The EnMAP L2A Processor

1st EnMAP User Workshop

Maximilian Langheinrich, Raquel de los Reyes, Martin Bachmann
Deutsches Zentrum für Luft- und Raumfahrt
10.10.2023

Structure of the L2A Processor

EnMAP L2A Processor

L1B_int

Simplified Atmospheric Correction for BOA reflectance interpolation (based on PACO)*

L2A Land

Full atmospheric correction based on PACO*

L2A Water

Full atmospheric correction over water pixels based on MIP**

*De Los Reyes, Raquel, et al. "PACO: Python-based atmospheric correction." *Sensors* 20.5 (2020): 1428.

**Heege, Thomas, et al. "Operational multi-sensor monitoring of turbidity for the entire Mekong Delta." *International Journal of Remote Sensing* 35.8 (2014): 2910-2926.

L1B_int – Simplified AC for interpolation on reflectances

Simplified assumptions to AC the individual EnMAP cubes in sensor geometry:

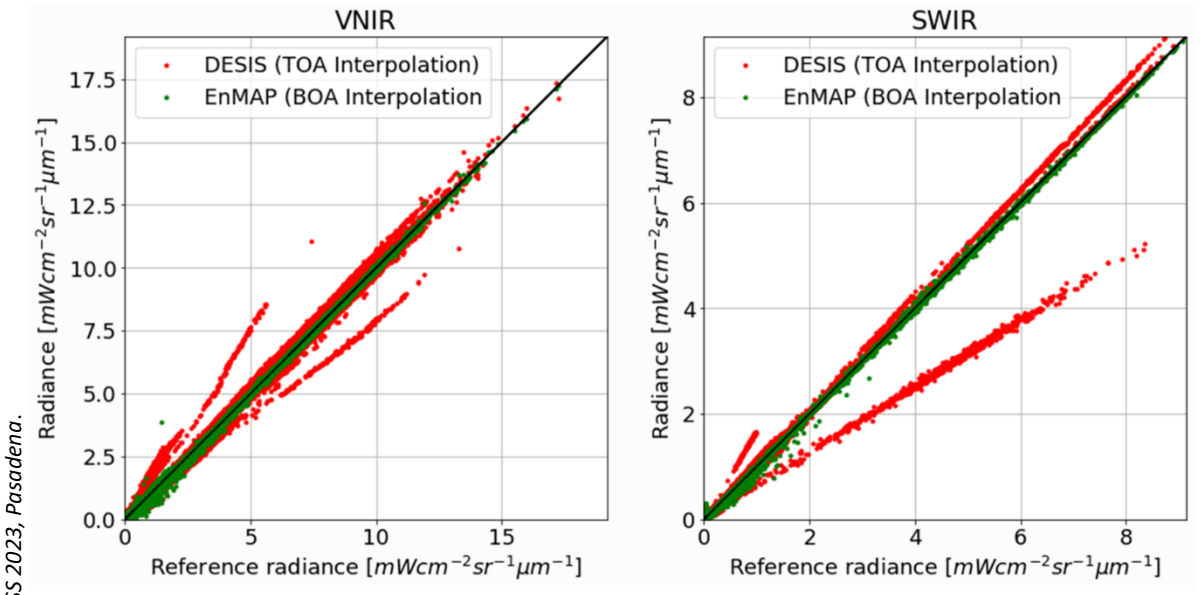
- *WV column variable (VNIR or SWIR is used depending on SNR, DEM is needed)*
- *Visibility constant 23 km*
- *No BRDF correction*
- *No spectral interpolation of absorption bands*
- *Clouds are not masked*
- *No adjacency correction*
- *No clipping of negative values*

