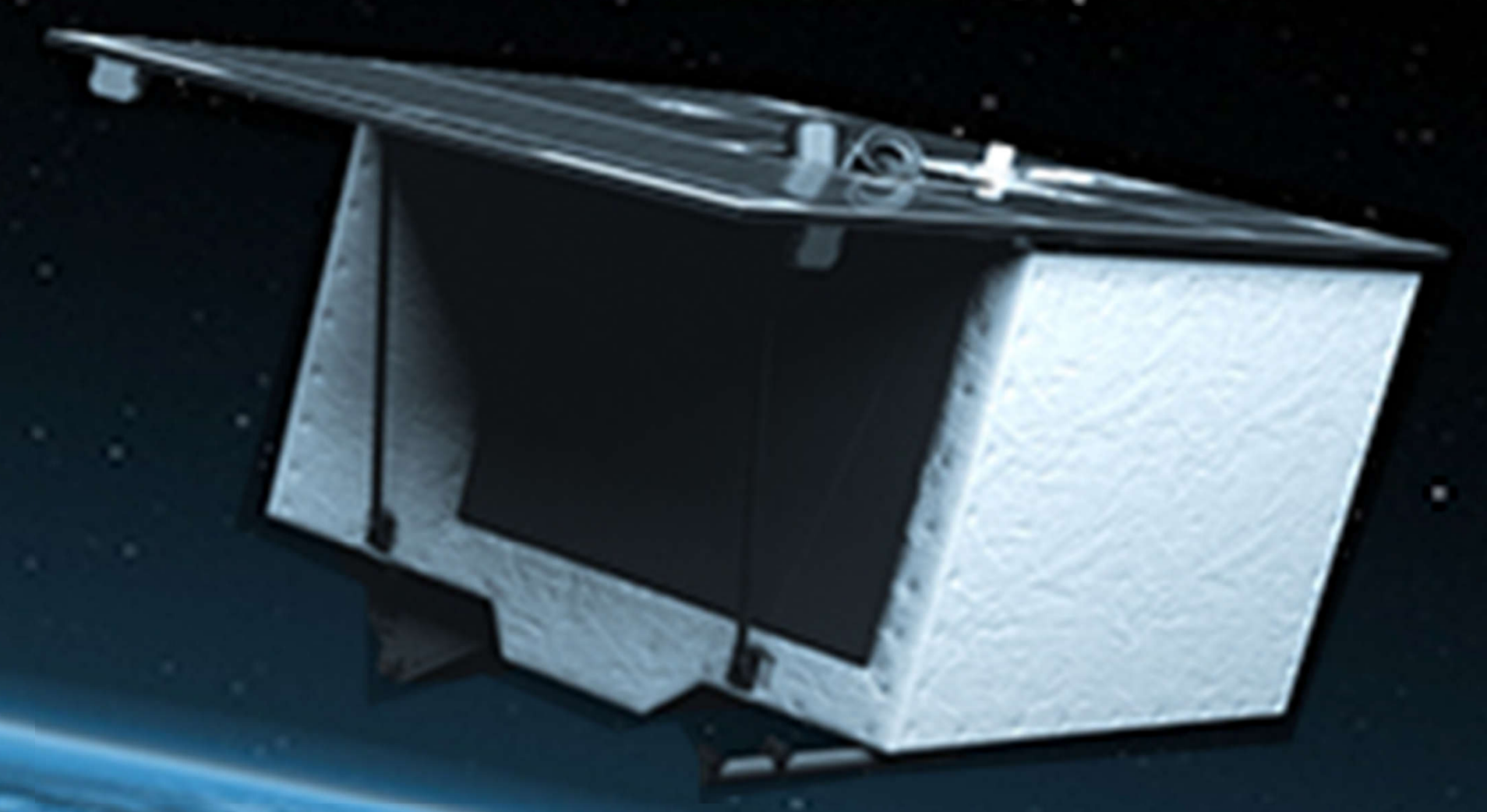


EnMAP

Hyperspectral Imager



Remote Sensing Technology Institute Photogrammetry and Image Analysis

SMILE CORRECTION IN THE ENMAP GROUND SEGMENT PROCESSOR: A QUALITATIVE ANALYSIS

Maximilian Langheinrich*, Rudolf Richter, Raquel de los Reyes, Gintautas Palubinskas, Tobias Storch

