CHIME-L2A: CORRECTION OF THE ATMOSPHERE'S EFFECTS ON THE CHIME HYPERSPECTRAL DATA TO RETRIEVE SURFACE AND WATER LEAVING REFLECTANCE FOR GLOBAL LAND AND WATER APPLICATIONS

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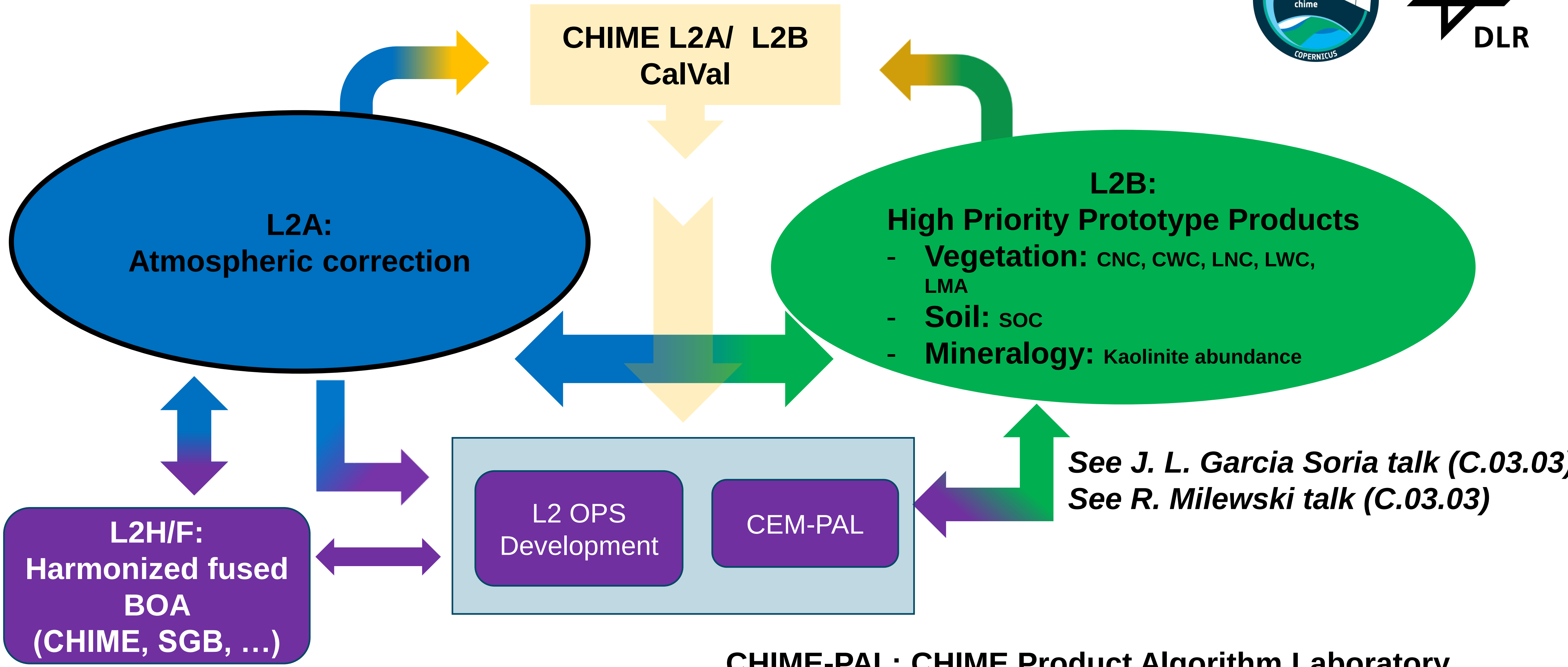
CHIME L2



CHIME-PAL: CHIME Product Algorithm Laboratory
(CEM-PAL: Copernicus Expansion Mission)

