutrition quality
- Sustainable use of nutrients and water
- Soil degradation and soil properties

Raw Materials
- Responsible raw materials exploration and mining
- Mine environment management
Secondary applications

- Hydrosphere/cryosphere
- Forestry
- Coastal/inland waters
- Environmental degradation/hazards
- Biodiversity
- Atmospheric gases
Hyperspectral Imaging Mission (CHIME)

Key Mission Requirements:

- Routine hyperspectral observations of land and coastal areas
- Revisit: 11 days (2 satellites)
- Spectral range: 400 – 2500 nm, bandwidth ≤ 10nm
- Ground Resolution: 30 m
- High radiometric accuracy, low spectral/spatial mis-registration
- Spectral bandwidth ≤ 10nm
- High SNR requirements to match performance of international missions (PRISMA, EnMap, SBG, etc.)
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%
# CHIME Core Data Products

<table>
<thead>
<tr>
<th>Data Product</th>
<th>Data Description</th>
<th>Data Definition</th>
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</thead>
<tbody>
<tr>
<td>L1-B</td>
<td>Top-of-atmosphere (TOA) radiance</td>
<td>CHIME Level 1-B products consist of quality controlled L1-A data that have been reformatted but not resampled in segments. Pixel quantity expressed as Top of Atmosphere (TOA) radiance (W.m(^{-2}).sr(^{-1}).μm(^{-1})) with all radiometric and spectral calibrations applied. Geometric information (e.g. refined viewing model) are computed and appended but not applied. In case a straylight correction is applied, it should be on L1-B.</td>
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<tr>
<td>L1-C</td>
<td>Top-of-atmosphere (TOA) reflectance</td>
<td>CHIME Level 1-C products consist of ortho-rectified TOA reflectance resampled in cartographic reference frame UTM/WGS84 and framed tiles. Level 1-C products shall be geometrically refined including geolocation correction from any residual bias and thermo-elastic distortion (intra-orbit and seasonal) and multi-temporal registration. In case a keystone correction is applied, it should be on L1-C. Tiles are defined for a size of 110 x 110 km and in line with the “Sentinel-2 tiling grid”.</td>
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<tr>
<td>L2-A</td>
<td>Surface reflectance (Bottom of Atmosphere; BOA)</td>
<td>Level 2-A products are geometrically corrected surface reflectance, and the main data product to be distributed to users by the mission core ground segment. In case a smile correction is applied, it should be on L2-A. L2-A products are ortho-rectified geometry (including usage of Digital Elevation Model; DEM) Bottom-of-Atmosphere (BOA) reflectance pixel-level information. A scene classification is appended (side product from the atmospheric correction process) allowing distinguished of opaque clouds, thin clouds, cloud shadows, vegetation, etc. Aerosol Optical Thickness (AOT) and Columnar Water Vapour (CWV) maps are appended as side products from the atmospheric correction process.</td>
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<tr>
<td>DOMAIN</td>
<td>THEMATIC AREA</td>
<td>VARIABLES CHPP</td>
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<td>----------------------------------------------------</td>
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<tr>
<td>AGRICULTURE / FOOD SECURITY</td>
<td>Assessment of biophysical and biochemical variables related to the crops and of agronomic interest</td>
<td>Leaf/Canopy Pigment Content</td>
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<tr>
<td></td>
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<td>Leaf/Canopy Nitrogen Content</td>
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<td></td>
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<td>LAI</td>
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<td></td>
<td></td>
<td>Canopy Water Content</td>
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<td></td>
<td>Leaf/Canopy Pigment Content</td>
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<tr>
<td></td>
<td></td>
<td>Leaf Mass/Area</td>
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<tr>
<td></td>
<td>Topsoil properties</td>
<td>Soil organic carbon content</td>
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<tr>
<td></td>
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<td>Soil texture (clay, silt, sand)</td>
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<tr>
<td>GEOLOGY &amp; MINERALS</td>
<td>Raw material detection</td>
<td>Mineral identification and abundances (Kaolinite, Smectite, Jarrosite, Dolomite)</td>
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<tr>
<td></td>
<td></td>
<td>Hematite-goethite ratio</td>
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<tr>
<td></td>
<td></td>
<td>Ferric oxide contents</td>
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<tr>
<td></td>
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<td>Kaolin Cristallinity</td>
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</tbody>
</table>
Support activities for the consolidation of performance and key mission requirements

**End-to-End Simulator (E2E)**
- Simulates end-to-end mission performance from the observed scene to the retrieved parameters
- Supports performance consolidation at mission level, trade-offs impact on the mission products, early preparation of user community for mission exploitation

**Requirements Consolidation Study**
- Analyse and quantitatively consolidate the key user mission and performance requirements
- Develop initial ATBDs for high priority prototype products

**Hypersense Campaign**
- Collect a large set of diverse datasets (airborne, spaceborne, in-situ) over European sites in collaboration with key international/national agencies, including NASA, ASI and DLR
- Support development of key algorithms related to CHIME key applications
- More information on campaign website: [https://ares-observatory.ch/esa_chime_mission_2021/](https://ares-observatory.ch/esa_chime_mission_2021/)
- See next presentation!!
AI based retrieval of CHIME Priority Products: Nitrogen, Chlorophyll and Soils

Based on Experimental AVIRIS Campaign—Grosseto, IT, 2018
CHIME E2E Study: HPPP retrievals and performance assessment

Kaolonite demonstration case: Aggeneys

Demmin East

Demmin West

SOC demonstration case: Demmin

No noise & L2GPP
CHIME RCS Study: Inland and Coastal Waters Applications to PRISMA and DESIS

**Status of activities:** PRISMA and DESIS images have been evaluated and used, along with in-situ hyperspectral data, to generate CHIME-like products. More data, including AVIRIS-NG, need to be explored to progress with the project.

Mantua lakes: phytoplankton (chl-a and phycocynin) and biomass of aquatic vegetation (DESIS 07/08/2019)

Lake Garda: simultaneously retrieval of water quality and bottom types (PRISMA 10/09/2020)

**First results:**
- First results show the potentiality of a CHIME-like sensor (as derived from e.g. PRISMA) for aquatic ecosystem mapping.
- Analysis of level 2 products from PRIMSA/DESIS showed the need of adopting atmospheric correction schemes specifically for waters.

The CHIME mission, with its unique value of spectral value and by cooperating with other satellite missions (e.g. OLCI, MSI, PACE) will provide significant global advances for water resource monitoring and aquatic ecosystems studies.
**CHIME System – External Framework**

Cooperation with ASI, DLR and NASA  |  Focus: Satellite Constellation and Data Fusion  |  No exchange of funds and/or hardware

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**ASI**  
Agenzia Spaziale Italiana

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

**DLR**

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

**NASA**

**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.
Thank you for your attention!