The EnMAP hyperspectral imager satellite mission

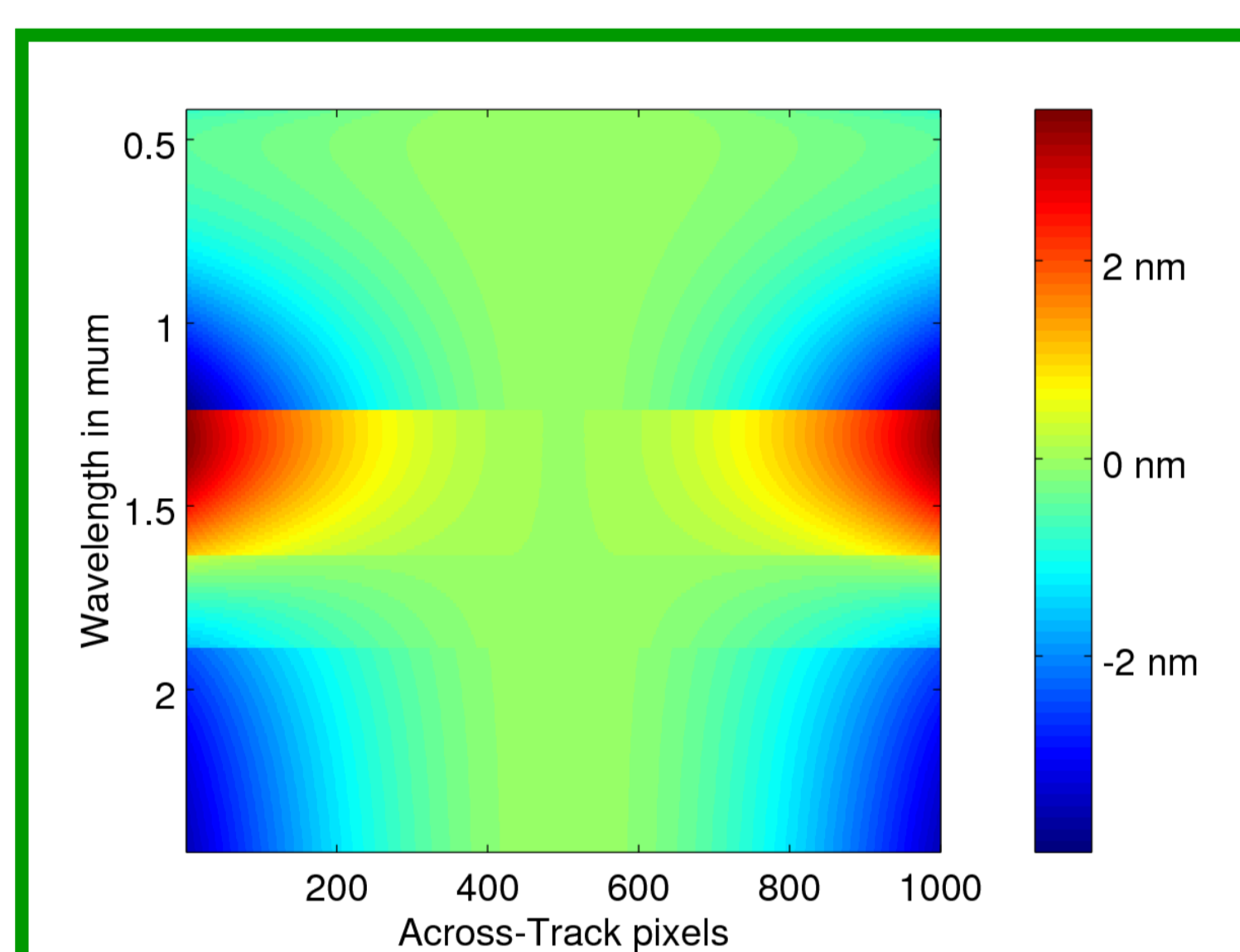
The Environmental Mapping and Analysis Program (EnMAP) is an upcoming German hyperspectral satellite mission aiming to observe and characterize the Earth's environment on a global scale.

