Comparing the annual shift of phenological development of submersed macrophytes based on in-situ remote sensing reflectances

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Keywords: Water Quality, Inland Waters, Mapping

Submerse aquatic macrophytes are used as long-term indicator plants characterizing the trophic state of freshwater lakes. In the context of the European Water Framework Directive, the appearance and the composition of the macrophyte species are investigated in routine monitoring cycles every three years. This conducted monitoring is still based on in-situ measurements. Due to climate change induced increasing water temperatures, some macrophyte species show high invasion dynamics. Their partly areal spread affects the lake as well as the complete ecosystem. To detect first changes, a more-frequented monitoring method is suggested.

The presented research is about a subtask of an integral concept for a remote sensing based inventory and monitoring system for freshwater lakes. One component of this system are combined growth and reflection models based on in-situ data collections. For comparing the in-situ measurements almost the same parameters are necessary. One limiting factor for continuous in-situ measurement series throughout the vegetation period is the precondition of a cloudless sky. Therefore, an interpolation model to calculate the remote sensing reflection intensities for selected submersed macrophytes was developed. Currently the spectral signatures of four different macrophyte species are integrated in this model. Species-specific remote sensing reflectances of the investigated macrophytes were collected in the years 2011 and 2015. The reflectance signal is greatly affected by different proportions of sediment and macrophyte coverage across a vegetation period.

To get the spectral variations during the growing season, systematic and multi-temporal measurements covering the complete growing season from May to October were done. In both years the same study sites at Lake Starnberg in Southern Germany were investigated. For data acquisition a hyperspectral, submersible RAMSES spectroradiometer-system was used. Additionally, the phenology of the observed populations of submerse macrophytes was recorded by underwater cameras. So the seasonal variability of the spectral signatures can be linked to the corresponding plant phenology.

Beside the seasonal variability the spectral response is affected by diverse meteorologic conditions. Due to differing air and water temperatures the duration of the vegetation period as well as the length of the four defined phenological stages are varying among the two years. The difference in phenology in the investigated years can be showed in the combined growth and reflection models. Phenological developments within each year as well as shifts in phenological stages attributed to the differences in weather conditions are well reproduced by the models. The development progress of the aquatic plants and the shift within the vegetation period are analysed and compared.