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Development of hybrid models for the operational retrieval of vegetation traits from the hyperspectral CHIME mission

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The Copernicus Hyperspectral Imaging Mission for the Environment (CHIME) is in preparation to carry a unique visible to shortwave infrared spectrometer. This mission is aimed to be operational, providing routine observations to support agricultural management and biodiversity conservation. In addition to the level 1B, 1C and 2A products, the mission will provide L2B products, i.e. among others including a set of vegetation traits. In view of preparing retrieval models applicable in an operational setting, we developed a hybrid retrieval workflow based on the combination of field data and look-up tables (LUT) generated from radiative transfer models (RTM) at leaf and canopy evel. The presented workflow corresponds to the version 1.8 of the L2B vegetation models. For each variable, the LUT was optimized by an active learning (AL) technique ran against field validation data. This hybrid optimization method is aimed to achieve a good trade-off between specialization, generalism and size of the LUT, in order to perform well in a variety of scenarios and deliver fast processing. Eventually the reduced LUTs were used to train final retrieval models. We selected Gaussian process regression (GPR) and heteroscedastic Gaussian process regression (VHGPR). These are nonlinear, machine learning algorithms that lie in a solid probabilistic framework and not only provide competitive estimates, but also associated uncertainties. Based on this workflow we developed 13 vegetation models of leaf and canopy variables, which are under investigation to be implemented into CHIME's L2B vegetation processing chain. Models performance was tested in ESA's CHIME end-to-end (E2E) simulator. Furthermore, we applied the prototype models to images derived from current hyperspectral airborne (APEX and HyPlant) and also spaceborne imagery (PRISMA) resampled to CHIME band settings, resulting into meaningful vegetation maps over heterogeneous European landscapes. For some canopy variables such as fraction of absorbed photosynthetically active radiation (FAPAR), fractional vegetation cover (FVC) and canopy nitrogen content (CNC), we obtained relative errors (NMRSE, in %) of 3.80, 4.25 and 16.83 respectively, and high quality maps. Altogether, obtained maps demonstrate the feasibility of routinely providing vegetation products from the CHIME imaging spectroscopy mission.