It will cover the spectral range from 429 nm to 2431 nm with a spectral sampling distance varying between 4.8 nm and 12.0 nm. It will acquire 30 km in the across-track direction with a ground sampling distance of 30 m and the across-track tilt capability of 30° will enable a target revisit time of less than 4 days. The launch is scheduled for 2020 with an operational lifetime of 5 years. The mission is in its production phase. The hyperspectral image products L1B (radiometrically corrected), L1C (orthorectified) and L2A (atmospherically corrected) will be freely available to the scientific user community for measuring and analyzing bio-, geochemical, and physical parameters characterizing the Earth's surface. This encompasses agriculture, forestry, soil and geological environments, as well as coastal zones and inland waters [Storch et al., 2018]. (Further information on the mission can be found on the website: <http://www.enmap.org>)

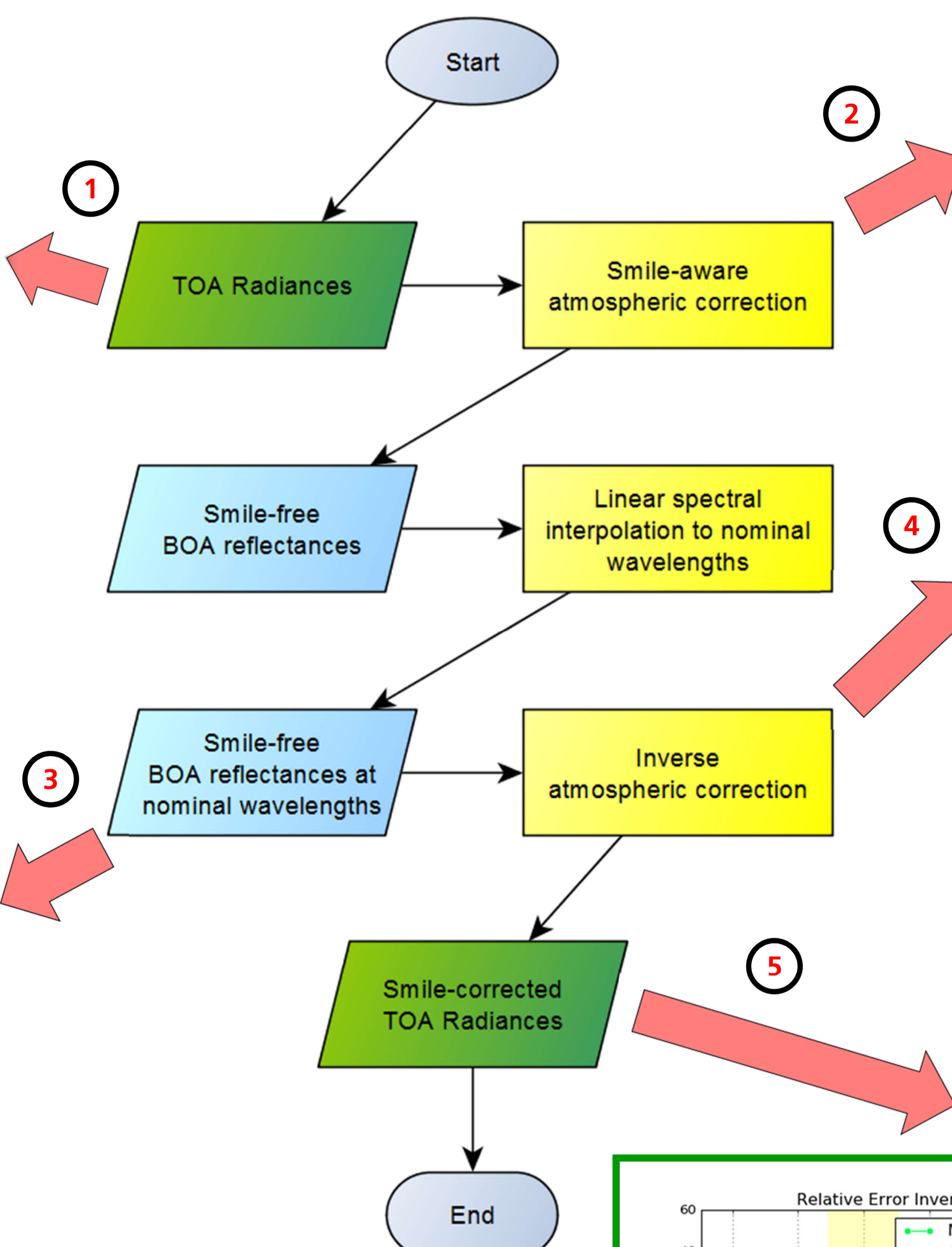
Smile correction in EnMAP processing

The proposed approach of smile correction in the EnMAP ground segment processor results from decisions concerning the design of the EnMAP mission's sensor payload Hyper Spectral Imager (HSI). The instrument's overall spectral range from 429 nm to 2431 nm is covered by two individual spectrometers, with the VNIR ranging from the visible spectrum to the very-near infrared and the SWIR covering the short-wave infrared. For EnMAP the VNIR and SWIR cubes are not spatially aligned in sensor geometry, featuring a spatial shift of approximately 20 scanlines in flight direction of the satellite. As the highly accurate spatial matching of the two hyperspectral cubes is conducted during the orthorectification process in processing level L1C resulting in a geocoded merged cube the smile correction has to be applied on the individual cubes in level L1B. These issues and the given condition that user products of the subsequent processing level L1C are required to be delivered in TOA radiances, create the necessity that the smile-corrected BOA reflectances are calculated back to smile-corrected at-sensor measurements. It is required to invert the atmospheric correction model as part of the intermediate L1B processing step.