CHIME L2A:
land + water atmospheric correction

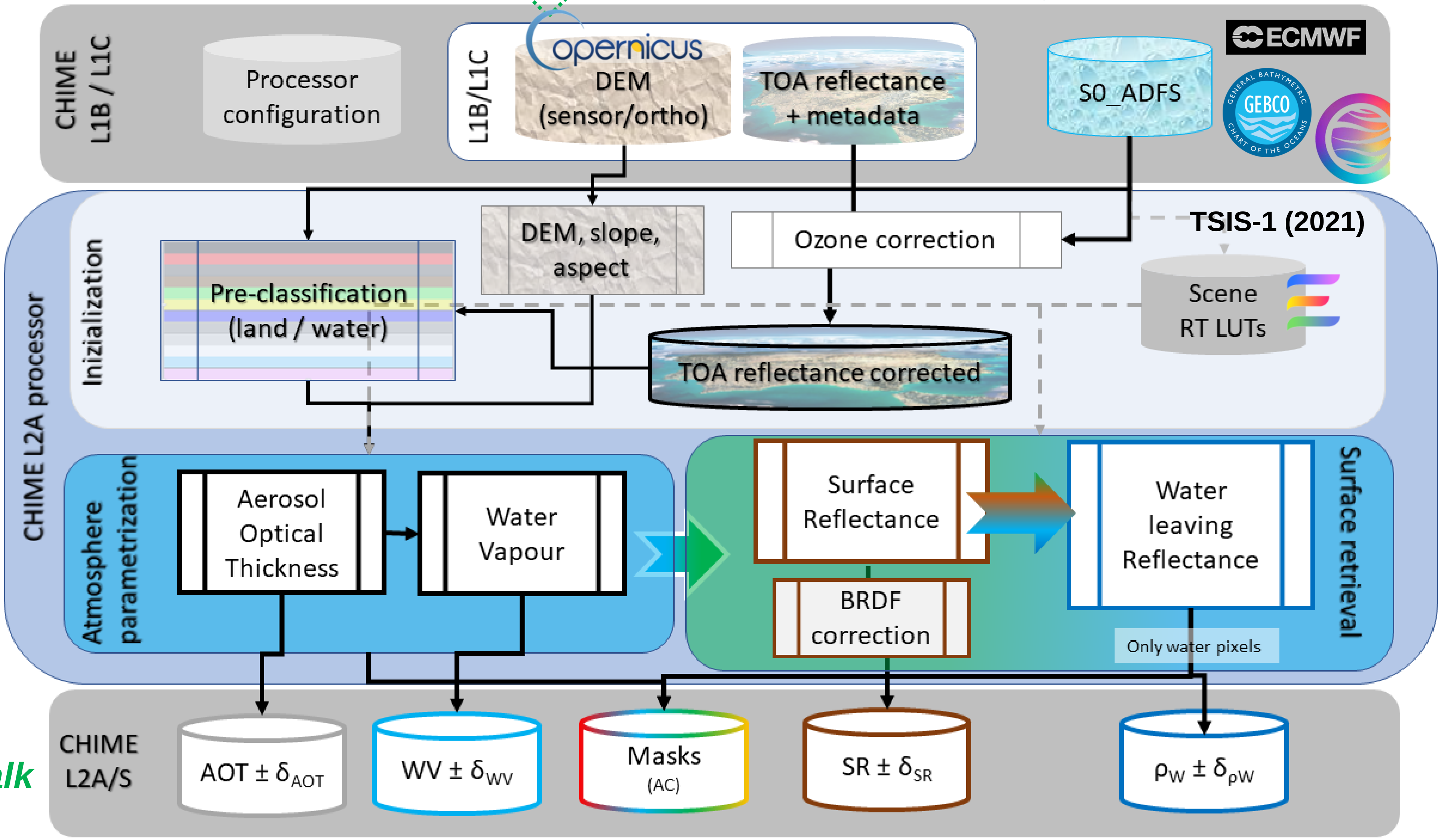
CHIME Open **S**ource **L**ibrary **(Apache 2.0)**

- land **&** water processor:
  - Atmosphere and Land Processor: PACO (ENMAP, DESIS land processor)
  - Water Processor: WASI
- consistent processor with Sentinel-2 (masks, LUTs, …)
- Improvement masking:
  - Clouds and clouds shadows
  - +6 CEOS ARD water masks (v 1.0)
  - new masks products: 2D-SCL -> **3D**-SCL
- Improvement in AOT/WV: specially over water (continuity over land)
- Improved SR for inter-sensors comparisons -> BRDF correction (HABA hyperspectral based on Sentinel-2).

CHIME L2A processor

Sentinel-2 SCL

Label	Classification
1	SATURATED_OR_DEFECTIVE
2	CAST_SHADOWS
3	CLOUD_SHADOWS
4	VEGETATION
5	NOT_VEGETATED
6	WATER
7	UNCLASSIFIED
8	CLOUD_MEDIUM_PROBABILITY
9	CLOUD_HIGH_PROBABILITY
10	THIN_CIRRUS
11	SNOW



L2A products **with uncertainties (δ)**

see A. Zimmermann talk (C.03.03)

see M. Weferli poster (C.06.07)

see C. Meier poster (C.06.07)

L1B -> L1C -> L2A
L1B -> L2S -> L2A

Ortho-
geometry
Sensor-

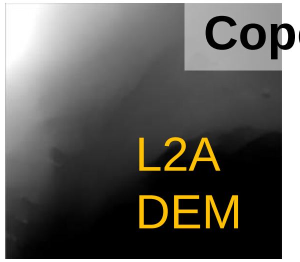
Figure 6-16: Bottom-Of-Atmosphere RGB (639.7 / 550.3 / 470.7 nm) of DESIS scenes over Hawaii on 21.06.2022. Left: DESIS-L2A, Centre: DESIS like CHIME-L2S, Right: DESIS like CHIME-L2A*.

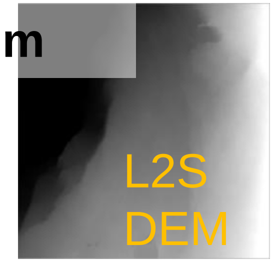
L2A / L2S pixel cubes: all algorithms yield pixel-based values and the reflectance calculates in per-band & per-pixel basis.

