CHIME - The Copernicus Hyperspectral Imaging Mission

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Nationales Forum für Fernerkundung und Copernicus 2018
Berlin, 27-29 November 2018
VISTA entwickelt Satelliten-basierte Anwendungen für die Landwirtschaft und Hydrologie

Gegründet: 1995, Sitz in München, Deutschland    Mitarbeiter: 24
Seit Juli 2017: BayWa AG hat 51% der VISTA GmbH übernommen

Unser Weg von Forschung und Entwicklung in operationelle Dienste:

**Landwirtschaft**
- Erntevorhersage
- Precision Farming
- Bewässerungsplanung
- Bio-Zertifizierung

**Hydrologie**
- Schneemonitoring
- Abflussvorhersage
- Wasserkraftproduktion
- Überschwemmungen
Evolution of the Copernicus Space Component

2014

Current Sentinel constellation

Sentinel-2

2025

Sentinel Expansion

CHIME

2030/2032

Both, current and expansion missions are replaced by NG missions

The Commission in particular

- underlined that the **enhanced** continuity of the existing Copernicus observation capacity is the overarching priority

- indicated a number of **major gaps potentially to be filled** by expansions to the Copernicus Space Component
Goal of the CHIME Hyperspectral Imaging Mission

“To provide routine hyperspectral observations through the Copernicus Programme in support of EU- and related policies for the management of natural resources, assets and benefits.

This unique visible-to-shortwave infrared spectroscopy based observational capability will in particular support new and enhanced services for food security, sustainable agriculture and raw materials.

This includes biodiversity management, soil properties characterization, sustainable mining practices and environment preservation.”

(source: CHIME Mission Requirements Document v 1.2)
EU Policies/Directives for Hyperspectral Imaging

EU Raw Materials Initiative
  European Innovation Partnership (EIP) on Raw Materials

EU Common Agriculture Policy
  Soil Framework (towards future Directive)
  Soil Thematic Strategy

EU Biodiversity Strategy
  EU Regulation 1143/2014 on Invasive Alien Species
  Natura 2000
  UN Convention on Biodiversity (UNCBD)

EU Forest Strategy
  FAO Global Forest resources Assessment
  Global Forest Convention

UN System of Environmental–Economic Accounting (SEEA) & UN Convention for Combating Desertification (UNCCD) and Land Degradation
  Soil Framework (towards future Directive)
  Soil Thematic Strategy

EU Water Framework Directive
  EU Bathing Water Directive

EU Arctic Policy
  .....

← e.g. Discovery of economically valuable deposits; identification of mine-waste type-, extent-, and concentration and corresponding dissemination pathways

← e.g. Mapping Essential Biodiversity Variables (EBV) on global scale; National reporting for UNCBD; Classification, monitoring of Invasive Alien Species

← e.g. Monitoring of salinization

← e.g. improved monitoring of nitrogen uptake by vegetation and soil mineralization
Technical Concept of CHIME

Routine spectroscopic observations in contiguous spectral bands conducted at:

- Instrument: Pushbroom Imaging Spectrometer 400 – 2500 nm, $\Delta \lambda \leq 10$nm,
- Revisit (temporal resolution) 10-15 days,
- GSD (spatial resolution): 20-30m,
- Sun synchronous orbit (LTDN 10:30 – 11:30),
- Nadir view covering land and coastal areas,
- High radiometric accuracy, low spectral/spatial misregistration.

Spaceborne Heritage in Europe

- **EnMAP (DLR)** and **PRISMA (ASI)** being readied for launch
- **OHB (D)** and **TAS (F)** now active in Phase A/B1 studies for CHIME
Each material on the Earth's surface has a unique spectral characteristic. Hyperspectral Imaging: Principles

Knowledge: location of absorption processes in between 400 – 2500nm

Identification / Quantification => Diagnosis

Pigments, Minerals, Man Made Objects

Shape

Position

Depth

Quantification

spectral reflectance [%]

Wavelength [nm]

Wavelength in microns

kaolinite

R_c

R_min

Also vegetation show “new” features in the hyperspectral domain
Why contiguous spectral measurements?

Courtesy: T. Hank, LMU
CHIME Core Data Products

The mission shall provide access to Level-1B, Level-1C and Level-2A products accessible via DIAS and with API support:
• Bottom-of-Atmosphere (BOA) reflectance (atmospheric corrected)
• Ortho-rectified geometry
• Basic pixel classification (opaque clouds, thin clouds, cloud shadows, vegetation, water, snow etc.)

Additionally the mission can provide a set of downstream products related to the different mission applications.

They can be part of the mission catalogue or as service offer from the EO value adding industry.
Sample Products for Administrations and Services

In the field of Sustainable Agriculture and Food Security:
- Yield Assessment and Forecast
- Species identification (e.g. crop type, invasive species, palatable/non palatable)
- Crop health and damage (water and nutrient stress)
- Detection of weeds
- Crop water requirement
- Mapping soil properties: structure and texture
- Estimation of carbon storage in soils
- Soil Erosion and degradation mapping
- Detection of soil pollution and soil contamination

In the field Raw Materials:
- Mineral mapping for discovery of raw materials for informed exploration
- Mineral compositions, chemistries and abundances for raw materials, characterisation and quantification in mining/extraction
- Monitoring and characterisation of surface contamination, atmospheric pollution, vegetation damage for active mining activities, mine dumps and legacy mines
- Establishing environmental baselines pre-mining, monitoring of progress of rehabilitation towards mine closure objectives
Sample Applications for Science and Services

Key soil products (a) clay and (c) soil organic carbon maps) from airborne and simulated spaceborne hyperspectral imagery. (Steinberg, Chabrillat et al. 2016).

Plus products for inland and coastal waters; biodiversity; Snow, ice and hydrology; Environmental degradation and hazards
Support activities (ongoing ESA activities) and potential German involvement

- **E-to-E-Simulator** study based on updated GFZ Simulator for EnMAP and EE-8 FLEX, with L1-L2 module
- **Requirements consolidation study**, e.g. to verify observation and performance requirements, to produce simulated level-1 data, L1-L2 retrieval development and requirement sensitivity studies
- **Airborne campaign in 2018 with APEX and AVIRIS-NG** at the same time;
- Similar airborne campaign also in discussion/planning for 2019

Also with the soon coming German ENMAP mission the potential involvement of Institutions, Research and Industry are large and manifold.
Conclusion

Copernicus Space Component (CSC) Expansion:
The CSC is ready to prepare a sound baseline to fill a number of major observation gaps:

1. Anthropogenic CO2 monitoring
2. High Spatio-Temporal Resolution Land Surface Temperature Monitoring
3. Polar Ice and Snow Topography
4. Passive Microwave Imaging
5. **HyperSpectral Imaging CHIME**
6. L-Band SAR Imaging

**Hyperspectral:**

- Mission and System Requirements are currently under consolidation by all parties: MAG, Industry and internally,
- Observation requirements are clear, however spatial dimension (high coverage rate 10 – 15 days, high spatial resolution 20-30m) needs further assessment
- Data continuity and long-term planning is considered as top requirements by all parties.
- International Cooperation and Coordination is of vital importance