EARSeL València 2024

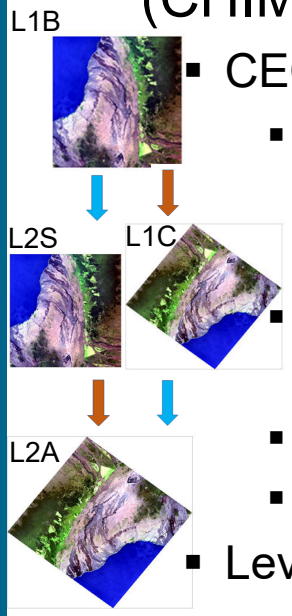
CHIME LEVEL 2A AND 2B: ATMOSPHERIC CORRECTION AND HIGHER-LEVEL PROCESSING

Tobias Storch, Raquel de los Reyes, Peter Schwind, Maximilian Langheinrich, David Marshall, Andreas Hueni, Pieter de Vis, Nicolas Lamquin, Vincent Levasseur, Jerome Louis, Sebastien Saunier, Martin Bachmann, Jochem Verrelst, Katja Berger, Stephane Guillaso, Karl Segl, Luigi Agrimano, Lucie Homolova, Kevin Alonso, Ferran Gascon, Valentina Boccia

16.04.2024

Objectives (L2A)

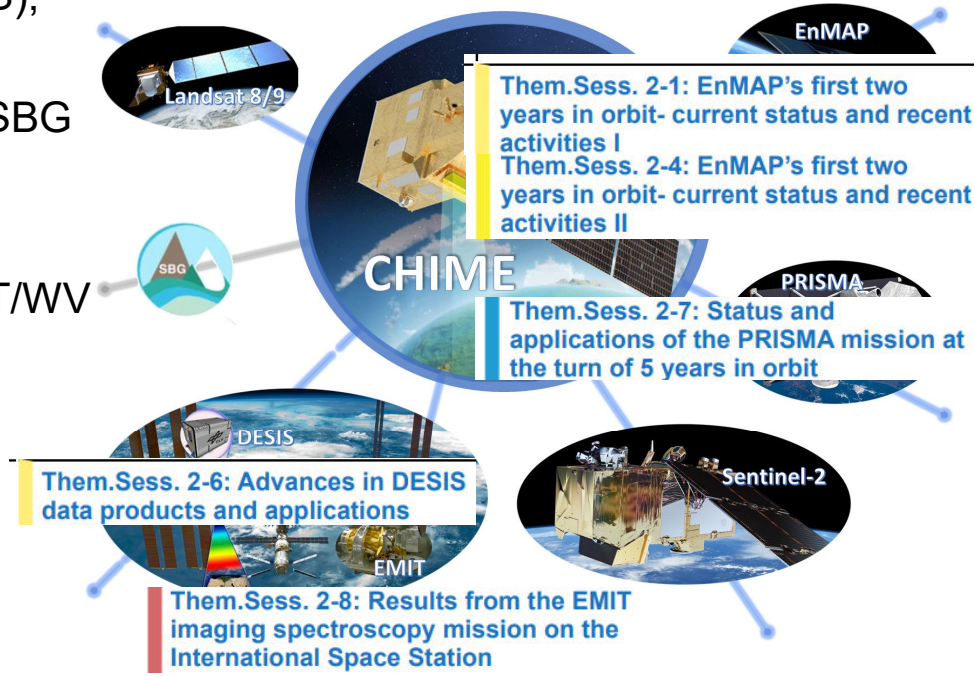
- Copernicus Hyperspectral Imaging Mission for the Environment (CHIME) L2 Algorithms & Processors Prototyping & Development (CHIME-L2)



  - CEOS ARD Level 2A land & water – open source software
    - Level 2S (based on Level 1B), Level 2A (based on Level 1C (default) or Level 2S), (DLR with Telespazio France, UV)
    - Level 2H/F (harmonization & fusion CHIME and SBG based on Level 1C) (Telespazio France)
    - Level 2A Operational Processor (ACRI-ST)
    - TOA to BOA, pixel classification, e.g. clouds, AOT/WV
  - Level 2A – open source software
    - Uncertainties (UZH with NPL)
    - Integration on CEM-PAL (ACRI-ST)
    - Cal/Val (L2A: Planetek)
    - (generic) Open Source (modular) Library (for atmospheric correction) (DLR)

The Copernicus Hyperspectral Imaging Mission For The Environment (CHIME): Current Status

Marco Celesti, Kevin Alonso, Valentina Boccia, Lauren Despoisse, Antonio Gabriele, Ferran Gascon, Nafiseh Ghasemi, Claudia Isola, Giuseppe Ottavianelli, Anke Schickling, Helene Strese, Heidrun Weber, Jens Nieke



