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Phenological dynamics of arctic tundra vegetation and its implications on satellite imagery interpretation

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Remote sensing is a key methodology when monitoring the responses of arctic ecosystems to climatic warming. The short growing season and rapid vegetation development, however, set demands to the timing of image acquisition in the arctic. We used multispectral very high spatial resolution satellite images to study the effect of vegetation phenology on the spectral reflectance and image interpretation in the low arctic tundra in coastal Siberia (Tiksi, 71°35'39"N, 128°53'17"E). The study site mainly consists of peatlands, tussock, dwarf shrub, and grass tundra, and stony areas with some lichen and shrub patches. We tested the hypotheses that (1) plant phenology is responsive to the interannual weather variation and (2) the phenological state of vegetation has an impact on satellite image interpretation and the ability to distinguish between the plant communities. We used an empirical transfer function with temperature sums as drivers to reconstruct daily leaf area index (LAI) for the different plant communities for years 2005, and 2010-2014 based on measured LAI development in summer 2014. Satellite images, taken during growing seasons, were acquired for two years having late and early spring, and short and long growing season, respectively. LAI dynamics showed considerable interannual variation due to weather variation, and particularly the relative contribution of graminoid dominated communities was sensitive to these phenology shifts. We have also analyzed the differences in the reflectance values between the two satellite images taking account the LAI dynamics. These results will increase our understanding of the pitfalls that may arise from the timing of image acquisition when interpreting the vegetation structure in a heterogeneous tundra landscape. Very high spatial resolution multispectral images are available at reasonable cost, but not in high temporal resolution, which may lead to compromises when matching ground truth and the imagery. On the other hand, to identify existing plant communities, high resolution images are needed due fragmented nature of tundra vegetation communities. Temporal differences in the phenology among different plant functional types may also obscure the image interpretations when using spatially low resolution images in heterogeneous landscapes. Phenological features of plant communities should be acknowledged, when plant functional or community type based classifications are used in models to estimate global greenhouse gas emissions and when monitoring changes in vegetation are monitored, for example to indicate permafrost thawing or changes in growing season lengths.