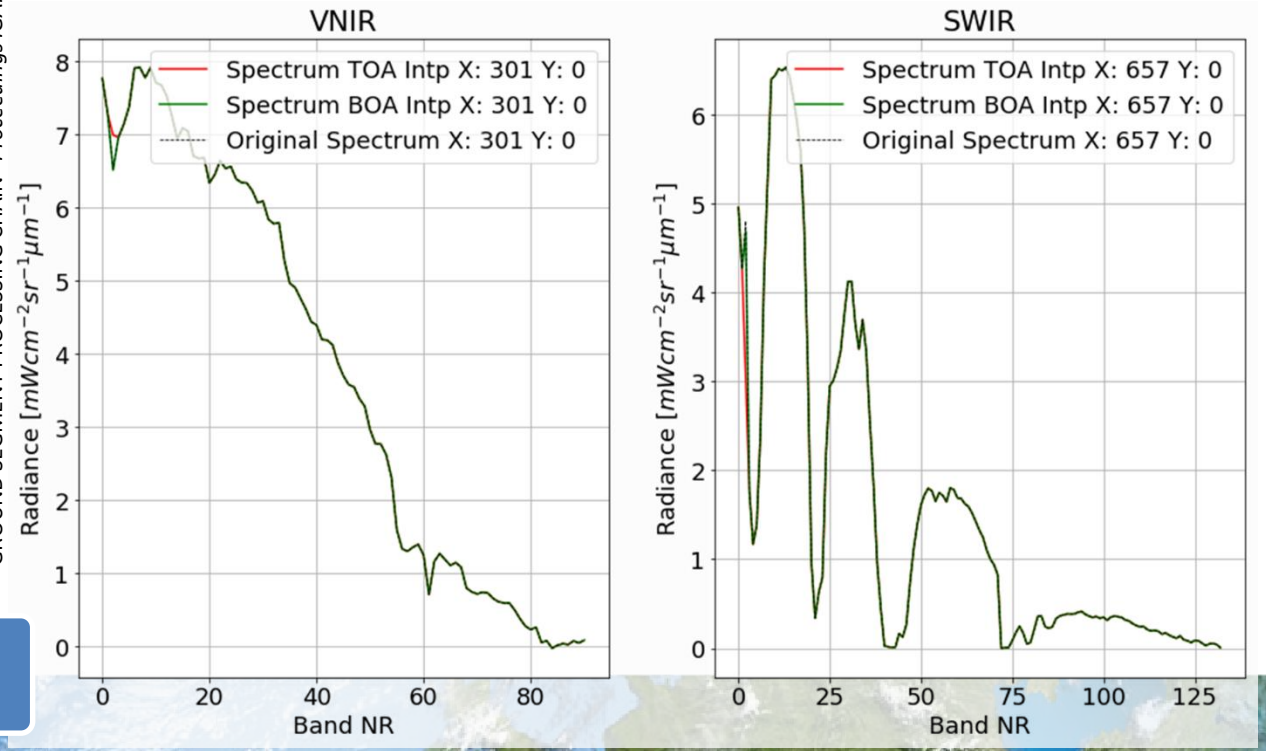
The L1B_int process

Simplified AC of L1B TOA radiances

Interpolation on BOA reflectances

Inversion of AC to reconstruct TOA radiances



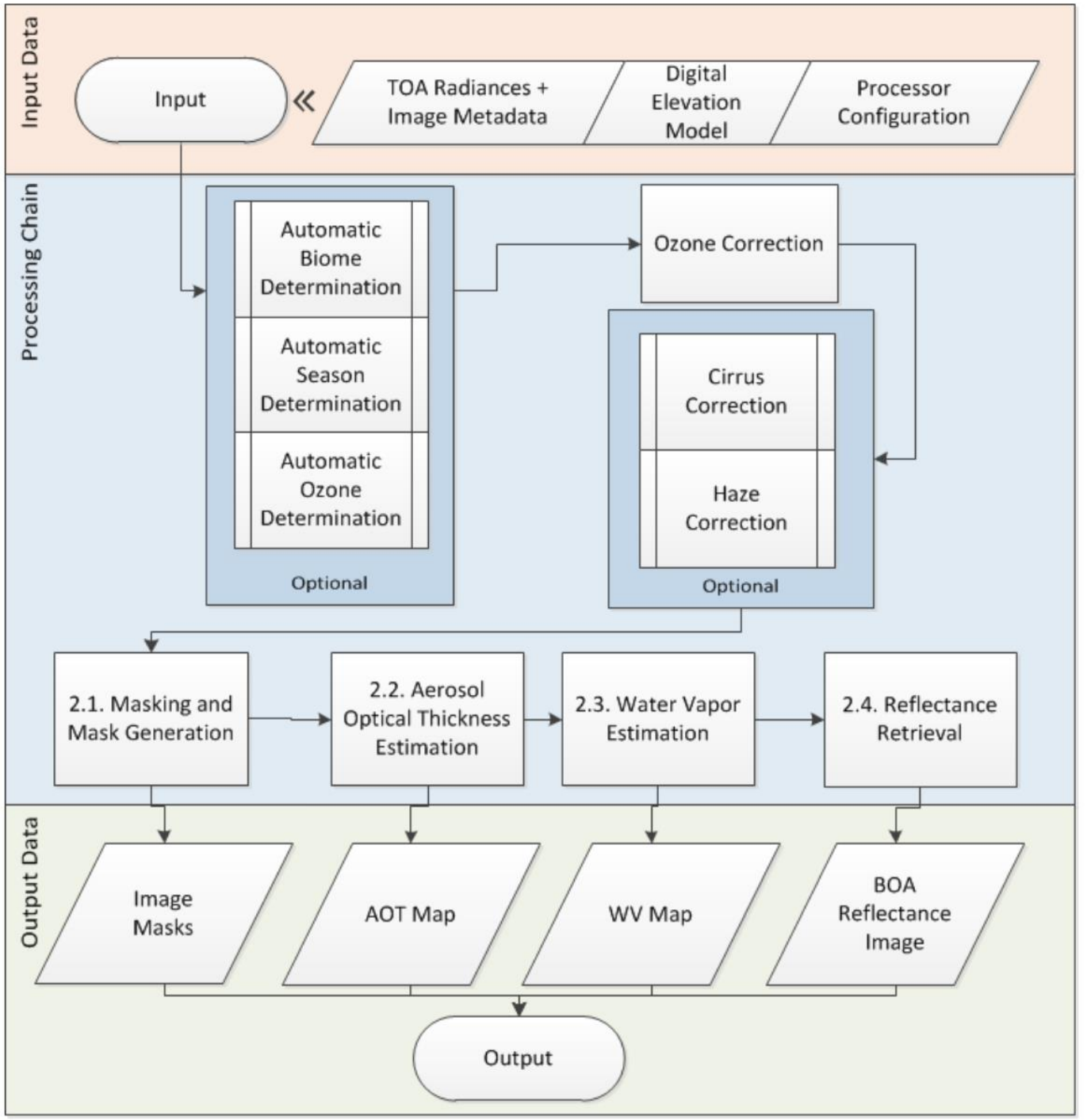


*Langheinrich, Maximilian, et al. "BOA REFLECTANCE BASED DEAD AND DEFECTIVE PIXEL INTERPOLATION IN THE ENMAP GROUND SEGMENT PROCESSING CHAIN" *Proceedings IGARSS 2023, Pasadena*.

L2A Land processor algorithm