Objectives (L2B)

- Copernicus Hyperspectral Imaging Mission for the Environment (CHIME) L2 Algorithms & Processors Prototyping & Development (CHIME-L2)
  - Level 2B – open source software
    - improved masking (DLR)
    - canopy & leaf (UV) ↓

      Latest Status of the Vegetation Traits Retrieval Processor and Models in the Context of Chime Mission Preparation

      José Luis García Soria, Miguel Morata, Jochem Verrelst, Ana Belén Pascual-Venteo, Katja Berger, Cinzia Panigada, Giulia Tagliabue, Ana María Sánchez Montero
    - soil & mineralogy (GFZ) →

      Progress in the Development of the L2B Mineral Module for the CHIME E2E Simulator (CHEES).

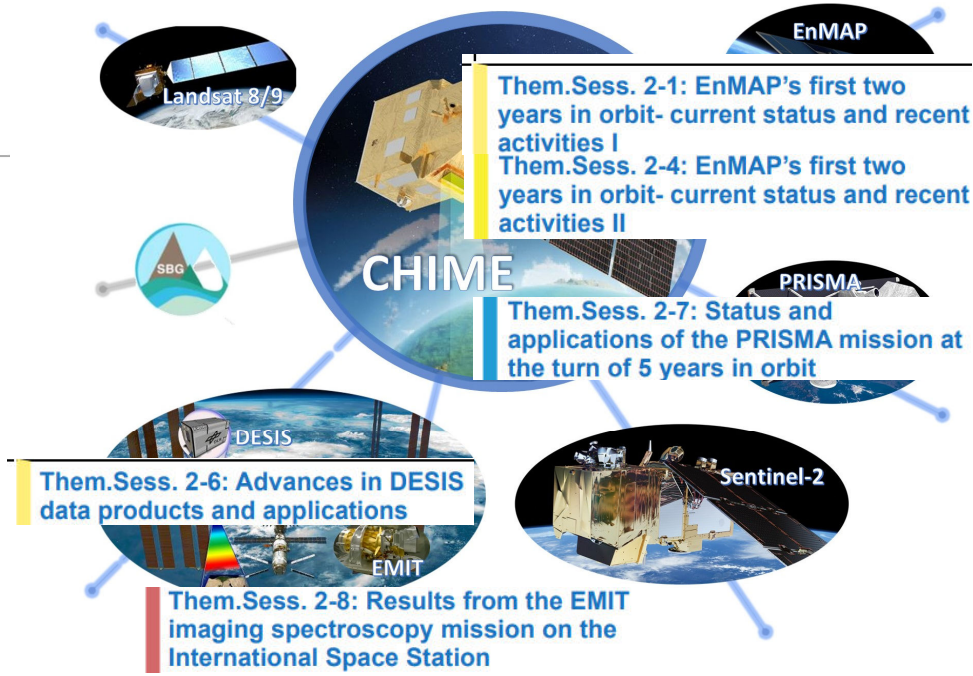
      Karl Segl, Stéphane Guillaso Guillaso, Saeid Asadzadeh, Massimo Musacchio, Ana Maria Sánchez Montero

      Progress in the Development of the L2B Soil Module for the CHIME-E2E Simulator

      Stéphane Guillaso, Karl Segl, Robert Milewski, Stefano Pignatti, Raffaele Casa, Ana Maria Sánchez Montero
  - Level 2B – open source software
    - Uncertainties (UZH with NPL)
    - Integration on CEM-PAL (ACRI-ST)
    - Cal/Val (L2B: CzechGlobe)
    - (generic) Open Source (modular) Library (DLR)

