ECLIPSE: Analyzing operating points for a hyperspectral satellite sensor dedicated to coastal applications

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Bottom-of-atmosphere (BOA) reflectance, as estimated from a hyperspectral satellite sensor, mainly depends on the sensor performances in one hand, and the precision of estimation of the atmosphere's parameters on the other hand. Consequently, in the context of coastal applications, the precision of estimation of the water column optical constituents also depends on those parameters. In the ECLIPSE study, we look at better understanding the impact of those sensor and atmosphere’s parameters on the water column optical constituents’ precision of estimation. This is critical for predicting the performances that can be reached by a sensor with regards to its selected design. Here, we set the errors that can be accepted on the water column constituents from the application point of view, and look at quantifying the precision that is needed on the sensor’s parameters and atmosphere’s parameters retrieval, in order to guarantee that we remain within the errors set on the water column’s parameters.

The approach is based on forward and inverse modelisation of the radiative transfer through the atmosphere and the water column. First, from an airborne hyperspectral image, we synthesize a surface reflectance scene over water scanning a large range of optical constituents. Then, we compute the top-of-atmosphere (TOA) reflectance for different optical thicknesses by using the 6S radiative transfer model in the atmosphere, and modify that TOA reflectance thanks to noise and calibration selected sensor’s characteristics. Then we compute back the surface reflectance and introduce an error on the optical thickness used in the atmospheric correction process. From the surface reflectance, we use a standard semi-analytical radiative transfer model in the water column, in order to retrieve the concentration of phytoplankton (C_{phy}), the concentration of non-algal particles (C_{nap}), the water depth (h), and one parameter that controls the sea bottom reflectance, which is simply modelised by using a linear combination of mineral and vegetal spectra. The absorption due to Color Dissolved Organic Matter is fixed to 0.1 m^{-1} in order to simplify the computations.

The errors that can be accepted on the water column constituents are set, based on the needs identified for different coastal applications. In the simulations, water column parameters are modulated while water depth ranges from 0.1 to 10 meters. We conclude that hydrographical applications (which include water depth and bottom reflectance estimation) are less demanding in noise reduction and calibration precision than water color applications (which include the estimation of C_{phy} and C_{nap}). Any effort to reduce noise is useless if the absolute calibration error is greater than 2%. Concerning aerosol optical thickness, a similar conclusion is obtained: a precision of 0.01 is required for C_{phy}, C_{nap} but only of 0.04 for water depth.