L2A User Parameters:

- **Correction_Type**
  (Combined, Land, Water)
- **Terrain_Correction**
  (Automatic, Yes, No)
- **Band_Interpolation**
  (Yes, No)
- **Cirrus_Haze_Removal**
  (No, Cirrus, Cirrus/Haze)
- **Ozone_Column**
  (Automatic, Custom Value)
- **Season**
  (Automatic, Summer, Winter)

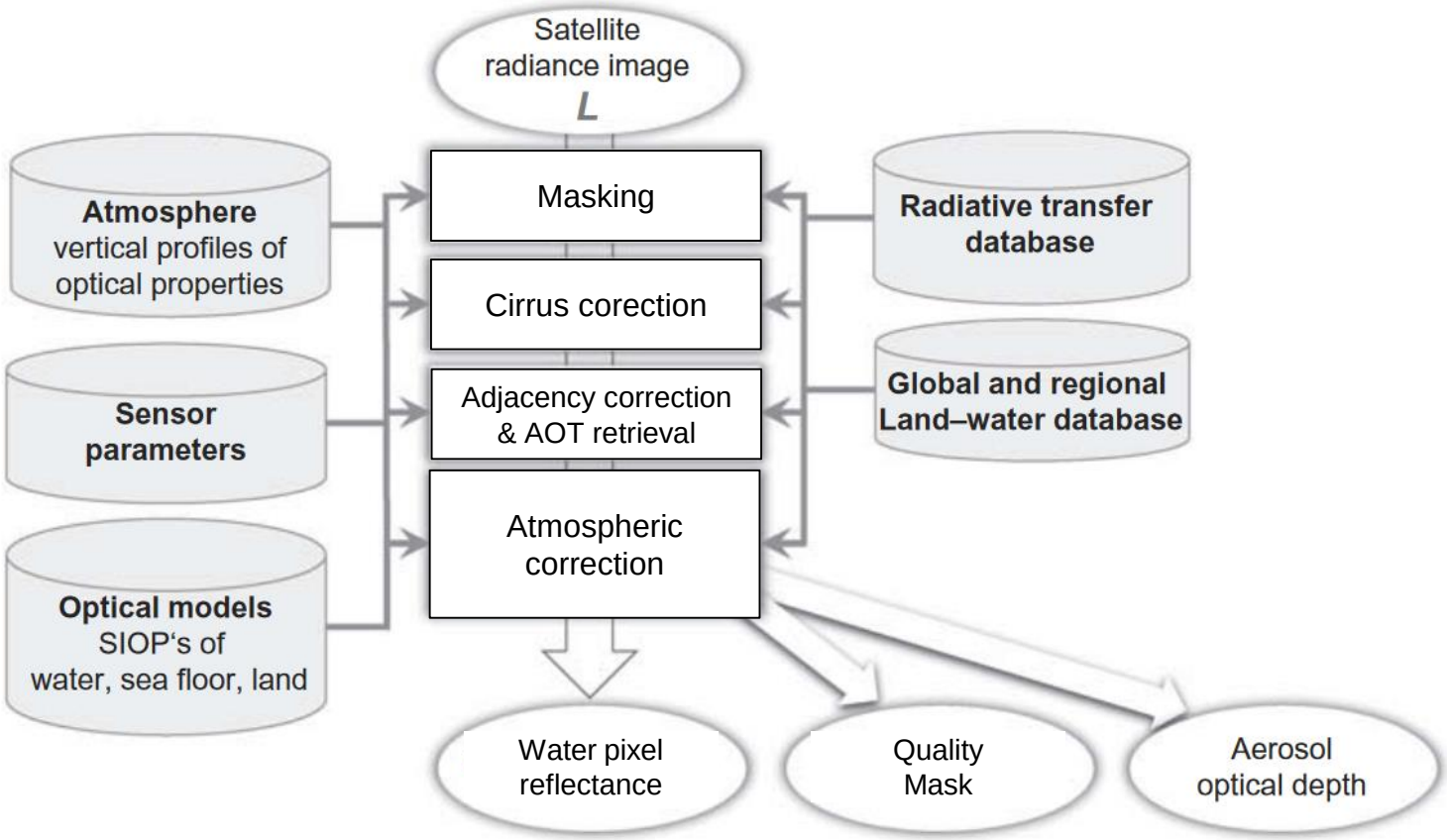


*De Los Reyes, Raquel, et al. "PACO: Python-based atmospheric correction." *Sensors* 20.5 (2020): 1428.