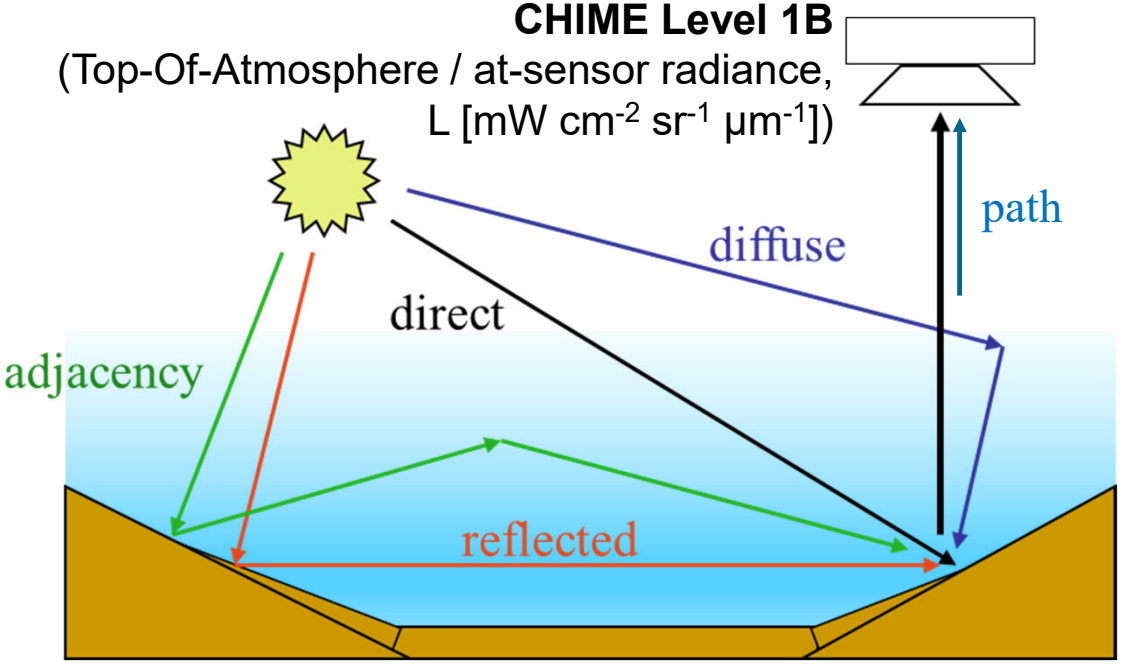
The Copernicus Hyperspectral Imaging Mission For The Environment (CHIME): Current Status

Marco Celesti, Kevin Alonso, Valentina Boccia, Lauren Despoisse, Antonio Gabriele, Ferran Gascon, Nafiseh Ghasemi, Claudia Isola, Giuseppe Ottavianelli, Anke Schickling, Helene Strese, Heidrun Weber, Jens Nieke



CHIME L2A (1/3)

CHIME Level 1B
(Top-Of-Atmosphere / at-sensor radiance,
L [mW cm^{-2} sr^{-1} µm^{-1}])

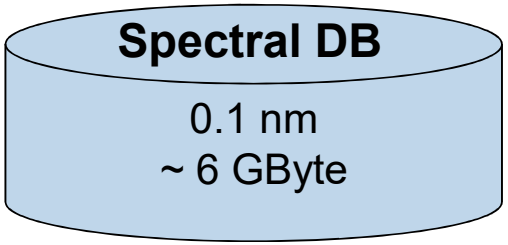


$$L = L_{path} + L_{direct} + L_{diffuse} + L_{reflected} + L_{adjacency}$$

CHIME Level 2A
(Bottom-Of-Atmosphere / ground reflectance,
ρ [unitless] [0;1])

