Functional grassland phenology discrimination and analyses with Himawari-8 geostationary data

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Climate change and extreme events are altering the functioning and composition of ecosystems with consequences for ecological processes, food security, and human health. Australia’s highly productive dry grassland ecosystems with biodiverse native flora are particularly vulnerable, yet there is very little knowledge of their health, functioning, and changes in response to climate change. A key bio-indicator of climate change is phenology (the study of recurrent life cycle events), and much progress has been made in Northern Hemisphere ecosystems in which many studies have documented advancing biological spring seasons with climate warming. By contrast less progress has been made in Southern Hemisphere ecosystems, due to the lack of long term phenology datasets, a high species diversity, and the absence of a marked dormant season. Satellite time series data enable repetitive and consistent measures of green-leaf phenology, however at coarse, nominal temporal resolutions of 8- and 16-day.

In this study we investigated the potential of geostationary satellite 'greenness' data to discriminate, characterize and retrieve key functional phenological information over a 3,000 km continental-scale grassland area encompassing subtropical C4 grasses to cool temperate C3 grasses, with an extensive areas of mixed, cool- and warm season grasses. Our aim was to assess whether C3 and C4 grass phenologies, as well as mixed phenology, can be identified and mapped for the purpose of monitoring grassland changes over time. There are few studies on characterizing phenology patterns of spatially mixed C3, C4 functional grassland ecosystems which have year round grass cover, and currently there are only meteorology estimates of C3 and C4 grassland areas.

We computed 10 minute vegetation indices (NDVI, EVI) from MAIAC-corrected surface reflectances and composited the data to daily values using solar noon and fixed view angle geometries. We found the resulting green-leaf phenology profiles, at daily timesteps, revealed important structural detail related to varying C3 and C4 grass composition and functional phenologies. C3 grassland phenologies were dominat in the spring season, while C4 grass areas exhibited summer- autumn phenologies. For the most part, mixed areas exhibited two distinct growing season profiles related to grass functional composition. Using the per-pixel geostationary data phenology profiles we mapped the grassland study area into C3, C4 and mixed C3-C4 grasslands. Lastly we verified the structural nature of the phenology profiles by comparison with in situ phenocams (time lapse cameras) which generated green-leaf phenology profiles using green chromatic coordinate (Gcc) values. Our results confirm the unique and valuable additional information available from daily resolution geostationary data for improved phenology assessments. With projected climate changes and extreme events showing continued warming and more intense droughts, the geostationary information will become increasingly important as early warning indicators of ecosystem change.

Keywords: Phenology, Grassland, Geostationary, Himawari-8, C3-C4 grass