L2A Water algorithm

L2A User Parameters:

- **Correction_Type**
  (Combined, Land, Water)
- **Terrain_Correction**
  (Automatic, Yes, No)
- **Band_Interpolation**
  (Yes, No)
- **Cirrus_Haze_Removal**
  (No, Cirrus, Cirrus/Haze)
- **Ozone_Column**
  (Automatic, Custom Value)
- **Season**
  (Automatic, Summer, Winter)
- **Water_Type**
  (Clear, Turbid, Highly Turbid)
- **Water_Reflectance_Product**
  (Normalized_Rrs, Subsurface_RE)



L2A Products

Remote Sensing Reflectance

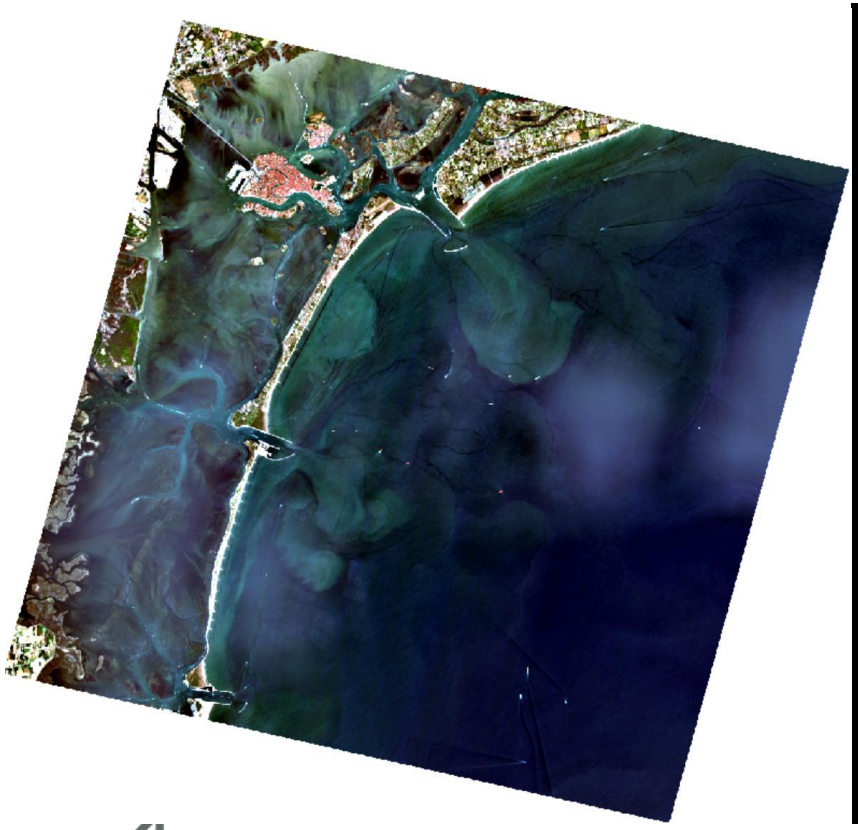
$$Rrs = \frac{L_u}{E_d}$$

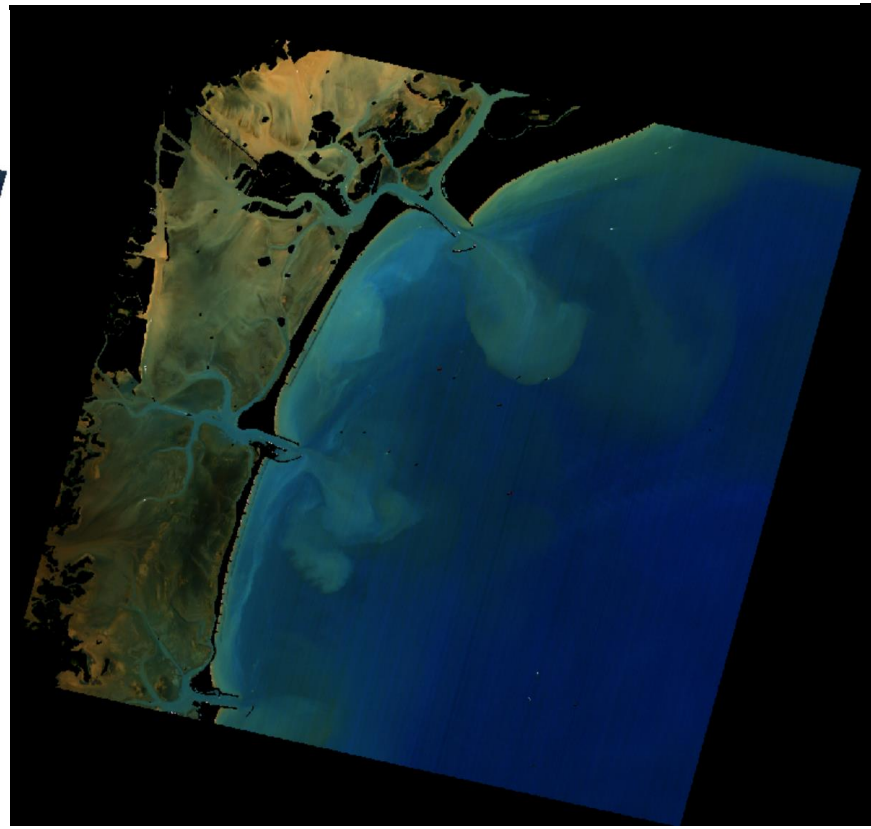
Normalized water-leaving reflectance

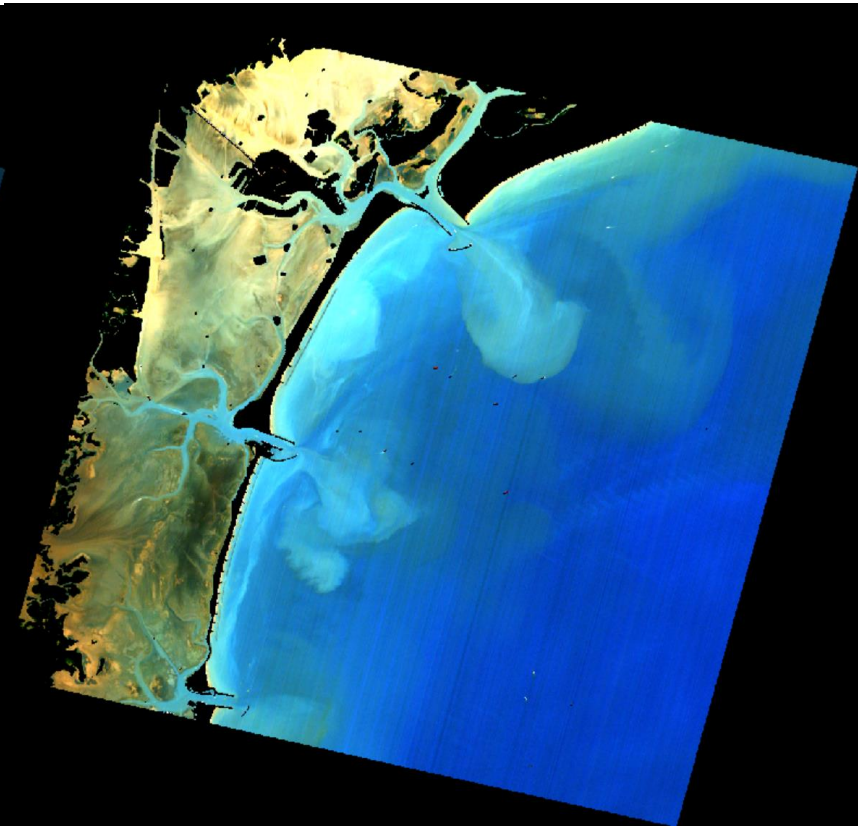
$$R_N = \pi * Rrs^{\{0+\}}(0,0) = \frac{\pi L_u^{\{0+\}}(0,0)}{E_d^{\{0+\}}(0)}$$

subsurface irradiance reflectance

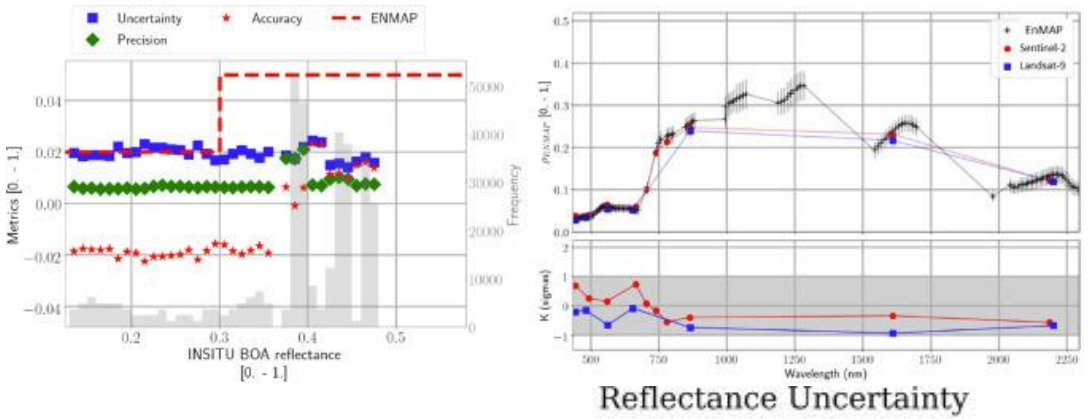
$$R^0(\Theta_s) = E_u^0(\Theta_s)/E_d^0(\Theta_s)$$