$$\rho = f(L, L_{path}, E_{direct}, \tau, E_{diffuse}, DEM, \ldots)$$

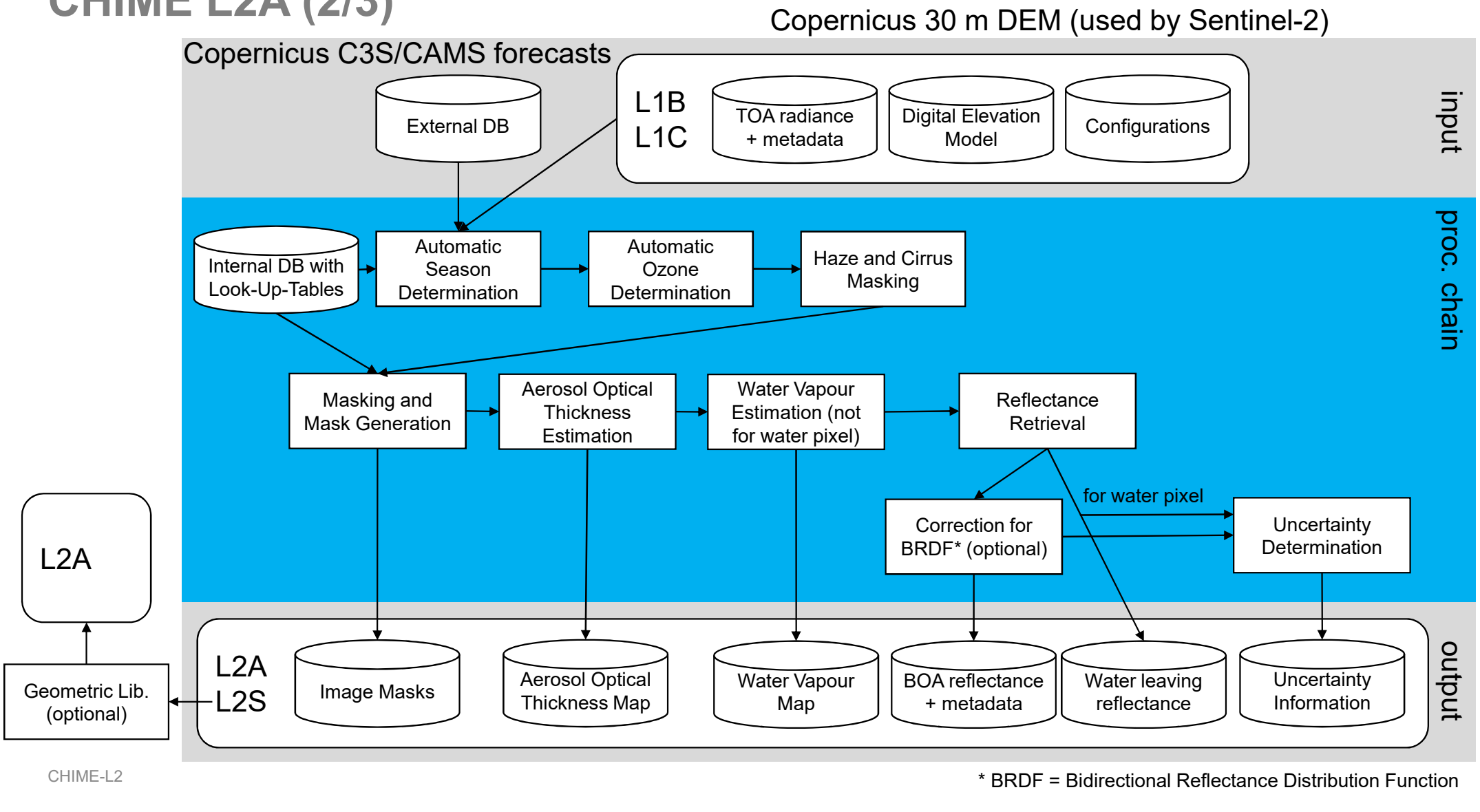
Radiative transfer simulations (based on libRadtran) & TSIS-1 solar irradiance spectra (used by Sentinel-2)



(Atmospheric) Look-Up-Tables

Parameter	Range [units]	Grid points [units]
Visibility	7, 10, 15, 23, 40, 80, 120 [km]	
Solar zenith angle	0. – 80. [°]	10 [°]
View zenith angle	0. – 20. [°]	10 [°]
Relative azimuth	0 – 180. [°]	30 [°]
Water vapor column	0.4, 1.0, 2.0, 2.9, 4.0, 5.0 [cm]	
Ground elevation	0.0, 0.7, 1.5, 2.5, 4.0 [km]	

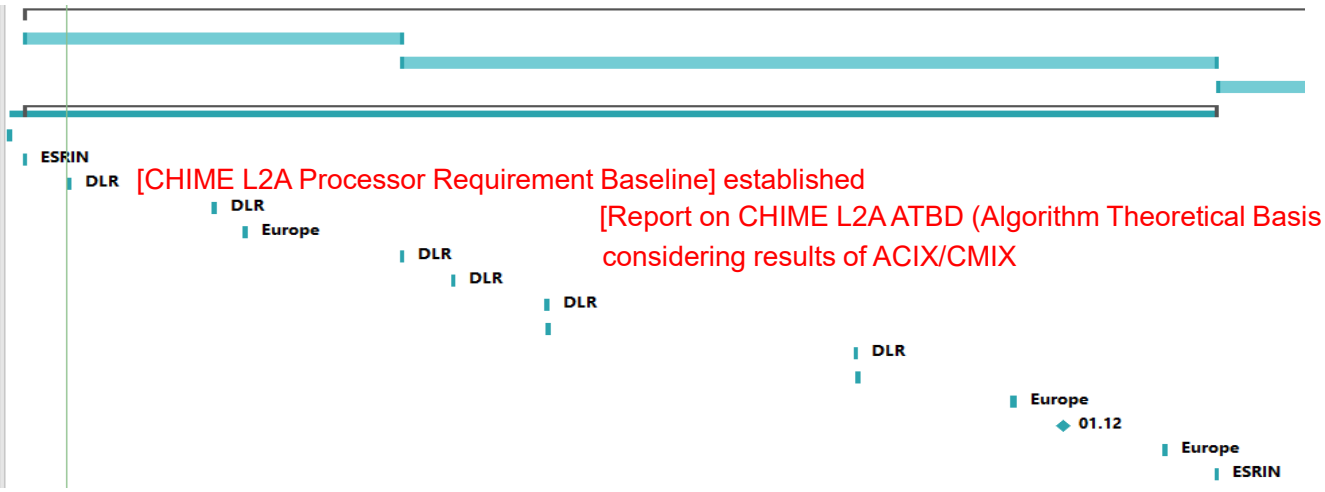
CHIME L2A (2/3)