DEM based cubes:

- Slope
- Aspect

Copernicus 30 m

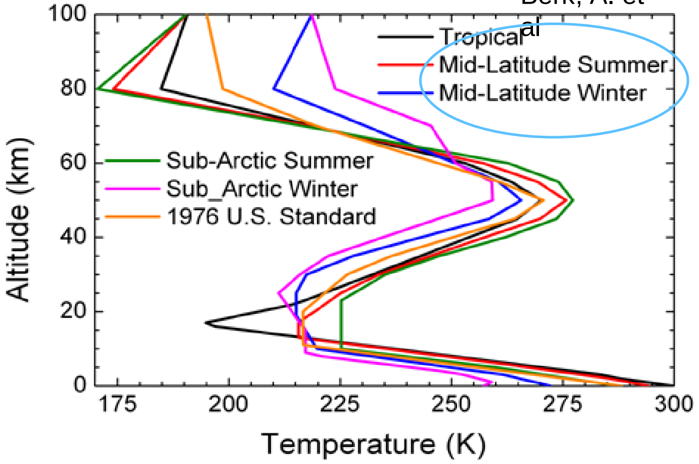




Same CHIME orthorectification in L1C and L2S
Same CHIME atmospheric correction in L2S and L2A

External parties / inputs

Berk, A. et al



- Eradiate @ Δλ = 0.1 (0.4) nm
- TSIS-1 solar model (2021)
- ECMWF and CAMS forecast variables (e.g. tco3, t2m, aod550, u10, v10, …)
- GEBCO (General Bathymetric Chart of the Oceans, 2024 Grid)
- GLOBathy (global lakes bathymetry dataset, Khazaei, B. et al, 2022)

DOI:

- Copernicus:
  - Digital Elevation Model (30 m)
  - ESA CCI: snow Tri-monthly climatology, Land Cover, …

Masking

- **CEOS** land **&** water masks
- Sentinel-2 SCL labels (2D)
  -> Masks “**quick-look**”

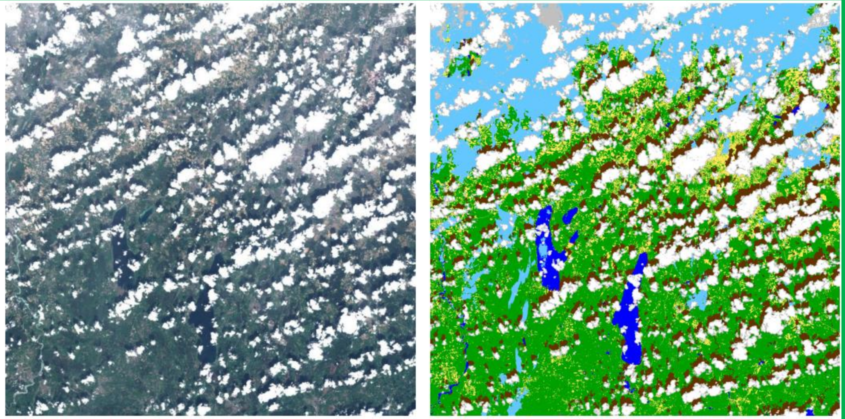
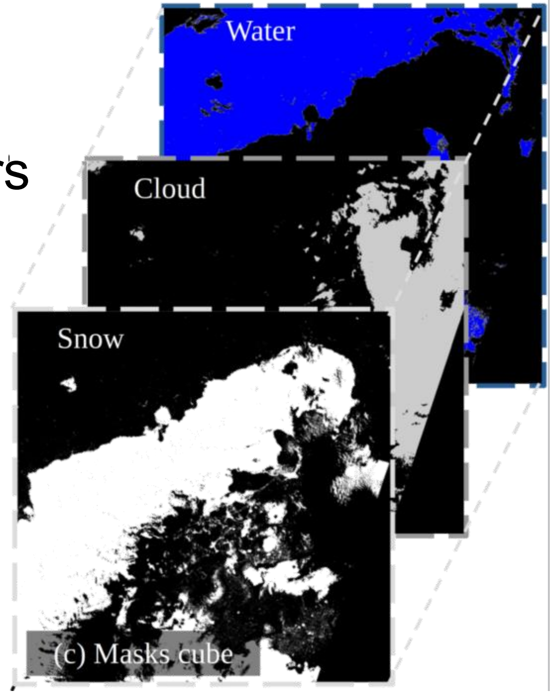


Figure 6-4: Example of Sentinel- 2 L1C True Colour Image (left) and Sen2Cor Scene Classification Algorithm output: SCL map (right).

- Separate **2D masks**
  -> provide masks “confusion” to users



Sentinel2 SCL

Label	Classification
0	BACKGROUND (NO DATA)
1	SATURATED OR DEFECTIVE
2	CAST_SHADOWS
3	CLOUD_SHADOWS
4	LAND_COVER
5	VEGETATION
6	NON_VEGETATED
7	WATER
8	UNCLASSIFIED
9	CLOUD_MEDIUM_PROBABILITY
10	CLOUD_HIGH_PROBABILITY
11	THIN_CIRRUS
12	SNOW
13	HAZE
CEOS ARD water masks (v 1.0)	
14	SUN_GLINT
15	WHITECAP_FOAM
16	FLOATING_VEGETATION_SCUM
17	DEEP_WATER
18	SHALLOW_WATER
19	OPTICALLY_DEEP_WATER
20	OPTICALLY_SHALLOW_WATER
21	TURBID_WATER