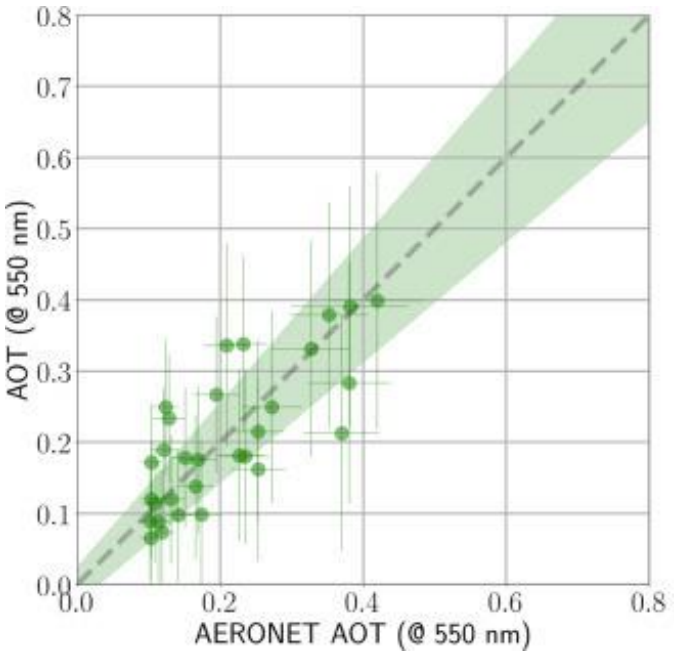


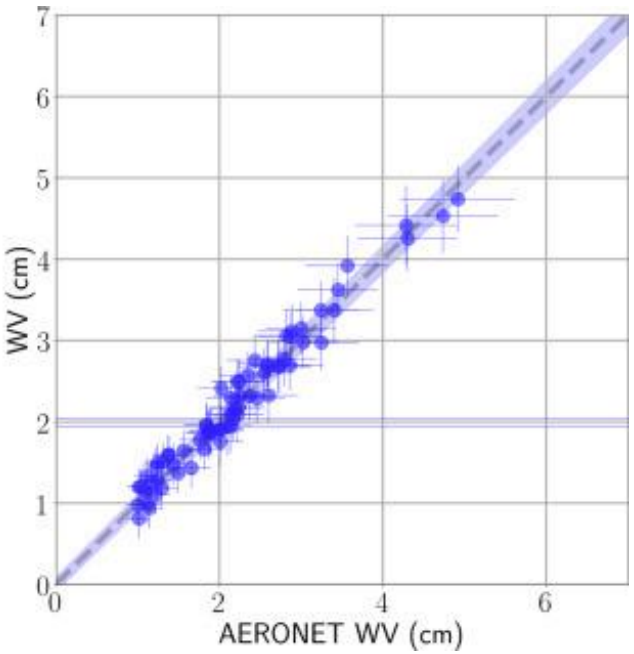


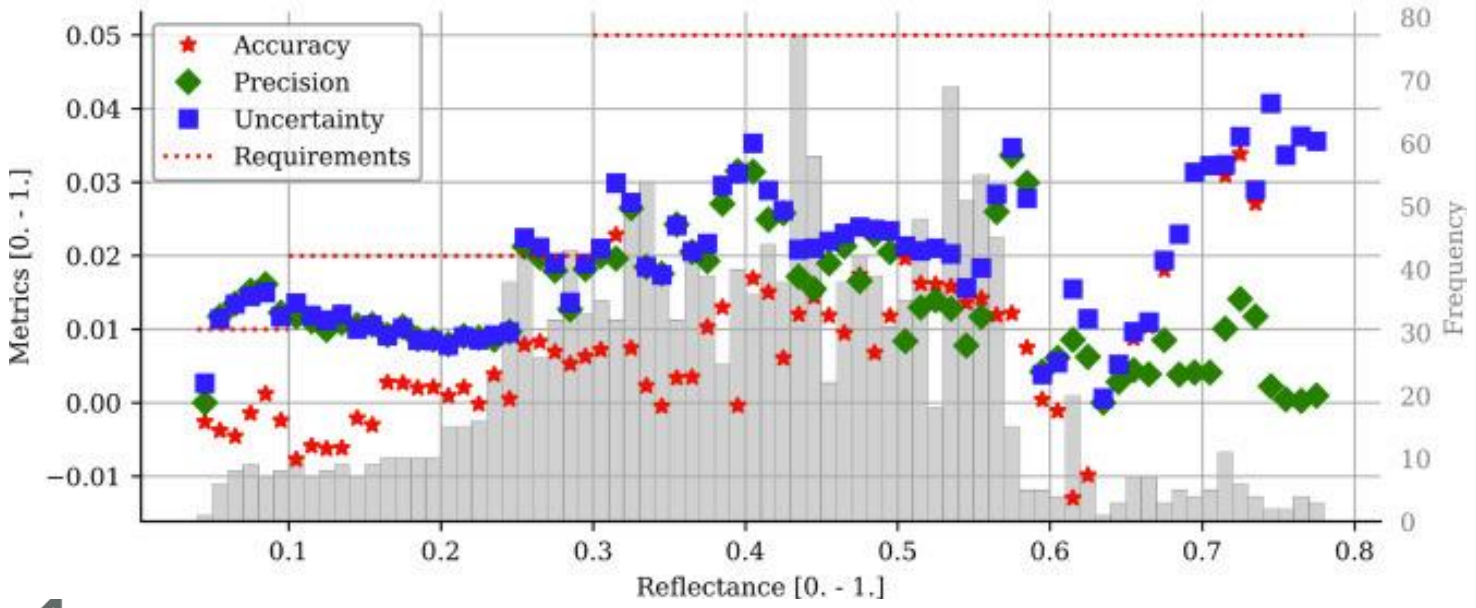


Validation (Land)



