Generating phenology adaptive pixel-based Landsat composites across large areas

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Currently, we face a rising demand for national pre-compiled wall-to-wall baseline products of remote sensing data at medium spatial resolution. National measurement, reporting and verification (MRV) systems are in urgent need of such data, e.g. in the context of monitoring national forest stocks in the upcoming REDD+ program. Landsat imagery is commonly the tool of choice for mapping forest change at the landscape level, though the generation of large area products is elaborate and not yet available to everyone due to the high technical demand in terms of data processing, storage and downlink capabilities. Thus, in order to provide the end-user a manageable baseline dataset that generically inhibits the full depth of the Landsat archive, the generation of pixel-based Landsat composites (PBC) is often approached. PBCs are commonly centered on a fixed Day-of-Year (DOY) while allowing data from several years to contribute. However, phenological diversity may prohibit the usage of a single target date if phenologically sound composites across large areas are to be targeted. Therefore, a dataset that provides seasonal breakpoint data for every pixel in the study area is ultimately required in order to adapt the compositing process accordingly.

Prior to generating adequate PBCs, we developed an operational pre-processing framework for the generation of a comprehensive Landsat surface reflectance dataset in a first step. The atmospheric correction module includes radiative transfer code based correction of multiple atmospheric scatterings with a variable illumination/view geometry, a joint database- and image-based estimation of aerosol optical depth over nominally zero reflecting targets, adjacency effect correction and a spatio-temporally variable water vapour correction using MODIS data. Topographic normalization is achieved by an image-based C-correction with 30 m SRTM data. The pixel distance to the next cloud or cloud shadow is computed with a modified version of the Fmask algorithm. We processed all available L1T Landsat data (Angola, Zambia, Zimbabwe, Botswana and Namibia) and stored them in a tiled MODIS-like data structure in binary image format.

In order to adjust the PBC process to an appropriate target DOY for each individual pixel, we developed a data fusion algorithm that reconstructs MODIS-derived phenology descriptors at the Landsat resolution. MODIS phenology was derived with a polynomial spline model approach. The reconstruction algorithm intensively considers the information from the local pixel neighborhood at both resolutions by utilizing several prediction proxies, including spectral distance and multi-scale heterogeneity metrics.

We developed a novel phenology adaptive pixel-based Landsat compositing algorithm that utilizes a parametric weighting scheme while adjusting time-specific scoring functions to the underlying phenological information of every single pixel. We successfully generated several national composites for Zambia that are centered at different phenological stages, i.e. wet season, cool dry season and hot dry season composites by utilizing different types of scoring functions.