Stramska & Peterlski, 2003
Matthews & Odermatt, 2015

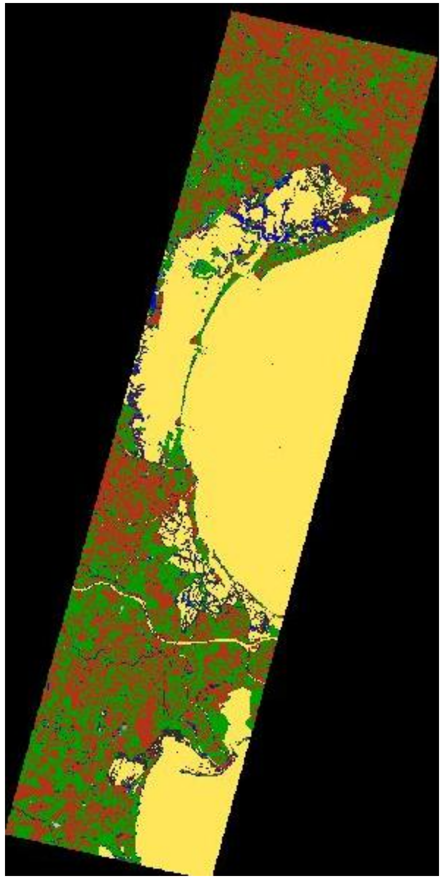
Barnes, 2013
McKinna, 2018

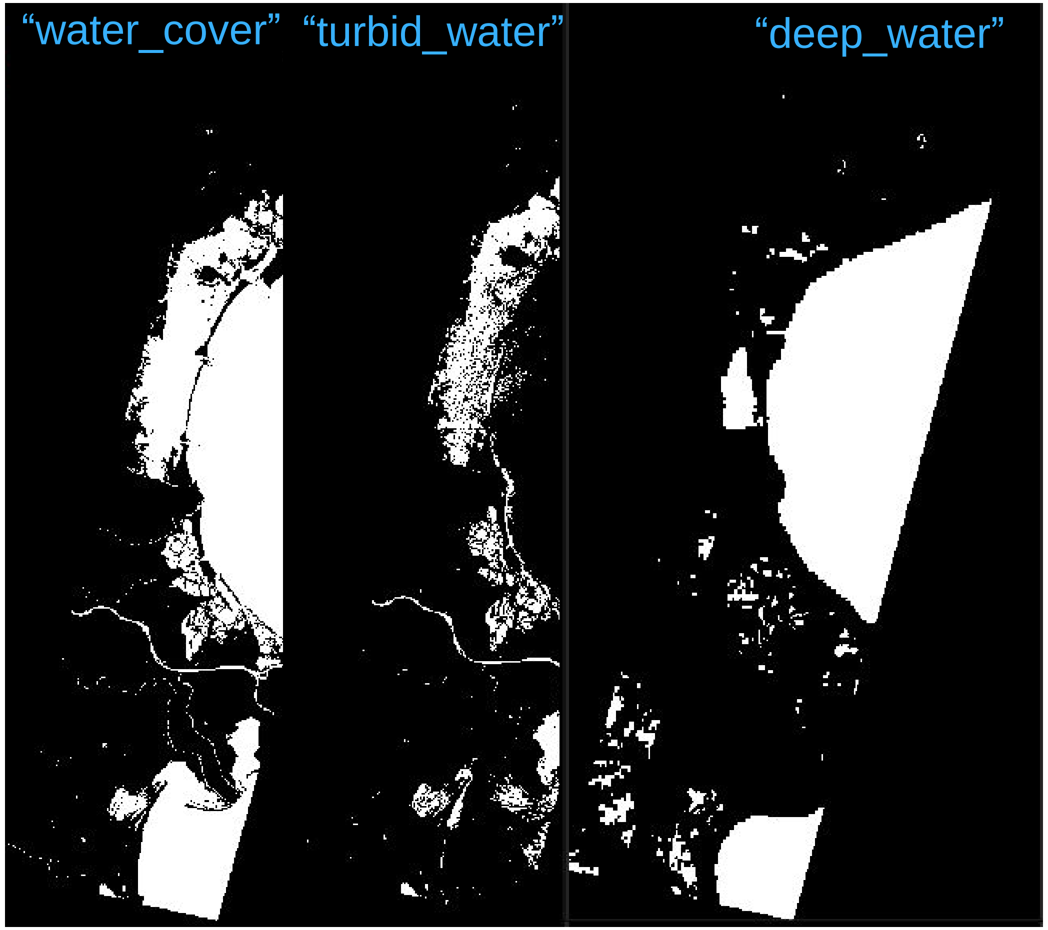
Shi & Wang, 2007

EnMAP (“CHIME-like”) as Test Data

2D binary masks (example)

2D **SCL** “quick-look”



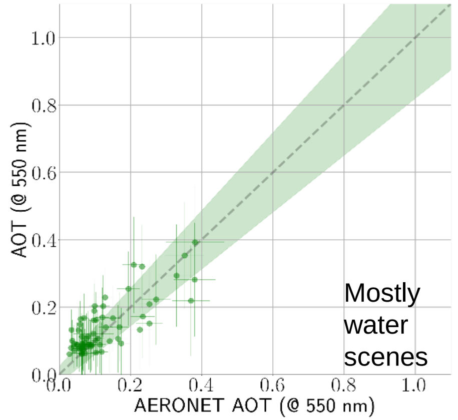


Atmosphere characterization: AOT and WV land and water surfaces

❖ AOT:

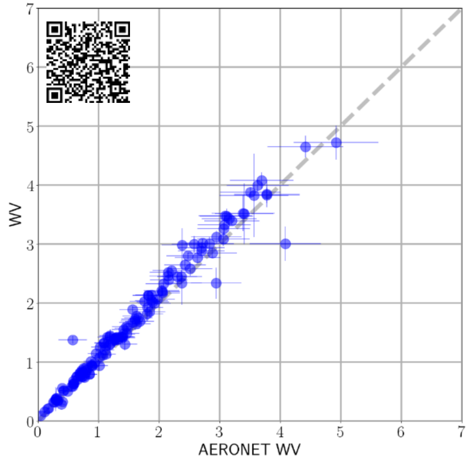
- CAMS (forecast) as initialization
- Dark-Dense vegetation / Dark pixels for retrieval
- WV: APDA method adjusted to water
    - 940 nm absorption feature create peaks to the water leaving spectra
    - Profit from hyperspectral features,
      e.g. 820 nm (lessons learned from DESIS)

$$U_{AOT} = 0.14 * AOT_{550} + 0.04$$



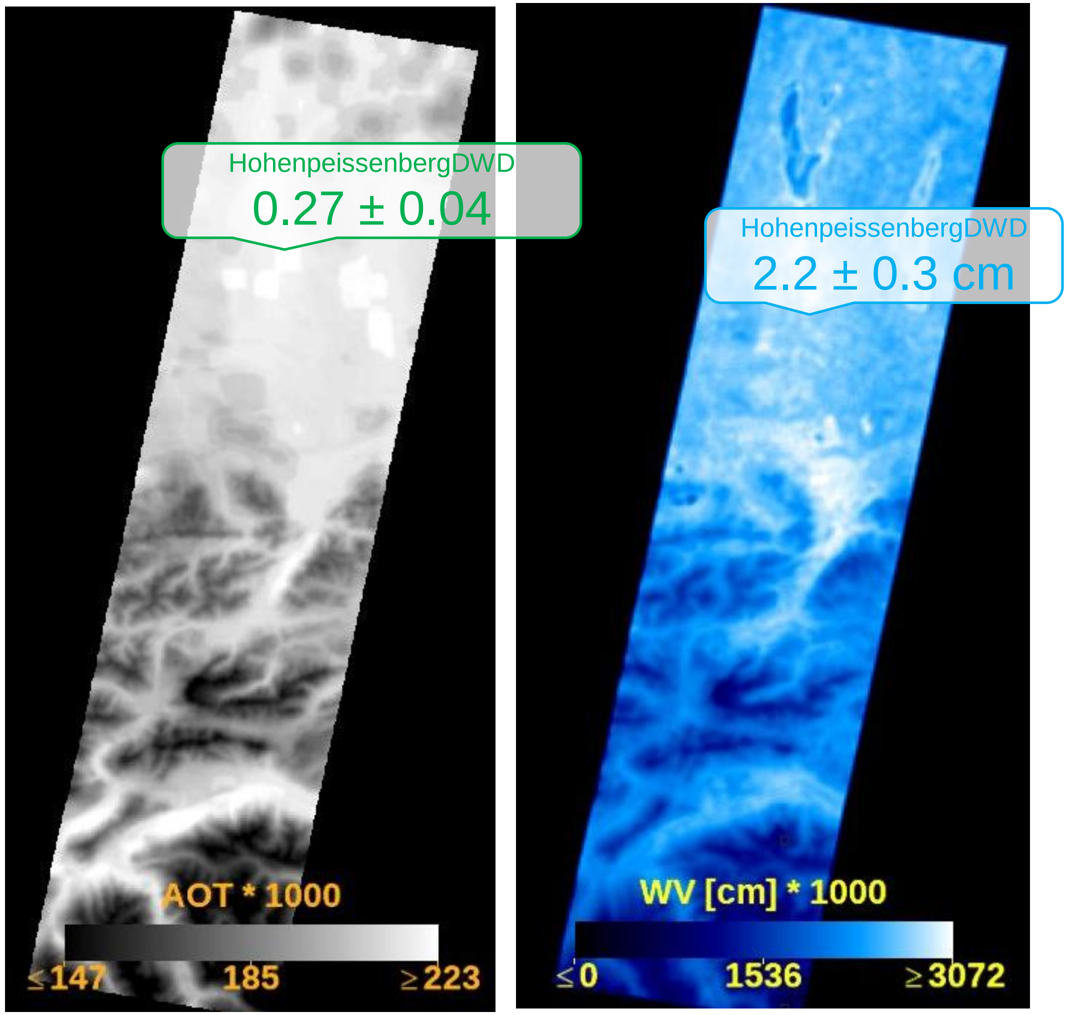
EnMAP (de los Reyes, R. et al, 2023, IGARSS)