* BRDF = Bidirectional Reflectance Distribution Function

Schedule & Software

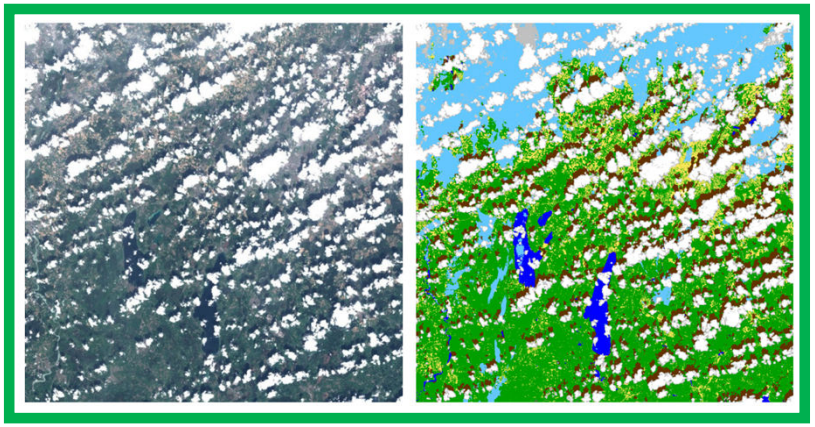
Phases	**1780 Tage**	**Mon 06.11.23**
Phase 1	482 Tage	Mon 06.11.23
Phase 2	1038 Tage	Mit 10.09.25
Phase 3	260 Tage	Mon 03.09.29
Milestones	**1520 Tage**	**Mon 06.11.23**
Prep. Meeting (MS1)	1 Tag	Mon 09.10.23
KO (MS1)	1 Tag	Mon 06.11.23
SRR1	1 Tag	Die 23.01.24
PDR (MS2)	2 Tage	Mon 07.10.24
System CDR (MS3)	2 Tage	Mon 02.12.24
CDR (MS4)	2 Tage	Mon 08.09.25
SRR2	1 Tag	Mon 08.12.25
FAT1 (with training) (MS5)	2 Tage	Mon 25.05.26
OSAT1 (MS5)	1 Tag	Mit 27.05.26
FAT2 (MS6)	1 Tag	Fre 26.11.27
OSAT2 (with training) (MS6)	2 Tage	Mon 29.11.27
ORR (MS7)	2 Tage	Fre 01.09.28
Launch	0 Tage	Fre 01.12.28
IOCR	2 Tage	Mit 30.05.29
FR (MS8)	1 Tag	Fre 31.08.29



[CHIME L2A Processor Requirement Baseline] established

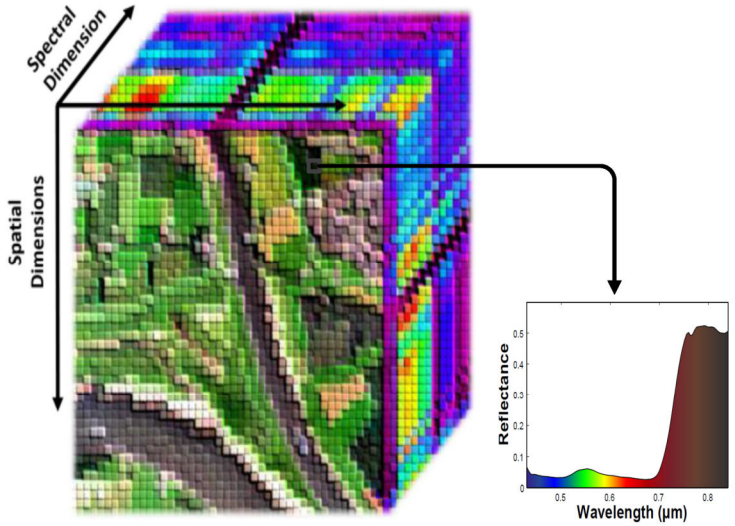
[Report on CHIME L2A ATBD (Algorithm Theoretical Basis Document)] next, considering results of ACIX/CMIX

