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VODCA v2: Multi-sensor, multi-frequency vegetation optical depth data for long-term canopy dynamics and biomass monitoring

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Vegetation optical depth (VOD) is a model-based indicator derived from microwave Earth observations. It quantifies the attenuation of surface microwave emissions by the overlaying vegetation. VOD is an indicator of the total water content stored in the vegetation canopy and is related to vegetation density, its relative moisture content, and above-ground biomass (AGB). VOD has been used in various applications such as phenology analysis, drought, biomass monitoring, and estimating the likelihood of fire occurrence, leaf moisture, and gross primary productivity. Most of these applications require consistent long-term measurements, which are not provided by single-sensor time series.

The first version of the global, long-term Vegetation Optical Depth Climate Archive (VODCA v1)[1] enables long-term analysis by harmonising VOD retrievals from multiple passive microwave sensors, derived through the Land Parameter Retrieval Model (LPRM)[2]. VODCA v1 provides separate VOD products for different spectral bands, namely the Ku-band (period 1987–2017), X-band (1997–2018), and C-band (2002–2018).

Here, we present a new version of the VODCA dataset. VODCA v2 comprises two new products: a multi-frequency product called VODCA CXKu (1987 – 2021), obtained by merging the C-, X- and Ku-band observations and an L-band product (2010 – 2021) based on LPRM-derived VOD from the SMOS (Soil Moisture and Ocean Salinity) and SMAP (Soil Moisture Active Passive) missions. Even though the single-frequency products of VODCA v1 have merits on their own, merging them into VODCA CXKu yields a dataset with lower random levels and improved temporal sampling. It provides similar spatiotemporal information to optical and microwave vegetation indicators, such as the Fraction of Absorbed Photosynthetically Active Radiation (fAPAR) from MODIS and the slope

of the backscatter incidence angle relation of Metop ASCAT (ASCAT slope). VODCA CXKu agrees best with fAPAR in short vegetation (Spearman's R: 0.57) and broadleaf forests (Spearman's R: 0.49) and with ASCAT slope in grassland (Spearman's R: 0.48) and cropland (Spearman's R: 0.48). Additionally, VODCA CXKu shows temporal patterns similar to the Normalised Microwave Reflection Index (NMRI) from in situ L-band GNSS measurements of the Plate Boundary Observatory (PBO) and sapflow measurements from SAPFLUXNET. VODCA L shows strong spatial agreement (Spearman's R: 0.86) and plausible temporal patterns with yearly AGB maps from the Xu et al. (2021) dataset.

We conclude that VODCA CXKu provides valuable information to study the vegetation canopy response to climate variability and anthropogenic impacts. We recommend using it in long-term vegetation monitoring studies focusing on short vegetation types and broadleaf forests. VODCA L provides valuable insight into AGB.

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