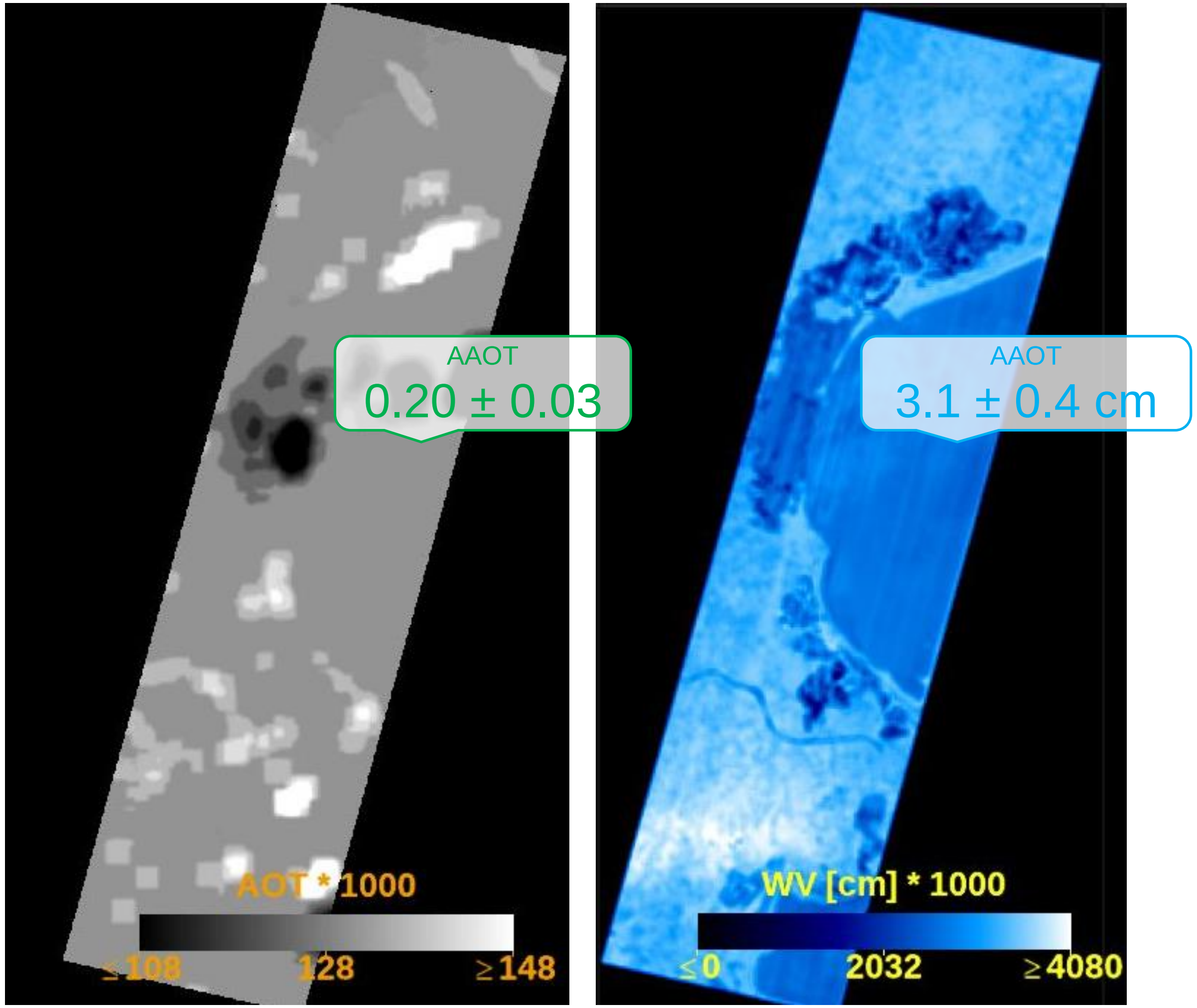
$$U_{WV} = 0.08 * WV + 0.06$$



DESIS (de los Reyes, R. et al, 2021)