- **L2A PROtotype processors & related OpenSourceLibrary**
  - **02.12.2024 (System CDR)**, 08.09.2025 (CDR), 27.05.2026 (FAT1/OSAT1), 26.11.2027 (FAT2/OSAT2)
- L2A OPerational processorS
  - 27.05.2026 (FAT1/OSAT1), 26.11.2027 (FAT2/OSAT2)
- L2H/F processor
  - 26.11.2027 (FAT2/OSAT2)
- L2B processor & related OpenSourceLibrary
  - 27.05.2026 (FAT1/OSAT1), 26.11.2027 (FAT2/OSAT2)
- Cal/Val tools
  - 27.05.2026 (FAT1/OSAT1), 26.11.2027 (FAT2/OSAT2), 01.09.2028 (ORR)



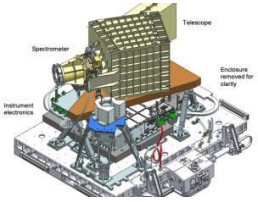
CHIME L2A (3/3)

- Combined land & water processor
- Most algorithms already successfully applied on other hyperspectral sensors (e.g. EnMAP) for retrieval over land
- Most algorithms already consistent and harmonious to Sentinel-2
- Several improvements required and planned:
  - Use of Copernicus C3S/CAMS forecast models as fallbacks
  - Masking, based on Sentinel-2, but considering CEOS ARD, modified algorithms for cloud and cloud shadows, and more bands to avoid masks confusions
    - Remark: pixels classified to be used for the atmospheric correction algorithms
  - AOT retrieval over water and water leaving reflectance
  - Retrieval for inter-sensor comparisons, e.g. BRDF correction
  - Rigorous uncertainty propagation from L1B/L1C to L2A (and L2B) based on sensitivity analysis

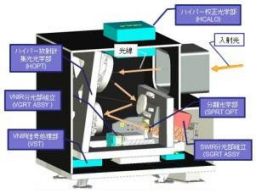


CHIME L2H/F

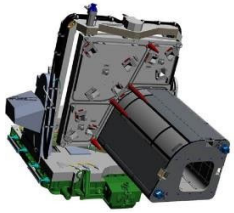
- Provide CHIME-like surface reflectance from different hyperspectral missions, in particular SBG, namely using SBG-VSWIR products as additional input
  - for long-term time-series covering timespan of several hyperspectral missions, e.g. EnMAP
  - for denser time-series covering mitigation of data unavailability, e.g. SBG, due to cloud cover



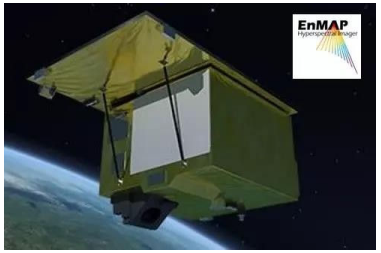
EMIT
(JPL)
(2022 -)



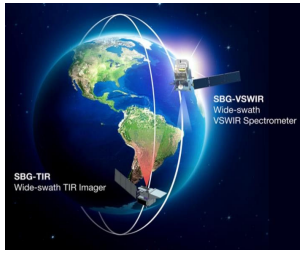
HISUI
(Japan)
(2019 -)



DESIS
(TBE & DLR)
(2018 -)



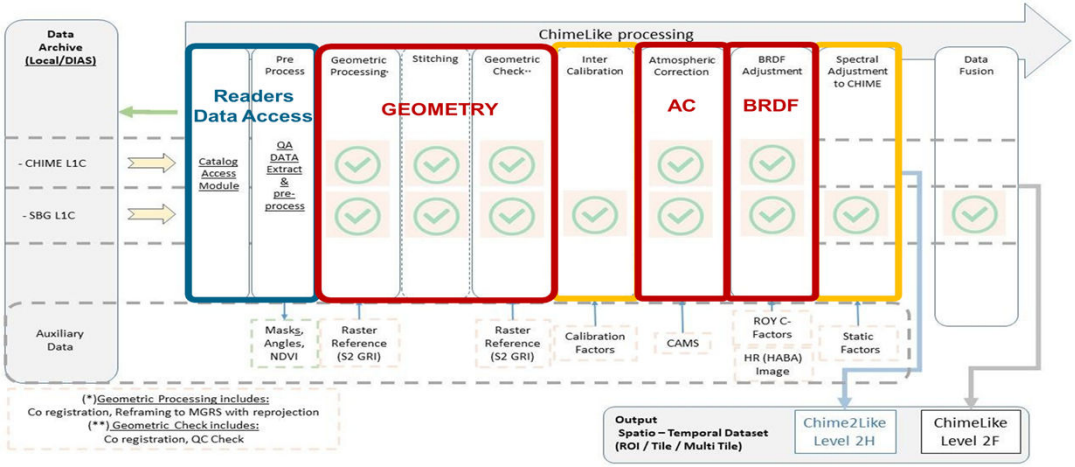
EnMAP (DLR) (2022 -)