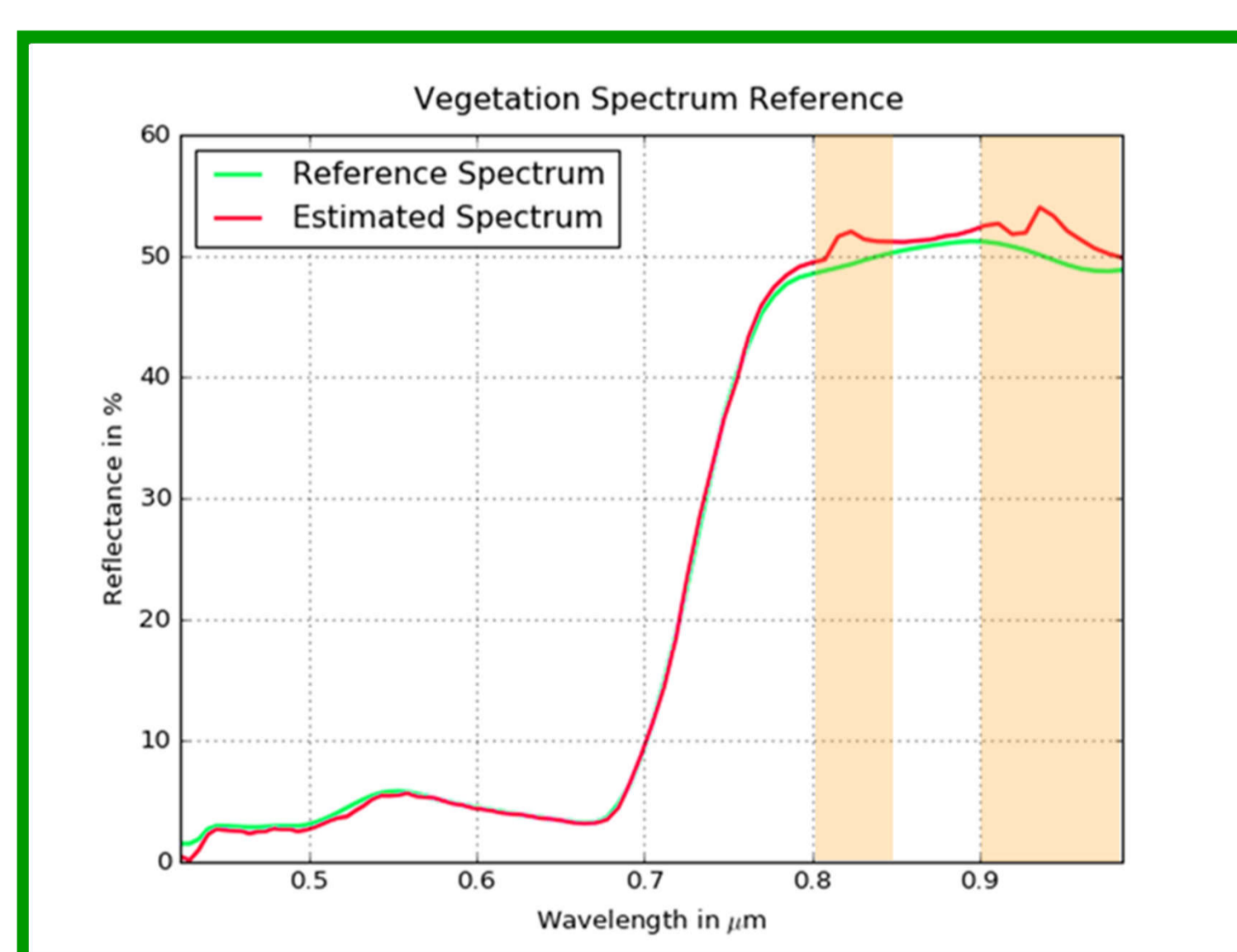
Smile-aware atmospheric correction – Assumptions and workflow	
Conditions	
▪	Constant Visibility of 23 km
▪	No bidirectional reflectance distribution function (BRDF) correction
▪	No spectral interpolation of absorption bands
▪	Clouds are not masked
▪	No adjacency correction and no clipping of negative values
Workflow	
▪	High spectral resolution (0.4 nm) atmospheric LUTs containing the radiative transfer functions for a discrete 6D parameter space are loaded.
▪	The LUTs are interpolated for scene related parameters like i.e. solar and sensor geometry, ground elevation.
▪	The interpolated database is convolved with the spectral response function of each band of the sensor. The actual response function is the sum of the nominal response function for the central wavelength of the band and the local sensor shift described by the polynomial.
▪	Smile-aware water vapor retrieval on a column-wise basis.
▪	Smile-aware, simplified surface reflectance retrieval on a column-wise basis.