EnMAP (CHIME-like) as Test Data

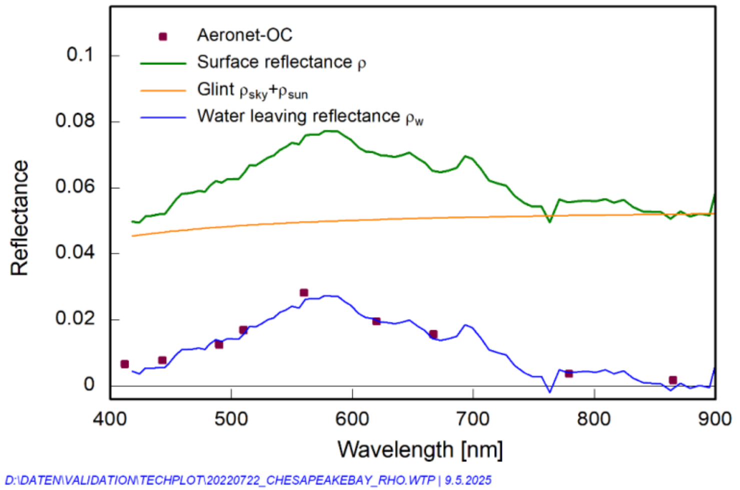


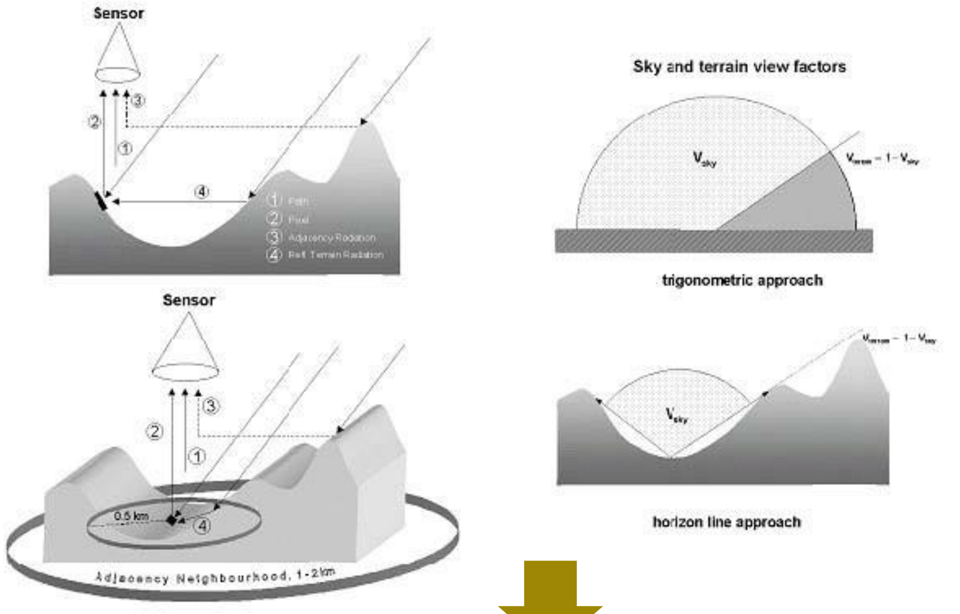


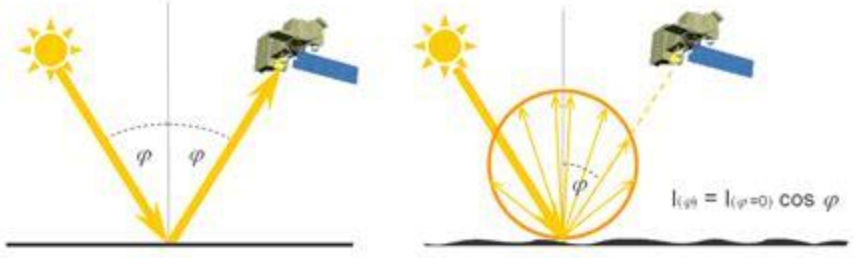
Atmosphere correction: SR and WR

- SR retrieval with rugged-terrain + adjacency correction
  - BRDF correction (optionally activated)
- WR extracted from SR:
  - same atmosphere characterization as land
  - Adjacency correction
  - + water specific correction (e.g. sun-glint, ..)

See P. Gege talk (C.03.03)