SBG-VSWIR (NASA) (~2027)

CHIME (Copernicus) (~2028)

PRISMA (ASI) (2019 -)



CHIME L2B

CHIME L2A / L2S Data + Uncertainty @ BOA_ref
CHIME L2A / L2S Masks (saturation / defective pix., cloud, snow, land/water, …)

Improved Masking Processor
(thematic masks of soil & vegetation fractional cover, urban areas (tbd))

(if required)

Static Auxiliary Masks
(e.g., World Settlement Footprint)

Internal L2A / L2S + Uncertainty @ BOA_Ref
with improved thematic masking (as L2A / L2S plus fractional cover masks for vegetation & soil) + Uncertainty

L2B Vegetation Processor

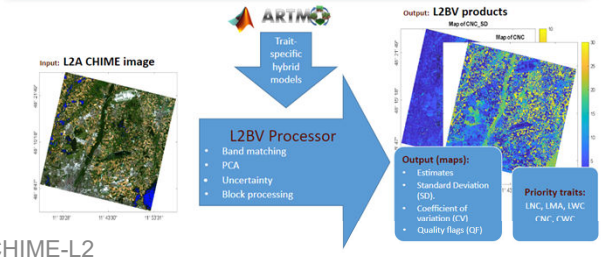
L2B Soil Organic Carbon Processor

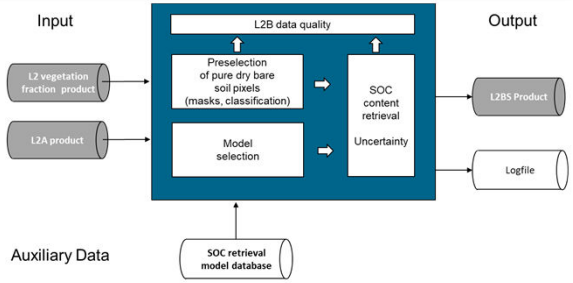
L2B Mineral Processor

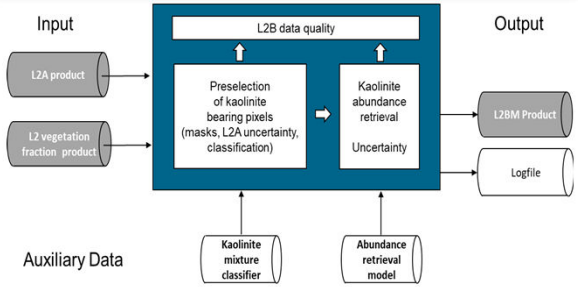
Vegetation Priority Traits
Leaf & Canopy Level
(CNC, CWC, LNC, LWA, LMA)
+ Uncertainty for each product