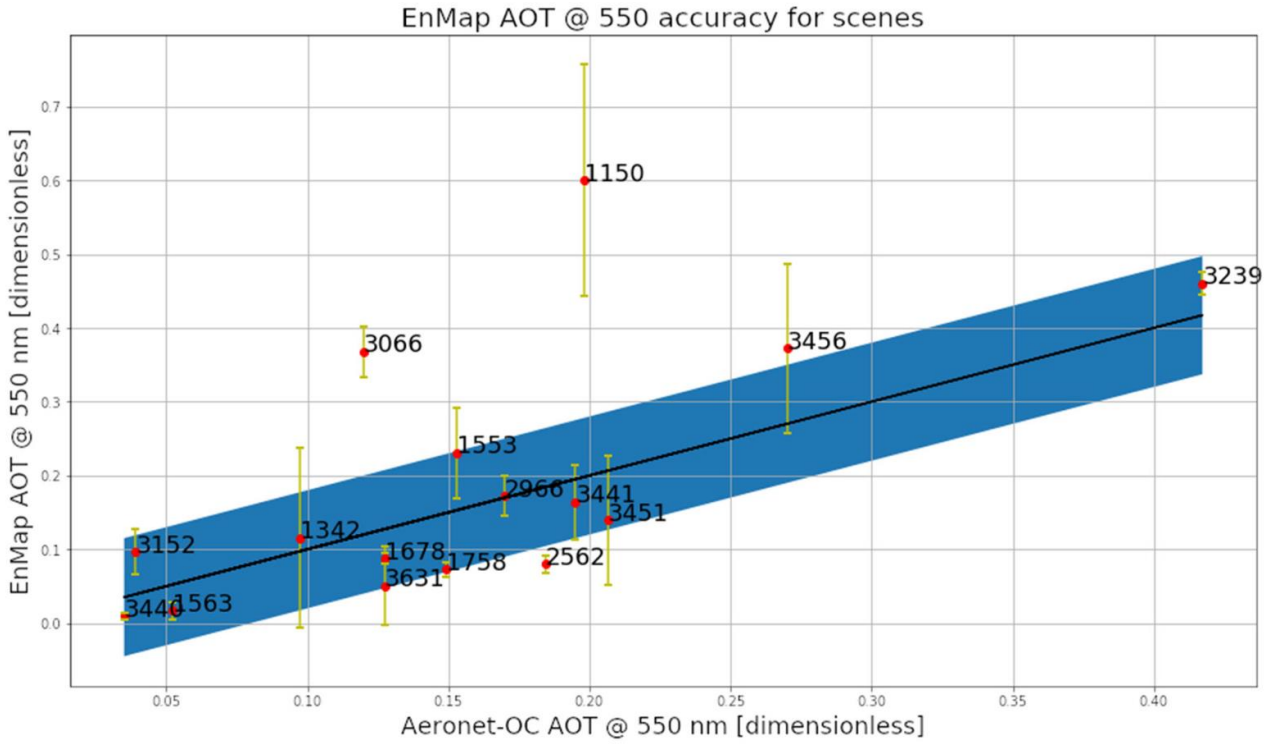


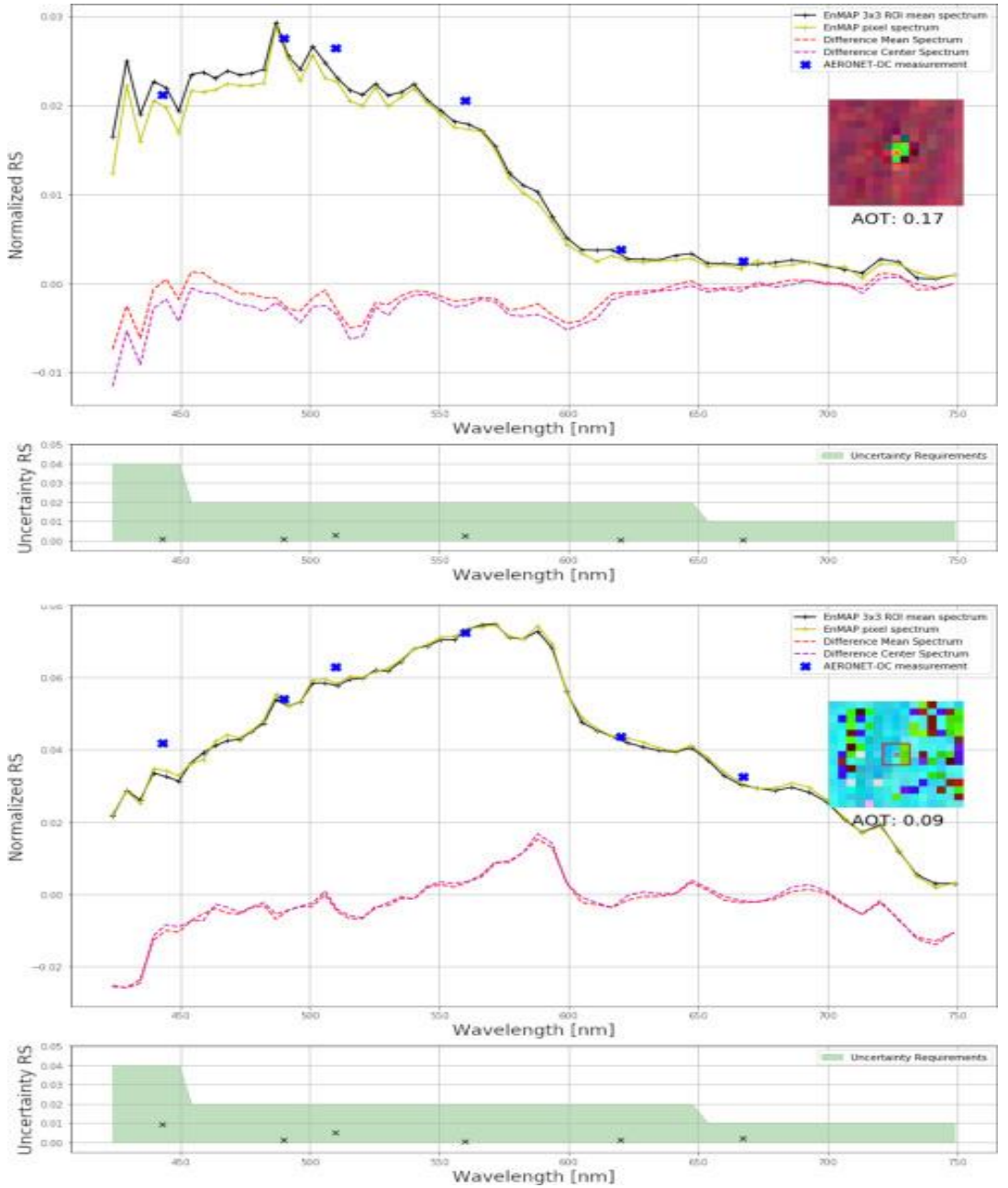




Storch, Tobias, et al. "The EnMAP imaging spectroscopy mission towards operations." *Remote Sensing of Environment* 294 (2023): 113632.

Validation (Water)





Storch, Tobias, et al. "The EnMAP imaging spectroscopy mission towards operations." *Remote Sensing of Environment* 294 (2023): 113632.

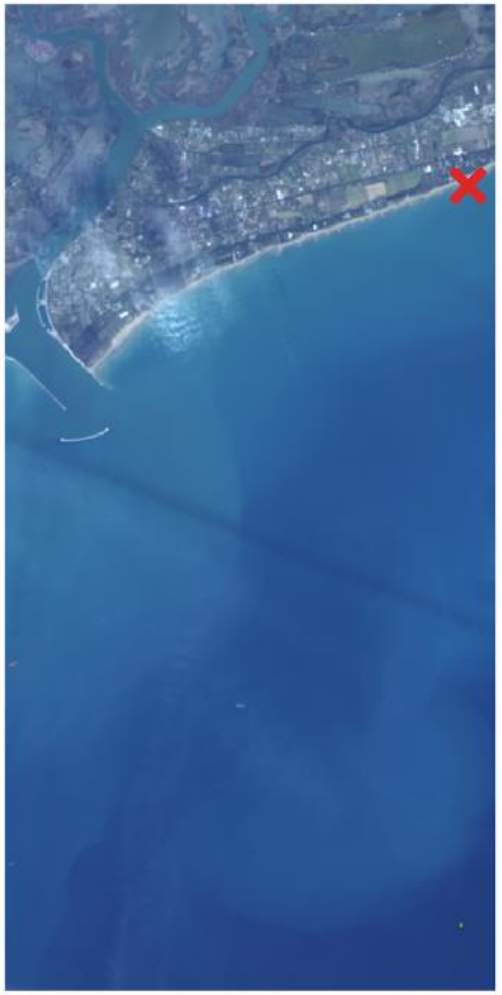
Conclusions

- EnMAP L2A Processor runs according to the mission requirements.
- EnMAP Hyperspectral mission delivers two unique, dedicated water products.
- Overall L2A product comes in different flavors that can be chosen by the user:
    - Land product from land AC processor
    - Subsurface irradiance reflectance for water from dedicated water AC processor
    - Normalized water-leaving reflectance for water from dedicated water AC processor
    - Combined product delivering results from both algorithms

Backup Slides

L2A
Water Adjacency

Radiance image of scene 1023 close to Venice on 2023-03-16.



The magnitude of the adjacency impact increases close to land (shown in black), with significant dependency on geometry and land albedo. The adjacency radiance is shown for band 10 at 463nm.

Ignoring adjacency effects results in significant errors of up to 100% for the retrieved water-leaving reflectance in the blue spectral region. The error is introduced by erroneous spectral compensation of increased aerosol optical thickness.