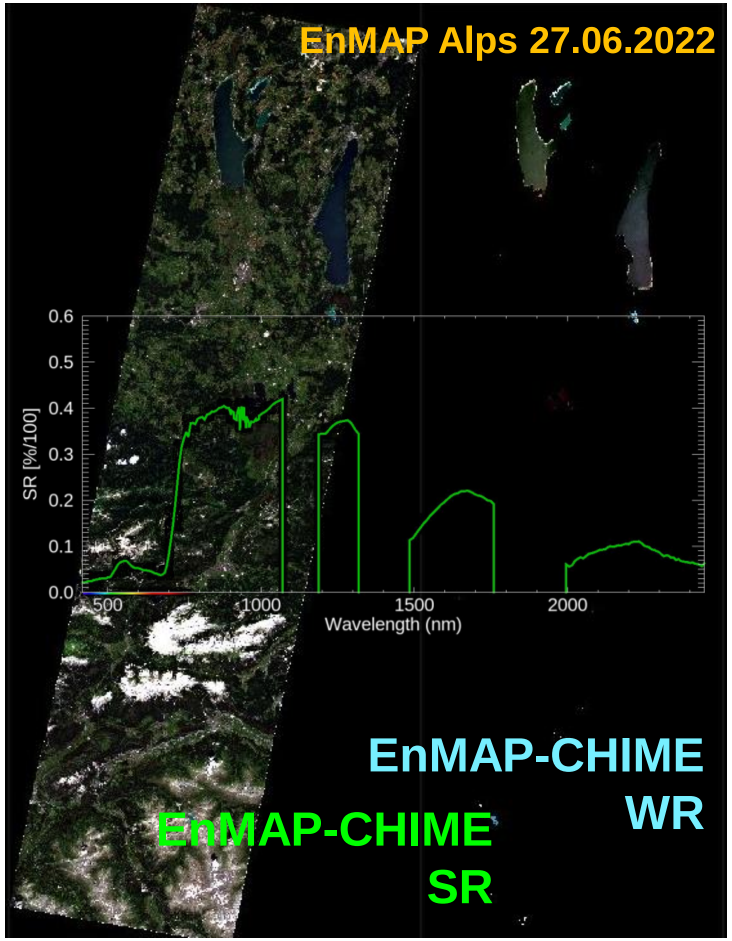


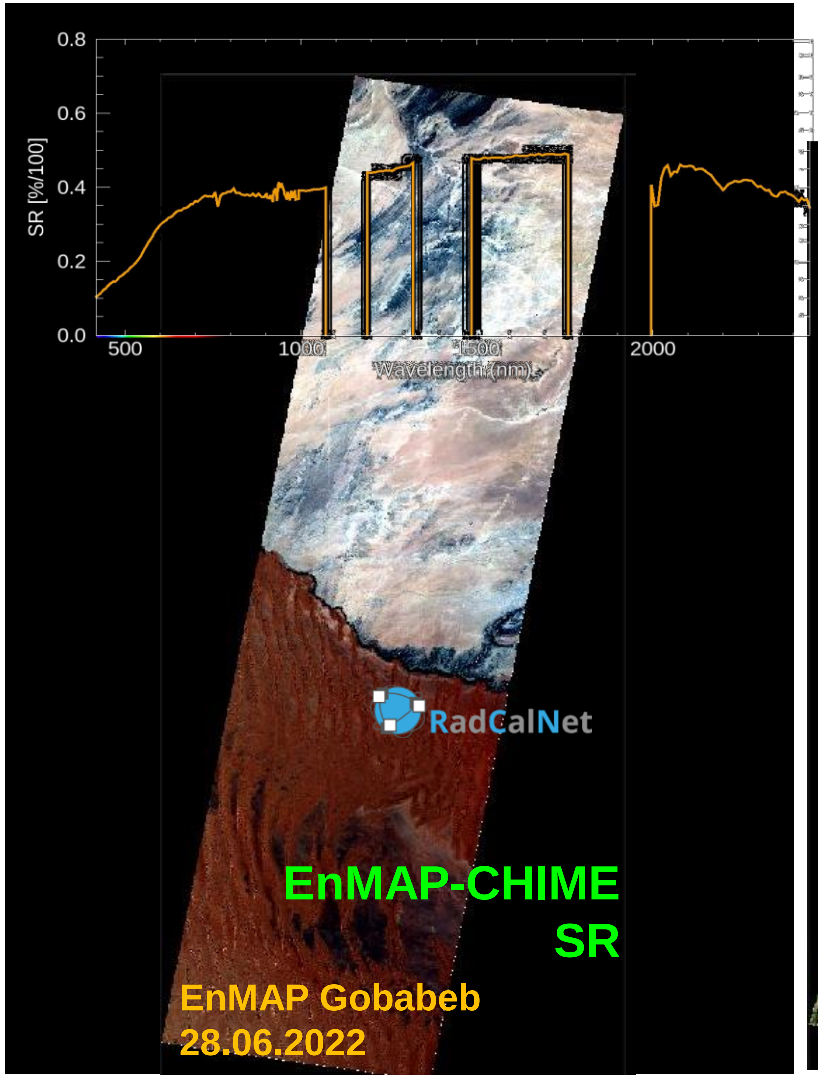


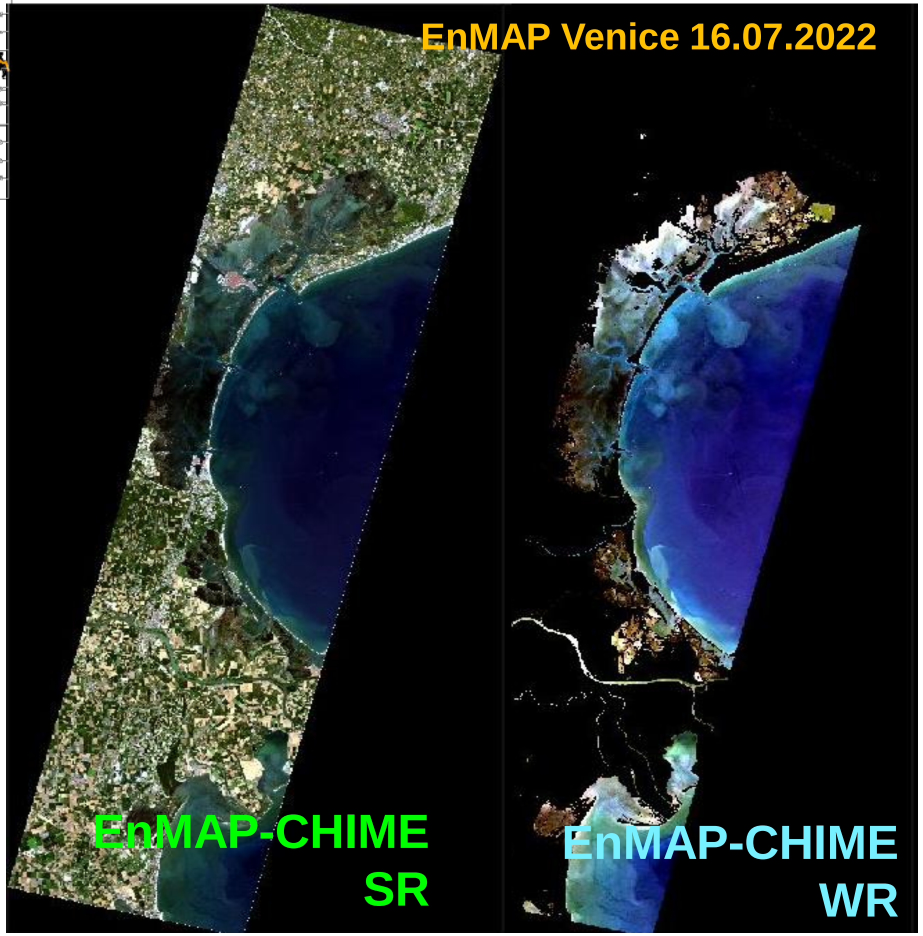


See C. Guerrero talk (C.03.03)

EnMAP (CHIME-like) as Test Data: land.reflectance & water.reflectance







Conclusions / summary

- ✓ First results of the CHIME L2A Prototype Processor & CHIME OSL @ System CDR using EnMAP L1C as Test Data Input. Next step to use CHIME E2E (continuous 400 – 2500 nm).
- ✓ **CHIME OSL AC hyperspectral processor:**
  - ❖ **ground** (PACO + HABA) + **water** (WASI) **reflectance**
- ✓ L2 products will contain the **measurements** and their **uncertainties**.
- ✓ Most of the algorithms are / could be harmonized with Sentinel-2 (Sen2Cor).
- ✓ **CHIME OSL** improvements/developments to current hyperspectral AC (based in PACO):
  - ✓ Sentinel-2 masking improvements
  - ✓ Addition of specific water masks and their application through the code (e.g. AOT)
  - ✓ Implementation of CAMS forecast models
  - ✓ Retrieval of water leaving reflectance
- ✓ **New** implementations to be added:
  - ✓ *RT function from Eradiate @ 0.1 (0.4) nm*
  - ✓ L1B/L1C Ortho-rectification using Copernicus libraries.