In the simulated dataset every band is affected by a smile shift in spatial direction, described by a fourth order polynomial per channel. The interpolated database is convolved with the spectral response function of each band of the sensor. The applied response function is the sum of the nominal (smile-free) response function for the central wavelength of the band and the local sensor shift (smile effect) described by the polynomial

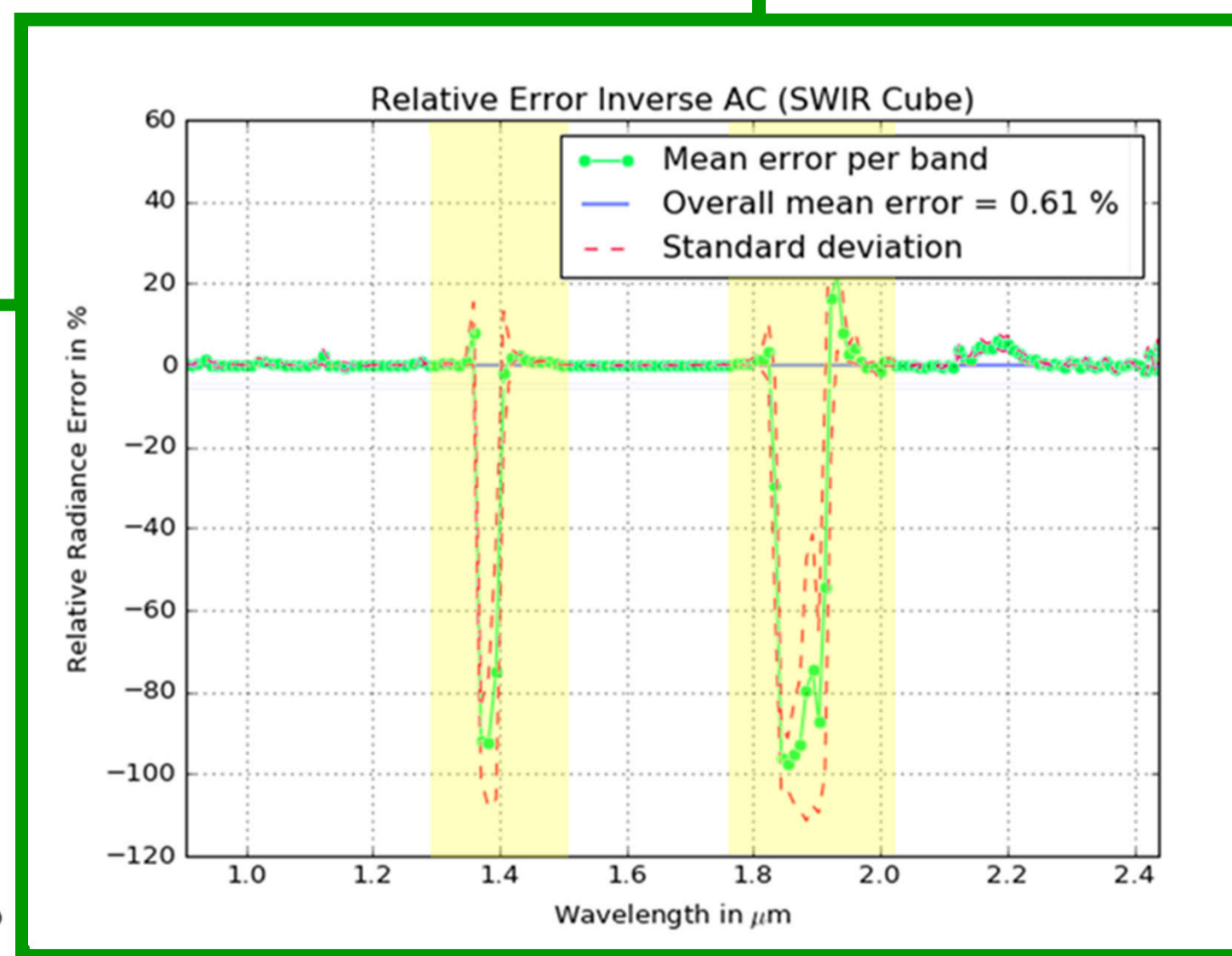
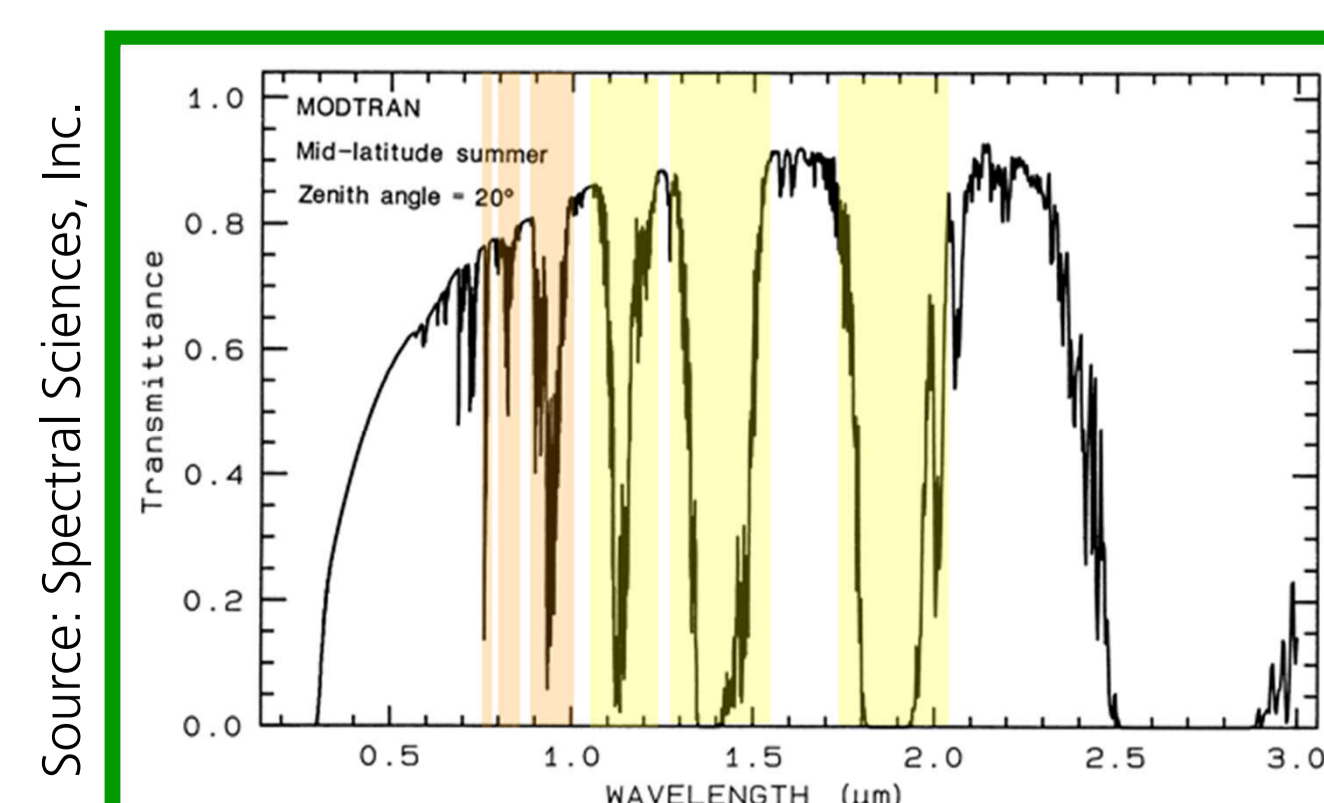


$$L_{TOA}^i = \left[\frac{(\rho_k^i \cdot a_1 + a_0) \cdot E_s(\lambda_i) \cos \theta_s}{\pi d^2} \right] - c_0^i$$



Example smile corrected BOA reflectances for VNIR of a vegetation pixel.

- Strong atmospheric absorption region VNIR
- Strong atmospheric absorption region SWIR



Error plots of TOA radiances after smile- and inverse atmospheric correction for the two separate sensor cubes.