Soil Organic Carbon (SOC)
+ Uncertainty

Kaolinite Abundance
+ Uncertainty



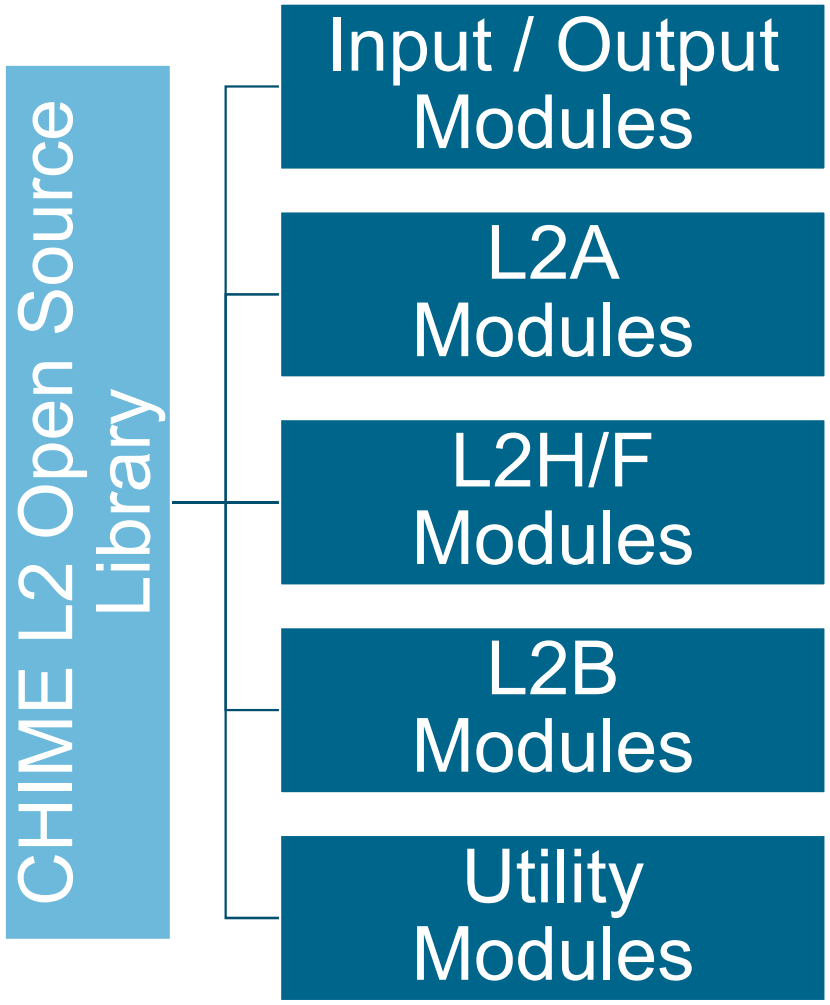




HPPP

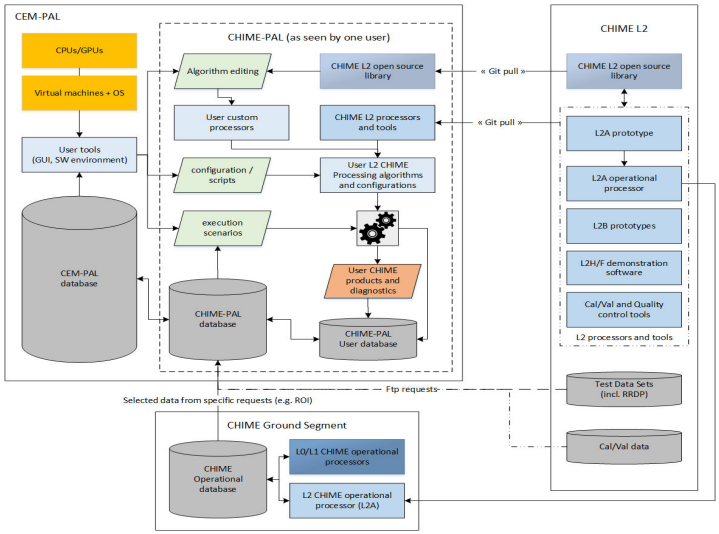
High Priority Prototype Products

CHIME-L2 OpenSourceLibrary and CEM-PAL



- (generic) Open Source (modular) Library (in particular, for atmospheric correction) to provide the users
  - visibility of and access to the CHIME L2 processing
  - ability to adopt CHIME L2 processing to their needs
  - ability to integrate L2 processing for their missions

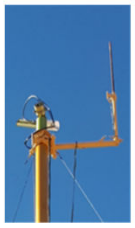
  in an open and transparent manner throughout the mission lifetime and beyond.
- CEM-PAL to provide the expert users, e.g. MAG,
  - virtual environments to efficiently realize and test algorithms
  - processing capabilities for CHIME L2 products
  - direct interfaces to CHIME L2 processors for future exploitation

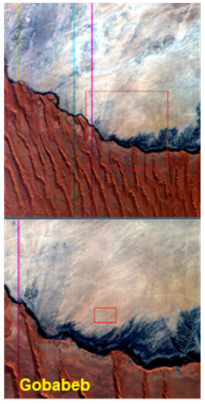


CHIME L2 Cal/Val

- Plans, catalogues, tools and reports for products of CHIME L2 processors
- Plans (with test sites selection and procedures) for all phases from beginning and evolving
  - Pre-flight phase
    - Synthetic data from E2E simulations
    - Products from similar missions, e.g. EnMAP, PRISMA
    - Airborne measurements
  - Commissioning phase
    - CHIME L2 products
    - Cross-Comparison with other satellites
  - Operational phase
    - CHIME L2 products
    - Cross-Comparison with other satellites
  - Both phases
    - Other Cal/Val initiatives, e.g. ESA campaigns
    - L2A: RadCalNet, HYPERNETS, AERONET (OC)
    - L2B: observation networks (ICOS, NEON); campaign data; databases (ECOSIS, TRY, LUCAS, ESDB)

- Image, Masks, Maps and Metadata of Products
  - L2A
  - L2S
  - L2H/F
  - L2B Vegetation
  - L2B Soil Organic Carbon
  - L2B Kaolinite





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